Fermi Gamma-ray Space Telescope

Precursors in GBM and LAT GRBs

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on behalf of the LAT and GBM GRB groups

Overview

0. Choose a definition

1. Identify GRBs with precursors

   1.1. Assign categories

2. Analysis

   2.1. Temporal

   2.2. Spectral

   2.3. Energetics

3. Future work

Define “precursor”

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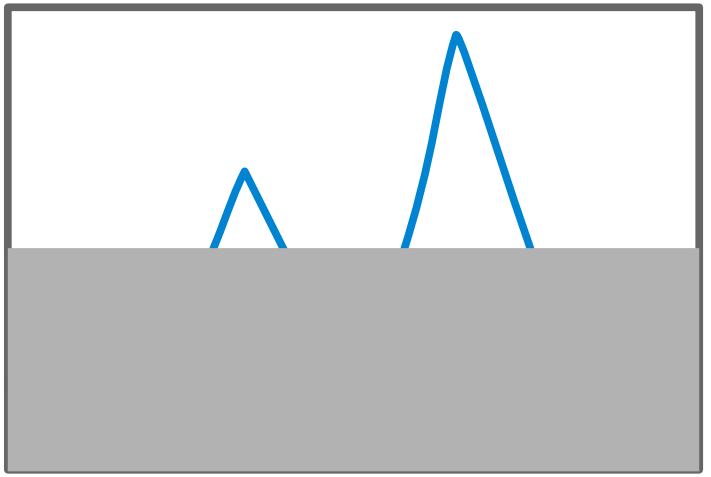
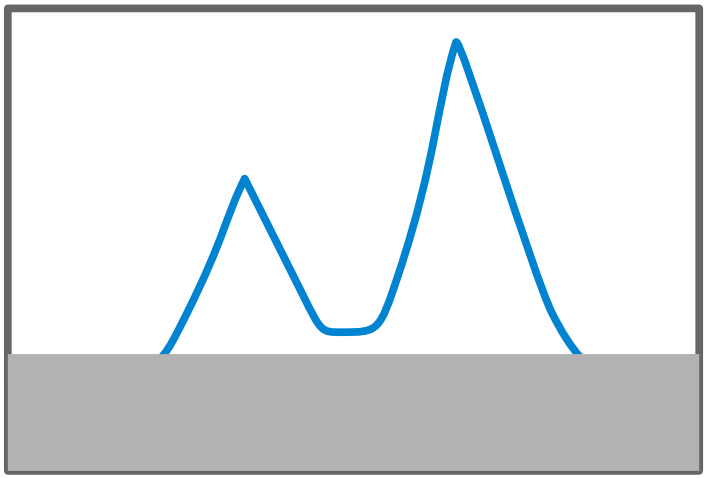


Which of these has a **precursor**?



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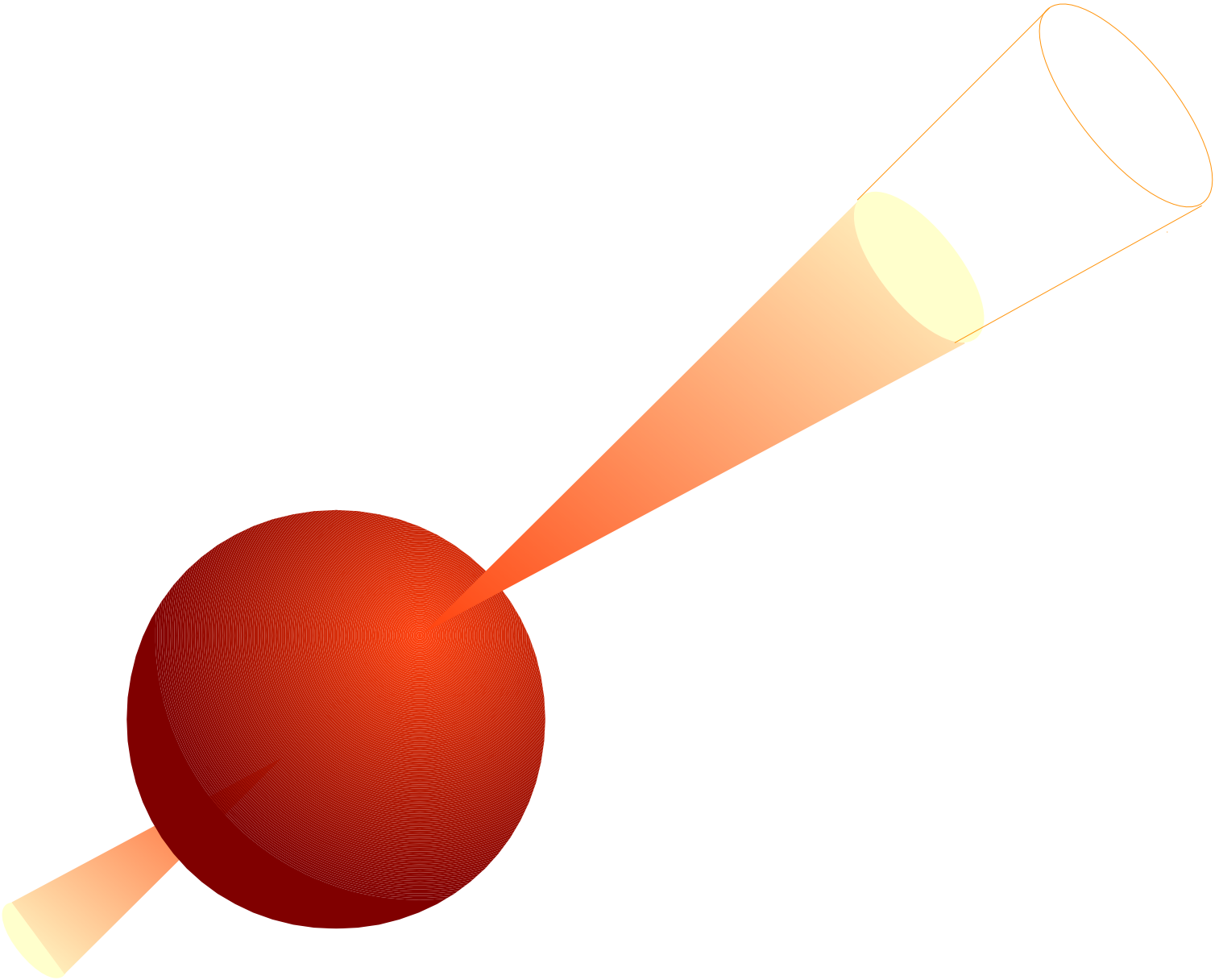
> I shall not today attempt further to define the kinds of material I understand to be embraced within that shorthand description [**“precursor”**]; and perhaps I could never succeed in intelligibly doing so. But **I know it when I see it**, and the motion picture involved in this case is not that. *[Emphasis added.]*
>
> —Justice Potter Stewart, *concurring opinion in Jacobellis v. Ohio 378 U.S. 184 (1964), regarding possible obscenity in The Lovers.*

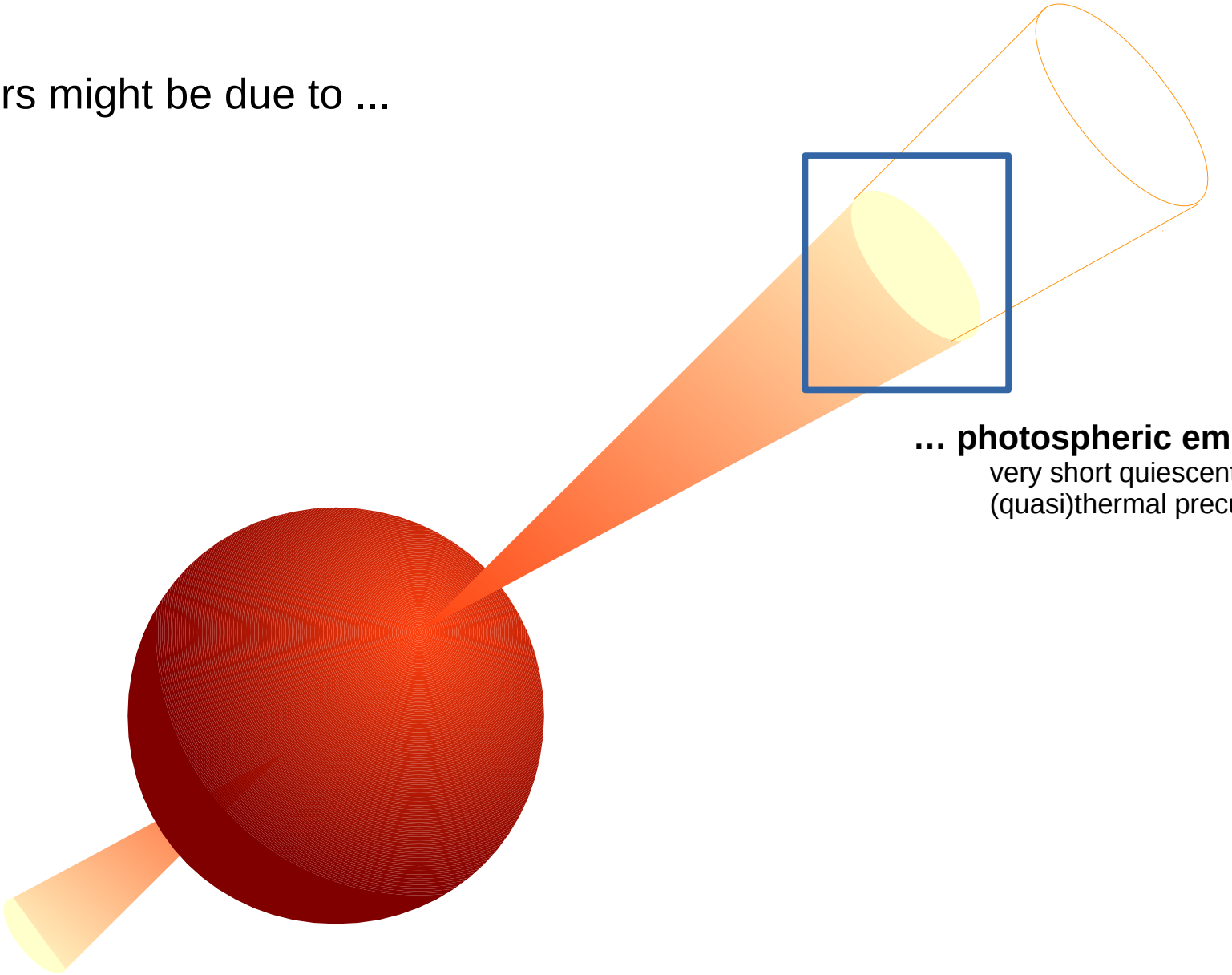
A **precursor** is an episode of **prompt emission** …
… that is **dimmer** than the dominant emission
… and **precedes** the dominant emission
… sometimes by a well-defined quiescent period
(but not always!)

Motivation



Motivation

Precursors might be due to ...



... photospheric emission

very short quiescent periods

(quasi)thermal precursor

Motivation

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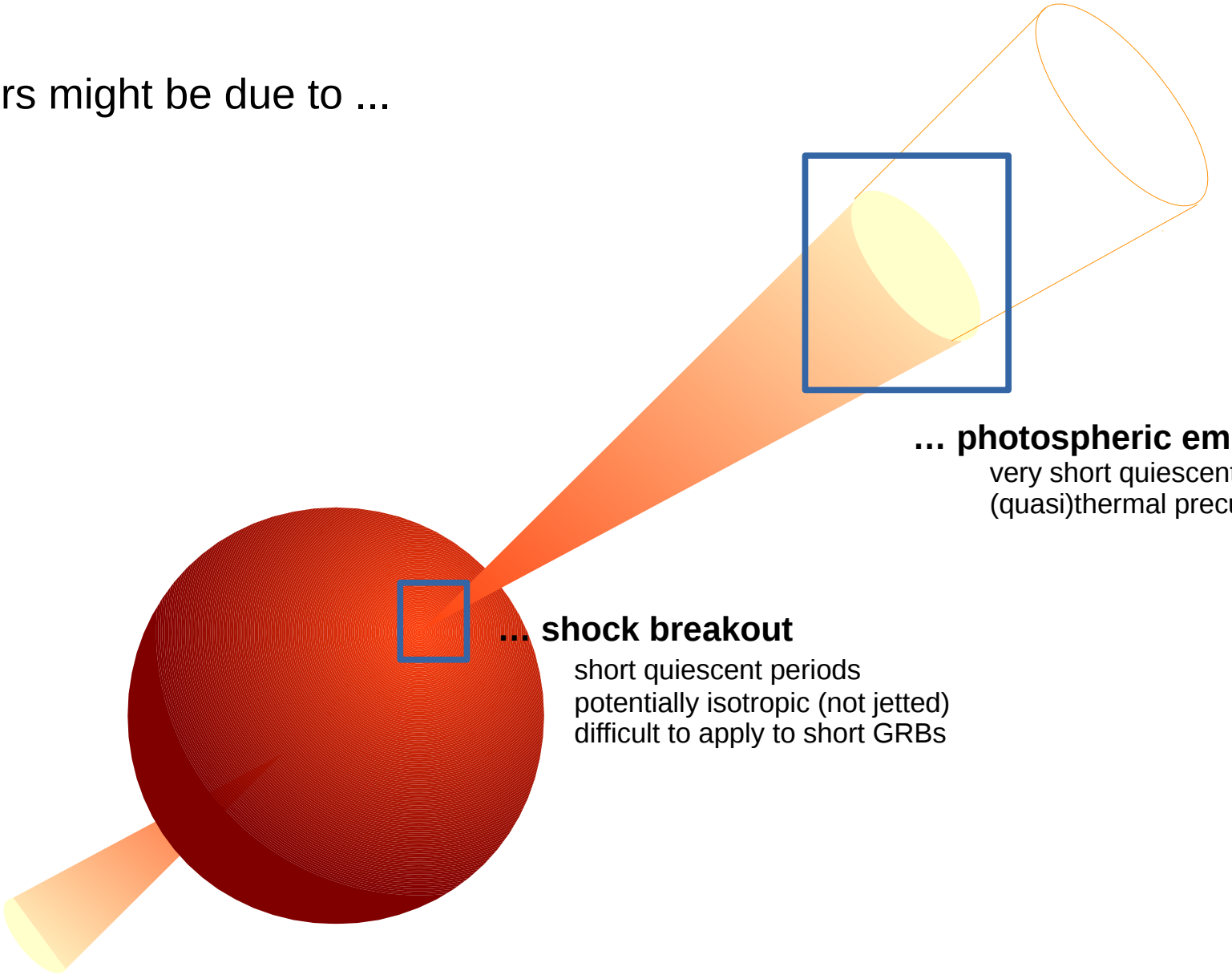


... photospheric emission

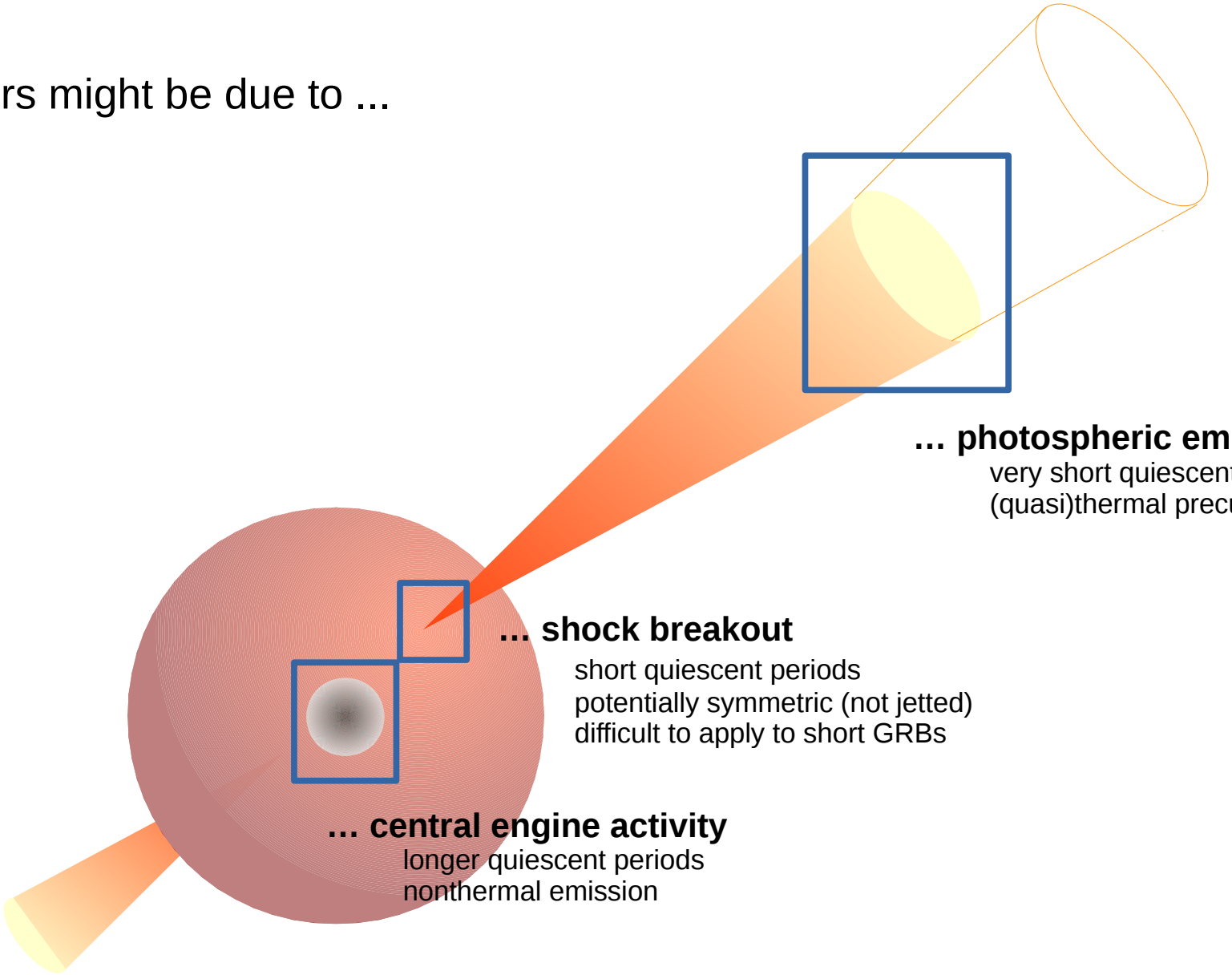
very short quiescent periods
(quasi)thermal precursor

... shock breakout

short quiescent periods
potentially isotropic (not jetted)
difficult to apply to short GRBs

Motivation

Precursors might be due to ...

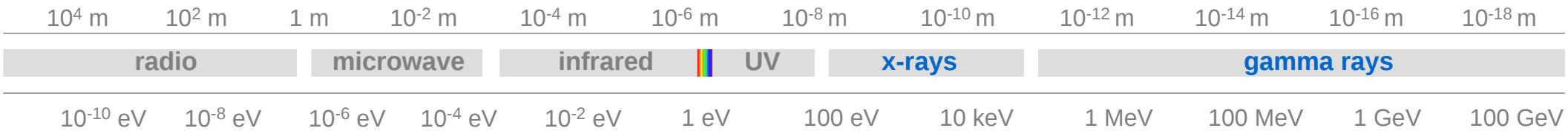


... photospheric emission
very short quiescent periods
(quasi)thermal precursor

... shock breakout
short quiescent periods
potentially symmetric (not jetted)
difficult to apply to short GRBs

... central engine activity
longer quiescent periods
nonthermal emission

Requisite slide on *Fermi*

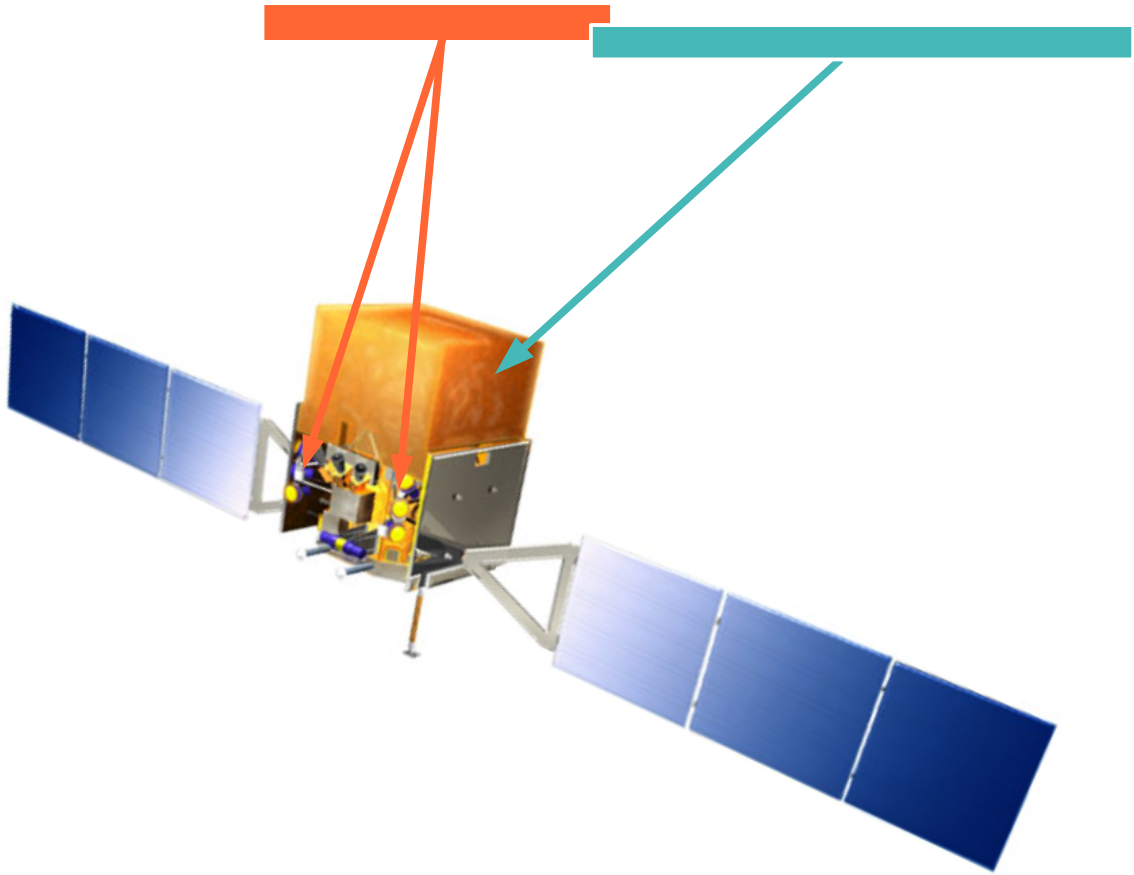


GBM **G**amma-ray **B**urst **M**onitor

12 (NaI) + 2 (BGO) detectors
FOV: entire unocculted sky
8 keV to 40 MeV
~1500 bursts (~1 every day or two)

LAT **L**arge **A**rea **T**elescope

Pair production telescope
FOV: 2.4 steradian (~20% of sky)
20 MeV to >300 GeV
84 bursts as of mid Oct 2014



Finding precursors

0. Choose a definition

1. Identify GRBs with precursors using a **Bayesian blocks** algorithm on all GBM bursts up to the end of 2013

1.1. Assign categories

Gory details:

- Run Bayes blocks on raw NaI LCs
  - Use the brightest 2 or 3 (unblocked) NaIs
  - Prior = # of change points expected
  - Define durations using the change points found
- Perform spectral analyses (RMFIT)
  - Power law, Band function, PL w/ exponential cutoff
  - Brightest (2 or 3) NaI + (1) BGO detectors
  - Standard energy selections (see GBM catalogs)
  - Standard background subtraction (see GBM catalogs)

2. Analysis

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Categories

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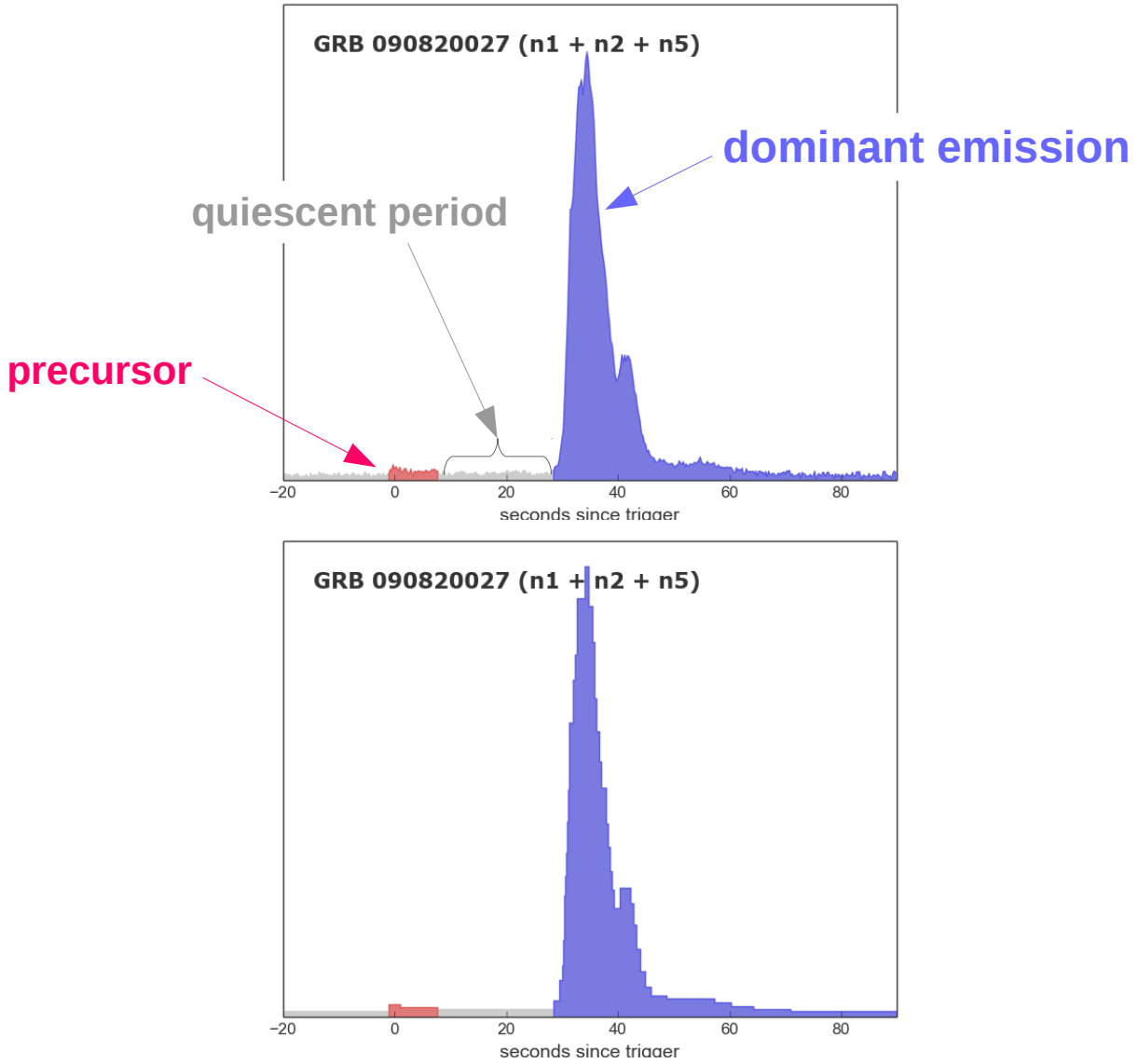
“Best”



Categories

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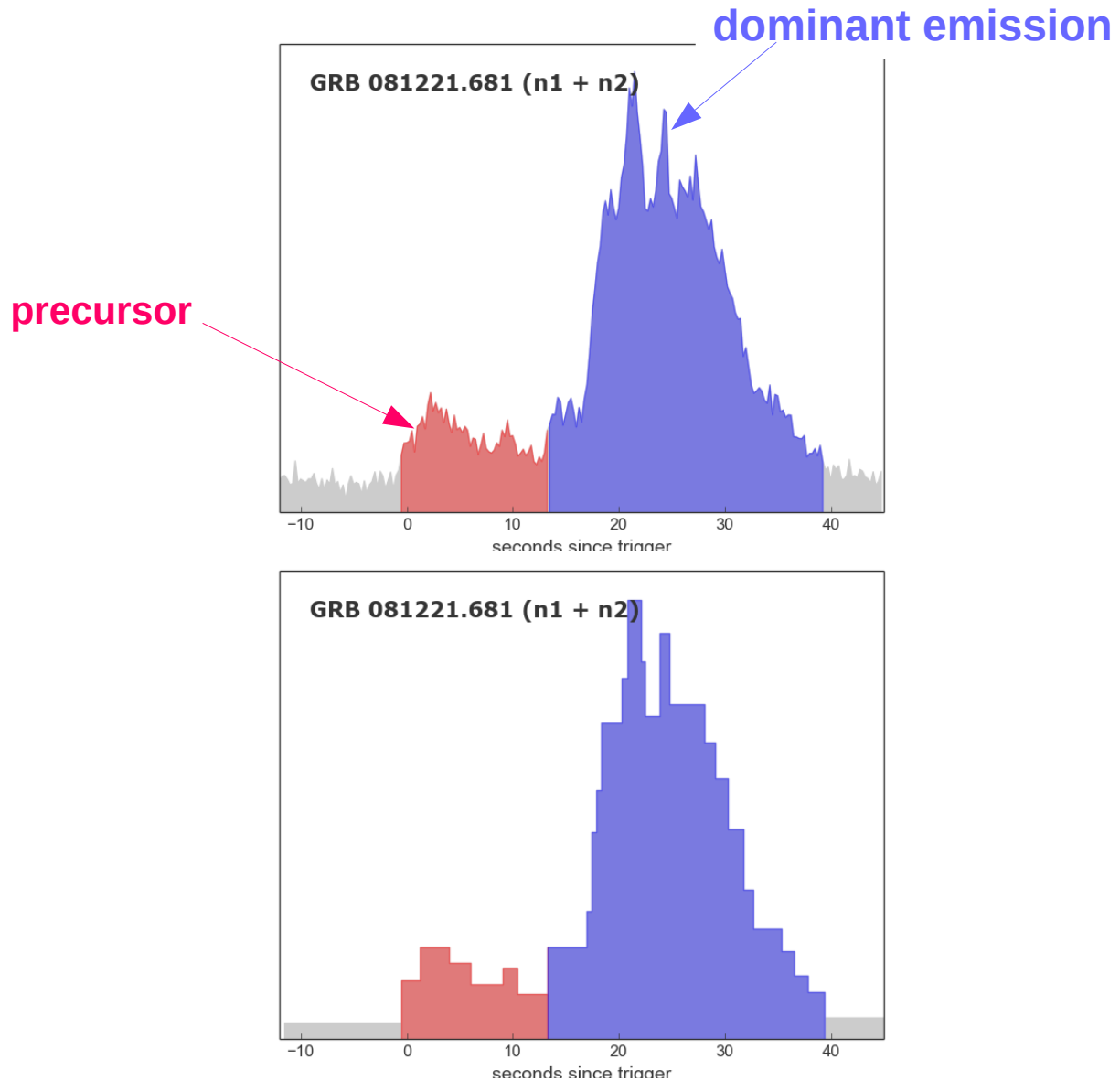
"Good"



Categories

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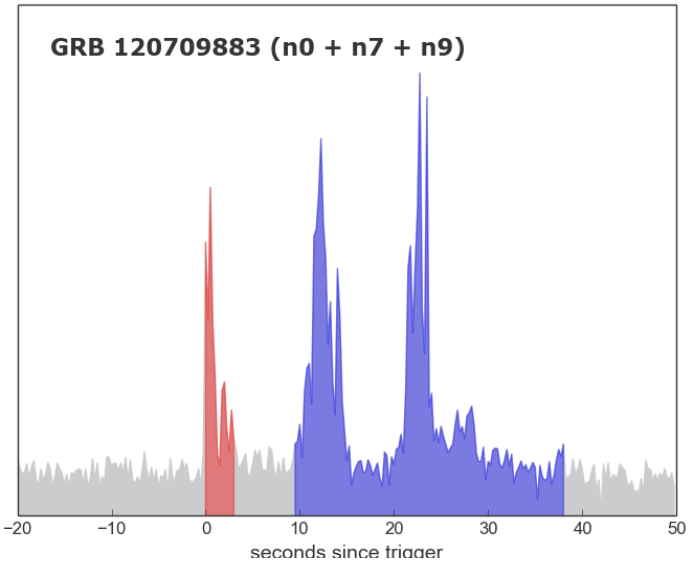
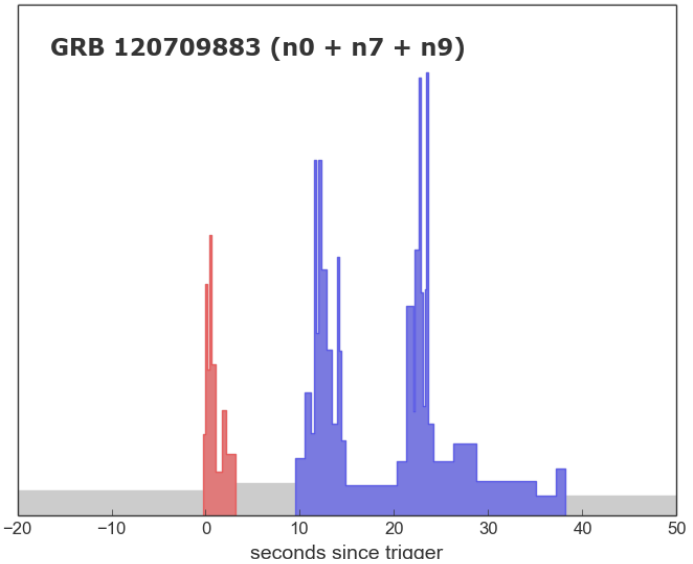
“OK”





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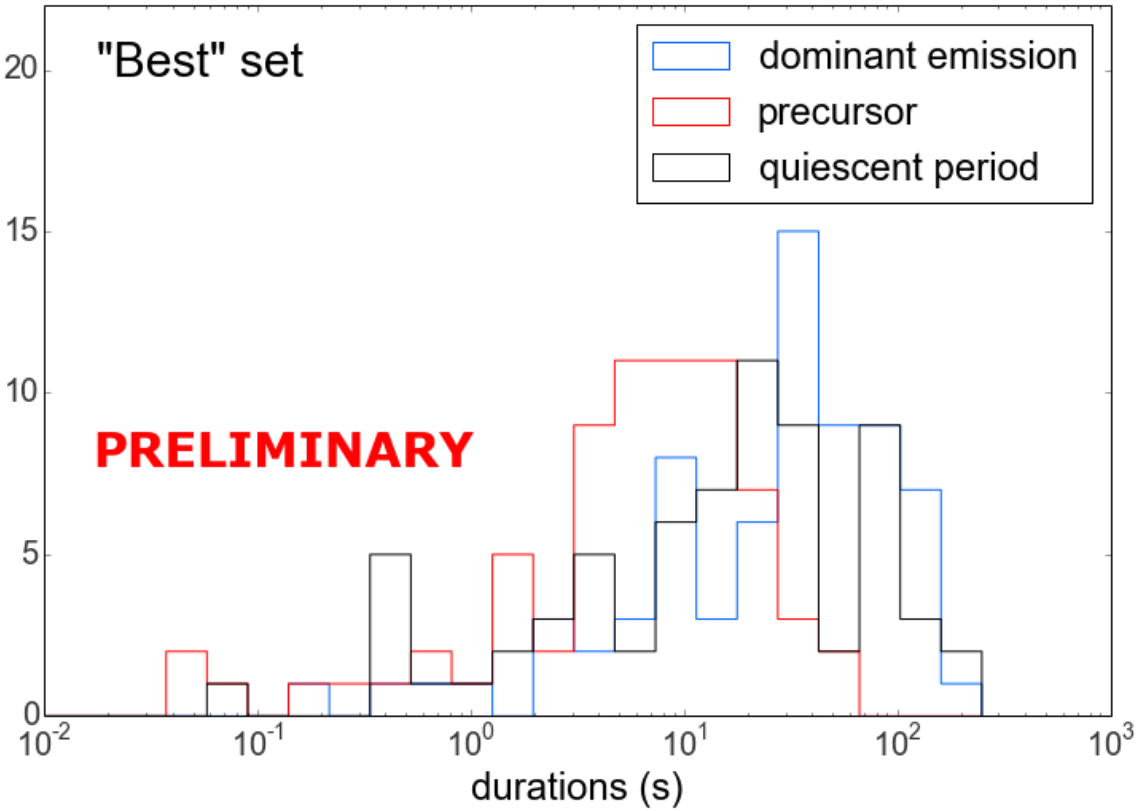
Durations



Short GRBs are ~15% of all GBM GRBs,
but only ~7-8% of the “best” set

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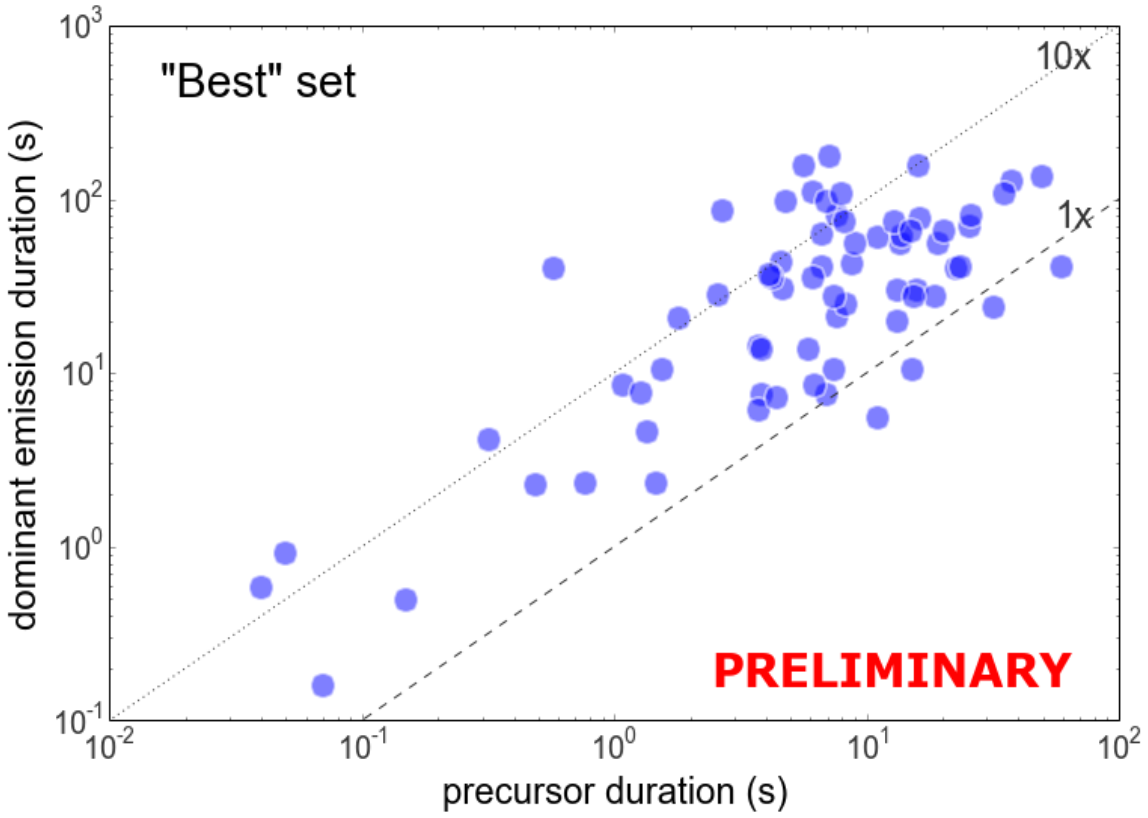
Durations: dominant emission vs precursor



Dominant emission almost always **longer** than precursor

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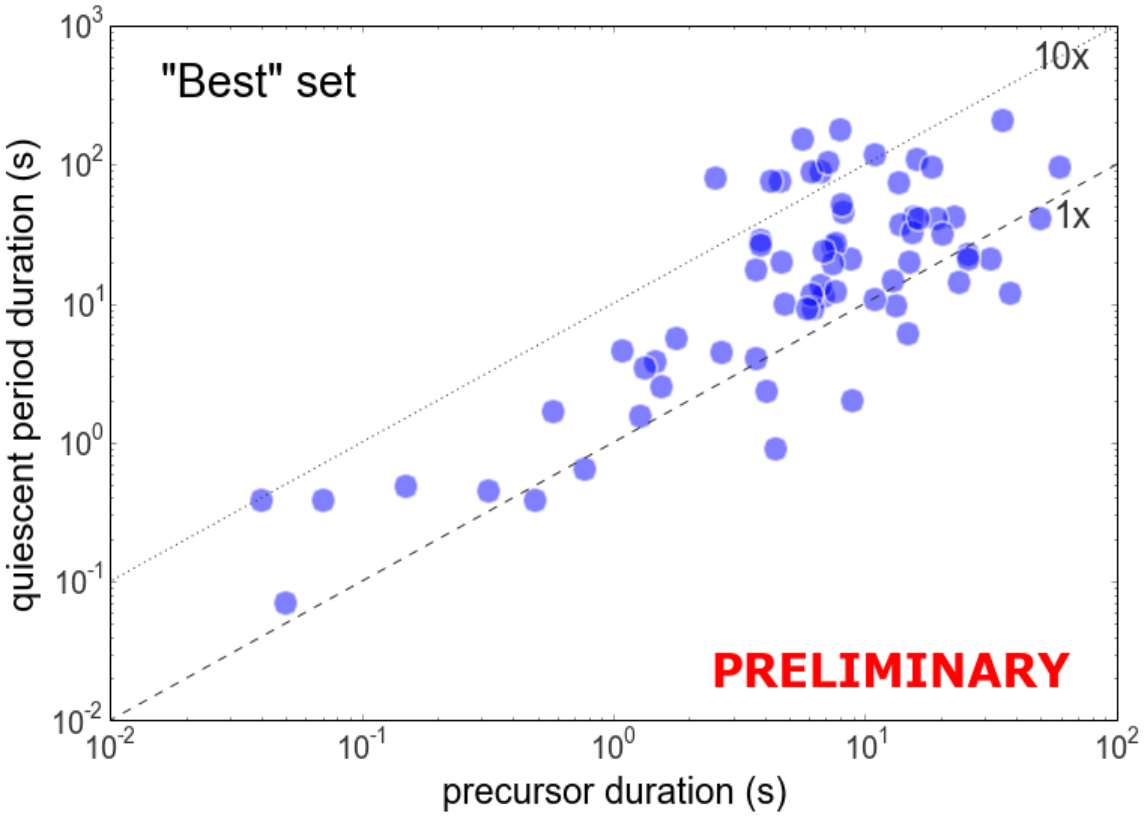
Durations: quiescent period vs precursor



Quiescent period **generally longer** than precursor

Spectral analyses

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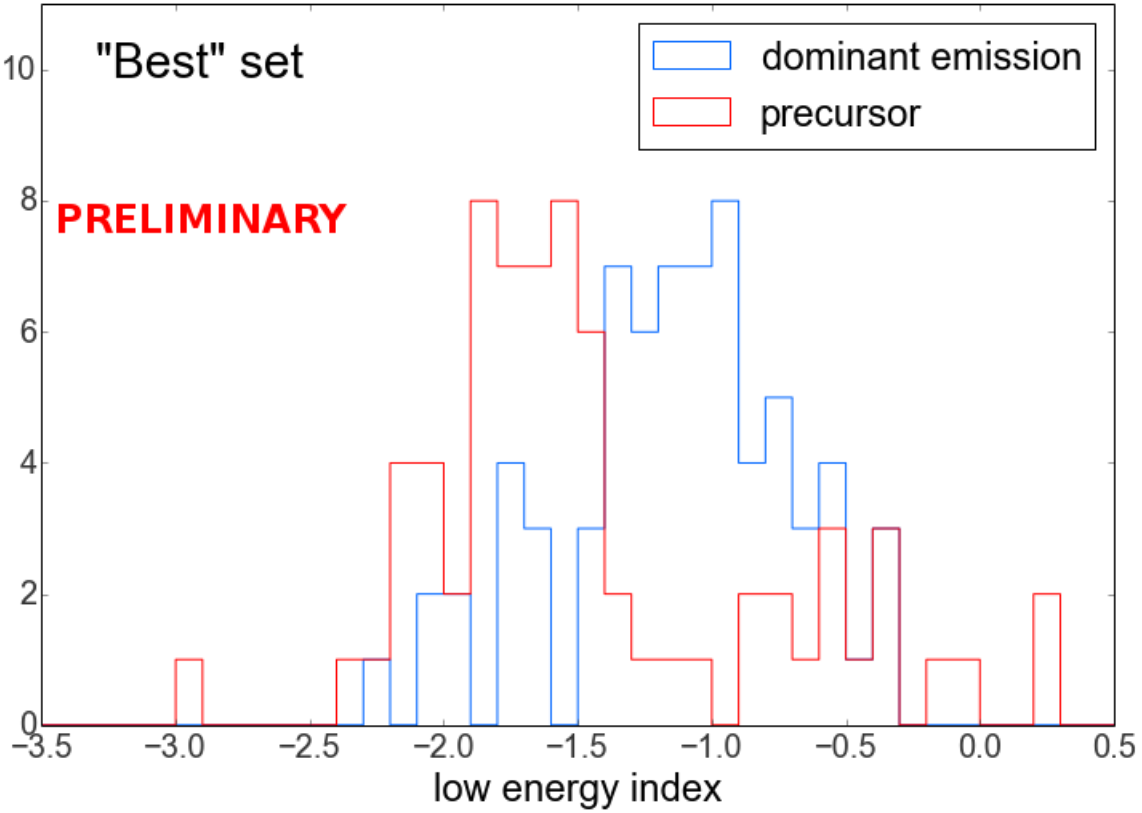
Low energy indices



Precursors tend to have **softer low-energy indices** than dominant emission

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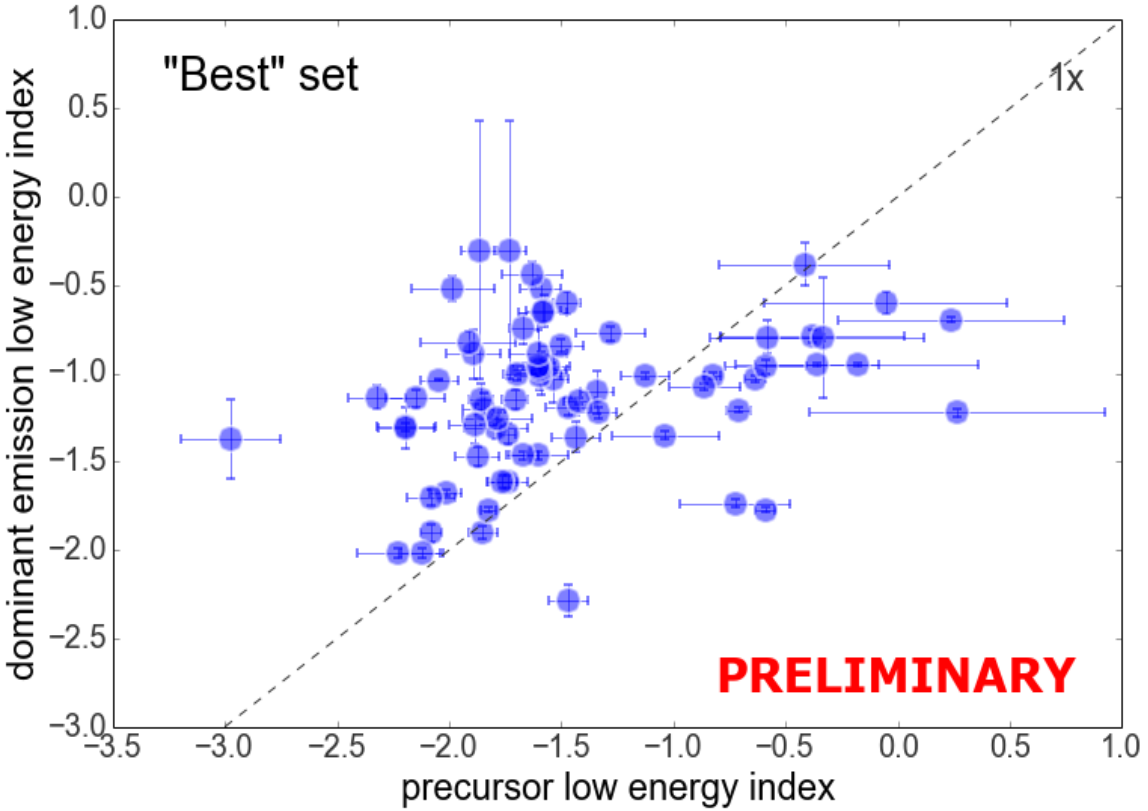

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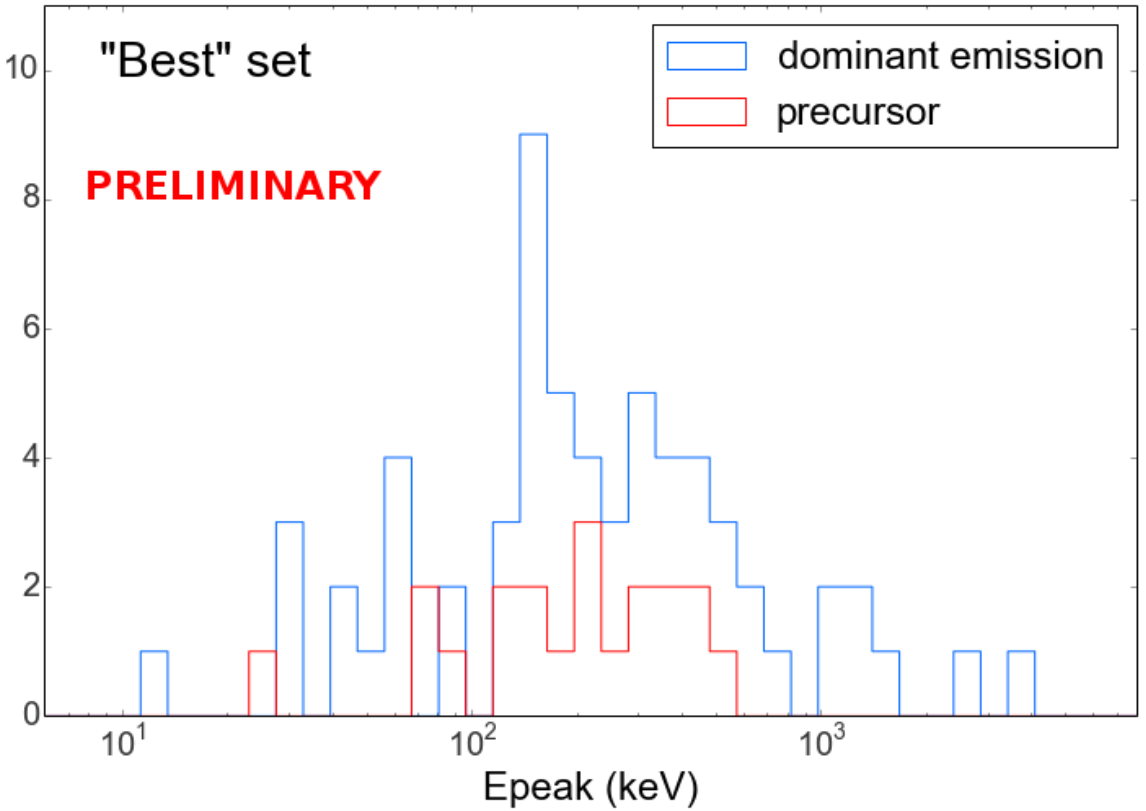
Epeaks



Epeak distributions look more similar
BUT
Precursors are dimmer, Epeak much harder to constrain

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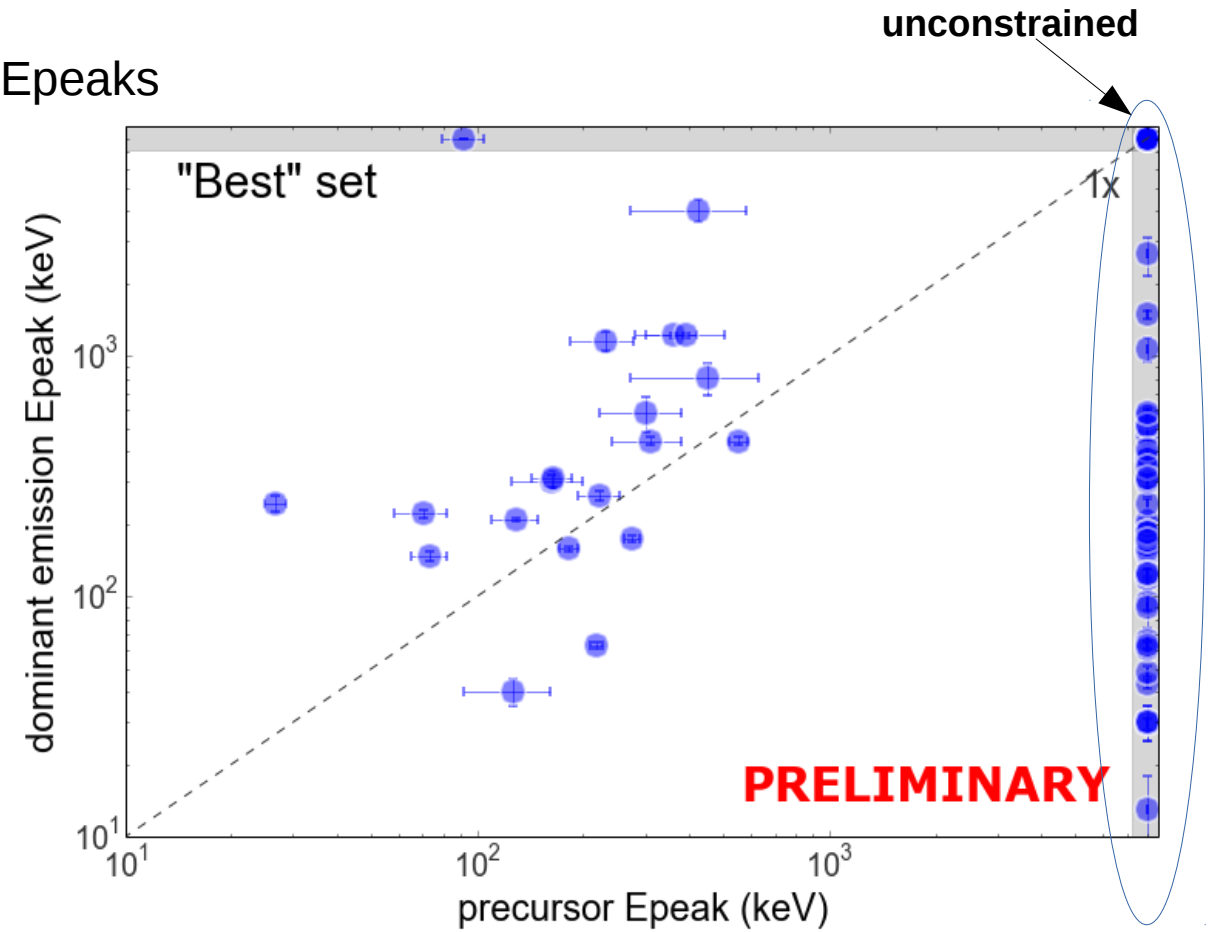

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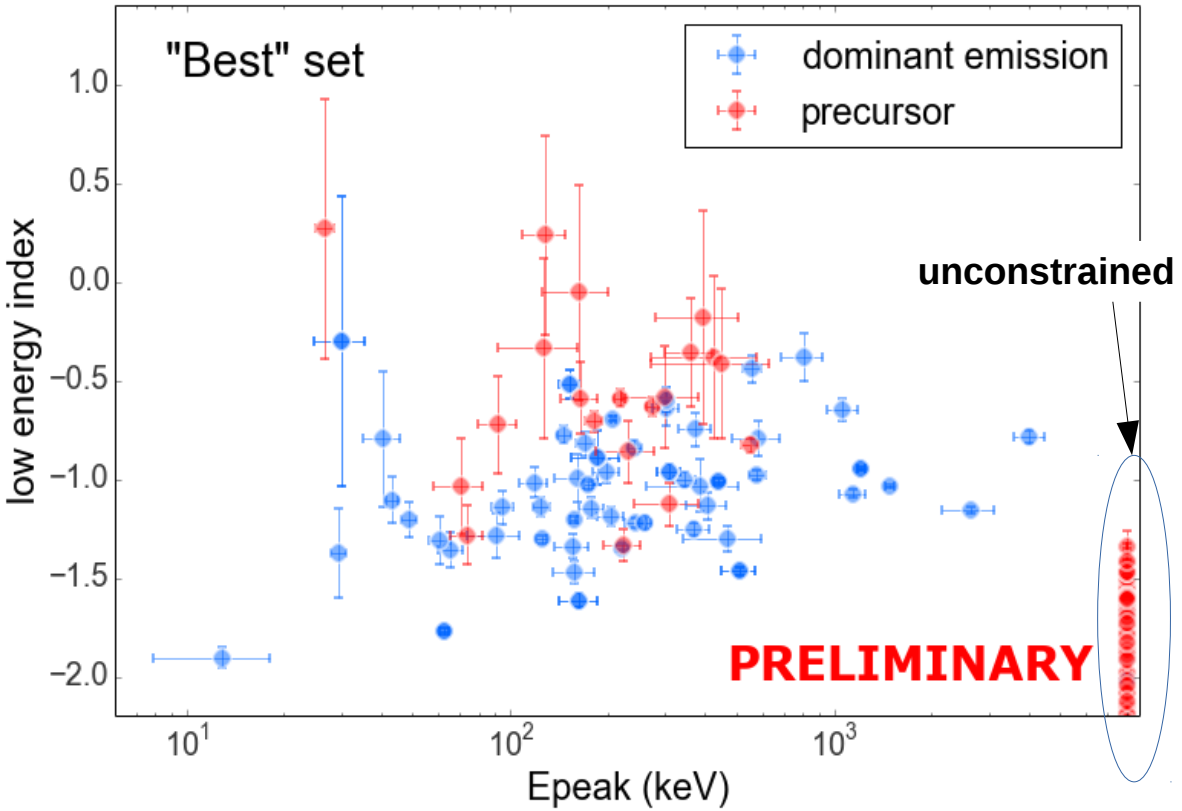
indices vs Epeaks



Be cautious drawing conclusions from this!
Could not measure Epeak for many precursors

Energetics

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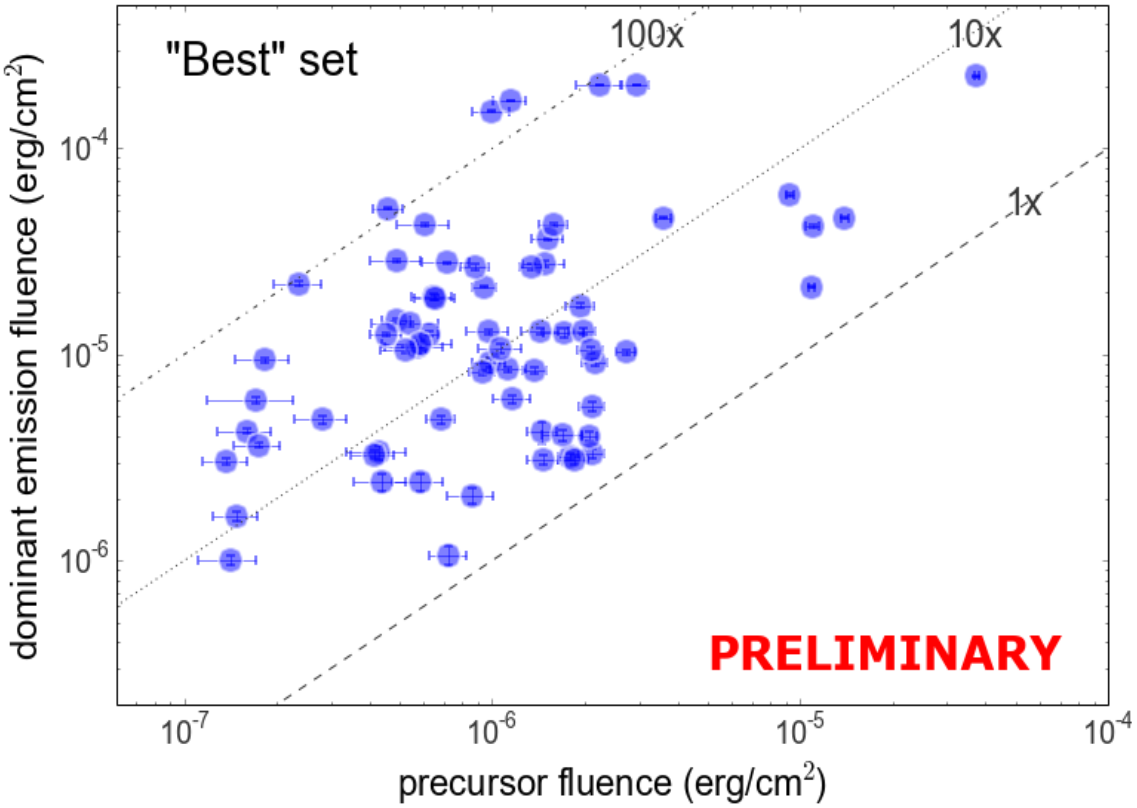
Dominant emission fluence vs quiescent duration



Dominant emission has a **higher fluence** than precursor

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Continued analyses

- Add in LAT data!
- Include the other categories (the “good” and “OK”)
- Include redshifts
- Perform time-resolved spectral analyses for the brightest bursts
- Test for correlations between properties
- Compare different categories
- Compare bursts with precursors and all bursts

Interpretation

- Test the “propeller” phase of the magnetar model
- Can we say something about the emission region?

Classification

- Working backwards, use measured properties to try to recover categories (i.e., is there such a thing as a “real” precursor?)

Revisit what's important

- Is the defining characteristic the quiescent period?