Raven

a scientific and technical Multi-Object Adaptive Optics (MOAO) demonstrator

Olivier Lardière, Célia Blain, Colin Bradley, Reston Nash, Darryl Gamroth, Kate Jackson, Dave Andersen, Shin Oya, Yoshito Ono, & all RAVEN team

Why MOAO?

- AO corrected FoV is limited by anisoplanetism

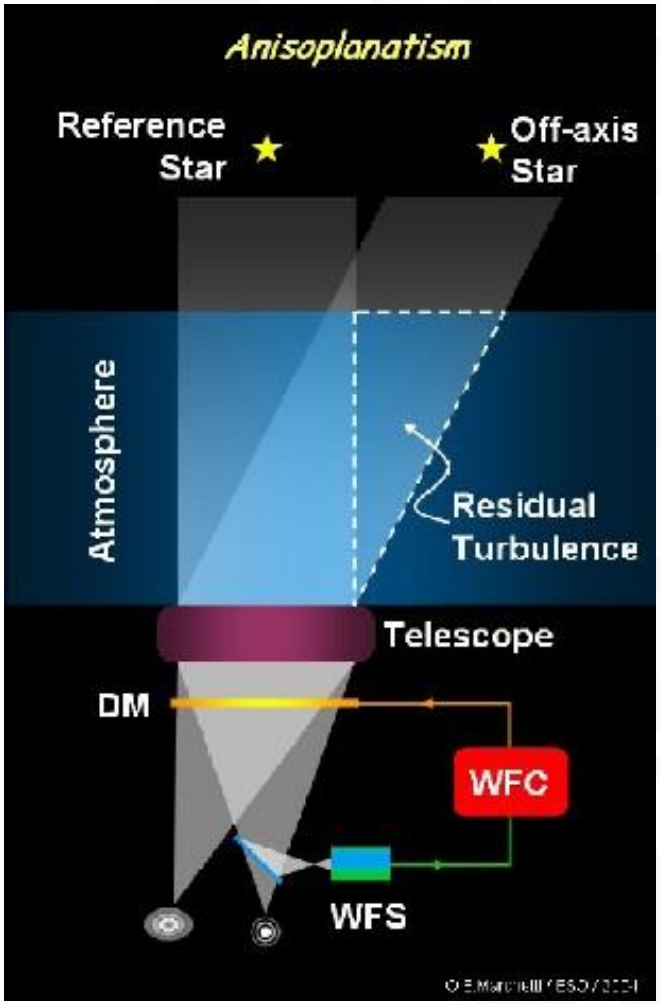
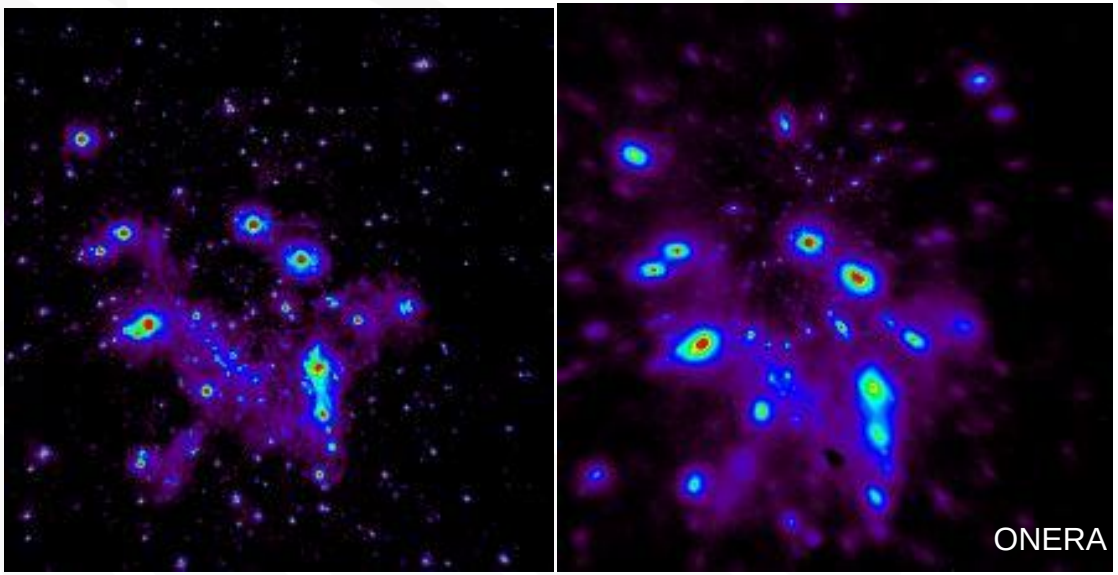


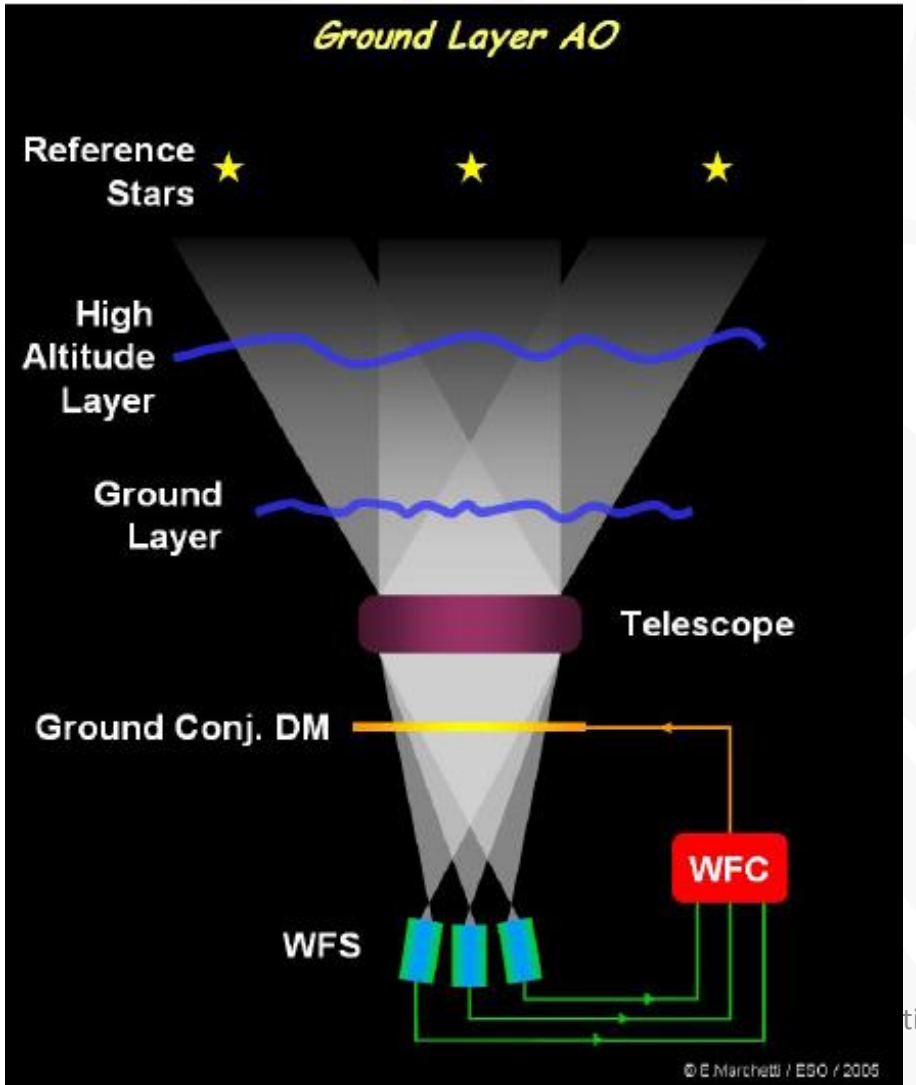
Image of galactic centre:

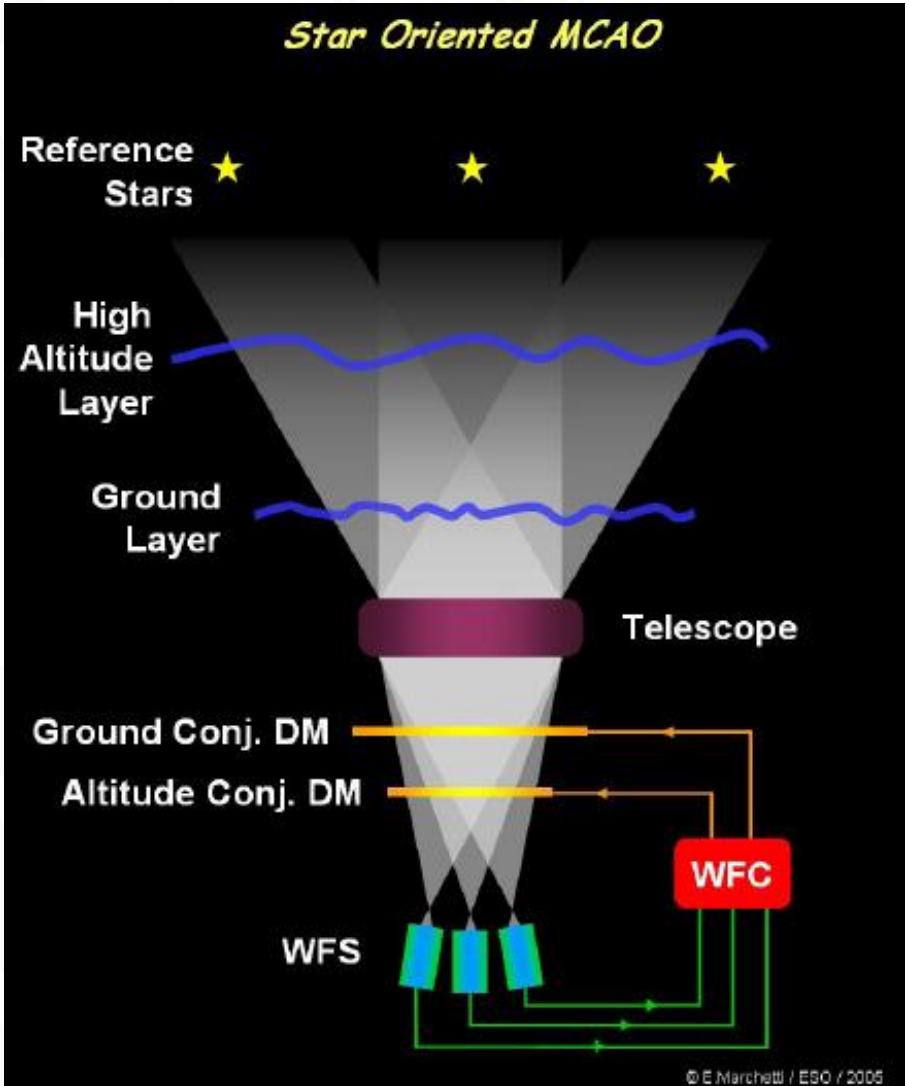
w/o anisoplanetism *w/ anisoplanetism*



How to increase the corrected FoV?

- Increase the # of guide stars and DMs

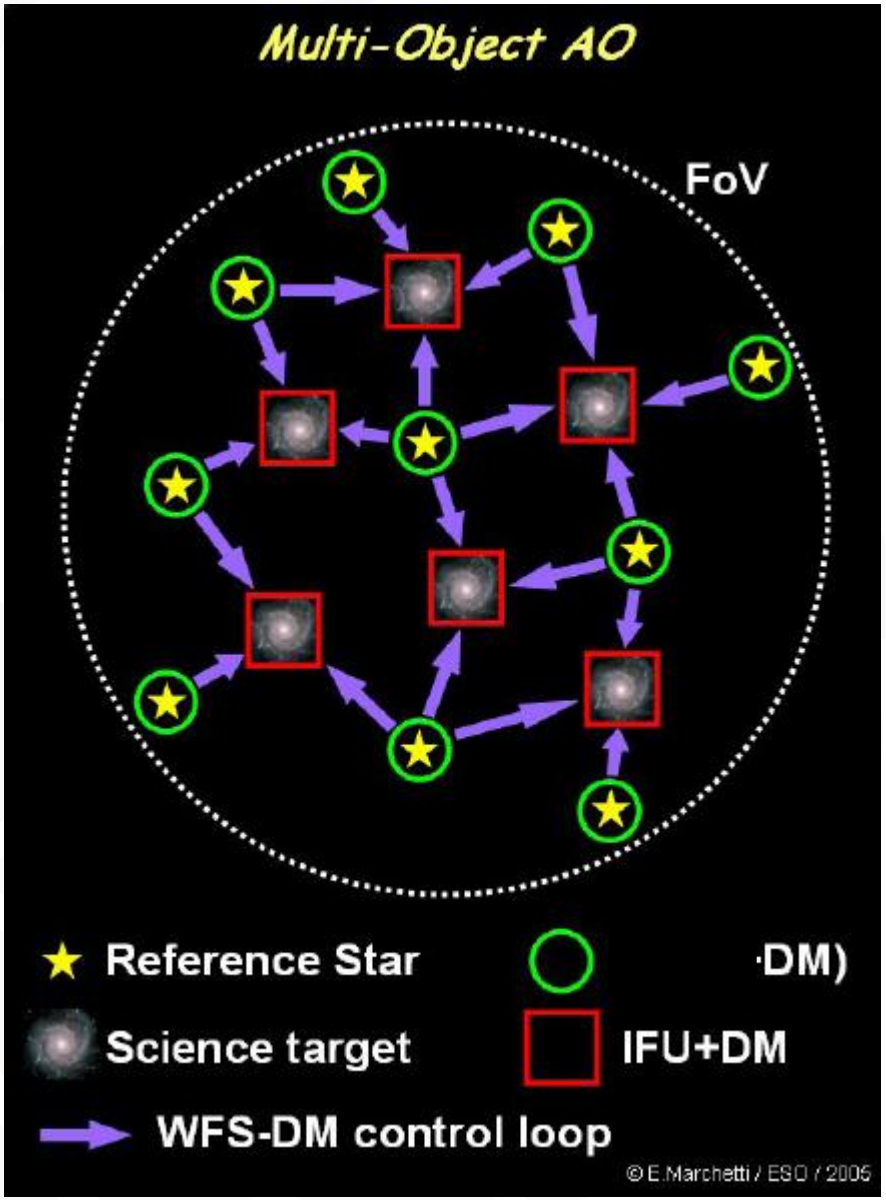




tical

Multi-Object Adaptive Optics

- We don’t need to correct the whole FoV, just a few patches
- MOAO uses multiple WFSs to reconstruct a volume of turbulence
- A single DM can be used to apply the optimal AO correction for any single location in the field



ESO

Multi-Object Adaptive Optics

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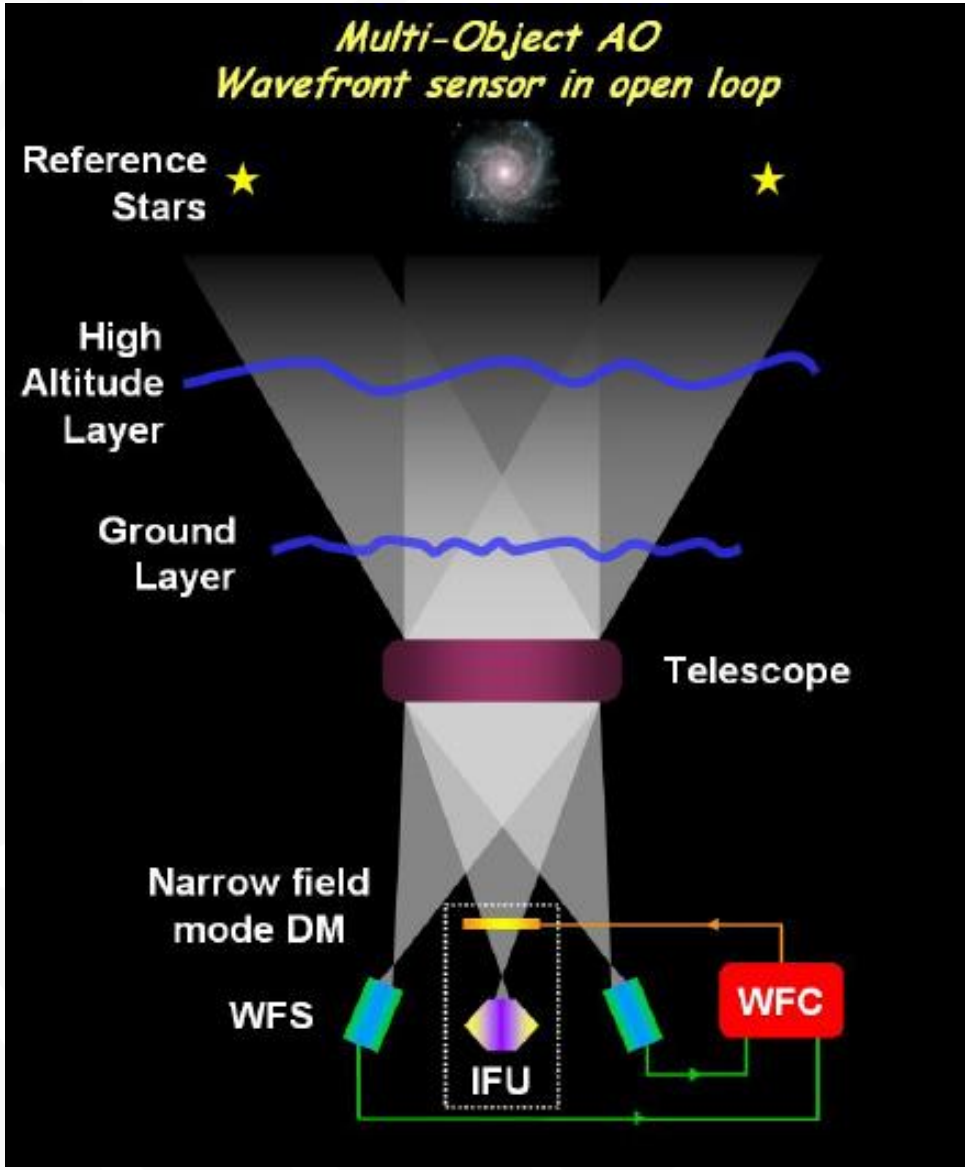
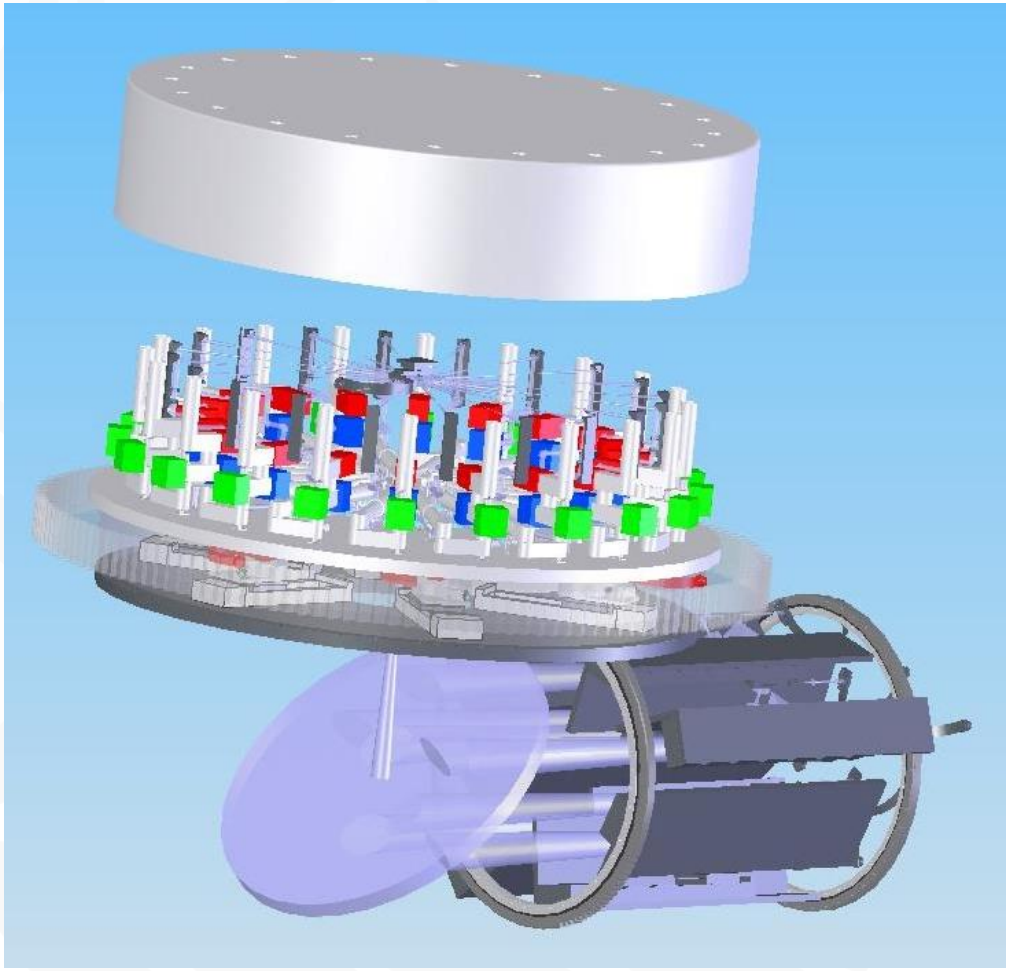
- A single DM can be used to apply the optimal AO correction for any single location in the field
- MOAO correction is applied in open loop



ESO

MOAO Challenges

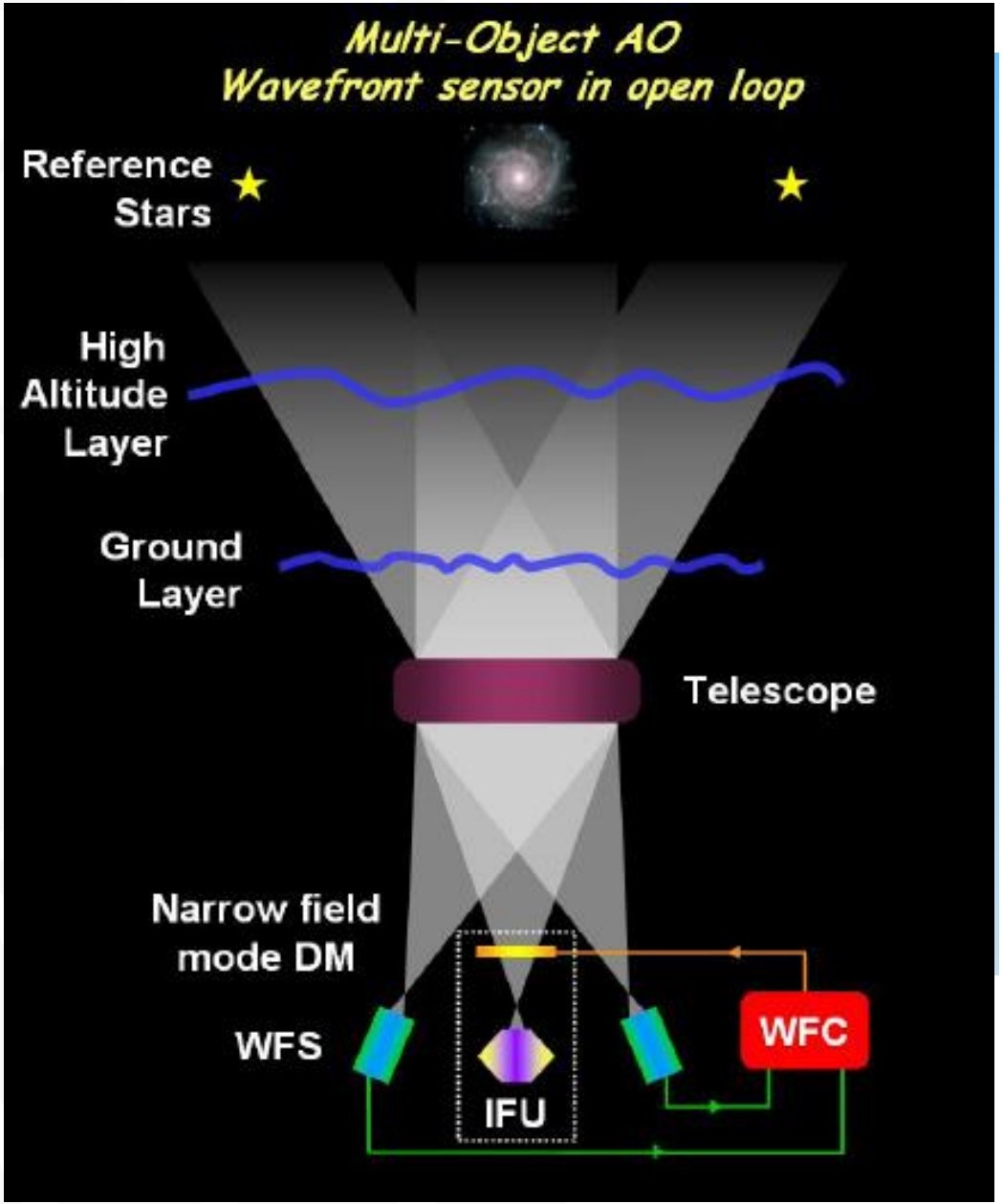
- Pickoff system
  - *Up to 20 deployable pickoff mirrors are planned for ELTs (IRMOS, MOSAIC)*



IRMOS (Eikenberry & Andersen 2006)

MOAO Challenges

- Pickoff system
  - *Up to 20 deployable pickoff mirrors are planned for ELTs (IRMOS, MOSAIC)*
- Tomography
  - *Finite number of WFSs*
  - *Requires turbulence model*
  - *Noise & static error propagation*
- Open-loop control
  - *Wide-field WFS*
  - *DM linearity & repeatability*
  - *DM/WFS calibration*

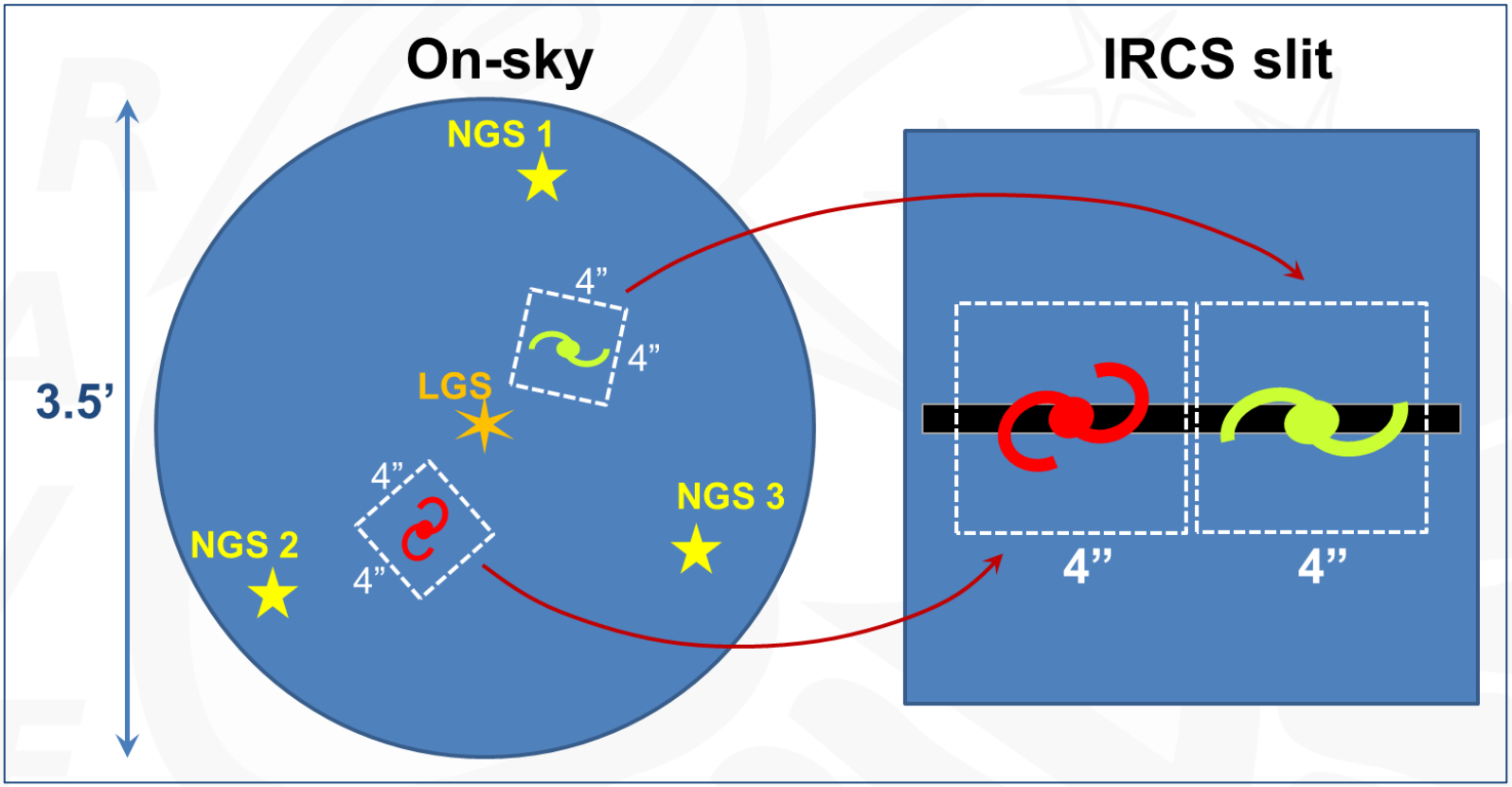


Goals of Raven

- Technical & Science demonstrator
  - *Prepare MOAO instrumentation for ELTs*
  - ***Get first science results from MOAO***

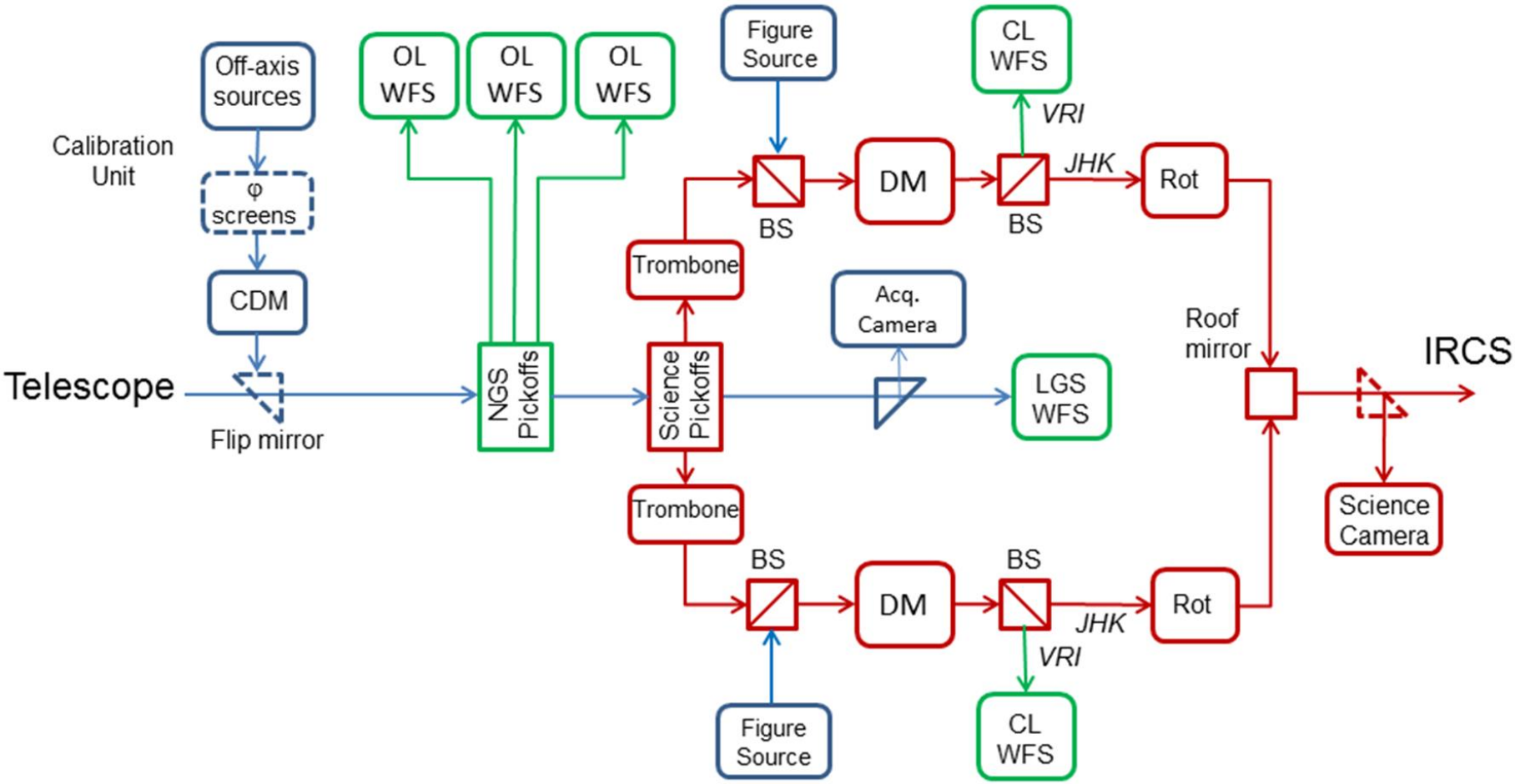
- Raven = 1st MOAO system on an 8m-class telescope feeding a NIR science instrument (IRCS):
  - *Founded by CFI (Canadian Fund for Innovation) ~ 4M$*
  - *Designed and built by UVic, HIA/NRC and INO*
  - *Fast track project:*
    - CoDR in Mar 2011
    - Shipped to Subaru in Jan. 2014,
    - First night in May 2014

Raven Concept

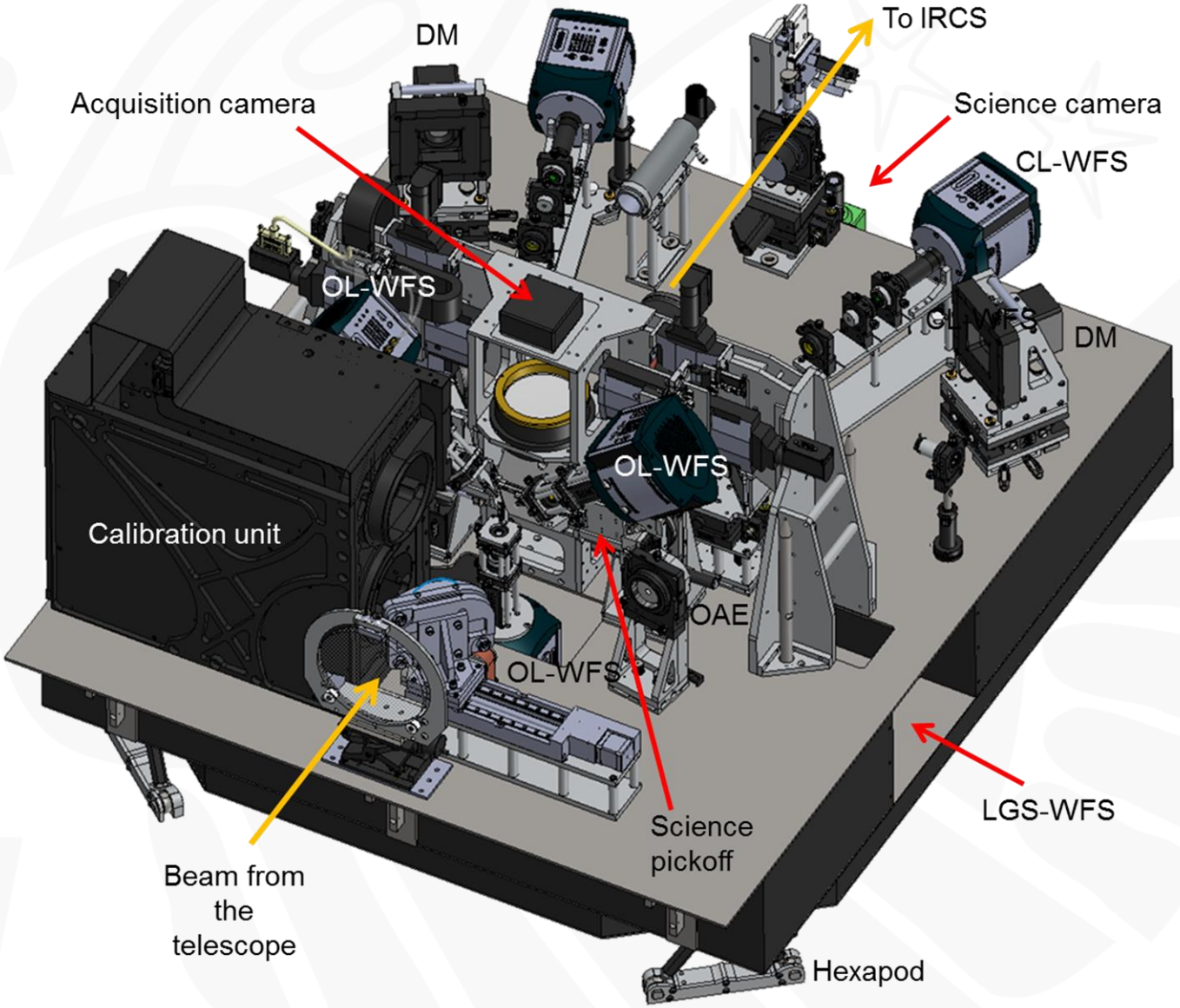


- 2 science targets are reimaged on the IRCS slit
- Each target can be positioned on the slit by moving the pickoff arms
- Each target can be rotated with the K-mirror

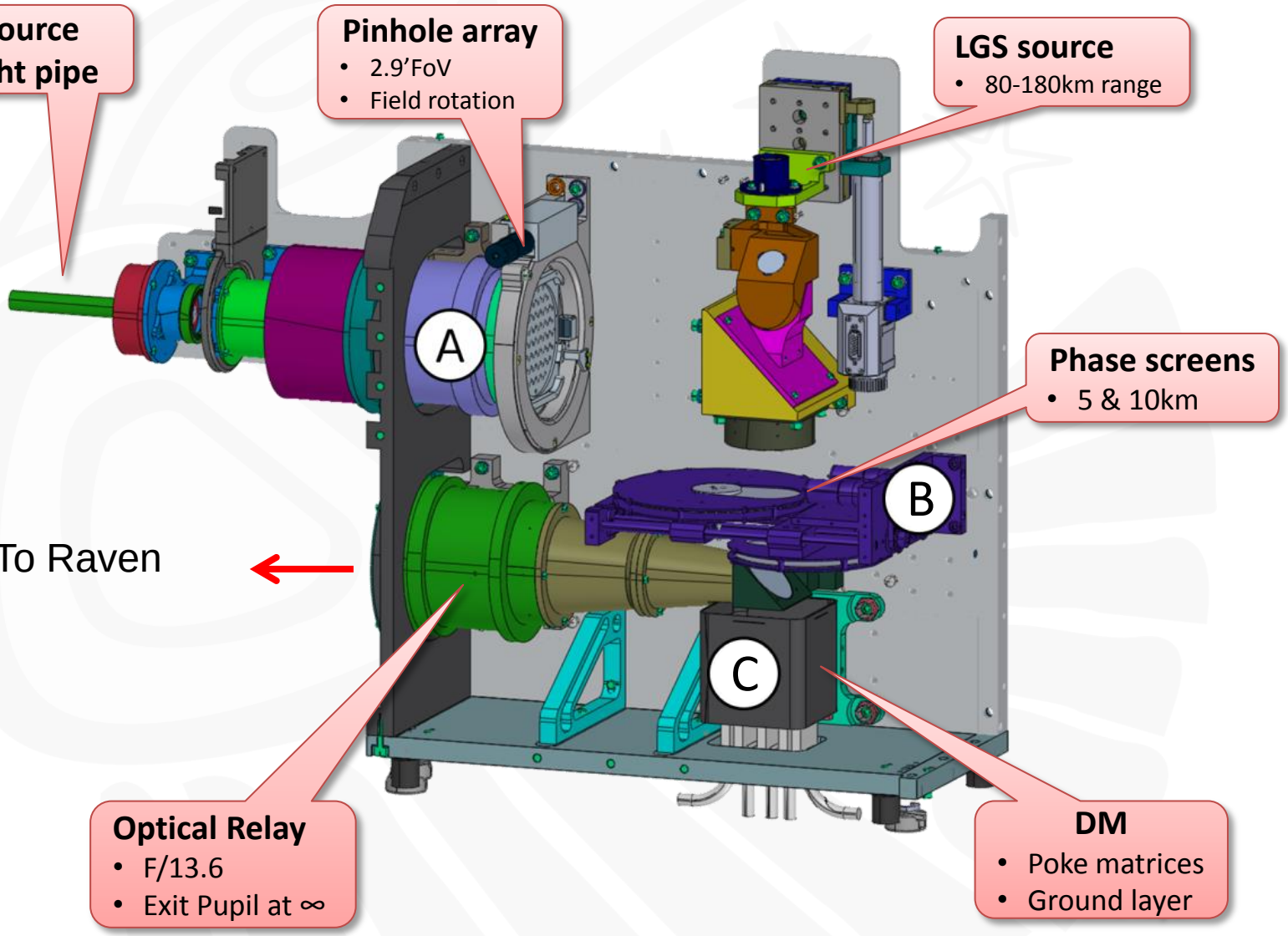
Optical Layout



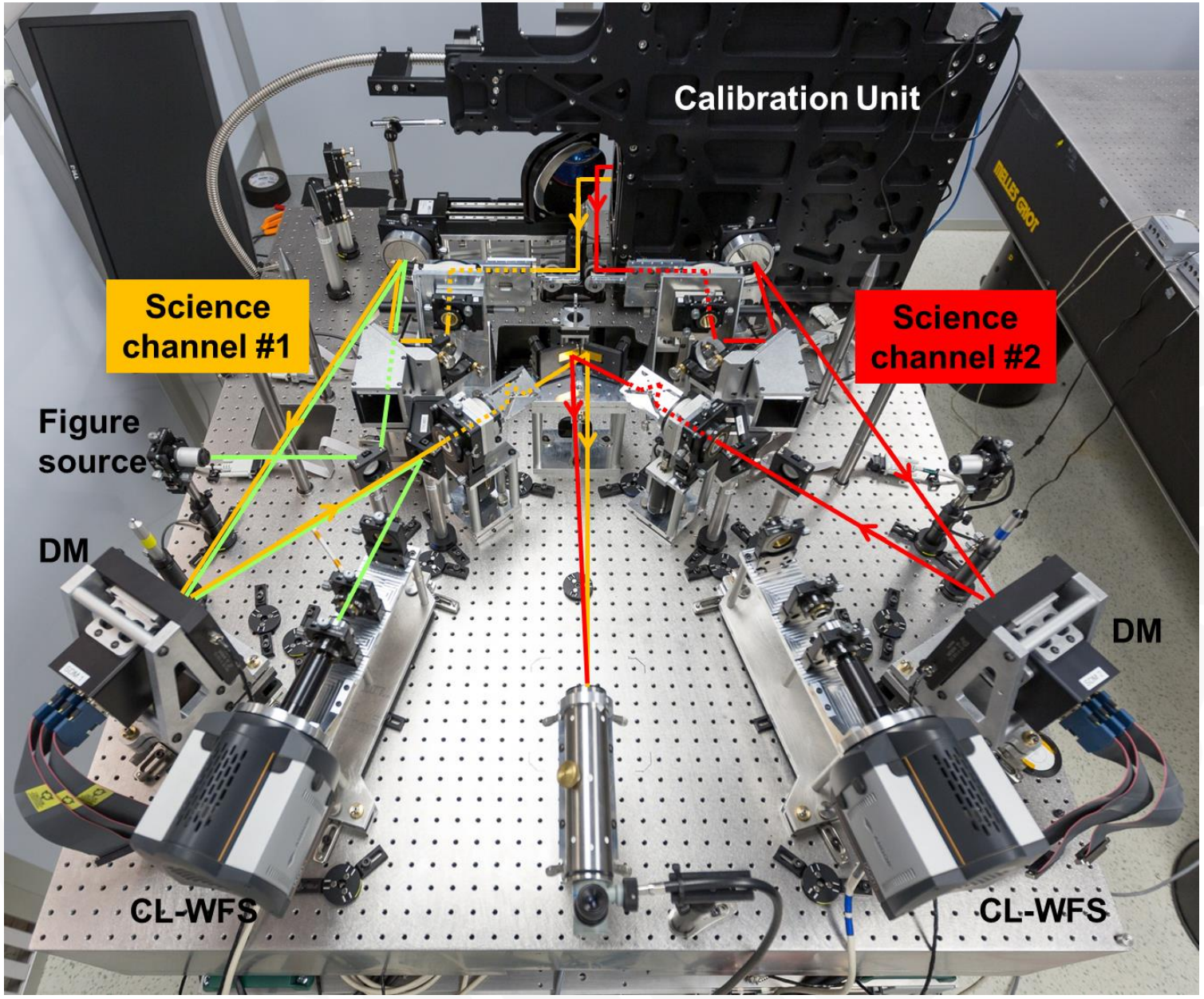
CAD Model


DM
To IRCS
Acquisition camera
Science camera
CL-WFS
OL-WFS
CL-WFS
DM
OL-WFS
Calibration unit
OAE
OL-WFS
Science
pickoff
LGS-WFS
Beam from
the
telescope
Hexapod

Calibration Unit = Subaru Telescope in a box!

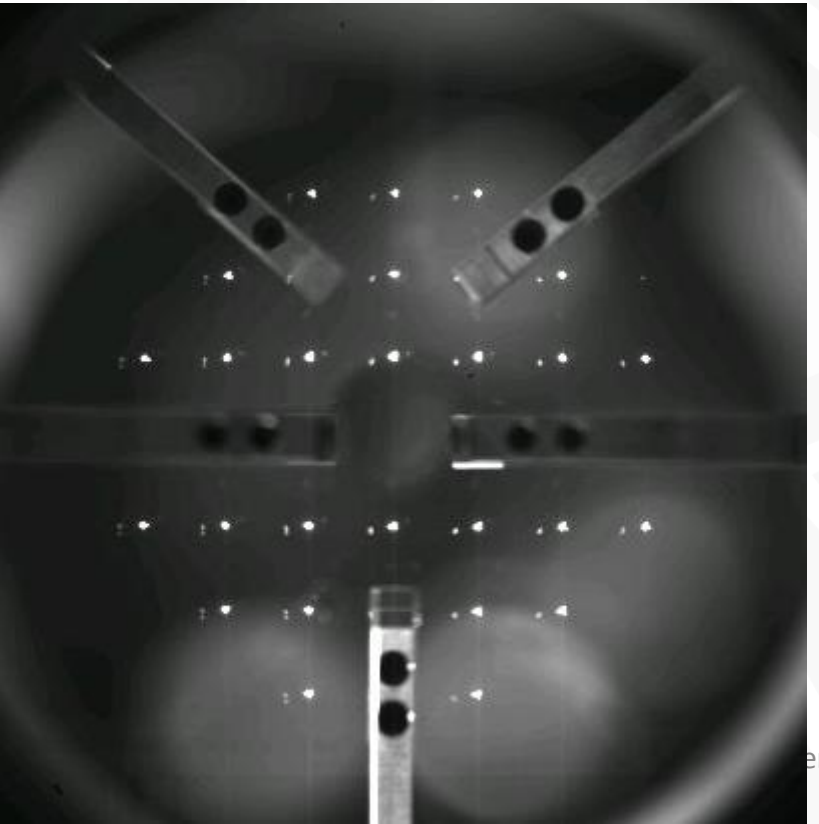


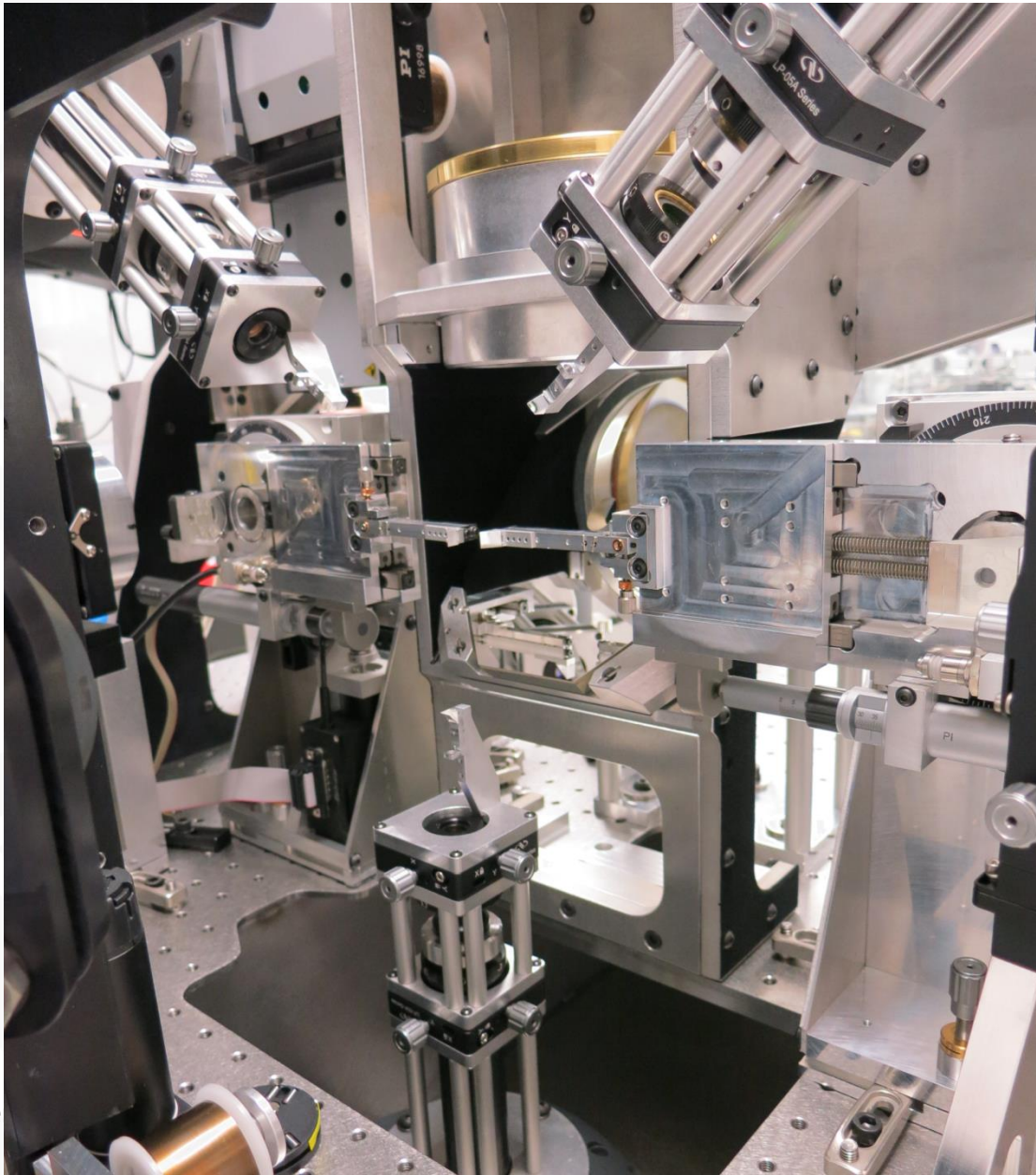
The 2 science channels implemented



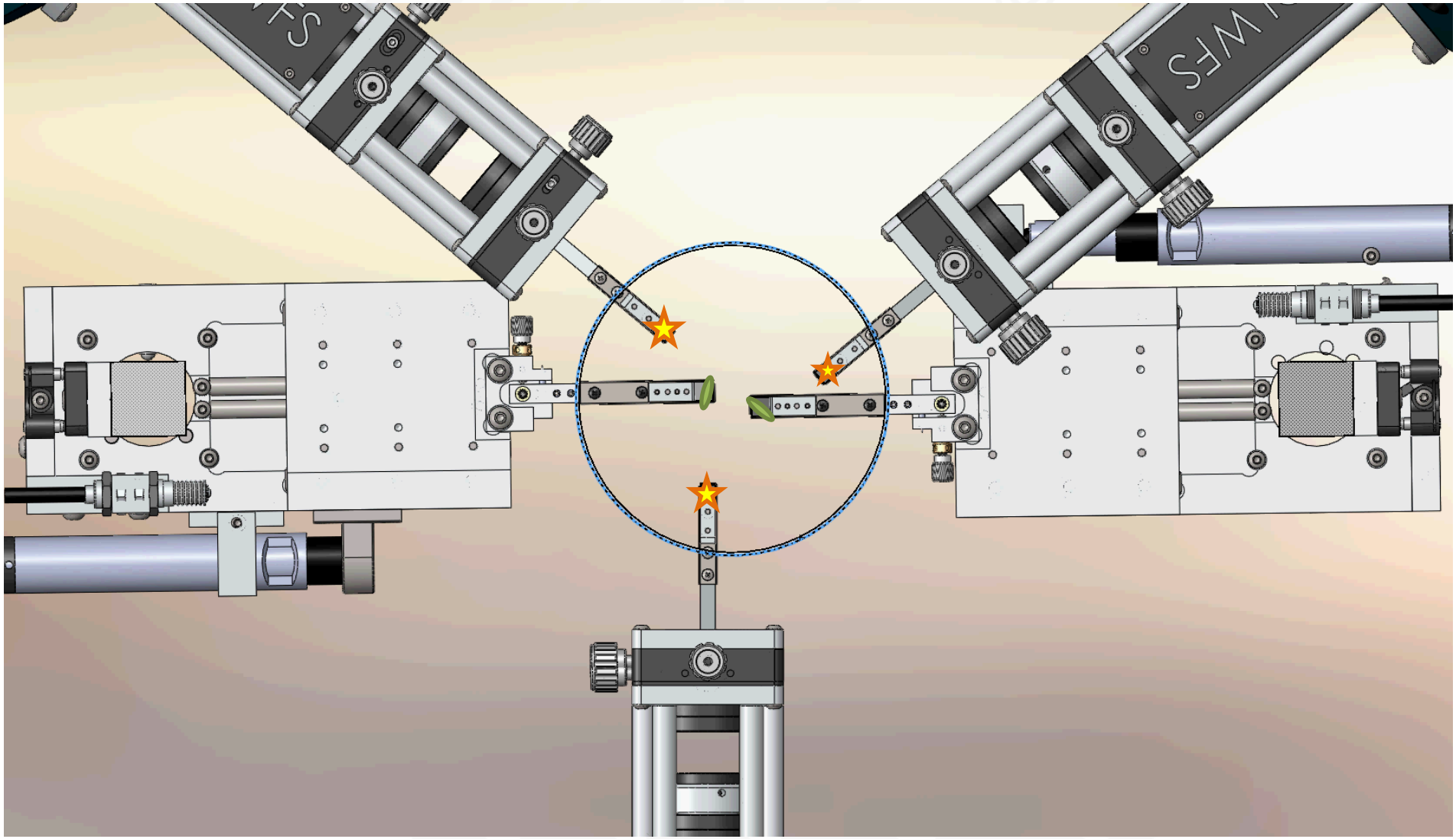
Raven pick-off mirrors

Acquisition camera image



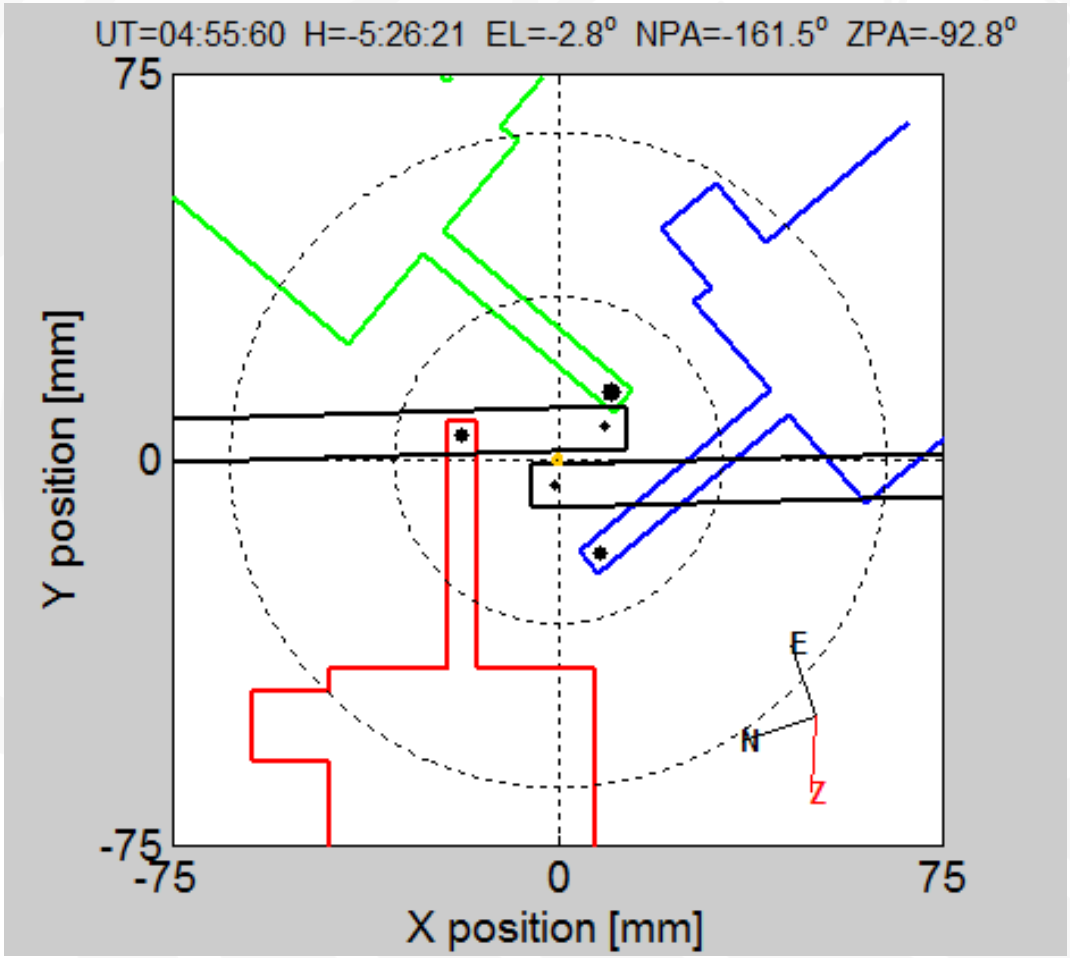


Field rotation tracking



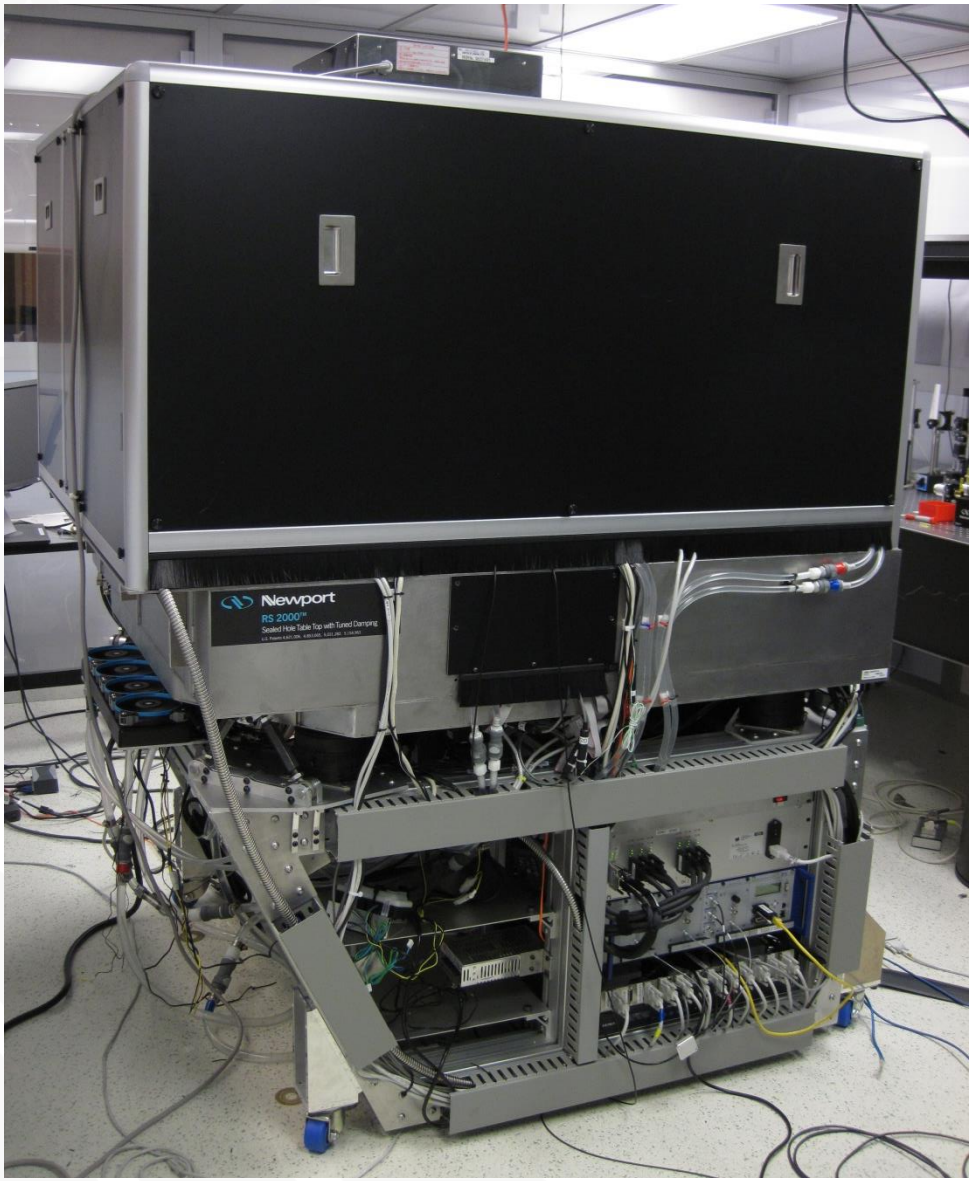
Simulation for a real science case

Example for Stanek field on 20/06/2013



Hardware completed at UVic (July 2012)

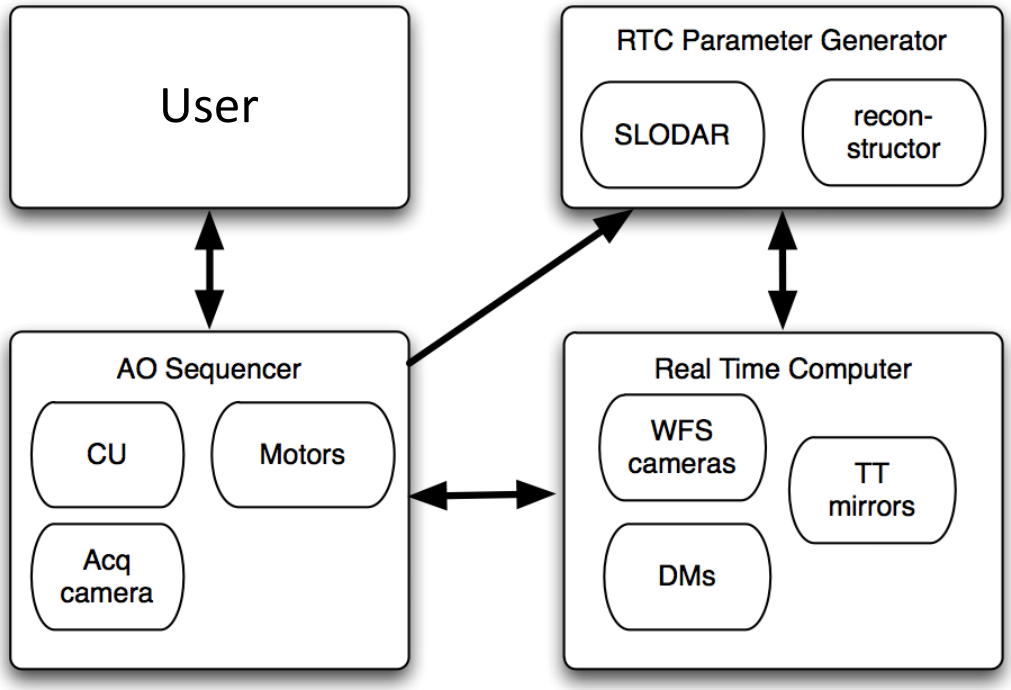
- All the opto-mechanical components are installed and aligned
- Most of the electronics are mounted in the frame under the bench



Software architecture

The Raven Software is divided into 3 subsystems:

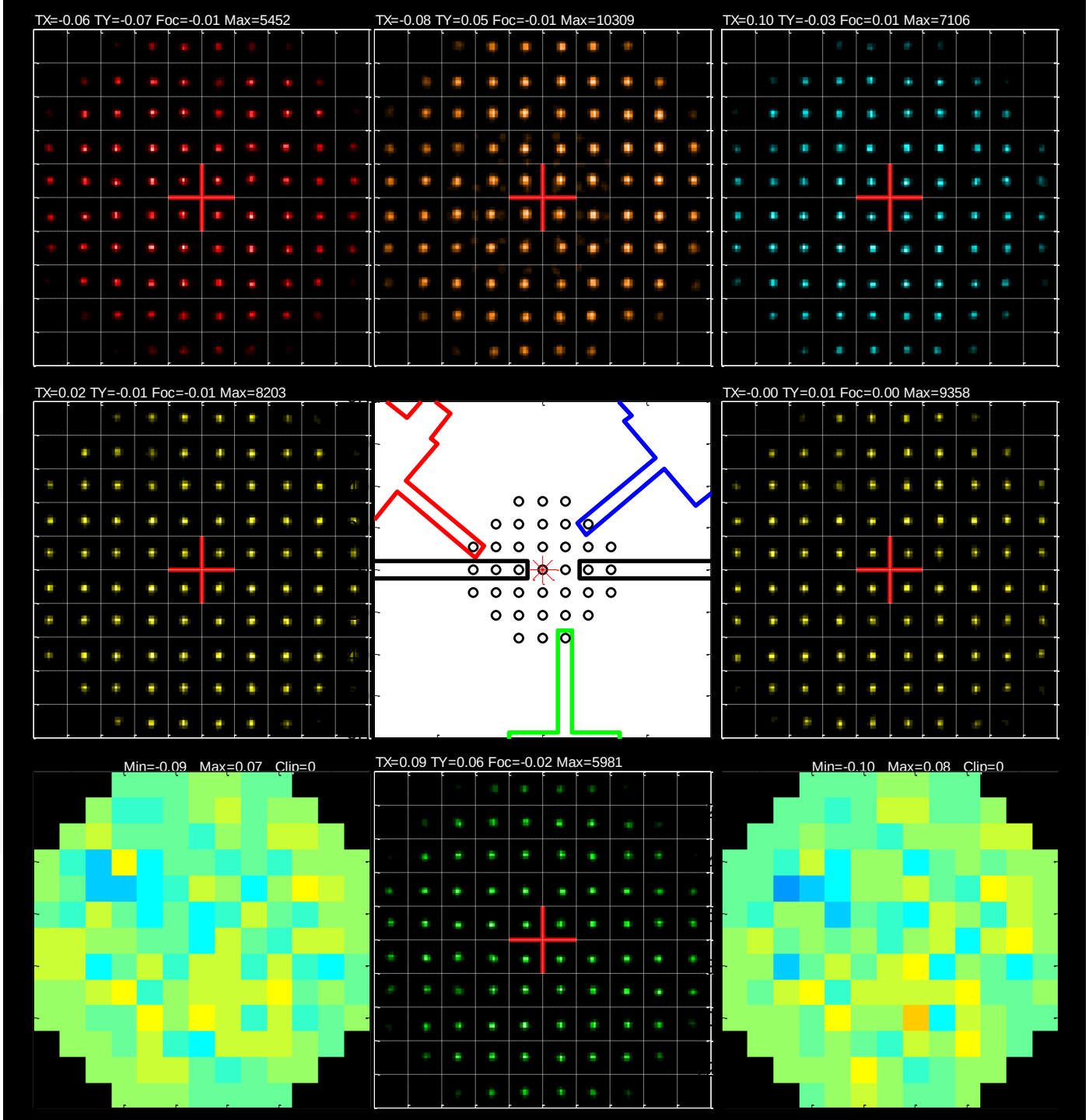
- The **AO Sequencer (AOS)** sets up the system and controls all non-real-time hardware, provides a user interface.
- The **Real-Time Computer (RTC)** processes the WFS pixels and generates the DM commands.
- **The RTC Parameter Generator (RPG)** updates the tomographic reconstructor as the conditions change using the WFS data (SLODAR or Learn&Apply).



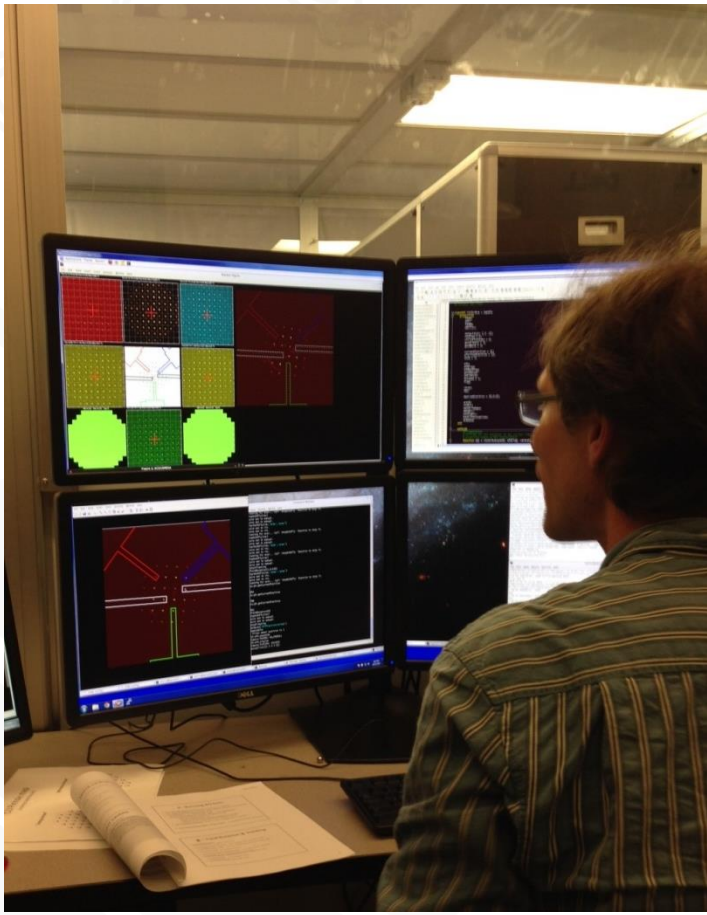
RTC supports different AO modes

AO mode	Description
SCAO	Single Conjugated AO: Close loop on bright science target
MOAO	Multi-Object AO: NGS (+LGS) WFSs feed tomographic reconstructor, then feed the DM (open loop)
GLAO	Ground-layer AO: WFS slopes are averaged and sent to the DM (open loop)
HP MOAO + LP SCAO	High-Pass-filtered MOAO + Low-Pass-filtered SCAO: • Fast turbulence is corrected in open-loop MOAO, • Slow turbulence & quasi-static aberrations are corrected in close-loop w/ **the CLWFS running at low frame rate on a possibly faint compact science target.**

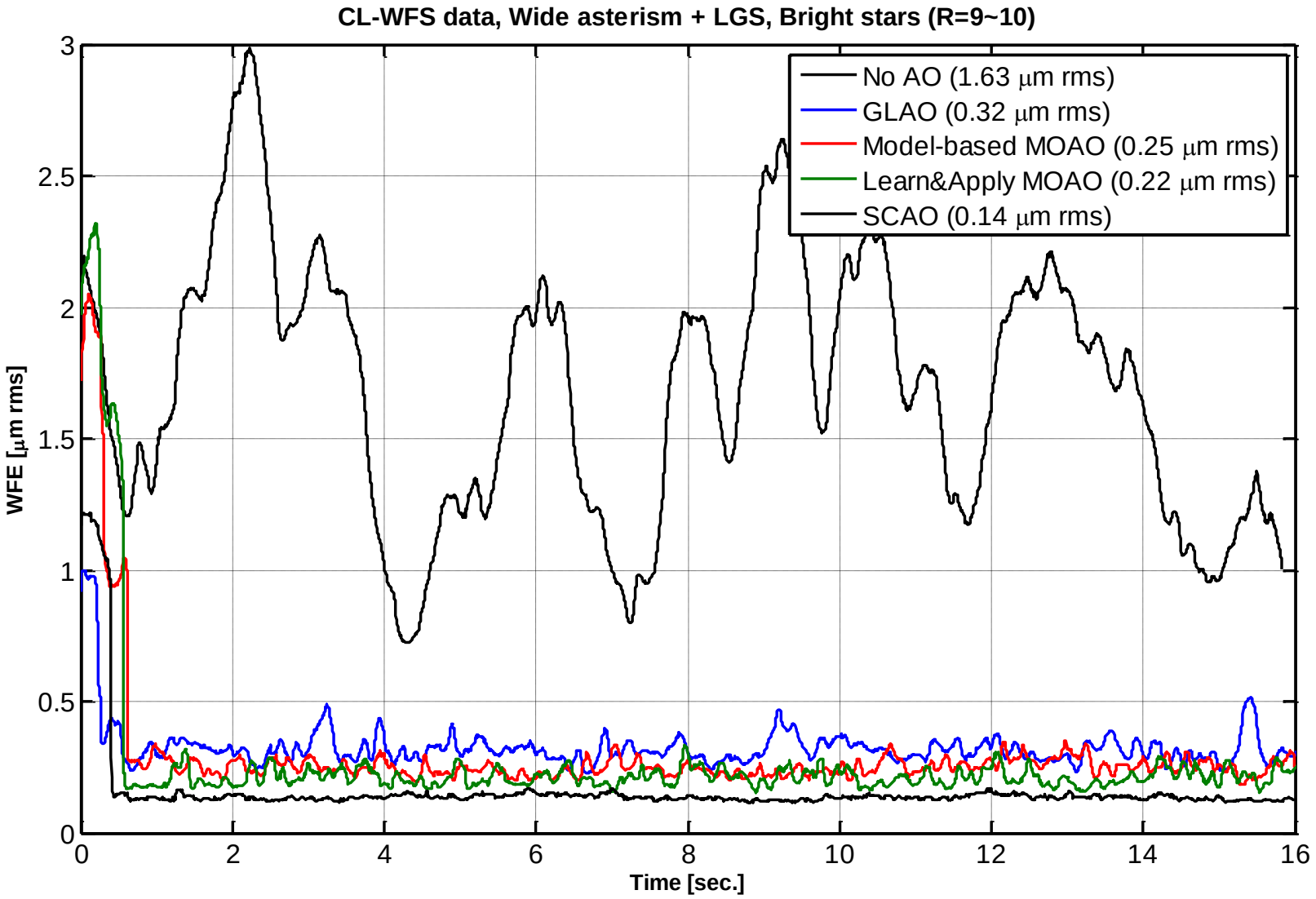
AOS user interface in Matlab



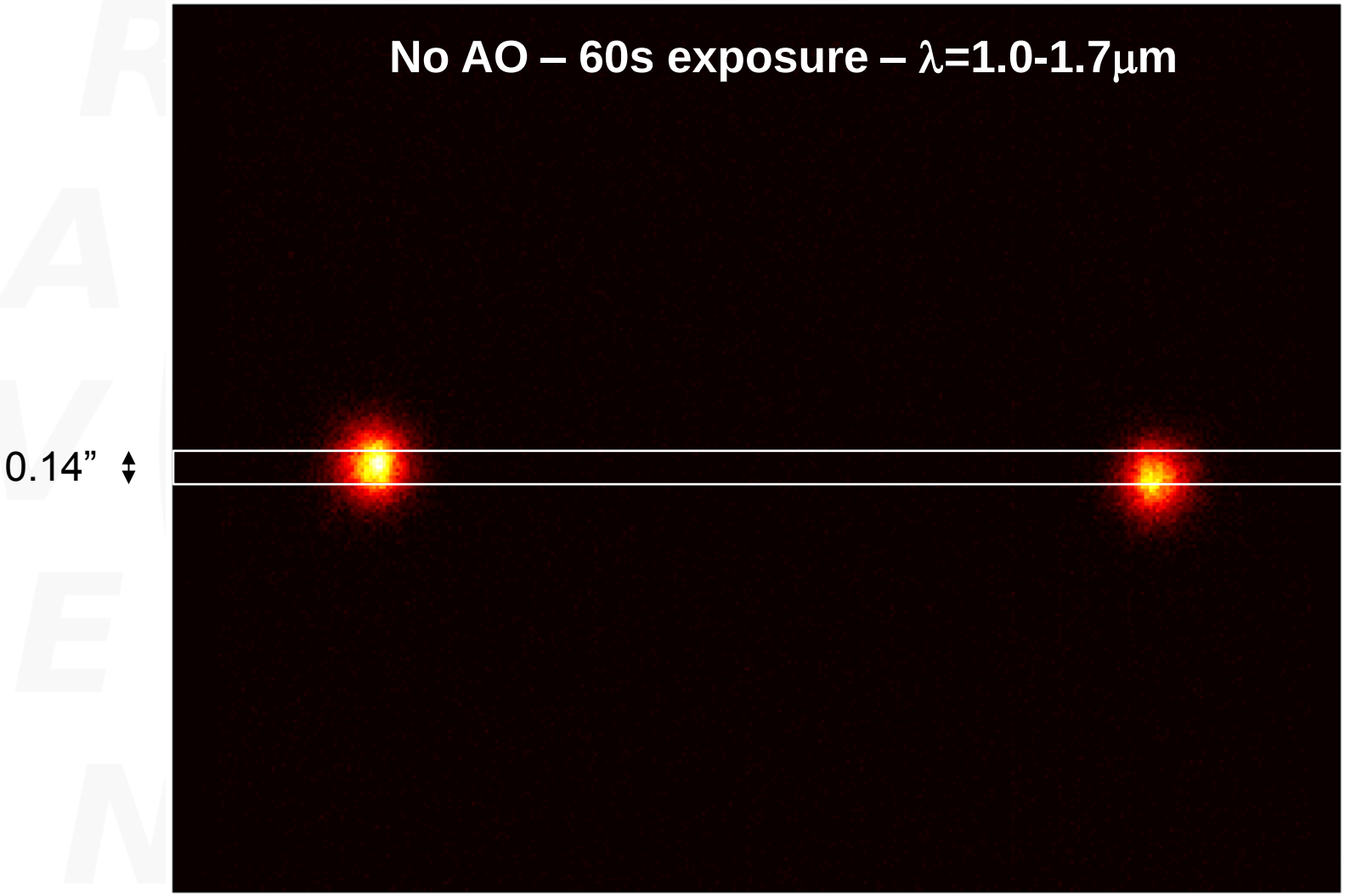
Raven Acceptance Review at UVic, 26 Nov. 2014



Lab Results obtained at UVic



Science camera long-exposure images



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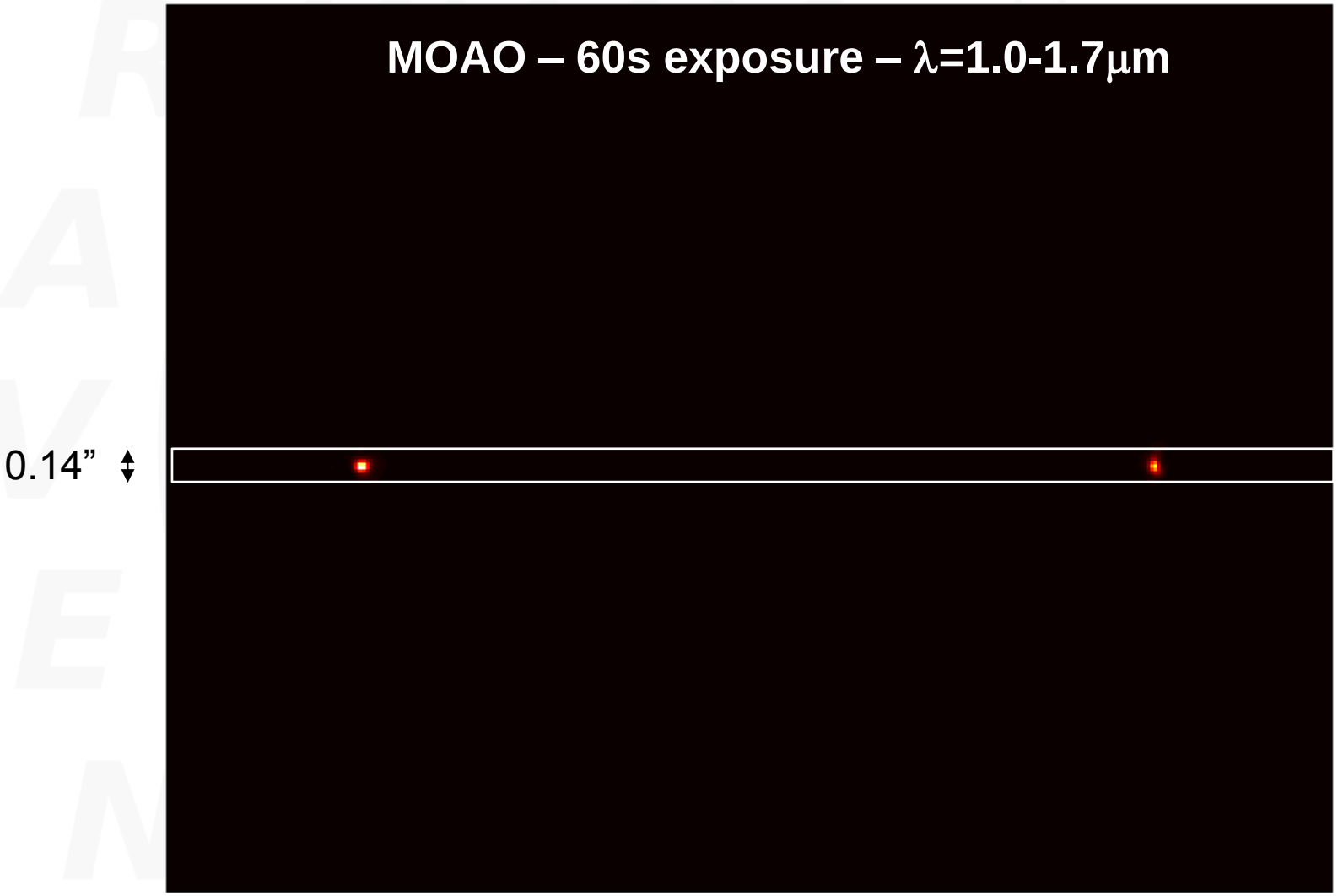
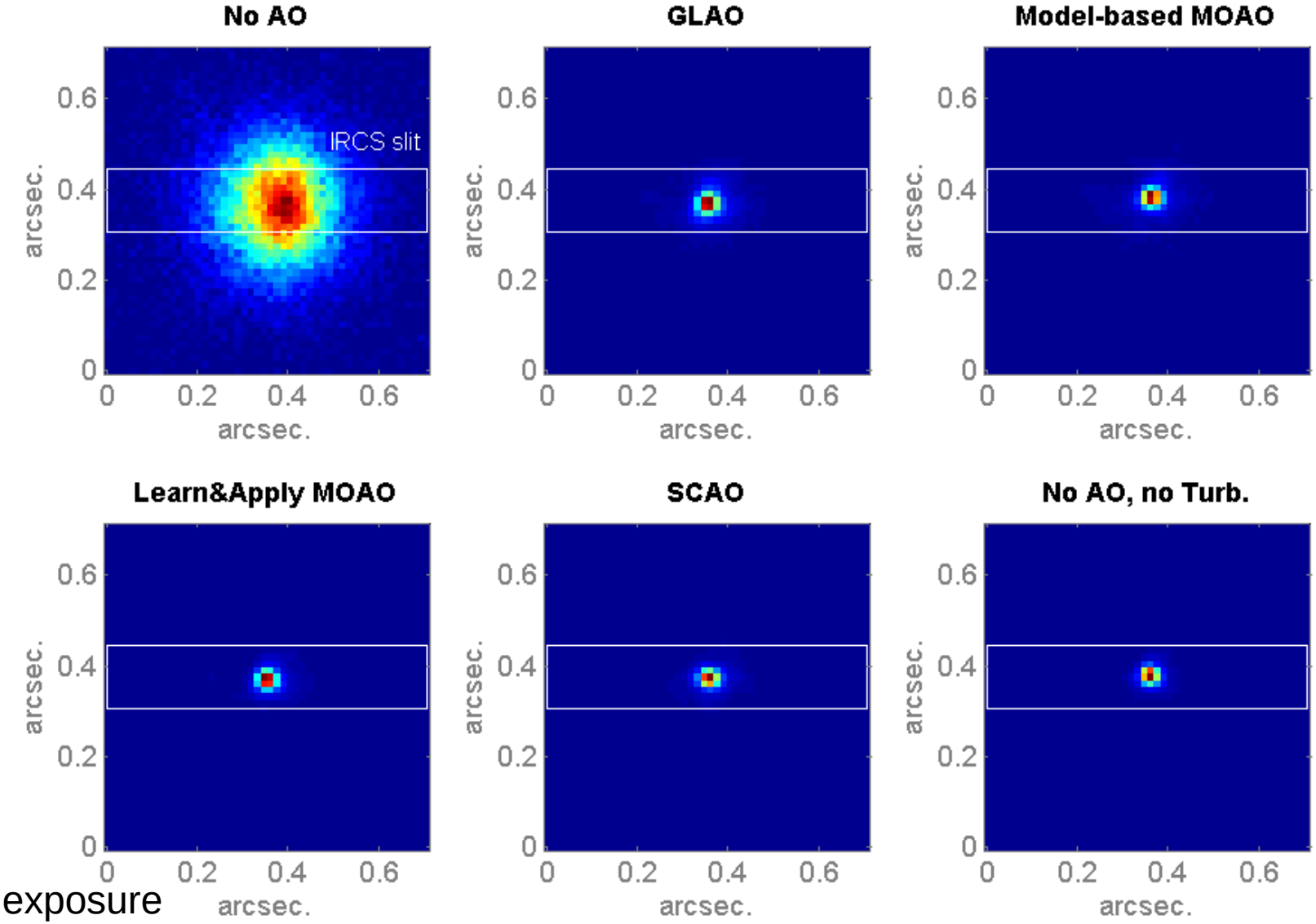


Science Camera long-exposure images

Bright & Wide Asterism + LGS



60s exposure

Conclusions

- Current performance meet science requirements
  - *In agreement with error budget*
  - *Good image correction: Strehl>20-50%*
  - *Limiting magnitude R≥14.25 w/ CoG*
- Upgrades & expected improvements
  - *Correlation centroiding (+1 mag.)*
  - *Predictor (+2mag)*

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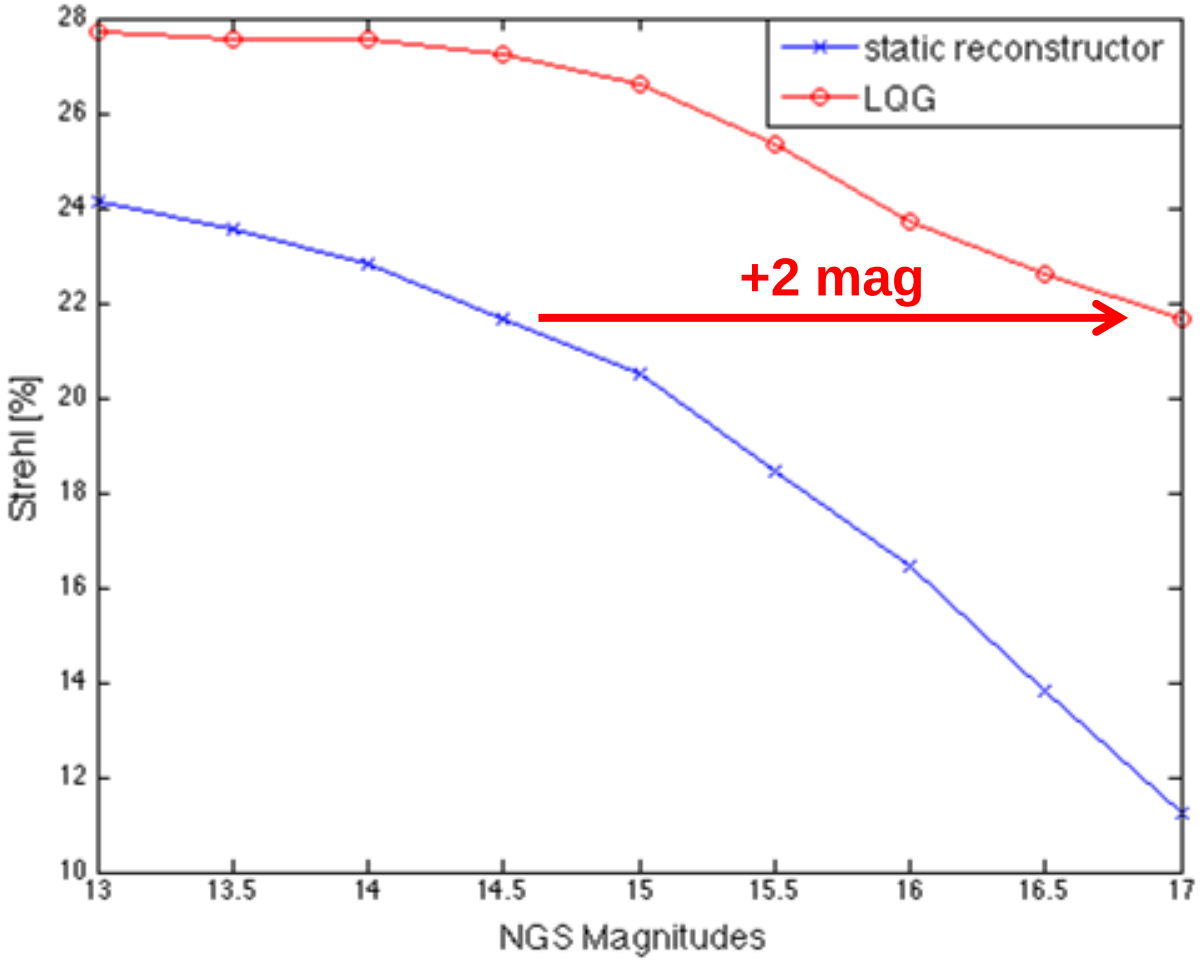

Conclusions

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  - *In agreement with error budget*
  - *Good image correction: Strehl>20-50%*
  - *Limiting magnitude R≥14.25 w/ CoG*
- Upgrades & expected improvements
  - *Correlation centroiding (+1 mag.)*
  - *Predictor (+2mag)*
- Science instrument ready to go on sky:
  - *Engineering nights in May and Aug 2014*
  - *Hoping for science nights in S14B and S15A*
  - *Little risks for science cases as GLAO meets science requirements too.*

Raven arrival (Jan 6th)

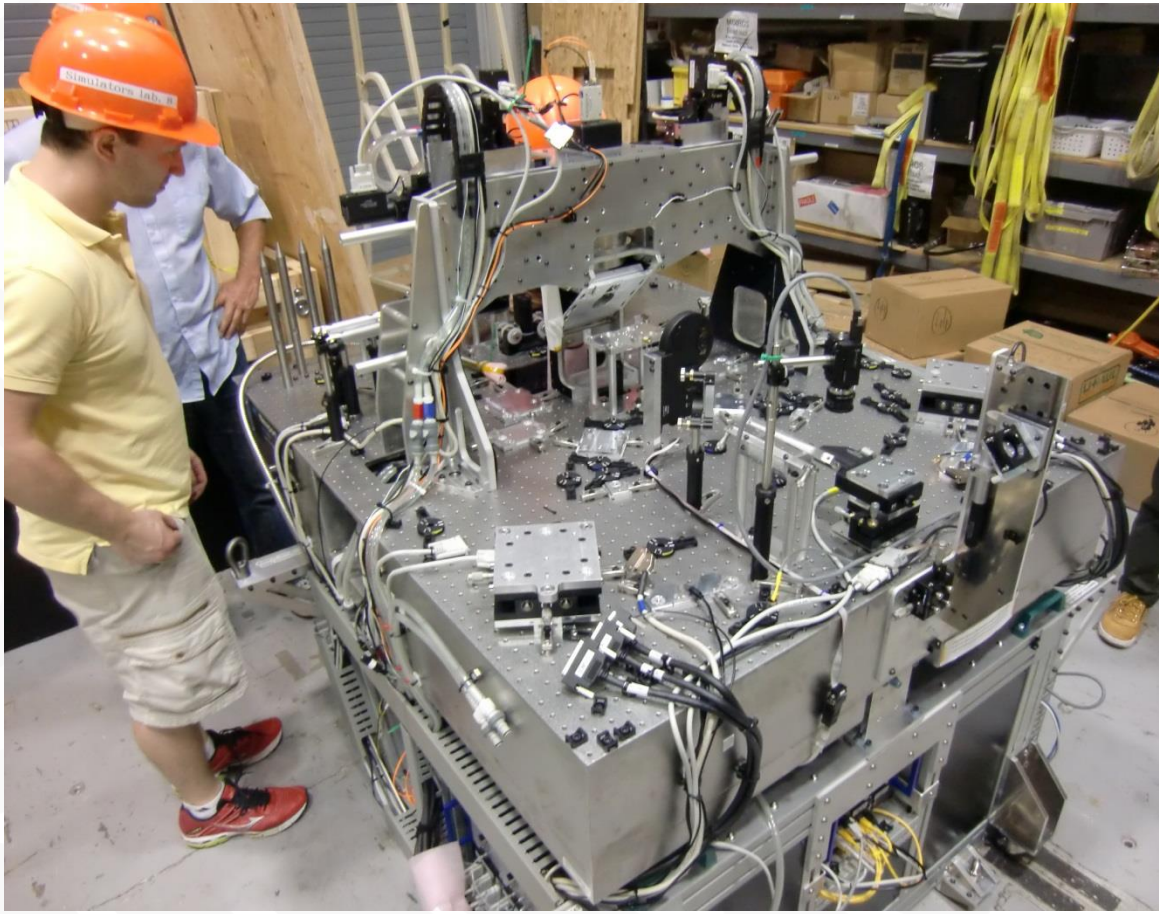
Matson SS Maui from Seattle to Honolulu

Photos: Shin Oya

Raven in the SimLab (Jan 7th)

Photos: Shin Oya

Raven in Simlab (Jan 7/8)

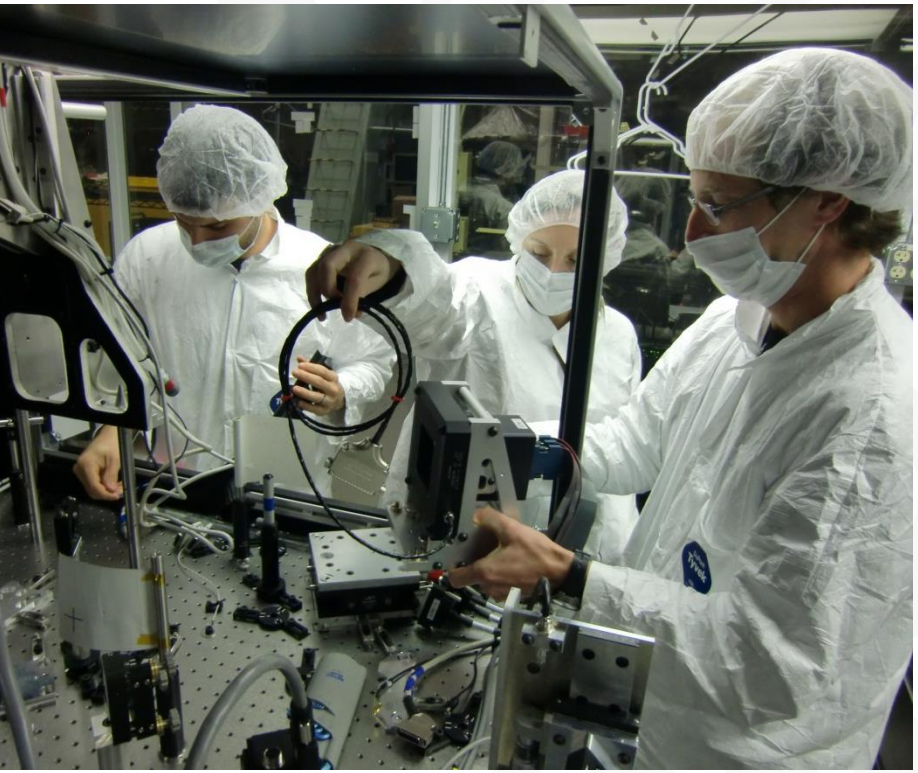


Photos: Shin Oya

Raven in Simlab (Jan 7/8)

Photos: Shin Oya

Alignment in SimLab clean room



Photos: Shin Oya

2014 Schedule

- ✓ Jan : Raven integration and alignment in the SimLab
- Feb-Mar :
  - Software upgrades & consolidation
  - Final tests
  - Prepare observation plan
- Mid-Apr : Raven ships to summit in BSIT truck
- **May 13/14 : First engineering nights**
- Aug : 2nd run of engineering nights

Thank you