TARSIS

"Tetra-ARmed Super-Ifu Spectrograph"

the new IPARCOS-led instrument for the Calar Alto 3.5m telescope

A. Gil de Paz (UCM, co-PI), J. Iglesias (IAA-CSIC, co-PI)

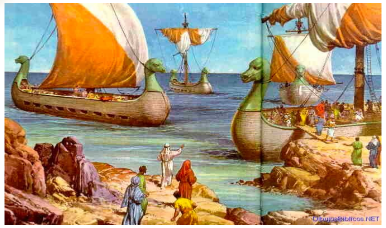
P. Sánchez-Blázquez (UCM), M. Relaño (UGR), J. Oñorbe (US), C. Kehrig (IAA-CSIC), A. Montaña (INAOE)

TARSIS CONSORTIUM & INSTRUMENT TEAM

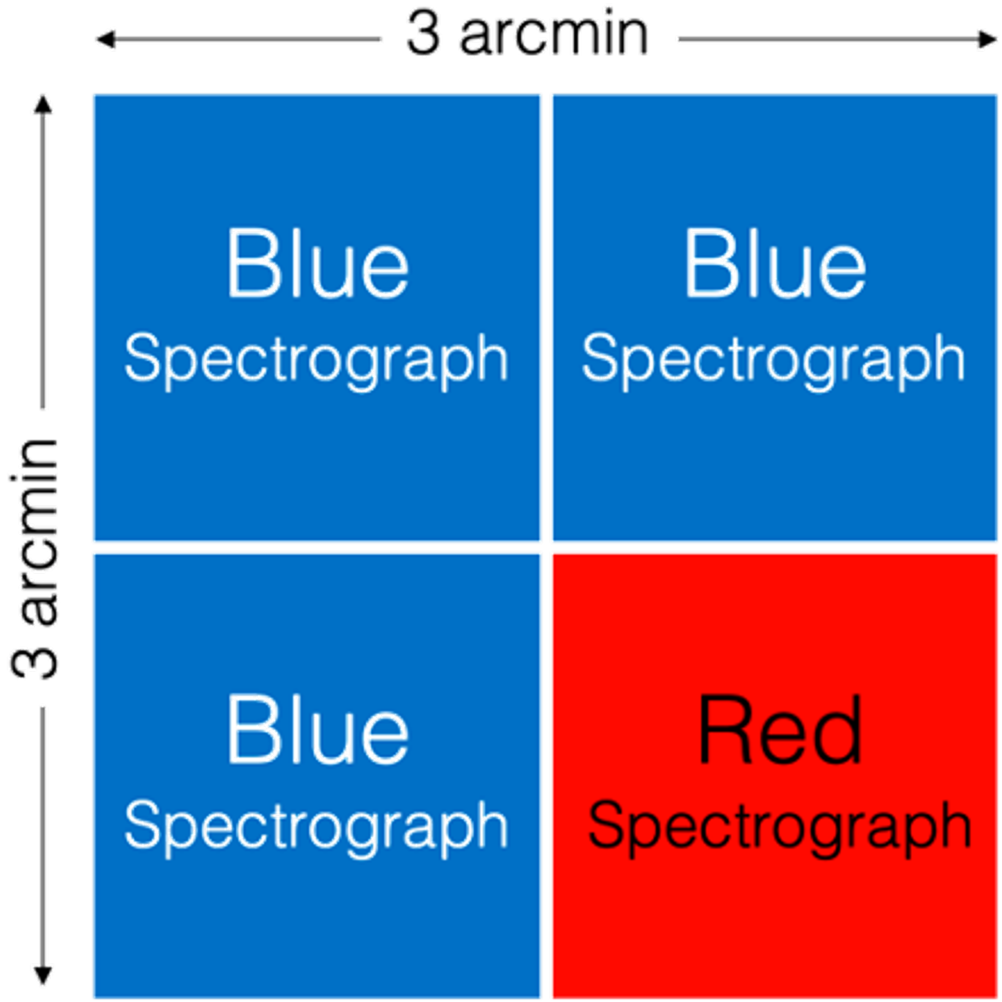
CATARSIS SURVEY TEAM

TARSIS: THE INSTRUMENT

TETRA-ARMED SUPER-IFU SPECTROGRAPH



Parameter	Specification
Efficiency	>20% (Blue), ~30% (Red)
Field-of-View (FoV)	9 arcmin^2 (3/4 Blue; 1/4 Red)
Spectral range	320-520 nm & 510-810 nm & 590-730 nm (HR)
Spaxel size	2 x 2 arcsec^2
Resolution element	3.6 pix
Spectral resolution	R≥800-1000 & R≥800-1000 & R=1500-2500



DESIGNED FOR LONG TRIPS WITH UNKNOWN DESTINIES...

THE CONSORTIUM

IAA-CSIC	UCM	INAOE	US	UGR	CAB INTA-CSIC	UAL	FRACTAL
Dr. Jorge Iglesias	Dr. Jesús Gallego	Dr. Esperanza Carrasco	Dr. José Oñorbe	Dr. Mónica Relaño	Dr. Javier Piqueras	Dr. G. Ester Martín	Dr. Marisa García

Instituto de Astrofísica de Andalucía, IAA-CSIC
Universidad Complutense de Madrid, UCM
Instituto Nacional de Astrofísica, Óptica y Electrónica, INAOE
Universidad de Sevilla
Universidad de Granada
Centro de Astrobiología (CAB, INTA-CSIC)
Universidad de Almería
FRACTAL S.L.N.E.

CAHA

Calar Alto

Dr. Jesús Aceituno

"Calar-Alto Tetra-Armed Super-Ifu Survey"

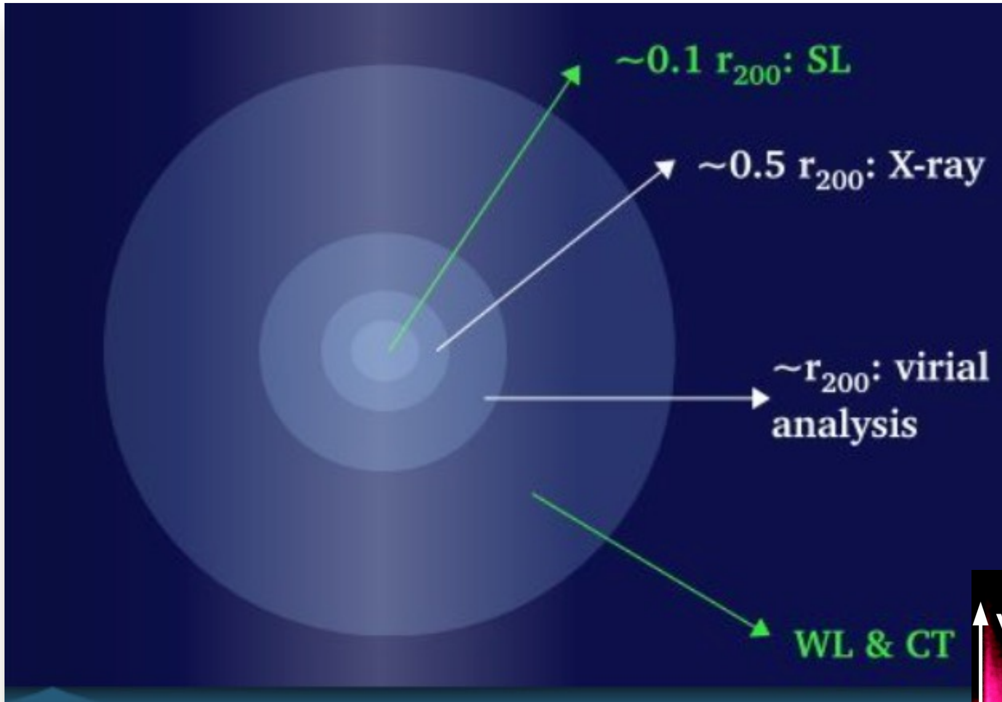
- **CATARSIS** will observe a sample **16 clusters** covering up to their virial radii, as well as targeted filaments for some of the clusters. This sample is selected from RedMapper, SPIDERS, LOCUSS, Hetspec and CLASH cluster surveys.

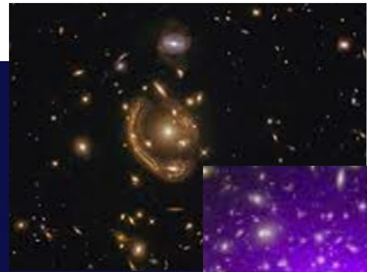
- The sample covers a **wide range in masses, richnesses and dynamical states**.

- Good quality **corollary data** are available for most clusters: GALEX (UV) data, HST imaging, X-ray data, etc…, thus allowing a more complete analysis combining them with the CATARSIS data.

- The **redshift range (0.15<z<0.23)** has been chosen so that the spectral features of interest fall within the TARSIS Blue and Red spectral ranges (**MgII2800Å** @ z=0.15, **Hα** @ z=0.23).

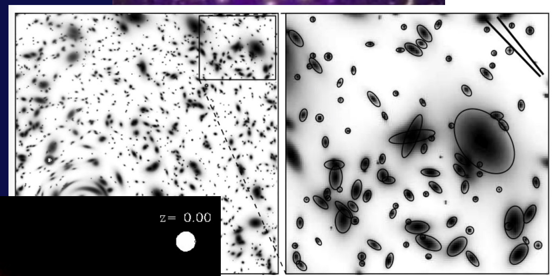
MASS PROFILES SO FAR …



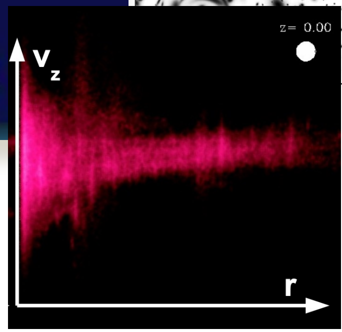


Only for the central parts

Assume hydrostatic equilibrium

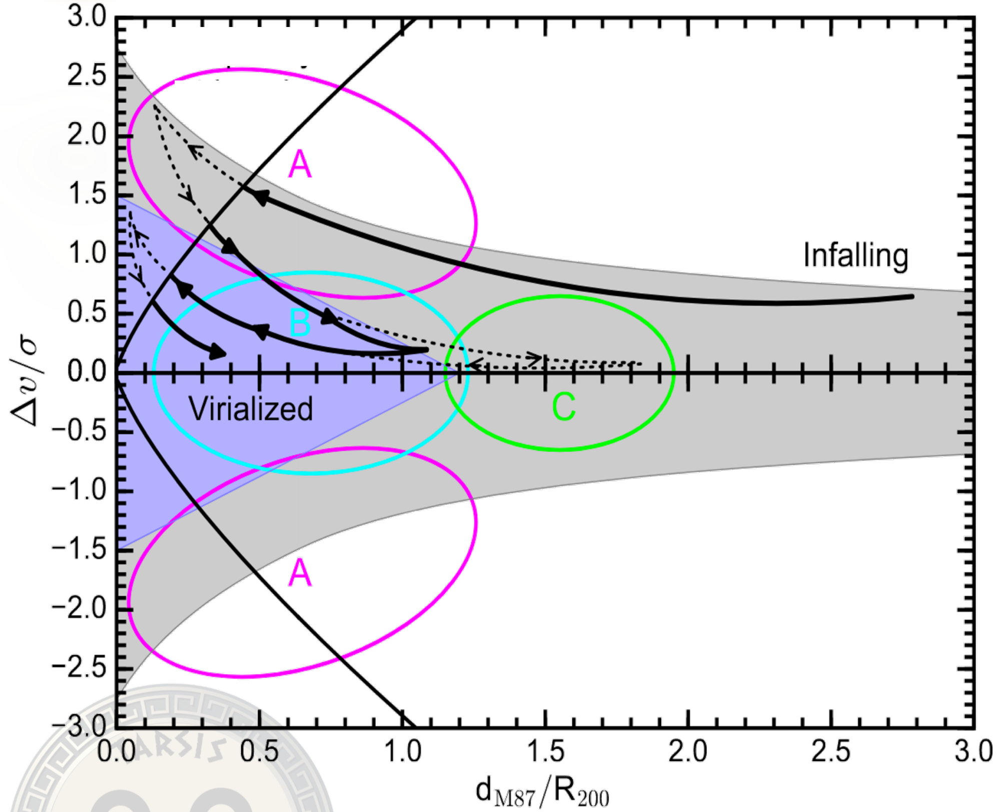

from Mellier (1999)

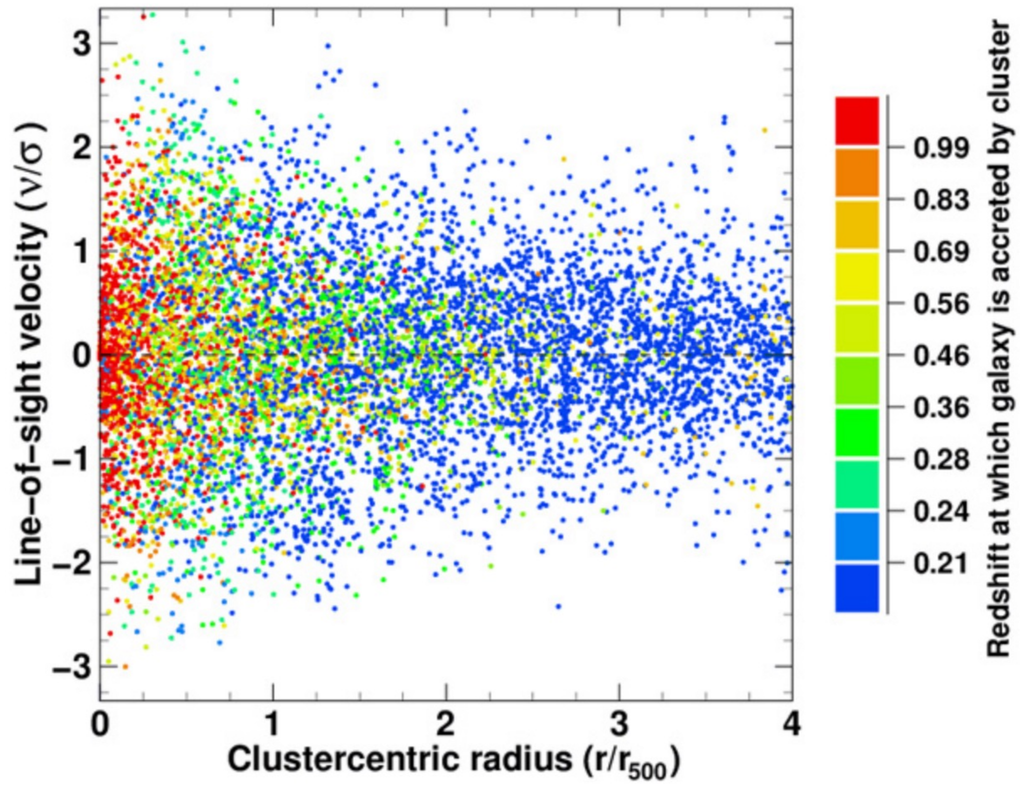
afected by cluster traixiality, large scale structure and intrinsic aligments



No affected by dynamical state
Not affected by large scale structure
Affected by elongation along the line of sight.

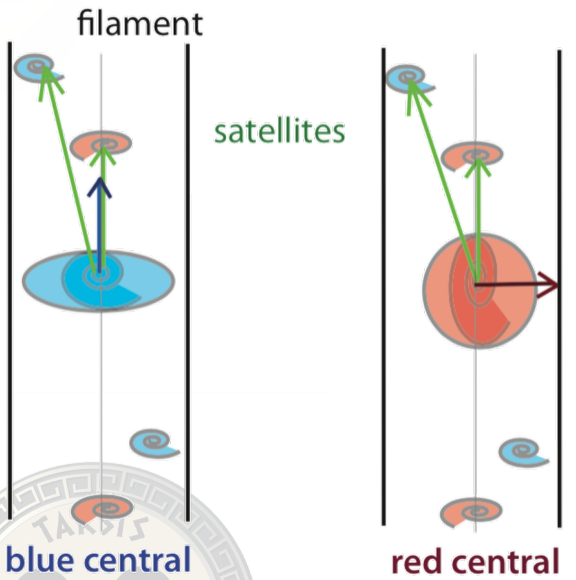
THE CAUSTIC METHOD

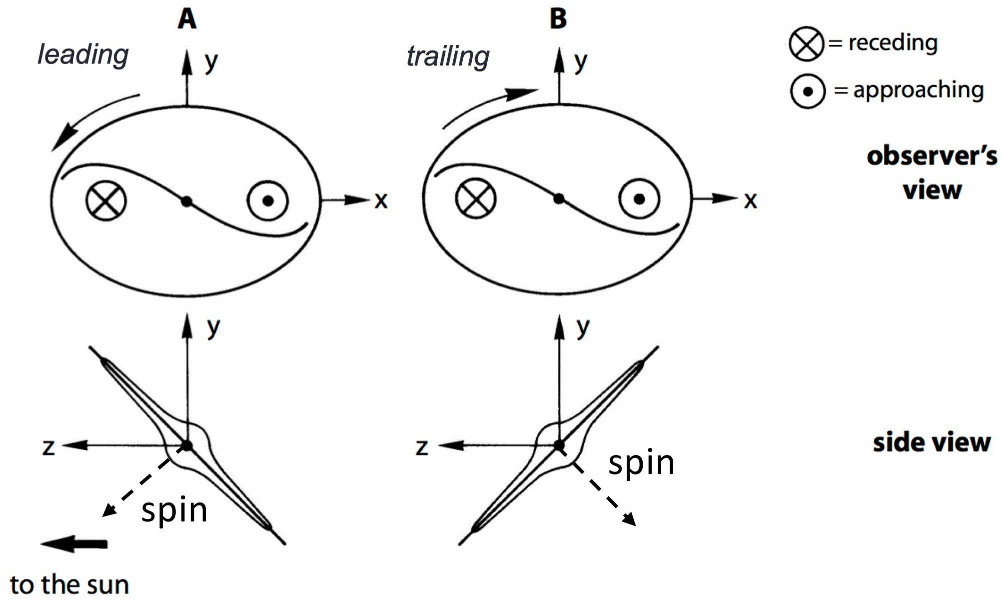




ALIGNMENTS

The orientation of early-type galaxies is thought to be largely determined by the build up of the large scale dark matter distribution that surround them



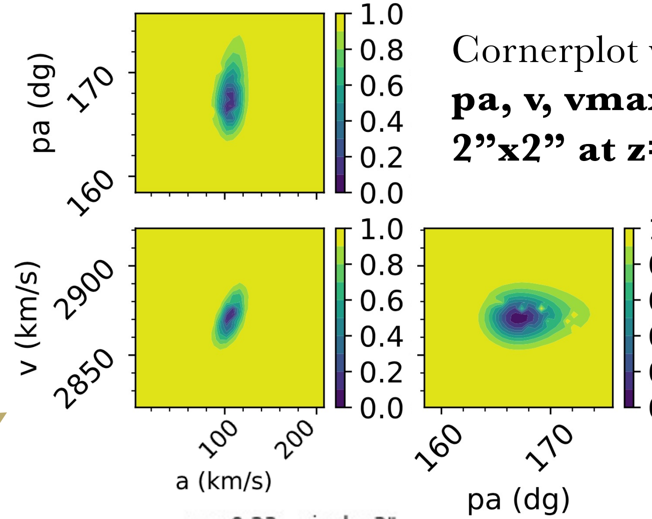


Predictions from ΛCDM:

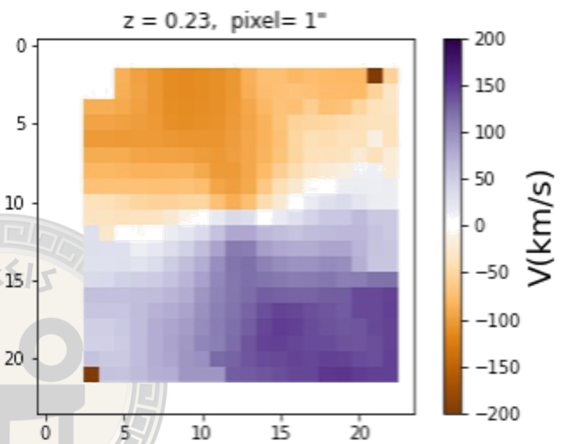
- spins of low-mass, blue, galaxies are preferentially aligned with the slowest collapsing direction of the large-scale tidal field
- massive, red, galaxy spins tend to be perpendicular to this direction.

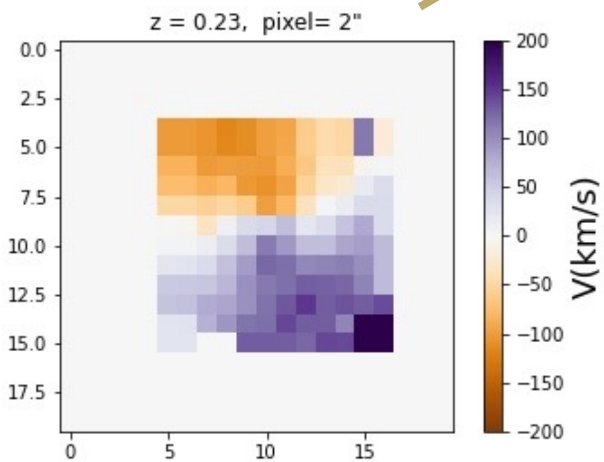
SPATIAL RESOLUTION NEEDS

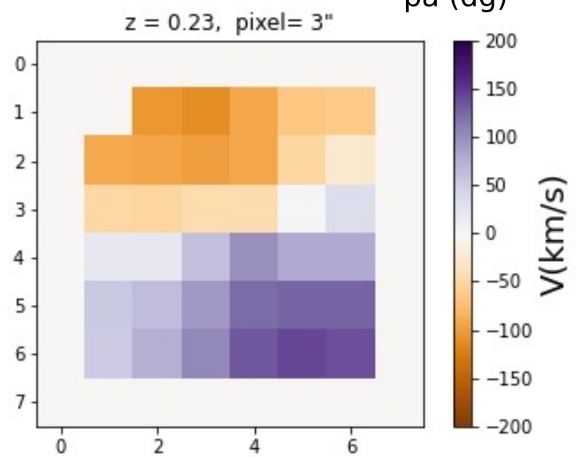
Red-shifting the MUSE datacube of NGC6902 (R25=15 kpc) to z=0.23



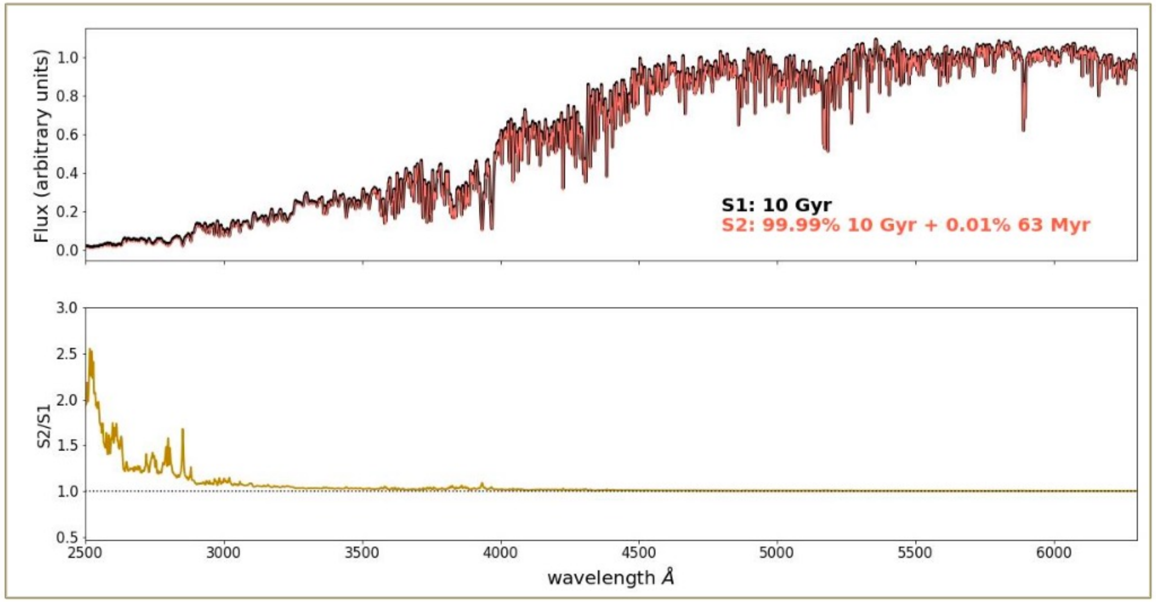
Cornerplot with **pa, v, vmax** for **2”x2” at z=0.23**

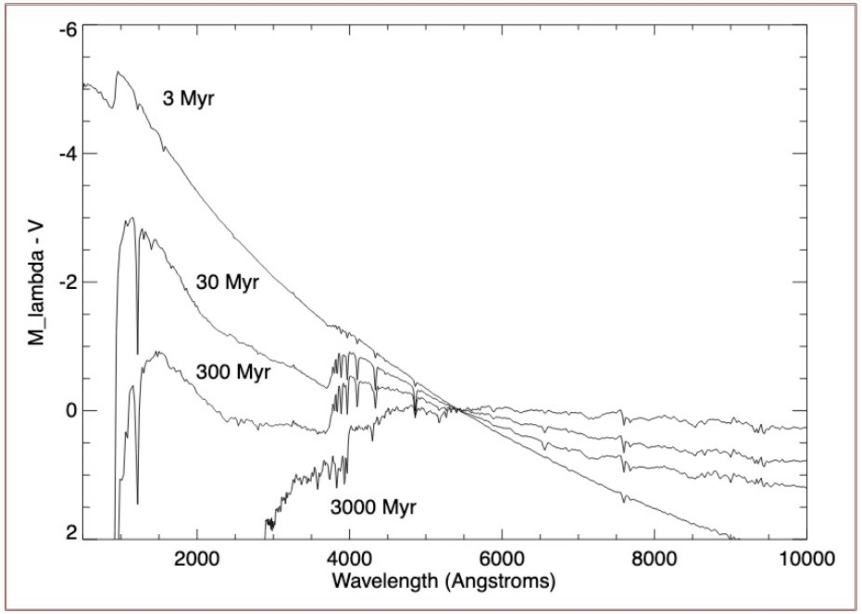






DETAILED STAR FORMATION HISTORIES



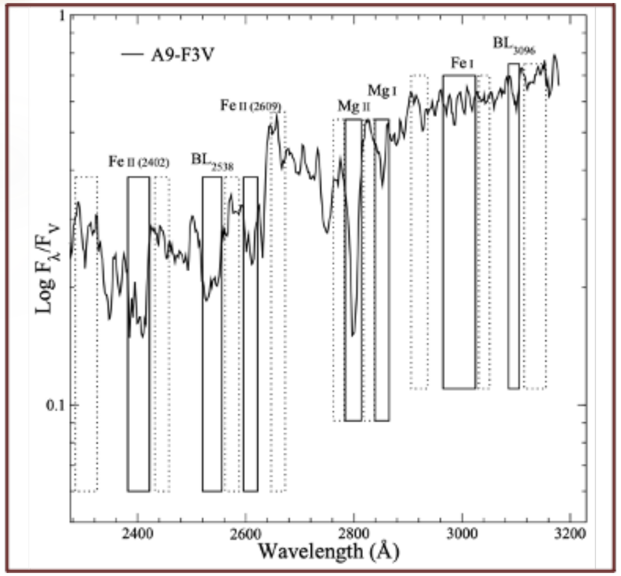


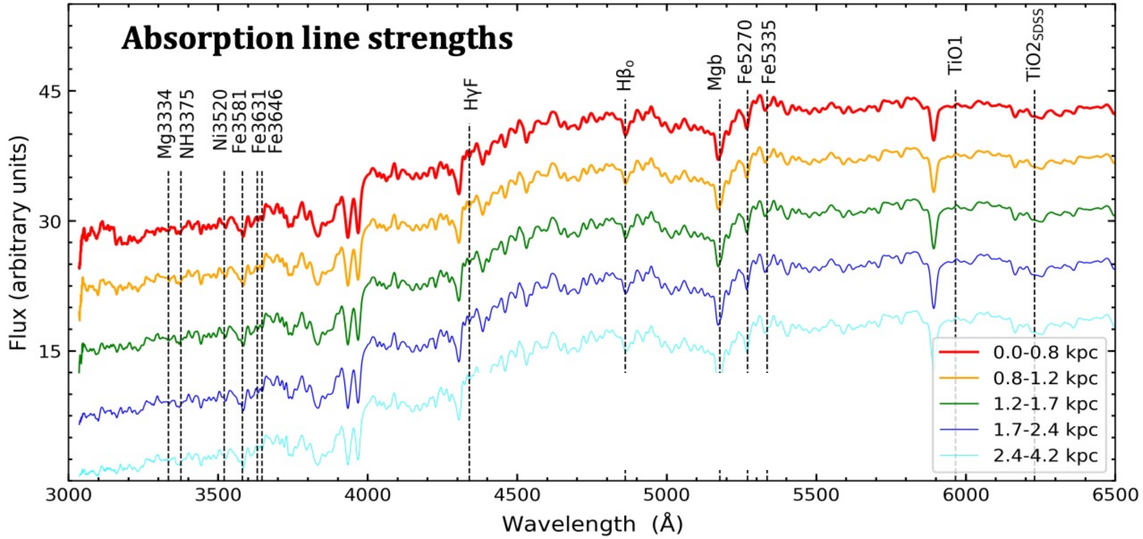
2850–3400 Å @ z = 0.15
2500–5940 Å @ z = 0.28

The wavelength range covered by TARSIS allow to detect the presence of a young population at the level of 0.01 % in mass.

The optical-IR range is not sensitive enough.

CHEMICAL ENRICHMENT





2850–7139 Å @ z = 0.15
2600–6667 Å @ z = 0.23

TiO : IMF indicator; Fe3581: IMF indicator (young population) → evolution of the IMF

NH3375 & CN : allow separation of C and N abundance

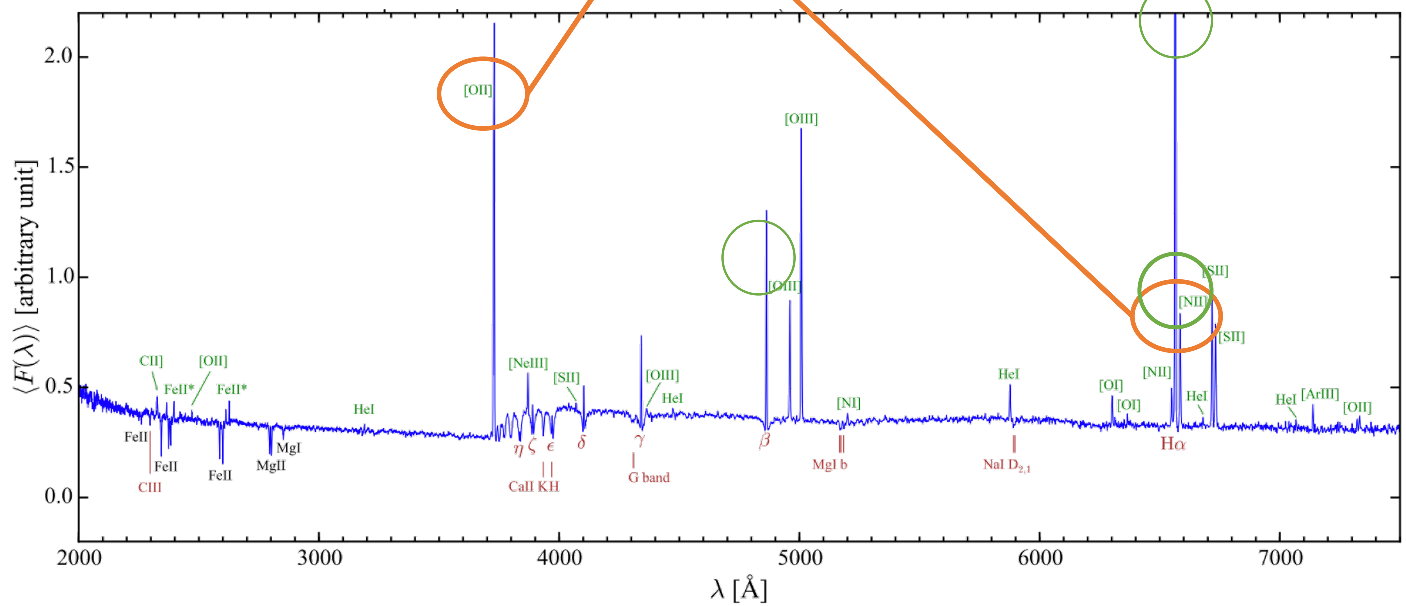
Mg3334 and Mgb: evolution of the Mg abundance...

CHEMICAL EVOLUTION

Feedback sources, nucleosyntesis yields, evolution of the IMF, dust depletion, metallicity scale in gas and stars...

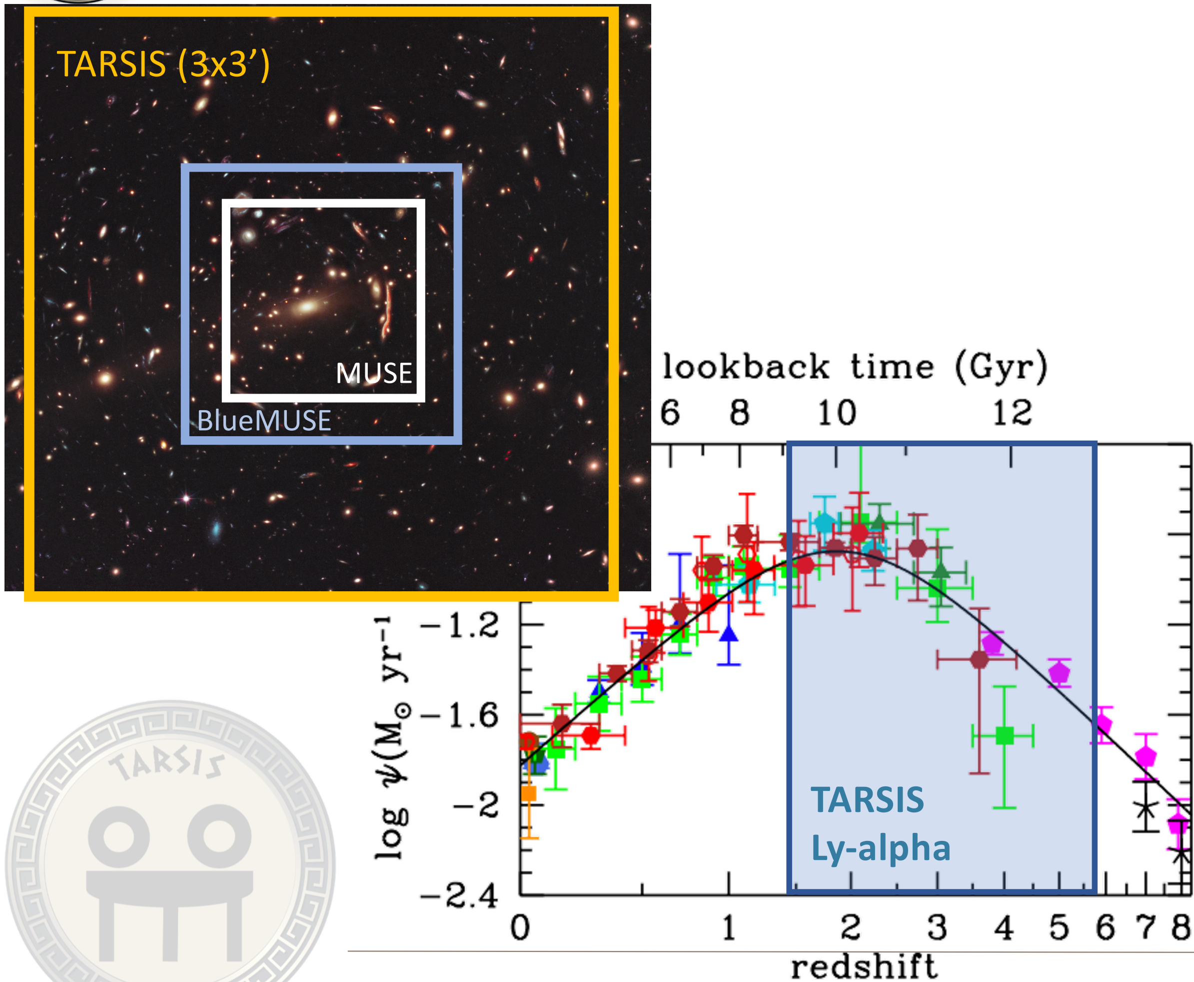
N/O (SFH)

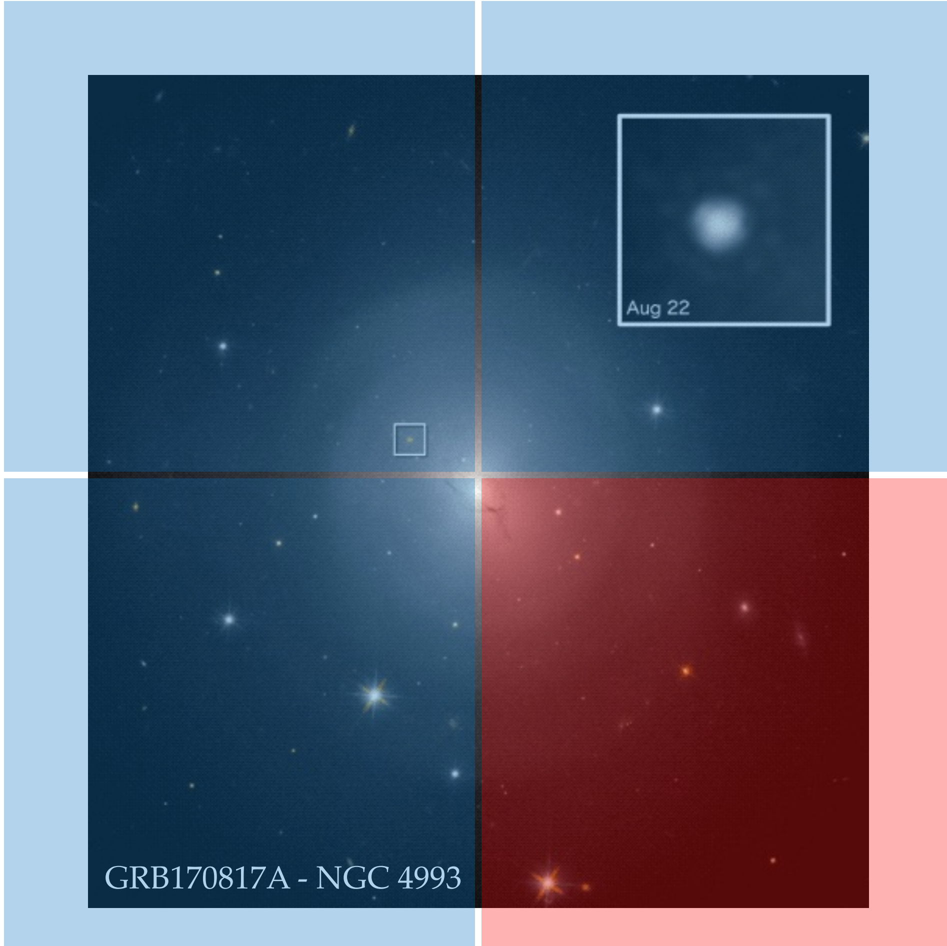
O/H chemical abundances



CATARSIS: THE SCIENCE

THE POTENTIAL TO DISCOVER

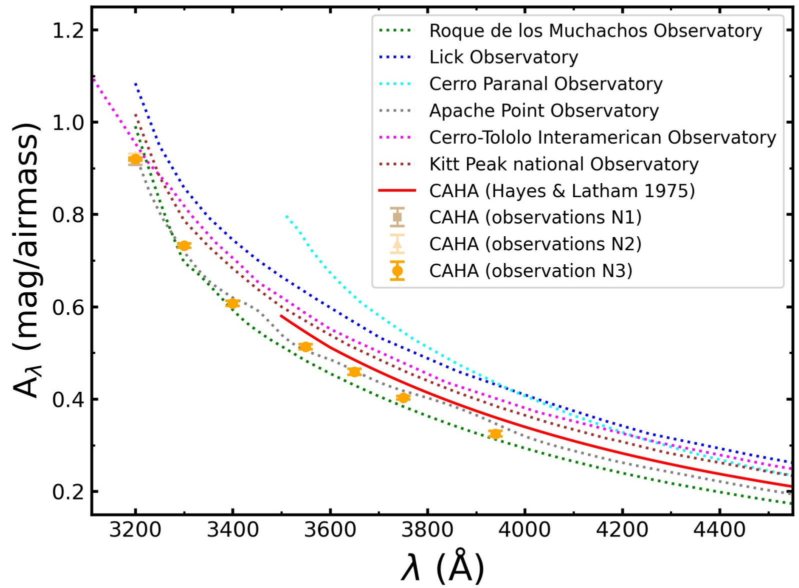




Observing goals

- The scientific goals of CATARSIS require reaching galaxies with continuum magnitudes **$m_{AB,r}$~21**, and limiting line fluxes **(1-2)x10^{-17} erg s^{-1} cm^{-2}**.

- The required exposure time per pointing is **28800s (8h) for the Blue range**, and **9600s (2h40m) for the Red**.

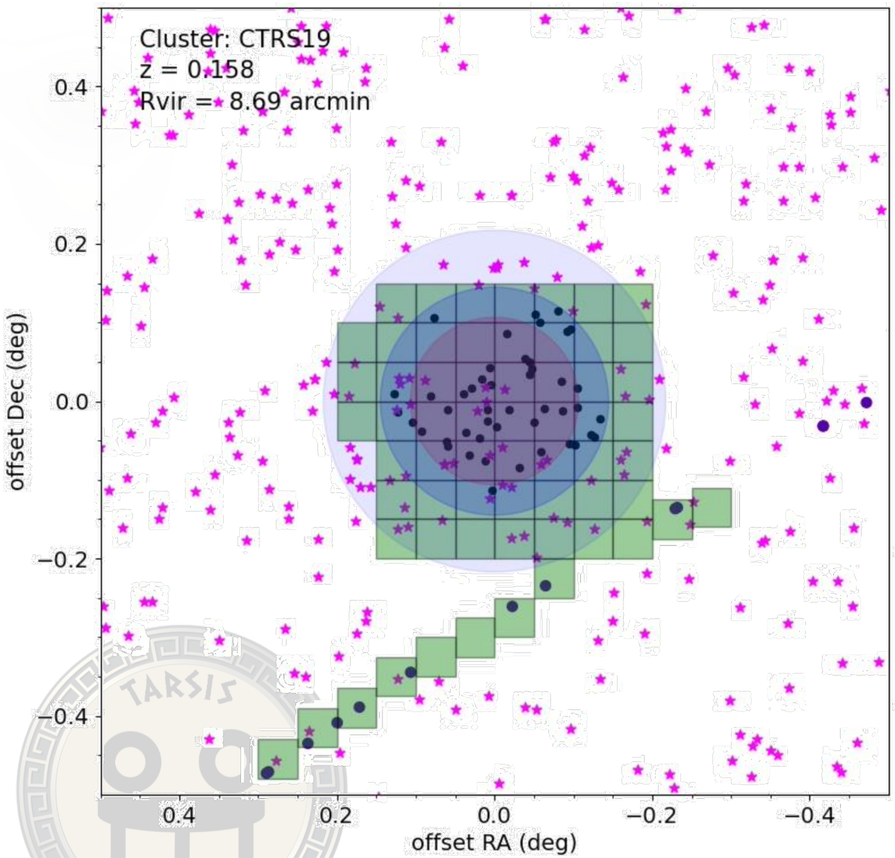


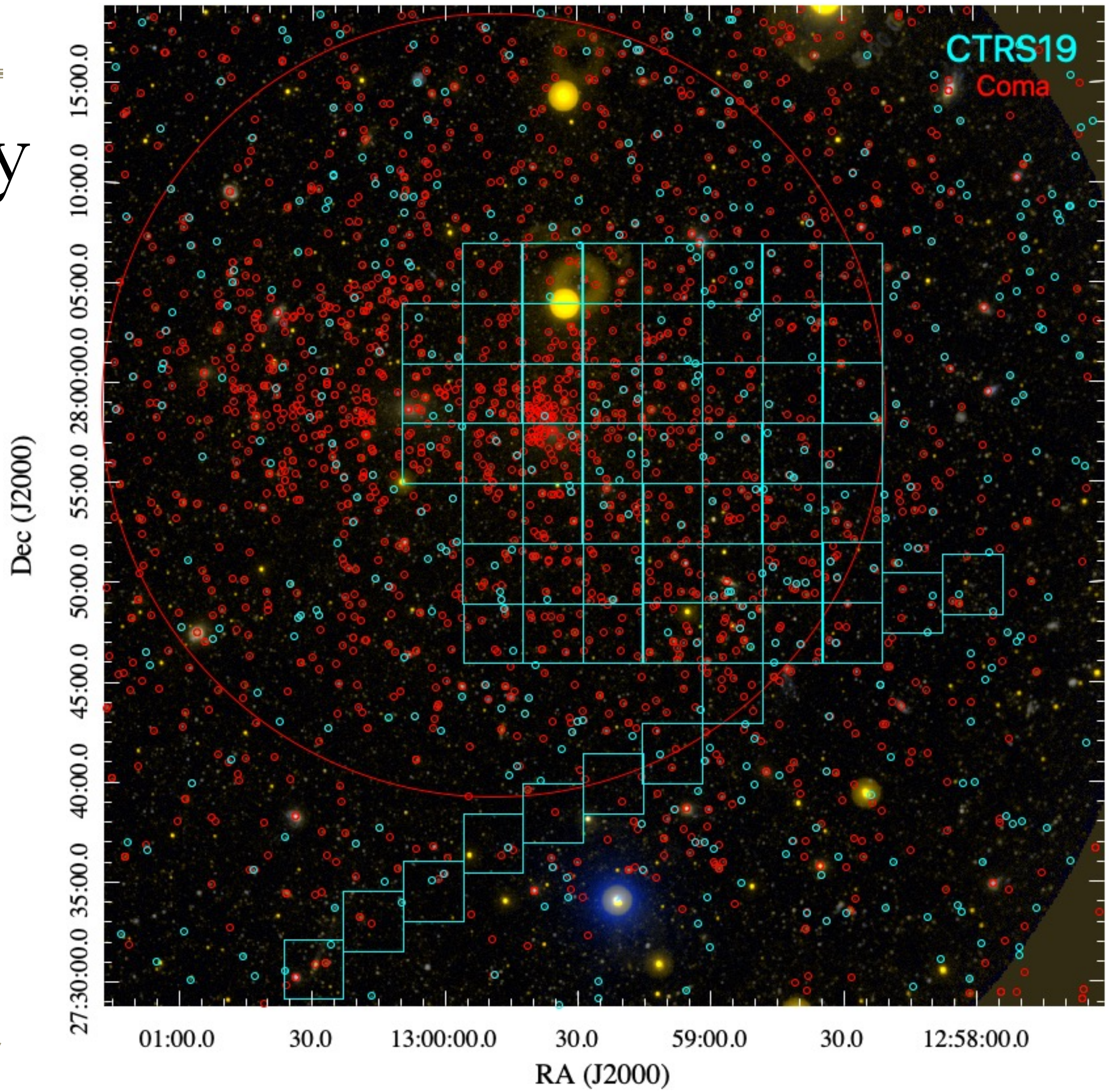
- To achieve these requirements, **observations will be carried out during clear dark (or with low Moon illumination) nights** (although not necessarily photometric).

- We require **AIRMASS to be lower than 1.22**, to limit the extinction at the blue end of the wavelength range and to fulfill our detection limits (**see CAHA UV extinction curve above**).

CATARSIS: THE SURVEY

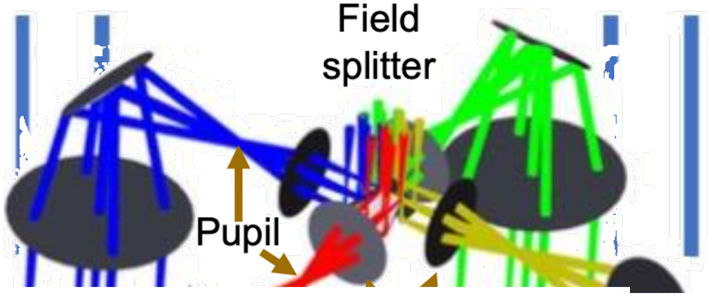
Observing strategy



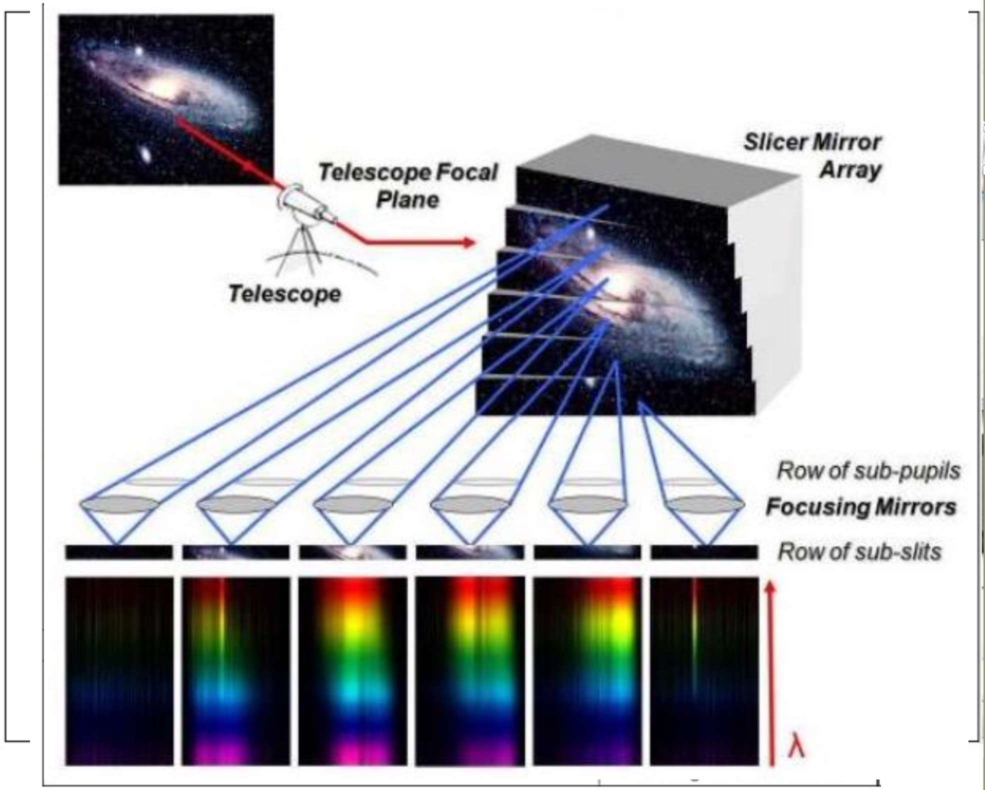


DESIGNED FOR LONG TRIPS WITH UNKN

Optical design: Image slicer



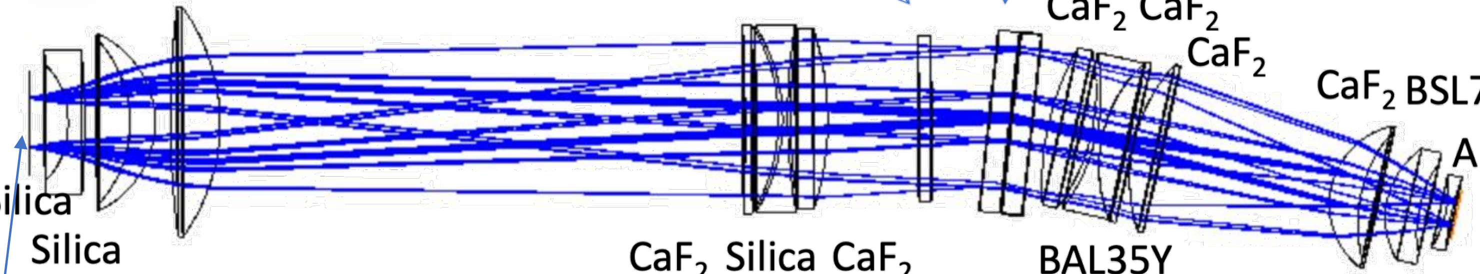
- It splits the light into 4 Qs, each 1.5'x1.5' (15x15 mm^2) in size with a gap of 0.75 mm (4.5").
- An optical relay converts the beam from F/10 to F/20.
- F/20 to F/9 slicer (from Winlight) with 42 slices per quadrant.
- Reimaging from F/9 to F/3 with flat and telecentric pseudo-slits (8 total) 112mm in length.



Optical design: Spectrographs

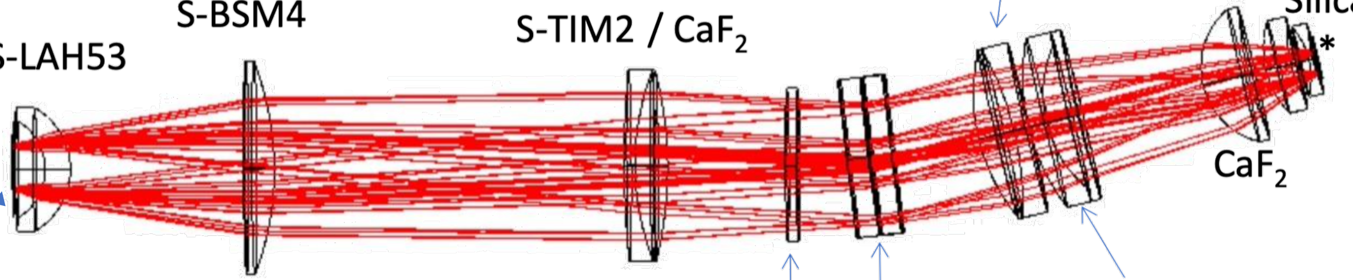
Blue Spectrograph(s)

13 lenses (6 in the F/3 collimator and 7 in the F/1.5 camera; 2 aspherics; < 280 mm)

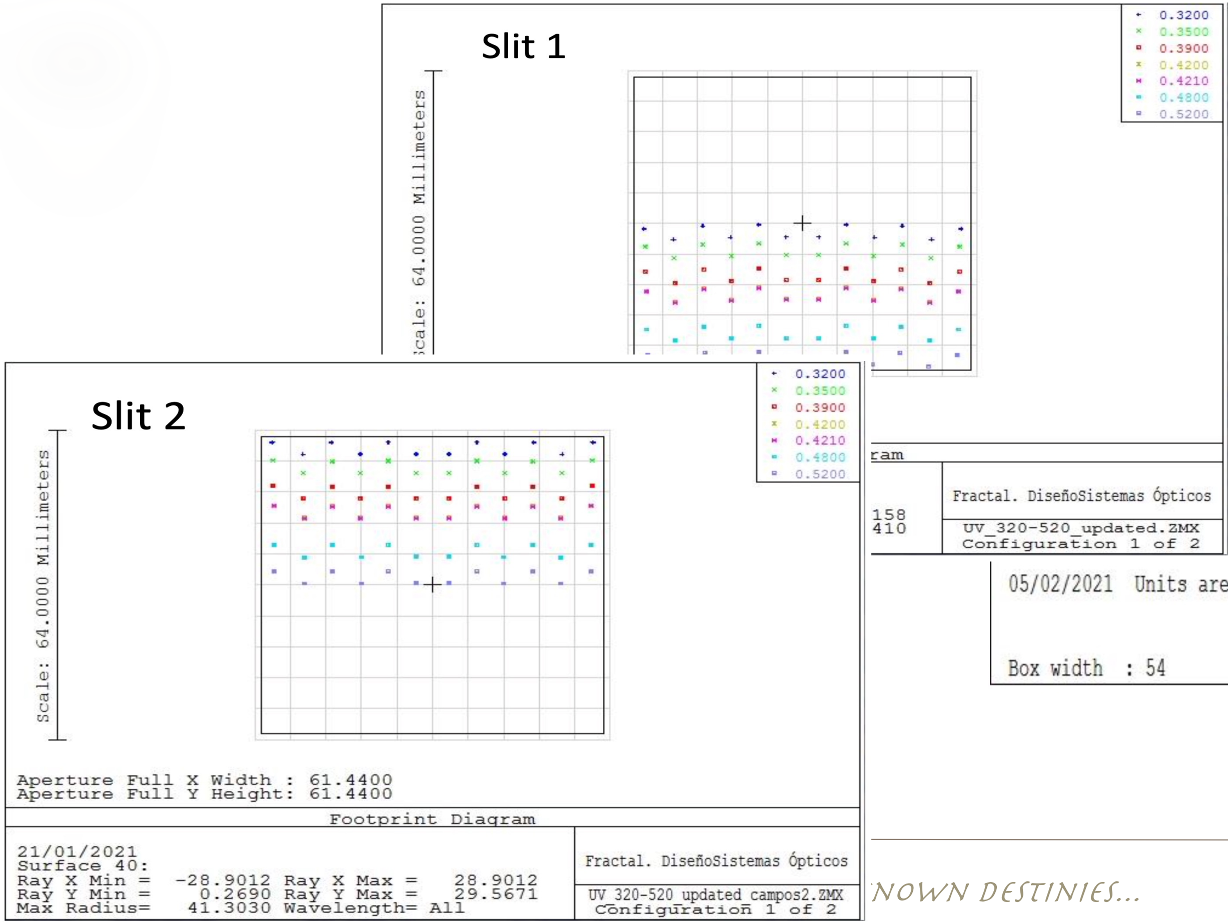


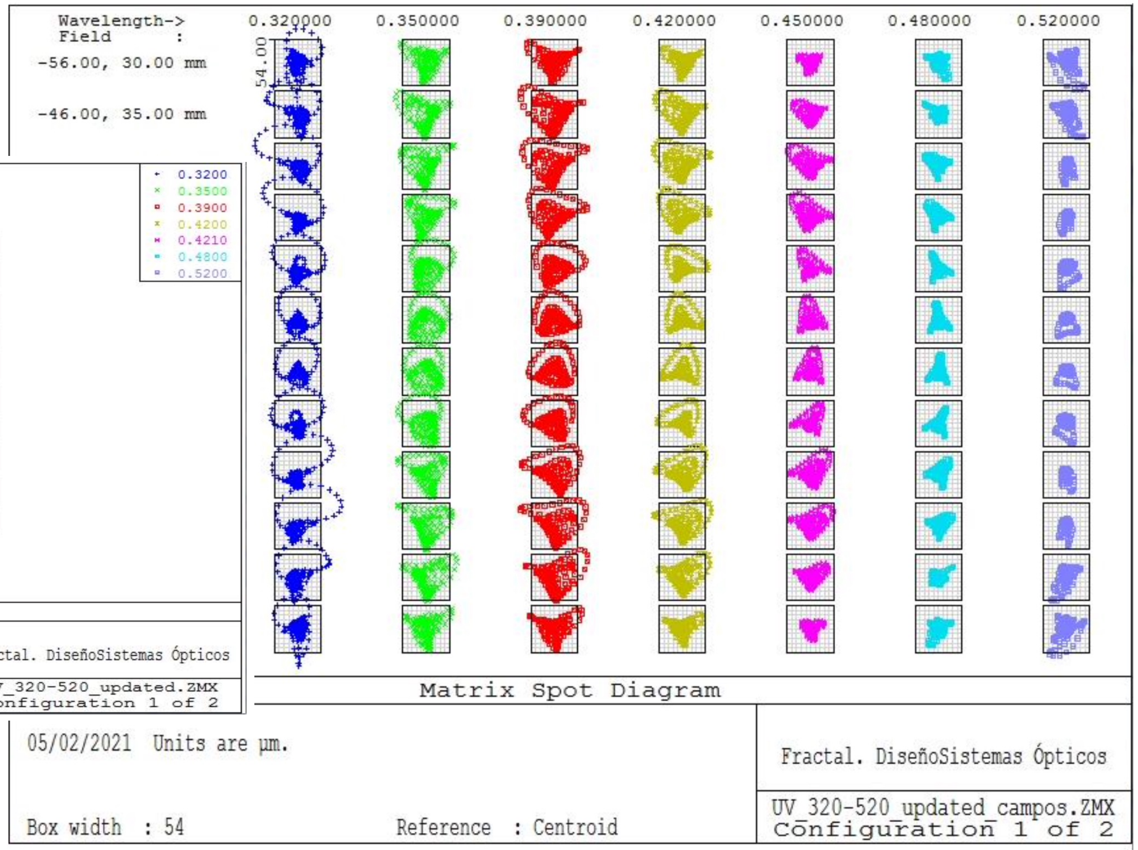
Red Spectrograph

11 lenses (4 in the F/3 collimator and 7 in the F/1.5 camera; 2 aspherics; < 295 mm)



Optical design:





Spot diagrams (Blue spectrographs)

Optical design:

Resolving power

Blue

Wavelength (nm)	Resolving Power, R (for 3.6 pix)	
	Slit 1	Slit 2
320	747	764
420	1042	1039
520	1309	1312

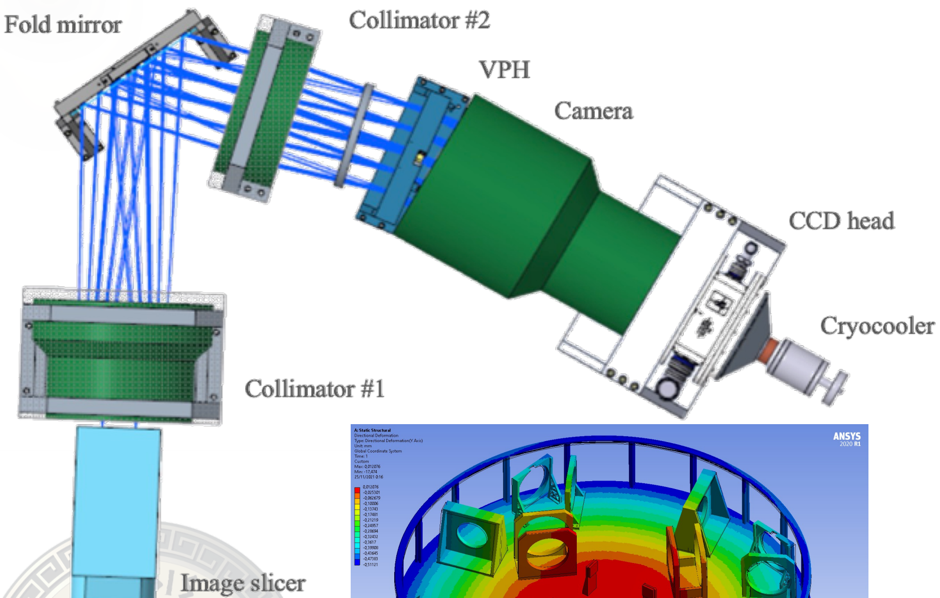
Red+RLR

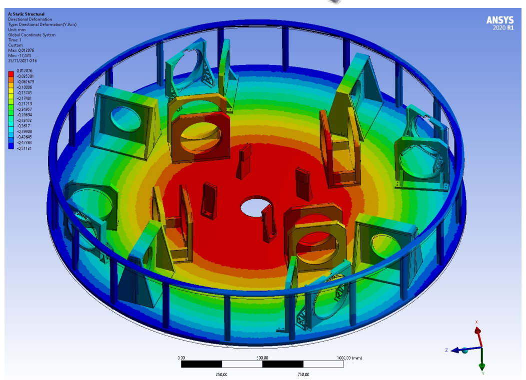
λ (nm)	Resolving Power, R (3.6 pix)	
	RLR	
	Slit 1	Slit 2
510	784	793
660	1057	1063
810	1320	1329

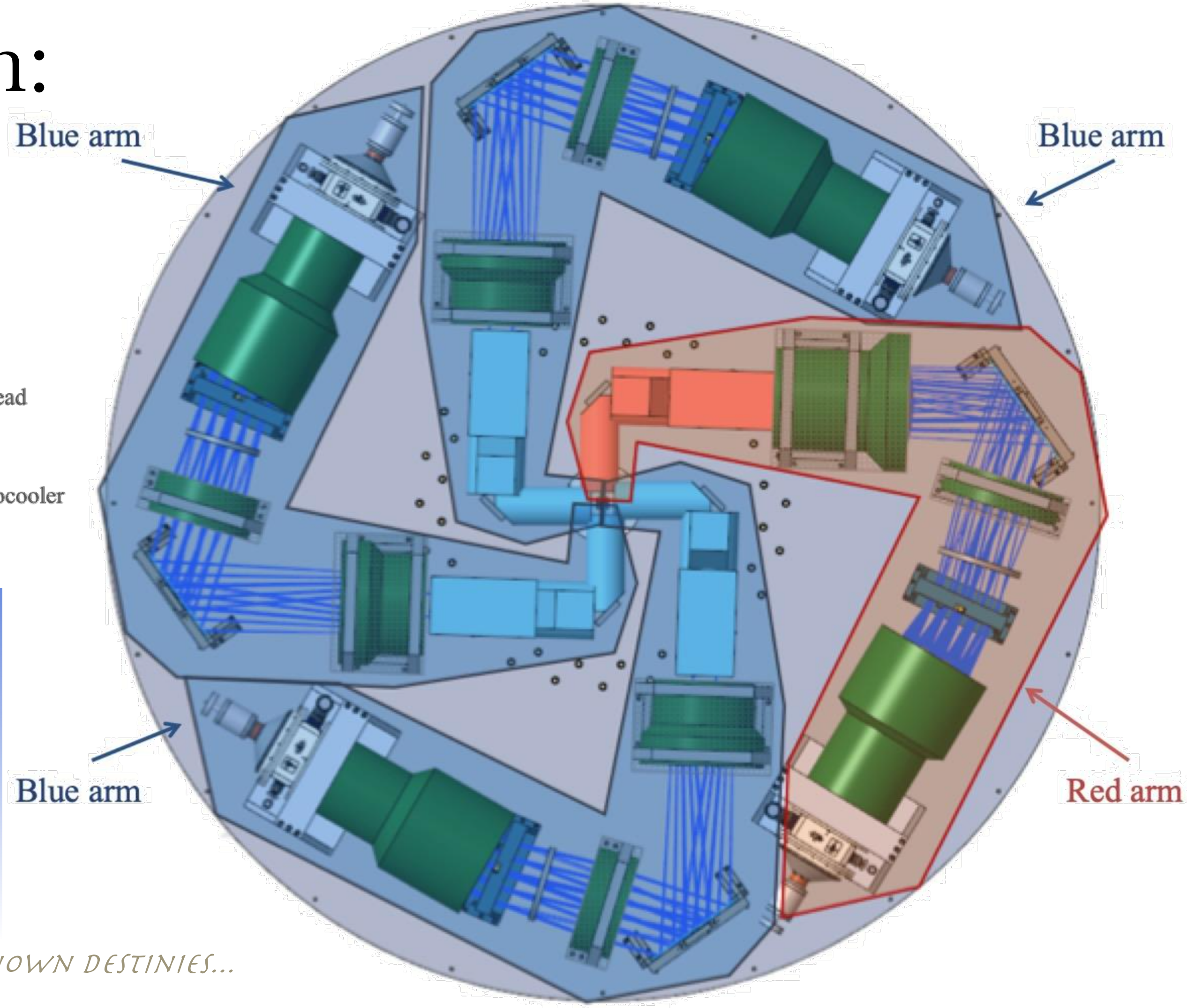
Red+RHR

λ (nm)	Resolving Power, R (3.6 pix)	
	RHR	
	Slit 1	Slit 2
590	1977	1999
660	2254	2267
730	2507	2514

Mechanical design:

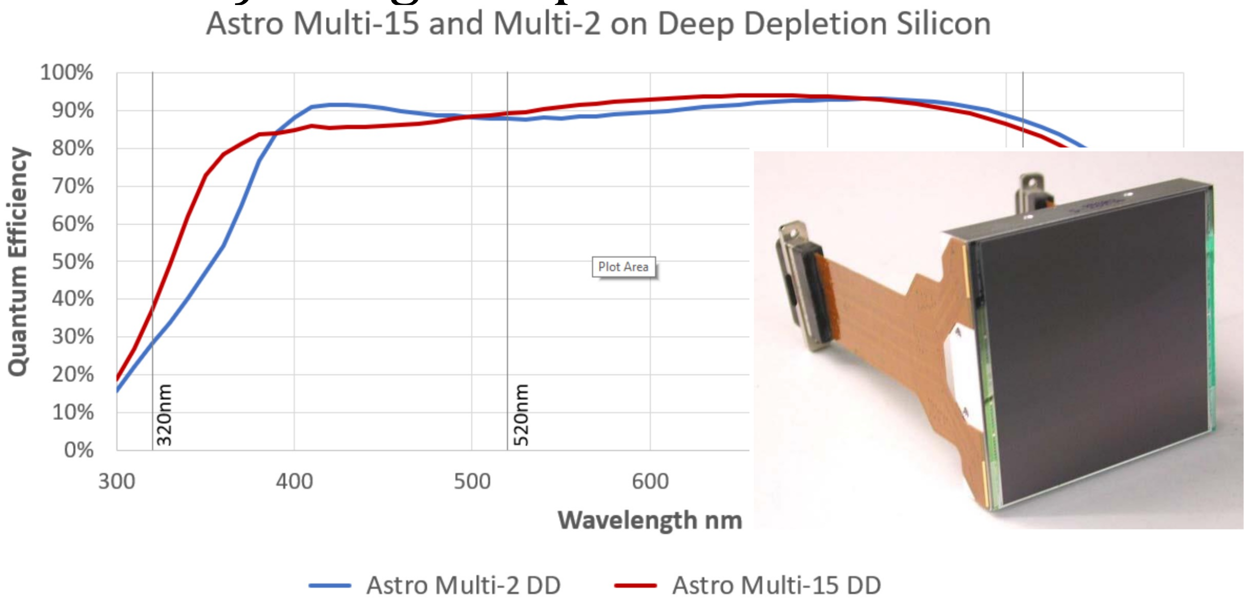






Detector: CCD

- 4x CCD231-84 (3 standard silicon, 1 DD) with Astro Multi-15 coating
- ESO-MUSE CCD head (as in CARMENES) using flex-prints



- Read through two diagonally-opposed amplifiers: RoN<3.5e⁻ & RoT<1 min
- CryoTel MT cryocooler & Sunpower AVC
- 2 (M&S) STA Archon controllers
- Lakeshore thermal control
- CCD window flushed with compressed air

BUDGETS

Technical budgets:

- Mass & momentum
- Envelope
- Data Storage

Performance:

- Image quality
- Transmission

Fore-optics (slicer) + VPHs + spectrograph + CCD

Components	Units	Unit mass (kg)	Mass (kg)	CoG z (mm)	Moment (Nm)
Image slicers	4	10	40	665	261
Collimators	4	80	320	665	2085
Cameras	4	90	360	665	2346
Fold mirrors	4	4	16	665	104
VPHs	4	6	24	665	156
CCD heads	4	7	28	665	182
Cryostats	4	2	8	665	52
CCD controllers	2	7	14	660	91
Support structure and cover	1	585	585	450	2580
Pending (shutters, baffles, AG, CU ...)	1	50	50	665	326
Total			**1445**		**8184**
CARMENES	1	250	250	170	417
Total with CARMENES			**1695**		**8600**
Contingency	1	234	234	665	1525
Total CARMENES and contingency			**1929**		**10125**
Requirement					**10125**

Wavelength (nm)

BUDGETS

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- Envelope
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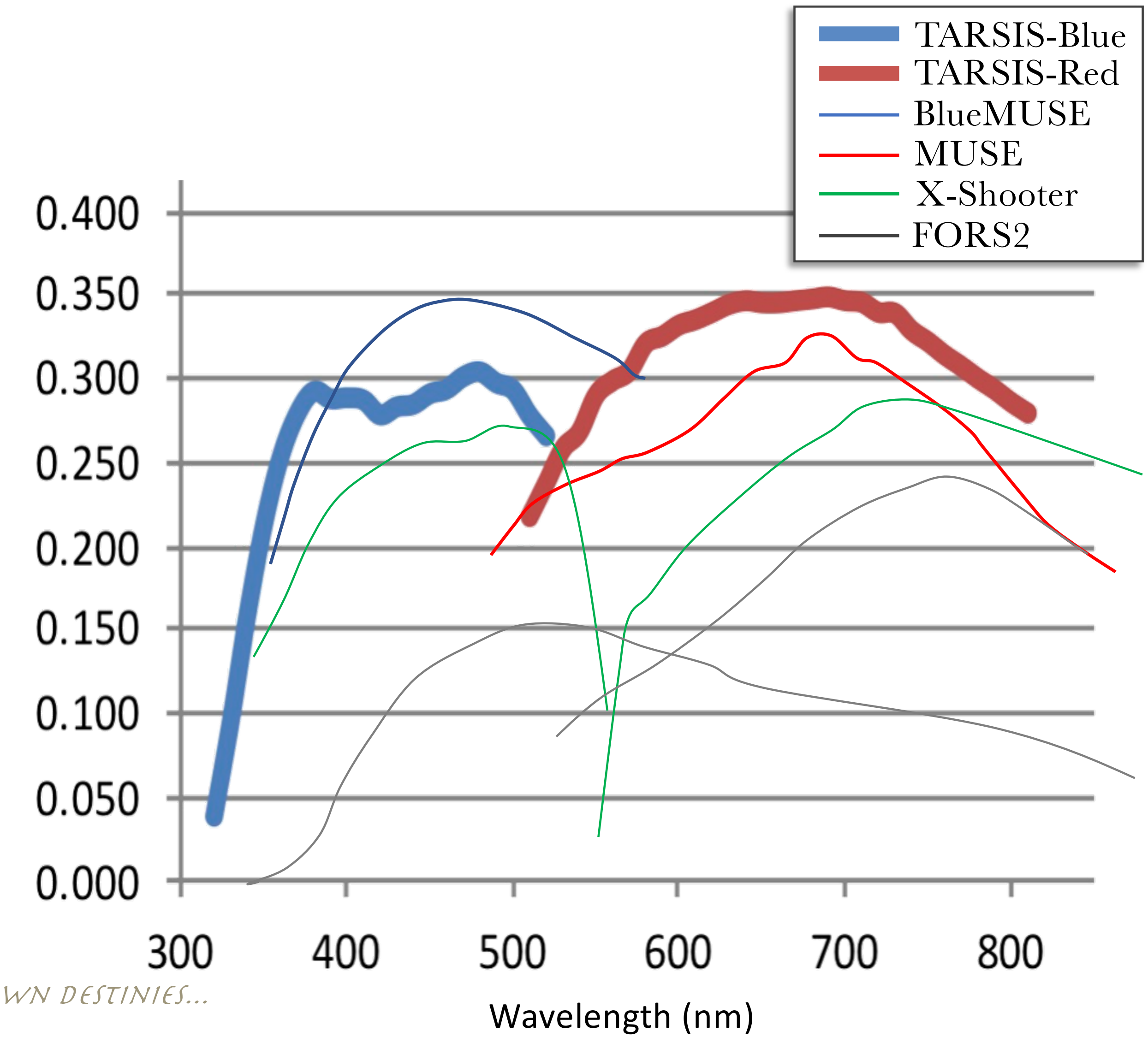
Performance:

- Image quality
- Transmission

  Fore-optics (slicer) + VPHs + spectrograph + CCD

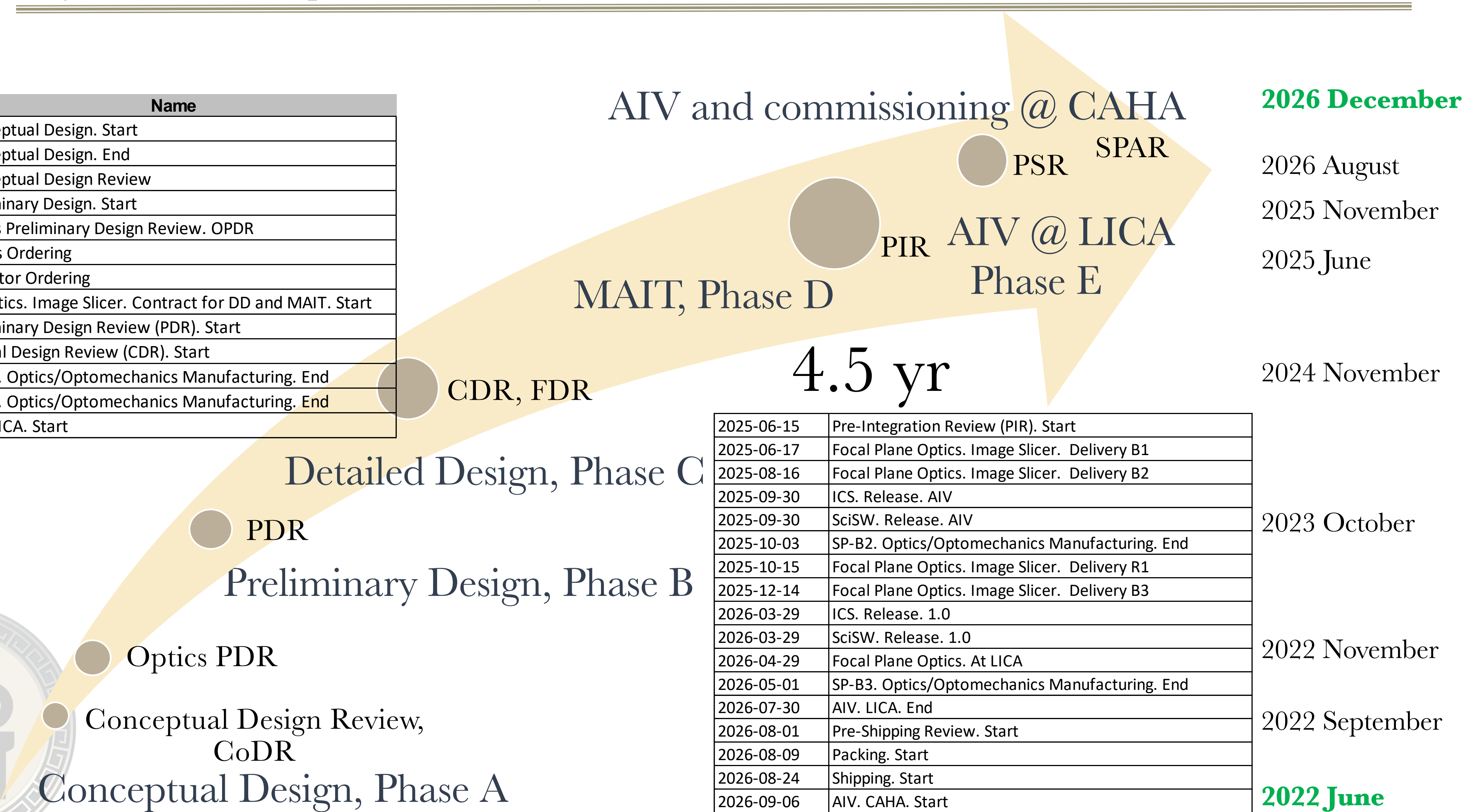


Work packages:

Code		Title	WP Manager
WP-TAR-00		FEASIBILITY STUDY	Gil de Paz, Armando
WP-TAR-01		SCIENCE	Sanchez Blazquez, Patricia
WP-TAR-02		MANAGEMENT	García Vargas, Marisa
WP-TAR-03		SYSTEM ENGINEERING	Perez Calpena, Ana
WP-TAR-04		OPTICS AND MECHANICS	García Vargas, Marisa
WP-TAR-05		OPTICS MANUFACTURING	Carrasco, Esperanza
WP-TAR-06		DETECTOR SYSTEM	Tulloch, Simon
WP-TAR-07		INSTRUMENT CONTROL SYSTEM	Iglesias Paramo, Jorge
WP-TAR-08		SCIENTIFIC SOFTWARE	Cardiel López, Nicolás
	WP-TAR-08.01	Simulator	Labiano, Alvaro
	WP-TAR-08.02	DRP Data Processing	Pascual Ramírez, Sergio
	WP-TAR-08.03	Post-processing	Castillo Morales, Africa
	WP-TAR-08.04	Quality Control	Kehrig, Carolina
	WP-TAR-08.05	High Performance Computing	González Ruiz, Vicente
	WP-TAR-08.06	Data Storage	Piqueras, Javier
	WP-TAR-08.07	CATARSIS software tools	Relaño Pastor, Monica
WP-TAR-09		SITE: UV CHARACTERIZATION	Oñorbe, Jose
WP-TAR-10		A&G AND CALIBRATION UNIT	Iglesias Paramo, Jorge
WP-TAR-11		OUTREACH AND MEDIA	Iglesias Paramo, Jorge

Project Calendar: phases and key milestones

Date	Name
2022-06-16	Conceptual Design. Start
2022-09-01	Conceptual Design. End
2022-09-15	Conceptual Design Review
2022-09-16	Preliminary Design. Start
2022-11-30	Optics Preliminary Design Review. OPDR
2022-12-07	Blanks Ordering
2022-12-07	Detector Ordering
2022-12-30	FP Optics. Image Slicer. Contract for DD and MAIT. Start
2023-10-11	Preliminary Design Review (PDR). Start
2024-11-12	Critical Design Review (CDR). Start
2025-04-06	SP-B1. Optics/Optomechanics Manufacturing. End
2025-04-06	SP-R1. Optics/Optomechanics Manufacturing. End
2025-05-07	AIV. LICA. Start

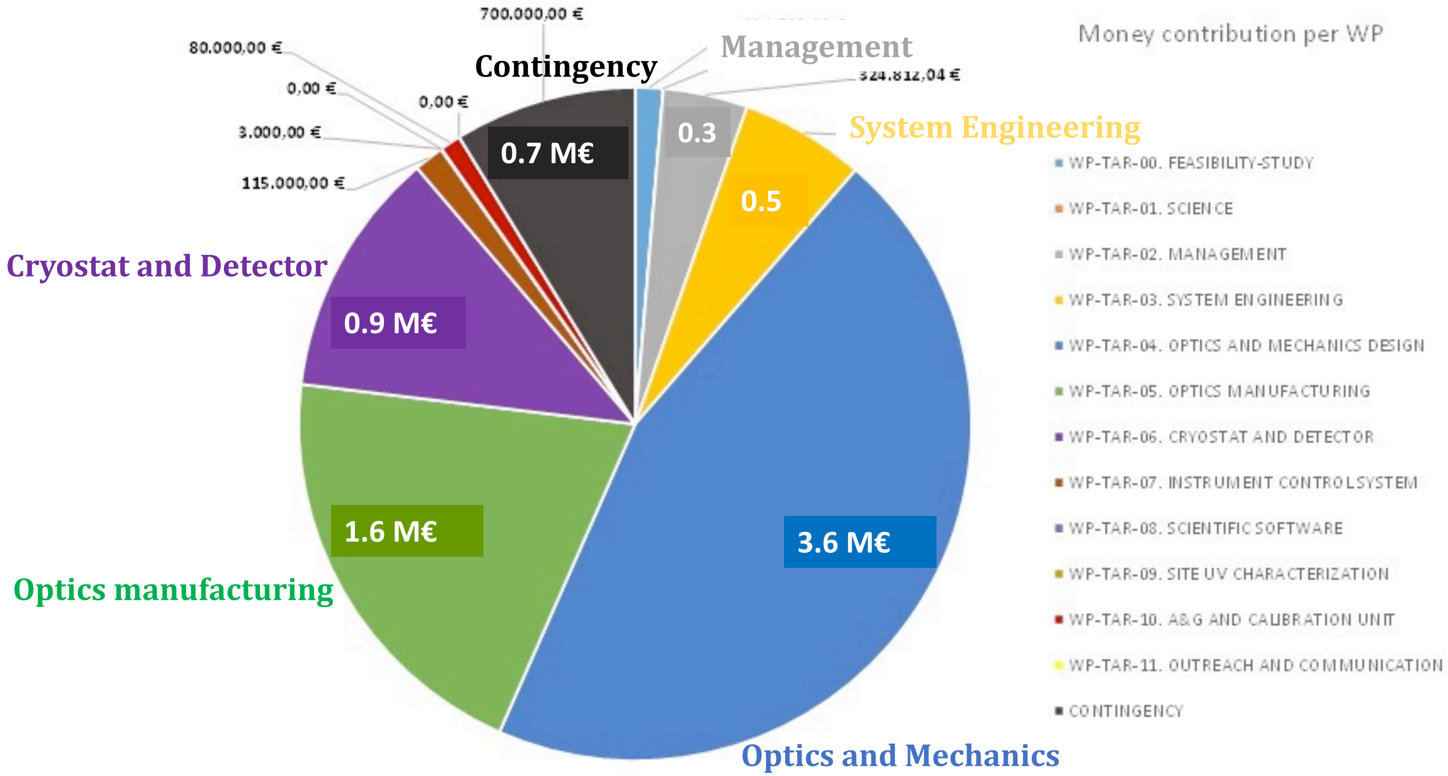


2025-06-15	Pre-Integration Review (PIR). Start
2025-06-17	Focal Plane Optics. Image Slicer. Delivery B1
2025-08-16	Focal Plane Optics. Image Slicer. Delivery B2
2025-09-30	ICS. Release. AIV
2025-09-30	SciSW. Release. AIV
2025-10-03	SP-B2. Optics/Optomechanics Manufacturing. End
2025-10-15	Focal Plane Optics. Image Slicer. Delivery R1
2025-12-14	Focal Plane Optics. Image Slicer. Delivery B3
2026-03-29	ICS. Release. 1.0
2026-03-29	SciSW. Release. 1.0
2026-04-29	Focal Plane Optics. At LICA
2026-05-01	SP-B3. Optics/Optomechanics Manufacturing. End
2026-07-30	AIV. LICA. End
2026-08-01	Pre-Shipping Review. Start
2026-08-09	Packing. Start
2026-08-24	Shipping. Start
2026-09-06	AIV. CAHA. Start
2026-10-01	Commissioning. Start
2026-12-31	TARSIS Day One

BUDGET: Cash

Conceptual Design to end of Commissioning Now-2026

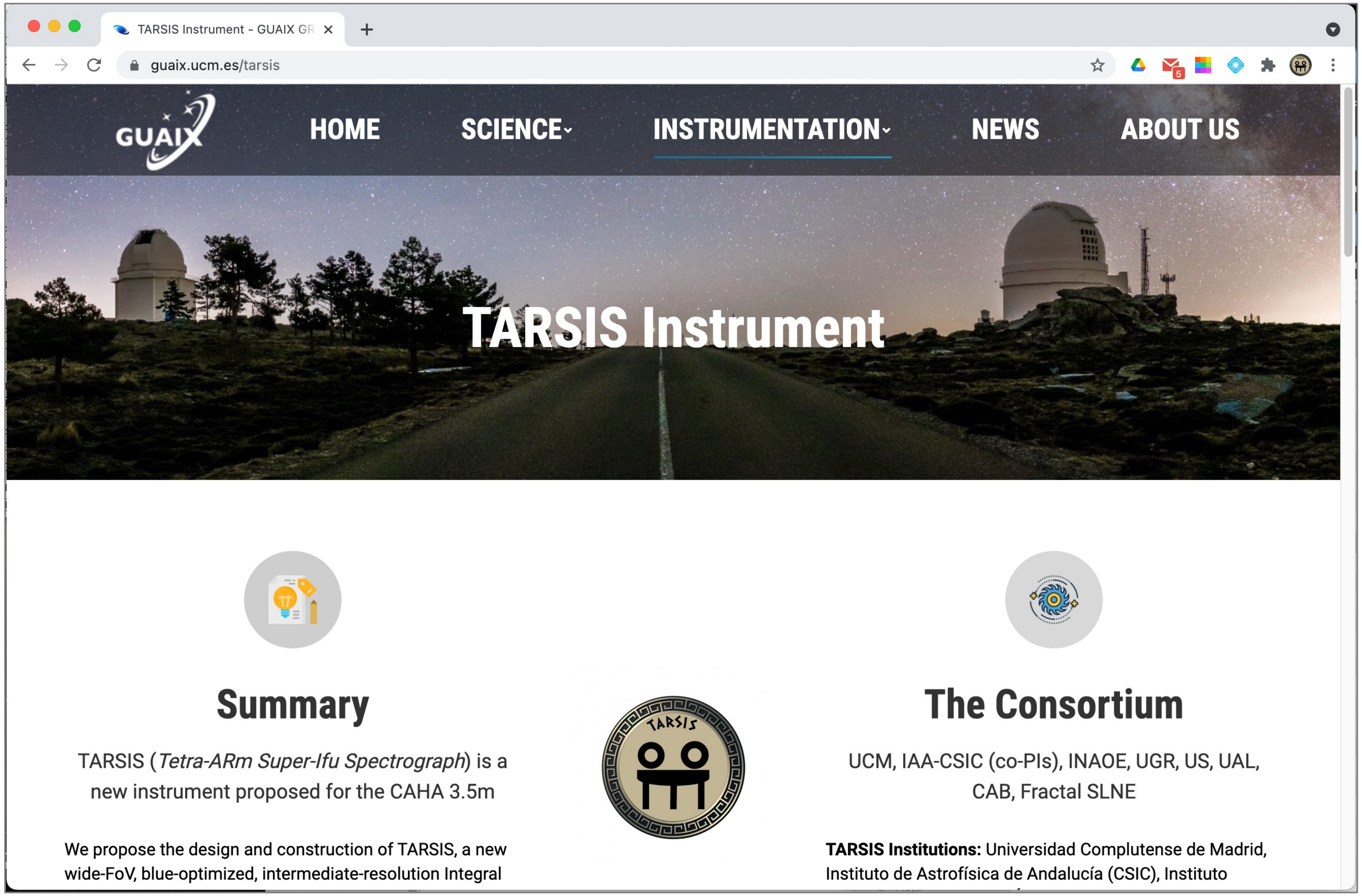
7.2 M€ + 0.70 M€ contingency = 7.9 M€



Conclusions

- TARSIS is feasible albeit ambitious since its driving science demand it.
- TARSIS is not simply another large-FoV IFU. With a FoV of 9 sq. arcmin will provide CAHA with a workhorse instrument that will also give CAHA international projection and visibility.
- The Consortium, the Science and Instrument teams are all committed and have ample experience in instrument design, construction and exploitation.
- TARSIS will be ready at the telescope in 2026. Despite being a "management challenge" we have done it before.
- Although optimized for CATARSIS, TARSIS should serve to multiple scientific purposes. TARSIS is also a discovery machine and an ideal tool for transients' *first-response* follow-up.

Webpage:



https://tarsis.caha.es/

https://guaix.ucm.es/tarsis