Study of the IRF for the GRB on-ground detection

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Introduction...

• GRB is a different class of sources:
  – They last few seconds (Prompt emission)
  – They are point sources
  – They can be triggered by the GBM providing duration and position.

• This implies:
  – The particle background is relatively low.
  – The photon background (non GRB gamma) is negligible.
  – Detecting GRB does not mean provide the best localization. (trade-off between Aeff vs PSF)

• DC2 IRFs may not be the best choice for GRB detection:
  – Detailed studies are required in order to optimize the GRB studies, in general (localization, energy resolution,...)
  – The following exercise, mainly on GRB sensitivity, is a starting point!
The procedure…

Set of Cuts

- All Gamma data
  - (_10M_v7r3p1)

- Particle Background data
  - _v9r3

- GRB “raw” data
  - From DC2 burst

- Effective Area

- “Residual” Background

- “Filtered GRB signal”
The sets of cuts

https://confluence.slac.stanford.edu/display/DC2/Trigger+and+Filter+settings+and+Event+classes

“TRIGGER”
(GltWord&10)>0&&(GltWord!=35)

“FILTER”
FilterStatus_HI==0 (none of the high order 17 bits of the OBF is 1)

“PREFILTER”
DC2PrefilterCal=CalEnergyRaw>5&&CalCsIRLn>4 (5 MeV in the Cal && >4 rad length in the CsI)

“Vetos”
… different vetoes conditions…all the vetos together:
TCut DC2Vetos =
    DC2AcdVeto||DC2ElectronVeto||DC2AnotherVeto||HeavylonVeto||AntiCorrVeto||ProtonVeto||GlobalRibbonVeto;
CLASSIFICATION CUTS:
//These are handy to use to make pruned tuples.
TCut Basic="CTBCORE>0.1&&!CTBBestEnergyProb>0.1&&!CTBGAM>0.";
TCut ratecut="CTBBestZDir<-0.3&&!CTBBestEnergy>100";
//-------------------------------------------------------------

// Add one of the following to select an event class.
TCut DC2Base1="CTBCORE>0.1&&!CTBBestEnergyProb>0.3&&!CTBGAM>0.35";
TCut DC2Base2="CTBCORE>0.1&&!CTBBestEnergyProb>0.1&&!CTBGAM>0.55";
TCut DC2Base3="CTBCORE>0.35&&!CTBBestEnergyProb>0.35&&!CTBGAM>0.50";

Final Event Classes
TCut GoodEvent1=(DC2Base1&&!DC2Trigger&&!DC2Filter&&!DC2PrefilterCal)&&!DC2Vetos;
TCut GoodEvent2=(DC2Base2&&!DC2Trigger&&!DC2Filter&&!DC2PrefilterCal)&&!DC2Vetos;
TCut GoodEvent3=(DC2Base3&&!DC2Trigger&&!DC2Filter&&!DC2PrefilterCal)&&!DC2Vetos;
Or:
TCut EventClassA = GoodEvent3;
TCut EventClassB = GoodEvent1&&!GoodEvent3;
Effective areas - all Gamma events

Starting DC2 events

~ telemetry data (OB filter)
First on-ground filters
(reduces low energy bkg)
“Minimal” gamma-classification

DC2 event classes
The effect of cuts on background

Starting DC2 events

~ telemetry data (OB filter)
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"Minimal" gamma-classification

DC2 event classes
BKG rate:

Downlink:  
- ~ 500 Hz

The correct downlink requirements are in byte
Effect of cuts on GRB events

- We use the information from the GBM trigger to extract LAT raw data:
  - Duration of the GRB given = GBM duration
  - Position (Ra, Dec) approximately known: 20 degrees around the GBM position
- To evaluate the “residual background” we extract the LAT raw data AFTER the GRB.

We applied the following cuts:

[TRIGGER & FILTER] : DC2Trigger && DC2Filter
[PREFILTER] : DC2Trigger && DC2Filter && DC2Prefilter
[BASIC] : PREFILTER && CTBCORE>0.1 && CTBBestEnergyProb>0.1 && CTBGAM>0.
[GoodEvent1 (DC2)] : PREFILTER && CTBCORE>0.1 && CTBBestEnergyProb>0.3 && CTBGAM>0.35

: ClassA && ClassB
Quick look at the data:

- **GRB080101283**:
  - Viewing angle: 64.8
  - GBM intensity: 6953.23

- Trigger & Filter
Quick look at the data:

- **GRB080101283:**
  - Viewing angle: 64.8
  - GBM intensity: 6953.23

- **Trigger & Filter & Prefilter**
Quick look at the data:

- **GRB080101283:**
  - Viewing angle: 64.8
  - GBM intensity: 6953.23
- **Trigger & Filter & Prefilter & BASIC**
No counts in DC2 data

- **GRB080101283:**
  - Viewing angle: 64.8
  - GBM intensity: 6953.23

- **GoodEvent 1**

- This is a burst with none LAT counts in DC2 data, but with an excess in the raw data! ("Not DC2 counts")
Another example:

- **GRB080104514**
  - Viewing angle: 20.3
  - GBM intensity: 697.885

- **Trigger & Filter**
• **GRB080104514**
  
  - Viewing angle: 20.3
  - GBM intensity: 697.885

• **Trigger & Filter & Prefilter**
- **GRB080104514**
  - Viewing angle: 20.3
  - GBM intensity: 697.885

- **Trigger & Filter & Prefilter & BASIC**
GRB080104514

- **GRB080104514**
  - Viewing angle: 20.3
  - GBM intensity: 697.885

- **GoodEvent 1**

- **This is an intense burst in DC2 data!**
Total number of GRB counts

- We select 26 bursts with at least one count in the raw data.
- 13 Not DC2 bursts.
**Average rate during the burst…**

- **Avg Rate:** GRBcounts/GRBduration
…to be compared with:

- Not DC2 burst have also not “Background” counts: high viewing angles.
Peak Flux

- Maximum/(Bin width)
  - Is a better estimator for triggering bursts
• Burst with few background counts (large viewing angles, SAA or file truncated) (6)
• Burst not visible in even in the RAW data (3)
• Burst candidates in the LAT RAW data, with no counts in the DC2 “GoddEvent1” data (4)
If the background is underestimated the S/N ratio is a wrong indicator!
• Burst with few background counts (large viewing angles, SAA or file truncated) (6)
• Burst not visible in even in the RAW data (3)
• Burst candidates in the LAT RAW data, with no counts in the DC2 “GoddEvent1” data (4)
The 4 burst candidates

- Some burst which are not visible in the DC2 data are “visible” in the LAT RAW data.
Bursts visible in DC2

- Advantages of a larger effective area (more events):
  - Pulse shape and temporal studies
  - Spectral coverage down to 10-30 MeV
  - GBM overlap!
  - A good GBM determination of the burst location (~5°): kills the background (>GeV).
GRB 080104.514

- “A $\gamma$-ray burst with a high-energy spectral component inconsistent with the synchrotron shock model”
- GRB 080104.514 has a delayed emission starting at $t \sim 300$ s after the GBM trigger.

Spectral analysis: spectral index = (FT1Viewer*): $1.53 \pm 0.07$ (52%)
(Xspec): $1.64 \pm .09$ (75%)

* [SLAC]/users/omodei/FT1Viewer
GRB afterglow

- **080104.514 afterglow is:**
  - “Hard” => Not so many low energy photons “to save”
  - “Long” => many background photons
- In this case it is also important to have a good localization, good energy resolution.

**Trigger & Filter:** prompt emission visible, ‘afterglow’ background dominated

**GoodEvent1:** prompt emission visible, ‘afterglow’ visible
Conclusion

• Two classes of bursts
  – GRB not visible in the DC2 GoodEvent1 selection, but visible in the Raw data. (4/13) (2 of them are clearly visible)
  – GRB visible in the DC2 GoodEvent1 selection (13/26)

• The sensitivity (S/N) increases with the selection cuts

• Importance of using “raw” data (minimal filter):
  – Low energy spectrum: overlap with the GBM
    • Good localization from the GBM
  – Temporal profiles (pulse shapes)

• The GRB afterglow detected in DC2 data have also been analyzed using Raw data:
  – The high energy emission combined with the long duration make hard the detection of AG in raw data.

• Future works needed:
  – Find optimized IRFs to be used with GRBs (ISOC needs)
  – Run trigger algorithms (on-board trigger algorithm should be applied to on-ground data) for testing the detection efficiency of GRB
  – Explore the energy resolution as well as the angular resolution for different sets of cuts and for different science requirements (study of the cut-offs, localizing bursts, afterglows)
The general trend is that filtering data \( \Rightarrow \) better S/N ratio!

\[
\frac{(S-B)}{\sqrt{B}}
\]

• \( S \): total count rate during the burst
• \( B \): total count rate AFTER the burst \(~100-500\) seconds, depending on the burst