ESPRESSO
At the level of 10 cm/s?
ESPRESSO
At the level of 10 cm/s


Consortium:
Switzerland: Univ. Geneva (Lead), University of Bern
Portugal: IA/Univ. of Porto (N. Santos), IA/Univ. Lisbon
Italy: INAF Trieste (S. Cristiani), INAF Brera
Spain: IAC (R. Rebolo Lopez)

Associated Partner:
ESO (L.Pasquini), Garching and Paranal
The Context

- 2007 STC and ESO identified need for a ‘HARPS’ on the VLT
- Call for proposal answered by ESPRESSO Consortium
- Project Kick-Off in January 2011
- Contract signature in August 2011
- ODR in November 2011
- CCD-FDR in June 2012
- FDR May 2013
- Integration 2017!
- Commissioning 2017/2018
- Start of scientific operations on September 2nd, 2018 (just now!)
1. Know your (main) scientific objective. Projects are means, instruments are tools.

2. Don’t let you distract, let your decisions be driven by the (one!) main scientific goal.

3. Don’t try to solve *all* the problems.

4. Don’t solve problems you don’t know about.

5. Start with the simplest possible solution.

6. A wrong decision is better than no decision. Take risks, but only when it’s necessary.

7. Never change a ‘winning team’ (solution). Build on your experience and change only what is strictly necessary.
Combined Coudé Lab
A stabilized environment
ESPRESSO’s First Light
November 27, 2017
First Light Spectrum
## System characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>singleUHR</th>
<th>singleHR</th>
<th>multiMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelengths</td>
<td>Blue arm: 380 – 520 nm</td>
<td>Red arm: 520 – 780 nm</td>
<td></td>
</tr>
<tr>
<td>Spectral coverage</td>
<td>Full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectra format</td>
<td>Echelle, up to 4 spectra per order (2 fibers, 2 spectra / fiber)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolving power</td>
<td>225’000</td>
<td>134’000</td>
<td>59’000</td>
</tr>
<tr>
<td>Aperture on sky</td>
<td>0.5 arcsec</td>
<td>1.0 arcsec</td>
<td>4x1.0 arcsec</td>
</tr>
<tr>
<td>Spectral sampling</td>
<td>2.5 pixels</td>
<td>4.5 pixels</td>
<td>10 pixels</td>
</tr>
<tr>
<td>Spatial sampling</td>
<td>9 pixels</td>
<td>18 pixels</td>
<td>44 pixels</td>
</tr>
<tr>
<td>Available binning</td>
<td>1x1</td>
<td>1x1 or 2x1</td>
<td>4x2 or 8x4</td>
</tr>
<tr>
<td>Sky/Simultaneous reference</td>
<td>Yes (mutually exclusive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumental RV precision</td>
<td>&lt;10 cm/s</td>
<td>&lt;10 cm/s</td>
<td>~1 m/s</td>
</tr>
</tbody>
</table>
Efficiency vs ‘seeing’

Chromatic efficiency vs airmass
Resolving power in UHR

\[ R = 220'000 \]
On star: No significant effect of variable CTI!
SNR effect on RV?

On FP: No significant effect of variable CTI!
Centering, focus, pupil

**Graph:**
- Decentering test 02-09-2018
- Drift (m/s)
- Spectrum # in series
- RV RMS: 35cm/s including the points with decentering of 1°,
  25cm/s including only the points with 0.5° offset (and the centers)
  26cm/s including only the positions at center (no guiding offset)
Short-term precision

**HD85512**

Average photon noise: 25 cm/s

Measured dispersion: 28 cm/s

**Benchmarks:**
- $M_v = 7.65, T_{exp} = 5$ min. $\rightarrow$ 25 cm/s
- $M_v = 10, T_{exp} = 2.5$ min. $\rightarrow$ 1 m/s
- $M_v = 4, T_{exp} = 1$ min. $\rightarrow$ 10 cm/s
Short-term precision

HD 190248
Wav. calibration zero-point

Same scientific exposure with 9 different calibration sets: rms 4 cm/s
Wav. calibration zero-point

Tau Ceti with different calibration set
Wav. calibration zero-point

Offsets between modes!
‘Long-term’ precision

Tau Ceti, 1 month, 62 cm/s
‘Long-term’ precision

HD 85512, 70 days time span, average photon error 20 cm/s dispersion 41 cm/s
‘Long-term’ precision

HD 85512, 7 days time span, average photon error 25 cm/s dispersion 25 cm/s
A 3-planet system orbiting an M dwarf
The RM effect seen by HARPS: The case of GJ 436b

RM detected by Bourrier et al. 2017:

- 3 HARPS transits
- Not detectable in velocimetry

- Reloaded RM (Cegla et al. 2016):
  - $\Psi = 80^\circ \pm 20^\circ \implies$ polar orbit
  - expected semi-amplitude of 1.3 m/s
The RM effect seen by ESPRESSO: The case of GJ 436b

\[ V = 10.68 !!!! \]
RM-Effect on WASP-43b

- no sky subtraction
- sky subtraction (from fiber B)

V = 12.40 !!!
4-UT mode: RM WASP XXX
The RM effect seen by ESPRESSO: The case of WASP-XXX

1 ESPRESSO (1UT) transit, 1 ESPRESSO (4UT) transit
The RM effect seen by ESPRESSO: The case of WASP-XXX

3 HARPS transits, 1 ESPRESSO (1UT) transit, 1 ESPRESSO (4UT) transit
Out-of-transit trend is removed.

HARPS
Brown et al. (2017)
Transit spectroscopy of WASP-76b

CCF between theoretical Fe I spectrum and in-transit (out-of-transit)
4-UT mode: QSO Spectra

ESPESSO - 4UT MR MODE – Dec 01, 2018 1\textsuperscript{st} exposure

- QSO @ z=3
- Magnitudes: g=17.21 r=16.90 i=16.77
- GAIA Gmag=16.92
- Resolution 70.000
- SNR @ 600nm = 60 per 0.04A pixel

- to be compared with 16\textdegree of UVES (LP Bergeron)
- SNR @ 600nm = 80 per 0.04A pixel
- Resolution ~50.000

Blue arm – reduction carried out in real time at the telescope with ESPRESSO DAS
Data & Analysis Center for Exoplanets

Observations

Exoplanets

Formation & evolution

Dynamical evolution

Stars

Solar system

Observability

Encyclopaedia