Main Parameters of HSFAs

the abbreviation HSFA stands for german words

(Horizontal SonnenForschung Anlage)

Coleostat Jensch type, Ø60cm x 2, moves on the oil layer

Telescope off-axial, Kutter type, stationary primary mirror, spherical, D50/3500cm, secondary flat M37cm,focal image of the Sun ~32.5 cm, i.e. ~5.9”/mm. Telescope theoretical resolution ~ 0.21” at λ=5500 A

Spectrograph Czerny-Turner, entrance slit in the telescope focal plane, movement of the grating, carussel with filters,

Slit height <1;100> mm, collimator M25/965 cm, camera M40/965 cm both spherical, diffraction grating Bausch&Lomb 632 grooves/mm, size 156 x 204 mm, blaze angle 26 degrees

Detectors: Photographic plates max. 18 x 24 cm, movable cassetes

Controlling electronics: guiding of the primary image in the focal plane, quick control and testing of the instrument, programmed scanning of the observed region in both directions with selected steps.

Other improvements were home made by individual users (slit-jaw recordings, TV cameras, photomultipliers, magnetograph with polarizators, etc.

ONDŘEJOV HSFA2, 1987

Spectrograph Czerny-Turner, changed to multichannel in 2004, two modernizations

of electronics. Operates. Detectors: Photoplates, films, CDD cameras.

Data and results available at asu.cas.cz~/sos

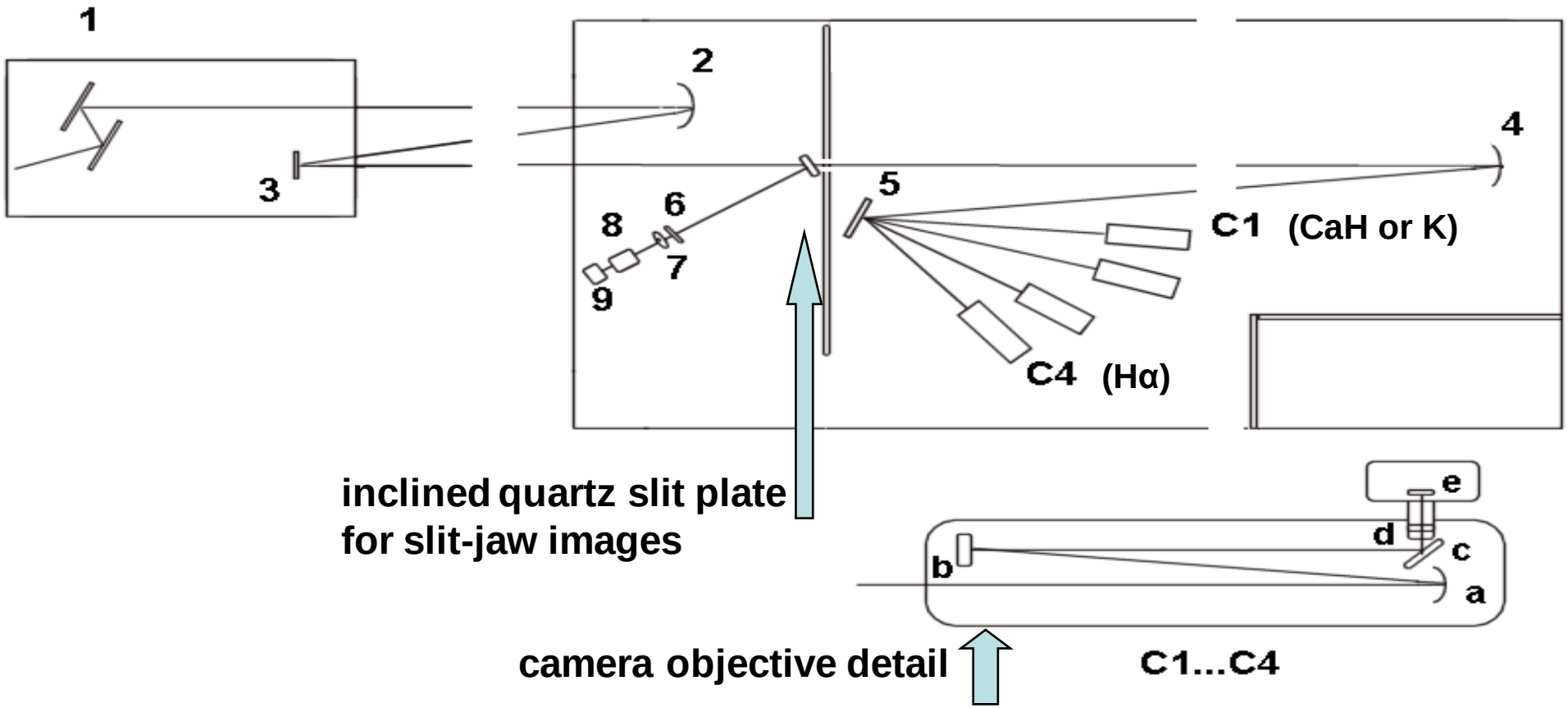
Estimated number of publications ~20

Used for education and practice of students

Plans: Observations of solar active phenomena spectra. Joint observational campaigns.

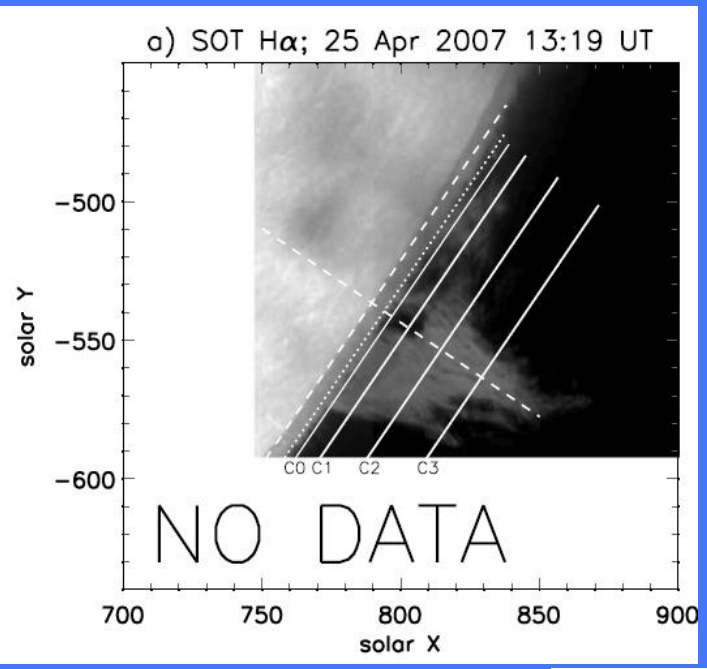
Responsible person: Pavel Kotrč

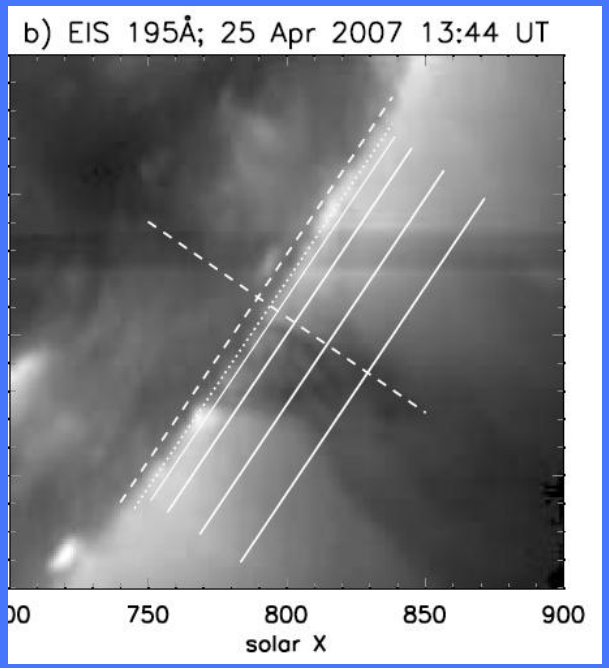
Optical Schema of the HSFA2

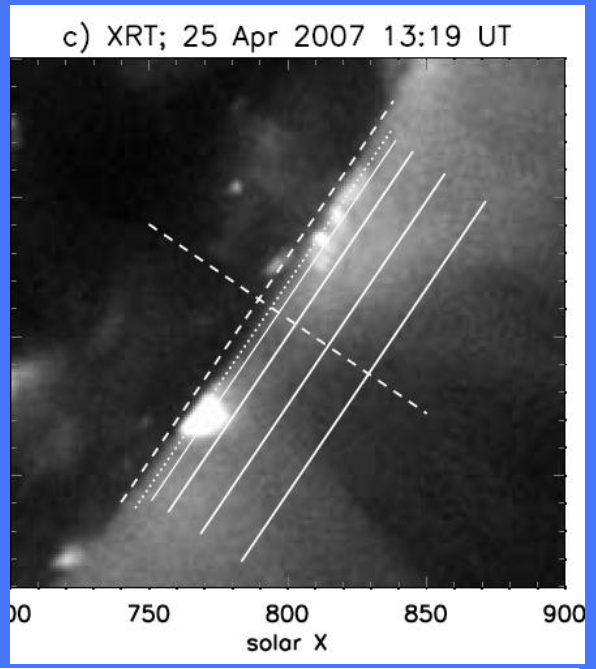


1 – Jensch coelostat, 2 – main objective, 3 – flat mirror, 4 – collimator, 5 – grating, 6 – thermal filter, 7 – slit-jaw objective, 8 – Hα filter, 9 – CCD camera
C1…..C4 (– C5) spectral camera objectives + CCD cameras,
a,b,c,d,e – folded optical system of cameras, correction of astigmatism and coma

Prominences in broad bands

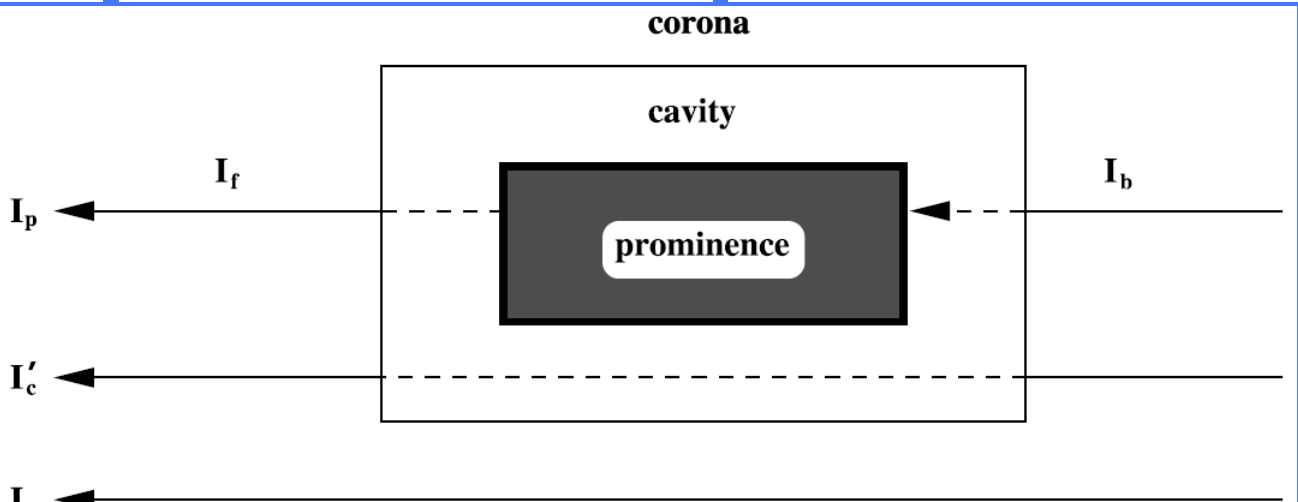






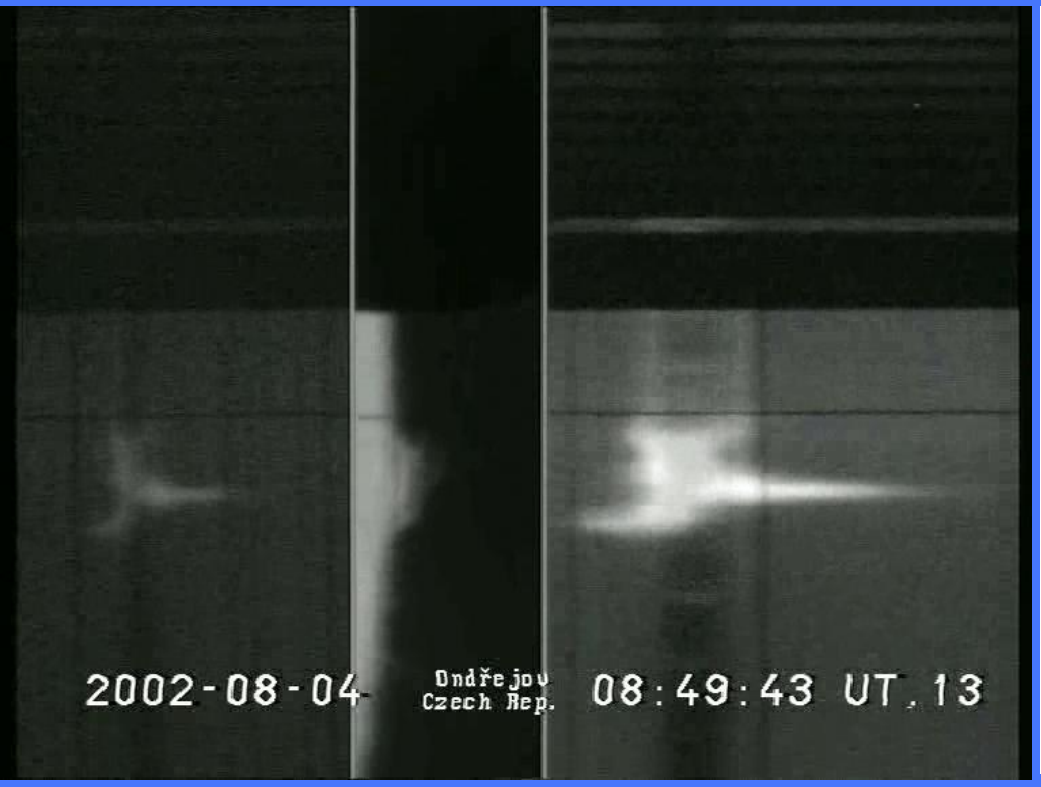
Hα spectra of QP calibrated at points of intersections

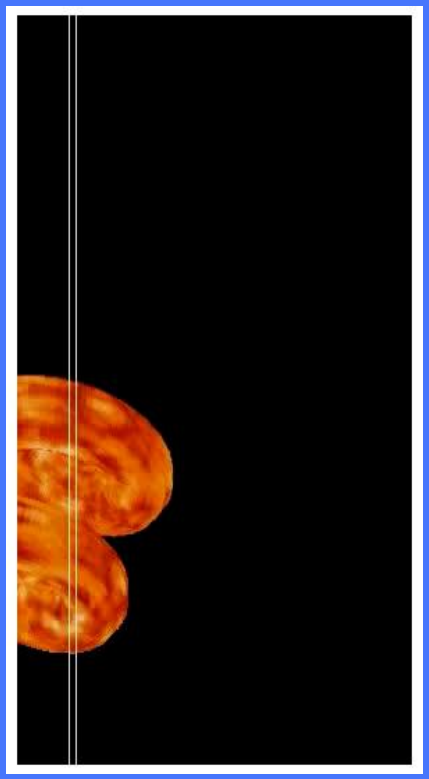
Heinzel et al. (2008), Astrophys. J. 686, 1383
Courtesy of J. Dudik



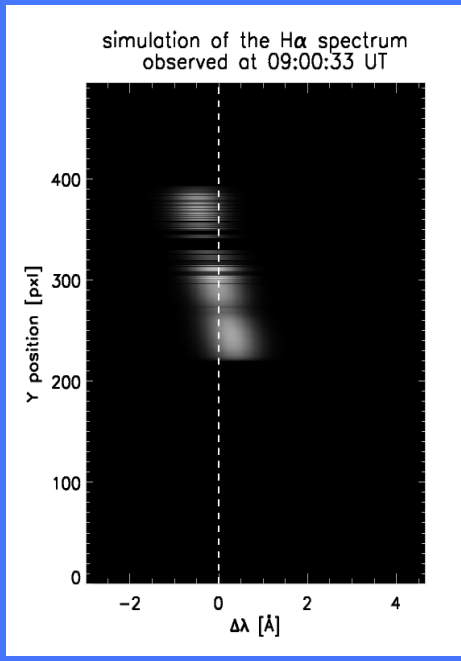
2002 August 8 limb flare

Kotrč et al, Solar Physics, 2012

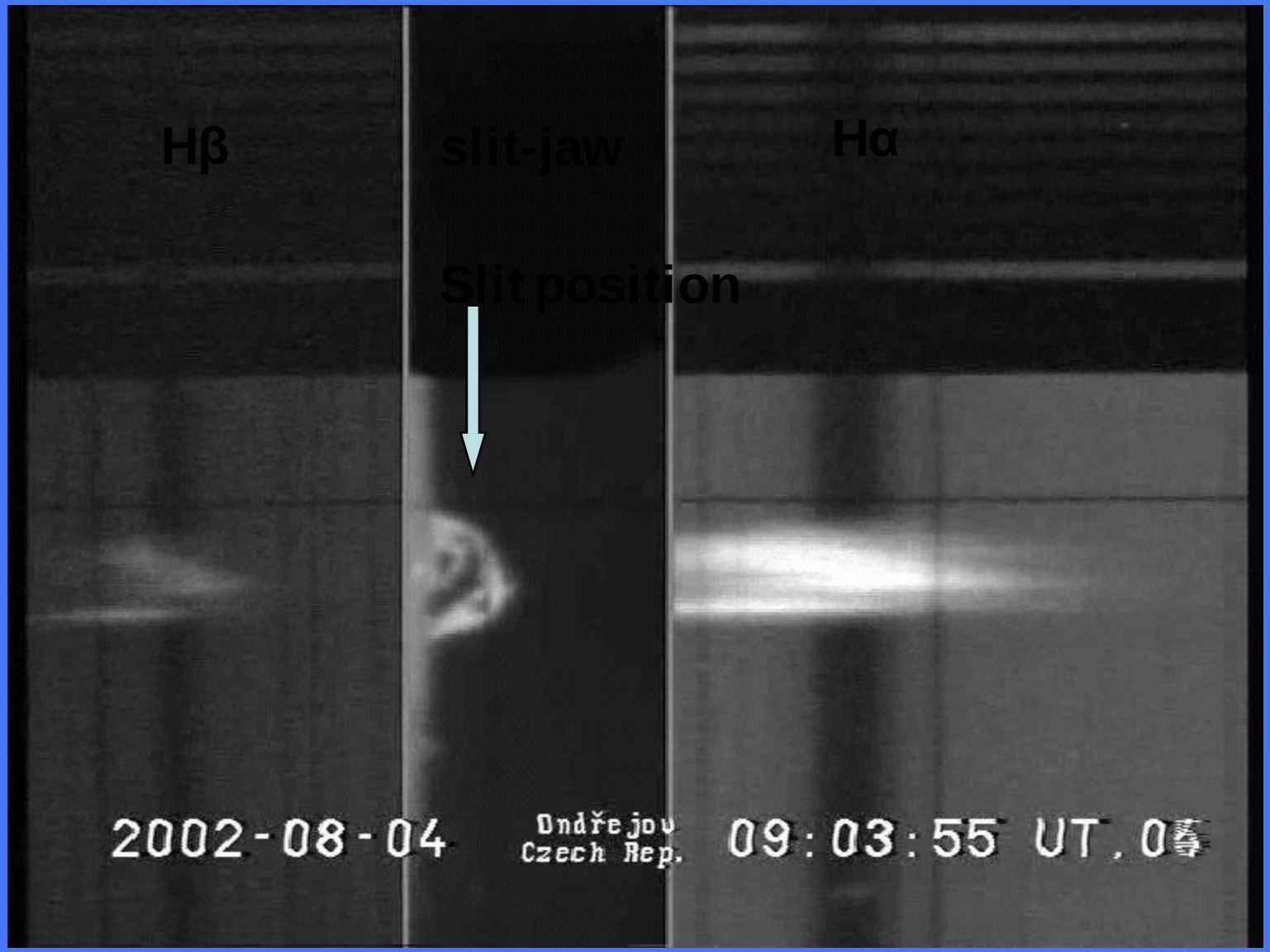




Kinematic mod

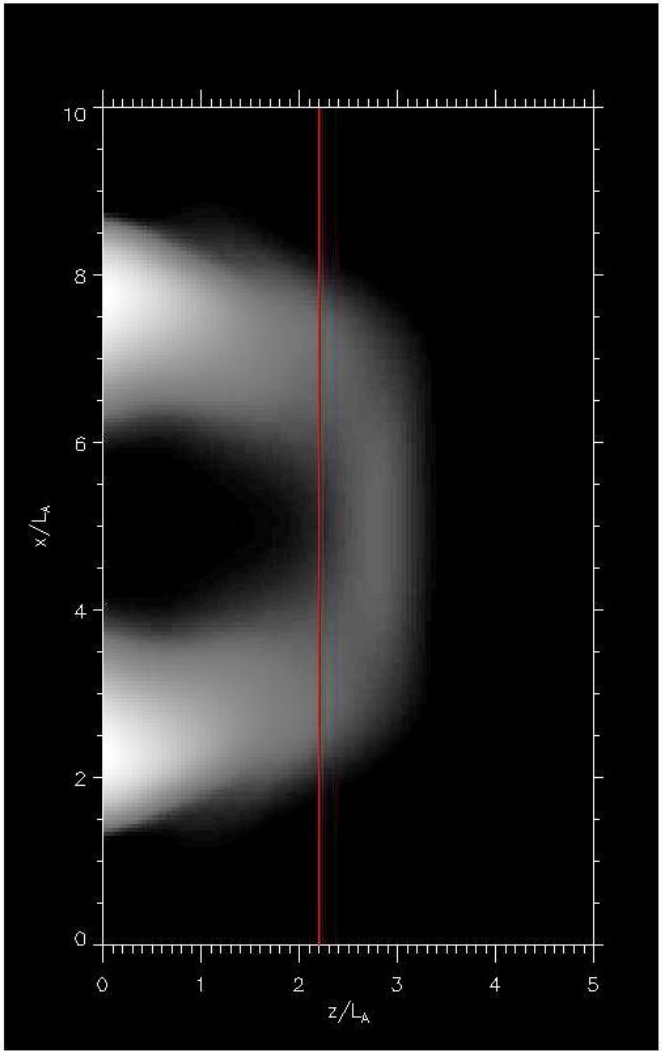


Observation -> MHD model

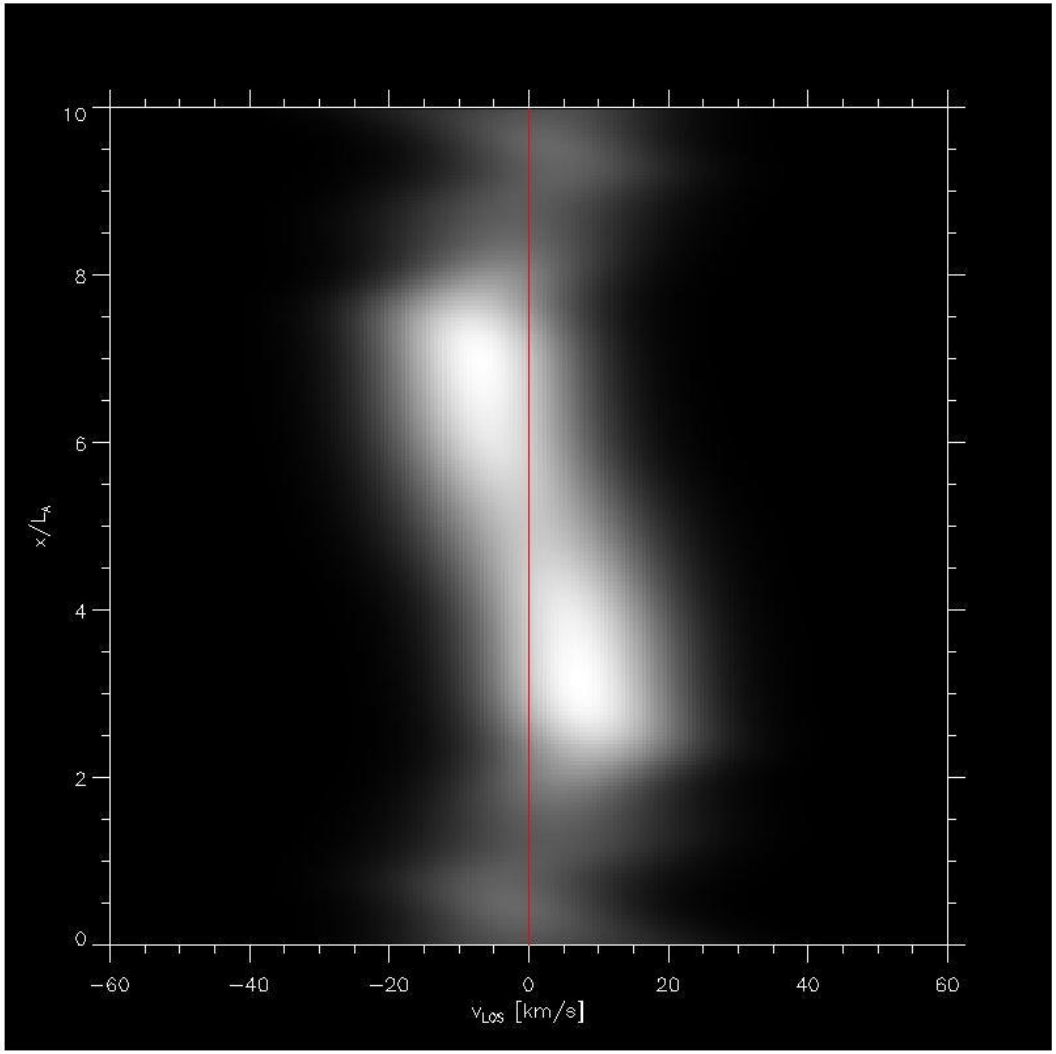


MHD model by Bárta, M.

Model

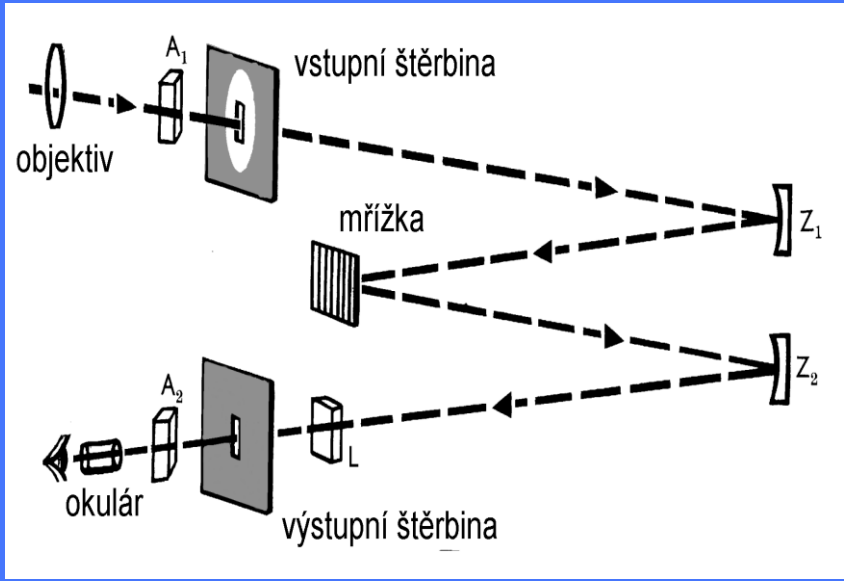


Slit–jaw image



Spectral line

Roots of Ondřejov solar spectroscopy: (Hurbanovo, Stará Ďala => Ondřejov)



In 1938 Dr. Bohumila Bednářová Nováková (*1904 -1985) constructed in Stará Ďala (now Hurbanovo) a Hale-type spectrohelioscope with two Anderson prismas, a Mt Wilson grating with 600“/mm, a line shifter, fed by 8/600 cm refractor. Dr. Bohumil Šternberk moved the spectrohelioscope to Ondřejov before the war.

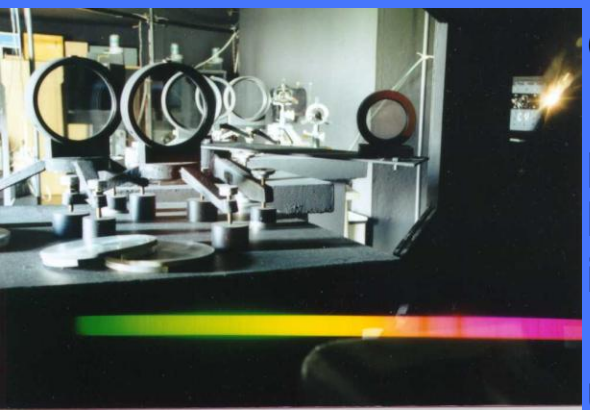
During the war the instrument was used by W. Schaube for regular solar observations for German Luftwaffe for forecasts organized by Dr. K.-O. Kiepenheuer.

The recording of solar activity was supposed to enable the most accurate forecast possible of the optimal frequencies used for military communications. Extremely fast building of several high mountain observatories Wendelstein, Kanzelhohe, Schauinsland, Skalnaté Pleso during the WWII for the same purposes.

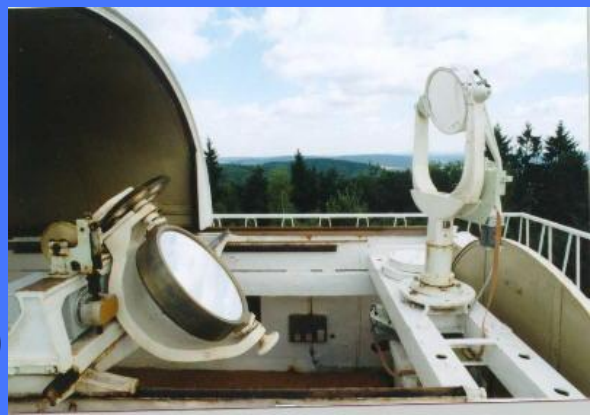
Multichannel Flare Spectrograph

MFS

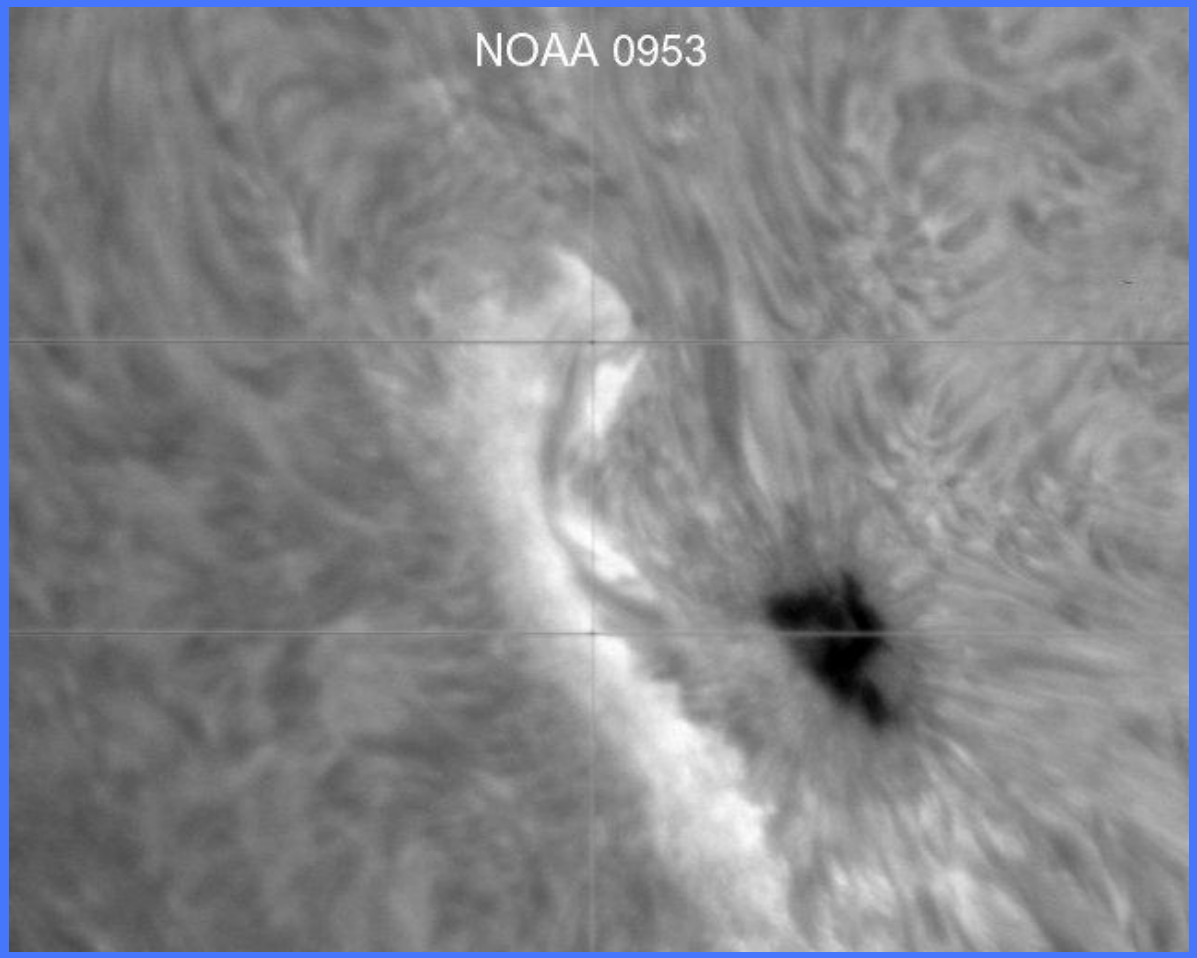
Constructed by Valníček, Švestka, Letfus et. al in 1958



Main Objective 230mm/1350 cm
Grating 850l/mm, 90 x 100 mm
Resolution 170 000 in the 2 order,
photograph. plates (films)
linear dispersion 1 A/ mm
in H-alpha, H-beta, H-gamma,
D-lines, Ca H and K (simultaneous)
up to the Balmer limit



A slit-jaw filtergramm
Hα DayStar 0.5 A filter

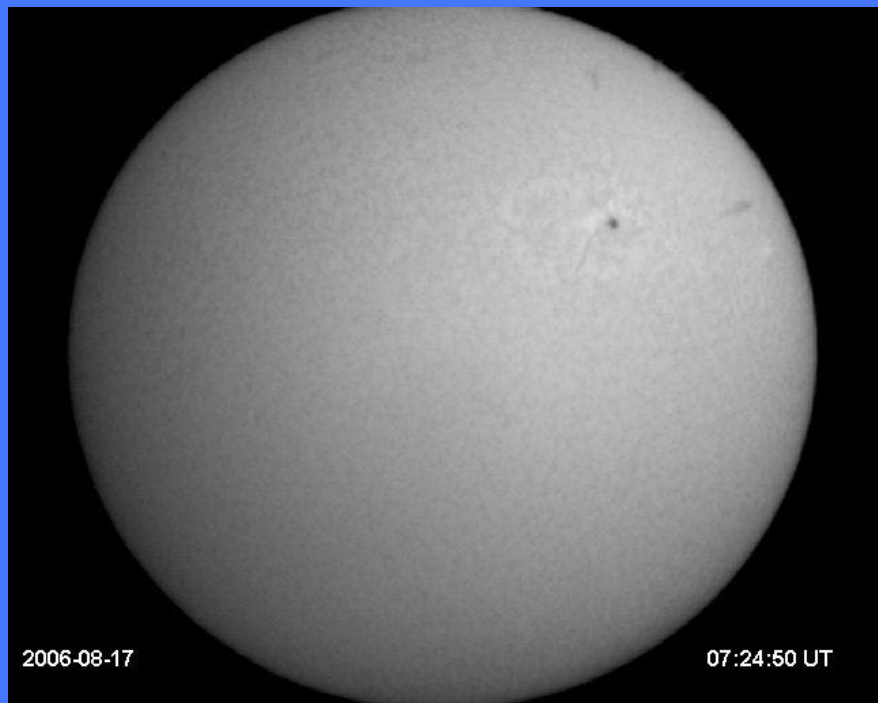


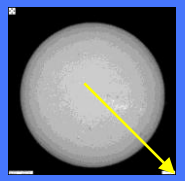
Thank you for your attention

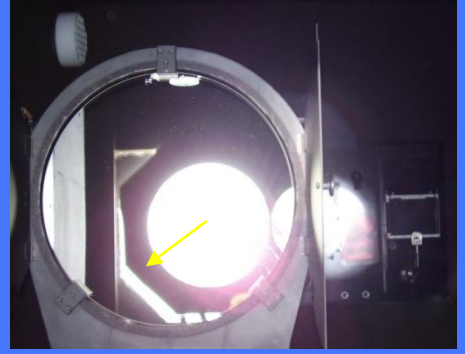
Technical improvements to decrase influence of local seeing.

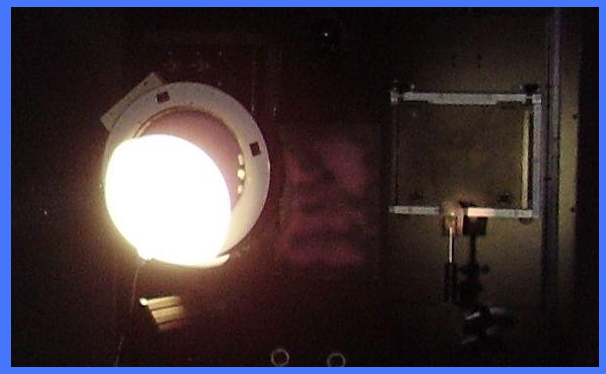
Jensch coelostat, detail
Φ of mirrors 60 cm
laid on oil seal

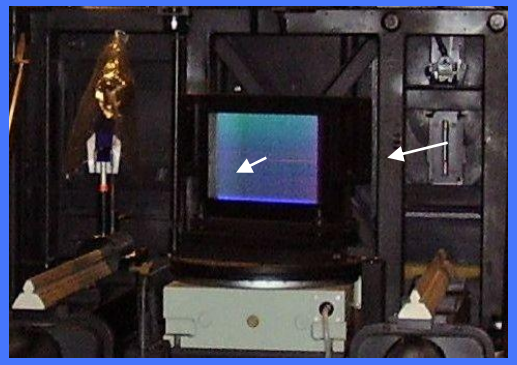
In front: A small auxiliary full-disk telescope with Coronado Hα filter

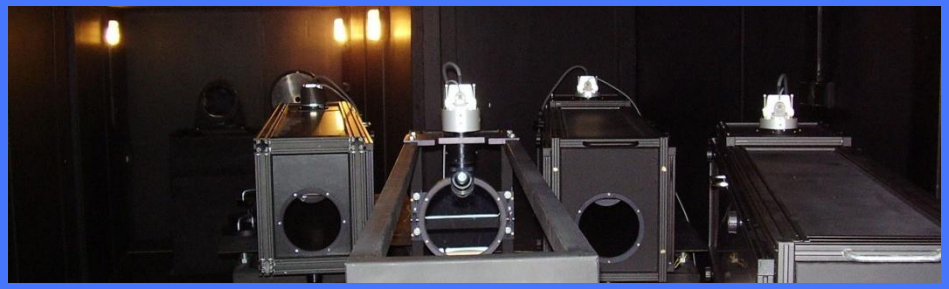








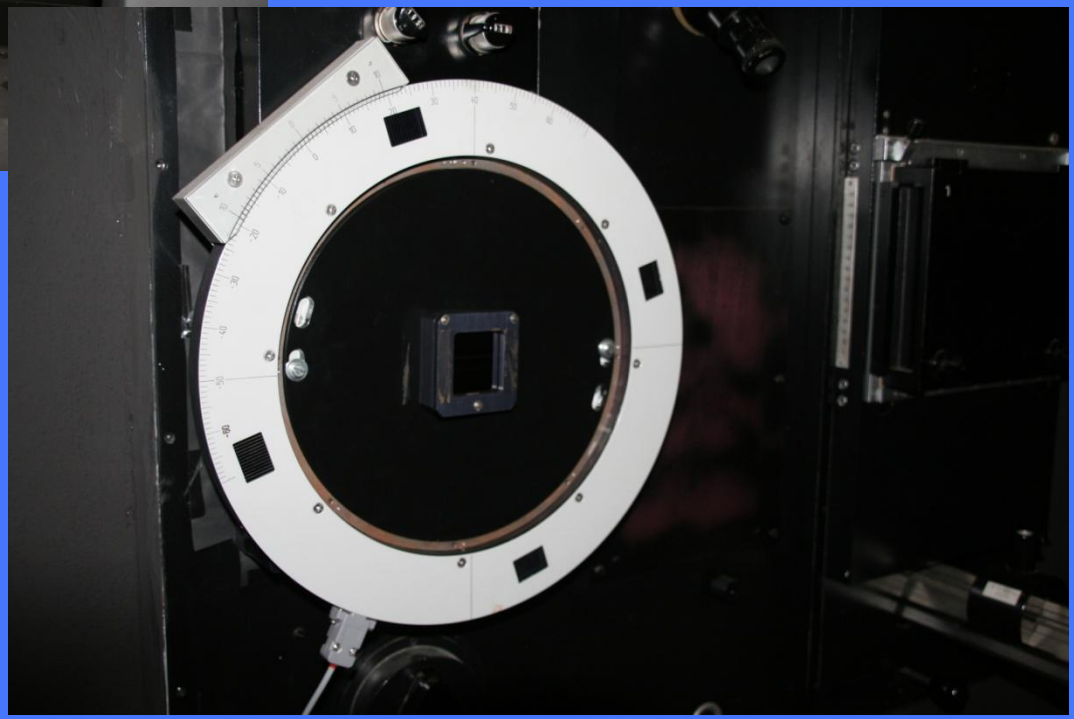




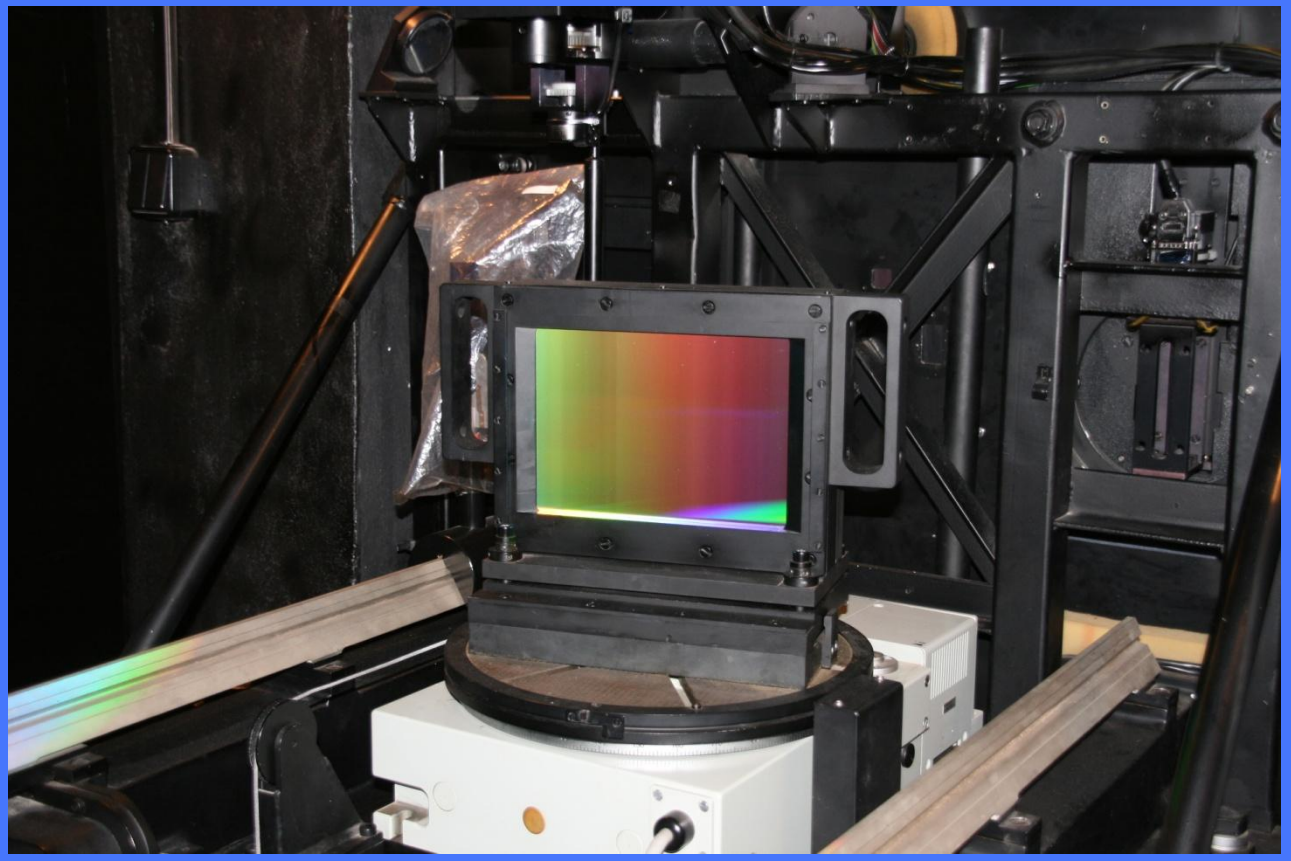
Light beams in the telescope and spectrograph

M1 50cm/35m

FOCAL PLANE & SLIT



Richardson grating



Modernization of electronics and optics

- **Instead of a large photographic detector 6 CCD cameras are used simultaneously (5 in the spectrograph, 1 at the slit jaw)**

- **Replacement of the old grating Bausch & Lomb, *C*=632.1 mm-1, W=206 mm, H=154 mm, ϕ=51°, blazed for 4th order for a new grating Richardson, *C*=1200'/ mm, W=206 mm, H=154 mm, ϕ=17.5°, blazed for 1st order**

- **Optimalization of the cameras and their optical systems with respect to small scale detectors and a limited space as well as concerns of conservation of spectral and angular resolution**

Main missions of the HSFA2
Advantages: flexibility and availability
The only limitations: weather and season

- Solar active phenomena observations (flares, prominences, filaments, spicules, dark mottles etc.)
- Cooperation with other ground based telescopes (optical and radio)
- Support of space born devices
- Spectral diagnostics and modeling of phenomena
- Education and practical training of students

Data Availability

- Raw spectra and slit-jaw images are stored at www.asu.cas.cz/~sos/
- in the *latest.data*, two modes view/full
- *full data* can be reached with permission due to still testing program
- calibration SW is partly developed and available on the website
- people are encouraged to use observations and make suggestions and proposals for using the spectrograph

Perspectives

- Flare and active prominences spectra in a new cycle, diagnostics of accelerated particles
- Exploration of the archive data, new observations,
- Cooperation, coordinated observations..
- Improving of the controlling SW which becomes obsolete ,information about position on the Sun and other parameters directly inti the FITS header, new cameras in the shorter wavelengths

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Valníček B., Letfus V., Blaha M., Švestka Z. and Seidl Z.: 1959, Bull. Astron. Inst. Czechosl. 10, 149.

Kotrč, P., Heinzel, P. and Knížek M.: 1993, JOSO Annual Report 1992, ed. A. V. Alvensleben, 114.

Kotrč P.: 1997; Hvar Obs. Bull., Vol. 21, p. 97-108.

Klvaňa M., Sobotka M., Kotrč P., Knížek M., Heinzel P.:2001, Astronomische Nachrichten, Vol. 322, p. 371-374.

Kotrč P., Kschioneck K.: 2003; ESA SP-535, A. Wilson (ed.), p. 717-722.

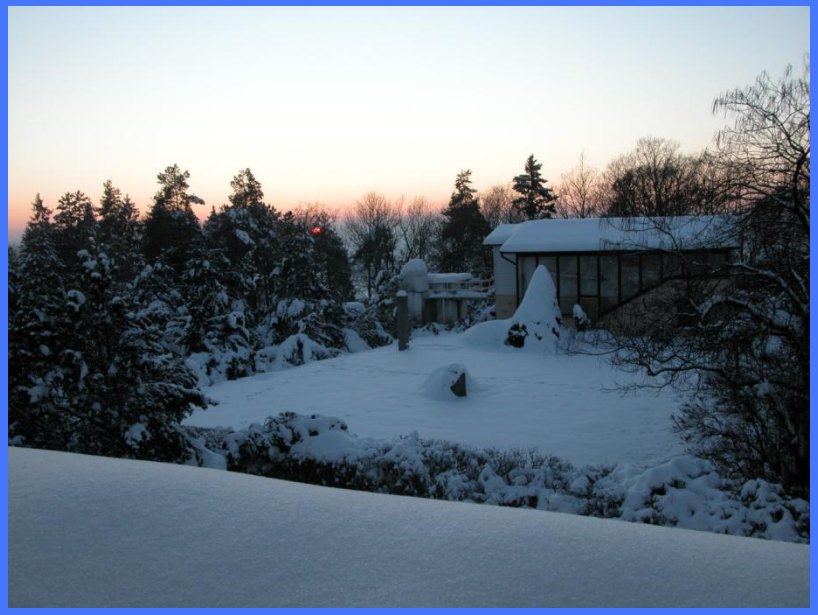
Kotrč P.: 2006,, In Coimbra Solar Physics Meeting Proceedings, ASP Conference Series, Vol. 368, pp. 559-568, P. Heinzel, I. Dorotovič and R. J. Rutten (eds.)

Ondřejov, HSFA2, 2009-10

A solar observation instrument with genius loci, where people like to meet and work.

Horizontal Rotable Spectrograph

- Designed by V. Bumba, finished in 1969 fed by 55/55 cm coelostat, M1=45cm/35m.
- Spectrograph Czerny-Turner, grating 600”/mm, size 150x140 mm, 2 camera mirrors of f/980 cm for photographic and photoelectric detection of solar magnetic field based on Zeeman effect and velocity fields. Rotation of the spectrograph was intended to study Evershed effect in the sunspots (mass flow)
- Due to installation of photoelectric magnetograph – (fixed output slits) –> no more rotation
- The telescope and spectrograph used as a prototype for the later developed series of HSFA spectrographs by Carl Zeiss Jena.
- It is interesting to compare the parameters with russian АЦУ 5 (astronomicheskaja celostatnaja ustanovka) Astronomical coelostat device. Qualitatively it is a similar device.



A Dream of Ondřejov Solar Tower and the **Reality**

In break of 60ies and 70ies: Solar Tower Telescope, in a good local seeing, a large aperture, evacuated, equipped with a large dispersion spectrograph,…

Negotiation with Carl Zeiss, specification of instruments, parameters, measurements of local seeing until 25 m, found that height 8 – 10 m is critical for local turbulence. The higher the better.

But the most critical was the budget for the solar tower. Estimated costs ~ 100 million Kcs, while the just finished Ondřejov 2m solar telescope was ~ 25 million Kcs.

The project of solar tower was stopped as unrealistic. The end of the dream.

Reality:

Instead of the Solar Tower, a project of 5 horizontal solar telescopes with spectrographs constructed by a professional company producing astro/instruments and build them both in Czech and Slovak parts was more acceptable from financial and political reasons

As a prototype, the Rotable (nonrotating] Horizontal Spectrograph was taken. Device consisting of Coelostat, Telescope and Spectrograph.

Carl Zeiss Jena had a tendency to use various mechanical parts developed for other astronomical devices, problems of controlling electronics, but they were able to promise everything (a spectroheliograph] to receive the job.

AFTER 25 YEARS

Technique and conditions have changed very much.

What is the shape of individual devices? How to compare and evaluate them?

Are they still in function?

How do the users feel the instruments? Like a burden, or like a valuable device?

We put a dozen of questions to the all actual users to figure out their meaning.

A SUMMARY OF 12 QUESTIONS

When was your HSFA put into operation?

What was its primary purpose? Was it changed?

What kind of detectors were used in its history?

Does it still works? If not, why?

Are its data or the main results available on web? Where?

What is a number of publicatons based on the data?

What you consider the main result obtained with the device?

Was it (is it) used for education and training of students?

What are your real plans with the device for next 5 years?

Send us at least one picture of the device.

Give us an email address of the person responsible for the instrument.

STARÁ LESNÁ - 1985

Spectrograph is still able to work.

Used detectors: photoplates, TV CCD camera

Data and results not available at a webpage.

Estimated number of publications: ~ 10

The main result: Obtained spectroscopic skills both by emploees and students

Plans for next 5 years: Optical elements testing, education and practice of students.

Responsible person: Aleš Kučera

STARÁ LESNÁ, 800 m above sea level

HURBANOVO, 200 m above sea level

HURBANOVO 1982

- Spectrograph still able to operate, modernization highly desired.
- Detectors: photographic plates, film, CCD camera Astropix.
- Estimated number of publications: ~7
- Main results: Measurements of Doppler velocities, flare spectra, time variation of teluric lines.
- Used for education of students.
- Plans for next 5 years: Registration of flare and other solar active phenomena spectra
- Responsible person: Theodor Pintér

ALMATY, Kazakhstan, 1989

- Spectrograph mounted in 1989 in Moscow University Observatory, beginning of 1990‘ nationalized by Kazakhstan, started to operate, in 1993-96 observation of H-alpha and CaII H&K spectra, primary images.
- Then stopped due to budget problems.
- Detectors: photographic plates and films
- No publications, no web page,
- Plans: Observations? Responsible persons:
- Kuratov K, Minasyants G.

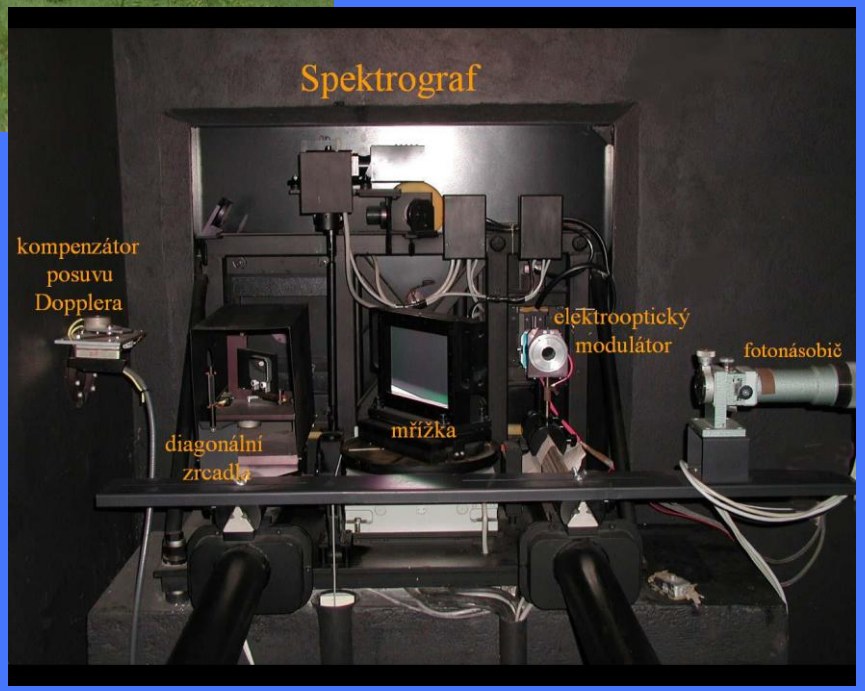
ALMATY, 2800 m above sea level

ALMATY, 2800 m above sea level

ONDŘEJOV, HSFA1, 1987

- Magnetograph 1990-2001, since 2003 two channel spectroheligraph, spectral analyzer SOLSPAN. Still able to operate.
- In 2001 – 2004 an unsuccesful modernization, still problems with electronics
- Detectors: Photomultipliers, 2 CCD cameras
- Data and results at: www.asu.cas.cz/~solmag
- Estimated number of publications: ~ 120
- Main results: Evershed flow, Doppler velocities, magnetic study of active regions,
- Used for education of students, plans: Evershed effect and Doppler velocities.
- Responsible person Miroslav Klvaňa

ONDŘEJOV, HSFA1, 520 m above sea



HSFAs: A family silver or a Greek gift?

Any heritage has two faces, like the god Janus.

One face is nice, other is ugly. HSFA are a heritage.

On the contrary to space experiments that fires, ground based telescopes remain on the ground.

They need mantainance, budget for improvement and enthusiasm for work and improvement. And the human power.

All these conditions are strongly related. When they are fullfiled, Janus shows his good face.

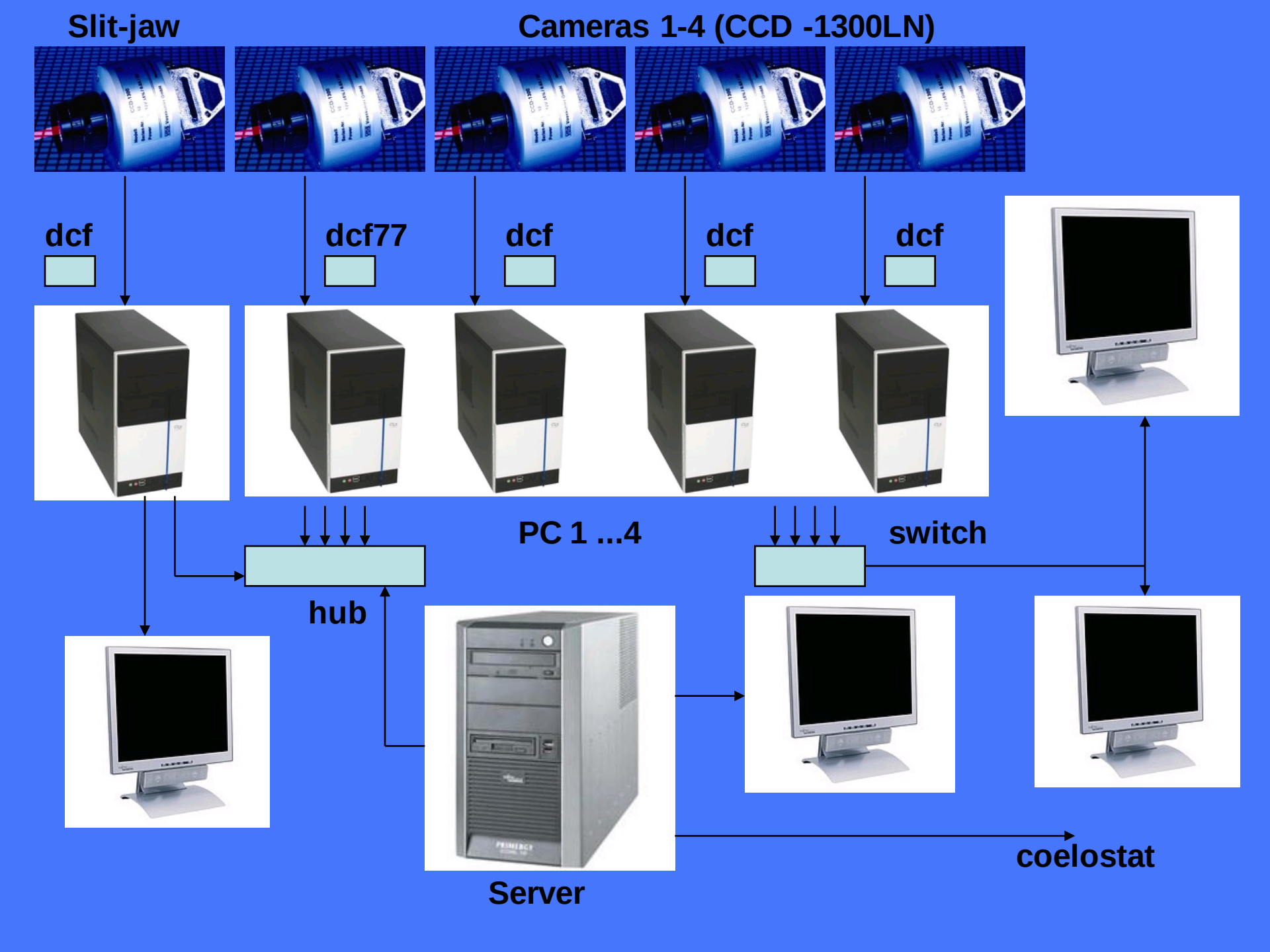
If not, it is better to give up the heritage to not to see its ugly face.

Thank you for your attention

Many thanks for invitation and your kind hospitality

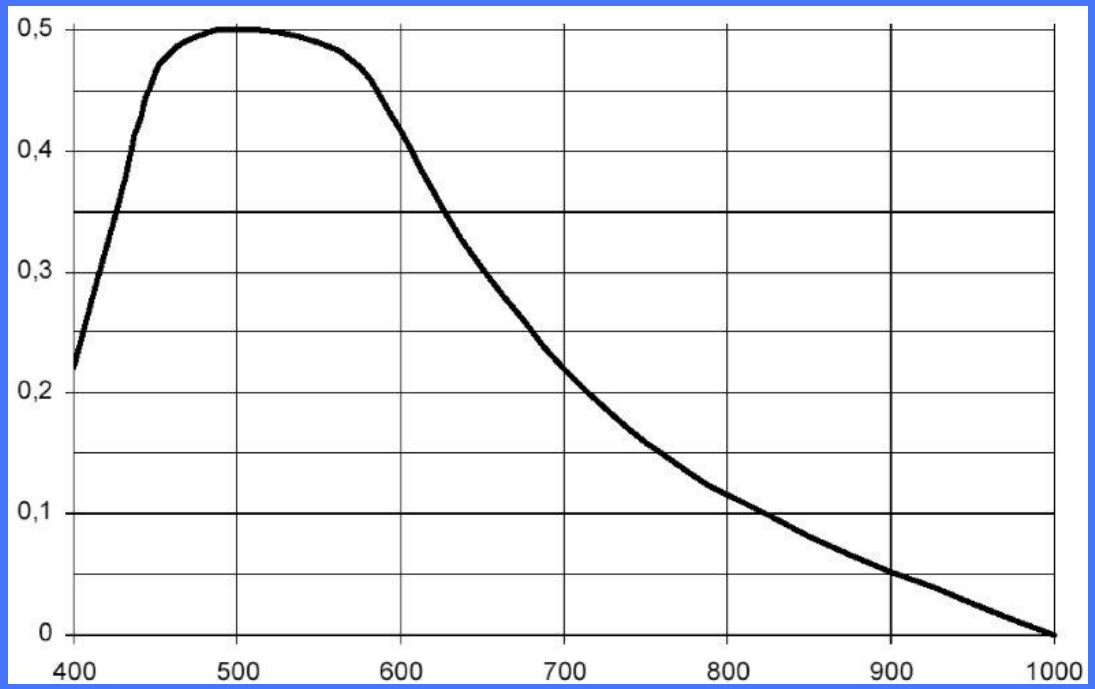
RECENT RESULTS

- 1 paper recently published (ApJ – prominences, SP – prominences), other one in preparation.
- Study of waves in spicules – H-alpha and spectral observation of prominences during 2008 solar eclipse – under preparation


Slit-jaw
Cameras 1-4 (CCD -1300LN)
dcf
dcf77
dcf
dcf
dcf
PC 1 ...4
switch
hub
Server
coelostat

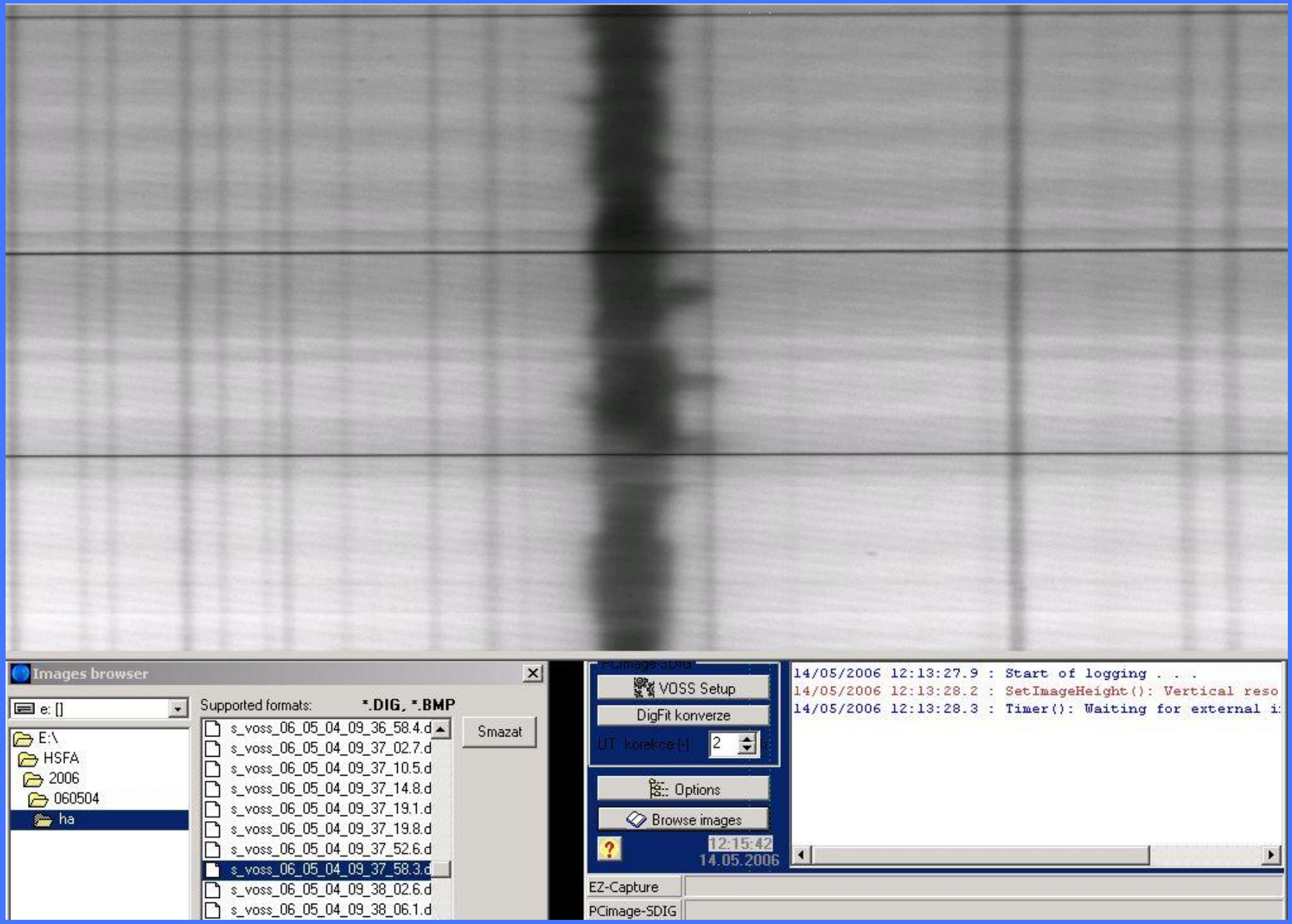
CCD Cameras Parameters

Chip quantum efficiency on wavelength in nm



asynchronous shutter, $1/10^4$ s – 10 s
reading noise ≤ 14e
sensor saturation ≥ 25 000e
dynamic range ≥ 1:2000
digital 12 bits output RS-644

- **CCD cameras VDS Vosskuehler CCD-1300LN, pixel 6.7μm x 6.7μm, chip size *s*=pH x pV=1280(H)x1024(V) pixels, combined with grabbers Matrix – Vision**



Visual information about individual cameras

Controlling desks of the observer in the pavilion basement

- Main controlling PC for telescope and spectrograph, monitors
- PC with frame grabbers for data acquisition of individual cameras

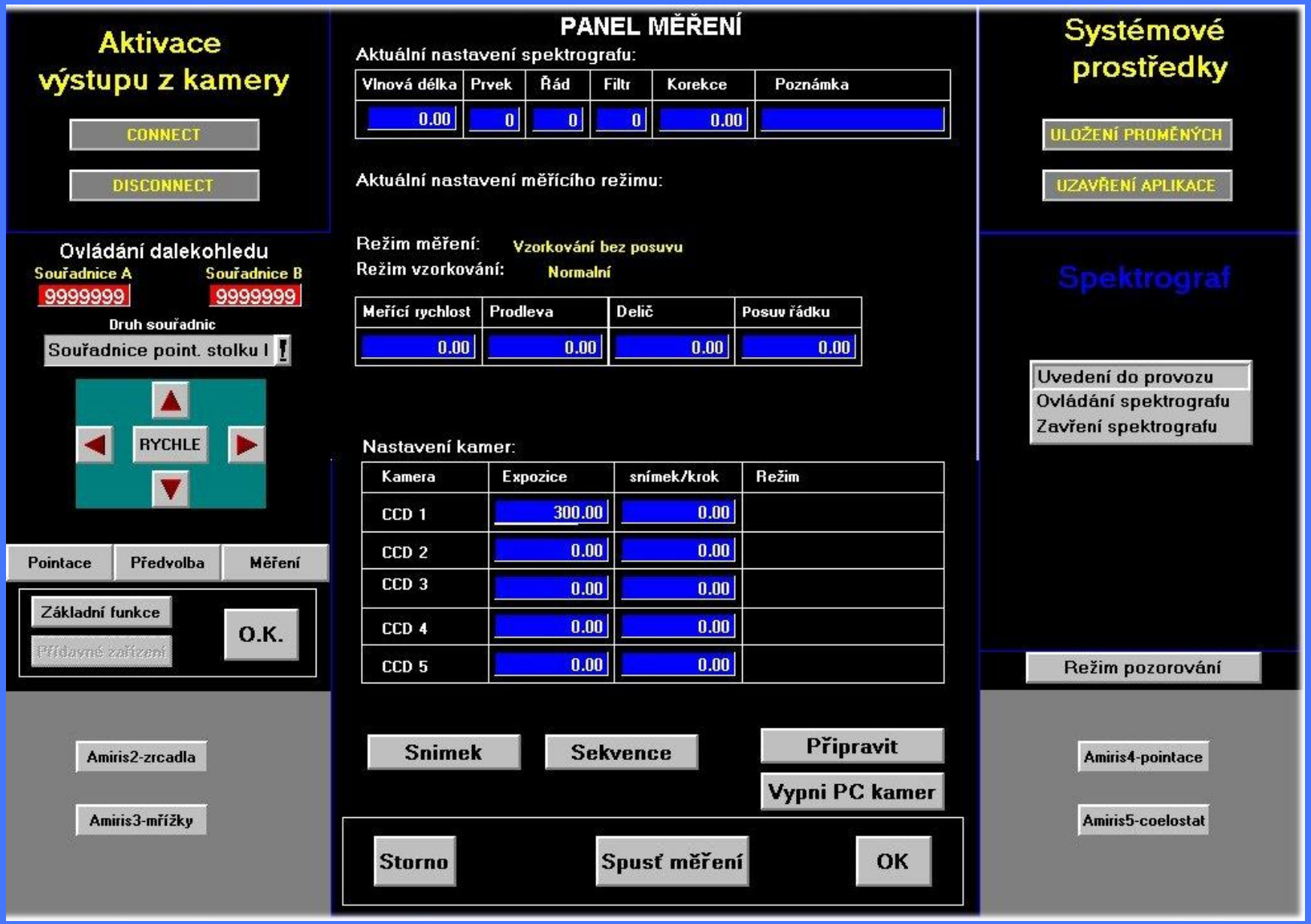
Ondřejov Observatory – Brief Data

Location: 50º N, 15º E, altitude 528- 548 m,
35 km SE to Prague center, 5 km E to D1 highway

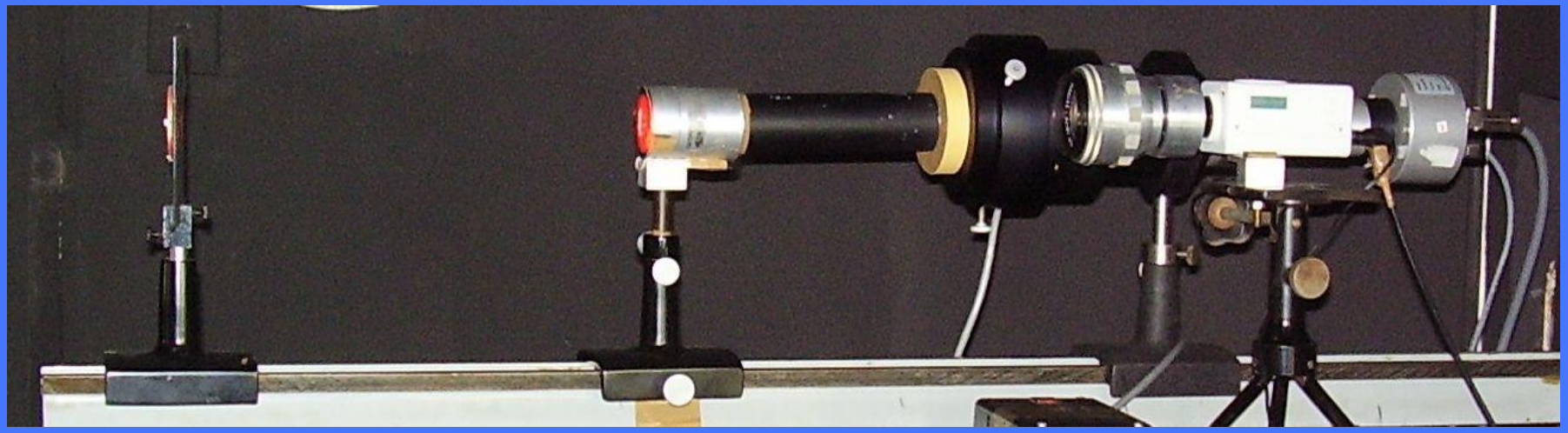
Oldest part founded in 1898 by J. & J. Frič as a private observatory (astrometry,geodesy) In 1928 donated to CR - Charles University, now used mainly as a museum for visitors.

Since 1945 new astronomical branches: Earth's ionosphere, solar and stellar astrophysics, solar system bodies, interplanetary matter, galactic & extra-galactic astronomy.

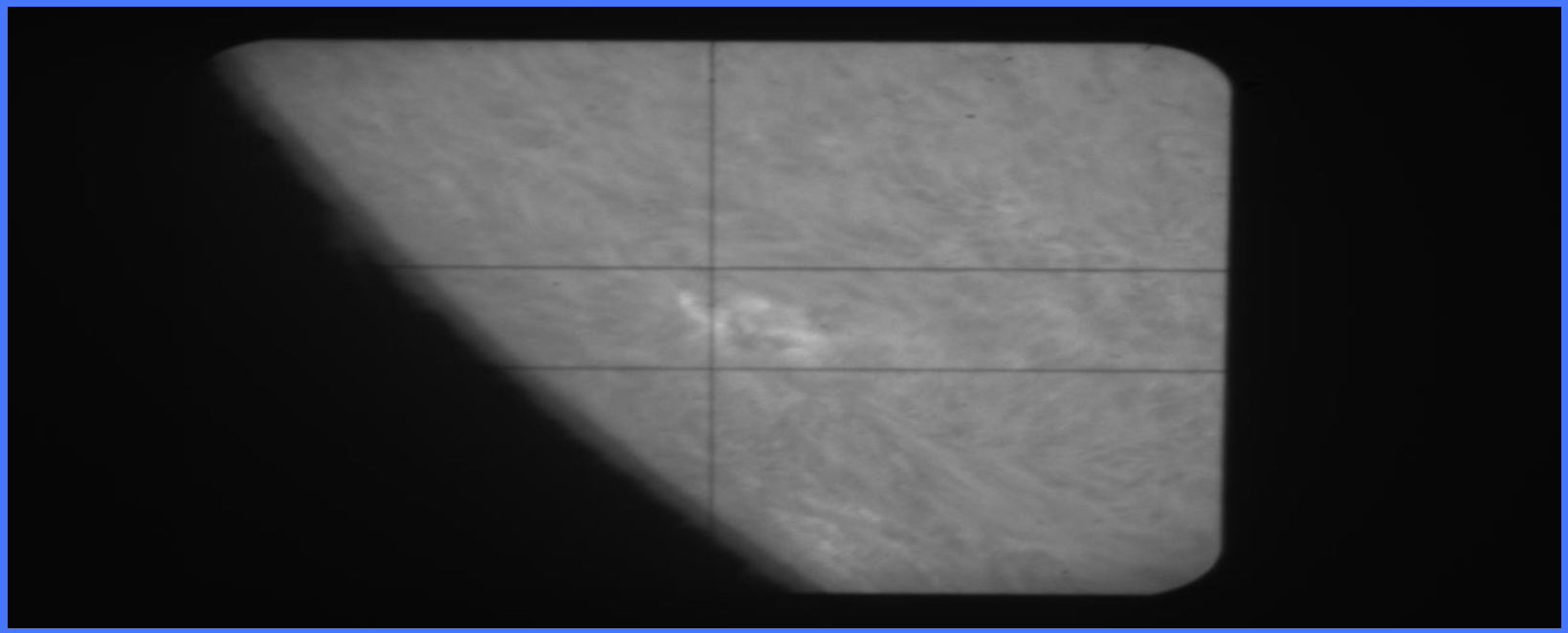
Main telescopes: 2m stellar telescope, 65 cmtelescope for asteroid photometry, network of meteoric cameras & radar photographic zenittelescope, plus solar telescopes as follows:



Controlling panel for the telescope, spectrograph and cameras



- **Telescope for H-α slit jaw images (behind).**
- **Camera for images of the primary focus information for the observer.**



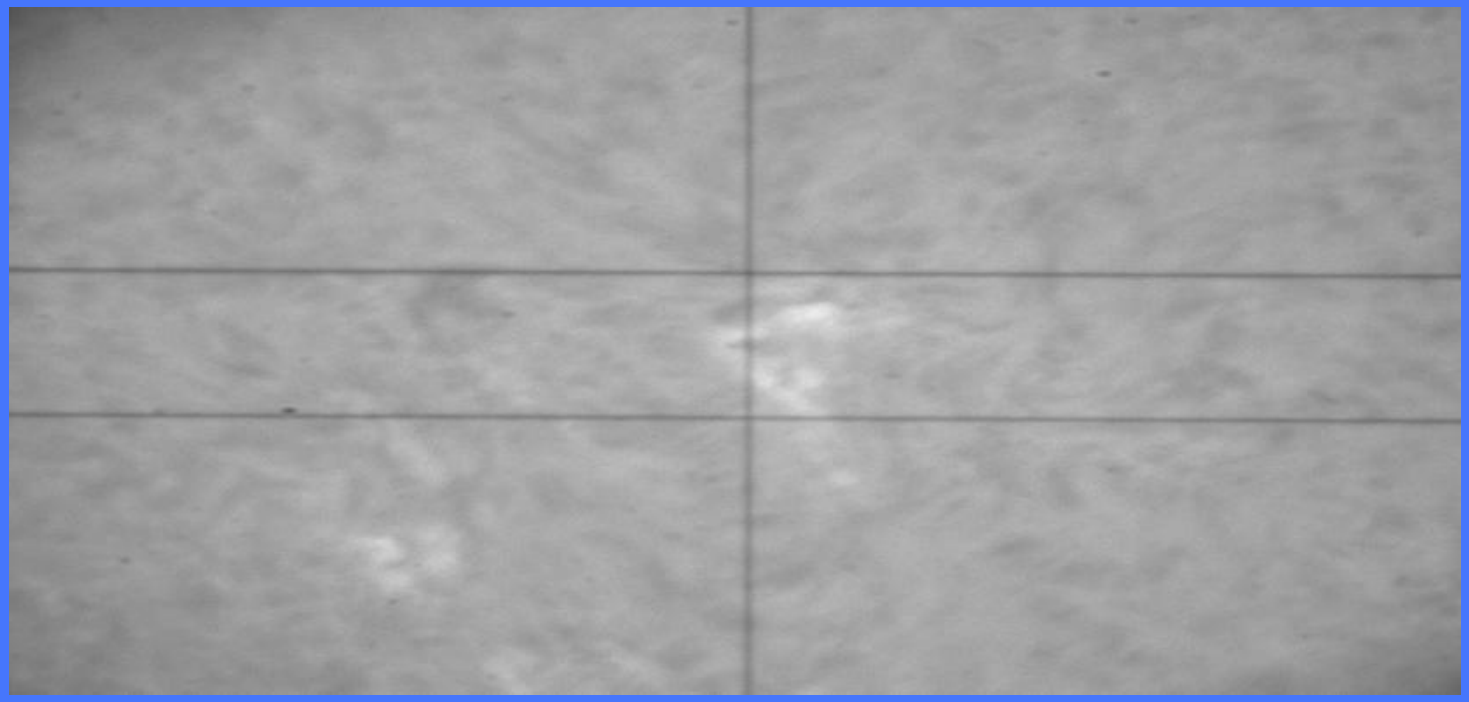
Hα slit-jaw imaging system, DayStar, halfwidth 0.7 A)

Slit jaw image on 2006 05 06 at 10 04 54 UT) chromospheric structure, rim and spicules visible

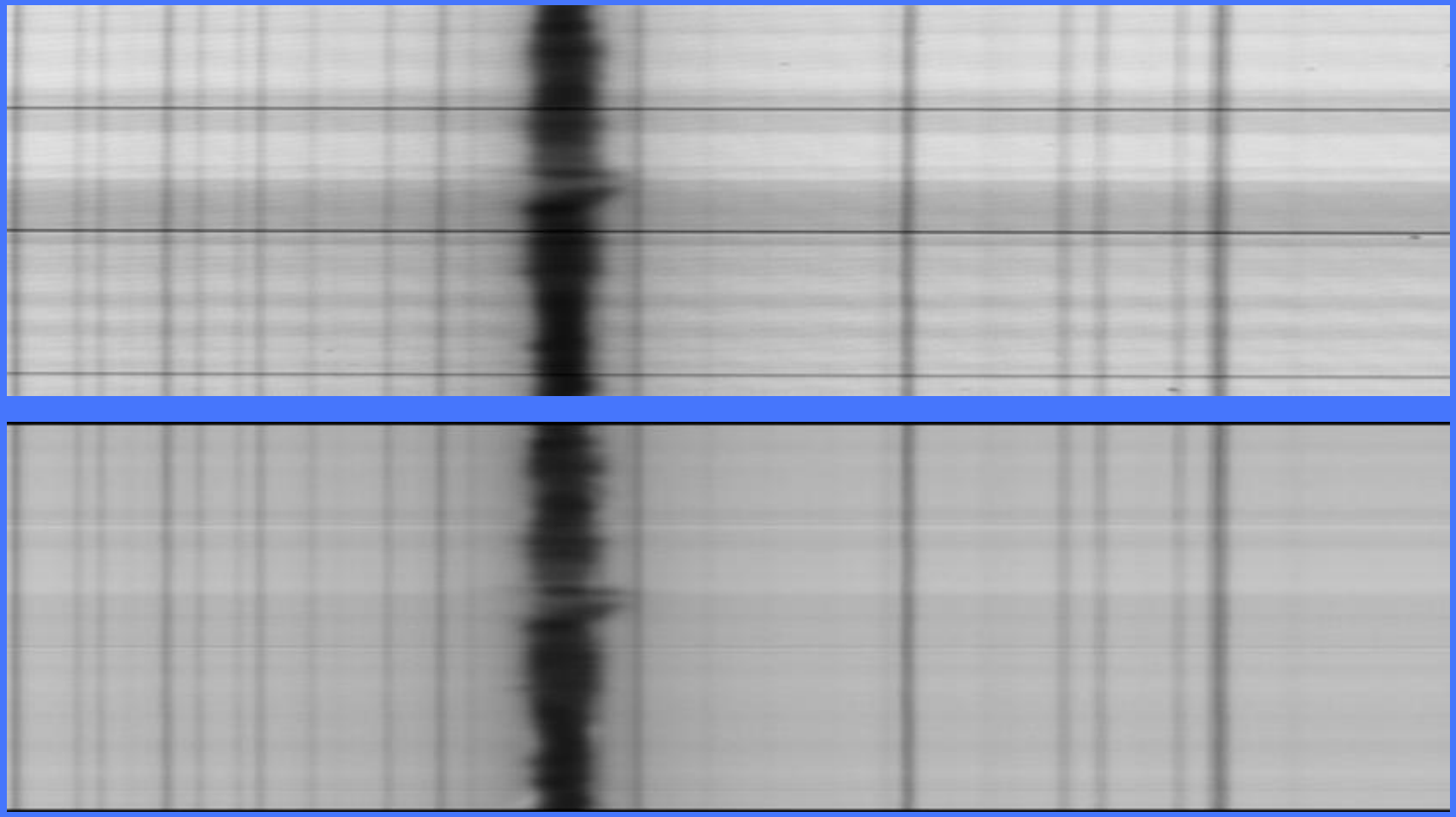
Hα filtrogram of the spectrograph slit

Image of a plage and a filament on 19. 5. 2006 at 12:55:48,5 s

A remnant of the NOAA 10880

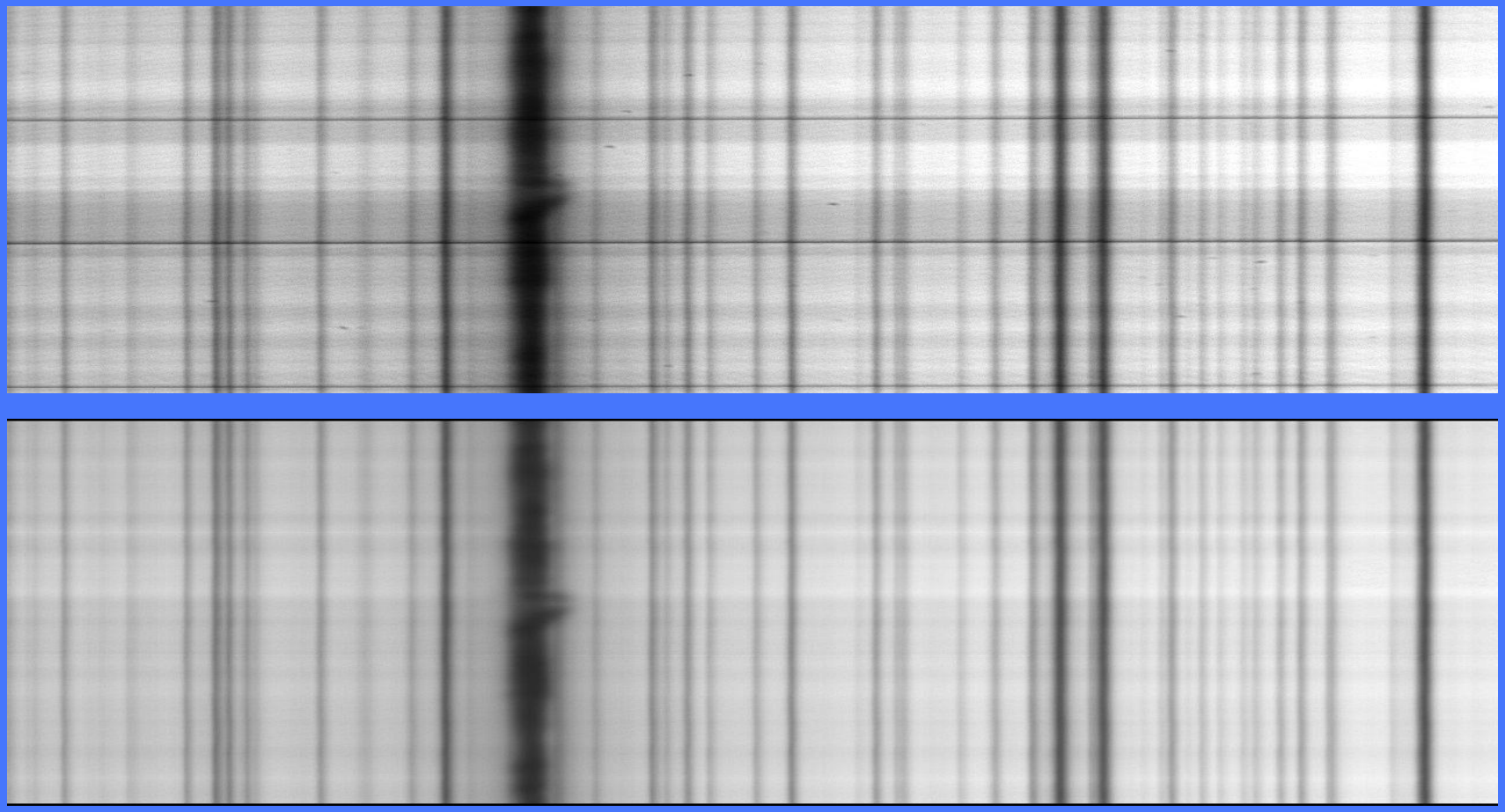


Hα spectrum of the NOAA 10880 on 19. 5. 2006
Up – a raw picture, bottom - after DF and FF



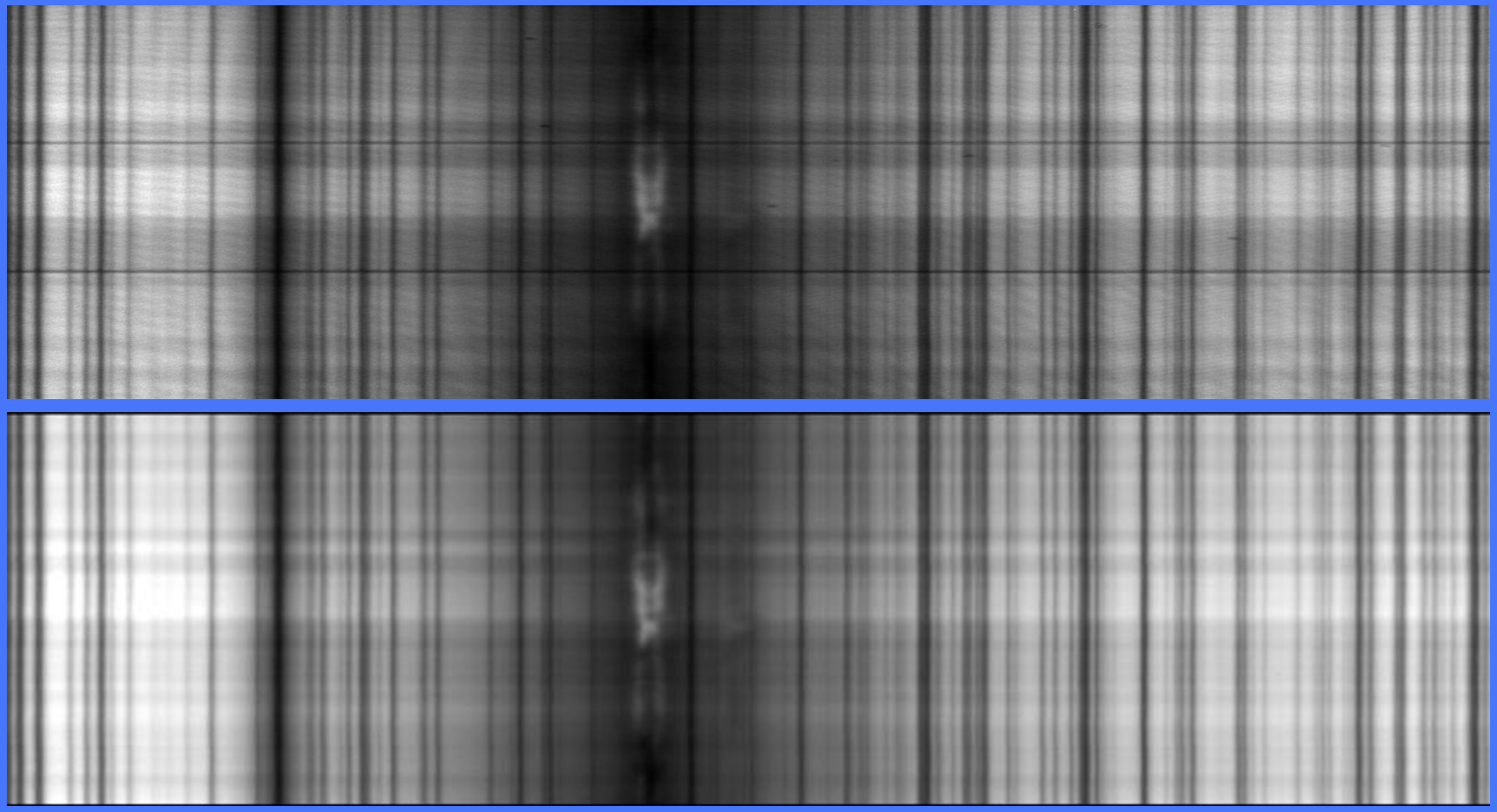
Hα (6563 6 Å, 0.01378 A/pixel, ∆λ=27 mA)

Hβ spectrum of the NOAA 10880 on 19. 5. 2006
Up – a raw picture, bottom - after DF and FF



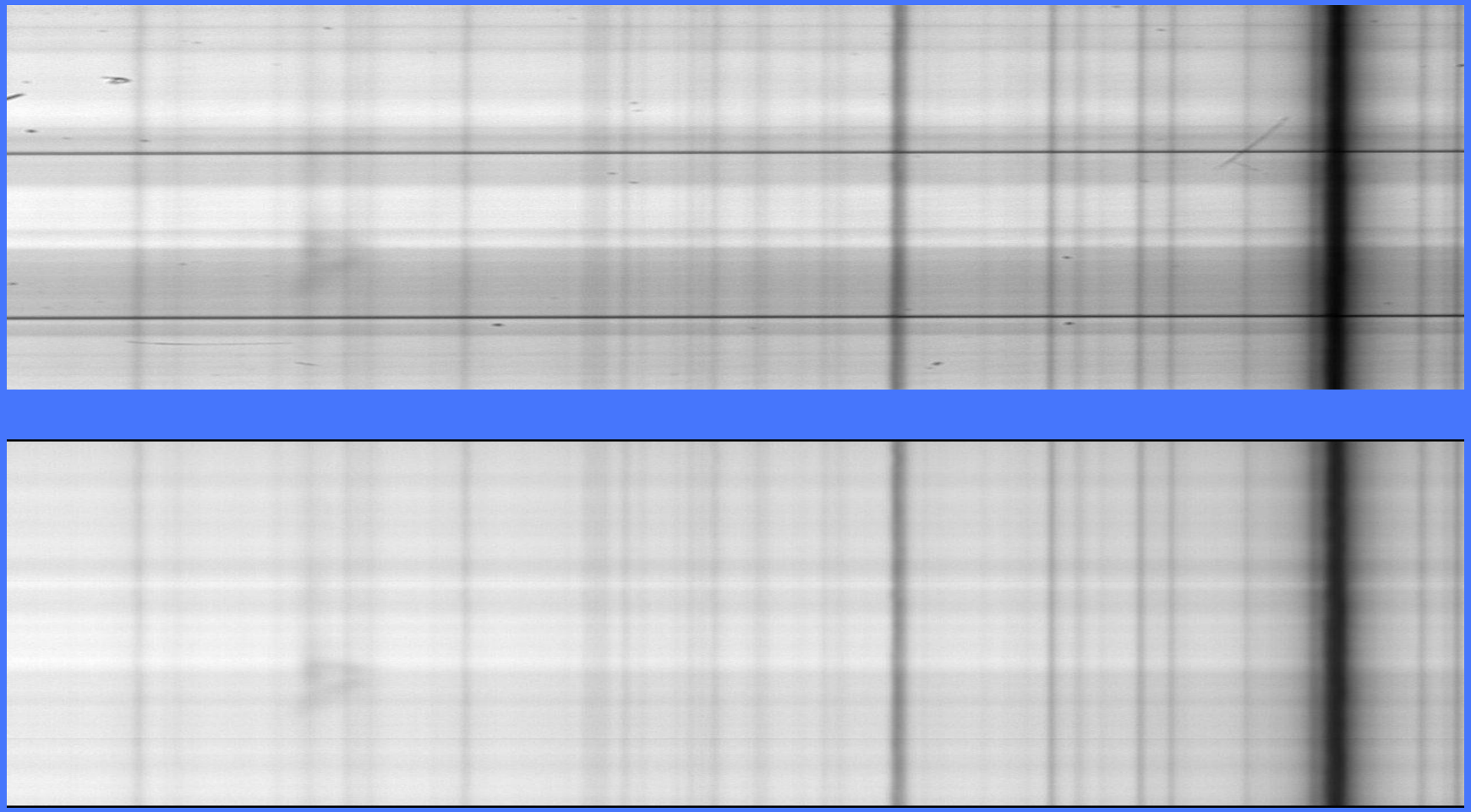
Hβ (4861 10 Å, 0.02074 A/pixel, ∆λ=20 mA)

CaH spectrum of the NOAA 10880 on 19. 5. 2006
Up – a raw picture, bottom - after DF and FF



CaII K or CaII H (3934 or 3968 10Å, 0.02108 A/pixel, ∆λ=16 mA)

D3 spectrum of the NOAA 10880 on 19. 5. 2006
Up – a raw picture, bottom - after DF and FF



D3 (5875 10 Å, 0.01926 A/pixel, ∆λ=24 mA)

Participation of the Serbian students in 2007

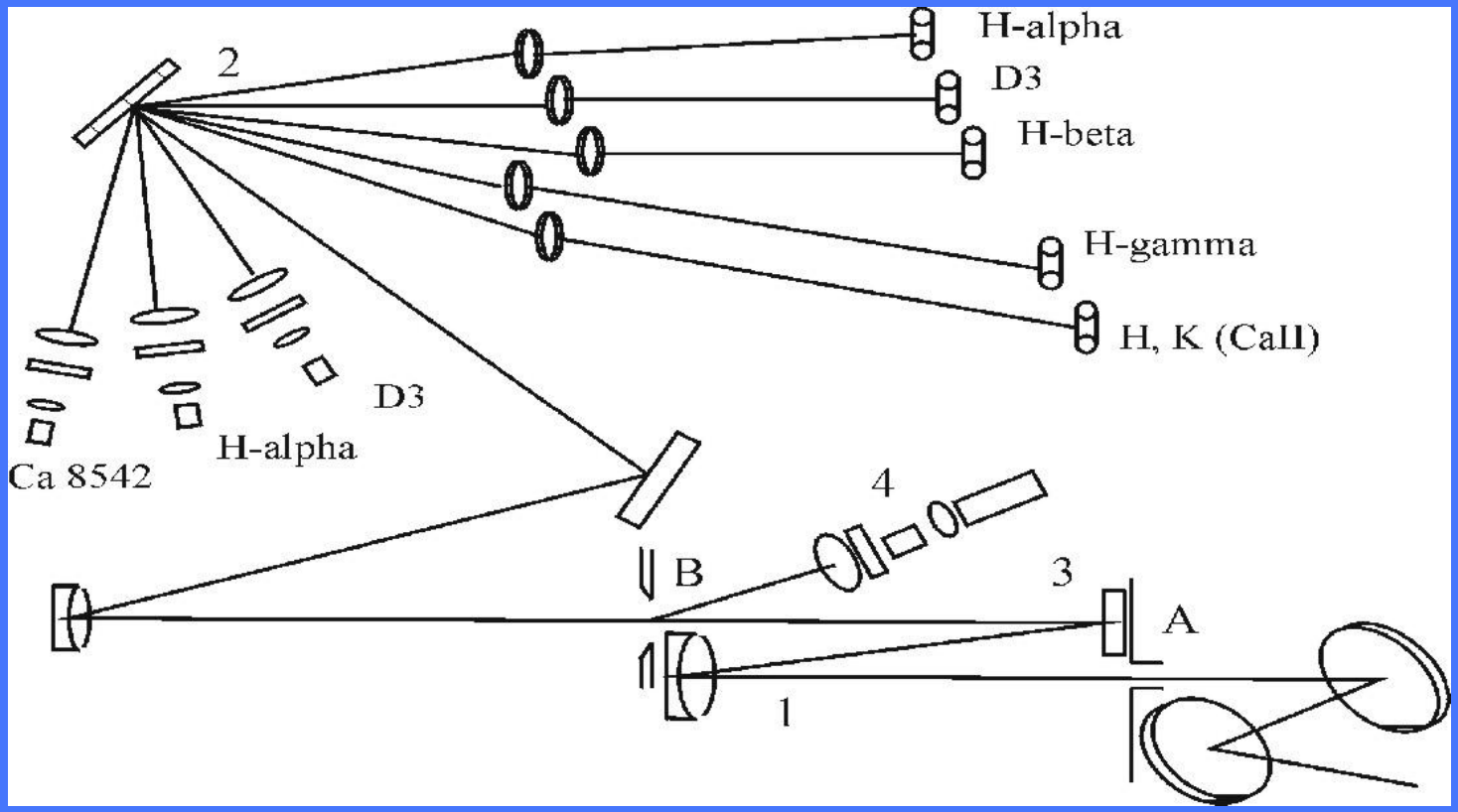
- A procedure for numerical determination of proper exposure time for CCD cameras.
- A procedure for selecting good pictures (without shifts of hairs) which can be used in improved procedure
- A procedure for recognizing overexposed and underexposed pixels.

Participation of the Serbian students in 2008

- A procedure for iterative determination of optical thickness τ_0 in the Hα line in both calibrated and non calibrated data– a tool for fast estimation of the prominence parameters…-> paper in SP ?

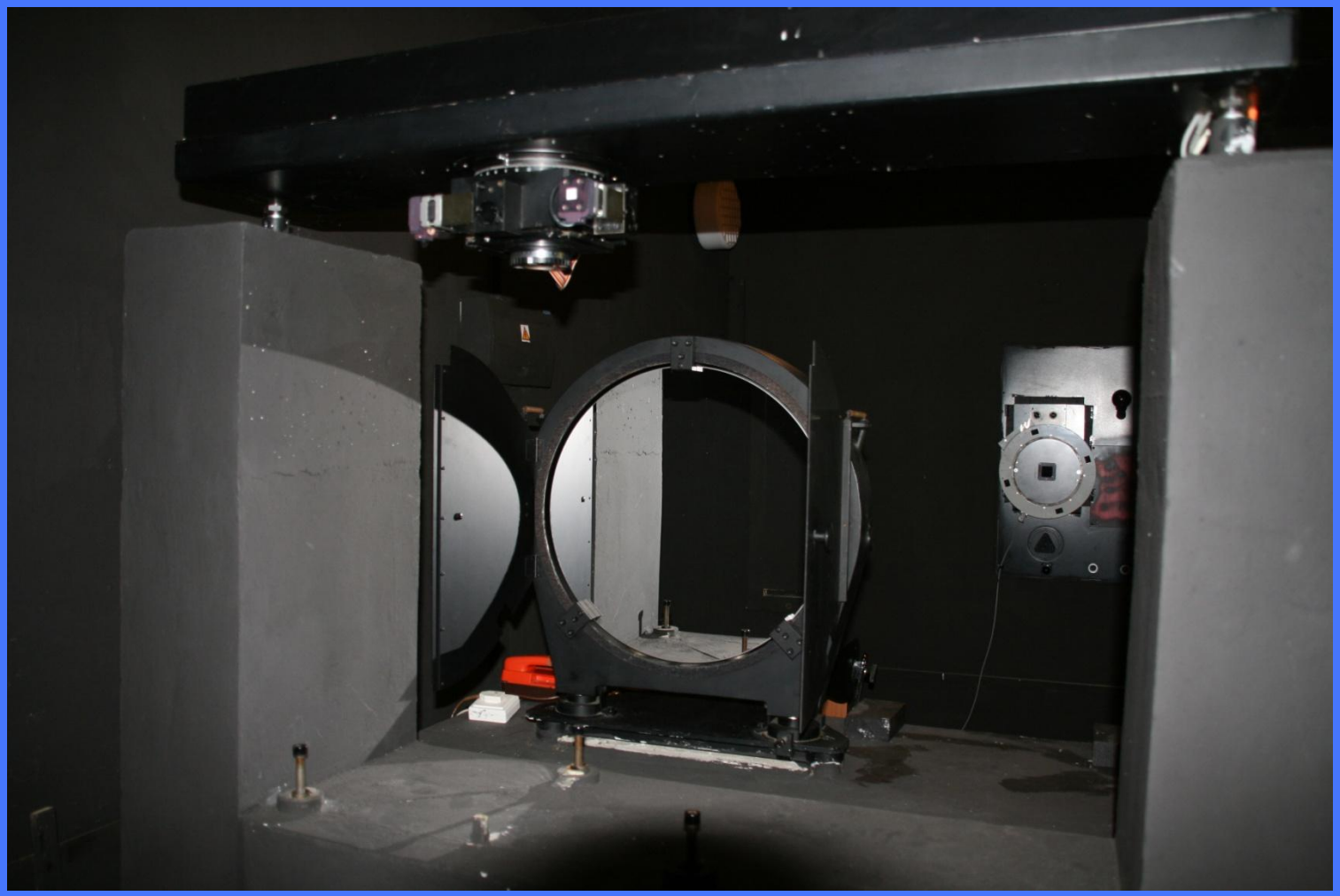
- To be continued..? To be productive ?
- Useful and interesting.

Optical Schema of the MFS



Originally 2nd right order, then + H-delta and Balmer higher lines,
then + H-alpha slit-jaw images added in 1980ies
then + video cameras in the left orders, (in 1990 ies)
with a high cadency 25 frames/s but in 8 bits only (eruptive events)

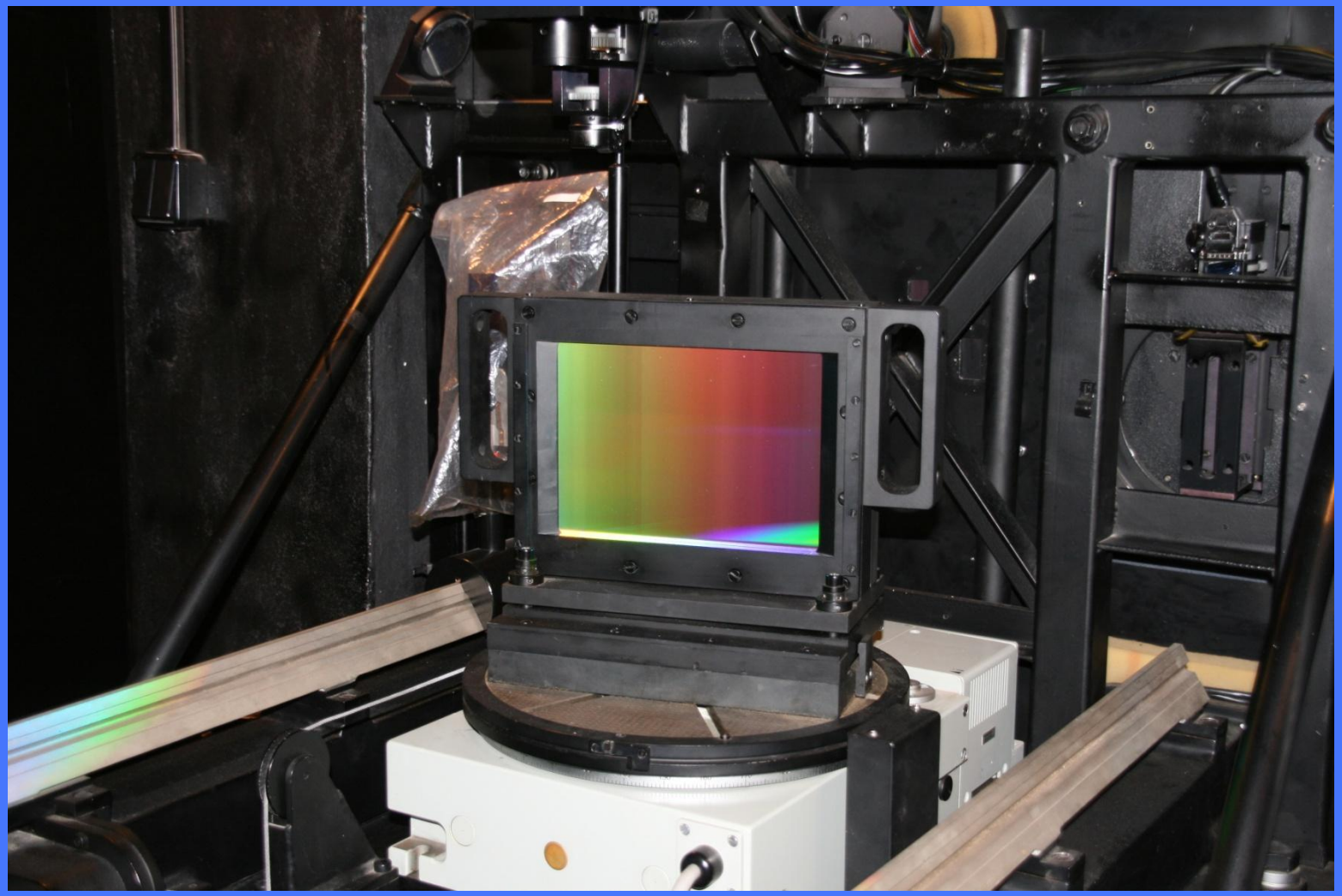
Main mirror of the telescope



- Φ 500 mm, f 34850 mm

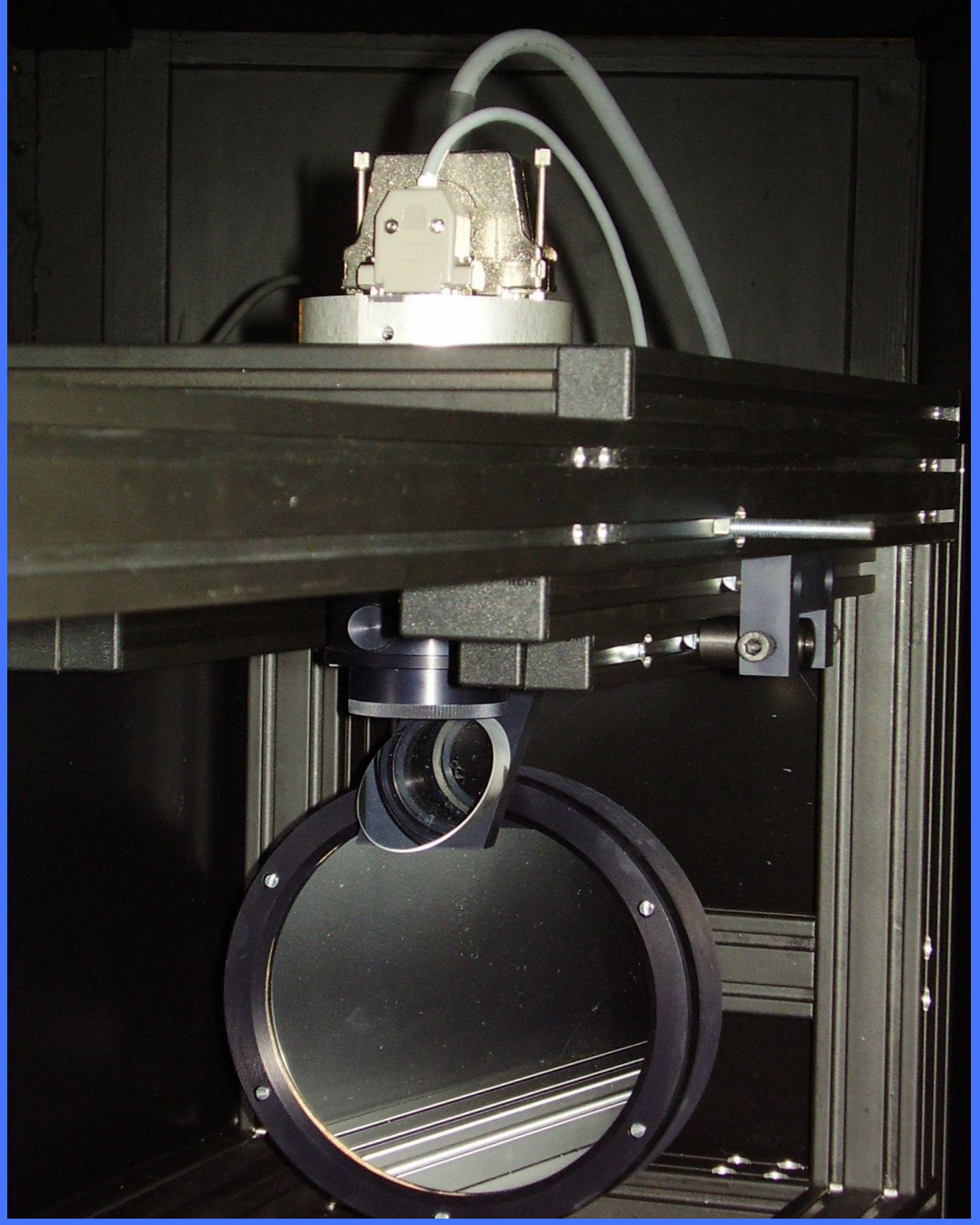
Mechanical parts are controlled by computers AMIRIS used in industry

- **Auxiliary flat mirror (left) Φ 30 cm**
- **Second coelostat mirror Φ 60 cm**

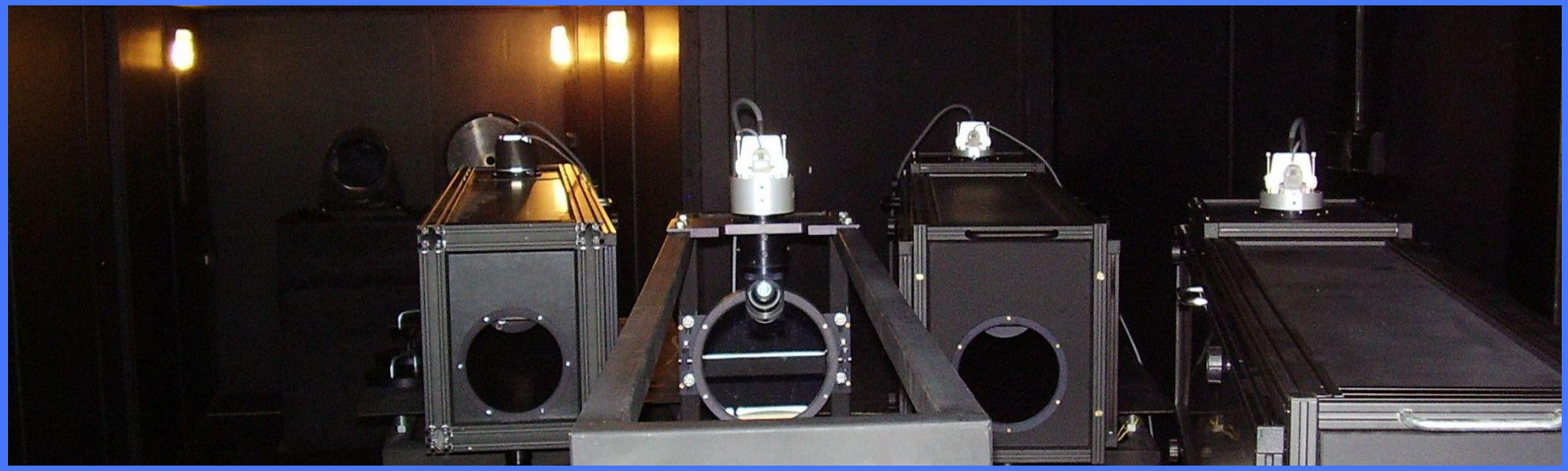


- **Inside the spectrograph, a view from collimator to the entrance slit, and the Richardson grating (1200 lines/mm)**

- **Main (20 / 250 cm) and diagonal camera mirrors**
- **Plate for correction of astigmatism**
- **CCD camera**

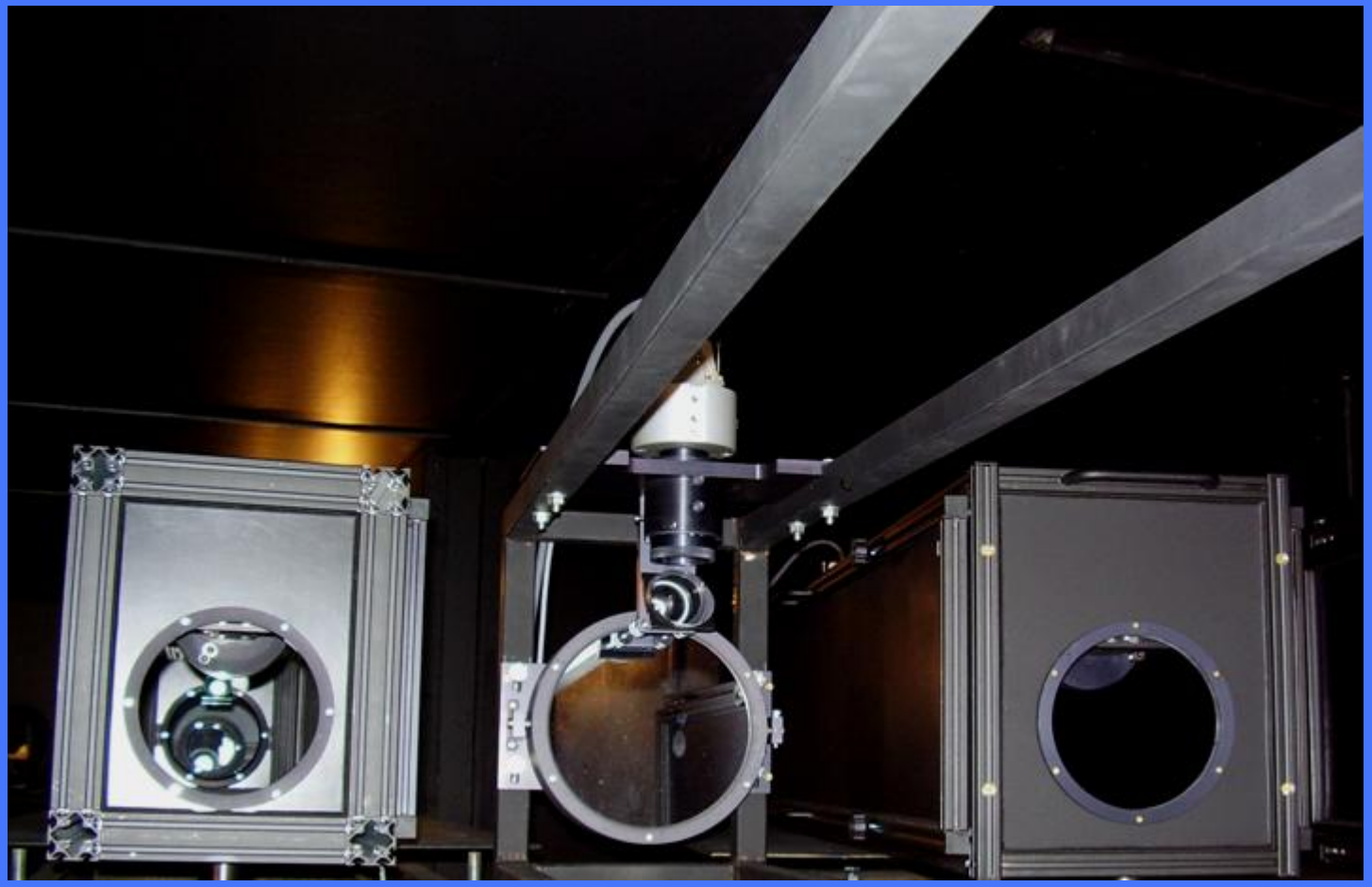


Spectral camera imaging systems



- Original single-camera spectrograph Czerny-Turner changed into a multicamera version, spectra are taken simultaneously in 4-5 cameras
- Inside the spectrograph, a view from grating to collimator (left), behind the left camera is the covered original camera mirror.
- Foreground:
- 4 imaging systems with 4 CCD cameras Vosskuehler 1300 LN

Details of the imaging system

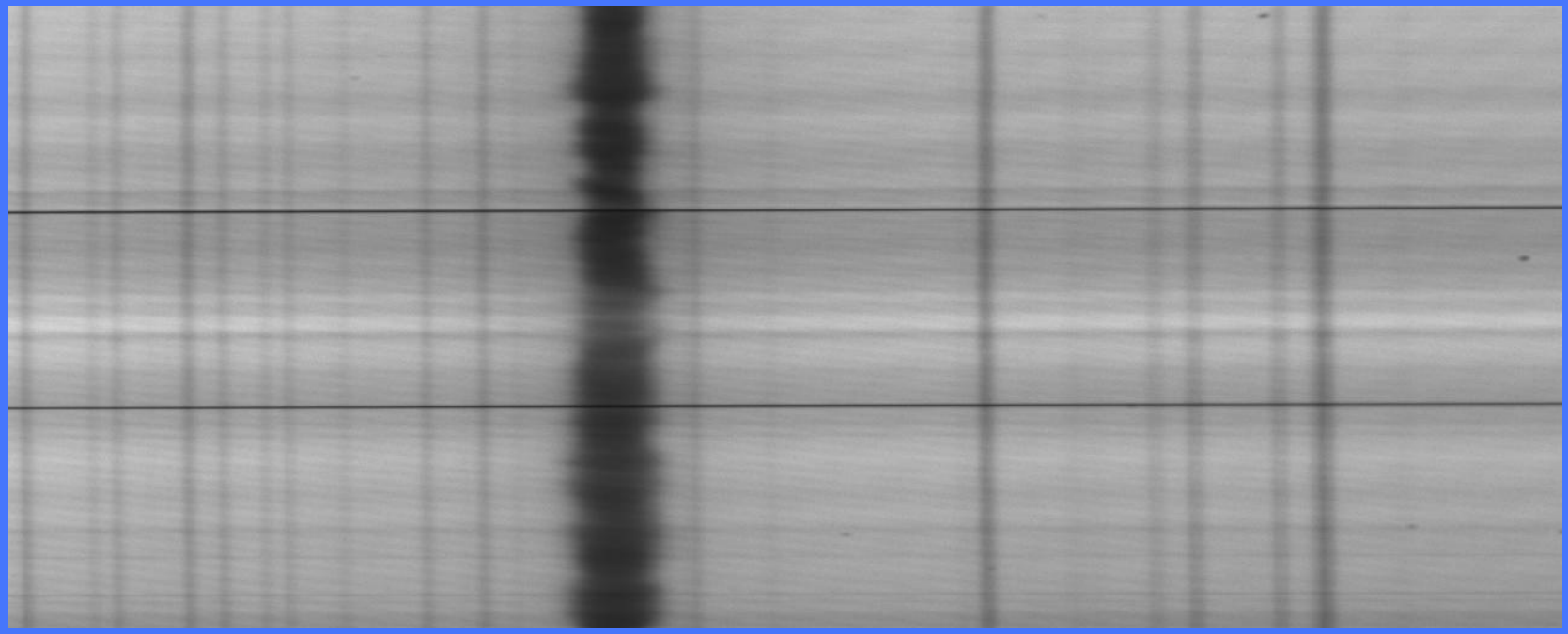


Camera systems (the middle one is open to see details, two are covered

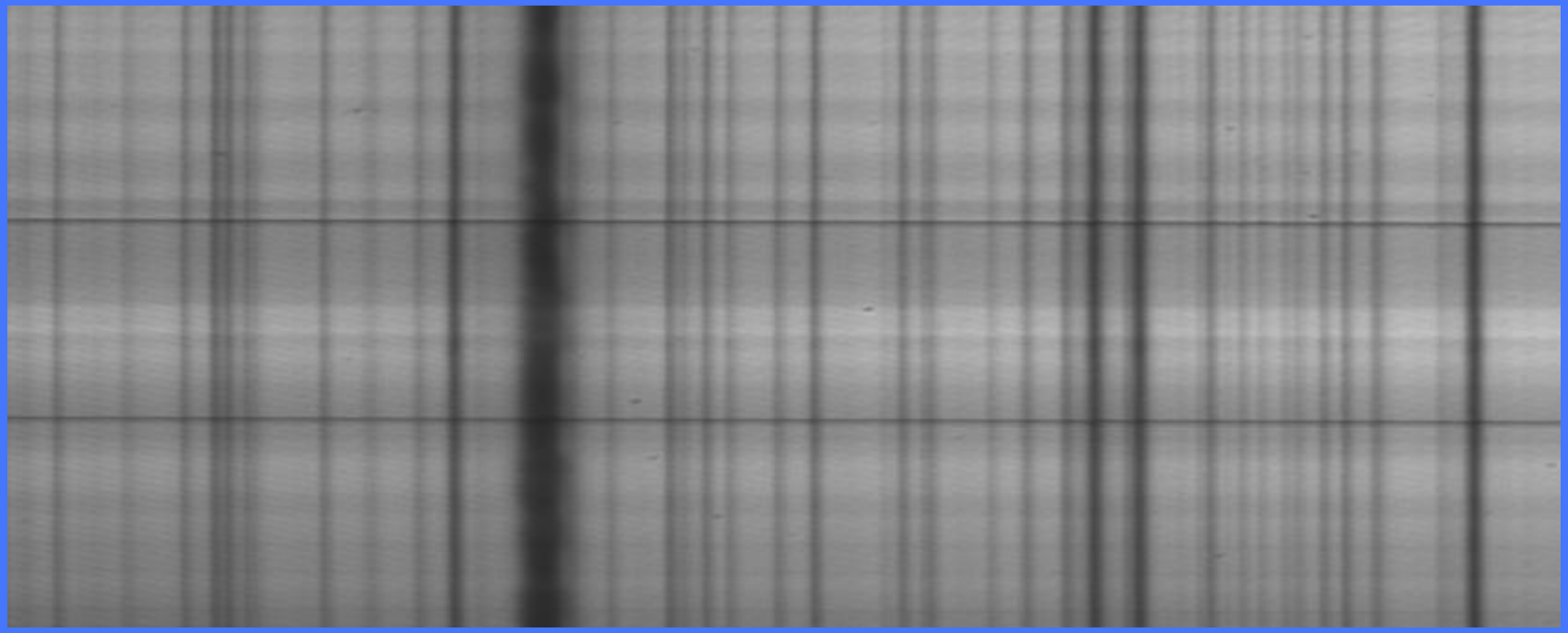
Used spectral lines (simultaneously)

- 1 Hα (6563 6 Å, 0.01378 A/pixel)
- 2 D3 (5875 10 Å, 0.01926 A/pixel)
- 3 Hβ (4861 10 Å, 0.02074 A/pixel)
- 4 CaII K or CaII H (3934 resp. 3968 10Å, 0.02108 A/pixel)
- 5 Ca IR 8542 Å is operated in a test regime (due to a limited CCD camera sensitivity)

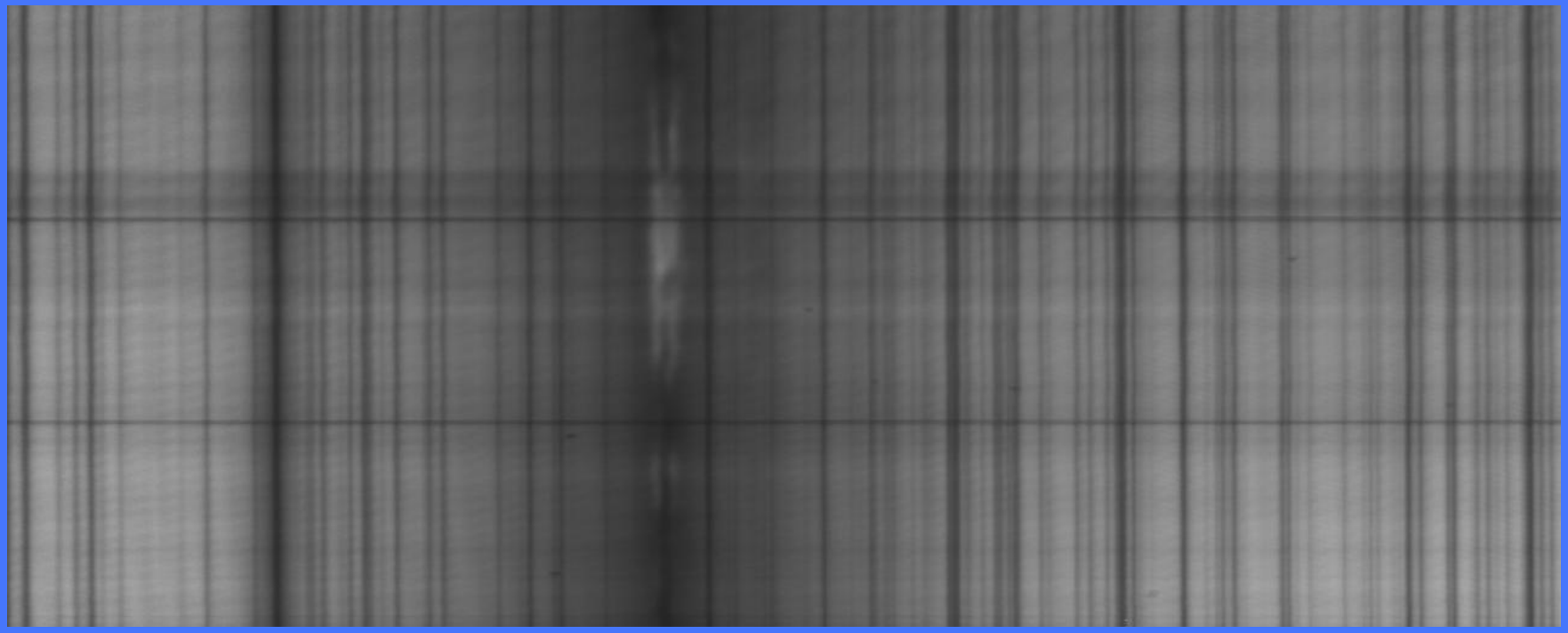
  (passband 20 A, 0.0202 A/pixel)
- 6 Hα slit-jaw imaging system, halfwidth 0.7 A)



- **A raw Hα spectrum before flat fielding 2006 05 06_10:04:54 UT)**

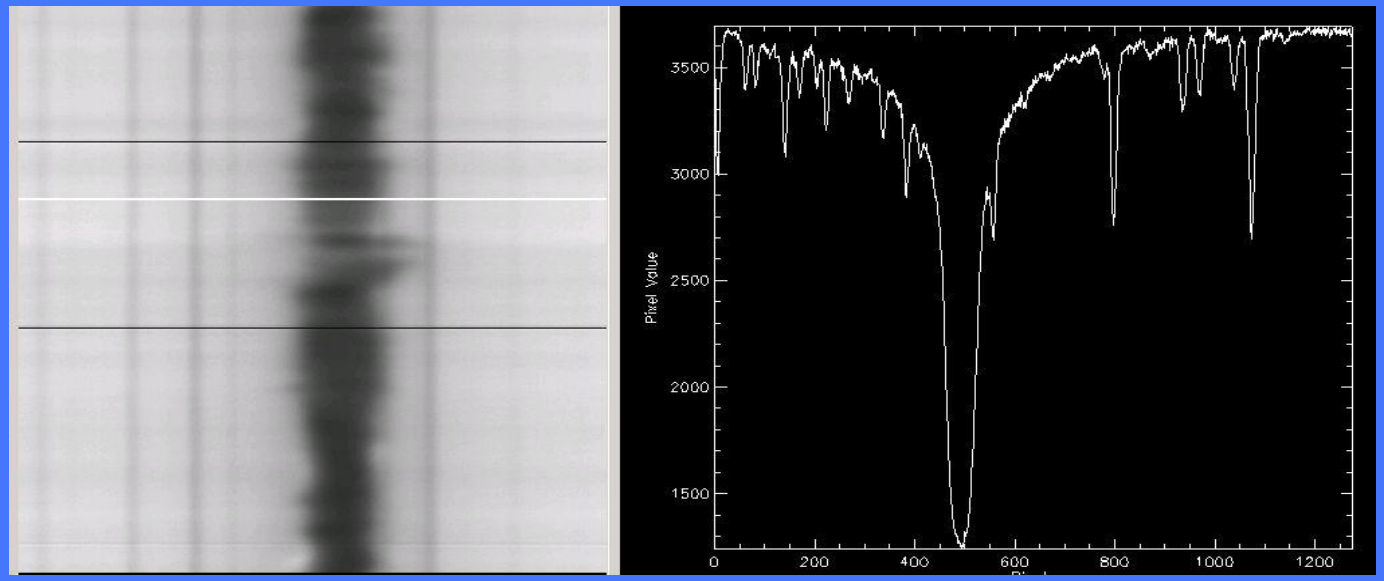


- A raw Hβ spectrum on 20060506_100454 UT)

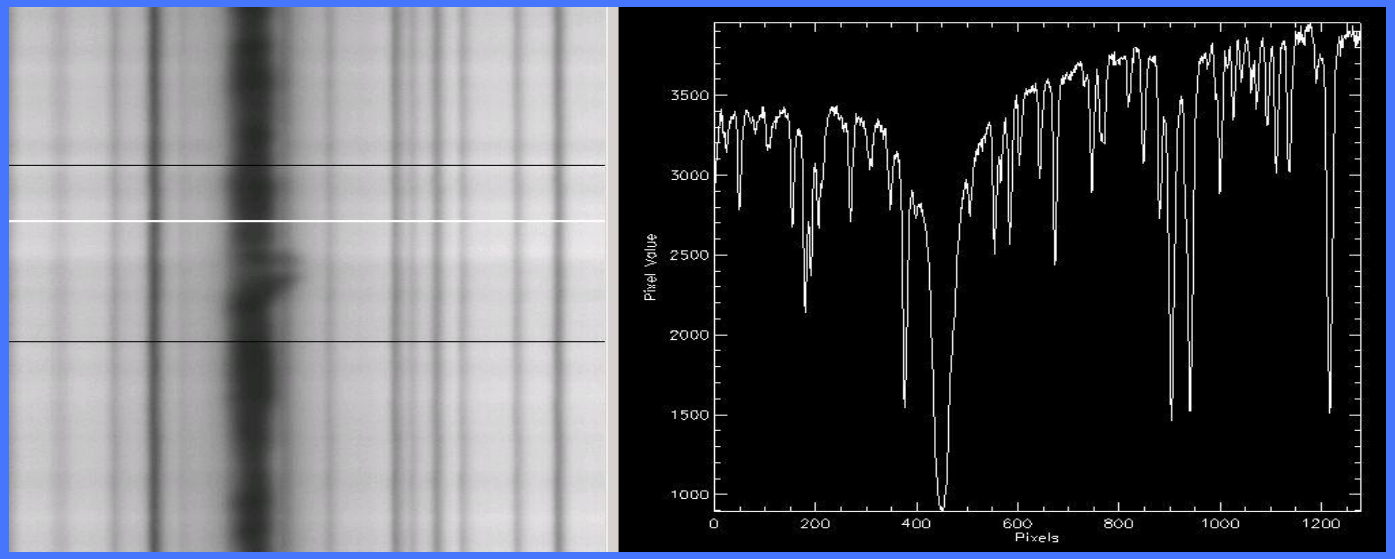


- **A raw CaII H spectrum on 20060506_10:04:54 UT)**

Profiles

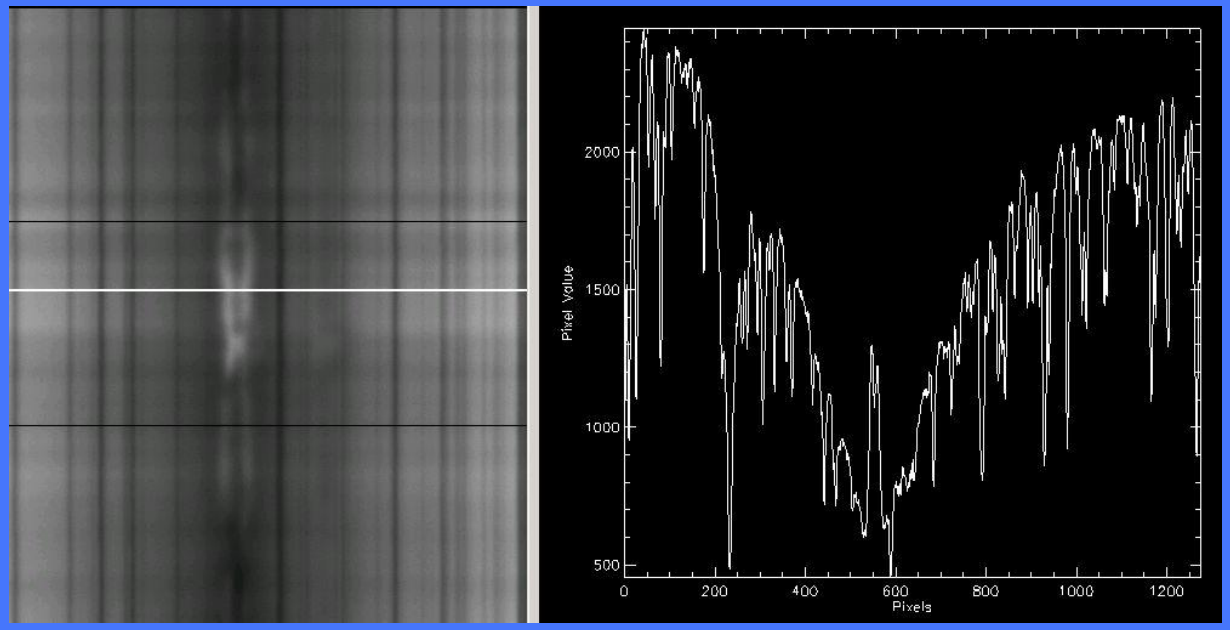


Hα

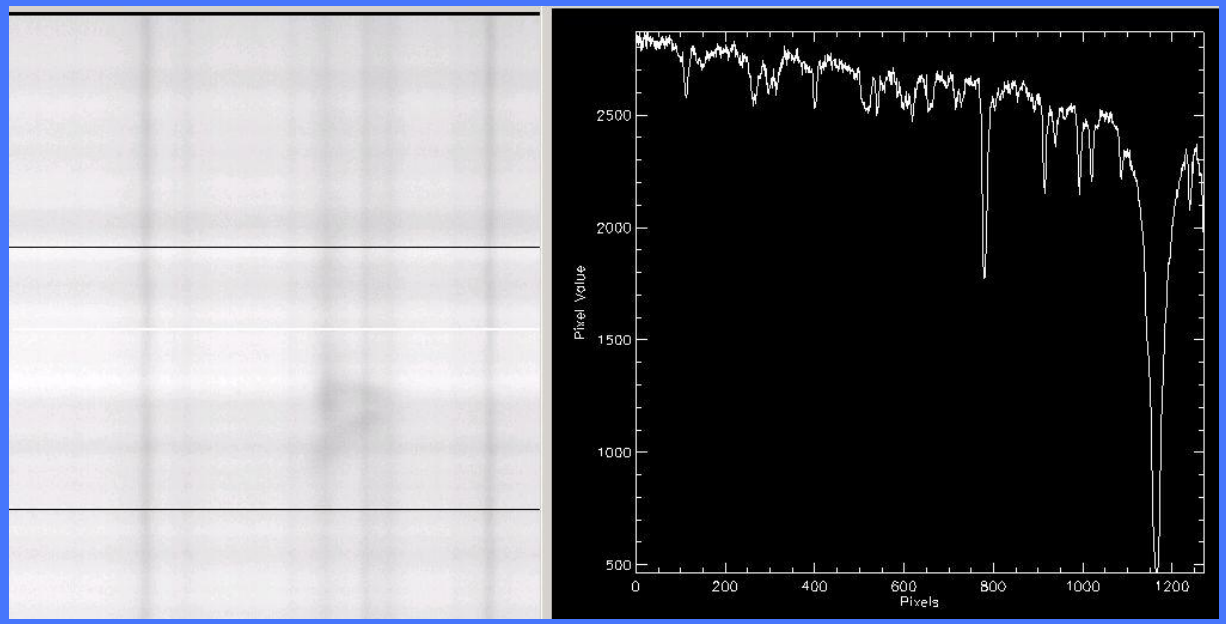


Hβ

Profiles



Ca II H



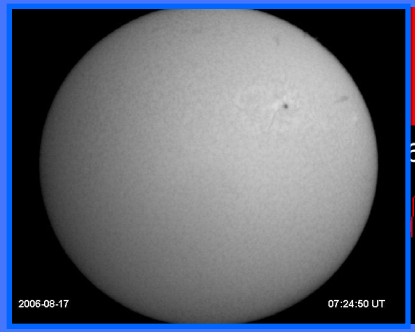
D3 He

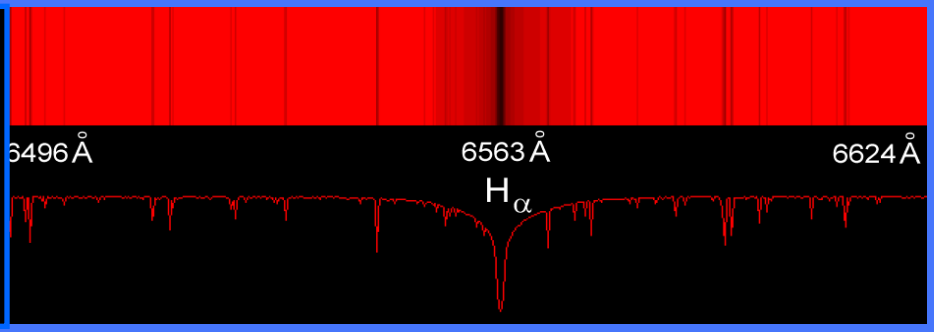
After the WWII

Since 1946 summer practice students observed solar chromosphere in the Hα line, flares, prominences. Since 1948 regular observations and measurements of the Hα line width in flares began. Used as an eye-piece solar patrol for the Multichannel flare spectrograph build in 1958.

Used until 1963, then replaced by a new Hale-type one, fed by a Jensch horizontal coelostat.

In 1976 spectrohelioscopic observations were ceased, and chromospheric patrol telescope 110/1650mm with the 0.07 nm Šolc-type filter started.





New Observatory Solar Telescopes

Site: quiet, no disturbances, but air pollution (Prague & airplanes)
~150 – 200 sunny days/year, seeing ~1 – 5", winter time: inversions,
Sun 17 above horizon at noon only, humidity high, T_{wint}~ <-20 C, +5 C>

Horizontal telescope

RT 10m dish