HARPS3

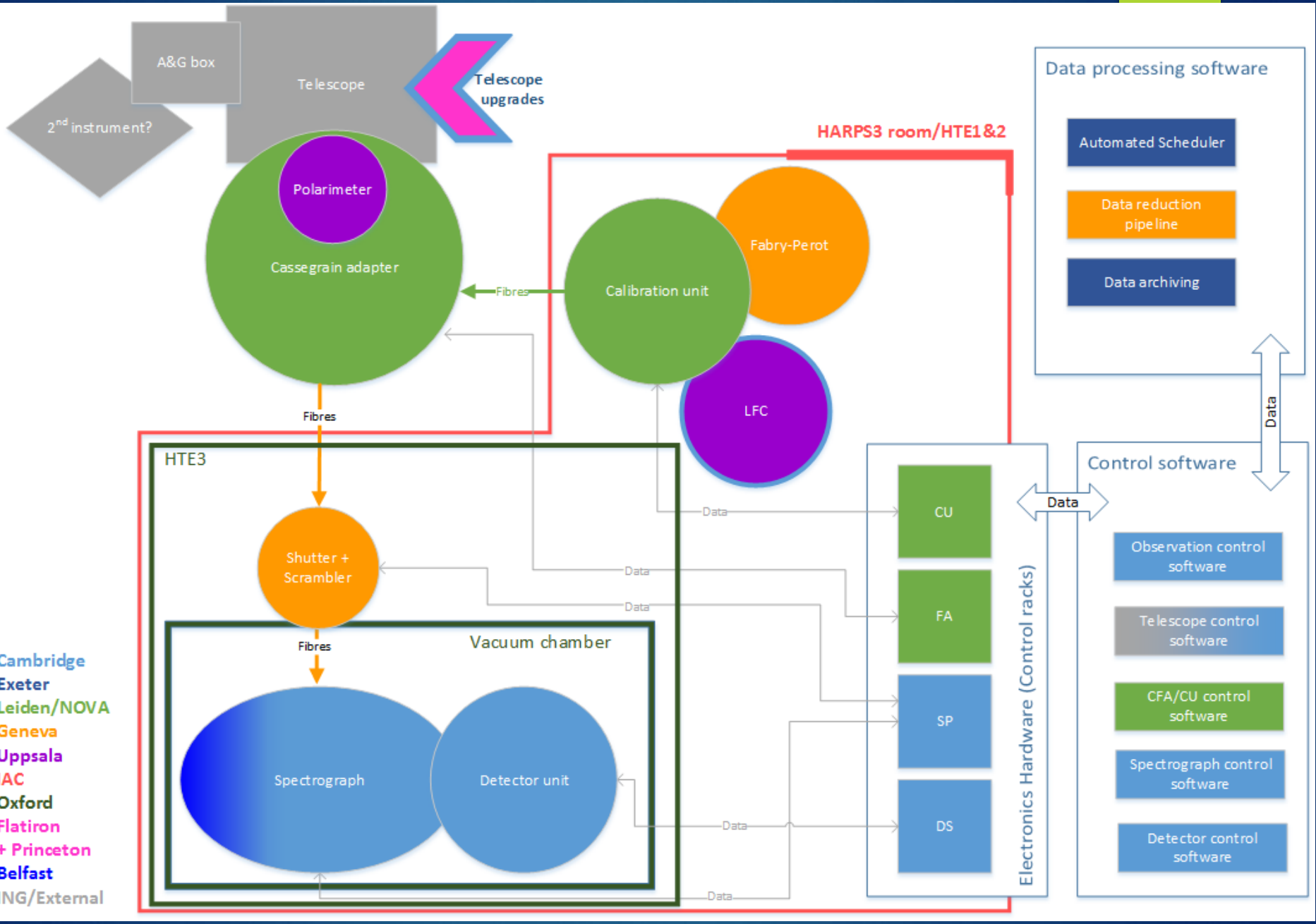
High **A**ccuracy **R**adial-velocity **P**lanet **S**earcher **3**

ING SEMINAR - 26TH APRIL 2019

Features of HARPS3

- Close-copy of HARPS/HARPS-N
  - R = 115,000, λ range: 380 – 690 nm
- Entrance fibre diameter 1.4 arcsec - better matched to seeing
- **Full-Stokes, dual-beam polarimeter** (integrated in the design of the Cass fibre adapter)
- Echelle grating substrate: **Zerodur Class 0 SPECIAL**
- **Detector Unit:**
  - A new design continuous-flow cryostat
  - Enhanced CCD calibration
- **Robotic operation**

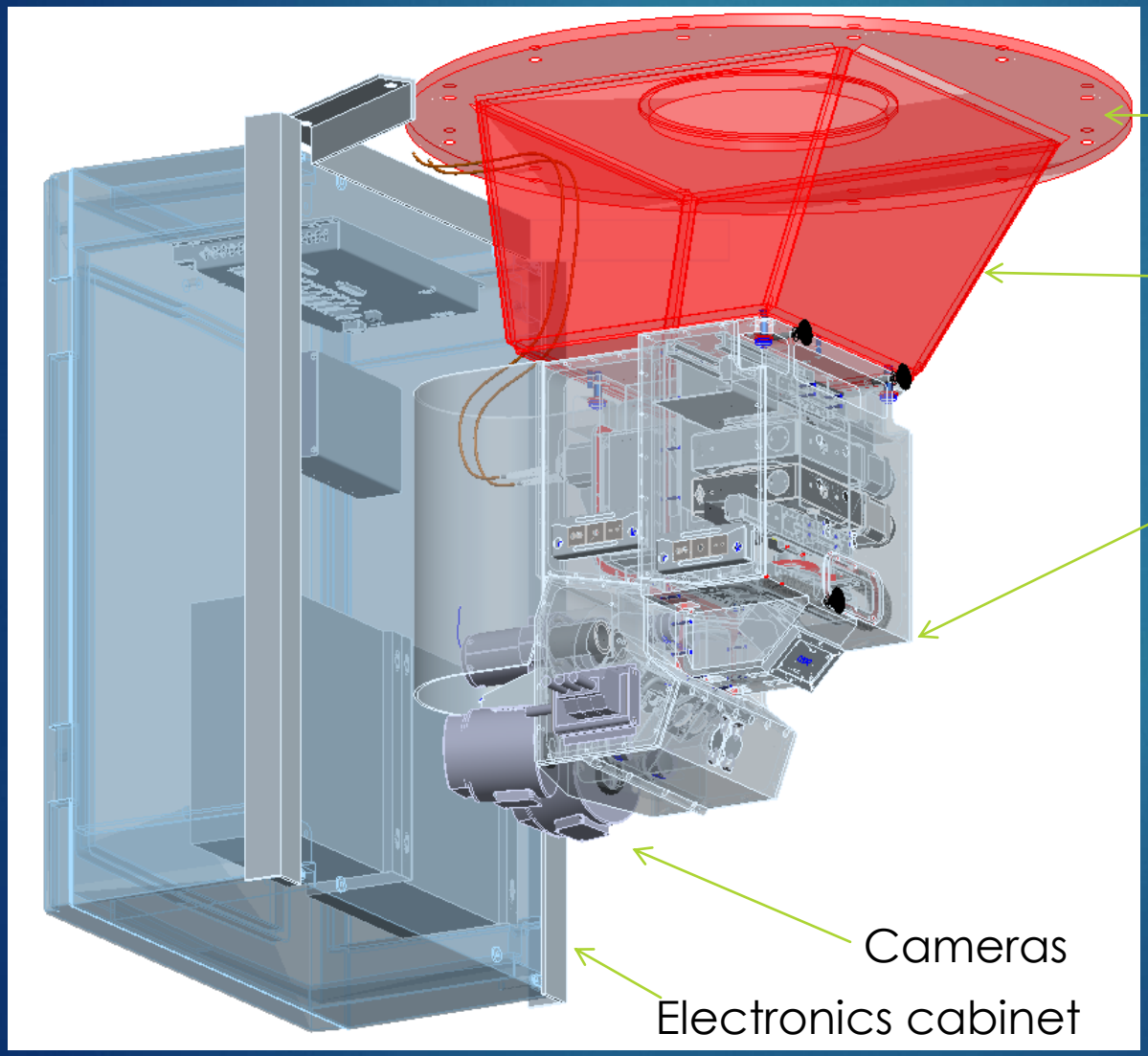
Project overview


A&G box
2nd instrument?
Telescope
Telescope upgrades
Polarimeter
Cassegrain adapter
Fibres
Calibration unit
Fabry-Perot
LFC
HARPS3 room/HTE1&2
Fibres
HTE3
Shutter + Scrambler
Fibres
Vacuum chamber
Spectrograph
Detector unit
Data
Data
Data
Data
Data processing software
Automated Scheduler
Data reduction pipeline
Data archiving
Data
Control software
Data
CU
FA
SP
DS
Electronics Hardware (Control racks)
Observation control software
Telescope control software
CFA/CU control software
Spectrograph control software
Detector control software
Cambridge
Exeter
Leiden/NOVA
Geneva
Uppsala
IAC
Oxford
Flatiron
+ Princeton
Belfast
ING/External

Cassegrain fibre adapter

Picture credit: ING
(http://www.ing.iac.es/Astronomy/telescopes/int/)

Mechanical design ISO view

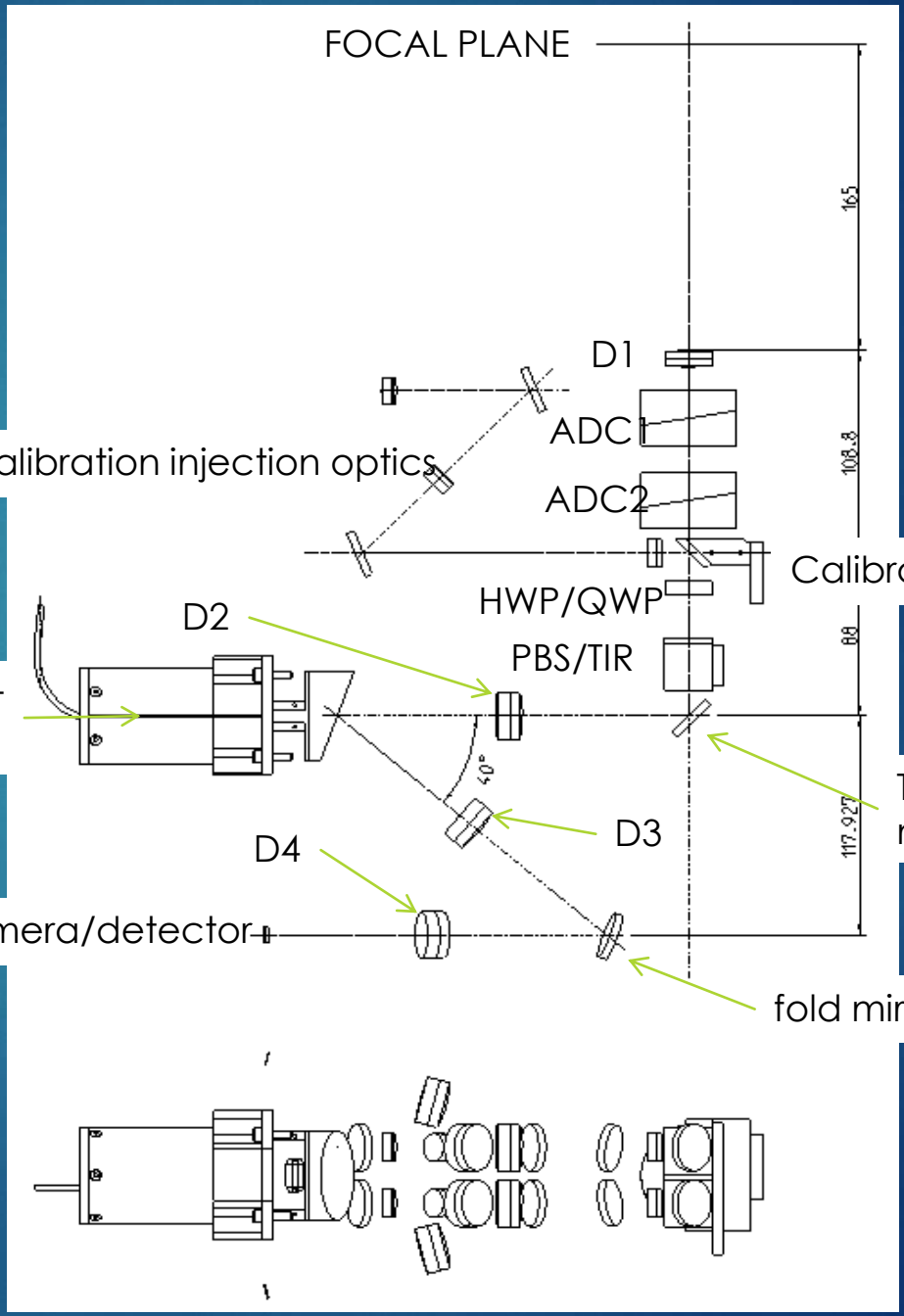


Global dimensions:
435 x 466 x 326 mm

Total mass ~ 138 kg

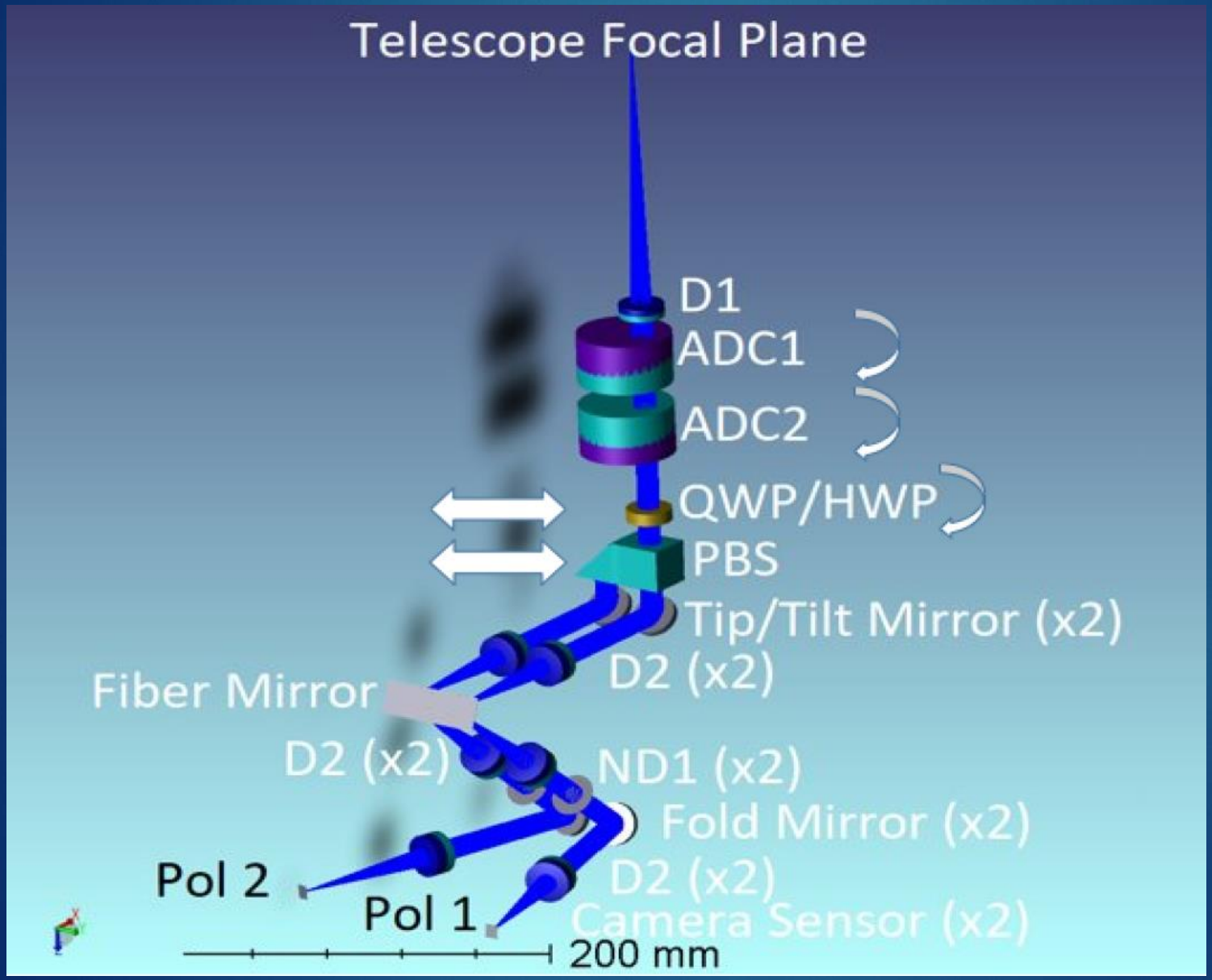
Slide credit:
Jan Kragt, NOVA

Optical model



Slide credit:
Jan Kragt, NOVA

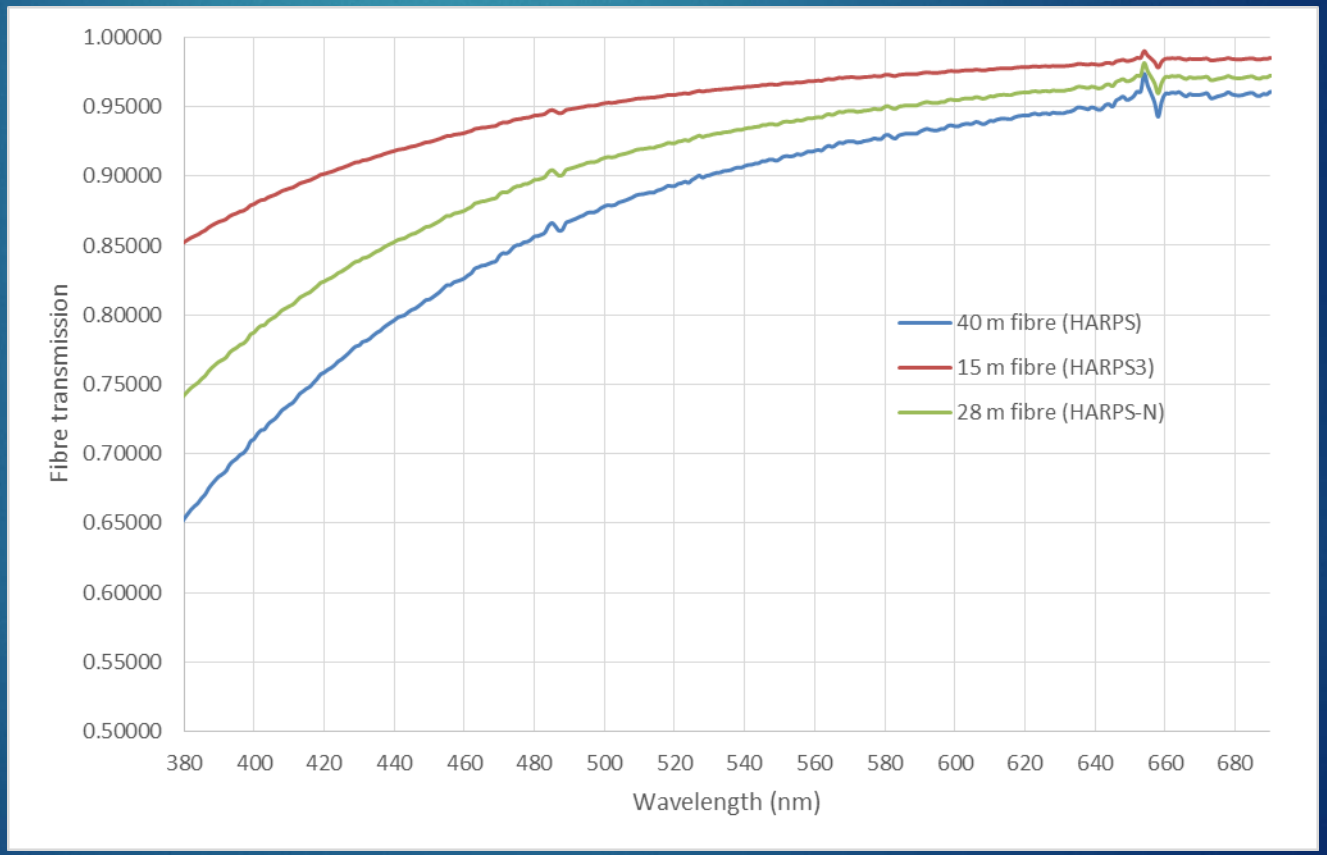
HARPS3-POL



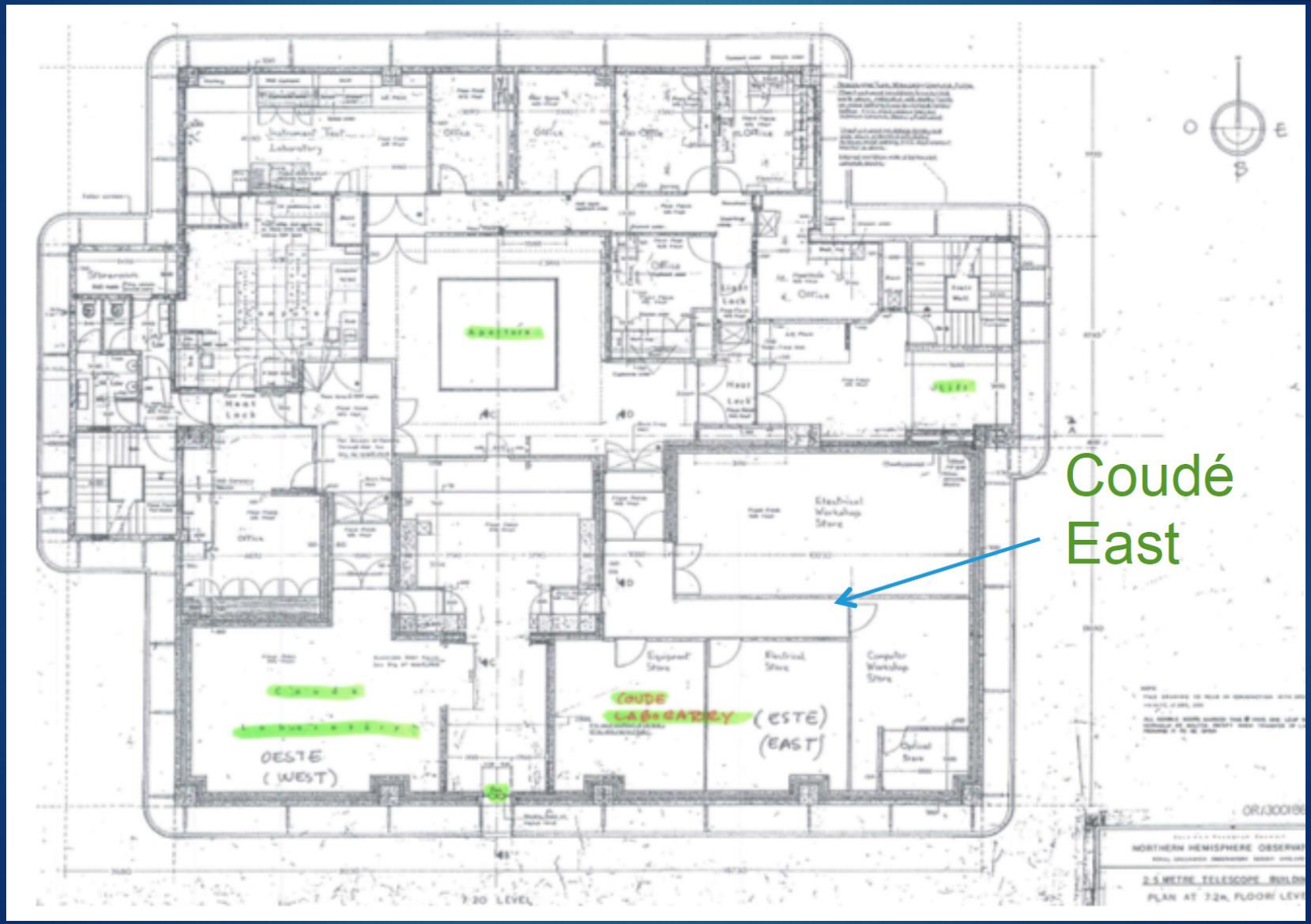
Slide credit: Patrick Dorval, Leiden

Fibre-link

- Octagonal fibres + double scrambler
- ~17 m fibre length => efficiency boost in the blue

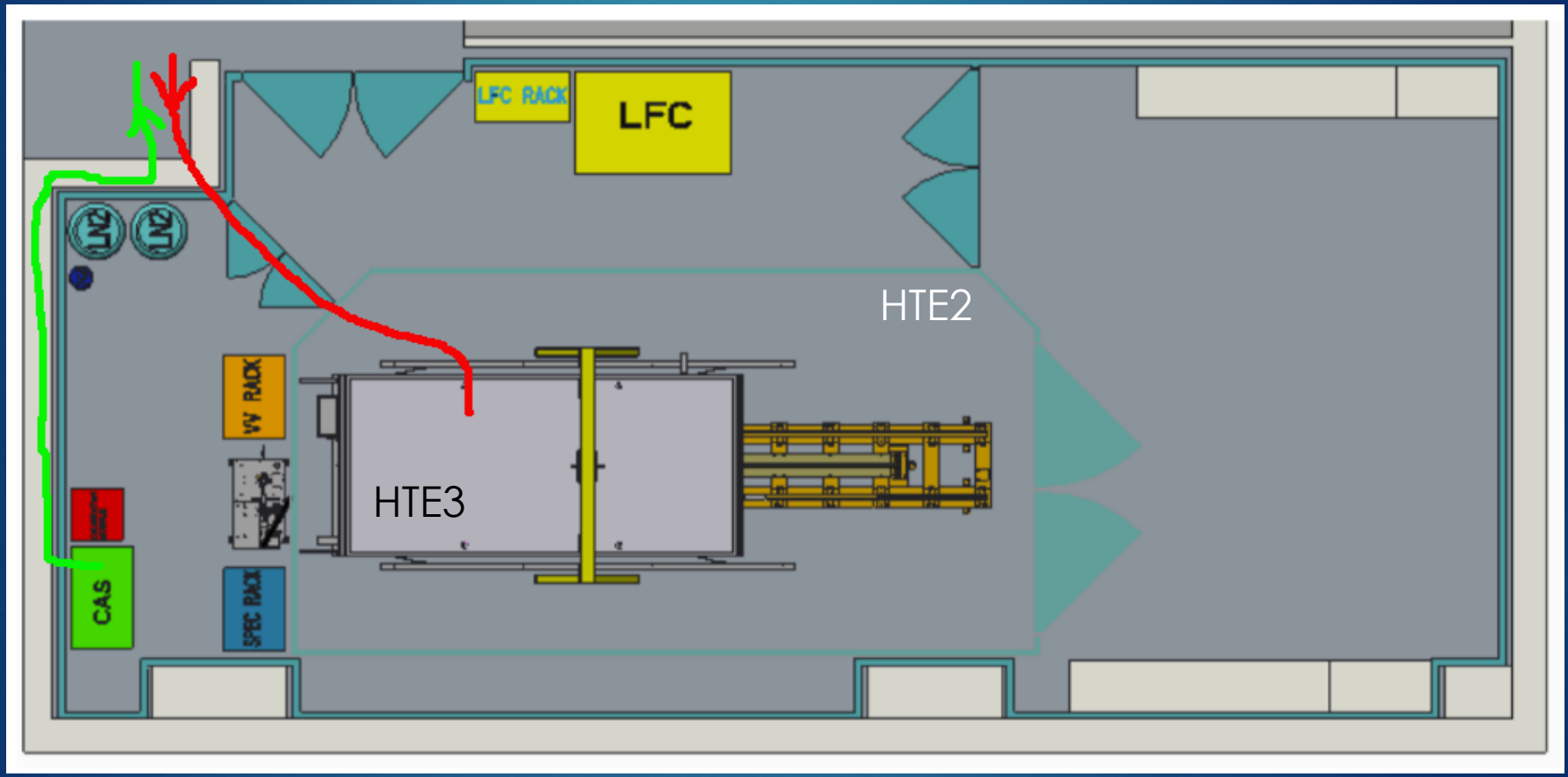


HARPS3 Room



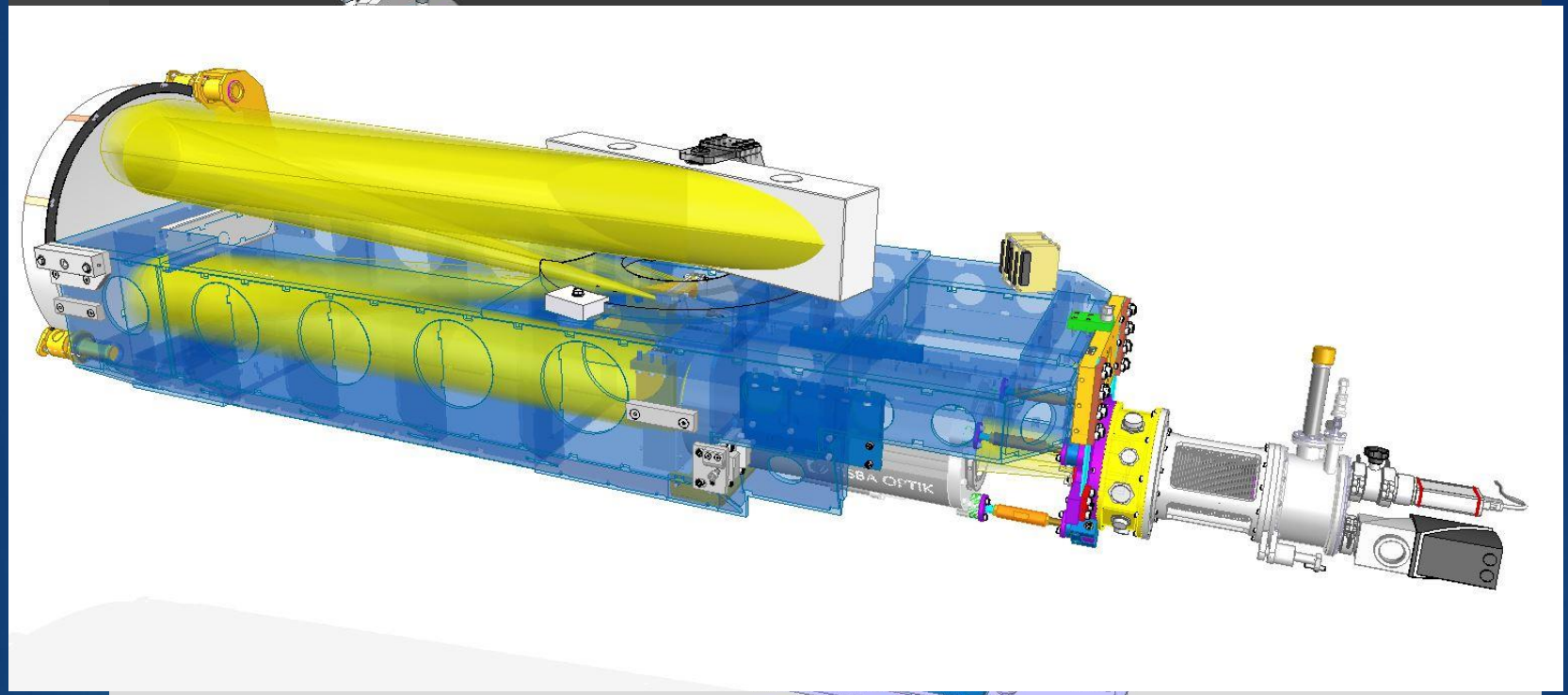
Room layout

Thermal enclosures: HTE1 (entire space), HTE2 and HTE3



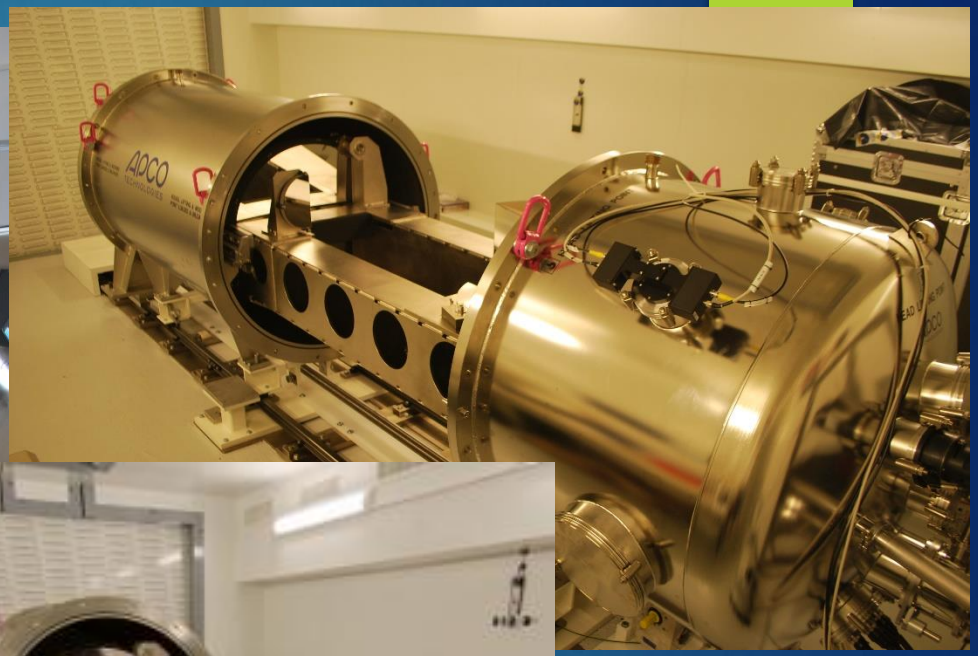
Picture credit: H3 team, IAC

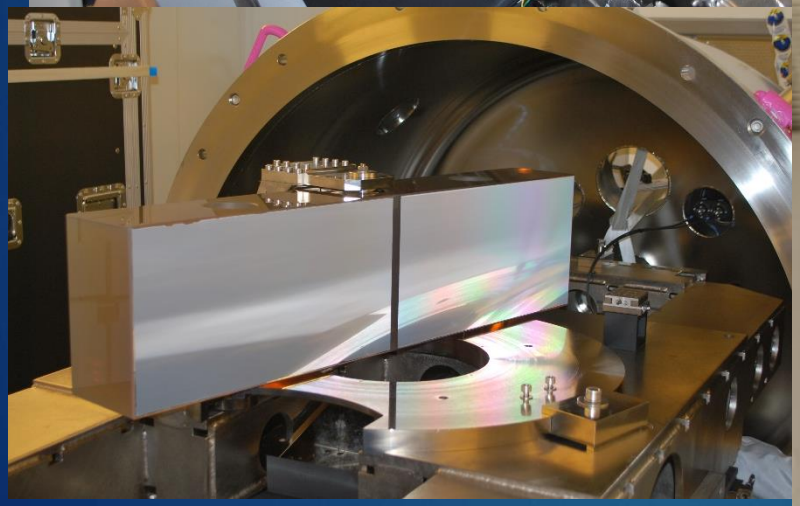
Spectrograph system



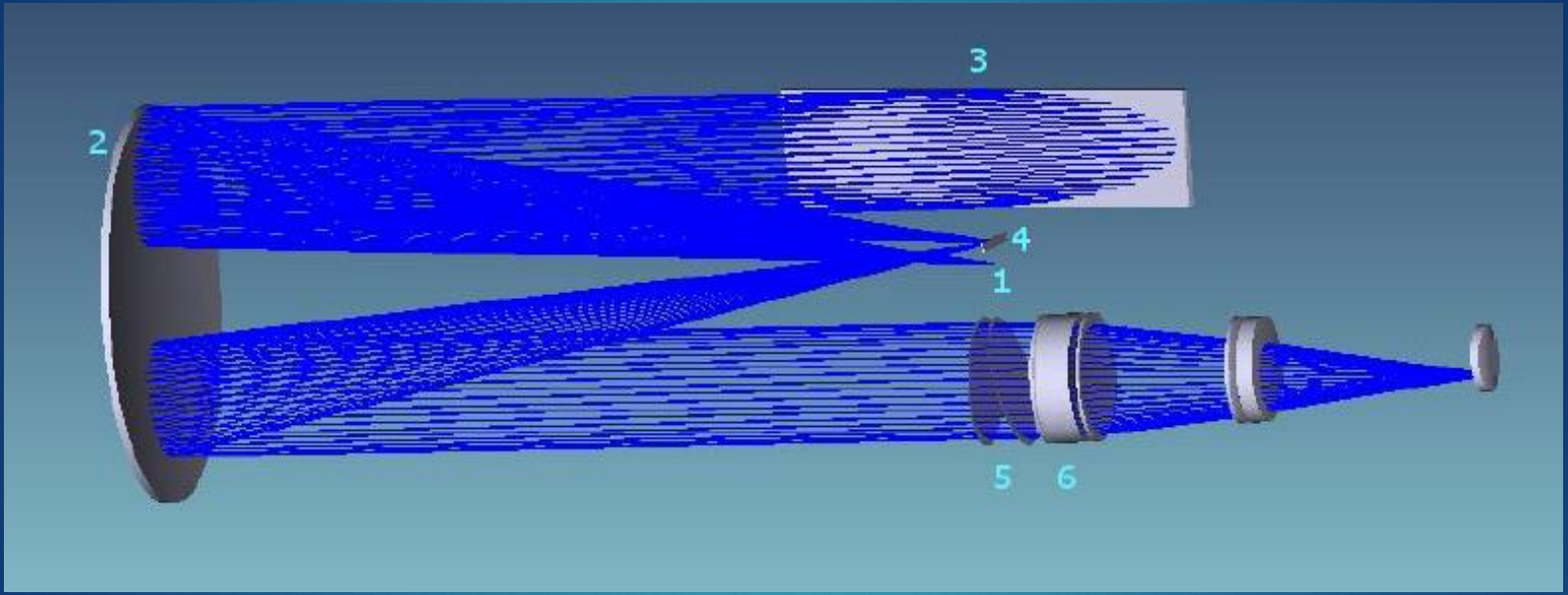
Picture credits: HARPS-N project

More pretty pics courtesy of HARPS-N project





Spectrograph Optics



Ray trace of main spectrograph optical components:

The light is injected at (1). The large (770mm diameter) parabolic collimating mirror (2) is used in triple pass. (3) Echelle grating, (4) flat fold mirror, (5) grism (cross-disperser), (6) until focus are the 6 lenses of the camera objective.

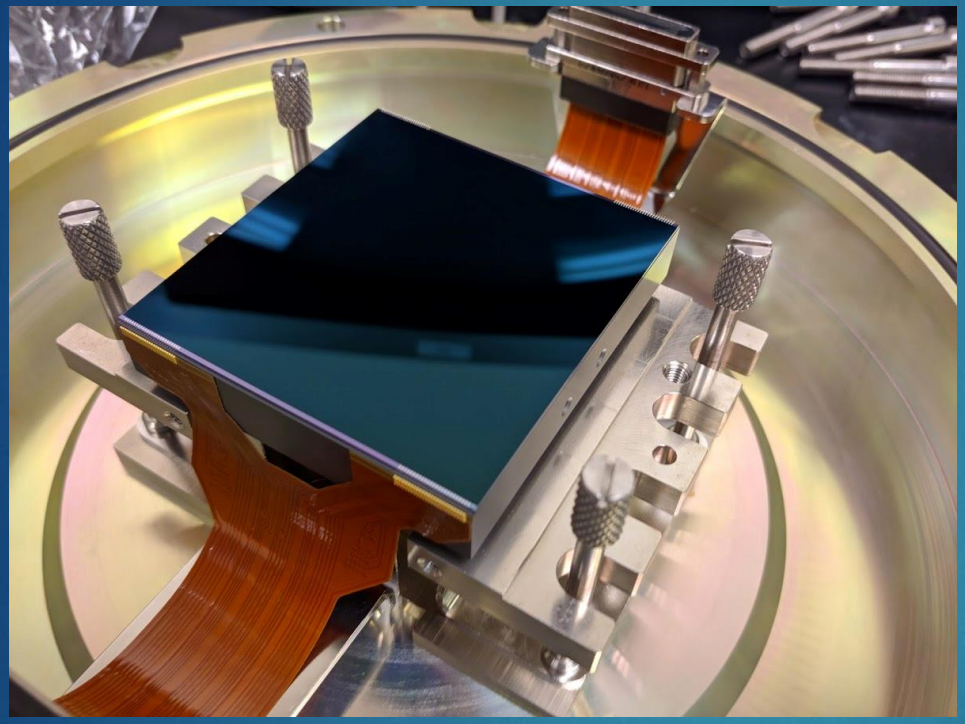
HARPS3 Echelle

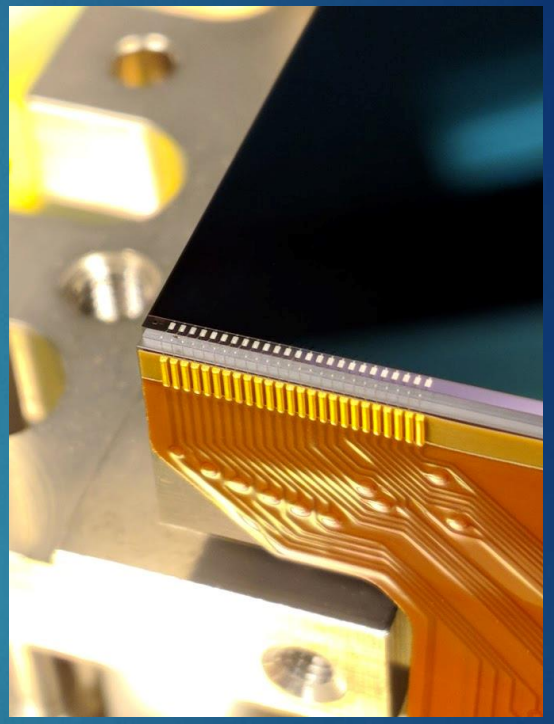
- Echelle grating substrate: Zerodur Class 0 SPECIAL, CTE = 0 ± 0.010 · 10^{-6}/K
- September 2018: 1st stage of manufacturing complete (Mosaic Substrate Verified)
- Alignment stage will be completed in the next few months
- Delivery anticipated before the end of this year

Detector Unit

- e2V chip: CCD231-84-0-G57
- CCD controller: ESO NGC unit
- New design continuous-flow cryostat
- Enhanced CCD calibration
  - 10 cm/s (Earth-like planet signal) == 1e-4 pixel!

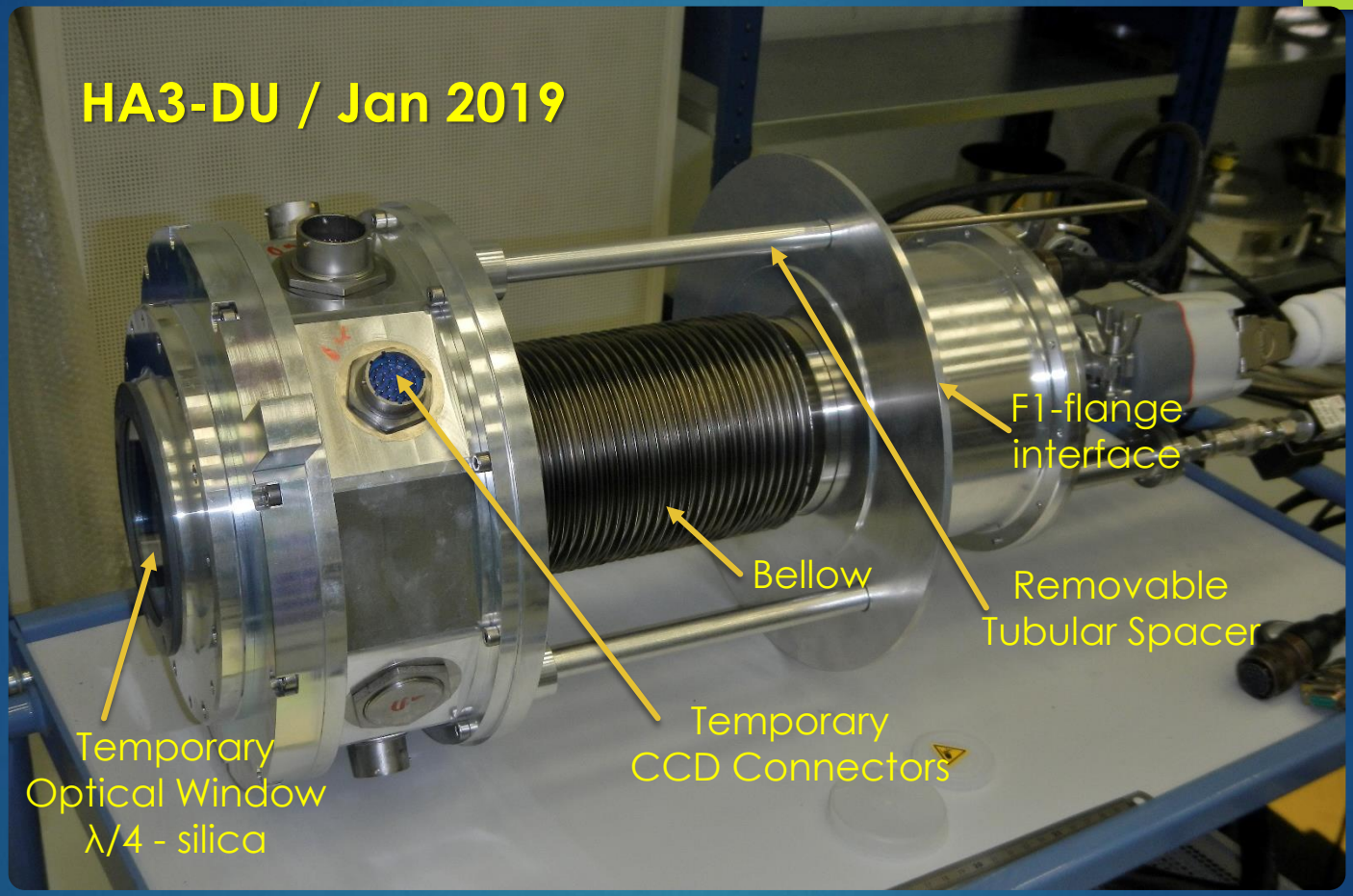
Grade 5 CCD Inspection





- Already received the Grade 6 and Grade 5 devices
- Expecting delivery of the Science (Grade 0) chip in June 2019
  e2V chip: CCD231-84-0-G57

Continuous-flow cryostat



- ~1 mK rms stability … verification tests this summer
- Vacuum pressure inside detector unit ~2x10^{-6} mbar

Calibration Unit

8 switchable light sources allowing illumination of Fibre A or Fibre B in any combination.

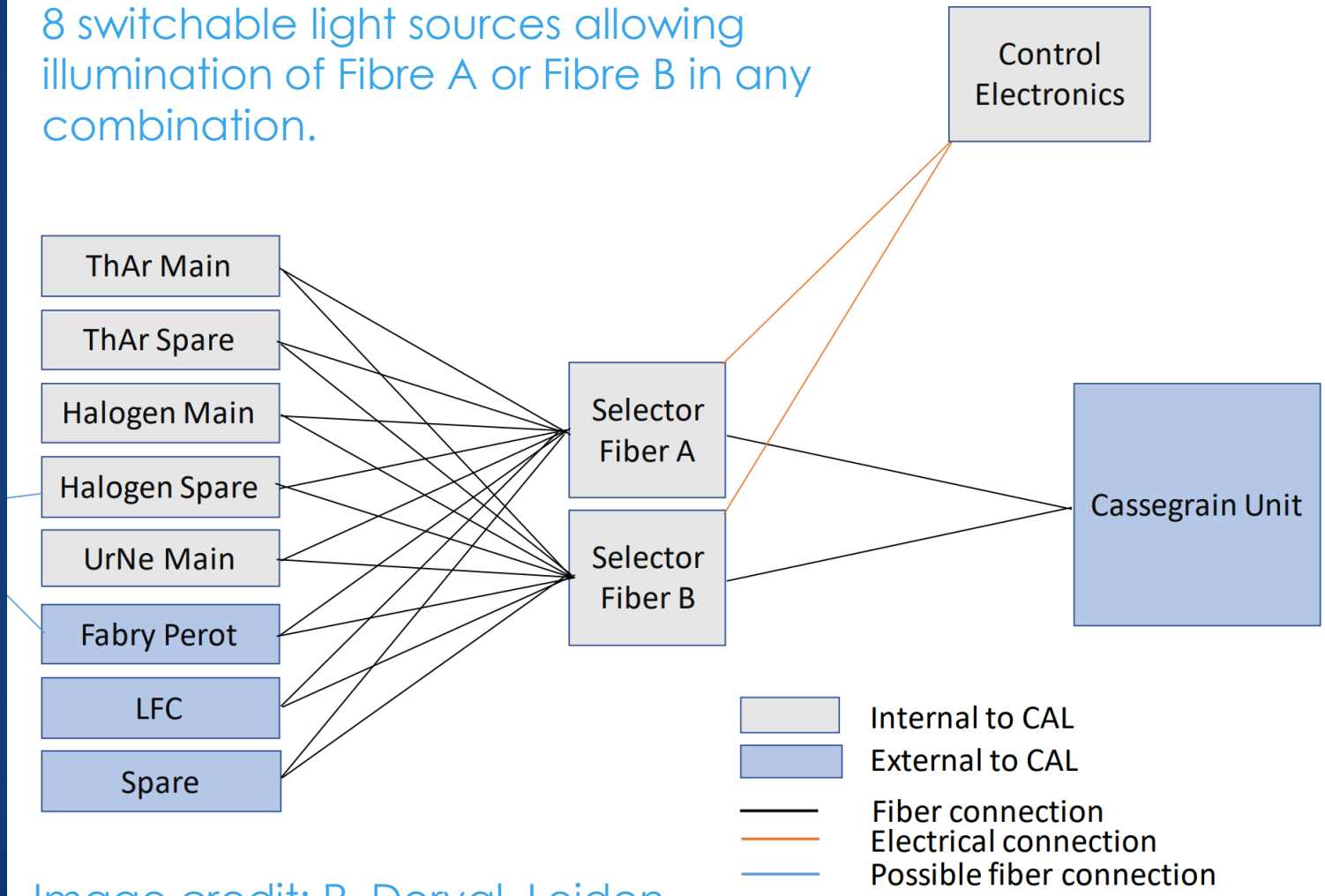


Image credit: P. Dorval, Leiden

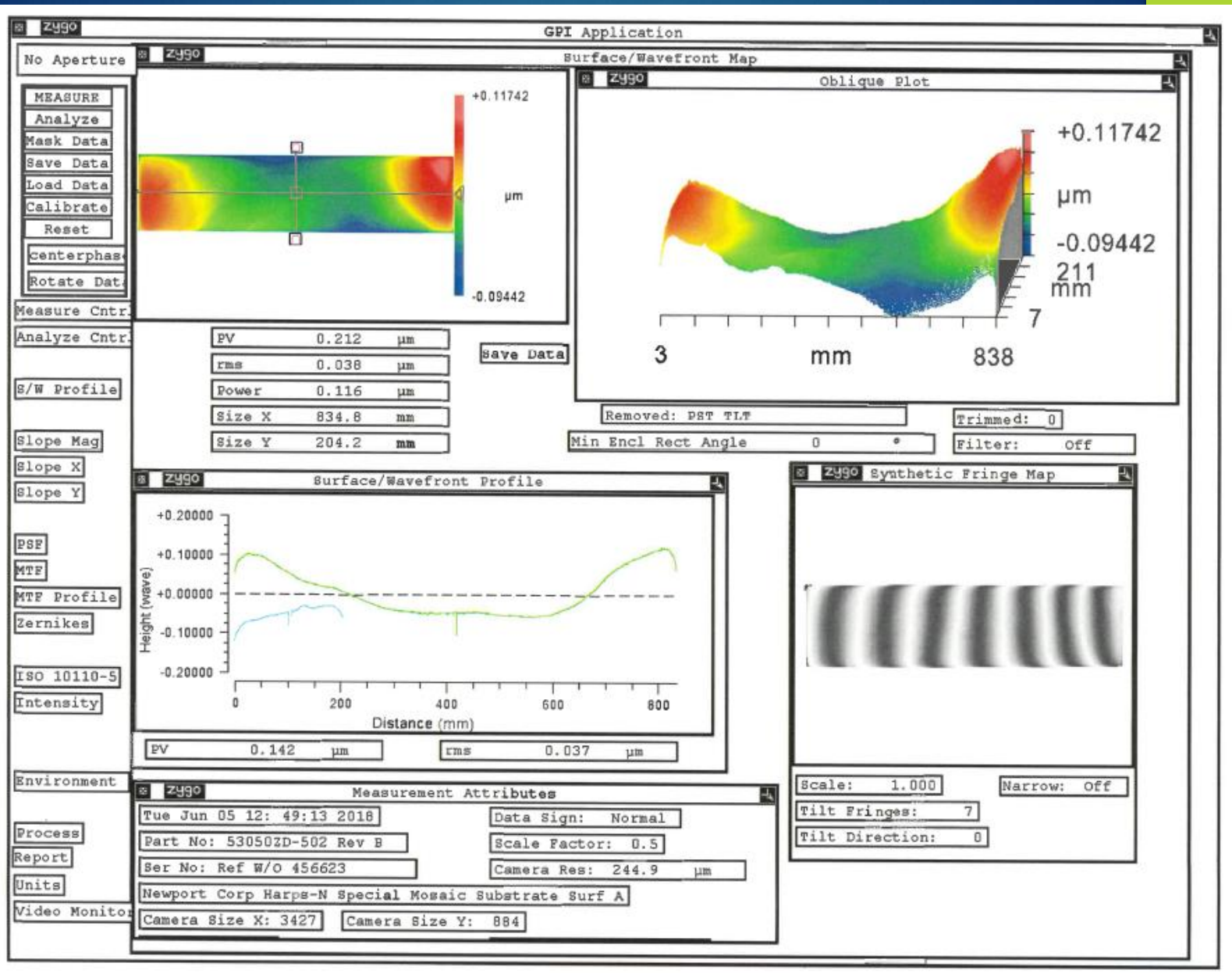
Important Milestones coming up this year:

- Camera ITT
- Telescope refurb ITT
- Cass Adapter WP (includes Cal Unit) Final Design Review
- Vacuum System ITT
- HARPS3 Room Design Review
- All other spectrograph optics (collimator, grism ...) ITTs
- CCD integration into new detector head unit
- Dataflow simulation test
- Announce telescope closure date to community (Sep/Oct)
- Delivery of Echelle grating to Cambridge
- Software systems FDR (Dec)

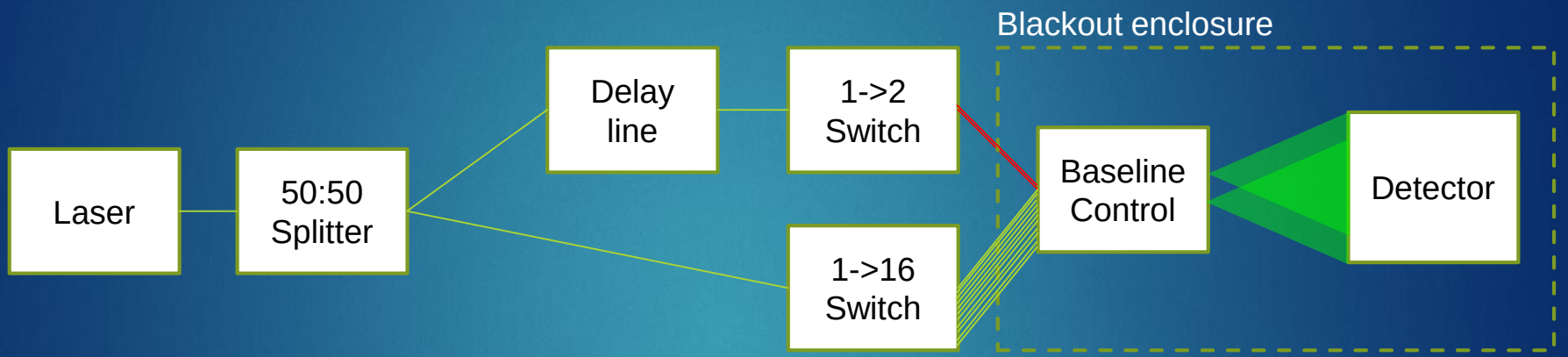
Schedule

- **2019**
  - HARPS3 is now fully funded – full steam ahead!
  - Final design reviews for Cass fibre adapter unit, telescope upgrade plans, software systems
  - Delivery of Grade0 CCD
  - Assembly and testing of new continuous flow cryostat
  - Delivery of Echelle grating
- **2020**
  - Completion of outfitting INT's East Coudé room
  - INT roboticization works begin
- **2021**
  - Assembly, integration and testing in labs (all sub-systems)
  -  HARPS3 First Light ~July 2021

Extra slides …


GPI Application
No Aperture
MEASURE
Analyze
Mask Data
Save Data
Load Data
Calibrate
Reset
centerphas
Rotate Dat
Measure Cntr
Analyze Cntr
S/W Profile
Slope Mag
Slope X
Slope Y
PSF
MTF
MTF Profile
Zernikes
ISO 10110-5
Intensity
Environment
Process
Report
Units
Video Monitor
Surface/Wavefront Map
+0.11742
µm
-0.09442
PV 0.212 µm
rms 0.038 µm
Power 0.116 µm
Size X 834.8 mm
Size Y 204.2 mm
Save Data
Oblique Plot
+0.11742
µm
-0.09442
211
mm
7
3
mm
838
Removed: PST TLT
Min Encl Rect Angle 0 °
Trimmed: 0
Filter: Off
Surface/Wavefront Profile
+0.20000
+0.10000
+0.00000
-0.10000
-0.20000
Height (wave)
0
200
400
600
800
Distance (mm)
PV 0.142 µm
rms 0.037 µm
Synthetic Fringe Map
Scale: 1.000
Narrow: Off
Tilt Fringes: 7
Tilt Direction: 0
Measurement Attributes
Tue Jun 05 12: 49:13 2018
Data Sign: Normal
Part No: 53050ZD-502 Rev B
Scale Factor: 0.5
Ser No: Ref W/O 456623
Camera Res: 244.9 µm
Newport Corp Harps-N Special Mosaic Substrate Surf A
Camera Size X: 3427
Camera Size Y: 884

Schematic of CCD measurement



532nm Diode 40mW

380-700nm

Fiber Stretcher

Chose any pair

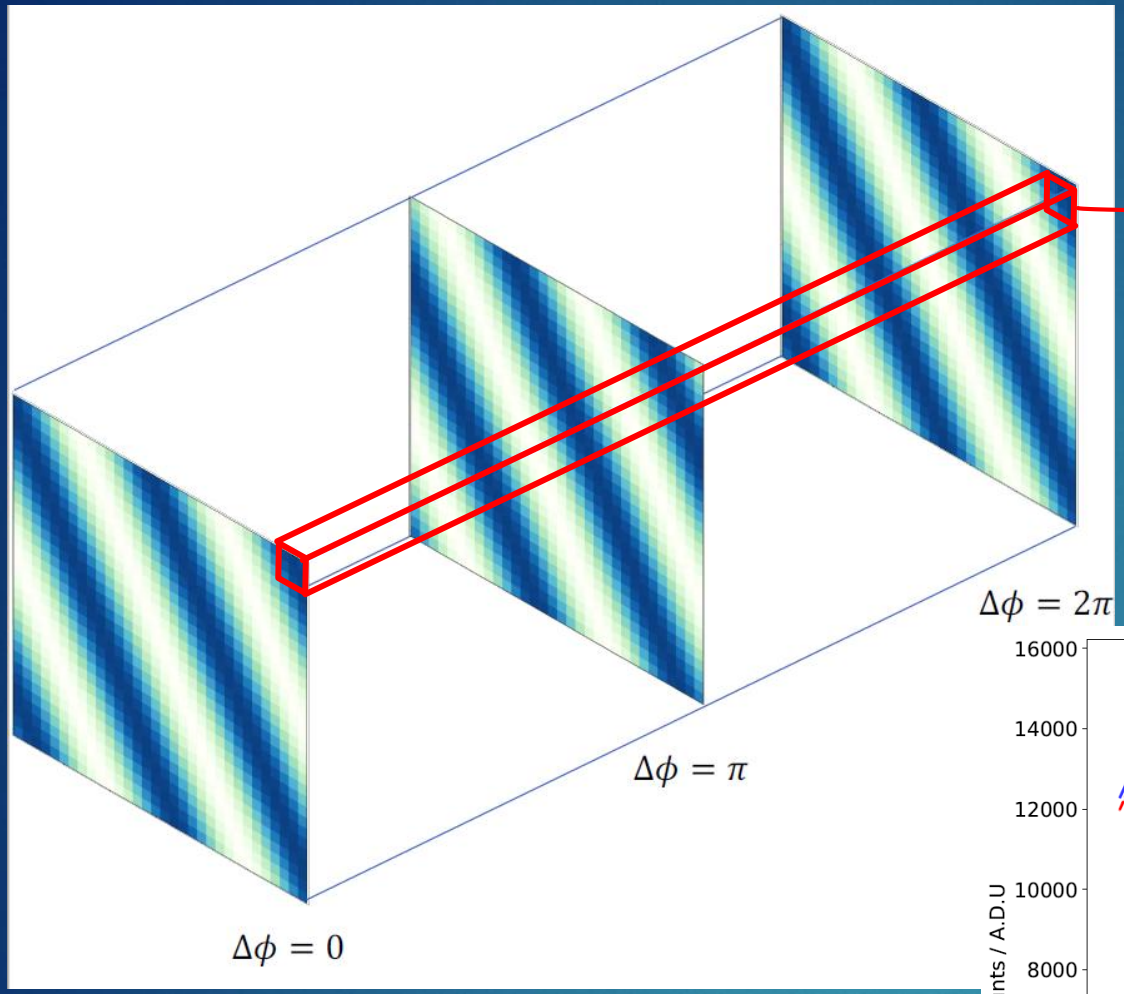
Machined block with precise grooves for fibers

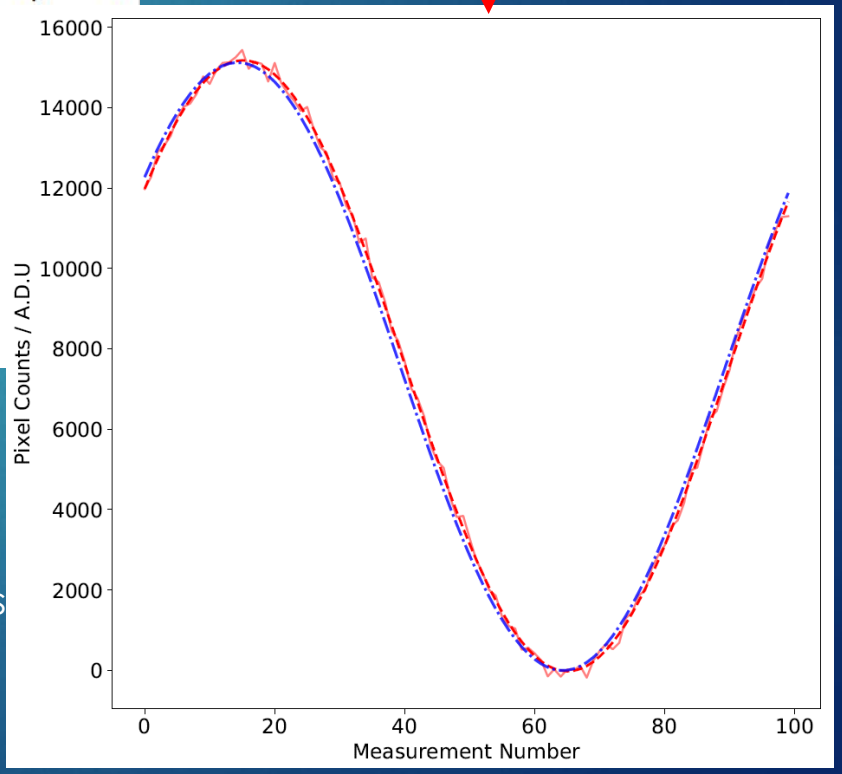
2K detector, room temp

Measuring the effective pixel positions for the HARPS3 CCD, *Richard Hall et al.*, **SPIE 2016, new paper in prep – 2019**

Method based on previous works by Shaklan+ 1995, Crouzier+ 2012

Slide credit: R. Hall





A schematic of the phase-swept data-cube. A column of the data from a single pixel yields a sine-wave which contains pixel displacement information.

The phase difference between the dashed lines is due to the component of the pixel displacement in the direction of the wavevector.