Solar Observations at Ondřejov

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AI AS CR, Ondřejov

A brief list of solar telescopes that have been used in the Ondřejov observatory is given. Currently, solar observation is concentrated to the following devices: Chromospheric anf photospheric telescopes of the solar patrol, horizontal spectrograph HSFA2, laboratory spectrograph SLS and the robotic telescope SORT which is still under finishing.
We give also a concise list of the Ondřejov solar radiotelescopes.
We describe the main technical parameters of the telescopes, properties of the detectors used, organization of observations, data archives and usage of the data in the solar research.

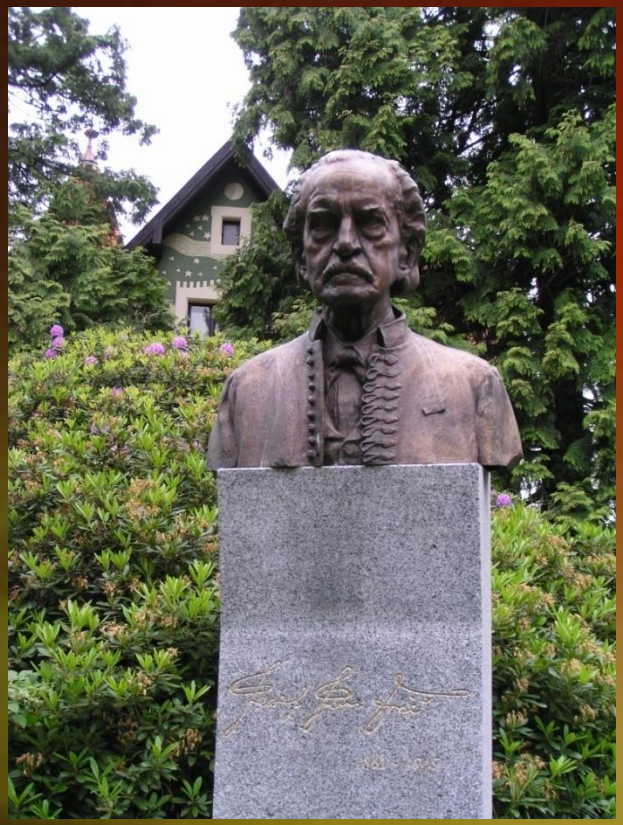
Ondřejov Observatory – Brief History

Location: 50° N, 15° E …
35 km SE to capital Prague …
Altitude: 528- 548 m

Founded in 1898 by Josef (& Jan) Frič as a private observatory (astrometry, geodesy)

1928 donated to CR - Charles University, now a part of Astronomical Institute of the Academy of Sciences of CR

Ondřejov Observatory founded by J.J. Frič in 1898
Remains main astronomical base for Czech astronomy



First solar observations during the WWII

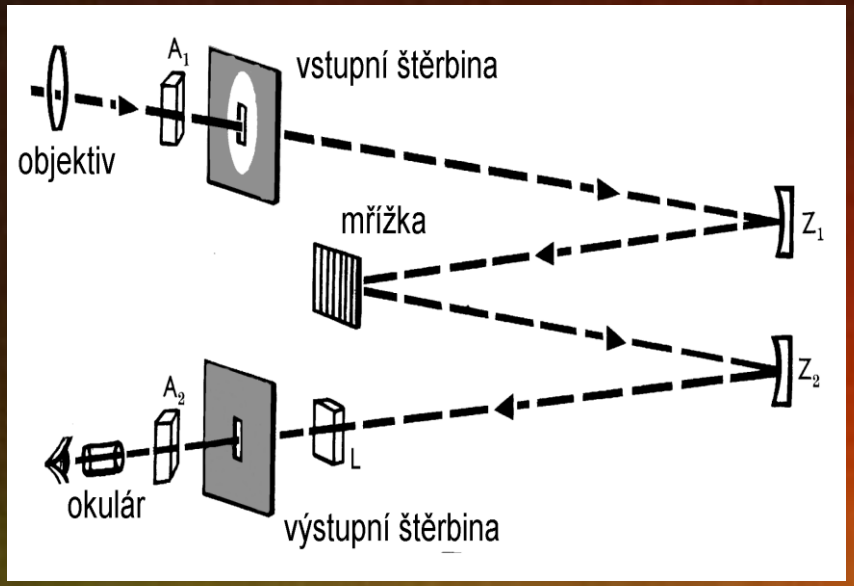
Since foundation of the Ondřejov observatory in 1898 until WWII only 2 (nonsolar) research programs (classical astronomy):

1. Photographing/mapping of the Northern Hemisphere Sky
2. Study of the Earth-axis vector components

During the WWII František Link and Walter Schaube started solar observations
Both direct (solar spectrohelioscope)
and undirect (ionospheric measurements)

Initial impulse was an interest of the German army to have information about current status if ionosphere due to radio connection.

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



In 1938 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. Bohumil Šternberk moved the spectrohelioscope to Ondřejov before the war.

During the war the instrument was used by W. Schaube and F. Link for solar observations for German Luftwaffe for forecasts organized by 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.

After the WWI – a new generation
A start of solar physics in Ondřejov

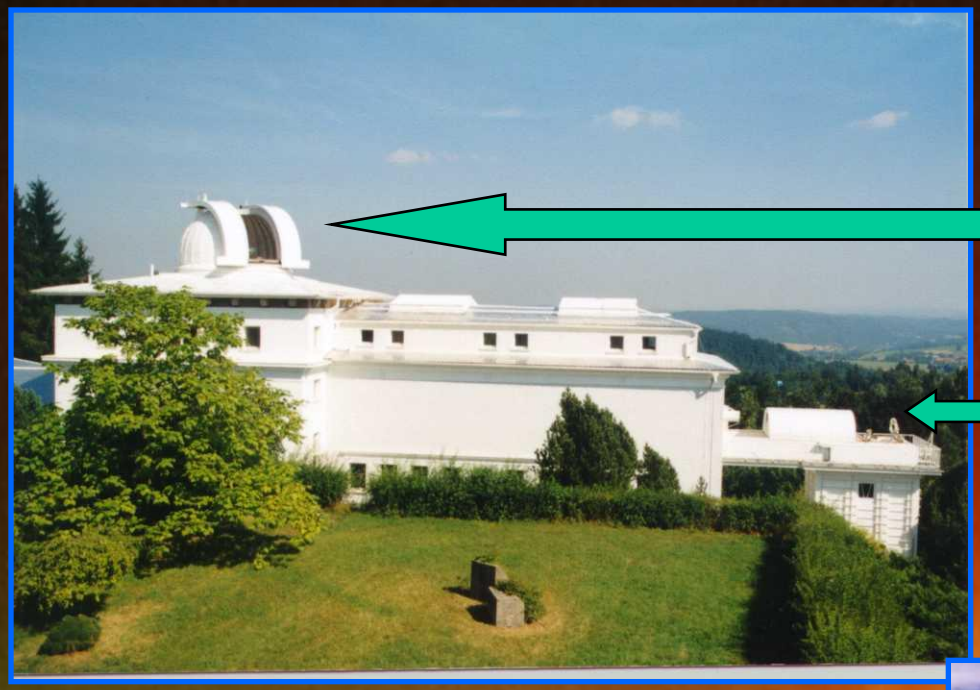
In 1945 new summer practise students, later on, students of Charles University appeared in Ondřejov. They formed a new generation of astronomers, most of them became solar physicists (V. Bumba, Z. Blaha, Z. Seidl, V. Letfus, Z. Švestka, J. Kleczek, Z. Ceplecha, L. Křivský, M. Kopecký, B. Valníček, A. Tlamicha, L. Neužil, B. Topolová).

Leadership of František Link, revolution against him, Link left solar research and later on left to France.

V. Guth and later on B. Šternberk became directors of AsU.

New plans and their realisation – Solar Laboratory with telescopes and spectrographs, solar radiotelescopes.

Old Observatory Solar Telescopes



Solar department building ~1955

Solar double refractor – solar patrol
(Clark 8"/280 cm, white light
& Zeiss 21cm/341 cm – Ha filter)
Former solar patrol - photographic

Multichannel Flare Spectrograph
1959 – 2004, since then: only
one-way experimental spectrograph

Solar radio dish, solar radio noise at
λ 115cm, 35 cm & 7 cm, used 1950 – 1995

These telescopes were ceased, their
operation postponed to other devices

New part of observatory (with 2m
telescope) since 1967 …
~700 m to N, meadows, park, woods &
forest …

SOLAR DEPARTMENT

Active ground-based instruments in Ondřejov :

1. Patrol observations in white-light and H-alpha
2. Horizontal spectrograph in optical region
3. Radio spectrograph in the 0.8-4.5 GHz range
4. Radio flux at 3 GHz and 30-600 MHz
5. Solar Robotical Telescope SORT

A list of Ondřejov „historical solar telescopes"

Spectrohelioscope – till 1976, donated to Valašské Meziříčí Observatory.
Double telescope of solar patrol, ended with photographic era
Rotating horizontal solar spectrograph used for photoeletric/photographic measurement of magnetic and velocity fields (ended with HSFA, museum)
Prominence coronograph – ended with photographic era, in depositum
RT1 radiotelescope (Wurtzburg type radar), given to Army museum
Measurement of atmospherics ended with Dr. L. Křivský retirement
Cosmic experiments-X ray photometers (Interkosmos) launched, museums

Solar Archives:

Radio data - www.asu.cas.cz/~radio/
X-ray data - www1.asu.cas.cz/HXRS/
Solar Optical Spectroscopy - www.asu.cas.cz/~sos/
Solar patrol an activity forecast - www.asu.cas.cz/~sunwatch/index.htm
Solar magnetograph - www.asu.cas.cz/~solmag/data/

MFS VHS observed flare catalogue

2002

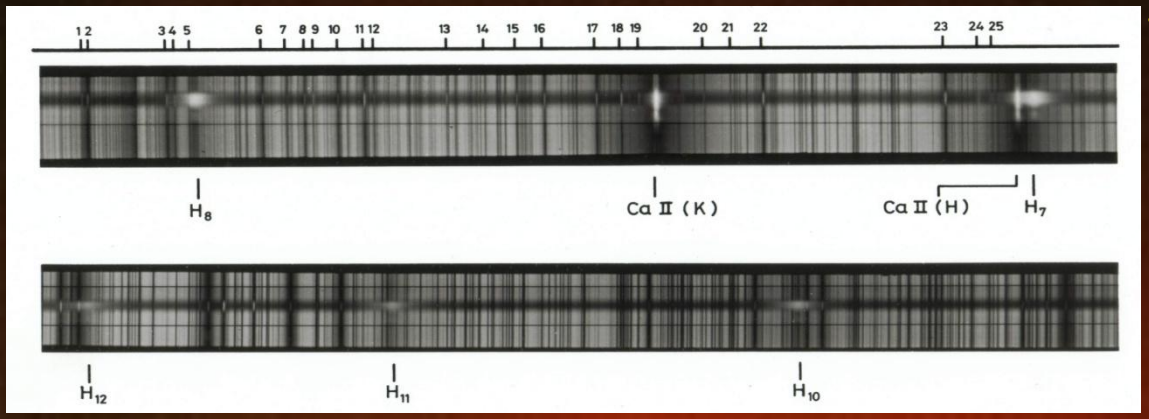
Date	Start NOAA	Max NOAA	End NOAA	Start MFS	End MFS	Type	AR	Trace	RESIK	GOES RHESSI	OSR	CME	Note
20020104	0924	0952	1035	0904	1004	C3.7	N38E87					+	
20020407	0814	0824	0830	0824	0832	C6.0	9893	+	+	+		+	
20020424	0730	0735	0744	0735	0737	C1.7	9913	+		+	+		
20020430	1106	1118	1135	1118	1133	C3.2	9914		+	+			
20020501	1202		1242	1227	1231	B0 A	9932	+	+	+			
20020507	0846	0852	0855	0830	0856	C2 8	9937		+	+		+	
20020508	1258	1327	1359	1317	1323	C4 2	9934	+	+	+	+	+	
20020509	0712	0715	0720	0717	0720	B9 5	9937	+	+	+		+	
20020514	0539	0603	0609	0531	0549	C2 2	9948	+		+			
20020515	0800	0813	0825	0824	0834	M1 0	9948	+	+	+	+	+	
20020516	0451	0521	0601	0516	0608	C5.0	9950		+	+		+	
20020516	0624	0627	0655	0627	0643	SF	9950	+	+	+		+	
20020517	0516	0523	0528	0516	0525	C7.0	9957	+	+	+			[8,9,10]
20020529	1021	1026	1030	1028	1029	C3.4	9973	+	+	+			
20020601	1044	1049	1052	1053	1055	M1 1	9979		+	+	+		
20020623	0819	0824	0827	0820	0827	C1.9	0005	+	+	+	+		
20020626	0624	0631	0636	0628	0640	C1.5	0000	+	+	+			

- - data partially processed at publications bellow
- - data under processing
- LMSAL Active Region #(8215-11000)
- Trace Flare Catalog and Trace Data Center
- RESIK CATALOGUE(20010830-20030429)
- ONDREJOV SOLAR RADIO EVENT ARCHIVE (OSR)
- Yohkoh Flare Catalogue(HXT/SXT/SXS/HXS)(1998-2001)
- GOES RHESSI(20020212 - 2009)
- Solar Activity Monitoring and Forecasting (Ondrejov) click number of AR -> images chromosphere in Hα
- SOHO LASCO CME CATALOG
- Calibration data
- Data archive MFS [FTS, AVI]
- Solar Ephemeris Calculation Utility

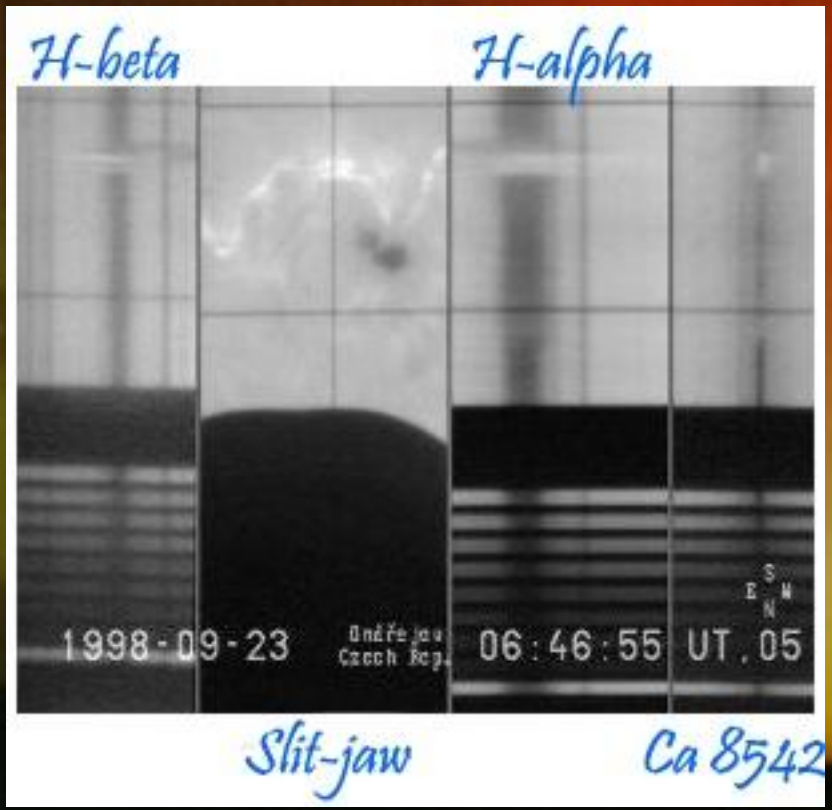
Available at:
www.asu.cas.cz/sos/flare_archive.html

Created by Kupryakov et al., 2009

MFS parameters, comparision



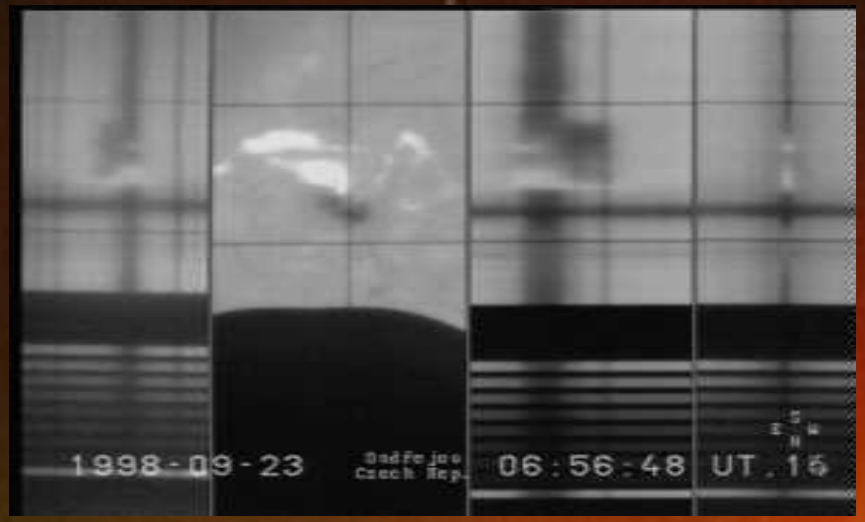
Two strips of MFS flare spectra
Large detectors, 13 x 18 cm
Large field of view of 80–120 Å
Exposure times tenths of sec
Maximum 12 spectra in a series

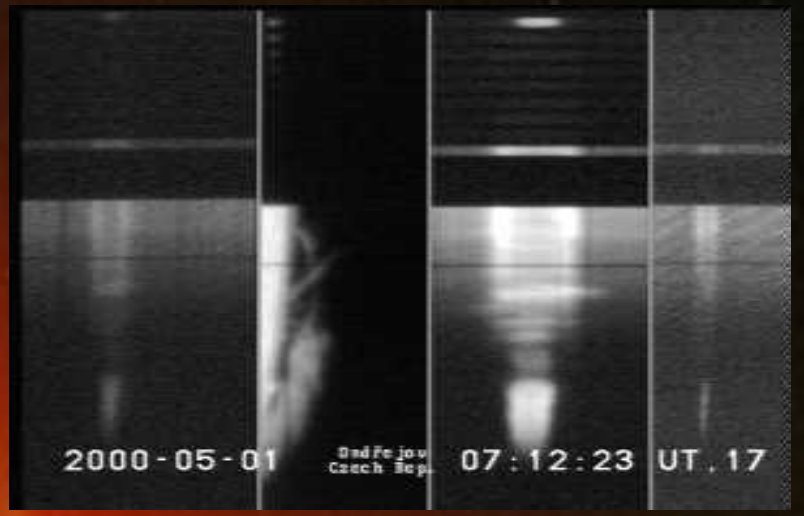


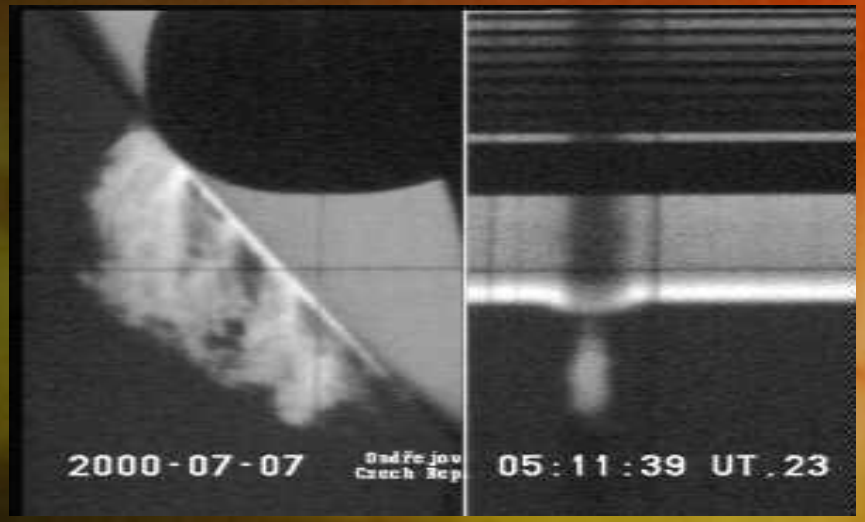
Intermezzo: Film strips – max. of 50 spectra in a series, developing, digitization, 12 – 16 bits.

Composed videosignal from 4 videocameras,
Analogue medium,
cheap (important in 90ies)
Small detectors, 1/3", small objectives
=> aberrations, small field of view ~ 4 ~Å
Short exposure times < 40ms, low signal but a
frequent saturation, small S/N
Digitization grame grabber, 8 bits,
complicated and tedious calibration,

Video Spectra and Hα filtergrams





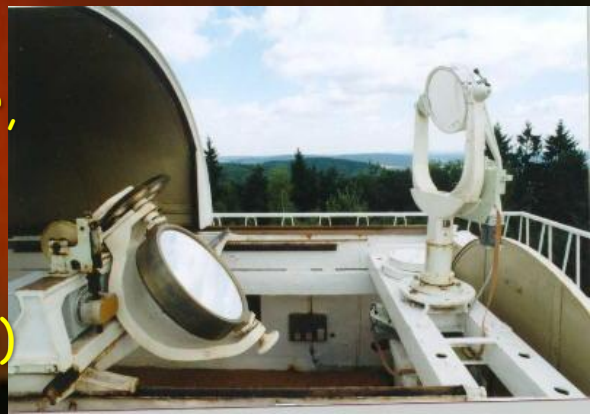


Hα + Hβ, Ca8542 A in flares, eruptive/quiescent prominences, Hα linear polarization

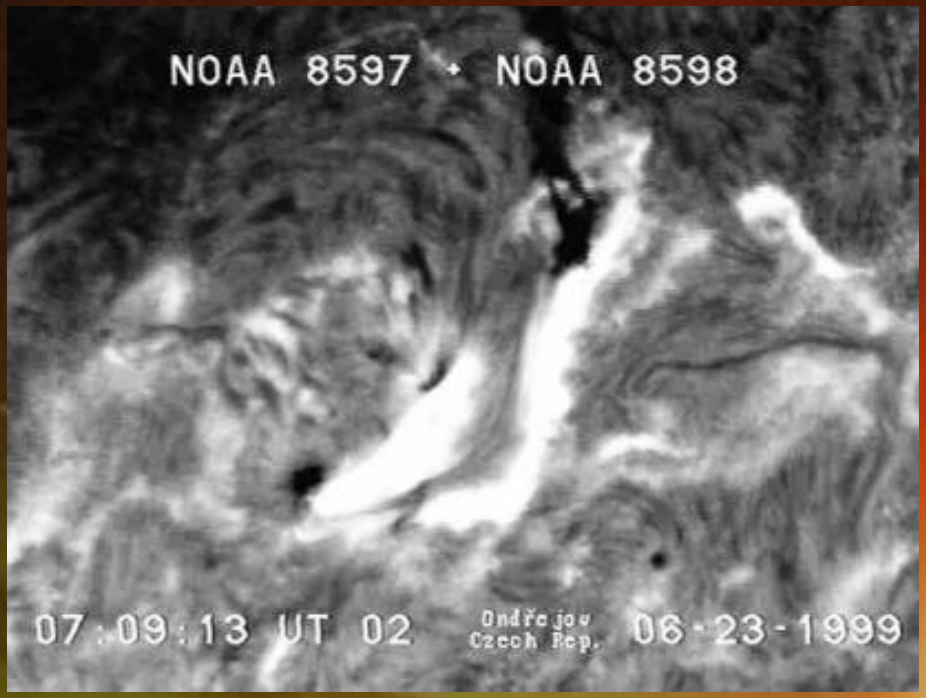
Multichannel Flare Spectrograph

Constructed by Valníček, Švestka, Letfus et. al in 1958
Copied twice in Nanjing, China

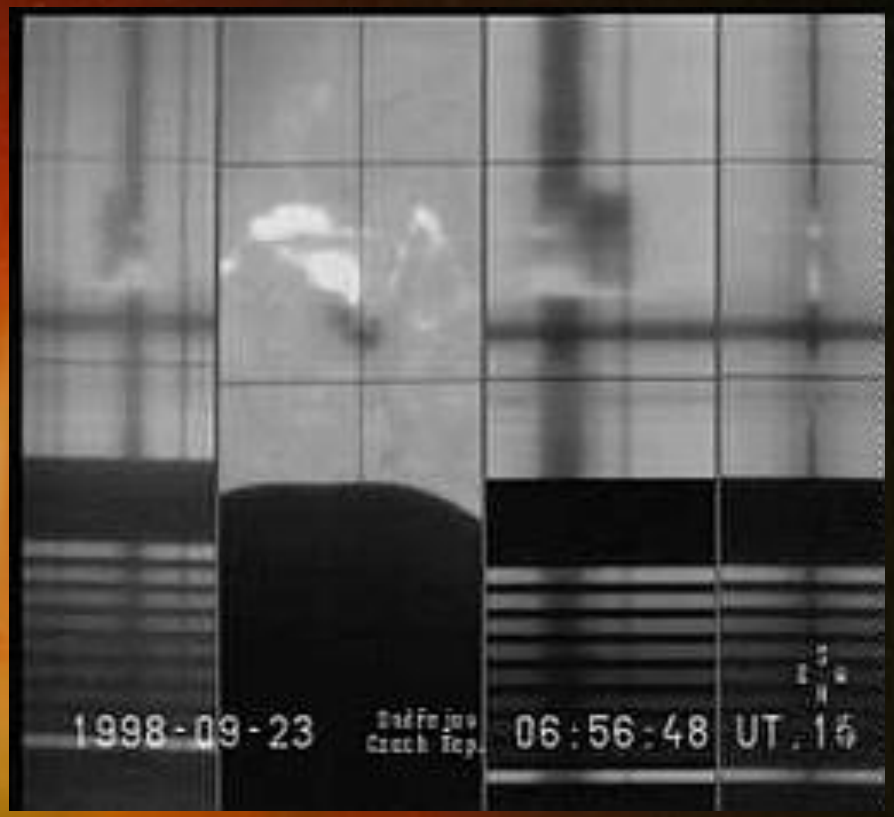
Main Objective 230mm/1350 cm
Grating 850l/mm, 90 x 100 mm
Resolution 170 000 in the 2 order,
photograph. plates (films)
linear dispersion 1 A/ mm
in H-alpha, H-beta, H-gamma,
D-lines, Ca H and K (simultaneous)
up to the Balmer limit



A solar flare



See the absorption features in Hα)



Multichanel Flare Spectrograph - studied topics

- photographic era:

… flares: asymmetry of spectral line profiles (plasma flows during flares), (Švestka 1962)

… from intensity in wings of lower Balmer lines - optical depth in flaring plasma; from width and shape of higher Balmer lines - electron density of flares

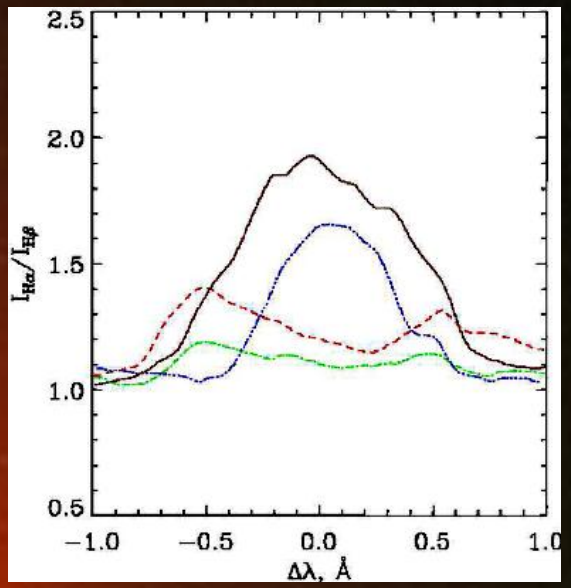
… prominences – flow of plasma, rotation

- CCD video-cameras (25 frames/s) era:

… flares – fast processes: velocity fields, line asymmetry, diagnostics of accelarated particle beams (Heinzel 1994, Prosecký…)

… bright prominences/filaments, surges: velocity fields and their kinematic models (Karlický et al., 2001)

MFS participated in join international observing campaigns

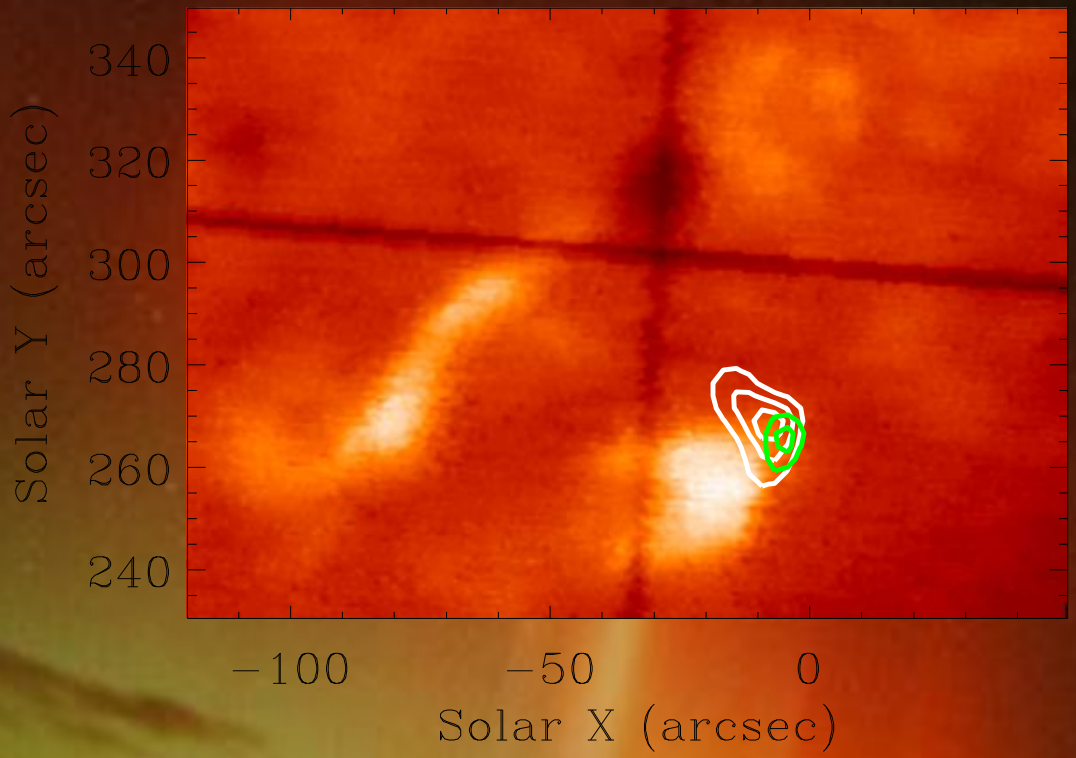


Kashapova et al., 2008

June 2004 - MFS reduced to one-way experimental spectrograph

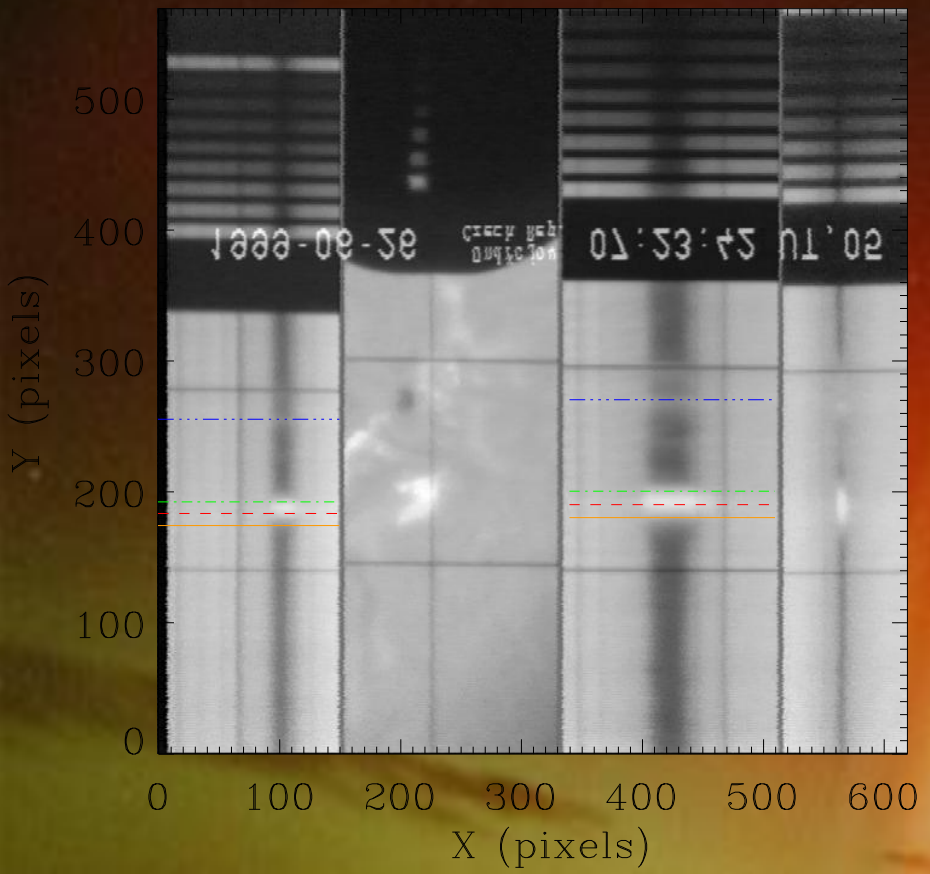
Observation of solar optical spectra moved into modernized HSFA2 spectrograph

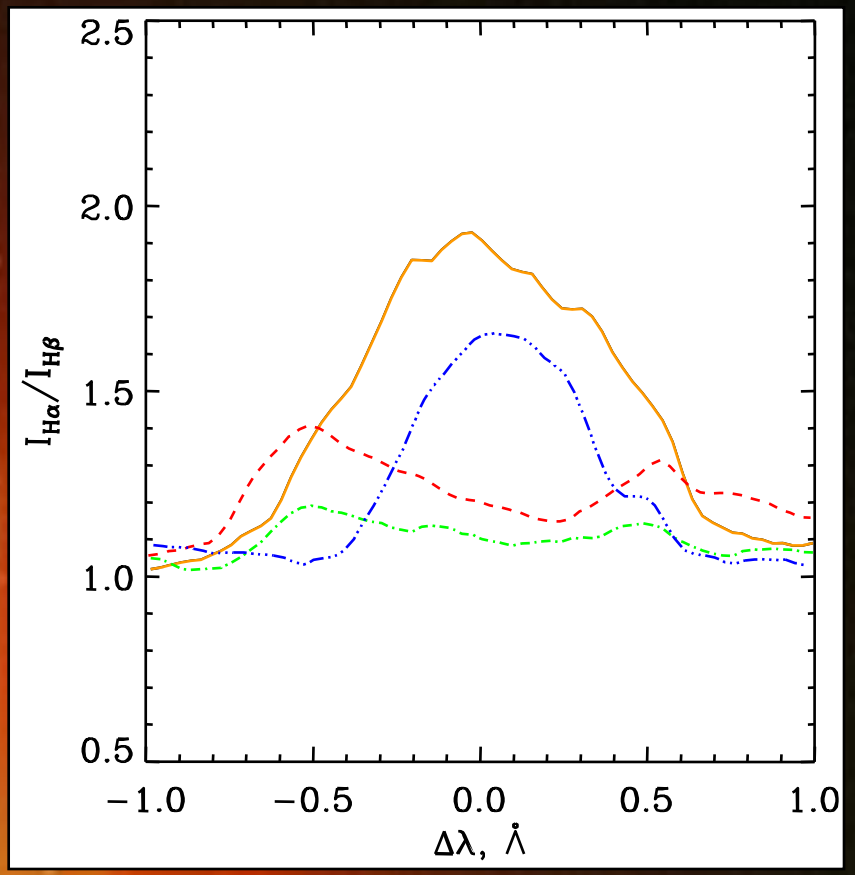
HXR and H-alpha data



Position of HXR source obtained by Yohkoh Hard X-ray Telescope (from 07:17:12.214 to 07:17:39.714 UT) as projected on the Hα slit-jaw image of the flare taken at 07:23:18 UT; the L band (13.9 -22.7 keV) and the M1 band (22.7 -32.7 keV) are marked by black and green lines, correspondingly.

Flare kernel analysis



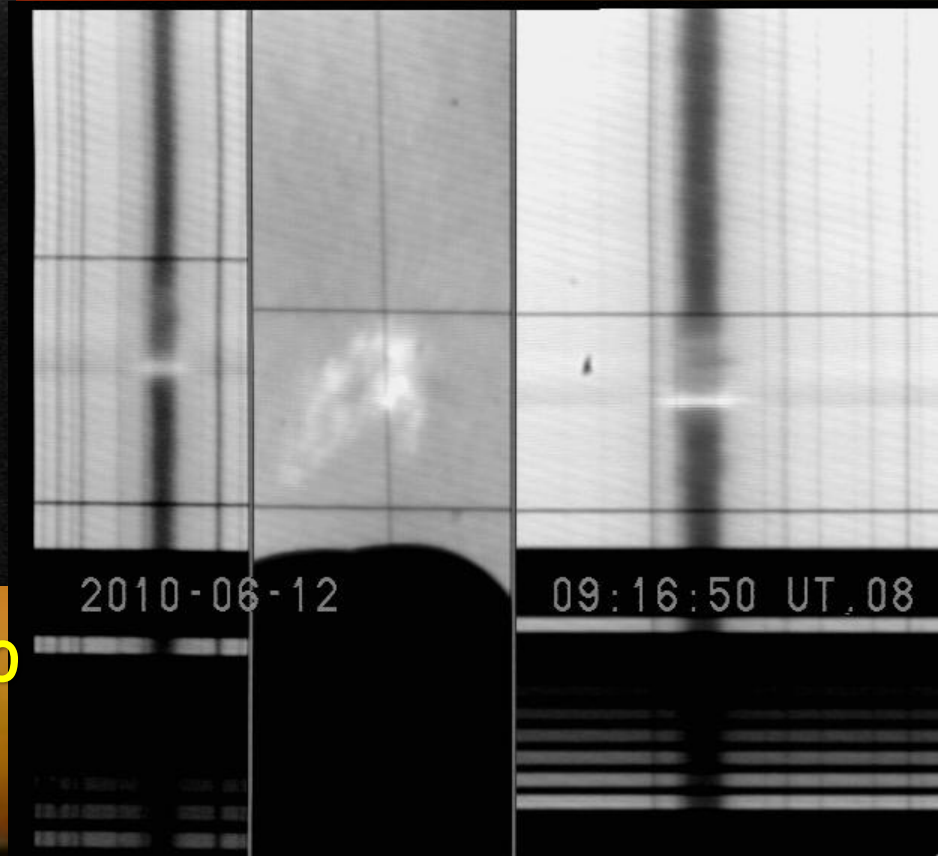


Left: Composed spectrograms of Hα (right), Hβ (left) lines and Hα slit-jaw filtergram (center) taken by MFS at 07:23:42 UT (the second flare phase). Right: The ratios of the Hα to Hβ intensity profiles. A color corresponds to a scan position as marked on the spectra panels.

Recent observations of the ‚MFS‘

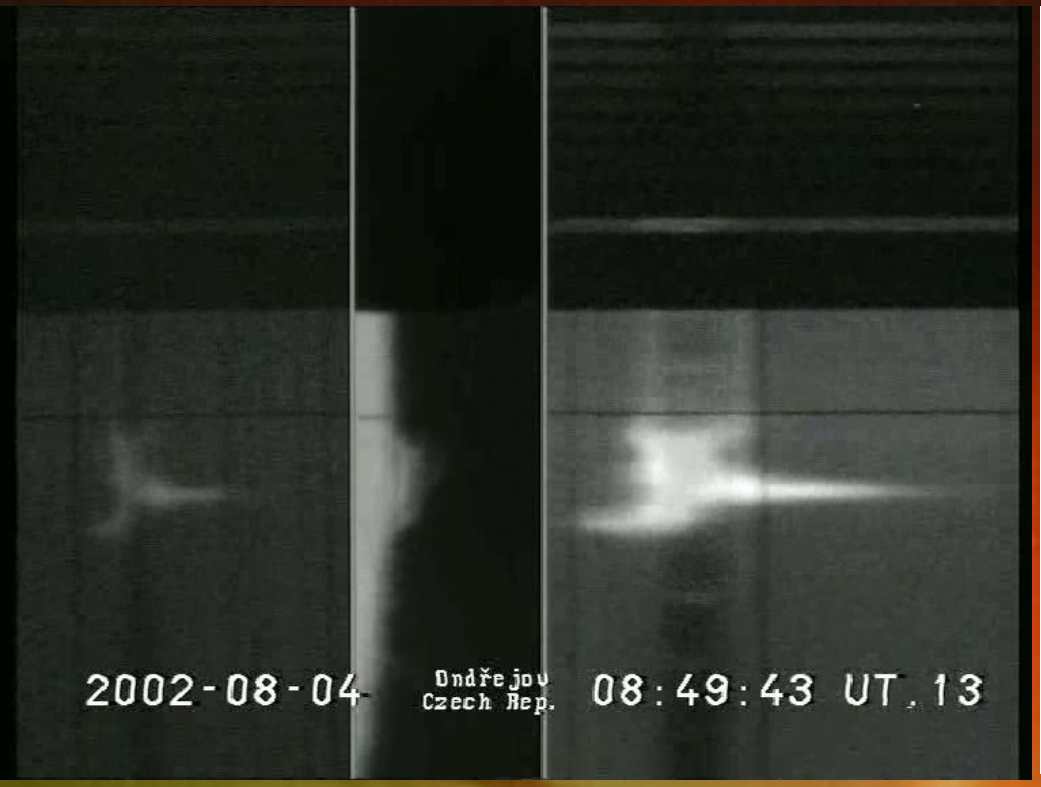
prominence on July 9, 2010

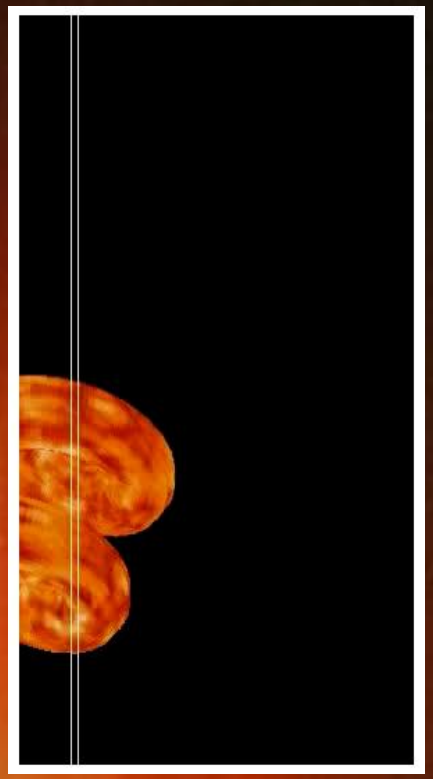
A flare on June 12, 201



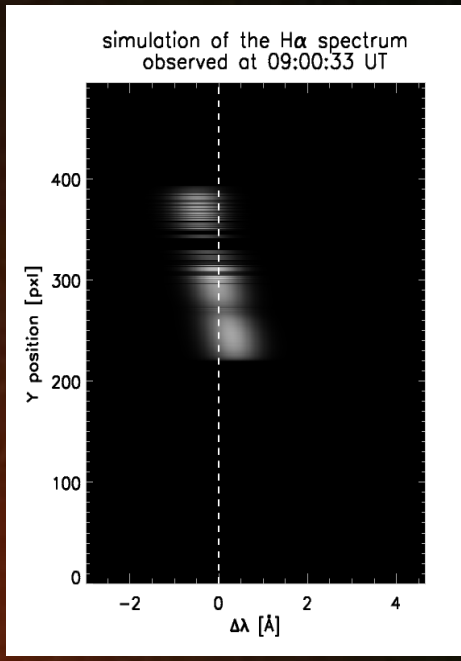
Recent work on 2002 August 8 limb flare

Kotrč P., Bárta M., Schwartz P. and Kupryakov Yu. A.

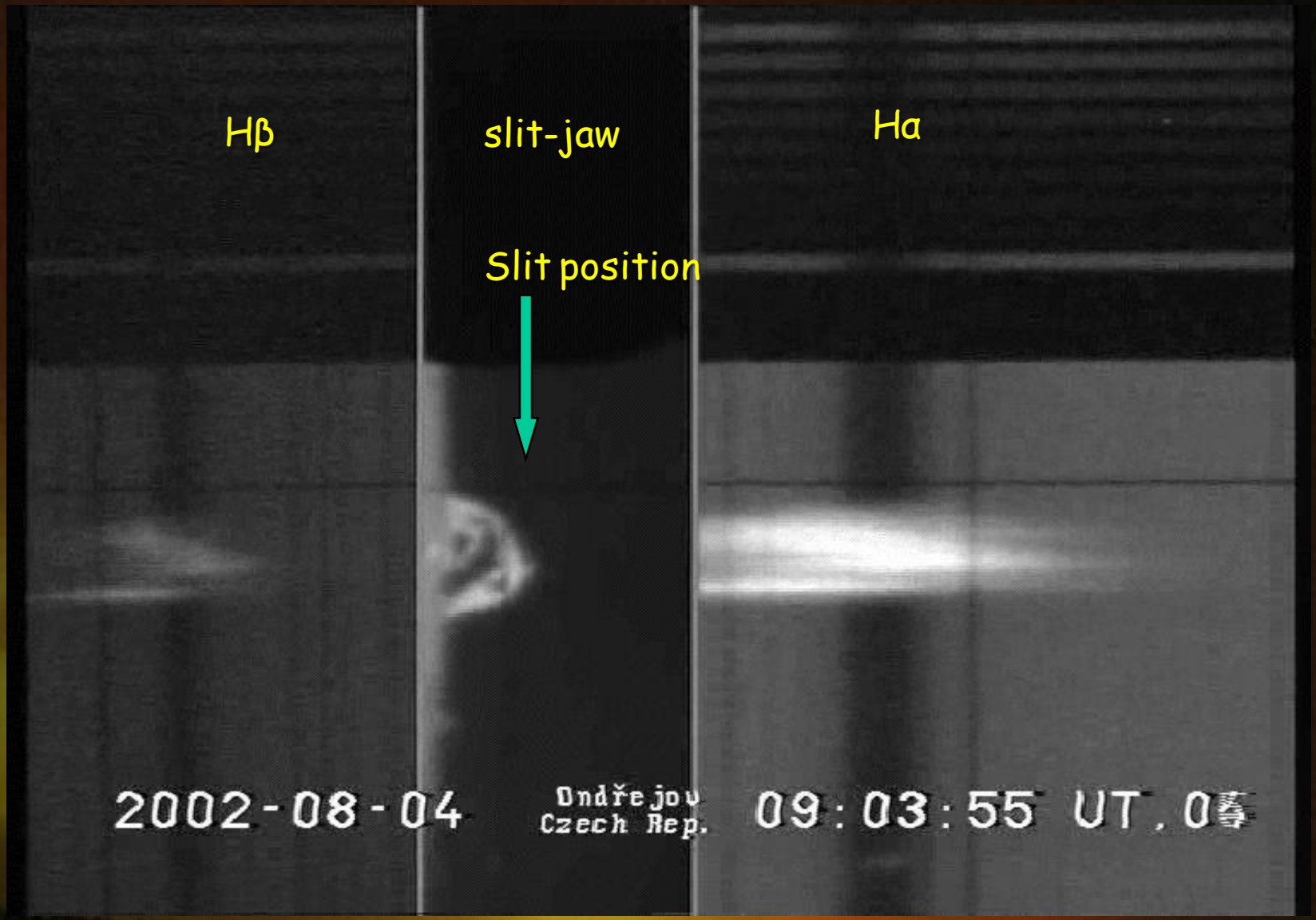




Kinematic model



Observation -> MHD model



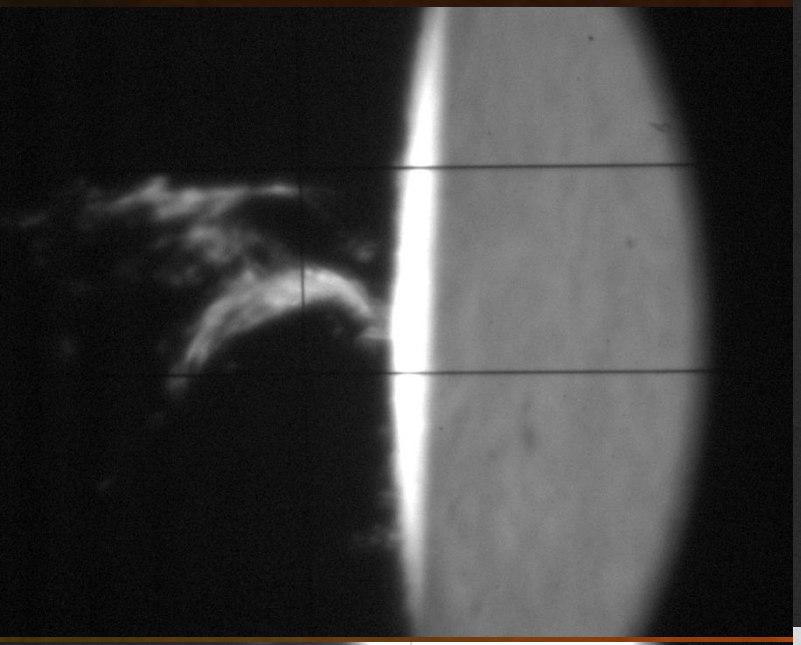
MFS data archives

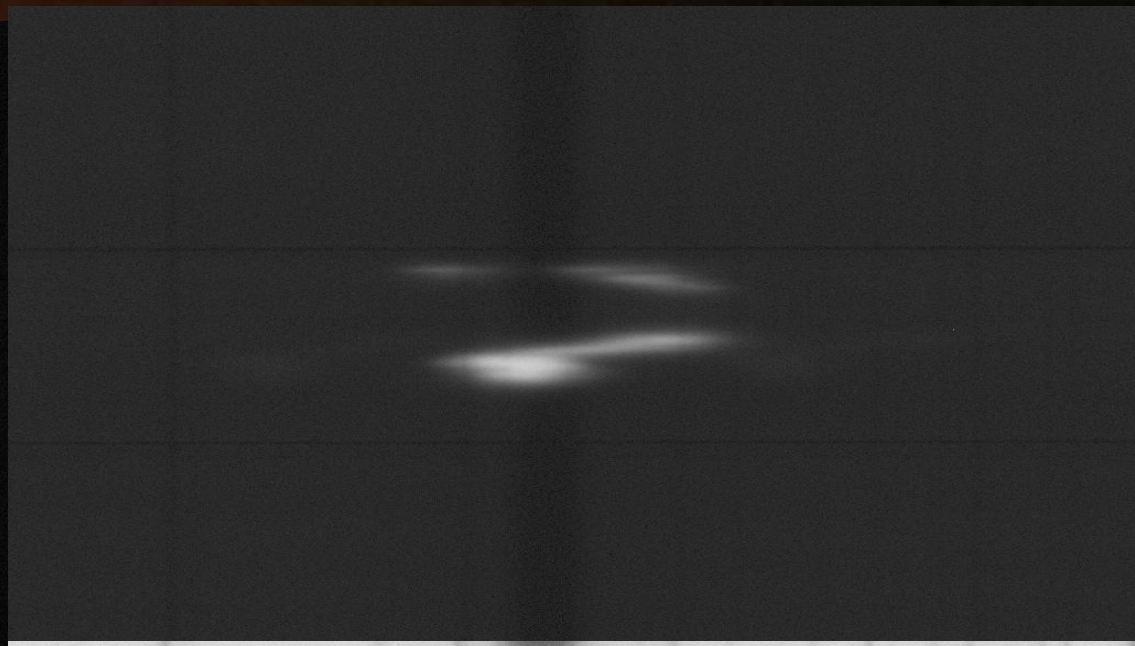
Photographic era: glass plates – digitilization
films – digitilization

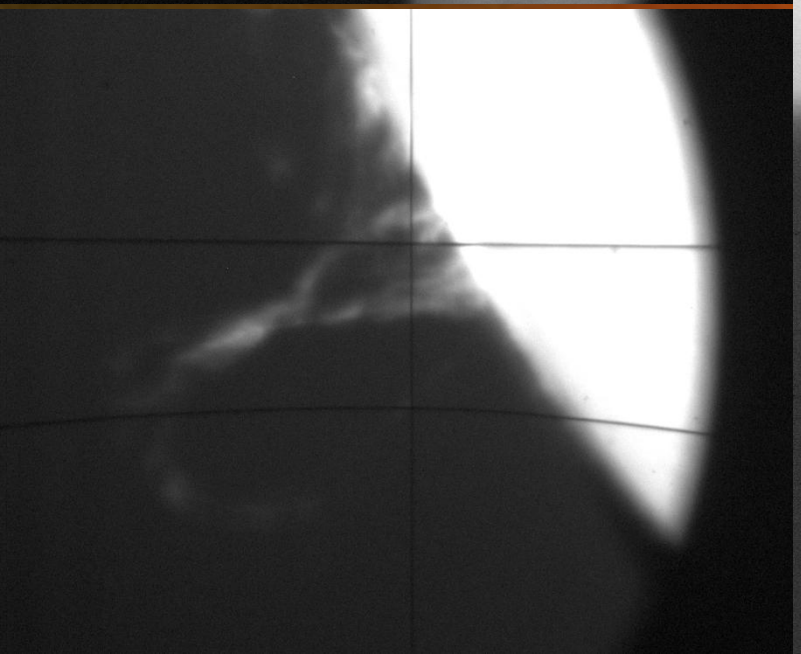
Video, both analog and digital. Archive at:
http://www.asu.cas.cz/~sos/archive_mfs.html

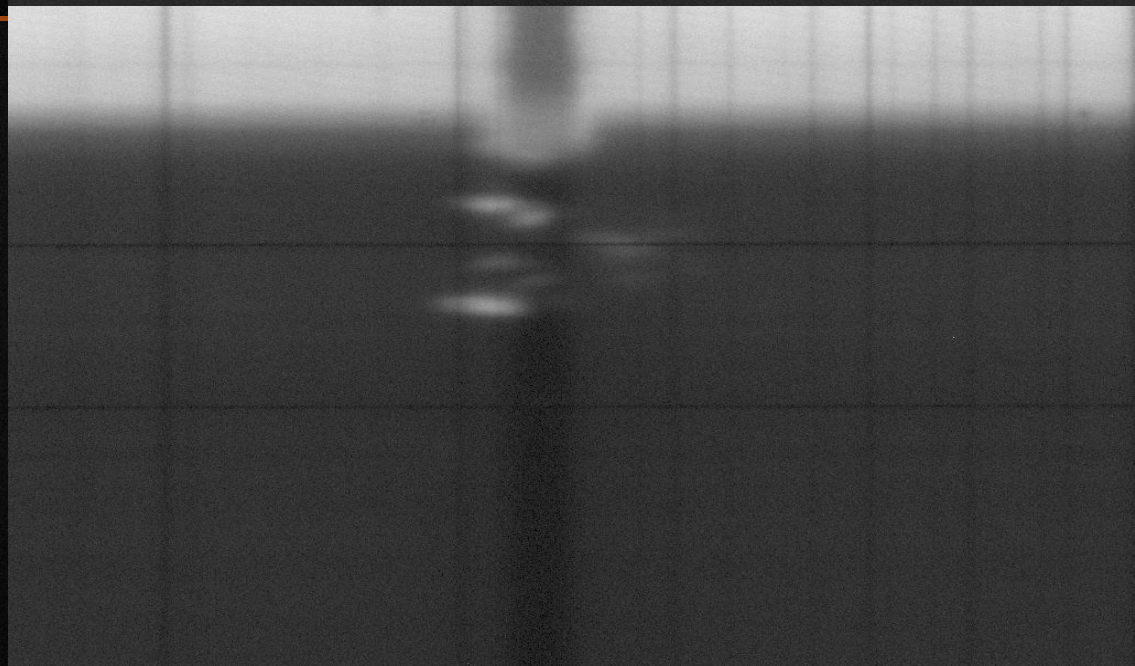
Data stored at tapes, disks, at the server Radegast disk field

Examples of the latest SLS data



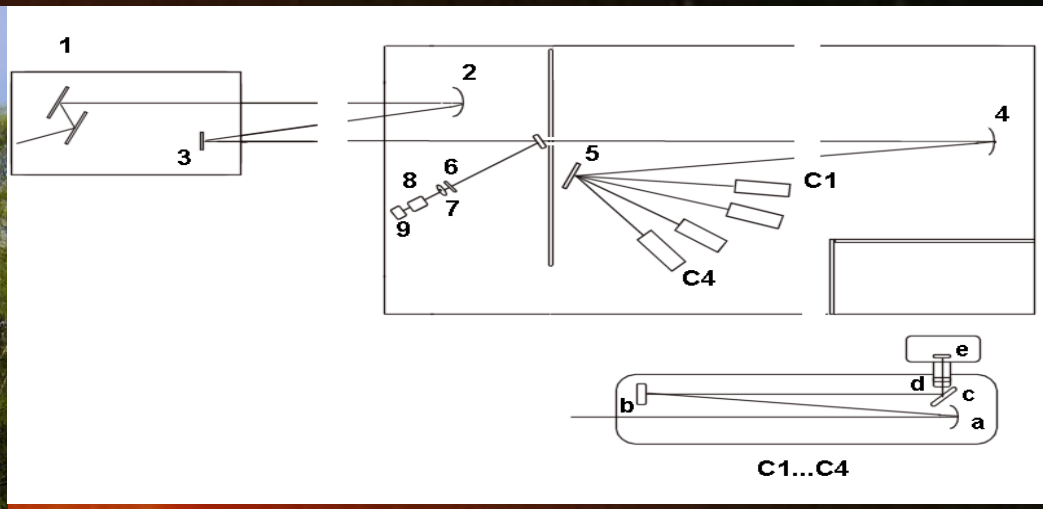






HSFA2 – modernized recently

Jensch type coelostat 4 – 6 m above ground, sliding shelter,
Φ of mirrors 60 cm,
M1 Φ 50 cm, f 35 m.

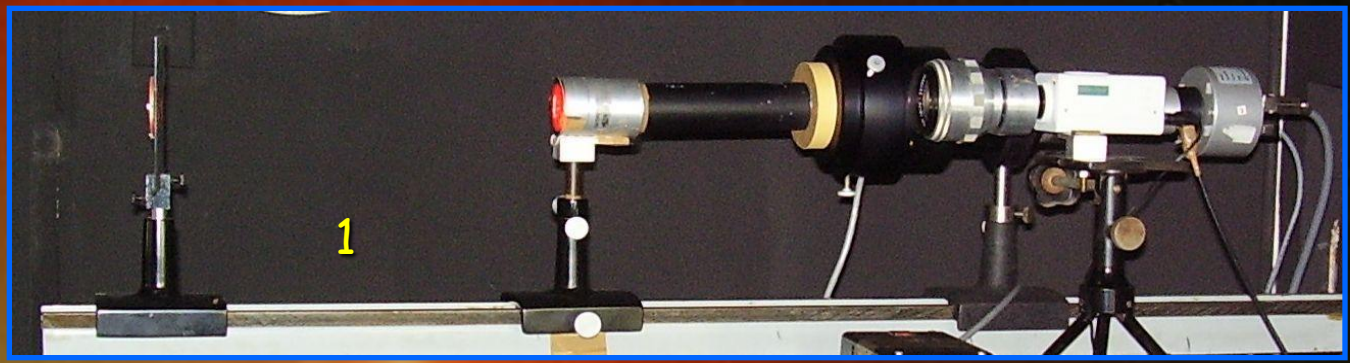


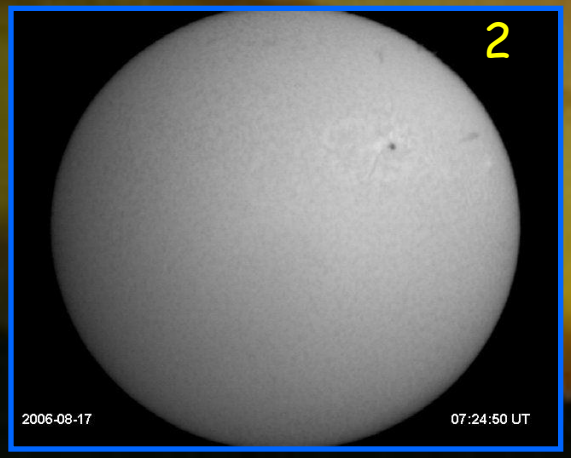
C1...C4

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

Horizontální dalekohled HSFA2 v Ondřejově

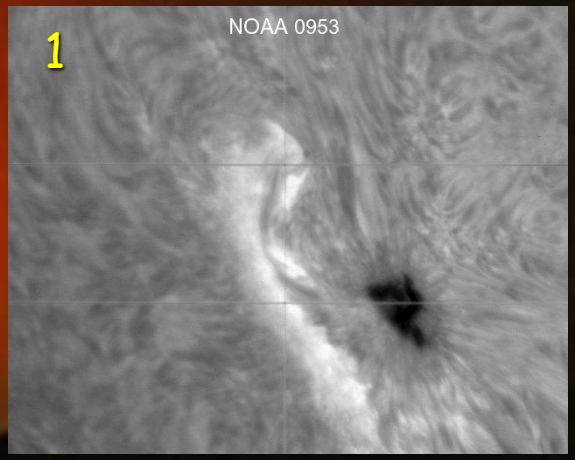
Na HSFA2: 2 úzkopásmové filtry
1 Slit-jaw dalekohled pro detaily
2 Celodiskový dalekohled





Day Star, FWHM 0.7 Angstrom
Detail AO 0953 na slit-jaw snímku

Filtr Coronado, 0.7 Angstremu
Celý disk Slunce



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

Examples of the latest HSFA2 data

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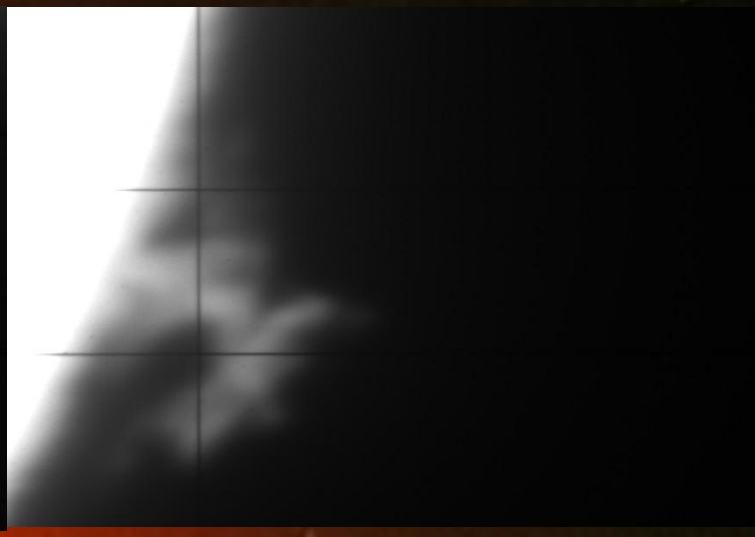
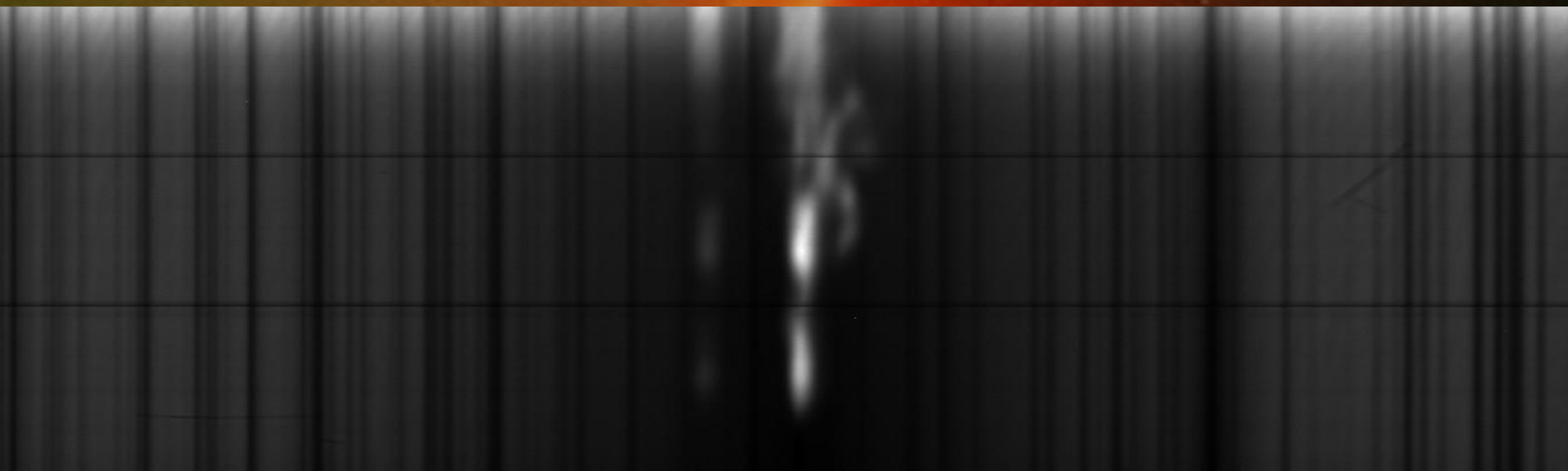
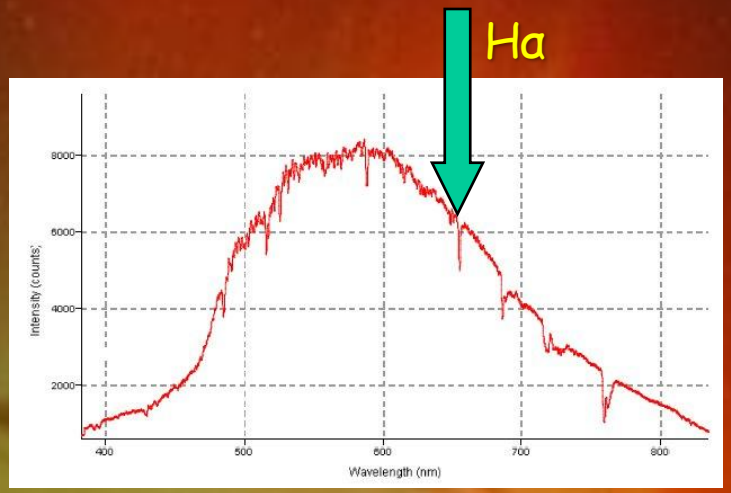




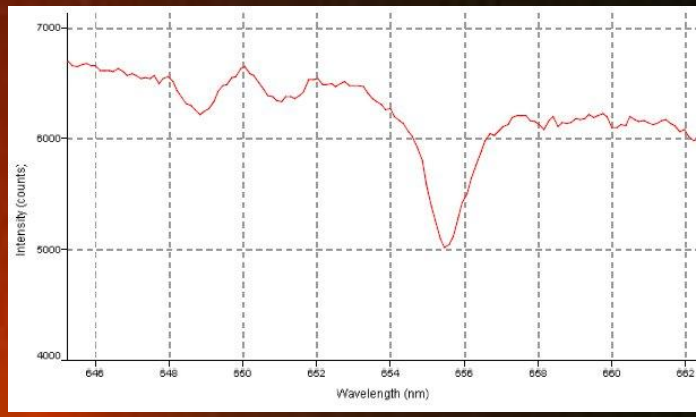
A test of LFS & HR4000 spectrometer

The HR4000 Spectrometer is a high-resolution spectrometer with a 3648-element CCD-array detector from Toshiba that enables optical resolution as precise as 0.02 nm (FWHM). It is responsive from 200-1100 nm, but the specific range and resolution depends on the grating and entrance slit choices.

Slit jaw in Ha
Condensing lens
Fiber cable
Spectrometer

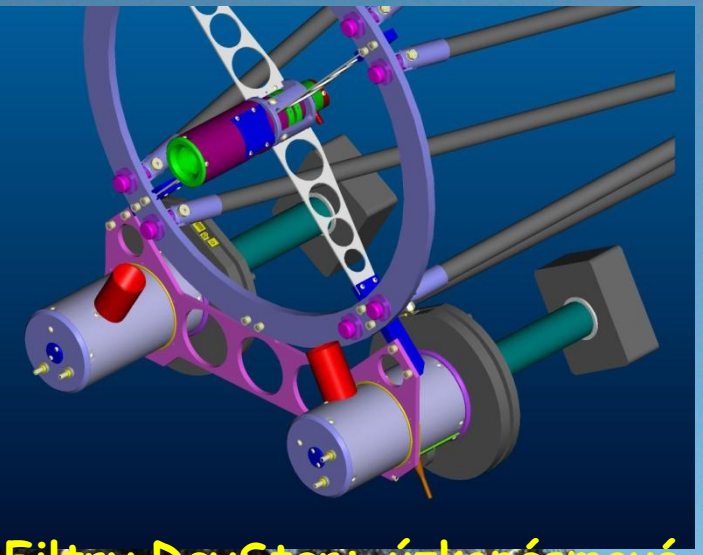


Solar spectrum along the slit
Exposure time ~ 50 - 100 ms



A detail in Ha range
resolution 5 px/Å

Ondřejovský robotický sluneční dalekohled SORT

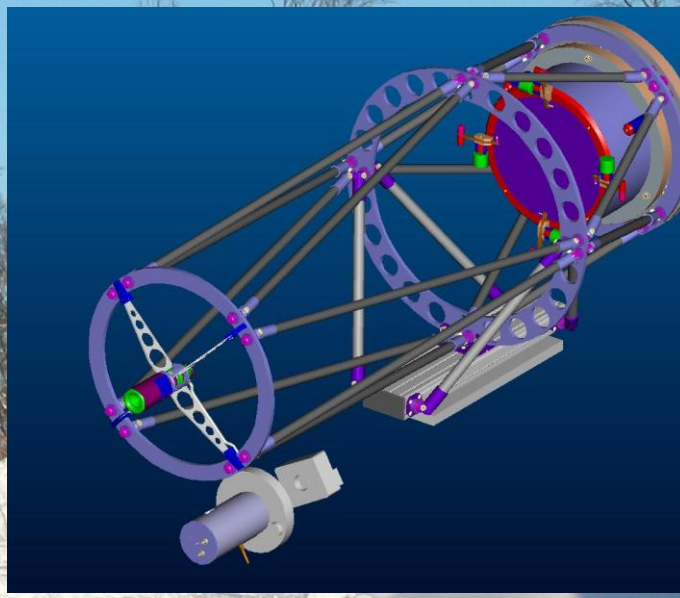


Filtry DayStar: úzkopásmové
Hα – FWHM ~ 0.3 Å
Ca II H – FWHM ~ ?? Å

?!
!?

Paramount ME, německá montáž

kopule Astro Haven Ø 3660 mm
hmotnost: ~ 200 kg, ovládání z PC



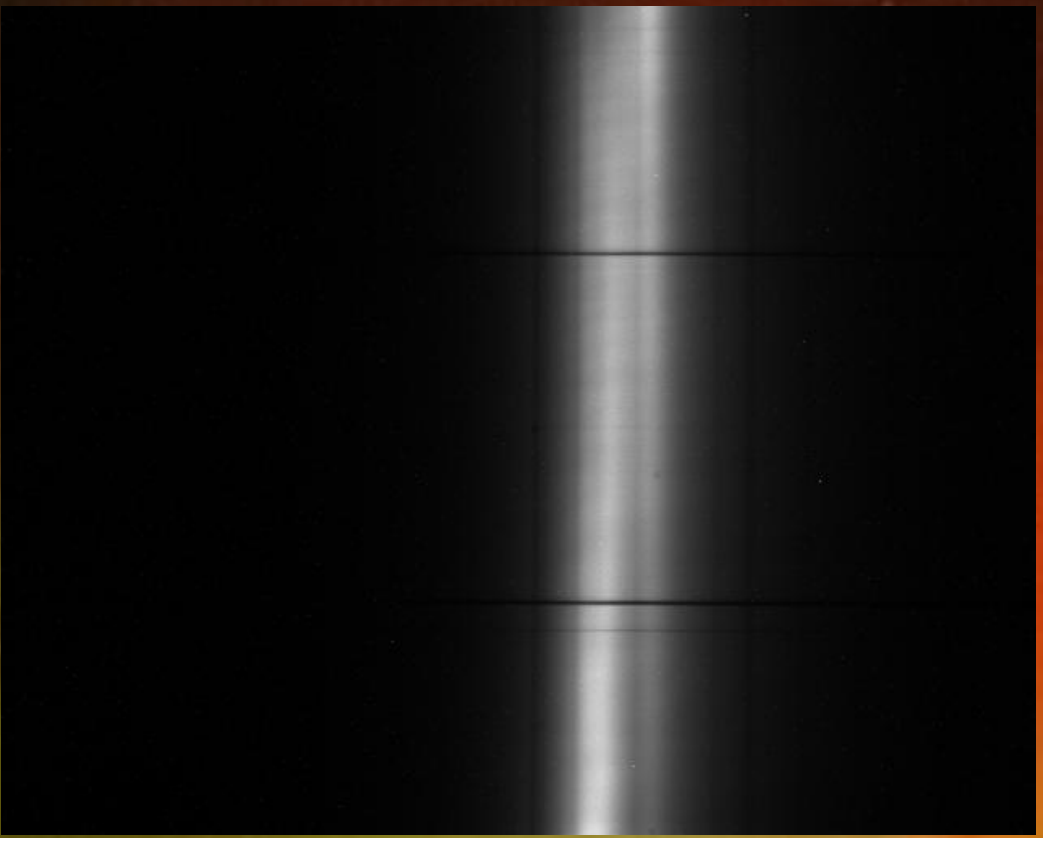
Reflektor s otevřeným tubusem
M1 d=280 mm (opt.) a f=1400

A new optical instrument under development
Solar Robotic Telescope (SORT)

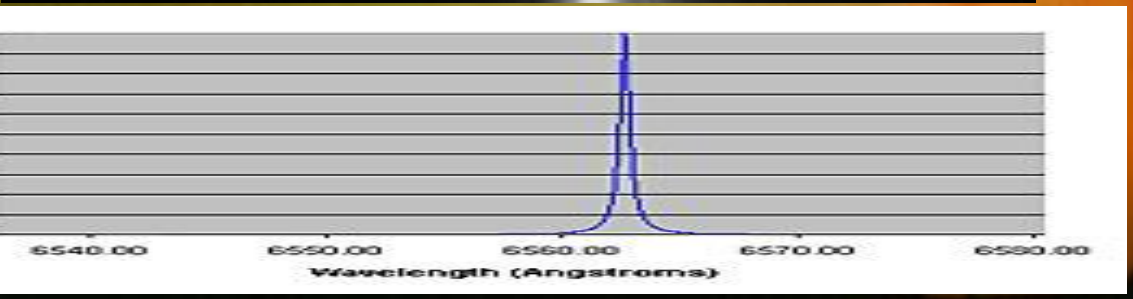
- Full disk camera in white light
- High resolution camera in H-alpha and Ca
- High temporal resolution

A life with the SORT - various birth pangs

Measurement of spectral profile after the H-alpha filter

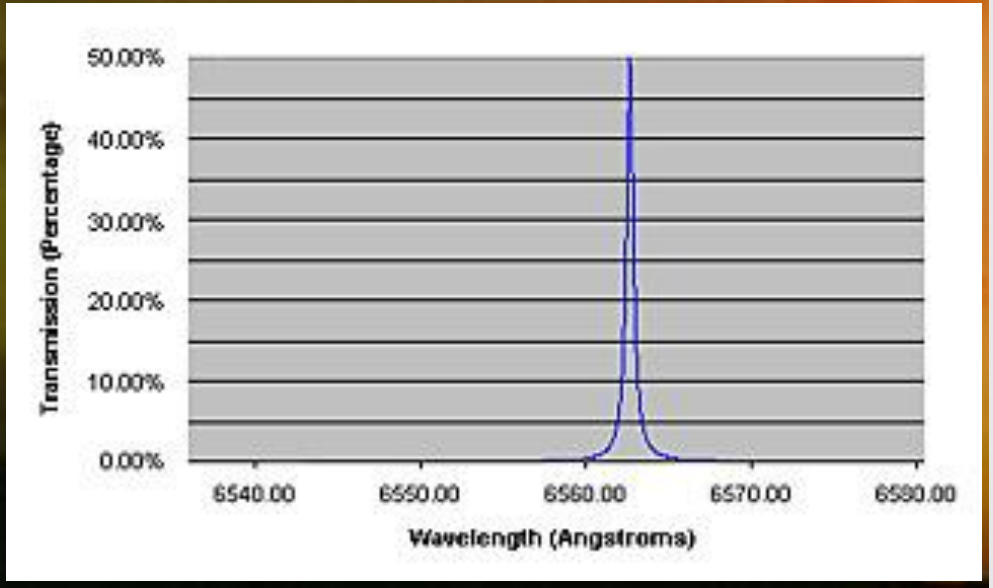


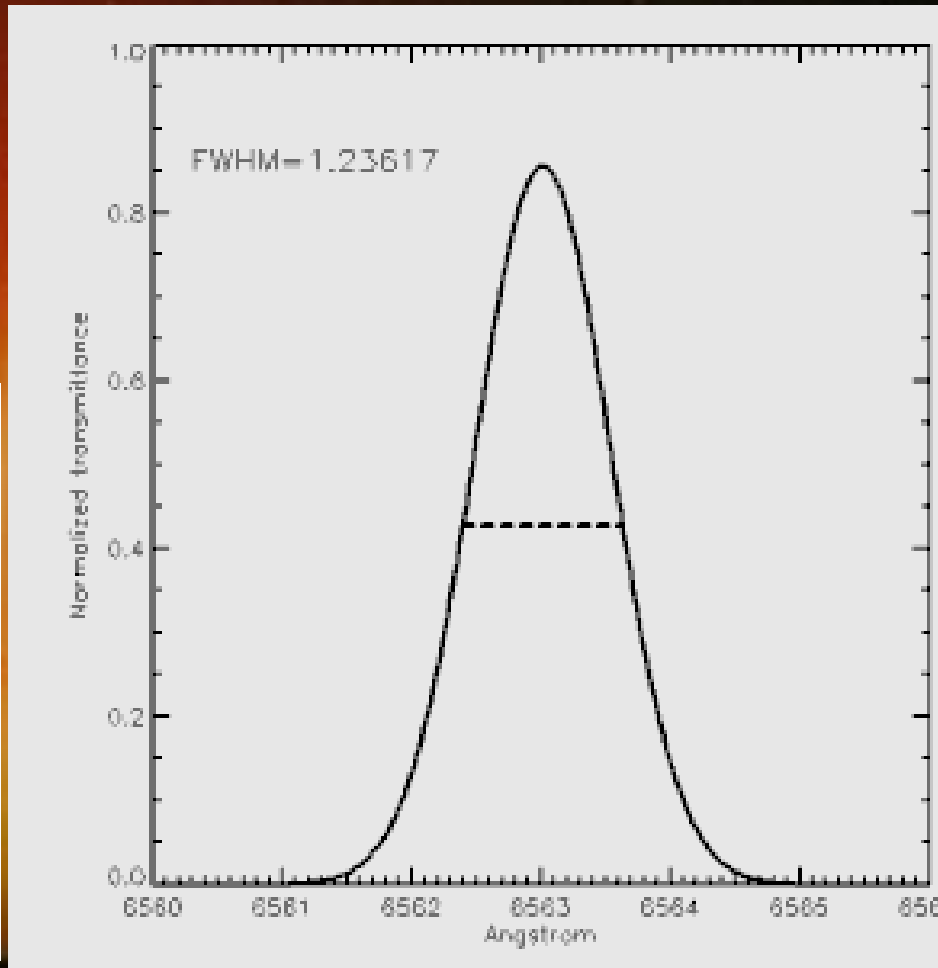
Transmitted profiles are substantially broader then declared by producer. They are different in various positions. Spectral line has different tilt when rotating filter while the optical systém remains szmmetrical along optical axis.



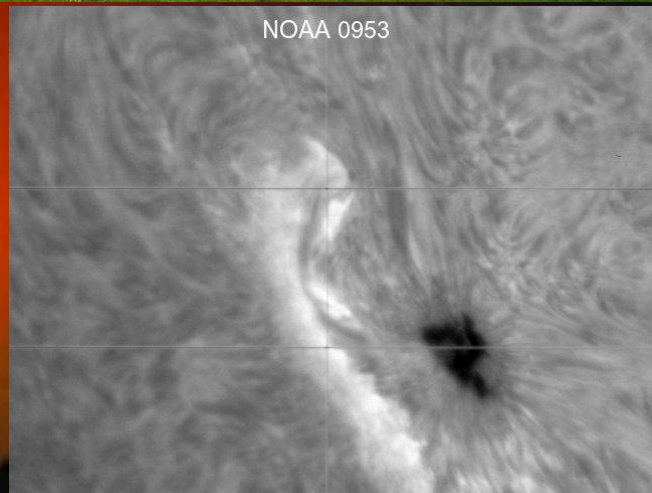
A conflict of parameters given by the producer with the measured reality

Producer:
DayStar Filters LLC, Warrensburg, USA





Thank you for attention



Invitation for an annual solar department seminary
At the HSFA2 - June 18, 2014
Welcoming of the summer solstice