



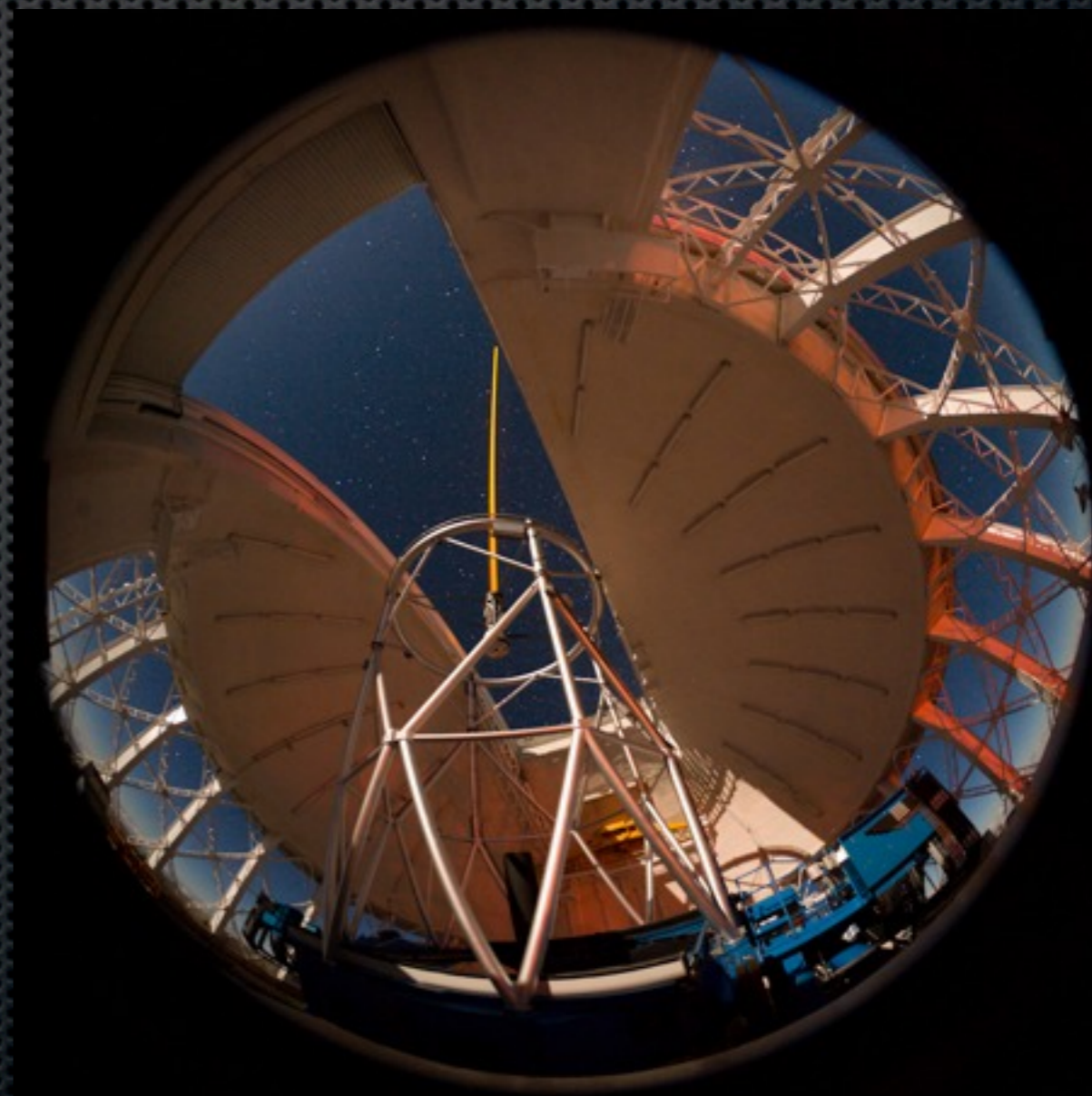
GEMINI
OBSERVATORY



GeMS

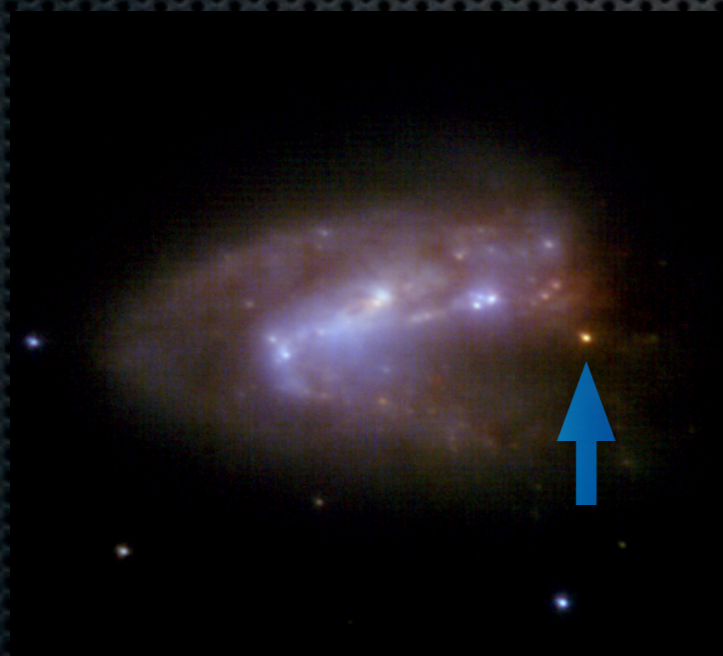
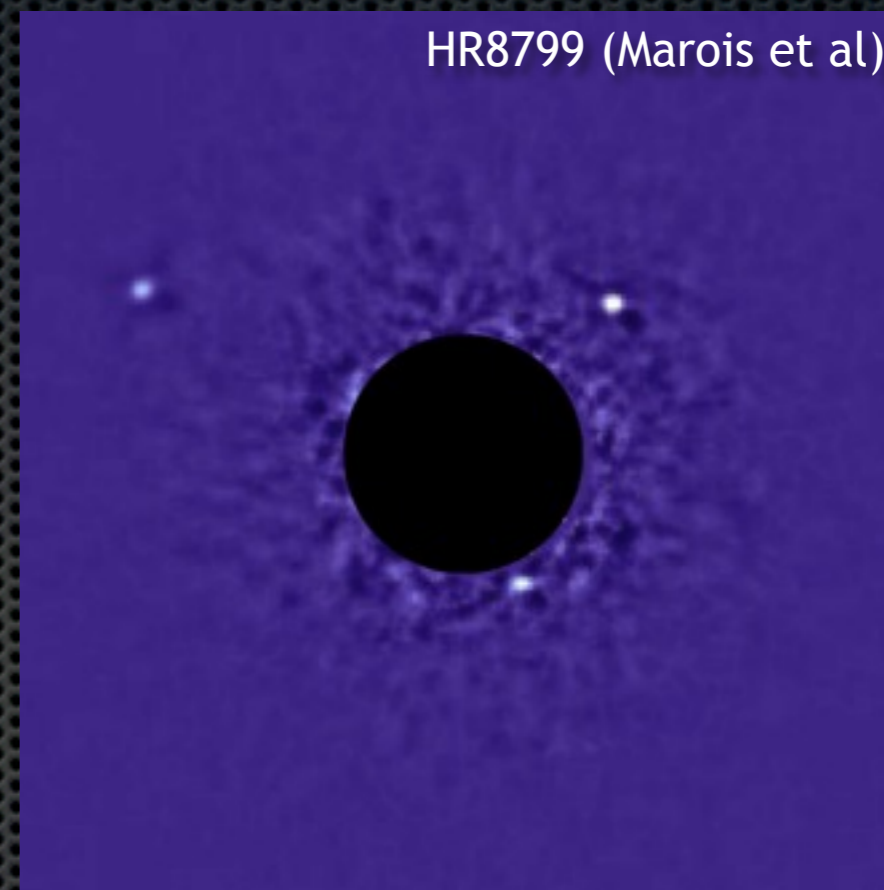
(Gemini Mcao System)

Francois Rigaut, Gemini

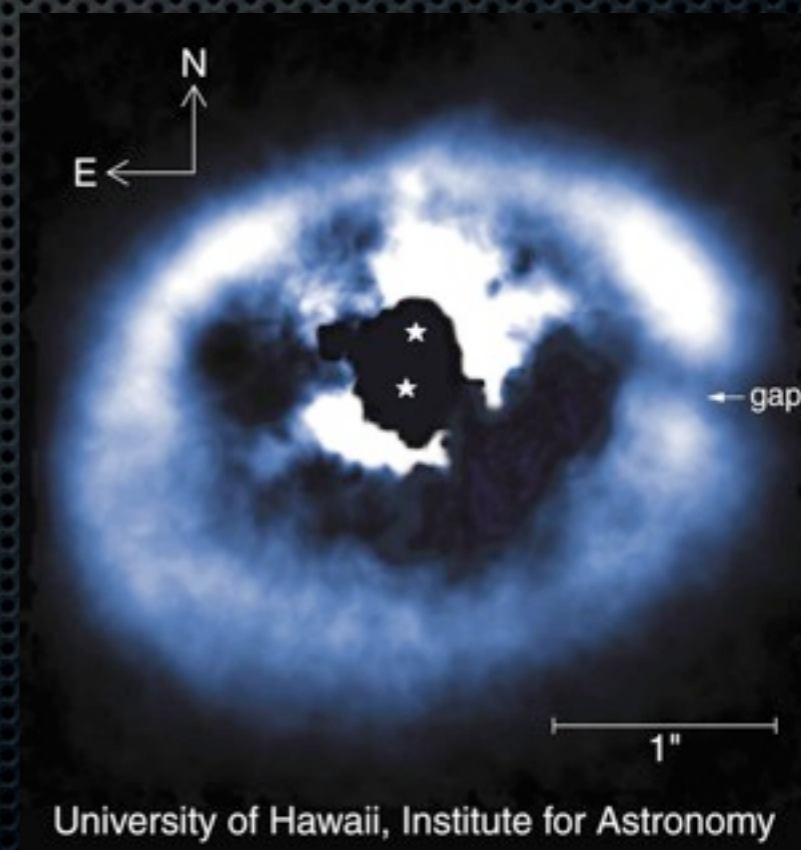


Talk outline

- Briefs about the Gemini AO instrumentation and program
 - Program flow, some nice images
 - Lasers, lasers, lasers...
- GeMS: the **G**emini **M**CAO **S**ystem
 - Description
 - Expected performance
 - Schedule & Status



HST NICMOS

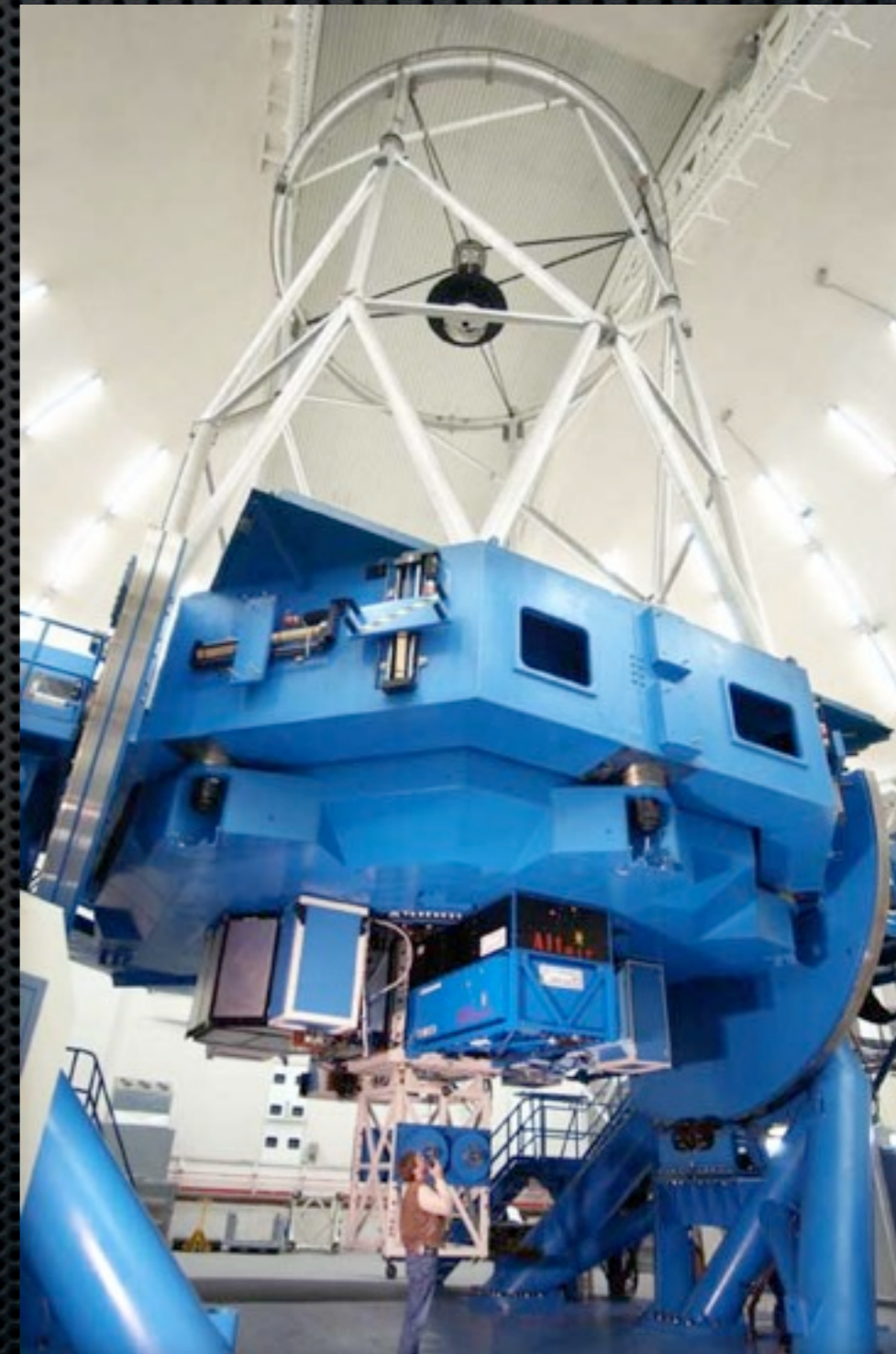


Ryder, 2008 (Altair LGS)

Gemini: A specialized telescope



- Gemini international community
- Optimized for:
 - Thermal IR
 - High angular resolution
- Optimization choices:
 - silver coating
 - low emissivity (2.5% M1+M2)
 - F/16 narrow field
 - Thin spiders
 - low diffraction
 - LLT space planed behind M2
- Cass: 3 instr.+Cal unit + AO system
- 90% Queue

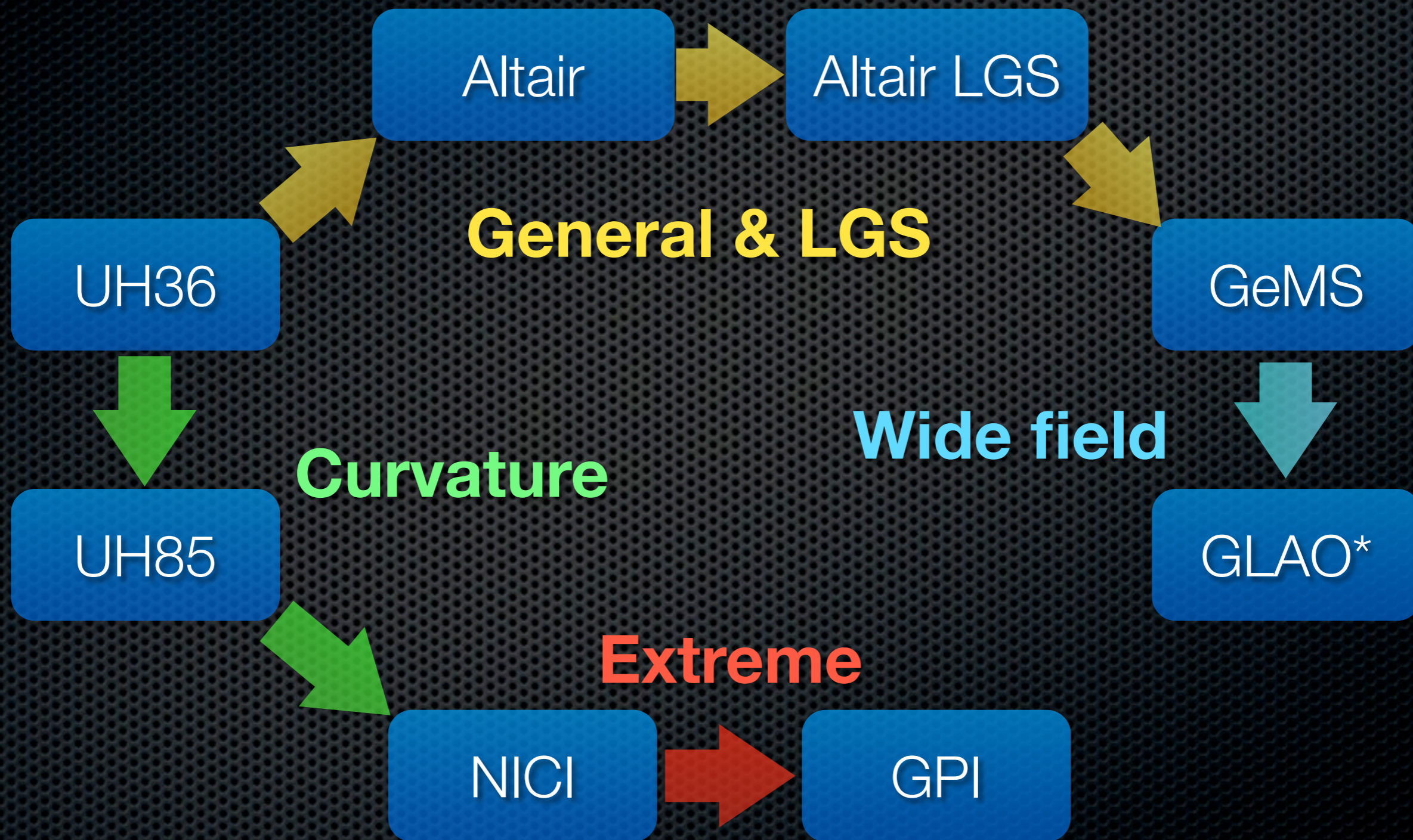


AO instrumentation @ Gemini

Past, present and future

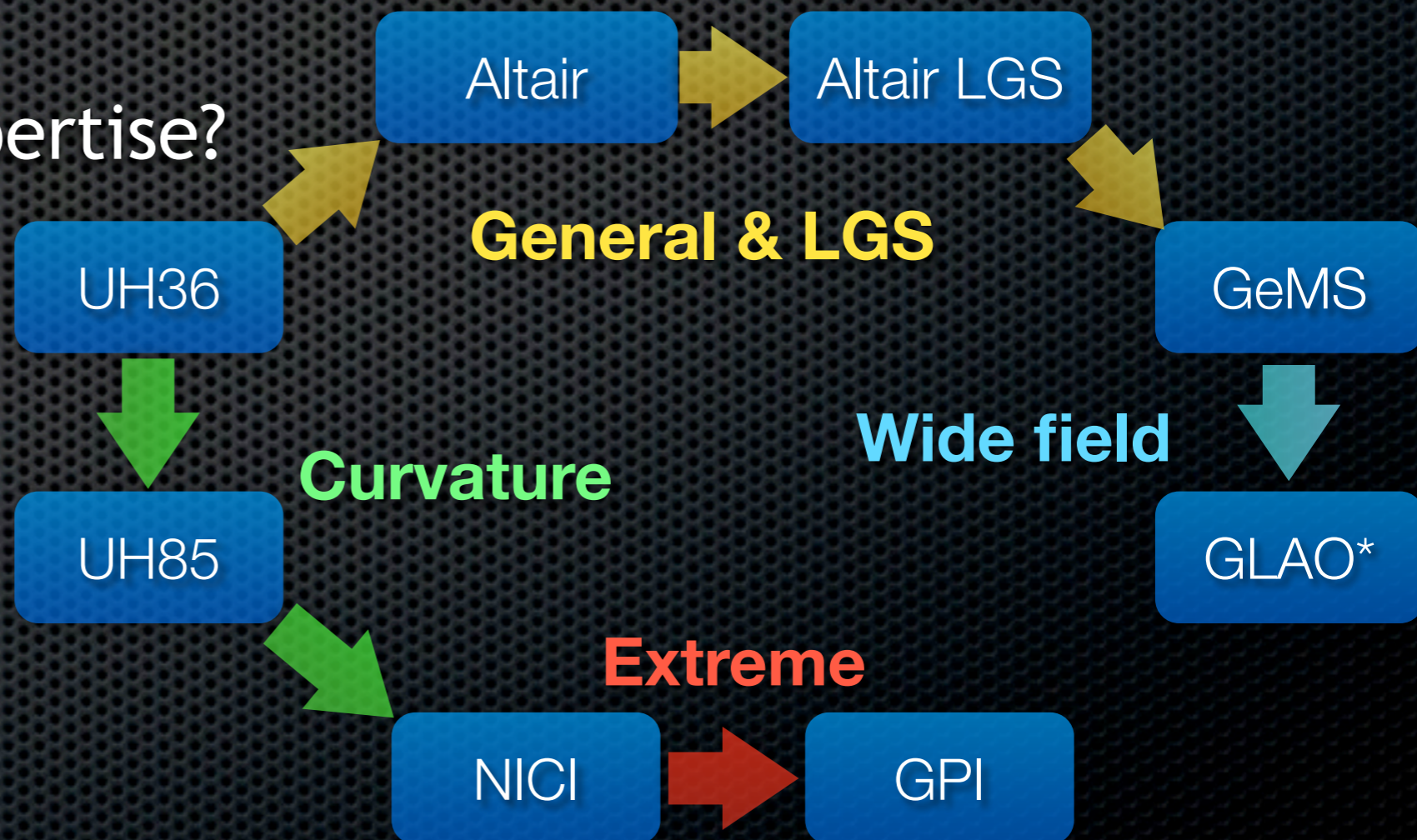
AO	Instrument	FoV (")	H Strehl	R lim (full/limit)	Sky cov (%)
UH36	QUIRC	20	15	15	1
Altair NGS	NIRI / NIFS	20	35	12/15	< 1
Altair LGS	NIRI / NIFS	20/50	20	15/18	~ 30
UH85	ABU	-	-	-	-
NICI	Corono imager	14	45	12/15	< 1
GeMS (MCAO)	GSAOI / F2	83	40	15/18	~ 30
GPI	Corono / IFU	? / 4	90	8/11	< 0.1
GLAO	all instruments	up to 360	5*	>15	100

Program Flow

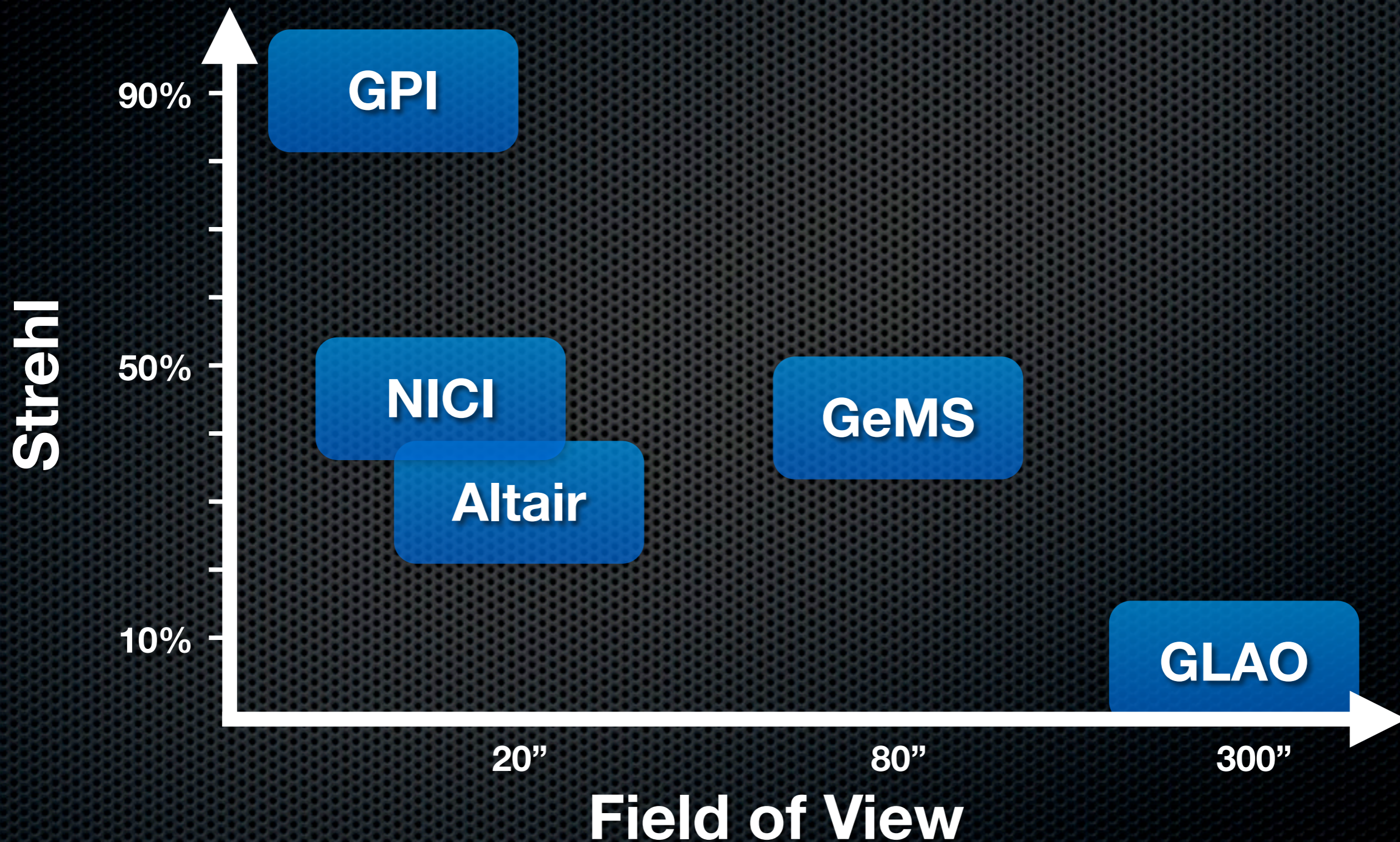


Program Flow

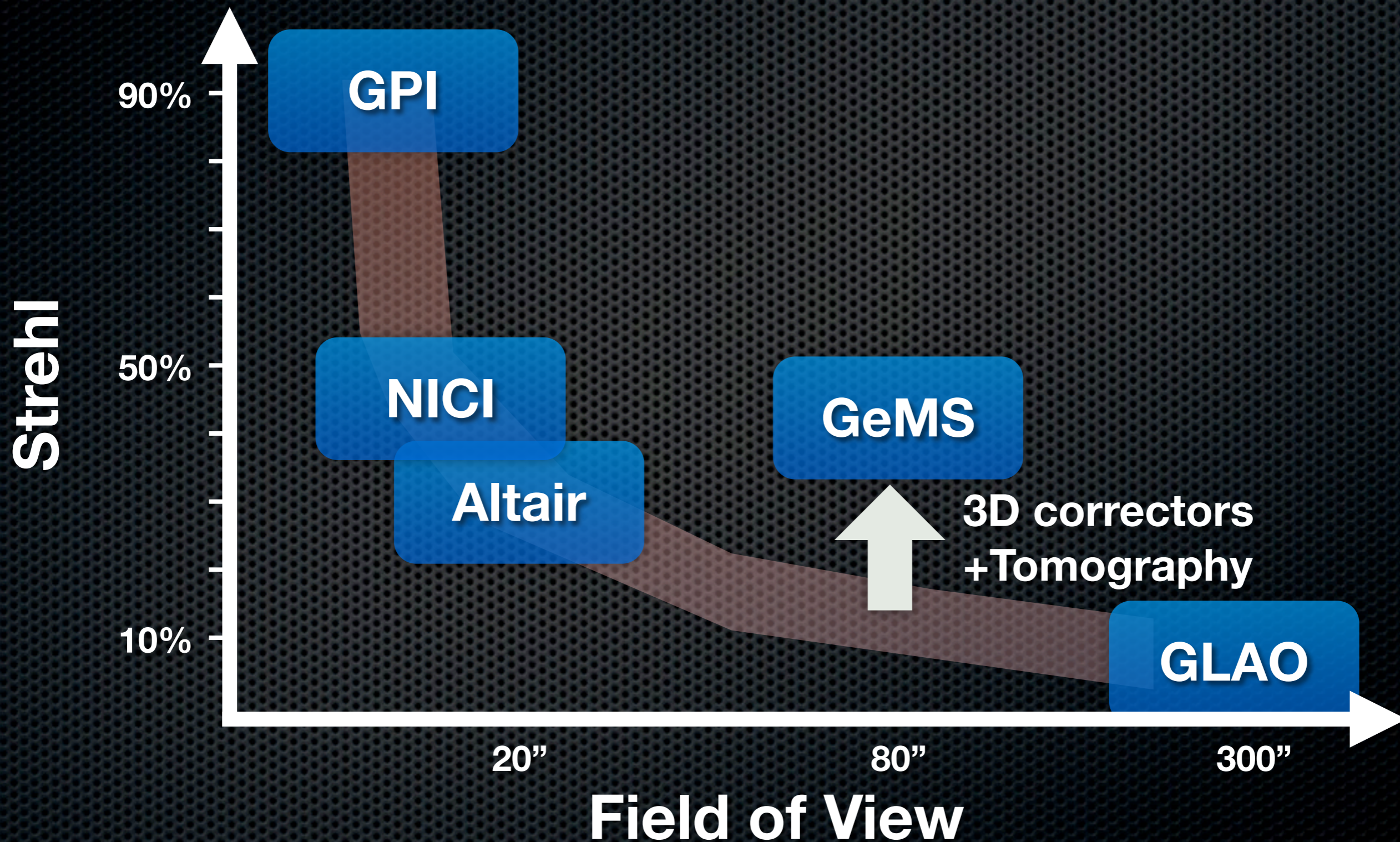
- Broad but not redondant
- Stick to newest techniques and technology to retain competitiveness for our user community
- Ability to retain expertise?
- Too ambitious?



Parameter space coverage

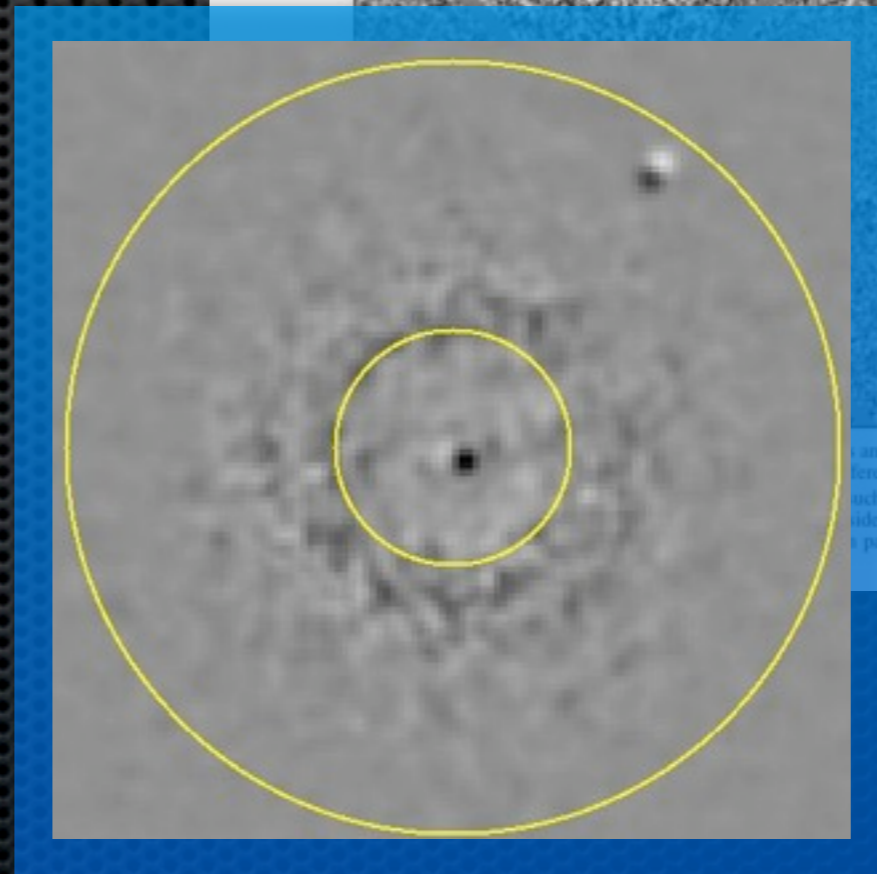
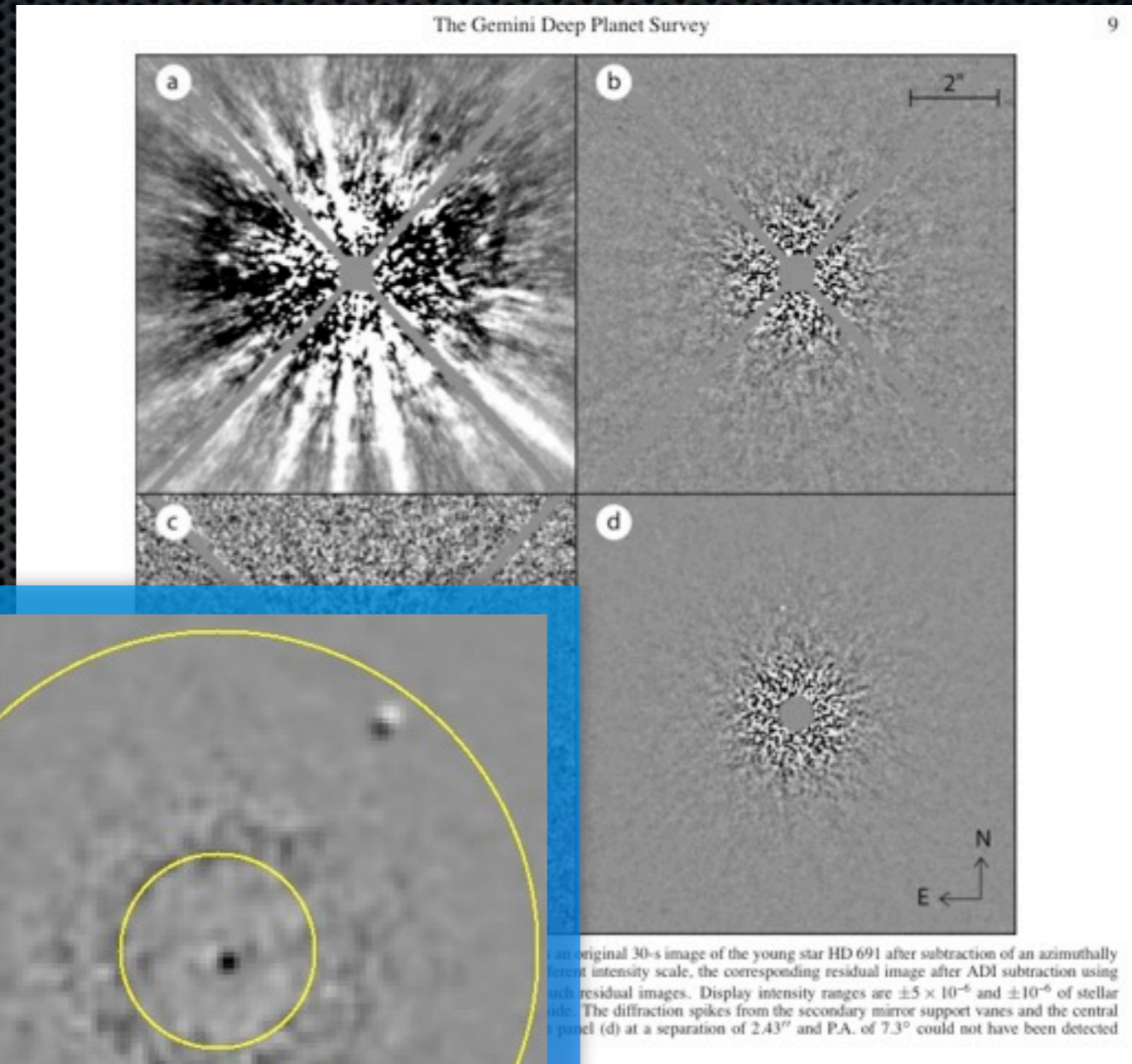


Parameter space coverage



Observing and DR Techniques

- ADI
- SDI
- PSF reconstruction
- Model fitting, minimization techniques
- Field-dependent-PSF photometry analysis
- etc...



Instruments

- Huge progress in the past 10 years:
 - “Large(r)” field of view imager (GSAOI)
 - Integral field spectrographs (NIFS)
 - High performance coronagraphs (NICI)

Science

- Recent Subaru/Gemini science conference with lots of talk and science results that were enabled by AO:
 - Solar system planets, minor bodies, extra-solar planets, YSO, PNs, supernovae, Galactic center, Galaxies dynamics, etc...

M16, Pillar details



HST V band

M16, Pillar details

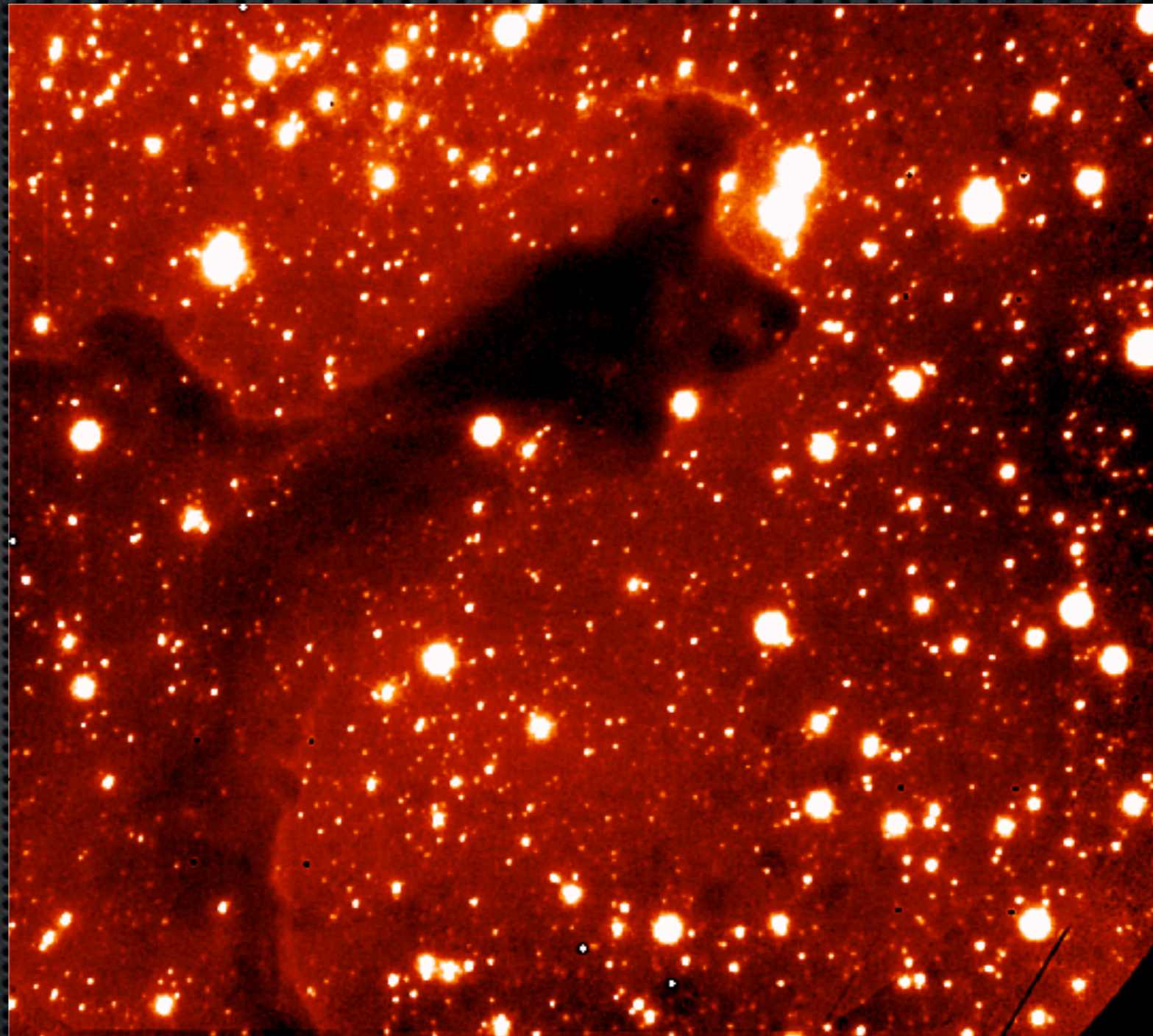
- HST:
 - V Band
 - WFPC2



HST V band

M16, Pillar details

- HST:
 - V Band
 - WFPC2
- Gemini Altair LGS:
 - 4x120s
 - K' band
 - FoV 43''x40''
 - FWHM <100mas
 - Meets or exceeds HST V resolution



ALTAIR-LGS K'

M16, Pillar details

- HST:
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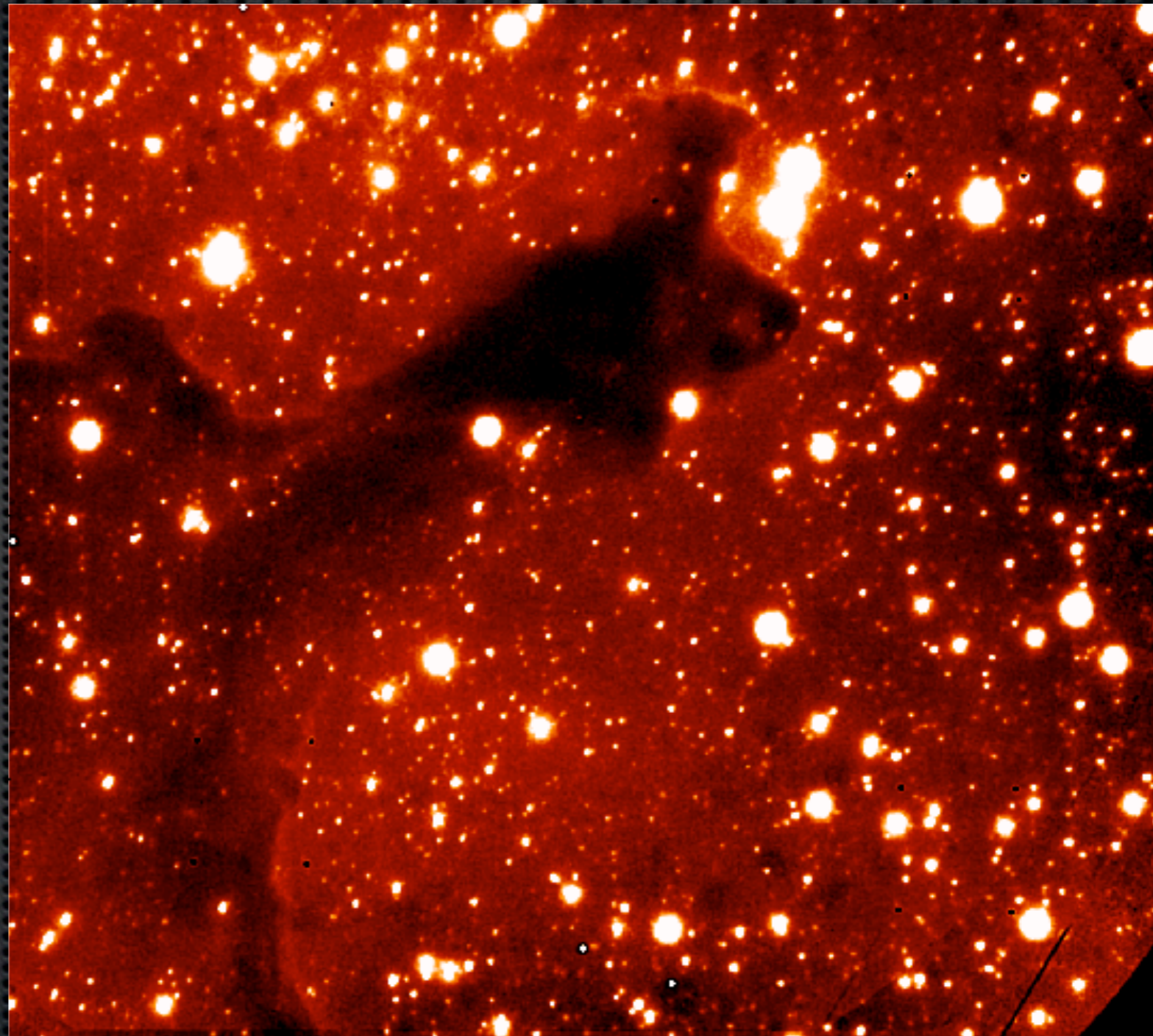


HST V band

ALTAIR-LGS K'

M16, Pillar details

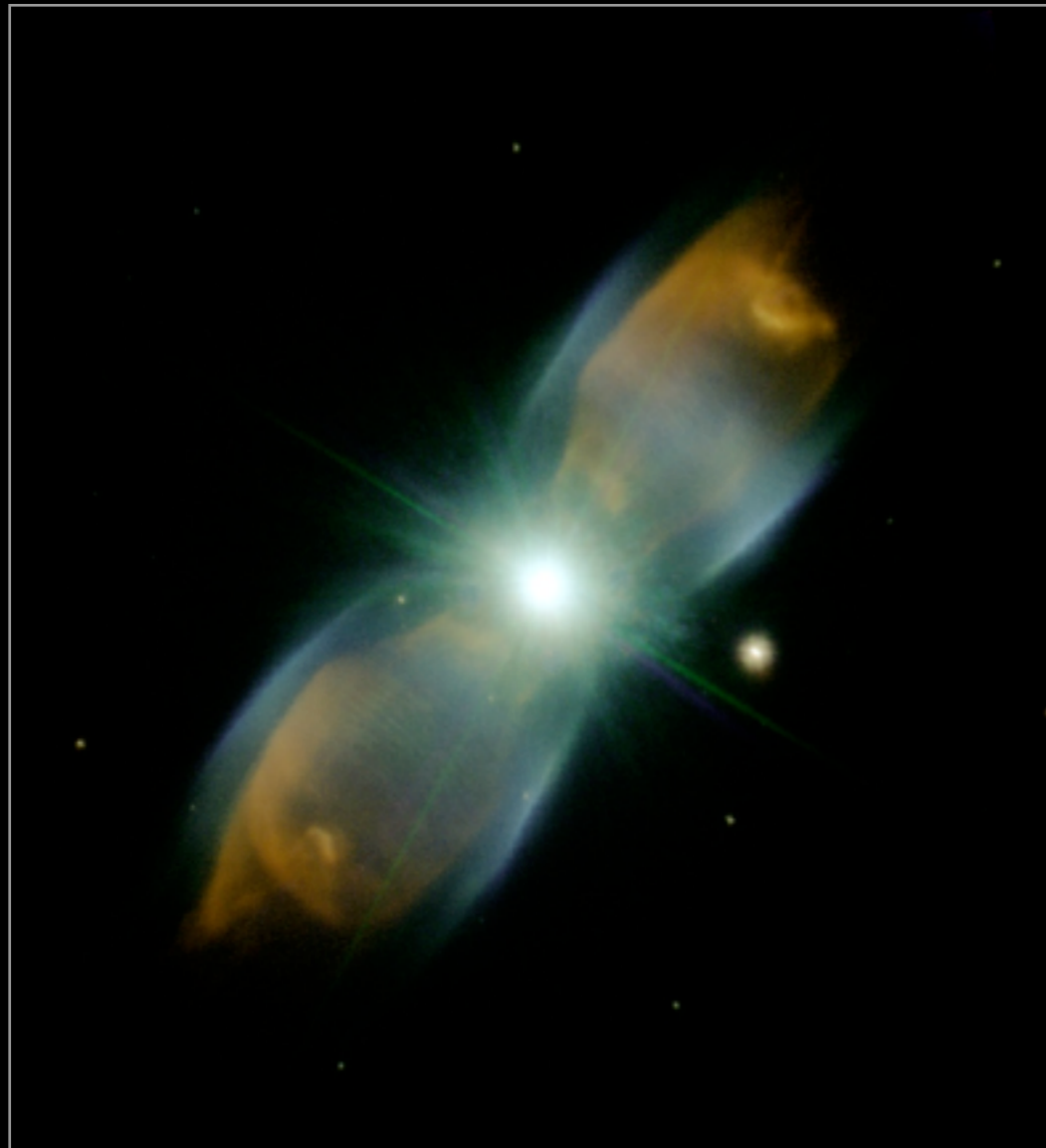
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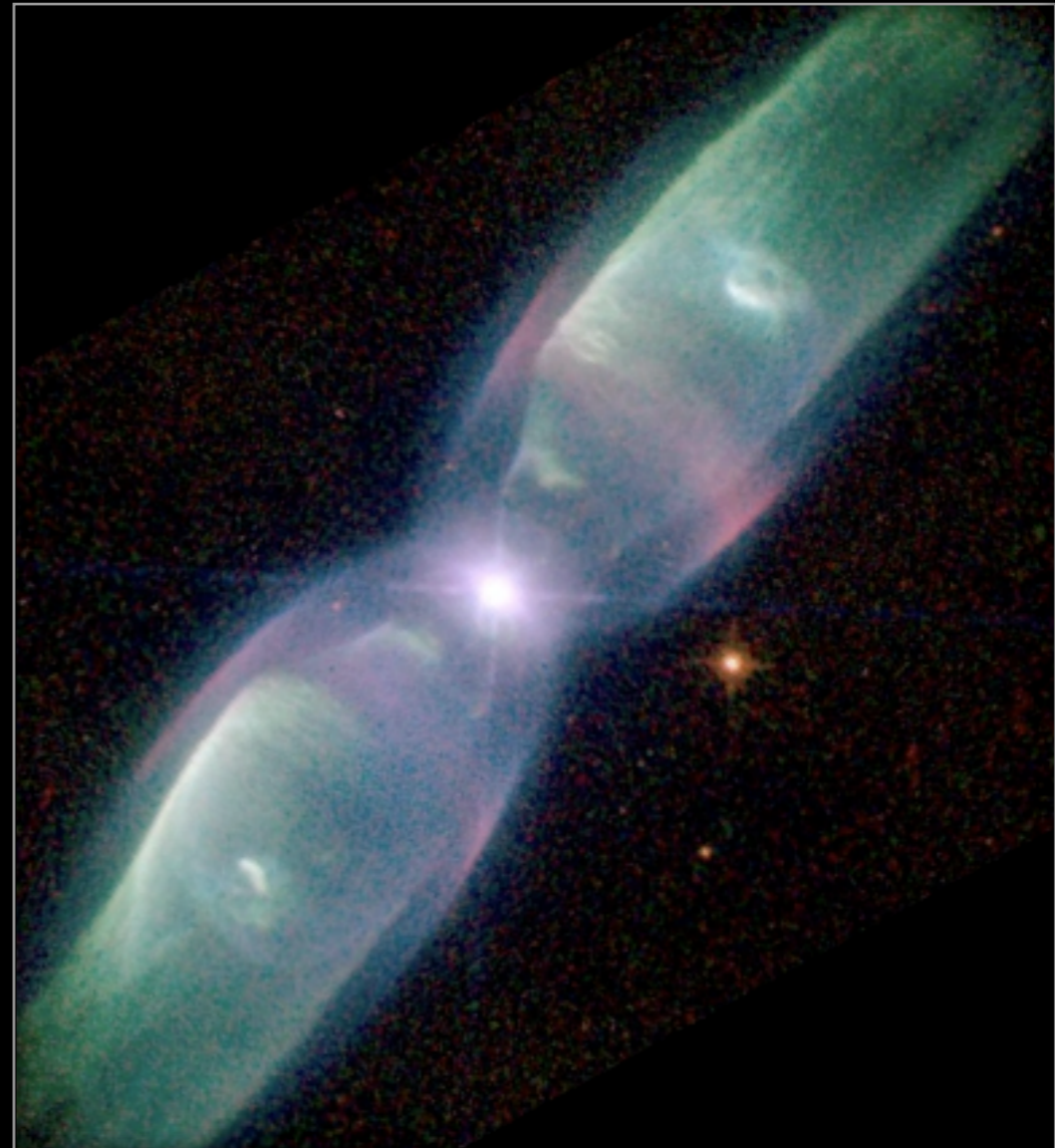
Similar resolution,
 different wavelengths:
 complementary

ALTAIR-LGS K'

Gemini AO (NIR) vs HST (visible)



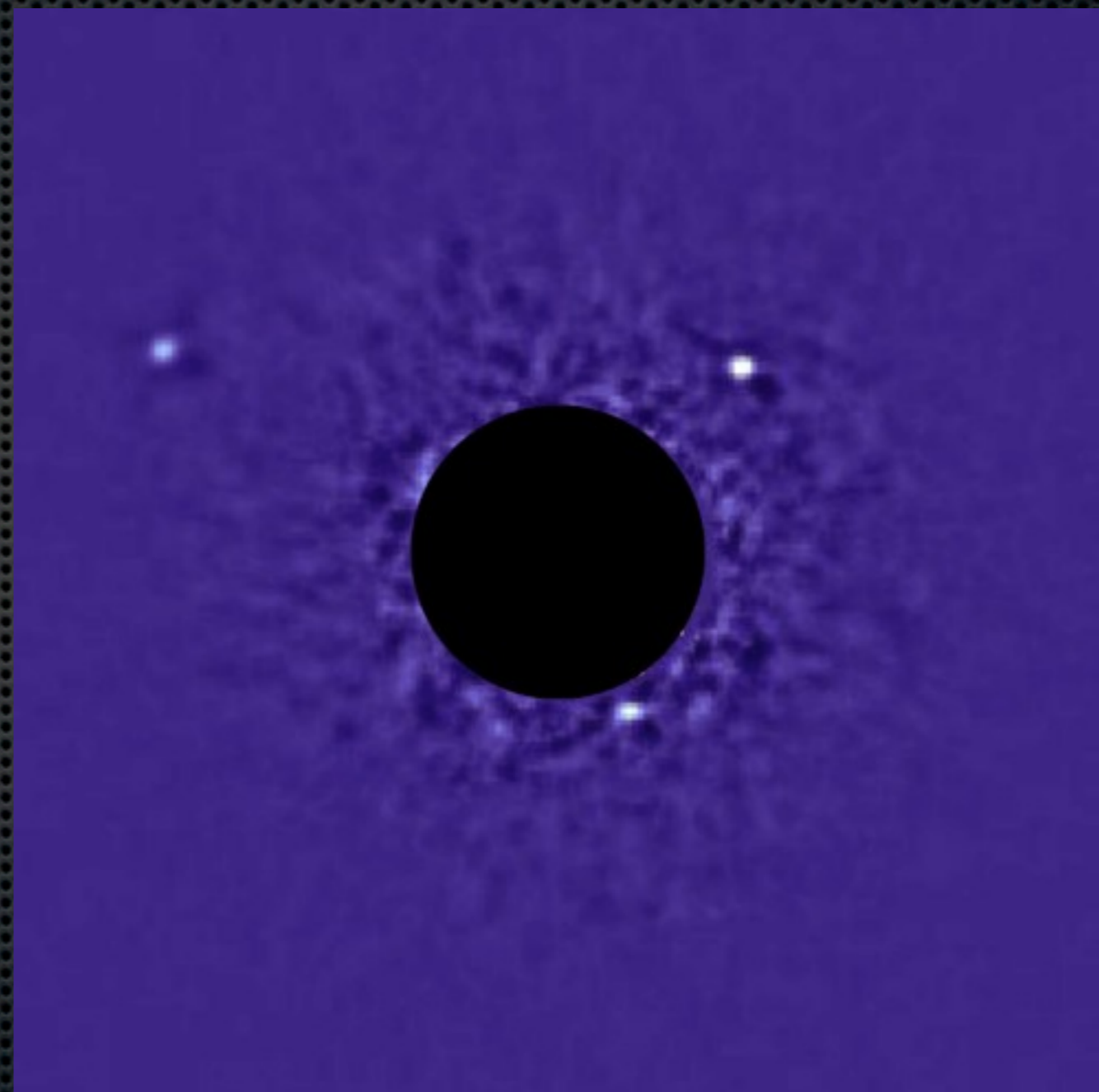
M2-9, Gemini, NIR, 2005



M2-9, HST, Optical, 1997

First planetary system around a main sequence star (HR8799)

- Gemini (Altair) & Keck
- First direct imaging of multiplanetary system
- 24, 38 & 68 AU from star
- approx 10, 10, 7 M_{JUP}
- Angular Diff. Imaging
- Canada/US consortium

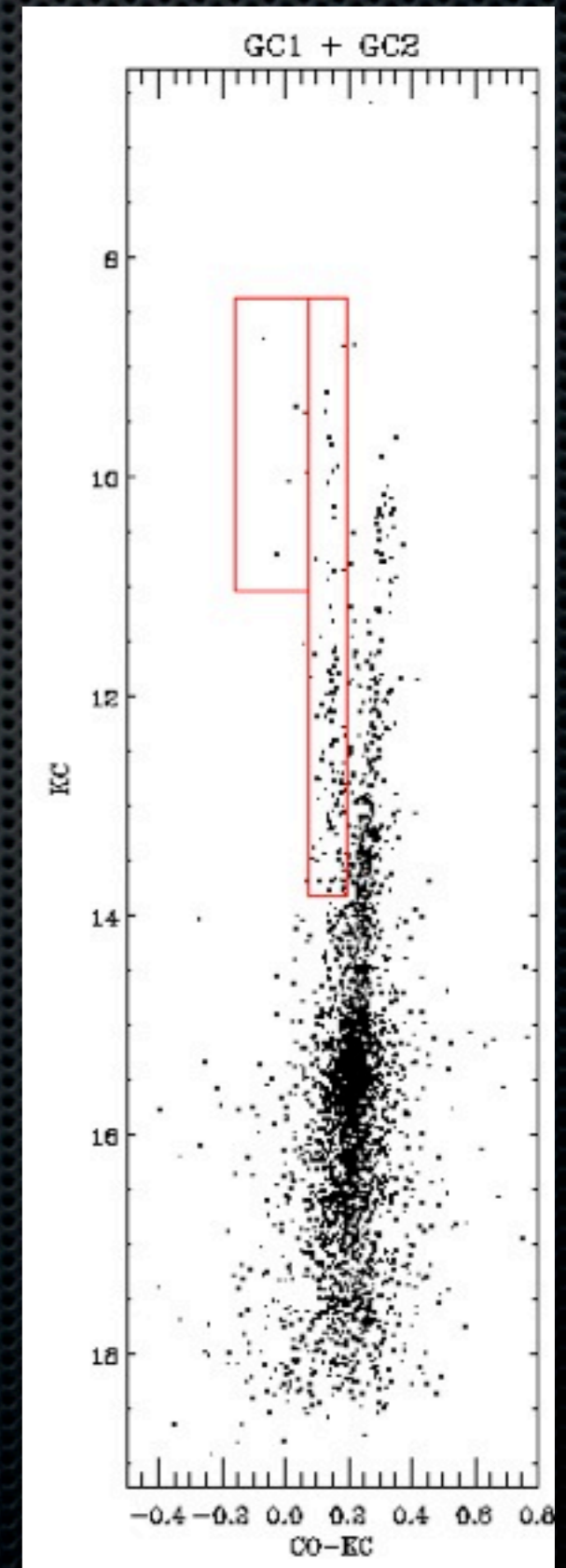
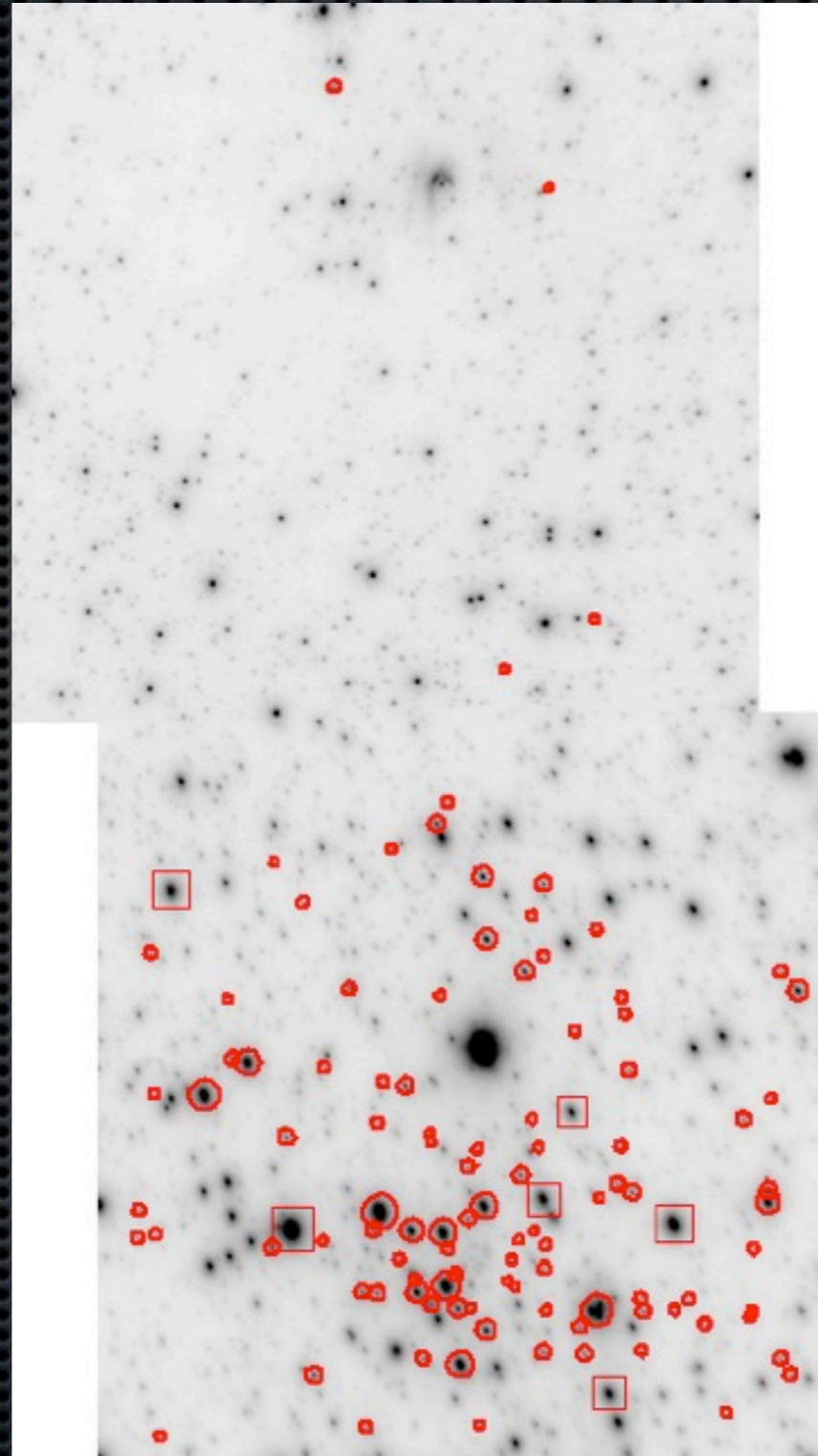


Credit: Christian Marois et al, CNRC
 arXiv:0811.2606v1 [astro-ph]

Photometric accuracy

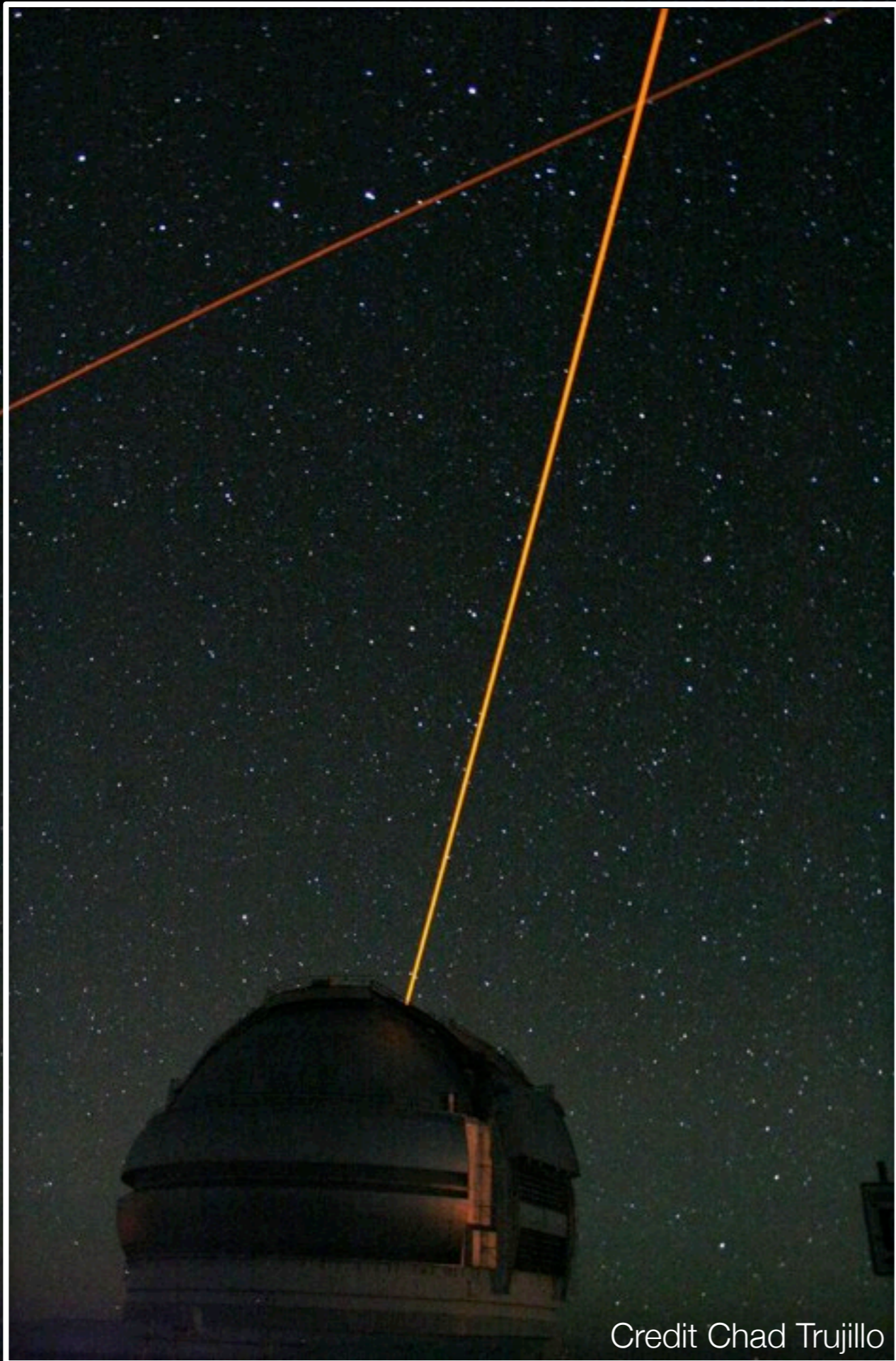
Challenging but doable

- error = 0.02 mag rms
- GC 20" x 30" FoV (crowded)
- Need proper calibrations

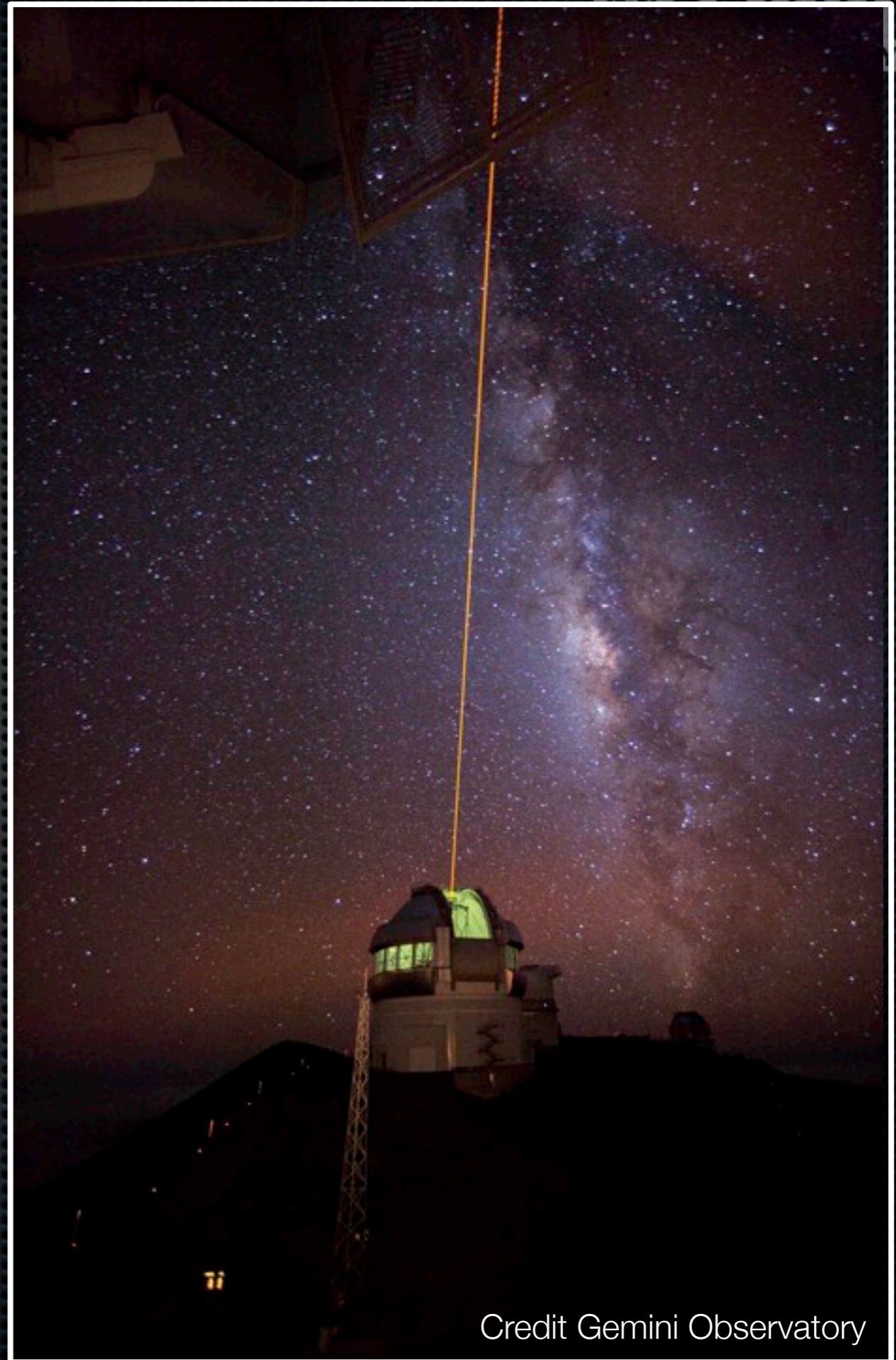


Lasers, lasers...





Credit Chad Trujillo



Credit Gemini Observatory



GeMS (MCAO)

Demonstrated Science



- Major limitations of AO:
 - Sky coverage
 - Small field of view
- MCAO provide ~30% sky coverage (LGS) and ~80" FoV
- Photometric accuracy (8x gain w.r.t AO)

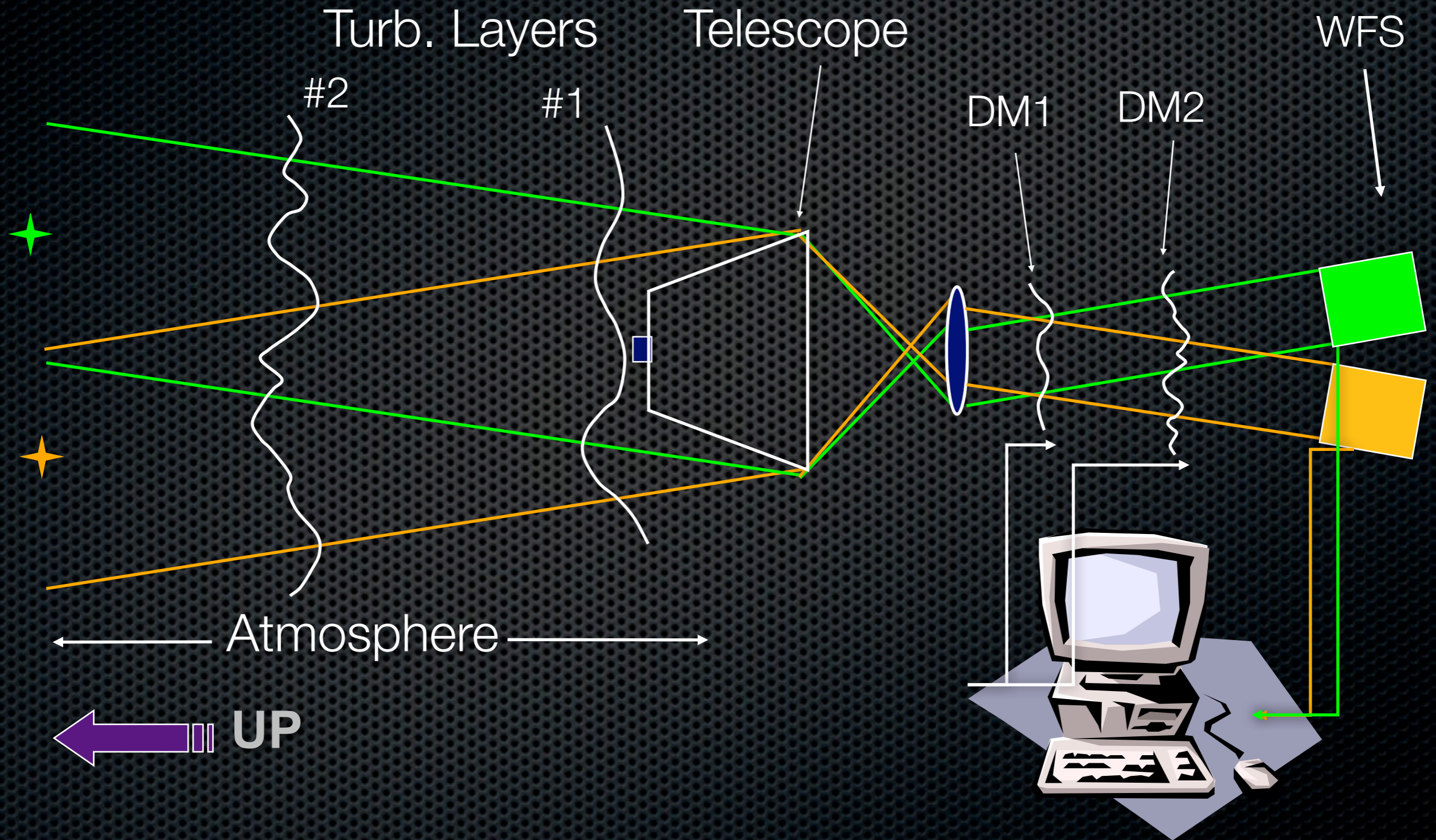
- **Gemini MCAO:**

Demonstrated physics

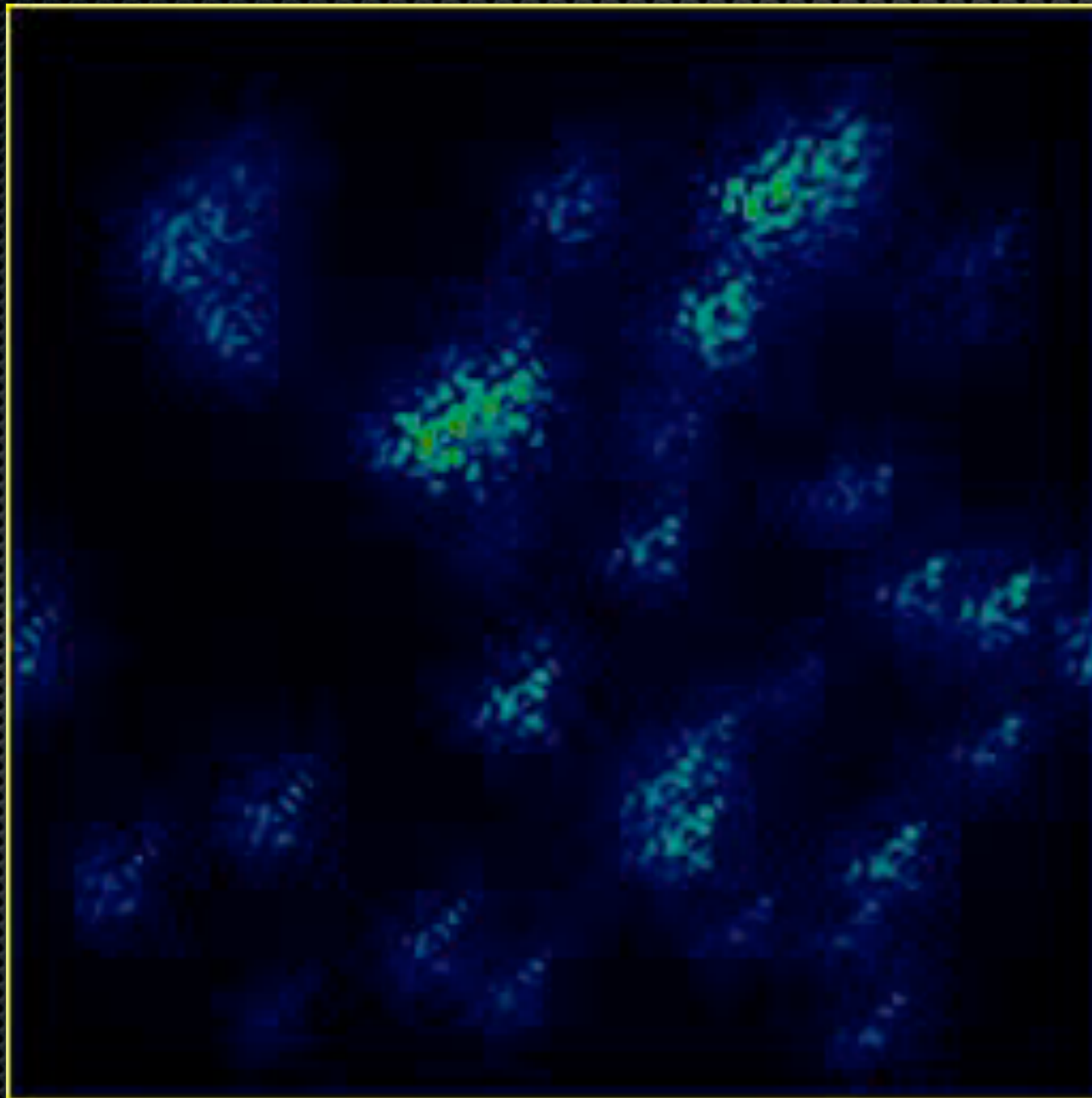


- Work started mid 99
- Funding was secured 2001-2002
- Being integrated in La Serena
- First light in 2010

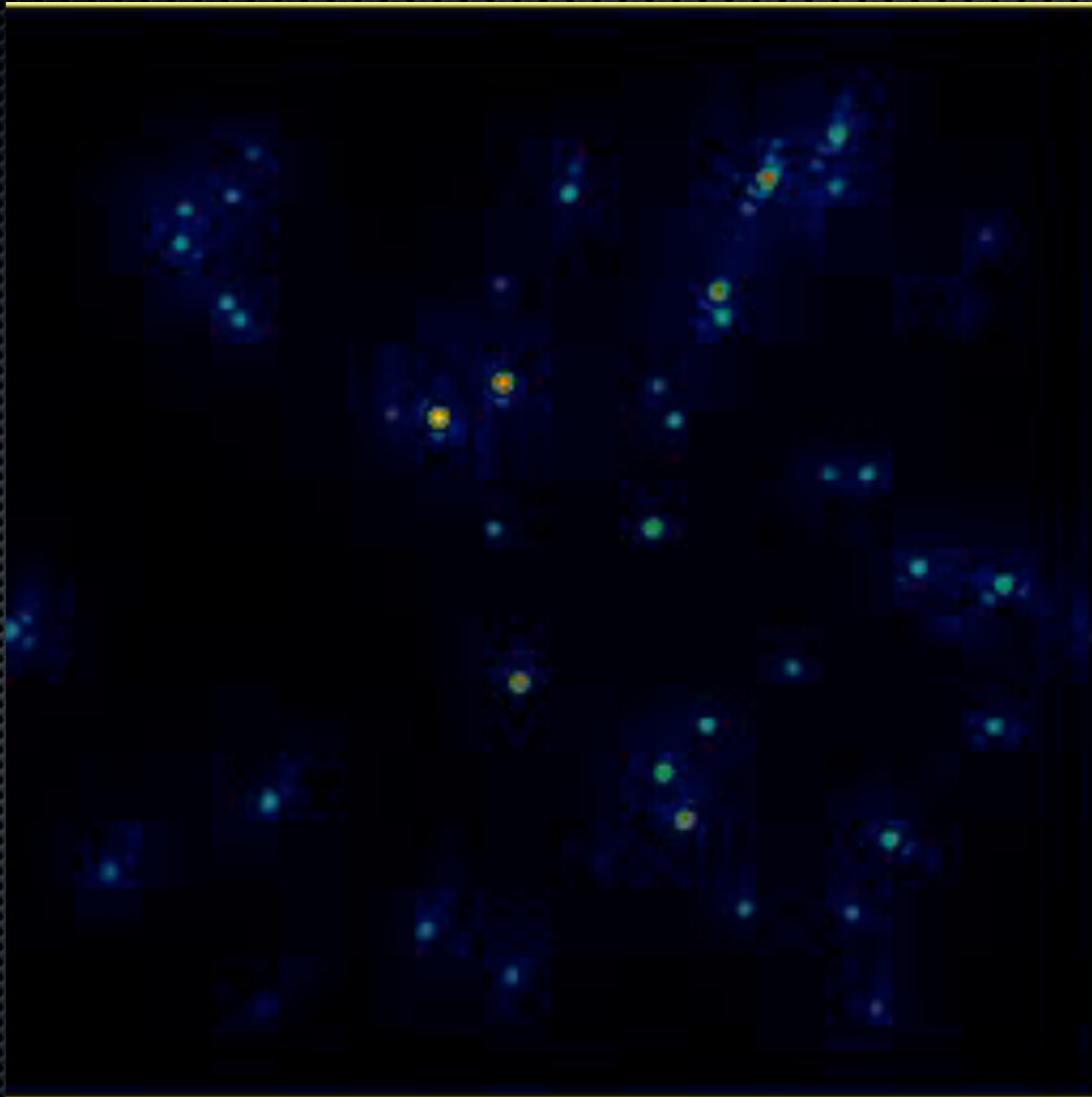
The multi-conjugate AO concept



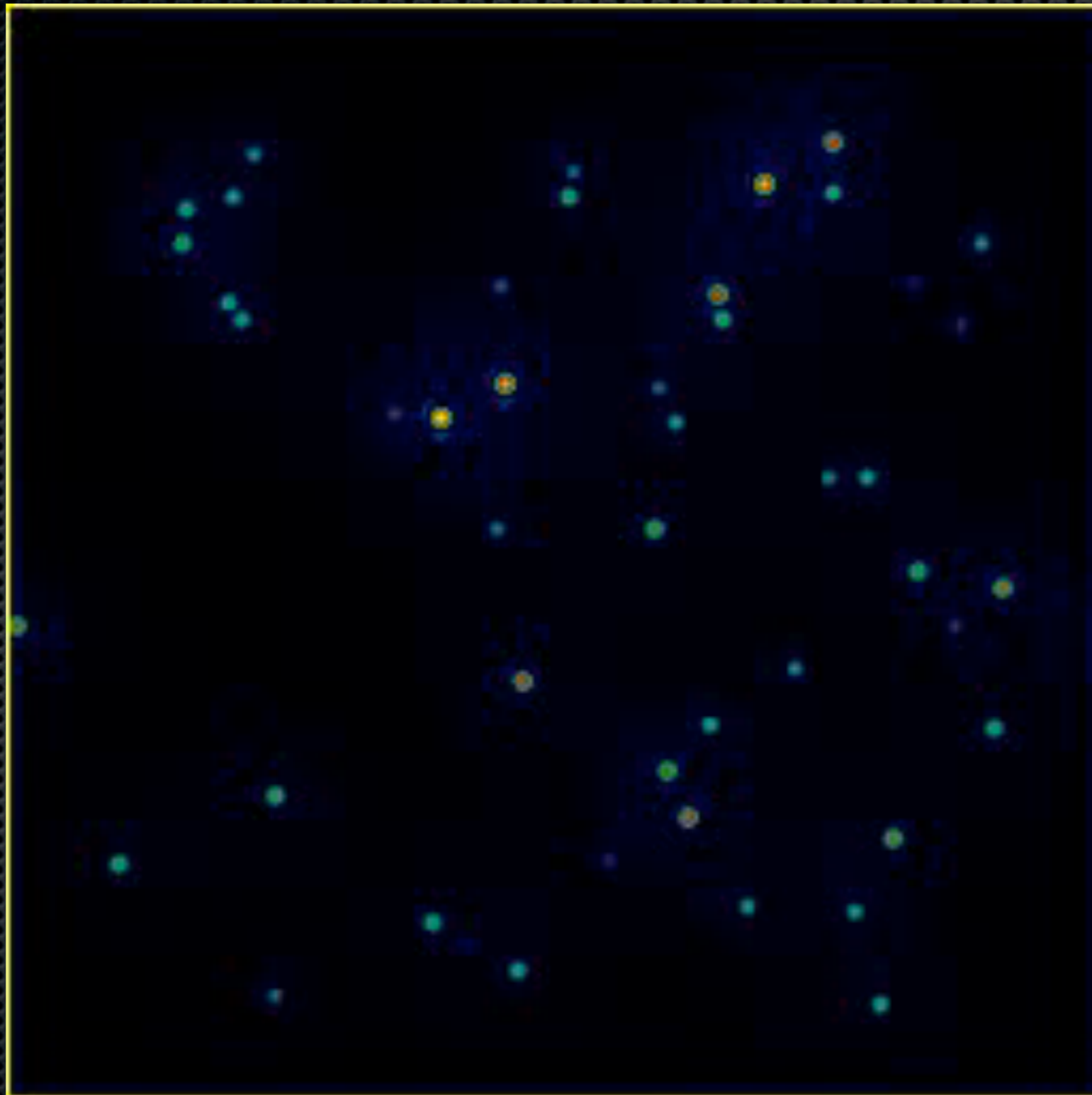
MCAO efficiency



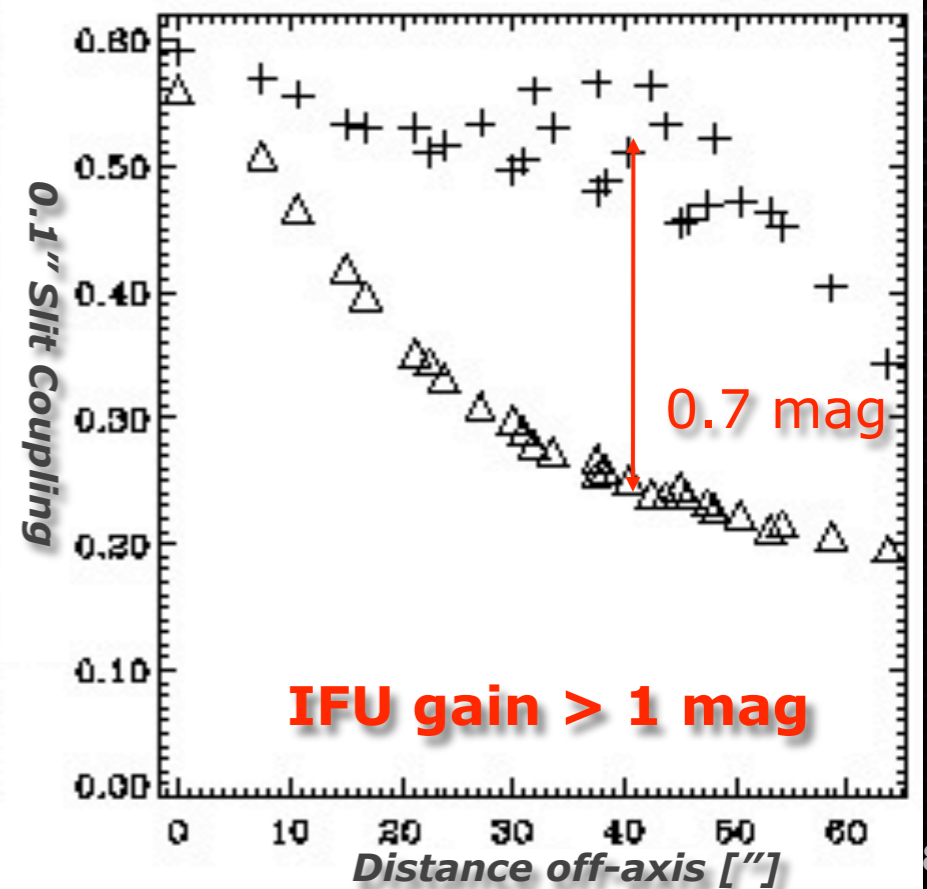
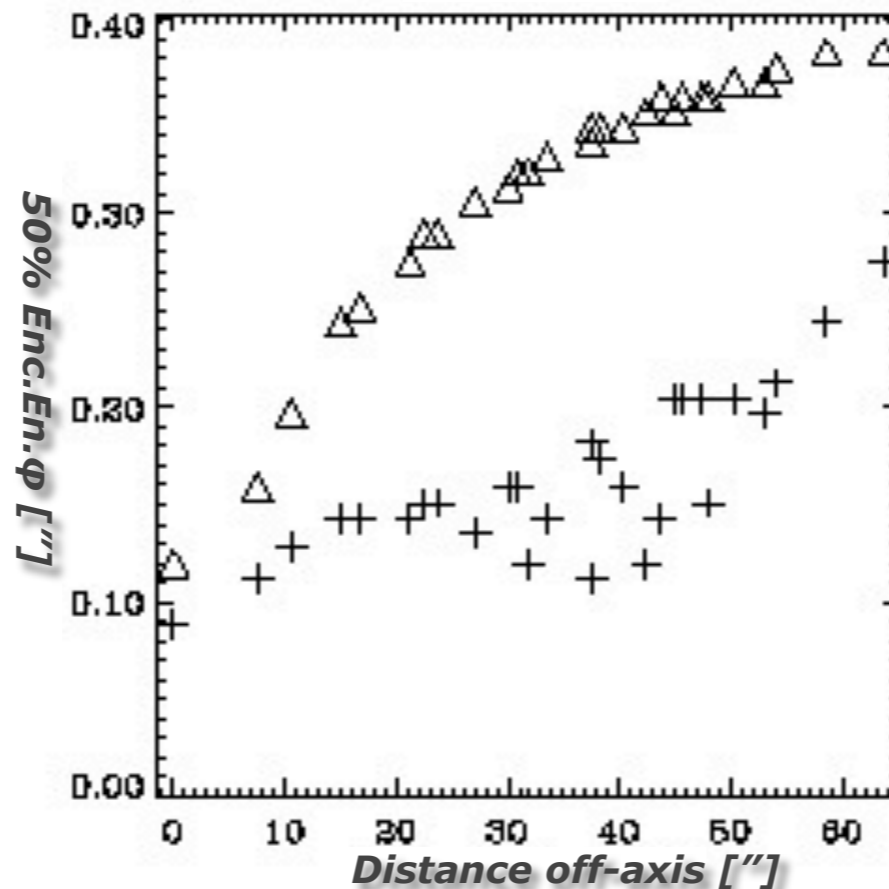
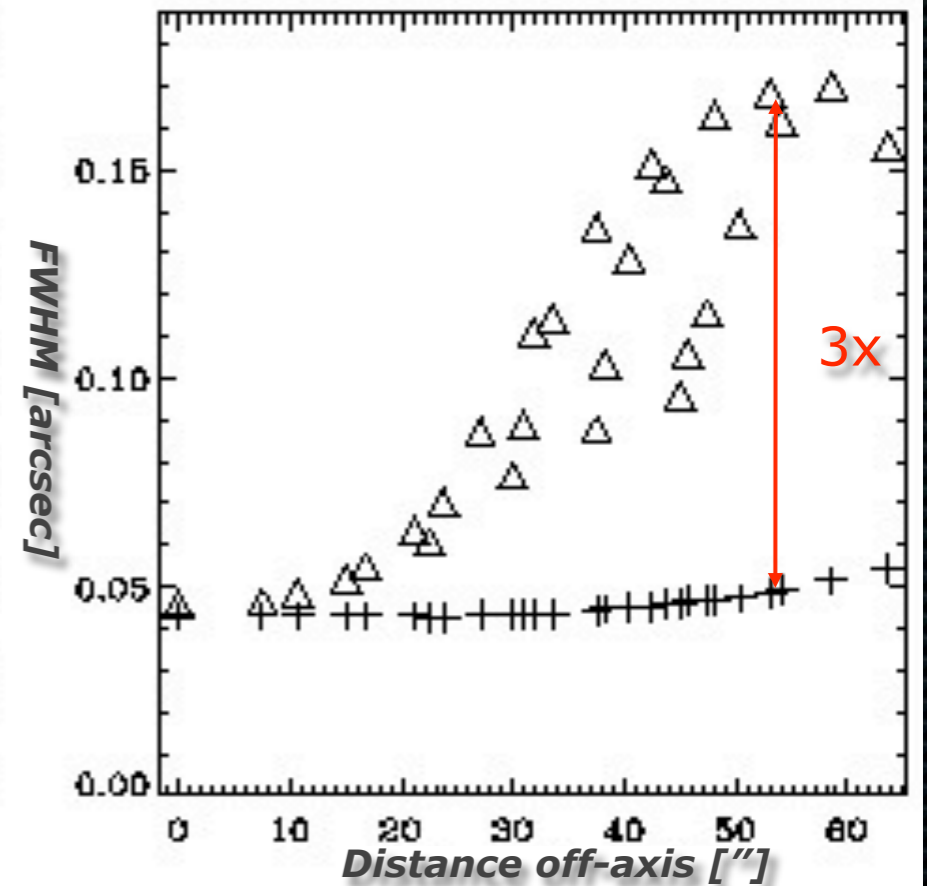
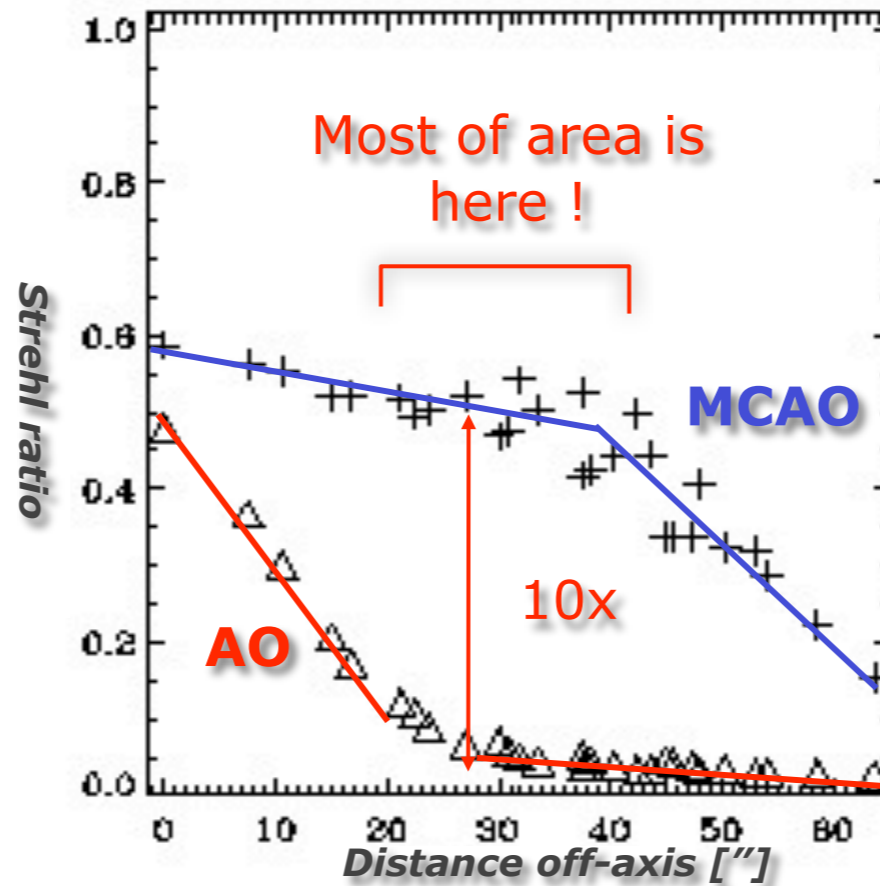
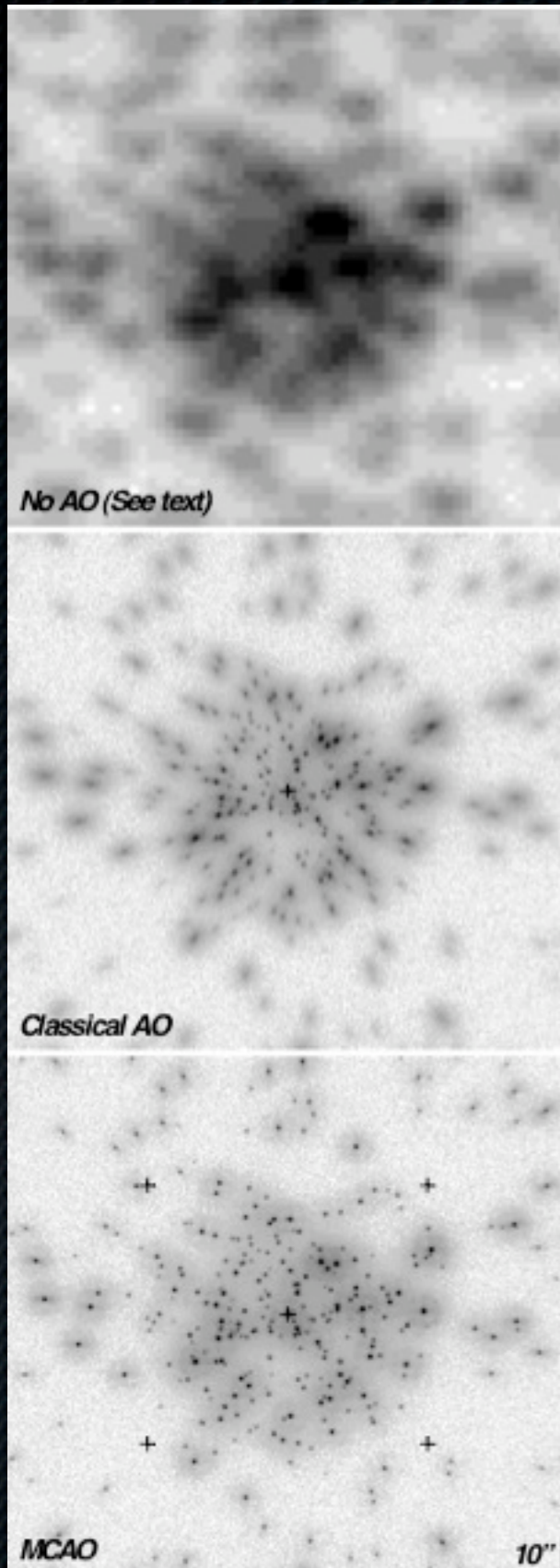
MCAO efficiency



MCAO efficiency



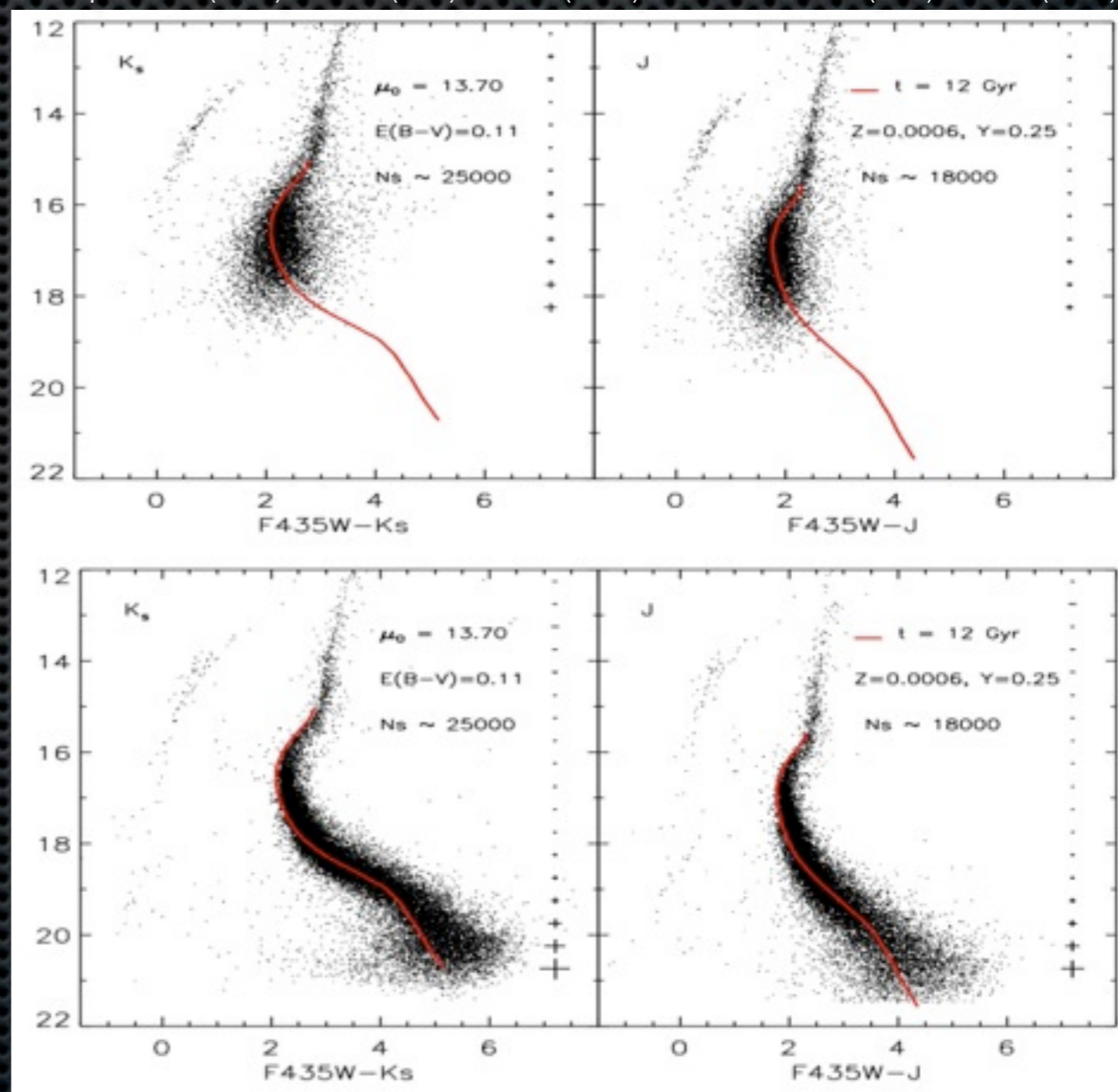
MCAO vs AO gains



A taste of the upcoming science with GeMS: MAD results @ the VLT

- A few (4-5) runs of technical commissioning + science (~25 nights)
- 0.5" seeing (ISAAC) -> 90mas (MAD) lead to a 3 magnitude gain in crowded region (see plot). MCAO should improve that by another 1.5 magnitude. In less crowded fields, expected limit = 24.9 (Ks), 26.3 (J) 5sigmas, 1hr
- MAD soon shipped back to Garching (out of targets?).
- MAD has demonstrated that MCAO and GLAO work. Gemini will do better in terms of (1) performance (684 actuators vs 120 for MAD) and sky coverage (LGSs vs NGSs for MAD)

Omega Cen central region. G.Bono et al, astro-ph 0803.2207
 Top: SOFI(NTT)/ISAAC(VLT) + ACS(HST). Bottom: MAD(VLT) + ACS(HST)



ISAAC/No AO

MAD/MCAO

GeMS history overview

April 1999	MCAO recommended as GS AO system
May - Sept 1999	MCAO feasibility study
Dec 1999 – May 2000	CoDR phase + review
June 2000 – May 2001	PDR phase + review
Oct 2001 – May 2004	CDR phase, RFP and external contract setup
2005	GN Altair LGS integration and commissioning
Dec 2005	MCAO internal project definition and launch
Jan – Oct 2006	In-house design phase
Oct 2006 – Mar 2010	Mix of on-going design, fabrication and I&T
Apr 2010	Scheduled first light
Apr - Dec 2010	On-sky technical and science commissioning

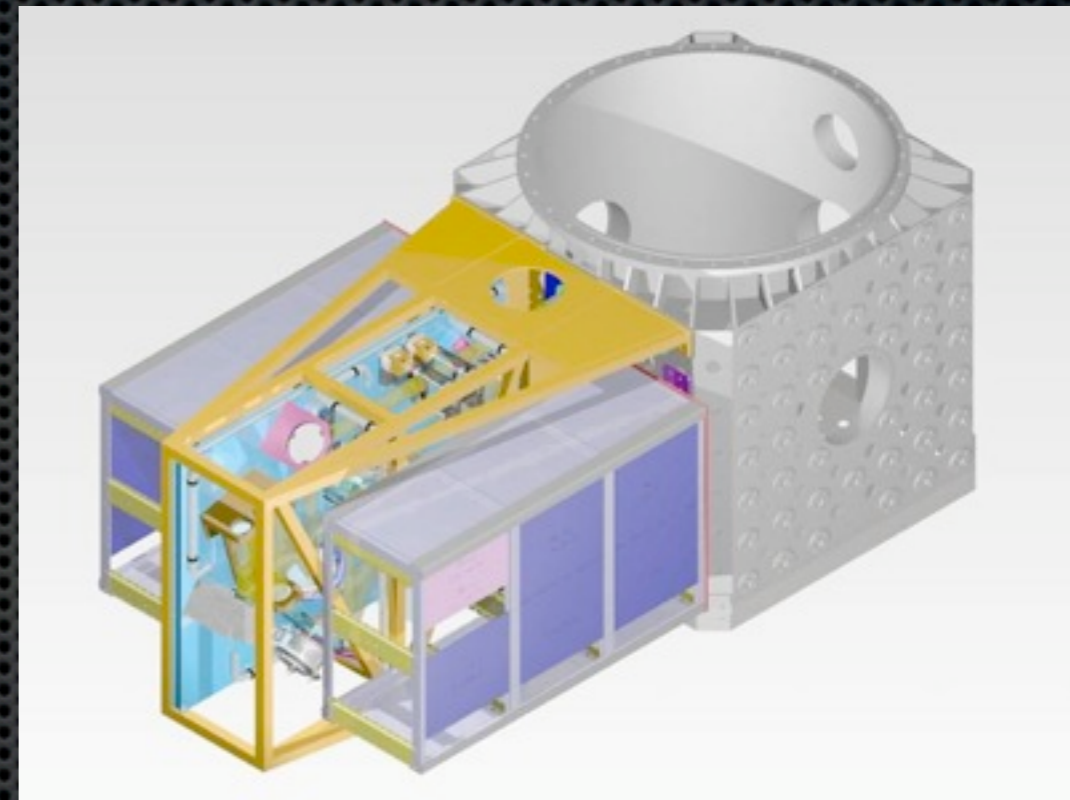


GeMS in numbers

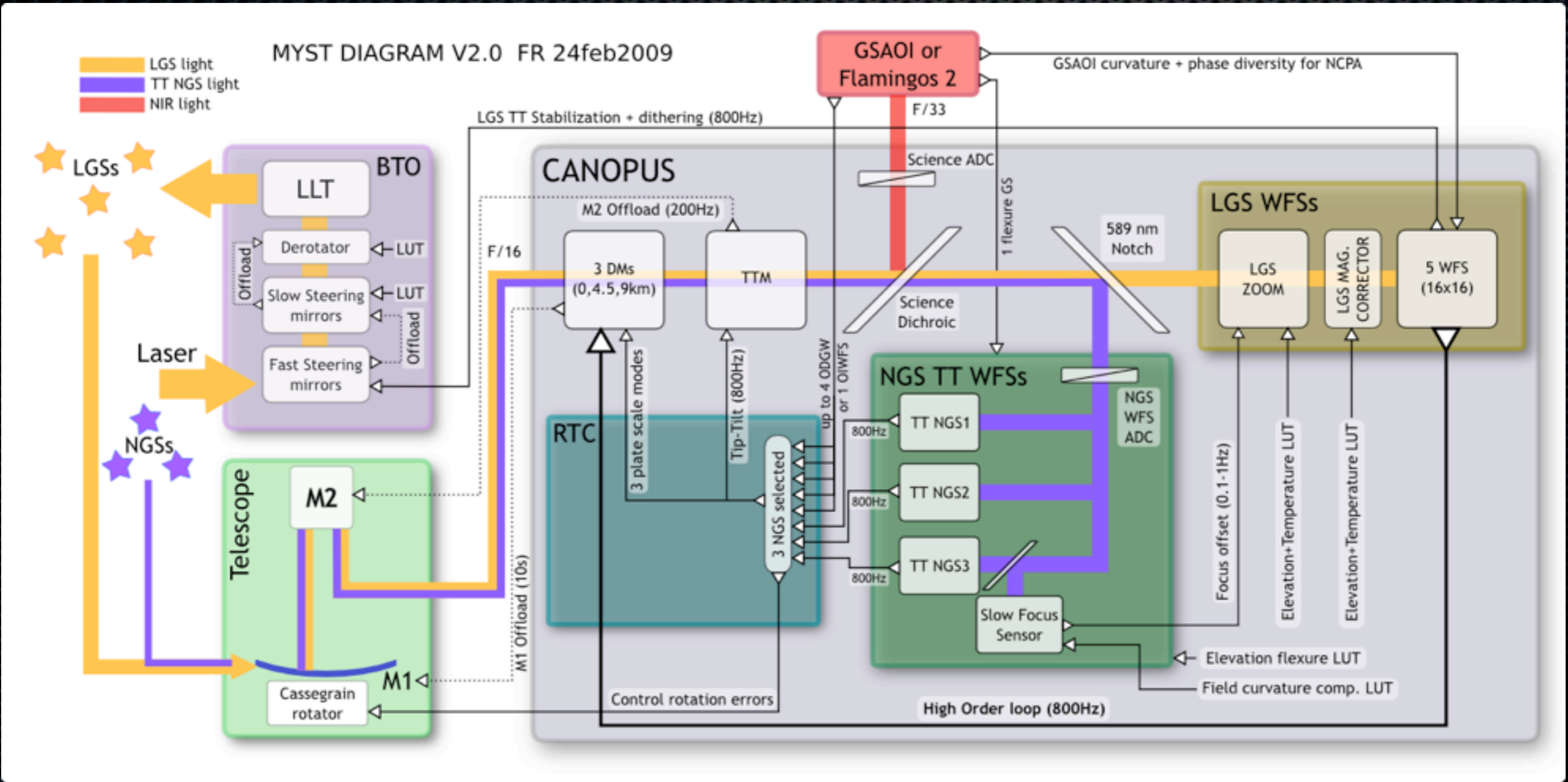
- 5 LGS WFS 16x16 Shack-Hartmann
 - 3 Deformable Mirrors totaling ~800 actuators, conjugated to 0, 4.5 and 9km ranges
 - 3 APD based NGS Tip-Tilt WFS
 - 1 NGS slow focus WFS
- } CANOPUS
- 1 x 50W laser divided in 5 x 10W beams placed on the corners and center of a 1' FoV
 - 2 dedicated instruments:
 - GSAOI (4k2 NIR imager), 80" FoV (20mas pixels)
 - Flamingo II (NIR MOS), 2' FoV
 - Many subsystems: ASCAM, Safety systems, infrastructure, laser(s), BTO, LLT, etc...

GeMS Subsystems

- Canopus = AO module (EOST)
 - includes all optomechanics
 - bench electronics+control
- Real-Time Computer (tOSC)
 - 2x6 CPUs TIGERSharks (RISC)
- LGS WFS (tOSC)
- Deformable Mirrors (CILAS)
- Off-axis parabola (U.Arizona OSC)
- Diagnostic WFS (in house)
- AIT (in house)
- laser, BTO, LLT, LSE, Safety systems



GeMS block diagram



“Side” subsystems (infrastructure)

Elevation platform extension



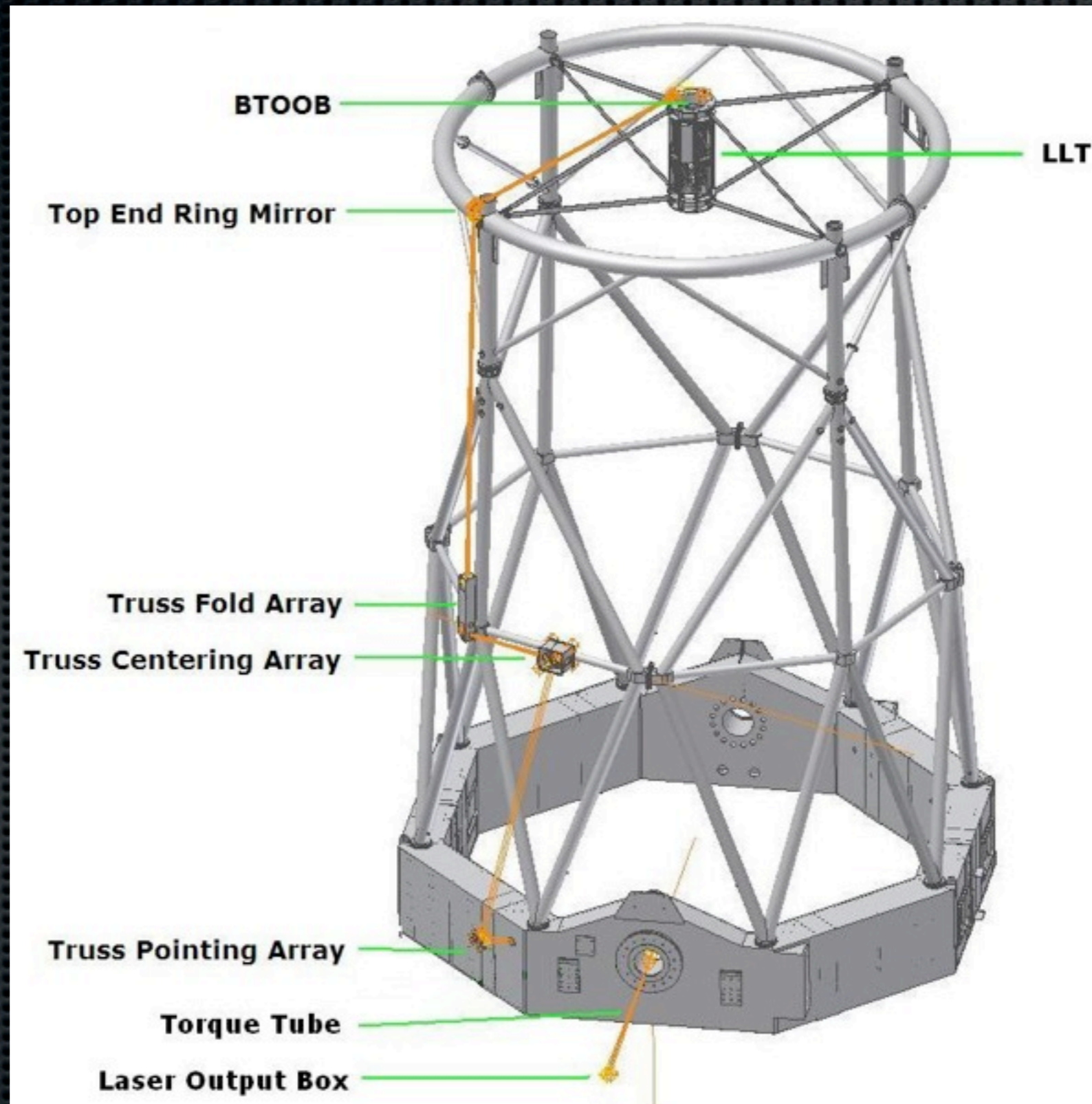
Laser Infrastructure (LSE)



Altair LGS woes and lessons learned

- Beam quality is primordial (LLT problem)
- Vibration can also occur @ launch (vibrations induced by M2 positioners)
- Laser stray light is powerful
- Operation is much more complex than NGS
- Requires interaction with
 - space command → issue for Queue scheduling
 - FAA (aircraft) → spotters / all sky camera
 - neighbors telescopes (beam collisions) → LTCS
- Spotters, insurance, laser maintenance is high cost
- Non-Common Path aberrations are an issue

Beam Transfer Optics



A modern GeMS Status Display



Window Menu Displays Help

Camera Control

exptime

temp-ctrl

Detect Aircrafts

Detection paused (Start to continue)

Status

CCD temp **STALE**

CCD power **STALE**

Frame 20070709T214052.fits

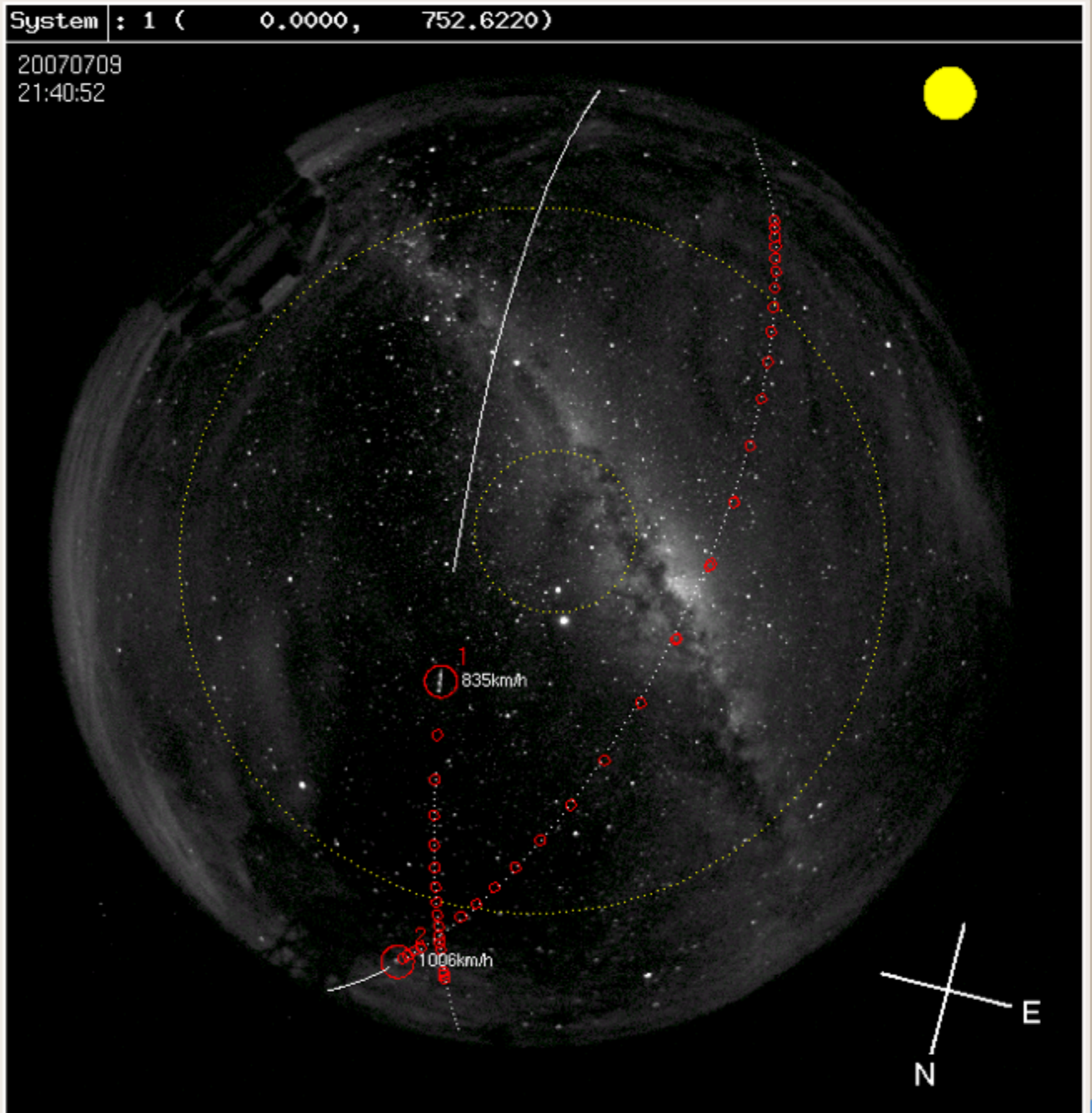
Proc. time 0.46 sec

Detection Aircraft -> 30el !

ASCAM SIMULATED


Trajectory Log

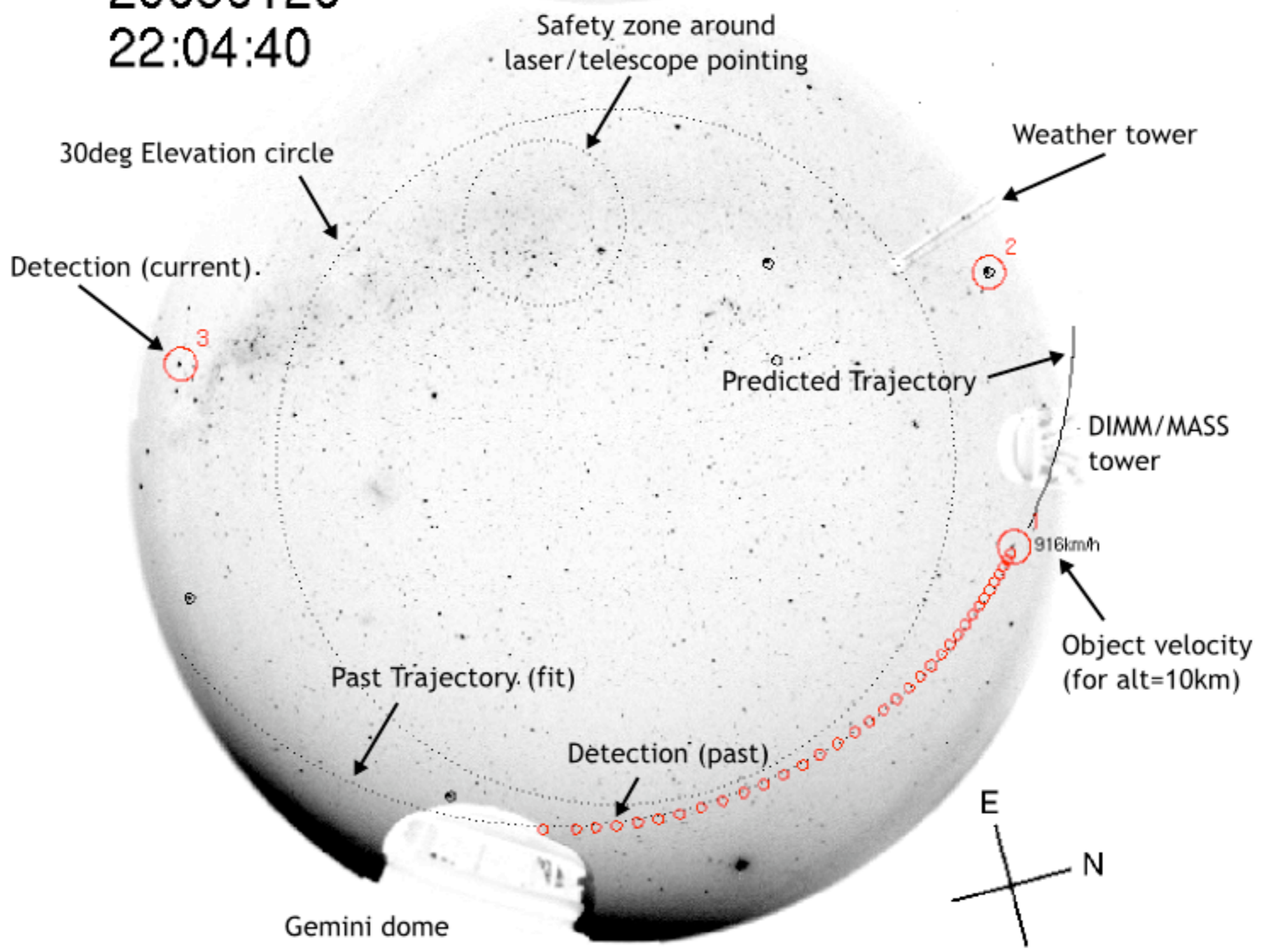
TIME	MXL	SPD	PA	IMP	NPT
21:38:39	63	1005	35	29	39
21:41:09	77	835	51	15	23



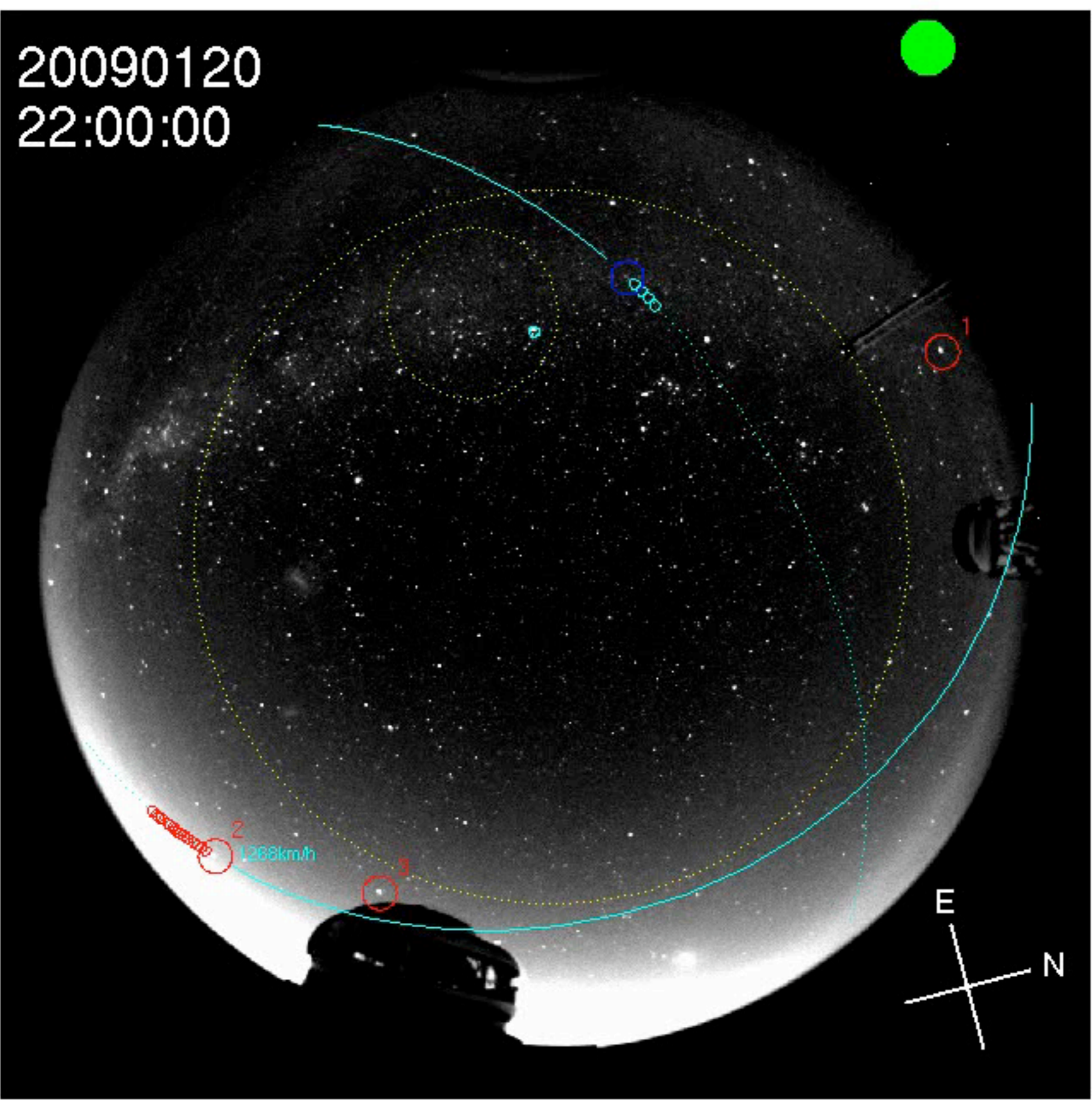
Date & Time

20090120
22:04:40

Alarm status




20090120
22:00:00



All loops closed in the lab

The screenshot displays the GEMINI Multi-Conjugate Adaptive Optics System Control Panel. The interface is divided into several functional areas:

- Top Left:** Pixel Gauges for RAW and SUBAP data, showing histograms and numerical values.
- Top Center:** Zernike Statistics and DM4.5 Phase plots, including 3D surface plots of phase errors.
- Top Right:** DM14.5 Phase plot and a large grid of data points.
- Middle Left:** DM0 Phase and DM0 Commands windows, showing camera phase maps and control commands.
- Bottom Left:** Calibration Controls, Servo Parameters (AD LOOP, TTM LOOP, TA LOOP), and Camera Settings (Camera View, Trigger, Exposure).
- Bottom Center:** Instant Replay controls for recording and playback.
- Bottom Right:** Corrected Camera and Subap Signal windows, displaying the resulting beam profiles.
- Status Bar:** Shows system parameters like rR: 289.62 cm, NormIU: 0.82, Rytov: 0.01, and system clocks.

All loops closed in the lab

The screenshot displays the GEMINI Multi-Conjugate Adaptive Optics System Control Panel. The interface is divided into several main sections:

- Top Left:** Pixel Gauges showing RAW and SURAP data, and Average DM0 Phase (microns) and (nanometers) 3D surface plots. The DM0 phase plots show a smooth, curved surface with a color scale from -2000 to 2000.
- Top Right:** Slope w/tilt/Focus, showing a 2D plot of slope data with yellow starburst patterns.
- Bottom Left:** Calibration Controls, Servo Parameters, and CCD39B Camera Settings. The Servo Parameters section shows gain and leakage settings for AD LOOP, TTM LOOP, and TAL LOOP, all with their respective loop status indicators (yellow dots) and 'Pause' buttons. The CCD39B Camera Settings show 'On Camera' selected and 'Simulator' disabled.
- Bottom Right:** Corrected Camera and Subap Signal, showing 2D camera images with a grid overlay and a subap signal plot.
- Bottom Center:** A status bar containing 'Files' (background taken at 2007:228:21:58:14), 'Atmosphere' (r0: 36.79 cm, NormIV: 0.84, Rytov: 0.01), and 'Clocks' (2007:228:22:24:22, screen update: 046 msec, window redraw: 1.577 msec, 913 fps).

All loops closed in the lab

The screenshot displays the GEMINI Multi-Conjugate Adaptive Optics System Control Panel. The interface is divided into several main sections:

- Top Left:** Pixel Gauges showing RAW and SURAP data for LIN COORDS and LIN FOC.
- Top Center:** Two 3D surface plots. The left plot shows the Average DM0 Phase (microns) with a color scale from 0 to 5. The right plot shows the Average DM9 Phase (microns) with a color scale from -2000 to 2000. Both plots are labeled with $\theta=0$ and $\phi=-45$.
- Top Right:** A large field of view showing a starry sky with the text "Slope w/o Tilt/Focus".
- Bottom Left:** Calibration Controls panel with tabs for Common, DM0, DM 45, and DM 9. It includes Surface Shapes (Flat, 9 Big Poles, etc.), DM Counts, and Actuator settings.
- Bottom Center:** Servo Parameters panel with controls for AD LOOP, TTM LOOP, and TA LOOP, including Gain and Leakage sliders.
- Bottom Right:** CCD39B Camera Settings panel with Camera View, Trigger, Exposure, and Simulator options.
- Bottom Far Right:** Corrected Camera and Subap Signal panels showing camera data and subaperture signals.
- Bottom Center-Right:** A status panel showing "background taken at 2007:228:21:58:14", Atmosphere parameters (rR: 41.11 cm, NormIV: 0.84, Rytov: 0.01), and Clacks (2007:228:22:22:54, screen update: 046 msec, window redraw: 1.612 msec, 792 fps).

All loops closed in the lab

The screenshot displays the GEMINI Multi-Conjugate Adaptive Optics System Control Panel. The interface is divided into several main sections:

- Top Left:** Pixel Gauges showing RAW and SURAP data for LIN COORDS and LIN FOC.
- Top Middle:** Two 3D surface plots. The left plot shows the Average DM0 Phase (microns) with a vertical axis from 0 to 5. The right plot shows the Average DM9 Phase (microns) with a vertical axis from -2000 to 2000. Both plots are labeled with $\theta = 0$ and $\phi = -45$.
- Top Right:** Slope w/o Tilt/Focus, showing a field of yellow stars.
- Bottom Left:** Instant Replay window with Record (100 Frames) and Playback controls.
- Bottom Middle-Left:** Calibration Controls window with tabs for Common, DM0, DM45, and DM9. It includes Surface Shapes (Flat, 9 Big Poles, etc.), DM Counts, and Actuator settings.
- Bottom Middle-Right:** Servo Parameters window with controls for AD LOOP, TTM LOOP, and TAL LOOP, including Gain and Leakage sliders.
- Bottom Right:** CCD39B Camera Settings window with Camera View, Trigger, Exposure, and Simulator options.
- Bottom Far Right:** Corrected Camera and Subap Signal windows showing grayscale images of the star field.
- Bottom Center:** Status bars for Files (background taken at 2007:228:21:58:14), Atmosphere (rR: 25.73 cm, NormIV: 0.84, Rytov: 0.01), and Clocks (2007:228:22:25:01, screen update: 046 usec, window redraw: 1.578 usec, 791 fps).

GeMS Status

- Laser:
 - Keck laser going through AT as we speak (delivers 40W, 20W spec)
 - but, LMCT short in resources to finish laser (fuzzy)
 - Planned delivery date: August 2009
- CANOPUS:
 - Going through I&T in the Gemini SBF lab
 - No major performance issue to date
 - Big software integration/automation/optimization effort
 - Remaining issues: Cooling redesign, electronic integration, TTWFS throughput
- Other subsystems (BTO/LLT/Infrastructure/Safety) proceeding well
- First light 2010A

