



Fermi

Gamma-ray Space Telescope



# Fermi-LAT Update

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Fermi User Group (FUG) meeting,  
July 30, 2018

# Overall Message

The LAT Collaboration is actively improving *improving* and *increasing interactions* between the science groups and public LAT data users to get the most out of the mission

**LAT Collaboration  
Meeting and Status**

**LAT Collaboration  
Response to March  
16 event**

**Recent Science  
Highlights**

***Looking Forward***

# Collaboration Meeting: Pisa, Italy



**12-16 March 2018: 103 registrants!**

5 days: mix of plenary/splinter sessions  
Plans for 10 year celebrations/symposium

**Junior Lunch: ~20 attendees**

Lots of good recommendations to  
improve communication

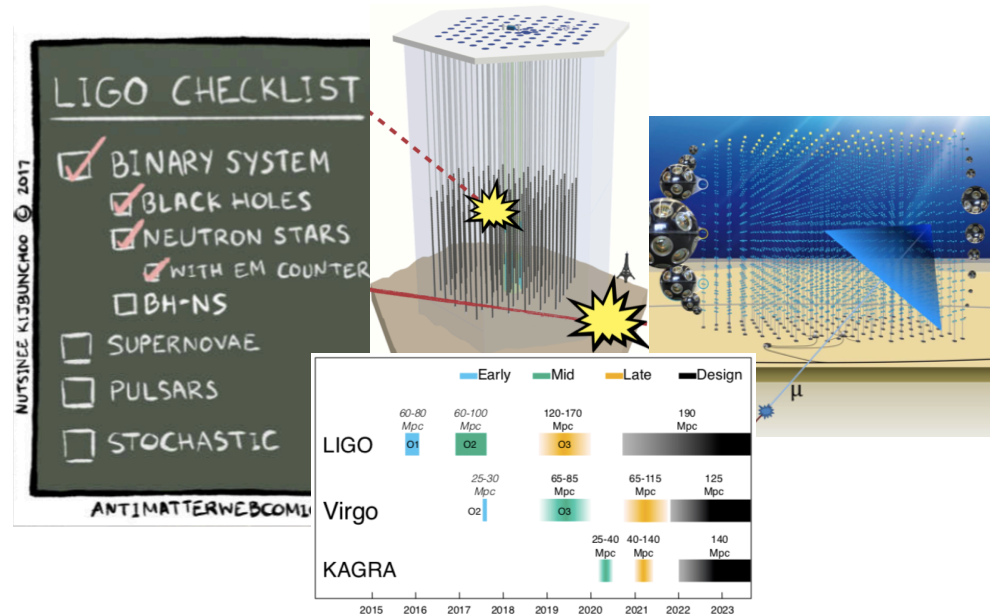
**Continued tradition:**

**Open session (see next slide)**

Next CM@GW before  
Fermi Symposium

# Open Session

- Talks from Collaborators:
  - IceCube, Km3NET, Virgo, GBM, GRAWITA, CTA, highlights on Novae, Open Universe, AGILE, Theory... and more
  - Theme: All the messengers! LAT is a key player



- Highlights from LAT Collaboration:
  - LAT Science, Building the collaboration and instruments, reflections on 10 years of the mission and 10 year celebration activities



# Fermi-LAT Status

- The LAT continues to operate well with no degradations in science performance
  - photon database: 1,140,815,240 photons, collected between 2008-08-04 15:43:36 UTC and 2018-07-27 13:39:09 UTC
  - event database: 301,9314,260 events, collected between 2008-08-04 15:43:36 UTC and 2018-07-27 13:39:09 UTC
- The LAT Collaboration continues to provide excellent coverage for all LAT instrument operations and data processing/analysis needs
  - good coverage in all areas due to multitasking by many collaboration members
  - collaboration actively engaged in data quality monitoring;
  - key commitments from partners for extended operations remain firm

# LAT Collaboration response to 16 March Event

## The Calibration and Analysis group led the validation effort:

On April 9 we had an important C&A meeting with reports from TKR, CAL, ACD, DQM experts and with analyses on Vela and 3C279.

More details are reported at the following confluence pages:

- TKR: <https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=233313436>
- CAL: <https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=233313441>
- ACD: <https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=233313444>
- DQM: <https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=233313453>
- Analyses of Vela: <https://confluence.slac.stanford.edu/display/SCIGRPS/2018/04/09/Vela+after+LAT+reactivation>
- Analysis of 3C279: <https://confluence.slac.stanford.edu/display/SCIGRPS/2018/04/09/3C+279+after+LAT+reactivation>
- Comparison of a few variables: <https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=233314230>

# Summary

A great work has been done by the LAT restart team to make checks on the different subsystems:

The safemod lasted 17 days and 8 hours.

The TKR, CAL, ACD are working at nominal values.

The DQM confirms this.

The Science cases for Vela flux and timing and 3C279 also confirm the LAT performance has not changed

We are therefore ready to make again exciting science with the LAT.



April 9



# Science Highlights

# Publications from LAT Team

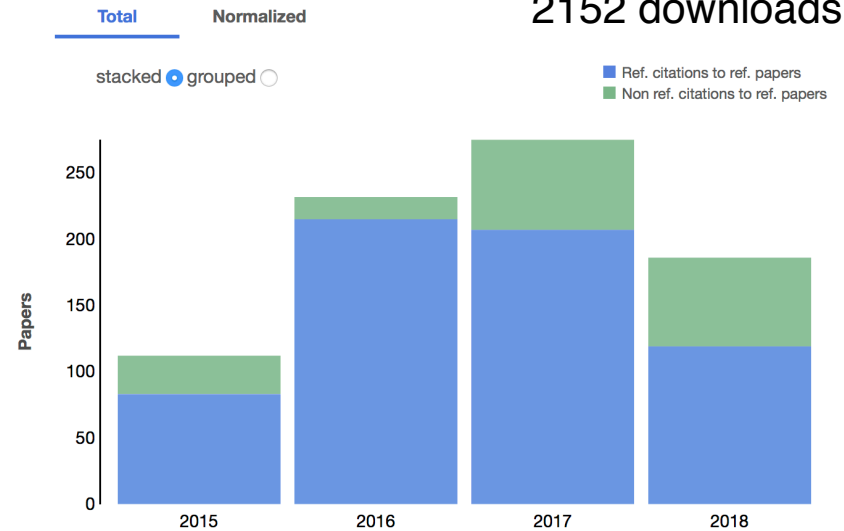
## Summary of Fermi LAT science publications

27 July 2018

### Category I and II papers in refereed journals

Journal	Published	In press	Total
Advances in Space Research	0+1=1	-	1
Astronomy and Astrophysics	8+69=77	0+6=6	83
Astroparticle Physics	2+6=8	-	8
Astrophysical Journal	102+125=227	0+5=5	232
Astrophysical Journal Letters	33+36=69	-	69
Astrophysical Journal Supplement	14+6=20	-	20
Astrophysics and Space Science	0+1=1	-	1
Journal of Cosmology and Astroparticle Physics	4+8=12	-	12
Journal of Geophysical Reserch	0+1=1	-	1
Monthly Notices of the RAS: Letters	0+2=2	-	2
Monthly Notices of the Royal Astronomical Society	0+55=55	0+1=1	56
Nature	2+1=3	-	3
Nature Physics	0+2=2	-	2
Nuclear Instruments and Methods	0+1=1	-	1
Physical Review D	11+8=19	-	19
Physical Review Letters	11+1=12	-	12
Physics Reports	0+1=1	-	1
Publ.Astron.Soc.Austral.	0+1=1	-	1
Publications of The Korean Astronomical Society	0+1=1	-	1
Publications of the ASJ	0+2=2	-	2
Science	21+0=21	1+0=1	22
<b>Total</b>	<b>208+328=536</b>	<b>1+12=13</b>	<b>549</b>

3FGL: 805 citations  
4948 reads  
2152 downloads



<http://fermi.gsfc.nasa.gov/ssc/library/pubs/>

R. <http://www-glast.stanford.edu/cgi-bin/pubpub>

# Published Specialized LAT Catalogs

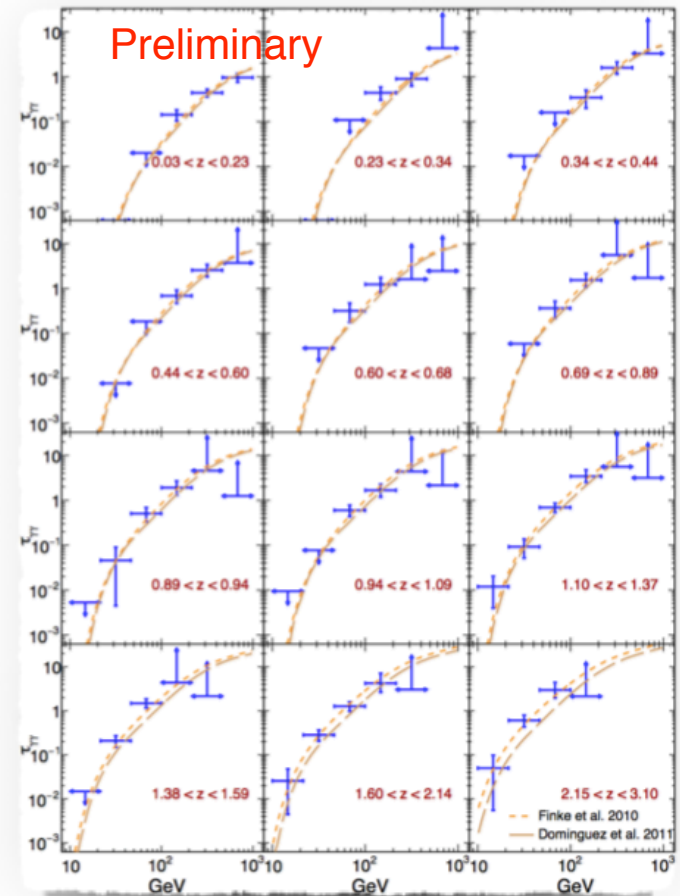
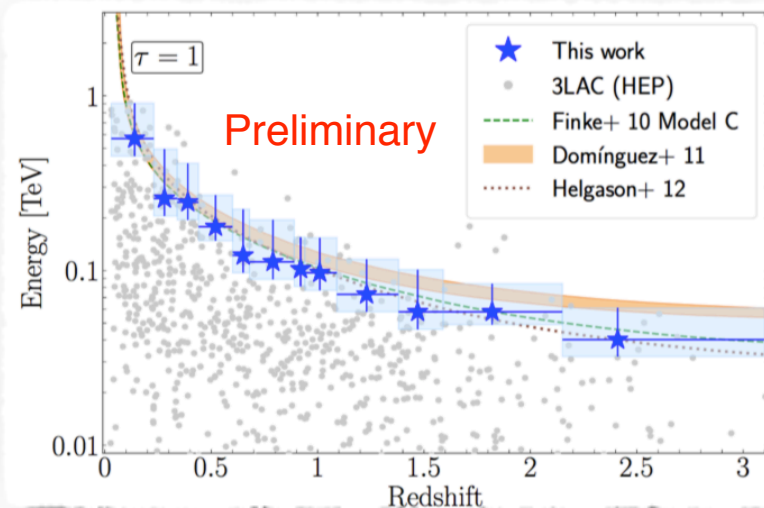
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- Specialized catalogs produced by LAT Team (past 2 years)
  - High-Latitude Extended Sources (FHES), ApJ, 2018
  - Novae Catalog, A&A, 2018
  - 3FHL, ApJS, 2017
  - 2FAV Catalog of flaring Sources, ApJ, 2017
  - Galactic Plane Extended Sources (FGES), ApJ, 2017

# Star formation history of the Universe using EBL measurements

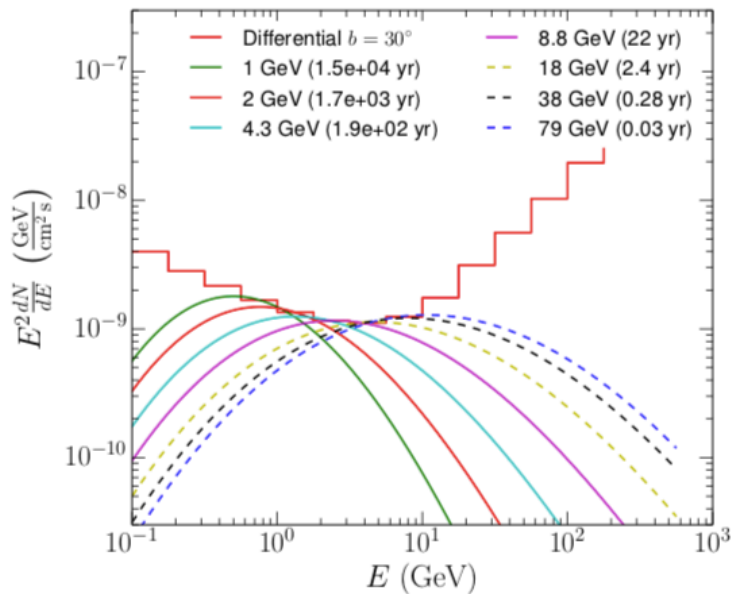
- Measure the attenuation due to the EBL as a function of energy at 12 redshifts
- Translate the attenuation measurement into measurements of the EBL and cosmic emissivity
- Derive the star-formation history of the Universe
- Place an upper limit to the cut-off luminosity of the galaxy UV luminosity function

Cosmic gamma-ray horizon

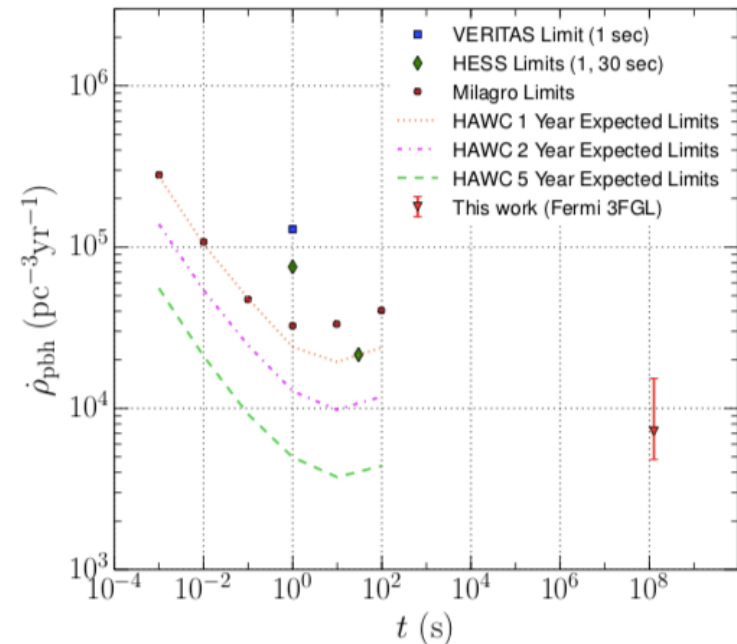


First reviews back from Science

# Search for Gamma-ray Emission from Local Primordial Black Holes with the Fermi Large Area Telescope



PBH spectra (Hawking radiation) compared with 3FGL sensitivity - Dashed lines, shorter than Fermi mission time

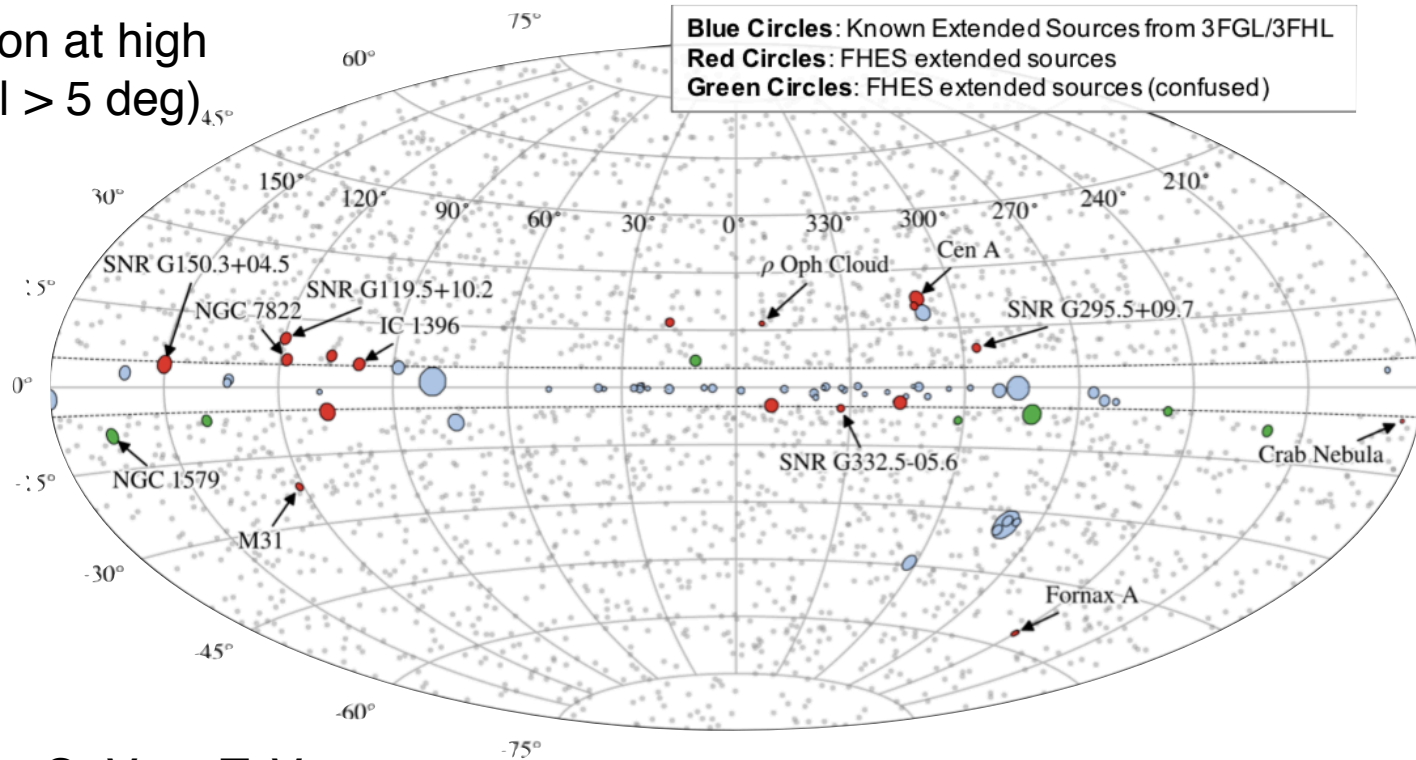


Limits on PBH evaporation rate in a new part of parameter space

Published ApJ

# Fermi High Latitude Extended Source Catalog

**FHES:** search for sources with angular extension at high Galactic Latitude ( $|b| > 5$  deg)

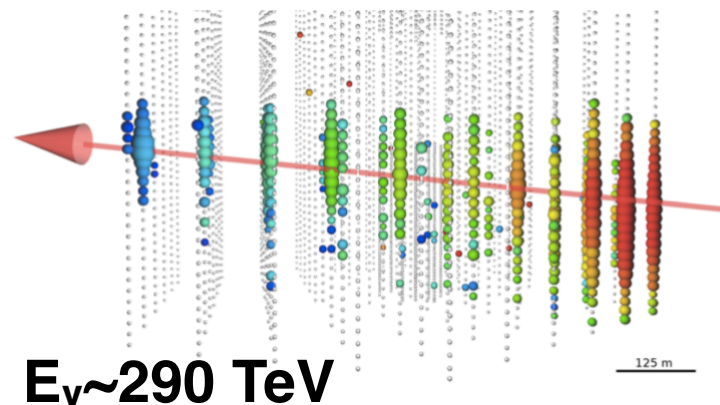
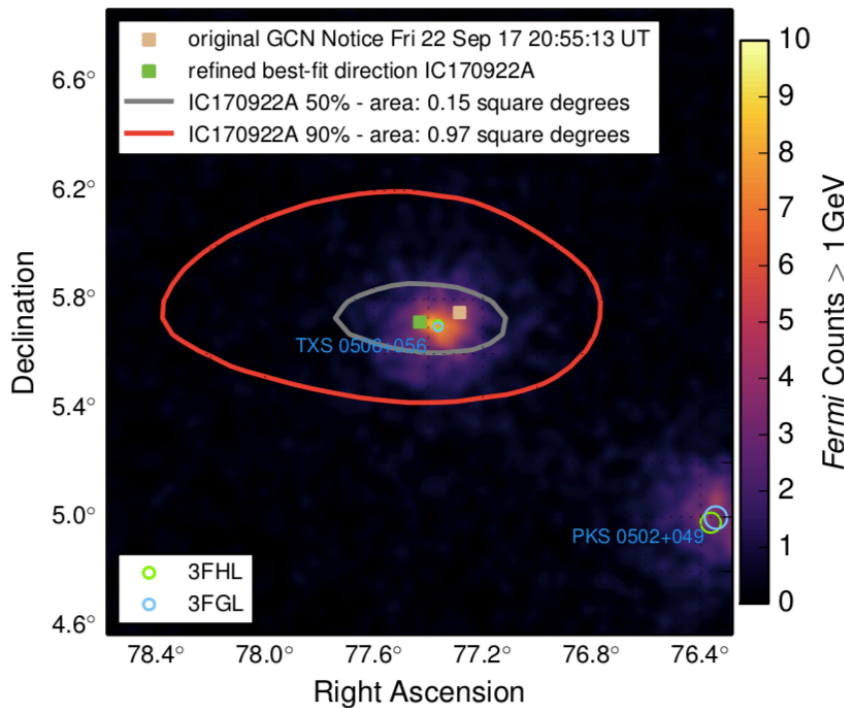
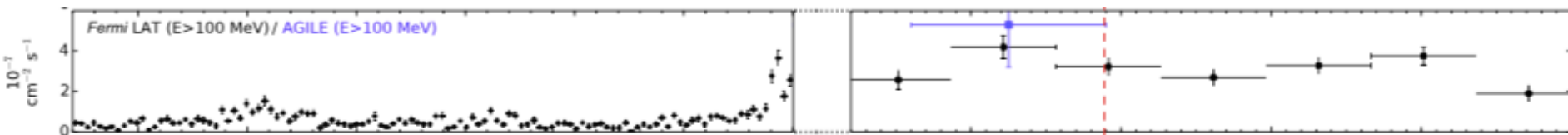


7.5 years, P8 data, 1 GeV - 1 TeV  
 24 extended sources: 5 known vs 19 new  
 19 new sources:  
 8 associated, 4 unassociated, 7 confused

Accepted by ApJ

# A Gamma-ray Blazar Candidate Origin of a Cosmic Neutrino

A flaring  $\gamma$ -ray blazar TXS 0506+056 and IC-170922A



Published in Science  
Lots of press activity

# Looking Forward



# Upcoming Analyses

## **Catalogs in the pipeline:**

4FGL, 4LAC, GRB, Solar Flare, Transient,  
3rd Pulsar

## **Selected Analyses:**

Instrument performance after 10 years

Gamma-ray polarization

Flare Properties of bright FSRQs, Misaligned AGNs

Joint Fermi/MAGIC/Veritas on 2HWC Sources

Pass 8 Interstellar Emission, All sky Fermi/Planck  
comparison IEM in the Galactic plane

DM from UNID sources, Quiet Sun... many many more

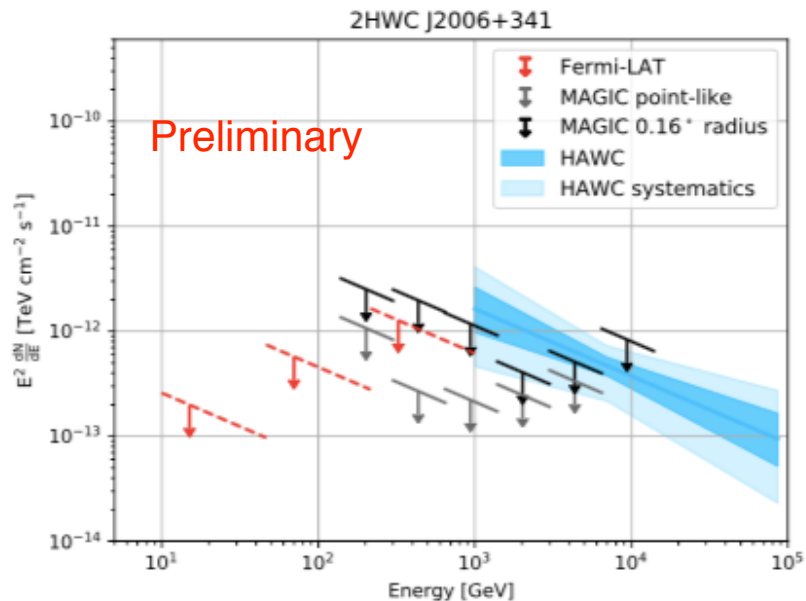
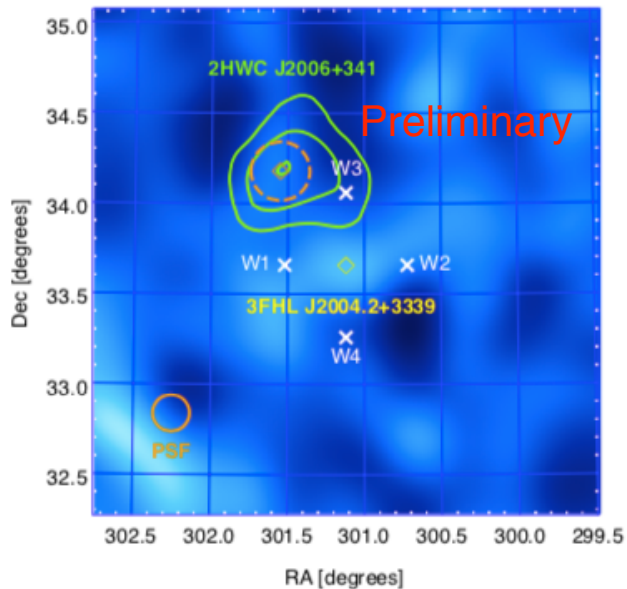
# 4FGL and Interstellar Emission Model Status

- The Takeaway: Switching to higher resolution data sets was more challenging than previously expected. We're now at a level that we were at with previous IEM
- We're aware that this is overdue...

# 4FGL and Interstellar Emission Model Status

- Updates/Challenges
  - Improved DNM from Planck (has been completely redone)
    - Planck: 2 maps for column density estimate: radiance and extinction.
      - Both estimates provide a non-linear estimate of the column density map.
    - Methods for determining extinction updated from the SFD (non-linear relations have changed)
    - Getting the DNM right requires iterations between dust and gamma-ray modeling very time consuming task.
  - HI4PI (All sky database of galactic HI) also more time consuming
  - Lower energies included (down to 50 MeV)
  - Many more point sources (>6000)
  - Analysis split in regions to break degeneracies between diffuse components
  - Coordination with many experts
    - Handling of energy dispersion is explicit
- 4FGL is ready to start running once this is complete

# Joint Fermi/MAGIC/Veritas on 2HWC Sources



## One example: 2HWC 2006+341

Detected by HAWC @  $\sim 6\sigma$ , spectral parameters taken from 2HWC  
 closest Fermi-LAT source is 3FHL J2004.2+3339 (searched for  
 pulsations (Clark et al. 2017), none found), area observed by MAGIC

***Fermipy*** - an open-source python framework that facilitates analysis of data collected by the *Fermi Large Area Telescope (LAT)*

- built on the Fermi Science Tools
- Supported by a team within the LAT collaboration (questions submitted via git)
- high-level interface for analyzing LAT data in a simple and reproducible way.
- Methods include:
  - extracting spectral energy distributions and lightcurves, generating test statistic maps, finding new source candidates, and fitting source position and extension...

The LAT team is working to a **new event selection which efficiently removes residual CR background:**

- heavy ion and ribbon cuts remove the non-isotropic bkg above 100 MeV
- This cleaner event class should replace the current SOURCE class
- Makes SOURCE class as clean as ULTRACLEAN VETO

## Fermi@10: Fermi-LAT in the next 10 years

The Future is transients (multi-messenger/wavelength sky)

Fermi-LAT has a key role in MM/MW observations, supporting:

- IceCube, LIGO/Virgo, JWST, CTA, SKA, LSST, ...

Flare advocate and Burst/GW advocate are critical to our success in the time domain era

- We've always been in the transient business

Many new exciting results for the Fermi Symposium in October (Baltimore)

- Next Collaboration meeting right before the symposium

# Summary

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- The collaboration continues to release quality products to the community
  - Expect new products coming out from the LAT team and released via the FSSC including new catalogs, new software, and new alerts
  - New data selection to the community
- Fermi-LAT has a critical role in the future of MM/MW astrophysics