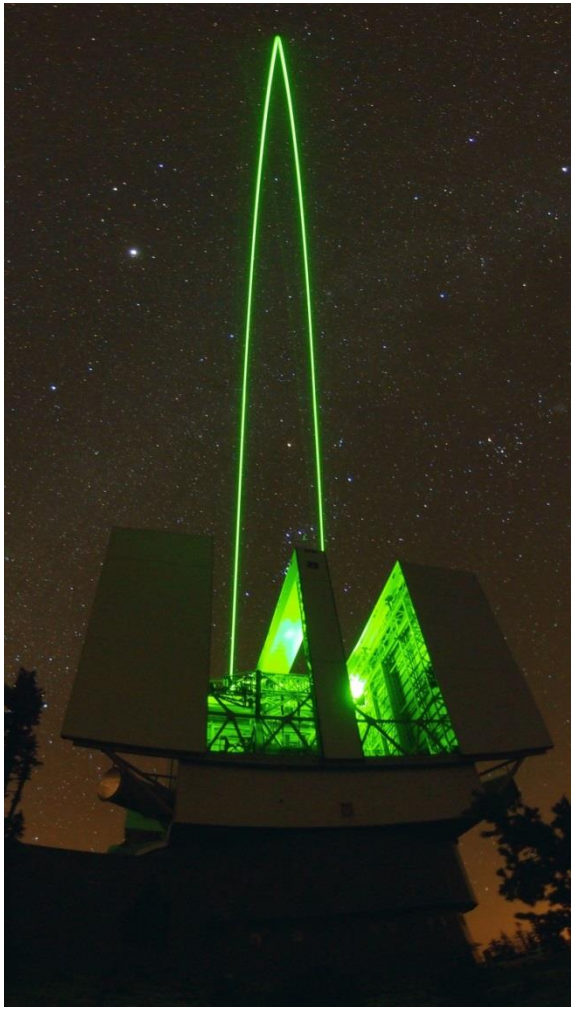
ARGOS

Advanced **R**ayleigh **G**round layer adaptive **O**ptics **S**ystem

Sharper vision with ARGOS eyes



Inst.: **W. Gaessler**, D. Peter
Konst.: (Th. Bluemchen), M. Ebert, N. Muench, RR. Rohloff
FWT: A. Boehm, Klaus Meixner, ++
SW: J. Borelli, M. Kulas, ++
Elect.: M. Lehmitz, L. Mohr, ++

Outline

- Who is involved and why did we start?
- Some notes on Adaptive Optics
- What's the goal of ARGOS
- How does ARGOS look like?
- Some struggle we had and solved?
- What is next?

Outline

- **Who is involved and why did we start?**
- Some notes on Adaptive Optics
- What's the goal of ARGOS
- How does ARGOS look like?
- Some struggle we had and solved?
- What is next?

ARGOS Consortium

- PI - Max Planck Institut für extraterrestrische Physik, Garching
- CoPI - Osservatorio Astrofisico di Arcetri, Florence
- **CoPI - Max Planck Institut für Astronomie, Heidelberg (Software, Calibration Unit, Vibration Compensation System)**
- CoPI - Center for Astronomical Adaptive Optics, Tucson

- Astrophysikalisches Institut, Potsdam
- Landessternwarte, Heidelberg
- Large Binocular Telescope Observatory, Tucson
- Max Planck Institut für Radioastronomie, Bonn
- Max Planck Institut Semiconductor Laboratory, Munich

History and Mission

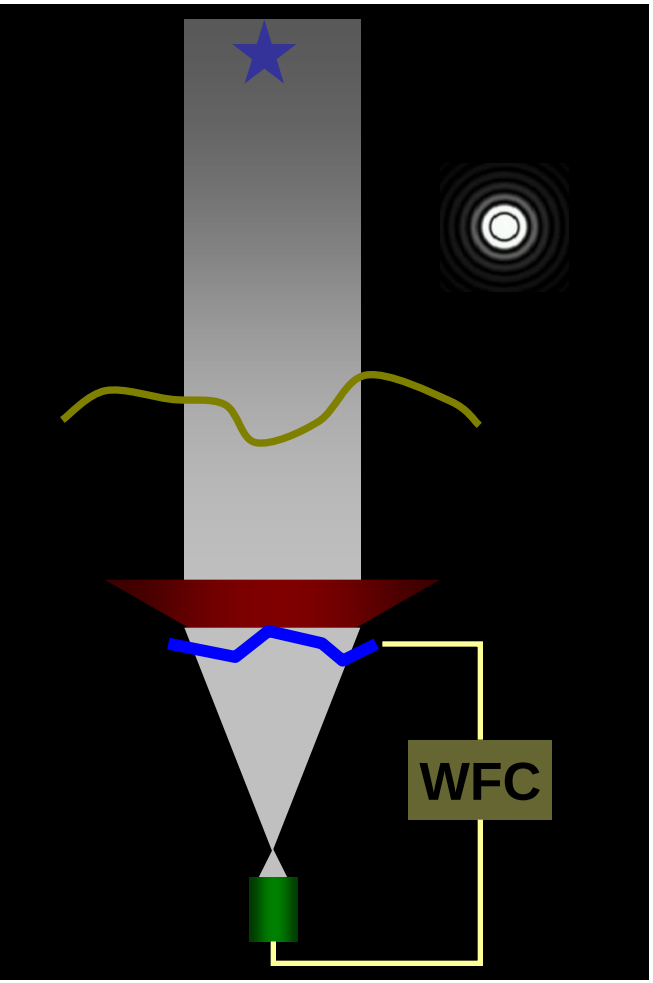
- Laser Guide Stars workshop, Florence Oct. 2006
- Phase A Kick off, Heidelberg May 2007

- Design of a laser and wavefront sensor system exploring the wide field capabilities of LUCIFER (MOS + Imaging).
  - Promptly implementation of a ground layer system.
  - Operability significant over median seeing.
  - Reliable, low maintenance, reasonable cost system.
  - Minimize impact to telescope and LUCIFER.
  - Identify upgrade paths to at minimum on-axis diffraction limited performance.

Outline

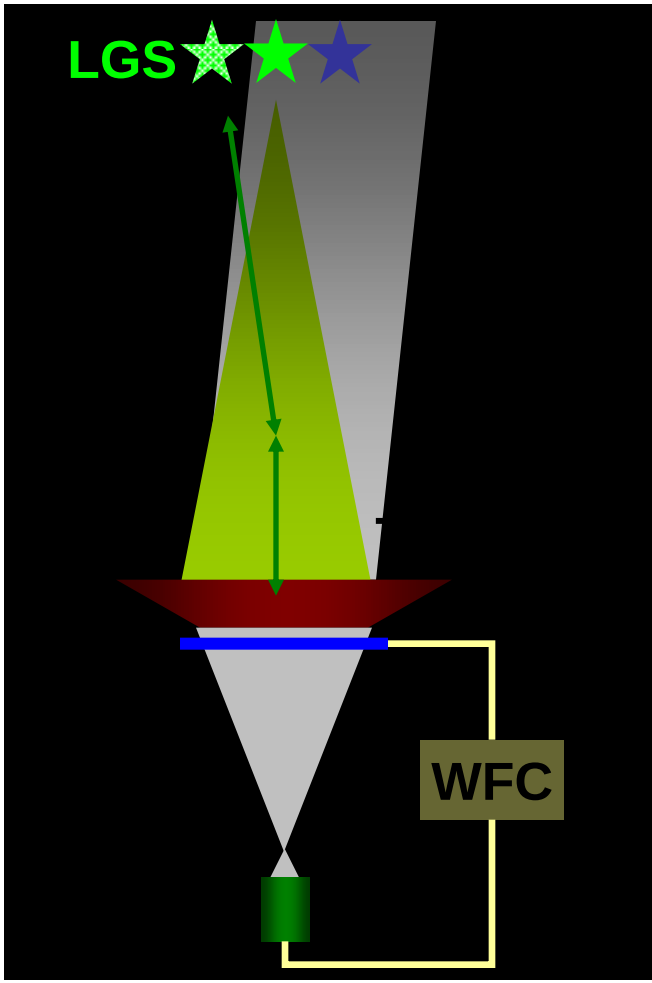
- Who is involved and why did we start?
- **Some notes on Adaptive Optics**
- What's the goal of ARGOS
- How does ARGOS look like?
- Some struggle we had and solved?
- What is next?

Adaptive Optics (AO) and Laser Guide Stars (LGS)

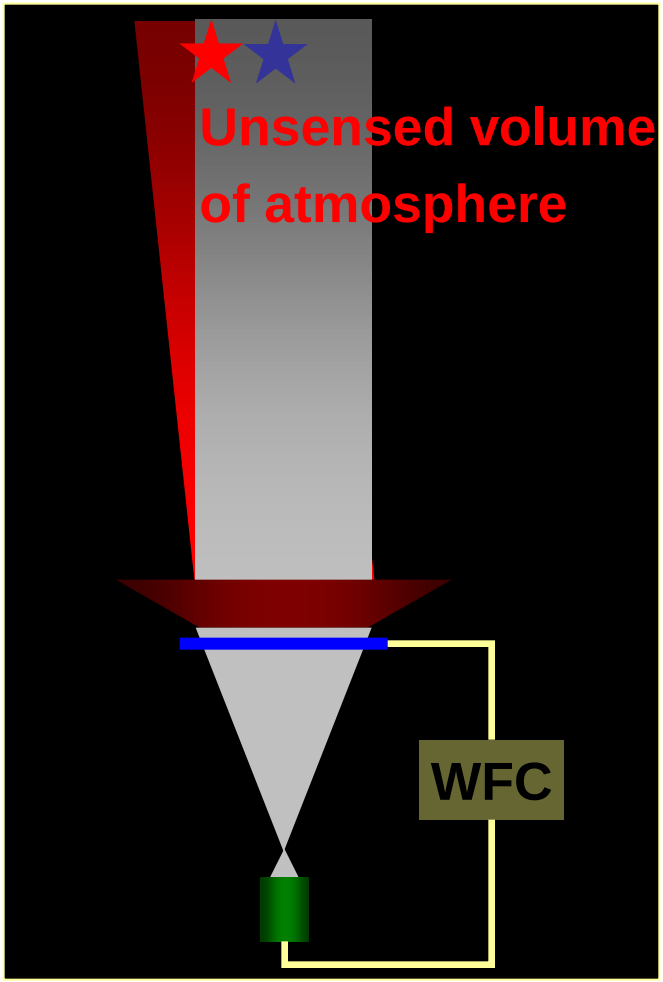


Sky Coverage

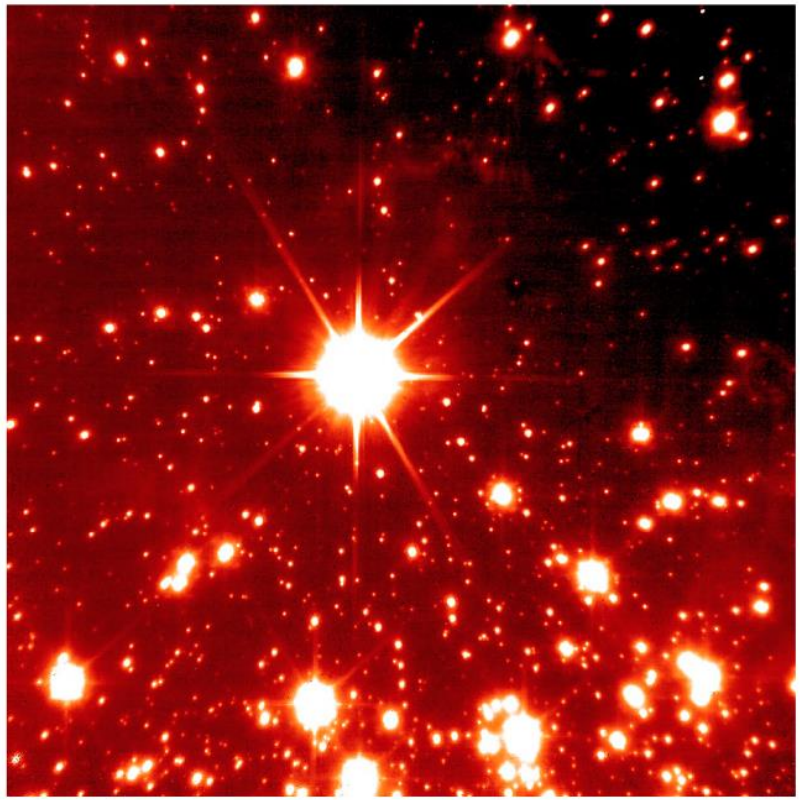
- ~5% with natural Guide Stars @V-Band
- ~ 50% with Laser Guide Stars (LGS) and natural Tip-Tilt (TT) star
- Up to 100% with LGS and w/o TT



Anisoplanatism
The problem with the Field



Correction
only
in
<1' FoV
@K-band

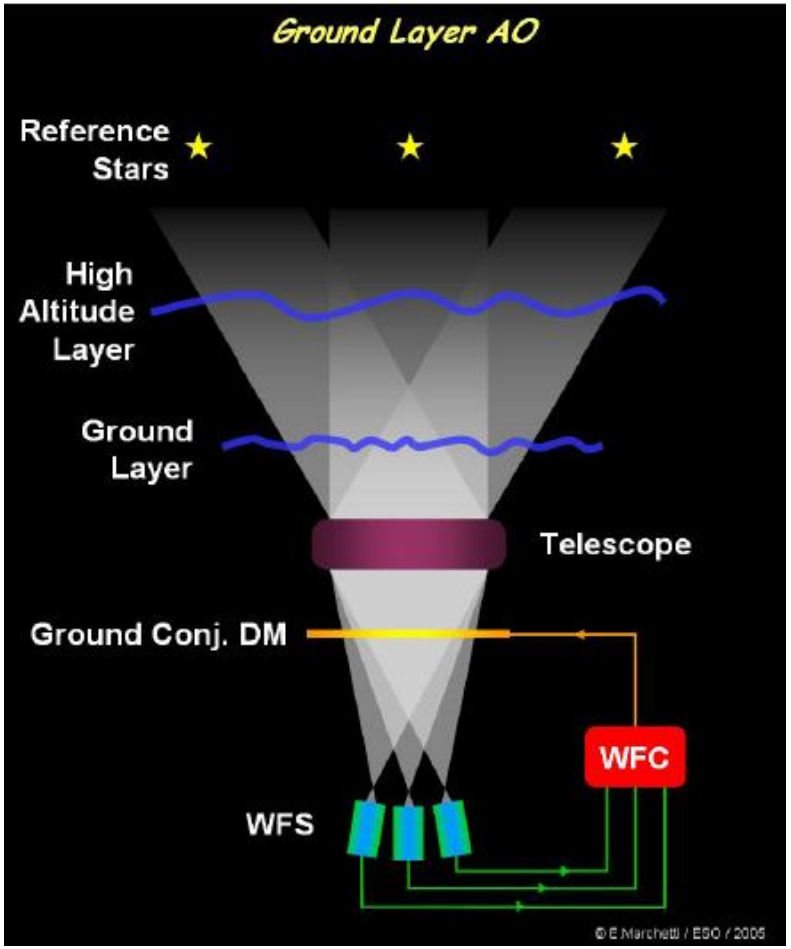


Area Near Centre of NGC 3603
(VLT YEPUN + NAOS-CONICA)

ESO PR Photo 33c/01 (3 December 2001)

GLAO
Ground layer Adaptive optics

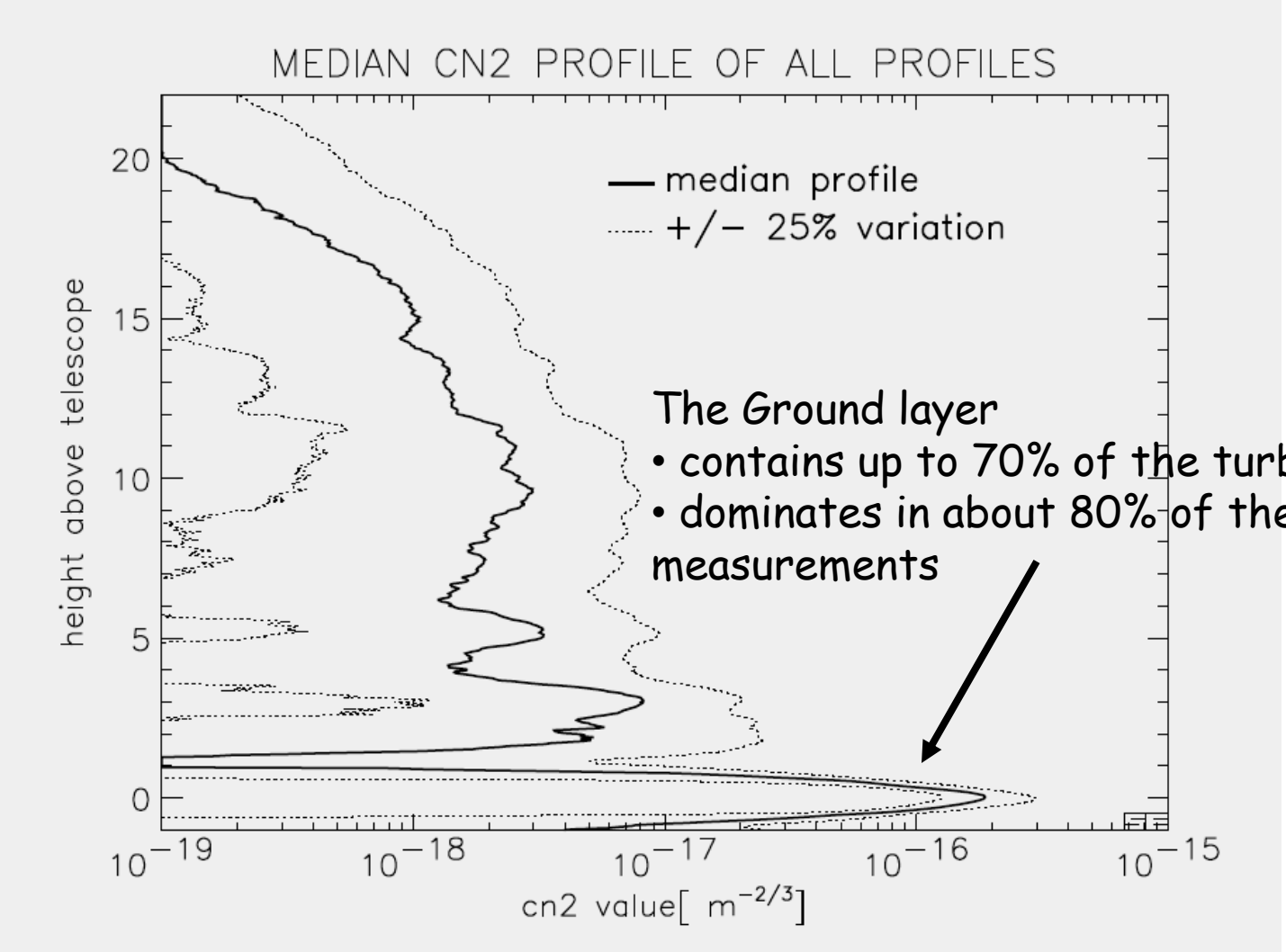
- Multiple sensors
- One Deformable Mirror
- Performance:
  - First order: only seeing reducer!
  - Better seeing statistic artificialy
  - Increase of encircled energy
  - Increase of observing efficiency
- Sky Coverage:
  - >17% with NGS
  - >50% with LGS
- FoV: >4'



Outline

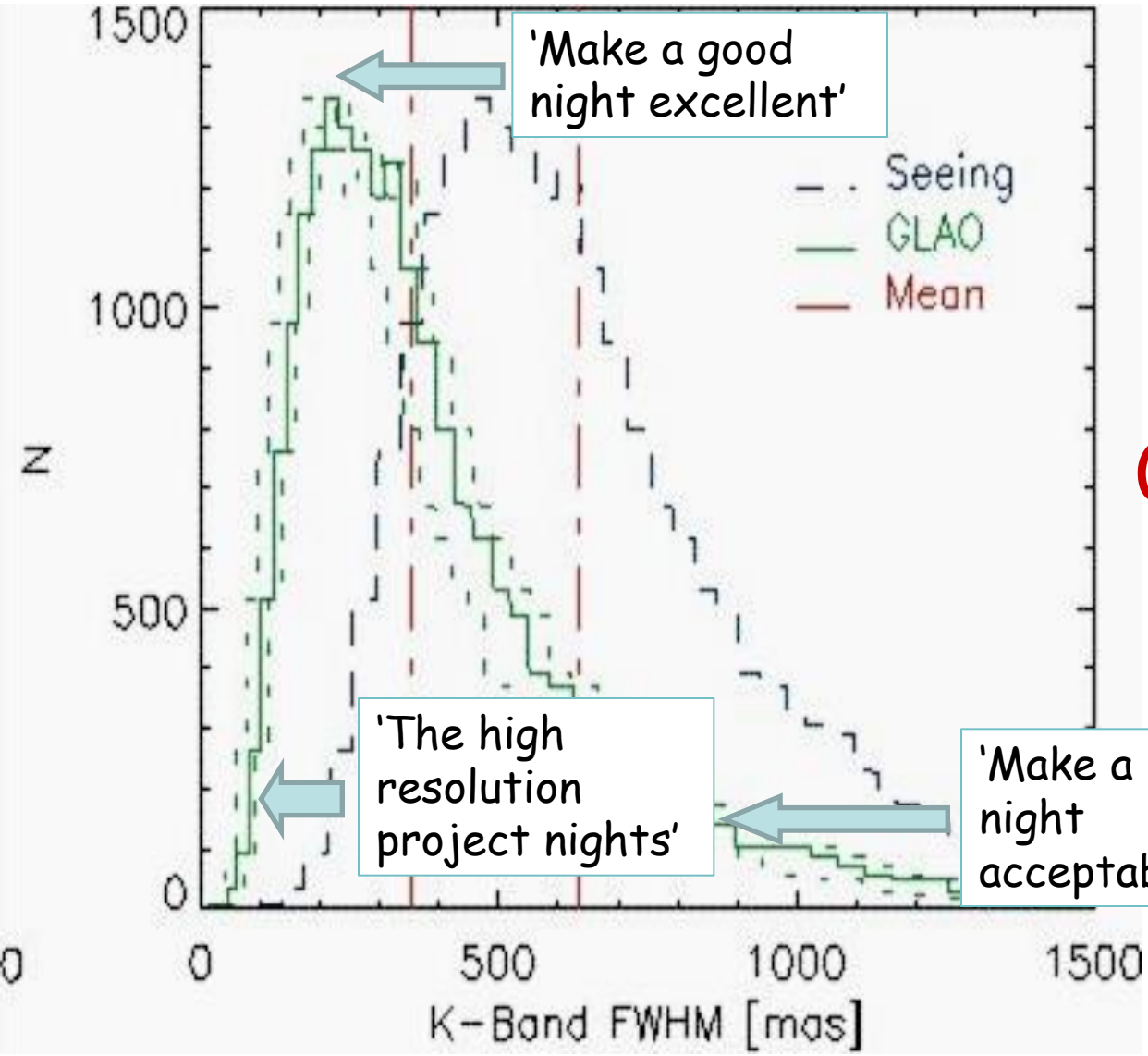
- Who is involved and why did we start?
- Some notes on Adaptive Optics
- **What's the goal of ARGOS**
- How does ARGOS look like?
- Some struggle we had and solved?
- What is next?

Ground Layer on Mt. Graham



$Cn^2(h)$ profile from Mt Graham (S. Egner, E. Masciadri)

ARGOS Goal



Improve the seeing

homogeneous

over a wide field

4'x4'

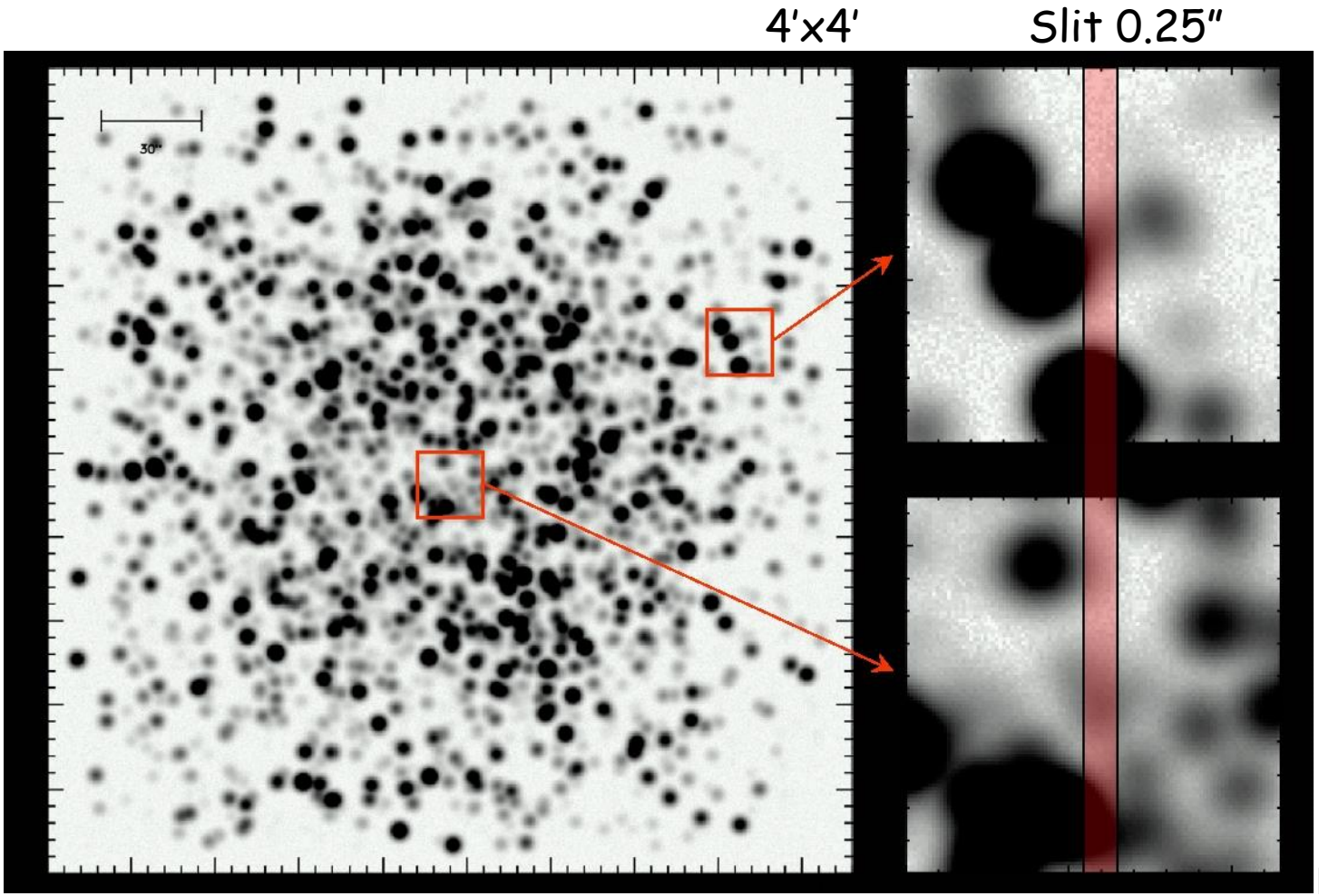
(currently only LUCI)

A factor

2-3 in FWHM

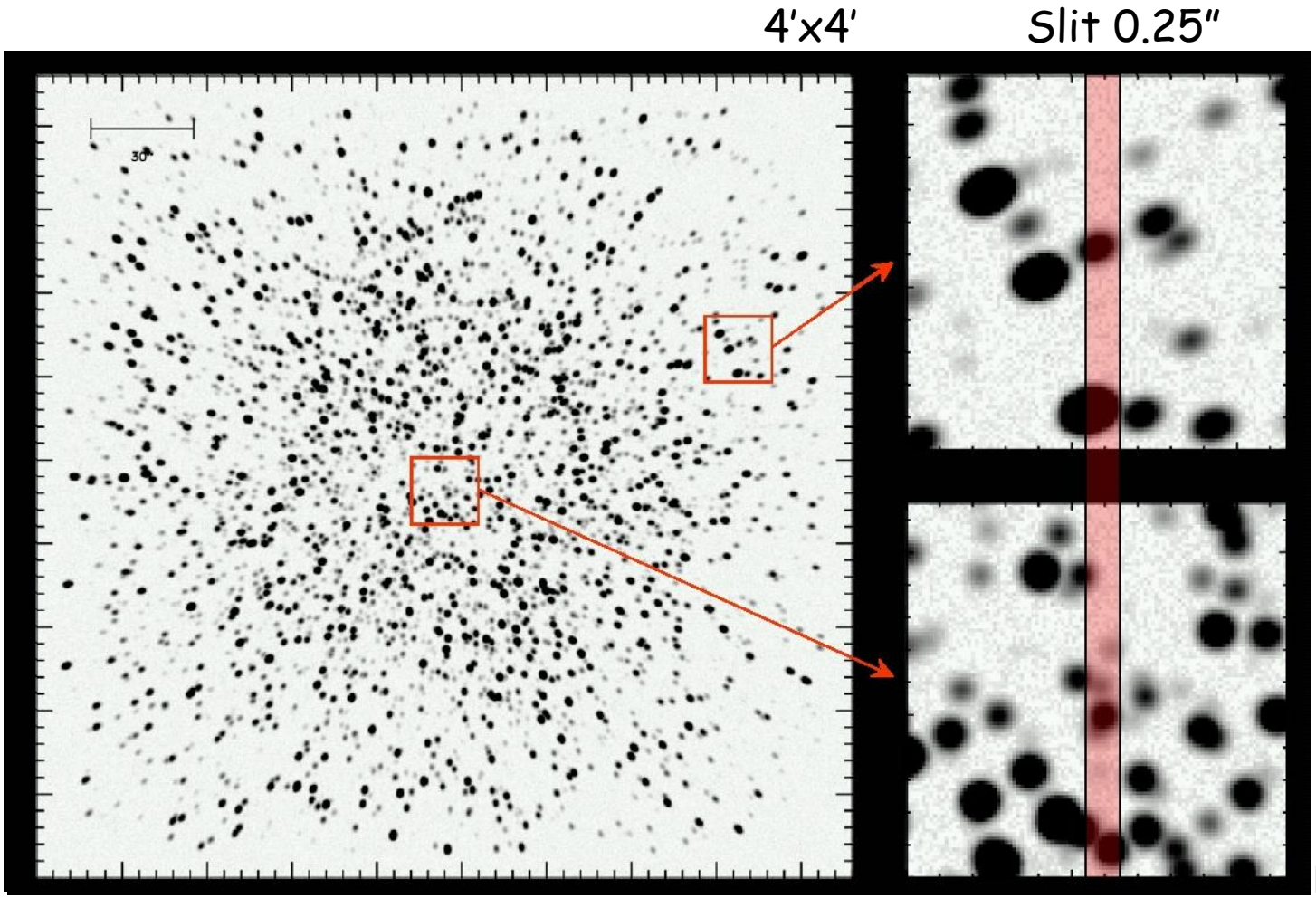
4-9 in slit flux

Increases point source sensitivity of LUCIFER



Rabien 2007

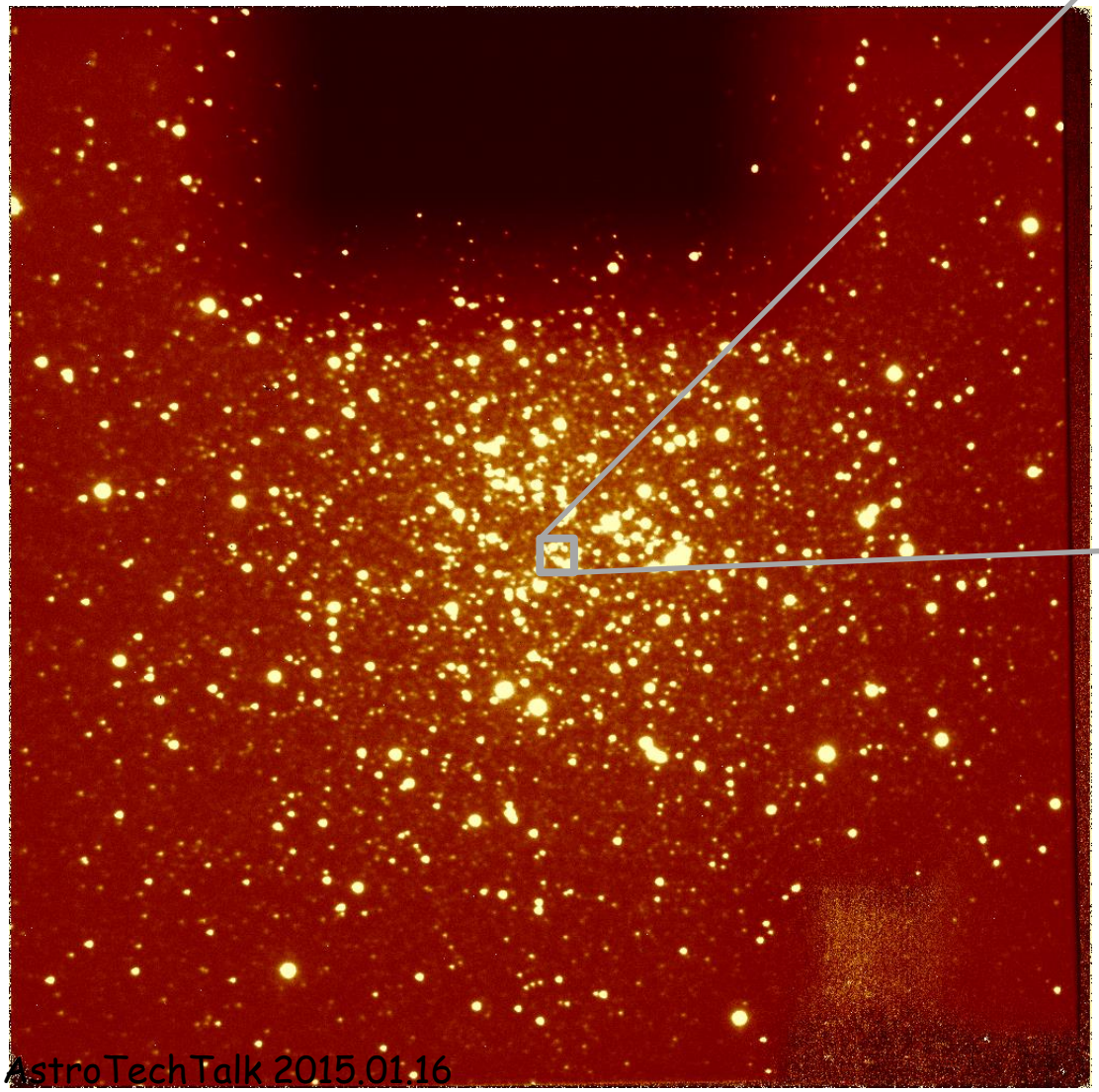
Increases point source sensitivity of LUCIFER



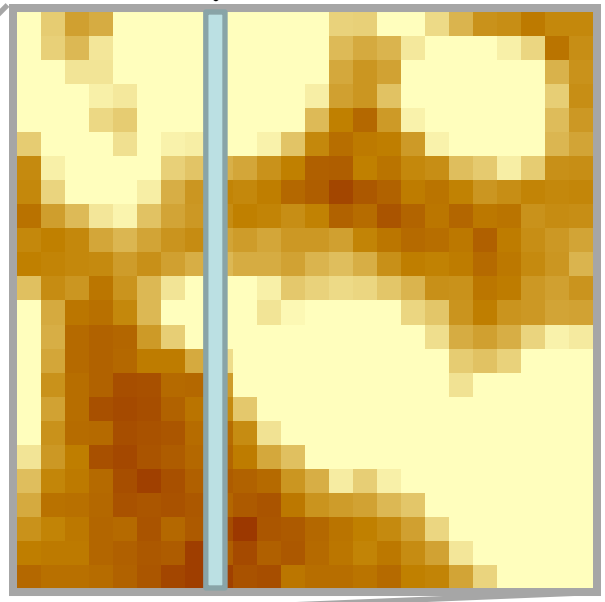
Rabien 2007

Increase point source sensitivity of LUCI

4'x4'



0.25" 7.5"x7.5"



16.05.2014 - M13

One natural guide star

400 Hz, 150 modes

FWHM ~0.3'' center

FWHM ~0.6'' edge

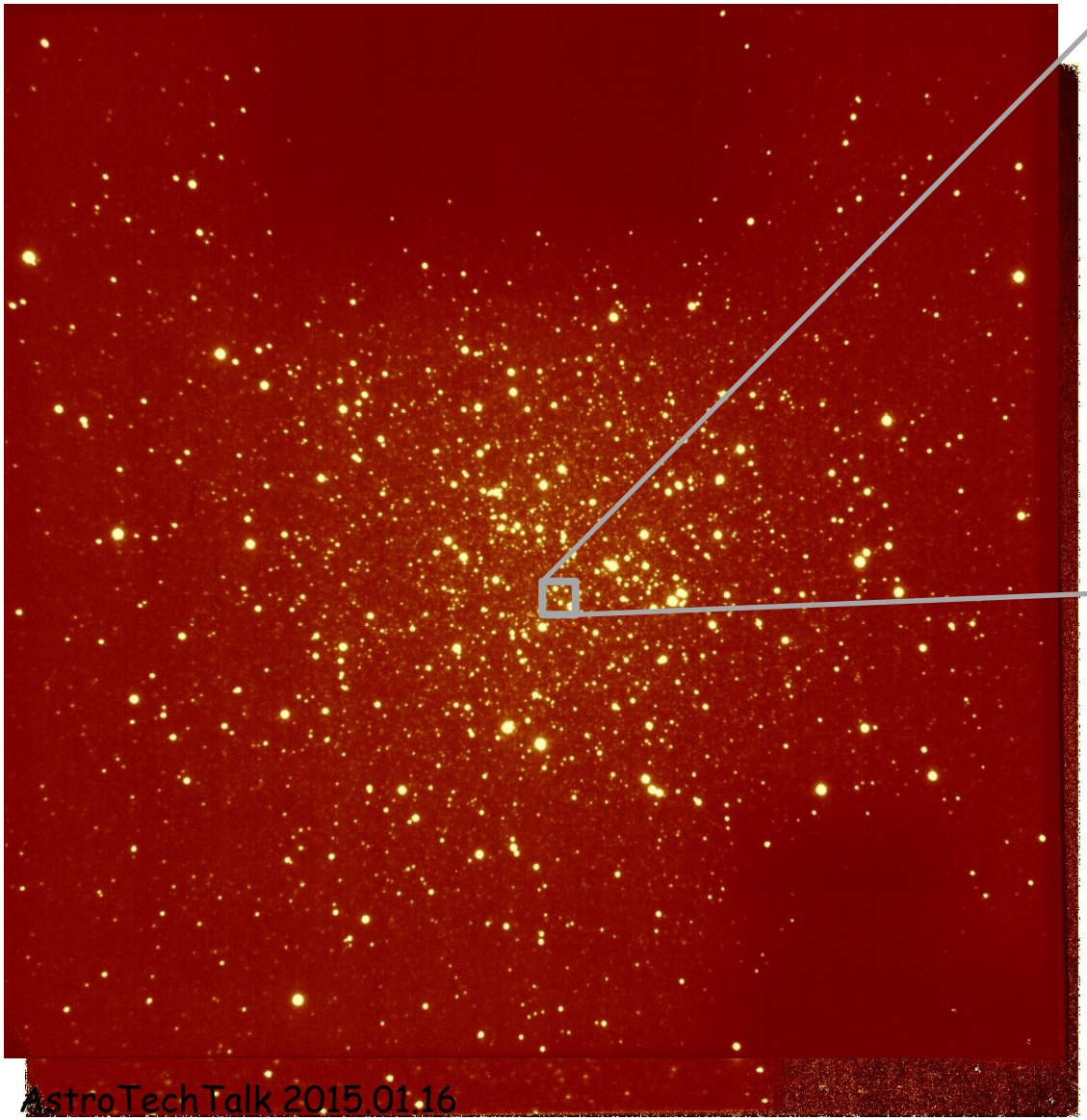
Seeing ~0.9''

Exptime 2.7 sec

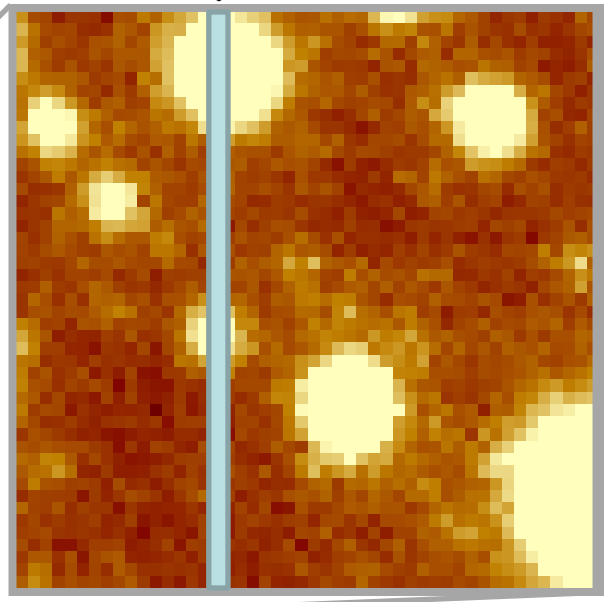
ARGOS

Increase point source sensitivity of LUCI

4'x4'



0.25" 7.5"x7.5"



16.05.2014 - M13

One natural guide star

400 Hz, 150 modes

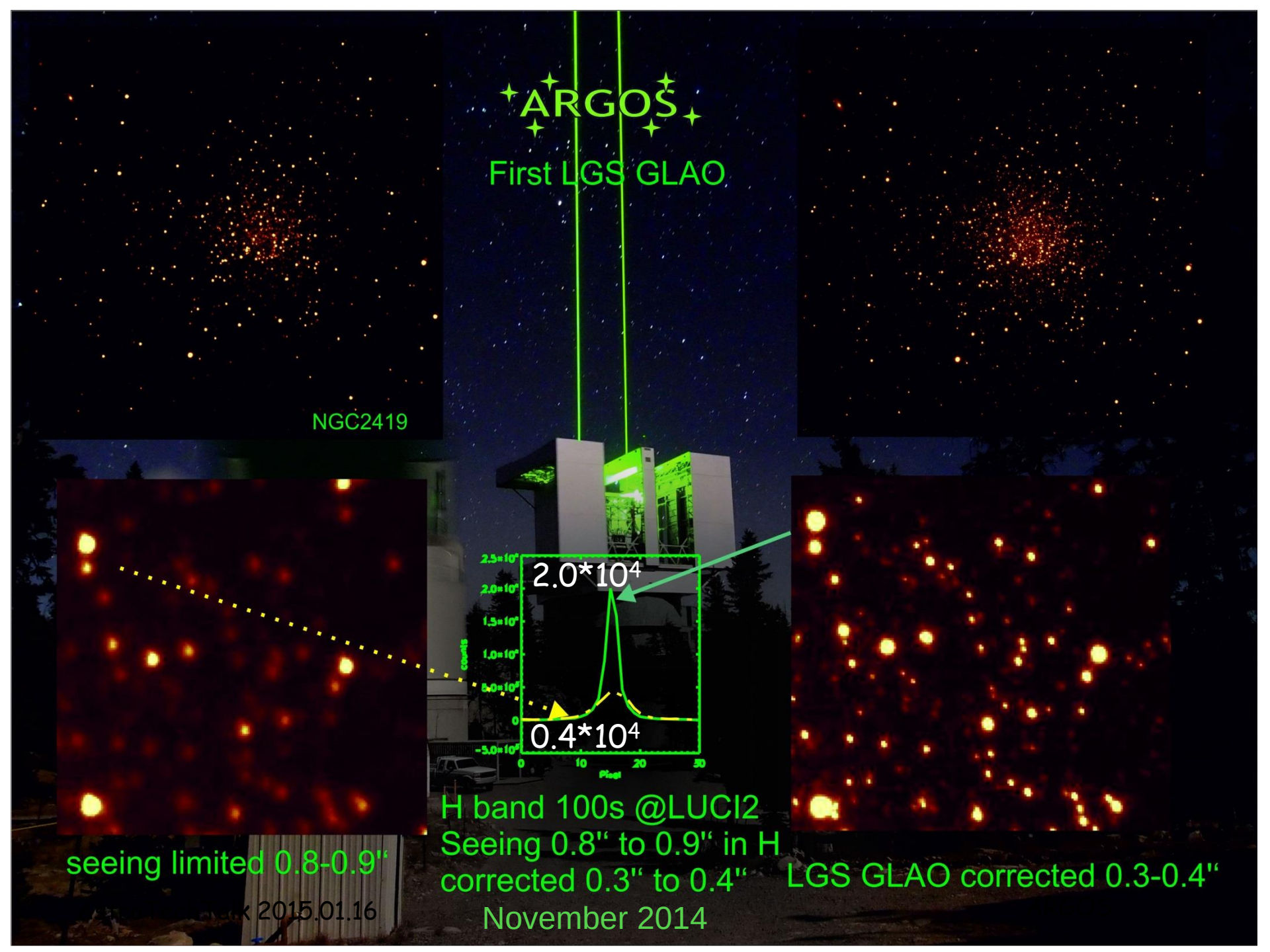
FWHM ~0.3'' center

FWHM ~0.6'' edge

Seeing ~0.9''

Exptime 2.7 sec

ARGOS

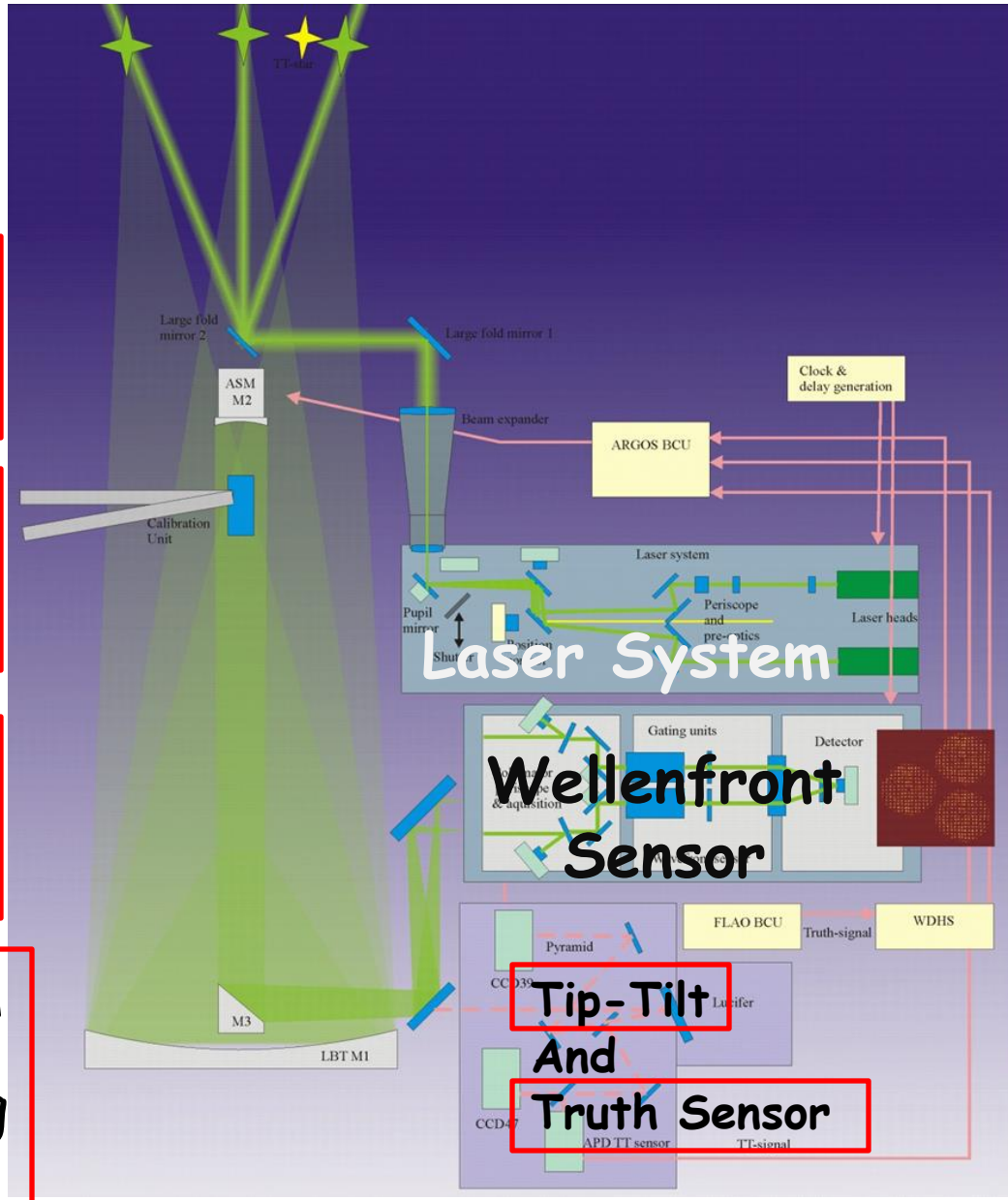

ARGOS
First LGS GLAO
NGC2419
2.0*10^4
0.4*10^4
counts
Pixel
seeing limited 0.8-0.9"
H band 100s @LUCI2
Seeing 0.8" to 0.9" in H
corrected 0.3" to 0.4"
November 2014
LGS GLAO corrected 0.3-0.4"
2015.01.16

Outline

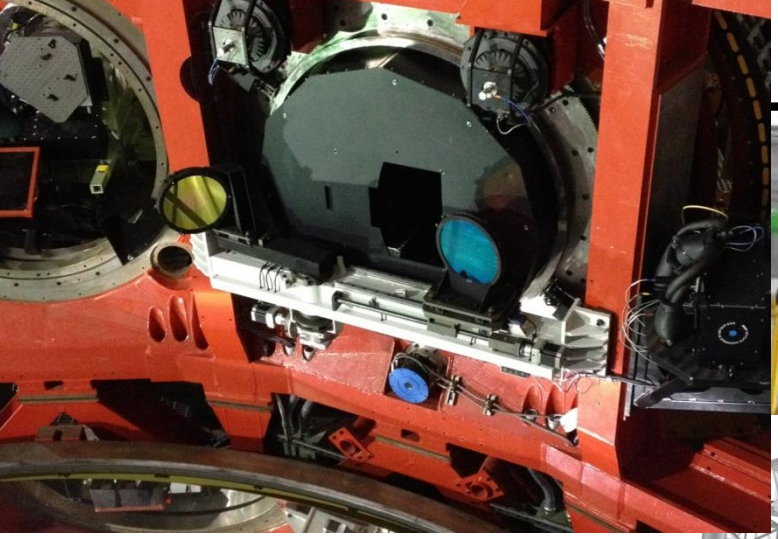
- Who is involved and why did we start?
- Some notes on Adaptive Optics
- What's the goal of ARGOS
- **How does ARGOS look like?**
- Some struggle we had and solved?
- What is next?

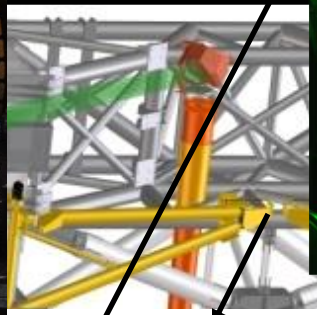
ARGOS Overview

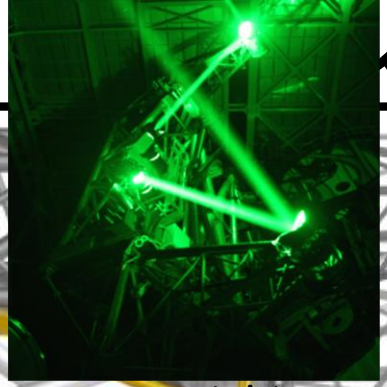
- **Ground layer** AO system
- 2x3 ~18W pulsed **Rayleigh laser** beacon @12km
- Gated **Shack-Hartmann** wavefront sensors
- Natural guide star tip tilt sensor (M_{limit} ~ 19)
- Truth sensor for long term non-common path (existing "First Light AO" sensor)



ARGO ke?

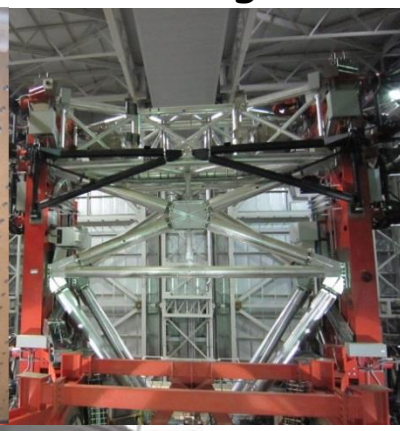






Laser launch system
Fold mirrors

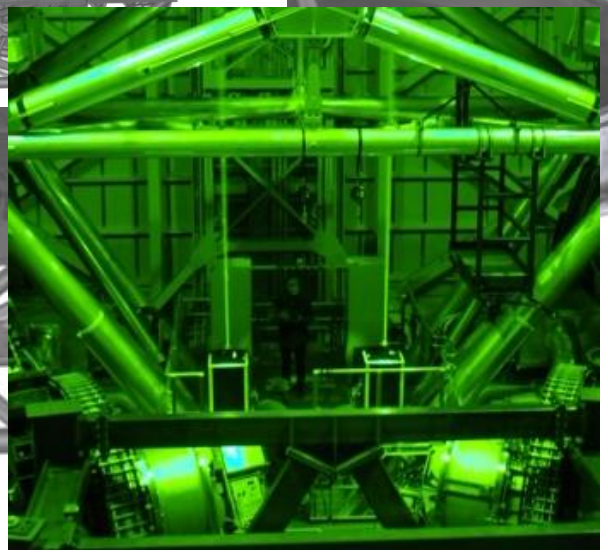
Calibration Unit + swing arms



Dichroic + Foldmirror

Wavefront Sensor

Lasers

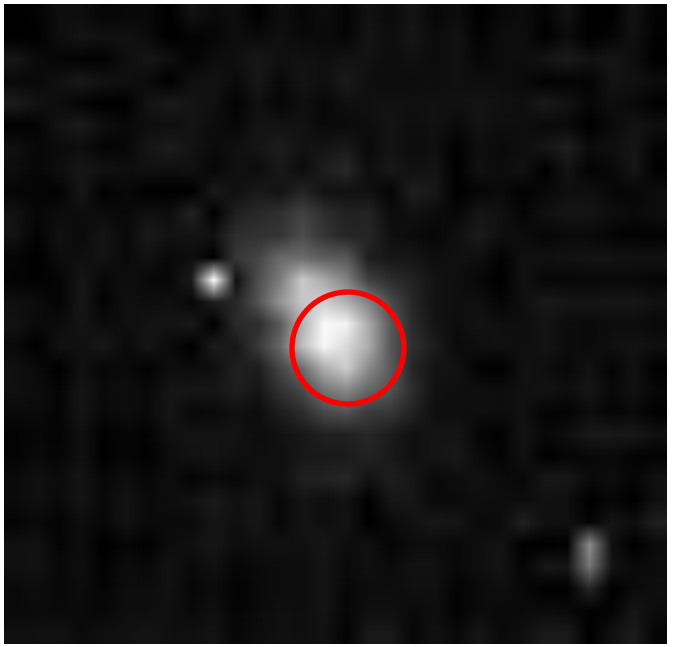


Outline

- Who is involved and why did we start?
- Some notes on Adaptive Optics
- What's the goal of ARGOS
- How does ARGOS look like?
- **Some struggle we had and solved?**
- What is next?

Launch Telescope

- Astigmatism due to radius on the "flat" launch mirrors
- Changes with temperature
- Lasers heating up the mirror

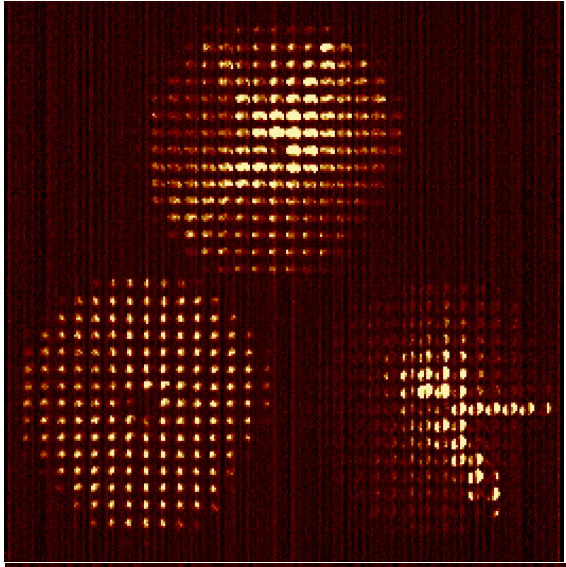


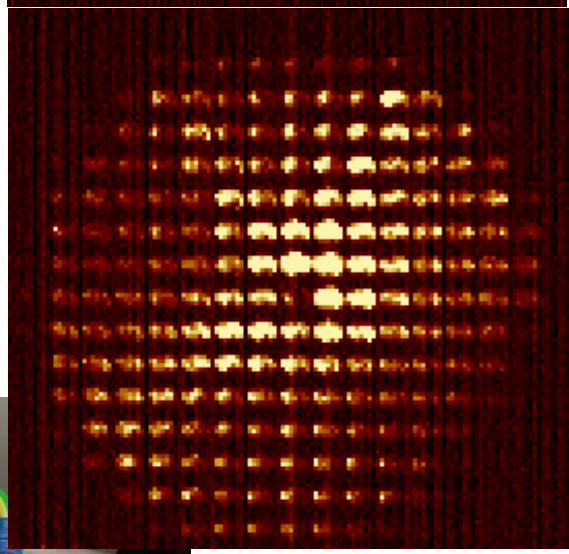
Countermeasure:

- Astigmatism corrector in the launch path, set by a temperature model
- Heater on the back side of the mirror?

Pockels Cells

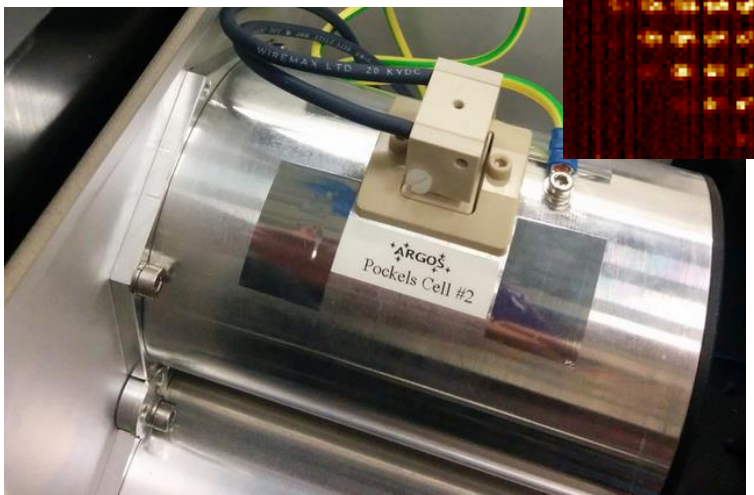
- Pockels cells "de-aligned"
- Ozone was "eating" the mounting





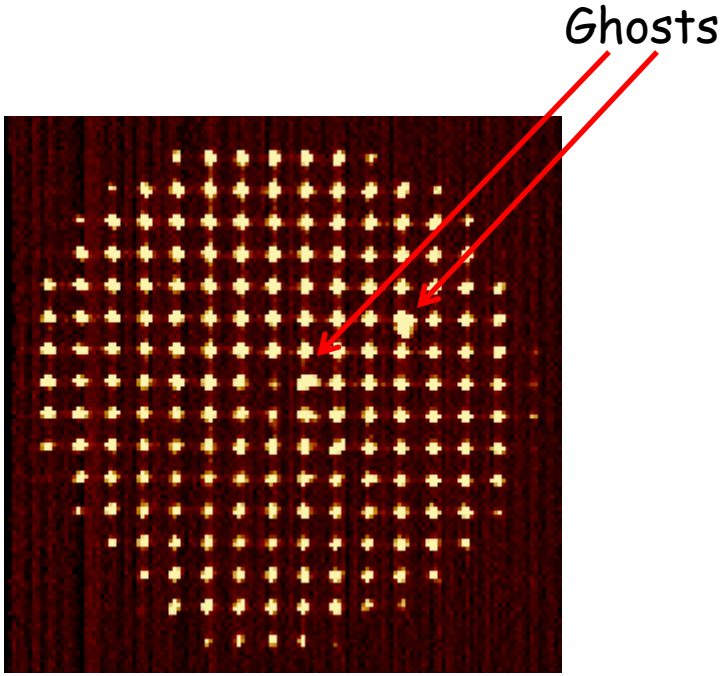
Countermeasure:

- New high voltage electrodes
- New material
  - LPVDF
- New mounting



Calibration Unit

1. Ghosts in sub-apertures
2. Couldn't get all three laser at once into the wavefront sensor



Countermeasure:

1. New hologram
2. Different fiber plate

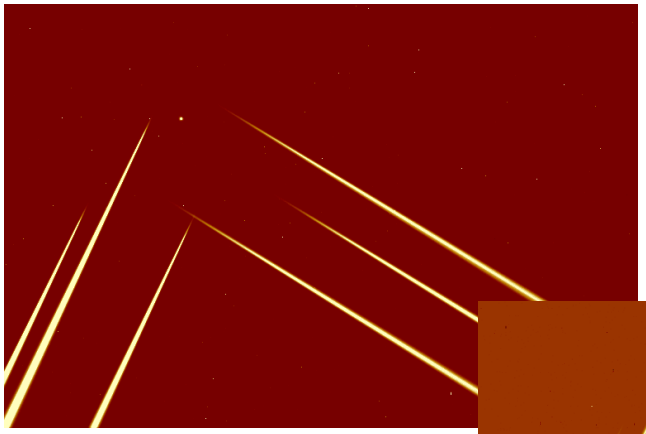
Operations

- Overheads due to
  - Spotters (2+2 spot + 1+1 coord)
  - Aircraft
  - Satellites
- Lot of people to operate (4+)

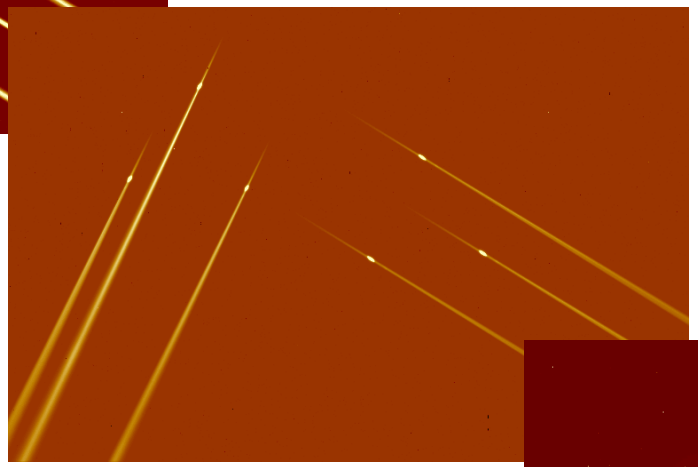
Countermeasure:

- Installation of TBAD
  - detects transmitted signal from airline planes
- Improved aircraft camera
- More Software, much more Software, a lot much more Software …..

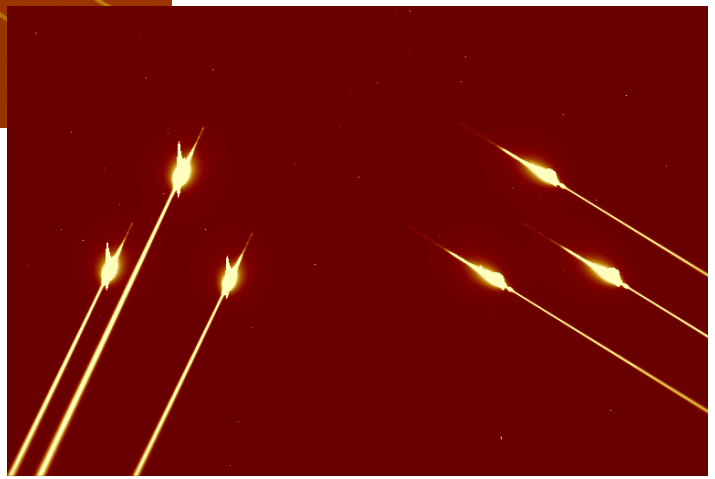
Observation vs. Cirrus



Clear sky

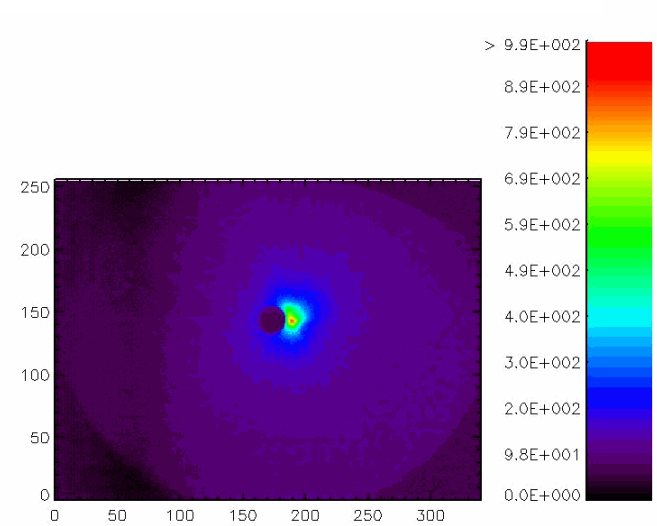


Some high cirrus
No problem

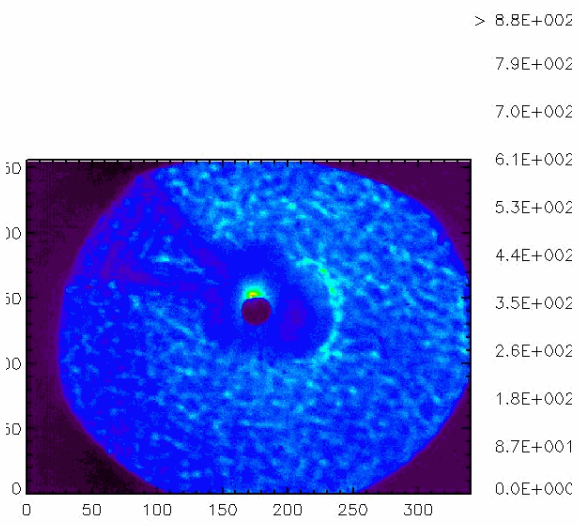


Strong attenuation

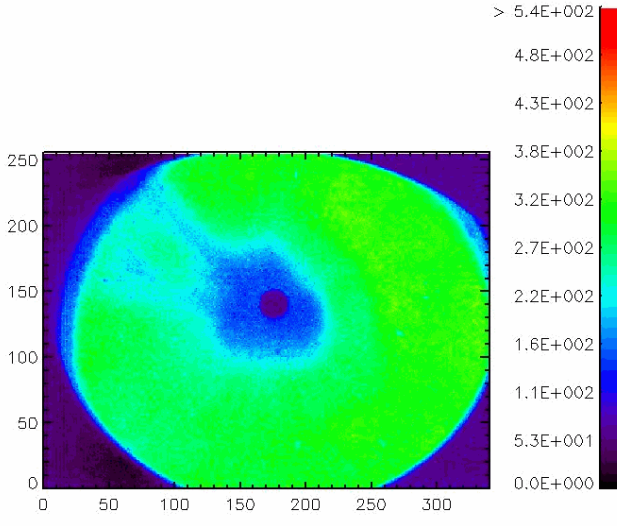
LGS with cirrus background



Clear sky



Some cirrus



Opaque sky

The political counterstrike

- Complain about launching lasers at Mt Graham
  - Through Forest Service to University of Arizona, which forwards the complain to LBT Observatory.
- No official statement who it is to the ARGOS team.

Outline

- Who is involved and why did we start?
- Some notes on Adaptive Optics
- What's the goal of ARGOS
- How does ARGOS look like?
- Some struggle we had and solved?
- **What is next?**

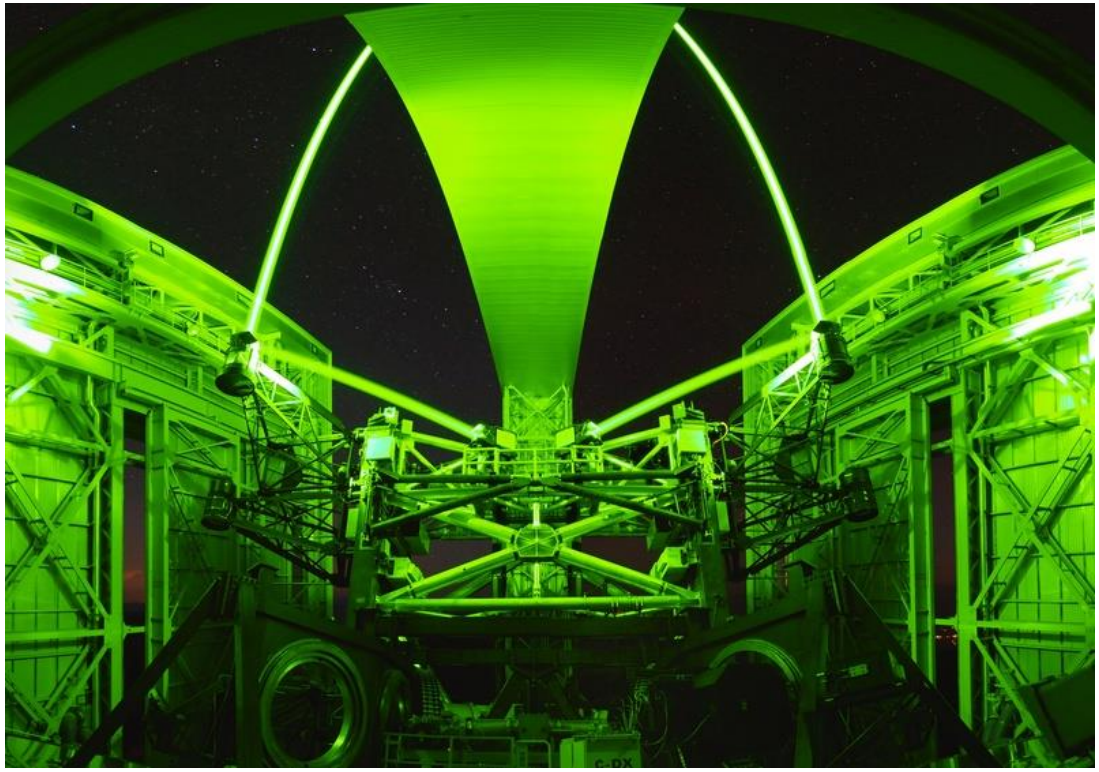
What is next?

Testing spectroscopy March 2015

Getting the system more efficient until July 2015

Installing, commissioning SX side July - Dec 2015

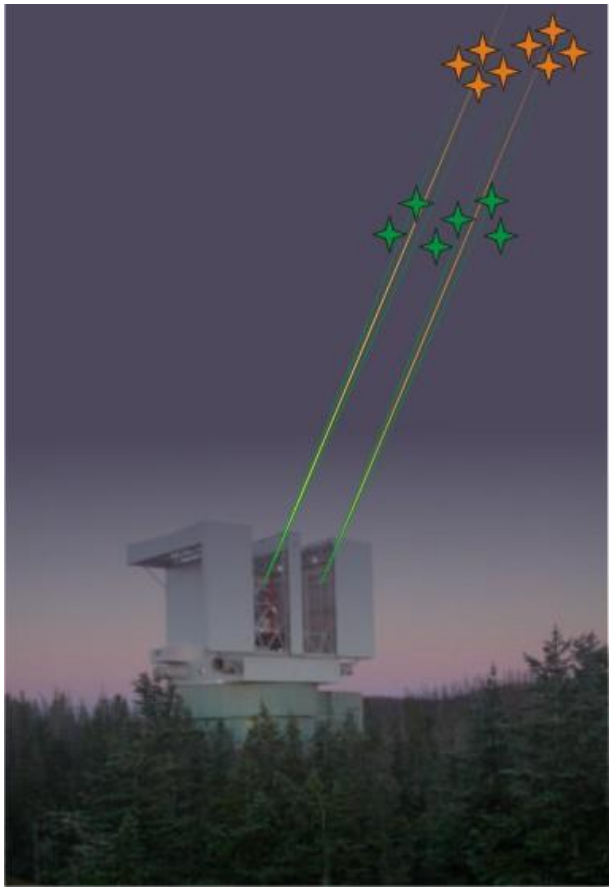
Binocular mode Jan - mid 2016, Handover mid 2016?



ARGOS Upgrade Proposal

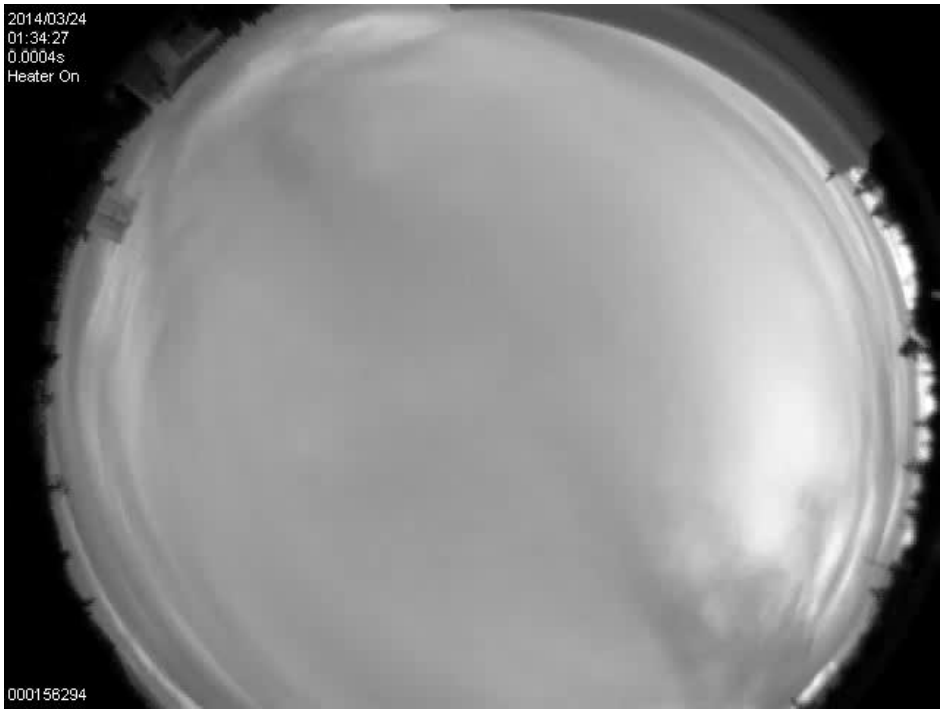
- A phased approach towards highest resolution at visible wavelength
- A Na laser port is already prepared in the system

1) All sky diffraction limit at IR
2) LGS AO at visible wavelength
3) LGS guided Interferometry



Conclusion

ARGOS works, works robust and stable and provides the promised performance.



SX is missing.

There is still a lot of work to get it easy to operate and integrated with LUCI.

ARGOS