

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



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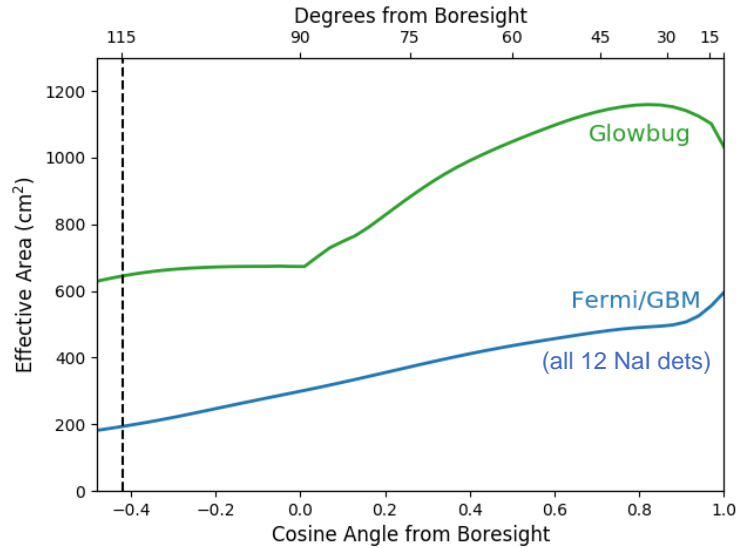
Matthew Kerr, U.S. Naval Research Laboratory

This work is supported by the NASA Astrophysics Research and Analysis Program



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

Glowbug is funded by APRA for early 2020s launch

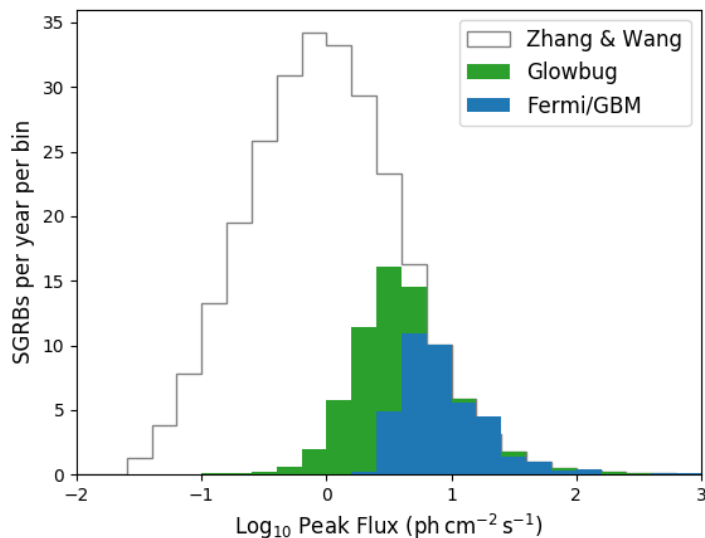
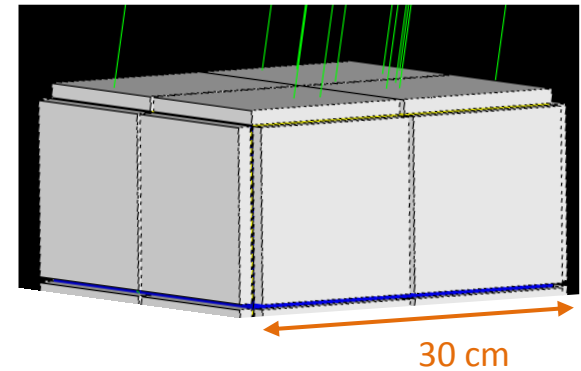


Good sensitivity
at low cost

**Effective area
~2 x Fermi GBM**

Modular array of large area
scintillators with SiPM readout

**Attached payload
Instrument ~40kg**

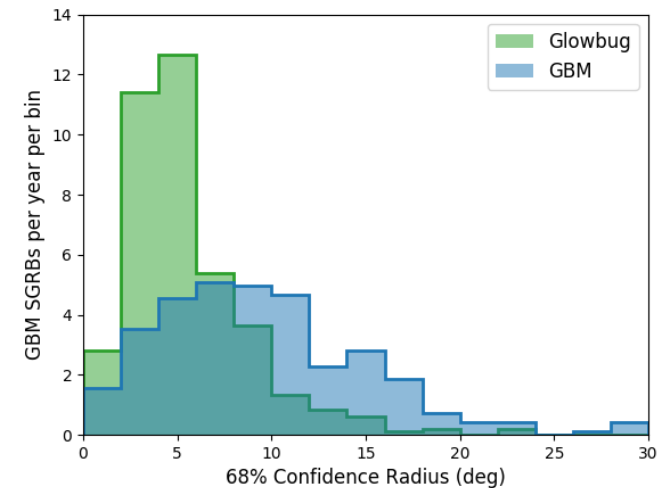


High rate of
GRB detections

**Rate ~ >70 short
GRBs / year**

Modest localization ability

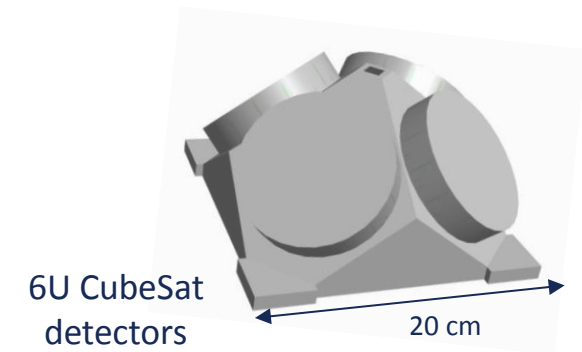
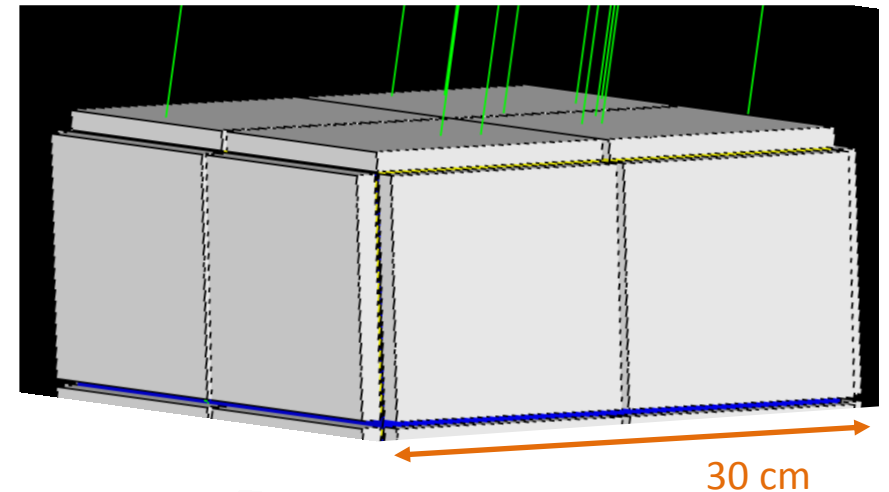
**Comparable
to Fermi GBM**



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

- Large scintillator array
 - Trade studies indicate complex designs yield only modest improvements to localization capabilities.
 - Modular, rectilinear design simplifies mechanical structure and fabrication
 - Csl(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 to begin January 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 detector array



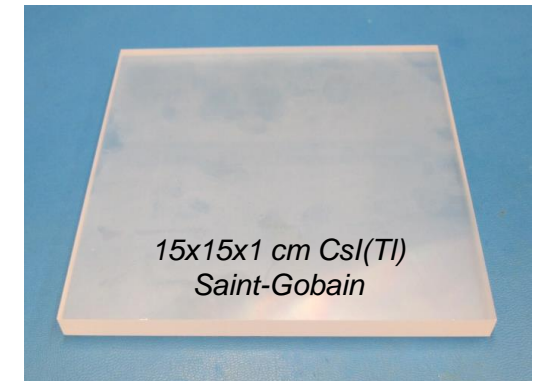
Glowbug detectors

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

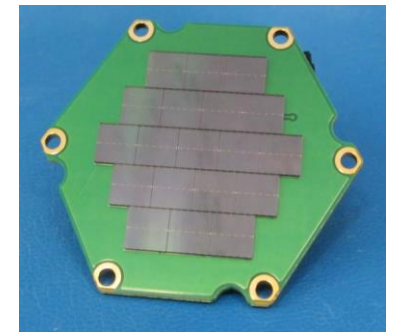
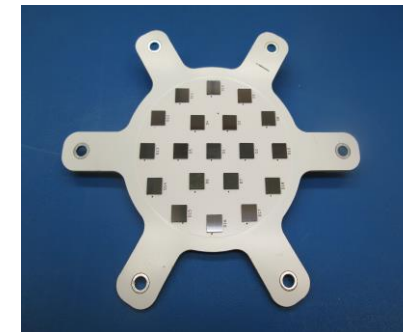
Can be built today with components at TRL 6 or higher

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



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

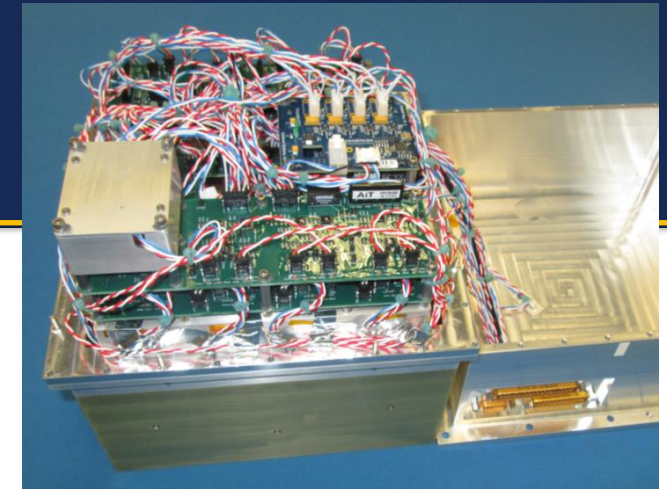


Glowbug data acquisition

Front end and data acquisition system

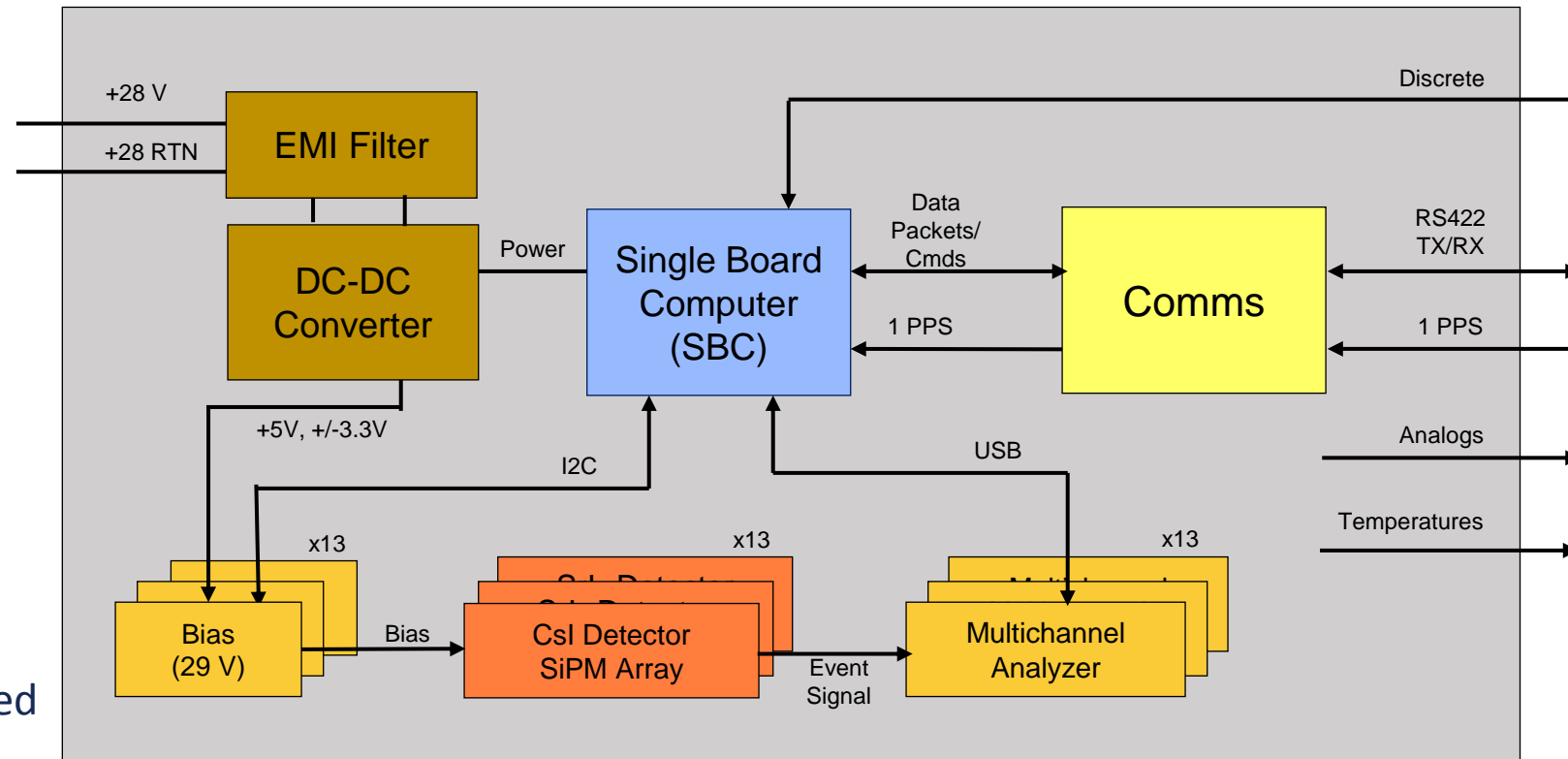
- Replicates existing SIRI-2 design
 - Average power 23 W
 - GPS-derived time stamps (<1 us)

SIRI-2 flight DAQ and sensor head



Concept of operations

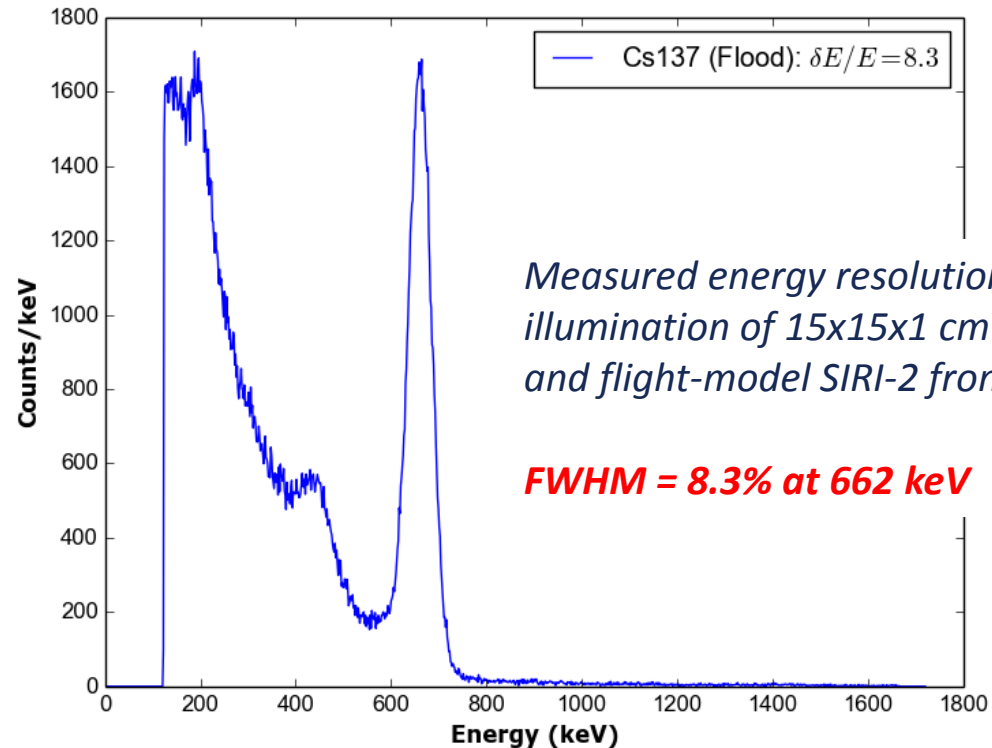
- Rate mode, formed from event list stream
- Autonomous burst detection, switching to event list downlink in ~100 sec pre and post window
- Burst Alert message
- Note: if ISS, entire ~3 GB/day event list dataset will be downlinked



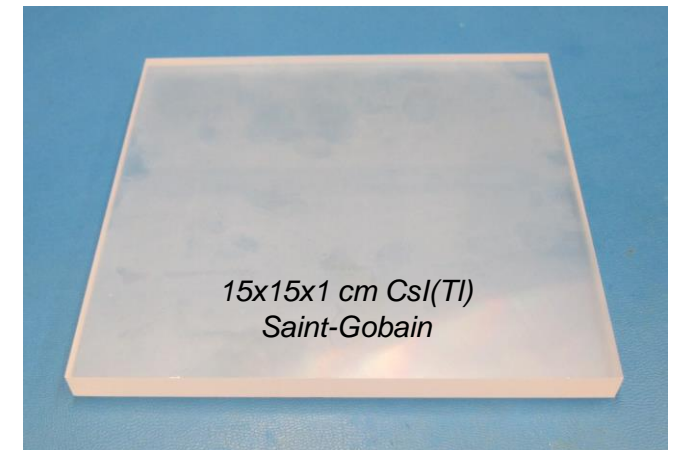
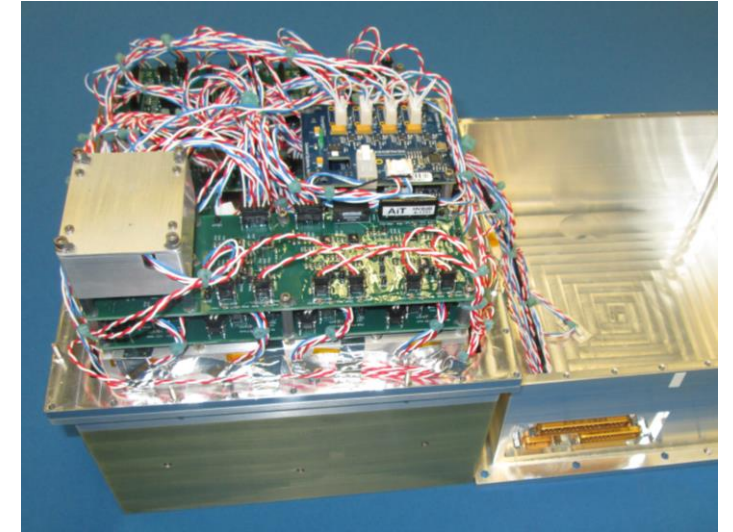
Bench test performance demo

Detector performance

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



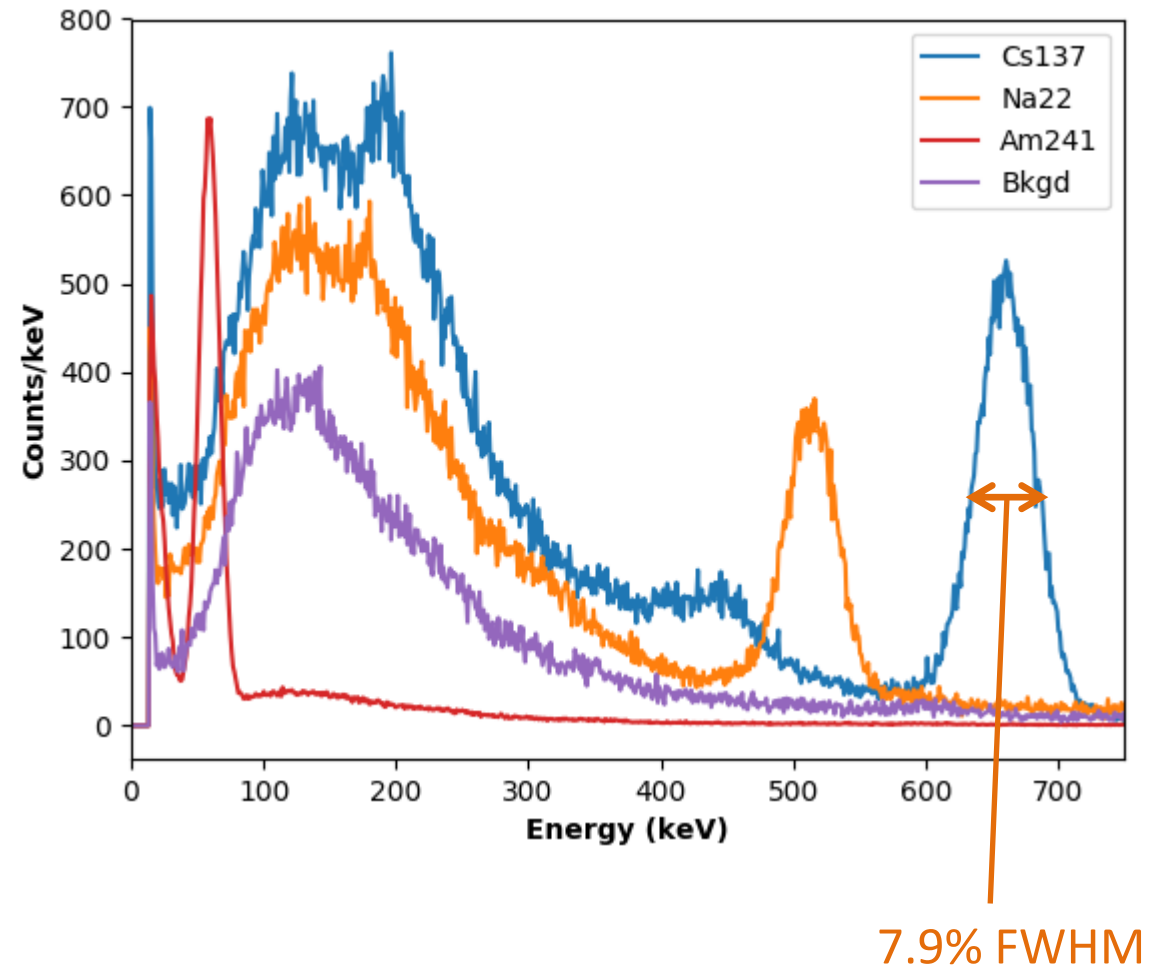
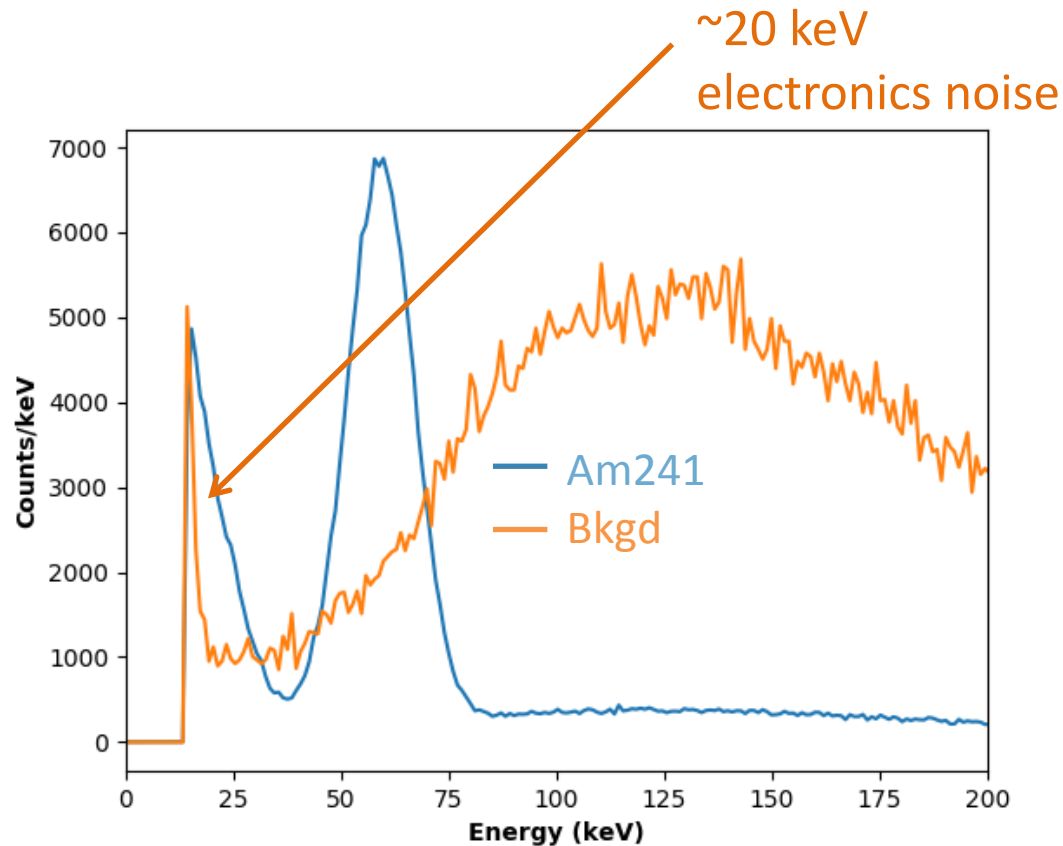
SIRI-2 flight DAQ and sensor head



Update for lower-energy threshold

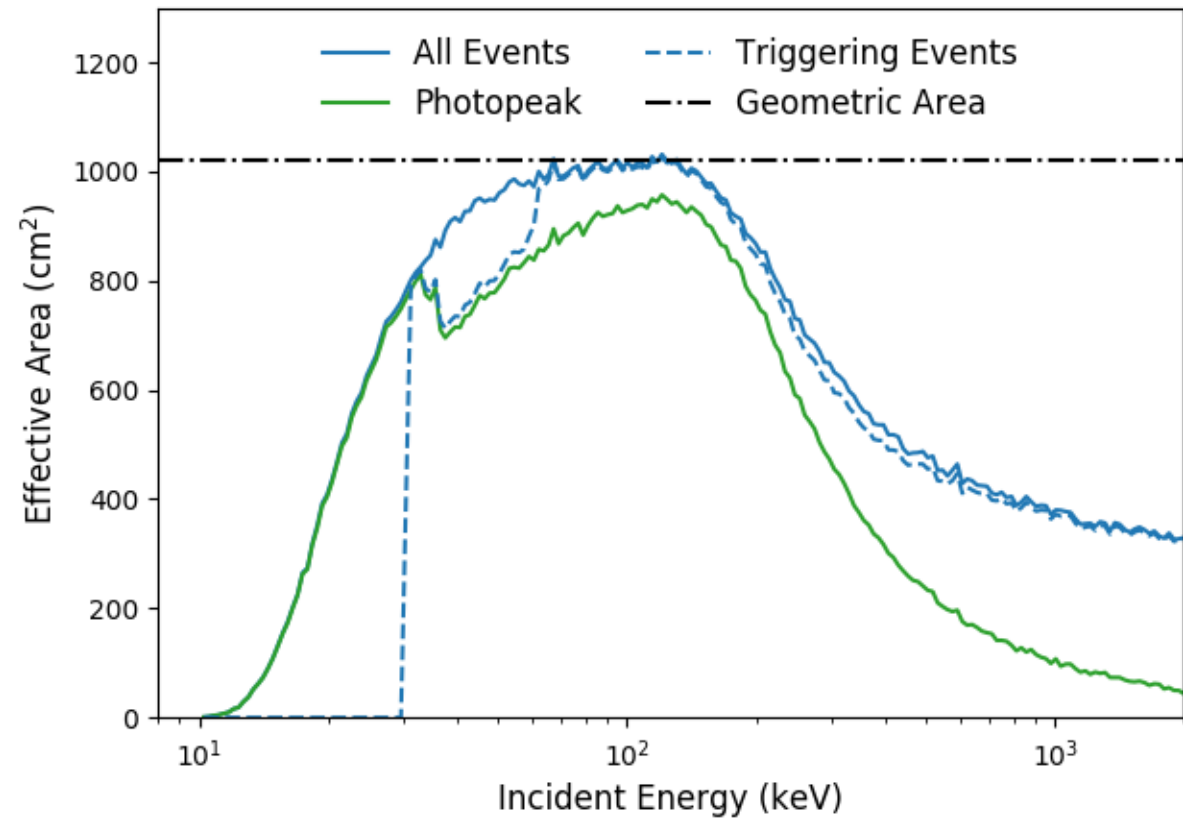
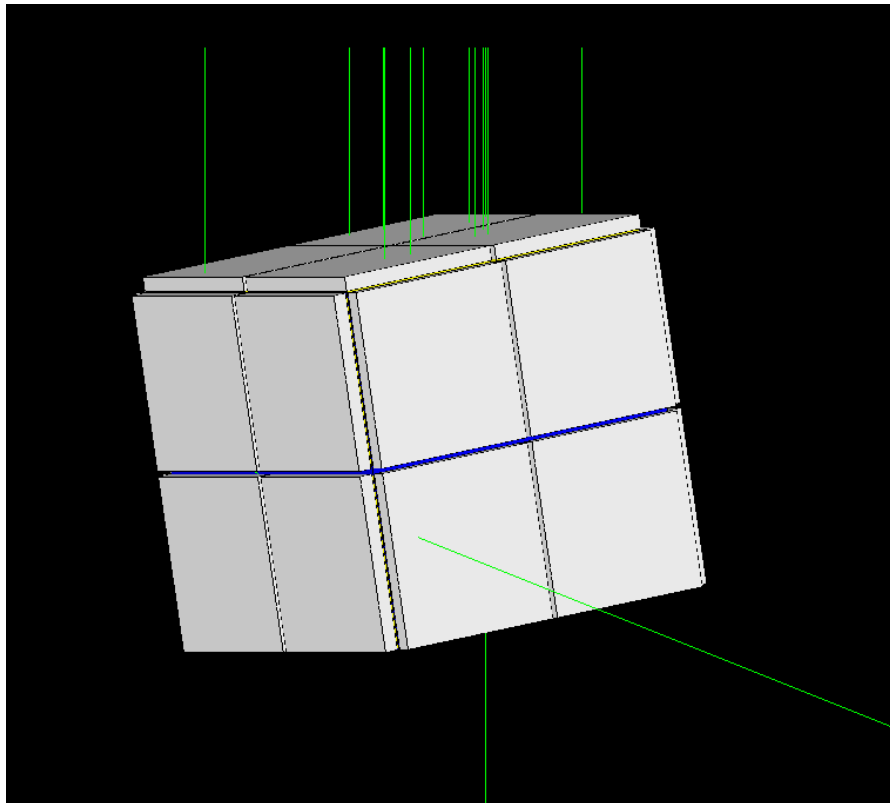
Test with new SiPM board, lab electronics

- 7.9% at 662 keV (flood illumination)
- <30 keV threshold



Instrument characterization

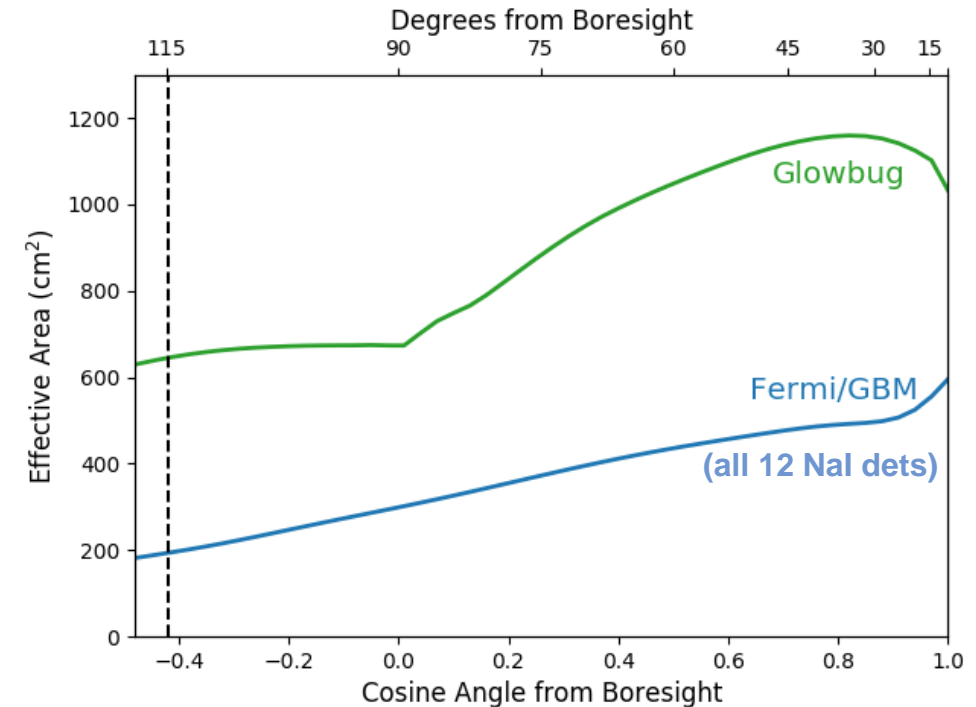
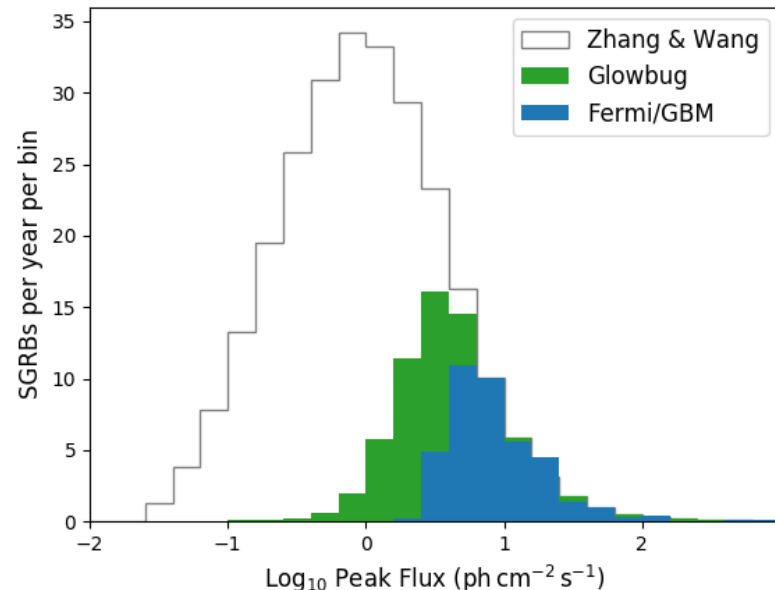
Use SWORD (wrapper for GEANT4) to run Monte Carlo simulations to characterize instrument response over wide range of incident energy and angle.



Instrument sensitivity

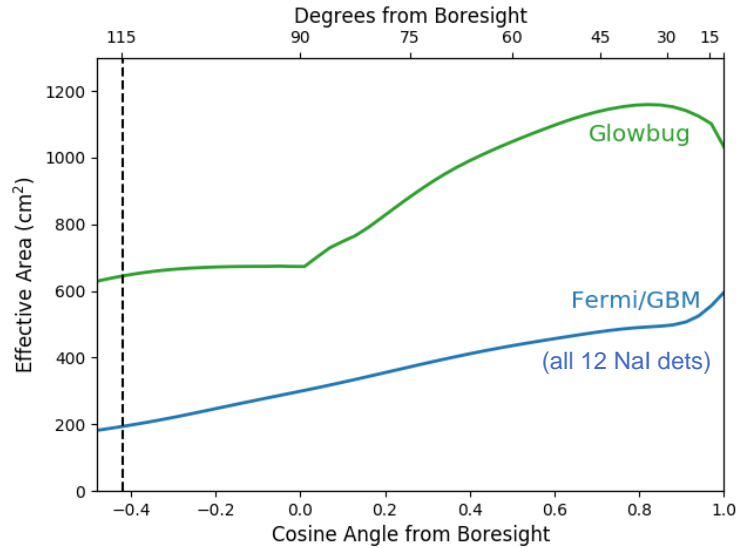
Performance estimated from detailed Monte Carlo simulations of scintillator modules, instrument geometry model, and maximum likelihood analyses performed using realistic GBM background

- **~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



Glowbug summary

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

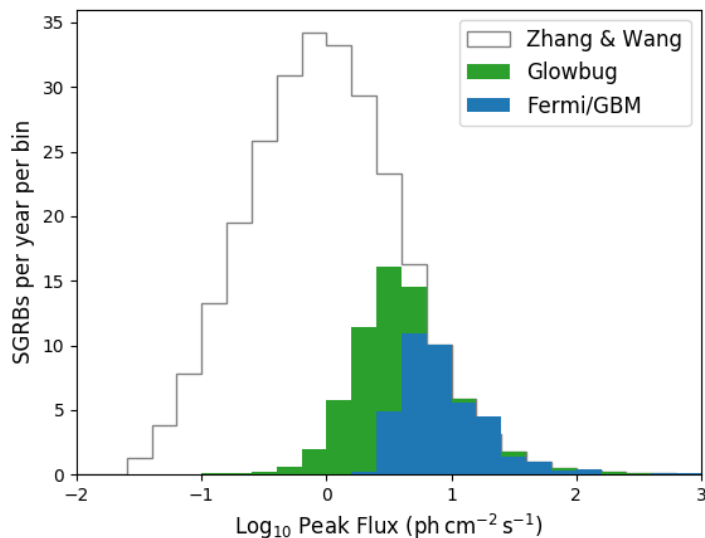
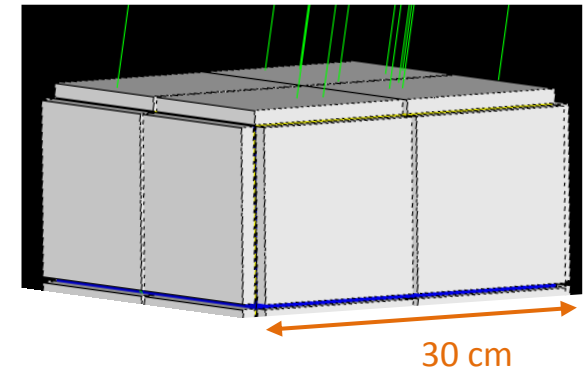


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Launch to be provided by DoD



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