The GOYA survey with EMIR-GTC

Goya

Galaxy Origins and Young Assembly

GOYA is a survey of high-redshift galaxies using EMIR and Gran Telescopio Canarias (GTC) in guaranted time. Several scientific projects use this survey for the study of key questions on galaxy cosmological evolution. This study includes the star-formation history and assembly of low-mass galaxies, stellar populations and IMF of the most massive galaxies, and the identification and characterization of sources on the cosmic reionization time.

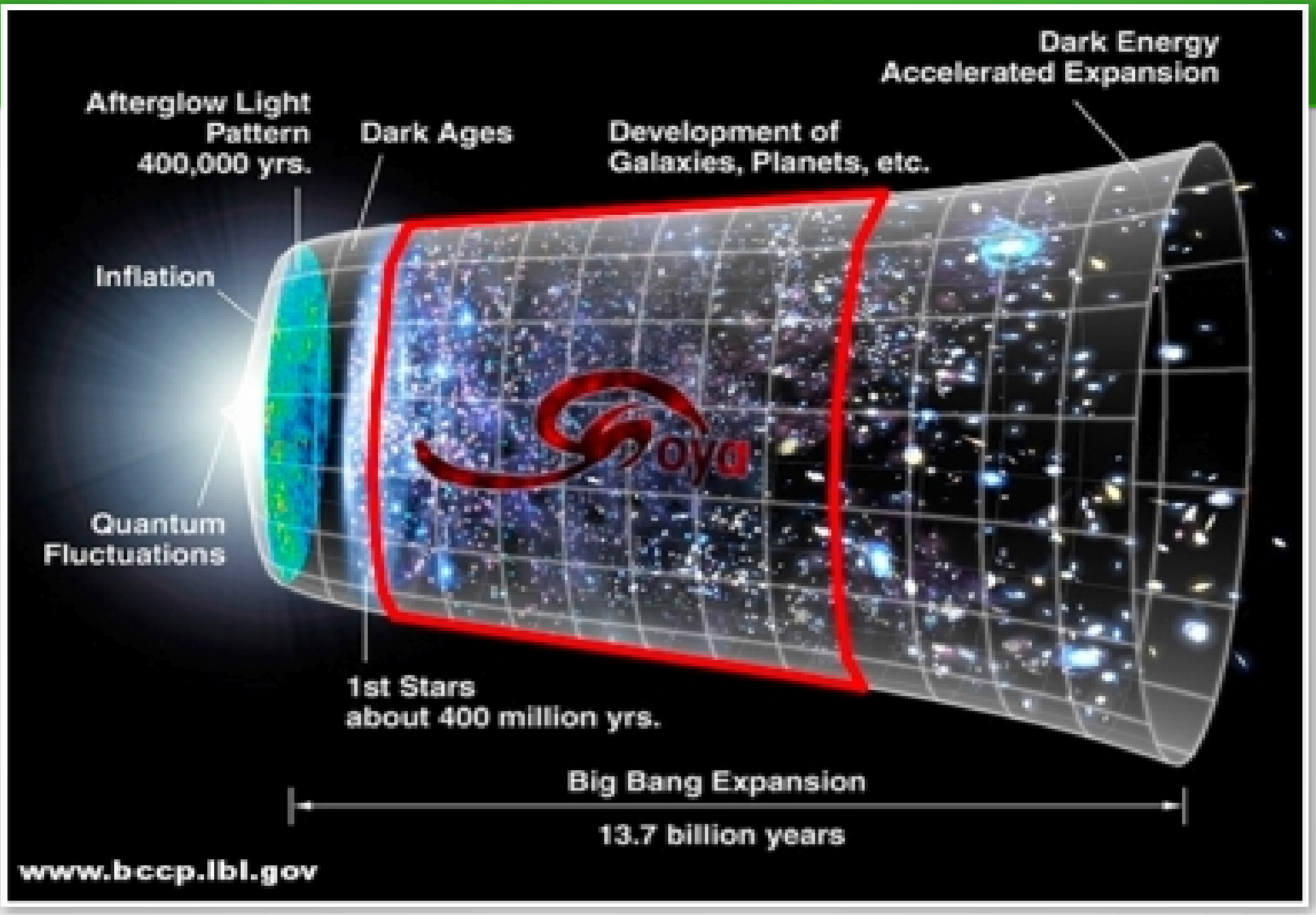
INSTITUTO DE ASTROFISICA DE CANARIAS · IAC

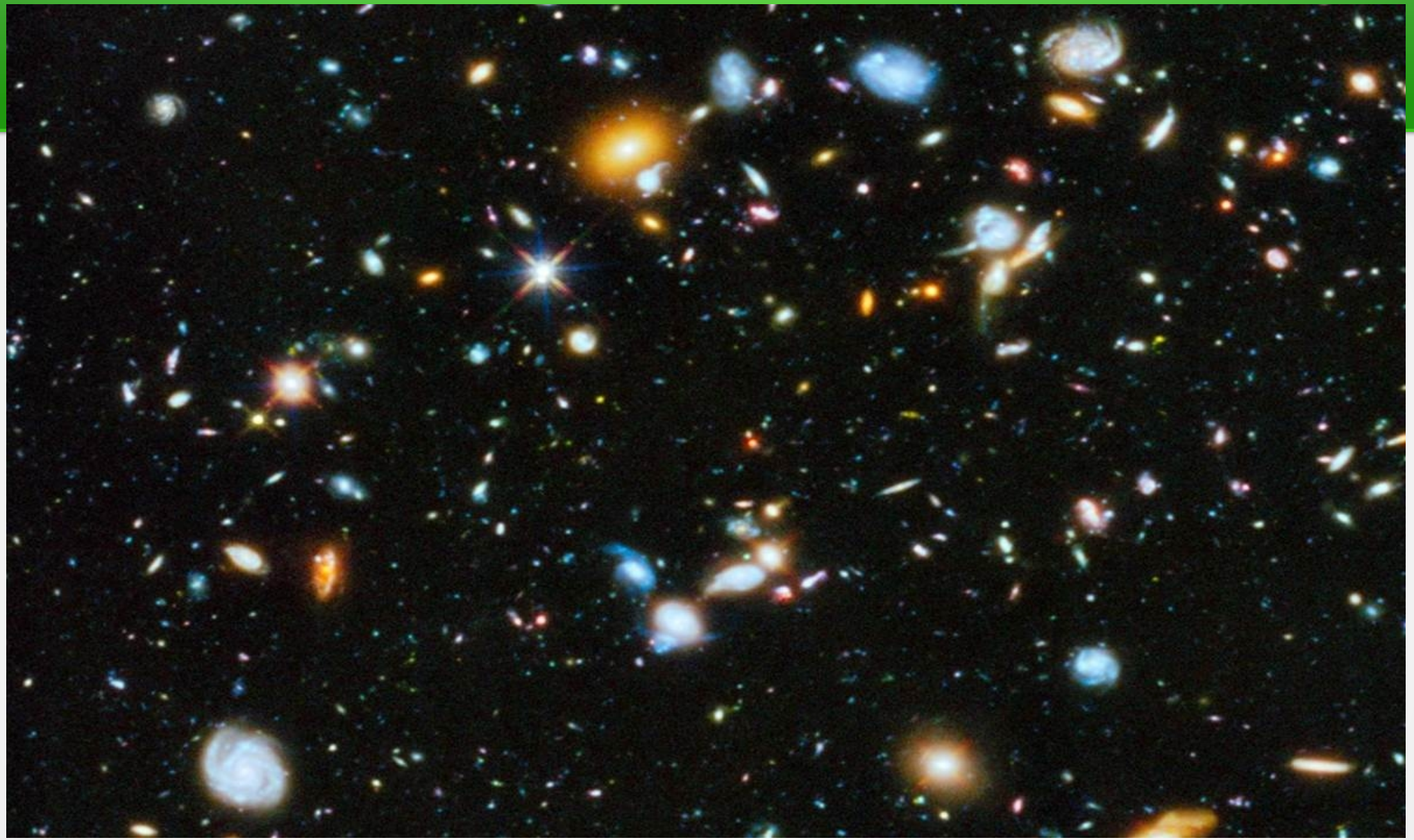
Observatoire Midi-Pyrénées OMP

UNIVERSIDAD COMPLUTENSE MADRID

UF UNIVERSITY of FLORIDA

LAM LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years
www.bccp.lbl.gov



Primera imagen de campo profundo del telescopio espacial Hubble (HDF)

NASA / ESA / IPAC / Caltech / STScI / ASU., HUDF, UV-IR, 2004

GOYA core and Associated scientists

- GOYA core group is that charged of the preparation of the Central Program of EMIR making use of Guaranteed Observational Time (GOT) awarded by GRANTECAN. These persons belong too to the EMIR Consortium.
- GOYA Associated scientists do not belong to the EMIR Consortium but they are collaborators of some member of GOYA core.

- (These are in accordance with the Charter on the Data Rights and Distribution of GOT in the EMIR Consortium)

GOYA team. GOYA core

- Stephane Arnouts, LAM
- Marc Balcells, ING-IAC
- Jesús Gallego, UCM
- Francisco Garzón, IAC-ULL
- Rafael Guzmán, UF
- Roser Pelló, OMP
- Mercedes Prieto, IAC-ULL

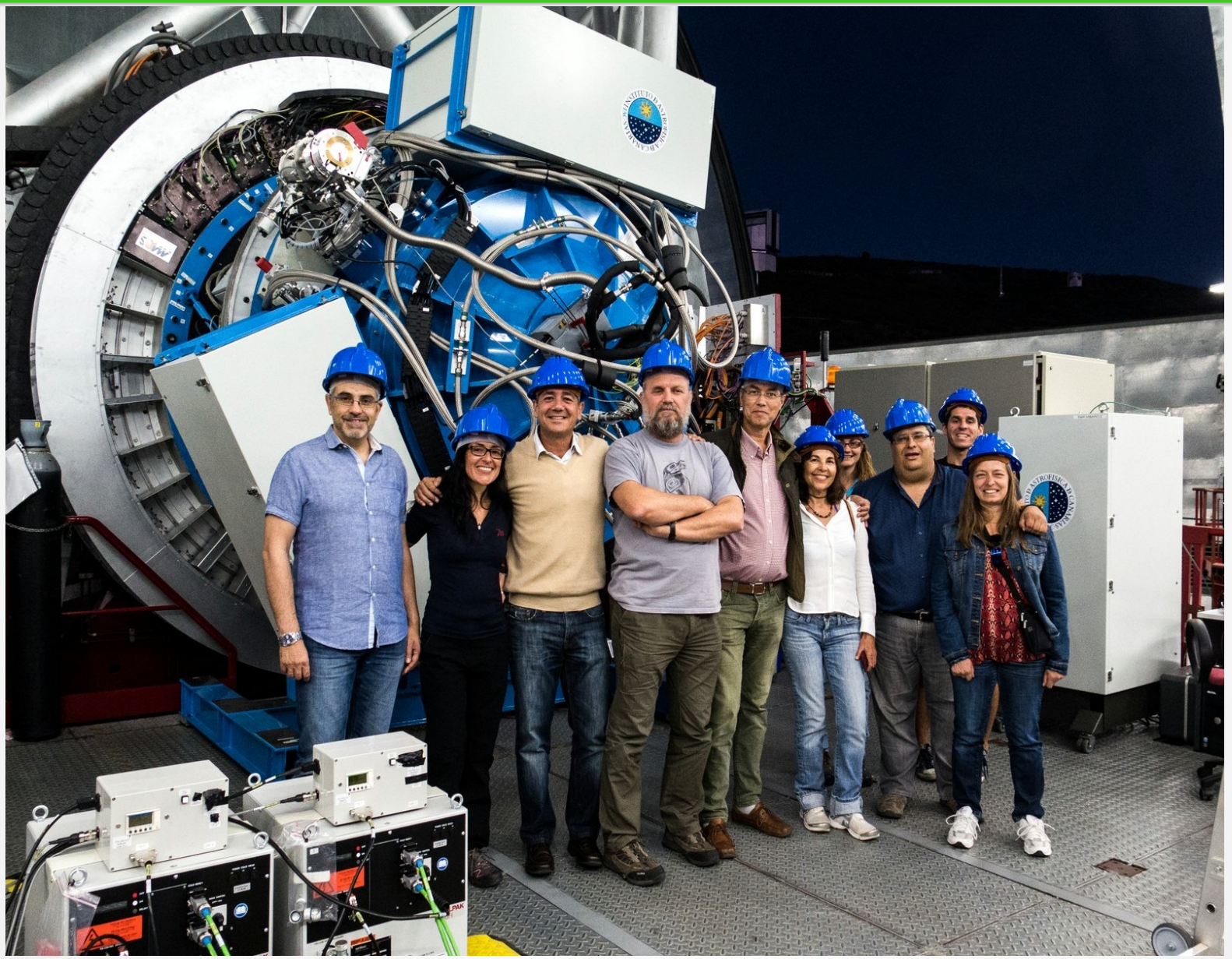
GOYA team. Associated Scientists

- Alfonso Aragón S., Nottingham
- Mike Beasley, IAC
- Fernando Buitrago, Lisbon
- Rosa Clavero, ING
- Lilian Domínguez, ING, IAC
- Jesús Falcón Barroso, IAC
- Ignacio Martín Navarro, UCSC
- Ignacio García la Rosa, IAC
- Reynier Peletier, Groningen
- Luís Peralta de Arriba, IoA Cambridge
- Pablo Pérez González, UCM
- Patricia Sánchez, UAM
- Ignacio Trujillo, IAC
- Alexandre Vazdekis, IAC
- N. Cardiel, UCM
- S. Pascual, UCM
- Florencia Jiménez (ING)
- Cristina Cabello (UCM)

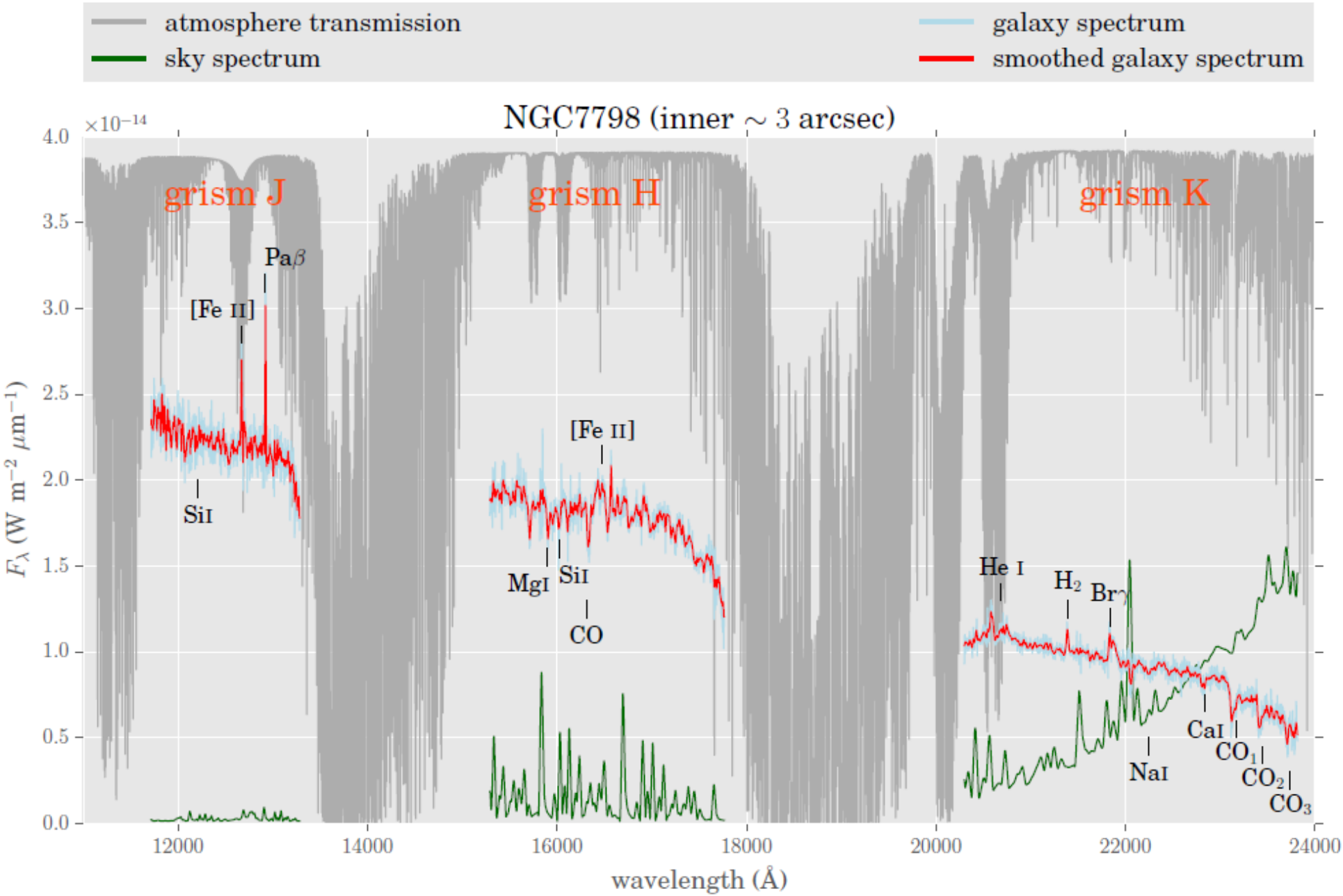
GOYA team. Associated Scientists (cont.)

- Lucía Rodríguez-Muñoz, Padova
- Camilla Pacifici, JPL
- Stephane Charlot, IAP
- Alba Vidal-García, IAP
- Olivier Le Fevre, LAM
- L. Tresse, CRAL
- T. Contini, IRP/OMP
- N. Laporte, IRP/OMP
- D. Schaerer, IRP/OMP
- O. Ilbert, LAM
- L. Tresse, CRAL/Lyon
- J. Richard, CRAL/Lyon
- J.M. Rodríguez-Espinosa, IAC
- Frederic Boone

2nd EMIR commissioning, 27 July 2016



First IR spectrum of a galaxy with EMIR, 2nd commissioning period, 27 July 2016.
It was observed by Paco Garzón and other GOYA core team members.
Nicolás Cardiel (UCM) carried out the preliminary reducction and figure.



GOYA main scientific projects

Low-Mass Galaxies
Led by Jesús Gallego

MAGINASTE
(MAssive Galaxies through InfrAred SpecTroscopy with EMIR**)**
Led by Marc Balcells

First Generation of galaxies.
Led by Roser Pelló

Cosmology
Led by Rafael Guzmán

Low-Mass Galaxies

The goal is to observe several hundres of galaxies of low mass ($\log M_* < 9$) at intermediate redshifts ($0.7 < z < 1.7$) to study mainly the formation redshift and cosmic role of dwarf galaxies.

- The high number of galaxies make necessary the use of MOS mode
- IR spectra is needed at these redshifts to detect the H_α line
- Their low luminosity makes necessary the use of GTC.

With EMIR&GTC we will obtain for first time a spectroscopy surveys of a complete sample of low mass galaxies at intermediate redshift.

Among others, we are interested in obtaining the period of their dominant star-formation activity, their stellar mass assembly, and the environment role on the stellar quenched of these galaxies.

MAGINASTE

The goal is to observe dozens of massive galaxies (log M_* > 11) at high redshifts (1 < z < 4) to explore their formation and evolution

- NIR spectra are necessary to detect the main rest-frame diagnostic lines in particular dynamical mass, age, metallicity and IMF
- To detect spectroscopically these galaxies at high redshifts we need to use GTC

EMIR&GTC will allow us to advance IMF diagnostics on an individual galaxy basis at z~1

Main objectives are to obtain Initial Mass Function (IMF) diagnostics to constrain its shape at high redshift, and other diagnostics to study the physical properties of the stellar populations of most massive galaxies.

First Galaxies

The main goal is obtain the Lyman alpha line of dozens of galaxies at very high-z ($z \geq 6$) to study their physical properties tracing the early epoch of mass assembly.

- Lyman alpha line from galaxies at very high-z is observed in NIR
- The great distance of these galaxies make necessary the use of GTC.

EMIR/GTC will provide unique capabilities in the search and study of galaxies beyond z ≥ 6, where it should have a profound impact on our knowledge of galaxy formation and cosmological reionization.

This study will provide a measurement of the SFR and a combined constraint on the maximum age / Initial Mass Function / metallicity of the objects based on models, and the contribution of these objects to cosmic re-ionization.

Cosmology

Extreme star-forming galaxies at high redshift can also be used as a standard candle.

GOYA survey will provide a sample of hundreds of these high-redshift galaxies suitable for distance measurements.

This project will use data from the Low Mass galaxies detected in the survey.

***This large sample will allow to constrain values of the cosmological parameters Ω_M and Ω_Λ , independently from any possible systematics affecting other methods, including CMB and SNIa*.**

GOYA Projects Coordination

The observational interests of the different projects in GOYA survey must be coordinated to make an unique observational strategy that satisfies all.

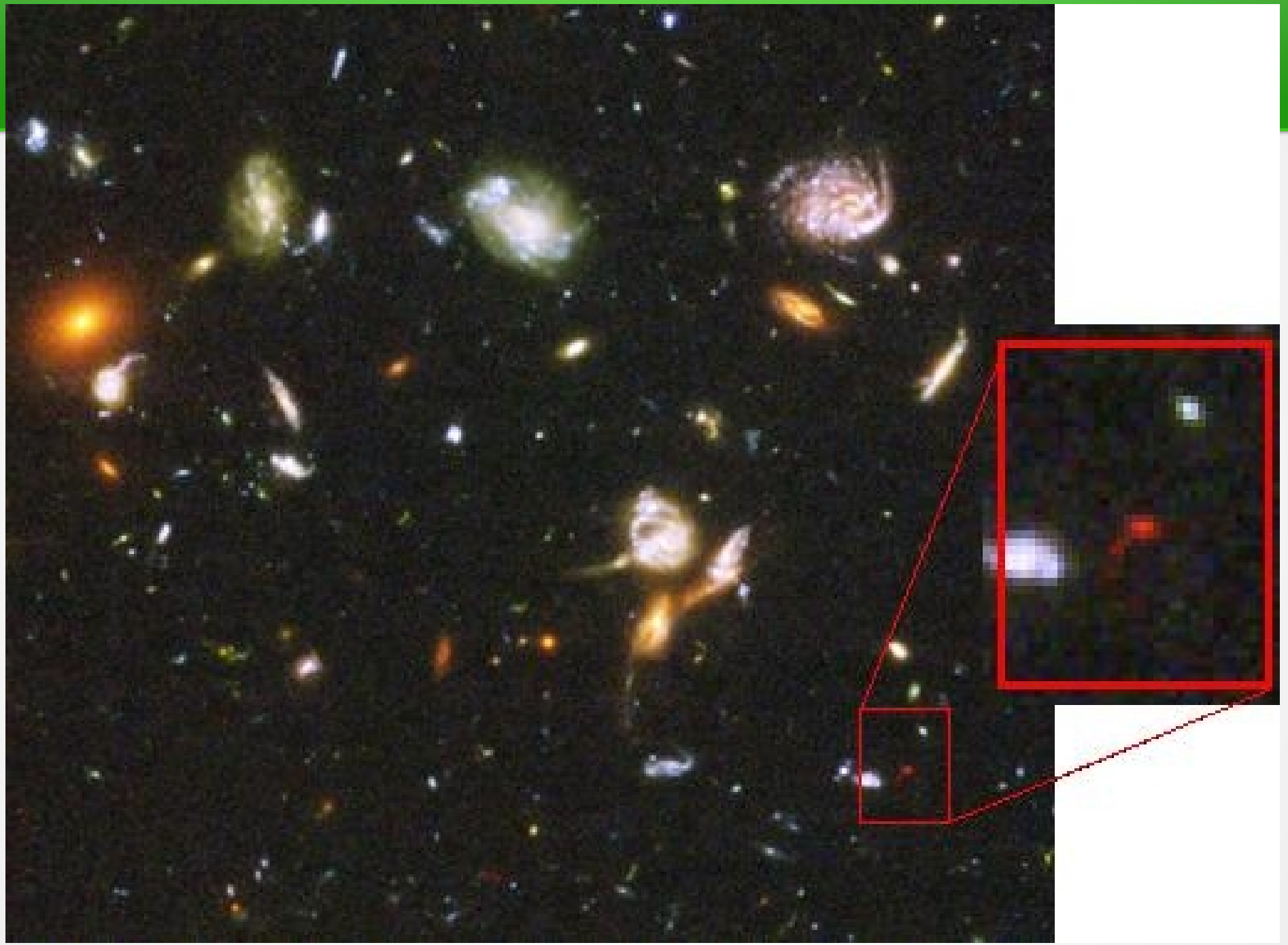
Each project must estimates their observational parameters, such as required depth, SNR, exposition time, number of galaxies in a EMIR FOV,... using the Exposition Time Calculator of EMIR (ETC) and others programs.

Once we have coordinated our observational interests, we must define the list of objects to observe, to design a set of masks with the EMIR Optimized Slits Positioner (OSP) in such a way that the required number of objects, positions and exposition times of the different projects are respected.

Exploring mask sharing in GOYA Survey

J filter

Project *	Depth (AB)	S/N per pixel (x2.5 after rebinning), and per FWHM(line) ó RE (conti.) from EMIR-ETC	Number of expected sources per mask	Total integral time per mask (hr) (+ 60% overhead)	Tentative number of sources per mask (in 53 hours ~ 7 noches) ***	Main Spectral features	Cosmological fields where densities were measured
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LMG 0.7 < z < 1.0 7 < log Ms < 9	Flux H_α ($x10^{-16}$erg/s/cm^2) 1.0 0.5 0.1	 12.3, 35.2 6.2, 17.8 1.2, 3.6	 84 240	 5 (8) 5 (8) 5 (8)	~27 (~179)	H_α + [NII]	EGS/AEGIS EGS/AEGIS
FG	J < 25.7 J < 26.3	~ 5	7.2 41	10 (16)	<~ 8 (~24)	L_α, CIV, HeII, SilV Line flux: ~5 $x10^{-18}$erg/s/cm^{-2}	WUDS + WIRDS HST - LF+HFF
HMGz1 (MAGINASTEz1) log Ms >11	J= 20.5 (σ=200 km/s)	12 (30), 29	4 for 0.9<z<1.2 + 4 for 1.4<z<1.8 + 4 low mass-z ? Total = 12 **	33 (53)	~15 (~15)	NaD, TiO2 for 0.9<z<1.2 Hβ for 1.4<z<1.8	GOODS-N GOODS-N
HMGz2 (MAGINASTEz2) log Ms > 11							
TOTAL per mask					52		



Courtesy of NASA

Example. Mask 1= 31 rendijas. 15 LM, 8FG, 8MA

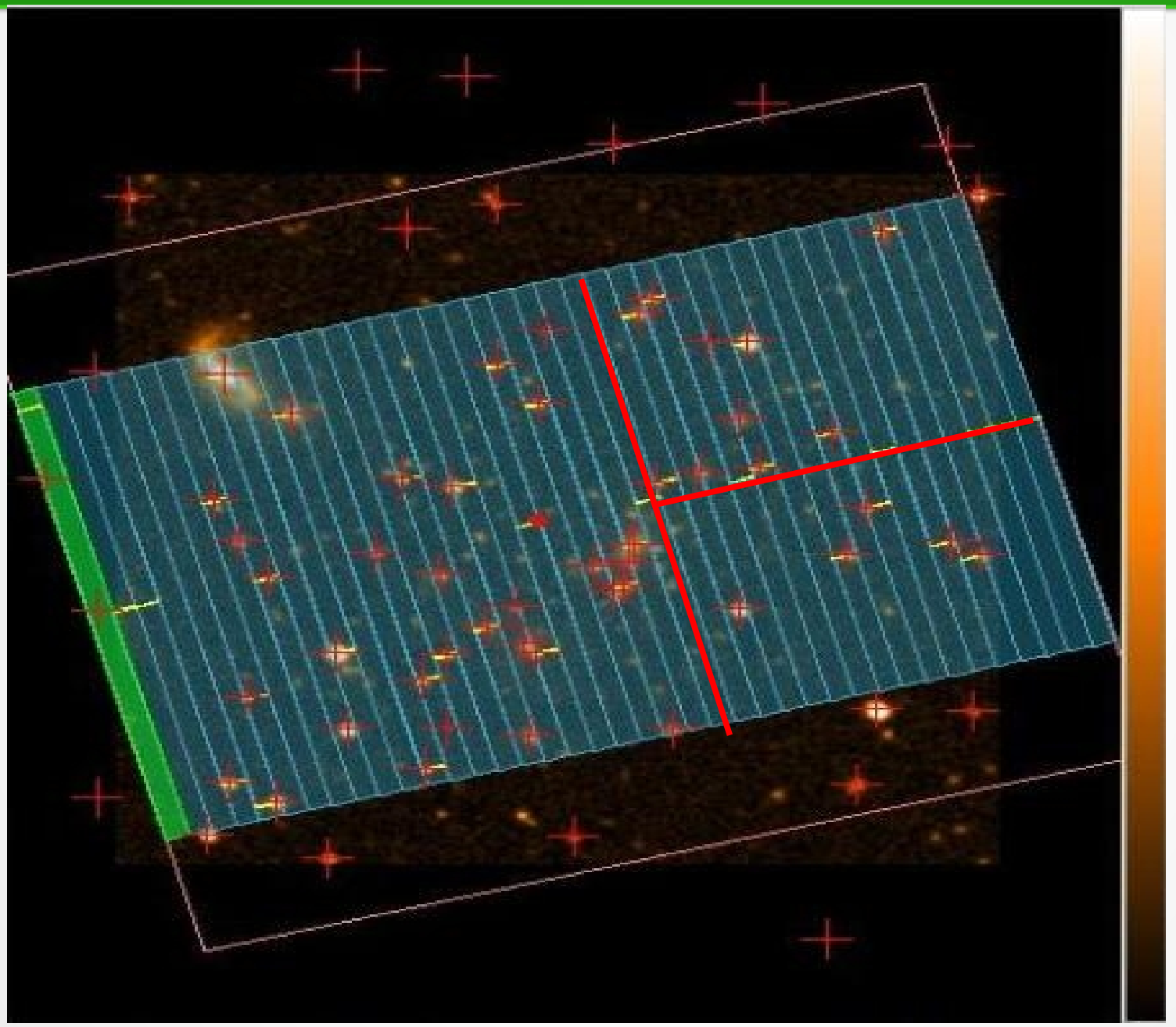


Image from OSP tutorial

Commissioning and Science Verification

- “The formation of massive, passive galaxies: pilot EMIR high-S/N H-band stellar spectra at z=1.0”

  EMIR SV / 17A , PI is Marc Balcells

- “The IMF of a relic galaxy beyond 1 micron”

  EMIR SV / 17A, PI is Mike Beasley

- Now, we are developing projects to be observed in the next MOS Commissioning to test and understand the characteristics of EMIR in deep surveys of galaxies and in nearby ones.

GOYA cosmological field selection

The selected fields were EGS for spring, and ABEL370 and UDS for fall

EGS (Extended Groth Strip) have been selected because has relatively good visibility in El Observatorio del Roque and is a CANDELS field, which implies that it is an excellent one.

GOYA have considered important pointing at least one lensing cluster with similar deep public data, extracted from the Hubble Frontier Fields Survey, the ABEL370.

UDS (Ultra Deep Survey in EGS) have been selected as a normal field for fall.

H filter

Project *	Depth (AB)	S/N per pixel (x2.5 after rebinning), and per FWHM(line) ó RE (conti.) from EMIR-ETC	Number of expected sources per mask	Total integral time per mask (hr) (+ 60% overhead)	Tentative number of sources per mask (in 53 hours ~7 noches) ***	Main Spectral features	Cosmological fields where densities were measured
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LMG	Flux H_α ($x10^{-16}$erg/s/cm^2) 1.0 0.5 0.1	 10.5, 30.3 5.2, 15.2 1.0, 3.1	 118 312	 5 (8) 5 (8) 5 (8)	25 (166)	H_α + [NII]	EGS/AEGIS EGS/AEGIS
FG	J < 25.7 J < 26.3 ~5 $x10^{-18}$erg/s/cm^{-2}		7.2 41	10 (16)	<~ 8 (27)	L_α, CIV, HeII, SiIV, CIII. Line flux: ~5 $x10^{-18}$erg/s/cm^{-2}	WUDS + WIRDS HST – LF + HFF
HMGz1 (MAGINASTEz1)	H = 20.5 (σ=200 km/s)	22.4 (56), 55.1	7 for 0.9<z<1.2 + 1 for 1.4<z<1.8 + 4 low mass-z? Total=12 **	33 (53)	14 (14)	Na and CaT for 0.9<z<1.2 ; NaD and TiO_2 for 1.4<z<1.8	GOODS-N GOODS-N
HMGz2 (MAGINASTEz2) - no actualizdo	H=24 (S/N=8) H=23 (S/N=20)		4 (K<24)	100 (160)	4	Balmer, Mg	GOODS-N
TOTAL per mask					52		