Solar Chromospheric Detector for the Lomnicky peak Observatory:

towards synoptic imaging spectroscopy and spectro-polarimetry

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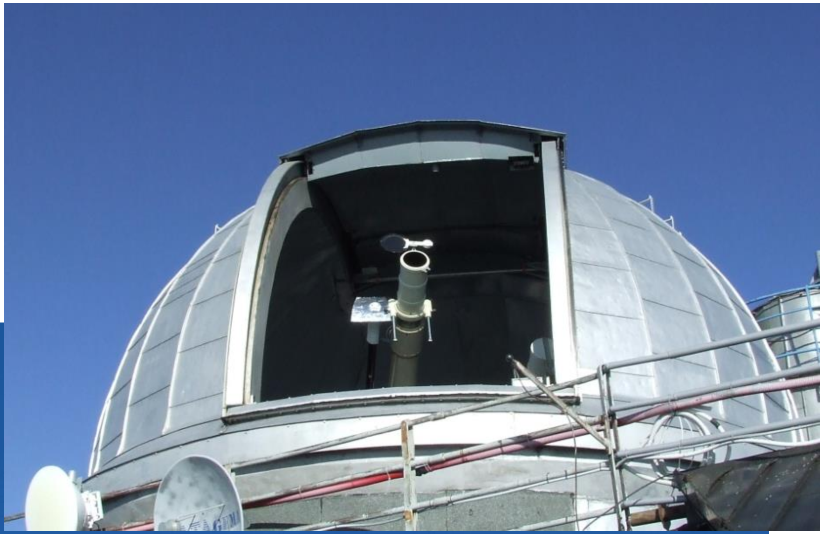
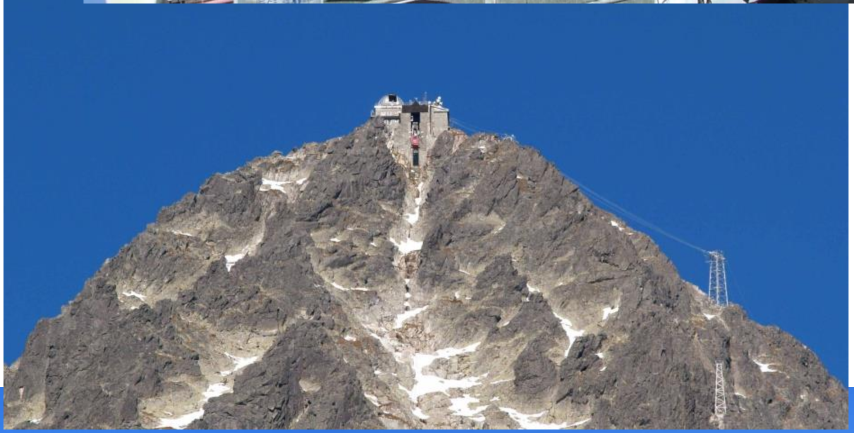
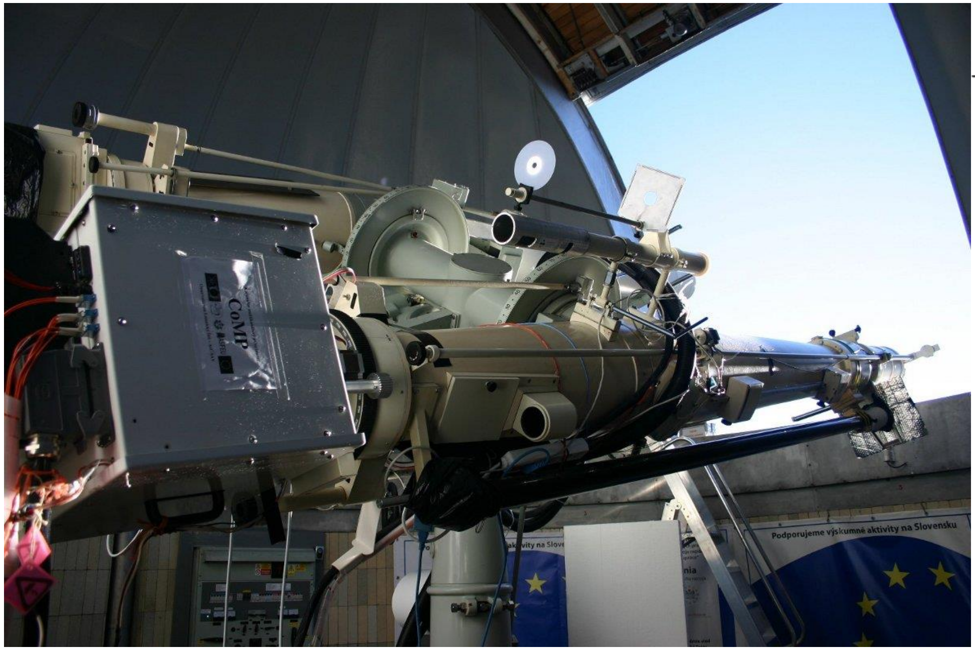
Lomnicky Peak Observatory



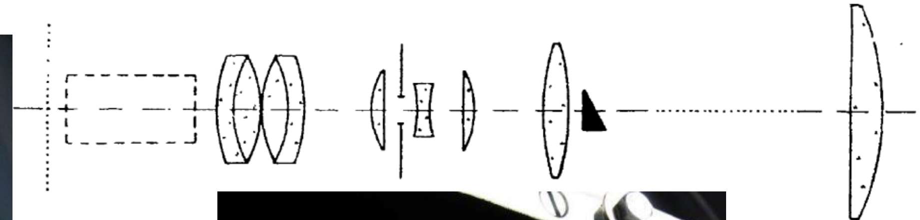
- 2633 m above see level on the 2nd highest peak of the High Tatras mountain in the North Slovakia
- one of a few sites still performing routine ground-based coronal observations

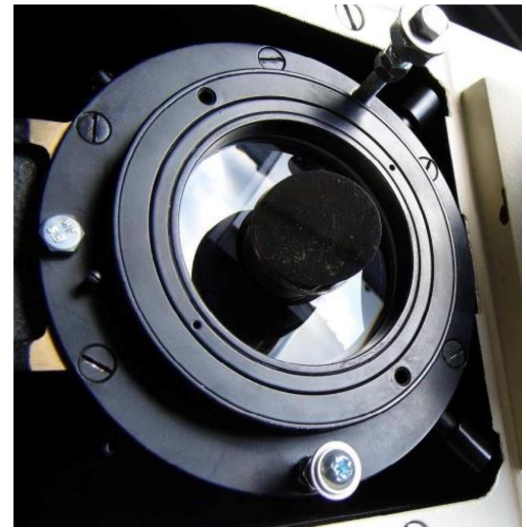


Zeiss coronagraphs



200-mm single-lens objective, f = 3000 mm





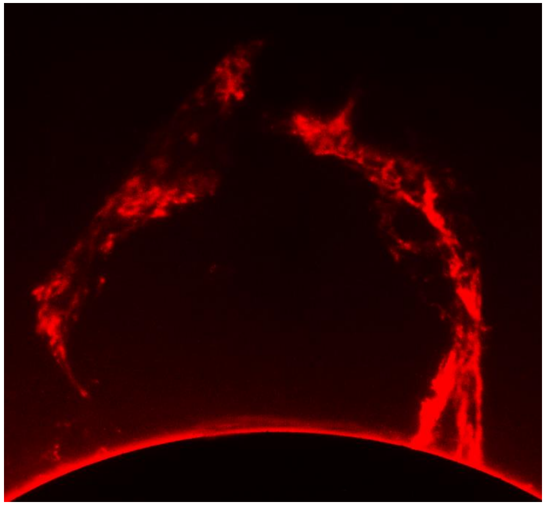
artificial moon in the field lens

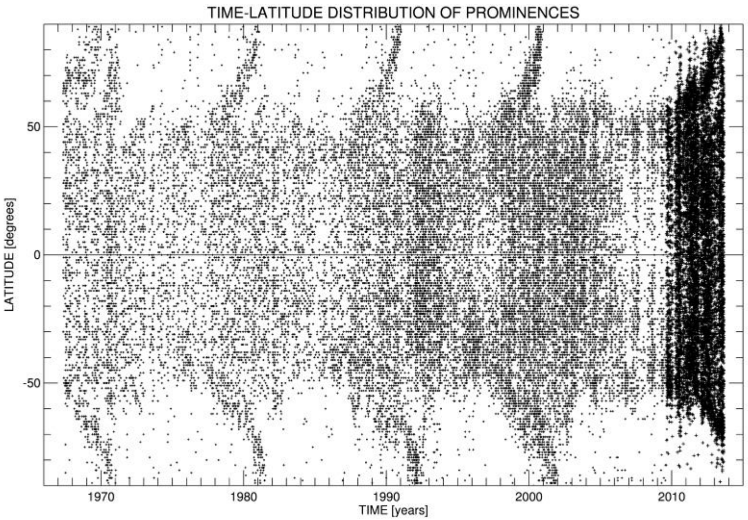
- two Zeiss 200/3000 coronagraphs on the common mount installed in 1961 and 1970
- optical twins, co-pointing precision of 2 arcsec → new align unit
- diffraction limited from 530 nm to 1100 nm
- focusing by moving the objective lens along the optical axis

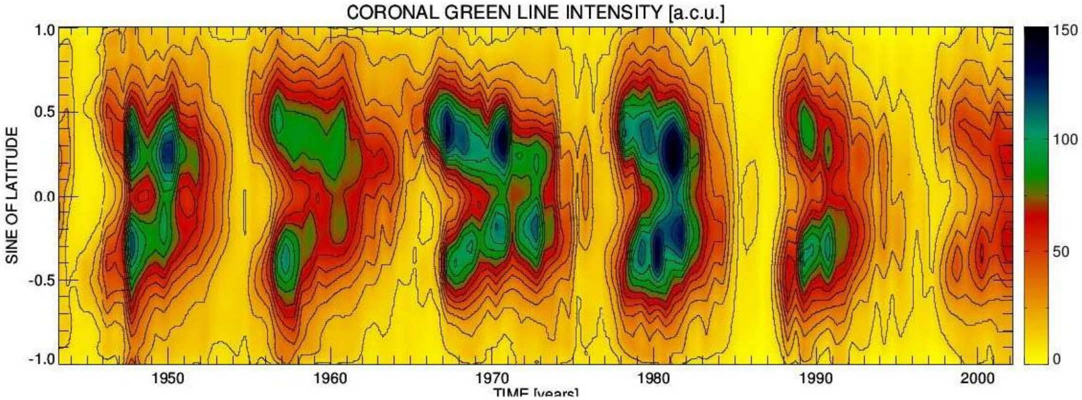
Achievements

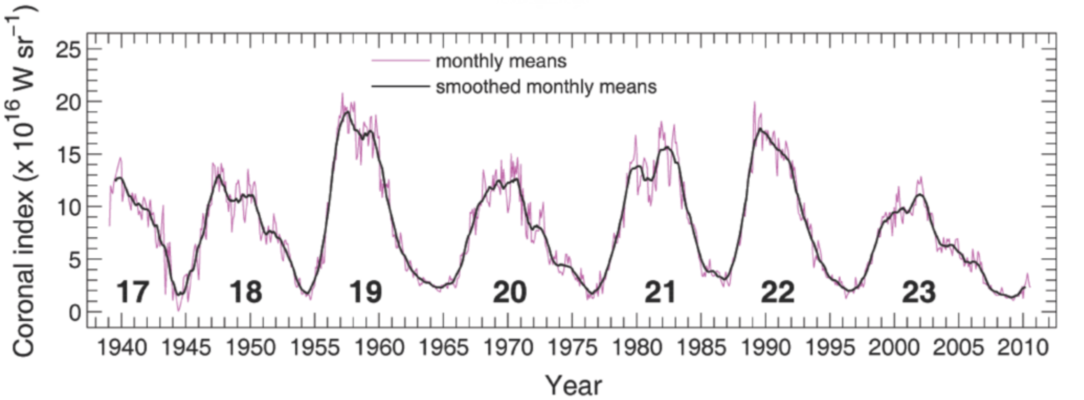
Long-term data sets of observations and catalogues of:

- prominences in Hα - since 2009 the data set continues using observations from the Kanzelhöhe Observatory (Austria)
- coronal green line (Fe XIV 530.3 nm) intensities and coronal index



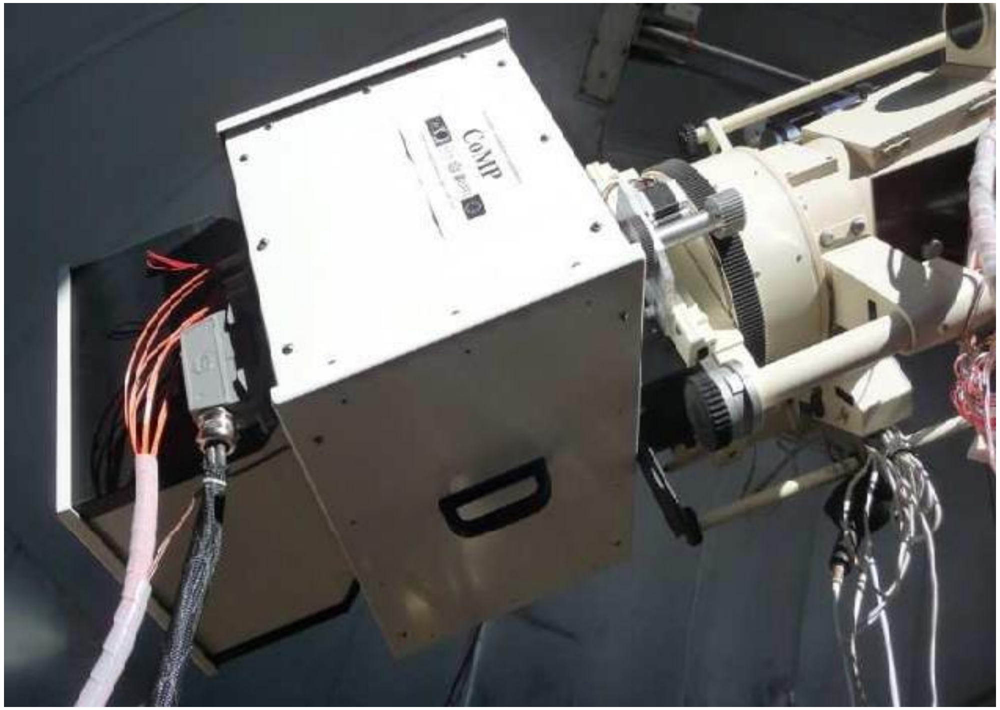






CoMP-S

- installed at Lomnicky peak Observatory in March 2011
- design and production: a team led by Dr. S. Tomczyk, HAO, NCAR, Boulder
- operating spectral range: 500 – 1100 nm
- field of view: 14 arcmin × 11 arcmin
- 4-stage tunable Lyot filter with polarimeter (two ferro-liquid crystal polarizers)
- sequential measurement of several VIS and near-IR lines
- expected deliverables: 2D full Stokes I, Q, U, V



SCD

- new challenge: **chromospheric dynamics and magnetism**
- why?
  - chromosphere - interface between the gas dominated photosphere and the magnetism dominated corona → observing the chromosphere is essential to understand the mass and energy balance of the outer solar atmosphere and the origins of solar activity
  - our models of chromospheric/coronal magnetism and eruptive phenomena rely almost exclusively on photospheric vector field measurements to extrapolate the magnetic lines into the corona → direct measurements of chromospheric magnetic fields needed for better description
- what is needed?
  - dynamic processes and phenomena in the chromosphere → high cadence observations at order of 10 seconds
  - the chromosphere is structured on very fine spatial scales (spicules, fibrils etc.) → observations should be taken with at least one arcsecond sampling
  - processes in the chromosphere → observations of the Doppler shifts and measurements of the chromospheric magnetic fields

  These requirements prefer filter-based instrument because a slit spectrograph is e.g. not capable of scanning the field at the required temporal cadence →
  Solar Chromospheric Detector (SCD)

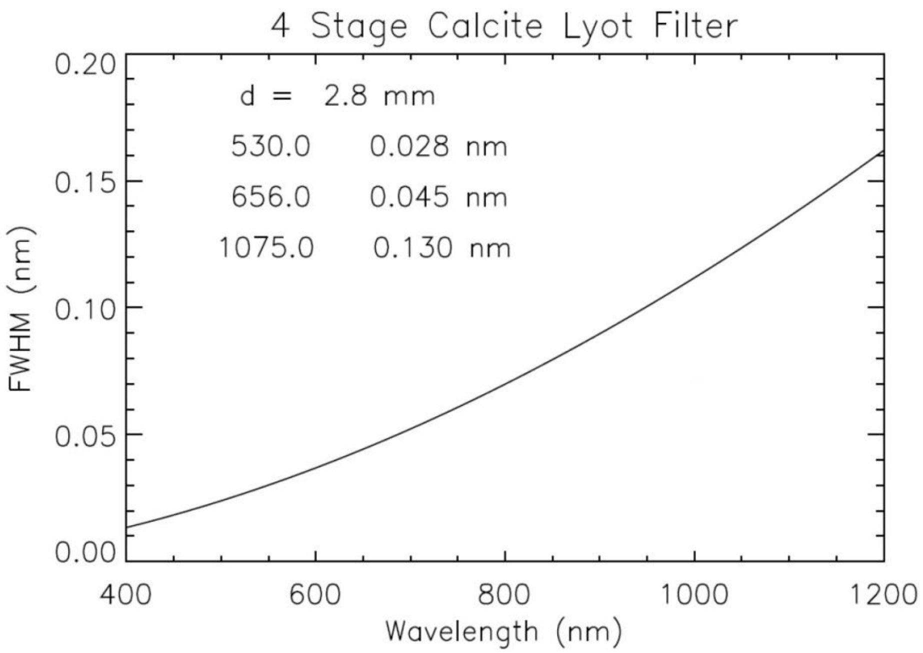
SCD

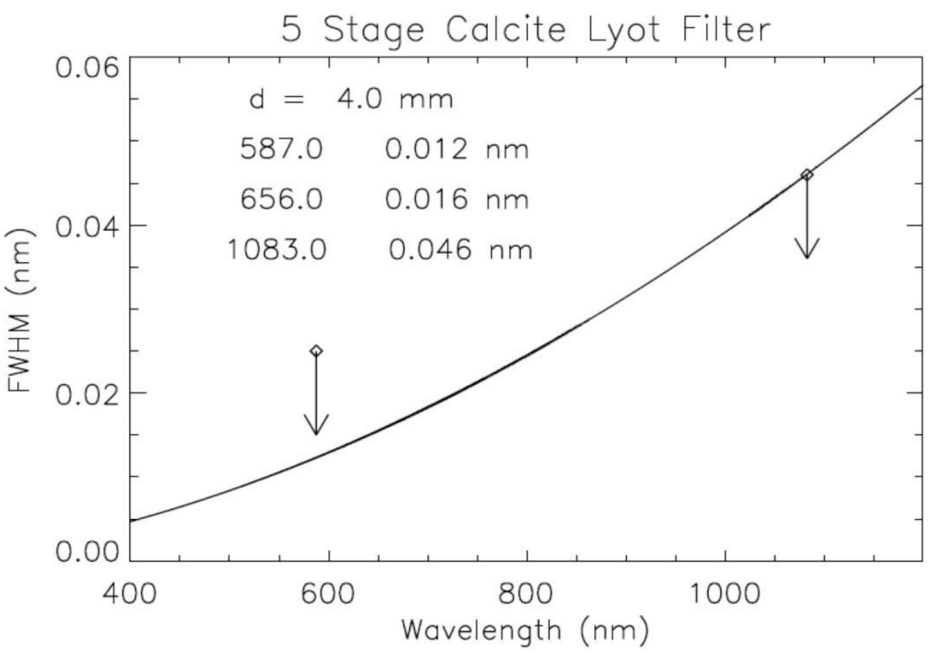
- **Solar Chromospheric Detector (SCD)**:
  - capable of observing the solar disk and prominences above the limb in a variety of spectral lines ranging in wavelength from 500 nm to 1100 nm
  - enable measurements of the complete polarization state across these solar lines providing information on the velocity field and vector magnetic field in the solar chromosphere
  - to be fabricated by team led by Dr. S. Tomczyk, HAO, NCAR, Boulder

- SCD derives its heritage from the ChroMag, CoMP and CoMP-S instruments but it is not their copy
- differences comparing to coronal polarimeters
  - the chromosphere is much cooler than the solar corona → chromospheric lines are significantly narrower in wavelength comparing to coronal ones → the filter for the SCD will need to have a finer spectral resolution that the coronal instruments by a factor of about three.

SCD

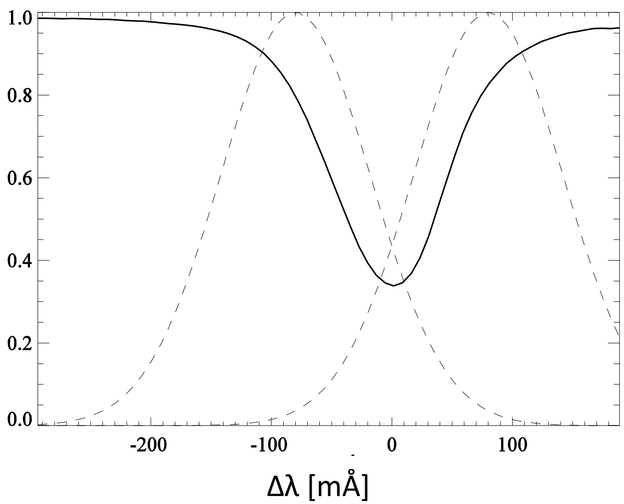
- differences comparing to coronal polarimeters

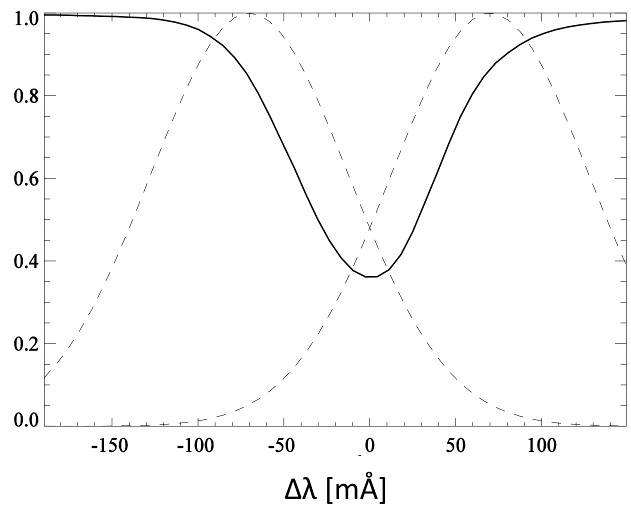


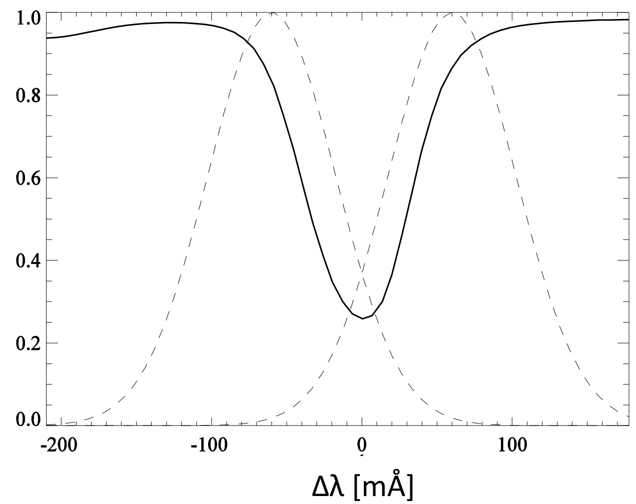


SCD

- photospheric observations?
  - Fe I 630.2 nm: performing on-board Hinode/SP (Landé factor g = 2.5)
  - Fe I 617.3 nm: performing on-board SDO/HMI (Landé factor g = 2.5)
  - Fe I 525.0 nm: performing on-board SUNRISE/IMAX (Landé factor g = 3)





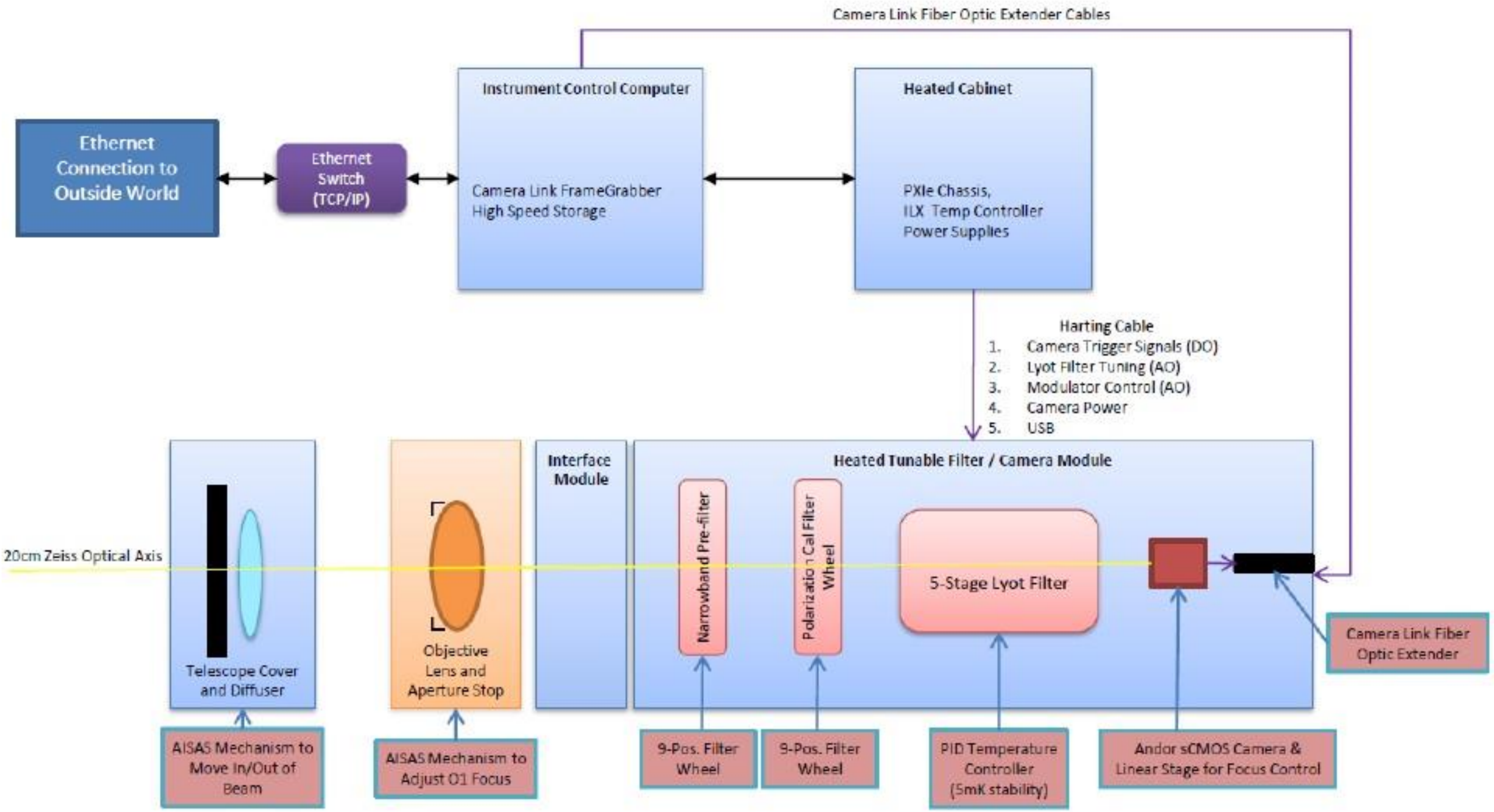


Fe I 630.2 nm:
- filter FWHM = 146 mÅ

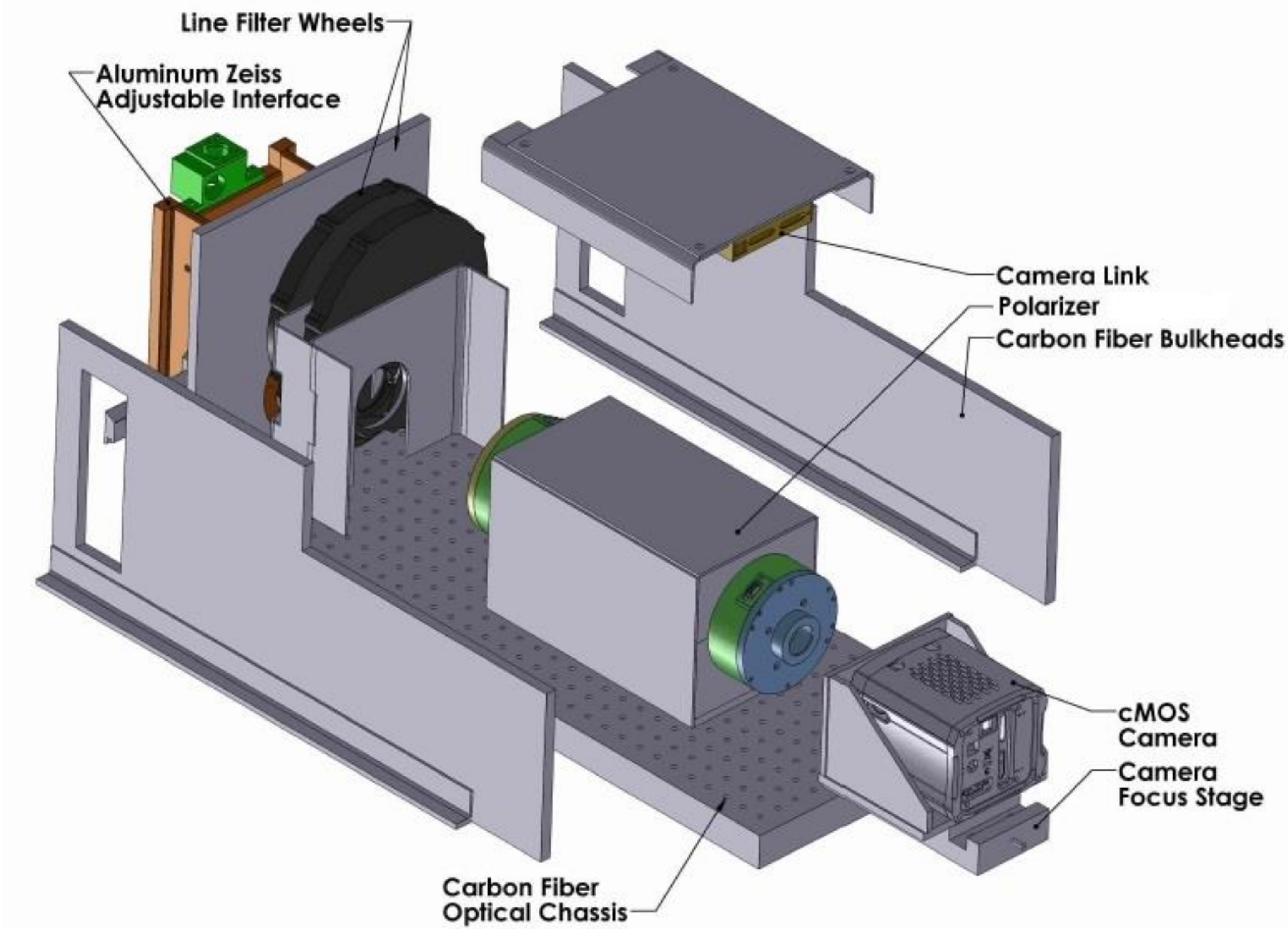
Fe I 617.3 nm:
- filter FWHM = 136 mÅ

Fe I 525.0 nm:
- filter FWHM = 100 mÅ

SCD: concept diagram



SCD: mechanical concept



SCD: technical details

- expected spatial resolution: 1 arcsecond
- expected temporal resolution: 10 seconds (for 10 positions across the line profile)
- spectral coverage: 500 nm to 1100 nm
- selected spectral lines:

  chromosphere
  - He I D3 587.6 nm: chromospheric magnetism at the limb
  - Hα 656.3 nm: principal chromospheric diagnostic
  - Ca II 854.2 nm: chromospheric Doppler mapper, an indicator of chromospheric heating
  - Ca II 866.2 nm: similar to Ca II 854.2 nm, but more sensitive
  - He I 1083.0 nm chromospheric magnetism

  photosphere?
  - Fe I 630.2 nm: performing on-board Hinode/SP (Landé factor g = 2.5)
  - Fe I 617.3 nm: performing on-board SDO/HMI (Landé factor g = 2.5)
  - Fe I 525.0 nm: performing on-board SUNRISE/IMAX (Landé factor g = 3)

  photosphere/low chromosphere
  - Ba II 649.7 nm quasi-Doppler line with a small Landé factor g = 0.83

- field-of-view: full solar disk or 835 x 692 arcseconds (under discussion)
- detector: Andor Neo 5.5 sCMOS camera with 2560 x 2120 pixels of 6.5 microns

Summary

- 2D wide-field chromospheric polarimeter SCD is planned for the Lomnicky peak Observatory
- expected data: high-cadence full Stokes observations taken with at least 1 arcsecond spatial and 10 s temporal resolution → dynamics and magnetism in chromosphere
- combination of the data-sets acquired by SCD with the coronal data provided by Coronal Multi-channel Polarimeter (COMP-S) → complex observations of the upper solar atmosphere
- expected synergy with the space-born observatories SDO and STEREO by providing behind imagery also Dopplershifts , spectral widths, and full Stokes vector

References

Kučera et al. 2010: Contrib. Astron. Obs. Skalnaté Pleso, 40, 135 – COMP-S
Lexa, J. 1963: Bulletin of the Astronomical Institute of Czechoslovakia, 14, 107 – coronagrph