

GIFTS

Gamma-ray Investigation of the Full Transient Sky

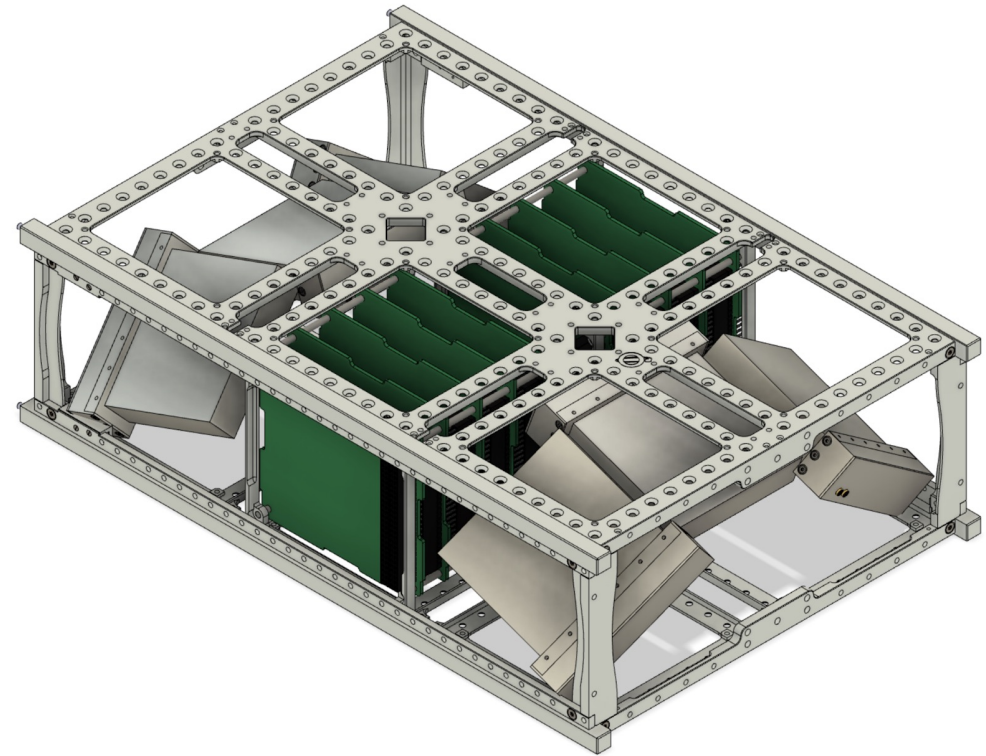
Cuán de Barra, Derek O'Callaghan, Alexey Ulyanov, Pádraig Mac Dermott, Sheila McBreen

Fermi Summer School – June 2024



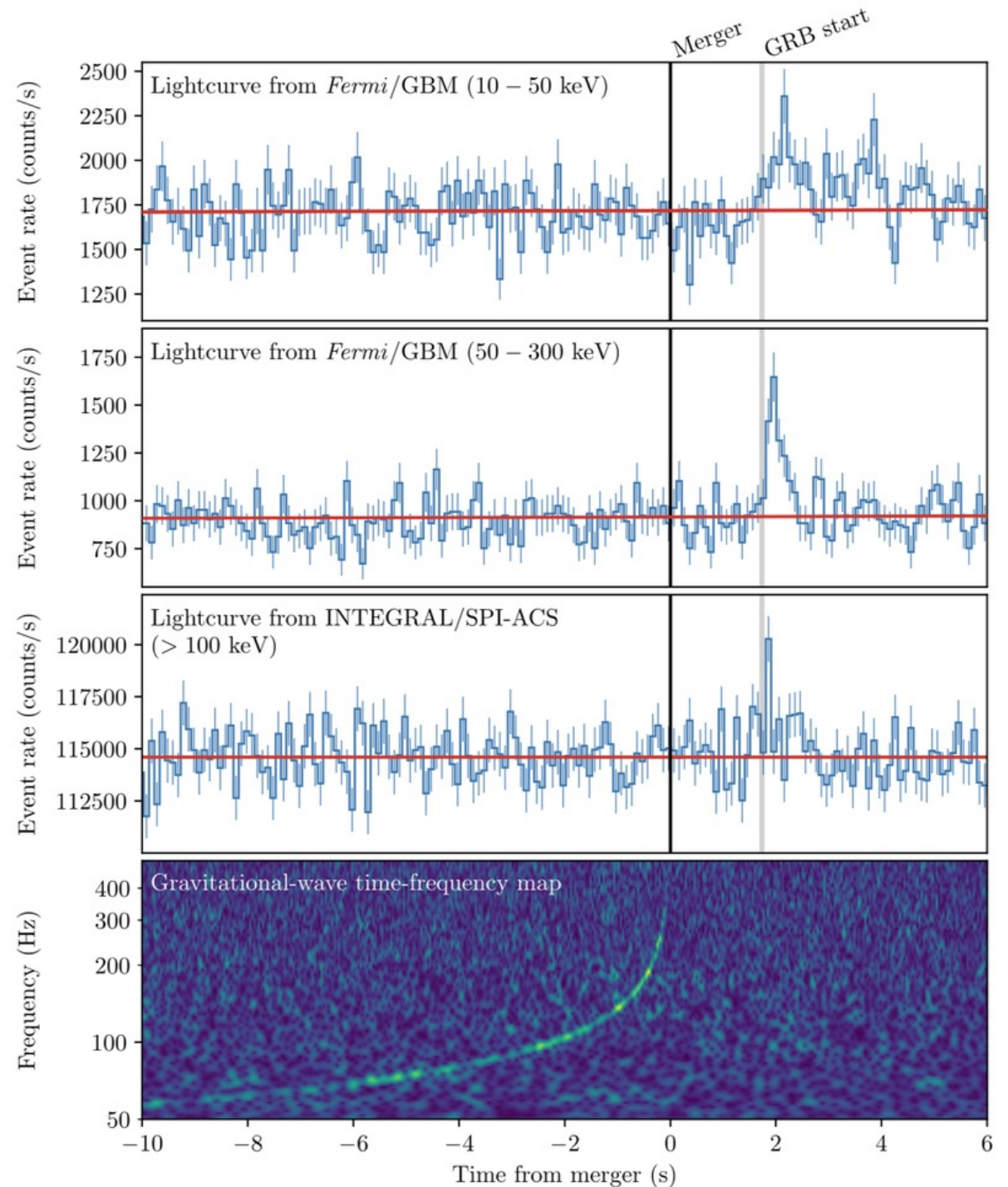
Mission Overview

- A 6U CubeSat mission designed to observe and localize transient gamma-ray events from low Earth orbit.
- Detector heritage has been developed in-house and on the *EIRSAT-1* CubeSat.
- *GIFTS* takes inspiration from a number of other missions:
 - NASA's CubeSat mission *BurstCube*
 - *Fermi* GBM
- *GIFTS* will detect ~70 GRBs per year,
 - 11 short GRBs
 - ~0.5 to 2 GRBs coincident with GW events



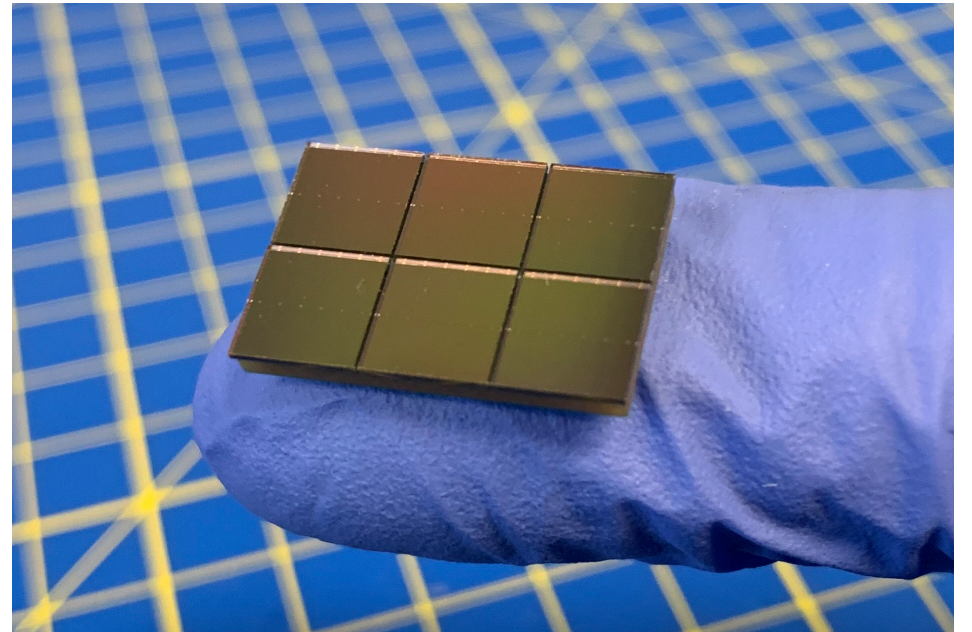
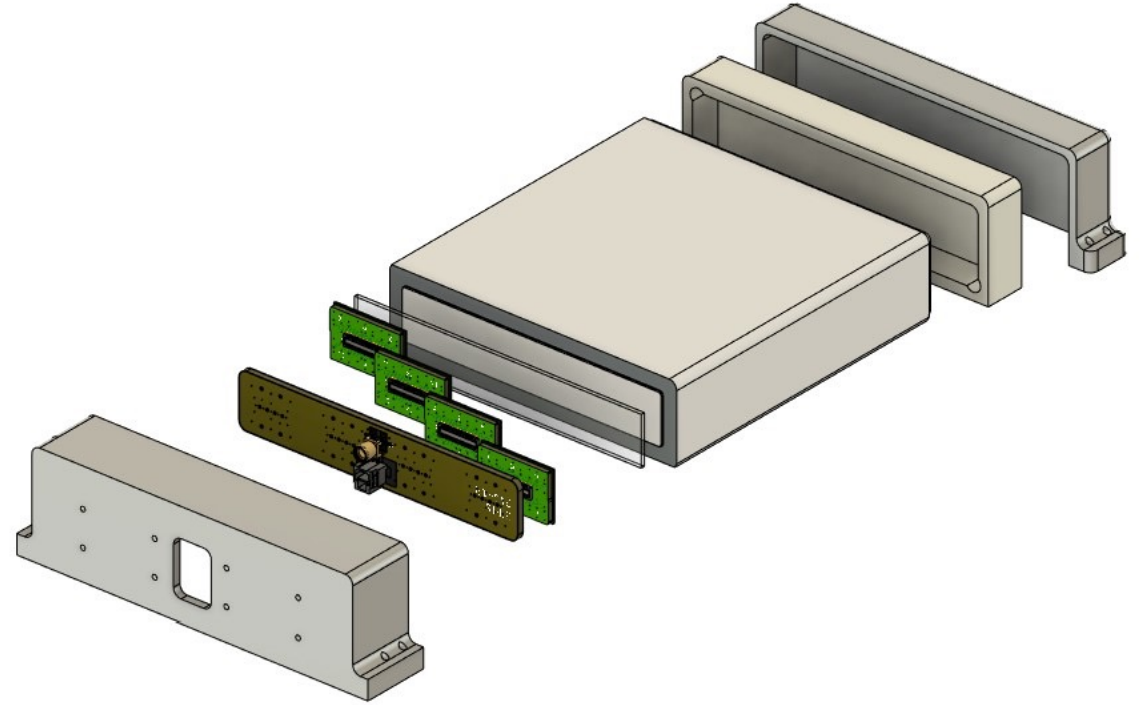
Science Motivation

- GRB 170817A/ GW170817
- What is the future for telescopes in this energy range?
- Small satellites with comparable effective areas can increase sky coverage
- Examples include...
 - *BurstCube*
 - *GRBA*Alpha
 - *HERMES*
 - *EIRSAT-1*



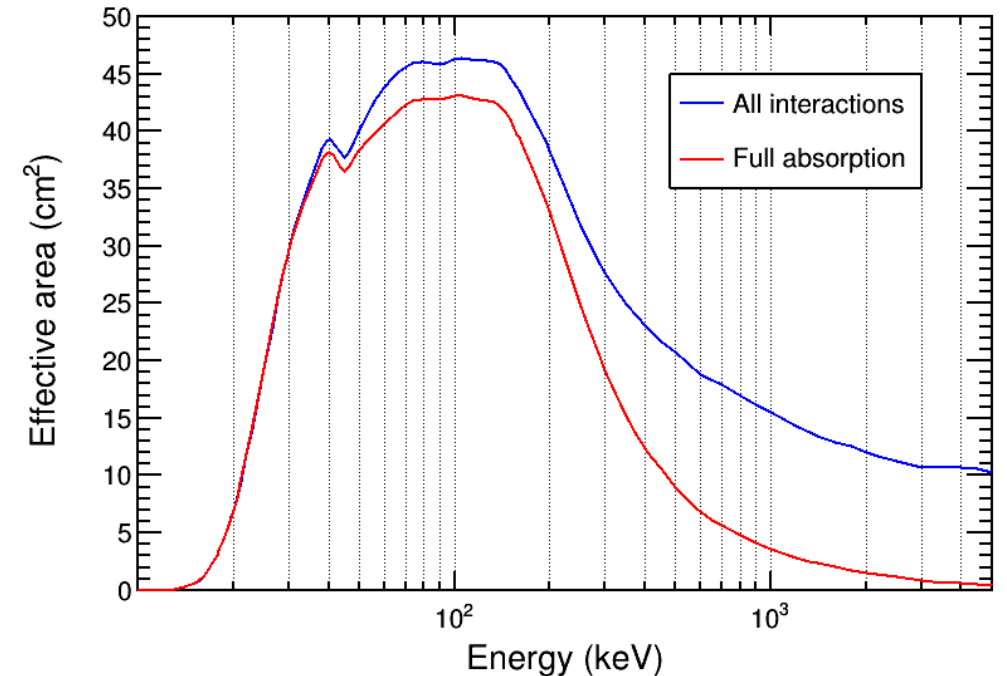
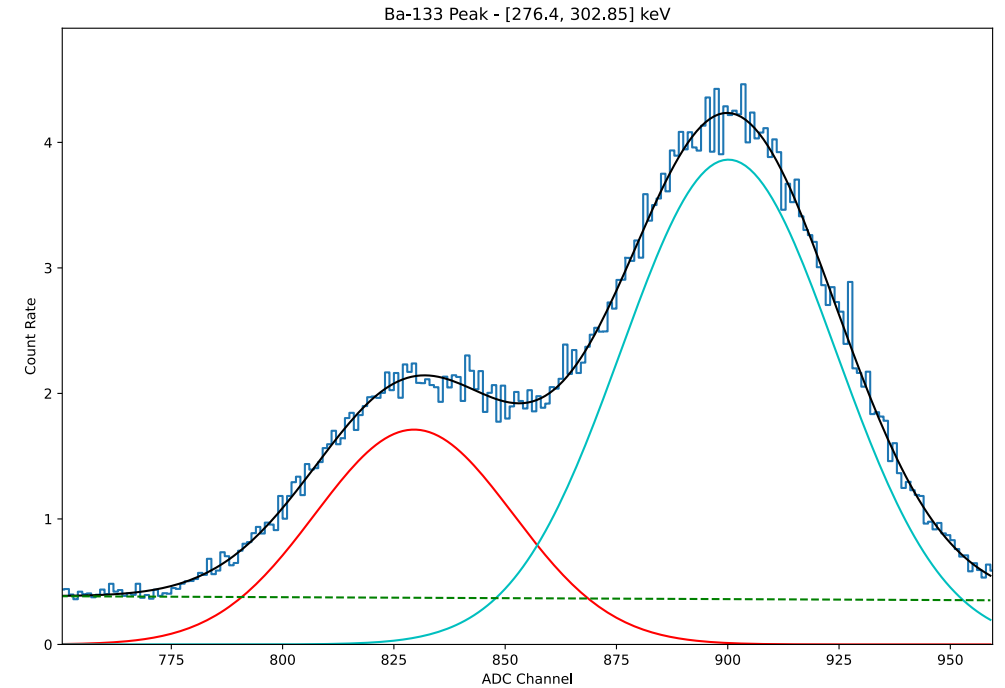
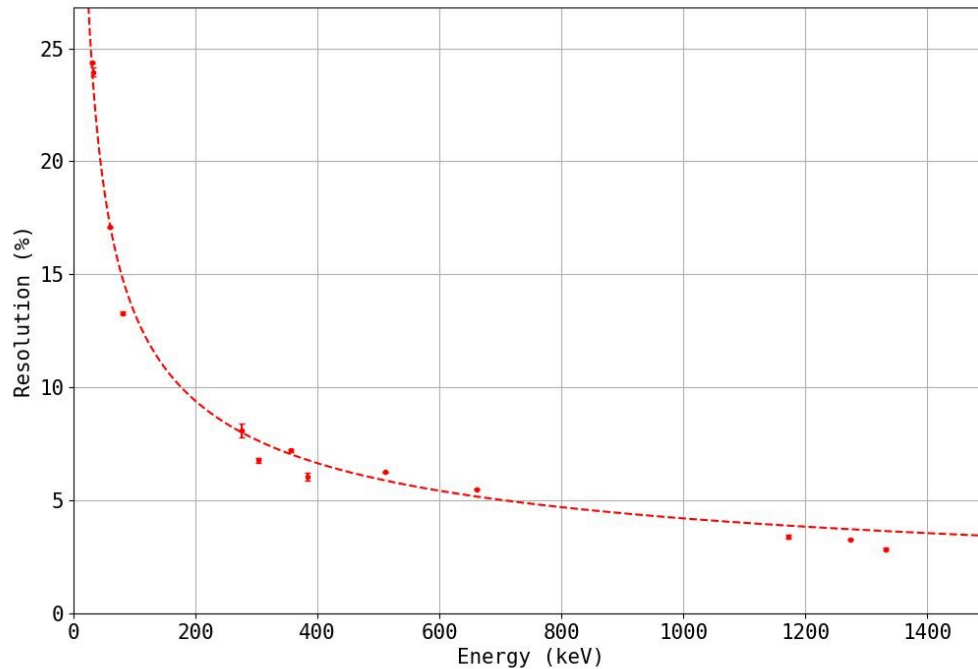
Detector Payload

- 6 novel scintillator detectors, suitable for the 50 keV – 300 keV GRB energy range.
- Each detector consists of
 - A monolithic Scionix CeBr₃ scintillator crystal housed in an aluminum casing.
 - Silicon optical interface pad
 - OnSemi J-Series SiPM array
 - Readout PCB
 - IDEAS SIPHRA ASIC (x2)



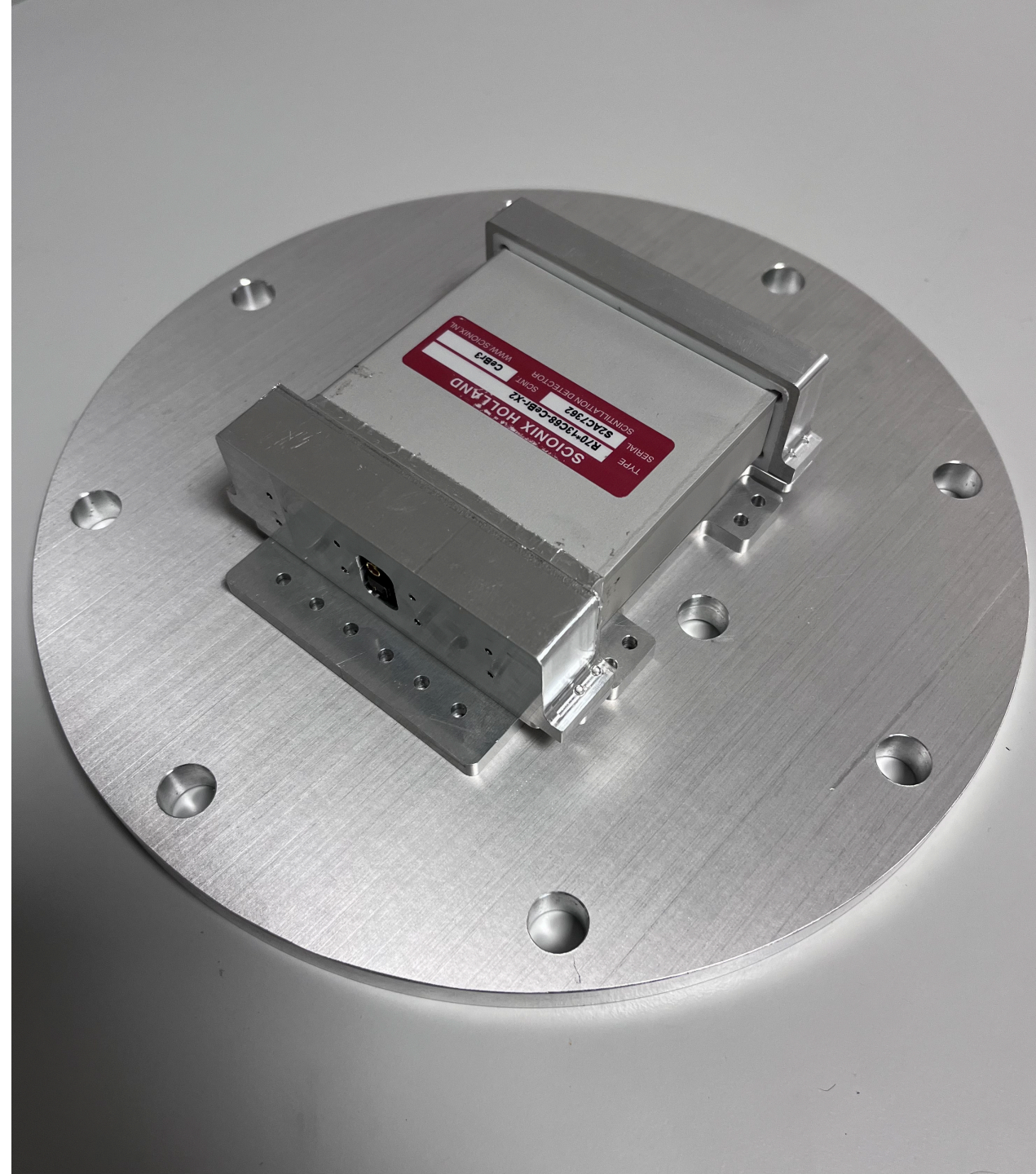
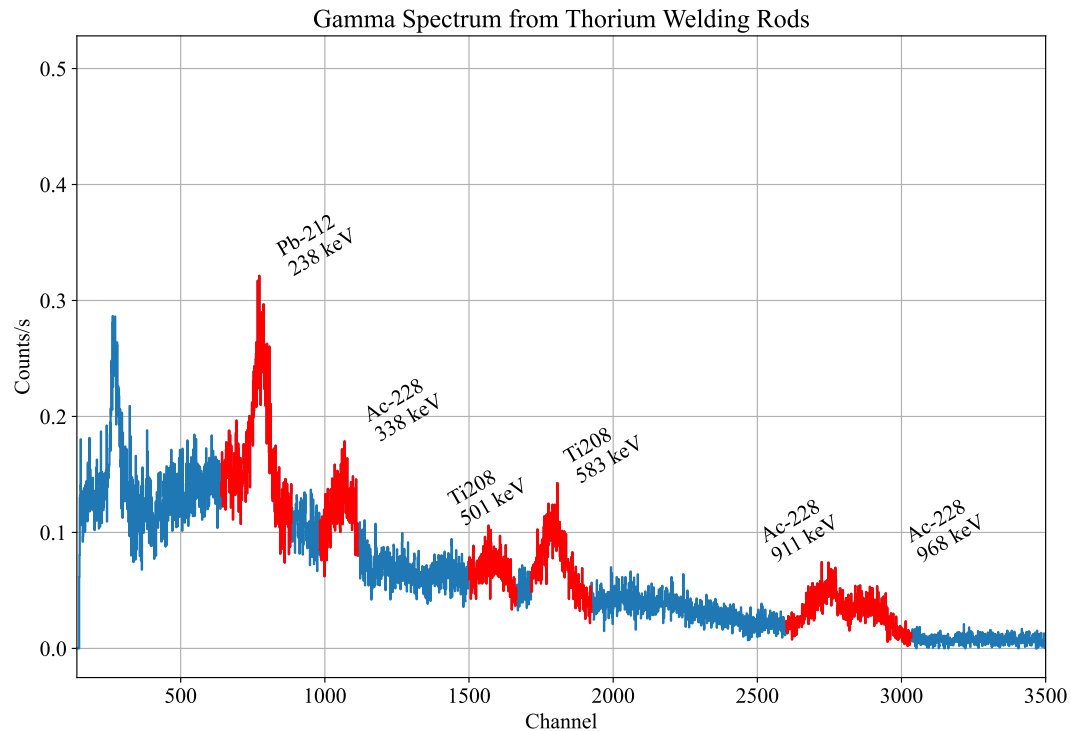
Scintillator Performance

- CeBr_3 has benefits for use in detector
 - High light yield (68 photons/keV)
 - Fast decay time (~ 20 ns)
 - Low intrinsic background
 - *GIFTS* Spectral resolution (5.5% @ 662 keV)



Detector Prototype

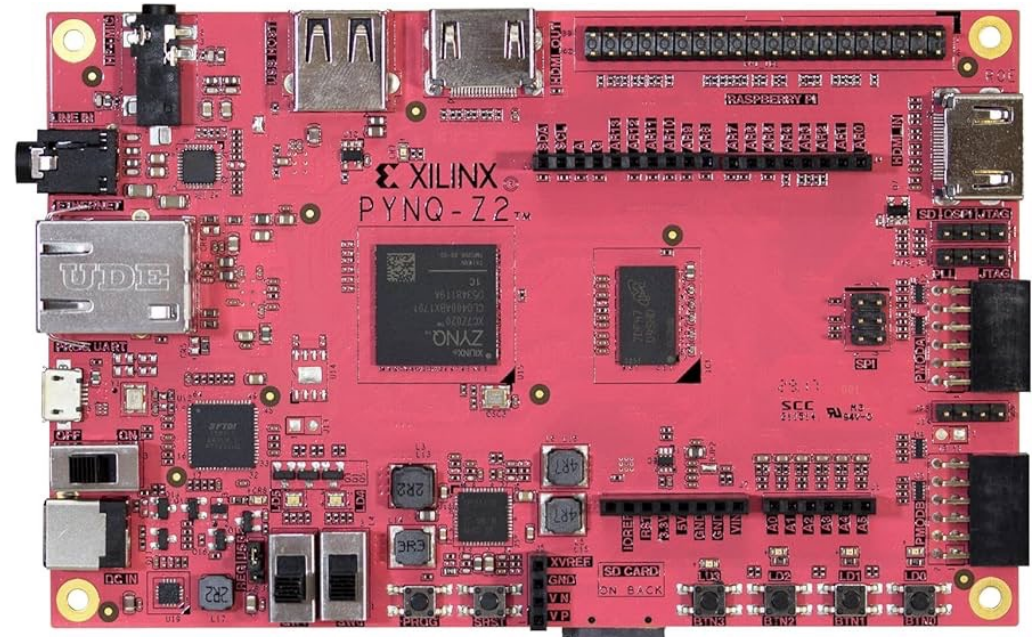
- Hot off the press!
- Developed for feasibility thermal and vibration testing
 - June 2024



On-Board Processing

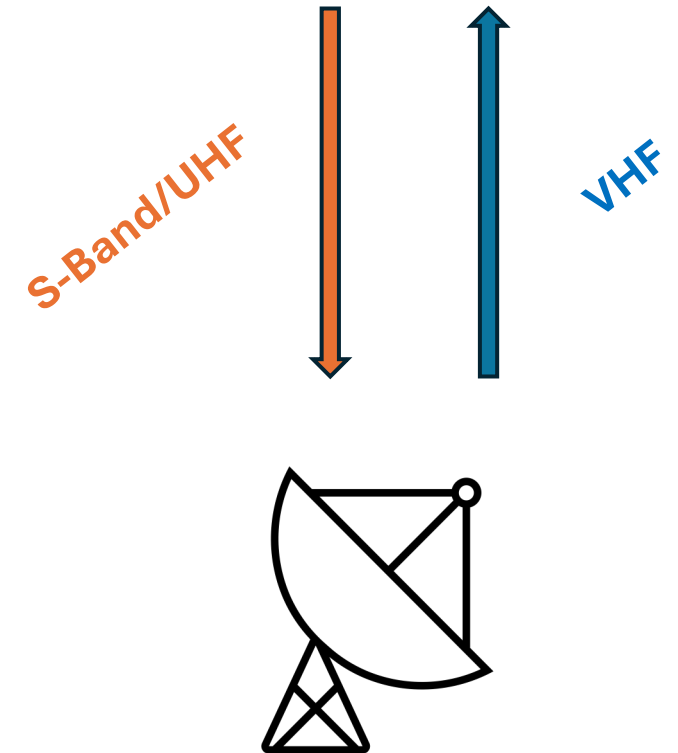
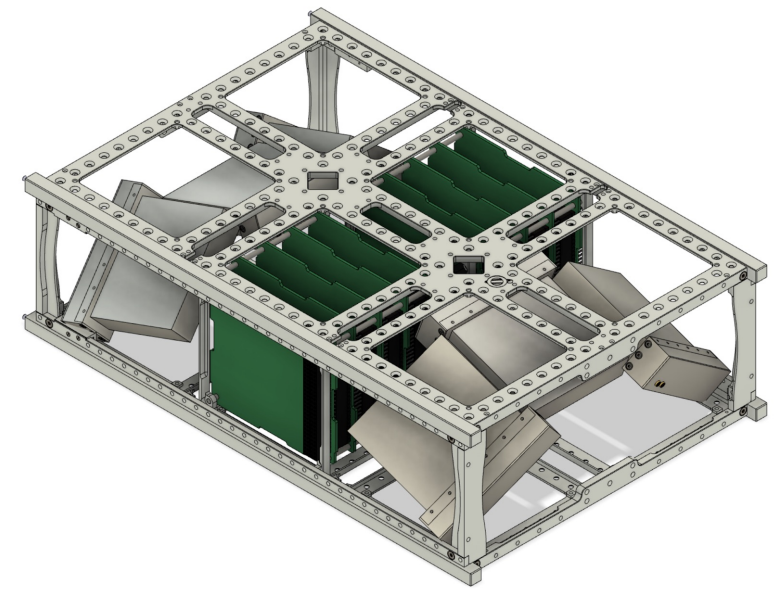
System on a Chip will perform all onboard processing

- **FPGA:**
 - Acquire SIPHRA ASIC data
 - Generate TTEs
 - Triggering
- **Processor:**
 - Source localization
 - Payload configuration/control
- Send trigger notification with localization. TTEs later.
- Currently using PYNQ-Z2 board (donated by AMD Ireland)
 - Zynq-7000 SoC XC7Z020-1CLG400C
 - TTE generation, Triggering IP blocks created with Vitis HLS
 - PYNQ overlay bitstream created with Vivado
- Corresponding board with space heritage will ultimately be used



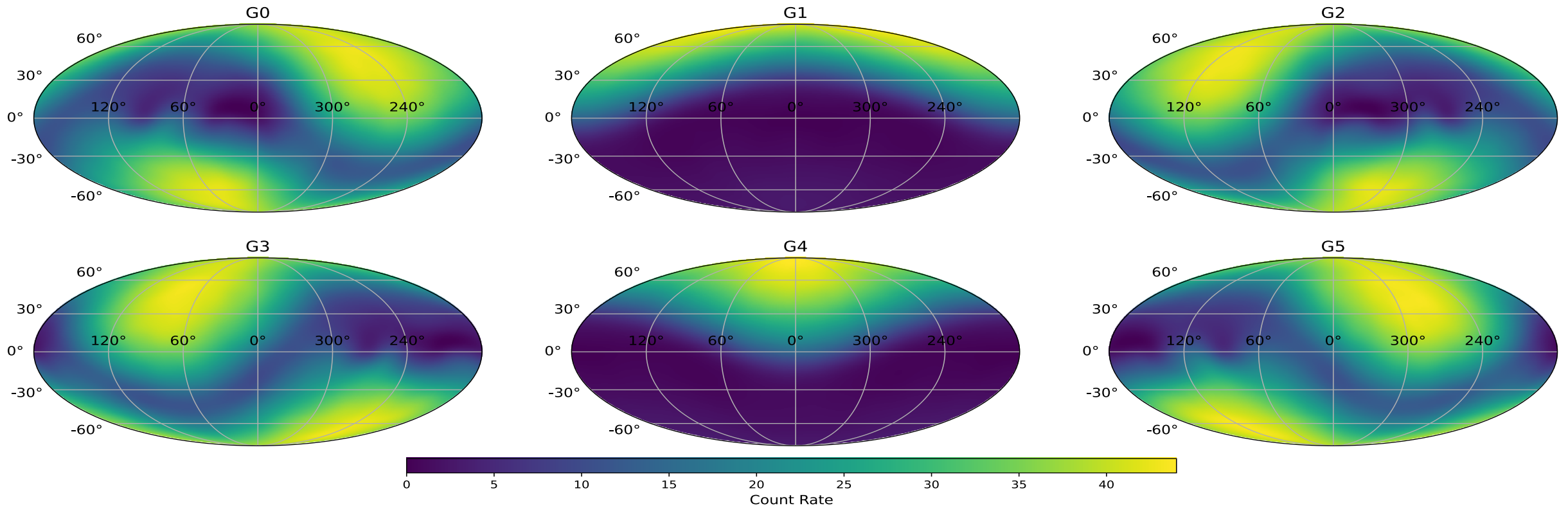
Ground Based Processing

- Downlink/persist onboard data:
 - TTEs
 - Initial triggers and localizations
 - Housekeeping data etc.
 - Refined ground-based triggering and localization.
- Public GIFTS data products will be created and distributed in a new catalog.
- Focus has been on data processing.
 - Payload Control of SIPHRAs,
 - SoC processing will be implemented in Q3/4 2024.



Localization with GIFTS

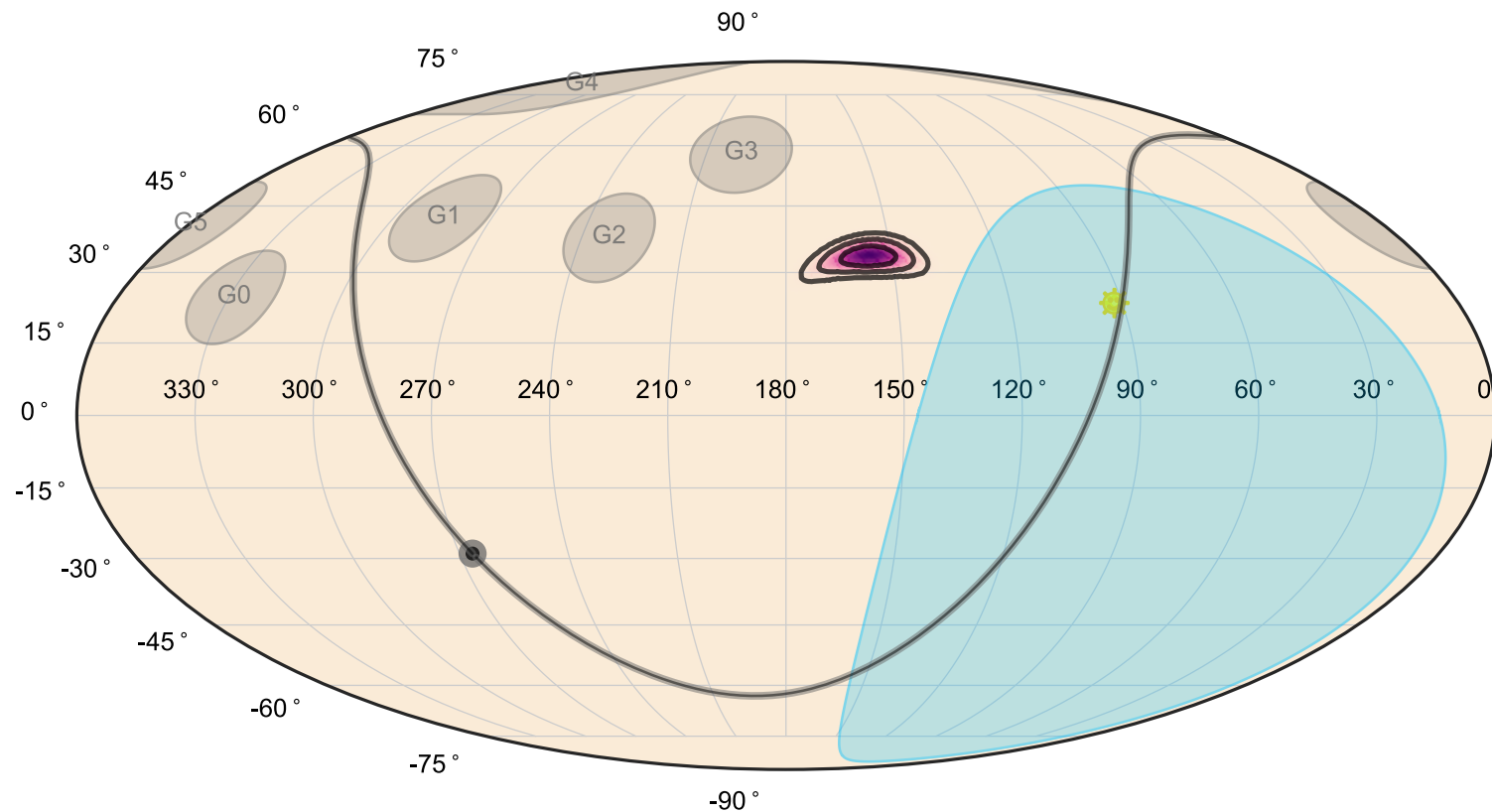
- GIFTS will perform localization via χ^2 minimization similar to GBM.
- An initial low resolution onboard localization; subsequently refined on the ground.



GIFTS Gamma Ray Data Tools


- Example localization skymap generated using `gdt-gifts`

- Builds on `gdt-core` and `gdt-fermi`:
 - Used for ground-based processing
 - Applicable to public GIFTS catalog



GDT-GIFTS

- Repo and Website to be provided.



GIFTS Gamma-ray Data Tools 0.1.0 documentation »

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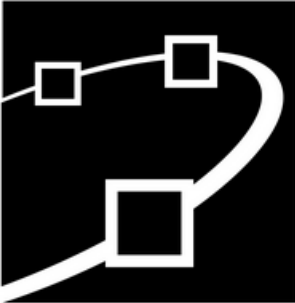
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GIFTS Gamma-ray Data Tools Documentation



GIFTS

Gamma-ray Investigation of the Full Transient Sky

The GIFTS Gamma-ray Data Tools (GDT) is a toolkit for GIFTS data products, which is built on the [GDT Core Package](#) and [Fermi Gamma-ray Data Tools](#).

Gamma-ray Investigation of the Full Transient Sky (GIFTS) is a 6U CubeSat under development. The aim of the mission is to detect gamma-ray bursts from low Earth orbit in the multi-messenger era. GIFTS will comprise six scintillating detectors mounted at different angles within the spacecraft. The light created in the scintillators will be measured by SIPM arrays which are read out by the [IDEAS SIPHRA integrated circuit](#). GIFTS will trigger on rate increases and localise gamma-ray bursts on-board using the relative rates in the detectors. GIFTS will measure the gamma-ray properties of these events, and deliver locations to observers in order to facilitate the search for confident GW events. Currently the toolkit services synthetic GIFTS data products generated during development, where future versions will support a public GIFTS data catalog.

Thanks for Listening!

- Questions?

