

GCN & TACH

(Gamma-ray Coordinates Network)
(Time-domain Astronomy Coordination Hub)

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NASA-GSFC

19-22 August 2019

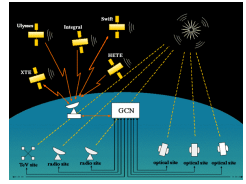
HTU#6, Chicago

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- * TACH Services and Status



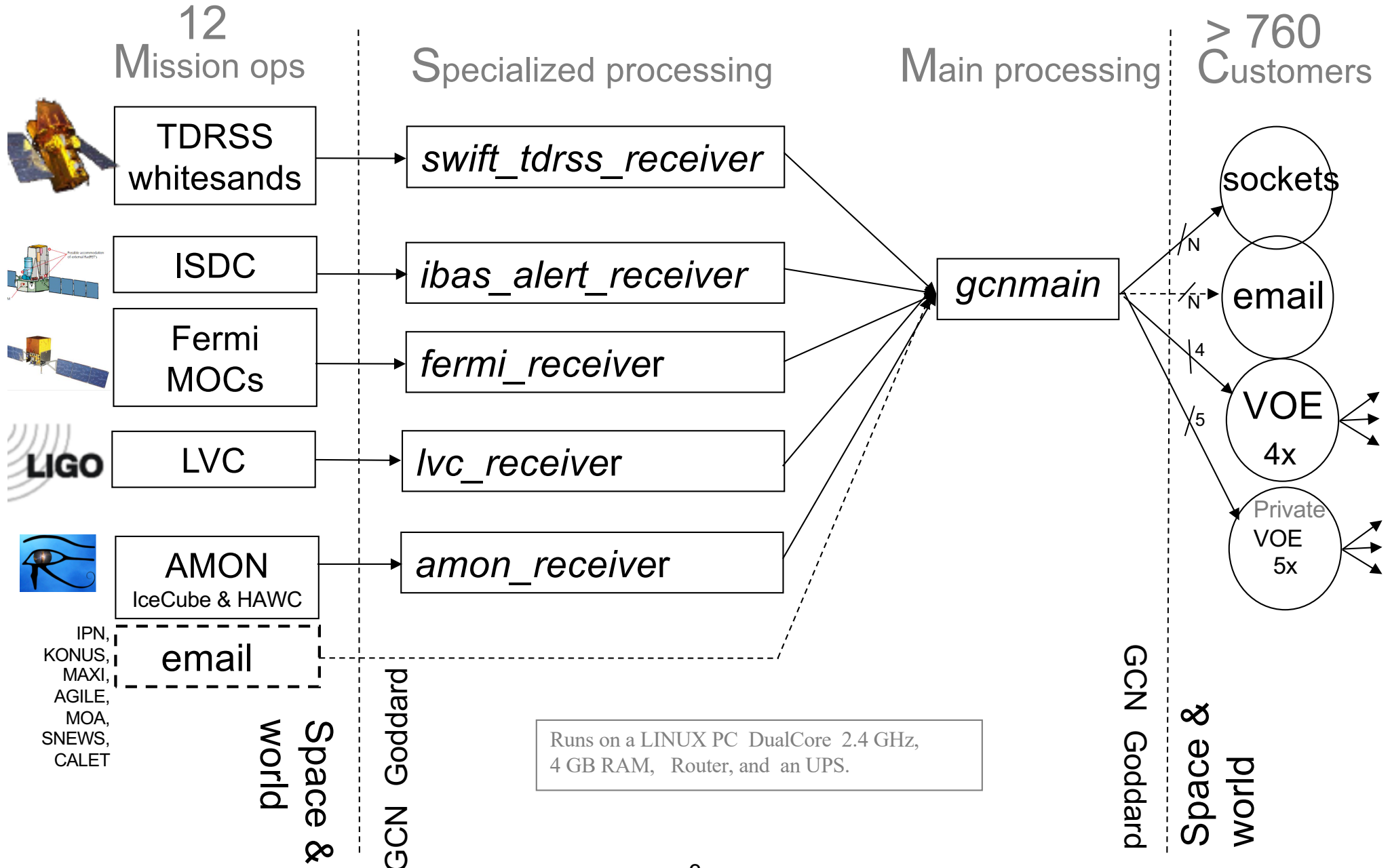
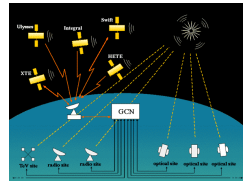
GCN and TACH FINANCIAL DEVELOPMENT



- GCN now paid for by special funding from NASA HQ
 - No more serial proposals every 1, 2, & 3 years to a wide range of AOs
- TACH is a 3-year initiative funded by NASA
 - If we are successful on TACH, it will be renewed.
- If both are successful, they will be permanently combined
 - Very likely within HEASARC

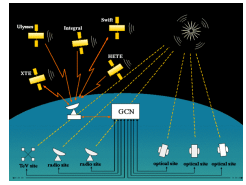


GCN Notices Diagram





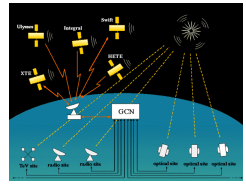
GCN Notices Processing



- Ingest Methods: Dedicated socket connection, email
- Distribution Methods: 9 format/protocol choices
 - 3 VOEvent (2 socket, 1 email), 1 binary socket TCP/IP, 5 email-based
- Filtering Criteria: 17 filter functions
 - Intensity, Significance, Position Error, Age, Above your horizon, Day/Night, Sky_Region, Distance from the Sun and Moon,
- Near-by Catalogs Matching:
 - Galaxy catalog, Bright Star catalog
- Other Services:
 - Private sub-networks (3 so far).
 - Special email alerts if your special source(s) is a trigger.
 - Project-internal operations notifications (Swift & Fermi: emergencies, modes, ...).
 - Archive all Notices, Circulars & Reports. (Circulars also grouped by event.)
 - Demo programs for the 3 types of socket connections to GCN.
 - Daily reports on connection & distribution statistics.



Notices By Mission Delay Times and Rates

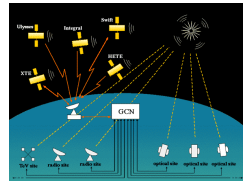


Mission	Num Types	Delays	# / Month
Swift	17 *	3 sec – 10 min	8
Fermi	17 *	3 sec – 15 min	18
LIGO/Virgo	4	1 min – 12 hr	5
INTEGRAL	6	10 sec – 1 hr	1
CALET	2	1 min – 3 hr	5
ICECUBE	2	30 sec – 60 sec	1
HAWC	1	30 sec – 60 sec	1 / yr
AGILE	7	30 min – 5 hr	0.5
KONUS	1	3 hr – 48 hr	14
MAXI	2	3 hr	7
MOA	1	1 – 10 hrs	60

* Does not include the Team-only special operations notifications.



VOEvent Servers: Public & Private

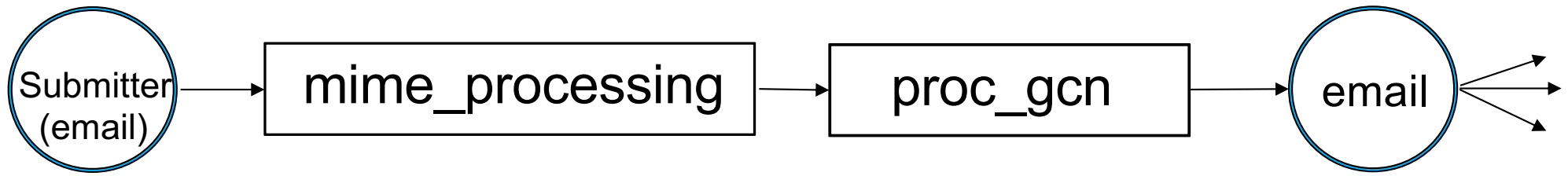
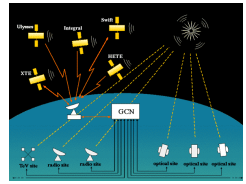


SERVER	Public		Private	
	Ver 1.1	Ver 2.0	Ver 1.1	Ver 2.0
Atlantic_2 209.208.78.170	8099		8092	8096
Atlantic_3 45.58.43.186		8099		
Linode 50.116.49.68	8099			8096
eApps 68.169.57.253		8099	8092	8096

- Multiple servers for redundancy.
- * Port Numbers for the 2 VOEvent versions (1.1 & 2.0) and Public vs Private distribution.
- Filtering if you sign up; or No filtering if anonymous connection.
- * You can also get VOEvents by:
 - GCN-protocol voevent socket method.
 - In emails as an attachment or in the body of email.



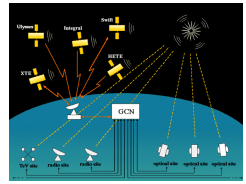
Circulars Processing



- Somebody submits a circular message
- Message is extracted from the mime variations
- proc_gcn does many things:
 - Checks that the submitter is on the vetting list
 - Does it have one of the ~40 “magic strings” in the Subject-line
 - Does a half-dozen other checks (eg “Re:”, “vacation”, ...)
 - Sends back to submitter an acceptance report / rejection report (why)
 - Prepends the Title/Date/SerNum/Subject/Author to the message
- Emails Circular to each on the recipient list
- 1901 recipients (and 2535 submitters)



GCN Web Site



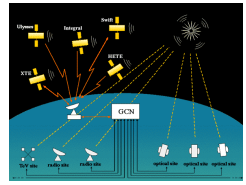
- Content:

- What Notice types are available
- Notice content, and brief descriptions of Mission/Instrument ops & capabilities
 - Rates, accuracies, energy bands, latencies, ...
- Sign-up for Notices and for Circulars
- Archive all Notices, Circulars & Reports. (Circulars also grouped by event)
- Demo programs for the 3 types of socket connections to GCN
- What's New page (check for recent additions to GCN)
- System Status page (check for operation problems)

- <https://gcn.gsfc.nasa.gov>



Categories by Source Objects

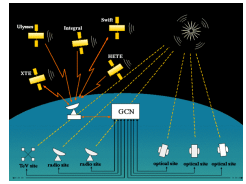


- GRBs (LIGO/Virgo, Swift, Fermi, INTEGRAL, AGILE, MAXI, IPN, KONUS, AMON)
- γ -/X-ray Transients (Swift-BAT, Fermi-GBM/-LAT, MAXI, CALET, HAWC)
- Gravitational Wave events (binary mergers: BNS, NSBH, BBH) (LIGO/Virgo)
- Gravitational Lensing events (MOA)
- Neutrinos from Supernovae (SNEWS, IceCube)
- 76 Notice types currently available (+15 more to various Instrument-Teams)
- 40 Notice types no longer available:
 - MILAGRO TeV γ -ray (& cosmic ray) atmospheric shower events
 - ALEXIS extreme UV events
 - CGRO, BeppoSAX, NEAR, HETE, XTE, Suzaku

About 80% of these Mission-Instruments have “test” notice types as well.



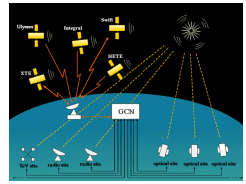
Categories by Notice Content



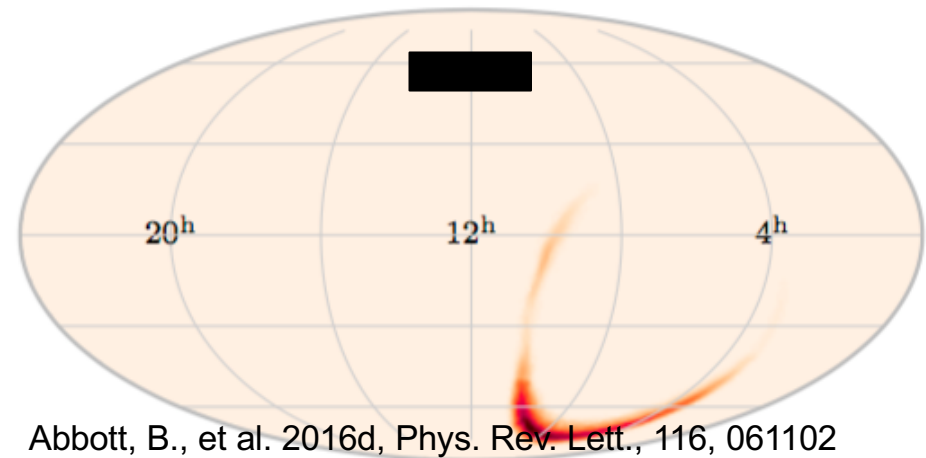
- Positions (LVC, Swift, INTEGRAL, Fermi, MAXI, MOA)
 - Fundamental data product. “where to look.”
- Lightcurves (Swift, KONUS, INTEGRAL, CALET)
 - Aids identification of the event (noise vs astrophysical, & what type of astrophysical).
 - Enables the IPN team to perfect their lightcurve cross-correlation calculations.
- Images and Spectra (Swift)
 - Images can be used as a finding chart, bright stars, noise vs astrophysical.
 - Spectra speak to the energetics of the source, of the event.
- Coincidences (Temporal (<100sec) and Spatial (<20arcmin) between events).
 - Each enhances the confidence of the other.
- Pointing Direction (Swift, Fermi, INTEGRAL)
 - Lets robotic observers follow the location of the mission, so they can take truly simultaneous data on the expectation there will be a trigger.
- Sub-threshold triggers (Swift-BAT, INTEGRAL, Fermi-GBM)
 - Cross-mission temporal/spatial correlations on these low confidence-level triggers.
- Monitoring (Swift-BAT, Fermi-LAT, MAXI “Knowns”)
 - These all-sky missions accumulate lightcurves of known sources and scan these LCs for outbursts/flares/etc and GCN distributes these events.
- Catalog Searching
 - Provide list of near-by sources from SIMBAD and NED.



LVC Specifics

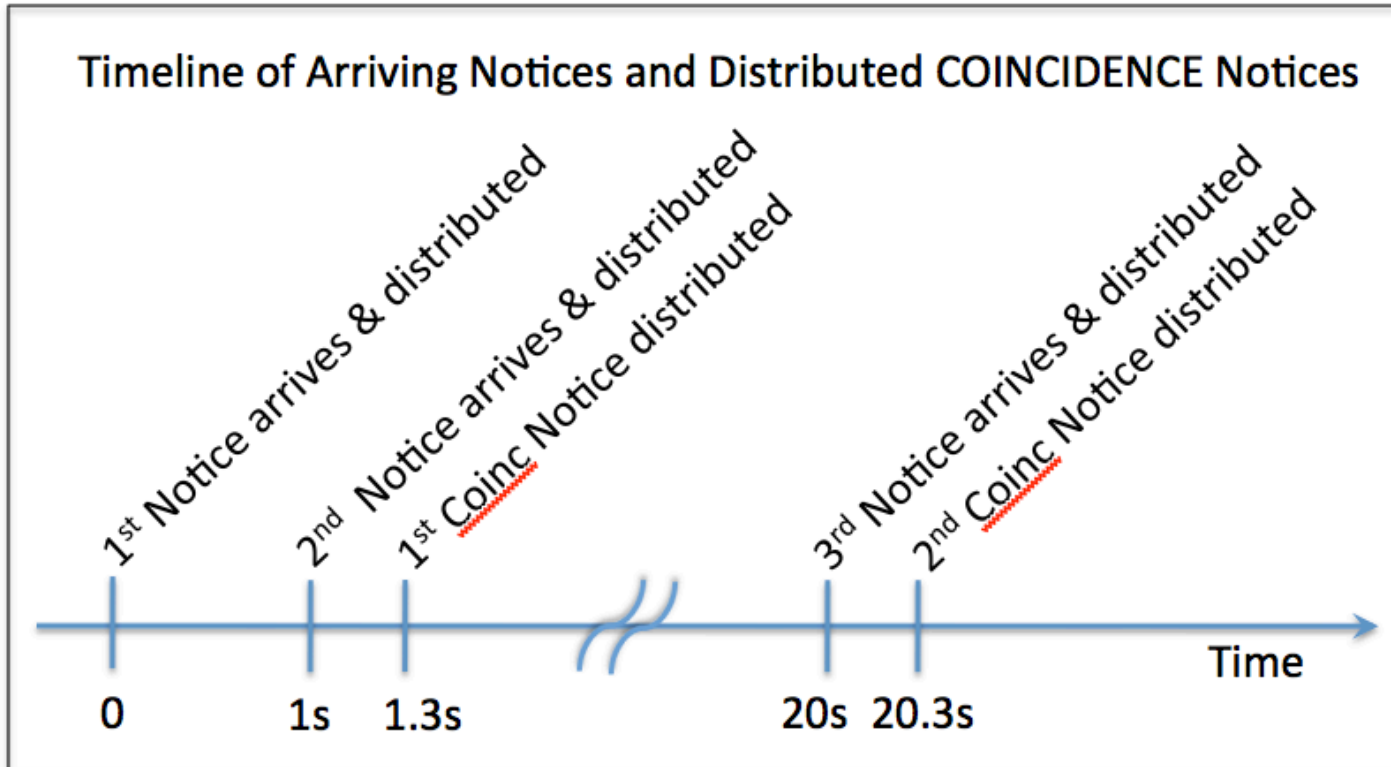
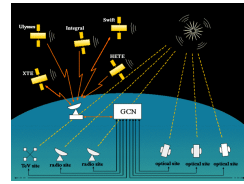


- LVC Triggers are candidate events from low-latency searches for transients in the gravitational wave data from the LIGO and Virgo observatories.
 - KAGRA will participate in a couple years
- Private Phase Operations (O1 & O2; 2015 & 2017)
- Public Phase Operations (O3; April 1st – Mar 2020)
 - Anyone can receive LVC-based Notices and Circulars.
- Notice Types: There are 4 LVC-based Notice types defined:
 - Preliminary: Trigger_Time & parameter values (no human involvement) (1 - 5 min)
 - Initial: Location probability skymap (humans involved) (10 min - hrs)
 - Updated: Updated skymap (using deeper analysis methods) (hrs - days)
 - Retraction: Further analysis yields no longer astrophysical (hr - days)
- Rate: 5 per month (23 in 4.5 mo in O3)





COINCIDENCE Notice Type



Example COINCIDENCE Notice: ~20 / month (doubles to quads)

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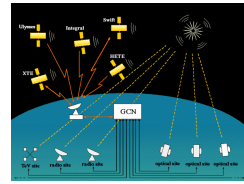
TITLE:          GCN/COINCIDENCE NOTICE
NOTICE_DATE:    Wed 05 Jul 17 16:22:22 UT
NOTICE_TYPE:    Coincidence
LABELS:
CONTRIB_1:     T P  Mission_Inst  NoticeType  TrigNum      TJD      TrigSOD      RA      Dec
CONTRIB_2:     1 0  KONUS          59          1793909956   17939    9956.000     0.000   0.000
CONTRIB_3:     1 0  SWIFT_BAT      61          760064      17939    9947.000    191.705  18.292
CONTRIB_4:     1 0  FERMI_GBM     115         520915556   17939    9951.000    187.099  21.160
CONTRIB_4:     1 0  INTEGRAL_SPIACS 52          7876        17939    9956.000     0.000   0.000
COMMENTS:      Coincidence between 2 or more events within the GCN streams.
COMMENTS:      There were 4 mission/instruments that contributed to this COINCIDENCE notice.
COMMENTS:      A '1' in the 'T' and 'P' columns indicates that the event participated in the Temporal and/or Positional coincidence.

```



GCN Statistics

(as of Aug 17)



• Notices:

- There are 762 Notice “site” recipients (1000+ people involved).

Number	Method	Sub-Method	Comment
93	socket	160-Byte binary	~70 connect often
63	socket	VOEvent, reg	~45 connect often
20-25	socket	VOEvent, anon	20-25 connect often
548	email	Full-format	All are active
72	email	Shorter formats	All are active

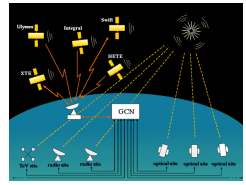
- 2,800 Transient Notices/yr; 45,000 Pnt/yr; 10,500 Test/yr; 1e6 Subthreshold/yr
- 25,000 – 36,000 notice_copies / day; 38,000 – 92,000 voevent_copies / day

• Circulars:

- 25,383 Circulars published since 1995
- 1902 recipients
- 235 Circulars / month
- 14,890 circ_copies / day



Near-term GCN Improvements



- Publication capability in the VOEvent servers
- Speeding up the Circulars distribution (currently 15–20 min 1900 recipients)
- Switch to a larger-content packet inside of *gcnmain* & **_receivers*.
 - Producer's information is getting larger with time
 - This will also carry over to another/new customer-available format
- Other new Notice formats & distribution methods: JSON,
- ????? (I encourage suggestions)
- Loner Term:
 - Include LSST events (2nd or 3rd level of delivery)



TACH Description

(Time-domain Astronomy Coordination Hub)

TACH

- **Lead:** Judith Racusin.
- **Sub-package Leads:** Scott Barthelmy, Alan Smale, Judith Racusin.
- **Team:** John Baker, Brad Cenko, Tito dal Canton, Tom McGlynn, Jeremy Perkins, Leo Singer, Eric Burns, Teresa Sheets
- NASA-funded initiative to implement new capabilities and efficiencies for multi-messenger / multi-wavelength transient science by building upon existing NASA resources and programs.



TACH Sub-Packages

TACH

- 1) Expand GCN
- 2) Create HEASARC Multi-mission Transient Database (MTD)
- 3) Transient Location Initiative (TLI)
- Approved & funded; and working on it for ~8 months.
- Currently a 3-year program, but the expectation is very high that it will be renewed, and become part of HEASARC.



#1: Continue / Expand GCN

TACH

- 1. Reduction of L-V location maps using other inputs (eg Fermi-GBM).
 - Using both correlative detections and non-detections.
 - Calculate and distributed these new probability maps.
- 2. Special effort to incorporate the “survey” projects:
 - ZFT, LSST, ????, ...
 - Emphasis on the optical to cross-match with the existing X-/ γ -ray missions/projects.
 - Load test GCN with Notices at ~1000 copies/sec.
- 3. Provide “real-time tracking & analysis of observation coverage to enable follow-up observers”.
- 4. Two hot/redundant back up systems for better reliability (>99.7%):
 - a) 2nd system on-Center, b) 3rd system off-Center (Cloud?)
 - Protection for both power and internet.



#2: Create HEASARC Multi-mission Transient Database (MTD)

TACH

- Build the database: MTD
 - Use the same format and structure of “tables” as HEASARC.
 - Already ingested the complete GCN archive to date.
 - A table for each (a) Mission/Instrument (M/I) and (b) ground producer.
 - Addition to the MTD & queries to the MTD are both low latency (<1 sec).
 - An “events” table which combines the appropriate pieces of the M/I tables.
 - All tables (events & M/I) are queryable by the public.
- Status:
 - Table design done (version 1.0).
 - Already ingested the complete GCN archive to date.
 - Started work on the user tools and interfaces:
 - Searching, correlating, extraction, and for uploading.
 - Current GCN contents yields ~20 coincidences per month
 - Queries can have delayed replies, ie waiting for Instrument_X to upload its information on a given event.



#3: Transient Location Initiative (TLI) TACH

- Cross-Mission Localizations:
 - Combining multiple γ - mission/instrument data sets to get better localization (or even any localization).
 - BurstCube (selected), plus ~8 other missions (in planning & selected stages), plus all the GCN-handled missions.
 - They use the detector rates as a function of director axis direction with respect to the GRB/transient.
 - This combines those cross-mission detector rates to yield a more accurate location.
 - Transmissions from missions will be real-time, so the results of the combining will be low-latency.
 - Uncertain about if each mission's mass model can be folded in.
 - Automated to make it faster.
 - Modules & open-source, so new missions can easily be incorporated.
 - They do not have to develop these codes themselves; can't on the small staffing and limited budgets.