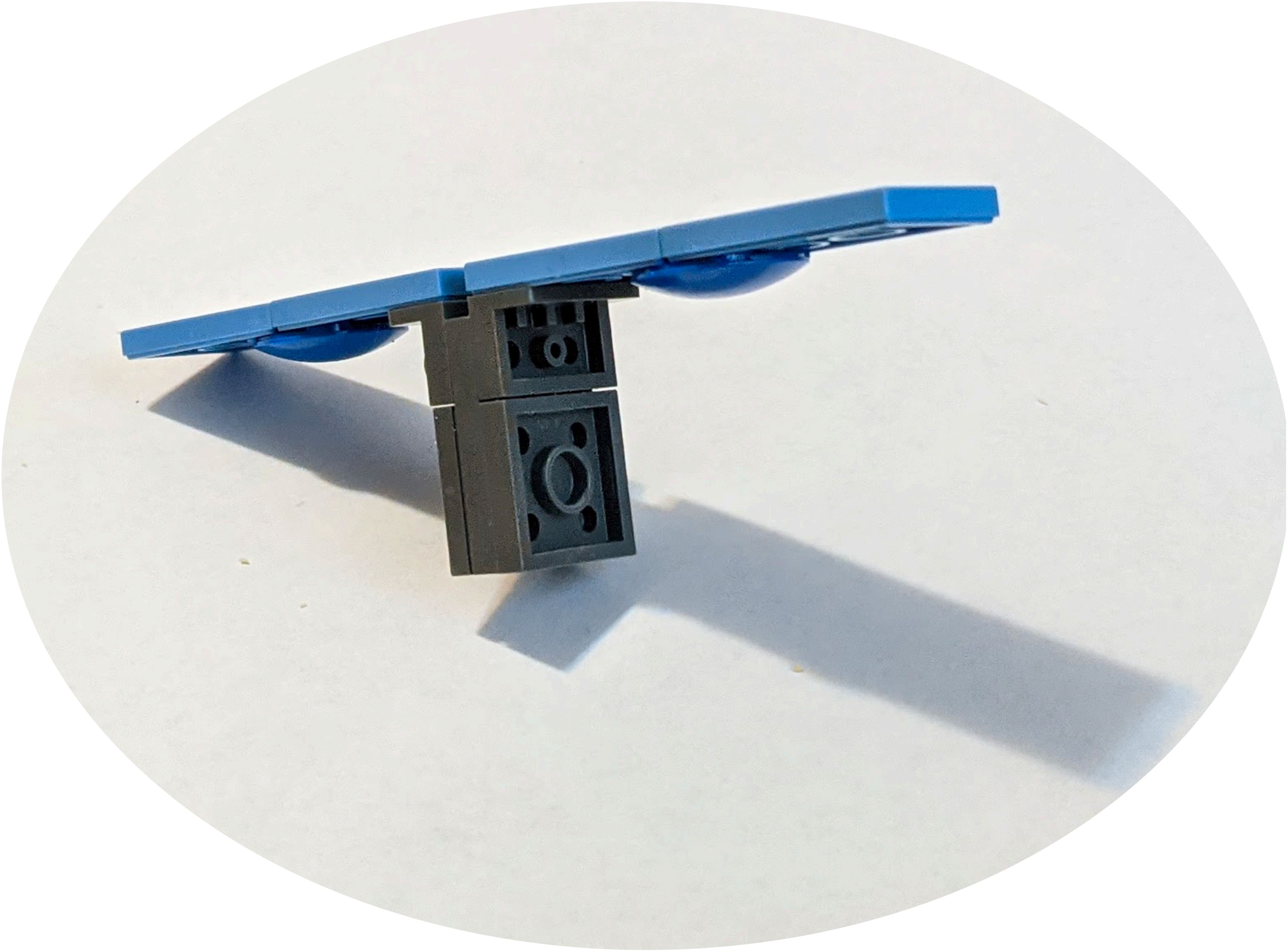
BurstCube:
status and public alerts



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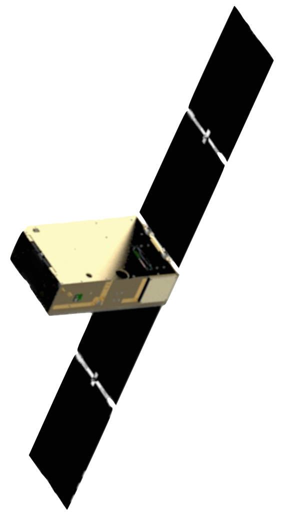
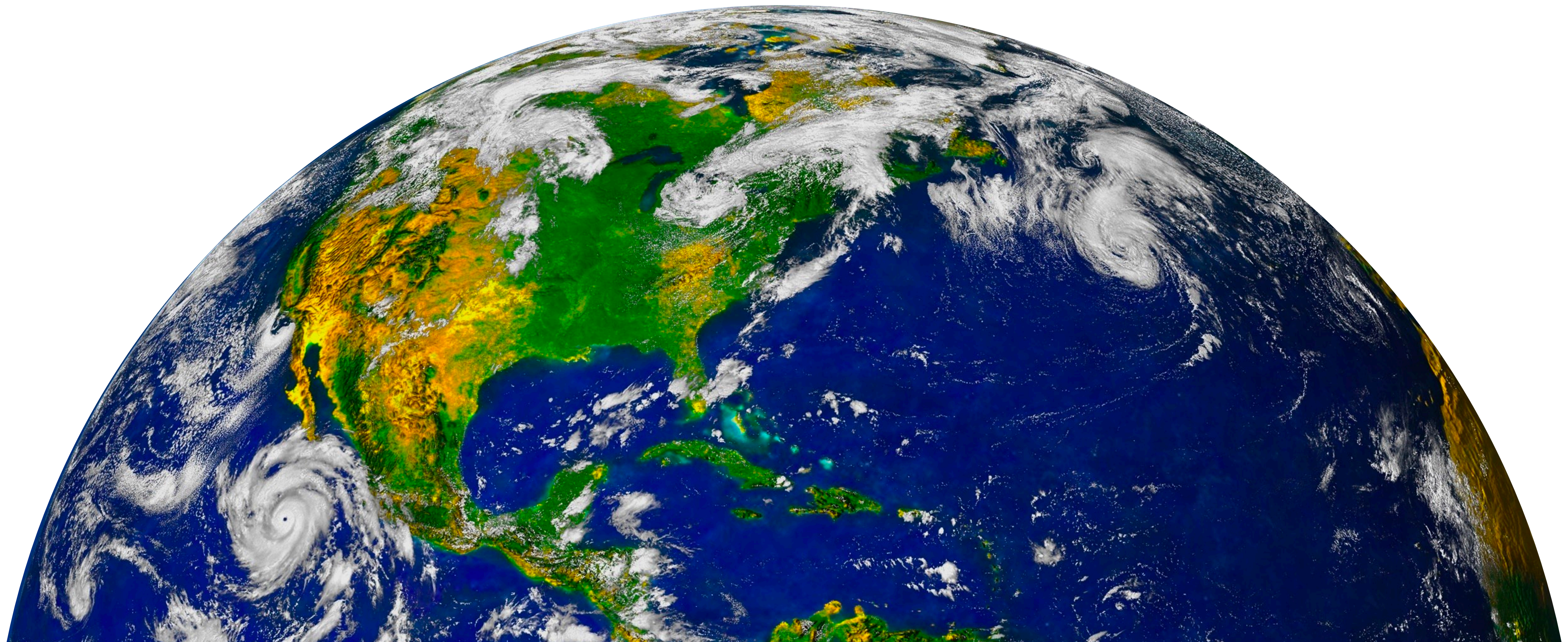
For the BurstCube Team
July 20, 2021 - ICRC

The case for CubeSat GRB detectors

- We need increased sky coverage to improve the number of joint Gamma-Ray Bursts and Gravitational Waves detections
    - Current space-based GRB detectors have a ~70% coverage
- Technology developments have made small GRB detector possible
    - Low volume, mass and power are critical for a CubeSat
- CubeSats are more accesible than traditional satellites
- Multiple CubeSat GRB detectors can join forces:
    - Joint analysis to improve sensitivity and localization

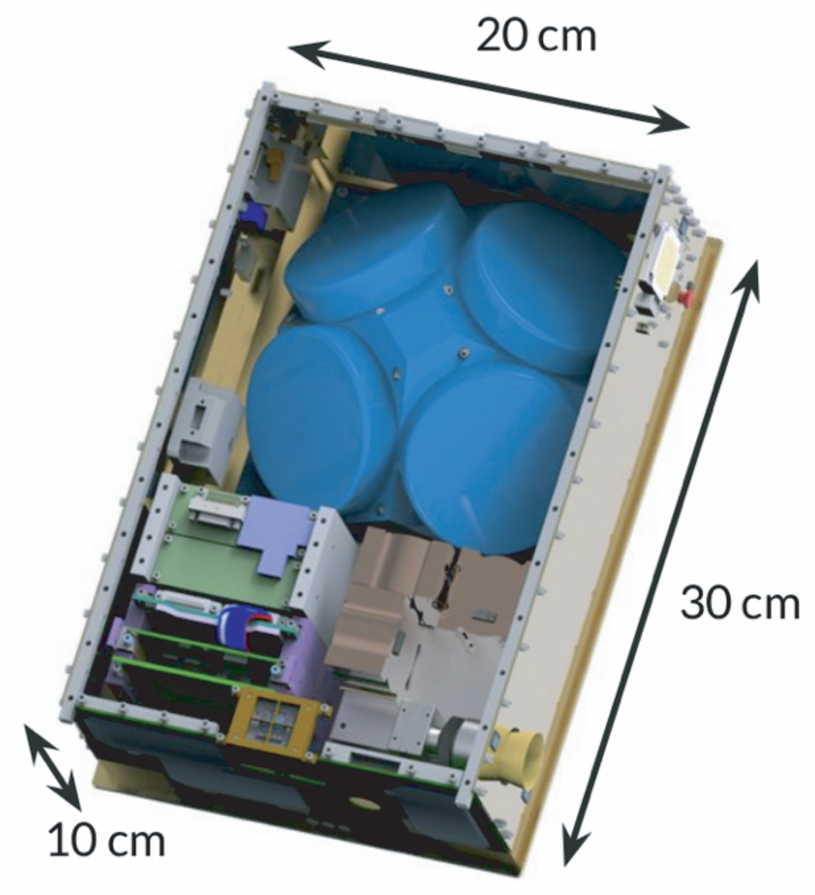




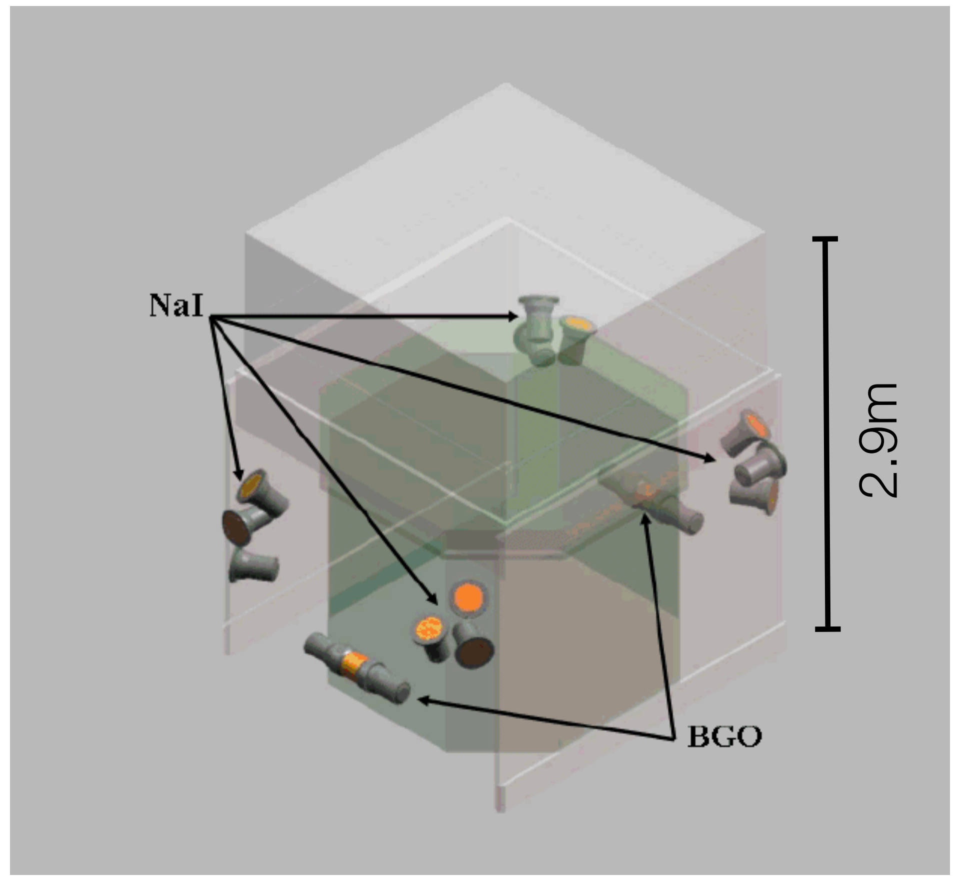
Enter the BurstCube

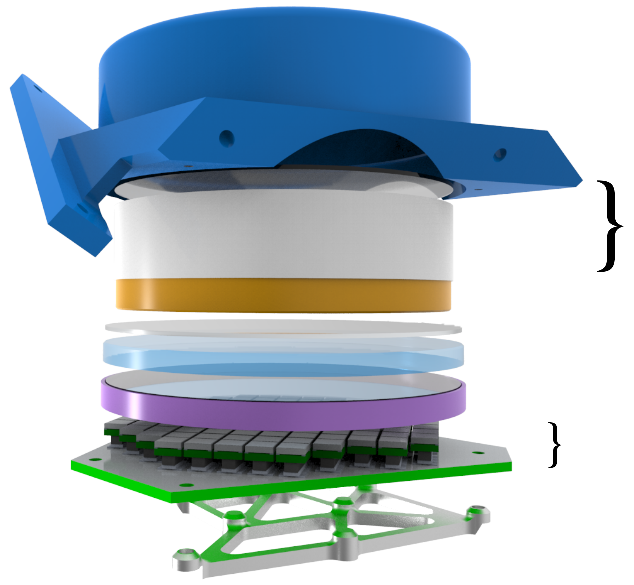
- Small (6U) gamma-ray detector with a wide-field-of-view
- Expected to launch in late 2022
- Sensitive from a few tens of keV to a few MeV
- Will increase the **sky coverage**, hoping to catch an event with a GW counterpart:
  - 1+ year mission
  - Overlapping with LIGO/Virgo/Kagra observation run O4
- Same principle as Fermi-GBM
- Pathfinder for the use of Silicon Photo-Multipliers (**SiPMs**) for this application
  - Light and compact design

BurstCube



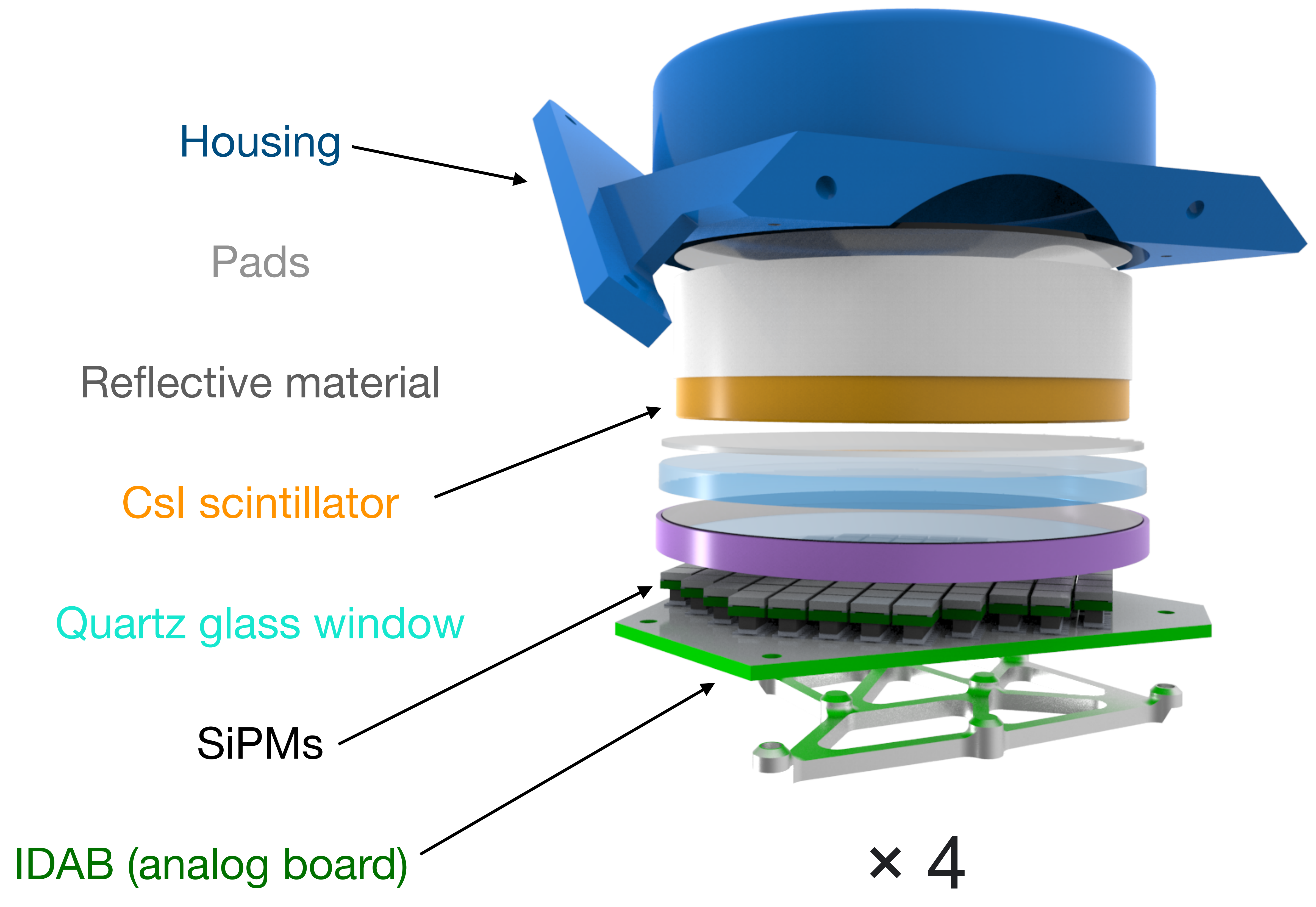
GBM

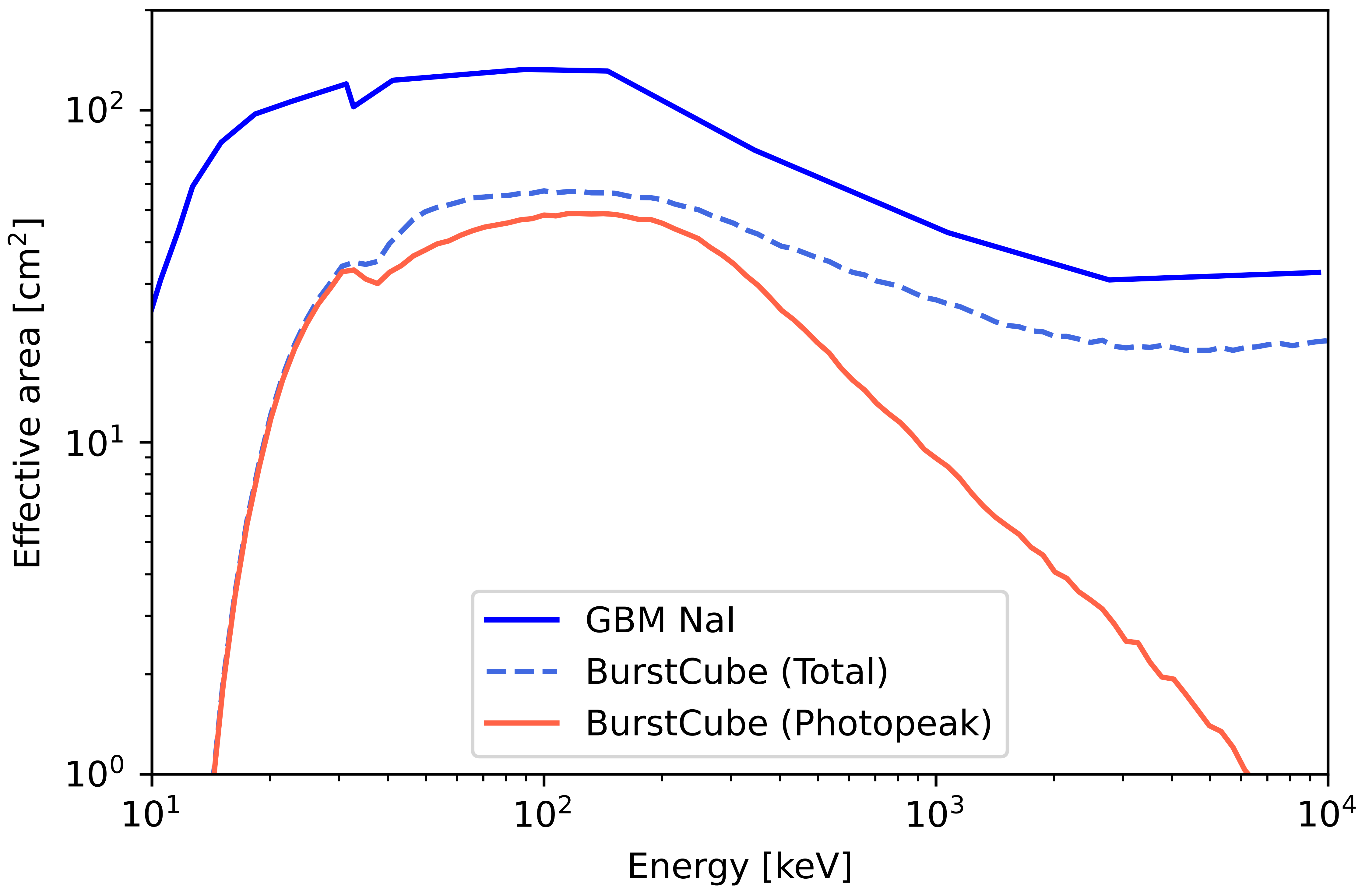




Single detectors 🍔

- A Cesium Iodide (CsI(Tl)) scintillator (90mm in diameter) acts as the target material
- Readout by a Silicon Photomultiplier array mounted on a custom board





The software side: bc-tools

- bc-tools is BurstCube's main software package
  - Written in Python and open source
  - Detector agnostic
- Tasks:
  - Detector response generation
  - Localization
  - Burst duration estimation
  - Data binning and light curve generation
  - Background estimation
  - Spectral fitting
  - Source injection

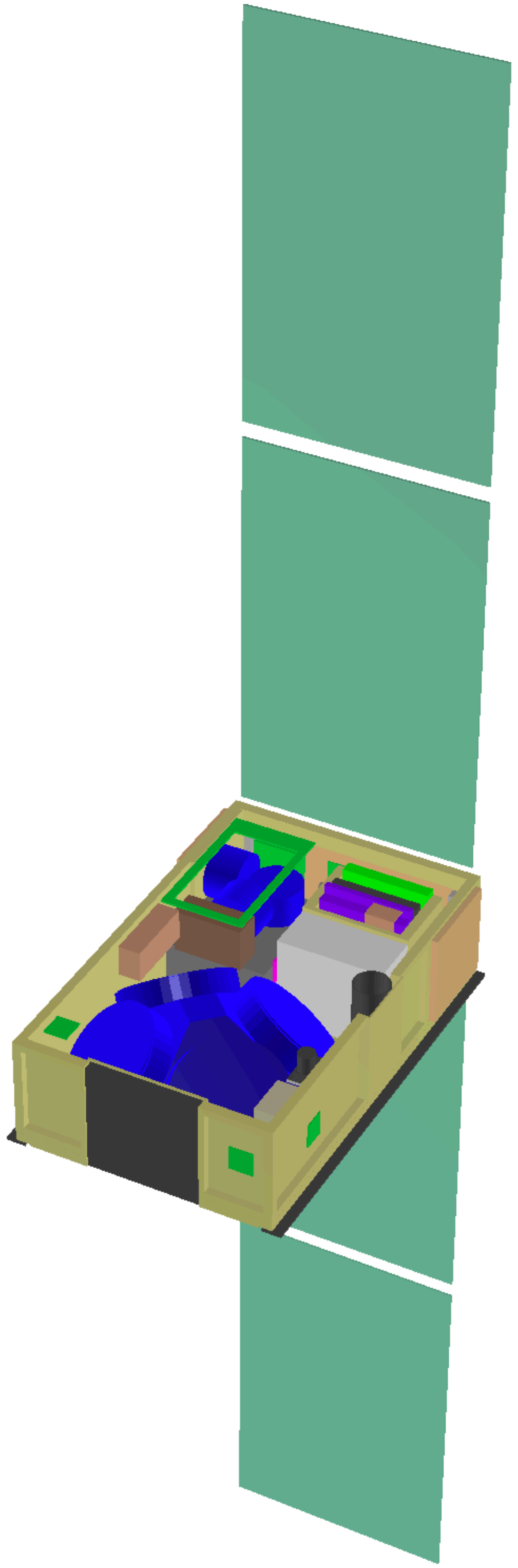
```
import gbm
```

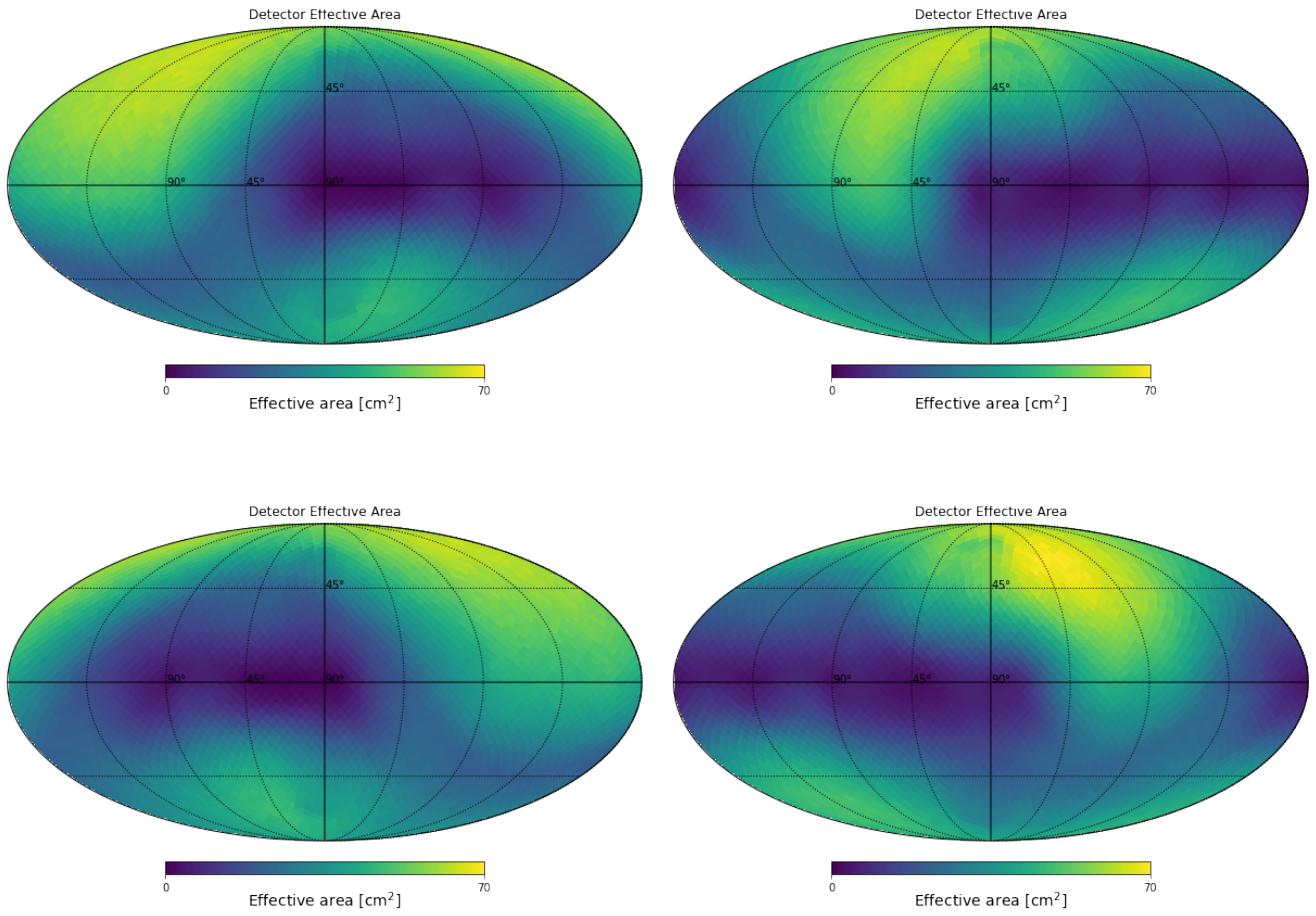
- Built around gbm-data-tools
  - Avoids duplicated code
  - Backwards compatible with GBM data

Simulations

- Particle-by-particle Monte Carlo simulation (using MEGAlib)
- A collection of response matrices encode:
  - Effective area
  - Photon energy to measured energy dispersion
  - Acceptance vs. incoming direction

} + Data = Localization, Spectral analysis

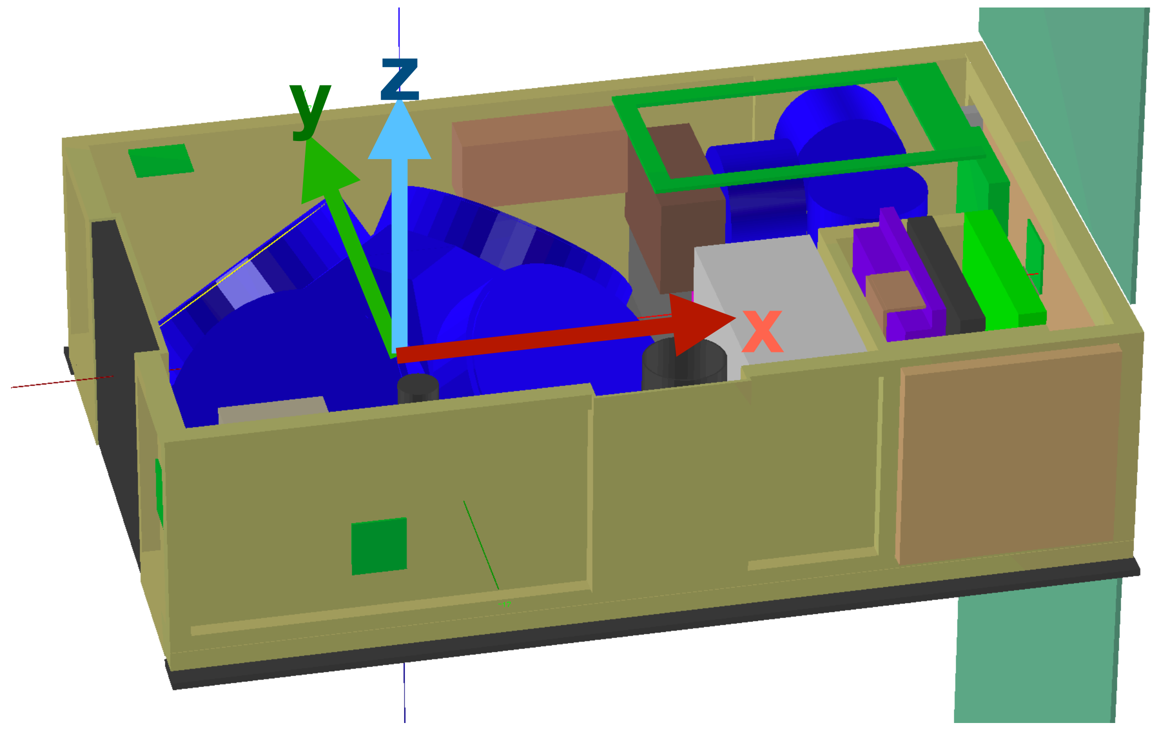


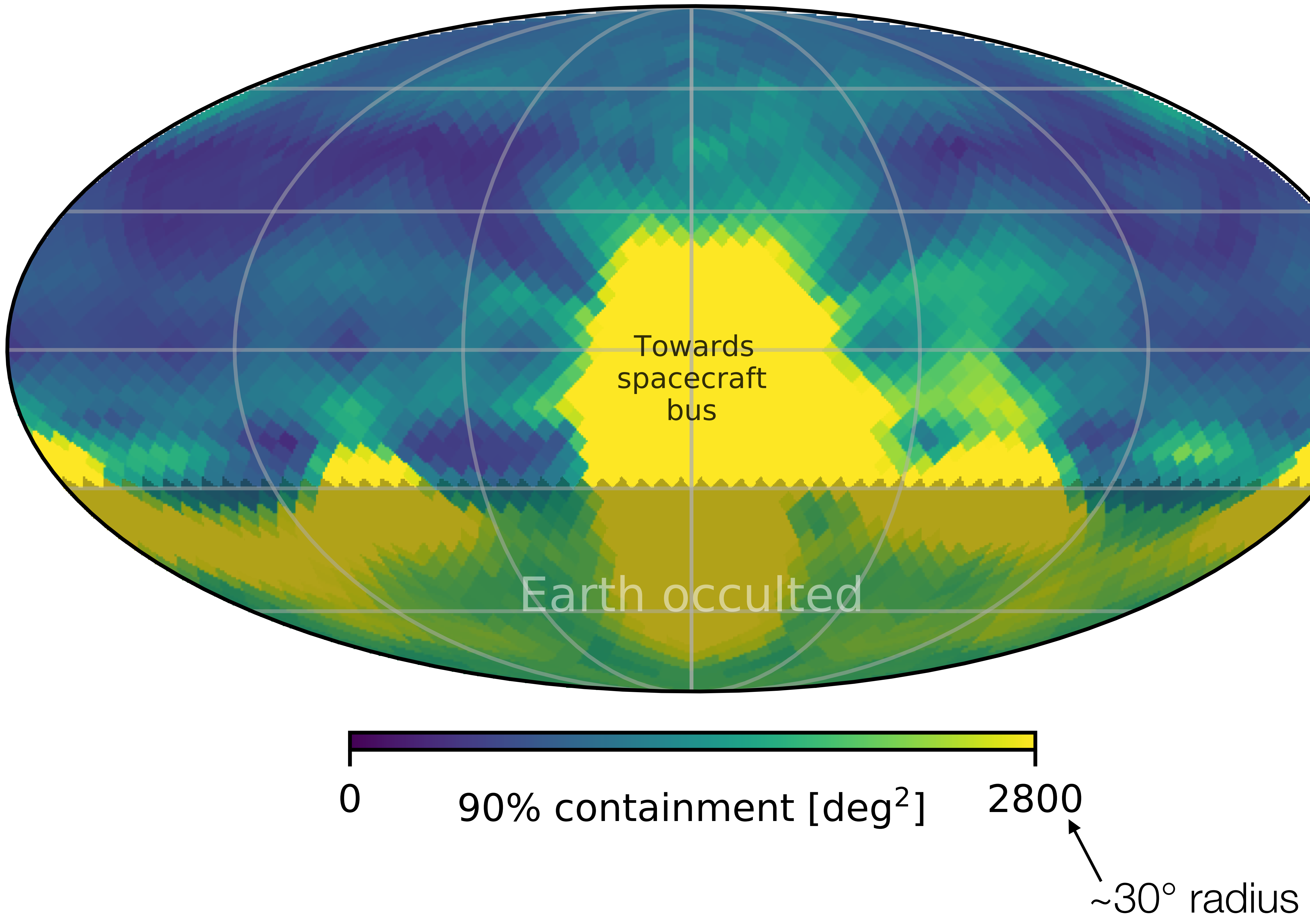


Effective area vs. incoming direction

Localization

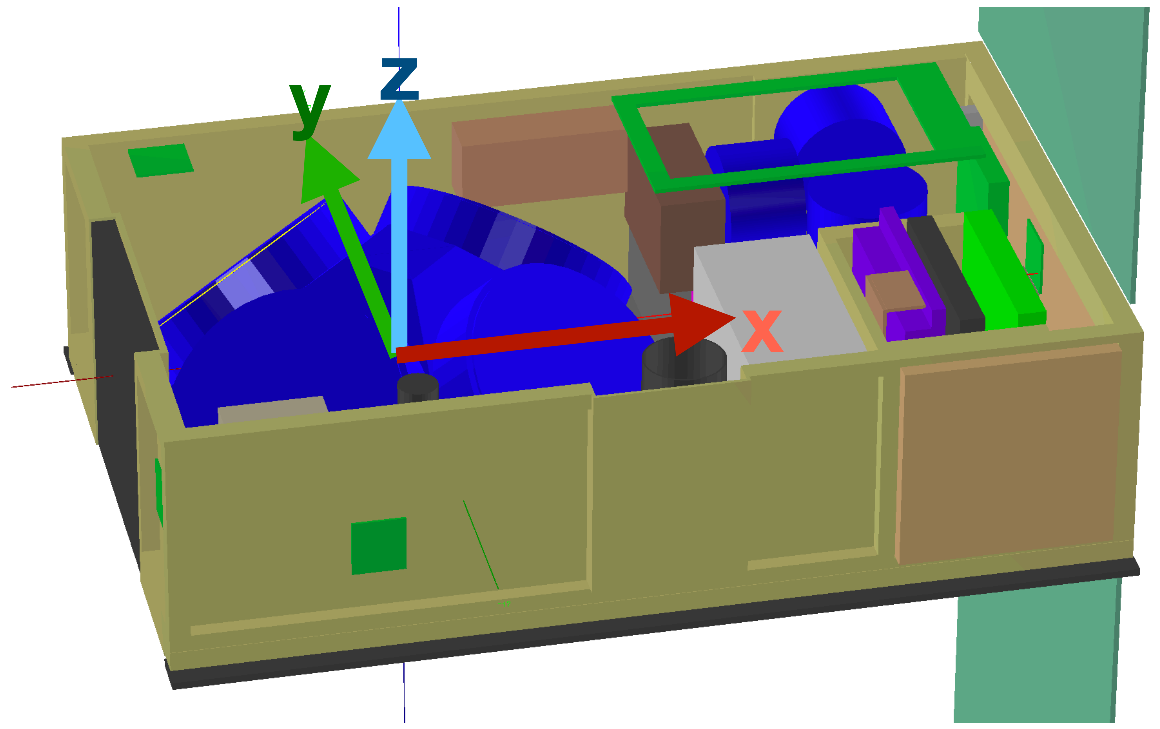
- Maximum likelihood analysis using the full detector response
- Events are typically localized within a radius <30° (fiducial source with a flux of 10 ph cm^{-2} s^{-1})

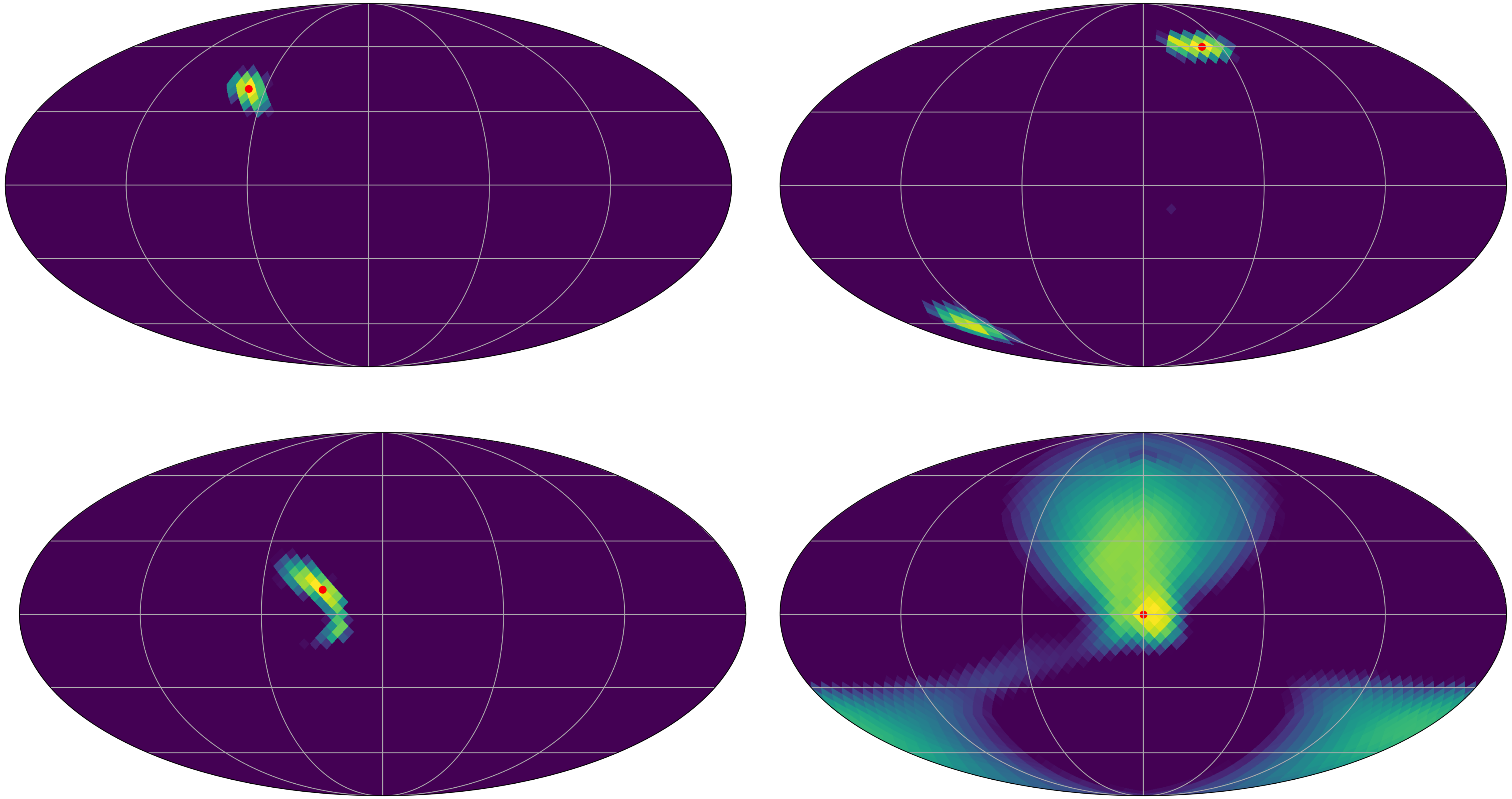




Localization

- The localization is not always well-described by an circle or ellipse
- Sky maps will be provided in the alerts.

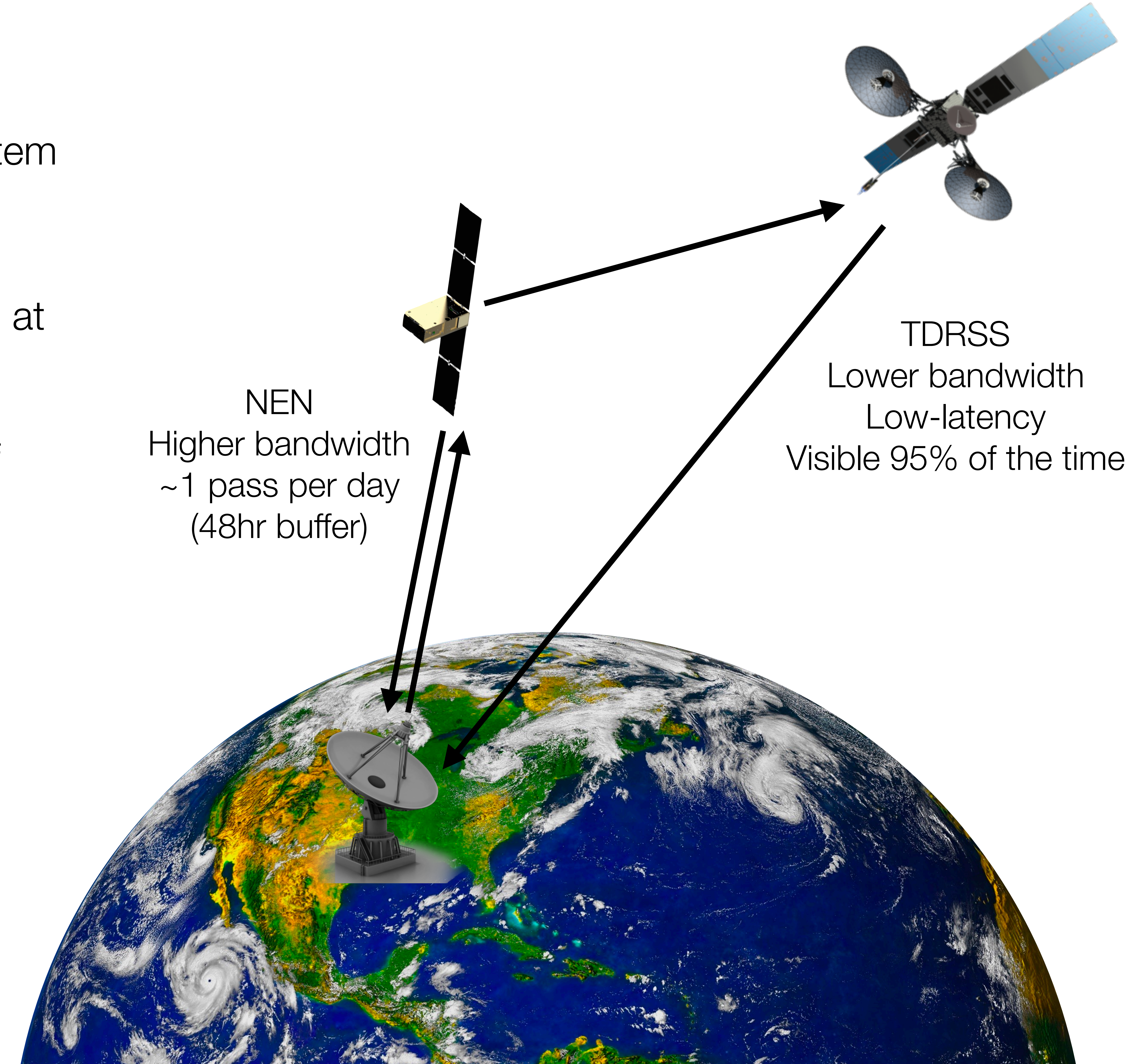




Examples of mock maps

Alerts: what to expect

- ~20 short GRBs detected per year
- Rapid alerts will be public, including localization
- Low-latency distribution thanks to the TDRSS system
  - Most within 1min (~10 min delay possible)
- Time-Tagged Events (TTE) data will be transmitted at a later time through NEN
- TTE data will only be downlinked around events of interest:
  - Self triggers
  - External GRB triggers
  - GW events
  - Other requests by the community

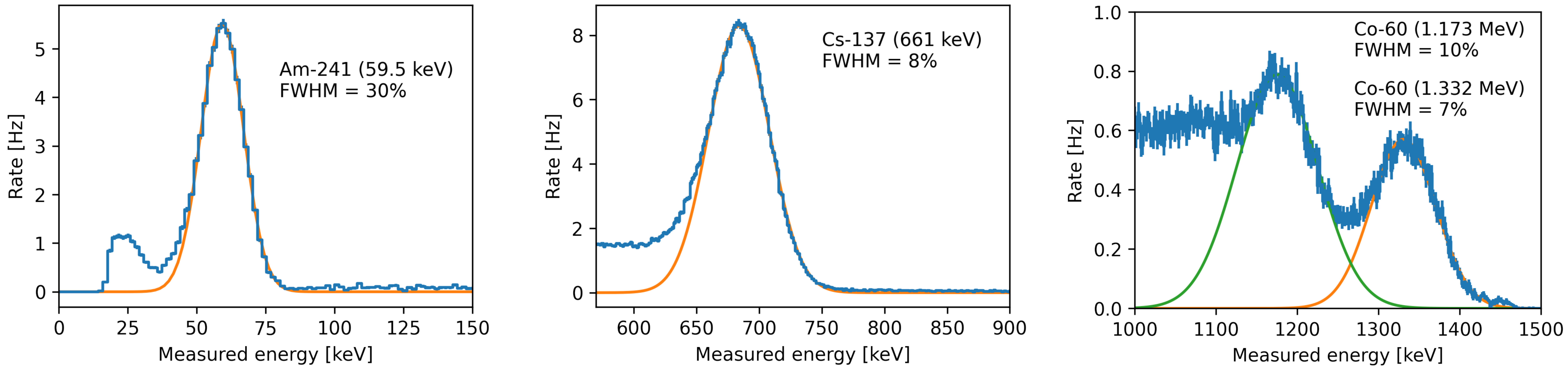


Conclusions

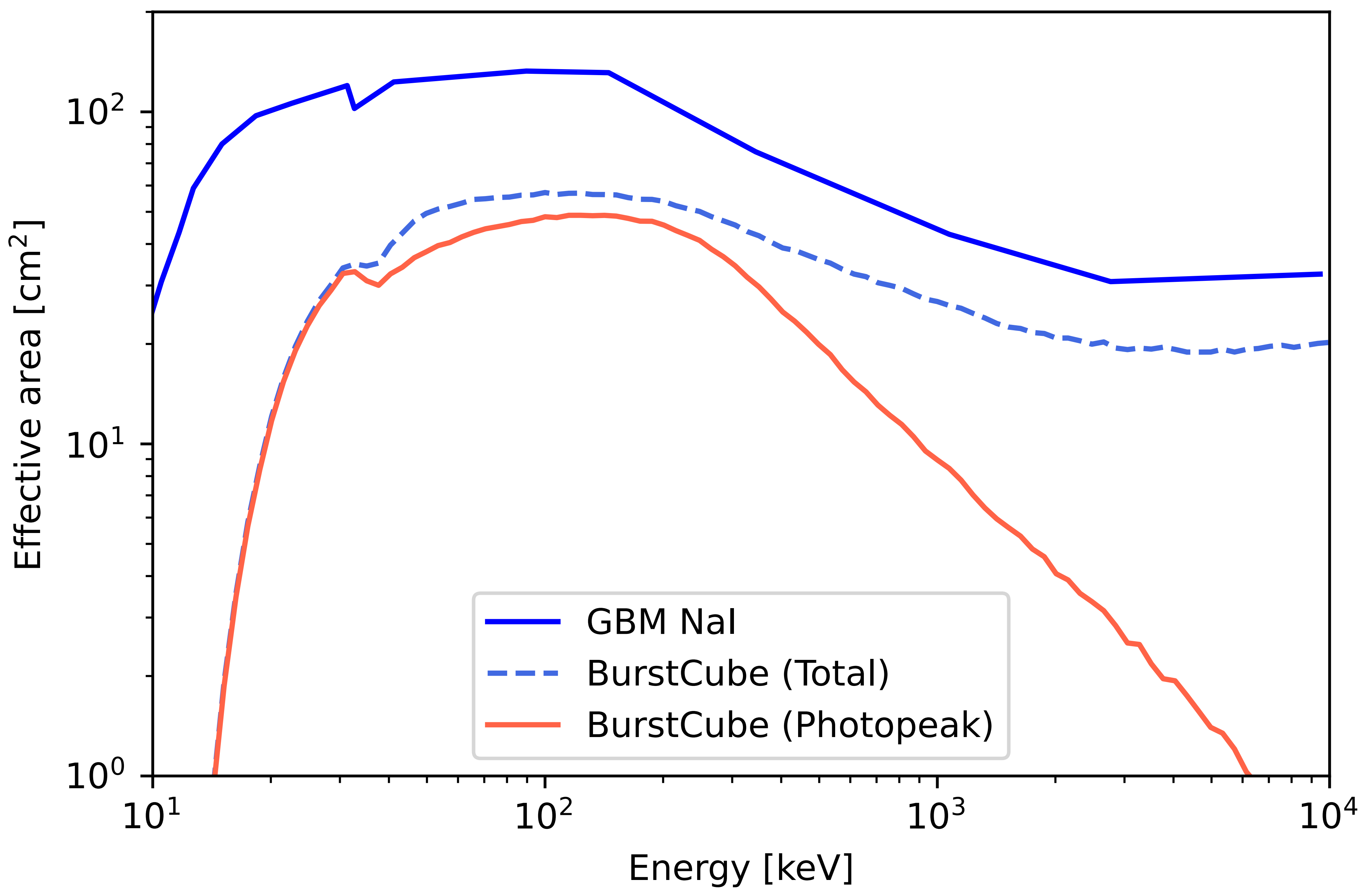
- BurstCube is a CubeSat to detect Gamma-Ray Bursts (GRBs) launching next year!
- It will improve our chances of detecting and localizing a gravitational-wave counterpart by increasing the sky coverage and providing rapid alerts.
- BurstCube is also a pathfinder for the next generation of GRB detectors.

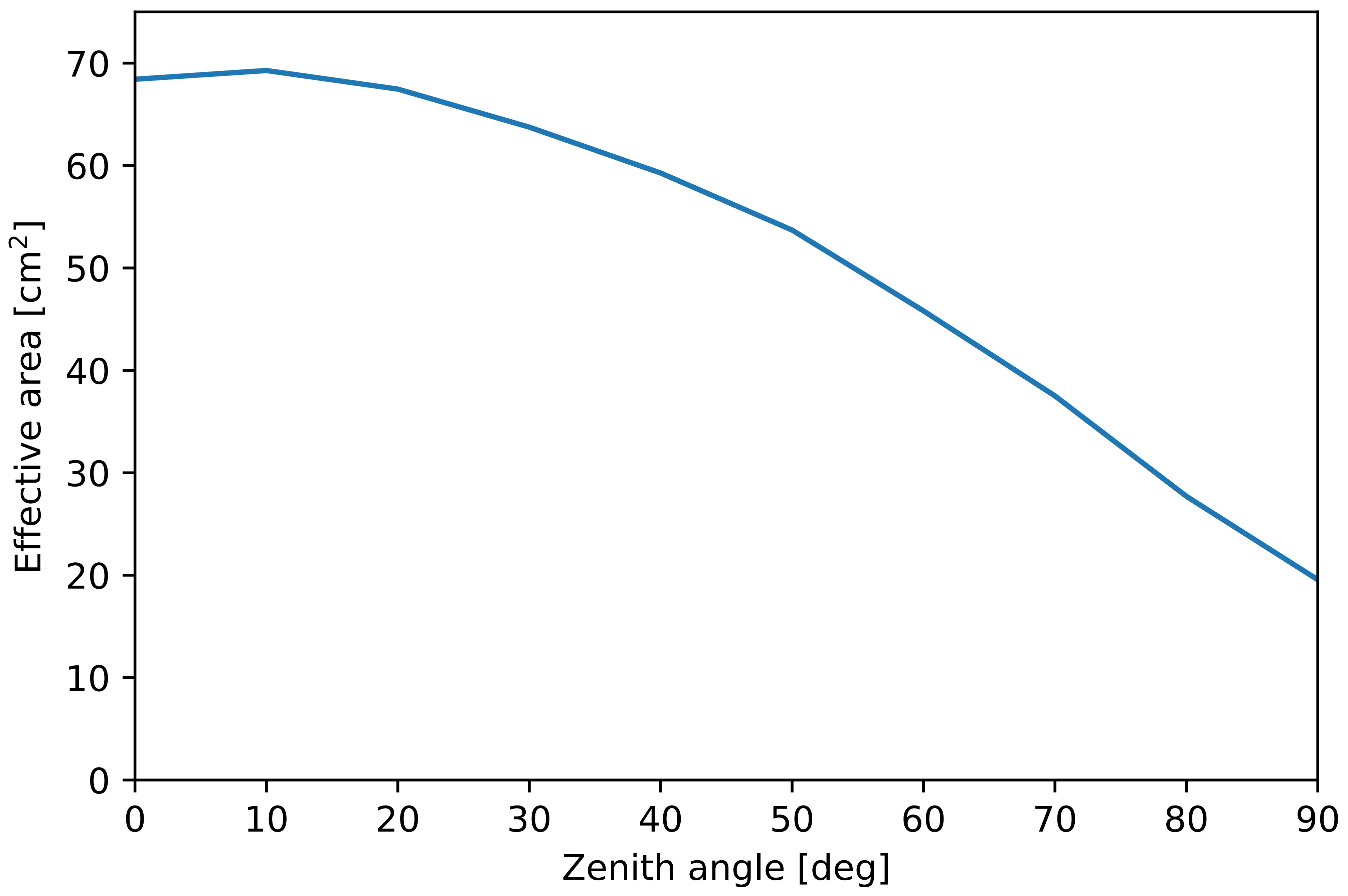
Backup

SQD energy range and resolution



Effective area





Localization

- For bursts resulting in a 10σ detection combining all 4 detectors