SphinX Events Catalogue: Progress report

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Abstract

Solar Photometer in X-rays (SphinX) was designed to measure soft X-ray emission from the Sun as a star in the energy range between 1.2 keV and 15 keV. The instrument operated aboard the CORONAS-Photon satellite from February to November 2009, during the phase of unprecedently low minimum of solar activity. SphinX as a high sensitive spectrophotometer was able to reliably measure solar X-ray emission at levels even much below GOES threshold. Thanks to this, SphinX observations provide a large database of weak flare and X-ray brightennings. Our goal is preparation of the catalogue of X-ray flare events based on interpretation of SphinX lightcurves. The catalogue will contain set of characteristics for every flare, micro-flare or brightenning which will be a subject of further statistical analysis. Important problems of background subtraction and deconvolution of complicated lightcurve into components will be described.

# SphinX Events Catalogue: Progress report

OUTLINE

- Sphinx instrument

- Sphinx observations

- Elementary SXR lightcurve flares profile

- Flares characteristics

- Flare fitting routine

- Examples of fitting

- Future plans

SphinX: Solar Photometer in X-ray

BASIC INFORMATIONS

LAUNCHED:	30 January 2009 at 13:30 UT from Plesetsk Cosmodrom
SATELLITE:	CORONAS – Photon
ORBITS PARAMETERS:	orbit duration- 96min altitude - 550km near polar orbit
MASS:	3.7 kg
POWER:	10 W
ENERGY RANGE:	1.2 keV - 15 keV in 256 energy bins
LIFESPAN OF THE MISSION:	20 February - 29 November 2009

CORONAS - Photon
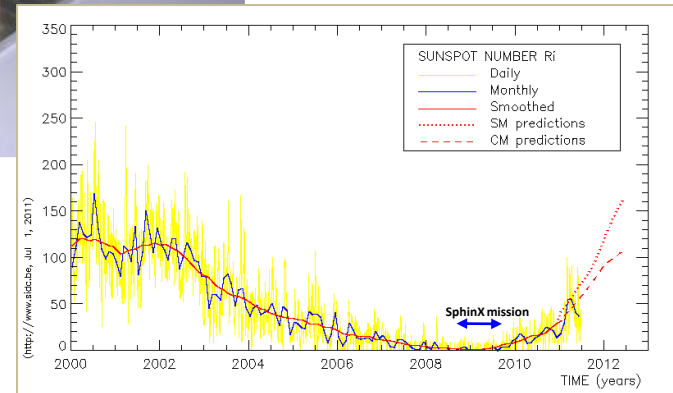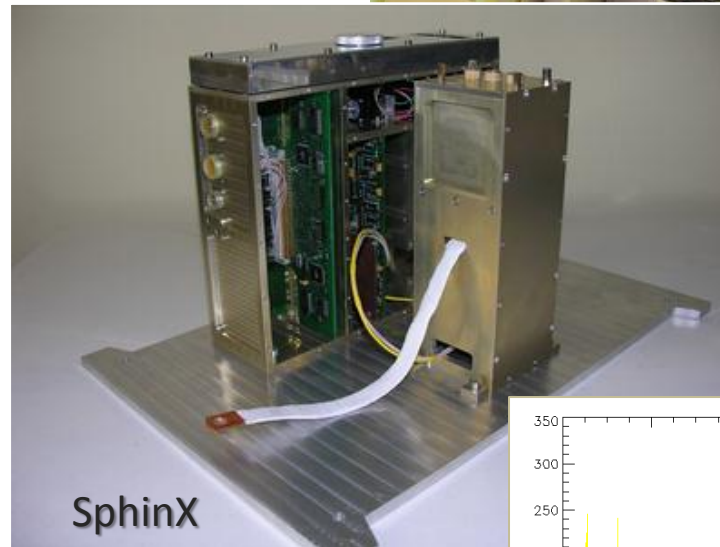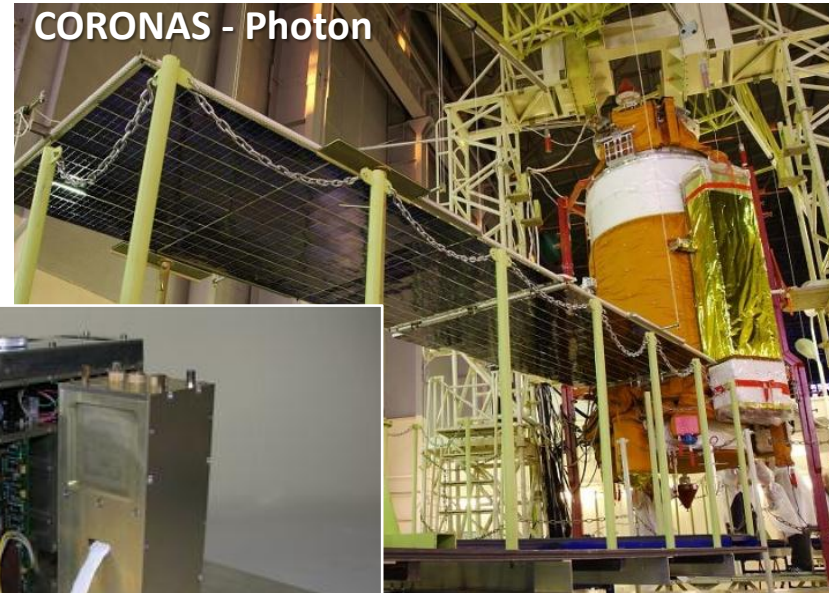
SphinX

SphinX Mission Observations, 2009
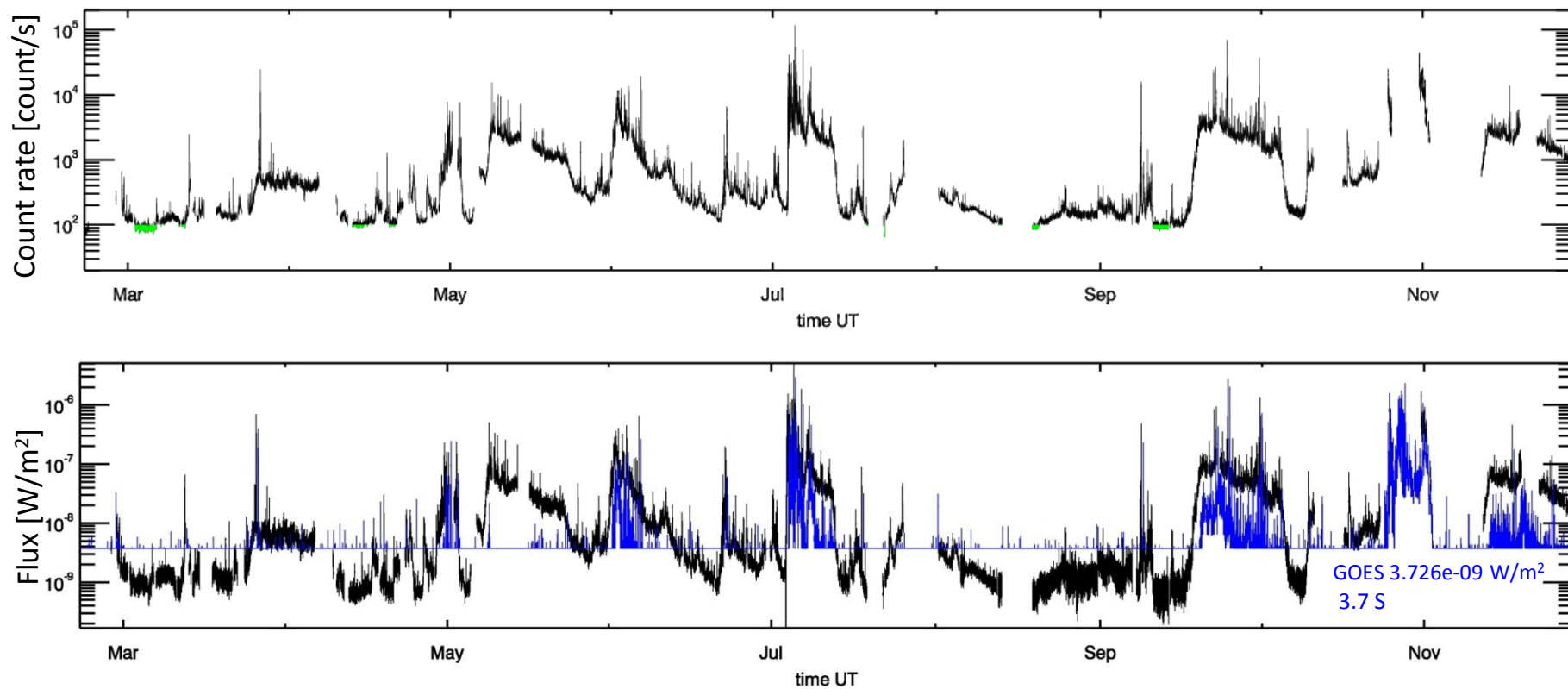
NEW SXR FLARES CLASSES:
S CLASS - S1 = 1. e-09 W/m²
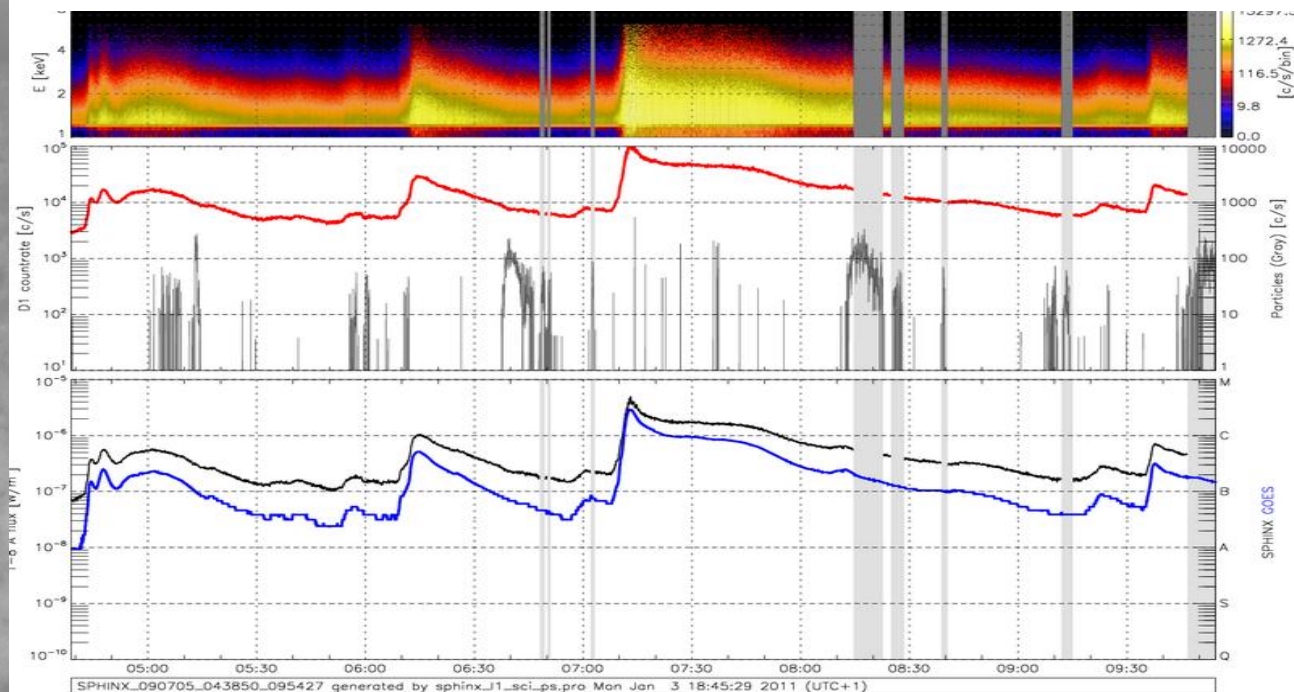Q CLASS - Q1 = 1. e-10 W/m²
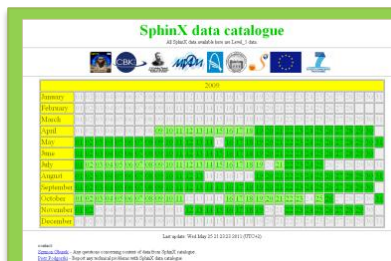
SphinX level1 data catalogue

- The catalog contains data from D1 SphinX detector
- All available data files are stored in FITS format
  (OGIP-93/003 format)

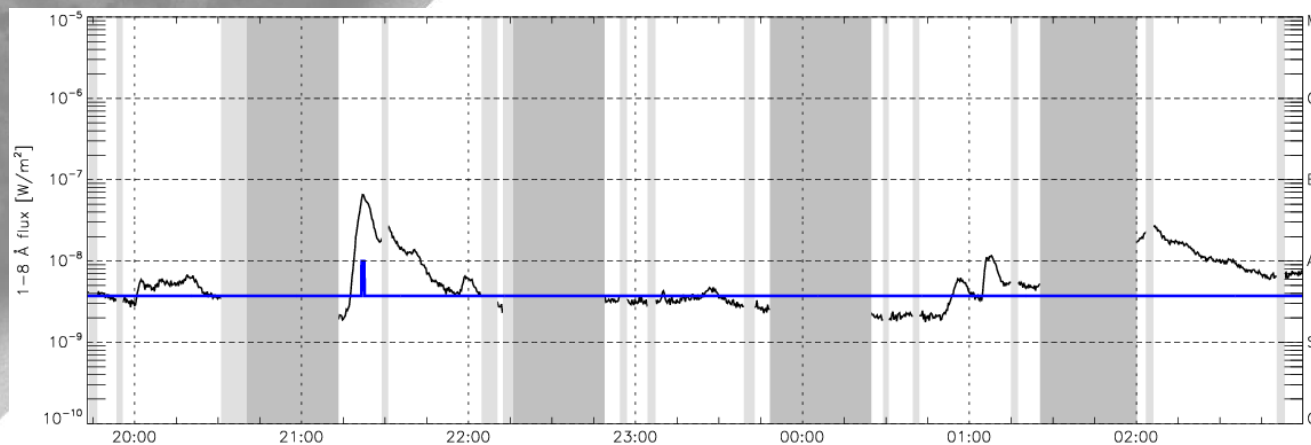http://156.17.94.1/sphinx_l1_catalogue/SphinX_cat_main.html

The largest flare observed by SphinX spectrophotometer

5th **July 2009**

C 2.7 GOES class flare

Examples of flare observed by SphinX

21th **June 2009**

GOES 3.726e-09 W/m²
3.7 S

SPHINX OPERATION MODES:

Basic mode:
- provides only lightcurves in 4 energy bands

Spectral mode:
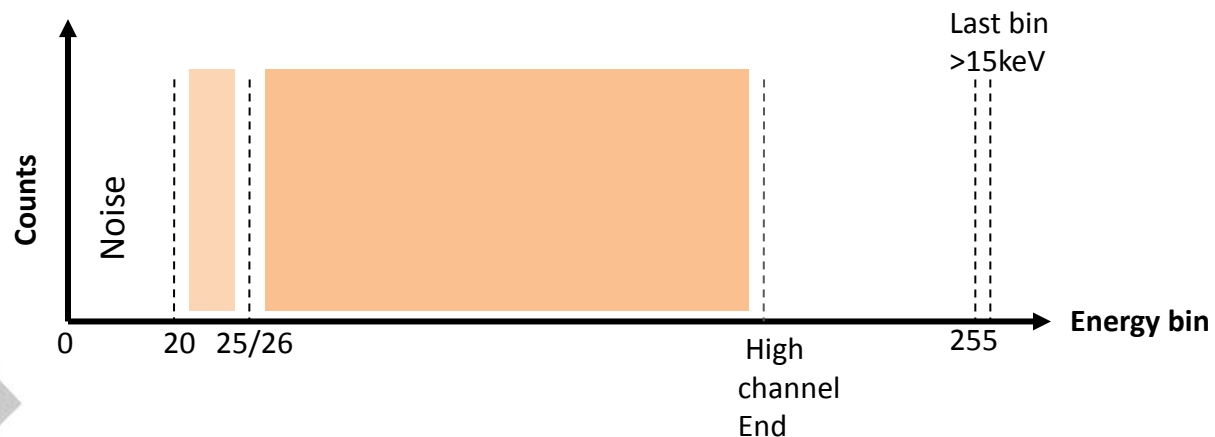- provides spectra (256 channels)

<u>Sequence mode:</u>
- provides full data – sequence of detector events described with their energies (in 256 bins) and arrival times
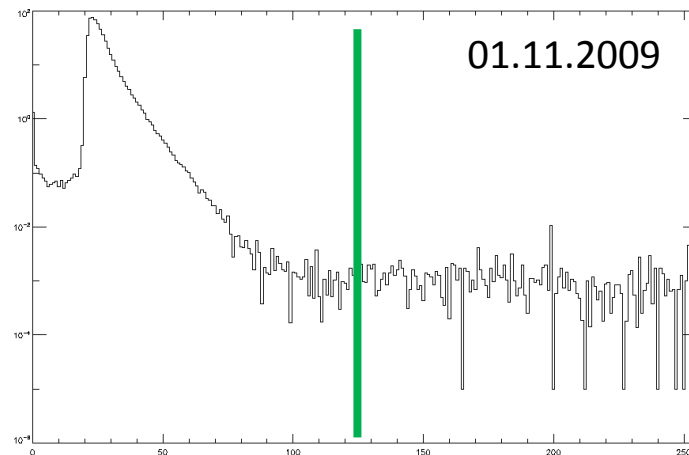
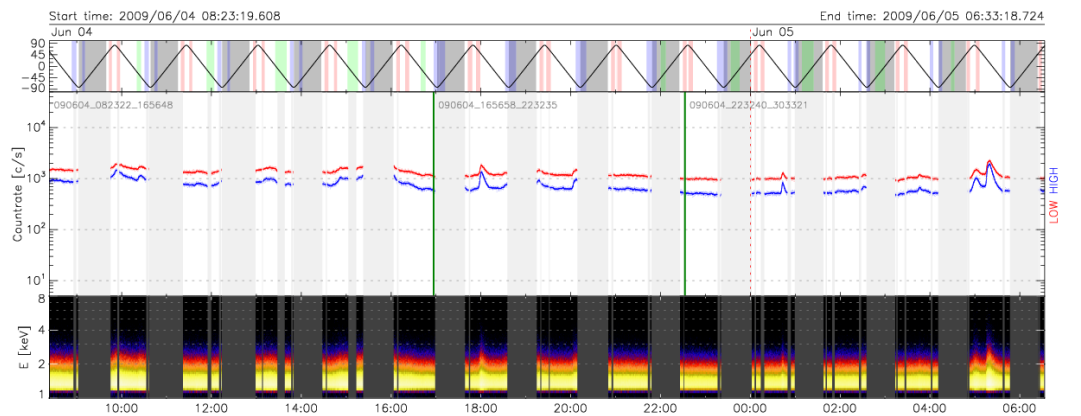# Two Spectral Channels – High & Low

SphinX lightcurves in two channels:

Low (red curve): countrates of photons within energy range 1.16 - 1.5 keV.

High (blue curve): countrates of photons within energy range 1.5 - 15.07 keV.

Elementary Soft X-ray Flare Profile

CONVOLUTION OF TWO FUNCTIONS:

Gauss function

$$f(t) = A e^{(-(t-B)^2/C^2)}$$
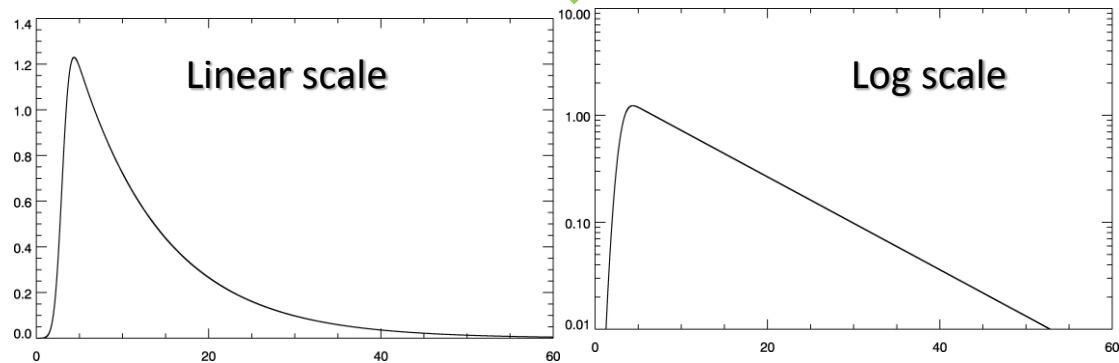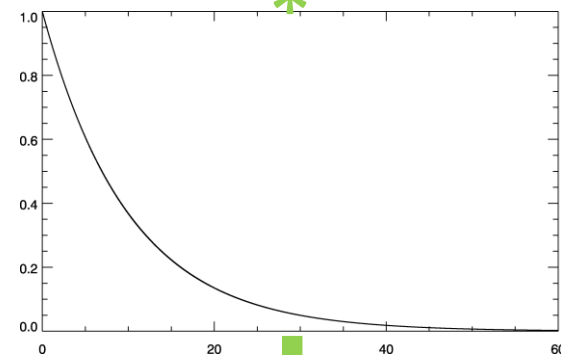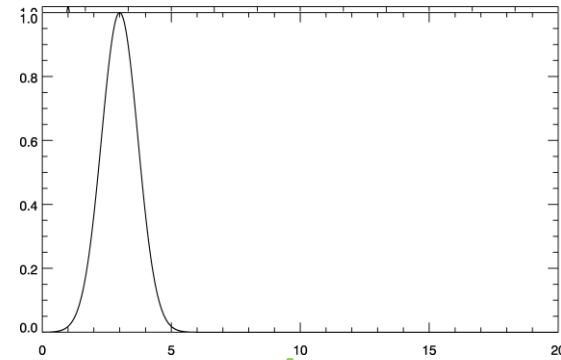
Exponential function

$$f(t) = e^{(-Dt)}$$

FLARE PROFILE FORMULA:

$$F(t) = 0.5 \sqrt{\pi} \ A \ C \ exp(D(B-t) + (C^2 D^2)/4) \cdot$$
$$[erf((2B + C^2 D)/2C) - erf((2(B-t) + C^2 D)/2C)] +$$
$$+ Et + F$$

Linear background

$$f_{bg}(t) = Et + F$$

4 parameters (flare) +
2 parameters (linear background-
attributable) = 6 PARAMETERS

*

Linear scale

Log scale

Flares Characteristics

PARAMETERS:
T_{start} time of start
T_{end} time of end
T_{max} time of maximum
Flare magnitude

FLARE AFTER BACKGROUND SUBTRACTION

T_{start} T_{max} T_{end}

Flare magnitude

Count rate [c/s]

Optimal fitting

Linear background
$f_{backg}(t) = E\,t + F$

1% above the background level

Time [s] from 2009-07-07 10:01:07.298
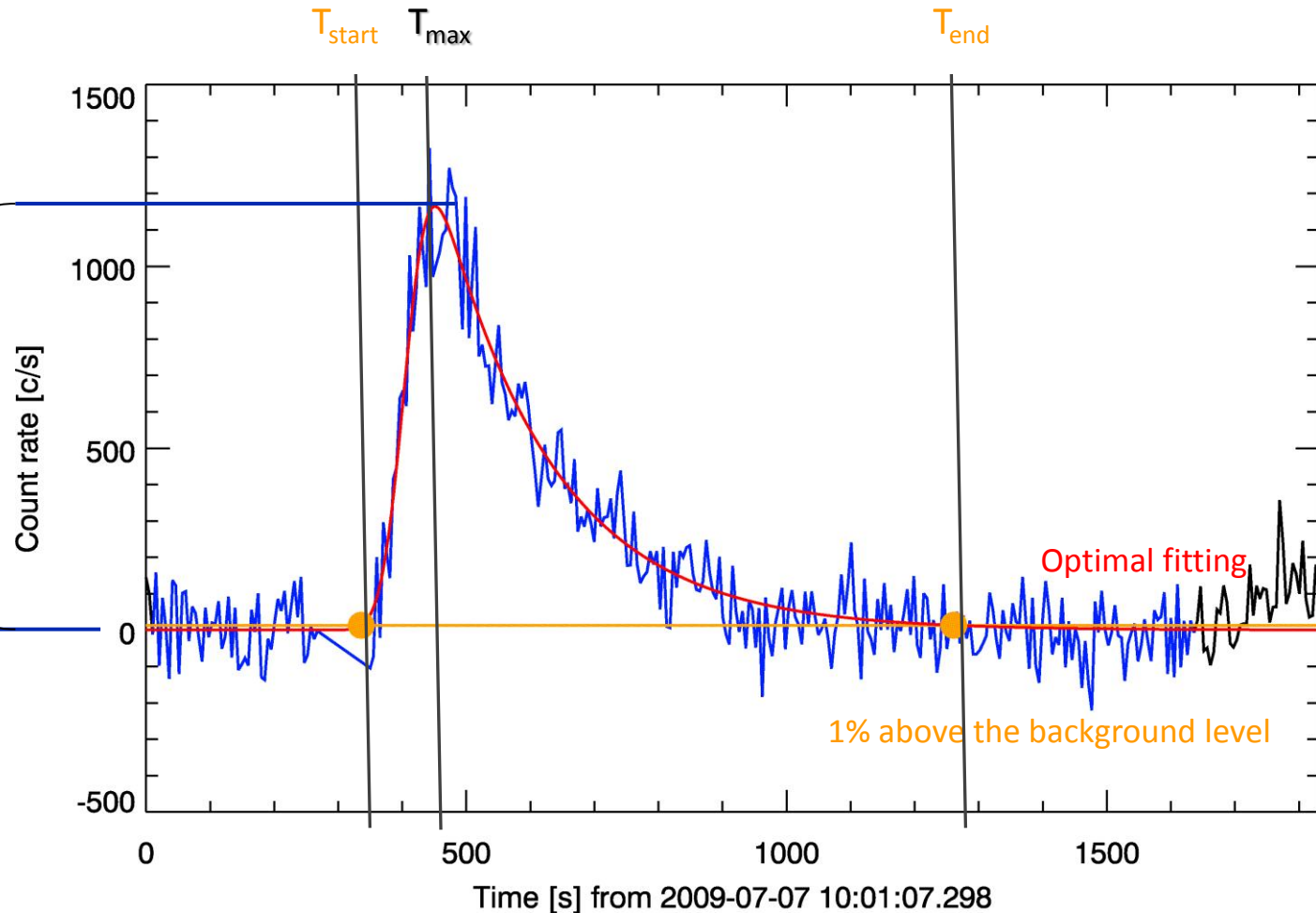
Flare fitting routine (FlareFit v1.0)
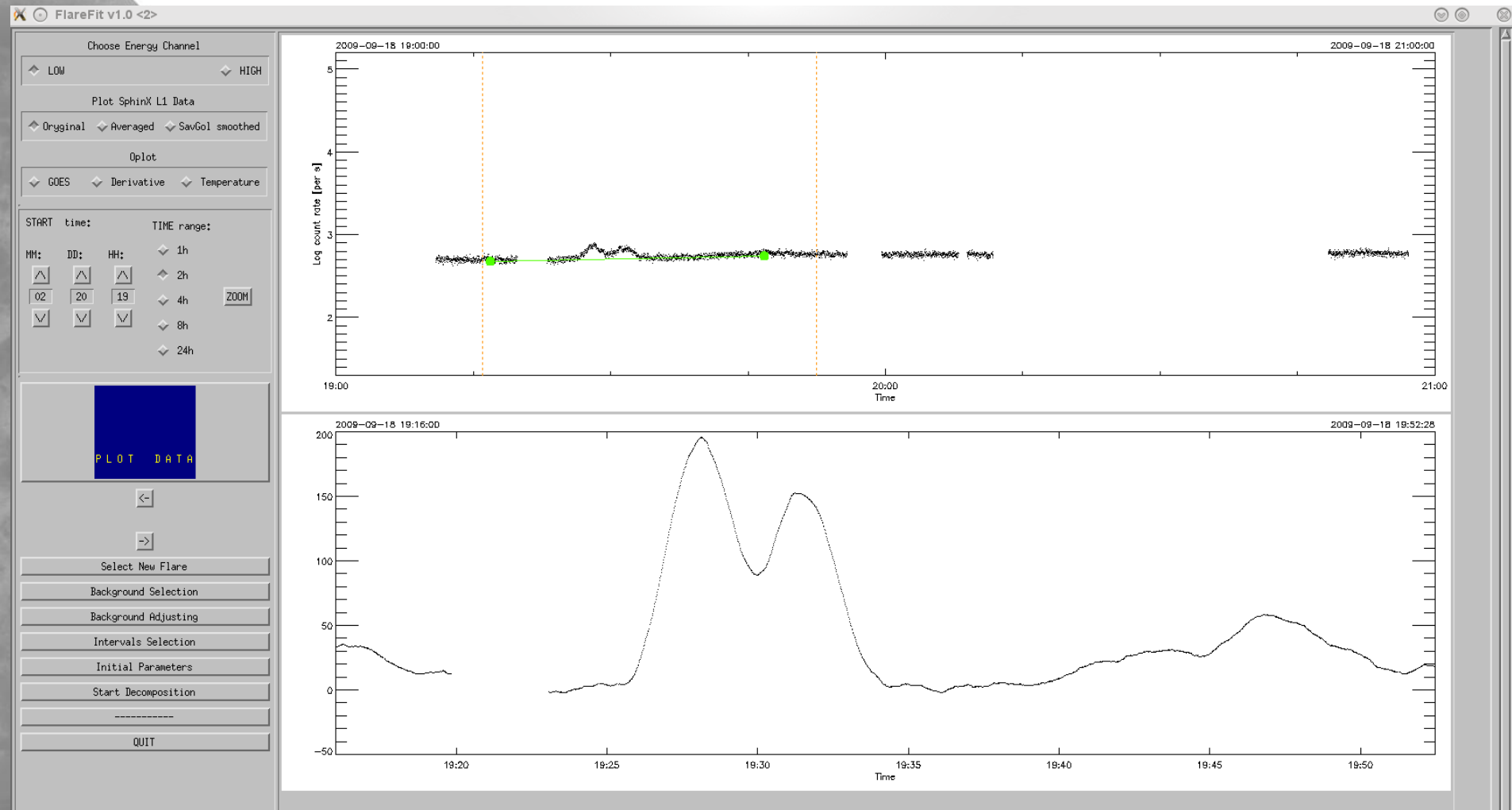
Scheme of FlareFit routine

Lightcurve to work with
High/Low channel

Flare

Steps of profiles fitting

Background
selection

Selection of data points for
fitting method

Profile Fitting
And
Profile subtraction
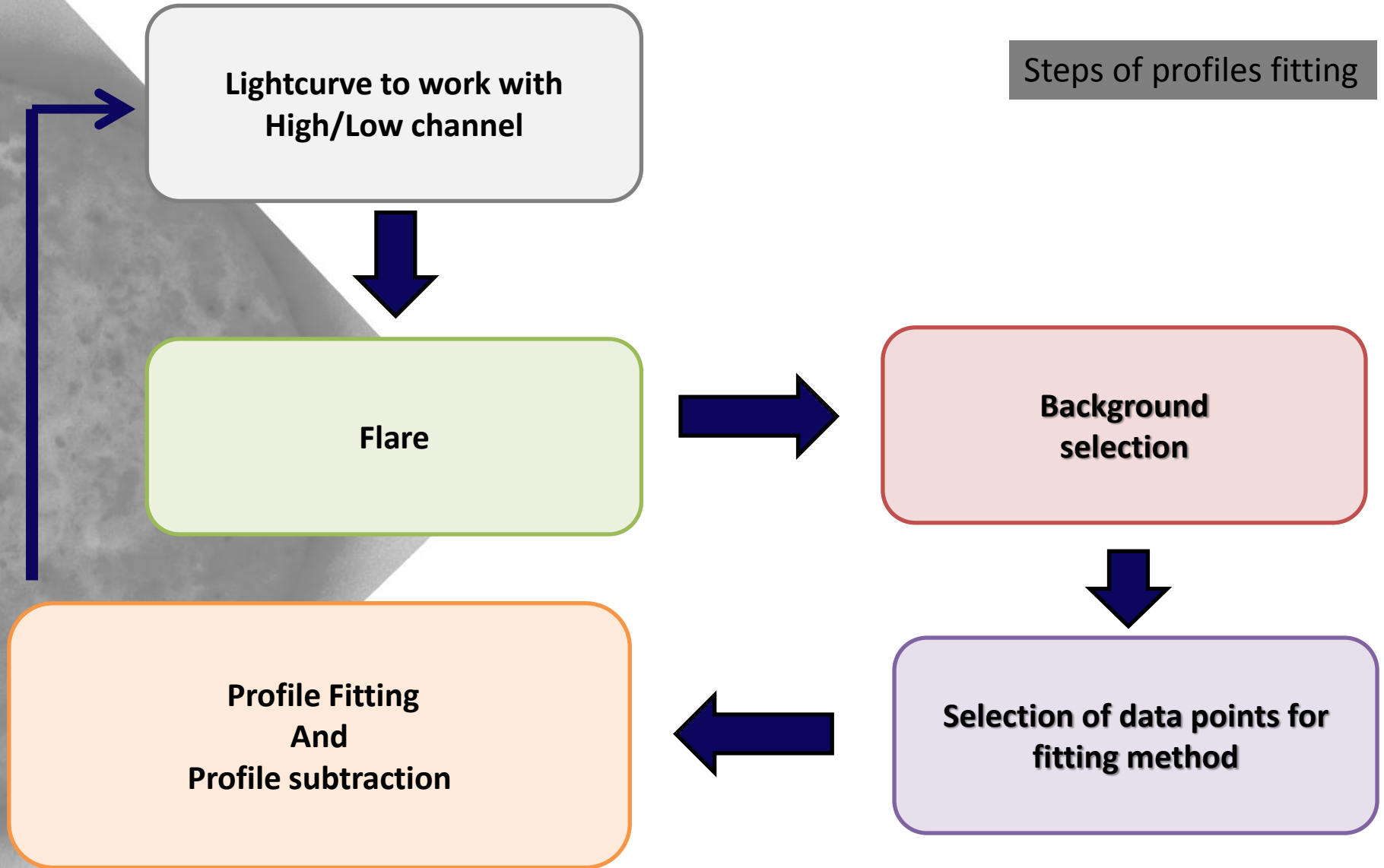
Existing Fitting Tools in IDL

General non-linear:

- CURVEFIT – Bevington algorithm (vectorized)
- LMFIT – Numerical recipes (not vectorized)

Specialized:

- LINFIT – linear (y = ax + b)
- POLY_FIT – polynomial
- SVDFIT – linear combinations
- GAUSSFIT – peak fitting

MPFIT routine

Craig Markwardt

University of Maryland and

NASA's Goddard Spaceflight Center

http://purl.com/net/mpfit

Perform Levenberg-Marquardt least-squares fit to IDL function

MPFIT fitting engine based on MINPACK-1 (Moré and collaborators; http://netlib.org/minpack/)

No.	Data (Day and Month 2009)	~Time maximum
1	19 April	02:10
2	10 May	00:30
3	17 May	06:30
4	26 May	10:45
5	31 May	10:30
6	04 June	18:00
7	20 June	20:00
8	01 July	22:45
9	07 July	10:10
10	18 July	02:00
11	25 August	13:30
12	07 September	22:00
13	25 September	20:30
14	27 September	22:20
15	05 October	03:15
16	11 October	01:45
17	18 October	16:40
18	19 November	03:50

26 May 2009
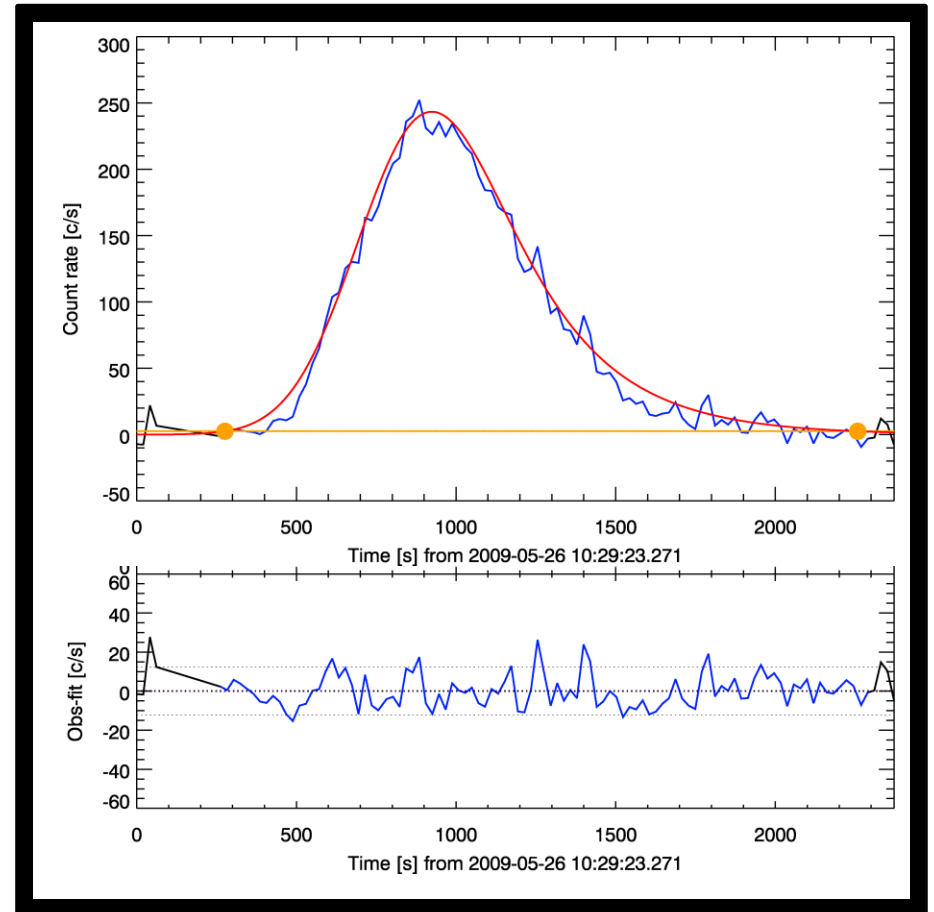
$Time_{start}$	10:34:04
$Time_{max}$	10:44:47
$Time_{end}$	11:06:42
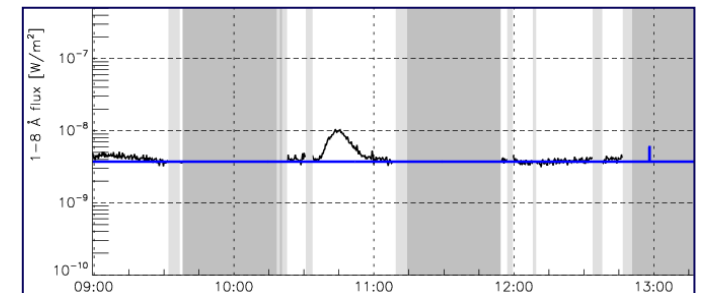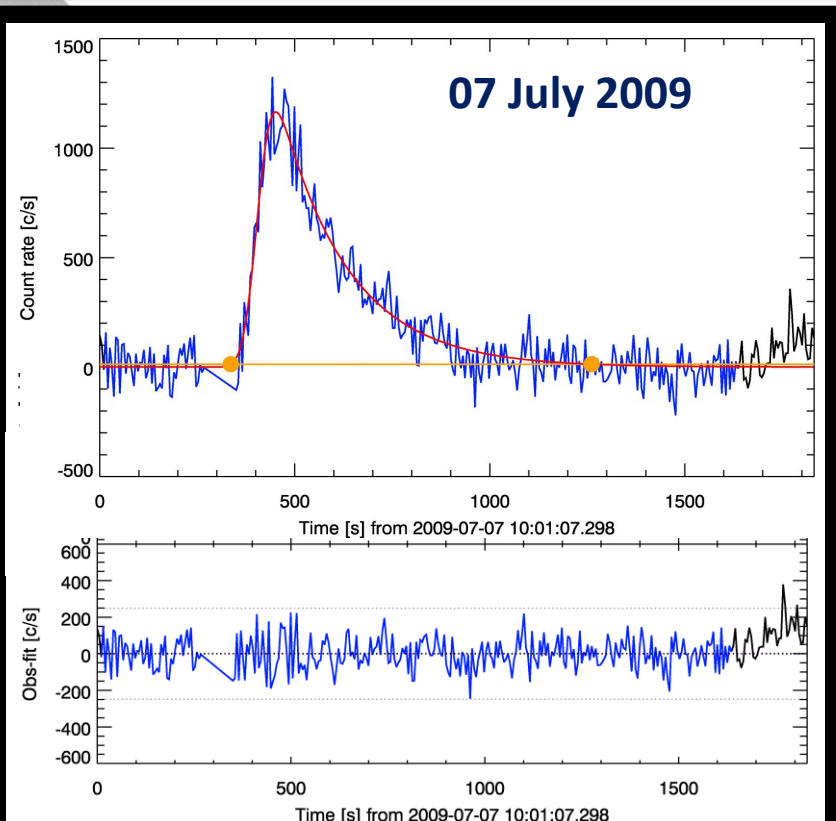
Time$_{start}$	Time$_{max}$	Time$_{end}$
10:06:43	10:08:38	10:22:08
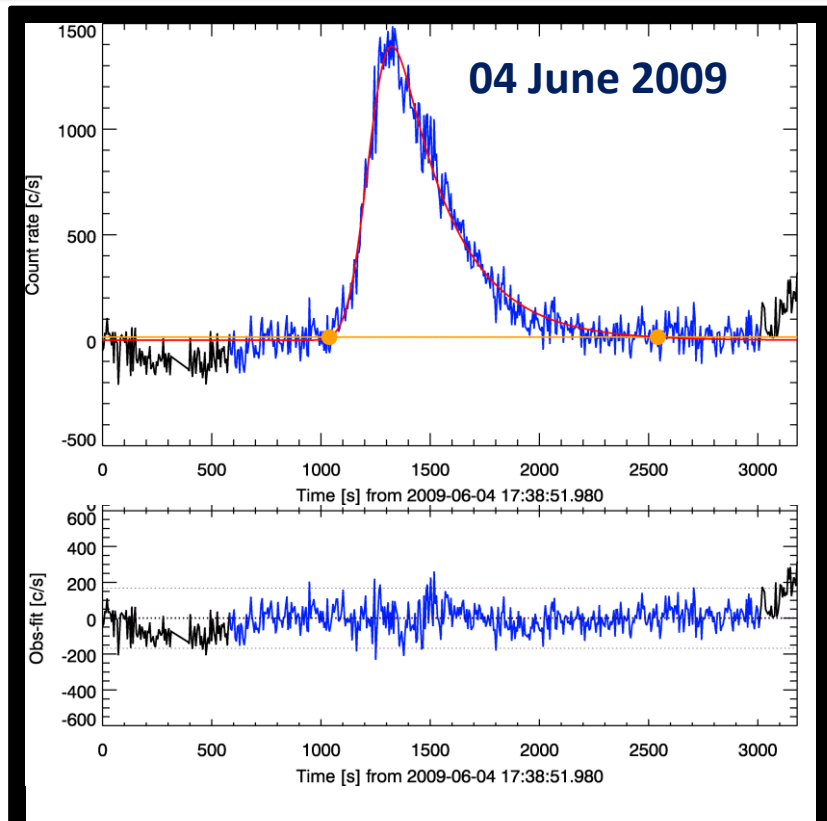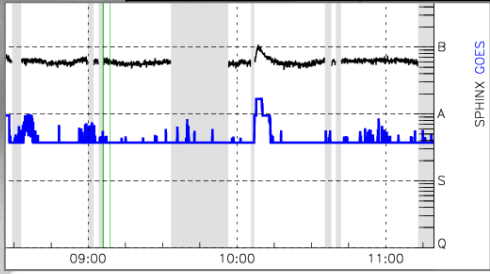
Time$_{start}$	Time$_{max}$	Time$_{end}$
17:56:10	18:00:56	18:21:12
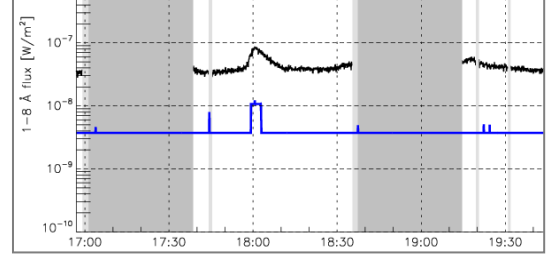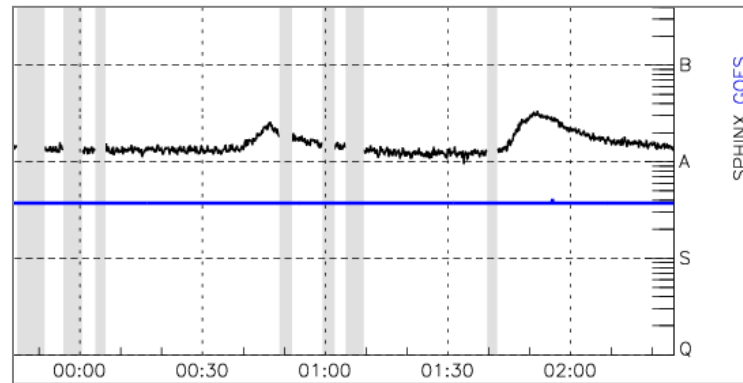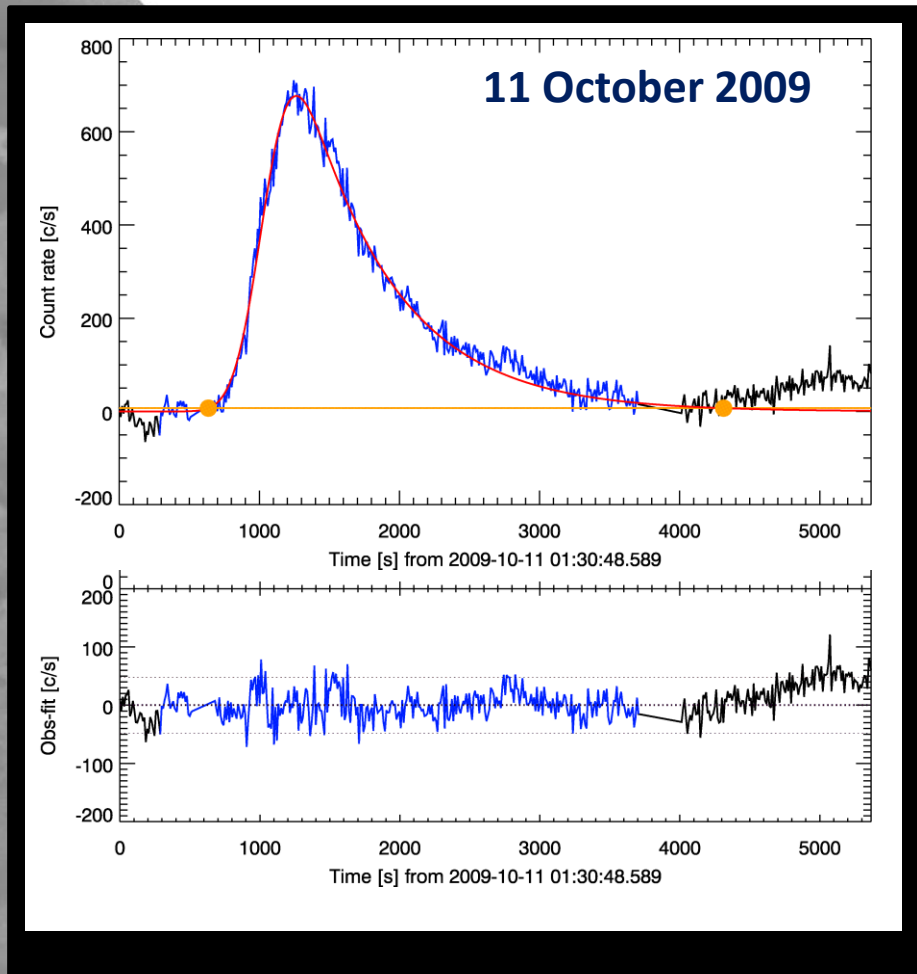
Time$_{start}$	Time$_{max}$	Time$_{end}$
01:41:25	01:51:52	02:42:43

05 June

2009
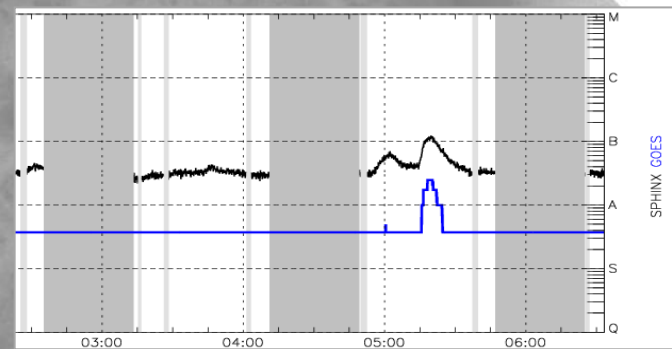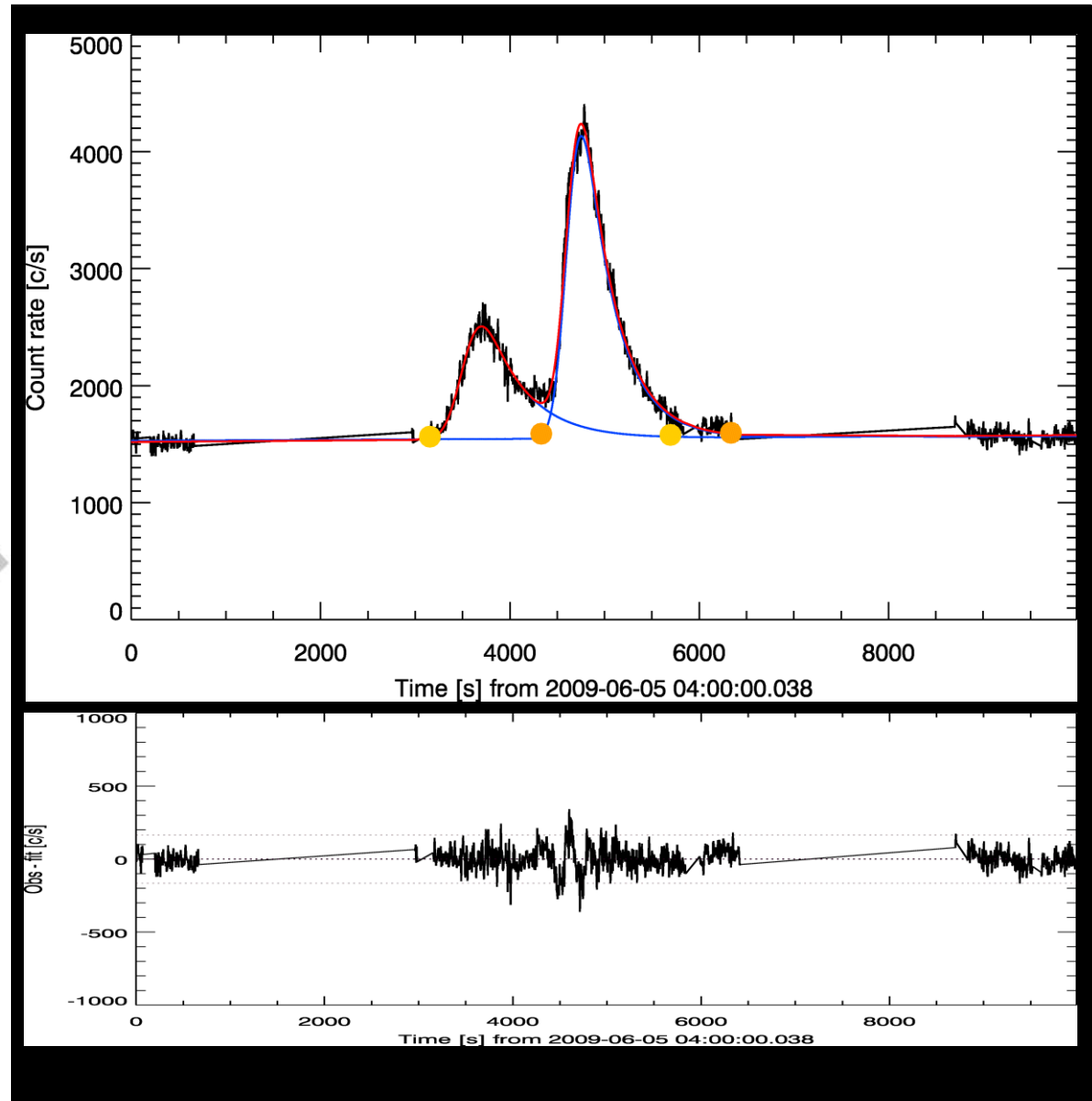
CONTENTS:

SphinX flaring events catalogue:
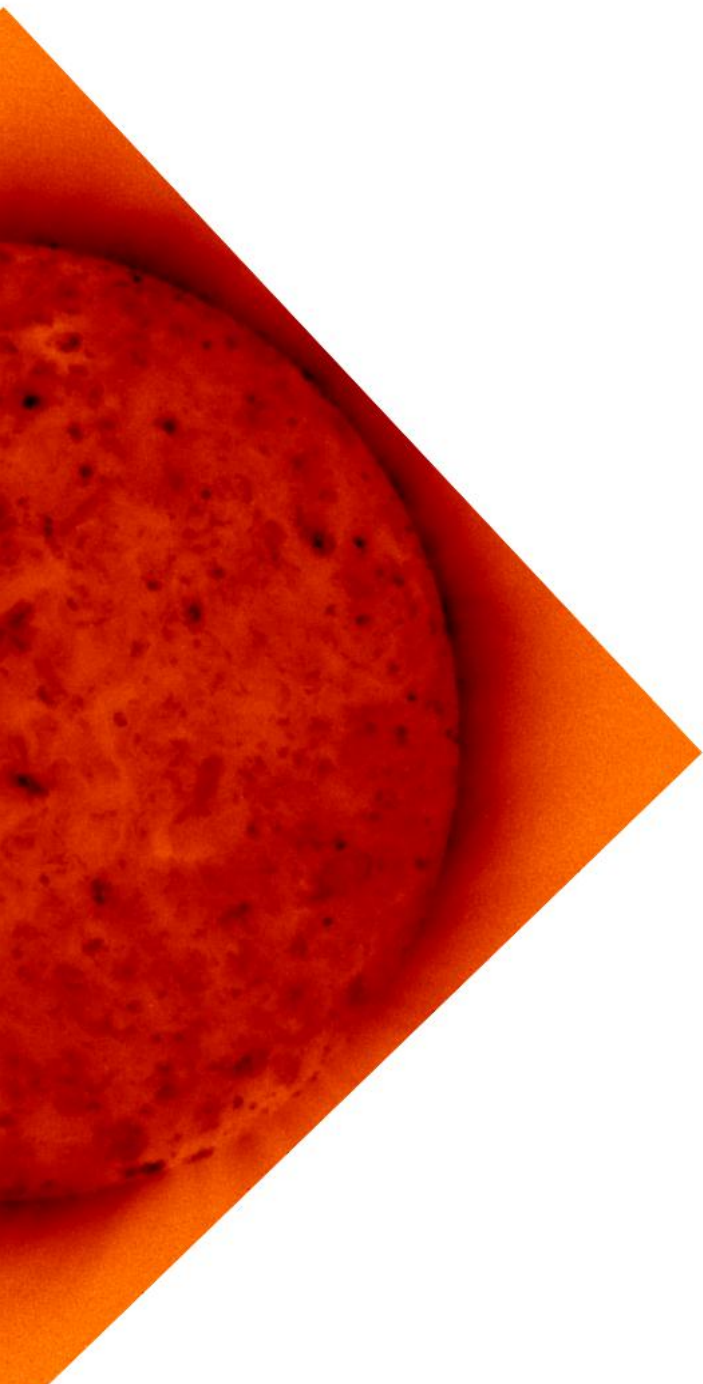**FLARE ID ,   Time$_{start}$,   Time$_{max}$,   Time$_{end}$,   Flare magnitude**

FUTURE PLANS:

Flare finding/detecting algorithm

Extended catalogue (Temperatures, Fluxes, …)

Analysis of flare flux observation in 1-8 Å wavelength range

Flare characteristics statistical analysis

The End