Iranian National Observatory

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Project Scientist

on behalf of the INO team

IRANIAN NATIONAL OBSERVATORY

A modern observatory in the land of ancient observatories

Site selection timeline

2001 – Site evaluation workshop @ IASBS

2001 – Potential sites identified

2004 – Sites short listed

2004 – Seeing measurement begins

2007 – Site selection concludes

2008– Site monitoring begins

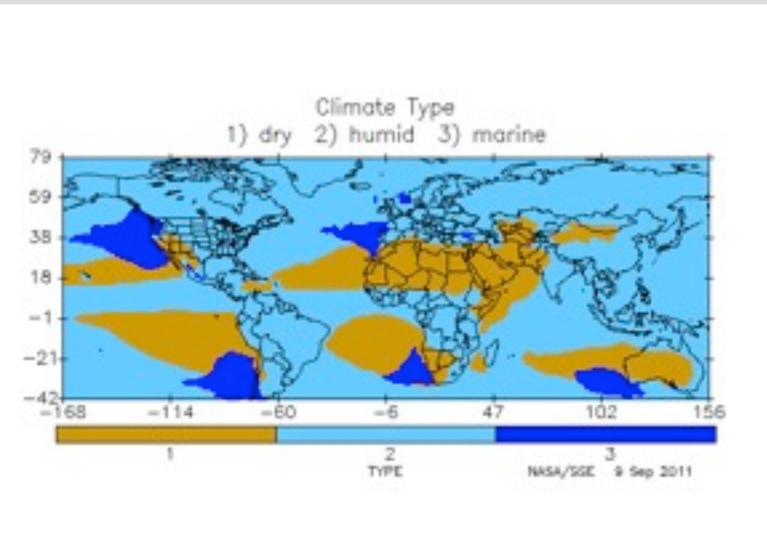
2010– Gargash selected to host the 3.4m telescope

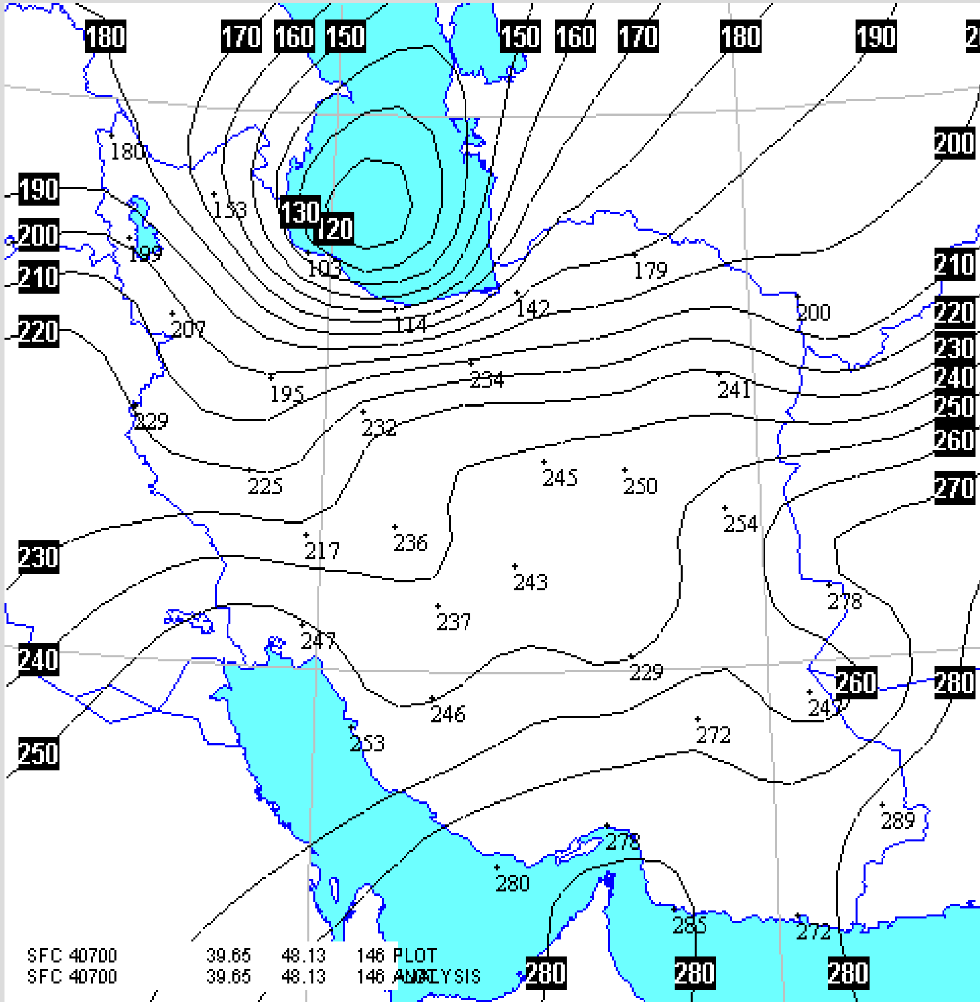
2011– Site development begins

2012– Preparation for continues monitoring begins

The climate

Meteosat cloud coverage data between 1983 and 1993 were studied and 33 regions across the country were identified.





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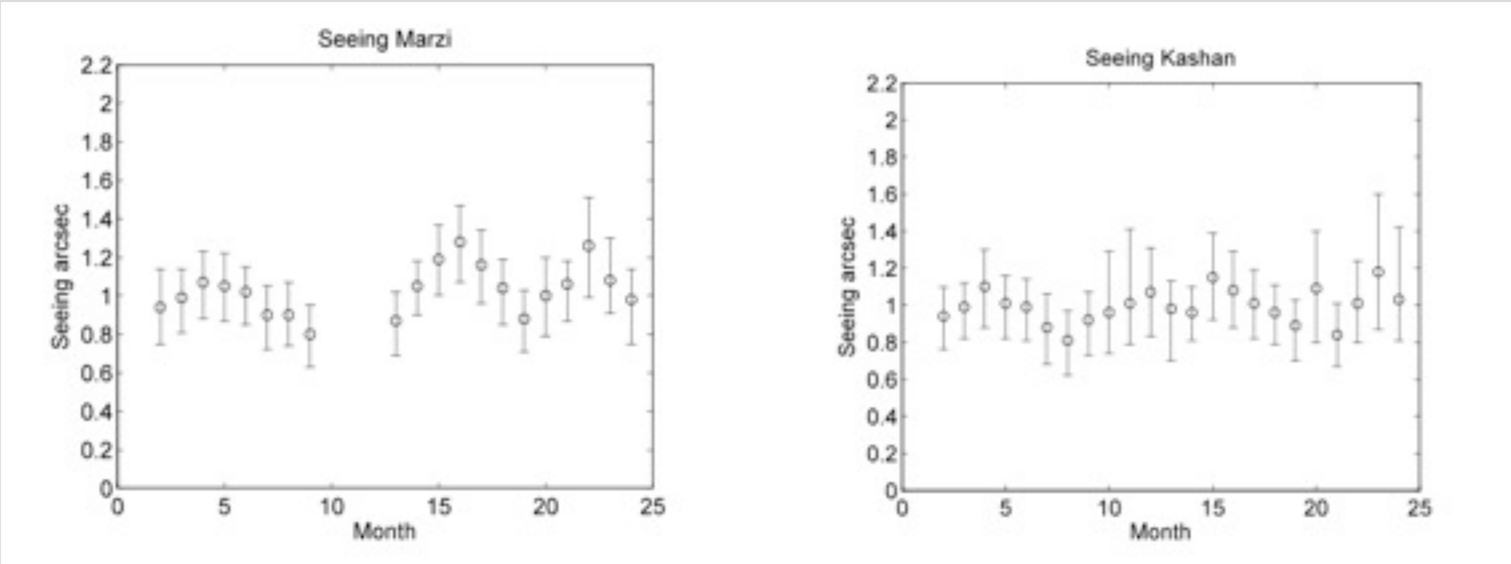
Site Selection

- Clear Sky
- Altitude
- Seeing
- Light Pollution
- Sky Brightness
- Access
- Wind
- Topography

Team led by S. Nasiri - 2000 to 2007

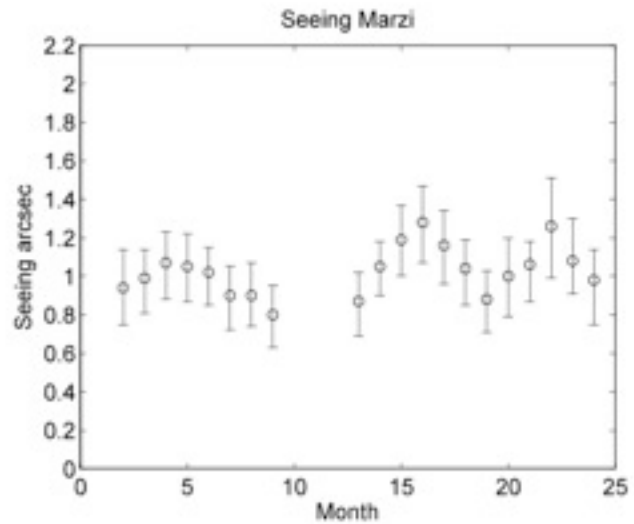
Seeing measurements - pre 2007

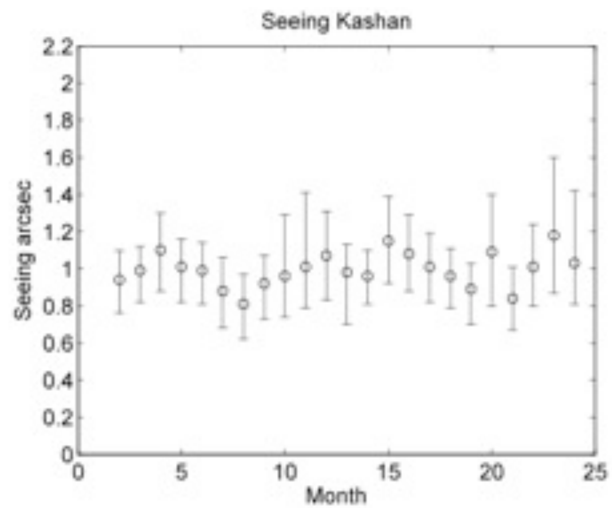


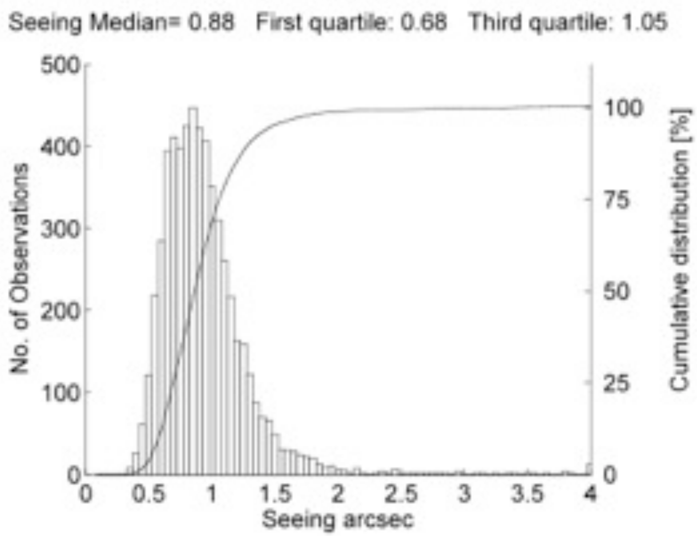
2 year of continuous monitoring in 2 sites around Kashan. The sites were at an altitude of 3000m.

In 2007 another site at 3600m was identified (previously not considered due difficulties in access) for further monitoring. Since 2009 two sites Dinava & Gargash were monitored continuously. except for the seeing measurements (summer only).

Seeing measurements - pre 2007







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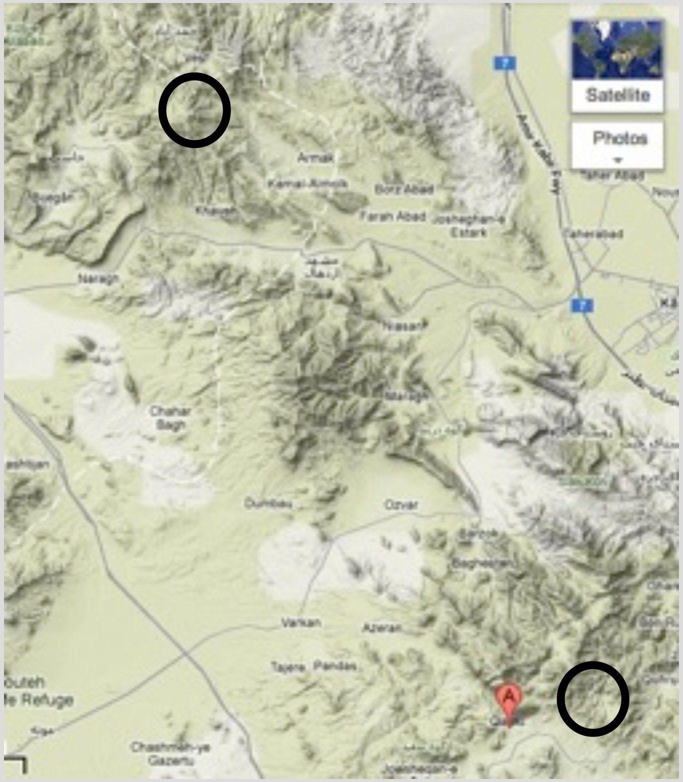
Dinava vs. Gargash

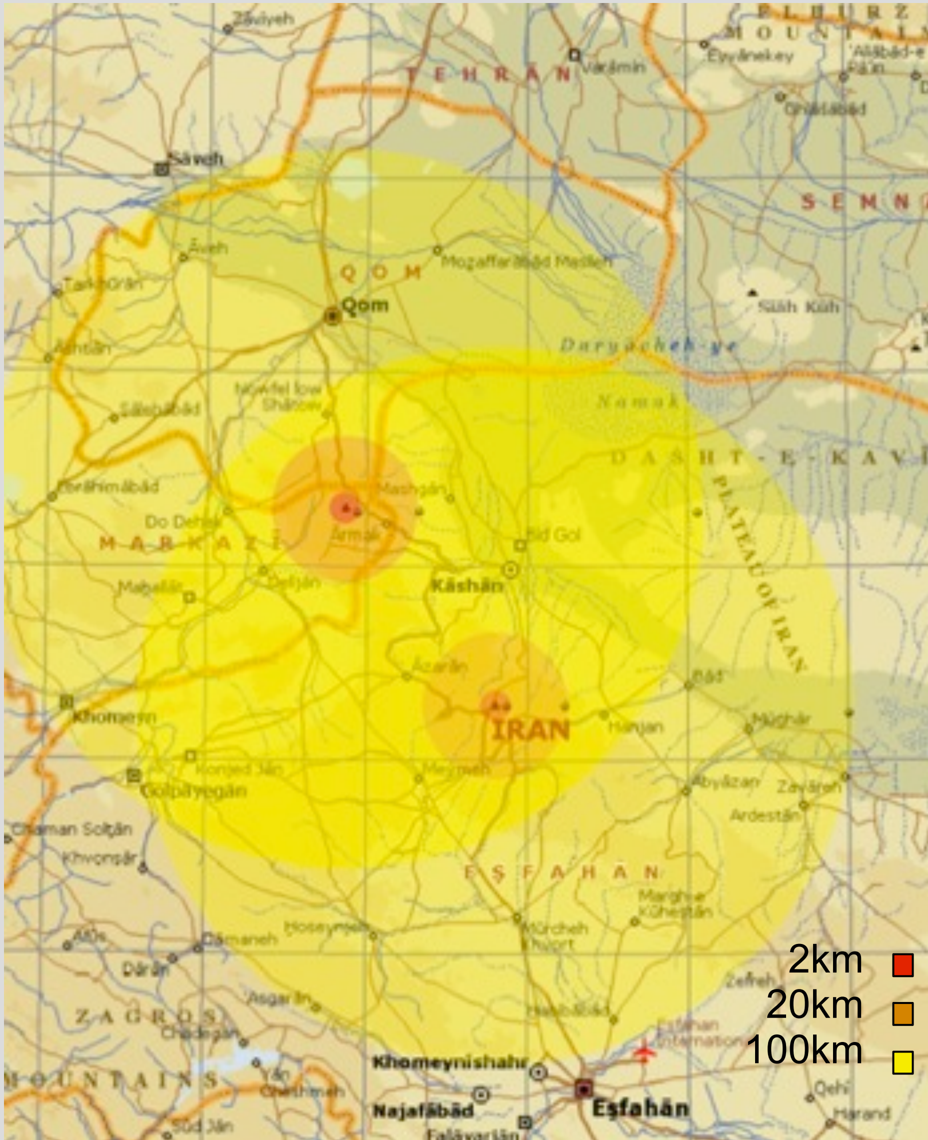
Weather (wind, humidity)

Seeing

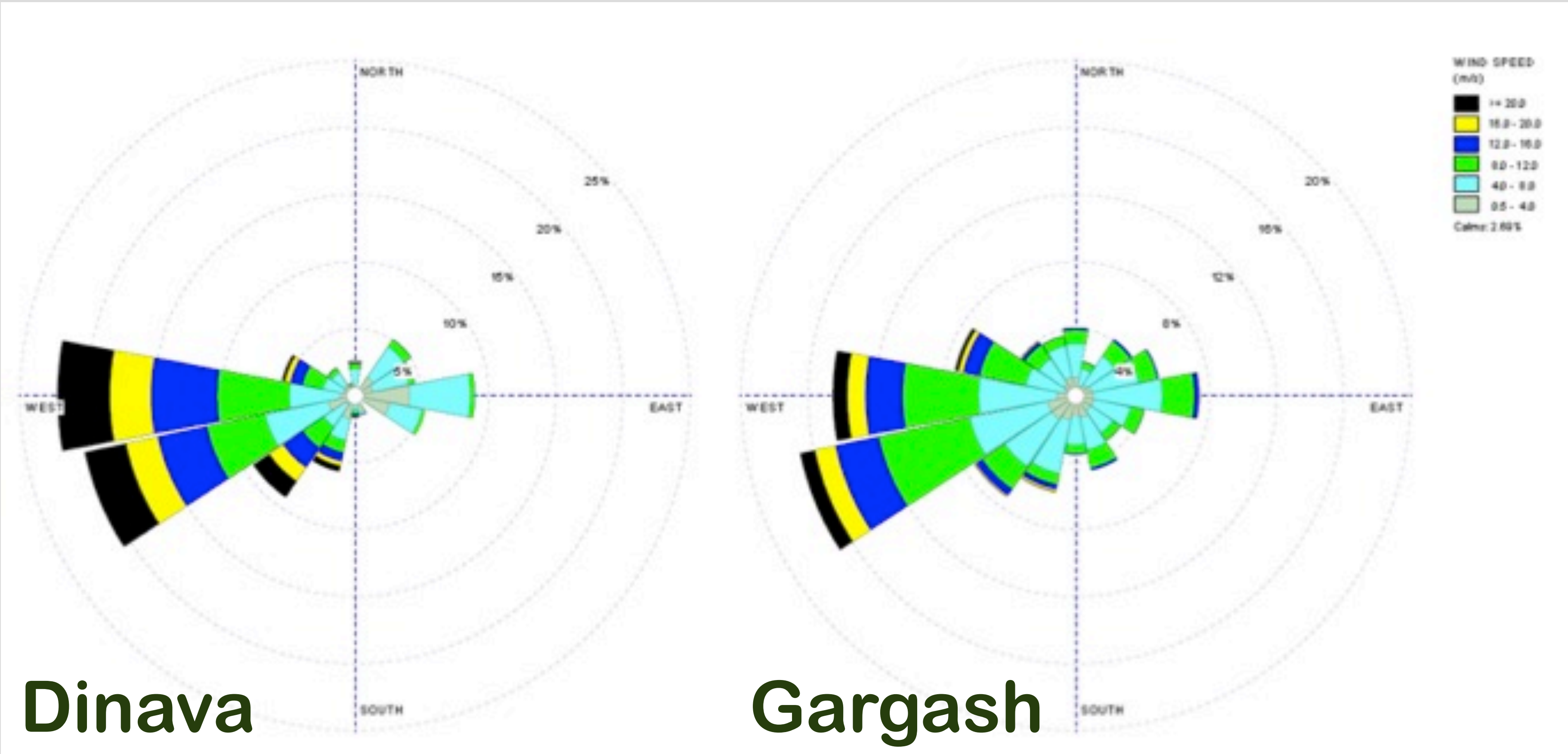
Micro-thermal variation

Sky brightness





Dinava and Gargash night time Windrose



Data from standard weather stations at the peak of Gargash and Dinava.

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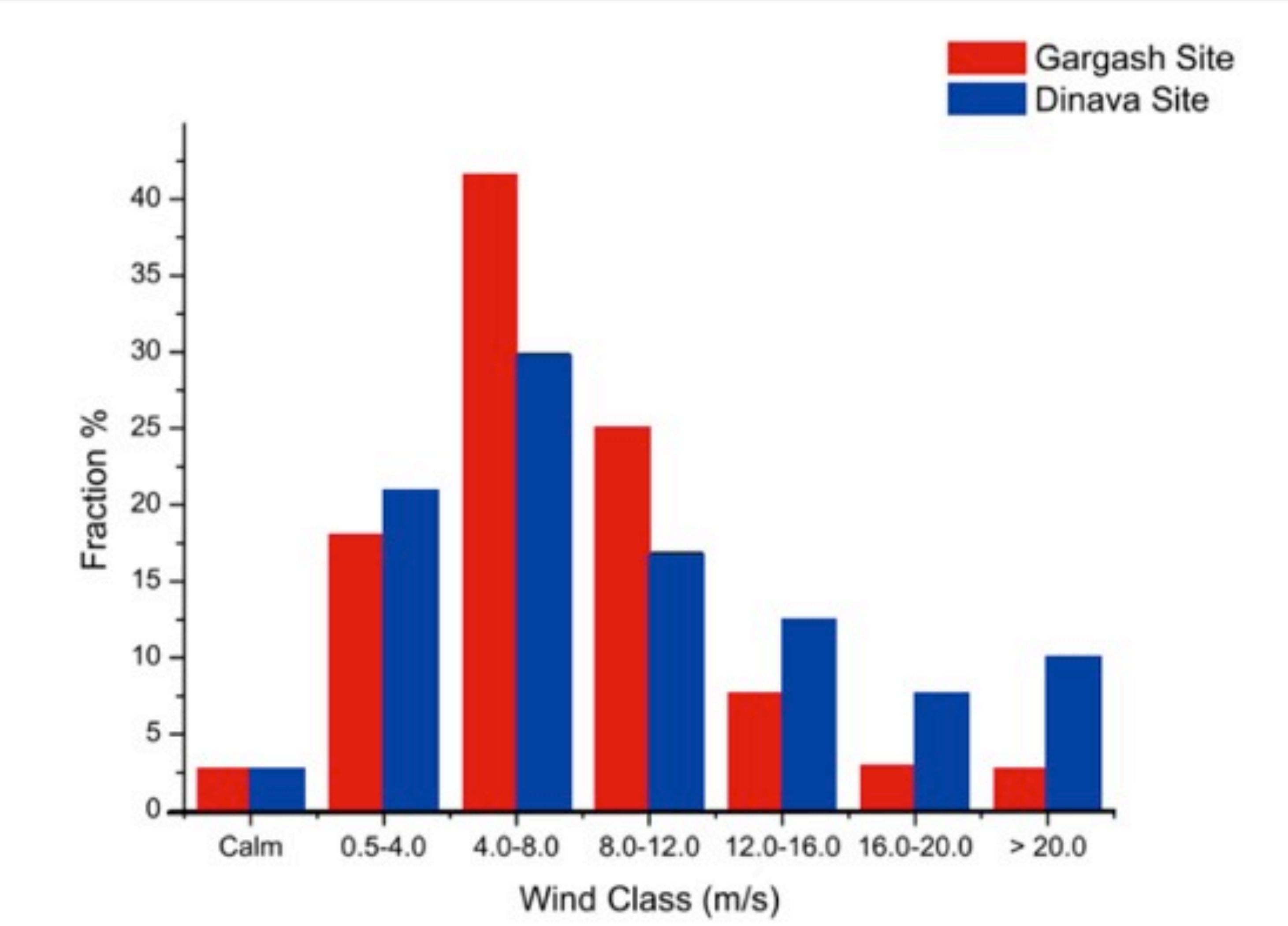
Wind speed



Wind speed is a 10min average.

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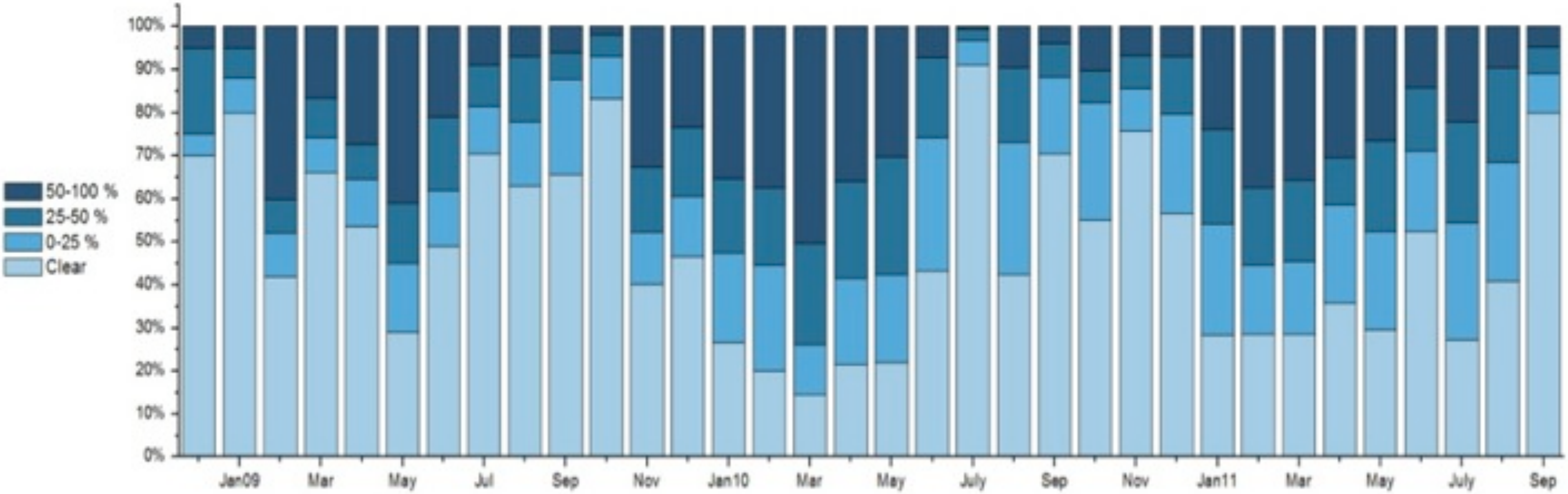
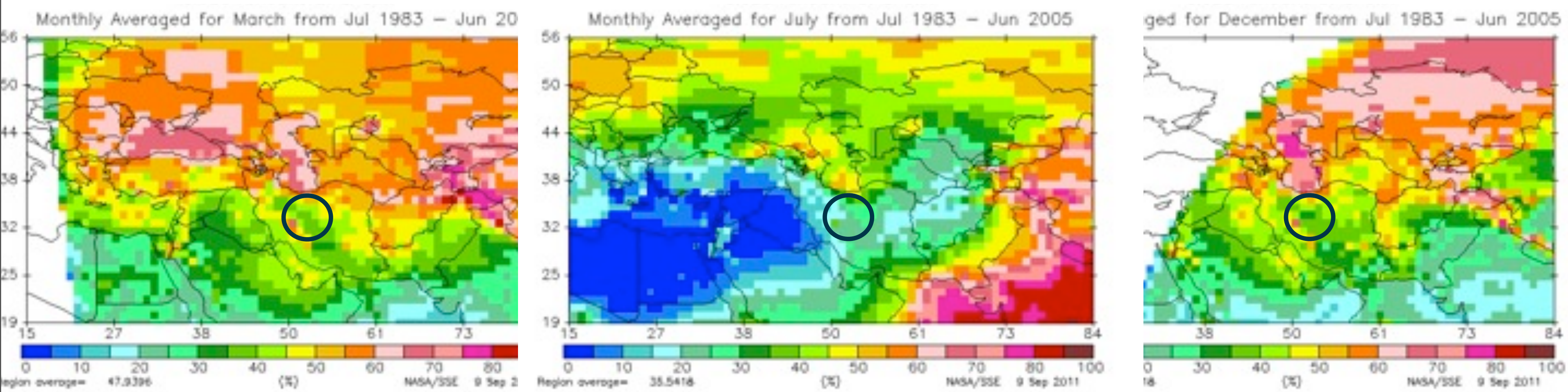
Clear sky


50-100 %
25-50 %
0-25 %
Clear
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jan09
Mar
May
Jul
Sep
Nov
Jan10
Mar
May
July
Sep
Nov
Jan11
Mar
May
July
Sep


Monthly Averaged for March from Jul 1983 – Jun 20
Monthly Averaged for July from Jul 1983 – Jun 2005
ged for December from Jul 1983 – Jun 2005
(%)
NASA/SSE 9 Sep 2011

Seeing Measurement

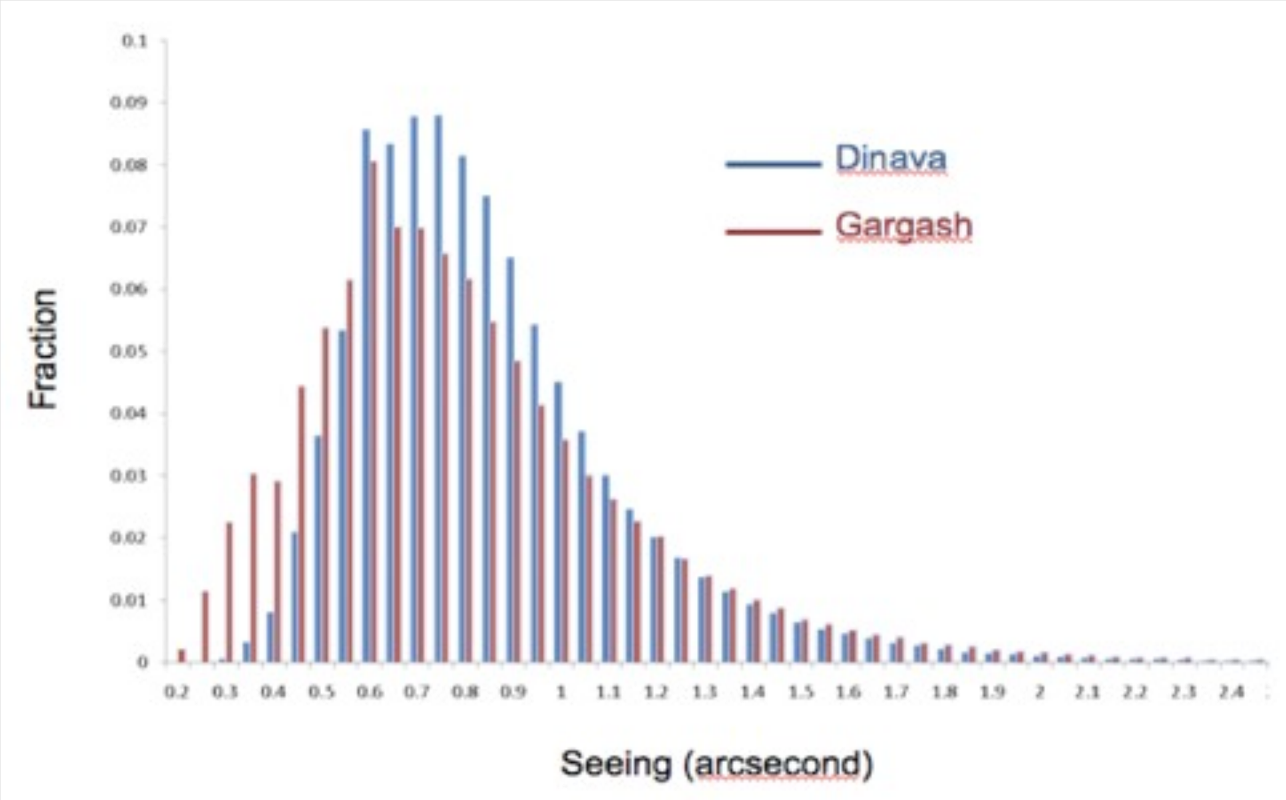
Summer 2010-2011

10


EQ6

Seeing Gargash vs Dinava

Seeing	1st quartile	2nd quartile	3rd quartile	median
Dinava	0.60” (0.09)	0.74” (0.09)	0.91” (0.09)	0.73” (0.09)
Gargesh	0.54” (0.04)	0.67” (0.04)	0.89” (0.04)	0.68” (0.04)



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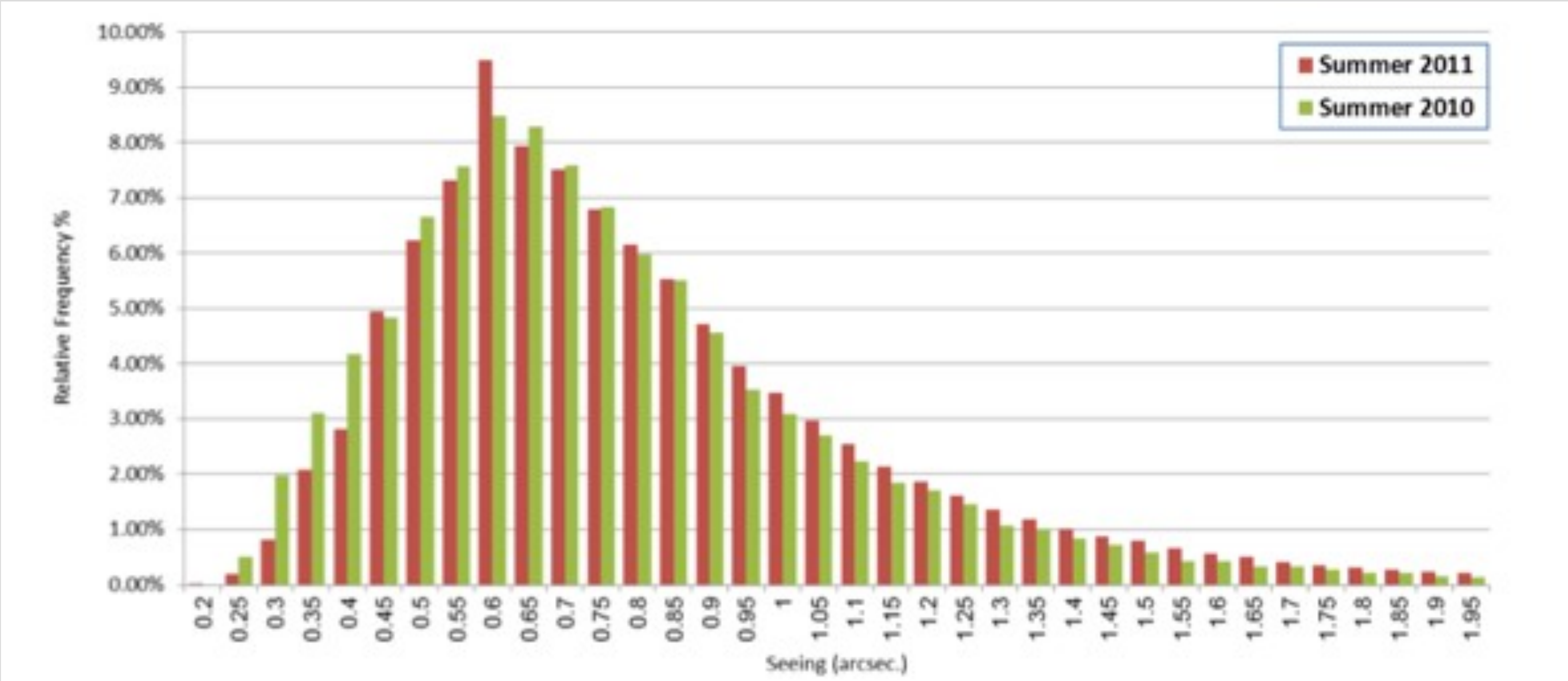
Seeing comparison

Seeing	1st quartile	2nd quartile	3rd quartile	median
Gargash 11	0.55”	0.72”	0.95”	0.72”
Gargash 10	0.54”	0.70”	0.88”	0.70”



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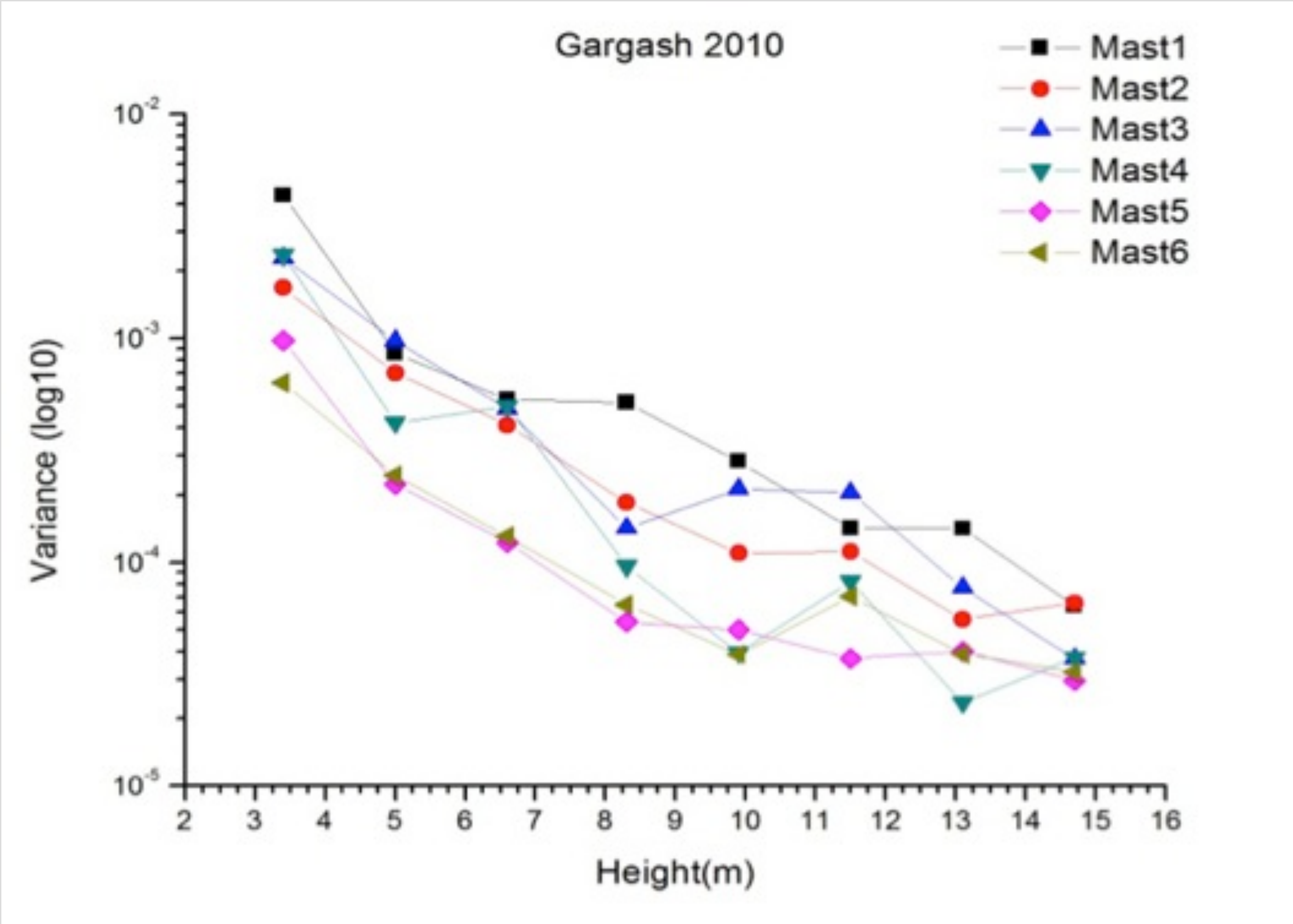
Future seeing monitoring

Micro-thermal measurements

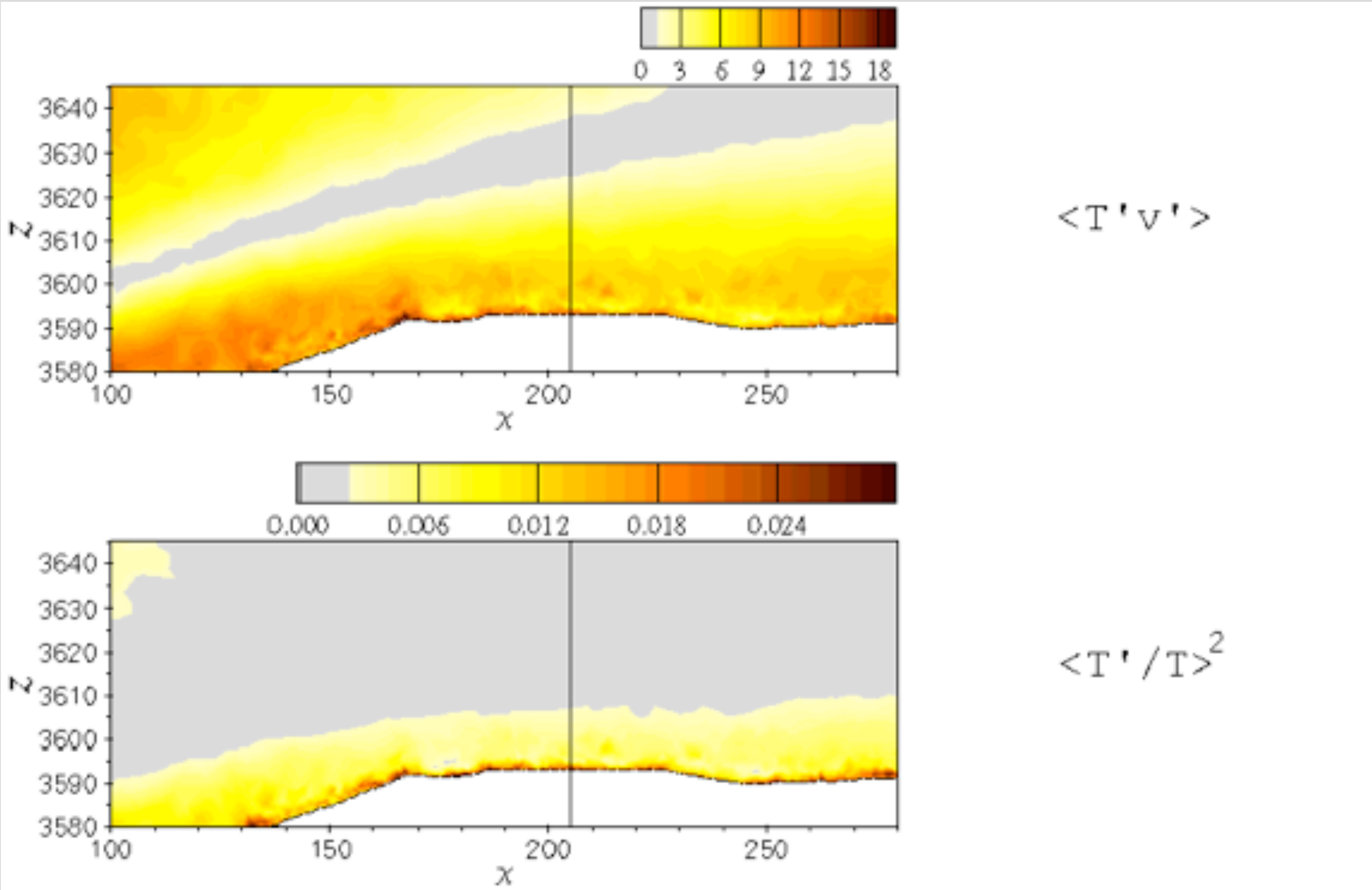
Microthermal measurements are used to determine the contribution of ground level turbulence to the astronomical seeing.

Masts location

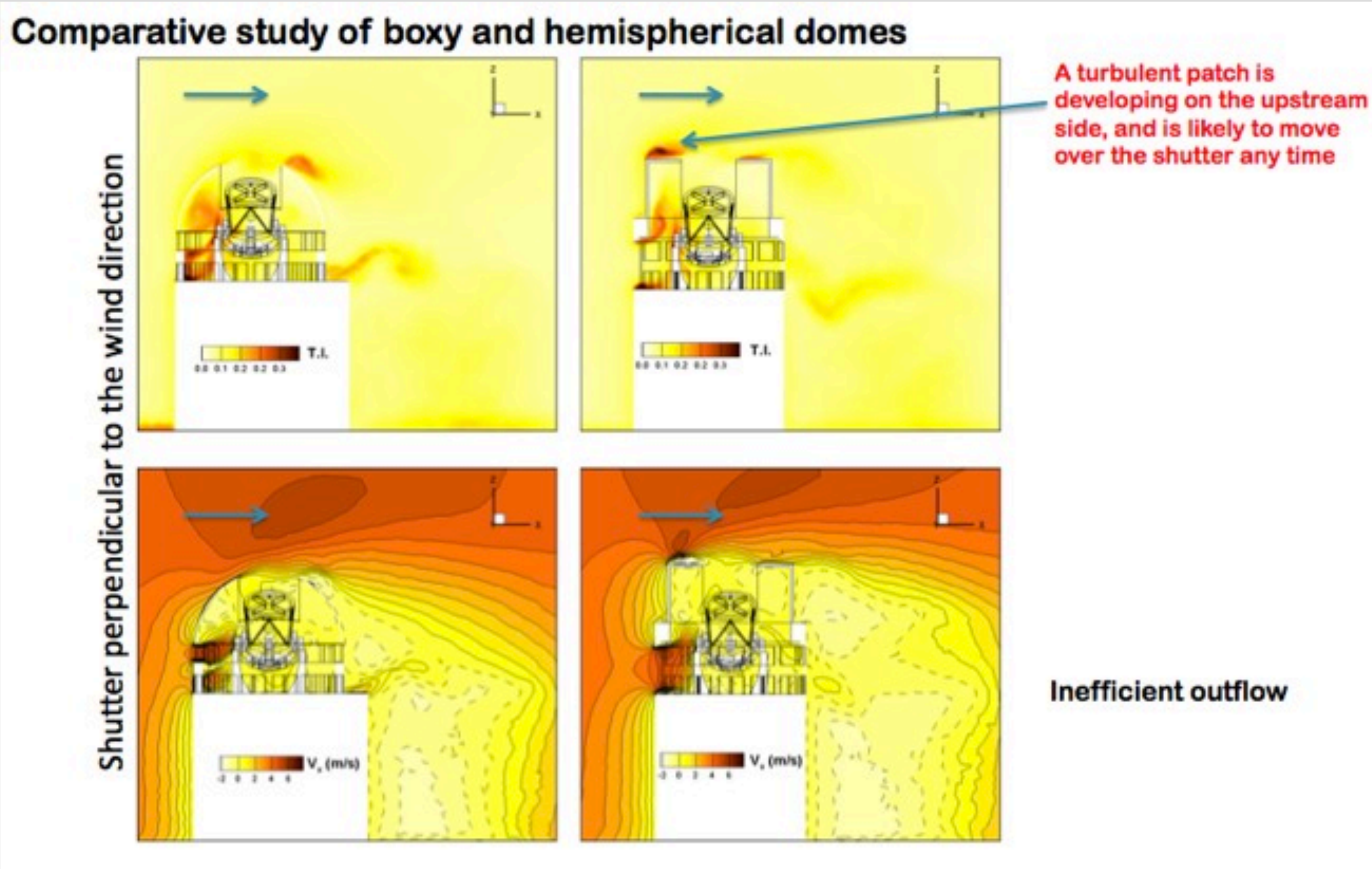
Gargash ground layer turbulence profile



CFD modelling of the peak



Dome models comparison



Sky Brightness

	Dinava mag/arcsec^{-2}	Gargesh mag/arcsec^{-2}	Kitt Peak mag/arcsec^{-2}
Filter B	21.8	22.3	22.7
Filter V	21.6	22.0	21.8
Filter R	20.2	20.6	20.9
Filter I	19.3	20.0	19.9

in no moon condition

Light Pollution Control

A pilot project in Qamsar

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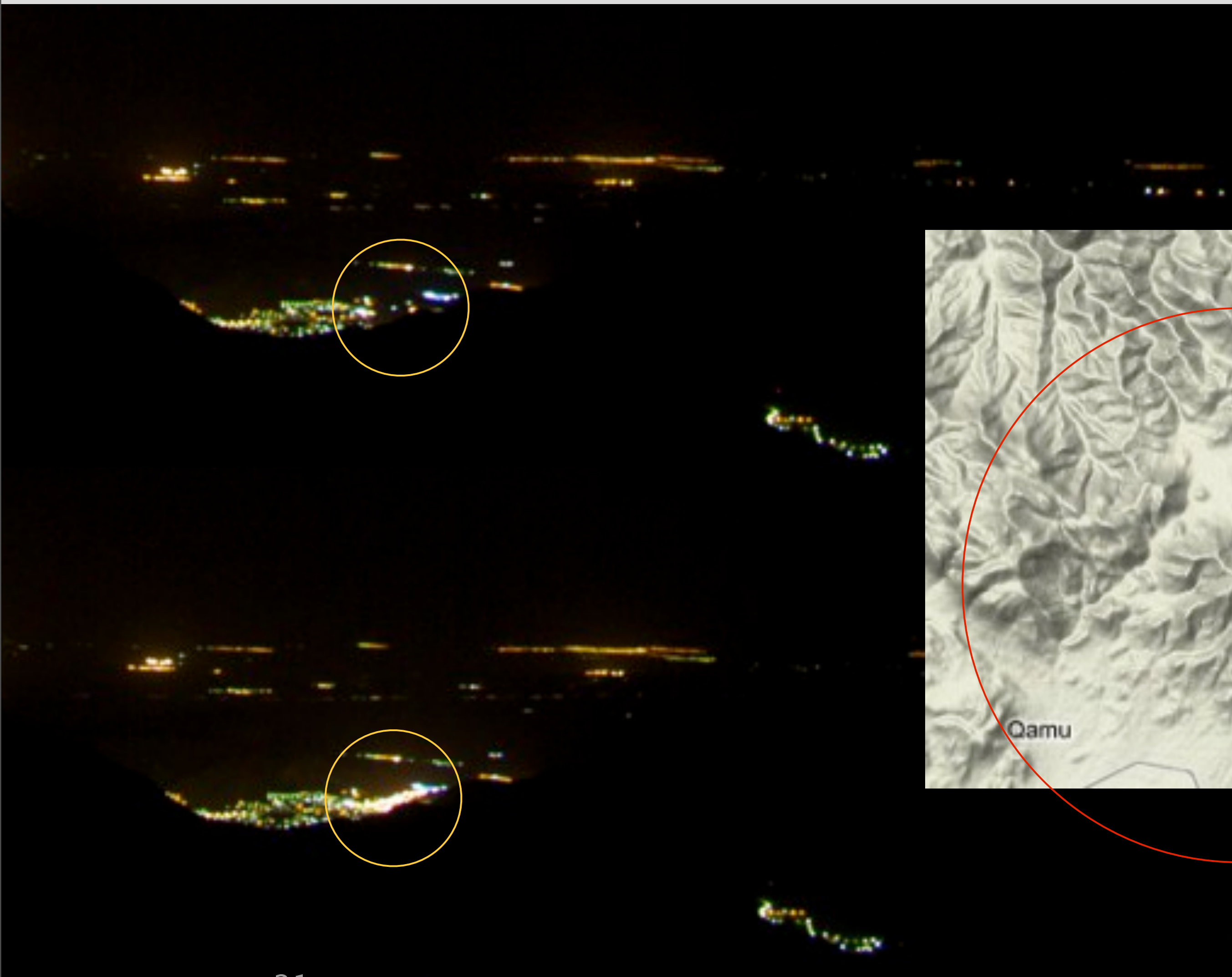
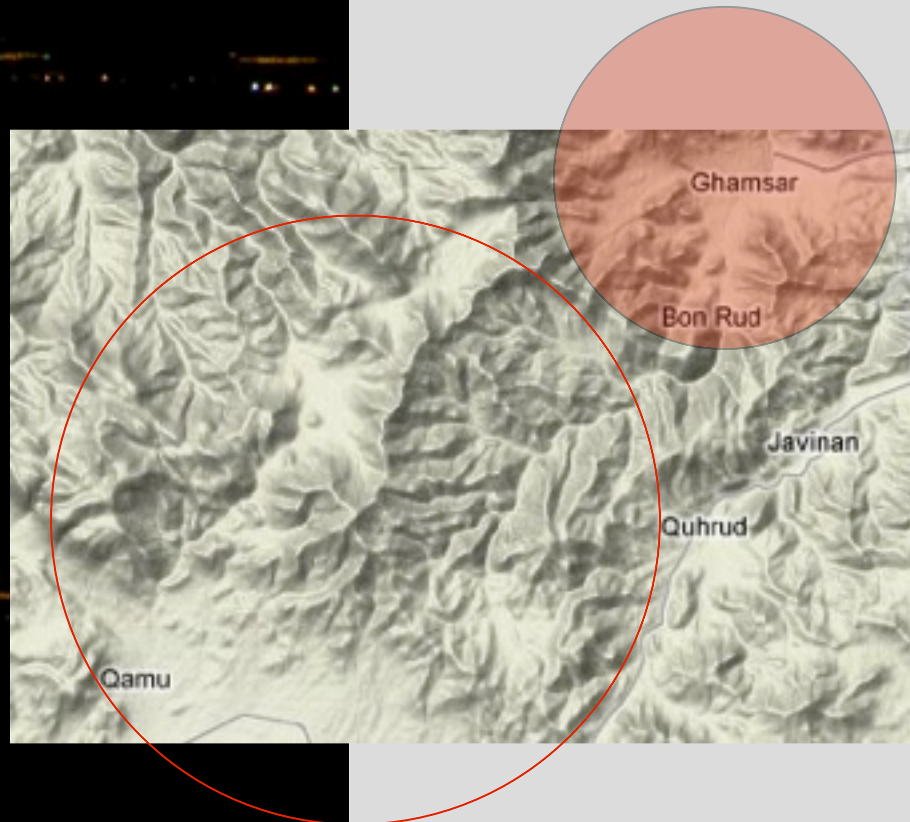
Light Pollution Control

A pilot project in Qamsar





Requirements on Telescope I

Item	Requirement	Rationale Technical	Rationale Scientific
Aperture in m	> 3.0 m		Limiting mag
Exit focal ratio	f/10.0 - f/12.0	Spectro design Imaging scale	Compatibility Visiting instr.
Wavelength range	325 - 2 500 nm		Obs. flexibility
Priority wavelength range	325 - 1 000 nm		Short λλ niche!

Requirements on Telescope II

Item	Requirement	Rationale Technical	Rationale Scientific
Cassegrain on-axis focal station	FoV 30’ bfd ~ 640 mm Instr < 1.5 ton		Wide-field img Multi-obj spec Obs. efficiency
Cassegrain side-port focal stations	FoV 15’ bfd ~ 200 mm Instr < 100 kg		Stand-by CCD Super-seeing! Multi-obj spec
Telescope pointing-angle interval	± 270 degrees in azimuth 15 - 89.5 degr. in altitude		Obs. efficiency Comets Rare events
Field-rotator	± 270 degrees		Obs. efficiency

Requirements on Telescope III

Item	Requirement	Rationale Technical	Rationale Scientific
Blind-pointing precision with pointing model	3 arcsec rms		Obs. efficiency Obj. identification
Tracking precision over 10 minutes	5” rms without auto-guider 0.2” rms with auto-guider		Image quality Obs. efficiency
Slewing speed, azimuth and altitude	> 3 °/s		Obs. efficiency Target of oppo
Acceleration, azimuth and altitude	> 1 °/s^2		Obs. efficiency Target of oppo

Requirements on Telescope & Enclosure IV

Item	Requirement	Rationale Technical	Rationale Scientific
Wind speed, unrestricted observations	< 12 m/s average	Telesc protect Wind shaking	Obs. efficiency Obs. flexibility
Wind speed, restricted observations	< 16 m/s average	Telesc protect Wind shaking	Obs. efficiency Obs. flexibility
Image quality* exclud atmos On-axis	0.1”		Image quality Crowded fields Globul clusters
Image quality* exclud atmos 15’ off-axis	0.6”		Wide-field imaging

***curved field, 80 % energy concentration diameter**

Basic design parameters

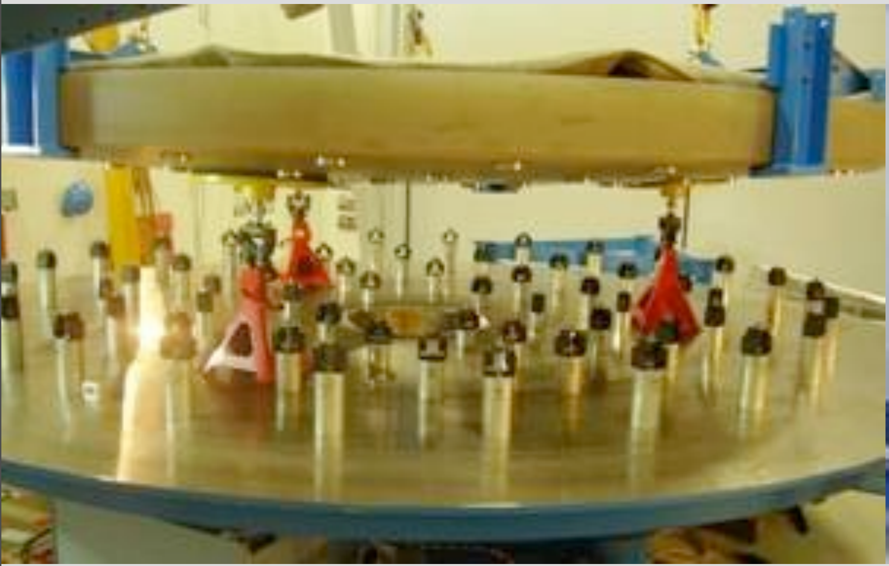
Optical configuration	Ritchey–Chrétien Cass
Wavelength range	325–2500 nm
Primary mirror diameter, ID/OD (Nominal)	3400/700 mm
Primary mirror focal ratio	f/1.5
Exit focal ratio	f/11.363
Entrance pupil location	On primary
Back focal distance	1750 mm
Unvignetted field of view diameter	30 arcmin

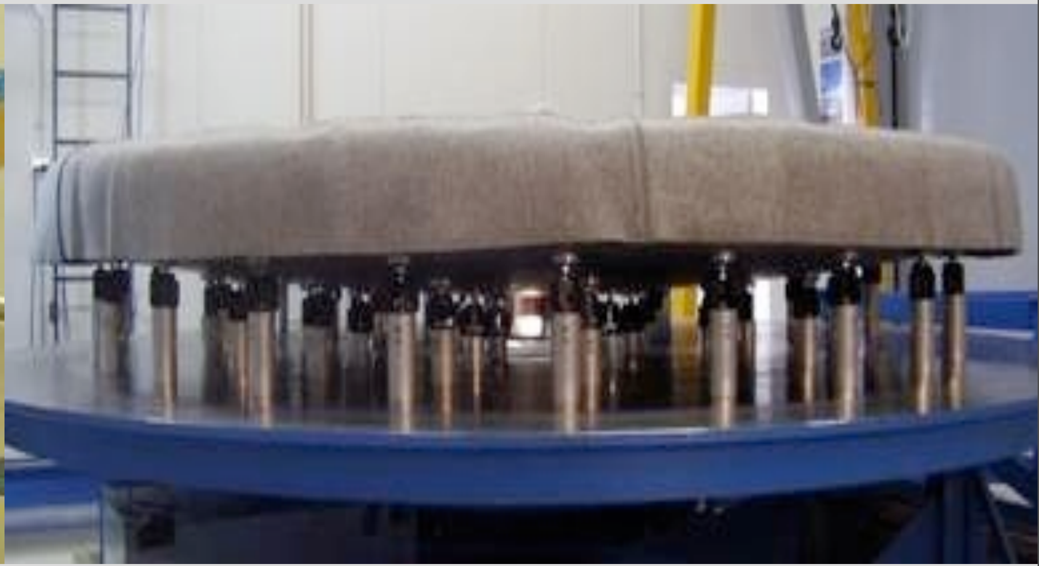
Derived design parameters

Surface	Radius of curvature (mm)	Distance to next surface (mm)	Optically used diameter (mm)	Deformation constant
M_1	−10200.000	−4301.2	3380/700*	−1.006472
M_2	−1840.550	6051.2	572/72*	−1.764029
Focal plane	−831.5	0	338	0

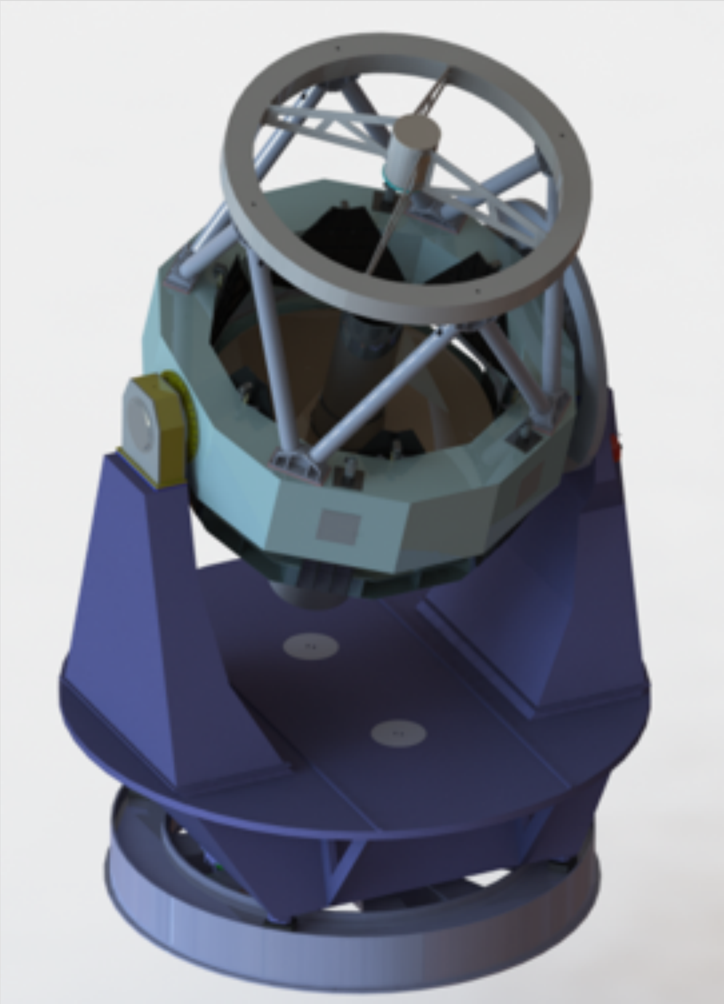
Scale in Cassegrain focus	0.18731 mm/arcsec (5.3388 arcsec/mm)

M1 blank and Polishing





Mechanics



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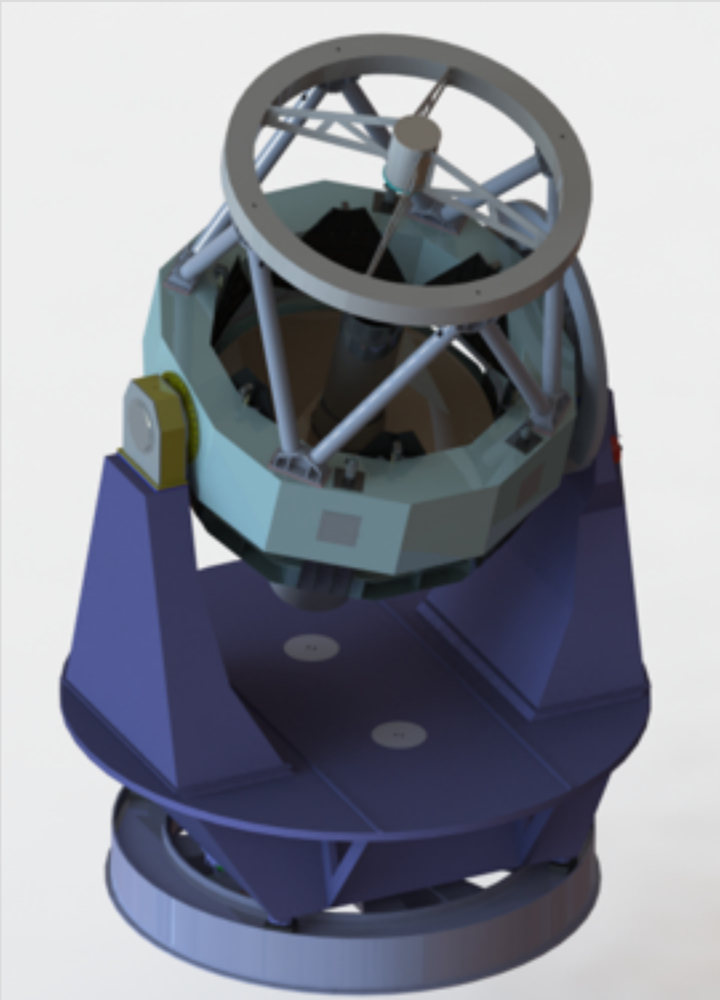

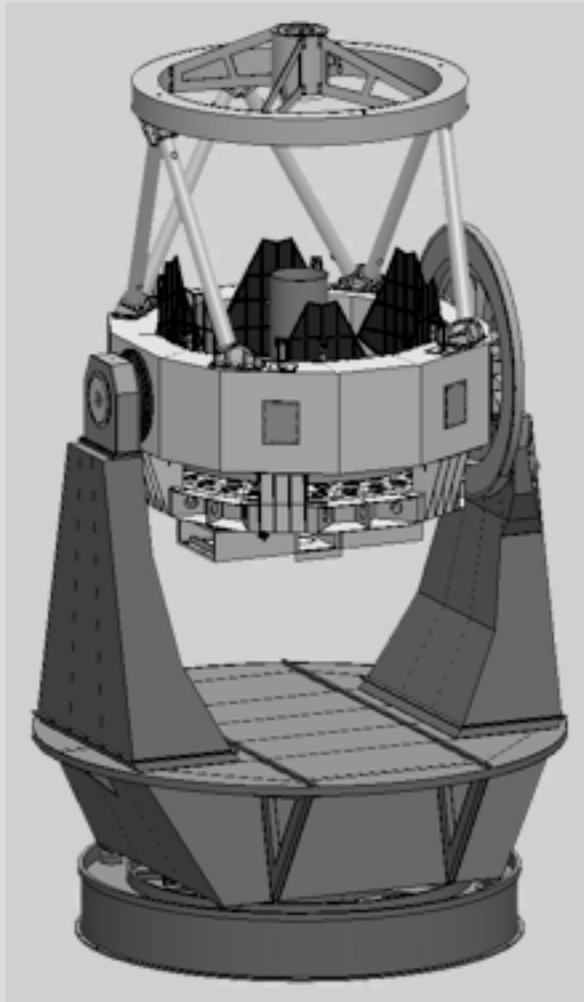

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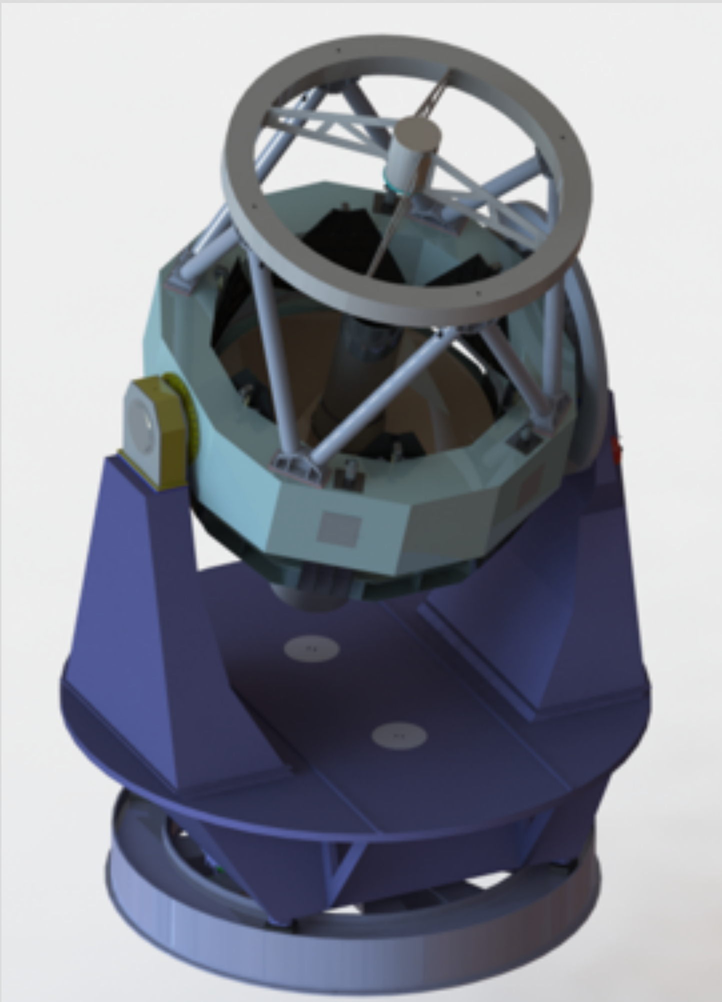

Equal Force Actuators

- **Advantages:**
  - Less costs;
  - Easier fabrication and assembly processes;
  - Less error in fabrication;
  - Less error in polishing;
  - Less error in controlling.

- **Complicated: Number of supports is coupled with ring forces**

- **It became possible because of:**
  - ✓ The mathematical modeling;
  - ✓ Optimization codes.

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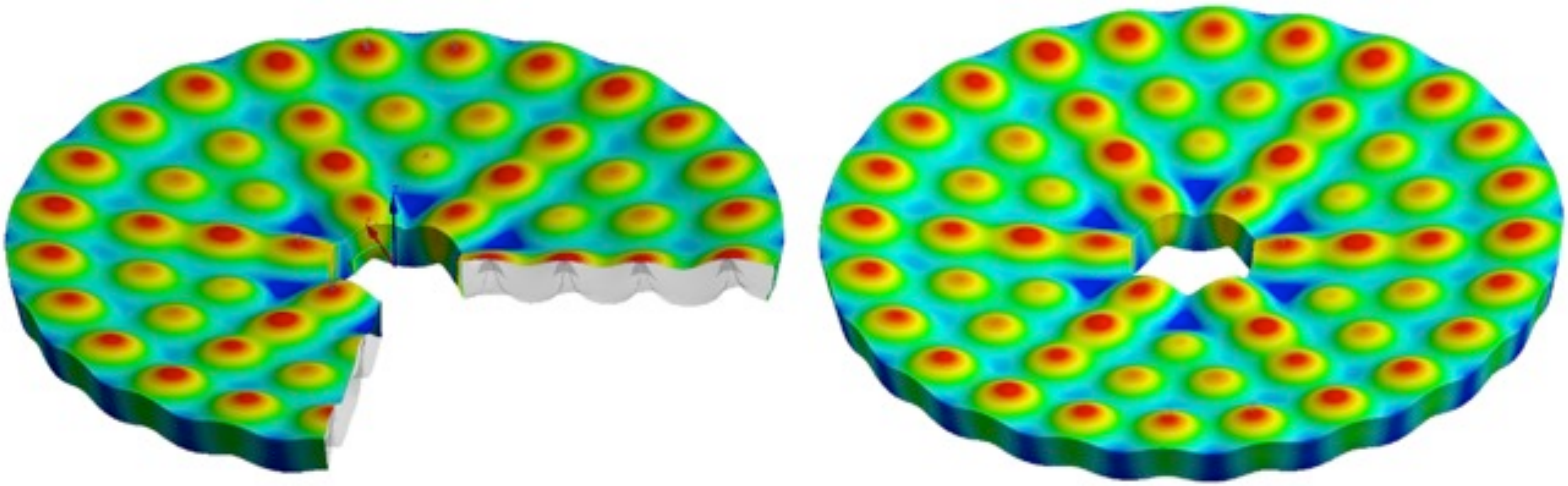

→ **RMS deflection = 5.5 nm**

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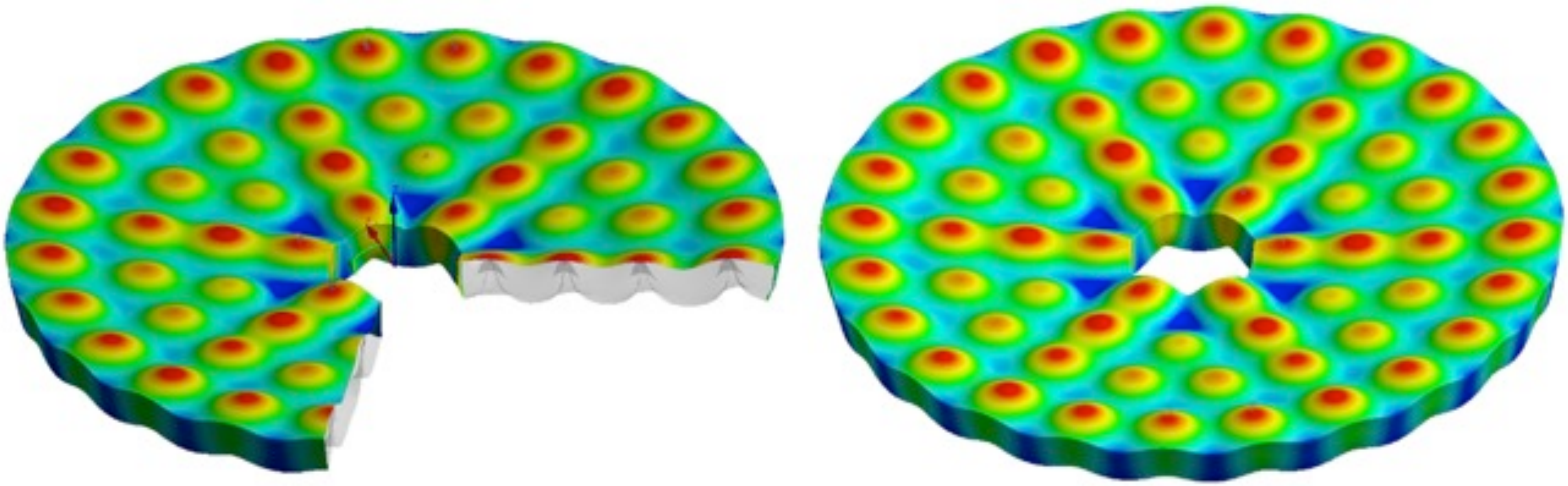


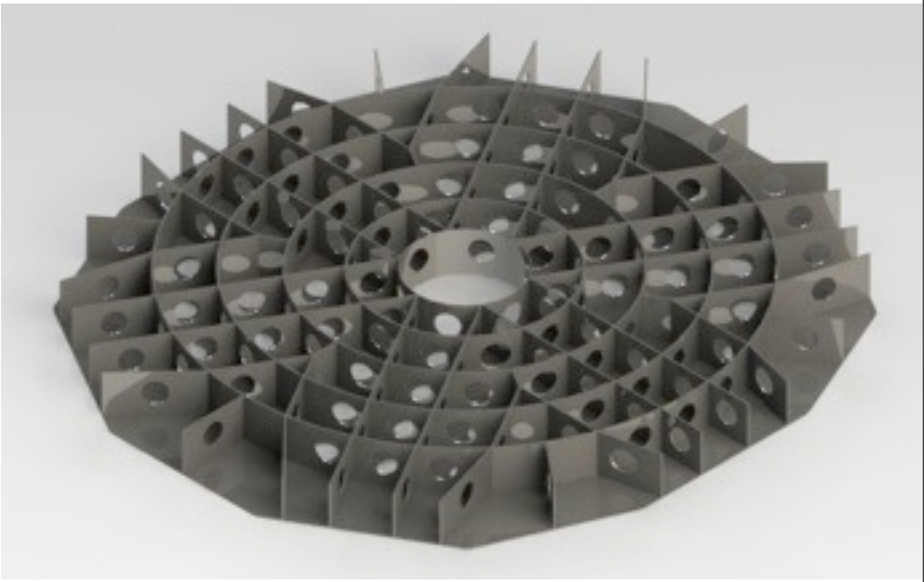
First part which has been fabricated

→ RMS deflection = 5.5 nm

Final M1 Cell

Optimized based on:

- ✓ **Pattern of axial actuators**
- ✓ **Pattern of lateral supports**
- ✓ **Stiffness**
- ✓ **Weight**
- ✓ **Connection to center section**
- ✓ **Location of axial HPs**
- ✓ **Stress analysis**



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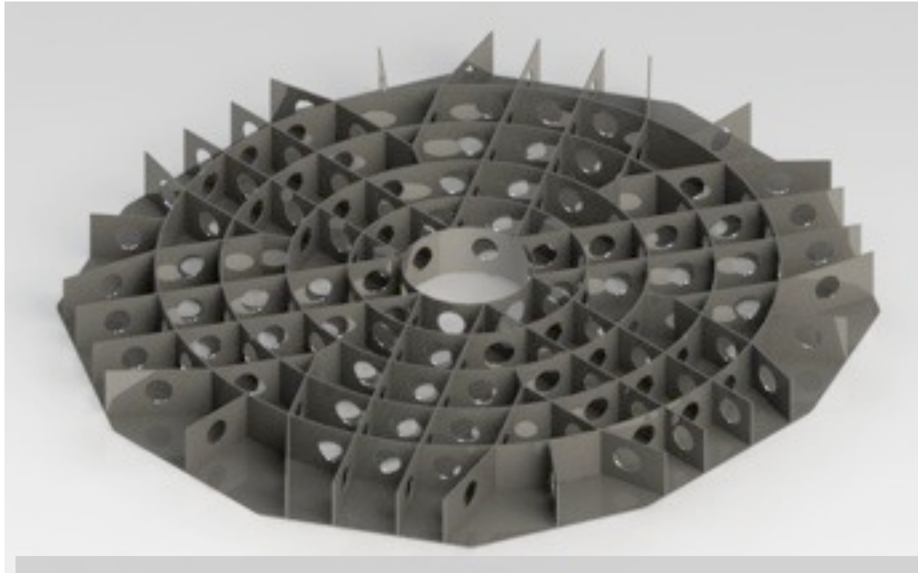

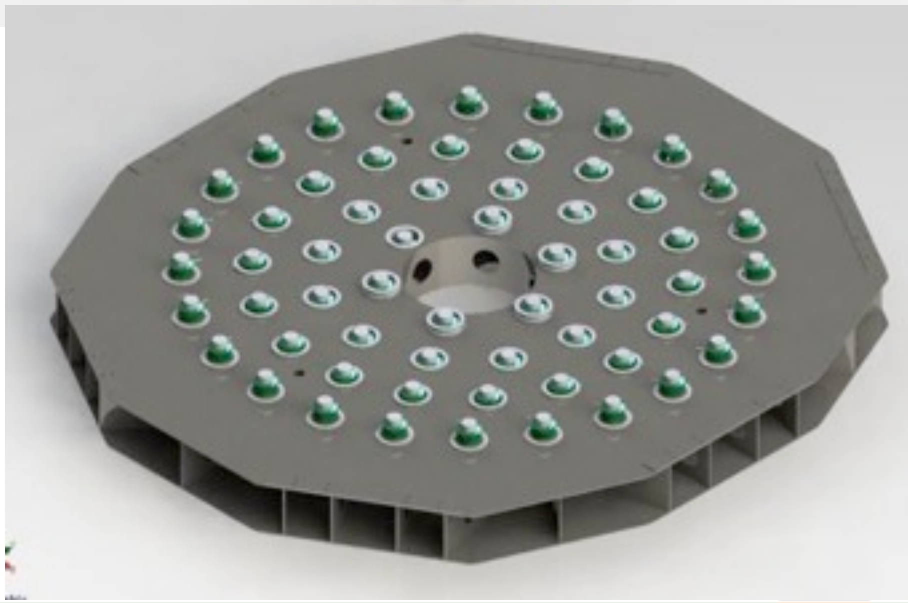

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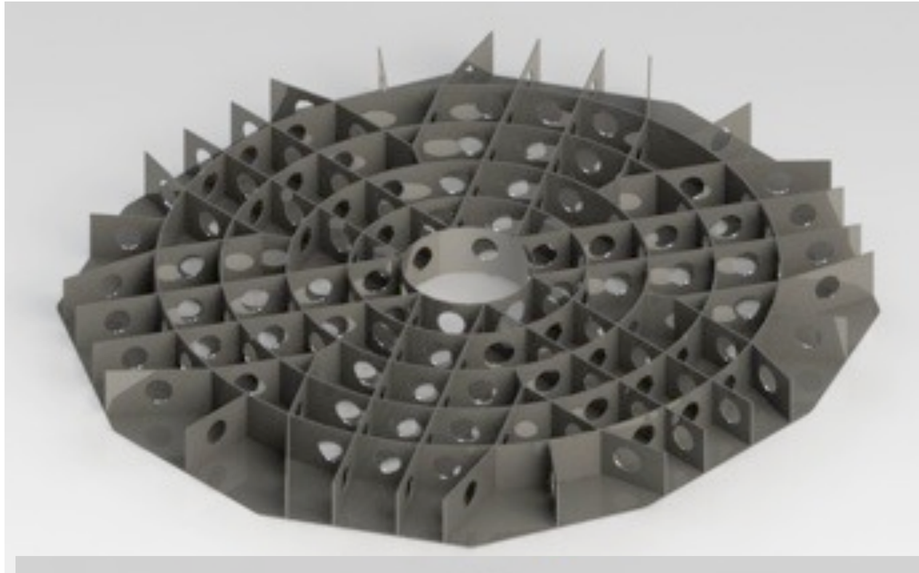
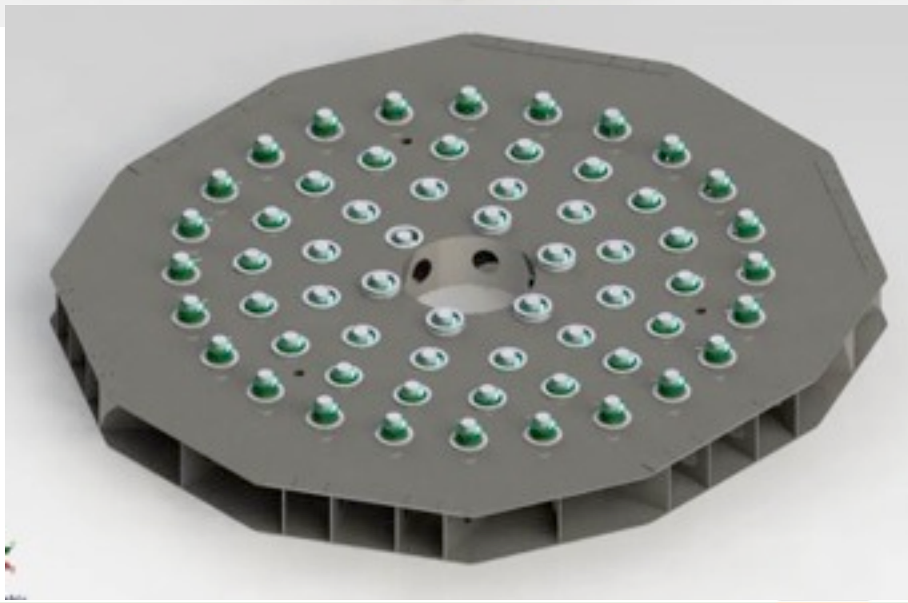
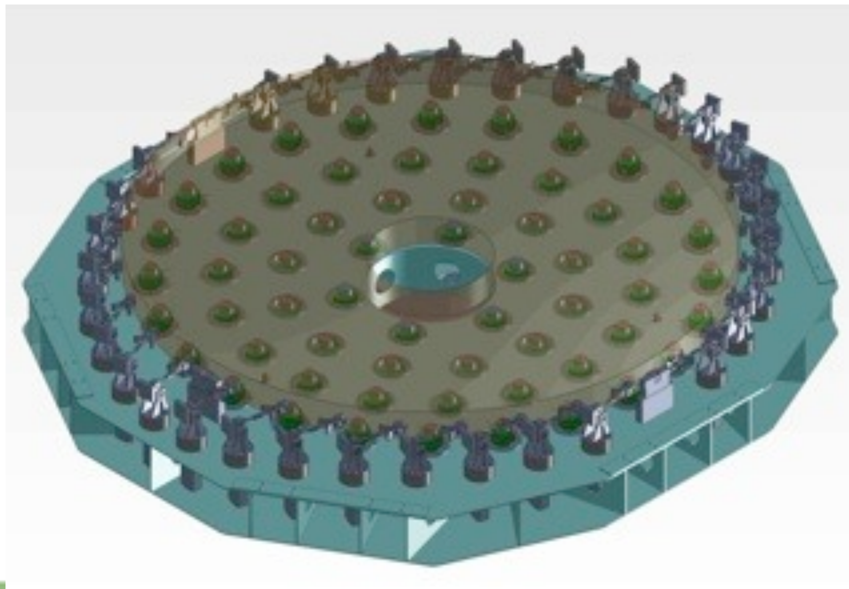
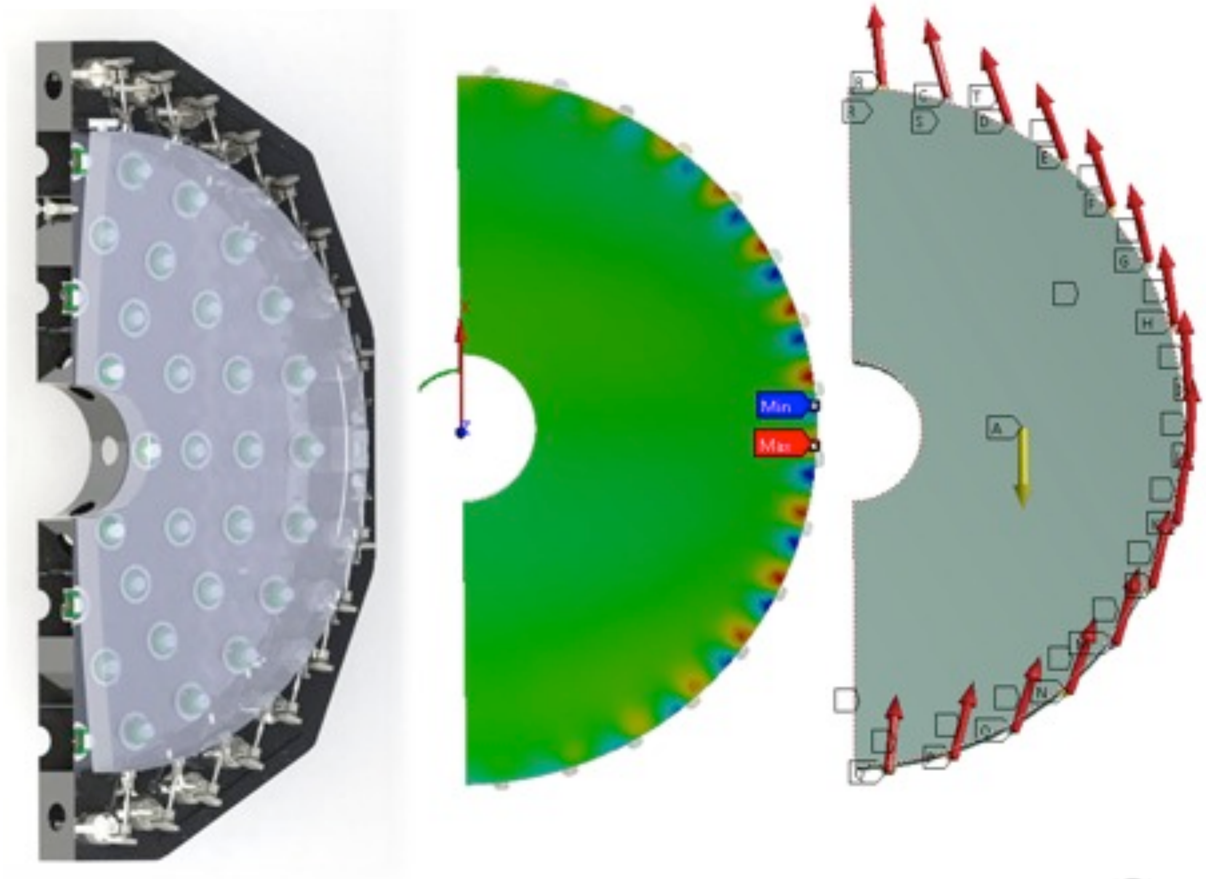






Final Pattern of Lateral Supports

- To reduce the maximum force from 2300 N
- Modified Schwesinger pattern
- α=5
- β=.67
- W=227 mm

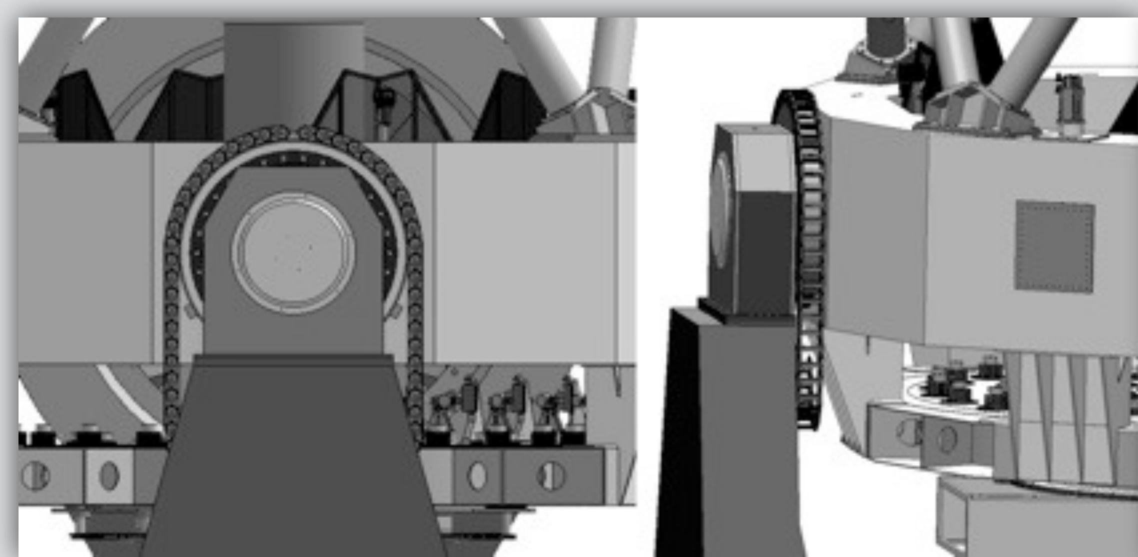


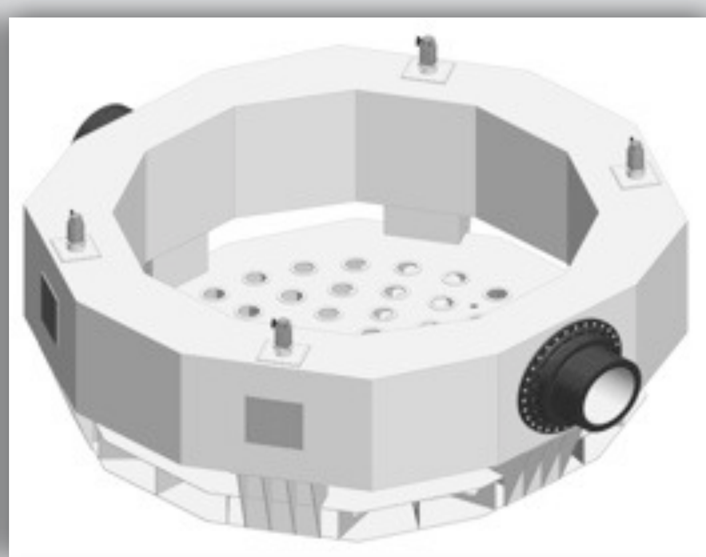
✓ Deflection= 5.8 nm RMS

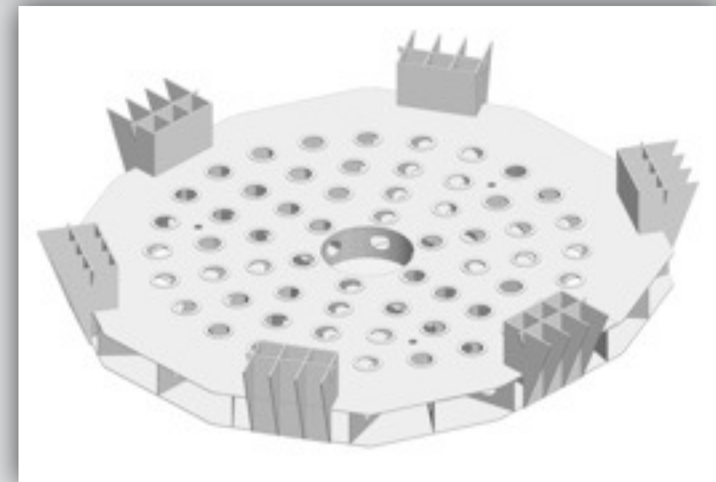
✓ Maximum Force= 1750 N

Cable Wraps etc

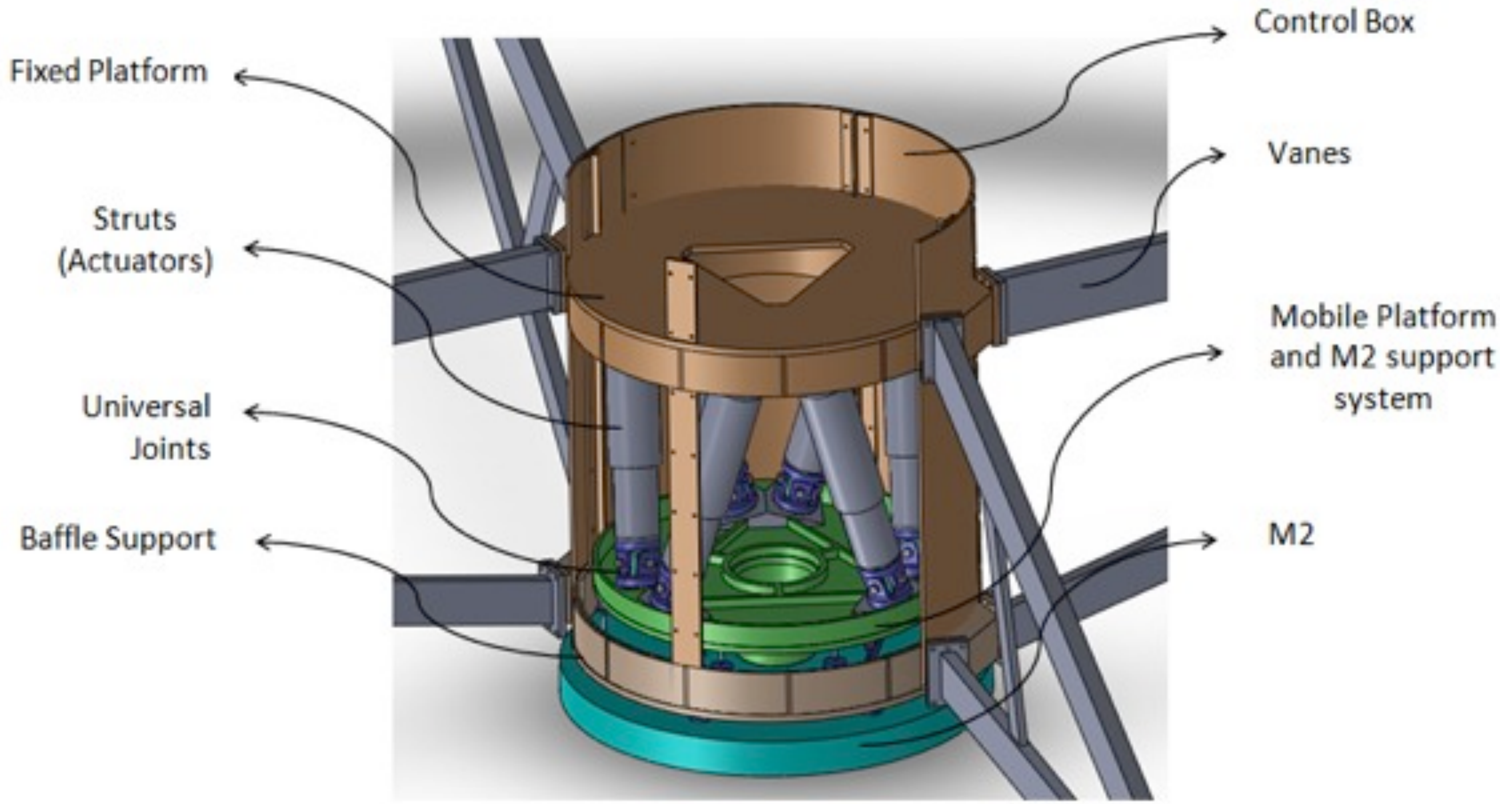
Cable Wraps etc







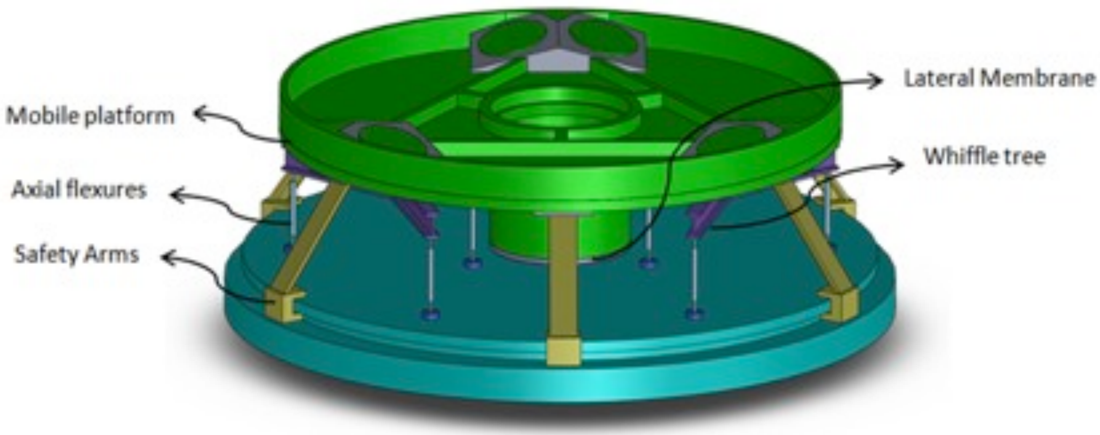
Top Unit

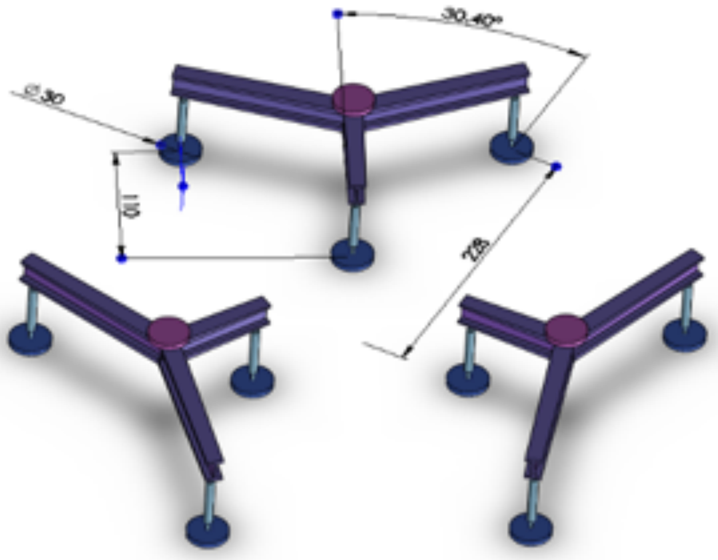


Hexapod has been selected for ACS because of →

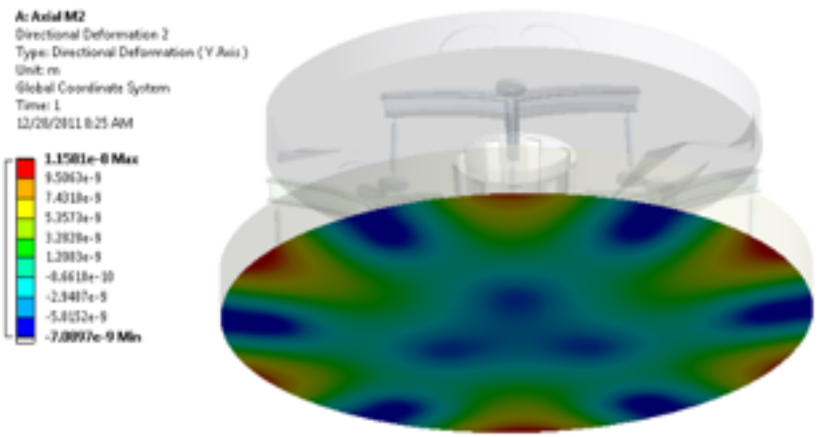
- **Precision**
- **Repeatability**
- **Stiffness**
- **Mass**

M2 Support System



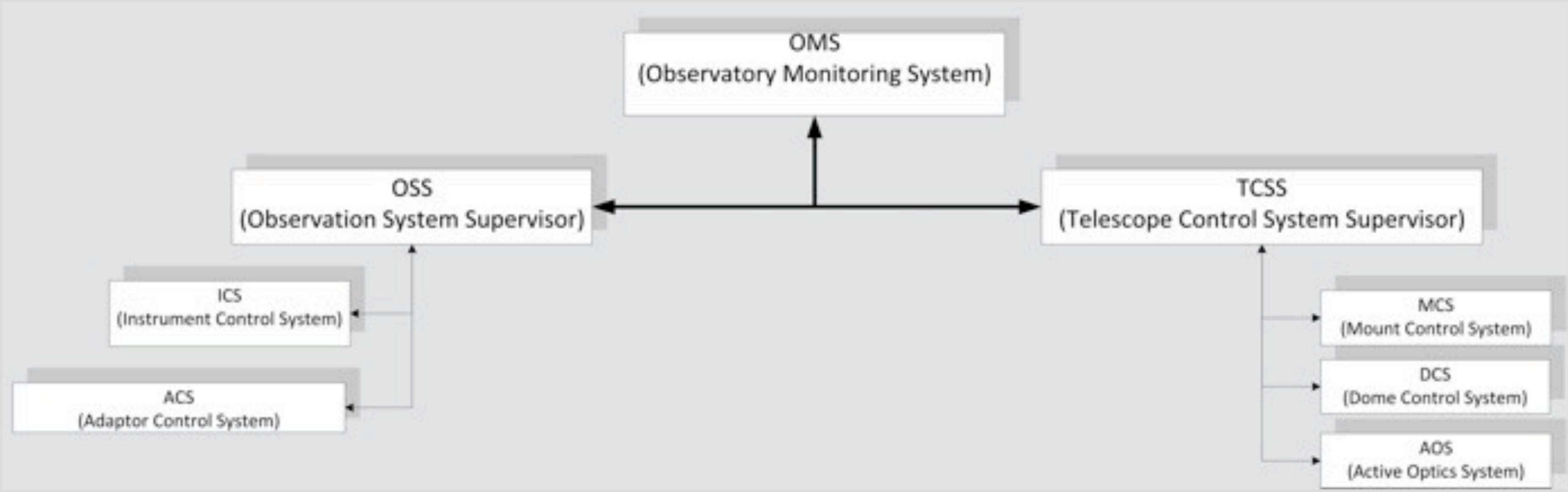


4.1 nm RMS **deformation**



Control System Functional Architecture

The functional software architecture will be divided into 3 main software systems: Observation System Supervisor (OSS), Observation Monitoring System (OMS), Telescope Control System Supervisor (TCSS).



Science case

I. What are the science questions which can be “efficiently” addressed with a 4m class telescope?

II. What can be done with a 4m-class telescope?

In Science Case II we tell what our involvements in studies of galaxies have been and what can be done (to some extend). The latest mid-size telescope reviews (ReSTAR and ETSRC) helps to see whether we are on track.

Given the time scale of the project:

Science case for INO340 should be a living document as priorities will naturally change.

>>>>>>>> Impact on the instrumentation? <<<<<<<<

Field of view and spectral resolution

Community demands; small and diverse

Objects	FOV	min	Wavelength	Imager	Spectrograph
AGN's, SNR's, star clusters, Galaxy clusters	100'	20'	3200-10000	Multifilter	Spectro-Polarimeter
Pixel-Lensing, Transient Follow-up	50'	5'		Multifilter	
GRB's	40'	20'	3200-10000		
Galaxies, Galaxy Systems	30'	10'	3000-14000	0.1" pixels	R~10000 (λ~6000)
SN, AGN monitoring	30'	1'			
Galaxy Structure	30'	5'	1000-5000	16k x 16k	100000
Weak Lensing	30'	5'	Optical – IR	16k x 16k	R~1000
Cataclysmic Variables	30'	20'	3800 – 10000	>7' Polarimeter	R~1000-3000
e-Rosita Clusters/AGN follow-up survey	30'	20'	3800-10000	20k x 20k	
M31 object identification	30'	20'	3800-10000		
Astroseismology of pulsating variables	30'	5'		mmag resolution	R~20000-100000
Large Scale Structure Surveys	30'	20'	3000-10000	20k x 20k	MOS with 150 slits
Galaxy Dynamics	20'	2'	4000 – 13000		IFU, R~30000
Stellar Clusters	20'	3'	4000 – 20000		R~ 2000-30000
Binaries in ext. galaxies, stars-planets follow-up	15'	5'	3000-10000	0.001 accuracy, wide-band filters	10000
Standard stars	10'	5'			
AGNs, Quasars	Few		3200 – 10000	Multi-filter at the same time	Long-slit, R~2000

Given the FoV/Image scale issues should we be selective?

Instrument requirements

What to have?

- Imaging capability
- Spectroscopic capability
- Polarimetric capability (optional)
- Instruments suitable for faint and bright objects, bright and dark time, good and poor observing conditions;

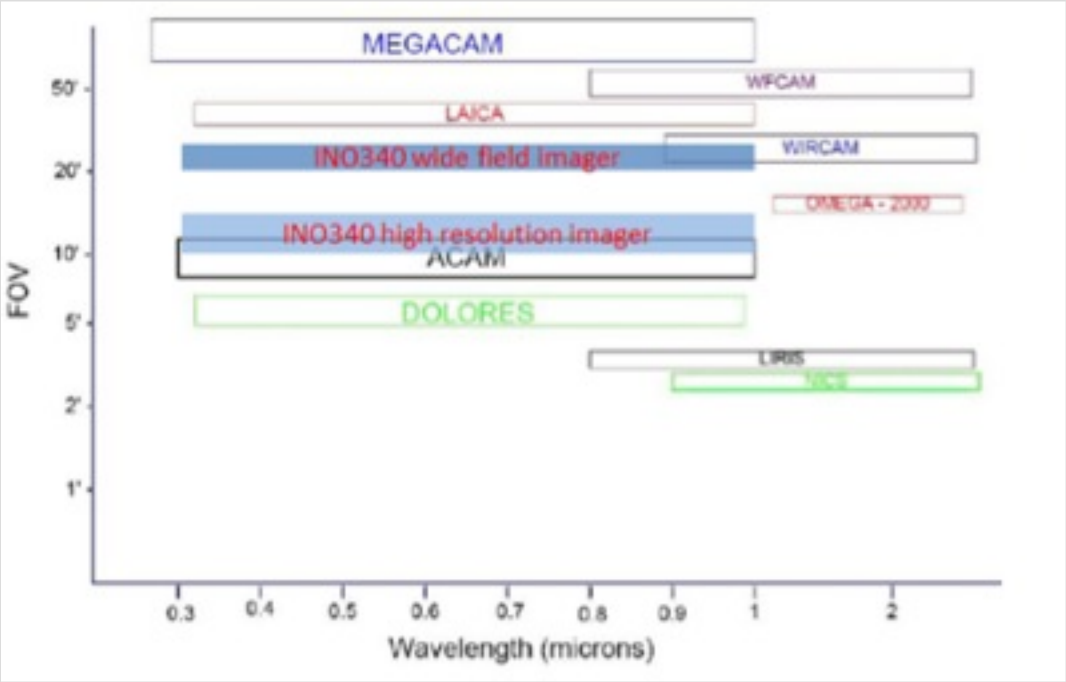
How to arrange?

- Fast switch between instruments with different capabilities to response to time-domain observation and alerts;
- All times imaging and spectroscopic capabilities;

Imaging

Deep imaging surveys of few square degree are highly appropriate in wide field mode;

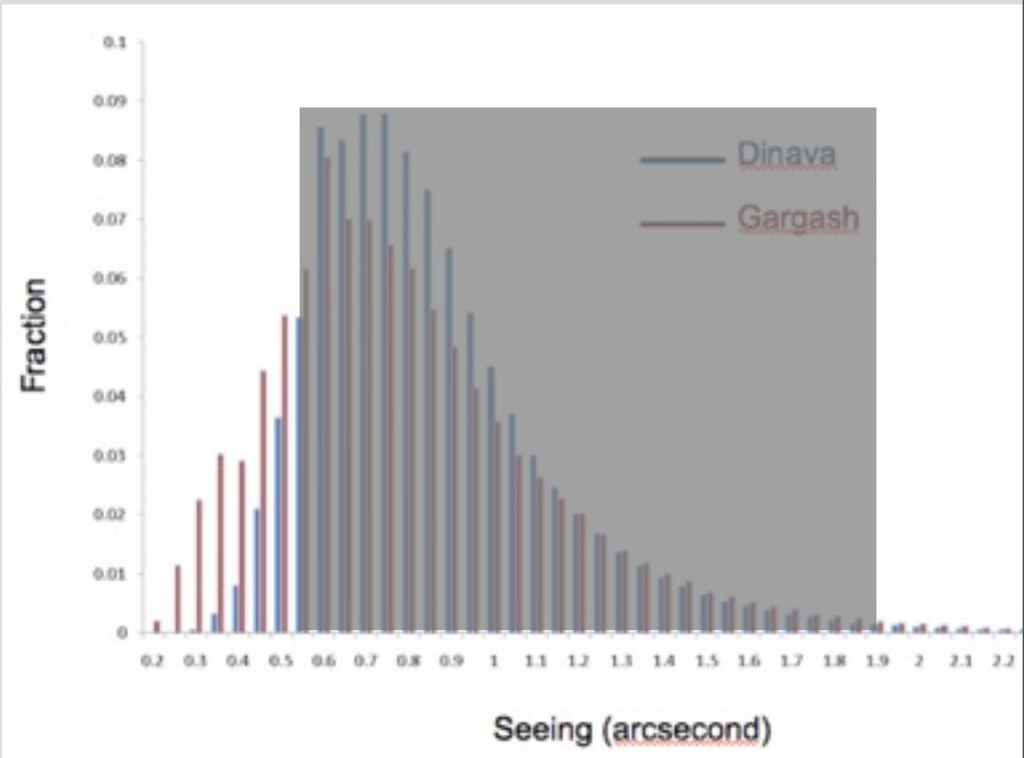
Photometry of galaxies and crowded fields can be accurately performed in high resolution mode;



High Resolution Imaging

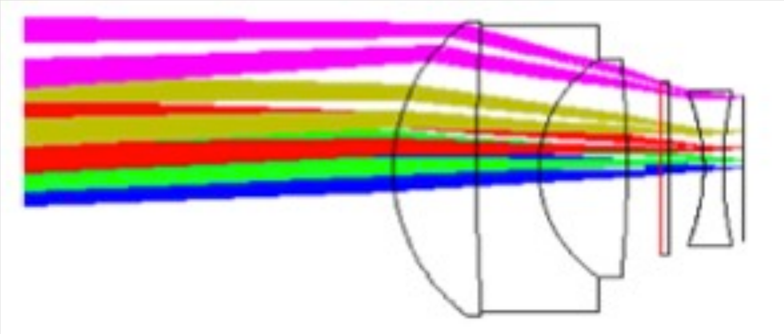
Requirement	Value
Field of view	10 arcmin
Wavelength range	340 - 1000 nm
Throughput (including filters and CCD)	> 0.4 (340-450 nm) > 0.7 (450-800 nm) > 0.4 (800-1000 nm)
Image scale	0.08 arcsec/pix
Detector	8k x 8k CCD
CCD type	Thinned backside illuminated
CCD pixel size	15 micron
CCD noise	<5e rms
CCD efficiency	> 0.6 (350-450 nm) > 0.9 (450-800 nm) > 0.5 (800-1000 nm)
Location	On axis Cassegrain **Side Cassegrain**

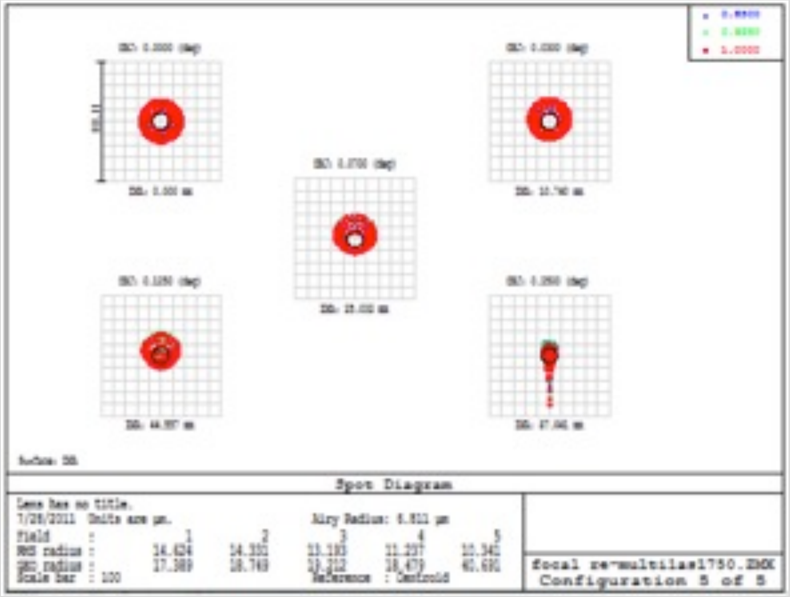
An instrument for the first seeing quartile and fast steering secondary both for on-axis and side Cass foci.



Wide Field Imaging

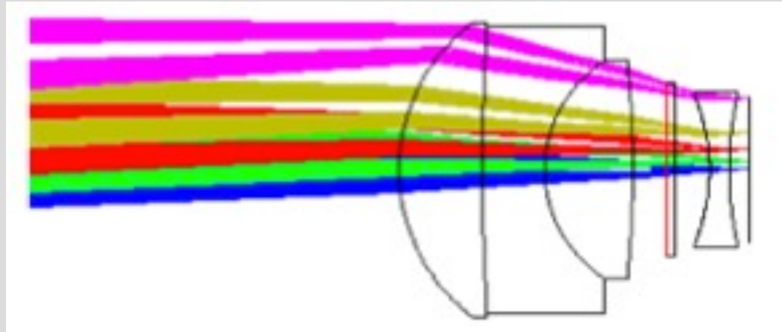
Requirement	Value	acceptable
Field of view	30 arcmin	25 arcmin
Wavelength range	340 - 1000 nm	
Throughput (including filters and CCD)	> 0.4 (340-450 nm) > 0.7 (450-800 nm) > 0.4 (800-1000 nm)	
Image scale	0.21 arcsec/pix	0.15
Filter wheel capacity	10 filters (7 inch diameter)	6 filters
CCD	8k x 8k CCD mosaic	
Location	Cassegrain	
Field corrector	Yes	
Focal Reduction	3	2

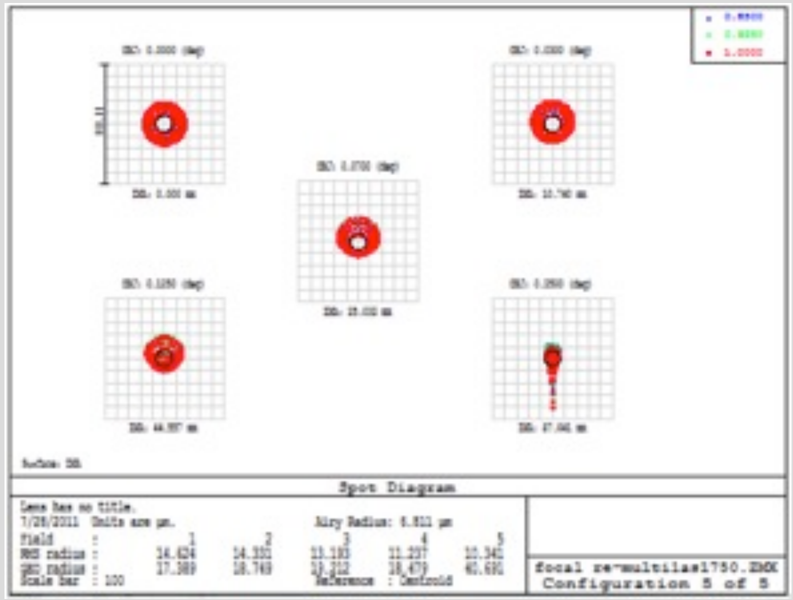




Wide Field Imaging

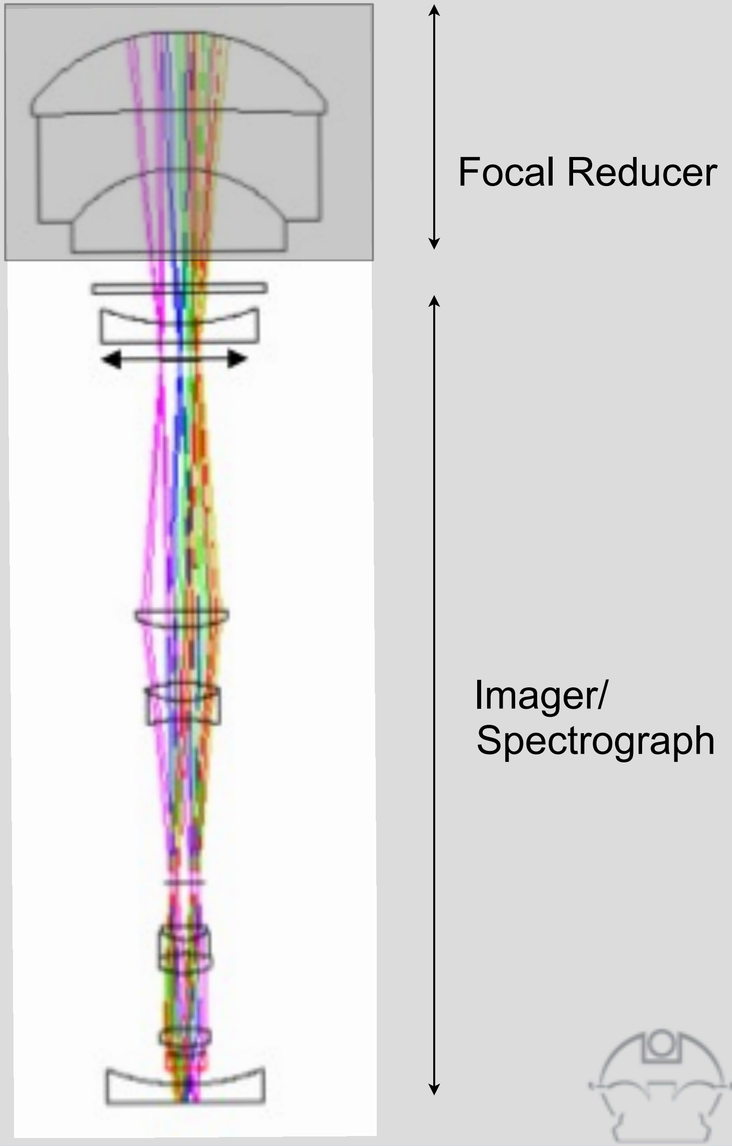
Requirement	Value	acceptable
Field of view	30 arcmin	25 arcmin
Wavelength range	340 - 1000 nm	
Throughput (including filters and CCD)	> 0.4 (340-450 nm) > 0.7 (450-800 nm) > 0.4 (800-1000 nm)	
Image scale	0.16 arcsec/pix	0.15
Filter wheel capacity	10 filters (7 inch diameter)	6 filters
CCD	12k x 12k mosaic	
Location	Cassegrain	
Field corrector	Yes	
Focal Reduction	3	2



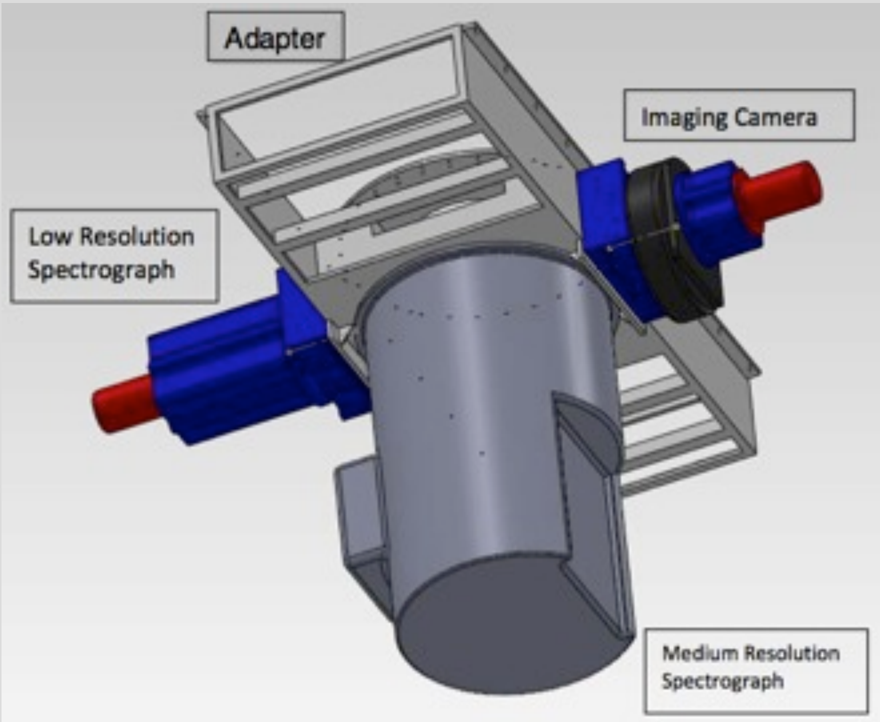


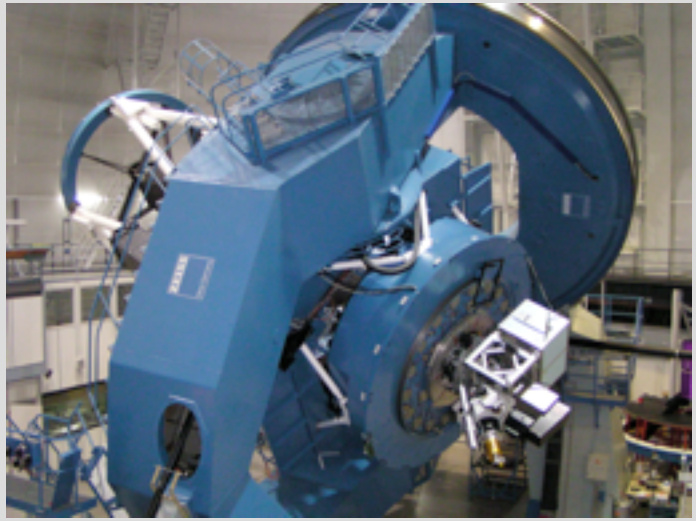
On axis multi-object spectrograph

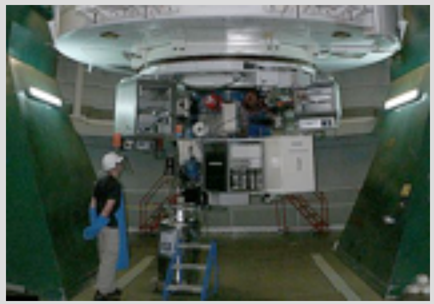
Requirement	Value	acceptable
Field of view	10 arcmin	6 arcmin
Wavelength range	350 - 900 nm	
Observing modes	Single slit	Variable width (0.5-10 arcsec), length 4 arcmin fixed
	Multi-slit	As on the slit mask (0.5 to 2.0 arcsec width)
	Optional Fiber couple	Can accept fiber inputs from side Cass
Throughput (excluding telescope, filters, CCD)	> 0.8 (350-900 nm)	
Spectroscopic resolution at 6000A with 1 arcsec slit	R > 1000 R< 5000	R > 1000, R< 4000
Dispersing element	VPH Grating, grism	
CCD	8k x 4k CCD	
Location	Cassegrain	



Instrument arrangement







High resolution imaging

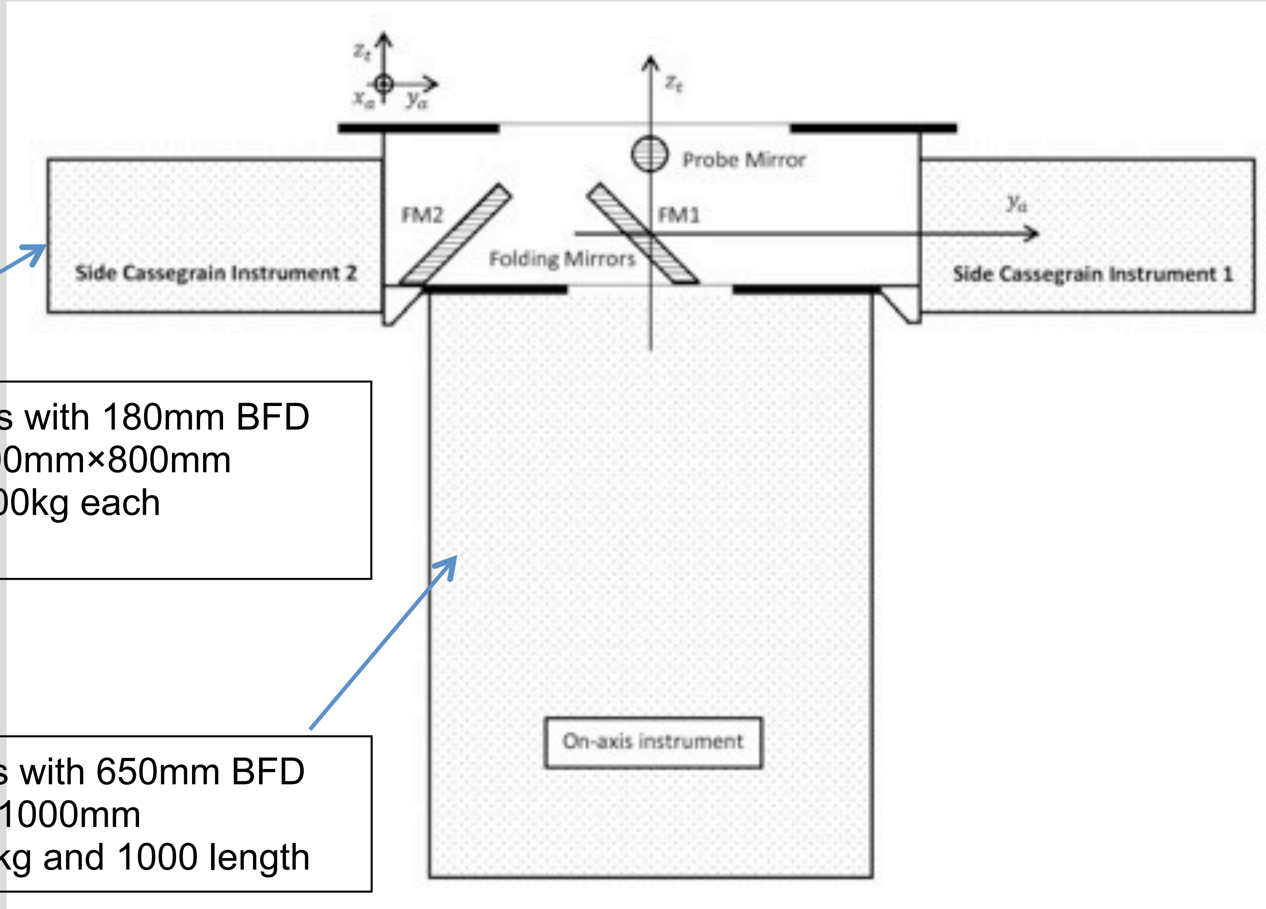
Intermediate resolution spectroscopy

Low resolution spectroscopy

ACAM a ToO instrument?

Adapter Layout

Side View



•15 arcmin. On Side Cass. focus with 180mm BFD
• Side Cass. Flange 350mm×600mm×800mm
• Side Cass. Instrument max. 100kg each
• Two side Cassegrain stations

30 arcmin. On Cassegrain focus with 650mm BFD
• Cass. Focus flange diameter=1000mm
• Cass. Instrument weight 1500kg and 1000 length

Adapter Layout
Top View

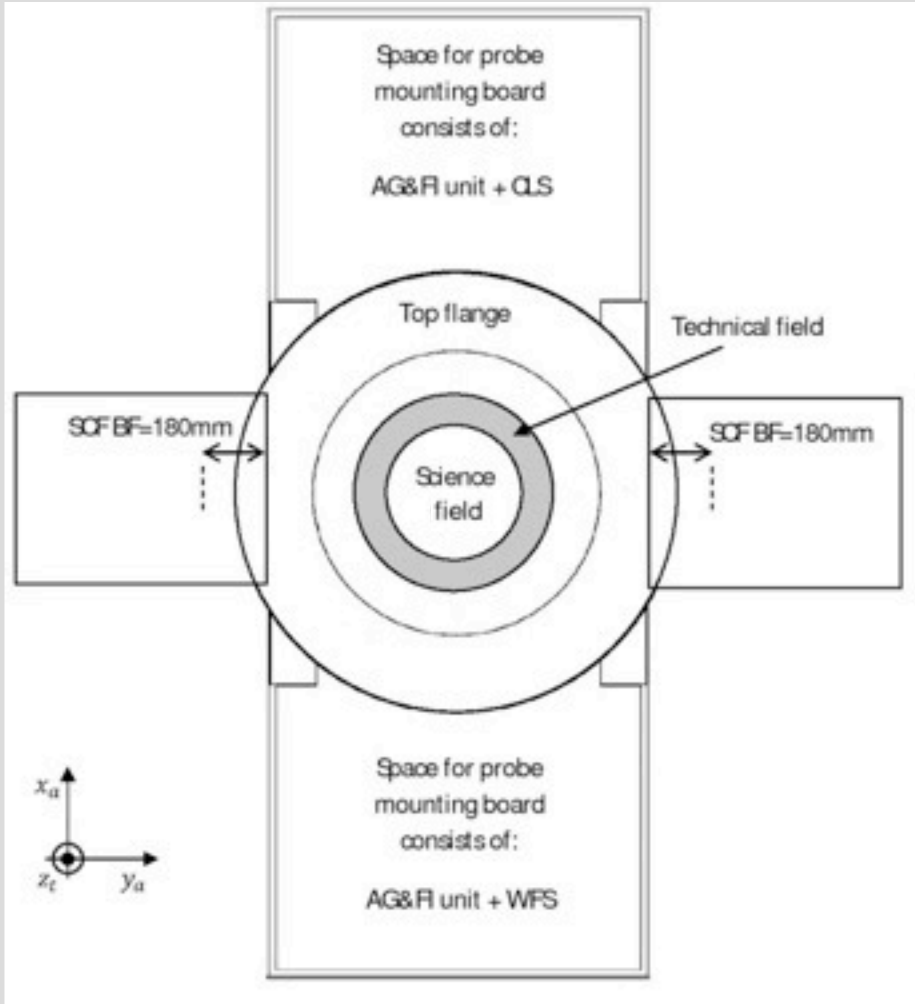
Subsystems: two AG & FI, one WFS and one CLS

At lest 20 arcmin. square field for each AG & FI unit

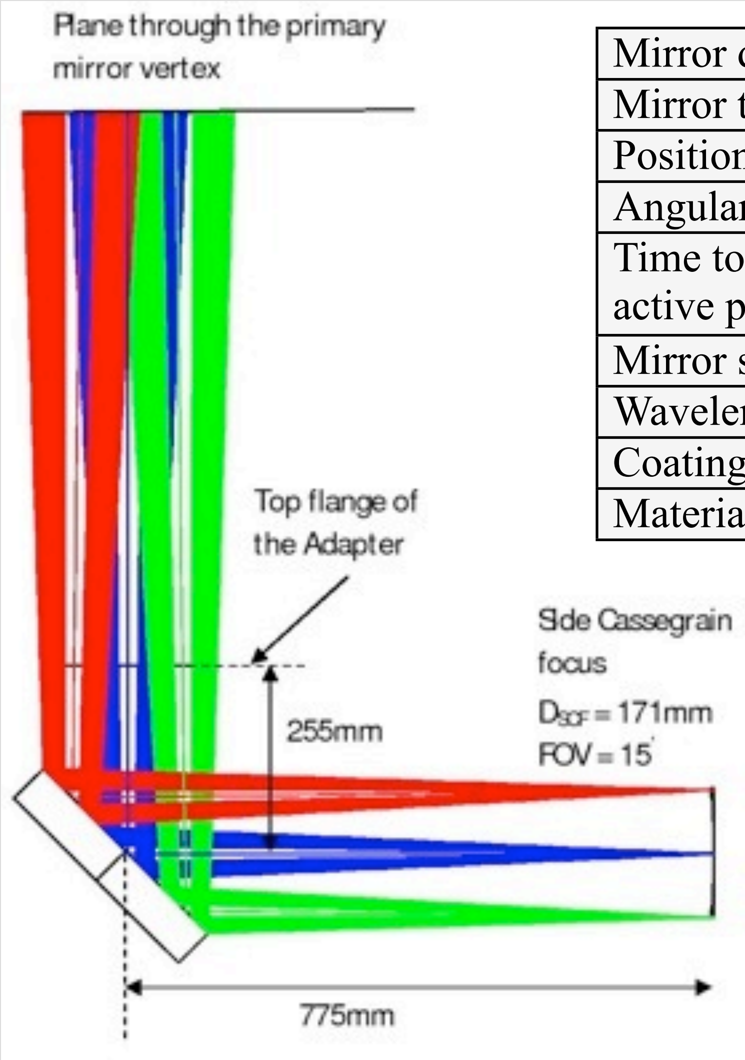
Technical field for auto-guiding and field-inspection

Center of the field for WFS and FI

No conflict between the folding mirror and the probe mirror



Folding Mirror



Mirror diameter	310 mm
Mirror thickness	55 mm
Position repeatability	±1 μm
Angular stability	0.5 arcsec.
Time to shift between park and active positions	Less than 1min
Mirror surface error	Less than 15 nm
Wavelength	320 nm to 2500 nm
Coating	Protected aluminium
Material	Zerodur

Auto-guider and Field Inspection Unit
Specifications

Auto-guider Unit

Number of auto guider units	2
Field of view	Depends on the size of selected subframe.
Spatial sampling	0.18 arcsec. / pixel
Exposure time	1 to 10
Sampling frequency	10fps at quarter subframe
Patrol field	4×12.5 arcmin. Square in technical field
wavelength	Sloan z, g, r, I, u filters

Camera

Item	Value	Scale
Array size	1340×1300	pixels
Pixel size	20×20	μm
Size of the CCD Chip	26.8×26	mm
Readout noise	3	e^-
Pixel well depth	200000	e^-
Quantum efficiency @600nm	95%	

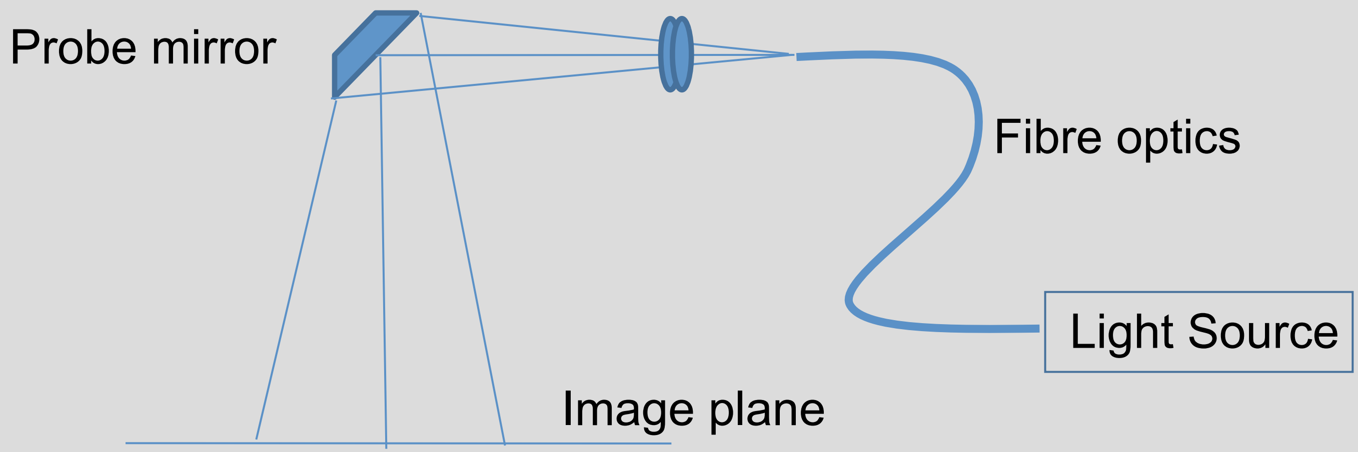
Auto-guider and Field Inspection Unit
Specifications II

Field Inspection Unit

Number of Field Inspection units	2
Field of view	4 arcmin
Spatial sampling	As AG mode
Temporal sampling	10μs–10s No shutter needed
Sampling frequency	It has 10fps at 8×8 binning
Patrol field	4×12.5 arcmin. square in technical field Access the center of the science field
wavelength	Visible

Calibration Light Source

Number of Light source units	1
Field coverage	150mm on SCF and CF (TBC)
wavelengths	Standard Lamps such as Mercury, Sodium, He, Argon, all cover 320 to 1000nm
Uniformity of illumination	TBD
Power	TBD
Stability	TBD



Project Schedule

	Work Package	Start Date	Finish Date	Duration
	Tasks before actual Start	21-Mar-01	1-Sep-08	2000 days
0	Project Kickoff	23-Mar-09	31-Mar-10	300 days
1	Management	20-Mar-12	20-Sep-16	1200 days
2	Science and derived documents	3-May-10	16-Apr-12	500days
3	Systems Engineering	1-Jun-10	25-Jun-13	800 days
4	Mechanics	22-Apr-10	2-May-14	1000 days
5	Optics	3-May-10	22-Apr-13	800 days
6	Control System	15-Apr-10	17-Mar-16	1550 days
7	Site Assesment	1-Apr-10	25-Dec-15	1500 days
8	Site Development	15-Apr-10	28-May-15	1400 days
9	Enclosure	3-May-10	27-Feb-15	1250 days

رصدخانه ملی ایران

Iranian National Observatory

... more than a telescope!

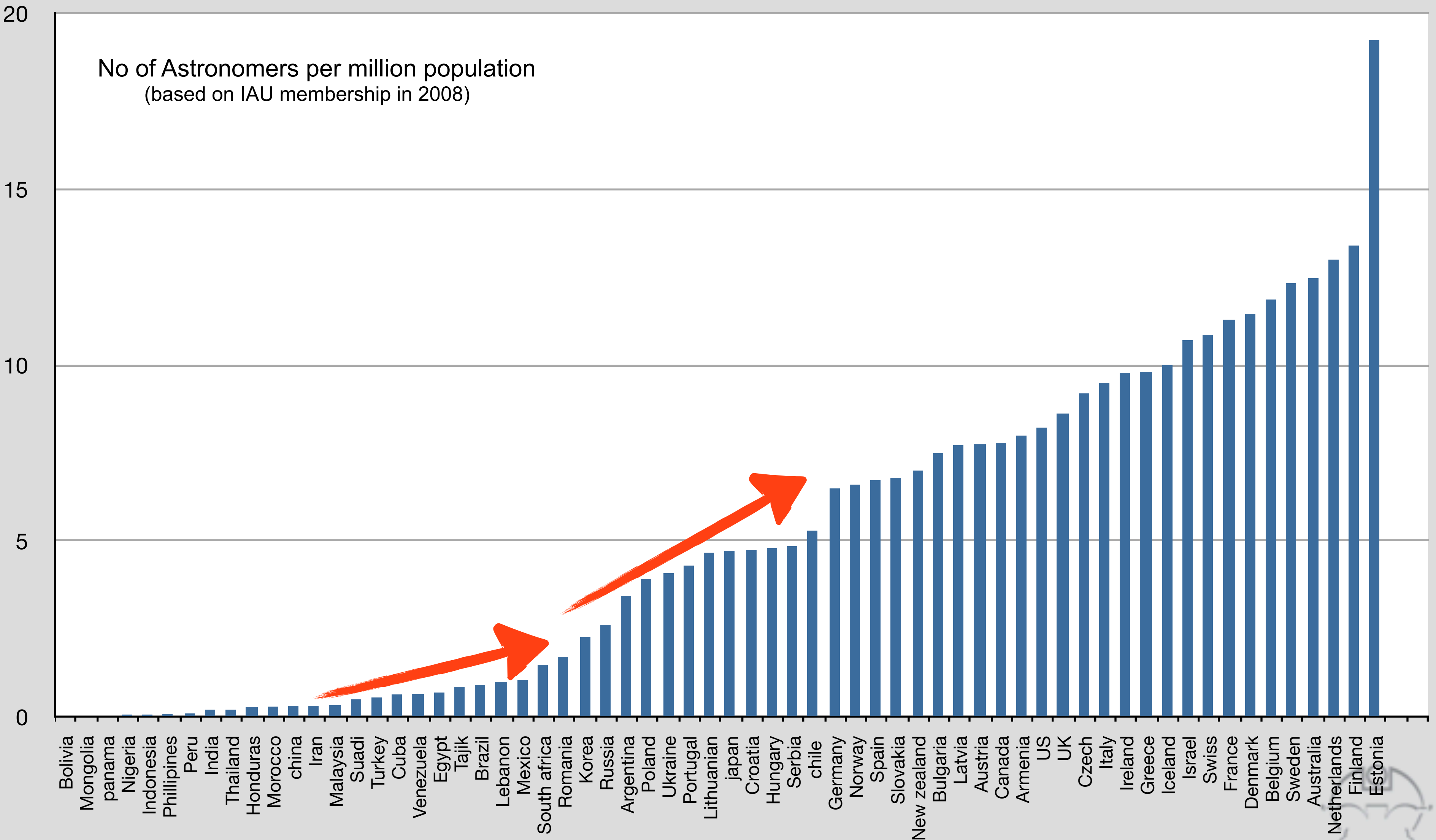
Astronomy in Iran, today

In undergraduate level astronomy syllabus forms 7% of the physics colloquium and is offered in very few universities.

More than 20 universities or institutes offer MSc or PhD in Astronomy, Astrophysics or Cosmology.

Observatory astronomy and cosmology training is VERY limited.

Astronomy ranking



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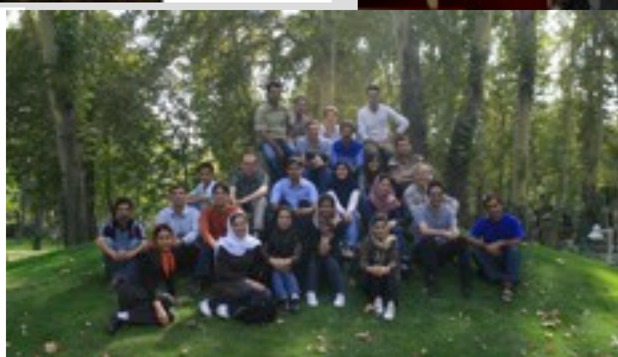
School of Astronomy @ IPM

Established in 2007 to support the Iranian National Observatory Project;

A vision and road map was developed in 2008 with focused on Observational Astronomy;

1 faculty, 5 postdocs, 7 part-time researcher, 5 students, 2 technical staff, 3 admin;

Observational Cosmology, Galactic Astronomy, Astrophysics and Theoretical Cosmology;



A scope for training

Observational Techniques

Observations and hands on experience with mid-size telescopes

Data handling, reduction, analysis

Virtual observatory

Observational Astronomy and Cosmology (Science)

Quality post-graduate training

Competitive research projects

On site training

Summary and plans

Direct training

PhD program (INO, SoA)

Training workshops @IPM

Observatory training (ING)

Observing runs (ING, IUCAA)

Development

Virtual Observatory

Software

Laboratory experiments

Instrument development

Network

Stay in contact with students and staff abroad

Support attendance to workshops

International Collaborations

Offer site facilities

Survey, follow-up projects

Visitor instruments