Swift/XRT GRB Spectral Analysis

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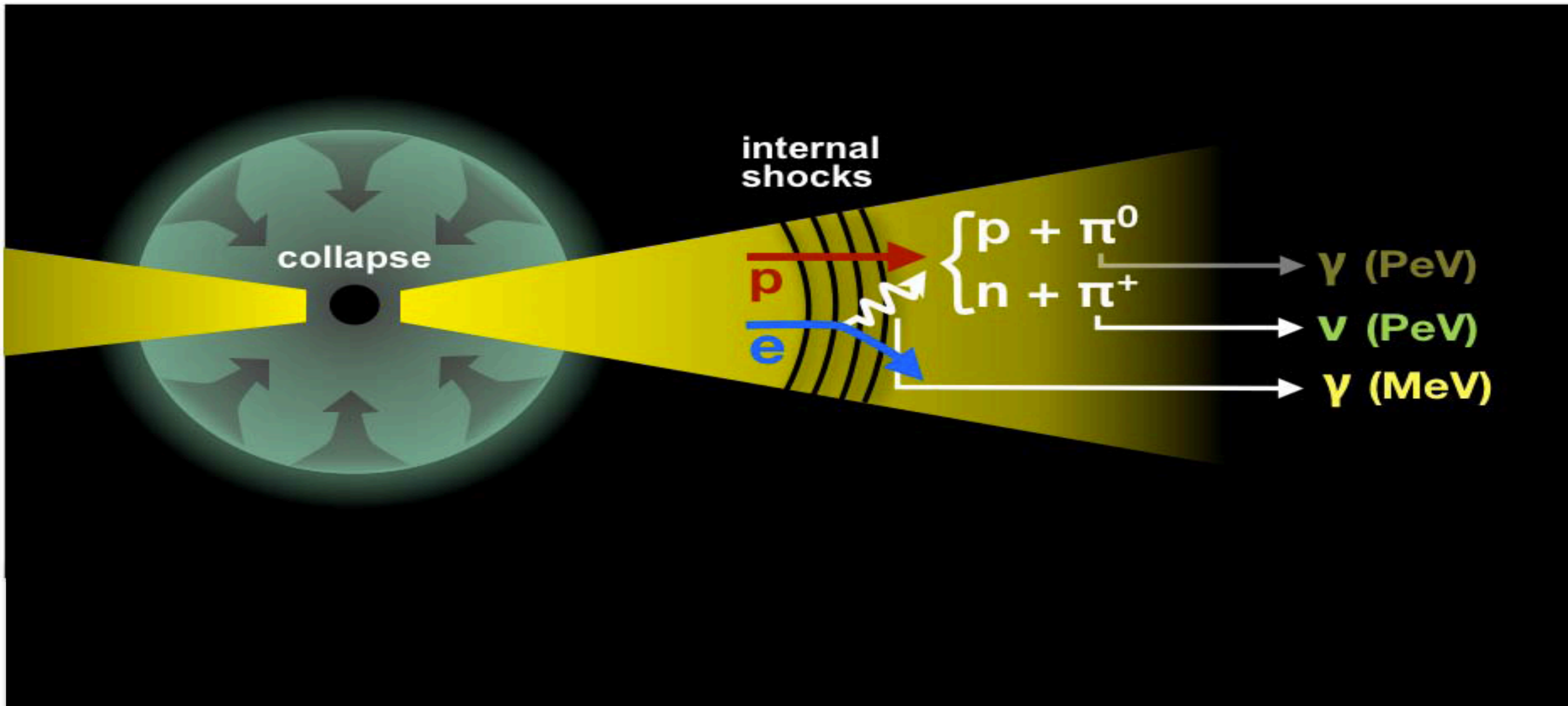
Goddard Space Flight Center

ASTR 288C, Lecture 11, 2017/11/13

GRB mechanism

Credit:Gabriele Ghisellini and Pe’er et al. (2015)



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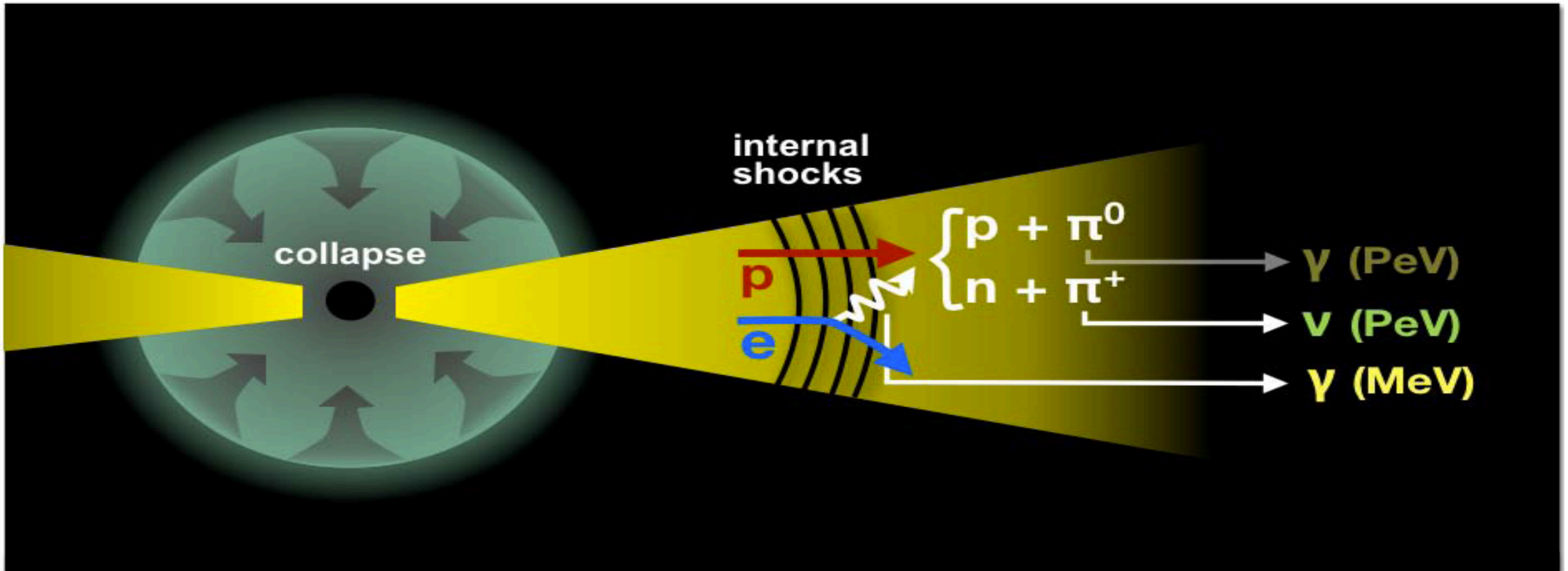

$t < 0$ s

$R \sim 10^{11}$ cm

$\sim$ R_sun

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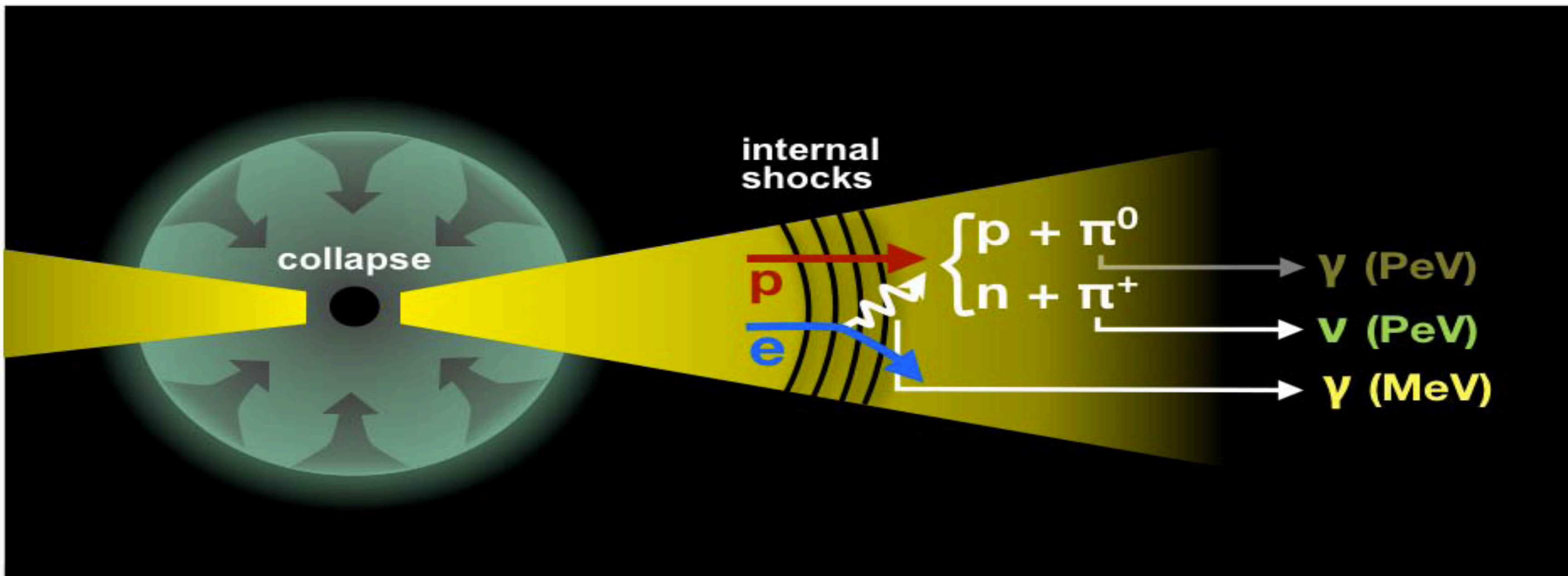

$t < 0$ s
$R \sim 10^{11}$ cm
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$t \sim 0$ s
$R \sim 10^{6}$ cm
= 6.2 miles
= UMD to Goddard

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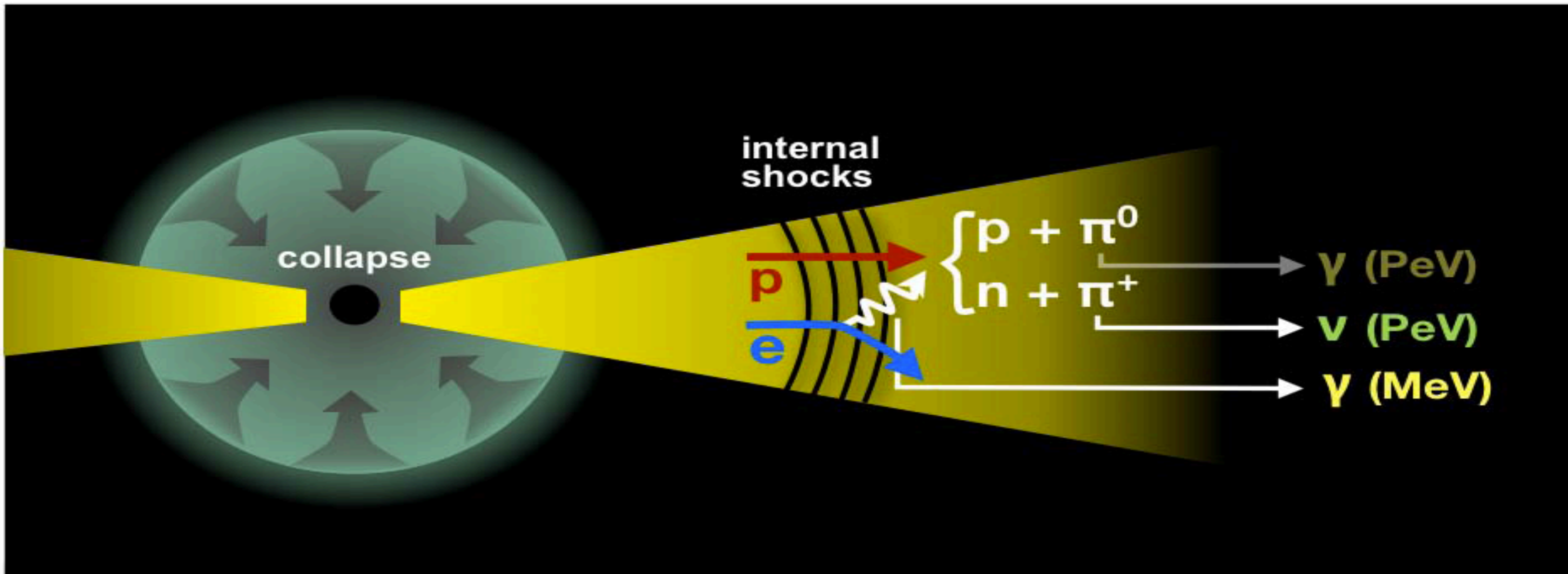

t < 0 s
R $\sim 10^{11}$ cm
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= 6.2 miles
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t $\sim 10^{3}$ s
R $\sim 10^{14}$ cm
= 6.2 x 10^{8} miles
= 6.7 x Earth_to_Sun

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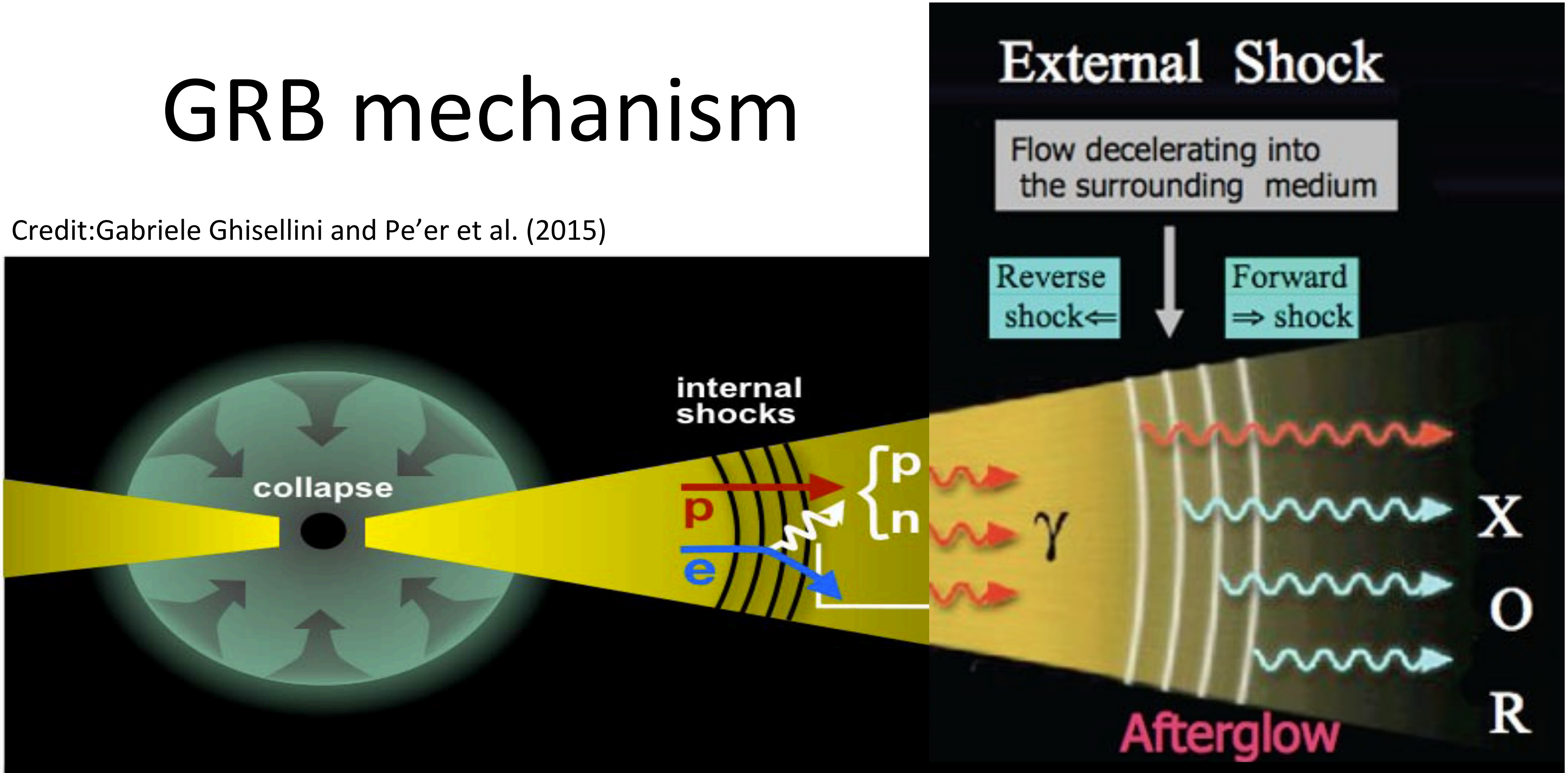

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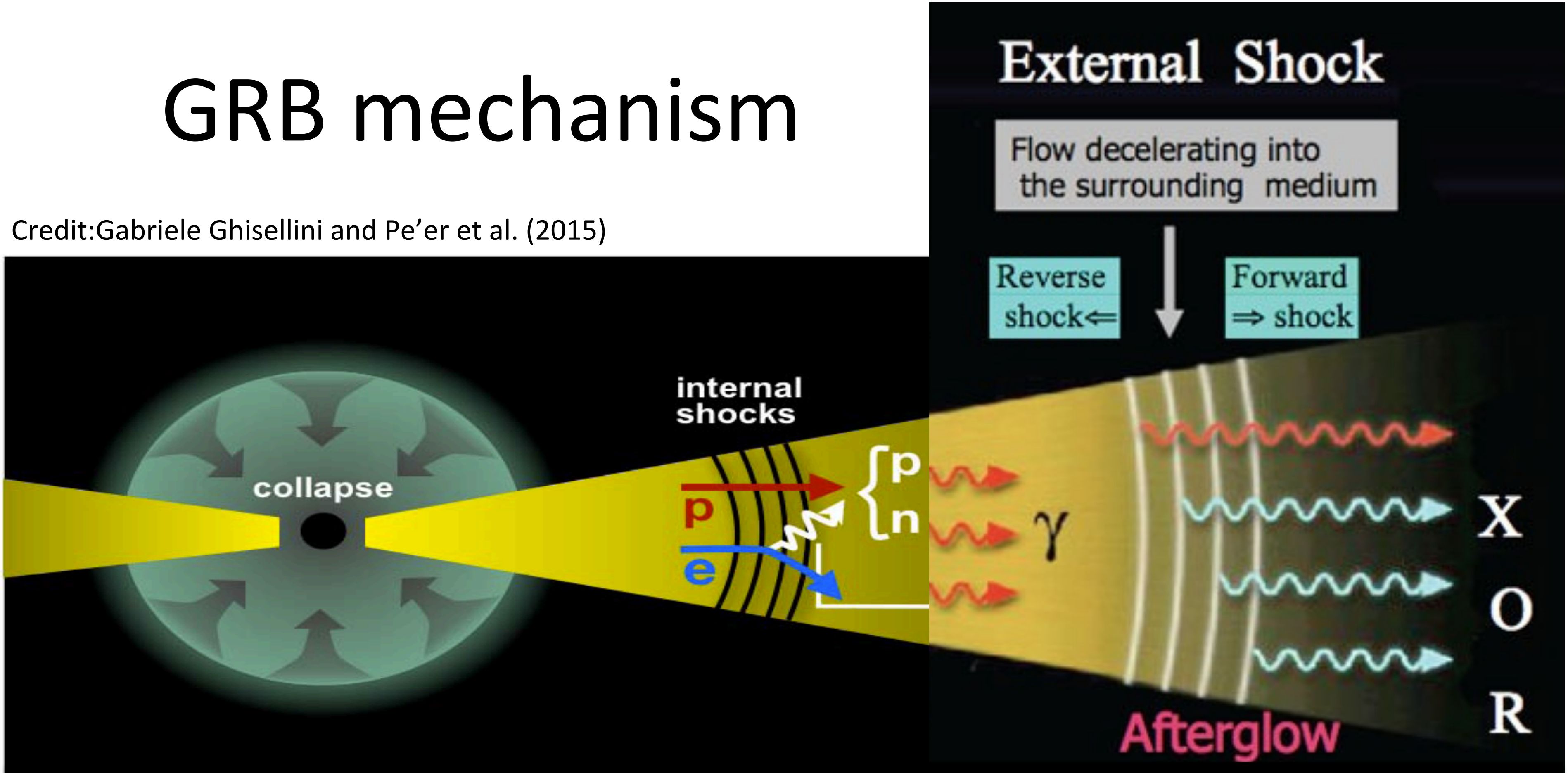
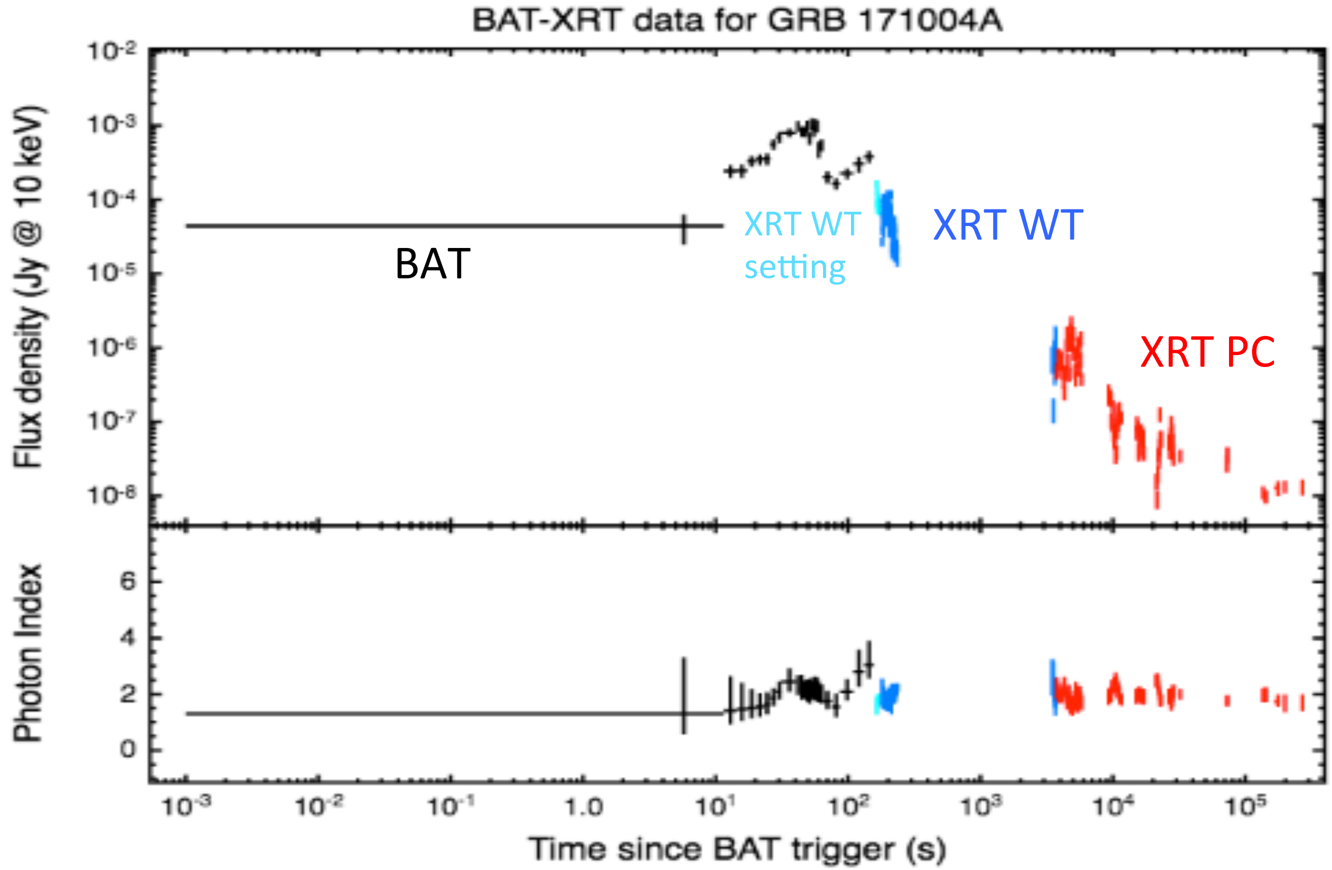


$t < 0$ s	$t \sim 0$ s	$t \sim 10^3$ s	$t \sim 10^6$ s
$R \sim 10^{11}$ cm	$R \sim 10^6$ cm	$R \sim 10^{14}$ cm	$R \sim 10^{16}$ cm
~ R_sun	= 6.2 miles	= 6.2 x 10^8 miles	= 6.2 x 10^{10} miles
	= UMD to Goddard	= 6.7 x Earth_to_Sun	= 670 x Earth_to_Sun
			= 10 x Pluto to Sun

GRB light curve
BAT+XRT



WT: Window timing mode: 1.7 ms time resolution for brighter sources

PC: Photon counting mode: 2.5 s time resolution for dimmer sources

WT setting: Usually only a very short time. Don't use these data in your spectra fitting

Synchrotron radiation

GRB mechanism

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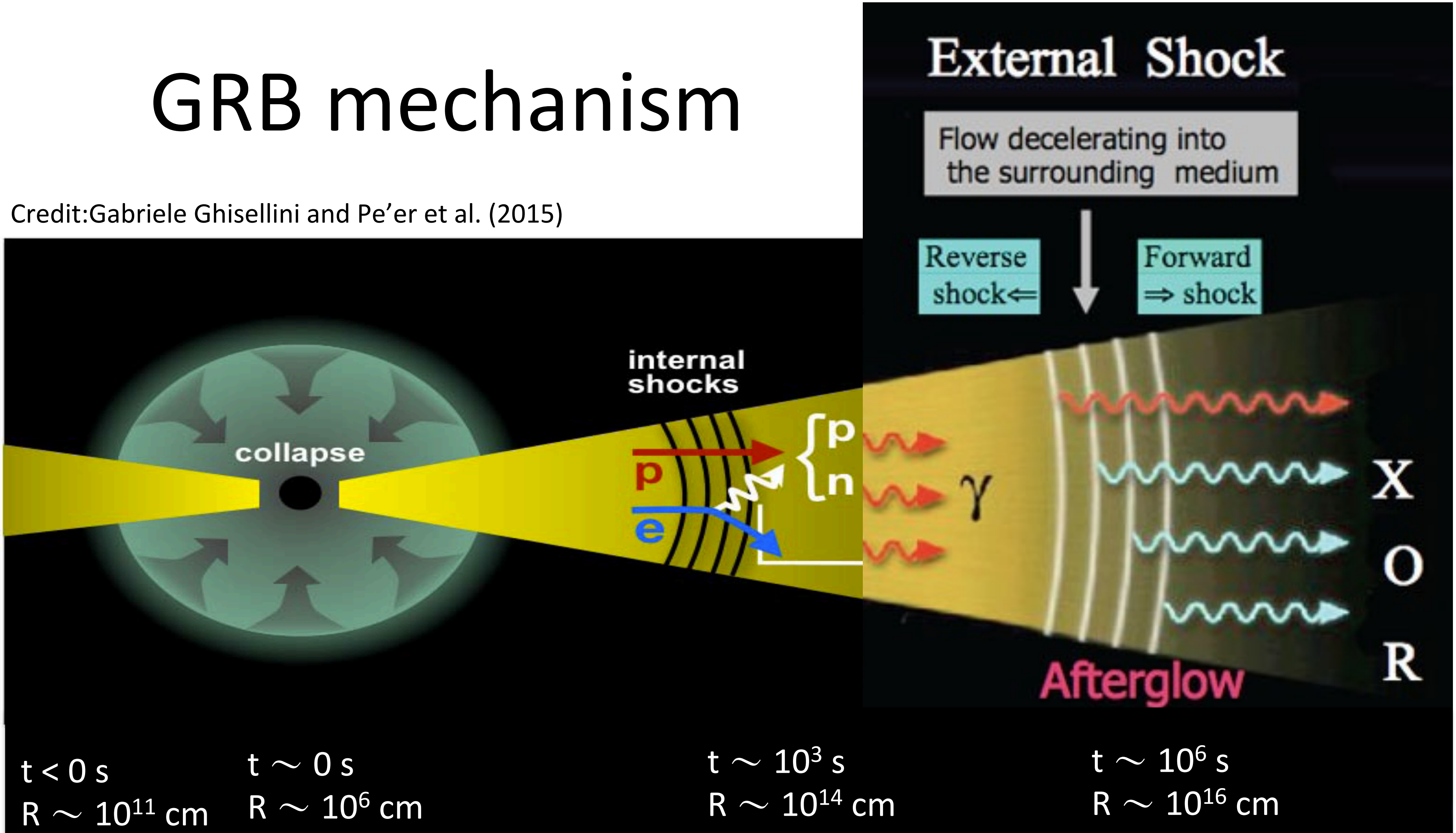

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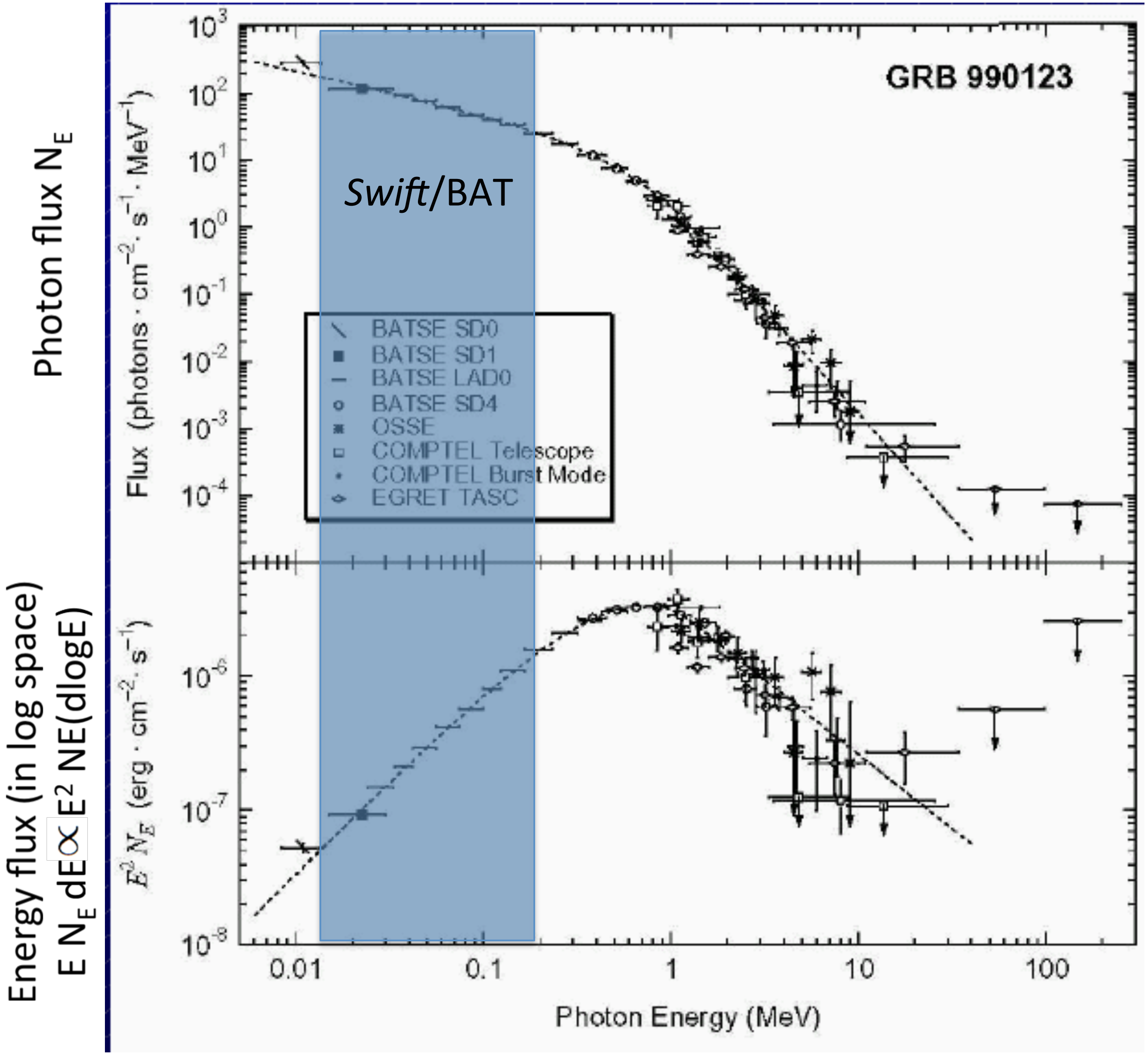
GRB Spectrum



Briggs et al. (1999)

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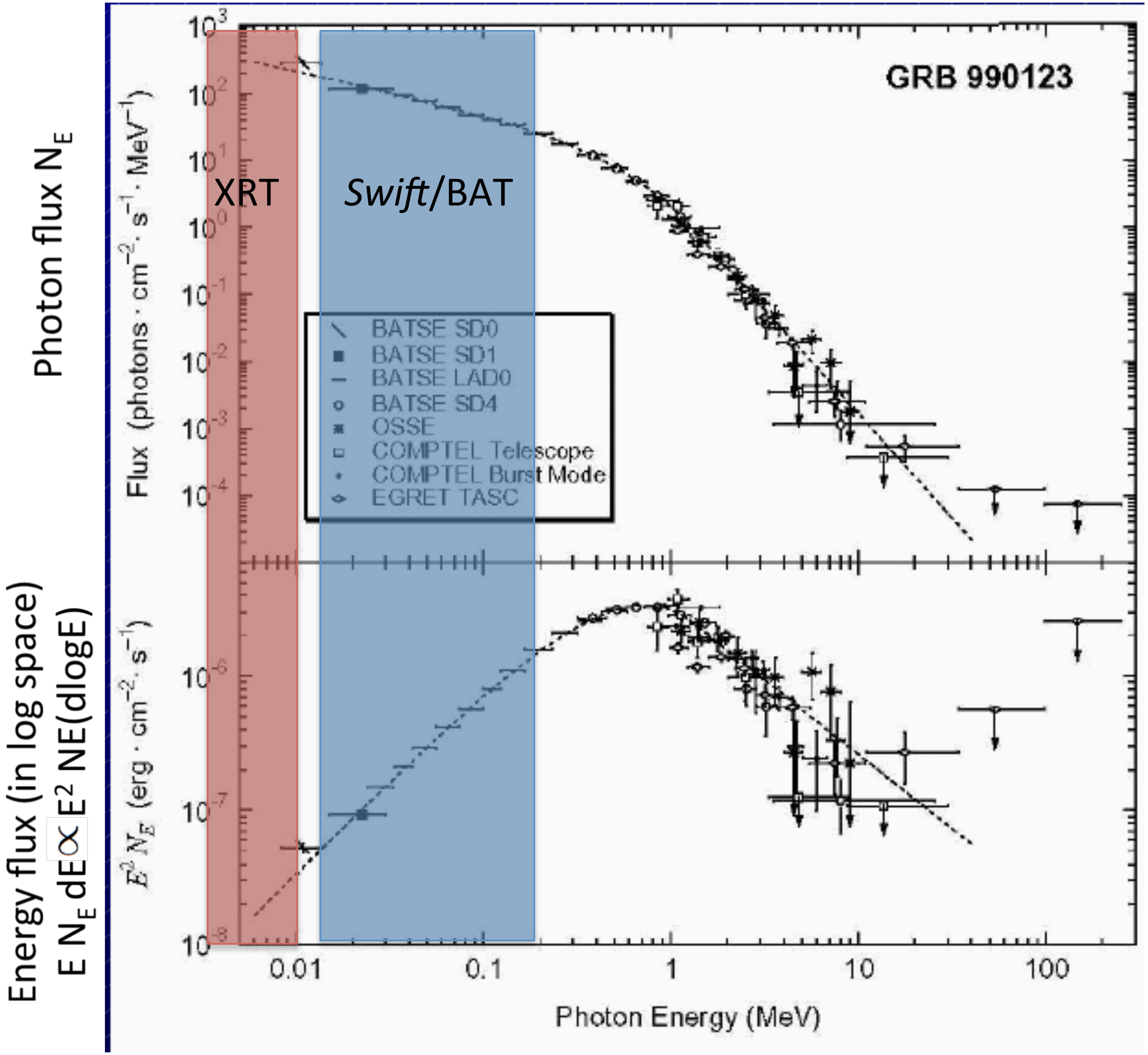

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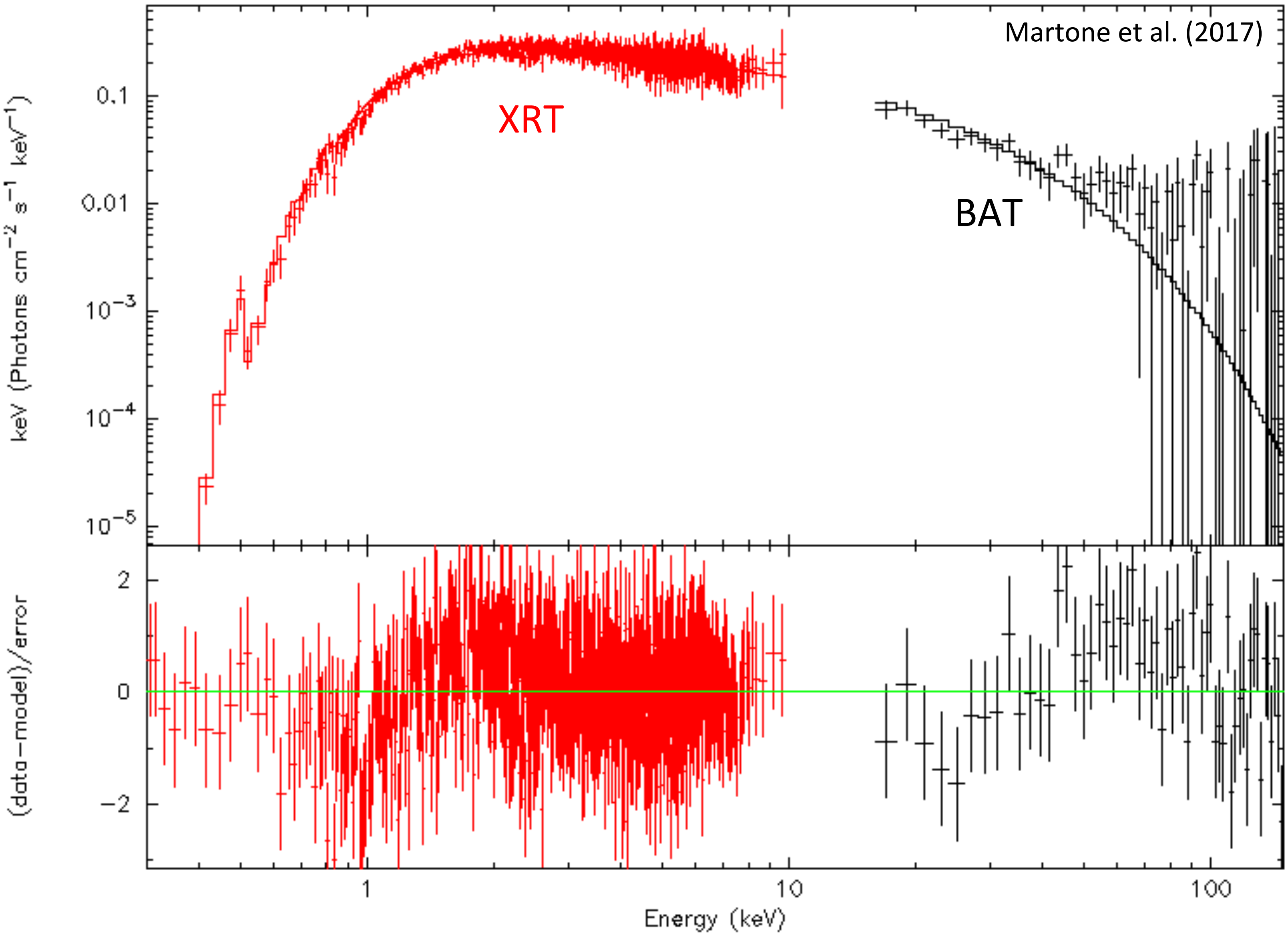
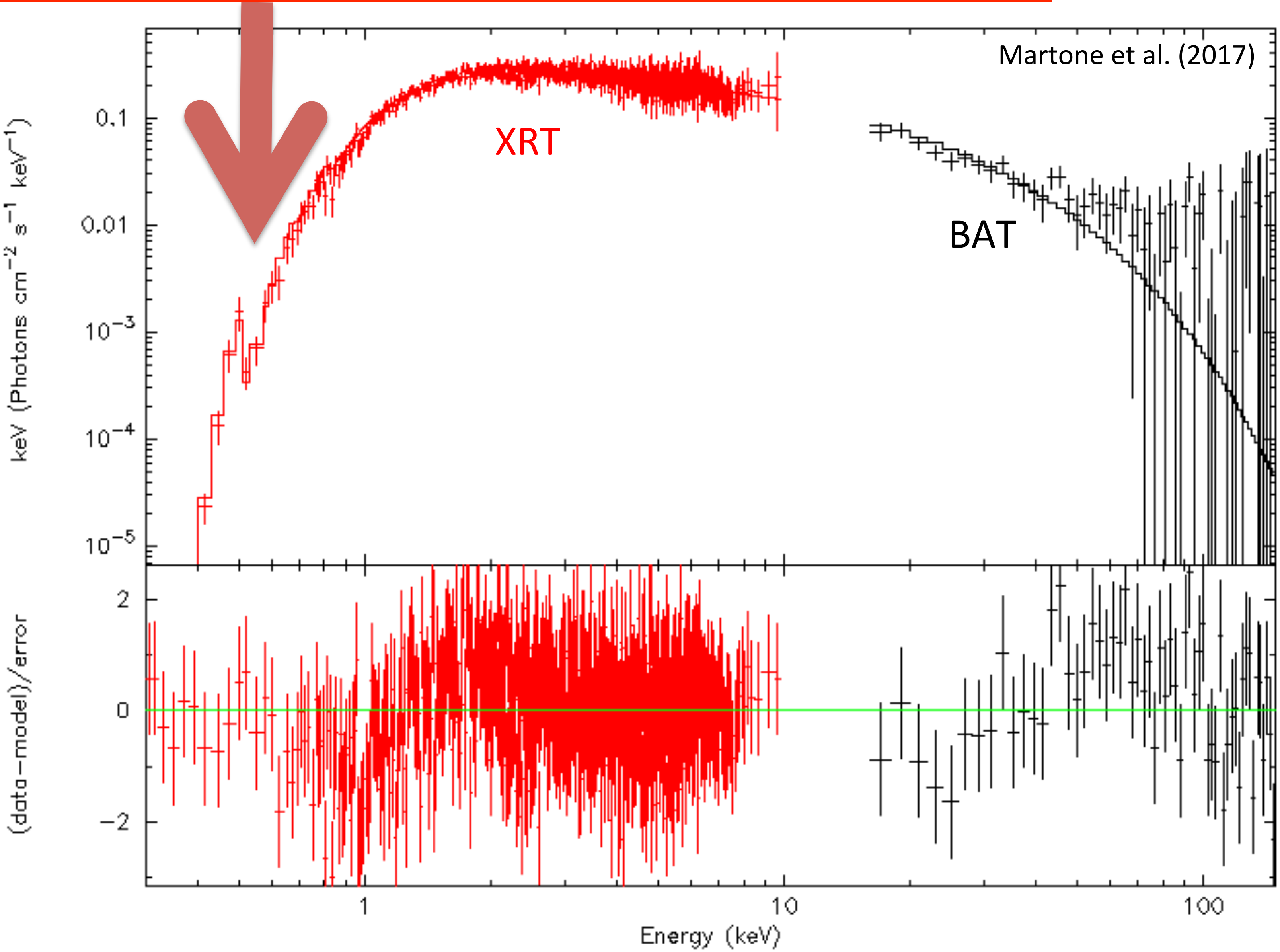


Galactic and Host galaxy absorption of X-ray photon below ∼ 2 keV due to gas and dust (mostly composed of hydroden)



GRB XRT Spectral Models

- If redshift is known:

  Simple power law (powerlaw) + Galactic absorption (TBabs) + Host galaxy absorption (zTBabs)
- If redshift is not known

  Simple power law (powerlaw) + Galactic absorption (TBabs) + Host galaxy absorption (TBabs)
- Example in Xspec:

  model TBabs*zTBabs*powerlaw

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Constrain Galactic N_H (TBabs)

Constrain host galaxy N_H (zTBabs)

N_H: Hydrogen column density (i.e. how many hydrogen are in the light of sight)

GRB XRT Spectrum

- GRB XRT spectrum are available at the burst analyser: http://www.swift.ac.uk/burst_analyser/

Swift-XRT spectra of GRB 171102B

Last updated after receiving ObsID 00785510991, version 4

Data were analysed using HEASOFT version 6.20

Related pages: Burst Analyser | Enhanced position | Light curve | Image | GRB Region information | XRT Catalogue entry | Download obs data | BAT analysis | GCN Notices | GCN Circulars

About these products.

Get another burst.

Add time-sliced spectrum.

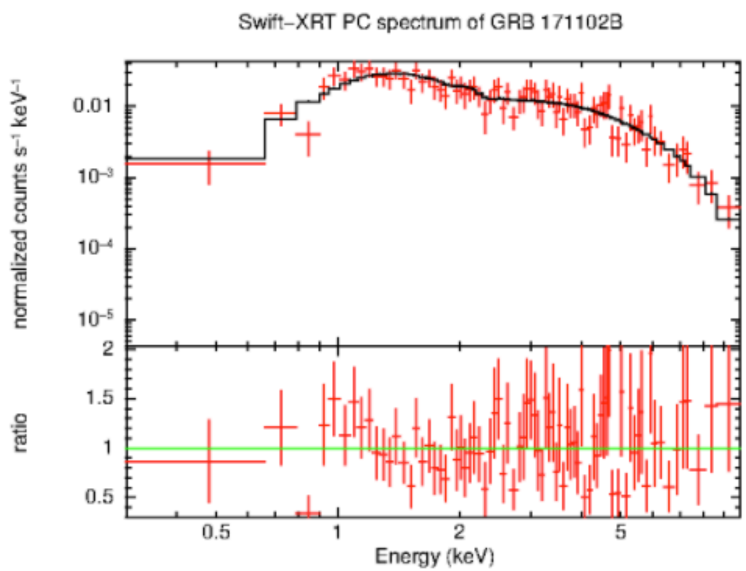
Jump to: Time-averaged | Late Time

Time-averaged spectrum (T0 + 132 to 24097 s)

Download spectral files for Time-averaged spectrum.

Plots to download

pc mode ps file | pc mode gif file |



PC mode. Mean photon arrival: T0+7096 s

N_H (Galactic)	4.51×10^{21} cm^{-2}
N_H (intrinsic)	1.3 (+1.7, -1.3) $\times 10^{21}$ cm^{-2}
z of absorber	0
Photon index	1.17 (+0.17, -0.16)
Flux (0.3-10 keV) (Observed)	6.8 (+0.7, -0.6) $\times 10^{-12}$ erg cm^{-2} s^{-1}
Flux (0.3-10 keV) (Unabsorbed)	8.0 (+0.5, -0.6) $\times 10^{-12}$ erg cm^{-2} s^{-1}
Counts to flux (obs)	6.94×10^{-11} erg cm^{-2} ct^{-1}
Counts to flux (unabs)	8.14×10^{-11} erg cm^{-2} ct^{-1}
W-stat (dof) What's this?	308.69 (397)
Spectrum exposure	10.4 ks

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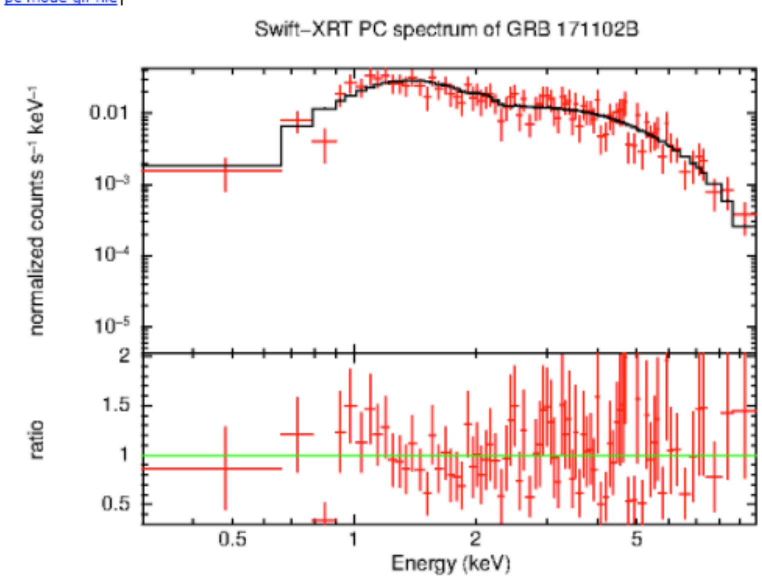

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C-statistic (Cash 1707)

- For low count data → Poisson distribution
- Likelihood for Poisson data:

$$L = \prod_{i=1}^{N} (tm_i)^{S_i} \mathrm{e}^{-tm_i} / S_i!$$

- Maximum likelihood:

$$C = 2 \sum_{i=1}^{N} (tm_i) - S_i \ln (tm_i) + \ln (S_i!)$$

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C-statistic (Cash 1707)

- For low count data → Poisson distribution

The C statistic does NOT provide a goodness-of-fit measure

https://asd.gsfc.nasa.gov/XSPECwiki/statistical_methods_in_XSPEC

$i=1$

- Maximum likelihood:

$$C = 2\sum_{i=1}^{N}(tm_i) - S_i \ln(tm_i) + \ln(S_i!)$$

→ Not χ^2 !

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Automation

- *.xcm file

```
method leven 100 0.5
abund angr
xsect vern
cosmo 70 0 0.73
xset delta -1
systematic 0
model  cflux*TBabs*zTBabs*powerlaw
            0.3         -1          0          0     1e+06     1e+06
             10         -1          0          0     1e+06     1e+06
       -11.4483       0.01       -100       -100       100       100
       0.155208         -1          0          0    100000     1e+06
       0.171087      0.001          0          0    100000     1e+06
           1.87         -1     -0.999     -0.999        10        10
        1.69134        0.1         -3         -2        10       100
              1         -1          0          0     1e+20     1e+24
~
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Some basic setup
e.g., what data library to use

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cflux is used to find out the uncertainty in flux

Some basic setup
e.g., what data library to use

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cflux	Emin	0.3	-1	0	0	1e+06	1e+06
cflux	Emax	10	-1	0	0	1e+06	1e+06
cflux	log10Flux	-11.4483	0.01	-100	-100	100	100
Tbabs	nH	0.155208	-1	0	0	100000	1e+06
zTBabs	nH	0.171087	0.001	0	0	100000	1e+06
zTBabs	redshift	1.87	-1	-0.999	-0.999	10	10
powerlaw	PhoIndex	1.69134	0.1	-3	-2	10	100
powerlaw	norm	1	-1	0	0	1e+20	1e+24

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Some basic setup
e.g., what data library to use

		Initial guess of the parameter	delta value when search for best fit (-1 means not value is fixed)	minimum value	bottom value	maximum value	top value
cflux	Emin	0.3	-1	0	0	1e+06	1e+06
cflux	Emax	10	-1	0	0	1e+06	1e+06
cflux	log10Flux	-11.4483	0.01	-100	-100	100	100
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~

Homework 11