ESPRESSO: a laboratory for ELT control technologies

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ESPRESSO

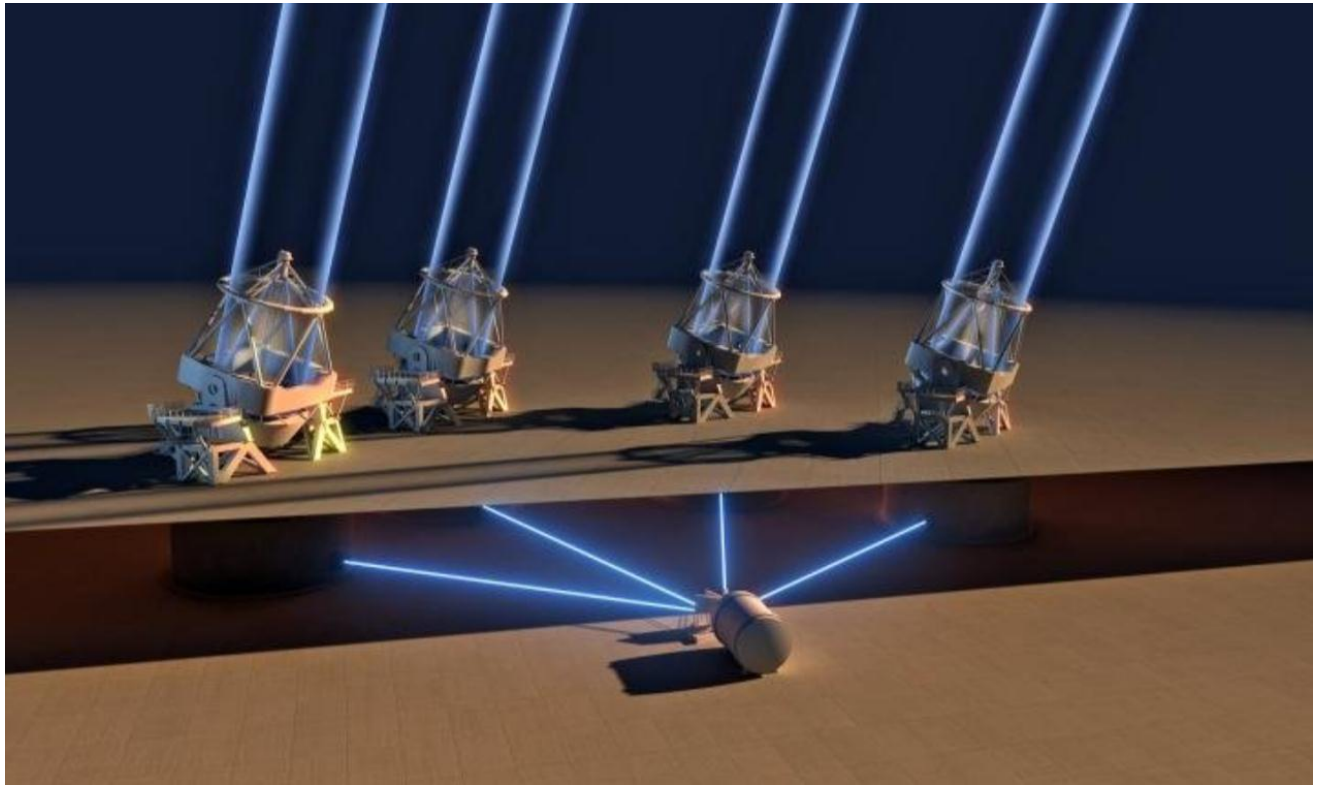
Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations

- Fiber fed
- High efficiency, high resolution
- Cross dispersed echelle spectrograph
- Covers the whole visible wavelength range (380-780 nm)

Funded, designed and built by a Consortium (Switzerland, Italy, Spain and Portugal) on behalf and in collaboration with ESO.

ESPRESSO@VLT

- Can be operated with one or four VLT Unit Telescopes
- Installed underground in the Coudé Combined Laboratory



Main scientific drivers

- Detection and characterization of rocky exoplanets (high precision radial velocity technique)
  - Designed to reach precision of ~10 cm/s
  - HARPS@3.6 m, La Silla: ~1 m/s
- Study of the variability of fundamental physical constants
- Analysis of the chemical composition of stars in nearby galaxies

Instrument modes

- High Resolution mode (HR)
  - 1-UT mode
  - R ~140000
- Ultra High Resolution mode (UHR)
  - 1-UT mode
  - R ~200000
- Medium Resolution mode (MR)
  - 4-UT mode
  - UTs light coupled into a single larger square fiber
  - R ~70000

First light and start of operations

- **First light**
  - 27 November 2017: 1 UT (start of official commissioning)
  - January 2018: 4 UT
- **Start of operations**
  - 1 October 2018: 1 UT (ESPRESSO offered by ESO for both open-time observations to the community and GTO to the ESPRESSO Consortium)
  - July 2019: 4 UT (ESPRESSO in final configuration and fully operational)

Scientific publications

- D. Ehrenreich et al., **Nightside condensation of iron in an ultrahot giant expolanet**, *Nature*, *11 Mar 2020, 580(7805): 597-60*

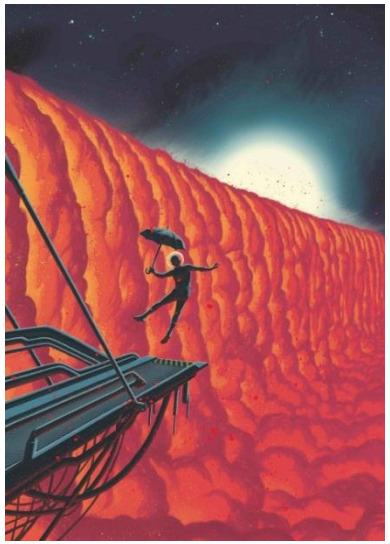
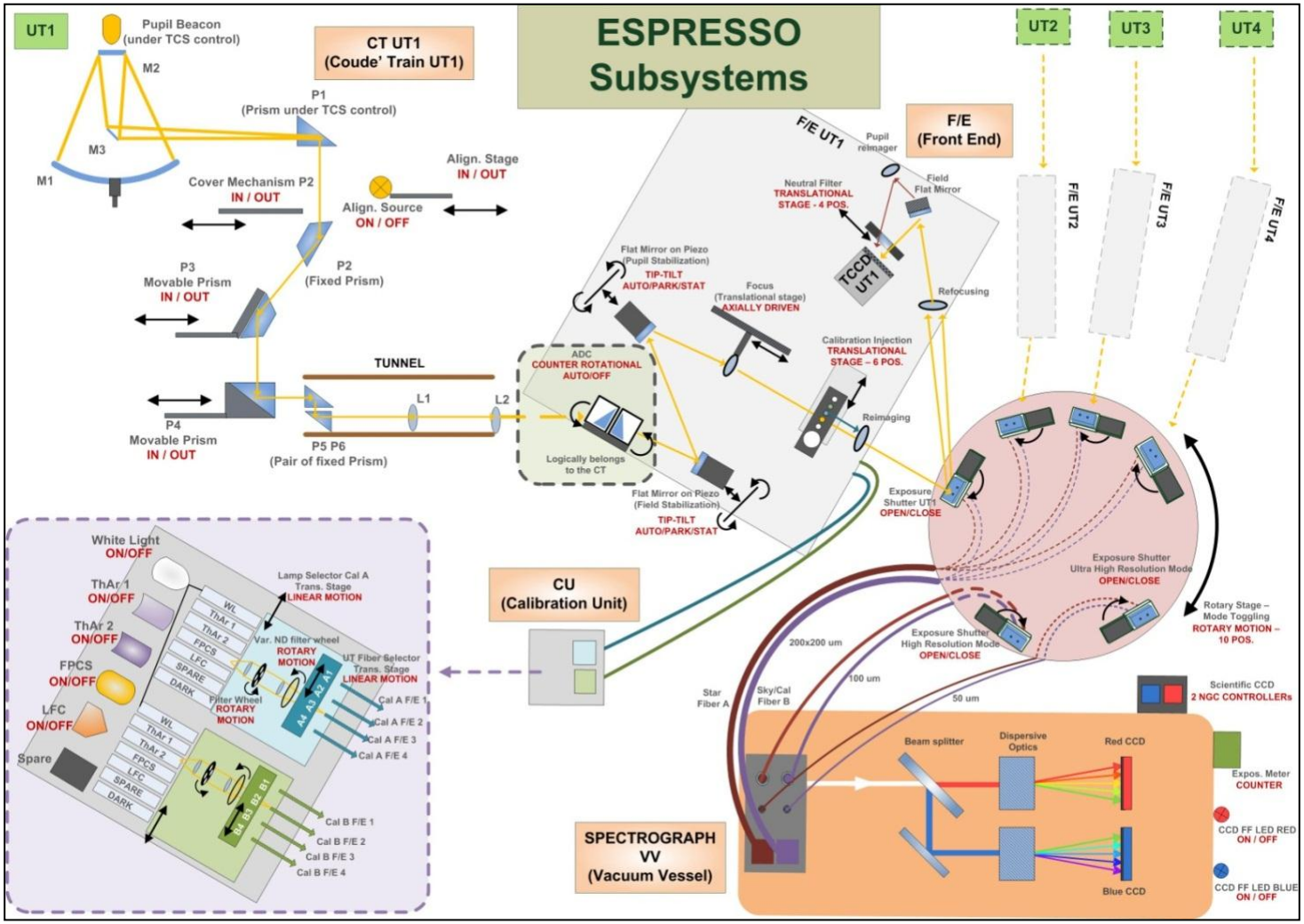


Image via Frederik Peeters / ESO

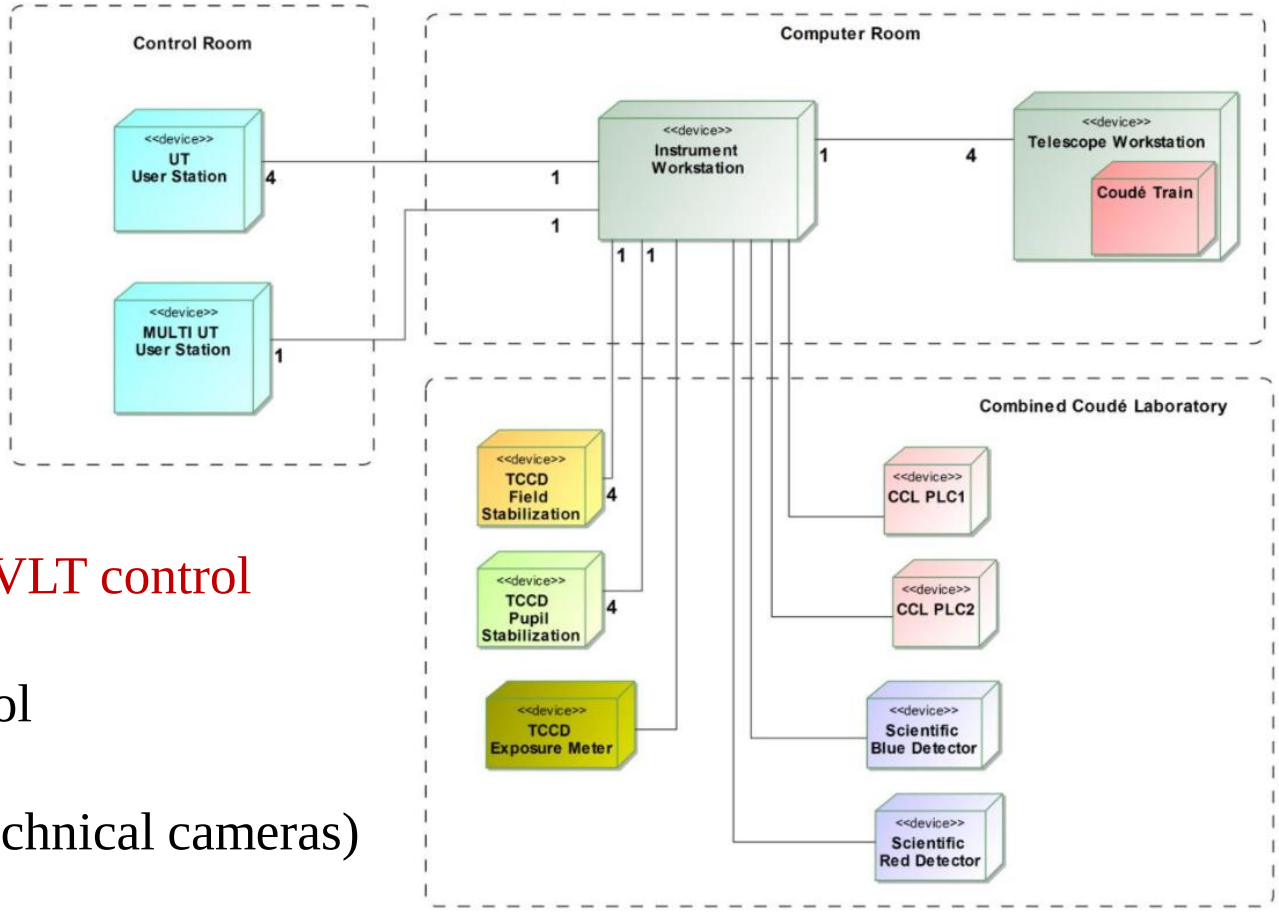
- B. Toledo et al., **Characterization of the K2-38 planetary system – Unraveling one of the densest planets known to date**, *A&A, 14 June 2020*
- A. Suárez Mascareño, **Revisiting Proxima with ESPRESSO**, A&A, 27 May 2020
- F. Pepe et al., **ESPRESSO@VLT – Observations, on-sky performance, first results and exact determination of the mass of π Men c**, *A&A, 15 April 2020*
- M. Damasso et al., **A precise architecture characterization of the π Men planetary system**, *A&A, 14 July 2020*

Instrument overview



Control architecture

Control software and electronics developed by INAF – OATs

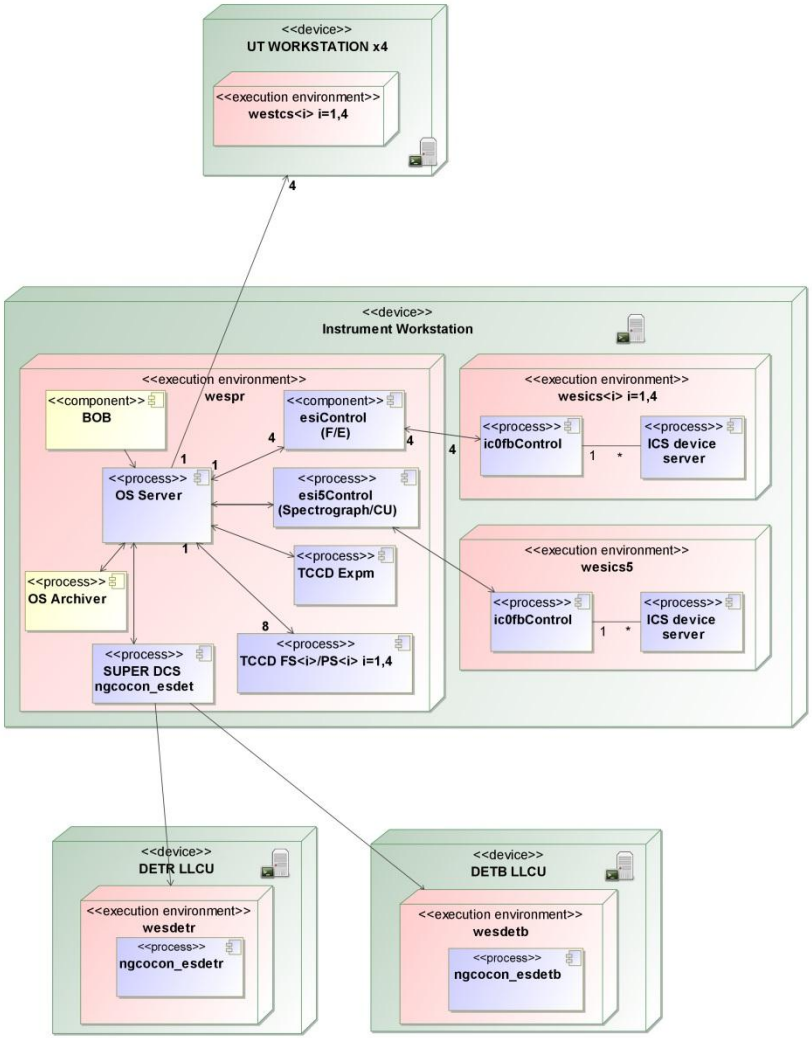


ESPRESSO - new VLT control standards:

- OPC-UA protocol
- PLCs
- TDCS (COTS technical cameras)

Control software architecture

- Control software compliant with the standard ESO/VLT Common Control Software
- Telescope Control Software (TCS)
- Detector Control Software (DCS)
- Instrument Control Software (ICS)
- Observation Software (OS)
- Maintenance Software (MS)
- Typical sequence of commands
  - SETUP (one or more)
  - START (exposure)
  - WAIT (till exposure is finished)
- FITS file generation and archiving



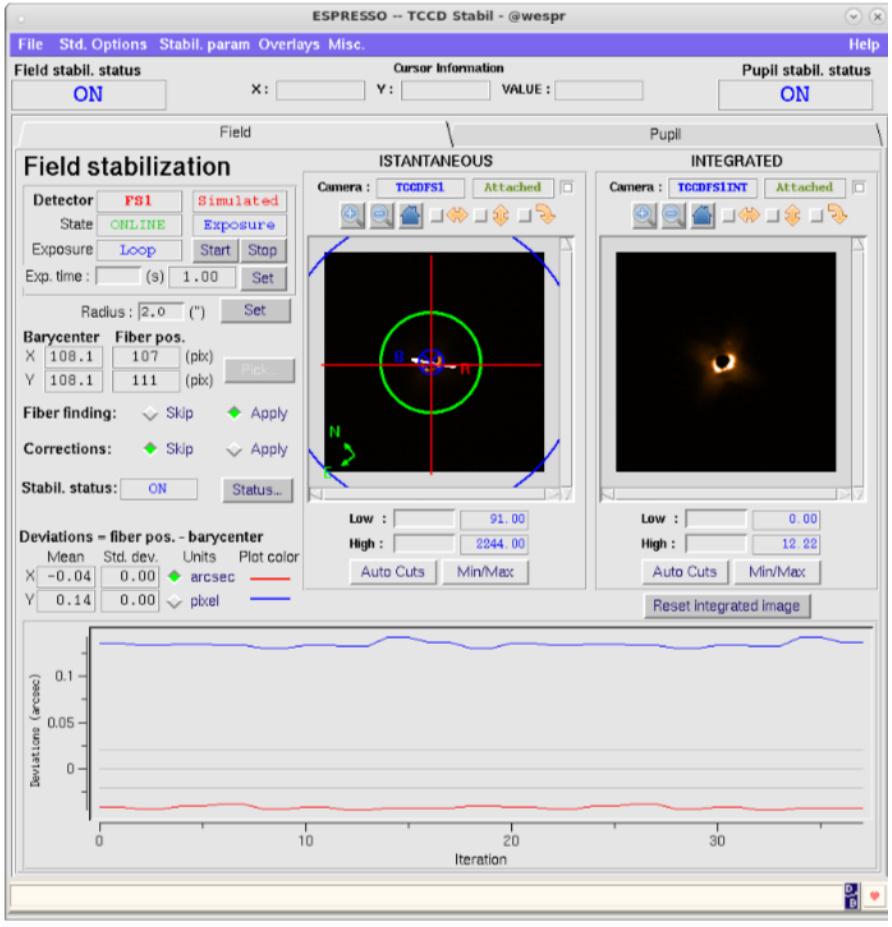
IC0 Field Bus extension

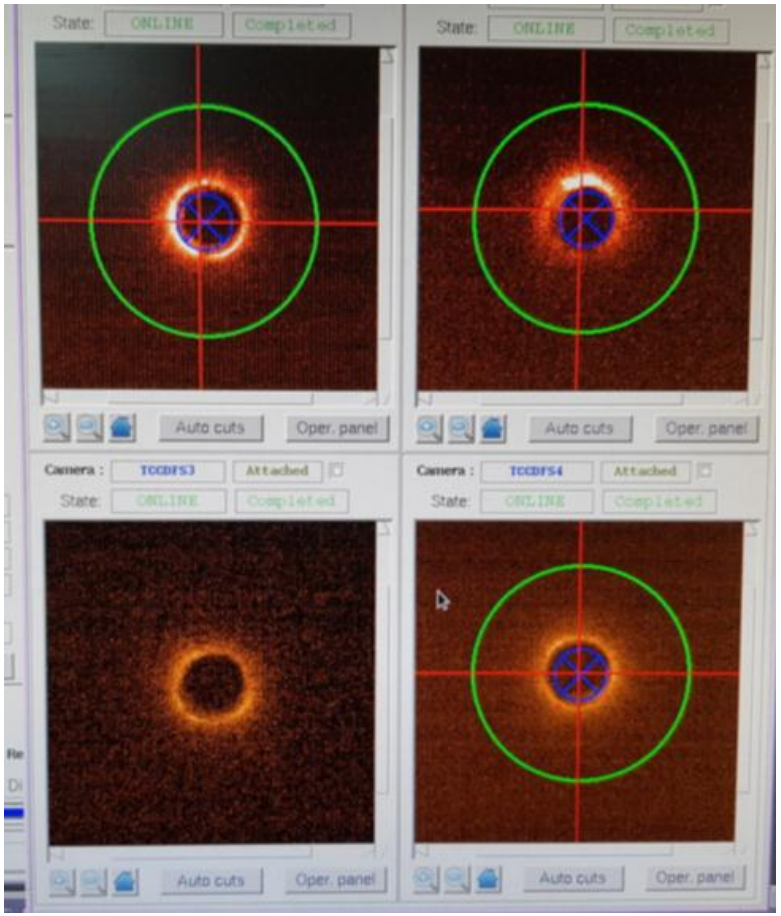
- ESO/VLT sw/hw framework for first and second generation instruments: controlled devices driven by standard ESO hw connected to Local Control Units (LCUs) (VME technology)
- In recent years support for field-bus technologies provided for instrument control at VLT
- IC0 Field-bus Extension (IC0/FB), open to different field-bus solutions
- IC0/FB interface seamlessly with the existing framework currently used to build VLT ICS applications

OPC Unified Architecture

- OPC UA protocol used for the communications between ICS and PLC(s) (ELT standard for communication between Instrument WorkStation ad Local Control System)
- OPC UA: platform-independent standard through which various kinds of systems and devices can communicate by sending messages over TCP networks
- Client/server architecture
- Both client and server can be implemented on any platform and can be provided by different suppliers

Acquisition & Field and Pupil stabilization system



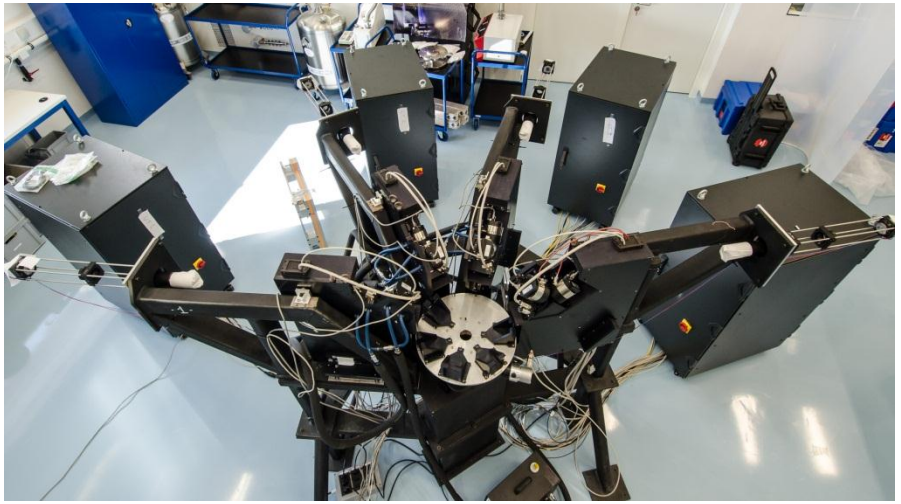


Technical CCDs

- 9 x AVT BigEye G-132 Cool cameras (COTS)
  - 4 x field stabilization, 4 x pupil stabilization, 1 x exposure meter
  - GigE Vision interface
- ESO Technical Detector Control System (TDCS)
  - PvAPI

Control hardware

- Control electronics of VLT instruments up to second generation based on VME systems with CPU(s) and boards for I/O and motion controls (boards maintenance and development of driver code performed by ESO)
- For ESPRESSO approach based on industrial PLCs
- Choice among hw suppliers that support OPC UA
- Beckhoff supplier chosen for motion control in ESPRESSO (solution adopted by ELT control electronics)
- Siemens PLCs for vacuum and cryo control



Control hardware architecture

- Modules driven by two CPUs (CX2030 series) where the PLC code and the OPC UA server run
- TwinCAT3 runtime (ELT standard)
- I/O modules decentralized from the CPU by means of EtherCAT (ELT standard)
- PI components for motion control