BurstCube: Measuring Gravitational Wave Counterparts on a CubeSat

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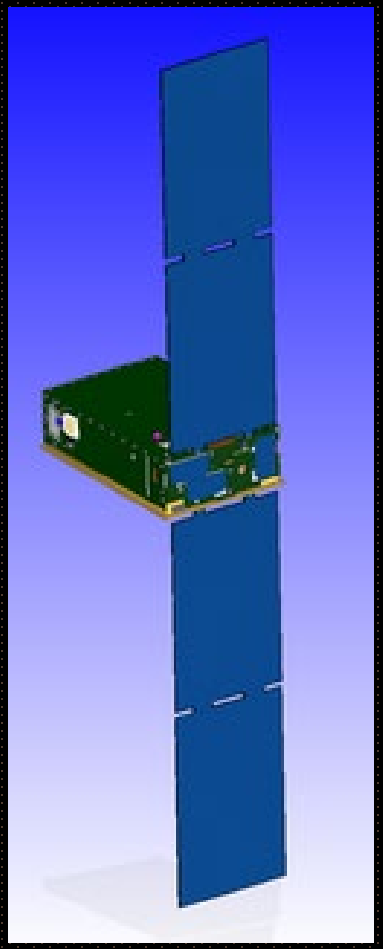
On behalf of BurstCube Team

Fermi Symposium 2018

Thursday October 18, 2018



Motivating Science

Some talks from Monday …

- "Observational constraints on the structure of gamma-ray burst jets and lessons from GW170817"
- "Understanding the Prompt Emission of GRB 170817A - Event Rates, Ejecta Topology, Radiation Mechanism and 1.7 s Time Delay"
- "The expected diversity of afterglows from future neutron star merger events to be detected by LIGO/Virgo "
- "Searching For GRB Counterparts To Gravitational Waves With Fermi GBM Future Science from Gamma-ray Observations of Neutron Star Mergers"
- "Location and Environments of Neutron Star Mergers in an Evolving Universe"
- "GRB emission mechanisms and open questions"
- "How far from the central engine are the GRBs produced?"

- Short gamma-ray bursts (sGRB) are a useful prompt emission after gravitational wave (GW) detection.
- If a GW detector is on, we need sGRB monitors in the sky.
- These need to detect sGRBs and promptly notify the community.
- Coordinated efforts between GRB-GW groups are needed.

BurstCube Team

Website: https://asd.gsfc.nasa.gov/burstcube/

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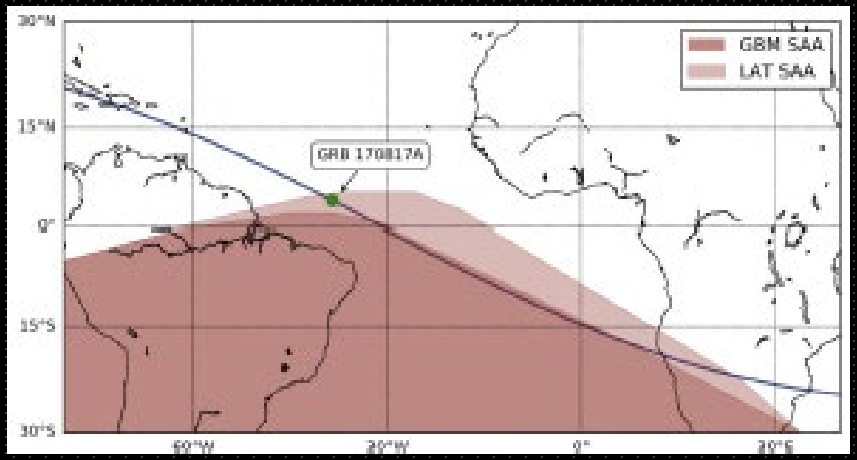
BurstCube Overview

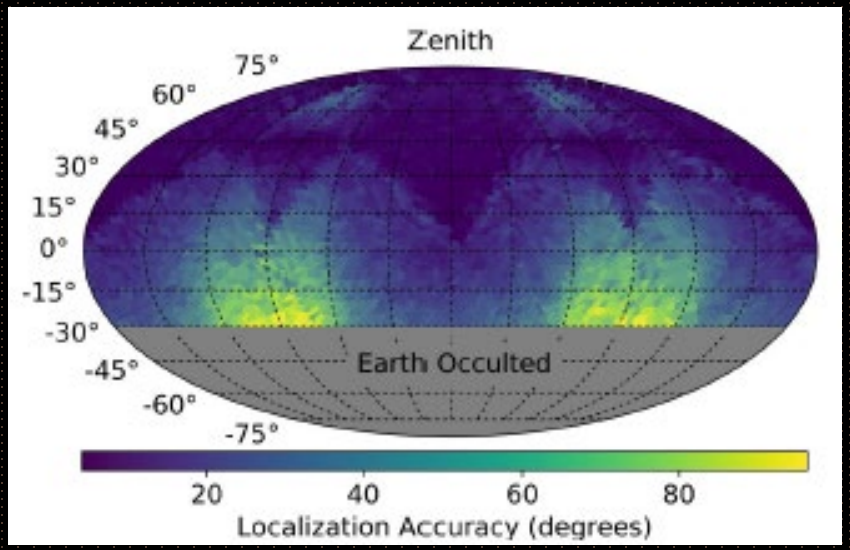
- BurstCube: a 6U CubeSat that will detect and characterize short gamma-ray bursts (sGRB) that are counterparts of gravitational wave (GW) sources
- Detectors: four CsI scintillators coupled with arrays of compact low-power Silicon photomultipliers (SiPMs).
  - Space qualify SiPMs
- Energy range: 30(50) keV - 1(2) MeV
- Spacecraft: based on NASA/GSFCs Dellingr platform with many components sources commercially-off-the-shelf (COTS).
- Complement existing/future facilities (Swift, Fermi/GBM, Glowbug, MoonBEAM, GRID…) and could be an interim GRB instrument before next generation missions fly.
- One BurstCube is funded, in the design phase, ready to launch late 2021, 6 month mission (1 year goal)

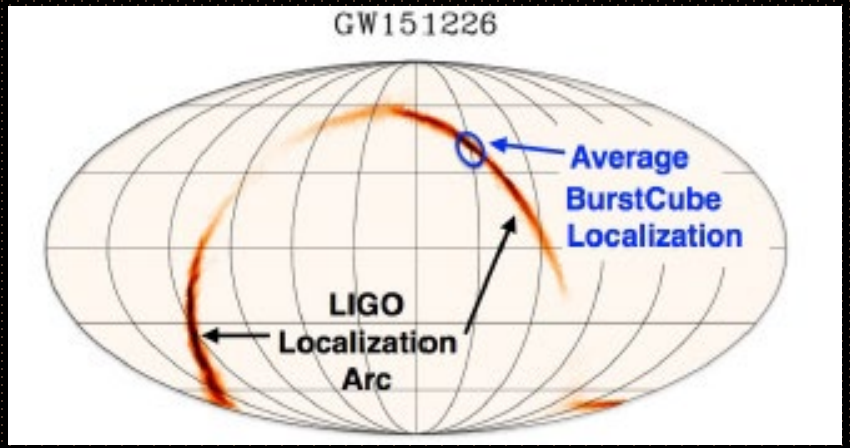
BurstCube Science I: GW Counterparts

- BurstCube will increase the sky coverage for short (<2 s) GRBs, especially important in the current era of GW discoveries.
- New GW detectors are coming online between now and 2021.
- The recent coincident detection of a sGRB (by Fermi and other multi-wavelength partners) and a GW trigger has provided concrete proof that at least some sGRBs are produced by BNS mergers.



BurstCube Science II: Localizations

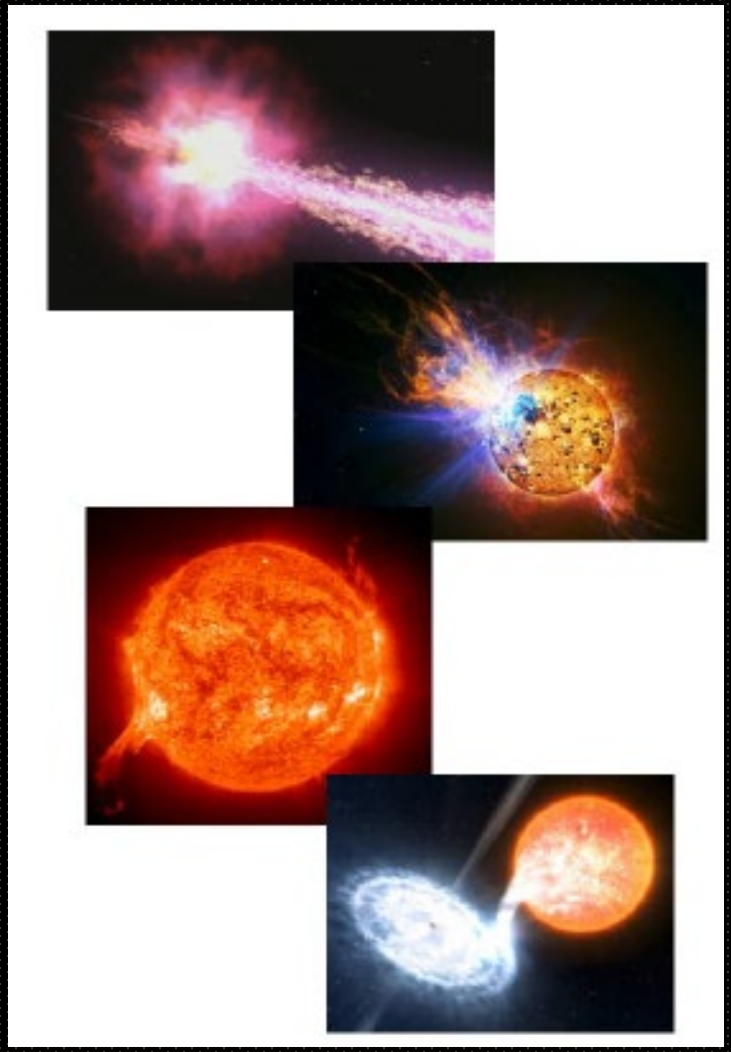




- Assist wide-field follow-up observers in afterglow detection and redshift measurement.
- Will lead to:
  - additional insight into cosmological parameter estimation,
  - constraint on the neutron star equation of state, and
  - an inventory of r-process elements in the Universe constrained by the faint short GRB kilonova signature (seen in the most recent event).

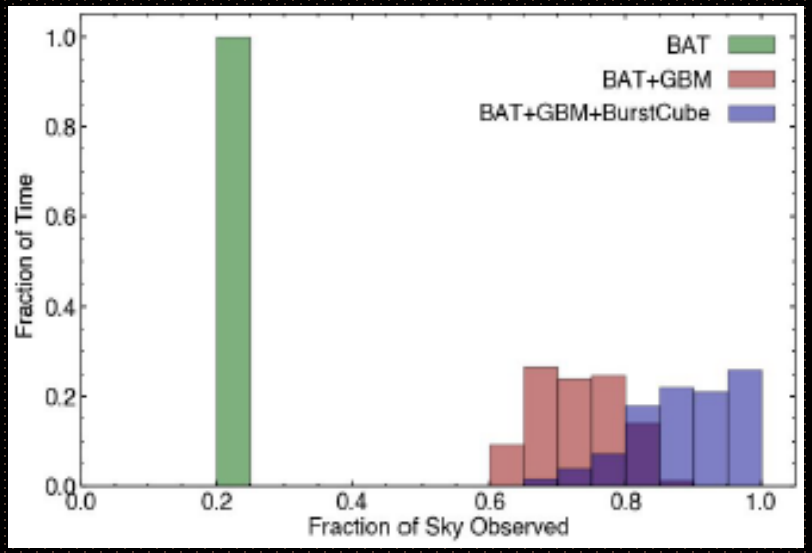
BurstCube Science III: General

- BurstCube will detect GRBs (long and short) from the entire unocculted sky
  - Providing broadband spectra for burst detected elsewhere
  - Rough localization for follow-up
  - Accurately timed light curves
- BurstCube will also detect solar flares, magnetar flares, and other hard X-ray transients, as well as persistent sources via occultation analysis
- BurstCube is complementary to current instruments
- On its own, BurstCube could provide all-sky coverage for a small fraction of the cost of an Explorer.



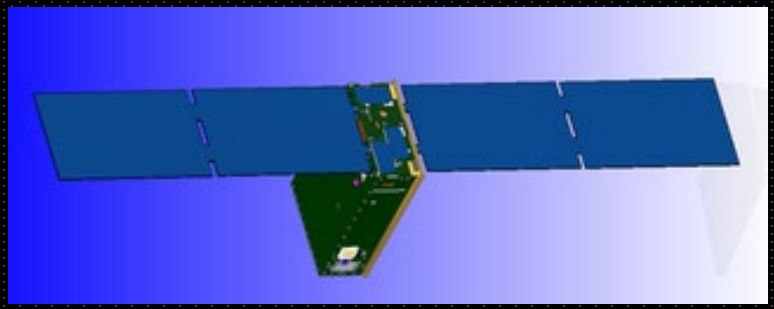
BurstCube Mission I: Concept

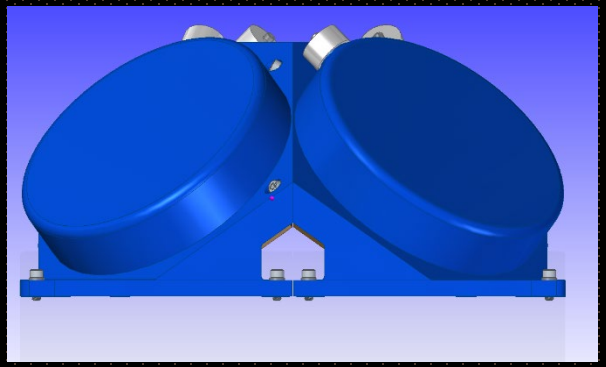
- BurstCube will detect, roughly localize, and characterize GRBs
- This approach is complementary to existing or upcoming facilities (e.g. Swift, Fermi, SVOM)
  - Especially if there is a gap between GRB missions operating at the peak of the GW observatory operations.
- As part of a "GRB Laboratory" in the sky, BurstCube increases sky coverage



BurstCube Mission II: Implementation

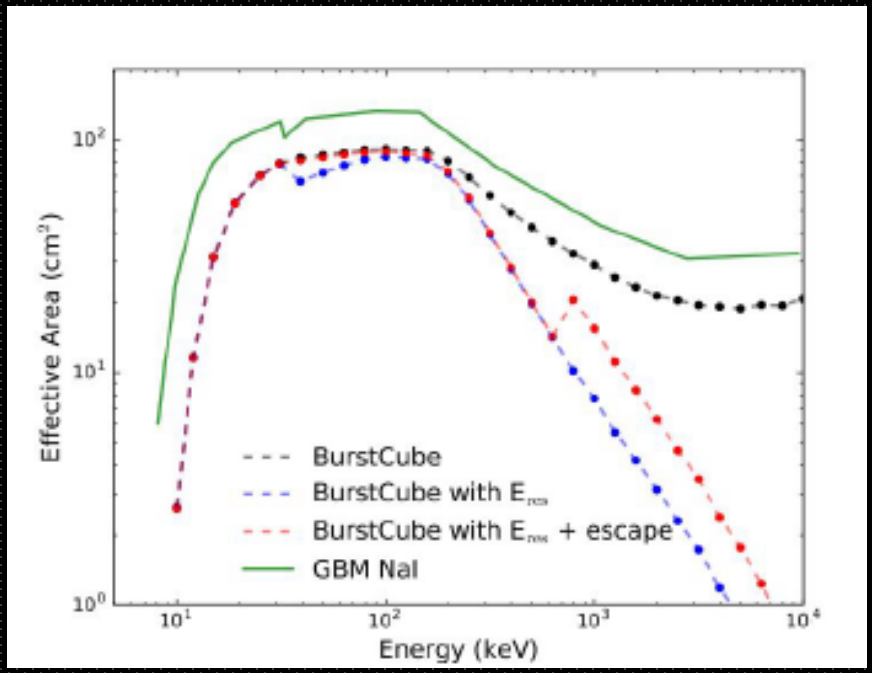
- BurstCube is a 6U CubeSat
  - Deployable Solar Panels & Full ACS System
  - 10 cm x 20 cm x 30 cm
- Instrument Package
  - 4 CsI scintillator crystals coupled to arrays of low-power SiPMs with custom electronics
  - 9 cm diameter, 1.9 cm thick
  - 120 SiPMs summed per crystal
- Zenith pointing
- BurstCube will relay data to the ground via TDRSS (5-15 minute goal)
- The instrument hardware and flight and ground software design relies heavily upon heritage from Fermi-GBM.





BurstCube Mission III: Performance

- Continuous science operations
- Expected detection of ~35 sGRBs/year
- Expected detection of > 100 long GRBs/yr in addition to other gamma-ray transients (solar flares, SGRs, etc.)
- Localizes GRBs based on relative intensities
- BurstCube has competitive performance with Fermi/GBM



Effective area is 70% that of the larger GBM NaI detectors at 100 keV and 15 degree incidence (MEGAlib based sims)

Towards a GRB Laboratory in the Sky

- In the next few years there will be multiple GRB detecting satellites in orbit
- These will be looking for transients and downlinking data to the community
- In Sept 2018 there was a international workshop on how to work together and maximize science output
- You're welcome to join this effort!

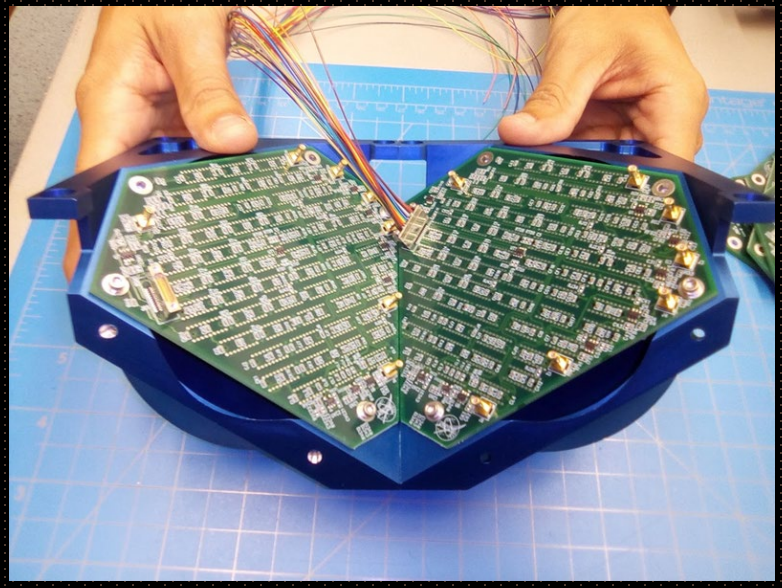
https://asd.gsfc.nasa.gov/conferences/grb_nanosats/

grb_nanosats_soc@bigbang.gsfc.nasa.gov.

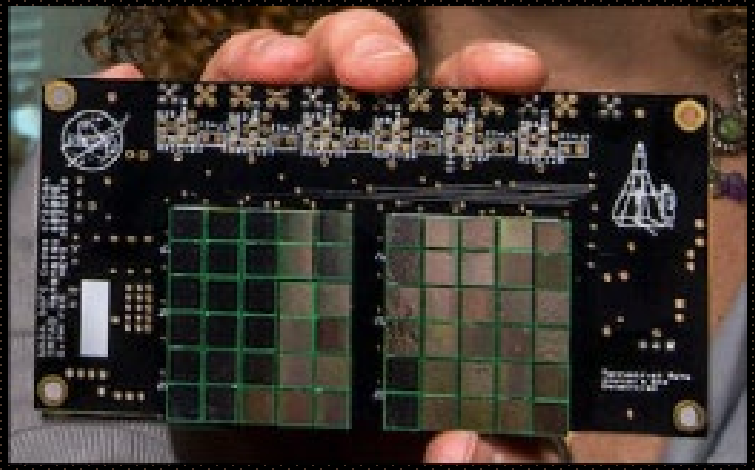
Contacts: Michelle Hui, Andras Pal, Jeremy Perkins, Judy Racusin, and Norbert Werner

BurstCube Updates

- Design and buildup for BurstCube is underway
  - Mechanical
  - Electrical
  - Communications (TDRSS)
- Prototype/Flight units of CsI crystals, SiPMs, and front-end electronics are ordered and in hand soon (some now)
- Testing SiPM array designs and proto-flight front-end electronics
- Developing efforts towards a network of GRB detectors



Proto-flight unit



Preliminary SiPM testing module