Work with the CoMP-S instrument at the Lomnicky Peak Observatory

Matúš Kozák

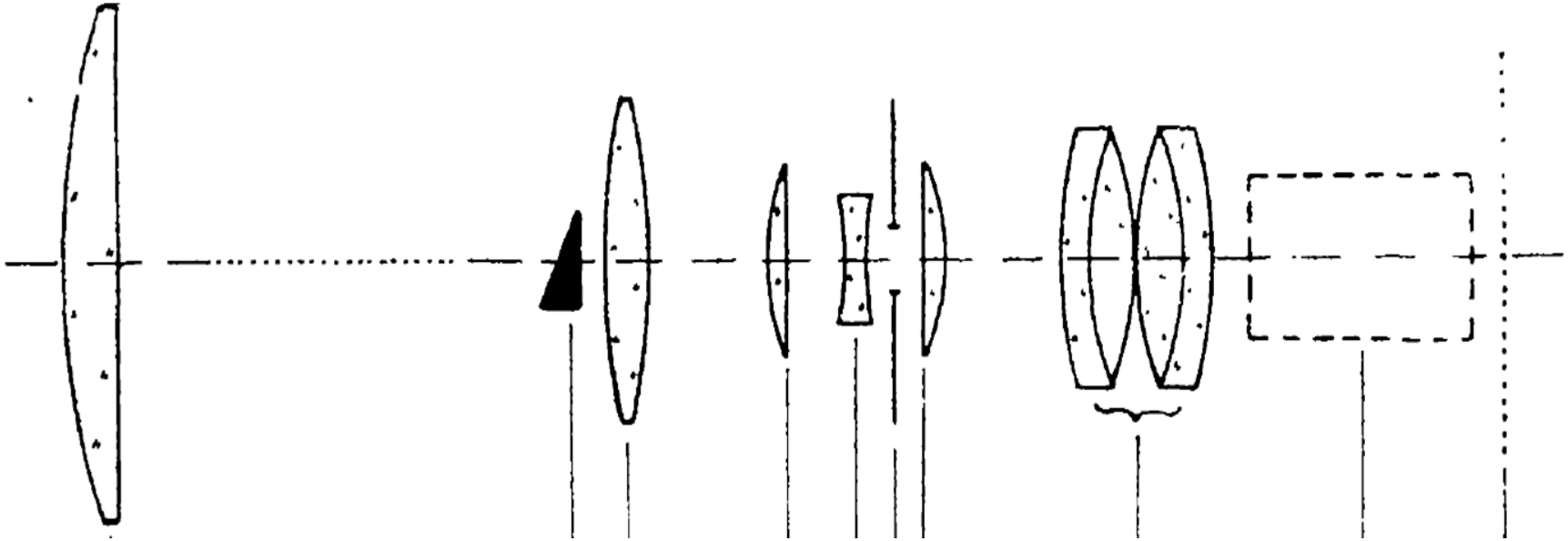
2nd SOLARNET School: "Ground- and space- based solar instruments",
Tatranska Lomnica (Slovakia), October 5-16, 2014

Lecture content

- LSO Zeiss coronagraphs
- LSO instrumentation
- LSO future plans

LSO Zeiss coronagraphs

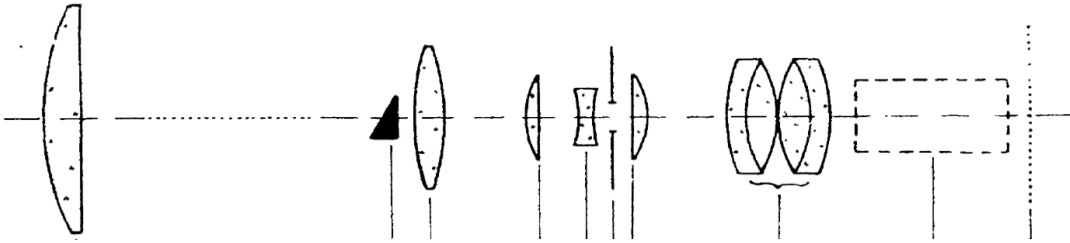
LSO Zeiss coronagraphs

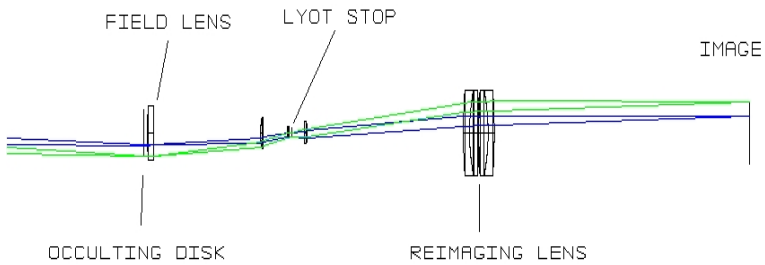


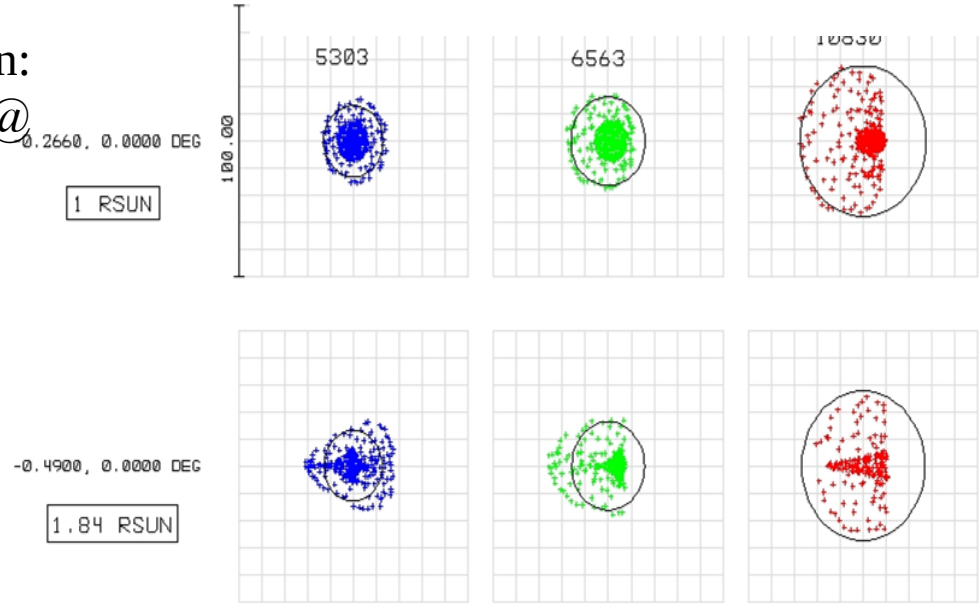
Lexa, J., 1963, BAC ***14****, 107*

LSO Zeiss coronagraphs

- Carl Zeiss Jena (GDR)
- Lyot type
- primary single objective lens
- artificial moon
- single field lens
- 3 corrective single lenses
- Lyot stop
- achromatic reimaging lenses
- diffraction limited: 530 - 1100 nm
- theoretical spatial resolution: 0.7”@530nm,0.8”@656nm, 1.4”@ 1083nm
- post-focus instrument:
  - rotation parallel to optical axis
  - variable offset to optical axis
  - variable focusing along op. axis
- only as individual instruments







Lexa, J., 1963, BAC ***14****, 107*

LSO instrumentation

CoMP-S (with PDSS)
pointer R
CorMag
pointer H
(SCD)

LSO: CoMP-S

- **The Coronal Multi-channel Polarimeter for Slovakia – CoMP-S**

- **Main feature:** wavelength range: **500 – 1100 nm** allowing spectropolarimetric measurements of several VIS + near-IR emission chromospheric and coronal emission lines (CoMP only 1070-1090nm)

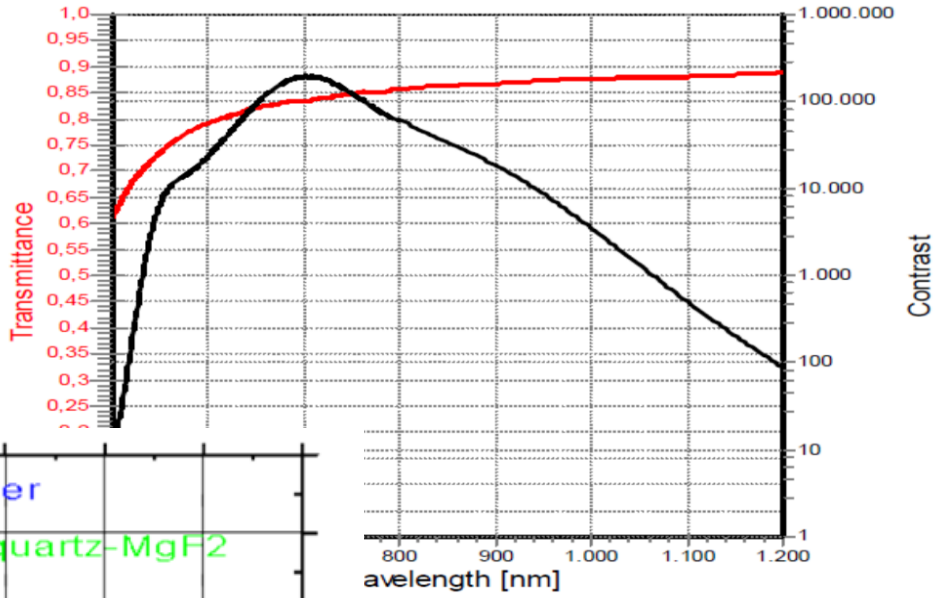
- **Other specifications:** not a full-disk FoV, simultaneous imaging of a 2D area, sequential data acquisition in wavelength and polarization, a refocusing needed when the spectral line is changed

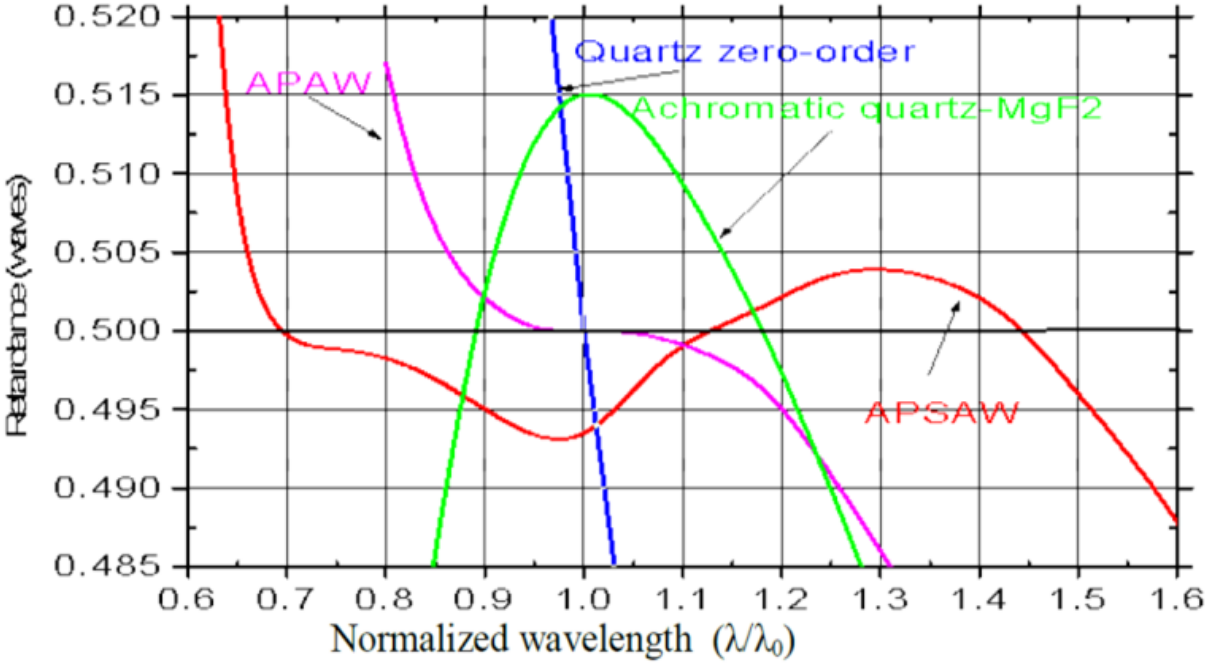
LSO: CoMP-S

- Advances in broadband polarizers and super-achromatic waveplates ...

  - polarizer material:
    VIS700BC4 by CODIXX
    more than ~70% transmission

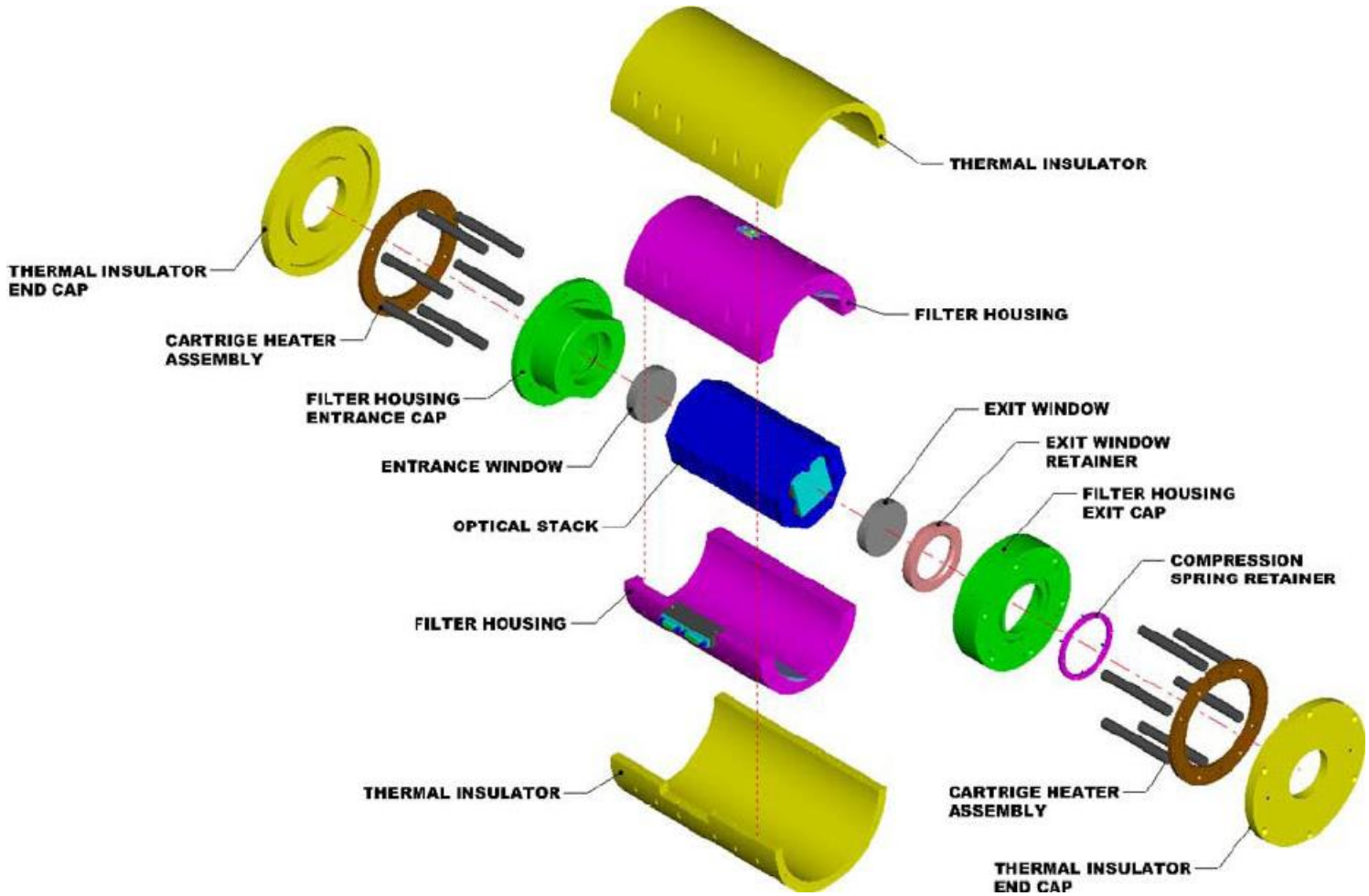
  - super-achromatic λ/2 plates:
    APSAW by ASTROPRIBOR
    range: 0.7- 1.5 $\lambda_{nominal}$





LSO: CoMP-S filter

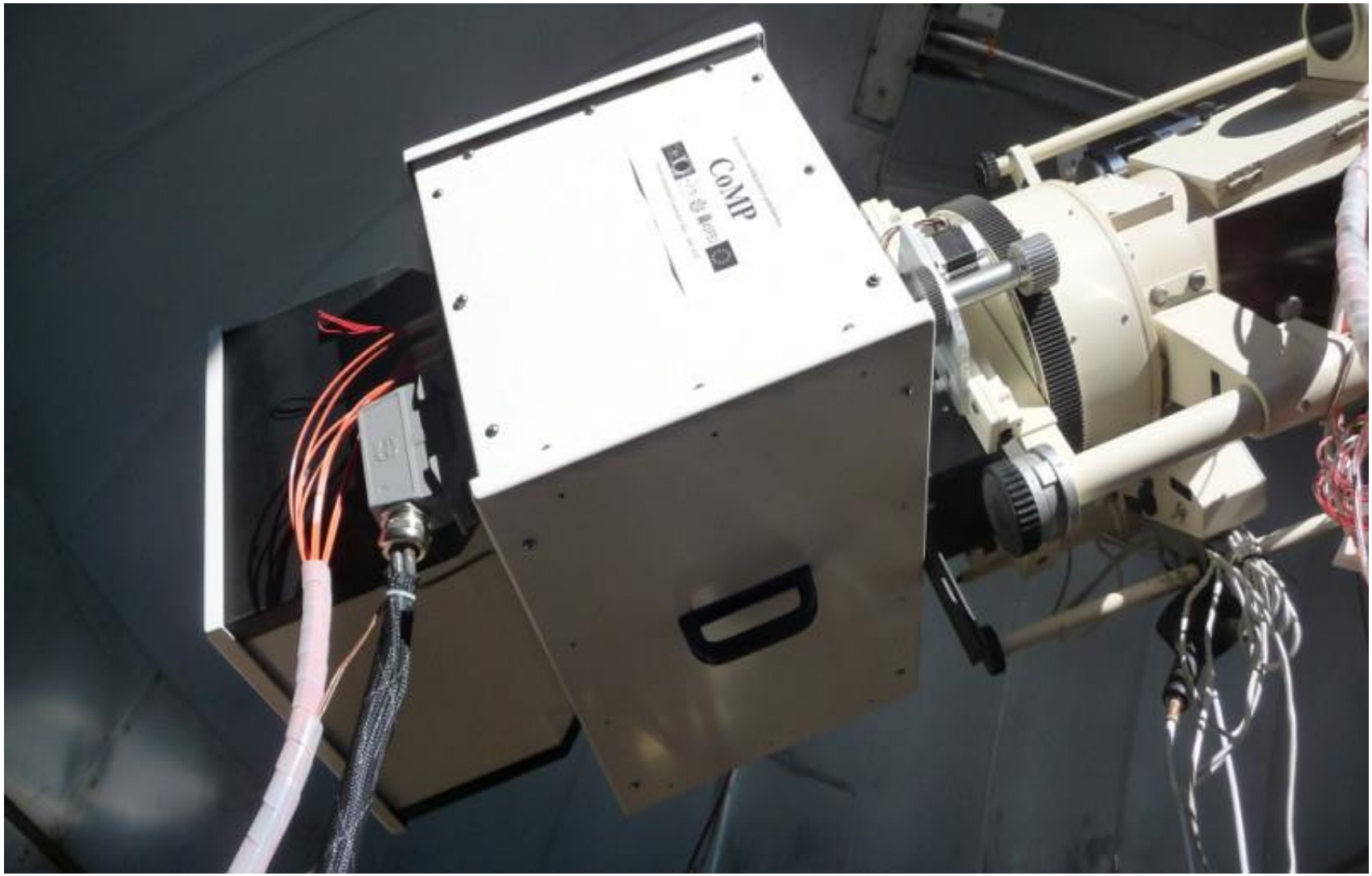
- 4-stage Lyot filter, diameter: 30mm for an unvignetted FoV
- temperature stabilization



Exploded view of the CoMP filter/polarimeter

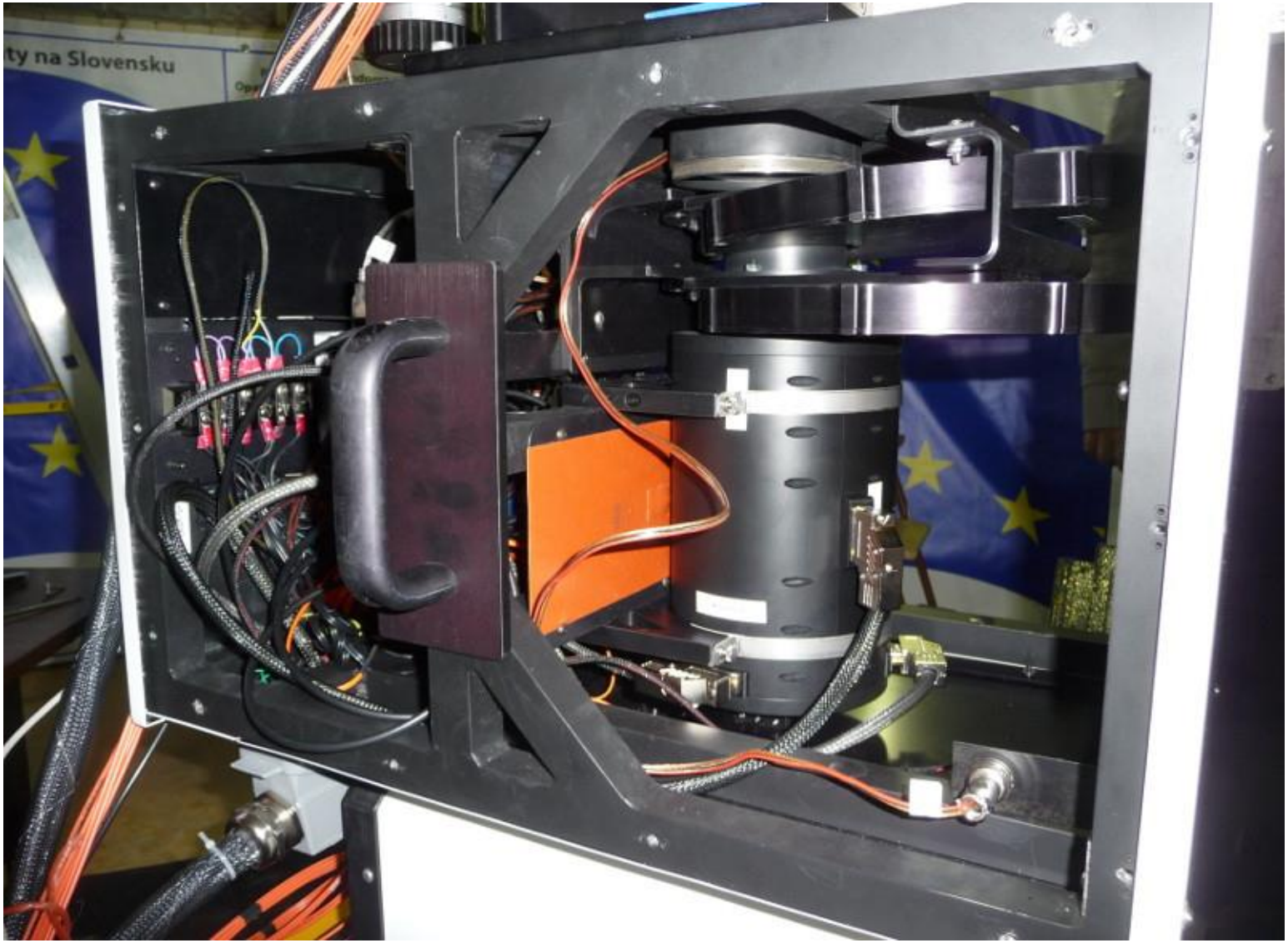
LSO: CoMP-S

Main modules: mechanical interface, filter module, camera module, ...



LSO: CoMP-S

Main modules: filter module



LSO: CoMP-S

Main modules: camera module

LSO: CoMP-S

CoMP-S briefly:

- installed in March 2011
- regular observations since May 2013

- 4 stage wide-field tunable Lyot filter, FLC polarimeter
- strategy: 2 orthogonal pol. states in shifted bandpasses simultaneously
- selected emission lines:

  corona: Fe XIV 530.3nm, Ca XV 569.5nm, Fe X 637.5nm,
  Fe XI 789.2nm, *Fe XIII 1074.7nm, 1079.8nm*

  prominences: He I 587.6nm, H I 656.3nm, Ca II 854.2nm,
  He I 1083.0nm

- deliverables: 2D I (A,v,w), *2D full Stokes I, Q, U, V*

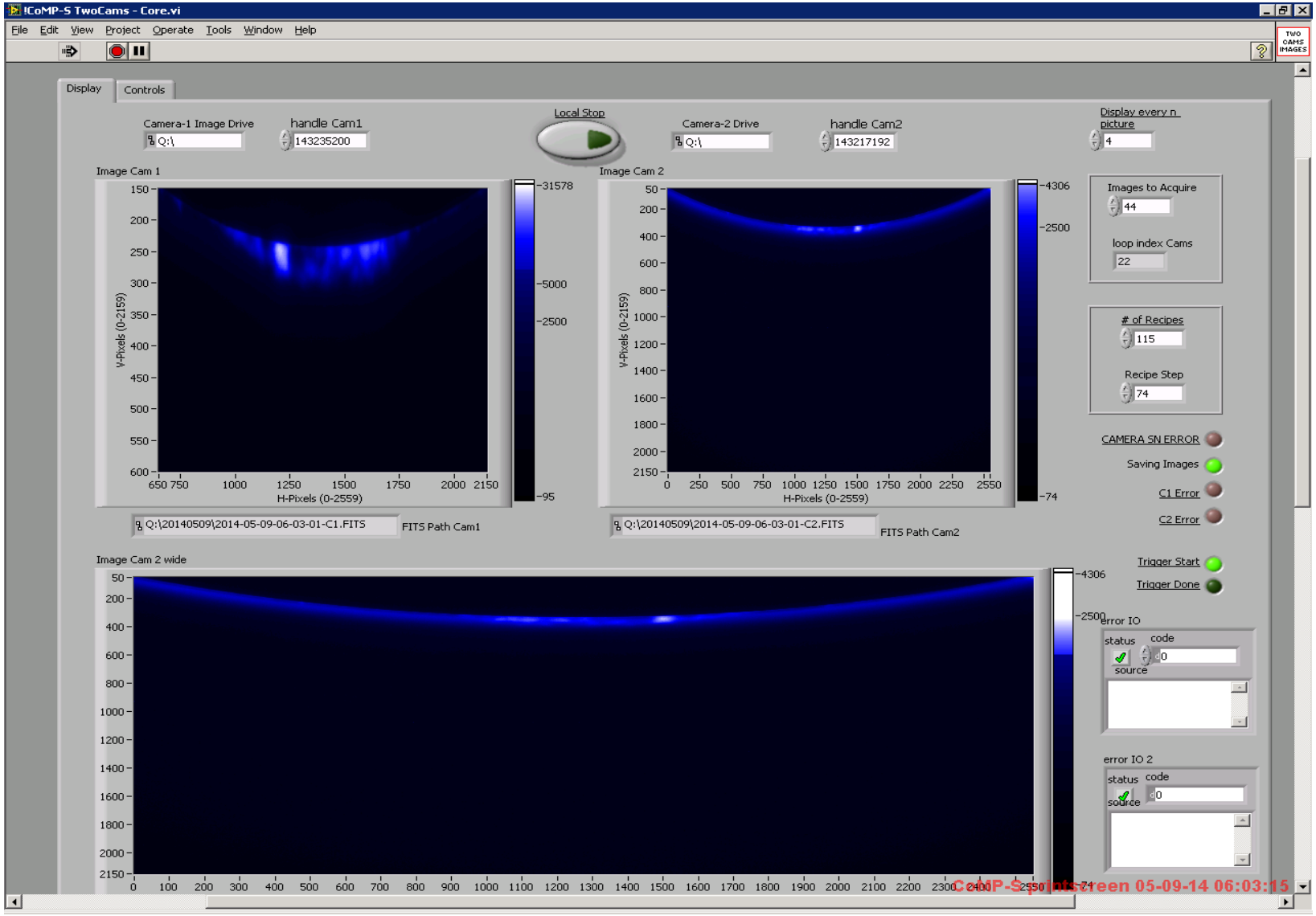
- FoV: ~860” x 680”, diffraction limited (0.33”/pixel @ 656.3nm)

- FWHM: 0.028 - 0.13 nm (530 – 1083nm)

- typical exposure times: ~100 ms – prominence lines
  ~1 s – coronal lines
- wavelength tuning time : ~0.2 s
- polarization change time: ~30 ms

LSO: CoMP-S

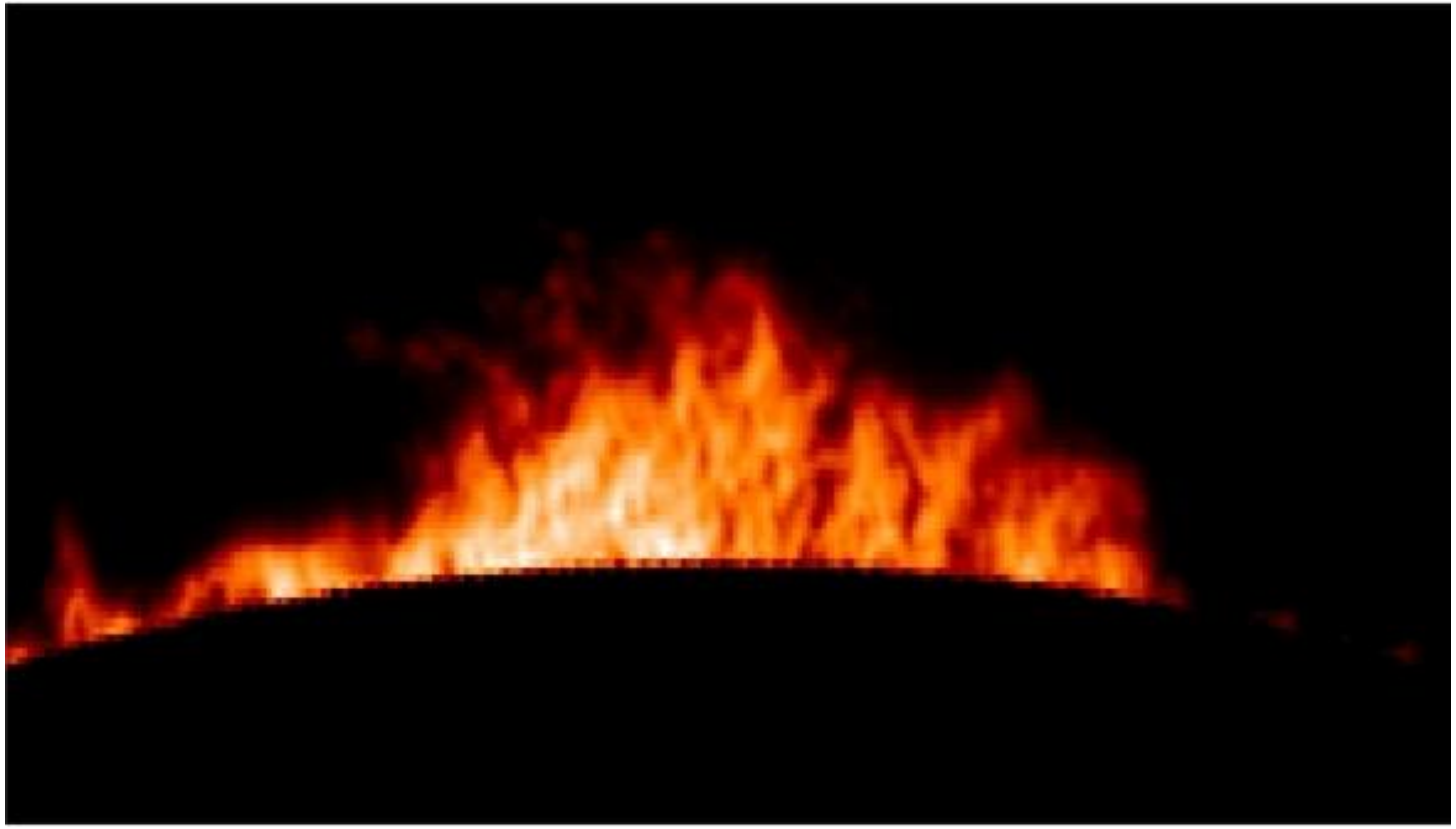
Example of the Labview control program GUI – 9/5/2014:



LSO: CoMP-S

Hα quiescent prominence – Oct 20, 2012, 07:09 UT:

- HOP 186 „Mass loading of quiescent prominences from multi-wavelength observations“
- Hα line profile: 11 wavelength settings, only Stokes I parameter presented
- Exposure time: 50 ms, total scan time: 20.75 s, wavelength steps: core: 0.1 Å, wings: 0.2 Å
- post-facto 4 x 4 pixel binning to final sampling: 1.3 arcsec/px
- Gaussian fitting of 11 samples of the H alpha profiles: **amplitude**



LSO: CoMP-S

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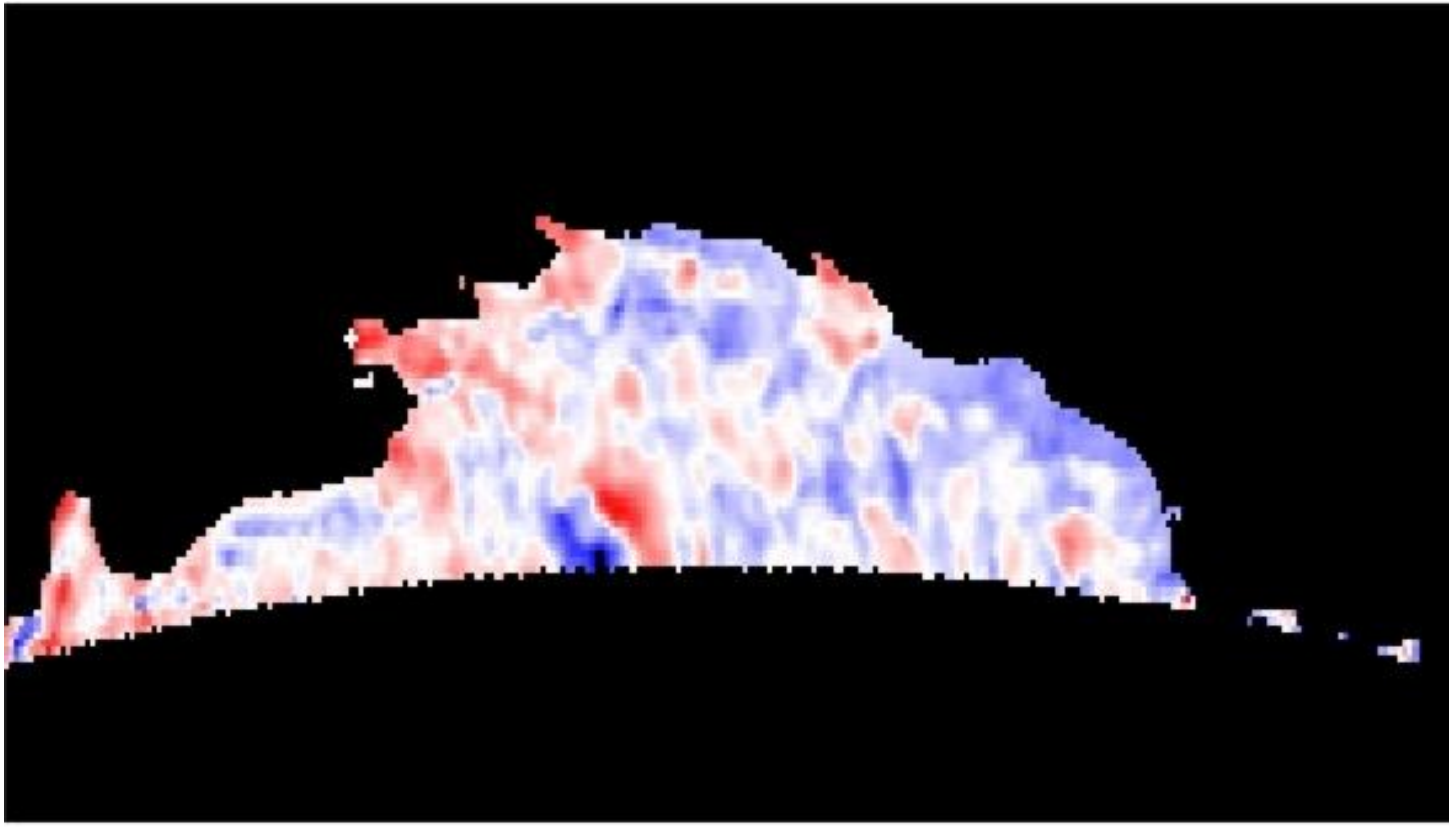
- post-facto 4 x 4 pixel binning to final sampling: 1.3 arcsec/px
- Gaussian fitting of 11 samples of the H alpha profiles: **dopplershifts [+/-12 km/s]**



LSO: CoMP-S

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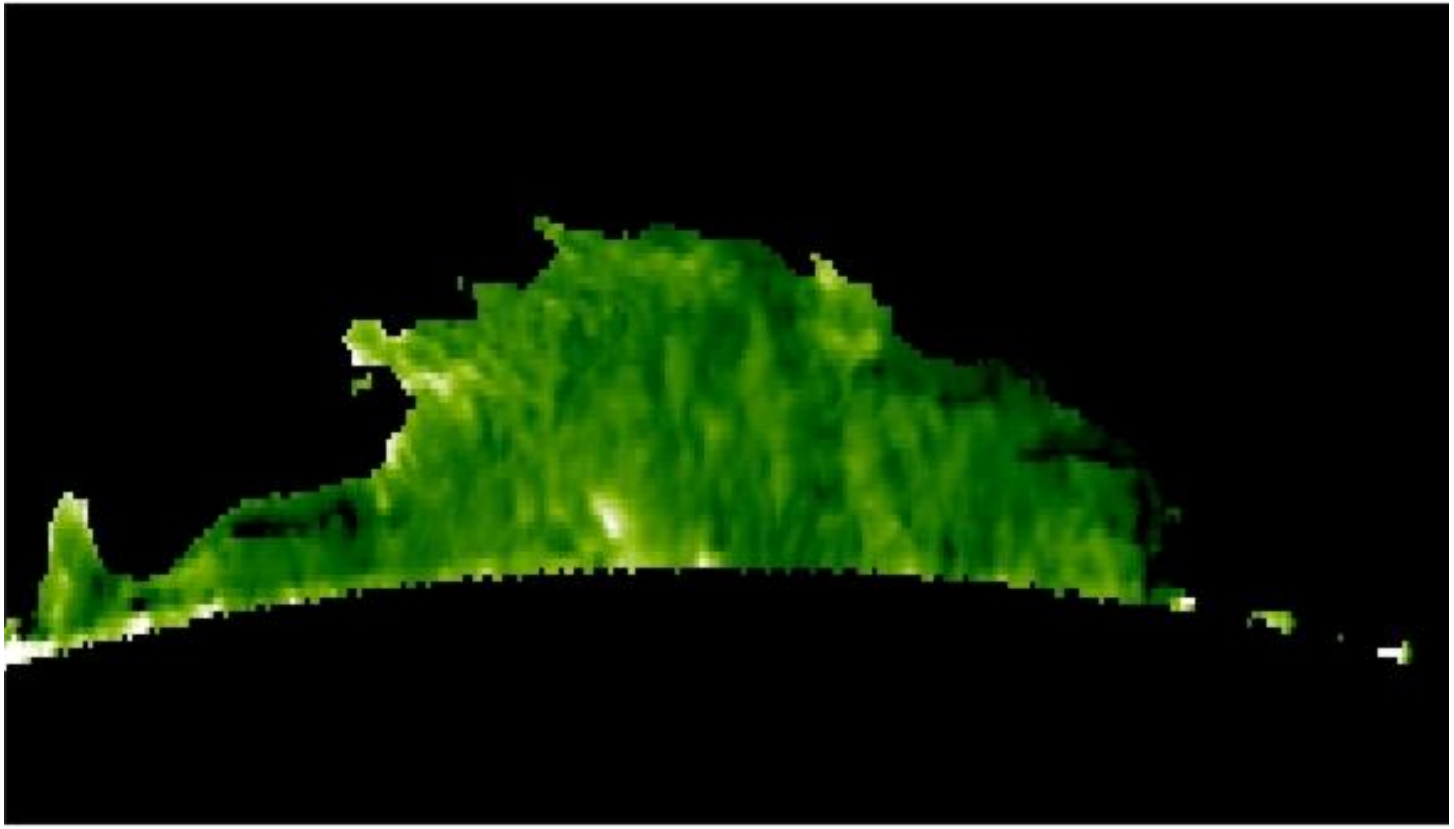
- post-facto 4 x 4 pixel binning to final sampling: 1.3 arcsec/px
- Gaussian fitting of 11 samples of the H alpha profiles: **Gaussian width [0.020-0.045 nm]**



LSO: CoMP-S

Hα quiescent prominence – Oct 20, 2012, 07:09 UT:

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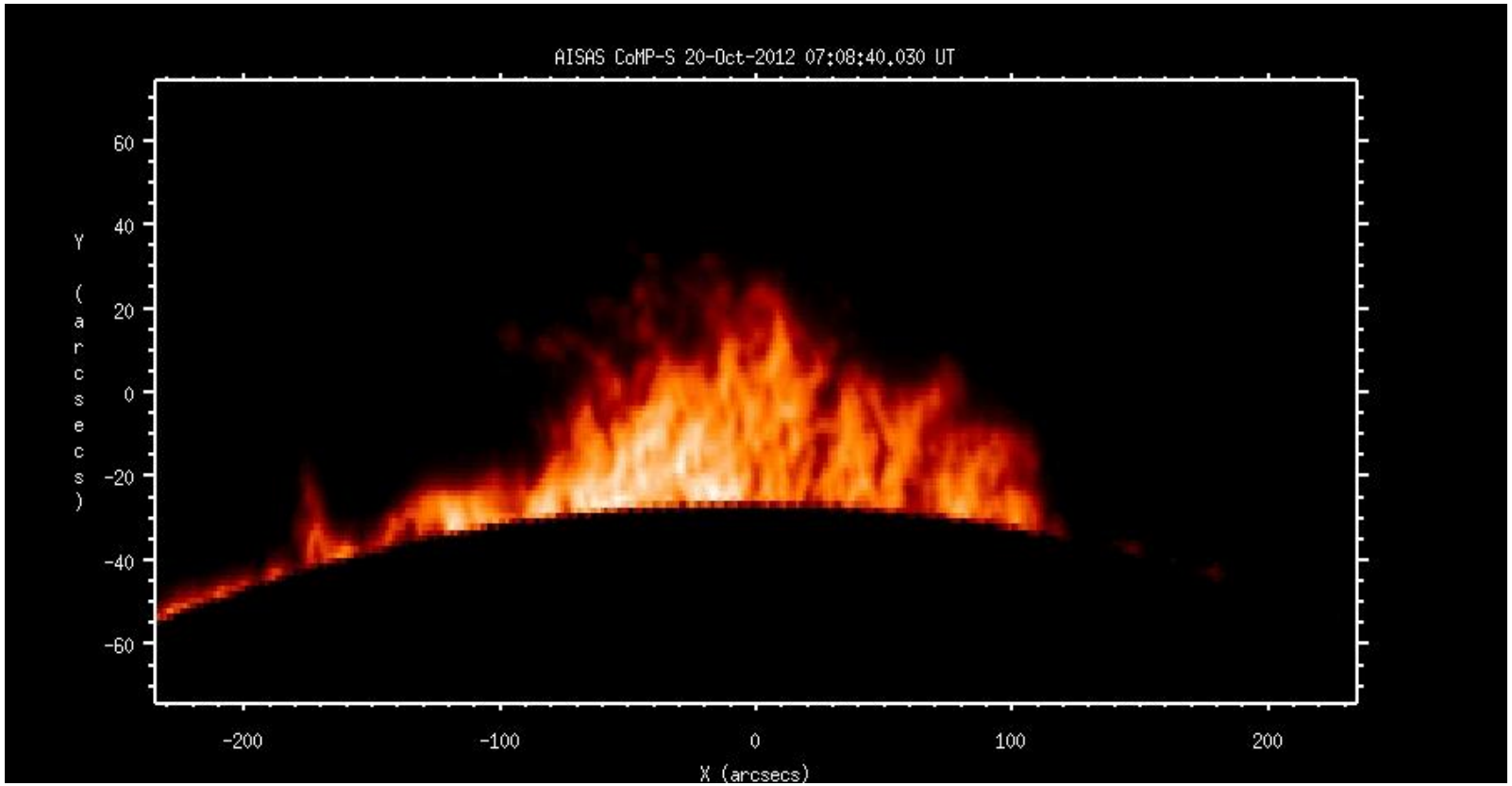
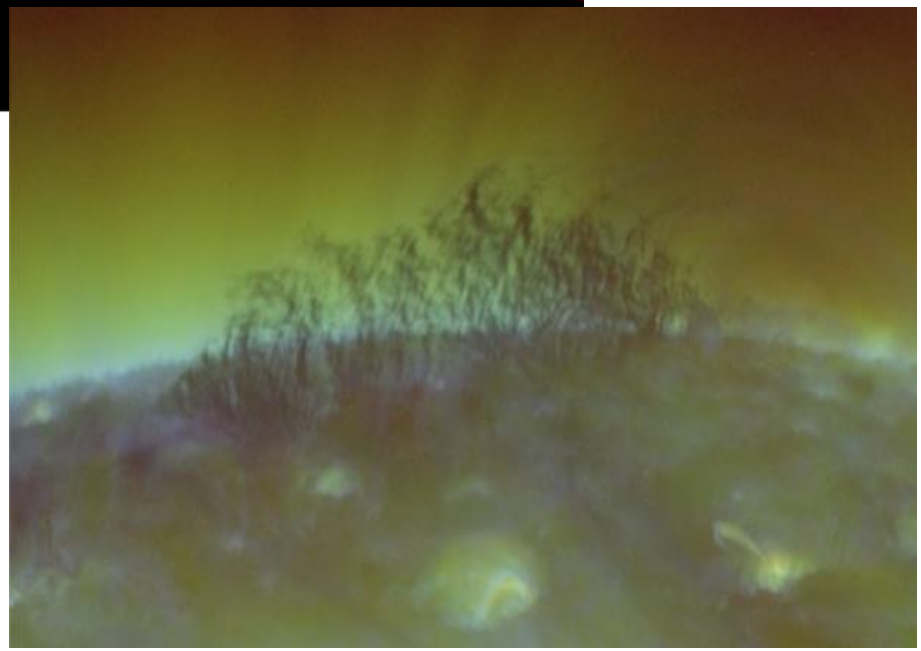
- Hα line profile: 11 wavelength settings, only Stokes I parameter presented
- Exposure time: 50 ms, total scan time: 20.75 s, wavelength steps: core: 0.1 Å, wings: 0.2 Å
- post-facto 4 x 4 pixel binning to final sampling: 1.3 arcsec/px
- Gaussian fitting: **amplitude ~ dopplershift ~ width**

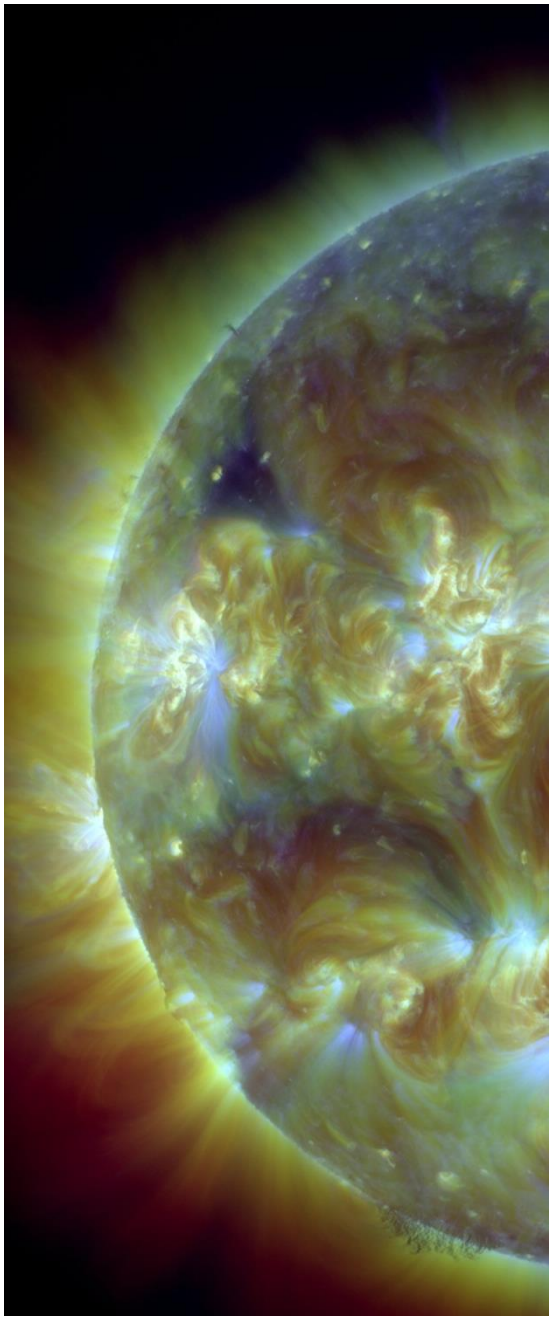


LSO: CoMP-S

Hα quiescent prominence – Oct 20, 2012:

CoMP-S:
07:09 UT,
H I 656,3 nm





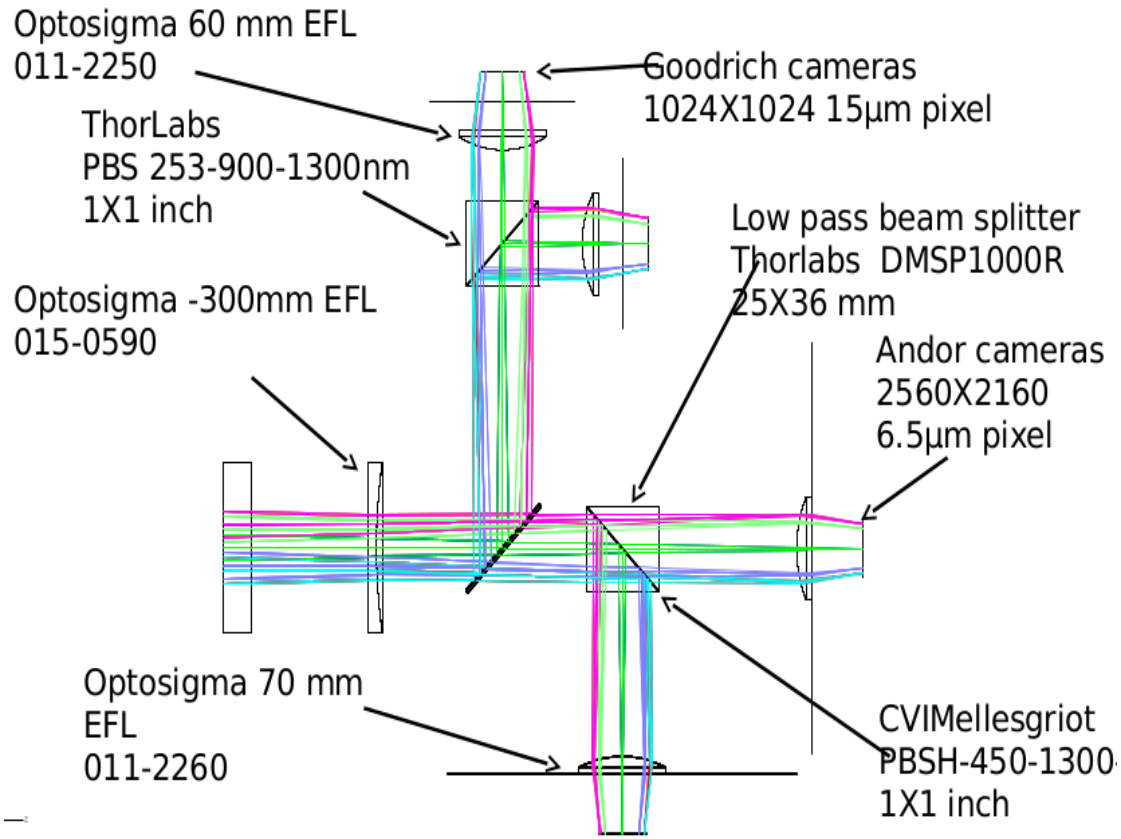
Help of J. Koza

AIA/SDO: 07:11 UT,
21.1+19.3+17.1nm

LSO: CoMP-S + PDSS

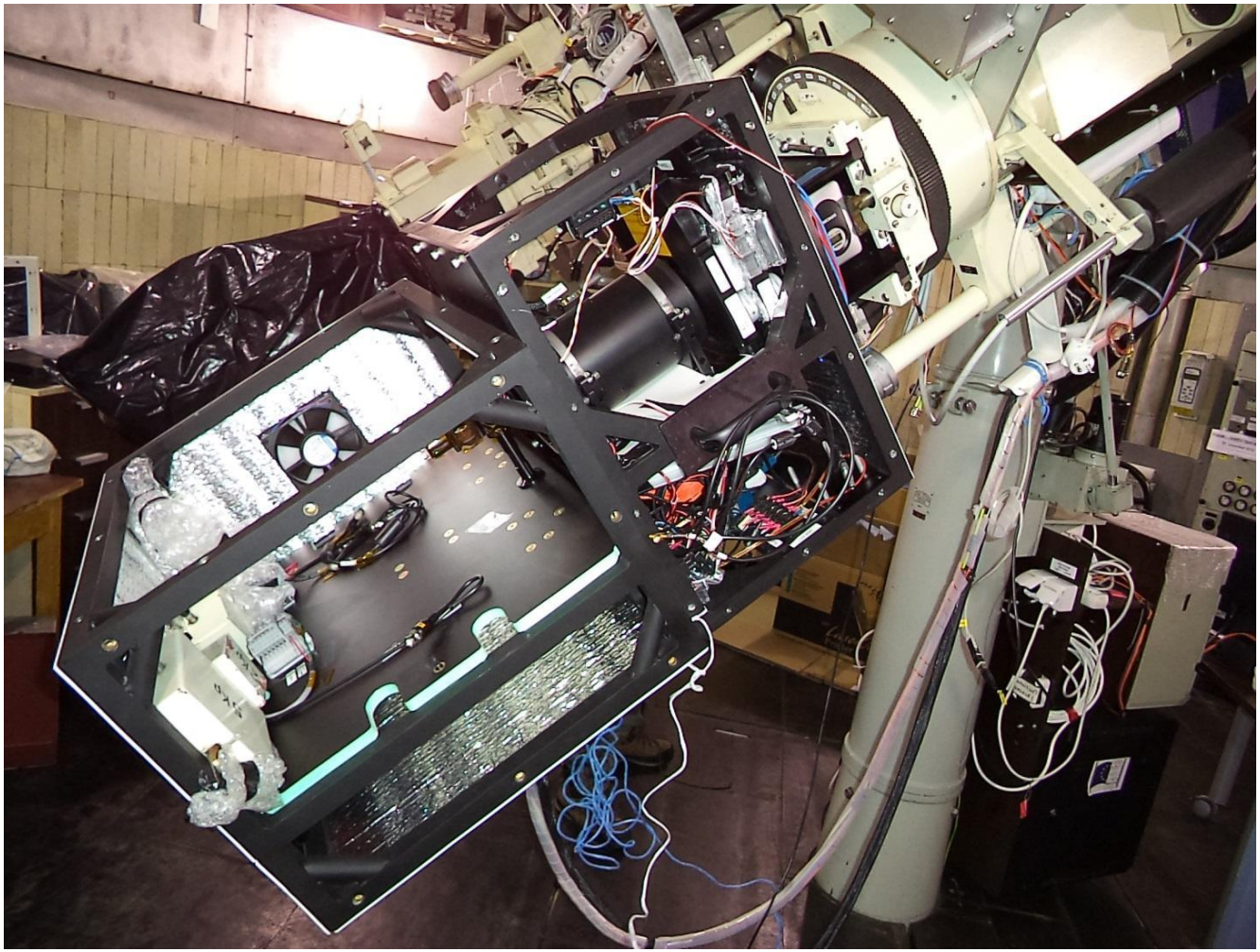
The Post-focus Detectors for Solar Spectrometer – PDSS: an upgrade of the original CoMP-S camera module

Main feature: new detectors for VIS + near-IR spectral ranges:
VIS - ANDOR Neo, near IR – Goodrich GJ 1280, better mechanics for stability, focusing, a new computer, a little more optics and electronics



LSO: CoMP-S + PDSS

The PDSS actual status: the instrument has been delivered to AISAS, the first mechanical and electrical tests have started recently



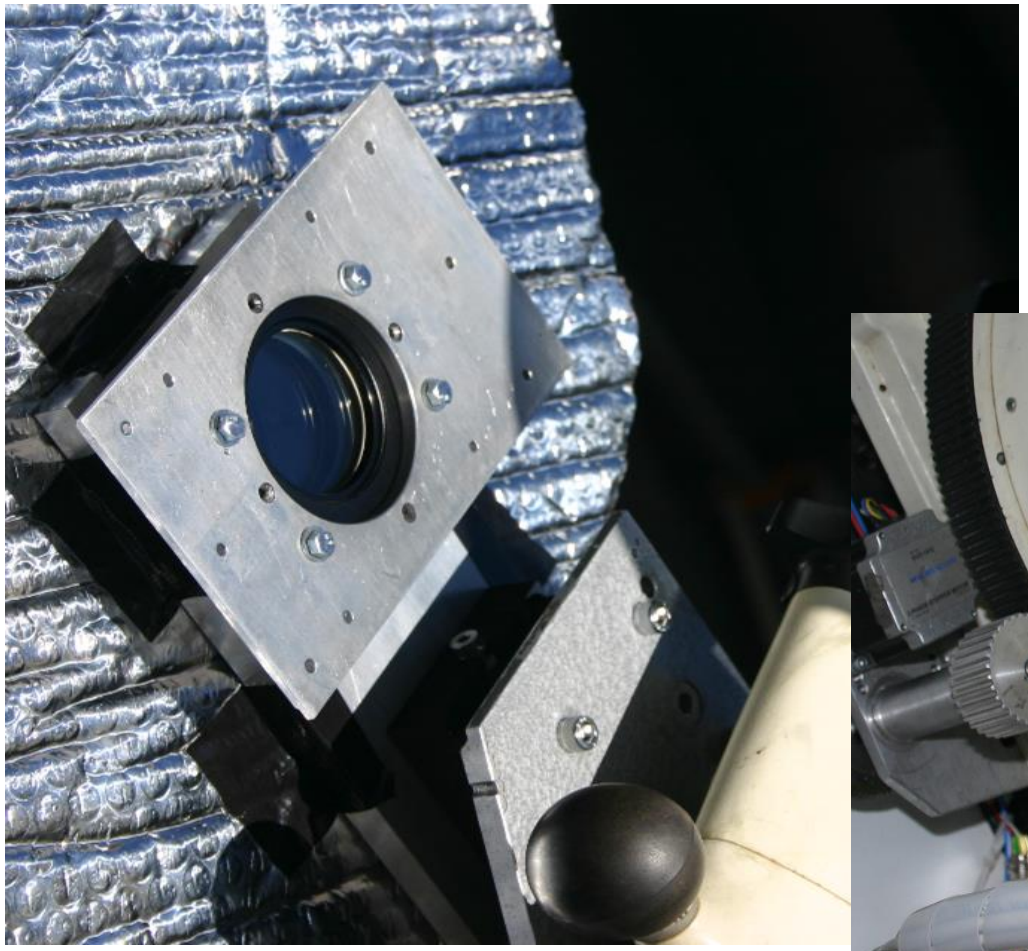
A test of the mechanical stability (13/05/2014)

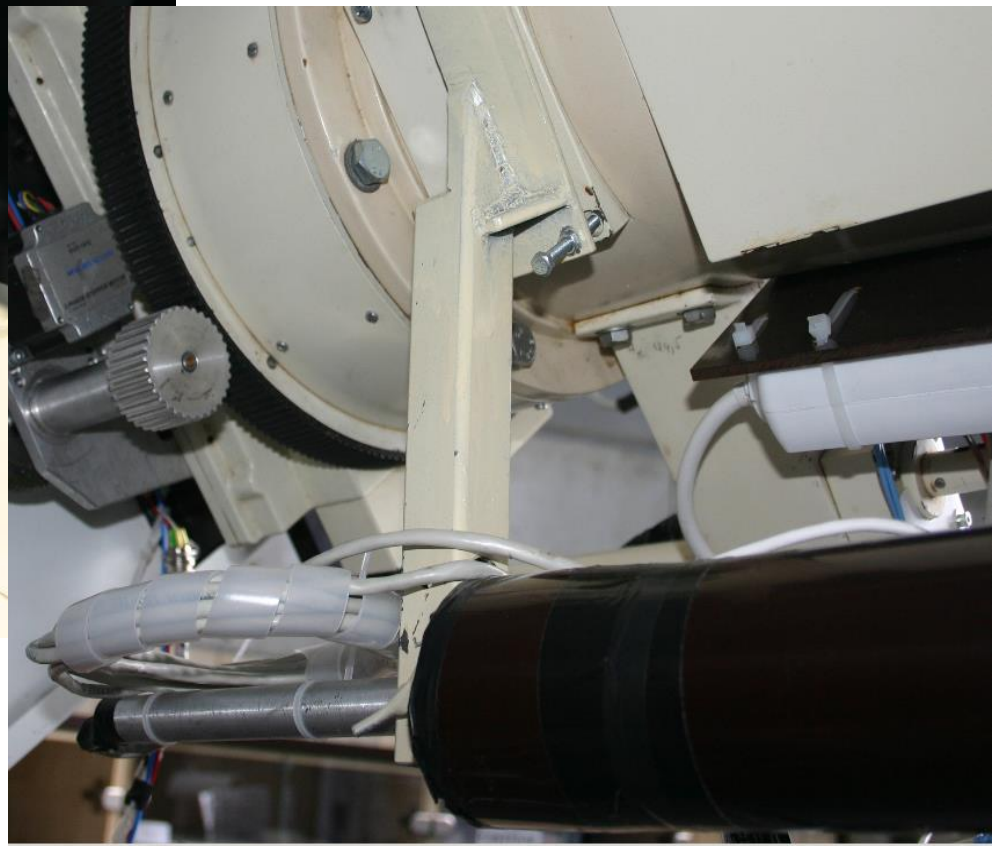
LSO: pointer R

Photoelectric digital pointing telescope: “uhrgang” is not enough due to changing declination of the Sun and a residual bending of the tube

LSO: pointer R

Photoelectric digital pointing telescope:

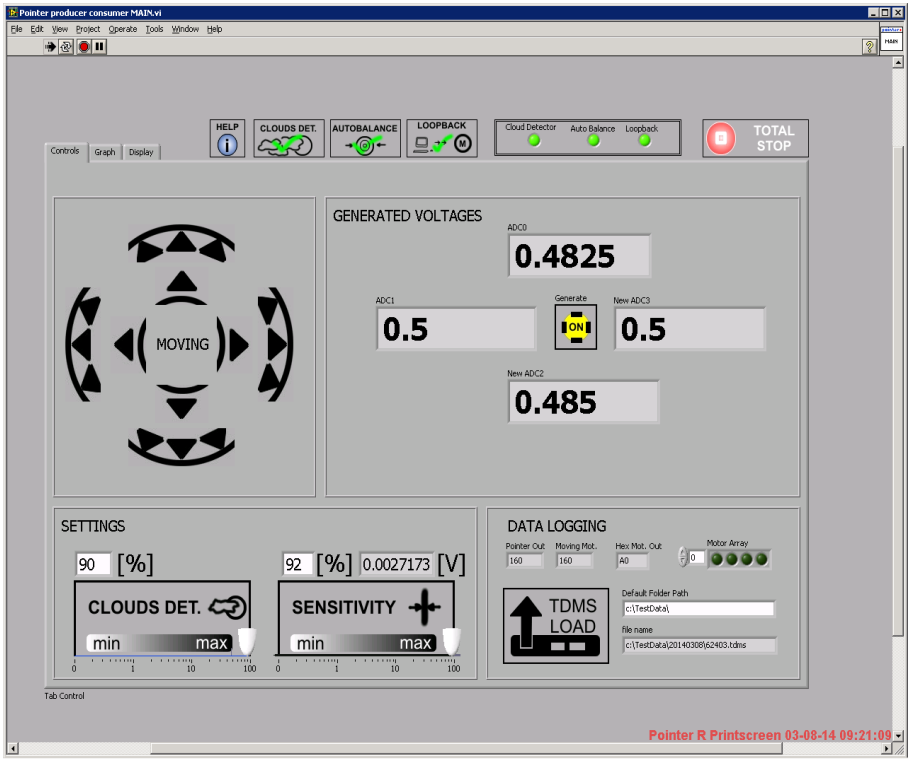


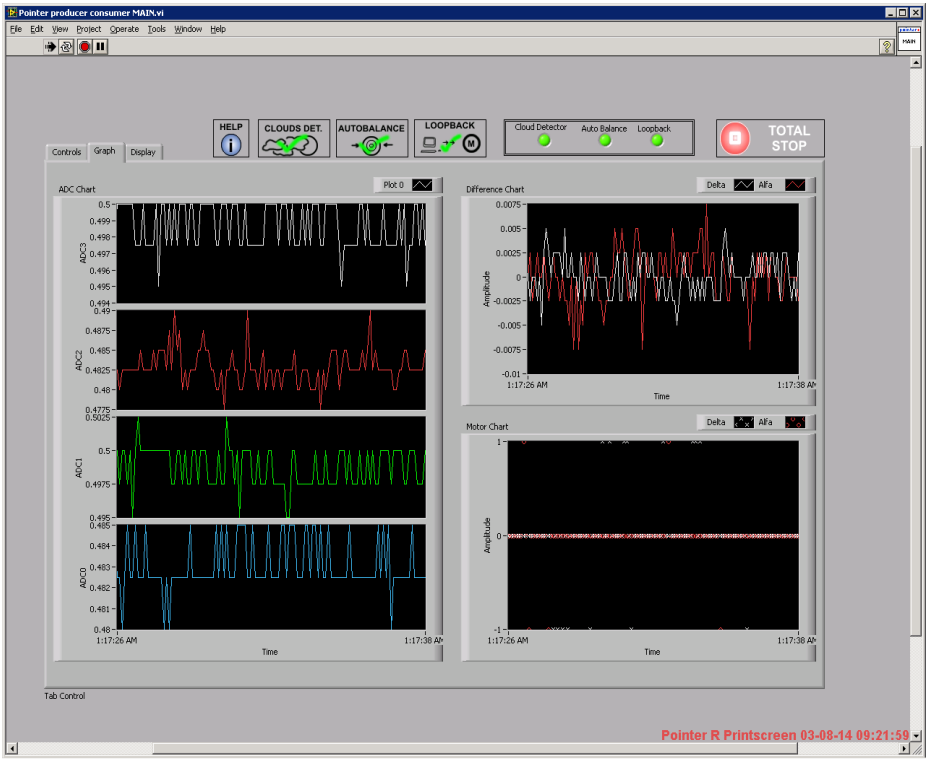


LSO: pointer R

Photoelectric digital pointing telescope:

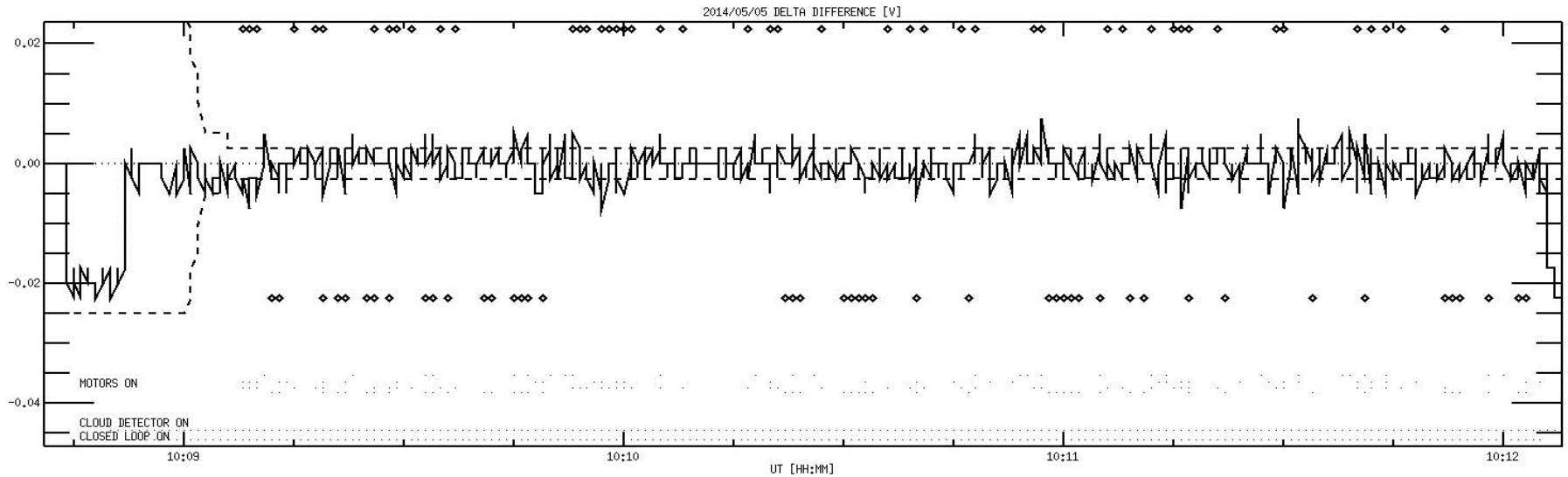
- work of Matúš Kozák
- electronics + LabView code
- ~3” pointing precision
- detector of clouds
- correction for an starting off-pointing
- logging

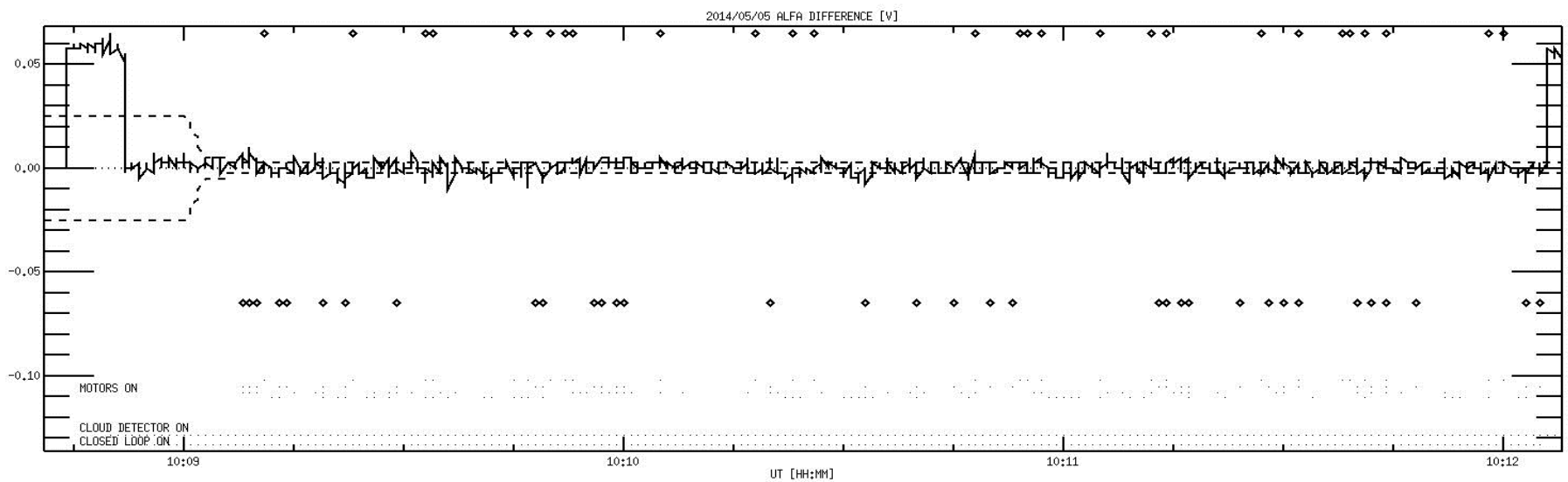




LSO: pointer R

Photoelectric digital pointing telescope: 4 photodiode voltages





LSO instrumentation

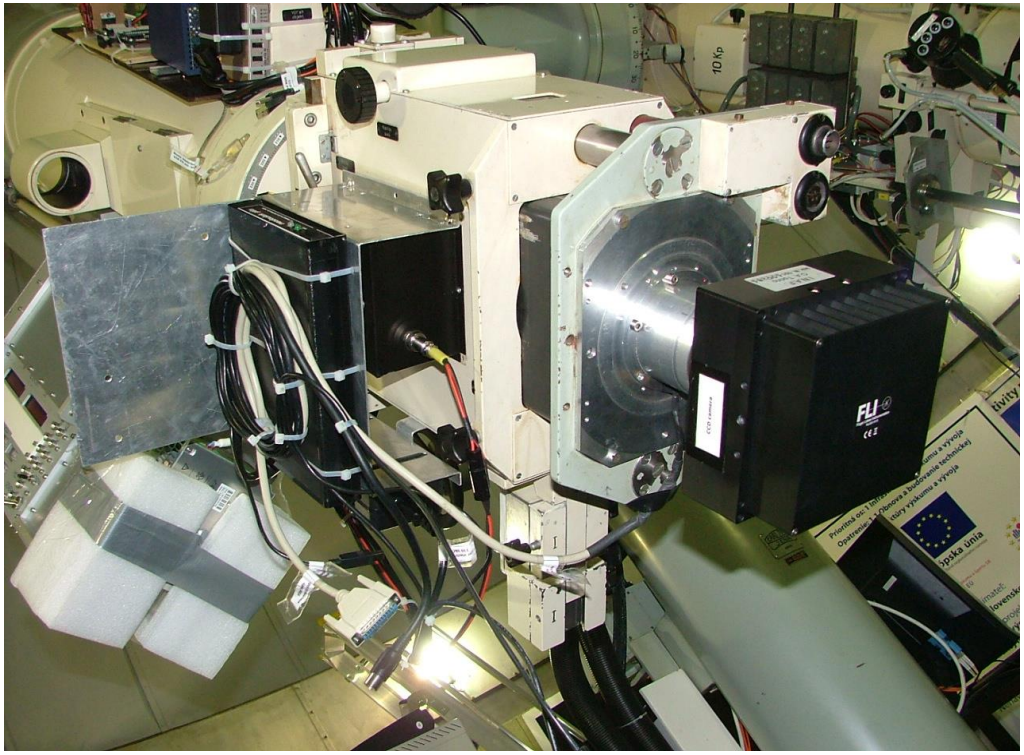
CoMP-S with PDSS
pointer R
CorMag
pointer H
SCD
H alpha full disk+aureola

LSO: CorMag

The Coronal Magnetometer (Cormag) at LSO since April 2014

Main feature: wavelength range: only ~**530 nm** allowing spectro-polarimetric measurements of only one emission coronal emission line (CoMP-S can observe this line as well)

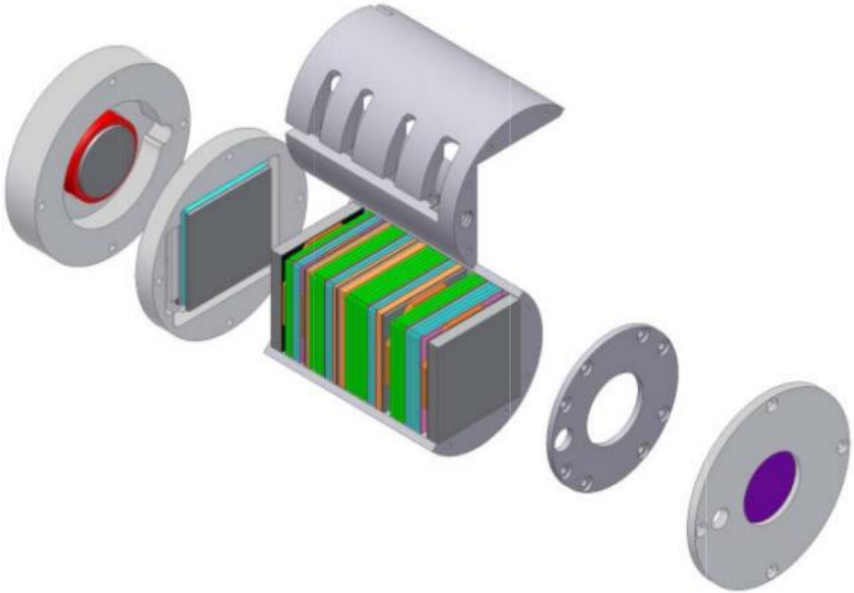
Other specifications: not a full-disk FoV, simultaneous imaging of a 2D area, sequential data acquisition in wavelength and polarization



LSO: CorMag

The Coronal Magnetometer (Cormag) at LSO since April 2014

- team of prof. S. Fineschi (Osservatorio Astronomico di Torino)
- originally part of ASPIICS - a solar coronagraph to be flown on PROBA 3
- a liquid crystal Lyot tunable-filter and polarimeter (LCTP)
- nematic liquid crystal variable retarders (LCVRs)
- a four stage Lyot filter with all four stages wide-fielded
- bandpass FWHM 0.15 nm, FSR 2.7 nm (at 530.3 nm)
- tunable in 0.01 nm steps



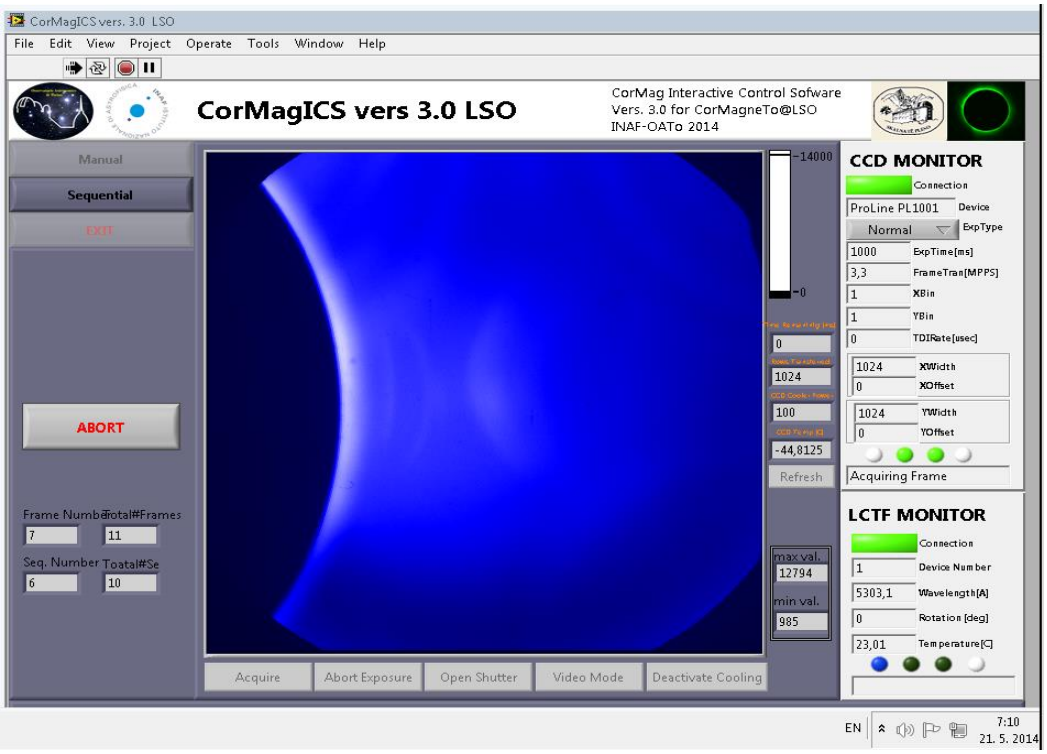
Fineschi et al., Proc. of SPIE ***8148,*** *814808-1, 2011*

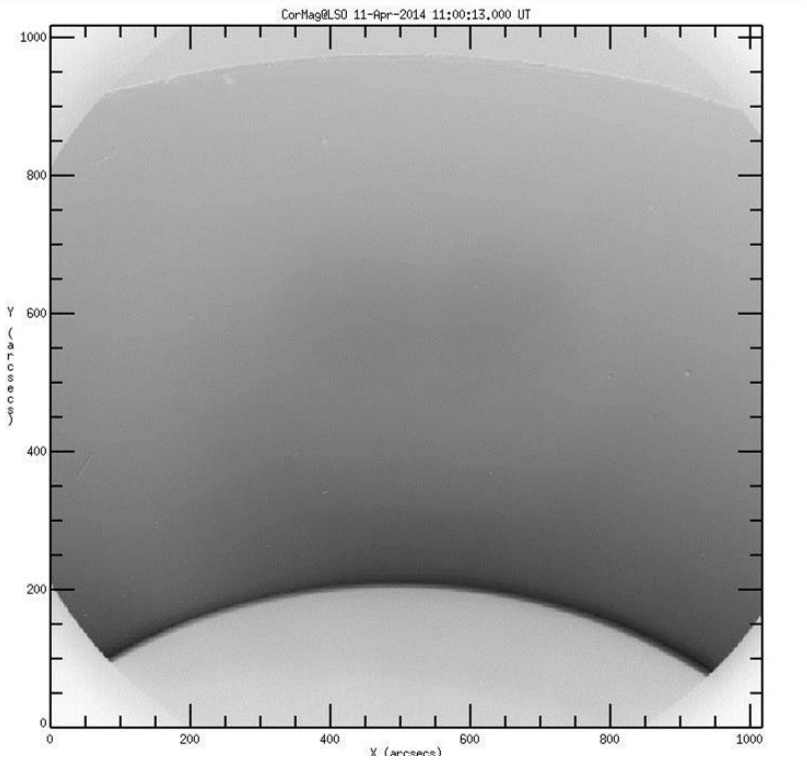
LSO: CorMag

The Coronal Magnetometer (Cormag) at LSO since April 2014

- tests/observations performed at LSO in April/May 2014
- Main result – most of the FoV (**but not whole**) with ghosts !!!
- More tests, calibrations, or even change of the optics could be needed

- Excellent plans in our minds: green-green, green-H alpha,...





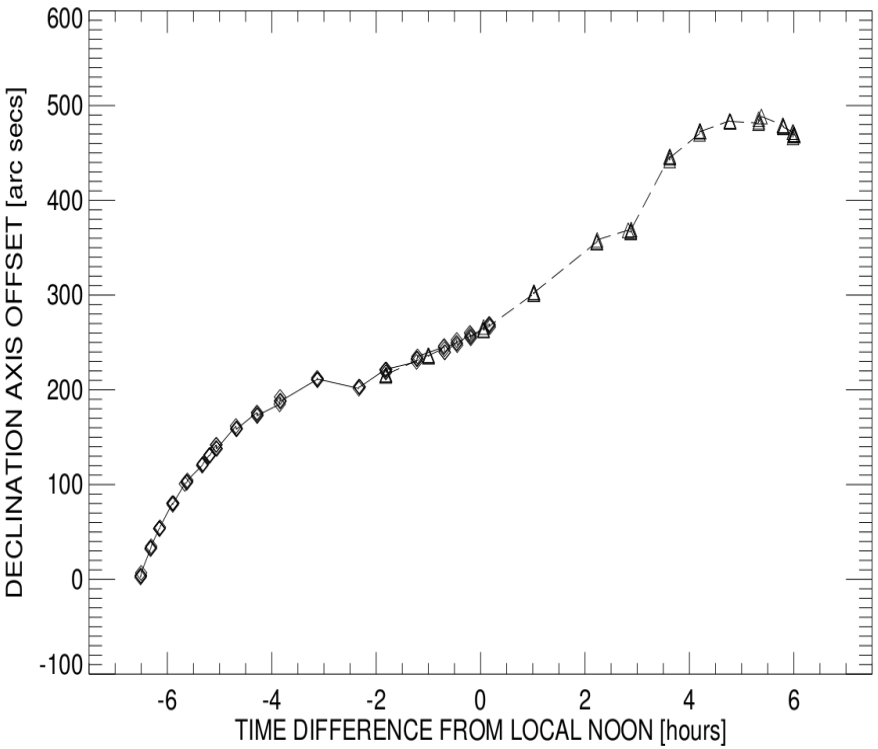
LSO: pointer H

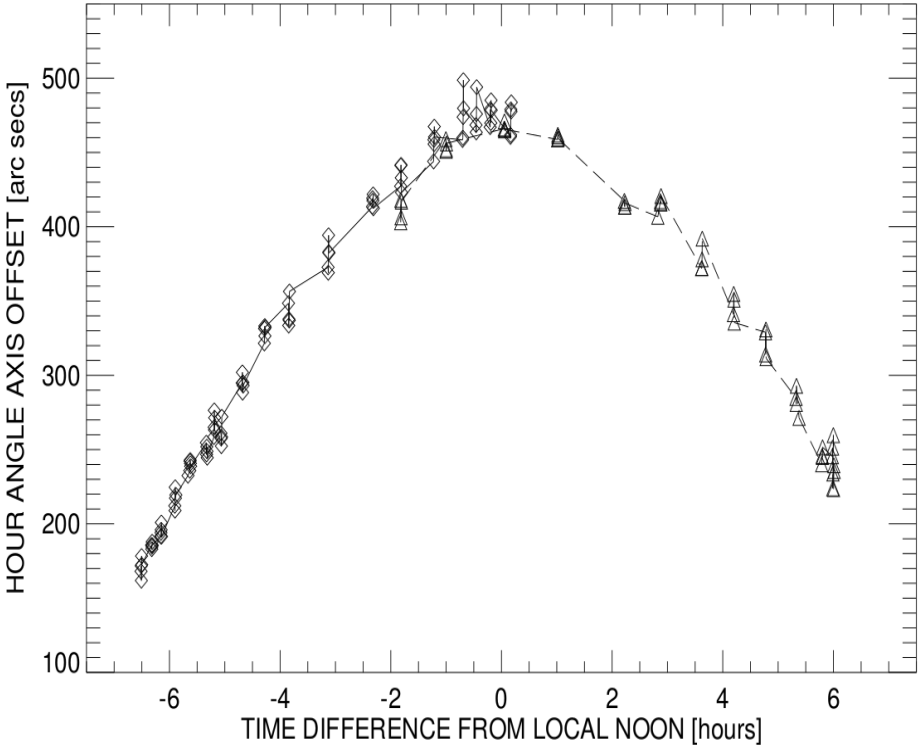
Pointer of the company HANKOM (pointer H)

Why another device is needed?

Reasons:

1/ two coronagraphs are offset now for hundreds of arc seconds
2/ individual tube is bending during the day (max. change of 8“/h)
3/ general offsets in declination and hour angle are variable

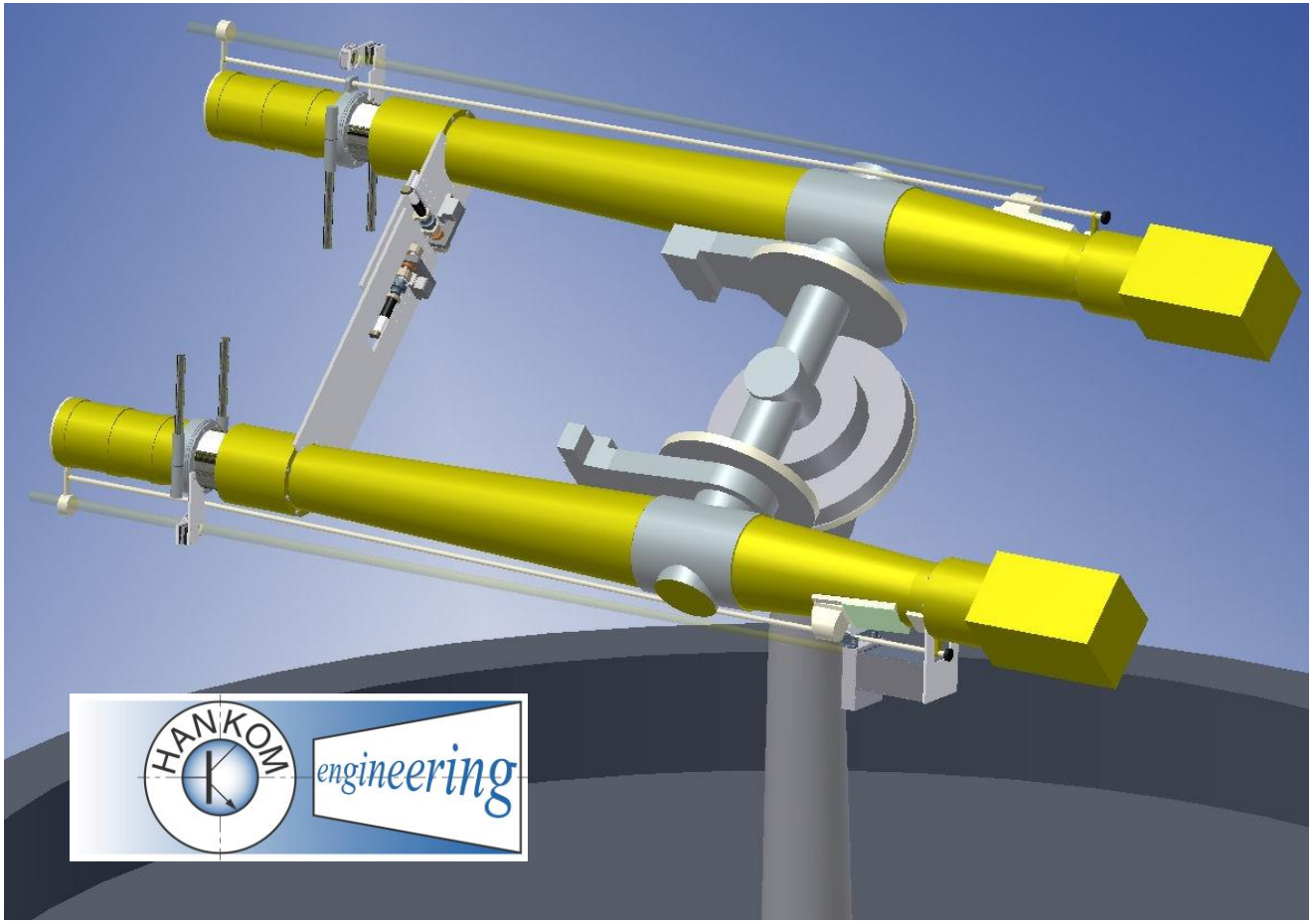




LSO: pointer H

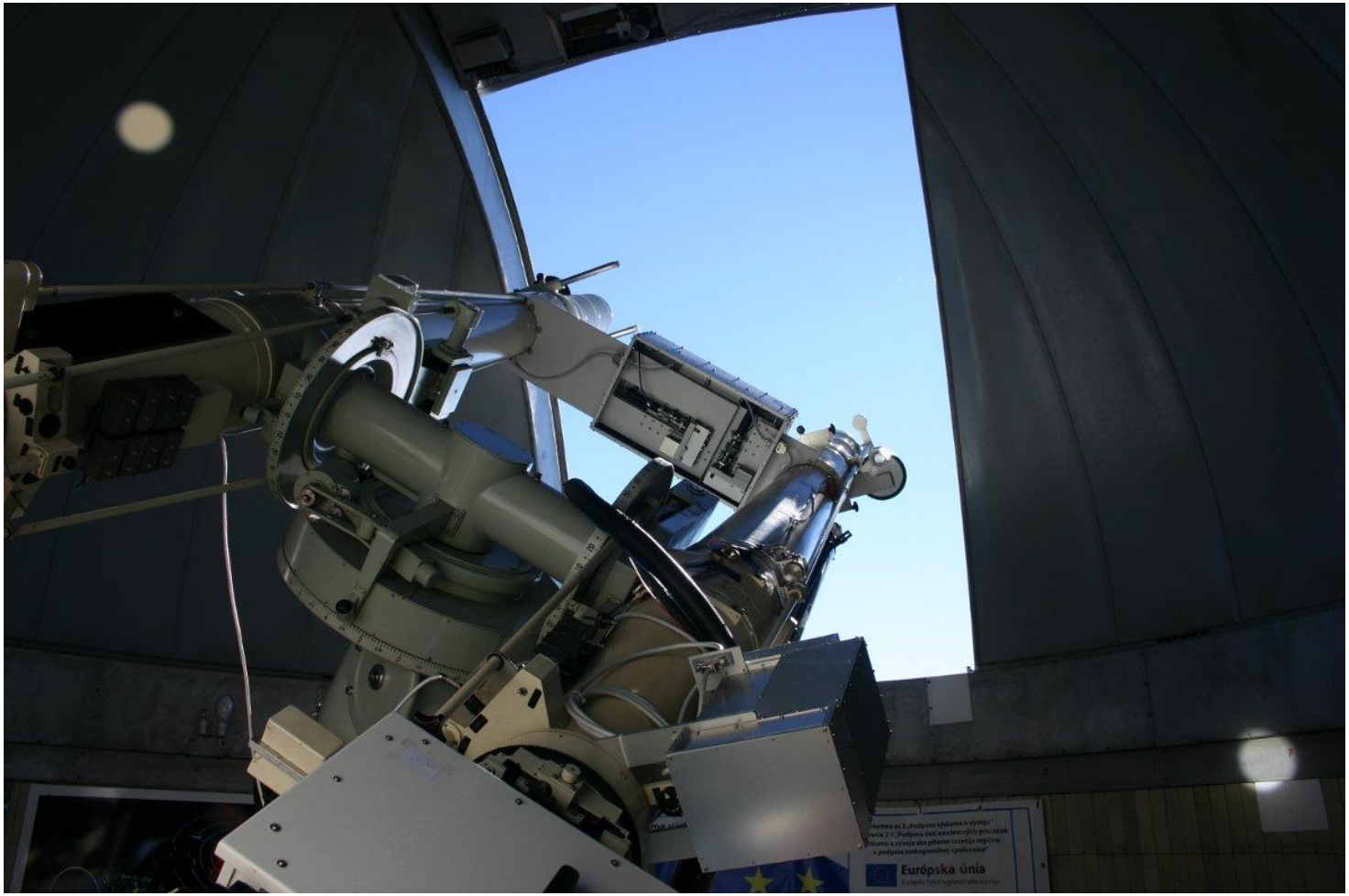
How to correct these mechanical problems?

Objective lens shift with an on-line correction of the tube directions by pulling/pushing their hour angle distance and variating their declination difference. Easy to write but a little harder to do! HANKOM company...



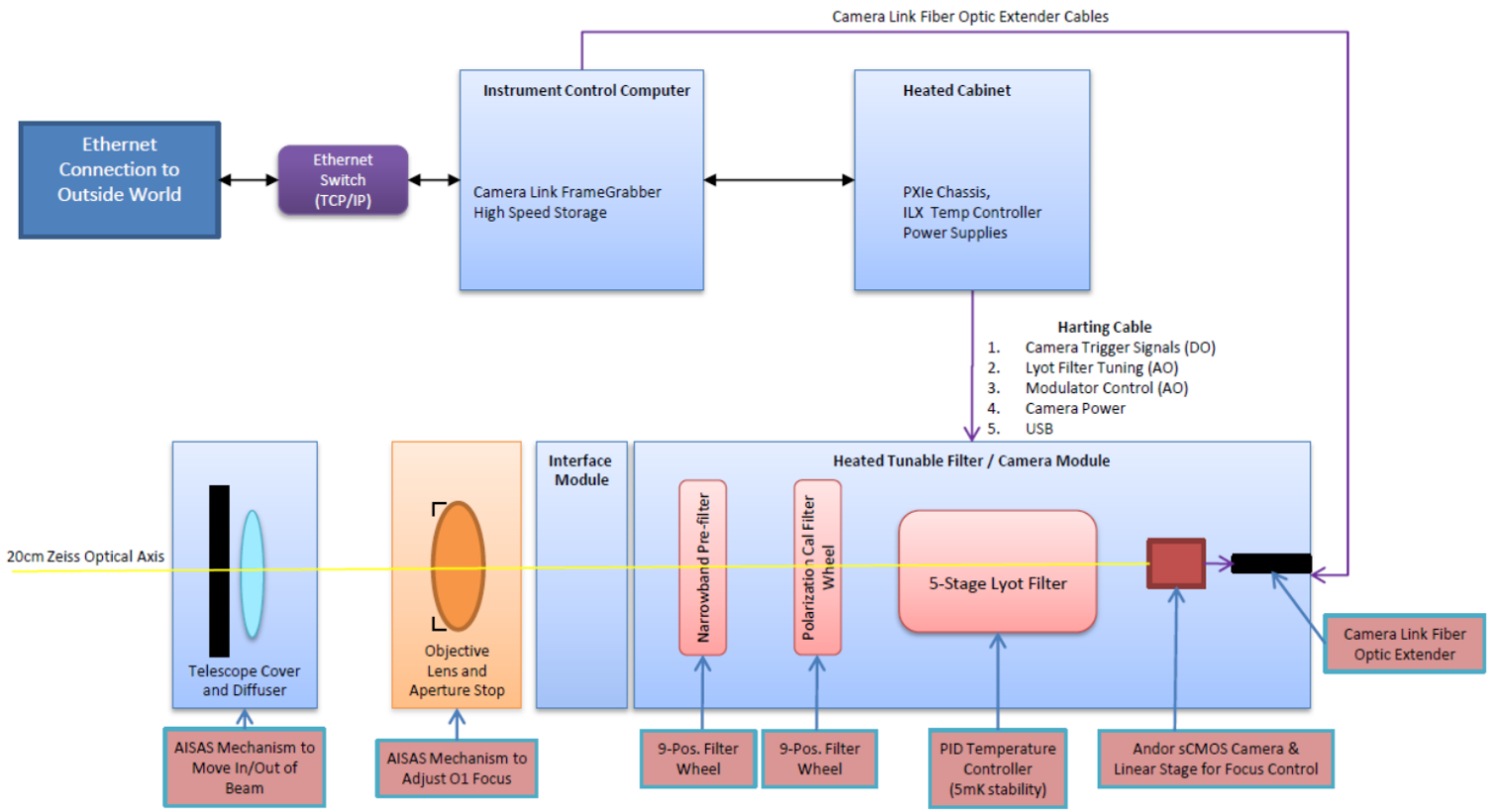
LSO: pointer H

Small celebration : two Zeiss coronagraphs pointed properly to the solar disk center for **simultaneous** coronagraphic scientific measurements for the first time on **21/05/2014** (for an hour in frame of the coordinated observing campaign with Hinode/EIS+XRT+SOT + IRIS)



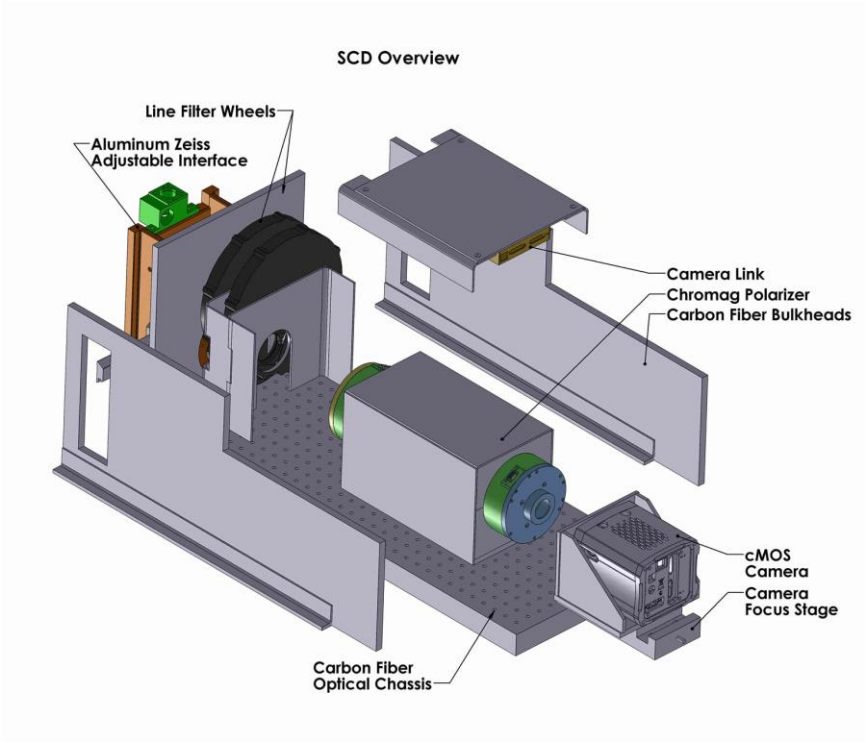
LSO: Solar Chromospheric Detector (SCD)

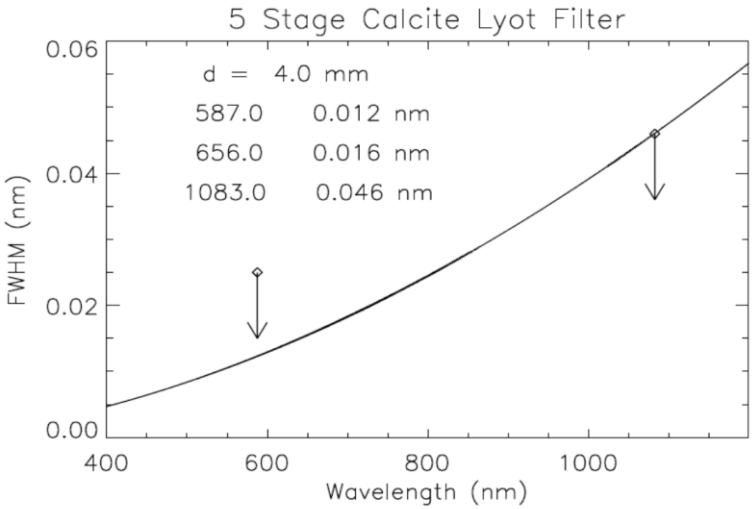
- a contract with HAO/NCAR – “CHROMAG for Slovakia“
- 5-stage Lyot filter + polarimeter
- wavelength range: 500-1100 nm
- chromospheric lines: He I 587.6 nm, Na I 589.6 nm, H I 656.3 nm,
  CaII IR triplet and HeI 1083.0 nm
  photospheric lines: Fe I 557.6 nm, Fe I 630.25 nm
- Andor sCMOS NEO camera: 2560 x 2160 pixels of 6.5 micron size

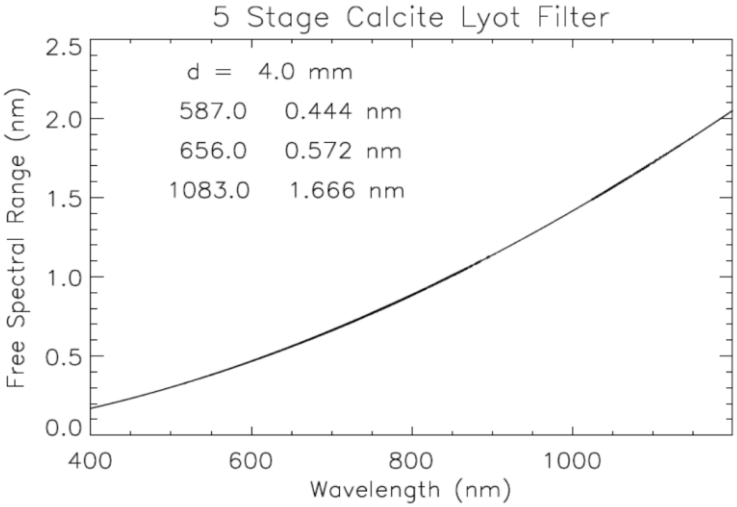


LSO: Solar Chromospheric Detector (SCD)

- a contract with HAO/NCAR – “CHROMAG for Slovakia“
- 5-stage Lyot filter + polarimeter
- FWHM: 0.012nm@587nm →
  0.046nm@1083nm







LSO future plans

Observations + Instrumentation

LSO future plans

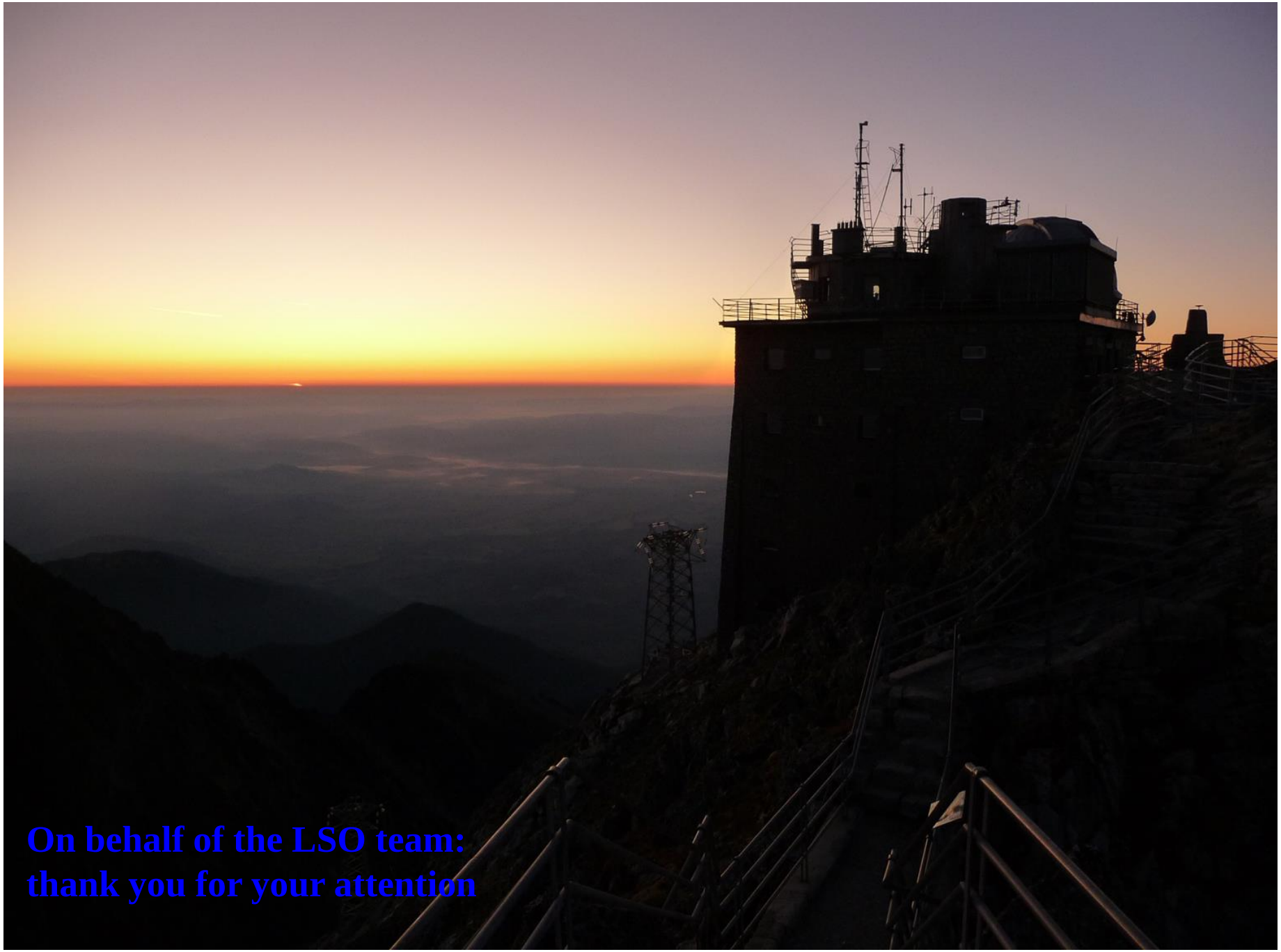
A short extraction of the LSO todo list for near future:

Observations:

- regular observing programs of the CoM-S and CorMag instruments
- observations in frame of the coordinated observing campaigns

Instrumentation:

- CoMP-S+PDSS: reliability of motor actions for diffuser and focusing, measurements of the passbands, replacement of the camera module
- CorMag: ghosts, operation under winter conditions
- pointer R: to improve resolution ~10 times
- operation all instruments from an office including fine motions of the LSO bino-coronagraph
- an automatic motion of the dome to keep all optical instruments fed by solar light
- database of the acquired data of observations


On behalf of the LSO team:
thank you for your attention