BurstCube: A CubeSat for Gravitational Wave Counterparts

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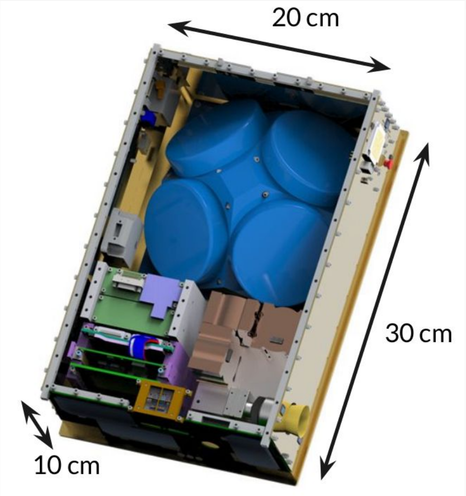
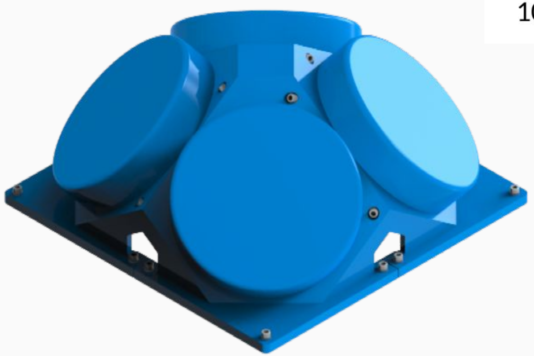
Overview

- 6U CubeSat with the **primary science goal to detect, localize, and characterize short gamma-ray bursts** (SGRBs)



- Instrument:
  - Four CsI scintillators coupled with arrays of silicon photomultipliers (SiPMs)
  - Energy range: ~50 keV - 1 MeV

- Launch in early 2020s
  - 6 month mission (1 year goal)



Silicon Photomultipliers (SiPMs)

SiPMs are solid state photodetectors

Bias voltage: 20-65 V

Compact and low mass

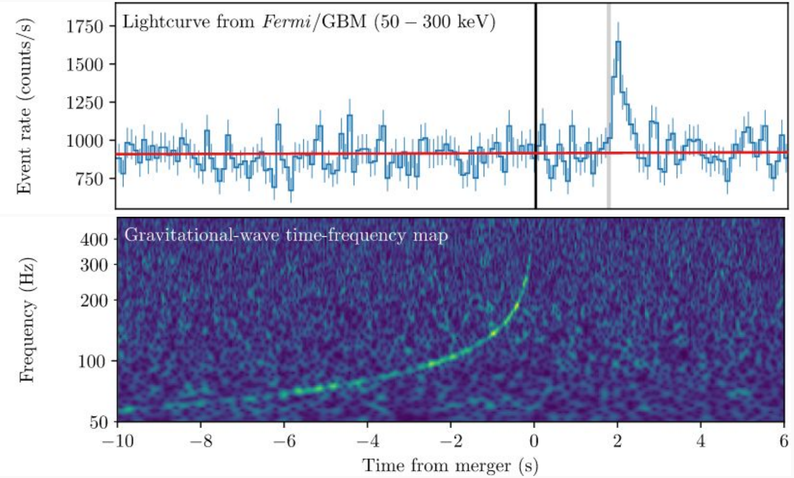
Insensitive to magnetic fields

BurstCube Science - Why now?

- Joint detection of GRB 170817A and GW170817
  - Proved that binary neutron star (BNS) mergers are progenitors of SGRBs
  - Measure speed of gravity relative to the speed of light

- Questions remain:
  - What is the structure of the relativistic jet?
  - What is the origin of gamma-ray emission?

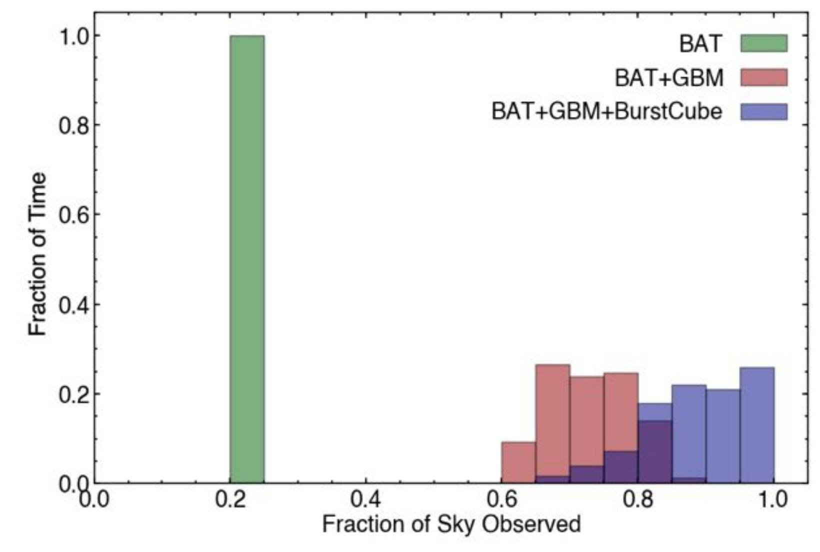
- Provide electromagnetic context to gravitational wave events detected by **LIGO, Virgo**, and **KAGRA.**



Abbott, et. al. 2017 arXiv:1710.05834

BurstCube Science - Why now II?

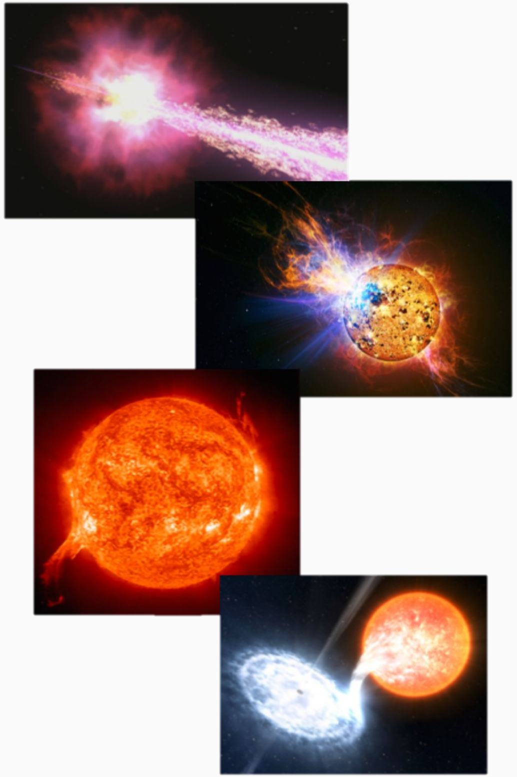
- Complement current, funded, and proposed missions
  - Current: Fermi, Swift, ect.
  - Future: Glowbug, ect.
  - Proposed (2025+): MoonBEAM, Nimble, Bia, etc.
    - Increase sky coverage
    - Detect and localize bursts



See: Judith Racusin, Jeremy Perkins et al. arXiv:1708.09292v1

BurstCube Science- What else?

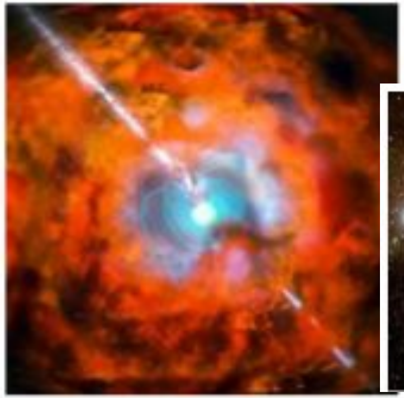
- BurstCube will **detect** GRBs from the **entire unocculted sky**
  - Broadband spectra
  - Rough localizations for follow-up
  - Accurately timed light curves
- BurstCube will also **detect solar flares, magnetar flares,** and other **transients.**
- Combined with Fermi and Swift, BurstCube will provide all-sky coverage for a **small fraction of the cost** of an Explorer mission



Mission Performance

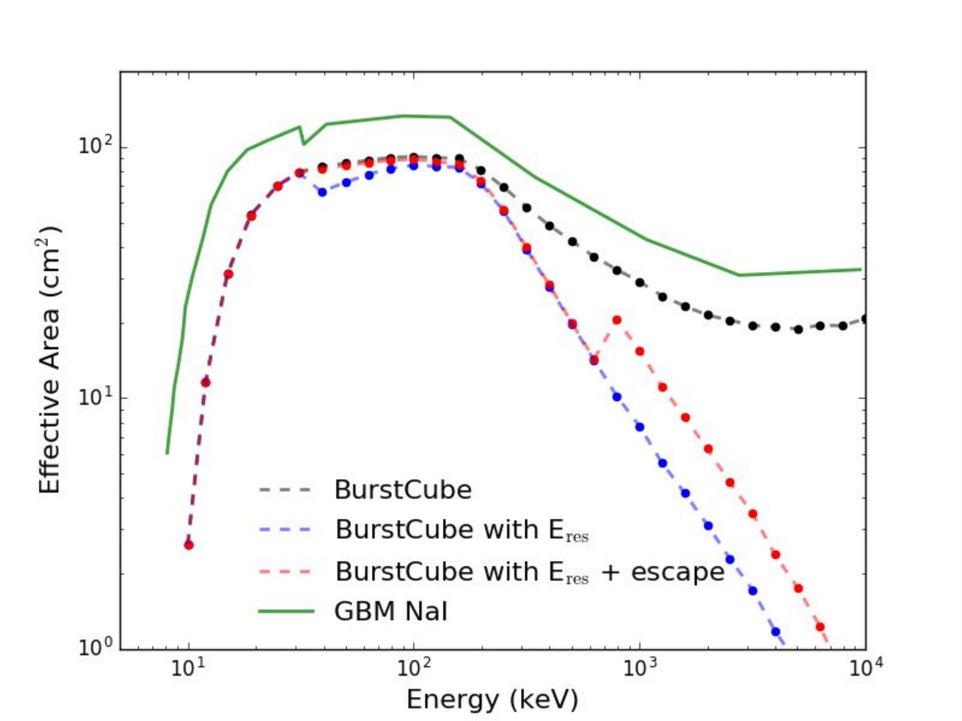
Energy range: ~50 keV - 1 MeV
Energy resolution: 10% at 662 keV
Field of View: ~50% of the sky (instantaneous)

BurstCube:
SGRBs: ~25 per year
LGRBs: >100 per year
GBM:
SGRBs: ~40 per year
LGRBs: ~200 long per year



Mission Performance-Effective Area

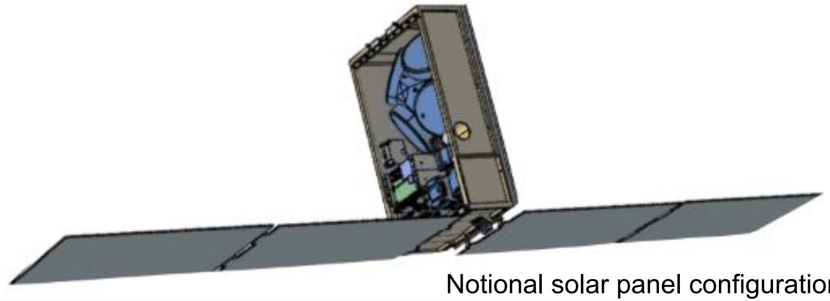
Effective area is 70% that of the larger GBM NaI detectors at 100 keV and 15 degree incidence



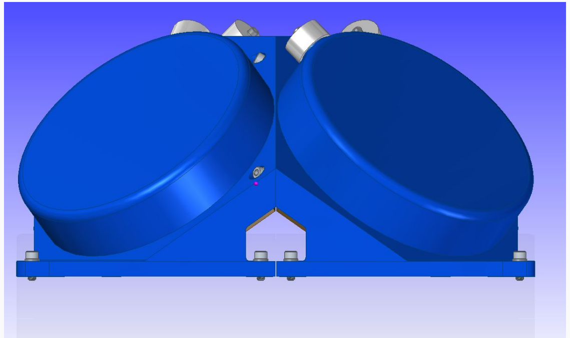
See: Judith Racusin, Jeremy Perkins et al. arXiv:1708.09292v1

Instrument

- Instrument Package
  - 4 CsI scintillator crystals coupled to arrays of low-power SiPMs with custom electronics
  - 9 cm diameter, 1.9 cm thick
  - 116 SiPMs summed per crystal
- Communications
  - BurstCube will relay data to the ground via TDRSS
    - 5-15 minute goal

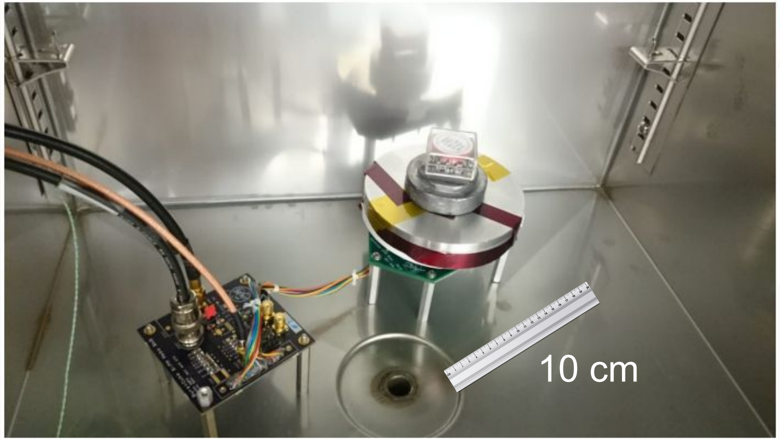


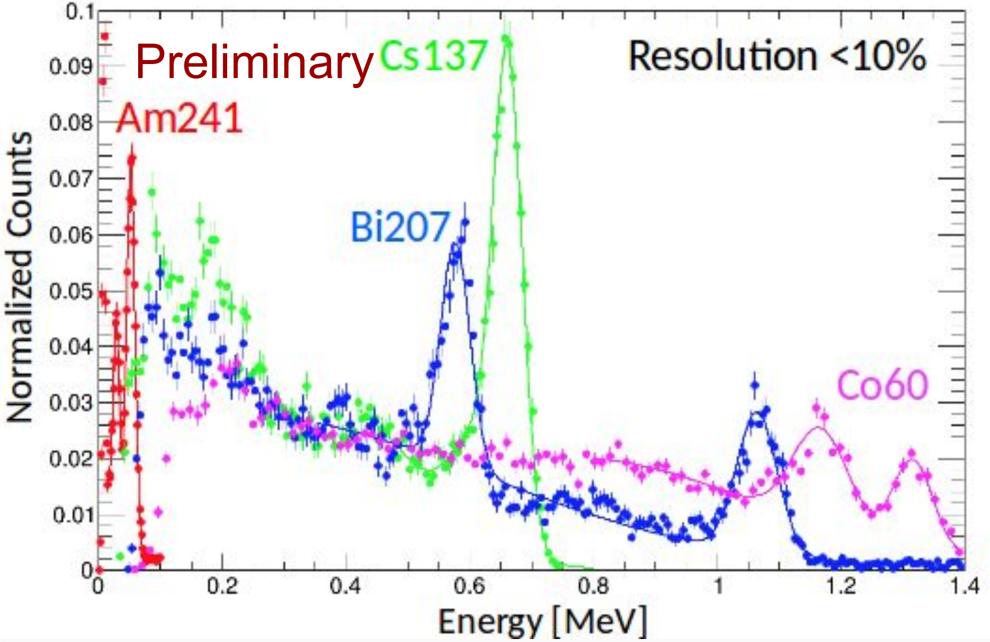
Notional solar panel configuration



Current Detector Performance

- Initial spectral measurements with front end electronics
- Spanning from about 50 keV to 1.4 MeV
- Energy resolution <10%



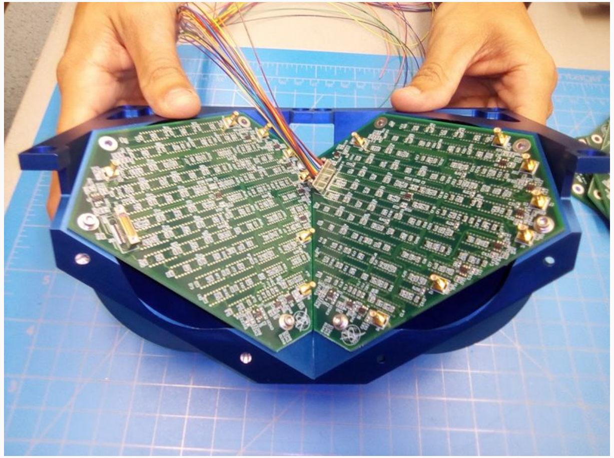


Critical Design Review I

Technical review to demonstrate that we can build the instrument and meet our stated performance requirements.

To prove this we must validate:

- Mechanical design
  - Detector assembly
- Front end and flat instrument electronics

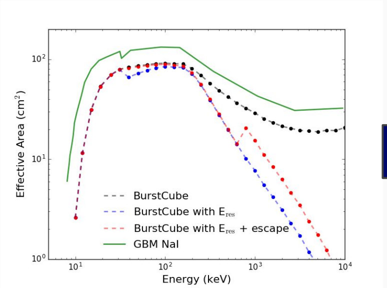


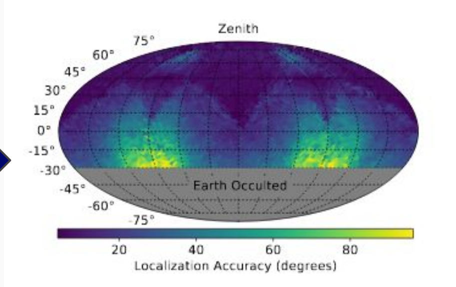
Critical Design Review II

- How will we accomplish this?
    - Build ¼ instrument
    - Vibe test
        - Prove the mechanical design is sound
    - Thermal vacuum (TVac)
        - Prove that instrument can withstand vacuum and temperature fluctuations
- Perform tests to show that the gain and energy resolution is unchanged

Instrument Calibration

- Localization and energy spectrum of a GRB are derived from the instrument energy dependent angular response
  - Ground calibrations prior to launch are critical





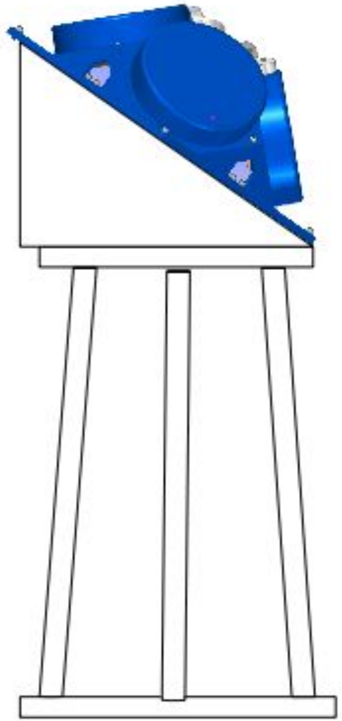
Simulations
Predict

Physical tests
Validate

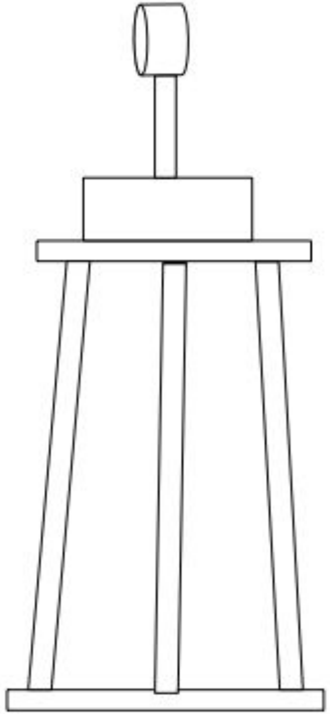
Detector response matrix
Create

Instrument Calibration

BurstCube Instrument



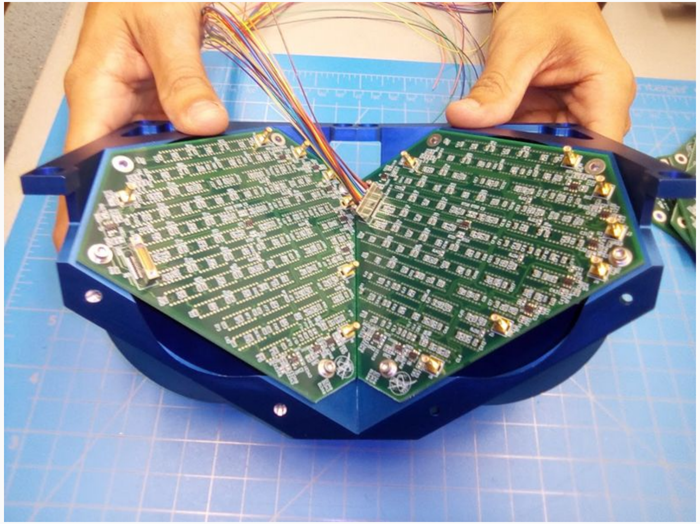
Source Holder



- Calibration measurements will utilize various calibrated radioactive sources in the energy range of BurstCube.
- Calibration Campaigns:
  - Energy response
  - Angular response
  - Spatial uniformity
- Instrument properties:
  - Channel-energy relationship
  - Effective area
  - Energy resolution
  - Sensitivity

Conclusion

- BurstCube: a 6U CubeSat that will detect and localize GRBs
  - focus on counterparts of gravitational wave (GW) sources
- Four CsI scintillators coupled with arrays of compact low-power SiPMs
- Spacecraft build started this year, the instrument to be delivered to spacecraft fall 2020, ship Q3 2021.



Thank you!

Extra Slide I