Swift/BAT GRB Spectral Analysis

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Goddard Space Flight Center

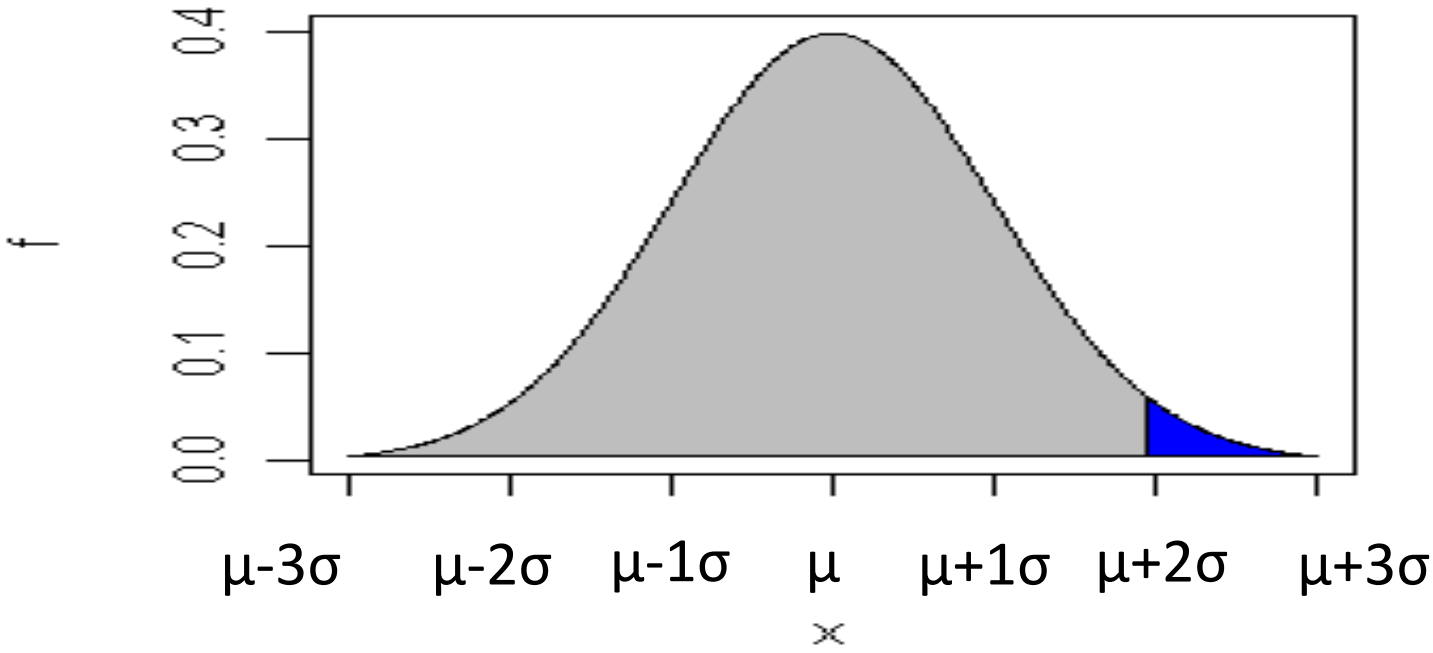
ASTR 288C, Lecture 9, 2017/10/30

Homework 9

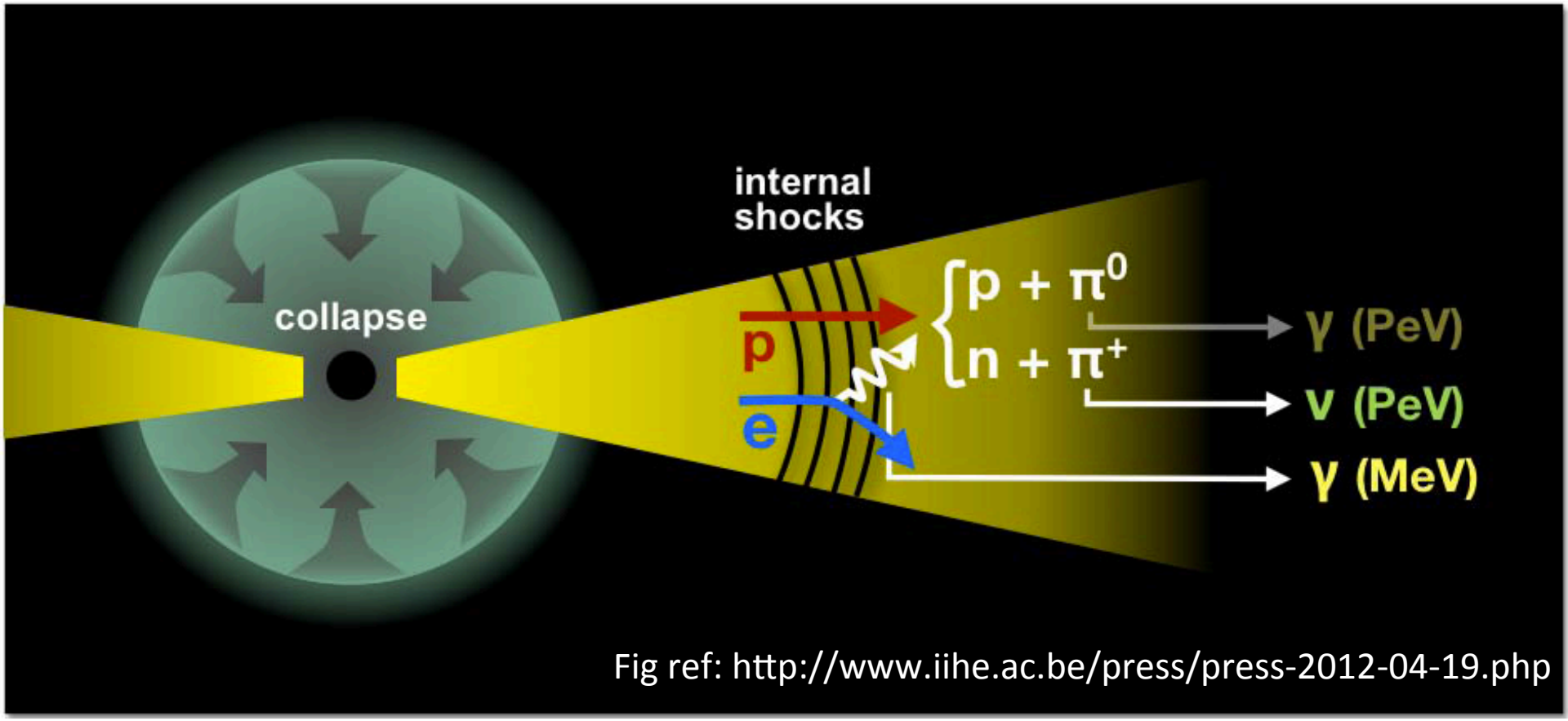
- Thank you for starting early and help debugging!

Homework 8

- Signal-to-noise ratio
  - Noise: σ
- False-detection rate above x sigma
  - Same with the Poisson distribution

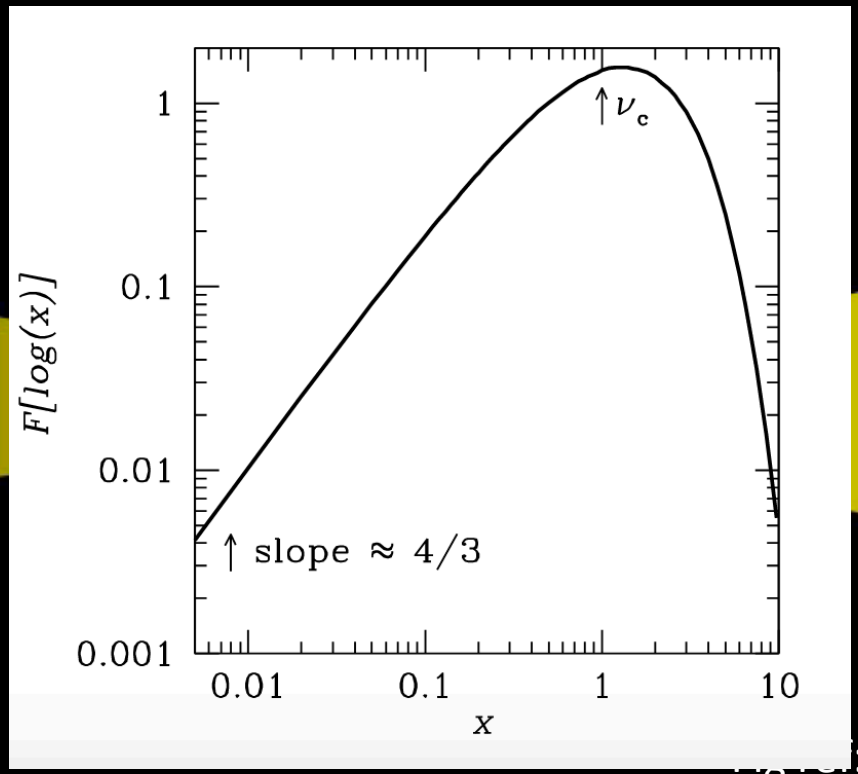


GRB mechanism



- Synchrotron radiation → power-law spectrum

GRB mechanism



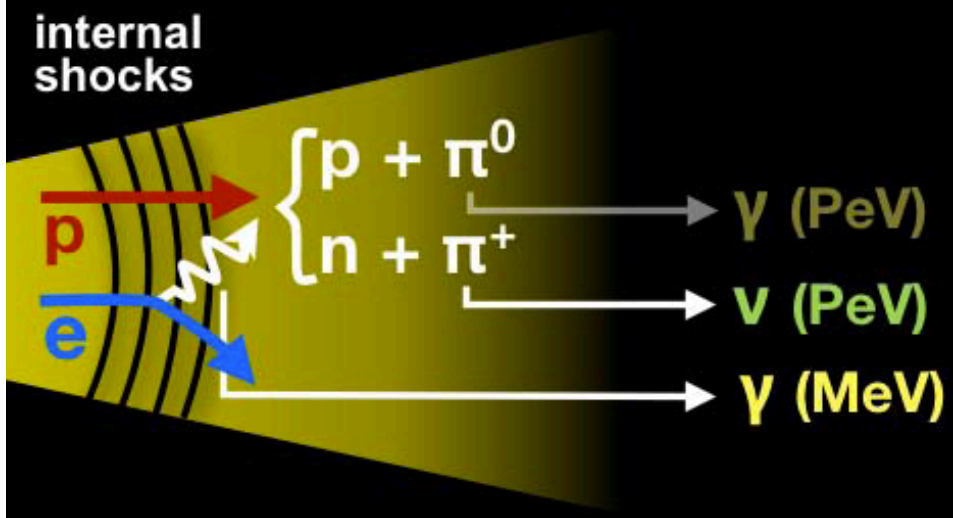


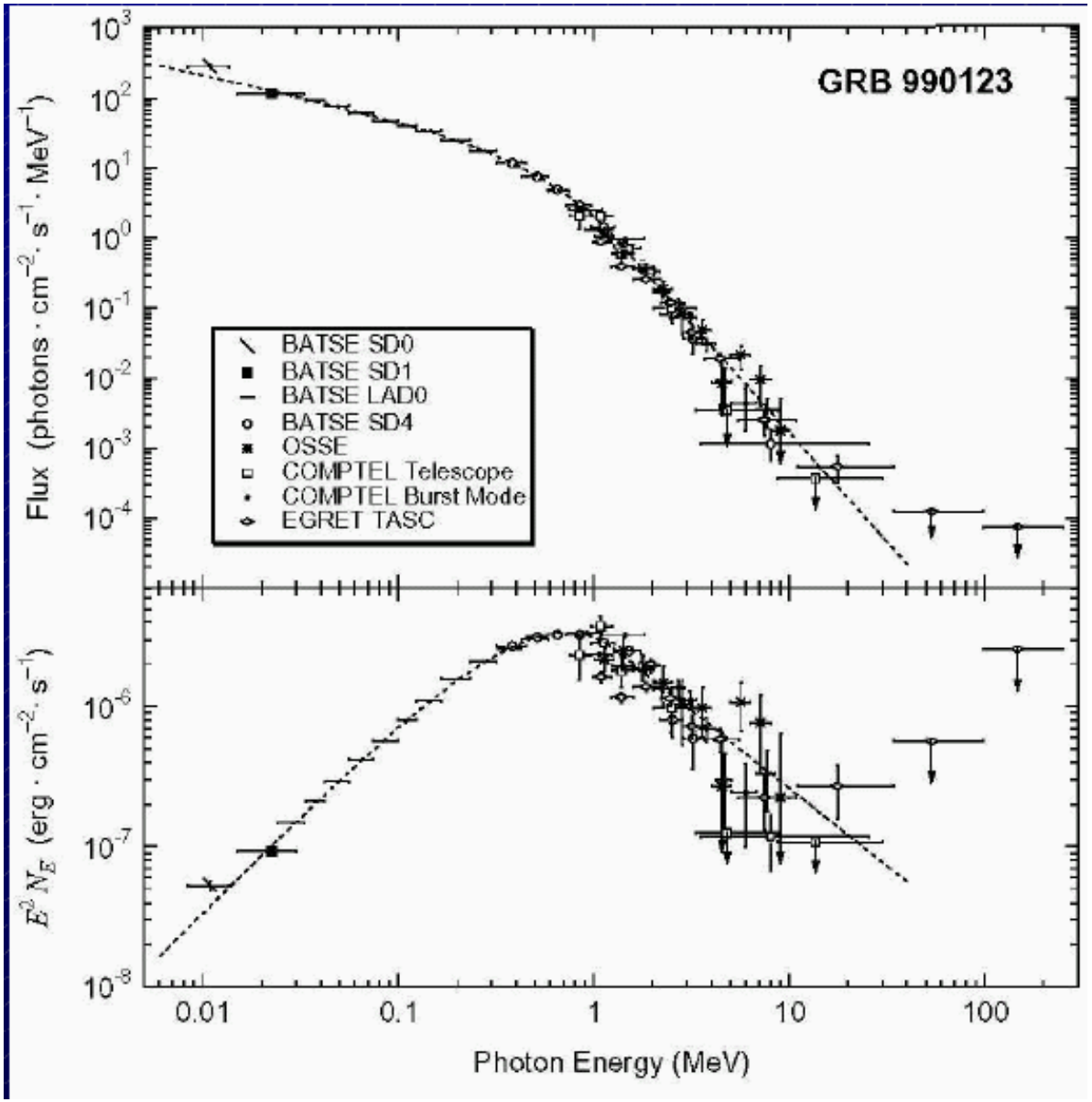
Fig ref: http://www.iihe.ac.be/press/press-2012-04-19.php

- Synchrotron radiation → power-law spectrum

GRB Spectrum

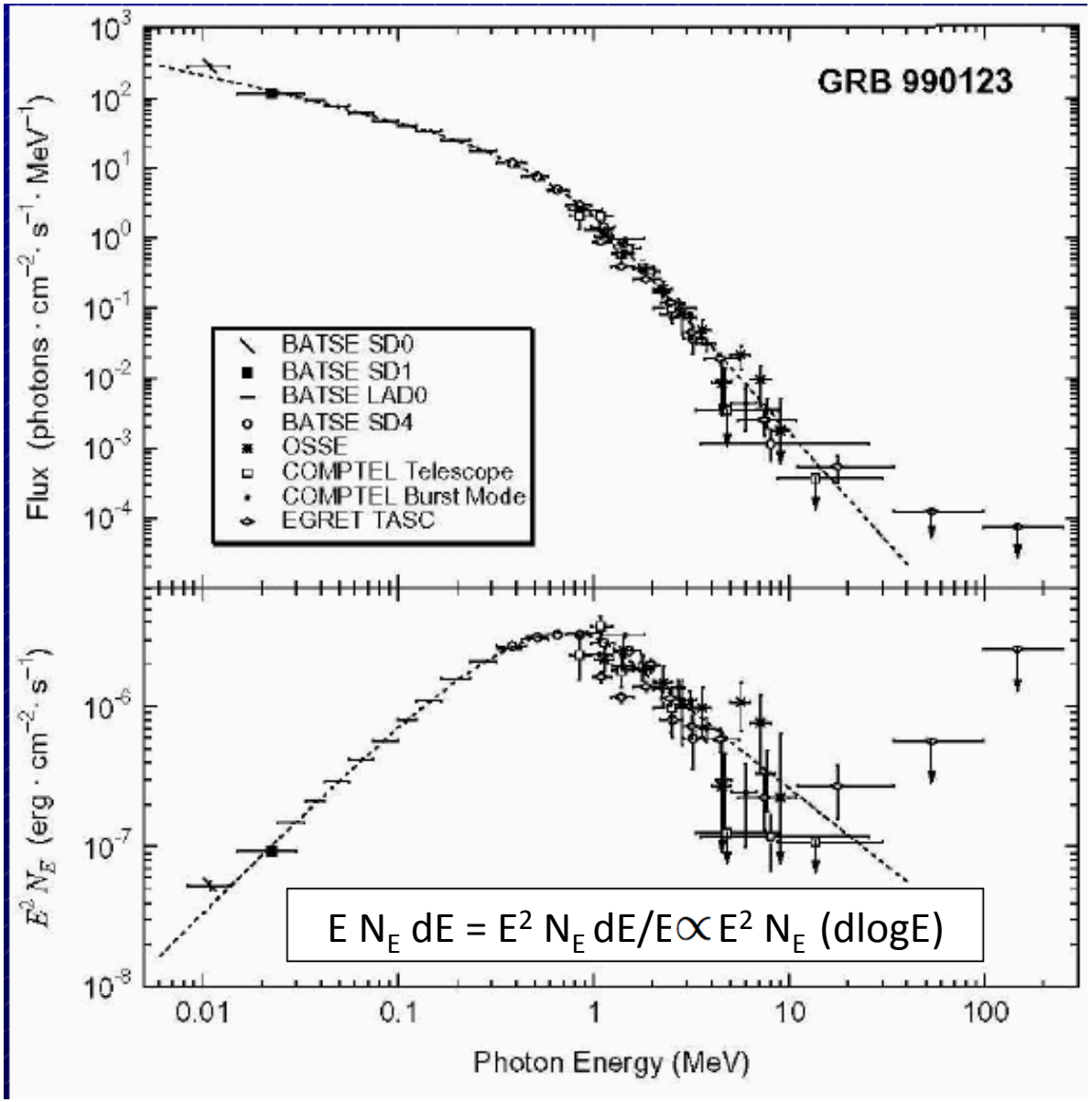
Photon flux N_E

Energy flux (in log space)
$E\,N_E dE \propto E^2\,NE(d\log E)$



Briggs et al. (1999)

GRB Spectrum



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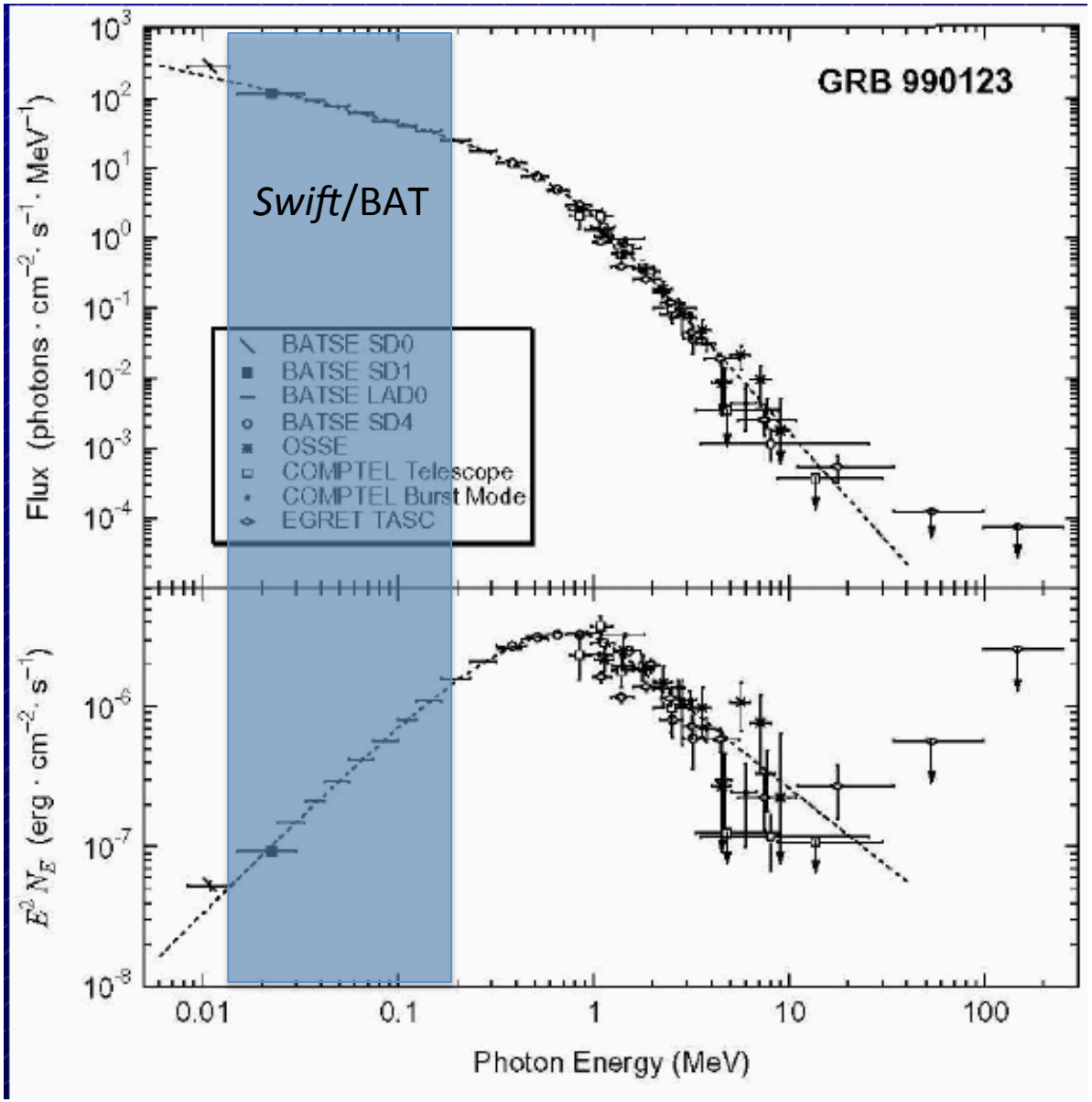

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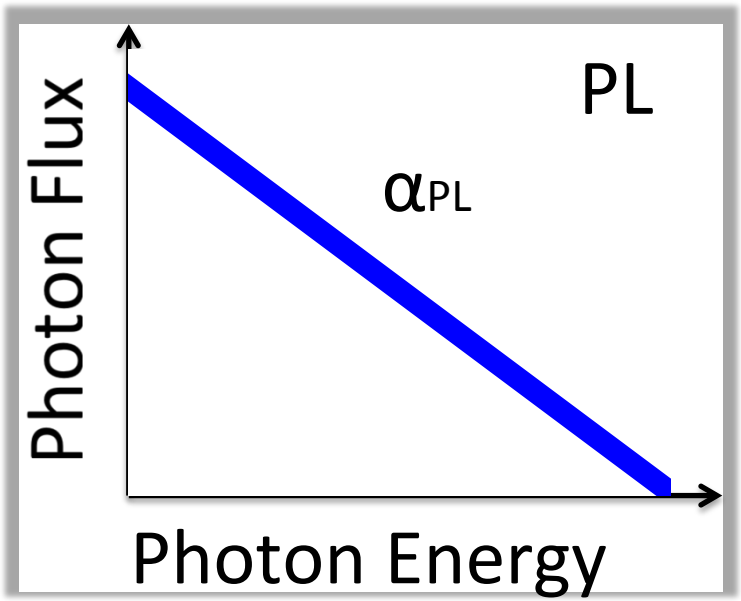
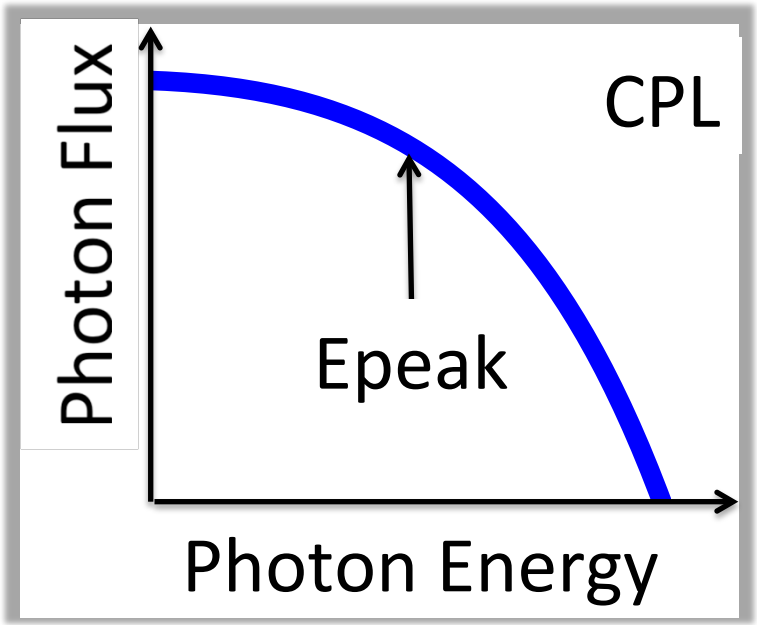
GRB Spectral Models

- Usual models we adopted for BAT spectra:
- (a) simple power law (PL)

  (b) cutoff power law (CPL)





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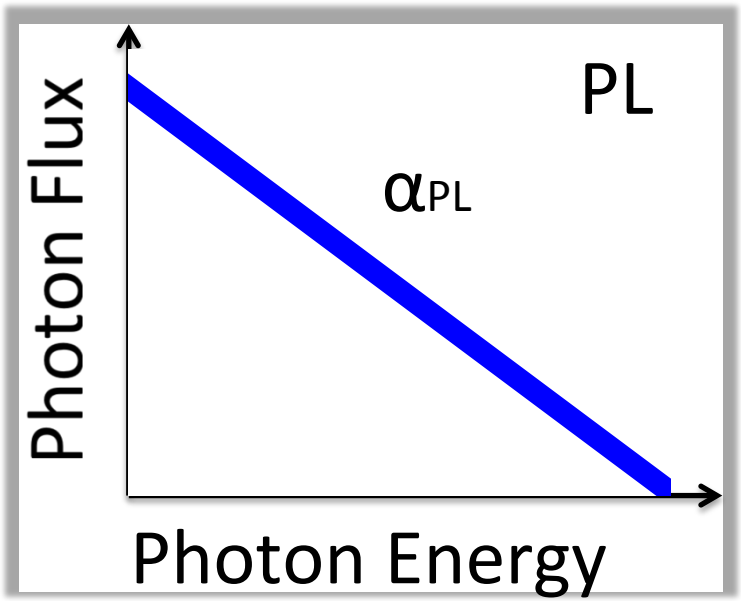
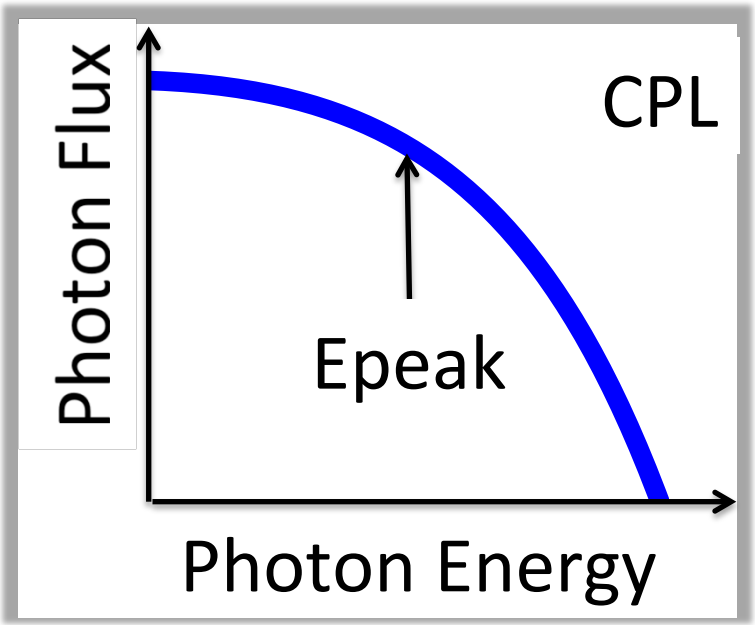
More negative alpha means?

Higher Epeak means?





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More negative alpha means?
Softer spectra (more photons distributed in the low energy range)

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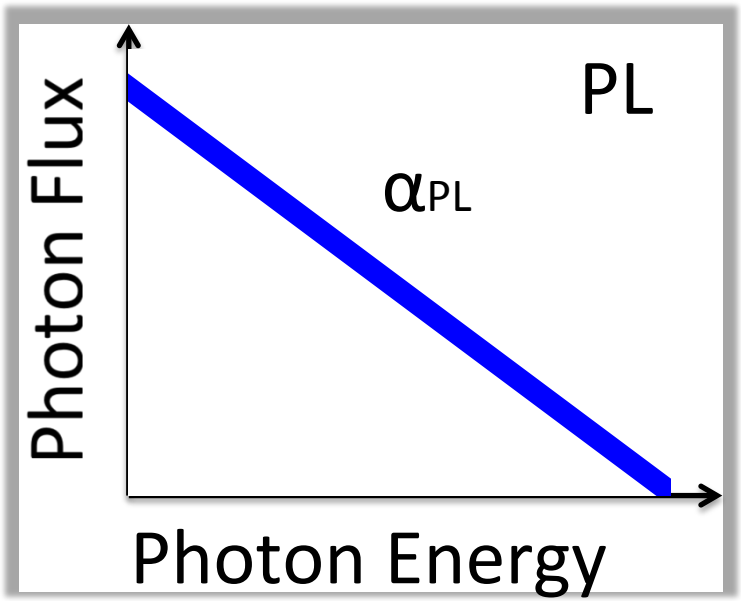

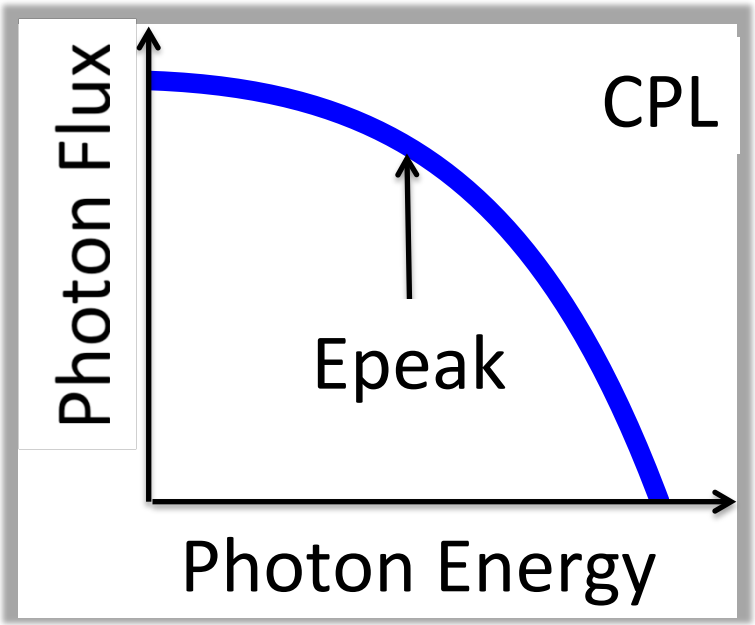

GRB Spectral Models

- Usual models we adopted for BAT spectra:
- (a) simple power law (PL)

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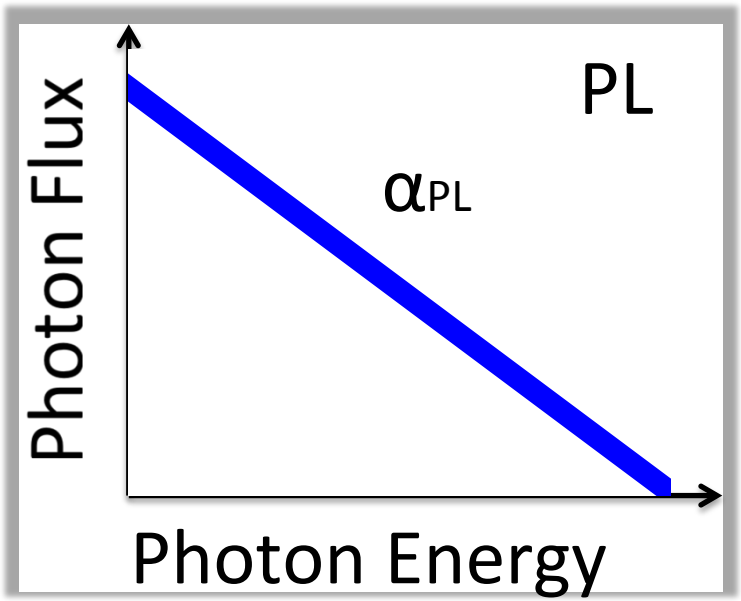
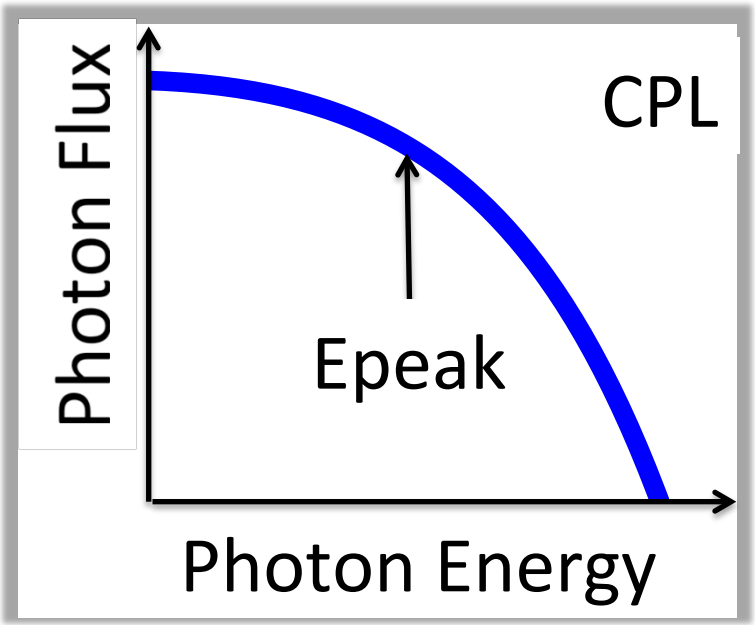
More negative alpha means?
Softer spectra (more photons distributed in the low energy range)

Higher Epeak means?
Harder spectra (more photons distributed in the higher energy range)





BAT spectrum and response file

- BAT spectrum: *.pha
  - Energy channel vs count rate (or count)
- BAT instrumental response: *.rsp
  - Probability of detecting a photon with energy X at channel Y.
  - Converting input photon flux to detector count.

How to create a BAT spectrum

batbinevt infile=00769177000-results/events/sw00769177000b_all.evt outfile=sw00769177000b_test.pha outtype=PHA timedel=0 timebinalg=u energybins='CALDB:80’ detmask=00769177000-results/auxil/sw00769177000b_qmap.fits ecol=ENERGY weighted=YES outunits=RATE tstart=XXX tstop=XXX clobber=yes

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Update spectrum keyword and systematic errors:
batupdatephakw
batphasyserr (see lab sheet for the full command)

How to create a BAT response file

batdrmgen infile=sw00769177000b_test.pha outfile=sw00769177000b_test.rsp chatter=2 hkfile=NONE clobber=yes

Model fitting

- Xspec
  - An X-Ray Spectral Fitting Package
  - https://heasarc.gsfc.nasa.gov/xanadu/xspec/
  - Fitting spectrum with some specific models (e.g., simple power law, cutoff power law, blackbody….etc).
  - Can select fitting statistics.
    - Default: Chi-square (the proper one for BAT spectrum).

This week's homework - Proposal

- Create the next half of the proposal, submit next week for review
  - Even for people doing projects with the same title, each person has to design your own method.
    - As always, you are encouraged discuss with each other, but need to have your own design using your own judgment of what is good for your project.
- 2 weeks later:
  - Proposal results: accepted vs revision
  - The top 3 accepted proposal will get a small prize (due to our limited budget).

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This week's homework - Proposal

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Research project:

- ✧ Look into problems that no one knows the answer yet.
- ✧ Need to find your own solution and convince others.

- 2 weeks later:
  - Proposal results: accepted vs revision (no rejection!)
  - The top 3 accepted proposal will get a small prize (due to our limited budget).

This week's homework - Proposal

Date	Lecture	Lab
11/13	Spectral analysis - XRT	Spectral fitting (Submit final proposal)
11/20	Scientific proposal	Discuss student proposal (Project start)
11/27	Dedicated time for research projects	Individual research
12/04	Science communication	Individual research (Paper draft)
12/11	Dedicated time for research projects	Individual research
12/15	Oral presentation	(Final paper submission)

- This project needs to be finished in $\sim$ 3 weeks
  - Clearly lay out your schedule in your proposal.
  - Each week for the individual research, we will review your work schedule.

Example:
Title: Increasing high redshift GRB detection.
Science rationale: Increase the number of high redshift GRB detections to better constrain the star-formation history in the early universe.
Project goal: Explore the detectability of high redshift GRBs based on the GRB spectral characteristics.

Date	Proposed goal	
11/27	Finish simulating BAT GRB light curves at different redshifts	
11/04	Finish estimating BAT GRB detectability and spectral indices at different redshifts. Finish paper draft.	
12/11	Finish summarizing the changes GRB detectability as a function of spectral index at different redshift.	
12/15	Oral presentation	(Final paper submission)

- This project needs to be finished in $\sim$ 3 weeks
  - Clearly lay out your schedule in your proposal.
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This week's homework - Proposal

- Proposal will be judged based on
  - Clarity: clearly state your scientific goal and method
  - Feasibility (in 3 weeks)
  - Relevant to Swift (use of Swift data). Specifically, use at least 3 of the following items:
    - Swift XRT/BAT GRB catalogs
    - Temporal/Timing analysis
    - Spectral analysis
    - Statistical analysis
    - Coding
  - Creativity
  - Riskiness/difficulty

This week's homework - Proposal

- Your final project will be judged by:
  - Completeness
  - Difficulty
  - Creativity
  - Quality of writing
  - Quality of oral presentation