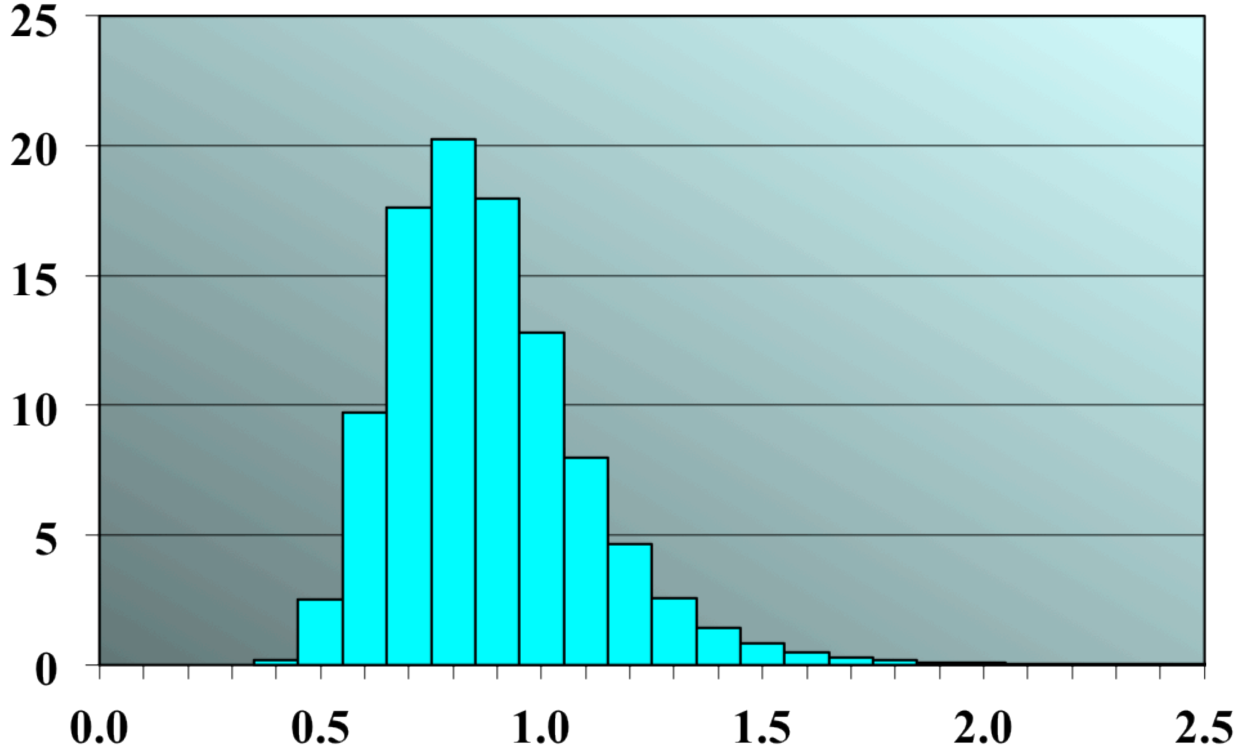
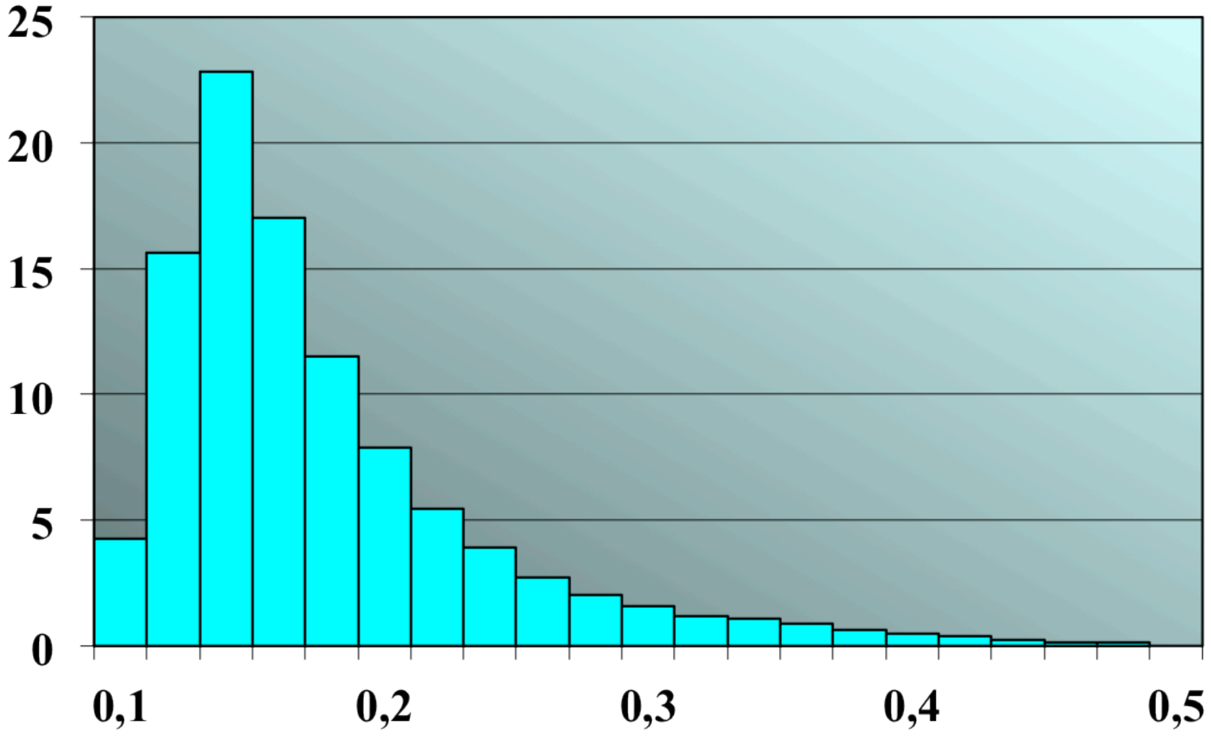
HEXA: una máquina para cartografiados espectroscópicos

III REG -- Sitges, 25 enero 2013

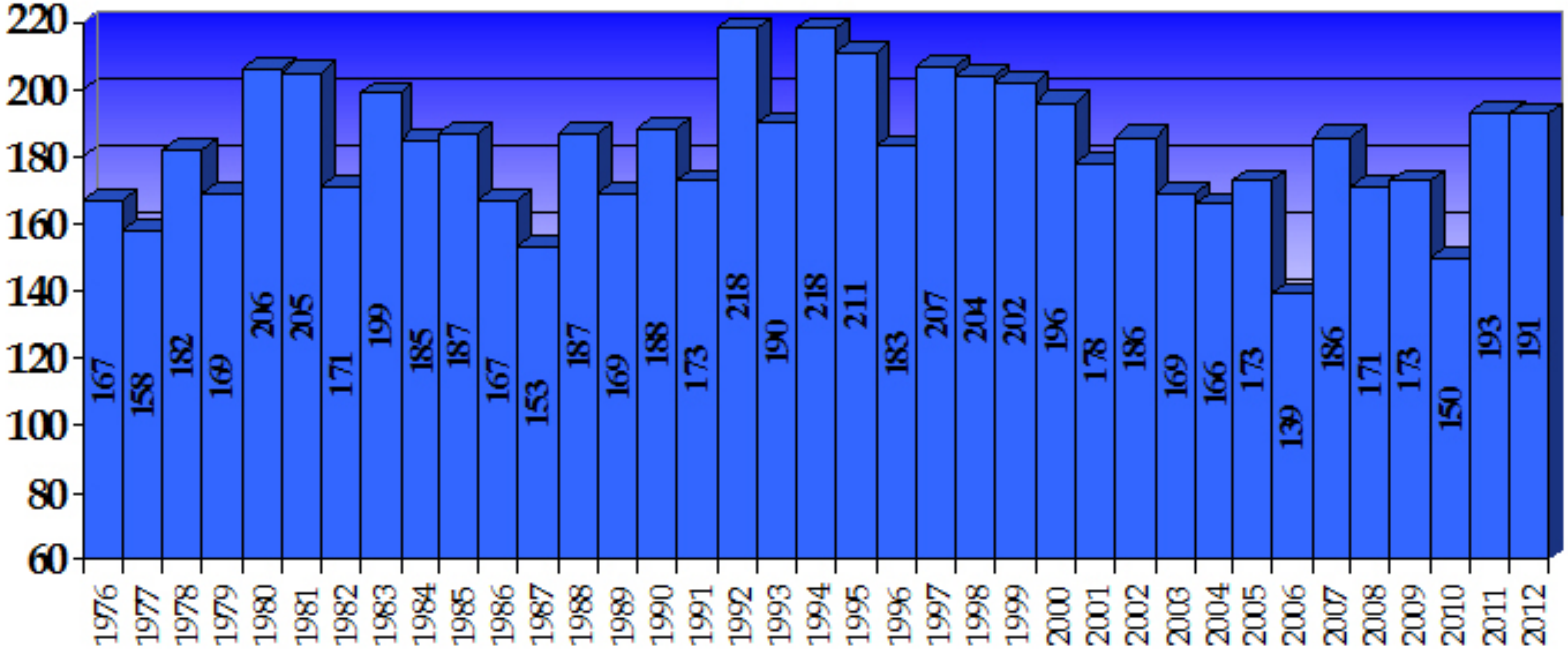
David Barrado



Seeing. Mediana: 0.80 arcsec (639364 puntos)



Extinción en la banda *V.* Mediana: 0.169 mag/χ (408820 puntos)



Noches despejadas 1976-2012

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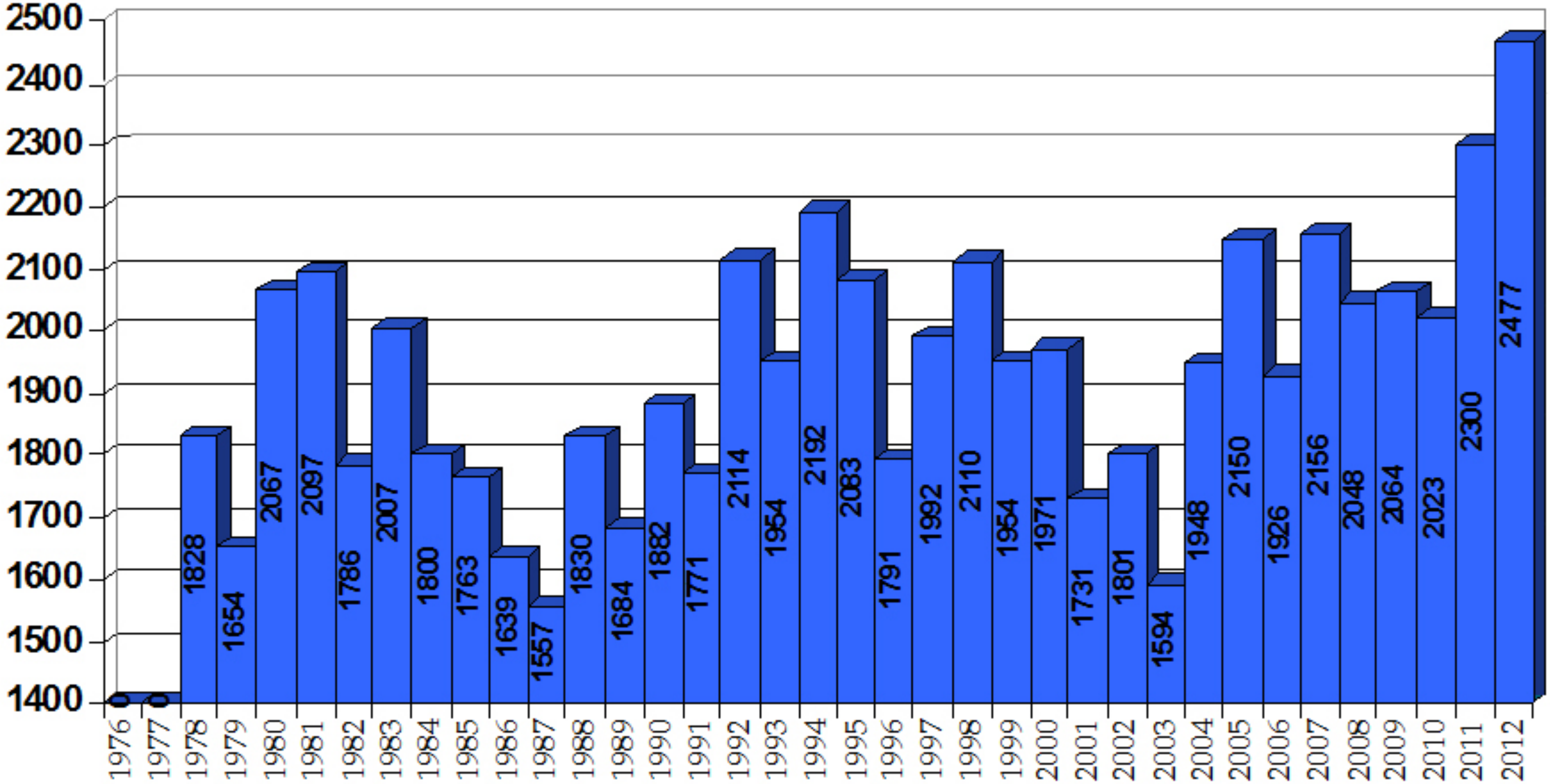
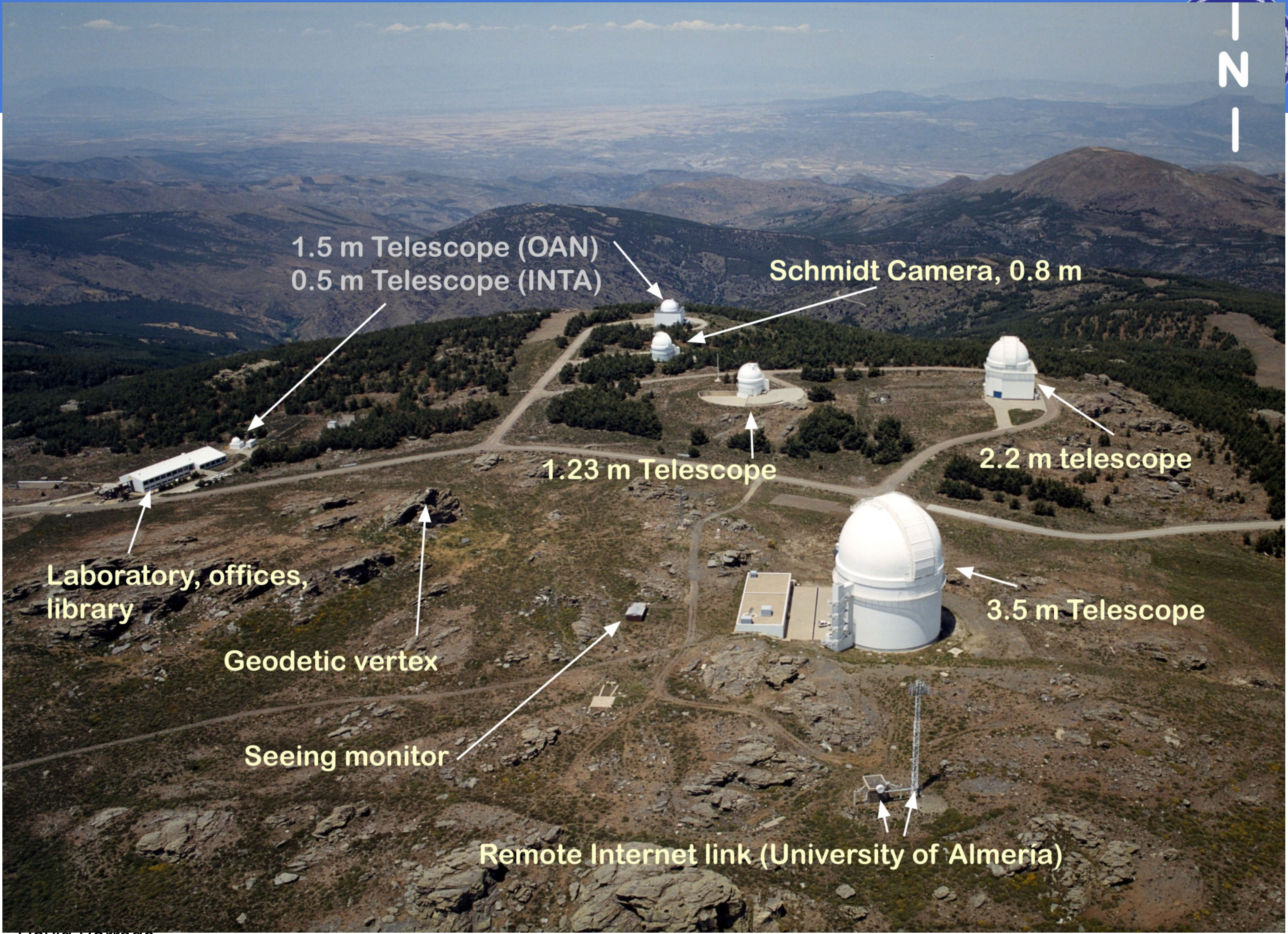


Horas de observación 1976-2012



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Instrumentación

Calar Alto Instruments:

1.23 m telescope:
- **<u>New</u> CCD camera for direct imaging**

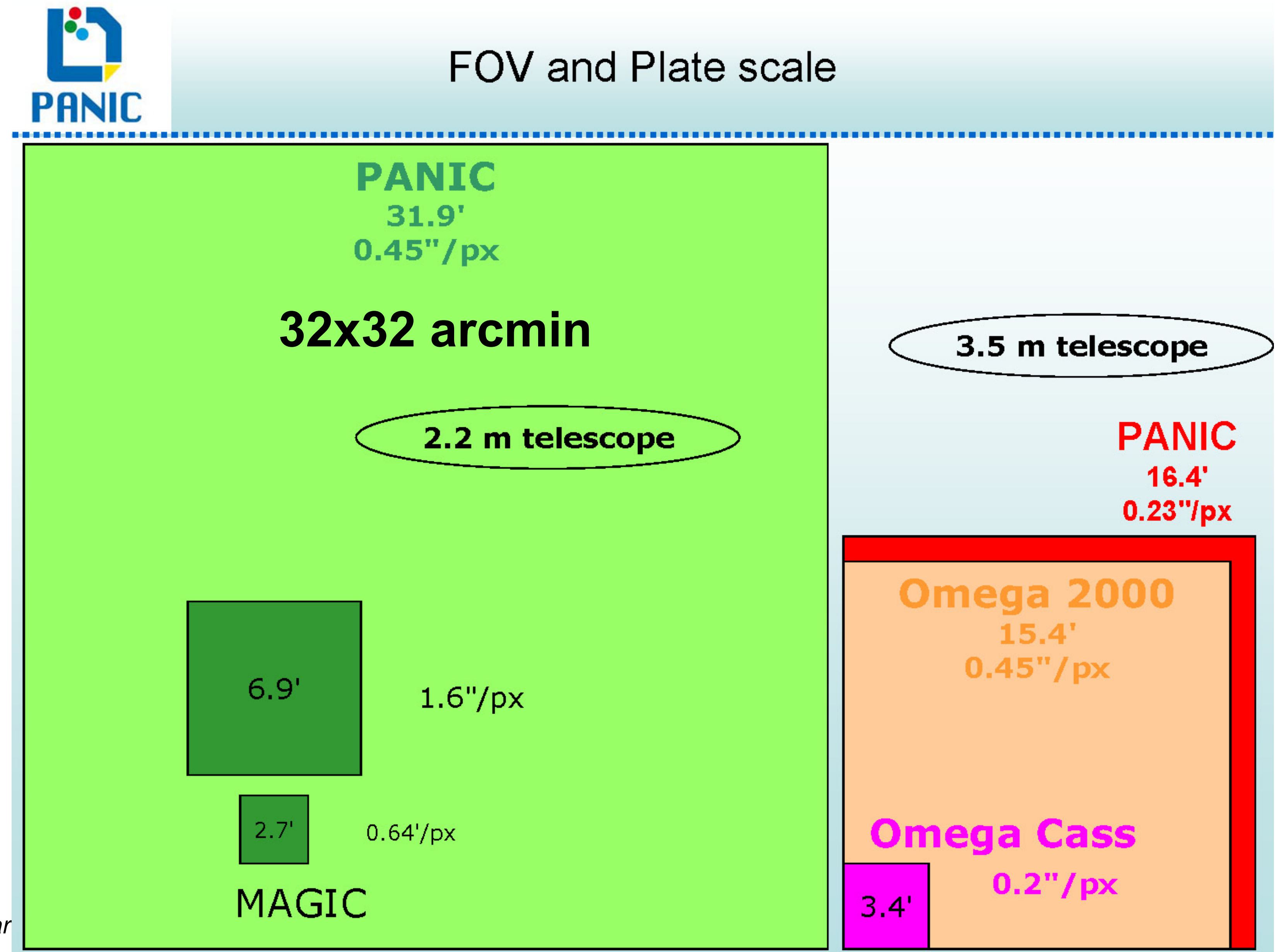
2.2 m telescope:
- **BUSCA, 4-detector camera (4-band simultaneous imaging in visible light)**
- **CAFOS, focal reducer camera and spectrograph with polarimetric capability**
- **CAFÉ, *échelle* VIS fiber-fed spectrograph (*R* 65 000)**
- **AstraLux, lucky imager in the near-infra-red**
- **PANIC, panoramic infra-red camera**

3.5 m telescope:
- **LAICA, 64 Mpix large area imager in visible light, 1 deg FOV**
- **MOSCA, focal reducer camera and spectrograph with polarimetric capability**
- **Omega-2000, second generation, high-performance IR camera**
- **PMAS, the world's largest FOV integral field spectrograph (1 arcmin)**
- **TWIN, long-slit, two-arm spectrograph (*R* up to 15 000)**
- **CARMENES, high-res VIS and IR échelle spectrograph**

CAFE

- Echelle Spectrograph: Design based on FOCES.
- Designed to be used in the 2.2m.
- Very stable (no movable parts)
- Resolution: 62000 ± 5000 (from blue to red).
- Wavelength Range: 3960 – 9500 A.
- Sensitivity: SNR~30 for a point-like source of V~14.5 magnitudes in a single integration of 2700s.
- More sensitive than FOCES at its best resolution

New instrumentation: PANIC (2012)



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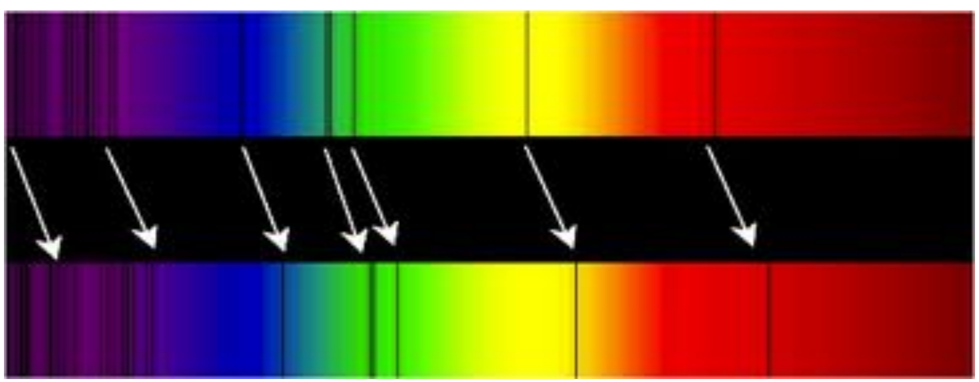
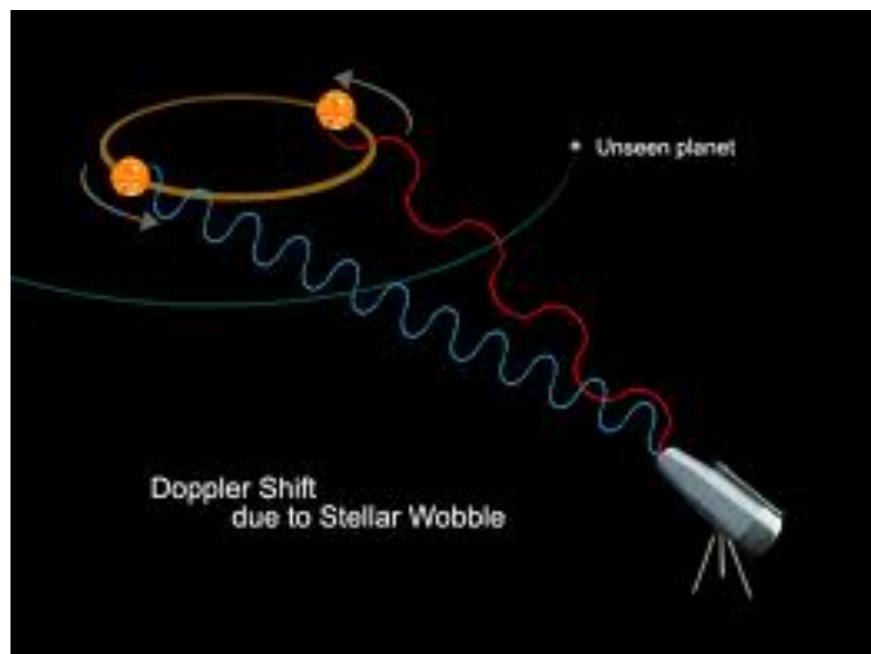
Nueva instrumentación: Carmenes (2014)

- <u>Objetivo</u>: búsqueda y caracterización de **exotierras** alrededor de estrellas frías
- <u>Técnica</u>: Velocidad radial
- <u>Hardware</u>: Espectrógrafo en los rangos ópticos (Heidelberg) e **IR (IAA, Granada)**





carmenes

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Why HEXA?

- Two decades of large photometric surveys: SDSS, 2MASS, WISE), there is a need of **massive spectroscopy**.
- Combination of photometric and spectroscopic data: key problems like the assembly and evolution of galaxies, cosmology , and stellar archeology, among others.

Extragalactic science:

a) **improved spectral resolution**,

b) with a **larger spatial coverage** (e.g. IFUs to resolve properties of nearby objects, as it is the case of CALIFA or MaNGA),

c) **deep enough** to observe low surface brightness galaxies (to ensure completeness of galaxy samples at low luminosities).

Stellar case will be dominated by the results of the **GAIA mission** (one billion stars down to magnitude V=20. Initial steps with Gaia-ESO

- "Astronet infrastructure road map" and "Science Vision for European Astronomy" reports (e.g. SV B7 at http://www.astronet-eu.org/).

We followed the MICINN/MINECO roadmap for new infrastructures:

RIA has informed very positively about HEXA

HEXA: 6.5m telescope for spectroscopic mapping

Base-line:

- Aperture 6.5m
- FOV 1.5 deg
- 500 multiplexing
- Medium to high-spectral resolution (R= 5,000 and 25,000)

Science with HEXA: some examples

a) Gaia follow-up: properties and evolution of stars and stellar associations

b) Plato/PlaVi: characterization of exoplanets

c) Extragalactic: post-CALIFA

Requirements Summary

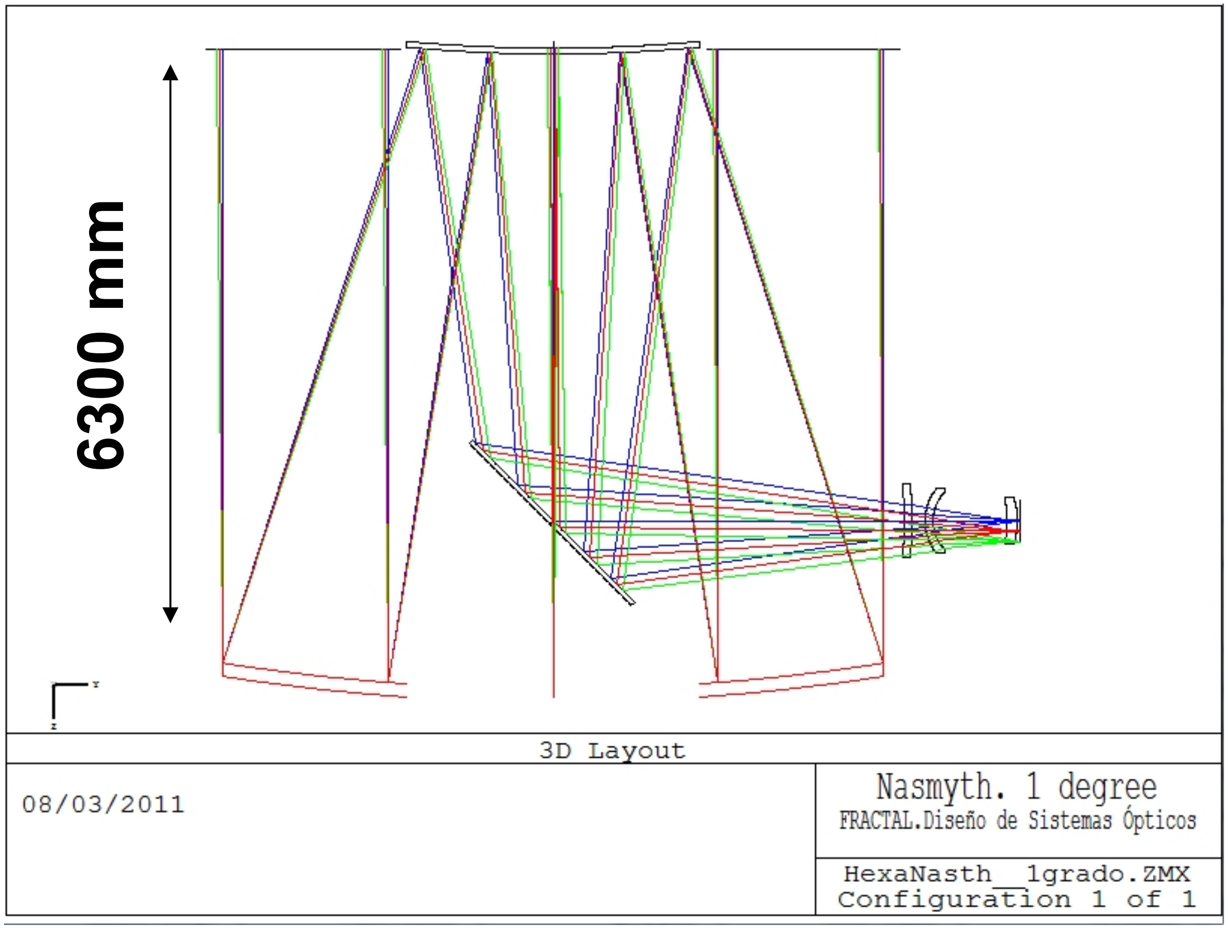
- Aperture: 6.5m diameter
- Output F# number = 3.6. (for the prime focus solution F#2.5 was used)
- Plate scale for 2M and 3M: 8.84 arcsec/mm (focal length 23.4m, F#3.6).
- Plate scale for 1M: 12.2 arcsec/mm (focal length 16.25 m, F#2.5)
- FOV: 1º to 2º Ø (diameter)
- Image quality: seeing limited
- Spectral range: narrow band filters 100 Å in the whole wavelength range : 3800 Å -11000 Å
- Optimized for fibers: Telecentric system and flat focal plane

Optical Designs

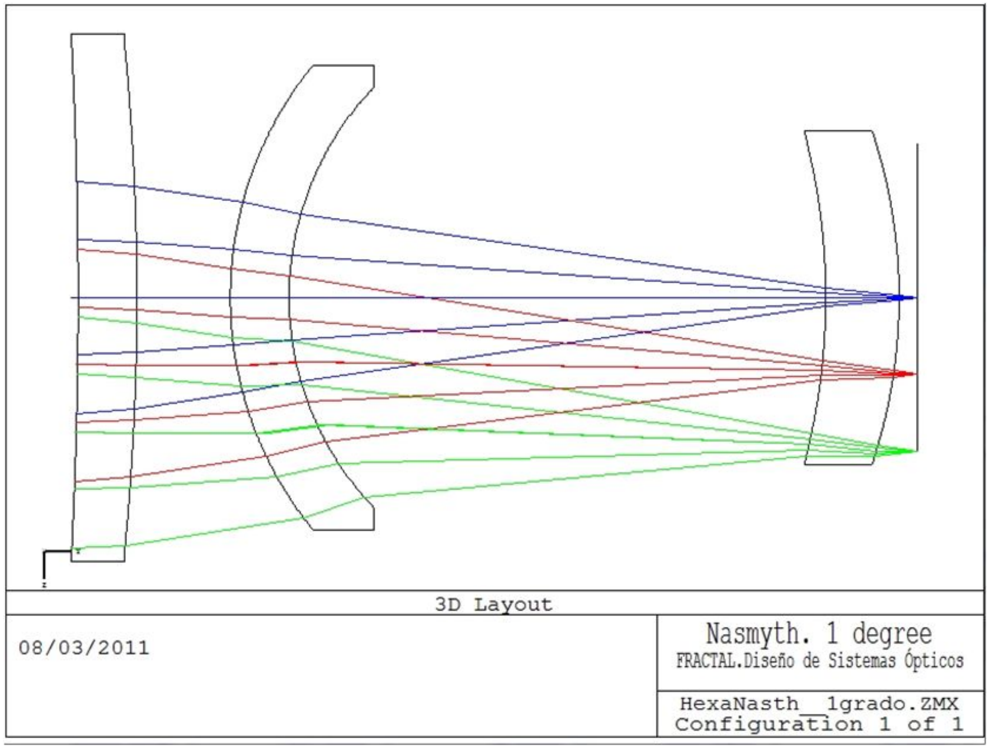
- Prime FOCUS 1 º
- Ritchie-Chrétien Cassegrain FOV: 1º
- Ritchie-Chrétien Cassegrain FOV: 2º
- Ritchie Chrétien Cassegrain FOV: 1.5º
- 3 Mirror solution FOV: 2º
- Ritchie-Chrétien Nasmith FOV: 1º

Design #6

- Nasmyth
- FOV 1º



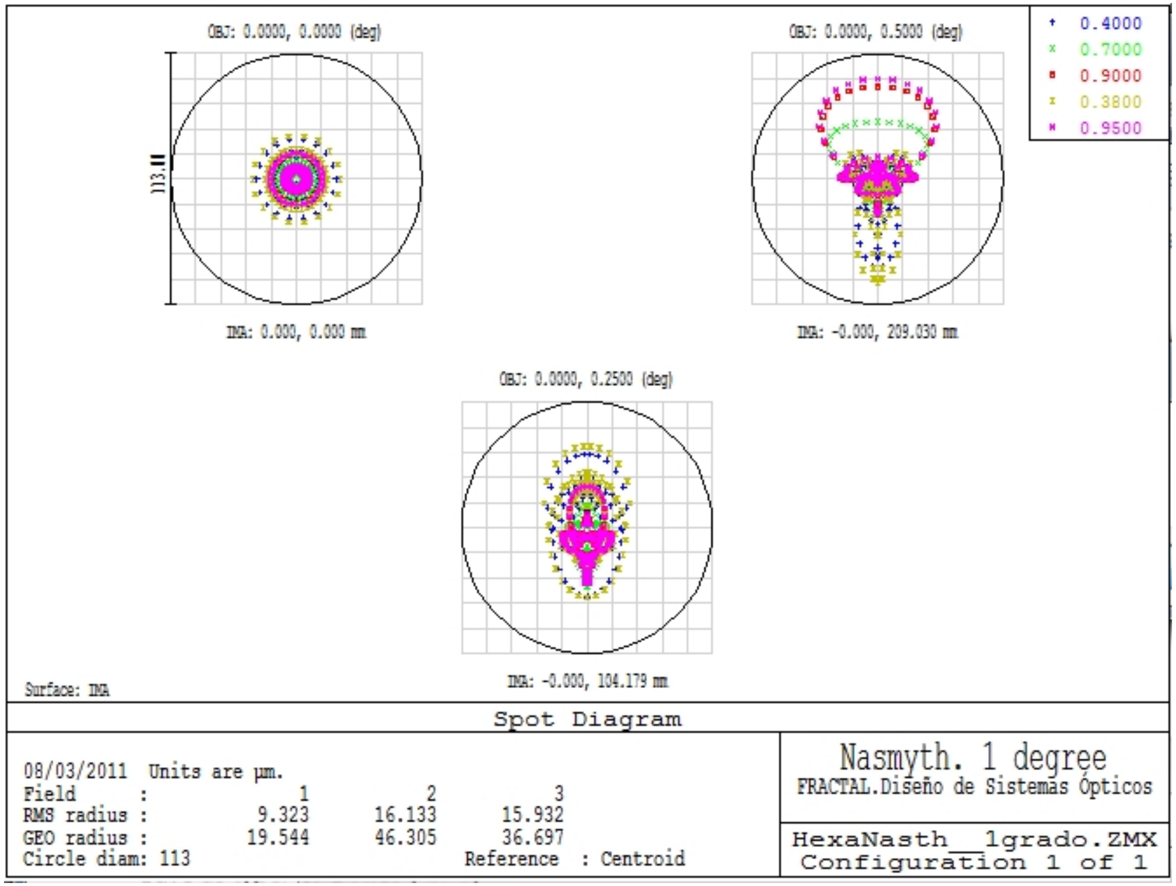
Corrector #6



	Glass	Diameter	Center Thickness	R1	R2	Aesf coeff
L1	N-FK5	720	80	-6863	-3600	
L2	N-BK7	630	80	500	412	
L3	N-FK5	460	100	-919	-719	yes

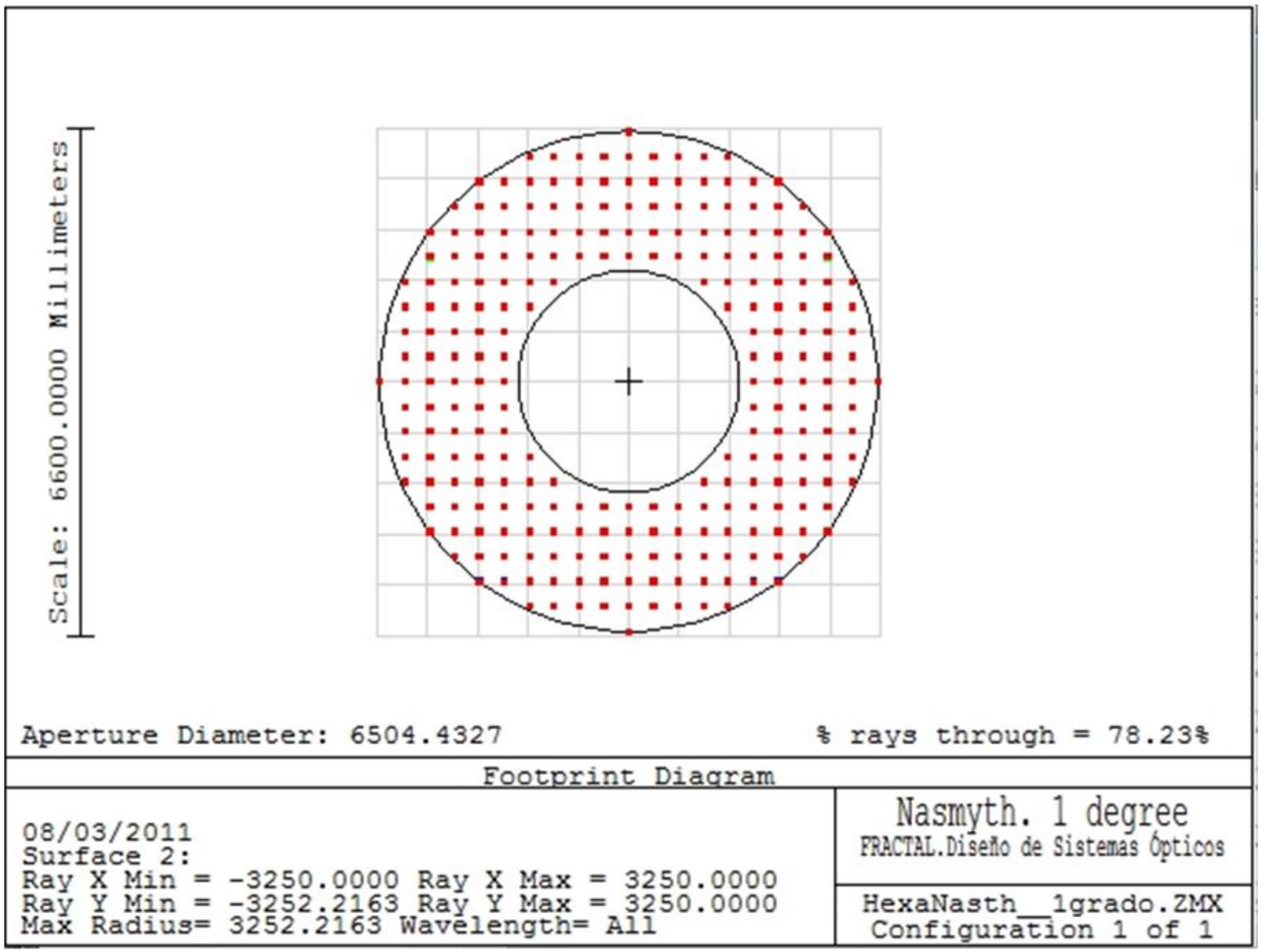
Image Quality #6

- Each circle is 1” Ø (113 μm).
- The following fields from the center :0º,0.25º,0.5º (Ø 0º,0.5º,1º)



Effective Aperture #6

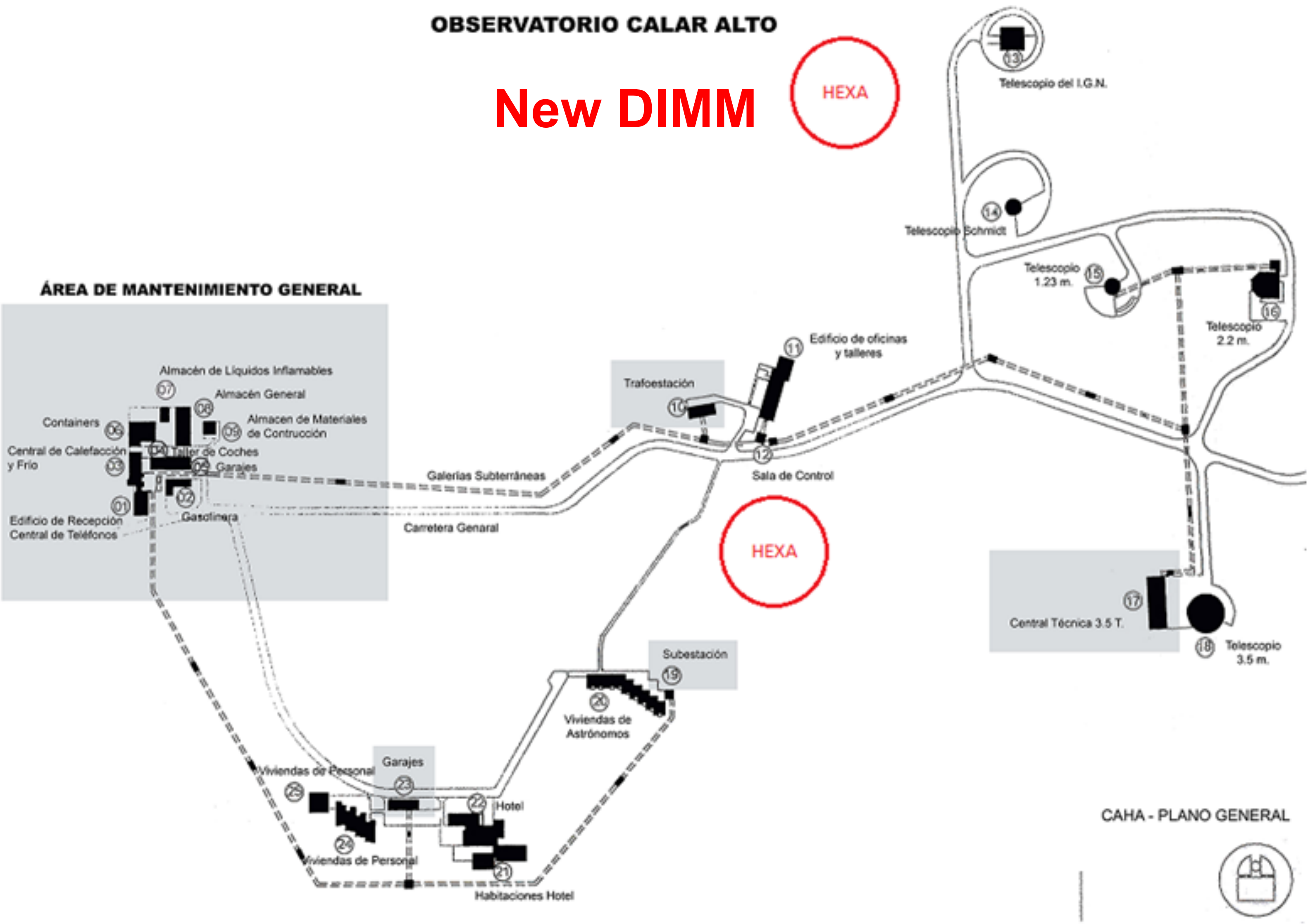
- Shows the aperture diameter and the effective % of flux through the aperture.
- Vignetting is 21.77%



Other considerations

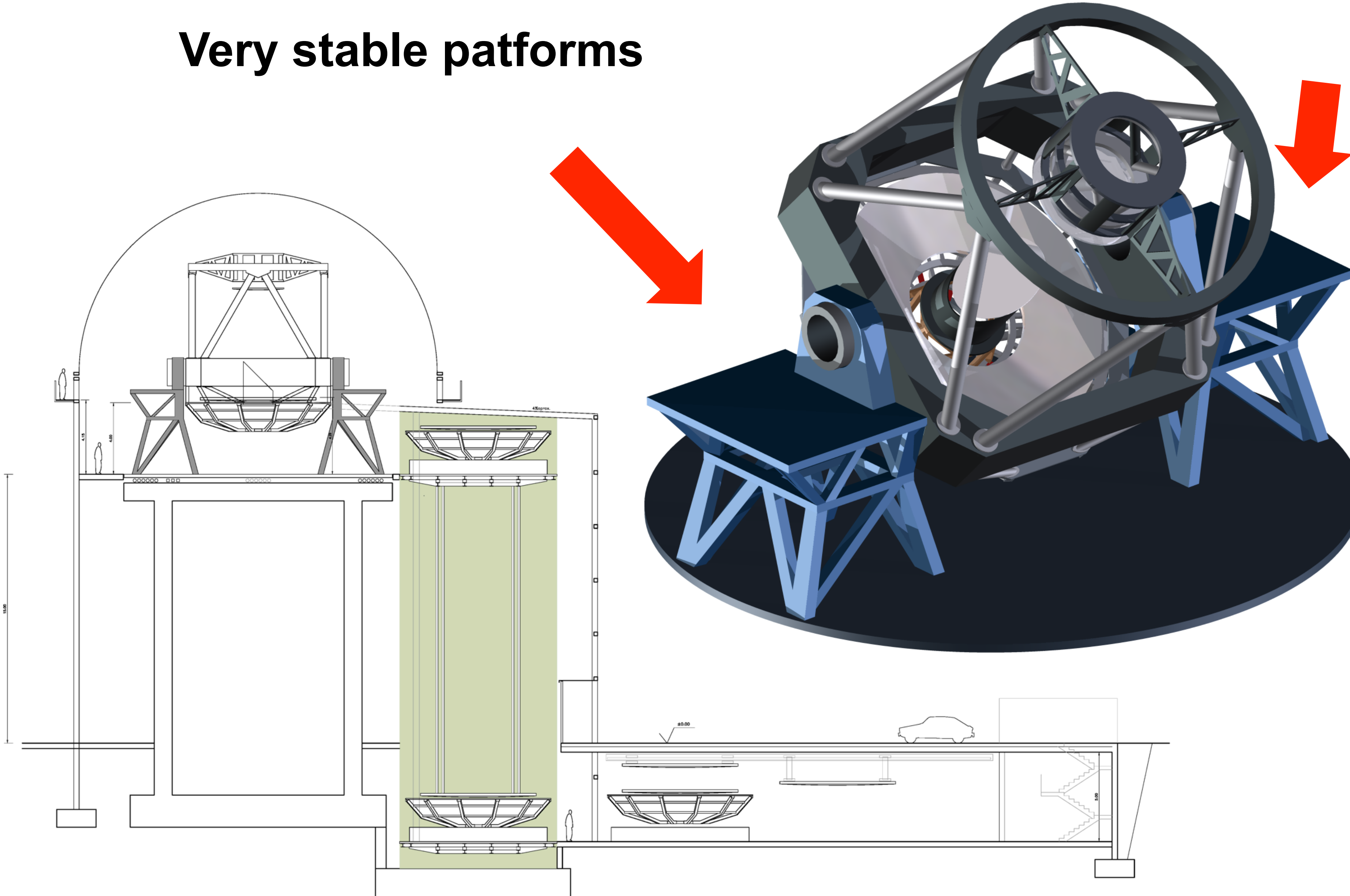
- ✓ Fully telecentric system.
- ✓ Good image quality (slightly worse and less efficient that Cas focus)
- ✓ Optimum design due to good access to the focal plane
- ✓ The most compact design
- ✓ Two foci keep two instruments at same time.
- ➢ Microlenses are needed to be coupled to fibers
- ➢ Need of baffle that could decrease the effective aperture (73% TBC)
- ➢ The most expensive

Location

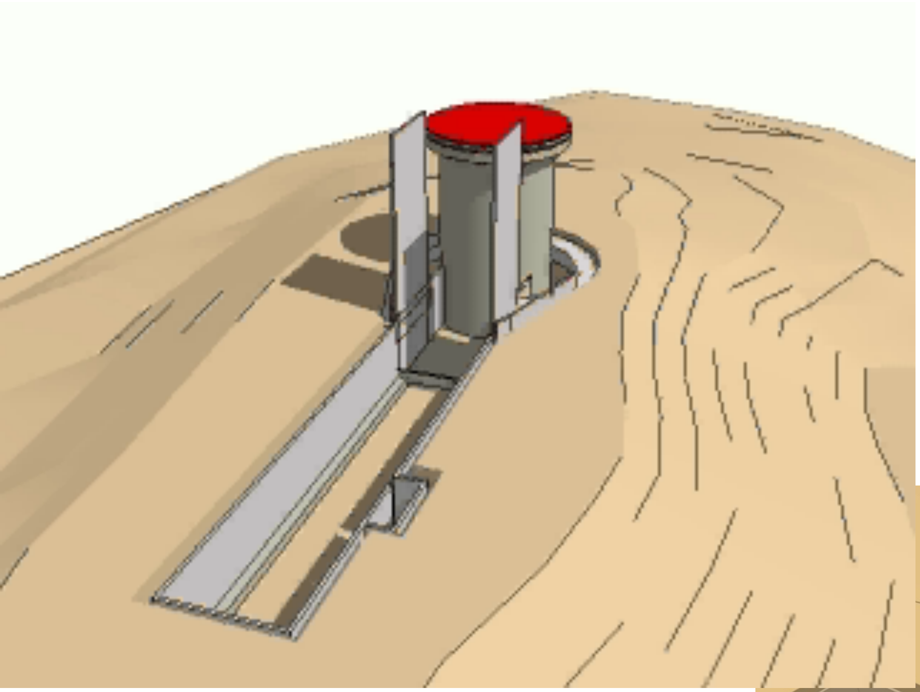

OBSERVATORIO CALAR ALTO
New DIMM
HEXA
HEXA
ÁREA DE MANTENIMIENTO GENERAL
Almacén de Líquidos Inflamables
Almacén General
Almacen de Materiales
de Contrucción
Containers
Central de Calefacción
y Frío
Taller de Coches
Garajes
Edificio de Recepción
Central de Teléfonos
Gasolinera
Galerías Subterráneas
Carretera Genaral
Trafoestación
Edificio de oficinas
y talleres
Sala de Control
Telescopio del I.G.N.
Telescopio Schmidt
Telescopio
1.23 m.
Telescopio
2.2 m.
Central Técnica 3.5 T.
Telescopio
3.5 m.
Subestación
Viviendas de
Astrónomos
Garajes
Viviendas de Personal
Hotel
Viviendas de Personal
Habitaciones Hotel
CAHA - PLANO GENERAL

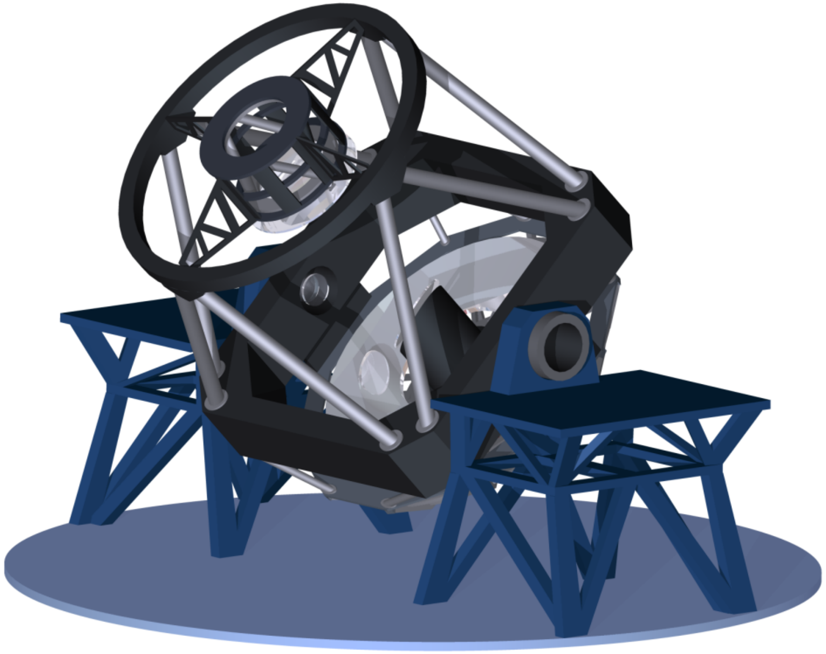
HEXA, 6.5m for massive spectroscopy

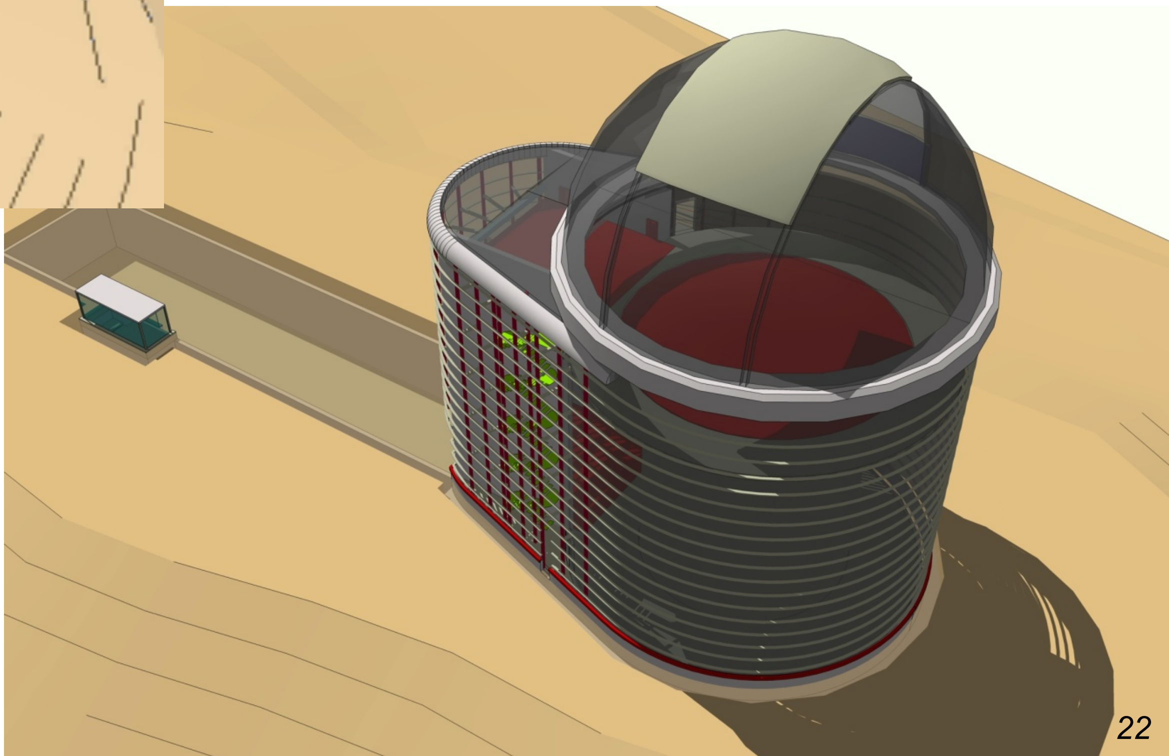
Very stable patforms



2017: HEXA at CAHA







CEO (MONSUL)

MONSUL

the HEXA Imaging Fourier Transform Spectrometer for Wide Field Astrophysics

Jorge Iglesias Páramo
Instituto de Astrofísica de Andalucía - CSIC

Technical requirements for *MONSUL*

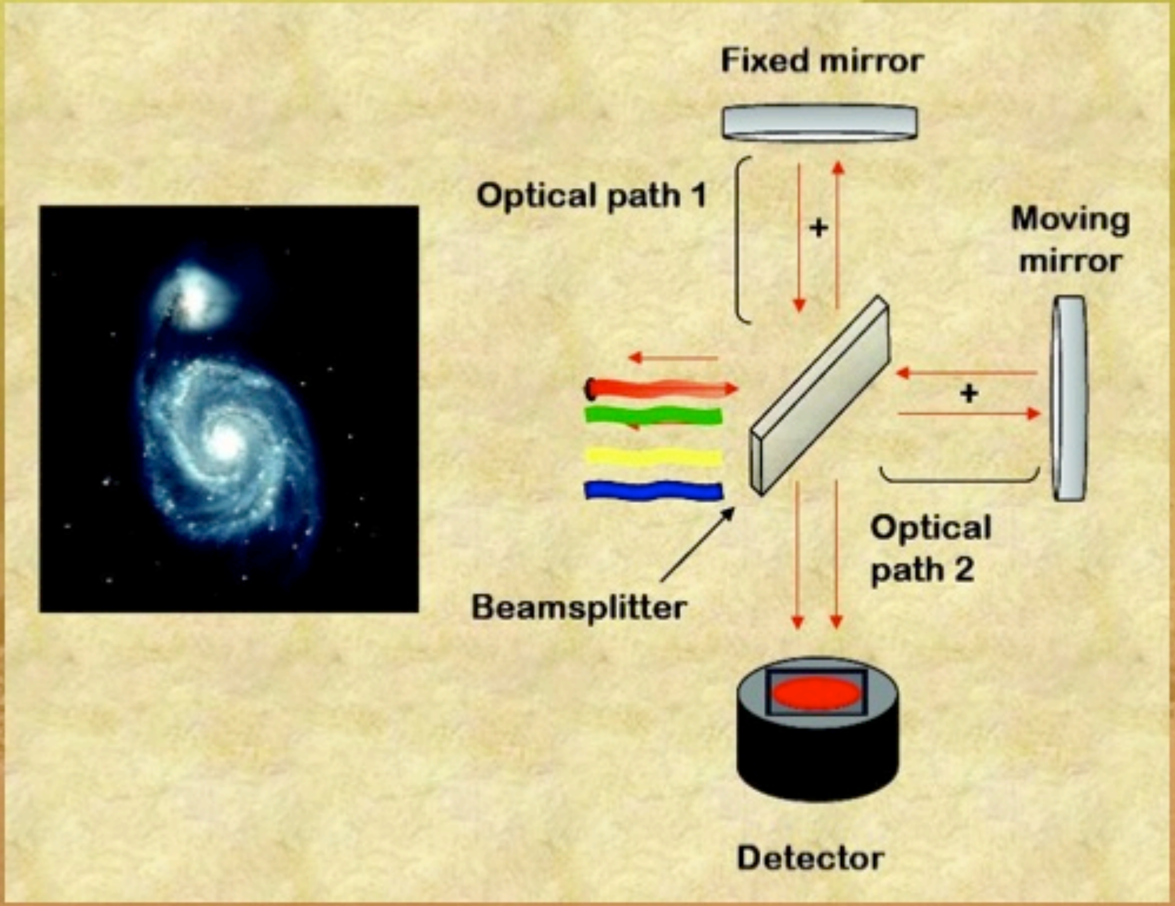
- **Field of view:** ~30 arcmin diameter (circular)
  Corresponds to a physical size of optical elements of ~20cm diameter (assuming a plate scale of 8.84"/mm).

- **Spectral coverage:** [3700,10000]Å
  Implies a minimal Optical Path Difference of 185nm (to cover the whole spectral range).
  Restricting to reduced spectral ranges saves observing time by means of narrow and/or broad band filters (increasing the Optical Path Difference without loosing spectral resolution).
  Efficient observations are achieved with broad/intermediate/narrow band filters, selecting the useful spectral range.

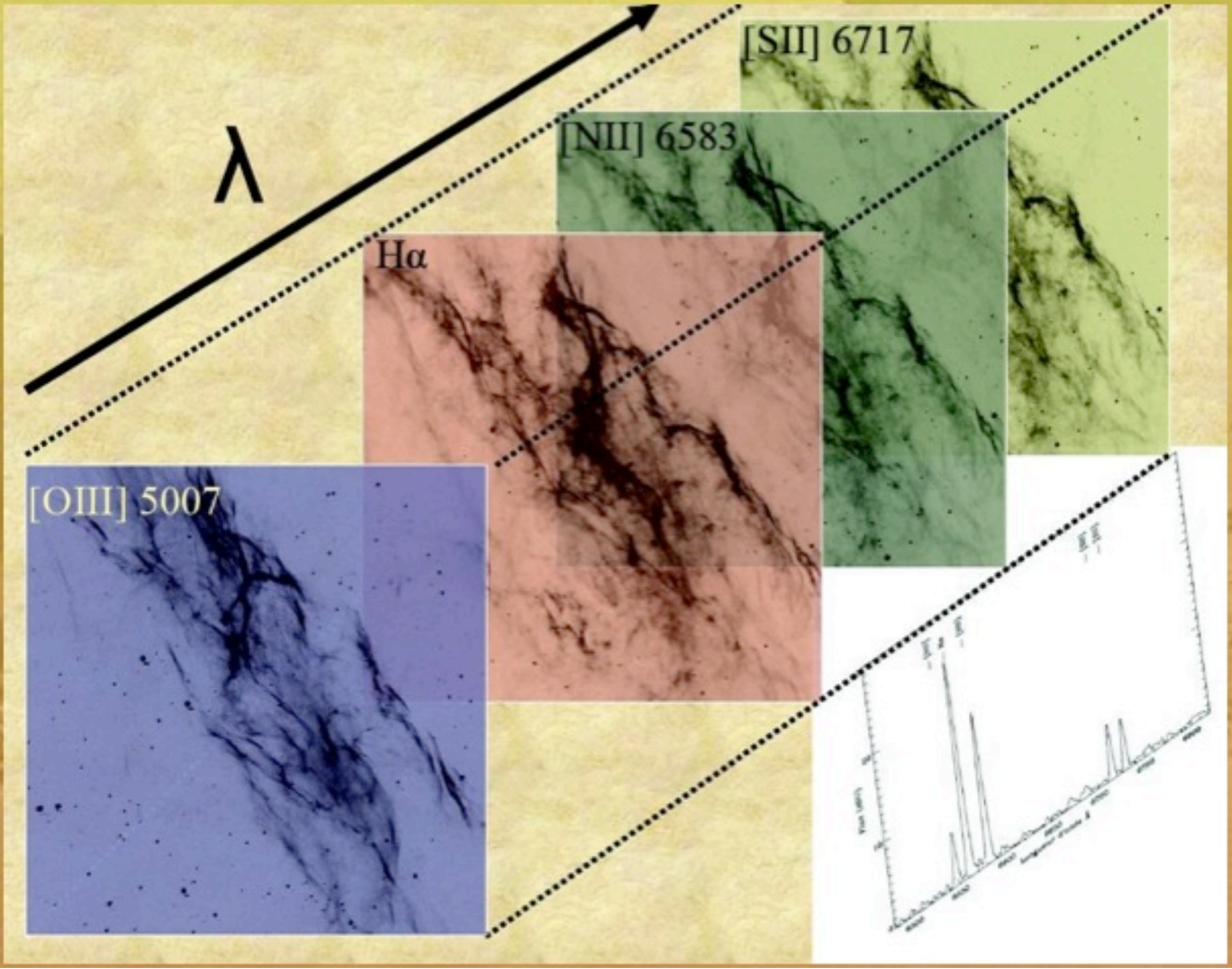
- **Resolving power:** flexible between $1 < R < 20000$
  Variable without changing mechanical elements during the observations.

IFTSs are based on the Michelson interferometry, with a fixed and a moving mirror.

The result of an exposure is a data cube in the 3-D space (R.A., Dec., OPD).

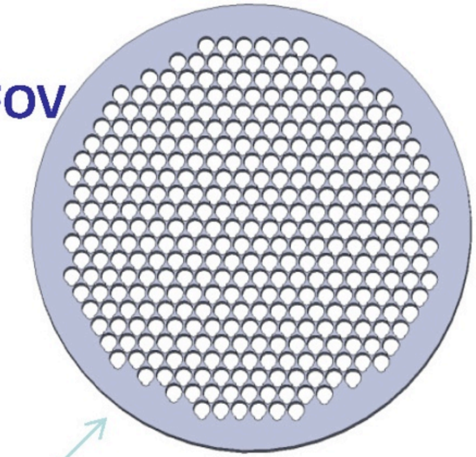


The final result is a data cube in the 3-D space (R.A., Dec., wavelength) that allows the construction of bi-dimensional maps of emission/absorption features or one spectrum per pixel of the CCD.

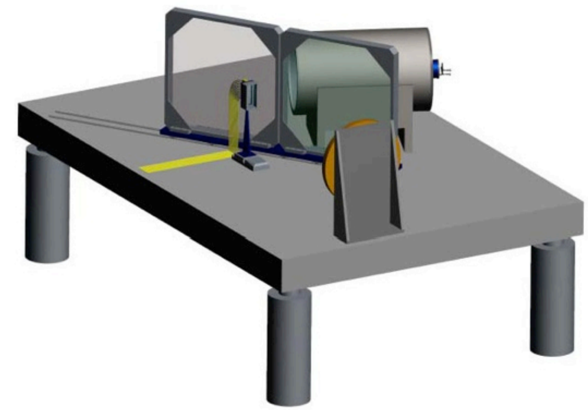


HECATE at HEXA

Fiber MOS
361 positioners over 1 degree FOV



Individual fibers, 150µm core sampling 1.33 arcsec on sky

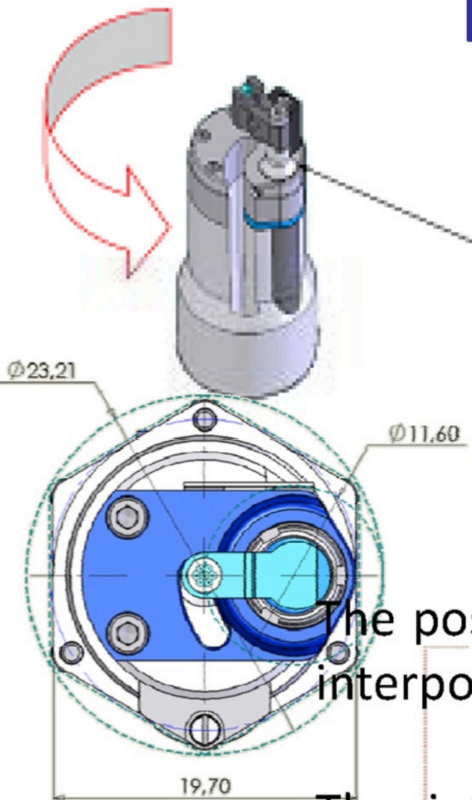


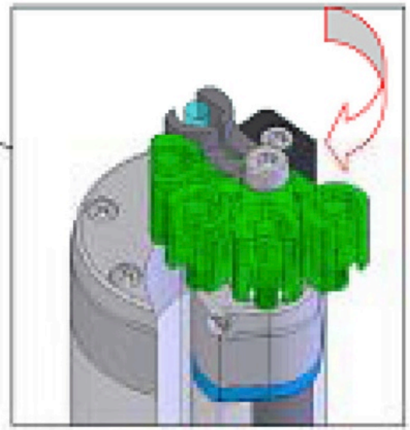
HEXA: 6.5m aperture, Ritchey-Chrètien

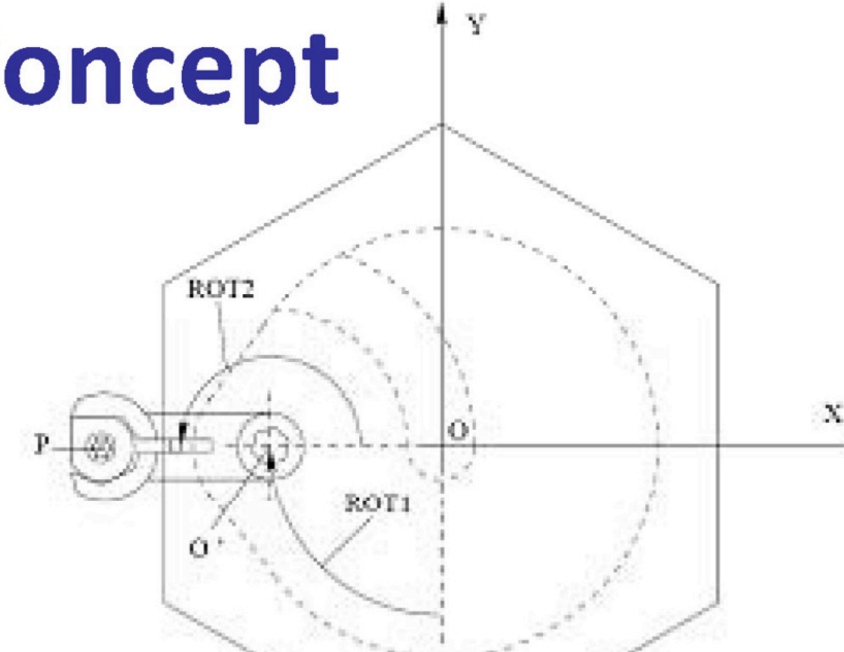
f/3.6 at Nasmyth and Cassegrain

High Resolution (R ~ 25000)
Fiber-fed spectrograph

Positioner Concept





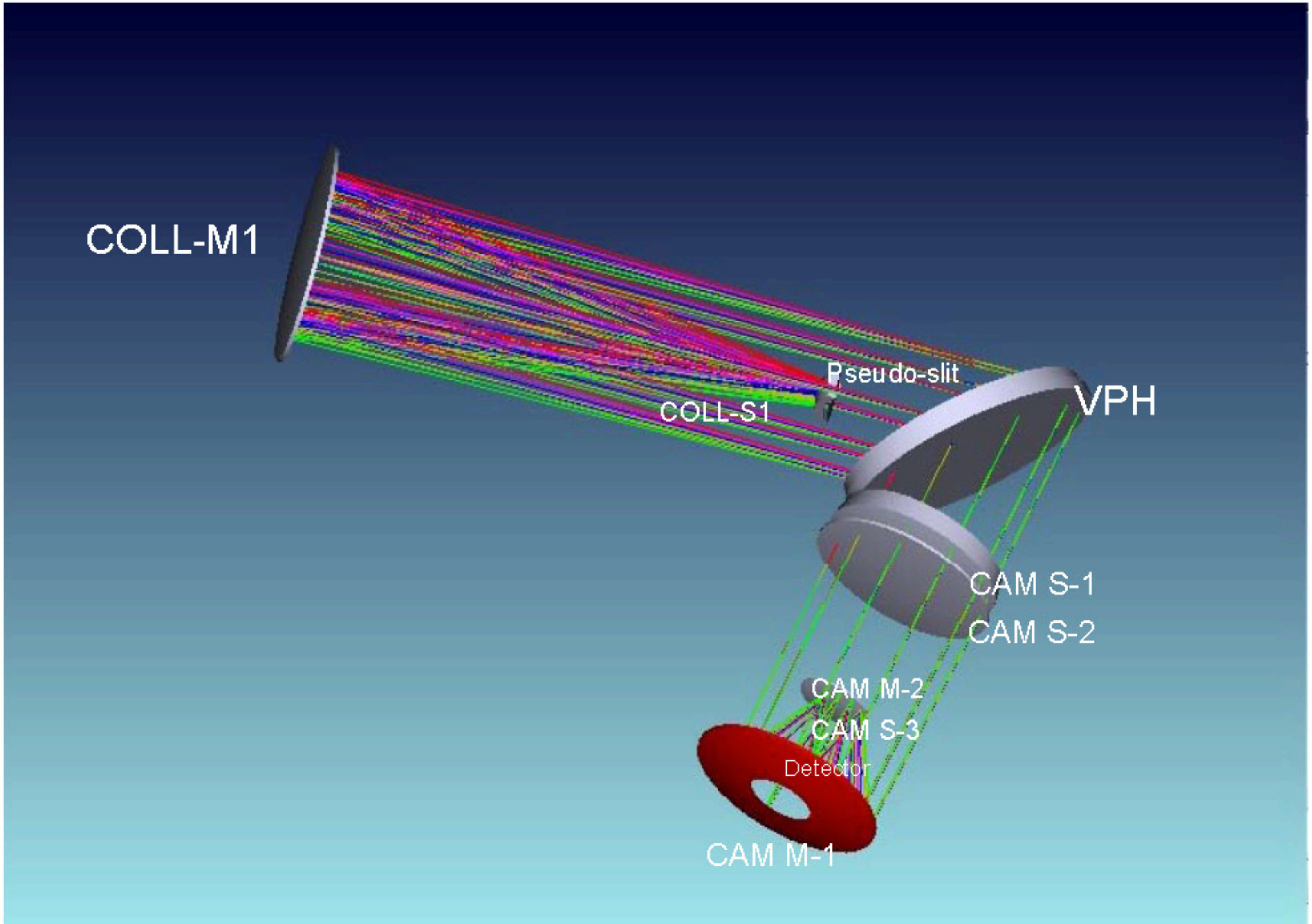


The positioning of the fiber optic bundle is performed combining the interpolation of two rotations.

The interpolation between the rotation 1 and rotation 2 allows covering the area assigned to each actuator. The combination of both movements covers a circle with a radius of 11.605mm from the centre of the actuator (this circle reaches the corners of the hexagon with an E/C of 20.1mm).

Combining both rotations the fiber tip can reach any point inside the circle of maximum diameter (patrol disc).

Spectrograph Optics



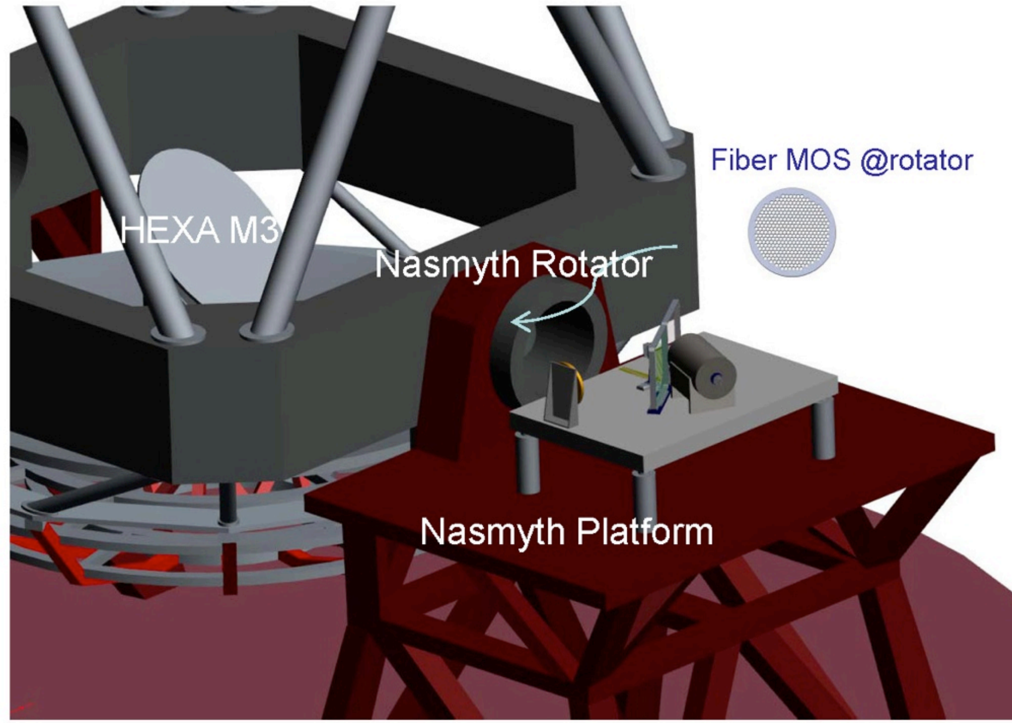
HECATE: Spectrograph Optics Conceptual Design

HECATE at Nasmyth

- Fiber MOS rotates with Nasmyth rotator
- The spectrograph is in the optimum position: fixed on Nasmyth platform
- This provides high stability
- Fibers are driven to pseudo-slit frame at the entrance of the spectrograph
- Fiber length estimation: < 8m

~ 4.0m (through Nasmyth rotator)

~ 3.5m (from rotator to pseudo-slit)

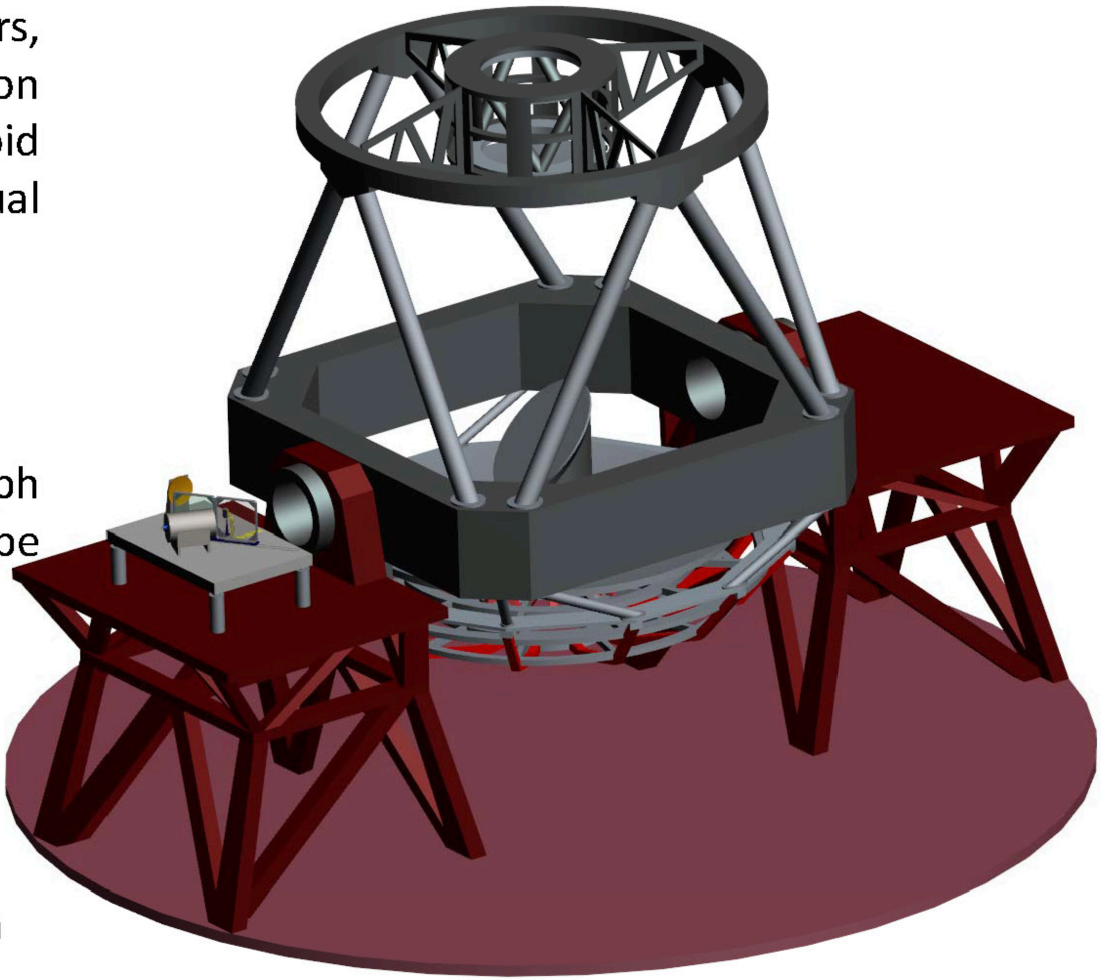


The length could be optimized to < 6m

(*) Nasmyth rotator is which is ~ 1.5m ∅

HECATE Conclusions

- HEXA optical design is highly optimized for the use of fibers
- The f# 3.6 is perfectly fitted to fibers, minimizing FRD and, in combination with the Nasmyth position, to avoid the use of microlenses for individual fibers
- HEXA beam is telecentric
- HECATE is a fiber-fed spectrograph specially designed for HEXA telescope capabilities.
- HECATE is composed by:
  - The fiber MOS at Nasmyth focal plane
  - The fiber bundles
  - The spectrograph on Nasmyth platform



HECATE Conclusions

- The spectrograph provides **R ~ 25000** over the whole visible wavelength range for the 361 objects simultaneously (single order, no echelle)

- For gratings have been designed centered at

- Hα (6563 Å) and Li I (6708 Å)
- K I (7700 Å)
- Na I (8200 Å)
- Ca II Triplet in the IR (8498, 8542, 8662) until 8700 Å.

- The current design is a **catadioptric system** with a small penalty (~ 25%) in throughput due to vignetting that however is compensated by the optical design of both telescope and instrument, and the use of single VPH.

- There is no competition with other telescopes