On the Measurement of Spectral Continua Flux in Solar Flares

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OUTLINE:

Introduction
White light flares, Balmer/blue continuum
Stellar and solar B.c.flare observations
A new device for B.c. flux measurements
First B.c. observation of flares in 2014
Preliminary results
Prospects

White-light flares (WLFs) / solar

The Carrington flare on Sept. 1, 1859 = WLF

WLF - the most energetic flaring events observable in the optical broad-band continuum of the solar spectrum (Wang, 2008)

Very small white-light kernels <3" (Neidig, 1989)

Role of atmospheric seeing in difficulties of detection of WLFs using ground-based telescope (Hiei, 1982)

WLFs are associated with more energetic EUV and SXT flares (Neidig and Cliver, 1983)

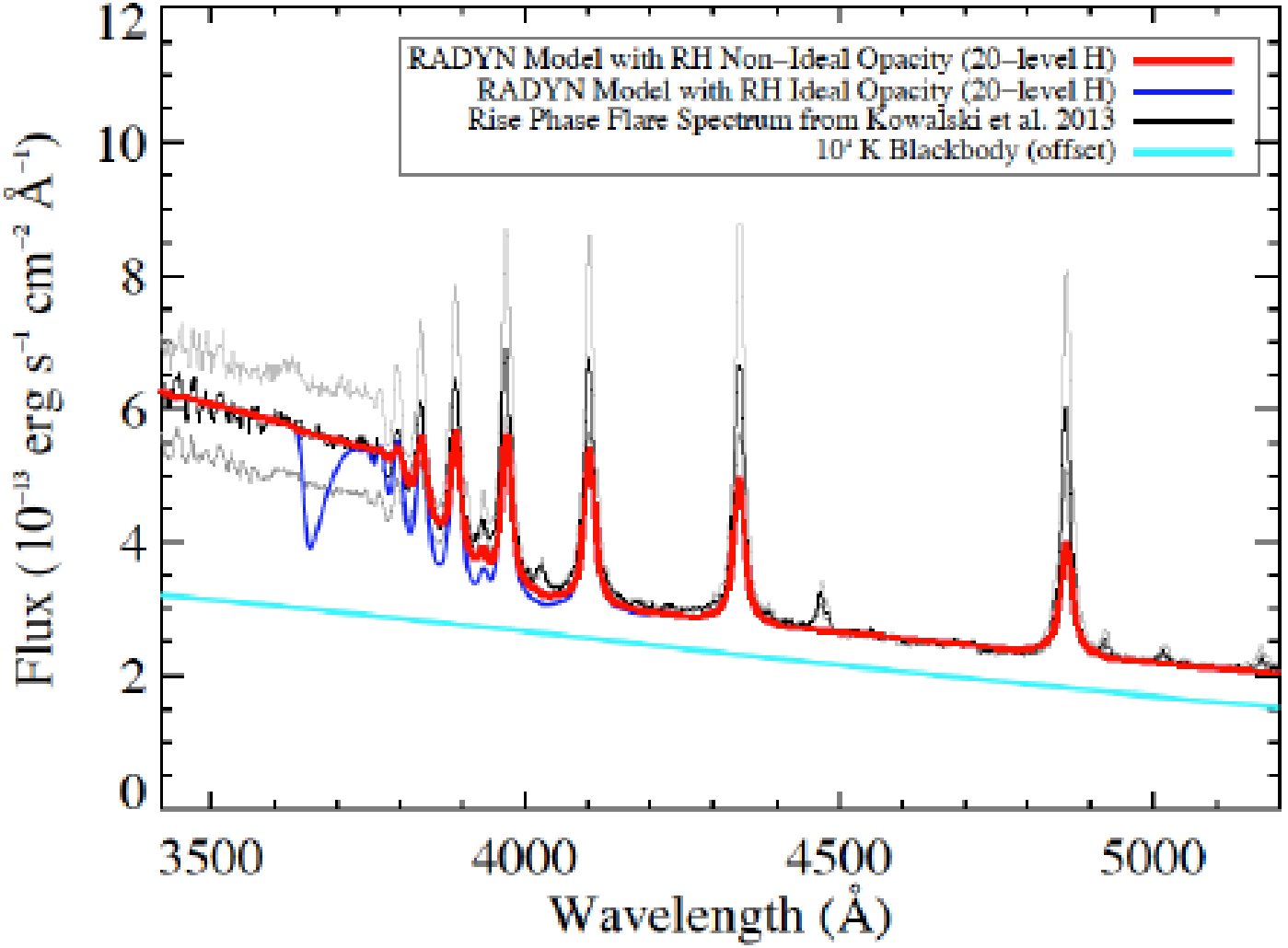
WLF mechanisms: (electron beams <20keV, Metcalf et al. 2003? or a back-warming effect in the energy transport from upper chromosphere – to photosphere? (Machado et al. 1989)

Ding, 2007, 2 classes of WLF, I-photospheric H^- temp. increase, II - chromospheric H recombination

White-light flares (WLFs) / stellar

- White-light flares observed on late types of stars, namely dwarfs type M with emission lines, dMe
- The WL enhancement ends when the impulsive stage of the flare has ceased (Bopp & Moffett,1973), while
- a gradual decay in continuum emission, even after the end of the impulsive phase was found by Hawley & Pettersen (1991)
- A new measurement of Kowalski et al 2013 reported an increase of Balmer continuum in dMe stars.

WLF at dMe star by Kowalski et al.

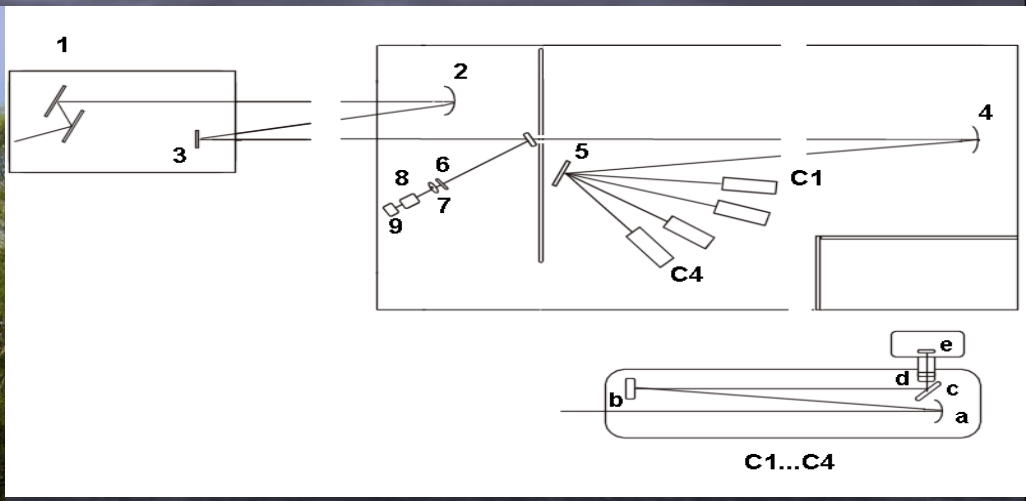


Raised questions (and problems)

- How to measure blue/Balmer continua flux in solar flares?
- How to increase contrast in flare against the disk?
- Either to use filtergrams or spectral measurements?
- Which device is the best tool for observations of blue continuum?
- What method is more perspective/efficient?
- How to study changes in various parts of blue continuum ?
- How to observe flares at b.c. and in Hα simultaneously?
- Can we detect real changes of blue continuum flux in real time?
- What is time correlation of b. c. with Hα, SXT, EUV, … ?
- Are we able to suggest a simple non expensive device for that task?

Ondřejov large horizontal telescope

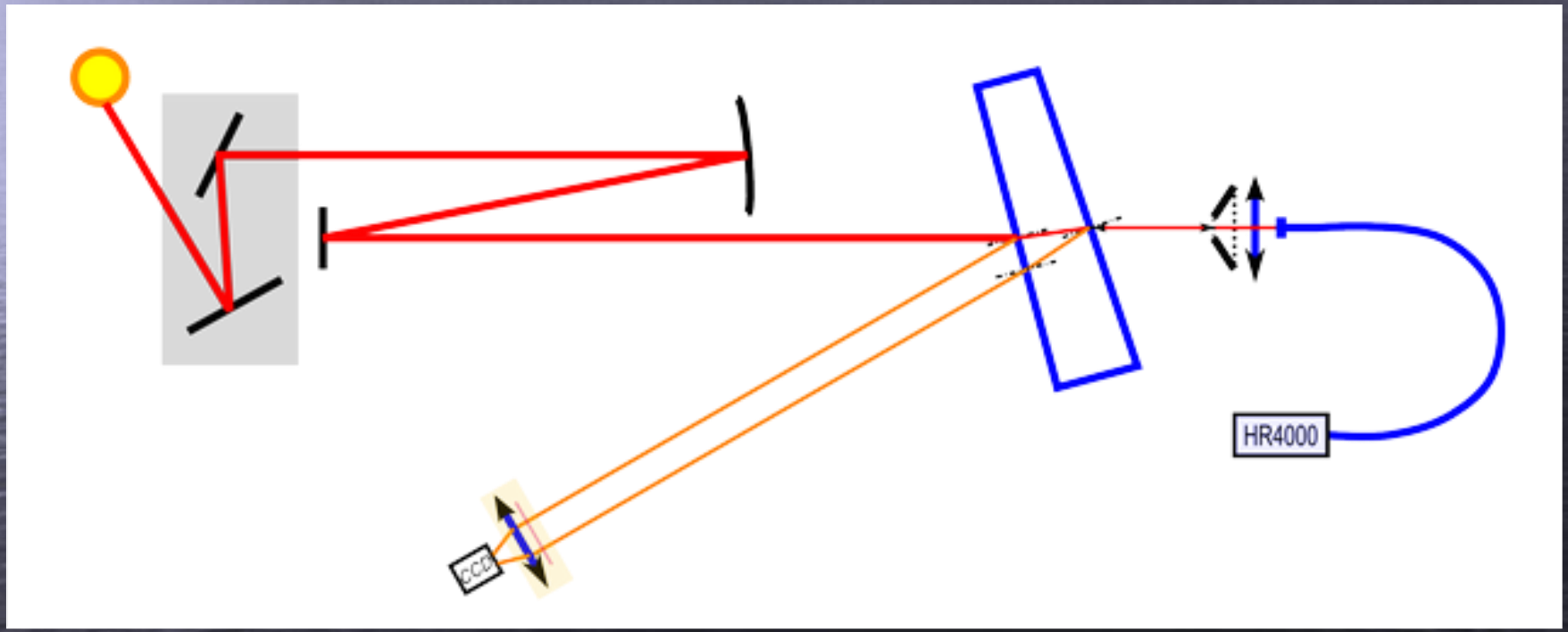
Jensch type coelostat 4 – 6 m above ground, sliding shelter, Φ of mirrors 60 cm, M1 Φ 50 cm, f 35 m.



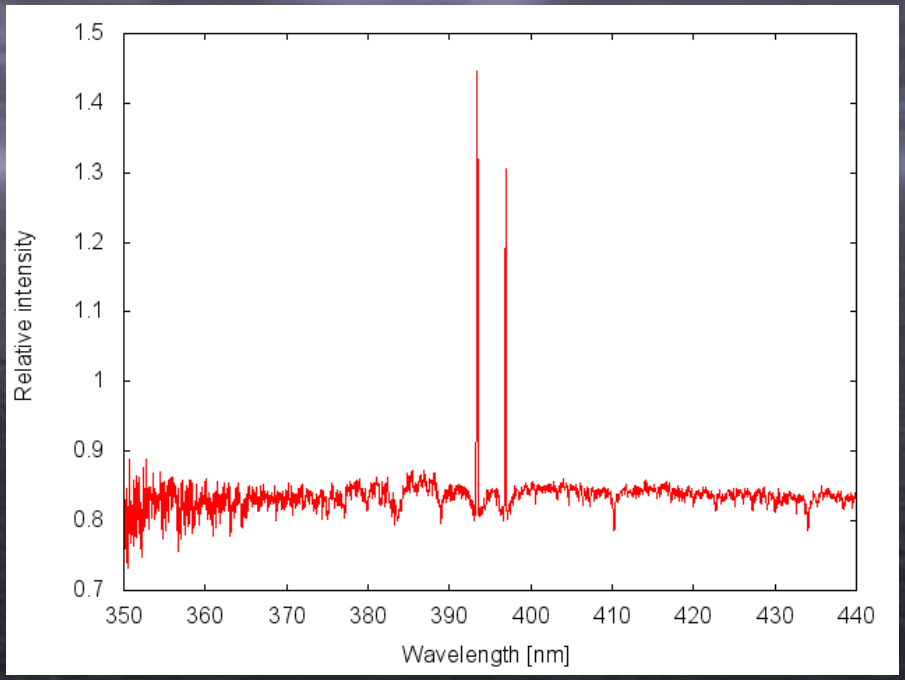
1 – Jensch coelostat, 2 – main objective, 3 – flat mirror, 4 – collimator, 5 – grating, 6 – thermal filter, 7 – slit-jaw objective, 8 – Hα filter, 9 – CCD camera

Only the telescope was used,
A new post-focus device installed

Optical schema of the device



Spectrometer

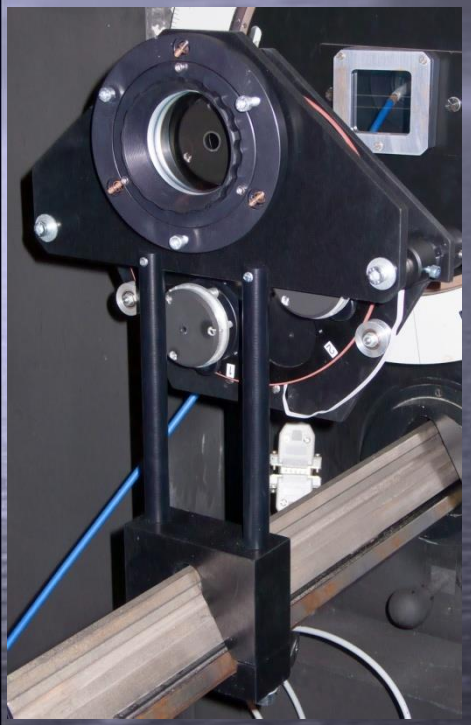


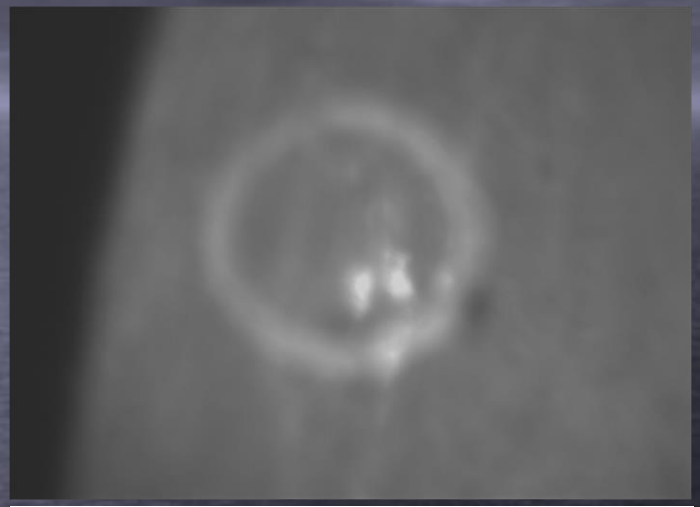
The HR4000 Spectrometer with a 3648-element CCD-array detector Toshiba enables optical resolution of 0.03 nm (FWHM).
Generally it can be responsive from 200-1100 nm, but the specific range and resolution depends on the grating and entrance slit choices.
We selected 350 – 430 nm device (grating 1800 gr./mm) as a first step.

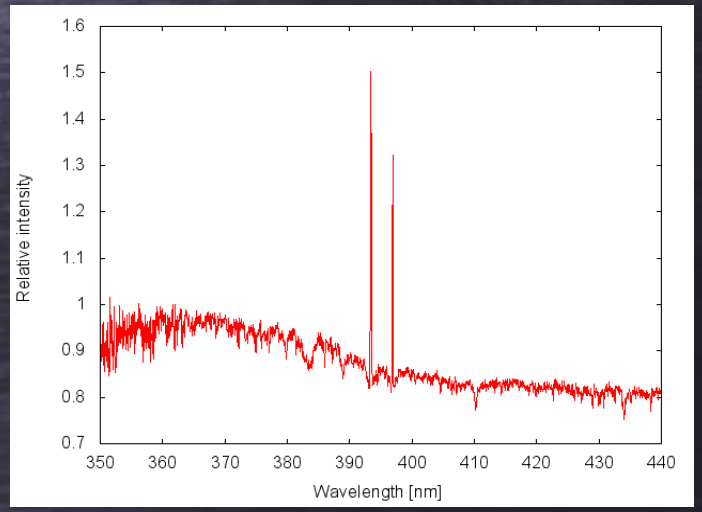
Boris Valníček's Solar Laboratory

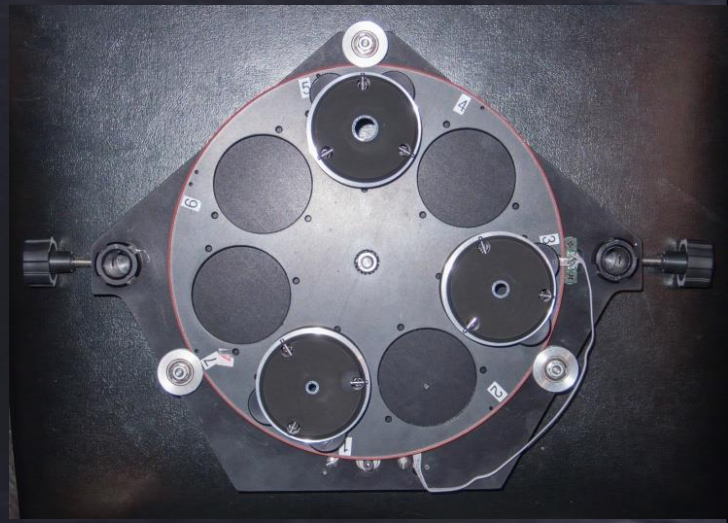
Horizontal solar telescope from 1950', main objective 1350/23 cm, (a precise guiding with x,y coordinates detection, spectra and filtegrams stored in fits files is under finishing in a few weeks)

Image selector

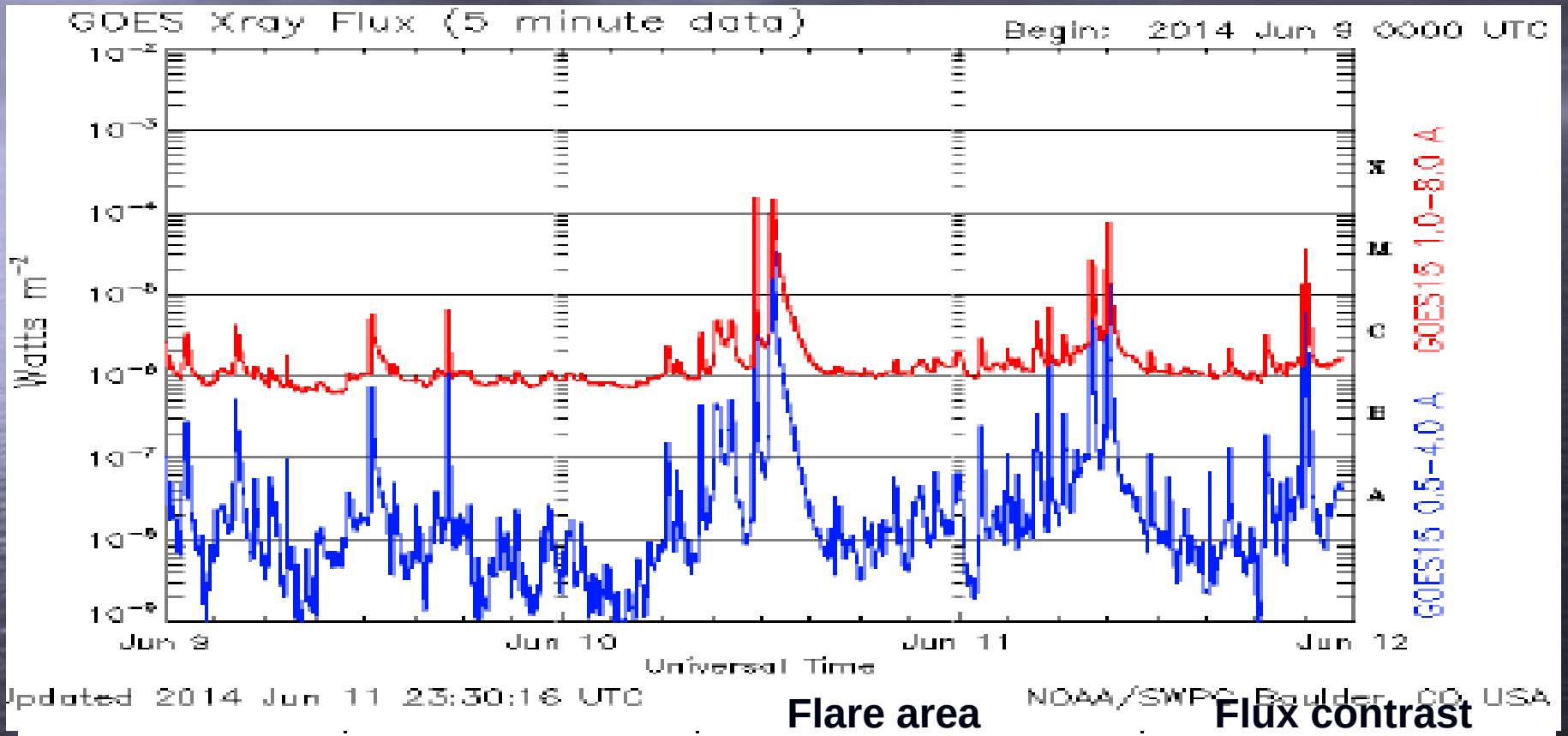






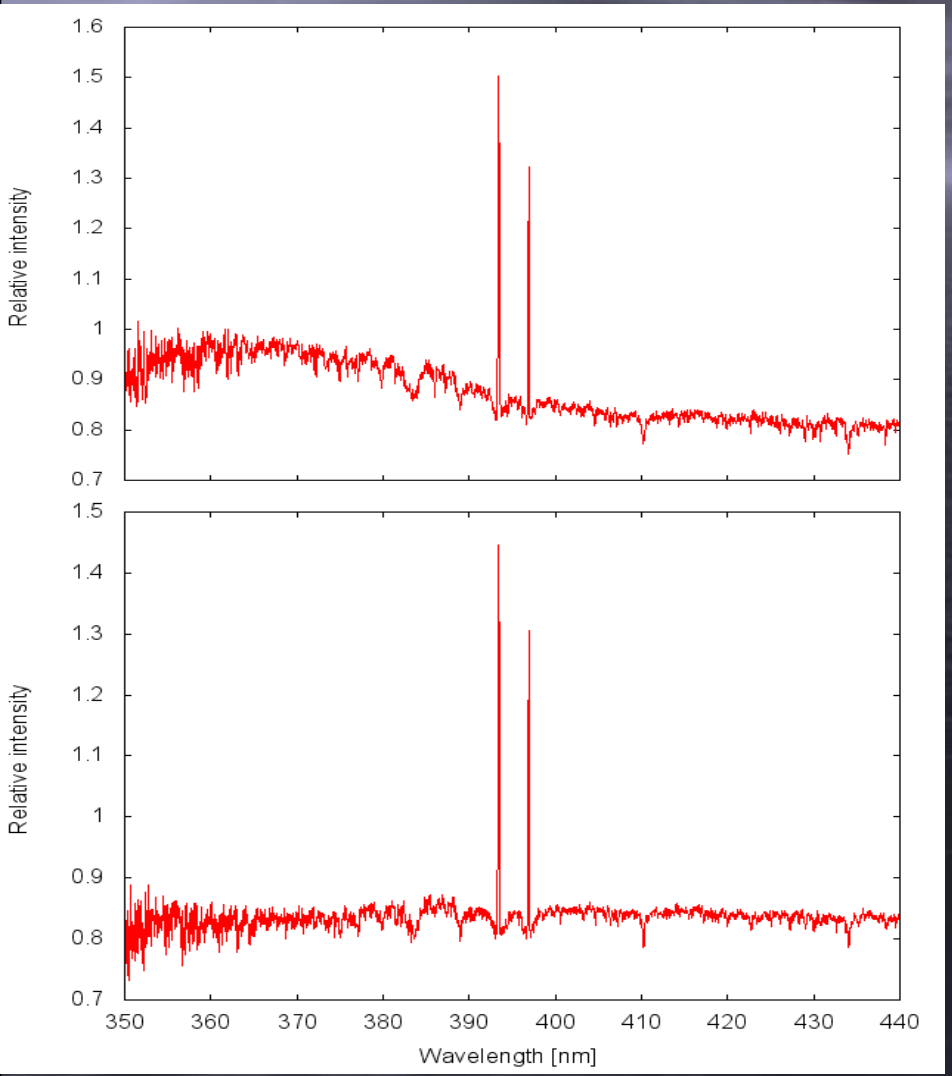


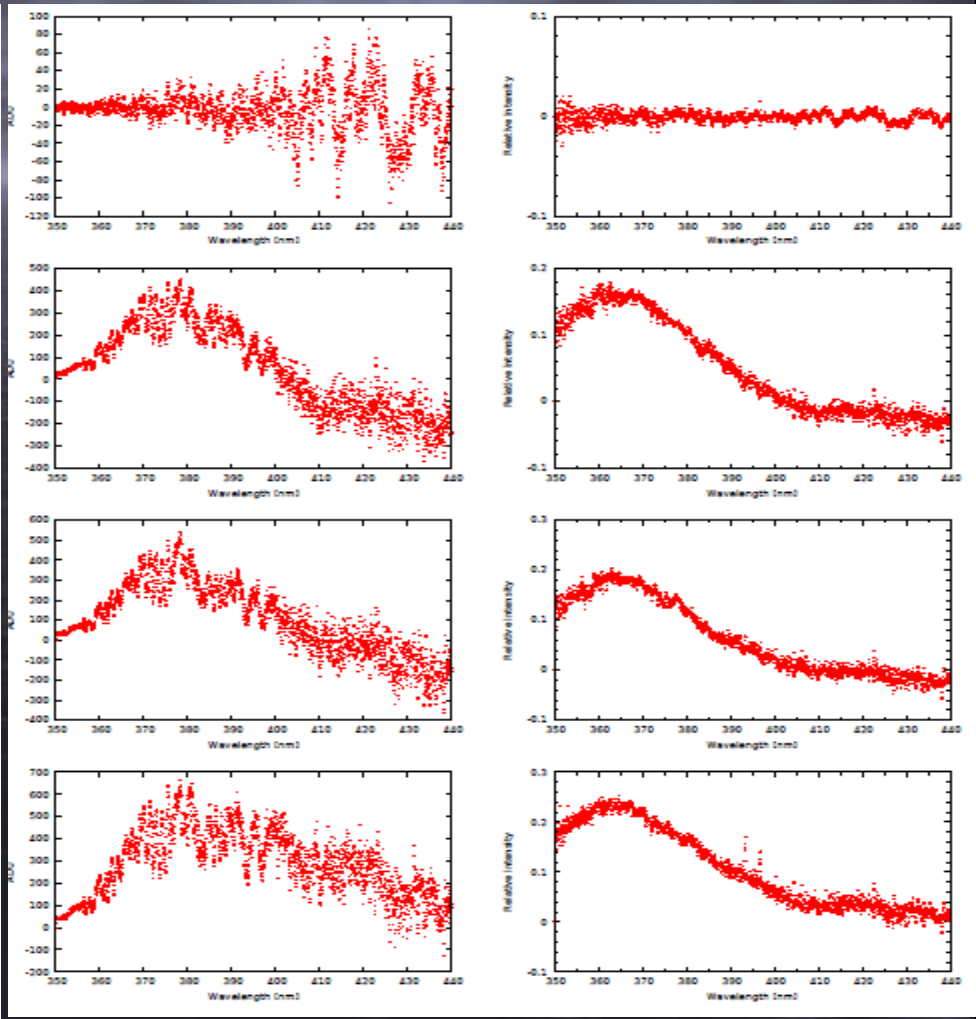
Measured flares in June 2014



		Flare area	Flux contrast
X2.2	10.6. 11:42 UT	2.86 %	16 %
X1.5	10.6. 12:52 UT	8.46 %	13 %
X1.0	11.6. 9:04 UT	3.8 - 7.4 %	17 - 21 %

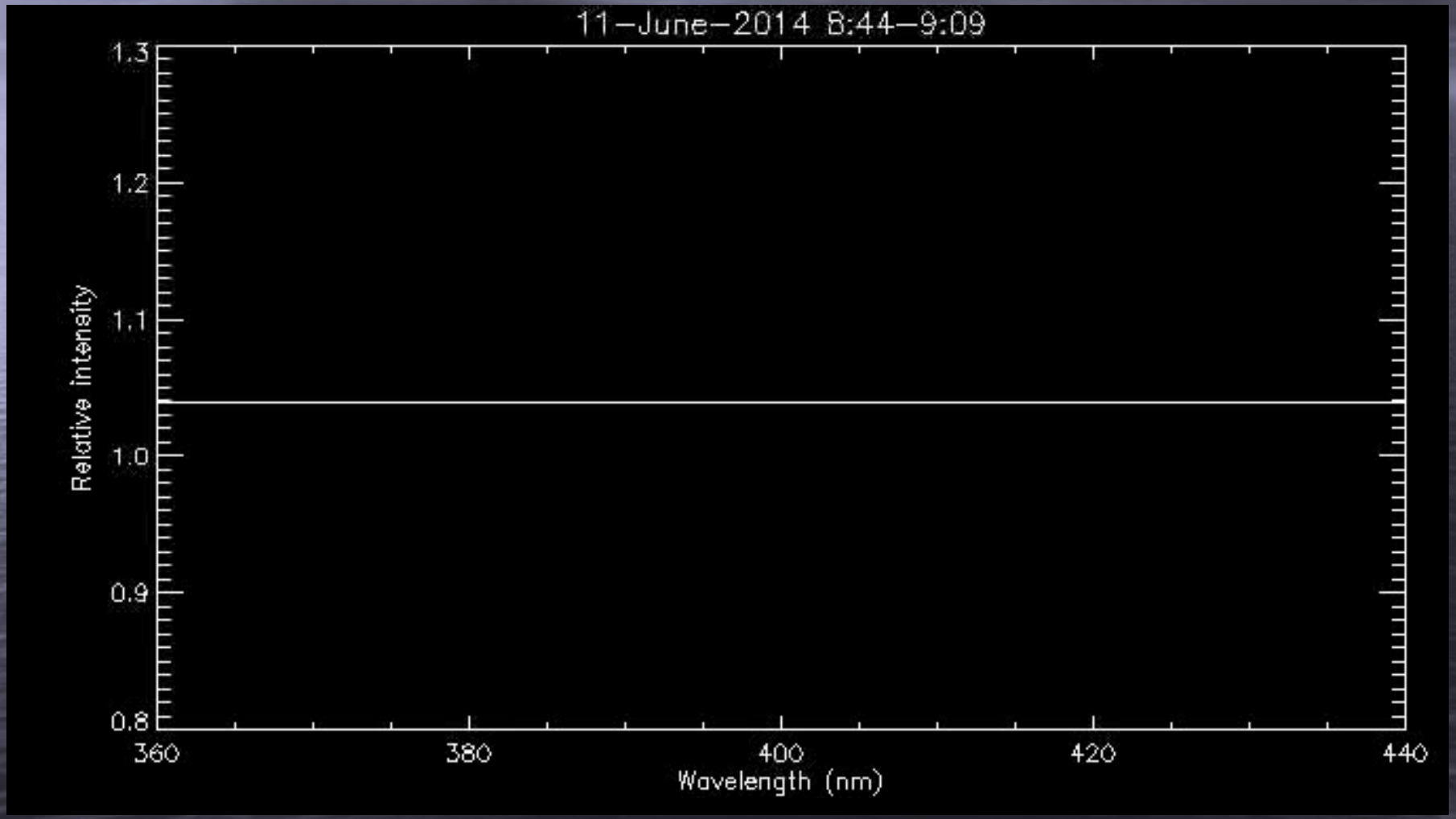
Measurements of blue continuum





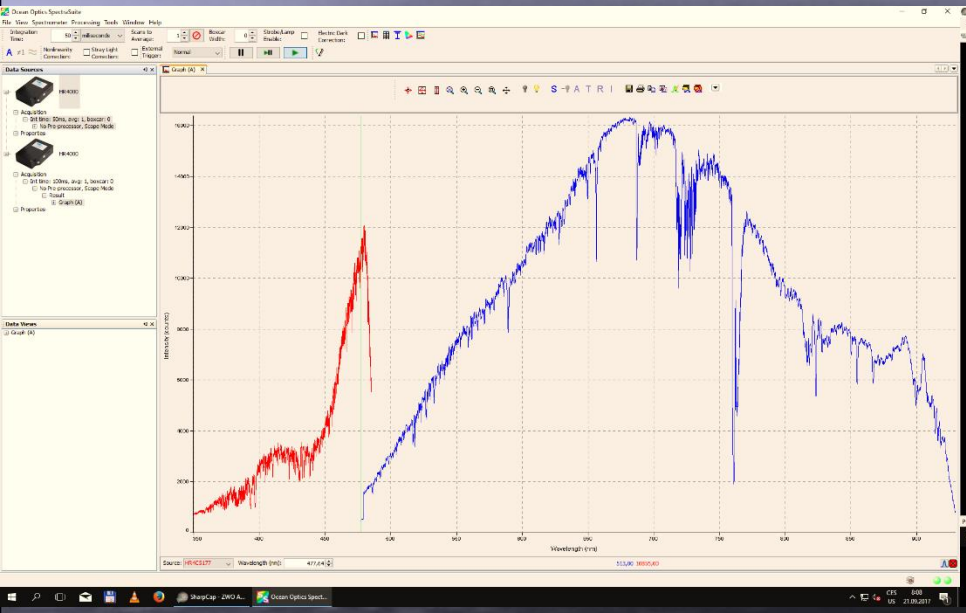
Difference F-QS **(F-QS)/QS**

Blue continuum - Seeing effects removed



Measurements from 350 to 920 nm

Now we split the light beam for a second spectrometer measuring simultaneously in the range of 480 – 920 nm (Paschen continuum).



Raw data taken on Sept. 21, 2017 from the NAAO 2680 Hsx region
Left 350 – 480 nm, center 480 – 920 nm, right H-alpha image of the limb situation

On the calibration of the spectral flux

For calibration we will use the Kitt Peak atlas of the solar spectrum for comparision with the quiet Sun solar disk center
We suppose that all the the data acquisition processes are linear
We will use interpolation for particular position on the solar disk using Allen's tables for each individual wavelength

Continuum flux measurement in solar flares is a perspective tool for studing mechanisms of energy release in flares.

Summary

- A new device for measuring blue continuum in solar flares was developed and put in operation in Ondrejov
- 3 X-class flares we observed, blue continuum was measured
- Contrast in Balmer continuum in flare maximum was evaluated to be 5 x higher than the background radiation
- Further observations and analysis of the data are performed (correlation of channels, presence of QPP, etc.)
- Feeding telescope was improved, data acquisition is complex
- Precise calibrations of the data for 350 – 920 nm are solved

References & acknowledgements

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