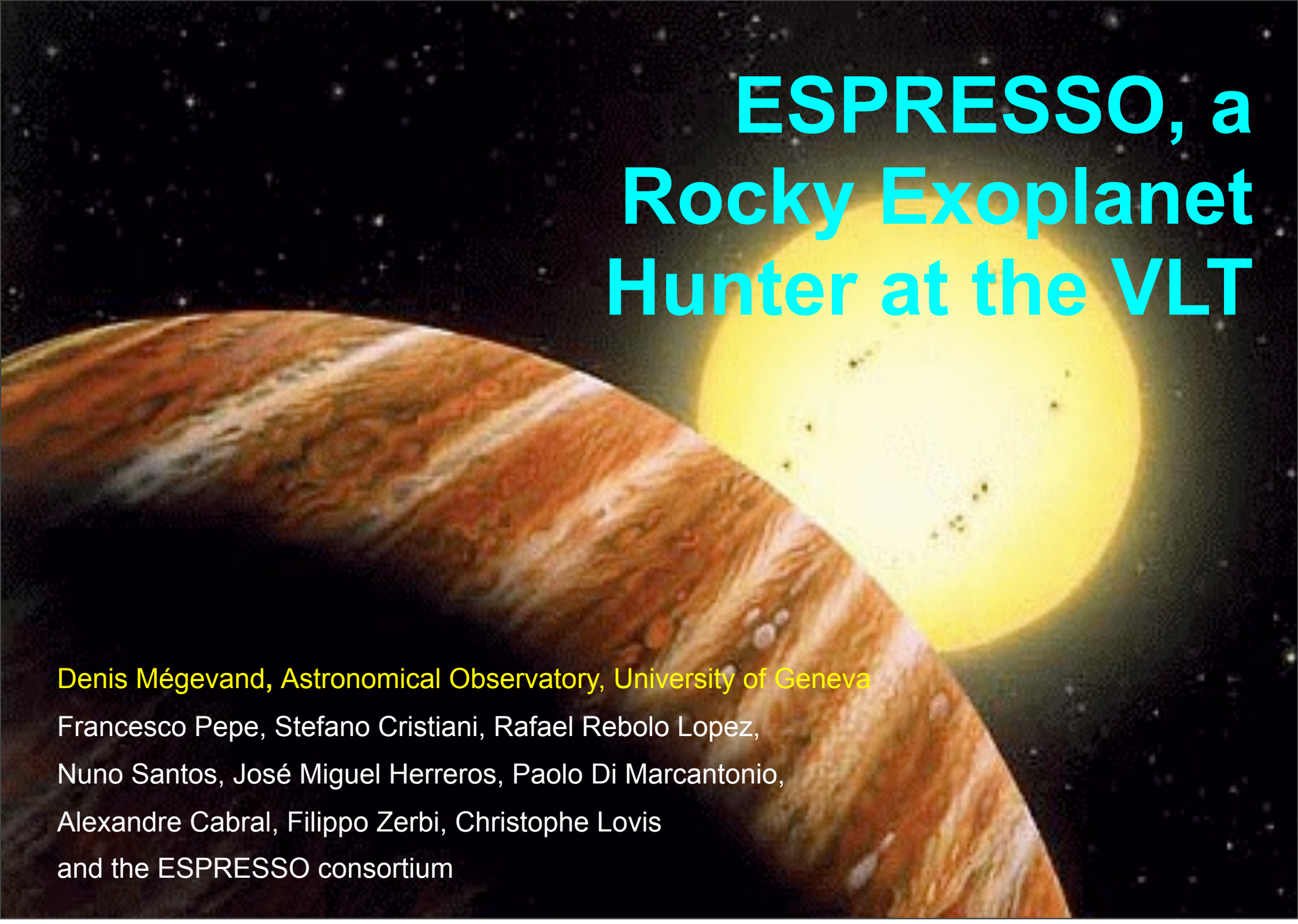
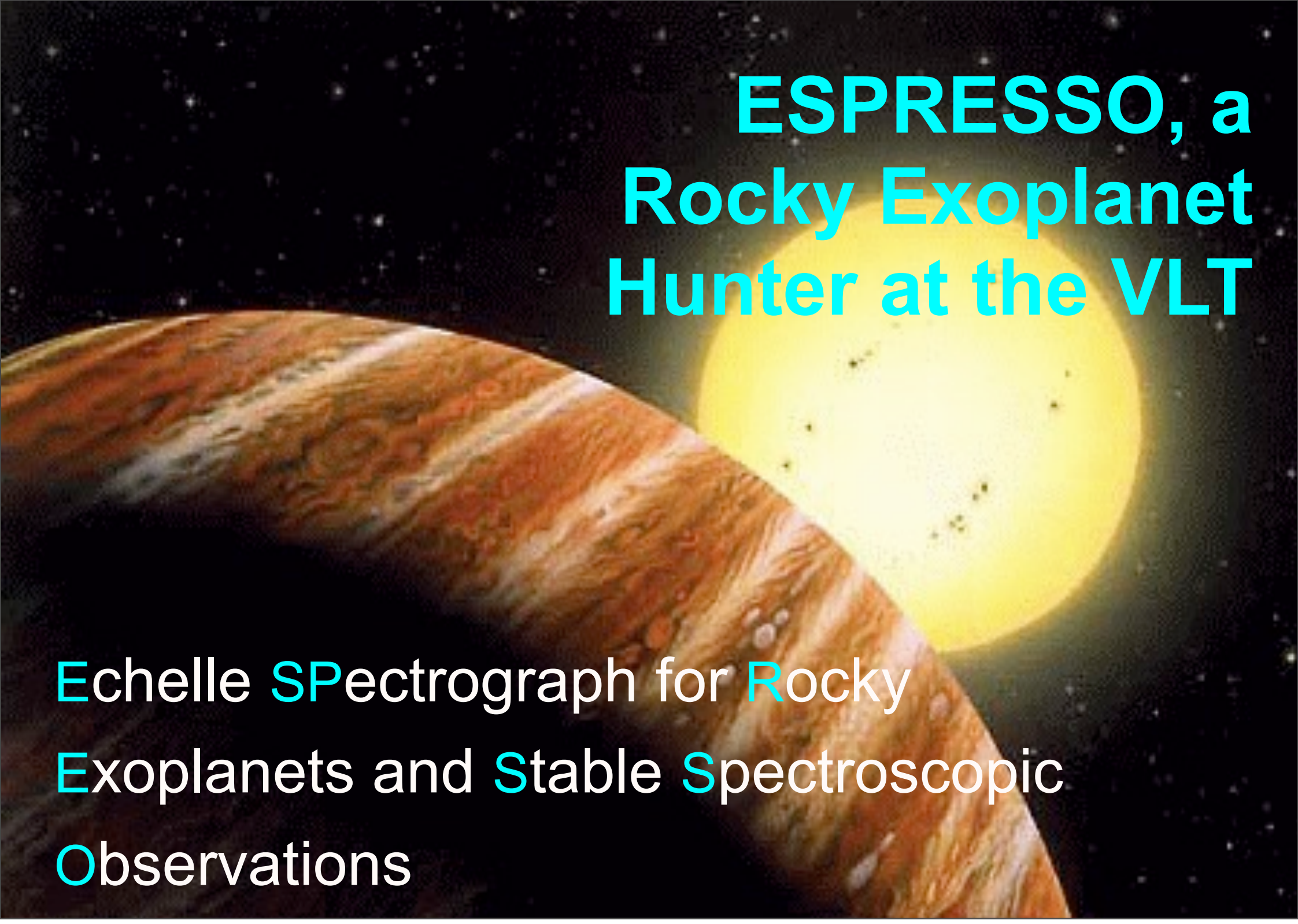


ESPRESSO, a Rocky Exoplanet Hunter at the VLT

Denis Mégevand, Astronomical Observatory, University of Geneva
Francesco Pepe, Stefano Cristiani, Rafael Rebolo Lopez,
Nuno Santos, José Miguel Herreros, Paolo Di Marcantonio,
Alexandre Cabral, Filippo Zerbi, Christophe Lovis
and the ESPRESSO consortium



ESPRESSO, a Rocky Exoplanet Hunter at the VLT

Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations

ESPRESSO facts

CONSORTIUM

- ✓ Geneva Observatory, Bern University (Switzerland)
- ✓ Milan Observatory and Trieste Observatory (INAF, Italy)
- ✓ CAUP, Porto and Universidade de Lisboa (Portugal)
- ✓ IAC (Spain)
- ✓ ESO

PROJECT

- ✓ Presently in post-Phase A
- ✓ Endorsed by ESO's Council
- ✓ Kick-off on October 4-5th, 2010
- ✓ Commissioning by 2015

INSTRUMENT

- ✓ Optimized HARPS+UVES design
- ✓ 1 or 4-UT mode
- ✓ Very-high resolution ~ 225'000
- ✓ R&D and synergies with CODEX

ESPRESSO Science

Rocky planets in the habitable zone

- ✓ Select a list of ~200 late G, K and M dwarfs
  - ✓ Non-active, non-rotating, quiet stars
- ✓ Focus on the 50 - 100 most promising stars to obtain 100-200 measurements per star -> multi-planetary system
- ✓ ~100-150 very-low mass planets expected
- ✓ Observational strategy: Observe ideally every 4 nights

Variability of physical constants

Other Science

The Deal: GTO

Guarantee Time Observations

- ✓ Capital and manpower investment by Consortium
- ✓ Instrument in exchange for time on large telescopes
- ✓ 'Quality guarantee' by the Consortium since directly interested

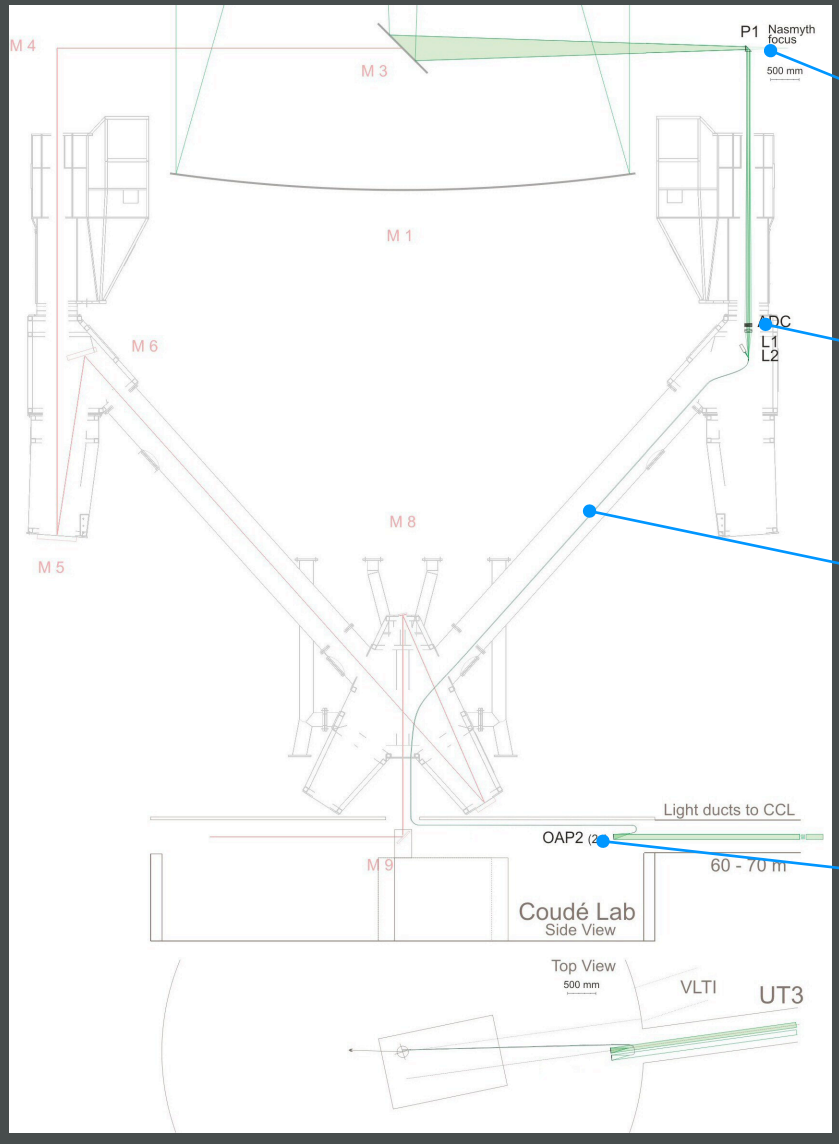
GTO time distribution

- ✓80% Rocky planets in habitable zone
- ✓10% Variability physical constants
- ✓10% 'Exquisite' science, TBD later

Design Concepts

- ✓ Fiber-fed, cross-dispersed echelle spectrograph with pupil slicing
- ✓ High stability spectrograph (vacuum, thermal, mechanical)
- ✓ FOV = 1.0 arcsec (1 UT)
- ✓ R = 70’000 (4 UT), 140’000 (1 UT) or 225’000 (1UT, high-resolution)
- ✓ Sampling = 3.5 pixels/RE @ R=140’000
- ✓ Wavelength range: 380 – 813 nm (divided in two arms)
- ✓ CCDs: Two 9 cm x 9 cm chips

Light injection from 1 to 4 UT



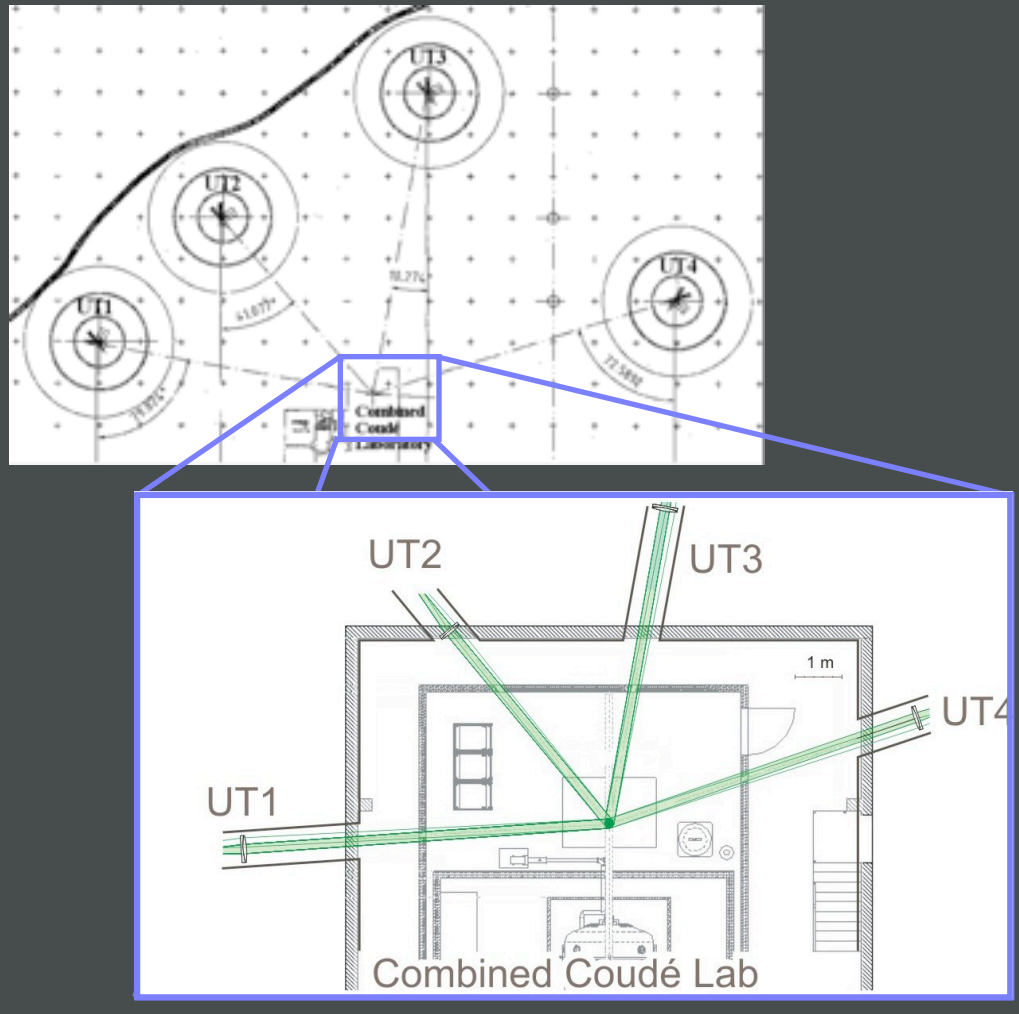
Nasmyth focus

Atmospheric Dispersion Corrector and Primary Guiding

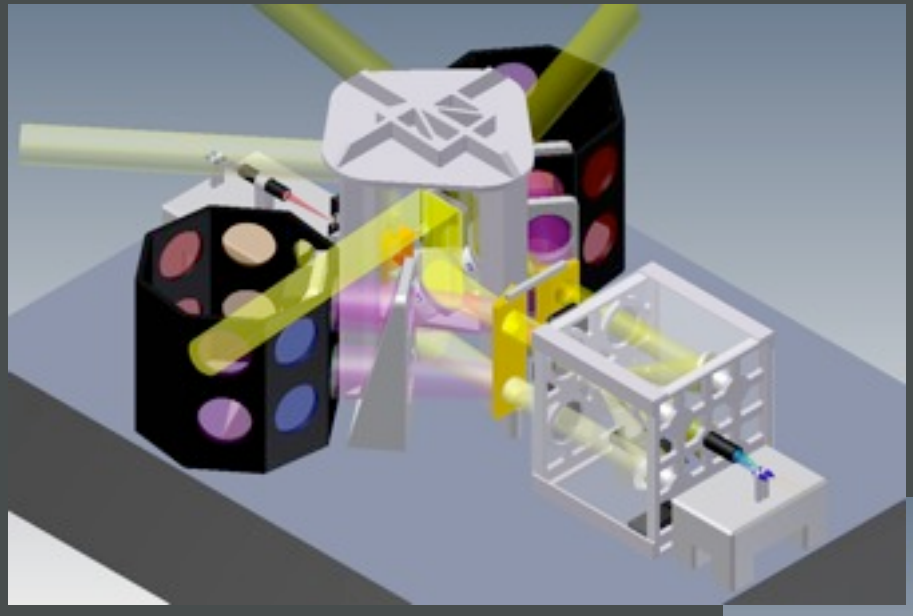
Optical Fiber

Transfer optics

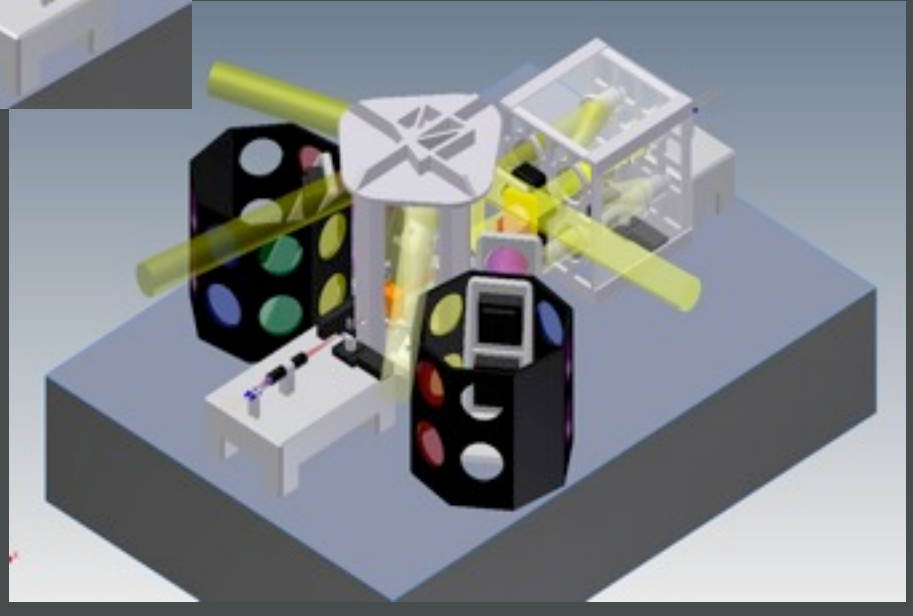
Recombination of the four beams in the CCL



Front-End Unit



- Receives and arranges the beam from the four UT and the beams from the Calibration Unit.
- Selects the mode 1-UT or 4-UT.



- Secondary Guiding
- Sends the beam in the Spectrograph fibers

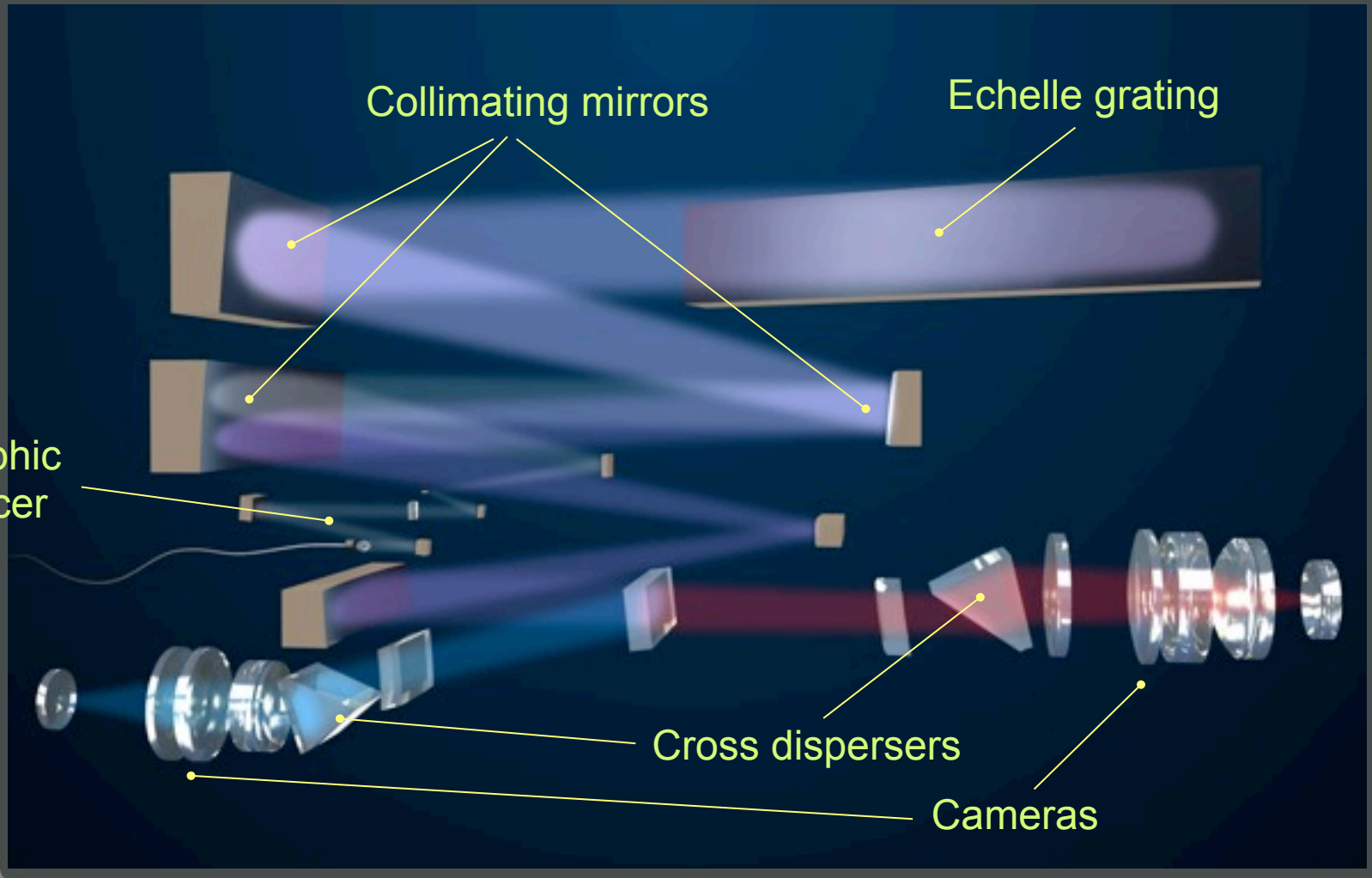
Optical Design

Innovative design:

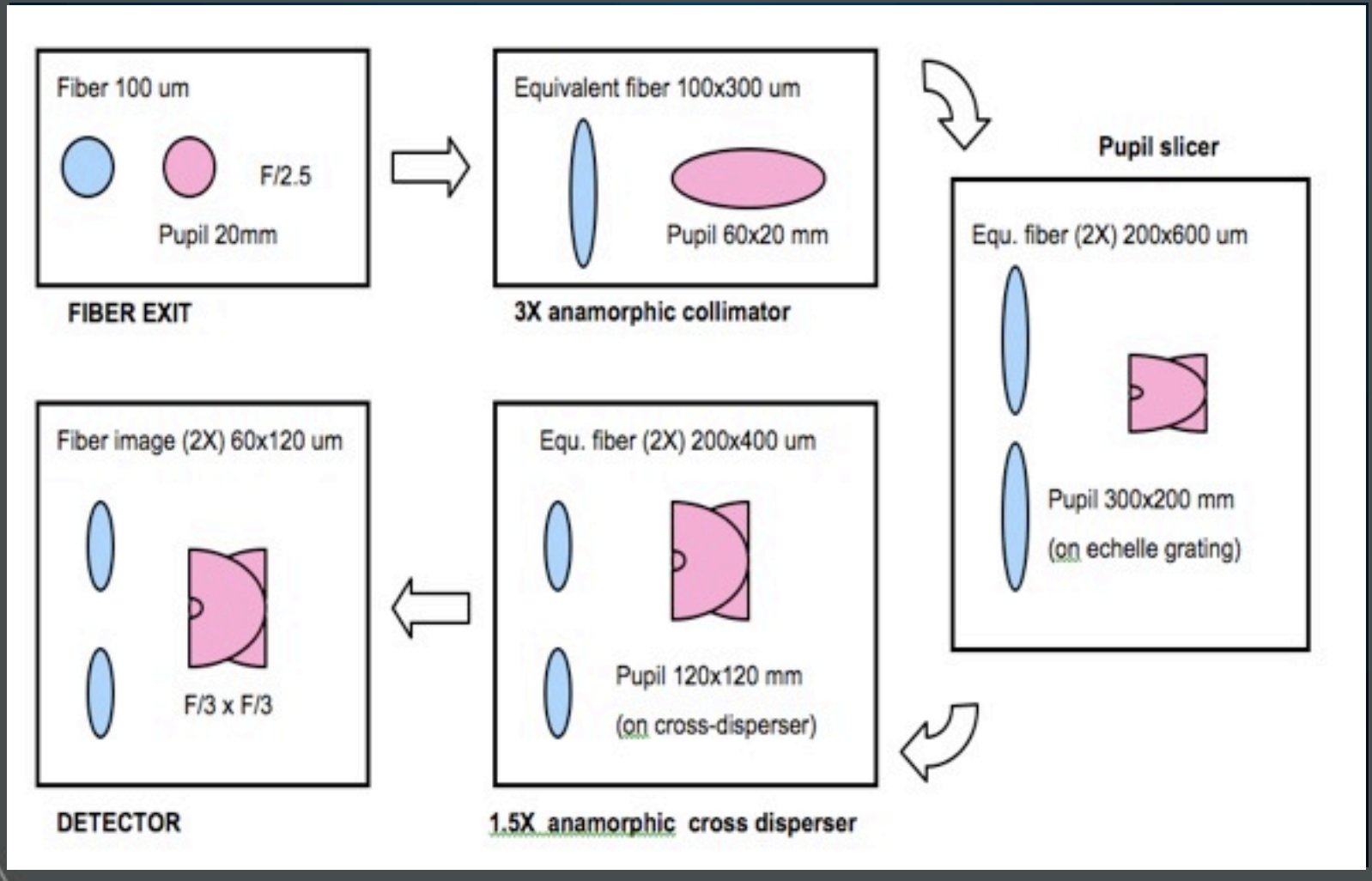
- Pupil slicing and anamorphism : increase resolution and reduce the size of optics
- Two optimized cameras : red and blue

- Presently, the design is still being studied, for optimization and simplification purposes.

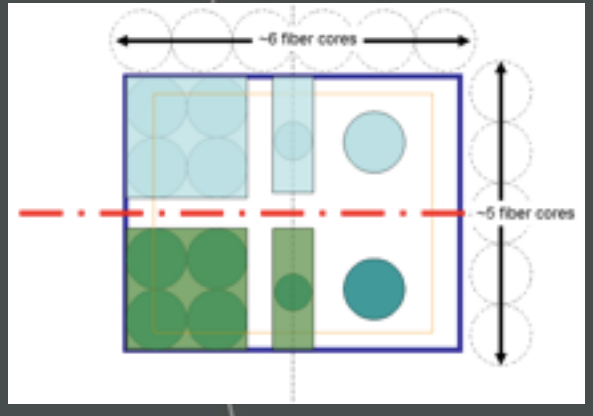
Optical Design



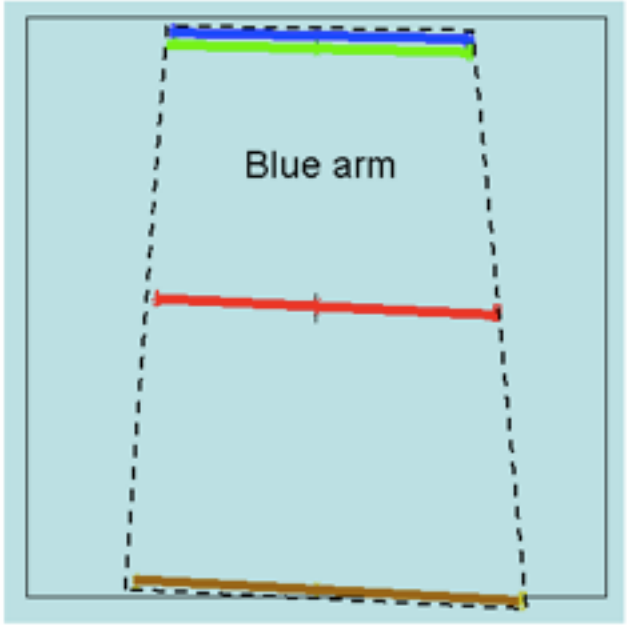
Optical Design

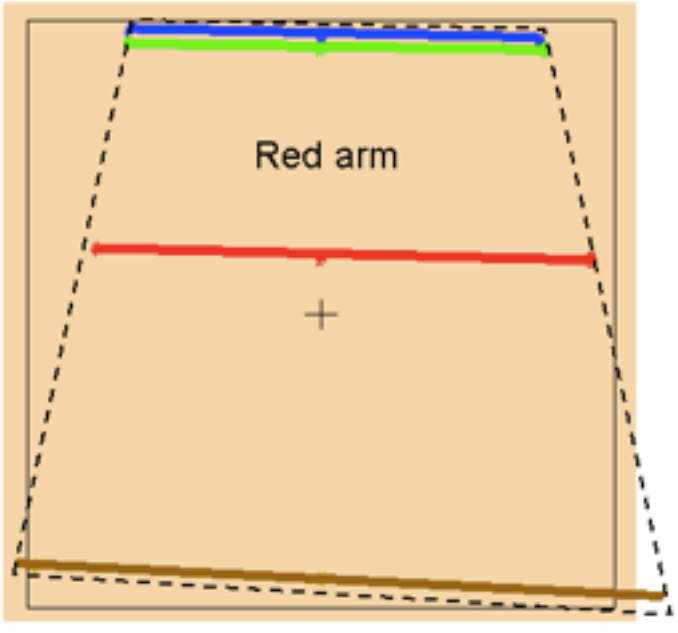


Spectral format



Entrance slit

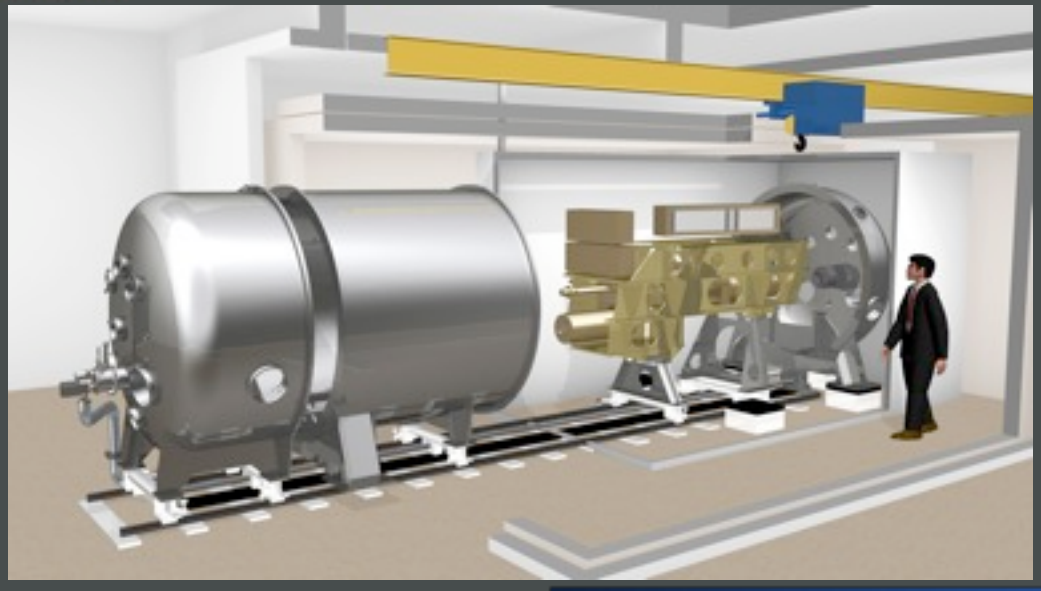




Free Spectral Range

6Kx6K CCD	6Kx6K CCD
44 orders: 380-523 nm	42 orders: 523-813 nm

Designed for stability



ΔRV =1 m/s

ΔT =0.01 K

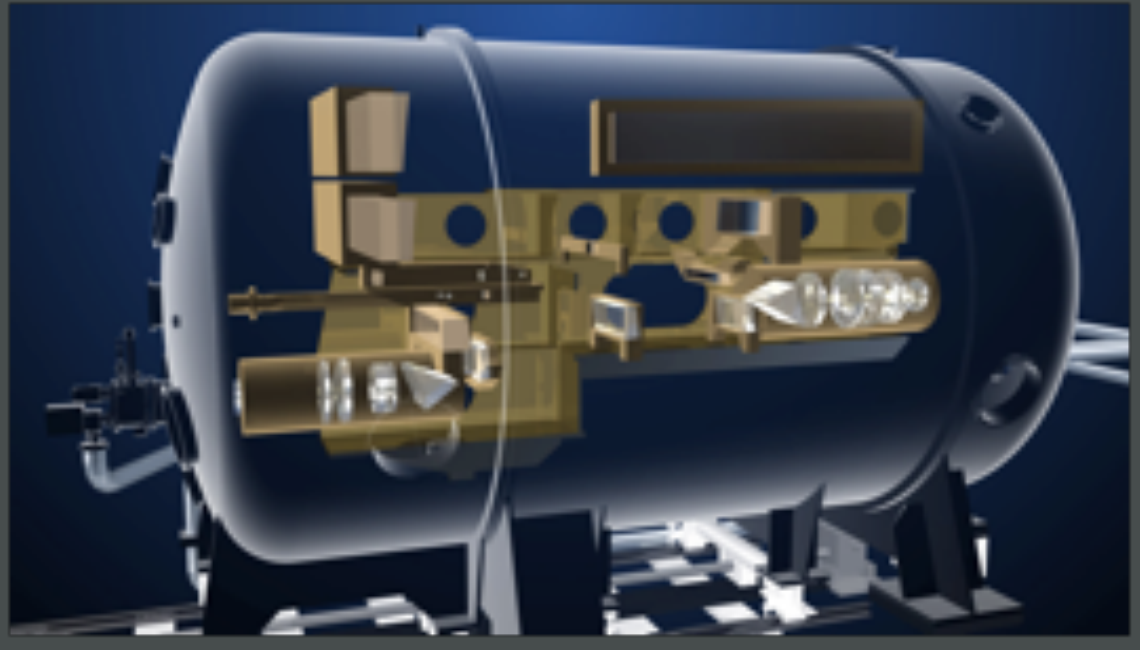
Δp=0.005 mBar

ΔRV =1 m/s

Δλ=0.00001 A

15 nm

1/1000 pixel

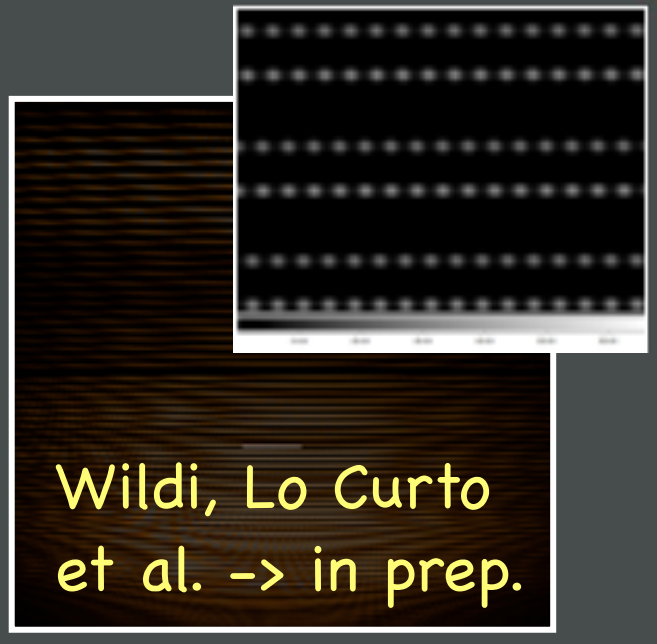


Main characteristics

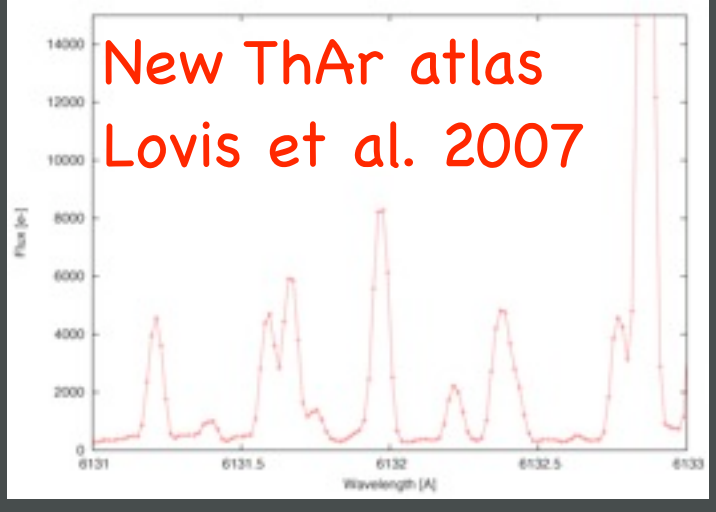
Parameter	Standard 1-UT	4-UT	Ultra-High Res 1-UT
Wavelength range	380-800 nm	380-800 nm	380-800 nm
Resolving power	140'000	60'000	225'000
Aperture on sky	1.0 arcsec	4x1.0 arcsec	0.5 arcsec
Sampling (average)	3.3 pixels	4.0 pixels (binned x2)	2.1 pixels
Spatial sampling	6.9 pixels	4.0 pixels (binned x4)	3.5 pixels
Simultaneous reference	Yes (no sky)	Yes (no sky)	Yes (no sky)
Sky subtraction	Yes (no sim. ref.)	Yes (no sim. ref.)	Yes (no sim. ref.)
Total efficiency	12%	12%	TBD
Instrumental RV precision	< 10 cm s^{-1}	~ 1 m s^{-1}	< 10 cm s^{-1}

Improving the calibration

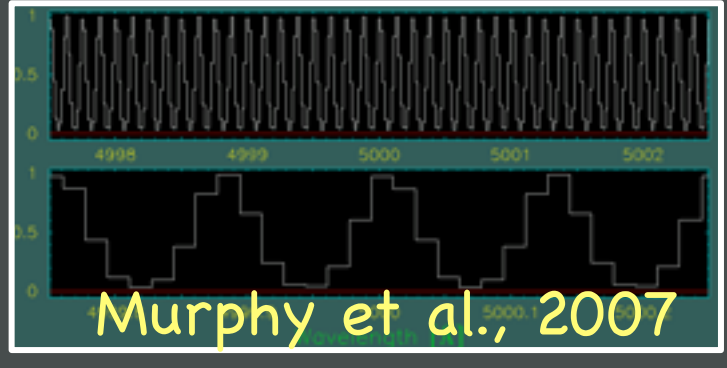
- ✓ Cover full spectral range
- ✓ High spectral resolution (again)
- ✓ Equally dense and unresolved lines
- ✓ No blends
- ✓ Knowledge of theoretical wavelengths
- ✓ Stability (repeatability) of 10^{-11} over > 20 years



Etalon raw frame

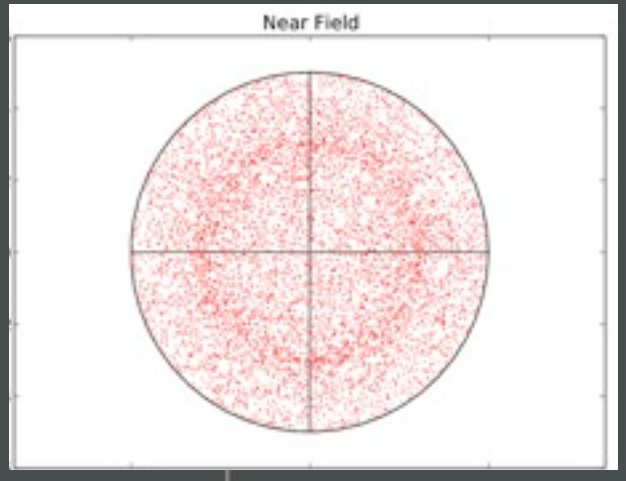


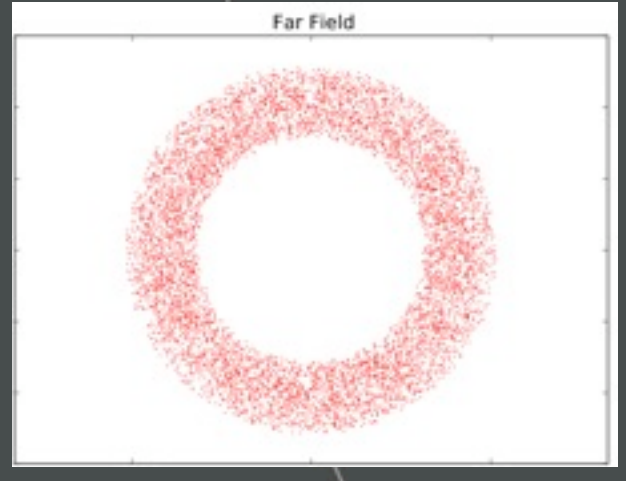
ThAr lamp

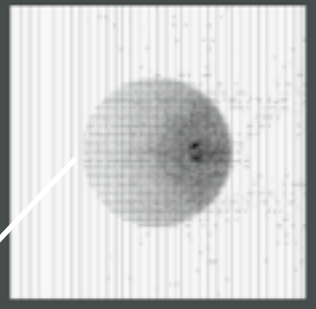


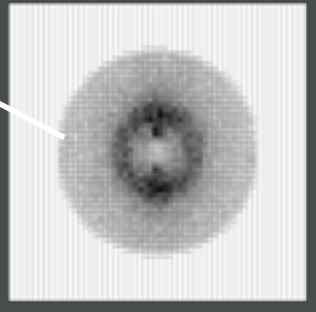
Laser comb or etalon

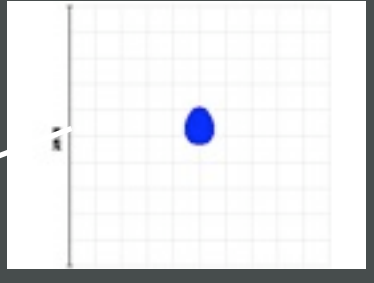
Improving the scrambling

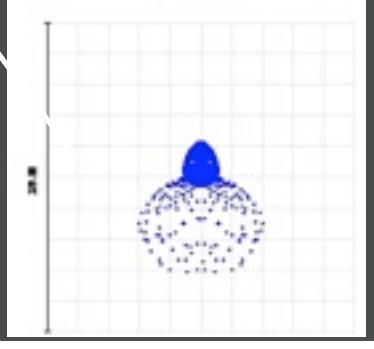


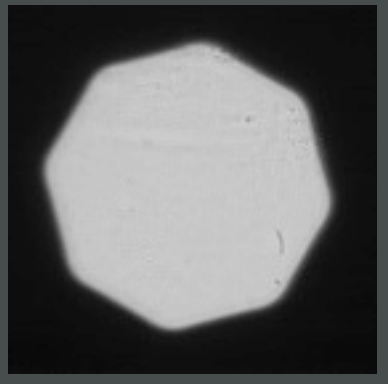


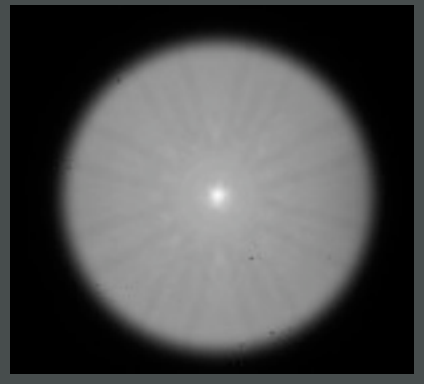


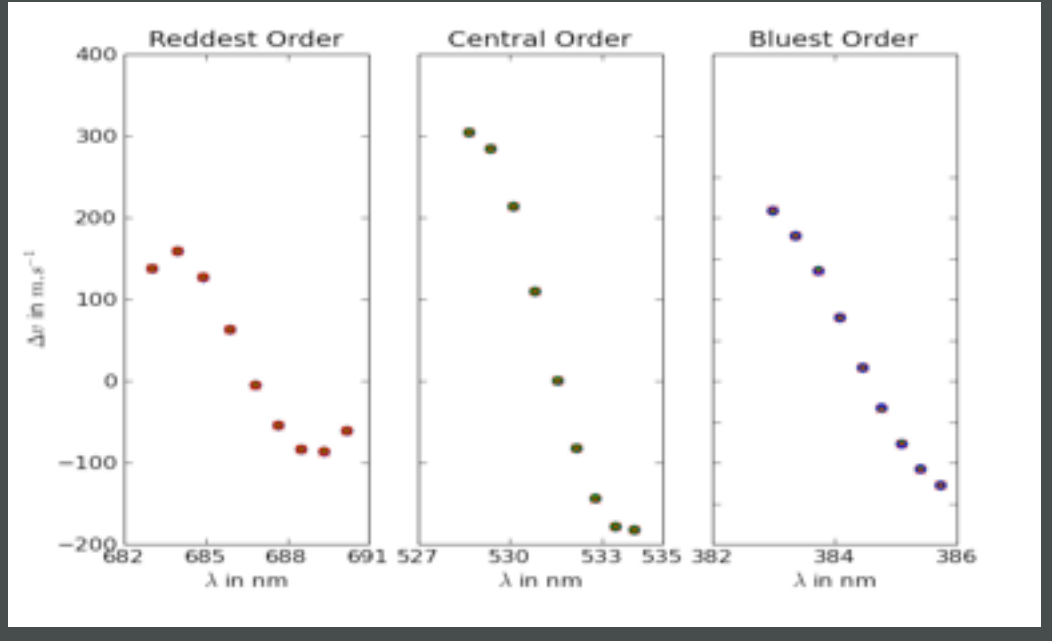




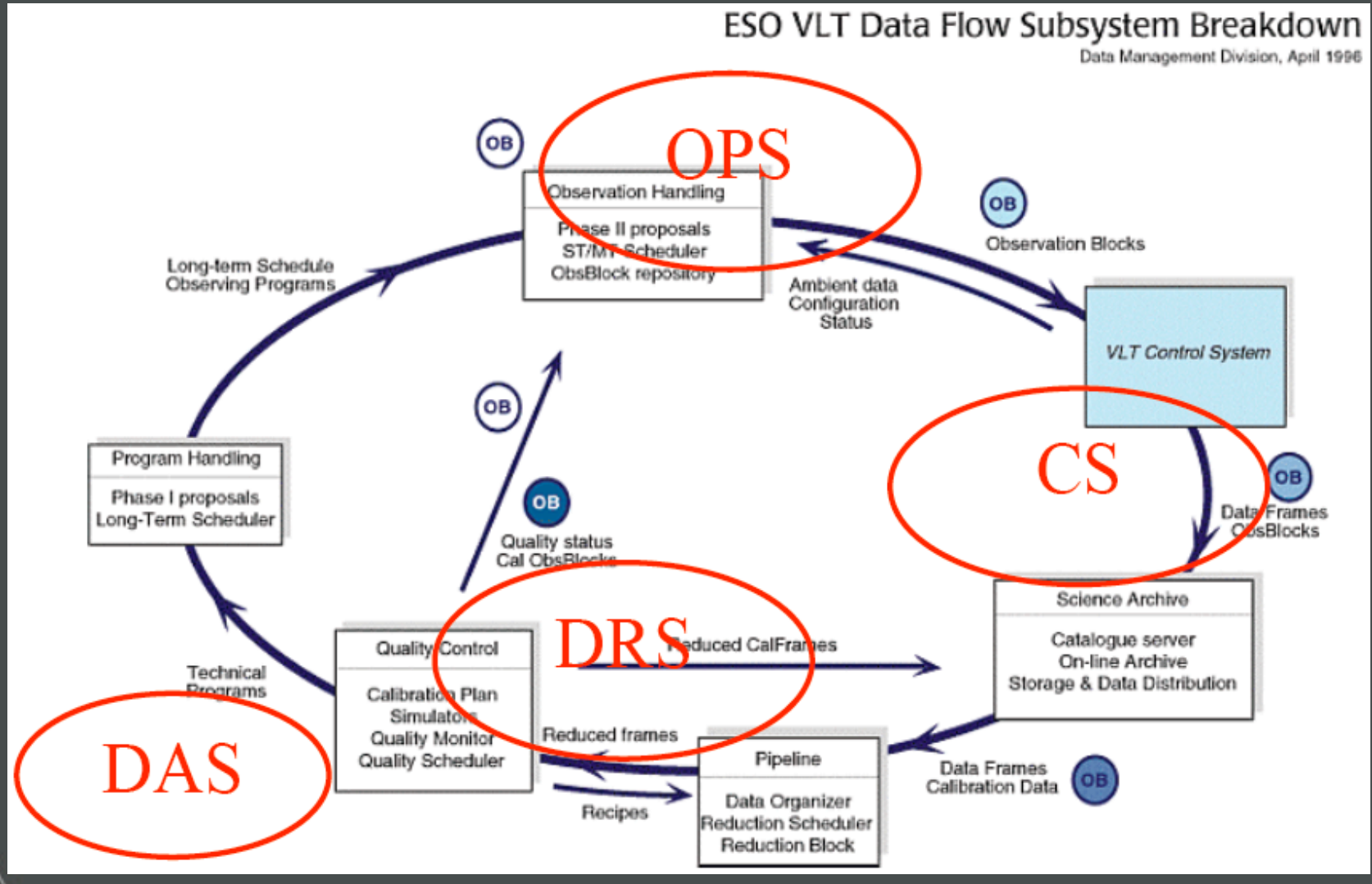








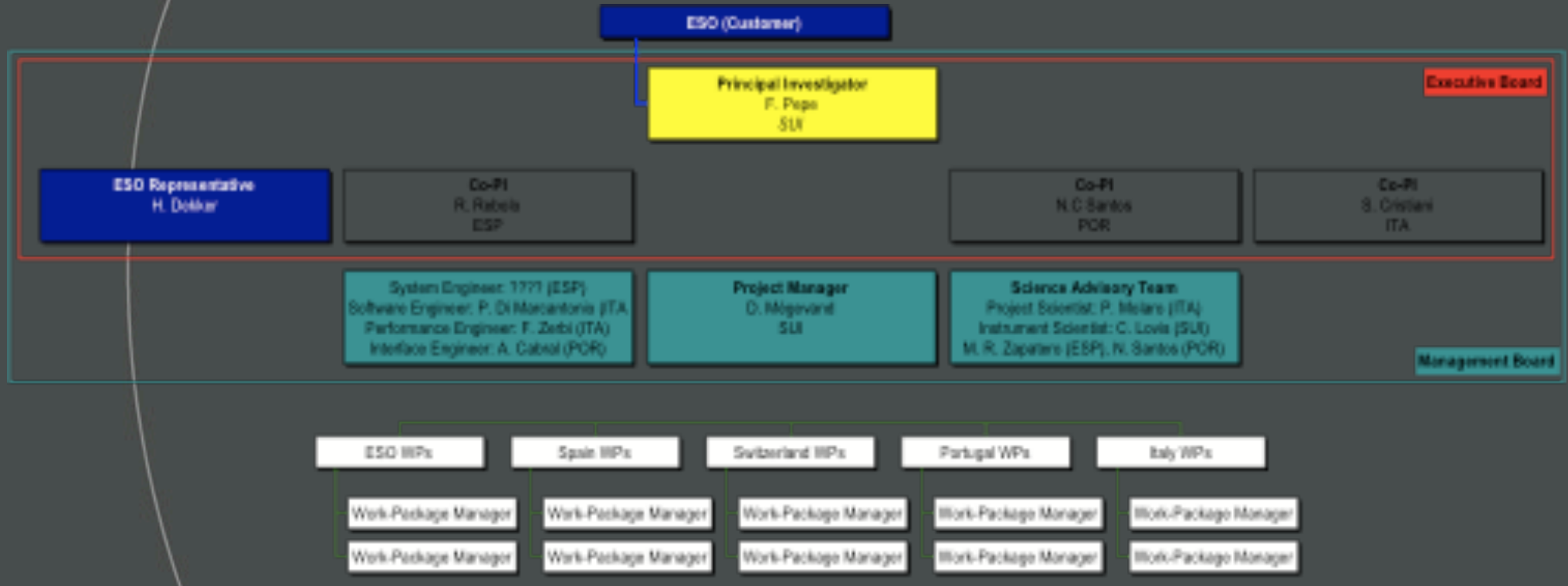
Integrated data processing



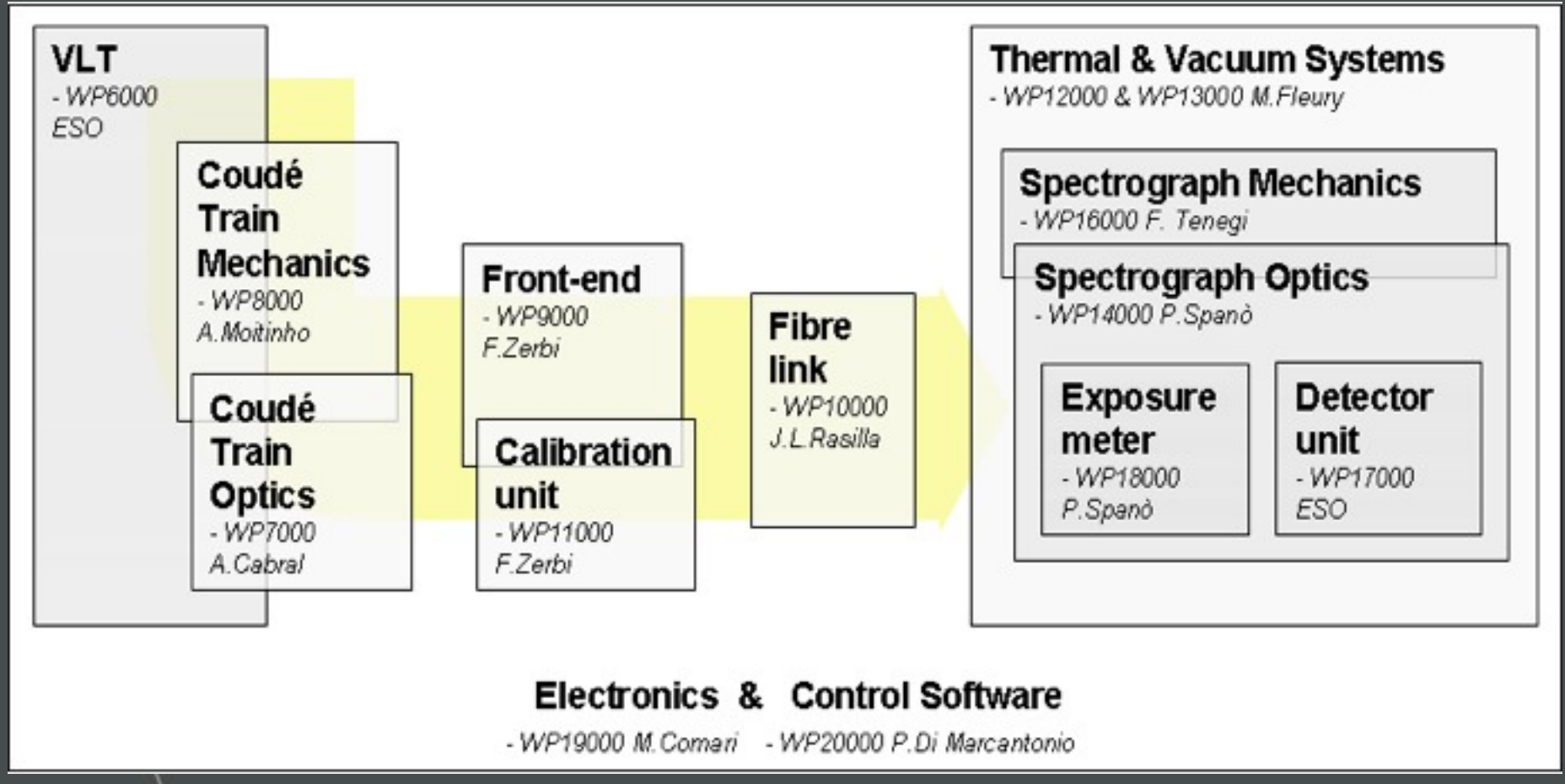
Project scheduling

Milestone	From T_0	Planned Date	Site
Project Kick-off	T_P	**October 4-5, 2010**	Geneva
Preliminary Design Review	T_P + 6 months	2nd quarter 2011	ESO Garching
Optics Final Design Review	T_P + 15 months	1st quarter 2012	
Final Design Review	T_P + 24 months	4th quarter 2012	ESO Garching
CT Instrument Readiness	T_P + 38 months	4th quarter 2013	
Instrument Readiness	T_P + 42 months	1st quarter 2014	
CT Preliminary Acceptance Europe	T_P + 44 months	2nd quarter 2014	Lisbon
Preliminary Acceptance Europe	T_P + 50 months	4th quarter 2014	Geneva
Preliminary Acceptance Chile	T_P + 57 months	**3rd quarter 2015**	ESO Paranal
Final Acceptance Chile	T_P + 90 months	2nd quarter 2018	ESO Paranal

Project management



Project work breakdown



Project WP management

VLT Interface	AVILA Gerardo	ESO
Coudé Train Optics	CABRAL Alexandre	LOLS-CAAUL
Coudé Train Mechanics	MOITINHO André	SIM
Front-End Unit, Calibration Unit	ZERBI Filippo	INAF BRERA
Fiber Link	RASILLA José Luis	IAC
Vacuum and Thermal System	FLEURY Michel	OBS GENEVA
Spectrometer Optics and Exposure Meter	SPANÓ Paolo	INAF BRERA
Spectrometer Opto-mechanics	TENEGI Fabio	IAC
Scientific Detectors	IWERT Olaf	ESO
Detector Unit	LIZON Jean-Louis	ESO
Control Electronics	COMARI Maurizio	INAF TRIESTE
Control Software	DI MARCANTONIO Paolo	INAF TRIESTE
Observation Software	SANTIN Paolo	INAF TRIESTE
Observation Preparation Software	SOSNOWSKA Danuta	OBS GENEVA
Data Reduction Software	LOVIS Christophe	OBS GENEVA
Data Analysis Software	D'ODORICO Valentina	INAF TRIESTE

Conclusions

ESPRESSO is

- ✓ A super-HARPS on a 10 m-class telescope
- ✓ A spectral coverage from 380 to 800 nm in one shot
- ✓ A wavelength calibration far more accurate than any other facility
- ✓ An instrument producing cleanest, best-quality spectra, both at high and low SNR
- ✓ A spectrograph on a 16 m telescope, the largest visible photon-collector until ELTs will be available
- ✓ An ultra-high resolution mode (R~225,000), far beyond other existing facilities on a 10 m-class telescope
- ✓ Fitting in standard VLT operations as far as possible