Flares Associated with Slowly Positively Drifting Bursts (SPDBs) Observed in 800-2000 MHz

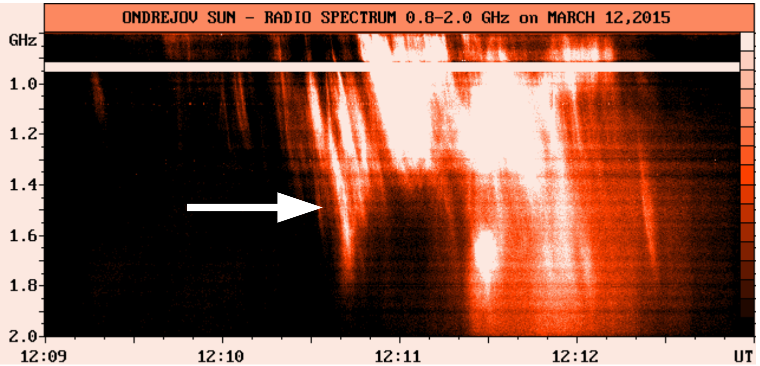
A. Zemanová (zemanova@asu.cas.cz)

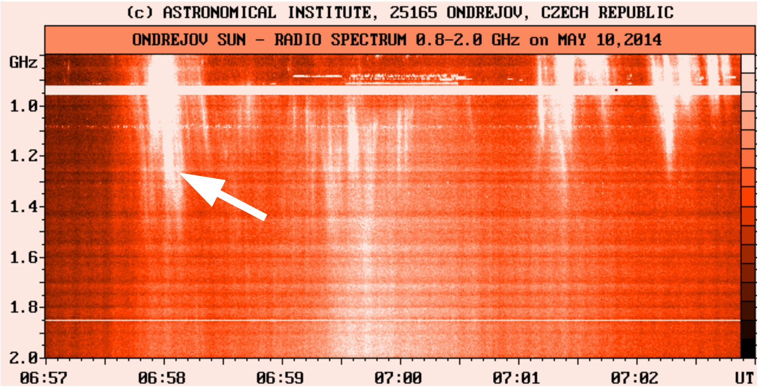
M. Karlický, J. Kašparová, J. Dudík

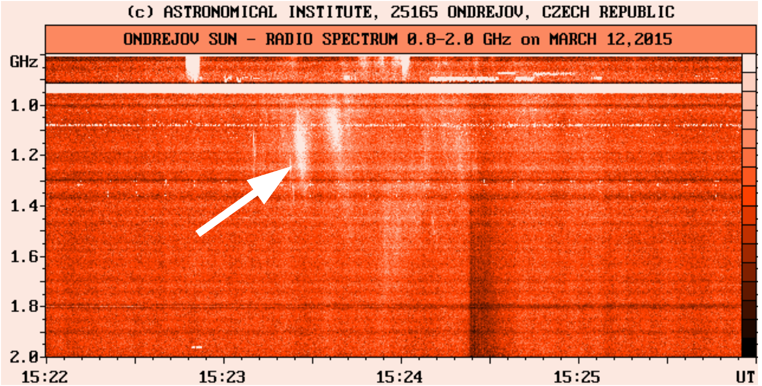
Astronomical Institute of the Czech Academy of Sciences

ASU AVČR, v.v.i.
Fričova 298, 251 65 Ondřejov
Česká republika

ESPM-16: 6-10 September, 2021 (on-line)
Contribution ID: 214, Poster Session 10.4





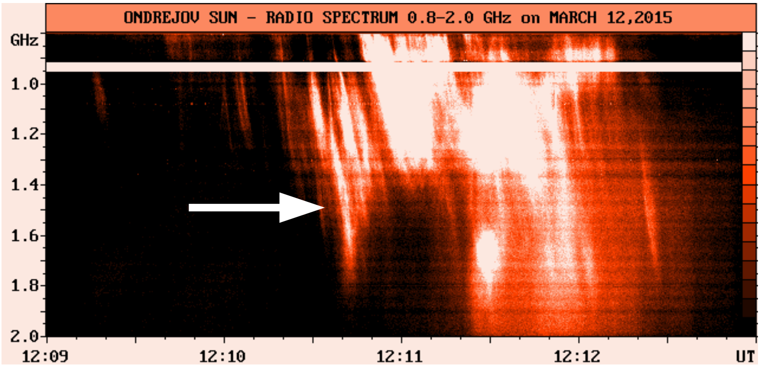


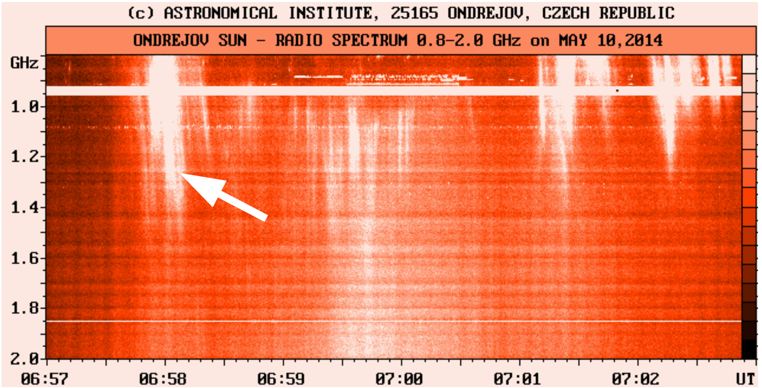
Slowly Positively Drifting Bursts (SPDBs) in 800-2000 MHz frequency range

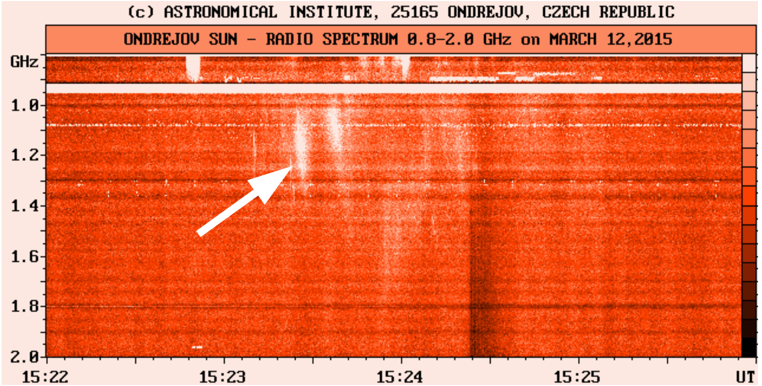
- SPDBs are rarely observed and their origin is unknown. Few papers concerning origin of SPDBs propose: shock wave (Kotrč et al., 1999), thermal conduction front (Karlický, 2015; Karlický et al., 2018), accelerated particles (Benz & Simnett, 1986; Zemanová et al., 2020).
- **SPDBs are similar to RS type III - proceed from lower to higher frequency**
  - frequency drifts are less than ~300 MHz/s
  - may occur as individual burst as well as group
  - their shape is usually linear but can be also slightly curved
- Assuming plasma emission mechanism & density model of the atmosphere (Aschwanden, 2002) – estimated velocities are ~ 2000-4000 km/s

Observation

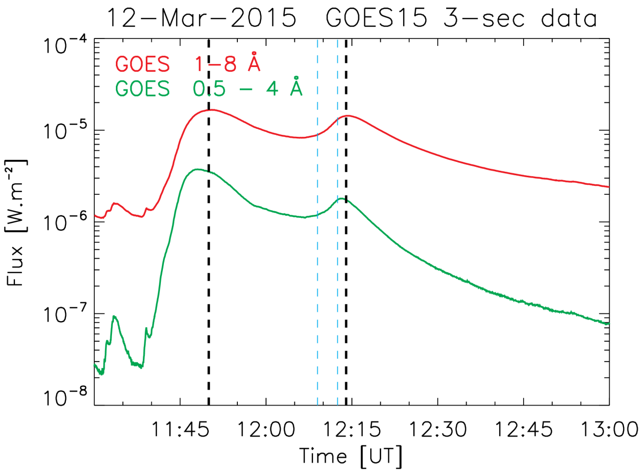
- Radio spectrum - no spatial information on radio source location - we inspected available imaging data (various instrument archives) – ***18 flares registered by Ondřejov RT5 during 2011-2015 – all connected to a filament activity (flares C, M)***.
- Here we present analysis of **3 events**:
  M1.4 2015-03-12T12:24 UT
  C8.7 2014-05-10T07:02 UT
  C1 flare-like event 2015-03-12 15:23 UT
- Data: radio 800-2000 MHz (RT5), SDO/AIA, RHESSI, GOES, GONG Hα synoptic images
- Light curves (LCs): flare brightenings:
  SDO/AIA filters 1600 Å, 304 Å;
  radio – spectrum cut ~1200 MHz;
  RHESSI 12-25 keV, 25-50 keV







M1.4 SOL2015-03-12T12:14



SPBD 12:10:34-12:10:41 (7s)

1000-1700 MHz

Drift ~ 100 MHz/s

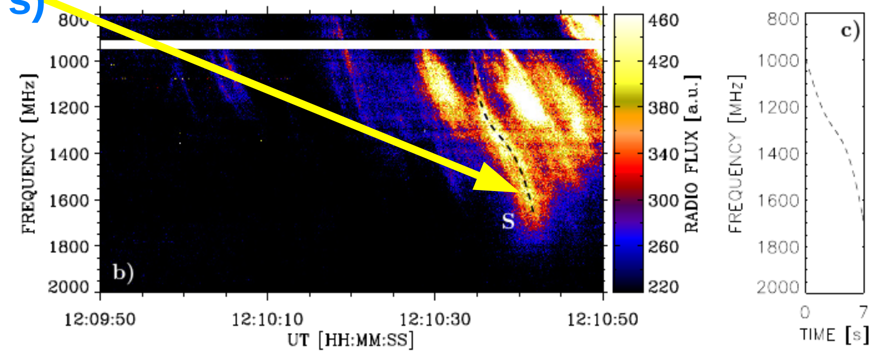
$V_{||}$ = D/Δt ~ 30 000 km/s

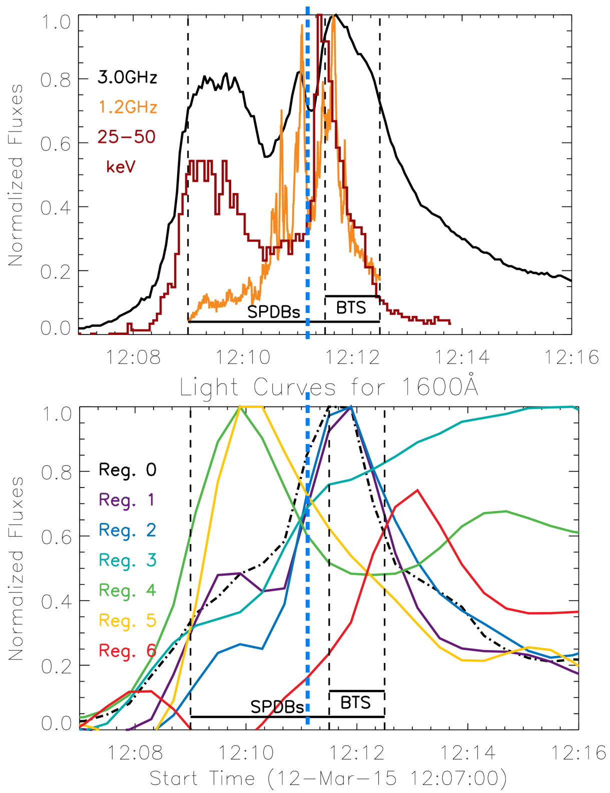
Stop time: (fund., harm.)

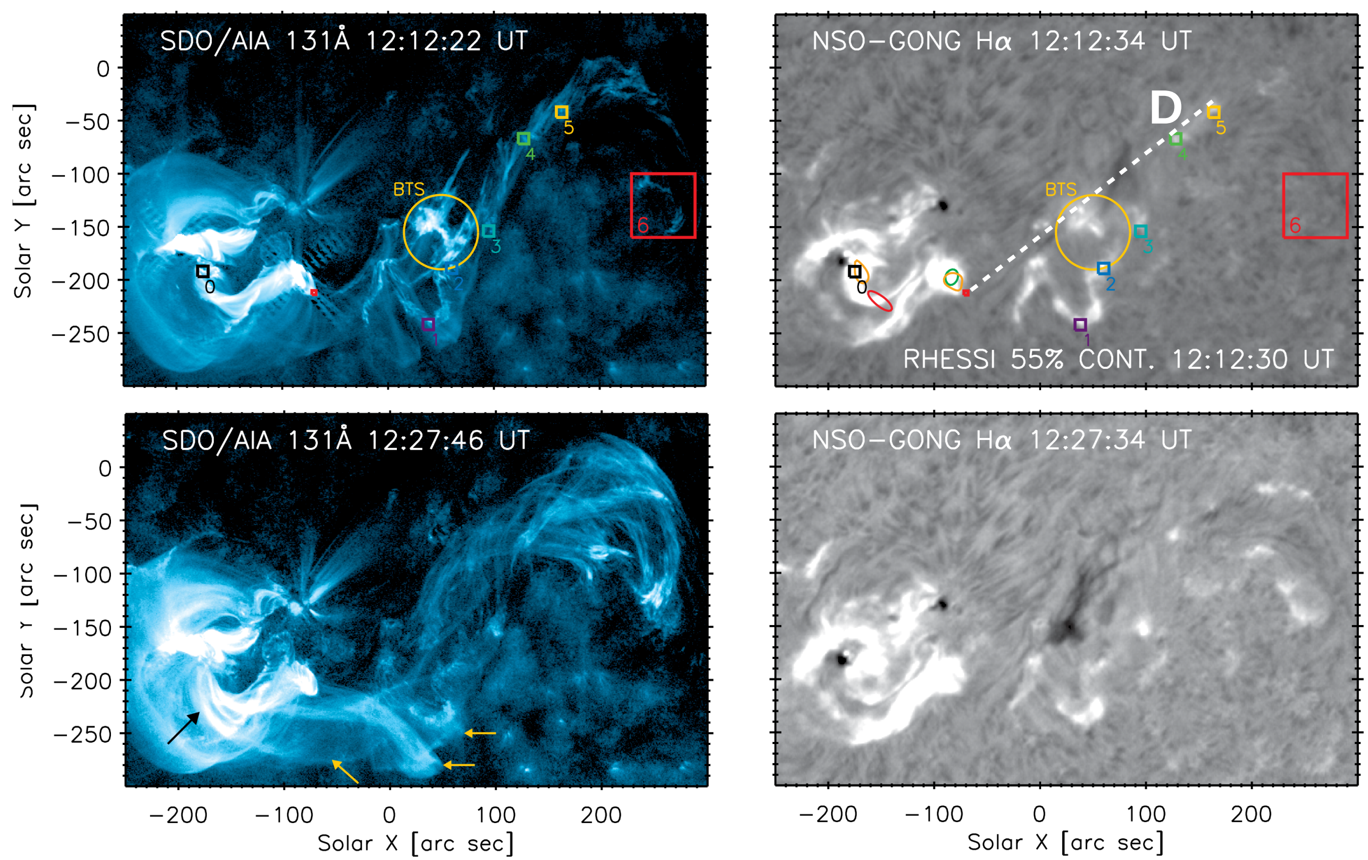
Electron: 0.023 s, 0.093 s

Proton: 64.1 s, 256.3 s

Model

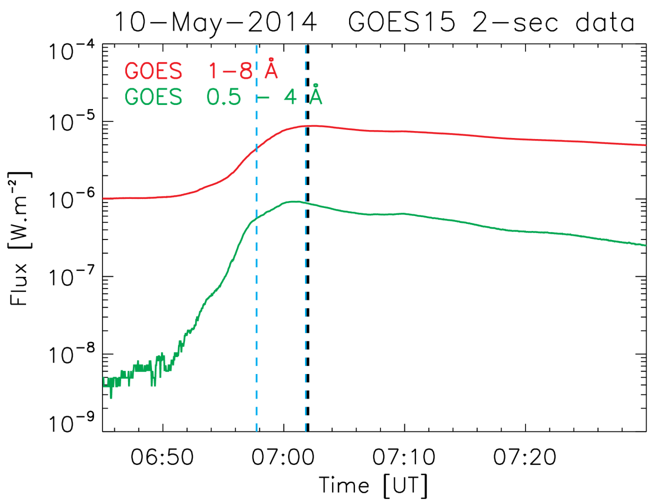


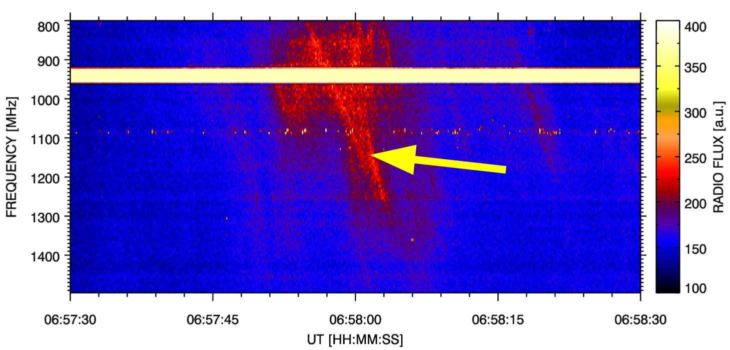




Zemanova et al., 2020

C8.7 SOL2014-05-10T07:02





SPBD 06:57:55-06:58:04 (9s)

800-1300 MHz

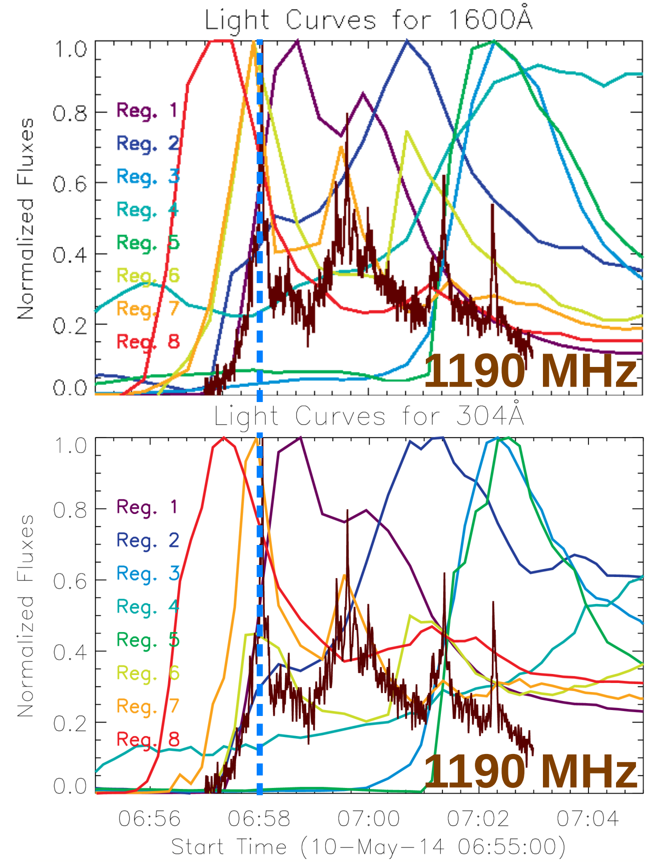
Drift ~ 56 MHz/s

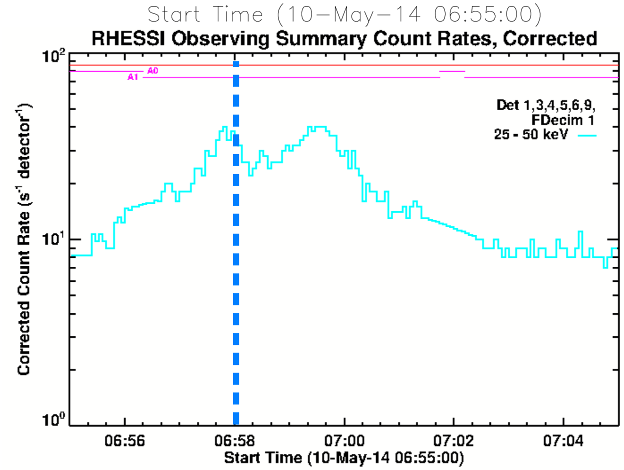
$V_{||}$= D/Δt ~ 14 000 km/s

Stop time: (fund., harm.)

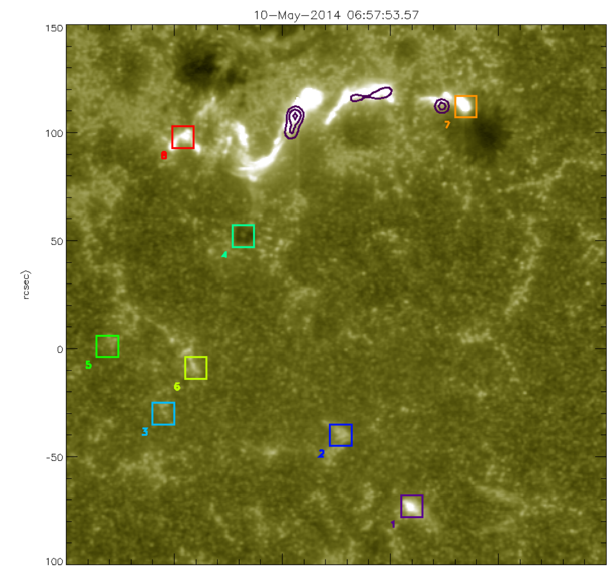
Electron: 0.004 s, 0.014 s

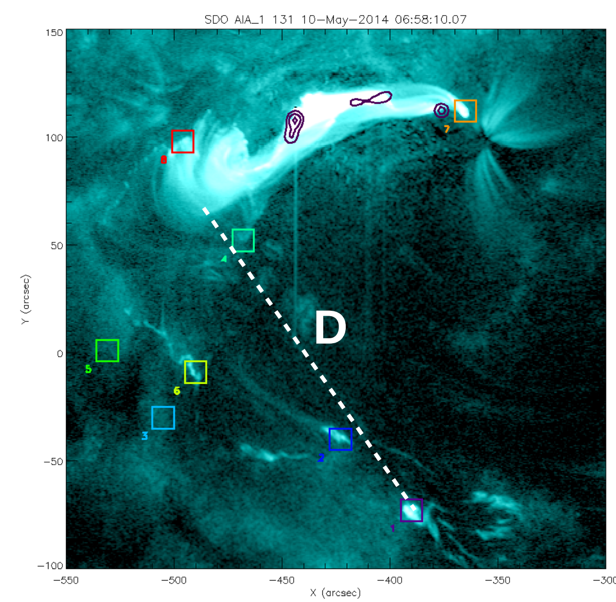
Proton: 9.8 s, 39.2 s



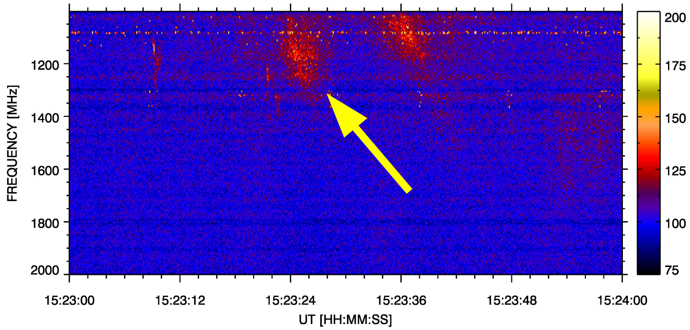


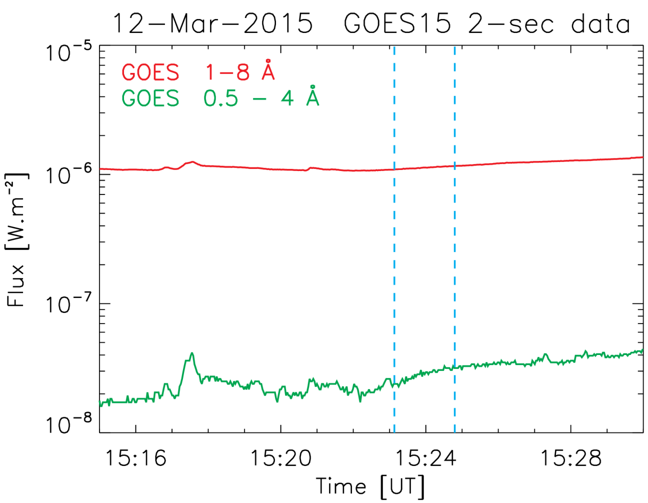
RHESSI cont. 25-50 keV 06:57:41-06:58:34 UT

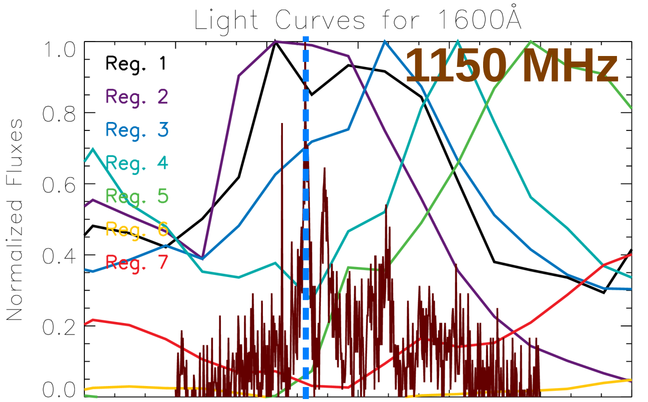


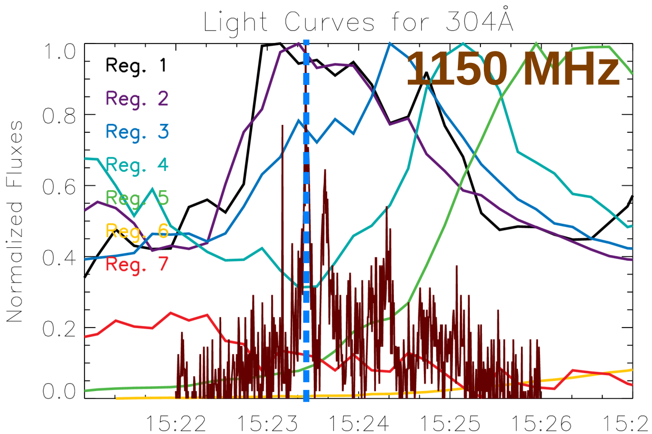


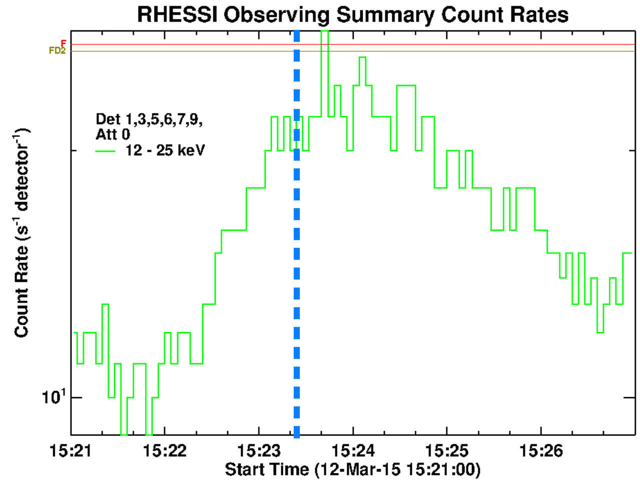
C1-class 2015-03-12 15:23-15:24UT

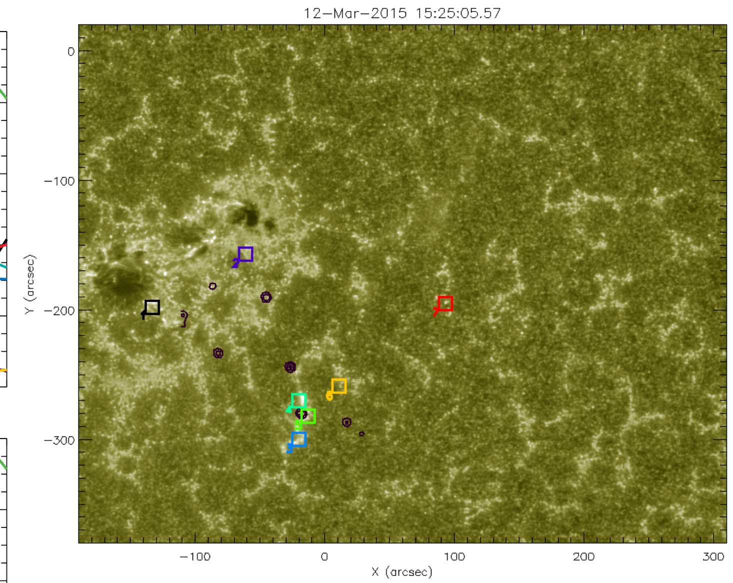




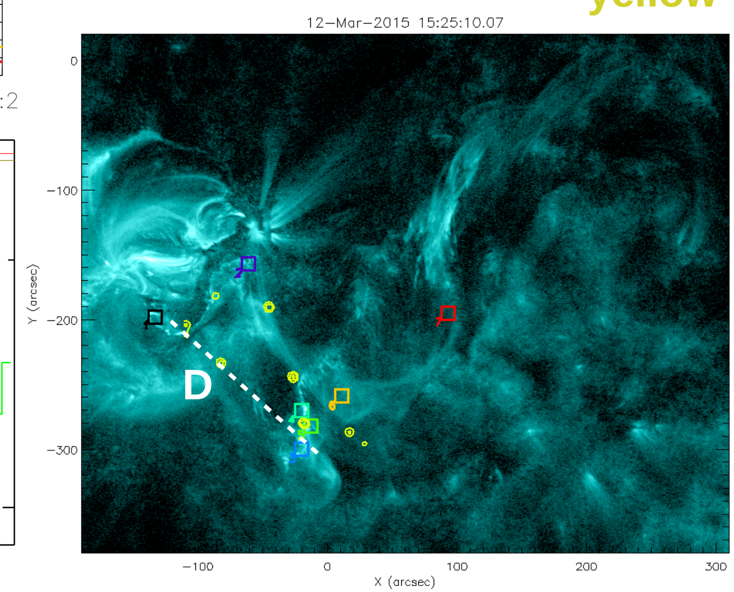








RHESSI cont. 12-25 keV black
15:24:31-15:25:52 UT
yellow



SPBD 15:23:24-15:23:27 (3s)

1000-1300 MHz

Drift ~ 143 MHz/s

$V_{||}$= D/Δt ~ 39 000 km/s

Stop time: (fund., harm.)

Electron: 0.067 s, 0.269 s

Proton: 185 s, 741 s

Summary

- Preliminary study of **18 SPDBs registered by Ondrejov spectrograph RT5 (2011-2015) – all flare events (C and M) involve a filament activity** (AR filaments, quiet filaments nearby AR)
- **Majority of SPDBs was observed during rise of (GOES) SXR flux – implusive phase of a flare – magnetic reconnection – initialisation process?**
- Magnetic reconnection – accelerated particles – **small drift of SPDBs** – assuming plasma emission mechanism for SPDBs – generation by **particle beams moving along almost horizontaly oriented (with respect to the solar surface) magnetic field lines**
- **Velocity estimation** - analysis of LCs from several flare brightenings (time coincidence with SPDBs) and SDO/AIA 131 Å images: **D/Δt ~ 10 000–40 000 km/s**; **D** - distance [km] from ‚reconnection region' to a footpoint of a new flare loop and **Δt** - burst duration[s]
- If we suppose that accelerated electrons with such velocities produce SPDBs, we come to conflict with burst duration: **electron stop time (Emslie, 1978) for N_e~1.5-2.5x10^{10} cm^{-3} is less than 1s < burst duration (~ several seconds)**
- **Protons? - stop times are of seconds BUT energies 1 – 8 MeV**
  + no other signs of protons observed => origin of SPDBs is unclear

Acknowledgement

- **Data sources:**
  AIA and HMI data are provided courtesy of NASA/SDO and the AIA and HMI science teams. We thank the RHESSI team for providing the data, great mission archive and software support. This work utilizes GONG data from NSO, which is operated by AURA under a cooperative agreement with NSF and with additional financial support from NOAA, NASA, and USAF. We are grateful to Helioviewer.org team for enabling easy access to quicklook data from various missions and instruments.

- **This work was supported by:**
  project RVO: 67985815, Grants: 18-09072S, 19-09489S, 20-09922J, 20-07908S of the GAČR.

- **References:**

Aschwanden, M., 2002, SSRv, 101, 1; DOI:10.1023/A:1019712124366
Emslie, A. G., 1978, ApJ, 224, 241; DOI:10.1086/156371
Karlický, M., 2015, ApJ, 814, 153; DOI:10.1088/0004-637X/814/2/153
Karlický, M. et al., 2018, ApJL, 854,L29; DOI:10.3847/2041-8213/aaadf9
Kotrč et al., 1999, ESA-SP 448, 841; BibCode:1999ESASP.448..841K
Benz & Simnett, 1986, Natur, 320, 508; DOI:10.1038/320508a0;
Zemanová, A. et al., 2020, ApJ, 905, 111; DOI:10.3847/1538-4357/abc424