KWSFD - the Konus-Wind Hard X-ray Solar Flare Database

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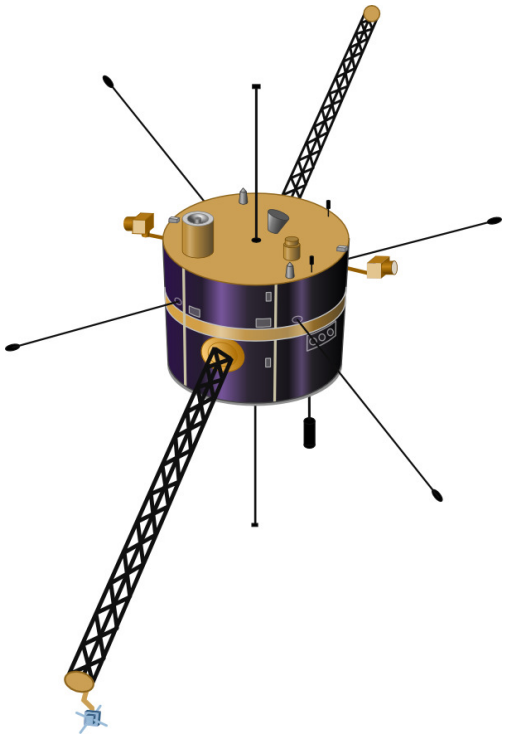
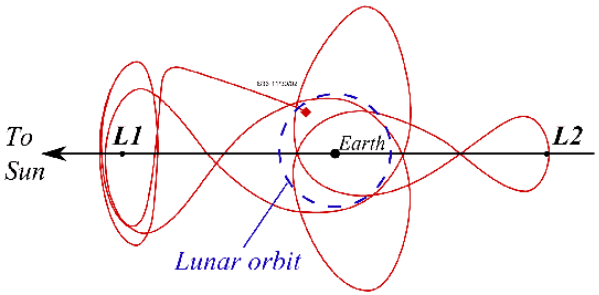
2016

Konus-Wind Instrument



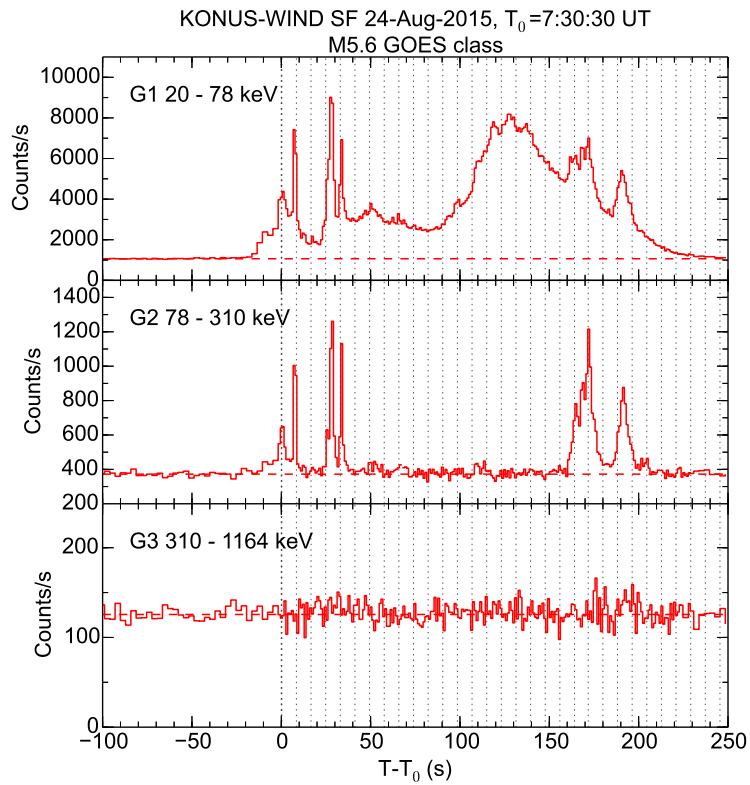


- Konus-Wind is a joint Russian-US experiment for gamma-ray burst and solar flare studies.
- Launched on November 1, 1994.
- Two detectors S1 and S2
  NaI(Tl) 13 cm x 7.5 cm, Be entrance window are located on opposite faces of the Wind spacecraft, observing correspondingly the southern and the nothern ecliptical hemispheres.
- Continuous observations of all sky.
- $\sim$ 20 keV–15 MeV energy range (present time).
- Since July of 2004 is orbiting around L1 at ~5 light seconds from Earth.
- Doesn't suffer from "nights".
- Exceptionally stable background.

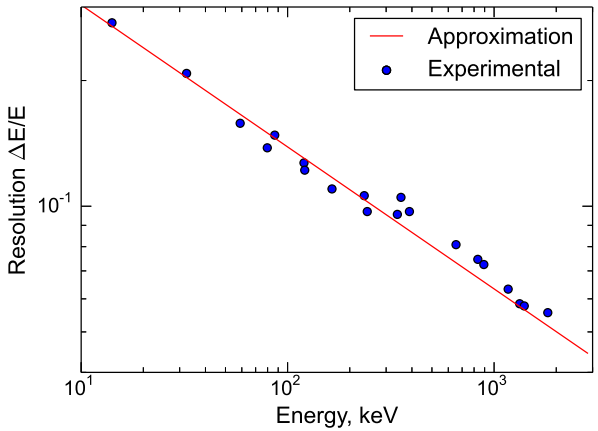
Konus-Wind Operating Modes

- Konus-Wind operating modes
  - Waiting mode:
    Count rate in 3 energy channels:
    G1 ($\sim$ 20–80 keV),
    G2 ($\sim$ 80–300 keV),
    G3 ($\sim$ 300–1200 keV) with accumulation time 2.944 s.
  - Triggered mode:
    Count rate in the same 3 channels with variable time resolution from 2 to 256 ms, the total duration ~240 s.
    64 multichannel spectra in two partially overlaping energy ranges $\sim$ 20 keV–15 MeV.
    Accumulation times:
    64 ms–8.192 s
- After accumulation of energy spectra the instrument is inactive for ~1 hour, only count rate curve in G2 channel is available with accumulation time 2.944 s.

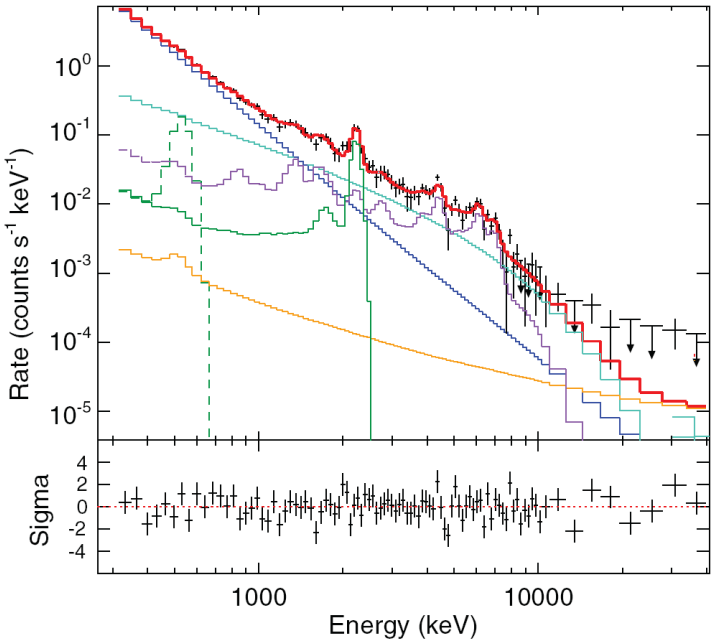
- Summary (up to June, 2016), only triggered events:
  - 2700 Gamma-Ray Bursts
  - 253 Soft Gamma Repeater Bursts
  - 1021 Solar Flares.

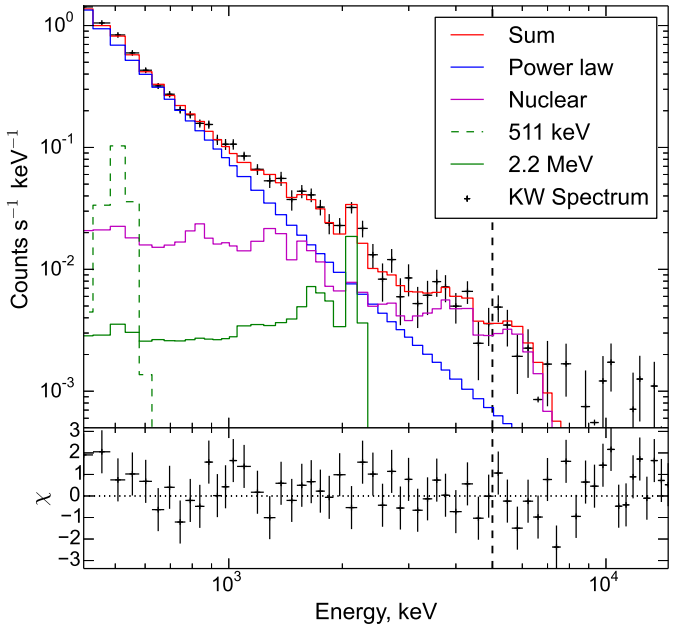


Konus-Wind Energy Resolution



- Konus-Wind energy resolution - FWHM/E.
- Fermi-GBM spectrum for solar flare 12-Jun-2010 ~0.55 UT from Ackermann et al., 2012 (bottom left).
- Konus-Wind spectrum for the same flare (bottom right), only second energy range was fitted, first range suffers from pile-up distortions.





Statistics of Solar Flare observations in the triggered mode

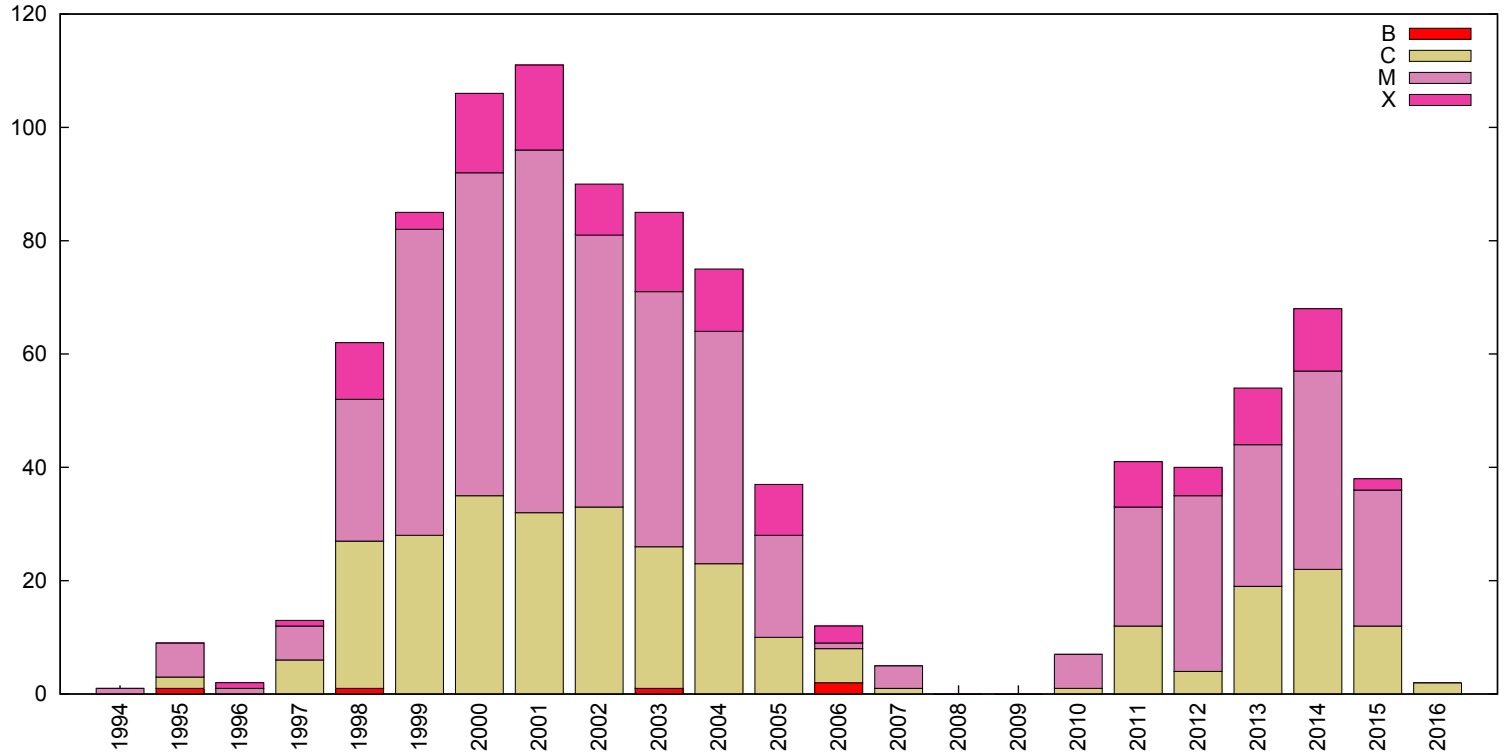
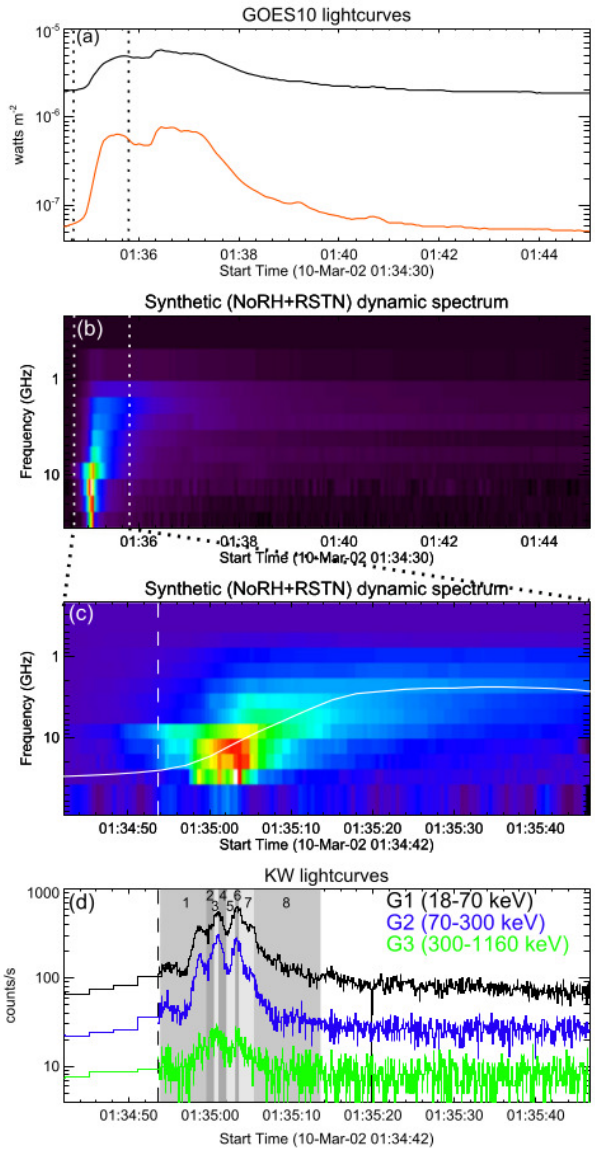


Figure : Annual solar flare trigger statistics over the experiment duration

Criteria for event to fall in solar database

- The flare presents in the GOES event list ftp://ftp.swpc.noaa.gov/pub/warehouse.
- $T_{begin}(GOES) < T_{trigger}(KW) < T_{max}(GOES)$.

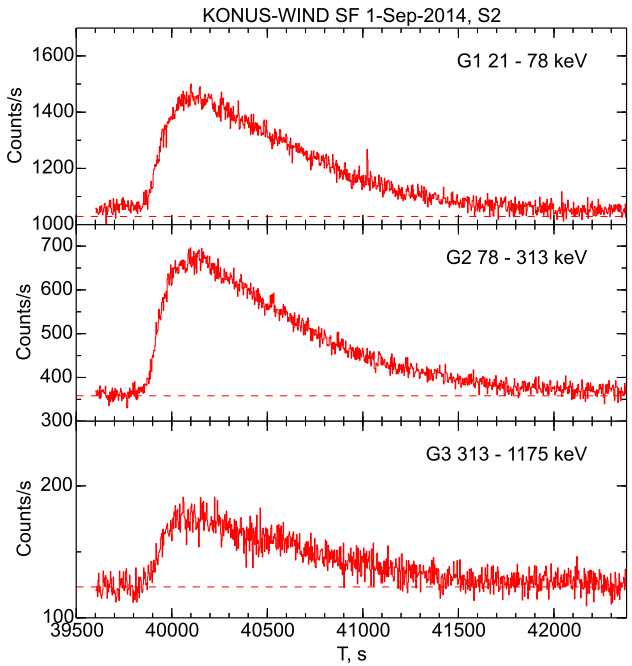
Solar Flare Examples: Flare with delayed heating 10-Mar-2002 01:35 UT

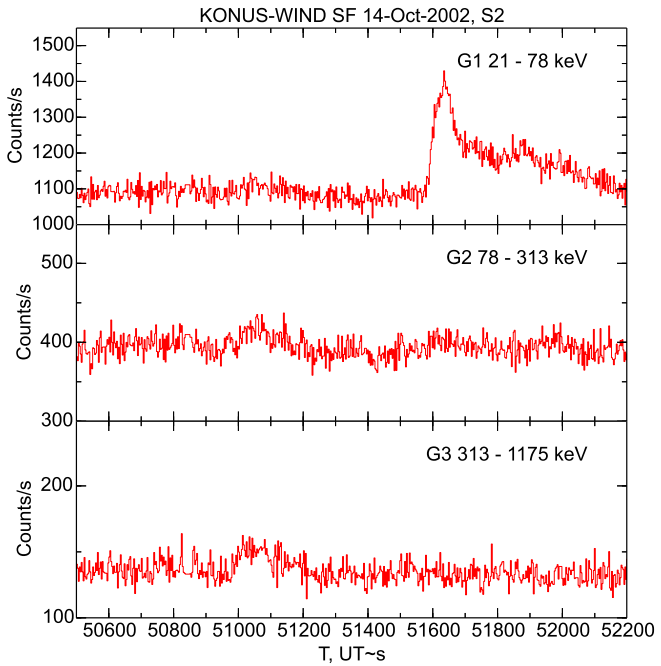


- A flare with delayed heating 10-Mar-2002 01:35 UT (GOES class C5.1) from Fleishman et al., 2016.
- Occured during RHESSI "night".
- Top to bottom: Soft X-ray (GOES), microwave (NoRP) and Hard X-ray (Konus-Wind) light curves.
- Very hard for a typical C-class flare (HXR spectral indices ~2.5).
- Delay of thermal SXR emission is due to interaction between small and big flaring loops.

Solar Flare Examples: Behind-the-limb Solar Flares

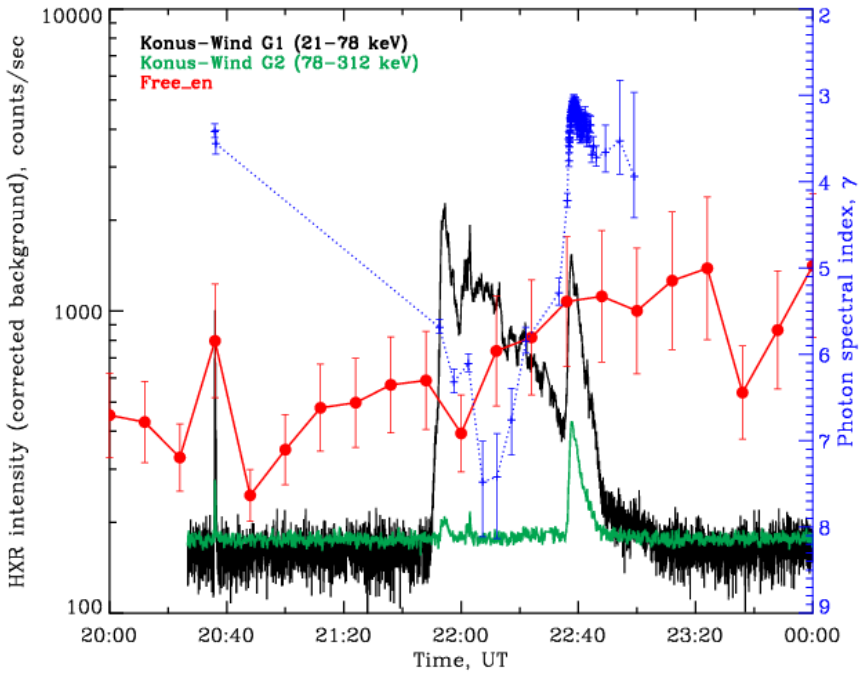
- Originate in the high corona.
- Show Frost-Dennis signature (originaiting from second stage acceleration) which is not contaminaited by "ordinary" X-ray emission:
  - No Soft X-ray event
  - Smooth hard X-ray time profile
  - Flat hard X-ray spectrum.
- Flare 1-Sep-2014 ~11:00 UT: long duration flare observed by Konus-Wind in waiting mode.
- Flare 14-Oct-2002 ~14:20 UT: observed by Konus-Wind in waiting mode.





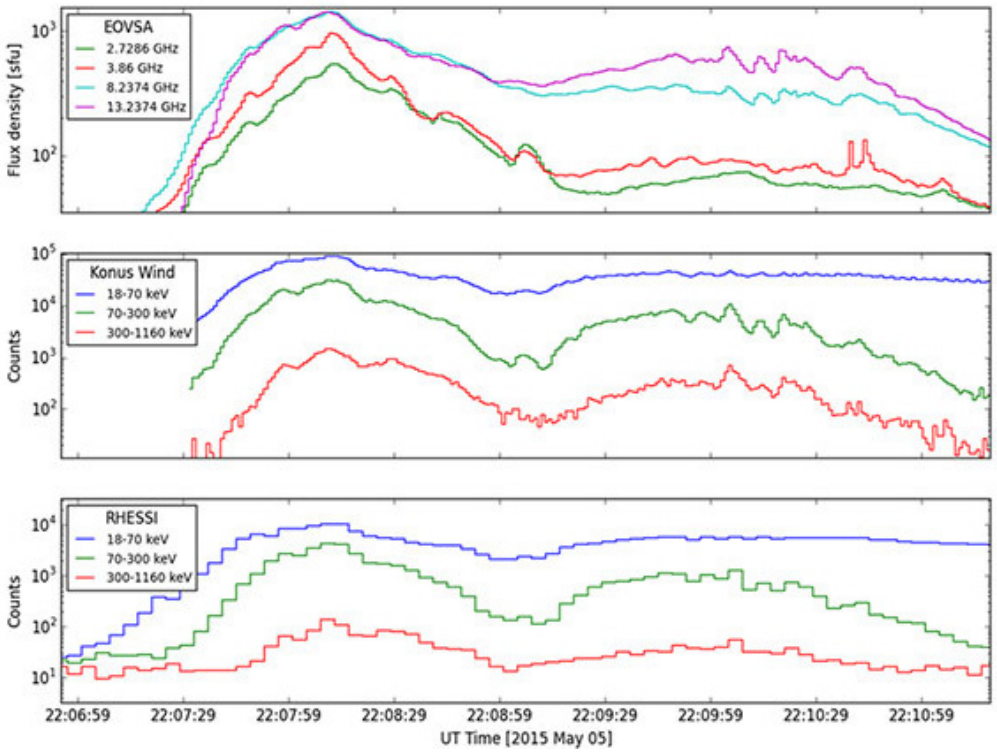
Solar Flare Examples: Flare of 7-Mar-2015

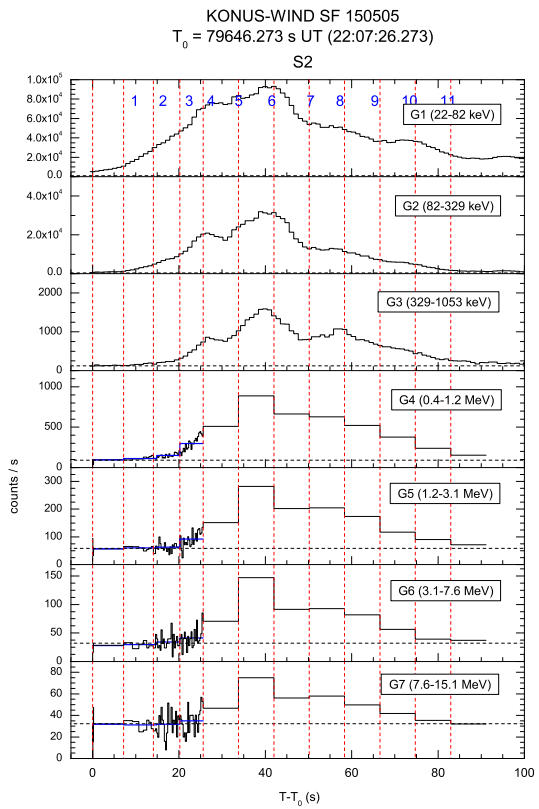
- The flare was detected by KW for the entire duration (1.5 hours) in the waiting mode (Kashapova et al, talk RHESSI 2015).
- Photon spectral index was found using 3-channel fitting.
- The first phase of electron acceleration followed by the decrease of the magnetic free energy.
- The harder peak onset was preceeded by significant rise of the magnetic free energy.
- The energy decrease didn't occur during the hardest phase of the flare. It happened later during the phase of post-eruptive source formation.



Solar Flare Examples: X2.7 class Flare of 5-May-2015

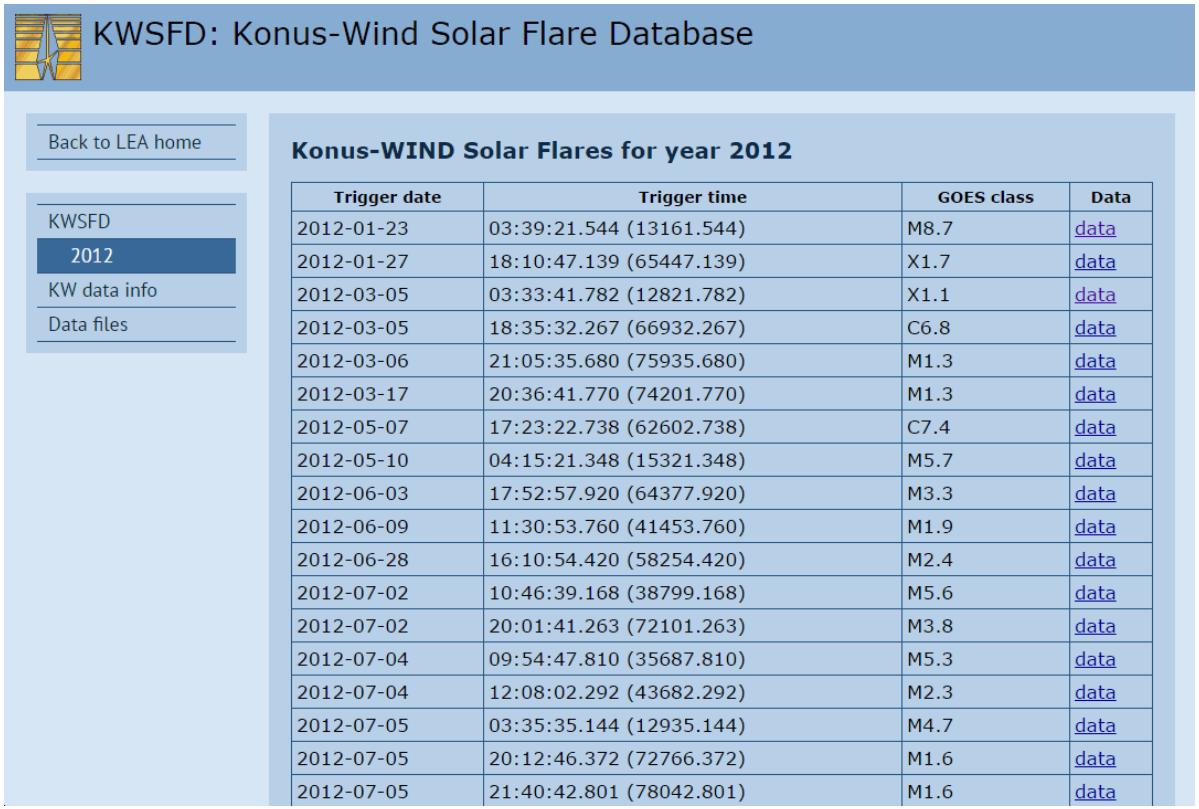
- The flare was detected in the triggered mode. (see RHESSI nugget by D. E. Gary and G. Fleishman).
- During the decay phase the microwave emission (from EOVSA) shows series of pulsations, also observed by Konus-Wind.
- There are 2 peaks seen in the 3.86 GHz curve (red) and Konus-Wind 300-1160 keV light curve about 22:10:40.
- Konus sees gamma rays with good SNR to energies well above 7 MeV.





Konus-Wind Solar Flare Database (KWSFD)

- KWSFD can be accessed from the Ioffe website (http://www.ioffe.ru/LEA/KWSFD).
- It contains flares registered in triggered mode.
- At present, only flares for year 2012 are available. The remaining events will be added within few months.



KWSFD: Konus-Wind Solar Flare Database

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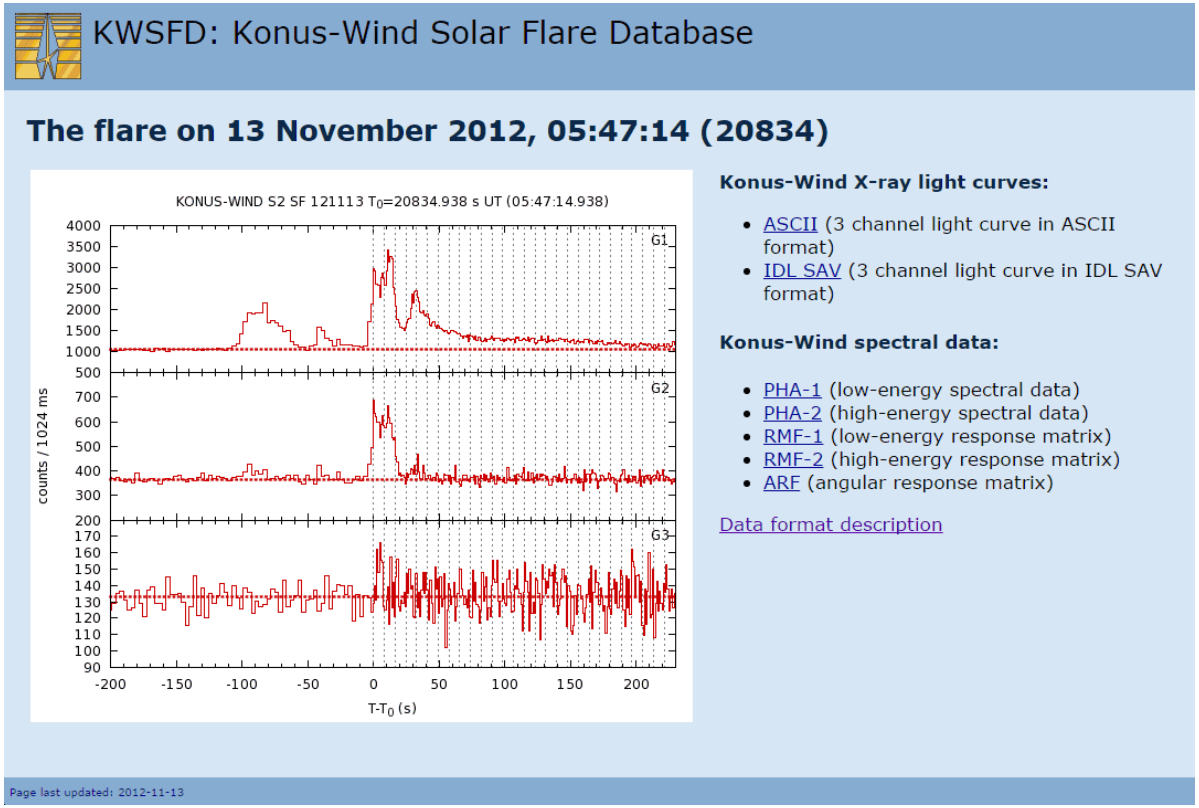
KWSFD
2012
KW data info
Data files

Konus-WIND Solar Flares for year 2012

Trigger date	Trigger time	GOES class	Data
2012-01-23	03:39:21.544 (13161.544)	M8.7	data
2012-01-27	18:10:47.139 (65447.139)	X1.7	data
2012-03-05	03:33:41.782 (12821.782)	X1.1	data
2012-03-05	18:35:32.267 (66932.267)	C6.8	data
2012-03-06	21:05:35.680 (75935.680)	M1.3	data
2012-03-17	20:36:41.770 (74201.770)	M1.3	data
2012-05-07	17:23:22.738 (62602.738)	C7.4	data
2012-05-10	04:15:21.348 (15321.348)	M5.7	data
2012-06-03	17:52:57.920 (64377.920)	M3.3	data
2012-06-09	11:30:53.760 (41453.760)	M1.9	data
2012-06-28	16:10:54.420 (58254.420)	M2.4	data
2012-07-02	10:46:39.168 (38799.168)	M5.6	data
2012-07-02	20:01:41.263 (72101.263)	M3.8	data
2012-07-04	09:54:47.810 (35687.810)	M5.3	data
2012-07-04	12:08:02.292 (43682.292)	M2.3	data
2012-07-05	03:35:35.144 (12935.144)	M4.7	data
2012-07-05	20:12:46.372 (72766.372)	M1.6	data
2012-07-05	21:40:42.801 (78042.801)	M1.6	data

Konus-Wind Solar Flare Database (KWSFD)

- KWSFD provides spectral data in FITS format as well as light curves in IDL SAV and ASCII formats.
- To be done: utility for extracting PHA for individual spectra (PHA-I) from PHA with multiple srectra (PHA-II).

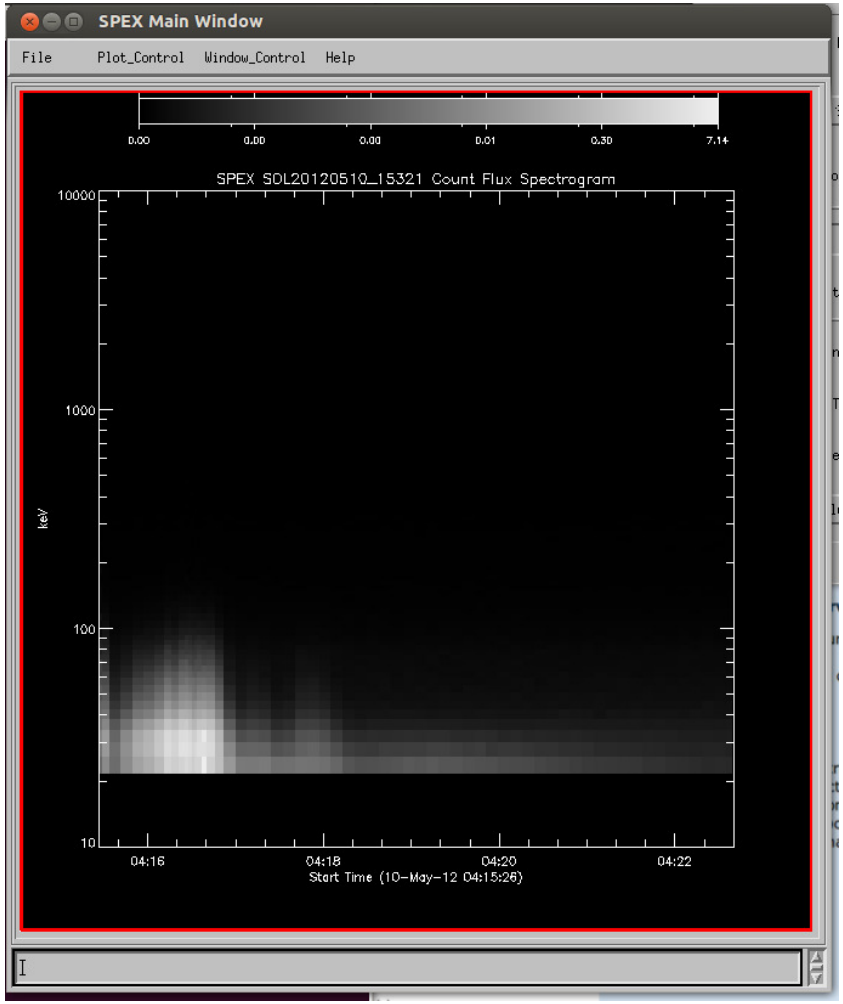


Information available from the light curve file:

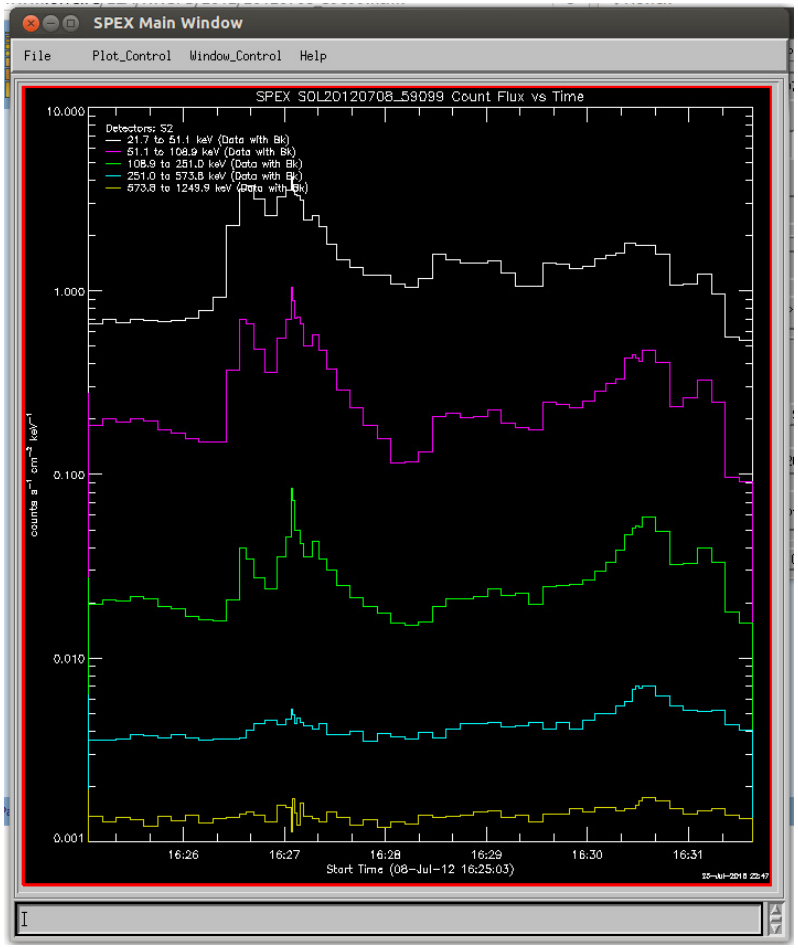
- Energy channel bounds.
- Statistics on background approximation.
- Begin and end of the time bin.
- Counts/s in G1, G2, G3 (dead-time corrected).
- Background in G1, G2, G3.
- Background substracted counts in G1, G2, G3.
- Background substracted count errors (1 sigma hereafter).
- Hardness ratio G2/G1 and its error.
- Hardness ratio G3/G2 and its error.

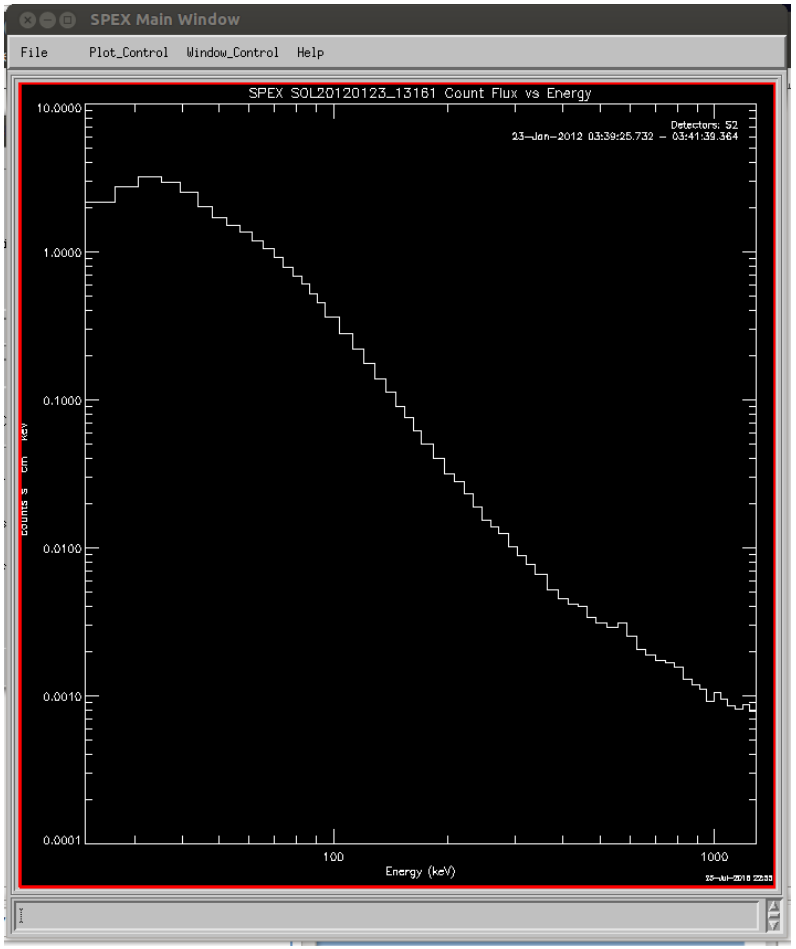
Konus-Wind Solar Flare Database (KWSFD)

- The IDL routine for reading and processing KW FITS spectral files has been added to the OSPEX package and now available from SSW.



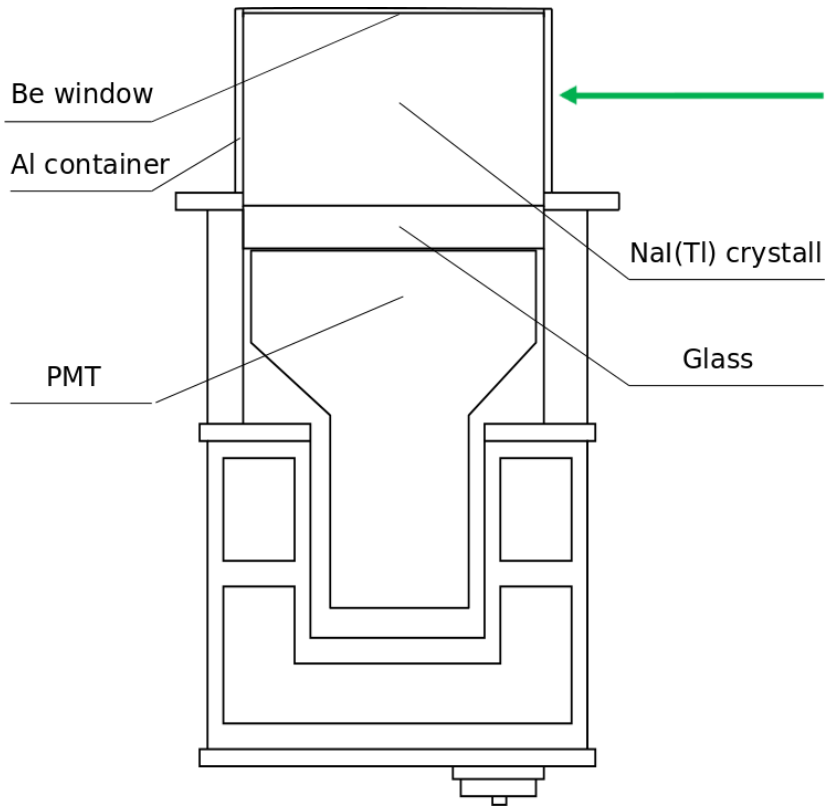
Konus-Wind Solar Flare Database (KWSFD)



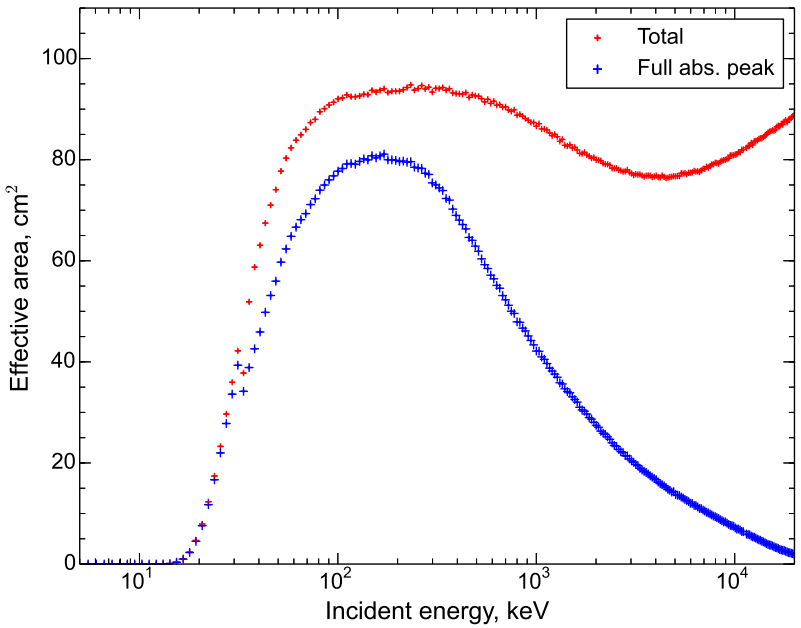


Thank you for your attention!

Konus-Wind Effective Area

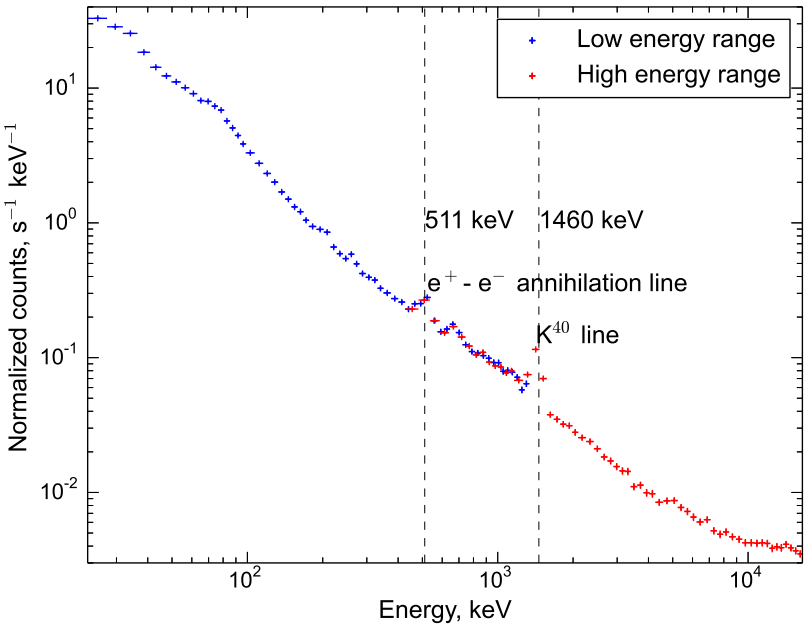


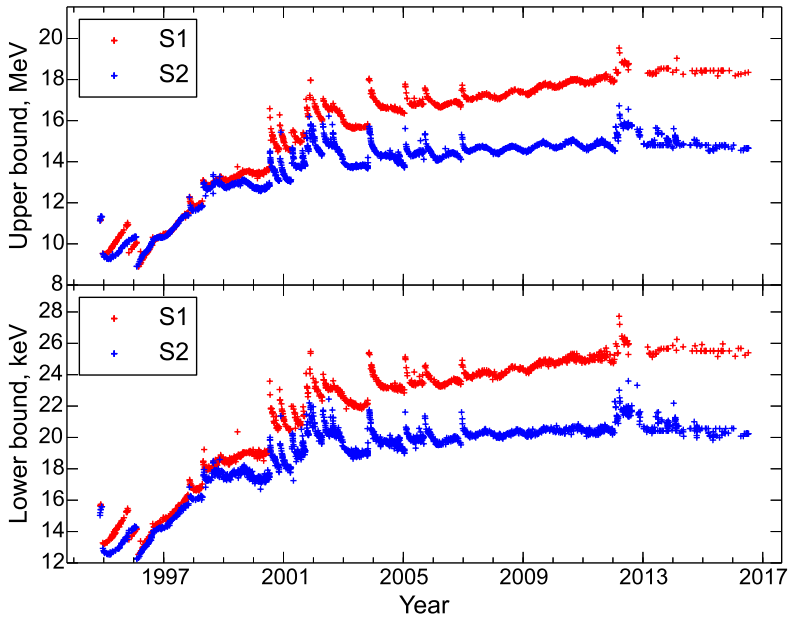
- NaI(Tl) crystal 13 cm x 7.5 cm, Be entrance window, Al container 1.75 mm thick (left).
- Incident angle for Solar flare emission θ=90^0.
- Effective area for θ=90^0 obtained from Geant4 modelling (right).



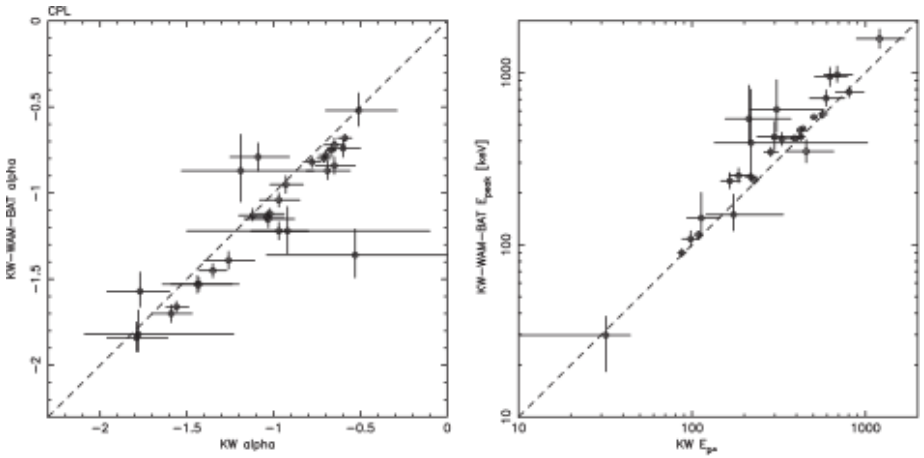
Energy Bounds Calibrations

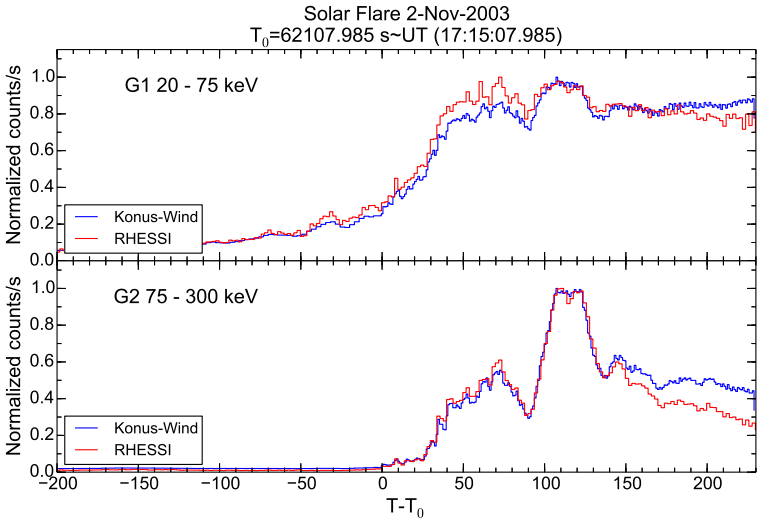
- Energy channel calibrations are held using 1460 keV line emitted by ^{40}K from the lead-glass PMT window.
- Energy bounds changed during Konus-Wind operating history within a factor of 2 for S1 and a factor of 1.5 for S2.



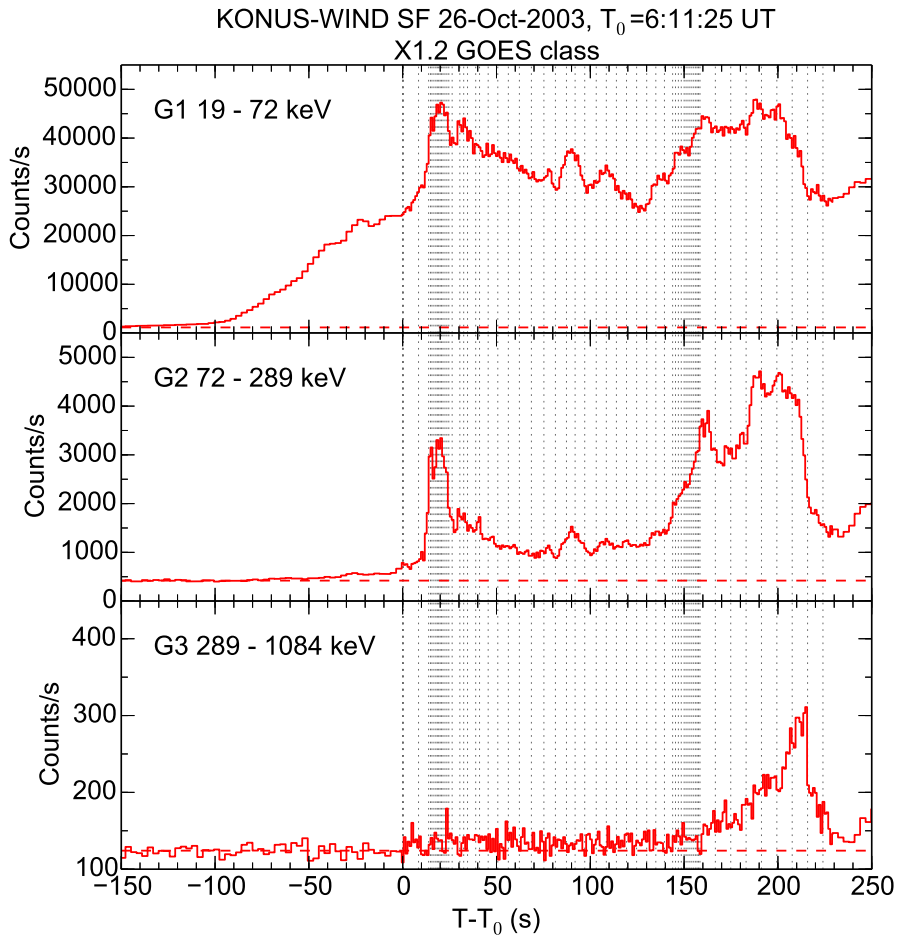


Cross-Calibrations with other Instruments





- Sakamoto et al. 2011a: cross-calibrations for Konus-Wind, Suzaku/WAM and Swift/BAT for GRBs spectral parameters.
- Light curves comparison between Konus-Wind and RHESSI for submillimeter solar flare SOL2003-11-02T17:17 (see also Silva et al., 2007, Krucker et al., 2013).
- To be done: spectral cross-calibrations for solar flares.

Konus-Wind Solar Flares Database (KWSFD)

- Caveat: For long-duration flares 64 energy spectra do not cover neither event continuation, nor background spectra. Example: : flare 26-Oct-2003 (see also I. Zimovets, A. Struminsky, 2012). To be done: Add background spectra from neighbouging trigger event with close background levels.