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Convergence Real-Virtual thanks to Optics & Computer Sciences

Xavier Granier

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***Convergence Real-Virtual
thanks to
Optics & Computer Sciences***

Xavier Granier



Spatial Augmented Reality

[Ridel – Reuter – Granier]

La torcia rivelatrice

Con un dito ridai ai marmi i colori antichi.

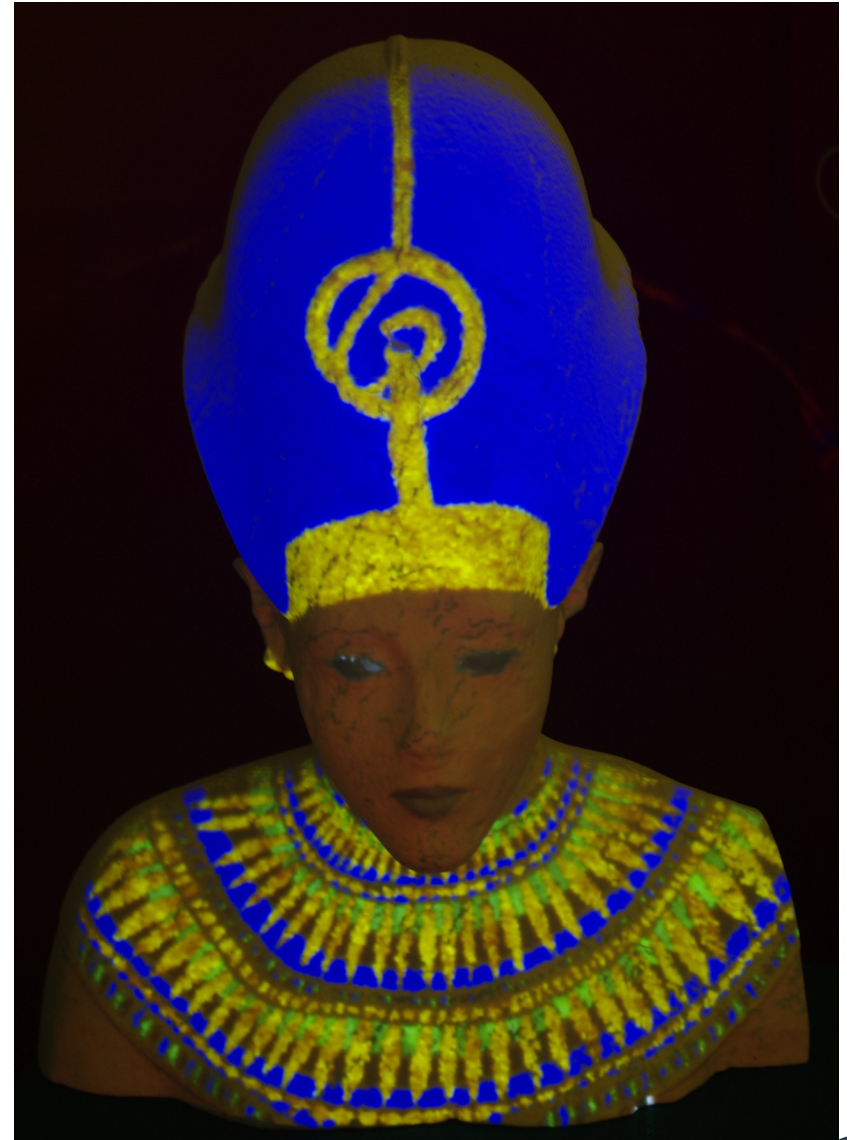
The revealing torch

Give back the marbles their ancient colors with your finger.



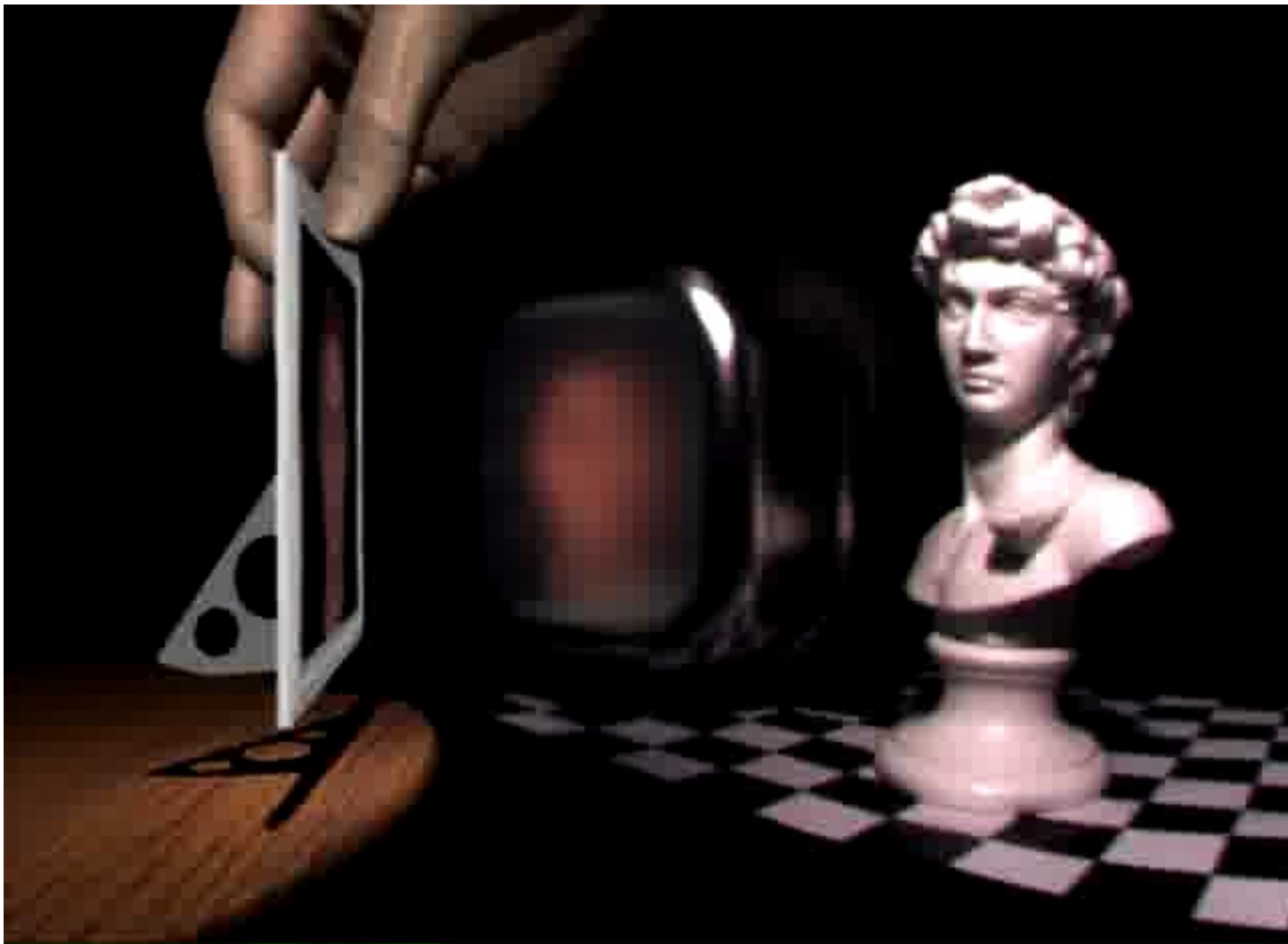
**Mercati di Traiano
Museo dei Fori Imperiali**

Convergence between real & virtual



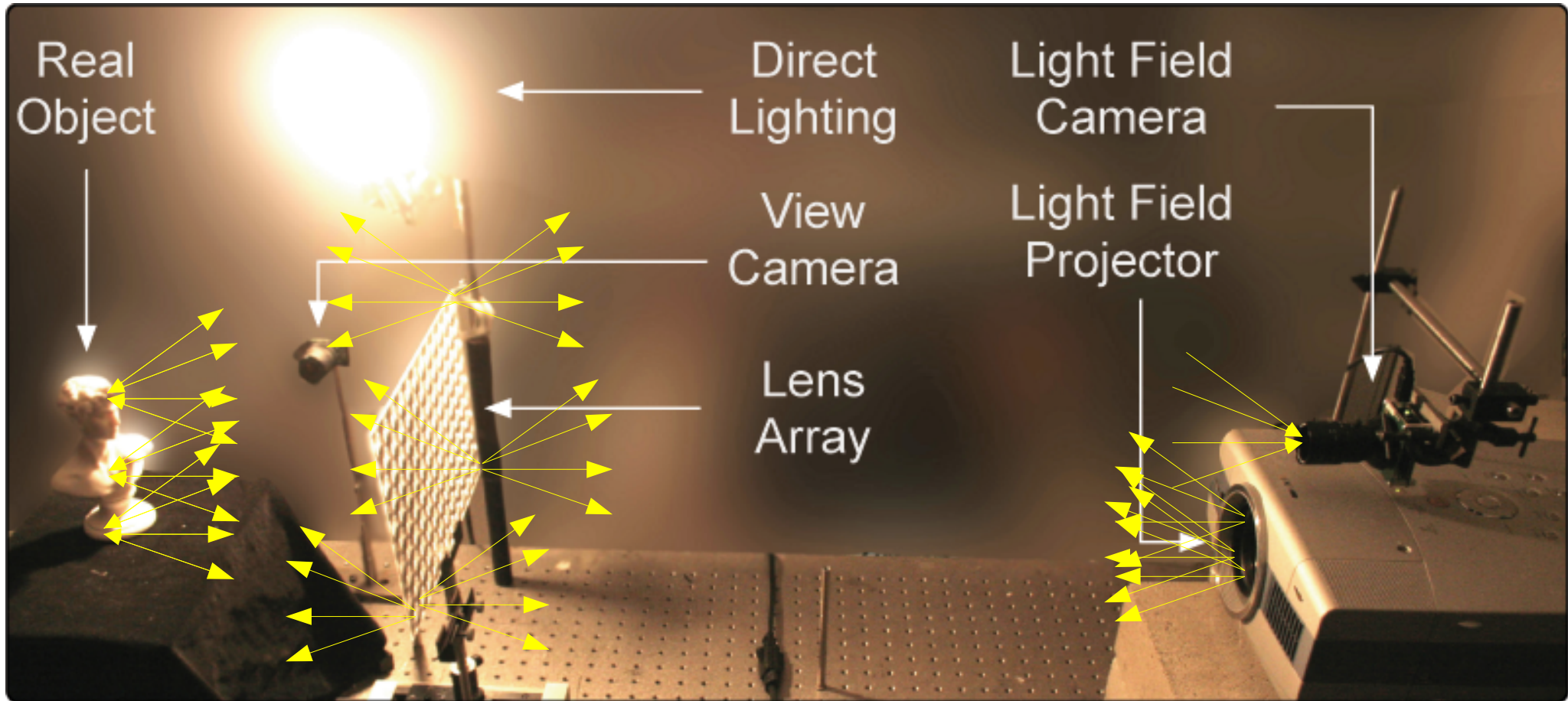
[Ridel – Reuter – Granier 2014]

Convergence between real & virtual



Columbia University 2008
Sino-French Symposium 2015

A unique representation in a hybrid systems

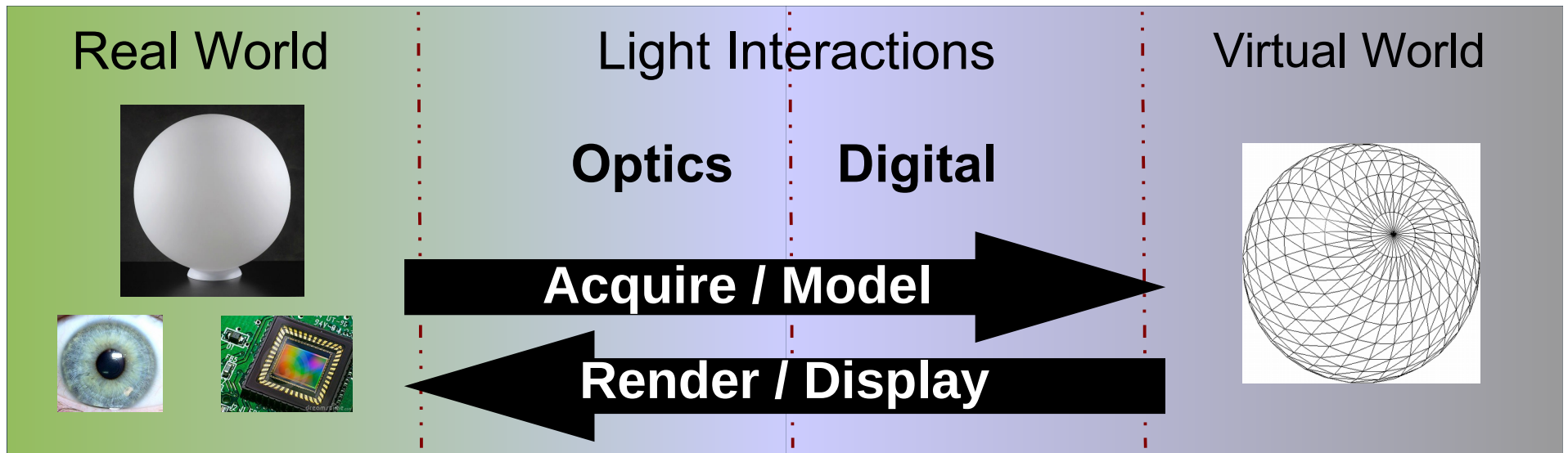


Cossairt – SIGGRAPH 2008

Convergence Real-Virtual

A **global but specialized view** of light interactions

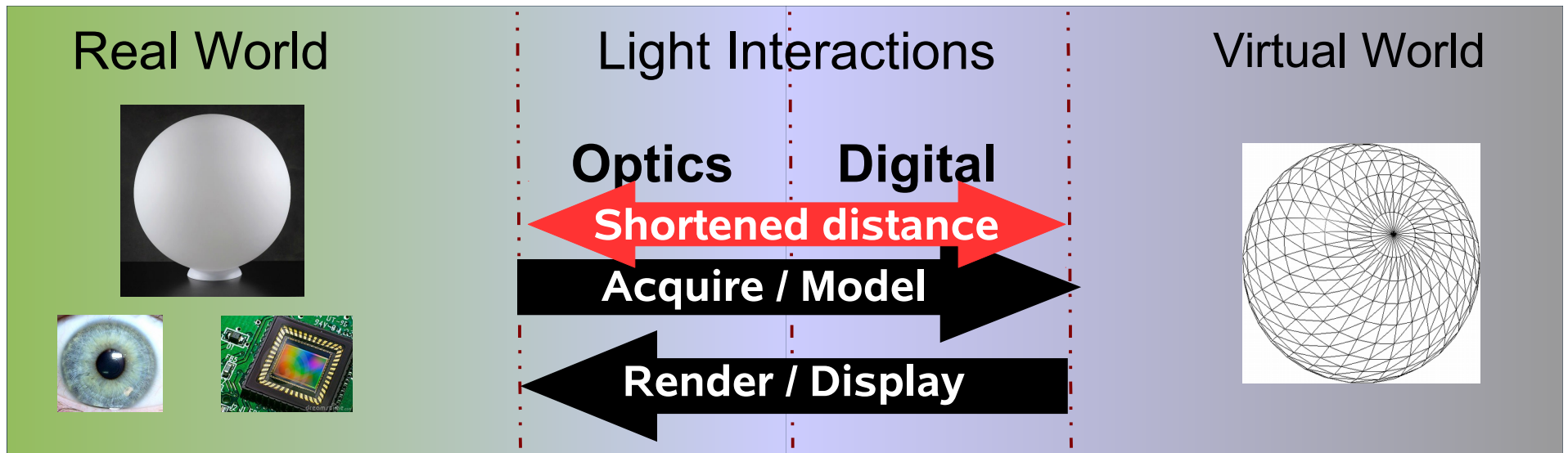
- ◉ **Real World:**
 - ◉ Physics and Optics laws
 - ◉ Sensors characteristics (physical & human)
- ◉ **Virtual World:** models & algorithms



Convergence Real-Virtual

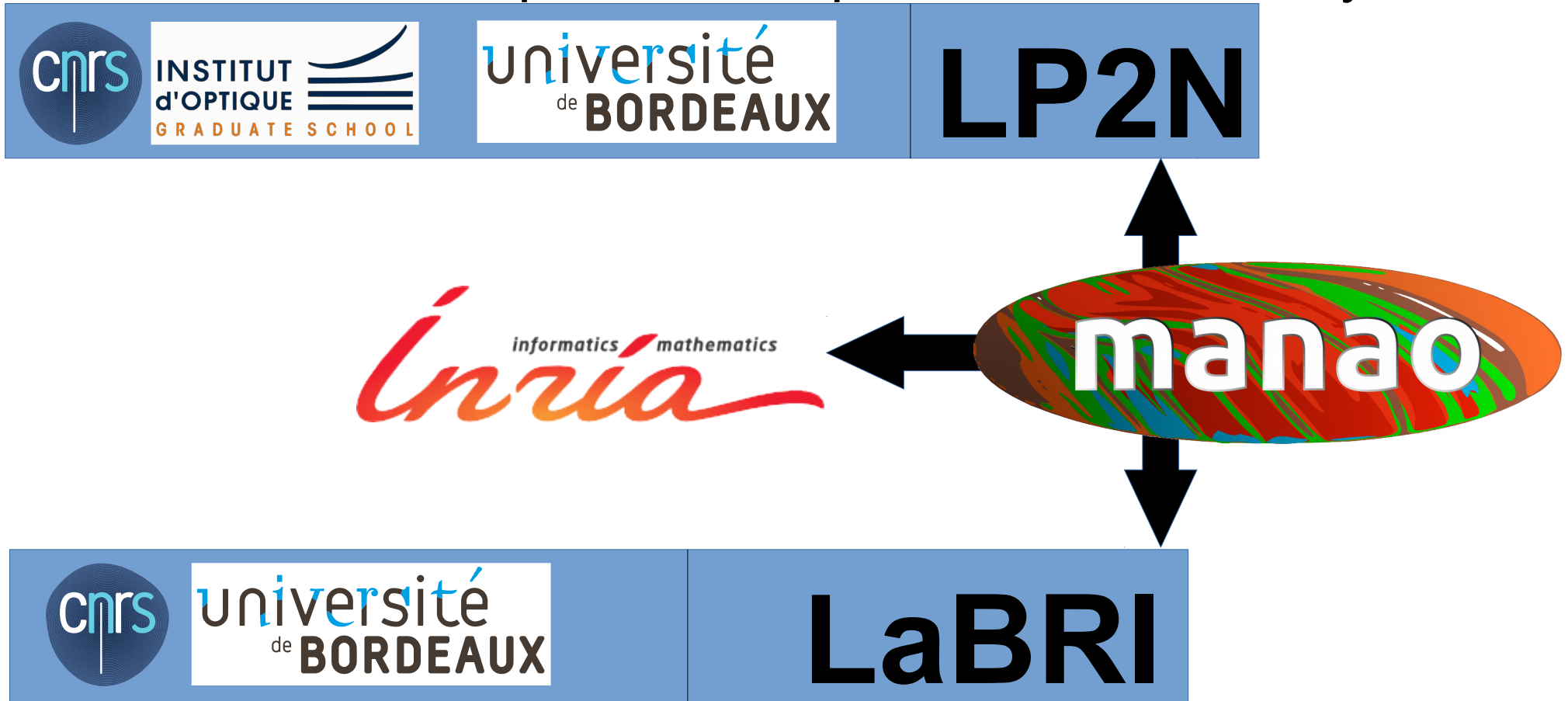
A **global but specialized view** of light interactions

- ◉ **Real World:**
 - ◉ Physics and Optics laws
 - ◉ Sensors characteristics (physical & human)
- ◉ **Virtual World:** models & algorithms



MANAO team-project: a bridge

Axe IV: Computational Optics & Mixed Reality



Team: Image & Sound

Group: Acquisition & Visualization

玛瑙科研组在哪里？



Convergence Optics & Computers

4 Challenges

1. Simulation

2. Tools for design & Co-design

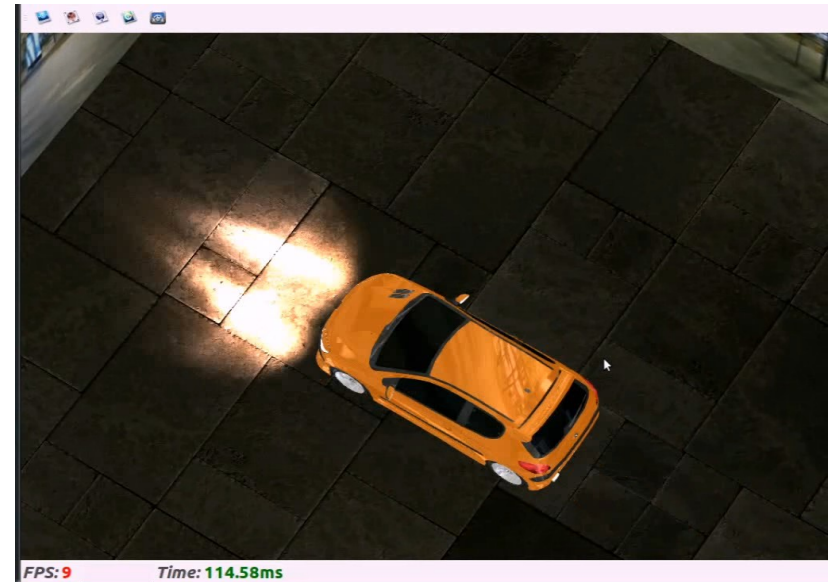
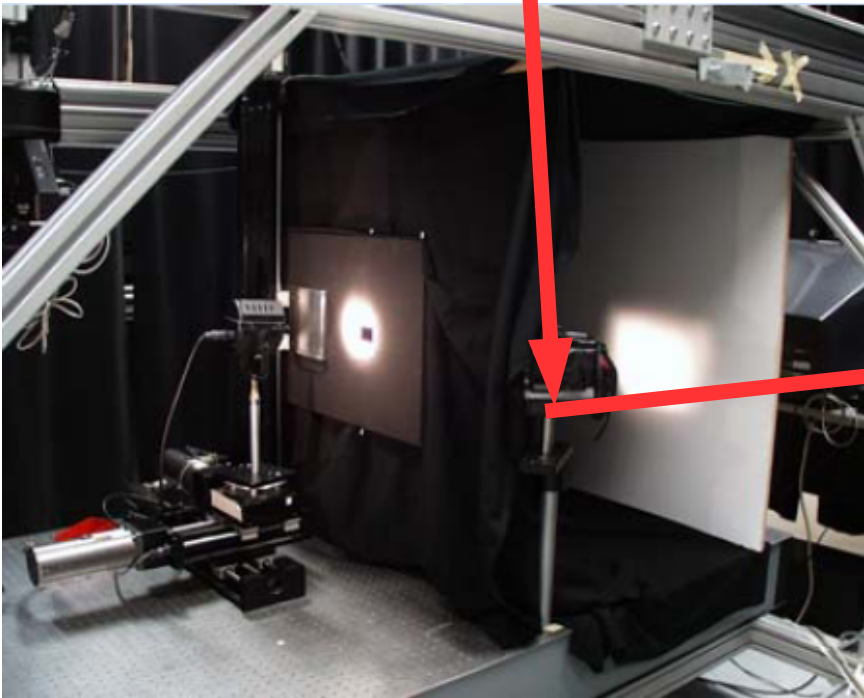
3. Hybrid systems

4. Certifications

- *Systems, tools*
- *Simulations*

Interactive simulation of transfers

$$L(p \rightarrow \vec{o}) = L_e(p \rightarrow \vec{o}) + \int_{\Omega} \rho(\vec{\omega} \rightarrow p \rightarrow \vec{o}) \langle \vec{n} \cdot \vec{\omega} \rangle L(\vec{\omega} \rightarrow p) d\vec{\omega}$$



$$L(u, v, s, t) = \sum_{ij} I_{ij}(s, t) \frac{d^2}{\cos^2 \varphi} \phi_{ij}(u, v)$$

[Lu – Pacanowski – Granier 2015]

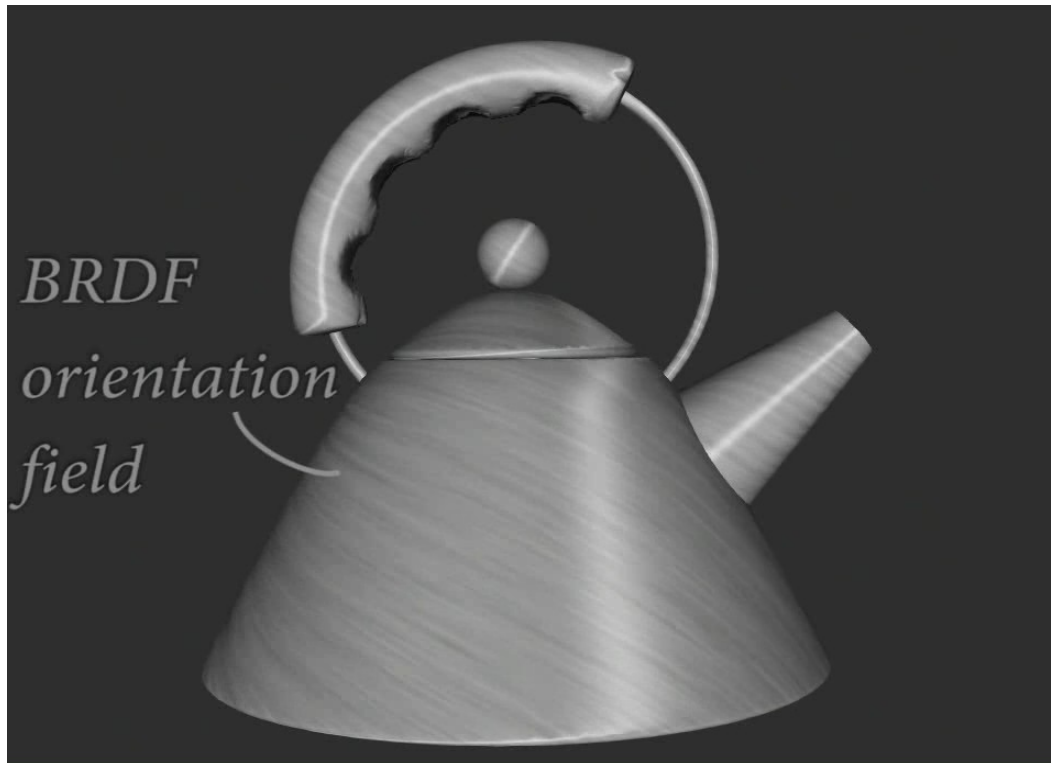
Conception : BRDF orientation field

- **Theoretical analysis**

- *BRDF orientation field*
- *Highlight tangent field*

- **Optimization**

- *Orientation field*
- *To obtain highlights*



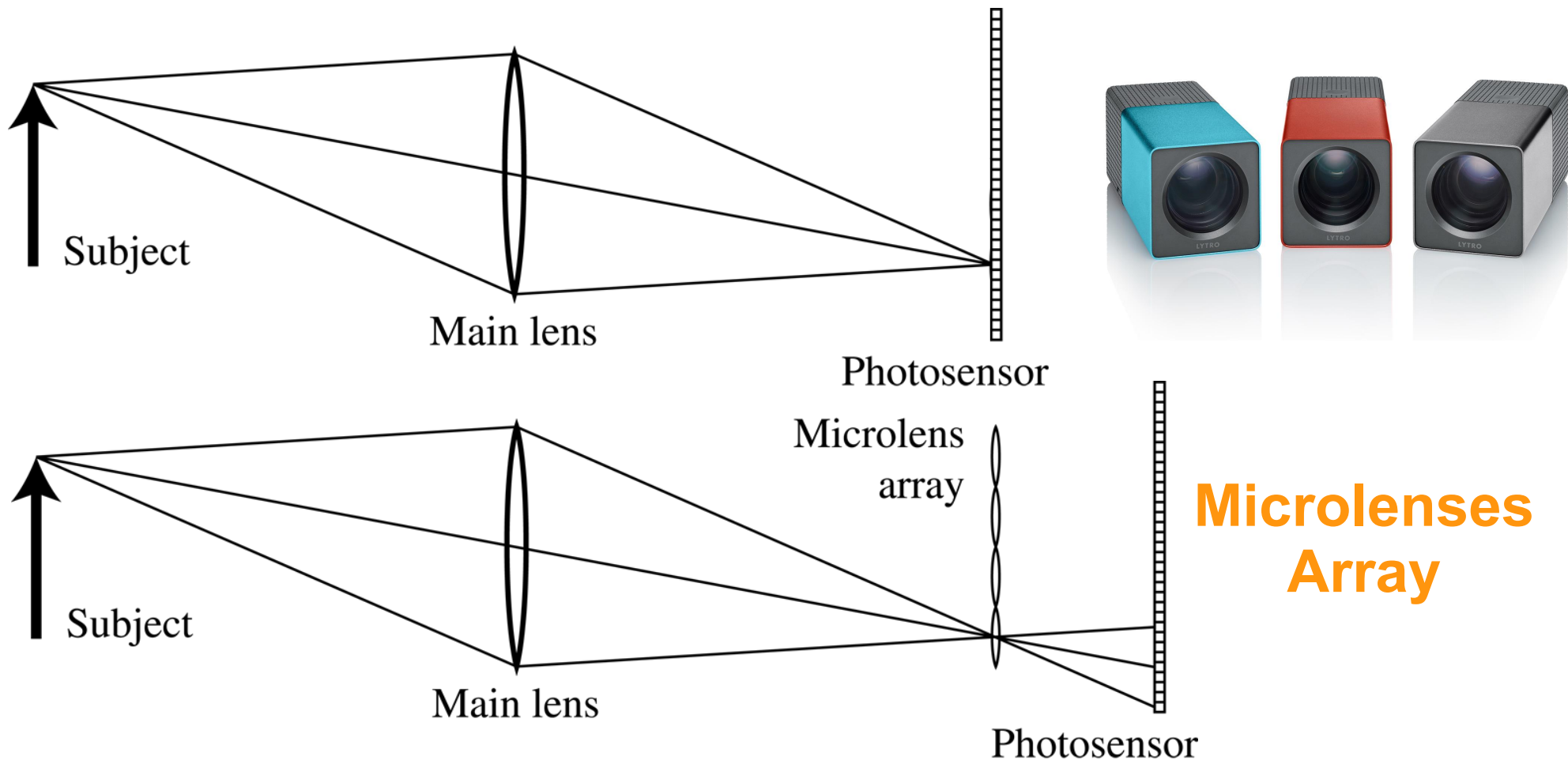
[Raymond – Barla – Guennebaud
– Pacanowski – Granier 2014]

Light-Field Acquisition



Lytro

Light-Field Acquisition



SIGGRAPH 2005 & TR 2005-02: Ng, Levoy, Brédif, Duval, Horowitz & Hanrahan

Co-design: Plenoptique Imaging



[Manakov – Retrepo – Ihrke 2013]

Generalized plenoptic imaging

- **Many copies of the same view**

- *HDR*
- *Spectral Imaging*
-

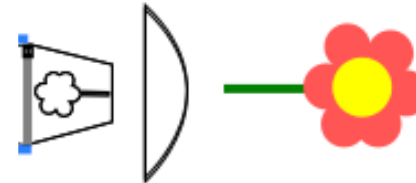
- **Many view-points**

- *Light-Field*

- ... $L(x, y, z, \vec{l}, \lambda, \vec{\psi}, t)$

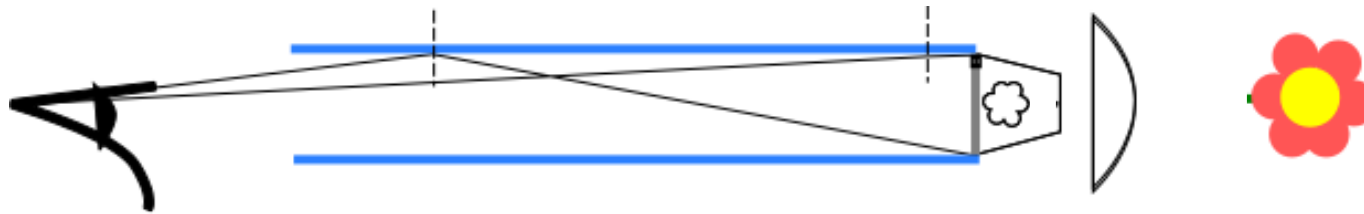
How to make many copies

- **Directly a diffuser**



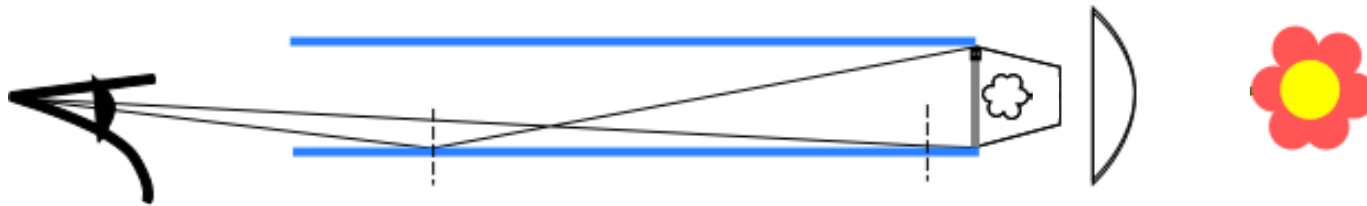
How to make many copies

- ... and after a reflection



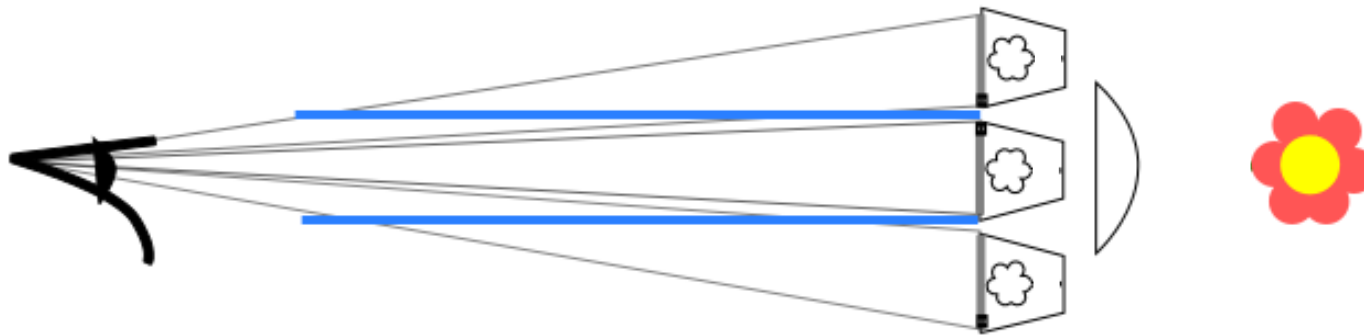
How to make many copies

- ... and another one

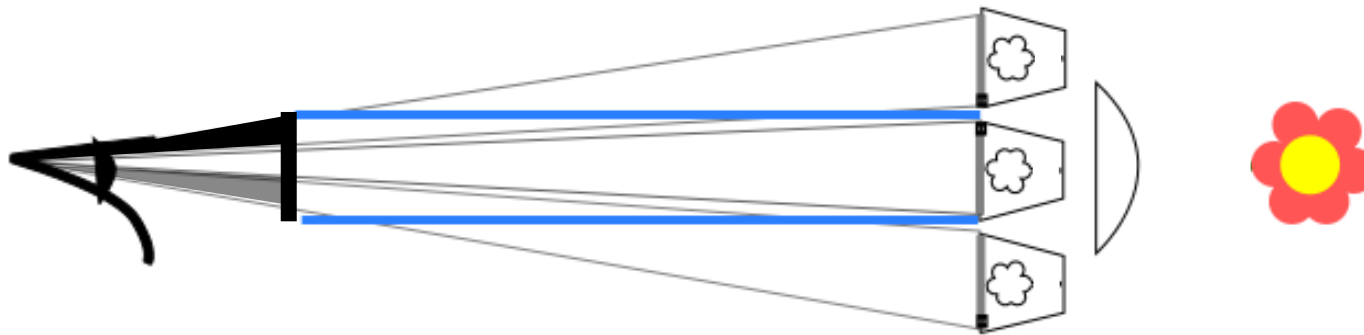


How to make many copies

- **Many virtual copies of the diffuser**



Application 1: HDR Imaging

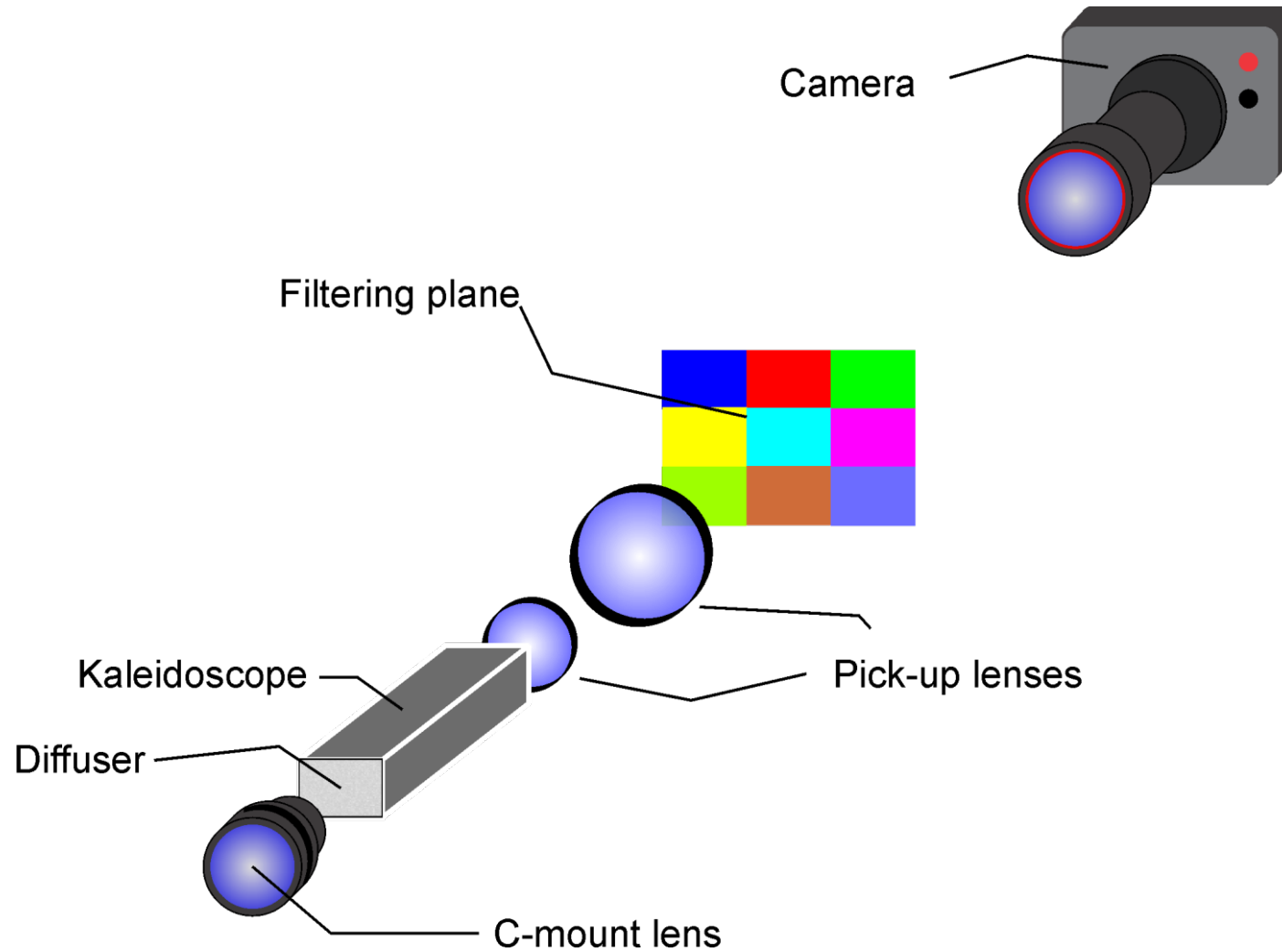


Neutral
Density
Filters

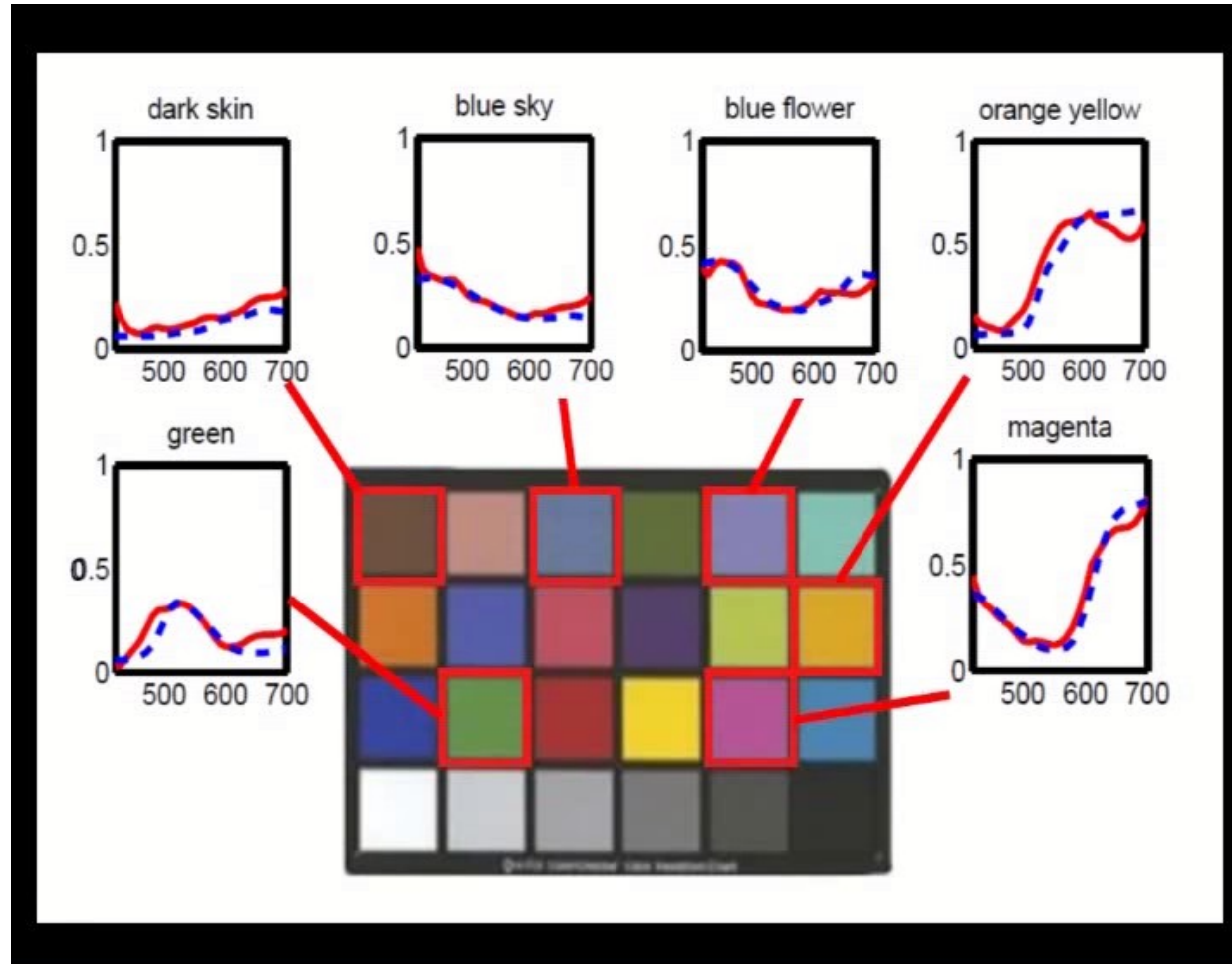
Application 1: HDR Imaging



Application 2: Spectral Imaging



Application 2: Spectral Imaging



Imagerie plénoptique généralisée

- **Many copies of the same view**

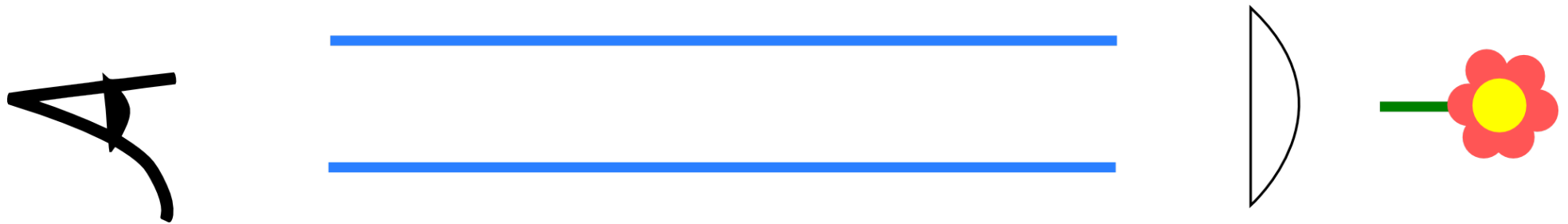
- *HDR*
- *Spectral Imaging*
-

- **Many view-points**

- *Light-Field*
 - ...
- $$L(x, y, z, \vec{l}, \lambda, \vec{\psi}, t)$$

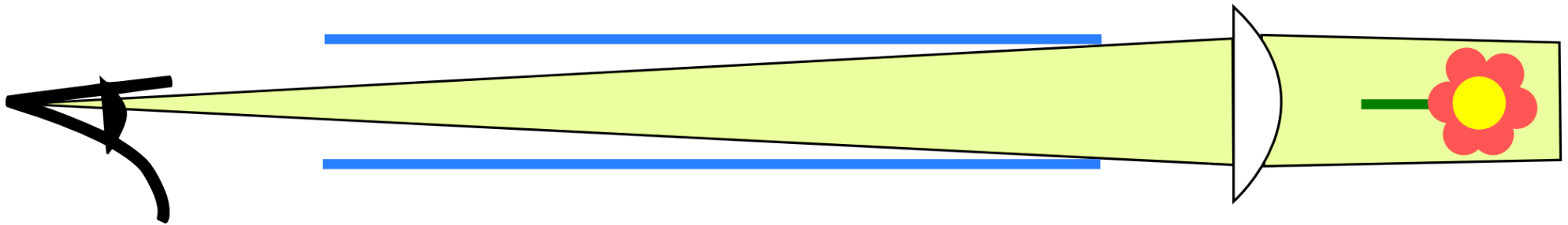
How to make many viewpoints

- Remove the diffuser



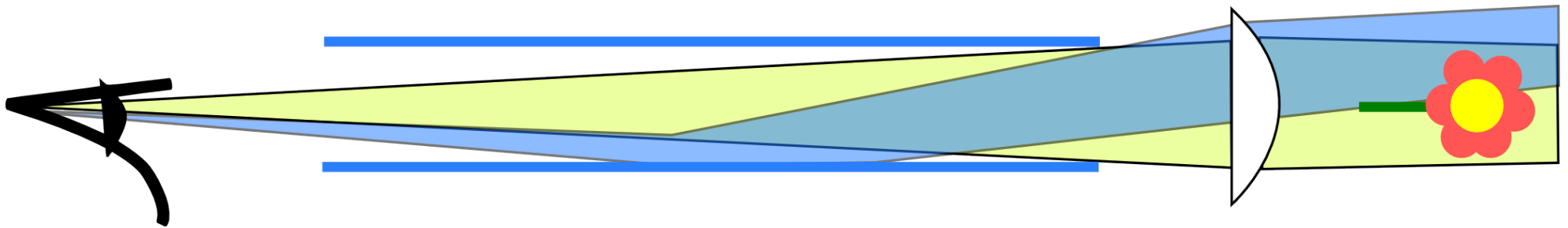
How to make many viewpoints

- **Direct view point**



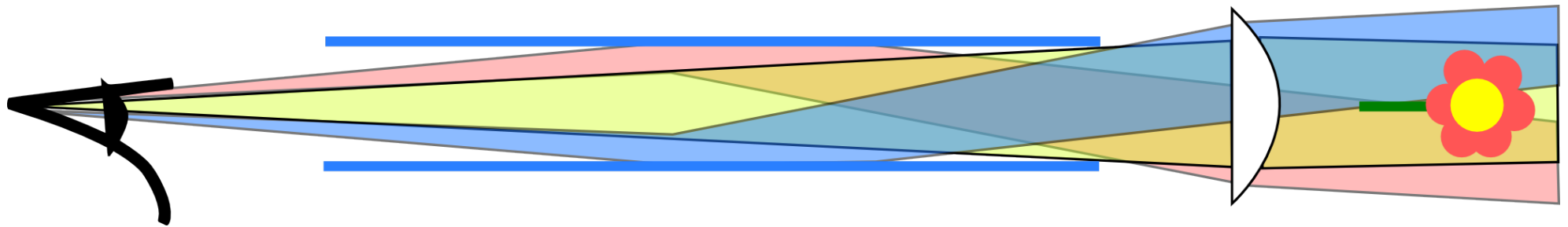
How to make many viewpoints

- ... and after a reflection



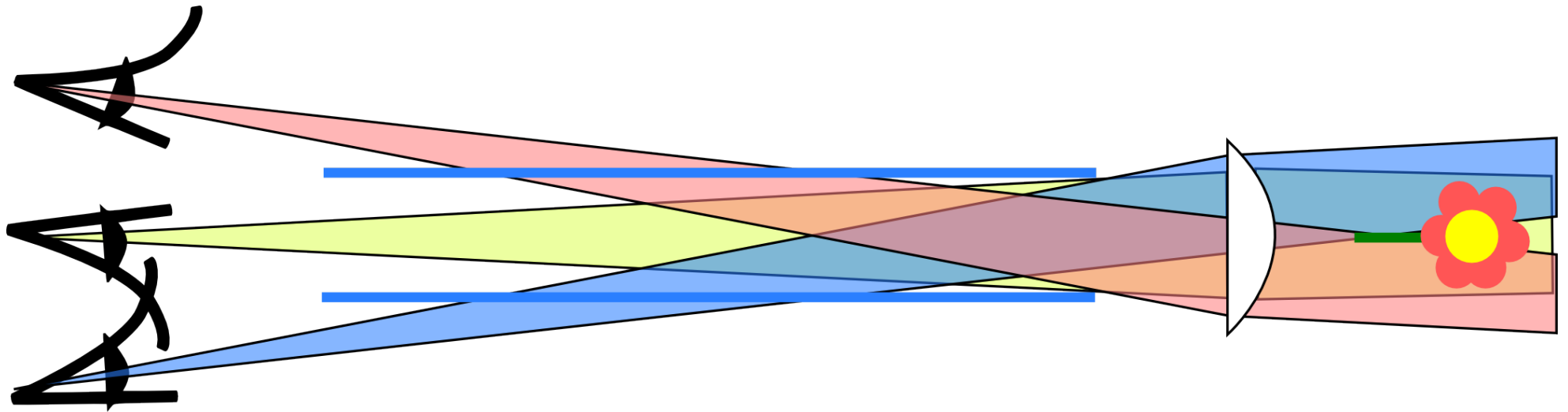
How to make many viewpoints

- ... and another one



How to make many viewpoints

- **Virtual view points**



Resulting Image



Application 3: Light field



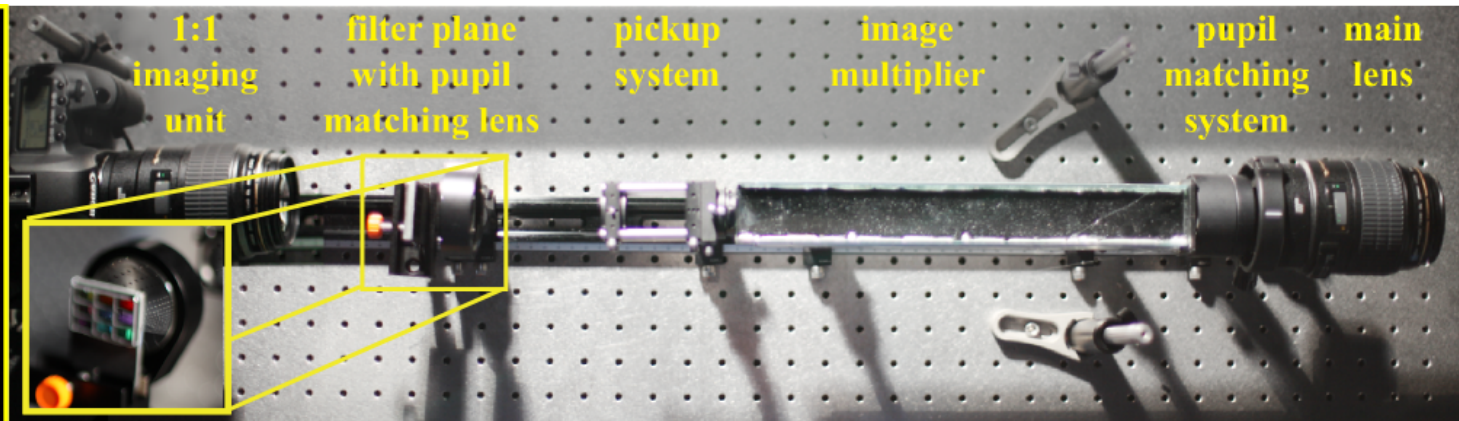
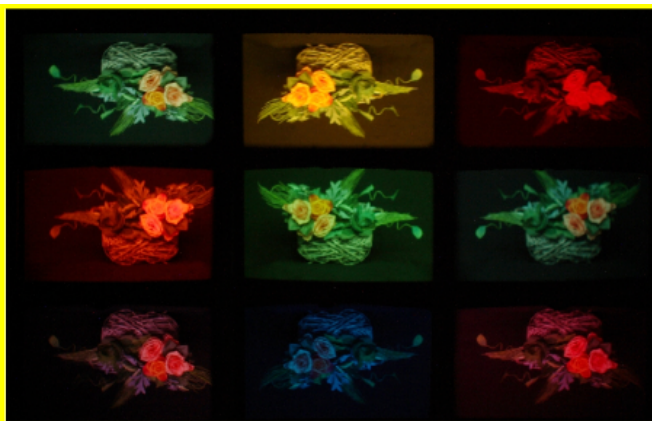
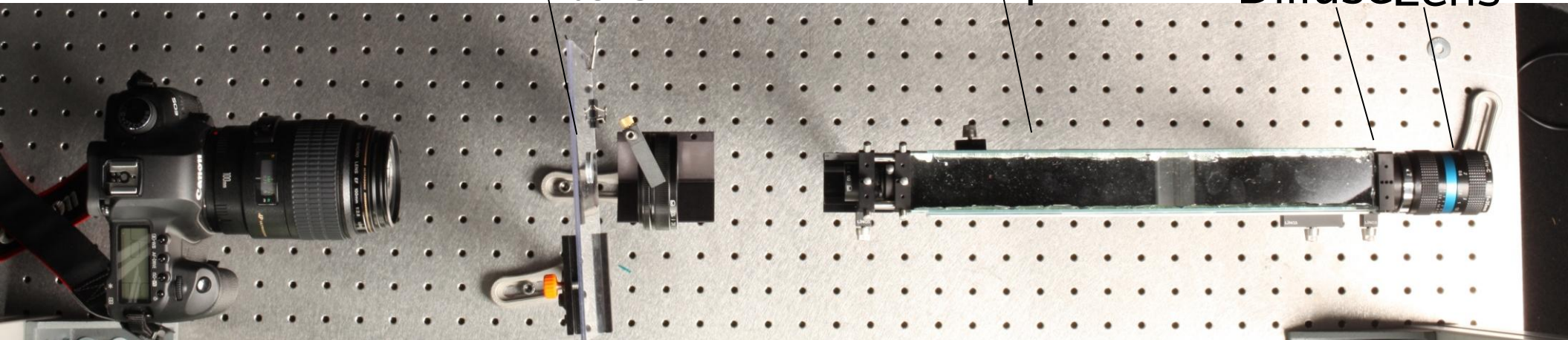
Reconfigurable Plenoptic Camera

Camera

Filters

Kaleidoscope

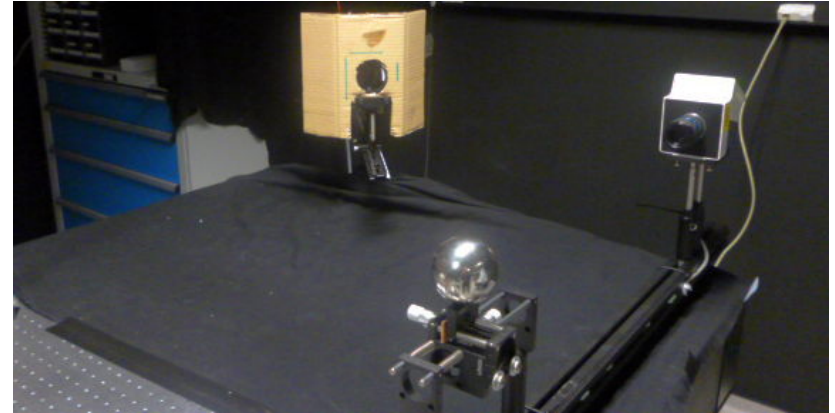
Diffuse Lens



COEL : Computational Optical Experimentation Lab

- **Experimentation platform**

- *Prototyping hybrid systems*
- *Optical and mechanical components*
- *Controlable lighting*
- *Computer resources*

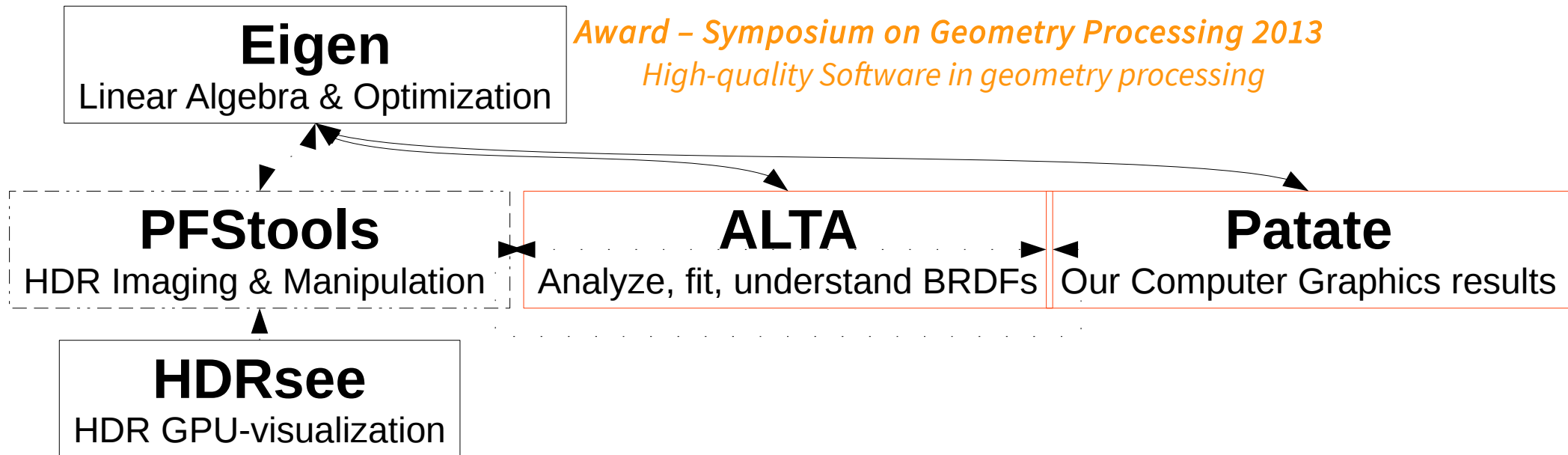


- **Common effort**

- *Optic (LP2N)*
- *Computer Science (Inria)*



Software ecosystem



- **For companies & academies**

- *Historical : Eigen, PFStools, HDRsee*
- *Recents : ALTA, Patate*

Certification - ALTA library

- Open-source C++ Library
 - Models comparisons (fitting)
 - Data analysis
- Plugins
 - Easy to extend
 - Connections (BRDF Explorer)
- Scripting
- Alpha version
 - Open Data format (MERL, ASTM)
 - Non-linear approximation
 - Rational functions
 - Analytic BRDFs
 - Moment analysis



[Pacanowski – Guennebaud – Barla 2014]

Conclusion

- **Convergence of Virtual - Real Worlds**
 - *From Acquisition to Display*
 - *Need of hybrid tools: Optics + Computer sciences*
- **Challenges**
 1. *Simulation*
 2. *Tools for design & Co-design*
 3. *Hybrid systems*
 4. *Certifications*