Gobierno de Canarias
Agencia Canaria de Investigación, Innovación y Sociedad de la Información

EXCELENCIA SEVERO OCHOA

MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Unión Europea
Fondo Europeo de desarrollo Regional
"Una manera de hacer Europa"

Universidad de La Laguna

EMIR & MIRADAS in the Gaia era: status and prospects

F. Garzón @ EMIR&MIRADAS Teams

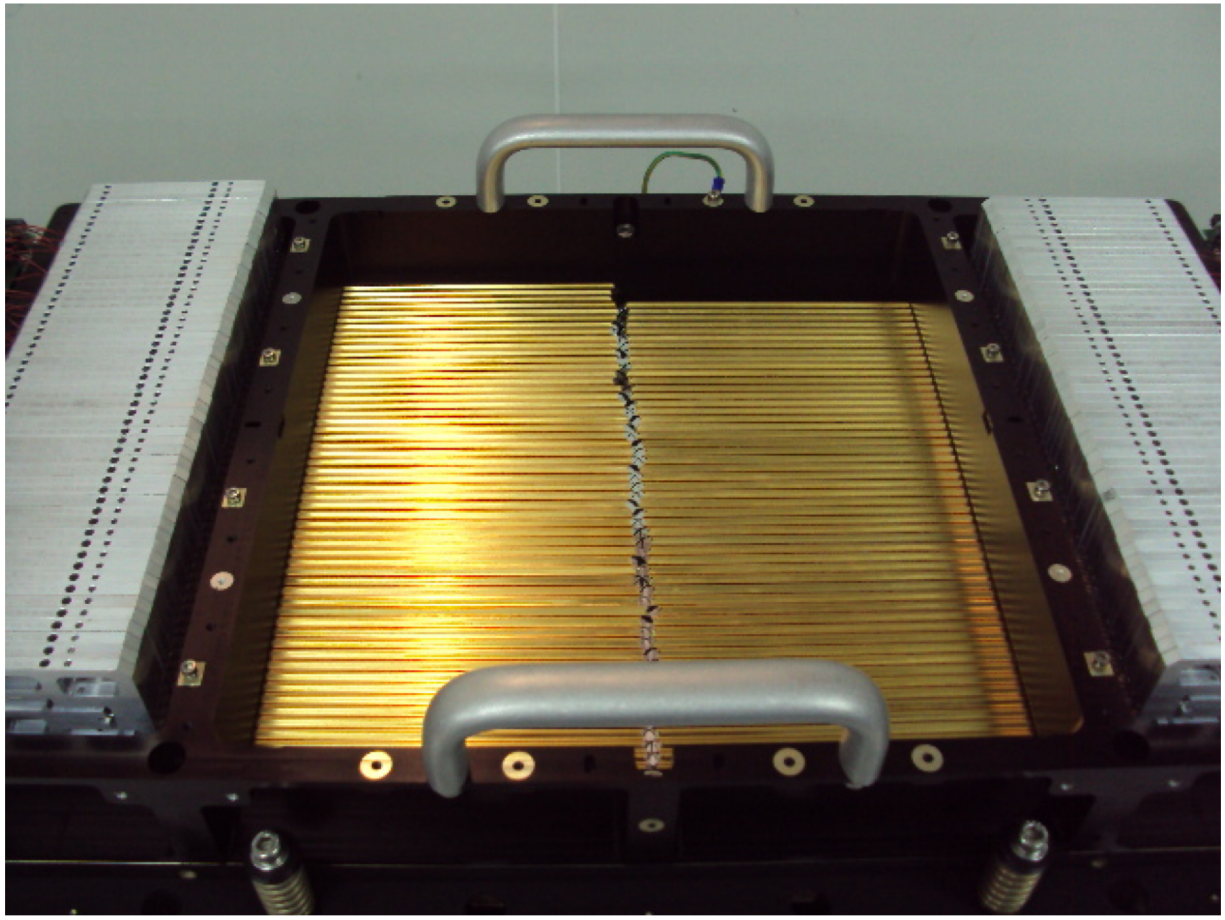
Expanding the Gaia legacy: the role of Spanish ground-based facilities

EMIR: general description

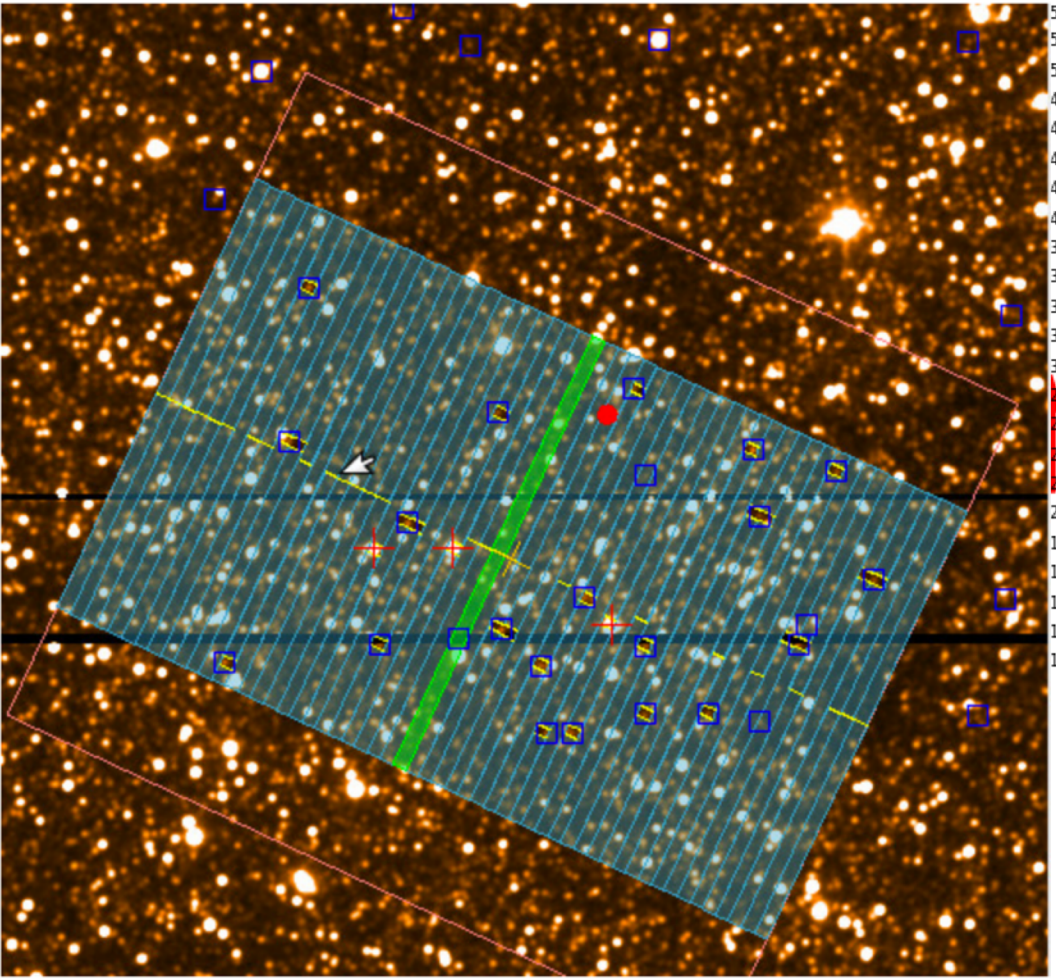
- EMIR is a NIR Imager and multi-object spectrograph, acting as a common user instrument for GTC

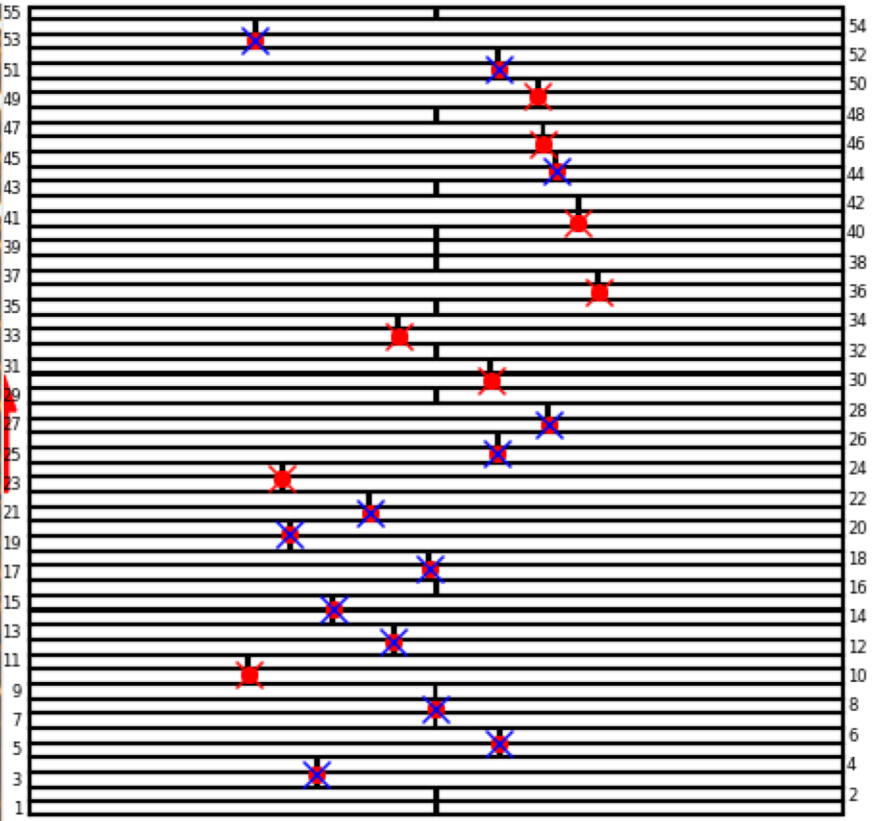
Spectral Range	0.9-2.5μm[1.1-2.5μm]	MOS mode	
Top priority	MOS in K band	FOV	6,7x4 arcmin (55 slitlets)
Spectral Resol.	5000,4250,4000 (JHK) ~987 HK + YJ	Sensitivity	K~20.1 in 2h @ S/N=5 (continuum)
Spectral coverage	1 single window/exp.		1.6×10^{-18} erg/s/cm^2/Å in 4h @ S/N=5 (line)
Detector	HAWAI2 2048^2	Image mode	
Plate Scale	0.2 arcsec/px	FOV	6.7x6.7 arcmin
Image quality	θ_{80} < 0.2 arcsec	Sensitivity	K~22.8 in 1h @ S/N=5 in 0.6 arcsec aperture

EMIR CSU



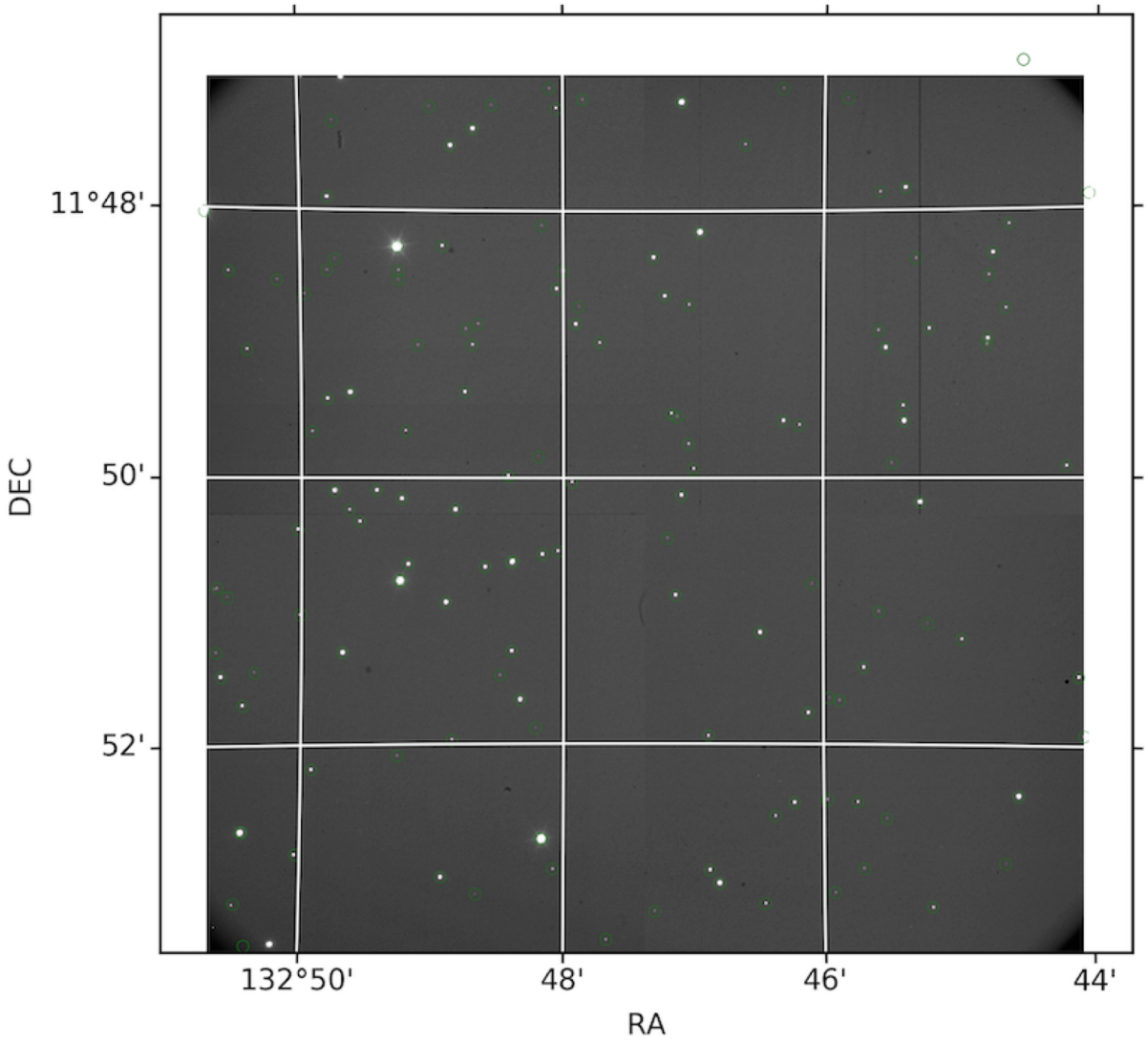
Immediate Gaia synergy





Use Gaia astrometry for the reference objects, at least

EMIR astrometry vs Gaia



Scientific Drivers

- Goya:
  - Census of galaxian populations at z~1-2.5
- Galep
  - Search the stellar population of the MW
- MasGomas
  - New clusters of massive stars in the inner Galaxy
- East sci. cases
- …

GALEP

- Use EMIR to obtain near IR spectroscopy of many thousands sources
  - vast majority located in the inner Galaxy
  - selected from their position on IR colour-magnitude diagrams
  - will include disc, bar, bulge and ring sources.
- NIR spectra (H & K bands) will allow accurate determination of the spectral type of the sources.
  - series of molecular lines, OH, H_2O and CO
  - metallic lines: Na, Ca, Fe, etc.
  - …
- Features relatively spread out between 1.5 and 2.4 microns
  - much higher resolution is not required.
- The relative strength of these lines coupled with the overall form of the spectra will allow the spectra type to be accurately determined.

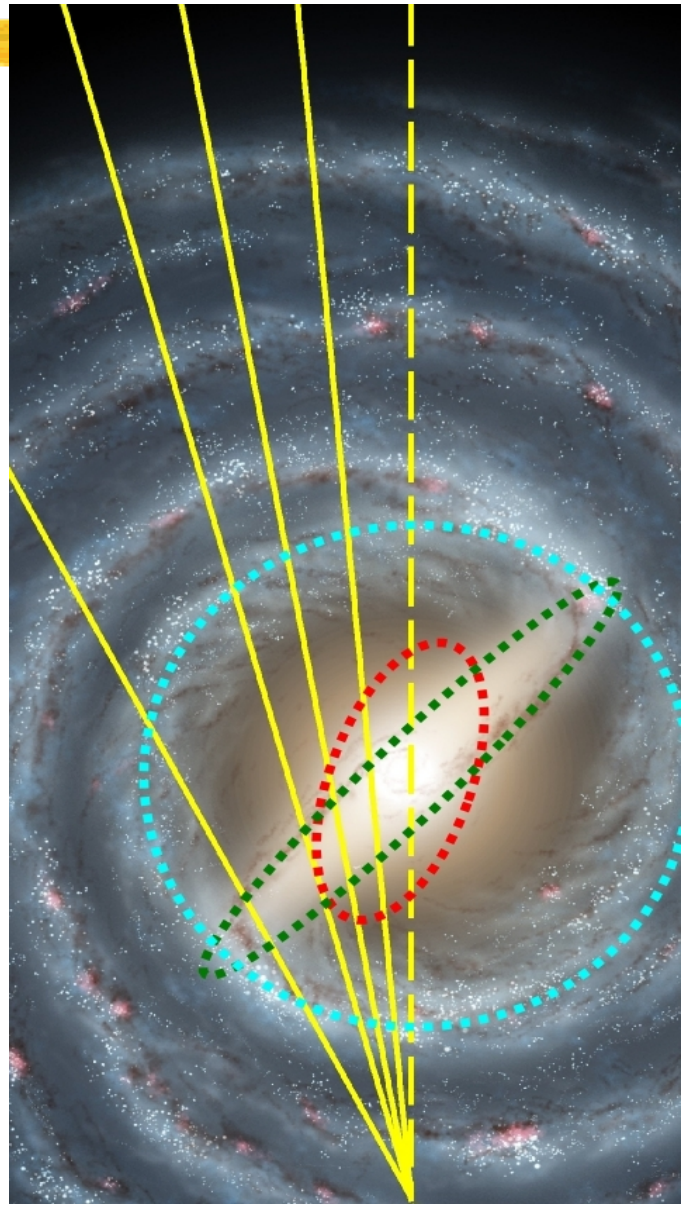
GALEP

EMIR will obtain ~20 - 40 spectra at once.

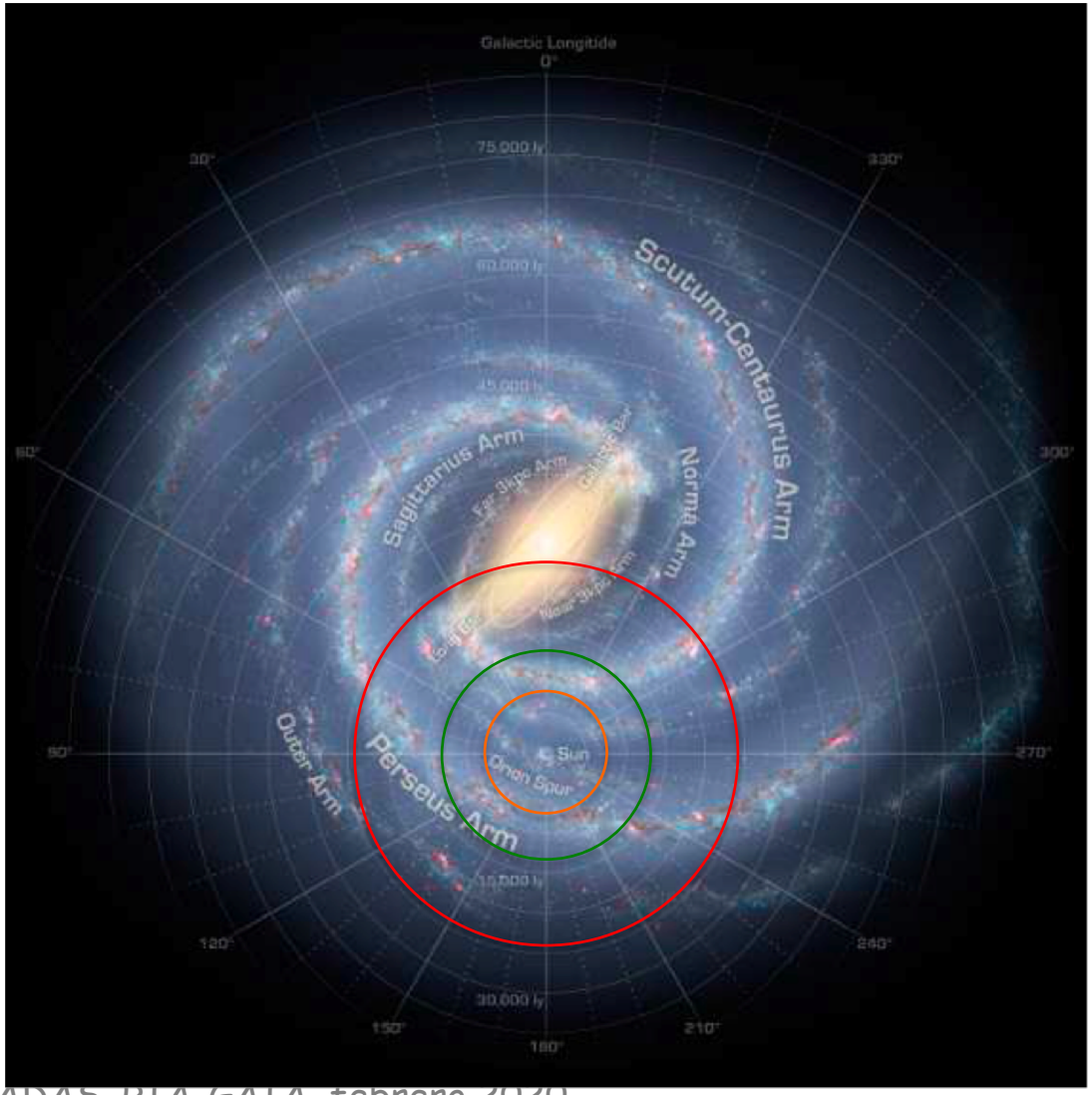
It can map:

- H-K window at R~1000.
- JHK windows at R~4000.

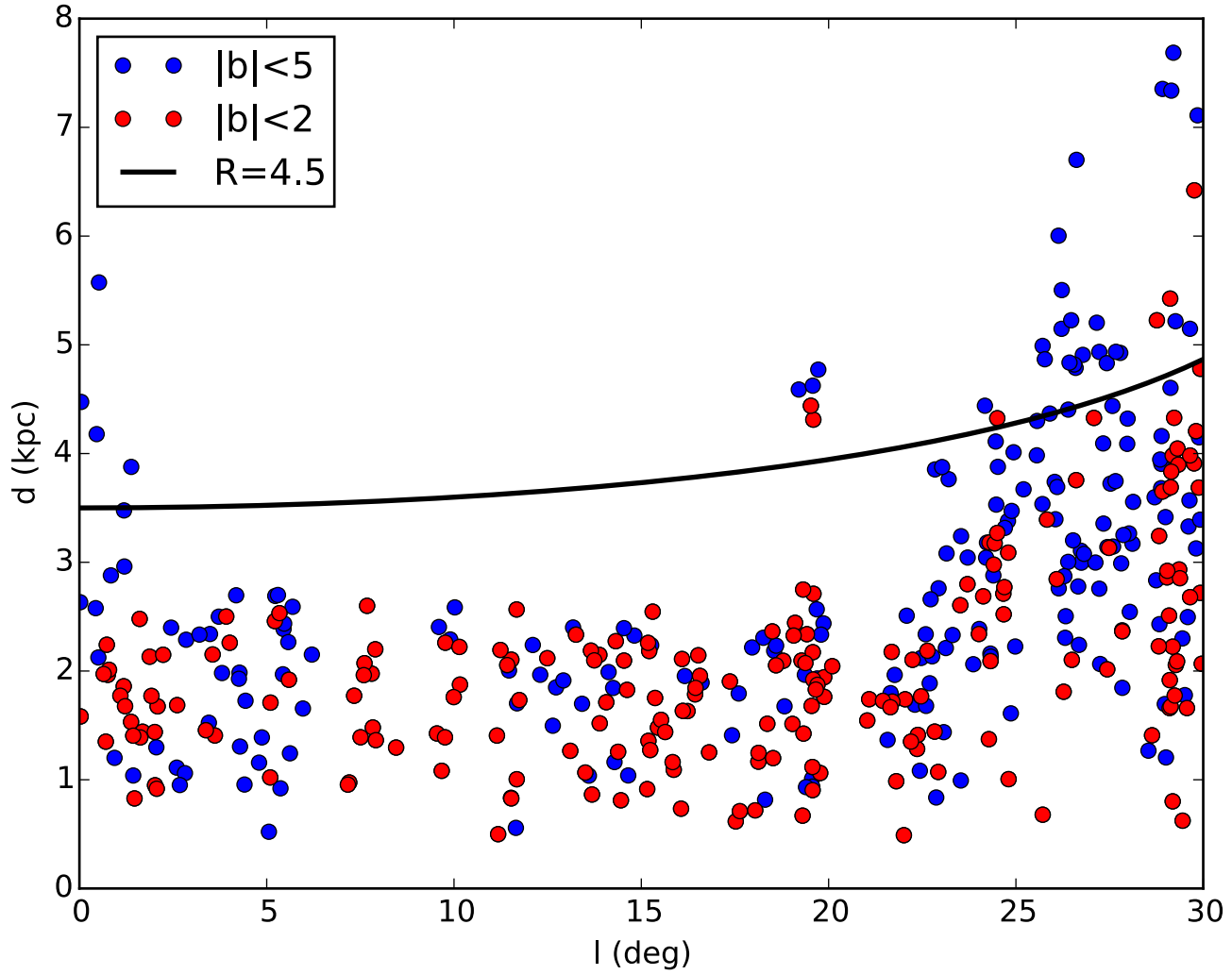
In a few nights, a statistically significant sample (~2000 spectra) can be gathered, and from it infer some of the properties of the Galactic structures of interest.



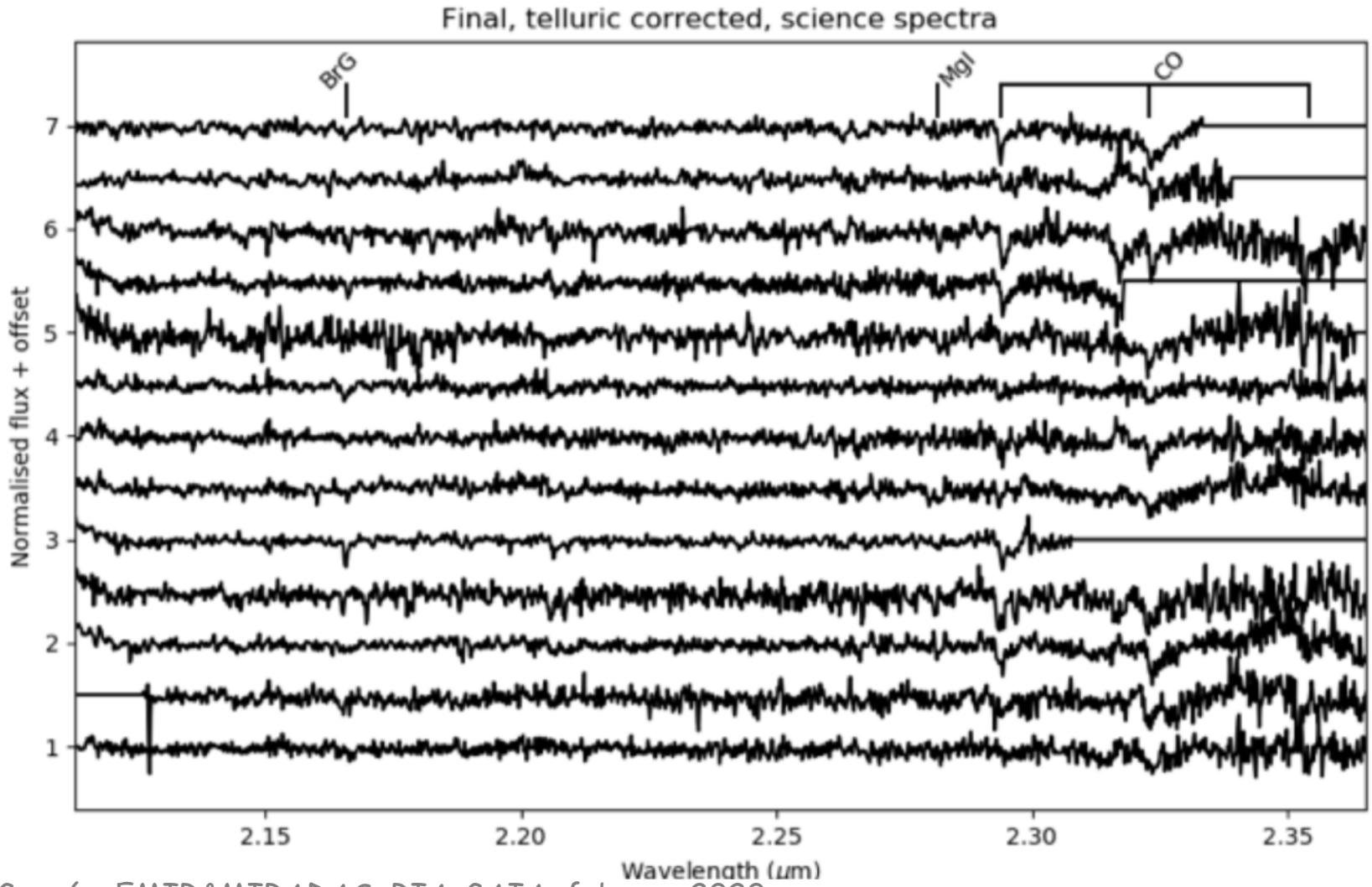
GALEP targets



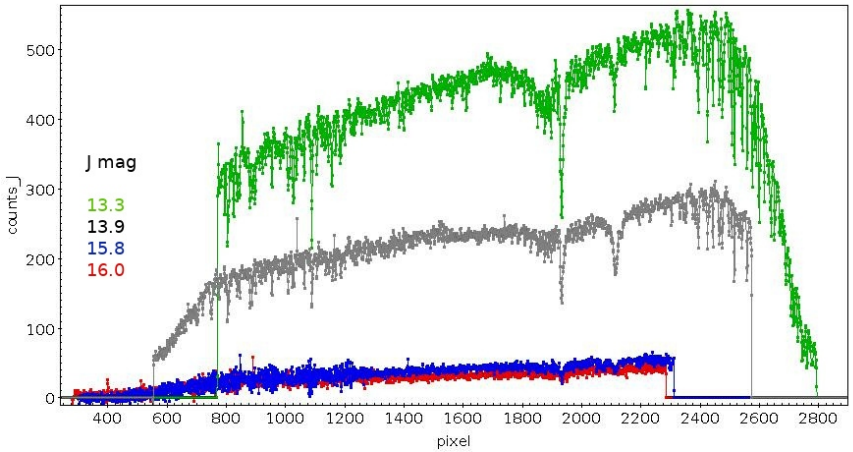
GALEP targets



GALEP


Final, telluric corrected, science spectra
BrG
MgI
CO
Normalised flux + offset
Wavelength (μm)
1
2
3
4
5
6
7
2.15
2.20
2.25
2.30
2.35

GALEP and EMIR instr. model

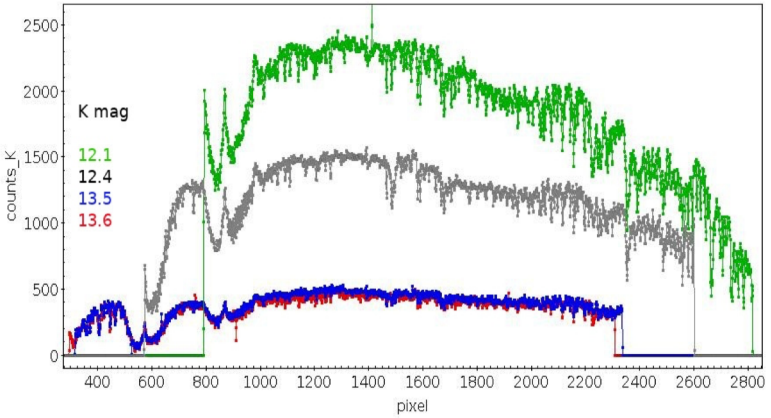


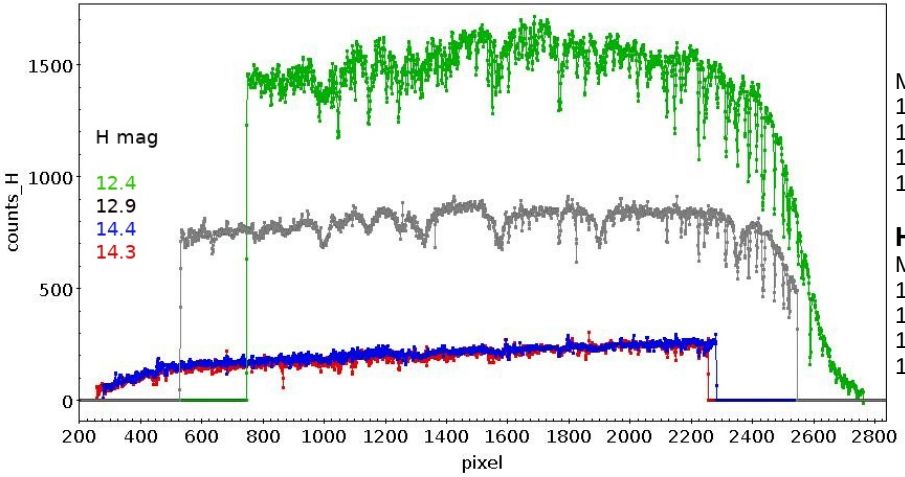
J band_count

Mag	ETC	Real
13.3	657	470-520
13.9	378	230-280
15.8	66	37-55
16.0	55	27-43

J band_SN

Mag	ETC	Real
13.3	118	77
13.9	73	74
15.8	14	15
16.0	12	12





H band_counts

Mag	ETC	Real
12.4	2107	1640
12.9	1327	870
14.4	334	220
14.3	366	210

H band_SN

Mag	ETC	Real
12.4	177	124
12.9	127	131
14.4	39	42
14.3	43	39

K band_counts

Mag	ETC	Real
12.1	1935	2412
12.4	1468	1510
13.5	533	506
13.6	486	470

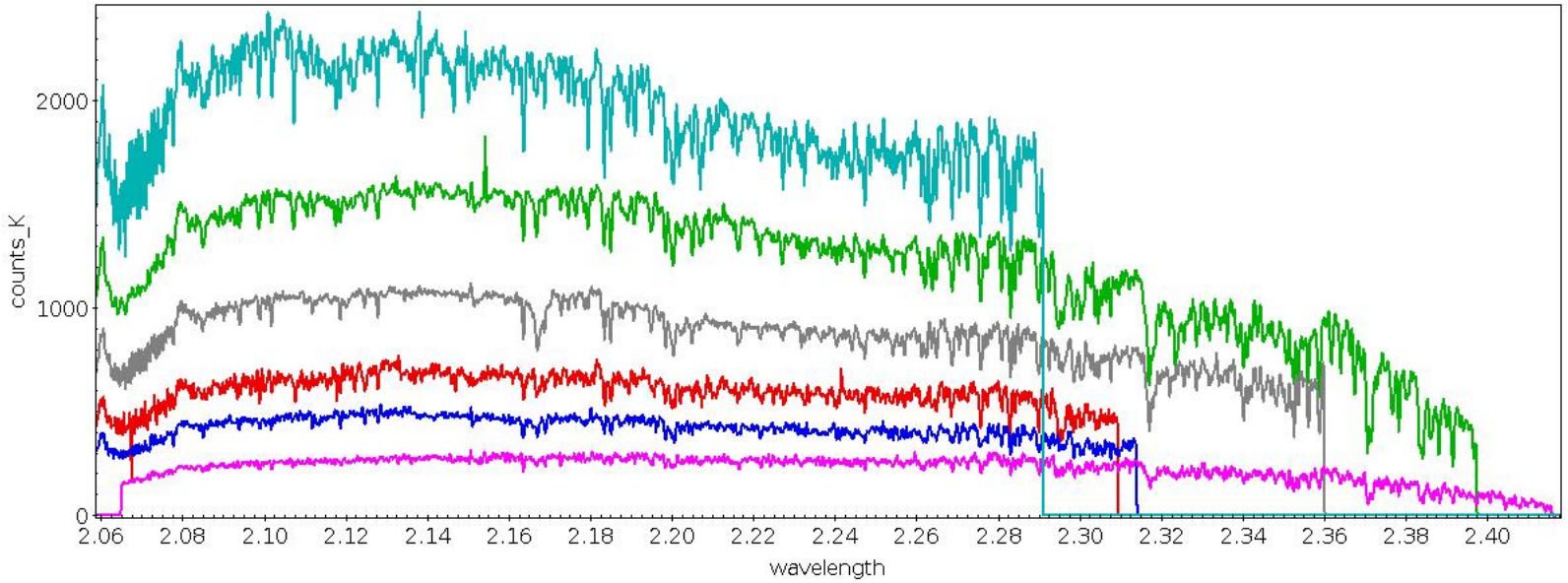
K band_SN

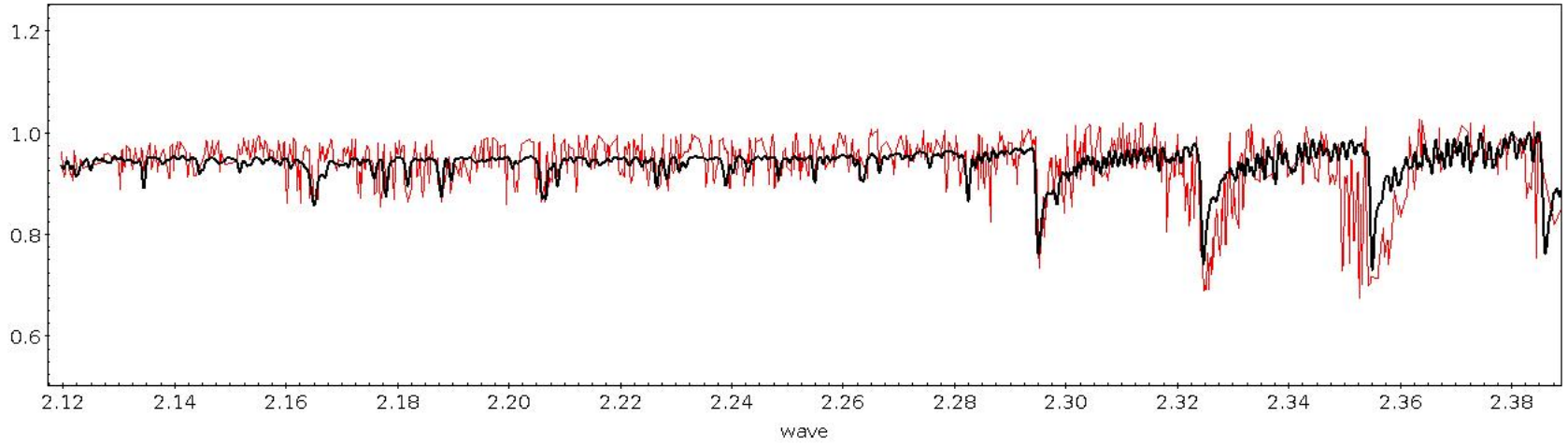
Mag	ETC	Real
12.1	162	130
12.4	132	138
13.5	56	35
13.6	52	31

GALEP status

- Analysing the pilot survey
- Refining the obs. strategy
- Revisiting target selection
- Adapting the DRP output for the Ferre code

Galep K band spectra

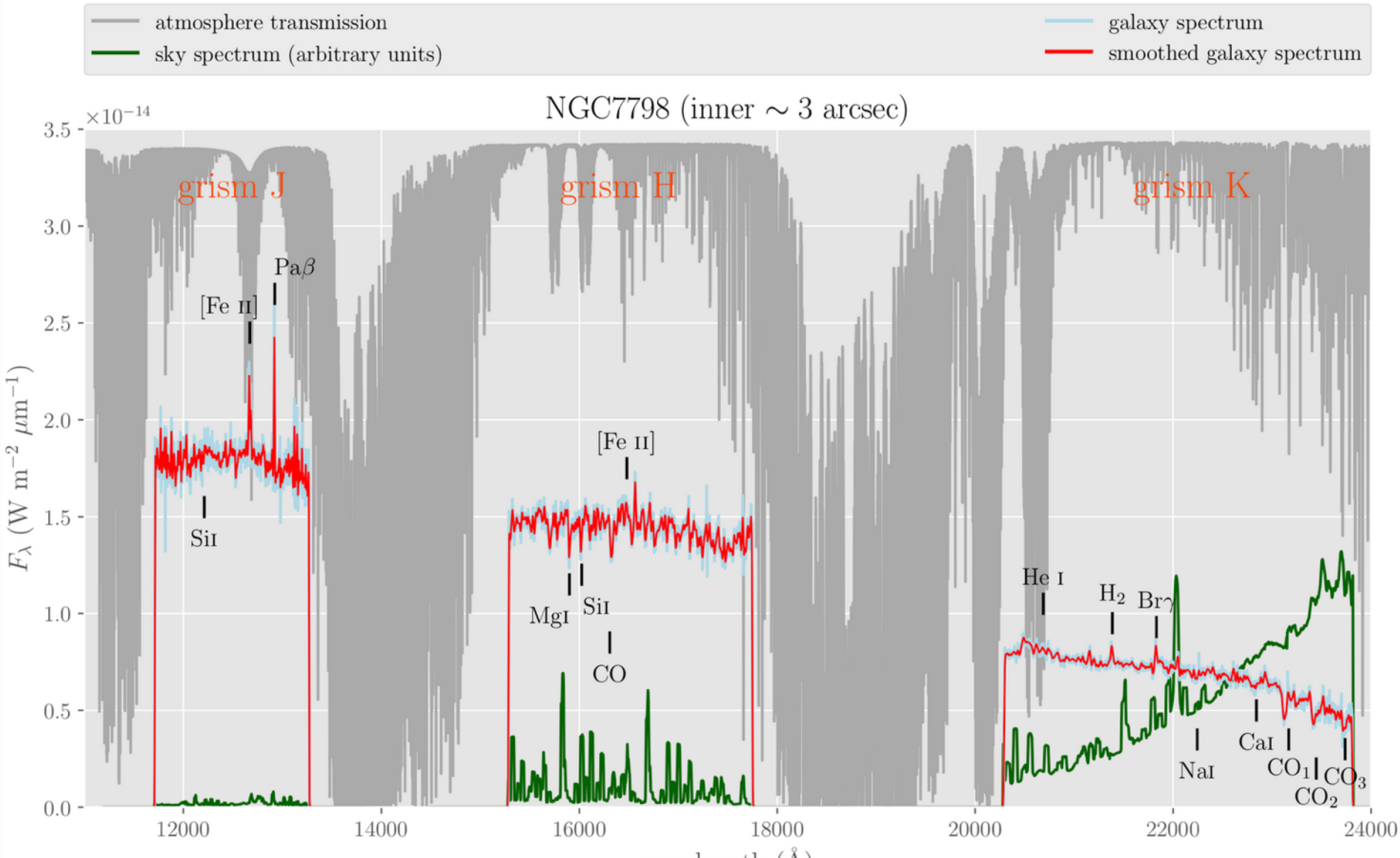




Current Status

- Fully operative in all obsmodes
  - Imaging:
    - ✓ BrBa: Y,J,H,Ks
    - ✓ NaBa: F1230,FeII,Brg, H2(1-0) + cont.
  - LS:
    - ✓ Widths=0.4, 0.6, 0.8, 1.2, 5 arcsec
    - ✓ 3 positions in the EMIR FOV
  - MOS:
    - ✓ OSP operative
    - ✓ Target acq. mode developed and in use
- Image & Spec DRP fully working

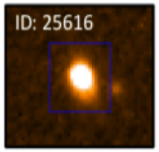
EMIR DRP

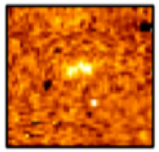

atmosphere transmission
sky spectrum (arbitrary units)
galaxy spectrum
smoothed galaxy spectrum
NGC7798 (inner ∼ 3 arcsec)
×10⁻¹⁴
grism J
grism H
grism K
Paβ
[Fe II]
SiI
[Fe II]
MgI
SiI
CO
He I
H2
Brγ
NaI
CaI
CO1
CO2
CO3
F_λ (W m⁻² μm⁻¹)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12000
14000
16000
18000
20000
22000
24000

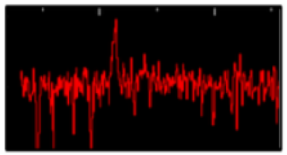
Current Status and prospects

- Two main problems limits EMIR performances, mostly for faint sources:
  - Excessive RON noise.
    - Higher Texp for the same SNR
      - ✓ Valid mostly for up to moderately faint sources (K <~19)
    - Some filtering scripts of limited success (web site)
    - New detector (Hw2RG) is coming
  - Relative drift bet. EMIR and the GTC A&G system
    - Limits the single int. time to ~1h IF good initial pos.
    - Working with GTC to identify and fix this.

Some Goya results

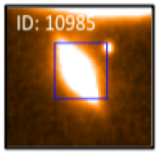




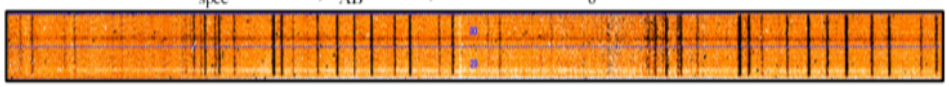


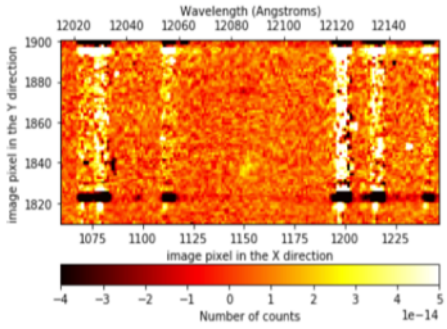
Hα emitter

z_{spec} = 0.8970, J_{AB} = 21.78, lmass = 9.38 M_o



Continuum z_{spec} = 0.4539, J_{AB} = 19.5, lmass = 10.6 M_o



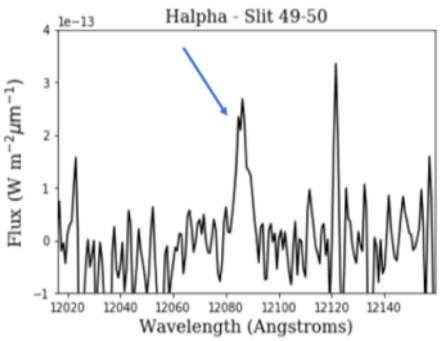


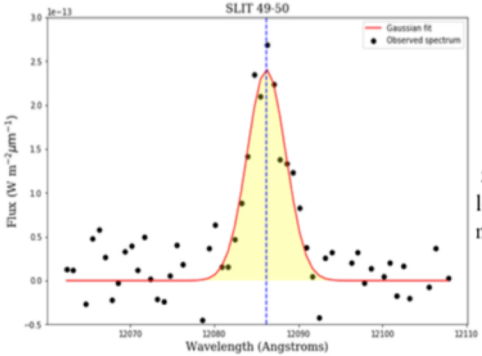
J band

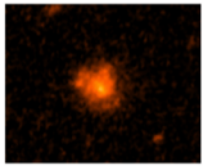
```
[[Model]]
    Model(gaussian)
[[Fit Statistics]]
    # fitting method   = leastsq
    # function evals   = 31
    # data points      = 60
    # variables        = 3
    chi-square         = 8.0957e-26
    reduced chi-square = 1.4203e-27
    Akaike info crit   = -3706.21361
    Bayesian info crit = -3699.93058
[[Variables]]
    sigma:      2.28930437 +/- 0.22094442 (9.65%) (init = 13.33494)
    center:     12086.1921 +/- 0.22094197 (0.00%) (init = 12085.11)
    amplitude:  1.3803e-12 +/- 1.1537e-13 (8.36%) (init = 2.687565e-13)
    fwhm:       5.39089972 +/- 0.52028434 (9.65%) == '2.3548200*sigma'
    height:     2.4053e-13 +/- 2.0104e-14 (8.36%) == '0.3989423*amplitude/max(1.e-15, sigma)'
[[Correlations]] (unreported correlations are < 0.100)
    C(sigma, amplitude) =  0.577
```

HST: log(Hα Flux) = -16.29 erg/s/cm2

EMIR: log(Hα Flux) = -16.19 erg/s/cm2



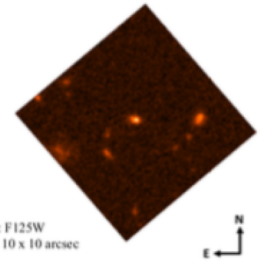




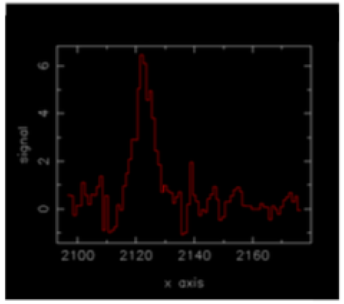
z = 0.8412

log (Mass/$M_\odot$) = 9.83

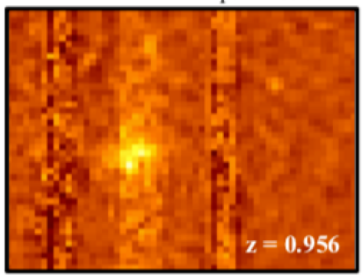
mag_F125W (AB) = 22.34



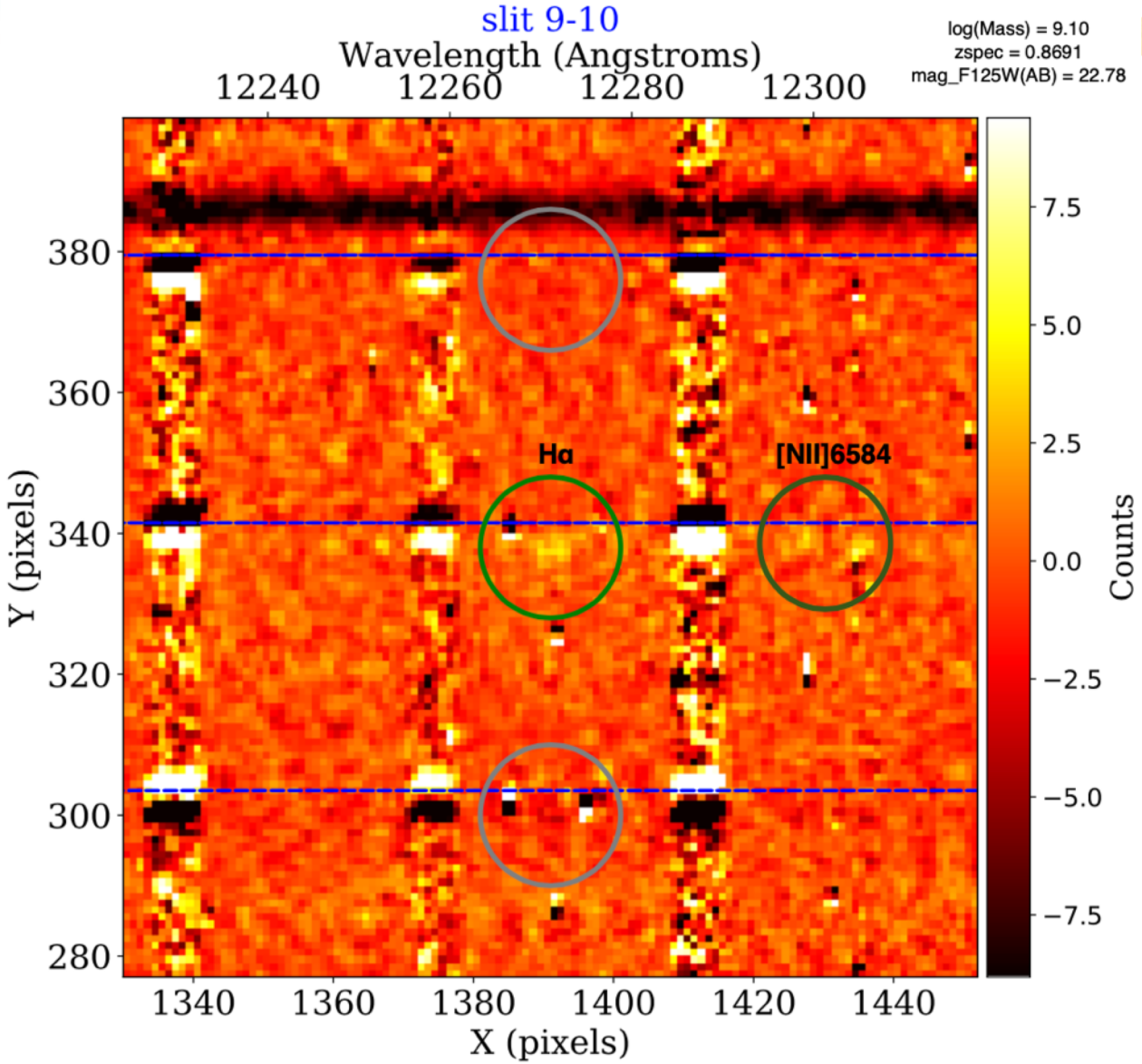
Slit 46 (mask1a_J)
ID: 23583
z_{phot} = 0.922
J(AB) = 23.39
Log(Mass/$M_\odot$) = 8.41



Exp.Time: 5.2h



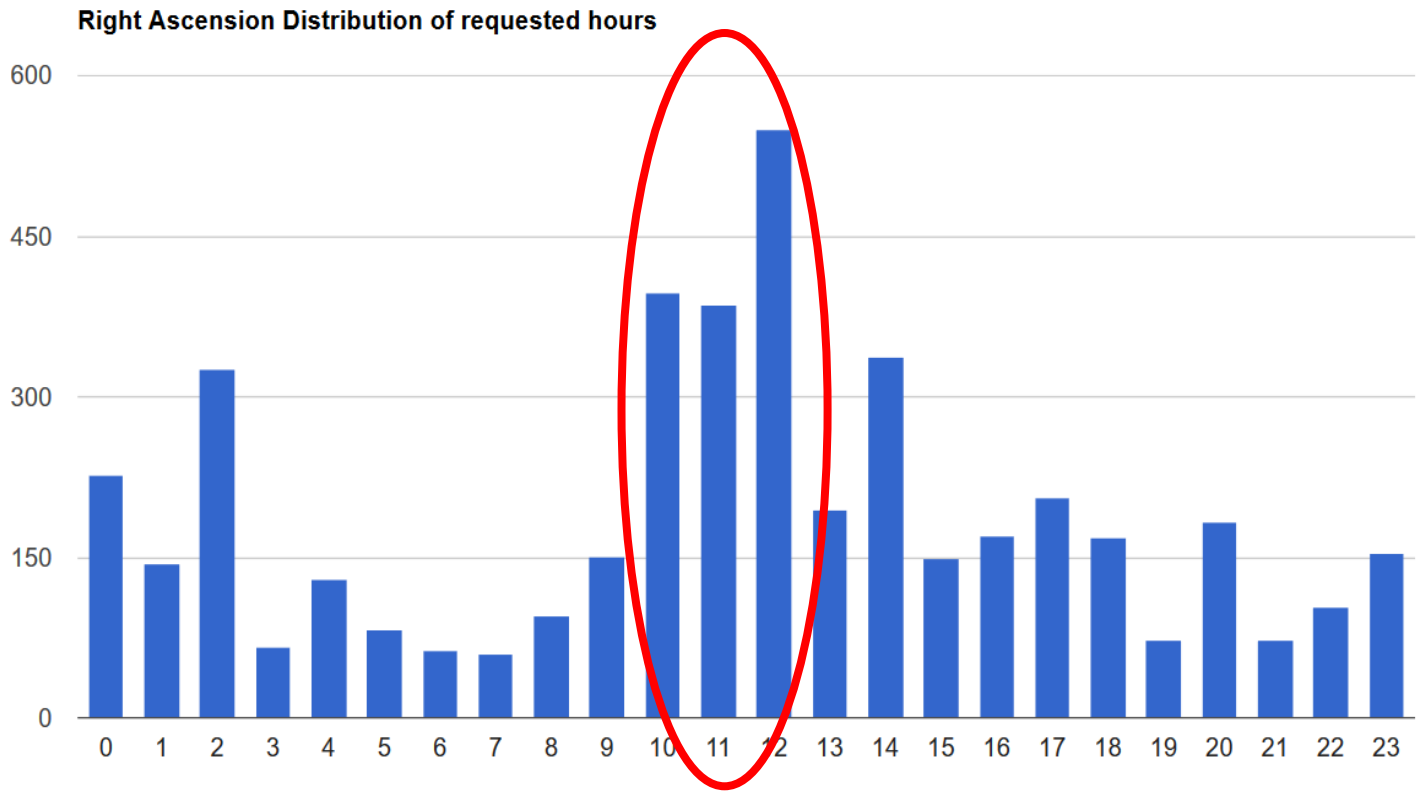
Refined positioning



Texp=2.8h

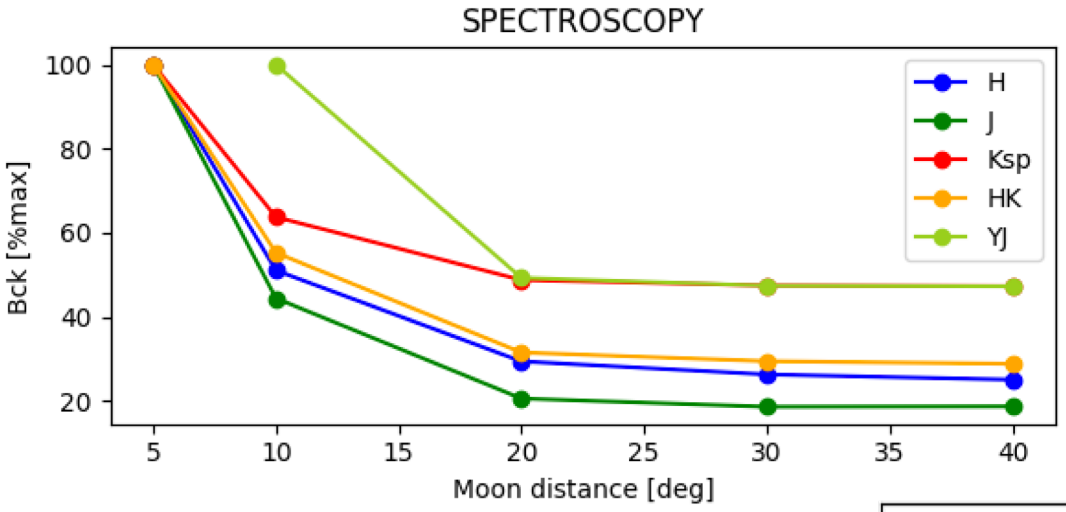
Previously unseen with Texp=5.2h

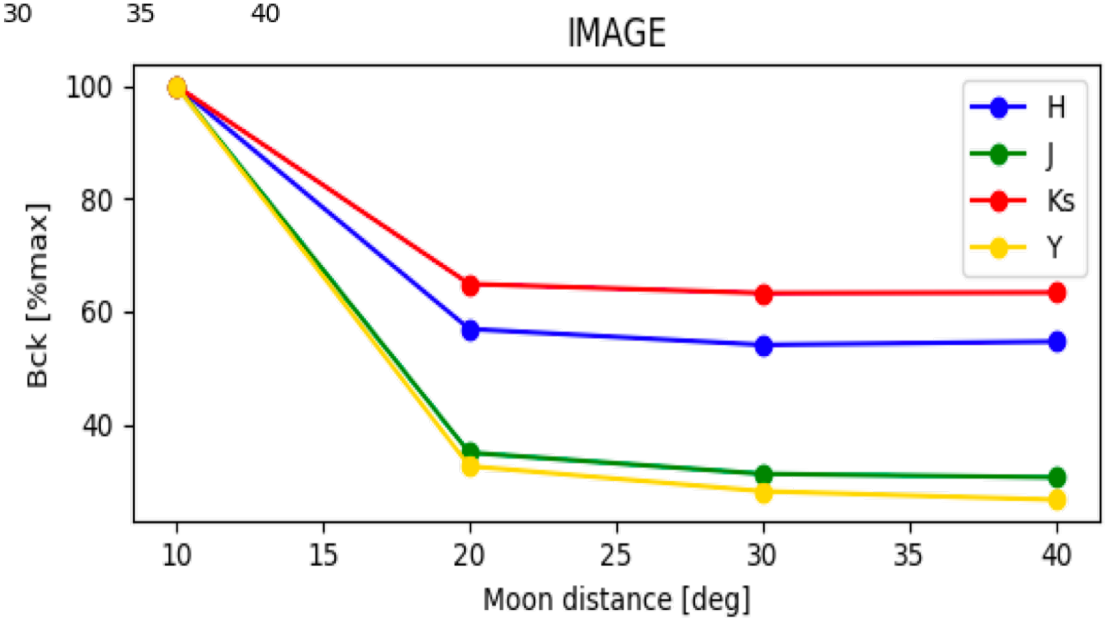
GTC: S19A + S19B



- Strong oversubscription in the 10 – 12 hours R.A. range.
- Filler programs are being executed due to the **lack of proposals for bright time. EMIR time!.**

Moon contamination





Moonlight contamination almost negligible for distances >20°

MIRADAS

- **MIRADAS is a near-infrared multi-object echelle spectrograph operating at spectral resolution R=20,000 over the 1-2.5 μm bandpass on the GTC**

- The MIRADAS Consortium includes:
  - University of Florida
  - Universidad de Barcelona; Institut d'Estudis Espacials de Catalunya
  - Instituto de Astrofisica de Canarias
  - Universidad Complutense de Madrid
  - **>45 science team members from >10 institutions in 3 countries**

MIRADAS Consortium

UCM: SWG; help on Data Pipeline

AVS: Industrial Partner

IAC: SWG; Software interface

U. Barcelona: SWG; Probe control

CEFCA: SWG

CAB: SWG

U. Alicante: SWG

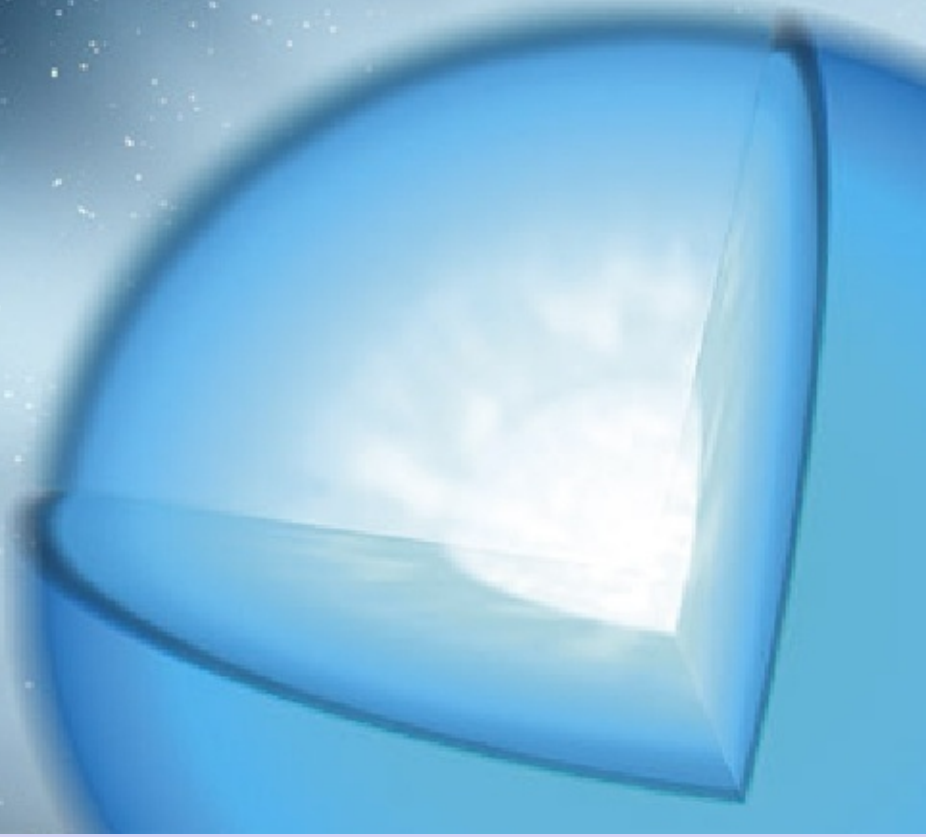
IAA: SWG

UF: SWG & Prime Contract

UNAM & INAOE: SWG

Massive Stars MIRADAS

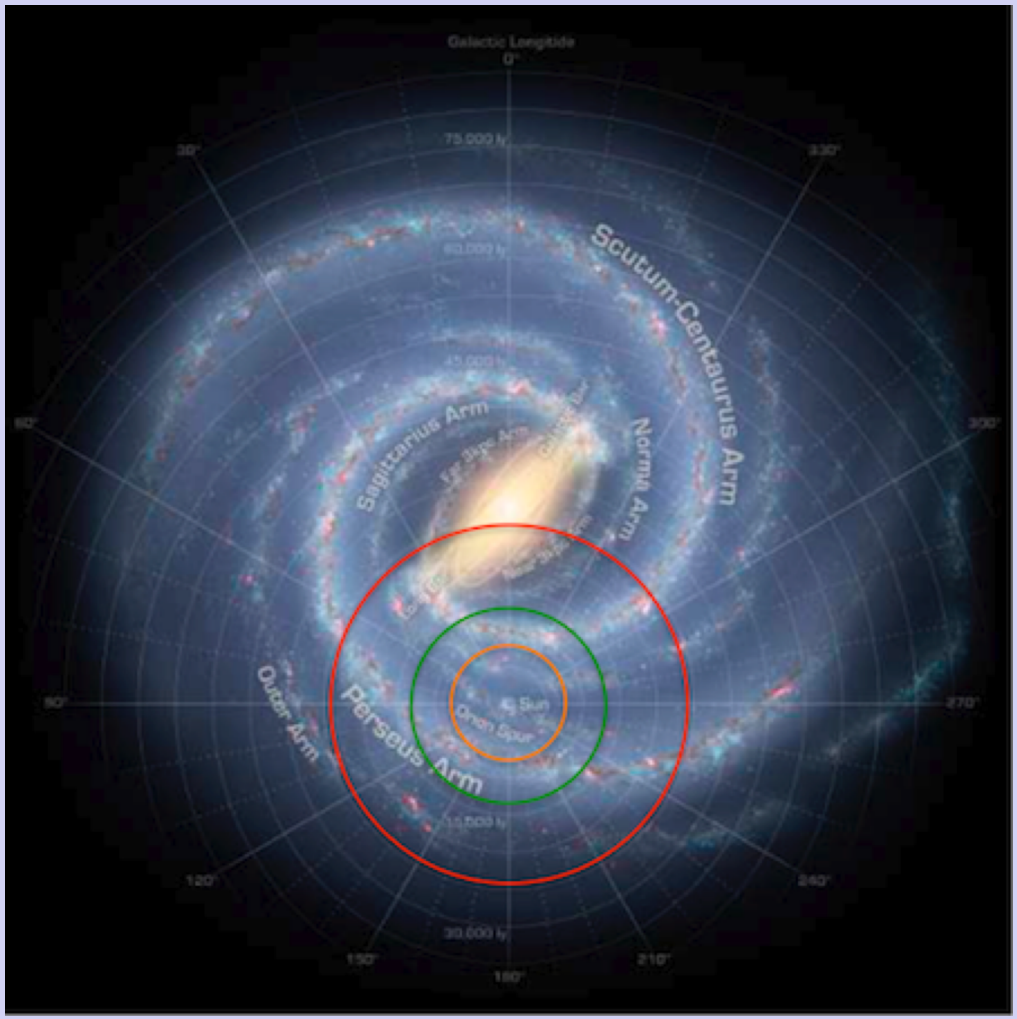
Ignacio Negueruela
Carlos González
Amparo Marco
Francisco Najarro
Sebastián Ramírez
Toni Marín
Artemio Herrero



MIRADAS meeting
IAC, Tenerife, March 8, 2012

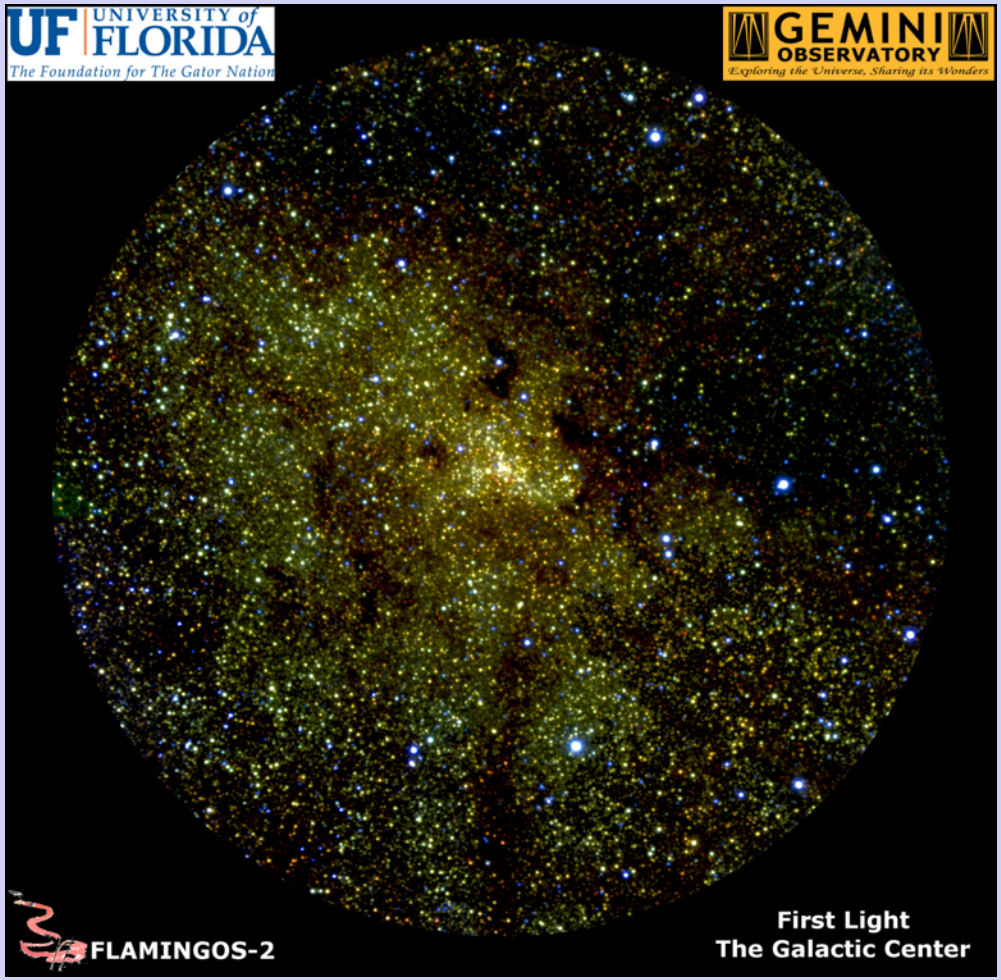
DRC: Chemo-Dynamics of Milky Way

- **Structure of our own Milky Way galaxy still poorly understood**
- **Major focus of GAIA mission and other surveys (including APOGEE)**
- **MIRADAS will reach MUCH deeper into the inner MW**
- **Strong complement to photometric and "near-MW" surveys**



DRC: Chemo-Dynamics of Milky Way

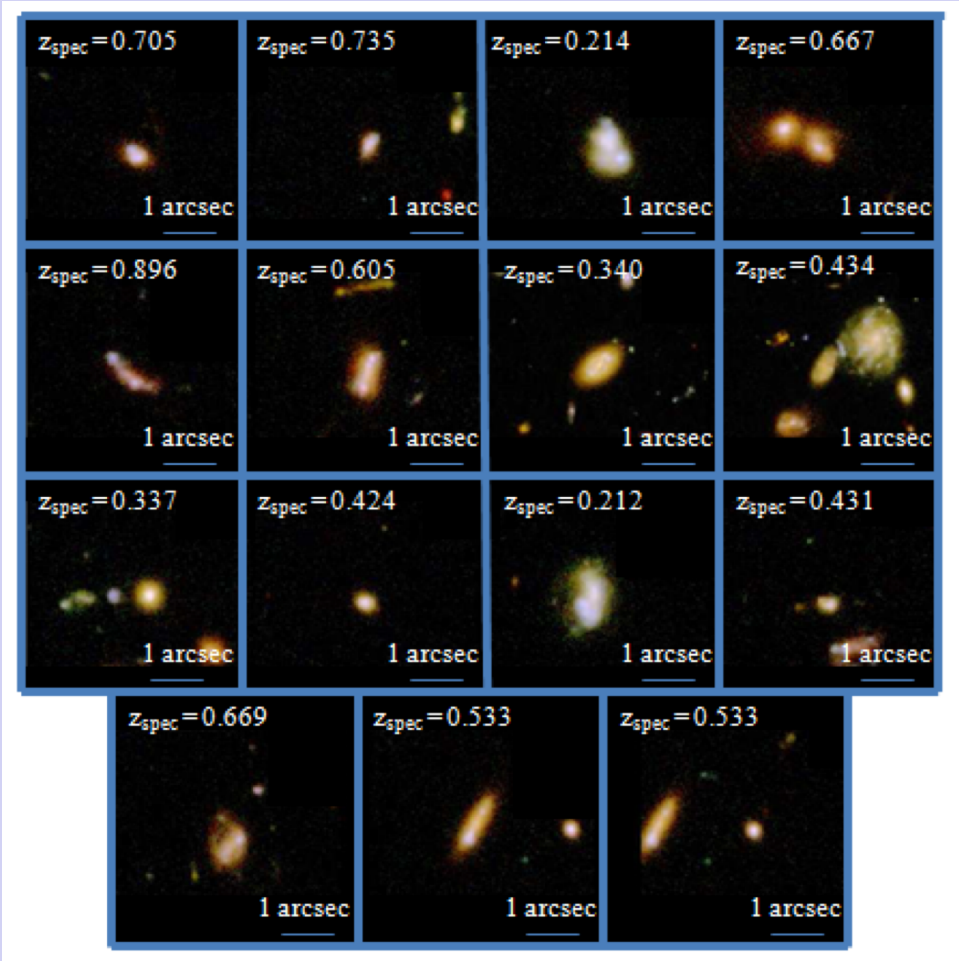
- **Abundances and kinematics of RGB stars**
- **Key for grasping MW structure and evolutionary history**
- **CD history of the inner MW and Sgr A* black hole mass evolution**



- **MIRADAS spectral resolution and multiplexing revolutionize this field!**

DRC: Blue Compacts Dwarfs @ z~0.5-1

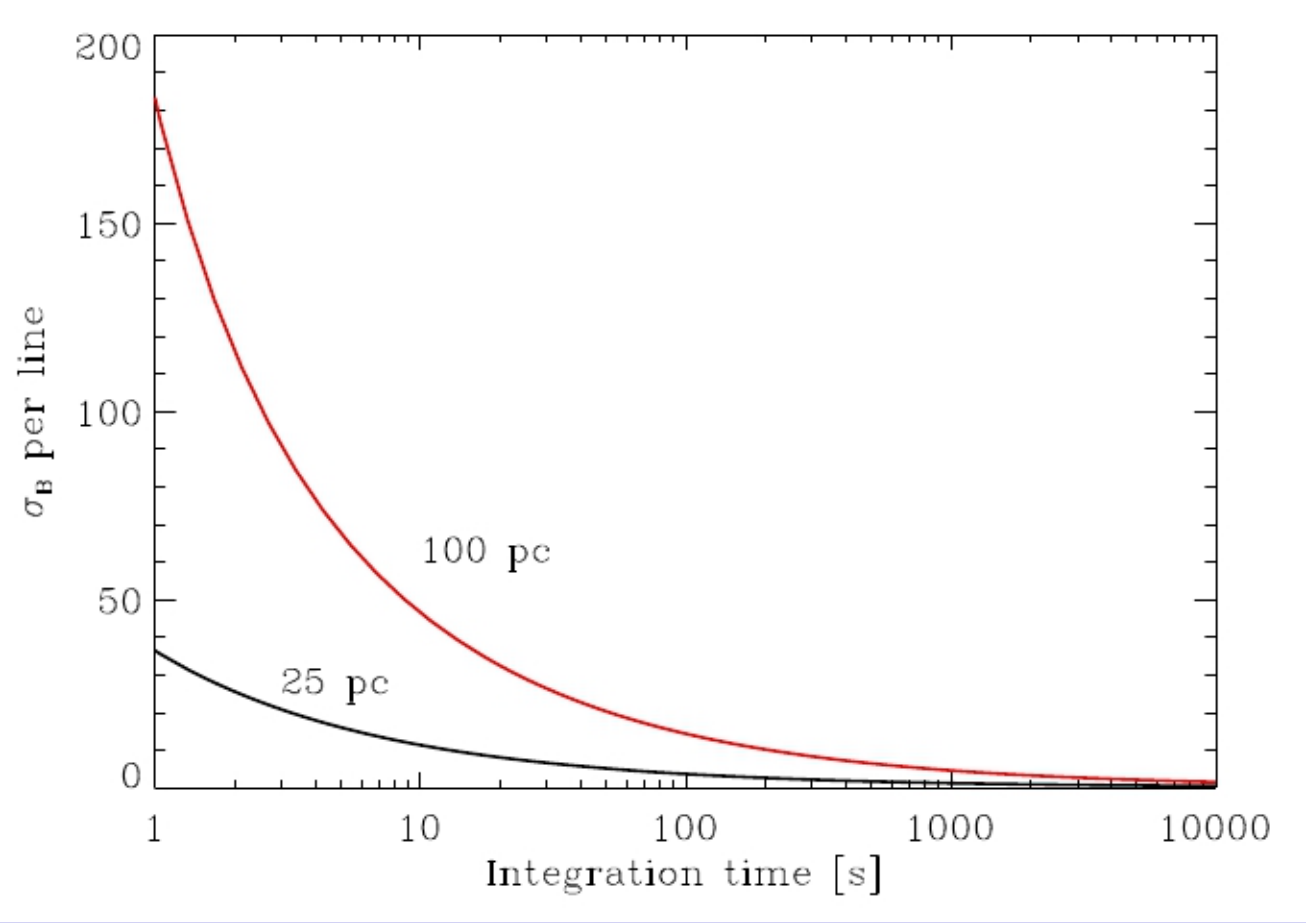
- **BCDs key for galaxy assembly & evolution**
- **z~0.5-1.0 is next frontier for this research area**
- **Narrow lines + redshift make R=20K and near-IR best match**



DRC: Spectro-Polarimetry

- **Physical effects of magnetic fields produce polarization signatures ~3-9x larger in NIR than optical (fundamental quantum physics of the line transitions)**
- **Signatures also increase with spectral resolution in many interesting cases**
- **Need large telescope collecting area to get high SNR required for measurements**

DRC: Spectro-Polarimetry

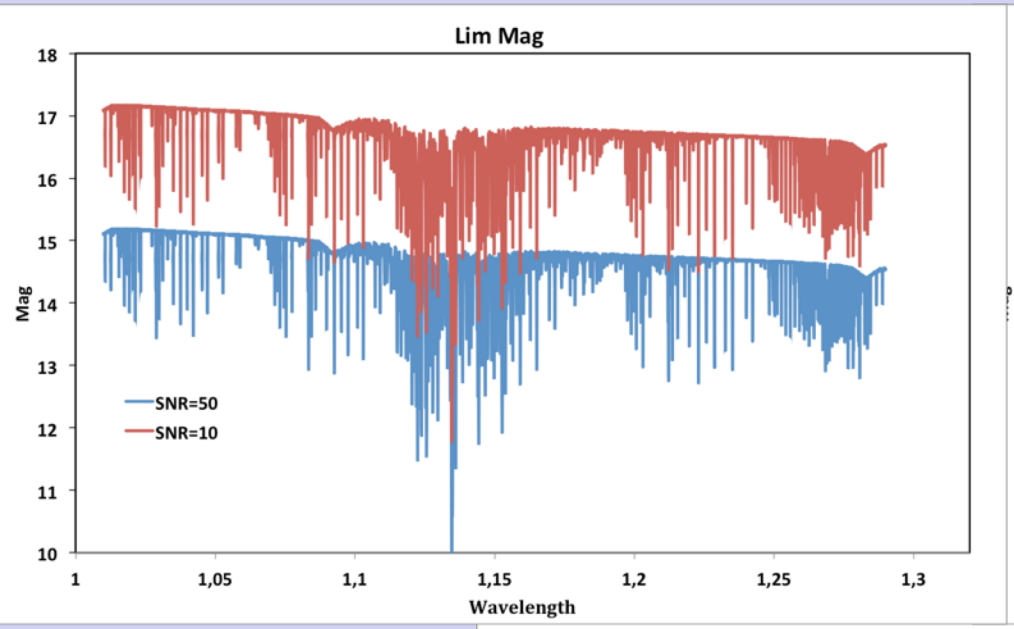


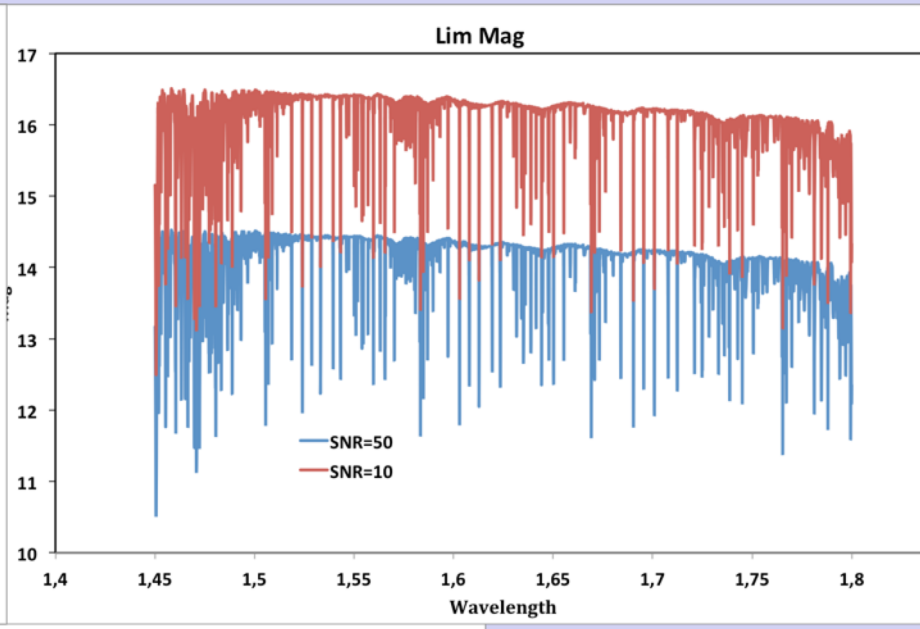
Magnetic Field Sensitivity in Sun-like Stars

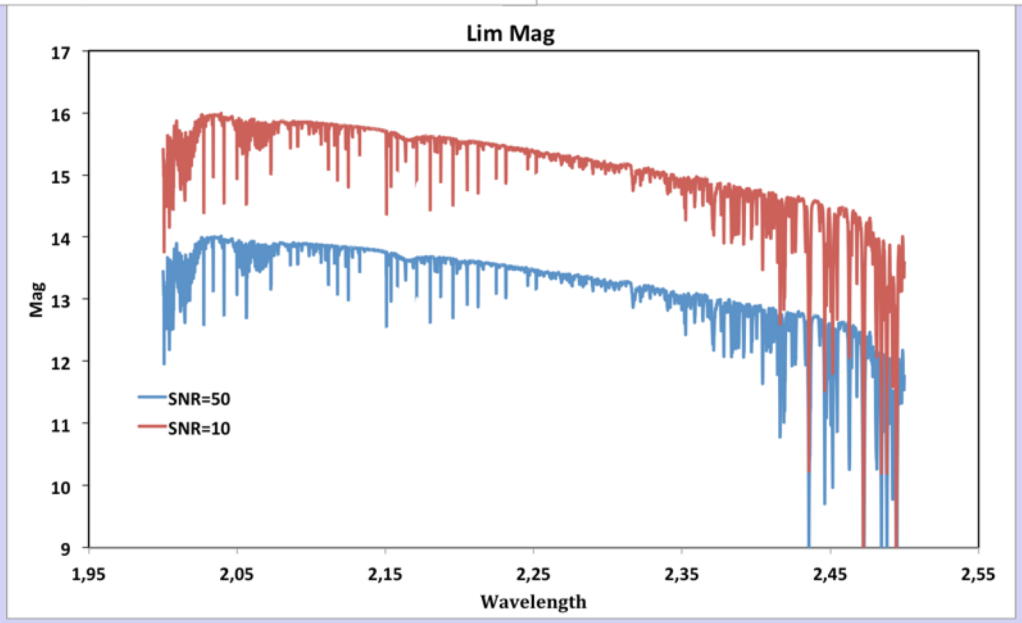
MIRADAS: Other Science

- **Many other science cases defined and expanded by MIRADAS Science Team members:**
  - **Milky Way Structure & GAIA Follow-up**
  - **Massive Star Formation Feedback**
  - **RV searches for extra-solar planets**
  - **Evolution of Angular Momentum in Young Low-mass Stars**
  - **Dynamical Studies of X-Ray Binaries**
  - **Abundance anomalies in X-ray Binaries & CVs**
  - **Magnetic fields of secondary stars in CVs**
  - **Metal-poor Bulge stars**
  - **Relativistic jet formation in SS 433**
  - **Dwarf galaxies in the Coma Cluster**
  - **Etc.**

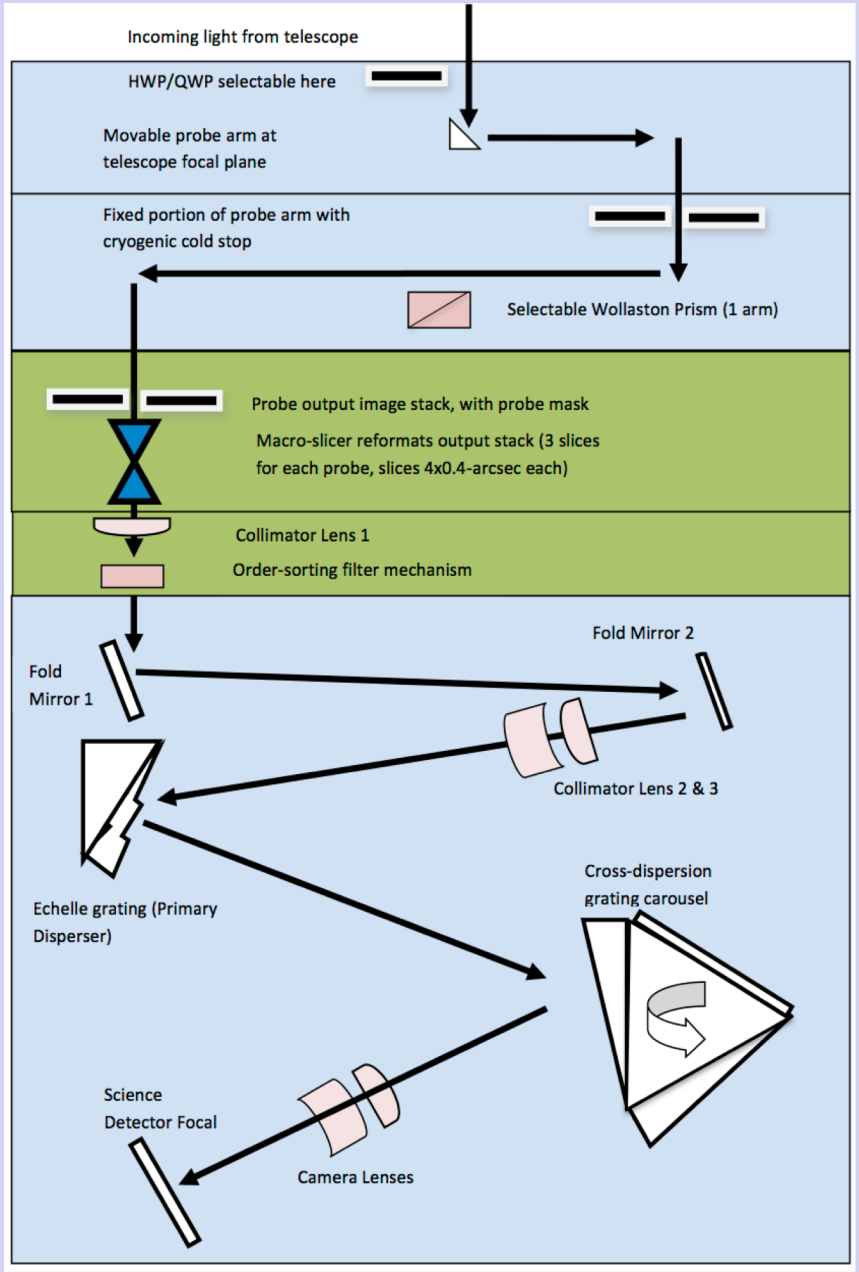
MIRADAS: expected lim. Mags.

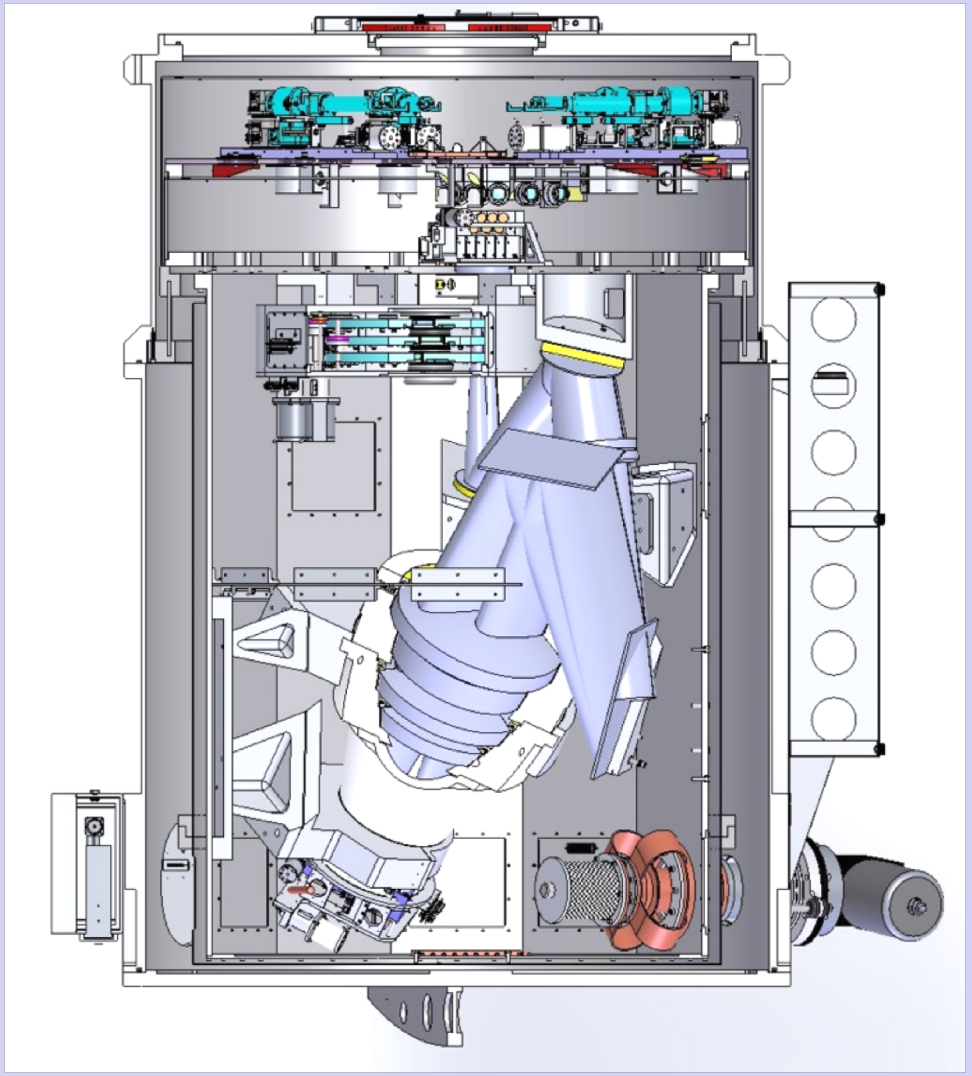




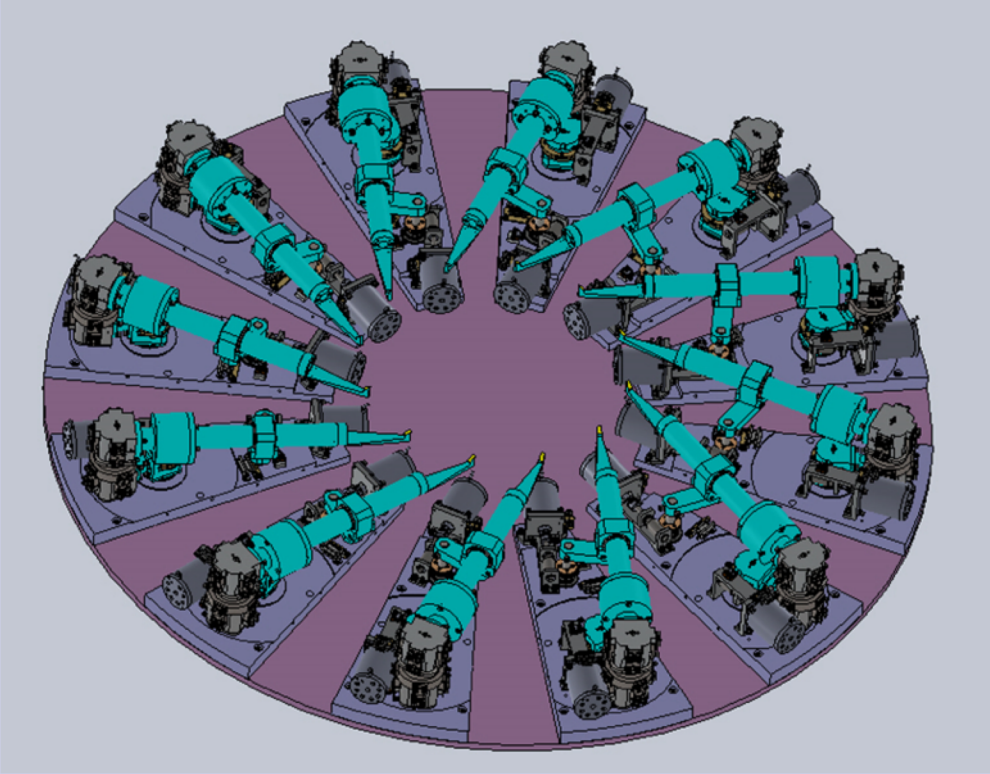


MIRADAS Schematic Overview



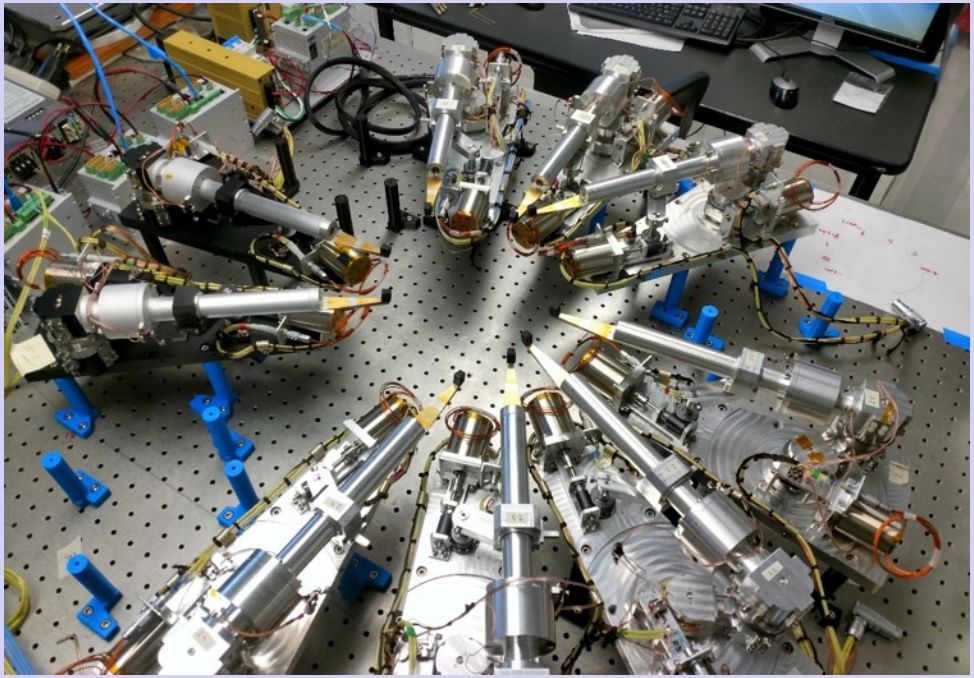


MIRADAS Multiplexing



- 12 cryogenic probe arms patrol the 5-arcmin diameter FOV at the GTC focal plane
- Pickoff mirrors at the probe tips select targets (3.7x1.2-arcsec FOV) and relay them to the rest of the instrument

MIRADAS Multiplexing



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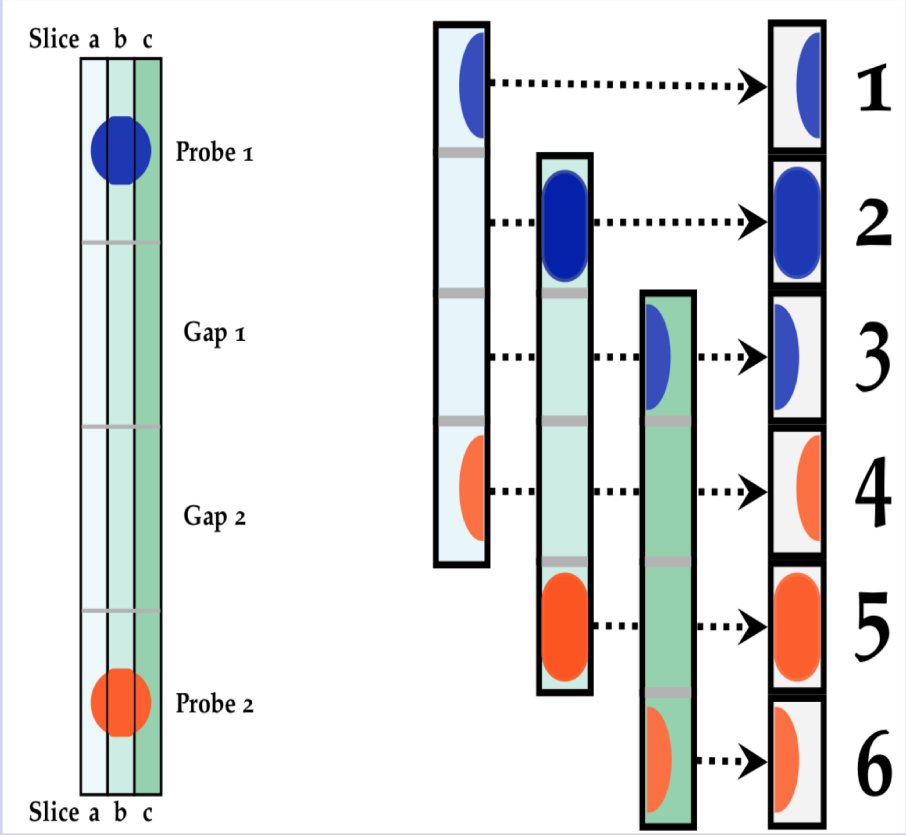
MIRADAS Macro-Slicer

3-slice integral field unit

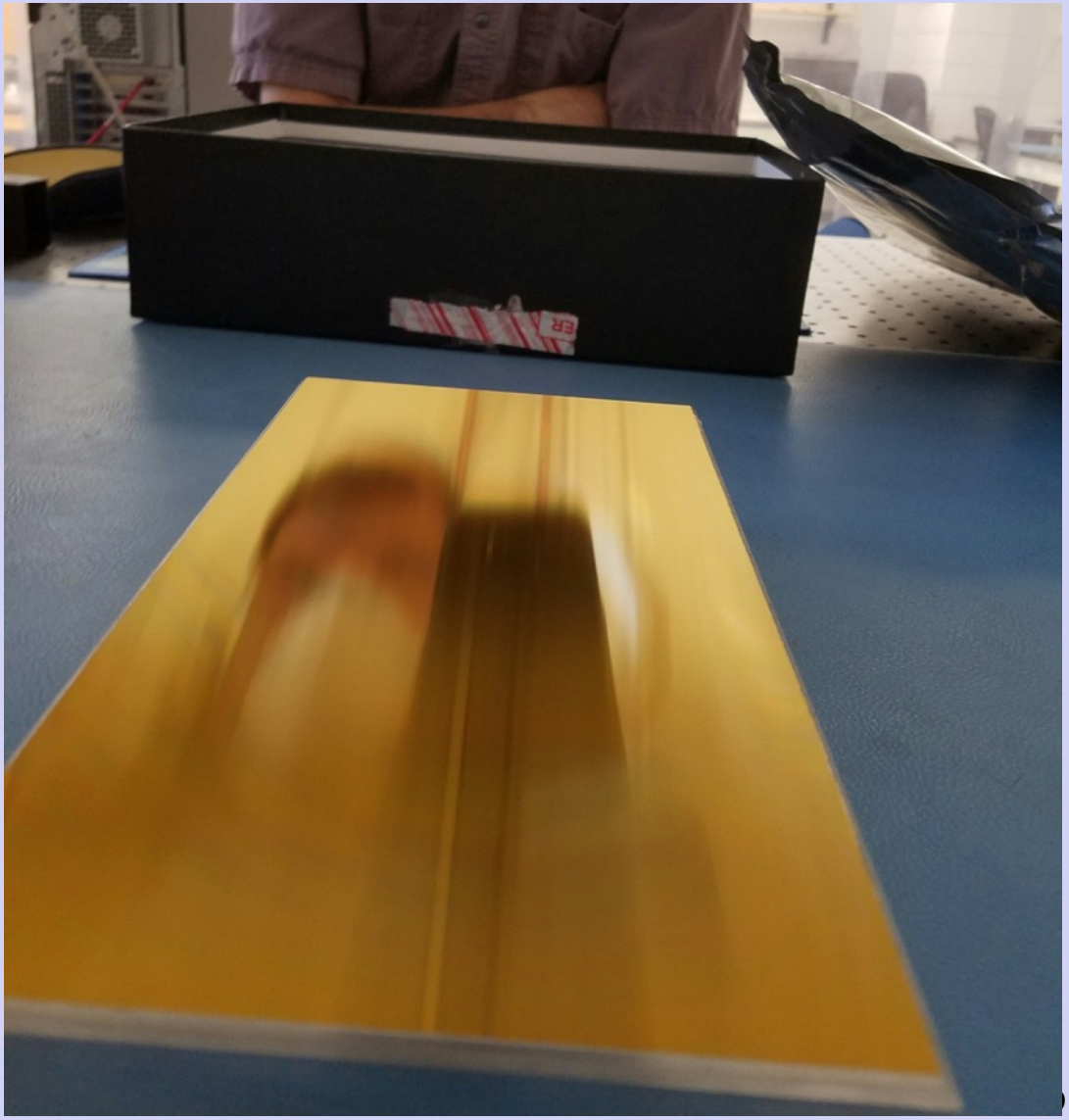
Accepts 3.7x1.2-arcsec field fr/each probe

Outputs 3x 3.7x0.4-arcsec pseudo-longslit for each probe



Maintains high throughput and constant slit-width/resolution across range of seeing (0.4-1.2-arcsec)

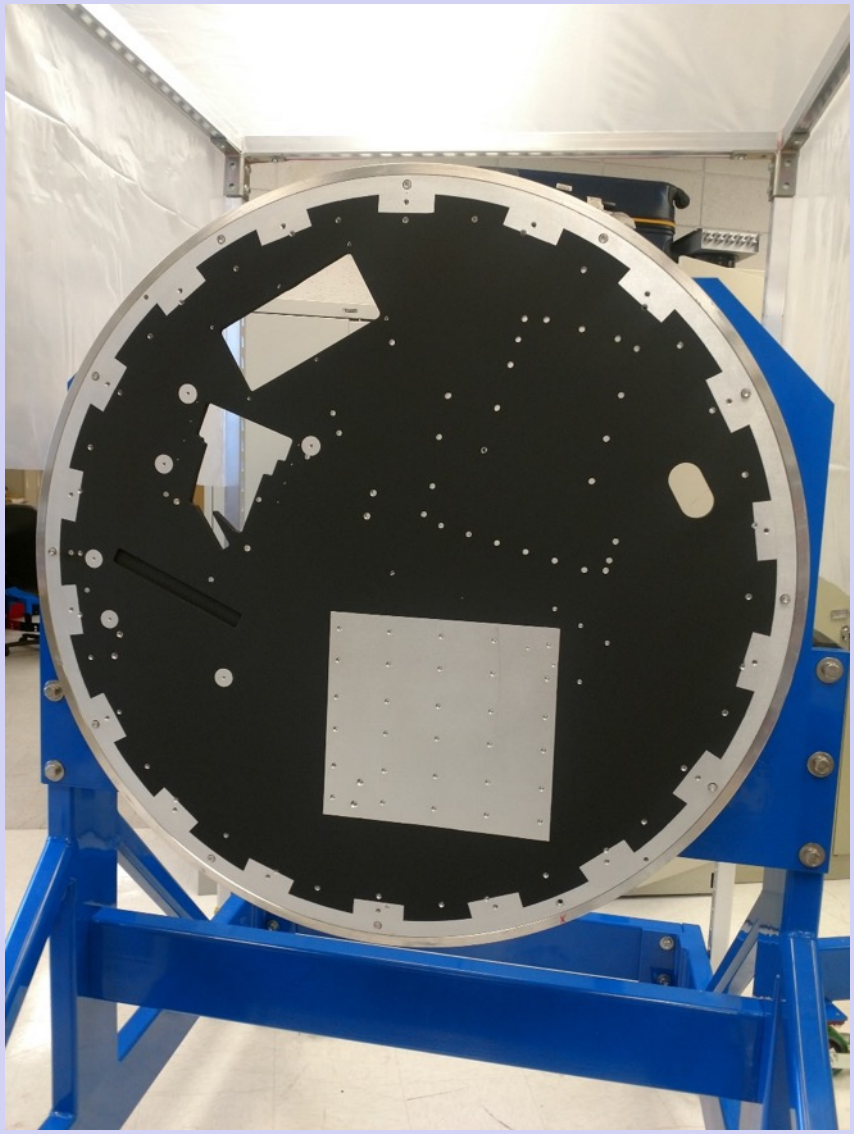
MIRADAS Echelle



Echelle Grating

Blaze photo

MIRADAS Mechanical: Vacuum Jacket



MIRADAS Status: Other

- **H2RG science-grade detectors delivered; installed into mosaic**
- **All major optics delivered**
- **Vacuum jacket fabrication complete**
- **Cryo-mechanisms being tested; almost all complete**
- **System integration underway, nearing completion**
- **Key software development on-schedule at IAC, UB, UF**
- **4 MXS probe arms funded by GTC contract**
- **5 externally-provided probe arms (3x Florida; 2x USP/Brazil)**
- **3 additional arms $\Rightarrow$ funding secured; fabrication completed, assembly and testing underway**

MIRADAS Schedule

- **Successful Final Design Review held in Gainesville, FL May 2015**
- **Currently in the phase of AV**
- **Subsystem AIV nearly complete**
- **Full system integration and testing underway**
- **Aim for delivery in mid-2020; Commissioning expected Q3 2020**