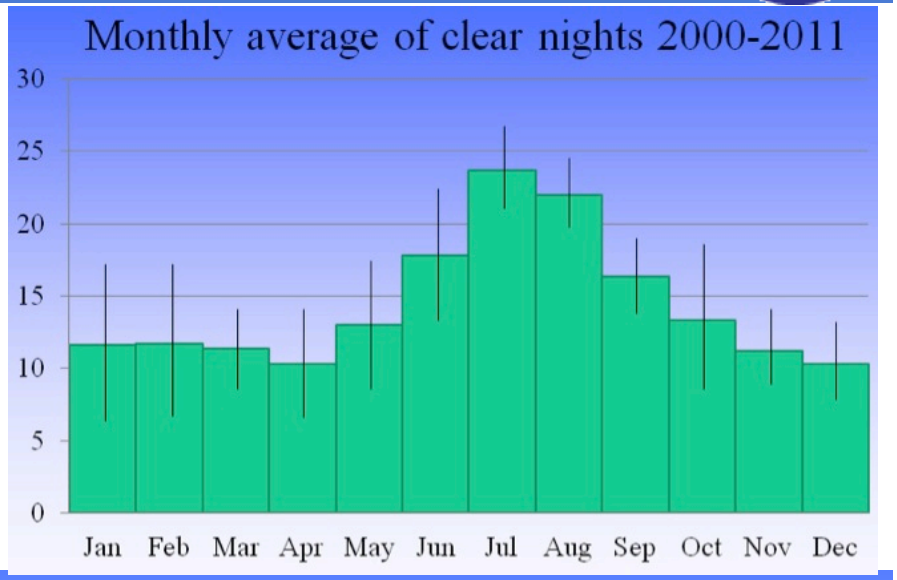
# Large surveys at CAHA

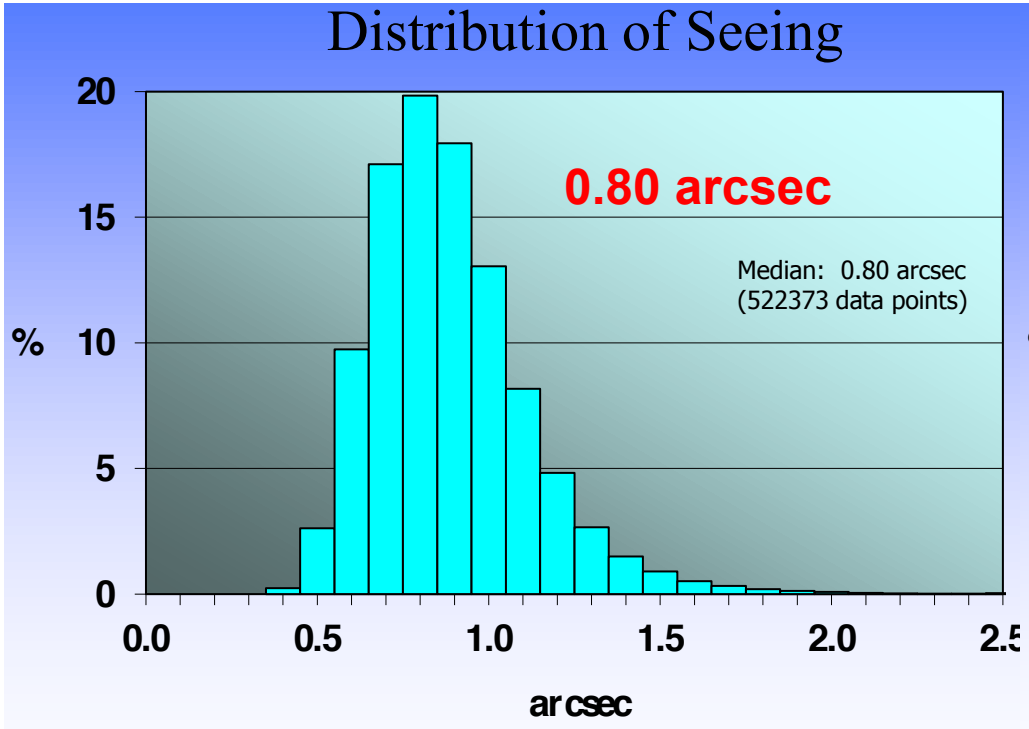
Valencia, March 30th, 2012

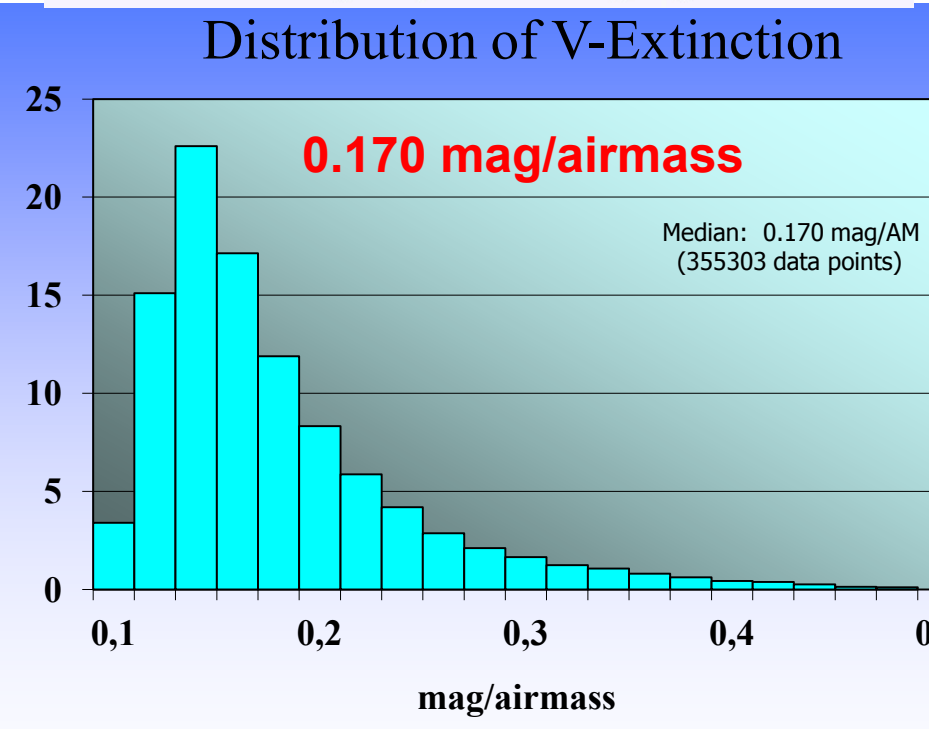
David Barrado

# The sky at Calar Alto

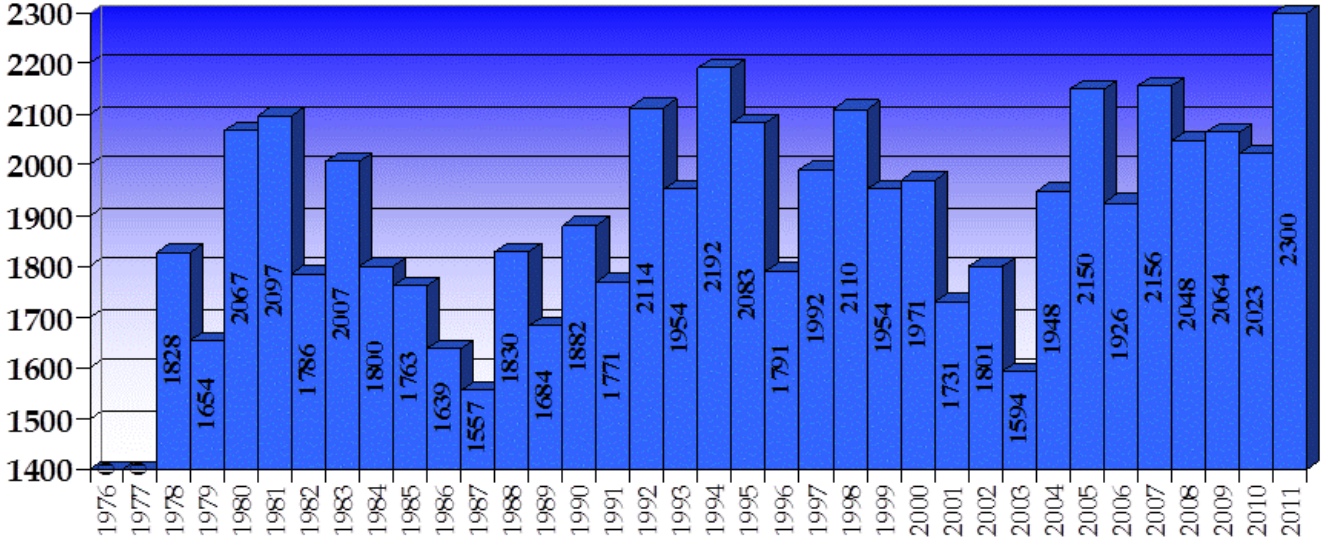
- **3.5m, 2.2m (& 1.23m, Schmidt)**
- OAN 1.5m
- INTA 0.5m
- GAW (cherenkov telescopes)



# The sky at Calar Alto

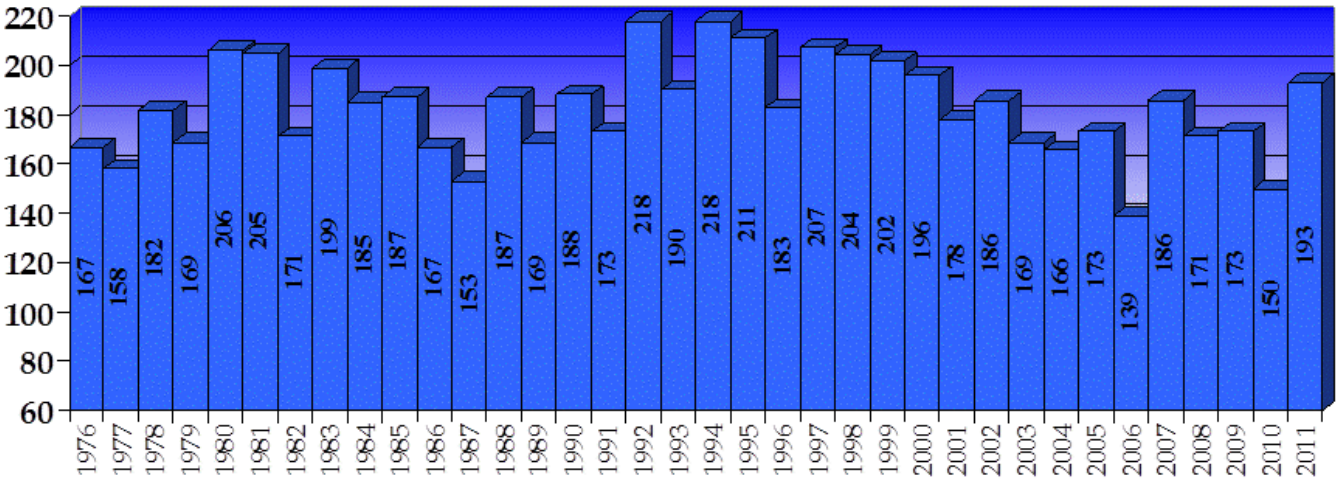



## Hours observed

Useful:

2010: 2023 hr

**2011: 2300 hr**




## Clear nights

*Clear: at least 6 observing hours of clear or mostly clear sky*

Photometric:

2010: 58 n

**2011: 106 n**

Clear:

2010: 150 n

**2011: 193 n**

**Fraction of useful time: ~70%** (~40% of the nights are 100% useful)

Analysis published in refereed journals (Sanchez et al. 2007, 2008)

*David Barrado*

# Time allocation

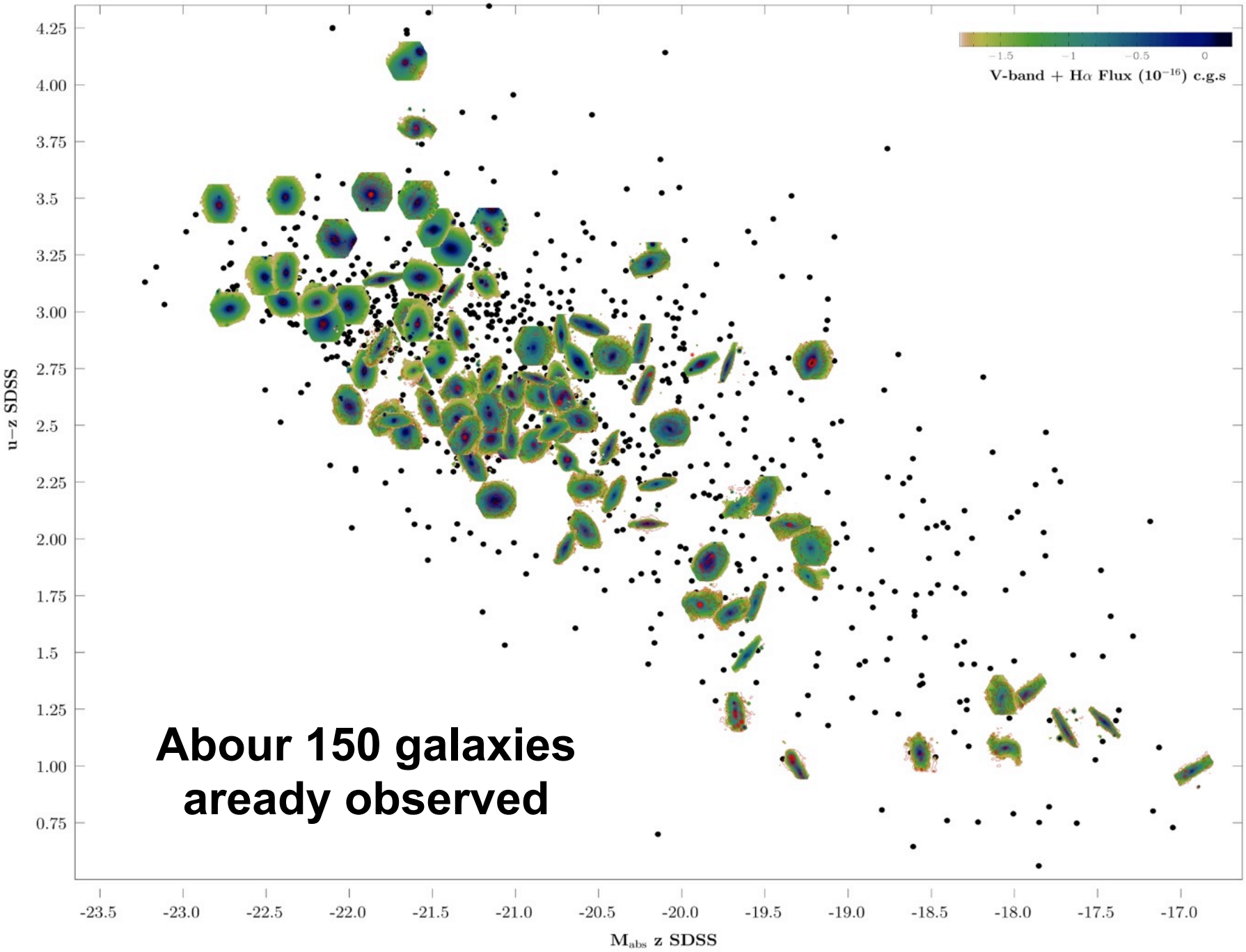
- **German (MPIA) and Spanish GT.-** 26 n per semester each, buffer

- **Legacy Programs.-**
  210 n (250 n) for CALIFA at the 3.5m, 600 n for CARMENES at 3.5

- **Open.-** German/Spanish TAC (pressure about 2 => 3)

# CALIFA: Introduction

- Legacy Survey of Galaxies in the Local Universe, using Integral Field Spectroscopy (CAHA 3.5m telescope).
- 82 members of 13 countries (25 institutes):
  - PI: S.F.Sánchez.
  - PS: C.J. Walcher.
  - Board (Chair: R. Kennicutt / P. Vilchez)
- 210 (250) dark nights in 3 years:
  - ~2.5 Millons Euros in Telescope time.
  - Extensive review process.
- Started on July 1st 2010. End late 2013


V-band + Hα Flux ($10^{-16}$) c.g.s
−1.5
−1
−0.5
0
u−z SDSS
4.25
4.00
3.75
3.5
3.25
3.00
2.75
2.5
2.25
2.00
1.75
1.5
1.25
1.00
0.75
-23.5
-23.0
-22.5
-22.0
-21.5
-21.0
-20.5
-20.0
-19.5
-19.0
-18.5
-18.0
-17.5
-17.0
$M_{abs}$ z SDSS
Abour 150 galaxies
aready observed

# CALIFA: Expected results

- ✓ Mapping the SFR in galaxies: relation with morphology, kinematics and merging history.
- ✓ Mapping the gas metallicity distribution: Secular evolution vs. interactions/bars.
- ✓ Spatially resolved Star-formation history of galaxies: relation with kinematics and morphology.
- ✓ Effects of the presence of an AGN: quenching, re-youth, feedback?
- ✓ Evolutionary paths along the CM diagram.

# The gates to ALL CAHA data

## CAHA

CALAR ALTO OBSERVATORY - *ARCHIVE*

**Accessing to Calar Alto Observatory Archive...**

Please use your account to log in.

Username :

Password :

Login >>

New Account

Forgot your account?


## Spanish Virtual Observatory


The Calar Alto Archive

This data server provides access to the CAHA Archive. The German-Spanish Astronomical Center at Calar Alto is located in the Sierra de Los Filabres (Andalucía, Southern Spain) north of Almeria. It is operated jointly by the Max-Planck-Institut für Astronomie (MPIA) in Heidelberg, Germany, and the Instituto de Astrofísica de Andalucía (CSIC) in Granada/Spain. Calar Alto provides three telescopes with apertures of 1.23m, 2.2m and 3.5m to the general community.

Resources

- **Calar Alto Archive**
- **Help Desk**
- **System Overview**
- **News**
- **Private zone**

The CAHA Archive has been developed in the framework of the Spanish Virtual Observatory project supported by the Spanish MICINN through grant AYA 2008-02156. The system is maintained by the Data Archive Unit of the CAB (CSIC -INTA)

If you use this service in your research, please include the following acknowledgement in any resulting publications:

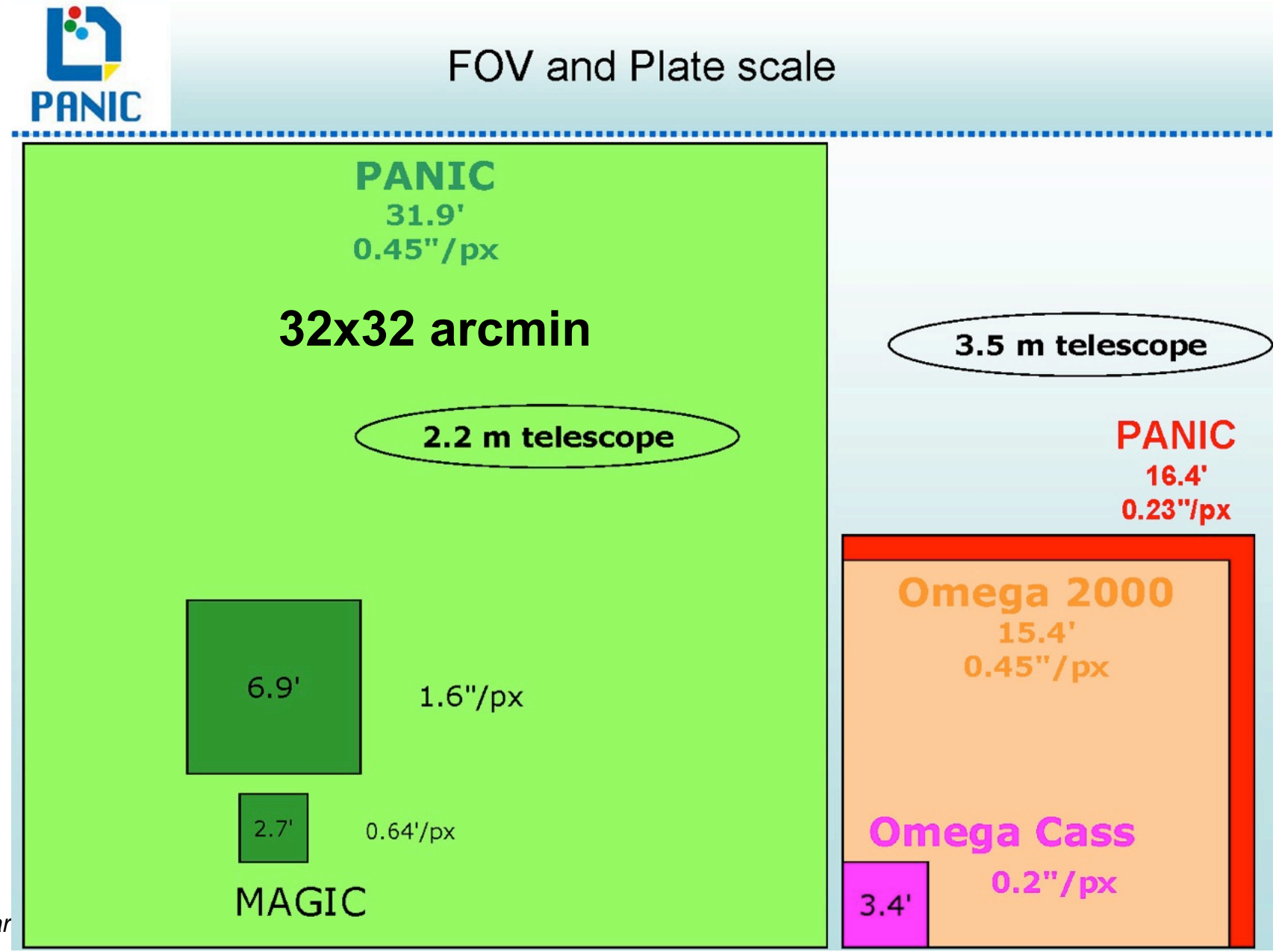
**"Based on data from the CAHA Archive at CAB (INTA-CSIC)"**

# Telescopes & instruments: from 2012 to 2014

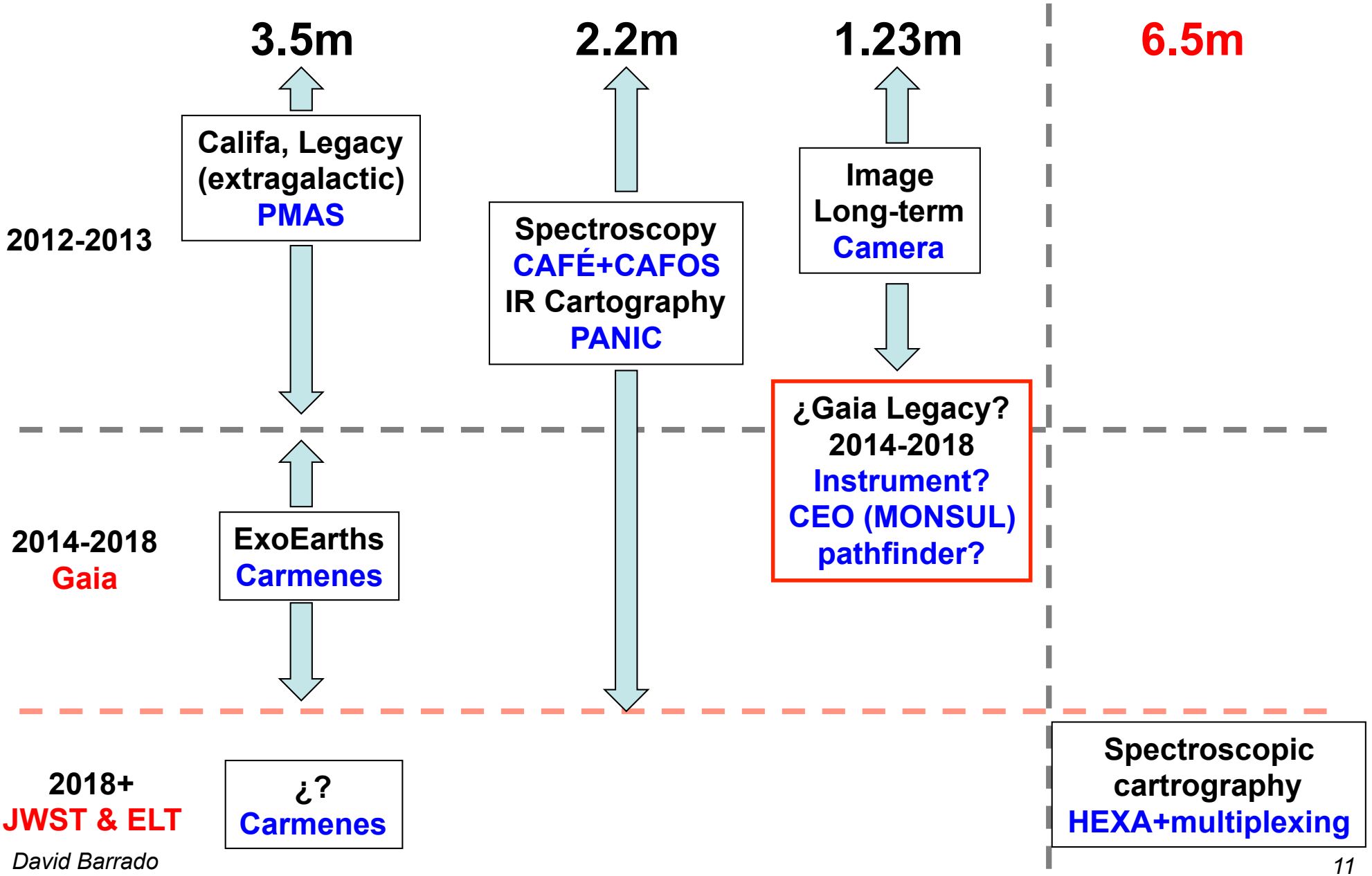
| | OPTICAL (moonless nights) 2012 | Near-infrared (shiny nights) | OPTICAL (moonless nights) 2014 | Near-Infrared (shiny nights) |
|---|---|---|---|---|
| **3.5m .-** | **PMAS**<br>TWIN<br>LAICA<br>MOSCA | **Omega2000**<br>~~OmegaCass~~ | PMAS<br>(TWIN) | **Carmenes**<br>(PANIC) |
| **2.2m.-** | **CAFOS**<br>BUSCA<br>**CAFÉ (2011)** | MAGIC<br>**PANIC (2012)** | **CAFÉ**<br>(CAFOS) | **PANIC** |
| **1.23m.-** | New CCD camera | | ????? | |
| | As many changes as requested | | - Two changes per month (every 15 days, from dark nights to bright and back) | |

| **Astronet recommendations** | Calar Alto | | |
|---|---|---|---|
| CAHA 3.5 | PMAS-PPAK | CARMENES<br>if selected, **if not →** | **1 deg$^2$ NIRCam?**[1] |
| CAHA 2.2 | CAFE | CAFOS | PANIC |

# New instrumentation: PANIC (2012)



# CALAR ALTO: 2012-2018+



# Why HEXA?

- Two decades of large photometric surveys: SDSS, 2MASS, WISE), there is a need of **massive spectroscopy**.
- The combination of both (photometric and spectroscopic) sets of data will allow the solution of open key problems like the assembly and evolution of galaxies, cosmology , and stellar archeology, among others.
- **Extragalactic science**:

a) **improved spectral resolution** (e.g. search for supermassive blackholes),

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, but radial velocities and chemical abundances only for restricted subsamples). 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 doanmap 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
- 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: characterization of exoplanets*

*c) Extragalactic: post-CALIFA*

*d) Cosmology: post-ALHAMBRA*

*e) Cosmology: dark energy and acustic barionic oscilations*

# Requirements Summary

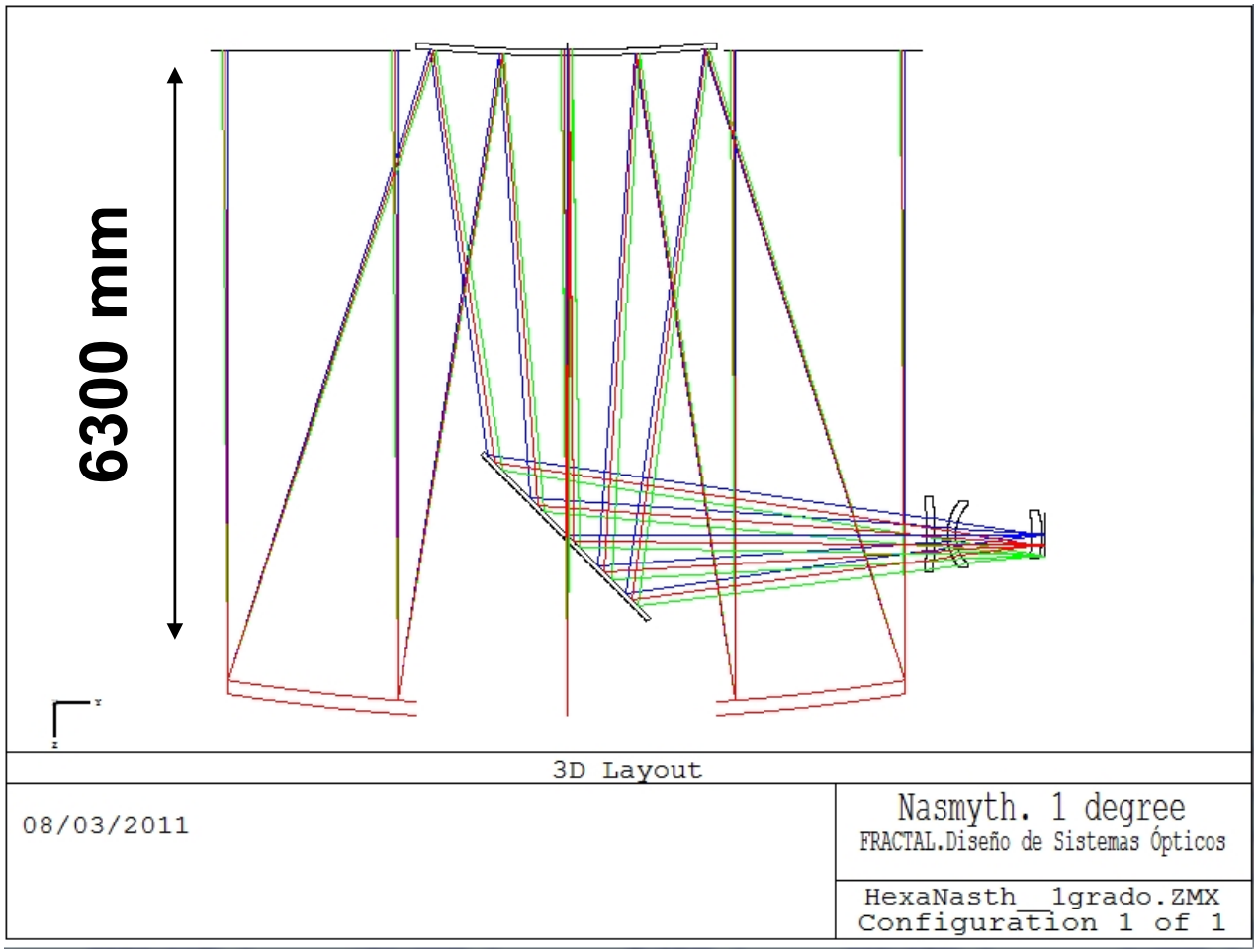
- Aperture: 6.5m diameter
- Output F# number = 3.6. (for the prime focus solution F#2.5 was used)
- Plate scale for 2M and 3M: 8.84 arcsec/mm (focal length 23.4m, F#3.6).
- Plate scale for 1M: 12.2 arcsec/mm (focal length 16.25 m, F#2.5)
- FOV: 1º to 2º Ø (diameter)
- Image quality: seeing limited
- 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

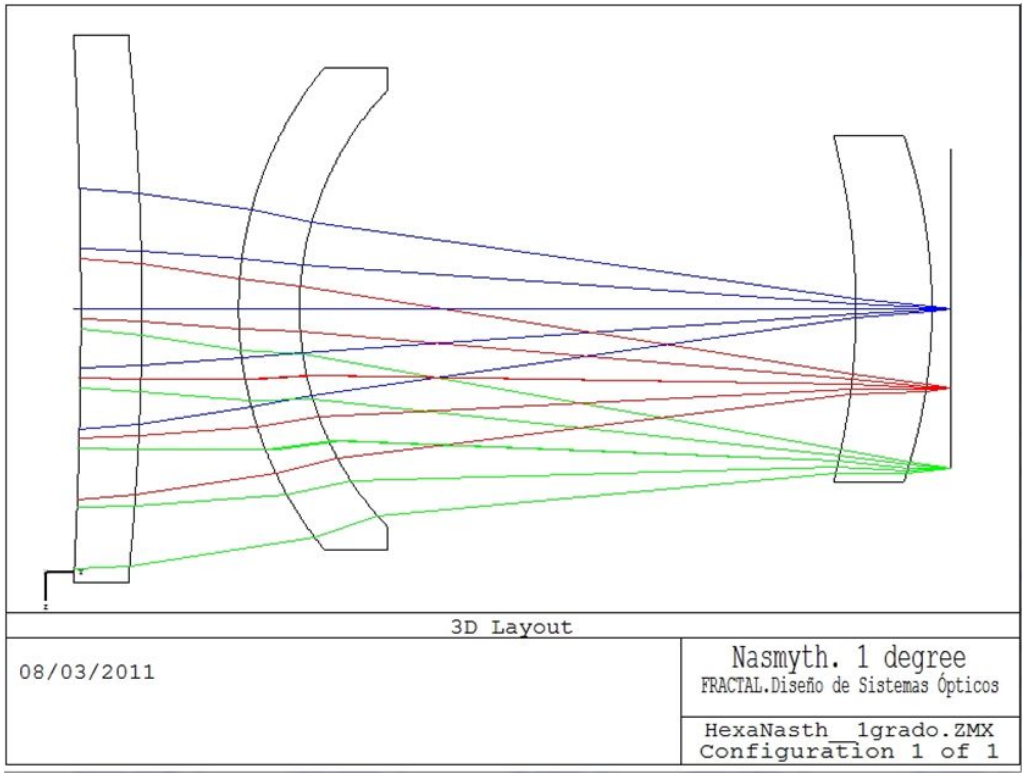
- Prime FOCUS 1 º
- Richie- Chretien Cassegrain FOV: 1º
- Richie-Chretien Cassegrain FOV: 2º
- Richie Chretien Cassegrain FOV: 1.5º
- 3 Mirror solution FOV: 2º
- Richie Chretien Nasmith FOV: 1º

# Design #6

- Nasmyth
- FOV 1º



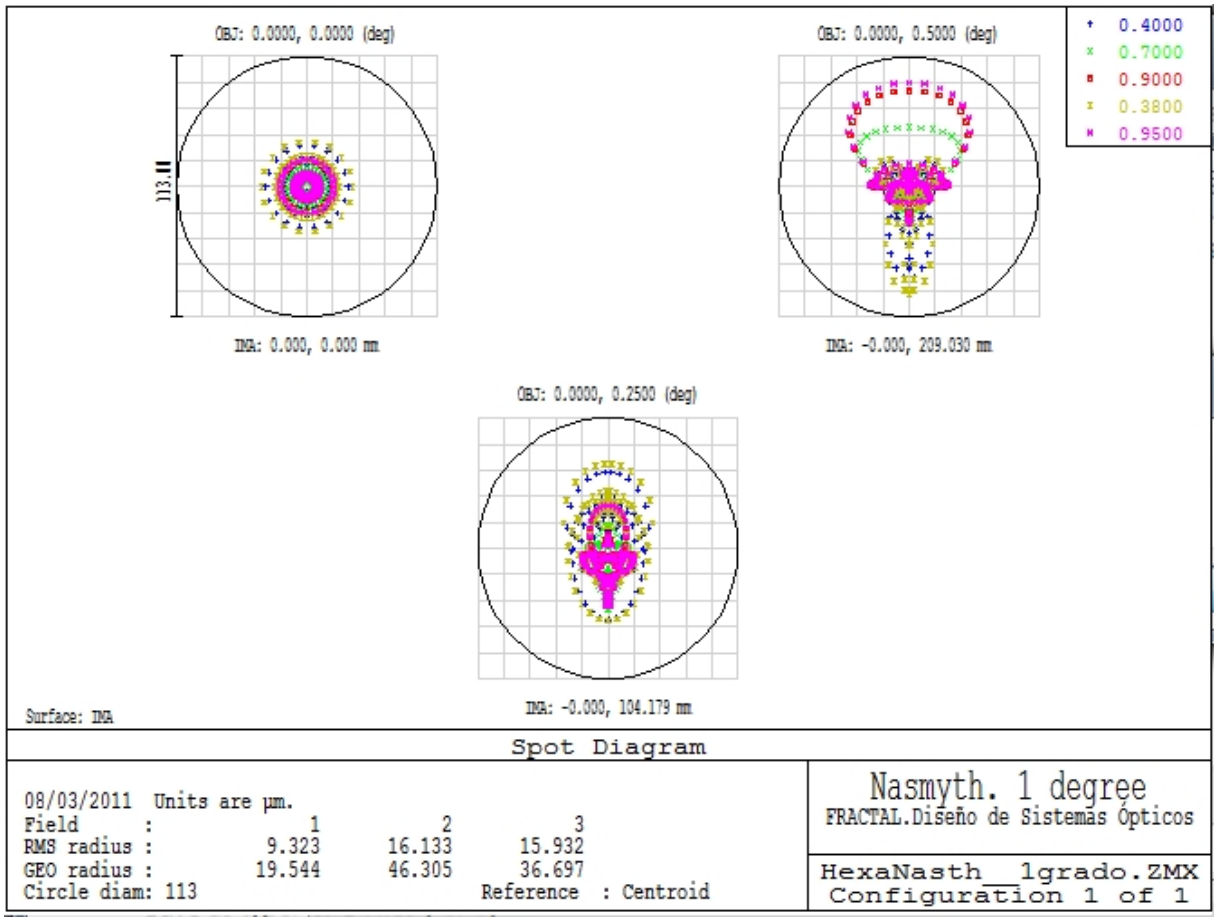
# Corrector #6




| | 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 |

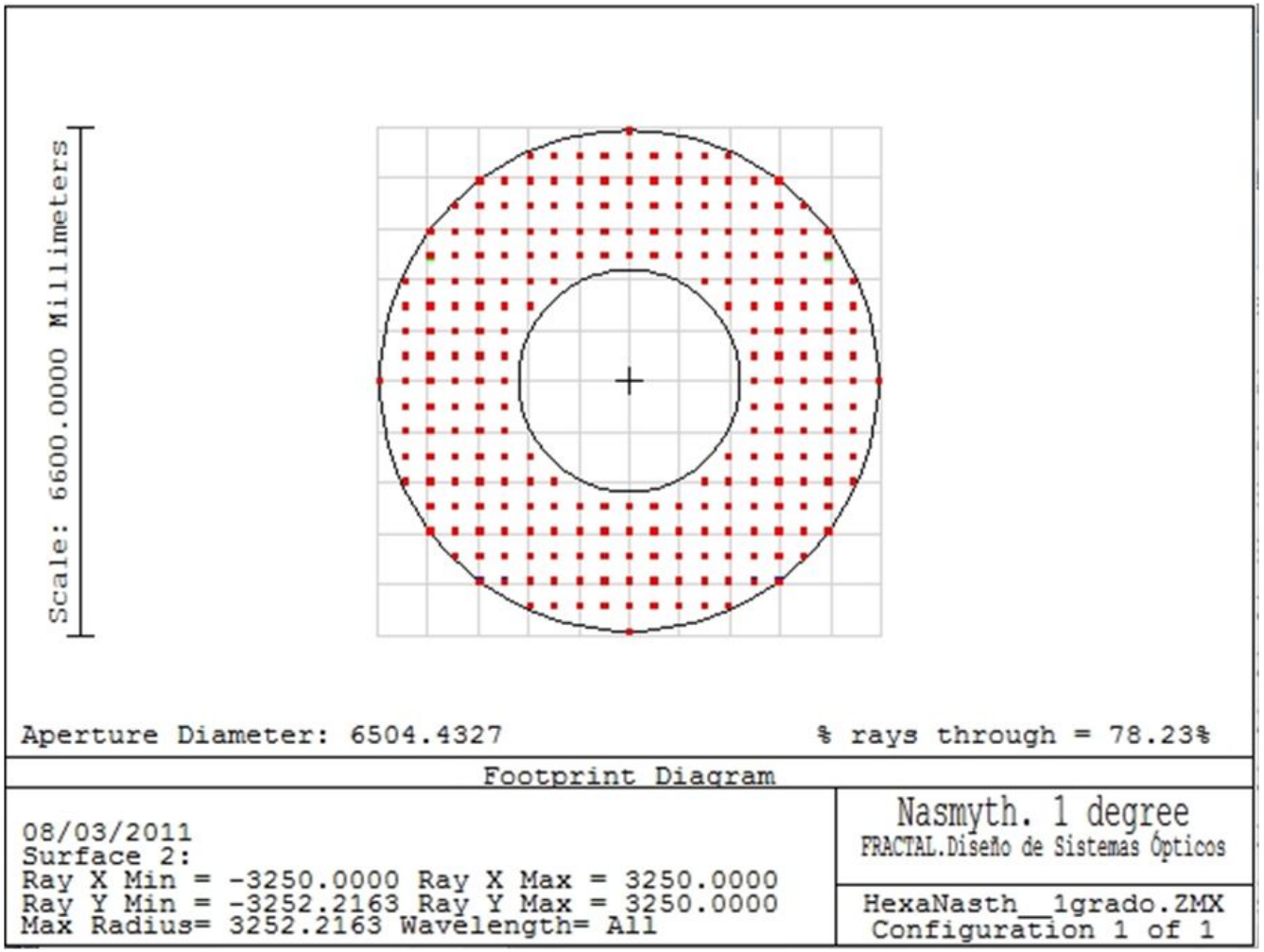
# Image Quality #6

- 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

# Mirror comparison

| | M1 (mm) | | | M2 (mm) | | | M3 (mm) | | | Corrector |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ø | R | cc | Ø | R | cc | Ø | R | cc | Nº lenses |
| Prime focus | 6500 | -3.4 x$10^4$ | -1.1 | - | - | - | - | - | - | 4 |
| Cass 1.0º | 6500 | -2.0 x$10^4$ | -1.2 | 2878 | -1.5x$10^4$ | -10.4 | - | - | - | 3 |
| Cass 1.5º | 6500 | -2.1x$10^4$ | -1.2 | 2938 | -1.5x$10^4$ | -10.9 | - | - | - | 3 |
| Cass 2.0º | 6500 | -2.1x$10^4$ | -1.3 | 3000 | -1.5x$10^4$ | -11.9 | - | - | - | 4 |
| 3_Mirror | 6500 | -2.4x$10^4$ | -1.3 | 2650 | -9698 | -2.92 | 2876 | -1.6x$10^4$ | -2.3 | 0 |
| Nasmyth 1º | 6500 | -2.0x$10^4$ | -1.2 | 2878 | -1.5x$10^4$ | -10.4 | 2254 | flat | - | 3 |

# Throughput comparison

| Design # | Configuration | Mirror | Corrector | Vignetting | TOTAL |
|---|---|---|---|---|---|
| 1 | 1M. Prime focus- 1º | 0.91 | 0.988 | 0.92* | 0.71 |
| 2 | Cassegrain 2M. - 1.0 º | $0.912^2$ | 0.986 | 0.73* | 0.53 |
| 3 | Cassegrain 2M - 1.5º | $0.912^2$ | 0.986 | 0.73 * | 0.53 |
| 4 | Cassegrain 2M - 2.0º | $0.912^2$ | 0.988 | 0.73 * | 0.53 |
| 5 | 3M - 2.0º | $0.913^3$ | - | 0.70 * | 0.53 |
| 6 | Nasmyth | $0.913^3$ | 0.986 | 0.73* | 0.48 |

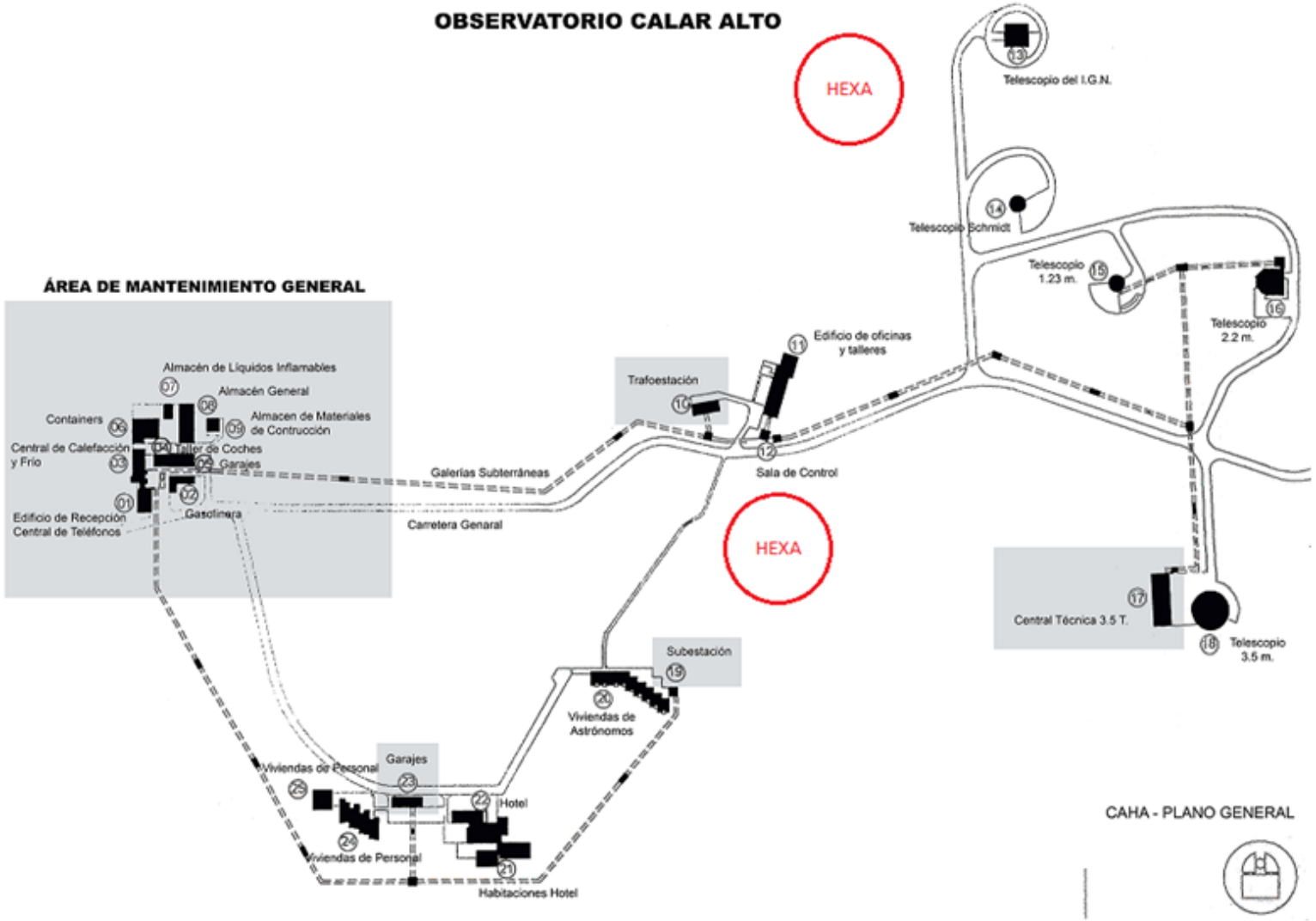
- Best system regarding transmission is the primary focus one.
- Lenslet arrays are needed for the 2M designs.
- A margin around 3-4% has been added to take into account some baffling.
- In the case of the 3 mirror option a 5% margin was used.
- Standard Al coating for mirrors.

# Design Comparison

| Design | #1 | #2 | #3 | #4 | #5 | #6 |
|---|---|---|---|---|---|---|
| FOV | 1.0º | 1.0º | 2.0º | 1.5º | 2.0º | 1.0º |
| Configuration | PF | R-C Cass | R-C Cass | R-C Cass | 3-M | R-C Nas |
| Telecentricity | ☺ | ☺ | ☺ | ☺ | ☹ (*) | ☺ |
| No need of microlenses | ☺ | ☹ | ☹ | ☹ | ☺ | ☹ |
| Image Quality | ☺ | ☺ | ☹ | ☺ | ☺ | ☺ |
| Vignetting | ☺ | 😐 | 😐 | 😐 | ☹ | 😐 |
| Polychromaticity | 😐 | 😐 | ☹ | 😐 | ☺ | 😐 |
| Transmission | ☺ | 😐 | 😐 | 😐 | 😐 | ☹ |
| Packaging | ☹ | 😐 | 😐 | 😐 | ☺ | ☺ |
| Optics Complexity | ☺ | 😐 | ☹ | 😐 | 😐 | 😐 |
| Optics Price | ☺ | 😐 | ☹ | 😐 | 😐 | ☹ |
| Accessibility to focal plane | ☹ | ☺ | ☺ | ☺ | ☹ | ☺ |

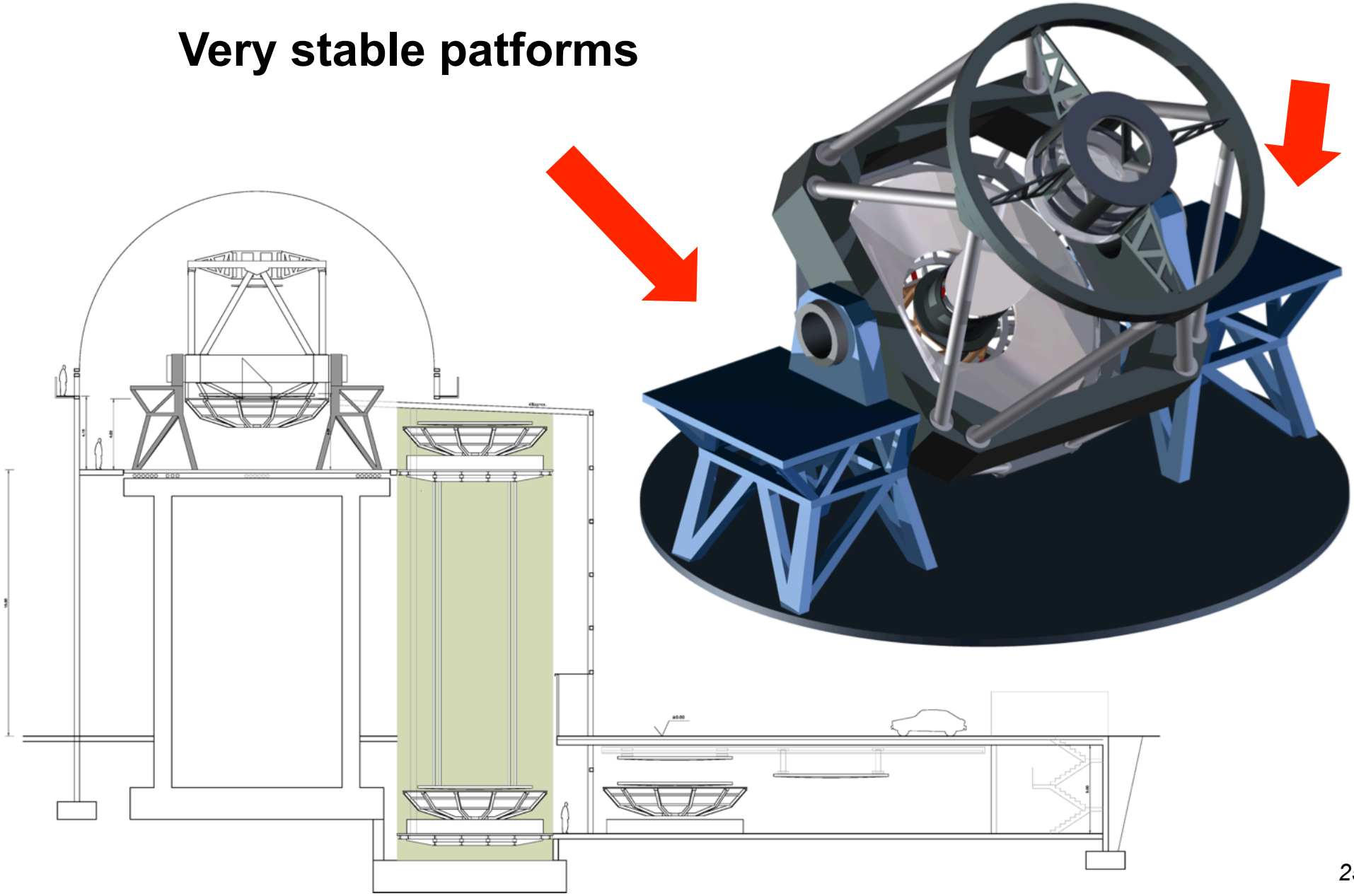
☺ Good - Superb performance
😐 Normal-Standard performance
☹ Bad performance

# Location

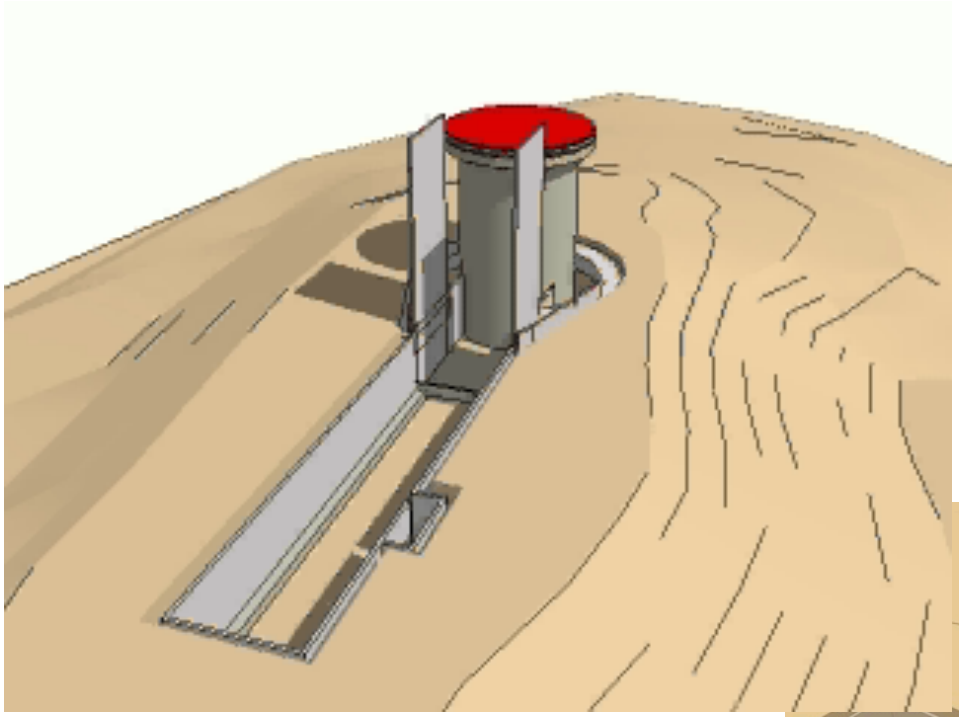

OBSERVATORIO CALAR ALTO
HEXA
Telescopio del I.G.N.
Telescopio Schmidt
Telescopio 1.23 m.
Telescopio 2.2 m.
ÁREA DE MANTENIMIENTO GENERAL
Almacén de Líquidos Inflamables
Almacén General
Containers
Almacen de Materiales de Contrucción
Central de Calefacción y Frío
Taller de Coches
Garajes
Edificio de Recepción Central de Teléfonos
Gasolinera
Edificio de oficinas y talleres
Trafoestación
Galerías Subterráneas
Carretera Genaral
Sala de Control
HEXA
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

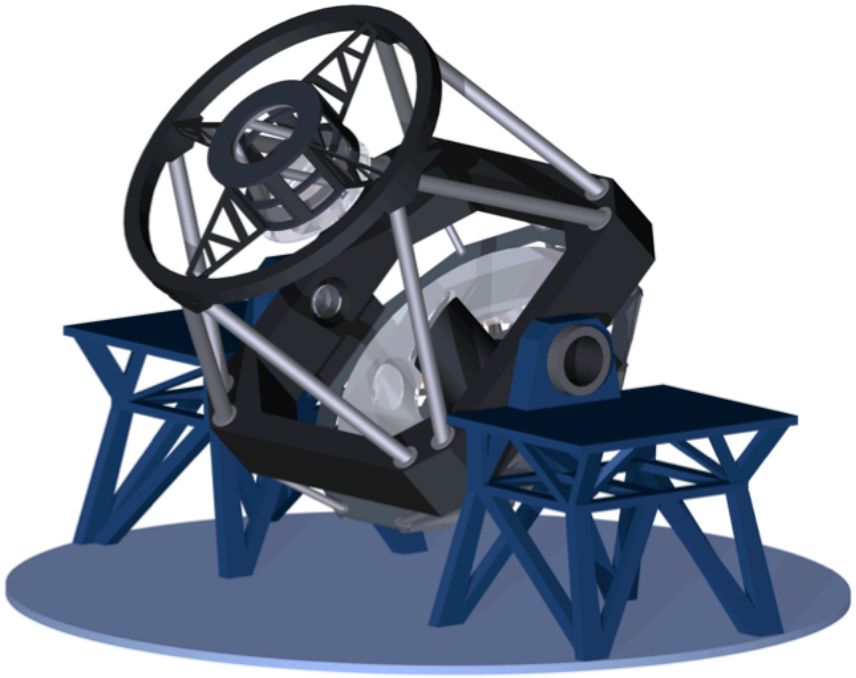
# HEXA, 6.5m for massive spectroscopy

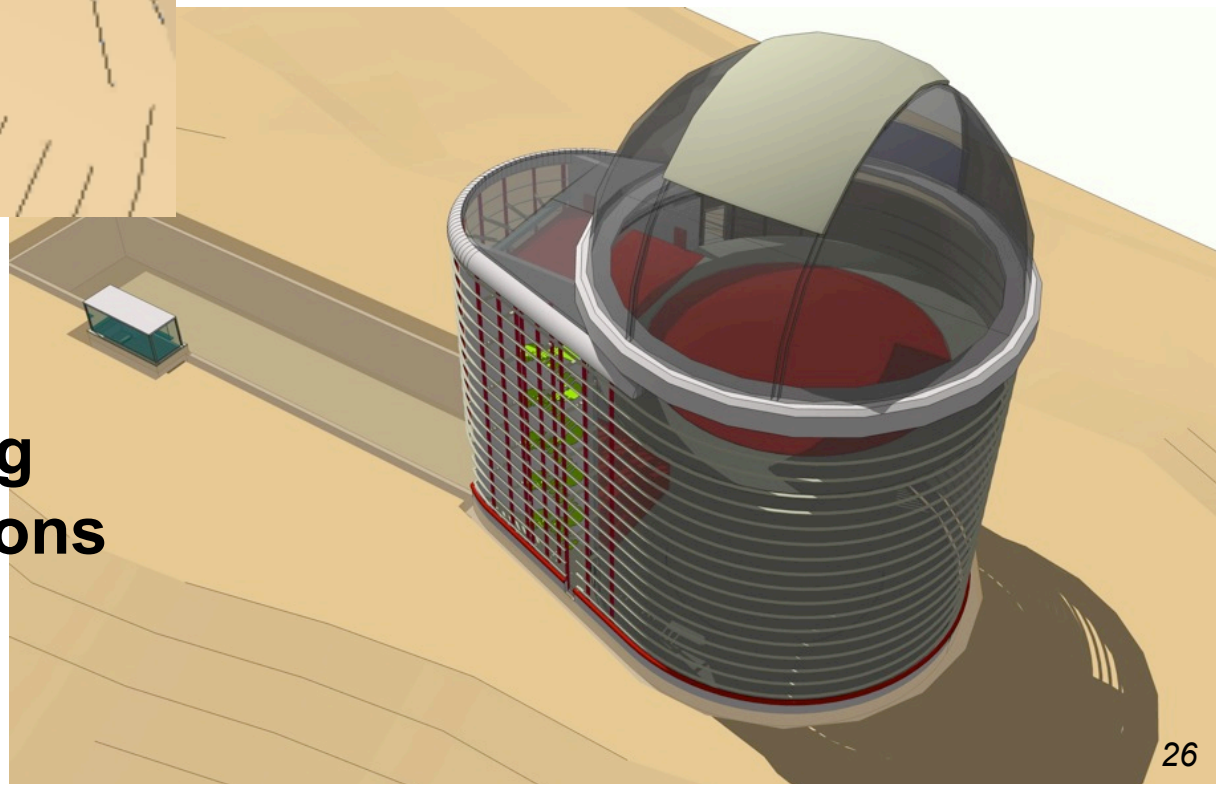
**Very stable patforms**



# 2017: HEXA at CAHA







**2015/16, civil work**
**2017/18, commissioning**
**2018, normal observations**

# Initial instrumental concepts

Nasmyth **A** (Hekatonkheires+Cyclops)

- Fiber positioner at Nasmyth: **HECATE** (Giraffe+Megara)
- Multifiber spectrograph**: GYGES**
- IFU bundle (PMAS/PPAK-like)
- Camera **BRONTESS** (more possible: one instead a fiber)

Nasmyth **B** (Titans):

- Slitless: **GEA** (based on Gaia), D Galadí
- Wide Field IFU (Fourier): **CEO** (MONSUL)**,** J. Iglesias

**Everything is open: science drives the instruments**

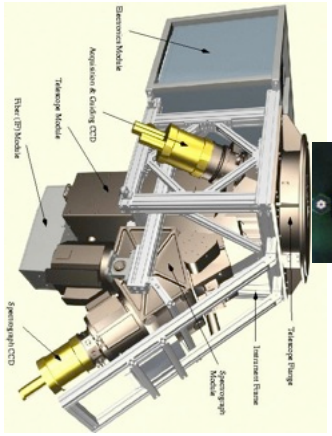
# Nasmyth A (Hekatonkheires & Cyclops)

**CAFE-like**
R=60,000, 1 fibre

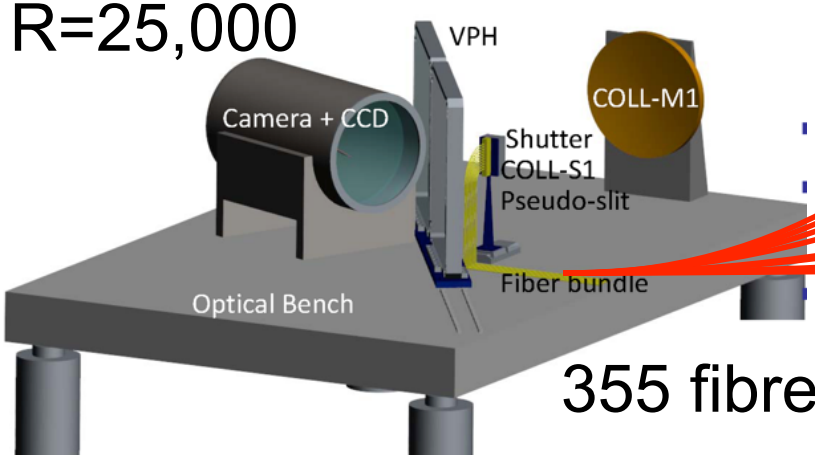
**Camera**
**BRONTESS**

**1 deg FOV**

**PMAS-type**
R=5000
1 Bundle
(3 or 9)
5 arcmin



**GYGES**
R=25,000




355 fibres to GYGES

**HECATE positioner**

# Efficiency

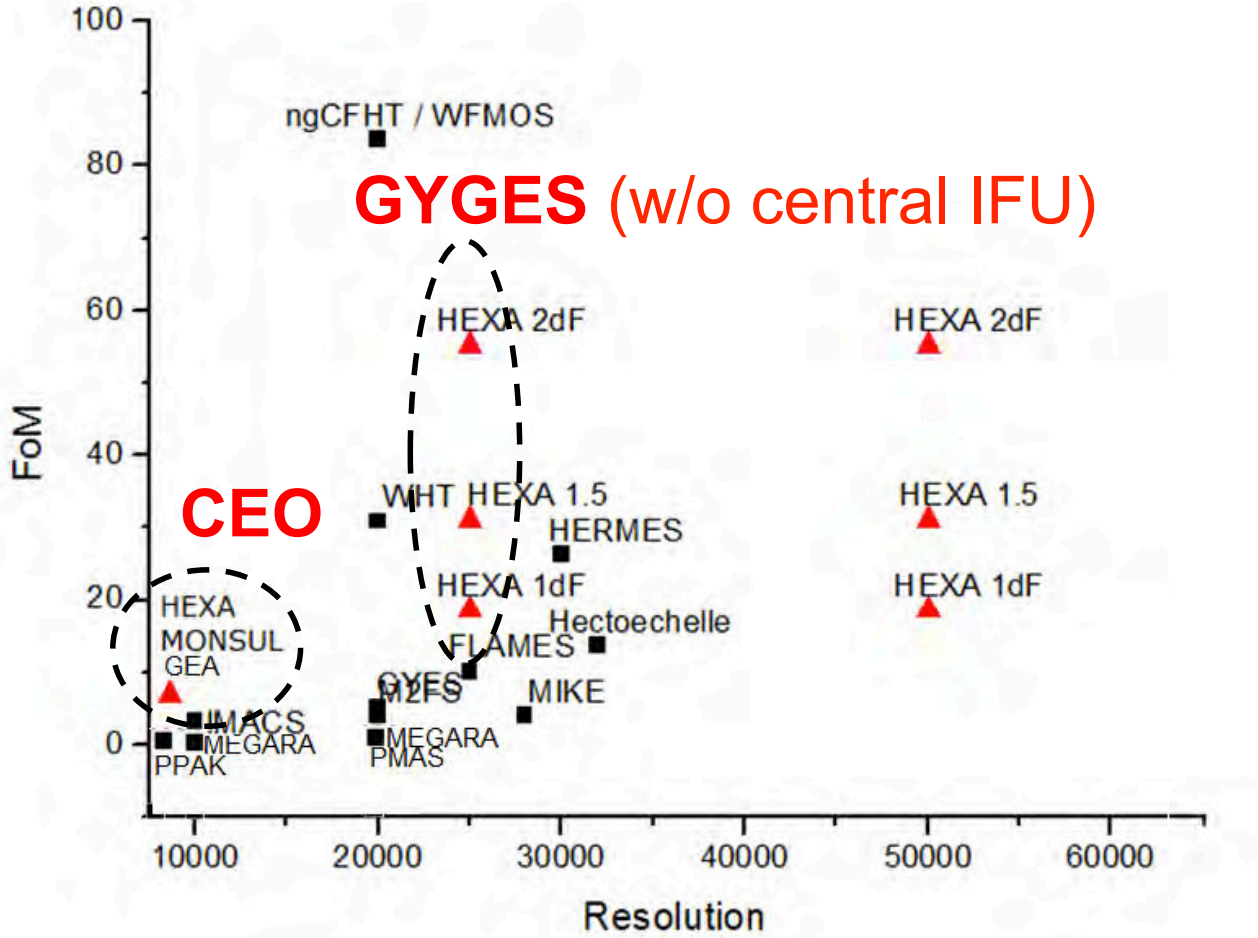



***Figure 2.57:*** *Comparison of the FoM (etendue x throughput correction factor) amongst the planned telescope+instruments for R larger than 10000. 2d HEXA has no rivals (ngCHT is a 10m telescope). Even a 1.5d HEXA could stand out in the high end, competing only with WHT/WEAVE due to the larger FoV planned for the WHT (if it is finally be implemented at the Primary Focus) (graphic by: Francisco Ocaña).*


CSIC
Consejo Superior de Investigaciones Científicas

# CEO (MONSUL)

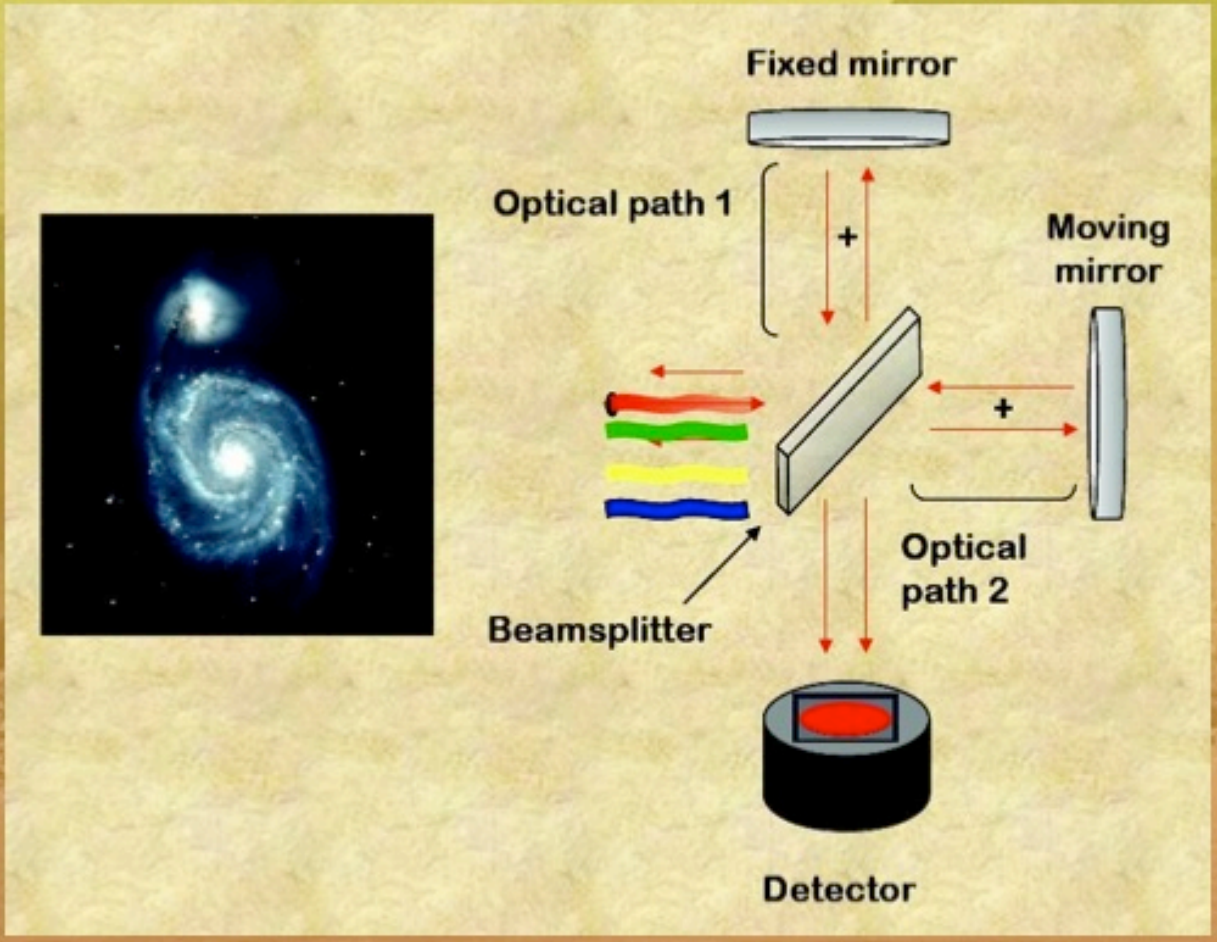
## MONSUL

## the HEXA Imaging Fourier Transform Spectrometer for Wide Field Astrophysics

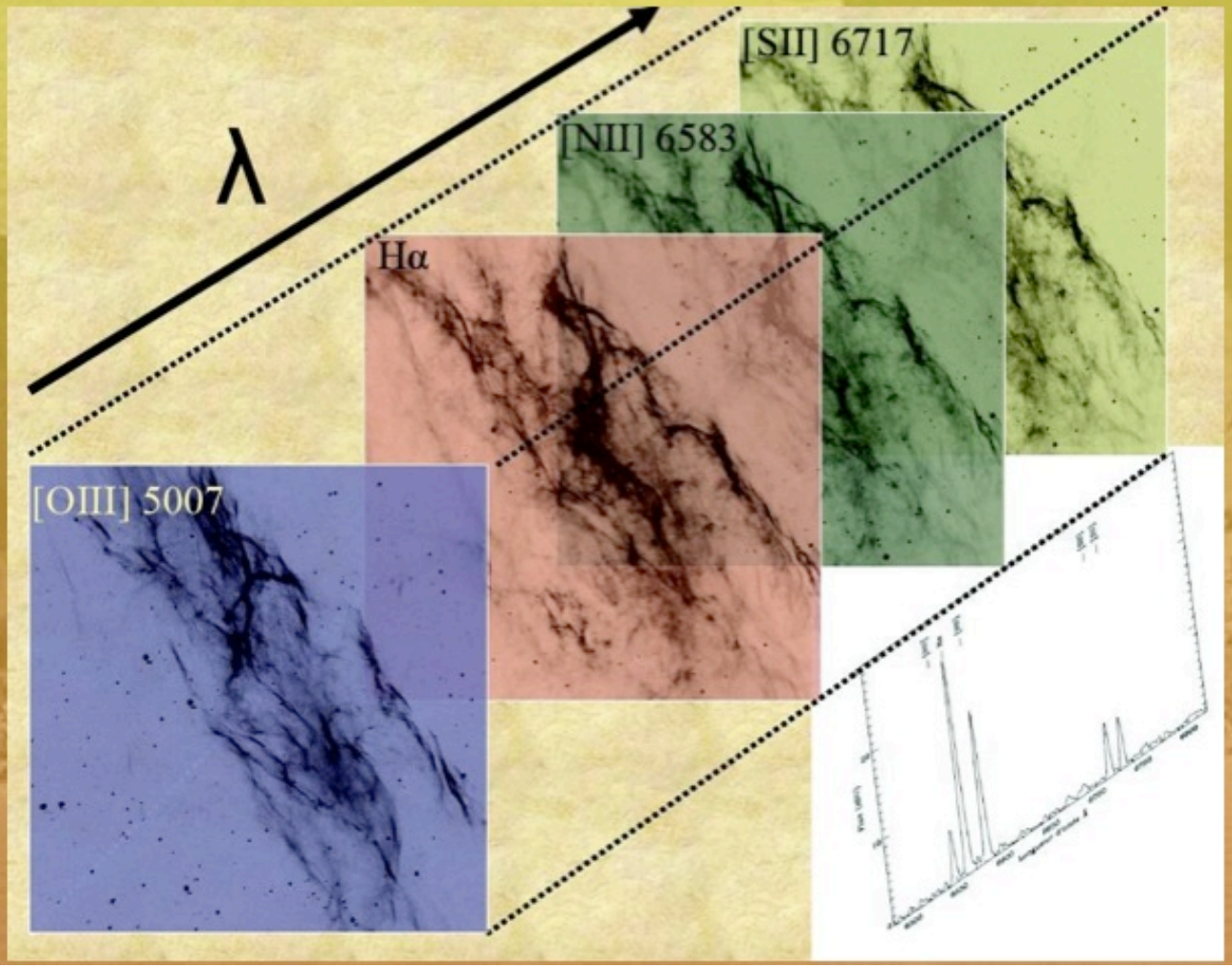
**Jorge Iglesias Páramo**
**Instituto de Astrofísica de Andalucía - CSIC**

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.**



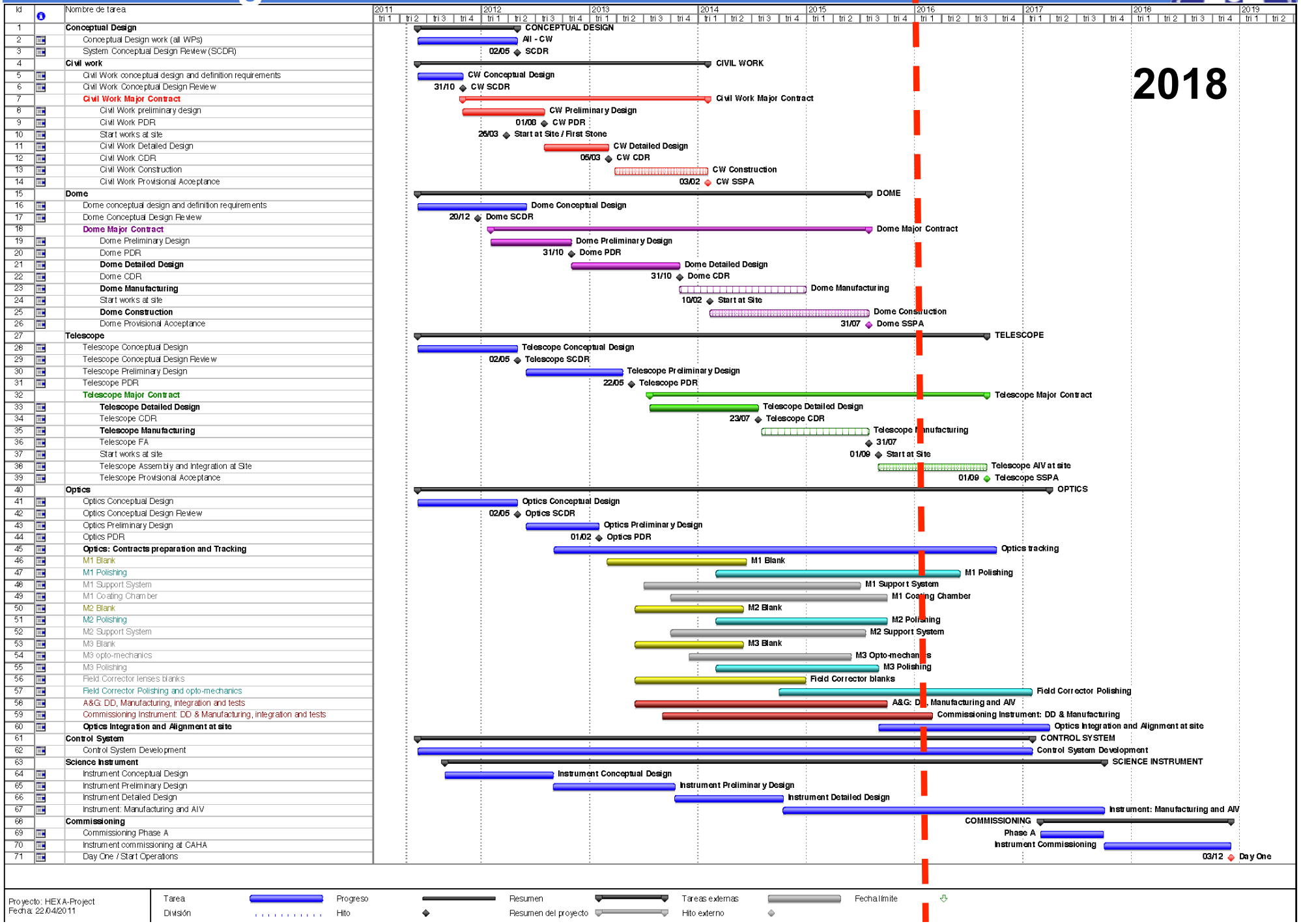
# Technical requirements for *MONSUL*

- **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.

# Chronogram



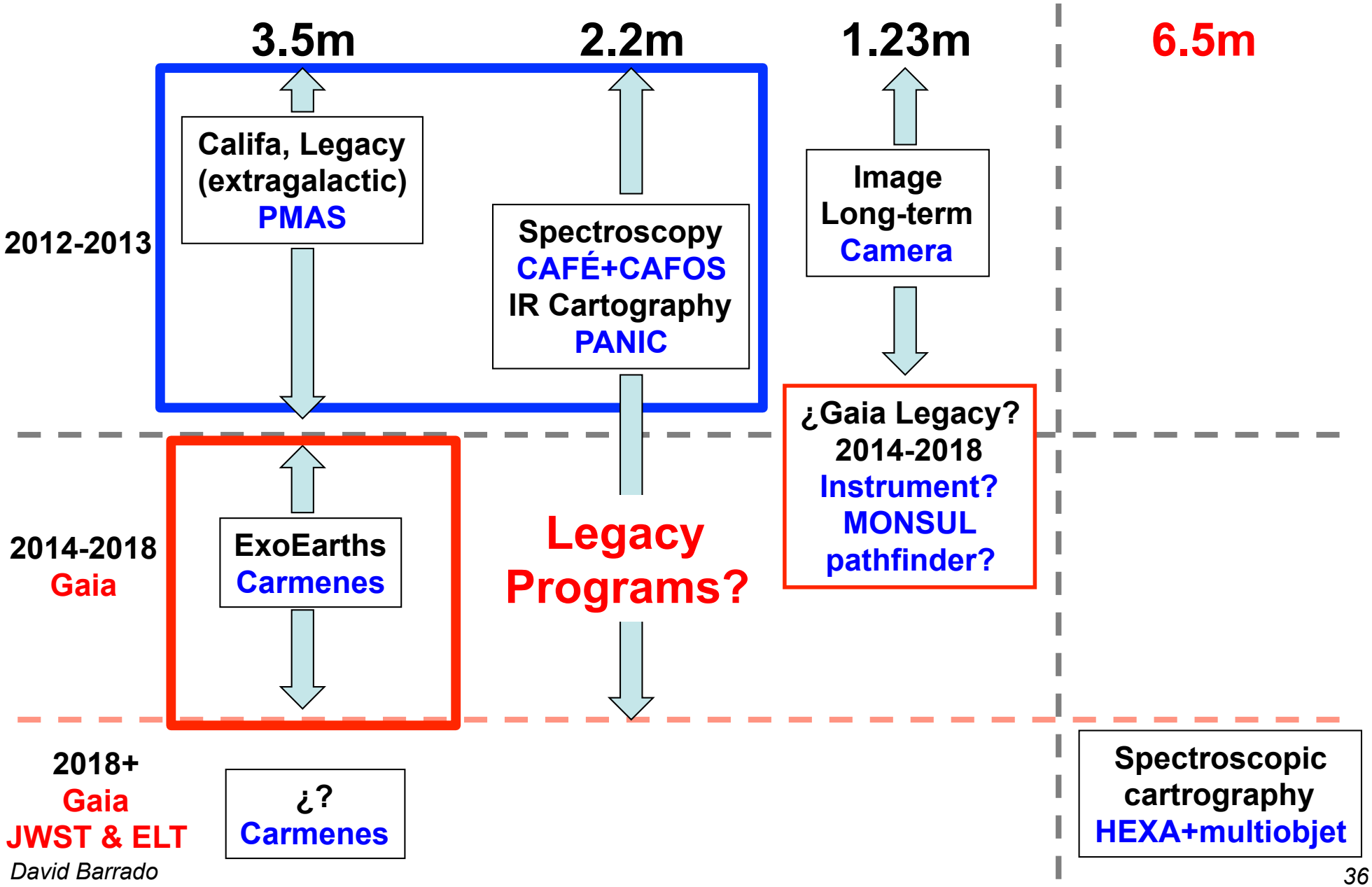

| Id | Nombre de tarea |
|---|---|
| 1 | **Conceptual Design** |
| 2 | Conceptual Design work (all WPs) |
| 3 | System Conceptual Design Review (SCDR) |
| 4 | **Civil work** |
| 5 | Civil Work conceptual design and definition requirements |
| 6 | Civil Work Conceptual Design Review |
| 7 | **Civil Work Major Contract** |
| 8 | Civil Work preliminary design |
| 9 | Civil Work PDR |
| 10 | Start works at site |
| 11 | Civil Work Detailed Design |
| 12 | Civil Work CDR |
| 13 | Civil Work Construction |
| 14 | Civil Work Provisional Acceptance |
| 15 | **Dome** |
| 16 | Dome conceptual design and definition requirements |
| 17 | Dome Conceptual Design Review |
| 18 | **Dome Major Contract** |
| 19 | Dome Preliminary Design |
| 20 | Dome PDR |
| 21 | **Dome Detailed Design** |
| 22 | Dome CDR |
| 23 | **Dome Manufacturing** |
| 24 | Start works at site |
| 25 | **Dome Construction** |
| 26 | Dome Provisional Acceptance |
| 27 | **Telescope** |
| 28 | Telescope Conceptual Design |
| 29 | Telescope Conceptual Design Review |
| 30 | Telescope Preliminary Design |
| 31 | Telescope PDR |
| 32 | **Telescope Major Contract** |
| 33 | **Telescope Detailed Design** |
| 34 | Telescope CDR |
| 35 | **Telescope Manufacturing** |
| 36 | Telescope FA |
| 37 | Start works at site |
| 38 | Telescope Assembly and Integration at Site |
| 39 | Telescope Provisional Acceptance |
| 40 | **Optics** |
| 41 | Optics Conceptual Design |
| 42 | Optics Conceptual Design Review |
| 43 | Optics Preliminary Design |
| 44 | Optics PDR |
| 45 | **Optics: Contracts preparation and Tracking** |
| 46 | M1 Blank |
| 47 | M1 Polishing |
| 48 | M1 Support System |
| 49 | M1 Coating Chamber |
| 50 | M2 Blank |
| 51 | M2 Polishing |
| 52 | M2 Support System |
| 53 | M3 Blank |
| 54 | M3 opto-mechanics |
| 55 | M3 Polishing |
| 56 | Field Corrector lenses blanks |
| 57 | Field Corrector Polishing and opto-mechanics |
| 58 | A&G: DD, Manufacturing, integration and tests |
| 59 | Commissioning Instrument: DD & Manufacturing, integration and tests |
| 60 | **Optics Integration and Alignment at site** |
| 61 | **Control System** |
| 62 | Control System Development |
| 63 | **Science Instrument** |
| 64 | Instrument Conceptual Design |
| 65 | Instrument Preliminary Design |
| 66 | Instrument Detailed Design |
| 67 | Instrument: Manufacturing and AIV |
| 68 | **Commissioning** |
| 69 | Commissioning Phase A |
| 70 | Instrument commissioning at CAHA |
| 71 | Day One / Start Operations |

# The telescope: phasing and milestones

| Phase | Name | Milestone at the end of the phase | Abbrev. |
|---|---|---|---|
| Phase 1 | Conceptual Design | System Conceptual Design Review | **SCDR** |
| Phase 2 | Preliminary Design | Preliminary Design Review | PDR |
| Phase 3 | Detailed Design | Critical Design Review | **CDR** |
| Phase 4 | Manufacturing and subsystem tests | Subsystem Acceptance Reviews | **SSAR** |
| Phase 5 | Assembly, Integration and Verification | System Preliminary Acceptance Review (at site) | **SPAR** |
| Phase 6 | Commissioning | System Acceptance Review (SA) at site and on sky (Final Acceptance) | **FA** |

**OK**

# CALA ALTO: 2012-2018+




*David Barrado*

# More info

More at:

www.caha.es

**"HEXA: a machine for spectroscopic cartography"**

http://www.riastronomia.es/opencms/opencms/Workshops/R_20111205.html

Some presentations:

ftp://ftp.caha.es/CApub/aceitun/HEXA/