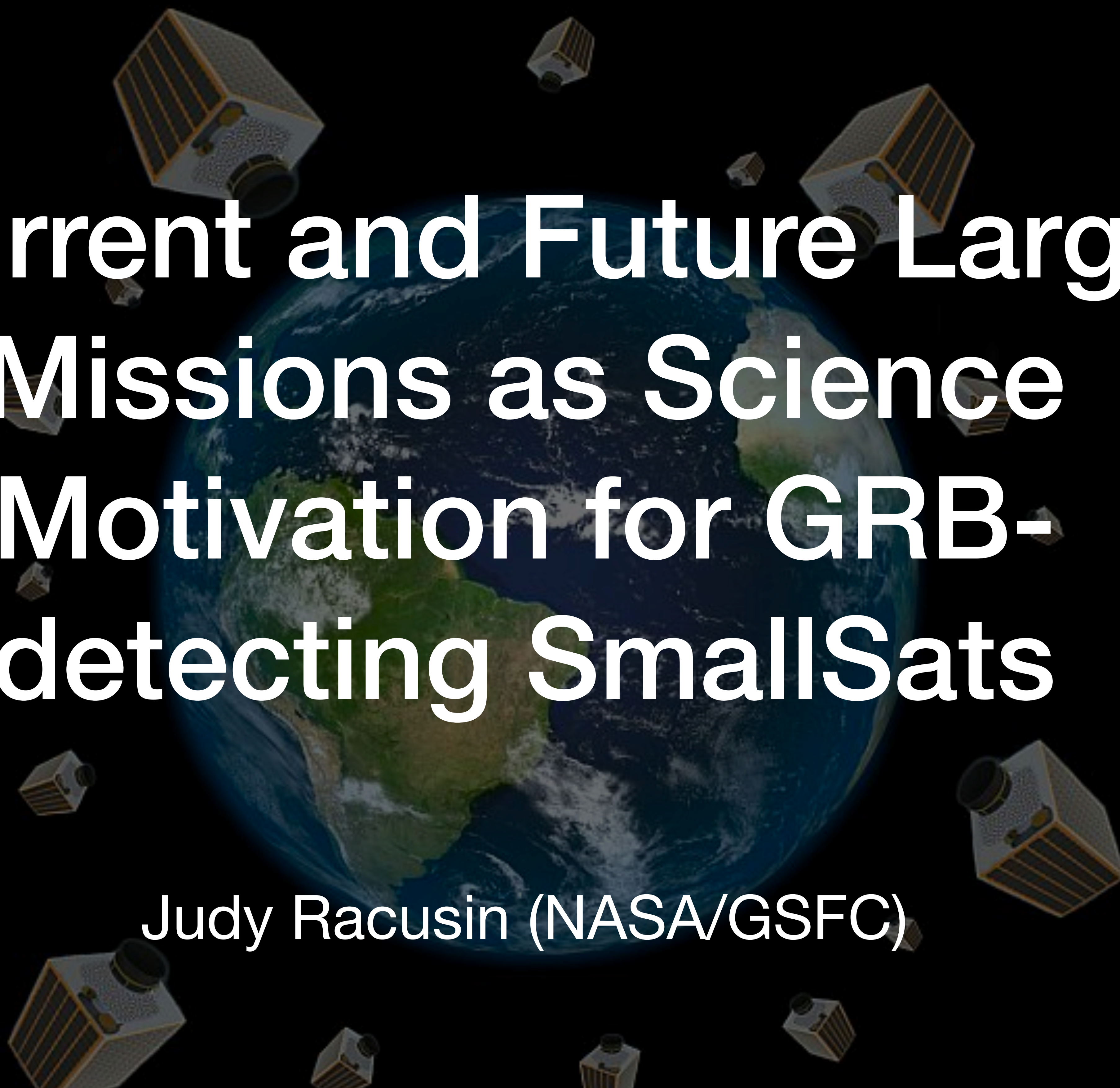


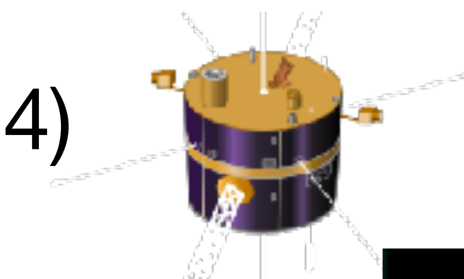
Current and Future Large Missions as Science Motivation for GRB-detecting SmallSats

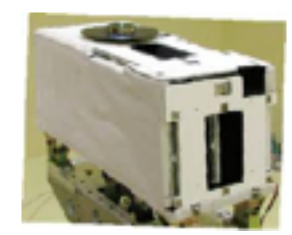
Judy Racusin (NASA/GSFC)

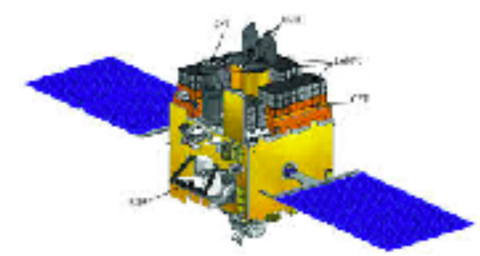
Towards a Network of GRB Detecting Nanosatellites, Budapest, September 2018

Current Suite of Large GRB-Detecting Missions

- Konus-WIND (launched 1994)
- INTEGRAL (launched 2002)
- Swift (launched 2004)
- Fermi (launched 2008)
- MAXI (launched 2009)
- AstroSAT (launched 2015)
- CALET (launched 2015)
- HXMT (launched 2017)
- [IPN only missions - Messenger, Odyssey]







History of Large GRB Missions

- Have led to the detection of 1000’s of GRBs
- >23k GCN circulars - including follow-up observations
- Focus on detecting faint GRBs over small area of the sky with excellent follow-up or detecting bright GRBs over large area of sky
- GRB detectors - sometimes optimized for GRBs and sometimes secondary science
- Open Questions motivating new missions
  - Gravitational Wave Counterparts
  - Jet Composition - Polarization
  - High-redshift GRBs as probes of cosmic chemical evolution
  - New sub-classes (ultra long, short with extended emission, hyper-energetic, nearby sub-luminous SN-GRBs)

Large Missions

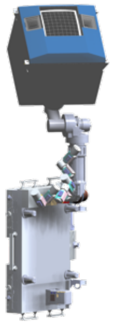
- Benefits:
  - sensitivity/wide FoV - lots of GRBs
  - automated multi-wavelength follow-up observations
  - rapid communications, ample power/mass
  - large teams
- Downsides:
  - cost $€¥£₩₨
  - long development timescale
  - large teams
  - requires large space program and/or big international efforts
  - requires well-developed low-risk technologies

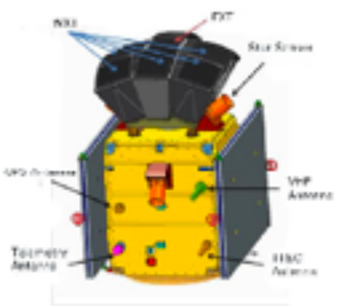
SmallSat Missions

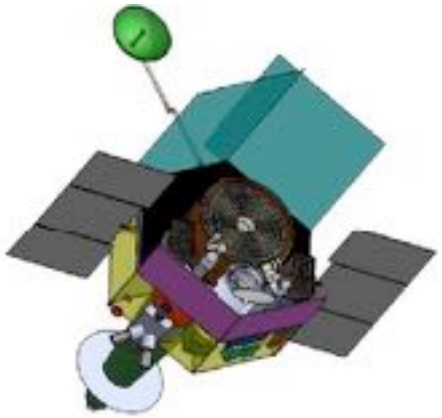
- Benefits:
  - short timescale development
  - low cost $€¥£₩₨
  - can be used to develop/qualify new technologies
  - can be build by students/universities without significant space hardware experience
  - lots of commercial off the shelf components
  - small teams
- Downsides:
  - mass/power limitations
  - rapid communications is harder
  - small teams

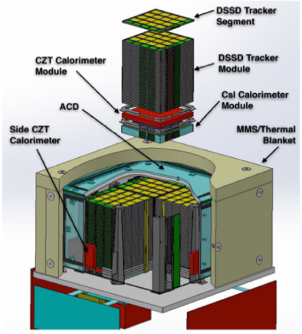
Future Large GRB-Detecting Missions

- SVOM (launch 2021)
- ISS-TAO (pending down-select in 2019, launch 2022)
- Einstein Probe (launch 2023)
- TAP (pending US Decadal Survey, launch ~2028)
- AMEGO (pending US Decadal Survey, launch ~2028)
- Nimble (NASA SMEX concept, launch ~2025)
- THESEUS (pending down-select in 2021, launch 2032)
- Others?



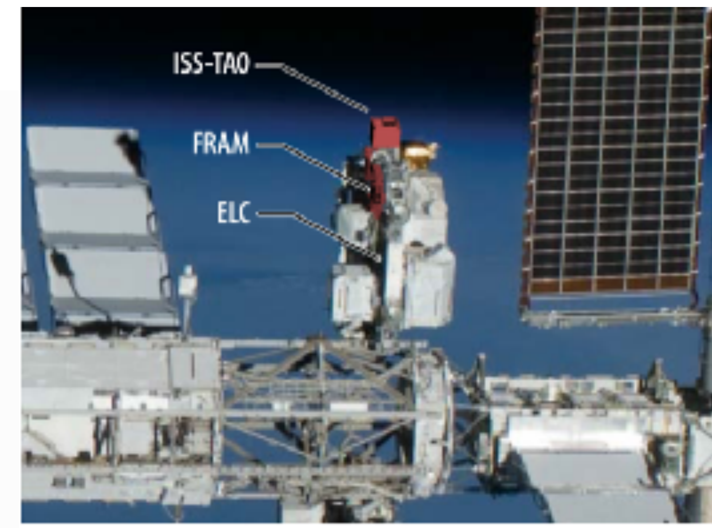


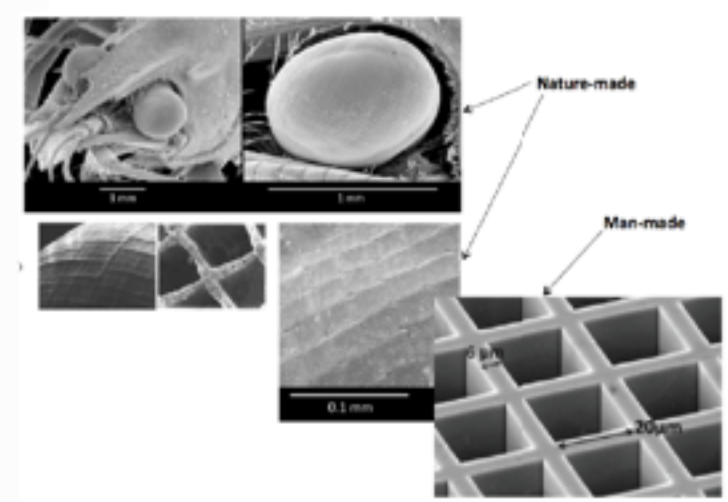




Transient Astrophysics Observatory on the ISS (ISS-TAO)

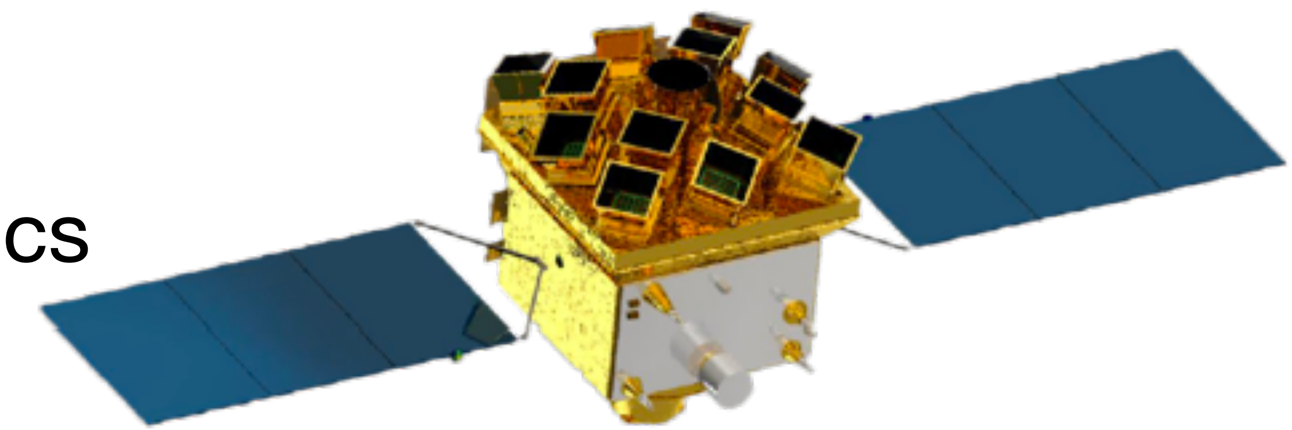
- Mission of Opportunity (MoO) proposed in 2016, currently in Phase A study
- ISS payload designed for ELC-3 inboard port
- ISS benefits and challenges
  - ample power, continuous uplink/downlink 87% of the time, sufficient data rates
  - complicated background, field of regard
- Instruments
  - Gamma-ray Transient Monitor (GTM)
  - Wide-field Imager (WFI)
- Operations:
  - Sky Survey & Target of Opportunity
  - Rapid (4 deg/s) autonomous repointing to new transients
- 2 year mission (5 year goal)
- launch in early-2022

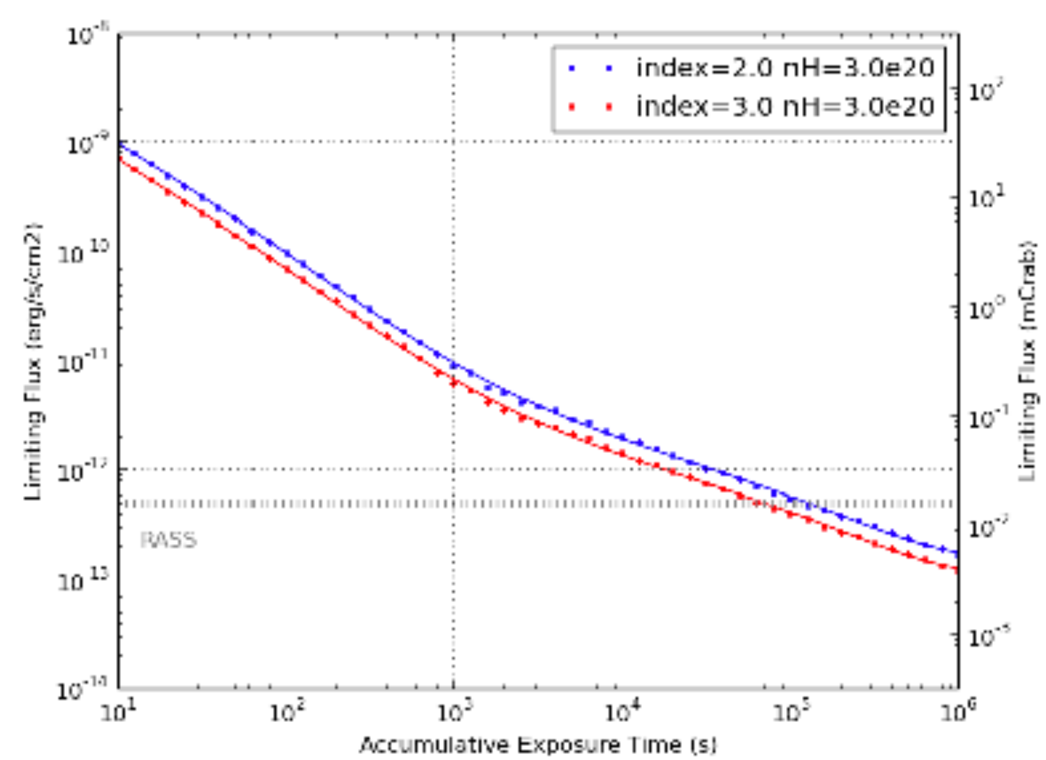




Einstein Probe

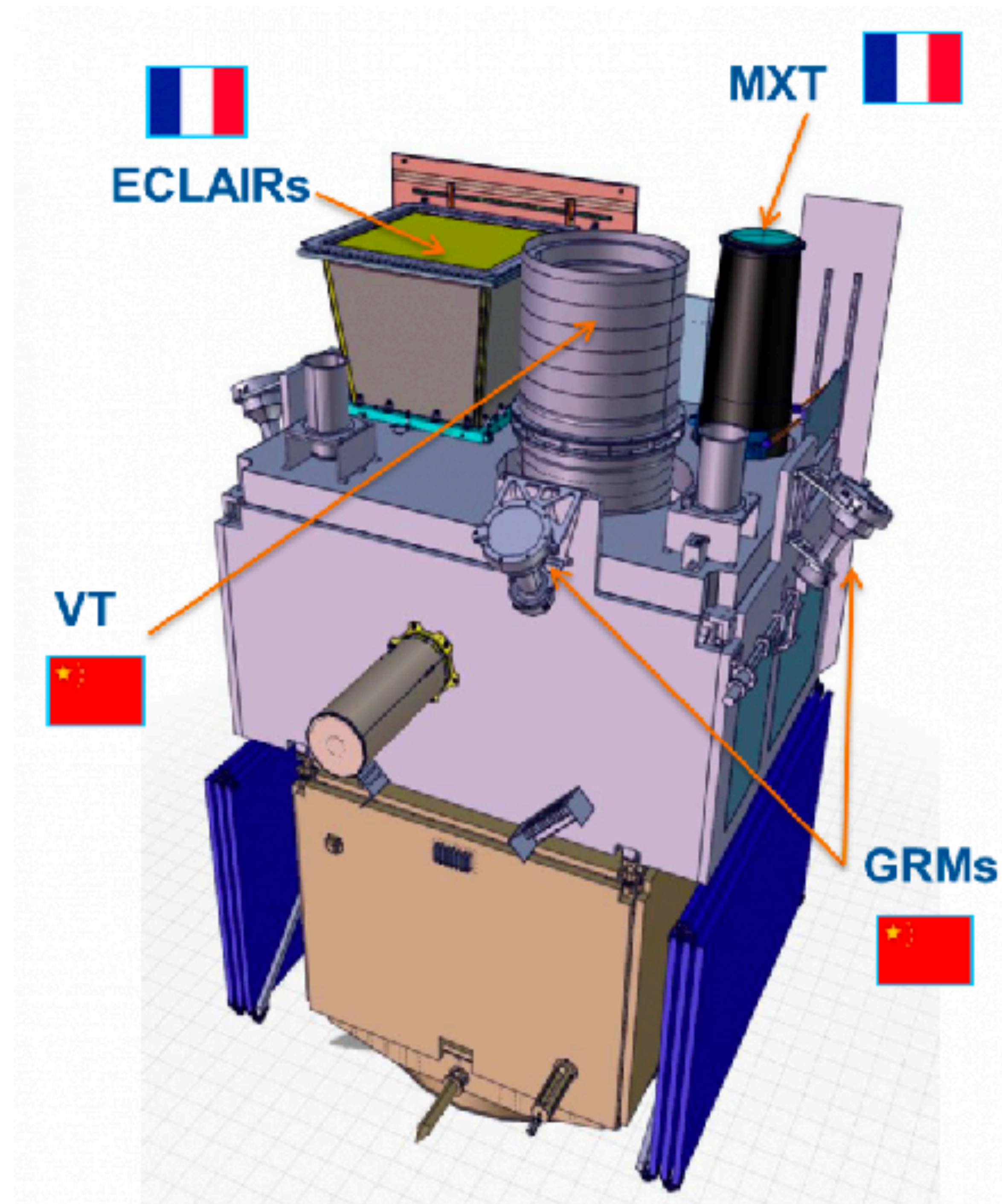
- Small Chinese Mission to launch by end of 2022
- Lobster micro-channel plate optics with CMOS focal plane (x12)
  - 0.5-4 keV
  - 3600 deg^2 FoV
- Follow-up X-ray Telescope (0.5-10 keV)
- X-ray transient discovery mission
- Rapid localization and follow-up
- http://ep.bao.ac.cn/





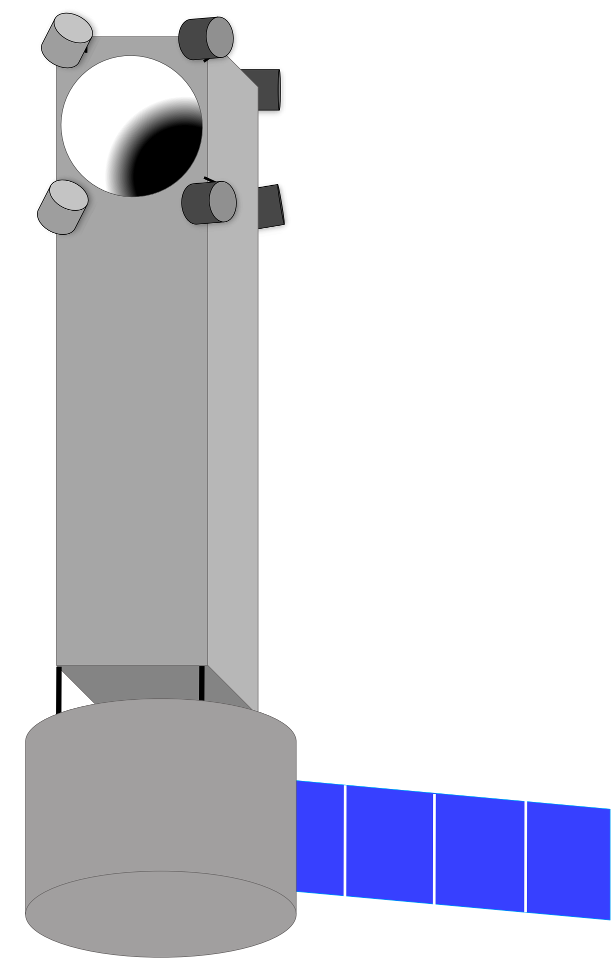
SVOM

- See Stéphane Schanne's talk tomorrow
- GRB detection and multi-wavelength follow-up mission
- https://svom.cnes.fr/en/home-32

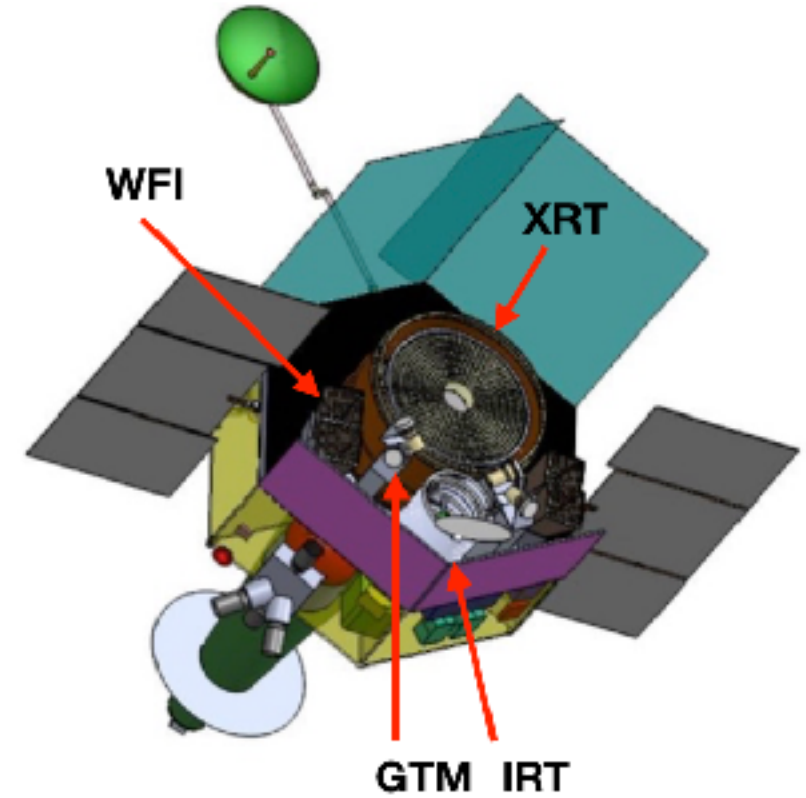


Nimble

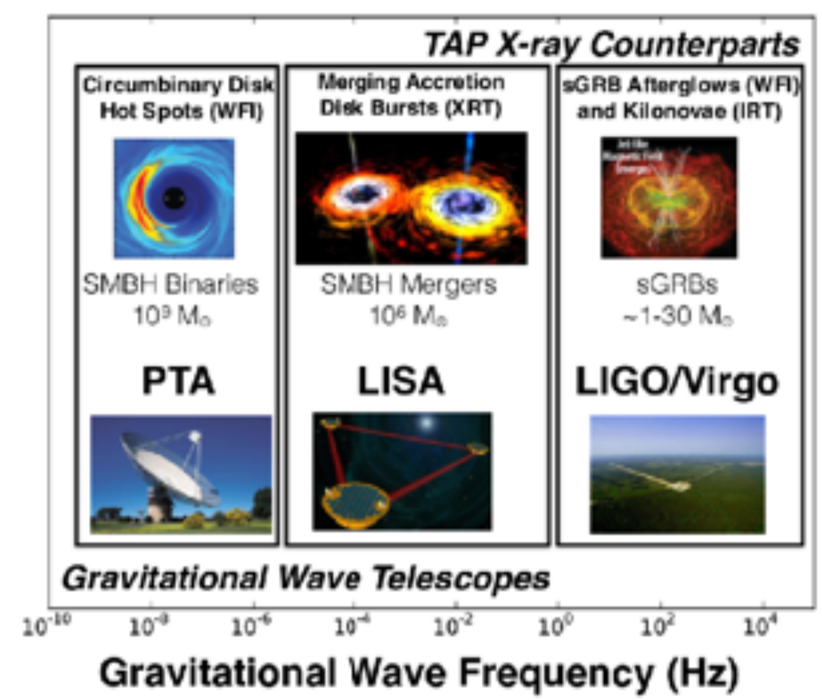
- NASA SMEX Concept – in preparation for anticipated 2019 call for proposals
- Science goals:
  - Detect gamma-ray and UV/optical/IR GW counterparts
  - Characterize exoplanet atmospheres
- Instruments
  - High-energy All-Sky Monitor (HAM)
    - Gamma-ray scintillator (GBM/BurstCube-like)
  - Small UV Optical IR telescope (SUVOIR)
    - Wide field 20 cm telescope with 18 square deg field of view
    - Narrow field 30 cm telescope with UV/Optical and Optical/IR channels with filters and grism to provide broadband photometry and low-resolution spectroscopy
- Sun-synchrotronous orbit (thermal considerations) - ~30-50% of sky accessible with rapid slewing and autonomous follow-up of HAM triggers or uploaded TOOs
- PI: Josh Schlieder (GSFC)



Transient Astrophysics Probe (TAP)

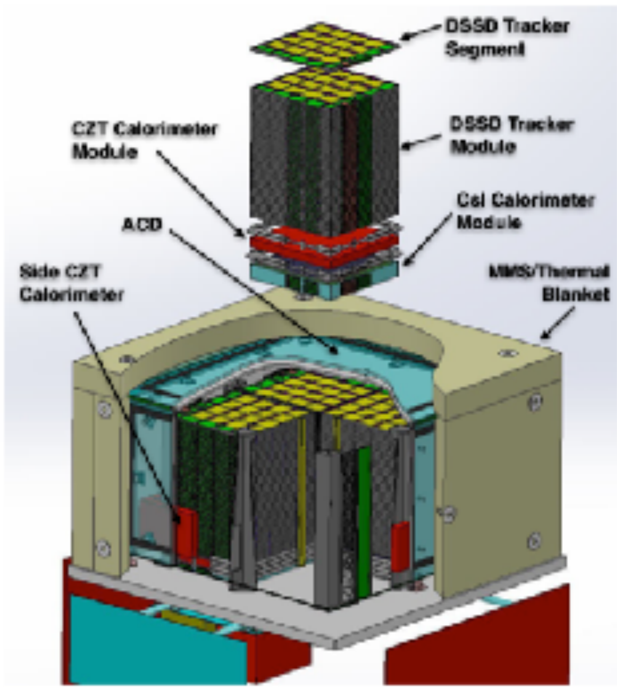


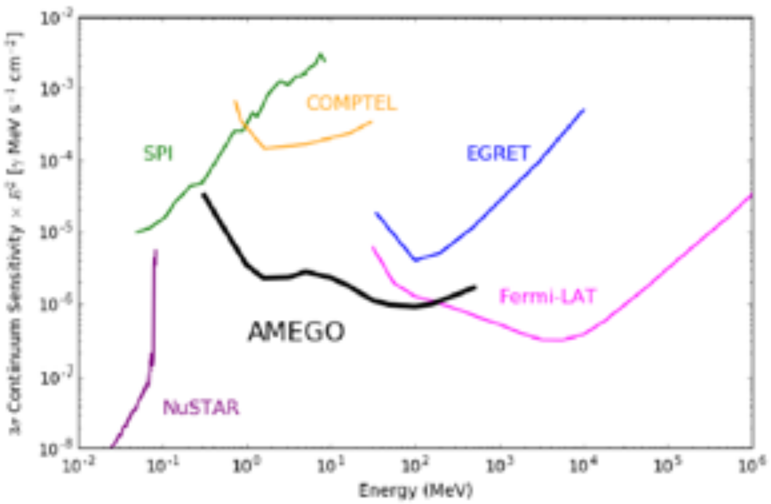
- Awarded one of the 2017 NASA Probe Concept Studies
  - To be submitted to 2020 Decadal Survey
- 4 Instruments
  - Wide Field Imager (WFI)
  - X-ray Telescope (XRT)
  - Infrared Telscope (IRT)
  - Gamma-ray Transient Monitor (GTM)
- Launch in late-2020’s
- Rapidly slewing spacecraft will autonomously detect and follow-up transients and variable sources, and conduct all-sky survey
- L2 orbit with 85% of sky viewable at any time
- For more information: https://asd.gsfc.nasa.gov/tap/

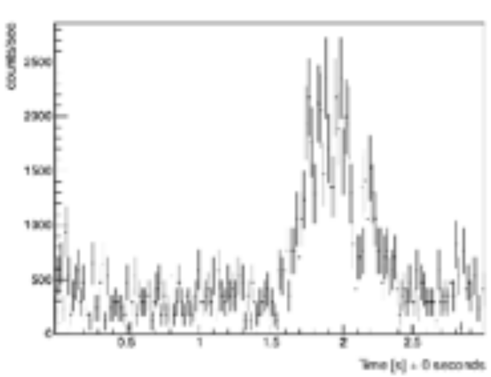


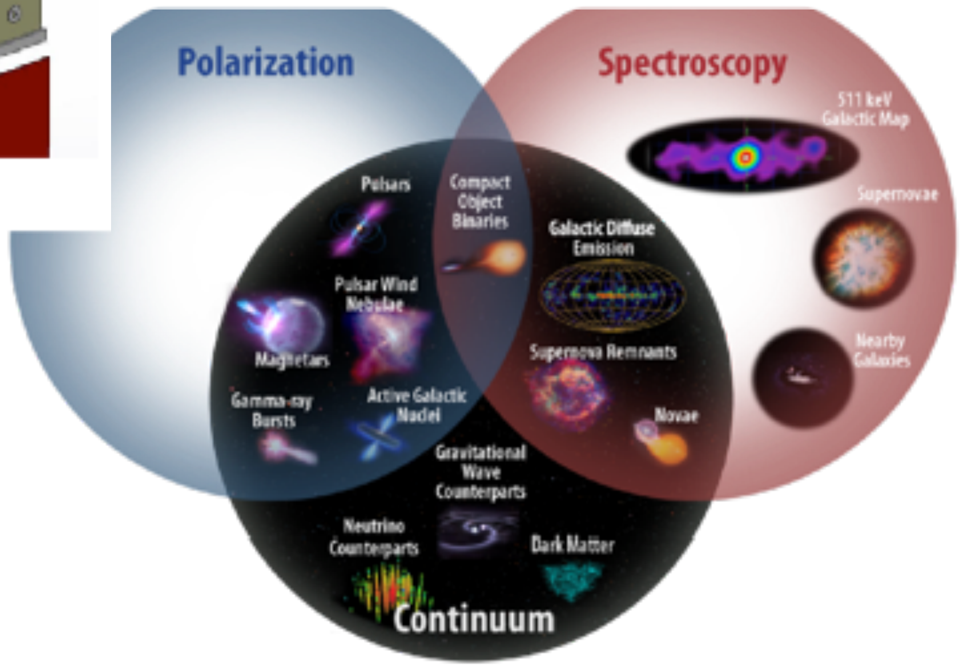
All-sky Medium Energy Gamma-ray Telescope (AMEGO)

- NASA Probe mission concept to be submitted to US Decadal Survey
- Double-sided silicon strip tracker, CZT & CsI calorimeters, ACD
- 200 keV – 10 GeV
- Compton & Pair Telescope viewing ~20% of sky surveying entire sky over 2 orbits (like LAT)
- Many sources have peak spectra in MeV band (AGN, pulsars, GRBs) – sensitive instrument needed to understand emission processes
- If GW-GRBs are under-luminous, AMEGO will be far more sensitive than scintillator instruments
- Launch in late 2020's
- PI: Julie McEnery (GSFC)
- https://asd.gsfc.nasa.gov/amego/



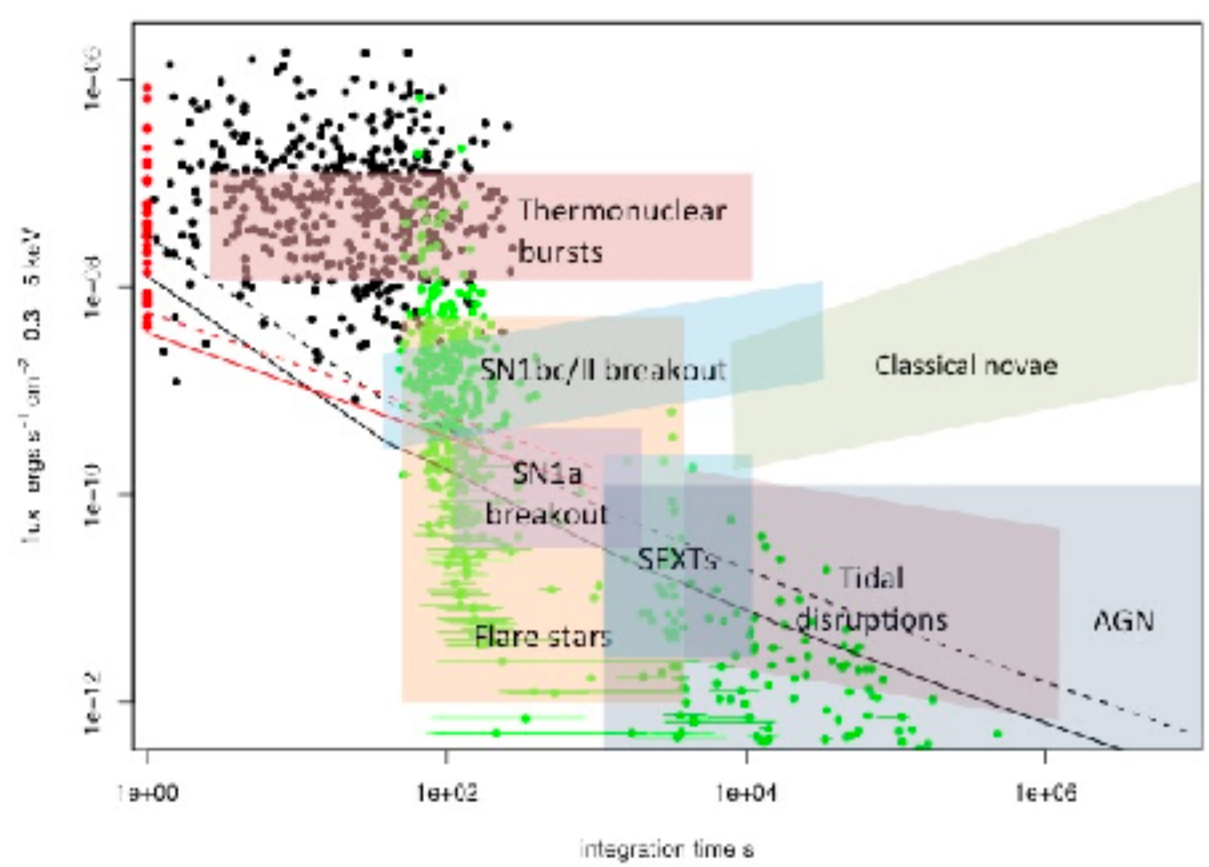




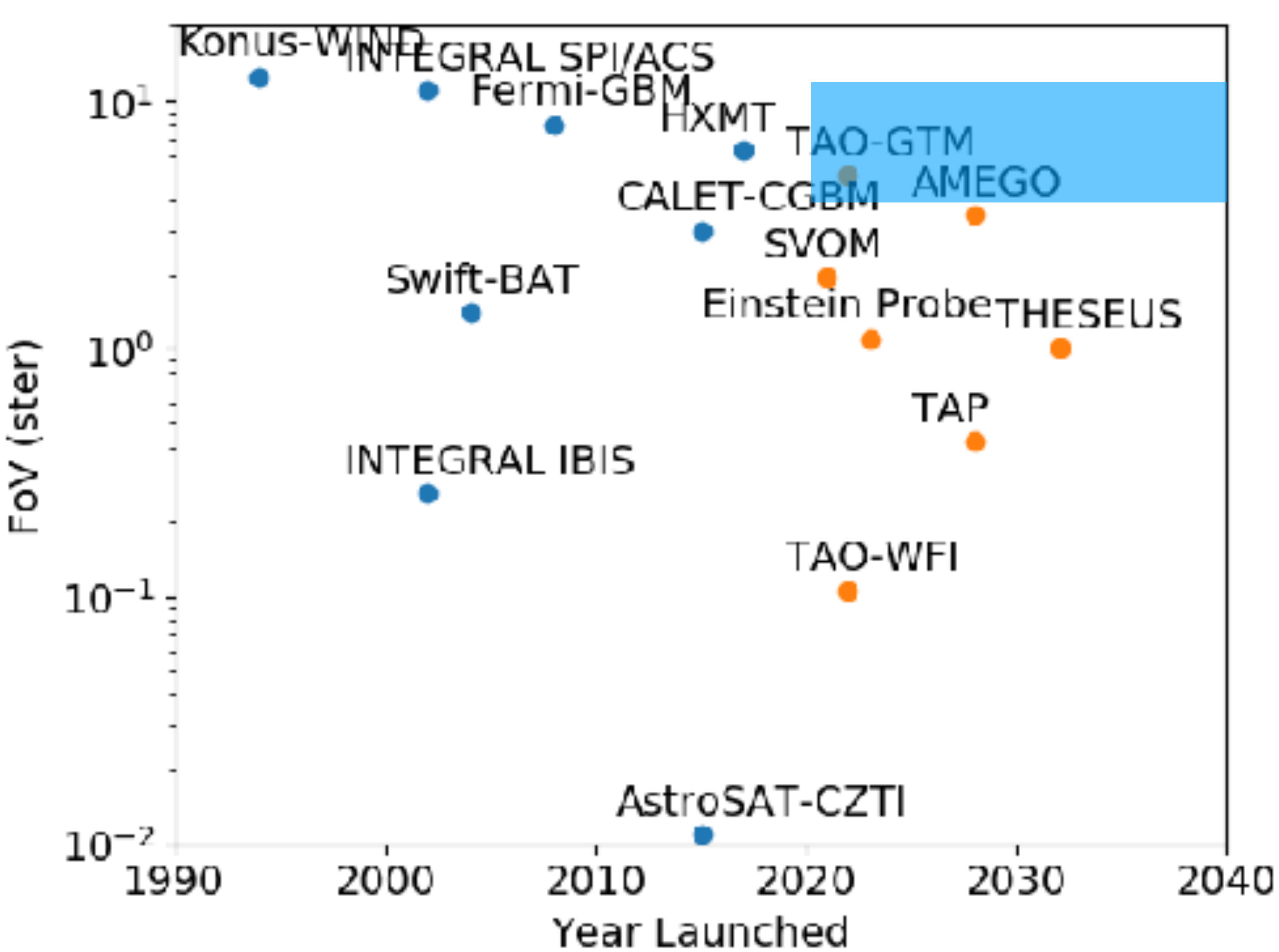


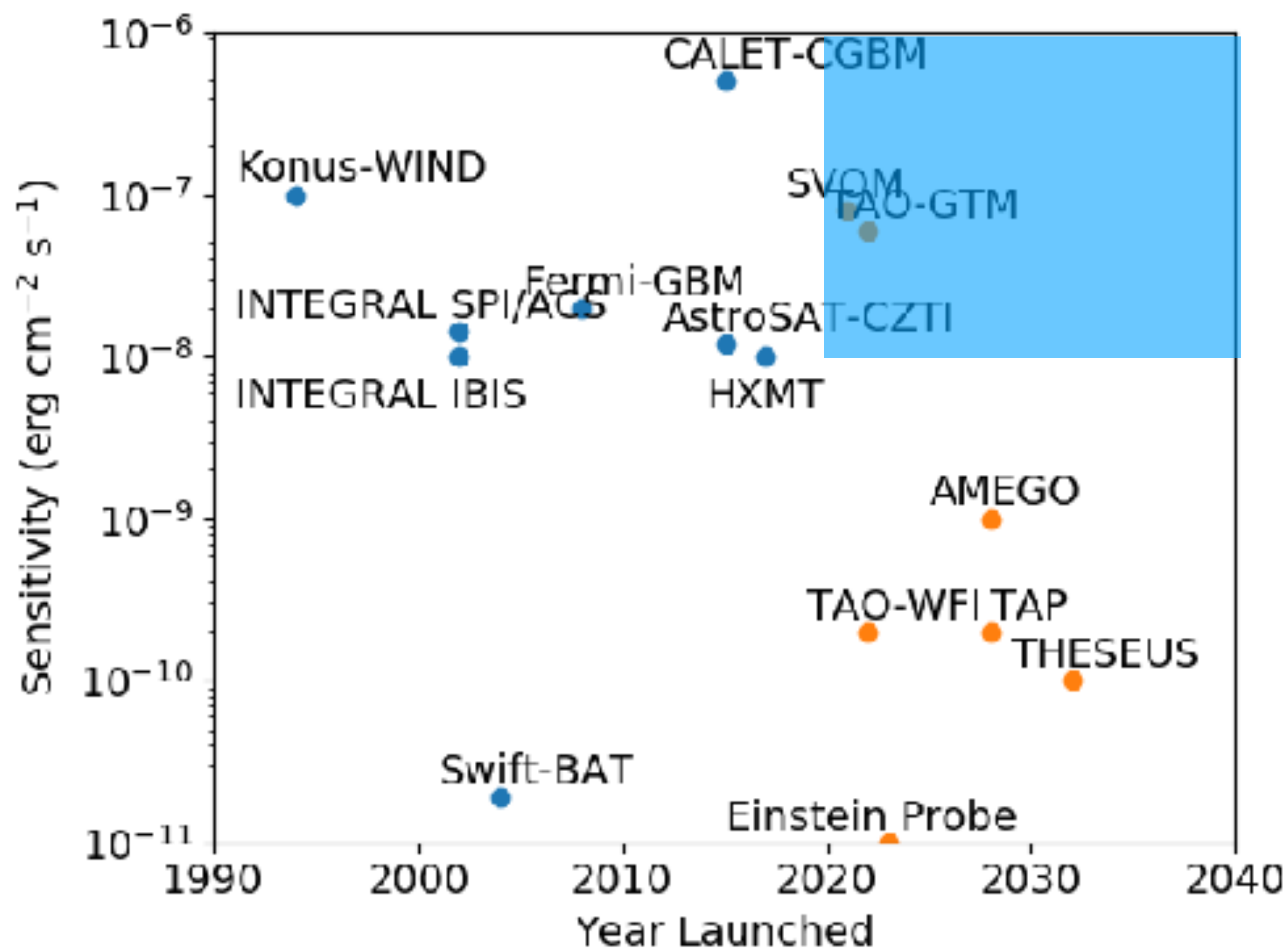
Transient High-Energy Sky & Early Universe (THESEUS)

- Selected for ESA Phase A, down-select in 2021, launch 2032
- Instruments
  - X-Gamma rays Imaging Spectrometer (XGIS, 2 keV – 20 MeV)
  - Soft X-ray Imager (SXI, 0.3 – 6 keV)
  - InfraRed Telescope (IRT, 0.7 – 1.8 μm)
- Low Earth Orbit
- Rapid Response Capability
- Science: High-energy transients, high-z GRBs
- https://www.isdc.unige.ch/theseus/



Current & Future Missions





Science Case for GRB-Detecting SmallSats

- Don’t miss the rare event -> all sky coverage
  - Gravitational Wave Counterparts
  - High-z GRBs
  - Ultra-long GRBs
  - Neutrino counterparts? FRB counterparts?
- Rapid communications?
- Simpler systematic effects
- Low cost access to space
- Help to filter huge expected increase in transients from optical/radio surveys

Gravitational Wave Counterparts

- GRBs provide independent coincident (within seconds) detections for on-axis events
  - GRBs can confirm single GW detector events which would otherwise not be reported
  - GRB detection could elevate sub-threshold GW signals, essentially increasing GW range
  - Joint GW+GRB localizations (blob+banana = smaller banana)
  - Especially as GW events are detected further, optical counterparts will be harder to find
- Concerns
  - Are nearby short GRBs bright enough to be detected out to GW horizon?
  - How on-axis do they have to be to be detectable?
  - Could there be short GRB counterparts to NS-BH or BH-BH mergers?

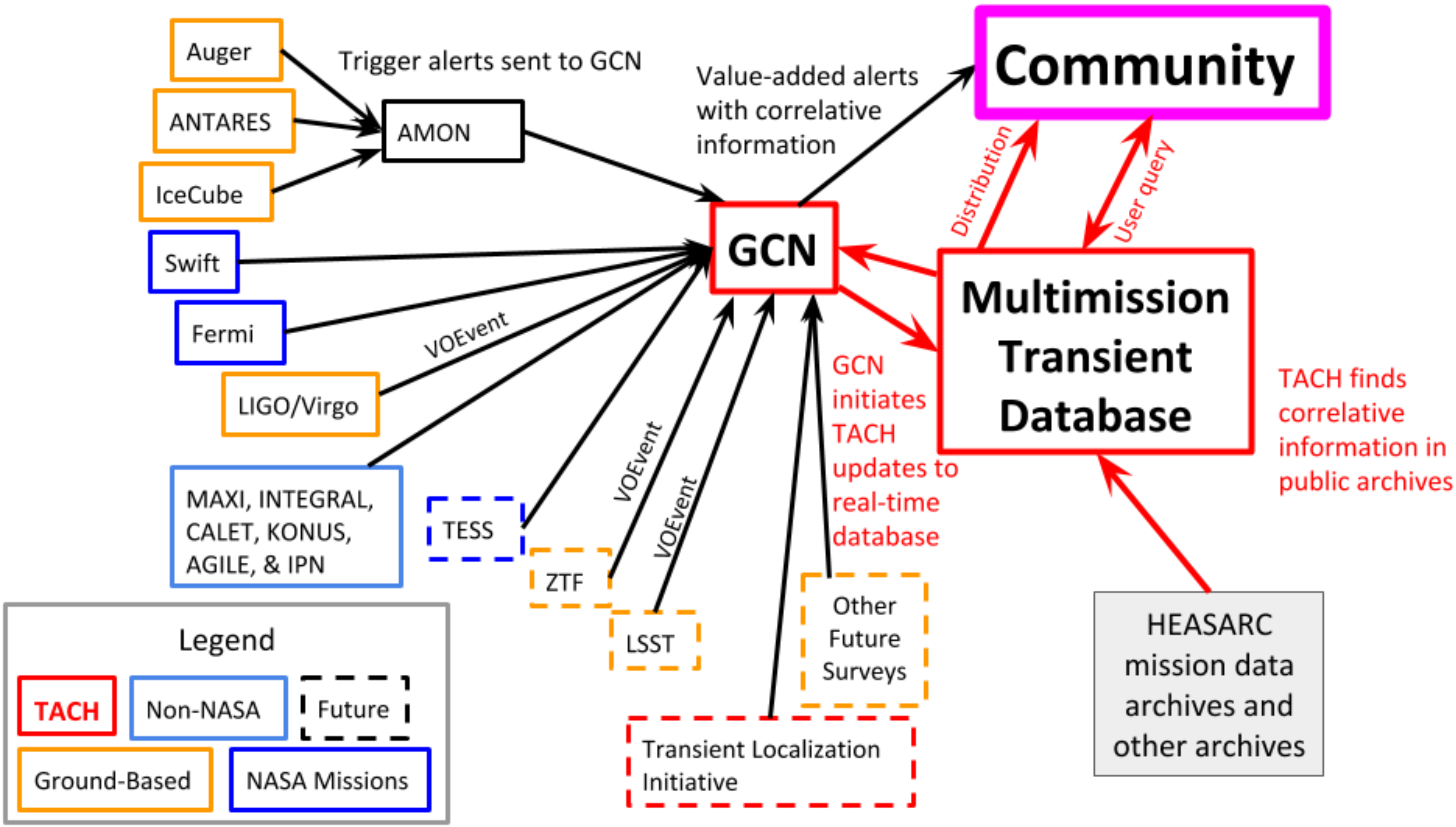
Gravitational Wave Counterparts

- Prospects for Future joint GRB-GW science
  - Better constraints on speed of gravity
  - Independent measure of Hubble Constant could help resolve SN Ia / CMB disagreement
  - GRB emission mechanisms, jet composition, jet structure
  - Neutron star equation of state
  - Role of magnetars
- Coming soon: Prospects for joint GW-GRB science - Eric Burns et al. in-prep

Time Domain Astronomy Coordination Hub (TACH)

- New initiative at NASA Goddard building upon community resources we already provide to address the needs of the multi-messenger/multi-wavelength transient deluge coming in the next decade
  - Improvements to GCN (add reliability with mirror sites, improved coincident source searches)
  - New realtime HEASARC database that ingests GCN & other public data streams to easily cross-correlate and be queryable by community
  - Provide infrastructure to do joint localizations with multiple GRB-detecting satellites
  - How can TACH help serve our community?

TACH


Auger
ANTARES
IceCube
Trigger alerts sent to GCN
AMON
Value-added alerts with correlative information
Community
Distribution
User query
Swift
Fermi
VOEvent
LIGO/Virgo
GCN
Multimission Transient Database
GCN initiates TACH updates to real-time database
TACH finds correlative information in public archives
MAXI, INTEGRAL, CALET, KONUS, AGILE, & IPN
TESS
ZTF
VOEvent
VOEvent
LSST
Other Future Surveys
HEASARC mission data archives and other archives
Transient Localization Initiative
Legend
TACH
Non-NASA
Future
Ground-Based
NASA Missions

Summary

- Let’s keep building Large GRB Missions
- Let’s build GRB SmallSats
- Let’s coordinate our efforts to get the most out of those SmallSats
- Let’s be ready to make the big discoveries of the next decade