



**HAL**  
open science

# BBOB 2010: Comparison Tables of All Algorithms on All Noiseless Functions

Anne Auger, Steffen Finck, Nikolaus Hansen, Raymond Ros

► **To cite this version:**

Anne Auger, Steffen Finck, Nikolaus Hansen, Raymond Ros. BBOB 2010: Comparison Tables of All Algorithms on All Noiseless Functions. [Technical Report] RT-388, INRIA. 2010, pp.152. inria-00516689

**HAL Id: inria-00516689**

**<https://inria.hal.science/inria-00516689v1>**

Submitted on 10 Sep 2010

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

***BBOB 2010: Comparison Tables of All Algorithms  
on All Noiseless Functions***

Anne Auger — Steffen Finck — Nikolaus Hansen — Raymond Ros

**N° 0388**

July 2010

Domaine 1

 *rapport  
technique*



## **BBOB 2010: Comparison Tables of All Algorithms on All Noiseless Functions**

Anne Auger , Steffen Finck , Nikolaus Hansen , Raymond Ros

Domaine : Mathématiques appliquées, calcul et simulation  
Équipe-Projet TAO

Rapport technique n° 0388 — July 2010 — [152](#) pages

**Abstract:** This document presents the results from the BBOB Black-Box Optimization Benchmarking workshop of the GECCO Genetic and Evolutionary Computation Conference 2010 in tables. Each table presents the performance of each algorithm submitted to BBOB 2010 on one function and dimension from the noiseless testbed.

**Key-words:** continuous optimization, benchmarking

Anne Auger, Nikolaus Hansen and Raymond Ros are affiliated to the TAO team-project, INRIA Saclay – Ile-de-France, Université Paris Sud, LRI, F-91405 Orsay Cedex, France.

Steffen Finck is affiliated to the Research Center PPE, University of Applied Science Vorarlberg, Hochschulstrasse 1, 6850 Dornbirn, Austria.

## **BBOB 2010: Tables de comparaison de tous les algorithmes sur toutes les fonctions non-bruitées**

**Résumé :** Ce document présente les résultats sous forme de table du workshop Black-Box Optimization Benchmarking (BBOB) de la conférence Genetic and Evolutionary Computation Conference (GECCO), Portland, Oregon, États-Unis, 2010. Chaque table présente les performances des algorithmes soumis à BBOB 2010 pour un problème de la suite de fonctions tests.

**Mots-clés :** optimisation continue, banc d'essai

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking (BBOB) at GECCO 2010<sup>1</sup>. Many algorithms have been tested on 24 benchmark functions in dimensions between 2 and 40. A description of the used objective functions can be found in [15, 11]. The experimental set-up is described in [14].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. If the target was never reached, the median over all trials of the best function value is shown. See [14] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values.

## List of Tables

1	$f_1$ in dimension 2	7
2	$f_2$ in dimension 2	8
3	$f_3$ in dimension 2	9
4	$f_4$ in dimension 2	10
5	$f_5$ in dimension 2	11
6	$f_6$ in dimension 2	12
7	$f_7$ in dimension 2	13
8	$f_8$ in dimension 2	14
9	$f_9$ in dimension 2	15
10	$f_{10}$ in dimension 2	16
11	$f_{11}$ in dimension 2	17
12	$f_{12}$ in dimension 2	18
13	$f_{13}$ in dimension 2	19
14	$f_{14}$ in dimension 2	20
15	$f_{15}$ in dimension 2	21
16	$f_{16}$ in dimension 2	22
17	$f_{17}$ in dimension 2	23
18	$f_{18}$ in dimension 2	24
19	$f_{19}$ in dimension 2	25
20	$f_{20}$ in dimension 2	26
21	$f_{21}$ in dimension 2	27
22	$f_{22}$ in dimension 2	28
23	$f_{23}$ in dimension 2	29
24	$f_{24}$ in dimension 2	30
25	$f_1$ in dimension 3	31
26	$f_2$ in dimension 3	32
27	$f_3$ in dimension 3	33
28	$f_4$ in dimension 3	34
29	$f_5$ in dimension 3	35
30	$f_6$ in dimension 3	36
31	$f_7$ in dimension 3	37

---

<sup>1</sup>see <http://coco.gforge.inria.fr/doku.php?id=bbob-2010>

32	$f_8$ in dimension 3	38
33	$f_9$ in dimension 3	39
34	$f_{10}$ in dimension 3	40
35	$f_{11}$ in dimension 3	41
36	$f_{12}$ in dimension 3	42
37	$f_{13}$ in dimension 3	43
38	$f_{14}$ in dimension 3	44
39	$f_{15}$ in dimension 3	45
40	$f_{16}$ in dimension 3	46
41	$f_{17}$ in dimension 3	47
42	$f_{18}$ in dimension 3	48
43	$f_{19}$ in dimension 3	49
44	$f_{20}$ in dimension 3	50
45	$f_{21}$ in dimension 3	51
46	$f_{22}$ in dimension 3	52
47	$f_{23}$ in dimension 3	53
48	$f_{24}$ in dimension 3	54
49	$f_1$ in dimension 5	55
50	$f_2$ in dimension 5	56
51	$f_3$ in dimension 5	57
52	$f_4$ in dimension 5	58
53	$f_5$ in dimension 5	59
54	$f_6$ in dimension 5	60
55	$f_7$ in dimension 5	61
56	$f_8$ in dimension 5	62
57	$f_9$ in dimension 5	63
58	$f_{10}$ in dimension 5	64
59	$f_{11}$ in dimension 5	65
60	$f_{12}$ in dimension 5	66
61	$f_{13}$ in dimension 5	67
62	$f_{14}$ in dimension 5	68
63	$f_{15}$ in dimension 5	69
64	$f_{16}$ in dimension 5	70
65	$f_{17}$ in dimension 5	71
66	$f_{18}$ in dimension 5	72
67	$f_{19}$ in dimension 5	73
68	$f_{20}$ in dimension 5	74
69	$f_{21}$ in dimension 5	75
70	$f_{22}$ in dimension 5	76
71	$f_{23}$ in dimension 5	77
72	$f_{24}$ in dimension 5	78
73	$f_1$ in dimension 10	79
74	$f_2$ in dimension 10	80
75	$f_3$ in dimension 10	81
76	$f_4$ in dimension 10	82
77	$f_5$ in dimension 10	83
78	$f_6$ in dimension 10	84
79	$f_7$ in dimension 10	85
80	$f_8$ in dimension 10	86
81	$f_9$ in dimension 10	87

82	$f_{10}$ in dimension 10	88
83	$f_{11}$ in dimension 10	89
84	$f_{12}$ in dimension 10	90
85	$f_{13}$ in dimension 10	91
86	$f_{14}$ in dimension 10	92
87	$f_{15}$ in dimension 10	93
88	$f_{16}$ in dimension 10	94
89	$f_{17}$ in dimension 10	95
90	$f_{18}$ in dimension 10	96
91	$f_{19}$ in dimension 10	97
92	$f_{20}$ in dimension 10	98
93	$f_{21}$ in dimension 10	99
94	$f_{22}$ in dimension 10	100
95	$f_{23}$ in dimension 10	101
96	$f_{24}$ in dimension 10	102
97	$f_1$ in dimension 20	103
98	$f_2$ in dimension 20	104
99	$f_3$ in dimension 20	105
100	$f_4$ in dimension 20	106
101	$f_5$ in dimension 20	107
102	$f_6$ in dimension 20	108
103	$f_7$ in dimension 20	109
104	$f_8$ in dimension 20	110
105	$f_9$ in dimension 20	111
106	$f_{10}$ in dimension 20	112
107	$f_{11}$ in dimension 20	113
108	$f_{12}$ in dimension 20	114
109	$f_{13}$ in dimension 20	115
110	$f_{14}$ in dimension 20	116
111	$f_{15}$ in dimension 20	117
112	$f_{16}$ in dimension 20	118
113	$f_{17}$ in dimension 20	119
114	$f_{18}$ in dimension 20	120
115	$f_{19}$ in dimension 20	121
116	$f_{20}$ in dimension 20	122
117	$f_{21}$ in dimension 20	123
118	$f_{22}$ in dimension 20	124
119	$f_{23}$ in dimension 20	125
120	$f_{24}$ in dimension 20	126
121	$f_1$ in dimension 40	127
122	$f_2$ in dimension 40	128
123	$f_3$ in dimension 40	129
124	$f_4$ in dimension 40	130
125	$f_5$ in dimension 40	131
126	$f_6$ in dimension 40	132
127	$f_7$ in dimension 40	133
128	$f_8$ in dimension 40	134
129	$f_9$ in dimension 40	135
130	$f_{10}$ in dimension 40	136
131	$f_{11}$ in dimension 40	137



132	$f_{12}$ in dimension 40 . . . . .	138
133	$f_{13}$ in dimension 40 . . . . .	139
134	$f_{14}$ in dimension 40 . . . . .	140
135	$f_{15}$ in dimension 40 . . . . .	141
136	$f_{16}$ in dimension 40 . . . . .	142
137	$f_{17}$ in dimension 40 . . . . .	143
138	$f_{18}$ in dimension 40 . . . . .	144
139	$f_{19}$ in dimension 40 . . . . .	145
140	$f_{20}$ in dimension 40 . . . . .	146
141	$f_{21}$ in dimension 40 . . . . .	147
142	$f_{22}$ in dimension 40 . . . . .	148
143	$f_{23}$ in dimension 40 . . . . .	149
144	$f_{24}$ in dimension 40 . . . . .	150

Table 1: Running time excess  $ERT/ERT_{best}^{2009}$  on  $f_1$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>1 Sphere</b>											
$\Delta ft_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	4.9	7.8	14	19	24	32	38	53	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.1</b>	<b>2.3</b>	8.4	15	19	28	34	48	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.8</b>	<b>2.9</b>	6.5	11	17	24	29	39	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	5.2	3.4	8.2	11	20	28	36	49	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	3.8	3.4	6.4	9.4	14	20	24	32	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.1</b>	<b>2.3</b>	6.6	10	16	19	22	30	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.1</b>	3.3	<b>2.4</b>	<b>4.8</b>	<b>8.5</b>	<b>11</b>	<b>14</b>	<b>17</b>	<b>24</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	5.1	3.5	6.4	<b>9.0</b>	13	16	<b>19</b>	<b>25</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.9</b>	3.4	7.1	11	13	18	20	27	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	3.0	<b>2.4</b>	<b>6.0</b>	9.3	<b>13</b>	<b>16</b>	20	25	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>2.3</b>	7.4	22	38	60	82	105	151	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>1.9</b>	<b>1.1</b>	<b>1.1</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	7.7	14	7.3	15	22	47	66	94	125	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	3.6	6.1	19	29	39	58	69	101	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	<b>2.5</b>	4.5	18	31	44	57	71	100	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	3.6	3.3	8.3	11	17	22	26	36	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	5.1	4.5	10	15	19	23	27	36	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>2.3</b>	3.6	22	44	74	92	122	171	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>2.5</b>	4.1	29	53	69	85	94	116	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	172	84	116	324	694	986	1394	1965	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.1</b>	<b>2.3</b>	3.3	16	25	38	55	67	91	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	54	82	153	342	2401	4014	6242	12106	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>2.2</b>	9.2	46	77	188	346	466	734	Basic RCGA [24]
SPSA	<b>1</b>	27	42	20	26	28	33	38	46	61	SPSA [13]

Table 2: Running time excess  $ERT/ERT_{best}$  2009 on  $f_2$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>2 Ellipsoid separable</b>											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$											$ERT_{best}/D$
(1,2)-CMA-ES	10	42	67	80	65	66	66	65	64	67	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	30	85	99	85	86	86	83	82	85	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.8	26	55	70	61	62	63	61	61	63	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.9	46	201	214	168	166	166	160	157	156	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>3.0</b>	<b>4.8</b>	17	26	24	26	27	26	27	28	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.3	6.2	23	29	25	25	26	26	26	28	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>3.5</b>	6.0	18	19	18	19	19	19	19	20	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.6	9.3	19	26	22	23	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.2	8.1	<b>11</b>	16	<b>14</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>16</b>	<b>17</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.5	<b>4.8</b>	<b>5.8</b>	<b>11</b>	<b>11</b>	<b>12</b>	<b>12</b>	<b>13</b>	<b>13</b>	<b>14</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	14	20	22	32	38	46	52	56	62	77	Artif Bee Colony [8]
avg NEWUOA	<b>1.2</b>	<b>1.1</b>	<b>1.9</b>	<b>5.6</b>	<b>8.5</b>	<b>10</b>	<b>14</b>	17	20	27	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	269	1331	1953	4172	4065	3995	3783	3689	3624	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	8.2	10	14	16	16	19	22	23	26	31	Adap DE (F-AUC) [10]
DE (Uniform)	8.0	10	12	16	16	19	22	23	27	32	DE (Uniform) [9]
IPOP-aCMA-ES	4.6	5.1	14	18	15	16	17	<b>17</b>	<b>18</b>	<b>19</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.2	7.5	16	21	18	19	20	20	21	22	IPOP-CMA-ES [22]
CMA+DE-MOS	13	20	24	30	34	40	45	54	59	69	CMA+DE-MOS [18]
NBC-CMA	15	21	38	102	118	157	203	253	295	305	NBC-CMA [21]
POEMS	179	330	377	408	392	450	546	568	642	807	POEMS [17]
PM-AdapSS-DE	7.5	11	12	<b>15</b>	15	19	22	24	25	30	PM-AdapSS-DE [9, 10]
pPOEMS	156	708	1840	2152	2416	2672	3142	3515	4175	5218	pPOEMS [17, 20]
Basic RCGA	10	18	37	56	64	125	155	266	350	543	Basic RCGA [24]
SPSA	12	149	1599	8950	13921	17255	<i>33e-2/1e5</i>	.	.	.	SPSA [13]

Table 3: Running time excess  $ERT/ERT_{best}$  2009 on  $f_3$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>3 Rastrigin separable</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.1</b>	3.2	14	15	47	47	47	47	47	46	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>2.1</b>	<b>3.3</b>	8.4	28	35	43	43	43	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.3</b>	3.0	<b>3.4</b>	6.2	18	25	25	25	25	25	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	4.7	18	15	44	44	43	51	51	50	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.6</b>	<b>2.5</b>	10	8.8	14	14	14	14	14	14	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.1</b>	3.5	3.8	5.4	6.1	6.1	6.1	6.2	6.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.3</b>	<b>2.0</b>	<b>2.1</b>	3.0	8.5	11	11	11	11	11	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>2.1</b>	4.5	5.3	7.1	20	24	24	24	24	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.6</b>	5.6	12	26	26	26	26	26	26	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.5</b>	9.2	6.6	8.6	8.6	8.6	8.6	8.6	8.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	<b>1.7</b>	5.6	<b>1.7</b>	<b>1.6</b>	<b>2.4</b>	<b>2.9</b>	3.5	4.1	5.0	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>2.7</b>	5.1	<b>1.6</b>	3.2	3.2	3.2	<b>3.2</b>	<b>3.2</b>	<b>3.1</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.1	10	96	273	443	726	1244	2884	2875	2815	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.3</b>	<b>1.6</b>	5.3	<b>2.0</b>	<b>1.6</b>	<b>2.0</b>	<b>2.4</b>	<b>2.6</b>	<b>2.8</b>	<b>3.1</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.2</b>	<b>1.6</b>	5.2	<b>2.0</b>	<b>1.7</b>	<b>2.3</b>	<b>2.5</b>	<b>2.7</b>	<b>2.9</b>	<b>3.1</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1.1</b>	<b>2.5</b>	4.2	3.5	7.1	7.4	7.6	7.7	7.8	8.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.2</b>	4.2	4.2	3.3	7.7	8.0	8.7	8.9	9.0	9.1	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	<b>2.2</b>	6.7	<b>2.4</b>	<b>2.2</b>	<b>2.9</b>	3.4	3.8	4.3	5.1	CMA+DE-MOS [18]
NBC-CMA	<b>1.3</b>	<b>1.7</b>	6.3	4.9	6.5	9.4	10	10	10	10	NBC-CMA [21]
POEMS	<b>1</b>	220	42	10	12	18	23	29	32	41	POEMS [17]
PM-AdapSS-DE	<b>1.3</b>	<b>1.6</b>	5.0	<b>1.8</b>	34	34	34	34	34	34	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>2.1</b>	45	22	42	103	125	157	201	267	pPOEMS [17, 20]
Basic RCGA	<b>1.1</b>	<b>1.6</b>	5.9	18	18	38	67	79	81	83	Basic RCGA [24]
SPSA	22	10266	998	943	1281	<i>14e-1/1e5</i>	.	.	.	.	SPSA [13]

Table 4: Running time excess  $ERT/ERT_{best}$  2009 on  $f_4$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	4 Skew Rastrigin-Bueche separ										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	5.0	8.4	13	58	73	70	68	67	65	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.1</b>	3.1	7.9	10	26	30	29	28	28	27	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	3.2	<b>2.2</b>	13	48	46	43	42	42	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	8.9	6.9	30	72	68	65	63	63	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	3.0	<b>1.3</b>	7.9	27	25	24	23	23	22	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>2.7</b>	<b>2.0</b>	8.5	24	27	26	25	25	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	5.5	6.0	5.0	14	17	16	16	16	15	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	3.3	3.4	3.9	18	17	16	16	16	15	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>2.0</b>	3.6	13	48	44	42	41	41	39	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.5</b>	<b>1.7</b>	4.8	<b>13</b>	<b>12</b>	<b>12</b>	<b>11</b>	<b>11</b>	<b>11</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.0</b>	<b>2.7</b>	3.7	<b>1.9</b>	<b>2.6</b>	<b>3.0</b>	<b>3.4</b>	<b>3.9</b>	<b>4.6</b>	<b>5.6</b>	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	4.5	6.2	4.0	14	13	12	12	12	11	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	23	19	178	1790	5680	5391	5242	5200	4998	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>2.8</b>	4.0	<b>2.0</b>	111	103	98	95	95	91	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>2.5</b>	4.5	<b>1.9</b>	111	104	142	137	136	131	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	4.1	3.1	5.7	39	62	80	84	85	85	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.1</b>	7.5	4.7	12	61	97	114	169	171	171	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	3.3	4.3	3.1	<b>5.2</b>	<b>5.8</b>	<b>6.1</b>	<b>6.3</b>	<b>6.8</b>	<b>7.6</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>2.7</b>	6.6	5.8	14	16	16	20	26	25	NBC-CMA [21]
POEMS	<b>1</b>	302	34	14	29	31	35	37	40	47	POEMS [17]
PM-AdapSS-DE	<b>1</b>	3.8	3.7	147	292	271	257	249	248	238	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>2.6</b>	34	31	45	103	131	150	180	216	pPOEMS [17, 20]
Basic RCGA	<b>1.1</b>	3.6	9.0	39	222	472	2793	<i>36e-3/5e4</i>	.	.	Basic RCGA [24]
SPSA	25	18094	4669	3783	<i>47e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 6: Running time excess  $ERT/ERT_{best}$  2009 on  $f_6$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>6 Attractive sector</b>												
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$	
(1,2)-CMA-ES	3.4	<b>2.4</b>	4.4	4.7	3.9	5.1	6.5	6.6	6.8	6.5	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	<b>2.7</b>	<b>2.5</b>	<b>2.4</b>	4.6	5.9	5.8	6.0	7.4	6.9	6.4	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	3.0	4.2	3.2	4.5	3.8	4.3	5.6	5.6	5.2	5.3	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	3.4	<b>2.8</b>	4.1	7.4	16	14	14	13	12	11	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	3.3	<b>2.8</b>	<b>1.6</b>	<b>2.8</b>	<b>2.6</b>	<b>2.9</b>	3.1	3.1	3.1	3.2	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	3.5	<b>2.3</b>	<b>1.4</b>	<b>2.2</b>	<b>2.7</b>	<b>3.0</b>	3.0	3.0	<b>3.0</b>	3.0	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	<b>1.8</b>	<b>1.5</b>	<b>1.7</b>	<b>2.7</b>	<b>2.5</b>	<b>2.4</b>	<b>2.5</b>	<b>2.4</b>	<b>2.4</b>	<b>2.3</b>	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	6.1	4.4	<b>2.0</b>	<b>2.6</b>	<b>2.7</b>	<b>2.6</b>	<b>2.7</b>	<b>2.8</b>	<b>2.7</b>	<b>2.6</b>	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	3.9	<b>2.7</b>	<b>2.1</b>	<b>2.5</b>	<b>2.2</b>	<b>2.3</b>	<b>2.2</b>	<b>2.2</b>	<b>2.1</b>	<b>2.1</b>	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	<b>2.1</b>	<b>1.6</b>	<b>1.1</b>	<b>1.9</b>	<b>1.8</b>	<b>2.0</b>	<b>1.9</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	5.4	3.9	<b>2.8</b>	9.5	20	51	149	571	874	1167	Artif Bee Colony [8]	
avg NEWUOA	<b>1.4</b>	<b>2.1</b>	3.1	4.7	3.9	4.4	4.4	4.5	4.7	4.6	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	13	132	72	909	1848	1428	1564	1318	1120	1129	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	<b>2.8</b>	<b>1.9</b>	<b>2.9</b>	5.9	6.3	7.3	7.8	8.5	8.6	8.9	Adap DE (F-AUC) [10]	
DE (Uniform)	<b>2.8</b>	<b>3.0</b>	<b>2.9</b>	7.8	7.8	8.5	9.1	9.2	9.4	10	DE (Uniform) [9]	
IPOP-aCMA-ES	4.2	<b>3.0</b>	<b>2.1</b>	3.2	3.2	3.5	4.0	4.0	4.0	3.8	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	4.6	3.5	<b>2.3</b>	5.0	4.2	4.7	4.5	4.6	4.4	4.5	IPOP-CMA-ES [22]	
CMA+DE-MOS	3.2	<b>2.3</b>	<b>2.4</b>	12	13	16	16	18	17	18	CMA+DE-MOS [18]	
NBC-CMA	3.1	<b>2.6</b>	<b>3.0</b>	8.4	33	28	24	22	20	17	NBC-CMA [21]	
POEMS	204	157	61	92	99	112	121	138	136	147	POEMS [17]	
PM-AdapSS-DE	<b>2.9</b>	<b>2.3</b>	<b>1.9</b>	4.0	6.1	8.2	8.8	9.0	8.8	8.9	PM-AdapSS-DE [9, 10]	
pPOEMS	68	62	54	116	362	602	806	846	915	976	pPOEMS [17, 20]	
Basic RCGA	4.3	16	6.0	121	375	596	1340	1819	3139	5724	Basic RCGA [24]	
SPSA	75	4649	10152	8487	7901	8286	19888	<i>27e-2/1e5</i>	.	.	SPSA [13]	

Table 7: Running time excess  $ERT/ERT_{best}$  2009 on  $f_7$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>7 Step-ellipsoid</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.5</b>	3.5	6.2	6.5	24	13	37	37	37	259	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.9</b>	<b>2.0</b>	5.5	9.2	10	17	23	23	23	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.5</b>	<b>1.9</b>	4.3	4.5	13	24	32	32	32	69	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>2.5</b>	3.5	21	21	15	27	35	35	35	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>2.4</b>	<b>2.5</b>	5.1	3.6	4.1	<b>2.8</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	4.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.1</b>	<b>1.8</b>	4.9	5.7	4.8	4.9	5.3	5.3	5.3	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.3</b>	<b>1.5</b>	16	6.3	4.4	<b>2.3</b>	<b>2.7</b>	<b>2.7</b>	<b>2.7</b>	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.7</b>	<b>2.1</b>	<b>3.5</b>	5.0	3.8	3.6	5.6	5.6	5.6	7.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.1</b>	<b>1.2</b>	<b>3.7</b>	<b>2.7</b>	<b>2.0</b>	<b>0.72</b>	<b>0.70</b>	<b>0.70</b>	<b>0.70</b>	<b>0.72</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.3</b>	<b>1.6</b>	4.7	4.3	<b>2.6</b>	<b>1.1</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	<b>0.99</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.5</b>	<b>1.8</b>	6.4	4.2	9.5	17	60	60	60	123	Artif Bee Colony [8]
avg NEWUOA	<b>1.7</b>	<b>2.7</b>	4.0	3.7	6.8	5.0	10	10	10	9.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	268	296	861	719	589	936	1093	1093	1093	1610	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.3</b>	<b>1.7</b>	<b>3.9</b>	<b>2.9</b>	<b>2.3</b>	<b>1.3</b>	<b>1.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.6</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.8</b>	<b>2.5</b>	6.5	3.9	<b>2.8</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.4</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.4</b>	<b>2.7</b>	6.2	3.8	<b>2.6</b>	<b>1.0</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.4</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.3</b>	<b>2.9</b>	7.4	4.0	3.7	<b>1.9</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.9</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.4</b>	<b>2.4</b>	4.3	3.9	5.2	3.0	3.4	3.4	3.4	3.5	CMA+DE-MOS [18]
NBC-CMA	<b>1.9</b>	<b>2.1</b>	4.0	3.9	4.5	<b>2.5</b>	<b>2.7</b>	<b>2.7</b>	<b>2.7</b>	4.5	NBC-CMA [21]
POEMS	182	189	166	39	41	19	22	22	22	24	POEMS [17]
PM-AdapSS-DE	<b>1.5</b>	<b>2.2</b>	4.3	<b>3.2</b>	<b>2.6</b>	<b>1.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.6</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.7</b>	33	109	41	45	69	96	96	96	125	pPOEMS [17, 20]
Basic RCGA	<b>1.2</b>	<b>1.5</b>	4.1	7.0	81	127	240	240	240	302	Basic RCGA [24]
SPSA	354	7871	17652	39270	<i>34e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 8: Running time excess  $ERT/ERT_{best}$  2009 on  $f_8$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>8 Rosenbrock original</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	6.5	6.0	26	65	36	35	22	22	23	20	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.2	4.1	24	47	27	30	18	18	18	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.3	5.4	5.7	19	15	21	12	12	12	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.1	4.5	53	236	123	117	87	90	96	82	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.8	3.1	5.3	22	14	13	8.0	8.2	8.4	7.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.4	3.8	5.5	8.0	6.8	7.9	5.4	5.7	6.1	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.3	<b>2.7</b>	<b>2.9</b>	10	7.0	8.7	5.1	5.0	5.2	4.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	<b>2.6</b>	5.6	18	11	11	7.0	7.2	7.2	6.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.1	3.1	5.2	12	6.5	<b>6.8</b>	<b>4.0</b>	<b>4.2</b>	<b>4.3</b>	<b>4.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>2.5</b>	<b>1.9</b>	<b>3.6</b>	<b>6.6</b>	<b>5.0</b>	<b>5.3</b>	<b>3.2</b>	<b>3.2</b>	<b>3.4</b>	<b>3.2</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.7	<b>2.6</b>	5.7	10	18	188	822	4247	18261	<i>92e-6/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	3.9	<b>2.5</b>	<b>2.6</b>	<b>4.6</b>	<b>2.4</b>	<b>2.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.3</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	36	16	20	42	34	43	24	26	26	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.6	3.9	7.3	11	<b>6.3</b>	10	6.7	7.7	8.2	8.5	Adap DE (F-AUC) [10]
DE (Uniform)	<b>2.9</b>	<b>2.9</b>	6.6	10	399	320	173	163	161	136	DE (Uniform) [9]
IPOP-aCMA-ES	5.2	4.5	6.6	<b>7.9</b>	7.6	8.6	5.2	5.2	5.6	5.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	9.2	5.2	5.5	14	10	11	6.3	6.4	6.7	6.1	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>2.6</b>	<b>2.9</b>	6.2	16	15	22	14	15	17	17	CMA+DE-MOS [18]
NBC-CMA	<b>2.9</b>	3.5	6.0	10	13	20	13	14	17	17	NBC-CMA [21]
POEMS	238	111	207	379	173	185	119	138	177	193	POEMS [17]
PM-AdapSS-DE	3.4	3.3	6.9	8.0	7.5	8.5	6.0	6.9	7.5	7.9	PM-AdapSS-DE [9, 10]
pPOEMS	40	85	111	109	128	486	463	546	796	1002	pPOEMS [17, 20]
Basic RCGA	<b>2.6</b>	3.1	10	16	144	478	781	1572	7166	12810	Basic RCGA [24]
SPSA	931	548	3157	7112	22724	61485	33559	<i>85e-2/1e5</i>	.	.	SPSA [13]

Table 9: Running time excess  $ERT/ERT_{best}$  2009 on  $f_9$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>9 Rosenbrock rotated</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>2.9</b>	8.1	69	38	55	51	36	33	32	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>2.7</b>	10	24	19	26	28	21	19	19	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.2	<b>6.1</b>	22	15	22	22	17	16	16	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.3	<b>6.4</b>	21	43	108	87	65	60	59	55	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.0	10	<b>21</b>	8.0	11	11	8.1	7.5	7.7	7.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>2.7</b>	6.9	22	<b>3.2</b>	11	9.5	7.5	7.1	7.1	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>2.9</b>	8.3	29	<b>4.0</b>	<b>6.1</b>	6.2	4.7	4.5	4.5	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.5	9.1	<b>15</b>	8.3	10	10	8.0	7.5	7.6	7.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	5.3	10	21	5.5	6.4	<b>5.7</b>	<b>4.2</b>	<b>4.1</b>	<b>4.2</b>	<b>4.1</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.5	6.9	26	5.0	<b>5.3</b>	<b>5.1</b>	<b>3.7</b>	<b>3.6</b>	<b>3.6</b>	<b>3.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.9	10	29	6.8	14	42	242	1552	5121	9398	Artif Bee Colony [8]
avg NEWUOA	7.7	10	22	<b>4.7</b>	<b>4.0</b>	<b>3.2</b>	<b>2.3</b>	<b>2.1</b>	<b>2.0</b>	<b>1.9</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	16	39	693	65	58	49	34	31	31	29	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	5.0	14	44	7.9	489	342	224	200	388	344	Adap DE (F-AUC) [10]
DE (Uniform)	3.1	8.9	28	7.3	10	12	10	10	10	11	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.0</b>	<b>4.8</b>	22	6.8	8.8	8.0	6.3	5.8	6.0	5.9	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.7	11	39	10	12	11	7.8	7.4	7.3	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.9</b>	11	<b>20</b>	6.2	8.4	11	11	11	13	14	CMA+DE-MOS [18]
NBC-CMA	3.3	7.3	32	8.1	18	17	13	14	16	17	NBC-CMA [21]
POEMS	337	444	558	58	75	104	106	106	127	156	POEMS [17]
PM-AdapSS-DE	7.1	19	33	11	497	716	467	412	390	346	PM-AdapSS-DE [9, 10]
pPOEMS	159	319	558	51	173	500	609	674	894	1105	pPOEMS [17, 20]
Basic RCGA	3.3	10	49	8.0	29	206	994	1278	2857	15260	Basic RCGA [24]
SPSA	469	1759	55199	8901	<i>96e-2/1e5</i>	.	.	.	.	.	SPSA [13]

Table 10: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{10}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
$\Delta f_{target}$											$\Delta f_{target}$
$ERT_{best}/D$											$ERT_{best}/D$
(1,2)-CMA-ES	13	56	39	39	36	34	30	28	27	23	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	8.9	25	49	36	33	30	27	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.4	14	29	23	22	23	21	20	19	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.7	109	120	115	106	95	92	85	80	68	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.4	6.0	8.9	11	11	11	10	9.2	8.8	8.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	7.9	10	12	13	12	11	10	10	9.4	8.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.1	<b>5.9</b>	7.9	7.5	8.1	7.6	7.1	6.8	6.6	5.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>5.8</b>	8.7	8.8	8.3	8.7	8.4	8.4	7.9	7.5	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	9.3	7.0	6.4	<b>5.5</b>	<b>5.6</b>	<b>5.6</b>	<b>5.2</b>	<b>5.0</b>	<b>5.0</b>	<b>4.6</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>5.9</b>	<b>4.6</b>	<b>5.7</b>	5.6	<b>5.4</b>	<b>5.0</b>	<b>4.8</b>	<b>4.6</b>	<b>4.5</b>	<b>4.2</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	12	13	20	97	771	6940	<i>11e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>2.6</b>	<b>3.6</b>	<b>3.8</b>	<b>4.8</b>	6.9	7.6	8.8	9.5	10	11	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	13	62	144	364	642	865	772	697	647	545	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	12	10	6.8	6.9	7.2	7.8	8.2	8.4	8.5	8.6	Adap DE (F-AUC) [10]
DE (Uniform)	9.1	10	7.2	7.0	7.5	8.1	8.4	8.6	9.1	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	8.8	8.8	<b>5.3</b>	<b>5.4</b>	<b>5.8</b>	<b>6.1</b>	<b>5.9</b>	<b>5.6</b>	<b>5.4</b>	<b>5.3</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	9.4	9.1	10	8.7	8.4	7.8	7.5	7.1	6.9	6.4	IPOP-CMA-ES [22]
CMA+DE-MOS	13	14	13	19	20	20	20	20	20	20	CMA+DE-MOS [18]
NBC-CMA	16	24	25	51	64	77	81	90	96	87	NBC-CMA [21]
POEMS	103	87	302	742	1322	1758	1884	2353	2694	2655	POEMS [17]
PM-AdapSS-DE	8.8	10	7.4	6.5	7.3	7.4	7.8	8.2	8.5	8.9	PM-AdapSS-DE [9, 10]
pPOEMS	90	117	155	463	837	1017	1256	1447	1579	1747	pPOEMS [17, 20]
Basic RCGA	25	27	115	1504	1874	3104	6551	19727	<i>17e-3/5e4</i>	.	Basic RCGA [24]
SPSA	29	229	874	1873	16681	24345	<i>27e-2/1e5</i>	.	.	.	SPSA [13]

Table 11: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{11}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>11 Discus</b>											
$\Delta ft_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	5.1	22	26	35	35	31	28	26	25	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	12	44	33	36	34	30	28	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.6	21	24	26	27	26	25	23	22	19	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	35	53	75	105	87	85	77	72	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.9	11	12	12	11	10	10	9.1	8.8	7.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.9	6.6	12	13	12	11	10	10	9.3	8.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>3.2</b>	<b>6.1</b>	6.9	8.5	9.2	8.4	8.0	7.4	7.1	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	10	18	11	10	10	8.6	8.3	7.9	7.6	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.5	6.9	<b>4.2</b>	<b>6.5</b>	<b>6.7</b>	<b>5.8</b>	<b>5.5</b>	<b>5.3</b>	<b>5.1</b>	<b>4.8</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>3.9</b>	<b>5.6</b>	<b>3.3</b>	<b>5.5</b>	<b>5.6</b>	<b>5.0</b>	<b>4.9</b>	<b>4.6</b>	<b>4.6</b>	<b>4.2</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.3	13	11	103	813	7859	40809	<i>11e-3/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.3</b>	<b>1.5</b>	<b>1.5</b>	<b>3.3</b>	<b>5.1</b>	<b>5.4</b>	6.8	7.3	8.0	8.8	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.1	128	517	994	1265	1264	1159	1041	962	812	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	7.6	13	6.3	7.0	8.0	7.9	8.2	8.7	8.8	9.0	Adap DE (F-AUC) [10]
DE (Uniform)	9.0	12	6.0	6.9	7.8	8.3	8.5	8.9	9.0	9.4	DE (Uniform) [9]
IPOP-aCMA-ES	4.2	6.7	5.1	6.7	6.9	6.2	<b>6.0</b>	<b>5.9</b>	<b>5.8</b>	<b>5.5</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.1	12	7.5	8.3	8.7	7.6	7.4	7.1	6.8	6.4	IPOP-CMA-ES [22]
CMA+DE-MOS	11	23	13	19	23	21	21	21	21	20	CMA+DE-MOS [18]
NBC-CMA	13	22	24	41	58	66	87	97	101	88	NBC-CMA [21]
POEMS	68	69	533	811	1297	1891	2292	2546	2824	3255	POEMS [17]
PM-AdapSS-DE	7.9	12	6.2	7.3	8.2	8.3	8.8	9.1	9.1	9.4	PM-AdapSS-DE [9, 10]
pPOEMS	76	124	113	477	866	1087	1260	1491	1643	1787	pPOEMS [17, 20]
Basic RCGA	10	23	75	958	2135	6917	<i>44e-3/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	15	483	1404	4983	17942	46844	42861	38450	<i>50e-2/1e5</i>	.	SPSA [13]

Table 12: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{12}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>12 Bent cigar</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	5.9	12	12	24	27	31	33	31	35	30	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.4	30	32	28	26	26	24	22	20	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	21	38	42	52	43	37	34	29	25	21	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.9	37	95	170	142	116	105	88	73	57	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	9.3	12	16	21	18	16	16	14	13	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	8.6	11	16	21	19	18	17	16	15	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.5	8.0	16	22	18	16	15	14	12	10	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>2.9</b>	6.8	14	20	16	15	14	13	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.6	7.0	8.8	10	7.7	<b>7.0</b>	<b>6.7</b>	<b>6.1</b>	<b>5.6</b>	<b>5.2</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.6	<b>3.2</b>	<b>4.2</b>	<b>7.6</b>	<b>6.9</b>	<b>6.5</b>	<b>6.5</b>	<b>6.4</b>	<b>5.9</b>	<b>5.6</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	8.9	7.7	13	175	568	1467	2630	3353	2793	2258	Artif Bee Colony [8]
avg NEWUOA	<b>1.7</b>	<b>1.1</b>	<b>0.96</b>	<b>1.6</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.4</b>	<b>1.4</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	438	1070	8143	10929	8731	12445	22378	18388	<i>15e-1/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	11	7.9	8.1	8.2	<b>7.5</b>	7.1	7.6	7.9	7.6	7.2	Adap DE (F-AUC) [10]
DE (Uniform)	10	7.7	8.1	320	417	334	302	253	209	165	DE (Uniform) [9]
IPOP-aCMA-ES	<b>4.4</b>	<b>3.8</b>	<b>5.0</b>	<b>7.8</b>	8.3	8.2	8.5	8.1	13	11	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.6	7.0	10	12	9.3	9.0	8.6	7.8	7.3	6.5	IPOP-CMA-ES [22]
CMA+DE-MOS	13	12	16	22	18	18	19	19	18	17	CMA+DE-MOS [18]
NBC-CMA	14	13	20	66	73	69	76	80	69	57	NBC-CMA [21]
POEMS	91	79	332	726	1039	1490	2235	2363	2530	2595	POEMS [17]
PM-AdapSS-DE	9.5	9.0	8.3	8.6	197	334	301	405	334	263	PM-AdapSS-DE [9, 10]
pPOEMS	76	78	282	408	622	667	730	788	801	843	pPOEMS [17, 20]
Basic RCGA	13	23	118	730	852	804	1022	912	1577	1575	Basic RCGA [24]
SPSA	3230	4072	15645	60799	37286	29781	<i>30e+0/1e5</i>	.	.	.	SPSA [13]

Table 13: Running time excess  $ERT/ERT_{\text{best}}^{2009}$  on  $f_{13}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	13 Sharp ridge										
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	<b>2.2</b>	3.4	17	30	31	29	29	28	28	37	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.1</b>	3.5	13	32	41	39	40	50	67	68	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>2.1</b>	13	11	26	30	31	37	43	51	51	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1.1</b>	19	69	57	99	97	94	115	102	152	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.3</b>	3.9	7.1	10	10	8.5	10	10	10	10	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.7</b>	3.5	6.3	7.7	7.7	11	11	11	11	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.5</b>	<b>2.4</b>	<b>2.9</b>	6.5	8.2	7.2	7.4	7.4	7.3	8.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.3</b>	6.3	9.2	10	10	10	10	10	10	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.4</b>	<b>2.3</b>	<b>4.1</b>	<b>5.6</b>	<b>6.8</b>	<b>6.6</b>	<b>6.1</b>	<b>6.0</b>	<b>7.1</b>	<b>8.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.1</b>	<b>1.8</b>	<b>3.7</b>	<b>5.6</b>	9.1	8.2	8.1	7.5	8.1	8.9	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.4</b>	3.6	5.6	61	2262	18469	<i>23e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.8</b>	6.7	6.7	17	38	54	73	131	140	771	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	95	386	2717	4951	9966	<i>48e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.5</b>	4.1	4.5	6.9	8.2	8.5	9.3	9.4	9.3	9.5	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.5</b>	<b>2.8</b>	4.5	7.1	8.5	8.2	8.8	9.5	10	10	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1.7</b>	4.2	4.3	<b>6.1</b>	<b>6.2</b>	<b>5.9</b>	<b>6.1</b>	<b>5.9</b>	<b>5.9</b>	<b>5.8</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.4</b>	<b>2.1</b>	5.0	6.3	<b>6.7</b>	<b>6.3</b>	<b>6.6</b>	<b>6.9</b>	<b>6.8</b>	<b>7.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.3</b>	<b>2.7</b>	7.7	17	19	19	20	20	19	19	CMA+DE-MOS [18]
NBC-CMA	<b>1.5</b>	3.0	7.9	14	17	25	44	52	48	40	NBC-CMA [21]
POEMS	125	104	54	103	146	491	1449	4402	15360	69407	POEMS [17]
PM-AdapSS-DE	<b>1.7</b>	3.3	5.2	6.4	7.8	8.1	8.7	9.1	9.2	9.1	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.4</b>	51	48	233	856	1073	1441	1587	1967	2202	pPOEMS [17, 20]
Basic RCGA	<b>1.4</b>	3.6	85	1010	2805	7126	20886	<i>19e-2/5e4</i>	.	.	Basic RCGA [24]
SPSA	23	27	47	332	2459	15906	20509	17764	31370	<i>21e-3/1e5</i>	SPSA [13]

Table 14: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{14}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta f_{target}$ $ERT_{best}/D$	14 Sum of different powers										$\Delta f_{target}$ $ERT_{best}/D$
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
(1,2)-CMA-ES	<b>1</b>	<b>1.7</b>	9.2	10	7.4	11	18	20	22	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.1</b>	<b>2.3</b>	4.5	5.5	11	14	22	30	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.7</b>	<b>2.6</b>	3.9	4.7	10	13	19	24	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.9</b>	<b>1.9</b>	3.9	8.3	13	29	56	64	86	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>2.0</b>	<b>2.6</b>	<b>2.8</b>	<b>2.8</b>	4.3	4.8	5.8	7.3	8.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.4</b>	<b>1.9</b>	<b>1.3</b>	<b>3.0</b>	3.8	6.1	6.3	7.9	10	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>1.9</b>	<b>2.3</b>	<b>2.5</b>	<b>3.1</b>	4.1	4.4	5.3	7.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	3.3	5.1	5.6	7.2	8.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	<b>2.1</b>	<b>2.7</b>	<b>3.2</b>	<b>3.1</b>	<b>4.0</b>	<b>4.5</b>	<b>5.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>1.5</b>	<b>1.8</b>	3.1	3.5	<b>3.5</b>	<b>3.9</b>	<b>3.9</b>	<b>4.0</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.3</b>	<b>1.6</b>	4.7	10	18	27	607	11891	<i>22e-6/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.4</b>	3.4	<b>2.2</b>	<b>1.4</b>	<b>1.3</b>	<b>1.6</b>	<b>1.8</b>	<b>2.2</b>	6.8	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.3	7.9	19	17	10	15	21	25	37	581	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	<b>1.1</b>	3.6	5.6	10	10	8.4	8.7	9.0	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.5</b>	<b>1.7</b>	3.6	7.8	9.5	8.5	8.1	8.9	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.1</b>	<b>2.3</b>	<b>2.7</b>	3.3	4.9	4.9	4.9	4.8	<b>5.9</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.2</b>	<b>2.9</b>	4.6	5.1	4.7	5.2	6.0	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.2</b>	<b>1.8</b>	4.3	13	17	18	18	19	20	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	<b>2.0</b>	<b>2.9</b>	11	17	14	13	16	22	NBC-CMA [21]
POEMS	<b>1</b>	185	213	74	67	141	165	177	246	2034	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.5</b>	<b>1.7</b>	<b>2.7</b>	7.6	10	9.3	8.9	8.6	9.0	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.7</b>	<b>2.2</b>	57	66	391	760	984	1037	1666	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.2</b>	<b>1.5</b>	3.6	28	33	71	284	456	1630	Basic RCGA [24]
SPSA	22	57	242	984	530	452	850	5362	41592	31154	SPSA [13]

Table 15: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{15}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>15 Rastrigin</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.1</b>	4.2	<b>2.9</b>	14	17	17	16	15	15	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.3</b>	<b>2.9</b>	<b>0.83</b>	7.8	10	13	13	13	12	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	4.2	<b>2.4</b>	6.8	9.5	9.2	8.9	8.5	8.1	7.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	5.6	9.5	15	20	24	23	22	21	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.3</b>	5.4	<b>2.1</b>	3.6	<b>2.7</b>	<b>2.7</b>	<b>2.6</b>	<b>2.5</b>	<b>2.4</b>	<b>2.1</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.1</b>	4.4	<b>1.1</b>	<b>2.8</b>	4.7	4.9	4.7	4.5	4.3	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.5</b>	3.4	<b>2.2</b>	3.6	5.0	4.9	4.7	4.5	4.2	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.1</b>	4.7	<b>2.4</b>	5.8	9.4	9.1	8.8	8.4	7.9	7.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>2.8</b>	3.1	4.0	6.5	6.3	6.1	5.8	5.5	4.9	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.1</b>	<b>2.8</b>	<b>1.6</b>	3.4	6.0	5.8	5.6	5.4	5.1	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	<b>2.3</b>	<b>1.9</b>	8.8	17	75	164	309	495	672	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>2.6</b>	<b>2.5</b>	<b>2.5</b>	3.3	3.2	3.1	<b>2.9</b>	<b>2.8</b>	<b>2.4</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	189	108	64	158	331	418	1128	1067	933	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.2</b>	<b>2.4</b>	<b>1.8</b>	<b>1.7</b>	<b>0.77</b>	<b>0.95</b>	<b>0.98</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.2</b>	<b>2.1</b>	<b>1.8</b>	<b>1.5</b>	<b>0.67</b>	<b>0.88</b>	<b>0.95</b>	<b>0.97</b>	<b>1.0</b>	<b>1.0</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1.1</b>	3.9	<b>1.3</b>	<b>2.6</b>	<b>2.5</b>	<b>2.9</b>	<b>2.8</b>	<b>2.8</b>	<b>2.7</b>	<b>2.4</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>2.5</b>	<b>0.98</b>	<b>2.8</b>	<b>2.5</b>	<b>2.5</b>	<b>2.4</b>	<b>2.4</b>	<b>2.3</b>	<b>2.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>2.4</b>	<b>1.6</b>	4.0	<b>2.7</b>	3.3	3.4	3.4	3.3	3.1	CMA+DE-MOS [18]
NBC-CMA	<b>1.1</b>	<b>2.8</b>	<b>2.2</b>	<b>2.7</b>	3.2	4.2	4.2	4.2	4.0	3.6	NBC-CMA [21]
POEMS	<b>1</b>	143	17	20	76	76	75	74	71	65	POEMS [17]
PM-AdapSS-DE	<b>1.1</b>	<b>2.3</b>	<b>2.1</b>	<b>1.7</b>	15	14	14	13	13	11	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	7.1	19	46	25	50	63	72	82	92	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.6</b>	3.1	32	32	40	51	62	79	114	Basic RCGA [24]
SPSA	28	962	39	1133	1352	<i>11e-1/1e5</i>	.	.	.	.	SPSA [13]



Table 16: Running time excess  $ERT/ERT_{\text{best}}^{2009}$  on  $f_{16}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>16 Weierstrass</b>											
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.6</b>	3.0	14	19	44	74	120	115	125	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.1</b>	23	14	32	21	20	21	21	19	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	12	20	27	21	29	34	48	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.5</b>	23	39	41	74	107	725	696	530	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.9</b>	10	13	7.1	4.2	<b>4.4</b>	4.9	4.8	4.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.4</b>	4.0	9.1	5.4	4.3	4.4	<b>4.2</b>	7.6	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.6</b>	<b>2.6</b>	5.9	<b>3.6</b>	5.3	4.9	4.6	5.3	4.2	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.5</b>	7.6	10	10	6.2	12	12	11	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.5</b>	5.6	6.8	5.6	5.6	7.4	10	12	10	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.5</b>	3.6	7.6	5.4	7.6	7.7	11	11	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.5</b>	<b>2.2</b>	<b>3.4</b>	8.7	38	202	1036	4754	3686	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	12	15	9.1	5.5	6.8	13	21	37	73	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1.7</b>	8.5	166	134	236	489	2332	<i>53e-4/1e5</i>	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.6</b>	<b>1.5</b>	<b>4.9</b>	<b>3.5</b>	<b>3.6</b>	<b>4.0</b>	<b>4.1</b>	<b>4.1</b>	<b>3.5</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	<b>2.8</b>	6.8	4.0	3.8	4.6	4.6	4.7	4.0	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.1</b>	3.8	8.3	6.1	<b>3.7</b>	<b>3.6</b>	<b>3.4</b>	<b>3.3</b>	<b>2.7</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.4</b>	<b>2.5</b>	11	5.0	<b>3.5</b>	4.6	4.3	<b>4.2</b>	<b>3.4</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.6</b>	5.3	6.0	<b>3.8</b>	5.0	5.8	5.7	6.5	6.5	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.5</b>	<b>2.4</b>	5.3	12	17	22	21	23	19	NBC-CMA [21]
POEMS	<b>1</b>	100	67	152	81	137	132	126	125	103	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.2</b>	3.1	<b>4.2</b>	4.6	47	44	41	39	30	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.6</b>	39	22	58	106	162	229	264	283	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.5</b>	<b>1.8</b>	5.2	68	73	87	160	219	290	Basic RCGA [24]
SPSA	13	71	71	137	298	424	822	2207	7266	<i>30e-4/1e5</i>	SPSA [13]

Table 17: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{17}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	17 Schaffer F7, condition 10										
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$	0.50	0.50	1.3	30	66	138	198	372	543	828	$ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.3</b>	38	9.1	18	17	59	393	<i>99e-5/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.3</b>	3.7	<b>1.6</b>	4.6	5.2	7.4	11	60	84	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>1.8</b>	<b>2.5</b>	<b>2.9</b>	4.2	14	27	62	180	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>2.9</b>	7.4	4.5	17	48	332	<i>33e-4/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.3</b>	3.8	<b>2.0</b>	3.6	3.1	5.0	5.7	13	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.3</b>	3.2	<b>1.8</b>	<b>2.6</b>	<b>2.6</b>	<b>2.9</b>	3.7	12	18	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.1</b>	<b>1.4</b>	<b>2.4</b>	5.2	3.3	<b>2.5</b>	3.7	11	36	32	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.3</b>	6.2	<b>1.8</b>	3.7	5.3	10	27	<i>30e-6/1e4</i>	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>2.5</b>	4.0	3.3	4.5	12	19	19	33	22	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.9</b>	3.1	<b>1.7</b>	<b>2.2</b>	4.0	3.0	4.3	5.6	3.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.0</b>	<b>1.3</b>	<b>2.2</b>	<b>2.5</b>	6.7	10	94	231	436	<i>29e-6/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	<b>1.1</b>	<b>1.3</b>	12	4.6	13	33	117	<i>75e-4/5e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.3	17	14	6.5	61	310	811	3768	<i>14e-4/1e5</i>	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	<b>2.9</b>	<b>1.9</b>	<b>2.5</b>	<b>2.0</b>	<b>2.1</b>	<b>1.5</b>	<b>1.3</b>	<b>1.2</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.1</b>	<b>2.5</b>	<b>1.8</b>	<b>2.5</b>	<b>2.1</b>	<b>2.1</b>	<b>1.5</b>	<b>1.3</b>	<b>1.2</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.3</b>	5.4	<b>2.6</b>	<b>2.2</b>	<b>1.8</b>	<b>1.5</b>	<b>1.2</b>	<b>1.3</b>	<b>1.1</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	19	<b>2.4</b>	<b>2.0</b>	<b>1.6</b>	<b>1.7</b>	<b>1.4</b>	<b>1.5</b>	<b>1.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.5</b>	<b>2.2</b>	4.9	6.6	5.0	5.0	3.3	3.1	<b>2.6</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>1.9</b>	<b>2.8</b>	4.6	<b>3.0</b>	<b>2.5</b>	<b>1.7</b>	<b>1.5</b>	<b>2.1</b>	NBC-CMA [21]
POEMS	<b>1</b>	66	130	18	33	28	32	24	21	19	POEMS [17]
PM-AdapSS-DE	<b>1.1</b>	<b>1.2</b>	<b>2.5</b>	<b>1.6</b>	<b>2.2</b>	<b>2.0</b>	<b>2.1</b>	<b>1.5</b>	<b>1.4</b>	<b>1.2</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.3</b>	51	23	116	179	220	157	142	133	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.2</b>	<b>2.9</b>	5.0	47	61	103	77	124	<i>23e-7/5e4</i>	Basic RCGA [24]
SPSA	1935	16834	27903	1683	771	1105	<i>17e-3/1e5</i>	.	.	.	SPSA [13]

Table 18: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{18}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>18 Schaffer F7, condition 1000</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.1</b>	17	8.4	7.7	16	72	82	144	<i>28e-3/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.1</b>	25	6.5	17	17	53	168	138	<i>20e-3/1e4</i>	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.5</b>	4.3	<b>1.7</b>	8.2	7.8	23	<i>13e-3/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1.3</b>	3.1	74	41	39	<i>98e-3/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.1</b>	<b>2.4</b>	3.5	10	8.1	10	11	22	119	102	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.1</b>	16	3.5	5.7	3.7	4.2	6.9	15	37	31	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.1</b>	<b>1.4</b>	<b>0.70</b>	4.1	<b>2.6</b>	8.0	20	144	<i>14e-4/1e4</i>	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.6</b>	<b>1.3</b>	<b>0.93</b>	6.7	6.3	12	15	144	<i>10e-4/1e4</i>	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.7</b>	8.1	<b>2.4</b>	10	17	33	172	<i>16e-3/1e4</i>	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.3</b>	<b>1.3</b>	7.6	12	39	173	143	<i>16e-3/1e4</i>	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.2</b>	<b>1.1</b>	<b>2.4</b>	8.2	20	596	2565	<i>20e-3/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.7</b>	7.9	5.4	9.0	6.1	62	<i>58e-3/6e3</i>	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.2	8.1	12	463	541	<i>27e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.1</b>	<b>1.3</b>	<b>2.6</b>	<b>1.4</b>	<b>0.73</b>	<b>0.62</b>	<b>0.66</b>	<b>0.68</b>	<b>0.74</b>	<b>0.81</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.1</b>	<b>0.98</b>	<b>2.9</b>	<b>1.8</b>	<b>0.77</b>	<b>0.63</b>	<b>0.63</b>	<b>0.65</b>	<b>0.71</b>	<b>0.80</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.1</b>	<b>2.1</b>	<b>1.4</b>	3.9	<b>1.2</b>	<b>0.78</b>	<b>0.71</b>	<b>0.71</b>	<b>0.85</b>	<b>0.92</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>2.9</b>	4.9	3.7	<b>1.5</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.0</b>	<b>1.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.5</b>	<b>1.3</b>	<b>2.5</b>	3.8	<b>2.6</b>	<b>1.9</b>	<b>2.1</b>	<b>1.9</b>	<b>2.6</b>	<b>2.5</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.1</b>	<b>1.1</b>	<b>2.4</b>	8.6	<b>2.9</b>	<b>2.3</b>	<b>2.3</b>	<b>2.1</b>	<b>2.0</b>	<b>2.2</b>	NBC-CMA [21]
POEMS	36	84	31	17	10	8.9	8.9	33	32	30	POEMS [17]
PM-AdapSS-DE	<b>1.1</b>	<b>0.90</b>	<b>2.6</b>	<b>1.5</b>	<b>0.71</b>	<b>0.65</b>	<b>0.63</b>	<b>0.65</b>	<b>0.70</b>	<b>0.77</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.1</b>	11	29	37	56	57	63	70	77	94	pPOEMS [17, 20]
Basic RCGA	<b>1.1</b>	<b>1.4</b>	<b>2.1</b>	114	137	352	836	<i>71e-3/5e4</i>	.	.	Basic RCGA [24]
SPSA	24	6520	3903	2418	1211	2253	<i>10e-1/1e5</i>	.	.	.	SPSA [13]

Table 19: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{19}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>19 Griewank-Rosenbrock F8F2</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	3.9	128	18	21	31	44	52	49	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.7</b>	<b>30</b>	21	19	39	43	58	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	3.7	56	17	13	23	30	37	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	<b>3.1</b>	68	12	32	41	50	56	53	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.1</b>	4.3	<b>28</b>	14	15	28	36	39	36	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	4.8	35	11	9.1	<b>10</b>	17	16	<b>15</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.2</b>	6.3	42	12	17	25	28	27	29	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	9.4	57	25	14	22	22	24	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>3.1</b>	52	76	24	23	22	21	20	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	4.7	50	16	13	<b>12</b>	<b>12</b>	<b>11</b>	<b>10</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.1</b>	6.1	56	11	<b>7.7</b>	16	37	73	882	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.3</b>	8.0	106	13	22	21	20	19	18	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	8.7	87	144	24	118	281	493	1300	2054	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.3</b>	6.5	63	<b>8.3</b>	147	143	138	132	122	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.3</b>	3.9	36	8.8	72	70	67	67	62	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.4</b>	5.1	32	9.2	<b>8.7</b>	14	19	19	18	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.1</b>	6.3	<b>22</b>	9.0	17	17	18	18	17	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	3.8	<b>30</b>	<b>6.7</b>	<b>1.9</b>	<b>3.1</b>	<b>4.0</b>	<b>5.0</b>	<b>5.4</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	5.4	36	<b>7.9</b>	11	13	<b>16</b>	<b>16</b>	18	NBC-CMA [21]
POEMS	<b>1</b>	102	310	549	46	464	451	432	415	389	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>2.1</b>	5.5	43	10	341	327	312	299	276	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.3</b>	68	539	49	38	81	122	185	258	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	5.7	47	8.9	18	22	71	107	453	Basic RCGA [24]
SPSA	20	67	573	982	202	889	1595	2506	11291	<i>48e-4/1e5</i>	SPSA [13]

Table 20: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{20}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>20 Schwefel <math>x*\sin(x)</math></b>												
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$	
(1,2)-CMA-ES	6.4	4.8	6.0	15	24	37	37	37	37	37	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	<b>2.3</b>	<b>3.0</b>	3.2	13	24	34	34	34	34	33	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	<b>2.2</b>	<b>2.2</b>	<b>2.1</b>	17	31	54	54	54	54	53	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	5.7	45	98	20	38	51	52	57	57	56	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	3.2	3.4	3.1	9.3	6.9	7.8	7.8	7.9	7.9	7.9	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	<b>1.8</b>	<b>2.3</b>	<b>2.4</b>	10	12	13	13	13	13	13	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	3.2	3.6	3.7	11	14	15	17	17	17	17	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	<b>2.1</b>	<b>1.7</b>	<b>1.6</b>	8.4	10	11	12	12	12	12	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	<b>3.0</b>	3.1	3.6	16	4.9	4.9	<b>5.0</b>	<b>5.0</b>	<b>5.1</b>	<b>5.1</b>	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	<b>1.6</b>	<b>1.7</b>	<b>1.7</b>	11	4.8	<b>4.9</b>	<b>4.9</b>	<b>5.0</b>	<b>5.0</b>	<b>5.0</b>	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	<b>2.1</b>	<b>2.6</b>	<b>2.6</b>	4.6	<b>2.2</b>	<b>4.1</b>	6.0	7.8	10	16	Artif Bee Colony [8]	
avg NEWUOA	<b>3.0</b>	<b>2.2</b>	<b>2.1</b>	10	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>3.9</b>	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	22	17	15	60	336	1100	3695	<i>49e-3/1e5</i>	.	.	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	<b>2.0</b>	<b>2.9</b>	<b>2.9</b>	<b>4.6</b>	482	481	481	480	476	470	Adap DE (F-AUC) [10]	
DE (Uniform)	<b>1.8</b>	<b>2.9</b>	<b>2.9</b>	<b>4.2</b>	276	276	276	276	274	270	DE (Uniform) [9]	
IPOP-aCMA-ES	<b>1.8</b>	<b>1.4</b>	<b>1.8</b>	12	10	11	12	12	12	12	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	4.5	5.7	5.6	12	11	12	12	13	13	13	IPOP-CMA-ES [22]	
CMA+DE-MOS	<b>2.0</b>	<b>2.6</b>	3.2	10	<b>4.8</b>	6.7	7.8	8.4	9.0	12	CMA+DE-MOS [18]	
NBC-CMA	<b>2.2</b>	3.6	3.6	11	6.7	7.6	8.1	8.4	8.5	8.7	NBC-CMA [21]	
POEMS	190	135	121	28	40	45	49	55	61	68	POEMS [17]	
PM-AdapSS-DE	3.3	<b>2.5</b>	<b>2.2</b>	<b>4.0</b>	628	627	627	626	620	612	PM-AdapSS-DE [9, 10]	
pPOEMS	75	101	92	45	43	83	132	185	228	301	pPOEMS [17, 20]	
Basic RCGA	<b>2.1</b>	3.7	3.6	33	38	143	335	641	849	1182	Basic RCGA [24]	
SPSA	65	78	101	9123	7680	7652	7654	7639	<i>11e-1/1e5</i>	.	SPSA [13]	

Table 21: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{21}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>21 Gallagher 101 peaks</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.3</b>	15	14	16	16	17	17	17	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.6</b>	7.6	8.8	8.7	13	17	17	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	5.5	13	13	16	16	15	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.5</b>	20	14	13	20	21	20	20	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.4</b>	8.9	5.8	4.4	4.4	4.2	4.1	4.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.6</b>	5.6	4.9	4.2	6.7	6.6	6.3	6.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.4</b>	6.6	4.7	3.7	<b>3.6</b>	<b>3.4</b>	<b>3.3</b>	<b>3.5</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.4</b>	9.3	7.6	6.0	5.7	5.5	5.2	5.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.6</b>	12	11	7.2	6.9	6.5	6.2	6.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.3</b>	12	7.9	5.1	4.9	4.6	4.4	4.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>1.2</b>	<b>2.0</b>	<b>1.8</b>	<b>2.6</b>	5.5	10	26	59	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	6.1	6.5	4.6	<b>2.9</b>	<b>2.8</b>	<b>2.7</b>	<b>2.6</b>	<b>2.7</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	7.5	12	23	34	75	96	201	234	500	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	<b>1.3</b>	284	83	53	51	48	46	45	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	<b>1.5</b>	<b>2.1</b>	<b>1.0</b>	<b>1.1</b>	<b>1.5</b>	<b>1.6</b>	<b>1.6</b>	<b>2.0</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>1.5</b>	6.2	7.0	4.9	5.3	5.4	5.2	25	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>1.3</b>	13	7.7	5.4	13	13	13	14	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>1.5</b>	<b>1.8</b>	<b>4.3</b>	4.9	5.3	6.5	10	12	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>0.96</b>	<b>2.3</b>	7.1	25	30	36	35	35	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	111	143	309	198	191	182	178	178	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	<b>1.7</b>	<b>1.7</b>	83	53	51	48	46	45	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	<b>1.8</b>	17	8.0	14	25	44	60	105	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>1.4</b>	14	13	34	71	96	197	285	Basic RCGA [24]
SPSA	<b>1</b>	21	47	94	266	218	223	297	320	753	SPSA [13]

Table 22: Running time excess  $ERT/ERT_{\text{best } 2009}$  on  $f_{22}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	22 Gallagher 21 peaks										
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	1	1	<b>2.1</b>	17	6.1	9.1	8.6	8.3	12	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	<b>1.4</b>	34	19	24	25	22	23	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	<b>1.3</b>	15	10	11	14	20	23	22	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	<b>1.6</b>	31	18	18	23	28	31	30	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	<b>2.2</b>	10	8.3	7.0	6.5	5.9	6.6	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	<b>1.6</b>	14	11	11	11	10	9.5	9.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	3.2	19	6.5	5.7	5.3	4.7	4.6	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	<b>1.5</b>	16	5.1	6.0	5.5	4.9	5.3	5.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	6.6	19	4.4	3.6	3.3	<b>3.0</b>	<b>3.0</b>	<b>2.9</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1	8.5	4.4	<b>3.5</b>	<b>3.2</b>	<b>2.8</b>	<b>2.8</b>	<b>2.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	<b>1.4</b>	<b>2.7</b>	<b>2.8</b>	4.2	8.9	21	47	373	Artif Bee Colony [8]
avg NEWUOA	1	1	<b>3.0</b>	3.8	<b>1.3</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.3</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	8.5	4.8	12	34	50	119	184	274	760	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	<b>1.9</b>	<b>2.2</b>	184	143	125	110	108	103	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	<b>1.3</b>	<b>2.2</b>	<b>1.0</b>	<b>1.3</b>	<b>1.5</b>	<b>1.7</b>	<b>1.8</b>	<b>2.2</b>	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	<b>1.2</b>	4.7	5.5	4.7	7.7	7.2	7.2	15	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	<b>1.6</b>	5.9	5.0	5.0	4.8	5.3	23	72	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	<b>1.2</b>	3.7	<b>2.9</b>	3.8	4.7	5.2	6.2	8.4	CMA+DE-MOS [18]
NBC-CMA	1	1	<b>1.3</b>	<b>2.2</b>	8.4	21	31	28	28	28	NBC-CMA [21]
POEMS	1	1	66	31	604	467	412	365	364	350	POEMS [17]
PM-AdapSS-DE	1	1	<b>1.5</b>	<b>2.4</b>	86	67	59	52	51	49	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	39	26	17	32	44	58	70	129	pPOEMS [17, 20]
Basic RCGA	1	1	<b>1.4</b>	<b>2.1</b>	11	25	69	119	232	604	Basic RCGA [24]
SPSA	1	22	107	284	373	750	1930	9991	9800	<i>38e-4/1e5</i>	SPSA [13]

Table 23: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{23}$  in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>23 Katsuuras</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.5</b>	22	214	253	222	213	192	243	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	4.2	10	76	81	71	68	62	57	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.2</b>	18	90	99	90	86	78	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.6</b>	14	103	225	288	276	249	770	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.1</b>	11	23	23	27	26	24	22	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	3.8	13	19	17	15	15	13	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	4.5	8.5	13	13	12	<b>12</b>	<b>11</b>	<b>10</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.2</b>	14	29	29	26	25	22	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	8.2	3.1	<b>4.5</b>	<b>4.5</b>	<b>4.5</b>	<b>6.1</b>	<b>5.6</b>	<b>5.4</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.0</b>	<b>2.2</b>	6.7	14	14	13	<b>12</b>	<b>11</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>2.1</b>	15	1791	<i>13e-2/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	4.2	6.7	25	103	262	<i>49e-3/6e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	<b>2.5</b>	4.0	12	2604	<i>17e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	<b>1.8</b>	<b>2.4</b>	<b>5.4</b>	<b>7.6</b>	<b>9.3</b>	<b>11</b>	13	15	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	<b>2.5</b>	<b>2.3</b>	6.0	<b>8.2</b>	10	12	13	16	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>2.8</b>	6.6	16	19	17	16	15	14	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>1.9</b>	7.8	162	233	204	196	177	162	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>2.0</b>	5.5	24	40	44	46	43	42	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>1.8</b>	10	737	761	668	639	576	529	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	13	41	253	245	233	234	225	230	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	<b>2.0</b>	<b>1.9</b>	<b>5.8</b>	8.5	<b>10</b>	12	13	16	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	11	61	659	866	996	1160	1199	1404	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>1.9</b>	5.2	256	889	4692	4487	<i>29e-3/5e4</i>	.	Basic RCGA [24]
SPSA	<b>1</b>	13	18	264	<i>49e-2/1e5</i>	.	.	.	.	.	SPSA [13]





Table 25: Running time excess  $ERT/ERT_{best}$  2009 on  $f_1$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>1 Sphere</b>											
$\Delta ft_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	6.3	9.3	16	26	31	40	46	66	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.9</b>	5.2	12	18	24	31	38	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.9</b>	4.0	8.2	13	19	23	30	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	5.5	6.7	12	19	28	34	42	60	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	3.1	4.5	10	14	19	24	29	37	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.1</b>	3.4	4.5	8.3	12	17	22	27	35	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	<b>3.4</b>	<b>5.8</b>	<b>8.8</b>	<b>12</b>	<b>15</b>	<b>20</b>	<b>26</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>2.7</b>	<b>3.7</b>	<b>6.7</b>	<b>11</b>	<b>14</b>	<b>18</b>	24	30	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.3</b>	3.9	8.8	12	16	20	23	31	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.9</b>	4.8	8.4	12	15	19	<b>23</b>	<b>29</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	5.4	20	41	64	88	118	147	210	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.3</b>	<b>2.4</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1.1</b>	23	13	14	24	40	69	107	139	197	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	<b>2.4</b>	15	33	53	76	96	118	163	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	3.4	14	35	57	79	105	126	174	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	3.6	6.4	11	16	23	28	33	44	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	3.6	4.9	11	18	23	30	35	47	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	<b>2.5</b>	18	48	72	100	128	152	208	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>2.3</b>	16	45	57	66	79	90	112	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	173	108	191	479	961	1309	1628	2506	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.4</b>	<b>2.4</b>	16	33	55	77	99	120	166	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	49	90	165	1519	3923	6568	9419	15398	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	<b>2.0</b>	20	77	152	268	497	693	1315	Basic RCGA [24]
SPSA	<b>1</b>	33	19	11	14	17	20	24	27	34	SPSA [13]









Table 30: Running time excess  $ERT/ERT_{best}$  2009 on  $f_6$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	6 Attractive sector										
$\Delta ft_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	4.0	3.3	5.0	7.6	6.3	6.1	5.8	5.3	5.0	5.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>2.7</b>	<b>2.6</b>	3.8	4.4	4.1	4.4	4.8	4.4	4.1	4.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>2.3</b>	<b>2.0</b>	<b>2.9</b>	3.5	3.5	3.7	3.4	3.3	3.4	3.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.2	4.6	8.2	8.4	6.9	8.0	7.5	6.8	6.8	7.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>3.0</b>	<b>2.7</b>	<b>1.9</b>	<b>2.5</b>	<b>2.3</b>	<b>2.4</b>	<b>2.5</b>	<b>2.3</b>	<b>2.4</b>	<b>2.5</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>2.3</b>	<b>1.9</b>	<b>2.3</b>	<b>2.7</b>	<b>2.6</b>	<b>2.6</b>	<b>2.6</b>	<b>2.3</b>	<b>2.4</b>	<b>2.5</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>2.1</b>	<b>1.7</b>	<b>1.5</b>	<b>1.8</b>	<b>1.8</b>	<b>1.8</b>	<b>1.7</b>	<b>1.8</b>	<b>1.7</b>	<b>1.7</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.0	<b>2.5</b>	<b>1.7</b>	<b>2.1</b>	<b>1.9</b>	<b>2.0</b>	<b>1.9</b>	<b>2.0</b>	<b>2.0</b>	<b>2.2</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.7</b>	<b>2.4</b>	<b>1.6</b>	<b>2.0</b>	<b>1.9</b>	<b>1.9</b>	<b>1.8</b>	<b>1.8</b>	<b>1.8</b>	<b>1.9</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.9</b>	<b>1.6</b>	<b>1.8</b>	<b>2.0</b>	<b>1.7</b>	<b>1.7</b>	<b>1.6</b>	<b>1.5</b>	<b>1.5</b>	<b>1.6</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.4	<b>2.2</b>	3.8	13	43	163	445	490	592	524	Artif Bee Colony [8]
avg NEWUOA	<b>1.2</b>	<b>2.3</b>	<b>2.6</b>	<b>2.9</b>	<b>2.9</b>	3.8	3.9	4.1	4.3	4.7	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.3	74	115	312	207	488	608	526	603	2355	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.9	<b>2.8</b>	5.3	8.8	8.9	9.0	8.9	9.1	8.7	9.5	Adap DE (F-AUC) [10]
DE (Uniform)	3.6	4.1	4.3	9.2	9.5	10	10	10	10	10	DE (Uniform) [9]
IPOP-aCMA-ES	4.0	4.3	3.3	3.3	3.2	3.3	3.2	<b>2.9</b>	<b>3.0</b>	3.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.9	<b>2.8</b>	<b>2.8</b>	3.3	3.3	3.3	3.2	<b>3.0</b>	<b>3.0</b>	3.1	IPOP-CMA-ES [22]
CMA+DE-MOS	4.2	3.4	5.8	14	13	15	14	13	13	14	CMA+DE-MOS [18]
NBC-CMA	6.0	3.5	4.5	14	11	9.3	8.4	7.6	7.2	6.9	NBC-CMA [21]
POEMS	150	84	34	61	83	92	101	95	96	109	POEMS [17]
PM-AdapSS-DE	5.1	3.3	3.7	8.6	8.7	9.2	9.4	9.3	9.4	10	PM-AdapSS-DE [9, 10]
pPOEMS	89	74	37	228	455	618	631	670	717	803	pPOEMS [17, 20]
Basic RCGA	23	14	13	160	302	813	1494	3510	4760	<i>18e-4/5e4</i>	Basic RCGA [24]
SPSA	23	4689	11501	11802	14416	<i>11e+0/1e5</i>	.	.	.	.	SPSA [13]

Table 31: Running time excess  $ERT/ERT_{best}$  2009 on  $f_7$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>7 Step-ellipsoid</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.3</b>	3.4	15	11	17	83	202	202	202	256	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.5</b>	3.2	3.4	6.8	8.0	20	27	27	27	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.3</b>	<b>2.4</b>	3.9	3.4	5.2	25	44	44	44	59	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1.1</b>	<b>2.1</b>	6.9	18	17	107	179	179	179	389	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.3</b>	4.8	3.9	<b>2.2</b>	3.1	3.4	6.7	6.7	6.7	16	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.3</b>	<b>2.1</b>	<b>2.2</b>	<b>2.1</b>	<b>1.9</b>	3.3	3.2	3.2	3.2	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.4</b>	<b>1.9</b>	14	3.8	<b>1.6</b>	<b>2.2</b>	3.9	3.9	3.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.2</b>	<b>2.5</b>	3.4	<b>2.6</b>	<b>2.6</b>	3.3	5.6	5.6	5.6	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.9</b>	<b>1.7</b>	<b>2.7</b>	<b>1.9</b>	<b>0.82</b>	<b>2.2</b>	<b>2.5</b>	<b>2.5</b>	<b>2.5</b>	<b>2.3</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.5</b>	<b>2.1</b>	<b>2.2</b>	<b>2.2</b>	<b>1.3</b>	<b>1.3</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	<b>1.4</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.2</b>	<b>1.6</b>	6.1	8.0	10	22	85	85	85	125	Artif Bee Colony [8]
avg NEWUOA	<b>1.3</b>	3.5	<b>1.2</b>	6.8	4.8	19	41	41	41	37	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	164	246	781	2492	9087	8751	8751	8751	7880	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.3</b>	<b>1.5</b>	<b>2.4</b>	3.4	<b>1.1</b>	<b>1.2</b>	<b>1.4</b>	<b>1.4</b>	<b>1.4</b>	<b>1.5</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.3</b>	<b>1.5</b>	5.5	4.2	<b>1.3</b>	<b>1.4</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1.3</b>	<b>2.6</b>	<b>2.9</b>	<b>1.7</b>	<b>0.93</b>	<b>0.90</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	<b>1.1</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.5</b>	<b>2.4</b>	3.5	7.2	<b>2.0</b>	<b>1.6</b>	<b>1.9</b>	<b>1.9</b>	<b>1.9</b>	<b>1.8</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	<b>2.2</b>	3.0	4.4	<b>2.3</b>	<b>2.2</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.4</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.1</b>	<b>2.2</b>	4.2	4.9	<b>2.5</b>	<b>2.2</b>	<b>2.2</b>	<b>2.2</b>	<b>2.2</b>	<b>2.1</b>	NBC-CMA [21]
POEMS	92	240	76	28	27	26	28	28	28	28	POEMS [17]
PM-AdapSS-DE	<b>1.5</b>	<b>1.8</b>	4.3	3.5	<b>1.2</b>	<b>1.3</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.6</b>	33	61	30	40	67	91	91	91	106	pPOEMS [17, 20]
Basic RCGA	<b>1.1</b>	<b>2.1</b>	5.6	43	80	161	212	212	212	208	Basic RCGA [24]
SPSA	59	193	20672	30144	<i>69e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 32: Running time excess  $ERT/ERT_{best}$  2009 on  $f_8$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>8 Rosenbrock original</b>												
$\Delta ft_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$	
$ERT_{best}/D$											$ERT_{best}/D$	
(1,2)-CMA-ES	5.0	10	12	28	16	17	18	18	18	18	(1,2)-CMA-ES	<i>[5, 3]</i>
(1,2m)-CMA-ES	<b>2.8</b>	<b>2.2</b>	10	20	9.3	10	11	11	11	11	(1,2m)-CMA-ES	<i>[5]</i>
(1,2ms)-CMA-ES	<b>2.6</b>	6.2	12	29	12	12	13	13	13	13	(1,2ms)-CMA-ES	<i>[5]</i>
(1,2s)-CMA-ES	<b>1.8</b>	<b>2.2</b>	3.9	50	23	25	28	29	29	29	(1,2s)-CMA-ES	<i>[3]</i>
(1,4)-CMA-ES	4.4	4.3	3.8	11	5.3	5.4	5.7	5.9	6.0	6.2	(1,4)-CMA-ES	<i>[6, 4]</i>
(1,4m)-CMA-ES	3.9	3.3	3.5	13	6.7	6.7	6.8	6.8	6.9	7.0	(1,4m)-CMA-ES	<i>[6]</i>
(1,4ms)-CMA-ES	<b>2.4</b>	<b>2.6</b>	3.5	10	4.3	4.4	4.6	4.6	4.7	4.8	(1,4ms)-CMA-ES	<i>[1, 6]</i>
(1,4s)-CMA-ES	<b>2.5</b>	<b>1.6</b>	<b>2.0</b>	10	5.0	5.4	5.7	5.7	5.8	5.8	(1,4s)-CMA-ES	<i>[4]</i>
(1+1)-CMA-ES	<b>2.5</b>	<b>2.6</b>	<b>2.5</b>	<b>6.5</b>	<b>2.9</b>	<b>3.0</b>	<b>3.0</b>	<b>3.1</b>	<b>3.2</b>	<b>3.4</b>	(1+1)-CMA-ES	<i>[7]</i>
(1+2ms)-CMA-ES	<b>1.7</b>	<b>1.7</b>	<b>2.1</b>	<b>4.8</b>	<b>2.3</b>	<b>2.3</b>	<b>2.5</b>	<b>2.5</b>	<b>2.7</b>	<b>2.8</b>	(1+2ms)-CMA-ES	<i>[2]</i>
Artif Bee Colony	<b>2.1</b>	3.9	3.8	17	26	235	3088	21956	<i>12e-4/1e5</i>	.	Artif Bee Colony	<i>[8]</i>
avg NEWUOA	3.1	<b>1.9</b>	<b>1.9</b>	<b>2.6</b>	<b>1.0</b>	<b>0.98</b>	<b>0.98</b>	<b>1.00</b>	<b>1.0</b>	<b>1.0</b>	avg NEWUOA	<i>[23]</i>
CMA-EGS (IPOP,r1)	35	17	25	50	21	22	22	22	24	25	CMA-EGS (IPOP,r1)	<i>[12]</i>
Adap DE (F-AUC)	3.5	4.7	9.1	13	7.2	7.9	8.5	9.1	10	11	Adap DE (F-AUC)	<i>[10]</i>
DE (Uniform)	5.1	5.2	8.4	16	9.5	11	12	13	14	15	DE (Uniform)	<i>[9]</i>
IPOP-aCMA-ES	3.6	4.1	3.5	7.4	3.8	4.1	4.2	4.3	4.5	4.7	IPOP-aCMA-ES	<i>[16]</i>
IPOP-CMA-ES	3.8	4.6	4.9	13	5.8	5.7	5.8	5.9	6.2	6.3	IPOP-CMA-ES	<i>[22]</i>
CMA+DE-MOS	3.4	6.1	11	19	12	13	13	14	15	16	CMA+DE-MOS	<i>[18]</i>
NBC-CMA	4.9	5.8	8.8	13	6.8	7.3	7.9	8.1	8.4	8.9	NBC-CMA	<i>[21]</i>
POEMS	147	55	44	88	55	74	163	283	300	380	POEMS	<i>[17]</i>
PM-AdapSS-DE	<b>2.2</b>	4.5	8.7	13	7.0	8.7	10	56	56	54	PM-AdapSS-DE	<i>[9, 10]</i>
pPOEMS	125	53	43	148	221	376	479	643	794	1066	pPOEMS	<i>[17, 20]</i>
Basic RCGA	<b>2.6</b>	7.0	13	61	640	1150	3462	<i>14e-3/5e4</i>	.	.	Basic RCGA	<i>[24]</i>
SPSA	490	275	267	8639	5825	24022	<i>12e-1/1e5</i>	.	.	.	SPSA	<i>[13]</i>

Table 33: Running time excess  $ERT/ERT_{best}$  2009 on  $f_9$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>9 Rosenbrock rotated</b>										
$\Delta ft_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$
$ERT_{best}/D$	0.33	0.33	6.9	22	42	50	53	55	56	59	$ERT_{best}/D$
(1,2)-CMA-ES	15	86	11	14	16	17	18	18	18	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	42	5.2	10	10	11	11	12	12	12	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>7.8</b>	39	16	17	13	13	13	14	13	14	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	10	54	4.8	6.7	16	21	22	24	24	25	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	10	37	4.2	7.4	6.4	6.6	6.9	7.0	7.2	7.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	36	3.1	3.8	4.1	4.6	5.0	5.2	5.4	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	9.4	<b>23</b>	<b>2.5</b>	<b>3.1</b>	3.5	3.9	4.1	4.2	4.3	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	11	39	<b>2.7</b>	9.1	7.2	7.3	7.3	7.3	7.3	7.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	10	31	<b>2.6</b>	<b>3.3</b>	<b>2.9</b>	<b>3.1</b>	<b>3.1</b>	<b>3.3</b>	<b>3.4</b>	<b>3.6</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	11	26	<b>2.8</b>	3.9	<b>3.3</b>	<b>3.3</b>	<b>3.4</b>	<b>3.5</b>	<b>3.6</b>	<b>3.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	54	5.2	7.3	93	473	4854	26815	<i>24e-4/1e5</i>	.	Artif Bee Colony [8]
avg NEWUOA	11	<b>20</b>	<b>1.7</b>	<b>1.7</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.2</b>	<b>1.2</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	125	163	26	37	29	27	27	28	28	29	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14	42	7.7	10	9.3	11	19	22	24	24	Adap DE (F-AUC) [10]
DE (Uniform)	11	45	9.2	9.1	10	12	13	14	14	15	DE (Uniform) [9]
IPOP-aCMA-ES	10	38	3.5	5.9	4.8	4.8	5.1	5.3	5.4	5.6	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>5.5</b>	<b>19</b>	<b>3.0</b>	4.8	4.4	4.8	5.0	5.2	5.5	5.7	IPOP-CMA-ES [22]
CMA+DE-MOS	10	55	11	4.9	6.9	9.3	10	11	12	14	CMA+DE-MOS [18]
NBC-CMA	8.8	56	10	9.1	8.7	9.3	10	10	10	11	NBC-CMA [21]
POEMS	603	753	55	213	138	176	252	352	461	604	POEMS [17]
PM-AdapSS-DE	<b>7.7</b>	31	7.6	8.4	8.4	10	10	11	12	13	PM-AdapSS-DE [9, 10]
pPOEMS	466	780	59	146	322	466	624	763	945	1276	pPOEMS [17, 20]
Basic RCGA	12	69	12	181	1567	7119	<i>94e-3/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	5984	12372	1417	9774	<i>12e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 35: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{11}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>11 Discus</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	10	74	36	27	14	12	12	12	12	11	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	18	80	28	23	12	10	10	10	10	9.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	16	44	20	19	9.5	8.5	8.3	8.2	8.2	8.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	34	119	36	36	19	17	17	17	16	15	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.2	18	10	8.8	4.7	4.3	4.3	4.3	4.2	4.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	24	12	9.3	4.7	4.3	4.3	4.3	4.3	4.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.7	11	7.0	6.9	3.6	3.2	3.1	3.1	3.1	3.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>3.7</b>	15	9.3	7.5	4.0	3.7	3.6	3.6	3.6	3.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>3.8</b>	13	5.9	5.3	<b>2.8</b>	<b>2.5</b>	<b>2.5</b>	<b>2.5</b>	<b>2.5</b>	<b>2.5</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.9	<b>6.8</b>	<b>5.3</b>	<b>4.5</b>	<b>2.5</b>	<b>2.3</b>	<b>2.2</b>	<b>2.2</b>	<b>2.2</b>	<b>2.2</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.0	<b>8.2</b>	28	262	2431	<i>14e-2/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.9</b>	<b>2.6</b>	<b>2.0</b>	<b>3.3</b>	<b>2.5</b>	<b>2.7</b>	3.3	3.7	4.3	5.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	172	78	59	29	25	24	24	23	23	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	20	5.7	5.5	3.0	3.4	3.7	4.3	4.6	5.3	Adap DE (F-AUC) [10]
DE (Uniform)	10	15	5.9	5.6	3.3	3.5	3.9	4.4	4.9	5.7	DE (Uniform) [9]
IPOP-aCMA-ES	6.1	9.1	<b>5.3</b>	<b>4.5</b>	<b>2.4</b>	<b>2.3</b>	<b>2.3</b>	<b>2.4</b>	<b>2.5</b>	<b>2.5</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	6.0	13	9.2	7.5	4.0	3.7	3.7	3.7	3.7	3.7	IPOP-CMA-ES [22]
CMA+DE-MOS	13	23	17	17	8.8	8.5	8.7	9.0	9.0	9.4	CMA+DE-MOS [18]
NBC-CMA	11	25	11	16	9.1	8.8	9.2	9.1	9.0	9.1	NBC-CMA [21]
POEMS	79	81	138	716	641	891	1259	1627	1683	2371	POEMS [17]
PM-AdapSS-DE	11	17	6.1	5.6	3.4	3.6	4.1	4.5	4.9	5.6	PM-AdapSS-DE [9, 10]
pPOEMS	70	62	86	383	312	447	534	679	787	943	pPOEMS [17, 20]
Basic RCGA	11	17	342	1203	2947	8132	<i>58e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	10	224	3544	18559	<i>58e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 36: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{12}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	12 Bent cigar										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	23	43	55	39	27	28	27	23	22	21	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.9	11	25	16	11	10	10	8.2	8.1	8.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	10	15	25	17	11	10	9.4	7.3	6.9	6.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	18	51	96	90	60	55	52	50	46	67	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.7	8.9	19	13	8.0	7.4	7.2	5.4	5.2	5.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.4	8.8	17	12	7.9	7.3	7.1	5.5	5.3	5.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>3.1</b>	<b>3.0</b>	13	10	6.8	6.4	6.2	4.9	4.7	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	<b>3.4</b>	<b>6.8</b>	7.2	5.6	5.6	5.5	4.3	4.2	4.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>3.1</b>	3.8	10	<b>6.2</b>	<b>4.1</b>	<b>3.9</b>	<b>3.8</b>	<b>2.9</b>	<b>2.9</b>	<b>3.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.1	3.6	10	7.9	5.1	5.0	4.7	<b>3.6</b>	<b>3.5</b>	<b>3.5</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	18	53	283	1651	10641	<i>12e-2/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.1</b>	<b>1.9</b>	<b>4.5</b>	<b>3.2</b>	<b>2.2</b>	<b>2.2</b>	<b>1.8</b>	<b>1.8</b>	<b>1.8</b>	<b>1.9</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	25	33	1357	1390	1873	2084	2726	3153	2827	2491	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14	15	14	44	146	132	173	126	114	145	Adap DE (F-AUC) [10]
DE (Uniform)	16	16	14	8.1	227	277	251	246	221	196	DE (Uniform) [9]
IPOP-aCMA-ES	4.7	4.7	10	7.8	6.2	6.0	5.9	4.7	4.6	4.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	6.0	7.3	<b>8.9</b>	<b>6.6</b>	<b>4.5</b>	<b>4.6</b>	<b>4.6</b>	3.7	3.7	4.1	IPOP-CMA-ES [22]
CMA+DE-MOS	24	23	25	19	13	12	12	9.3	9.2	9.1	CMA+DE-MOS [18]
NBC-CMA	16	16	24	15	10	11	11	8.8	8.5	8.7	NBC-CMA [21]
POEMS	122	173	2189	3753	4466	5469	<i>22e-2/3e5</i>	.	.	.	POEMS [17]
PM-AdapSS-DE	14	17	344	284	229	505	456	360	324	286	PM-AdapSS-DE [9, 10]
pPOEMS	190	430	852	604	443	539	618	543	582	650	pPOEMS [17, 20]
Basic RCGA	41	42	592	577	414	1104	1141	3519	<i>96e-3/5e4</i>	.	Basic RCGA [24]
SPSA	3876	5174	7183	11674	12506	<i>21e+0/1e5</i>	.	.	.	.	SPSA [13]

Table 37: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{13}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>13 Sharp ridge</b>											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$											$ERT_{best}/D$
(1,2)-CMA-ES	<b>2.6</b>	7.3	21	29	27	29	26	23	24	41	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>0.92</b>	<b>2.8</b>	17	26	33	32	25	31	36	56	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.8</b>	4.2	15	19	21	22	20	19	28	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1.8</b>	7.8	17	45	47	47	37	46	67	91	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.8</b>	<b>2.9</b>	6.6	8.1	8.7	7.9	6.1	6.9	6.9	8.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	3.1	5.2	8.6	8.2	7.8	5.9	7.0	7.1	7.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.8</b>	<b>2.1</b>	<b>3.4</b>	<b>5.1</b>	5.9	6.1	<b>4.6</b>	5.3	6.3	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.5</b>	<b>2.3</b>	7.3	7.7	7.6	7.2	5.6	5.8	6.0	5.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.3</b>	<b>2.3</b>	4.1	7.7	6.9	6.6	5.2	5.2	5.0	6.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>0.87</b>	3.6	5.2	5.1	<b>5.1</b>	<b>4.8</b>	<b>3.4</b>	<b>3.6</b>	<b>3.6</b>	<b>4.5</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	6.7	12	160	3803	31398	<i>86e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>2.5</b>	<b>1.0</b>	5.6	14	42	114	159	277	256	<i>36e-4/8e3</i>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	8.4	1628	2638	18147	<i>61e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.6</b>	5.8	7.4	7.7	8.6	8.8	7.0	7.1	7.3	7.2	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.4</b>	7.1	8.8	8.9	10	10	7.6	7.7	7.9	7.7	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.2</b>	<b>2.7</b>	<b>3.4</b>	<b>3.6</b>	<b>3.9</b>	<b>4.3</b>	<b>3.3</b>	<b>3.2</b>	<b>3.4</b>	<b>3.4</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>2.2</b>	3.0	<b>3.4</b>	<b>5.0</b>	<b>5.9</b>	<b>5.7</b>	4.6	<b>4.4</b>	<b>4.6</b>	<b>4.5</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.4</b>	4.5	14	15	15	15	11	11	11	10	CMA+DE-MOS [18]
NBC-CMA	<b>1.5</b>	7.9	9.5	9.1	12	12	8.8	8.7	8.7	8.6	NBC-CMA [21]
POEMS	191	48	67	1186	3456	4088	11632	<i>43e-4/3e5</i>	.	.	POEMS [17]
PM-AdapSS-DE	<b>2.0</b>	5.8	7.8	8.1	9.5	10	7.5	7.6	7.8	7.7	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.6</b>	51	101	595	922	1236	1020	1162	1390	1653	pPOEMS [17, 20]
Basic RCGA	<b>1.2</b>	10	115	440	1252	3765	5106	4324	3914	<i>46e-3/5e4</i>	Basic RCGA [24]
SPSA	21	34	110	2720	41486	<i>67e-2/1e5</i>	.	.	.	.	SPSA [13]

Table 38: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{14}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta f_{target}$ $ERT_{best}/D$	14 Sum of different powers										$\Delta f_{target}$ $ERT_{best}/D$
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
(1,2)-CMA-ES	<b>1</b>	<b>1.2</b>	13	6.3	6.5	7.3	12	17	21	18	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>1.6</b>	4.2	4.4	4.9	6.8	10	15	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.3</b>	<b>2.5</b>	3.1	3.9	5.1	9.3	13	12	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.3</b>	3.5	3.3	5.1	8.5	12	25	31	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.7</b>	4.7	<b>2.8</b>	3.3	3.9	4.2	5.6	7.7	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.9</b>	<b>2.0</b>	<b>2.6</b>	<b>3.0</b>	3.5	5.7	7.2	7.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.3</b>	<b>1.8</b>	<b>1.5</b>	<b>2.2</b>	<b>2.6</b>	<b>3.0</b>	<b>3.9</b>	5.2	4.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.5</b>	4.2	<b>1.8</b>	<b>2.6</b>	3.5	4.4	5.2	6.6	5.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.1</b>	3.4	<b>2.2</b>	<b>3.0</b>	<b>2.9</b>	3.4	4.0	<b>4.4</b>	<b>3.9</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	<b>2.1</b>	<b>2.6</b>	<b>2.5</b>	<b>2.7</b>	<b>3.4</b>	<b>3.8</b>	<b>3.3</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.2</b>	<b>1.5</b>	8.9	14	26	315	2547	12654	<i>55e-6/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.2</b>	4.7	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.2</b>	<b>1.6</b>	<b>2.7</b>	6.9	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.7	25	44	14	12	15	25	37	36	422	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	<b>2.1</b>	3.7	10	12	10	10	10	8.3	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.1</b>	<b>1.6</b>	4.4	11	14	11	12	12	8.8	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>2.3</b>	<b>2.7</b>	3.7	4.2	3.7	4.5	5.0	<b>4.2</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.5</b>	<b>2.8</b>	3.7	4.0	4.6	4.8	5.8	6.8	5.8	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	<b>1.2</b>	4.0	15	17	15	17	18	14	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	<b>2.2</b>	5.8	12	12	9.4	10	11	8.7	NBC-CMA [21]
POEMS	<b>1</b>	39	269	54	63	113	138	161	313	14624	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.6</b>	<b>1.9</b>	5.4	12	12	11	11	11	8.7	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.1</b>	41	43	91	467	735	1010	1223	1506	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	<b>1.9</b>	10	36	71	210	646	1886	<i>51e-7/5e4</i>	Basic RCGA [24]
SPSA	10	47	534	295	205	165	429	785	2270	<i>48e-7/1e5</i>	SPSA [13]

Table 39: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{15}$  in **3-D**, in *italics* is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>15 Rastrigin</b>											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$	0.33	0.78	40	457	2095	2761	2810	2863	2929	3014	$ERT_{best}/D$
(1,2)-CMA-ES	<b>2.1</b>	7.9	7.6	31	67	51	50	49	48	47	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.1</b>	3.3	<b>2.7</b>	8.2	12	9.0	8.8	8.7	8.5	8.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.6</b>	3.7	3.6	10	11	8.4	8.3	8.1	7.9	7.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1.4</b>	4.7	9.0	39	33	25	25	24	24	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.8</b>	<b>2.5</b>	3.9	5.7	7.0	5.3	5.2	5.1	5.0	4.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>2.1</b>	<b>1.2</b>	<b>2.9</b>	8.3	6.3	6.2	6.1	6.0	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.5</b>	<b>2.7</b>	<b>2.2</b>	<b>2.0</b>	<b>2.6</b>	<b>2.0</b>	<b>1.9</b>	<b>1.9</b>	<b>1.9</b>	<b>1.8</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.1</b>	3.2	4.2	3.9	22	17	17	16	16	16	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.8</b>	3.2	<b>2.5</b>	3.8	11	8.3	8.2	8.1	7.9	7.7	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.4</b>	<b>2.5</b>	<b>2.1</b>	7.0	7.2	5.5	5.4	5.3	5.1	5.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	<b>1.8</b>	3.6	34	42	88	250	496	<i>29e-3/1e5</i>	.	Artif Bee Colony [8]
avg NEWUOA	<b>2.0</b>	3.4	3.2	3.7	3.1	<b>2.3</b>	<b>2.3</b>	<b>2.2</b>	<b>2.2</b>	<b>2.1</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	18	23	12	36	325	519	<i>99e-2/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.3</b>	<b>1.9</b>	<b>1.8</b>	<b>1.4</b>	<b>0.41</b>	<b>0.37</b>	<b>0.38</b>	<b>0.40</b>	<b>0.40</b>	<b>0.43</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	3.9	<b>2.3</b>	<b>1.6</b>	3.9	3.0	<b>3.0</b>	<b>3.0</b>	<b>2.9</b>	<b>2.9</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.5</b>	4.2	<b>0.98</b>	<b>1.6</b>	<b>1.0</b>	<b>0.85</b>	<b>0.85</b>	<b>0.85</b>	<b>0.85</b>	<b>0.85</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.3</b>	<b>2.9</b>	<b>2.4</b>	<b>1.4</b>	<b>1.2</b>	<b>0.93</b>	<b>0.93</b>	<b>0.93</b>	<b>0.92</b>	<b>0.93</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.3</b>	<b>1.5</b>	4.9	3.8	<b>1.5</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.2</b>	<b>1.3</b>	3.2	3.1	3.1	<b>2.4</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.2</b>	NBC-CMA [21]
POEMS	<b>1</b>	217	15	26	85	65	65	64	63	62	POEMS [17]
PM-AdapSS-DE	<b>1.4</b>	<b>2.6</b>	<b>2.3</b>	<b>1.5</b>	3.9	3.0	<b>3.0</b>	<b>3.0</b>	<b>2.9</b>	<b>2.9</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.1</b>	20	17	46	23	21	23	26	28	32	pPOEMS [17, 20]
Basic RCGA	<b>1.3</b>	<b>2.0</b>	5.3	24	9.3	7.5	9.4	12	17	39	Basic RCGA [24]
SPSA	282	9719	473	3249	<i>21e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 40: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{16}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>16 Weierstrass</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.5</b>	19	37	96	160	68	92	<i>25e-2/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	12	21	40	26	27	23	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.7</b>	<b>2.5</b>	11	19	25	17	22	16	64	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.4</b>	27	33	97	129	115	<i>17e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.5</b>	3.3	13	15	19	10	9.2	8.7	61	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.3</b>	5.4	5.3	8.1	8.6	5.6	5.4	5.0	5.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>1.9</b>	4.5	5.3	6.5	7.3	10	6.9	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.8</b>	6.2	8.1	12	18	14	19	16	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.4</b>	3.1	3.7	10	20	28	30	27	66	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>1.9</b>	3.4	4.7	13	12	34	41	60	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.8</b>	<b>1.2</b>	<b>3.1</b>	19	142	2272	<i>45e-4/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.3</b>	3.7	6.1	23	59	73	<i>19e-3/7e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1.2</b>	15	14	91	445	5699	<i>80e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.3</b>	<b>2.5</b>	4.4	6.7	5.8	<b>2.7</b>	12	8.5	8.2	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	<b>2.2</b>	4.5	7.3	7.5	3.4	3.1	<b>2.2</b>	<b>2.2</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.2</b>	<b>1.5</b>	<b>3.2</b>	<b>2.7</b>	<b>3.1</b>	<b>1.5</b>	<b>1.3</b>	<b>0.93</b>	<b>0.93</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.7</b>	<b>2.2</b>	<b>3.2</b>	<b>3.8</b>	<b>3.3</b>	<b>1.4</b>	<b>1.3</b>	<b>0.88</b>	<b>1.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.2</b>	<b>1.5</b>	5.3	<b>4.4</b>	<b>3.8</b>	<b>1.9</b>	<b>1.8</b>	<b>1.3</b>	<b>1.4</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.5</b>	<b>1.5</b>	7.5	7.1	8.6	3.8	3.4	<b>2.4</b>	<b>2.4</b>	NBC-CMA [21]
POEMS	<b>1</b>	20	18	28	523	521	225	195	133	128	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.4</b>	<b>1.6</b>	6.4	11	11	17	15	10	10	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.4</b>	18	15	85	112	105	139	103	119	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>1.6</b>	17	45	117	125	135	117	199	Basic RCGA [24]
SPSA	<b>2.7</b>	107	106	312	1571	<i>28e-2/1e5</i>	.	.	.	.	SPSA [13]

Table 41: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{17}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	17 Schaffer F7, condition 10										
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$	0.33	0.33	1.2	26	94	164	378	602	782	1156	$ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.7</b>	6.4	11	25	138	<i>14e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.3</b>	4.0	5.1	3.9	4.3	11	54	187	<i>26e-5/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.5</b>	3.8	<b>1.3</b>	5.1	7.5	22	119	184	124	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	388	113	30	50	859	<i>44e-3/1e4</i>	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.3</b>	19	7.4	8.4	16	19	28	91	<i>12e-5/1e4</i>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.6</b>	4.1	4.5	3.3	5.9	4.2	15	61	129	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.7</b>	13	3.6	3.8	3.8	6.5	17	87	<i>58e-6/1e4</i>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.1</b>	3.9	4.9	6.9	12	18	<i>54e-5/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.4</b>	12	5.2	15	36	88	243	<i>26e-4/1e4</i>	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	10	6.3	6.3	13	17	55	92	125	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.5</b>	3.2	6.6	11	42	469	2342	1803	<i>11e-4/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.9</b>	3.3	8.0	13	153	<i>32e-3/5e3</i>	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.9	19	16	17	12	243	739	2328	1793	<i>61e-4/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.3</b>	4.3	<b>3.3</b>	<b>2.7</b>	<b>2.6</b>	<b>1.6</b>	<b>1.4</b>	<b>1.3</b>	<b>1.2</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.3</b>	<b>2.2</b>	3.6	<b>2.8</b>	<b>2.7</b>	<b>1.7</b>	<b>1.4</b>	<b>1.4</b>	<b>1.3</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1.1</b>	<b>2.3</b>	4.5	6.6	<b>2.8</b>	<b>2.1</b>	<b>1.6</b>	<b>1.2</b>	<b>1.2</b>	<b>0.95</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	3.5	20	<b>2.2</b>	<b>1.1</b>	<b>1.8</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.0</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.3</b>	<b>2.4</b>	5.9	6.8	6.2	5.2	4.3	3.7	3.4	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.4</b>	<b>2.6</b>	4.0	<b>2.1</b>	<b>1.7</b>	<b>0.93</b>	<b>0.72</b>	<b>1.4</b>	<b>1.2</b>	NBC-CMA [21]
POEMS	<b>1</b>	164	184	22	26	28	18	15	15	30	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.5</b>	<b>1.9</b>	3.7	<b>2.5</b>	<b>2.7</b>	<b>1.7</b>	<b>1.3</b>	<b>1.3</b>	<b>1.2</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.1</b>	<b>1.2</b>	16	19	129	185	125	108	106	105	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.3</b>	3.1	25	72	81	51	111	155	<i>63e-6/5e4</i>	Basic RCGA [24]
SPSA	57	21735	32080	4518	1302	2511	<i>11e-1/1e5</i>	.	.	.	SPSA [13]

Table 42: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{18}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	18 Schaffer F7, condition 1000										
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$											$ERT_{best}/D$
(1,2)-CMA-ES	<b>1.2</b>	5.9	9.0	29	23	137	<i>69e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	3.6	<b>1.3</b>	10	14	26	<i>42e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	5.4	<b>1.4</b>	4.2	6.1	20	<i>11e-3/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	5.8	15	46	103	<i>24e-2/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.1</b>	4.1	5.4	7.2	5.5	16	120	<i>12e-3/1e4</i>	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.1</b>	48	4.6	5.0	3.1	6.2	18	<i>24e-4/1e4</i>	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	4.2	4.0	4.7	5.8	8.7	17	107	<i>15e-4/1e4</i>	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.2</b>	4.6	5.2	12	8.8	19	125	<i>15e-3/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	3.6	6.0	21	11	35	<i>42e-3/1e4</i>	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	61	5.8	11	9.5	26	128	<i>24e-3/1e4</i>	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	3.1	3.4	15	70	315	<i>23e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.3</b>	4.8	11	30	15	89	<i>76e-3/6e3</i>	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	38	13	62	284	<i>19e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.1</b>	<b>2.6</b>	<b>2.9</b>	3.7	<b>0.86</b>	<b>0.57</b>	<b>0.67</b>	<b>0.76</b>	<b>0.78</b>	<b>0.86</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1.5</b>	<b>2.8</b>	3.5	3.6	<b>0.86</b>	<b>0.57</b>	<b>0.68</b>	<b>0.77</b>	<b>0.78</b>	<b>0.86</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	7.4	<b>1.3</b>	<b>1.3</b>	<b>0.61</b>	<b>0.91</b>	<b>0.90</b>	<b>0.86</b>	<b>0.92</b>	<b>0.94</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.3</b>	6.4	<b>1.4</b>	<b>1.8</b>	<b>1.2</b>	<b>1.0</b>	<b>1.2</b>	<b>1.3</b>	<b>1.4</b>	<b>1.3</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	<b>1.8</b>	<b>2.9</b>	7.8	<b>2.1</b>	<b>1.7</b>	<b>2.0</b>	<b>1.9</b>	<b>1.8</b>	<b>2.0</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.3</b>	3.4	<b>2.3</b>	4.8	19	8.1	7.1	6.6	5.8	5.4	NBC-CMA [21]
POEMS	43	260	23	27	8.9	50	110	107	158	226	POEMS [17]
PM-AdapSS-DE	<b>1.5</b>	3.6	<b>2.1</b>	<b>3.6</b>	<b>0.86</b>	<b>0.55</b>	<b>0.66</b>	<b>0.76</b>	<b>0.77</b>	<b>0.85</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.1</b>	54	28	82	55	42	53	67	68	83	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.6</b>	24	86	61	327	<i>33e-3/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	43	1240	3787	3149	1547	<i>20e-1/1e5</i>	.	.	.	.	SPSA [13]

Table 43: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{19}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>19 Griewank-Rosenbrock F8F2</b>										
$\Delta t_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta t_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	<b>4.8</b>	469	177	30	<i>32e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	6.7	239	132	20	<i>39e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	8.5	556	87	21	29	29	29	29	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	31	550	173	31	58	58	58	58	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>5.5</b>	329	99	6.7	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.1</b>	10	420	60	10	13	13	13	12	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	10	<b>171</b>	89	6.7	28	28	27	27	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	11	251	123	65	<i>58e-3/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	7.4	415	186	20	18	18	18	18	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.1</b>	12	364	121	14	28	28	28	28	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.1</b>	12	391	52	8.0	24	72	295	<i>14e-5/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.5</b>	13	319	122	39	76	76	76	76	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.2	15	47	346	150	49	98	266	265	566	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	12	218	27	5.0	12	12	12	12	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.1</b>	7.3	335	32	5.5	13	13	13	13	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>6.0</b>	234	41	4.0	4.6	4.6	4.7	4.7	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.1</b>	11	<b>196</b>	67	4.4	<b>4.1</b>	<b>4.1</b>	<b>4.1</b>	<b>4.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	11	<b>213</b>	<b>5.8</b>	<b>3.7</b>	<b>3.6</b>	<b>3.7</b>	<b>3.7</b>	<b>3.8</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.2</b>	8.9	235	29	<b>3.2</b>	<b>4.3</b>	<b>4.3</b>	<b>4.3</b>	<b>4.3</b>	NBC-CMA [21]
POEMS	<b>1</b>	42	611	1680	251	81	168	167	169	169	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.9</b>	7.9	237	<b>25</b>	<b>2.3</b>	12	12	12	14	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.5</b>	260	1717	259	10	11	13	15	21	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	10	273	<b>16</b>	8.7	24	51	141	289	Basic RCGA [24]
SPSA	18	71	258	10394	2974	637	<i>83e-3/1e5</i>	.	.	.	SPSA [13]

Table 44: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{20}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	20 Schwefel $x*\sin(x)$										
$\Delta$ target $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta$ target $ERT_{best}/D$
(1,2)-CMA-ES	4.5	4.2	4.9	4.1	16	15	17	17	16	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>2.4</b>	<b>2.8</b>	3.2	8.1	41	39	38	37	36	34	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>2.6</b>	3.2	3.9	7.9	91	87	84	83	81	75	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.3	7.9	7.7	11	32	32	31	31	30	28	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1.8</b>	<b>2.0</b>	<b>2.8</b>	4.1	11	11	10	10	10	9.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1.3</b>	<b>1.3</b>	<b>2.0</b>	7.8	18	17	16	16	16	15	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.2</b>	<b>1.6</b>	<b>1.7</b>	4.7	54	52	50	49	48	45	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>0.95</b>	<b>1.4</b>	<b>1.9</b>	6.0	21	20	19	19	19	17	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>2.1</b>	<b>2.1</b>	<b>2.4</b>	<b>3.0</b>	10	10	9.5	9.3	9.1	8.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.3</b>	<b>1.4</b>	<b>1.8</b>	<b>2.0</b>	9.2	8.8	8.5	8.4	8.3	<b>7.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>2.6</b>	5.0	5.6	<b>1.1</b>	<b>1.3</b>	<b>1.8</b>	<b>3.7</b>	6.0	6.9	9.3	Artif Bee Colony [8]
avg NEWUOA	<b>1.5</b>	<b>1.3</b>	<b>1.3</b>	<b>2.3</b>	10	9.5	9.2	9.0	8.9	8.2	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	12	13	158	<i>45e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1.6</b>	<b>2.9</b>	4.5	3.7	34	33	32	31	31	28	Adap DE (F-AUC) [10]
DE (Uniform)	<b>2.9</b>	3.4	4.6	<b>2.8</b>	34	32	32	31	31	28	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.3</b>	<b>1.9</b>	<b>2.0</b>	5.1	5.8	5.9	5.9	<b>5.9</b>	<b>5.9</b>	<b>5.6</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>2.1</b>	<b>2.8</b>	<b>2.9</b>	4.5	<b>5.6</b>	<b>5.7</b>	<b>5.6</b>	<b>5.7</b>	<b>5.7</b>	<b>5.4</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>3.0</b>	3.9	4.5	4.3	<b>3.5</b>	<b>4.0</b>	<b>4.8</b>	<b>4.9</b>	<b>5.1</b>	7.8	CMA+DE-MOS [18]
NBC-CMA	<b>1.9</b>	4.0	4.9	3.8	13	12	12	12	12	11	NBC-CMA [21]
POEMS	110	83	80	8.2	146	141	138	137	135	128	POEMS [17]
PM-AdapSS-DE	<b>1.9</b>	<b>2.5</b>	<b>2.8</b>	<b>2.8</b>	21	20	20	19	19	18	PM-AdapSS-DE [9, 10]
pPOEMS	63	60	65	20	17	27	36	44	52	64	pPOEMS [17, 20]
Basic RCGA	<b>2.2</b>	3.2	4.6	64	217	916	887	<i>41e-2/5e4</i>	.	.	Basic RCGA [24]
SPSA	34	39	51	5071	<i>15e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 45: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{21}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>21 Gallagher 101 peaks</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	6.8	11	25	28	27	27	27	26	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.6</b>	7.7	7.7	11	11	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	8.1	12	13	18	17	17	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	4.1	21	40	42	40	40	40	39	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.4</b>	7.4	13	13	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.1</b>	5.4	21	26	27	27	27	26	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.6</b>	5.1	7.4	7.3	7.0	6.9	6.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	8.0	11	11	11	11	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.5</b>	5.3	10	10	9.4	9.2	9.2	9.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.7</b>	7.4	8.9	8.7	8.4	8.3	8.2	8.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>2.4</b>	<b>2.5</b>	3.7	5.9	10	26	60	145	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	4.0	<b>2.5</b>	<b>2.1</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	19	10	35	220	305	293	577	573	559	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	<b>2.0</b>	<b>2.1</b>	<b>1.6</b>	<b>2.0</b>	<b>2.4</b>	<b>2.7</b>	<b>2.9</b>	<b>3.1</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	<b>1.3</b>	<b>1.9</b>	<b>1.9</b>	<b>2.3</b>	<b>2.6</b>	<b>2.8</b>	<b>3.0</b>	<b>3.3</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	6.6	10	10	10	10	11	11	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>1.5</b>	11	10	11	11	11	11	11	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>1.7</b>	13	22	106	488	746	744	860	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>1.3</b>	5.1	31	55	52	52	51	50	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	90	1001	800	777	745	739	735	722	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	<b>1.1</b>	<b>1.7</b>	52	51	49	48	48	47	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	31	12	11	24	39	57	92	145	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>1.8</b>	21	59	162	164	216	269	293	Basic RCGA [24]
SPSA	<b>1</b>	30	30	439	1223	1188	1139	1134	1155	2915	SPSA [13]

Table 46: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{22}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>22 Gallagher 21 peaks</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	4.0	17	28	35	34	33	33	32	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	15	11	22	25	25	25	25	24	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	7.1	7.6	20	31	30	35	34	33	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	18	16	26	26	27	27	27	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	4.0	7.8	7.8	7.9	7.6	7.5	7.4	7.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	3.6	6.8	7.3	7.4	7.2	7.2	7.1	7.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.8</b>	10	15	16	15	15	15	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	9.0	7.0	10	10	10	9.4	9.3	9.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	6.4	8.7	7.2	<b>7.2</b>	<b>6.9</b>	<b>6.8</b>	<b>6.7</b>	<b>6.6</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	3.1	<b>2.7</b>	<b>3.4</b>	<b>3.5</b>	<b>3.3</b>	<b>3.3</b>	<b>3.3</b>	<b>3.3</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>2.5</b>	<b>1.7</b>	<b>4.3</b>	29	105	241	329	4862	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>2.8</b>	<b>2.0</b>	<b>2.9</b>	<b>2.9</b>	<b>2.8</b>	<b>2.9</b>	<b>2.9</b>	<b>3.1</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	16	3.6	43	237	523	798	1172	1152	1117	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	<b>2.1</b>	<b>2.2</b>	132	130	123	120	118	115	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	<b>1.3</b>	<b>1.5</b>	132	130	123	120	118	115	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	6.6	7.1	27	83	228	224	222	217	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>1.2</b>	5.0	21	90	247	290	286	281	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>1.5</b>	16	22	28	31	42	44	193	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>1.4</b>	109	174	225	213	208	204	198	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	2130	623	989	974	921	901	889	868	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	<b>1.3</b>	127	213	209	198	193	190	184	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	29	12	211	227	234	266	298	361	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>1.3</b>	32	111	389	518	601	1218	5387	Basic RCGA [24]
SPSA	<b>1</b>	28	31	320	5903	12219	<i>40e-2/1e5</i>	.	.	.	SPSA [13]

Table 47: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{23}$  in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>23 Katsuuras</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	7.2	37	237	177	197	194	190	<i>68e-2/1e4</i>	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	6.5	12	48	104	57	89	87	<i>22e-2/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	5.3	18	69	81	45	64	63	61	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	10	54	231	180	199	<i>66e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.5</b>	7.3	20	16	10	10	10	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	<b>3.0</b>	6.2	19	21	14	14	14	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	6.1	8.2	30	27	15	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	9.5	16	40	41	34	43	43	55	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	5.6	3.4	13	19	13	15	20	29	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	4.9	3.6	10	21	16	25	24	23	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	4.2	10	<i>24e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	11	<b>2.5</b>	22	85	147	<i>46e-3/7e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	7.1	16	11	<i>29e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	3.1	3.1	<b>5.1</b>	<b>6.6</b>	<b>5.1</b>	<b>6.4</b>	<b>7.8</b>	<b>10</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	4.0	<b>2.4</b>	<b>5.3</b>	<b>7.2</b>	5.5	6.9	8.4	11	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	7.2	5.3	10	<b>7.7</b>	<b>4.3</b>	<b>5.4</b>	<b>5.4</b>	<b>5.4</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	4.9	5.2	80	60	33	32	32	31	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	3.9	7.5	10	8.6	<b>5.2</b>	<b>5.2</b>	<b>5.3</b>	<b>5.4</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>2.7</b>	15	353	263	145	142	140	134	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	20	21	106	141	83	85	86	88	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	4.1	<b>2.5</b>	<b>5.7</b>	26	16	17	19	20	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	14	64	264	276	189	227	255	328	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	5.4	16	271	837	<i>15e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	<b>1</b>	26	113	946	<i>99e-2/1e5</i>	.	.	.	.	.	SPSA [13]





Table 49: Running time excess  $ERT/ERT_{best}$  2009 on  $f_1$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>1 Sphere</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	3.1	7.4	15	27	37	47	54	63	80	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	3.2	10	15	21	28	35	40	53	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.1</b>	7.2	13	18	24	30	35	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.3</b>	4.5	12	22	29	38	48	55	71	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.5</b>	6.9	11	16	21	25	30	40	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.2</b>	6.2	10	15	19	23	27	37	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.0</b>	<b>5.0</b>	<b>8.3</b>	<b>12</b>	<b>15</b>	<b>18</b>	<b>22</b>	<b>30</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.9</b>	<b>2.5</b>	6.5	10	15	18	22	26	34	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.1</b>	5.6	10	13	17	21	24	32	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.5</b>	<b>4.9</b>	<b>8.0</b>	<b>12</b>	<b>15</b>	<b>18</b>	<b>21</b>	<b>28</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.4</b>	12	32	62	89	122	156	191	255	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	3.3	<b>1.5</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>2.3</b>	27	7.2	16	24	34	43	55	67	87	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.3</b>	5.9	37	67	104	132	166	203	266	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.3</b>	8.6	42	80	117	155	194	236	313	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.3</b>	3.2	8.9	15	22	27	33	39	51	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.5</b>	8.0	14	20	27	32	39	51	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	6.5	33	66	90	121	142	169	217	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	5.6	26	42	53	65	74	85	108	NBC-CMA [21]
POEMS	<b>1</b>	263	102	136	329	766	1195	1592	2001	2796	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>2.1</b>	4.8	39	74	111	145	182	223	292	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.2</b>	97	129	614	2849	5775	8274	12299	18337	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	8.7	72	155	329	561	831	1141	1741	Basic RCGA [24]
SPSA	<b>1</b>	43	11	15	19	22	27	31	36	44	SPSA [13]









Table 54: Running time excess  $ERT/ERT_{best}$  2009 on  $f_6$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	6 Attractive sector										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>2.6</b>	13	5.9	5.1	5.0	4.8	4.3	4.2	3.9	4.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1.5</b>	6.4	<b>2.7</b>	<b>2.4</b>	<b>2.5</b>	<b>2.1</b>	<b>1.8</b>	<b>1.7</b>	<b>1.4</b>	<b>1.4</b>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1.5</b>	4.2	<b>2.2</b>	<b>2.0</b>	<b>2.1</b>	<b>1.9</b>	<b>1.6</b>	<b>1.4</b>	<b>1.1</b>	<b>1.1</b>	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.8	11	6.5	6.6	7.7	7.3	6.8	6.5	5.8	5.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>2.2</b>	<b>2.4</b>	<b>1.6</b>	<b>1.8</b>	<b>1.8</b>	<b>1.7</b>	<b>1.5</b>	<b>1.4</b>	<b>1.3</b>	<b>1.2</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>2.2</b>	4.7	<b>1.8</b>	<b>1.6</b>	<b>1.7</b>	<b>1.5</b>	<b>1.3</b>	<b>1.2</b>	<b>1.00</b>	<b>0.96</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.9</b>	<b>2.8</b>	<b>1.1</b>	<b>1.1</b>	<b>1.2</b>	<b>1.1</b>	<b>0.91</b>	<b>0.83</b>	<b>0.70</b>	<b>0.69</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>2.0</b>	5.0	<b>1.8</b>	<b>1.9</b>	<b>1.9</b>	<b>1.8</b>	<b>1.5</b>	<b>1.4</b>	<b>1.1</b>	<b>1.1</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1.8</b>	3.5	<b>1.8</b>	<b>1.5</b>	<b>1.9</b>	<b>1.7</b>	<b>1.4</b>	<b>1.3</b>	<b>1.1</b>	<b>1.4</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.2</b>	<b>2.3</b>	<b>1.1</b>	<b>1.2</b>	<b>1.6</b>	<b>1.4</b>	<b>1.4</b>	<b>1.6</b>	<b>1.6</b>	<b>2.2</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.7	8.3	4.9	15	365	408	619	522	498	507	Artif Bee Colony [8]
avg NEWUOA	<b>1.2</b>	<b>2.6</b>	<b>1.3</b>	<b>1.6</b>	<b>2.6</b>	<b>2.6</b>	<b>2.6</b>	<b>2.6</b>	<b>2.4</b>	<b>2.5</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.0	54	241	657	518	518	372	300	220	230	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.8	7.1	6.5	7.6	8.5	8.1	7.0	6.5	5.3	5.4	Adap DE (F-AUC) [10]
DE (Uniform)	4.7	7.2	9.0	9.2	10	9.2	7.8	7.3	6.1	6.1	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.6</b>	5.3	<b>2.5</b>	<b>2.1</b>	<b>2.2</b>	<b>2.0</b>	<b>1.6</b>	<b>1.5</b>	<b>1.2</b>	<b>1.2</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.9</b>	3.2	<b>2.5</b>	<b>2.1</b>	<b>2.2</b>	<b>2.0</b>	<b>1.7</b>	<b>1.5</b>	<b>1.3</b>	<b>1.2</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	11	11	8.0	8.6	8.8	7.7	6.3	5.7	4.8	4.6	CMA+DE-MOS [18]
NBC-CMA	9.2	8.5	8.2	19	16	11	8.4	6.8	5.1	4.3	NBC-CMA [21]
POEMS	102	81	26	46	54	51	45	43	36	37	POEMS [17]
PM-AdapSS-DE	6.0	7.4	8.1	8.1	9.0	8.3	7.3	6.7	5.7	5.7	PM-AdapSS-DE [9, 10]
pPOEMS	91	76	31	202	313	323	306	300	266	282	pPOEMS [17, 20]
Basic RCGA	29	28	26	72	255	434	598	<i>47e-4/5e4</i>	.	.	Basic RCGA [24]
SPSA	521	13582	28485	32769	25181	<i>44e+0/1e5</i>	.	.	.	.	SPSA [13]





Table 56: Running time excess  $ERT/ERT_{\text{best}} 2009$  on  $f_8$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	8 Rosenbrock original										
$\Delta f_{\text{target}}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$
$ERT_{\text{best}}/D$	3.6	8.8	15	55	67	74	78	80	82	84	$ERT_{\text{best}}/D$
(1,2)-CMA-ES	6.5	12	10	10	14	14	15	15	15	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.1	5.7	5.6	5.7	7.2	7.8	8.1	8.3	8.4	8.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.2	4.5	4.2	5.8	6.8	7.3	7.5	7.6	7.6	7.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.8	15	12	14	19	19	20	20	21	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>2.6</b>	<b>2.9</b>	<b>2.6</b>	4.9	5.7	5.8	5.9	6.1	6.2	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>2.0</b>	3.2	<b>2.9</b>	3.6	4.3	4.7	4.8	5.0	5.0	5.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1.4</b>	<b>2.6</b>	<b>2.3</b>	<b>2.9</b>	<b>3.5</b>	<b>3.6</b>	<b>3.7</b>	<b>3.8</b>	<b>3.8</b>	<b>4.0</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1.5</b>	<b>2.3</b>	<b>2.4</b>	4.1	5.0	5.2	5.4	5.4	5.5	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>2.5</b>	<b>2.5</b>	<b>2.3</b>	3.5	3.8	3.8	3.8	3.9	4.0	4.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.7</b>	<b>2.0</b>	<b>1.9</b>	3.0	<b>3.2</b>	<b>3.2</b>	<b>3.3</b>	<b>3.4</b>	<b>3.4</b>	<b>3.5</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.4	5.0	6.0	12	52	449	2509	<i>10e-4/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1.3</b>	<b>1.6</b>	<b>1.2</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	9.0	8.2	7.6	8.2	8.5	8.8	9.3	10	11	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.5	11	13	8.9	11	11	11	12	13	14	Adap DE (F-AUC) [10]
DE (Uniform)	7.2	12	15	10	14	16	17	17	18	20	DE (Uniform) [9]
IPOP-aCMA-ES	<b>2.1</b>	<b>2.4</b>	<b>2.8</b>	<b>3.0</b>	3.6	3.8	4.0	4.1	4.2	4.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>2.6</b>	3.8	3.5	4.8	5.3	5.5	5.6	5.7	5.8	6.1	IPOP-CMA-ES [22]
CMA+DE-MOS	6.3	6.8	11	11	12	13	13	14	14	15	CMA+DE-MOS [18]
NBC-CMA	4.4	7.5	7.1	7.0	8.1	8.4	8.6	8.8	8.9	9.3	NBC-CMA [21]
POEMS	66	40	58	52	117	380	689	1132	1485	2230	POEMS [17]
PM-AdapSS-DE	5.5	11	13	9.4	15	18	19	19	20	21	PM-AdapSS-DE [9, 10]
pPOEMS	56	36	84	262	365	482	583	689	795	1052	pPOEMS [17, 20]
Basic RCGA	5.7	12	32	558	1450	2992	2983	9295	<i>54e-2/5e4</i>	.	Basic RCGA [24]
SPSA	360	1473	3764	12308	<i>50e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 57: Running time excess  $ERT/ERT_{best}$  2009 on  $f_9$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>9 Rosenbrock rotated</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	131	285	12	27	24	23	21	21	20	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	62	164	7.4	14	12	12	11	11	11	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	57	273	14	12	11	10	10	9.3	9.2	8.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	98	382	16	51	40	37	34	33	33	31	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	31	218	9.0	14	11	10	9.4	9.1	9.0	8.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	30	111	5.2	9.5	8.2	7.6	7.2	7.0	7.0	6.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	26	117	5.4	10	7.7	6.8	6.3	6.1	6.0	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	28	128	5.7	11	9.2	8.3	7.7	7.4	7.3	6.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>22</b>	<b>65</b>	<b>3.3</b>	13	9.0	7.8	7.2	6.8	6.8	6.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>25</b>	102	<b>4.6</b>	<b>6.2</b>	<b>5.0</b>	<b>4.4</b>	<b>4.2</b>	<b>4.0</b>	<b>4.0</b>	<b>3.9</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	86	259	14	69	699	3988	<i>13e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>20</b>	<b>56</b>	<b>2.4</b>	<b>3.1</b>	<b>2.1</b>	<b>1.8</b>	<b>1.7</b>	<b>1.6</b>	<b>1.6</b>	<b>1.5</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	276	692	48	79	56	50	45	46	46	45	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	97	393	24	18	16	16	16	16	16	17	Adap DE (F-AUC) [10]
DE (Uniform)	143	444	30	23	21	22	21	21	22	22	DE (Uniform) [9]
IPOP-aCMA-ES	28	97	5.4	<b>6.2</b>	<b>5.7</b>	<b>5.3</b>	<b>5.0</b>	<b>4.9</b>	<b>5.0</b>	<b>4.9</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	29	<b>92</b>	6.0	11	8.7	7.9	7.5	7.3	7.3	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	98	367	13	10	17	18	17	17	17	17	CMA+DE-MOS [18]
NBC-CMA	84	281	15	11	11	10	10	9.5	10	9.5	NBC-CMA [21]
POEMS	1148	1606	109	116	176	616	1039	1473	1856	2809	POEMS [17]
PM-AdapSS-DE	90	374	25	22	21	22	21	21	21	22	PM-AdapSS-DE [9, 10]
pPOEMS	1126	1981	287	563	596	630	722	850	994	1200	pPOEMS [17, 20]
Basic RCGA	118	318	40	8950	<i>17e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]
SPSA	8379	1.78e5	13128	56959	<i>54e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 59: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{11}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>11 Discus</b>											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$	
$ERT_{best}/D$											$ERT_{best}/D$	
(1,2)-CMA-ES	31	91	28	25	7.3	6.0	5.1	4.5	4.3	3.9	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	25	91	24	20	5.6	4.6	3.9	3.5	3.3	<b>3.0</b>	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	37	59	19	16	4.8	3.9	3.3	<b>3.0</b>	<b>2.8</b>	<b>2.6</b>	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	6.8	88	31	29	9.1	7.3	6.3	5.6	5.3	4.9	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	<b>3.9</b>	20	10	10	<b>2.9</b>	<b>2.3</b>	<b>2.0</b>	<b>1.8</b>	<b>1.7</b>	<b>1.6</b>	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	5.7	39	12	10	<b>2.8</b>	<b>2.3</b>	<b>2.0</b>	<b>1.8</b>	<b>1.7</b>	<b>1.6</b>	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	5.7	37	10	7.9	<b>2.2</b>	<b>1.8</b>	<b>1.5</b>	<b>1.4</b>	<b>1.3</b>	<b>1.2</b>	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	17	31	10	8.1	<b>2.3</b>	<b>1.9</b>	<b>1.7</b>	<b>1.5</b>	<b>1.4</b>	<b>1.3</b>	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	4.0	12	5.8	6.9	<b>2.1</b>	<b>1.8</b>	<b>1.5</b>	<b>1.3</b>	<b>1.3</b>	<b>1.2</b>	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	<b>4.0</b>	<b>7.7</b>	<b>4.9</b>	<b>5.2</b>	<b>1.7</b>	<b>1.4</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>0.98</b>	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	6.1	<b>8.5</b>	160	6088	9336	<i>15e-1/1e5</i>	.	.	.	.	Artif Bee Colony [8]	
avg NEWUOA	<b>2.6</b>	11	<b>5.4</b>	7.2	<b>2.7</b>	<b>2.6</b>	<b>2.8</b>	<b>2.9</b>	3.1	3.4	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	10	180	61	51	14	11	9.0	8.0	7.4	6.7	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	12	12	6.2	6.6	<b>2.2</b>	<b>2.1</b>	<b>2.0</b>	<b>2.1</b>	<b>2.2</b>	<b>2.4</b>	Adap DE (F-AUC) [10]	
DE (Uniform)	10	14	6.2	6.6	<b>2.4</b>	<b>2.3</b>	<b>2.4</b>	<b>2.4</b>	<b>2.6</b>	<b>2.8</b>	DE (Uniform) [9]	
IPOP-aCMA-ES	7.1	12	<b>5.6</b>	<b>4.7</b>	<b>1.4</b>	<b>1.2</b>	<b>1.0</b>	<b>0.97</b>	<b>0.95</b>	<b>0.92</b>	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	5.9	17	8.6	7.3	<b>2.1</b>	<b>1.8</b>	<b>1.6</b>	<b>1.4</b>	<b>1.4</b>	<b>1.3</b>	IPOP-CMA-ES [22]	
CMA+DE-MOS	8.0	13	18	17	4.9	4.2	3.7	3.4	3.3	3.2	CMA+DE-MOS [18]	
NBC-CMA	8.4	13	13	14	4.1	3.4	<b>3.0</b>	<b>2.7</b>	<b>2.6</b>	<b>2.4</b>	NBC-CMA [21]	
POEMS	78	44	558	918	466	496	571	571	680	739	POEMS [17]	
PM-AdapSS-DE	11	15	6.3	<b>6.5</b>	<b>2.3</b>	<b>2.2</b>	<b>2.3</b>	<b>2.3</b>	<b>2.4</b>	<b>2.7</b>	PM-AdapSS-DE [9, 10]	
pPOEMS	80	50	95	393	204	232	251	261	291	341	pPOEMS [17, 20]	
Basic RCGA	10	<b>11</b>	473	5466	<i>26e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]	
SPSA	21	8415	49100	<i>63e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]	



Table 61: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{13}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	13 Sharp ridge											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$	
$ERT_{best}/D$											$ERT_{best}/D$	
(1,2)-CMA-ES	7.1	15	25	27	37	65	22	22	28	98	(1,2)-CMA-ES	[5, 3]
(1,2m)-CMA-ES	<b>2.0</b>	4.2	9.4	30	34	34	14	16	27	37	(1,2m)-CMA-ES	[5]
(1,2ms)-CMA-ES	5.9	3.1	4.6	17	21	24	14	16	18	36	(1,2ms)-CMA-ES	[5]
(1,2s)-CMA-ES	7.7	7.6	16	32	44	60	23	24	46	153	(1,2s)-CMA-ES	[3]
(1,4)-CMA-ES	<b>2.6</b>	3.6	7.0	10	11	10	3.0	3.1	4.2	5.1	(1,4)-CMA-ES	[6, 4]
(1,4m)-CMA-ES	5.8	3.3	6.4	11	10	9.1	<b>2.8</b>	3.1	3.2	3.9	(1,4m)-CMA-ES	[6]
(1,4ms)-CMA-ES	<b>2.5</b>	4.3	<b>2.9</b>	<b>4.9</b>	7.7	6.7	<b>2.5</b>	3.5	3.1	3.1	(1,4ms)-CMA-ES	[1, 6]
(1,4s)-CMA-ES	3.1	3.1	5.0	10	10	8.8	3.3	3.1	3.1	5.0	(1,4s)-CMA-ES	[4]
(1+1)-CMA-ES	<b>2.4</b>	<b>2.2</b>	3.7	7.1	8.3	7.9	<b>2.4</b>	<b>2.2</b>	<b>2.2</b>	3.1	(1+1)-CMA-ES	[7]
(1+2ms)-CMA-ES	<b>1.9</b>	<b>2.1</b>	<b>3.1</b>	7.9	<b>7.1</b>	<b>6.1</b>	<b>1.9</b>	<b>2.0</b>	<b>2.0</b>	<b>2.3</b>	(1+2ms)-CMA-ES	[2]
Artif Bee Colony	<b>1.9</b>	11	18	187	6618	<i>15e-2/1e5</i>	.	.	.	.	Artif Bee Colony	[8]
avg NEWUOA	4.0	<b>1.0</b>	4.5	8.1	42	67	68	450	391	<i>15e-4/9e3</i>	avg NEWUOA	[23]
CMA-EGS (IPOP,r1)	28	<b>30</b>	506	1310	8016	10188	5347	<i>38e-2/1e5</i>	.	.	CMA-EGS (IPOP,r1)	[12]
Adap DE (F-AUC)	<b>2.9</b>	14	10	11	11	11	3.2	3.3	3.2	3.1	Adap DE (F-AUC)	[10]
DE (Uniform)	<b>2.3</b>	15	11	12	13	13	3.7	3.8	3.8	3.7	DE (Uniform)	[9]
IPOP-aCMA-ES	<b>2.6</b>	3.3	<b>3.0</b>	<b>4.1</b>	<b>4.2</b>	<b>4.0</b>	<b>1.2</b>	<b>1.2</b>	<b>1.2</b>	<b>1.1</b>	IPOP-aCMA-ES	[16]
IPOP-CMA-ES	3.8	4.0	3.1	<b>5.0</b>	<b>5.3</b>	<b>5.1</b>	<b>1.4</b>	<b>1.6</b>	<b>1.6</b>	<b>1.6</b>	IPOP-CMA-ES	[22]
CMA+DE-MOS	<b>1.7</b>	15	11	12	14	13	3.5	3.4	3.4	3.2	CMA+DE-MOS	[18]
NBC-CMA	<b>1.8</b>	9.5	6.2	7.5	9.3	9.3	<b>2.6</b>	<b>2.6</b>	<b>2.7</b>	<b>2.6</b>	NBC-CMA	[21]
POEMS	286	52	904	2912	9139	18912	16068	13841	<i>12e-2/3e5</i>	.	POEMS	[17]
PM-AdapSS-DE	<b>2.1</b>	13	10	11	12	12	3.4	3.5	3.5	3.4	PM-AdapSS-DE	[9, 10]
pPOEMS	26	57	446	793	1067	1220	390	472	1316	9956	pPOEMS	[17, 20]
Basic RCGA	<b>2.4</b>	34	282	1074	6915	11505	<i>50e-2/5e4</i>	.	.	.	Basic RCGA	[24]
SPSA	22	55	2055	<i>43e-1/1e5</i>	.	.	.	.	.	.	SPSA	[13]

Table 62: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{14}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta f_{target}$ $ERT_{best}/D$	14 Sum of different powers										$\Delta f_{target}$ $ERT_{best}/D$
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
(1,2)-CMA-ES	<b>1</b>	<b>1.8</b>	<b>2.3</b>	5.0	5.9	6.3	8.3	11	13	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	4.3	3.5	3.9	4.3	5.8	8.2	11	9.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.8</b>	3.1	3.2	3.3	3.6	4.8	6.9	9.2	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.2</b>	3.5	6.4	6.4	6.3	11	14	17	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.6</b>	<b>1.7</b>	<b>1.9</b>	3.1	3.2	4.2	5.0	6.8	5.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.6</b>	<b>2.3</b>	<b>2.1</b>	<b>2.9</b>	3.3	3.9	4.6	6.0	5.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.5</b>	<b>1.7</b>	<b>1.8</b>	<b>2.3</b>	<b>2.3</b>	<b>2.9</b>	3.6	4.5	4.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>2.5</b>	<b>2.0</b>	<b>2.0</b>	<b>2.5</b>	3.0	3.8	4.2	5.2	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.6</b>	<b>1.2</b>	<b>1.8</b>	<b>2.3</b>	<b>2.5</b>	<b>2.7</b>	<b>3.1</b>	<b>4.1</b>	<b>3.3</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.6</b>	<b>0.82</b>	<b>1.4</b>	<b>1.7</b>	<b>2.0</b>	<b>2.7</b>	<b>2.9</b>	<b>3.2</b>	<b>2.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.9</b>	3.5	11	19	29	679	33788	<i>27e-5/1e5</i>	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.7</b>	<b>2.1</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	<b>1.2</b>	<b>1.8</b>	5.0	1029	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.1	25	14	7.3	7.5	8.8	17	21	27	203	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.3</b>	<b>2.2</b>	9.4	15	15	13	11	11	8.2	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	<b>2.3</b>	10	16	18	15	13	13	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>2.3</b>	<b>1.5</b>	<b>2.2</b>	3.2	3.6	3.6	3.4	<b>3.8</b>	<b>2.9</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.2</b>	<b>2.9</b>	3.8	4.3	4.7	4.7	5.4	4.4	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.2</b>	<b>2.9</b>	13	14	15	14	13	14	11	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	<b>1.4</b>	7.0	8.7	8.1	7.4	6.6	7.7	6.4	NBC-CMA [21]
POEMS	<b>1</b>	280	111	43	79	124	136	130	501	<i>46e-8/3e5</i>	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.5</b>	<b>1</b>	9.4	17	17	15	12	12	8.9	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	69	61	47	140	597	798	868	1057	2134	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	<b>1.5</b>	23	40	59	273	1453	14895	<i>90e-6/5e4</i>	Basic RCGA [24]
SPSA	24	120	167	106	86	69	99	601	2141	<i>60e-7/1e5</i>	SPSA [13]





Table 64: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{16}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>16 Weierstrass</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.4</b>	42	259	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	16	29	45	70	69	63	62	<i>18e-2/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	15	43	38	36	<i>17e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.3</b>	58	589	<i>28e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.1</b>	7.2	27	31	34	<i>22e-2/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.9</b>	5.8	12	6.1	11	29	<i>98e-4/1e4</i>	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.5</b>	5.6	16	19	15	33	<i>39e-3/1e4</i>	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.8</b>	8.1	20	33	72	<i>14e-2/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>2.0</b>	21	19	33	<i>71e-3/1e4</i>	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	<b>1.7</b>	7.7	16	<i>62e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.7</b>	<b>2.3</b>	10	95	<i>48e-3/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.2</b>	<b>2.6</b>	12	47	<i>35e-2/8e3</i>	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1.3</b>	20	7.8	179	409	324	671	<i>15e-2/1e5</i>	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.2</b>	6.4	39	31	8.2	12	11	11	10	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	4.3	44	20	13	17	16	16	15	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.1</b>	3.9	<b>2.4</b>	<b>1.7</b>	<b>0.56</b>	<b>0.82</b>	<b>0.84</b>	<b>0.84</b>	<b>0.85</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.3</b>	<b>2.5</b>	<b>2.3</b>	<b>1.7</b>	<b>0.55</b>	<b>0.96</b>	<b>0.94</b>	<b>0.94</b>	<b>0.95</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.6</b>	<b>1.6</b>	<b>2.9</b>	<b>2.6</b>	<b>1.2</b>	<b>1.2</b>	<b>1.2</b>	<b>7.7</b>	7.7	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.3</b>	3.0	4.0	<b>1.3</b>	<b>0.81</b>	<b>0.86</b>	<b>0.84</b>	<b>0.83</b>	<b>0.83</b>	NBC-CMA [21]
POEMS	<b>1</b>	57	11	14	92	56	74	68	68	66	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.3</b>	3.9	124	55	16	20	18	28	27	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.5</b>	10	52	40	53	116	110	113	116	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.4</b>	<b>2.4</b>	60	49	80	351	322	<i>16e-3/5e4</i>	.	Basic RCGA [24]
SPSA	4.3	280	548	1367	594	349	695	<i>12e-1/1e5</i>	.	.	SPSA [13]

Table 65: Running time excess  $ERT/ERT_{best, 2009}$  on  $f_{17}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>17 Schaffer F7, condition 10</b>											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$
$ERT_{best}/D$	0.20	0.20	1.0	43	180	572	734	959	1270	1587	$ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.1</b>	52	54	404	<i>14e-2/1e4</i>	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.3</b>	6.7	5.3	6.2	13	64	<i>51e-4/1e4</i>	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.3</b>	5.3	5.0	13	22	<i>87e-4/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.3</b>	52	87	397	<i>36e-2/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	116	20	18	31	<i>27e-3/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	20	<b>2.3</b>	4.1	7.2	90	<i>34e-4/1e4</i>	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.1</b>	5.1	<b>0.71</b>	4.5	28	<i>12e-3/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	4.2	3.6	18	54	<i>23e-3/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	15	25	94	<i>14e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	15	17	24	<i>38e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.1</b>	6.5	15	64	1259	<i>31e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.2</b>	<b>3.1</b>	42	405	<i>24e-2/1e4</i>	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	37	17	3.3	<b>2.5</b>	40	62	120	1104	<i>36e-5/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.2</b>	5.7	3.9	<b>2.3</b>	<b>1.2</b>	<b>1.3</b>	<b>1.3</b>	<b>1.3</b>	<b>1.4</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	3.8	4.3	<b>2.7</b>	<b>1.4</b>	<b>1.6</b>	<b>1.6</b>	<b>1.5</b>	<b>1.6</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.3</b>	4.3	<b>0.89</b>	<b>0.53</b>	<b>0.59</b>	<b>0.77</b>	<b>0.74</b>	<b>1.00</b>	<b>1.1</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.1</b>	4.8	<b>1.1</b>	<b>0.97</b>	<b>0.61</b>	<b>0.77</b>	<b>0.80</b>	<b>0.81</b>	<b>1.0</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	<b>2.8</b>	5.8	5.2	3.9	5.4	4.7	3.9	4.0	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.2</b>	5.6	<b>2.2</b>	<b>1.9</b>	<b>0.74</b>	<b>0.68</b>	<b>0.68</b>	<b>1.6</b>	3.3	NBC-CMA [21]
POEMS	<b>1</b>	78	221	17	15	8.2	14	61	98	139	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.3</b>	4.2	4.0	<b>2.3</b>	<b>1.2</b>	<b>1.4</b>	<b>1.4</b>	<b>1.3</b>	<b>1.4</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.3</b>	169	22	88	57	71	75	73	82	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	<b>2.9</b>	57	48	35	56	124	173	<i>30e-5/5e4</i>	Basic RCGA [24]
SPSA	35977	77306	48618	2098	2228	2447	<i>85e-2/1e5</i>	.	.	.	SPSA [13]

Table 66: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{18}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>18 Schaffer F7, condition 1000</b>											
$\Delta target$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta target$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1.1</b>	<b>2.4</b>	36	201	<i>11e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	4.7	3.7	28	23	<i>16e-2/1e4</i>	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	5.4	8.2	27	21	83	<i>13e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	7.6	29	601	<i>19e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	3.5	<b>3.0</b>	31	21	84	<i>14e-2/1e4</i>	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>2.1</b>	<b>1.9</b>	5.9	9.2	19	<i>67e-3/1e4</i>	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>2.7</b>	3.1	18	6.4	84	<i>39e-3/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	5.4	8.8	35	20	<i>13e-2/1e4</i>	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	4.1	8.6	52	87	<i>42e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1.1</b>	3.6	15	48	33	85	<i>14e-2/1e4</i>	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	<b>1.6</b>	5.0	27	300	<i>14e-2/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	5.4	10	272	<i>57e-2/3e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	28	53	<b>2.2</b>	7.2	25	122	<i>22e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>2.4</b>	4.3	3.8	<b>0.75</b>	<b>0.55</b>	<b>0.69</b>	<b>0.75</b>	<b>0.88</b>	<b>0.98</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>2.7</b>	4.0	4.3	<b>0.81</b>	<b>0.58</b>	<b>0.73</b>	<b>0.80</b>	<b>0.95</b>	<b>1.1</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	5.8	3.5	<b>1.6</b>	<b>0.70</b>	<b>0.69</b>	<b>0.77</b>	<b>0.73</b>	<b>0.80</b>	<b>0.84</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1.6</b>	7.5	<b>1.2</b>	<b>2.7</b>	<b>0.87</b>	<b>1.1</b>	<b>1.0</b>	<b>0.98</b>	<b>1.0</b>	<b>0.99</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	<b>1.7</b>	4.9	6.7	<b>2.9</b>	<b>1.7</b>	<b>1.7</b>	<b>1.6</b>	<b>1.6</b>	<b>2.0</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>2.3</b>	3.1	<b>3.0</b>	<b>0.41</b>	<b>0.48</b>	<b>1.2</b>	3.4	6.2	15	NBC-CMA [21]
POEMS	<b>2.5</b>	260	19	23	33	207	449	2029	<i>15e-3/3e5</i>	.	POEMS [17]
PM-AdapSS-DE	<b>1.1</b>	4.4	4.3	4.1	<b>0.76</b>	<b>0.54</b>	<b>0.67</b>	<b>0.74</b>	<b>0.89</b>	<b>1.0</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1.1</b>	77	18	95	34	30	39	46	55	69	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	3.5	7.9	88	23	35	187	347	<i>53e-4/5e4</i>	.	Basic RCGA [24]
SPSA	3.33e5	6.26e5	19476	18540	<i>31e+1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 67: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{19}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>19 Griewank-Rosenbrock F8F2</b>										
$\Delta ft_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta ft_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	31	16363	<i>56e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	62	4556	945	<i>27e-2/1e4</i>	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.4</b>	22	8527	1393	<i>39e-2/1e4</i>	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	55	25341	<i>59e-2/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	21	6463	<i>39e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	20	8960	659	<i>19e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>17</b>	3093	478	7.0	6.1	6.1	6.0	6.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	25	10110	<i>34e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>13</b>	5123	1482	<i>20e-2/1e4</i>	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>17</b>	6018	233	<i>98e-3/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.2</b>	34	2898	3823	69	<i>12e-2/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	24	15619	995	<i>55e-3/1e5</i>	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	37	97	5695	2016	33	<i>73e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	29	2586	1726	10	11	11	11	10	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	35	3449	1630	15	13	13	13	13	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>14</b>	<b>1207</b>	<b>123</b>	<b>0.84</b>	<b>0.95</b>	<b>0.95</b>	<b>0.96</b>	<b>0.96</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	21	1720	<b>125</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.2</b>	27	<b>658</b>	<b>108</b>	<b>3.9</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>	<b>4.8</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.1</b>	39	2946	2141	40	35	35	35	35	NBC-CMA [21]
POEMS	<b>1</b>	202	1047	30587	10531	98	87	86	86	86	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.7</b>	37	2000	2054	22	19	19	19	29	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.1</b>	982	18467	1645	12	27	27	27	27	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	33	<b>1019</b>	463	<i>63e-3/5e4</i>	.	.	.	.	Basic RCGA [24]
SPSA	36	97	422	2.10e5	29091	<i>59e-2/1e5</i>	.	.	.	.	SPSA [13]



Table 69: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{21}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>21 Gallagher 101 peaks</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	6.9	8.6	13	13	13	13	13	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	5.7	5.8	9.0	9.0	8.9	8.9	8.9	8.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	5.0	10	9.4	9.4	9.4	9.3	9.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	24	14	23	23	23	23	23	22	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	5.7	<b>2.9</b>	6.9	6.8	6.8	6.8	6.8	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	3.5	3.4	6.1	6.1	6.1	6.0	6.0	6.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.2</b>	<b>1.7</b>	<b>3.1</b>	<b>3.1</b>	<b>3.1</b>	<b>3.1</b>	<b>3.1</b>	<b>3.1</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	5.1	4.3	<b>5.3</b>	<b>5.3</b>	<b>5.3</b>	<b>5.2</b>	<b>5.2</b>	<b>5.2</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.7</b>	3.4	5.6	5.5	5.5	5.5	5.5	5.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	7.6	3.8	7.5	7.4	7.4	7.3	7.3	7.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	3.2	<b>1.8</b>	6.7	10	13	24	84	265	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>1.7</b>	<b>2.5</b>	<b>3.6</b>	<b>3.5</b>	<b>3.5</b>	<b>3.5</b>	<b>3.5</b>	<b>3.5</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	21	3.4	114	217	267	287	327	374	458	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	5.2	<b>1.7</b>	110	109	109	108	107	106	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	4.5	33	76	76	75	75	74	74	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	3.5	7.3	32	33	33	33	33	33	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	6.3	5.6	30	30	31	31	31	31	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	4.6	69	280	478	485	485	483	527	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>2.5</b>	96	119	118	117	116	115	114	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	25	744	1429	1415	1405	1397	1389	1371	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	4.0	33	201	199	198	196	195	192	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	28	11	214	238	243	254	263	283	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	<b>2.5</b>	84	105	129	129	134	135	140	Basic RCGA [24]
SPSA	<b>1</b>	34	34	299	1985	1967	1958	1997	4056	3995	SPSA [13]

Table 70: Running time excess  $ERT/ERT_{\text{best}}^{2009}$  on  $f_{22}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>22 Gallagher 21 peaks</b>										
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	18	31	31	30	30	29	29	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	10	11	20	19	19	19	18	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	15	21	51	49	48	47	47	46	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	23	32	49	47	46	46	45	44	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	6.9	13	16	16	15	15	15	15	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	12	10	12	12	12	12	12	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	10	12	15	15	14	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	16	18	12	11	11	11	11	11	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	3.7	8.0	<b>8.5</b>	<b>8.2</b>	<b>8.0</b>	<b>8.0</b>	<b>7.9</b>	<b>7.8</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>3.1</b>	<b>6.5</b>	<b>4.9</b>	<b>4.7</b>	<b>4.6</b>	<b>4.6</b>	<b>4.6</b>	<b>4.5</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	5.1	7.6	35	237	374	1160	3311	6900	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>3.4</b>	<b>2.6</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.4</b>	<b>2.4</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	27	58	336	1483	1421	1384	1364	1933	1885	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	4.8	203	803	768	747	734	724	706	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	6.6	203	469	450	437	430	424	414	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	8.8	21	65	276	270	265	262	257	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	12	48	166	165	161	159	158	155	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	3.7	24	299	483	557	551	549	541	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>3.0</b>	264	289	360	350	343	339	331	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	1137	2347	2593	2485	2417	2377	2348	2292	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	4.1	<b>4.6</b>	469	449	437	430	424	414	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	29	24	268	276	284	305	326	362	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	6.2	154	365	857	1697	1716	1706	3410	Basic RCGA [24]
SPSA	<b>1</b>	42	676	1318	7823	<i>69e-2/1e5</i>	.	.	.	.	SPSA [13]

Table 71: Running time excess  $ERT/ERT_{\text{best}}^{2009}$  on  $f_{23}$  in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>23 Katsuuras</b>											
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	1	1	<b>2.8</b>	101	<i>97e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	15	37	16	13	23	23	22	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	6.4	23	9.5	26	<i>18e-2/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	3.1	105	<i>98e-2/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	5.7	28	7.0	12	11	22	22	21	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.8	12	4.2	<i>87e-3/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	<b>2.2</b>	8.9	24	25	<i>20e-2/1e4</i>	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	<b>3.0</b>	23	51	<i>23e-2/1e4</i>	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	5.0	<b>5.4</b>	5.5	12	<i>10e-2/1e4</i>	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	4.7	<b>1.3</b>	9.3	<i>12e-2/1e4</i>	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	<b>2.2</b>	19	<i>37e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	6.0	<b>2.5</b>	14	<i>15e-2/9e3</i>	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	8.1	15	33	<i>55e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	<b>2.4</b>	9.3	<b>2.3</b>	<b>2.5</b>	<b>3.4</b>	<b>4.4</b>	<b>5.3</b>	<b>6.9</b>	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	<b>2.0</b>	11	<b>2.5</b>	<b>2.7</b>	<b>3.6</b>	<b>4.6</b>	<b>5.5</b>	<b>7.2</b>	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	<b>1.6</b>	20	76	39	34	33	33	32	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	<b>2.2</b>	26	33	17	15	15	14	14	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	<b>2.2</b>	16	<b>4.1</b>	<b>3.5</b>	<b>3.8</b>	<b>3.7</b>	<b>4.0</b>	<b>3.9</b>	CMA+DE-MOS [18]
NBC-CMA	1	1	<b>1.4</b>	42	299	153	135	132	129	124	NBC-CMA [21]
POEMS	1	1	12	21	41	63	57	56	55	54	POEMS [17]
PM-AdapSS-DE	1	1	<b>1.8</b>	8.9	12	15	14	15	21	27	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	3.4	71	29	43	42	44	47	53	pPOEMS [17, 20]
Basic RCGA	1	1	<b>2.2</b>	37	119	<i>53e-2/5e4</i>	.	.	.	.	Basic RCGA [24]
SPSA	1	105	309	1779	<i>11e-1/1e5</i>	.	.	.	.	.	SPSA [13]





Table 73: Running time excess  $ERT/ERT_{best}$  2009 on  $f_1$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>1 Sphere</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	23	13	21	31	40	48	58	67	85	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	13	6.5	12	17	23	28	34	40	52	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	8.3	5.9	11	15	20	25	31	36	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	20	10	19	28	35	45	53	62	81	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	11	4.7	10	14	20	25	30	36	46	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>2.7</b>	4.1	8.2	13	17	21	26	30	39	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	5.5	<b>3.6</b>	<b>6.7</b>	<b>10</b>	<b>13</b>	<b>16</b>	<b>20</b>	<b>23</b>	<b>29</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	14	4.3	8.3	13	16	21	25	29	38	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	11	4.1	8.1	12	15	19	23	27	34	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	9.3	<b>3.7</b>	<b>6.8</b>	<b>10</b>	<b>13</b>	<b>17</b>	<b>20</b>	<b>24</b>	<b>31</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	4.9	24	55	86	114	165	203	238	306	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	27	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	<b>1.7</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.7	85	11	19	26	34	42	49	57	72	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	4.5	37	91	137	189	239	290	343	443	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	4.9	48	121	198	269	344	423	496	649	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	9.2	6.2	13	19	26	32	39	44	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	7.7	5.0	11	18	24	30	37	43	56	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	5.9	19	57	71	94	124	140	166	214	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	5.8	16	25	34	45	54	63	73	93	NBC-CMA [21]
POEMS	<b>1</b>	1684	130	244	608	1045	1469	1958	2403	3321	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>4.3</b>	41	95	158	218	275	338	399	518	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	527	125	252	1035	3154	5744	8009	10514	16455	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>4.0</b>	33	105	207	345	1034	1984	2693	3761	Basic RCGA [24]
SPSA	8.4	104	7.7	11	13	16	19	22	25	31	SPSA [13]



























Table 86: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{14}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta f_{target}$ $ERT_{best}/D$	14 Sum of different powers										$\Delta f_{target}$ $ERT_{best}/D$
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
(1,2)-CMA-ES	<b>1</b>	3.8	9.1	6.7	6.9	7.6	7.9	10	12	4.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	4.0	4.2	3.7	3.9	4.2	4.4	6.3	7.7	<b>2.5</b>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>2.9</b>	3.4	<b>2.8</b>	3.0	3.3	3.6	5.3	6.7	<b>2.1</b>	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	23	10	6.6	7.1	7.7	7.6	11	13	4.0	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	7.5	<b>2.8</b>	<b>2.8</b>	3.2	3.7	3.6	5.3	6.1	<b>1.8</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	3.3	<b>2.3</b>	<b>2.4</b>	<b>2.7</b>	<b>3.0</b>	3.1	4.4	5.5	<b>1.6</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.9</b>	<b>2.1</b>	<b>1.9</b>	<b>2.2</b>	<b>2.5</b>	<b>2.6</b>	<b>3.6</b>	<b>4.4</b>	<b>1.3</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	7.3	<b>2.8</b>	<b>2.5</b>	<b>2.9</b>	3.1	3.1	4.1	4.8	<b>1.4</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	3.4	<b>2.0</b>	<b>1.9</b>	<b>2.3</b>	<b>2.4</b>	<b>2.4</b>	3.8	4.9	<b>1.1</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	3.1	<b>1.8</b>	<b>1.6</b>	<b>2.0</b>	<b>2.1</b>	<b>2.1</b>	<b>3.0</b>	<b>3.7</b>	<b>1.0</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.9</b>	6.4	17	22	35	703	<i>64e-5/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	9.2	<b>1.7</b>	<b>1.3</b>	<b>1.3</b>	<b>1.2</b>	<b>1.1</b>	<b>2.2</b>	7.1	64	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.9	71	9.2	5.7	6.1	6.2	8.4	19	26	64	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>2.1</b>	10	18	26	24	16	15	13	<b>2.8</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>2.0</b>	9.5	25	34	33	22	22	19	4.1	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	3.7	<b>2.1</b>	<b>2.8</b>	3.7	3.8	3.1	3.6	<b>3.5</b>	<b>0.84</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	5.4	<b>2.2</b>	<b>2.9</b>	3.8	4.2	3.8	4.8	5.0	<b>1.3</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	3.0	7.5	13	14	14	13	15	14	3.2	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>2.3</b>	5.2	5.7	6.5	6.3	5.1	6.6	7.1	<b>1.9</b>	NBC-CMA [21]
POEMS	<b>1</b>	847	73	53	105	142	116	186	1491	<i>33e-7/3e5</i>	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.9</b>	13	21	29	27	19	18	15	3.2	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	103	73	61	193	496	570	818	987	<i>61e-8/3e5</i>	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>2.1</b>	5.5	30	44	91	1052	13979	<i>76e-5/5e4</i>	.	Basic RCGA [24]
SPSA	21	348	97	74	61	49	53	293	1046	<i>43e-7/1e5</i>	SPSA [13]





Table 88: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{16}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>16 Weierstrass</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1.7</b>	553	<i>11e+0/1e4</i>	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1.4</b>	26	96	<i>25e-1/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.3</b>	32	96	<i>32e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.3</b>	779	<i>15e+0/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1.5</b>	22	45	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1.4</b>	11	14	91	<i>64e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.4</b>	12	24	<i>13e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.5</b>	27	97	<i>28e-1/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.7</b>	5.2	46	<i>16e-1/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1.2</b>	4.2	97	<i>13e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.3</b>	3.3	149	<i>92e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.5</b>	<b>3.3</b>	41	<i>13e-1/1e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	53	14	20	89	308	<i>10e-2/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.7</b>	70	<i>51e-1/1e5</i>	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.7</b>	104	<i>45e-1/1e5</i>	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.3</b>	<b>1.6</b>	<b>0.95</b>	<b>1.2</b>	<b>0.84</b>	<b>1.1</b>	<b>0.91</b>	<b>0.92</b>	<b>0.87</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.3</b>	3.5	<b>1.2</b>	<b>1.2</b>	<b>0.87</b>	<b>0.90</b>	<b>0.72</b>	<b>0.75</b>	<b>0.71</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.3</b>	<b>2.6</b>	<b>0.55</b>	<b>0.99</b>	<b>1.2</b>	<b>1.4</b>	<b>1.1</b>	<b>1.2</b>	<b>1.2</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.5</b>	9.4	<b>0.71</b>	<b>1.3</b>	<b>1.8</b>	<b>2.9</b>	3.5	11	19	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	11	3.8	130	428	382	301	298	274	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.5</b>	70	<i>34e-1/1e5</i>	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.3</b>	16	18	89	189	243	192	192	178	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.3</b>	7.9	13	38	50	142	112	<i>87e-3/5e4</i>	.	Basic RCGA [24]
SPSA	<b>1</b>	1551	1239	2107	<i>56e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 89: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{17}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	17 Schaffer F7, condition 10										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>2.5</b>	119	3362	<i>25e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>2.7</b>	5.5	55	196	229	<i>18e-2/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1.1</b>	31	52	327	<i>34e-2/1e4</i>	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1.2</b>	204	3343	<i>24e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	9.3	82	<i>38e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	3.1	22	324	<i>24e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1.1</b>	<b>2.6</b>	51	214	<i>15e-2/1e4</i>	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1.7</b>	3.4	121	<i>69e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1.3</b>	17	443	<i>13e-1/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	6.2	717	<i>13e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.2</b>	11	954	<i>65e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1.1</b>	<b>2.2</b>	987	<i>10e-1/3e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	24	59	6.2	<b>1.4</b>	<b>0.77</b>	<b>0.74</b>	<b>2.0</b>	4.4	70	530	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.1</b>	7.4	8.0	3.2	<b>1.8</b>	<b>1.6</b>	<b>1.4</b>	<b>1.5</b>	<b>1.5</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.1</b>	5.4	11	4.6	<b>2.7</b>	<b>2.4</b>	<b>2.1</b>	<b>2.0</b>	<b>2.0</b>	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1.1</b>	<b>2.4</b>	<b>1.2</b>	<b>1.8</b>	<b>1.2</b>	<b>1.3</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1.6</b>	<b>2.7</b>	<b>2.6</b>	<b>1.5</b>	<b>0.83</b>	<b>1.0</b>	<b>0.90</b>	<b>0.88</b>	<b>1.0</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.4</b>	3.3	30	10	4.1	3.3	4.8	3.8	3.3	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.1</b>	<b>2.9</b>	<b>1.8</b>	<b>0.72</b>	<b>0.87</b>	<b>1.6</b>	7.7	31	<i>16e-6/3e4</i>	NBC-CMA [21]
POEMS	<b>1</b>	274	86	24	111	42	84	104	178	1591	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.2</b>	4.6	8.5	3.6	<b>2.0</b>	<b>1.8</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.2</b>	91	32	72	54	52	45	44	146	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.1</b>	5.8	16	48	36	40	50	111	<i>16e-5/5e4</i>	Basic RCGA [24]
SPSA	6.67e5	8.76e5	34195	32685	<i>86e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 91: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{19}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta$ ftarget $ERT_{best}/D$	<b>19 Griewank-Rosenbrock F8F2</b>										$\Delta$ ftarget $ERT_{best}/D$
	1e+03 0.10	1e+02 0.10	1e+01 0.10	1e+00 0.10	1e-01 1061	1e-02 98379	1e-03 1.37e5	1e-04 1.37e5	1e-05 1.38e5	1e-07 1.39e5	
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	514	7.33e5	<i>24e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	128	1.55e5	<i>90e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	164	2.24e5	<i>11e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	239	1.46e6	<i>32e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	82	1.99e5	<i>13e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	68	45284	<i>58e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	57	43406	<i>68e-2/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	79	75584	<i>77e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	63	65610	<i>85e-2/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>54</b>	22281	<i>55e-2/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1.1</b>	410	4.22e6	<i>12e-1/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>48</b>	7.08e5	<i>83e-2/1e5</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	64	223	28056	422	<i>20e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1.2</b>	303	4.04e5	<i>59e-2/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1.2</b>	390	8.37e5	<i>52e-2/1e5</i>	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	68	<b>9042</b>	<b>10</b>	<b>0.61</b>	<b>0.53</b>	<b>0.53</b>	<b>0.53</b>	<b>0.54</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>56</b>	<b>12509</b>	<b>8.9</b>	<b>0.55</b>	<b>0.53</b>	<b>0.53</b>	<b>0.53</b>	<b>0.53</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1.1</b>	212	<b>5852</b>	<b>6.5</b>	<b>1.2</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1.2</b>	117	2.11e6	<i>15e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	<b>1</b>	253	2538	5.19e5	4011	<i>55e-2/3e5</i>	.	.	.	.	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1.7</b>	256	5.48e5	<i>81e-2/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1.2</b>	2624	3.58e5	4022	<i>23e-2/3e5</i>	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1.2</b>	167	70727	157	<i>17e-2/5e4</i>	.	.	.	.	Basic RCGA [24]
SPSA	44	126	658	6.65e6	<i>18e-1/1e5</i>	.	.	.	.	.	SPSA [13]



Table 93: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{21}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>21 Gallagher 101 peaks</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	18	14	22	21	21	20	19	8.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	8.4	11	14	14	13	13	12	5.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	4.3	<b>5.4</b>	7.3	7.1	7.0	6.6	6.4	<b>2.9</b>	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	39	20	18	18	17	17	16	7.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	6.2	6.4	11	11	10	10	10	4.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	4.2	6.7	<b>4.7</b>	<b>4.6</b>	<b>4.5</b>	<b>4.3</b>	<b>4.1</b>	<b>1.9</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	4.8	<b>4.3</b>	<b>3.6</b>	<b>3.5</b>	<b>3.4</b>	<b>3.3</b>	<b>3.1</b>	<b>1.4</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	7.0	6.4	6.9	6.8	6.6	6.3	6.0	<b>2.7</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	4.2	6.3	<b>4.4</b>	<b>4.3</b>	<b>4.2</b>	<b>4.0</b>	<b>3.8</b>	<b>1.7</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>4.1</b>	6.5	6.0	5.8	5.7	5.4	5.2	<b>2.3</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	8.0	<b>2.9</b>	8.5	10	12	24	39	82	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>3.2</b>	8.2	4.7	4.7	4.5	4.3	4.1	<b>1.9</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	62	13	101	60	59	58	56	55	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	23	114	84	83	81	77	74	33	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	25	115	116	113	110	105	101	45	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>2.6</b>	31	58	57	55	53	50	23	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	5.9	14	52	51	50	47	45	21	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	25	347	512	503	489	466	447	201	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	12	275	188	184	179	170	163	73	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	3498	2668	1648	1615	1570	1494	1431	642	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	18	226	262	256	249	237	227	102	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	38	746	980	1122	1317	1259	1211	547	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	121	120	86	86	86	84	82	38	Basic RCGA [24]
SPSA	<b>1</b>	102	94	1309	1543	1515	1488	2894	2780	1272	SPSA [13]

Table 94: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{22}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>22 Gallagher 21 peaks</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	19	9.2	30	29	28	28	23	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	18	9.3	18	17	16	16	14	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	20	11	25	24	24	23	19	16	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	62	12	40	39	38	37	31	25	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	15	7.0	10	9.3	9.1	9.0	7.5	6.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	12	6.6	12	11	11	11	8.9	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>8.2</b>	<b>4.1</b>	14	14	14	13	11	8.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	16	8.4	13	13	12	12	10	8.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>9.3</b>	4.5	<b>4.0</b>	<b>3.8</b>	<b>3.8</b>	<b>3.7</b>	<b>3.1</b>	<b>2.5</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	22	4.5	<b>5.0</b>	<b>4.8</b>	<b>4.7</b>	<b>4.6</b>	<b>3.9</b>	<b>3.1</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	17	<b>4.3</b>	34	364	<i>13e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>3.6</b>	<b>2.6</b>	<b>2.1</b>	<b>2.1</b>	<b>2.0</b>	<b>2.0</b>	<b>1.7</b>	<b>1.4</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1</b>	53	22	417	1024	982	957	939	784	628	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	32	706	<i>20e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	31	405	2206	2117	2061	2024	1689	1354	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	44	203	663	636	620	608	508	407	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	42	90	666	640	623	612	510	409	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	171	538	1268	1218	1187	1166	974	781	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	792	221	<i>51e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	4774	4231	3072	2950	2873	2822	2356	1892	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	28	706	<i>20e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	2258	363	424	412	404	401	338	276	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	711	205	343	520	<i>69e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	3.3	69	2954	831	<i>51e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 95: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{23}$  in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>23 Katsuuras</b>											
$\Delta$ target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta$ target	
$ERT_{best}/D$	0.10	0.10	0.28	92	1643	18390	20350	20641	20893	21351	$ERT_{best}/D$	
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	38	1557	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	4.7	68	<i>35e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	8.6	70	<i>39e-2/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	44	797	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	7.5	33	<i>35e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	5.7	33	<i>34e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	5.0	15	91	<i>23e-2/1e4</i>	.	.	.	.	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	5.7	58	<i>60e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	6.5	<b>4.5</b>	<i>28e-2/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	5.1	<b>4.5</b>	<i>26e-2/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	<b>1</b>	<b>1</b>	<b>2.5</b>	33	<i>49e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]	
avg NEWUOA	<b>1</b>	<b>1</b>	11	<b>2.6</b>	<i>21e-2/1e4</i>	.	.	.	.	.	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	<b>1</b>	35	34	397	<i>84e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	<b>2.3</b>	85	160	<i>15e-2/1e5</i>	.	.	.	.	Adap DE (F-AUC) [10]	
DE (Uniform)	<b>1</b>	<b>1</b>	<b>1.5</b>	97	278	<b>80</b>	<b>72</b>	<b>71</b>	<b>70</b>	<b>69</b>	DE (Uniform) [9]	
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>1.8</b>	458	<i>71e-2/2e5</i>	.	.	.	.	.	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	376	308	<b>65</b>	<b>59</b>	<b>58</b>	<b>57</b>	<b>56</b>	IPOP-CMA-ES [22]	
CMA+DE-MOS	<b>1</b>	<b>1</b>	<b>1.7</b>	24	<b>15</b>	<b>4.0</b>	<b>3.6</b>	<b>3.6</b>	<b>3.6</b>	<b>3.5</b>	CMA+DE-MOS [18]	
NBC-CMA	<b>1</b>	<b>1</b>	<b>1.4</b>	692	<i>11e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]	
POEMS	<b>1</b>	<b>1</b>	9.1	26	<b>50</b>	107	<i>36e-3/3e5</i>	.	.	.	POEMS [17]	
PM-AdapSS-DE	<b>1</b>	<b>1</b>	<b>1.6</b>	81	<i>28e-2/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]	
pPOEMS	<b>1</b>	<b>1</b>	5.7	161	<b>77</b>	111	211	<i>25e-3/3e5</i>	.	.	pPOEMS [17, 20]	
Basic RCGA	<b>1</b>	<b>1</b>	<b>2.5</b>	162	436	<i>44e-2/5e4</i>	.	.	.	.	Basic RCGA [24]	
SPSA	<b>1</b>	173	1046	3799	<i>11e-1/1e5</i>	.	.	.	.	.	SPSA [13]	





Table 97: Running time excess  $ERT/ERT_{best}$  2009 on  $f_1$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	1 Sphere										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	63	15	25	34	44	53	63	72	93	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	26	8.9	15	20	25	30	35	41	52	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	25	8.1	13	18	22	27	32	36	47	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	63	17	26	35	44	53	62	72	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	18	7.7	13	18	23	27	33	38	49	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	15	6.2	11	15	19	24	28	32	42	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	14	<b>4.7</b>	<b>8.1</b>	<b>11</b>	<b>14</b>	<b>18</b>	<b>21</b>	<b>24</b>	<b>31</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	17	6.3	11	15	19	23	26	31	40	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	11	5.5	10	14	18	21	25	29	37	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>10</b>	<b>4.9</b>	<b>8.5</b>	<b>12</b>	<b>15</b>	<b>19</b>	<b>23</b>	<b>26</b>	<b>33</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	50	36	66	94	136	177	244	292	374	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	18	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	<b>2.3</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	47	41	13	19	26	33	40	47	54	68	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	79	93	180	265	350	431	515	597	763	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	89	146	298	442	588	734	882	1027	1319	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>9.4</b>	7.9	14	20	27	33	39	45	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>10</b>	8.0	14	20	26	33	39	46	58	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	34	34	58	68	91	123	134	148	200	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	17	13	21	30	38	46	54	62	79	NBC-CMA [21]
POEMS	<b>1</b>	804	183	411	853	1372	1783	2331	2828	3744	POEMS [17]
PM-AdapSS-DE	<b>1</b>	69	101	196	291	377	465	555	646	827	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	847	196	468	1052	1852	2567	3510	4501	7123	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	36	55	133	868	2715	3825	4686	5435	6380	Basic RCGA [24]
SPSA	158	59	12	16	20	25	29	34	38	46	SPSA [13]

























Table 109: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{13}$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	13 Sharp ridge											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$	
(1,2)-CMA-ES	11	10	20	25	41	87	47	63	<i>13e-3/1e4</i>	.	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	4.8	5.2	13	12	24	36	33	62	55	93	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	4.5	4.7	4.6	6.9	23	37	49	130	116	94	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	10	9.5	13	29	41	115	36	<i>27e-3/1e4</i>	.	.	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	4.2	5.0	8.3	15	25	42	21	65	121	<i>46e-4/1e4</i>	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	3.4	4.0	6.4	10	16	28	8.0	18	36	<i>32e-5/1e4</i>	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	<b>2.6</b>	<b>3.2</b>	<b>4.5</b>	6.6	11	26	21	30	56	<i>18e-4/1e4</i>	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	3.5	4.0	7.6	4.9	14	23	17	30	57	<i>10e-4/1e4</i>	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	<b>2.5</b>	3.3	6.5	<b>4.8</b>	10	16	4.1	5.4	7.6	13	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	<b>2.3</b>	<b>3.0</b>	4.9	6.0	<b>7.7</b>	13	3.3	3.6	5.2	18	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	25	41	25	73	627	3931	1555	<i>60e-3/1e5</i>	.	.	Artif Bee Colony [8]	
avg NEWUOA	<b>2.1</b>	<b>1.8</b>	<b>1.5</b>	5.3	14	30	14	57	172	<i>67e-5/2e4</i>	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	6.4	6.5	6.8	7.6	37	125	108	256	556	<i>90e-5/1e5</i>	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	35	55	25	12	11	<b>11</b>	<b>2.4</b>	<b>2.4</b>	<b>2.5</b>	<b>2.5</b>	Adap DE (F-AUC) [10]	
DE (Uniform)	57	90	43	20	19	19	4.1	4.1	4.2	4.2	DE (Uniform) [9]	
IPOP-aCMA-ES	3.9	5.3	<b>3.6</b>	<b>3.4</b>	<b>3.7</b>	<b>3.4</b>	<b>0.80</b>	<b>0.98</b>	<b>1.3</b>	<b>1.3</b>	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	3.5	5.3	6.5	<b>4.8</b>	<b>6.2</b>	<b>5.1</b>	<b>1.4</b>	<b>1.6</b>	<b>1.7</b>	<b>2.3</b>	IPOP-CMA-ES [22]	
CMA+DE-MOS	16	18	10	9.1	12	12	<b>2.8</b>	<b>2.9</b>	3.2	3.0	CMA+DE-MOS [18]	
NBC-CMA	6.0	7.6	4.7	15	29	24	5.7	7.4	9.3	45	NBC-CMA [21]	
POEMS	98	201	6277	41616	<i>90e-1/3e5</i>	.	.	.	.	.	POEMS [17]	
PM-AdapSS-DE	41	63	28	13	12	12	<b>2.6</b>	<b>2.6</b>	<b>2.6</b>	<b>2.6</b>	PM-AdapSS-DE [9, 10]	
pPOEMS	104	223	938	2244	6207	24363	4562	<i>57e-2/3e5</i>	.	.	pPOEMS [17, 20]	
Basic RCGA	19	112	232	296	825	1228	<i>28e-2/5e4</i>	.	.	.	Basic RCGA [24]	
SPSA	76	2892	<i>29e+0/1e5</i>	.	.	.	.	.	.	.	SPSA [13]	

Table 110: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{14}$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

$\Delta f_{target}$ $ERT_{best}/D$	14 Sum of different powers										$\Delta f_{target}$ $ERT_{best}/D$
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	
(1,2)-CMA-ES	<b>1</b>	156	16	8.2	8.2	8.2	7.8	10	14	4.8	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	62	7.7	3.8	4.1	4.2	4.2	5.6	8.1	<b>2.0</b>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	41	6.0	3.1	3.3	3.5	3.6	4.9	6.6	<b>1.6</b>	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	143	14	6.9	7.4	7.4	6.9	9.3	13	5.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	16	5.7	3.1	3.6	4.0	3.9	5.2	7.3	<b>1.6</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	19	5.0	<b>2.8</b>	3.1	3.3	3.2	4.5	6.4	<b>1.4</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	16	3.8	<b>2.1</b>	<b>2.3</b>	<b>2.6</b>	<b>2.6</b>	3.5	<b>5.0</b>	<b>1.1</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	17	4.7	<b>2.6</b>	<b>2.9</b>	3.4	3.2	4.2	5.4	<b>1.3</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	12	<b>2.9</b>	<b>1.9</b>	<b>2.3</b>	<b>2.5</b>	<b>2.2</b>	<b>3.3</b>	5.4	<b>1.2</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	13	<b>2.3</b>	<b>1.6</b>	<b>1.9</b>	<b>2.1</b>	<b>1.9</b>	<b>2.7</b>	<b>4.5</b>	<b>0.97</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1.1</b>	<b>4.0</b>	18	18	28	53	3378	<i>10e-4/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	38	<b>2.7</b>	<b>1.5</b>	<b>1.6</b>	<b>1.3</b>	<b>1.3</b>	<b>2.7</b>	9.3	26	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	26	159	10	4.6	5.2	5.7	6.2	11	22	4.8	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>4.5</b>	33	30	38	36	23	20	19	<b>2.8</b>	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	5.5	53	50	64	60	38	32	31	4.2	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	10	3.6	<b>2.7</b>	3.5	4.0	3.2	3.4	<b>3.9</b>	<b>0.67</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	13	3.7	<b>2.8</b>	3.6	4.2	3.9	4.7	6.0	<b>1.2</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	5.1	20	10	11	13	12	13	14	<b>2.3</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.1</b>	<b>3.5</b>	5.5	3.7	4.6	5.3	5.1	6.9	9.0	<b>1.7</b>	NBC-CMA [21]
POEMS	<b>1</b>	3152	98	65	123	165	131	1158	<i>27e-6/3e5</i>	.	POEMS [17]
PM-AdapSS-DE	<b>1</b>	5.1	43	34	43	40	25	21	20	<b>2.8</b>	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	743	102	72	143	423	353	443	4529	<i>78e-7/3e5</i>	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	4.9	16	26	57	298	1502	<i>11e-4/5e4</i>	.	.	Basic RCGA [24]
SPSA	59	853	98	51	45	39	56	234	1207	<i>85e-7/1e5</i>	SPSA [13]













Table 116: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{20}$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	20 Schwefel $x*\sin(x)$											
$\Delta f_{target}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$	
$ERT_{best}/D$	2.8	3.5	4.1	2307	1.55e5	2.76e5	2.77e5	2.78e5	2.80e5	2.82e5	$ERT_{best}/D$	
(1,2)-CMA-ES	15	13	13	30	<i>12e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES	[5, 3]
(1,2m)-CMA-ES	7.5	6.9	6.5	30	<i>11e-1/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES	[5]
(1,2ms)-CMA-ES	6.0	5.6	5.3	<i>11e-1/1e4</i>	.	.	.	.	.	.	(1,2ms)-CMA-ES	[5]
(1,2s)-CMA-ES	14	12	11	15	<i>12e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES	[3]
(1,4)-CMA-ES	5.9	5.6	5.1	61	<i>12e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES	[6, 4]
(1,4m)-CMA-ES	5.0	4.6	4.6	31	<i>11e-1/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES	[6]
(1,4ms)-CMA-ES	3.8	3.6	3.5	11	<i>11e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES	[1, 6]
(1,4s)-CMA-ES	4.7	4.4	4.4	7.3	<i>10e-1/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES	[4]
(1+1)-CMA-ES	<b>3.5</b>	<b>3.5</b>	<b>3.3</b>	20	<i>12e-1/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES	[7]
(1+2ms)-CMA-ES	<b>3.2</b>	<b>3.1</b>	<b>2.9</b>	18	<i>11e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES	[2]
Artif Bee Colony	20	18	16	<b>0.12</b>	<i>23e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony	[8]
avg NEWUOA	<b>1.8</b>	<b>1.4</b>	<b>1.3</b>	107	<i>12e-1/2e4</i>	.	.	.	.	.	avg NEWUOA	[23]
CMA-EGS (IPOP,r1)	10	8.7	7.9	<i>20e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1)	[12]
Adap DE (F-AUC)	43	42	40	643	<i>15e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC)	[10]
DE (Uniform)	76	77	76	<i>17e-1/1e5</i>	.	.	.	.	.	.	DE (Uniform)	[9]
IPOP-aCMA-ES	4.5	4.7	4.7	3.2	<b>0.83</b>	<b>0.58</b>	<b>0.58</b>	<b>0.59</b>	<b>0.59</b>	<b>0.60</b>	IPOP-aCMA-ES	[16]
IPOP-CMA-ES	4.9	4.8	4.6	6.4	<b>0.65</b>	<b>0.57</b>	<b>0.57</b>	<b>0.58</b>	<b>0.58</b>	<b>0.58</b>	IPOP-CMA-ES	[22]
CMA+DE-MOS	23	23	21	<b>0.97</b>	<b>0.08</b>	<b>0.05</b>	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>	<b>0.07</b>	CMA+DE-MOS	[18]
NBC-CMA	8.2	8.0	7.3	91	<i>12e-1/1e4</i>	.	.	.	.	.	NBC-CMA	[21]
POEMS	129	124	118	<b>2.4</b>	8.6	<i>30e-2/3e5</i>	.	.	.	.	POEMS	[17]
PM-AdapSS-DE	51	51	46	<i>22e-1/1e5</i>	.	.	.	.	.	.	PM-AdapSS-DE	[9, 10]
pPOEMS	128	128	134	<b>1.8</b>	<i>24e-2/3e5</i>	.	.	.	.	.	pPOEMS	[17, 20]
Basic RCGA	10	10	10	<i>22e-1/5e4</i>	.	.	.	.	.	.	Basic RCGA	[24]
SPSA	14	15	16	<i>22e-1/1e5</i>	.	.	.	.	.	.	SPSA	[13]

Table 117: Running time excess  $ERT/ERT_{\text{best}}$  2009 on  $f_{21}$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>21 Gallagher 101 peaks</b>											
$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{\text{target}}$ $ERT_{\text{best}}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	13	8.3	10	10	11	11	10	9.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	5.9	<b>3.3</b>	3.6	3.5	3.4	3.4	3.3	<b>2.9</b>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	7.2	4.9	4.0	4.0	3.9	3.8	3.7	3.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	6.8	9.3	9.1	9.0	8.9	8.6	8.4	7.4	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.1</b>	3.6	4.7	4.6	4.5	4.4	4.3	3.8	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	3.9	4.7	4.8	4.7	4.7	4.5	4.4	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	<b>1.7</b>	<b>1.8</b>	<b>1.8</b>	<b>1.7</b>	<b>1.7</b>	<b>1.6</b>	<b>1.5</b>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	3.8	<b>2.3</b>	<b>2.6</b>	<b>2.6</b>	<b>2.5</b>	<b>2.4</b>	<b>2.4</b>	<b>2.1</b>	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	3.5	5.5	5.4	5.3	5.2	5.1	4.9	4.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	3.3	4.6	3.9	3.8	3.8	3.7	3.6	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	5.0	22	25	26	27	30	35	85	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	3.2	5.7	<b>3.5</b>	<b>3.5</b>	<b>3.4</b>	<b>3.3</b>	<b>3.3</b>	<b>2.9</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>2.7</b>	106	<b>1.9</b>	211	217	214	210	204	197	175	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	12	613	568	560	547	531	515	456	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	21	461	568	560	548	532	516	457	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	<b>1.9</b>	81	66	65	64	62	60	54	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	3.7	139	110	108	106	103	100	88	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	11	262	285	281	275	268	260	231	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	84	69	59	58	56	55	53	47	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	11053	5970	<i>47e-1/3e5</i>	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	12	351	568	560	547	531	515	456	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	137	1172	956	1186	1160	1127	1093	974	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	119	103	85	85	86	97	96	87	Basic RCGA [24]
SPSA	3.5	251	597	1240	<i>18e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 118: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{22}$  in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>22 Gallagher 21 peaks</b>										
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1,2)-CMA-ES	<b>1</b>	<b>1</b>	10	27	124	120	116	111	108	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	<b>1</b>	<b>1</b>	8.8	13	21	20	20	19	18	3.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	<b>1</b>	<b>1</b>	8.2	13	17	16	16	15	15	<b>3.0</b>	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	<b>1</b>	<b>1</b>	35	22	37	36	35	34	33	6.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	<b>1</b>	<b>1</b>	18	6.6	<b>11</b>	<b>11</b>	<b>11</b>	<b>10</b>	<b>10</b>	<b>2.0</b>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	<b>1</b>	<b>1</b>	<b>5.6</b>	7.7	16	16	15	15	14	<b>2.9</b>	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	<b>1</b>	<b>1</b>	9.0	<b>5.0</b>	28	27	26	25	24	4.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	<b>1</b>	<b>1</b>	<b>4.7</b>	13	27	26	25	24	24	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	17	9.4	15	14	14	13	13	<b>2.6</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	10	<b>4.4</b>	<b>10</b>	<b>10</b>	<b>9.2</b>	<b>8.8</b>	<b>8.6</b>	<b>1.7</b>	(1+2ms)-CMA-ES [2]
Artif Bee Colony	<b>1</b>	<b>1</b>	10	47	77	578	<i>44e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	<b>1</b>	<b>1</b>	<b>2.0</b>	<b>5.6</b>	<b>14</b>	<b>13</b>	<b>13</b>	<b>12</b>	<b>12</b>	<b>2.4</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	<b>1.9</b>	104	676	546	<i>20e-1/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	675	1436	<i>26e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	1580	989	<i>20e-1/1e5</i>	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	462	264	<i>20e-1/6e4</i>	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	445	287	<i>20e-1/6e4</i>	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	536	797	677	659	638	610	594	118	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	323	350	<i>73e-1/1e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	<b>1</b>	<b>1</b>	6453	6994	<i>73e-1/3e5</i>	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	1572	2332	<i>51e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	<b>1</b>	<b>1</b>	2022	1439	1680	1634	1584	1513	1474	294	pPOEMS [17, 20]
Basic RCGA	<b>1</b>	<b>1</b>	1186	1200	<i>73e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]
SPSA	7.6	240	1073	1439	<i>26e-1/1e5</i>	.	.	.	.	.	SPSA [13]







Table 121: Running time excess  $ERT/ERT_{best}$  2009 on  $f_1$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

	<b>1 Sphere</b>										
$\frac{\Delta f_{target}}{ERT_{best}/D}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\frac{\Delta f_{target}}{ERT_{best}/D}$
	0.03	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	
(1+1)-CMA-ES	<b>1</b>	<b>3.2</b>	<b>7.1</b>	<b>11</b>	<b>15</b>	<b>19</b>	<b>23</b>	<b>27</b>	<b>31</b>	<b>39</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>2.7</b>	<b>6.1</b>	<b>10</b>	<b>13</b>	<b>17</b>	<b>20</b>	<b>24</b>	<b>27</b>	<b>35</b>	(1+2ms)-CMA-ES [2]
avg NEWUOA	<b>1</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	139	7.7	15	22	30	37	44	52	59	74	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	65	205	383	594	823	1086	1353	1573	2016	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	113	376	642	898	1164	1442	1709	1982	2502	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	3.3	10	16	21	28	34	40	46	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	3.3	9.4	16	21	27	33	39	45	57	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	18	50	58	65	76	106	126	134	162	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	4.7	12	19	26	32	38	45	52	66	NBC-CMA [21]
PM-AdapSS-DE	<b>1</b>	75	212	364	524	694	871	1063	1252	1643	PM-AdapSS-DE [9, 10]
Basic RCGA	<b>1</b>	12	72	1089	4155	5781	7051	8001	8768	9840	Basic RCGA [24]
SPSA	478	11	15	20	24	29	33	37	41	50	SPSA [13]

























Table 133: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{13}$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>13 Sharp ridge</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1+1)-CMA-ES	<b>3.2</b>	<b>3.4</b>	3.1	5.4	10	25	10	8.6	14	23	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>2.9</b>	<b>2.9</b>	<b>2.8</b>	<b>3.2</b>	<b>7.2</b>	<b>14</b>	7.0	16	29	<i>82e-5/1e4</i>	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	7.6	6.4	<b>2.7</b>	4.2	37	215	780	669	570	<i>67e-4/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	78	105	37	17	18	17	3.3	3.3	3.2	3.3	Adap DE (F-AUC) [10]
DE (Uniform)	145	168	54	22	23	20	4.0	3.9	3.8	3.9	DE (Uniform) [9]
IPOP-aCMA-ES	<b>4.4</b>	<b>4.7</b>	<b>1.6</b>	<b>2.1</b>	<b>4.7</b>	<b>5.9</b>	<b>1.3</b>	<b>1.4</b>	<b>1.6</b>	<b>1.9</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.8	5.1	<b>2.8</b>	<b>3.5</b>	<b>6.6</b>	<b>10</b>	<b>2.3</b>	<b>2.9</b>	<b>2.7</b>	<b>2.9</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	26	14	6.4	7.0	11	15	<b>3.1</b>	3.4	<b>3.2</b>	3.6	CMA+DE-MOS [18]
NBC-CMA	5.6	5.7	<b>2.5</b>	5.0	16	26	10	25	<i>63e-4/7e3</i>	.	NBC-CMA [21]
PM-AdapSS-DE	85	102	34	15	16	15	3.1	<b>3.2</b>	3.2	<b>3.3</b>	PM-AdapSS-DE [9, 10]
Basic RCGA	29	733	319	177	724	1169	402	<i>20e-2/5e4</i>	.	.	Basic RCGA [24]
SPSA	75	4772	14665	8631	6843	<i>52e+0/1e5</i>	.	.	.	.	SPSA [13]

Table 134: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{14}$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>14 Sum of different powers</b>											
$\Delta f_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta f_{target}$ $ERT_{best}/D$
(1+1)-CMA-ES	<b>1</b>	<b>36</b>	<b>1.7</b>	<b>1.6</b>	<b>1.8</b>	<b>2.1</b>	<b>2.0</b>	<b>3.0</b>	<b>5.1</b>	<b>1.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	57	<b>1.7</b>	<b>1.5</b>	<b>1.7</b>	<b>1.9</b>	<b>1.9</b>	<b>2.7</b>	<b>4.2</b>	<b>0.85</b>	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	85	316	5.4	3.8	4.3	5.1	6.3	10	19	4.3	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	128	38	46	63	68	47	37	34	4.0	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	74	72	80	99	95	61	45	40	4.5	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>31</b>	<b>2.5</b>	<b>2.4</b>	<b>3.0</b>	<b>3.7</b>	<b>3.4</b>	<b>3.5</b>	<b>3.9</b>	<b>0.57</b>	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>32</b>	<b>2.7</b>	<b>2.5</b>	3.0	3.9	4.3	5.2	6.7	<b>1.1</b>	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1.1</b>	118	12	7.8	7.7	10	12	16	19	<b>2.7</b>	CMA+DE-MOS [18]
NBC-CMA	<b>1.1</b>	44	<b>2.9</b>	<b>2.6</b>	3.2	4.4	5.3	8.1	11	<b>1.8</b>	NBC-CMA [21]
PM-AdapSS-DE	<b>1.1</b>	90	44	47	59	60	41	32	30	3.7	PM-AdapSS-DE [9, 10]
Basic RCGA	<b>1</b>	51	12	28	366	484	1403	<i>10e-4/5e4</i>	.	.	Basic RCGA [24]
SPSA	195	1670	58	41	36	33	41	130	6065	<i>22e-6/1e5</i>	SPSA [13]













Table 140: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{20}$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>20 Schwefel <math>x*\sin(x)</math></b>											
$\frac{\Delta target}{ERT_{best}/D}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\frac{\Delta target}{ERT_{best}/D}$
(1+1)-CMA-ES	<b>3.5</b>	<b>3.0</b>	<b>2.6</b>	<i>13e-1/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>3.4</b>	<b>2.9</b>	<b>2.5</b>	<i>14e-1/1e4</i>	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	10	8.3	7.0	<i>19e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	70	59	52	<i>30e-1/1e5</i>	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	154	134	116	<i>29e-1/1e5</i>	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	<b>5.1</b>	<b>4.3</b>	<b>3.7</b>	<b>8.4</b>	<b>0.19</b>	<i>12e-2/3e5</i>	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.5	4.9	4.1	<b>15</b>	<b>0.33</b>	<i>14e-2/3e5</i>	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	25	20	16	<b>3.8</b>	<b>0.01</b>	<b>1.84e6</b>	<b>1.95e6</b>	<b>2.04e6</b>	<b>2.26e6</b>	<b>2.50e6</b>	CMA+DE-MOS [18]
NBC-CMA	6.6	6.0	5.1	<i>14e-1/7e3</i>	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	79	69	58	<i>30e-1/1e5</i>	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	8.2	8.9	8.5	<i>23e-1/5e4</i>	.	.	.	.	.	.	Basic RCGA [24]
SPSA	11	10	10	<i>22e-1/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 141: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{21}$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>21 Gallagher 101 peaks</b>											
$\frac{\Delta f_{target}}{ERT_{best}/D}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\frac{\Delta f_{target}}{ERT_{best}/D}$
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>5.0</b>	<b>1.9</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	<b>0.97</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>2.4</b>	<b>2.3</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	<b>1.1</b>	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	20	224	14	107	62	62	62	62	62	62	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	293	758	258	258	257	256	256	255	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	36	287	557	555	553	552	550	548	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	9.2	161	118	118	118	117	117	116	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	10	166	83	83	83	83	82	82	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	15	224	101	101	101	100	100	100	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	73	199	42	42	41	41	41	41	NBC-CMA [21]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	295	1231	<i>21e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	<b>1</b>	<b>1</b>	<b>7.7</b>	<b>89</b>	<b>31</b>	<b>33</b>	<b>33</b>	<b>34</b>	<b>34</b>	<b>35</b>	Basic RCGA [24]
SPSA	188	541	880	2650	<i>25e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 142: Running time excess  $ERT/ERT_{best}$  2009 on  $f_{22}$  in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

<b>22 Gallagher 21 peaks</b>											
$\Delta_{target}$ $ERT_{best}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta_{target}$ $ERT_{best}/D$
(1+1)-CMA-ES	<b>1</b>	<b>1</b>	<b>9.1</b>	<b>6.2</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	<b>1</b>	<b>1</b>	<b>1.9</b>	<b>4.9</b>	<b>9.0</b>	<b>8.9</b>	<b>8.9</b>	<b>8.9</b>	<b>8.9</b>	<b>8.9</b>	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	21	205	326	226	<i>20e-1/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	<b>1</b>	<b>1</b>	478	312	<i>26e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	<b>1</b>	<b>1</b>	661	453	<i>73e-1/1e5</i>	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	<b>1</b>	<b>1</b>	295	174	<i>20e-1/7e4</i>	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	<b>1</b>	<b>1</b>	367	133	<i>20e-1/8e4</i>	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	<b>1</b>	<b>1</b>	490	205	<i>20e-1/1e5</i>	.	.	.	.	.	CMA+DE-MOS [18]
NBC-CMA	<b>1</b>	<b>1</b>	<b>49</b>	<b>23</b>	<i>51e-1/7e3</i>	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	<b>1</b>	<b>1</b>	654	1581	<i>56e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	<b>1</b>	<b>1</b>	335	101	<i>20e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]
SPSA	183	630	769	737	<i>51e-1/1e5</i>	.	.	.	.	.	SPSA [13]







## References

- [1] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Benchmarking the (1, 4)-CMA-ES with mirrored sampling and sequential selection on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1617–1624.
- [2] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Comparing the (1+1)-CMA-ES with a mirrored (1+2)-CMA-ES with sequential selection on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1543–1550.
- [3] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 2)-CMA-ES on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1591–1596.
- [4] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 4)-CMA-ES on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1597–1604.
- [5] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 2)-CMA-ES compared on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1551–1558.
- [6] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 4)-CMA-ES compared on the noiseless BBOB-2010 testbed. In Pelikan and Branke [19], pages 1559–1566.
- [7] Anne Auger and Nikolaus Hansen. Benchmarking the (1+1)-CMA-ES on the BBOB-2009 function testbed. In Franz Rothlauf, editor, *GECCO (Companion)*, pages 2459–2466. ACM, 2009.
- [8] Mohammed El-Abd. Black-box optimization benchmarking for noiseless function testbed using artificial bee colony algorithm. In Pelikan and Branke [19], pages 1719–1724.
- [9] Álvaro Fialho, Wenyin Gong, and Zhihua Cai. Probability matching-based adaptive strategy selection vs. uniform strategy selection within differential evolution: an empirical comparison on the BBOB-2010 noiseless testbed. In Pelikan and Branke [19], pages 1527–1534.
- [10] Álvaro Fialho, Marc Schoenauer, and Michèle Sebag. Fitness-AUC bandit adaptive strategy selection vs. the probability matching one within differential evolution: an empirical comparison on the BBOB-2010 noiseless testbed. In Pelikan and Branke [19], pages 1535–1542.
- [11] S. Finck, N. Hansen, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Presentation of the noiseless functions. Technical Report 2009/20, Research Center PPE, 2009. Updated February 2010.
- [12] Steffen Finck and Hans-Georg Beyer. Benchmarking CMA-EGS on the BBOB 2010 noiseless function testbed. In Pelikan and Branke [19], pages 1633–1640.

- [13] Steffen Finck and Hans-Georg Beyer. Benchmarking SPSA on BBOB-2010 noiseless function testbed. In Pelikan and Branke [19], pages 1657–1664.
- [14] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2010: Experimental setup. Technical Report RR-7215, INRIA, 2010.
- [15] N. Hansen, S. Finck, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Noiseless functions definitions. Technical Report RR-6829, INRIA, 2009. Updated February 2010.
- [16] Nikolaus Hansen and Raymond Ros. Benchmarking a weighted negative covariance matrix update on the BBOB-2010 noiseless testbed. In Pelikan and Branke [19], pages 1673–1680.
- [17] Jirí Kubařík. Black-box optimization benchmarking of two variants of the POEMS algorithm on the noiseless testbed. In Pelikan and Branke [19], pages 1567–1574.
- [18] Antonio LaTorre, Santiago Muelas, and José María Peña. Benchmarking a MOS-based algorithm on the BBOB-2010 noiseless function testbed. In Pelikan and Branke [19], pages 1649–1656.
- [19] Martin Pelikan and Jürgen Branke, editors. *Genetic and Evolutionary Computation Conference, GECCO 2010, Proceedings, Portland, Oregon, USA, July 7-11, 2010, Companion Material*. ACM, 2010.
- [20] Petr Posík and Jirí Kubařík. Comparison of Cauchy EDA and pPOEMS algorithms on the BBOB noiseless testbed. In Pelikan and Branke [19], pages 1703–1710.
- [21] Mike Preuss. Niching the CMA-ES via nearest-better clustering. In Pelikan and Branke [19], pages 1711–1718.
- [22] Raymond Ros. Black-box optimization benchmarking the IPOP-CMA-ES on the noiseless testbed: comparison to the BIPOP-CMA-ES. In Pelikan and Branke [19], pages 1503–1510.
- [23] Raymond Ros. Comparison of NEWUOA with different numbers of interpolation points on the BBOB noiseless testbed. In Pelikan and Branke [19], pages 1487–1494.
- [24] Thanh-Do Tran and Gang-Gyoo Jin. Real-coded genetic algorithm benchmarked on noiseless black-box optimization testbed. In Pelikan and Branke [19], pages 1731–1738.



---

Centre de recherche INRIA Saclay – Île-de-France  
Parc Orsay Université - ZAC des Vignes  
4, rue Jacques Monod - 91893 Orsay Cedex (France)

Centre de recherche INRIA Bordeaux – Sud Ouest : Domaine Universitaire - 351, cours de la Libération - 33405 Talence Cedex  
Centre de recherche INRIA Grenoble – Rhône-Alpes : 655, avenue de l'Europe - 38334 Montbonnot Saint-Ismier  
Centre de recherche INRIA Lille – Nord Europe : Parc Scientifique de la Haute Borne - 40, avenue Halley - 59650 Villeneuve d'Ascq  
Centre de recherche INRIA Nancy – Grand Est : LORIA, Technopôle de Nancy-Brabois - Campus scientifique  
615, rue du Jardin Botanique - BP 101 - 54602 Villers-lès-Nancy Cedex  
Centre de recherche INRIA Paris – Rocquencourt : Domaine de Voluceau - Rocquencourt - BP 105 - 78153 Le Chesnay Cedex  
Centre de recherche INRIA Rennes – Bretagne Atlantique : IRISA, Campus universitaire de Beaulieu - 35042 Rennes Cedex  
Centre de recherche INRIA Sophia Antipolis – Méditerranée : 2004, route des Lucioles - BP 93 - 06902 Sophia Antipolis Cedex

---

Éditeur  
INRIA - Domaine de Voluceau - Rocquencourt, BP 105 - 78153 Le Chesnay Cedex (France)  
<http://www.inria.fr>  
ISSN 0249-0803