



PROGRAM
CEZHRANIČNEJ
SPOLUPRÁCE
SLOVENSKÁ REPUBLIKA
ČESKÁ REPUBLIKA



EURÓPSKA ÚNIA
EURÓPSKY FOND
REGIONÁLNEHO ROZVOJA
SPOLOČNE BEZ HRANÍČ

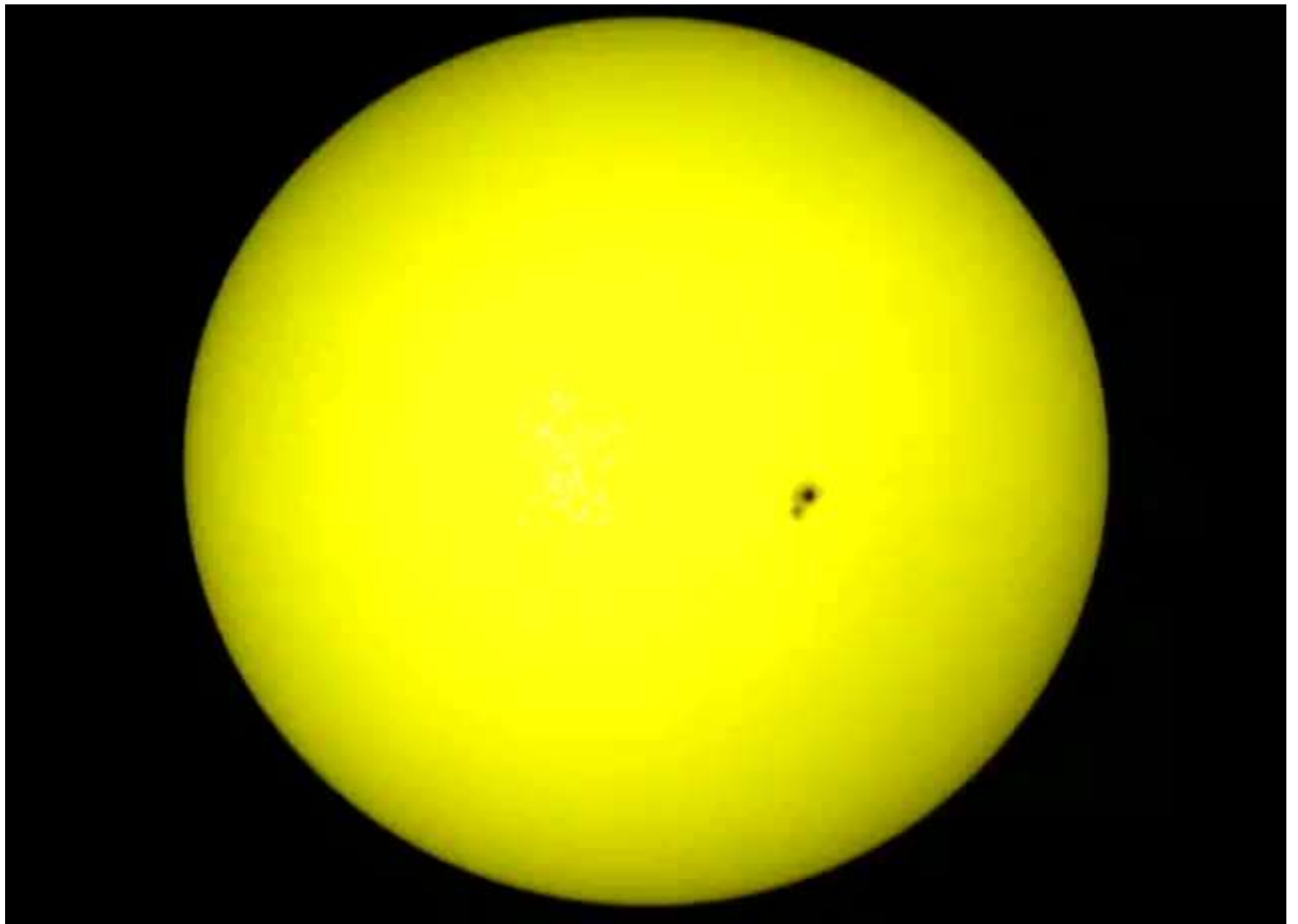


FOND MIKROPROJEKTŮ

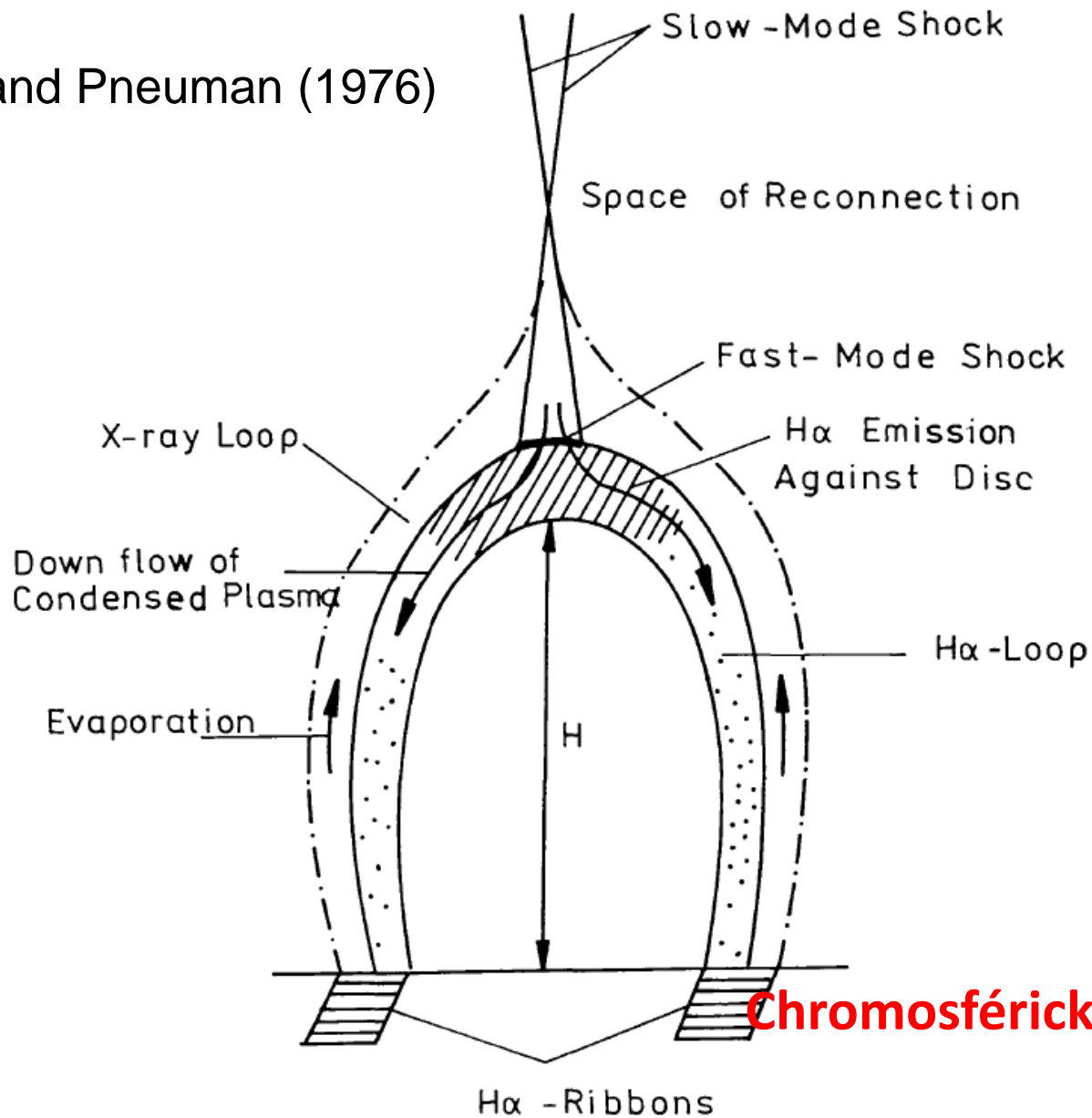
Pozorování a modelování slunečních erupcí

P. Heinzel

Astronomický ústav Akademie věd ČR
Ondřejov

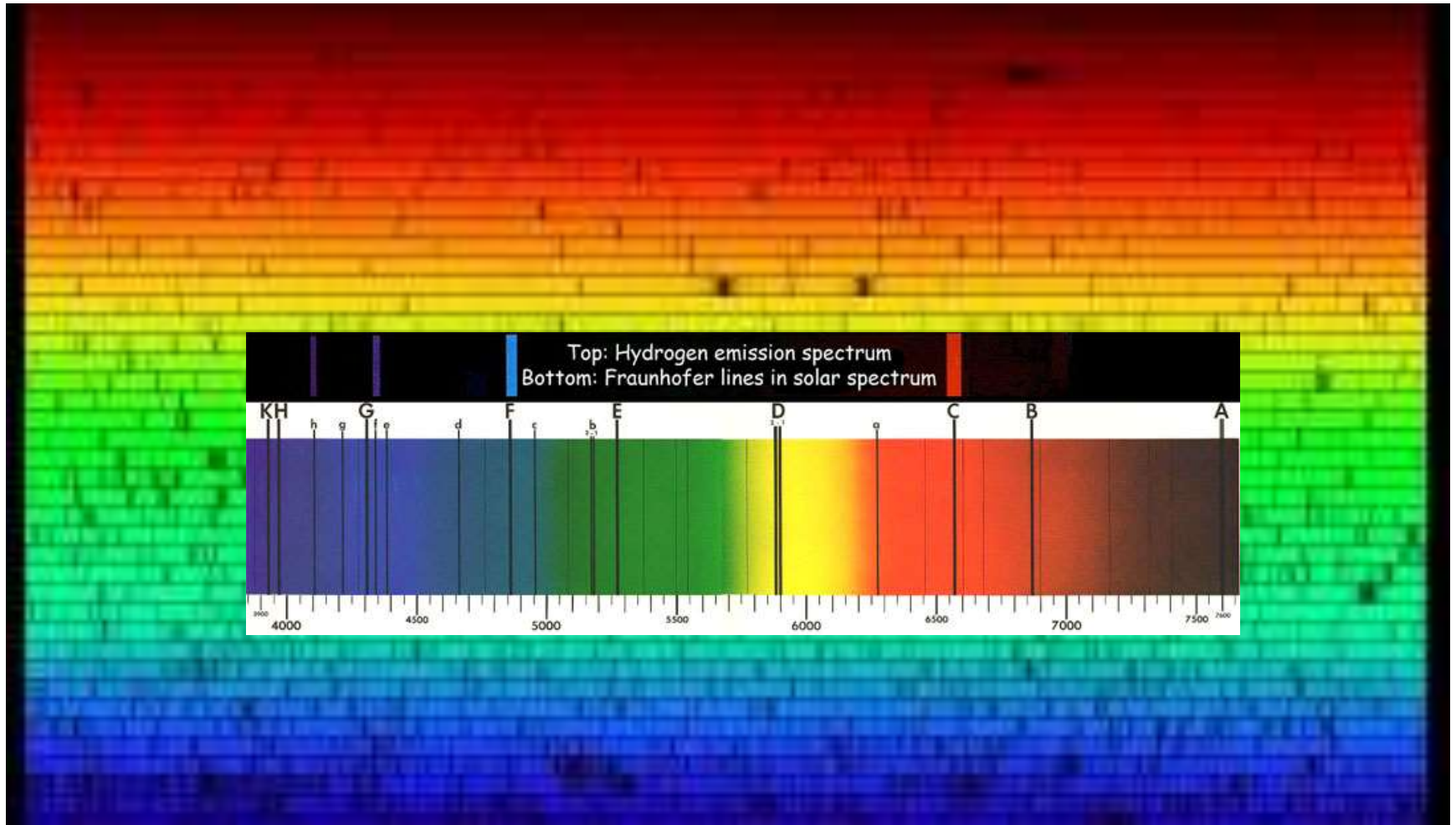


Kopp and Pneuman (1976)



Chromosférická erupce

Solar spectrum



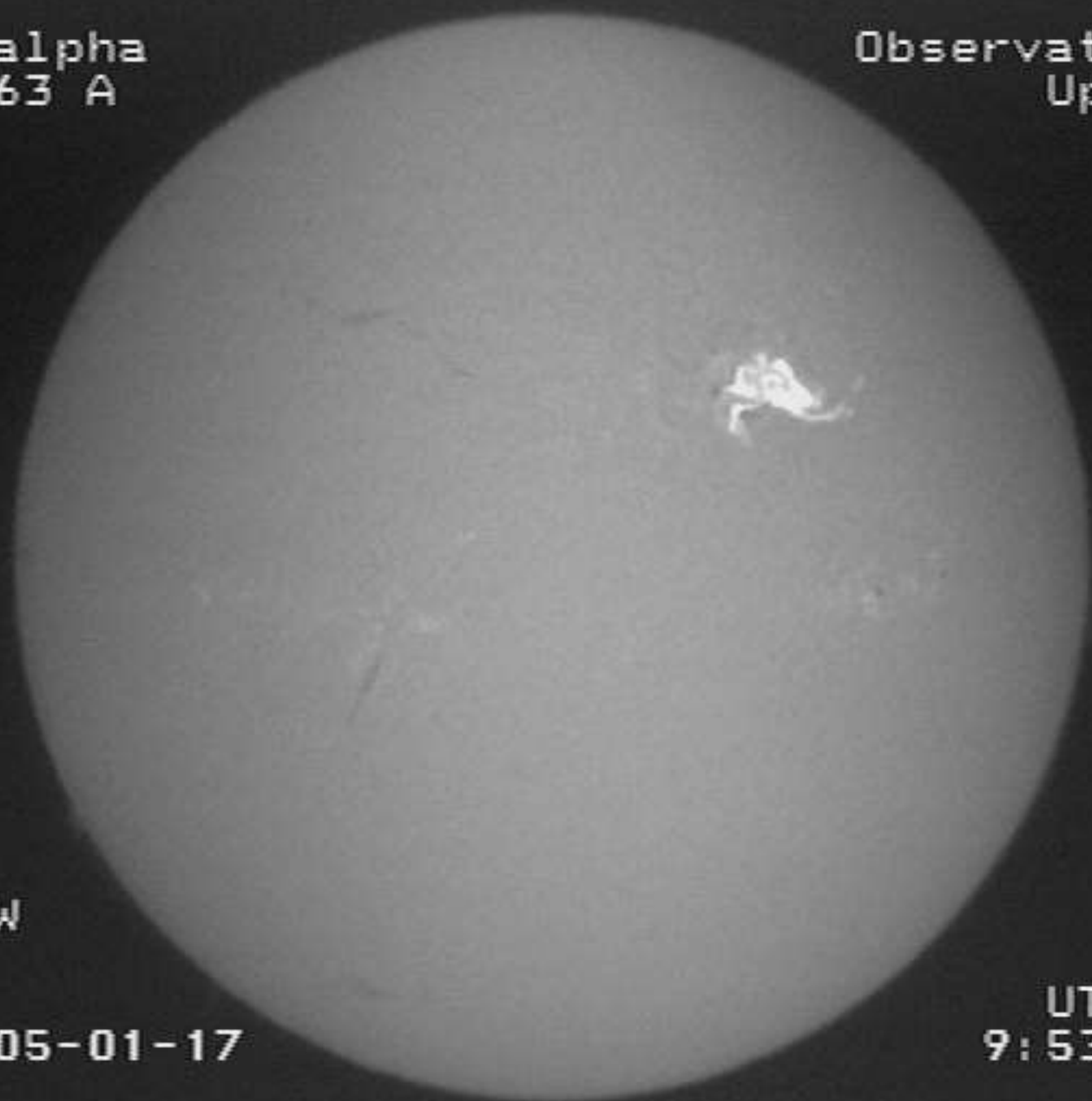
H-alpha
6563 A

Observatory
Upice

N
E W
S

2005-01-17

UT
9:53:29



CaII-K
3934 A

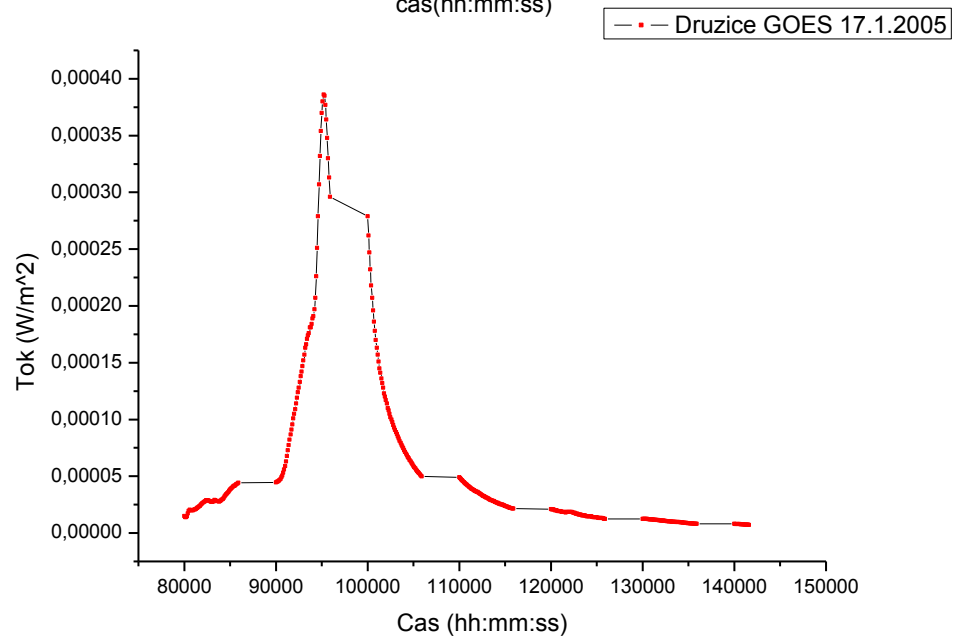
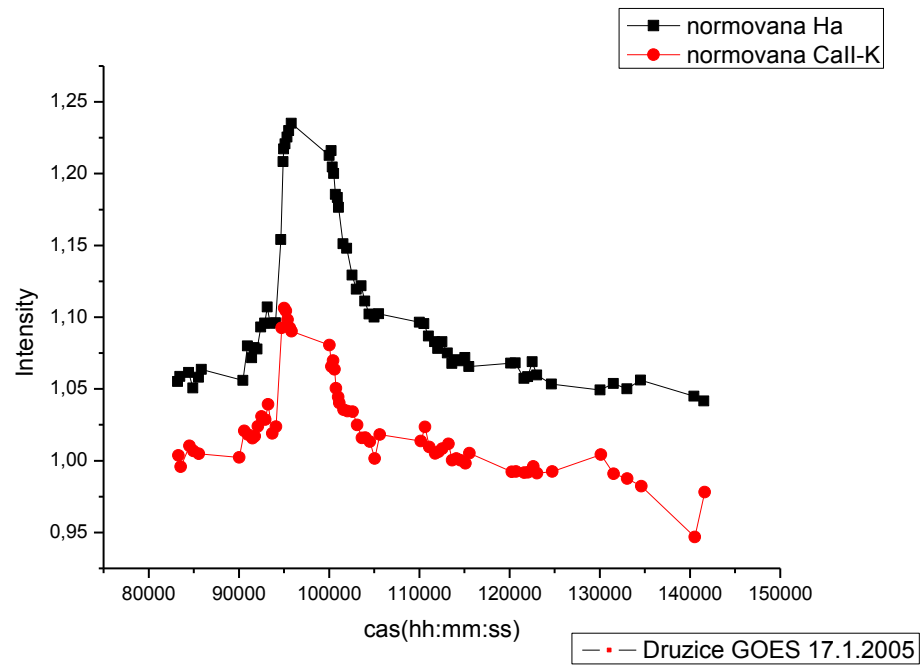
Observatory
Upice



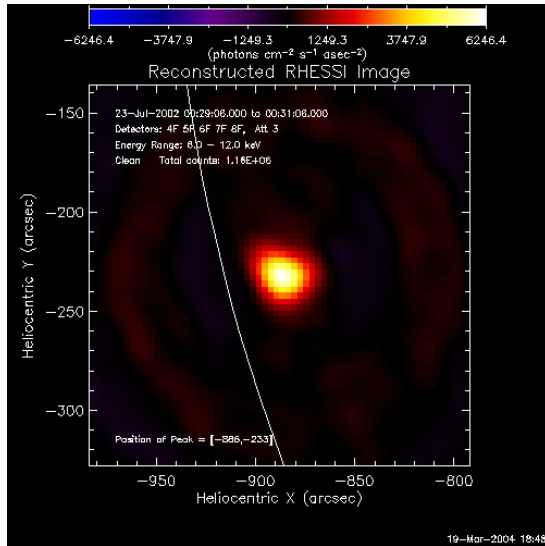
N
E W
S

2005-01-17

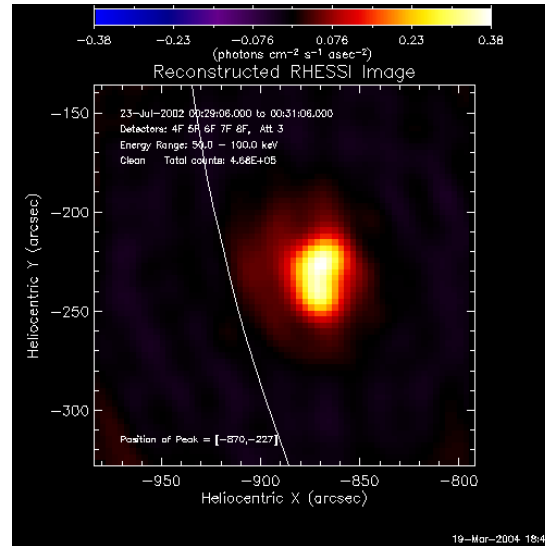
UT
9:52:17



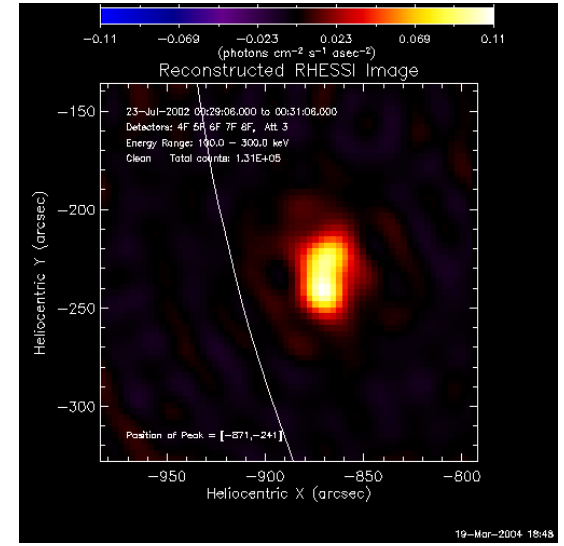
Flare observed by RHESSI



6-12 keV

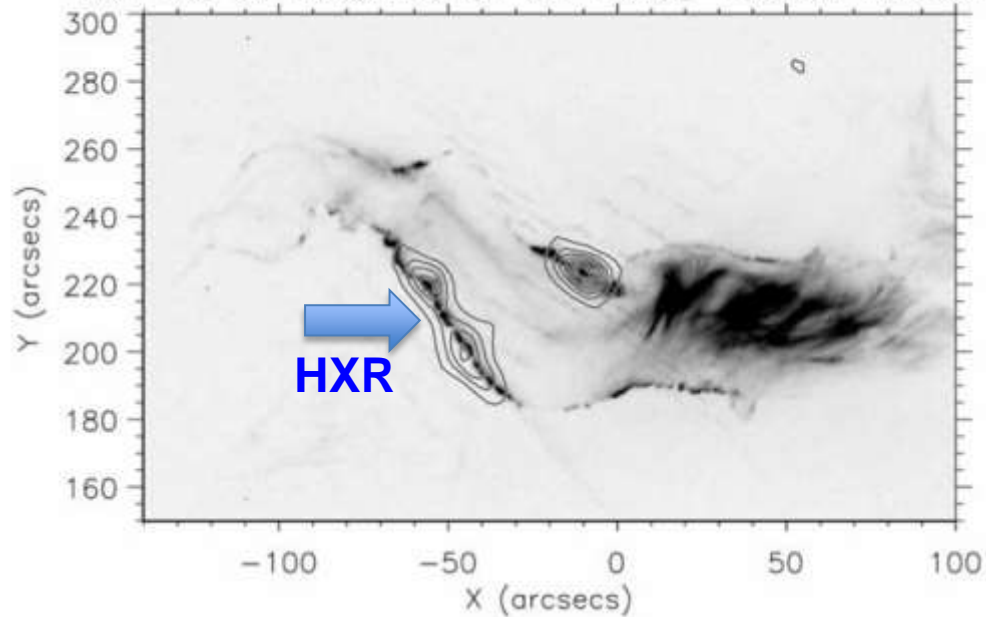


50-100 keV



100-300 keV

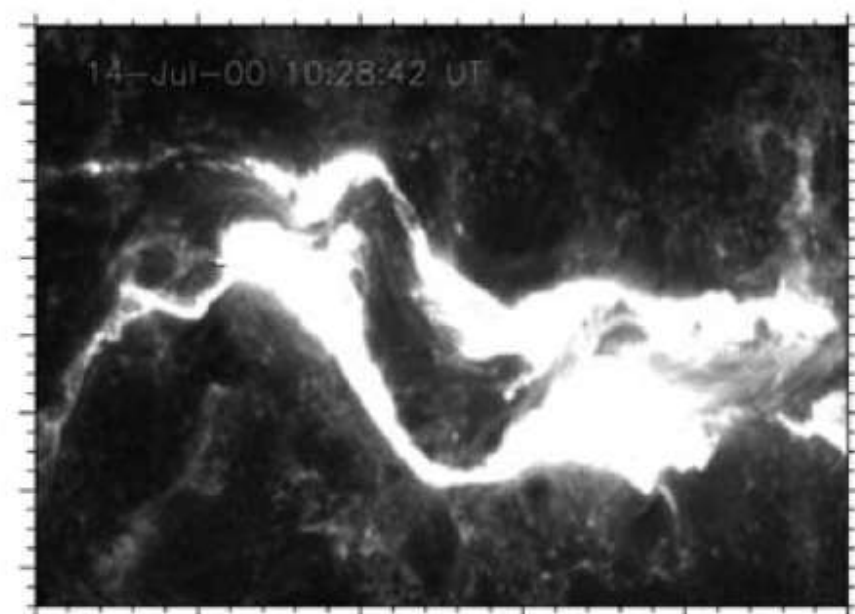
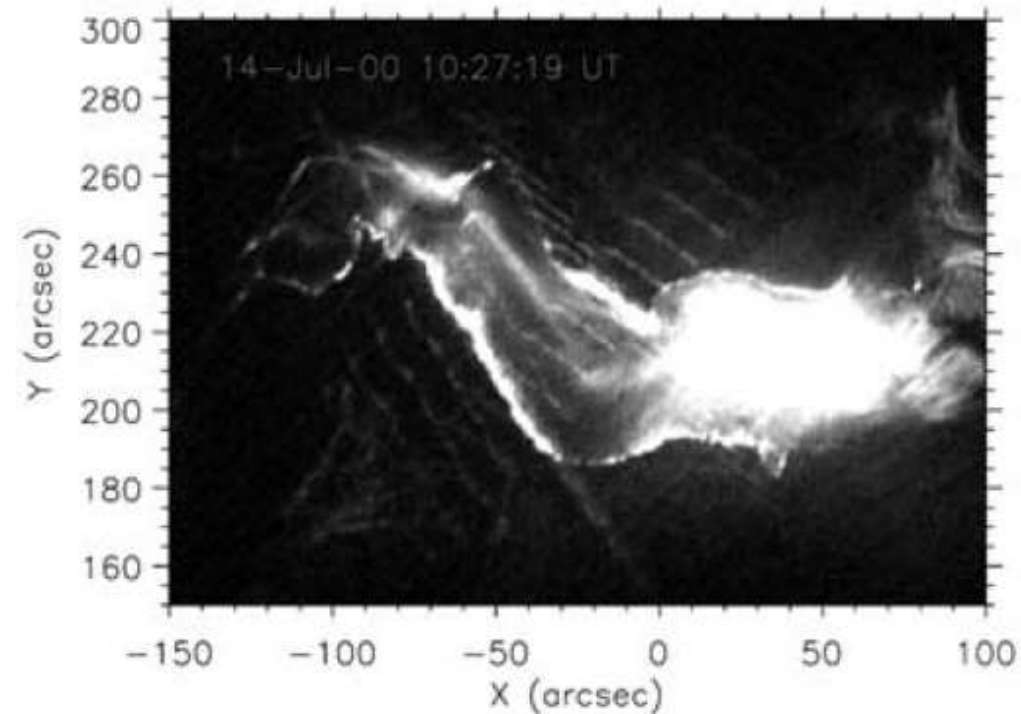
HXT M2 at 10:27:00 UT on TRACE 195 at 10:27:11



Bastille-day Flare 14 July 2000

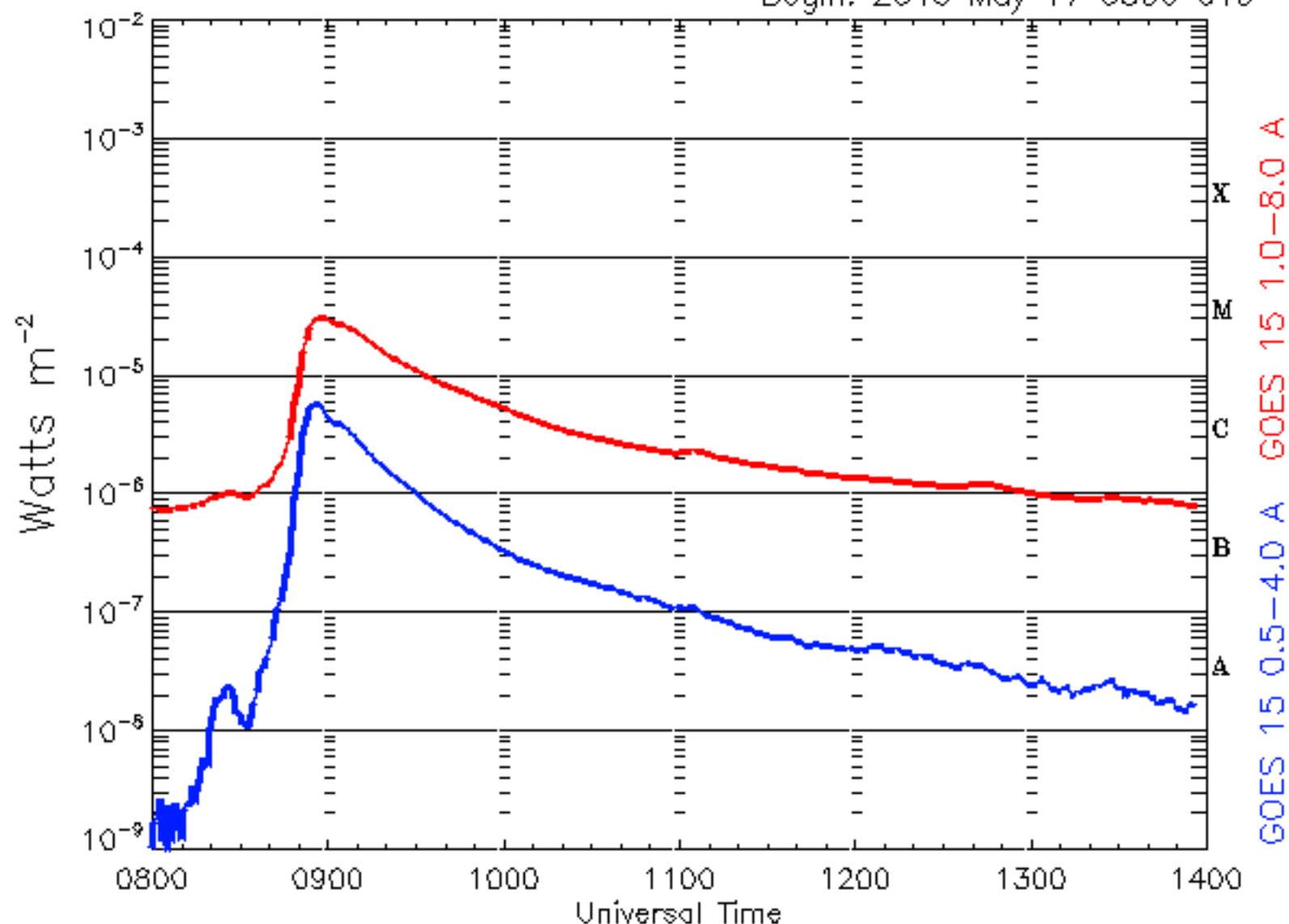
(Fletcher and Hudson 2001)

TRACE 160 nm



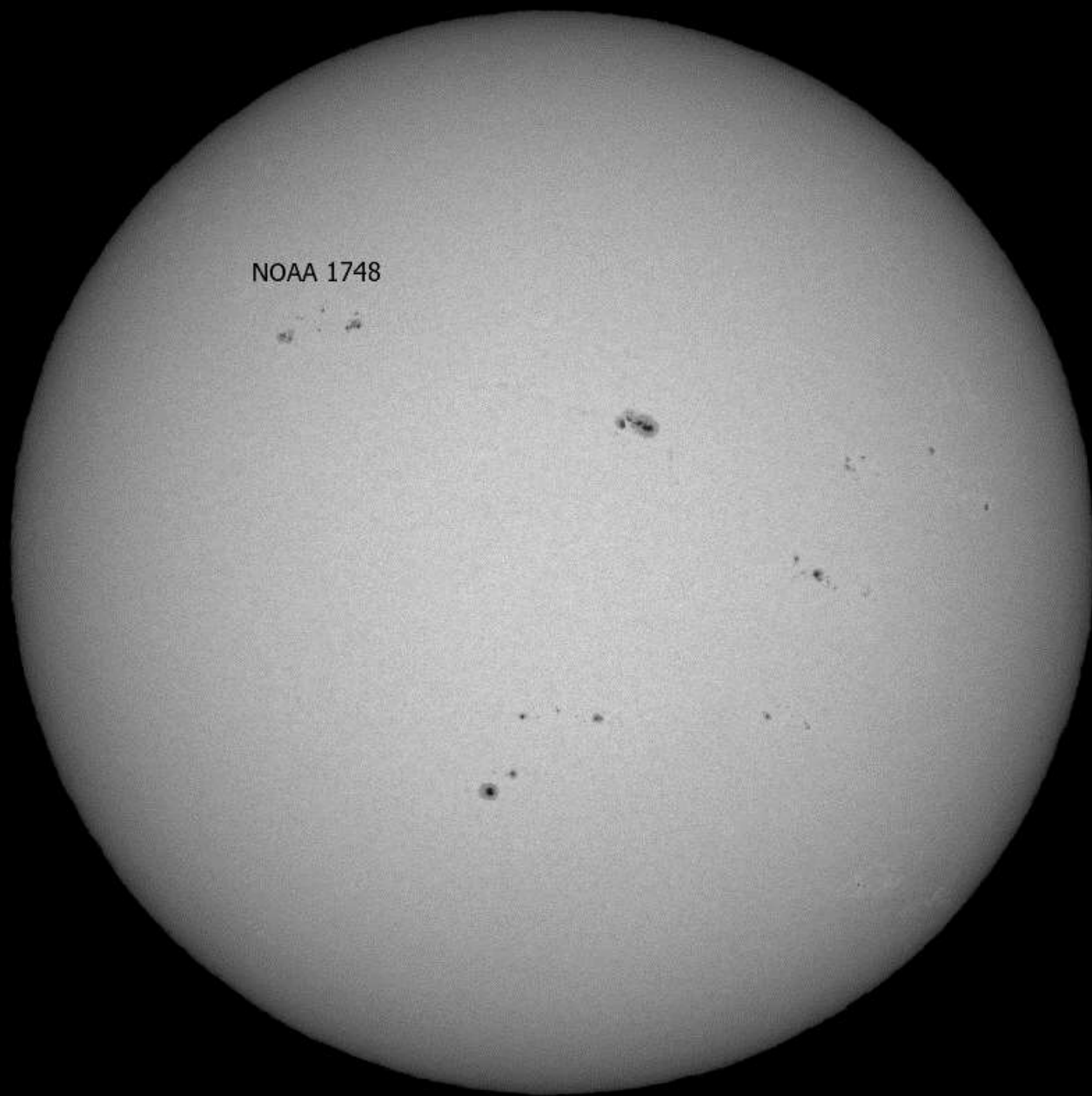
GOES X-ray Flux (1 minute data)

Begin: 2013 May 17 0800 UTC



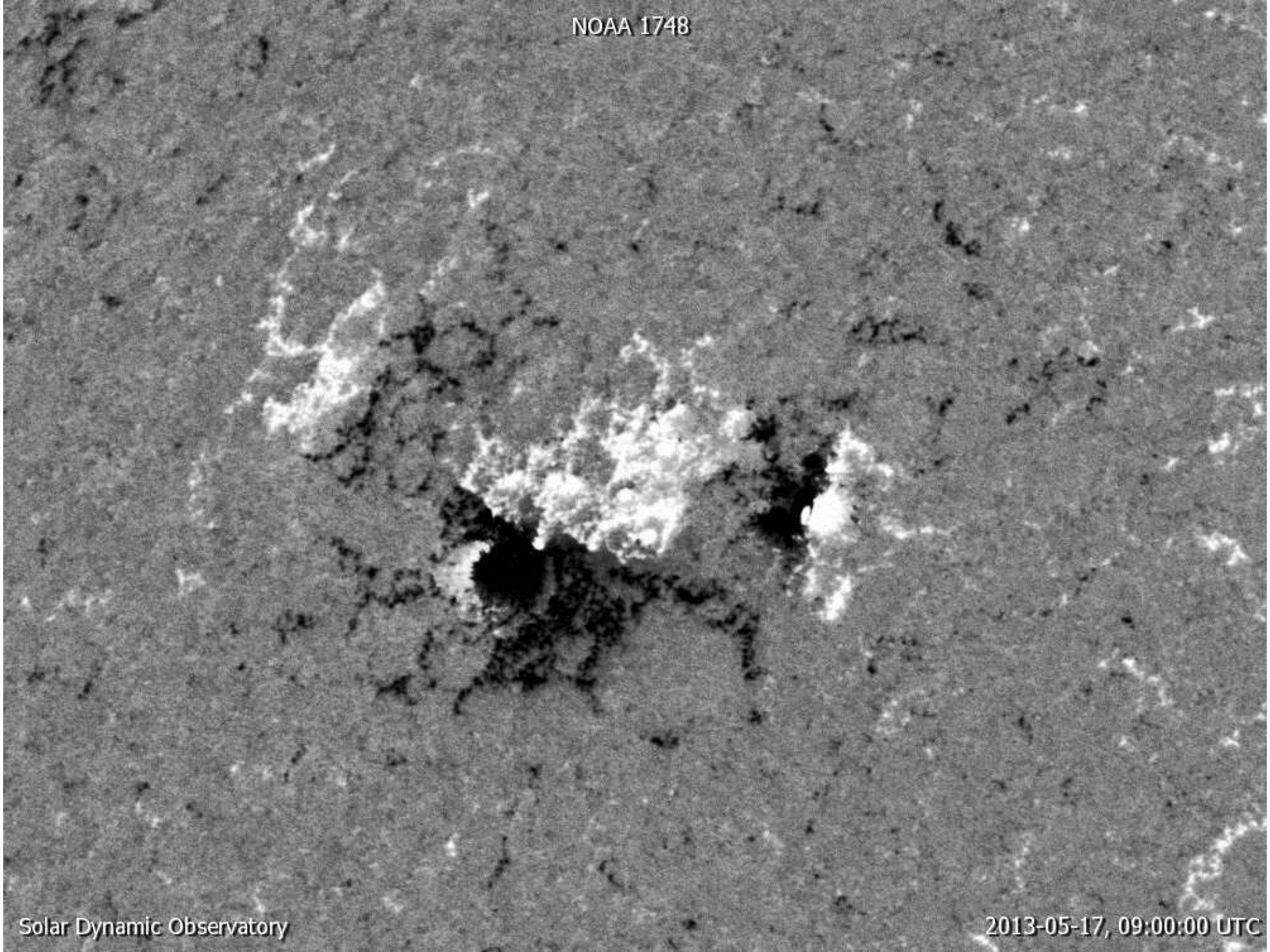
Updated 2013 May 17 1357 UTC

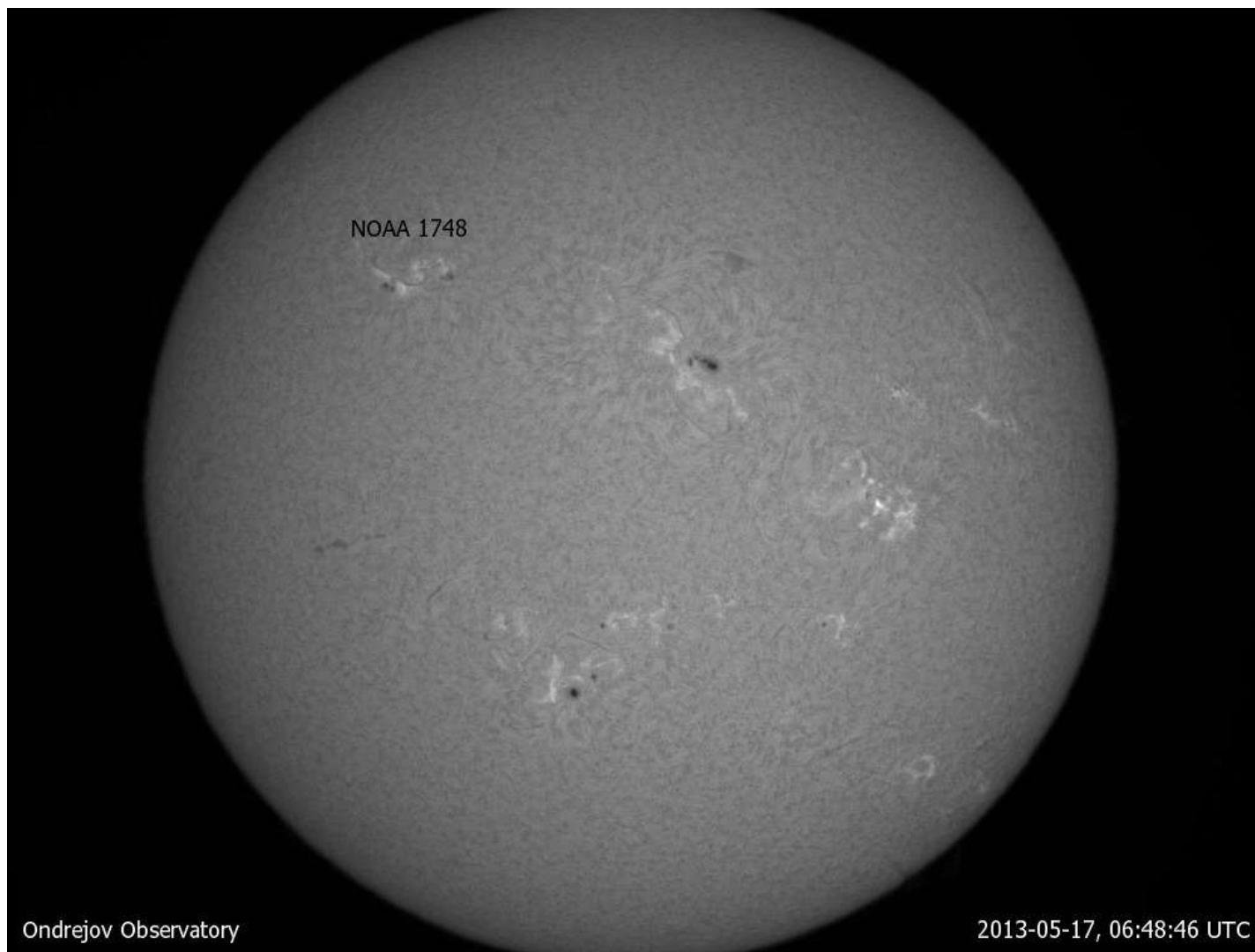
NOAA/SWPC Boulder, CO USA



NOAA 1748

NOAA 1748

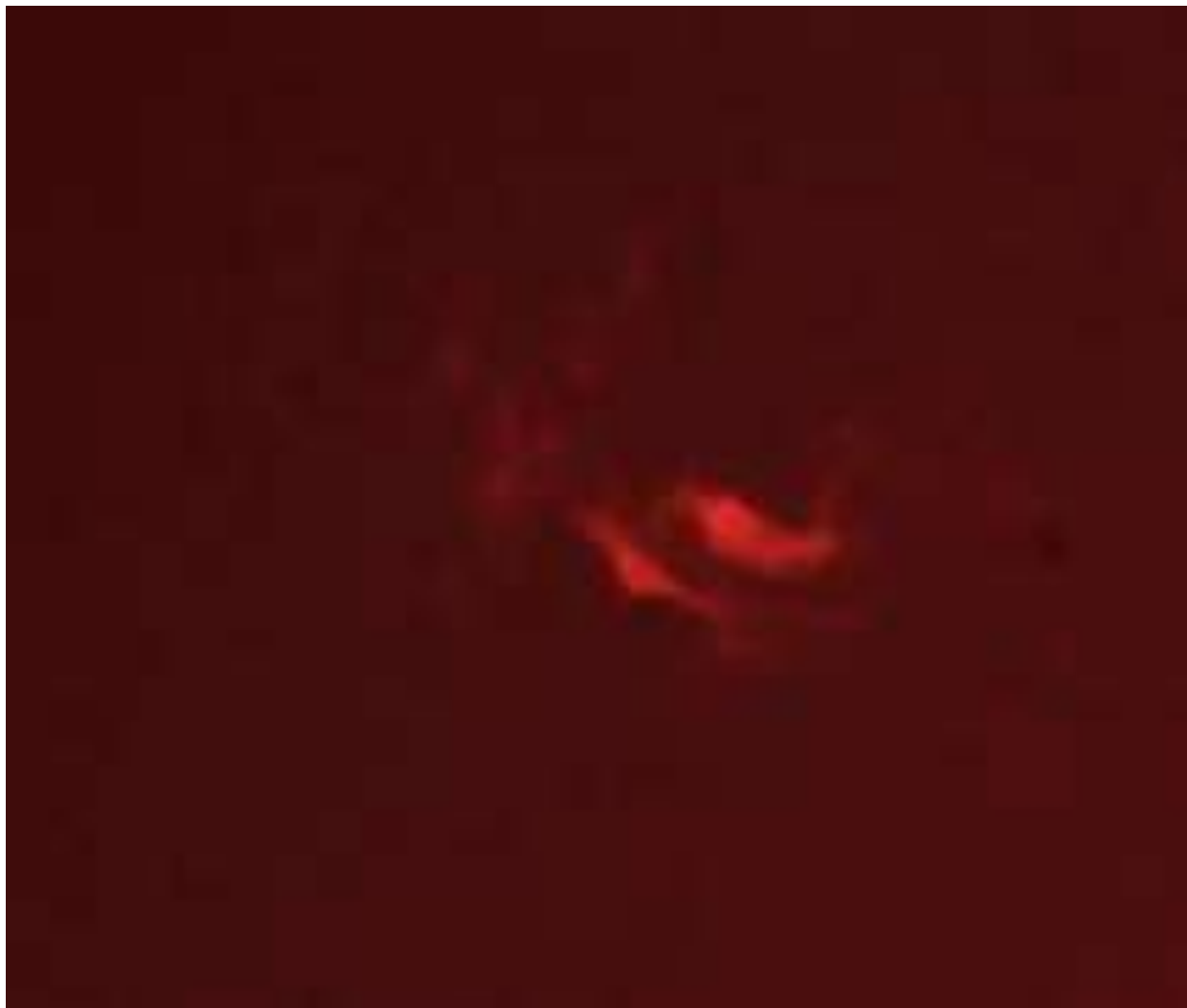




NOAA 1748

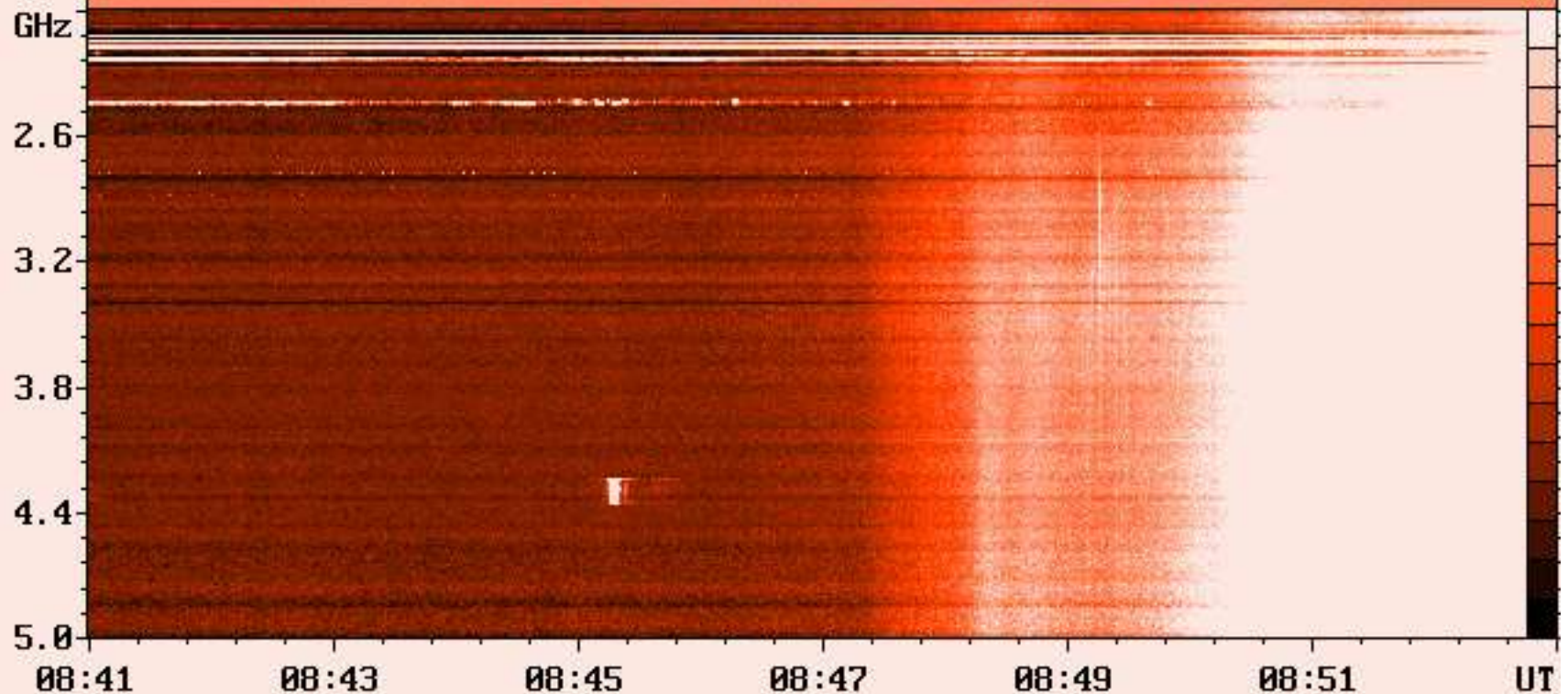
Ondrejov Observatory

2013-05-17, 06:48:46 UTC

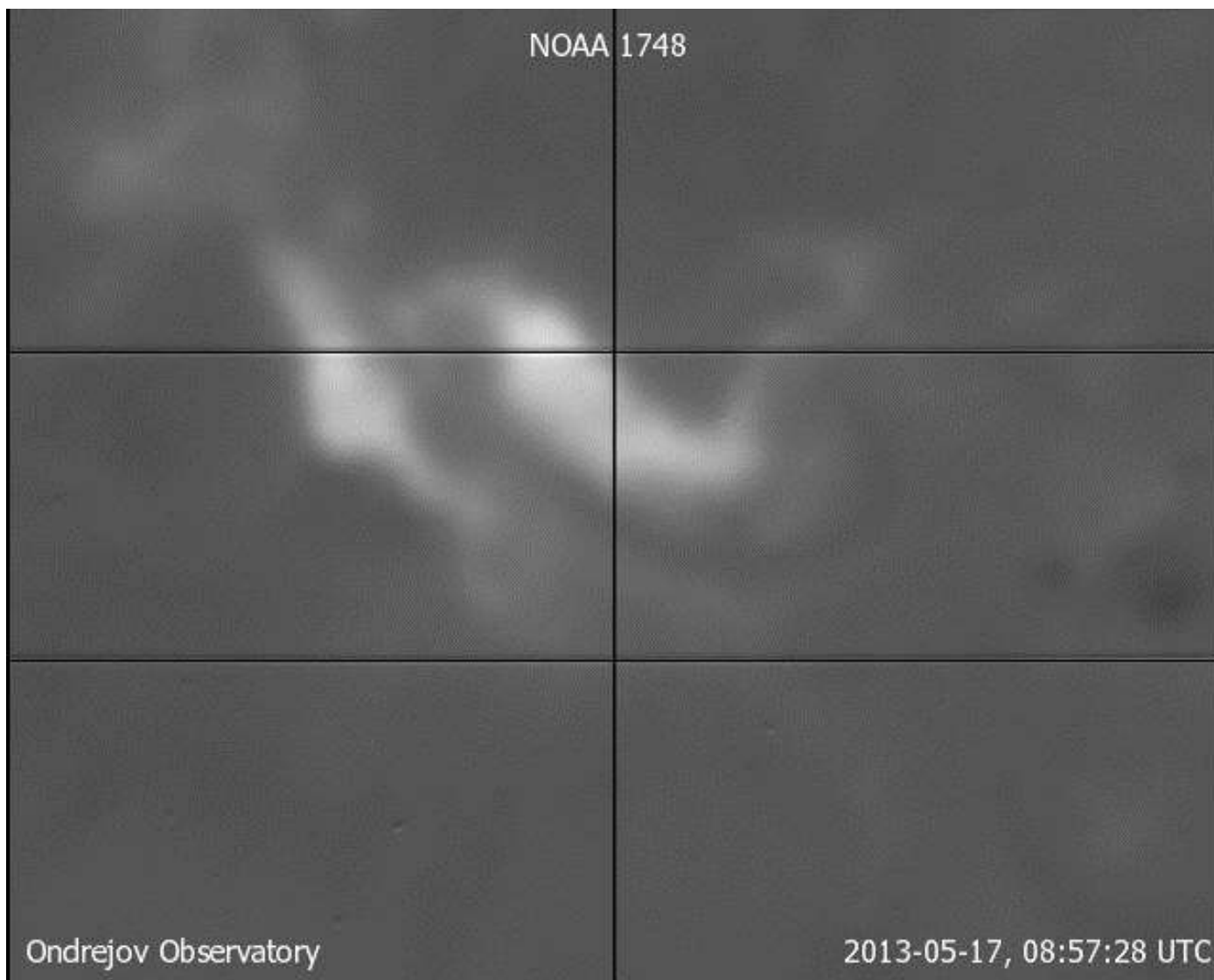


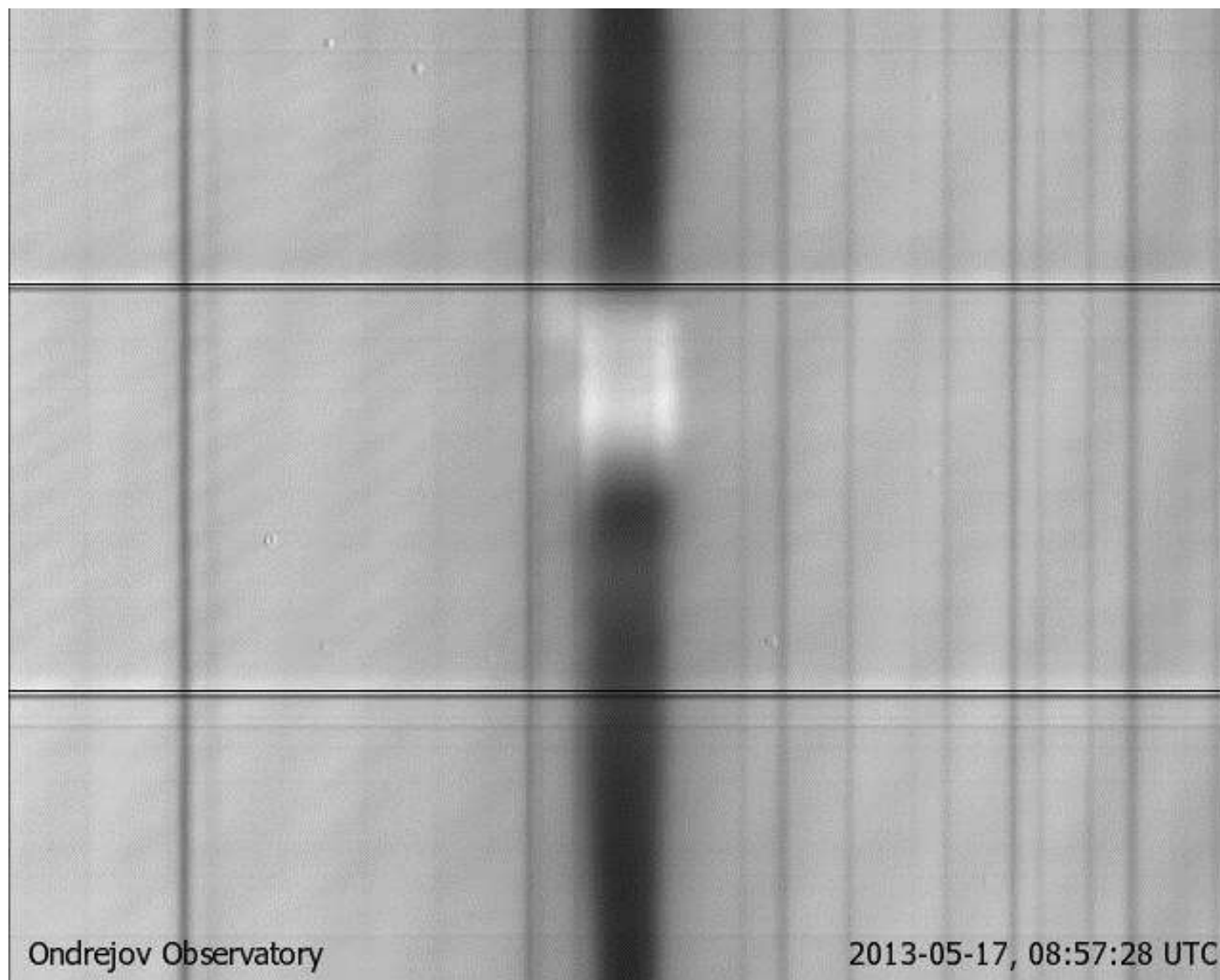
(c) ASTRONOMICAL INSTITUTE, 25165 ONDREJOV, CZECH REPUBLIC

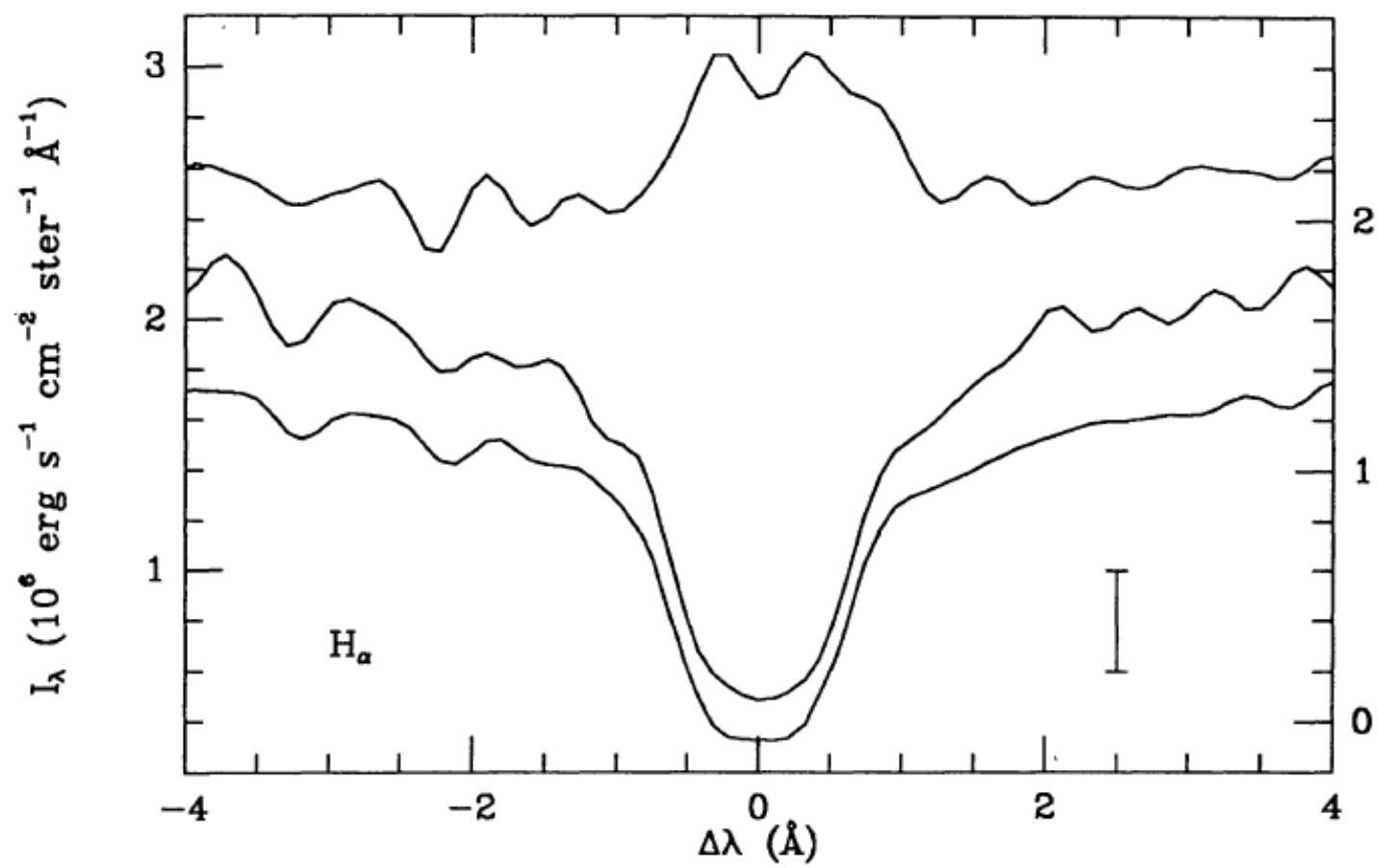
ONDREJOV SUN - RADIO SPECTRUM 2.0-5.0 GHz on MAY 17, 2013

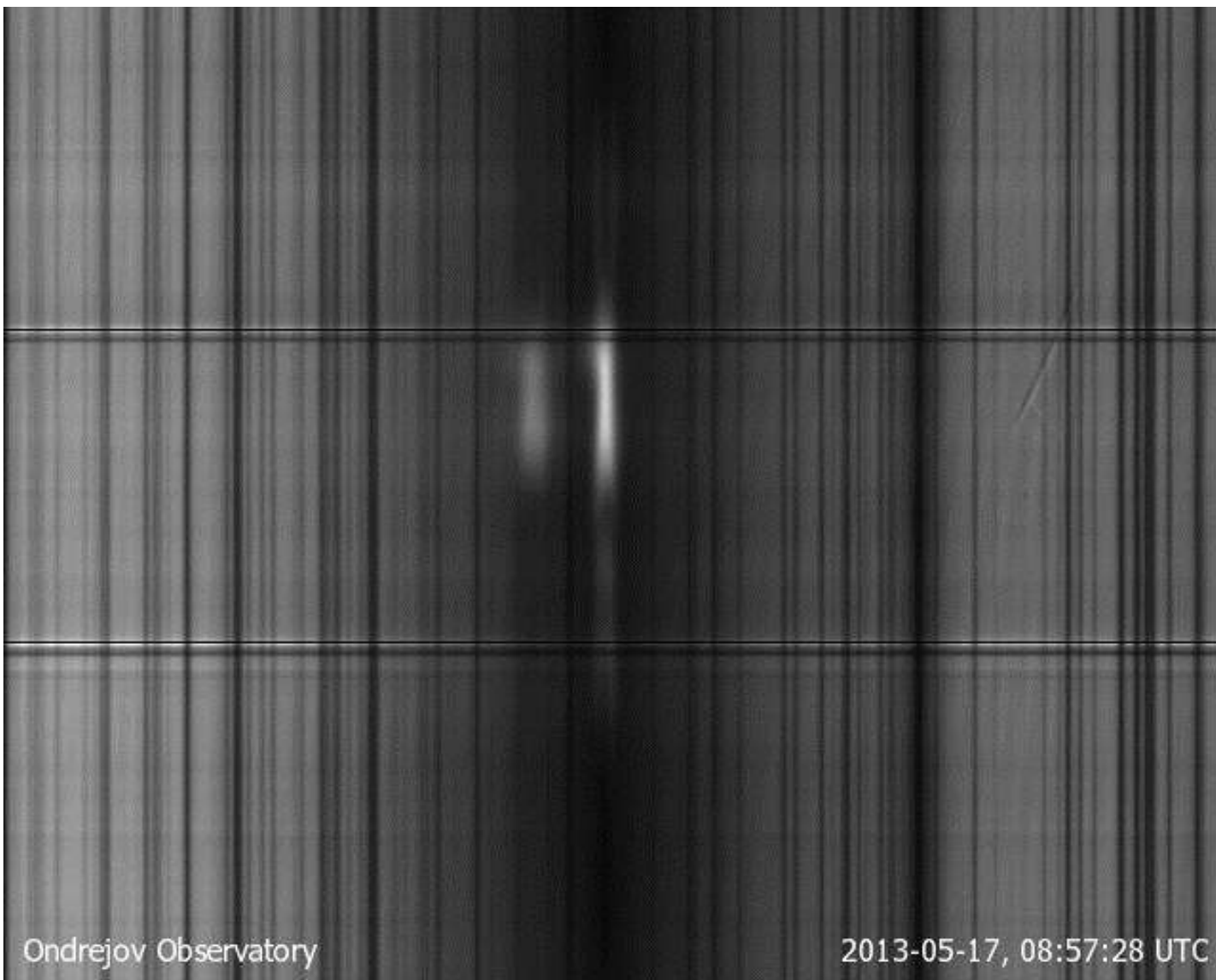


HSFA – 2 Ondřejov Observatory



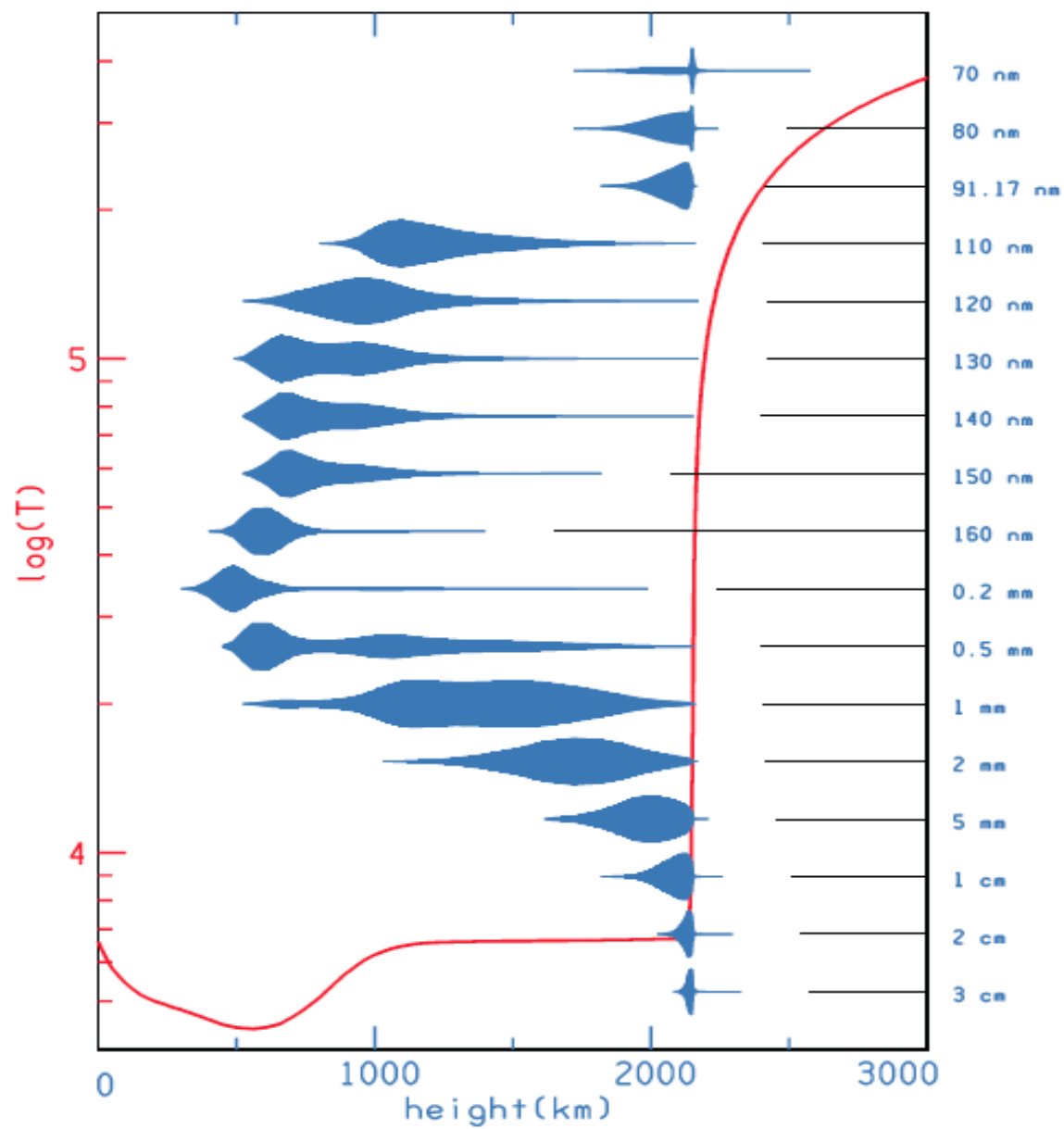




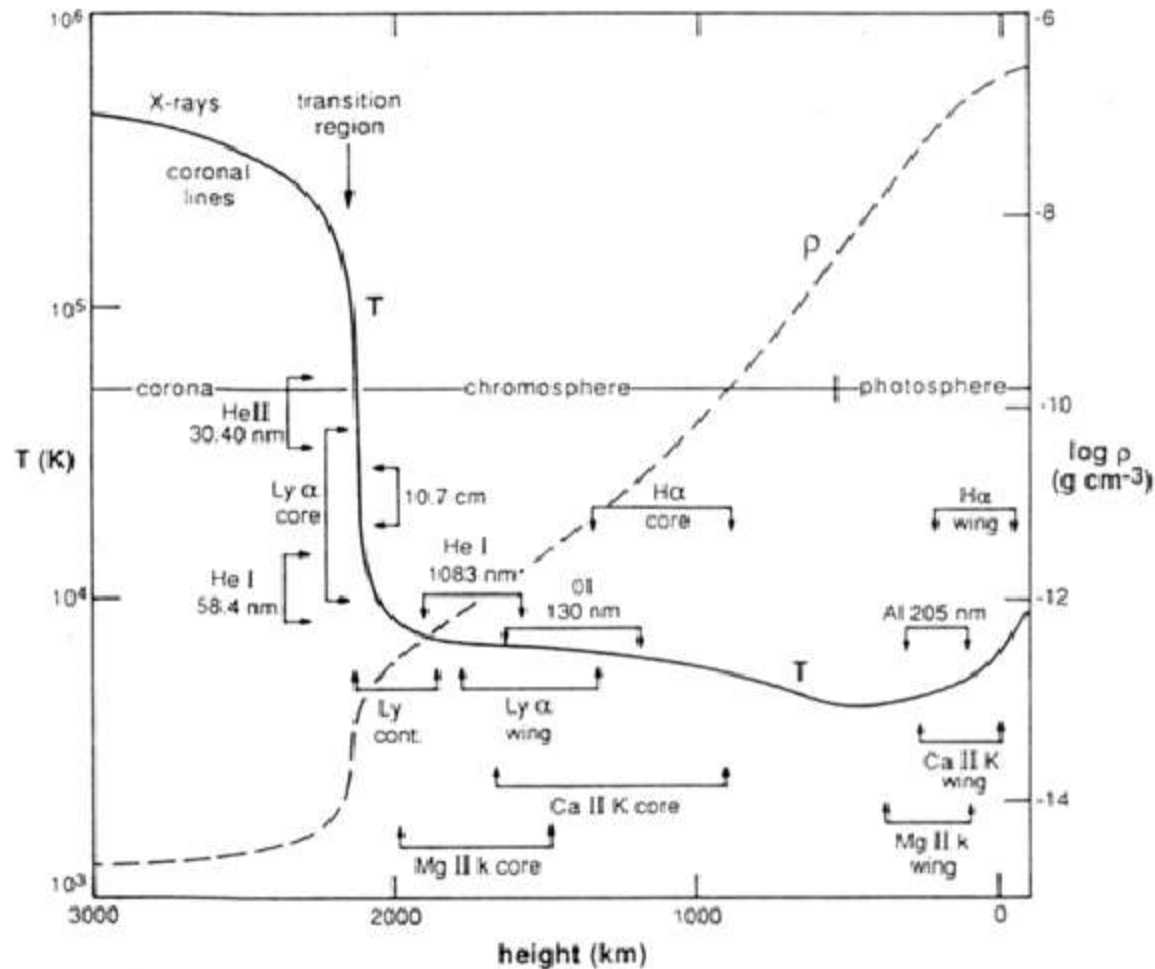


Ondrejov Observatory

2013-05-17, 08:57:28 UTC



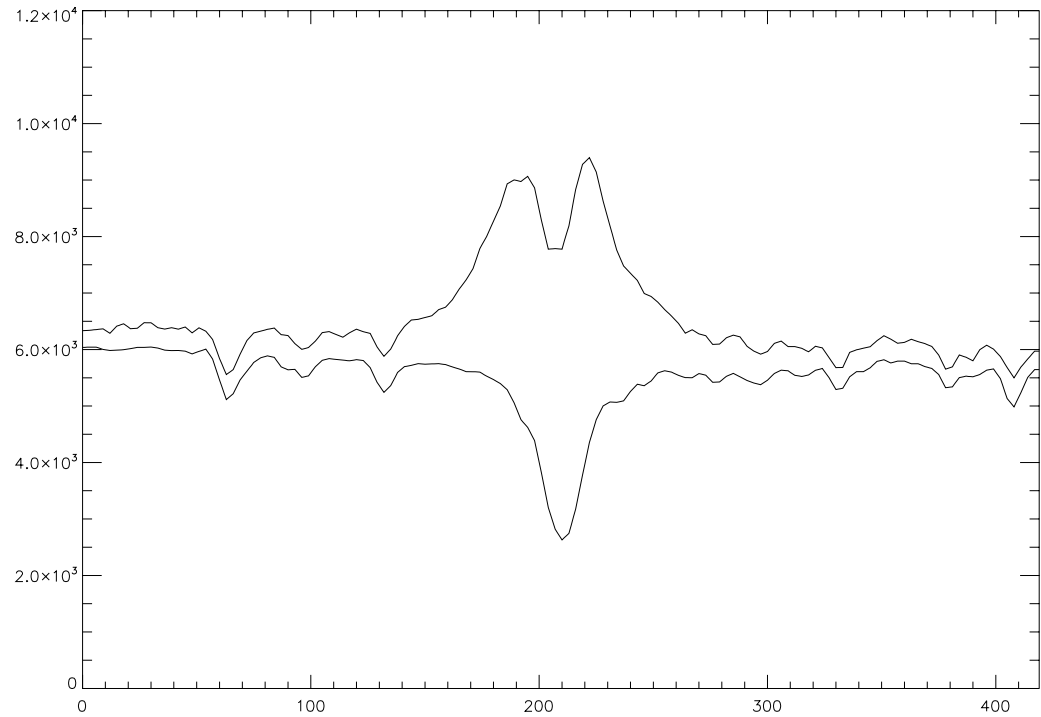
Structure of the solar atmosphere



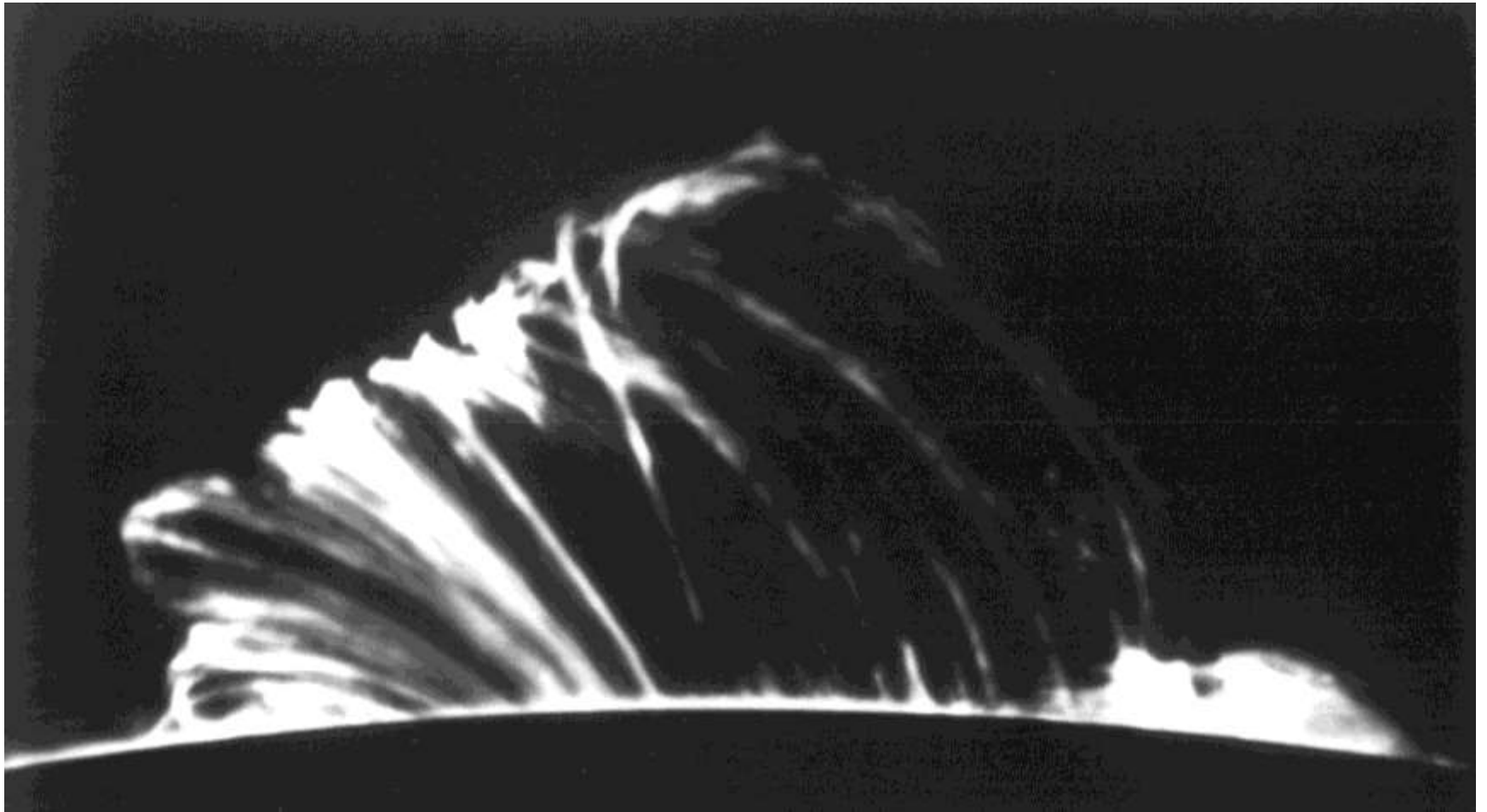
White-light X-flare (Coimbra)

August 9, 2011

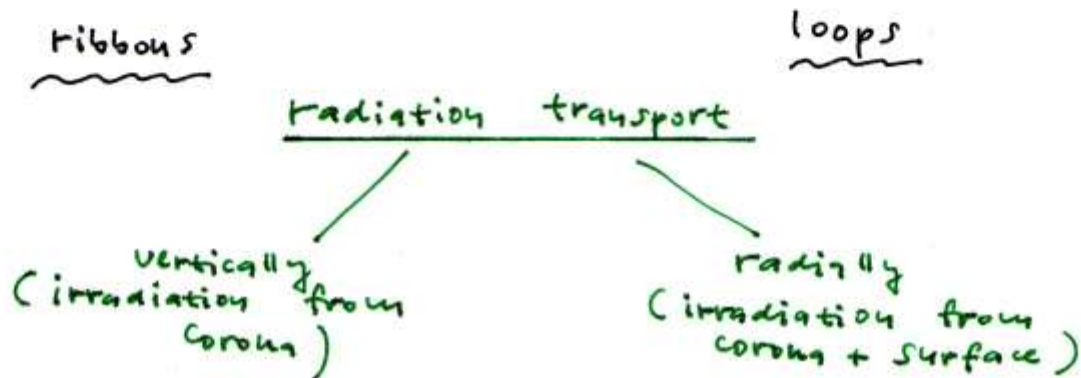
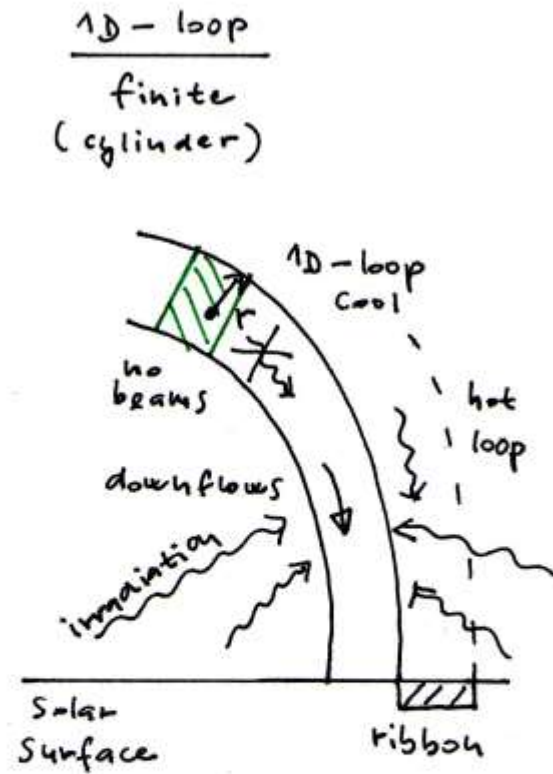
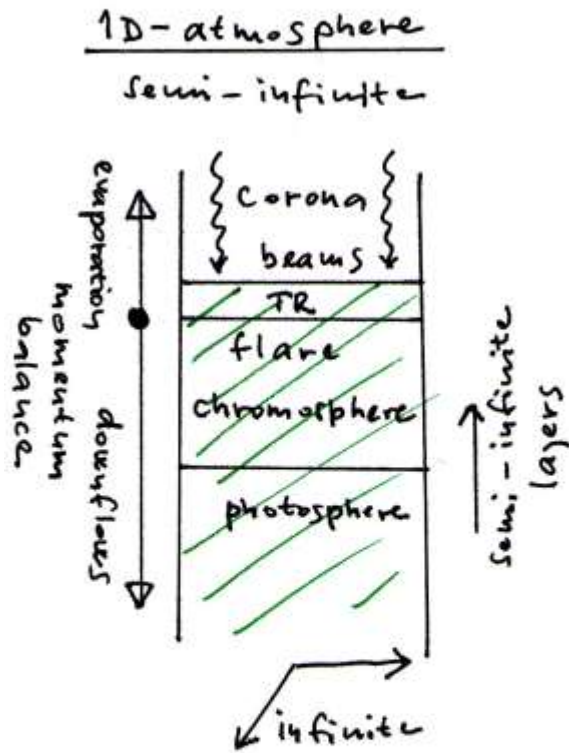
CONTINUUM VISIBLE

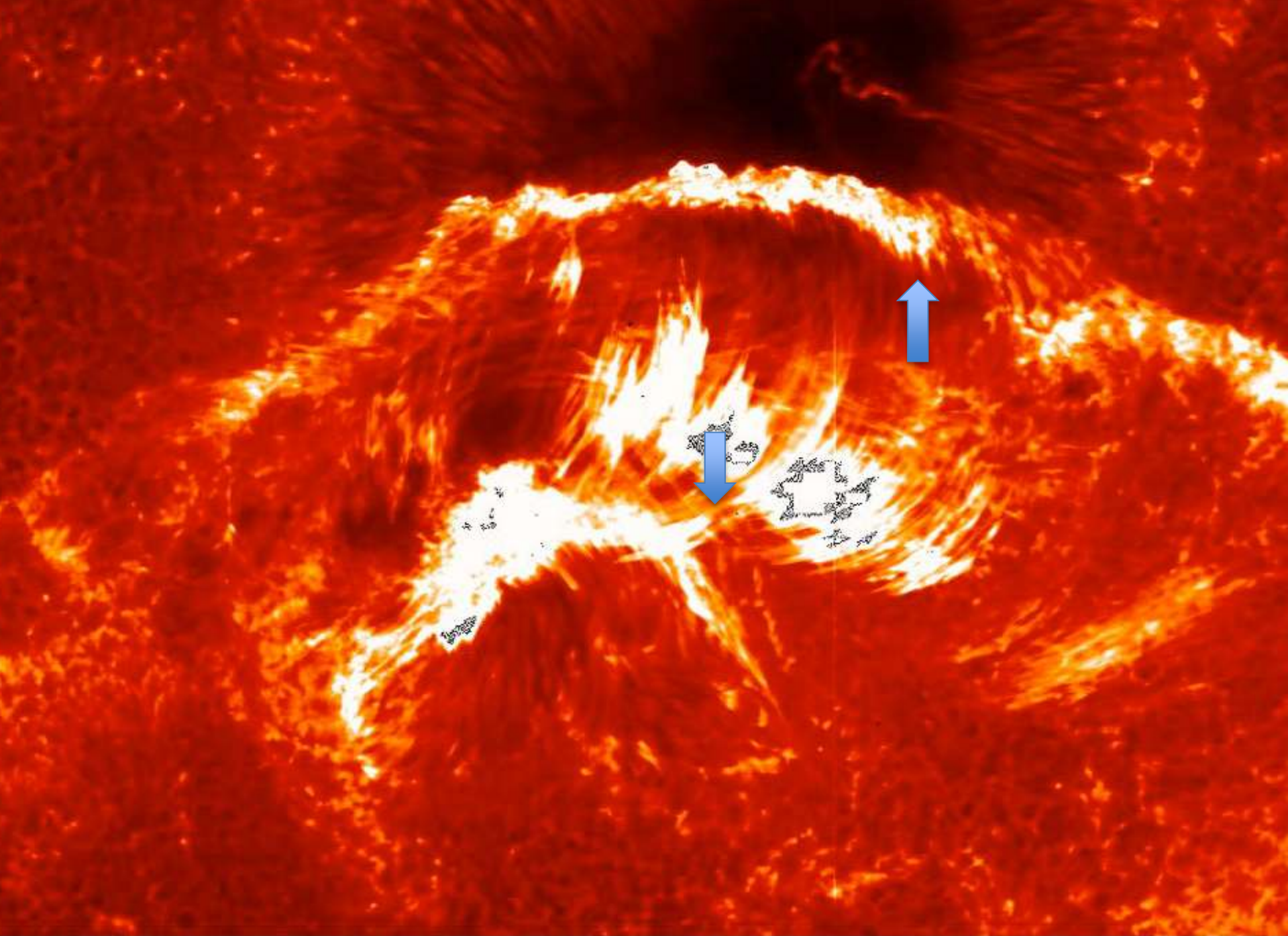


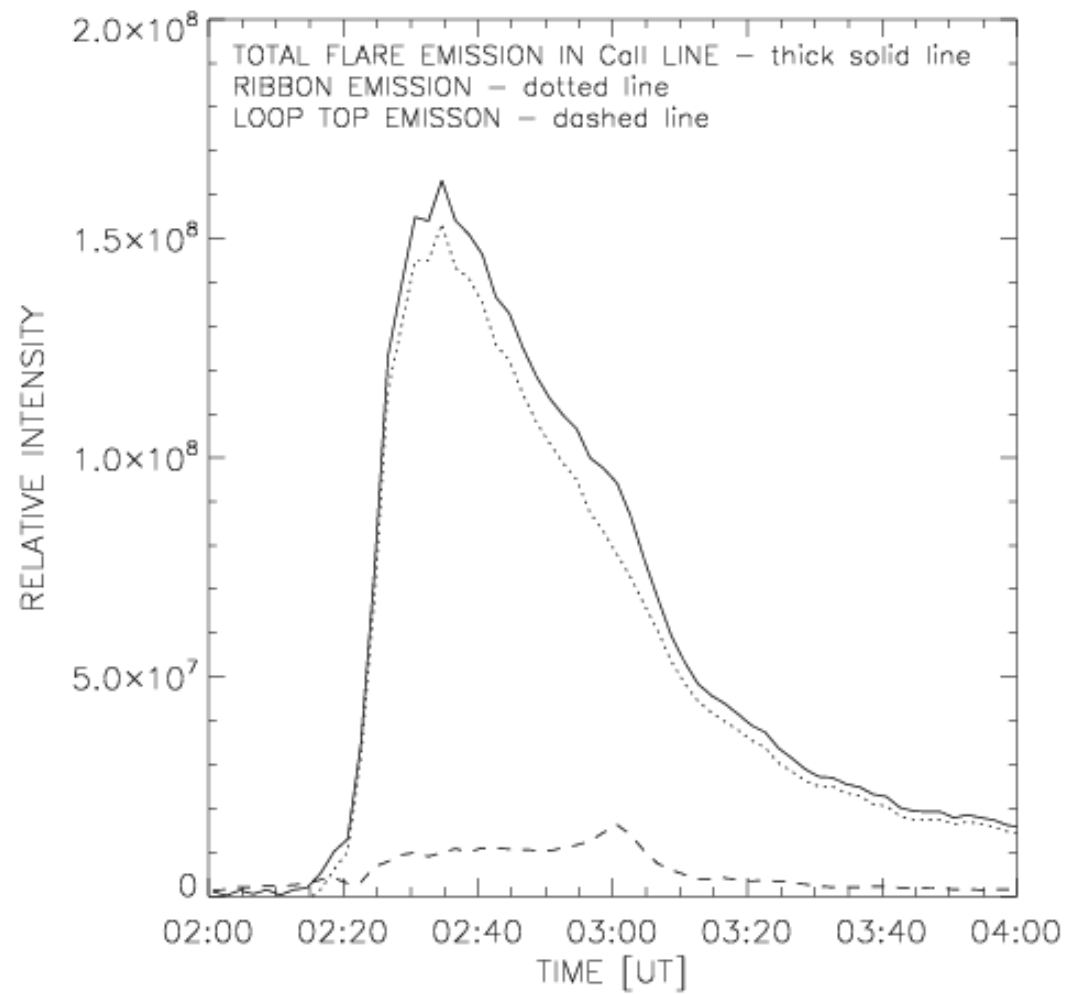
H α loops (Wroclaw observatory)



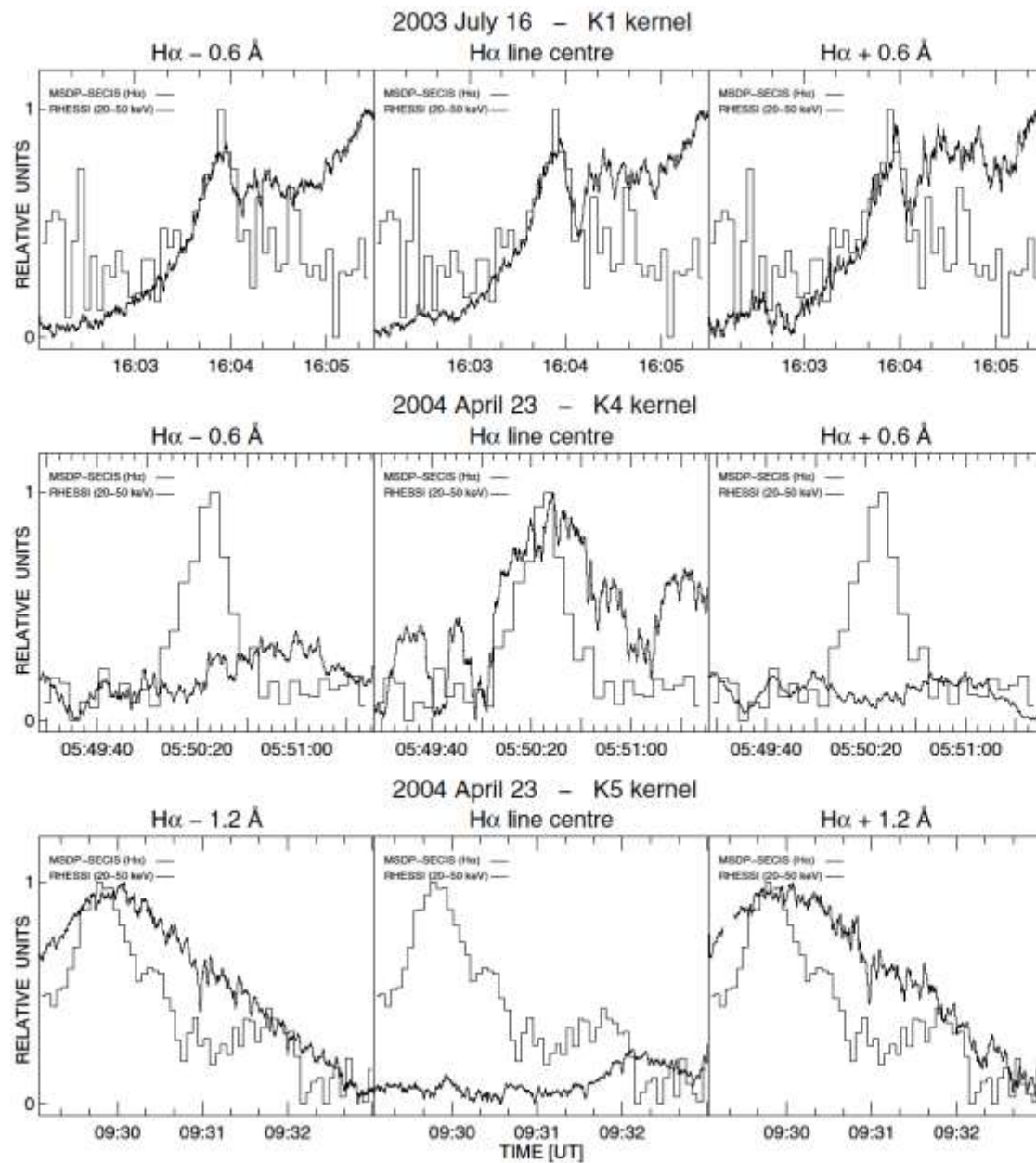
ribbons vs. loops (cool) (cartoon)







Berlicki & Heinzel 2010



Radziszewski et. (2007, 2011)

Set of 1D plane-parallel equations of RHD

The plane-parallel equations of radiation hydrodynamics are the equations of mass conservation,

$$\frac{\partial \rho}{\partial t} + \frac{\partial \rho v}{\partial z} = 0 , \quad (1)$$

momentum conservation,

$$\frac{\partial \rho v}{\partial t} + \frac{\partial \rho v^2}{\partial z} + \frac{\partial}{\partial z} (p + q_v) + \rho g = 0 , \quad (2)$$

and internal energy conservation,

$$\frac{\partial \rho e}{\partial t} + \frac{\partial \rho v e}{\partial z} + (p + q_v) \frac{\partial v}{\partial z} + \frac{\partial}{\partial z} (F_c + F_r) - Q = 0 , \quad (3)$$

along with the level population equation

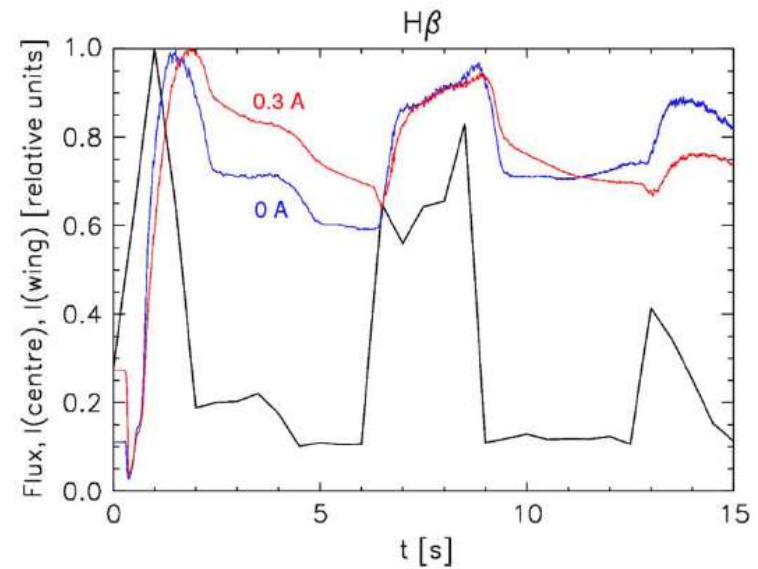
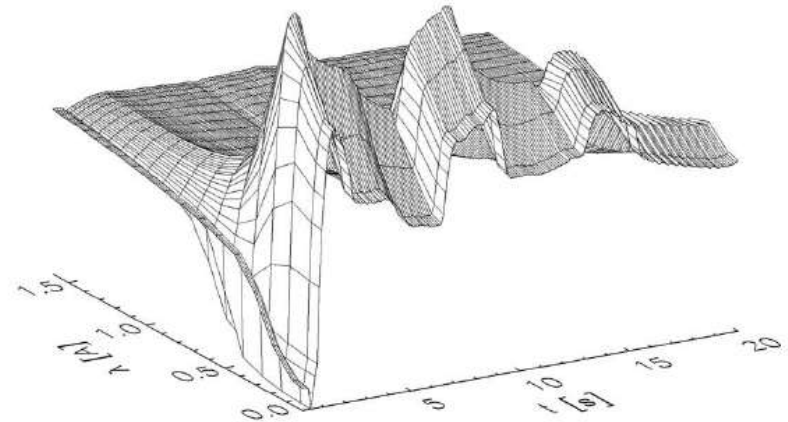
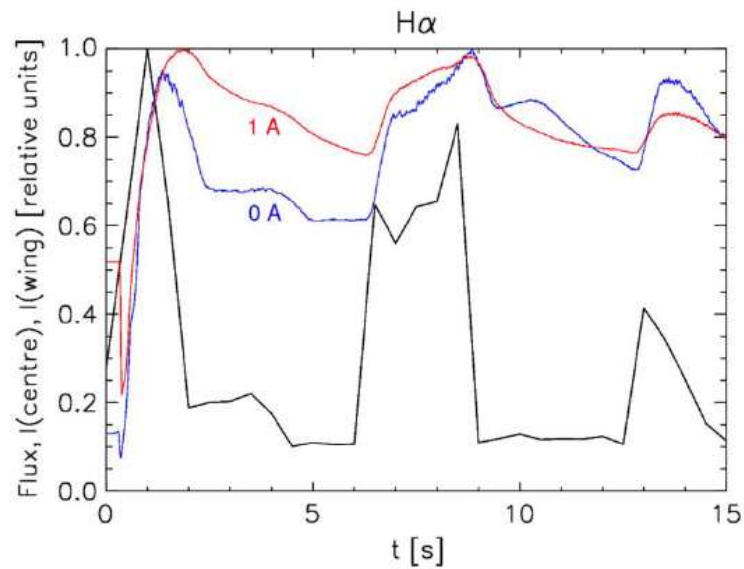
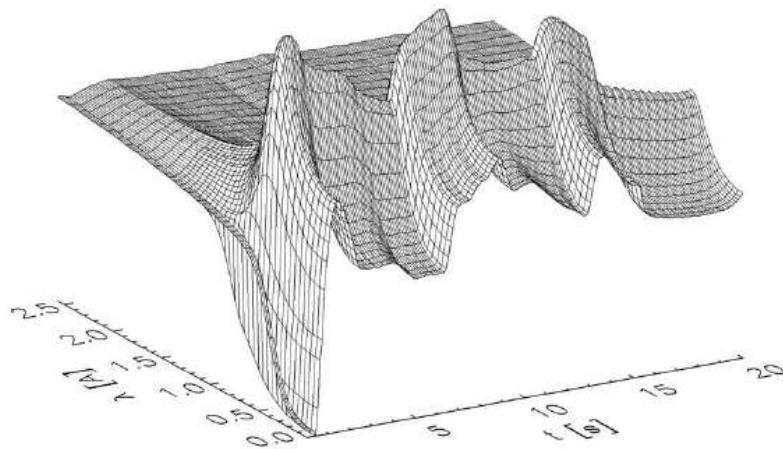
$$\frac{\partial n_i}{\partial t} + \frac{\partial n_i v}{\partial z} - \left(\sum_{j \neq i}^{N'} n_j P_{ji} - n_i \sum_{j \neq i}^{N'} P_{ij} \right) = 0 , \quad (4)$$

and the equation of radiative transfer

$$\mu \frac{\partial I_{\nu\mu}}{\partial z} = \eta_{\nu\mu} - \chi_{\nu\mu} I_{\nu\mu} . \quad (5)$$

- **RHD codes:**
- **RADYN (Oslo, UW)**
- **HYBRID (Ondrejov)**

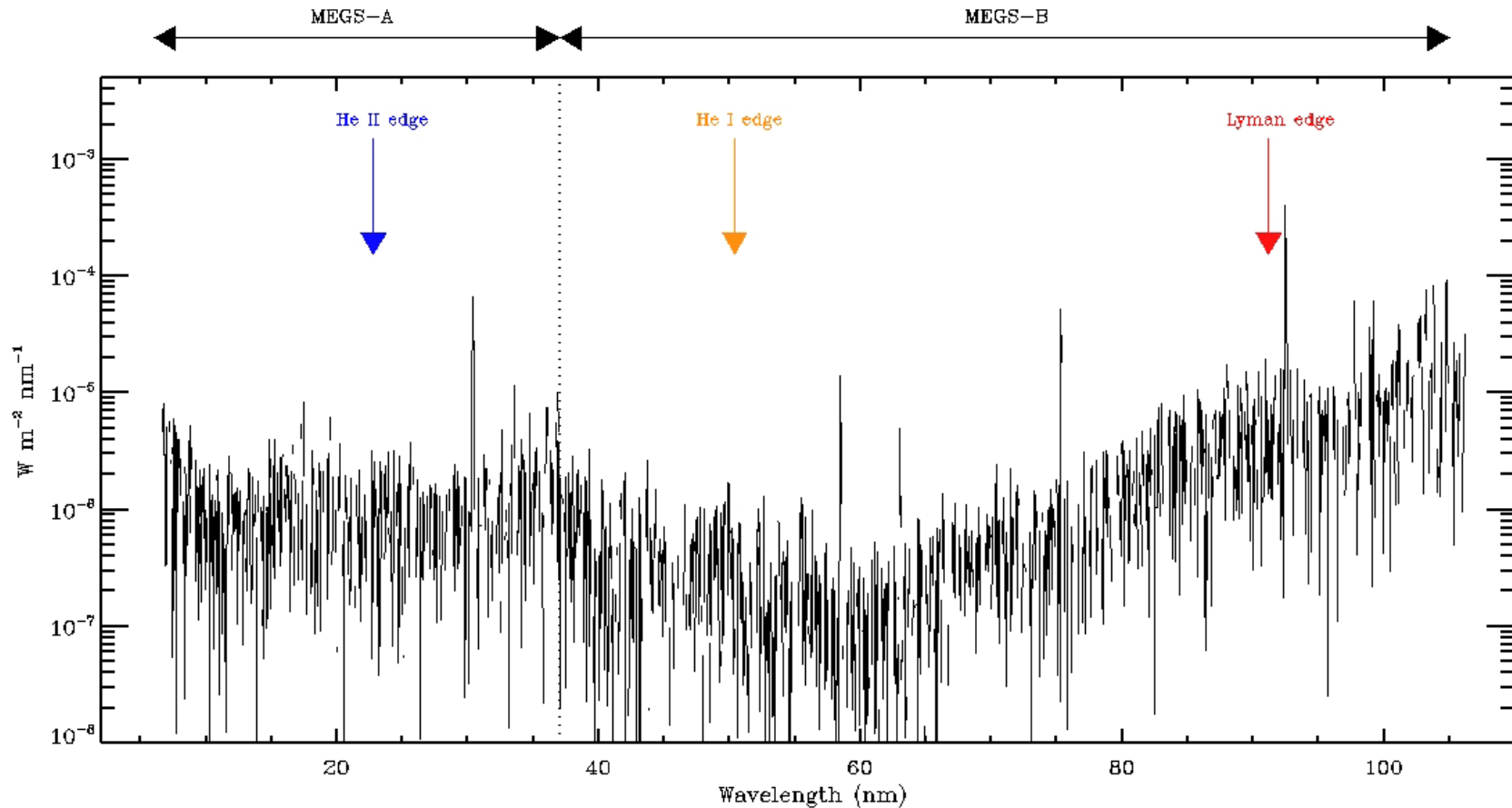
Simulations with the HYBRID code



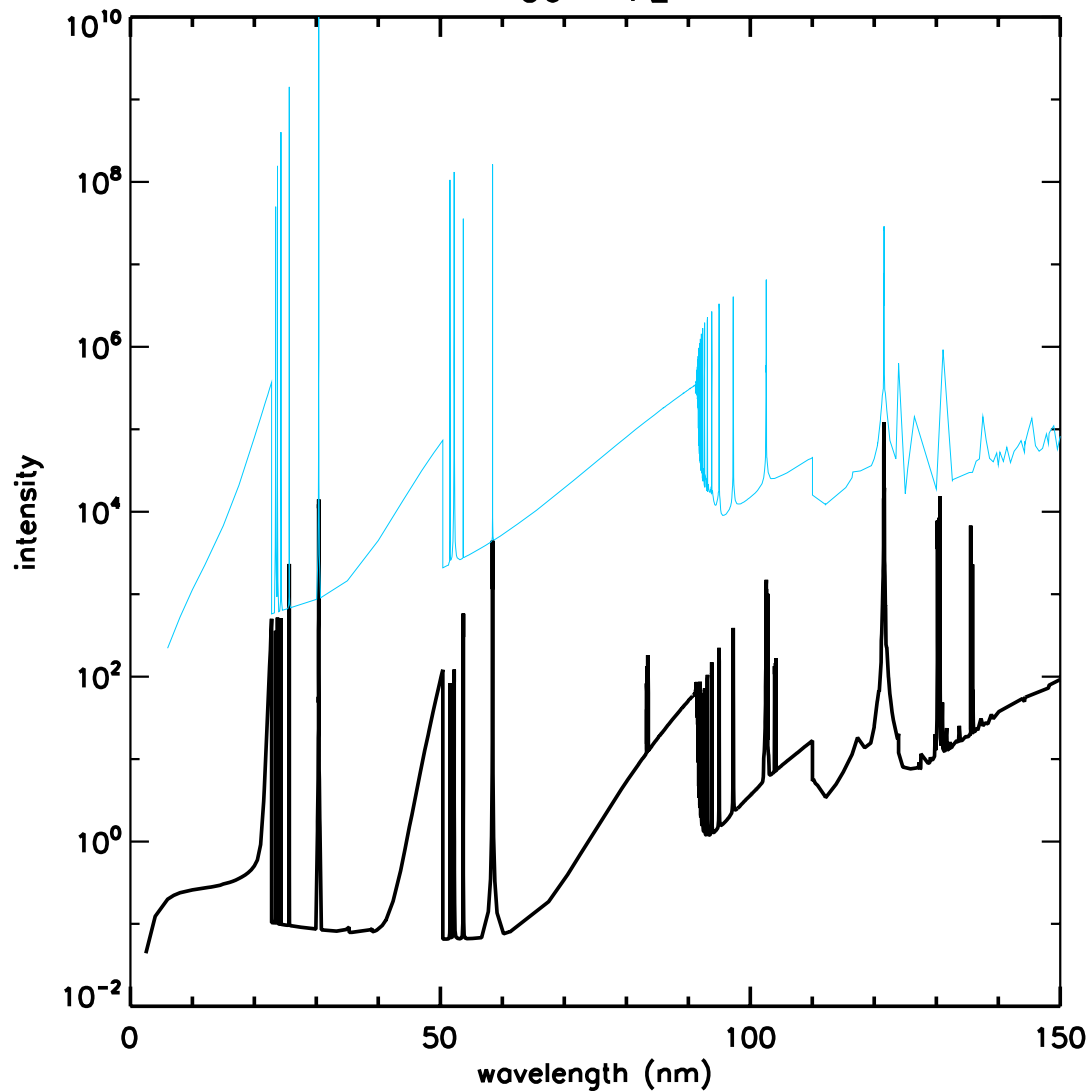
Varady et al. (2010)

SDO/EVE: total solar irradiance (Sun-as-a-star)

15 Feb 2011 X-class flare (difference spectrum)

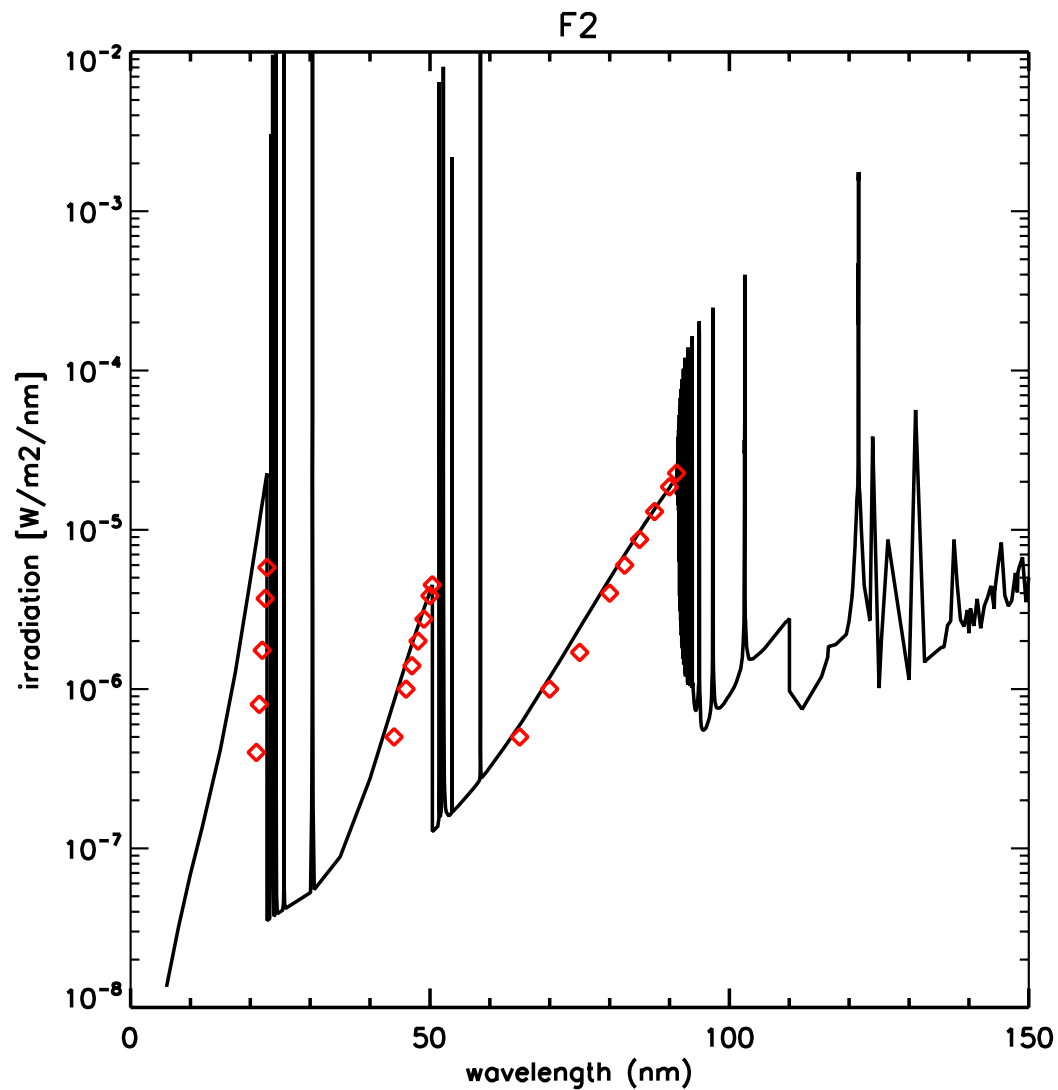


C6 – F2



C6 – quiet-Sun model of Avrett and Loeser (2008)

F2 – flare model of Machado et al. (1980)

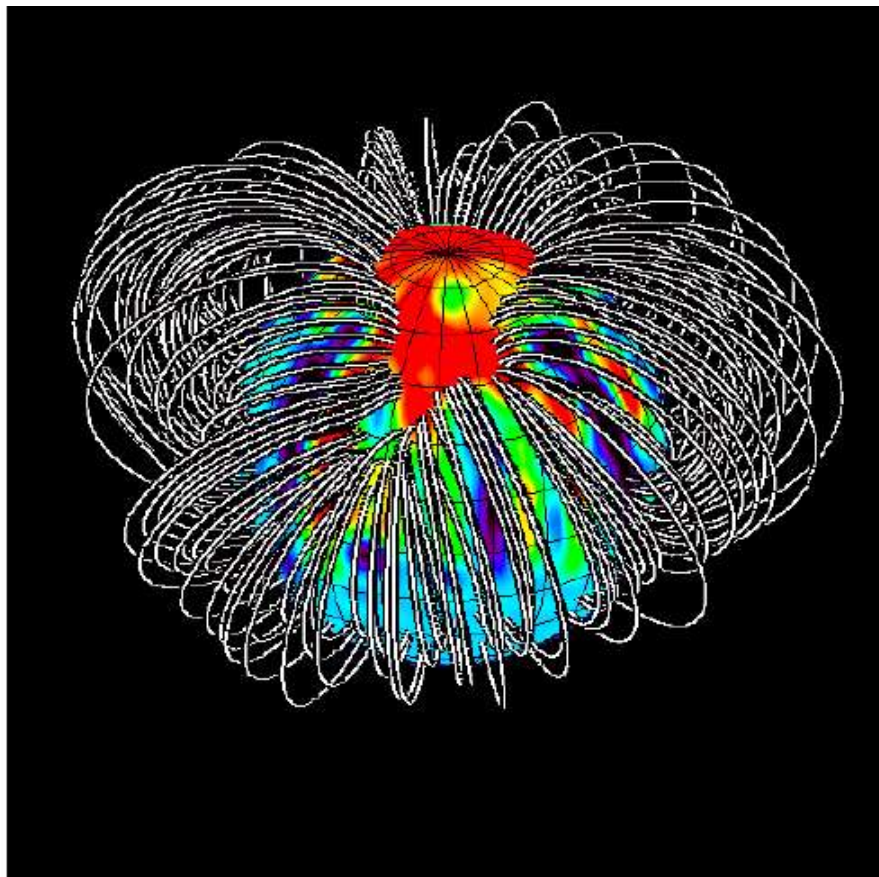
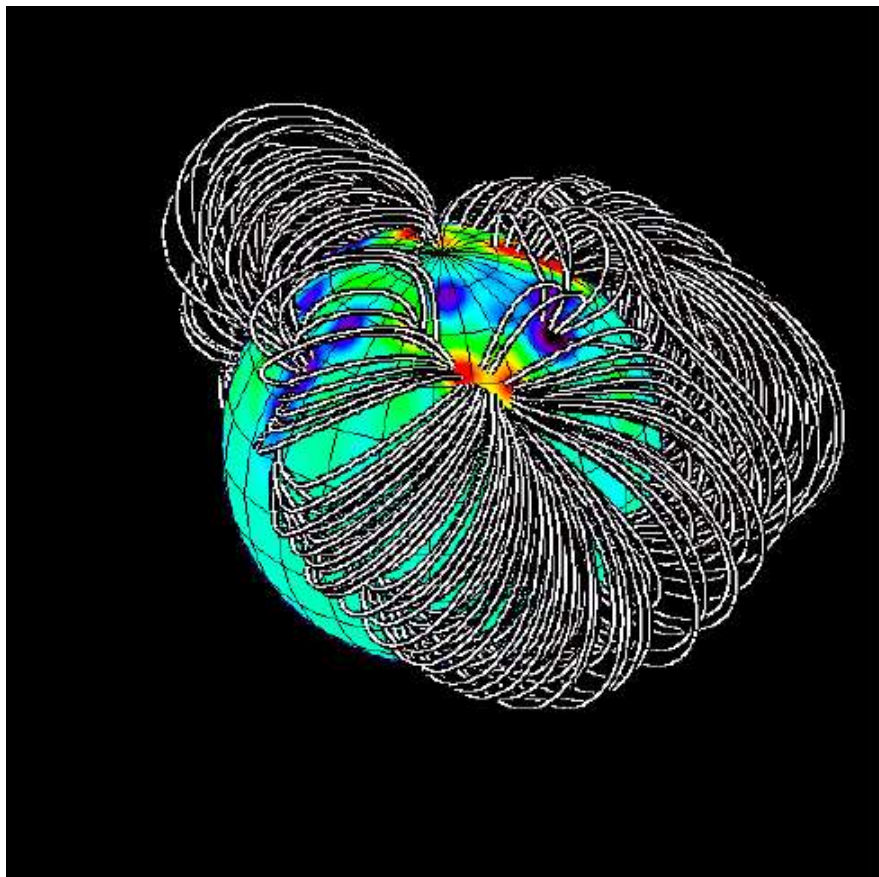


Irradiance difference:

FLARE – pre-FLARE spectrum
(diamonds)

Milligan et al. (2012)

The actual flare area is not known from EVE observations, therefore we fit the irradiance at 50.4 nm where the observations show a clean and less time-dependent spectrum



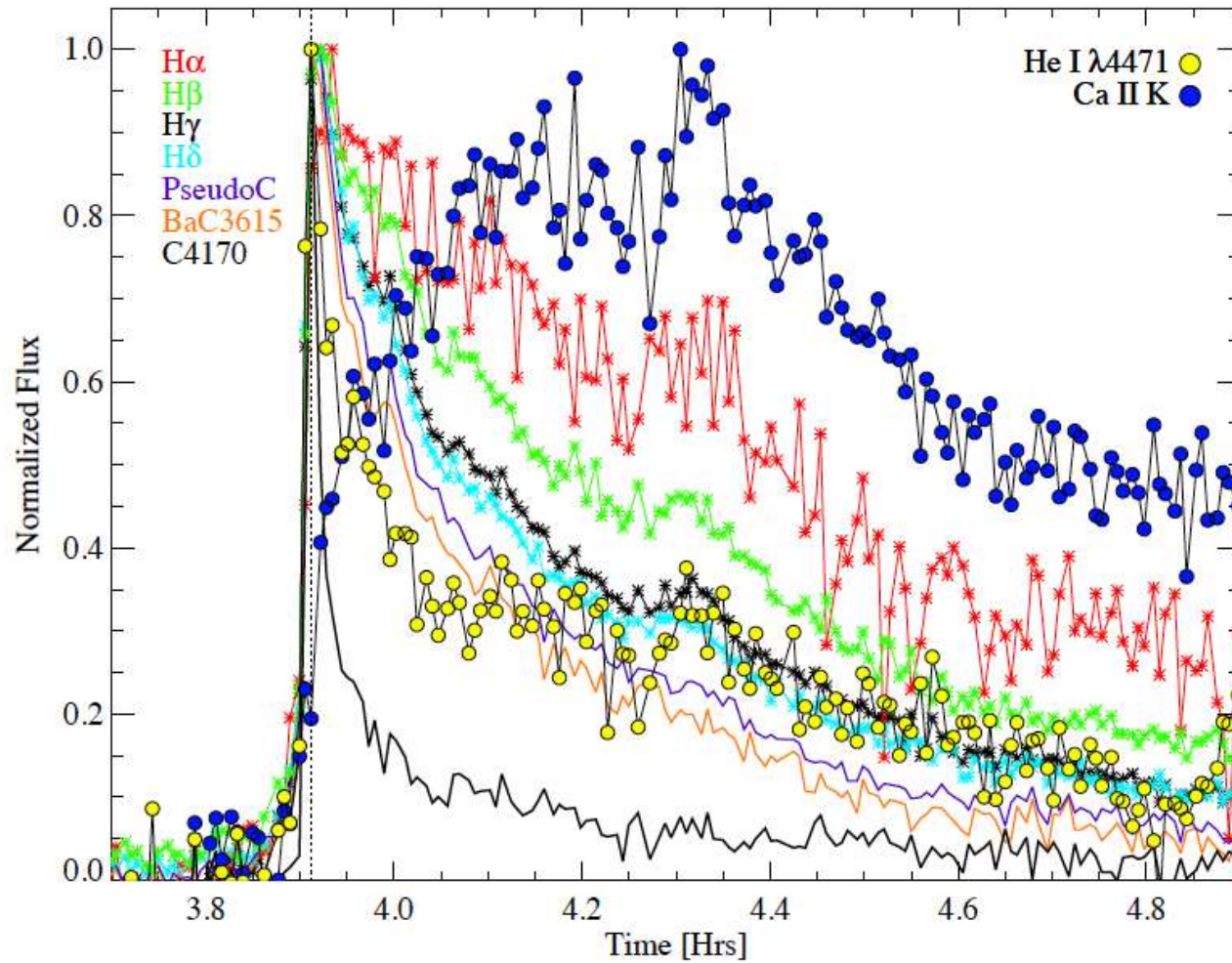
dMe flare stars

Name	Spectral type	Position (ep=J2000)	Fluxes (mag)
EV Lac	M4.5Ve	Ra = 22 46 49.7317 Dec = +44 20 02.3569	U = 13,000 B = 11,450 V = 10,090
YZ CMi	M4.5Ve	Ra = 07 44 40.17401 Dec = +03 33 08.8350	U = 13,761 B = 12,831 V = 11,225
AD Leo	M4.5Ve	Ra = 10 19 36.277 Dec = +19 52 12.06	U = 12,000 B = 10,970 V = 9,430
V711 Tau		Ra = 03 36 47,3 Dec = +00 35 15,9	B = 6,800 V = 5,905
V773 Tau (HD 283447)		Ra = 04 14 12.92168 Dec = +28 12 12.2960	U = 13,160 B = 11,800 V = 10,700

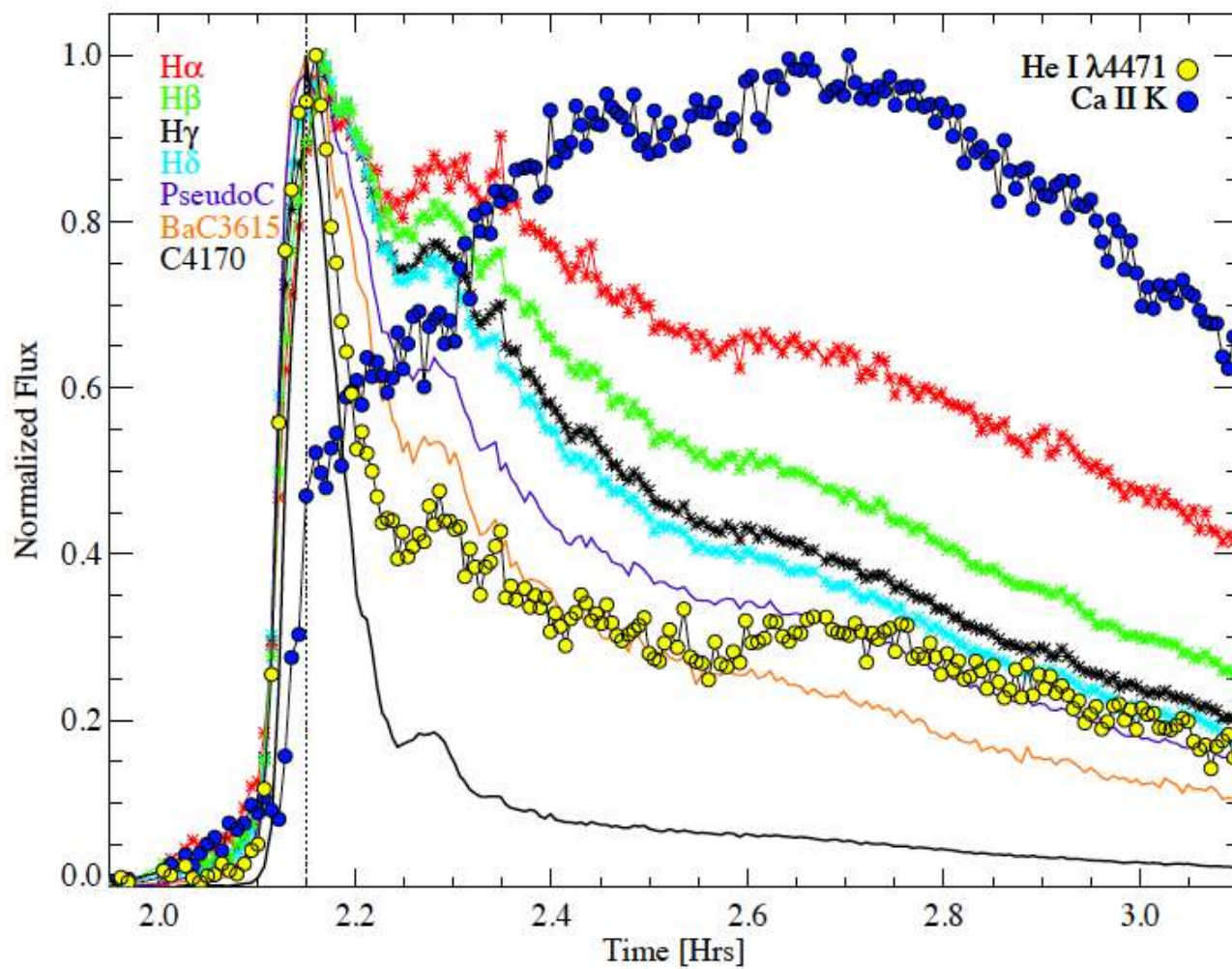
APO – 3.5m telescope

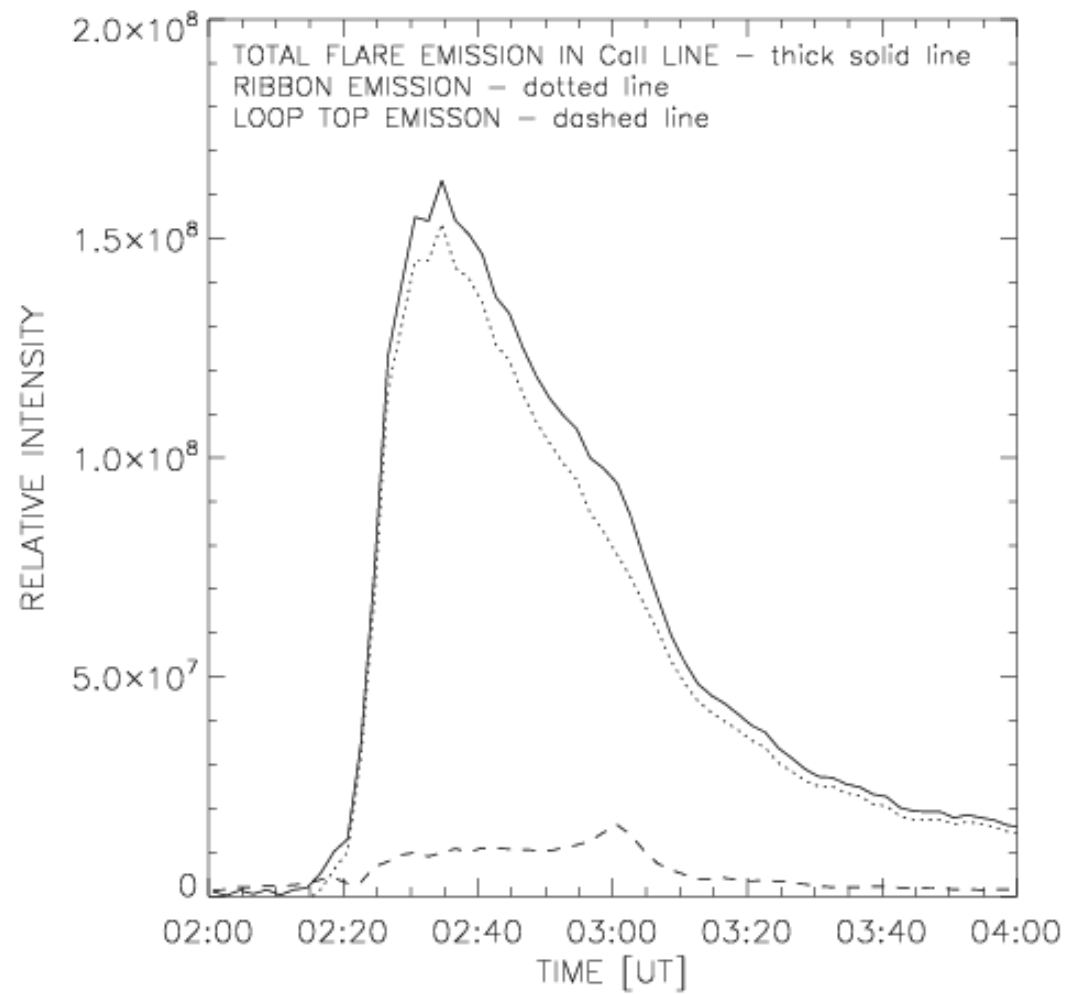


AD Leo



YZ CMi





Berlicki & Heinzel 2010

Ondřejov Observatory 2-m Telescope

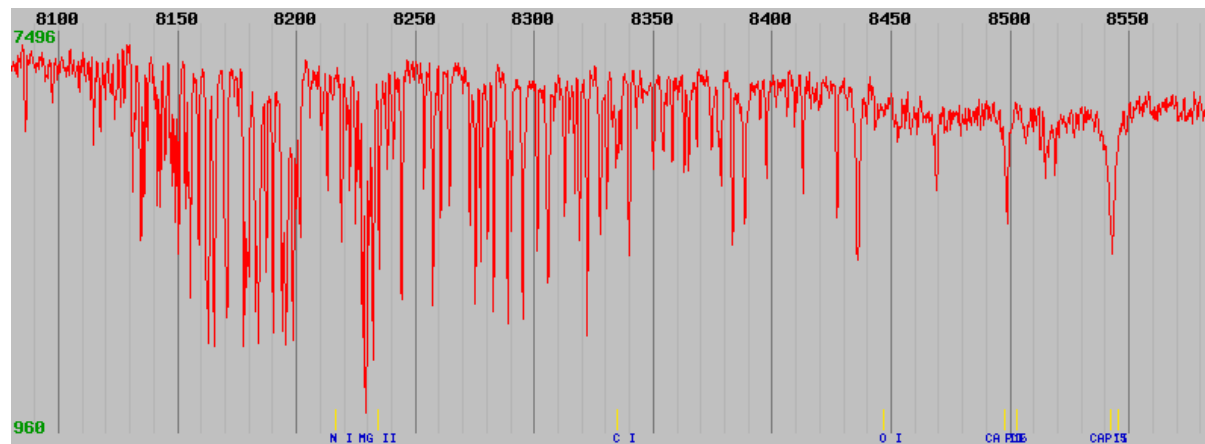
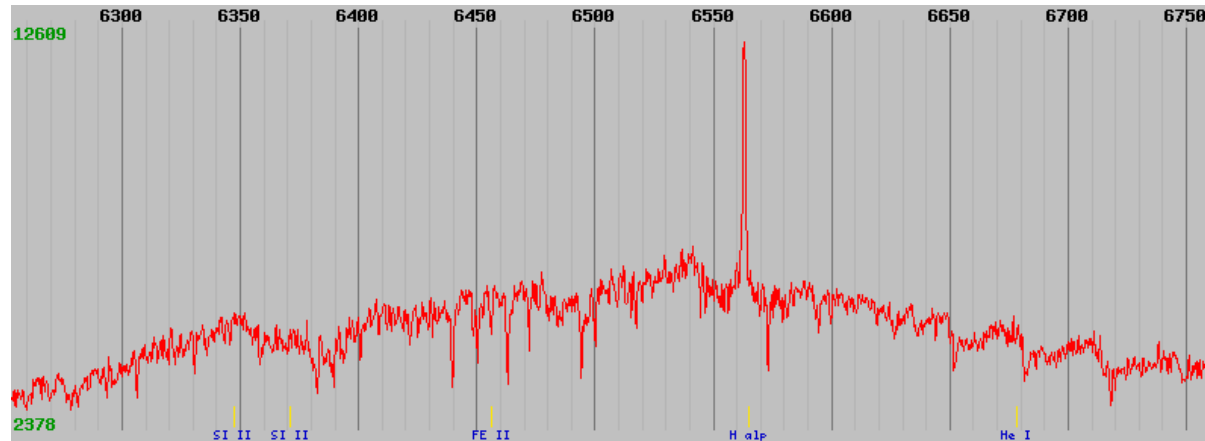
- The 2-meter telescope is in operation since 1967.
- Two cameras:
 - 400 mm (low dispersion)
 - 700 mm (medium dispersion)
- Spectral region 4000Å - 7000Å
- Telescope parameters:

Primary mirror:	Diameter:	2m
Focal length:	Primary:	9m
	Cassegrain:	29.16m
	coudé:	63.5m
Mounting:	Equatorial	

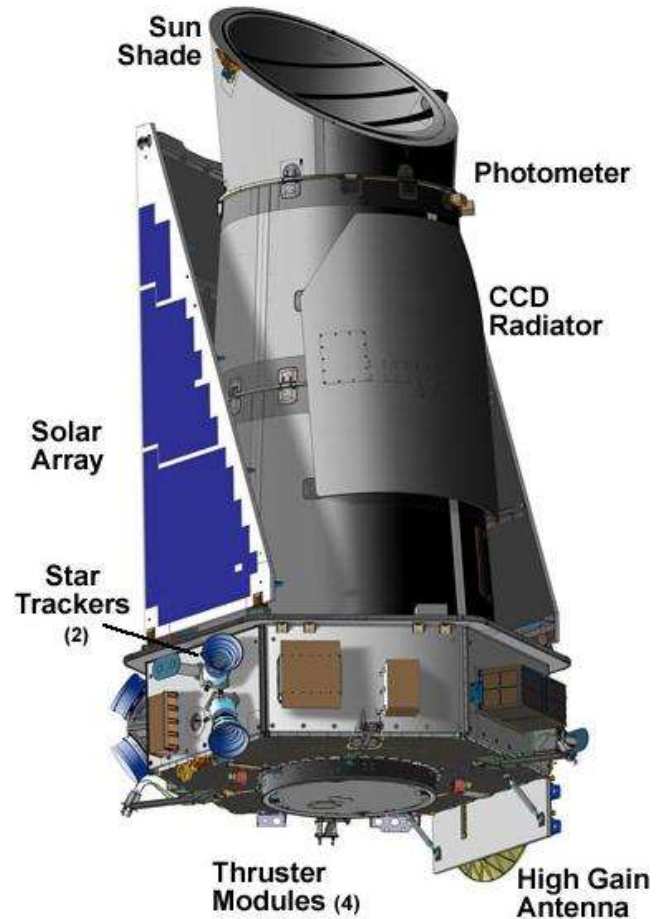


Quiescent spectra of V1054 Oph

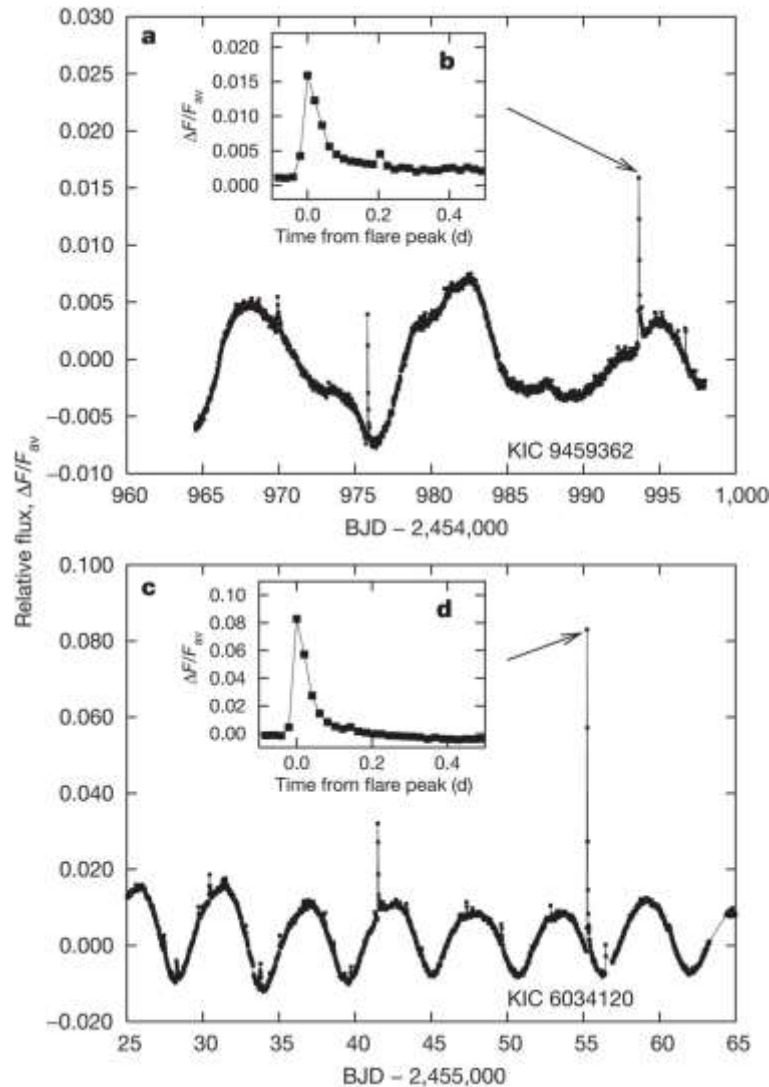
Ondrejov 2m telescope

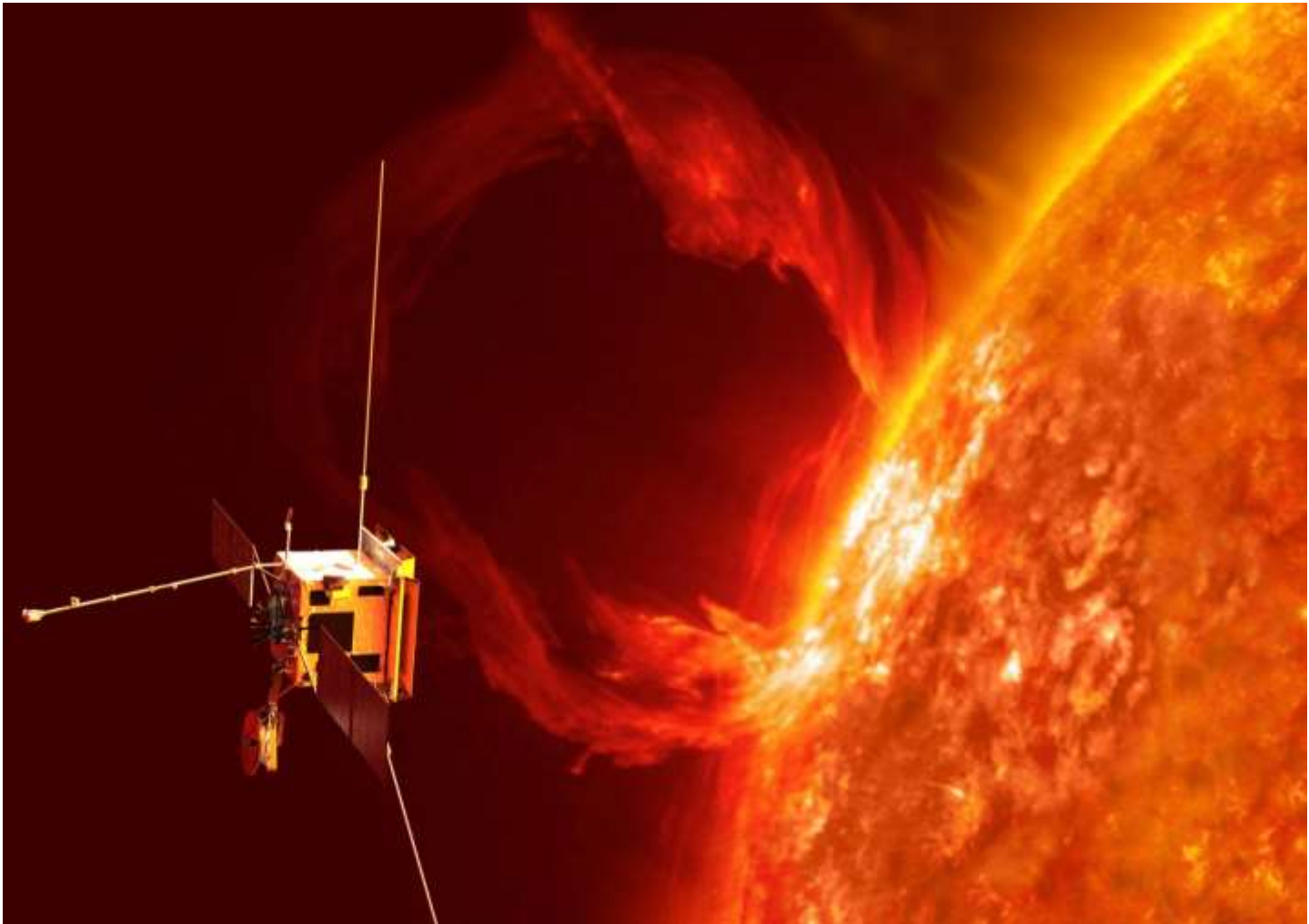


NASA Kepler Mission

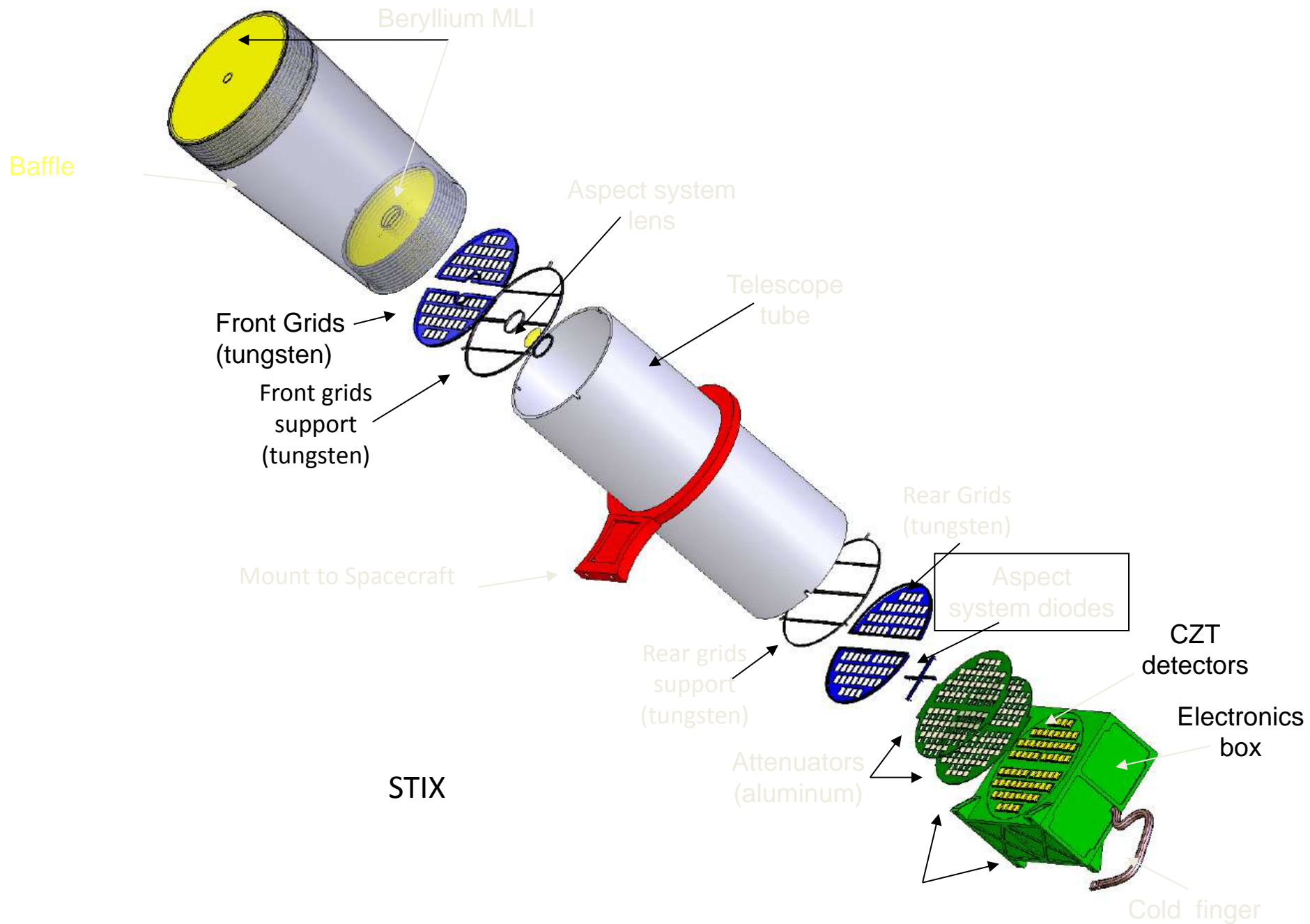


Kepler discovery of super flares on solar-type stars





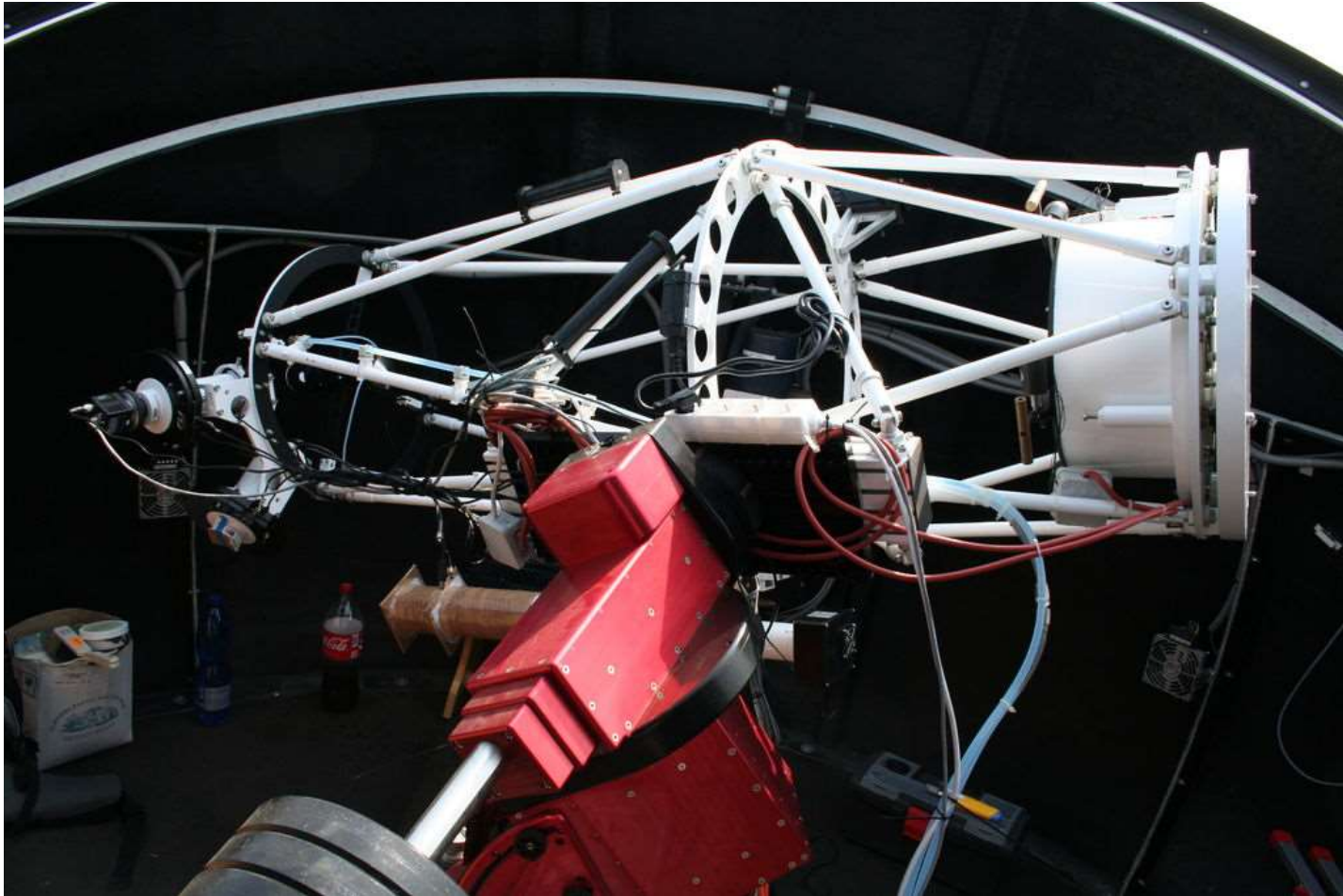
Solar Orbiter ve vzdálenosti 0.27 AU



Ondřejov-Pecný



SORT





GREGOR - Tenerife







Solar & Stellar Flares:

Observations, simulations & synergies

**Conference in honor of
Zdenek Svestka**

23 – 27 June 2014, Prague

SOC

**B. Dennis, L. van Driel, F. Farnik, L. Fletcher (Co-Chair), S. Hawley,
P. Heinzel (Co-Chair), H. Hudson, M. Karlicky, E. Priest, K. Shibata,
J. Sylwester, A. Veronig**