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Glowbug: a gamma-ray telescope for bursts and other transients

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Glowbug: all-sky 30 keV – 2 MeV band transient monitor optimized for GRBs

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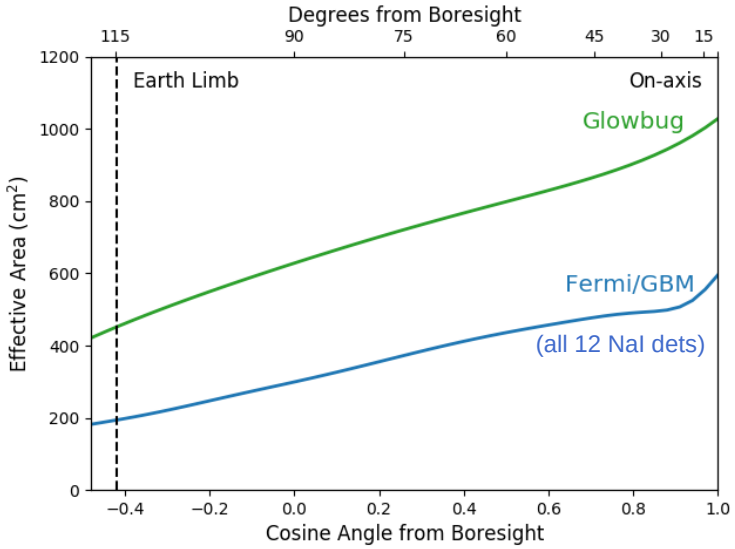
Glowbug is funded by APRA for early 2020s launch

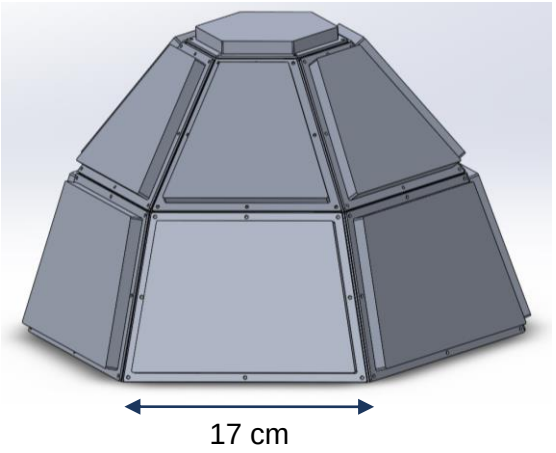


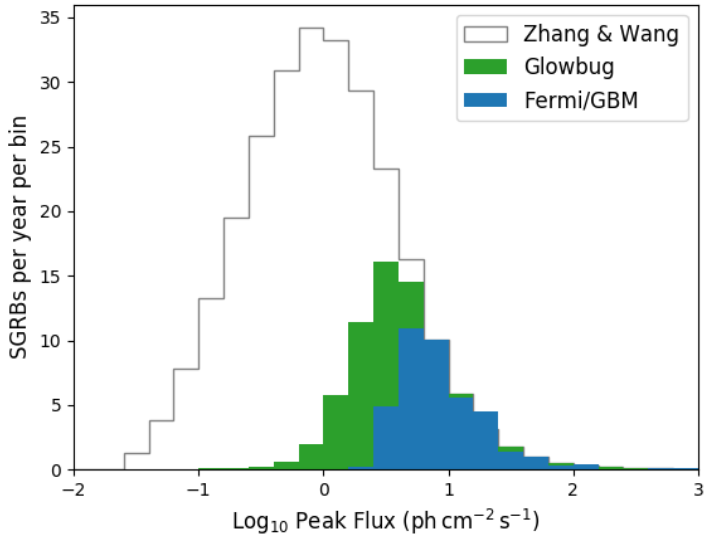
Good sensitivity at low cost

Effective area ~2 x Fermi GBM

Large area scintillators with SiPM readout

Attached payload Instrument ~40kg



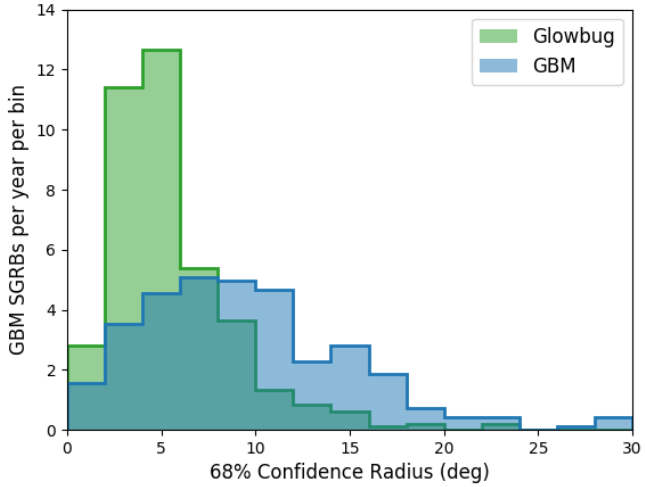


High rate of GRB detections

Rate ~ 70 short GRBs / year

Modest localization ability

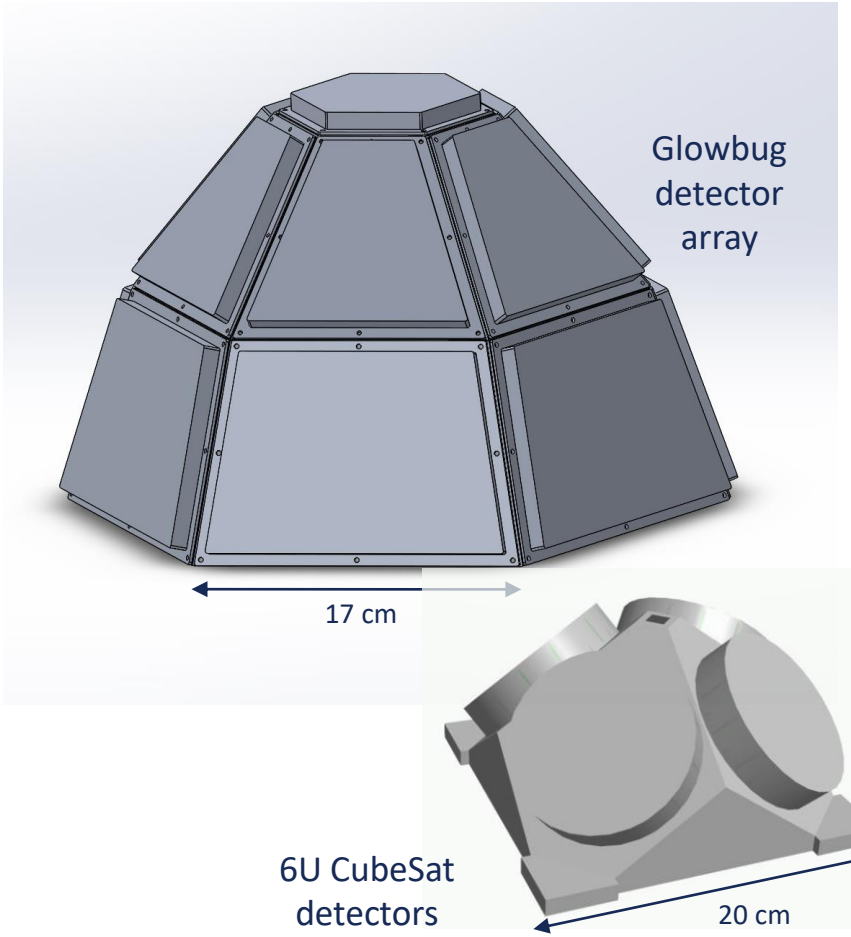
Comparable to Fermi GBM



Glowbug instrument

Tech demonstrator (half-scale) for GAMERA SmallSat mission concept

- Large scintillator array
  - CsI(Tl) + SiPM readout
    - Good stopping power; not hygroscopic
    - Low size, weight, and power readout
  - Front end and DAQ from NRL's SIRI-2
    - Low power, space qualified
- Selected by NASA APRA
  - **Funding began March 2019**
- Launch via DoD Space Test Program (STP)
  - Proposed for STP-H9 to International Space Station (ISS) in early 2023
  - STP provides integration, launch, and 1 year operations costs

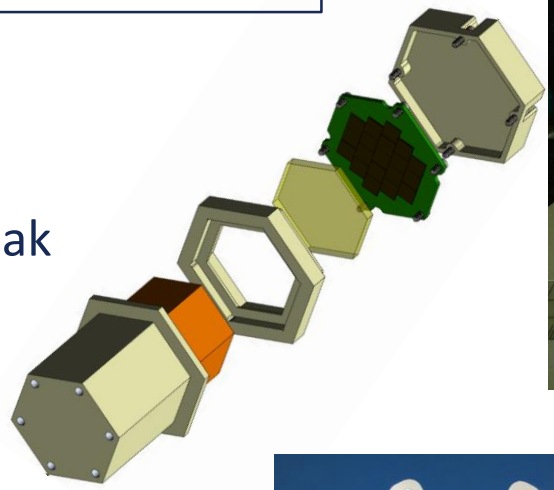


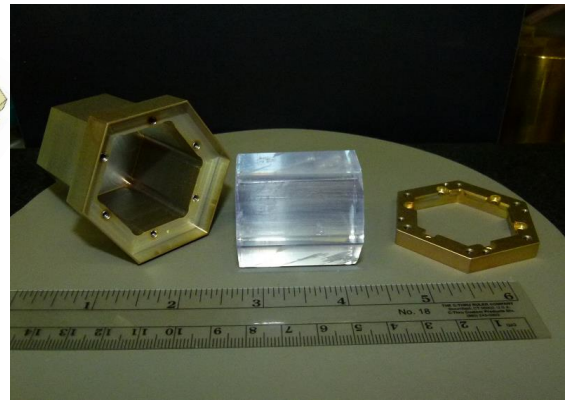
Glowbug detectors

Goal: obtain the best-possible sensitivity (maximal detector area, minimal background) and degree-scale localization as tech demonstrator for SmallSat mission concept

Design concept: large-area array of SiPM-read CsI(Tl) scintillators

Can be built today with components at TRL 6 or higher

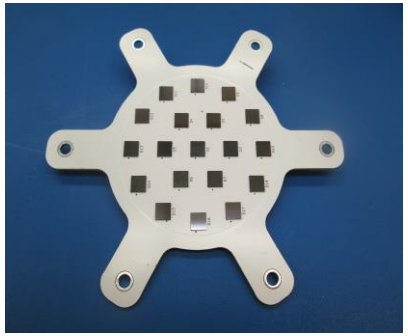


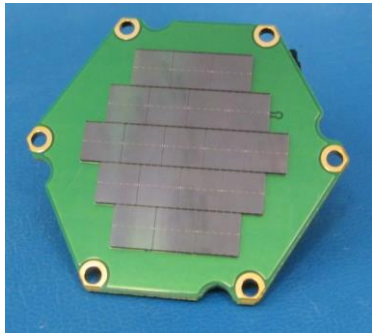


Cesium iodide CsI(Tl): better stopping power and photopeak efficiency than NaI, and is minimally hygroscopic, which eliminates need for hermetic enclosures

Silicon photomultipliers (SiPMs): fast readout of large areas of thin scintillators with low size, weight, and power (SWaP). Low cost and low operating voltage

- **Heritage through NRL's Strontium Iodide Radiation Instrumentation (SIRI) program**

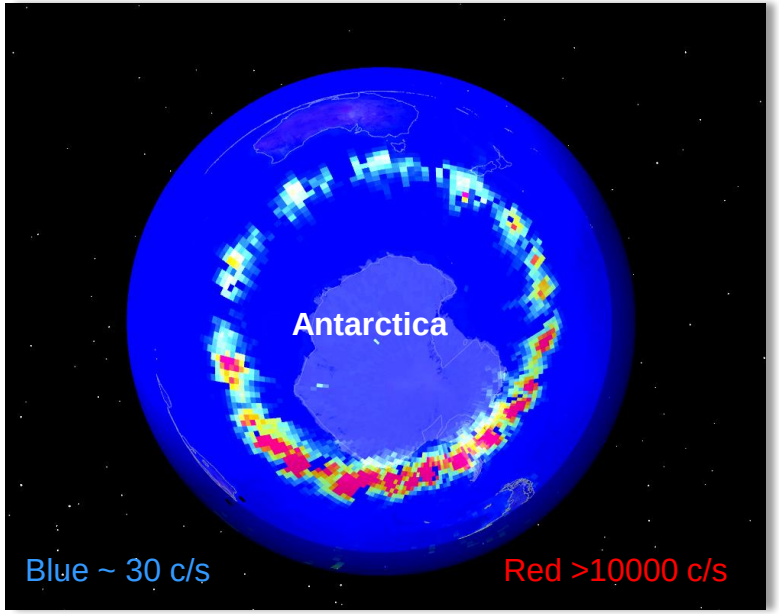




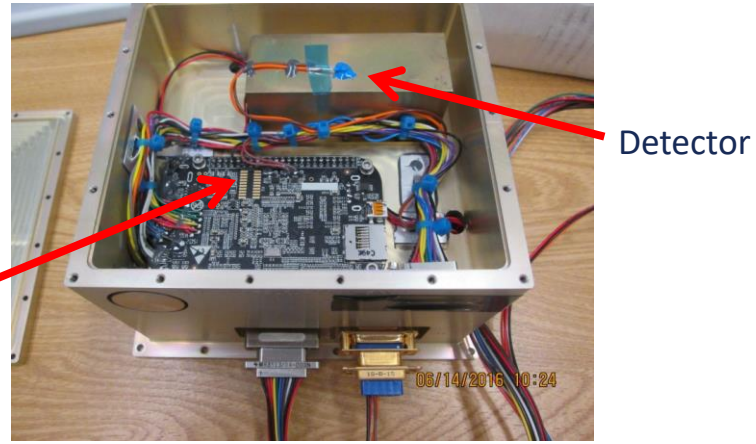
Aside: SIRI-1 space-qualifies SiPMs, SrI_2

Strontium Iodide Radiation Instrumentation

- Purpose: Space-qualify high-resolution scintillator SrI2 (<3% at 662 keV), SensL SiPMs, with BeagleBone Black Single-Board Computer (SBC)
- SIRI-1 launched 3 December 2018 on STPSat-5
- SensL J-series SiPMs are operating today on orbit
  - Performance same as on ground. No issues



Gamma-ray count rate (E > 30 keV) in SIRI-1 in southern hemisphere during Feb 2019.

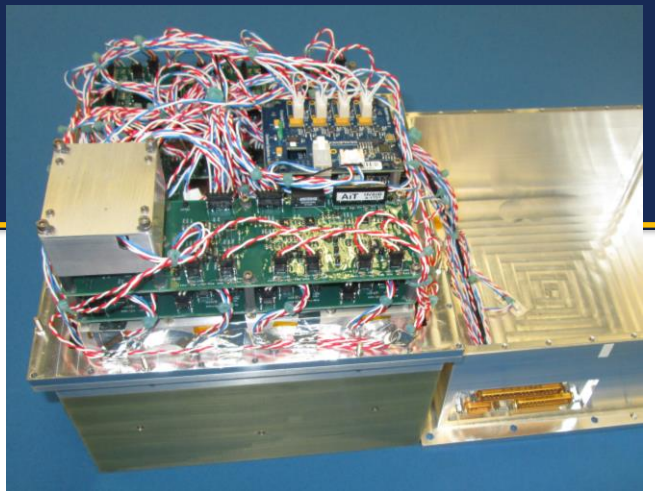


Instrument paper:
Mitchell et al. 2017 Proc. of SPIE Vol. 10397, 103970B

Glowbug data acquisition

Front end and data acquisition system

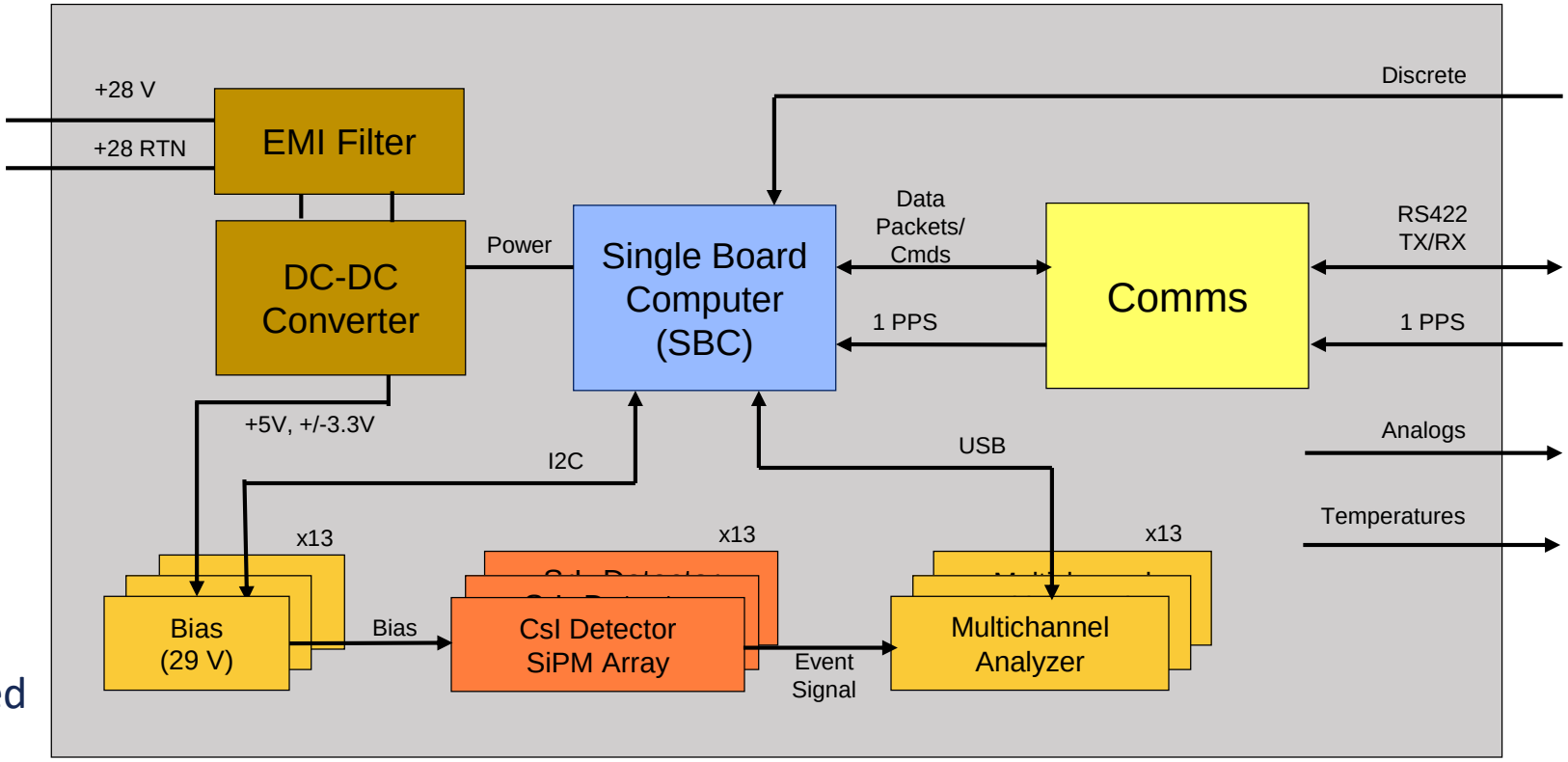
- Replicates existing SIRI-2 design
  - Average power 23 W
  - GPS-derived time stamps (<1 us)



SIRI-2 flight DAQ and sensor head

Concept of operations

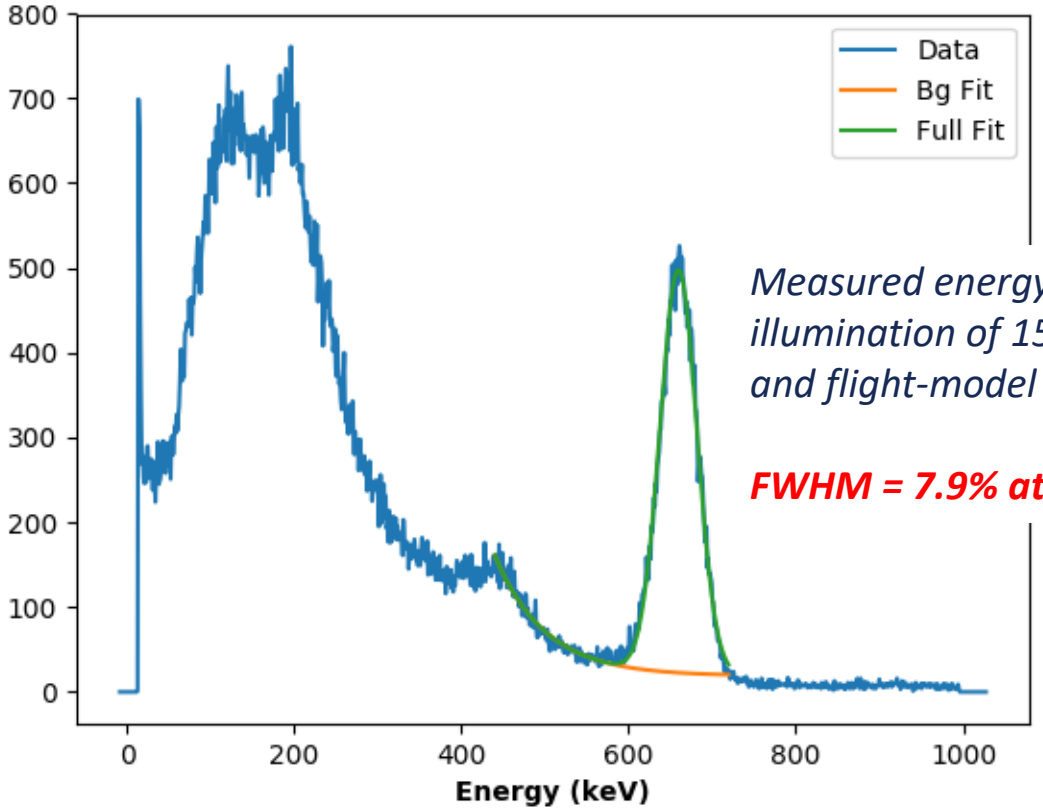
- Rate mode, formed from event list stream
- Autonomous burst detection, switching to event list downlink in ~100 sec pre and post window
- Burst Alert message
- Note: if ISS, entire ~3 GB/day event list dataset will be downlinked



Bench test performance demo

Detector performance

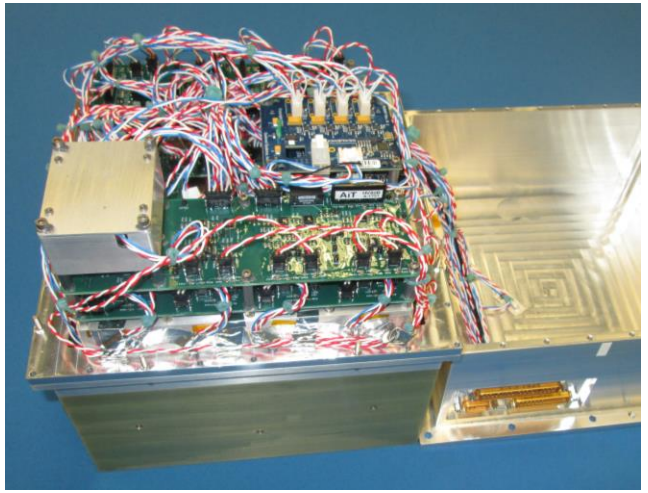
- Used SIRI-2 flight unit to shape, digitize largest Glowbug detector
  - CsI(Tl) crystal 15x15x1 cm
  - SiPM array

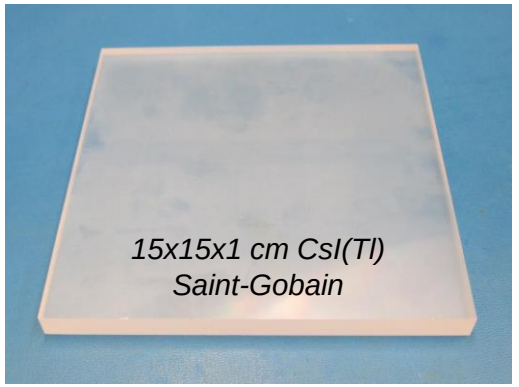


Measured energy resolution with flood illumination of 15x15x1 cm CsI(Tl) tile, SiPMs, and flight-model SIRI-2 front end and DAQ.

FWHM = 7.9% at 662 keV

SIRI-2 flight DAQ and sensor head





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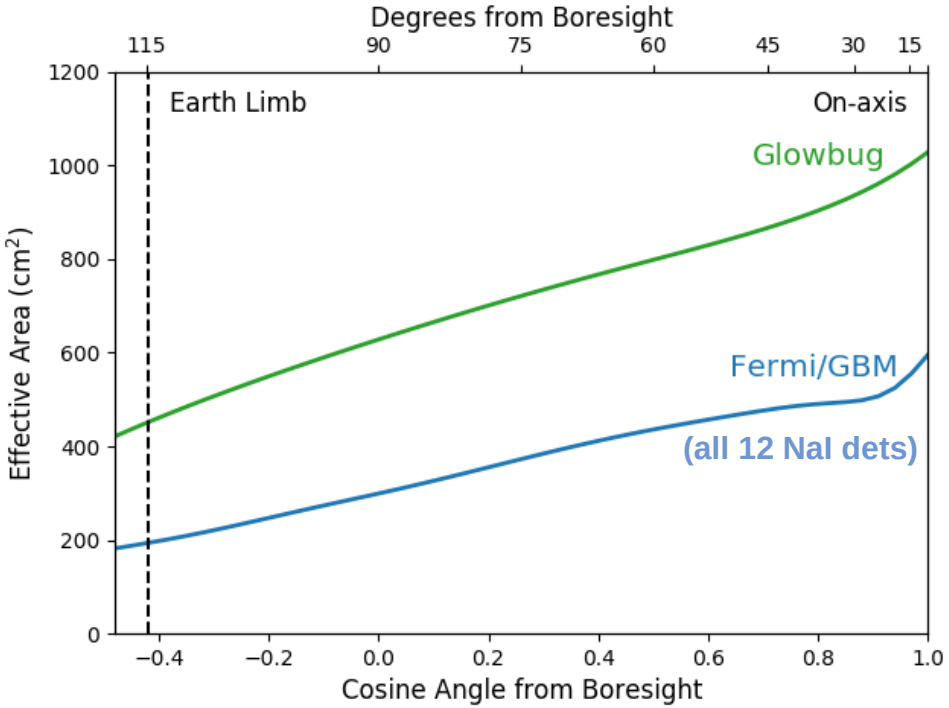
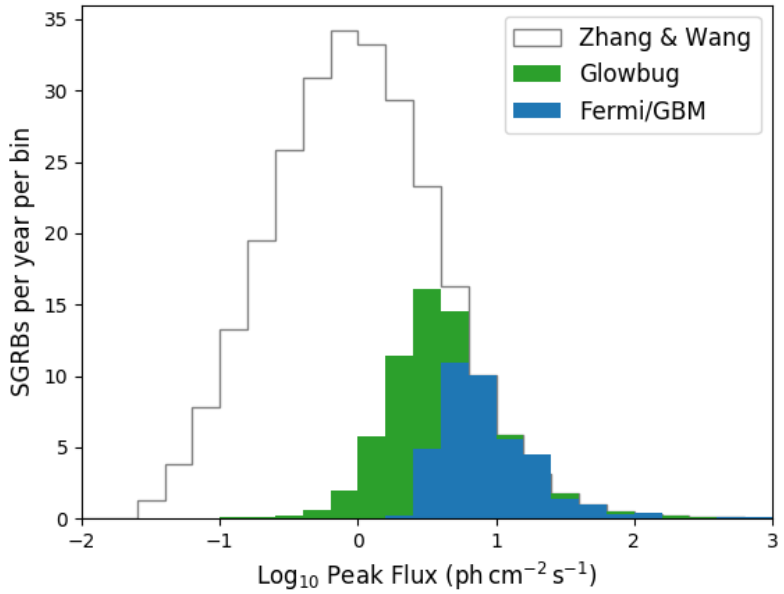
Instrument sensitivity

Performance estimated from detailed Monte Carlo simulations of scintillator modules, instrument geometry model, and maximum likelihood analyses performed using realistic GBM background

- **~2x Fermi GBM effective area** (total, 12 NaI dets) for typical GRB spectrum
- **~ ½ x effective area at 2 MeV** of two BGO detectors of Fermi GBM



- Increase in effective area expands horizon for faint sources in local universe by ~1.4



- Estimate **~ 70 sGRB / yr**
- EM counterparts of GW binary mergers

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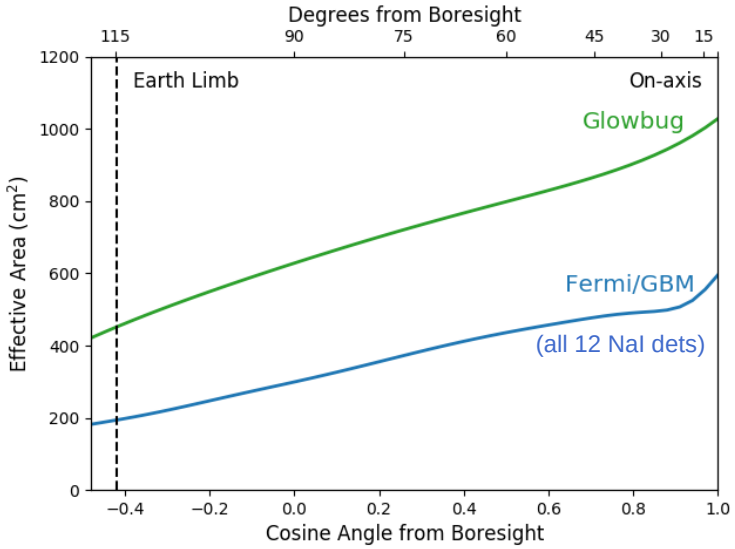
Glowbug summary

Postdoc opportunities available
Email me: eric.grove@nrl.navy.mil

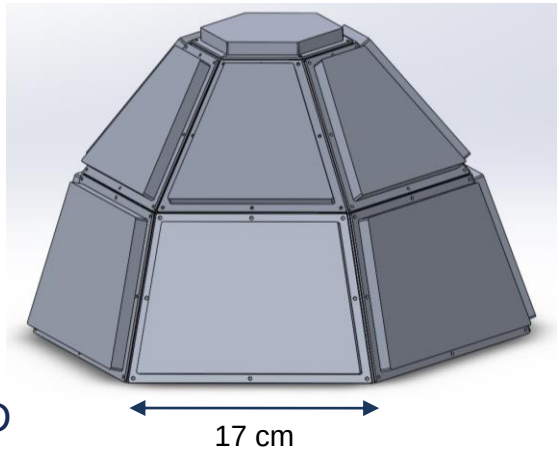


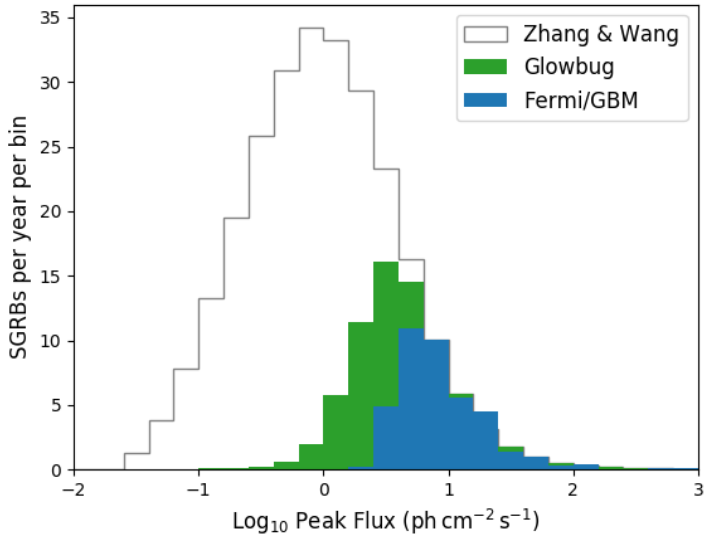
Good sensitivity at low cost

Effective area ~2 x Fermi GBM

Larger than CubeSat Instrument ~40kg

Funded by NASA
Launch to be provided by DoD





High rate of GRB detections

Rate ~ 70 sGRBs / year

Modest localization ability

Comparable to Fermi GBM