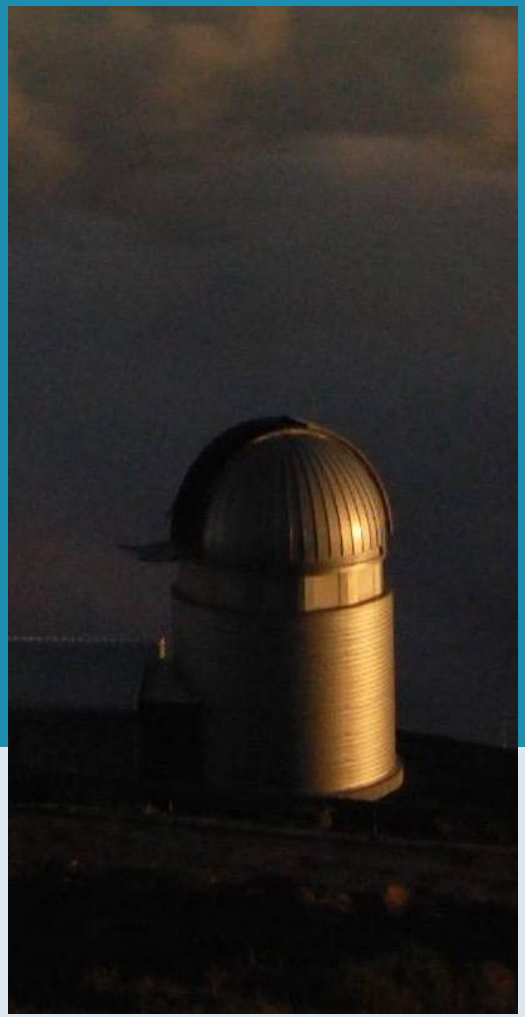
KU LEUVEN

INSTITUTE OF ASTRONOMY

Upgrading HERMES

An improved fibre link and a New wavelength calibrator

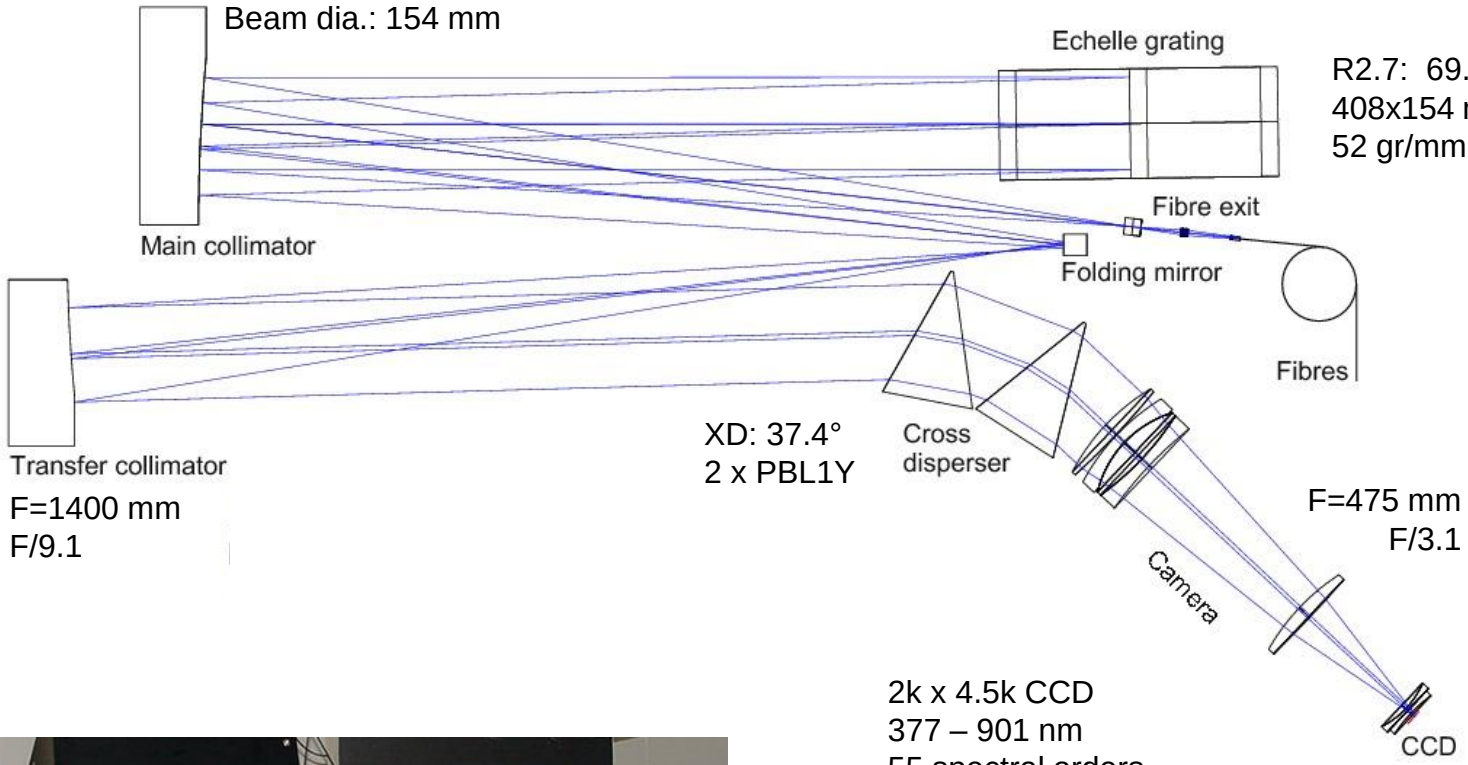


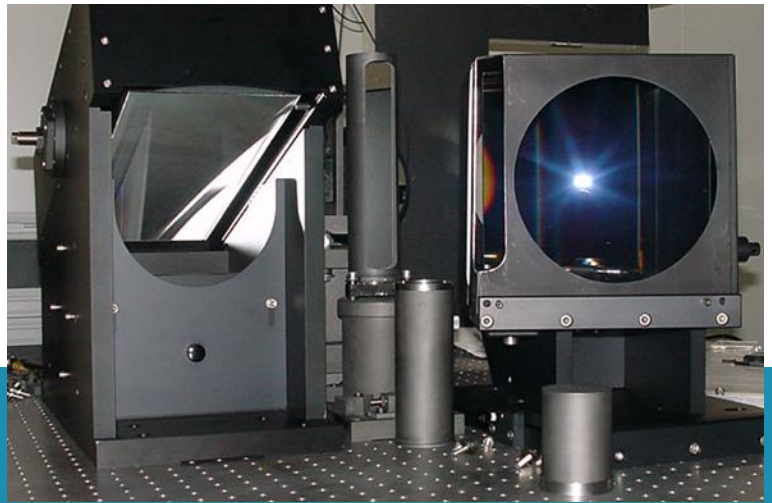
BINA 2018

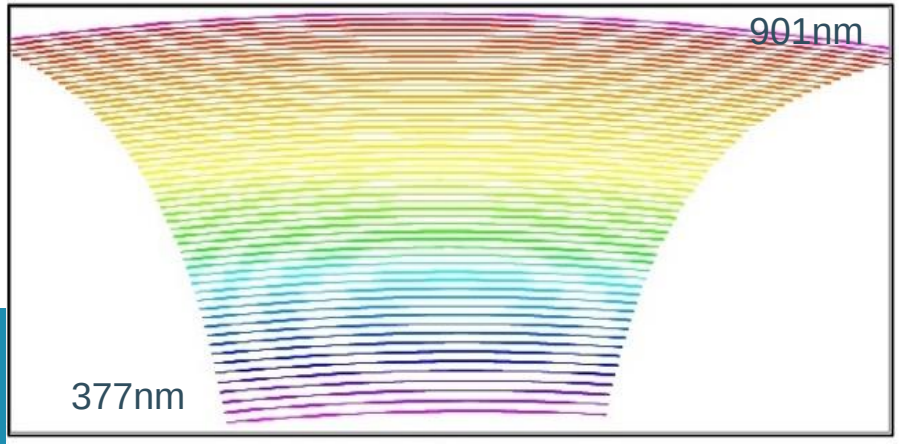
9 October 2018, Uccle

Gert Raskin

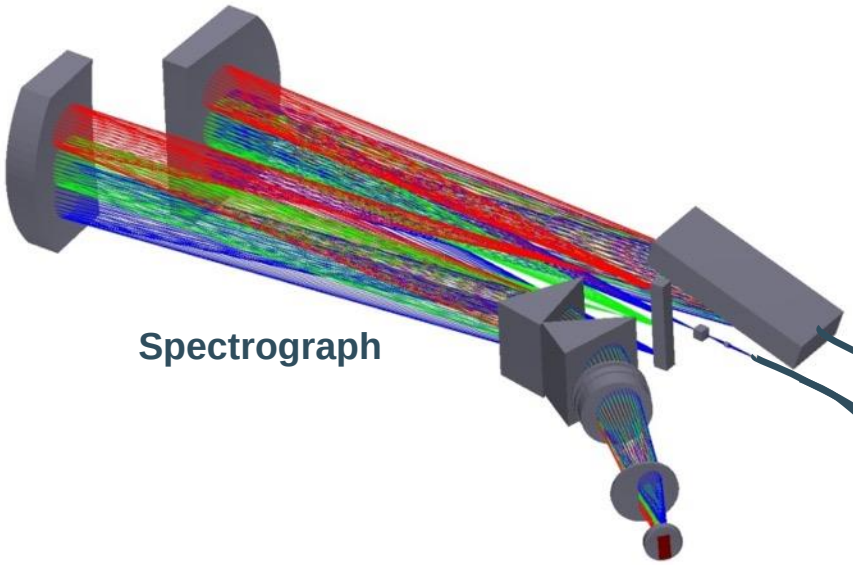
HERMES layout







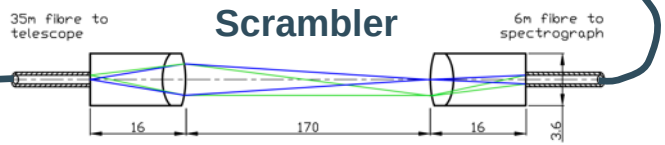
1. Fibre link: original configuration



Spectrograph

2 Observing modes:

- **HRF**: high resolution (**R=85000**) & high efficiency, with **image slicer**
- **LRF**: low(er) resolution (**R=63000**), no slicer, **Scrambler** for high illumination stability (70% eff.), interlaced with wavelength reference fibre (WRF)



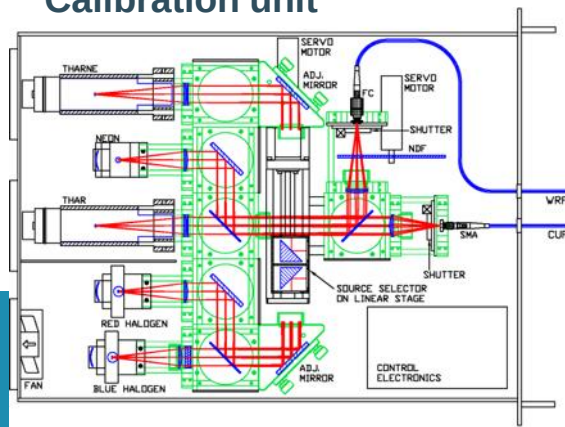
WRF: 60 µm

HRF: 80 µm
2.5 arcsec

LRF: 60 µm
2.15 arcsec

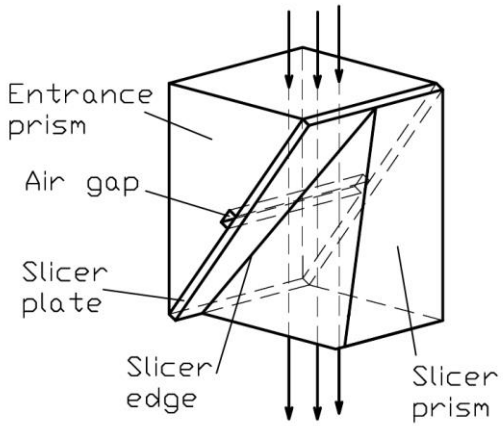
CF: 300 µm

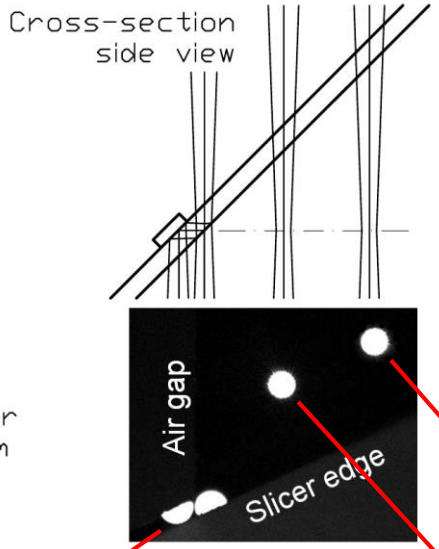
Calibration unit

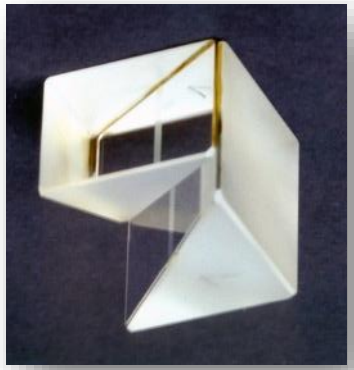


Telescope interface

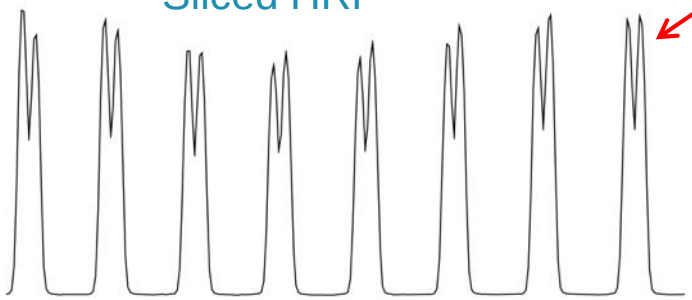
Fibre link: original configuration



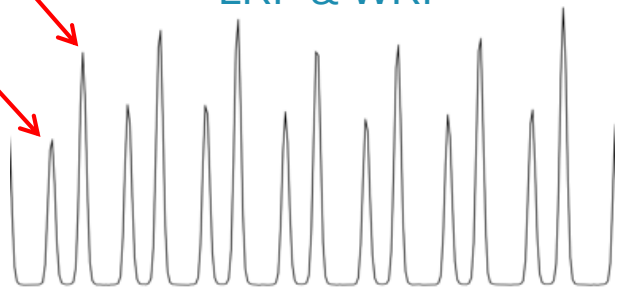


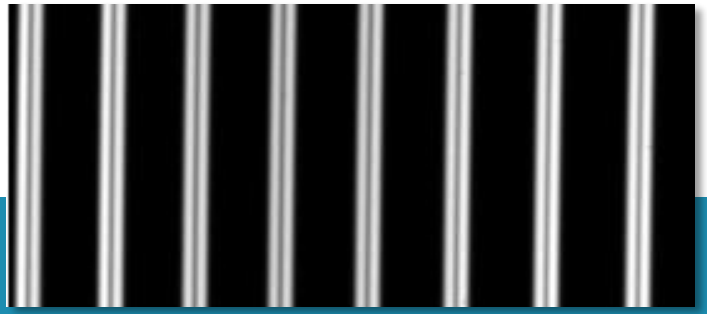


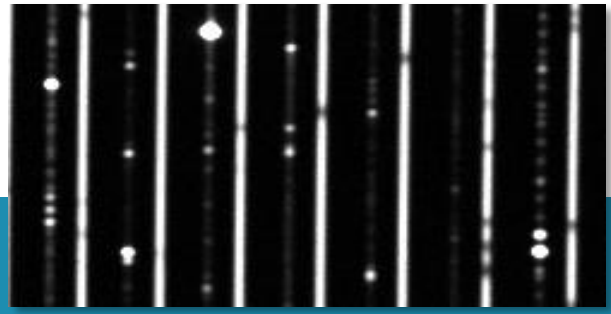
Sliced HRF



Unsliced interlaced LRF & WRF



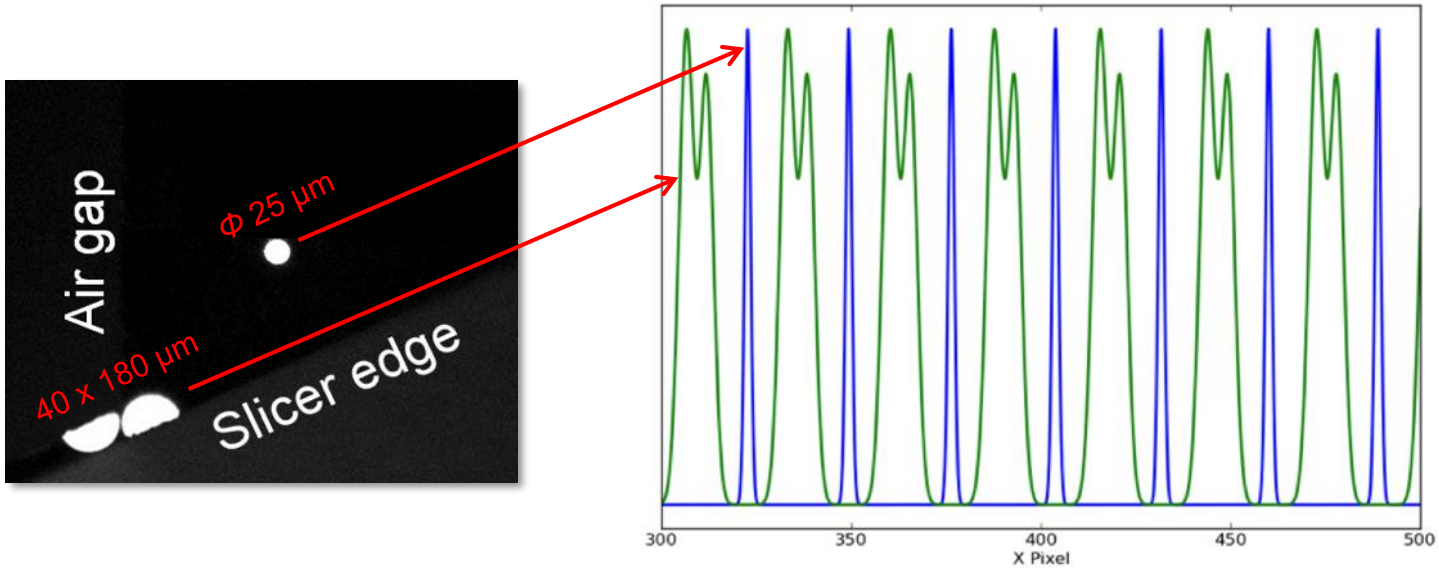




Fibre-link: New configuration

Changes wrt old configuration:

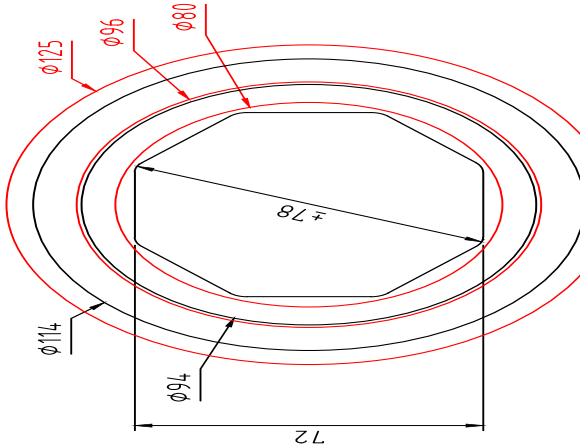
1. Replace 60-µm WRF with narrow unsliced 25-µm or single-mode fibre that fits HRF inter-order space (old LRF-WRF mode removed)

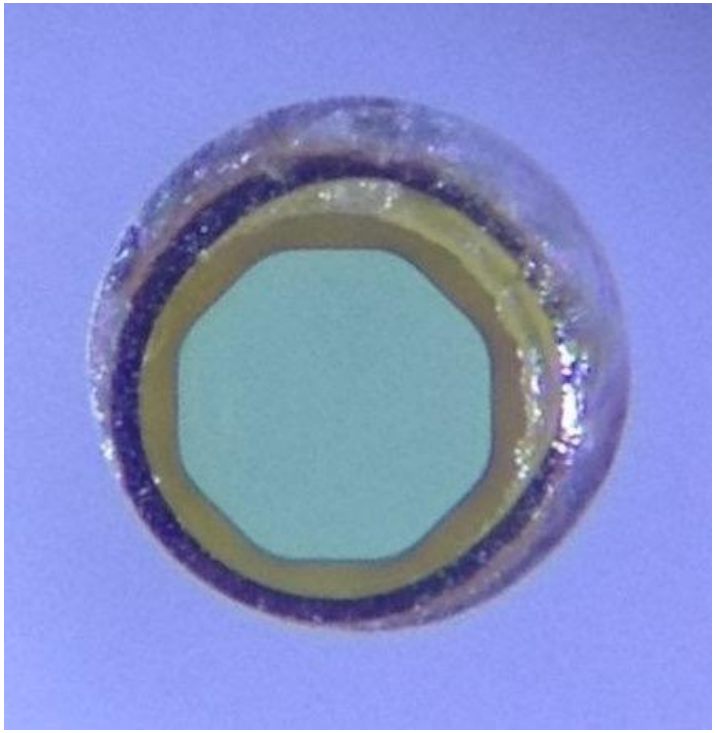


2. Use octagonal fibre for better scrambling of HRF (+ better throughput)
3. Image star image instead of telescope pupil on fibre entrance

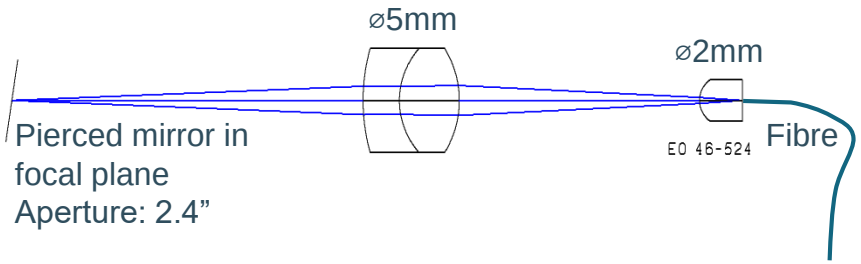
Octagonal fibre

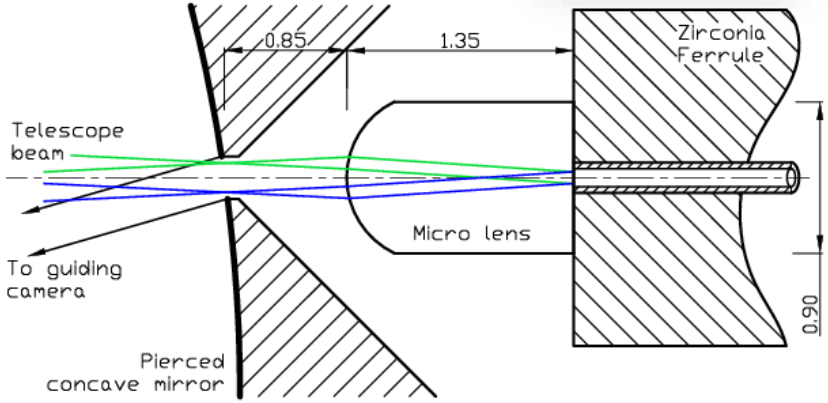
- Polymicro 72 μm face-to-face (original circ. fibre: 80 μm diameter)
  => Higher spectral resolution
- Circular symmetry broken
  => Better scrambling
  => More stable spectrograph illumination
- Smaller focal ratio degradation (FRD)
  => Higher throughput





Star versus Pupil imaging





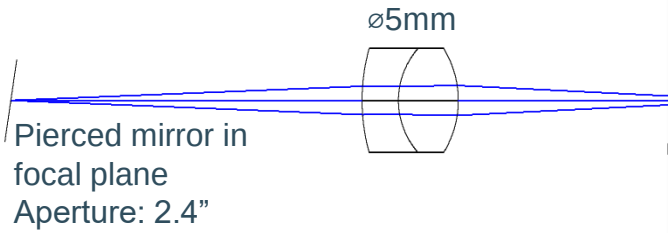
Star image on fibre entrance

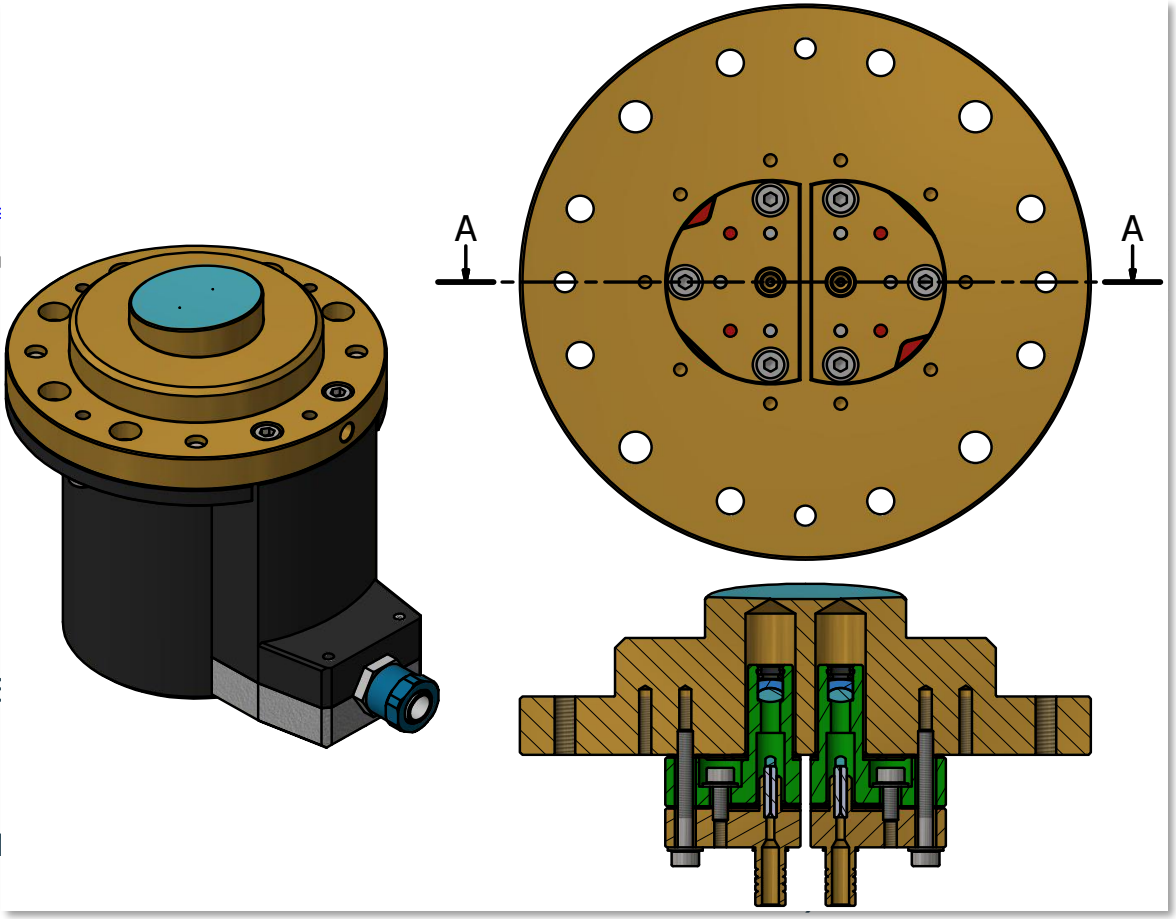
- More complex optics (1 Achromat & 1 PCX)
- More complex alignment
- Better scrambling: reduce guiding & seeing effects

Image of telescope pupil on fibre entrance

- Simple optics (1 PCX singlet)
- Simple alignment
- Poor image scrambling (pupil is scrambled)

Star imaging: new fibre head





Star image on fibre entrance

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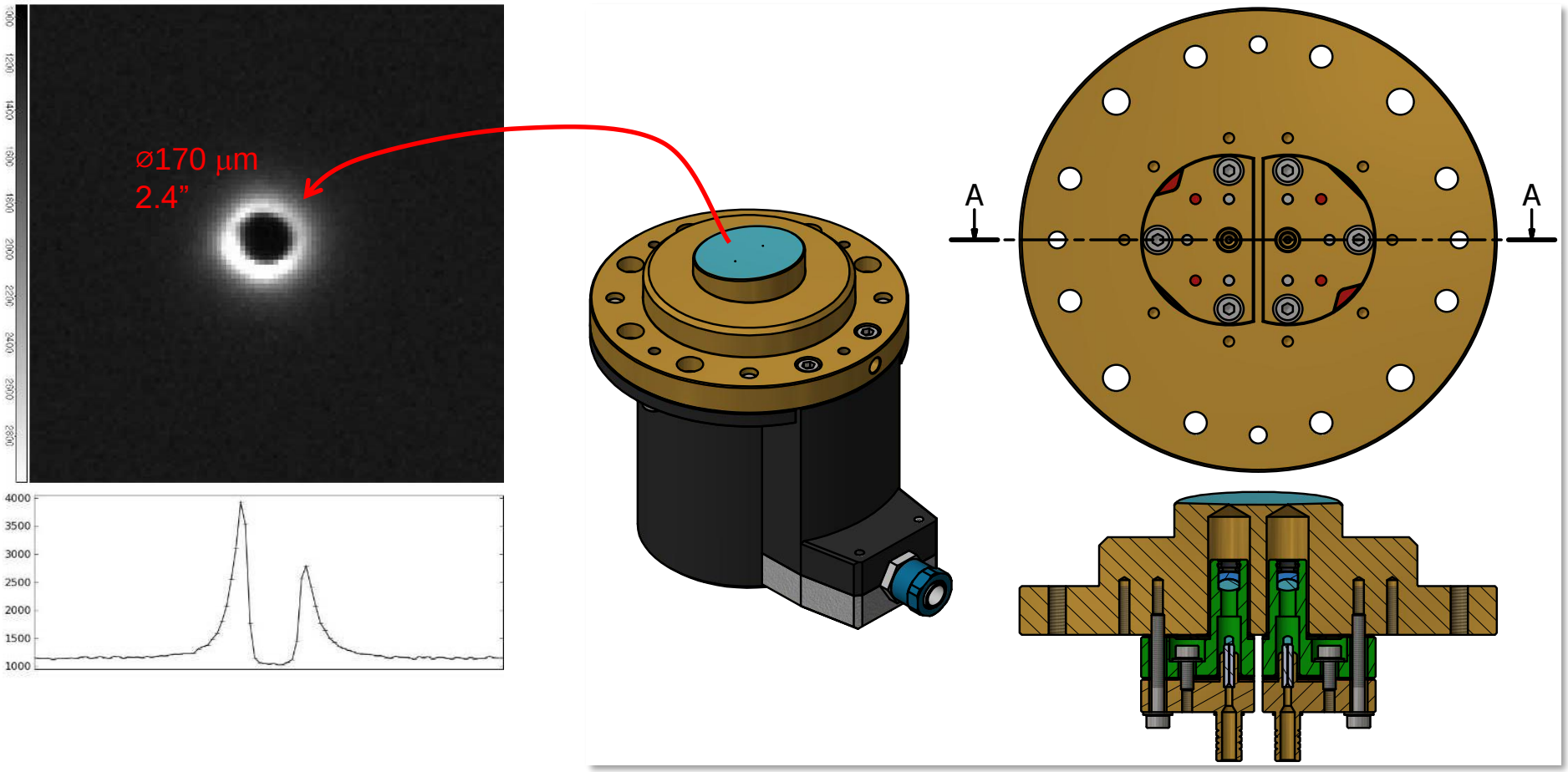
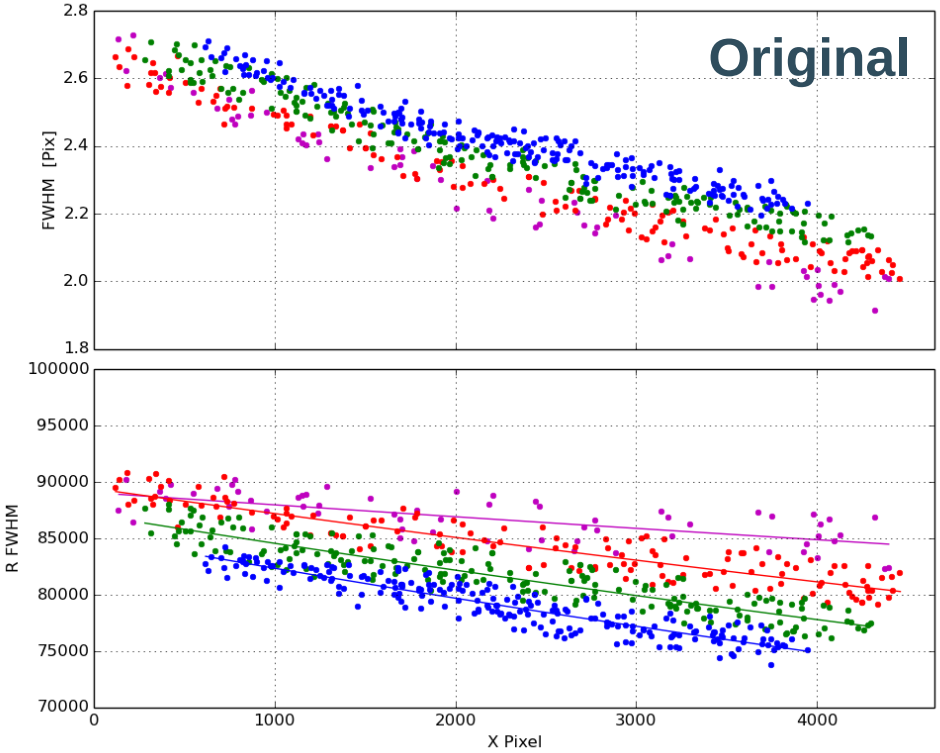
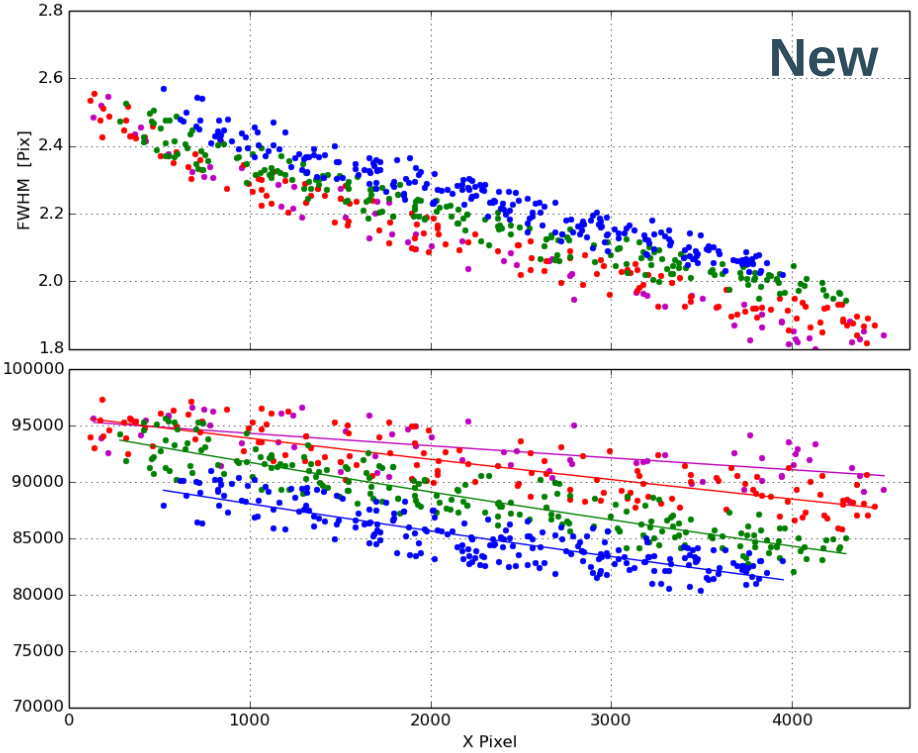
Star imaging: new fibre head



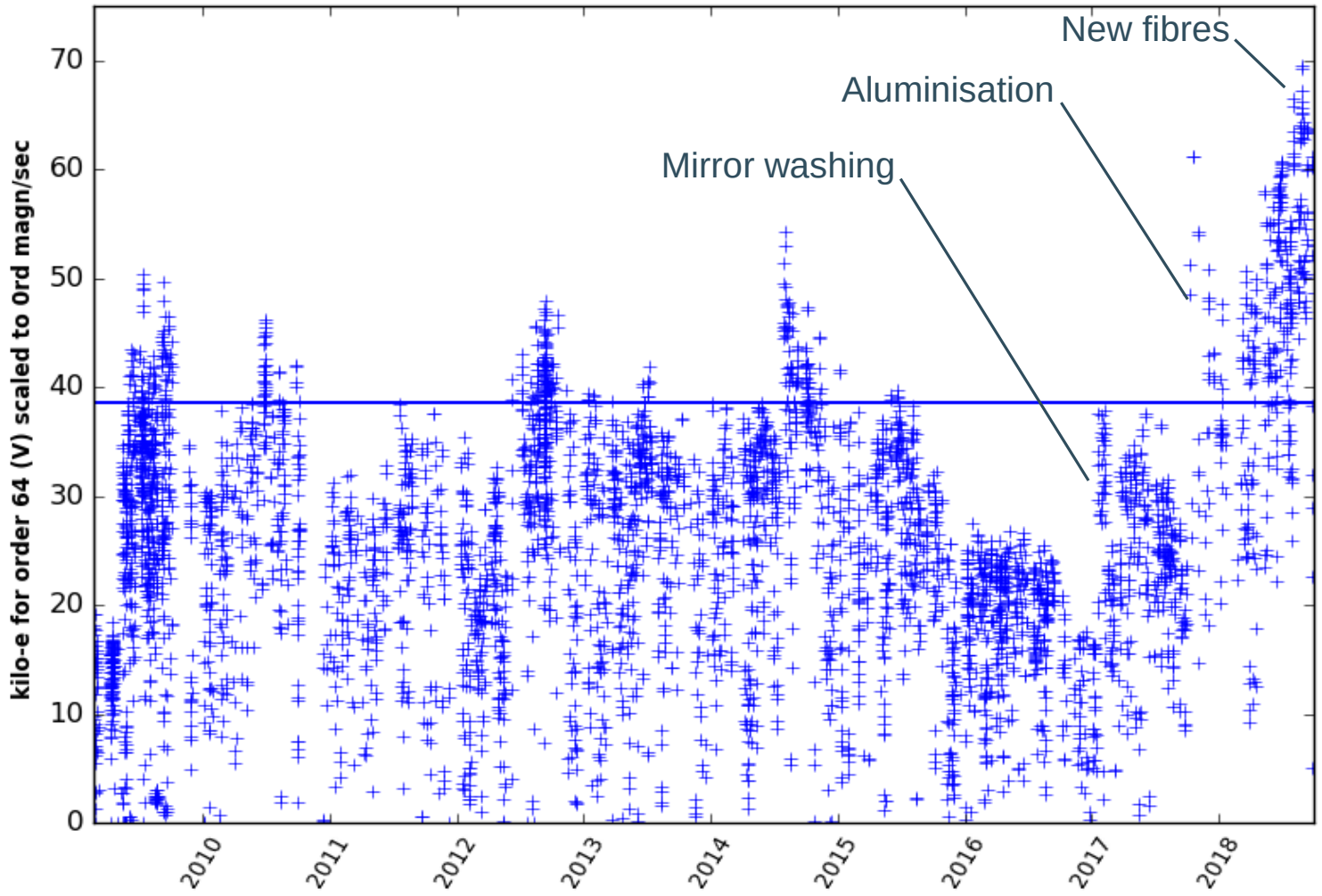
Spectral resolution

- Original circular HRF: R = 75000 – 90000
- New octagonal HRF: R = 80000 – 95000

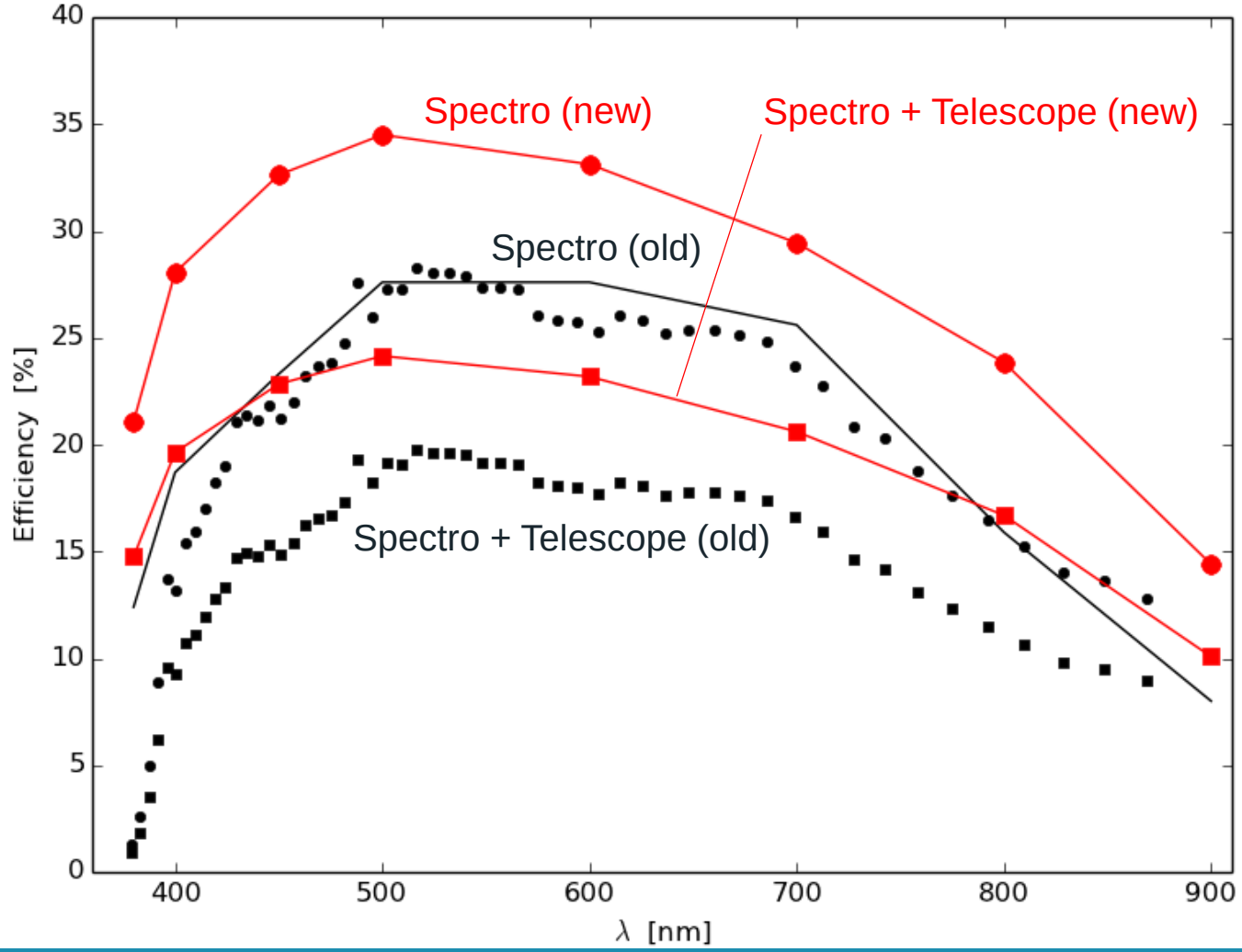




Throughput: + ~10%

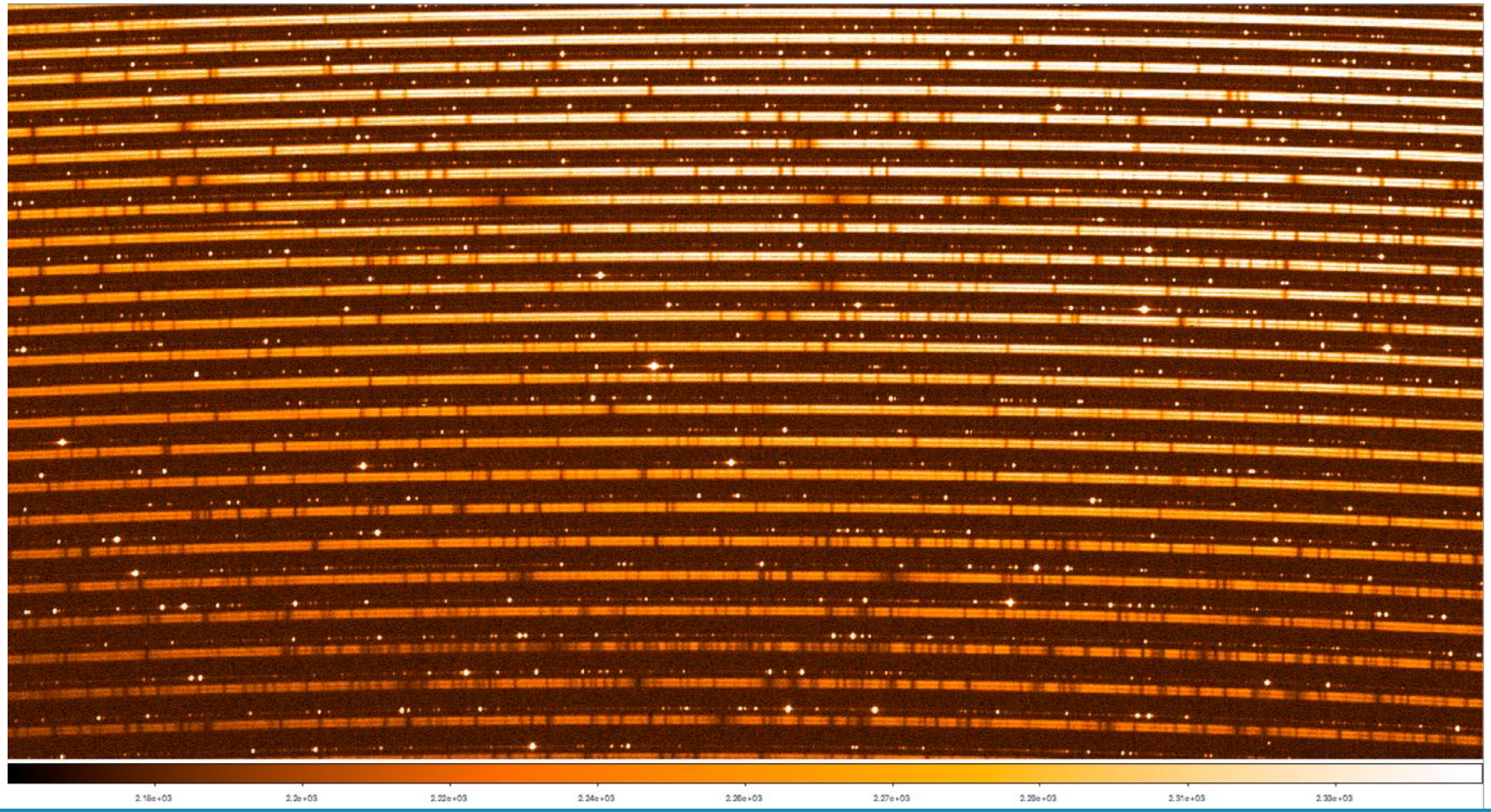


Peak throughput: + ~10%



RV accuracy of simultaneous reference mode

Data will be available soon (work on data-reduction pipeline on going)



2. Improved wavelength calibration for precision RV spectroscopy

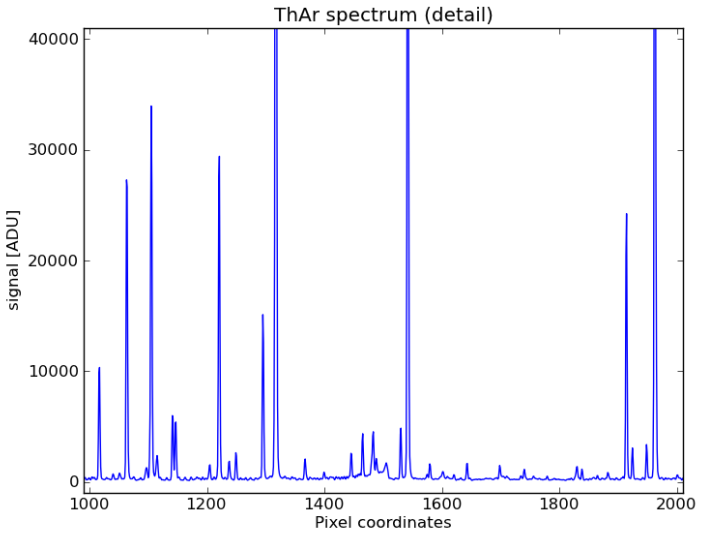
Project: Rubidium-traced etalon wavelength calibrators

Collaboration:

- Macquarie (Sydney)
- Chicago University
- KU Leuven

Improving HERMES wavelength calibration

- Overcome limitations of Thorium-Argon lamps
- Th-Ar lamps with pure atomic Thorium are no longer available =>
  - Spectrum contaminated with Thorium-oxides lines
  - Blending of faint thorium lines
  - Wavelength calibration quality loss

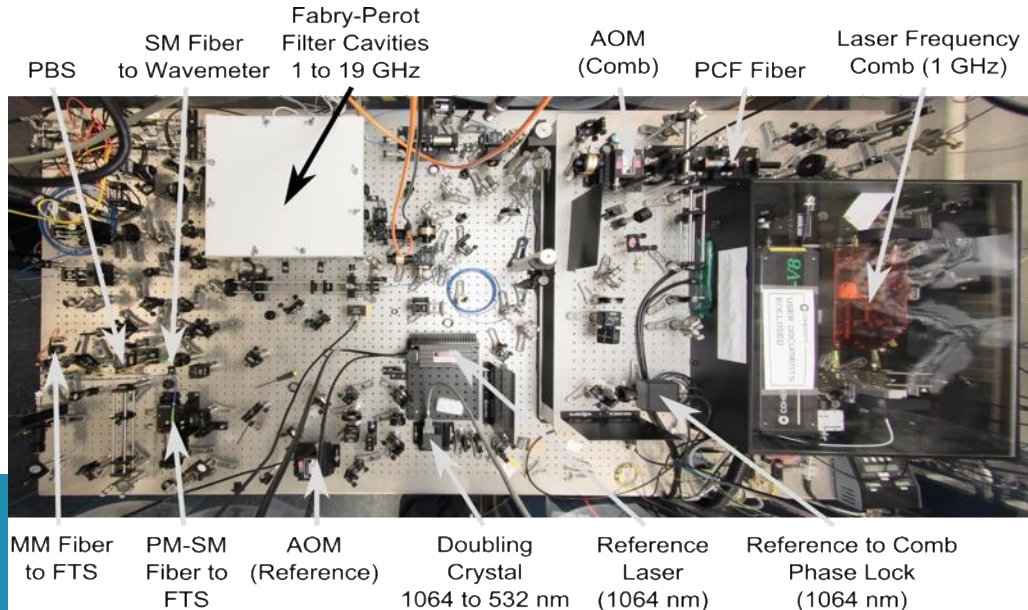


- Perfect alternative for accurate RV observations:

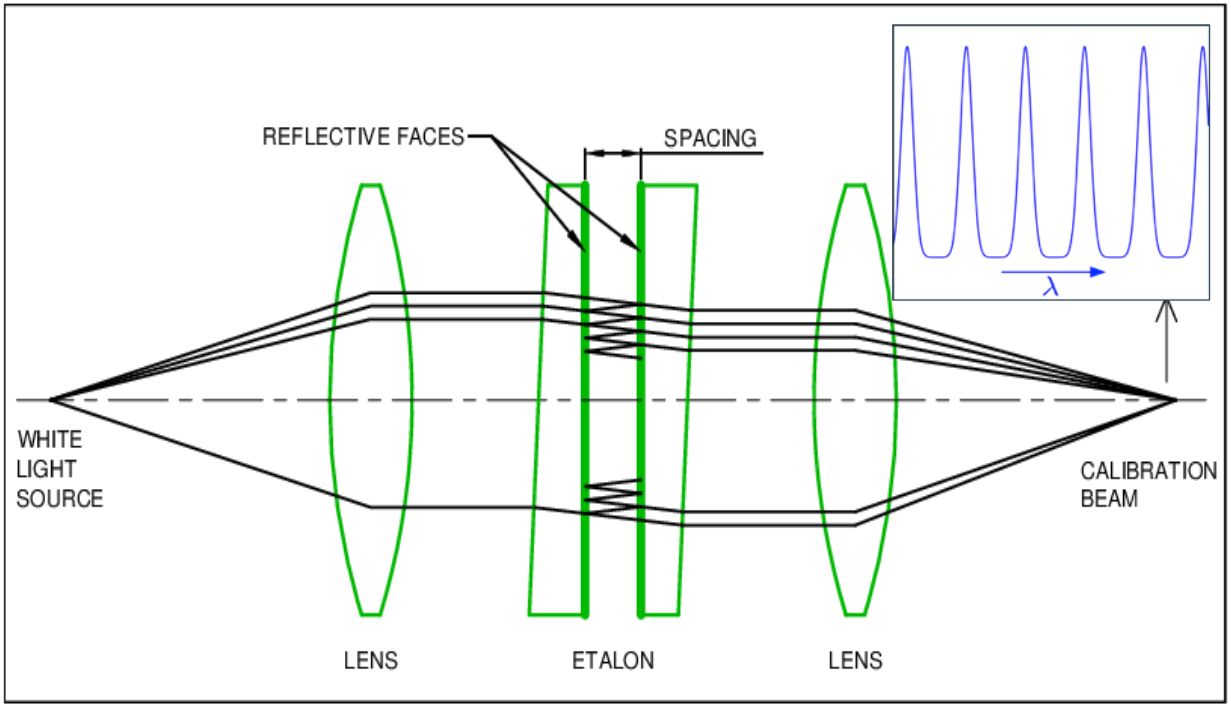
  Laser frequency comb

  Complex

  Expensive!



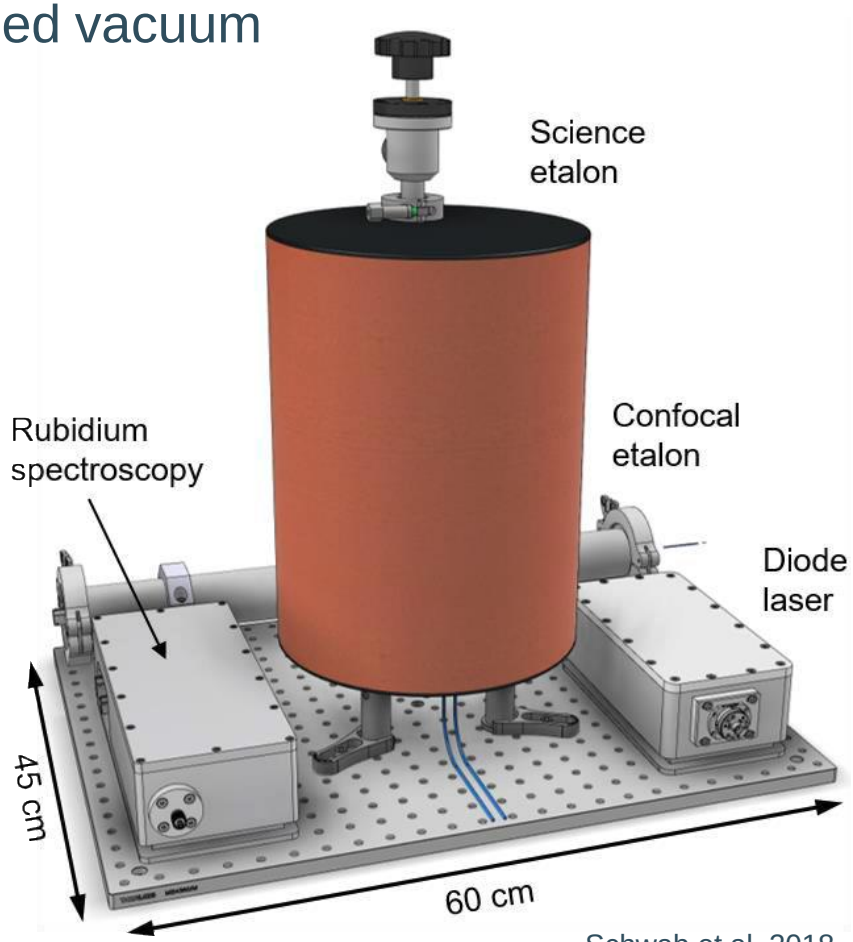
Fabry-Perot etalon



- Comb spectrum of equally-spaced transmission peaks (spacing defined by mirror separation), matched to spectrograph resolution
- Line width and amplitude controlled by mirror reflectivity
- Absolute stability depends on temperature and pressure

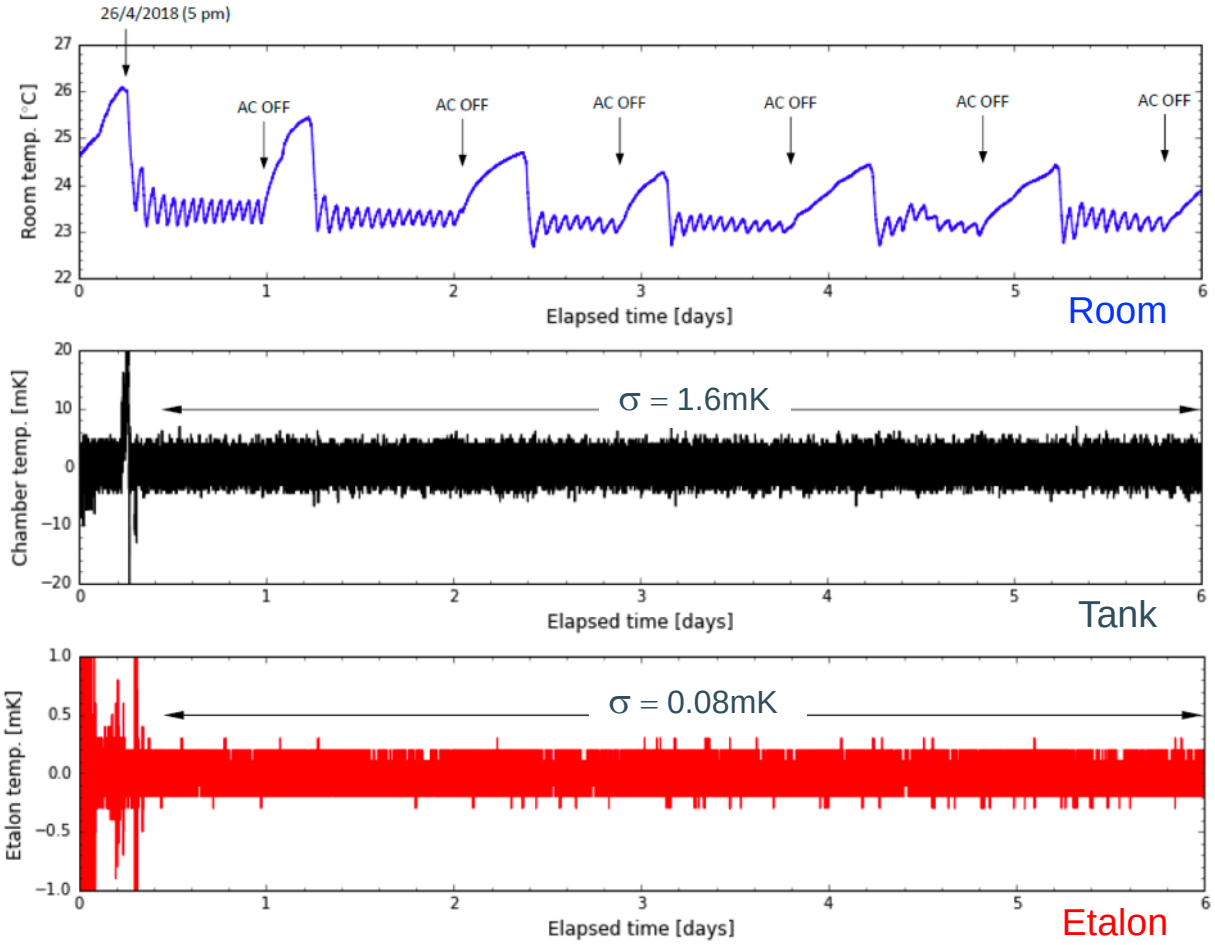
Passively stabilized FP etalon

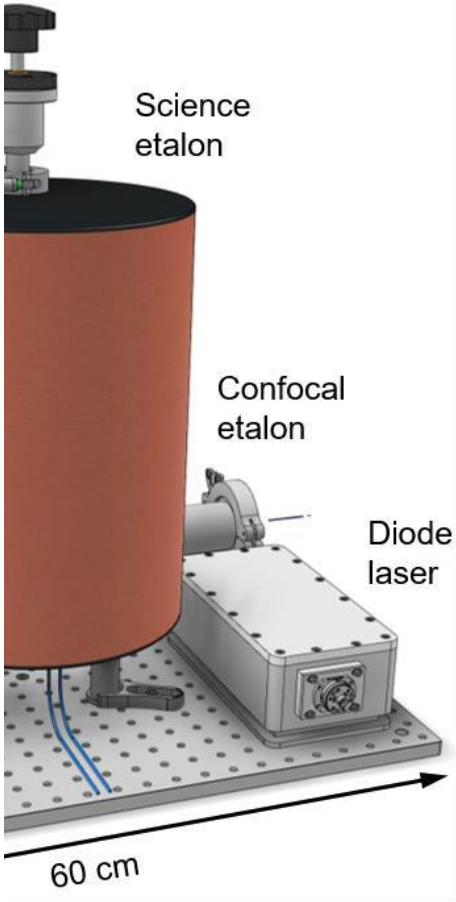
- Install etalon in temperature-controlled vacuum tank



Schwab et al. 2018

Passively stabilized FP etalon



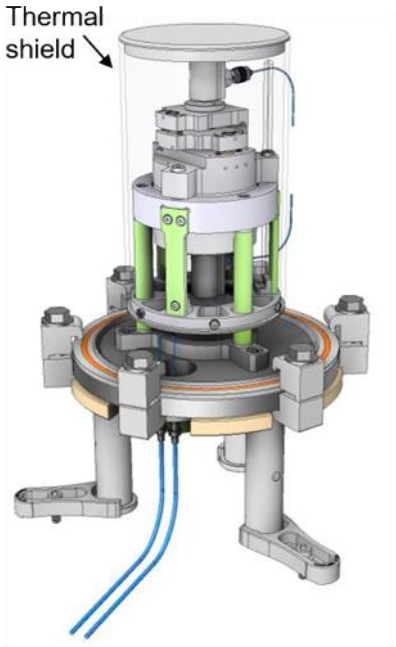


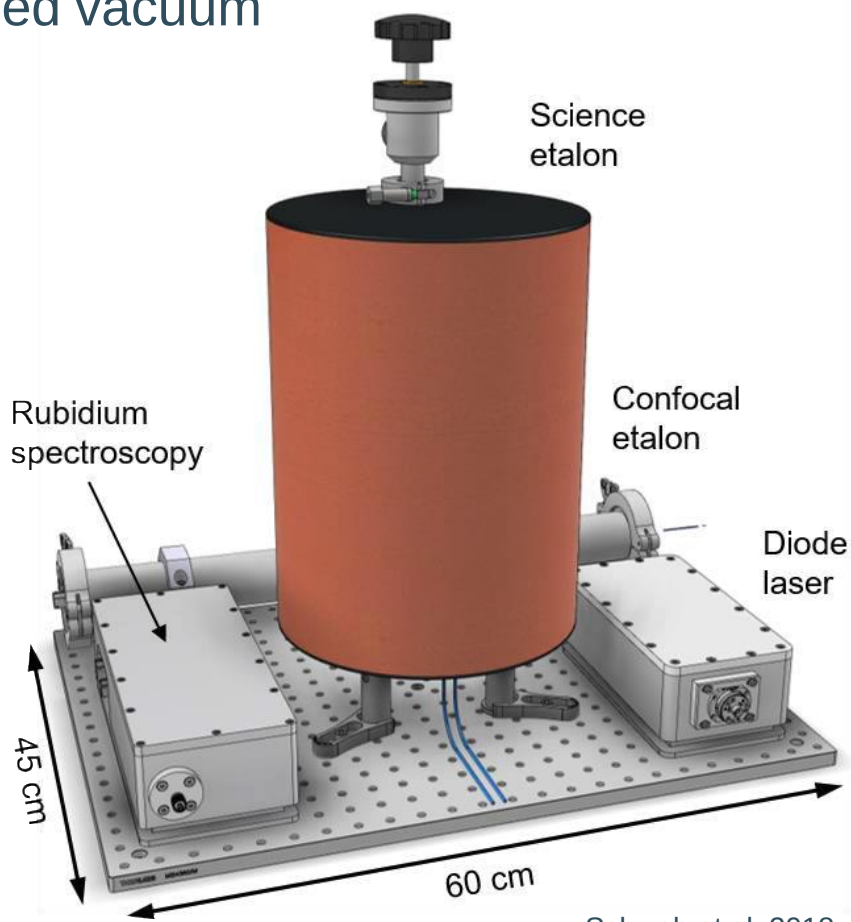
Schwab et al. 2018

Excellent **short-term** stability (~1 night)

Passively stabilized FP etalon

- Install etalon in temperature-controlled vacuum tank
- Stable etalon mount

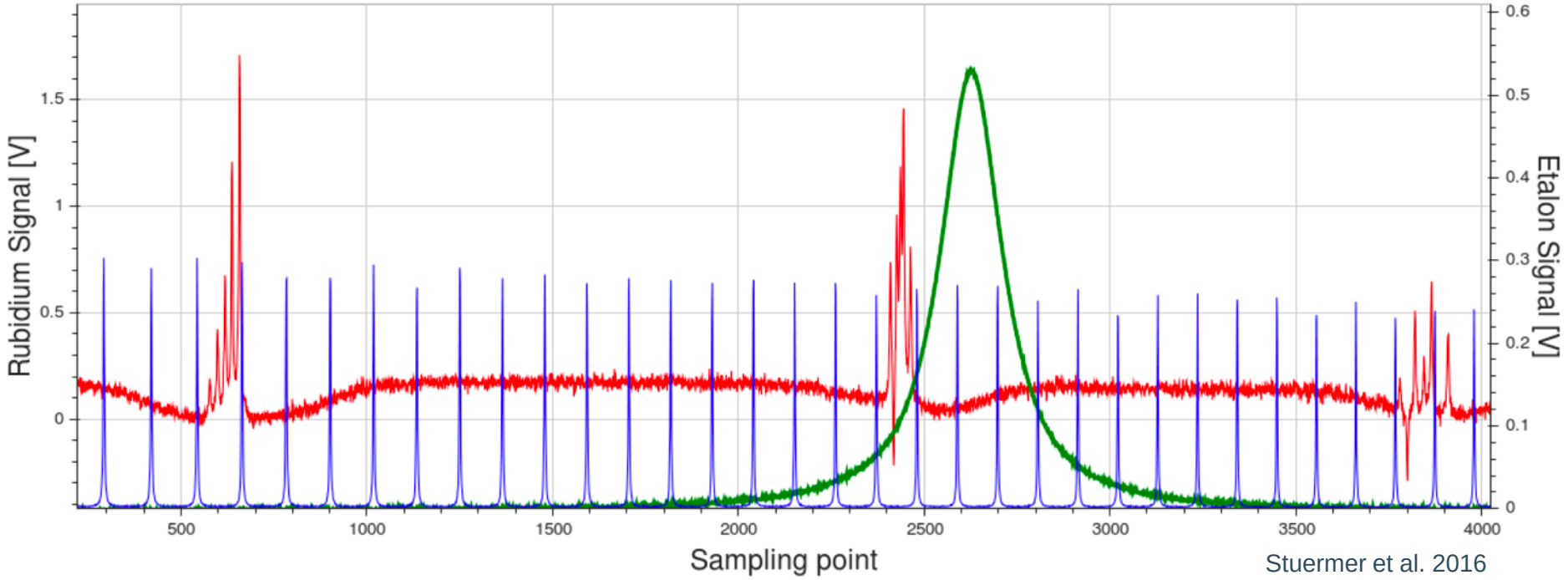




Schwab et al. 2018

Tracking FP etalon drifts

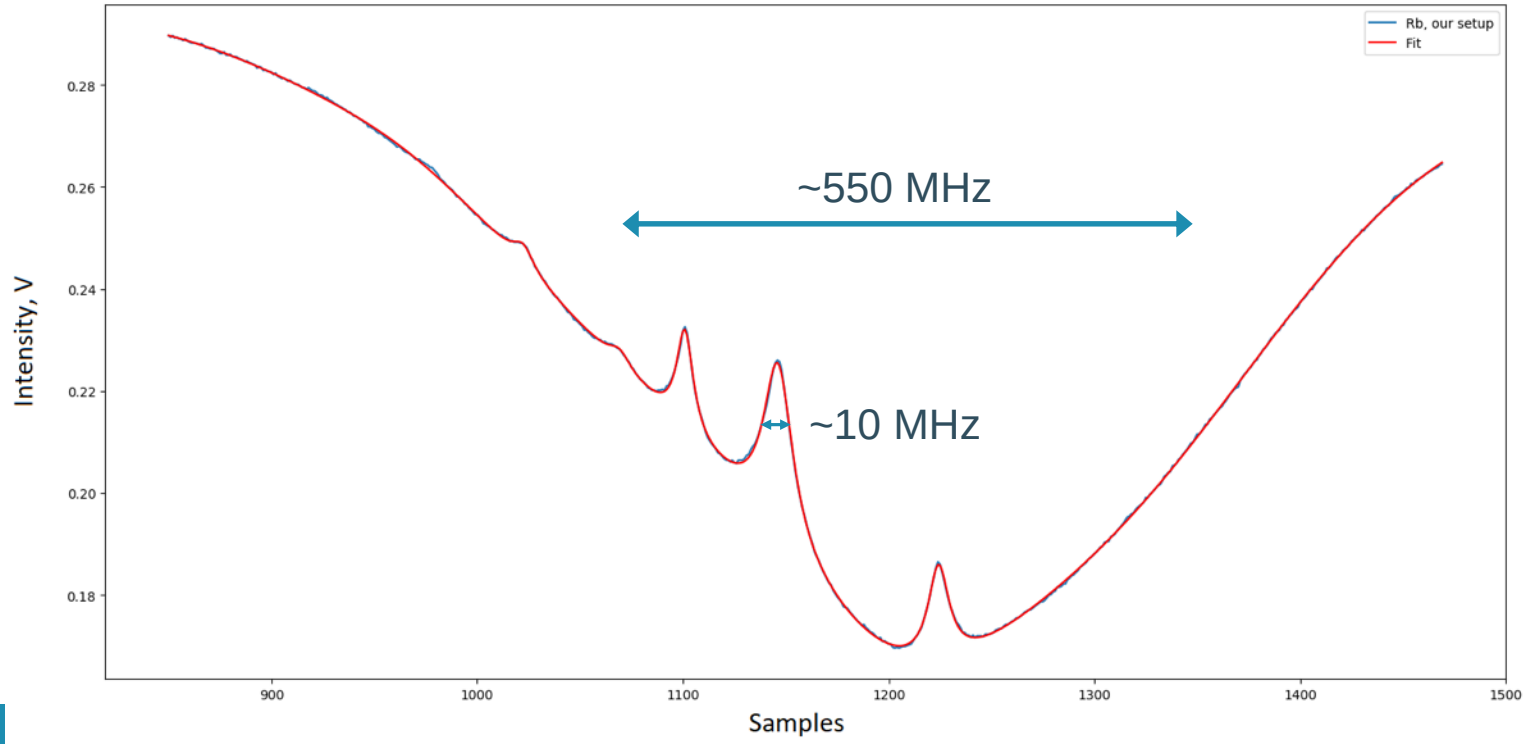
- Reference one FP line to an absolute scale, e.g. atomic transition:
  Hyper-fine lines of Rubidium D2 (780 nm)
- Scan Rb hyper-fine lines and etalon peak with tunable laser
- FP etalon peak accuracy: < **3 cm/s**



Stuermer et al. 2016

Laser spectroscopy

- Doppler broadening limits spectral resolution of Rb absorption lines
- **Saturated absorption spectroscopy** to measure Doppler-free hyper-fine transition lines
- PhD Dmytro Rogozin



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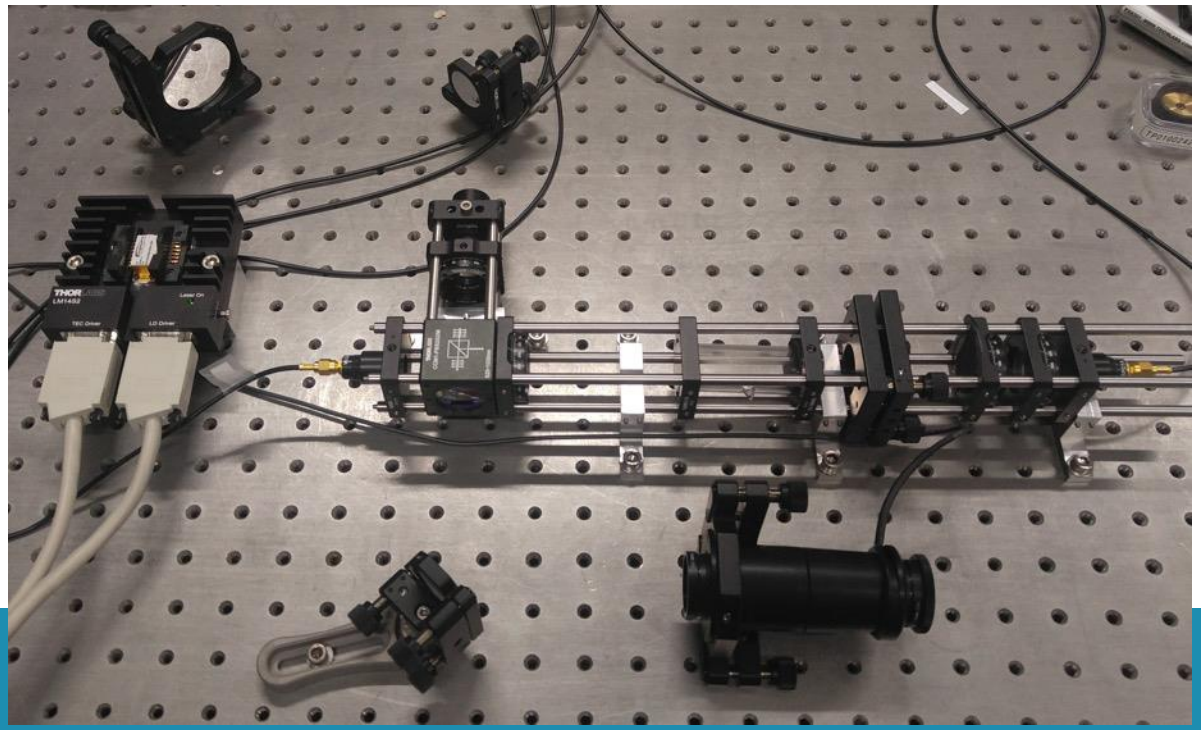
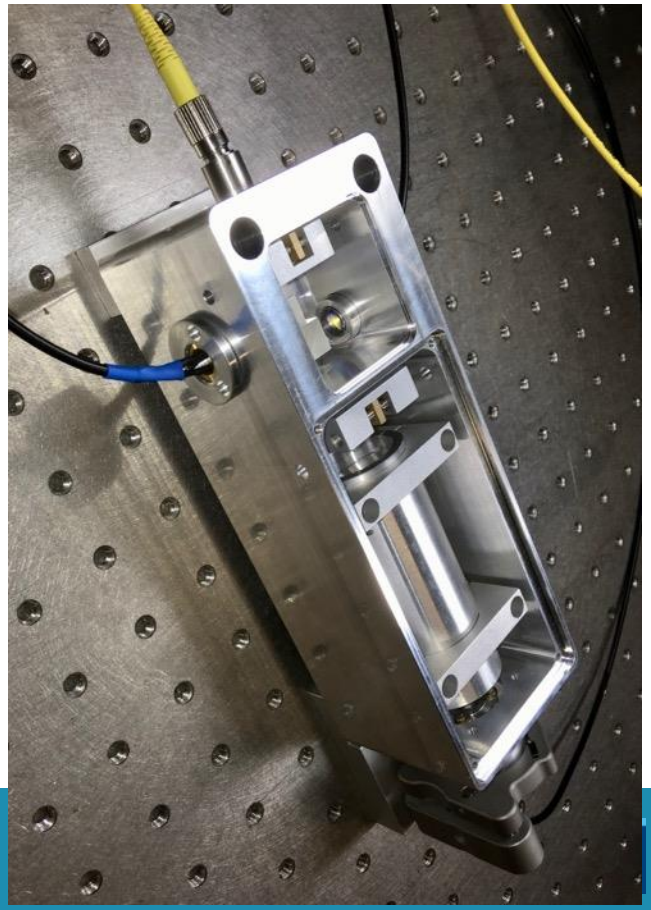
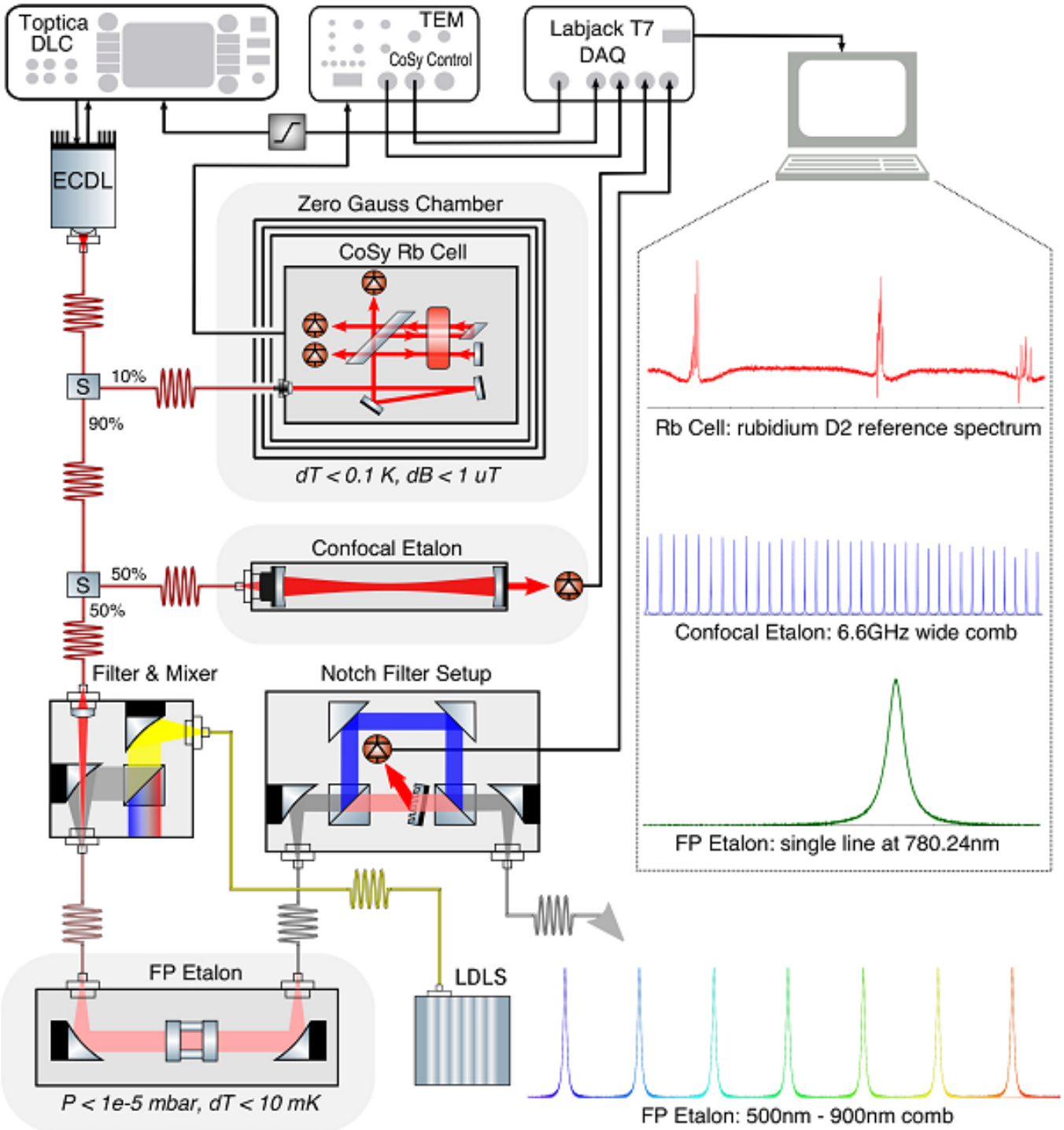


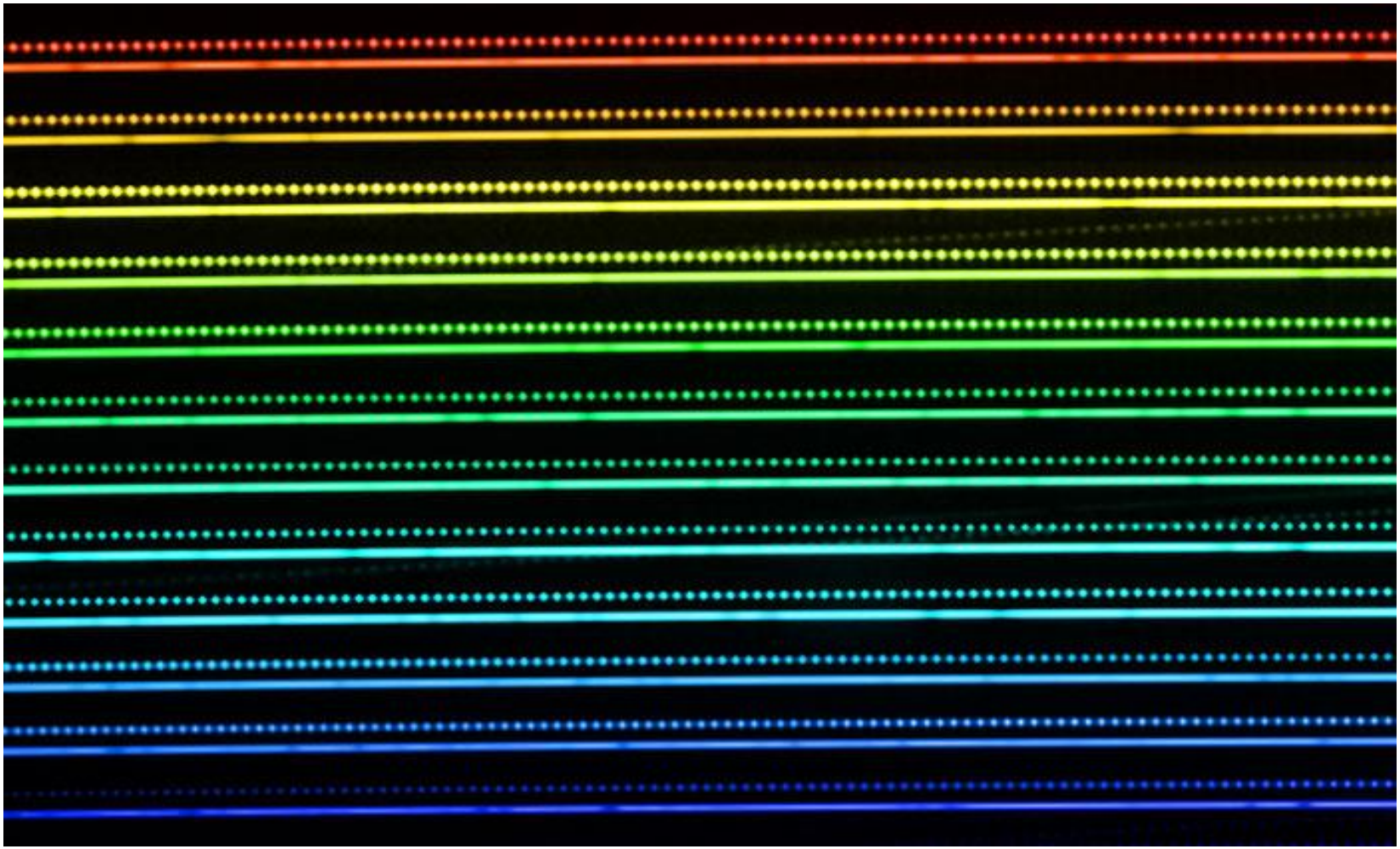


FP setup



Stuermer et al. 2016

Simultaneous FP spectrum simulation



Conclusion

- New fibre link: commissioned in July 2018
  Simultaneous Reference mode will follow shortly
- FP etalon wavelength calibration:
  Commissioning in 2020
  To be deployed a various observatories (LBT, Gemini, NOT, etc.)
- All HERMES observing programs will benefit from upgrades:
  - Higher throughput
  - Higher spectral resolution
  - Improved wavelength calibration
- RV-accuracy is / will become substantially better