Calibration of Adaptive Optics fed instruments

Overview Talk

The 2007 ESO Instrument Calibration Workshop
Garching, January 23-26, 2007

Presented by
N. Ageorges

Plan

- Adaptive Optics instrument at ESO
  - Overview of the instruments involved in this talk
  - Basic reminders of AO principles
  - Presentation of some science results
- AO specific calibrations
- The case of MACAO(s)
  - What exist
  - Planed improvements
- The NAOS case
  - What exist
  - What would be desirable

Adaptive Optics instruments at ESO

One “adaptive optics telescope” - Yepun (UT4)

All UTs Coude focus equipped with AO for the VLTI

AO specific calibrations:

- ✓ Not (really) part of IOT discussions (no scientific calibrations).
- ✓ Essentials for proper functioning of instrument
- ✓ Discussed in the parAOgar meetings

parAOgar meeting = AO group Garching & Paranal (IS & engineers)

AO telescope: Yepun (UT4)

Nasmyth focus

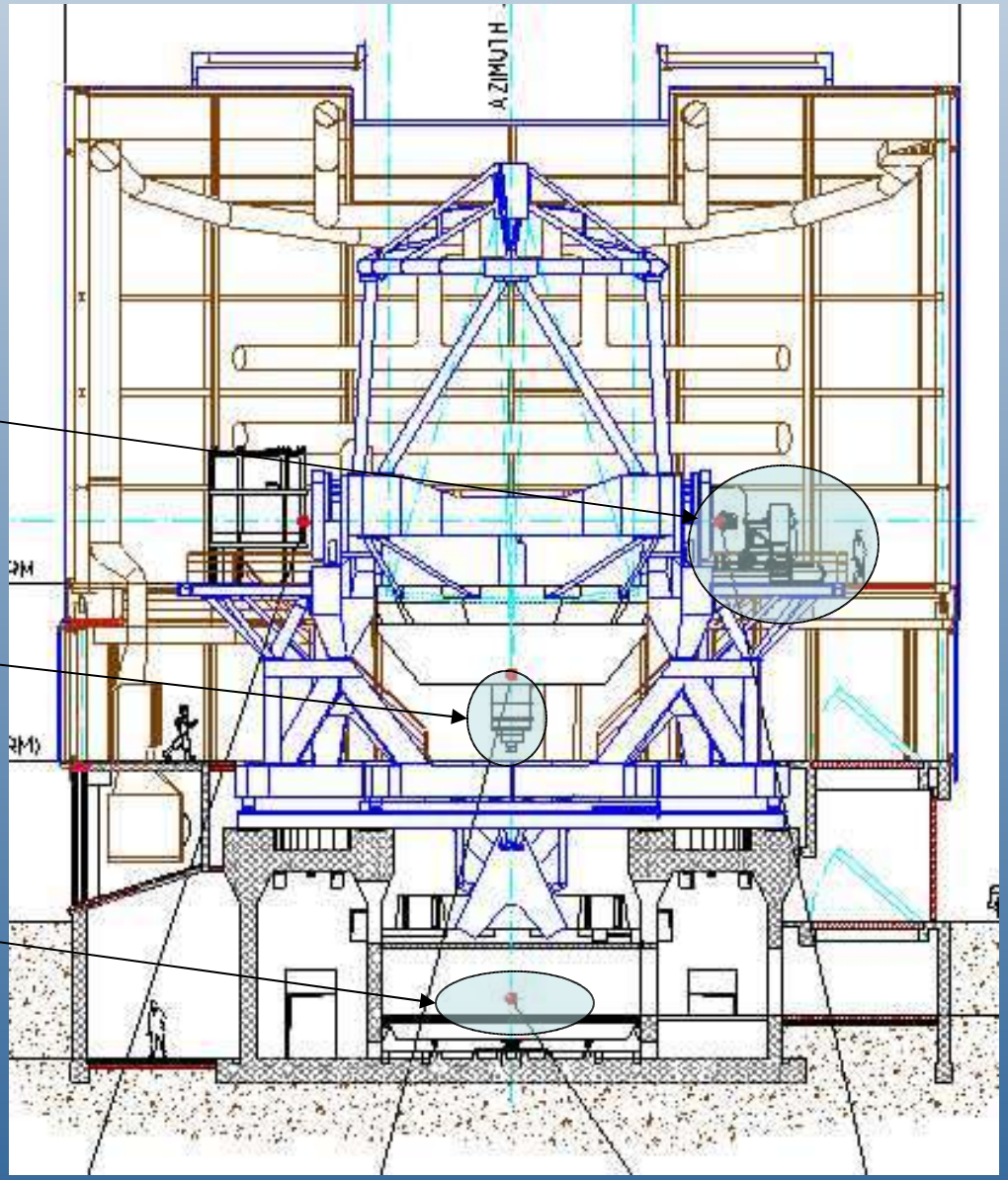
NAOS

Cassegrain focus

MACAO

Coude focus

MACAO



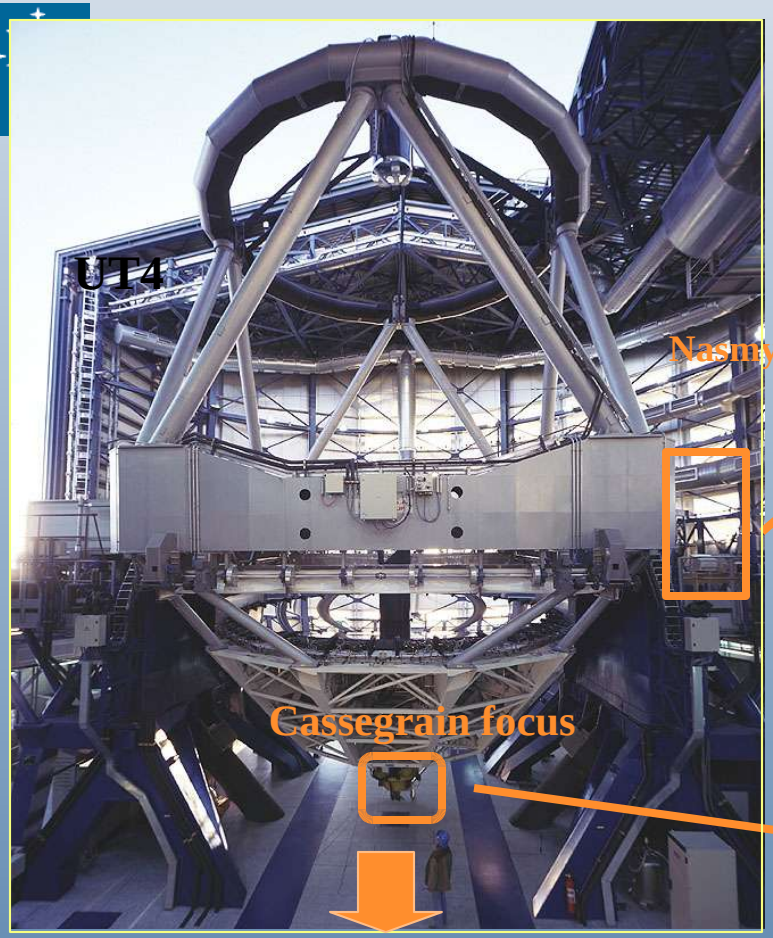
AO instruments

- AO = NAOS
  - ✓ Shack-Hartmann WFS
- Instrument =
  - ✓ NaCo

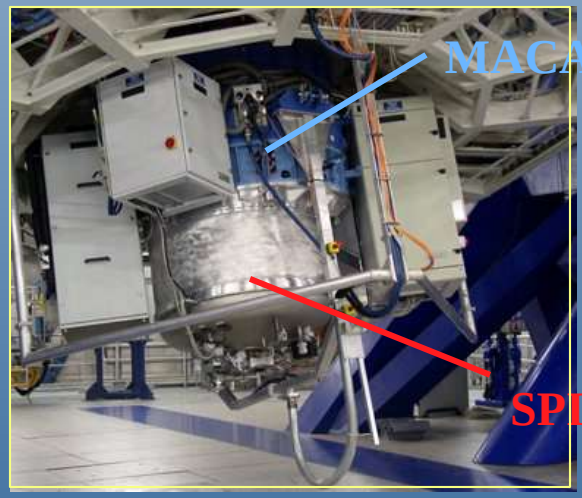
- AO = MACAO
  - ✓ Curvature sensing WFS

Instrument(s) =

- ✓ SINFONI
- ✓ CRIRES
- ✓ VLTI instruments:
  - MIDI
  - AMBER


UT4
Nasmyth Focus
Cassegrain focus

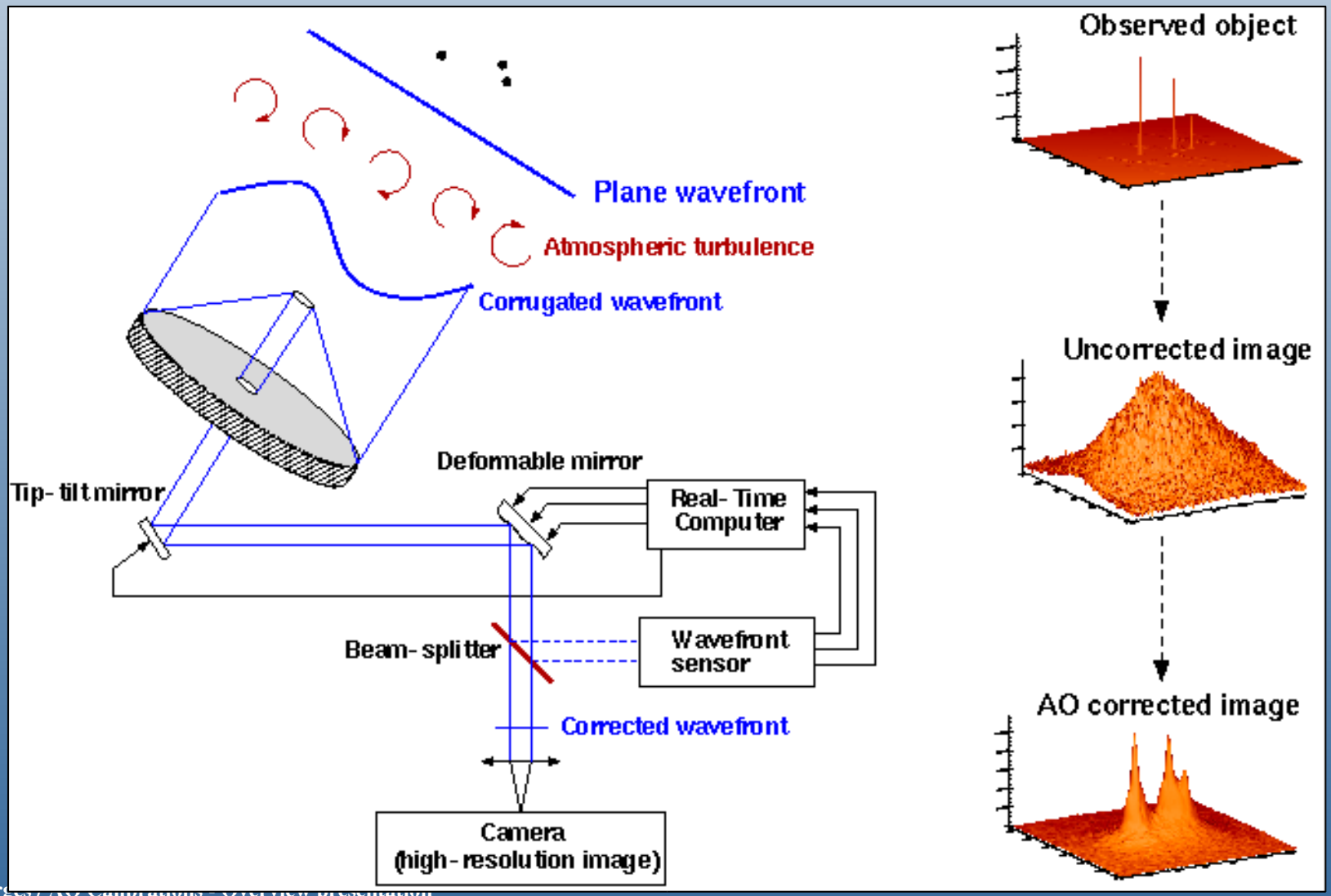

NAOS
CONICA
NaCo


MACAO
SPIFFI

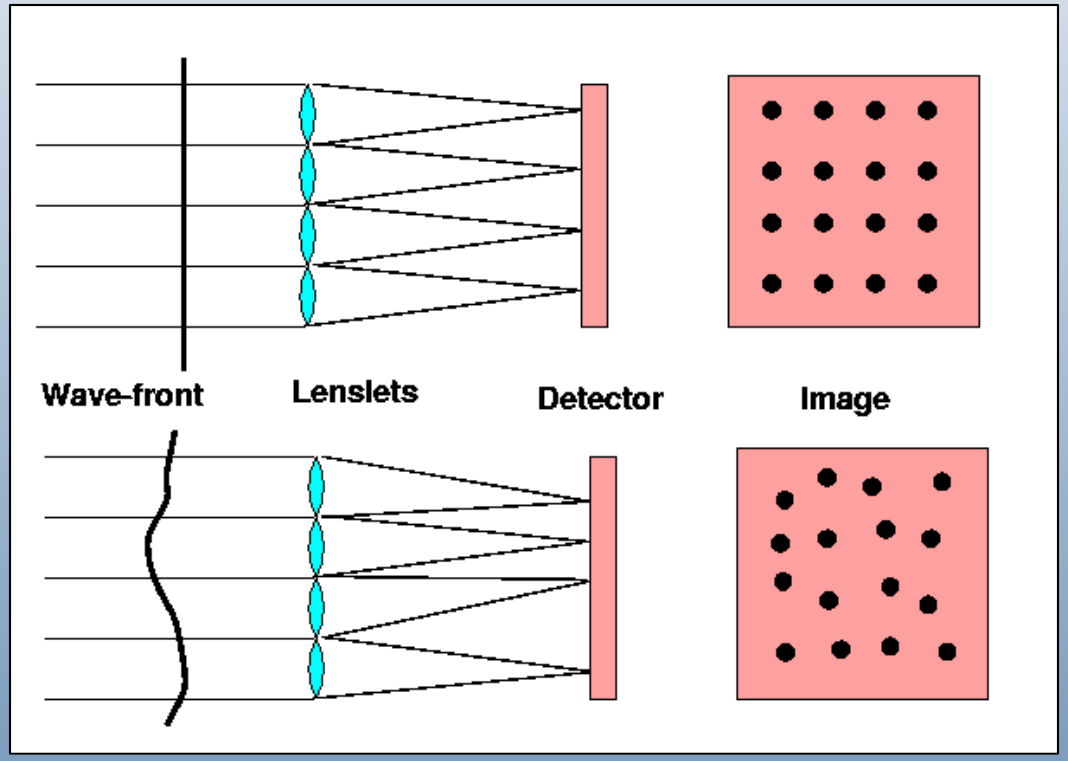

Coude focus
MACAO- VLTI

SINFONI

Principle of Adaptive Optics

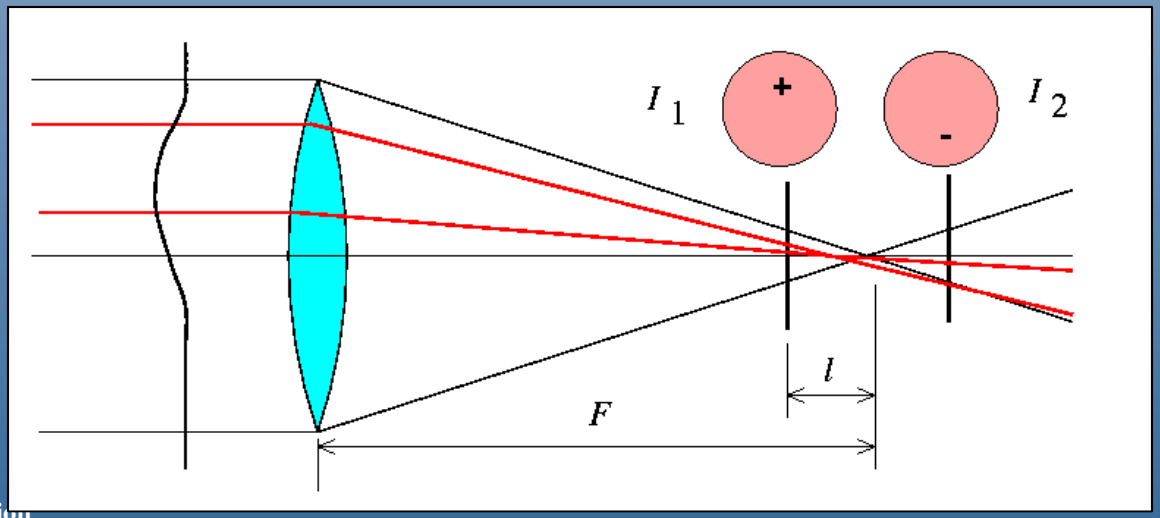


Wavefront sensing

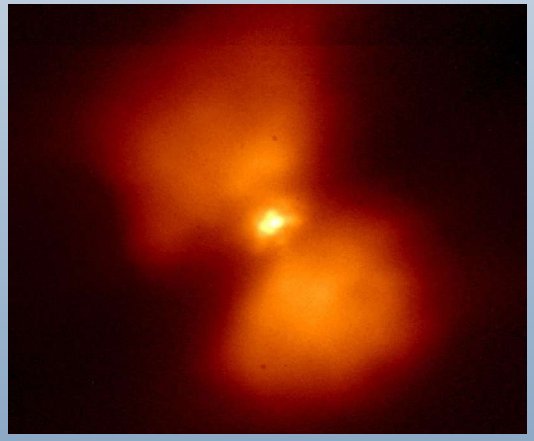


Shack Hartmann WFS

Curvature WFS



MACAO-VLTI: Results on UT2

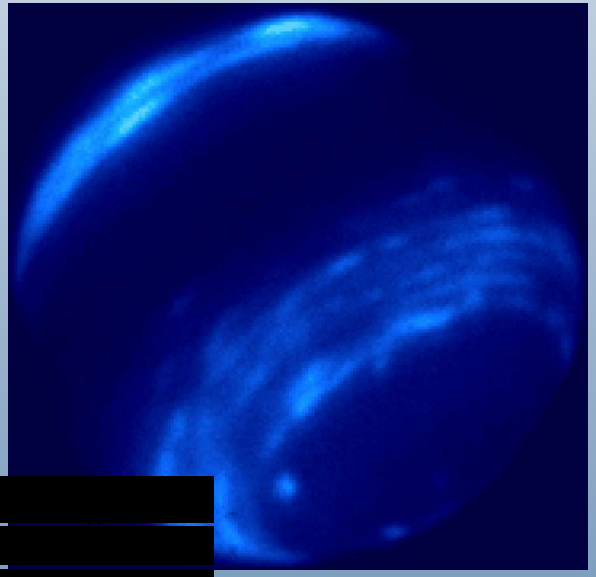


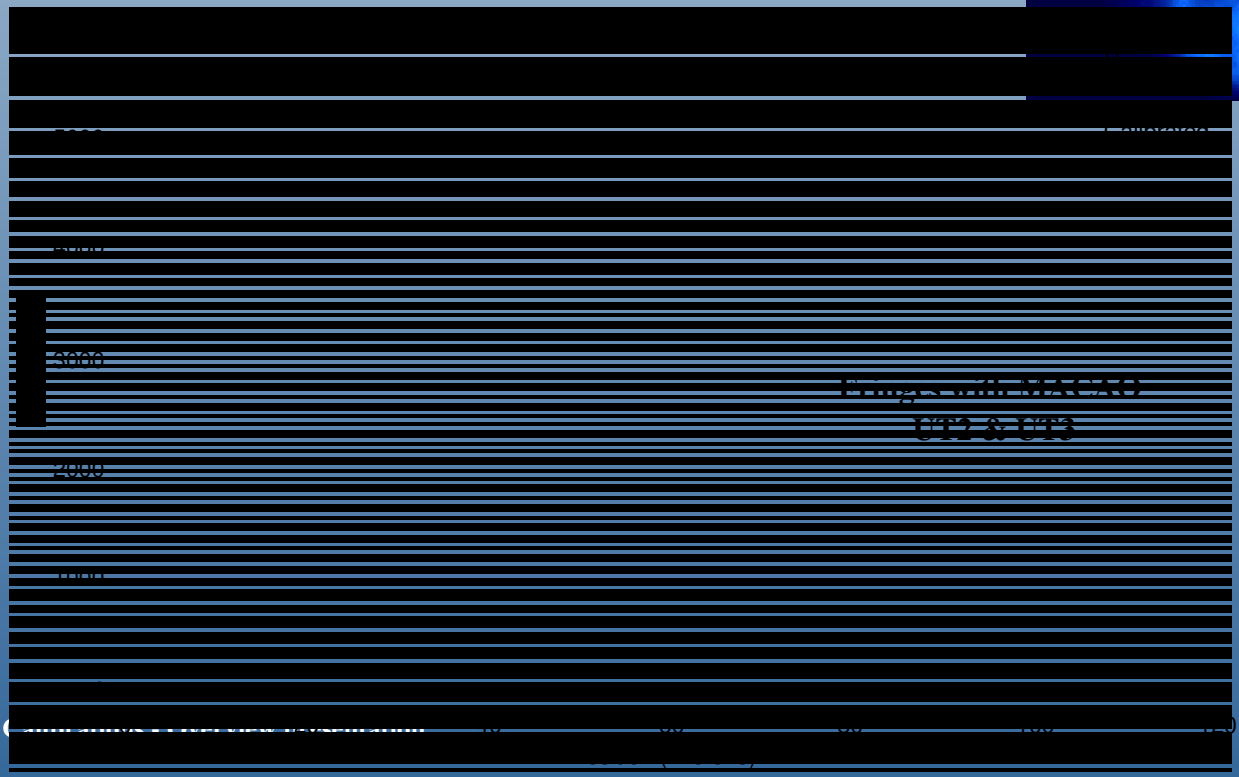
"Frosty Leo"
5"x5" - K band

Seeing ~ 0.7", V~11
AO ref ~ 3" wide
corrected IQ ~0.1" FWHM

MACAO - UT2

Neptune - H band
MACAO - UT3





Fringes with MACAO
UT2 & UT3

NaCo: Some scientific results

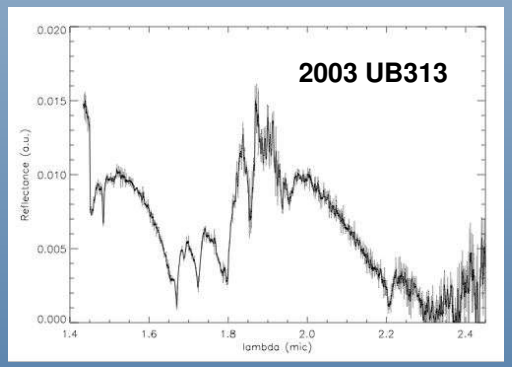
Schoedel et al., 2003, Nature 419, 694-696

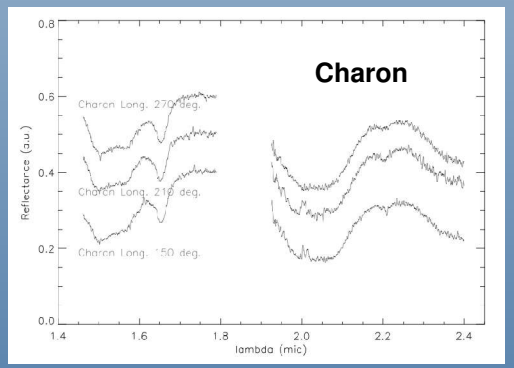
A star in a 15.2-year orbit around the supermassive black hole at the centre of the Milky Way

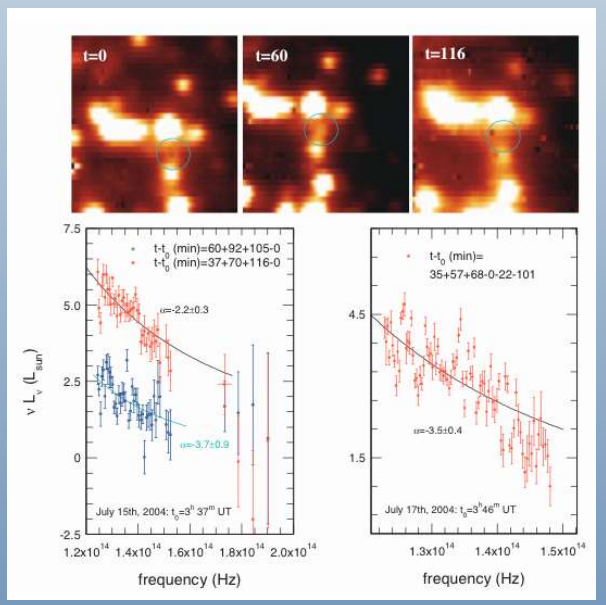
SINFONI: Some science hits

Composition of large Kuiper-belt objects (Dumas *et al.* 2006)

- Charon: Ammonia hydrate (NH_3:H_2O) present over the entire surface (N^+ implantation from Pluto's escaping atmosphere?).
- UB313: CH_4 & N_2 (same as Pluto)







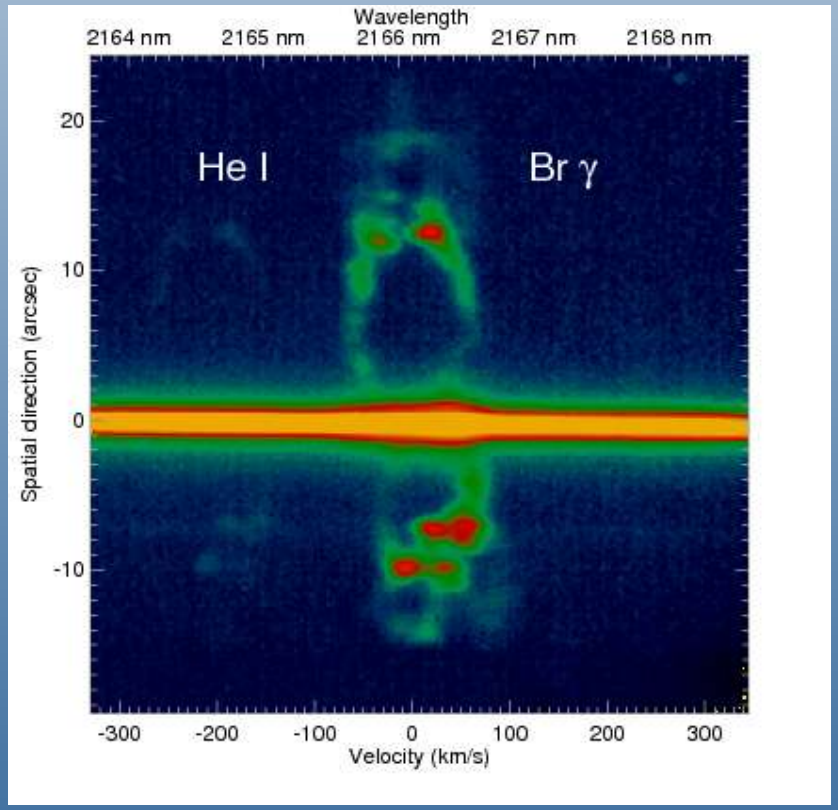
Galactic center (Eisenhauer *et al.* 2005. ApJ).

Infrared emission from flares:

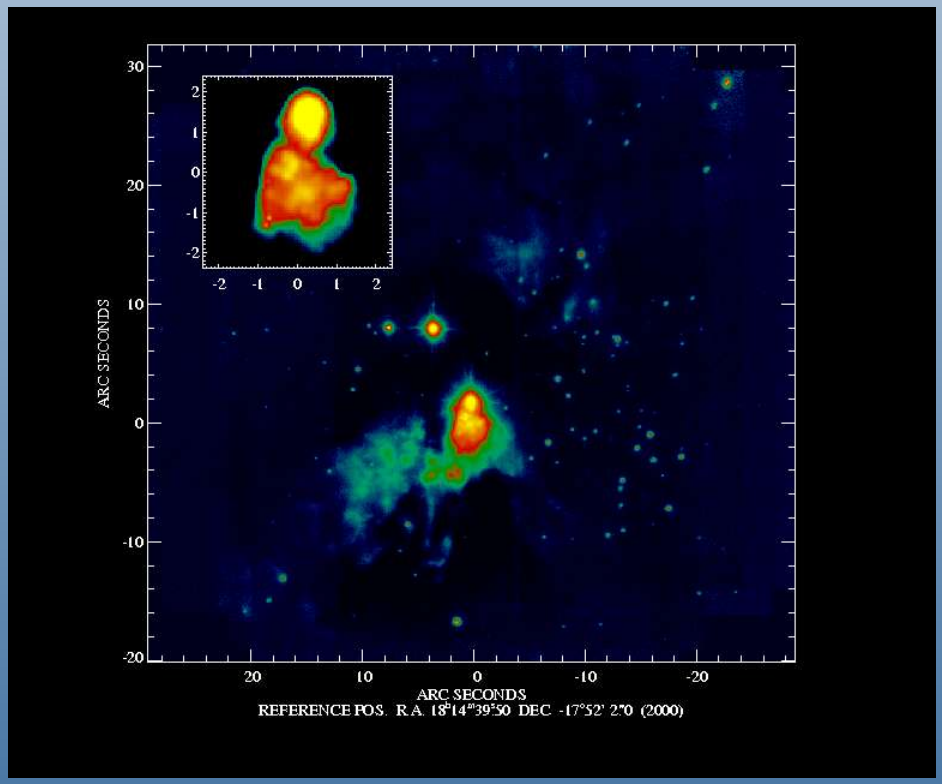
- Two low-activity flares detected
- Synchroton emission of highly-energetic electrons (>1GeV)

CRIRES MACAO results

PN Menzel 3 - Ant nebula



Galactic HII region W33A
K band - slit viewer camera



AO specific science calibration

- Only ‘science’ AO calibration

  = PSF reconstruction

  ✓ So far only NaCo provides something =

  For each file residual & mirror modal covariance matrices provided

  ✓ See next talk

- Estimation of performance based on Strehl ratio

- All other calibrations are instrument calibration fundamental for the well behaving of the system

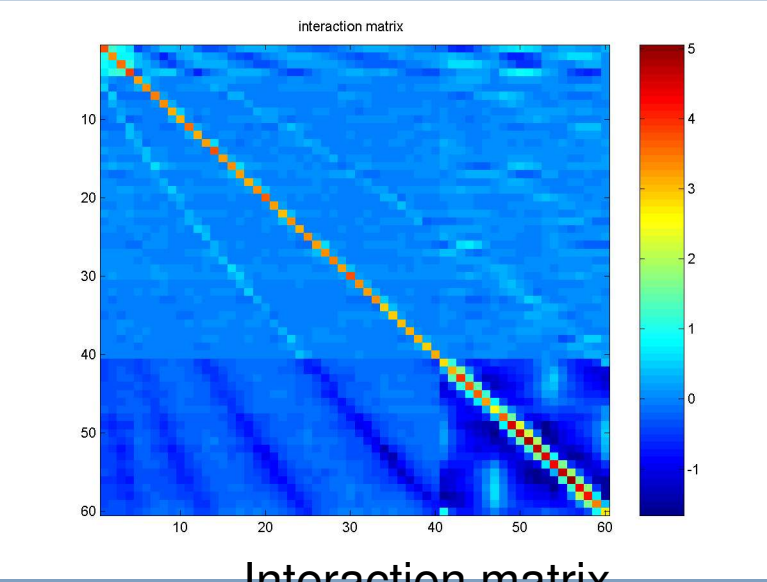
MACAO calibrations

- Daytime calibrations:
  - ✓ Membrane phase lag (daily/weekly) - Results applied
    (Synchronisation of membrane)
  - ✓ Reference vector (daily) - Results applied
    (flatten curvature)
  - ✓ Interaction matrix (daily) - not applied
    ==> Radius of Curvature (RoC)
    ==> Pupil center/offset
    ==> Dead electrode
    ==> Electrode short cut & slow/dead electrode

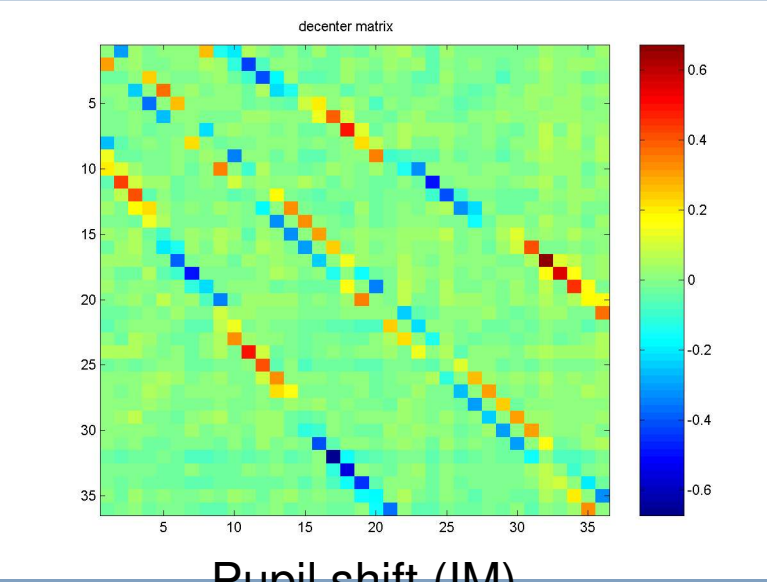
- Evening:
  - ✓ Close loop on fiber and measure strehl ==> QC

- Night:
  - ✓ SINFONI /CRIRES: recompute reference vector (flatten mirror) before non-AO observations
  - ✓ Checked once a month on VLTIs

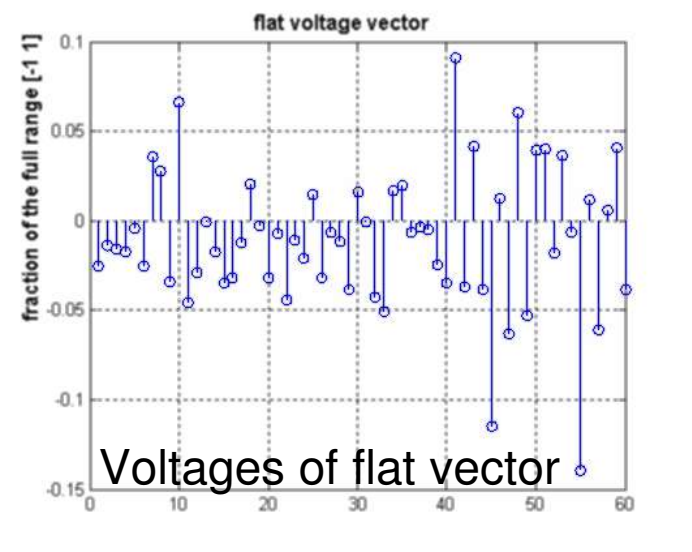
Illustration of MACAO calibrations



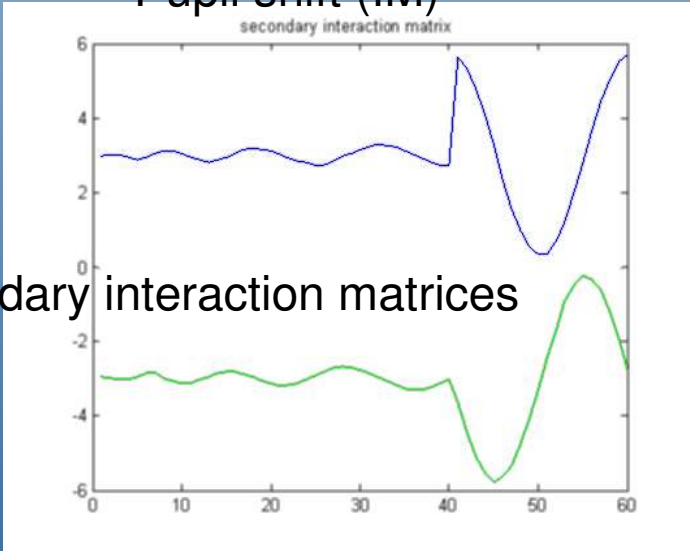
Interaction matrix



Pupil shift (IM)



Voltages of flat vector



Secondary interaction matrices

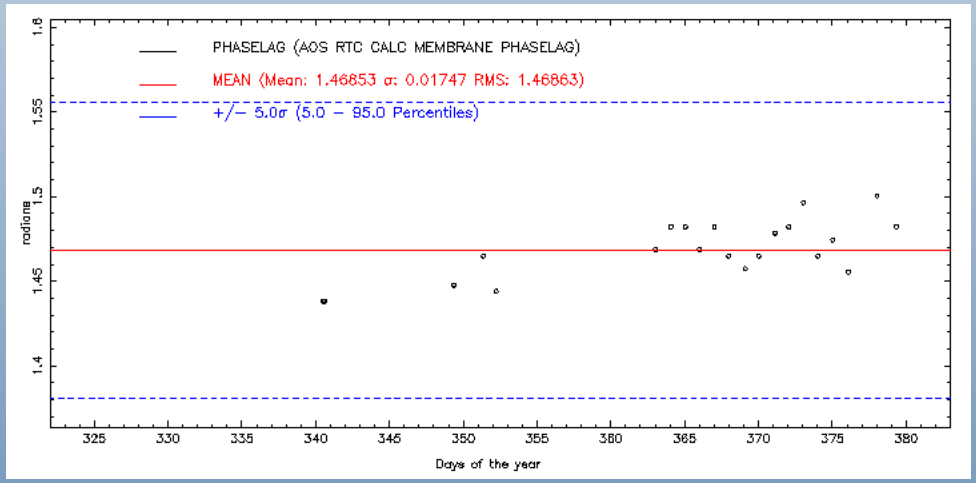
Performance Monitoring

AutRep, Performance monitor and diagnostic tool:

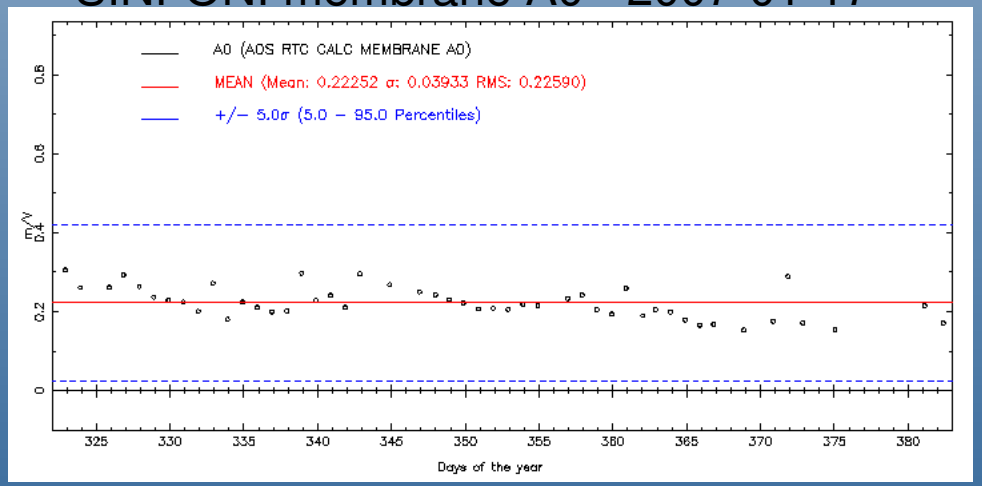
- Automatic report of daily monitoring (MACAO parameters) over a 60 days period (we plot mean +/- 5-sig to identify problem and trigger automatic alarm):
  - Radius of Curvature versus voltage (m/volt)
  - Membrane phase lag (rad)
  - Deformable mirror (DM) electrodes response (volts)
  - DM slow electrodes (volts)

- Diagnostic/investigation tool: Dynamic report of key-parameters can be plotted (parameter versus time, parameter versus other parameter) to investigate possible correlations (e.g. A_0 versus DM temperature)

CRIRES membrane phase lag - 2007-01-17



SINFONI membrane A0 - 2007-01-17



MACAO pending / improve

- Secondary IM, IM daily health status, membrane surface quality (reflectivity??)
- Do not correct high order static aberrations only differential tip-tilt & defocus
- New template to measure transfer function
- Not clear when to compute new IMs

NAOS

List of things to (re)calibrate regularly:

- Pupil
- Field (illumination on WFS)
- Static aberrations
- Focus
- Reference slopes
- Interaction matrices

Monitoring plan

- Daily: CheckPupil & CheckAO
- Weekly: CheckPerformance
- Monthly: CheckPupil
- To do: Check WFS, Check static aberrations
- Done in average once a year = Check flexure compensation (pending to correct them)

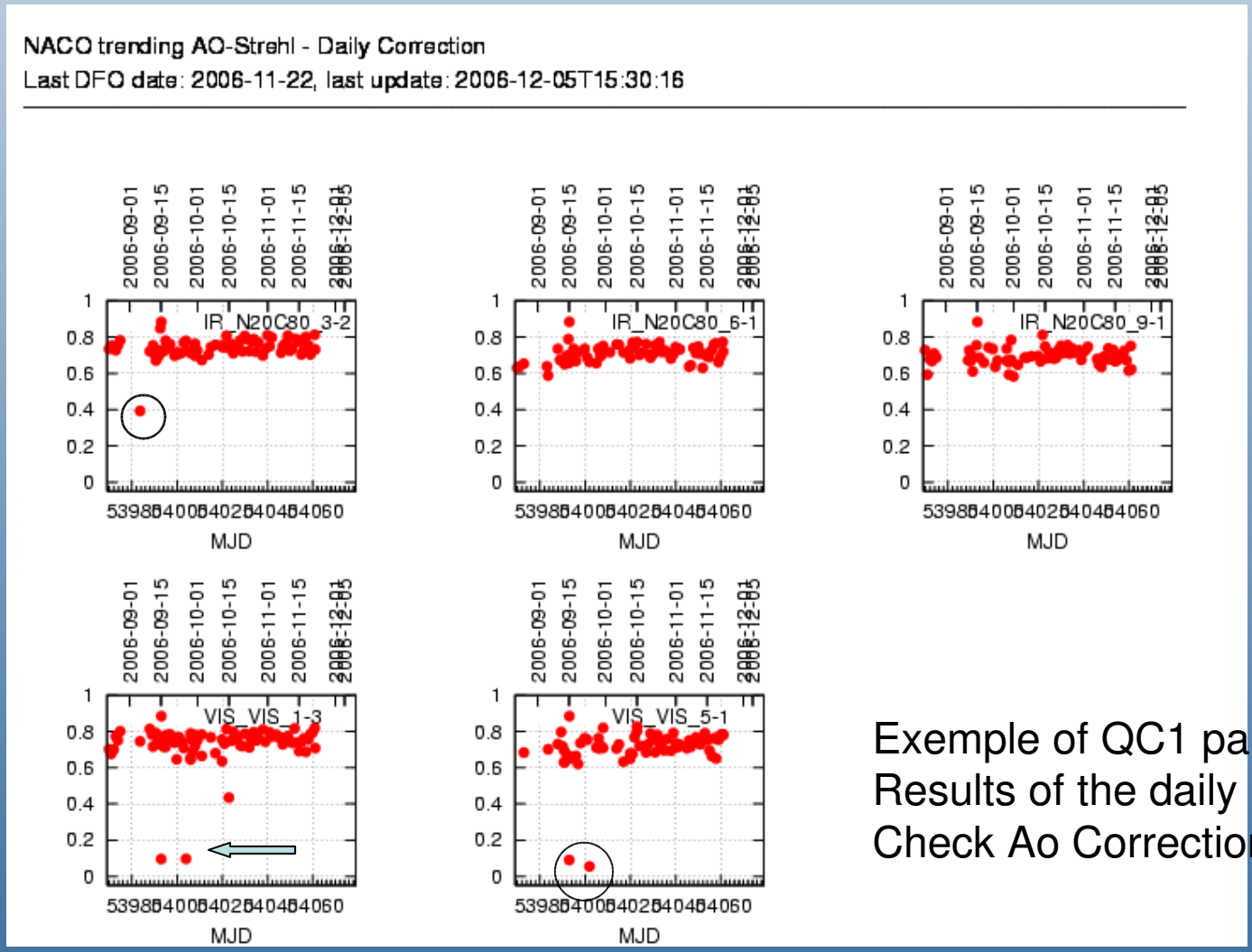
NAOS pupil alignment

Exemple of result output of the daily CheckPupil

VIS WFS (14x14) - Dichroic VIS : -0.0384784 0.0723252
VIS WFS (7x7) - Dichroic VIS : 0.0380239 -0.0326174
IR WFS (14x14) - Dichroic N20C80 : 0.0294762 -0.107975
IR WFS (7x7V0) - Dichroic N20C80 : -0.0440543 0.0992913
IR WFS (7x7V1) - Dichroic N20C80 : 0.0249882 0.0111194
IR WFS (14x14) - Dichroic N90C10 : 0.100903 0.0305231
IR WFS (14x14) - Dichroic JHK : 0.0389628 0.0312667
IR WFS (14x14) - Dichroic K : 0.192338 -0.0548553

GOOD : abs(Delta_x, Delta_Y) < 0.1
Medium : 0.1 < abs(Delta_x, Delta_Y) < 0.15
To avoid if possible tonight
BAD : abs(Delta_x, Delta_Y) > 0.15
Cannot be used tonight

NAOS - Check AO correction



Exemple of QC1 parameter
Results of the daily
Check Ao Correction template

Other calibrations

- On sky alignment:

  Checked each time NAOS &/or CONICA has been detached

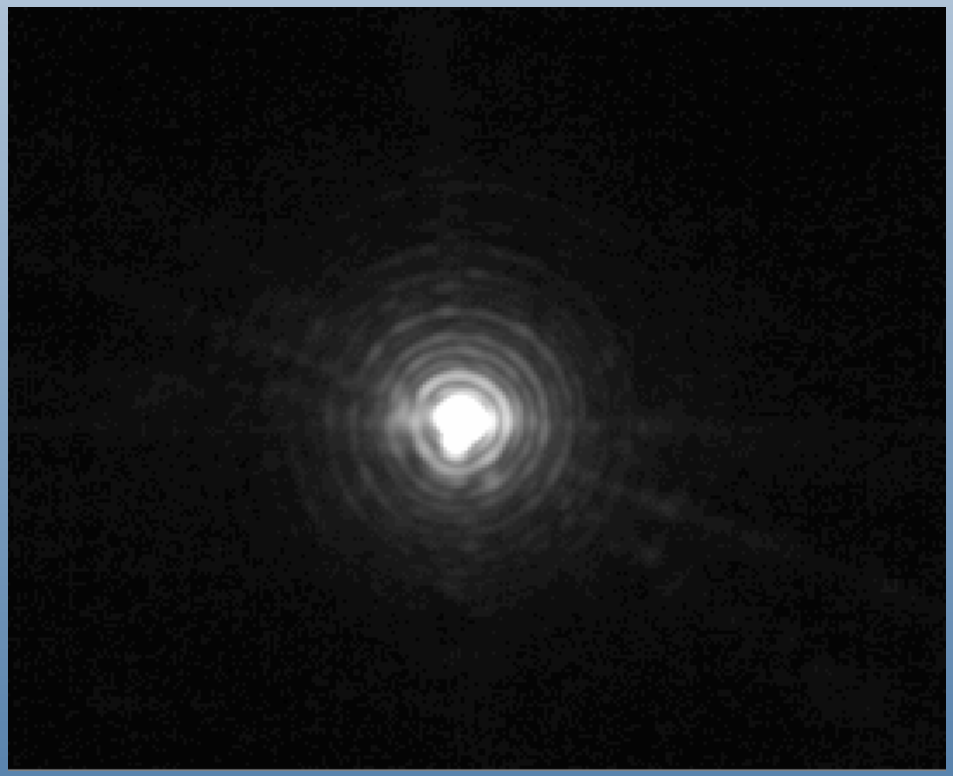
  Both open & closed loop

  Requested by user's to have access to the data ==> webpage (pending).
- Field distortion:

  our "mea culpa" = no information provided

Conclusion

Illustration of the importance of proper calibrations



On sky measurement - 02/02/2006
60% strehl on pipeline recombined image - NB_3.74

Point source
30% mis-aligned pupil