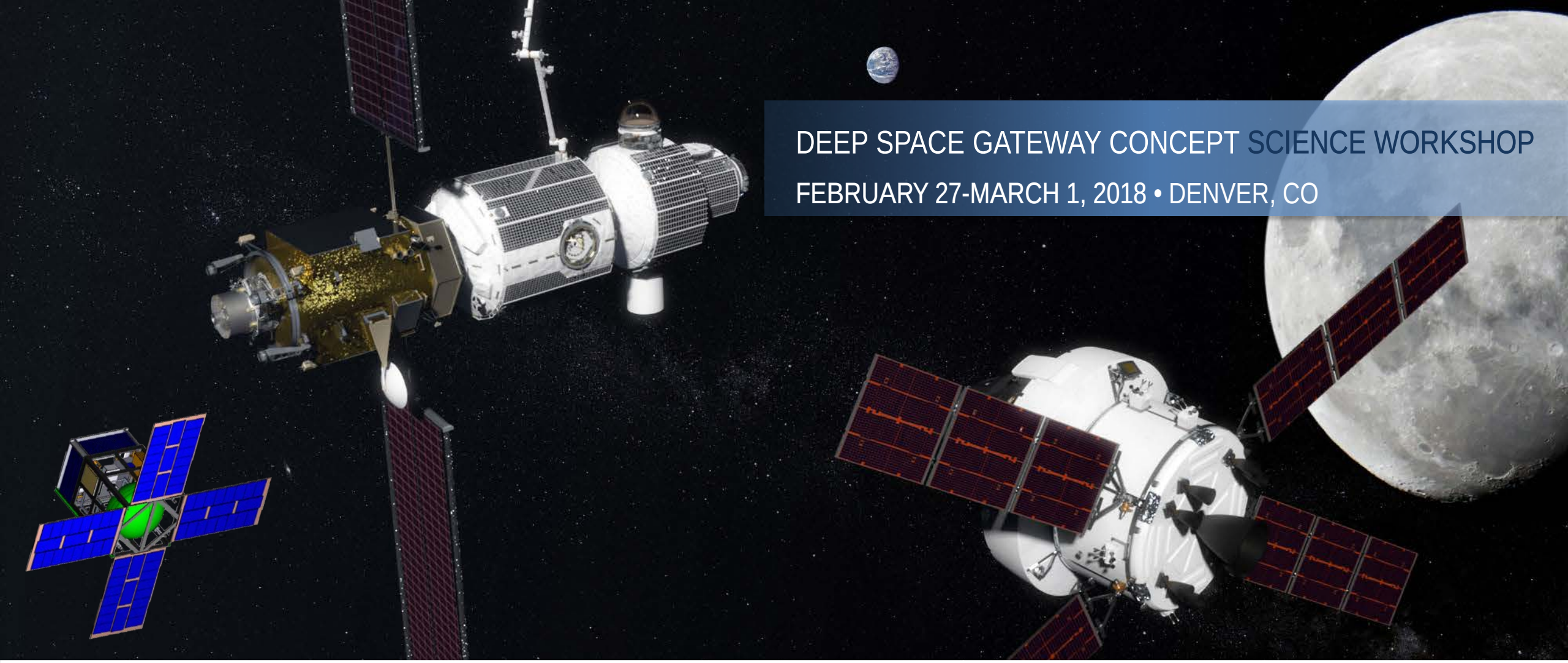


DEEP SPACE GATEWAY CONCEPT SCIENCE WORKSHOP

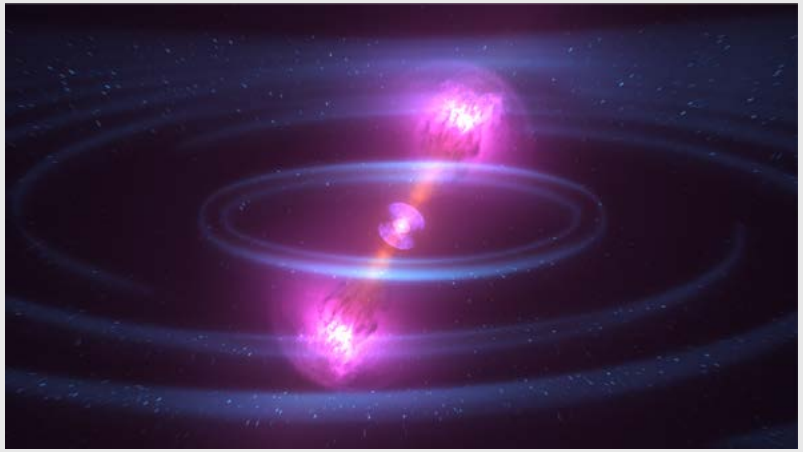
FEBRUARY 27-MARCH 1, 2018 • DENVER, CO

MoonBEAM: A Beyond-LEO Gamma-ray Burst Detector for Gravitational-Wave Astronomy

Feb 27, 2018

C. Michelle Hui, Research Astrophysicist, NASA/MSFC

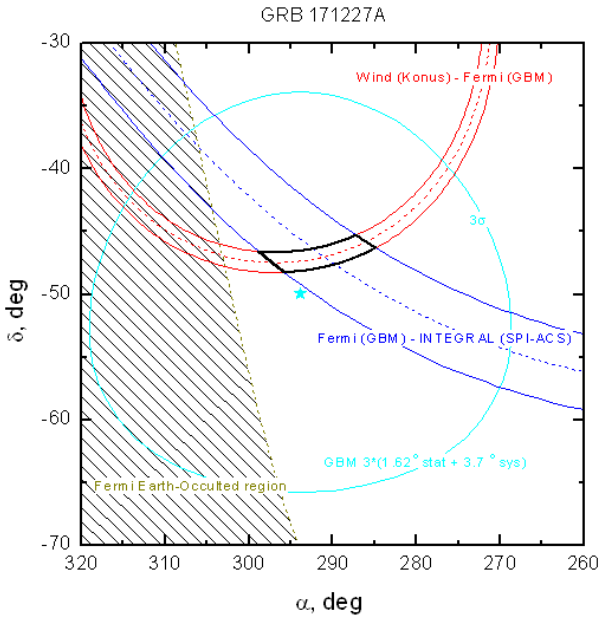
Instrument Function Statement and Gateway Usage

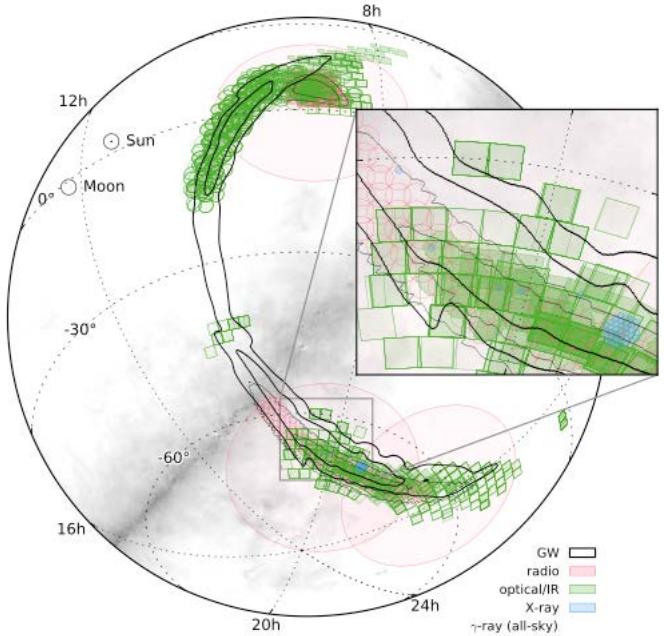
STATEMENT	INSTRUMENT/CONCEPT DETAILS
FUNCTION STATEMENT 	• Improve localization precision for gamma-ray bursts (GRBs) by utilizing the light travel time difference between instruments in lunar and Earth orbits. • Increase sky coverage and the number of GRB detections. Current GRB all-sky monitor (*Fermi*-GBM) covers 70% of the sky instantaneously and location precision no better than a few degrees. • Probe the extreme processes in cosmic collision of compact objects and facilitate multi-messenger time-domain astronomy to explore the end of stellar life cycles and black hole formations.
WHY IS THE GATEWAY THE OPTIMAL FACILITY FOR THIS INSTRUMENT/RESEARCH?	• Cislunar space can improve localization for 20+ short GRBs per year with 1+ second time difference paired with an Earth-orbit instrument, more if searching below trigger threshold events in continuous data coincident with triggers from another instrument. • A reduction of 50% is achievable for the average short GRB when viewed at a 45◦ angle to the baseline of the two instruments. • Fast, timely communication is still possible compared to other planetary orbits.

Instrument Function Statement and Gateway Usage

The Interplanetary Gamma-Ray Burst Timing Network demonstrated an average improvement by a factor of 180 relative to *Fermi*-GBM when combining with additional detection from another spacecraft in a different orbit.

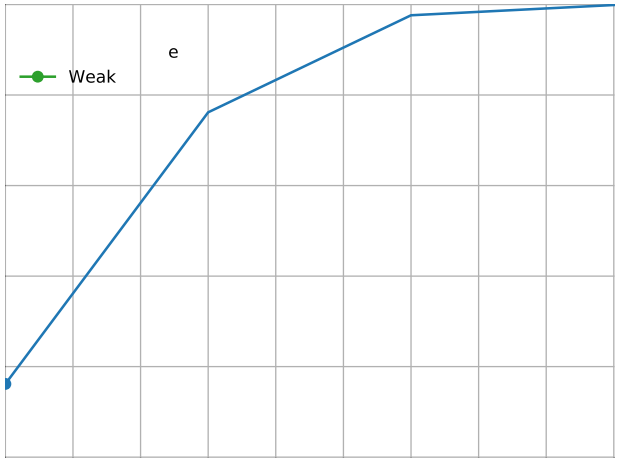
- Low Earth Orbit is <0.1s, improvement to only top 5% brightest short GRBs.
- Cis-lunar space gives ~1.3 seconds time difference, still close enough for rapid communication.





Localization area reduction relative to *Fermi*-GBM assuming 385,000 km baseline for short GRBs with different intensities.

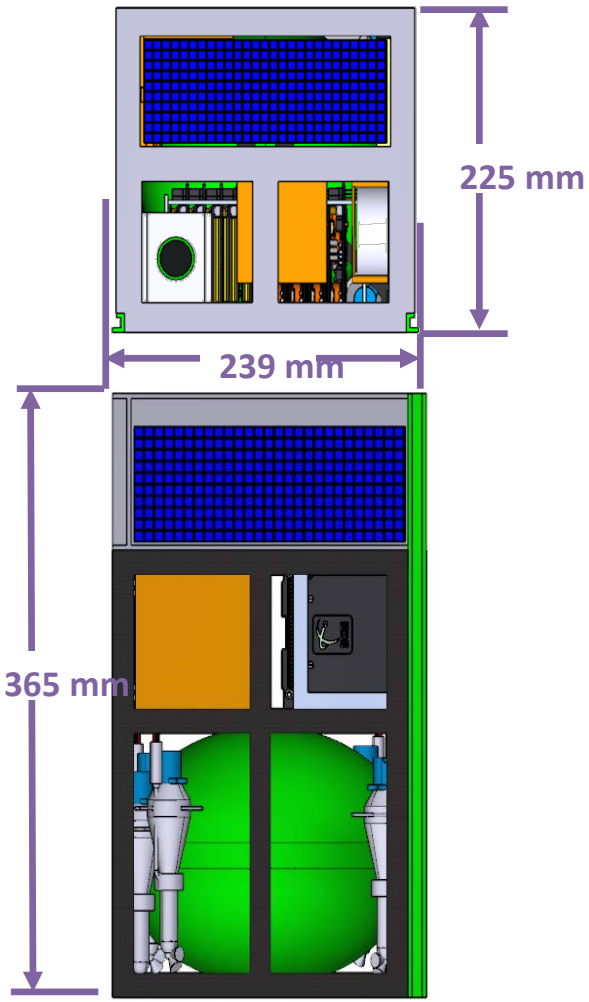
A >50% area reduction is achievable for short GRBs with average brightness at a baseline angle of 45deg.

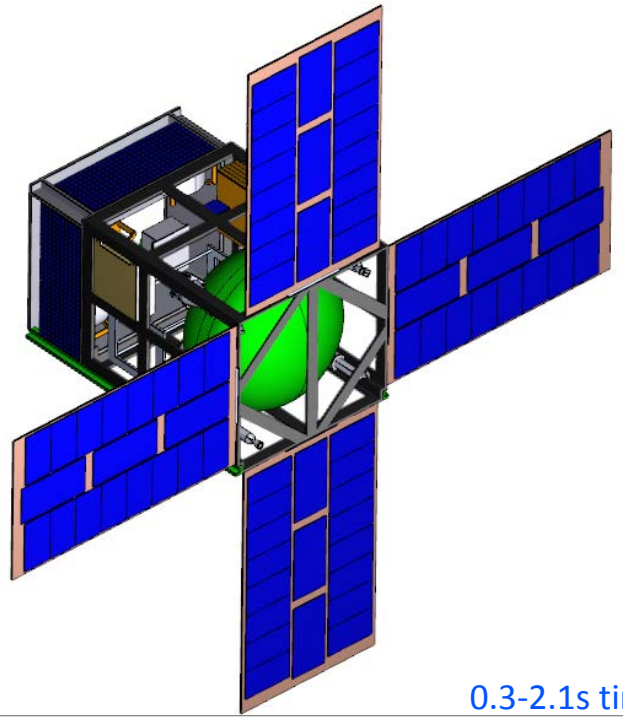


Tiling observations done by different instruments for the first gravitational wave detection sky contours [ApJL 826, L13, 2016].

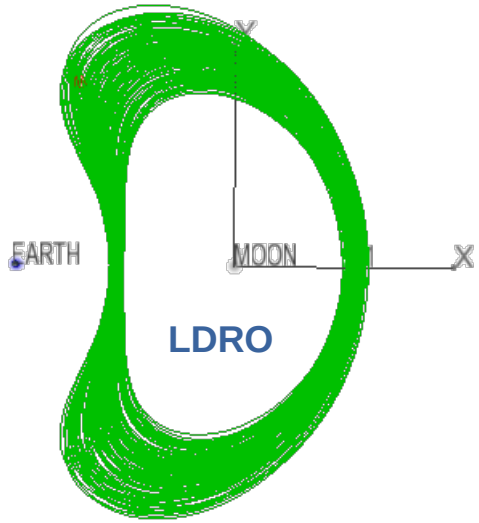
Most instruments have small viewing and rapid followup is difficult when localization area is large.

Instrument Function Statement and Gateway Usage

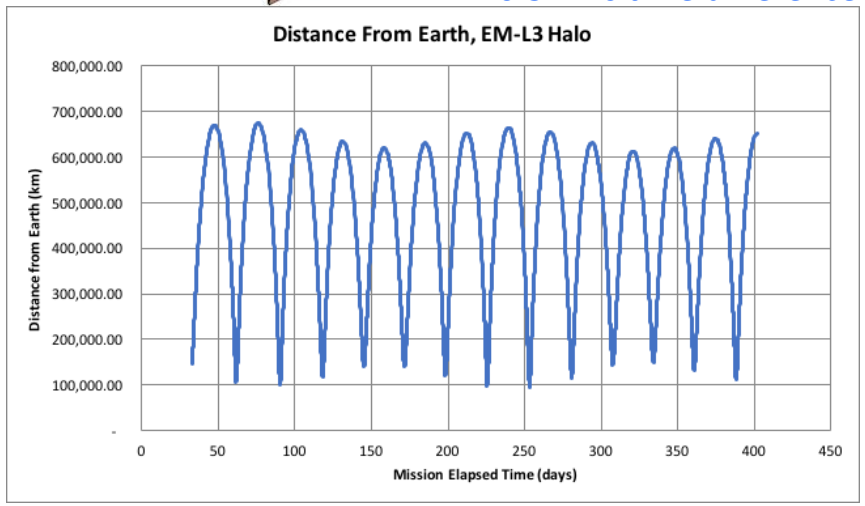


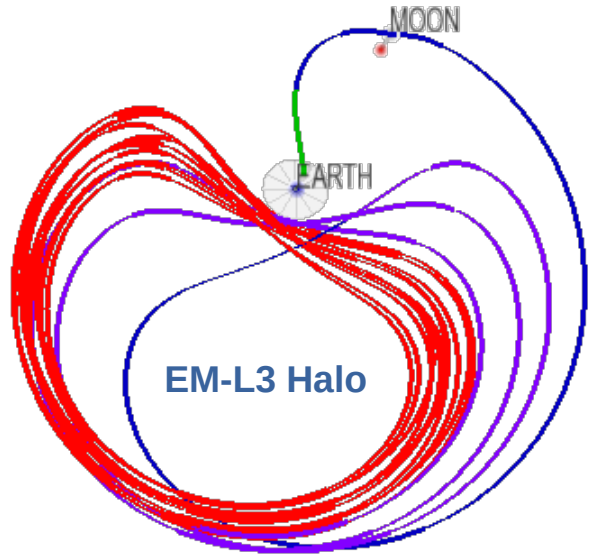


TESS-type orbit



0.3-2.1s time difference





Basic Instrument Parameters – CubeSAT deployment

PARAMETER	INSTRUMENT ESTIMATE & ANY COMMENTS
MASS (KG)	24.73* kg (Earth deployment assumed, 20% mass in propulsion system; 13% avg margin included).
VOLUME (M)	12U
POWER (W)	38W for Science operation, max 82W during burn (provided by solar panels and battery).
THERMAL REQUIREMENTS	0 – 40C operating temperature.
DAILY DATA VOLUME	250MB/day, transfer as frequently as possible. Occasional uplink for software updates (~MB).
CURRENT TRL	Thruster configuration + propellant combination currently not yet flight qualified. UHF crowdsource communication is uncommon. Everything else is flight ready.
WAG COST & BASIS	$15mil (including 35% reserves, launch vehicle cost excluded; FY18 dollars based on NASA inflation tables).
DURATION OF EXPERIMENT	2 years desired, 1 year minimum.
OTHER PARAMETERS	Event triggered data transfer: 100kb/trigger, up to 10 triggers per day, preferably within minutes. 20kbps downlink planned with crowdsource UHF, 1kbps for command uplink.

Instrument Gateway Usage – CubeSAT deployment

USAGE	INSTRUMENT REQUIREMENTS & COMMENTS
ORBIT CONSIDERATIONS	Earth-Moon L3, Lunar DRO, TESS-type.
FIELD OF VIEW REQUIREMENTS	All-sky.
REQUIRES USE OF AIRLOCK	Depends on how cubeSATs are launched.
CREW INTERACTION REQUIRED?	No.
WILL ASTRONAUT PRESENCE BE DISRUPTIVE?	If they are in front of the detectors during operations.
DOES THE INSTRUMENT PRESENT A RISK TO THE CREW	May need propellant to achieve cubeSAT orbit.
OTHER CONSUMABLES REQUIRED	None.
SPECIAL SAMPLE HANDLING REQUIREMENTS	None.
NEED FOR TELEROBOTICS?	No.
OTHER REQUIREMNTS OF THE GATEWAY?	Triggered low-latency communication link.

Basic Instrument Parameters – External Mount alternative

PARAMETER	INSTRUMENT ESTIMATE & ANY COMMENTS
MASS (KG)	~5kg (detectors only; no margins, more to include structure etc.).
VOLUME (M)	~4U
POWER (W)	38W for Science operation (directly from cubeSAT design, which includes avionics and communication; detectors only need 5W).
THERMAL REQUIREMENTS	0 – 40C operating temperature.
DAILY DATA VOLUME	250MB/day, transfer as frequently as possible. Occasional uplink for software updates (~MB).
CURRENT TRL	Flight ready.
WAG COST & BASIS	$750k (from cubeSAT science instrument cost estimate).
DURATION OF EXPERIMENT	2 years desired, 1 year minimum.
OTHER PARAMETERS	Event triggered data transfer: 100kb/trigger, up to 10 triggers per day, preferably within minutes. 20kbps downlink planned with crowdsource UHF, 1kbps for command uplink.

Instrument Gateway Usage – External Mount alternative

USAGE	INSTRUMENT REQUIREMENTS & COMMENTS
ORBIT CONSIDERATIONS	
FIELD OF VIEW REQUIREMENTS	All-sky.
REQUIRES USE OF AIRLOCK	Depends on how external mount works.
CREW INTERACTION REQUIRED?	No.
WILL ASTRONAUT PRESENCE BE DISRUPTIVE?	If they are in front of the detectors during operations.
DOES THE INSTRUMENT PRESENT A RISK TO THE CREW	No, instrument consists of stationary gamma-ray detectors.
OTHER CONSUMABLES REQUIRED	None.
SPECIAL SAMPLE HANDLING REQUIREMENTS	None.
NEED FOR TELEROBOTICS?	No.
OTHER REQUIREMNTS OF THE GATEWAY?	Triggered low-latency communication link.

References and Status of Work in this Field

Gamma-ray coverage from Earth – the near future

- Fermi gamma-ray space telescope is currently operating, there are also other smaller field-of-view gamma-ray instruments in operation in Earth orbit.
- Gamma-ray cubeSATs in Earth orbit to monitor transients are being proposed. Concept studies of gamma-ray probe missions are also moving forward.

Backup/Additional Information