From ESPRESSO@VLT to HIRES@ELT: Instrument Control Software and Electronics developed at INAF-OATs

Veronica Baldini

Summary

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- ESPRESSO @ VLT
  - scientific goals
  - hardware configuration
  - control electronics distribution
  - core of the control system
  - main control software features
  - integration and PAE tests

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- HIRES @ ELT
  - science cases
  - proposed system architecture
  - instrument control electronics and software purpose

ESPRESSO is ready for Chile

DALL'ESO SEMAFORO VERDE PER IL CILE

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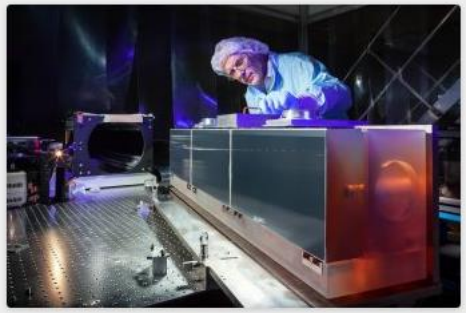
Espresso è pronto, destinazione Paranal

Il cacciatore d'esopianeti di nuova generazione, erede di Harps, ha superato tutti i test preliminari. Stefano Cristiani (Inaf): «A fine anno lo strumento vedrà la "prima luce" in cielo, e noi scienziati speriamo finalmente, dopo sei anni di lavoro, di poter iniziare lo studio di pianeti extrasolari»

di Redazione Media Inaf Segui @mediainaf martedì 22 agosto 2017 @ 17:01

Si chiama Espresso, ha tutte le carte in regola per diventare il cacciatore di pianeti extrasolari più avanzato al mondo, ed è finalmente pronto per essere spedito a Cerro Paranal, in Cile, dove già lo attende la struttura dedicata – il Coudé Combined Laboratory – che lo collegherà ai quattro telescopi del Vlt dell'Eso. Così da garantirgli un'area di raccolta della luce corrispondente a quella d'un unico telescopio con uno specchio da 16 metri di diametro.



L'enorme reticolo di diffrazione al cuore dello spettrografo ad alta precisione Espresso durante i test nella camera bianca del quartiere generale di Eso a Garching a Monaco, in Germania. Crediti: Eso/M. Zamani

Il principio di funzionamento di Espresso si basa sul metodo della misura della velocità radiale delle stelle, ed è identico a quello di Harps, lo spettrografo installato sul telescopio da 3.6 metro dell'Eso a La Silla, sempre in Cile, del quale Espresso è il successore. In pratica, lo spettrografo permetterà di individuare i pianeti extrasolari registrando le variazioni quasi impercettibili che questi inducono, con la loro attrazione gravitazionale, sul moto della propria stella ospite, facendola oscillare. Una rilevazione indiretta e particolarmente difficile, soprattutto per i piccoli pianeti rocciosi che Espresso si propone di scoprire, visto che l'ampiezza delle oscillazioni indotte sul moto delle stelle dipende dalla massa dei pianeti. Ed è per questo l'entrata in funzione di Espresso, la cui precisione è dieci volte superiore a quella di Harps, sta entusiasmando gli astronomi.

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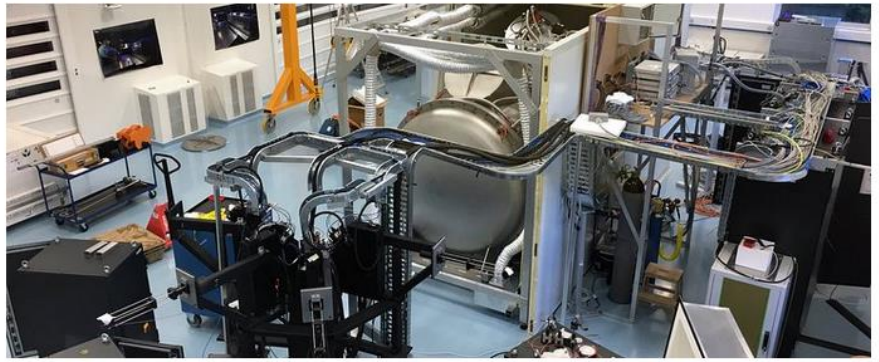
ESPRESSO Planet Hunter Heads for Chile

22 August 2017



ESPRESSO — the Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations — has passed ESO's Preliminary Acceptance Europe (PAE). This means that it has successfully completed all preliminary testing, and the instrument will now be packed up and shipped to Chile, where it will be installed at the combined coudé focus of the Very Large Telescope (VLT). ESPRESSO is expected to see first light later in 2017.

ESPRESSO, an echelle spectrograph, is one of the most eagerly awaited instruments in the astronomical world [1]. It is the successor to ESO's planet-hunting HARPS instrument on the ESO 3.6-metre telescope at La Silla, and will exceed HARPS's precision by about 10 times [2]. As the next-generation planet hunter, ESPRESSO will measure minuscule changes in the light from stars, as planets — many of them smaller than Neptune — rotate around them. This radial velocity method, as it is known, records tiny changes in the motion of the star arising from the planet's gravitational influence — the star "wobbles" as the planet goes around it. The smaller the planet, the smaller the wobble, and in order to detect small, rocky and potentially life-bearing exoplanets an instrument with very high precision is required. Using this method ESPRESSO will be able to detect some of the smallest planets we expect to find [3].

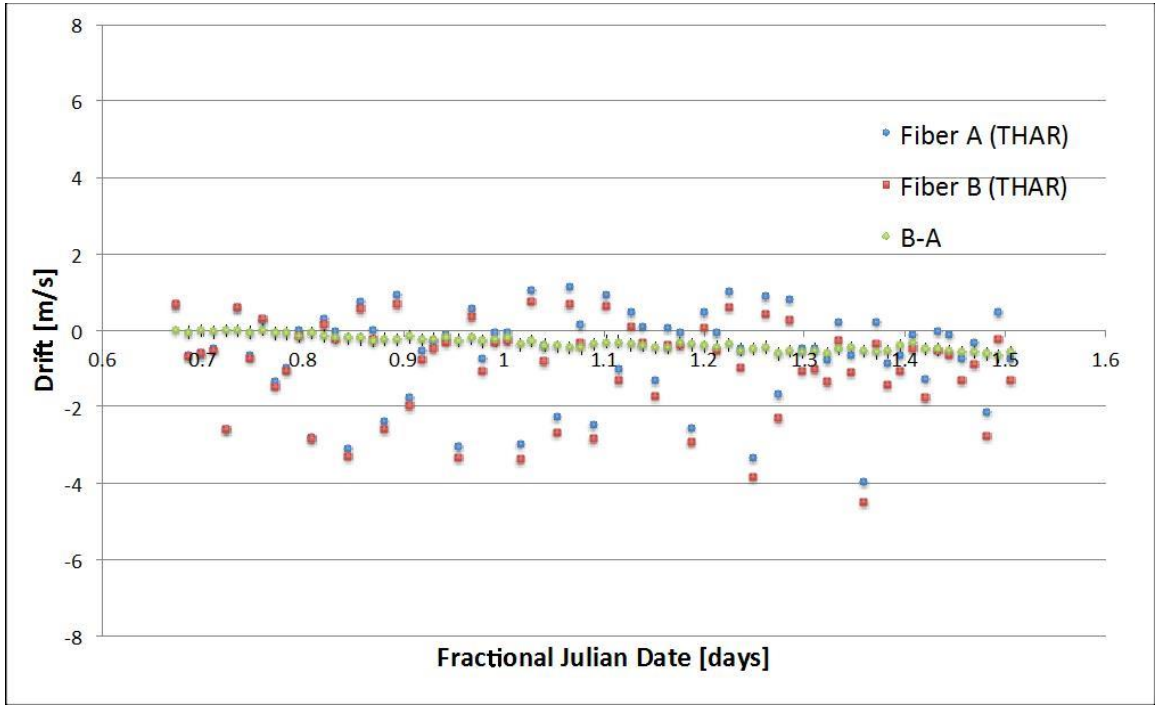
ESPRESSO @ VLT

Scientific goals

- ESPRESSO is considered the successor, with 10-fold higher accuracy precision, of one of the most famous exoplanet hunters with the radial velocity method: the HARPS instrument (at 3.6m ESO telescope in La Silla)
- The main scientific goals of ESPRESSO are:
  - the measurement of high precision radial velocities of solar type stars for search for rocky planets
  - the variation of the fundamental constants physics
  - the properties of the intergalactic medium and
  - the chemical composition of stars in nearby galaxies

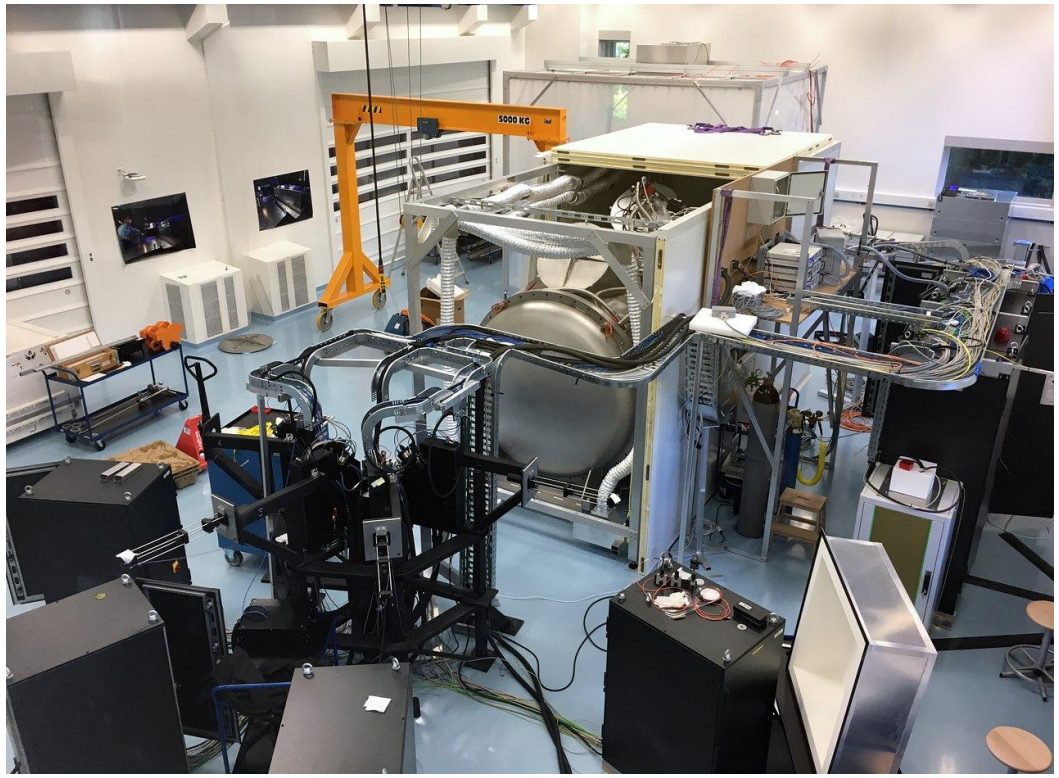
For further information: F. Pepe et al., *ESPRESSO: The next European exoplanet hunter*, Astronomische Nachrichten, Vol 335, Issue 1, p.8

First results

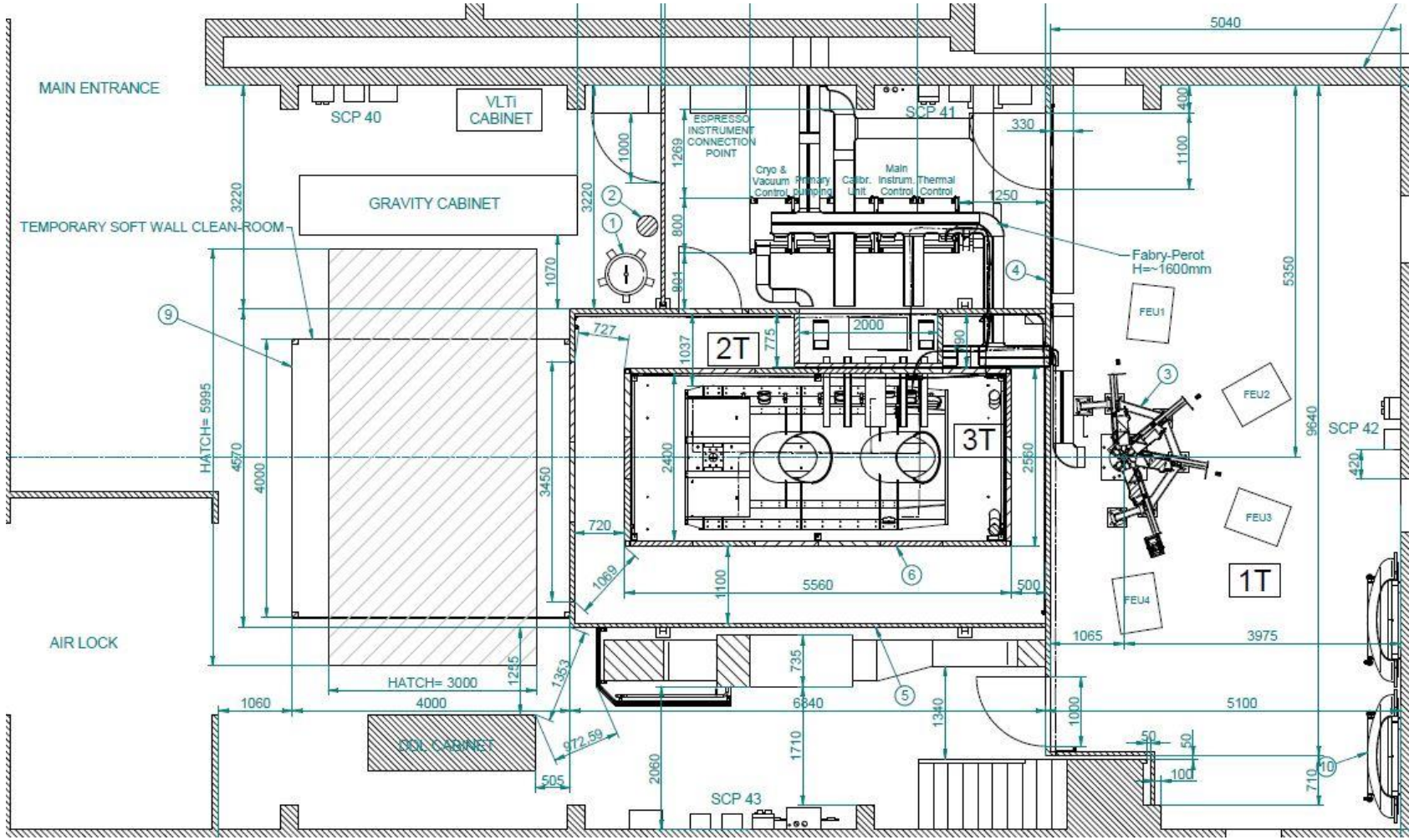


- With over 12 consecutive continuous tests, the differential displacement between the optical fibers A and B is 9.2 cm/s, comparable with the photon noise. This is a performance never achieved by HARPS, even in the best observational conditions.

ESPRESSO instrument location

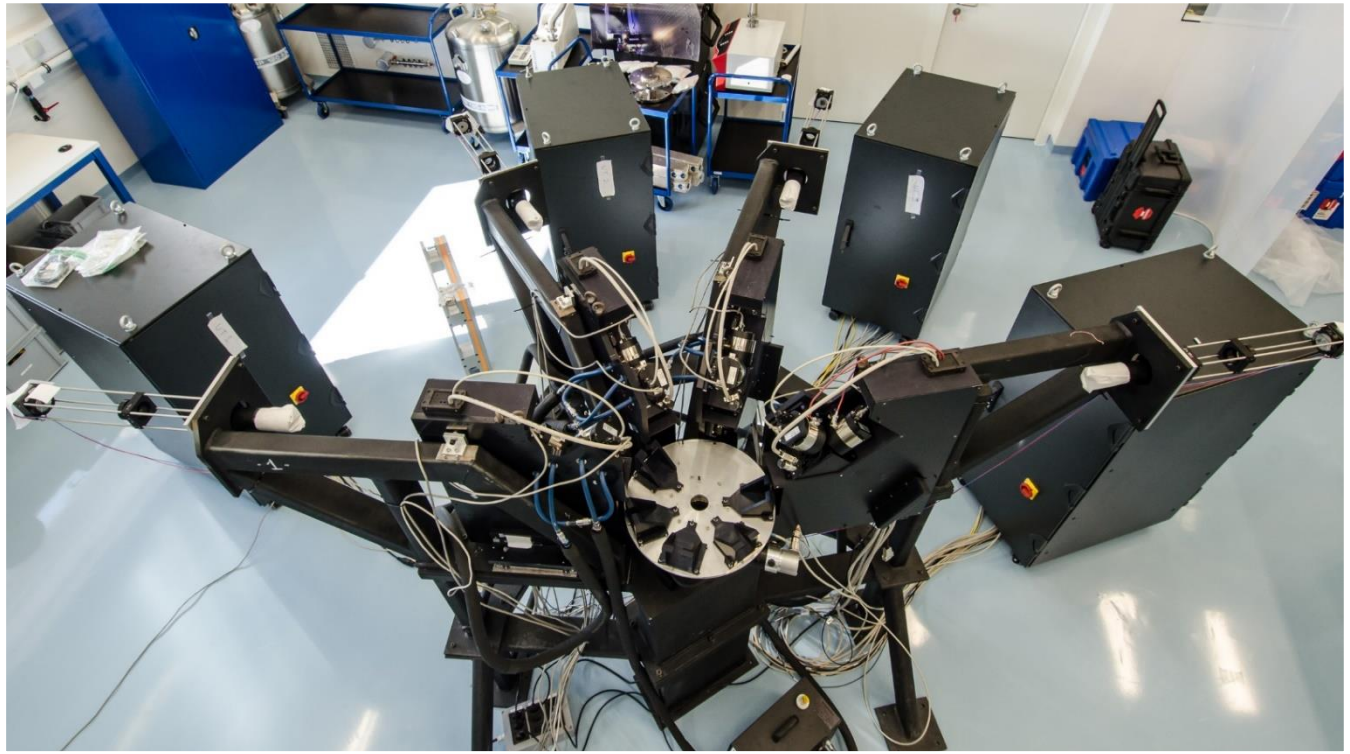


ESPRESSO hardware configuration

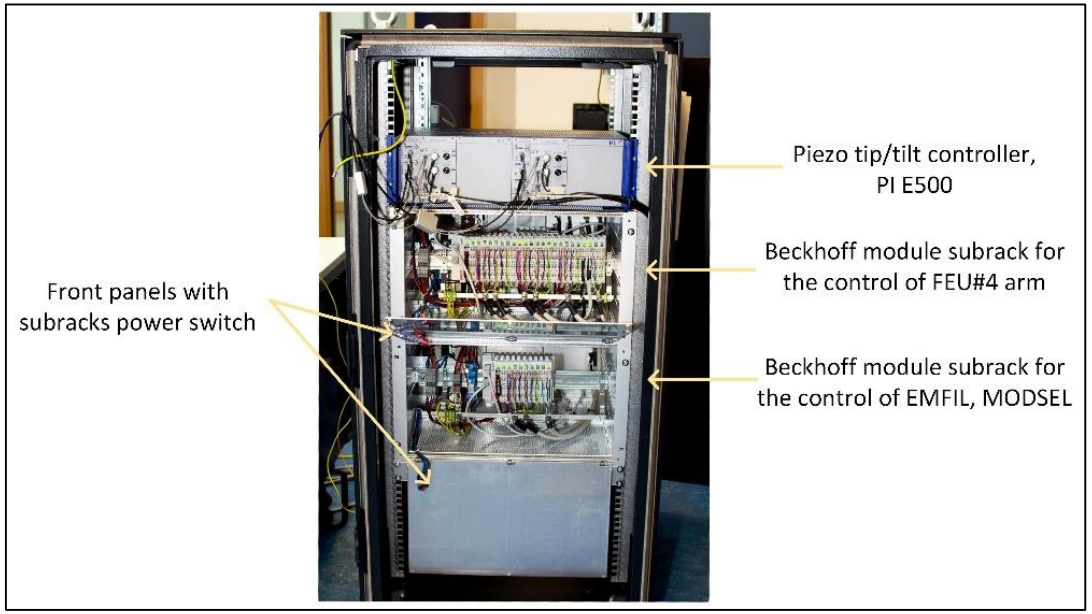


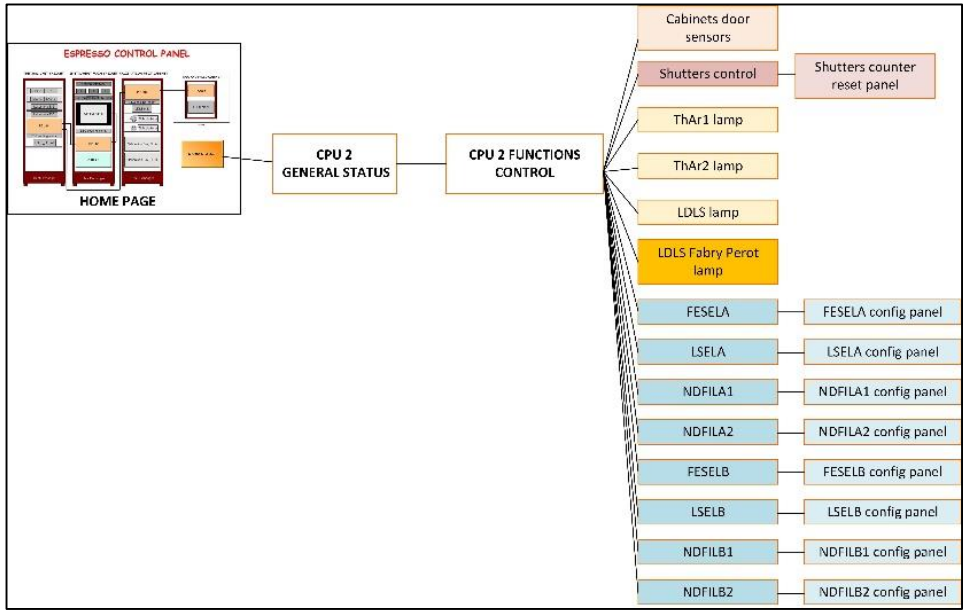
- About 40 motors
- Several calibration lamps
- More than 90 sensors

Control electronics cabinets

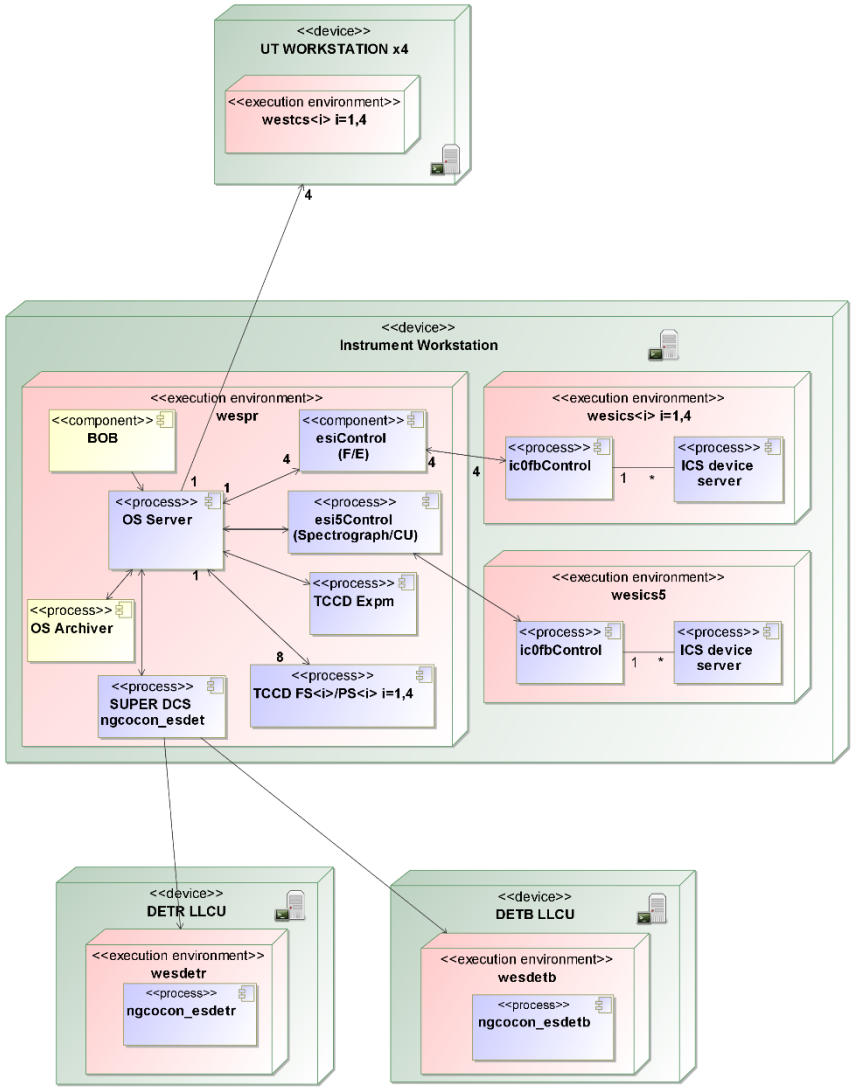


Beckhoff PLC: the core of the control system



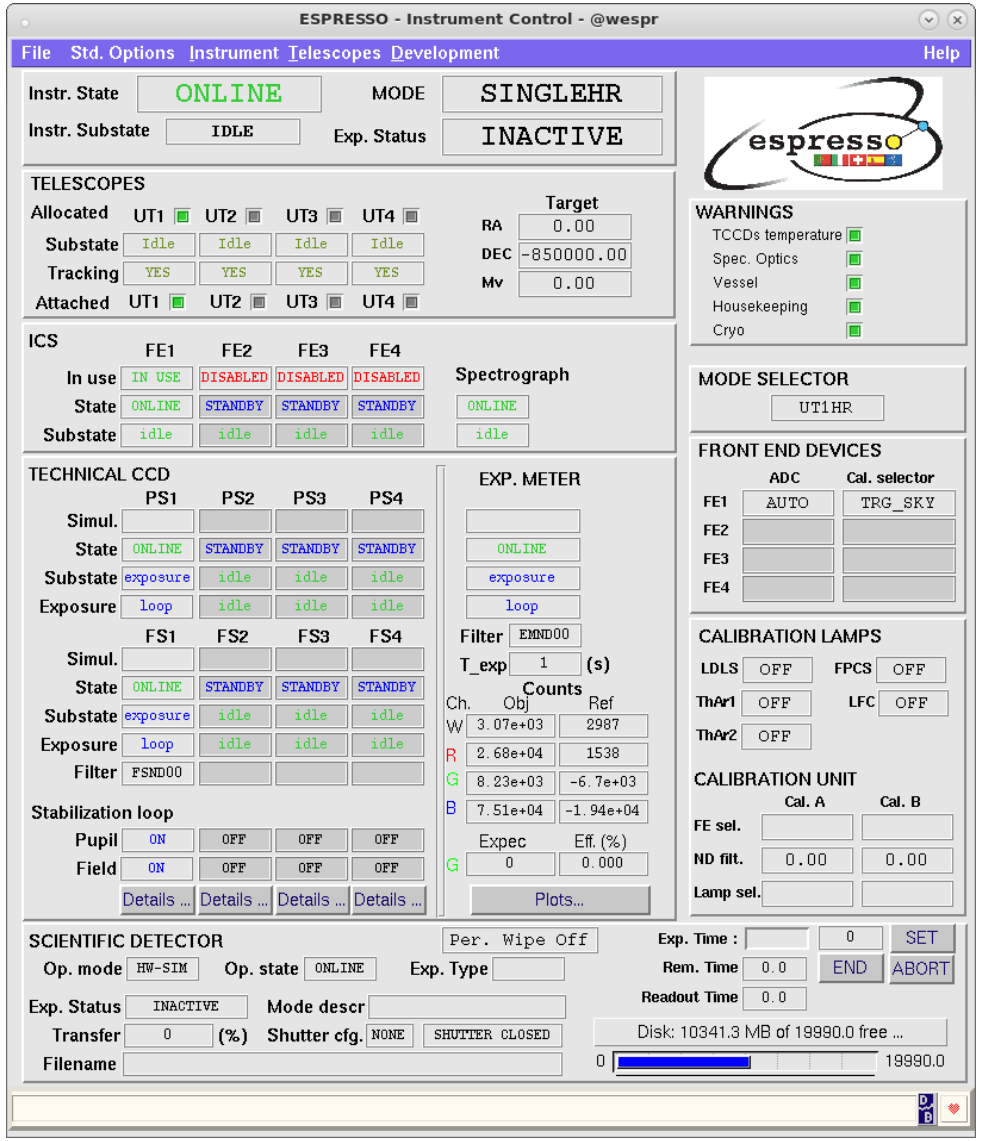


Control software architecture



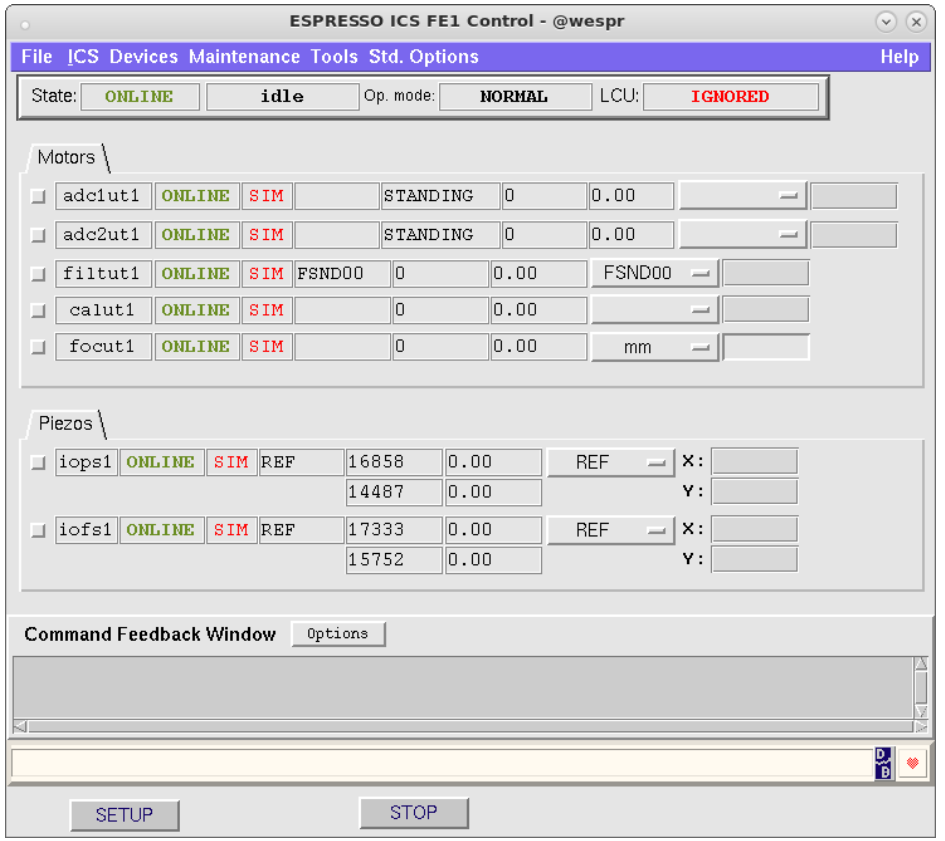
- Based on VLT standard software
- Communication with PLC through OPC-UA server
- OS server as core of the control system
- Final images are saved in fits files

Control software examples:



Instrument control panel

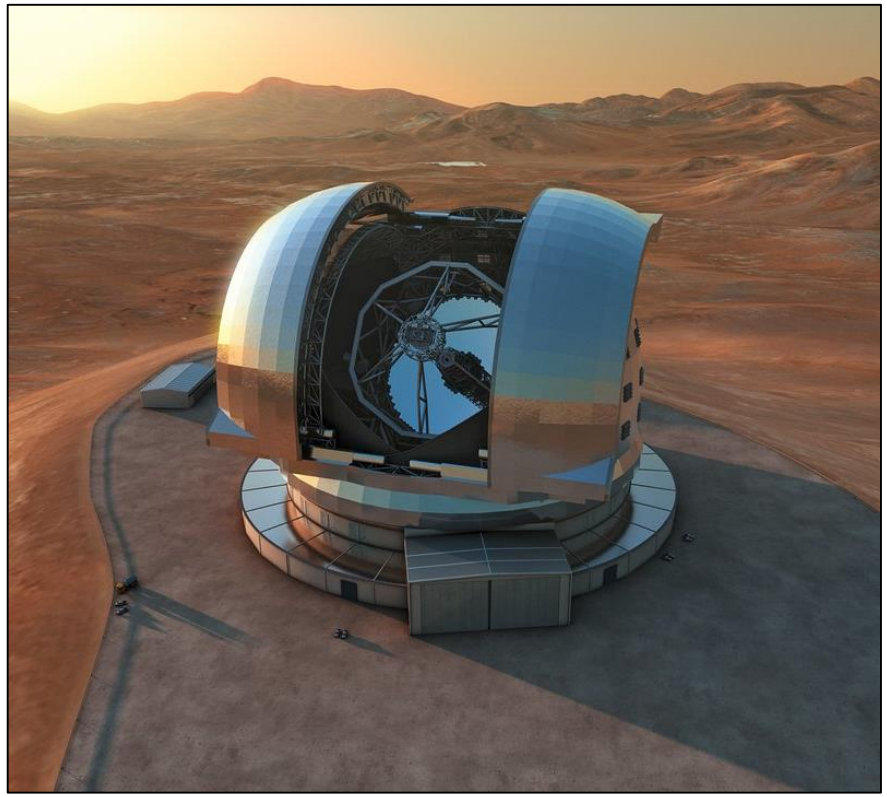
Example of FEU devices control panel



PAE and integration test

- **ESPRESSO Instrument Control Electronics tests**
  - EMC
  - Devices correct functioning
  - Accuracy in motor positioning (ADCs, linear stages…)
  - Electrical test (overcurrents, overtemperature, power peak, alarms..)
  - Stress tests (cables disconnected, unexpected power failure,…)
- **ESPRESSO Control Software tests**
  - Observation Software (OS) for the observation coordination
  - Instrument Control Software (ICS) for the low level device control
  - Detector Control Software (DCS) for the scientific detectors control
  - Test of the whole suite of calibration and maintenance templates

Towards HIRES@ELT



High resolution spectroscopy applied to larger photon collecting area

Consortium

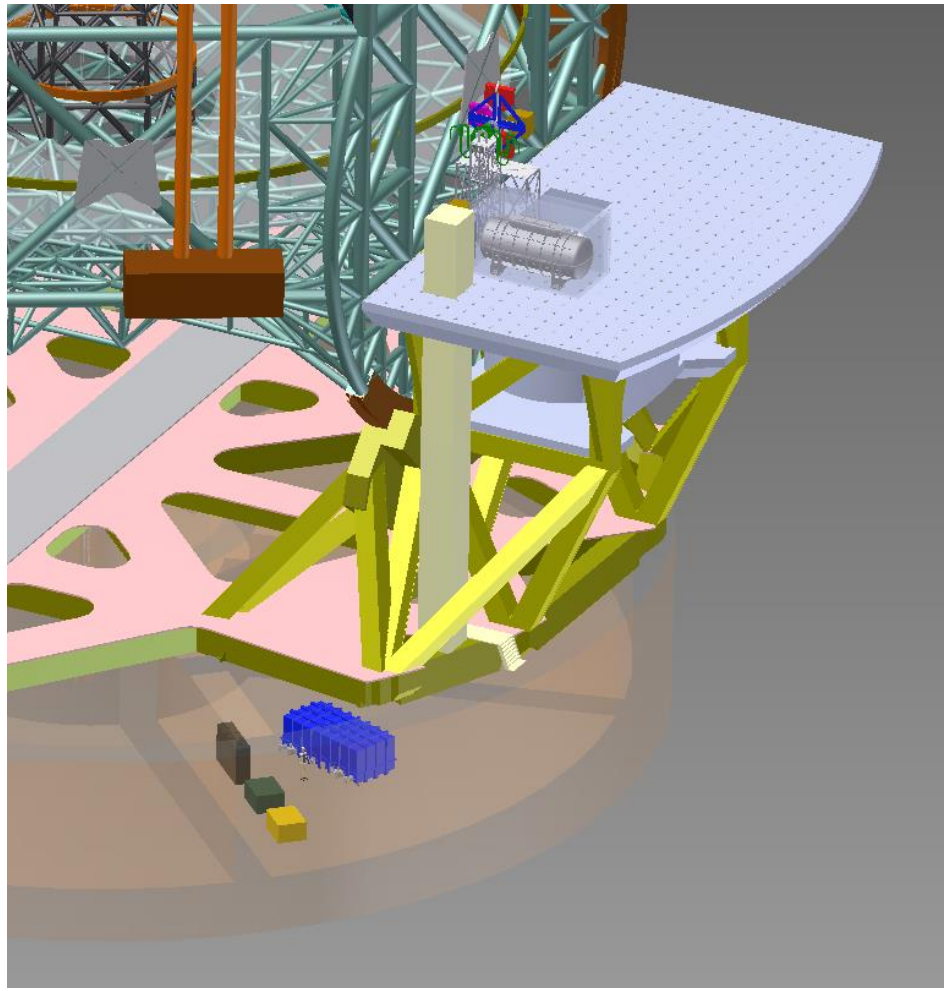
Brazil, Chile, Denmark, France, Germany, Italy, Poland, Portugal, Spain, Sweden, Switzerland, United Kingdom

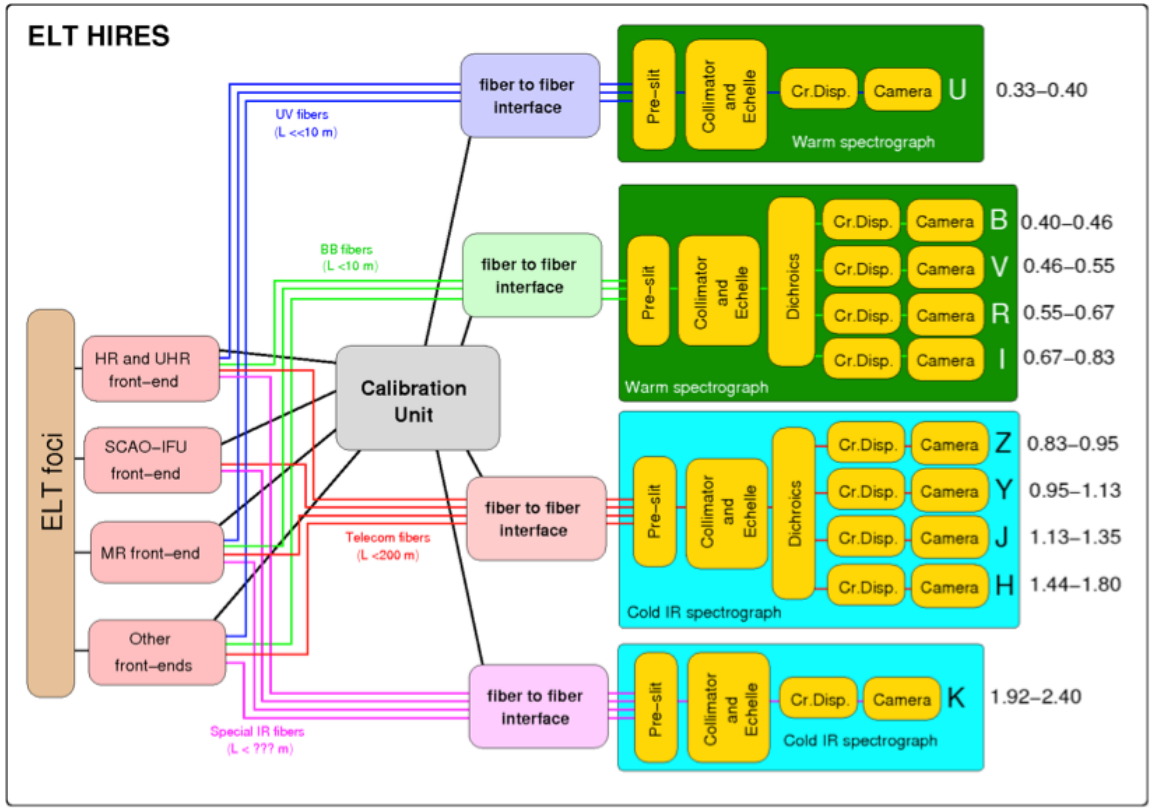
HIRES@ELT science cases

- **Stars and Stellar Populations**
  - the detection of the first generation of stars, through their chemical fingerprint in the primordial Universe
  - individual stars, distant red giants, very faint red dwarfs, ...
- **Galaxies and Intergalactic Medium**
  - thanks to its resolution and wavelength extent in the NIR, HIRES will enable the detection of pristine gas directly in the reionization epoch
  - population III stars, intergalactic medium, massive galaxies evolution, …
- **Cosmology and Fundamental Physics**
  - the detection of the variation of some of the fundamental constants of Physics, such as the electron-to-proton mass ratio, or providing the most stringent constraints on these quantities
- **Exoplanets and Circumstellar Discs**
  - the characterization of atmospheres in Earth-like planets in other solar systems, with the ultimate goal of the detection of signatures of life
    - Transit transmission spectroscopy
    - Direct detection of planet's reflected light

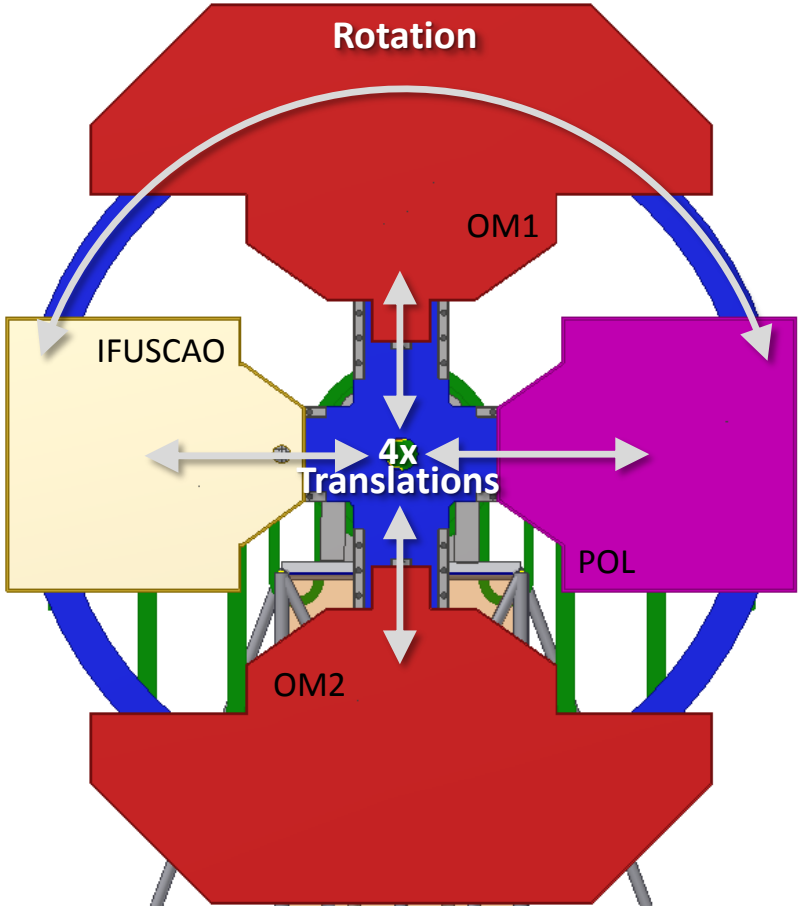
For further information: A. Marconi et al., *EELT-HIRES the high-resolution spectrograph for the E-ELT*, SPIE2016

HIRES proposed baseline

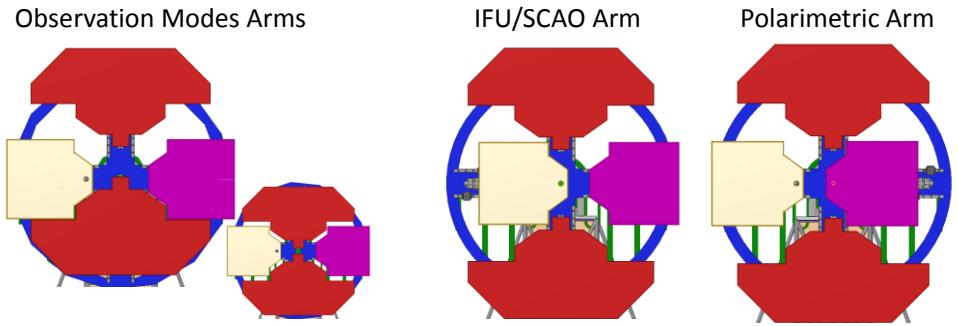




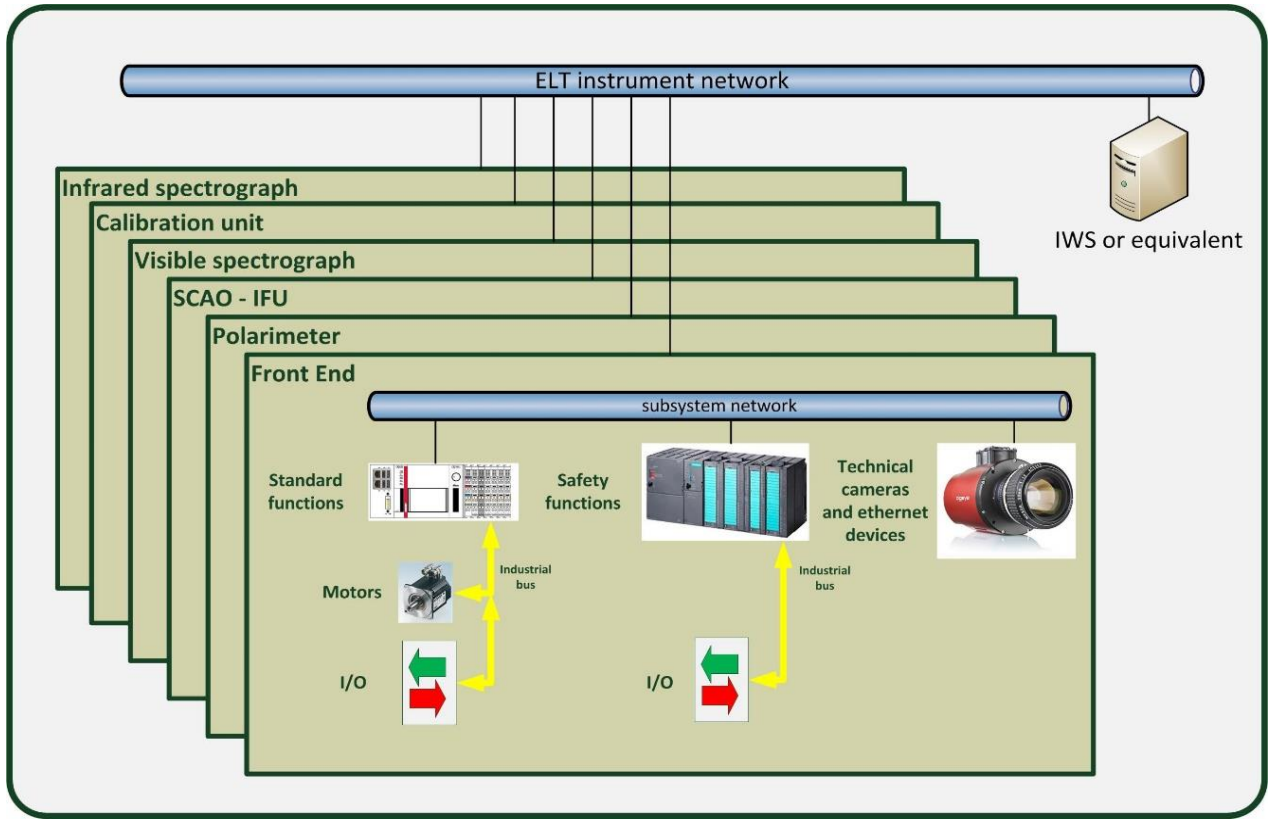
Target selection



- To reach the observing FOV and to enable target selection, the FE structure will have a rotating part and 4 translation mechanisms
- Only the two OM arms will observe simultaneously
- De-rotation mechanism to follow the sky object
- A fiber-link allow the light coming from the FE to reach the selected spectrograph
- Several observing mode are foreseen (about 12)



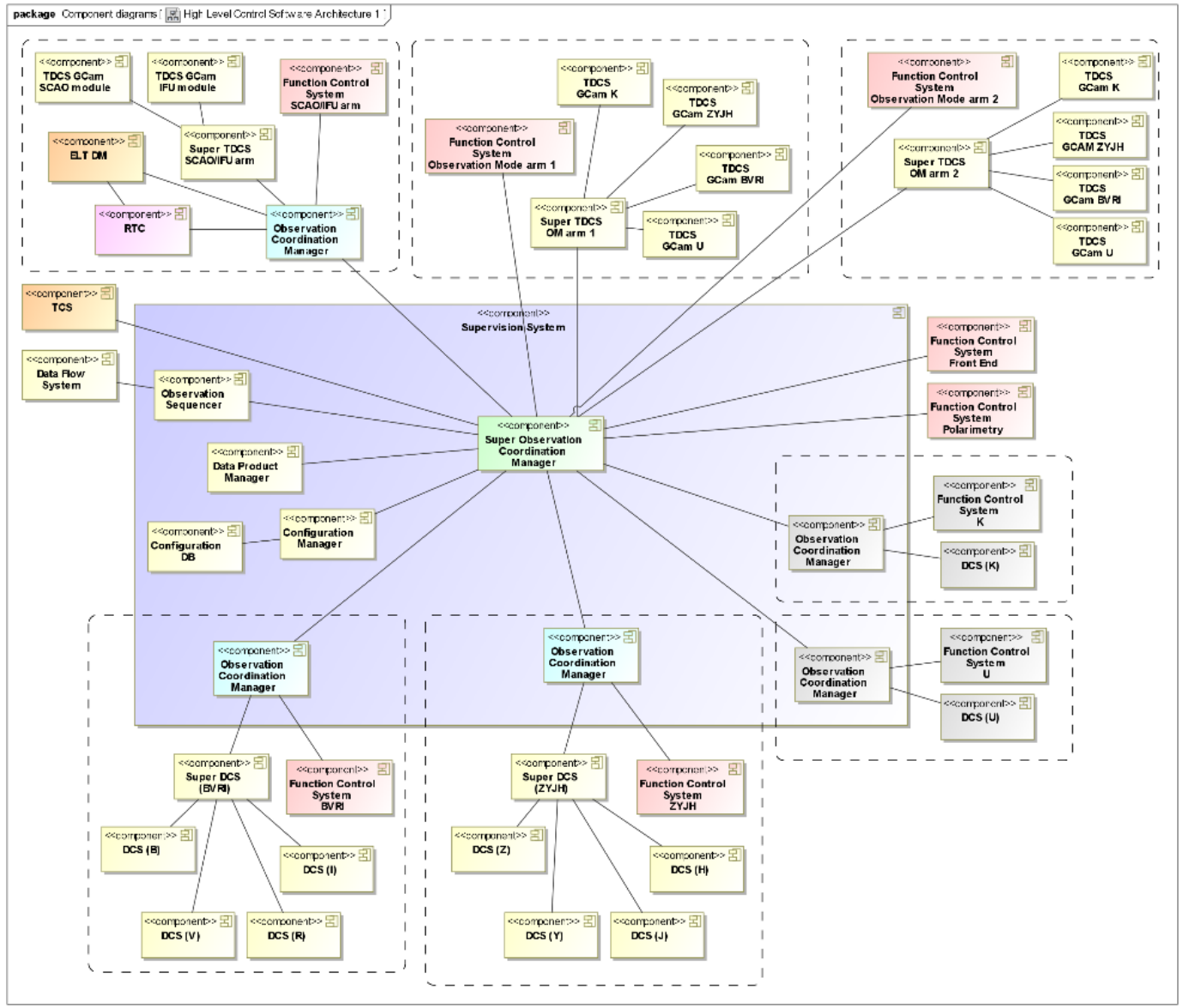
HIRES control electronics baseline



Instrument Control Electronics architecture

- Commercial off the shelf components (PLCs)
- Standard functions and safety functions
- Modularity, extensibility, precision accuracy in motor positioning
- Different type of devices/sensors from ESPRESSO and major number
- More updated technology (CPU series...)

HIRES control software baseline



- Based on a common framework (TBD)
- Complex diagram due to high complexity of the system
- Super Observation Coordination Manager as core element of the control software

Conclusion

- ESPRESSO control system based on Beckhoff PLC and VLT control software
- In-depht test were performed for the PAE on each subsystem
- Instrument is now being integrated in Chile
- First ligh foreseen at the end of November

- Looking forward to ELT and HIRES
- Baseline design in a good status
- Control system based on COTS components and standard common framework


espresso


HIRES

Thank you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