

Gamma-ray Transient Network Science ~~Action~~ Analysis Group

Eric Burns, Michael Coughlin
(soon to be, all of you)

Outline

- What is a SAG
- A quick history of the InterPlanetary Networks (IPNs)
- The current status of the IPN
- The SAG and the future

Science Action Groups (SAG)

- NASA / APAC
 - Physics of the Cosmos Program Analysis Group
 - Science Action Groups
- Fixed term special interest groups who deliver a report to APAC with a specific charge
 - Used widely by the exoplanet community
 - Less frequently in our area of work
 - GTN SAG
 - (soon) Comms SAG
 - GO SAG

Multimessenger SAG – pre Decadal

- <https://pcos.gsfc.nasa.gov/sags/mmasag.php>
 - Google 'MMA SAG'
- Final Report:
https://pcos.gsfc.nasa.gov/sags/mmasag/MMA_SAG_Final_Report_R3.pdf

GTN SAG

- <https://pcos.gsfc.nasa.gov/sags/gtn-sag.php>
- Full Terms of Reference
<https://pcos.gsfc.nasa.gov/sags/gtnsag/Gamma-ray%20Transient%20Network%20Science%20Analysis%20Group%20TOR.pdf>
- My summary:
 1. What science results require the IPN and GRB monitors?
 2. What software and programmatic improvements can be made to how this community cooperates?
 3. What future hardware and instruments are needed for Decadal-aligned science?

1. IPN and GRB Monitor Science

- Gamma-ray bursts
 - Localization via Swift
 - Gravitational Waves and short Gamma-ray Bursts
 - Very High Energy detections of long Gamma-ray Bursts
- Magnetars
 - Discovery of new magnetars
 - Magnetar giant flares
 - Fast radio bursts as counterparts to soft gamma-ray repeater flares
- Coverage of
 - Neutrinos (choked GRBs)
 - Gravitational wave burst events
 - UVOIR-identified relativistic transients
- Others?
 - Tidal disruption events?

Key partners with

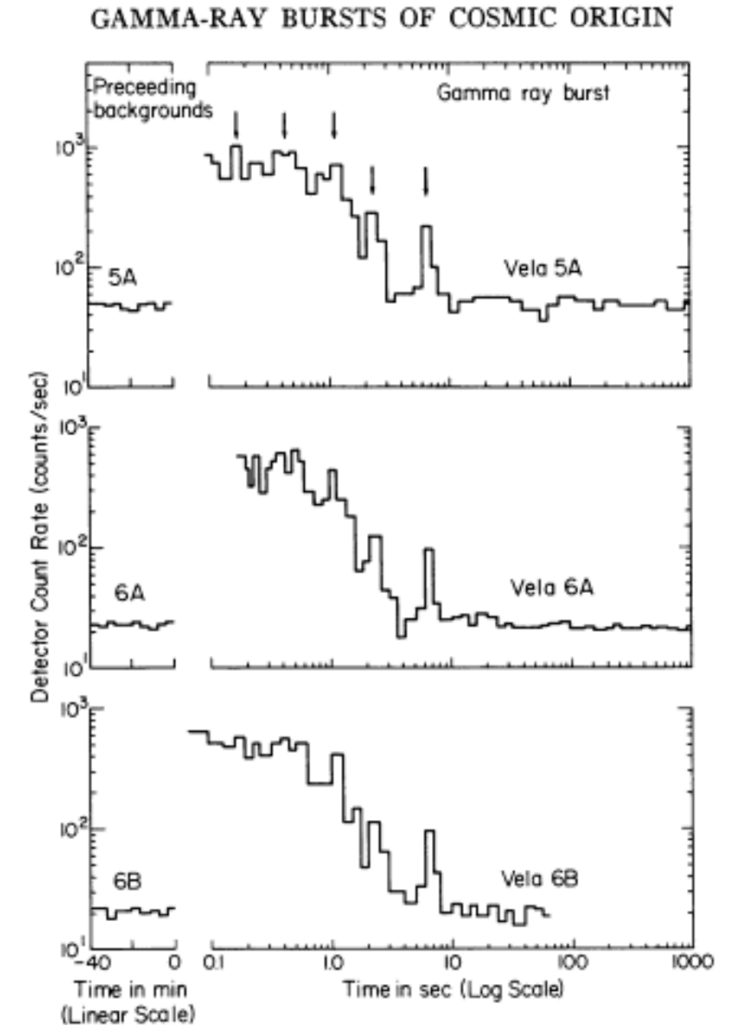
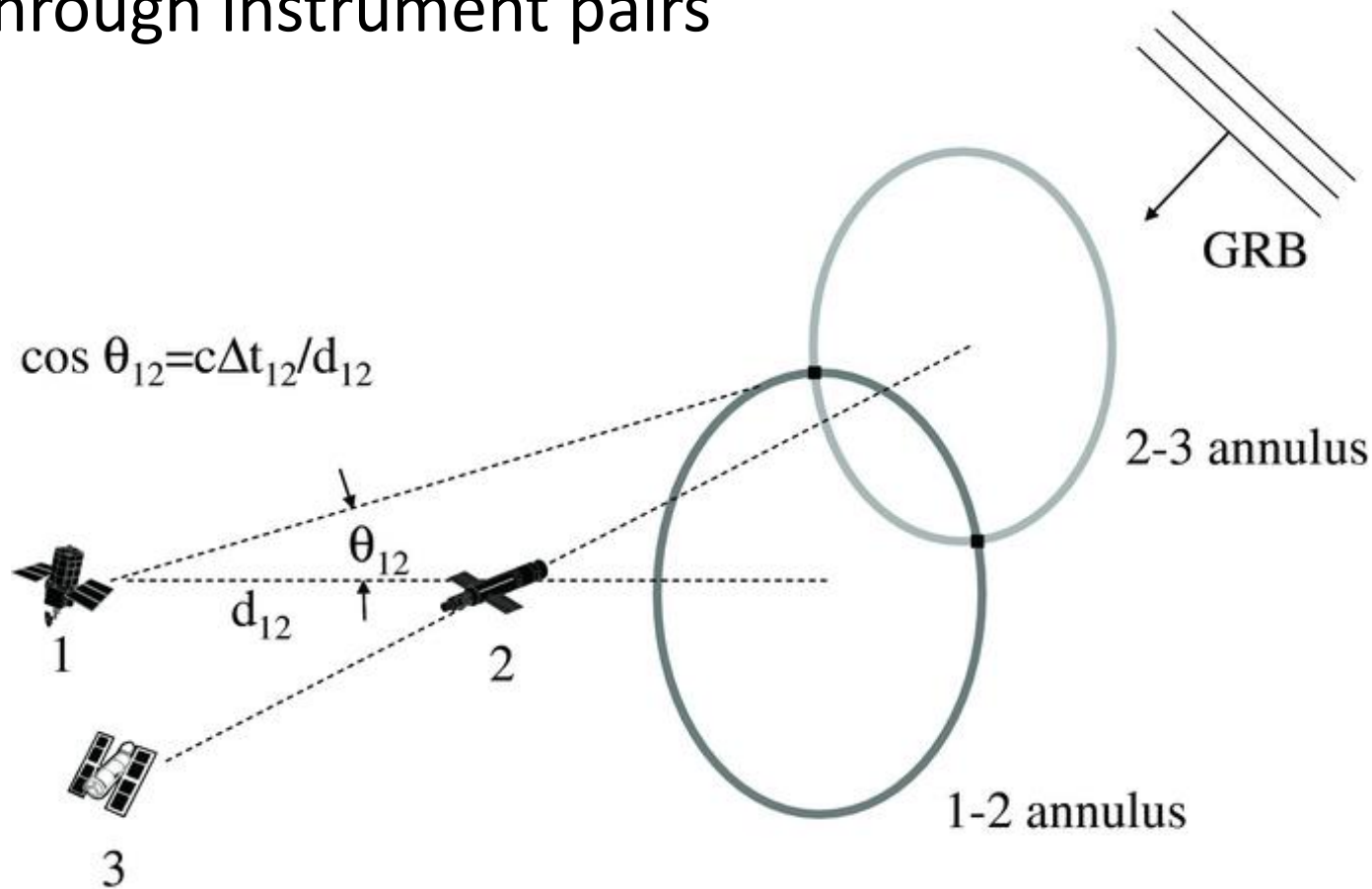
- LVK
- IceCube
- ZTF, Rubin, ULTRASAT, NEO Surveyor, etc
- Full GRB follow-up community
- DSA-2000, SKA, etc
- IACTs, CTA, HAWC, LHAASO,
- Others?

2a. Current Operating Method

- Instrument teams operate their own instruments, and largely operate independently.
- Real-time:
 - Teams separately report alerts, upper limits, etc
 - Joint detections often identified through circulars
- Archive
 - Generally separate archives
 - InterPlanetary Network GRB and SGR flare archive. Neither are actively maintained at the moment.
 - Plans to create a general IPN GRB archive
 - No archive of upper limits

InterPlanetary Network: Gamma-ray Burst Triangulation

Geometric determination of transient location through instrument pairs



2a. Current Operating Method

- Collaboration:
 - InterPlanetary Network
 - GW-GRB Working Group
 - Ad hoc, as needed
 - GRB 221009A had very early Swift and Fermi communication to sort out what had happened
 - GRB 190114C for Fermi and Swift
- Potential option: operate as a consortium for prompt alerts, upper limits, and key events of interest
 - Many reasons why this isn't done

2b. Current Software Model

- Instrument teams generally use separate software
- Examples:
 - rmfit
 - Xspec
 - GBM Data Tools
 - BurstCube Data Tools
- Potential option: general community tools
 - Gamma-ray Data Tools
 - IPN Software Package
 - Others?

3. Future hardware / instruments

- Should we continue the IPN?
- If so, how should the instruments change?
 - Higher temporal resolution
 - Ability for faster downlink
- Is there similar science possible by high-energy monitors that require a different approach?

Discussions

- Have we missed anything important?
 - In general?
 - Science
 - Operations and Collaborations
 - Future needs
- GTN SAG operation
 - ~Monthly cadence meetings at varying week days / times
 - Next one focus on science?
 - Overleaf – link to be shared
 - Ask team members to contribute science in the next ~3 weeks, with iteration for ~1 week before the next meeting

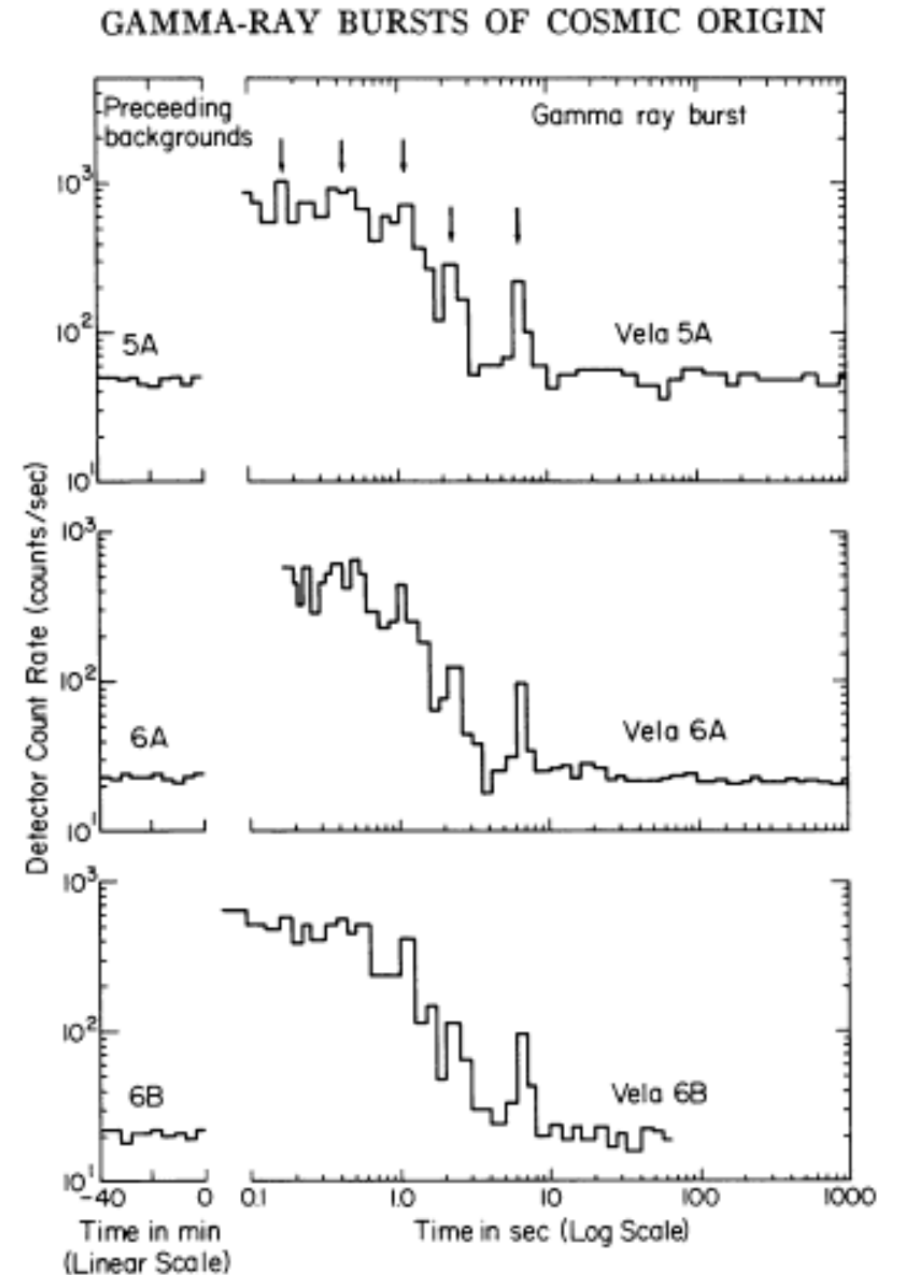
Backup slides

The Future of the Interplanetary Network

- Missions:
 - Current: Konus-Wind (1994-), Mars Odyssey (2001-), INTEGRAL (2002-), Swift (2004-), AGILE (2007-), Fermi (2008-), BepiColombo (2018-)
 - Upcoming (non-LEO): Psyche, MEGANE
- Contributors (incomplete list):
 - Individuals from the above instrument teams
 - Dmitry Svinkin, Dmitry Frederiks, Anna Ridnaia, Alexandra Lysenko
- Current caretakers in the US: Eric Burns, Adam Goldstein, Judy Racusin, John Tomsick
 - With past or offered help from Michael Briggs, Brad Cenko, Valerie Connaughton, Greg Paschall, Alan Smale

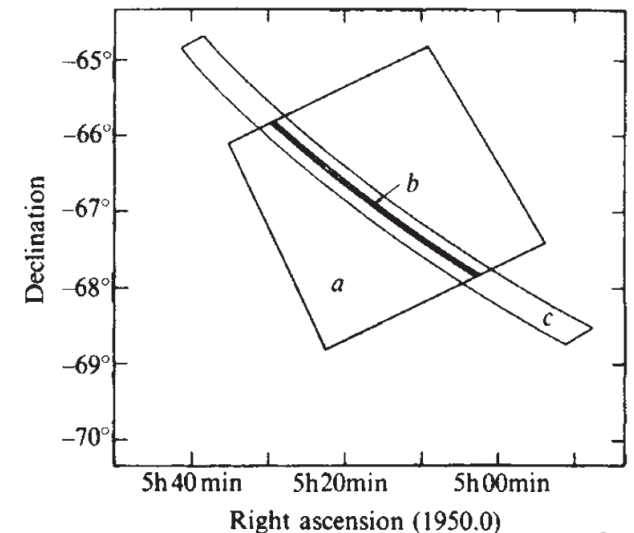
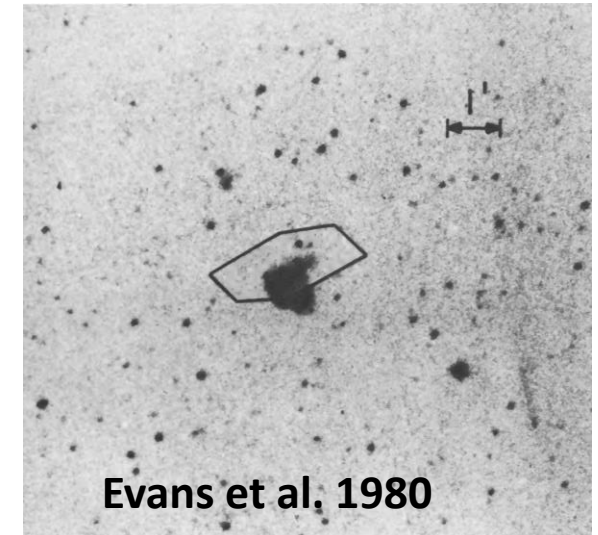
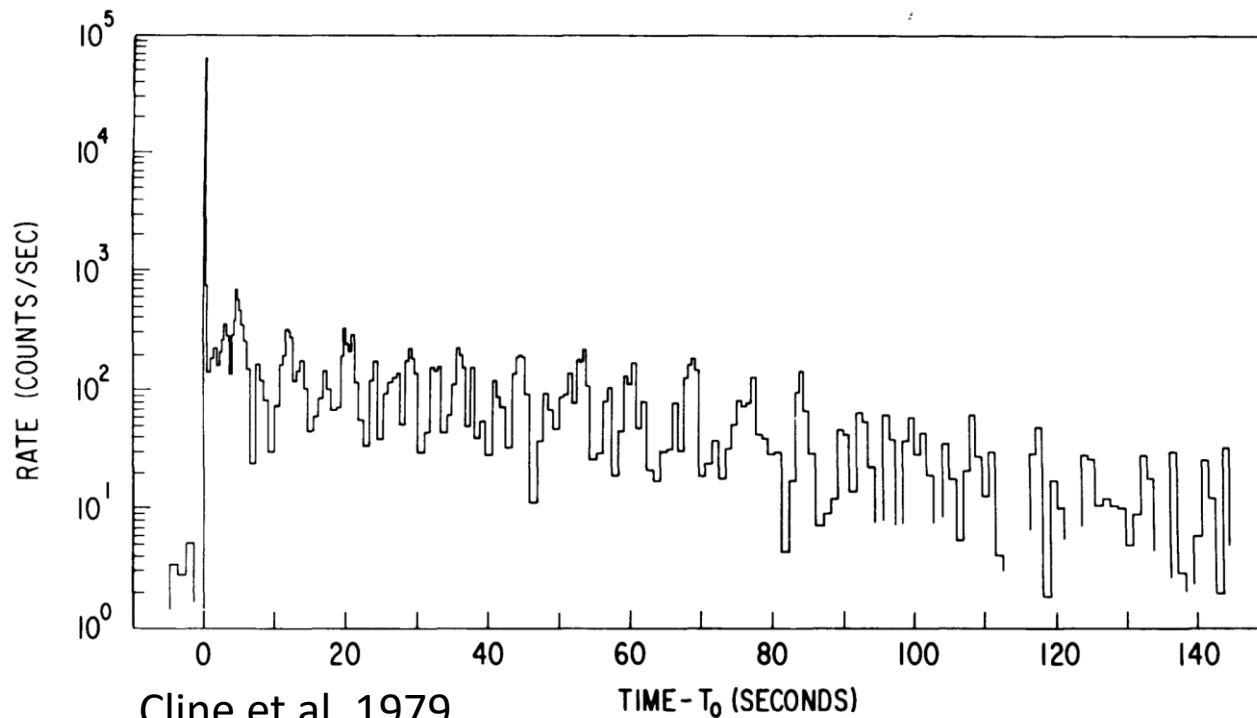
Gamma-ray Burst Discovery

- Discovery of GRBs, Klebesadel et al. 1973
- Triangulation by the Vela satellites
 - Orbit around Earth, $\sim 1.2 \times 10^5$ km radius



The First InterPlanetary Network 1978-1980

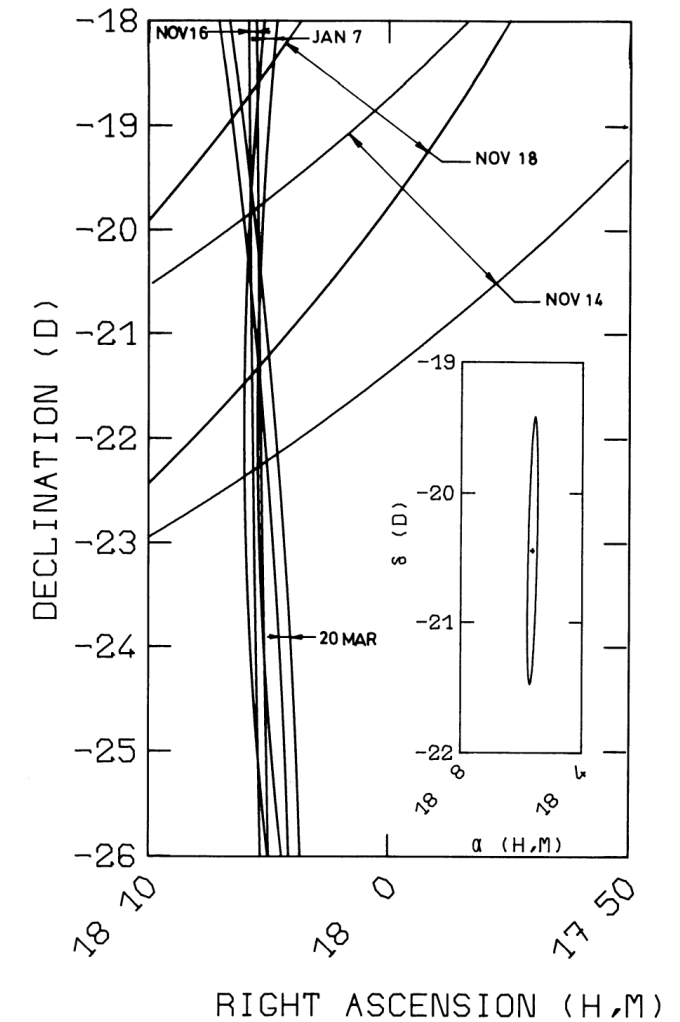
- Name first used for papers on GRB 790305B
- The first: GRB source identification, signal from a magnetar, GRB repeater, magnetar giant flare, US-Soviet GRB collaboration (I think)



Mazets et al. 1979

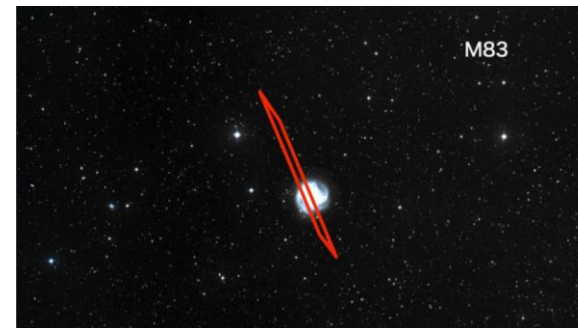
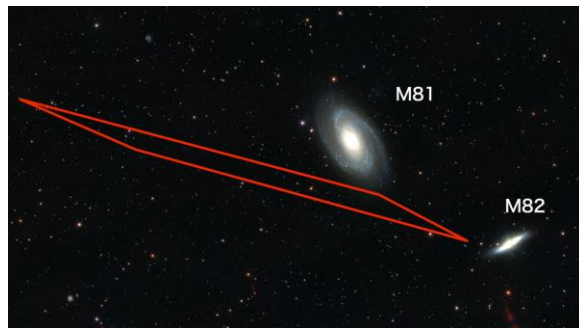
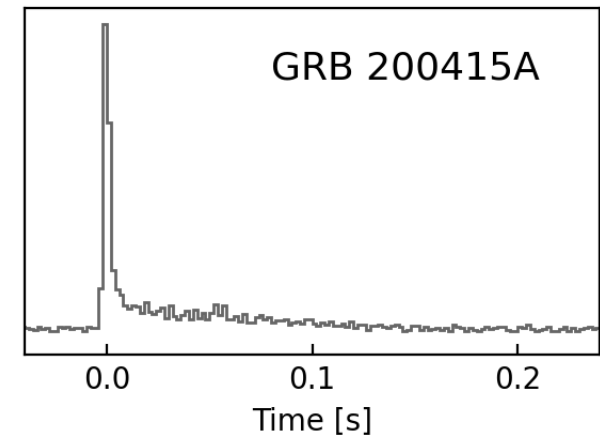
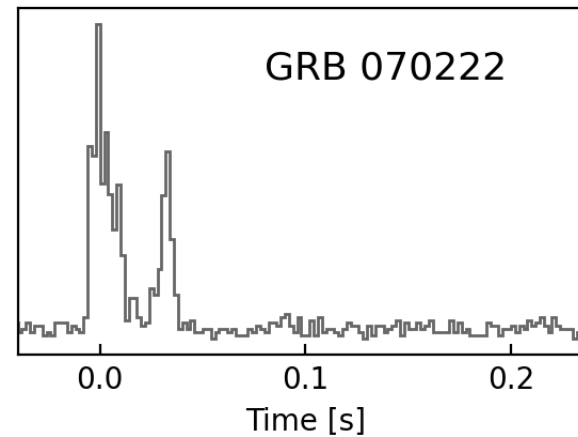
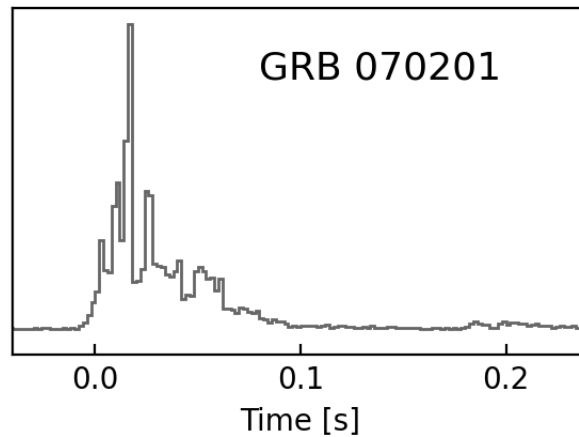
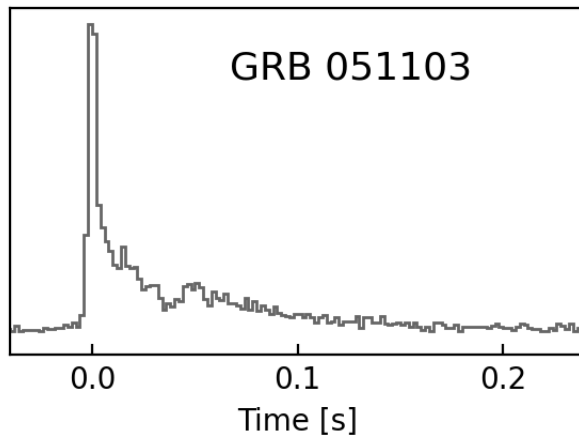
The Second InterPlanetary Network 1981-84

- Spatial isotropy and homogeneity of GRBs
- Non-uniformity of GRB repeaters
- Isolation of soft gamma-ray (SGR) repeater flares from GRBs



The Third InterPlanetary Network 1990-

- Location and association of SGR 1900 and SGR 1806 giant flares
- Identification and study of the extragalactic magnetar giant flares



The formation of the InterPlanetary Network

- Kevin Hurley, a U.S. astronomer working in France, started a clearinghouse for probe data that allowed researchers at Los Alamos National Laboratory, NASA, and in Moscow to pool information using him as a middleman, forming what would come to be called the InterPlanetary Network. **“There wasn't a lot of collaboration at the time,” Hurley says, “but there was no formal interdiction not to do it.”**

The current state of the InterPlanetary Network

- For now, though, astronomers are stuck with some basic questions—like whether a magnetar that has launched one giant flare has enough magnetic energy left to muster another—which could take centuries to answer. **“Not in my lifetime,” Hurley says. “I’ve become a lot more patient since I started working on the InterPlanetary Network.”**
- Hurley is still wrangling gamma ray sensors across the Solar System—and space agencies. **NASA committees are less enthused about funding the project, he says, now that the world has higher tech gamma observatories like Fermi and Swift, leaving its future in doubt.** But Europe's BepiColombo probe, en route to Mercury, will soon be the 33rd mission to participate, and NASA's Psyche mission to an asteroid, slated to launch next year, will follow. Their gamma detectors will be ready, attuned to the off chance of another big, rare shot in the dark

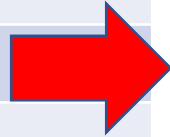
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The Future of the Interplanetary Network

Previously

Task	Responsible Party
GCN Circulars	Kevin Hurley, Russian IPN Team
Healpix Maps	Russian IPN Team
Archiving GRBs	Kevin Hurley
Archiving SGR Flares	Kevin Hurley
Annulus code development	Kevin Hurley, Russian IPN Team



Currently

Task	Responsible Party
GCN Circulars	Russian IPN Team
Healpix Maps	Eric Burns, Russian IPN Team
Archiving GRBs	Eric Burns
Archiving SGR flares	Eric Burns?
Annulus code development	Adam Goldstein, Russian IPN Team

Planned

Task	Responsible Party
GCN Notices	Shared (specifics TBD)
Archive automation	Shared (specifics TBD)

Science Interest Groups and Science Action Groups

- Science Interest Groups (e.g. GR SIG) are nominally permanent groups providing metrics and assessments for current and future needs of specific topics
- Science Action Groups (SAGs) are temporary groups tasked with providing a document with a specific task by a predetermined deadline
 - Examples: multimessenger SAG, Great Observatory SAG
 - Proposed within one of the PAGs (ours is PhysPAG), presented to APAC / NASA HQ for approval
 - Greatly used by ExoPAG (currently on SAG #23)

(To be proposed) Gamma-ray Transient Network SAG

1. What time-domain and multimessenger sources rely on the InterPlanetary Network? What scientific discovery will the IPN enable? How does it fit into the new astrophysical landscape? What would be lost of the IPN ends?
2. Where can improvements be made to the existing IPN? What are the needs of the full astronomical community, especially the needs of those who study fast radio bursts, optically-identified relativistic transients, the gravitational wave community, and the neutrino community? What are the needs of the international gamma-ray satellite community? Should the IPN and these new satellites coordinate? Should these instruments coordinate and integrate to a greater degree? How can we make use of advances to the Global Coordinates Network?
3. Should the IPN be continued beyond the current instruments? What future missions and instruments are needed to fully realize the Decadal-recommended science in partnership with the advancing capabilities in other wavelengths and other messengers?

Nominal report deadline: December 2022; Outreach to GR SIG, current IPN members, gamma-ray community, as well as individuals from member communities (LIGO/Virgo/KAGRA, Fast Radio Burst groups, optical surveys, etc)

If interested in joining email me (ericburns@lsu.edu) or wait for the dedicated email to GRSIG (if approved)