

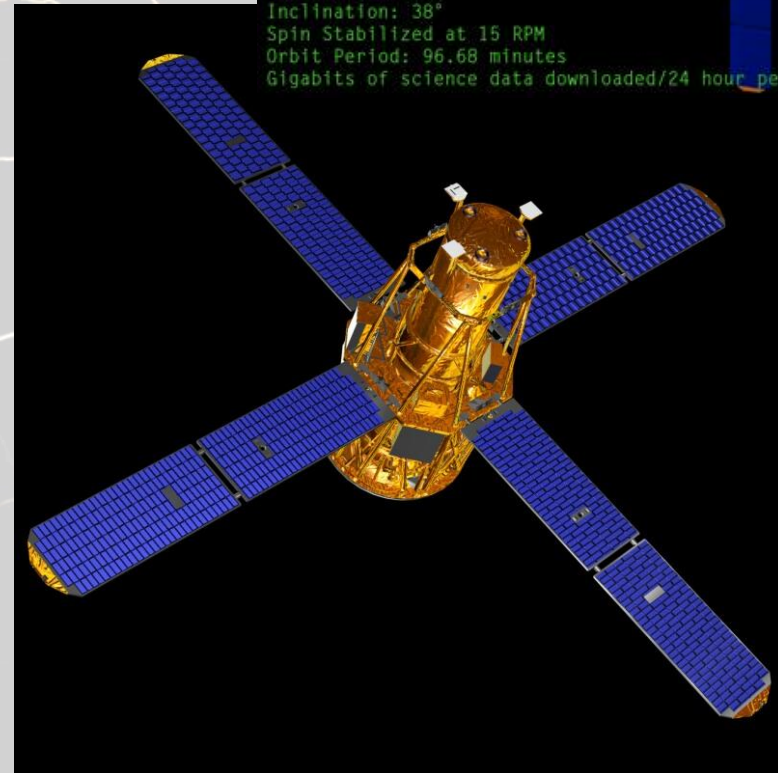
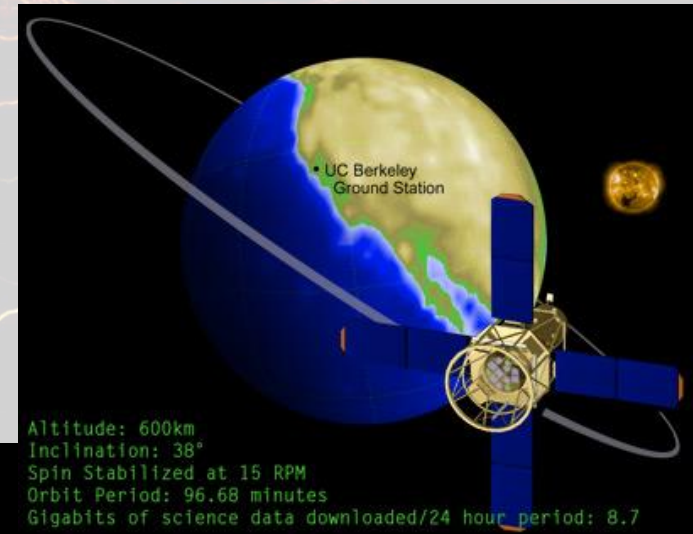


# **New method for RHESSI orbital background subtraction**

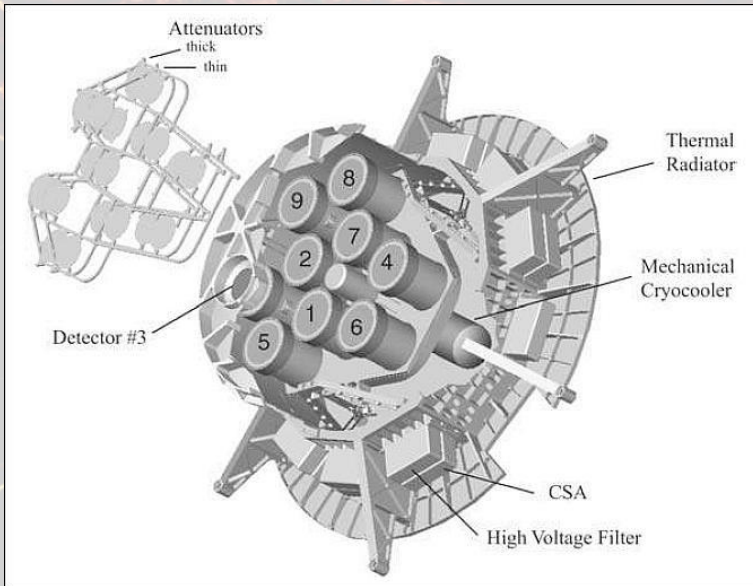
**Mrozek, T. & Netzel, H.**

# RHESSI

- Launched 5-Feb-2002 r.
- Initial orbit: 600 km circular, 38°
- Planned for 2 years + 3 years of extended mission
  
- 13+ years of observations
- More than 70 000 orbits
- Almost 100 000 flares (7+ TB of data)
- Present altitude: 534 x 517 km
- First possible reentry: 2018  
(expected: 2023)
  
- All subsystems performing well
- Systematical decrease of detectors performance due to aging (sensitivity, resolution, noise)
- Annealing performed last year.
- No visible changes in grids orientation.
- Precise spectroscopy and imaging still possible



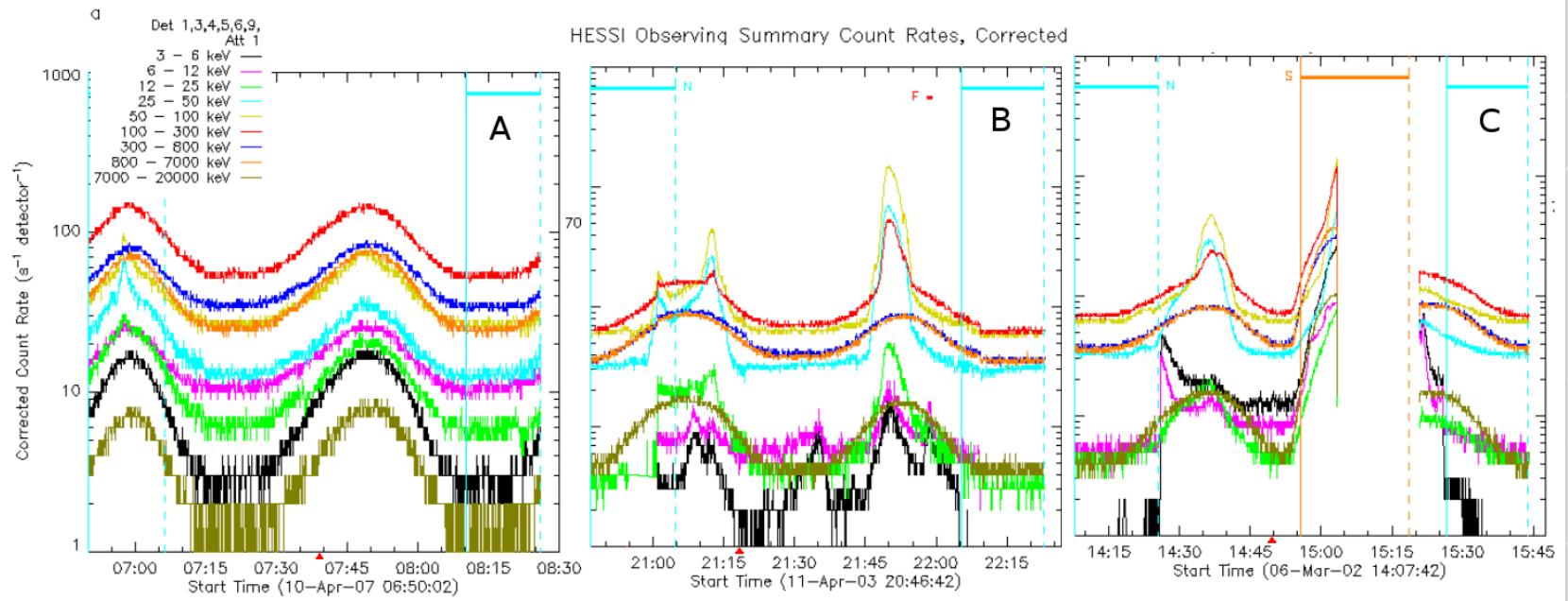
# RHESSI background from particles



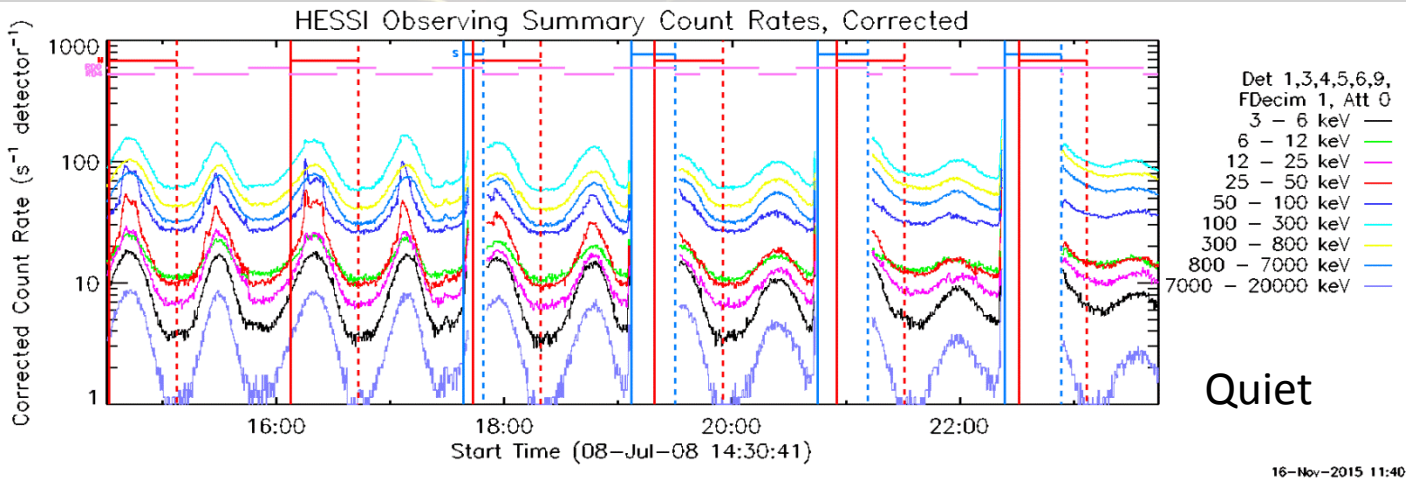
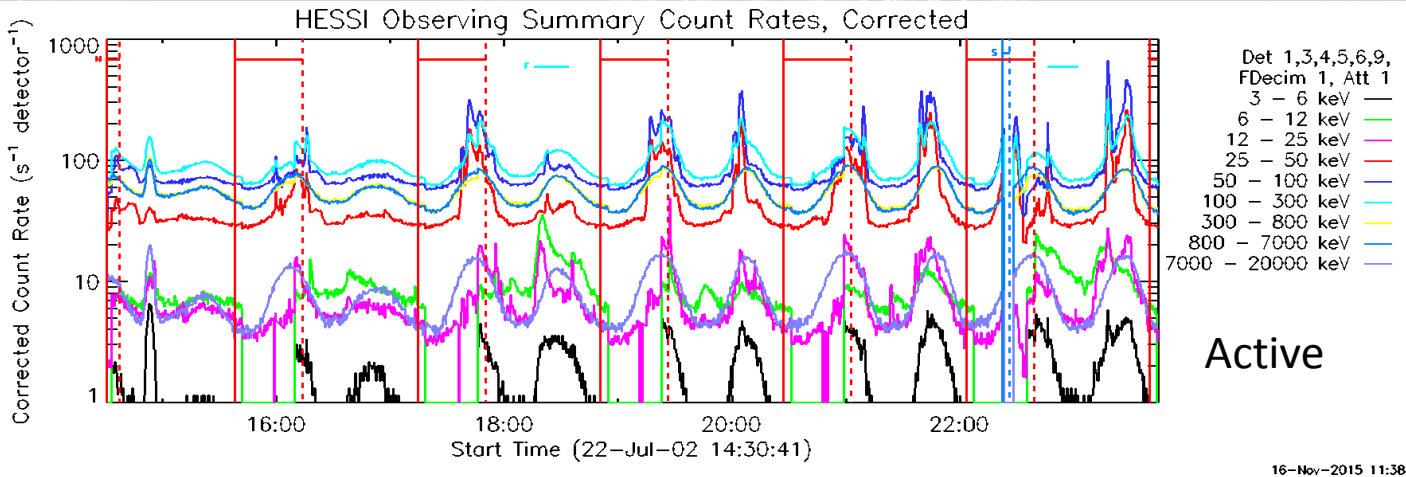
The orbit is inclined ( $38^\circ$ ) – passages through radiation belts and South Atlantic Anomaly (SAA)

There is no shielding of the instruments – many artifacts in light curves (particles, gamma ray bursts etc.).

All RHESSI's energy channels are affected by particles.

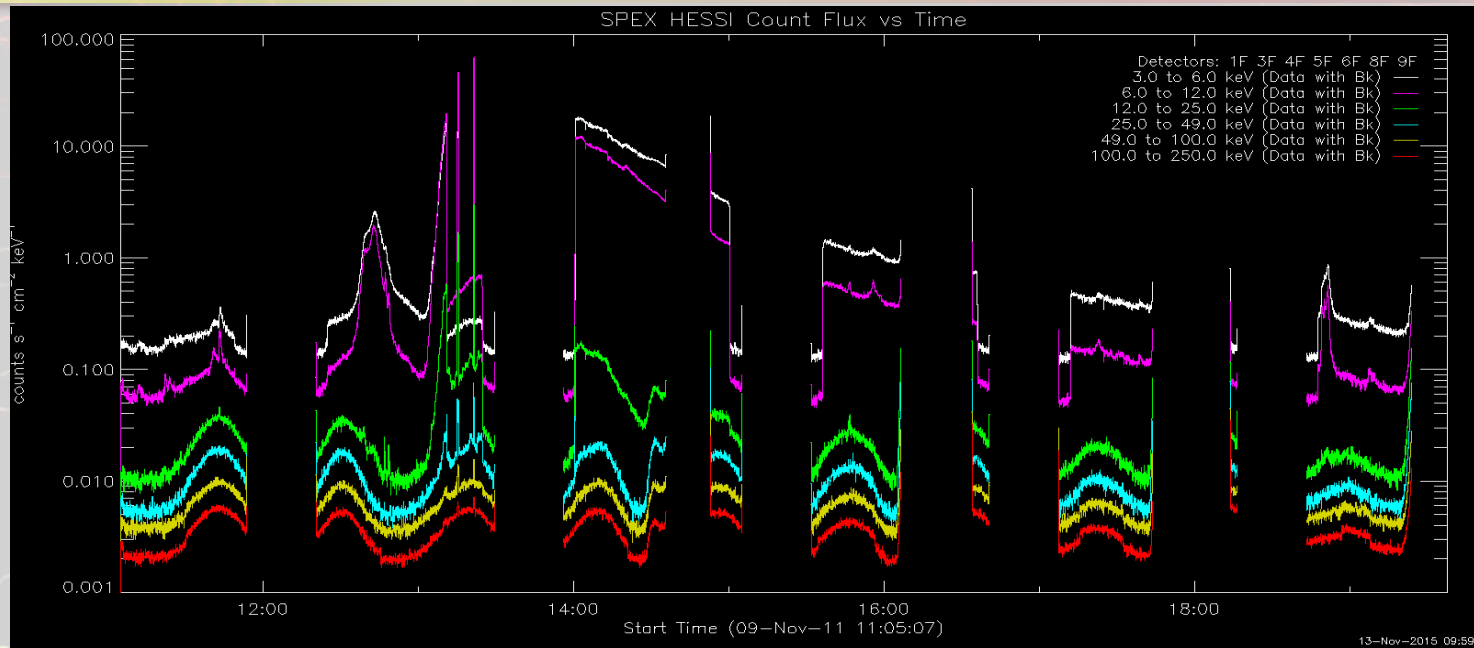


# How severe is particle background problem?



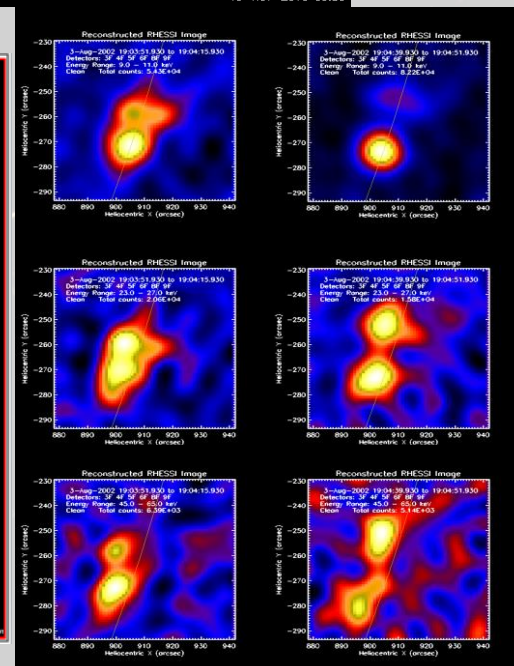
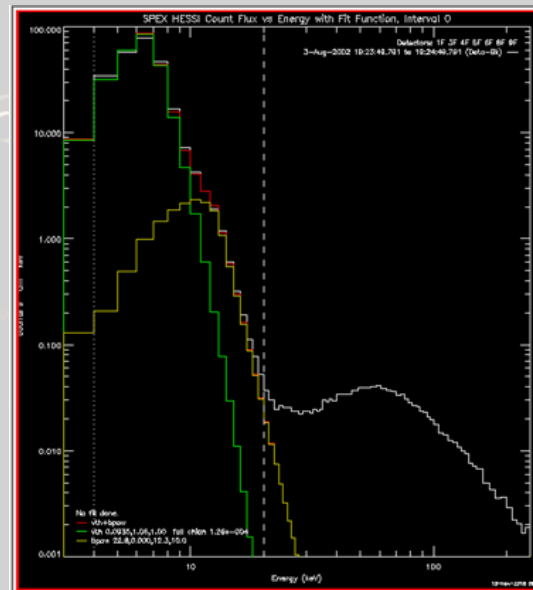
- Orbital background is always present in all energies measured by RHESSI
- Almost sinusoidal shape when the Sun is quiet
- Unpredictable shape during active periods
- Particle signals are changing with time and energy
- Around 60% of data is affected.

# Observations during RHESSI radiation belt passage.



Very often decay phase signal is highly affected by radiation belt passages. Several methods may be used in such case:

- narrow energy range for fitting (cut out high energies)
- imaging spectroscopy – background is not modulated
- ignore flares registered during RHESSI radiation belts passages (means rejection of at least 60% of observations)



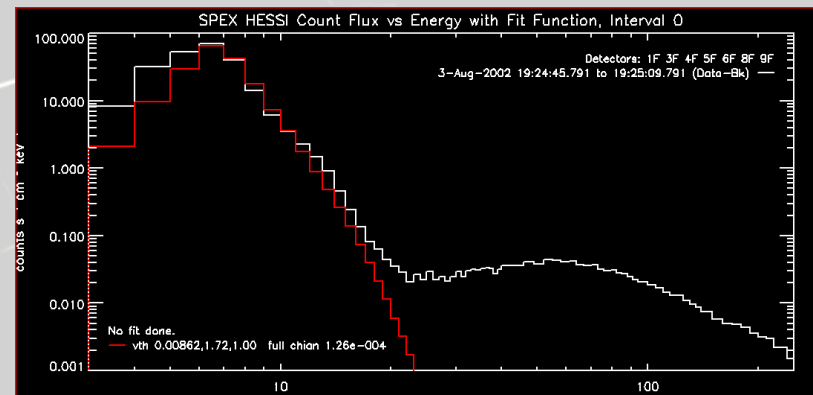
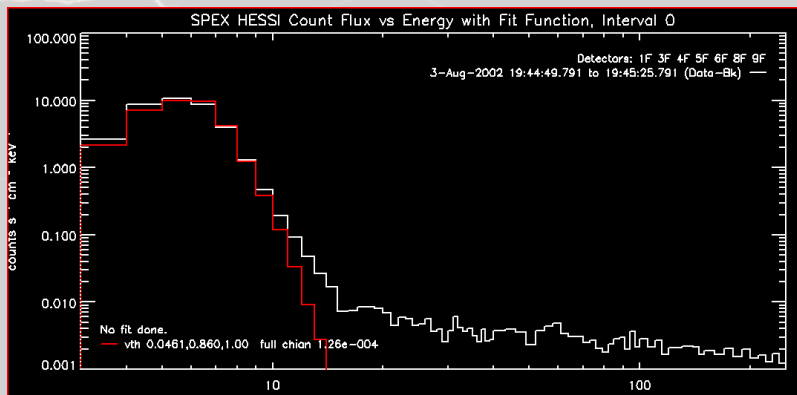
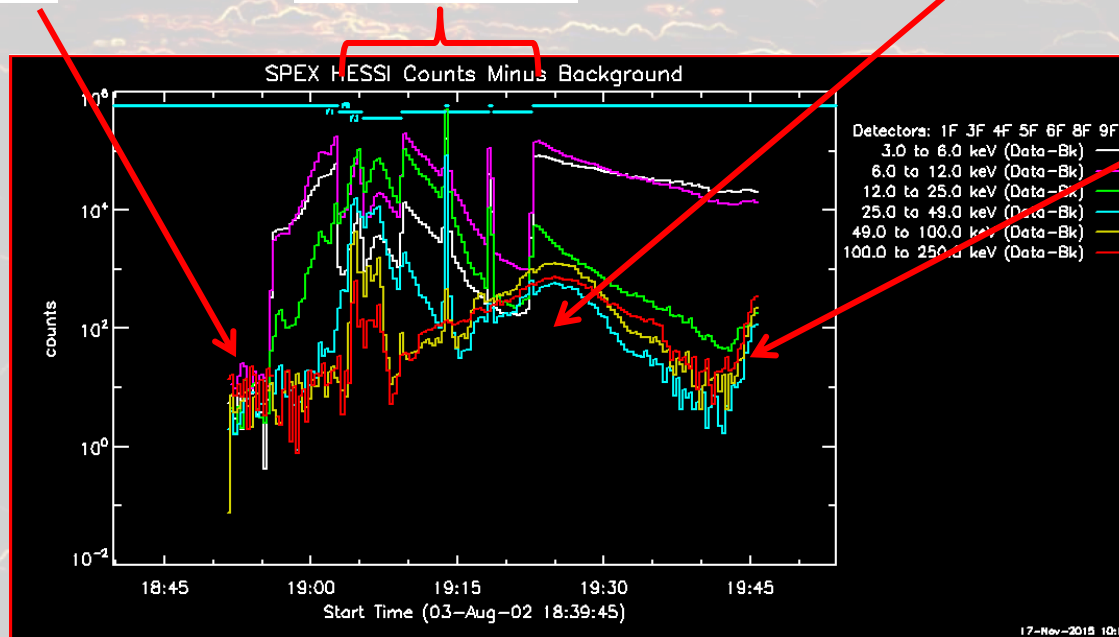
# Why we afraid of this background?

night part of orbit

attenuators in

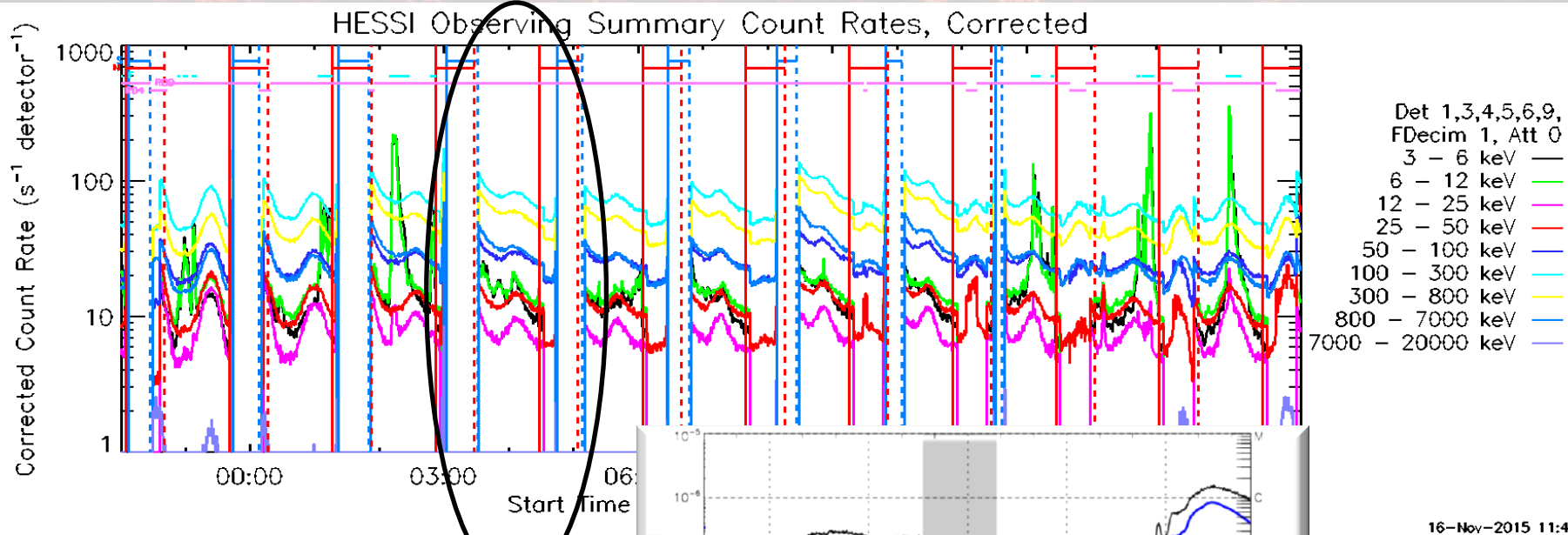
radiation belt passage

SAA entry



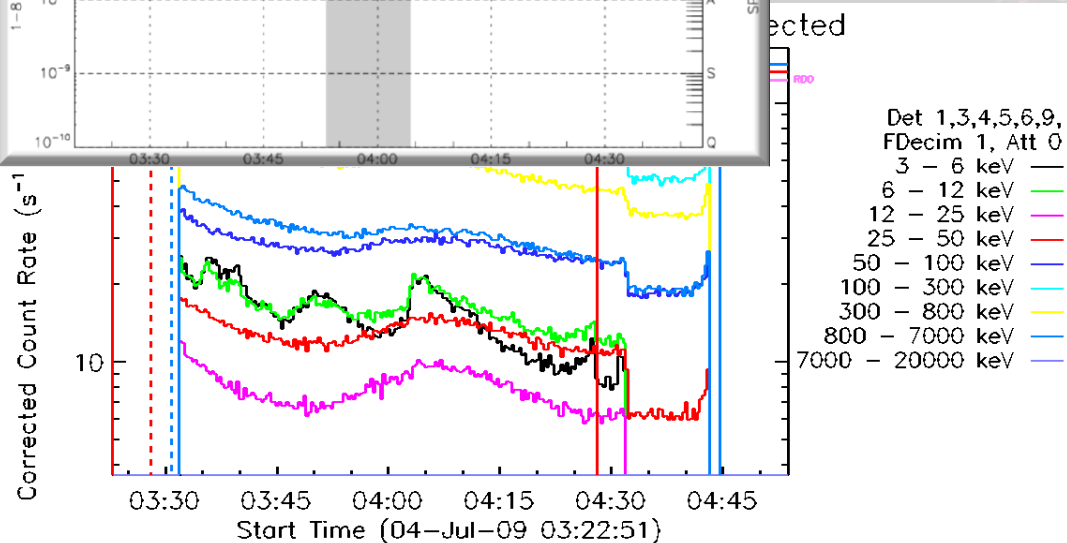
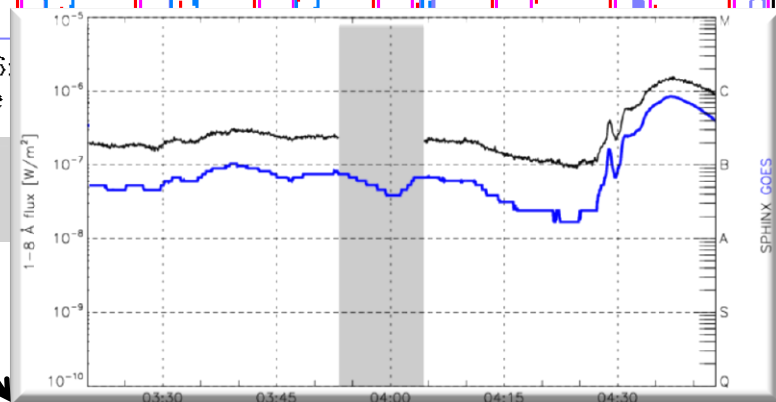
It is not possible to define background from particles with high accuracy. Background changes in intensity and energy – estimation from pre- or after-flare flux is insufficient, especially in case of weak signal measured by RHESSI.

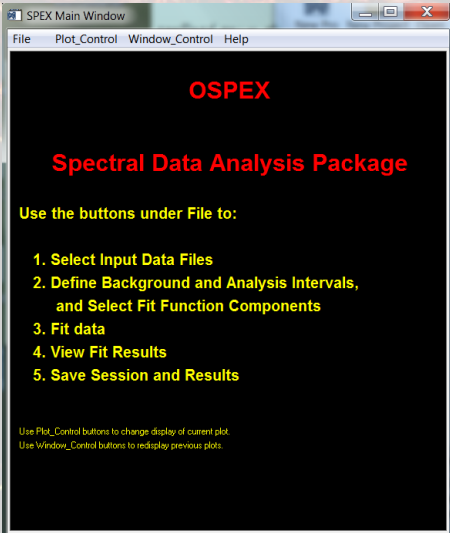
# The aim



We do not want to analyse radiation belt physics from RHESSI data!

Our aim is to reject orbital background, as good as possible, and analyse weak RHESSI signals (SphinX flares, late decay phase of LDEs, micro- and nanoflares etc.)





Load data (RHESSI  
spectrum and DRM files)



# OSPEX

SPEX Main Window

File Plot\_Control Window\_Control Help

## OSPEX

### Spectral Data Analysis Package

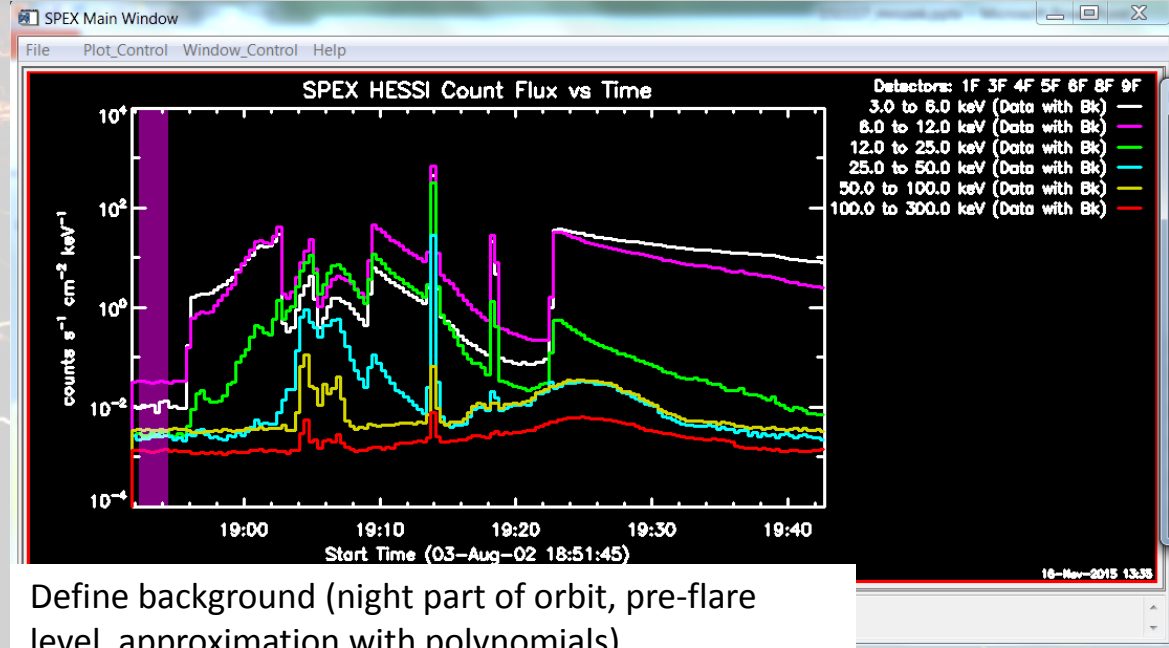
Use the buttons under File to:

1. Select Input Data Files
2. Define Background and Analysis Intervals, and Select Fit Function Components
3. Fit data
4. View Fit Results
5. Save Session and Results

Use Plot\_Control buttons to change display of current plot.  
Use Window\_Control buttons to redisplay previous plots.



Load data (RHESSI spectrum and DRM files)



Define background (night part of orbit, pre-flare level, approximation with polynomials)

# OSPEX

SPEX Main Window

File Plot\_Control Window\_Control Help

## OSPEX

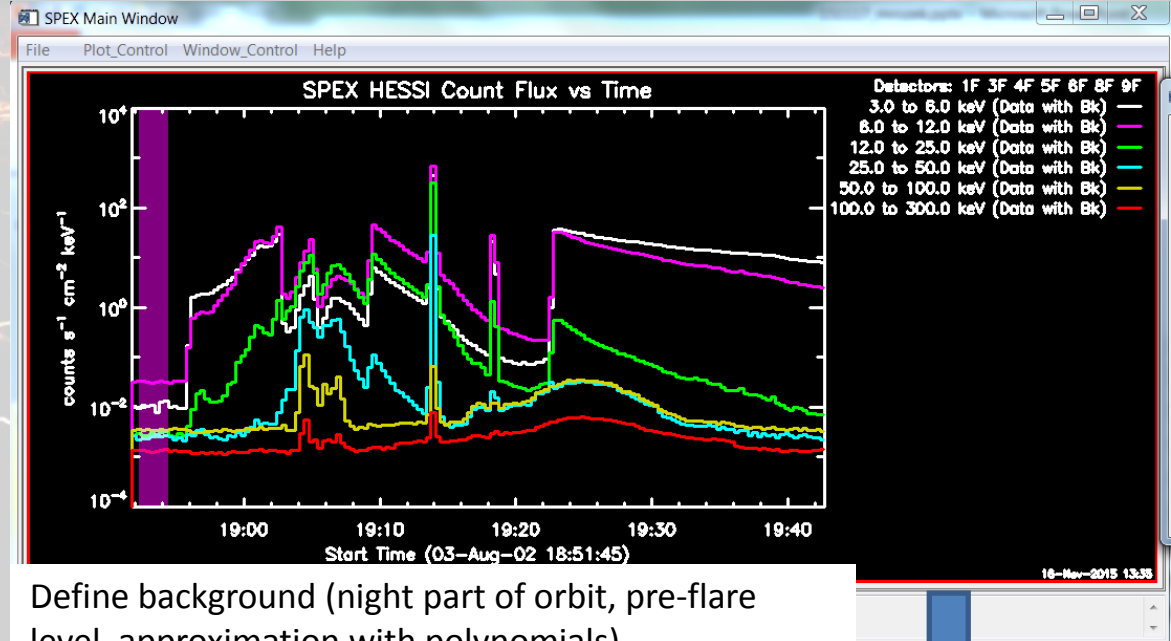
### Spectral Data Analysis Package

Use the buttons under File to:

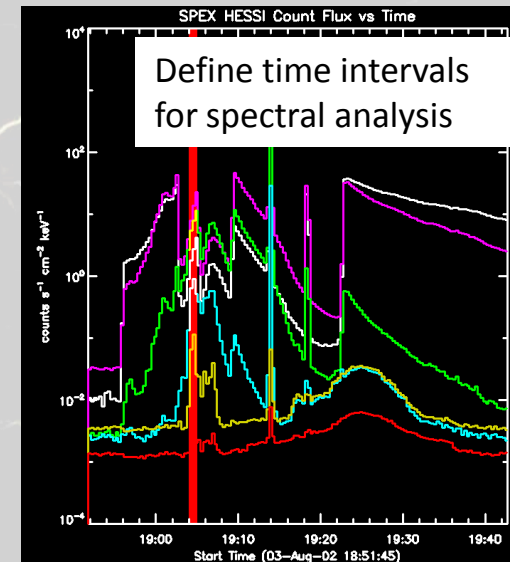
1. Select Input Data Files
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# OSPEX

## OSPEX

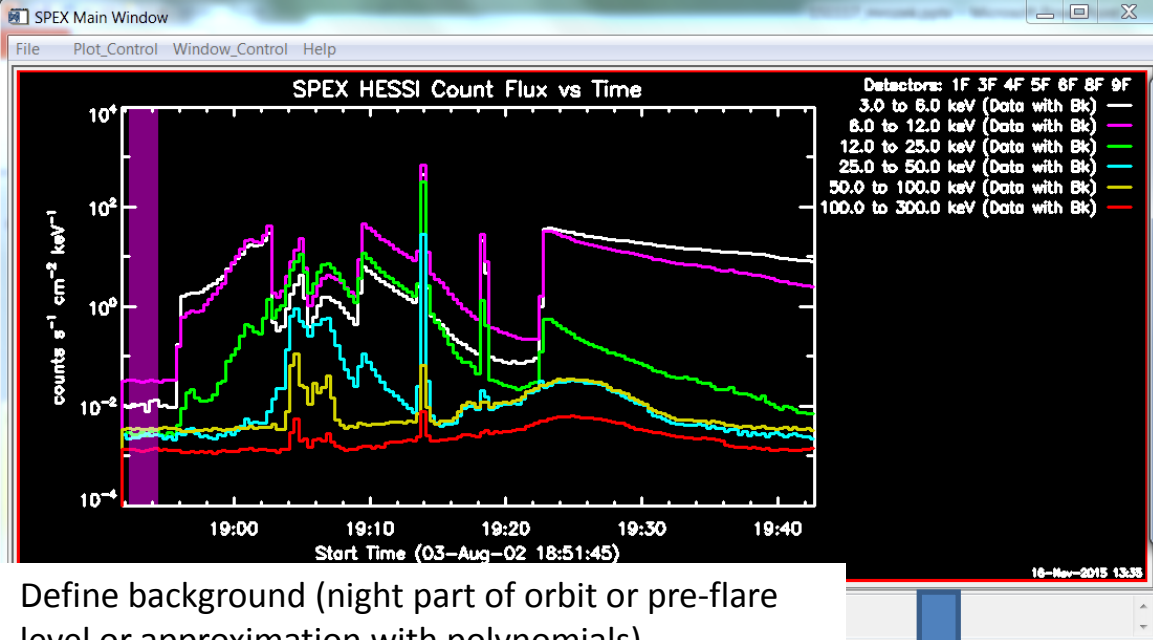
### Spectral Data Analysis Package

Use the buttons under File to:

1. Select Input Data Files
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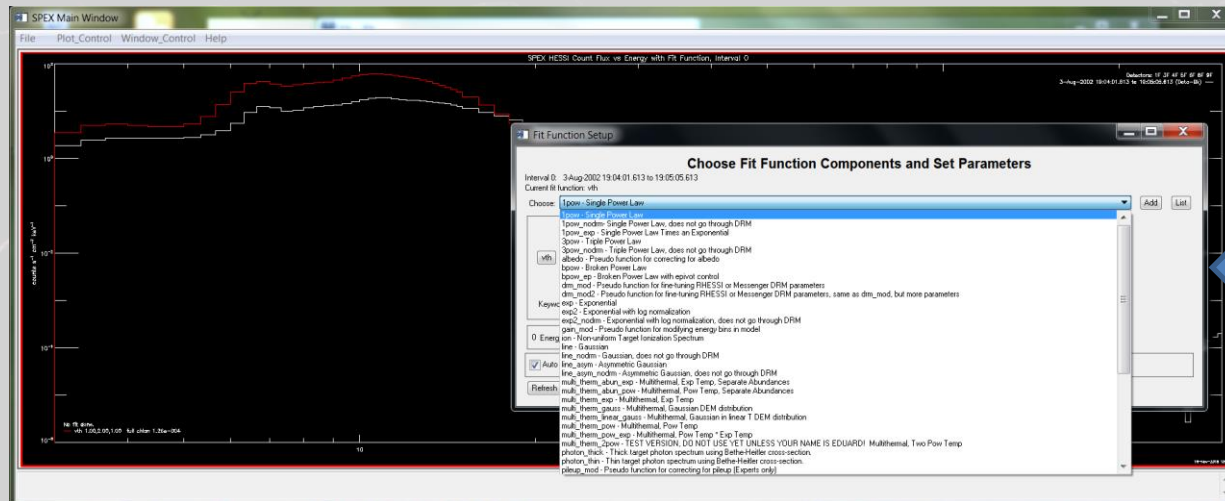
Use Plot\_Control buttons to change display of current plot.  
Use Window\_Control buttons to redisplay previous plots.

Load data (RHESSI spectrum and DRM files)

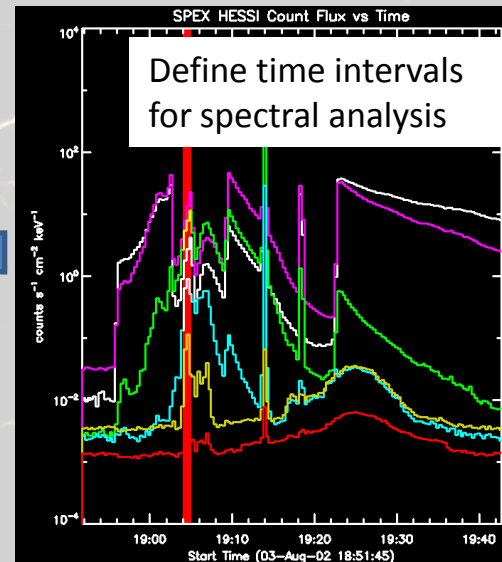


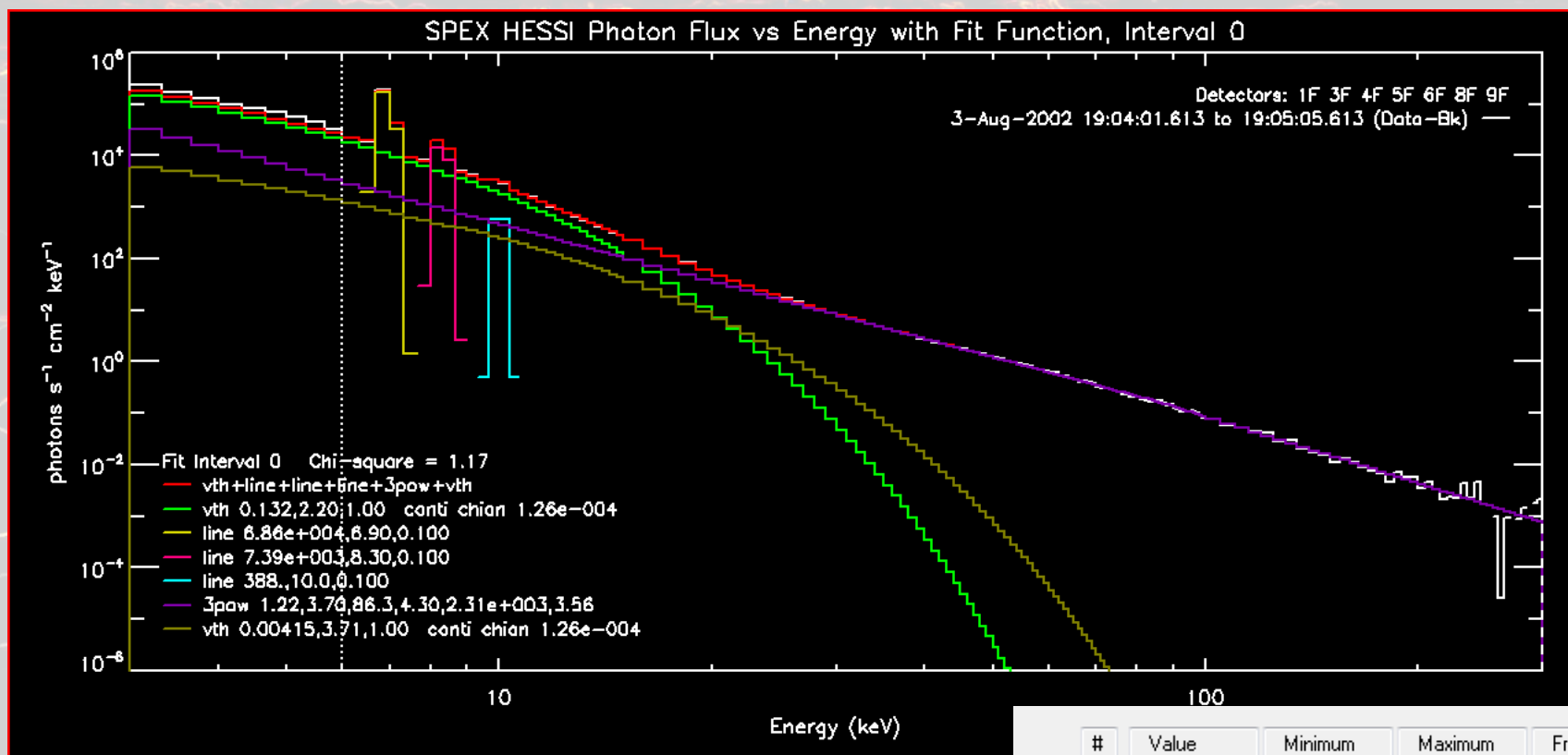
Define background (night part of orbit or pre-flare level or approximation with polynomials)

Define time intervals for spectral analysis

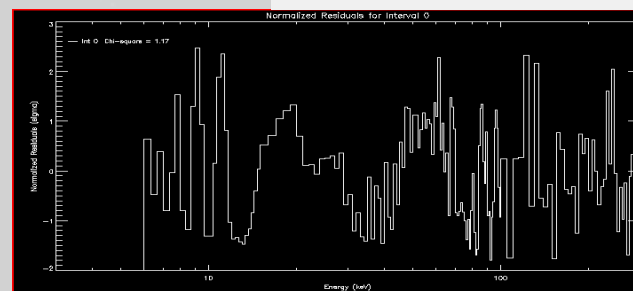


Build a model with a use of pre-defined functions and perform fitting

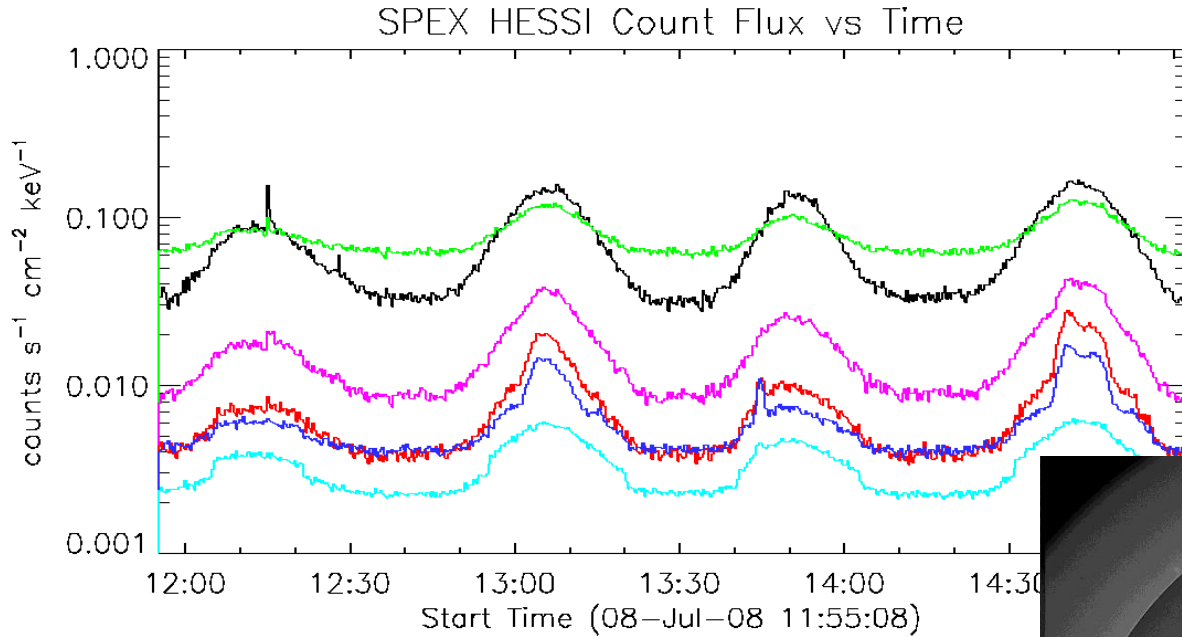




- energy range may be narrowed
- 3-4 keV problems with DRM
- Ge fluorescence
- attenuators
- each function's parameter may be free/fixed
- good fit – random residuals
- ... and much more

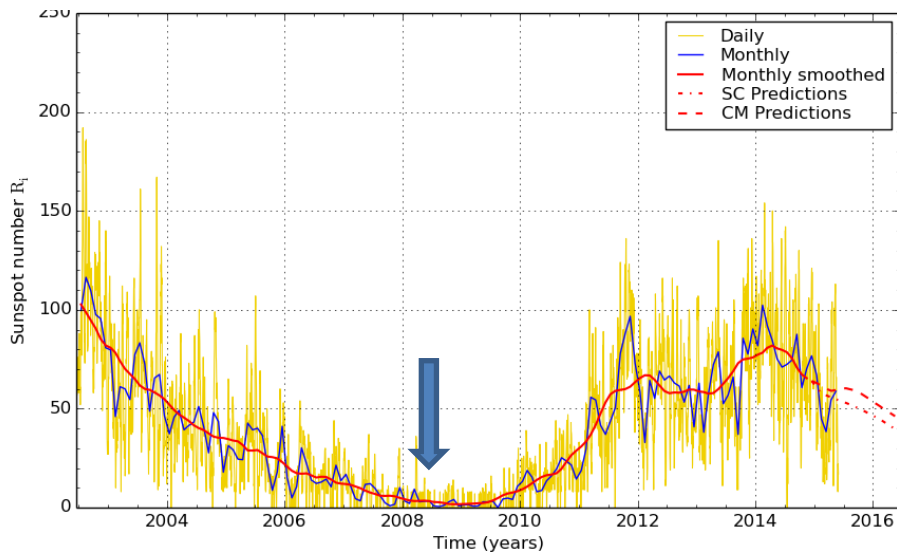


# Orbital background spectrum



Detectors: 1F 3F 6F 8F 9F  
 3.0 to 6.0 keV (Data with Bk) —  
 6.0 to 12.0 keV (Data with Bk) —  
 12.0 to 25.0 keV (Data with Bk) —  
 25.0 to 49.0 keV (Data with Bk) —  
 49.0 to 100.0 keV (Data with Bk) —  
 100.0 to 250.0 keV (Data with Bk) —

We selected intervals when Sun was extremely quiet.

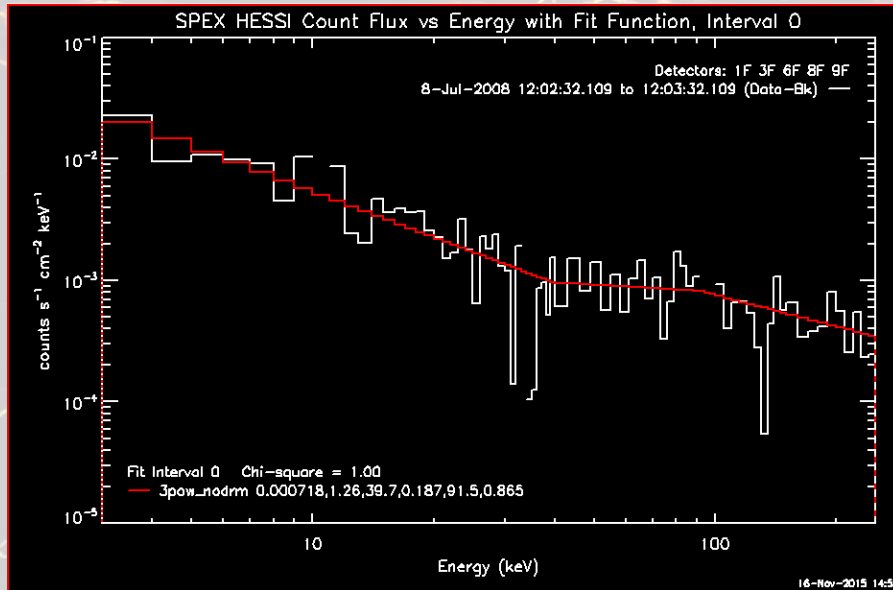


SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium 2015 June 1



6-Jul-2008, Kanzelhoehe observatory (H $\alpha$ )

# Orbital background spectrum

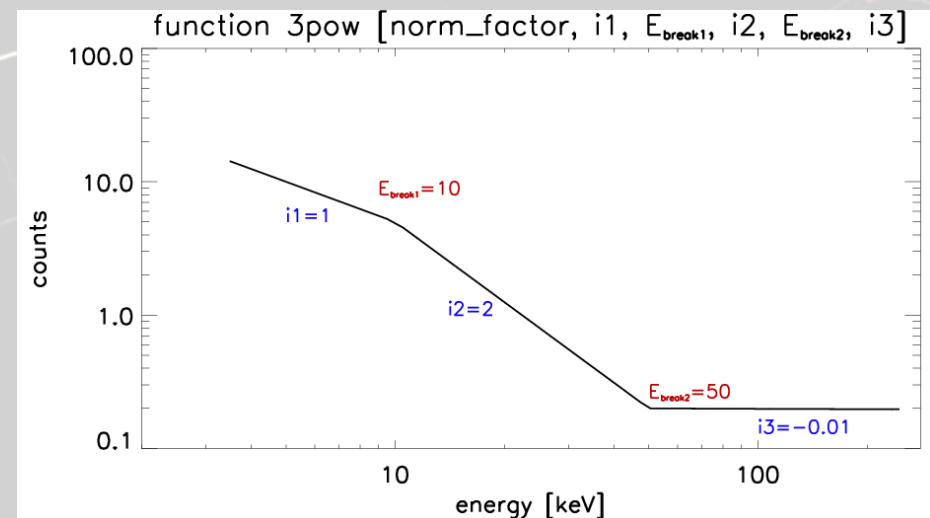
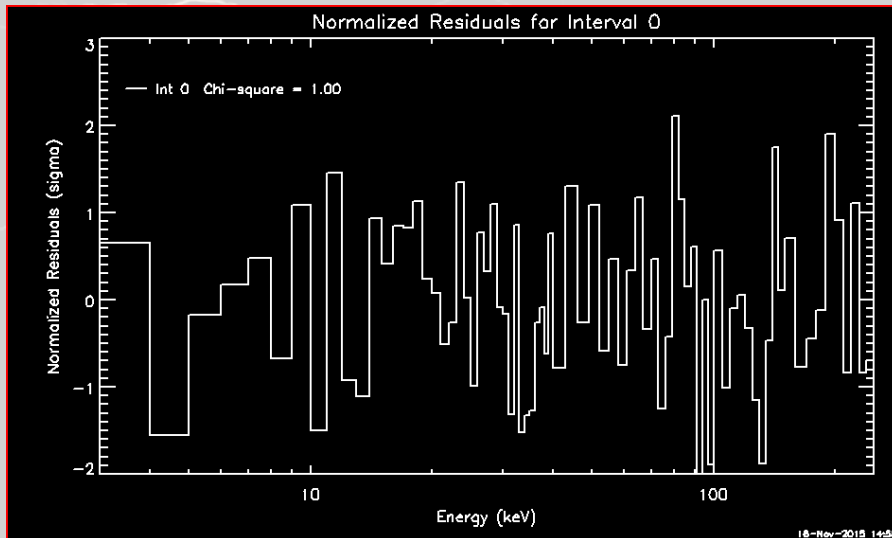


f\_3pow (without DRM processing) with all parameters free.

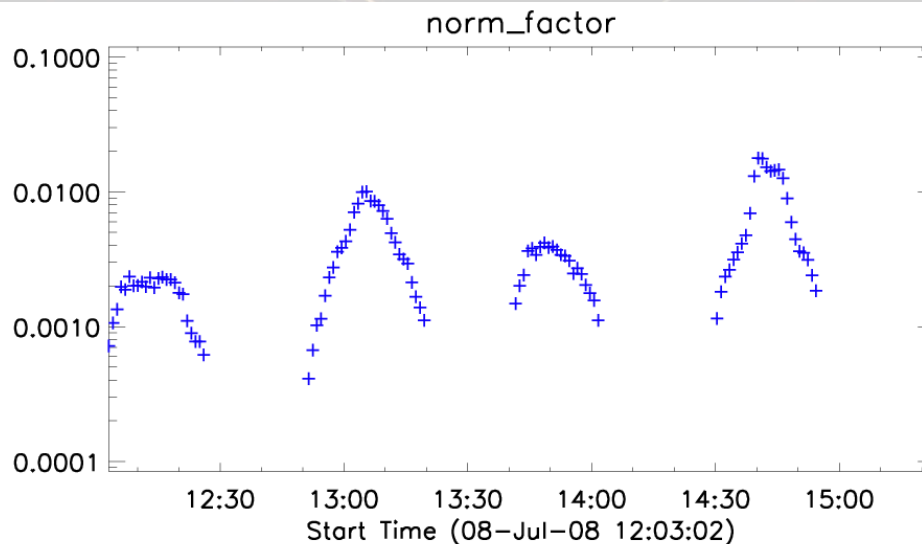
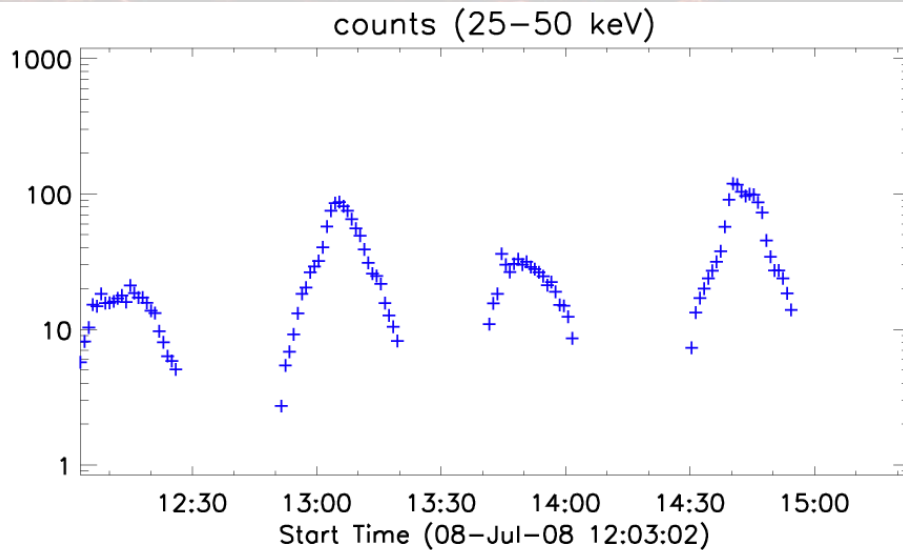
All fits are of good quality (residuals are random, Chi-square < 1.0)

#	Value	Minimum	Maximum	Free (green)
0	0.00184609	1E-020	1E+020	<input checked="" type="checkbox"/>
1	1.12427	0.1	6	<input checked="" type="checkbox"/>
2	49.1174	10	50	<input checked="" type="checkbox"/>
3	0.206165	-3	6	<input checked="" type="checkbox"/>
4	159.603	90	200	<input checked="" type="checkbox"/>
5	1.36564	0.1	6	<input checked="" type="checkbox"/>

3pow\_nodrm



# Orbital background spectrum



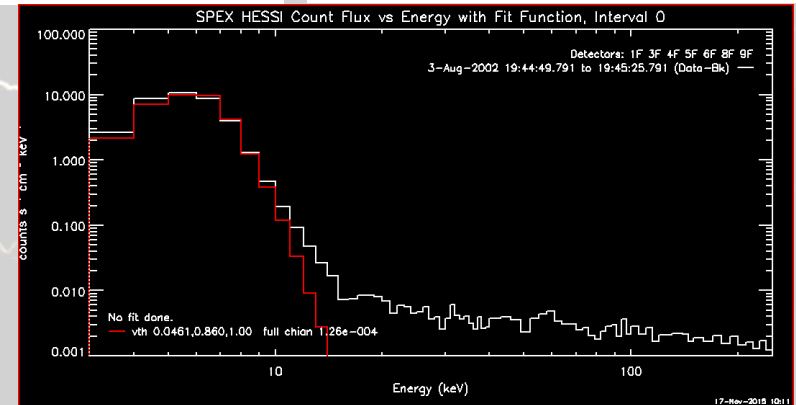
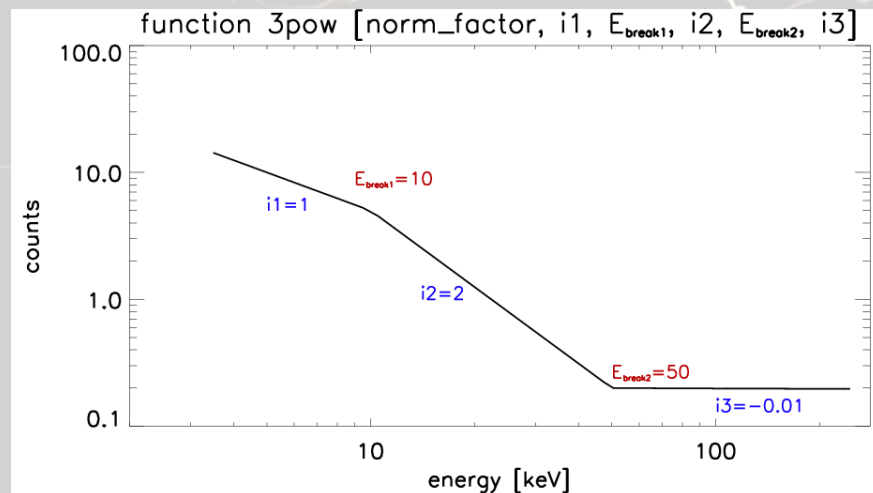
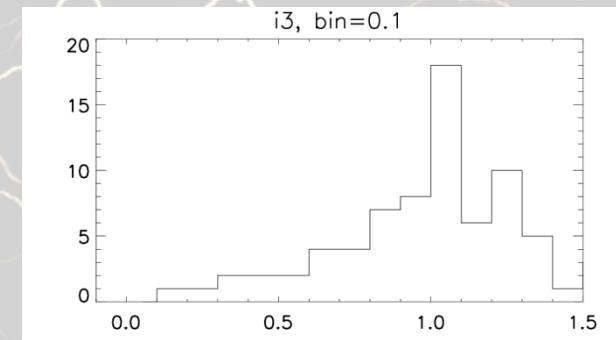
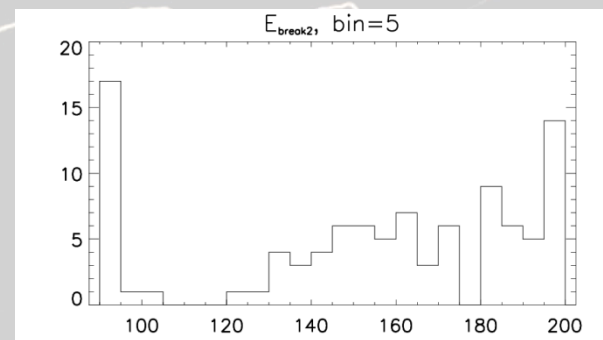
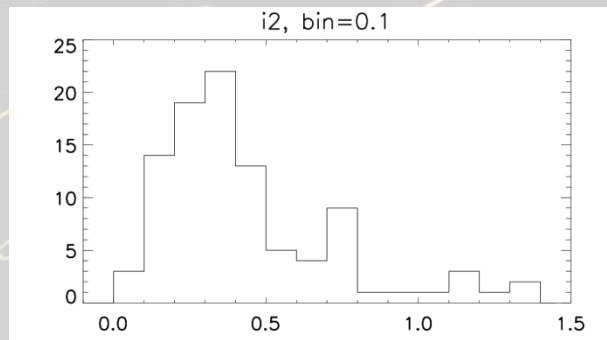
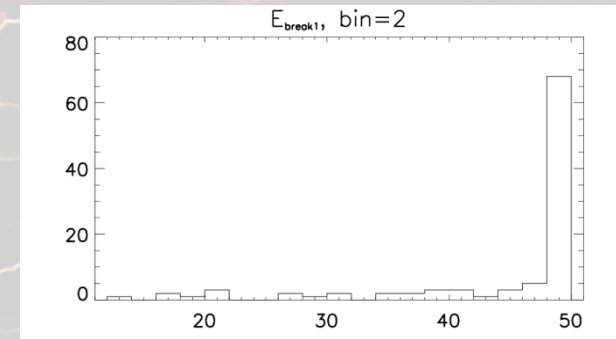
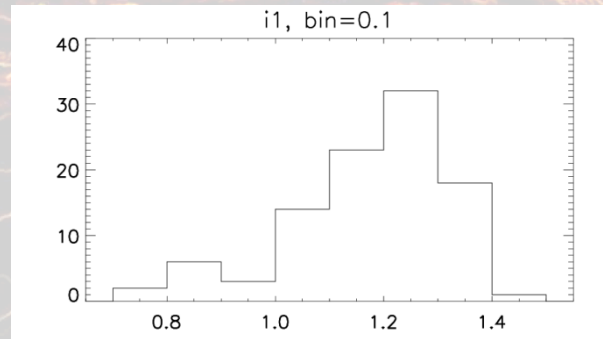
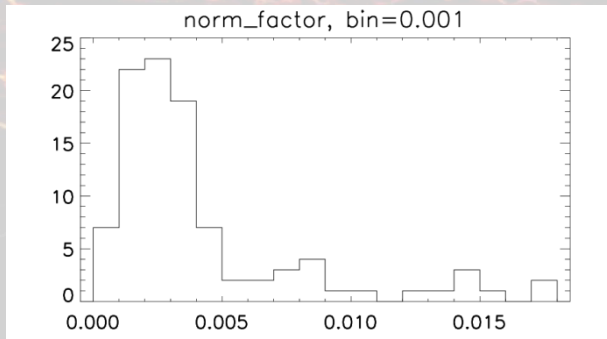
Count rates correlate well with normalization coefficient.

Fits get worse for higher signal, more variable background, SAA passages etc., but still give valuable estimation of background.

Other parameters are less correlated with overall evolution of count rates, but we are able to estimate range of their changes.

#	Value	Minimum	Maximum	Free (green)
0	0.00184609	1E-020	1E+020	<input checked="" type="checkbox"/>
1	1.12427	0.1	6	<input checked="" type="checkbox"/>
2	49.1174	10	50	<input checked="" type="checkbox"/>
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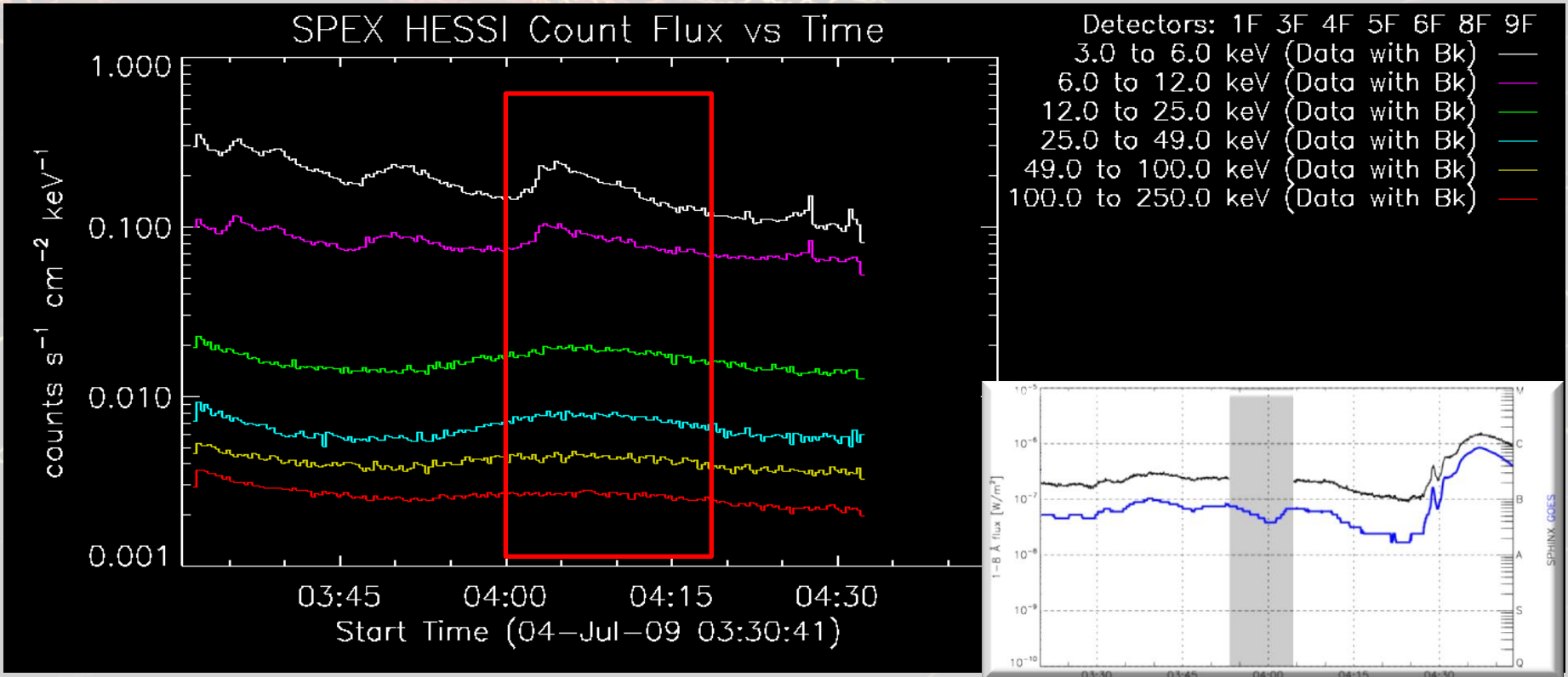
# Orbital background spectrum



The 3pow fit is „controlled” by high energy counts. Therefore we assumed that obtained ranges are enough to make all parameters free for flare observations.



4-Jul-2009

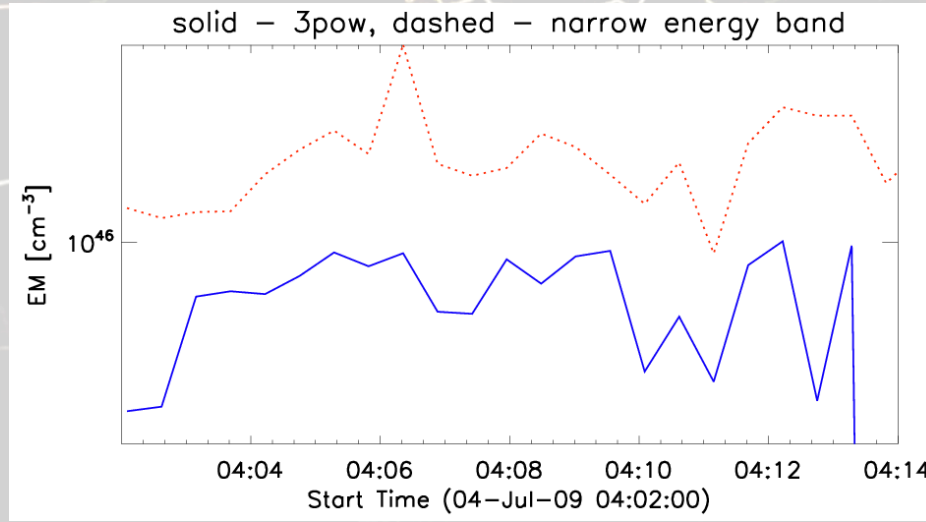
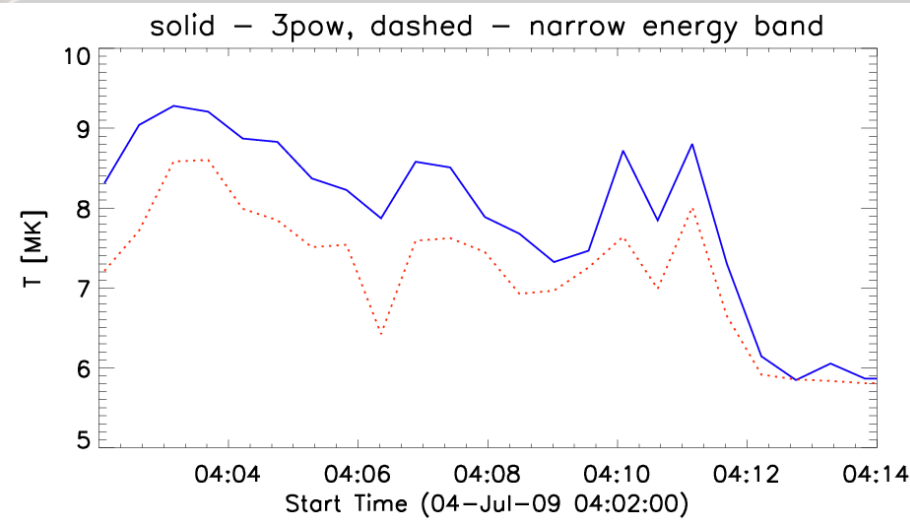
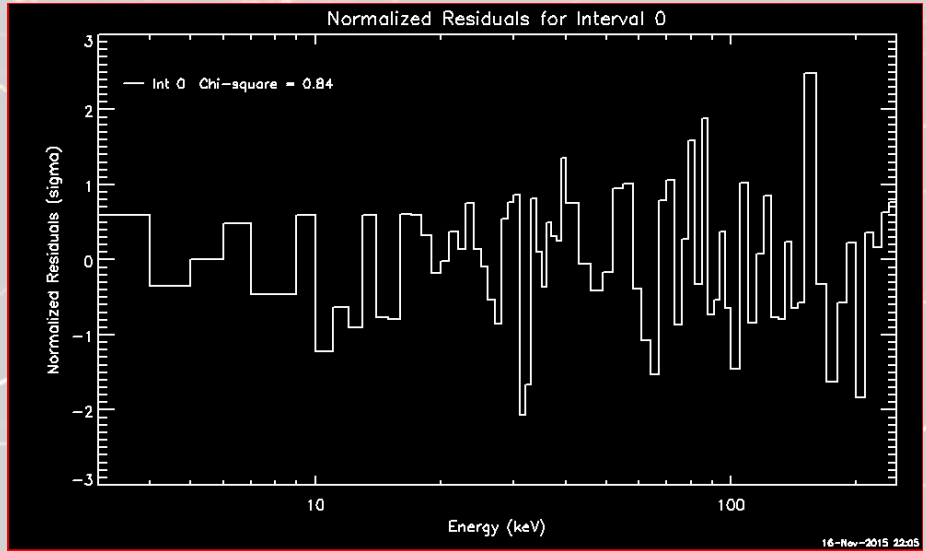
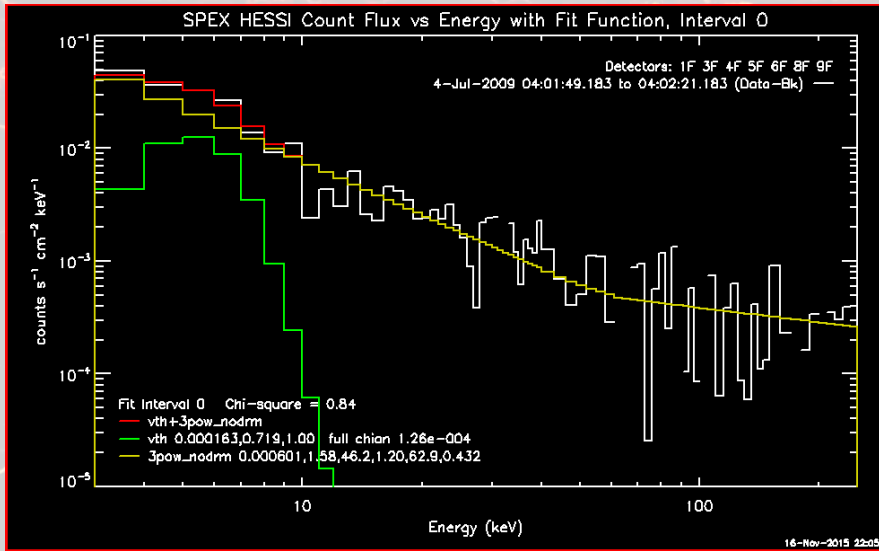


Observation from July 2009 – overlapping SphinX observations exist. This case was rejected from previous analysis of RHESSI-SphinX flares.

Two approaches:

- background subtracted from pre-flare spectrum
- above + additional 3pow function for estimation of particles influence

4-Jul-2009



Plasma parameters show similar shape of time evolution, but values differ in temperature by 5-15%, and in density by 10-40%.

## Final remarks

- We tried to estimate particle background in RHESSI data with a use of additional component in spectral model fit.
- It was found that obtained plasma parameters may differ significantly from the ones calculated with standard methods of background estimation.
- High signals in radiation belts should be also investigated, but F\_3BPOW needs some modifications (power-law index  $< -0.01$ )
- Stronger flares are less affected by orbital background – fit parameters are similar, however for 3bpow function obtained plasma parameters are less noisy
- We significantly increase number of SphinX-RHESSI events (60% is affected by RB).
- SAA borders need similar work.

