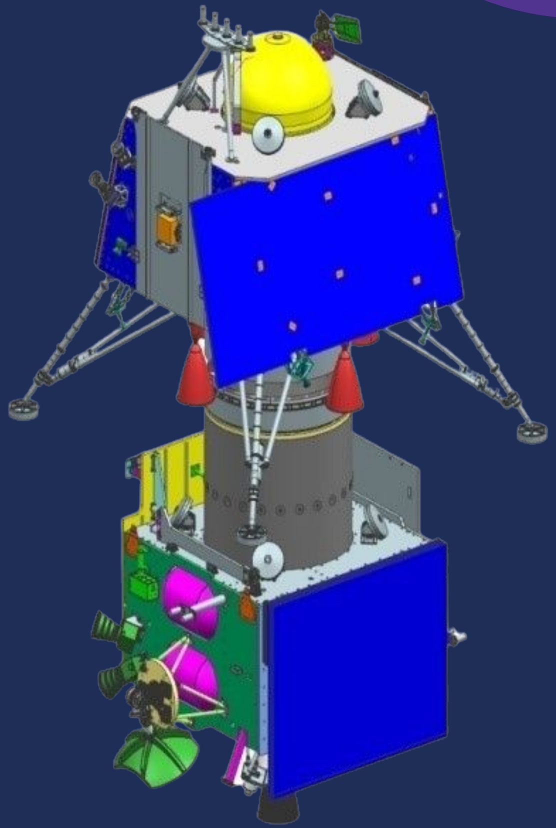
Solar Flare Analysis

XUVI: Lecture - 5

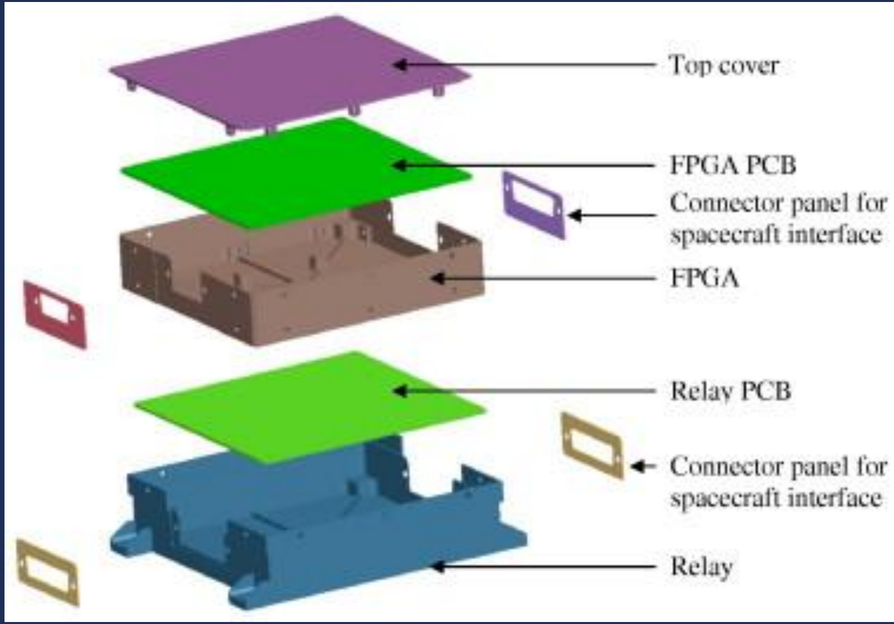
Data Capturing

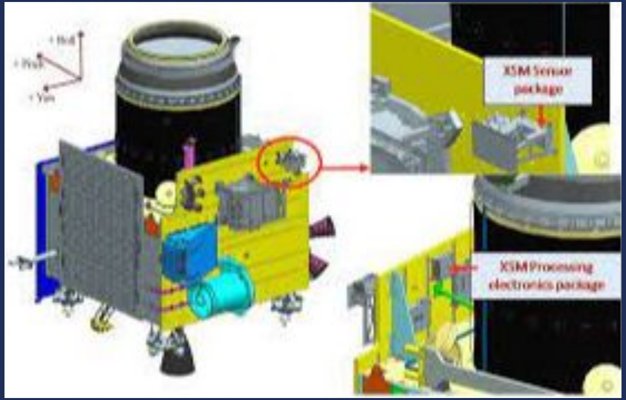
Solar brightness can be measured as a function of number of photos striking the observational area per unit time (usually every second)

The data that we'll be working on is captured by Solar X-Ray Monitor (XSM) aboard the Chandrayaan-2 orbiter and can be obtained from the Pradan website maintained by ISRO



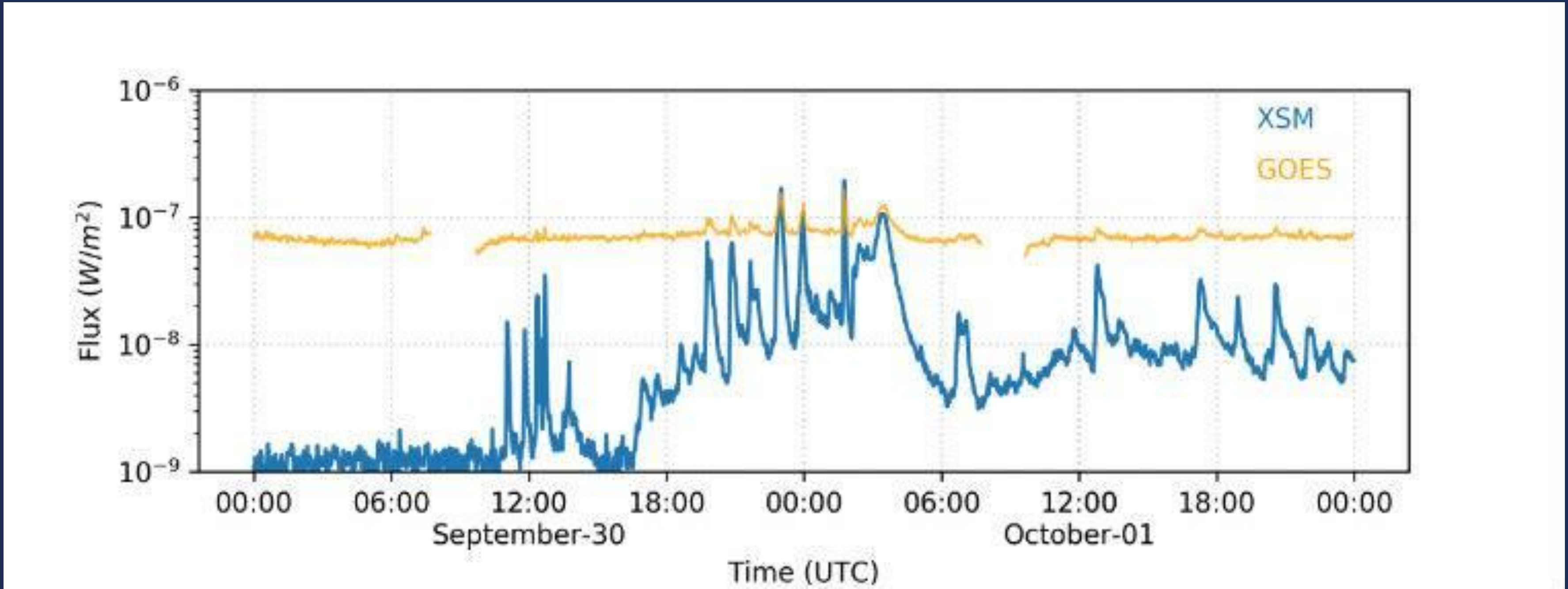
Solar X-Ray Monitor





Reference: [Link]

Sensitivity



Solar Flare Modelling

A Solar Flare can be modelled as a convolution of 2 functions:

Gauss function:

$$f(t) = Ae^{(-(t-B)^2/C^2)}$$

Exponential function:

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

Plus some background level represented as:

Linear background

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

Reference: [Link]

EFP - Convolution of two Functions

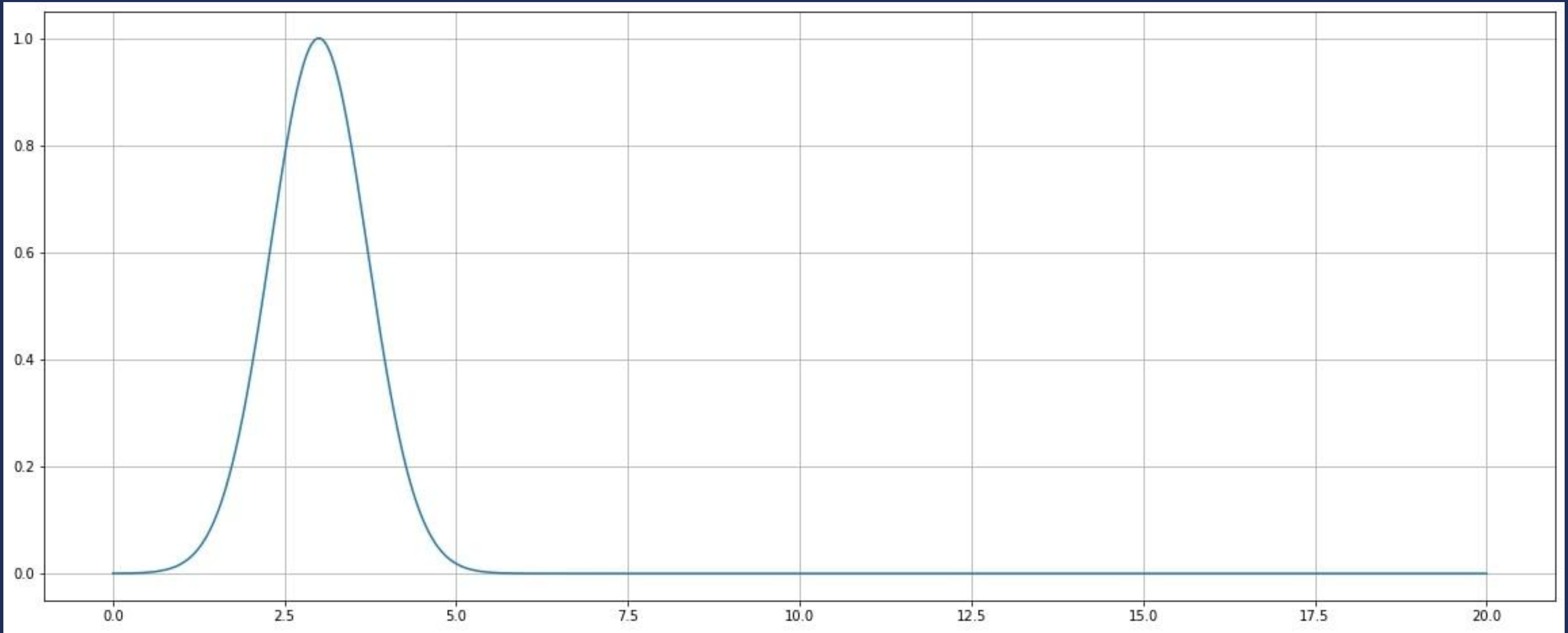
$$f(t) = \frac{1}{2}\sqrt{\pi} A C \exp\left[D(B-t) + \frac{C^2 D^2}{4}\right]\left[\operatorname{erf}(Z) - \operatorname{erf}\left(Z - \frac{t}{C}\right)\right]$$

The Solar Flare Profile (also known as the Elementary Flare Profile (EFP)) helps to model single flare events and to decompose multi-peak events in terms of single-peak events.

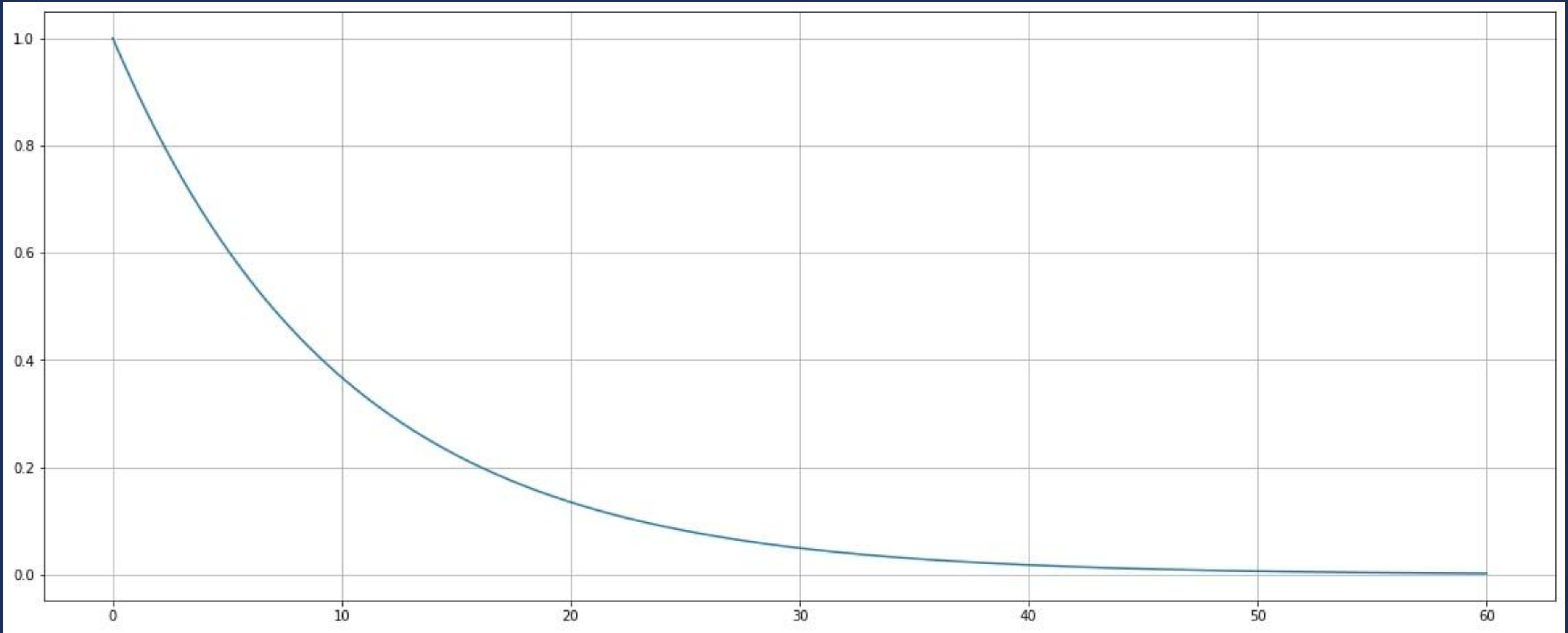
The main task at hand is to determine these 6 parameters to successfully model a flare.

$$Z = \frac{2B + C^2 D}{2C}$$

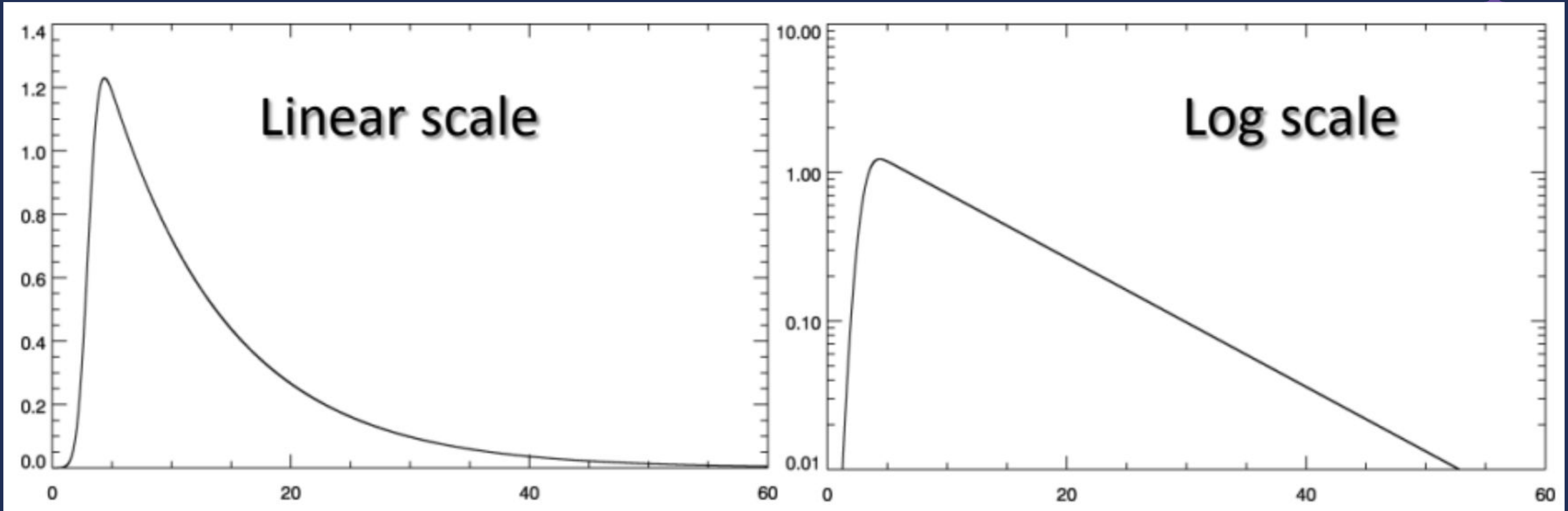
Gauss Function



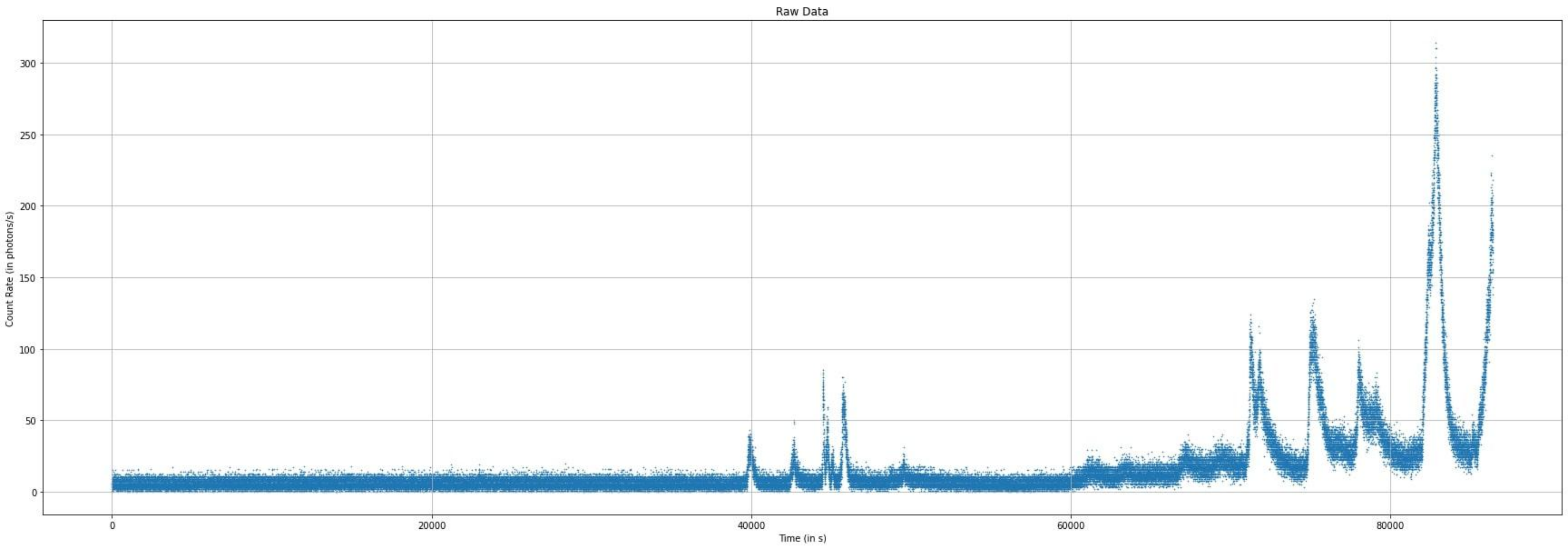
Exponential Function



Convolution



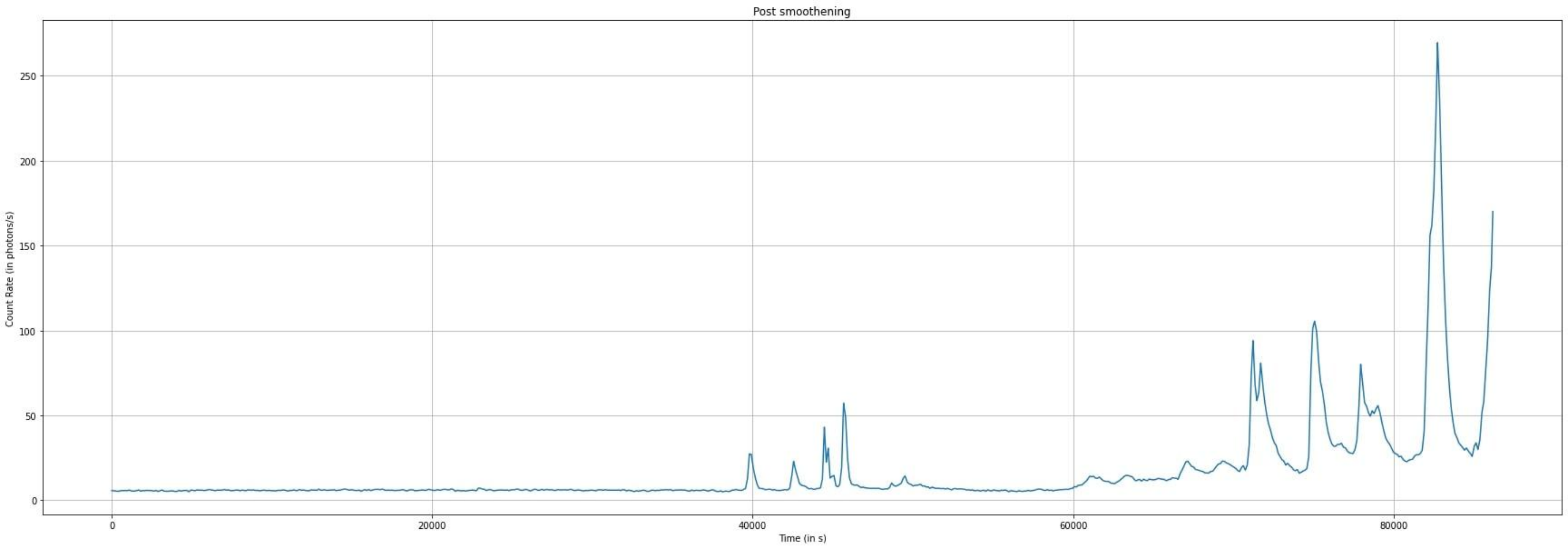
Raw Data



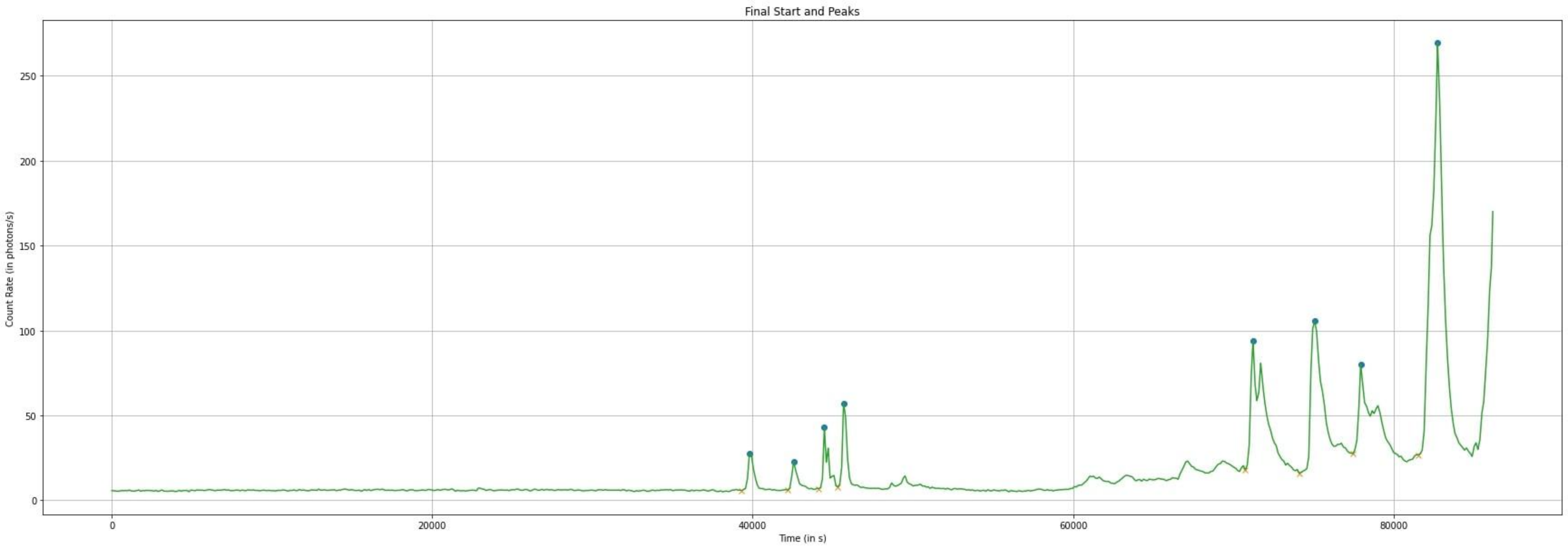
Raw Data
Count Rate (in photons/s)
300
250
200
150
100
50
0
0
20000
40000
60000
80000
Time (in s)

Pre-Processing

Guess the method for noise reduction?

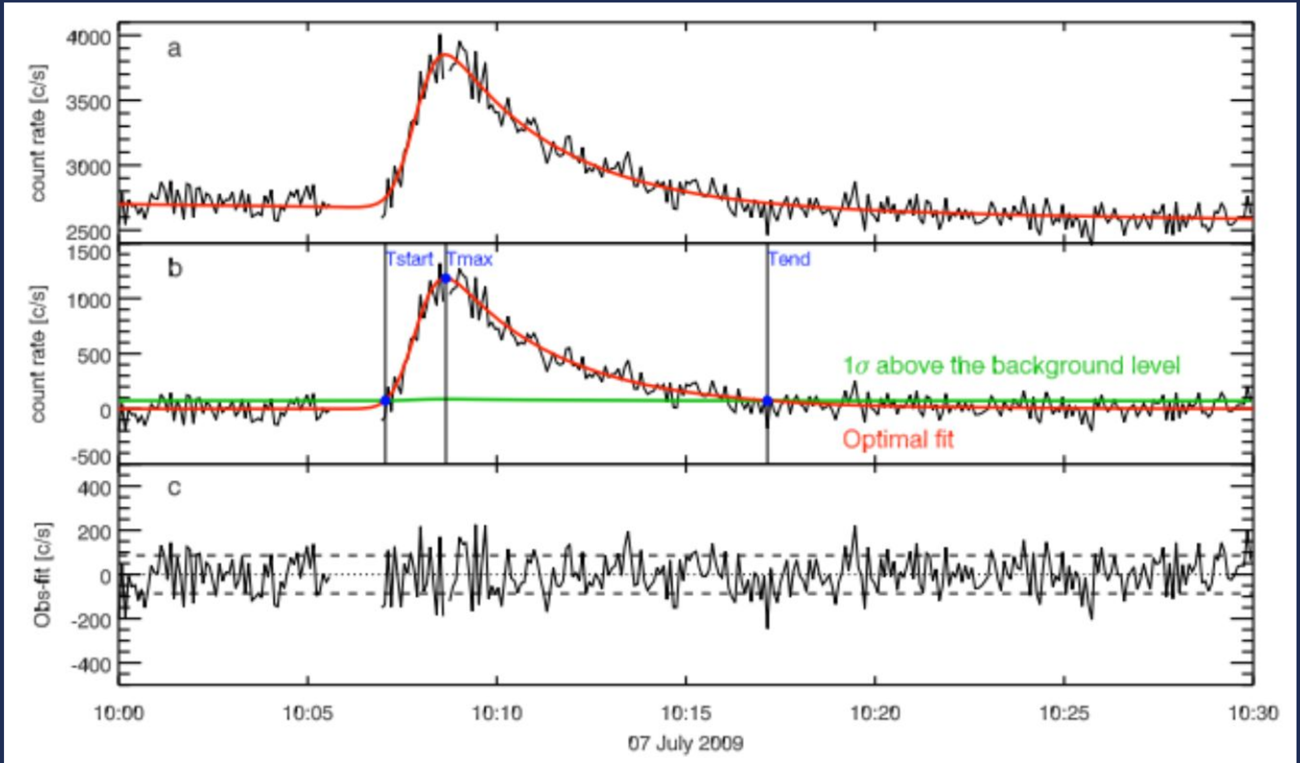


Isolating Flares

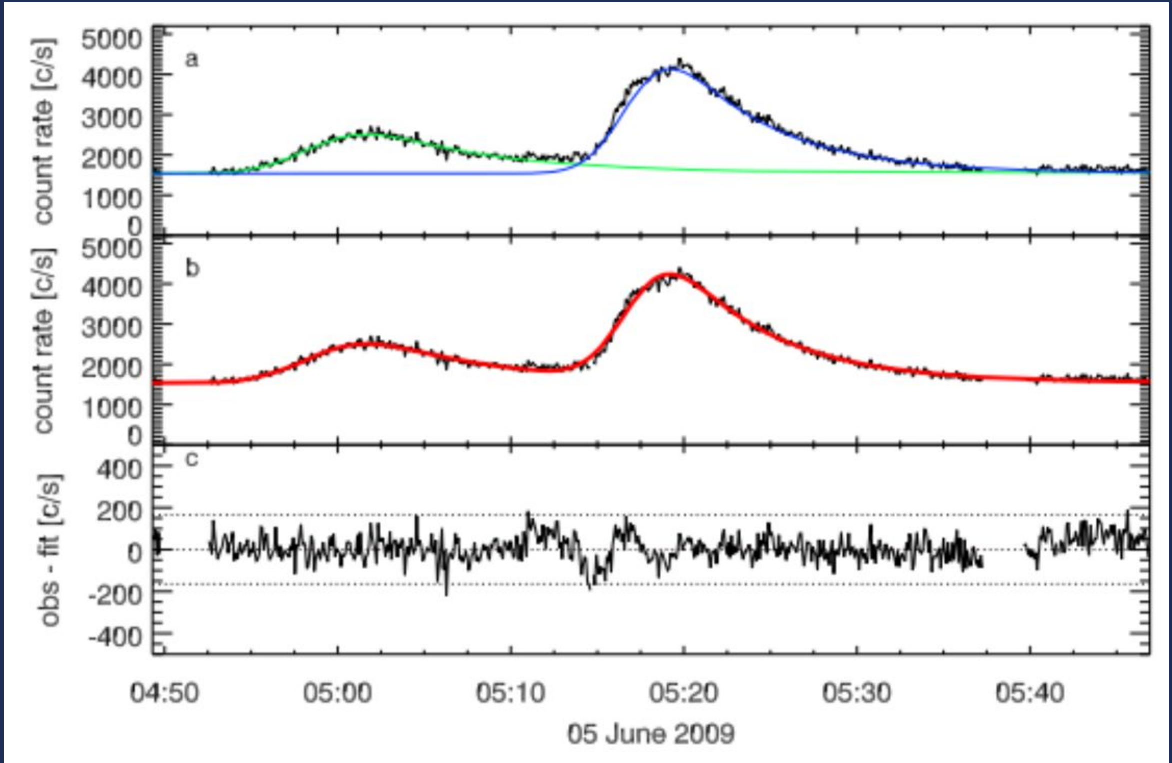


Reference: Link

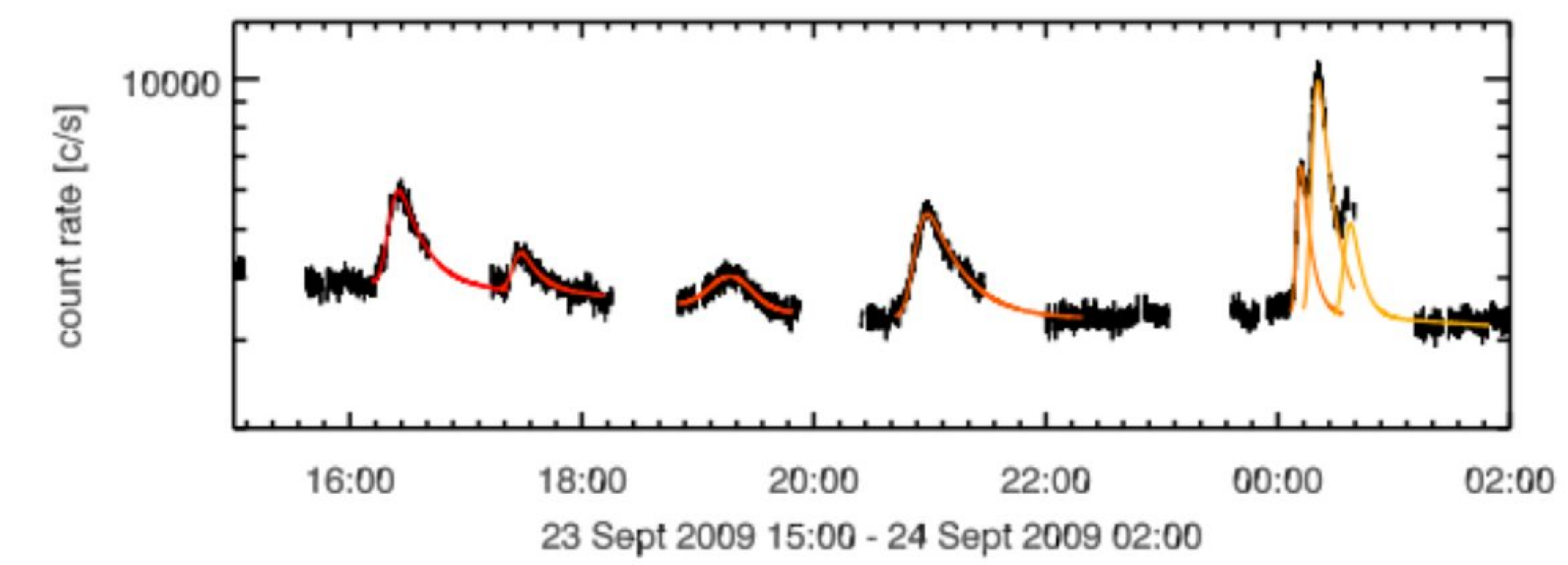
Extracting Information



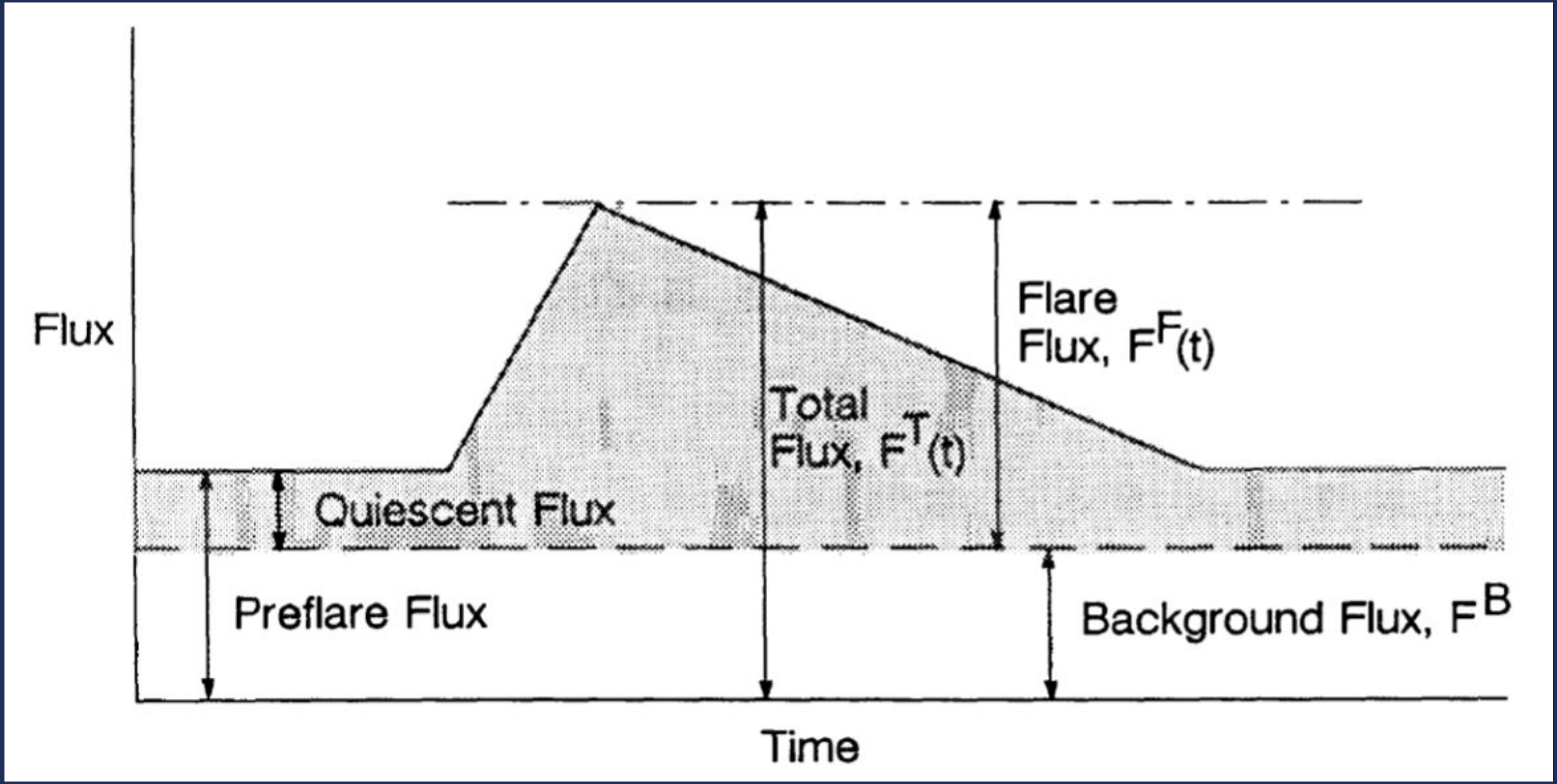
Multiple Flares



Over Longer Duration



Flux Levels



Flux
Flare
Flux, $F^F(t)$
Total
Flux, $F^T(t)$
Quiescent Flux
Preflare Flux
Background Flux, F^B
Time

Classification Criteria

Flares can be classified based on their peak flux or peak count rate. We'll be using count rate to classify the flux as per the following table:

CLASS	FLUX (Wm^{-2})	COUNT RATE (s^{-1})
A	$X < 10^{-7}$	$N < 250$
B	$10^{-7} < X < 10^{-6}$	$250 < N < 2{,}500$
C	$10^{-6} < X < 10^{-5}$	$2{,}500 < N < 25{,}000$
M	$10^{-5} < X < 10^{-4}$	$25{,}000 < N < 250{,}000$
X	$10^{-4} < X$	$N > 250{,}000$

Further discrete classification can be done by taking logarithms since each class is an order of magnitude greater than its preceding class. Doing so each class can be further divided into 10 subclasses (0-9). For example, peak flux of M3 class would be $10^{-5*(10\wedge(3/10))} = 10^{-4.7}$