LAT Report

Judy Racusin (LAT Deputy Analysis Coordinator)

On behalf of Peter Michelson (LAT PI),
Gulli Johannesson (LAT Analysis Coordinator),
for the LAT Collaboration

11 year skymap
Pass 8 (P8_P305)
Source class
E > 1 GeV

4FGL

- ## 8 year source catalogs
  - ### 5065 sources
  - ### Source list: gll_psc_v20.fit
- ## Paper submitted to ApJS, arXiv:1902.10045
- ## Improvements relative to 3FGL
  - ### Pass 8 data
  - ### New Galactic Diffuse model (gll_iem_v07.fits)
  - ### Weighted maximum likelihood analysis
  - ### Tested all sources with three spectral models (power law, log normal and power law with subexponential cutoff)
  - ### Modeled 75 sources as extended emission regions
  - ### Light curves and variability in one year and two months time bins
  - ### Updated counterpart catalogs
- ## https://fermi.gsfc.nasa.gov/ssc/data/access/lat/8yr_catalog/

Table 1. Previous *Fermi*-LAT catalogs

| Acronym	IRFs/Diffuse model	Energy range/Duration	Sources	Analysis/Reference
1FGL	P6_V3_DIFFUSE	$0.1 - 100$ GeV	1451 (P)	Unbinned, F/B
	gll_iem_v02	11 months		Abdo et al. (2010a)
2FGL	P7SOURCE_V6	$0.1 - 100$ GeV	1873 (P)	Binned, F/B
	gal_2yearp7v6_v0	2 years		Nolan et al. (2012)
3FGL	P7REP_SOURCE_V15	$0.1 - 300$ GeV	3033 (P)	Binned, F/B
	gll_iem_v06	4 years		Acero et al. (2015)
FGES	P8R2_SOURCE_V6	10 GeV $- 2$ TeV	46 (E)	Binned, PSF, $|b| < 7°$
	gll_iem_v06	6 years		Ackermann et al. (2017b)
3FHL	P8R2_SOURCE_V6	10 GeV $- 2$ TeV	1556 (P)	Unbinned, PSF
	gll_iem_v06	7 years		Ajello et al. (2017)
FHES	P8R2_SOURCE_V6	1 GeV $- 1$ TeV	24 (E)	Binned, PSF, $|b| > 5°$
	gll_iem_v06	7.5 years		Ackermann et al. (2018)
4FGL	P8R3_SOURCE_V2	0.05 GeV $- 1$ TeV	5065 (P)	Binned, PSF
	gll_iem_v07 (§ 2.4.1)	8 years		this work

New Diffuse Model (gll_iem_v07.fits)

- Updates/Changes
  - New H I survey
  - New rotation curve
  - New spectral line profile fitting
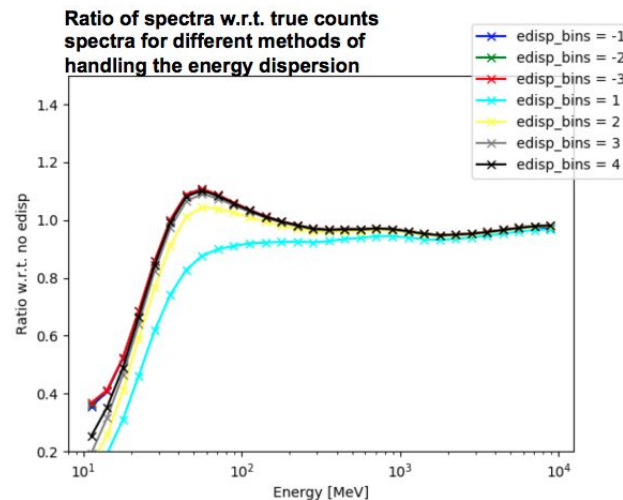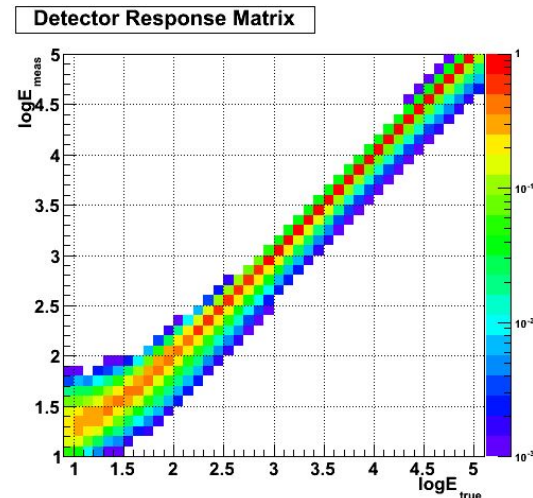 - New interpolation across the GC and anticenter regions

- Details:
  https://fermi.gsfc.nasa.gov/ssc/data/analysis/software/aux/4fgl/Galactic_Diffuse_Emission_Model_for_the_4FGL_Catalog_Analysis.pdf
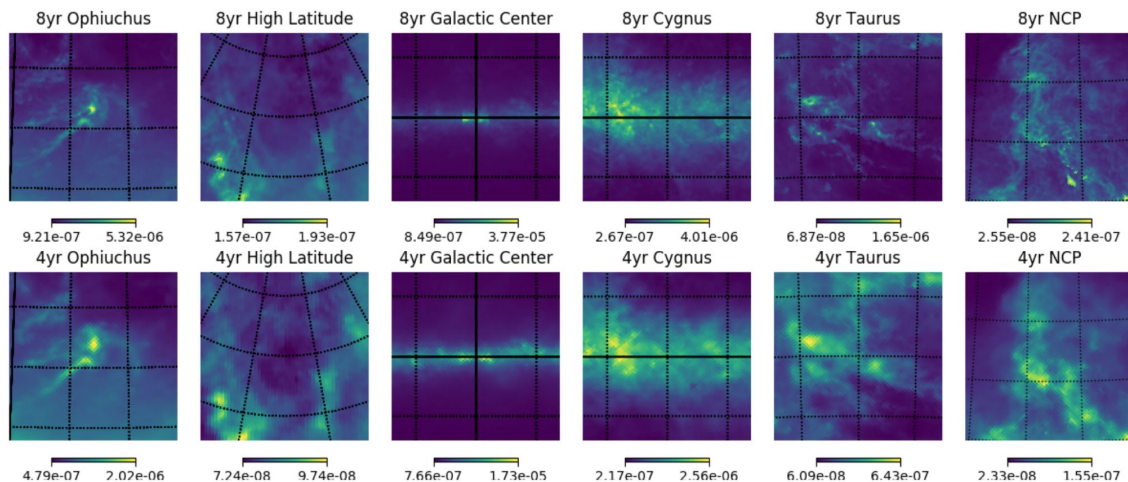
LAT Software

- New version of FermiTools (1.1.7) released Oct 1, includes new energy dispersion handling
- Analyses using the new diffuse model and 4FGL must take into account energy dispersion
  - Especially important < 300 MeV and ~2-3 GeV
- Documentation: https://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Pass8_edisp_usage_future.html

Detector Response Matrix

Ratio of spectra w.r.t. true counts spectra for different methods of handling the energy dispersion

4

Fermitools/Fermipy
(in collaboration with FSSC)

- Recent updates
  - Adding PLSuperExpCutoff2 spectral model
  - Energy dispersion
  - Weighted likelihood (especially important in Galactic Plane < 1 GeV)
  - Bug fixes
- Possible upcoming additions to fermipy
  - Support for using different pixelizations in fermipy
  - Batch farm processing support (for large scale parallel processing, e.g., light curves or spectra)
  - Generic stacking analysis framework
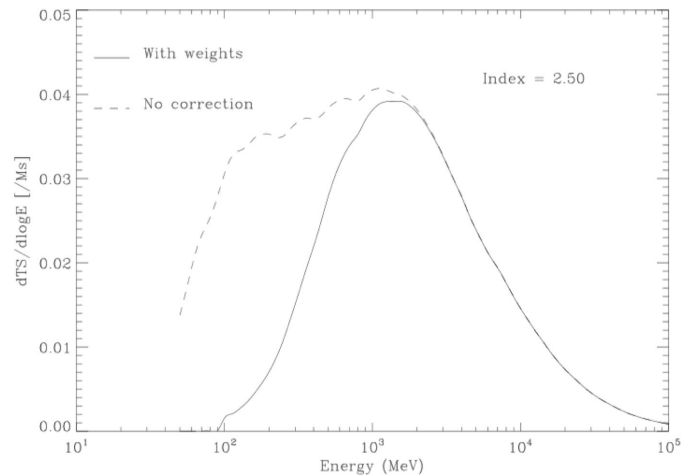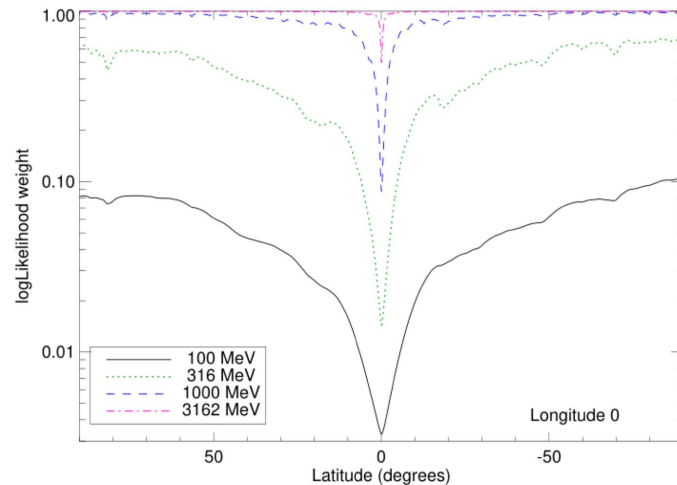
Figs 22 & 23 from 4FGL

Spacecraft File Reprocessing

- Adding velocity vector columns - beneficial for pulsar analyses
  - Allows for complete spacecraft position solution from spacecraft file
  - Validation studies complete
- Modified altitude correction - improves calculation of Geodetic Lat/Lon
  - Completing validation
- Reprocessing starts soon
  - Takes ~1 month

Multimessenger: Gravitational Wave Follow-up

- LIGO-Virgo
  - O3a (3rd LIGO-Virgo Observing Run) - April 1 - October 1, 2019
  - O3b - November 1, 2019 - April 30, 2020
  - 33 candidate detections (21 BBH, 4 BNS, 2 MassGap, 4 NSBH, 2 Terrestrial)
  - https://gracedb.ligo.org/superevents/public/O3/
- LAT analysis run on every GW Sky Map
  - No significant counterparts detected
  - Two independent LAT pipelines - make slightly different analysis choices, run on separate systems
  - GCN Circulars put on on every event
- Plan to create public facing GW follow-up FSSC table
  - Contain summary of observations, upper limit maps, links to GCNs

7

Multimessenger: Neutrino Follow-up


- LAT-IceCube Studies
  - 10 Year neutrino point source searches - Extragalactic sources from 3FGL, weighted with IceCube sensitivity
  - NGC 1068 in a p-p dominated scenario (Seyfert 2 @12.5 Mpc, possible signal hard to explain physically or background source)
  - Time dependent neutrino emission from 3LAC
  - Multi-wavelength studies of neutrino source candidates
  - Source population study
  - Multi-epoch modeling of TXS0506+056 and predictions for its long-term neutrino emission

- Realtime Follow-up
  - LAT Source searches for each HESE, Gold, Bronze event
  - ATels + MWL follow-up observations
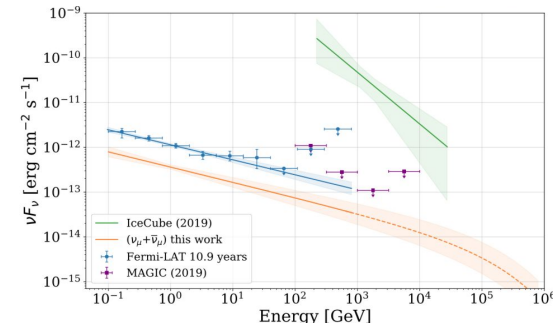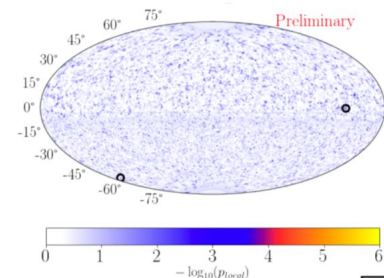
Petropoulou et al. in-prep
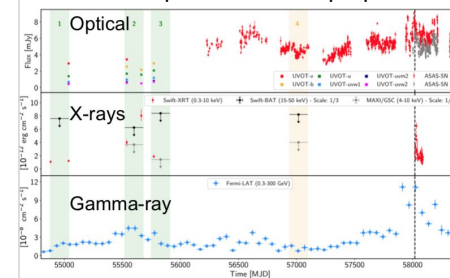
Catalogs

- Recently Published
  - 2nd LAT GRB Catalog
- Submitted
  - 4FGL
- In-progress
  - Solar Flare Catalog
  - Dark Matter Catalog
  - Flaring sources
  - 3PC (Pulsars)
  - 4LAC (AGN) - source list (ArXiv:1905.10771)
- Proposed
  - Incremental 4FGL every 2(?) years
    - Same diffuse/pipeline as 4FGL
    - Rerun for new sources and associations
    - Should produce ~500 new sources every 2 years
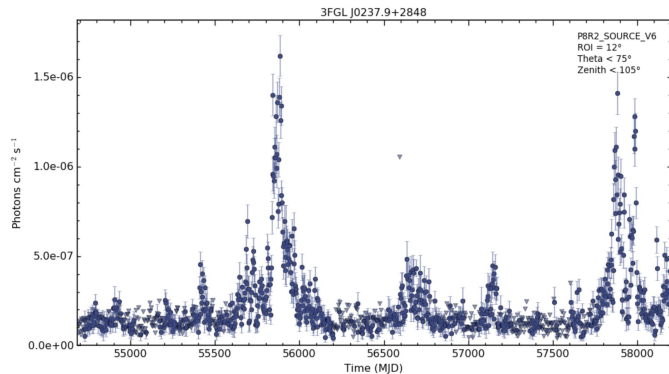 - 5FGL?

Light Curve Repository

- Proposed in 2019 Senior Review
  - Aid in neutrino counterpart identification
- Implementation Plan
  - Based upon FAVA infrastructure (7-day photometric binned transient variability search, automatically triggers follow-up likelihood analysis)
  - Distributed likelihood tool developed for GW counterpart searches is starting point
  - Maintain light curves of 4FGL sources on timescales of days, weeks, months???
- Concerns
  - How to add new sources?
  - Crowded regions
  - Computationally expensive
- Prototype page
- Comments/Suggestions?