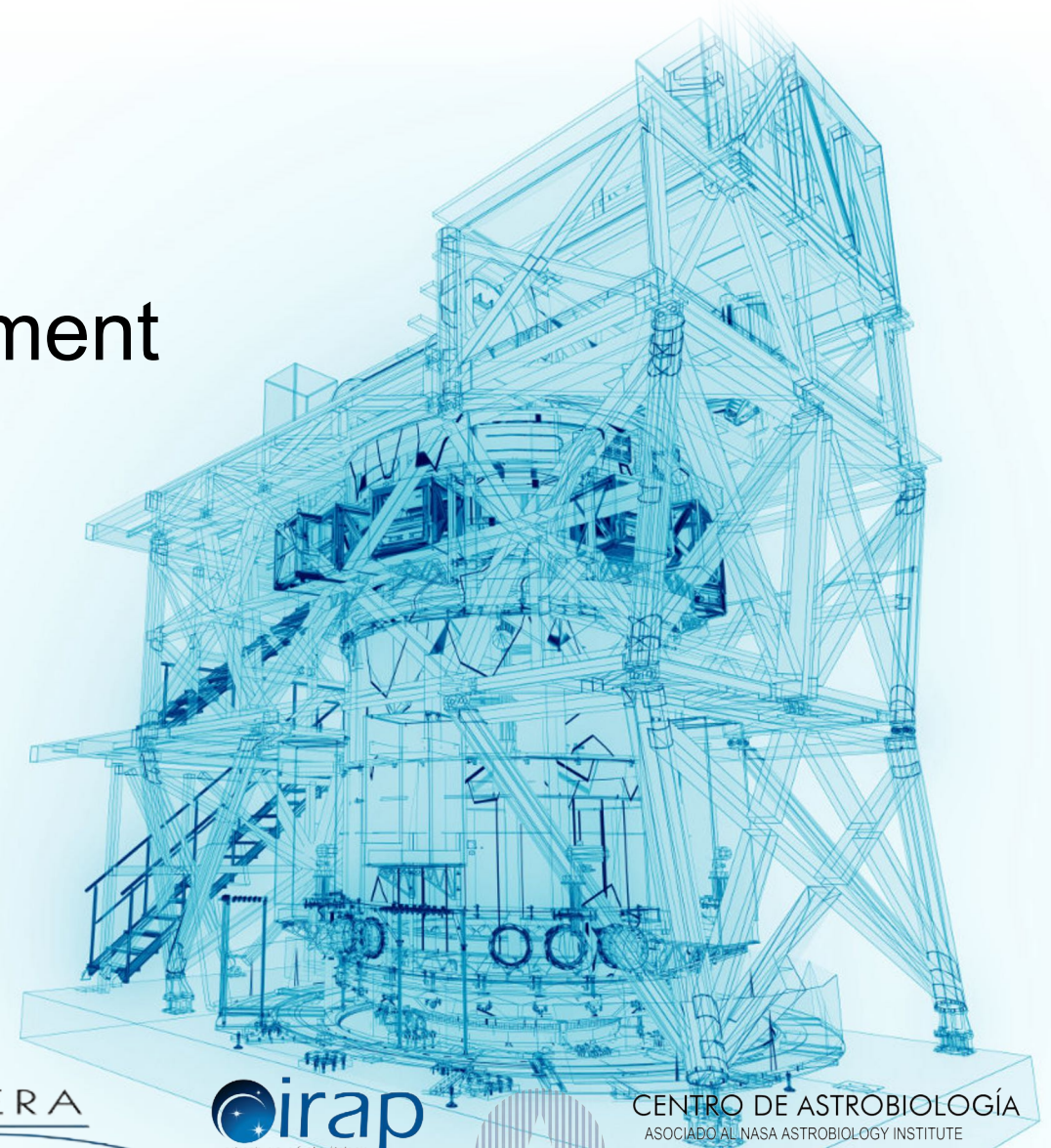


# CAB Contribution to the Instrument HARMONI for the ELT

Javier Piqueras López (CAB CSIC/INTA)

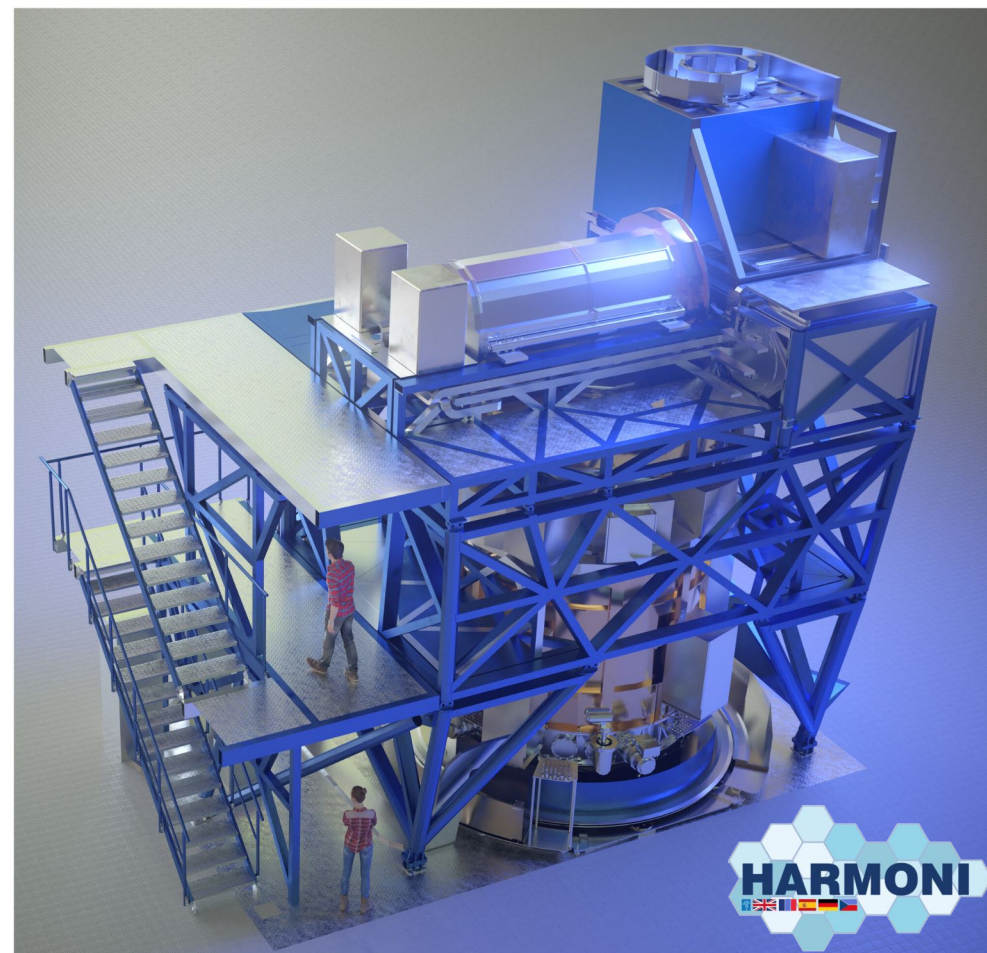
*HARMONI Calibration Scientist and CAB Project Manager*

*piqueraslj@cab.inta-csic.es*

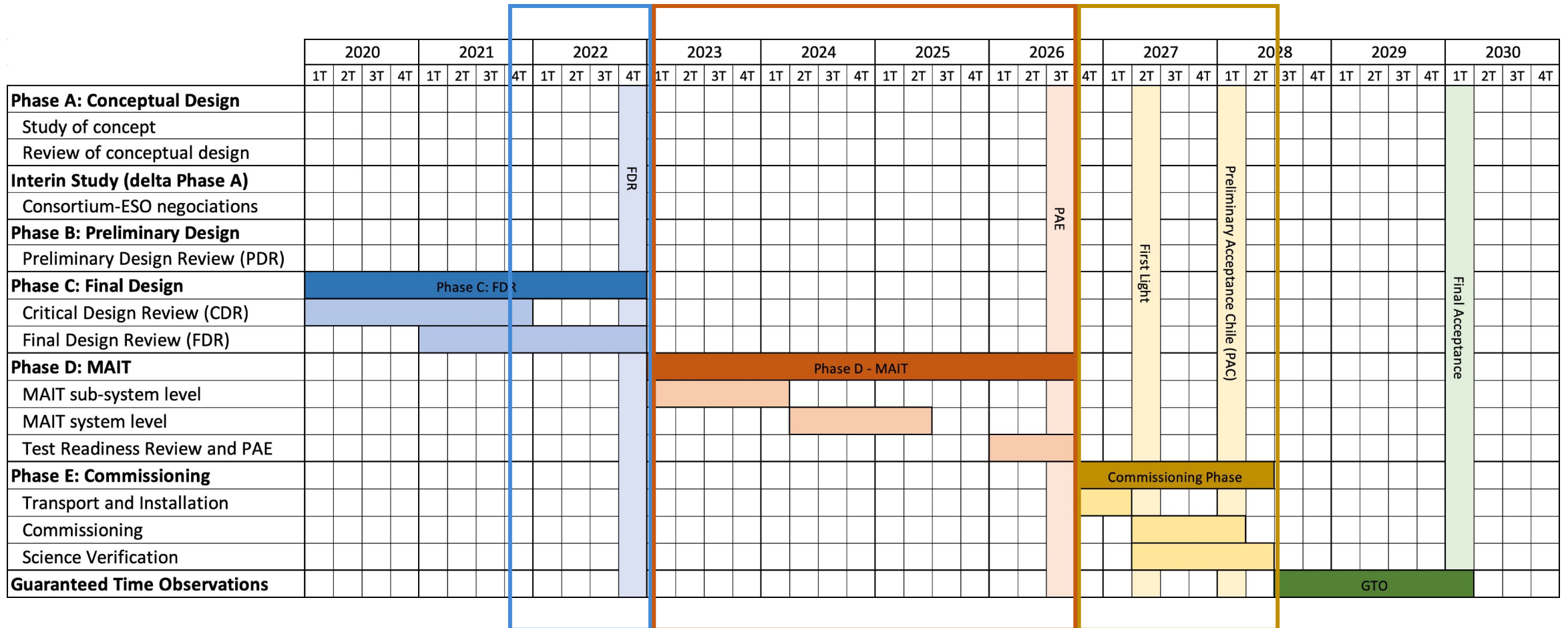


# HARMONI: the first-light spectrograph for the ELT

- The HARMONI Consortium is led by the University of Oxford and the UK-ATC in Edinburgh, and is also conformed by the University of Durham, CRAL-Lyon, LAM, IAC-Tenerife, CAB-Madrid, and the University of Michigan
- ~700 FTE + ~70M€ (hardware cost, partially funded by ESO)
- Design as a workhorse instrument for integral field spectroscopy in VIS and NIR wavelengths
- It will allow the community to address an ample range of the ELT science programs
- HARMONI in a nutshell:
  - VIS and NIR IFS (~32000 spectra)
  - Wavelength range: 0.47 – 2.45  $\mu\text{m}$
  - Spectral resolution: ~3500, 7000, 18000
  - Pixel scales: 30 mas, 20 mas, 10 mas and 4 mas
  - FoV: ~9"x6", 4"x3", 2"x1.5", 0.8"x0.6"
  - LTAO, SCAO, HCAO and No-AO observations

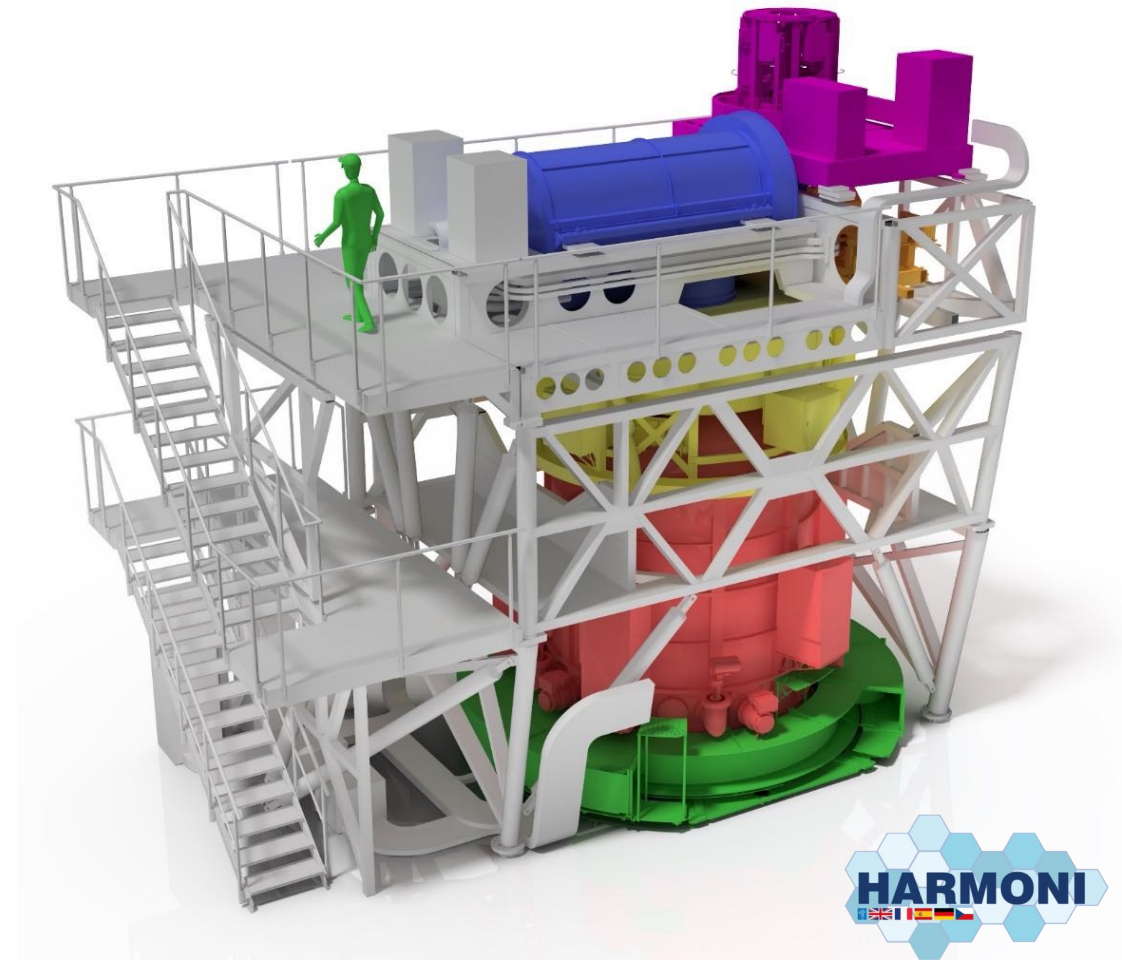


# Current status of the project



# CAB Contribution to HARMONI

- IAC and CAB contributed to all the HARMONI phases since its original proposal in 2007
- Their contribution to the project (~ 20%, 12.9% IAC and 7.2% CAB) constitutes the Spanish contribution to ELT first-light instruments
- CAB contribution to HARMONI
  - Technical work-packages
  - Instrument Calibration Plan
  - HARMONI Science Simulator (HSIM)
  - HARMONI Science Team



# CAB Contribution to HARMONI

- Team at CAB

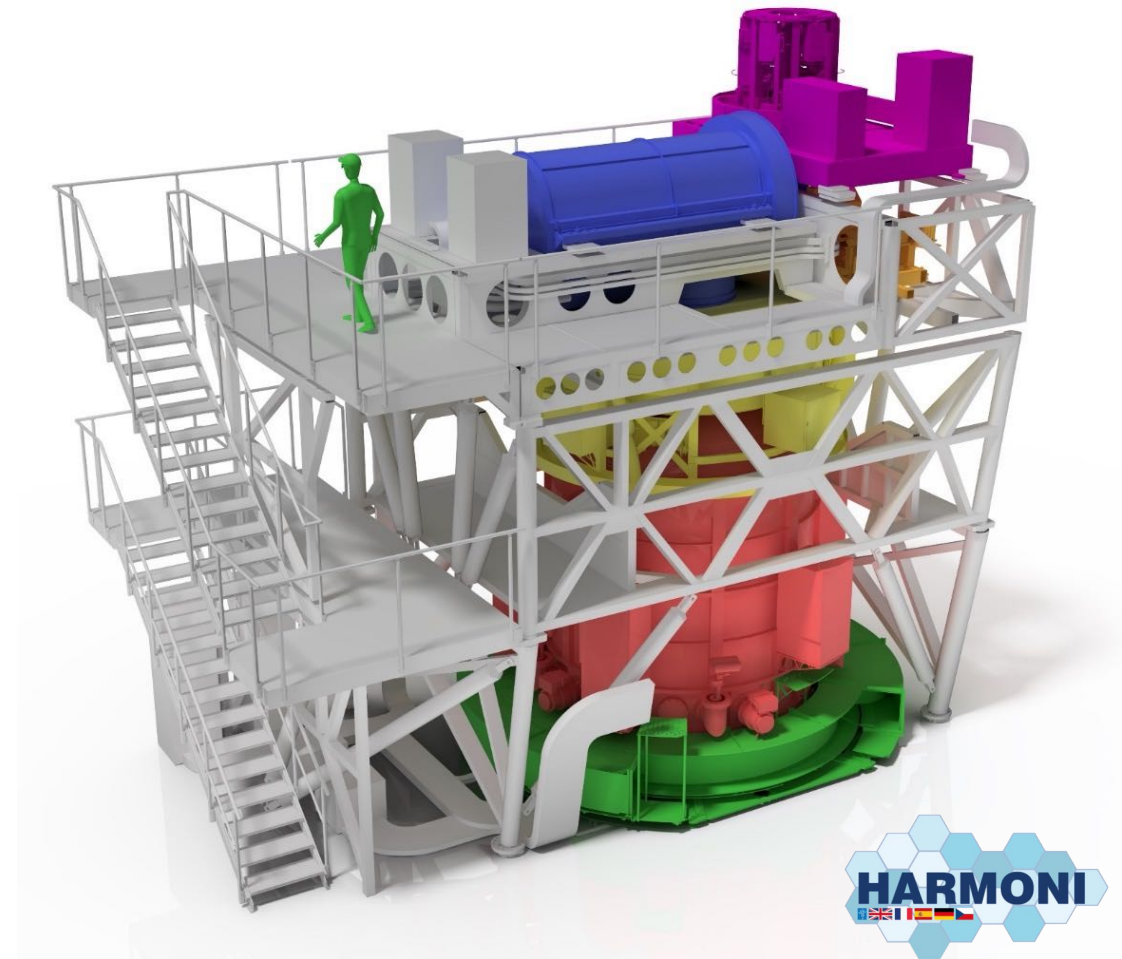
- Santiago Arribas Mocoroa – HARMONI Co-I and Science Team
- Miguel Pereira Santaella – HARMONI Simulation Scientist, HSIM and Science Team
- Javier Piqueras López – HARMONI Calibration Scientists, IPM and Science Team
- Alberto Estrada – System Engineer and LOWFS WP Manager
- Heribert Argelaguet – AIV specialist and CM WP Manager
- Alonso Álvarez – Electronic Engineer
- Gonzalo José Carracedo Carballal – PhD Student and Software Engineer
- Michele Perna – Science Team
- Miriam García – Science Team
- Members of the Space Instrumentation Group (Eduardo Sebastián, Ricardo Ferrandiz)

- INTA Collaborators

- LINES (Tomás Belenguer, Luis Miguel González, Marianela Fernández, Daniel Garranzo)
- Santiago Martín Iglesias - Prototyping

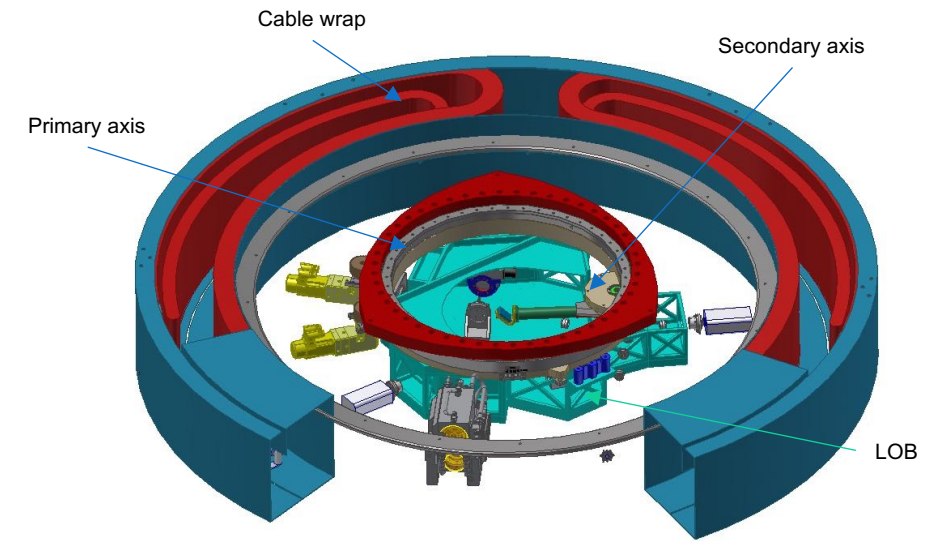
- Former members and collaborators

- Adolfo García Marín – Optical Engineer
- Cecilia Martínez – Electronic Engineer
- Javier Moreno Ventas – Optical Engineer
- Ismael Martínez Delgado – IPM Phase-A
- AVS – Phase B CM design
- SENER – Conceptual designs of the WP and Phase B POA design



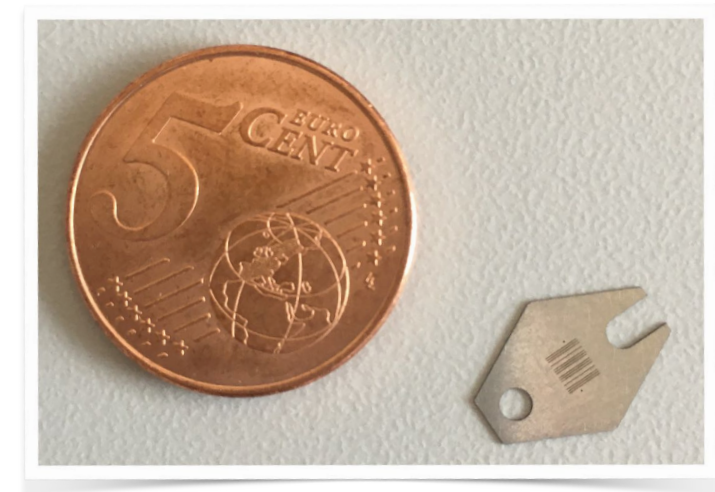
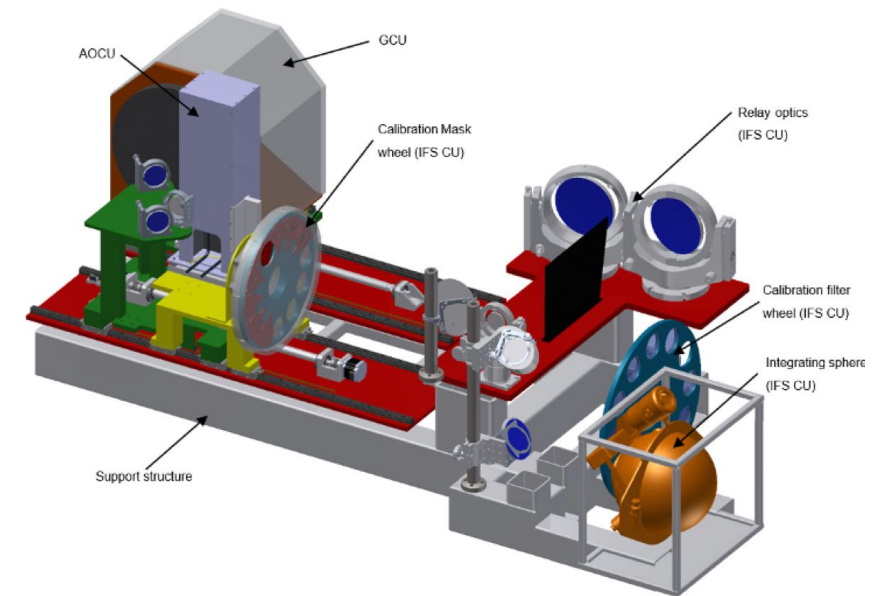
# CAB Technical Work-packages

- LOWFS – Low-order Wavefront Sensing Sub-system
  - Pick-off arm (POA) – Alberto Estrada's presentation
    - Pick-off mirror that can be positioned around the entire technical field and scientific field of view of the instrument
    - Host the wavefront sensing cameras on a mechanical stage (LOB)
    - Challenging positioning accuracy of  $\sim 10\ \mu\text{m}$  over the whole 400mm diameter technical field
  - Low-order optical bench (LOB, developed by U. Durham)
  - The POA is critical to maintain the IQ closer to the ELT diffraction limit, and to transfer the absolute on-sky coordinates to the detector plane
  - Technology development: a prototype of the POA is under development and test at INTA



# CAB Technical Work-packages

- CM – Calibration Module
  - The CM includes all functions necessary to remove the instrumental signature from the observed science data:
    - Provide uniform (continuum and arcs) illumination at the ELT focal plane
    - Provide well-known spatial and spectral patterns
    - Monitor the health and stability of the instrument
  - Three units to provide different sets of calibration data:
    - IFS unit: science calibrations
    - AO unit: SCAO and NGS calibrations
    - GCU: Geometrical Calibration Unit to calibrate the POA and SCAO
- IFS test equipment
  - Modified copy of the CM for IFS and pipeline testing during AIV



# Calibrations and HSIM

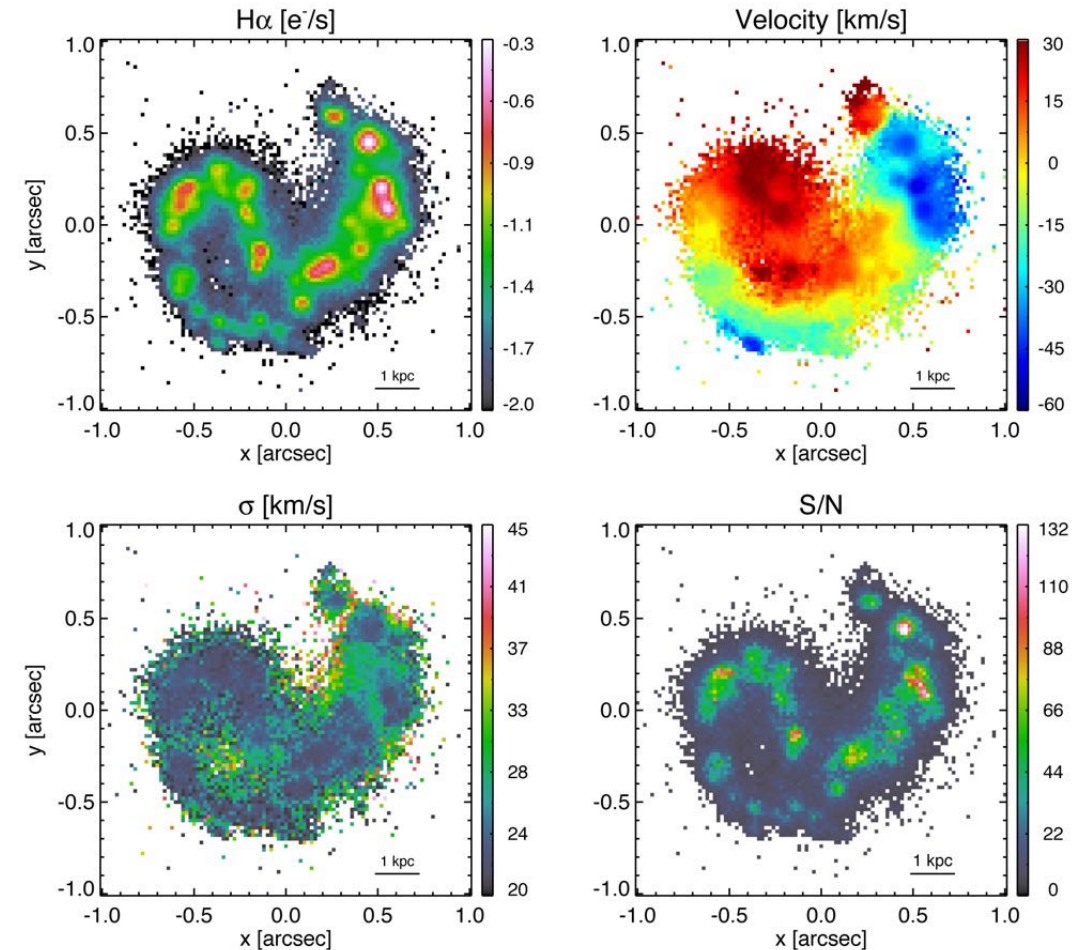
- Instrument Calibration Plan

- CAB hosts the Calibration Scientist of HARMONI, responsible of the development of the Calibration Plan of the instrument
- The Instrument Calibration Plan describes all the tasks and procedures needed to perform the calibration of science data, and to perform the monitoring and AO calibrations
- We also study, establish and refine the procedures and patterns to equip the CM with all the needed elements (lamps, masks, etc) to perform the instrument calibrations

- HSIM – HARMONI Science Simulator (Miguel Pereira Santaella's poster)

- CAB hosts the HARMONI Simulation Scientist (M. Pereira), responsible of the development of the Science Simulator, and of the coordination of the science simulations across the Consortium.
- HSIM is an open-source (<https://github.com/HARMONI-ELT/HSIM>) parallel processing code to simulate HARMONI observations based on the user inputs
- It is an essential tool for the future HARMONI users to optimize the ELT observing time

HSIM Simulations of  $z \sim 2$  ULIRGs



# Science Support Activities

- Science Support Activities

- Scientific analysis to support the technical team
  - Availability of guiding sources
  - Impact of the differential atmospheric diffraction on the IQ
  - Impact of the thermal background on the sensitivity
  - HARMONI pointing model (Gonzalo Carracedo's presentation)
- Trade-off and flow-down of top-level science requirements
- ESO ELT Working groups
  - Detectors
  - PSF simulations
  - Telluric correction
  - Skylines subtraction
  - STD

- HARMONI Science Team

- CAB participates on the definition of the science cases for the HARMONI scientific exploitation
- We are also responsible for the development of science simulations with HSIM

