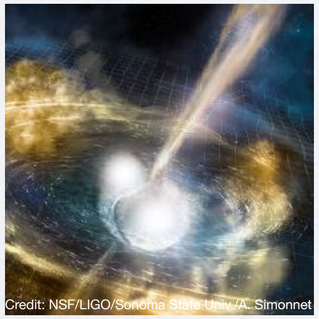
Moon Burst Energetics All-sky Monitor

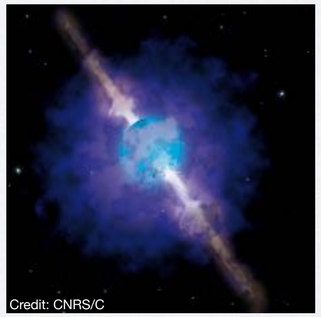
OVERVIEW

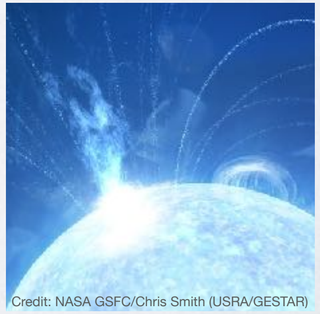
- Moon Burst Energetics All-sky Monitor is 3-year gamma-ray mission in cislunar orbit to explore the behavior of matter and energy under extreme conditions.
- Gamma-ray observations are an essential component to multi-wavelength and multi-messenger observations of relativistic astrophysical explosions.
- MoonBEAM provides key capabilities that are difficult to achieve in Low Earth Orbit:
  - instantaneous all-sky gamma-ray field of view
  - uninterrupted observations with >96% duty cycle
  - background radiation stability
- 3 years of mission operation will provide observations of:
  - 1600 binary compact mergers
  - 5900 optically discovered core collapse supernovae
  - 140 magnetar giant flares
  - and enables 55 very high energy gamma-ray and 360 optical follow-up observations.

Proposed to 2021 Astrophysics Explorers Mission of Opportunity


Credit: NSF/LIGO/Sonoma State Univ./A. Simonnet

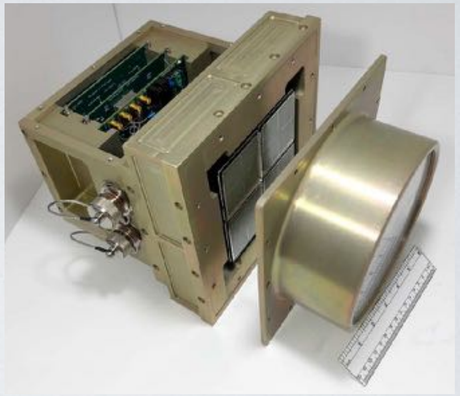

Credit: Carl Knox, OzGrav-Swinburne University

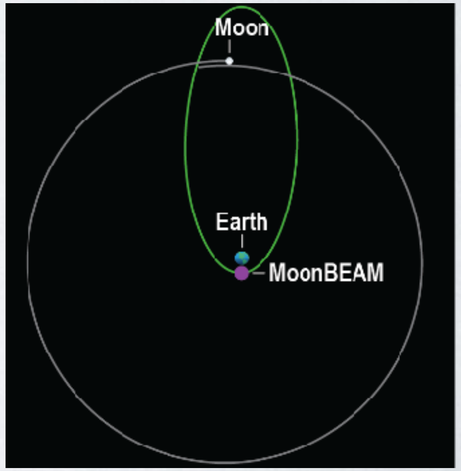

Credit: CNRS/C


Credit: NASA GSFC/Chris Smith (USRA/GESTAR)

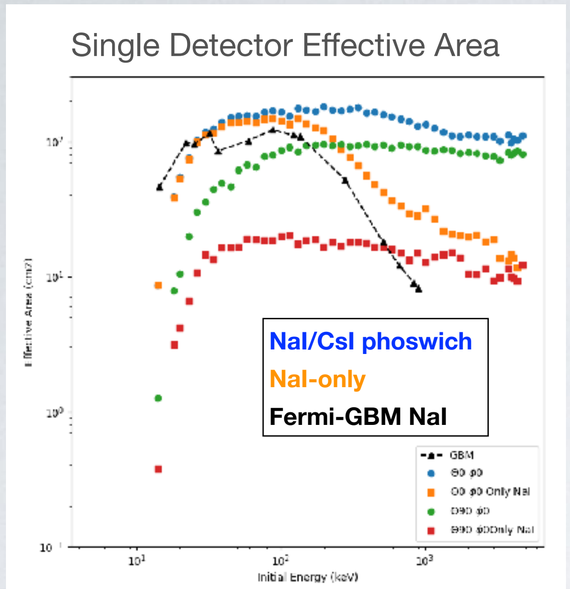
MISSION DESIGN

- Instrument
  - 6 scintillating detectors positioned for instantaneous all-sky coverage, no pointing needed.
  - each detector module consists of a NaI(Tl)/CsI(Na) phoswich and flat panel PMTs, sensitive to 10—5000 keV.
  - phoswich design enables simultaneous dual-mode observations:
    - low background, direction dependency for localization
    - wide energy range and wide field-of-view for spectroscopy
- Lockheed Martin SmallSat spacecraft bus
  - reusing >90% of high-maturity Lunar Trailblazer design.
  - compatible with ESPA Grande mass and volume constraint.
  - high-heritage deep space propulsion approach to lunar resonant orbit from *any* Geosynchronous Transfer Orbit (GTO) rideshare launch.
- Orbital distance up to 460,000km from Earth (1.5 light-seconds).
- Orbital period of 13.7 days.
- Mission lifetime of 3 years.
- Communication
  - continuous burst alert coverage with dedicated ground stations.
  - daily data downlink with the Near Space Network.

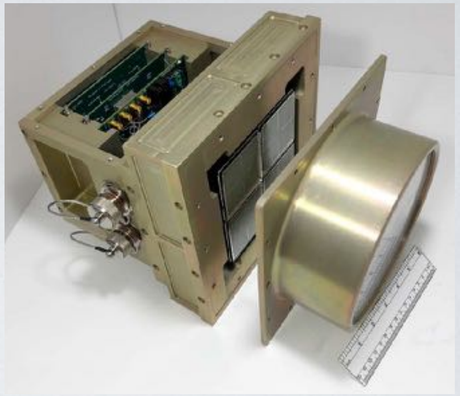


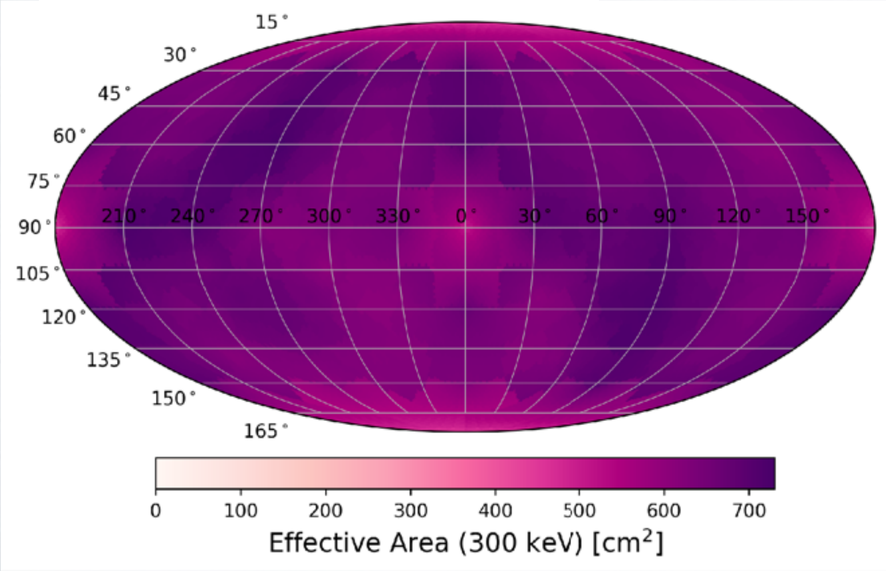


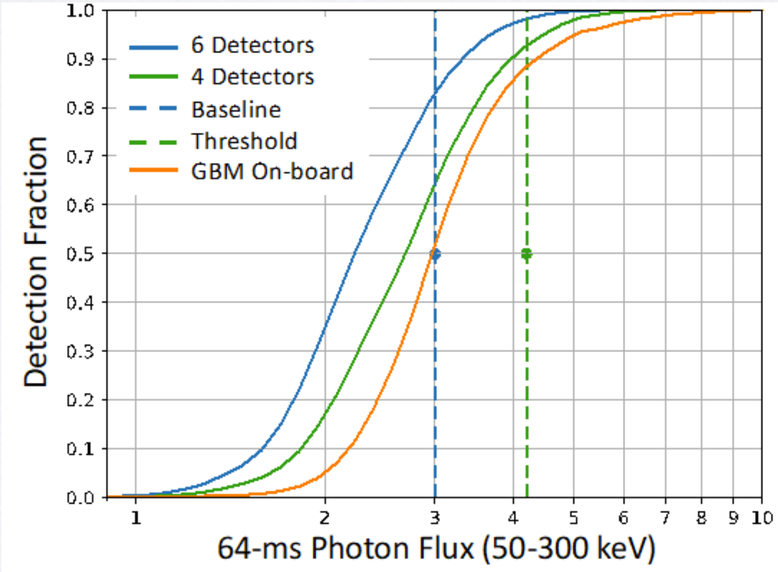
INSTRUMENT PERFORMANCE

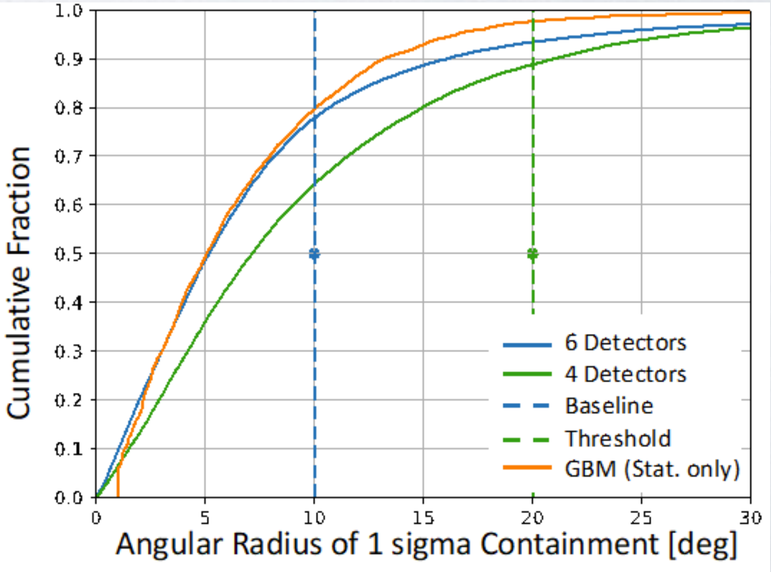


- Instrument
  - 6 scintillating detectors positioned for **instantaneous all-sky coverage, no pointing needed**.
  - each detector module consists of a NaI(Tl)/CsI(Na) phoswich and flat panel PMTs, sensitive to 10—5000 keV.
    - ▸prompt GRB peak energy range
  - phoswich design enables simultaneous dual-mode observations:
    - low background, direction dependency for localization
    - wide energy range and wide field-of-view for spectroscopy

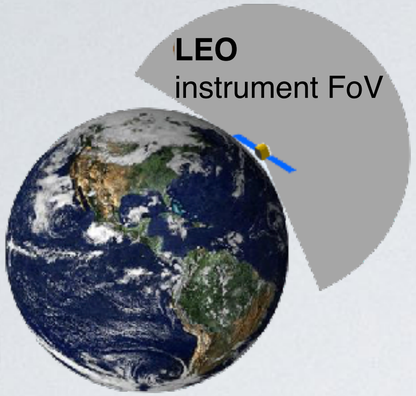




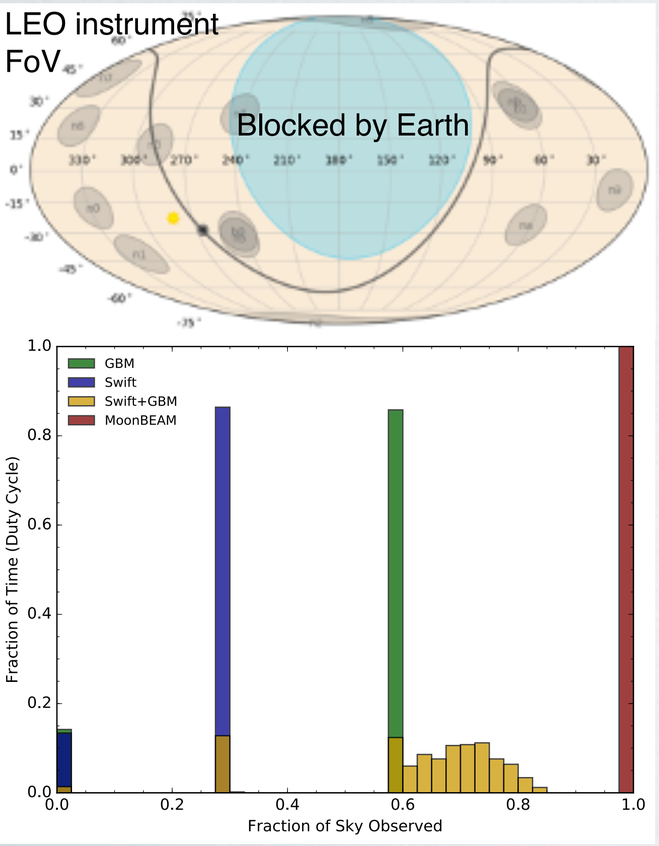


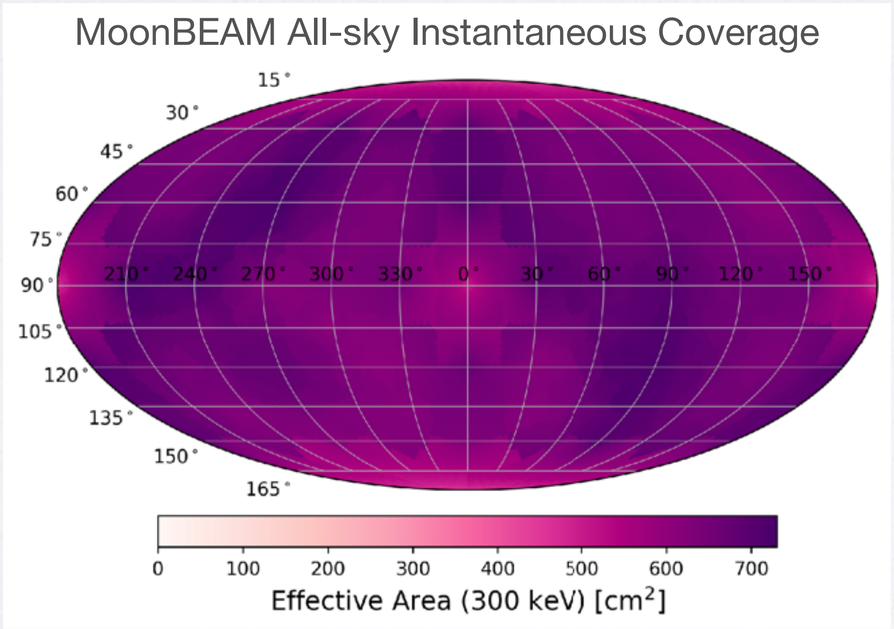


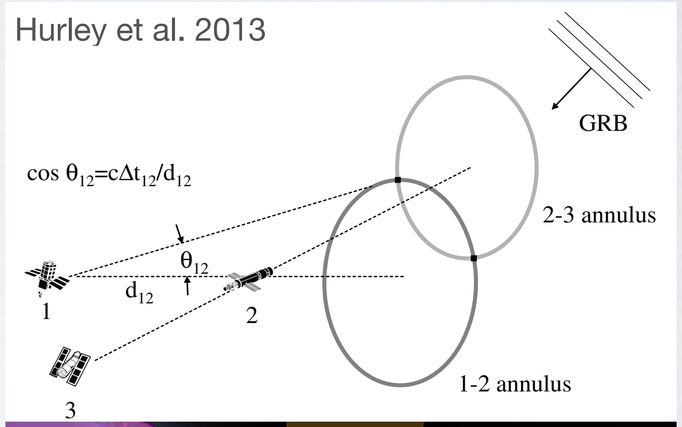
MISSION CAPABILITY

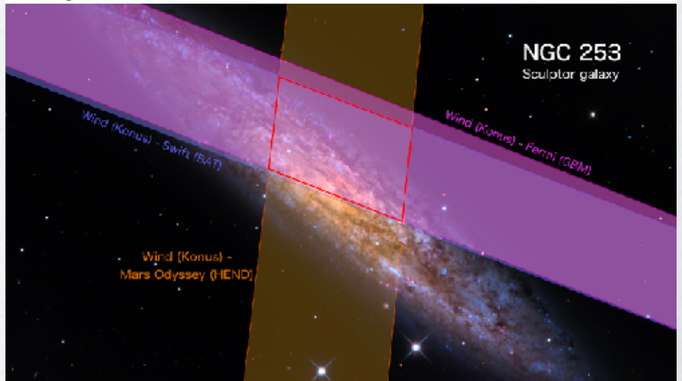


- Orbital distance 22,000km to 460,000km from Earth (up to 1.5 light-seconds).
  - **Instantaneous all-sky field of view**: Earth occults ~2% of the sky at closest approach, <<1% on average.
  - **high duty cycle >96%, 13+ days uninterrupted livetime**: no passage through the South Atlantic Anomaly (SAA).
  - **more stable background** compared to Low Earth Orbit: no atmospheric scattering and SAA-related radiation.
  - **additional localization improvement** using timing triangulation technique with other gamma-ray missions.

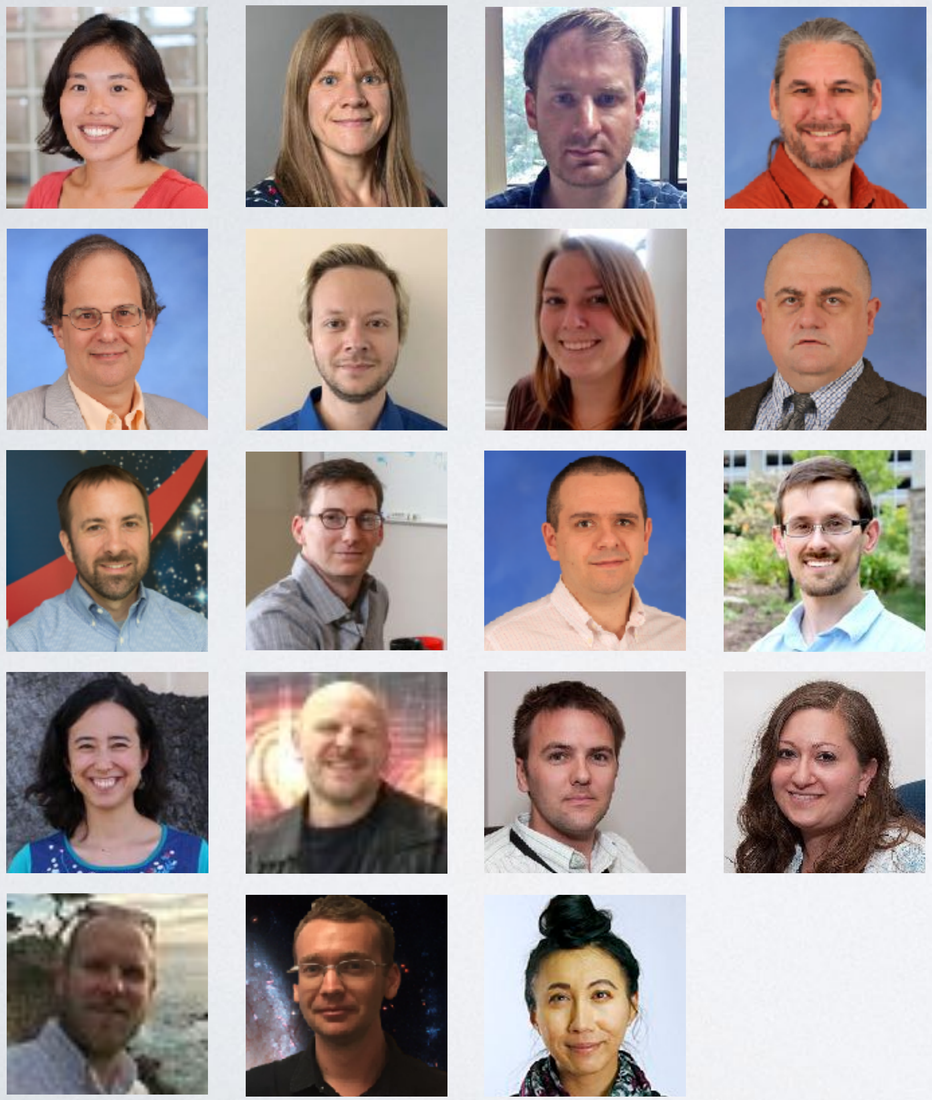








SCIENCE TEAM

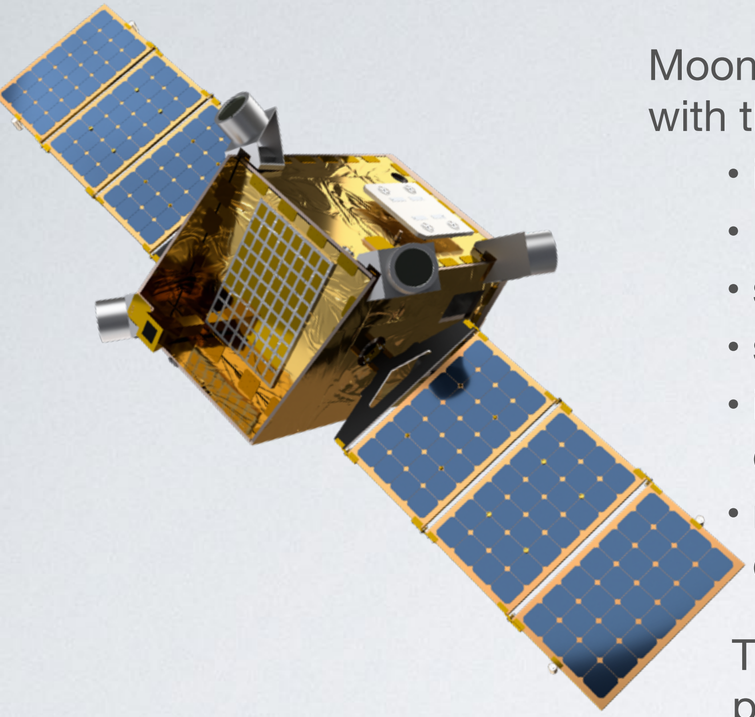


PI: C. Michelle Hui (MSFC)
Deputy PI: Colleen Wilson-Hodge (MSFC)
Project Scientist: Adam Goldstein (USRA)
Instrument Scientist: Peter Jenke (UAH)

Co-Is:
Michael Briggs (UAH)
Eric Burns (LSU)
Corinne Fletcher (USRA)
Boyan Hristov (UAH)
Daniel Kocevski (MSFC)
Tyson Littenberg (MSFC)
Peter Veres (UAH)
Joshua Wood (MSFC)

Collaborators:
Anna Ho (UC Berkeley)
Eric Howell (UWA)
Jeremy Perkins (GSFC)
Judith Racusin (GSFC)
Oliver Roberts (USRA)
Jacob Smith (GSFC)
Sylvia Zhu (DESY Zeuthen)

SUMMARY



MoonBEAM provides essential gamma-ray observations of relativistic astrophysical transients with the following capabilities:

- instantaneous all-sky field of view from lunar resonant orbit.
- 13+ days of uninterrupted livetime.
- stable background for ultra long duration GRBs.
- sensitive to prompt GRB emission energy range, with broad coverage for spectroscopy.
- independent localization and longer baseline for additional localization improvement with other gamma-ray missions.
- rapid alerts to the astronomical community for contemporaneous and follow-up observations.

The era of transient and multi-messenger astronomy: to construct a comprehensive picture of stellar explosions, simultaneous broadband observations are needed.

Potential future collaborations with MoonBEAM:

- LIGO Laboratory
- IceCube Neutrino Observatory
- InterPlanetary Network for Gamma-ray Bursts
- Cherenkov Telescope Array Consortium
- Southern Wide-field Gamma-ray Observatory

Astro2020 Decadal Survey: Astronomical Transient Events

"Higher sensitivity all-sky monitoring of the high-energy sky, complemented by capabilities in the optical such as from Kepler and TESS, is a critical part of our vision for the next decade in transient and multi-messenger astronomy."