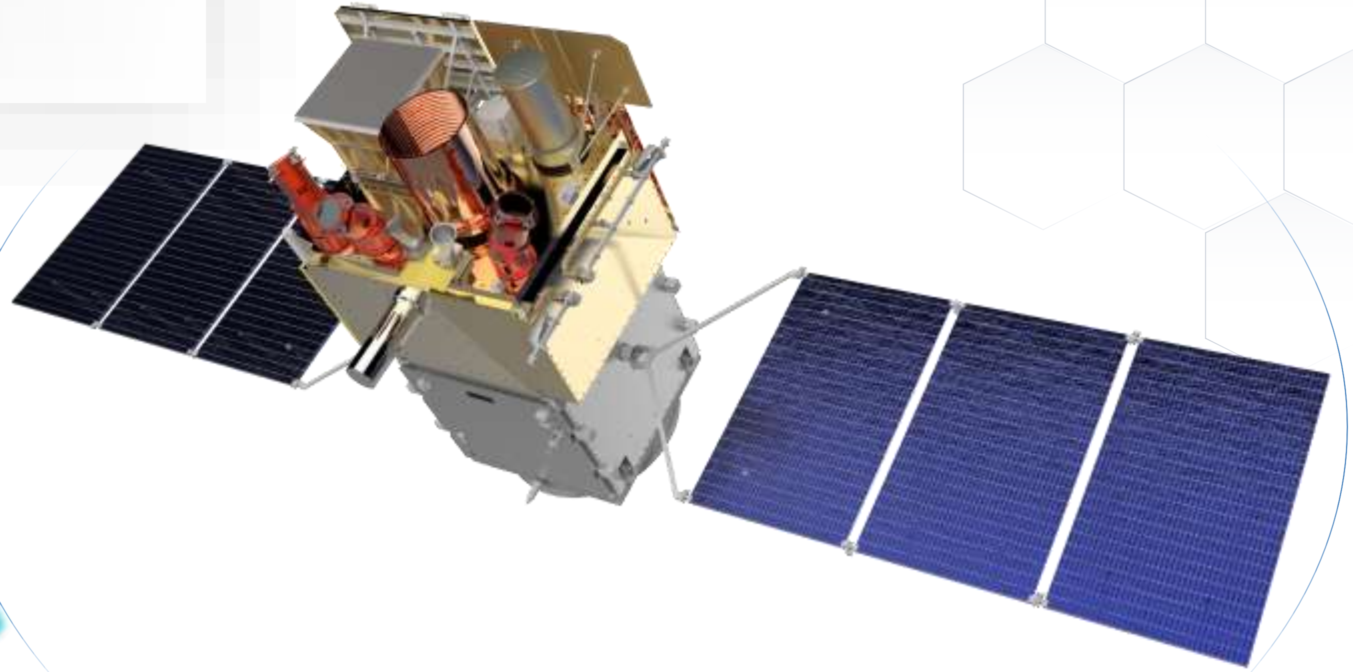
2024 IACHEC

Calibration plan of GRM onboard SVOM



Shijie Zheng and Xiaoyun Zhao

On behalf of GRM-IC team

IHEP, CAS

2024-04-22

OUTLINE

OUTLINE

Overview of SVOM

To be launched in June, 2024

VT
“The Visible Telescope”
Narrow-field visible telescope

appeture： Φ=400mm; 视场: 26’×26’
Dual Channel: 400 – 650 nm(blue)
650 – 1000 nm(red)
positioning accuracy：1arcsec

GRM
“The Gamma-Ray burst Monitor”
X-rays and Gamma-rays detectors

Energy band:15keV – 5MeV
FoV: ±60° (one GRD)
Det area: >200 cm^2 (one GRD)
Energy resolution: ≤ 19%@60 keV
GRB detection: >90/year
Position accuracy: < 5°

ECLAIRs
“The trigger camera”
Wide-field X and Gamma rays telescope

Energy band : 4keV–150keV
Det area: ≈1000cm2
FoV: 89°×89°
Energy Resolution: <1.6keV @ 60keV
Position accuracy : 13arcmin

MXT
“The Multi-channel X-ray Telescope”
Narrow-field X-ray telescope

Energy : 0.2–10keV, 35 cm^2@1.5keV
FoV: 64’×64’
Energy Resolution: 80eV @1.5keV
Position accuracy: 2arcmin

GFT-1&2
“Ground-based Follow-up Telescope”

GWAC
“Ground Wide-Angle Cameras”

For GFTs&GWACs

- 5 minutes after receiving burst message to provide 0.5 arcsec of burst localization, shall include:
  - ☐ Pointing slew(start in 40s for French GFT, in 60s for Chinese GFT)
  - ☐ Exposure time
  - ☐ Data processing duration
- FGFT, CGFT, GWACS Availability: 90%
- GWACs observation limit magnitude Mv = 15

Beidou

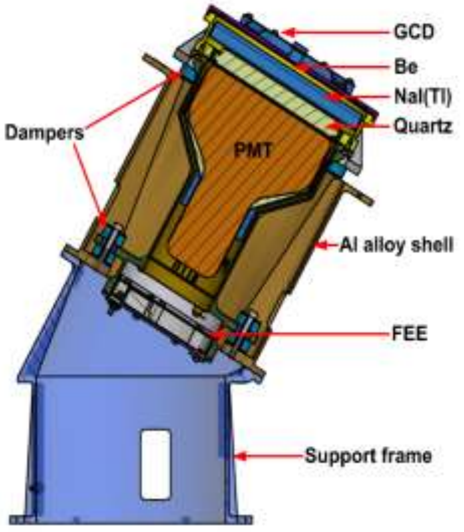
VHF Alert Network

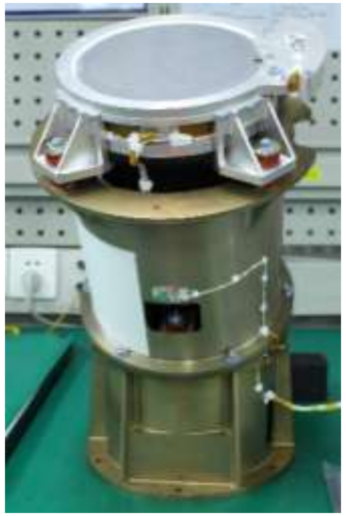
... and more !

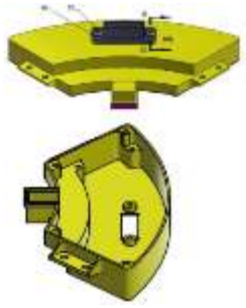
Tracking antennas

Gamma-ray monitor (GRM)

GRD(GCD)

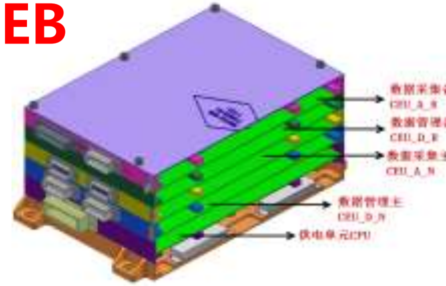






GPM

GEB



GRD (Gamma Ray Detector)：3GRDs (NaI + PMT)，onboard trigger，localization (~5 deg) and spectrum

GCD (GRM Calibration Detector)： 3GCDs，^{241}Am+PS+SiPM，in orbit calibration.

GPM (GRM Particle Monitor)：PS+PMT，if in SAA.

GEB (GRM Electronic Box).

More information about GRM: https://grm.ihep.ac.cn/

Gamma-ray monitor (GRM)

Flight Model

GRD&GCD

GPM

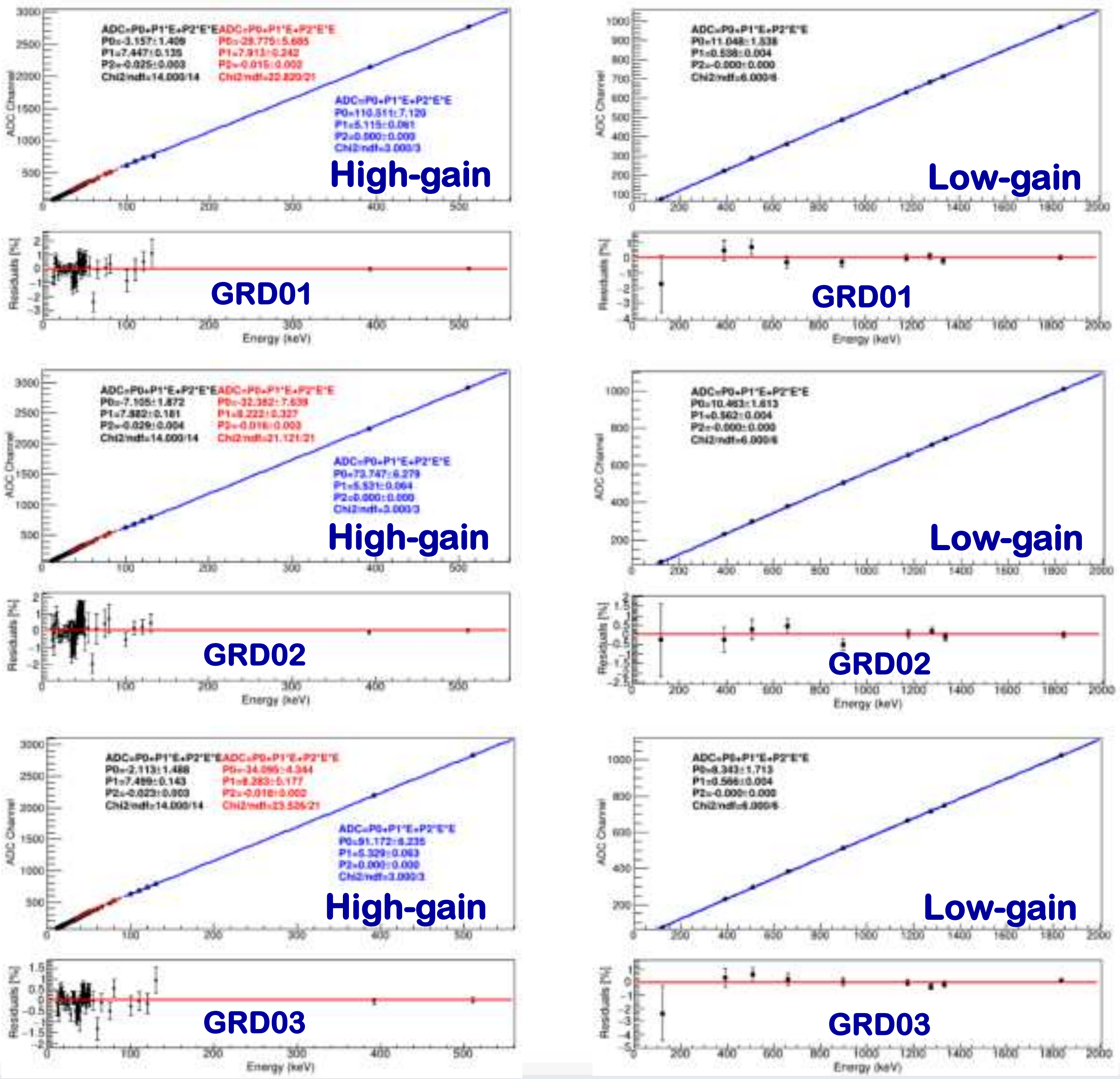
OUTLINE

Simulation and Ground Calibration

E-C relation

- High-gain channel E-C relation of GRD01 with hard X-ray beam and radioactive sources
- Low-gain channel E-C relation of GRD01 with radioactive sources

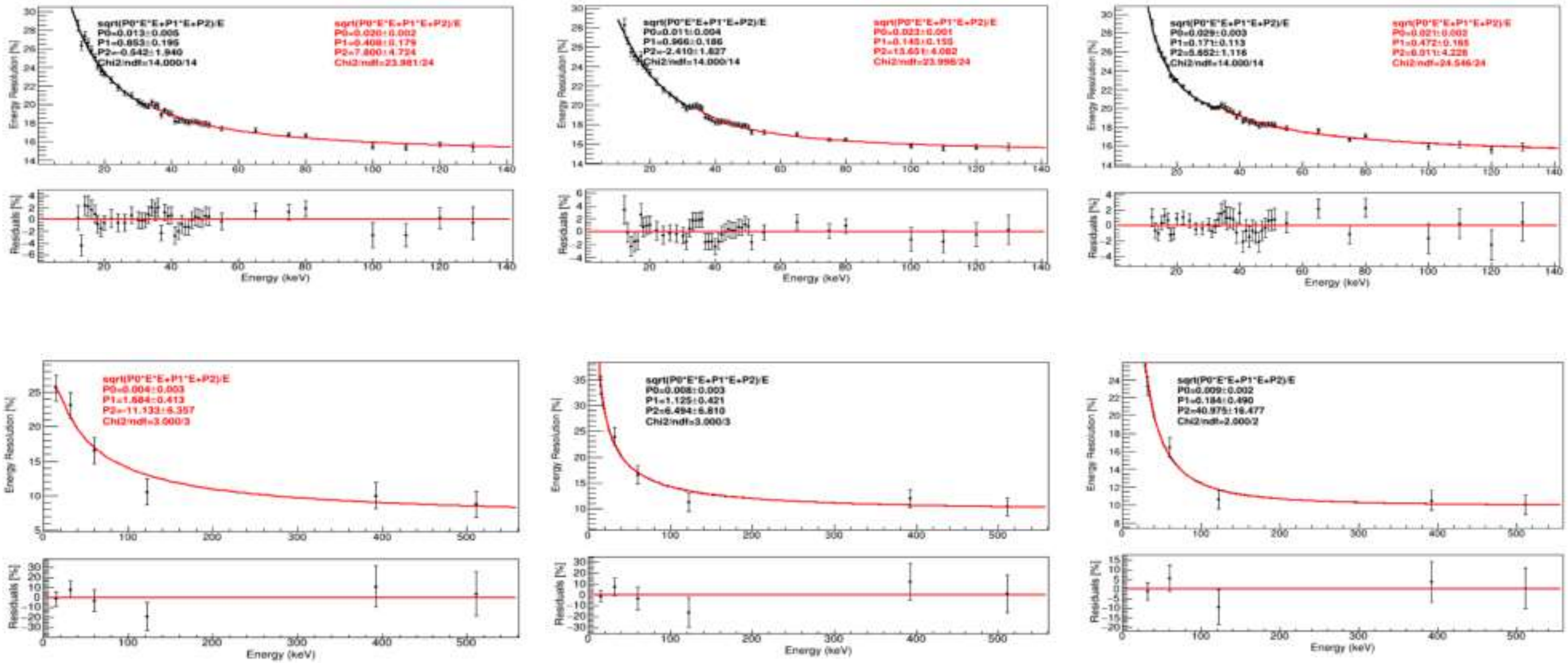
GRD#	Measured range (keV)	Designed range (keV)
GRD01	~ 8 - 5927	
GRD02	~ 8 - 5675	15 - 5000
GRD03	~ 8 - 5638	



Simulation and Ground Calibration

Energy resolution

- 17.02%, 17.09% and 17.19%@60 keV for GRD01-03 with hard X-ray beam
- 16.54%, 16.53% and 16.46%@60 keV for GRD01-03 with ^{241}Am

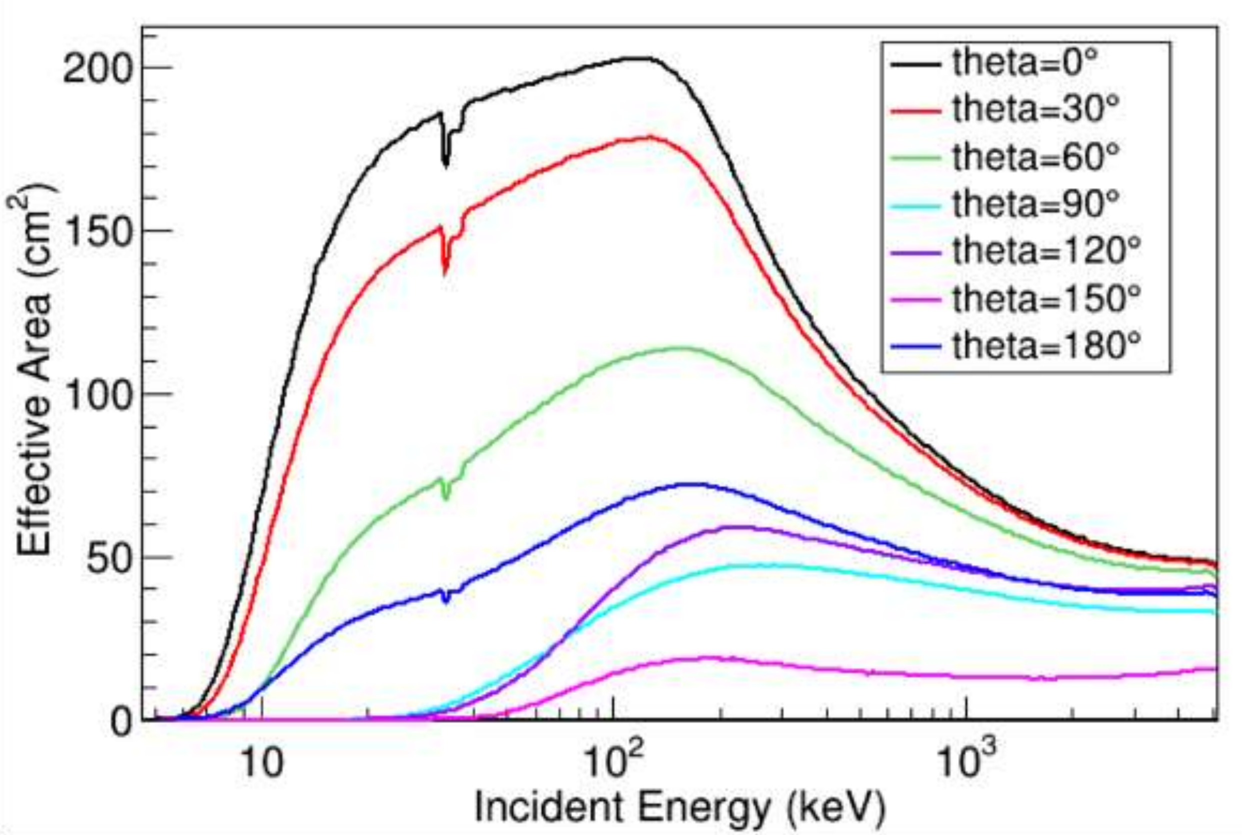


Energy resolutions of GRD01-03 vs energy. Measured with radioactive sources

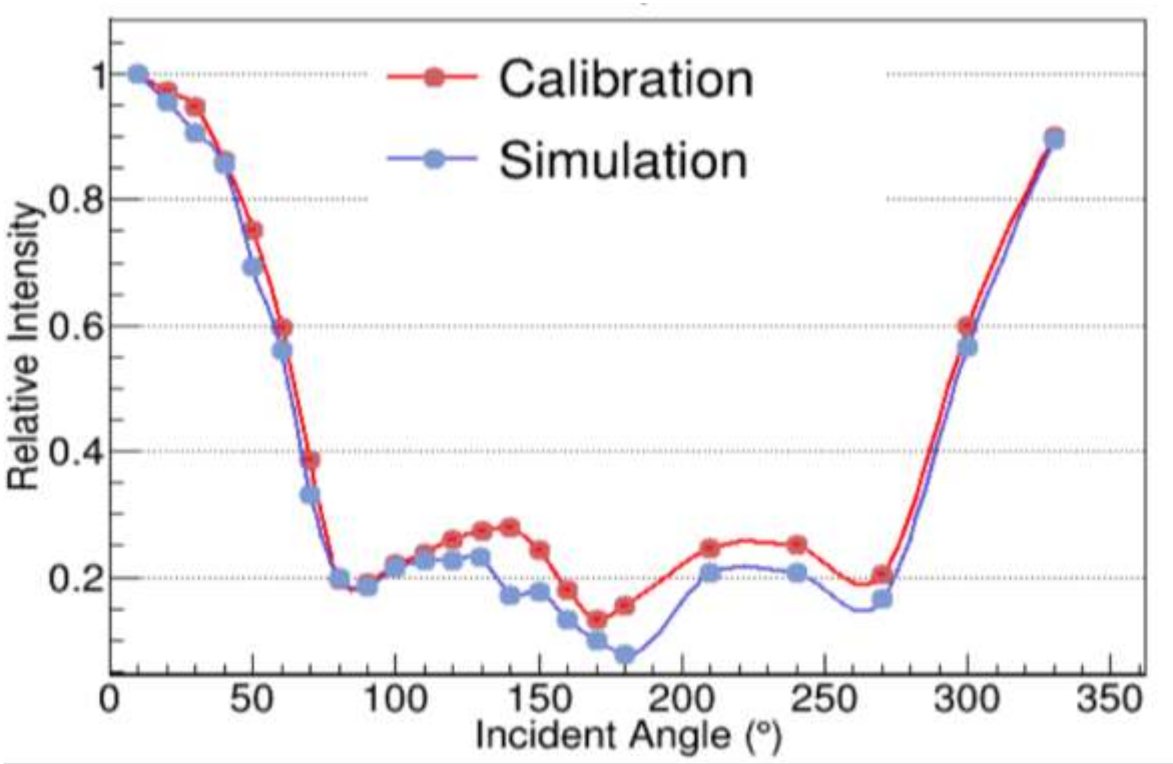
Simulation and Ground Calibration

Effective area

With the incident angle ~60 deg,the effective area of GRD drops half



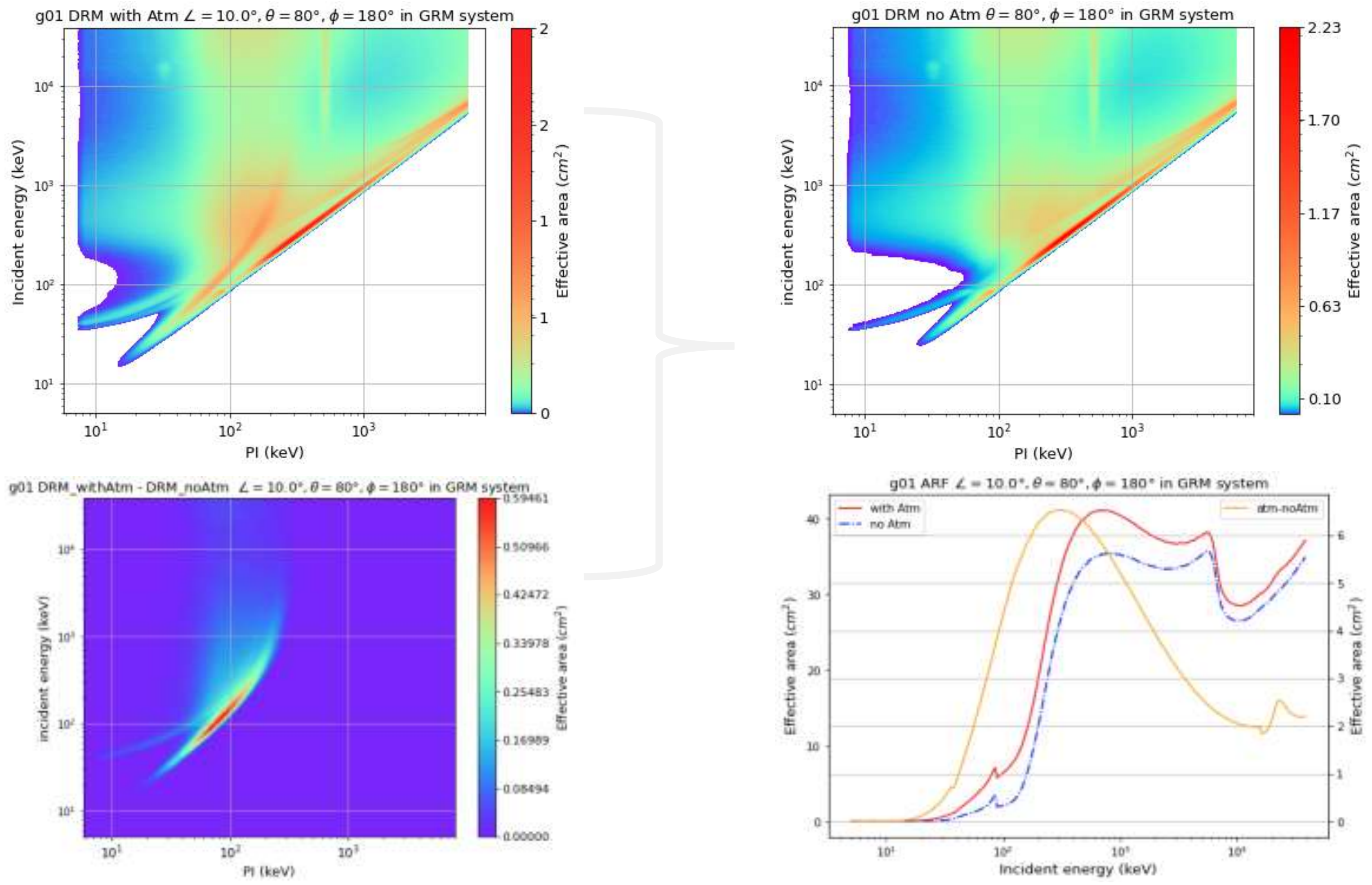
Effective area vs incident photon energy with different incident angles



Relative efficiency of the 392 keV full energy peak of ^{113}Sn

Simulation and Ground Calibration

- Atmospheric albedo effects (Guo et al, 2020)
  - dDRM: the direct detector response matrix
  - aDRM: the atmospheric albedo matrix



The final response matrix when considering atmospheric albedo

Simulation and Ground Calibration

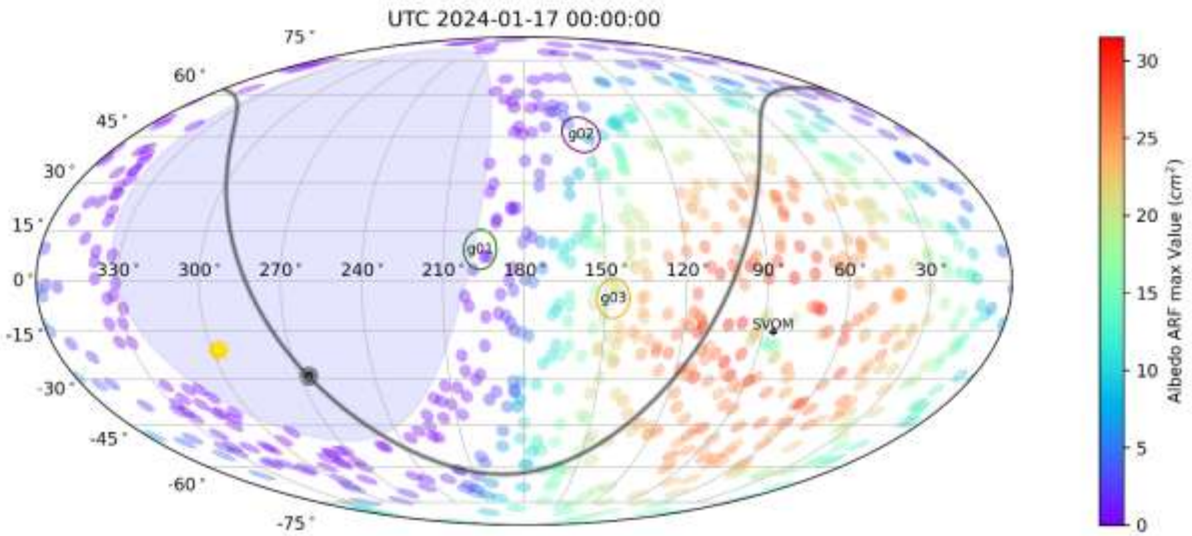
① Orbit height：625 km;

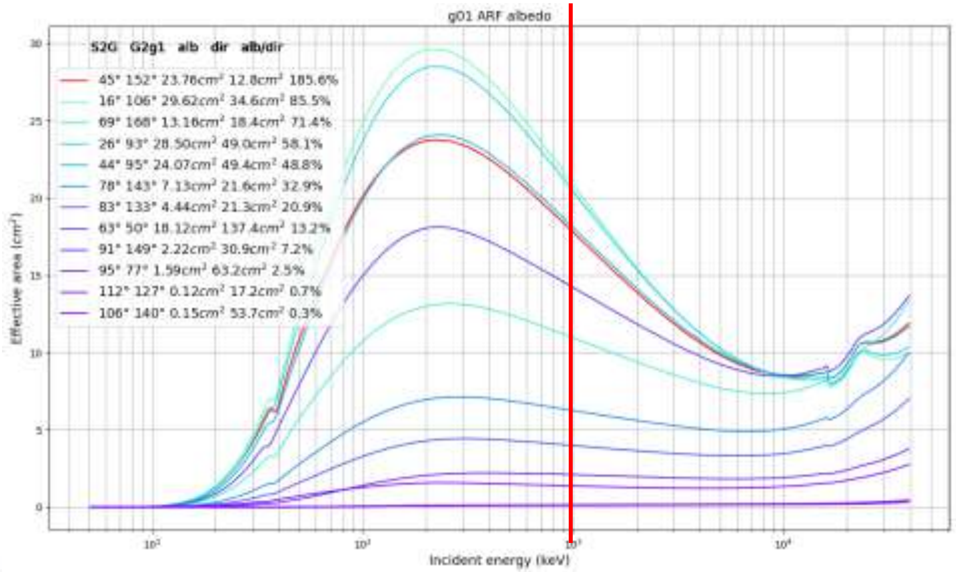
② Randomly sample 1000 GRB locations;

③ Remove those in the earth shadow;

④ The remaining 705 locations are the subject of this study;

⑤ The spherical angle between the GRD01 LoS and the Earth center is 68.03° which indicates nearly the worst case.





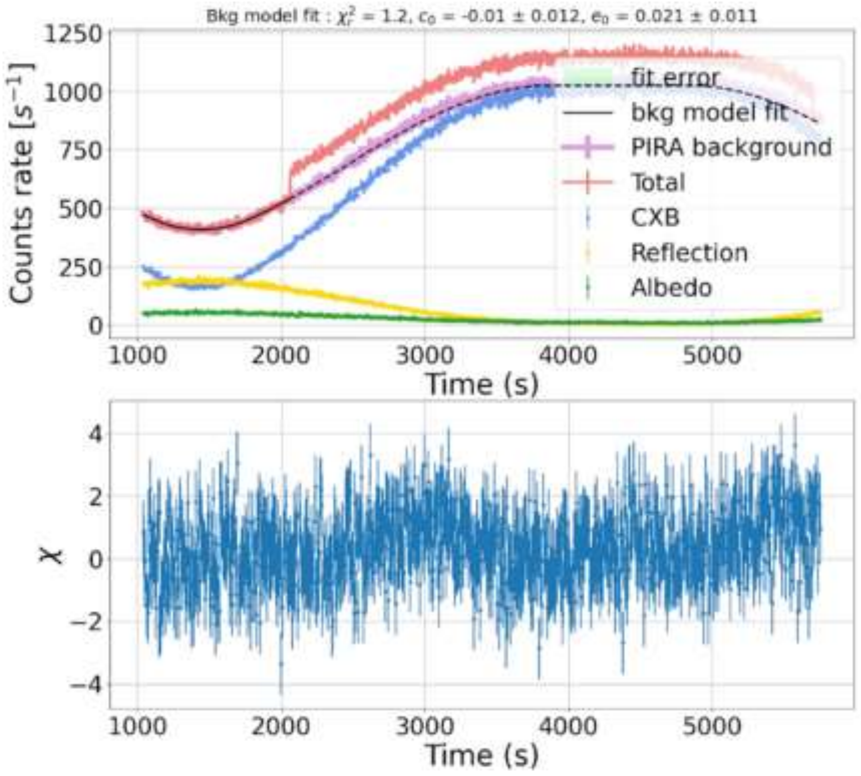
OUTLINE

In orbit Calibration Plan

GRM: Large FoV, no imaging, no collimated/focused hard to get background spectrum directly.

Some choises:

- Background Model (by Aurélia Maïolo and Frédéric Piron)
- Pulsar: with pulse on/off
- Earth before/after occulation
- Other short burst: GRB, SGR



Crab nebula: background estimation with a physical model (CXB, reflection, albedo) in GRD1 of GRM (5%-10%),

From Fred's PPT.

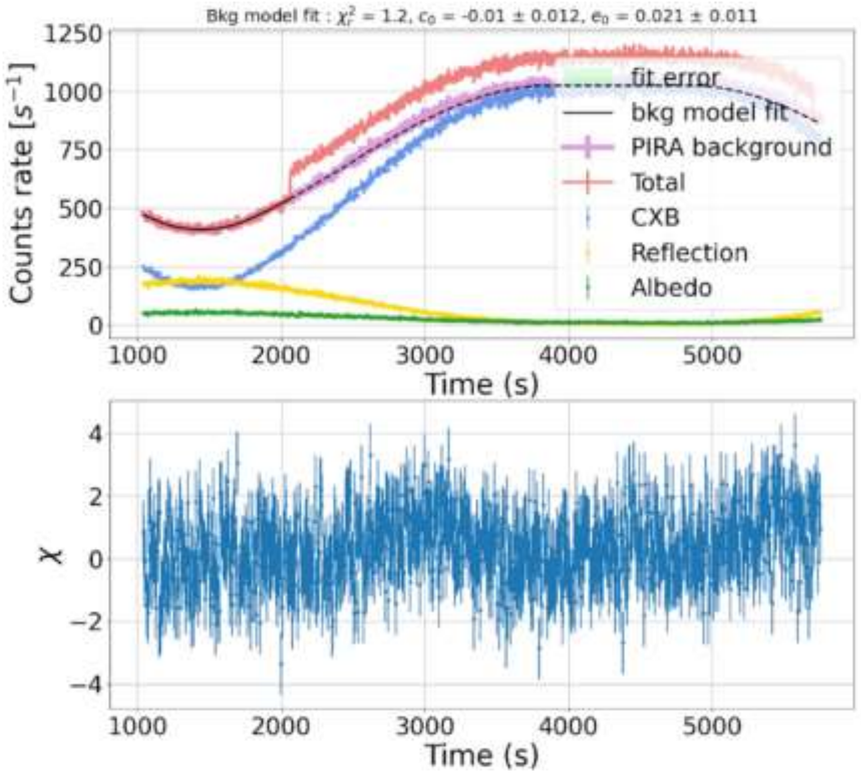
In orbit Calibration plan

Flux precision Cal:

GRM: Large FoV, no imaging, no collimated/focused hard to get background spectrum directly.

Some choises:

- Background Model (by Aurélia Maïolo and Frédéric Piron)
- Pulsar: with pulse on/off
- Earth' s occulation
- Other short burst: GRB, SGR



Crab nebula: background estimation with a physical model (CXB, reflection, albedo) in GRD1 of GRM (5%-10%), From Fred's PPT.

In orbit Calibration plan

☐ Calibration with Crab pulsar

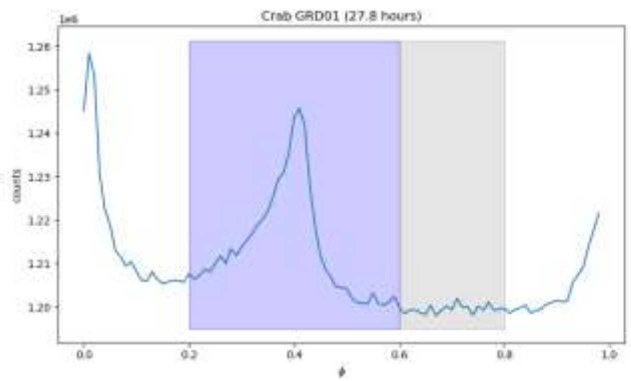
- Get the phase resolved spectral parameters (Youli, Tuo, et al 2019).
- MC simulations including Crab pulsar events and background events with GRM mass model;
- GRM product generated, background spectrum generated with the specific phase.

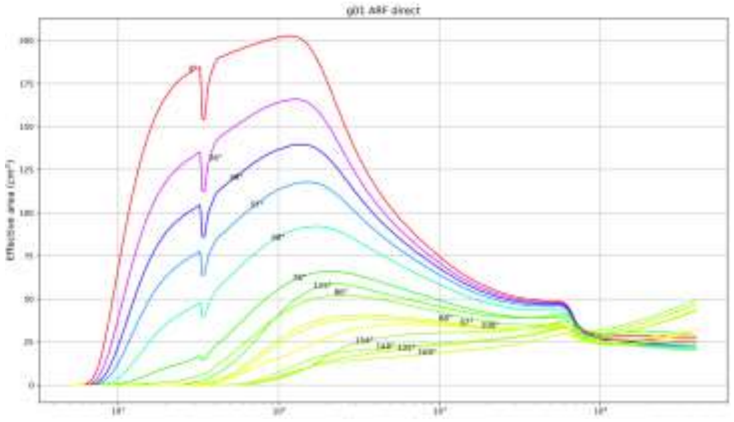
Table 3: The phase-resolved spectral analysis results of HE together with those of ME. A *powerlaw* model was used.

Pulse Phase Range	Normalization	Spectral Index	Reduced χ^2
0.0 – 0.01	$6.42^{+0.09}_{-0.09}$	$2.16^{+0.005}_{-0.005}$	1.197
0.01 – 0.02	$6.77^{+0.13}_{-0.13}$	$2.087^{+0.006}_{-0.007}$	1.139
0.02 – 0.03	$4.98^{+0.12}_{-0.12}$	$2.033^{+0.008}_{-0.009}$	1.117
0.03 – 0.04	$2.67^{+0.09}_{-0.08}$	$1.984^{+0.012}_{-0.012}$	0.976
0.04 – 0.05	$1.75^{+0.07}_{-0.07}$	$1.972^{+0.015}_{-0.014}$	1.013
0.05 – 0.06	$1.18^{+0.05}_{-0.05}$	$1.933^{+0.016}_{-0.017}$	1.003
0.06 – 0.07	$0.87^{+0.05}_{-0.04}$	$1.906^{+0.019}_{-0.018}$	1.035
0.07 – 0.08	$0.73^{+0.04}_{-0.04}$	$1.912^{+0.021}_{-0.020}$	0.990
0.08 – 0.09	$0.57^{+0.04}_{-0.03}$	$1.866^{+0.022}_{-0.023}$	0.997
0.09 – 0.1	$0.49^{+0.03}_{-0.03}$	$1.867^{+0.024}_{-0.024}$	0.992
0.1 – 0.11	$0.42^{+0.03}_{-0.03}$	$1.843^{+0.025}_{-0.024}$	1.058
0.11 – 0.12	$0.39^{+0.03}_{-0.03}$	$1.844^{+0.026}_{-0.026}$	1.047
0.12 – 0.13	$0.39^{+0.03}_{-0.03}$	$1.866^{+0.026}_{-0.026}$	0.969

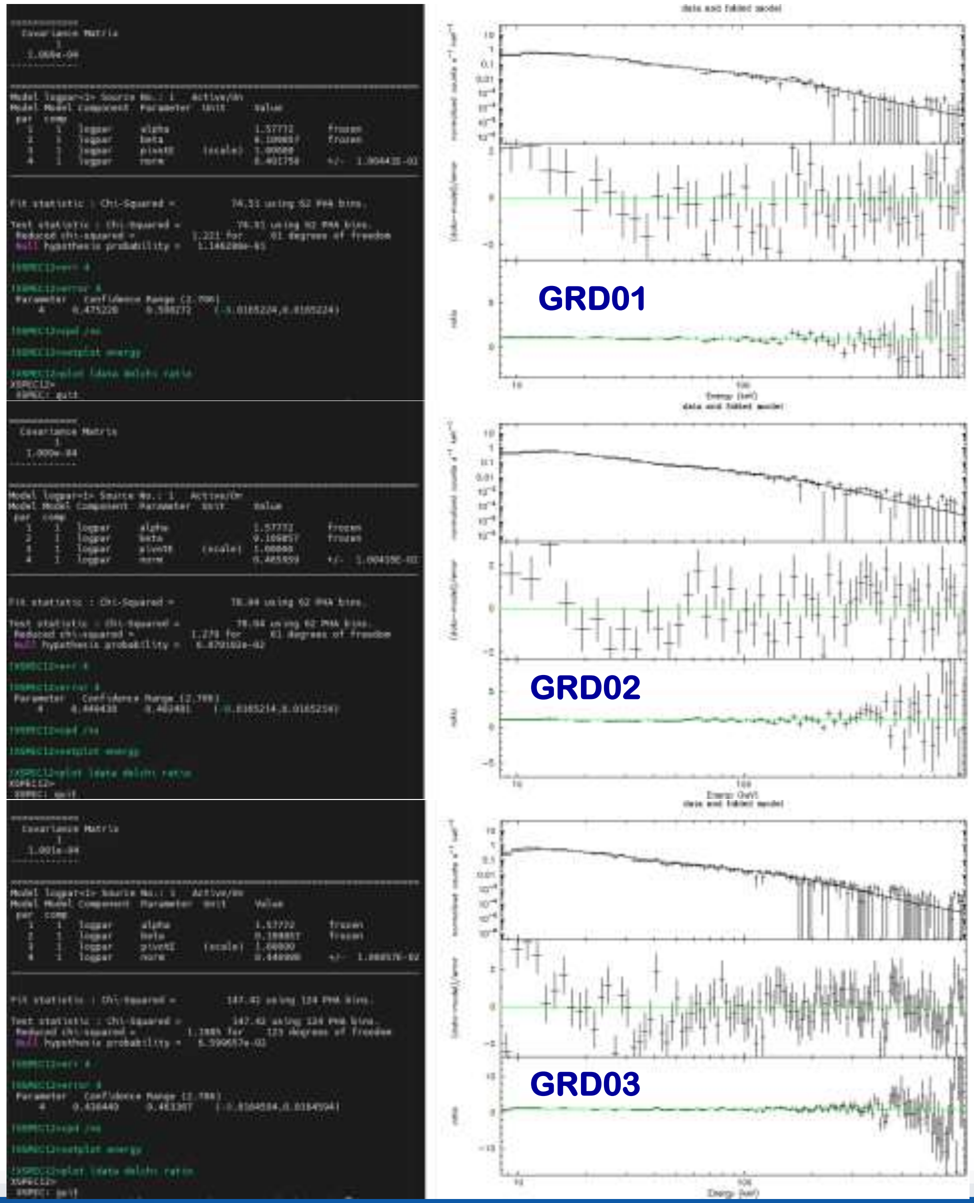
The phase resolved spectral parameters of Crab from *Insight*-HXMT/HE, ME(Youli, Tuo. et al 2019)

In orbit Calibration plan





IDX	Norm(logpar)	Confidence Range (2.706)		
GRD01	0.491750+/-1.00441E-02	0.475228	0.508272	(-0.0165224,0.0165224)
GRD02	0.465959+/-1.00435E-02	0.449438	0.482481	(-0.0165214,0.0165214)
GRD03	0.446908+/-1.00057E-02	0.430449	0.463367	(-0.0164594,0.0164594)



Notice,

1) Background is considered,

2) Crab Nebula is not yet considered

3) Albedo effected not yet considered

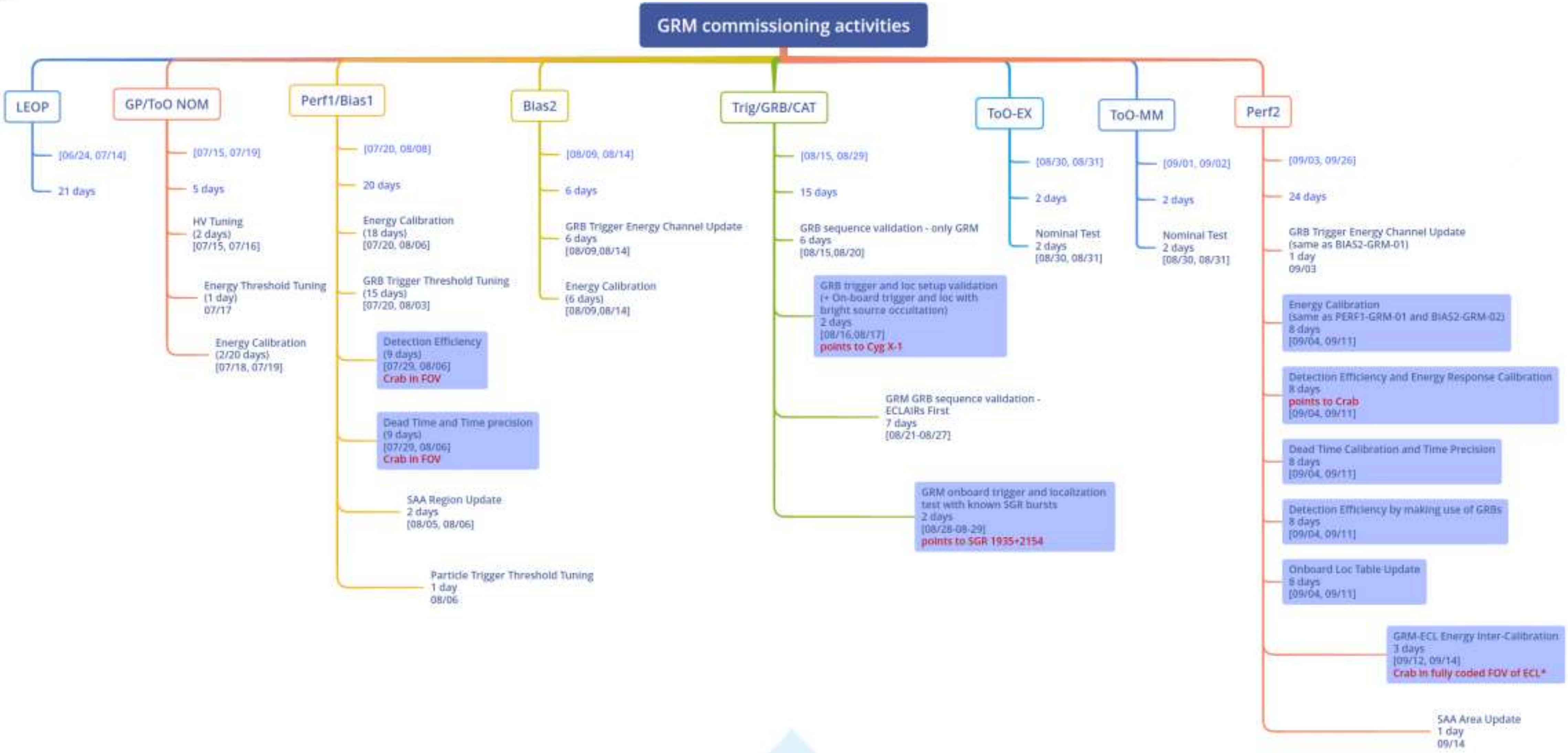
4) The Crab pulsar is offset by an angle of θ = 30° from the axis.

In orbit Calibration plan

Crab not observable before Fall 2024 → use Sco-X1, Cyg-X1 (high state) during commissioning

– Relative ECLAIRs / GRM calibration, possibly simultaneous observations by Swift or Integral

Simulation and Ground Calibration



Summary

- SVOM to be launched soon, calibration plan developed.
- The Crab pulsar (and nebular)will be used to absolute calibration (more work needed: specific nebular/pulsar spectrum)
- Relative calibration is through joint observation of Cyg X-1 and/or Sco X-1 (maybe simultaneous observations by Swift or Integral and ???)

Comments and suggestions are welcomed,

Thanks!