# Hardware: Pathways to Stability

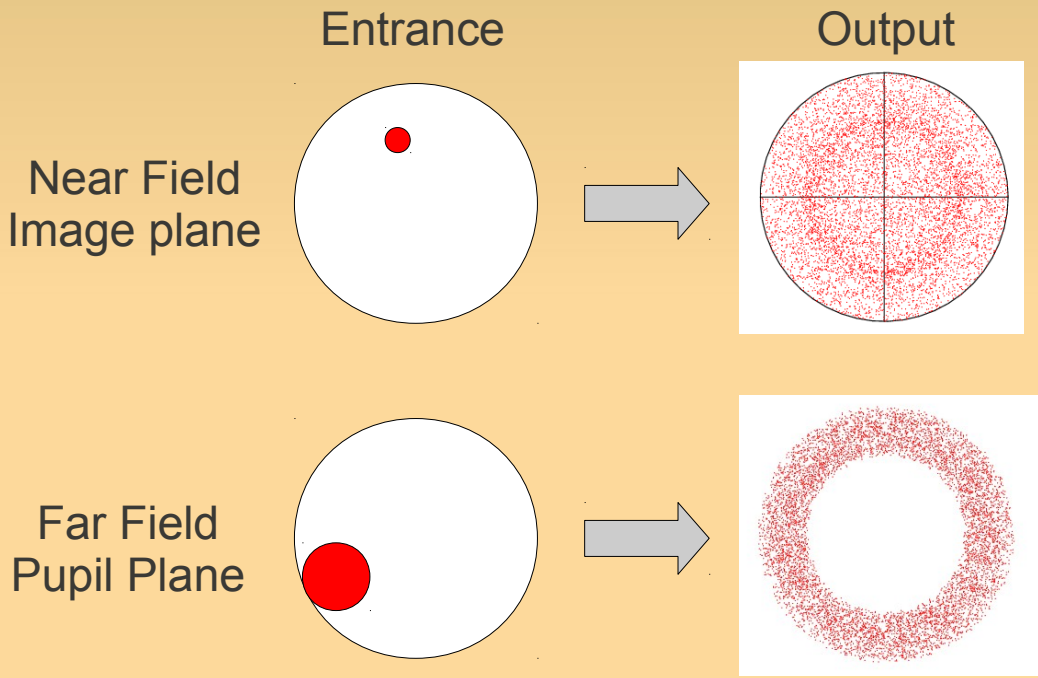
## Optical fibers scrambling to improve PRV measurements : simulations and measurements

Bruno Chazelas, Francesco Pepe, François Wildi, François Bouchy

August 2010

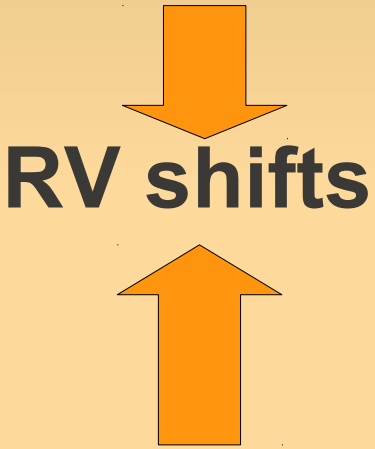
# Circular fibers

- Near Field :
  - Azimuthal scrambling (quasi perfect)
  - Radial dependence of illumination
- Far field :
  - Azimuthal scrambling
  - Radial dependence of illumination



# Consequences

- **Near Field:**
  - Residual movements of photocenter




- **Far field:**
  - Modification of the instrument pupil illumination
  - Instrument profile modification
  - Wavelength dependent effect

# New Geometries ?

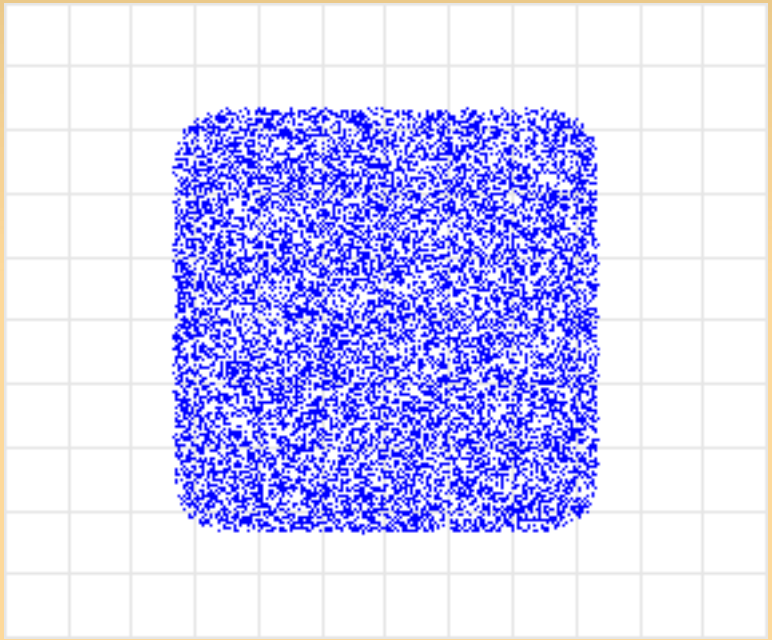
- Classic beam homogenizers :
  - polygonal light-pipes

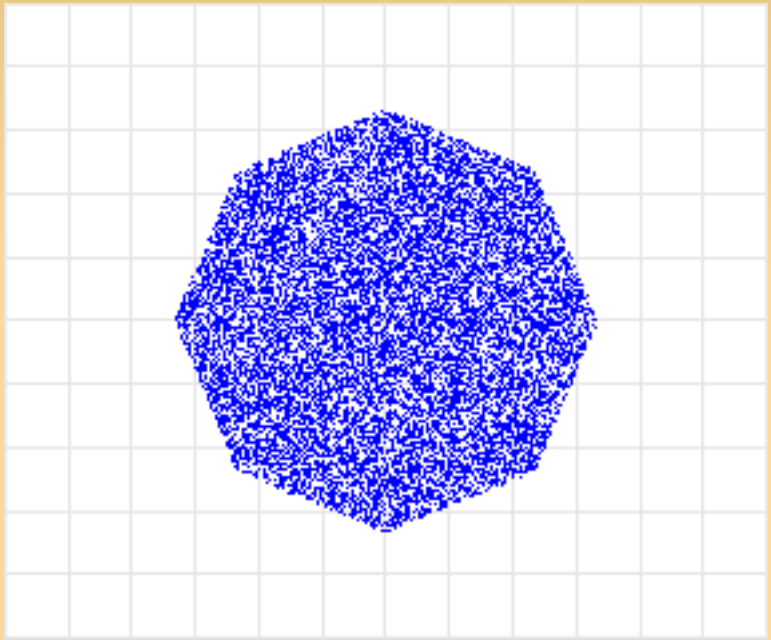
Newport
Experience | Solutions

- Polygonal optical fibers
  - Square fibers (obvious) however geometric loss
  - Octagonal fibers better for circular telescopes

# Geometrical properties (simulations)

- Near Field:

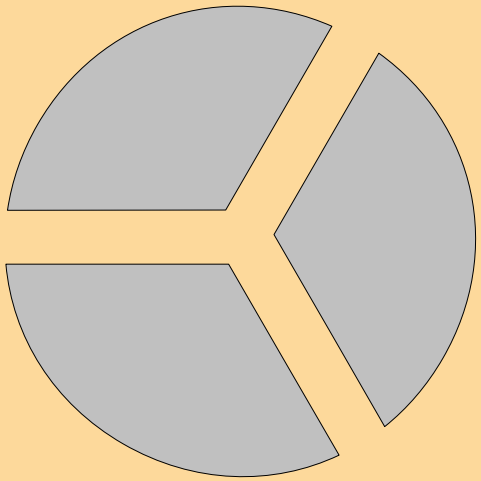




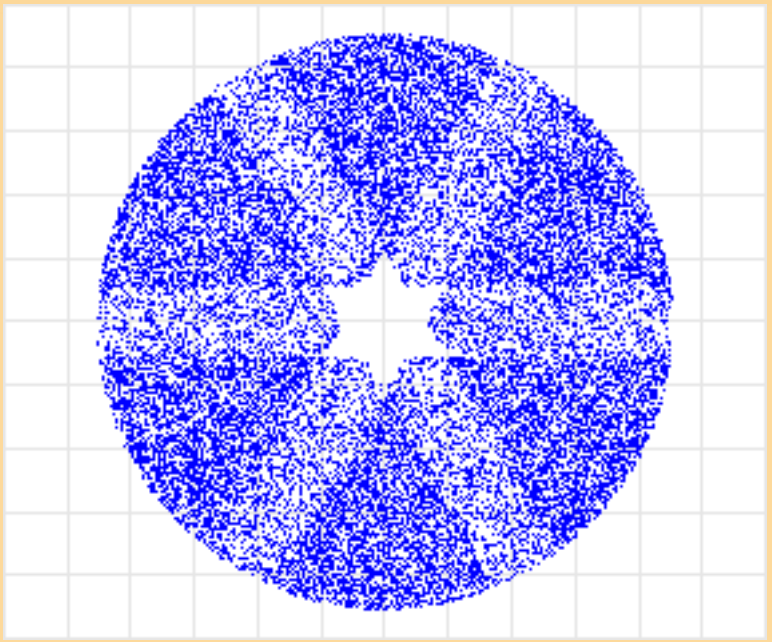
- Perfect scrambling properties

# Far Field

- Far field : (octagonal fiber)
  - No scrambling. A reproduction of the entrance pupil with symetries



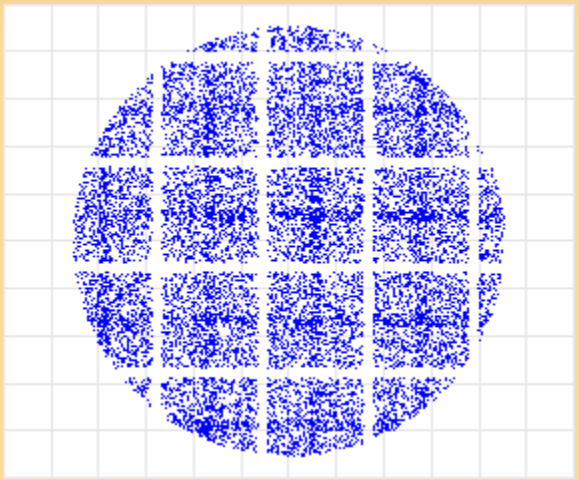
Entrance pupil

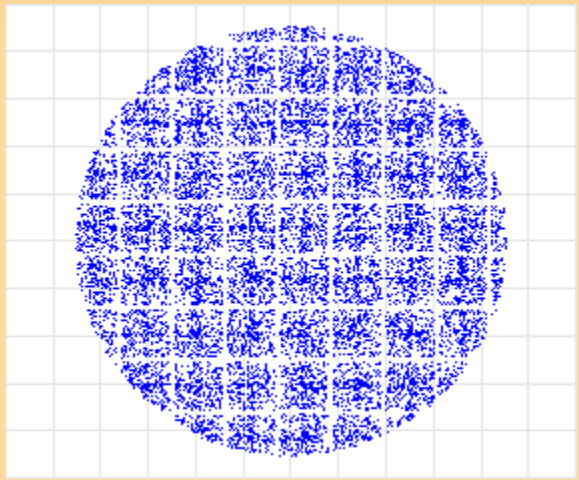


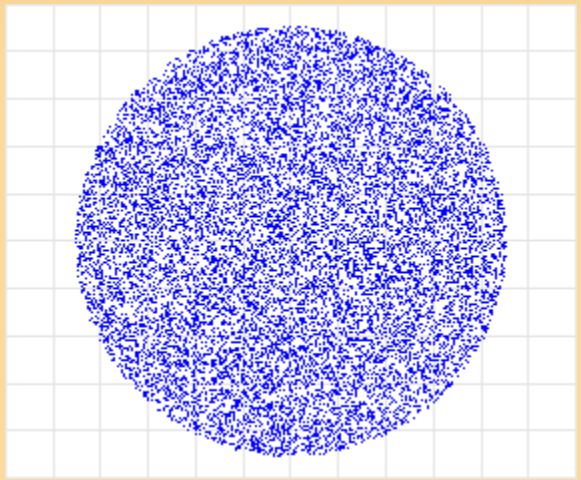
Output pupil

# Geometrical properties (simulations)

- Far field (square fiber) :
  - Patterns if too short

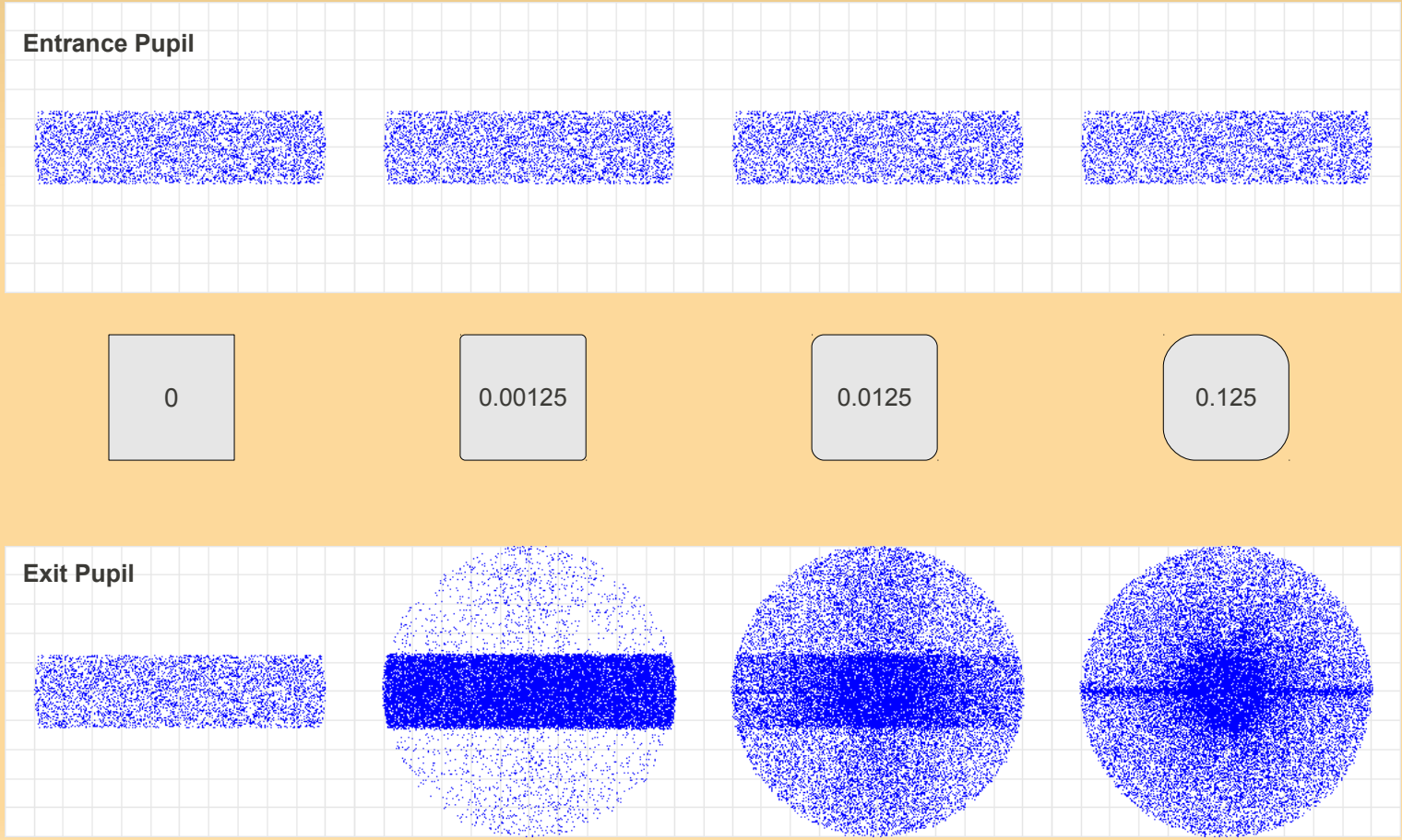






# Geometrical properties (simulations)

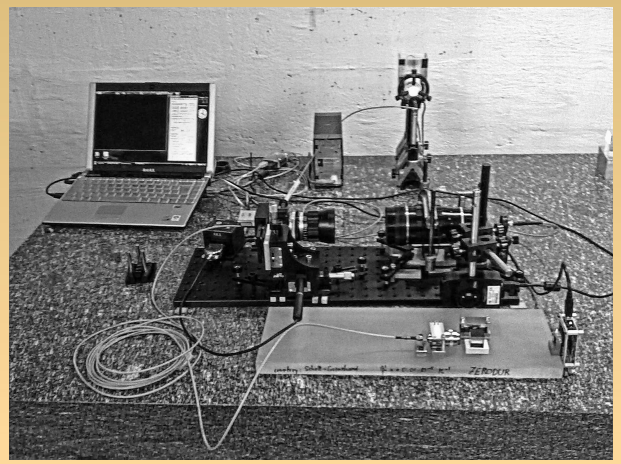
- Far Field:
  - Effect of rounded corner

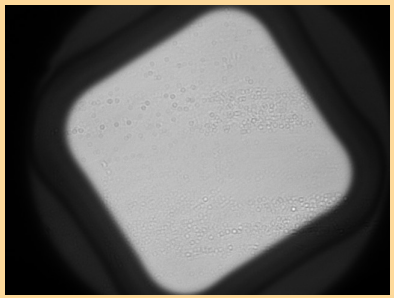


# Does it work in the lab ?

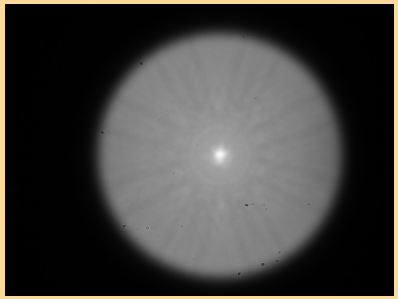
- Polygonal fibers are also used for high power laser transport
- 2 provider were tested :
  - CERAMOPTEC (Nice Fused silica fibers)
    - But outer layer of nylon
  - Le Verre Fluoré (Fluoride glass)
- A test bench was set up to test them

# Practical Tests Methodology





Near Field

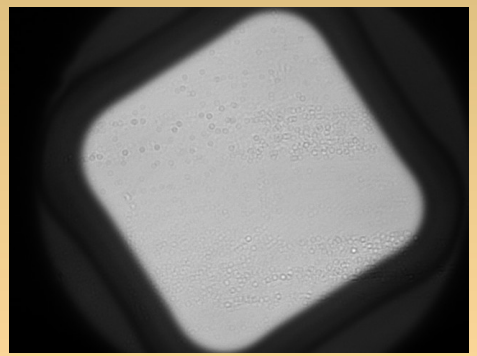


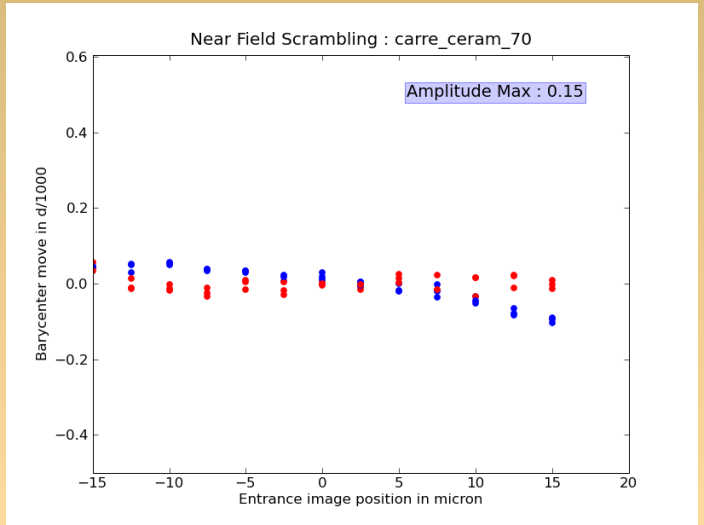
Far Field

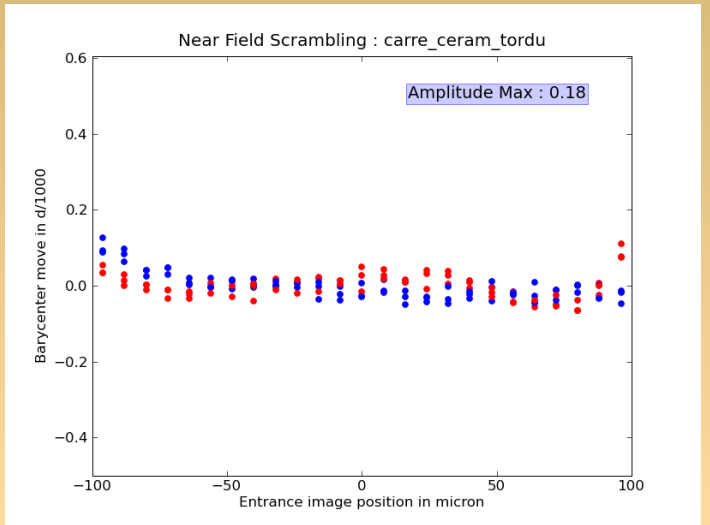
- Light injection
  - tunable aperture
  - tunable image size
- Near field Stability
  - imaging with microscope
- Far field, and FRD
  - direct imaging of far field
  - angular calibration  of images

# Square fibers (Near Field)

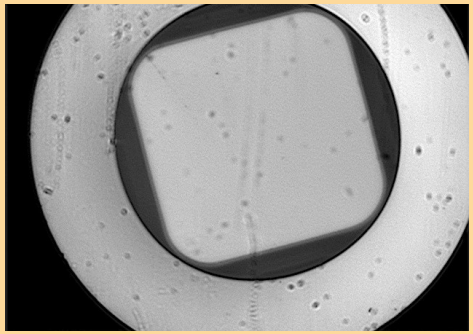
70 micron core





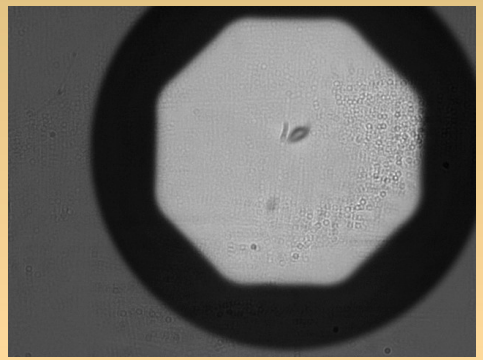

200 micron core

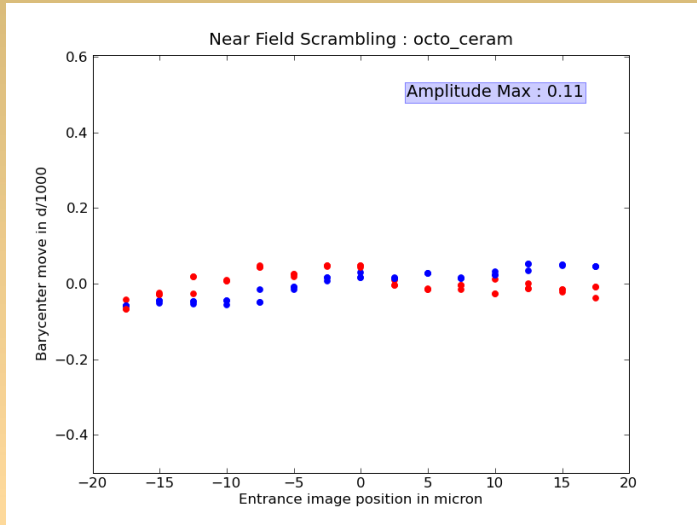


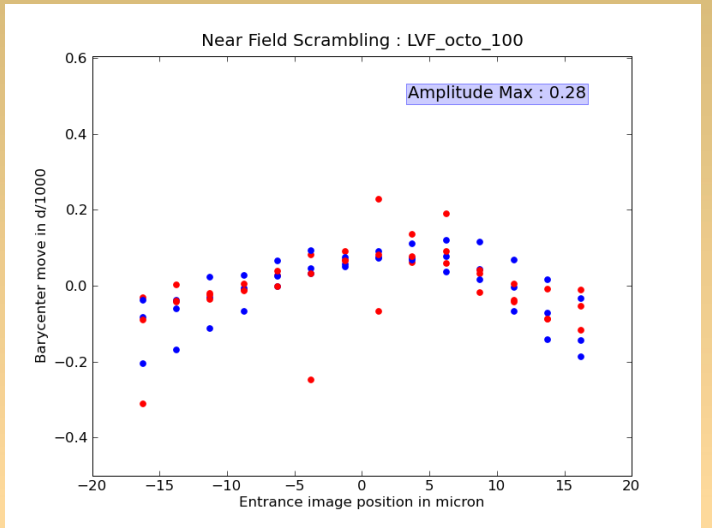
| FIBER | Square 70 microns | Square 200 microns | Circular |
|---|---|---|---|
| **Scrambling Ratio** | **9100±2000** | **5500±1100** | 930±30 |

# Octagonal fibers (Near Field)

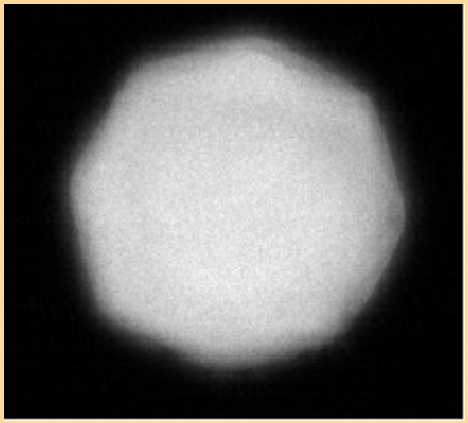
70 micron core





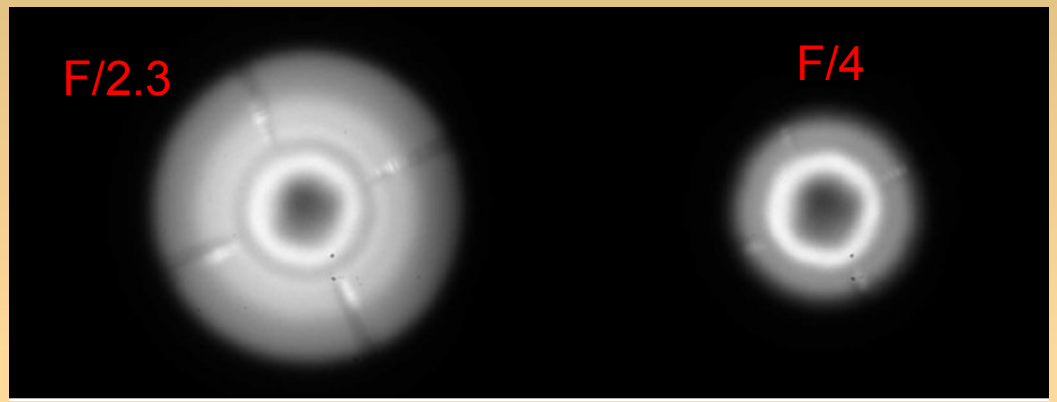

100 micron core



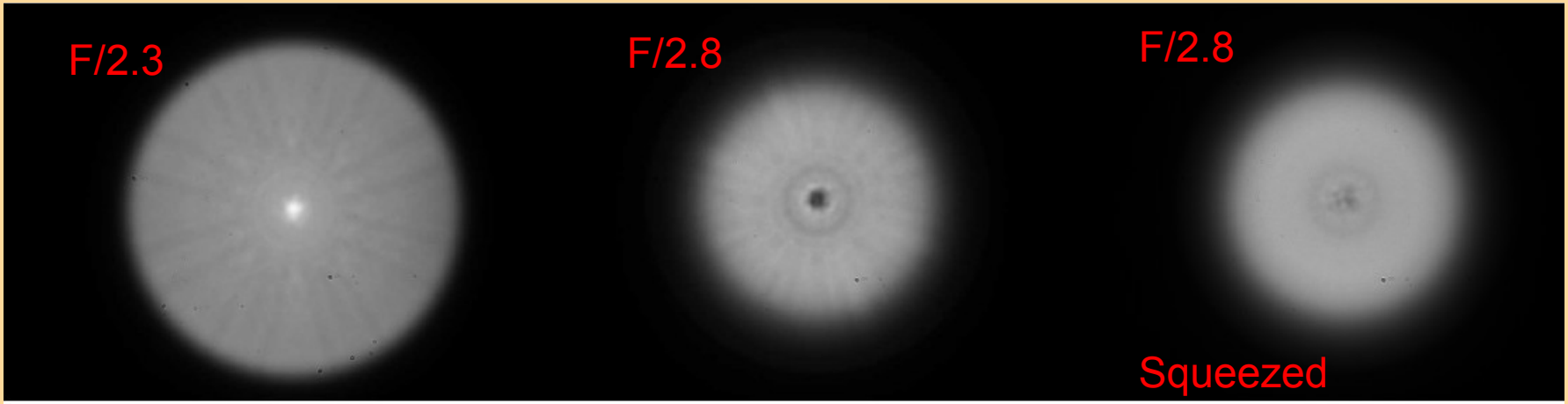
| FIBER | Octagonal 70 microns | Octagonal 100 microns | Circular |
|---|---|---|---|
| **Scrambling Ratio** | **6600±1100** | **3500±800** | 930±30 |

# Strange Far Fields

Square Fibers 200 microns core

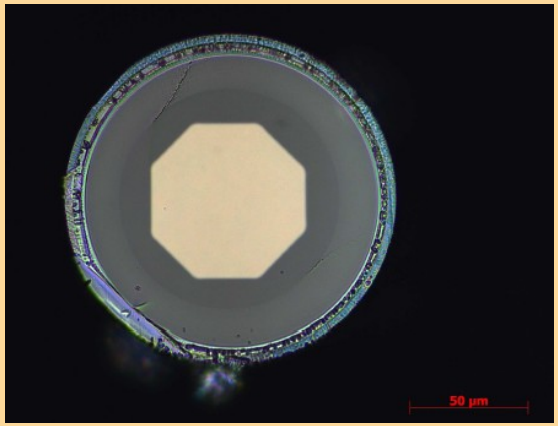


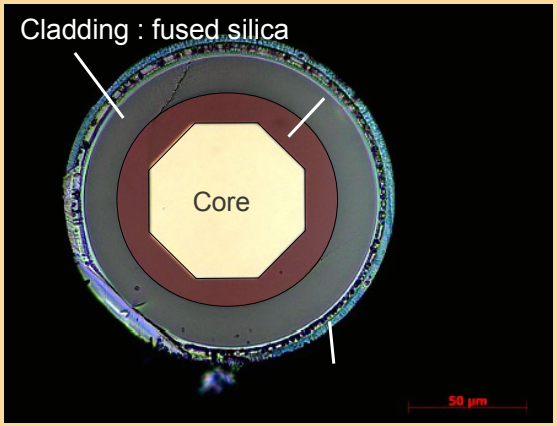

Octagonal fiber 70 microns core



# What is this Far field ?

- Modal phenomenons ?
  - Number of mode in the fiber ~ 15000
  - Illumination is incoherent
  - ???????
- Test fibers without the Nylon layer



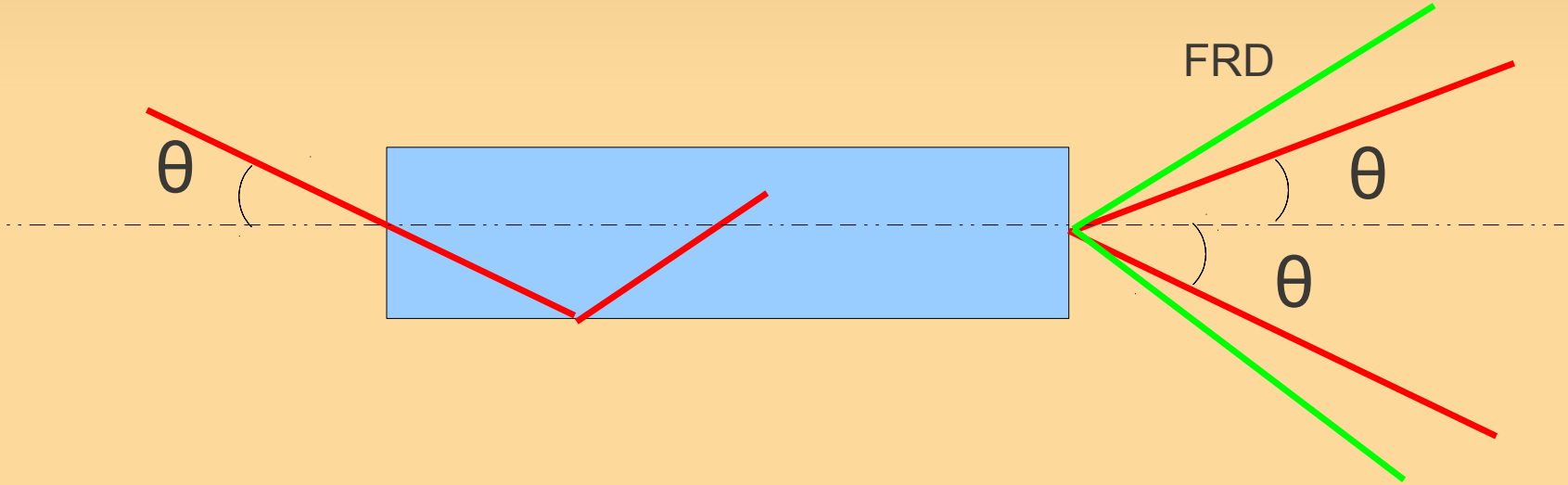



# Conclusion

- To get better PRV measurement there is a need for a better scrambling
- Current optical fibers show their limits
- Non circular fibers seem to be good candidates

# Optical fiber 101

- **Near Field** : illumination of the output face of the fiber
- **Far field** : angular distribution of light at output




- **Focal Ratio Degradation** : increased aperture of output beam

# FRD measurements