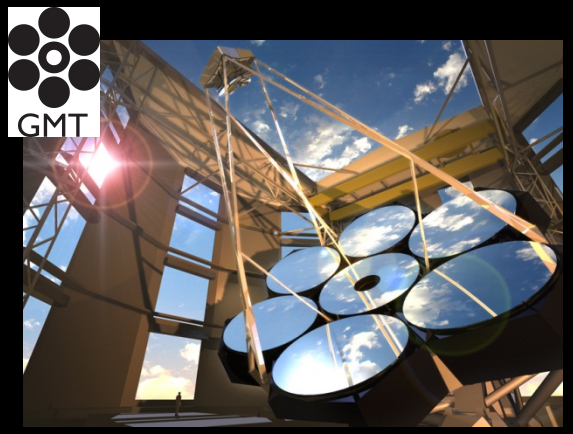
Guido Agapito
Astrobingé 15/10/2013

GIANT MAGELLAN TELESCOPE – NATURAL GUIDE STAR AO

Giant Magellan Telescope

Giant Magellan Telescope

www.gmto.org



Optical configuration	gregorian
Diameter	24m
Segments	7 X 8.4m
Collecting area	368m²
Diffraction limit @1μm	9mas
AO Systems	SCAO, LTAO, GLAO (6 Na Lasers)
Cost	700 M$

- Location:
  - Las Campanas Observatory (near Magellan telescopes).
- Headquarters:
  - Pasadena, CA.
- Partners from:
  - USA, Australia, Korea
- Schedule:
  - Start construction, early 2014
  - Early science (4 segm, No AO) 2019
  - Final commissioning 7 segm w/ AO, 2022

Astronomy Australia Ltd.

ANU
THE AUSTRALIAN NATIONAL UNIVERSITY

CARNEGIE INSTITUTION FOR SCIENCE

Harvard-Smithsonian Center for Astrophysics

KASI Korea Astronomy and Space Science Institute

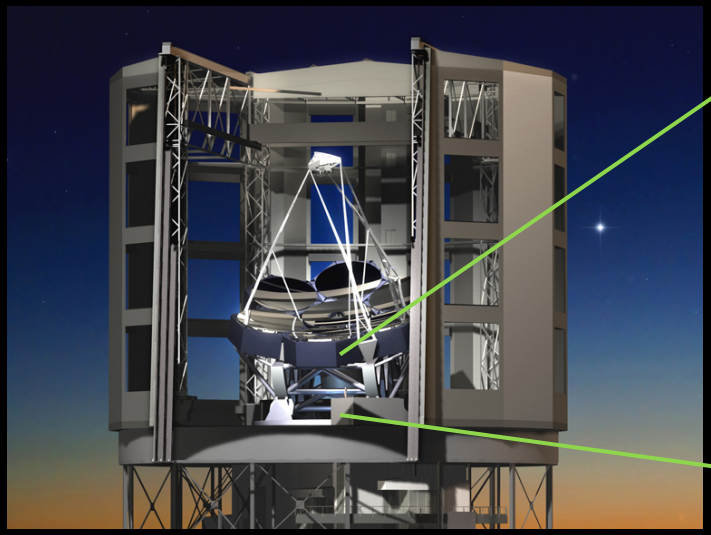
THE UNIVERSITY OF TEXAS AT AUSTIN

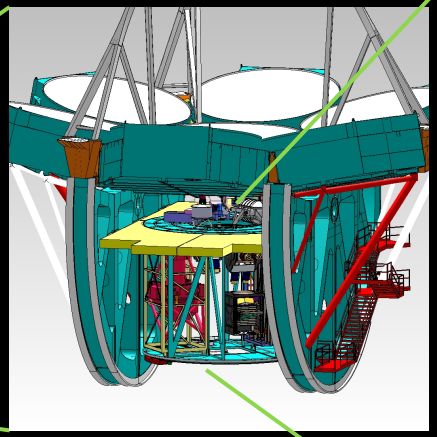
TEXAS A&M UNIVERSITY

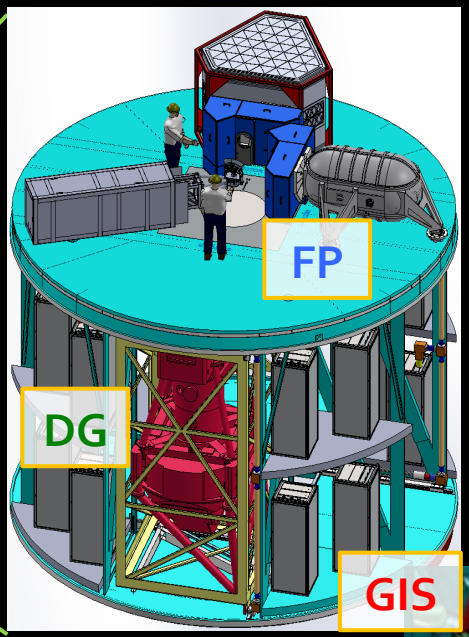
THE UNIVERSITY OF ARIZONA.
Arizona's First University.

THE UNIVERSITY OF CHICAGO

GMT Instrumentation







High spatial Resolution instruments

Wide field instruments

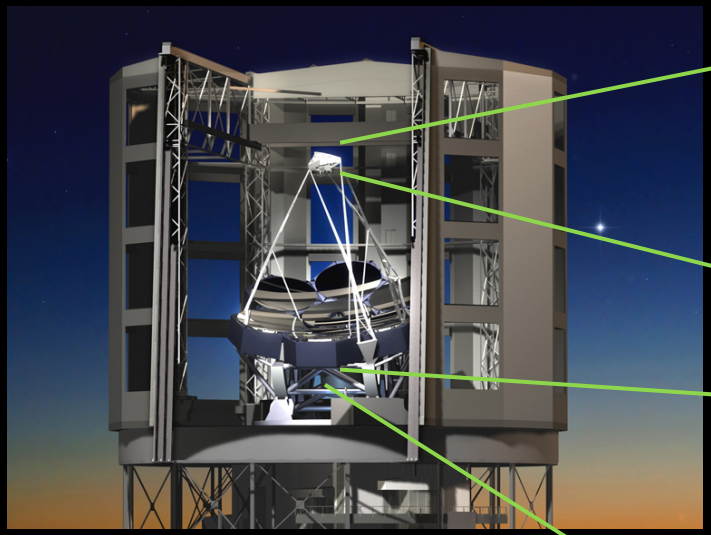
Aplanatic Gregorian
No Nasmyth focus
Primary f/0.7
Gregorian focus f/8

First Generation

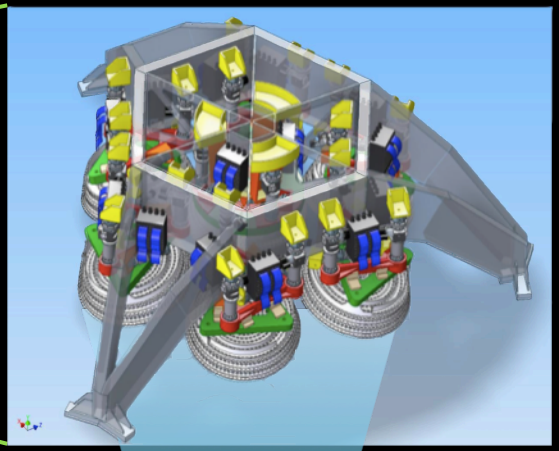
Instrument	Function	λ Range, μm	Resolution	Field of View	Loc
GMACS *	Optical Multi-Object Spectrometer	0.36 – 1.0	1500 – 4000, 10,000	40 – 80 arcmin²	DG
NIRMOS	Near-IR Multi-Object Spectrometer	0.9 – 2.5	2700 – 5000	42 arcmin²	DG
G-CLEF*	Optical High Resolution Spectrometer	0.35 – 0.95	20 – 100K	7 x 1" fibers	GIS
GMTNIRS*	Near-IR AO-fed High Resolution Spectrometer	1.2 – 5.0	50 – 100K	Single Object	FP
TIGER	Mid-IR AO-fed Imager and Spectrometer	1.5 – 14	300	0.25 arcmin²	FP
GMTIFS*	NIR AO-fed IFU / Imager	0.9 – 2.5	4000 – 10,000	10 / 400 arcsec²	FP
MANIFEST*	Facility Robotic Fiber Feed	0.36 – 1.0		300 arcmin²	DG

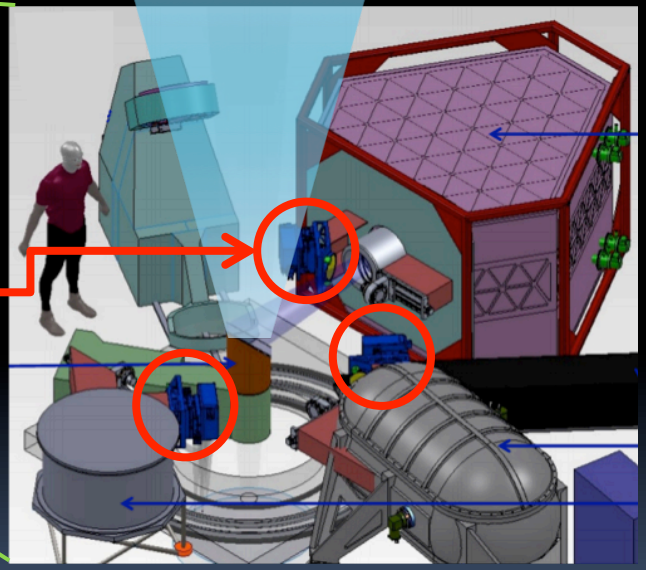
DG = Direct Gregorian
GIS = Gravity-Invariant instrument Station
FP = Folded Ports

GMT Adaptive Optics



Adaptive secondary mirror
feeding all the focal stations
7 deformable shells of 1.1m
4700 actuators





Adaptive optics modes

- Natural Guide Star AO (NGSAO):
  - Single Conjugate Adaptive Optics (SCAO)
- Laser Tomography AO (LTAO):
  - 6 sodium lasers.
- Ground Layer AO (GLAO):
  - Direct Gregorian instrumentation.

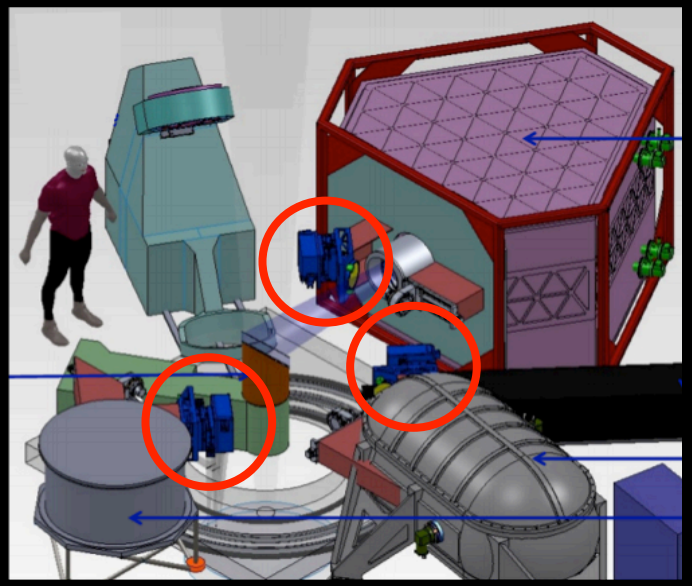
High spatial Resolution instruments

GMTNIRS*	Near-IR AO-fed High Resolution Spectrometer
TIGER	Mid-IR AO-fed Imager and Spectrometer
GMTIFS*	NIR AO-fed IFU / Imager

GMT Natural Guide Star AO

Natural Guide Star AO

- Single Conjugate Adaptive Optics (SCAO):
  - Correction on a small FoV:
    - High Strehl Ratio.
    - High contrast.
  - Bright Guide Star (GS).
- Pyramid WaveFront Sensor (PWFS):
  - Sampling frequency up to 1kHz.
  - 92x92 sub-apertures.
- First AO system with GMTIFS (Near-IR IFU and Adaptive Optics Imager)



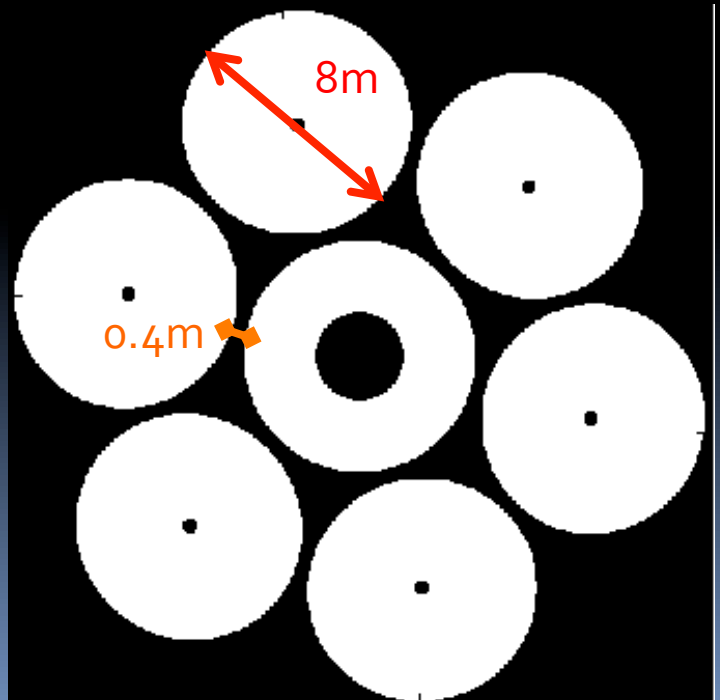
Arcetri Adaptive Optics group – contract

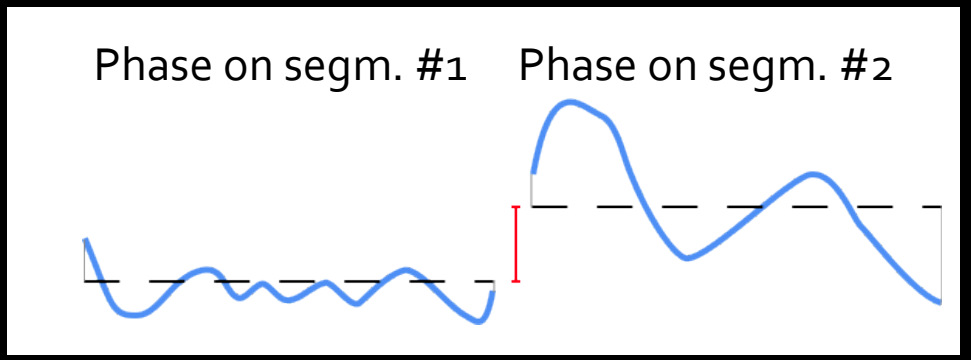
- GMTO contacts Arcetri AO group to develop the NGSAO:
  - Contract for *Preliminary Design Study* - Kick Off Meeting 01/2012

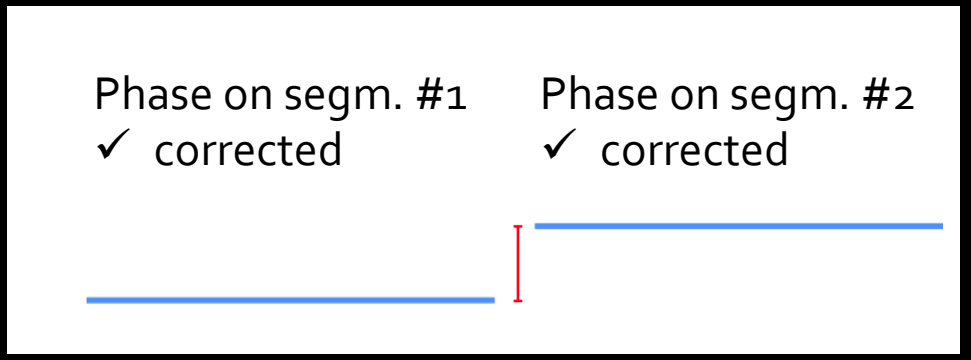
GMT NGSAO Preliminary Design Study

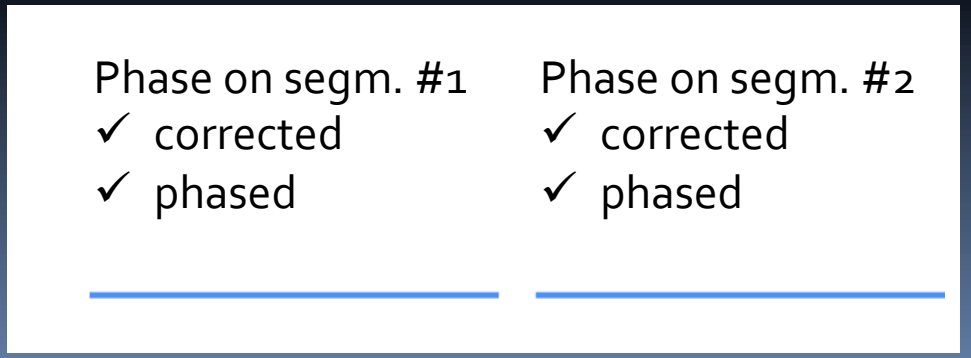
Segmented pupil → new problem

- Classic AO + co-phasing required:
  - Pyramid wavefront sensor can measure differential piston (PYramid Phasing Sensor - PYPS for the ESO Active Phasing Experiment - APE).
- Big separation between segments (w.r.t. wavelength):
  - "weak" signal.
  - high probability of "big" (> 1 wavelength) differential segment piston.









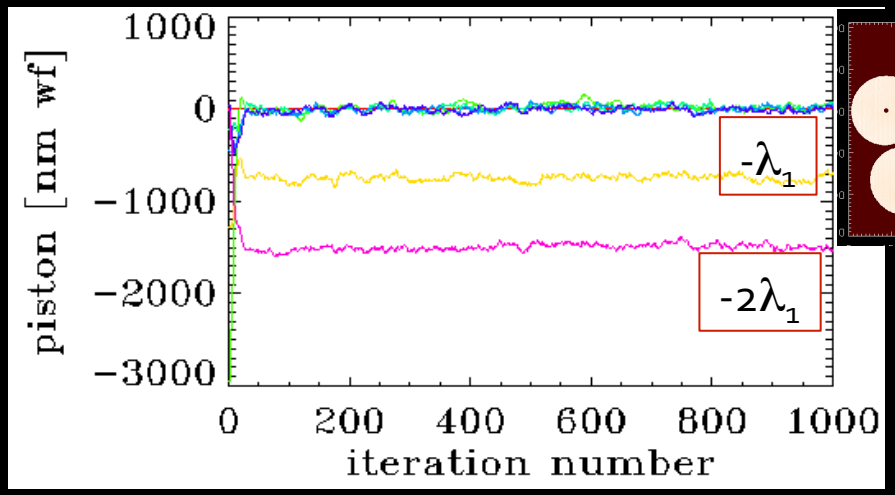
GMT NGSAO phase unwrapping

WF phase 2pi ambiguity

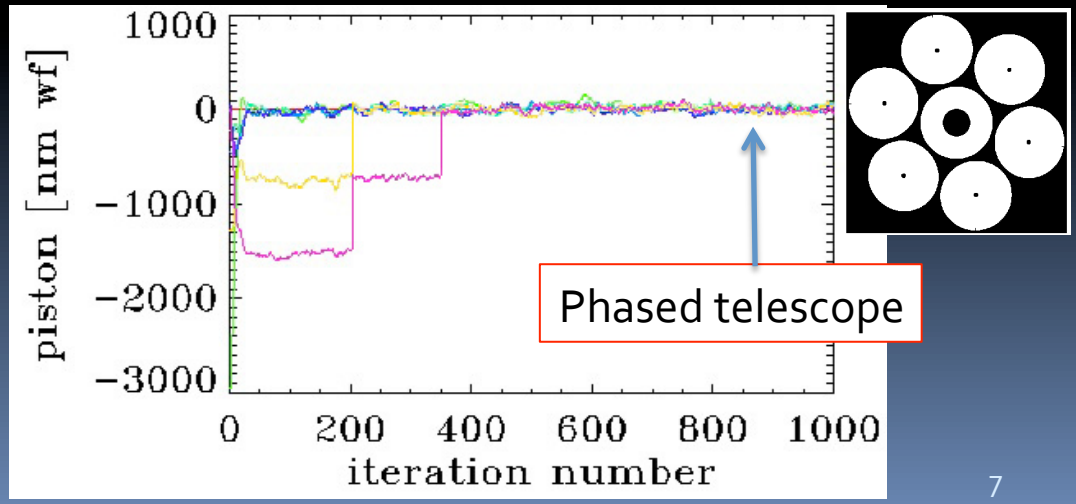
- Single wavelength WFS is blind to wave multiples:
  - Simulations show that at times segments converge to λ–multiples (λ = 750nm).
- Two wavelengths technique implemented:
  - Firstly developed for APE (non-real-time, no AO correction)
  - Needs one WFS for each wavelength (real-time and AO correction).

Segment average WF pistons

1st WFS channel:



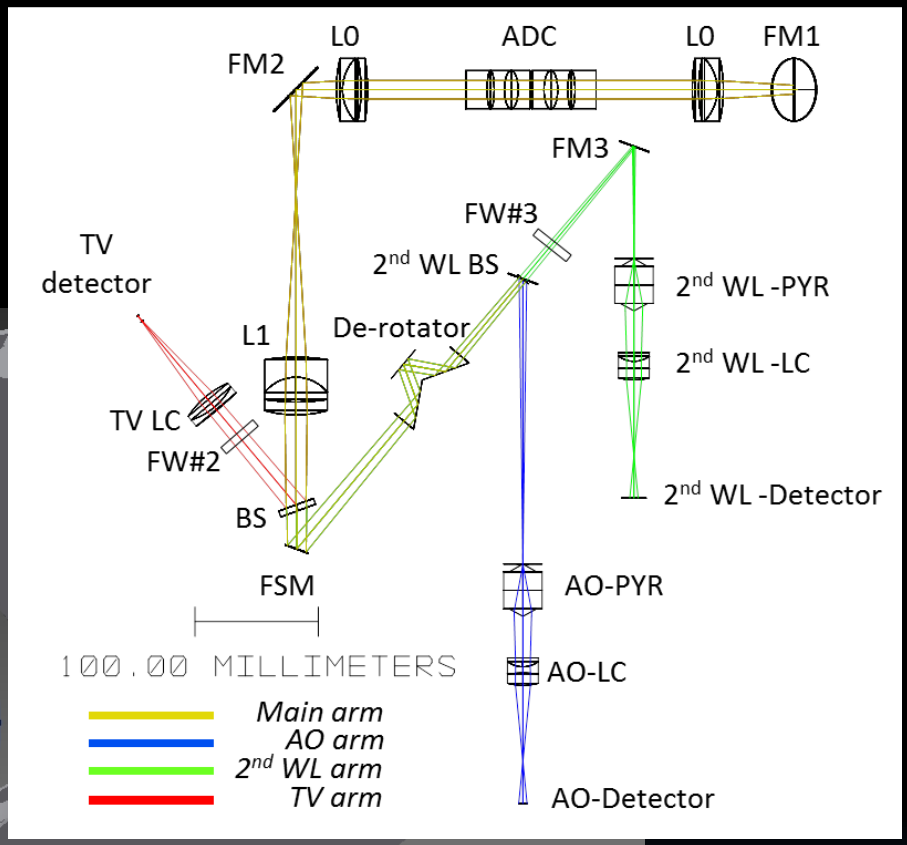
1st and 2nd–λ WFS channels:

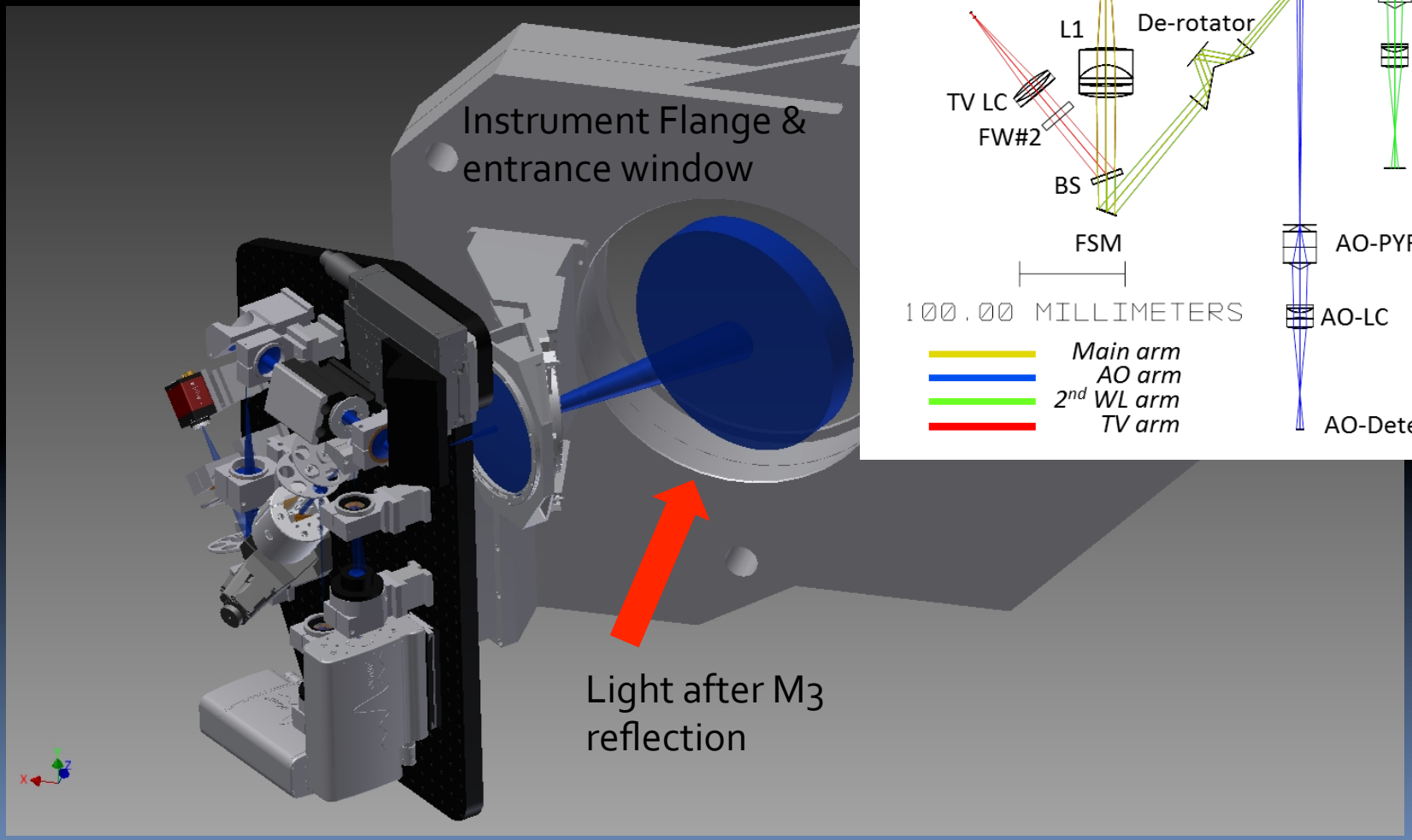


GMT NGSAO optical and mechanical design

Design

- The WFS design has two pyramids allowing parallel sensing at 2 wavelength.

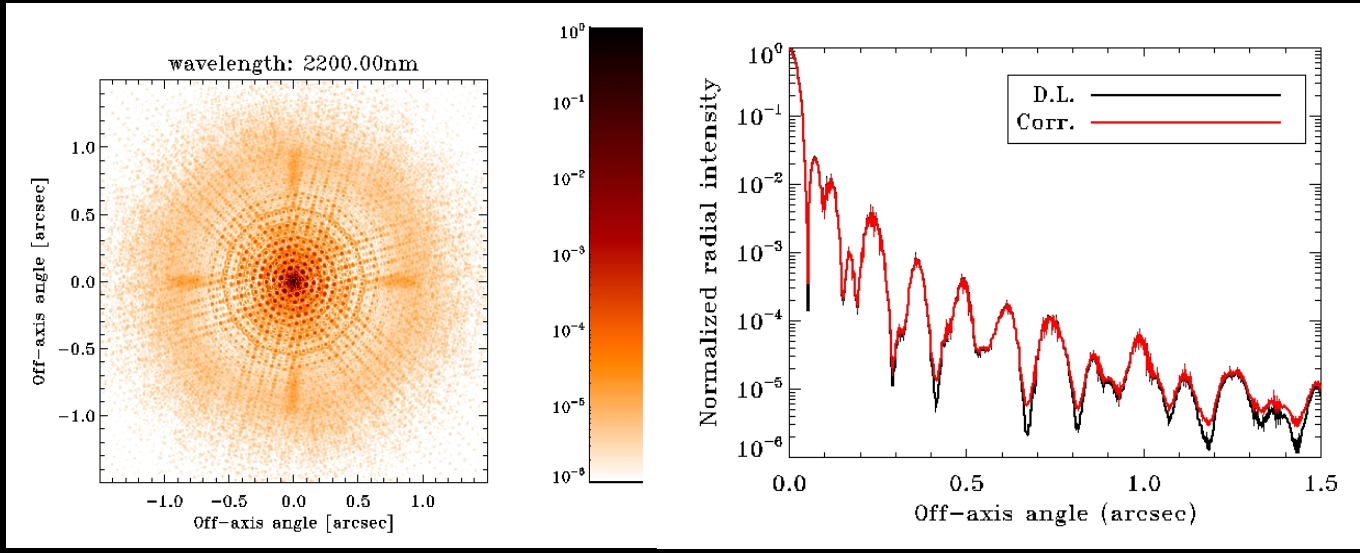




GMT NGSAO performance

Performance (E2E simulation)

- Condition:
  - Seeing 0.63”
  - Mean wind speed 13.5m/s
  - 8th magnitude GS
  - K band (2.2µm)
- SR = 95.6%
- Residual WF = 74nm RMS



Arcetri Adaptive Optics group – contract

- GMTO **APPROVED** *Preliminary Design Study* - 07/2013
- New contract for *Prototyping and Simulation Study* – Kick Off Meeting 10/2013 – end 02/2015

Science with GMT NGSAO

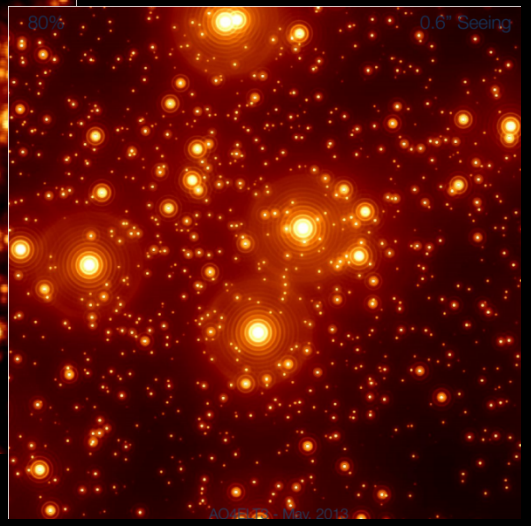
Natural seeing 0.6″

HST - NICMOS

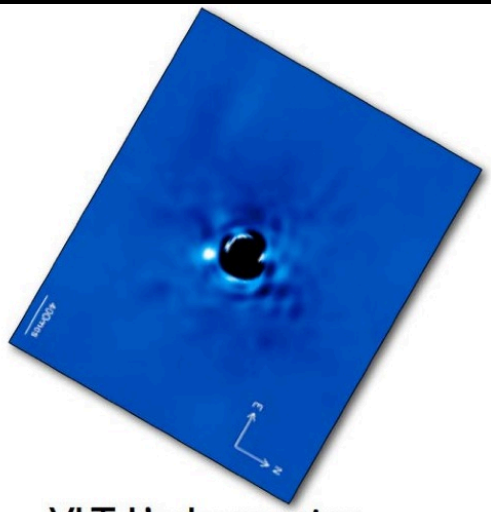
JWST NIRCAM

Crowded fields
Simulated
K-band imaging of a dense star cluster

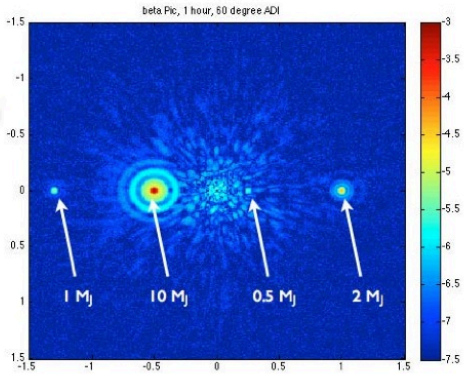
GMT Strehl Ratio 80%



Credit: P. McCarthy



VLT L' observation



GMT L' simulation

Exoplanets
Simulated GMT observations of the β Pic system

… and much more!
(see science cases @ www.gmto.org)