PSF reconstruction for extremely large telescopes
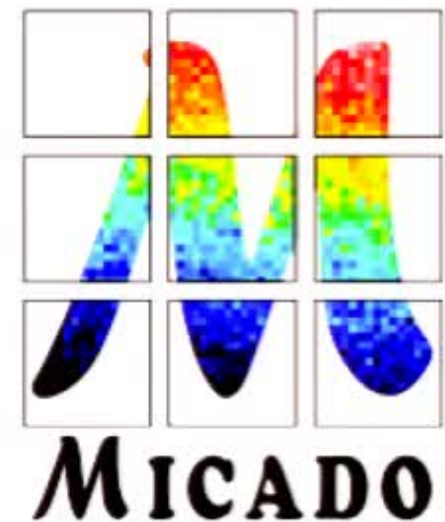
Roland Wagner

joint work with Ronny Ramlau and Daniela Saxenhuber

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Linz, Austria

Atlanta, October 27, 2015

Outline

- E-ELT, MICADO and AO
- Atmospheric Tomography
- PSF reconstruction
- Application

MICADO

European Extremely Large Telescope (E-ELT)

- built by ESO - European Southern Observatory
- operates several astronomical telescopes, e.g. VLT (4x8m, Atacama desert)
- E-ELT: Cerro Armazones (3060m), primary mirror $\emptyset \sim 39$ m, first light 2024
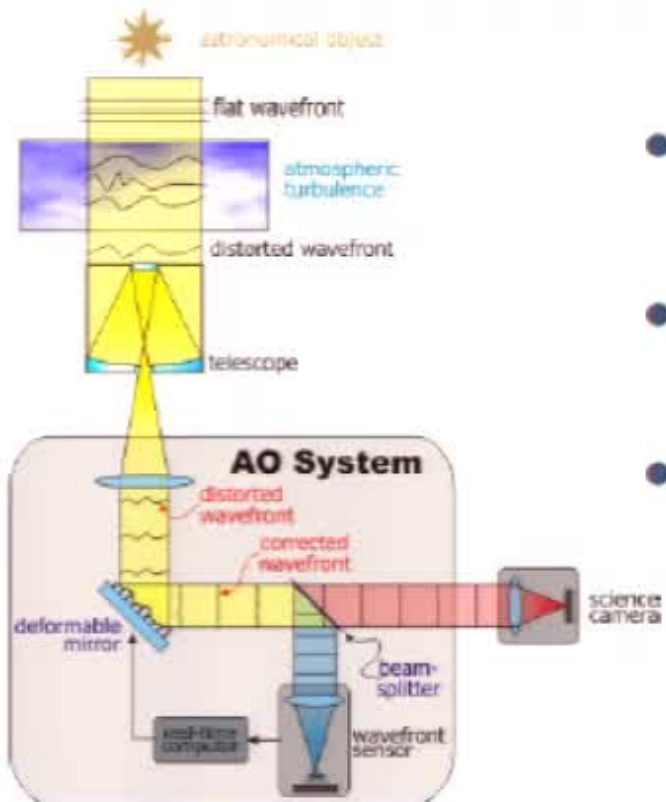- correct for astronomical seeing: **Adaptive Optics**

MICADO

Multi-AO Imaging Camera for Deep Observations

Source: MICADO Consortium

- First light instrument of the E-ELT
- Certain AO modes
- High contrast imaging
- Motions of stars in globular clusters
- Exoplanet search

Adaptive Optics (AO)

astronomical object
flat wavefront
atmospheric turbulence
distorted wavefront
telescope

AO System
distorted wavefront
corrected wavefront
deformable mirror
beam-splitter
real-time computer
wavefront sensor
science camera

- light wavefronts coming from natural guide stars (NGS) or laser guide stars (LGS)

- atmospheric turbulences distort incoming wavefronts

- AO system:
  - commands for deformable mirror are calculated from wavefront sensor (WFS) measurements
  - deformable mirror adjusts for atmospheric turbulences
  - very short time frame $\sim$1ms

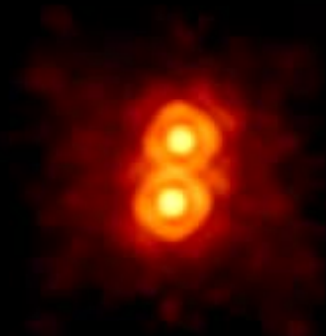- better image quality is achieved

Source:

http://www.vikdhillon.staff.shef.ac.uk/teaching/phy217/telescopes/phy217_tel_adaptive.html
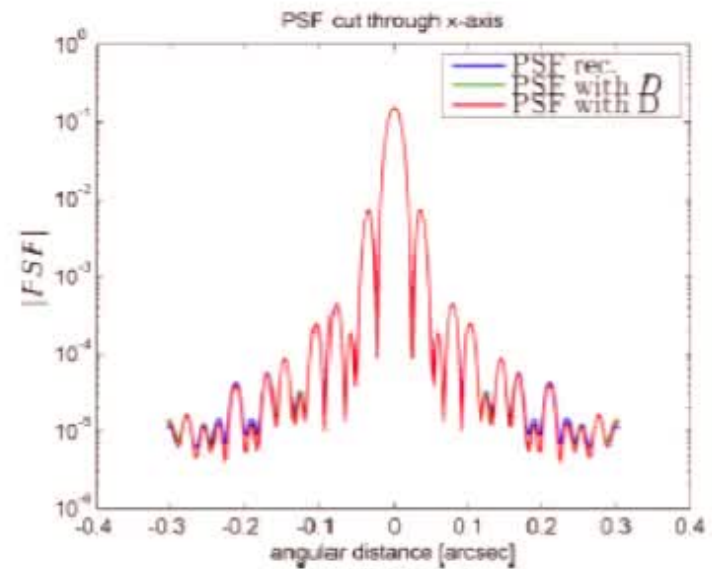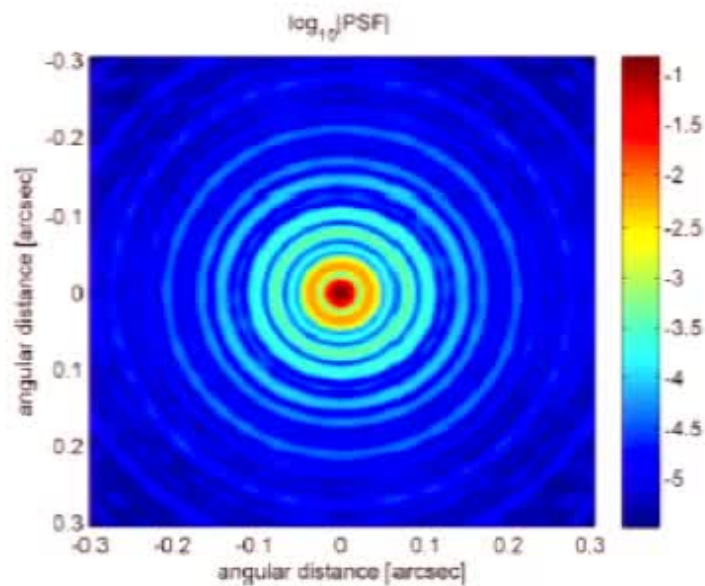
Without Adaptive Optics
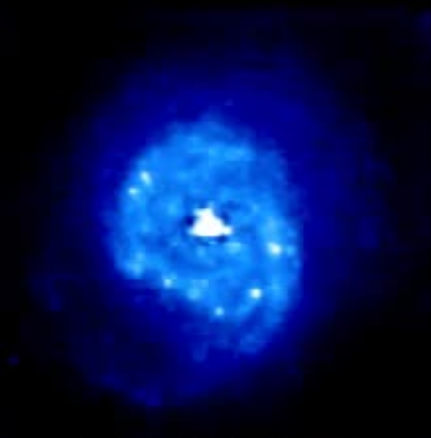
With Adaptive Optics

PSF reconstruction for MCAO

- Use tomographic reconstruction of the atmosphere from measured data (intermediate result of gradient-based method)
- Project through the atmosphere to get PSFs for each desired direction using A_{dir} (as in gradient-based method)
  $\rightarrow$ pseudo-wavefronts to calculate the corresponding $\mathcal{OTF}$s.
- Simulate higher order terms not seen by WFS as before.
- Combine the three parts of the $\mathcal{OTF}$ together
- Apply the inverse Fourier transform.

PSF reconstruction for MCAO

Deconvolution