

National Aeronautics and Space Administration



# Fermi

Gamma-ray Space Telescope

[www.nasa.gov/fermi](http://www.nasa.gov/fermi)

# Fermi

Gamma-ray Space Telescope

**Users Group Meeting  
November, 2015**

**Mission Status Update**

**J. McEnery**

## Some goals for this meeting

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- **Comments and feedback from the users group on:**
  - **Pass 8 release**
    - **Is there anything we could have done better?**
  - **Senior review! (in dedicated afternoon discussion)**
- **Of course, comments on suggestions on any aspect of the mission are welcomed!**

# Action Items from last meeting

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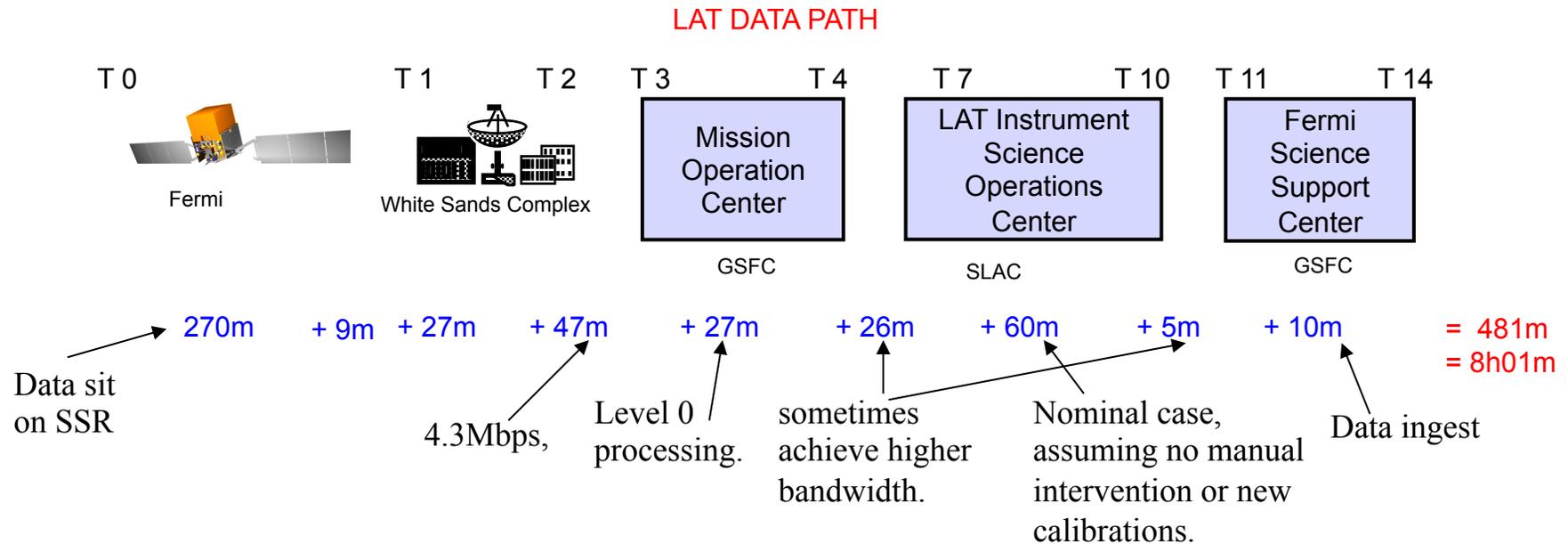
- **Fermi Symposium**
  - We suggest more advertisement, create a flyer (done)
  - More community participation in the meeting and invited talks
- **LAT**
  - Document any limitations of P8 (done, but welcome feedback)
  - Track incremental impact of P8 on publications (probably too soon to see full picture, but >30 papers submitted so far)
- **EPO**
  - Track status of iPad project (being turned into web material)
  - Consider newsletter
- **Management**
  - Get public correction on SR page correcting misunderstanding (done)
  - Reduce future lien from multi year GI awards (done)

# Observatory Status Highlights

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- **Observations:**
  - Regular +/-50 deg sky survey with occasional ARR
  - ToO: Nova SGR, 3C279
- **FOT/engineering activities**
  - Continuing improvements to flight dynamics (orbit tracking etc)
  - Switching MOC systems to use VMs
  - Significant effort to reduce data latency (see next slide)

# Data Latency



- **Changing downlink scheduling to reduce time that data sit on SSR**
- **Parallelizing data transfer from White Sands provides additional saving**

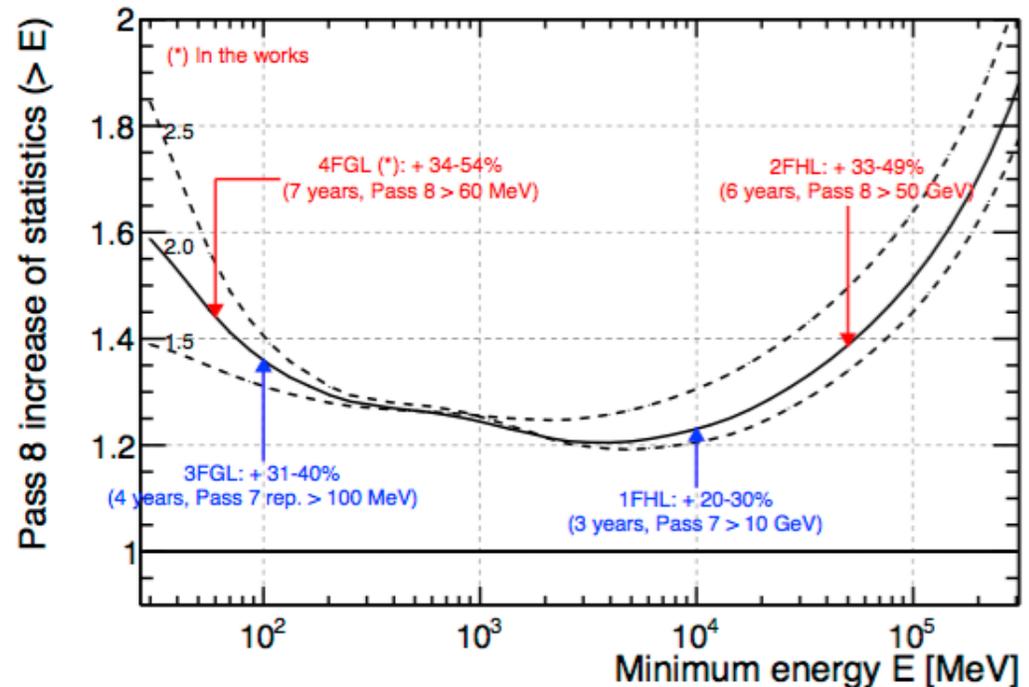
## Pass 8

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- **Pass 8 is the most profound revision of the LAT event-level analysis since launch.**
- **The LAT processing pipeline and FSSC data server transitioned to Pass 8 data on June 24.**
  - **Released associated analysis components and tools.**
- **A fundamental milestone, closing a loop started in 2009.**
- **An extraordinary example of collaboration between the LAT Science Team, the LAT Instrument Science Operation Center and the Fermi Science Support Center.**

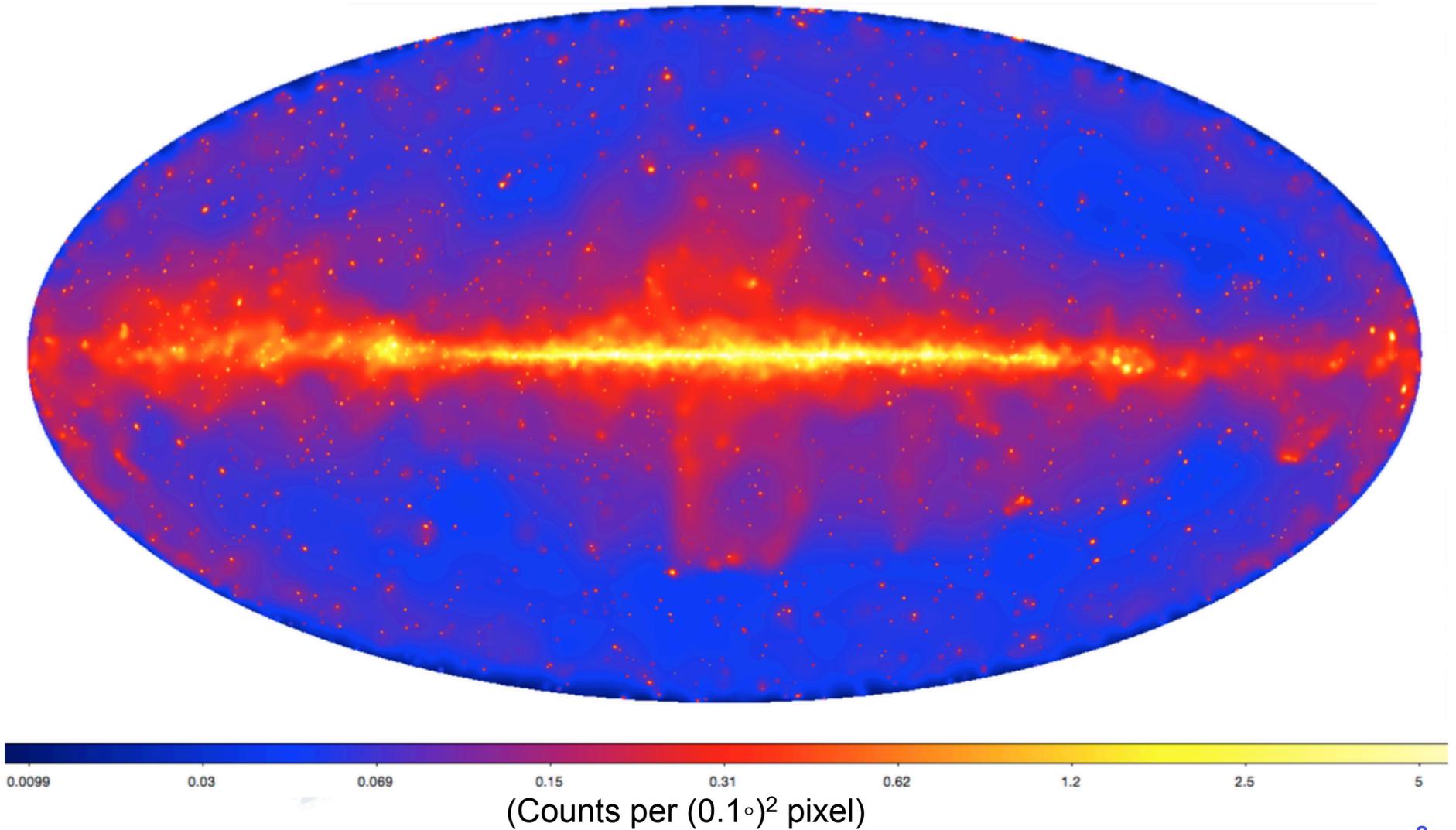
## Pass 8

- **Pass 8 released!**
- **Significantly increase the gamma-ray throughput (>  $\times 1.2$  everywhere).  $\times 1.5$  above  $\sim 60$  MeV and above  $\sim 50$  GeV.**



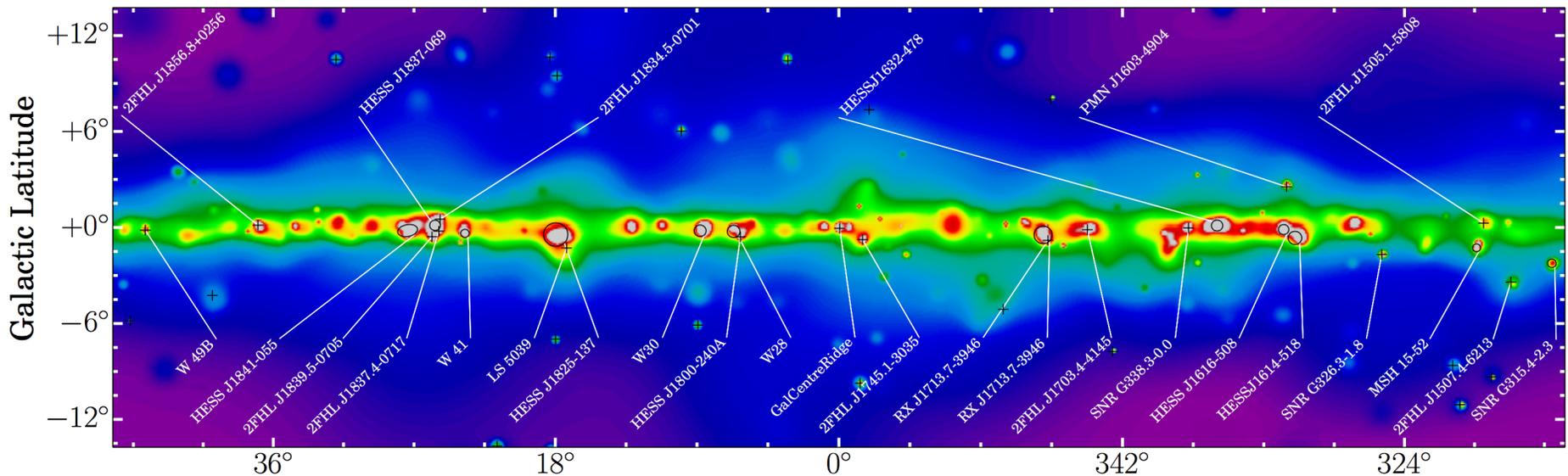
- **Better angular resolution—and better modeled.  $\times 1.3$  at 10 GeV (or background  $\times 0.6$ ).**
- **Event-by-event reconstruction quality fully integrated in the analysis framework.**
  - **PSF event types (dSphs, source extension, AGN pair halo).**
  - **Energy dispersion event types (searches for spectral lines and ALPs).**

# >10 GeV map, 80 months of P8 data



## 2<sup>nd</sup> Hard Source Catalog

- 6 years, Pass 8 data, 50 GeV – 2 TeV
- 360 sources (75% extragalactic, 11% Galactic, 13% unassociated )
  - 47 new gamma-ray sources (not in any previous gamma-ray catalog)
  - Only 25% previously detected by Cherenkov telescopes
- Work on the 3FHL (90–100 months above 10 GeV) already started. 1502 sources in a 80-month run (i.e., ~ 1FHL × 3, faster than linear!).



## Pass 8 – more to come!

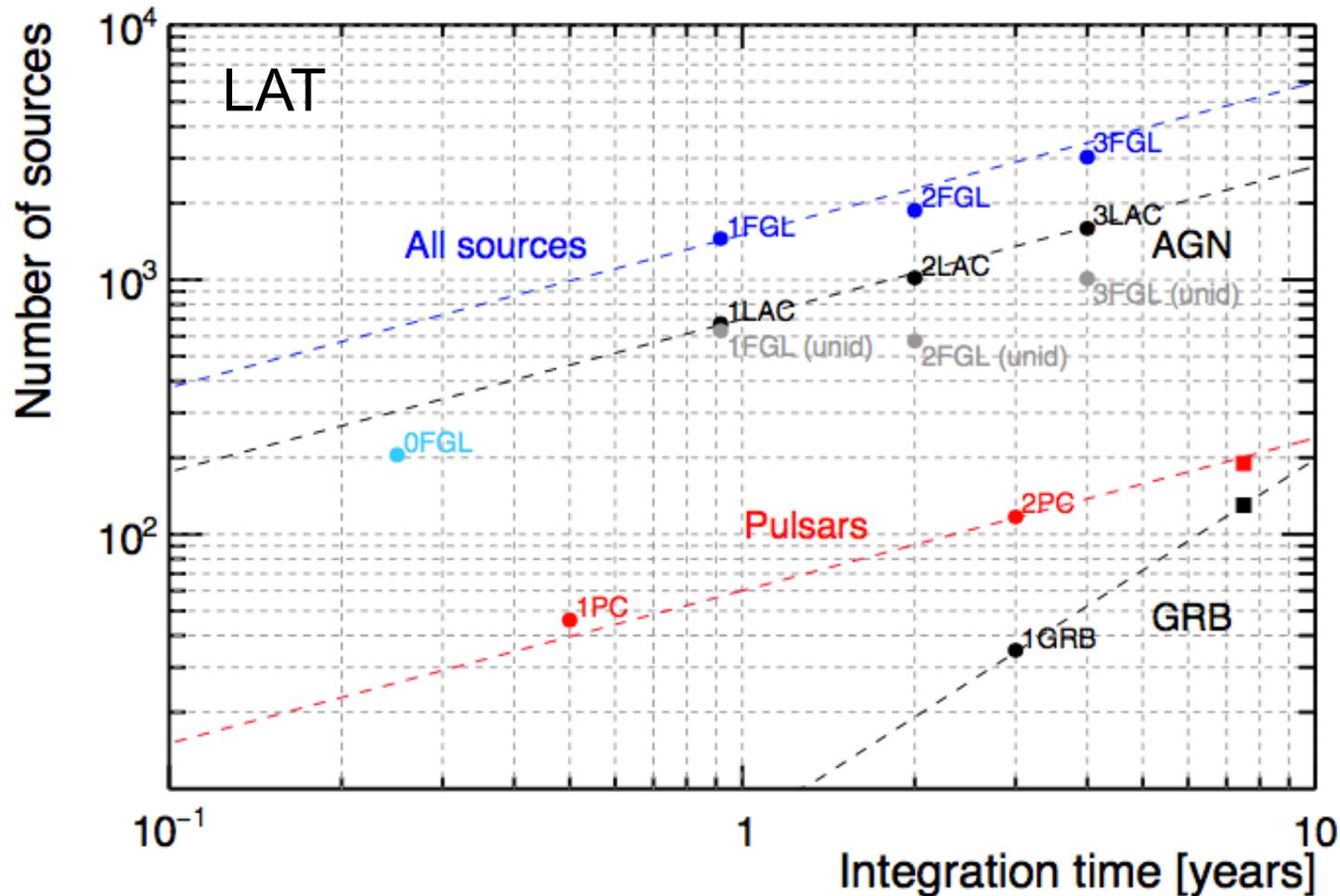
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- **Especially at the lowest energies.**
  - **More (detailed incremental) work, but also significant discovery space.**
- **Acceptance  $\times 3$  ( $\times 7$ ) above 50 MeV (30 MeV) compared to Pass 7.**
  - **Spectral analysis is challenging: steeply falling effective area and relatively large PSF and energy dispersion.**
- **An improved diffuse emission model is key to fully exploiting Pass 8 at low energy.**
- **Pass 8 is significantly enlarging the LAT low-energy field of view.**
  - **Good—we see more transients.**
  - **At the same time the CR-induced  $\gamma$ -ray emission from the Earth atmosphere is comparatively more important.**

**Bottomline: expect a new public release of the Pass 8 analysis framework on a timescale of  $\sim 1$  year.**

**We're actively working on all of these items, and each has (at least) one corresponding contribution at the Fermi Symposium this week.**

# Catalogs Drive Fermi Science



GBM 2, 4 and 6 year GRB catalogs  
 GBM SGR catalog  
 Online catalogs for TGF and Type 1 X-ray bursts



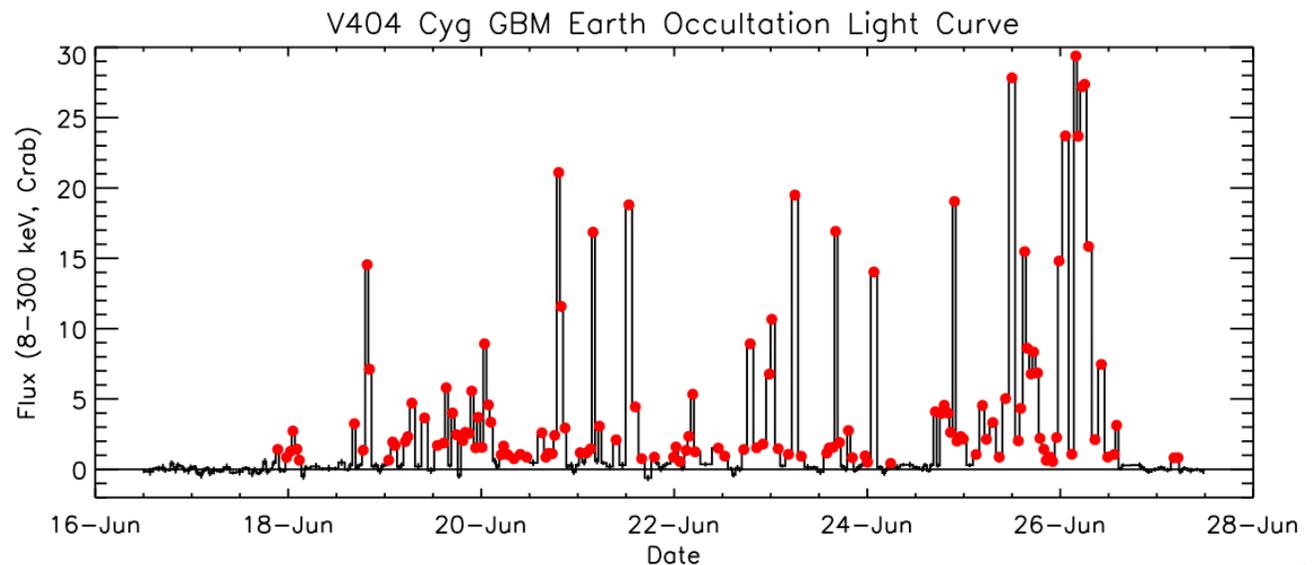
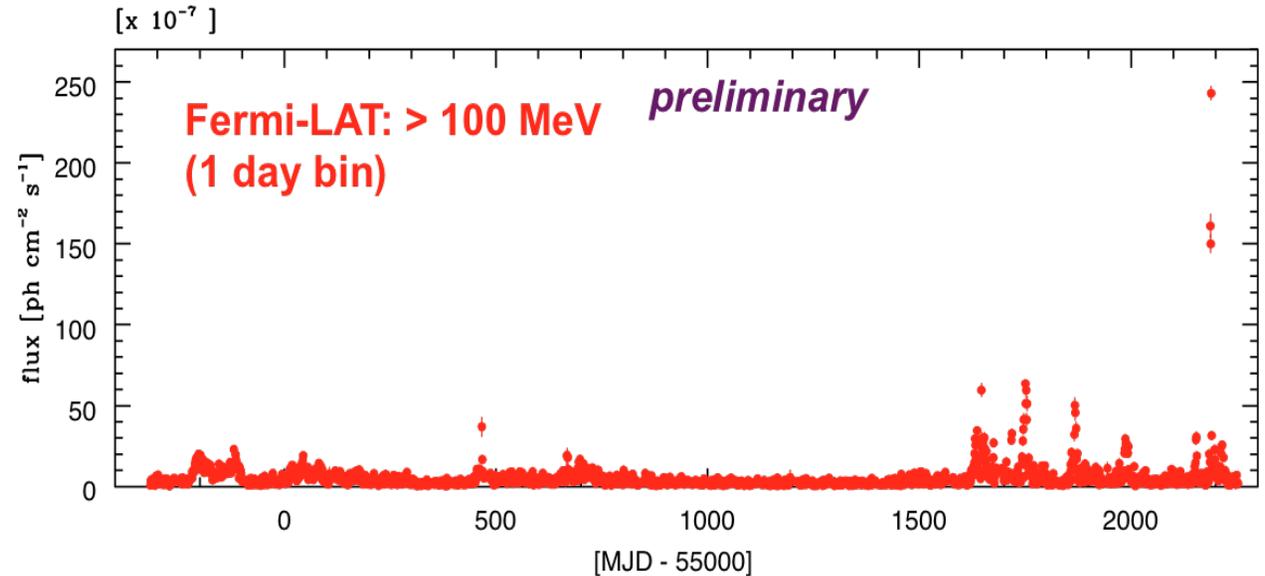
# Transient and Variable Source Pipelines

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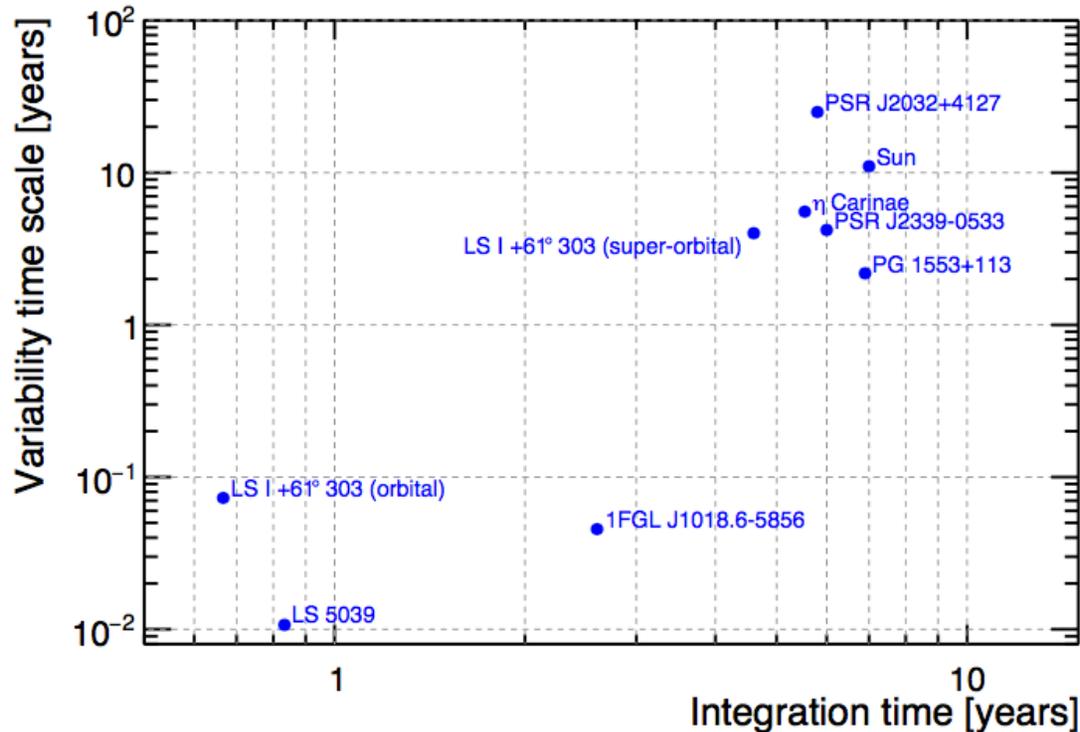
- **Pass 8 allows a search for variability to shorter timescales, currently improving standard pipelines**
  - **Anticipate sending alerts of flaring AGN and new galactic transients on timescales of 0.5 day or less c.f. 1-2 days now**
- **2<sup>nd</sup> FAVA (Fermi All sky Variability Analysis) catalog will be released shortly**
  - **Will include new public webpage to promptly alert the community of new flaring sources**
- **First catalog of transients on monthly timescales**
  - **Fills the gap between FAVA and the “regular” catalogs**
  - **First time this has been tried, huge discovery space**

# An exciting week – 3C279 and V404 Cyg

- **Extraordinary flare from 3C279, responded with Fermi ToO**
- **12 hours later V404 Cyg became active – LARGE number of GBM triggers/alerts!**



# Seeing benefits of Long Temporal Baseline



The LAT is already probing periodicities/ quasi-periodicities on characteristic timescales of 10+ years.

For some of these sources (e.g., PG 1553+113) a longer baseline is key.

- Also interesting future events that we can predict, e.g.:
  - PSR J2032+4127 (20–30-year period) periastron passage in February–March 2018.
  - PSR B1259-63 (3.4-year period) 3rd periastron passage in September 2017.

## Advanced LIGO and Virgo

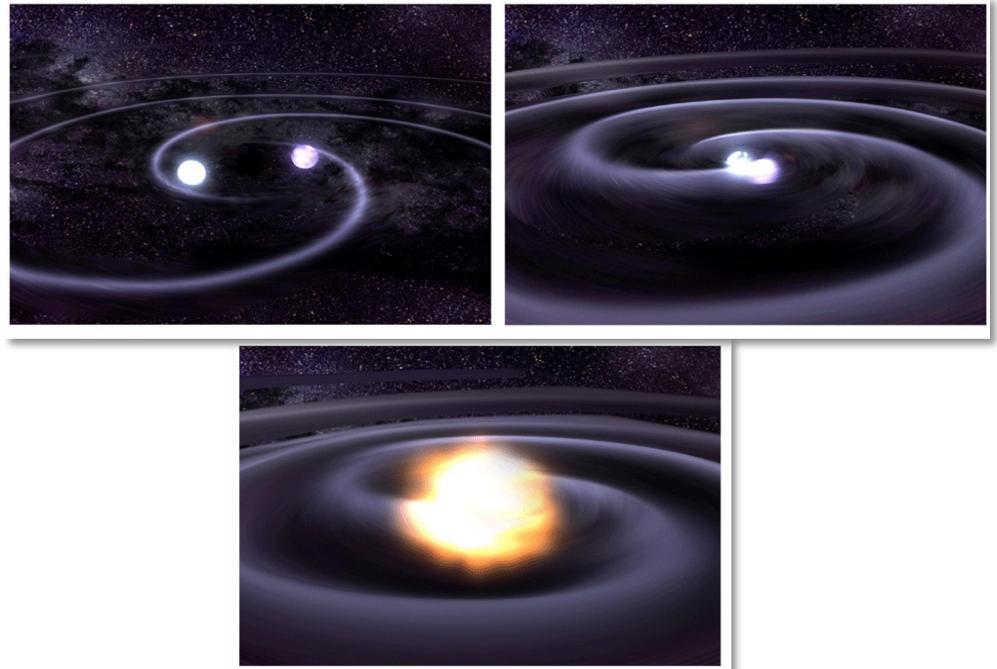
- **LIGO - Two interferometers (4km length) in Livingston, LA and Hanford, WA**
- **Virgo – One interferometer (1km length) in Cascina, Italy**

Sensitive to GW produced in mergers of compact objects (ns-ns, ns-bh, bh-bh)

Ns-ns and ns-bh mergers are also believed to be the progenitors of short GRB

GBM currently detects 40 SGRB/year and will significantly increase this with a new search on CTTE data

Fermi-LAT can also search for EM counterparts to LIGO/Virgo triggers

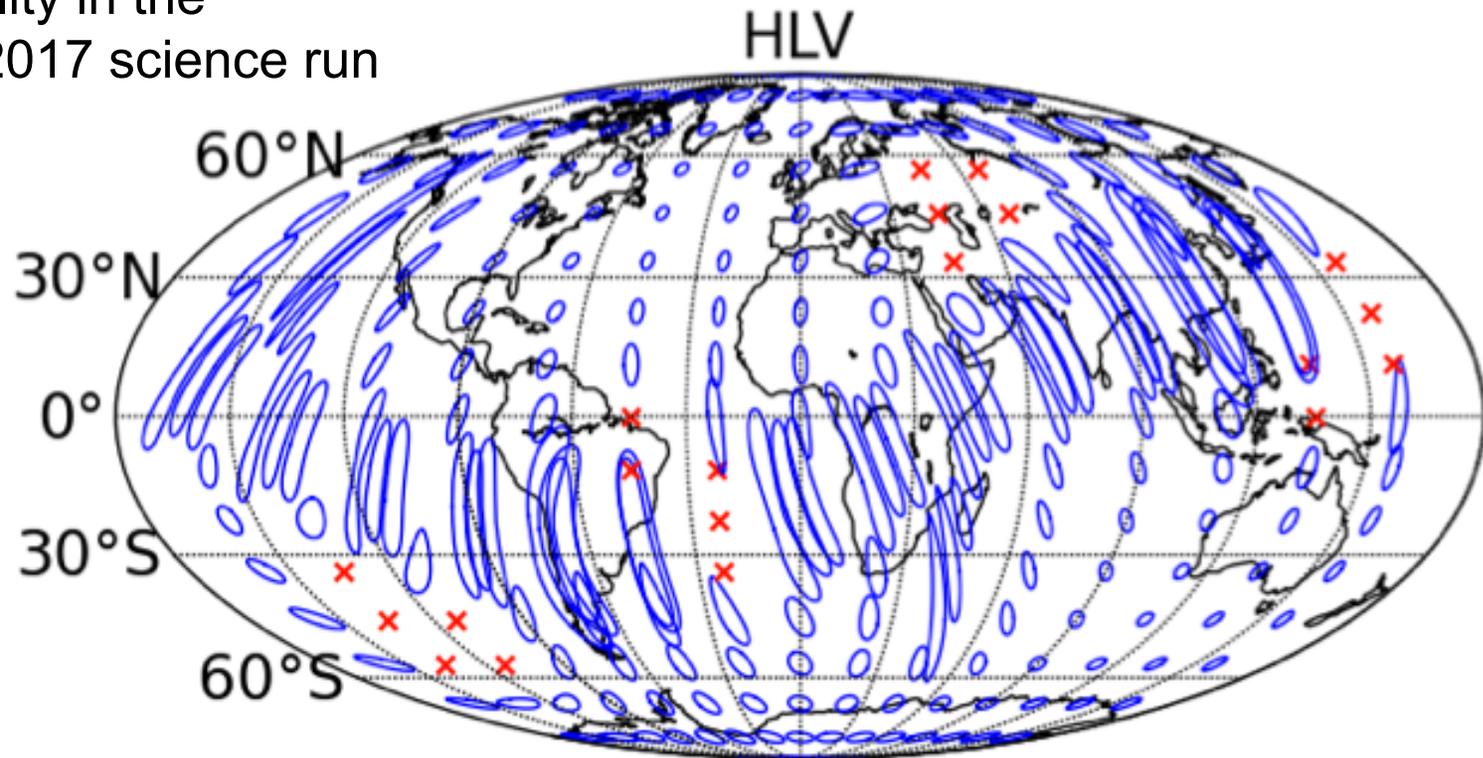


**Detection of EM counterparts to GW detections is crucial to maximise science potential.**

Grav. radiation → inspiral characteristics ;  
*Fermi* → jet properties & environment

# Analysis Challenges

Expected localization  
capability in the  
2016-2017 science run



- **Signals are localized by triangulation between interferometers**
  - **This results in large “arc-like” location uncertainties in early observations**
  - **Fermi is ideal for counterpart searches**

# Planned LVC (LIGO Virgo Consortium) science runs

| Epoch         | Estimated Run Duration | $E_{GW} = 10^{-2} M_{\odot} c^2$ Burst Range (Mpc) |         | BNS Range (Mpc) |          | Number of BNS Detections | % BNS Localized within |                     |
|---------------|------------------------|--|---------|-----------------|----------|--------------------------|------------------------|---------------------|
|               |                        | LIGO   | Virgo   | LIGO            | Virgo    |                          | 5 deg <sup>2</sup>     | 20 deg <sup>2</sup> |
| 2015          | 3 months               | 40 – 60  | –       | 40 – 80         | –        | 0.0004 – 3               | –                      | –                   |
| 2016–17       | 6 months               | 60 – 75  | 20 – 40 | 80 – 120        | 20 – 60  | 0.006 – 20               | 2                      | 5 – 12              |
| 2017–18       | 9 months               | 75 – 90  | 40 – 50 | 120 – 170       | 60 – 85  | 0.04 – 100               | 1 – 2                  | 10 – 12             |
| 2019+         | (per year)             | 105  | 40 – 80 | 200             | 65 – 130 | 0.2 – 200                | 3 – 8                  | 8 – 28              |
| 2022+ (India) | (per year)             | 105  | 80      | 200             | 130      | 0.4 – 400                | 17                     | 48                  |

- **As detector commissioning continues, a sequence of science runs are planned with**
  - **Increases in sensitive volume (distance to which LIGO can see a ns-ns merger)**
  - **Improved localization**
  - **Longer science run duration**



# Fermi-LIGO/Virgo Analysis Workshops

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- **March 23-24, 2013 and March 14-15, 2015**
- **Advertised to and attended by members of LIGO, Virgo, Fermi-GBM, Fermi-LAT**
- **First meeting focused on analysis and coordination**
  - **Each team discussed:**
    - **current and future instrument capabilities**
    - **handling of GRB searches and transients**
    - **and then guided a hands on analysis workshop**
  - **Fermi people played with LIGO data, and the LIGO/Virgo folks looked at LAT and GBM data**
- **Second meeting focused on science**
- **Very successful, the teams interacted extremely well, the act of going through each others analysis chain helped provided insights into how we can best help one another search for joint GW-EM detections.**

# Formalities

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- **July 2013 – submitted letter of intent between Fermi and LIGO/ Virgo (on the Fermi-side, including the people who participated in the workshops)**
- **Coordination meeting in September 2013 between LIGO and all the LOI groups**
- **Dec 2014, MOU signed on behalf of both Fermi-LAT and Fermi-GBM (same Fermi names as for the LOI). For LIGO, the MOU facilitates information flow on an individual scientist basis**
  - **Similar to the Planck MOU**
- **First LIGO science run**
  - **Started Sept 18, 2015**
  - **Will end Jan 12, 2016**
- **Joint Fermi-LIGO analysis ongoing under the auspices of the MOU**



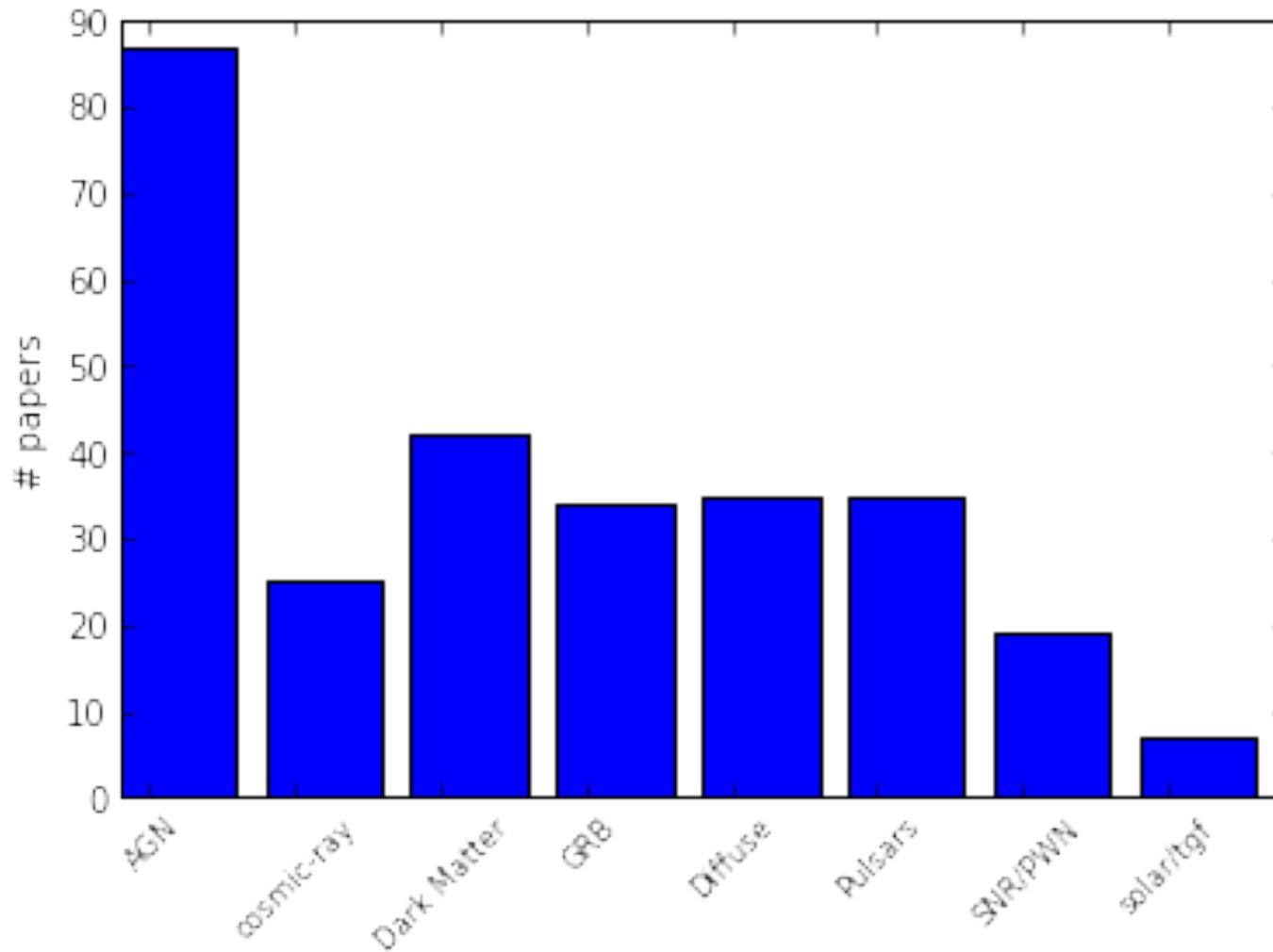
# Public Outreach

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- **NASA Press releases (coordinated by Fermi)**
  - **NASA's Fermi Sees Record Flare from a Black Hole in a Distant Galaxy**
  - **Astronomers Predict Fireworks from Rare Stellar Encounter in 2018**
  - **NASA Missions Monitor a Waking Black Hole**
- **Other relevant press releases**
  - **Hidden in Plain Sight - Scientists Discover Elusive Gamma-ray Pulsar (Max Planck)**
- **Upcoming press releases**
  - **PG 1553 periodicity: First gamma-ray and multiwavelength quasi-periodical oscillation in an active galactic nucleus.**
  - **LMC pulsar: first gamma-ray pulsar observed in another galaxy (LMC), one of which has the brightest pulsed emission yet identified (> 20 times the Crab's).**
  - **Pass 8 feature**

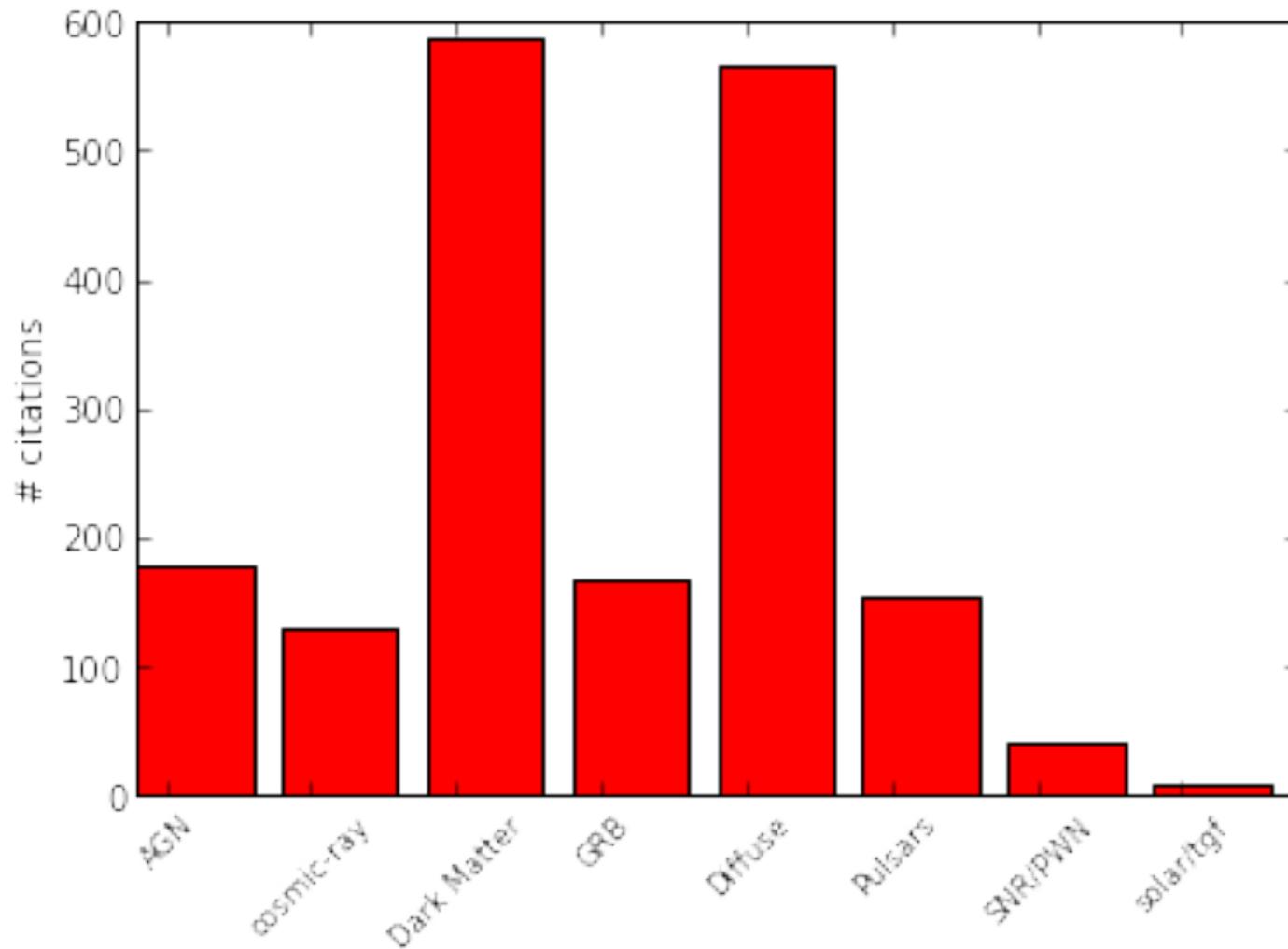
# Paper Status for 2015

- From Jan-Sept 2015
  - 280 papers with 1551 citations



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## 4 Fermi papers in top 10 most cited in 2015

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1. Joint Analysis of BICEP2/Keck Array and Planck Data *BICEP2/Keck and Planck Collaborations*, PhRvL (173 citations)
2. The EAGLE project: simulating the evolution and assembly of galaxies and their environments *Schaye, Joop, et al.* MNRAS (170 citations)
3. UV Luminosity Functions at Redshifts  $z \sim 4$  to  $z \sim 10$ : 10,000 Galaxies from HST Legacy Fields *Bouwens, R. J., et al.* ApJ (121 citations)
4. **Dark Matter with Pseudoscalar-Mediated Interactions Explains the DAMA Signal and the Galactic Center Excess** *Arina, Del Nobile, & Panci*, PhRvL (114 citations)
5. **Fermi Large Area Telescope Third Source Catalog** *Acero, F., et al.* ApJS (110 citations)
6. **Background model systematics for the Fermi GeV excess** *Calore, Cholis, & Weniger* JCAP (103 citations)
7. Baryon acoustic oscillations in the Ly $\alpha$  forest of BOSS DR11 quasars *Delubac, et al.* A&A (87 citations)
8. The Eleventh and Twelfth Data Releases of the Sloan Digital Sky Survey: Final Data from SDSS-III *Alam, et al.* ApJS (86 citations)
9. **The Spectrum of Isotropic Diffuse Gamma-Ray Emission between 100 MeV and 820 GeV** *Ackermann, M., et al.* ApJ (80 citations)
10. Advanced Virgo: a second-generation interferometric gravitational wave detector *Acernese, F., et al.* CQGra (79 citations)

**Questions?**