GRB + FRB Transients

Andrew Taylor & Francesco Longo

Contributions to be covered……

Time

GRB Precursors

GRB Localisation

GRB Polarisation

Hadronic Emission from GRB

Search for GW170817-Like GRB Events

Off-Axis GRB Emission Modelling

Contributions to be covered……

GRB Precursors

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Off-Axis GRB Emission Modelling

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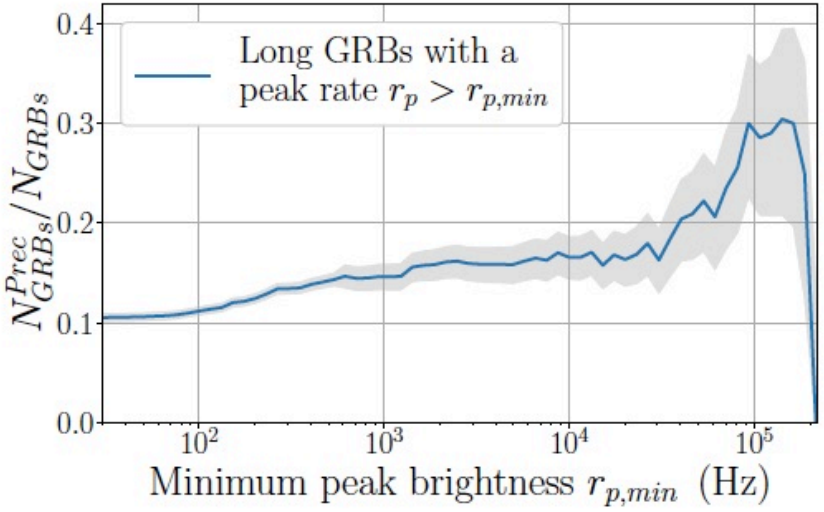
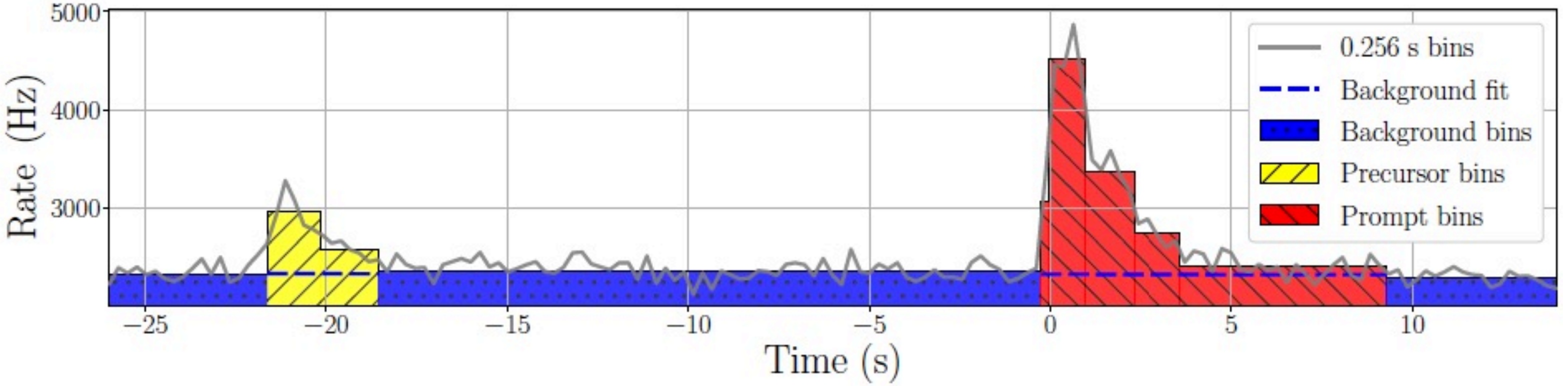
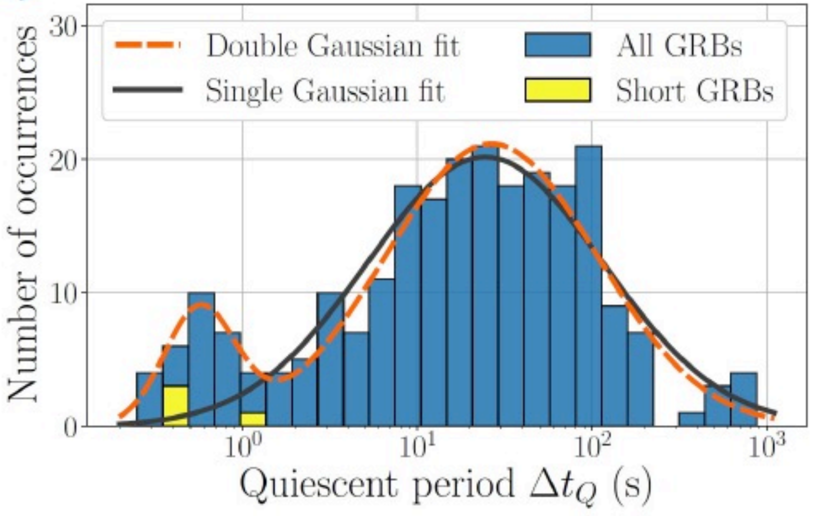
Presenter: Paul Coppin

GRB precursors

- Searched for precursors from GRBs detected by Fermi-GBM
- Analyzed 2364 bursts:
  - ~10% of long GRBs & ~1% of short GRBs have a precursor
    → More if only bright bursts are used
  - Precursors short bursts <2 s before prompt
  - 3 IACT bursts: GRB 190114C, GRB 180720B & GRB 190829A
- Quiescent time exhibits bimodal distribution
  → Two physical mechanisms?



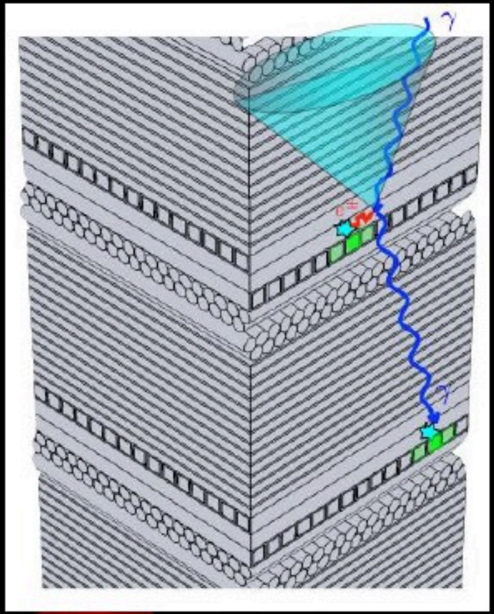




A FAST GRB SOURCE LOCALIZATION PIPELINE FOR THE ADVANCED PARTICLE-ASTROPHYSICS TELESCOPE

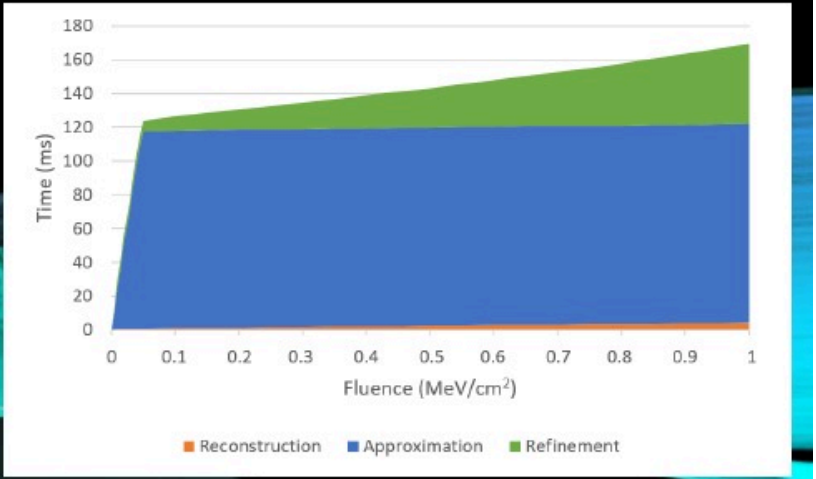
Marion Sudvarg et al.

- We are developing a space-based observatory to survey the entire sky for GRBs
- It will fly with low-powered computing hardware to perform GRB source localization onboard in real-time
- Needs to rapidly communicate with narrow-band instruments for multi-messenger follow-ups
- We reconstruct incident gamma-ray photons using the approach of Boggs and Jean[1], implemented as an efficient tree search with pruning
- The source is localized to an annulus described by the vector between the first two scatterings and the angle predicted by the Compton law
- Multiple annuli are selected at random for an initial approximation of the source direction
- Then, iterative least-squares refinement produces a final estimate
- This pipeline consistently achieves subdegree localization for 1-second, 1 MeV/cm^2 fluence events in under 200ms



A cross-section of the APT instrument. A gamma-ray photon, g, enters the instrument from the top, then Compton-scatters, before finally being photoabsorbed. The vector between the two interactions, and the scattering angle inferred from the photon's energy before and after the first interaction, define a circle that describes the set of possible source vectors of the photon.

Fluence	Mean Error	Std Dev	68% Containment	95% Containment
0.03 MeV/cm^2	2.15	1.22	**2.53**	4.42
0.1 MeV/cm^2	1.21	0.64	1.45	2.32
0.3 MeV/cm^2	0.70	0.36	0.87	1.32
1.0 MeV/cm^2	0.35	0.20	0.42	**0.72**



[1]S. Boggs and P. Jean, *Event reconstruction in high resolution Compton telescopes*, *Astronomy and Astrophys. Supp. Series* **145** (2000) 311.

Gamma-Ray Polarization Results of the POLAR Mission and Future Prospects

Merlin Kole* for the POLAR-2 collaboration

*Department of Nuclear and Particle Physics (DPNC), University of Geneva, Switzerland

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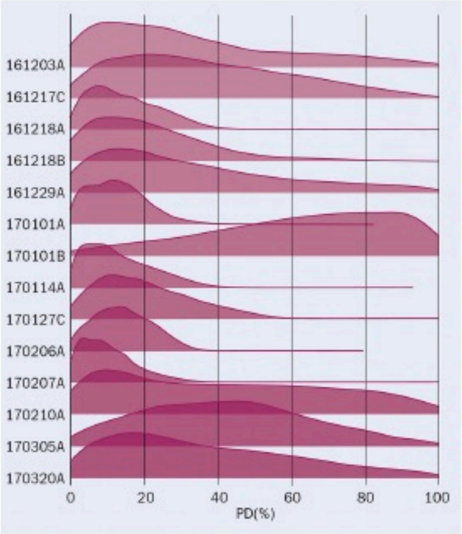
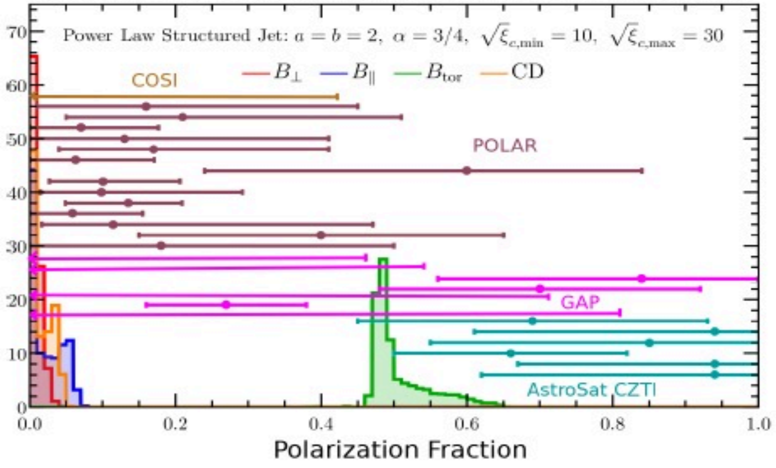
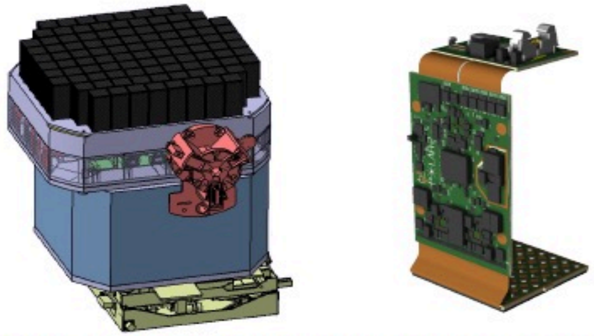


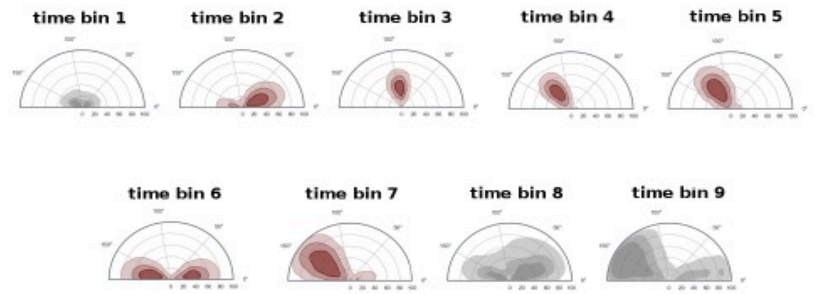
- POLAR was a dedicated GRB polarimeter sensitive in the 50-500 keV energy range
- It detected a total of 55 GRBs during 2016 and 2017
- Polarization analysis possible on 14 GRBs
- Results are consistent with prompt emission being unpolarized or lowly polarized
- Results are consistent with most emission models
- Synchrotron emission from torroidal magnetic field is disfavoured

Based on model figure from: R. Gill & J. Granot & P. Kumar, 2019, MNRAS, Volume 491, Issue 3

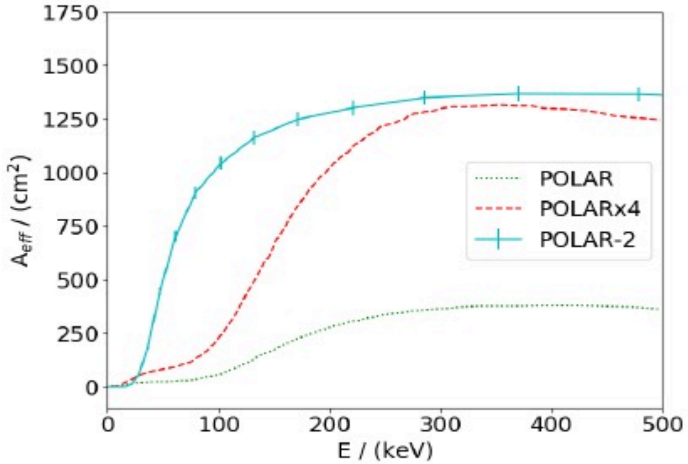


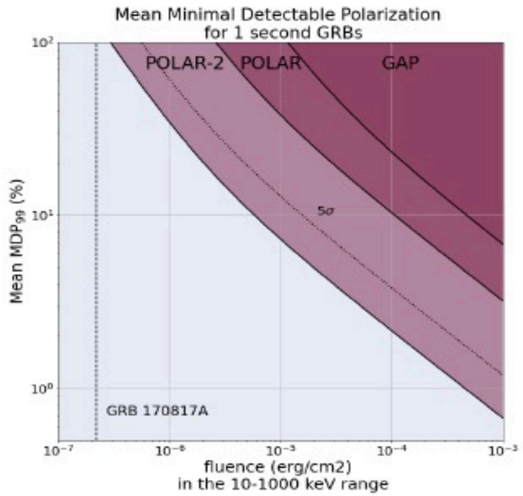


- POLAR results indicate the need for more precise measurements
- POLAR-2 project was started in 2018 → accepted for launch in 2019
- To be launched in 2024 to China Space Station
- Effective area significantly improved over POLAR
- Will perform GRB polarization on almost half of all the GRB with a fluence above $10^-6\,(\mathrm{erg/cm^2})$



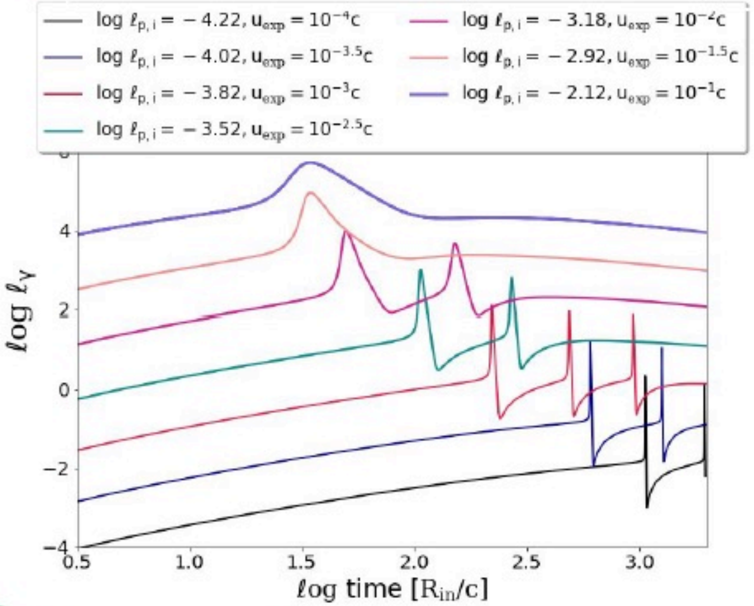
Time resolved studies show hints of quick evolution of PA within the single peak (FRED like) GRB.





“An expanding hadronic supercritical model for γ-ray burst emission”

1 **Light curves from one expanding blob**



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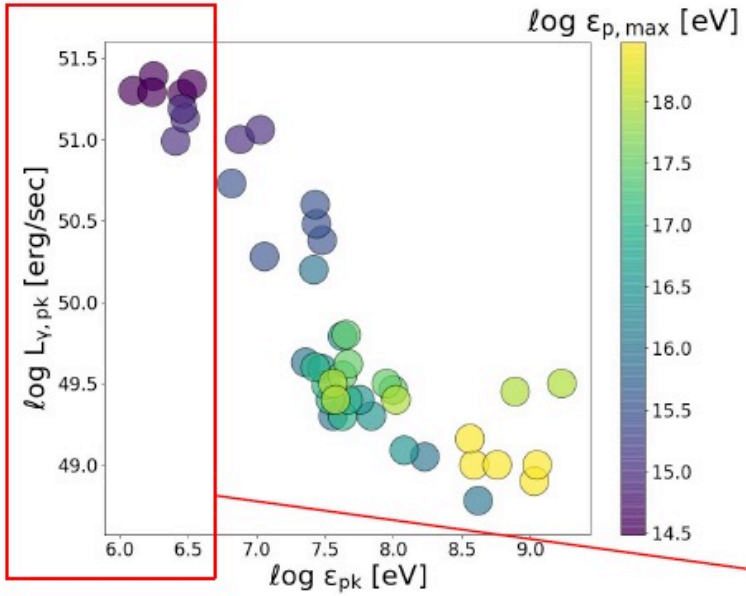
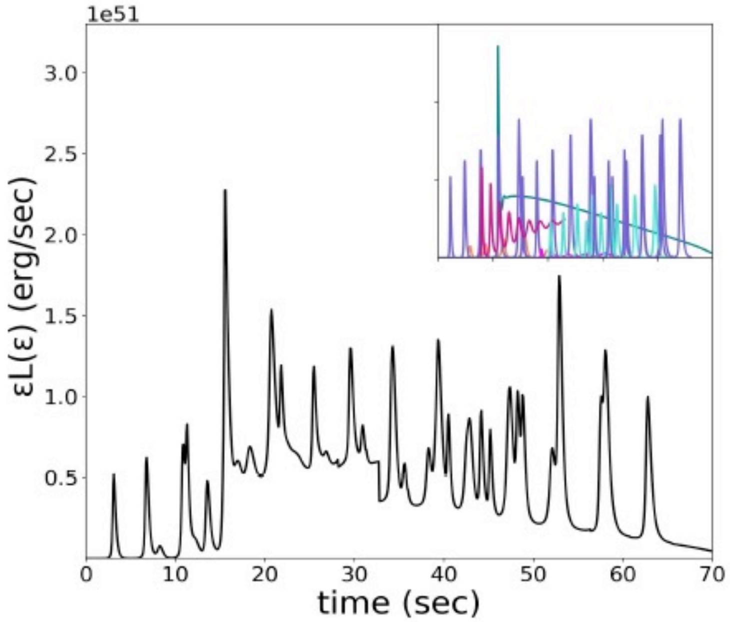


Small values of proton energy preferable

3 **A long GRB light curve**

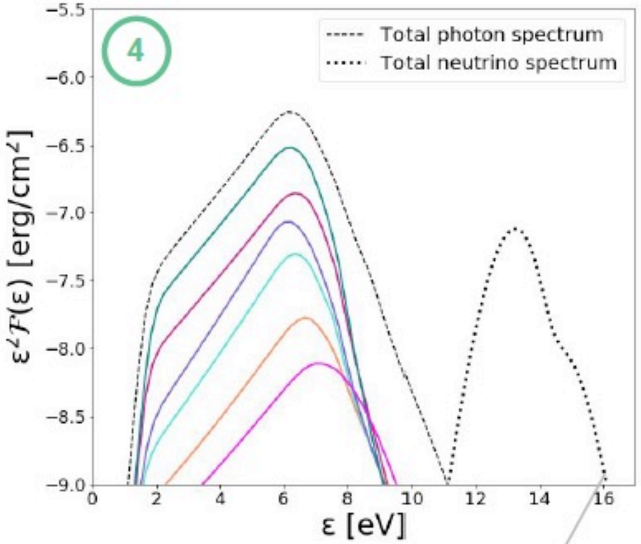


Model Results

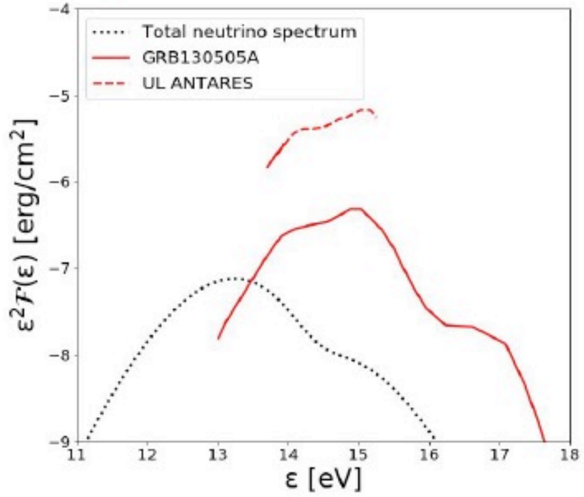
Γ	ϵ_{eff} %	E_{iso} [erg]	ε_{pk} [eV]	$\varepsilon_{\nu pk}$ [eV]	$\mathcal{F}_{\gamma,pk}/\mathcal{F}_{\nu,pk}$	T_{90} [sec]
100	23.7	5.68×10^{51}	9×10^{5}	1.6×10^{13}	7.9	60

Photon and neutrino spectra

4



Comparison with *Albert et al 2017*



Search of Gamma Ray Bursts detected by GBM alike to GRB170817A

J. R. Sacahui[1], M. M. González,[2] Y. Pérez[2] & N. Fraija[2]

1. *Instituto de Investigación en Ciencias Físicas y Matemáticas, USAC Guatemala.*
2. *Instituto de Astronomía, Universidad Nacional Autónoma de México*

Follow up of the 10 year search in GBM bursts made by von Kienlin et al. 2019.

Short bursts T90<5 s.

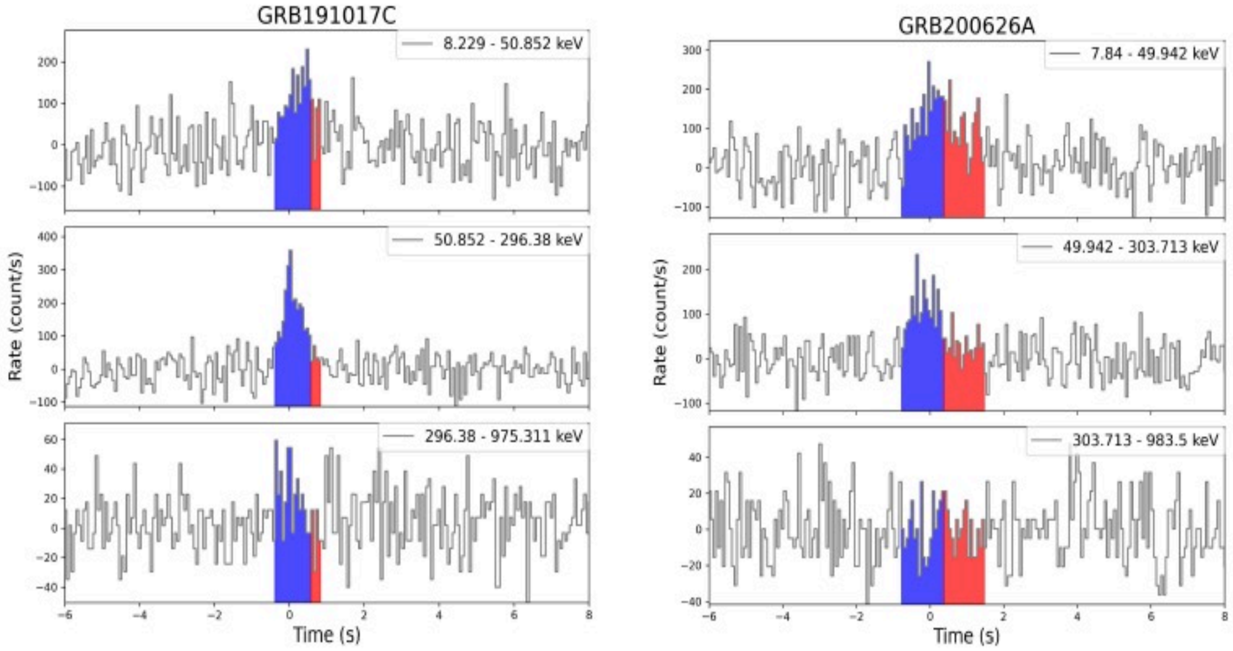
From lightcurves two episodes are notorious:

1. Luminous peak at initial times that highlights at energies between 50-300 keV
2. Soft tail that follows the initial peak that highlights at energies between 8-50 keV

13 candidates!

From spectral analysis:

1. Initial luminous peak is described with a Comptonized function.
2. Soft tail that is described with a Black Body funtion.



After the two parts of the analysis was made, two burst present similar properties:

1. GRB 191017C
2. GRB 200626A

A THEORETICAL MODEL OF AN OFF-AXIS GRB JET

Boris Betancourt Kamenetskaia[a,b], Nissim Fraija[c], Maria Giovanna Dainotti[d,e,f,g], Antonio Gálvan-Gámez[c], Rodolfo Barniol Duran[h] and Simone Dichiara[i,j]

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[b] LMU Physics Department, Ludwig Maxmillians University, Theresienstr. 37, 80333 Munich, Germany
[c] Instituto de Astronomía, Universidad Nacional Autónoma de México, Ciudad de Mexico, Mexico
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[e] Space Science Institute, Boulder, CO, USA
[f] Obserwatorium Astronomiczne, Uniwersytet Jagielloński, ul. Orla 171, 31-501 Kraków, Poland
[g] Interdisciplinary Theoretical & Mathematical Science Program, RIKEN(iTHEMS), 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan
[h] Department of Physics and Astronomy, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819-6041, USA
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[j] Astrophysics Science Division, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771, USA

Broad-lined Ic supernovae (SNe) have been commonly linked with long duration gamma-ray bursts (lGRBs). In the particular case of such a SN, SN 2020bvc, the radiation was isotropic with an X-ray flux. Both facts lend themselves to be studied under the formalism of an afterglow produced by an off-axis jet which expands laterally and becomes on-axis, which our model makes possible. We have researched the evolution of the afterglow of an off-axis top-hat jet when it interacts with a stratified circumburst medium ($n(r) \propto r^{-k}$). We have developed a model for the synchrotron radiation due to such an interaction before and after the jet enters our line of sight. With basis on external forward shocks, we have analyzed the behavior of the afterglow in the relativistic phase (before the jet breaks) and in the lateral expansion phase. We have obtained synchrotron light curves in the fast- and slow-cooling regimes in both timescales. The model has been successfully applied to the observed X-ray emission from SN 2020bvc with a stratification parameter $k = 1.5$.

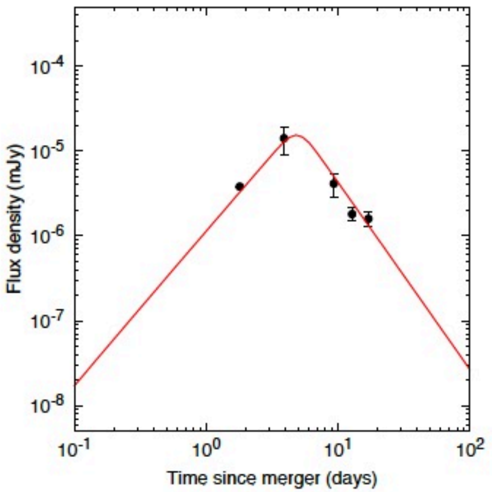

Figure 1: The X-ray data points of SN 2020bvc with the best-fit curve obtained with our model for a stratification parameter of $k = 1.5$.

Transients- GRB “Big Questions”

Andrew Taylor & Francesco Longo

Question 1

- Where is the present observational frontier of GRB physics? What area of GRB physics is presently most contested?

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Question 2

- Where are the observational bottlenecks limiting out ability to probe GRB physics? How have recent results affected these limitations?

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Question 3

- What future observations are now needed to take the field beyond the current observational frontier?

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Question 4

- Are the instruments planned for the coming decade sufficient in order to achieve the required next observations needed?

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Question 5

- What observational strategies have we learnt to be most effective in ensuring that the most relevant GRB physics is probed? What mistakes have we made? (and what lessons have we learned?)

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