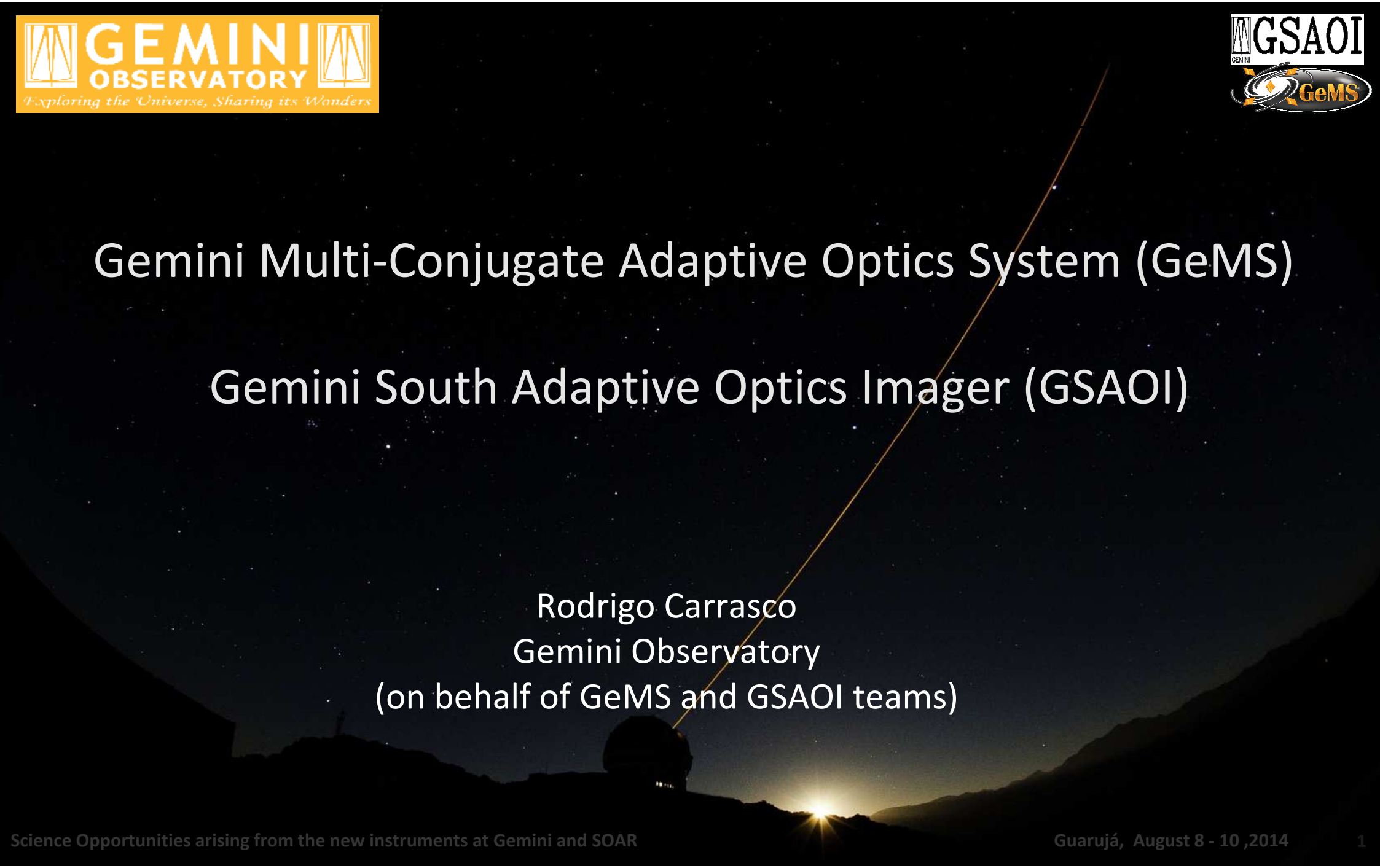
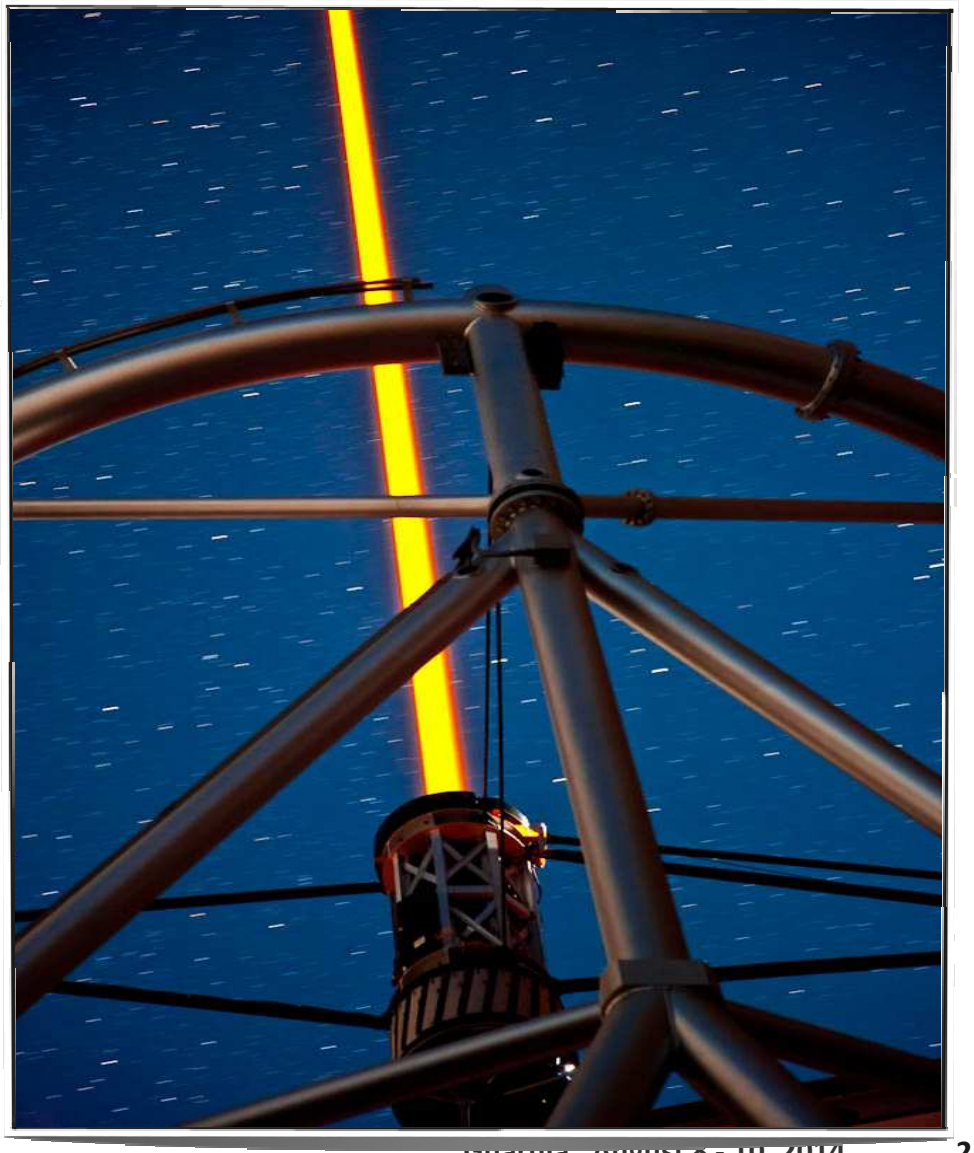


Gemini Multi-Conjugate Adaptive Optics System (GeMS)

Gemini South Adaptive Optics Imager (GSAOI)

Rodrigo Carrasco
Gemini Observatory
(on behalf of GeMS and GSAOI teams)

- Introduction (brief)
- GeMS overview
- GSAOI overview
- From commissioning/SV to Operations
- GeMS/GSAOI on-sky performance
- Science with GeMS/GSAOI
- Observing with GeMS/GSAOI
- **GSAOI Data and data processing**



Introduction

GeMS Overview

AO/MCAO/GeMS documentation and links

AO Tutorial (Andrei Tokovinin): http://www.ctio.noao.edu/~atokovin/tutorial/index.html
Introduction to MCAO: http://www.gemini.edu/sciops/instruments/gems/mcao-nutshell
Introduction to GeMS: http://www.gemini.edu/sciops/instruments/gems/introduction-gems

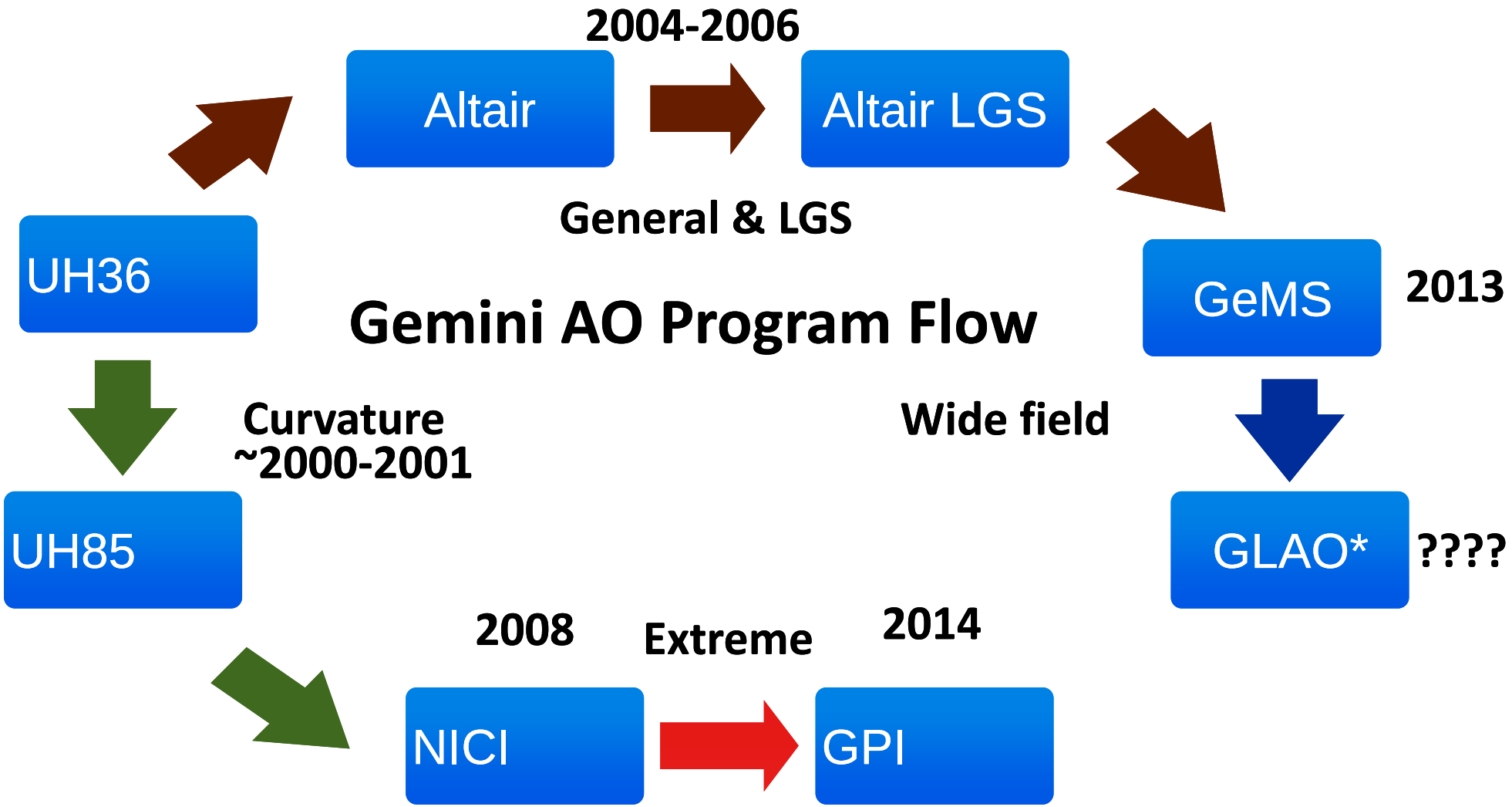
Refereed articles

- Rigaut et al., 2014, MNRAS, 437, 2361 "Gemini multi-conjugate adaptive optics system review - I. Design, trade-offs and integration"
- Neichel et al. 2014, MNRAS, 440, 1002 "Gemini multi-conjugate adaptive optics system review - II. Commissioning, operation and overall performance"

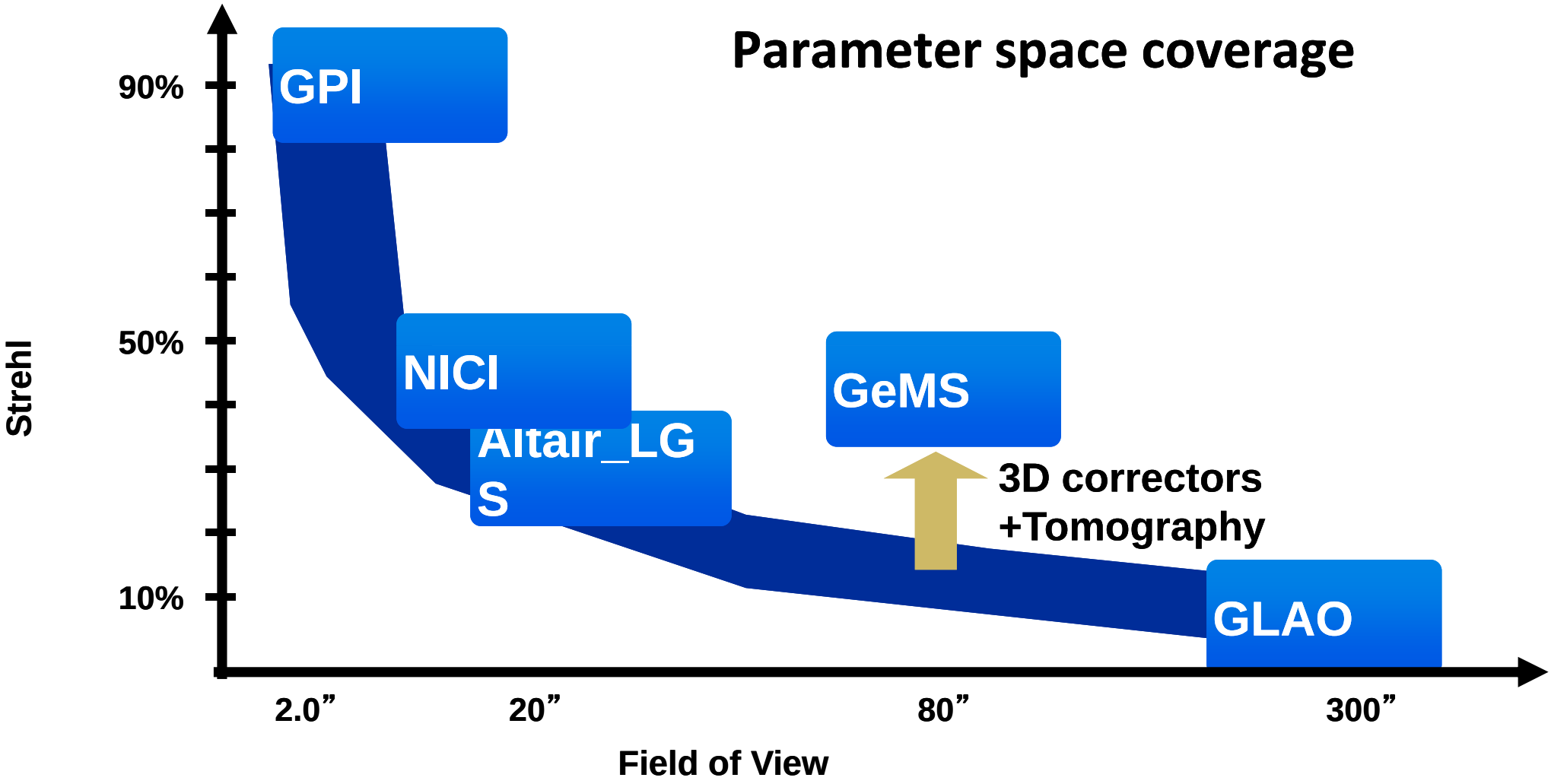
Conference proceedings:

- Vidal et al. 2013, AO4ELT3 proceeding "GeMS telemetry"
- Hibon et al. 2013, AO4ELT3 proceeding "GeMS/GMOS-S"
- Lu et al. 2013, AO4ELT3 proceeding "GeMS astrometric performance"
- Rigaut et al., 2012, SPIE, 8447 "GeMS performance"
- More documents at http://www.gemini.edu/sciops/instruments/gems/documents

Introduction



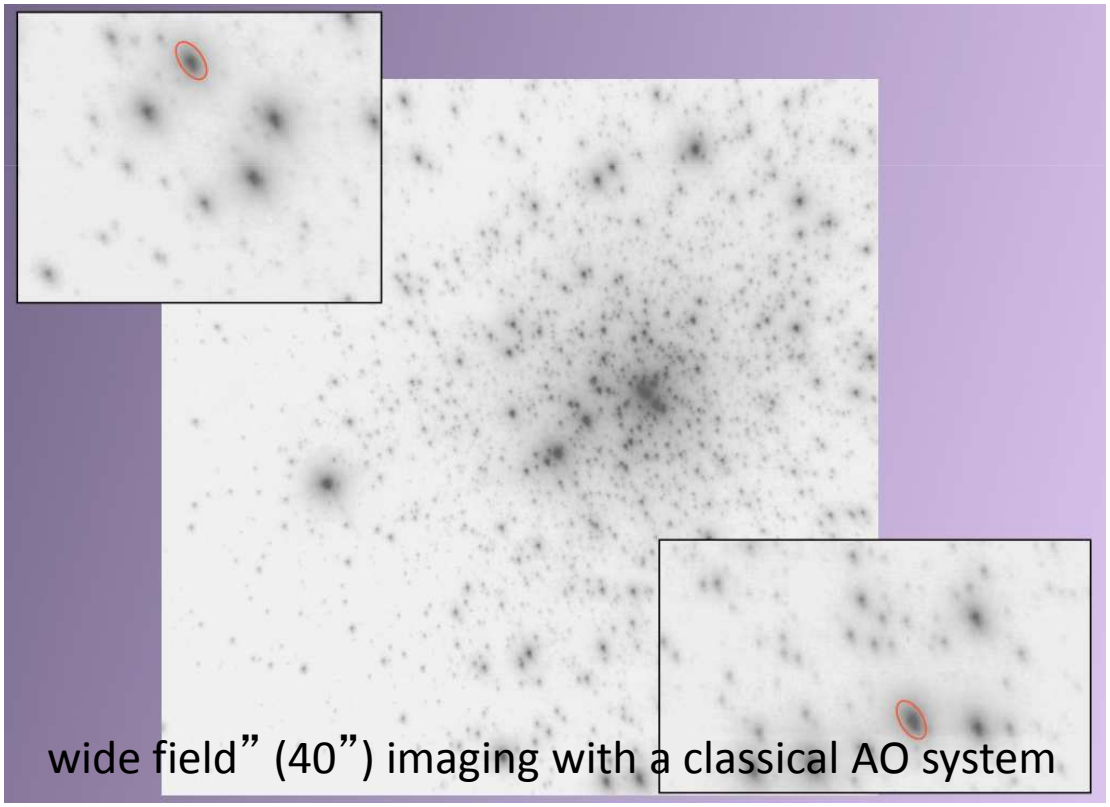
Introduction



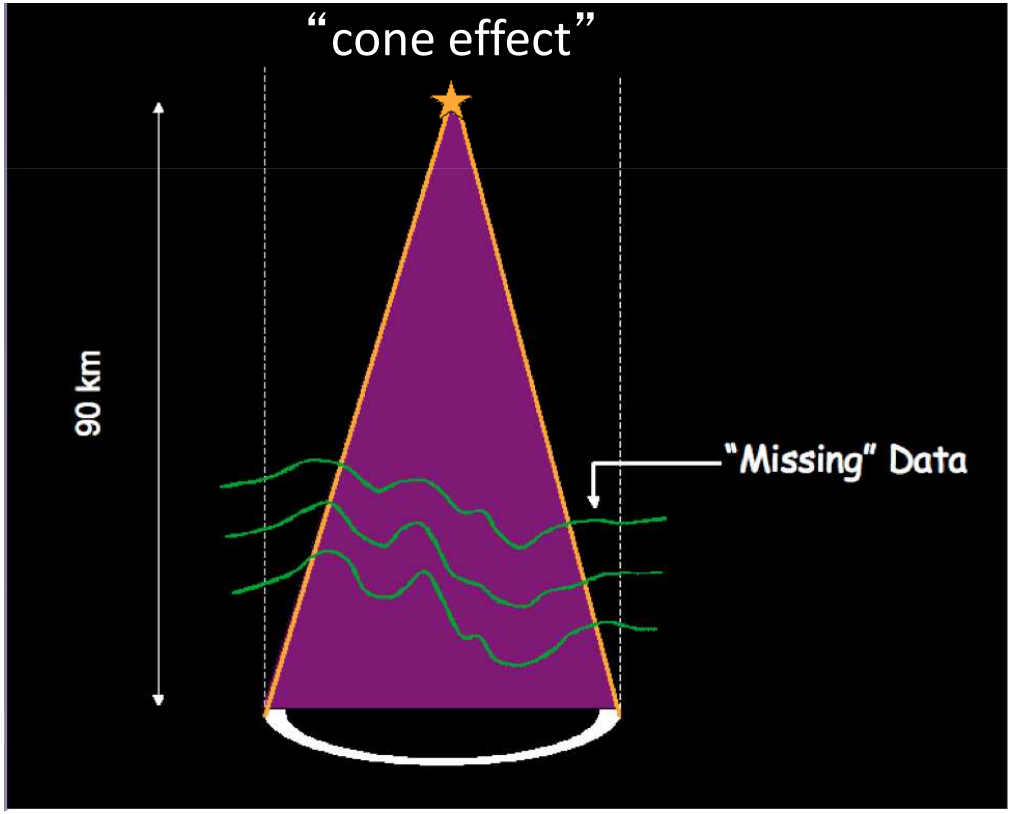
Introduction

SCAO - Single-Conjugate Adaptive Optics (classical AO)

- Limited isoplanatic angle (20” in J band, 30” in H band, and 40” in K band)
- cone effect
- limited sky coverage

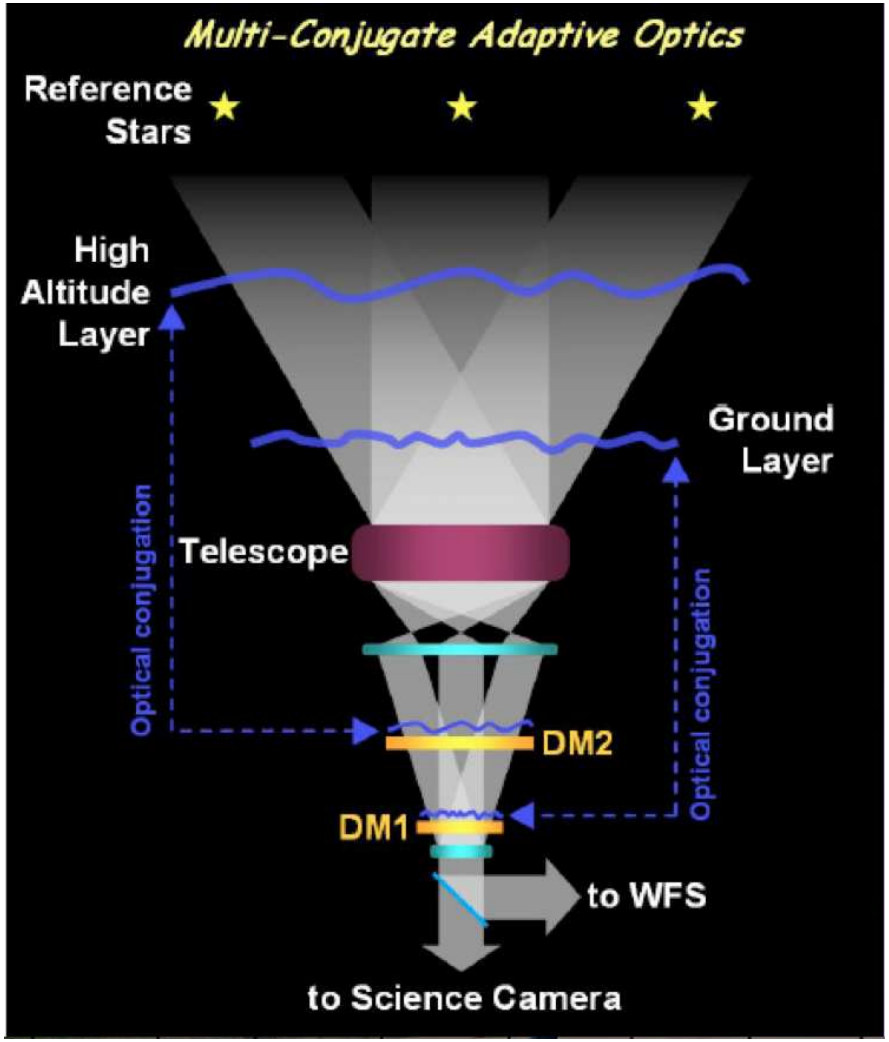


wide field” (40”) imaging with a classical AO system



Introduction

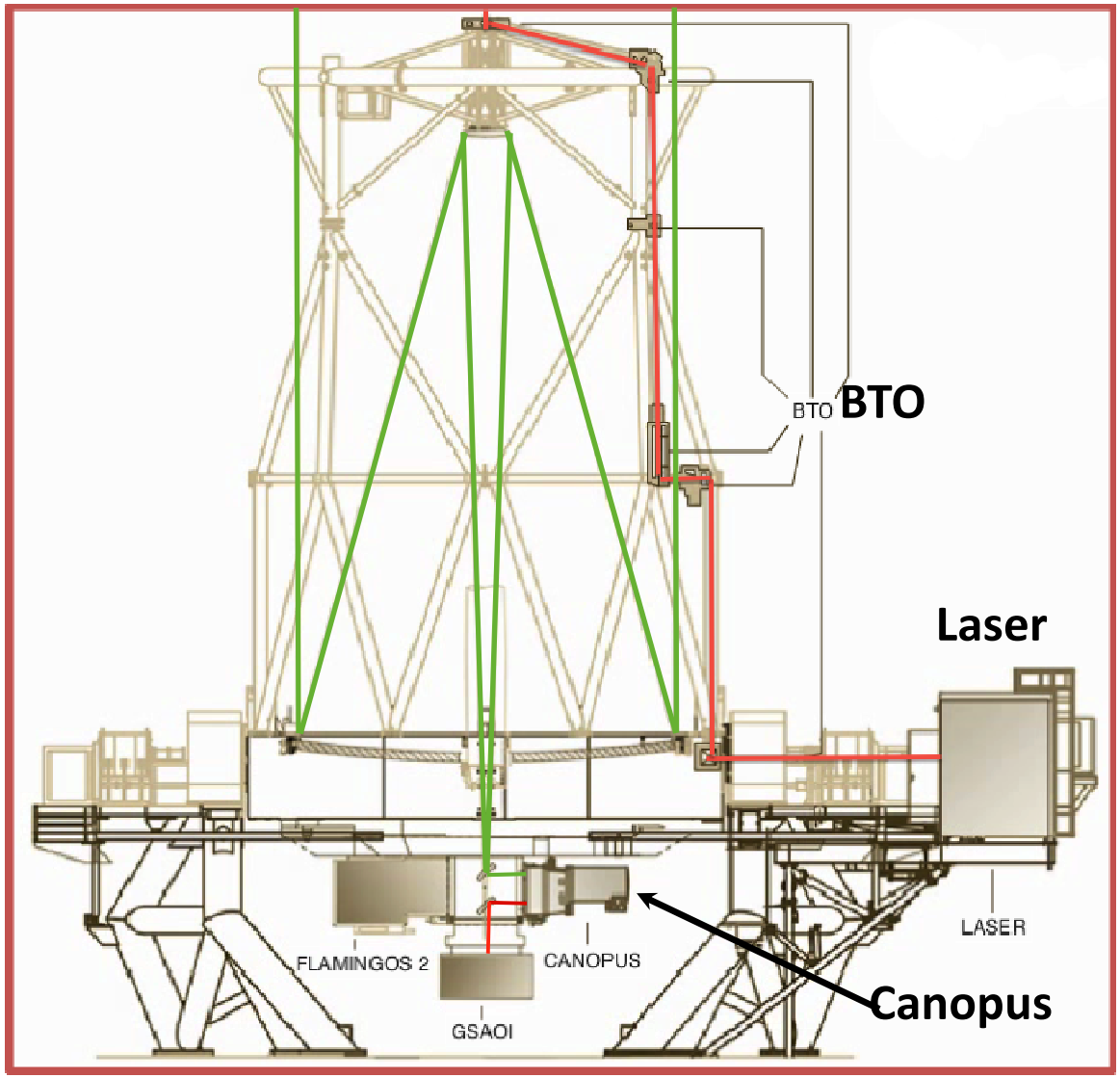
- **MCAO** - **M**ulti-**C**onjugate **A**daptive **O**ptics
  - provides uniform image quality (diffraction-limited in the near-IR) over a much wider field than regular AO (up to two arcmin in diameter depending on the IQ criterion)
  - removes the "cone effect" associated with the use of laser guide stars.
  - larger sky coverage (wide field)



GeMS overview

GeMS Overview

- Three main subsystems
  - Laser
  - Beam Transfer Optics (BTO)
  - AO bench (Canopus)
- All three system are linked together loops and offloads.
- Instrument feed by GeMS
  - GSAOI (near-infrared imager)
  - Flamingos-2 (NIR MOS & Imager - see Percy's talk)
  - GMOS-S (Optical MOS & Imager)



GeMS Overview

- **50W laser** split in 5x10W (in practice 4W on sky/LGS) - Laser, BTO
  - **5 sodium Laser Guide Stars** on X shape, 60 arcsec on a side, with 5 **16x16 Shack Hartmann WFS**

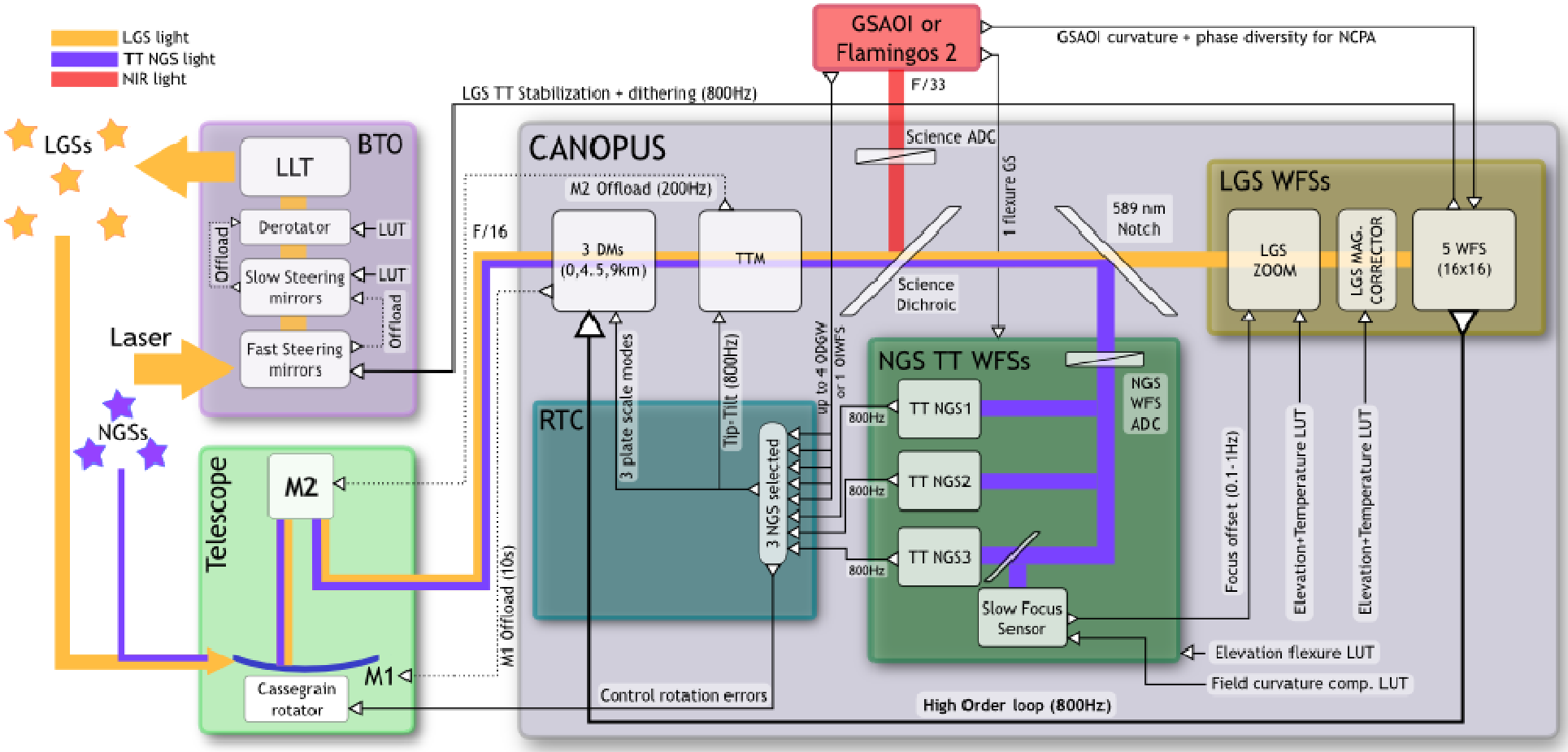
- Tip-Tilt, plate scale and rotation correction done from either:
  - (up to) **3 visible NGS** (Canopus) + one flexure GS using On-Detector Guide Window (ODGW, GSAOI)
  - (up to) **3 NIR ODGW** (GSAOI) + one visible GS for slow focus (Canopus)

- **3 Def. Mirrors** conjugated at 0, 4.5 and 9 km (currently 0 and 9 only) (Canopus)

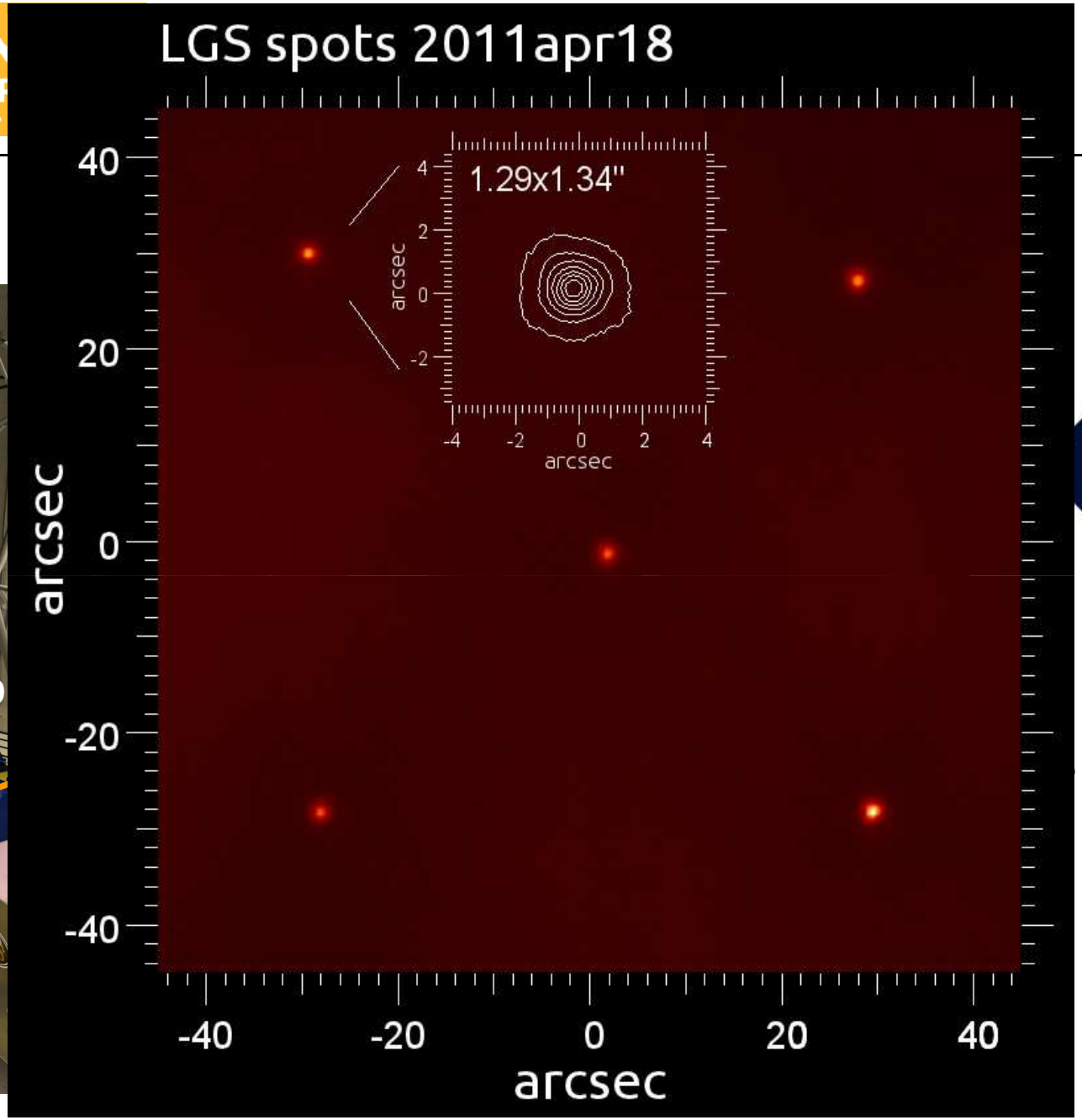
- **Many other subsystems:** Laser Launch Telescopes, Laser Traffic Control, Plane traffic control, Telescope laser extension, Safety systems, etc, etc

- Commissioning started - 01/2011

GeMS Overview

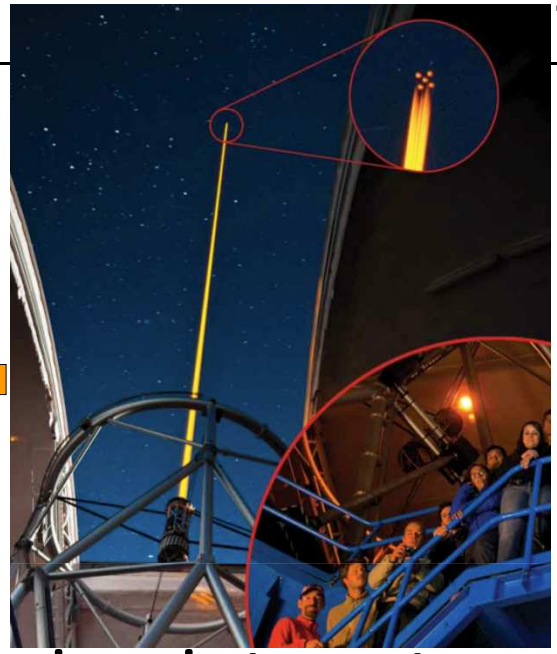


~ 20 loops and offloads

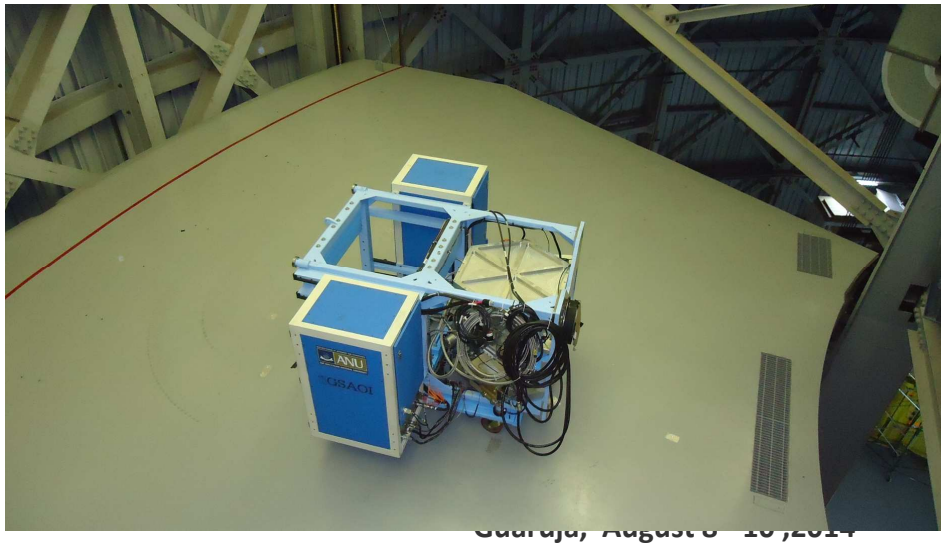


LGS constellation

GeMS Overview



To science instruments



GSAOI overview

GSAOI Overview

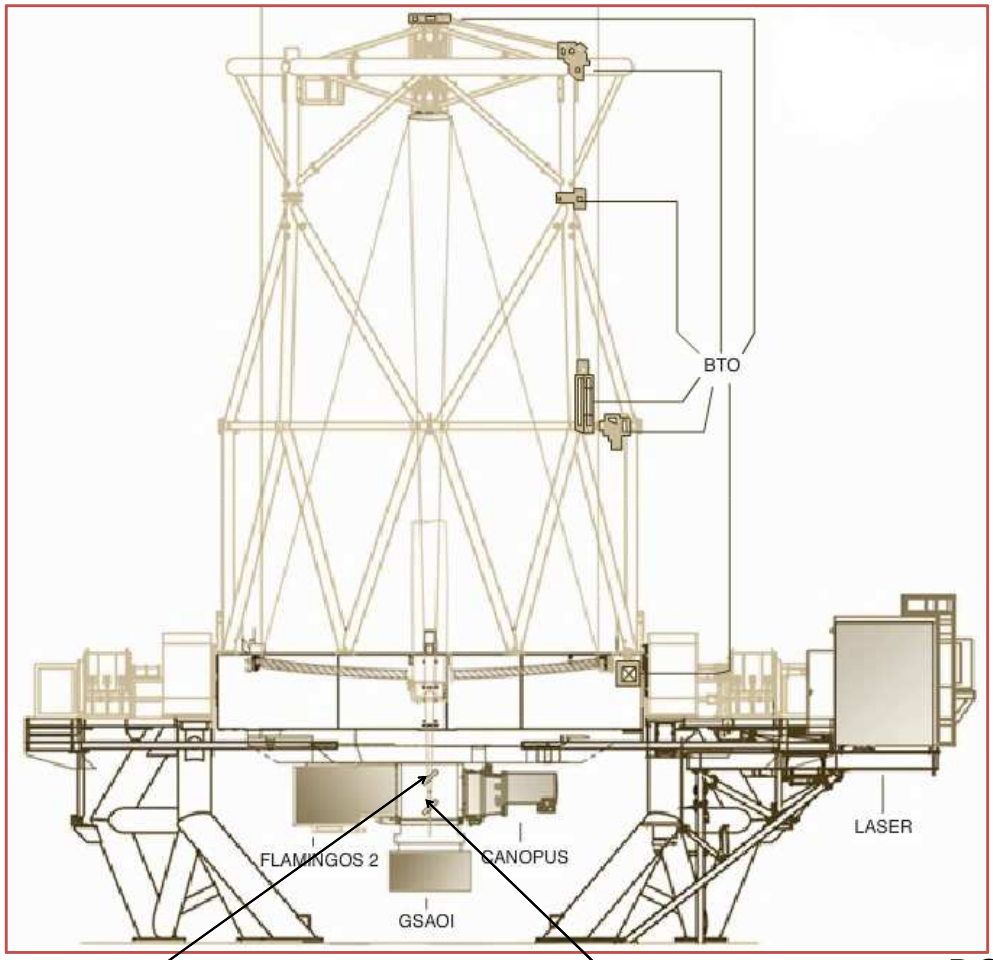
GSAOI documentation and links

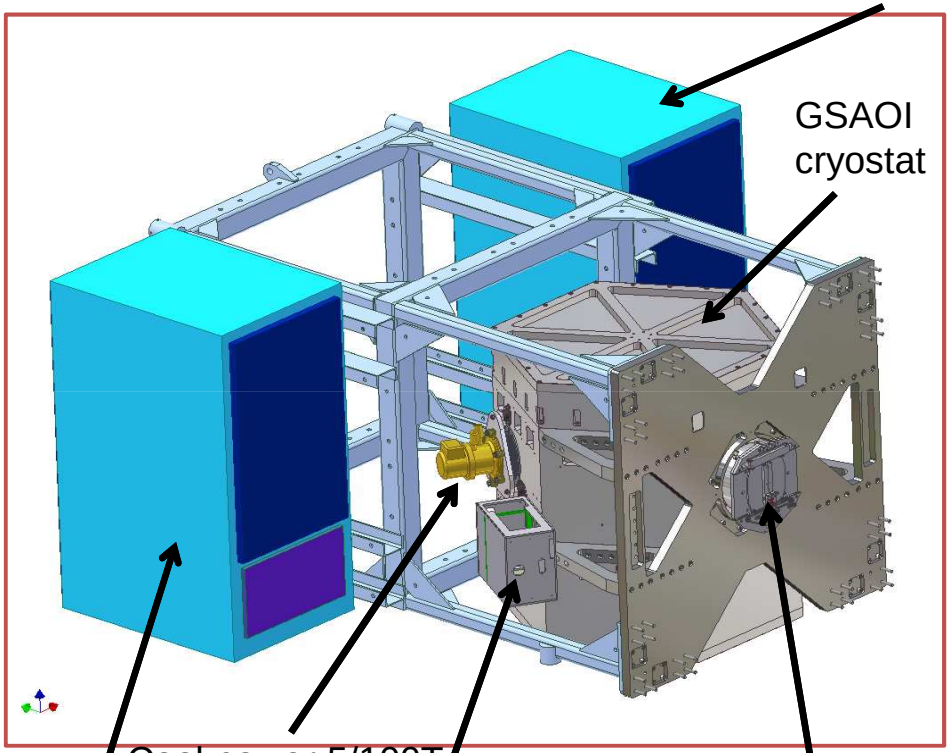
GSAOI Web pages: http://www.gemini.edu/sciops/instruments/gsaoi/?q=sciops/instruments/gsaoi

Conference proceedings:

- McGregor et al. 2004, SPIE, 5492, 1033 "Gemini South Adaptive Optics Imager (GSAOI)"
- Carrasco et al. 2012, SPIE, 8447, 84470N "Results from commissioning of the Gemini South Adaptive Optics imager (GSAOI) at Gemini South"
- More documents at http://www.gemini.edu/sciops/instruments/gsaoi/documents/?q=sciops/instruments/gsaoi/documents

GSAOI Overview





CC thermal enclosure

GSAOI cryostat

Cool power 5/100T cryocooler

DC thermal enclosure

SDSU III detector controller box

Environmental cover and cryostat window

AO Fold mirror

Science Fold mirror

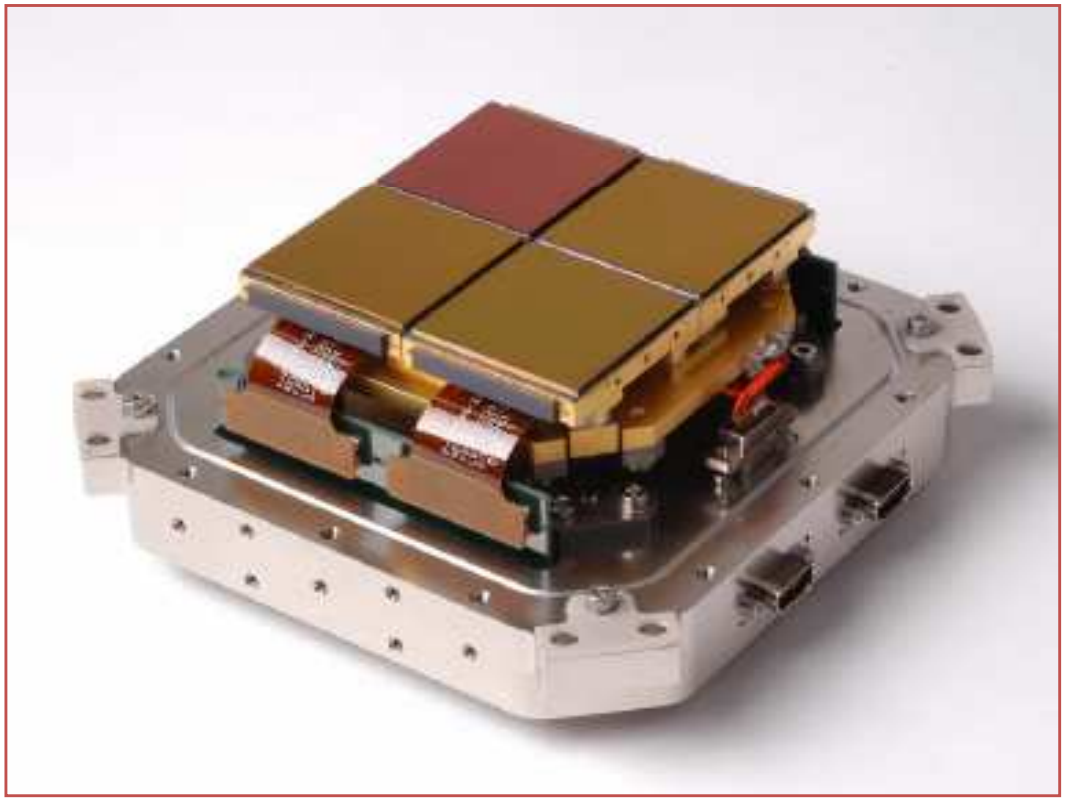
GSAOI overview

- 4 Rockwell 2048x2048 HAWAII-2RG HgCdTe arrays
  - 0.9 – 2.6µ
  - 2040 x 2040 active pixels (18µm) -- 2 x 2 mosaic of 4080 x 4080 pixels (85” x 85” on-sky)
  - Pixel scale: 0.02”, Gaps between array: ~3” (2.5mm)

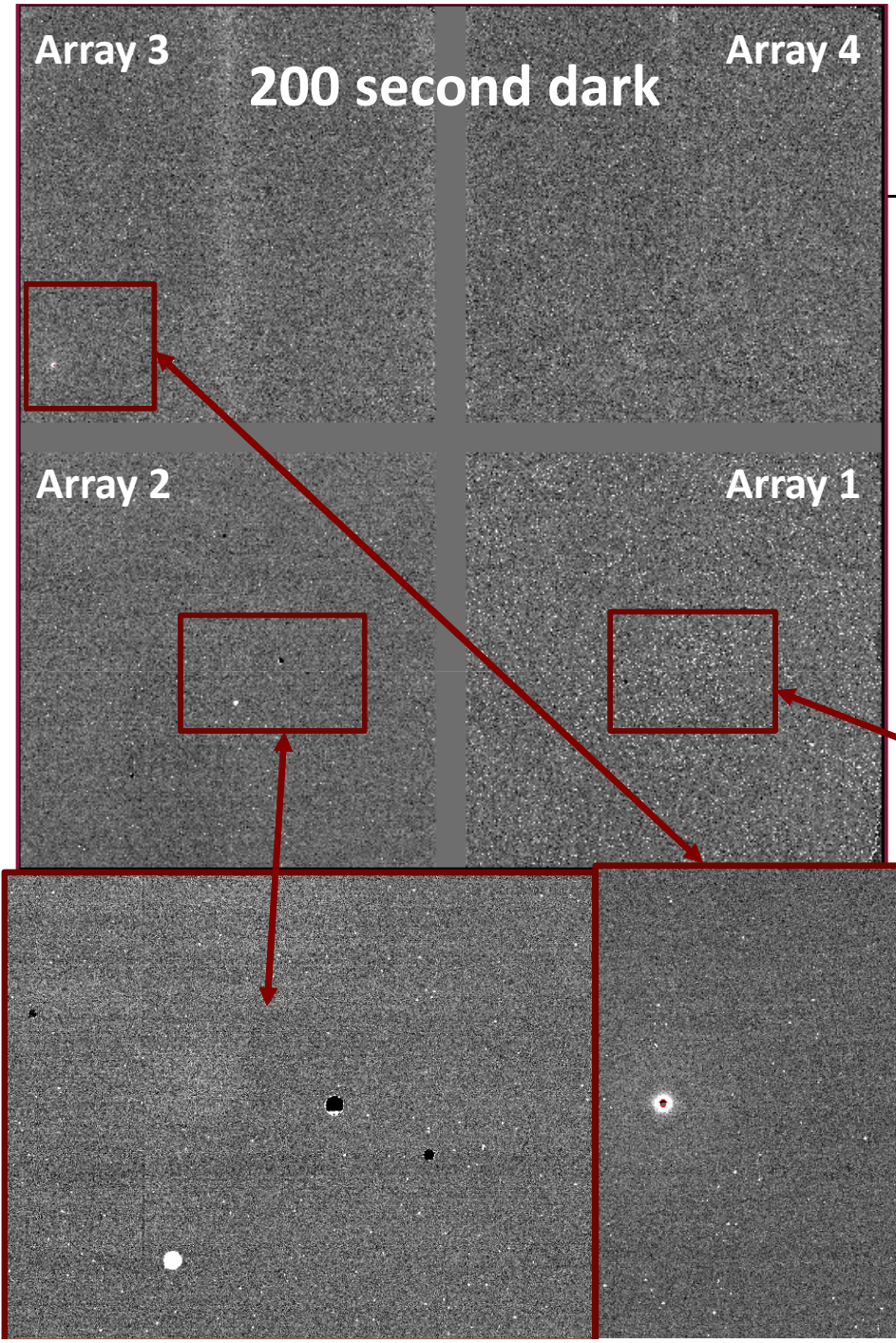
- 4 amplifiers per array (512 x 2048)
  - Simultaneously read out
  - minimum read out time and exp. : 5.3sec

- Low dark current: ~0.01 e-/s/pix
  - Large number of “hot” pixels
  - Spatial structure (up to 10 ADU)

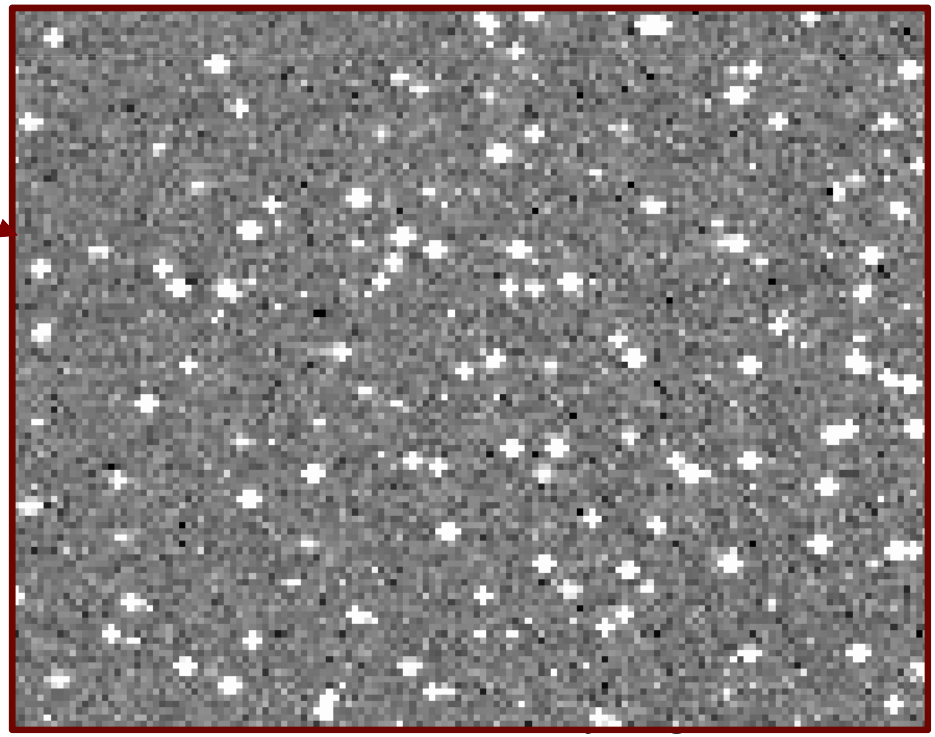
- Imperfect cosmetic
  - Dead pixels
  - Light emitting-diode pixels
  - Linearity correction is required



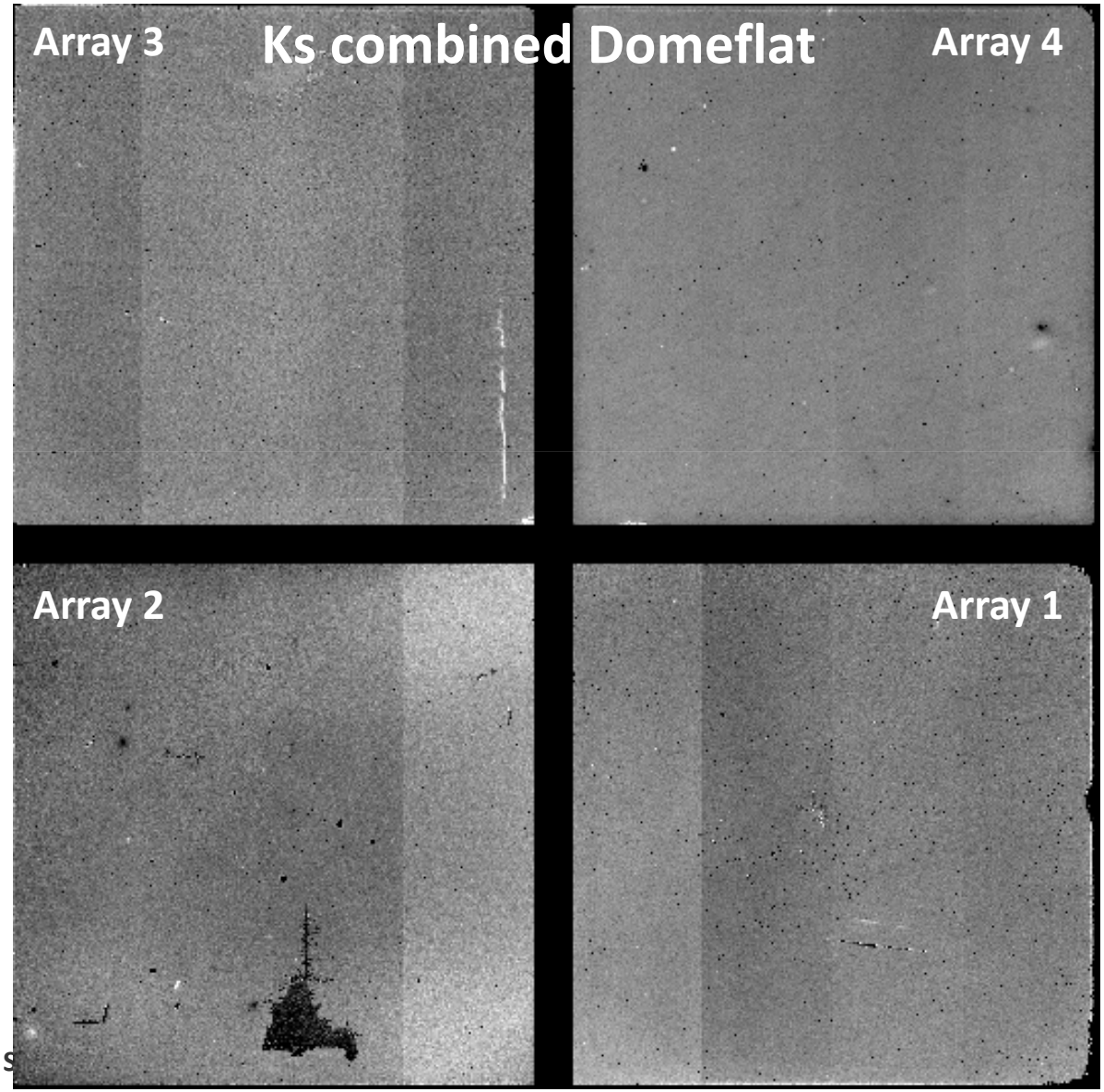
GSAOI overview: darks

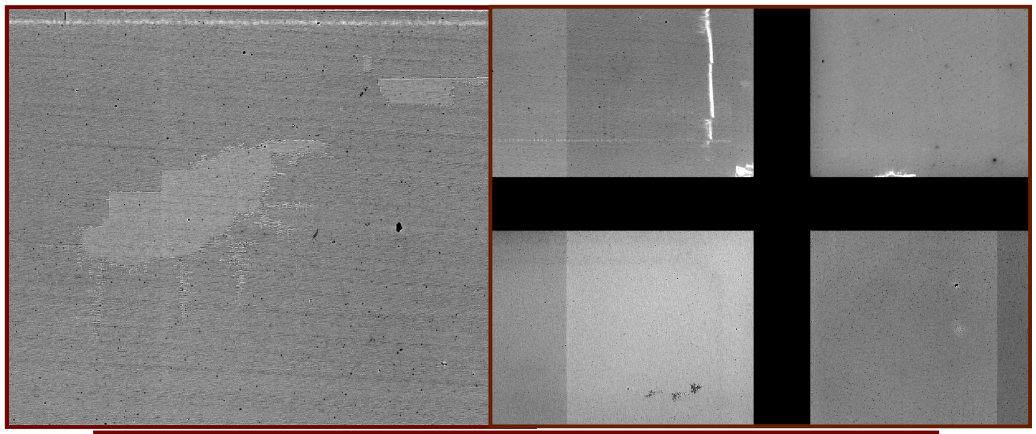


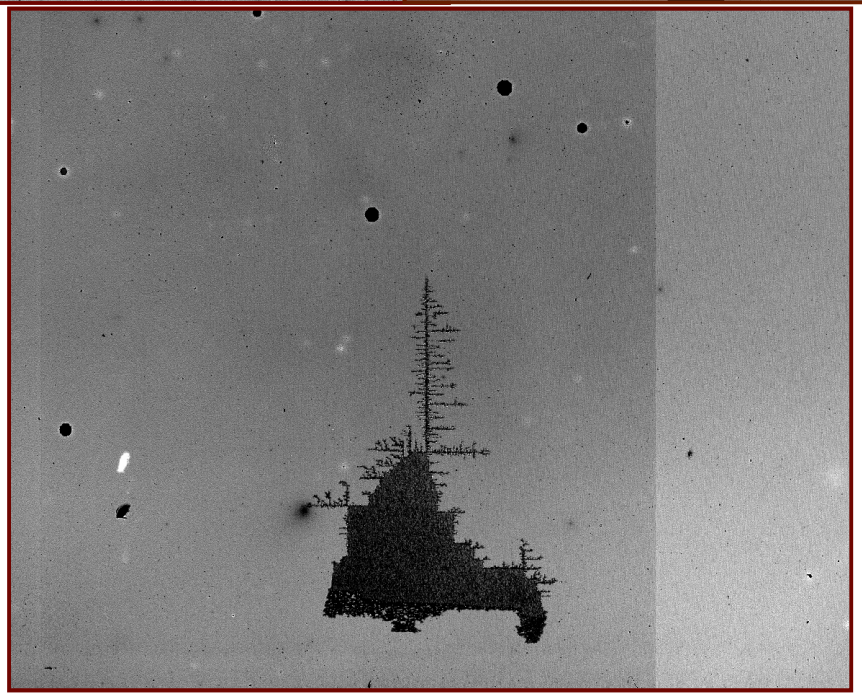
- Large number of hot pixels. Appear as a single high dark current pixels with adjacent moderately high dark current pixels (cross shape form)
- Spatial structure within each array (up to 10 ADU).
- Temporal variation in amplitude within each array.
- All effects are small --> dark subtraction is not required.



GSAOI overview: flats







GSAOI overview: ROIs

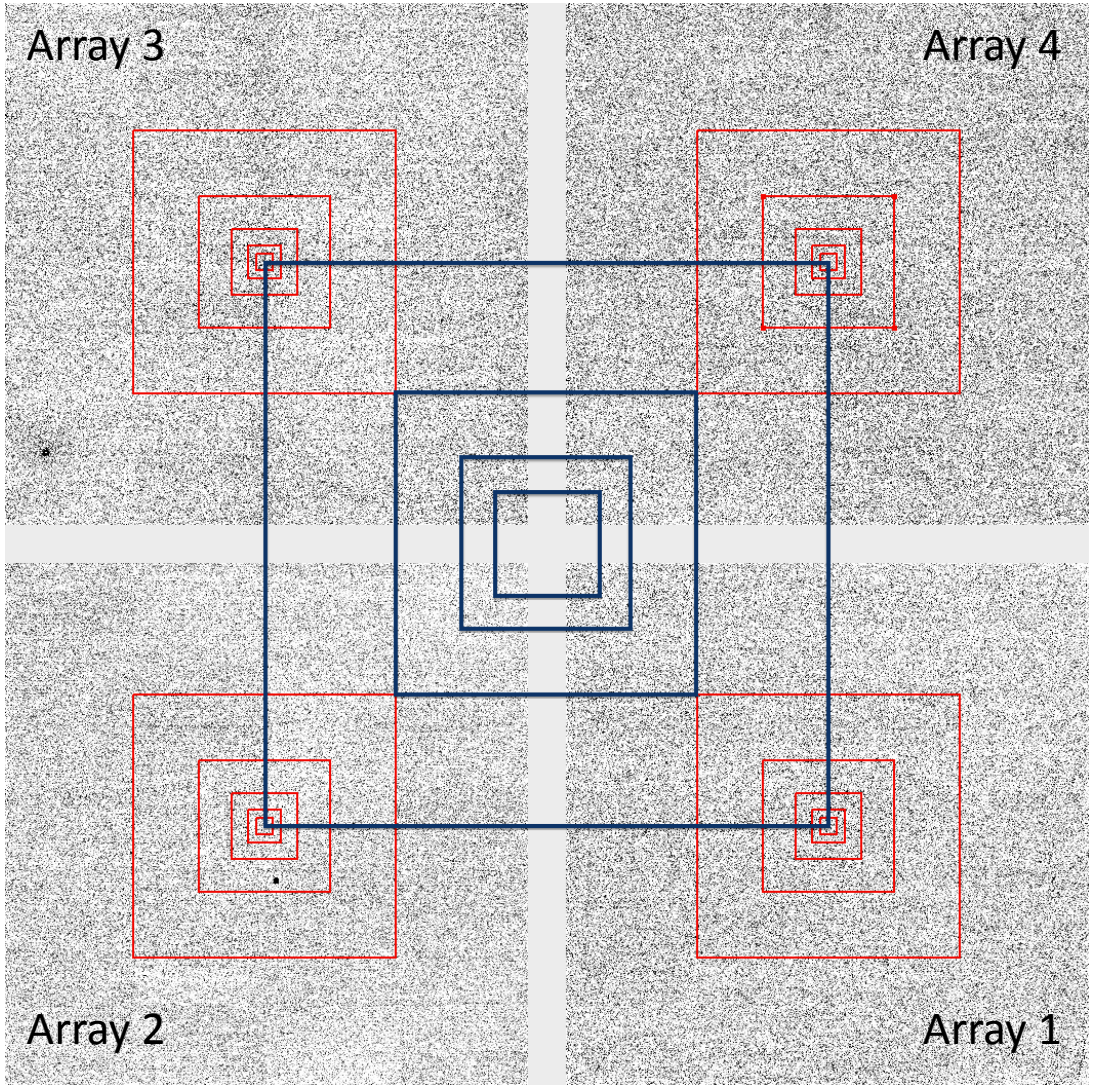
- Full frame readout
  - 4096 x 4096 pixels

- Center of each detector
  - 32x32, 64x64, 128x128, 512x512 and 1024x1024

- Center of the mosaic
  - 64x64, 128x128, 512x512 and 1024x1024

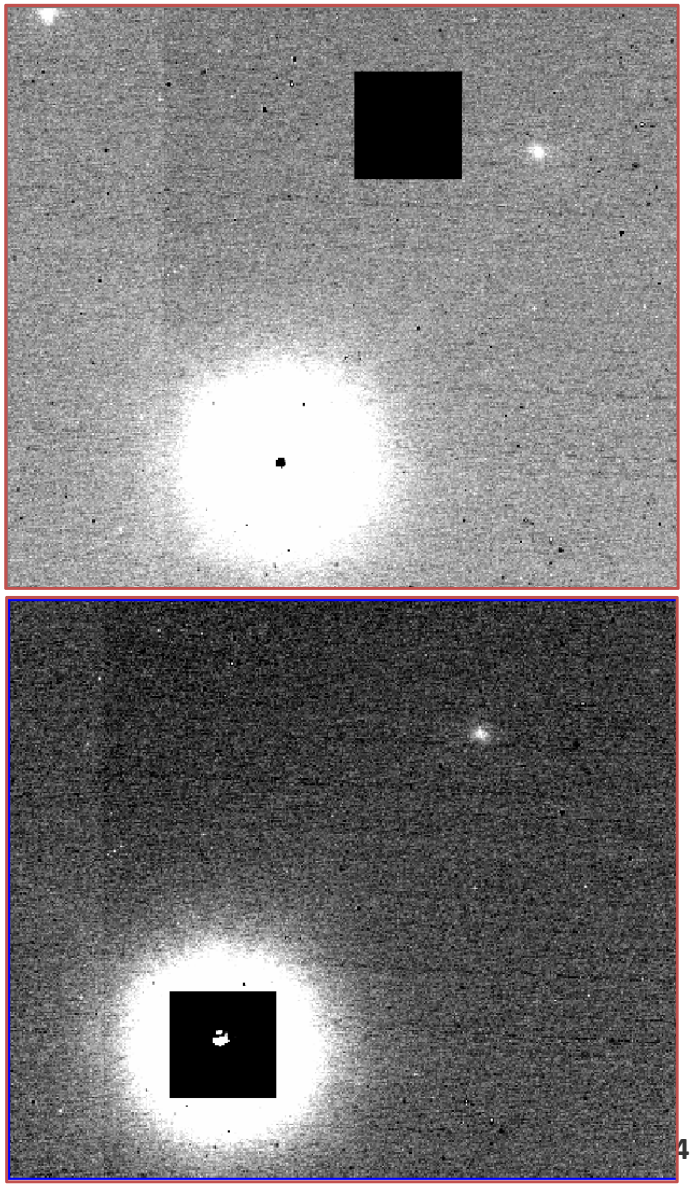
- Shorter read out speed
  - Photometric Standards
  - Instrument testing
  - Detector characterization

- Not offered for science yet



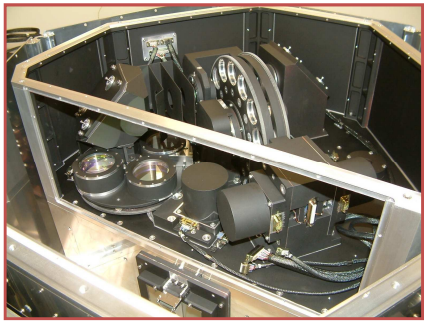
GSAOI overview: ODGW

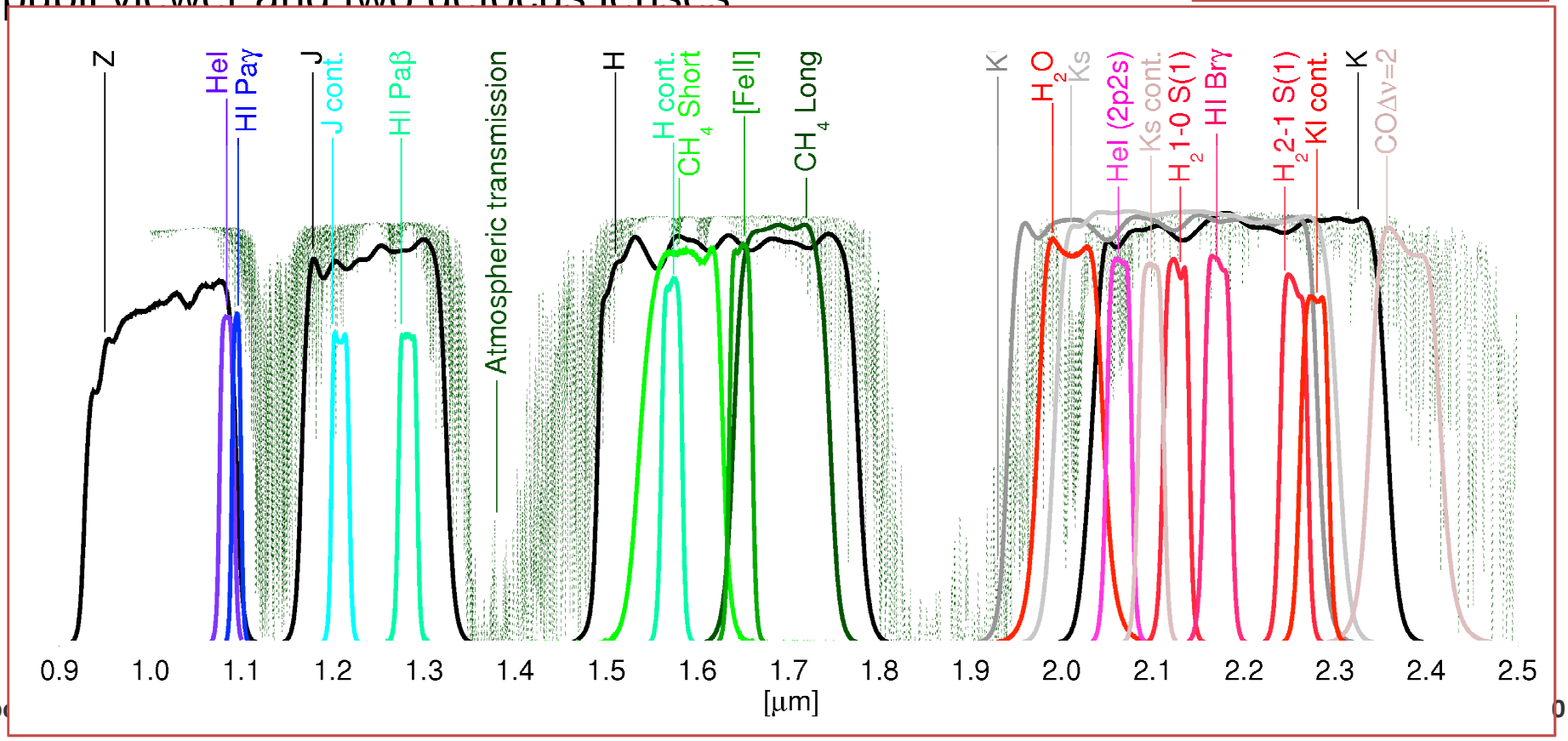
- One programable ODGW per detector
  - Correction for differential flexure between Canopus and GSAOI
  - can be used for fast tip-tilt correction (mode 3 ODGW + 1 CWFS for SFS)
- Sizes between 2x2 - 128x128 pixels
  - Science: 4x4 or 8x8 pixels
- Read out sub-arrays while remaining pixels are integrating.
- ODGW for fast tip-tilt correction not implemented yet.
- ODGW for flexure correction →works, but there are some issues.



GSAOI overview: Filters

- 2 filter wheels
  - Broad- (Z, J, H, K', Ks and K) and narrow-band (16) filters
- 1 utility wheel
  - pupil viewer and two defocus lenses





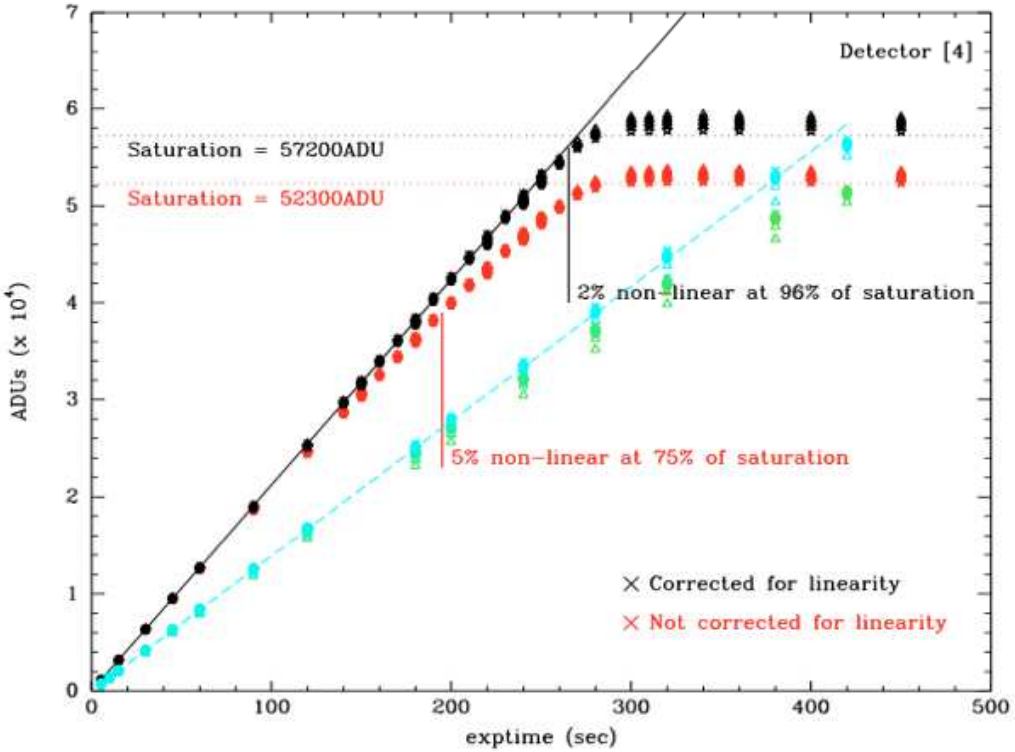
GSAOI overview: Linearity correction

- Implemented using a polynomial fit to raw data counts using H- and Z-band flats

  L. C. F = a + b * ADU + c * ADU

- L.C for count leves > 3000 ADU

Detector	a	σ_a	b	σ_b $[\times 10^{-7}]$	c $[\times 10^{-7}]$	σ_c $[\times 10^{-11}]$	Correlation	σ_{res}
1	0.9947	0.0007	7.4	0.7	2.5	0.1	0.993	0.003
2	0.9940	0.0010	6.0	1.0	3.7	0.3	0.989	0.005
3	0.9947	0.0006	7.1	0.6	2.2	0.1	0.991	0.003
4	0.9959	0.0006	5.7	0.6	2.7	0.1	0.991	0.003



- Count levels < 3000 ADU
  - Presence of non-linear behavior of increasing response to lower levels.
  - Effect is as larger as the scatter in the data points
- Linearity correction is implemented in the GSAOI IRAF package.

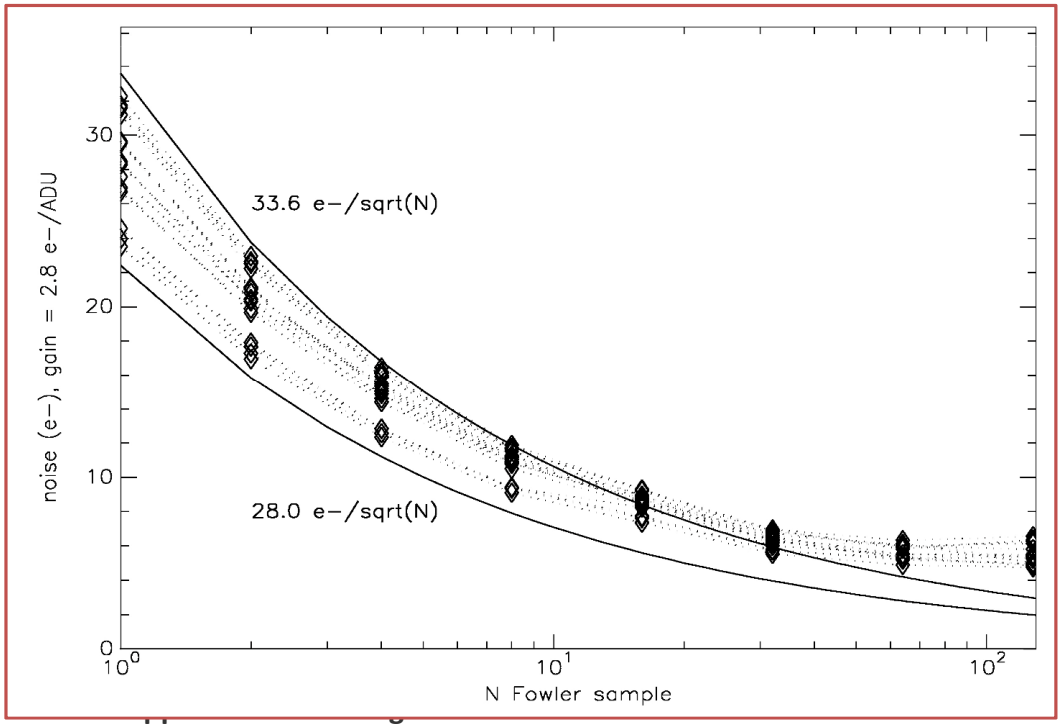
GSAOI overview: read out noise and gain

- Readout noise --> determined using darks exposures for different Fowler Sampling NDRs 2, 8, 16 and 32
- Gain --> determined using the same dataset used for linearity correction

Fowler-Mortara Variance Analysis Method

$$V_{ADU} = (RN_{ADU})^2 + S_{ADU}/g$$

Readout noise vs. FS (2008, Lab. measurements)



Readout noise and Gain (03/2011)

Detector	Read noise [ADU] $FS1-1$	FS 4-4	FS 8-8	$FS16-16$	Gain [e-/ADU]
1	11.6	5.6	4.2	3.2	2.434
2	9.5	4.9	3.7	2.9	2.010
3	11.2	5.9	4.4	3.3	2.411
4	12.4	6.3	4.8	3.7	2.664

Readout modes implemented in GSAOI

Mode	Fowler Sampling	NDRs	Read Noise	Readout time	Min. Exp. Time
Bright Object	1	2	28 e-	10.0 sec	5.3 sec
Faint Object	4	8	13 e-	26.2 sec	21.1 sec
Very Faint Object	8	16	10 e-	47.7 sec	42.2 sec

From Commissioning/SV to Operations

10 years of development
~100 night of commissioning

2007 - GSAOI arrives to Gemini South
2007-2008: Canopus arrives to GS.
Starting integration at SBF Labs

Jan - May 2011
Nov 2011 - May 2012
LGSF/MCAO Technical commissioning

Dec 2011 - May 2012
MCAO Performance demonstration and optimization

May 2012 - Nov 2012
GeMS shutdown - working to improve several sub-systems

Jan 2012 - Feb 2013
Integration into regular science operations

Dec 2012 - Jan 2013
GSAOI Commissioning completed

Aug 2012 - Call for System Verification process:
- 28 proposals requesting 138 hours (offered ~60 hours) --> oversubscription factor of 2.3!!!
- 13 programs observed between Dec 2012 - March 2013 --> 89% completion

September 2012 - regular call for proposal for 2013B
- 16 programs accepted (184 hours) --> oversubscription factor of 2

2014 - GeMS moved to regular science operations

GeMS and GSAOI teams: past and present

François Rigaut, Benoit Neichel, Rodrigo Carrasco, Fabrice Vidal, Marcos A. van Dam, Vincent Garrel, Maxime Boccas, Céline d'Orgeville, Gustavo Arriagada, Vincent Fesquet, Ramon L. Galvez, Gaston Gausachs, Chad Cavedoni, Angelic W. Ebbers, Stan Karewicz, Eric James, Javier Lührs, Vanessa Montes, Gabriel Perez, William, N. Rambold, Roberto Rojas, Shane Walker, Matthieu Bec, Gelys Trancho, Michael Sheehan, Benjamin Irarrazaval, Corinne Boyer, Brent L. Ellerbroek, Ralf Flicker, Damien Gratadour, Aurea Garcia-Rissmann, Felipe Daruich, Constanza, Araujo, Alvaro Arias, Andrew Cardwell,, Emanuel Costa, Sarah Diggs, Camila Duran, Ariel Lopez, Claudio Marchant, Eduardo Marin, Cristian Moreno, Peter Pessev, Rolando Rogers, Carlos Segura, Andrew Serio, Chad Trujillo, Cristian Urrutia, Patricio Veliz, Tomislav Vucina, Claudia Winge, Michelle Edwards, Etienne Artigau, and many others ....

From Comm./SV to Operations

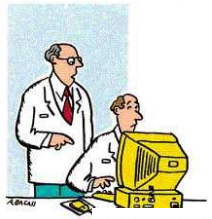
- A long path since January 2011 → 1.8 years of commissioning
- GeMS/GSAOI Commissioning completed at the end of January 2013 →some pending tasks: e.g. ODGW fast tip-tilt mode
- Lesson learned
  - Operate GeMS is not straightforward
  - Key resources are required to support GeMS/GSAOI for every night
  - System efficiency could be significantly improved (current SE ~ 50%)
  - AO performance is average (**from an AO Scientist Point of View ☺!!!**)

From Comm./SV to Operations

Current support

3 Spotters

1 laser technician



AO Scientists

Instrument operator

Telescope operator

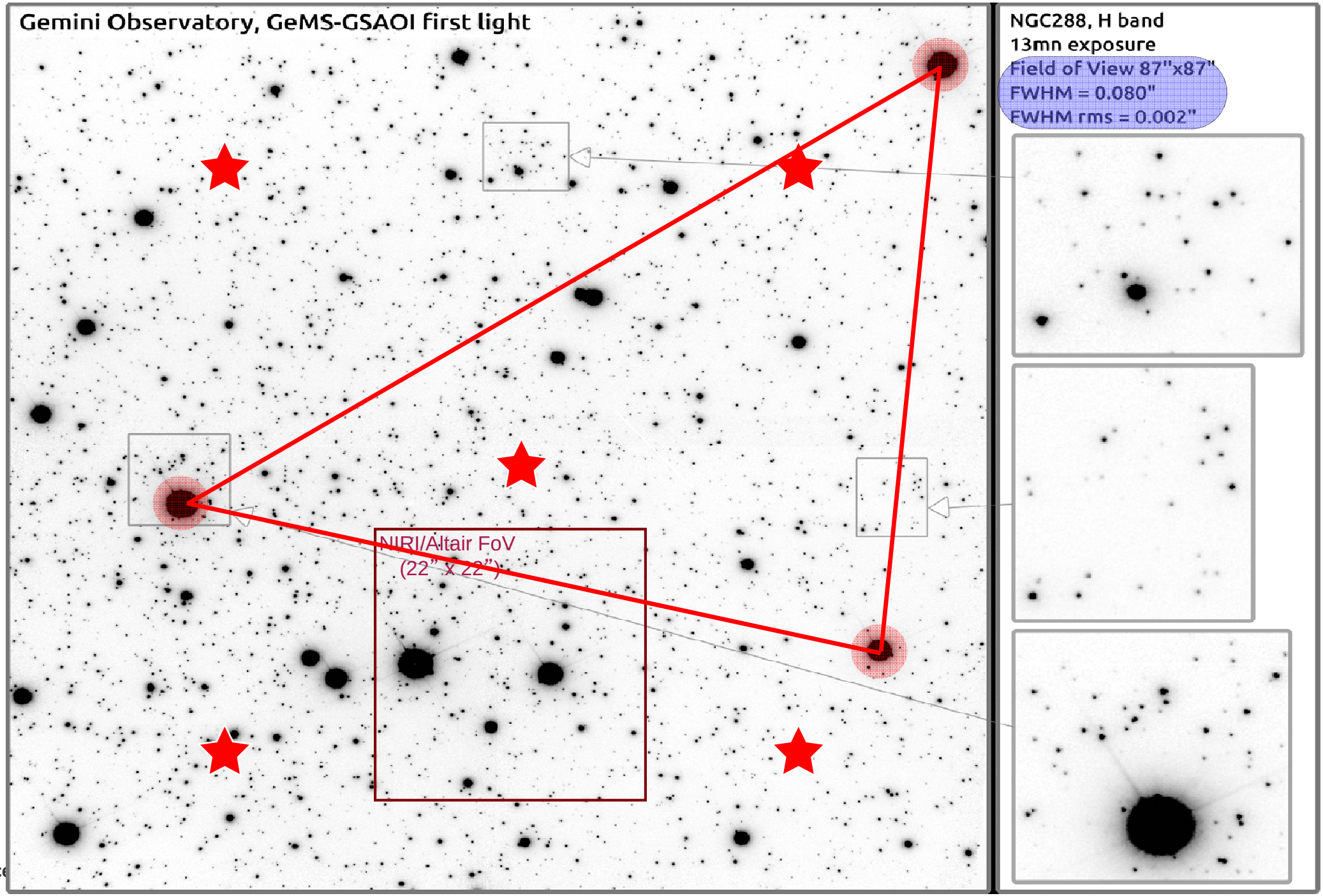
7 people + Eng. Support

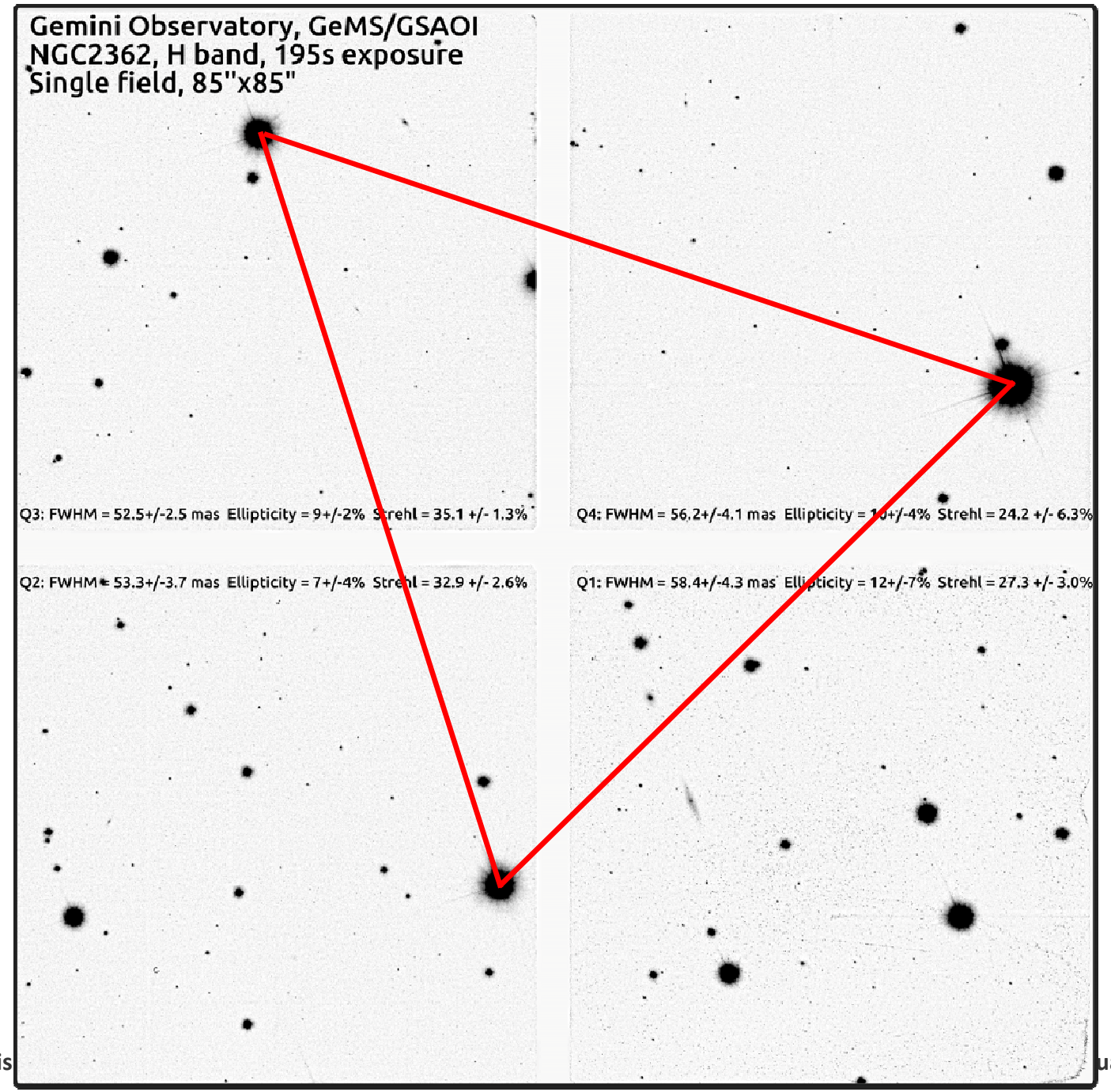
Requires a good coordination

GOAL

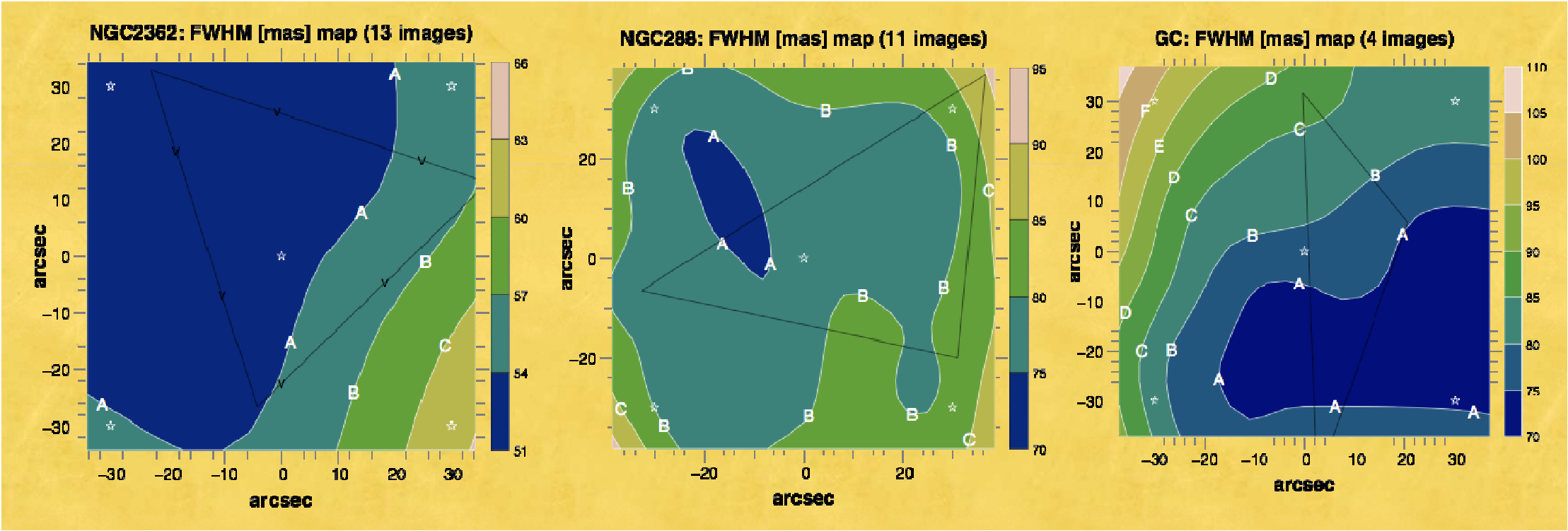
1 Laser Tech + 1 tel. operator + 1 Instrument Operator

GeMS/GSAOI on-sky performance


Gemini Observatory, GeMS-GSAOI first light
NIRI/Altair FoV
(22” x 22”)
NGC288, H band
13mn exposure
Field of View 87"x87"
FWHM = 0.080"
FWHM rms = 0.002"

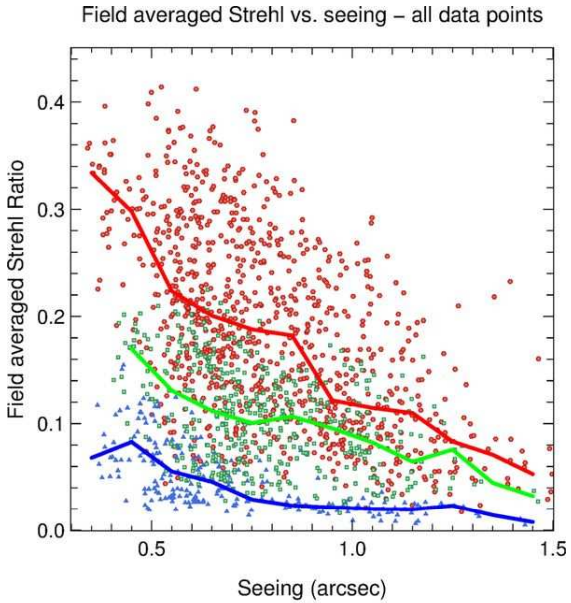

Gemini Observatory, GeMS/GSAOI
NGC2362, H band, 195s exposure
Single field, 85"x85"
Q3: FWHM = 52.5+/-2.5 mas Ellipticity = 9+/-2% Strehl = 35.1 +/- 1.3%
Q4: FWHM = 56.2+/-4.1 mas Ellipticity = 10+/-4% Strehl = 24.2 +/- 6.3%
Q2: FWHM = 53.3+/-3.7 mas Ellipticity = 7+/-4% Strehl = 32.9 +/- 2.6%
Q1: FWHM = 58.4+/-4.3 mas Ellipticity = 12+/-7% Strehl = 27.3 +/- 3.0%

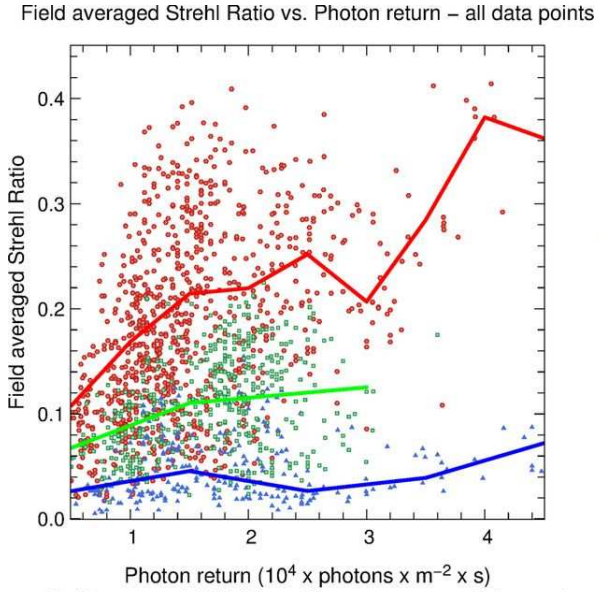
Data set	#images	total exptime	lambda [mic]	Seeing ["]	Loop freq. [Hz]	FWHM avg [mas]	FWHM rms [mas]	Strehl (avg) [%]
NGC2362	13	195s	1,65	0,3	250	53	2,0	30
NGC288	11	780s	1,65	0,65	200	80	2,5	18
GC	4	60s	2,10	0,6	300	84	3,5	19

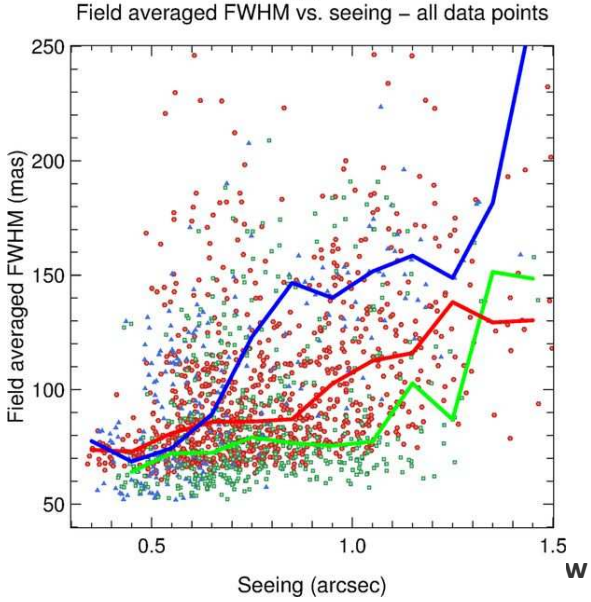


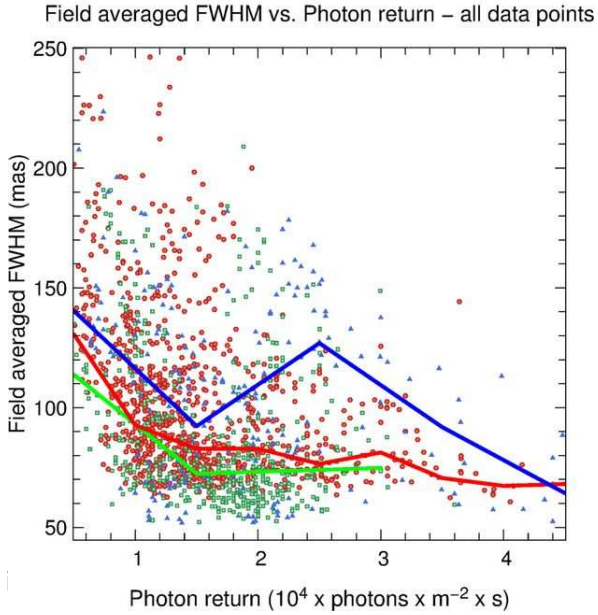
PSF is uniform, with 3-4% FWHM relative variations over GSAOI field of view

Average Strehl and FWHM delivered by GeMS (Neichel et al. 2014, MNRAS, 440, 1002)









- Based on observations performed between December 2012 and May 2013 (33 nights)
- Using 3 NGS, images with t_{exp} > 10 sec and 950, 454 and 243 GSAOI scientific images in K, H and J bands. Median seeing 0.73” (at 550nm).

Table 1. Delivered average Strehl ratios for different seeing conditions (seeing @ 550nm)

Natural Seeing @550nm	Strehl ratio (J)	Strehl ratio (H)	Strehl ratio (K)	Gemini IQ constrain (zenith)
<0.45"	10%	15%	30%	20%-ile
0.45" - 0.80"	5%	10%	15%	70%-ile
0.80" - 1.00"	2%	5%	10%	85%-ile

Table 2. Delivered FWHM for different seeing conditions (seeing @ 550nm)

Natural Seeing @550nm	FWHM (J)	FWHM (H)	FWHM (K)	Gemini IQ constrain (zenith)
<0.45"	0.08"	0.07"	0.06"	20%-ile
0.45" - 0.80"	0.13"	0.10"	0.09"	70%-ile
0.80" - 1.00"	0.15"	0.13"	0.12"	85%-ile

Original requirements for IQ=20%-ile

Filter	J	H	K
Strehl	16%	35%	55%

GeMS/GSAOI on-sky performance

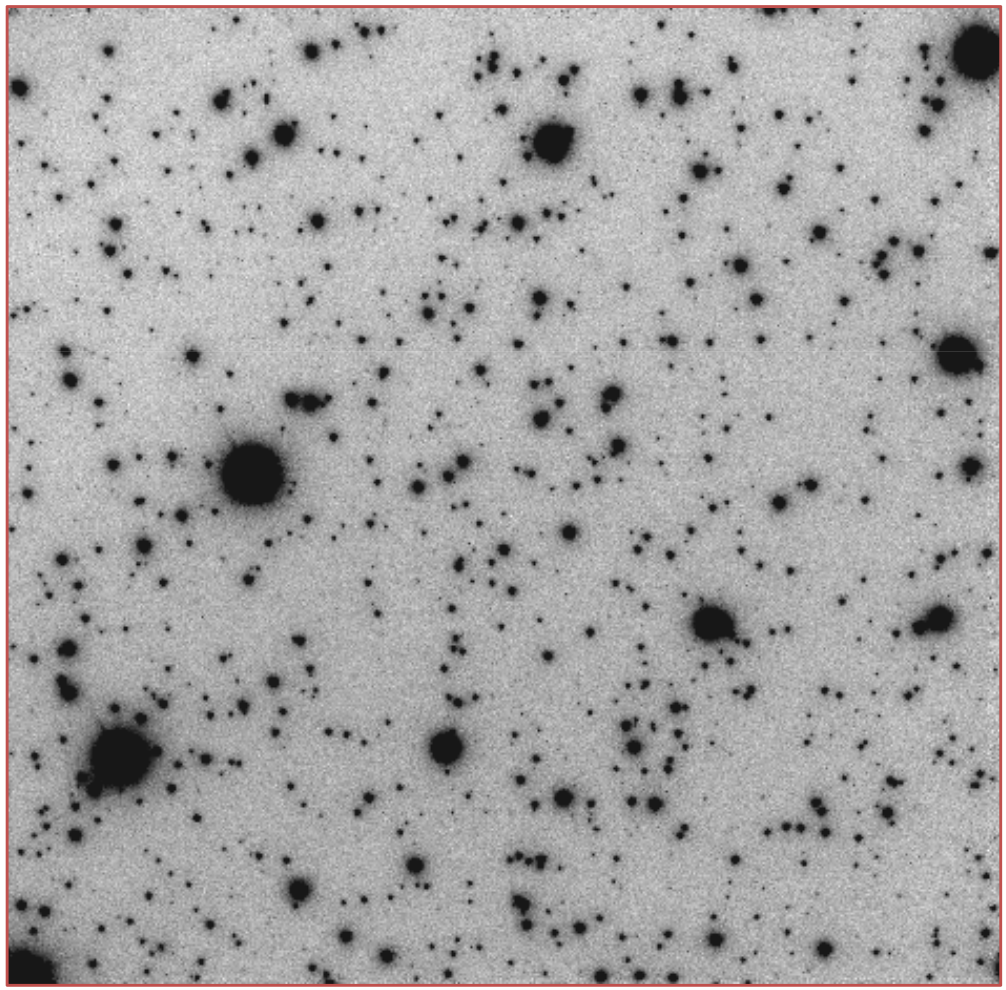
GeMS/GSAOI System throughput

- End-to-end system throughput calculated from the measured zero points (Dec. 2011 - April 2012).
- For H and K the throughput obtained are better than the throughput assumed for the instrument initially (0.23). For J band is similar.

Carrasco et al. 2012, SPIE, vol. 8447

	Filters		
Run	τ_J	τ_H	τ_K
May 2011	0.24	0.35	0.24
Dec 2011		0.39	
Jan 2012	0.19	0.32	0.28
April 2012	0.21	0.38	0.28

NGC 288, 13 minutes (13 x 60sec)
H-band, FWHM=<0.08”>



GeMS/GSAOI on-sky performance

Photometric Zero Points and Background Surface Brightness

- Photometric ZP. Measured using aperture photometry with DAOPHOT
  - Aperture size: 1.4 FHWM
  - Instrumental magnitides ($m_\lambda = -2.5 * \log(F_\lambda)$) compared with the 2MASS magnitudes (or with other catalogs when available).

	Filters						
	J		H		K_s		
Date (UT)	ZP	S.B.	ZP	S.B.	ZP	S.B.	Comments
20110518	-26.59	14.94	-26.63	13.19	-26.17	12.10	Dust in the cryostat window
20111216			-26.75	13.29			Cryostat window cleaned
20120112	-26.30	15.65	-26.51	13.68	-25.95	12.18	
20120215	-26.09	15.09	-26.01	13.18	-25.08	11.09	cryostat window coating damage
20120415	-26.43	15.31	-26.72	13.80	-26.12	12.38	New Cryostat window installed
20120430			-26.65	13.93			

- Sky brightness at Cerro Pachón:
  - μ_J = 16.2 mag/[“], μ_H = 13.8 mag/[“], μ_K = 14.6 mag/[“]
  - Differences in J-band and K_s

GeMS/GSAOI on-sky performance

Stability of the photometry

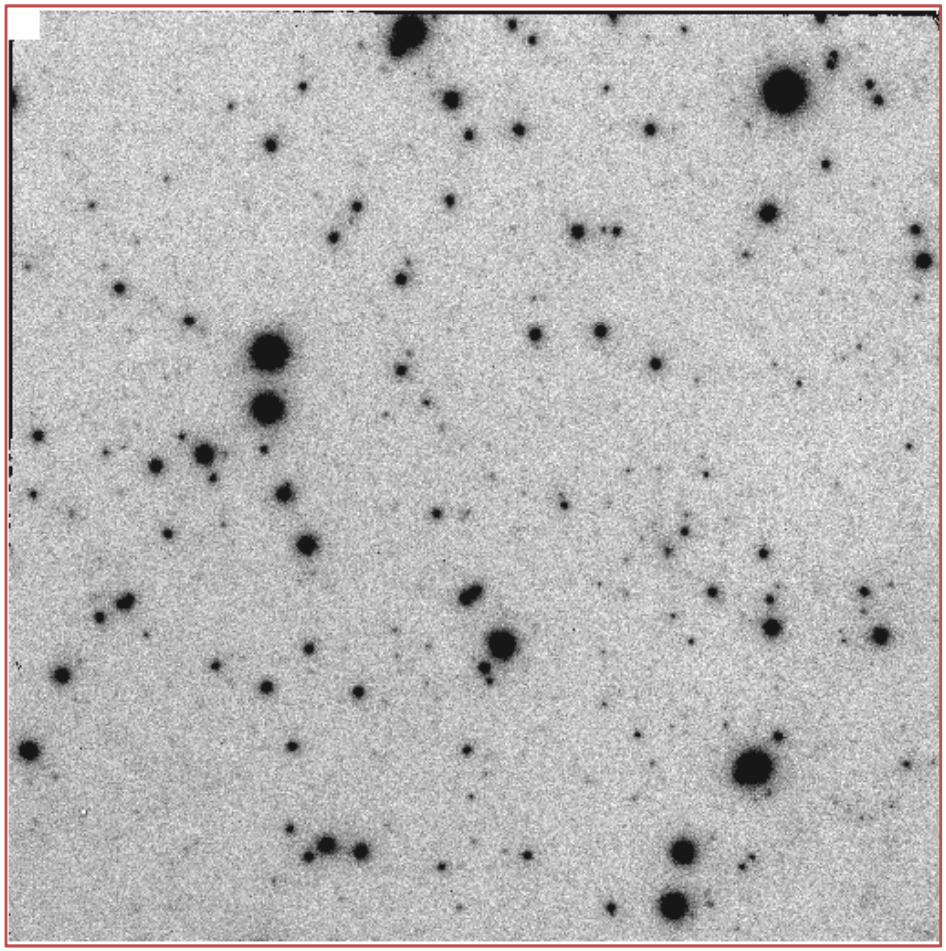
- LMC observations (2012 Feb):
  - Large offsets (~10")
  - Comparing the magnitudes of the same stars observed in different arrays.
- Main differences between arrays

  $\Delta m_{1,2}$ = -0.015

  $\Delta m_{1,3}$ = -0.032

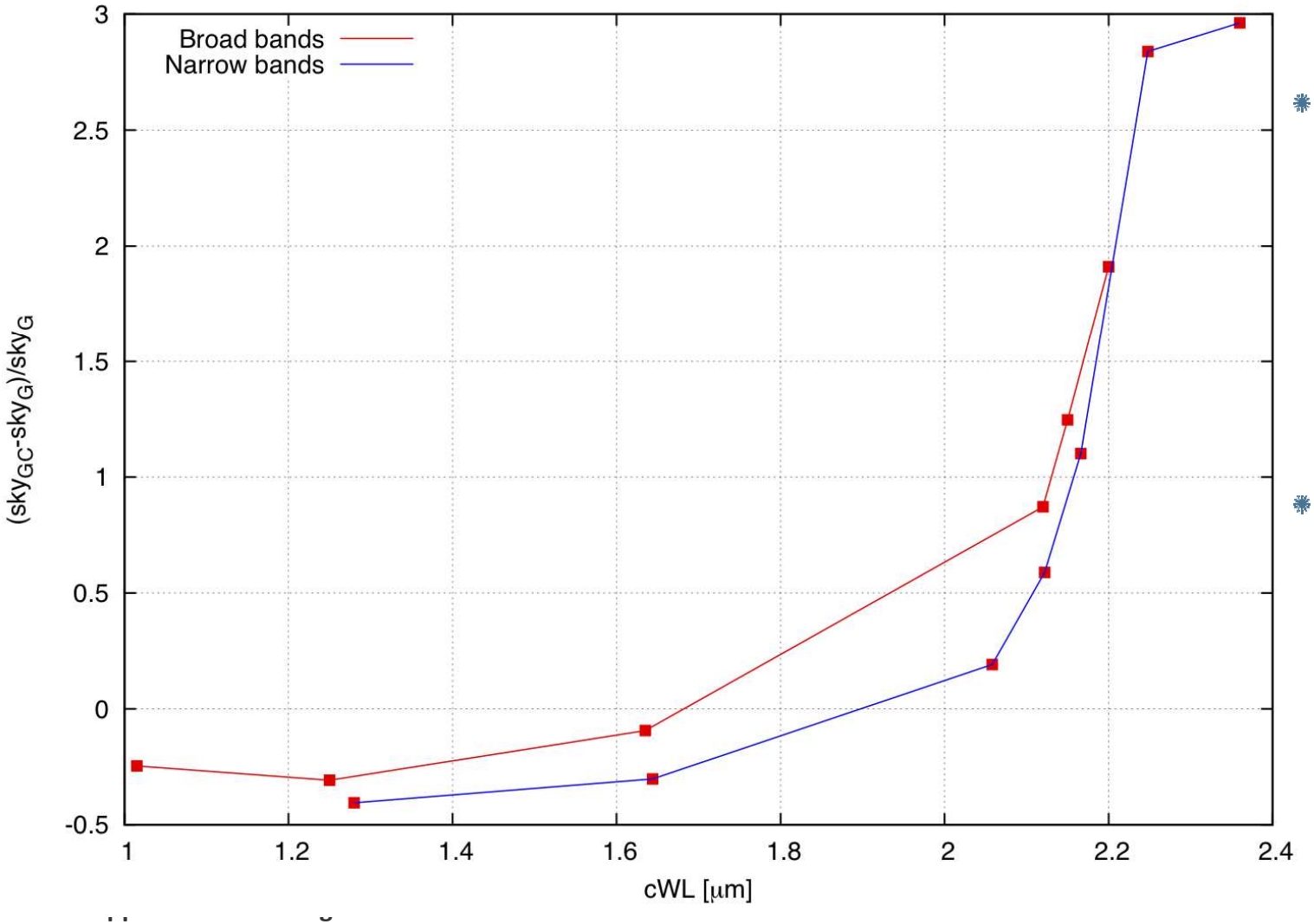
  $\Delta m_{1,4}$ = -0.030
- Photometric accuracy: ~0.05 mag
- Difference due to:
  - Flat fielding
  - Accuracy in the Gain determination

LMC Astrometric field (Array. 3)



GeMS/GSAOI on-sky performance

Background brightness

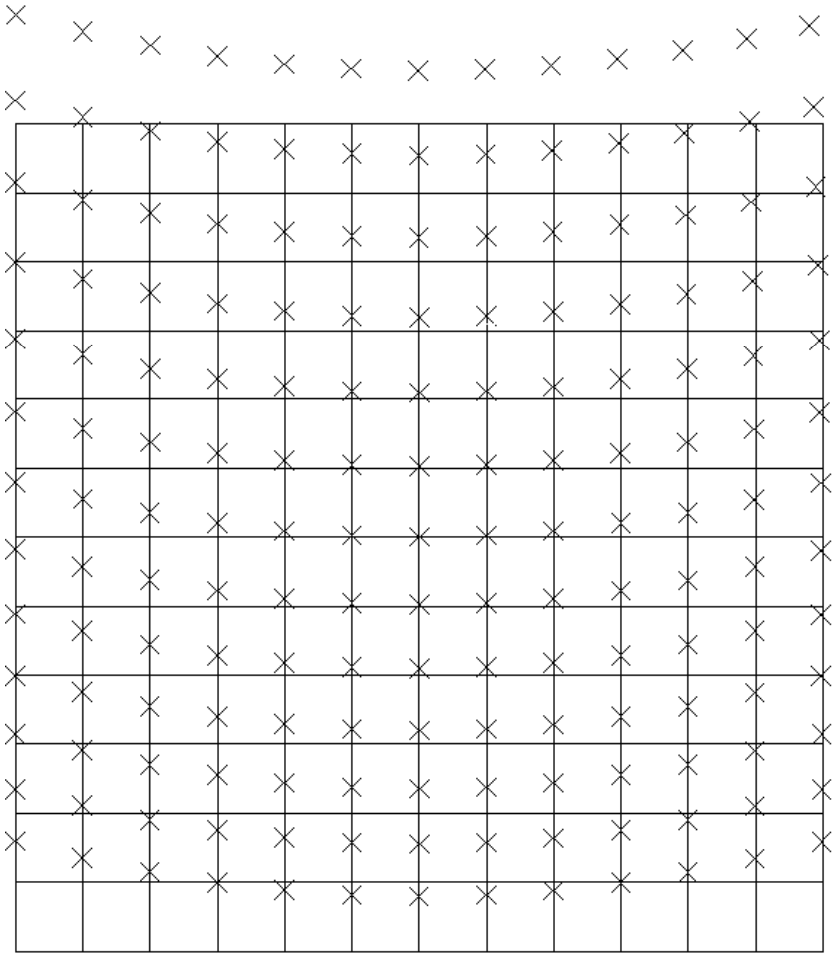


- Determination of background contribution from CANOPUS using observations of sky blank fields with GSAOI+CANOPUS and with GSAOI by-passing CANOPUS.
- Large contribution in the thermal background (>1.8 microns) from CANOPUS

GeMS/GSAOI on-sky performance

- The GSAOI field is distorted by the off-axis parabola system used in GeMS.
- The good news -- most of the distortion can calibrated out.
- The bad news -- residual “dynamic” distortion --> depend on NGS asterism --> difficult to remove
- Affects data reduction --> mosaic and combine images

Distortion x 10



GeMS/GSAOI on-sky performance

GeMS performance is limited by:

- Laser
  - Stability
  - BTO transmission and polarization improvement --> on-going
  - Laser beam quality
  - Low photon return during the summer (December - March)
  - More laser power --> feasibility to acquire a new laser for 2015+
- Canopus
  - Limiting magnitude for NGS WFS is not what was expected: problems in the design flow and alignment issues
  - current limiting magnitude R=15.5 (R=17.5 original --> limited sky coverage)
  - New NGS are expected to be installed in 2015 (ANU/Gemini effort) --> R=17.5 - 18.0

Science with GeMS/GSAOI

Science with GeMS/GSAOI

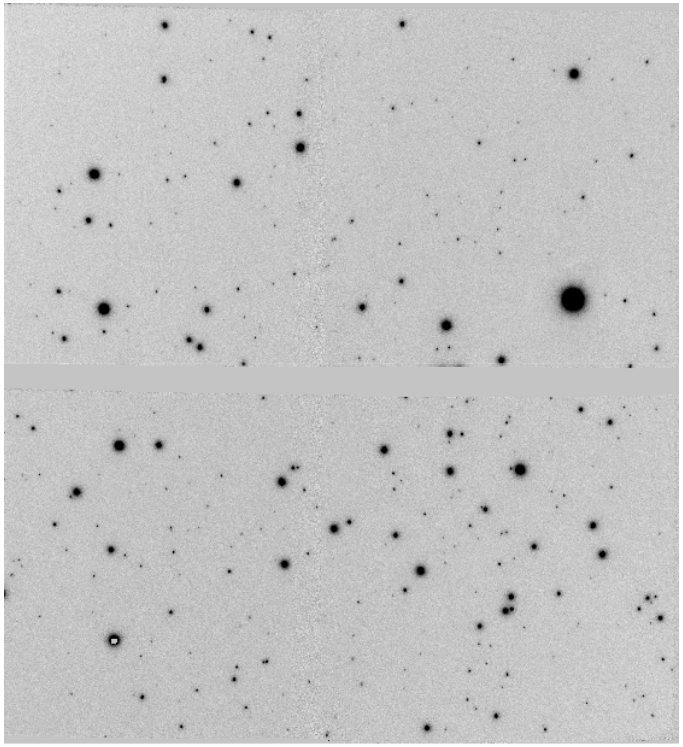
Key Science drivers for GeMS identified by Gemini Community, SC, CA, October 2000

- Low mass stellar and sub-stellar mass functions in young star-forming regions.
- Stellar population variations in star-forming regions (e.g. Ophiuchus).
- Open cluster mass functions to the bottom of the H-burning sequence and the end of the white dwarf cooling sequence to provide independent age determinations.
- Mass functions in nearby globular clusters over a range of metallicities.
- Stellar populations of super-star cluster analogs in the Galaxy and Magellanic Clouds such as NGC 3603 and 30 Doradus.
- SN1a zero point calibration via red giant branch tip star distances to E/S0 galaxies.
- Stellar populations in starburst regions of nearby galaxies.
- Evolution of dIrr versus dE galaxies in different environments.
- Early chemical histories of nearby galaxy spheroids.
- Intergalactic stars in nearby galaxy clusters.
- Color distributions among extragalactic globular clusters.
- Spatially resolved spectral energy distributions of high redshift field galaxies.
- Evolution of galaxies in high redshift clusters.

Science with GeMS/GSAOI

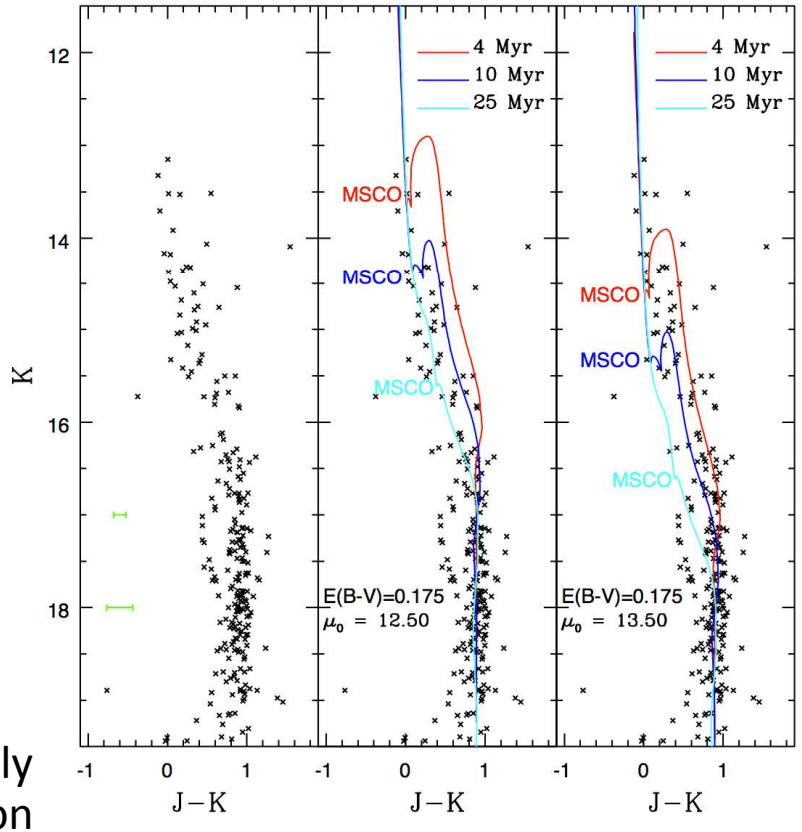
Haffner 16: A Young Moving Group in the Making

T. J. Davidge, E. R. Carrasco, C. Winge, P. Pessev, B. Neichel, F. Vidal, F. Rigaut, 2013, PASP, 125, 1181



FWHM in J: 0.24”
FWHM in K: 0.15”

Gemini IQ=85%-ile

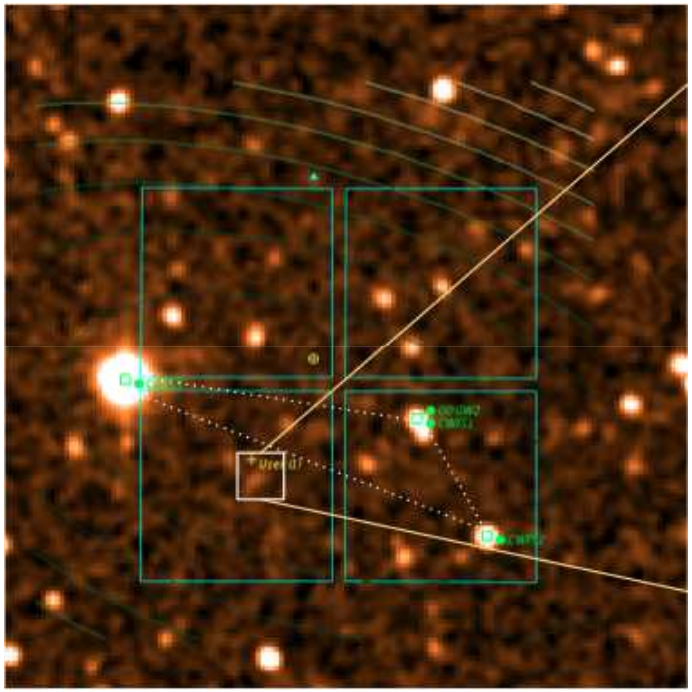


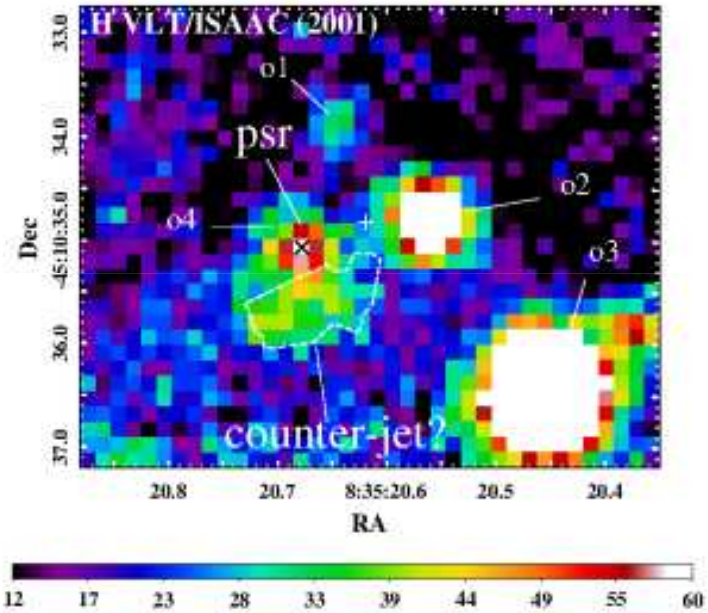
- A rich population of PMS stars is identified with an age < 10 Myr
- When compared with the solar neighborhood, Haffner 16 is roughly a factor of two deficient in objects with sub-solar masses.
- PMS objects in the cluster are also more uniformly distributed on the sky than bright MS stars.

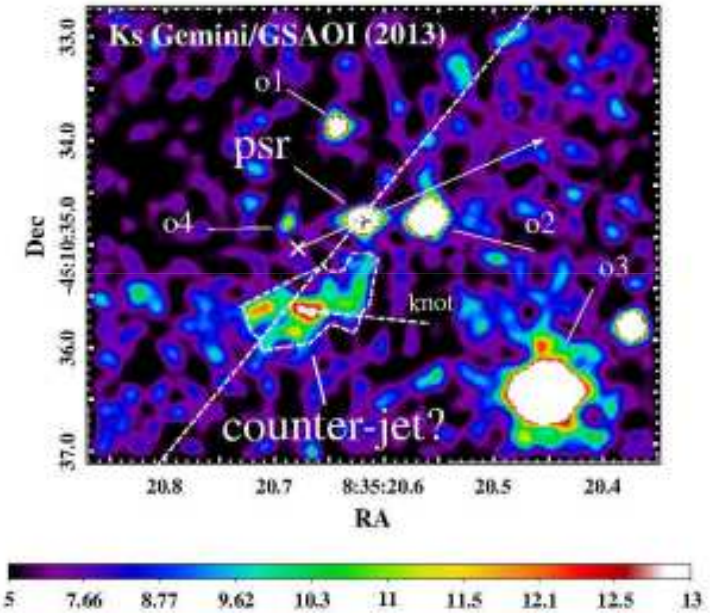
Science with GeMS/GSAOI

The Vela pulsar and its likely counter-jet in K_s band

D. Zyuzin, Yu. Shibanov, A. Danilenko, **R. E. Mennickent**, and S. Zharikov, 2013, ApJ, 775, 101







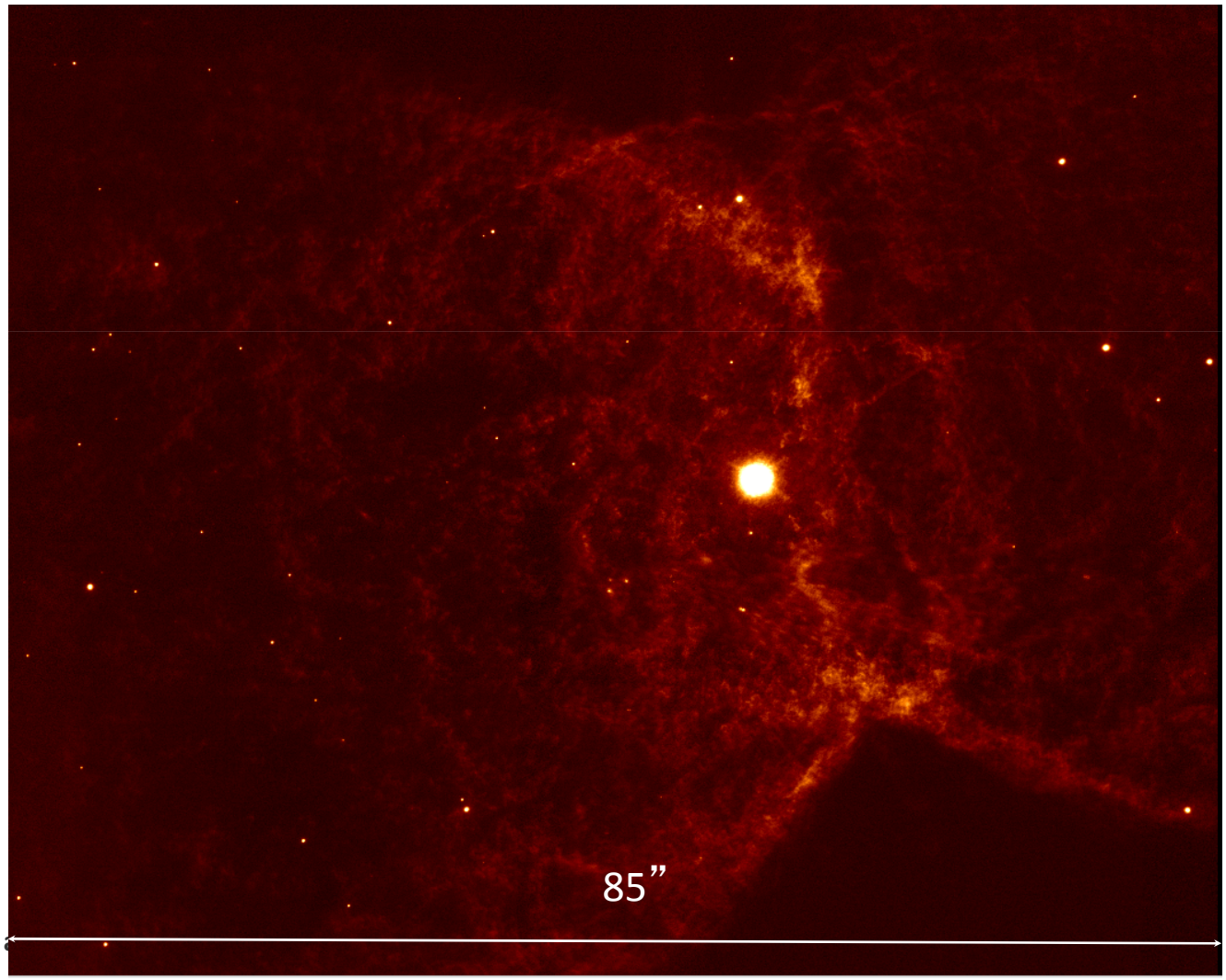
For the first time, we have firmly detected the pulsar in Ks band with Ks~21.8 mag, and have resolved in detail an extended feature barely detected previously in the immediate vicinity of the pulsar in the JsH bands. The pulsar Ks flux is fully consistent with the extension of the flat optical spectrum of the pulsar toward the IR and does not confirm the strong IR flux excess in the pulsar emission suggested earlier by the low spatial resolution data. The extended feature is about two times brighter than the pulsar and is likely associated with its X-ray counter-jet. It extends ~2'' southward of the pulsar along the X-ray counter-jet and shows knot-like structures and a red spectrum.

Science with GeMS/GSAOI

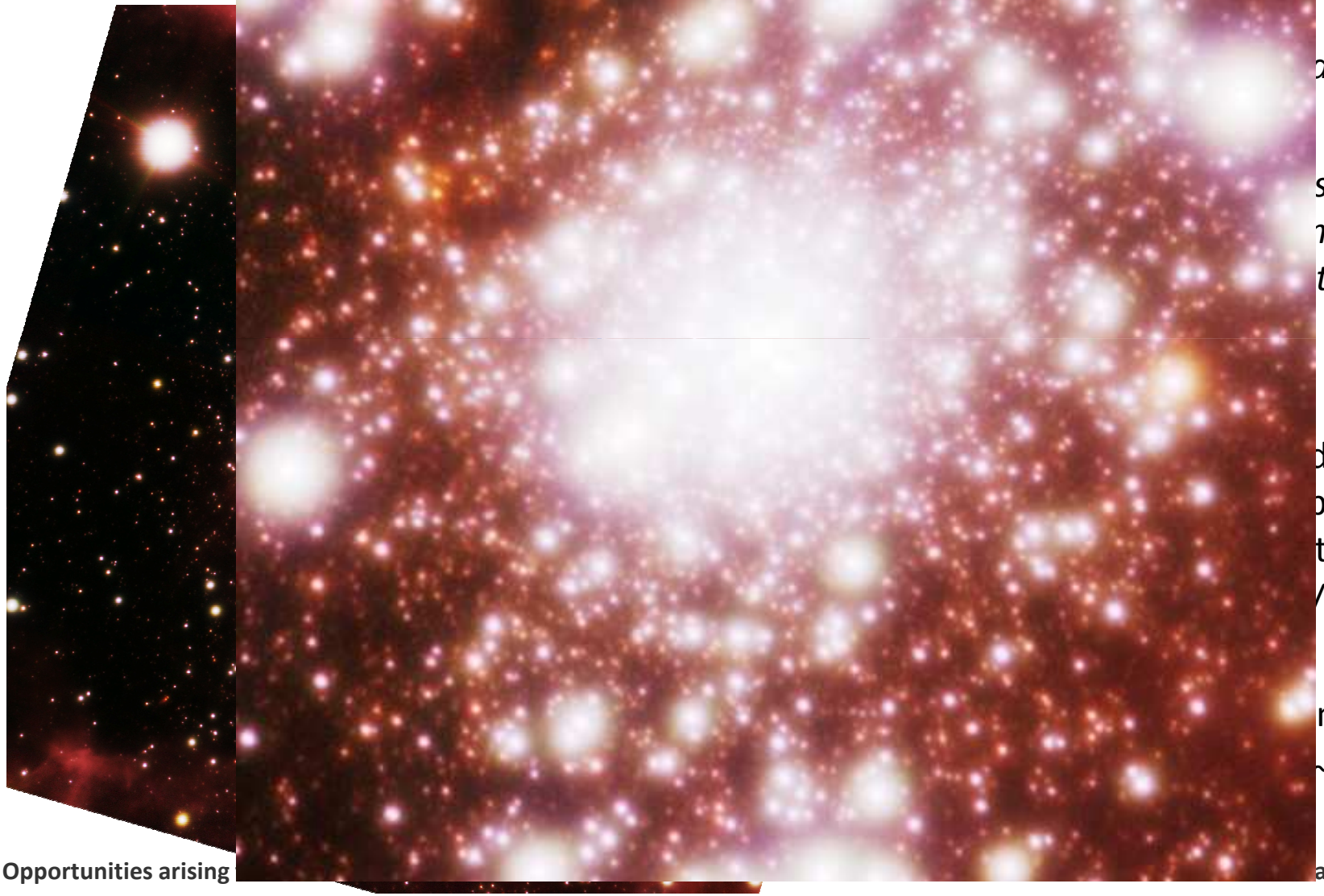
Galactic planetary nebula NGC 2346 with GeMS/GSAOI (L Stanghellini, A. Manchado, R. Shaw, A. Garcia-Hernandez, E. Villaver, P. Garcia-Lario)

Observations: narrow-band H2 1-0 S(1) 2.122, Brg 2.166, and H2 2-1 S(1) 2.248 mm filters; observing time 3h including overhead for all filters, bright H2 image only needed 1/3h. Final combined, distortion corrected, dithered images FWHM~0.08" for the H2 1-0 image

"The images shows unprecedented detail (FWHM 0.08" across field) which is ideal to study in details the knots and filaments expected in such a PN. The pixel size is 7 AU at the distance of NGC 2346, by comparison, the Helix program on HST was based on resolving knots of 28 AU"



Low ma … g regions



…and A. Damineli

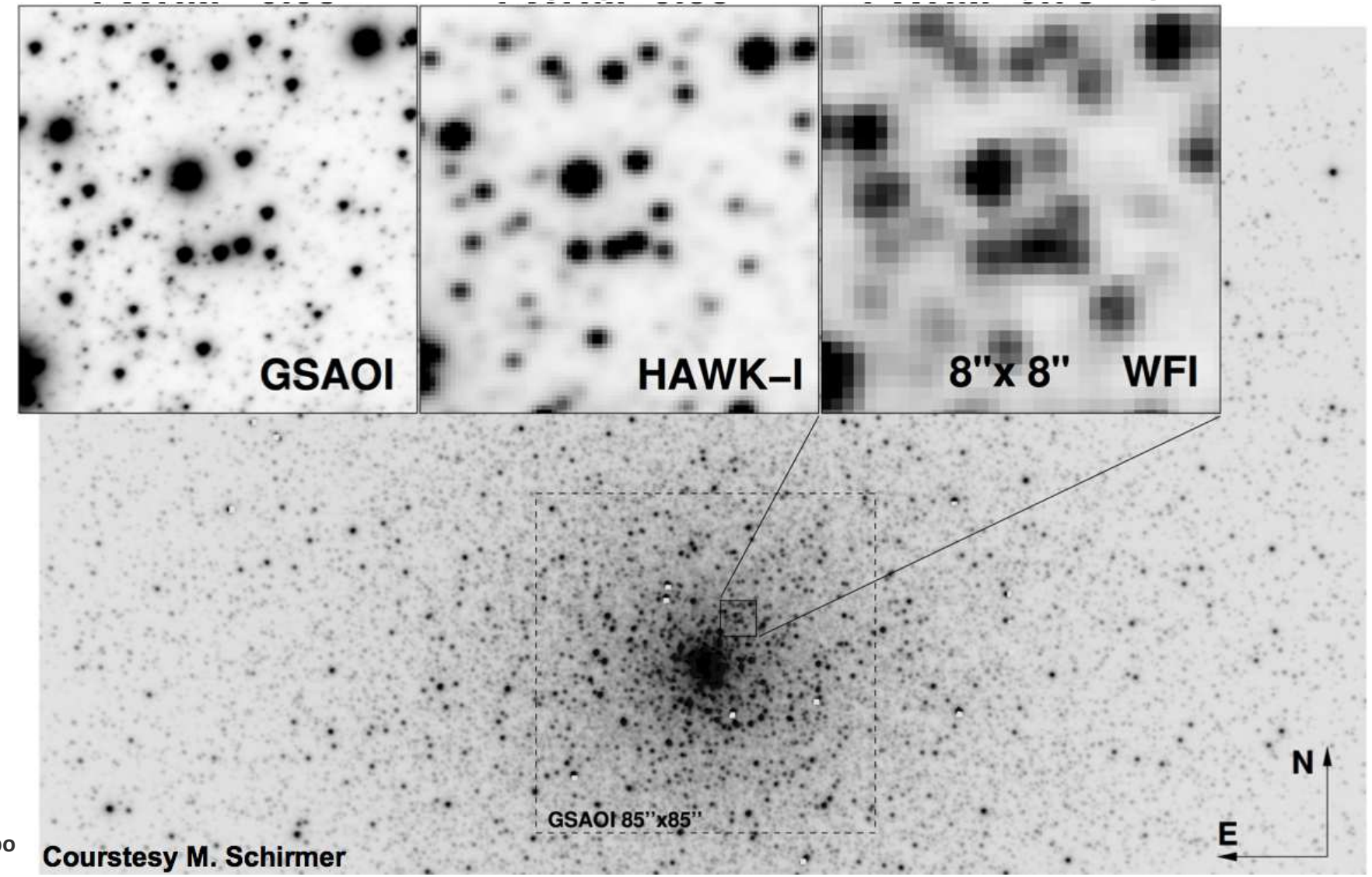
…s have been suggested
…nd of the IMF in R136
…t about 2 Msun

…deep images in JHKs
…ble cluster R136/R141-
…the pre main sequence
…M ~ 1 Msun)

…minutes per filter)
…~ 0.12” - 0.18”

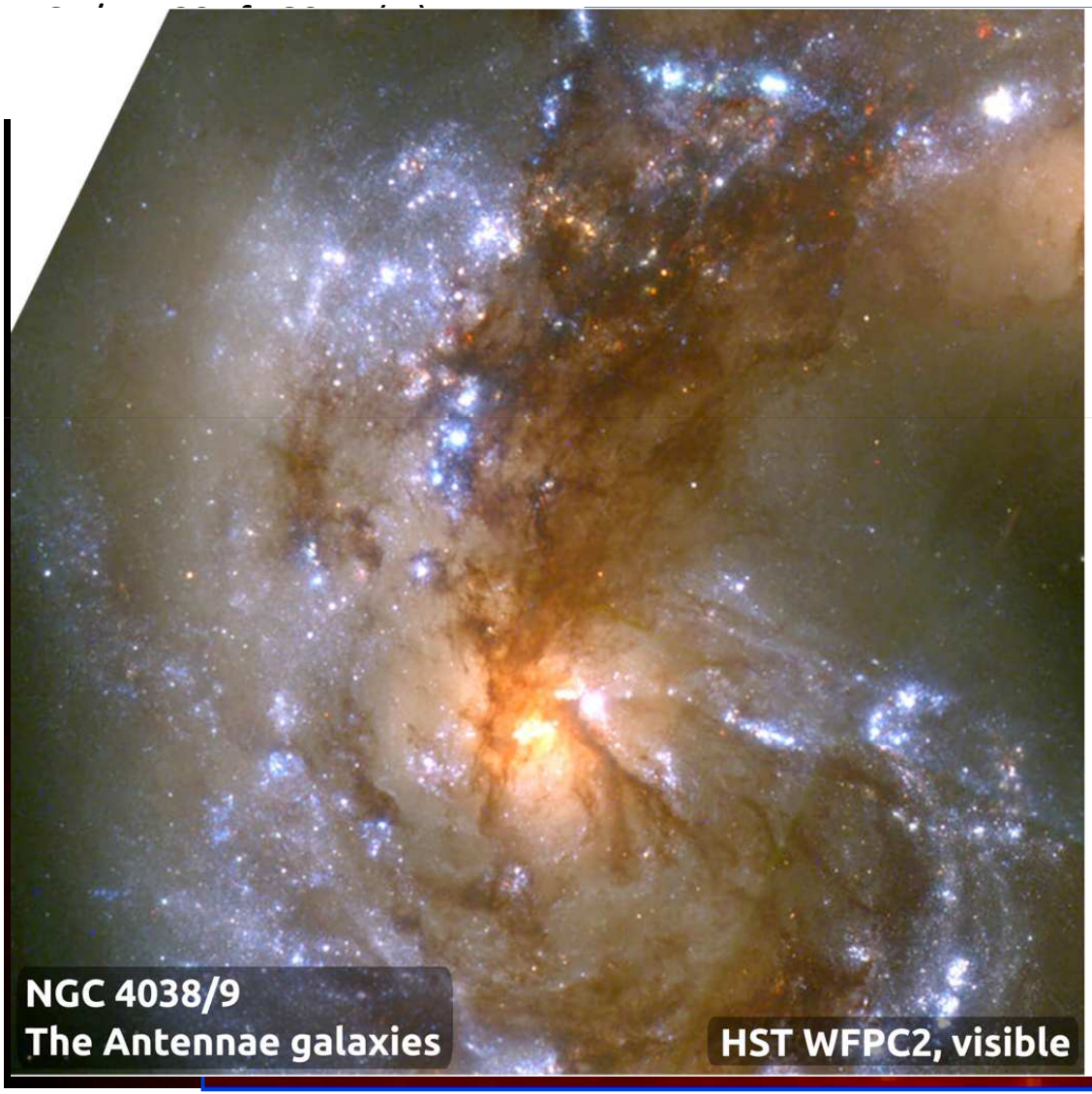
Science with GeMS/GSAOI

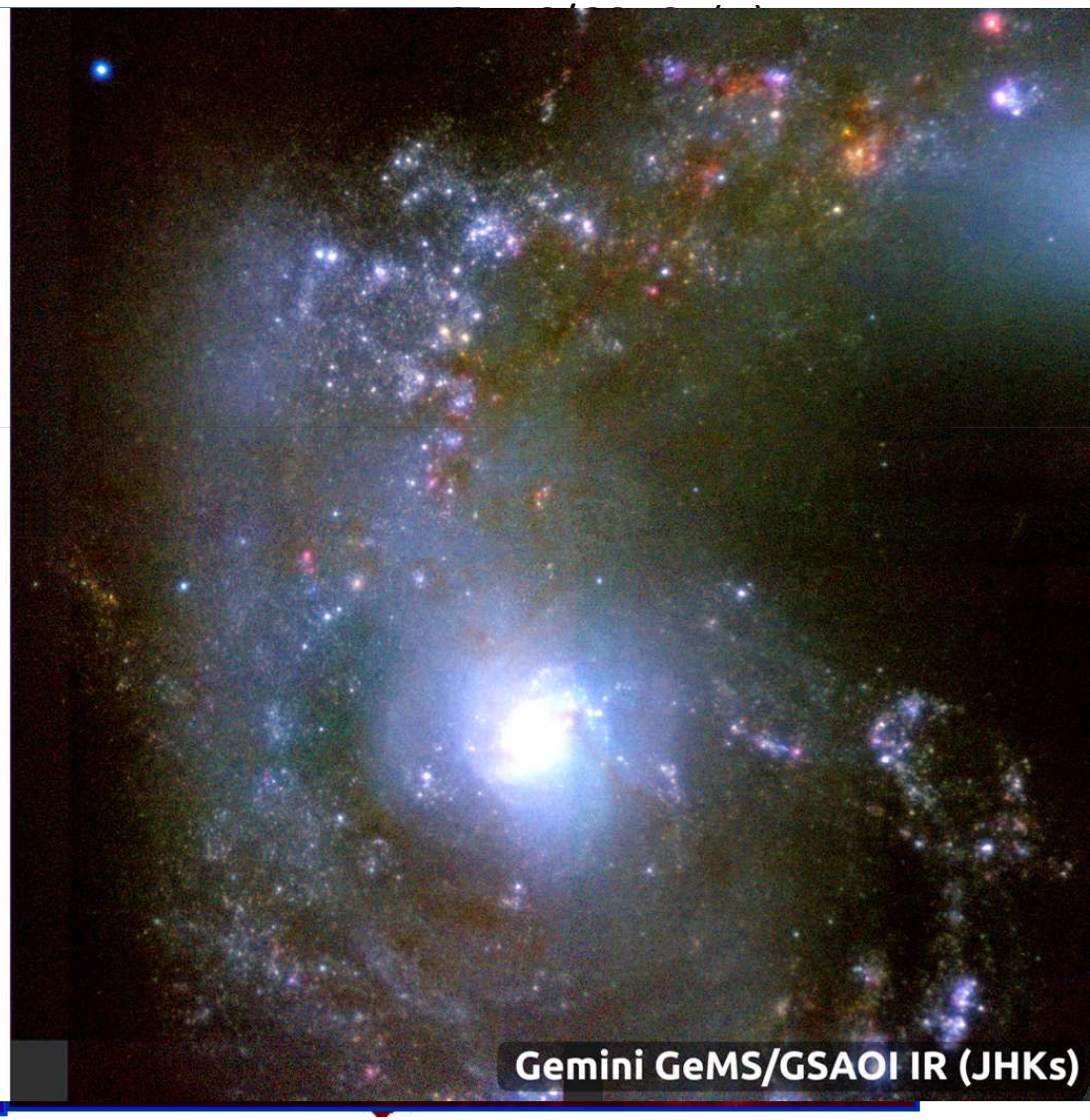
Wide field imaging of NGC 1851: different pointings



Science with GeMS/GSAOI

Young Star clusters in merging/interacting systems





GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

p Ks-images
IS/GSAOI

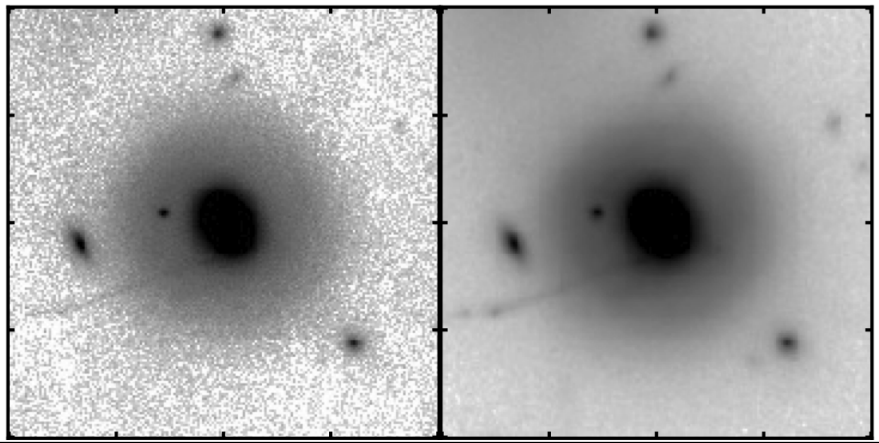
GSAOI
GEMINI
GeMS

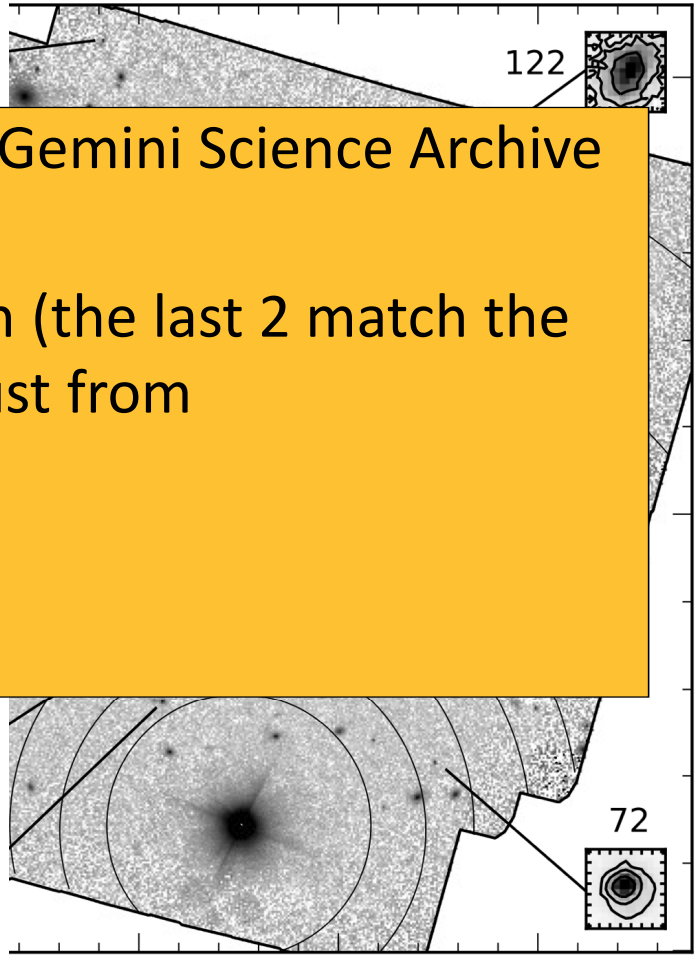
- 5.3 hours of on-sourc

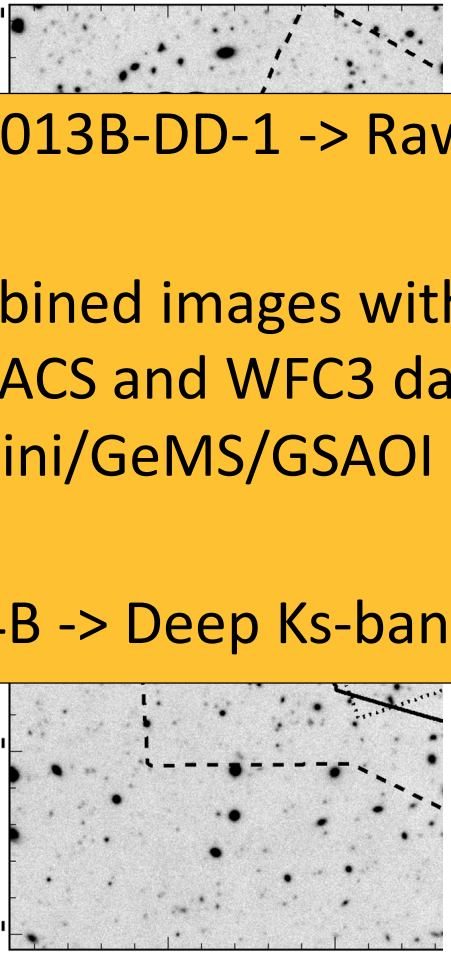
122", only one NGS used

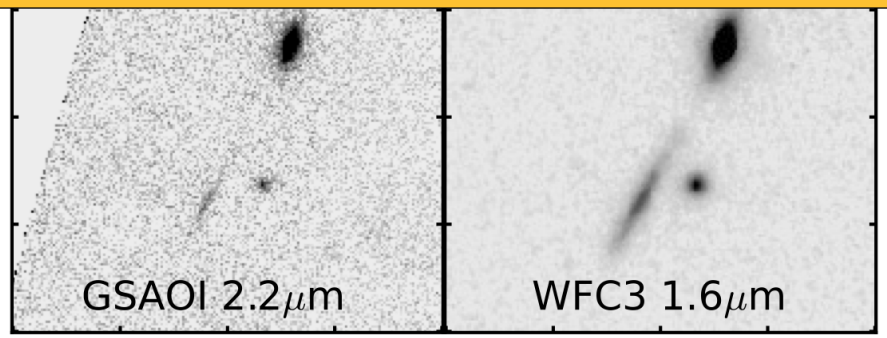
HST/WFC3 F160W

GeMS/GSAOI Ks-band









- GS-2013B-DD-1 -> Raw data is public and available from Gemini Science Archive
- Combined images with 0.02", 0.03" and 0.06" resolution (the last 2 match the HST/ACS and WFC3 data) will be available at end of August from Gemini/GeMS/GSAOI web pages.
- 2014B -> Deep Ks-band images of Abell 2744

Precise Astrometry with GeMS

GeMS/GSAOI can be used for precise astrometry due to the powerful combination of high spatial resolution and a large field of view. Potential astrometric science cases: exo-planets, star formation, stellar evolution, star clusters, nearby galaxies, black holes and neutron stars, and the Galactic center.

- analysis of deep, mono-epoch images, multi-epoch images and distortion calibrated data (2011-2012)

- an astrometric error below **0.2 mas** can be achieved for single epoch, not dithered data with exposure times > 60s, if enough stars are available in the field to remove high-order distortions

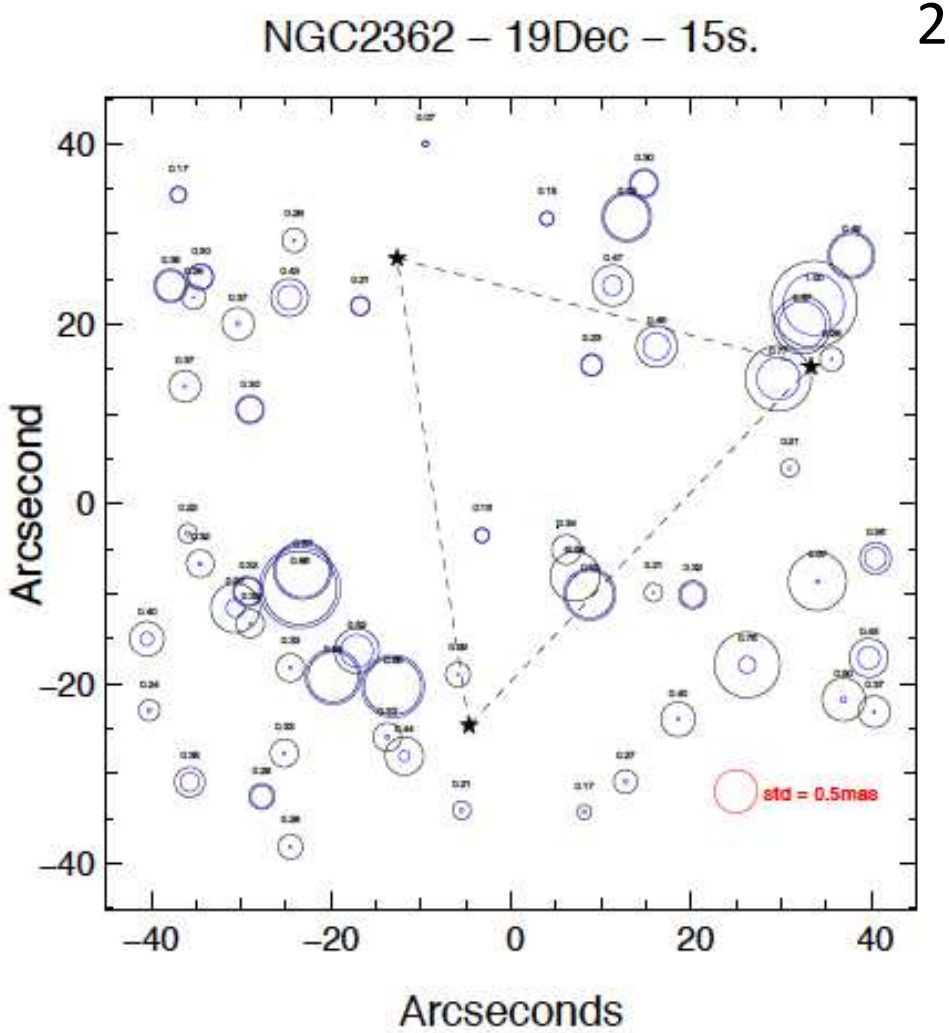
- this performance is not reproducible for **multi-epoch observations and dithered** data --> and an additional systematic error of **0.4 mas is evidence**

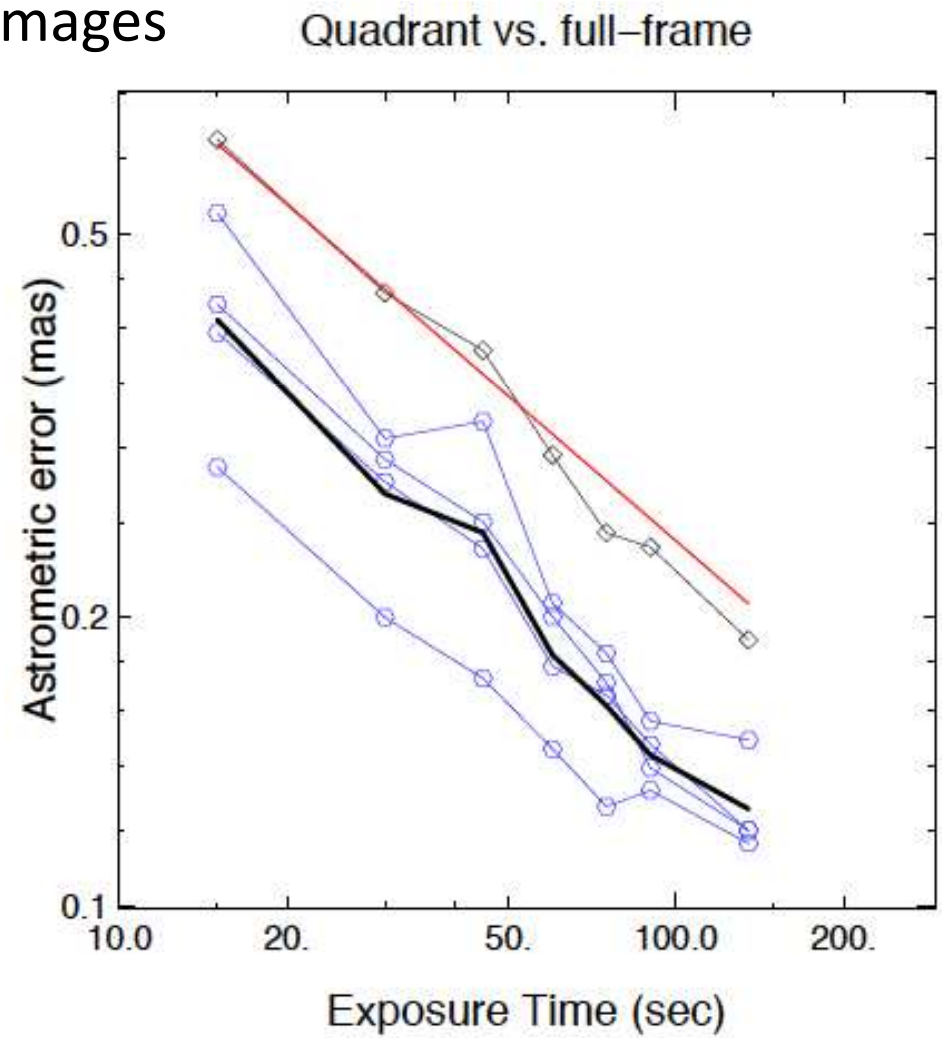
Neichel, Lu, Rigaut, Ammons, Carrasco & Lassalle (2014, MNRAS, submitted)

Science with GeMS/GSAOI

Astrometric error - single epoch, no dithering

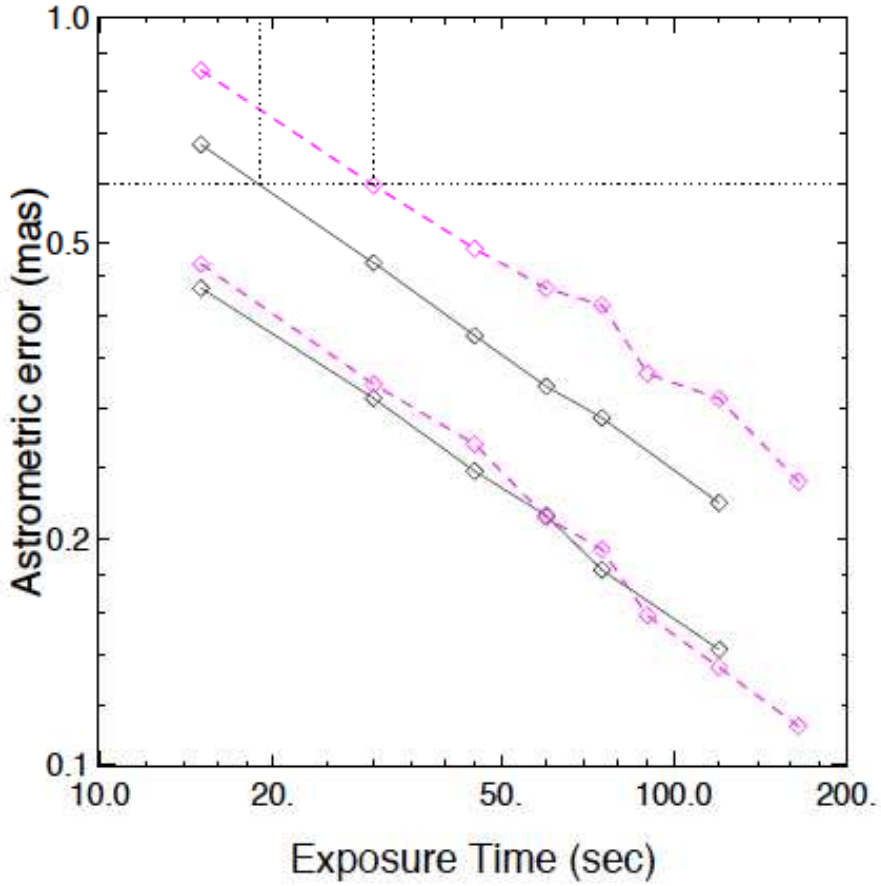
27 images





Astrometric error - single epoch, dithering and no dithering data

35 images observed with a 4-point square dithering of 3” x 3”

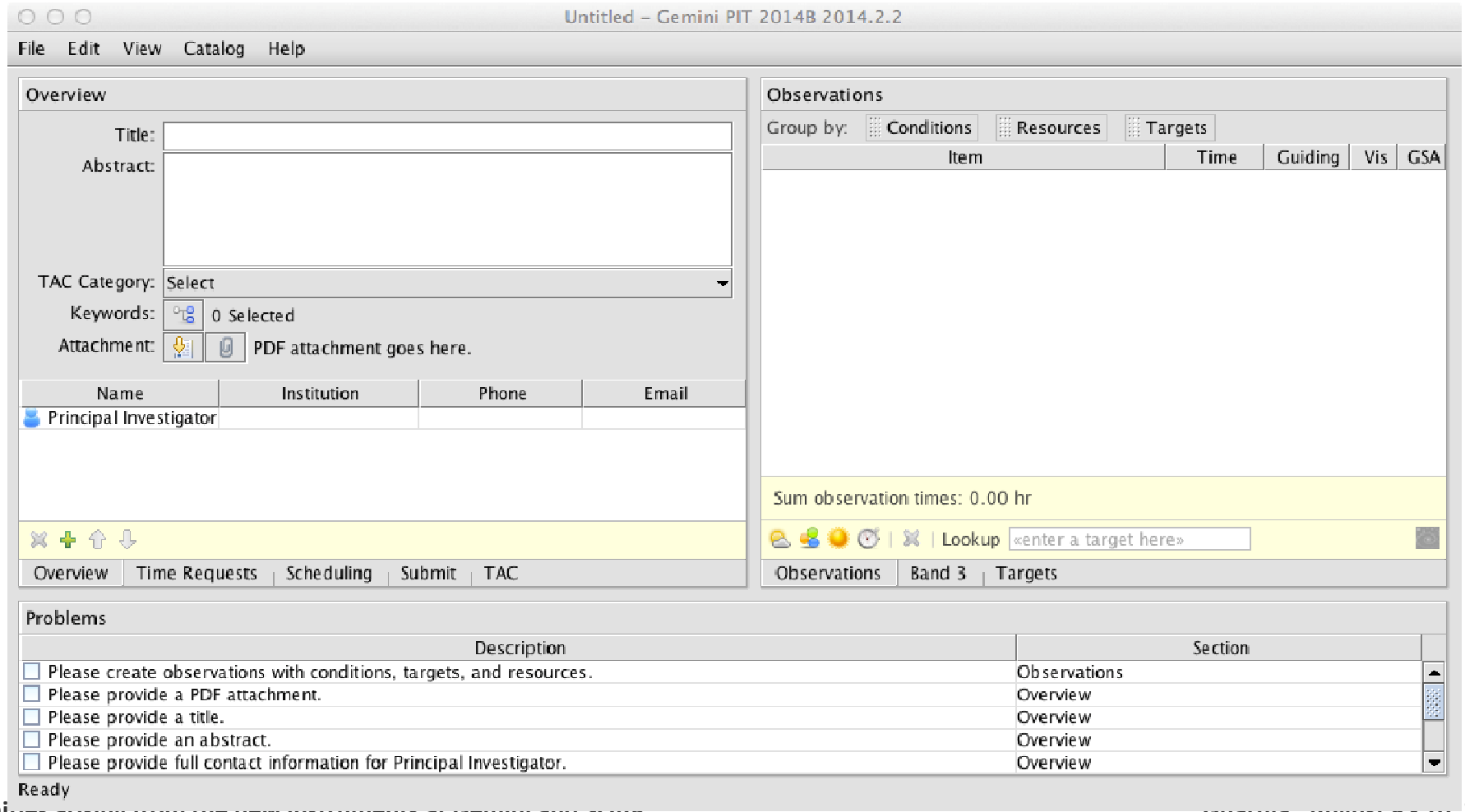


Observing with GeMS/GSAOI

Observing with GeMS/GSAOI

Great IDEA → submit your proposal with Phase I Tool

http://www.gemini.edu/node/12176#PIT



Observing with GeMS/GSAOI

When the proposal is accepted → **PhaseII using the Observing Tool**

Gemini Observing Tool (OT)

"Software used for detailed definition and pre-planning of observations from approved proposals during the PhaseII process. The OT is also the high-level interface for on-site (classical and staff) observers. It supports observations with all facility instruments."

Other Tools used by the observers (Gemini staff and classical observers) with GeMS/GSAOI

- GSAOI Instrument Status Display
- MCAO Yorick Smart tool (MYST) to monitor the GeMS loops, LCH shutter windows, etc.
- On-site IRAF/PyRAF installation and the GSAOI package
- ODWG Quick Look Tool monitor
- Telemetry tools for on-site real time quality assessment (Strehl and AO corrected FWHM values)

Observing with GeMS/GSAOI

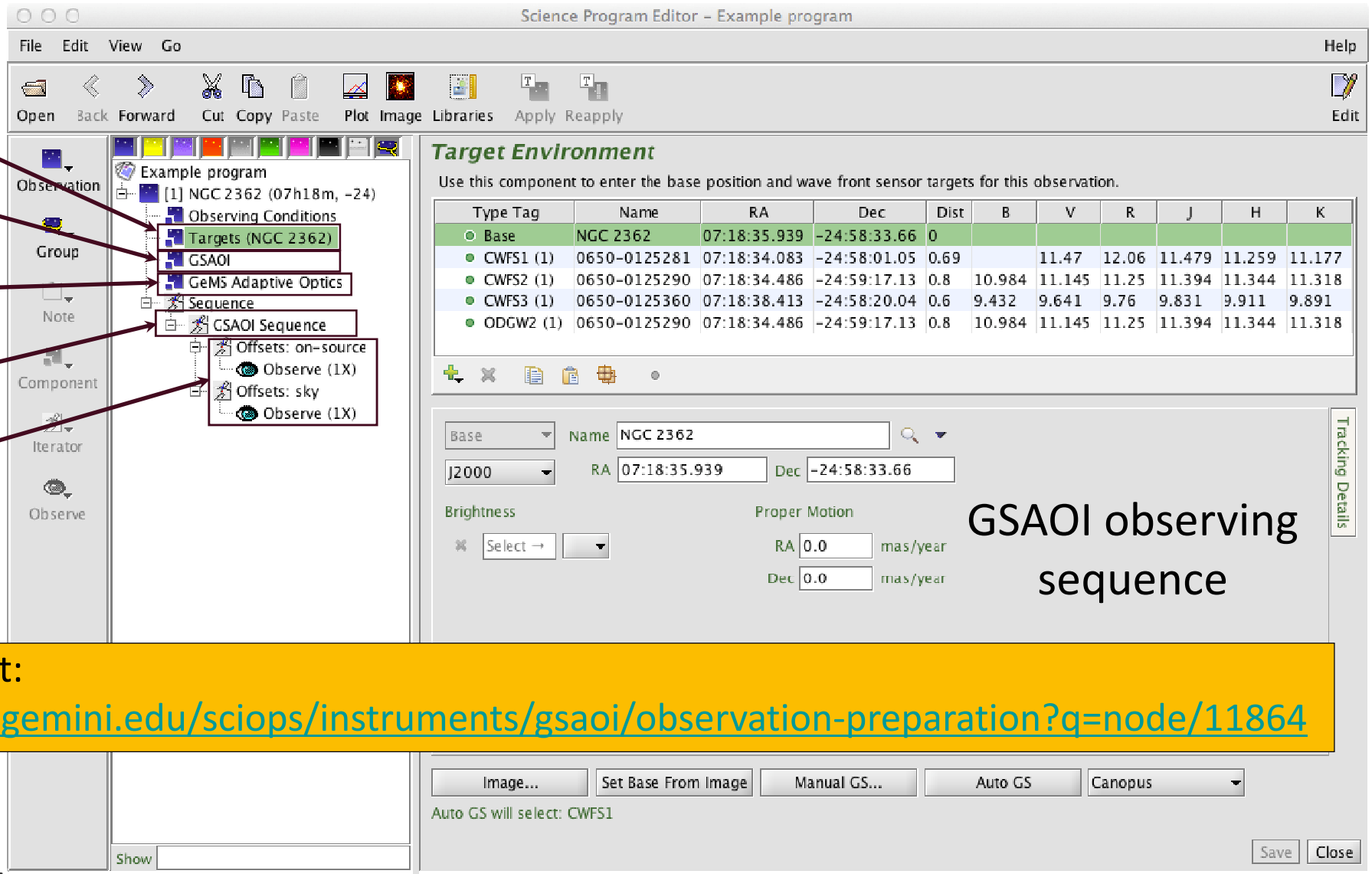
Target component

GSAOI component

GeMS component

GSAOI sequence component

Offset iterators

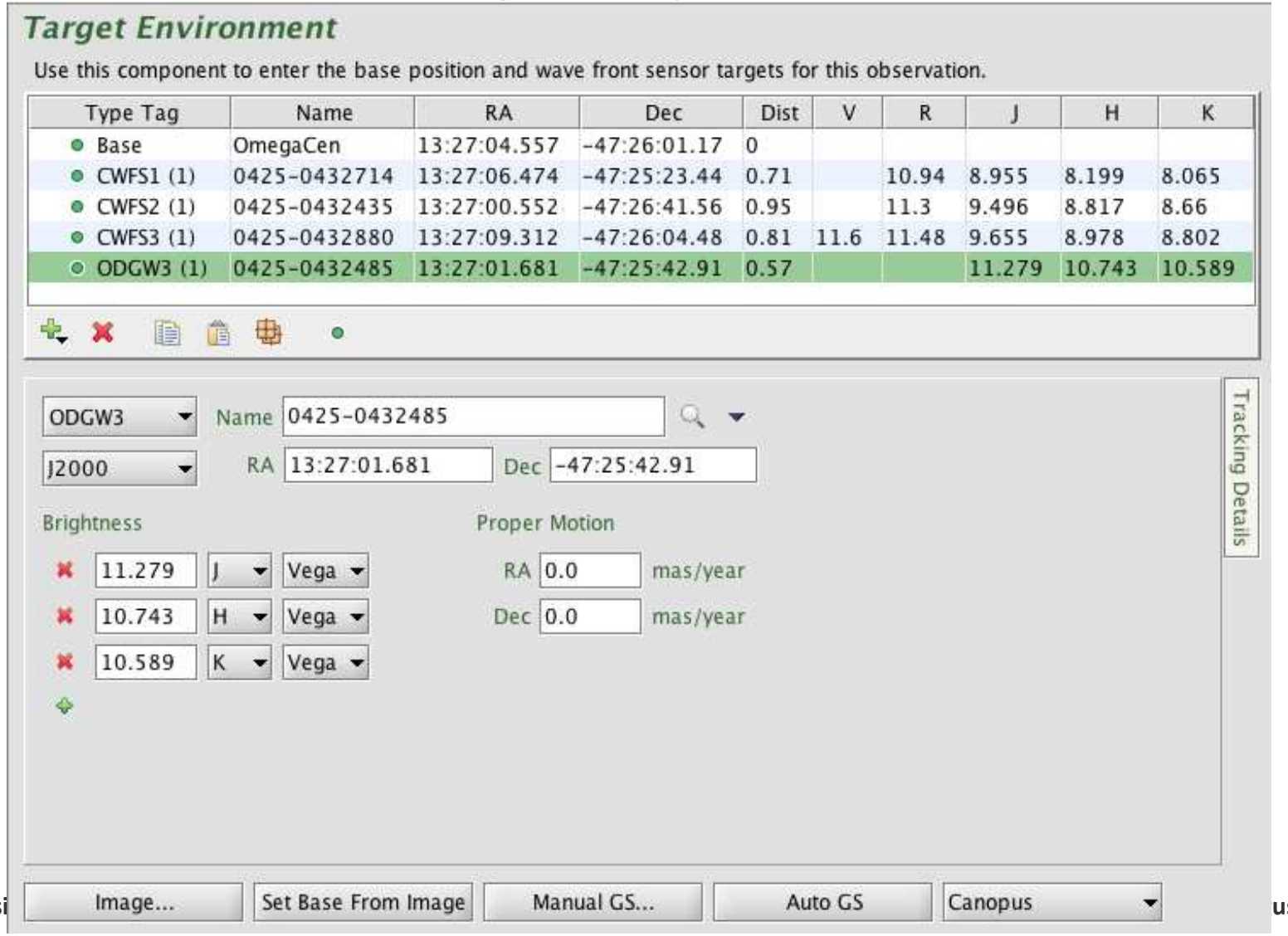


GSAOI observing sequence

See details at:
http://www.gemini.edu/sciops/instruments/gsaoi/observation-preparation?q=node/11864

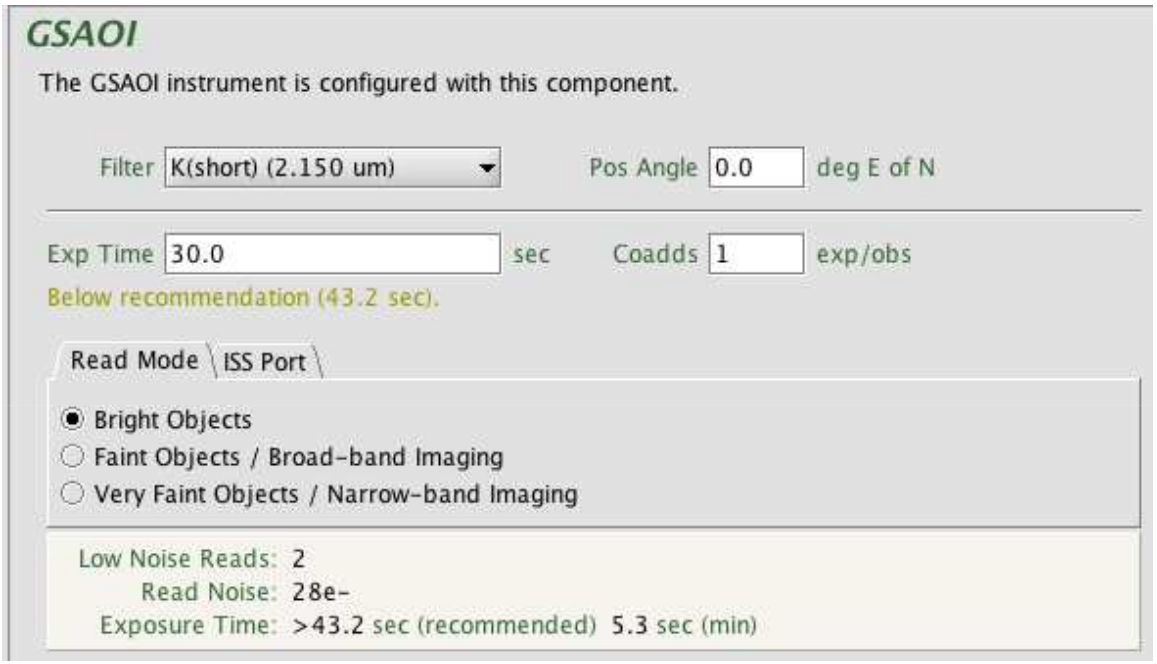
Observing with GeMS/GSAOI

Target Component

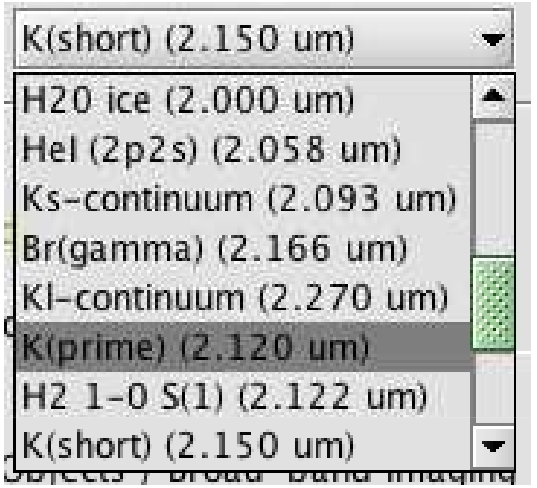


Observing with GeMS/GSAOI

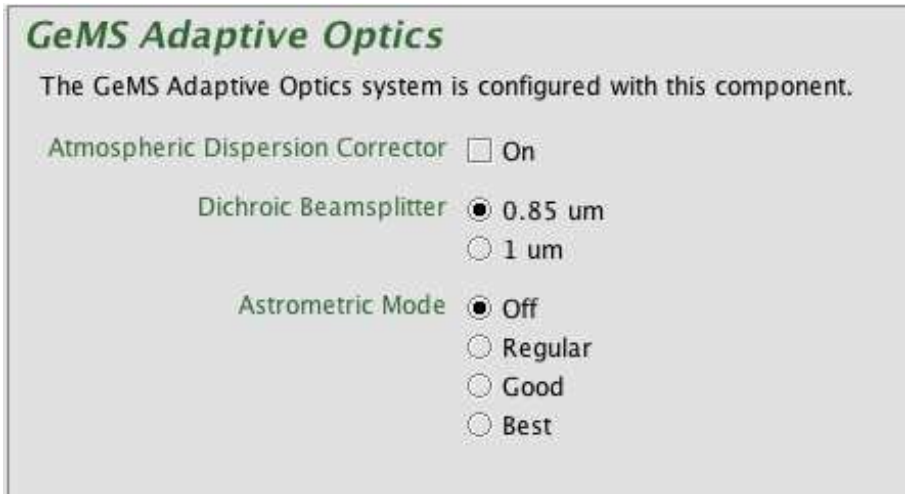
GSAOI Instrument Component



Filters

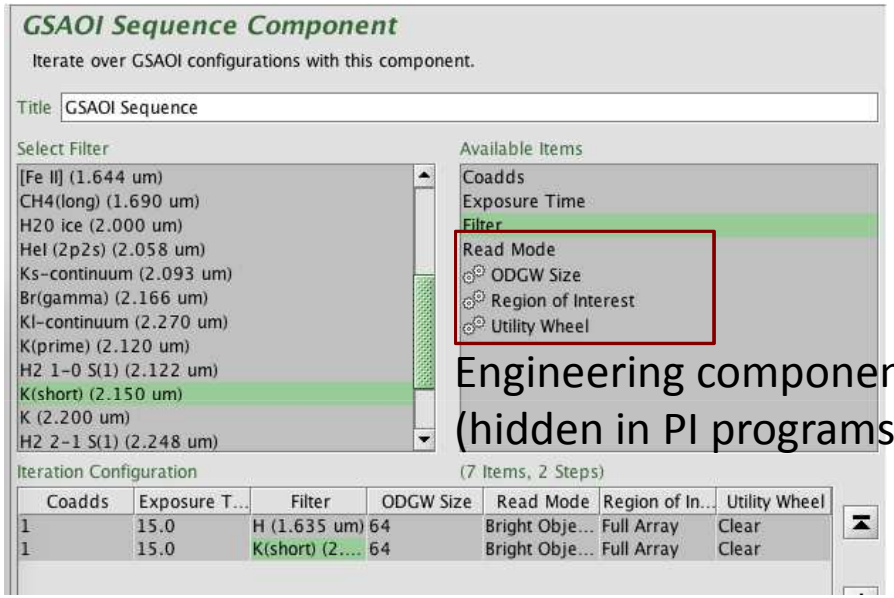


GeMS component



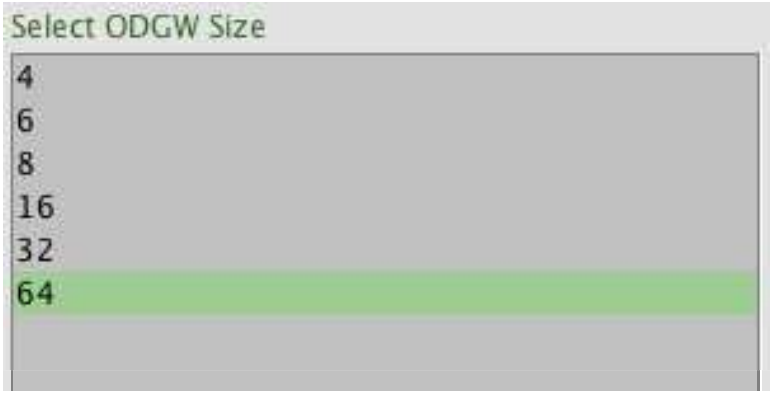
Observing with GeMS/GSAOI

GSAOI Sequence Component

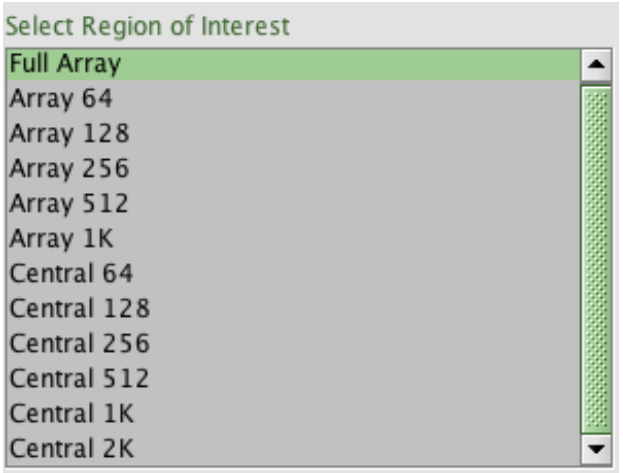


Engineering component (hidden in PI programs)

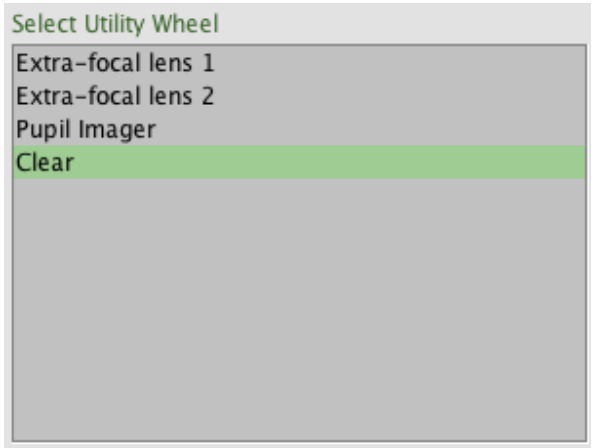
ODGW size



ROI setup (Phot. Std)

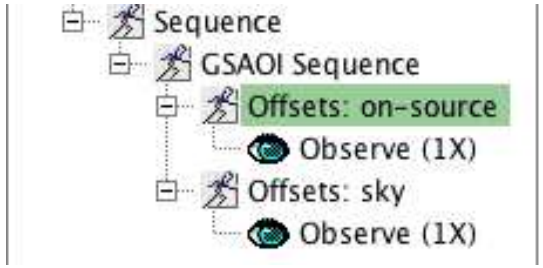


Utility wheel



Observing with GeMS/GSAOI

Offset iterator



Offset Sequence Component

Configure offset based patterns with this component.

Title: Offsets: on-source

Index	p	q	Guiding
0	0.0	0.0	on
1	4.0	4.0	on
2	-4.0	4.0	on
3	-4.0	-4.0	on
4	4.0	-4.0	on

Offset Sequence Component

Configure offset based patterns with this component.

Title: Offsets: sky

Index	p	q	Guiding
0	66.0	-150.0	off
1	70.0	-146.0	off
2	62.0	-146.0	off
3	62.0	-154.0	off
4	70.0	-154.0	off

Base Sequence Component

This component contains the sequence of operations that generates the observation science data.

Title: Sequence

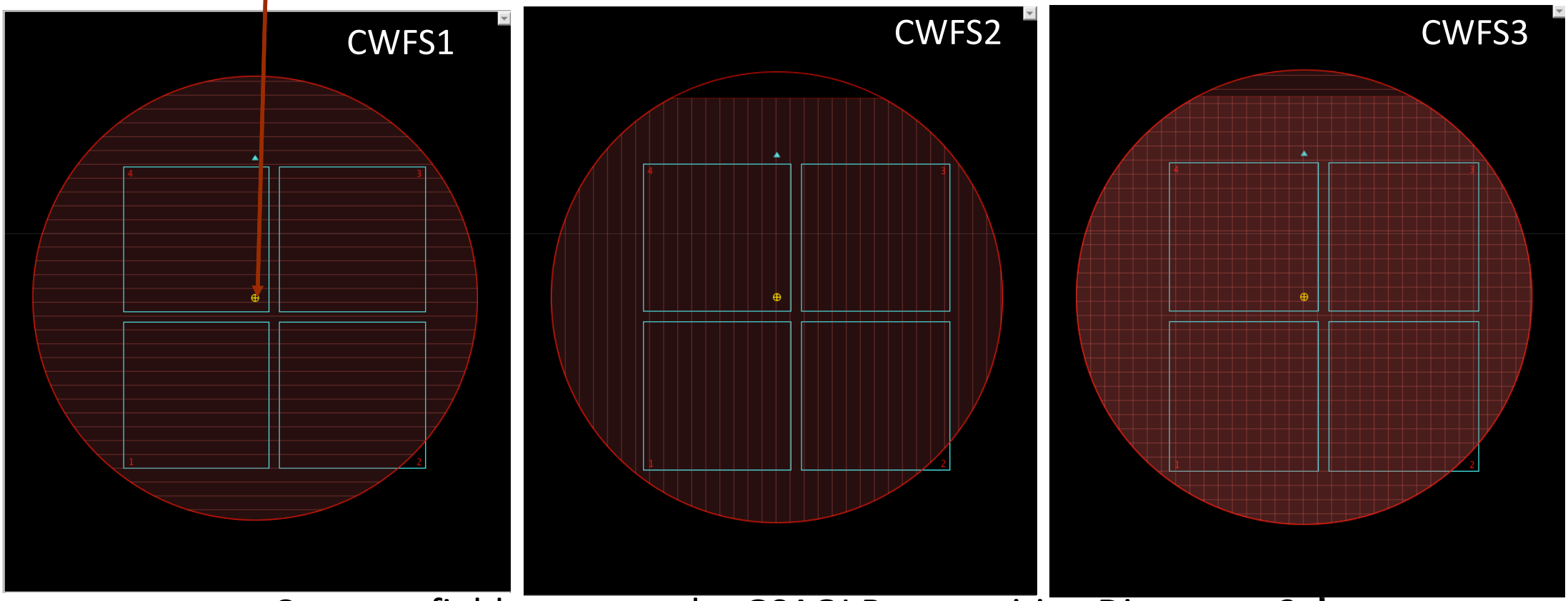
Sequence | Timeline

Data Label	Class	P	Q	Filter	Observing Wavelength	Guide With CWFS1	Guide With CWFS2	Guide With CWFS3	Guide With ODGW2
-001	Science	0.0	0.0	K(short) (2.150 um)	2.150	guide	guide	guide	guide
-002	Science	4.0	4.0	K(short) (2.150 um)	2.150	guide	guide	guide	guide
-003	Science	-4.0	4.0	K(short) (2.150 um)	2.150	guide	guide	guide	guide
-004	Science	-4.0	-4.0	K(short) (2.150 um)	2.150	guide	guide	guide	guide
-005	Science	4.0	-4.0	K(short) (2.150 um)	2.150	guide	guide	guide	guide
-006	Science	66.0	-150.0	K(short) (2.150 um)	2.150	freeze	freeze	freeze	freeze
-007	Science	70.0	-146.0	K(short) (2.150 um)	2.150	freeze	freeze	freeze	freeze
-008	Science	62.0	-146.0	K(short) (2.150 um)	2.150	freeze	freeze	freeze	freeze
-009	Science	62.0	-154.0	K(short) (2.150 um)	2.150	freeze	freeze	freeze	freeze
-010	Science	70.0	-154.0	K(short) (2.150 um)	2.150	freeze	freeze	freeze	freeze
-011	Science	0.0	0.0	CH4(short) (1.580 um)	1.580	guide	guide	guide	guide
-012	Science	4.0	4.0	CH4(short) (1.580 um)	1.580	guide	guide	guide	guide
-013	Science	-4.0	4.0	CH4(short) (1.580 um)	1.580	guide	guide	guide	guide
-014	Science	-4.0	-4.0	CH4(short) (1.580 um)	1.580	guide	guide	guide	guide
-015	Science	4.0	-4.0	CH4(short) (1.580 um)	1.580	guide	guide	guide	guide
-016	Science	66.0	-150.0	CH4(short) (1.580 um)	1.580	freeze	freeze	freeze	freeze
-017	Science	70.0	-146.0	CH4(short) (1.580 um)	1.580	freeze	freeze	freeze	freeze
-018	Science	62.0	-146.0	CH4(short) (1.580 um)	1.580	freeze	freeze	freeze	freeze
-019	Science	62.0	-154.0	CH4(short) (1.580 um)	1.580	freeze	freeze	freeze	freeze
-020	Science	70.0	-154.0	CH4(short) (1.580 um)	1.580	freeze	freeze	freeze	freeze

Observing with GeMS/GSAOI

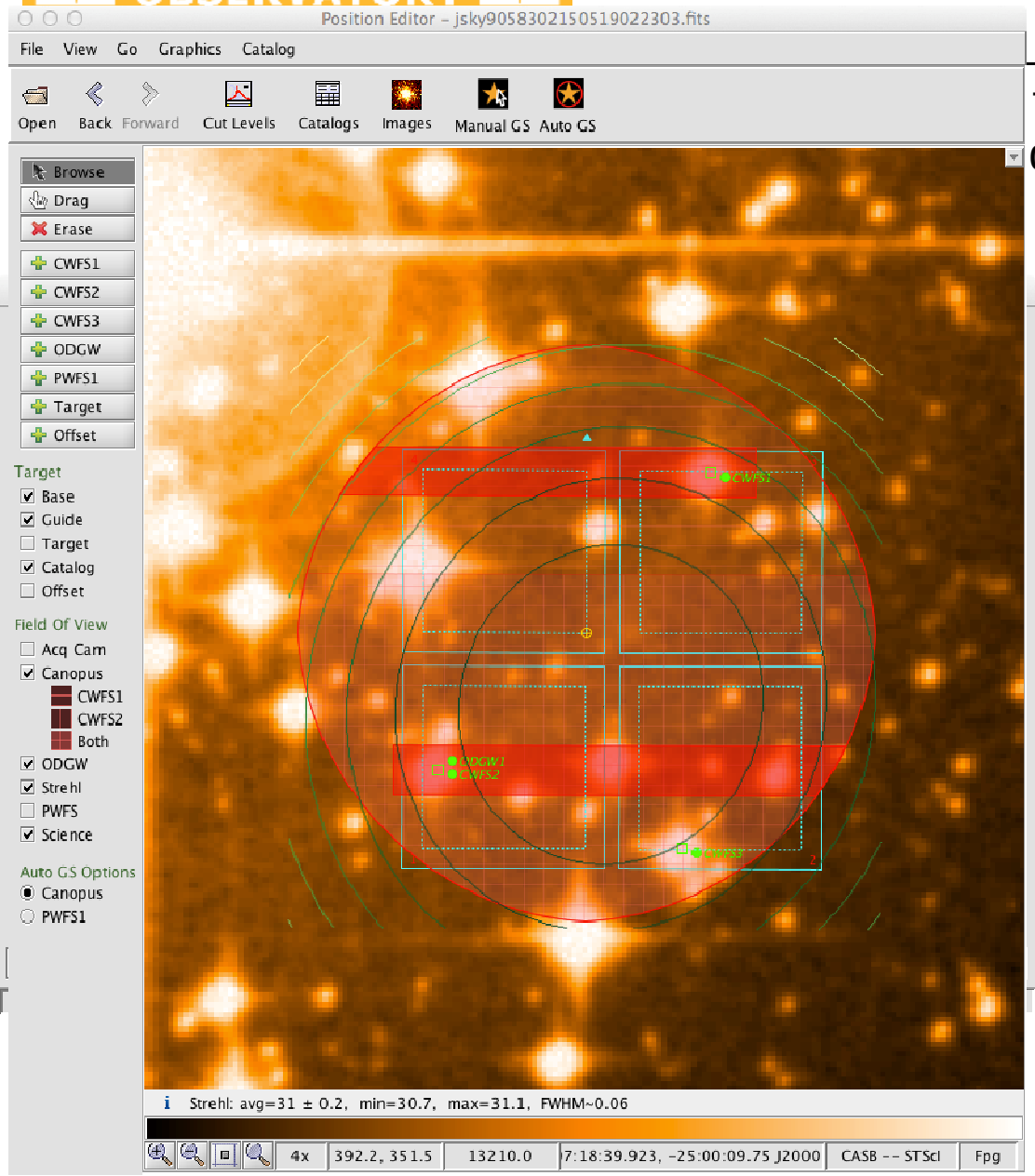
Position Editor: CWFSs patrol field area

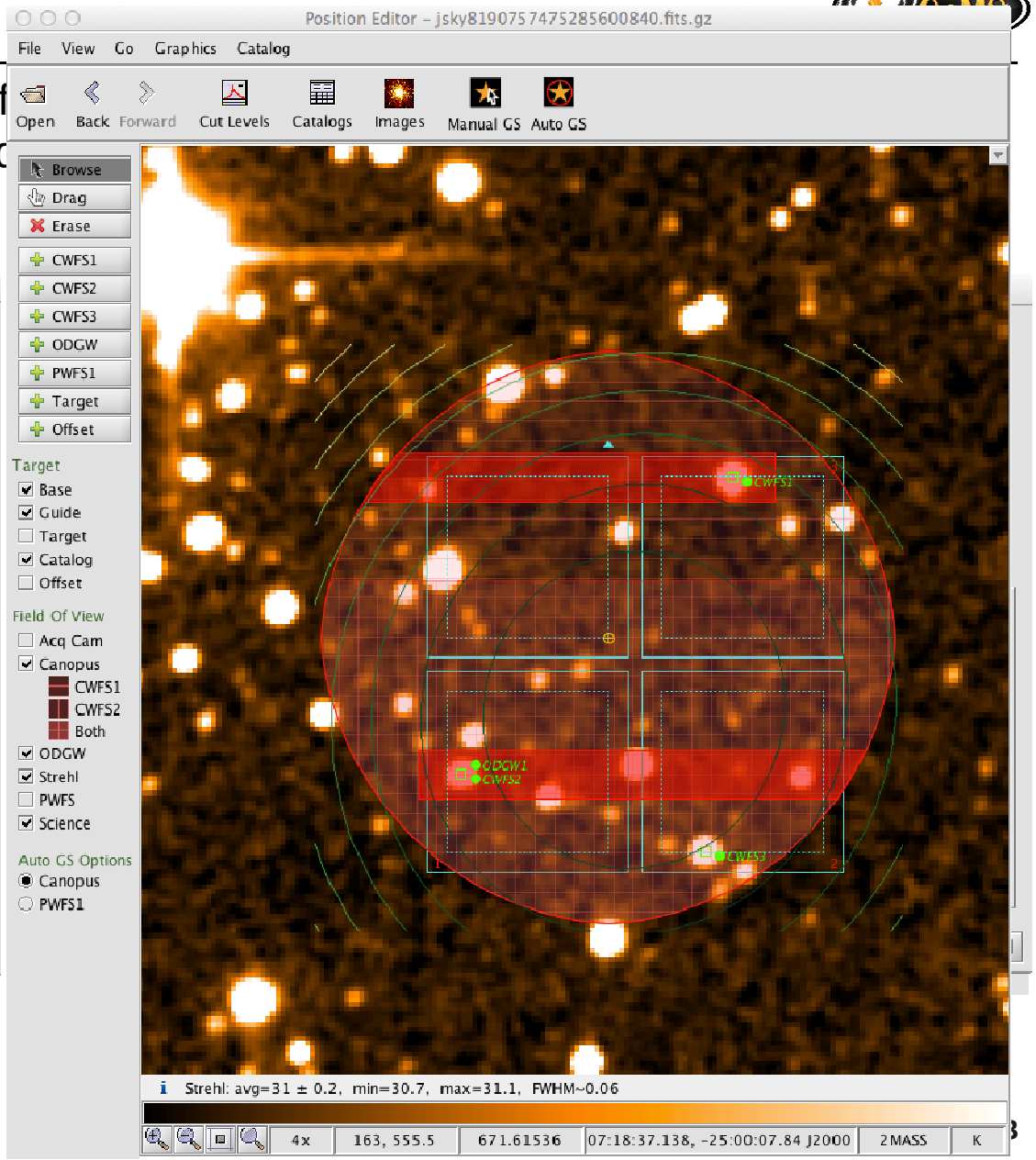
GSAOI Base Position (Hot Spot)



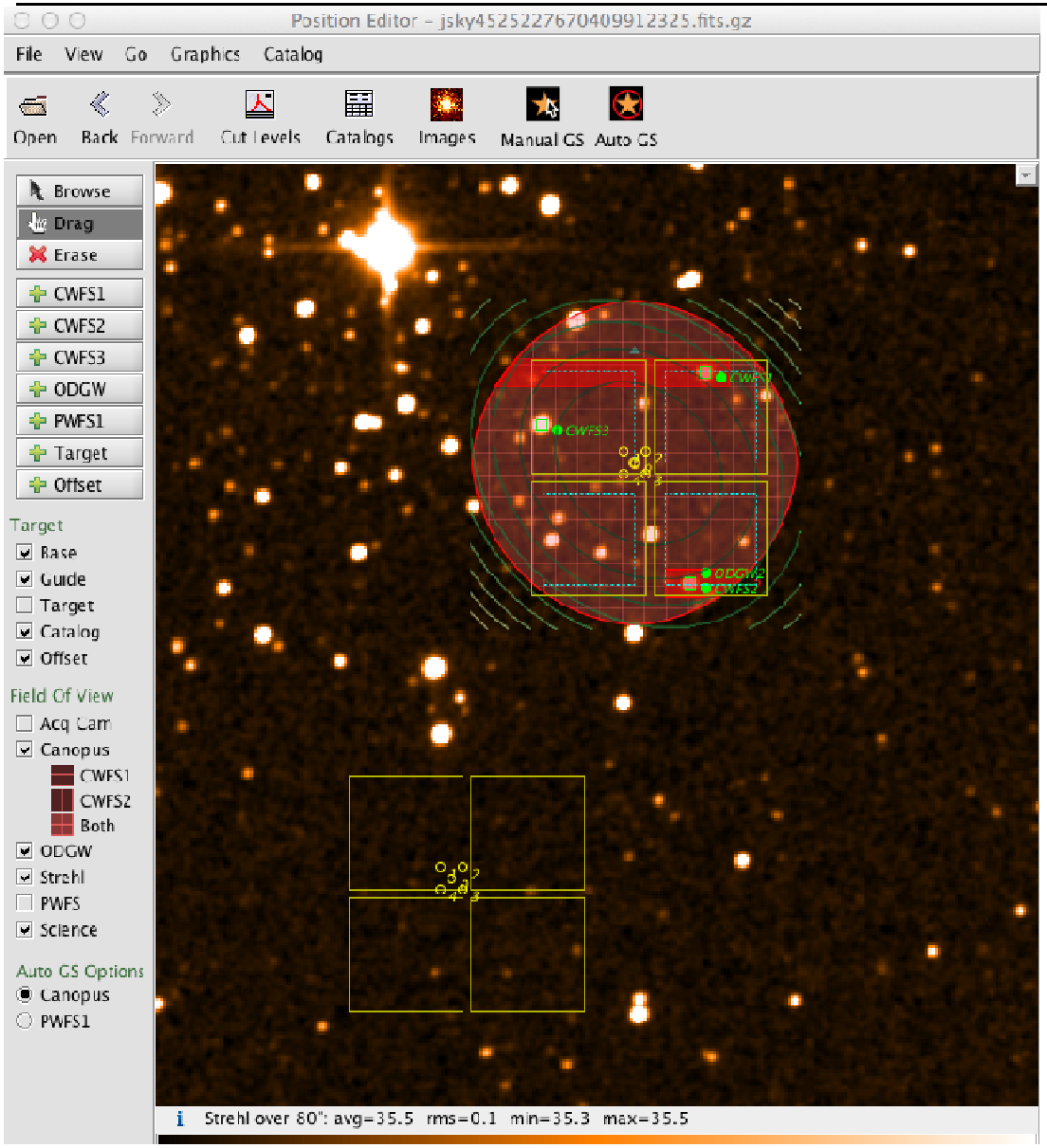
Canopus field center at the GSAOI Base position Diameter: 2

Observing with GeMS/GSAOI





Observing with GeMS/GSAOI



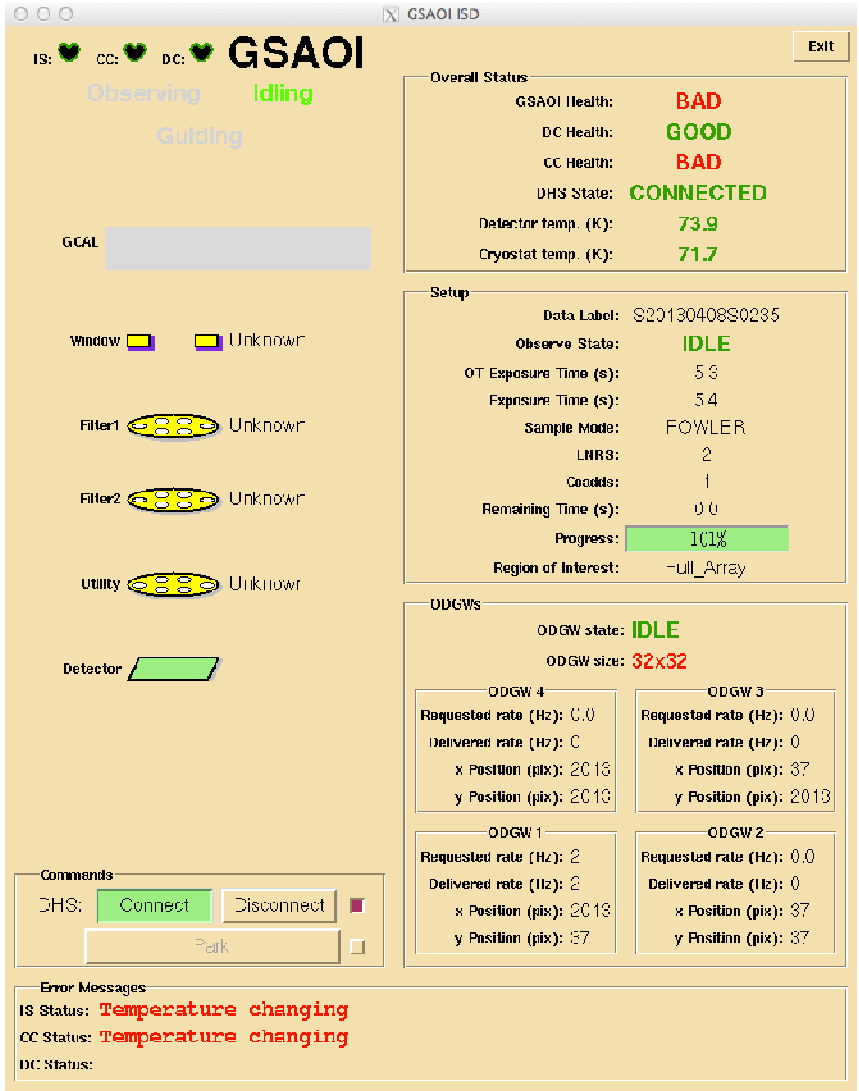
Phase II checks

- Canopus CWFS limiting magnitude R=15.5
- CWFS/ODGW are not outside the patrol field areas at different offsets (error message).
- Offset to the sky: laser must be shuttered when the offsets are larger than 5 arcmin from bse position → **this is not done automatically**

A separate sequence is required

- Phase II templates for
  - Sparse field
  - Crowded fields (sky < 5')
  - Crowded fields (sky > 5')

Observing with GeMS/GSAOI



GSAOI ISD and DMs → open from the Gemini pull down menus

Gemini → Instruments → GSAOI ISD/DM

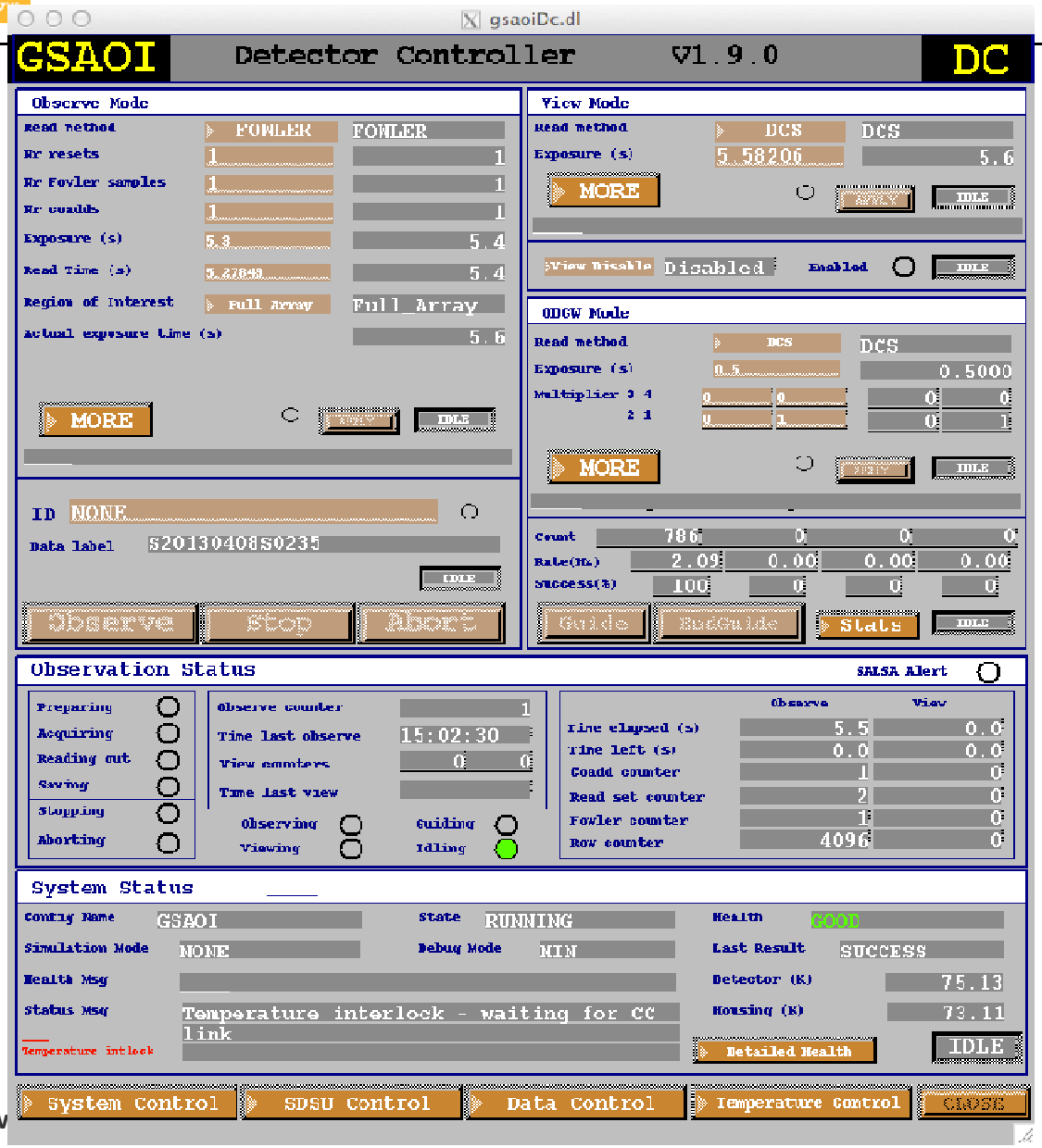
End of the night – park the instrument

-Close the window cover

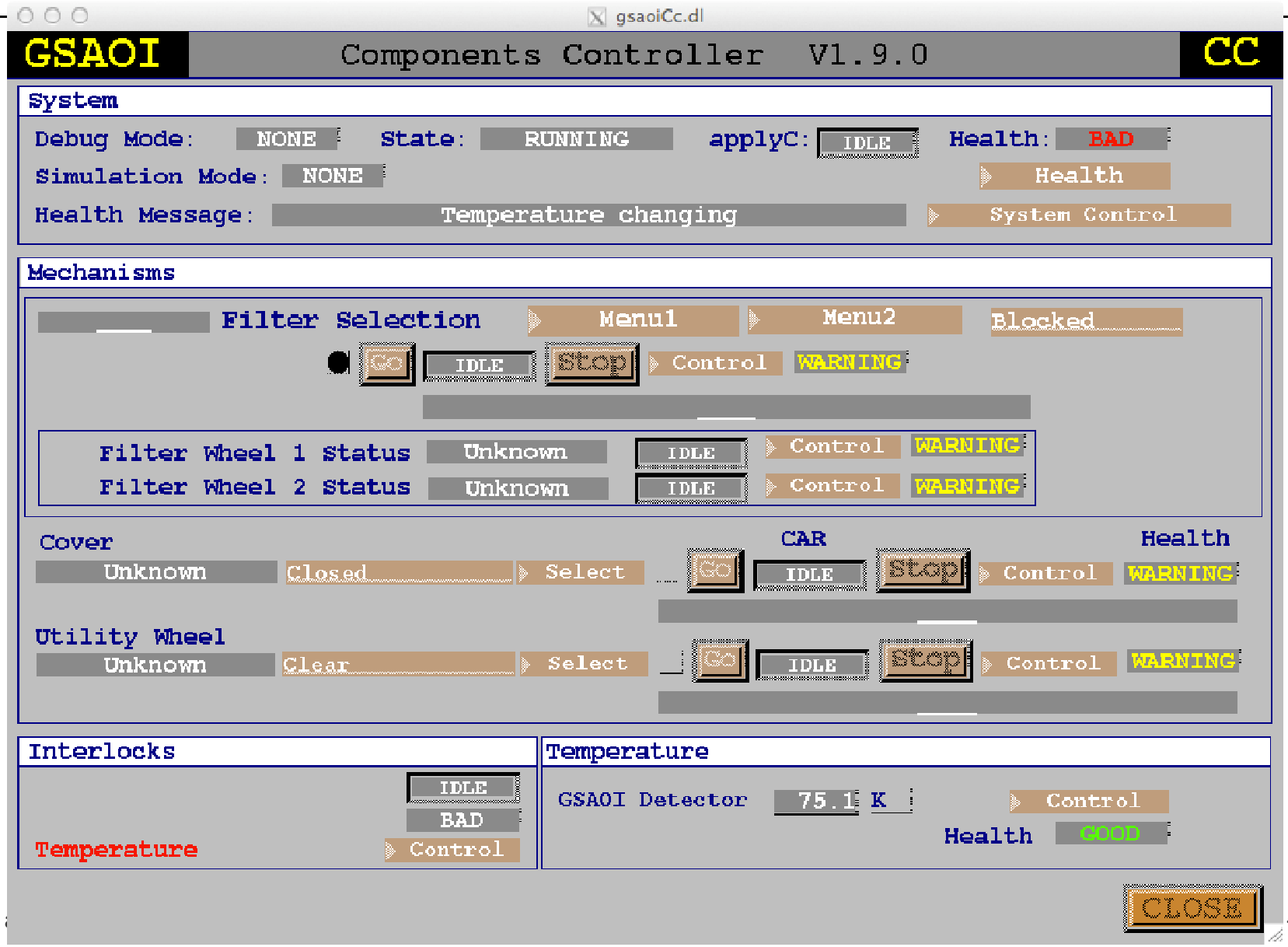
-Mover Filter 1 to blocked position

-Move Filter 2 to blocked position

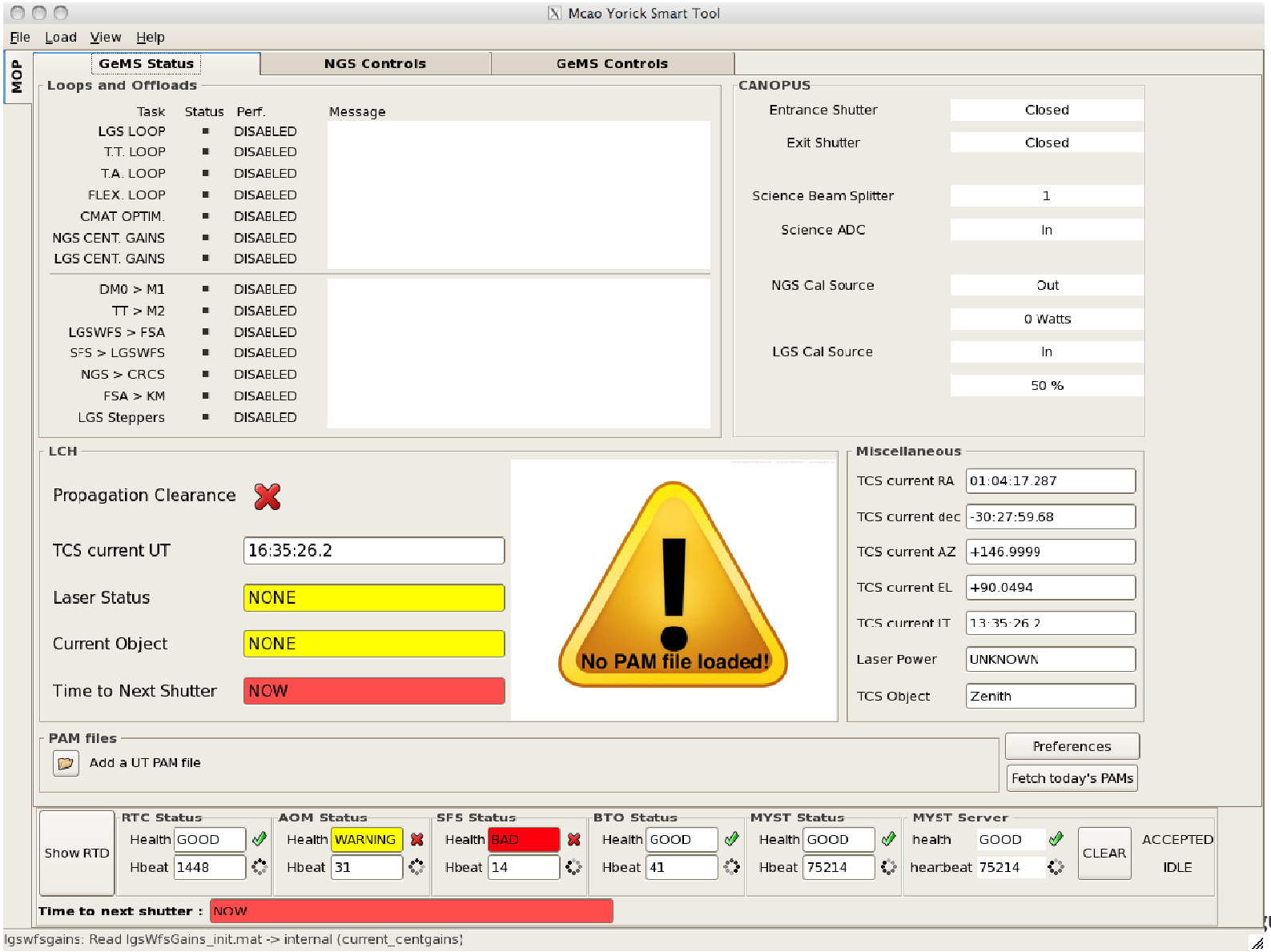
Observing with GeMS/GSAOI



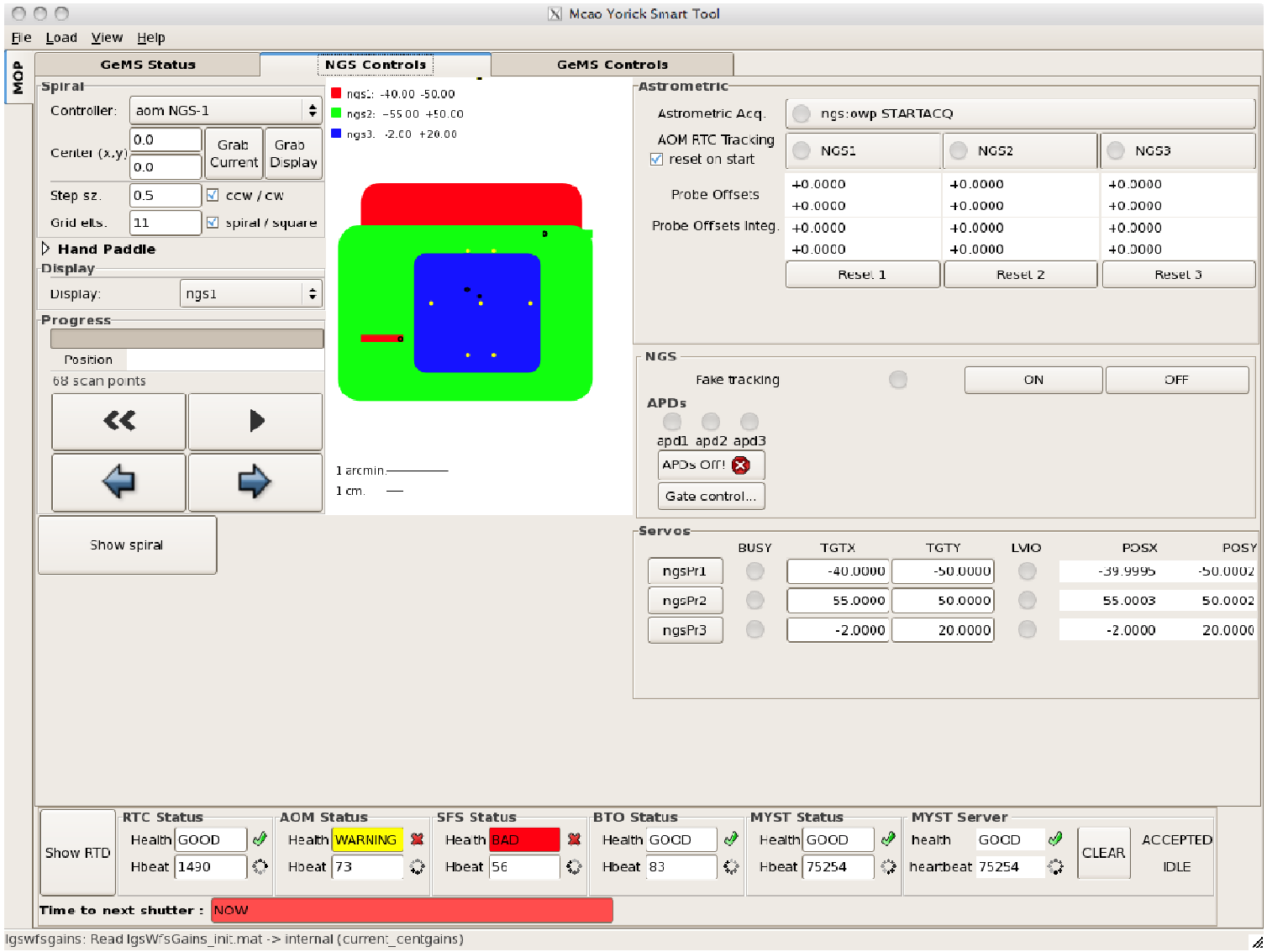
Observing with GeMS/GSAOI



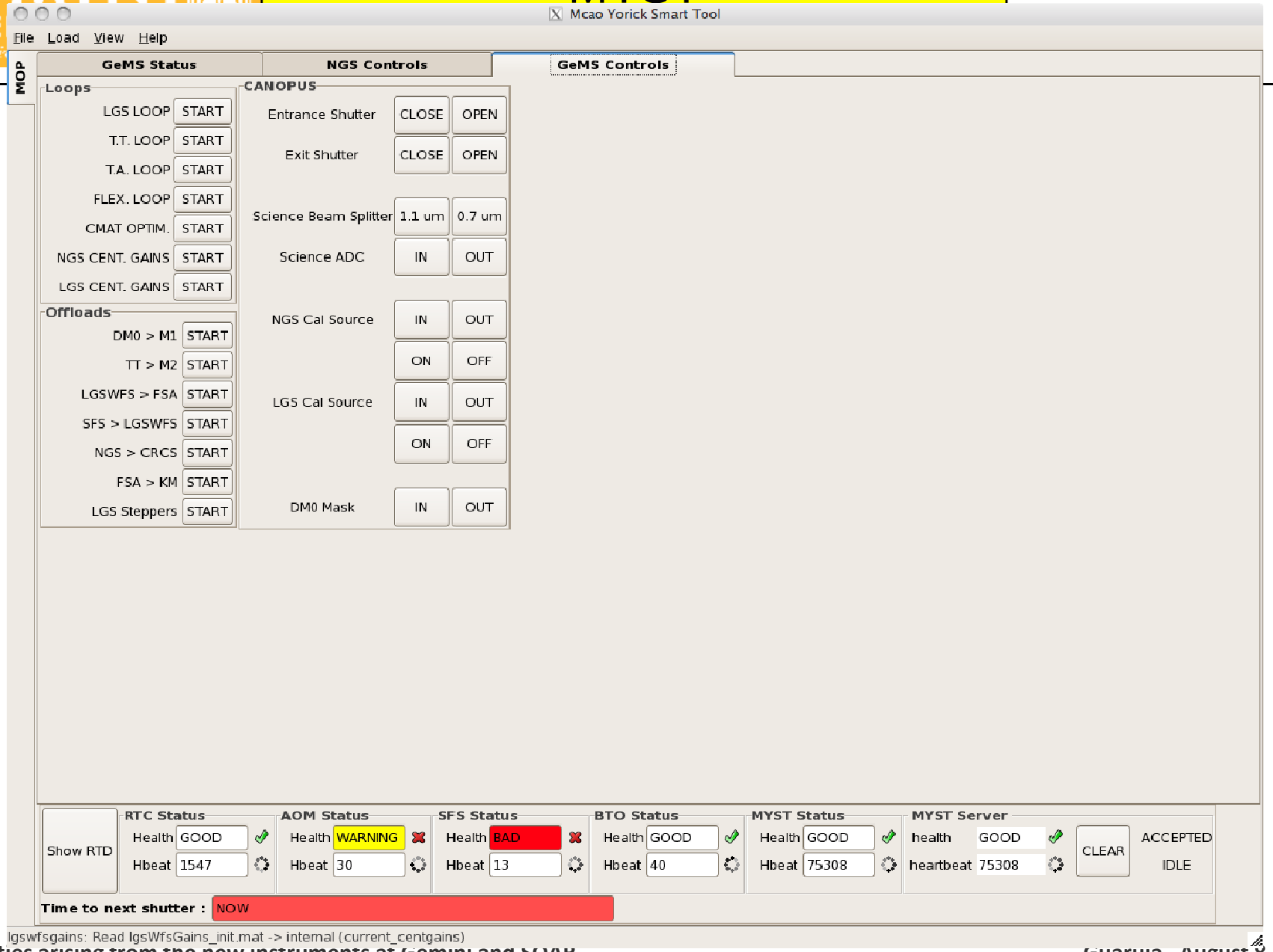
Observing with GeMS/GSAOI



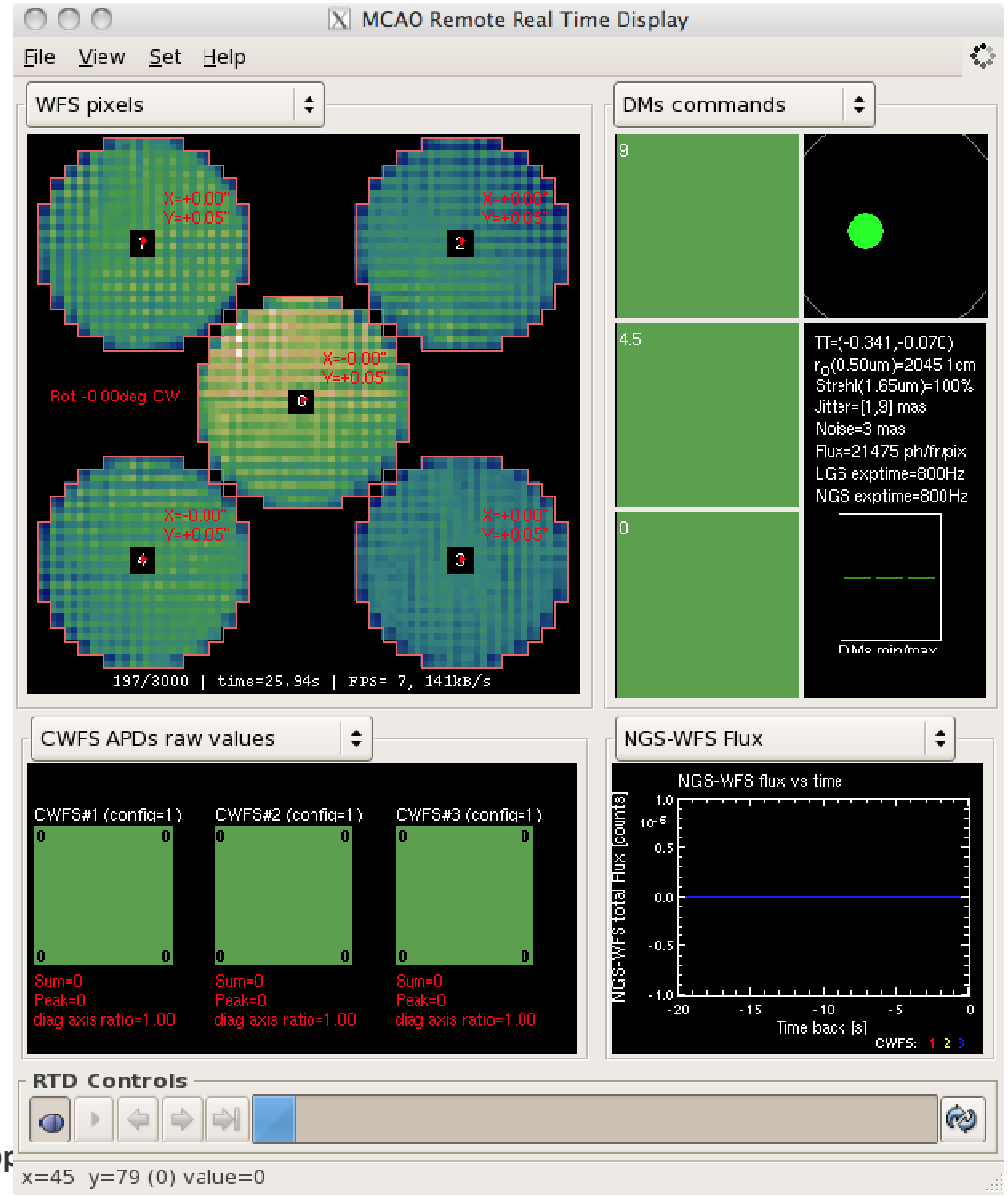
Observing with GeMS/GSAOI



MYST


Mcao Yorick Smart Tool
File Load View Help
MOP
GeMS Status
NGS Controls
GeMS Controls
Loops
LGS LOOP START
T.T. LOOP START
T.A. LOOP START
FLEX. LOOP START
CMAT OPTIM. START
NGS CENT. GAINS START
LGS CENT. GAINS START
Offloads
DM0 > M1 START
TT > M2 START
LGSWFS > FSA START
SFS > LGSWFS START
NGS > CRCS START
FSA > KM START
LGS Steppers START
CANOPUS
Entrance Shutter CLOSE OPEN
Exit Shutter CLOSE OPEN
Science Beam Splitter 1.1 um 0.7 um
Science ADC IN OUT
NGS Cal Source IN OUT
ON OFF
LGS Cal Source IN OUT
ON OFF
DM0 Mask IN OUT
Show RTD
RTC Status
Health GOOD
Hbeat 1547
AOM Status
Health WARNING
Hbeat 30
SFS Status
Health BAD
Hbeat 13
BTO Status
Health GOOD
Hbeat 40
MYST Status
Health GOOD
Hbeat 75308
MYST Server
health GOOD
heartbeat 75308
CLEAR
ACCEPTED
IDLE
Time to next shutter : NOW
lgswfsgains: Read lgsWfsGains_init.mat -> internal (current_centgains)

Observing with GeMS/GSAOI



- Monitor all GeMS parameters:
  - LGS WFS, NGS WFS, r0, Strehl, flux, LGS and NGS guiding frequency.

- LGS WFS → very good clouds detector.

- Quick Look Tool → GSAOI images are displayed automatically for Quick image check.

- GSAOI IRAF/PyRAF package to evaluate the image quality

Observing with GeMS/GSAOI

The On-site data quality assessment is done using a set of tools written by Fabrice Vidal to monitor and plot the delivered image quality (FWHM) and Strehl (web page interface)

GSAOIFile	FWHM	SR	seeing	seeing@LambdaObs	filter	object	ExpTime	LoopFreq
S20130321S0157	0.119	7.3	0.888	0.701	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0158	0.103	8.1	0.905	0.714	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0159	0.083	10.5	0.896	0.707	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0160	0.085	9.1	0.688	0.543	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0161	0.106	6.2	0.839	0.662	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0162	0.104	7.9	0.608	0.479	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0163	0.090	12.7	0.804	0.634	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0164	0.090	11.7	0.842	0.665	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0165	0.082	10.2	0.957	0.755	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0166	0.096	8.2	0.995	0.785	H	CenA-arc	10.1	400.0 CLOSED Fast Fast Fast
S20130321S0167	0.070	13.6	0.810	0.639	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0168	0.078	9.2	1.017	0.802	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0169	0.067	14.4	0.823	0.650	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0170	0.075	11.8	0.913	0.720	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0171	0.065	16.2	0.826	0.651	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0173	0.062	16.4	0.622	0.491	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0174	0.065	16.8	0.973	0.768	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast
S20130321S0175	0.081	10.4	0.981	0.774	H	CenA-arc	10.0	400.0 CLOSED Fast Fast Fast