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NASA

Uncertainty and Underestimation of GRB Prompt Emission Duration with Swift/BAT

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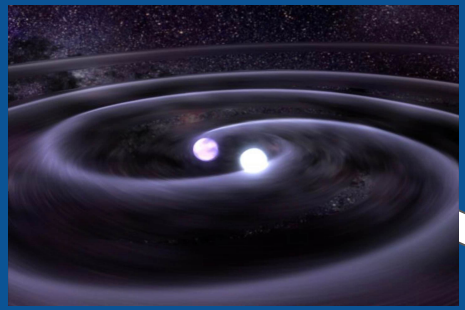
Collaborators:
Amy Lien (NASA/GSFC, CRESSTII, UMBC),
Sylvain Guiriec (NASA/GSFC, CRESSTII, GWU)

Context - GRB Phenomena



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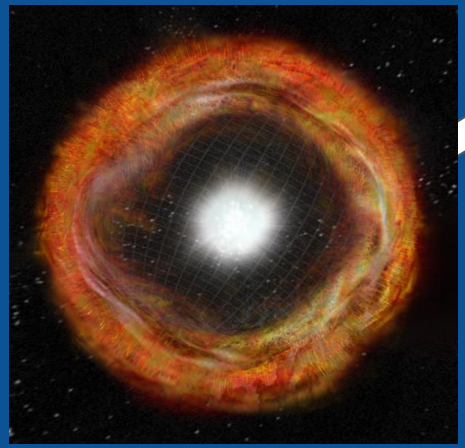

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NASA/Goddard Space Flight Center

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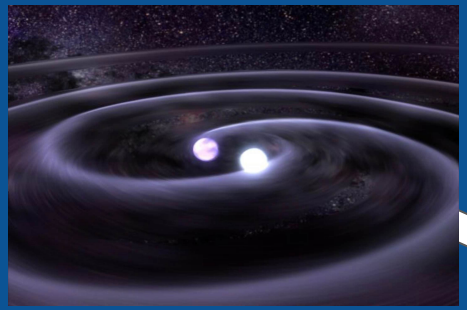

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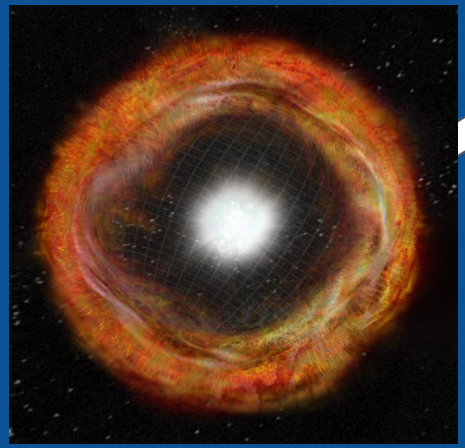

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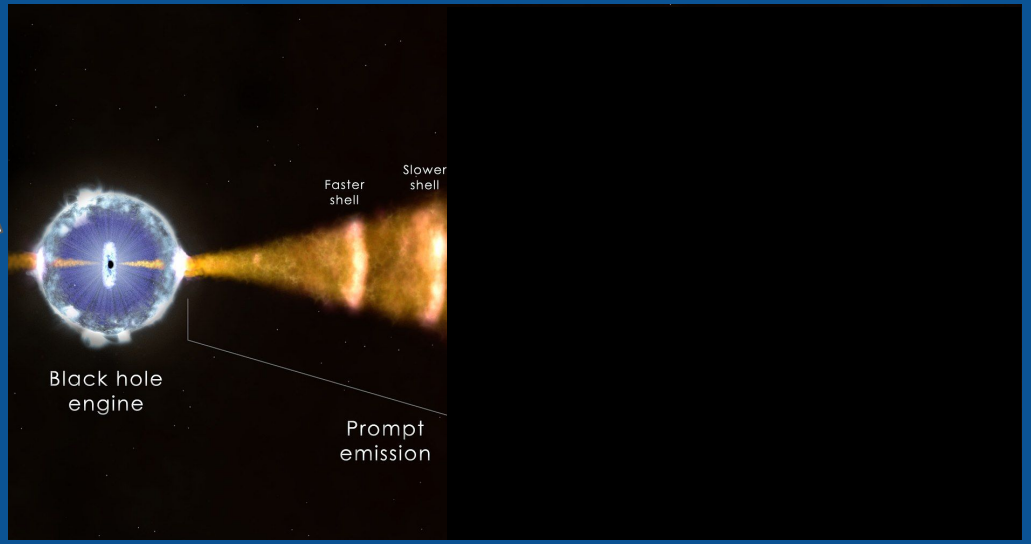

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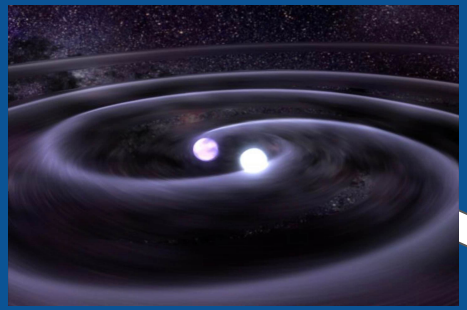

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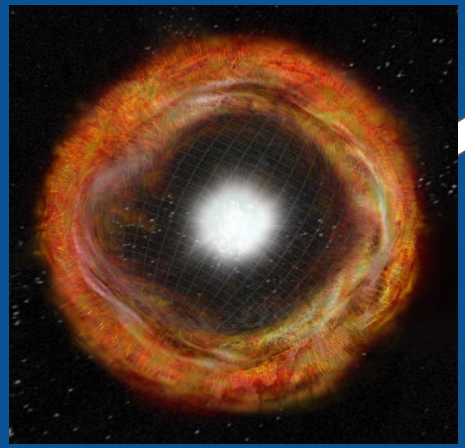

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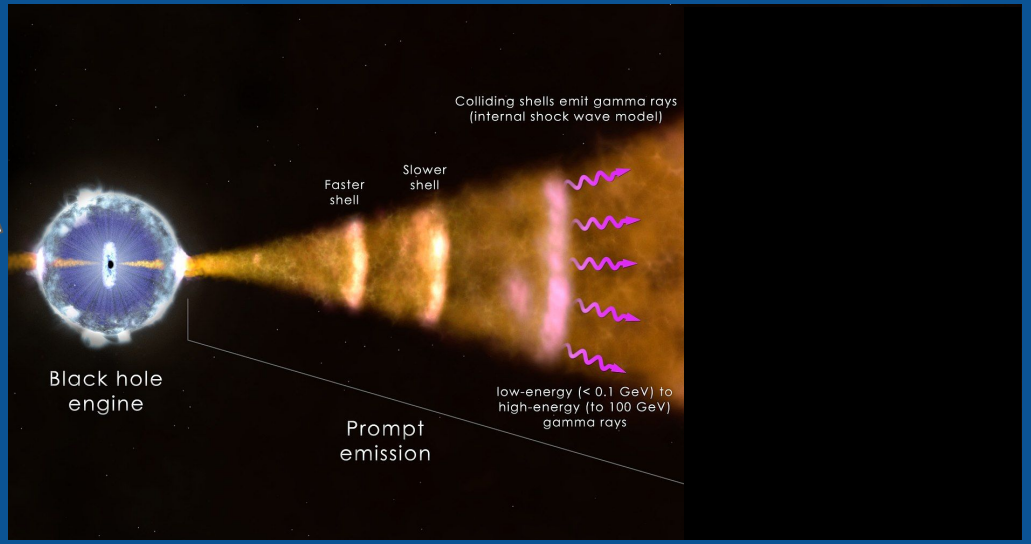

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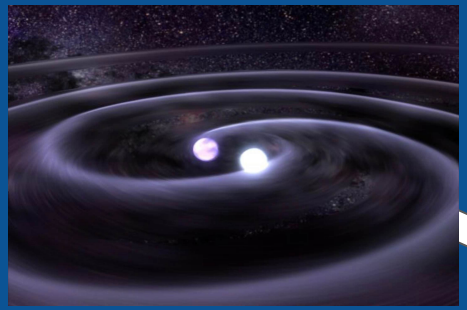

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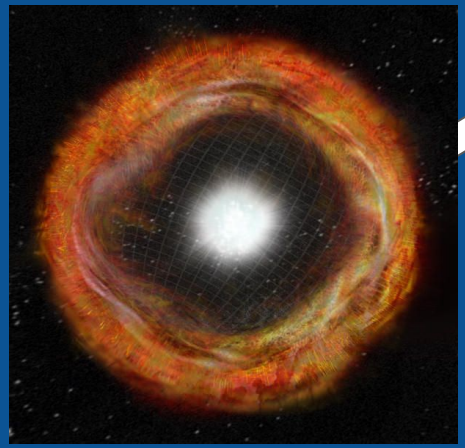

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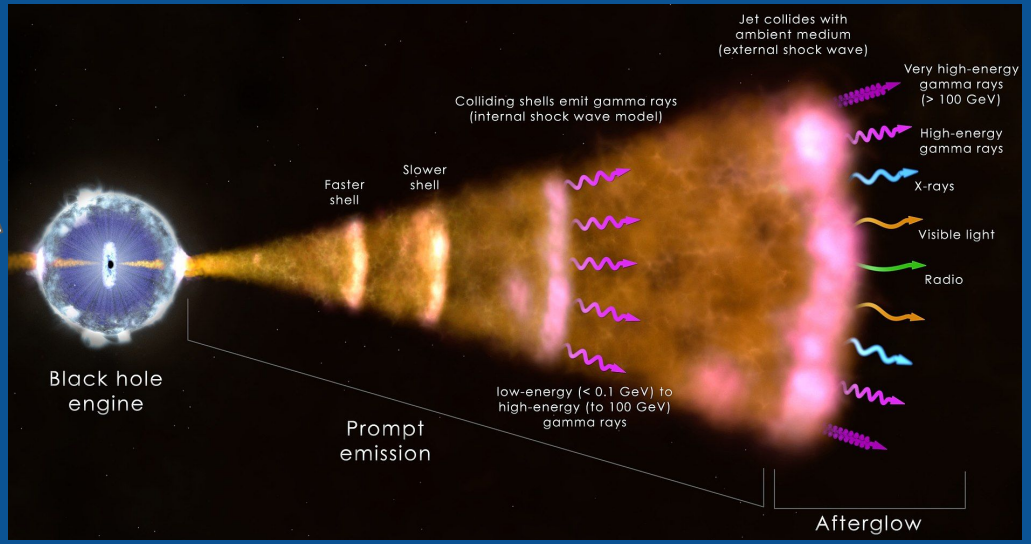

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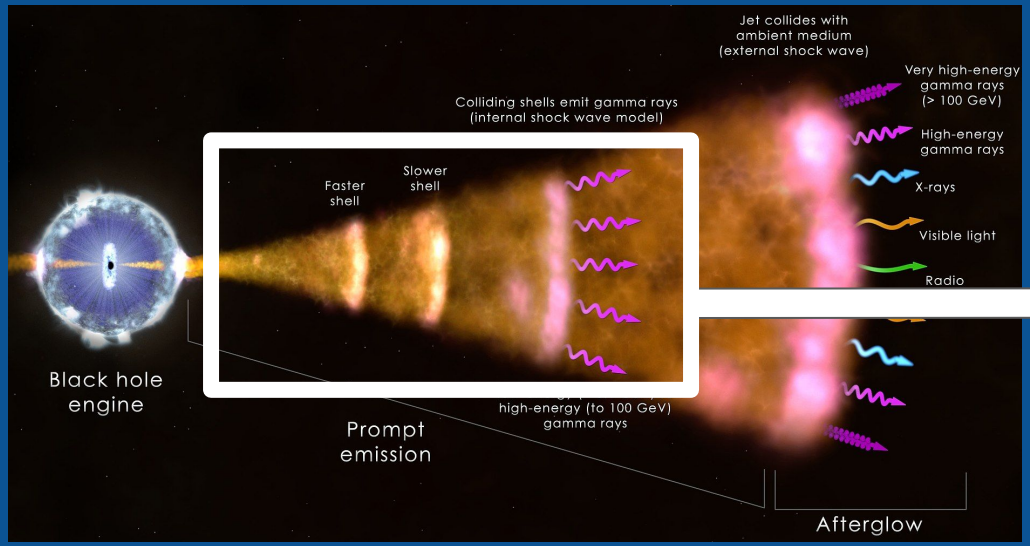

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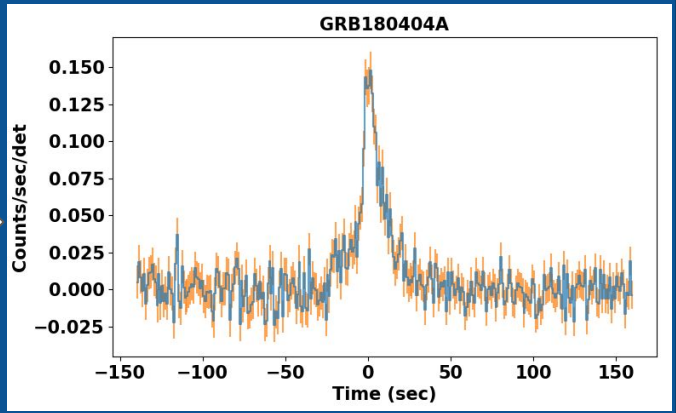

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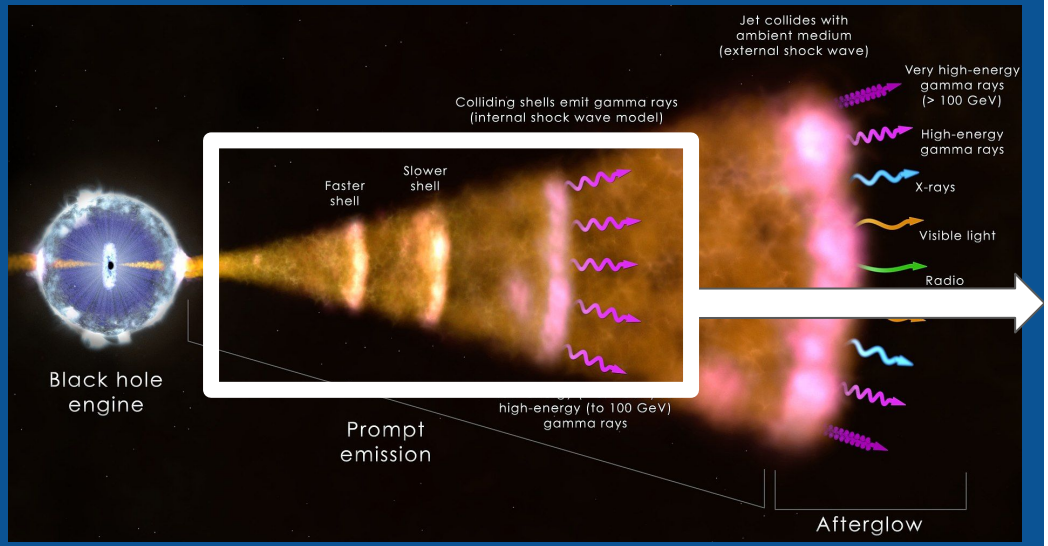

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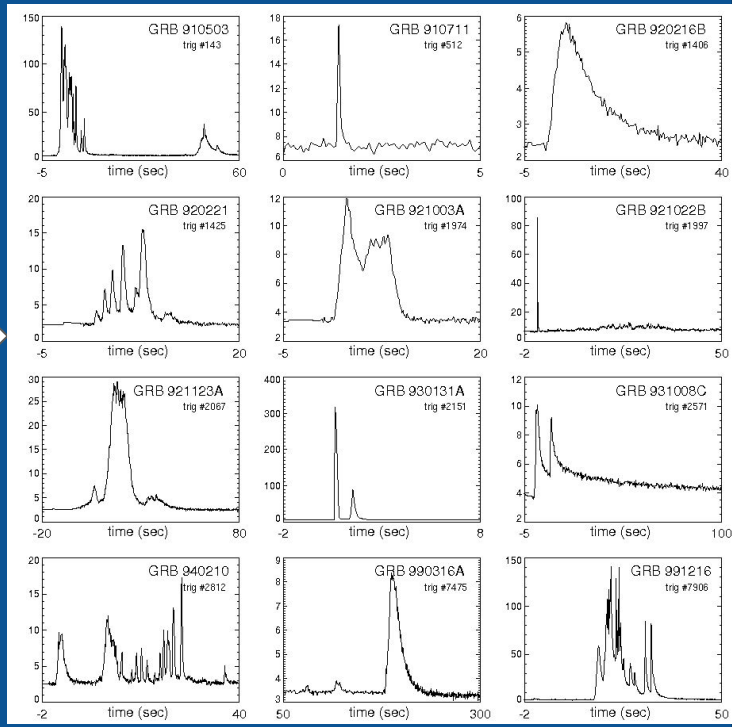
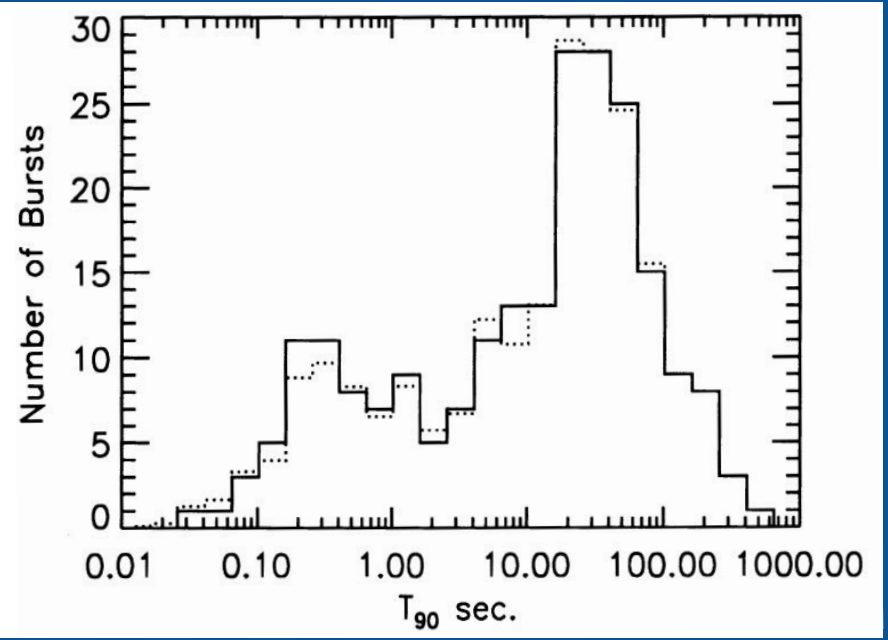
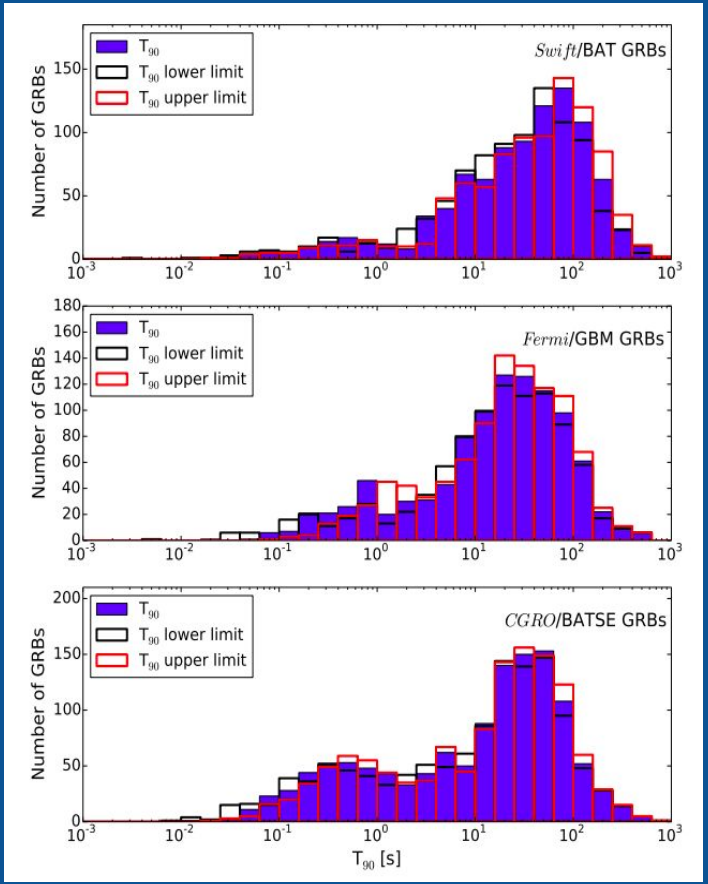


T90 Distribution



Kouveliotou et al., 1993

T90 Distribution - Instrumental Effects



Lien A. et al., 2016

Project Goal

To determine if the measured T90 durations of GRBs observed with *Swift*/BAT are accurate approximations of their true durations

Instrumental Considerations- SVOM/Eclairs

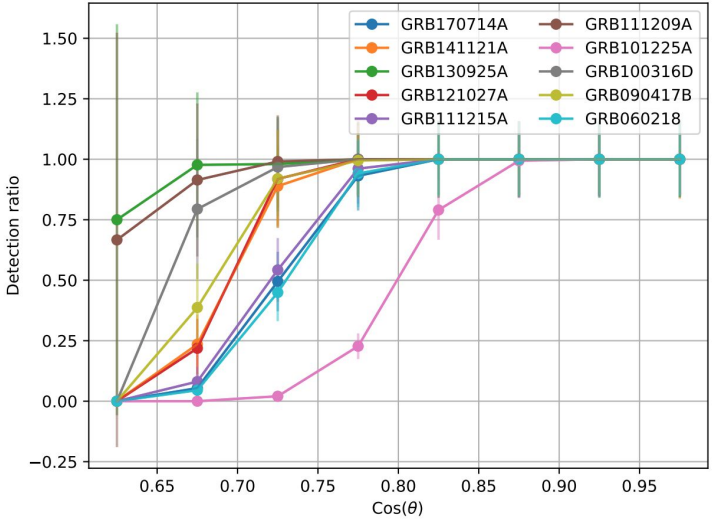


Fig. 9 Detection ratio (the ratio between the number of positions at which the burst is detected and the number of simulated positions) for each of the 10 ulGRBs as a function of $\cos\theta$.

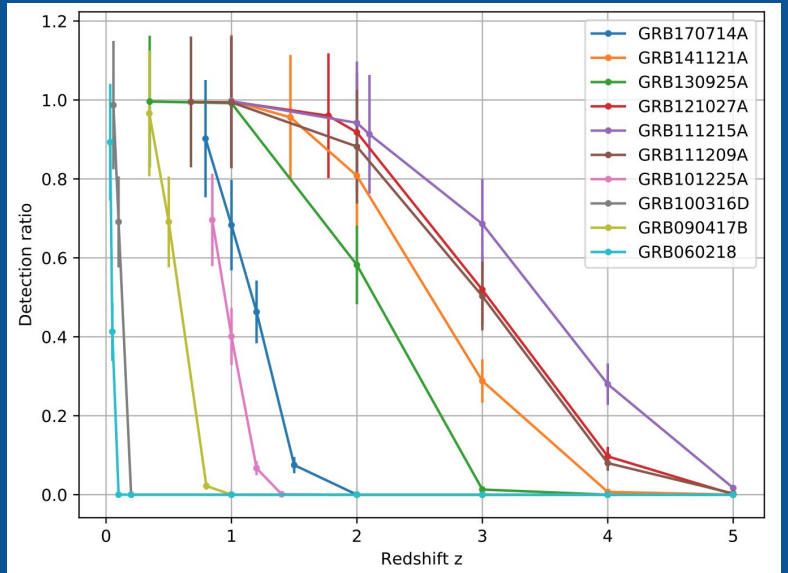
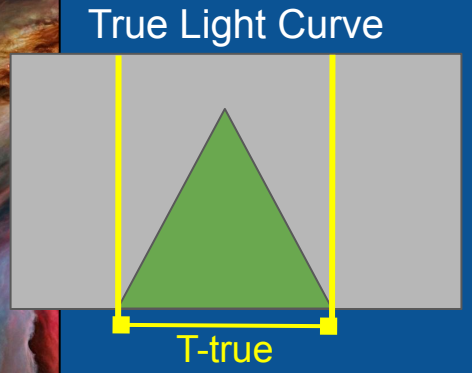


Fig. 16 Detection fraction (the ratio between the number of positions at which the burst is detected and the number of simulated positions) for each of the 10 ulGRBs according to the redshift.

Dagoneau, Schanne, Atteia, Götz, and Cordier (2020)

Instrumental Effects on GRB Light Curves



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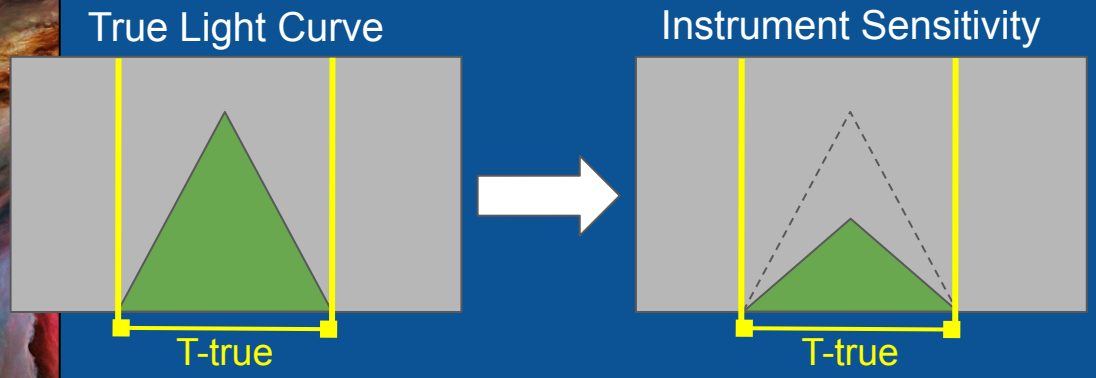

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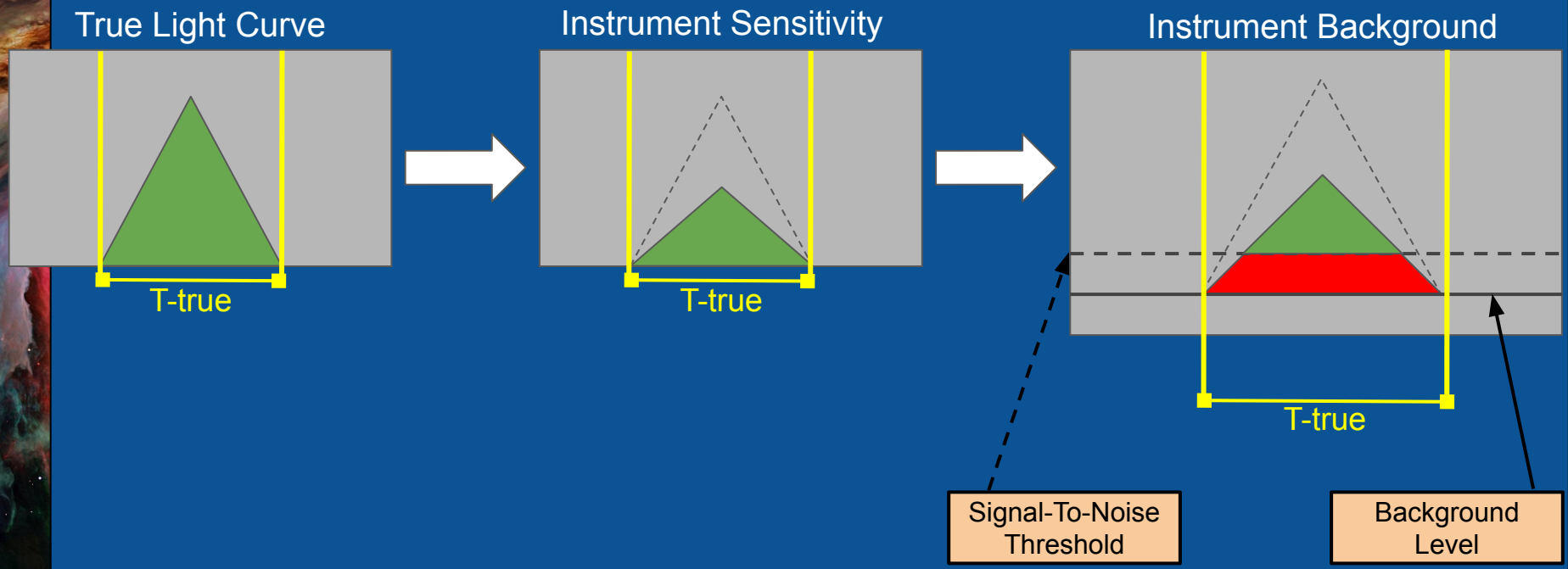

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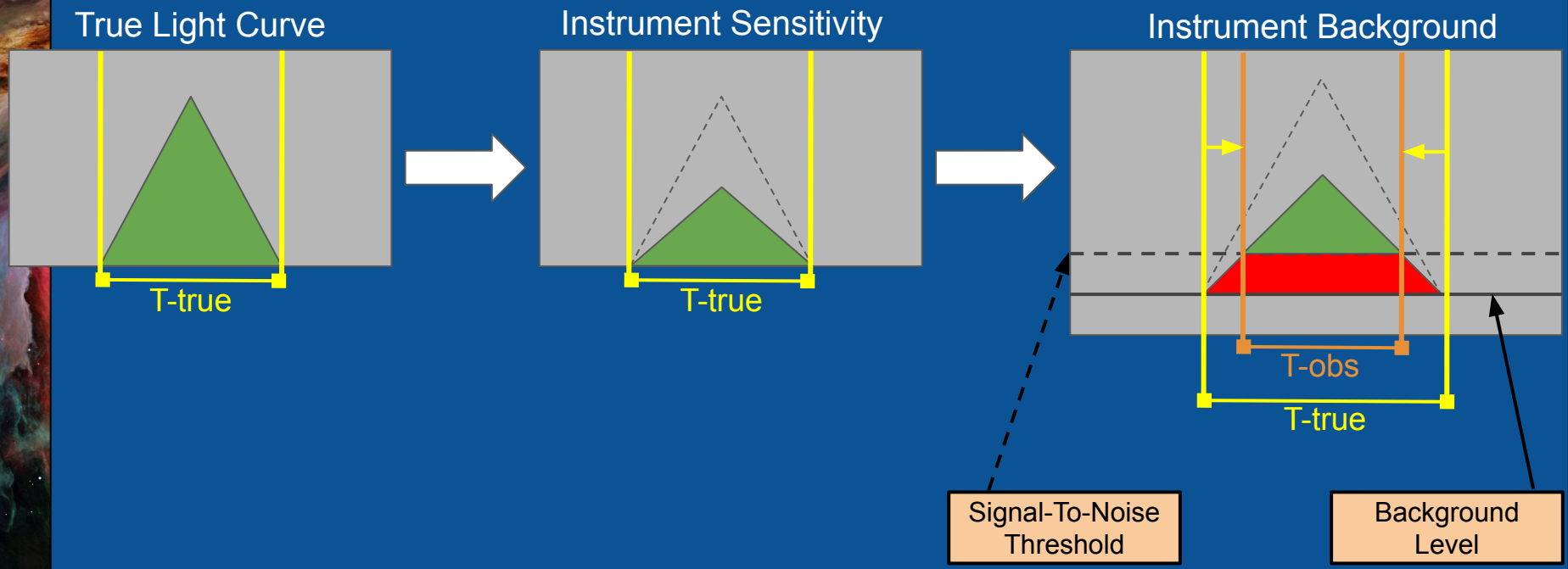
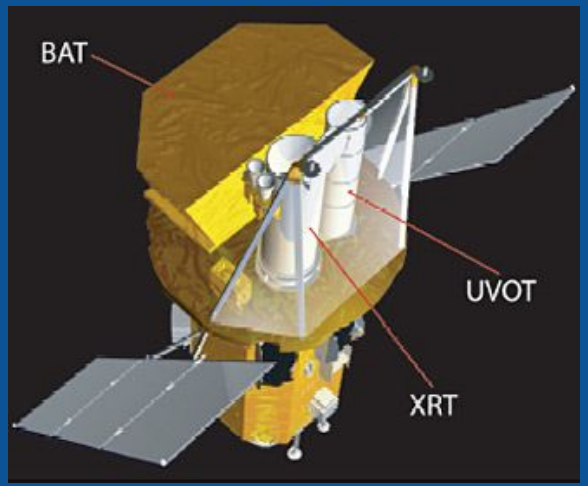
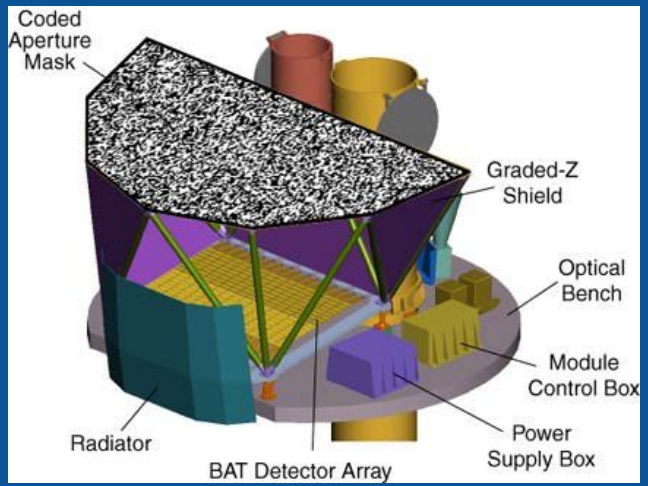


The *Neil Gehrels Swift Observatory*
Burst Alert Telescope





https://www.nasa.gov/mission_pages/swift/spacecraft/
https://swift.gsfc.nasa.gov/about_swift/bat_desc.html

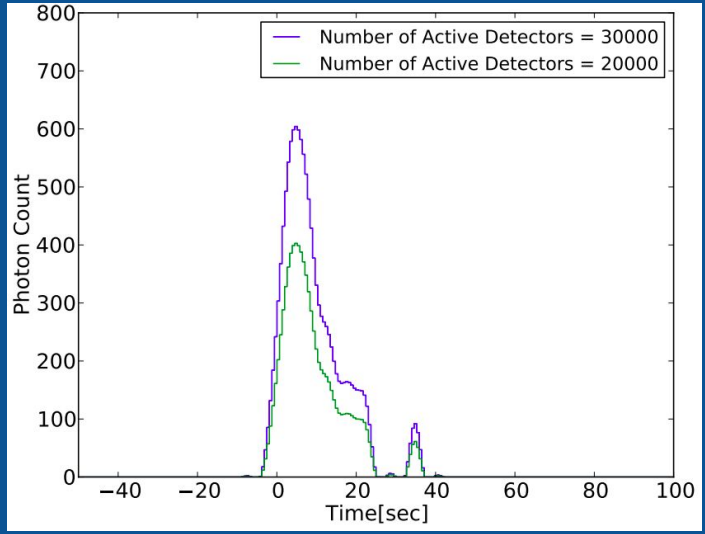
Swift/BAT Instrumental Parameters

Relevant Parameters:

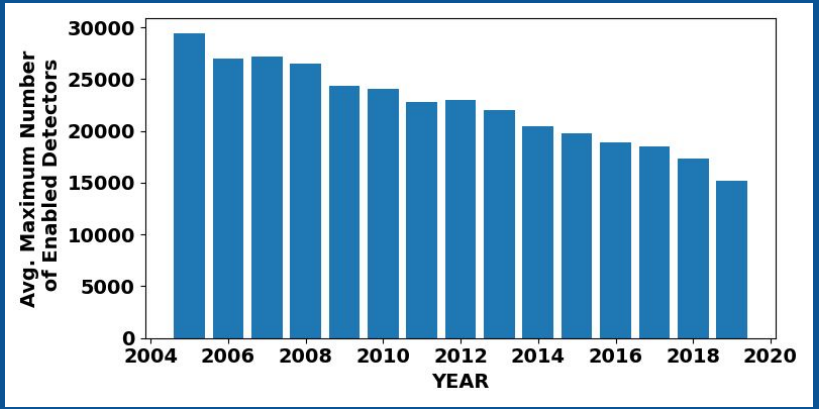
- **Number of Active Detectors (NDETS)**
- Incident angle (PCODE)
- Background

Not Relevant:

- Energy band



Lien A. et al., 2014



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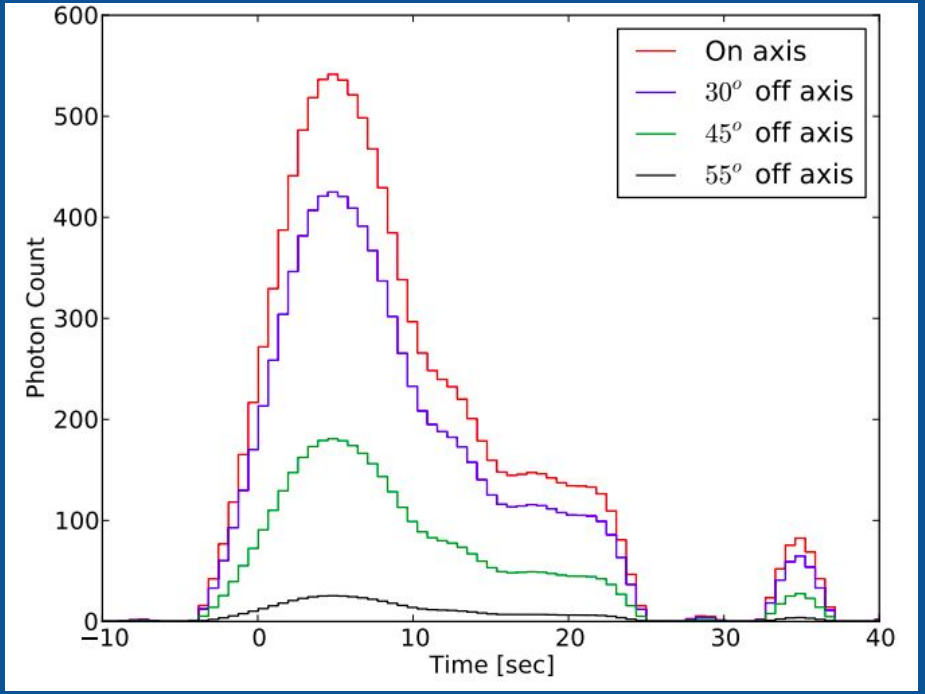
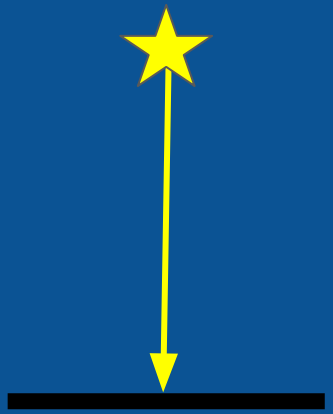
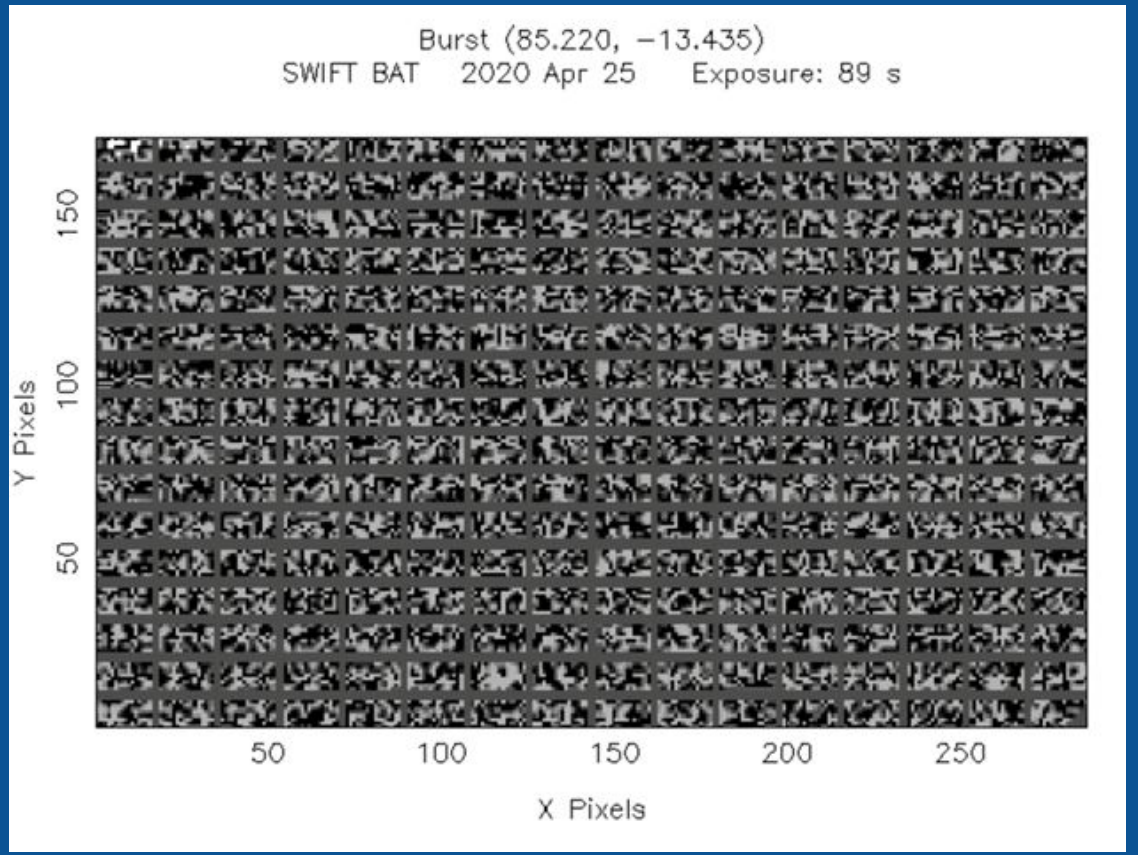


Lien A. et al., 2014

PCODE and Incident Angle



Incident Angle = 0 deg
PCODE = 1



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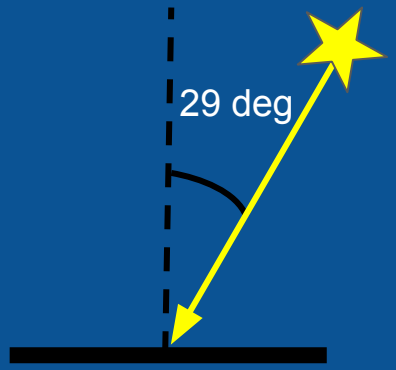
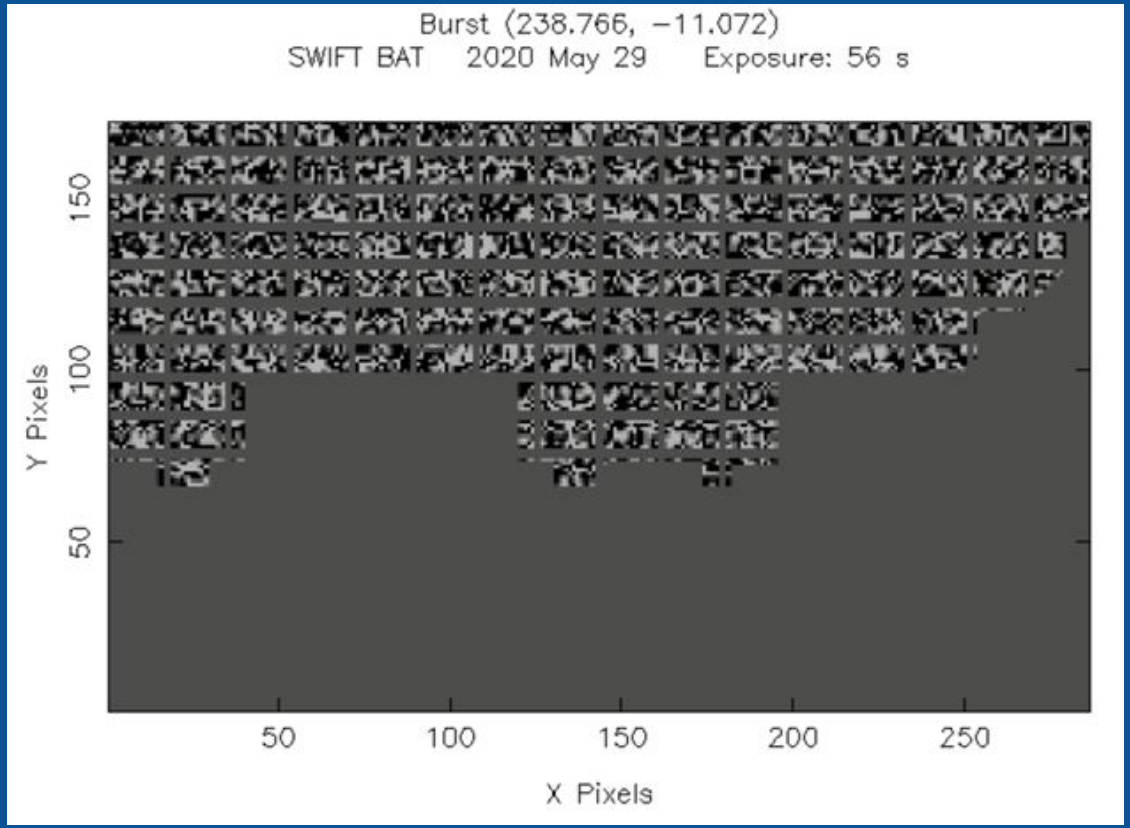
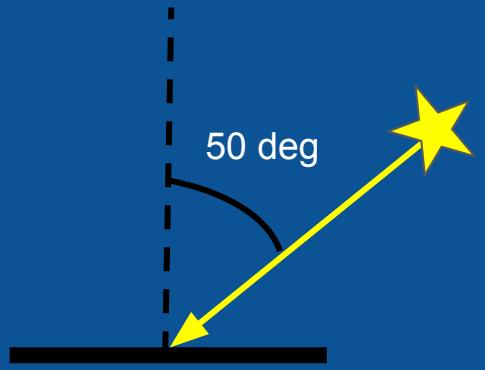


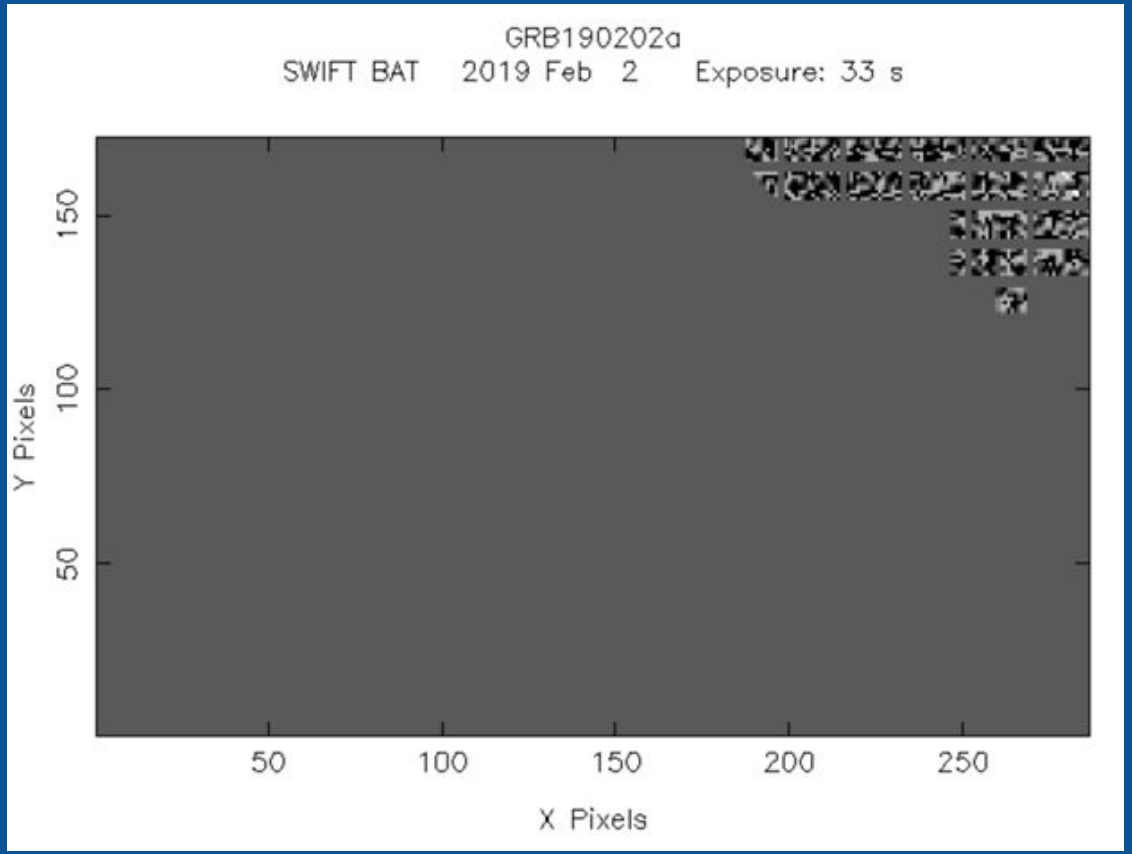
Incident Angle = 29 deg
PCODE = 0.5



PCODE and Incident Angle

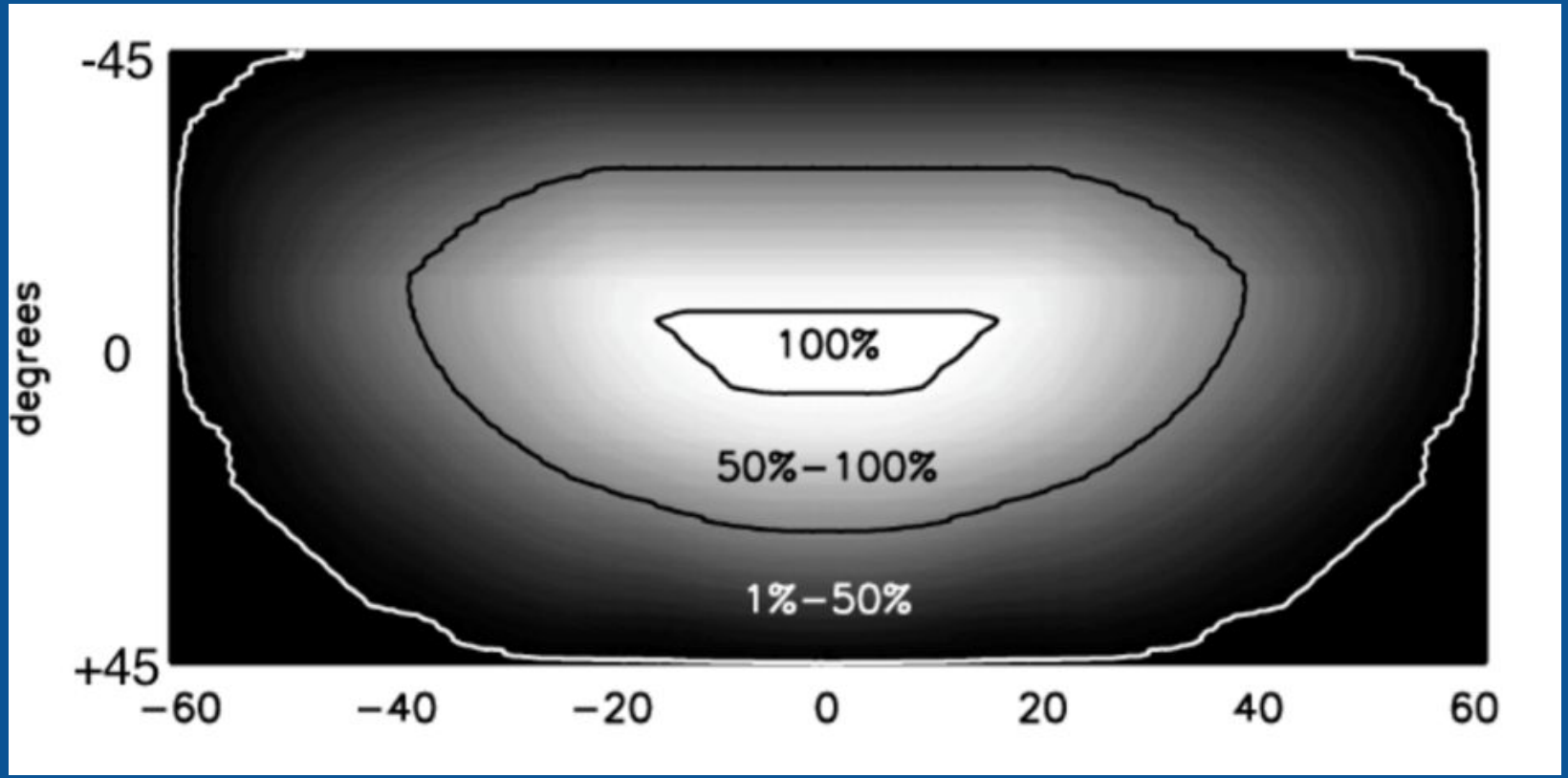


Incident Angle = 50 deg
PCODE = 0.04



PCODE vs BAT Field of View

Not exactly one-to-one with incident angle



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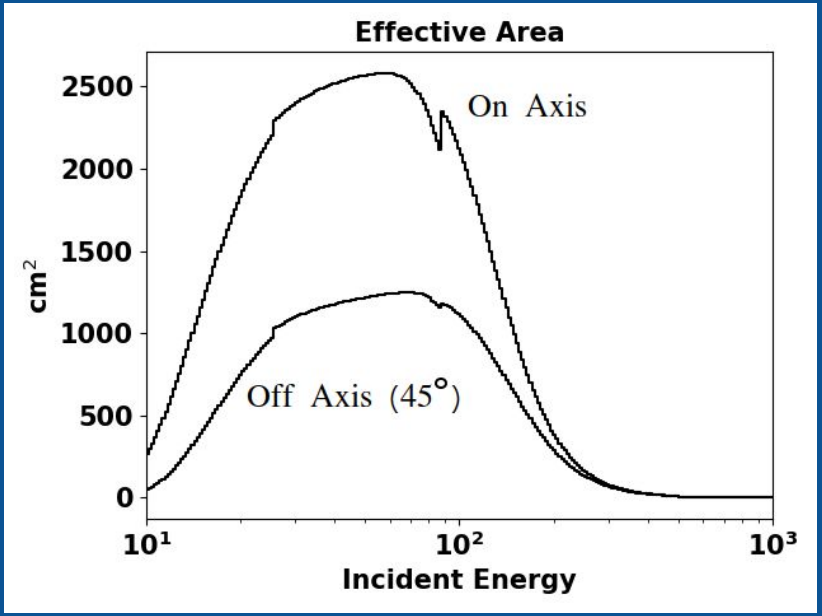
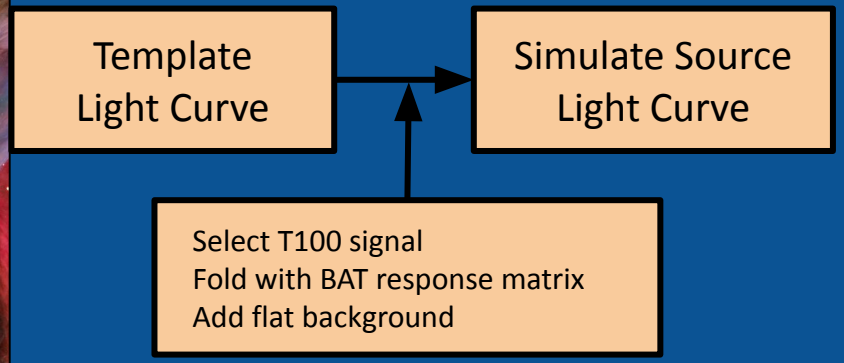


Simulation Method Summary



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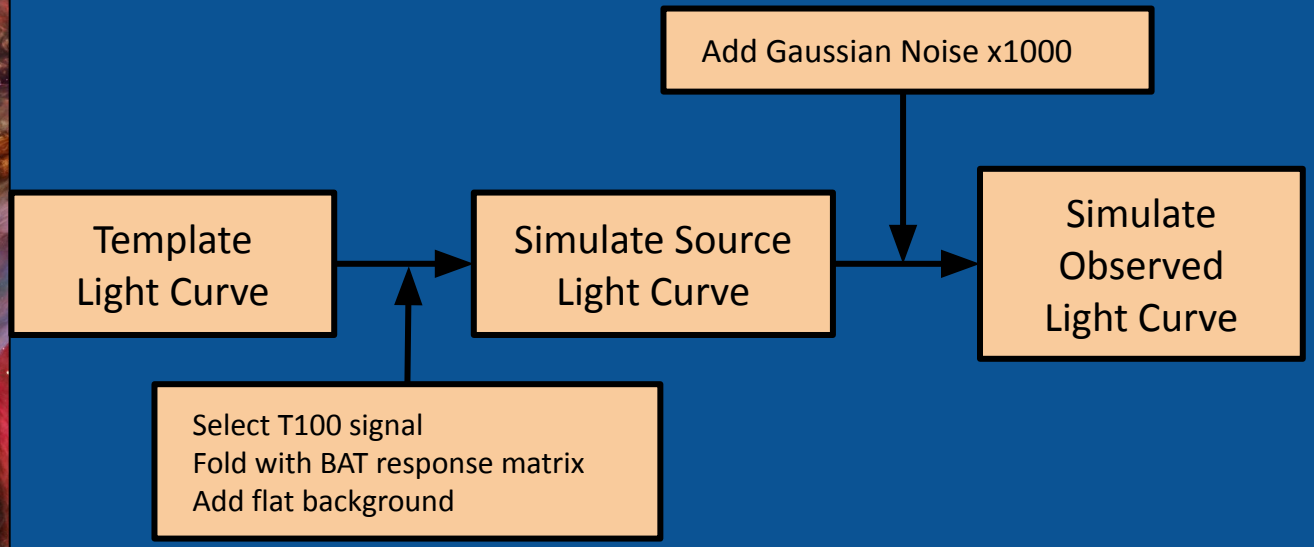

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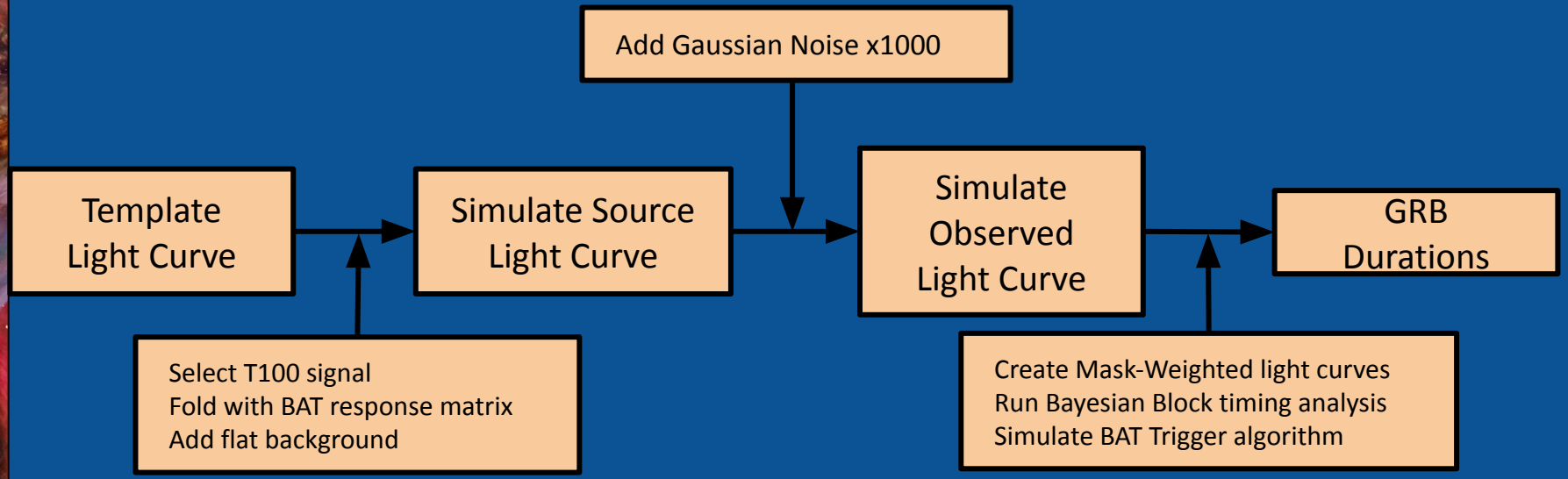
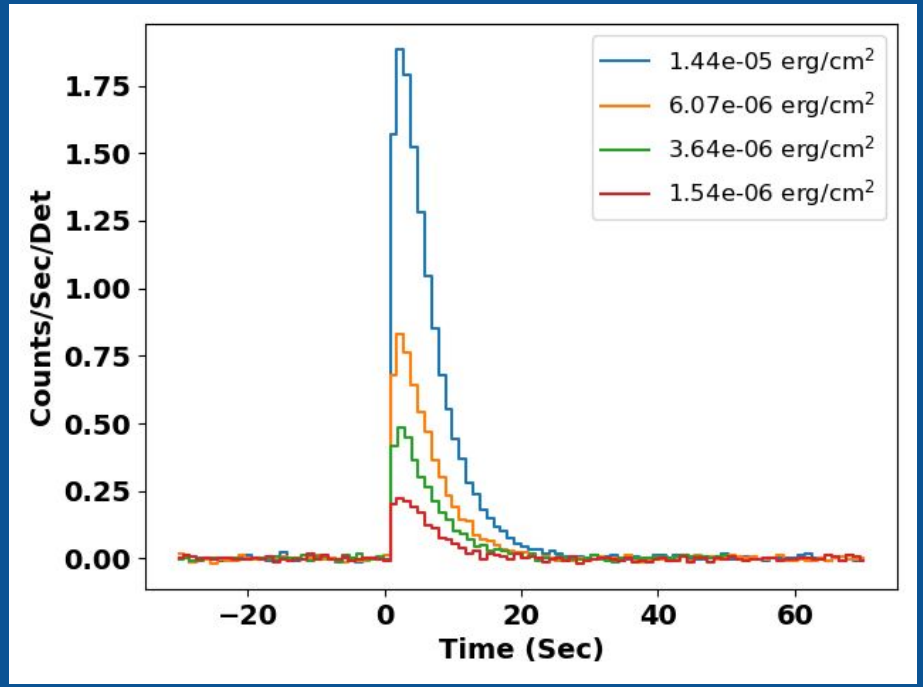


Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations

$$I(t) = A\lambda e^{[-\tau_1/(t-t_s)-(t-t_s)/\tau_2]}$$

Hakkila and Preece, 2014

A	t_s	τ_1	τ_2	Fluence (erg/cm^2)
20000	-0.1	1	4.5	1.44e-0.5
9000	-0.1	1	4.5	6.07e-06
5000	-0.1	1	4.5	3.64e-06
2500	-0.1	1	4.5	1.54e-06



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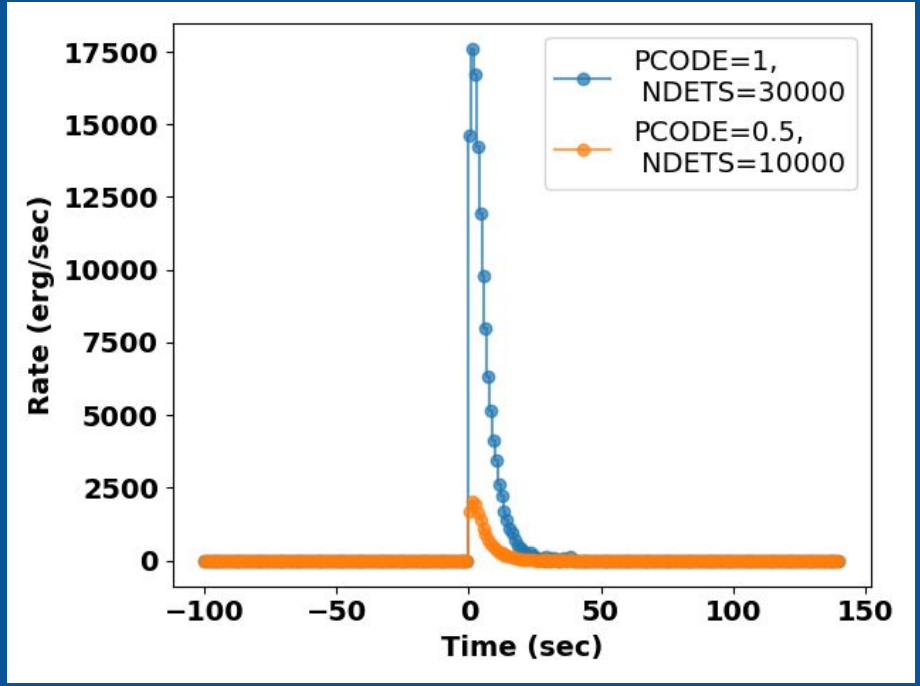

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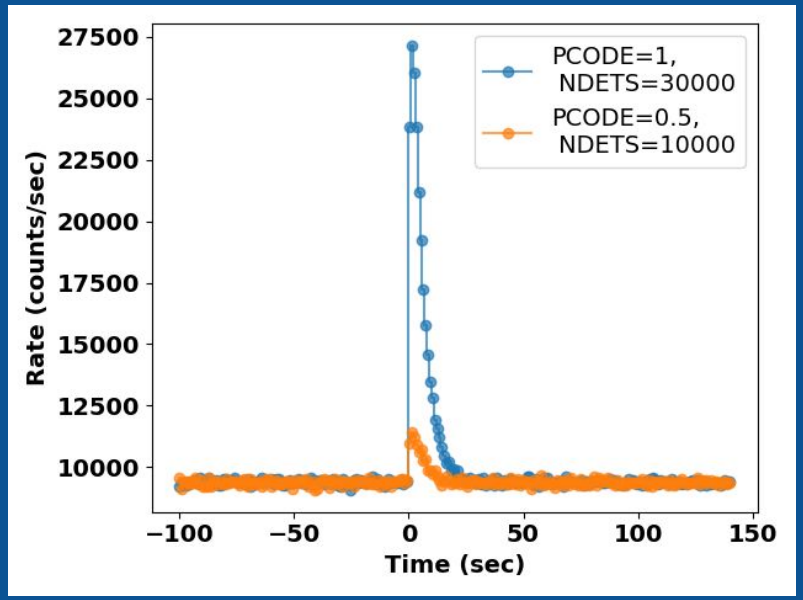
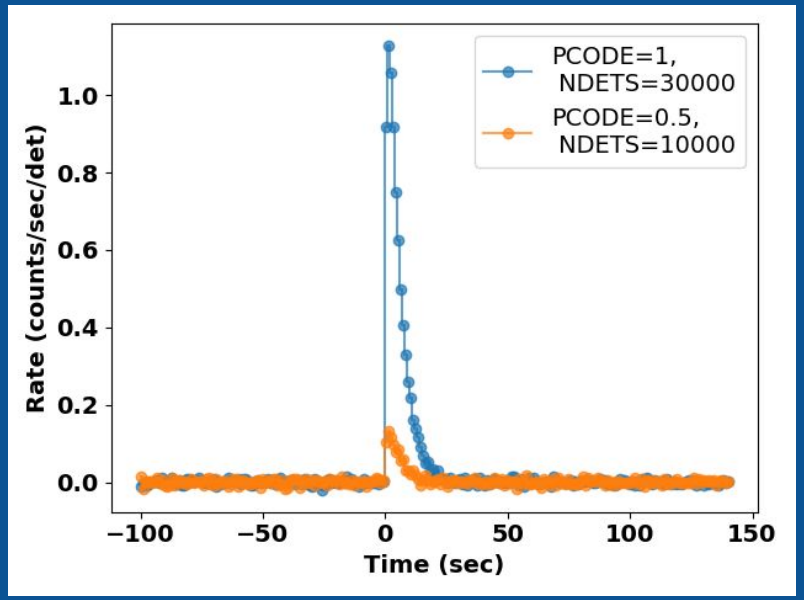
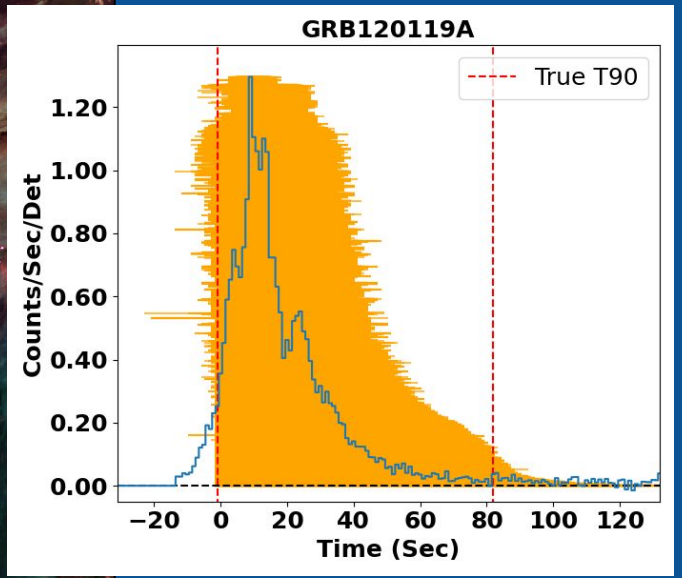
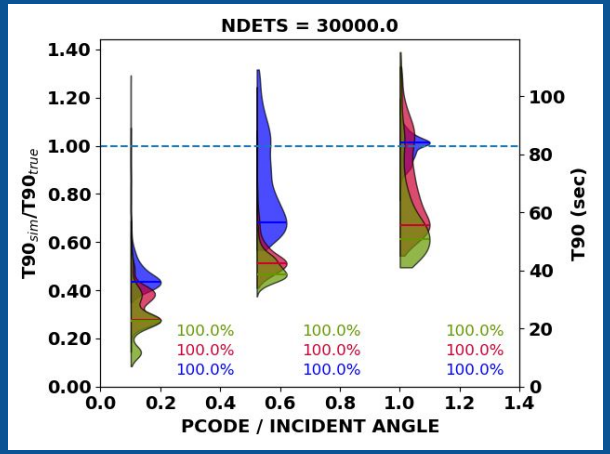


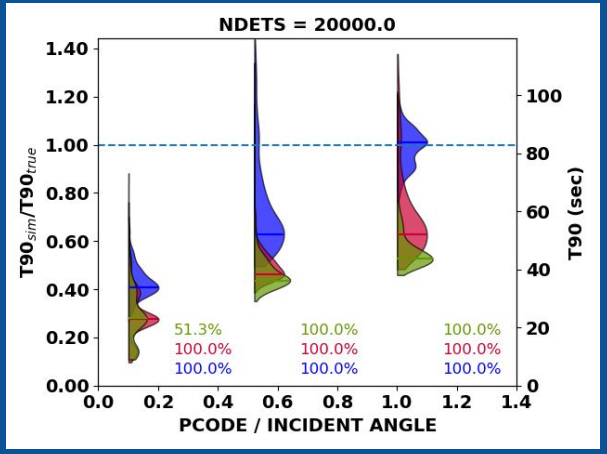


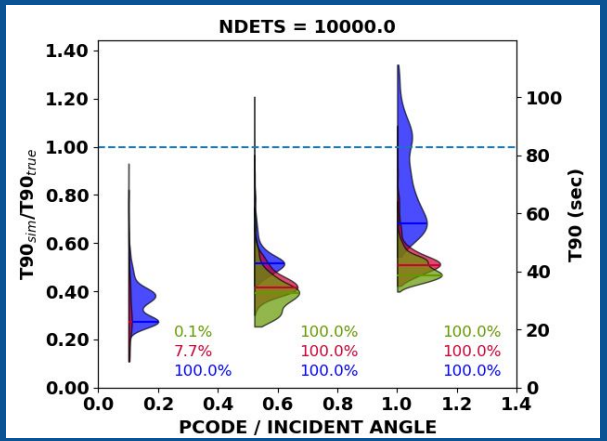
$$\mathrm{MWLC} = \frac{(LC - \mathrm{Bckgnd})}{\cos(\theta_\mathrm{i}) * \mathrm{NDETS} * \mathrm{pcode} * f(\mathrm{pcode})}$$

Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations



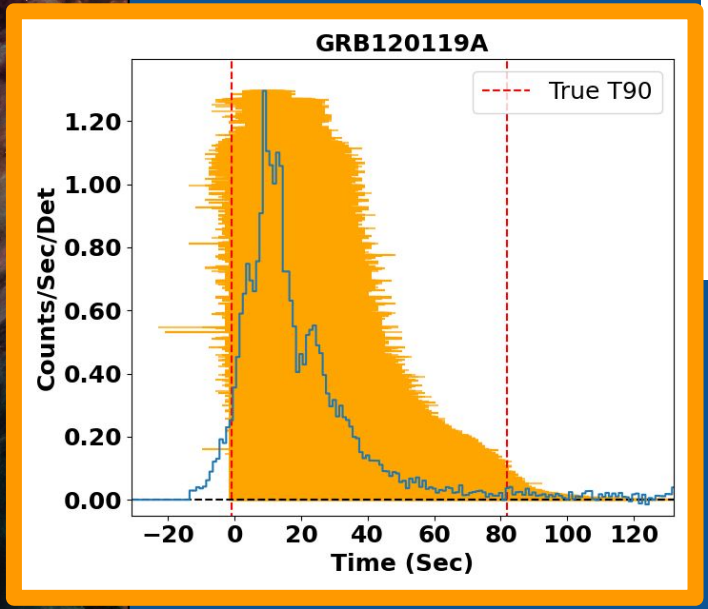


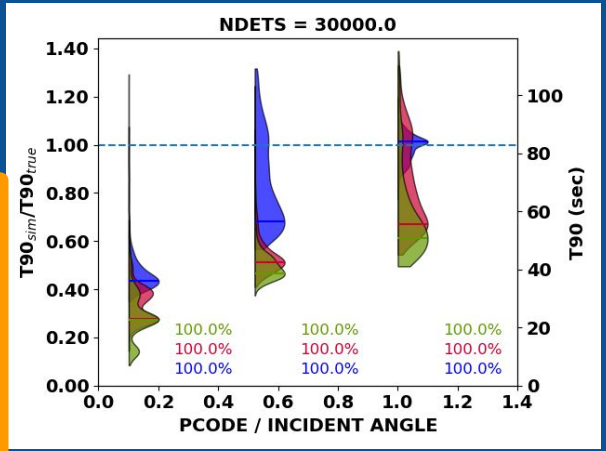


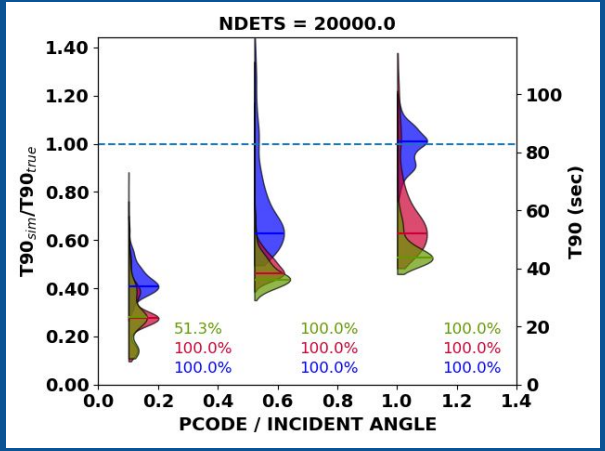


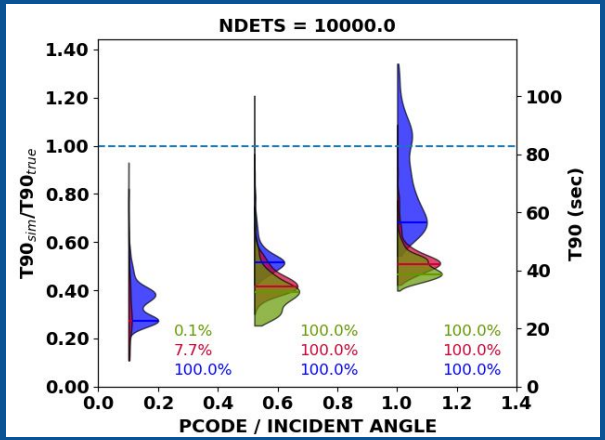
BGDLVL: 1000.0 c/s 9500.0 c/s 22000.0 c/s

Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations









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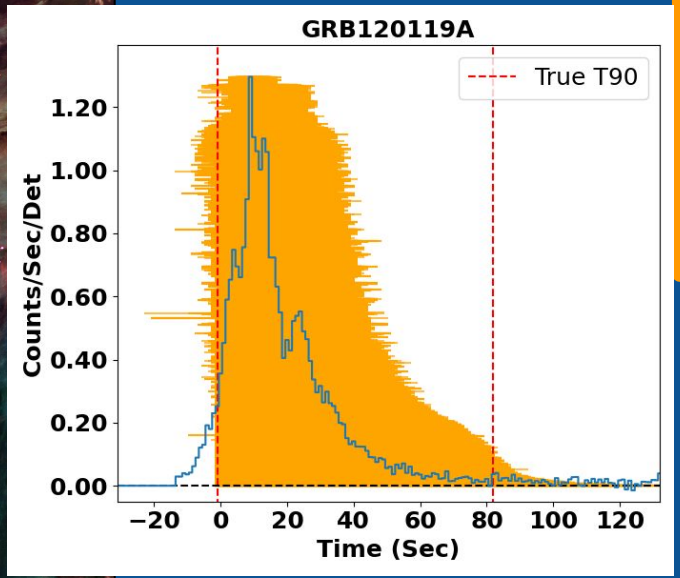
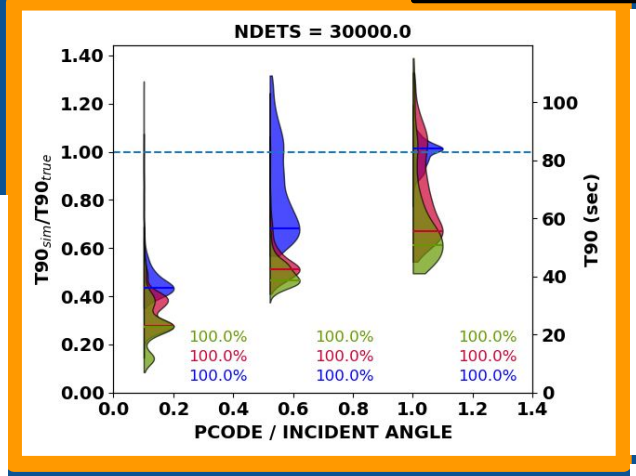
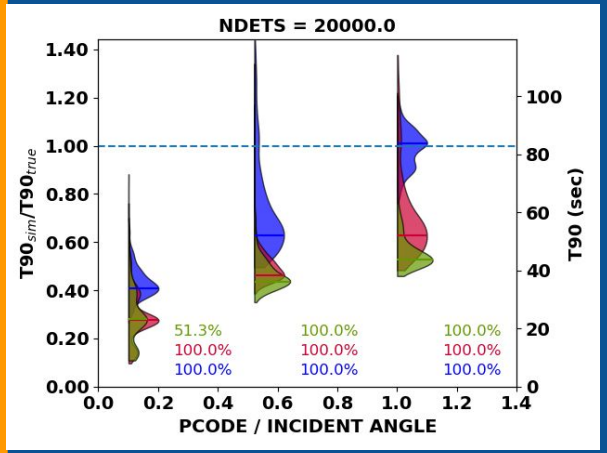
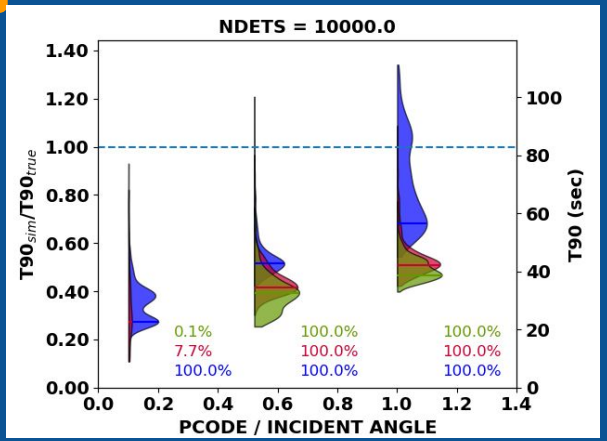
Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations









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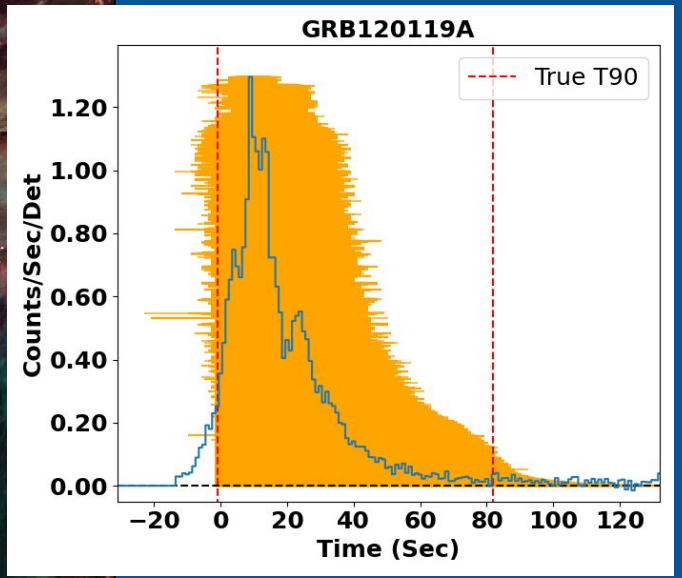

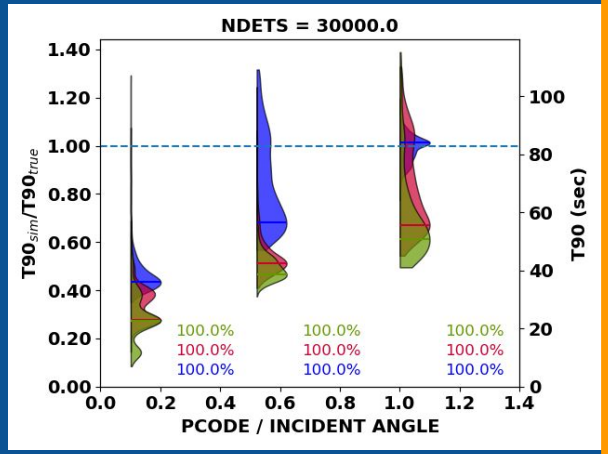

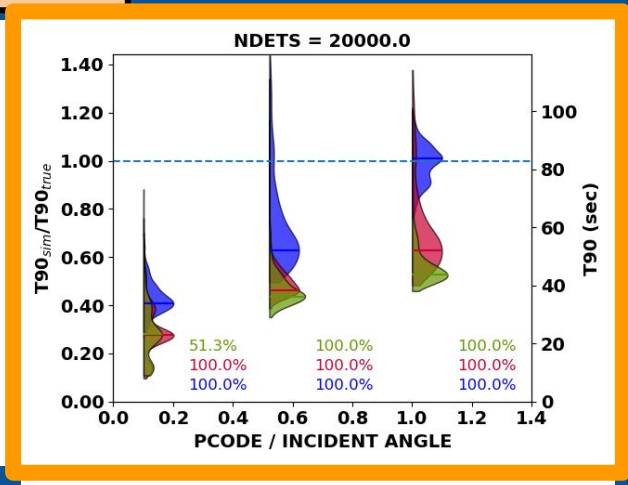

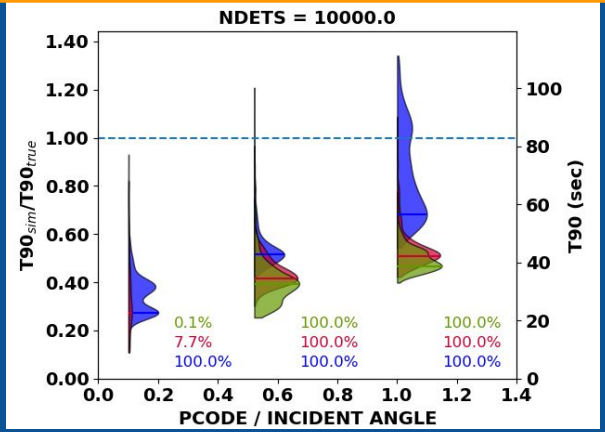

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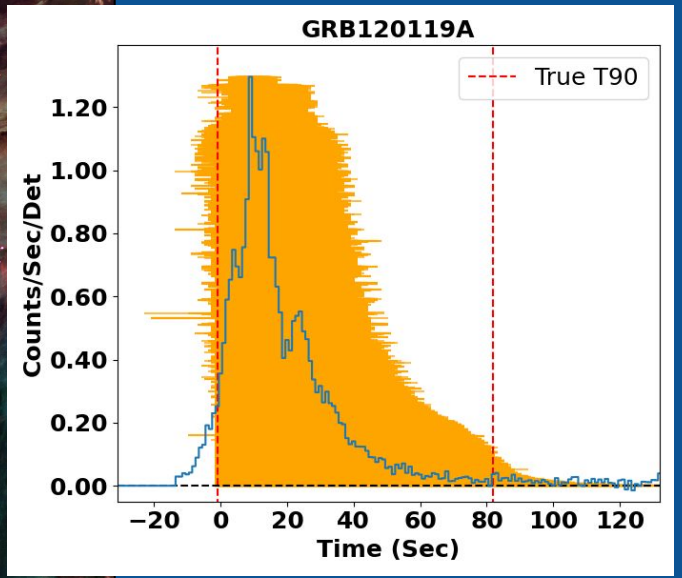
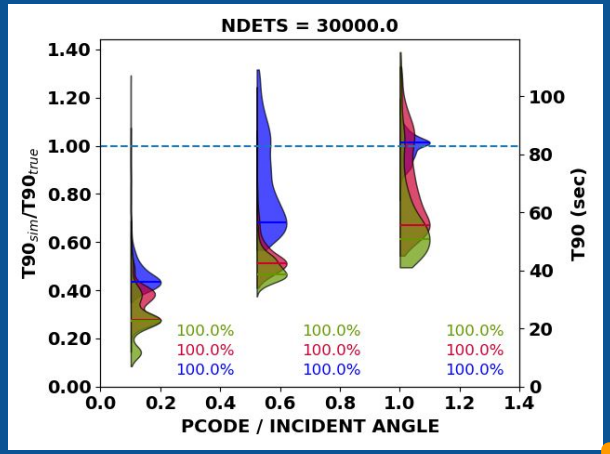
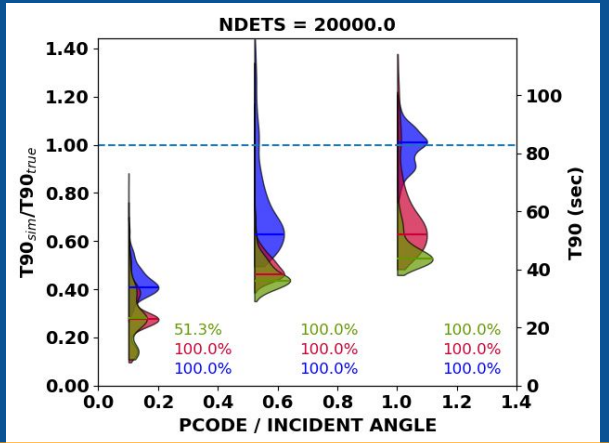
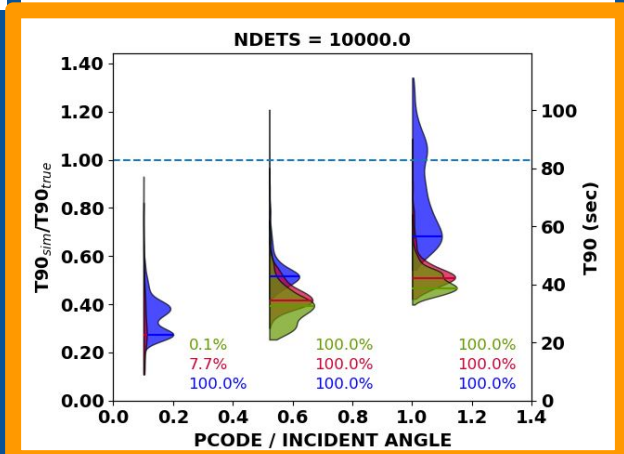


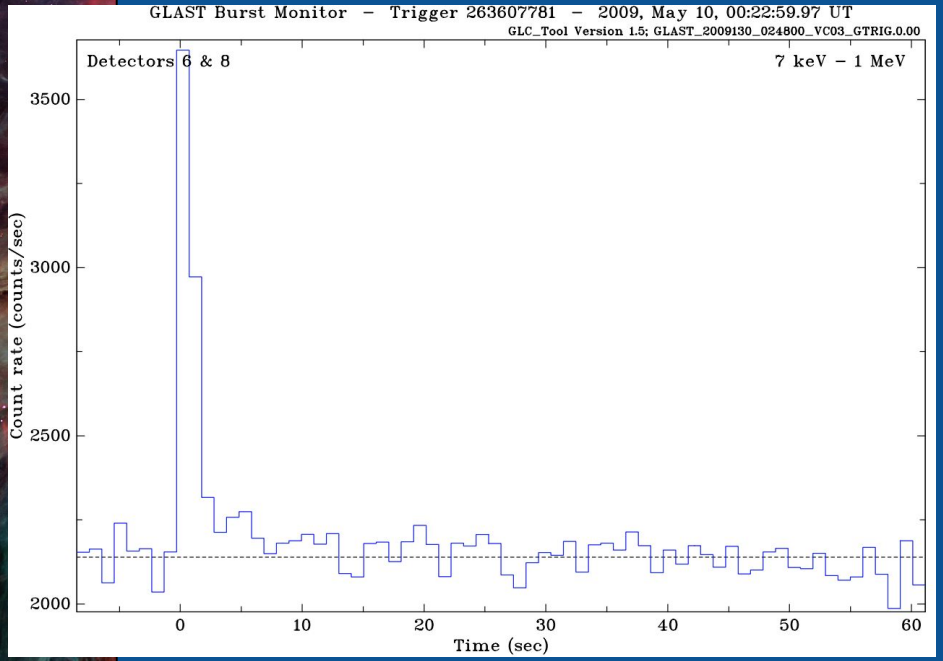


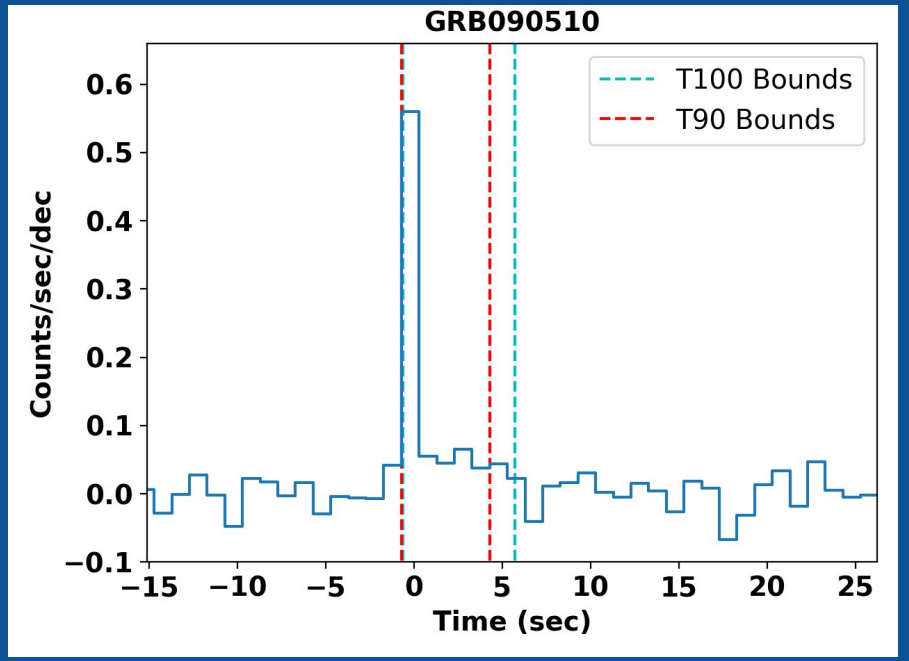




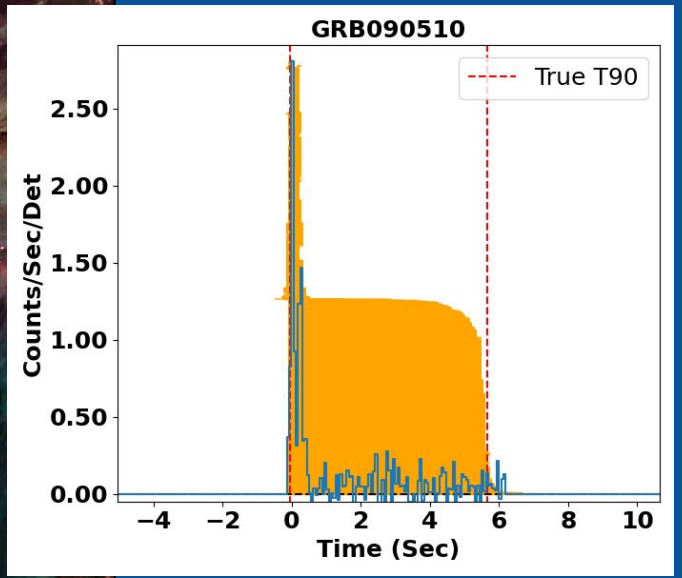
BGDLVL: 1000.0 c/s 9500.0 c/s 22000.0 c/s

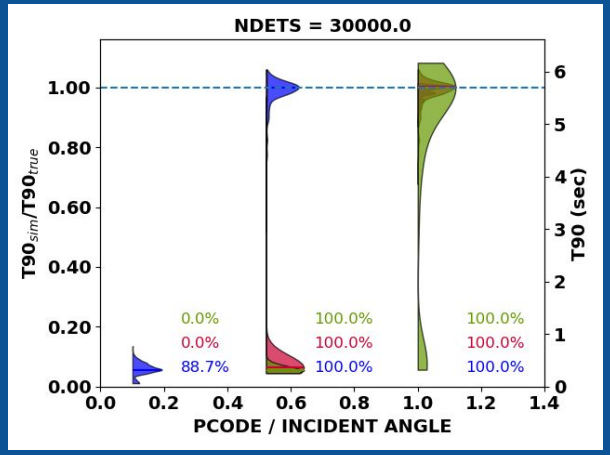
GRB090510

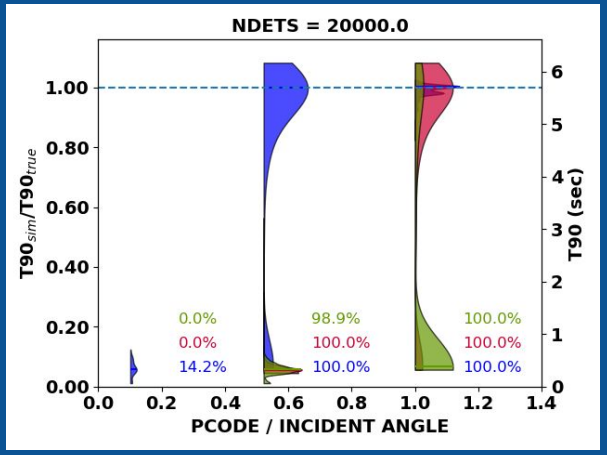

GLAST Burst Monitor – Trigger 263607781 – 2009, May 10, 00:22:59.97 UT
GLC_Tool Version 1.5; GLAST_2009130_024800_VC03_GTRIG.0.00
Detectors 6 & 8
7 keV – 1 MeV
Count rate (counts/sec)
Time (sec)

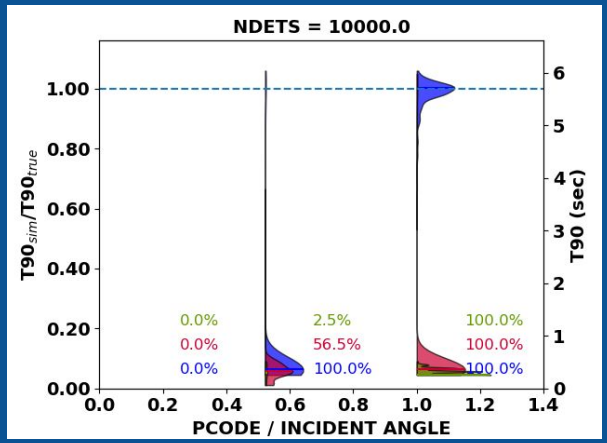

GRB090510
T100 Bounds
T90 Bounds
Counts/sec/dec
Time (sec)

Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations



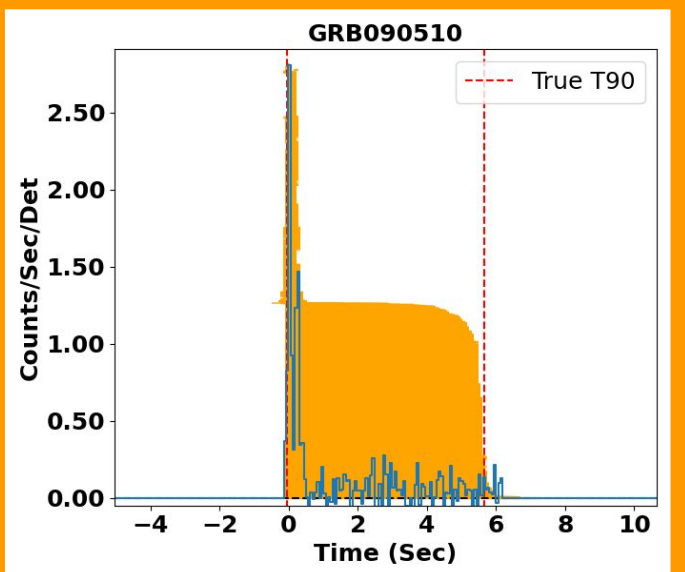


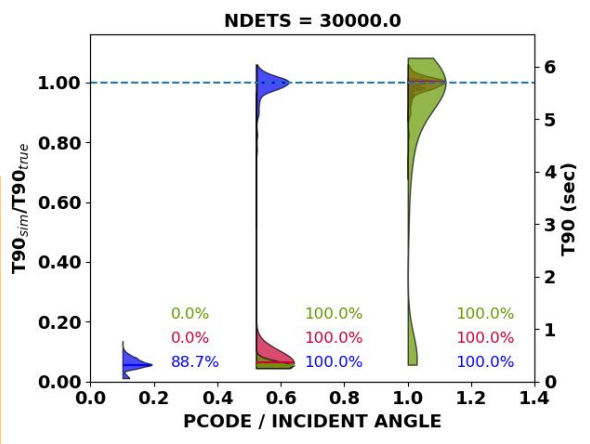


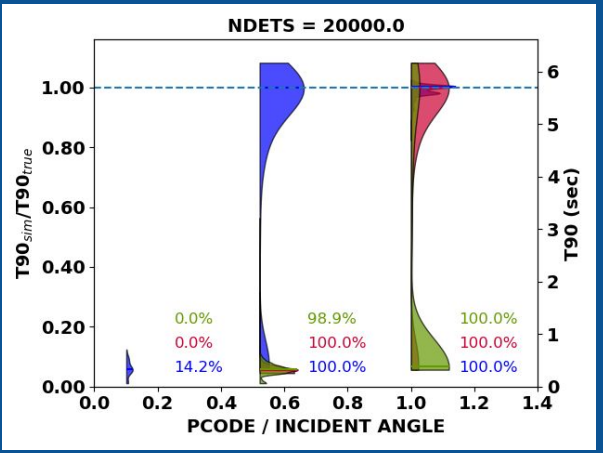


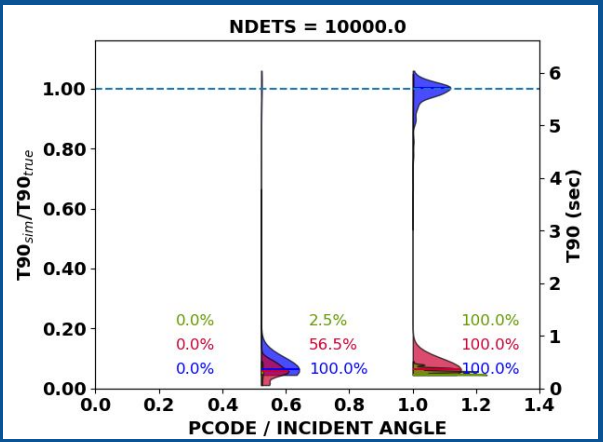
BGDLVL: 1000.0 c/s 9500.0 c/s 22000.0 c/s

Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations









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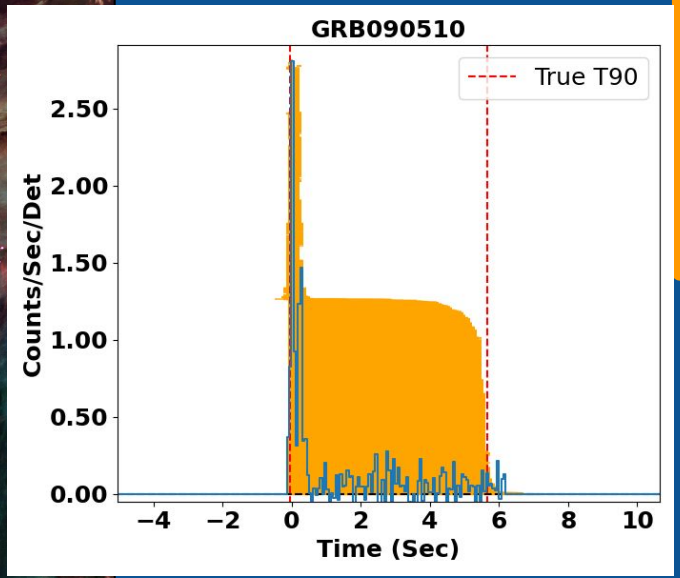

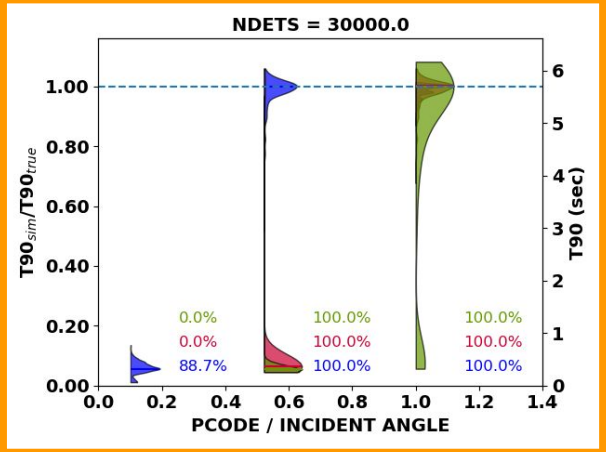

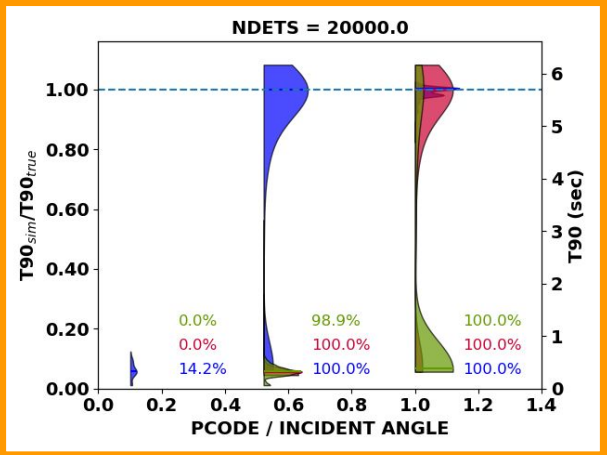

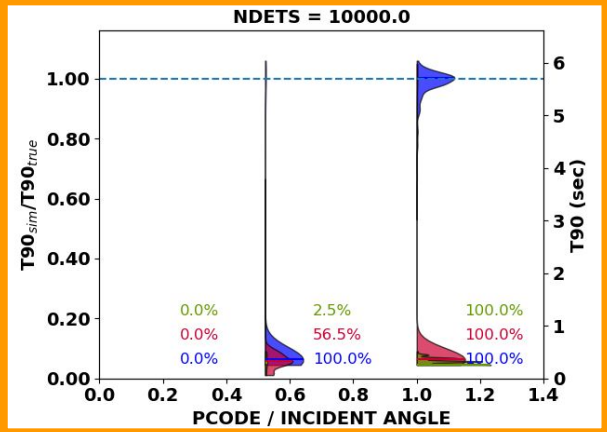

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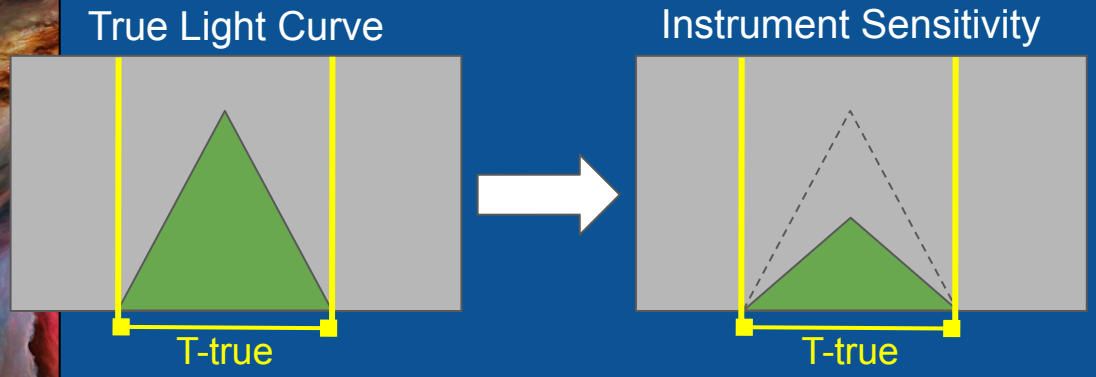
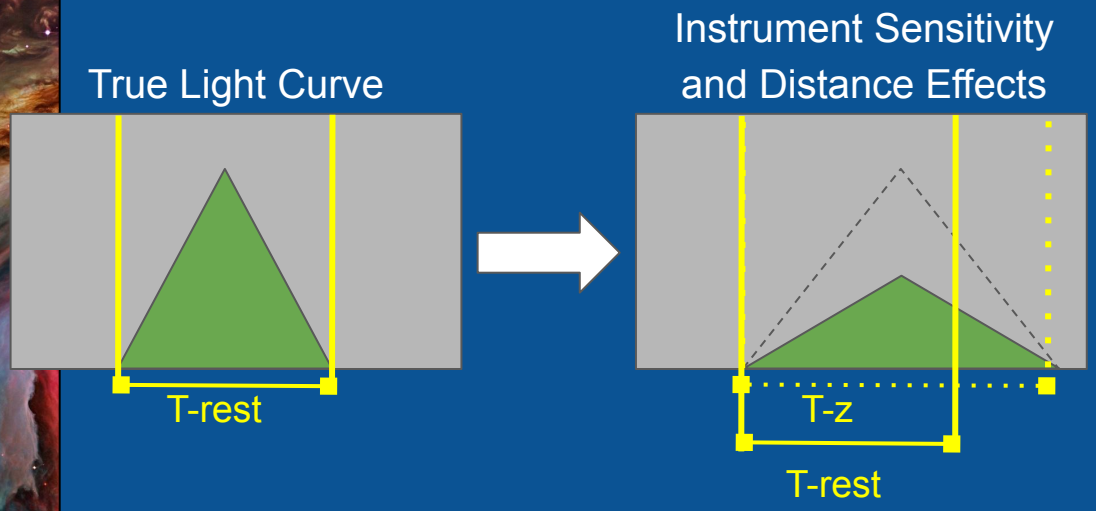
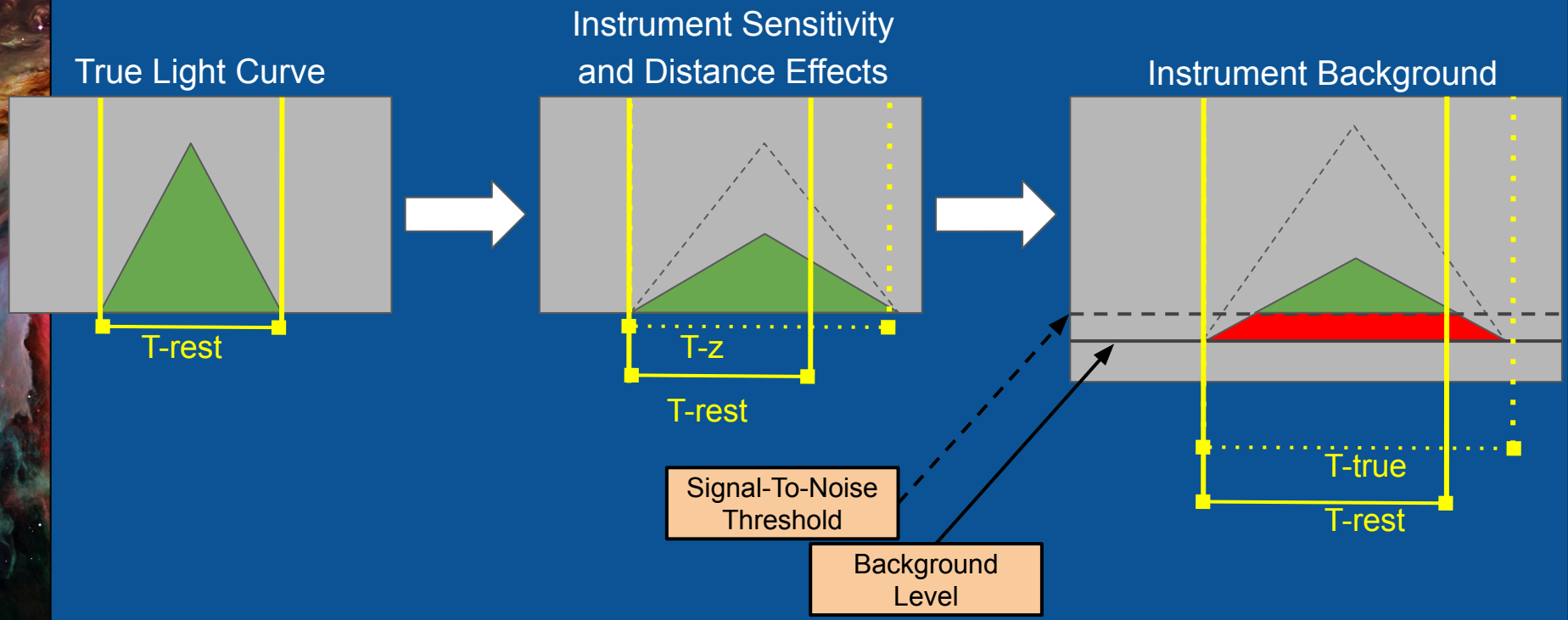
Distance Effects on GRB Light Curves



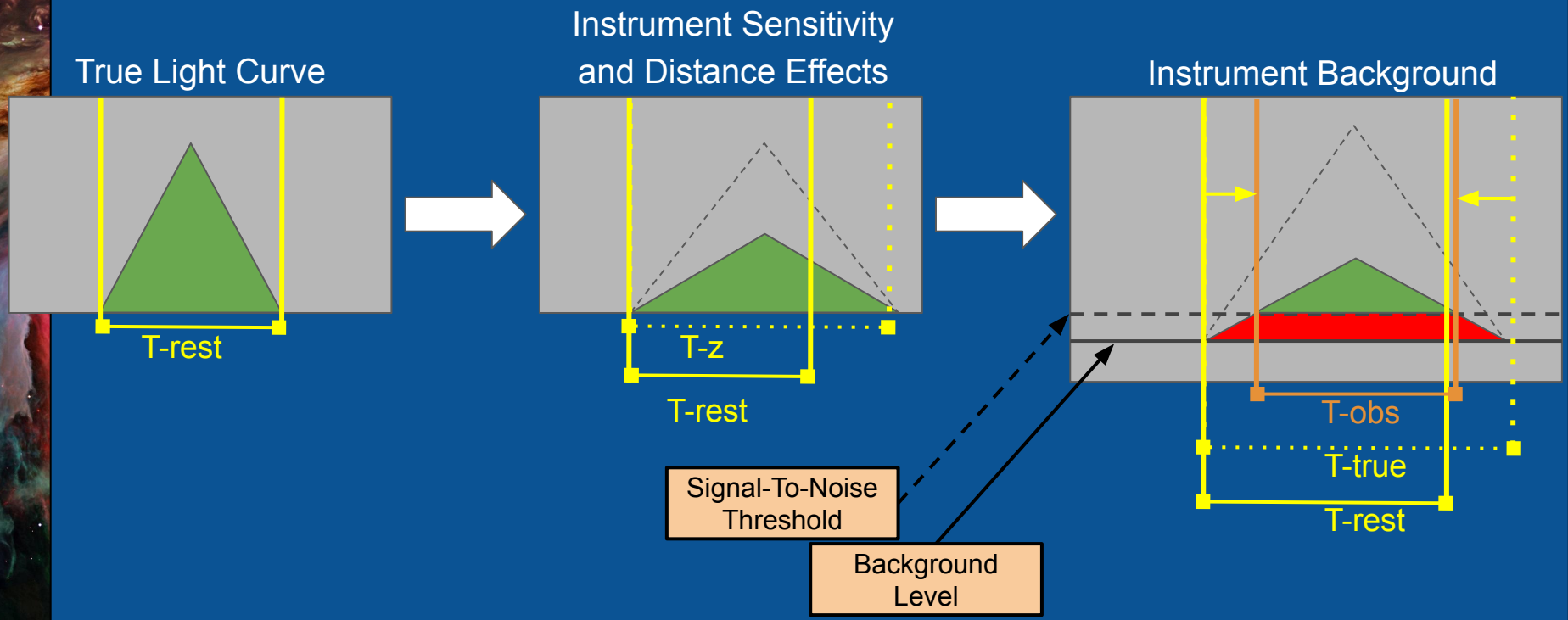
Distance Effects on GRB Light Curves



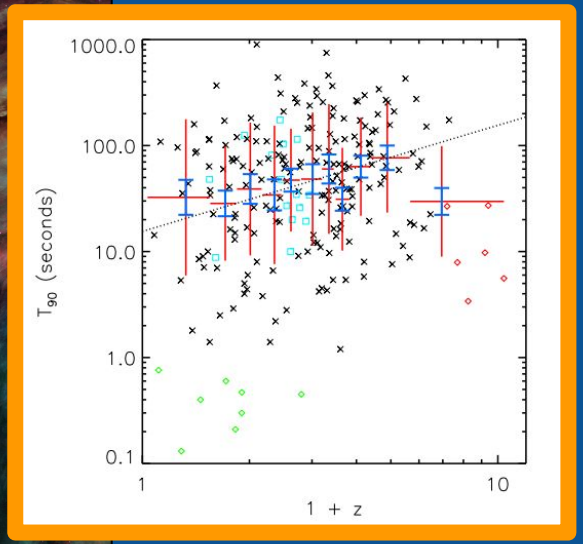
Distance Effects on GRB Light Curves



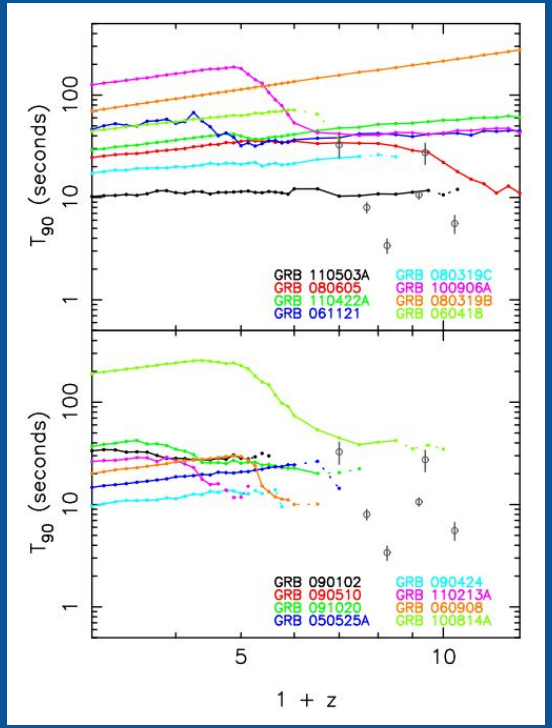
Distance Effects on GRB Light Curves

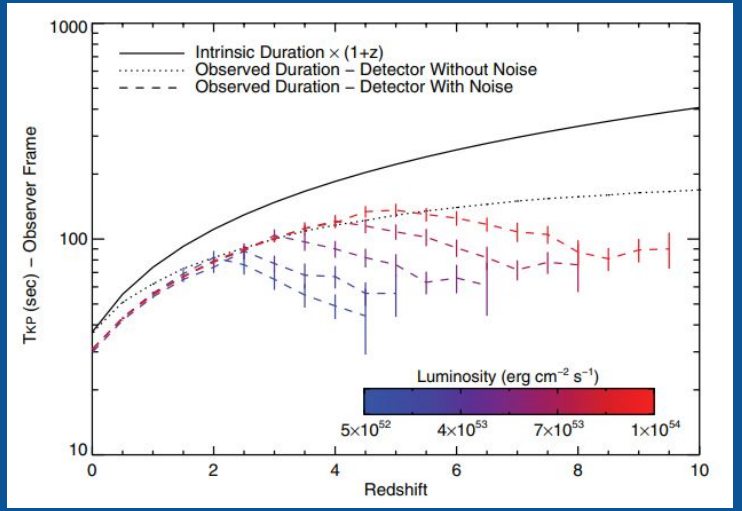


Distance Considerations



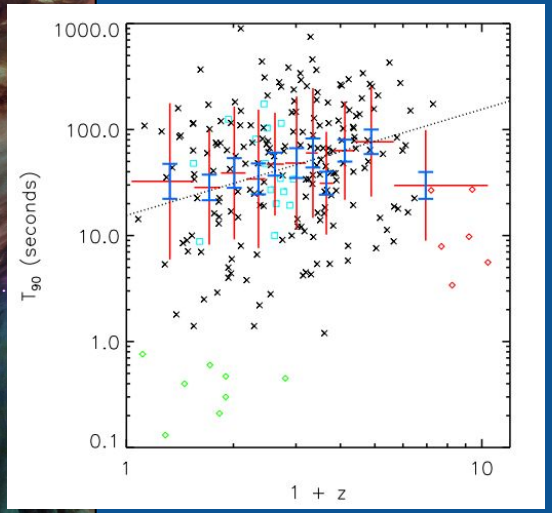
Littlejohns et al., 2013

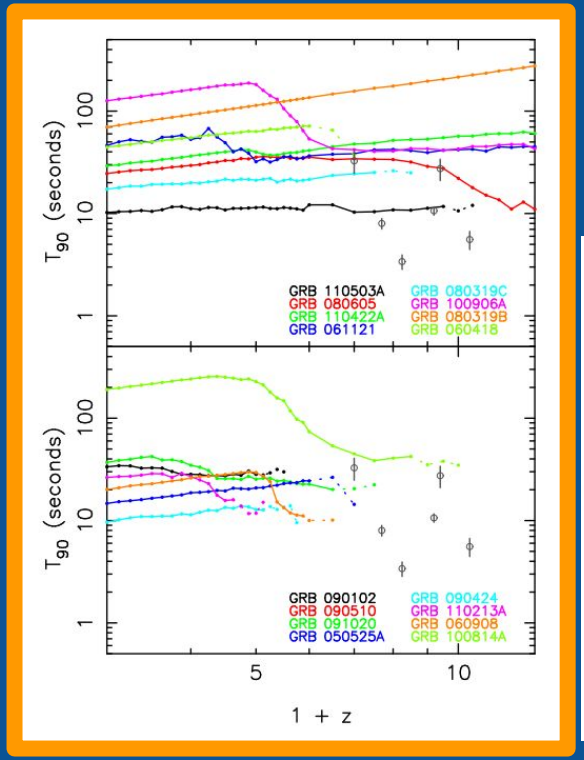


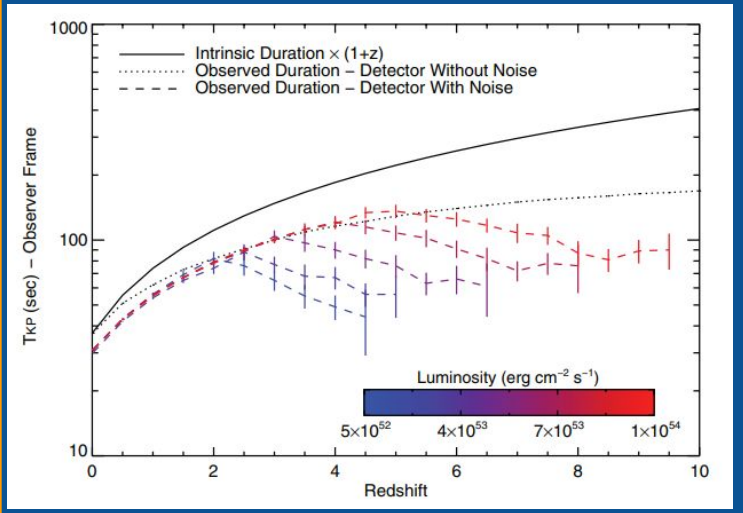


Kocevski and Petrosian, 2013

Distance Considerations



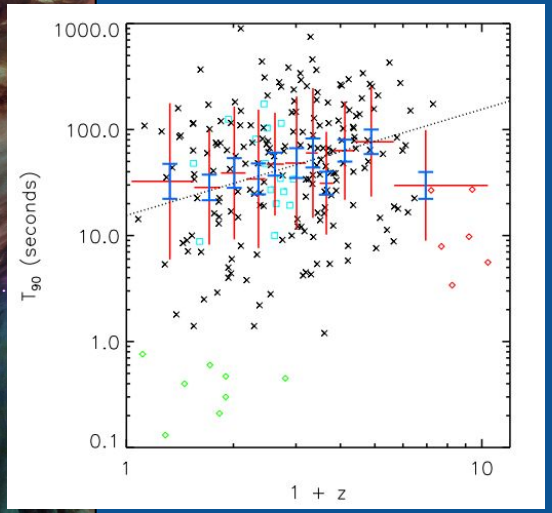


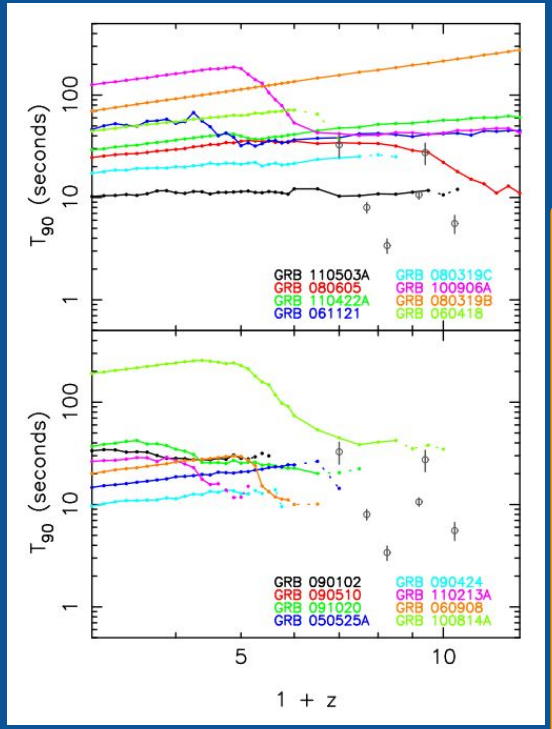


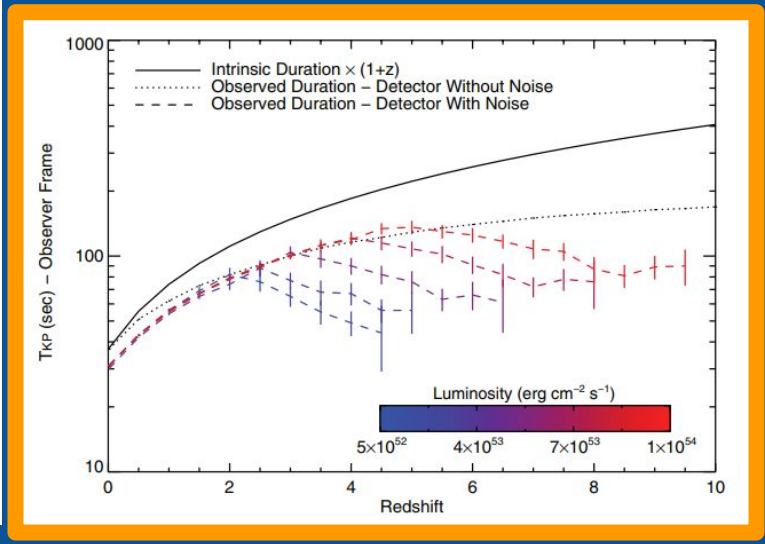
Littlejohns et al., 2013

Kocevski and Petrosian, 2013

Distance Considerations





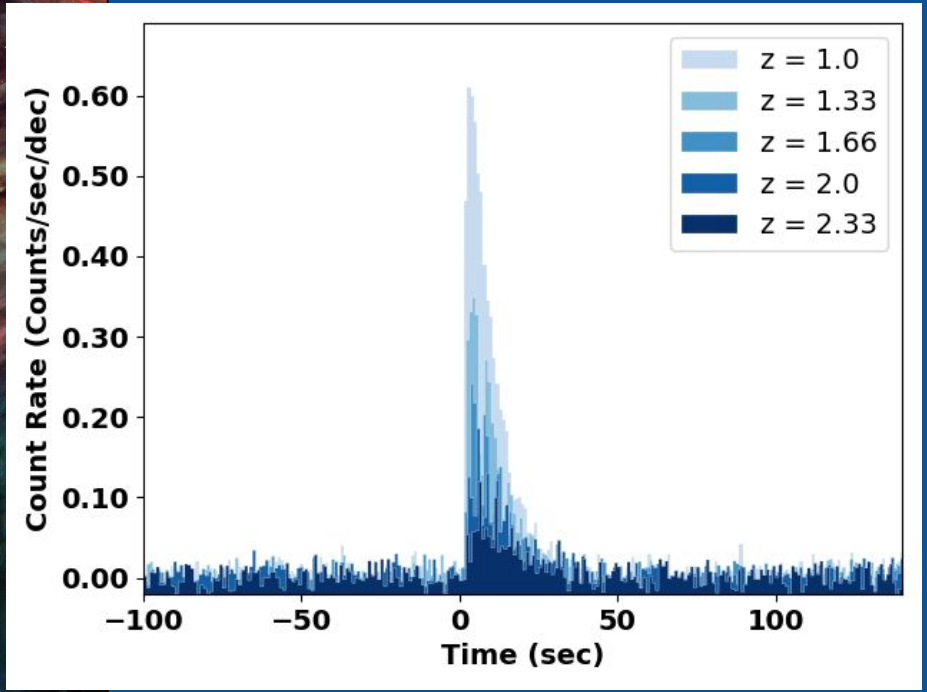


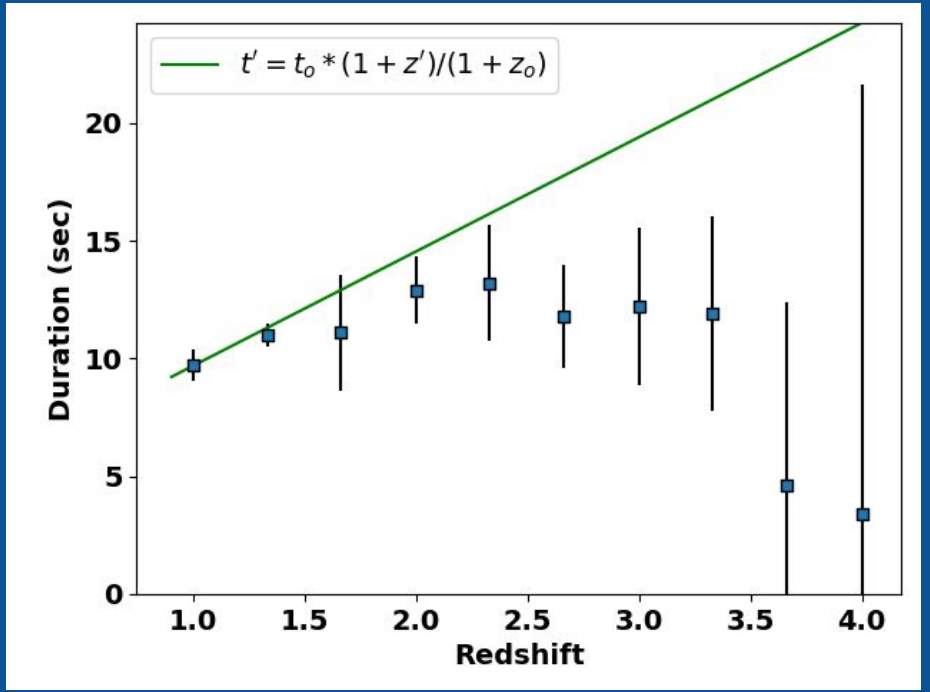
Littlejohns et al., 2013

Kocevski and Petrosian, 2013

Distance Considerations - Results

This is preliminary, to be further investigated at a later time.





Distance Considerations - Results

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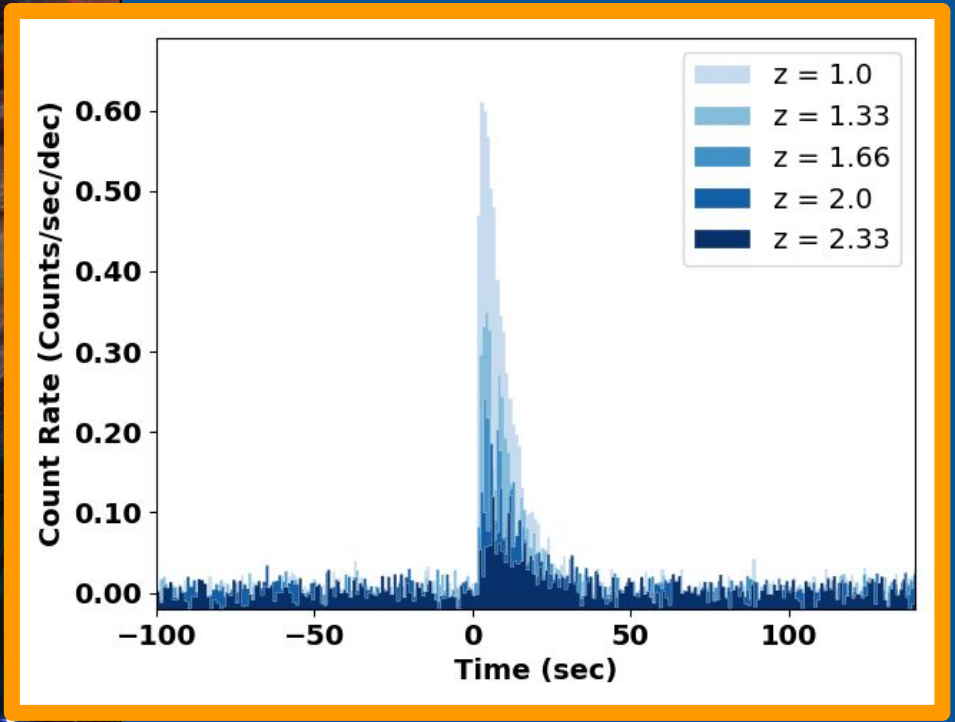

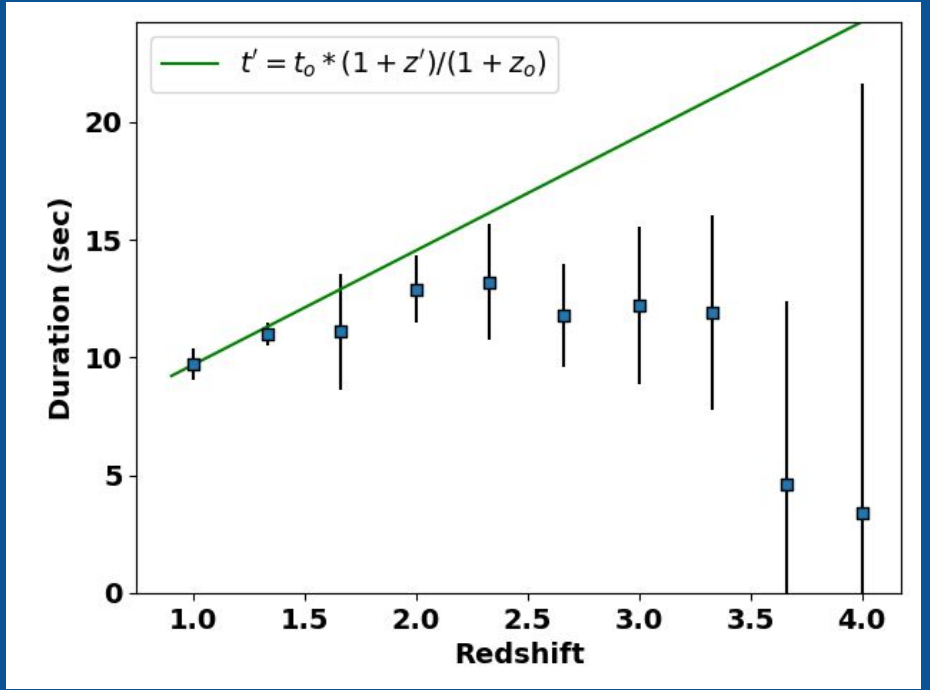

Distance Considerations - Results

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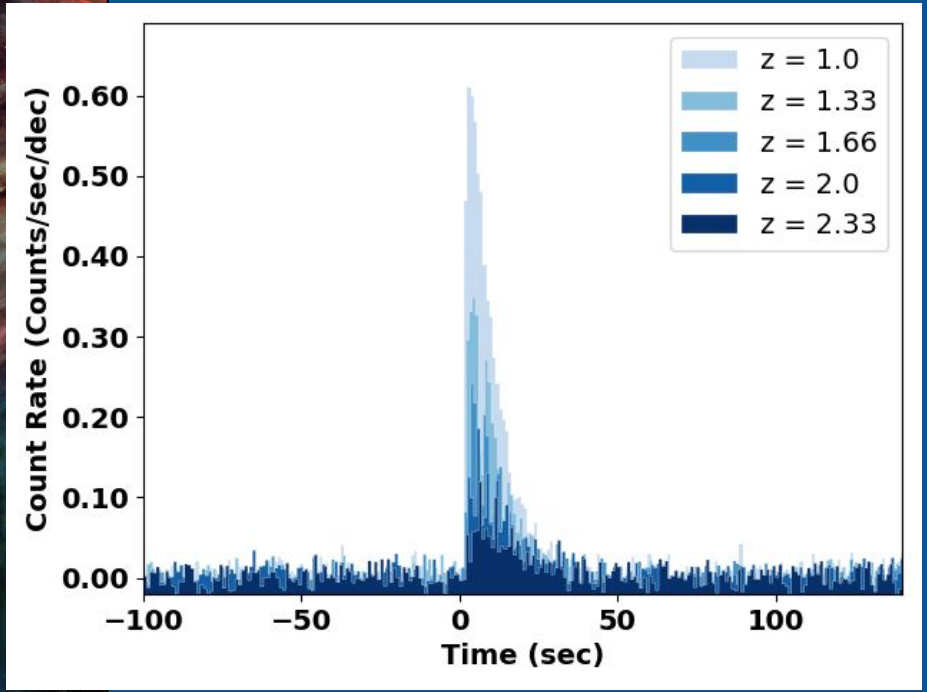
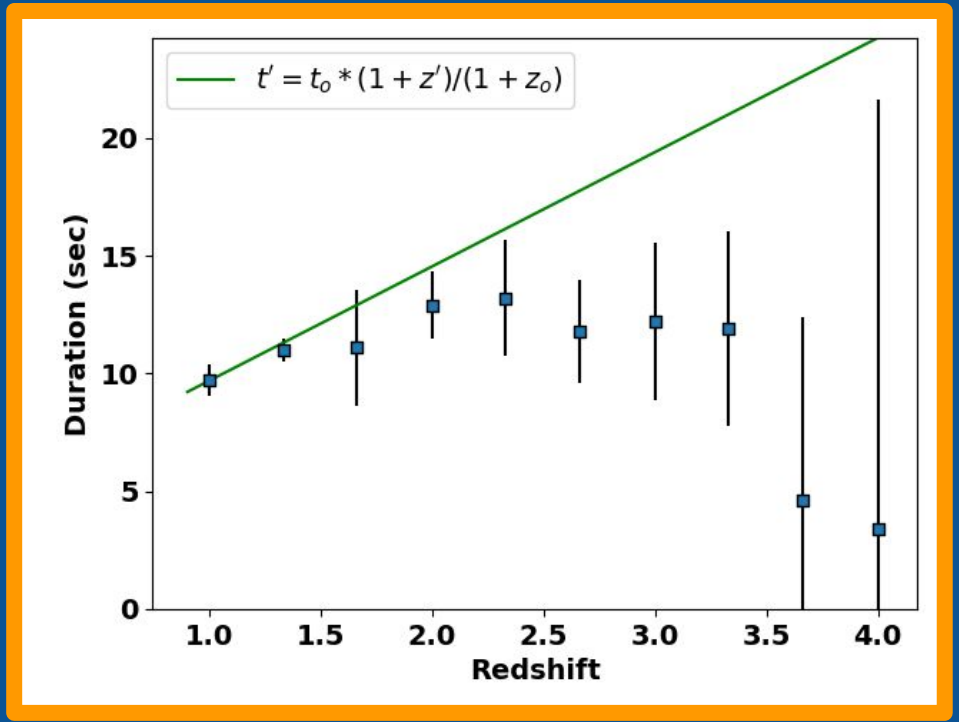




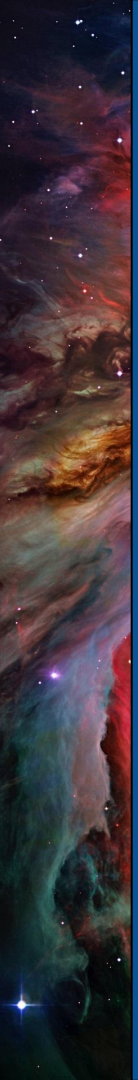
Conclusions

T90 may not be an accurate representation of true source duration due to instrumental effects

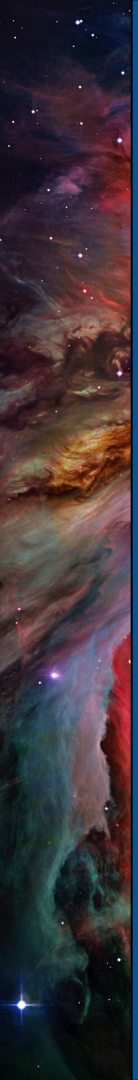
The T90 is not enough to distinguish between Short and Long GRBs

May be possible to quantify (and correct for) these biases

How are the observed luminosity and T90 distributions affected?
How do other instruments behave?

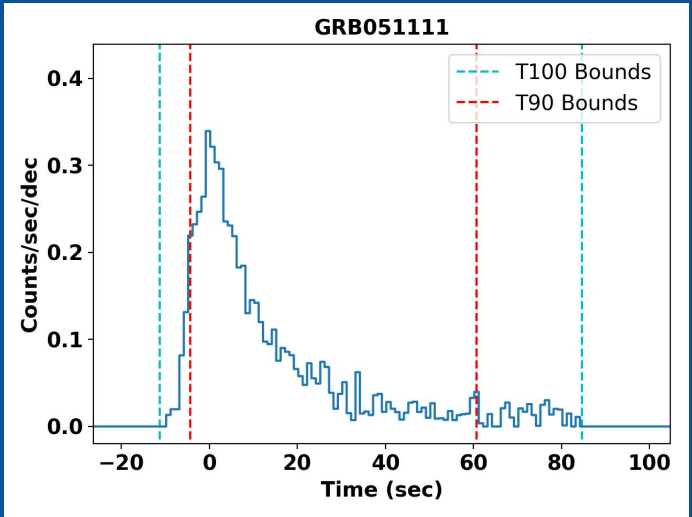


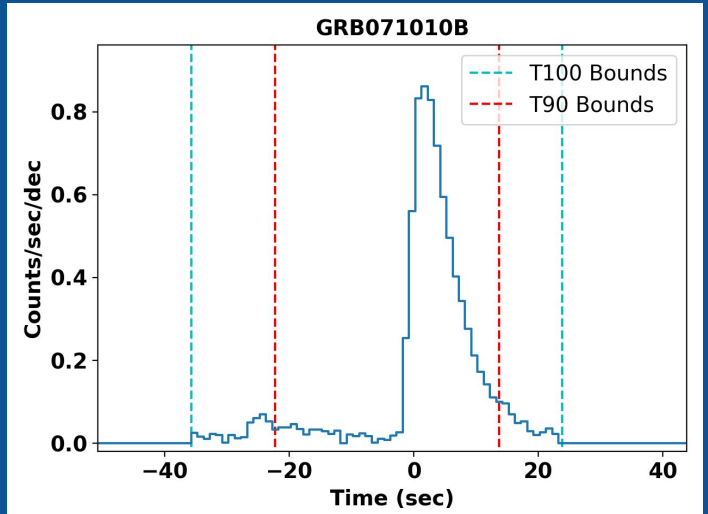
Thank you!

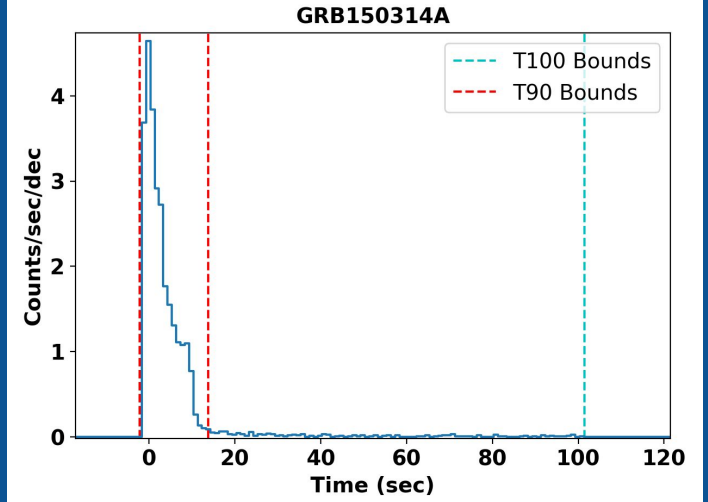


Backup Slides

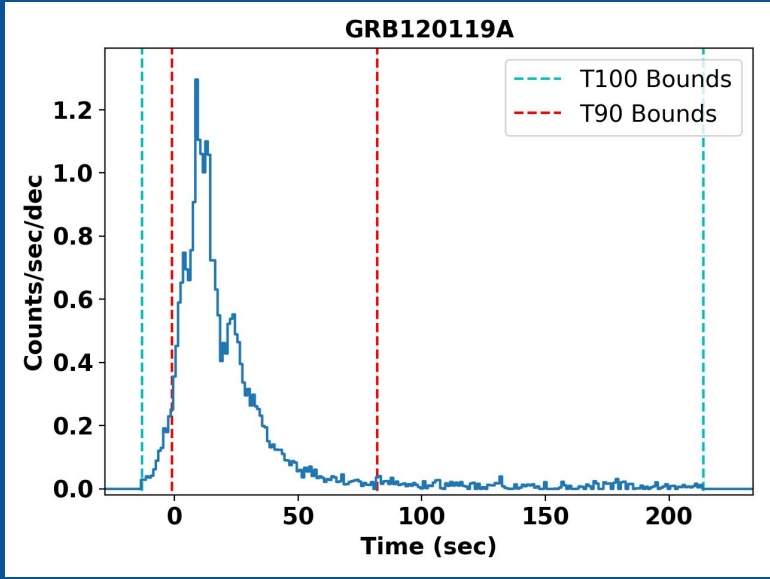
GRB Light Curves FRED-like

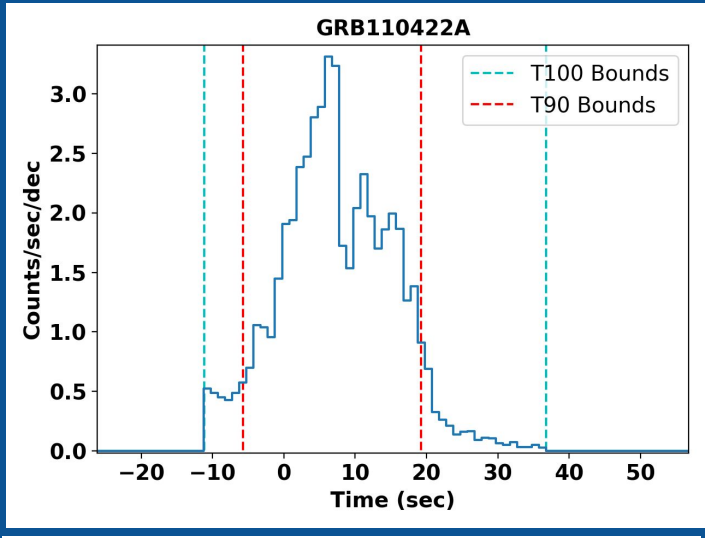


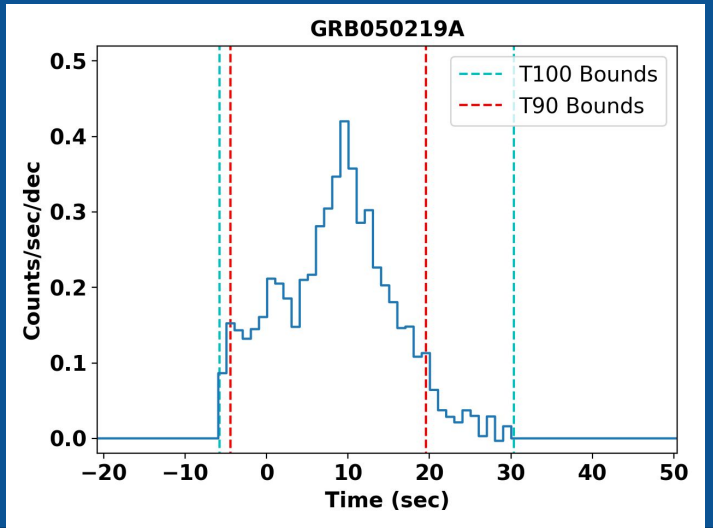




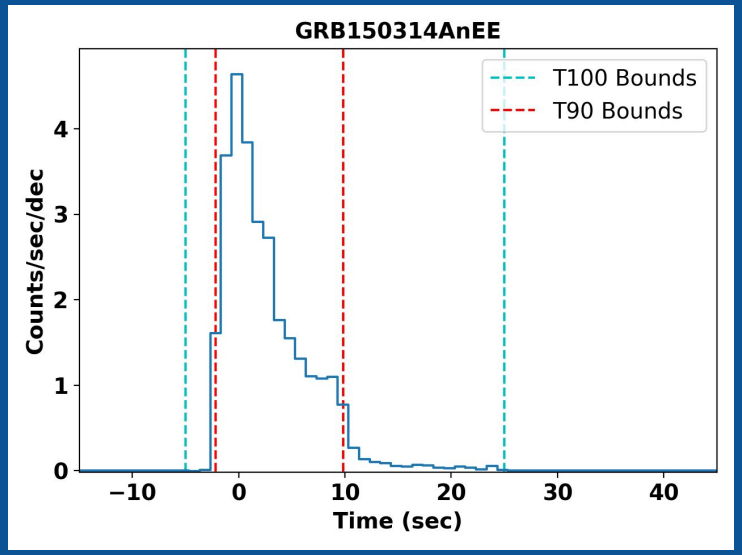
GRB Light Curves Symmetric

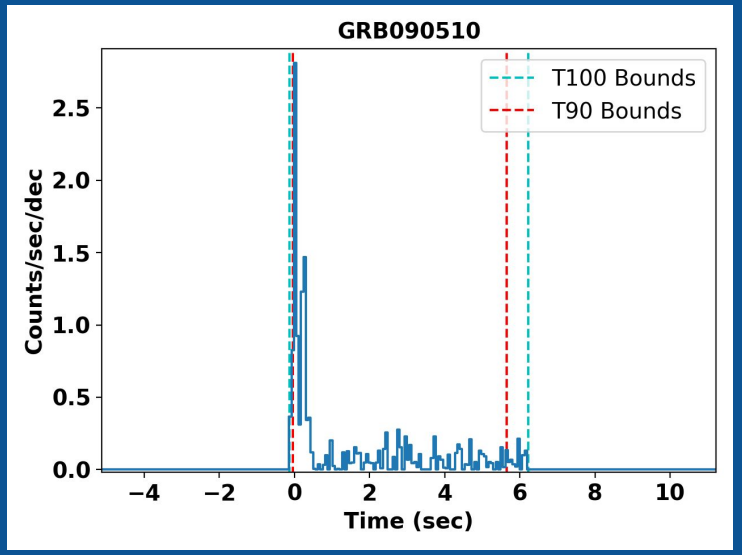




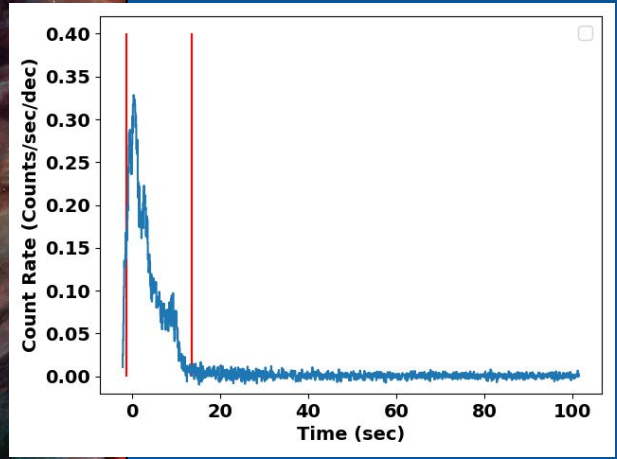


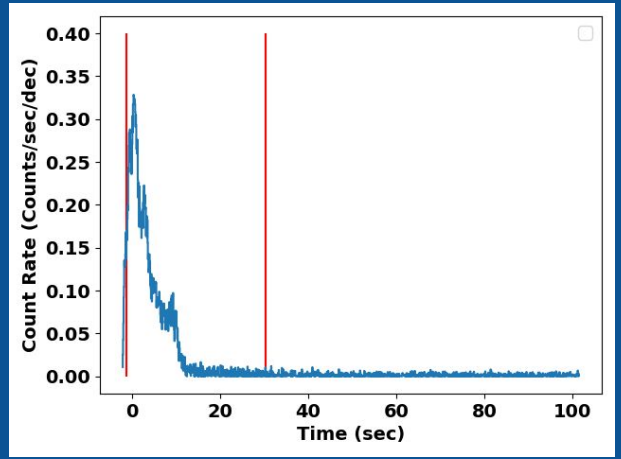
GRB Light Curves
Unique Selection

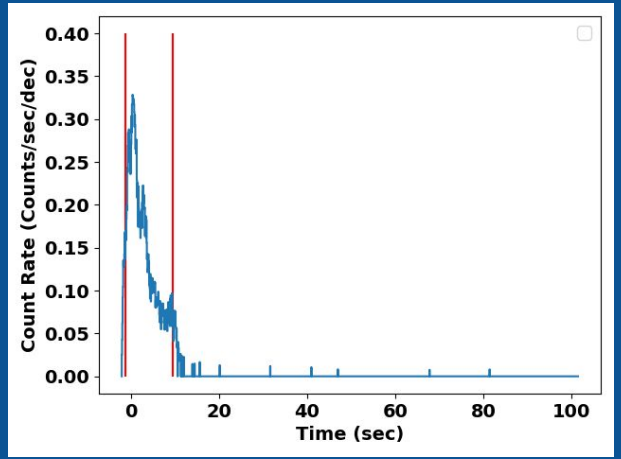




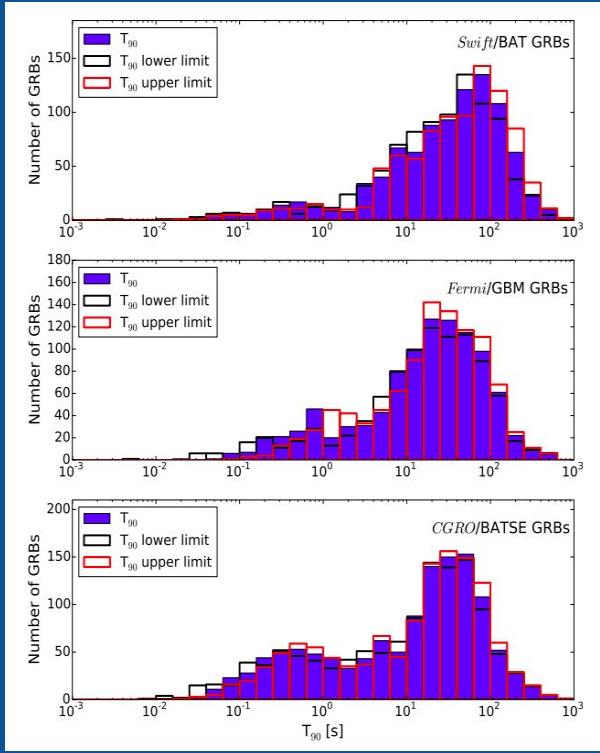
Template Light Curve → Simulate Source Light Curve → Simulate Observed Light Curve → GRB Durations



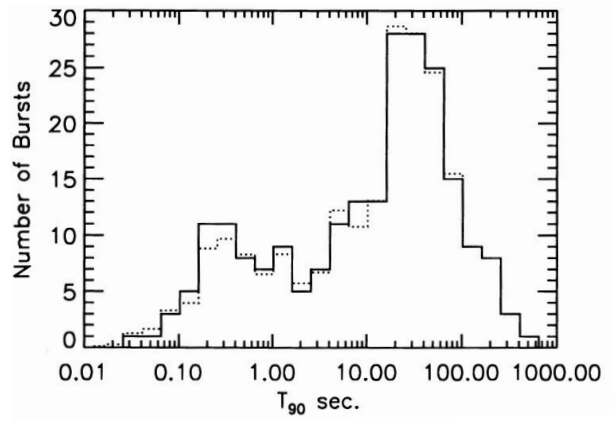




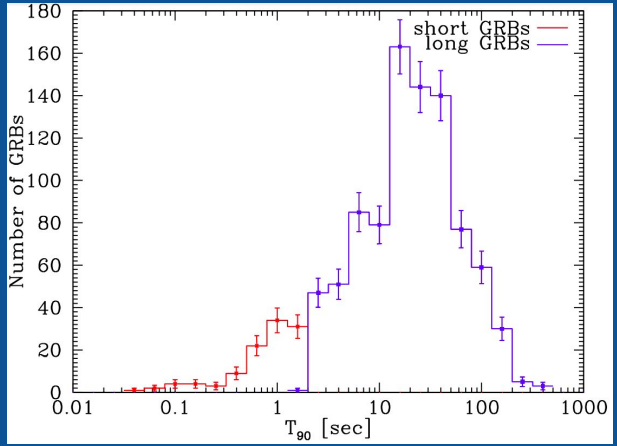
Instrument Considerations



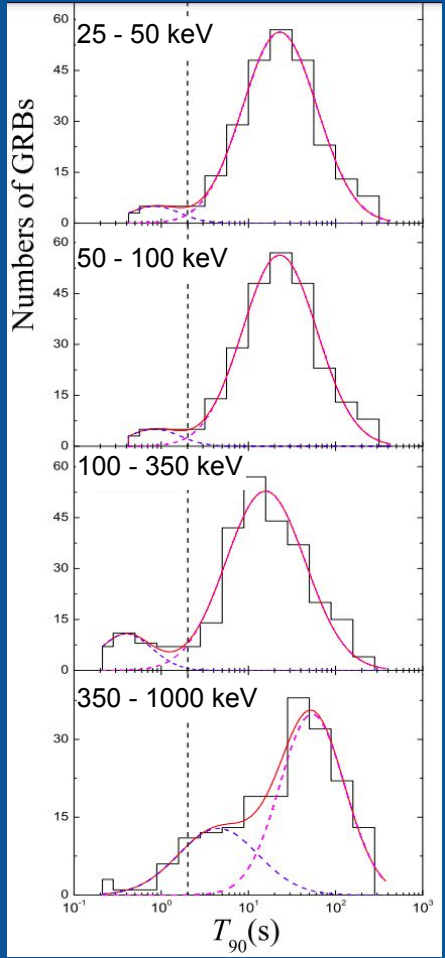
Lien A. et al., 2016



Kouveliotou et al., 1993



Frontera et al., 2009



Qin et al., 2013