

« DISCO »

# Dividing Interferometer for Stars Characterization and Observation

F. Millour, S. Lagarde, P. Berio,  
Y. Bresson, R. Petrov, L. Abe ...

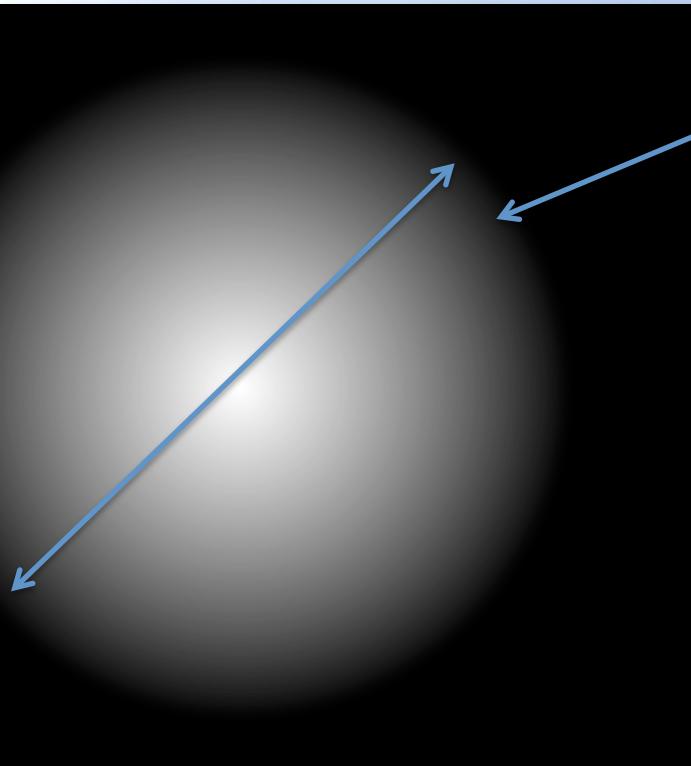


# This talk is about...

- Just an idea...
- Thinking about bringing high-dynamic range imaging to the ELT
- Not yet published, not yet advanced...

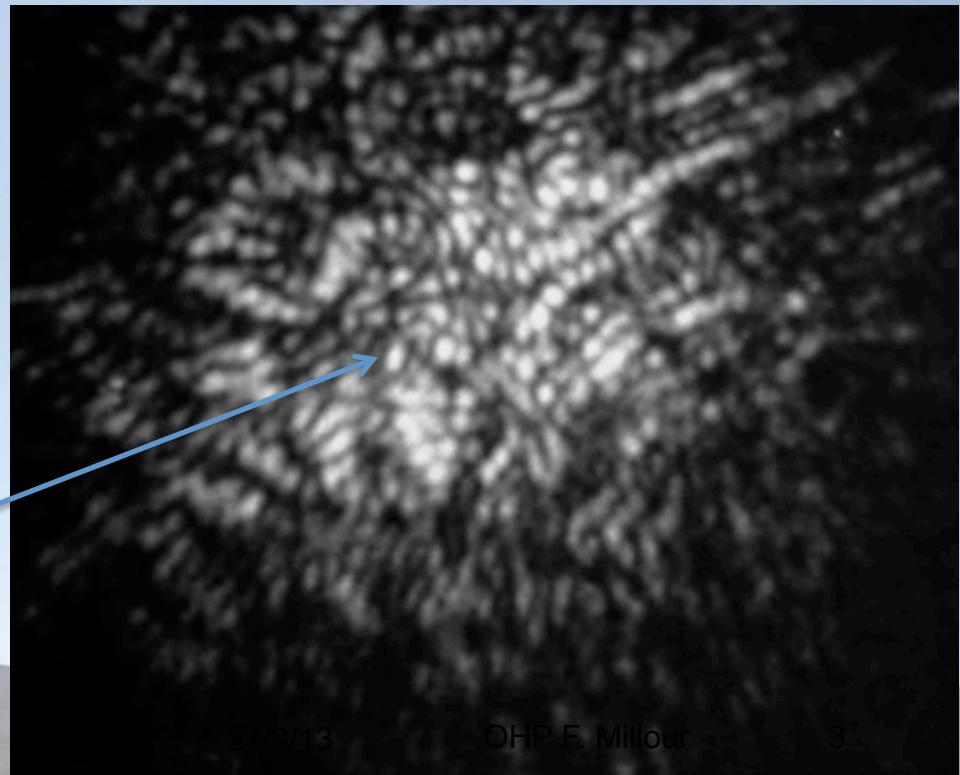
# Speckle / interférométrie

Image longue pose



Tache de seeing  $r_0/D$   
 $r_0$  = diamètre de Fried  
(10cm dans un bon site)

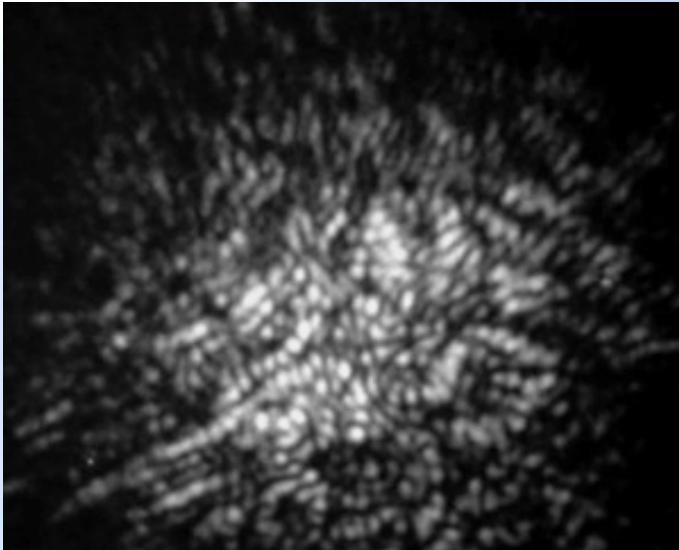
Image courte pose



Tavelure : taille typique  $\lambda/D$

# Speckle / interférométrie

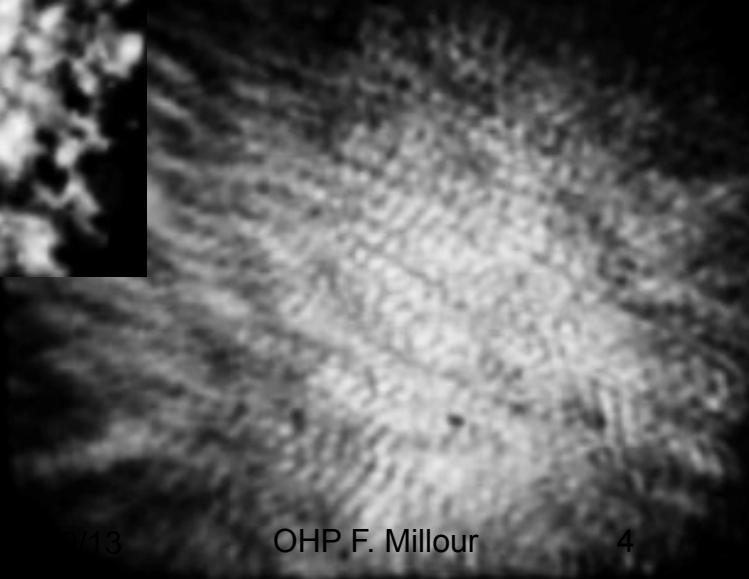
Étoile simple (non résolue)



Étoile résolue

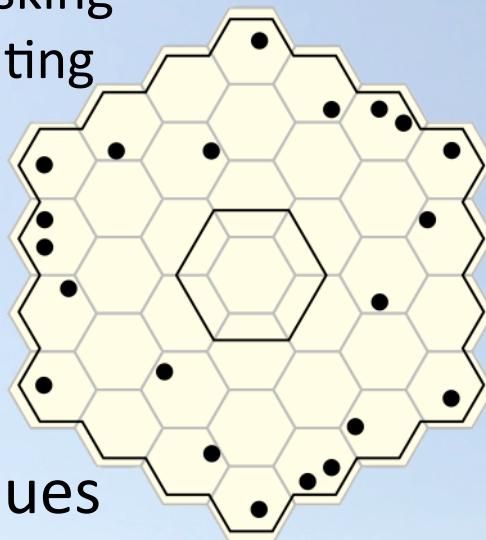


Étoile double



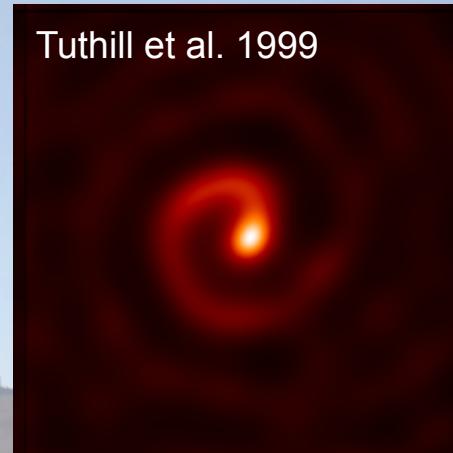
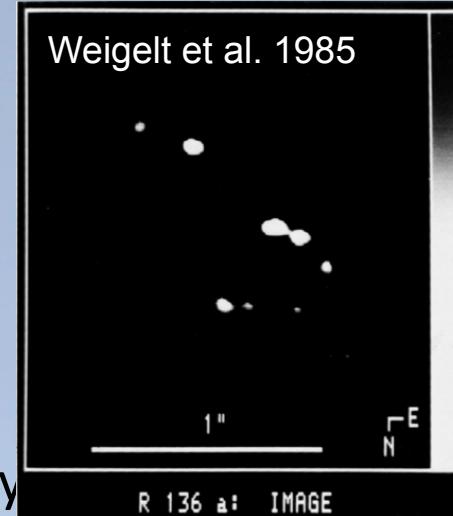
# Speckle interferometry

- Historical techniques
  - « genuine » Speckle
  - Speckle Masking
  - Segment-Tilting

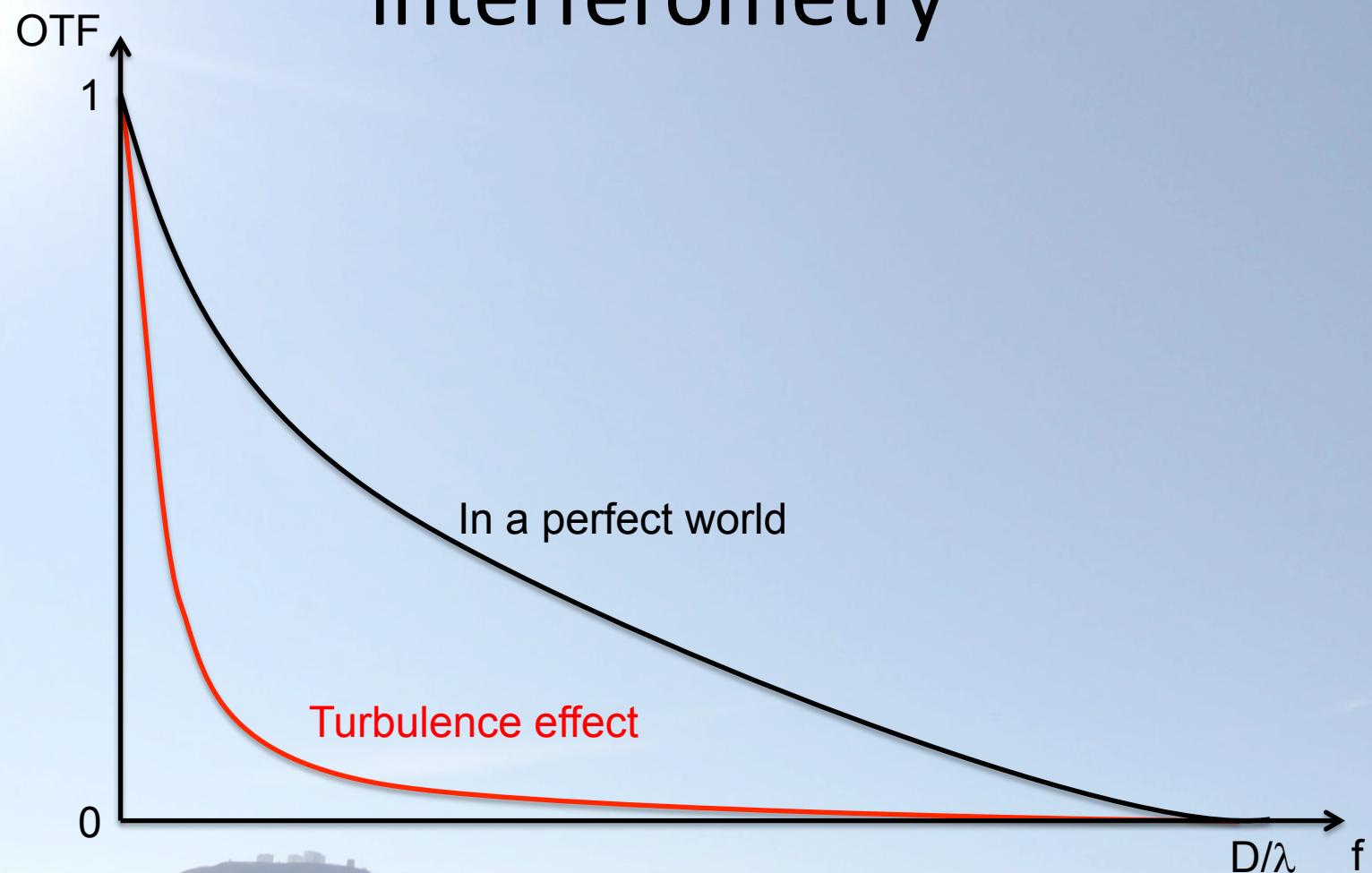


- New Techniques
  - Pupil remapping (Perrin / Lacour)
  - Spatio-spectral remapping (This talk)
  - Densification (Labeyrie)
  - Pupil (re-)sampling (Patru)

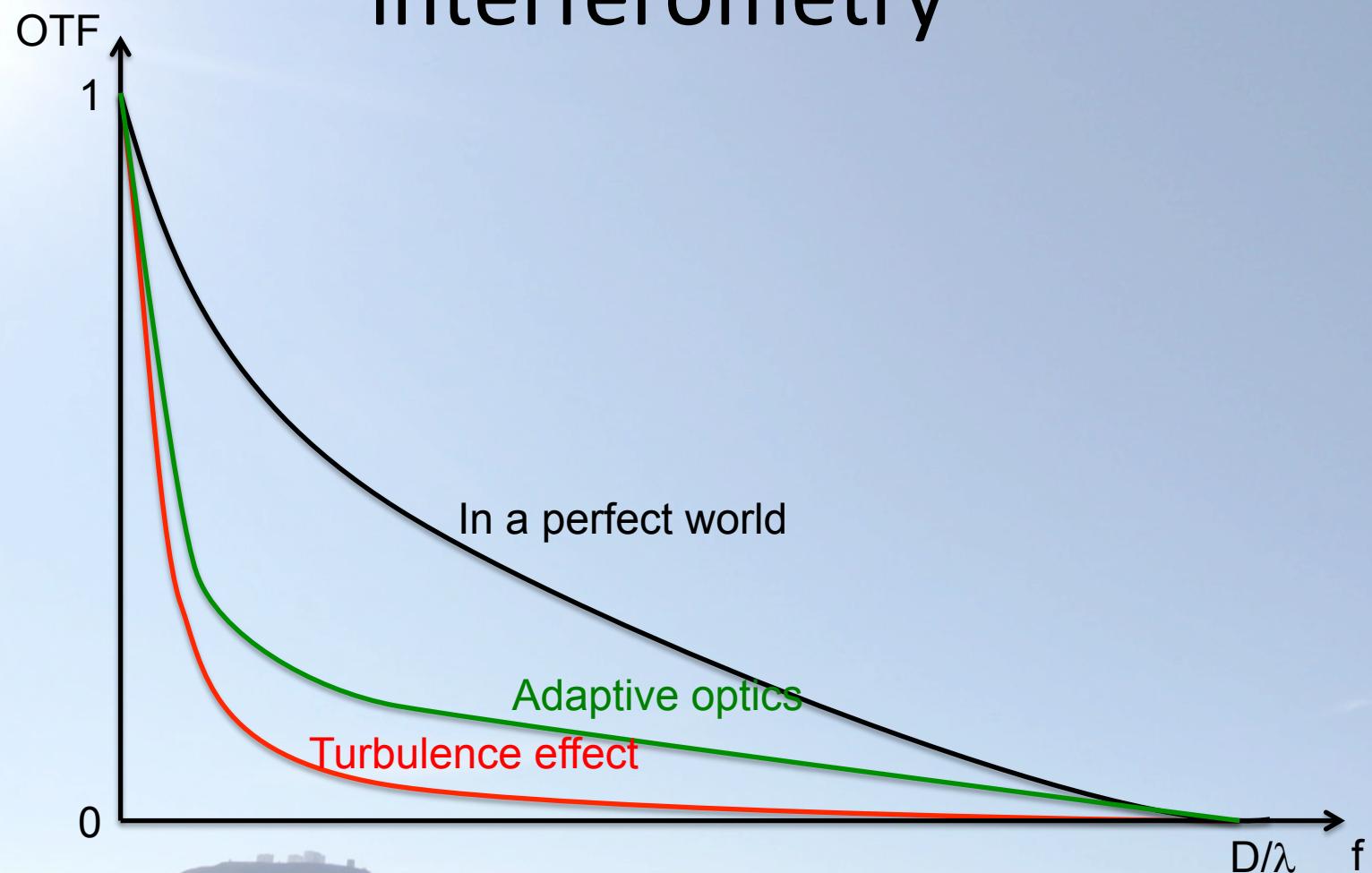
- Top results
  - R136a is not a  $M > 1000 M_{\odot}$  star
  - Wolf-Rayet star's « pinwheels »
  - Protoplanetary disk gap detection



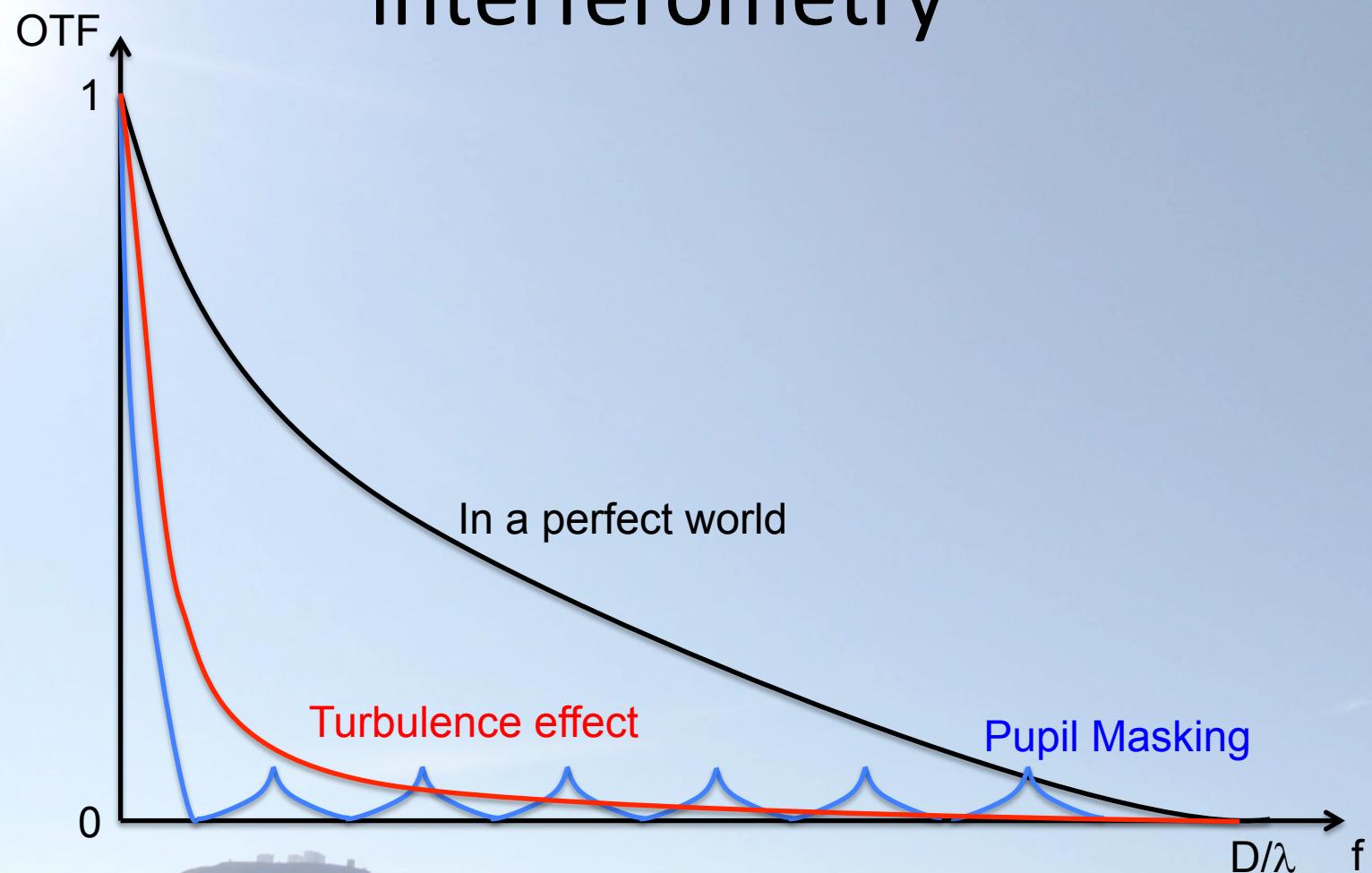
# The idea behind speckle interferometry



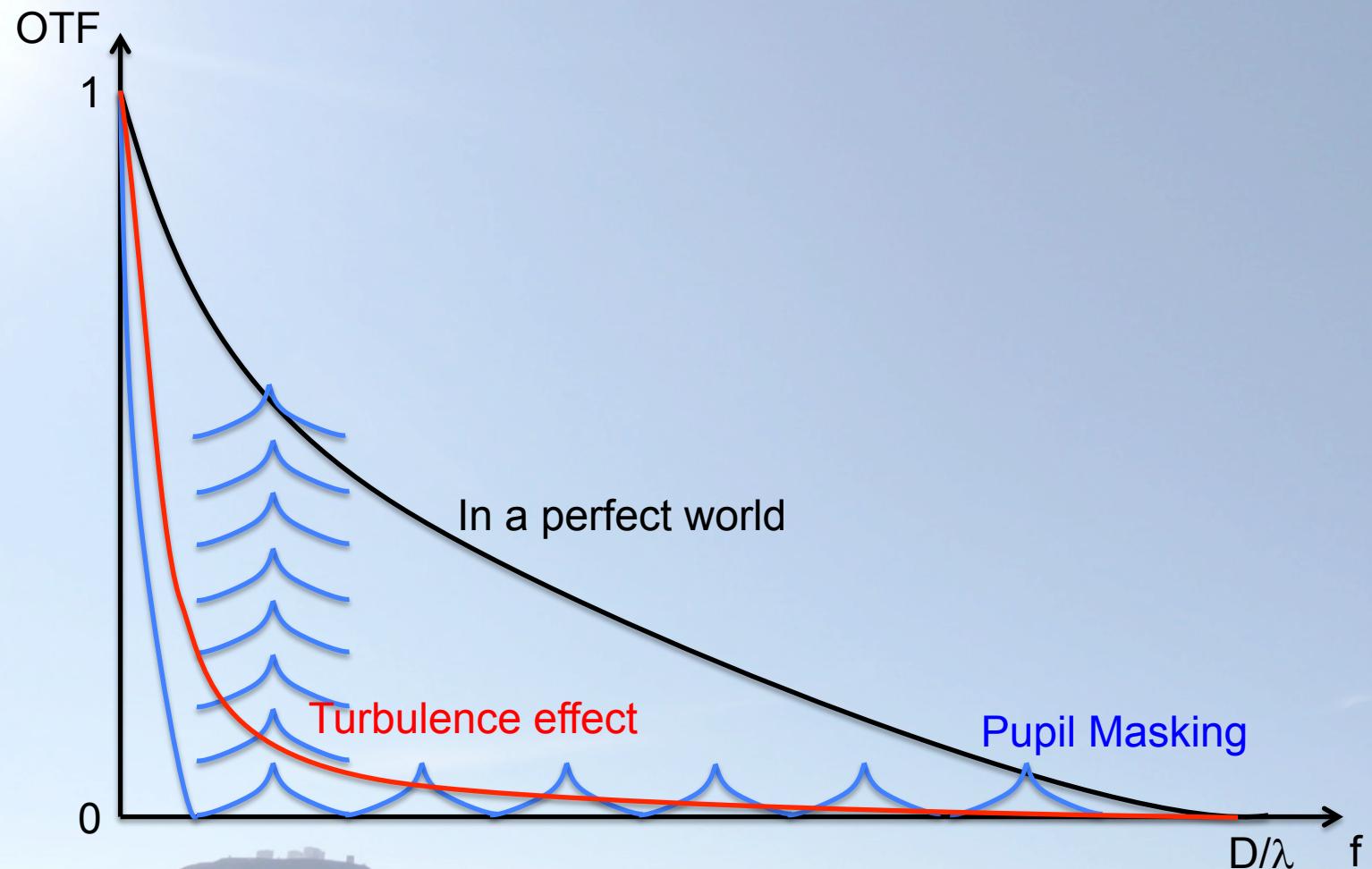
# The idea behind speckle interferometry



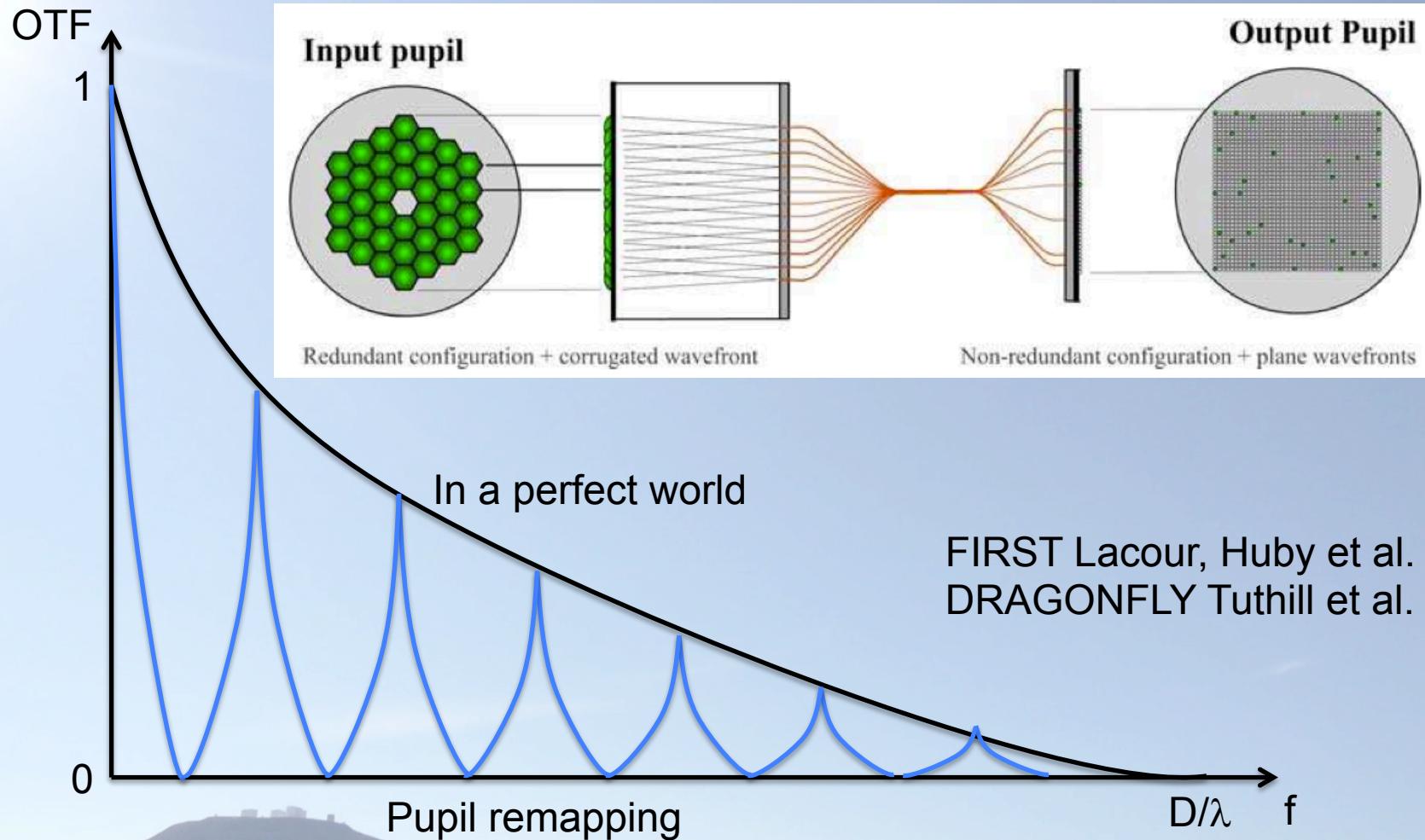
# The idea behind speckle interferometry



# Perrin et al. 2006 (MNRAS)



# Perrin et al. 2006 (MNRAS)



# Open questions

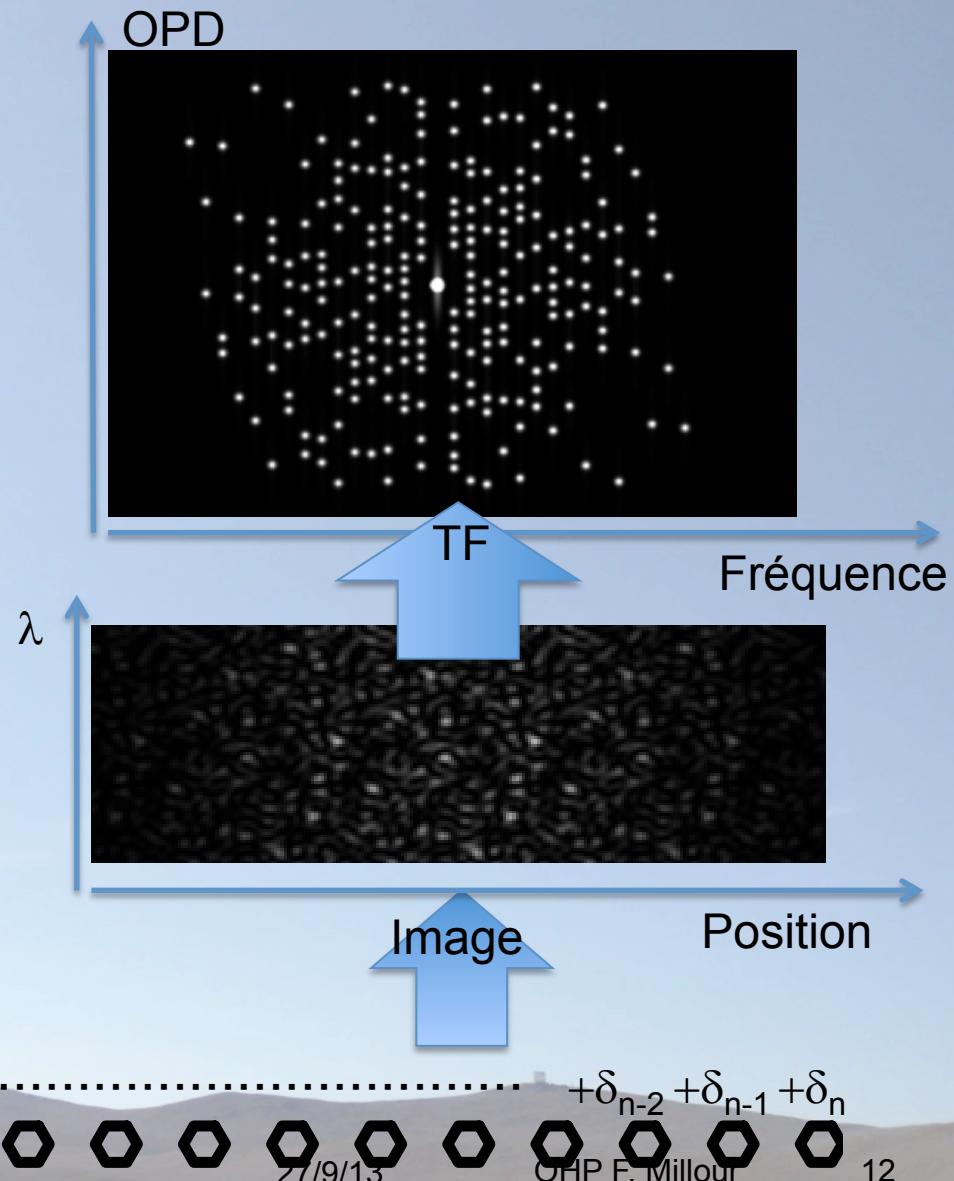
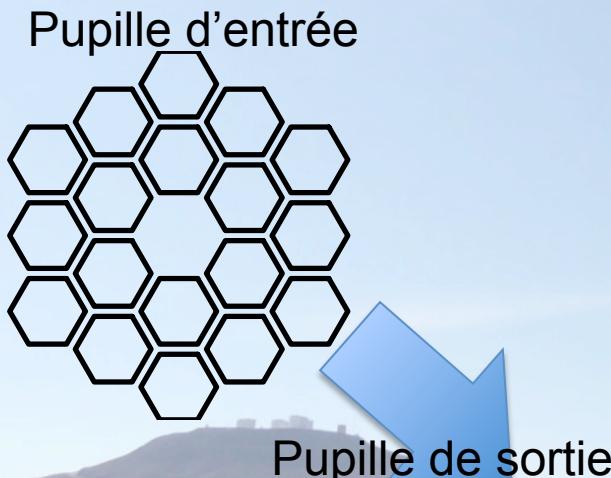
- How to re-arrange ~1000 pupil (ELTs)?
- How to optimize SNR with many sub-pupils (i.e. many pixels)?
  - Recombine sub-groups of pupils (Dragonfly, FIRST)
  - Play with spectral dimension:
    - build on VEGA/CHARA experience:
      - » full-redundant 4 telescope recombiner
      - » 3 redundant baselines, coding on OPDs
      - » See Mourard et al. 2010 for an explanation

# Spatio-spectral remapping

Redundant configuration of the pupil  
Non-redundant configuration of OPDs

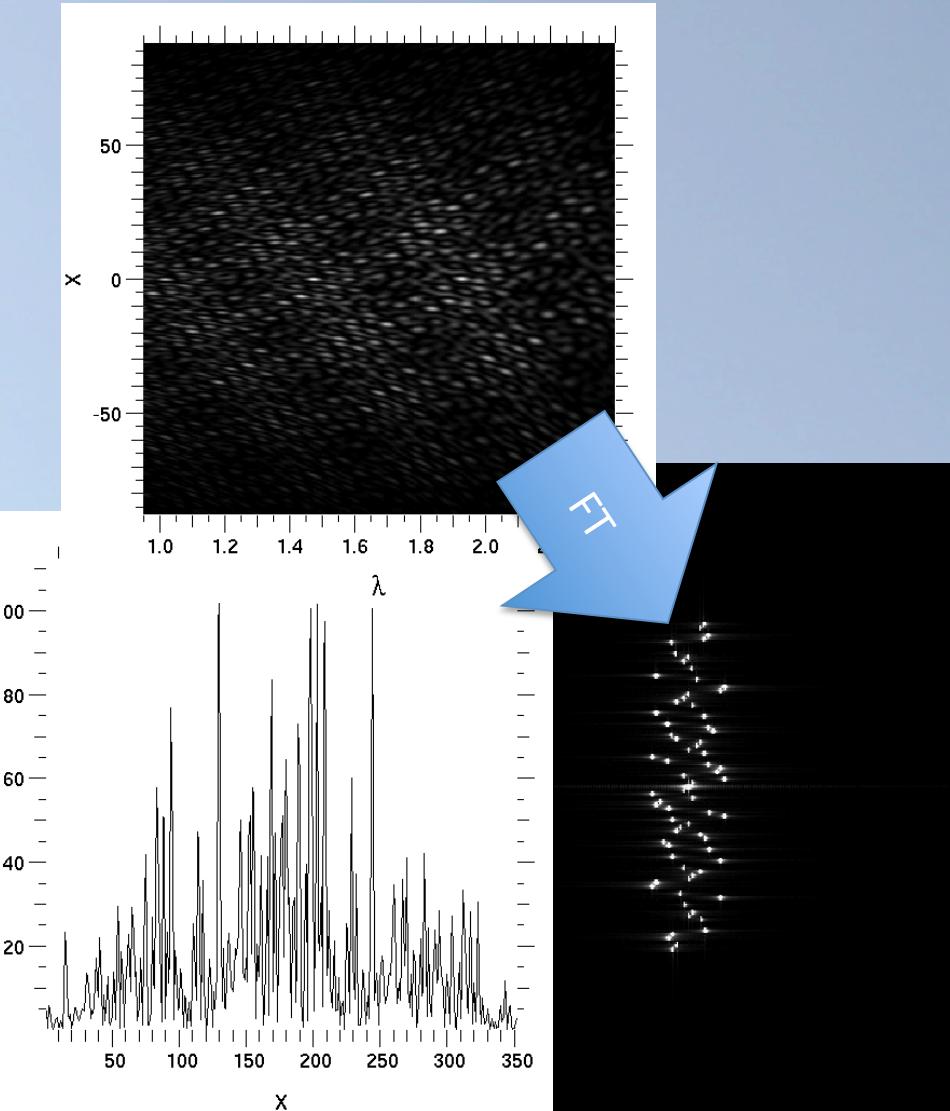
Allow one to save  
 $f \times \text{nbBases} / \text{tbTels}$  pixels  
for 18 pupils,  $f=1$  : save a factor 8

Needs margins on coherence length =  
higher spectral resolution



# Let's look at a practice case

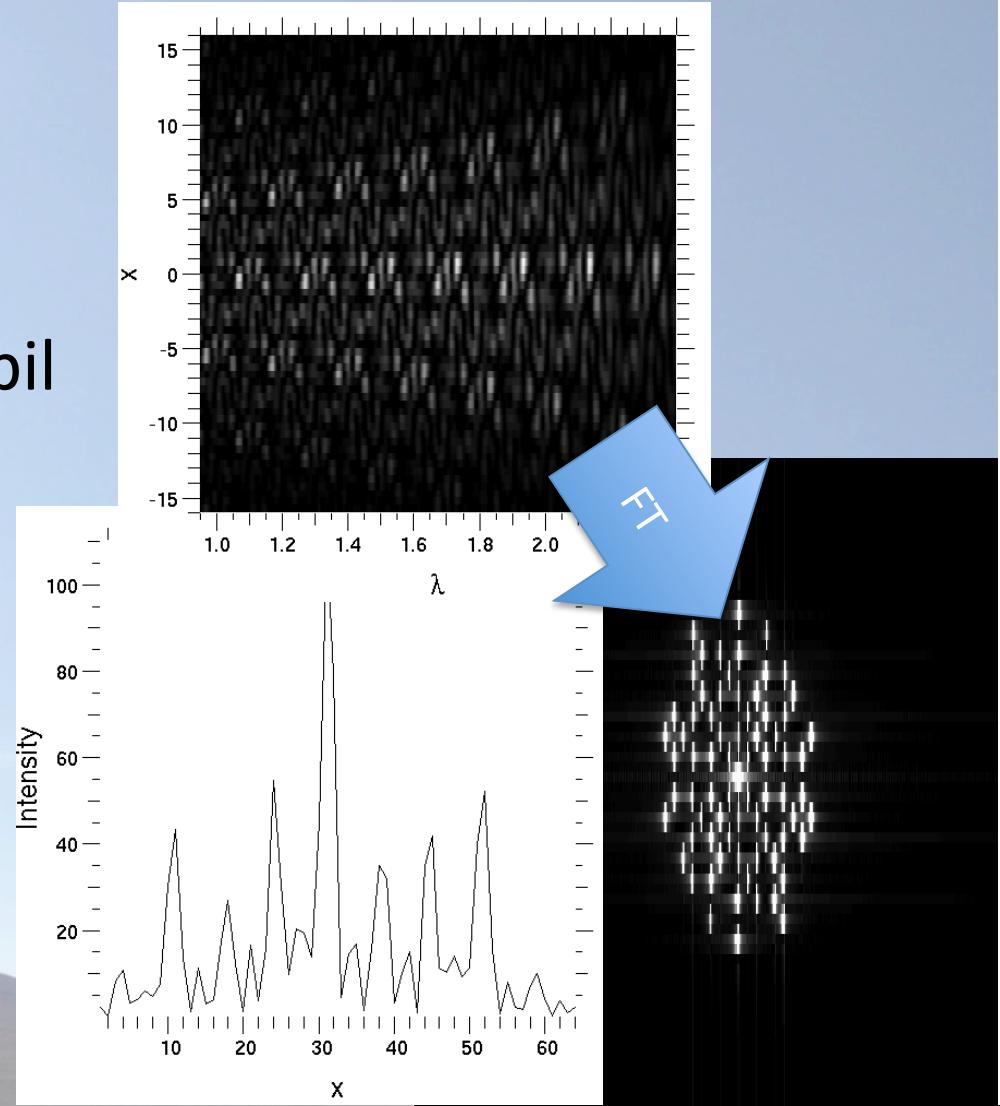
- 9 entrance pupils
- 512 spectral channels across JHK ( $R \sim 600$ )
- Non-redundant output pupils from Huby et al. 2012
- Needs  $\sim 350$  pixels for proper fringe sampling



# Let's look at a practice case

- 9 entrance pupils
- 512 spectral channels across JHK ( $R \sim 600$ )
- Redundant output pupil with non-redundant OPDs
- Needs  $\sim 64$  pixels for proper sampling

**FACTOR 5.5  
( $\sim 1.8$  MAG)**



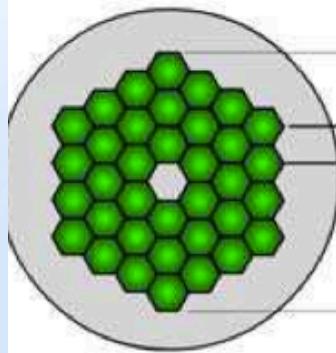
# Other aspects

- Peaks should be separated by ~fringe wandering of the atmosphere, i.e.  $\pm 20\mu\text{m}$  @Paranal
- Maximum OPD should be  $< L_c / 2$
- For 9 sub-pupils,  $L_{c_{\min}} = 320\mu\text{m}$   
→  $R_{\min} = 335$  @  $0.95\mu\text{m}$
- For 18 sub-pupils,  $L_{c_{\min}} = 1.7\text{mm}$   
→  $R_{\min} = 1800$  @  $0.95\mu\text{m}$

# An example setup

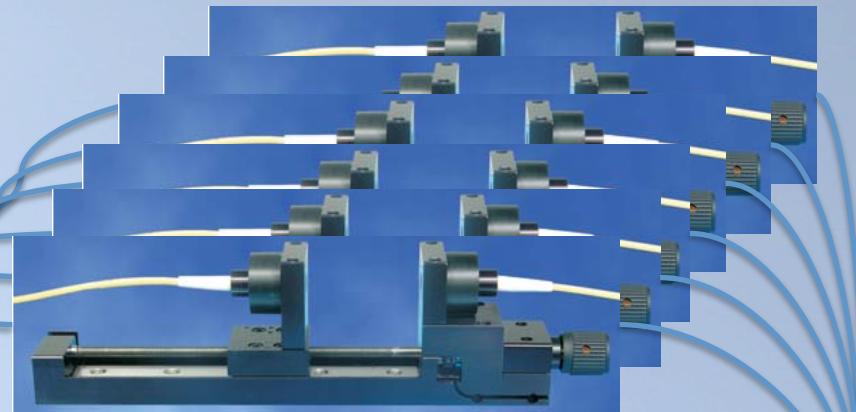
This is the FIRST entrance

**Input pupil**



Redundant configuration +<sub>ugated</sub> wavefront

Small-stroke fibered delay lines



Spectrograph      Microlens array

Detector



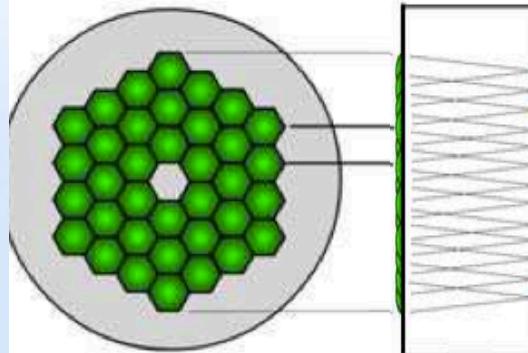
V Groove



# An example setup

This is the FIRST entrance

**Input pupil**



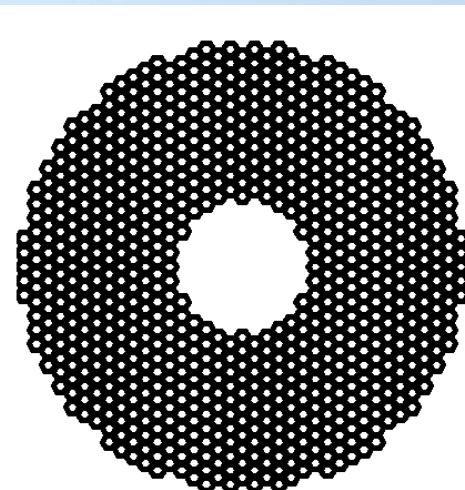
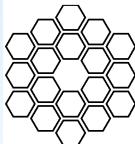
Small-stroke fibered delay lines



Detector

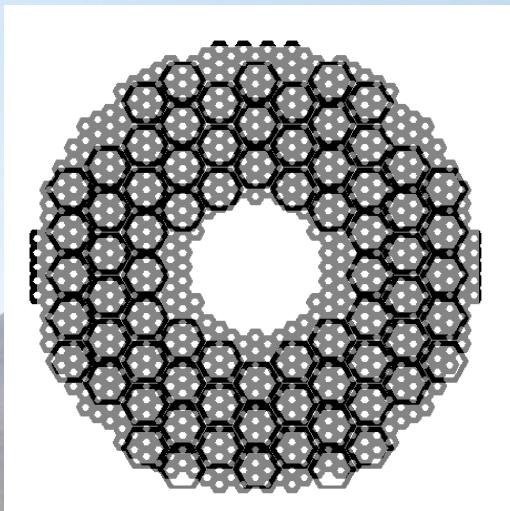
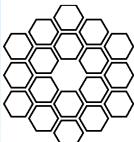
# What happens when telescope size increases?

- 8m-class telescopes
- Can be subdivided into 18 ~1m segments
- Possible to split into sub-groups (FIRST: 2 groups of 9 segments)
- 40m-class telescopes
- ~1000 1m segments
- How to recombine all of them?
  - ~100 9-pupils recombiners?
  - Combine groups of segments?



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# Optimize ~100 sub-pupils groups?

- 9 sub-pupils
  - 64x512 pixels
- 18 sub-pupils
  - 128x2000 pixels
- 100 sub-pupil
  - 512x40000 pixels detector...

# That's all!