Fermi Gamma-ray Space Telescope

Improving the Scientific Potential of Pass 8: Status and Plans for a future Pass 8 Release

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on behalf of the Fermi-LAT Collaboration

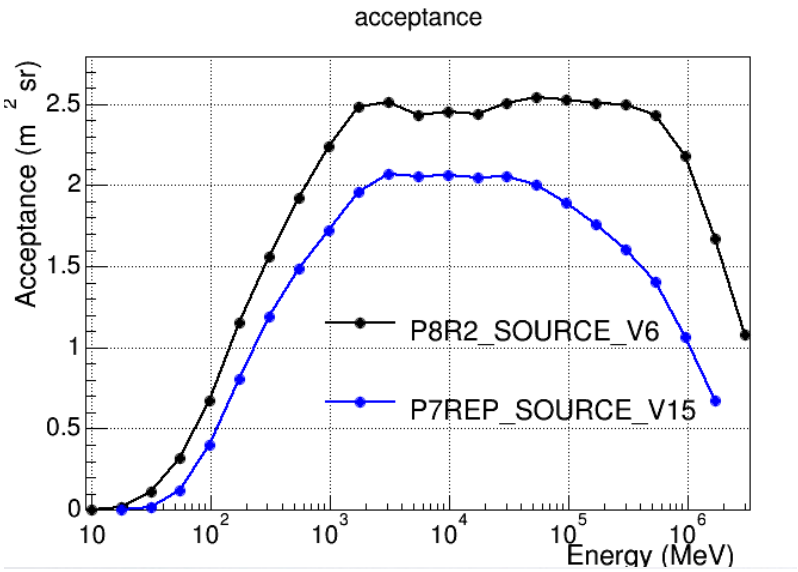
6th Fermi Symposium

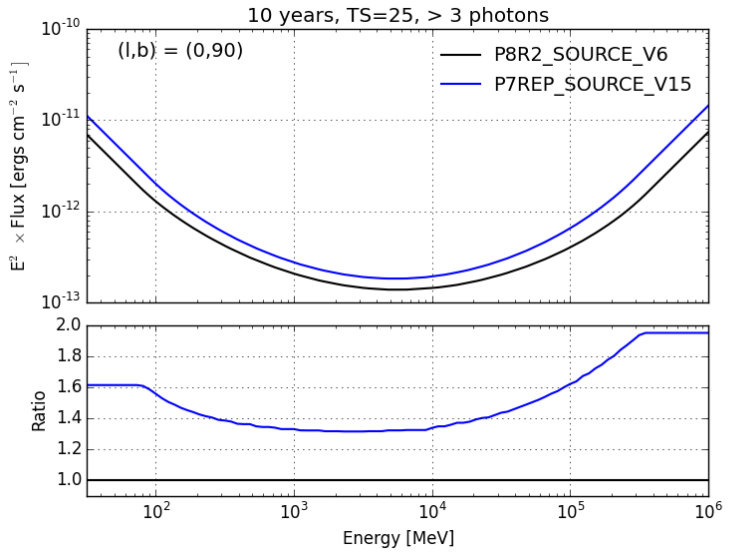
November 13th, 2015

Motivation

- The first Pass 8 release provided a substantial improvement in the capabilities of the LAT
  - 40% increase in point-source sensitivity
  - Up to 2x gain in acceptance at very low (< 100 MeV) and very high (> 100 GeV) energies

- Upcoming data and software releases will build on the performance gains of Pass 8
  - In-flight IRFs
  - Cal-Only Event Class
  - New Science Tools Features
  - Improved models for residual Earth Limb contamination, CR background, and Galactic Diffuse emission

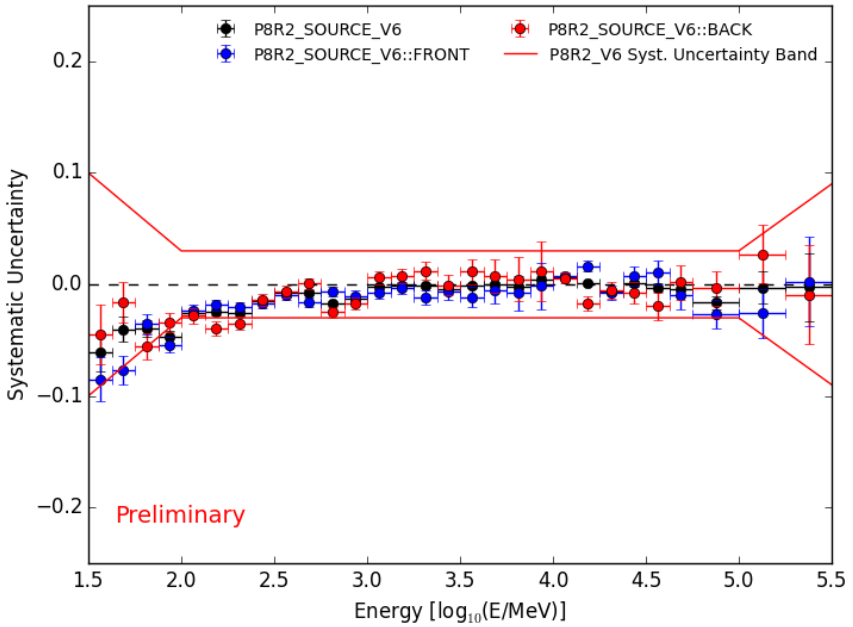




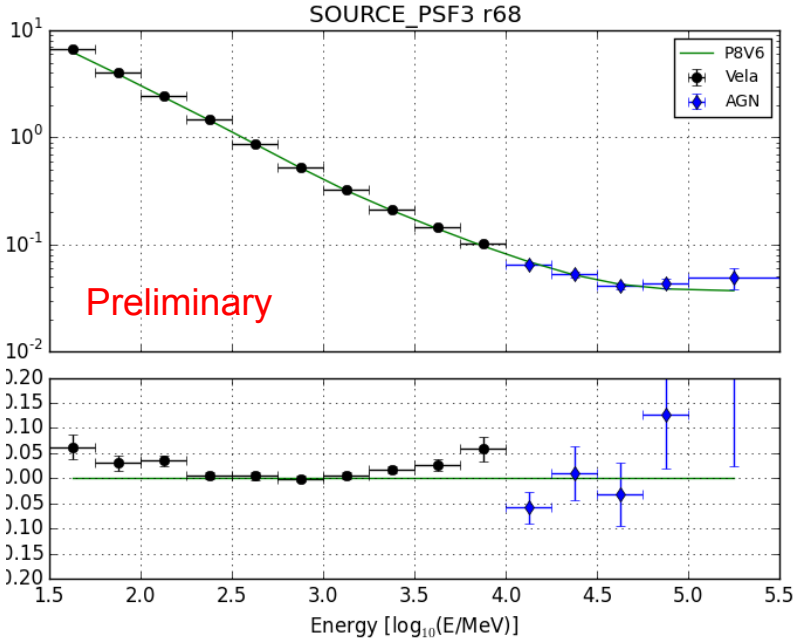
Pass 8 IRF Systematics

- Improvements to the accuracy of Pass 8 instrument simulation have reduced systematic uncertainties in the IRFs with respect to P7REP
  - Effective area systematics for FRONT/BACK are < 3% when enabling correction for energy dispersion (100 MeV – 100 GeV)
  - Systematics in the PSF are < 5% (100 MeV – 100 GeV; all event types) with no discrepancy at high energies

SOURCE FRONT/BACK Effective Area

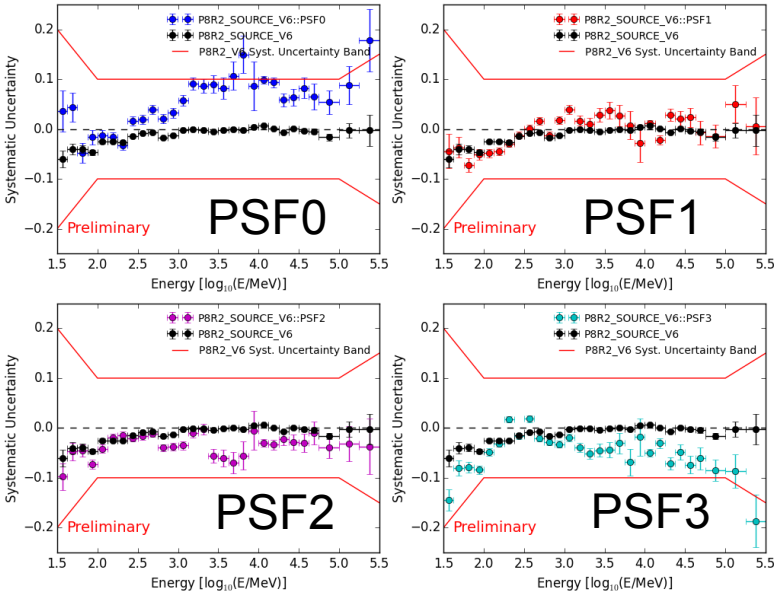


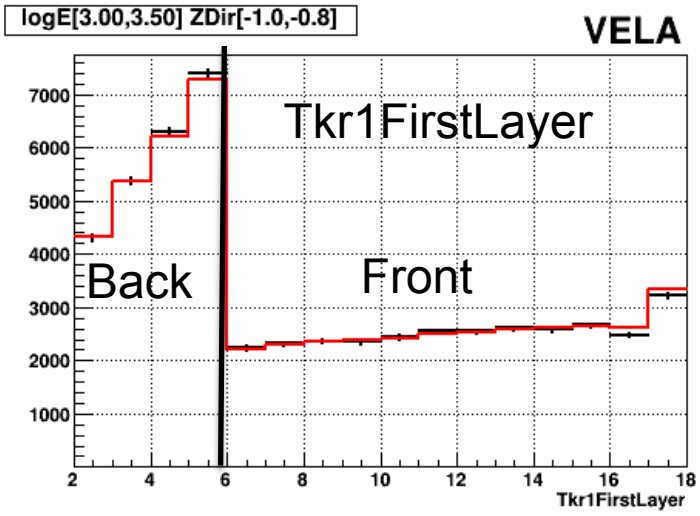
P8R2_SOURCE::PSF3

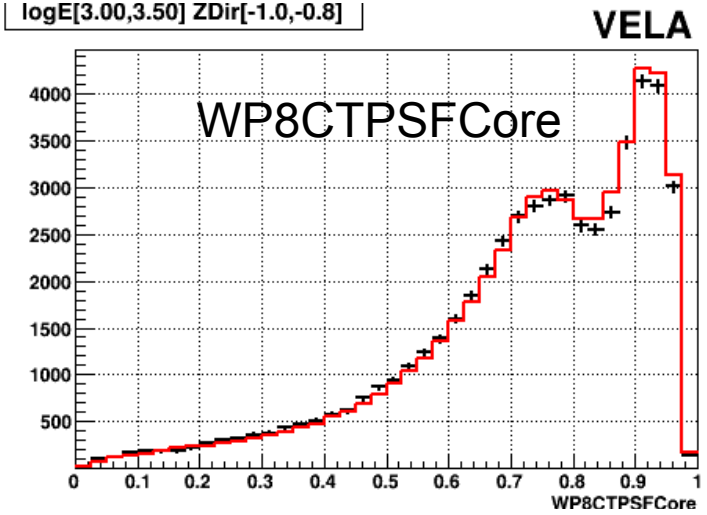


Pass 8 IRF Systematics: PSF/EDISP Types

- PSF and EDISP selections depend on CT variables that have poorer Data/MC agreement than the first conversion layer (used for FRONT/BACK selection)
- This is responsible for 5-10% systematic errors in the efficiency of each type with respect to the full class selection



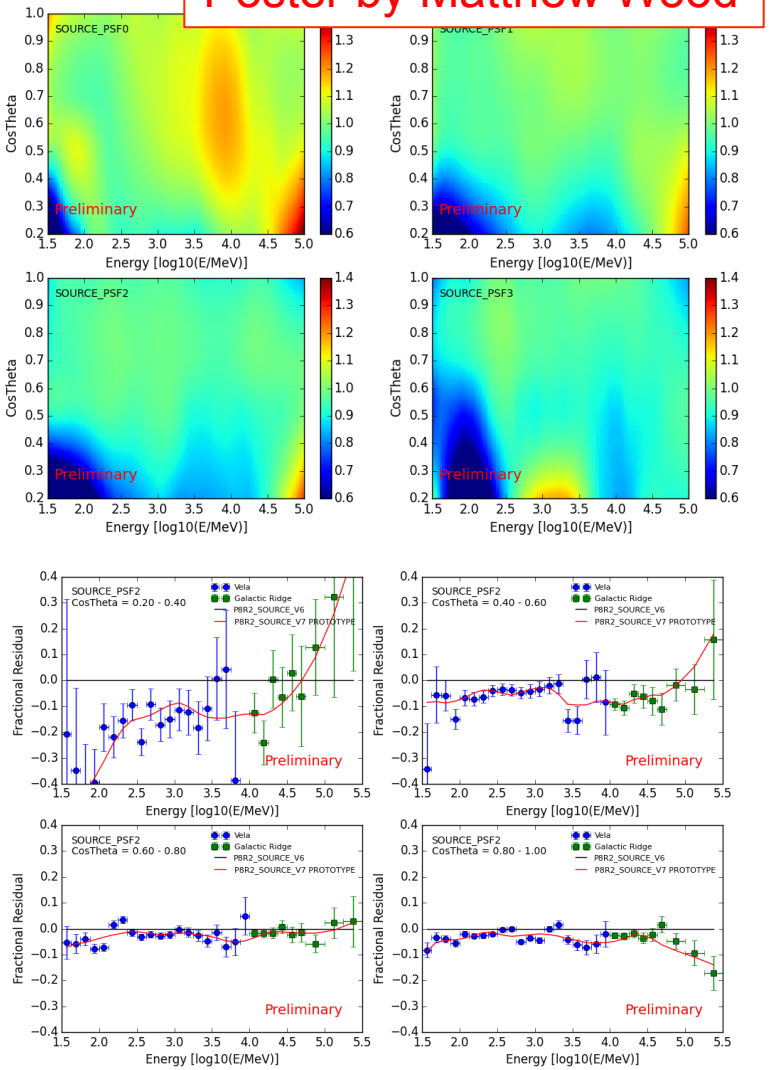




In-Flight IRFs for Pass 8

Poster by Matthew Wood

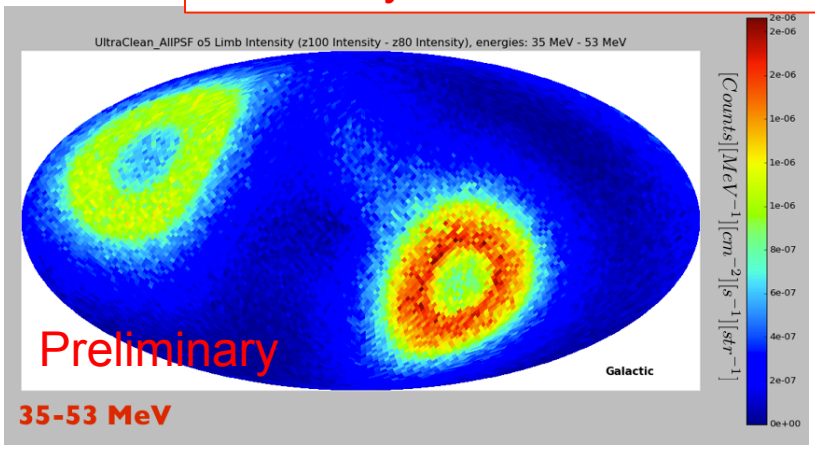
- Next Pass 8 IRF release (P8R2_V7) will include in-flight corrections that will address the inconsistencies in the PSF/ EDISP event type effective areas
- Correction is applied to the MC-based effective area (P8R2_V6) as a function of energy and incidence angle
- In-flight corrections will reduce systematic uncertainties for analyses using a single PSF or EDISP event type

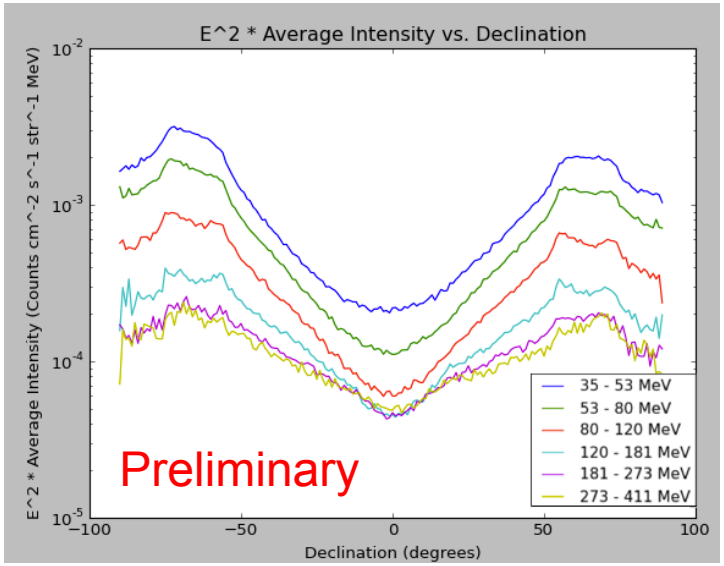


Modeling the Earth Limb

Poster by Elliott Bloom et al.

- Residual Earth Limb contamination is a major challenge for analyses using data below 100 MeV
- A model for the residual Earth Limb is needed to fully take advantage of the improvement in Pass 8 acceptance below 100 MeV
- A Limb tool is currently in development
  - ST application that builds an Earth Limb template for a given time selection and zmax cut
  - Input is a Phenomenological Earth Limb model derived in Earth-centered coordinates

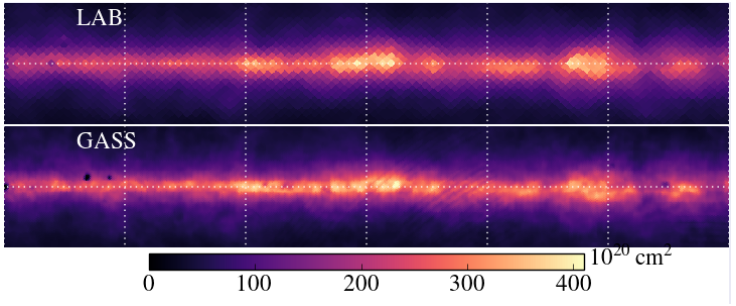


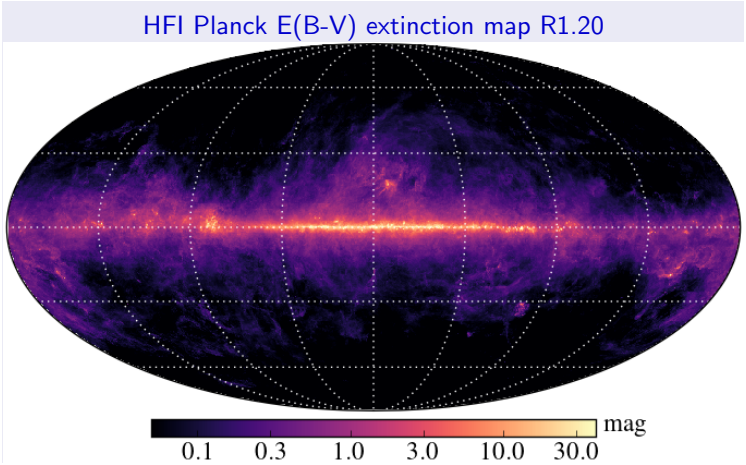


Pass 8 Galactic Diffuse Model

- Current Pass 8 Galactic IEM (gll_iem_v06) is based on the P7REP model with a small energy-dependent correction to account for differences in energy dispersion in P7REP and Pass 8

- A new Galactic IEM based entirely on Pass 8 data is currently under development
  - New surveys (Planck) and higher resolution gas maps
  - Inclusion of energy dispersion effect at fit level
  - Extension of the model to lower and higher energies (~30 MeV and ~1 TeV)





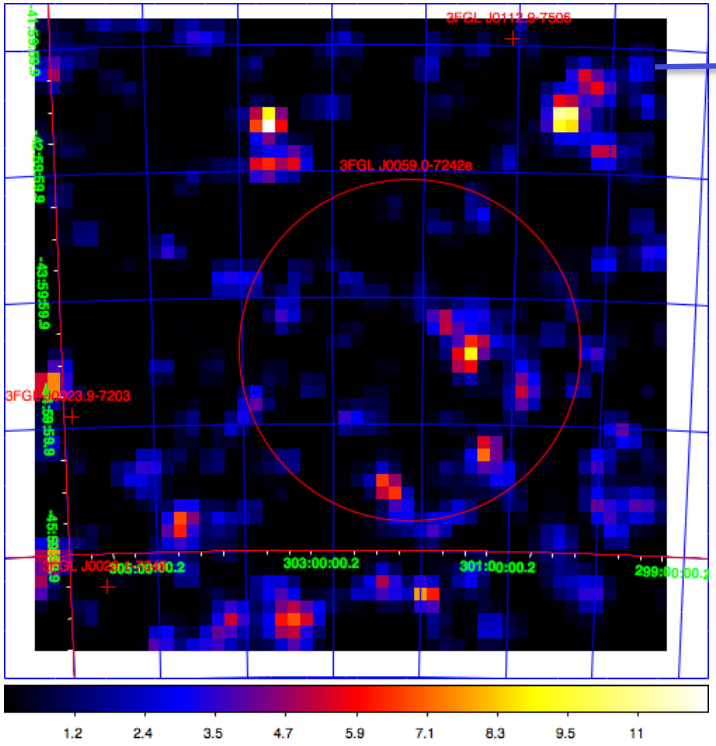
See Talk by Gulli Johannesson

New ST Features: Test Statistic Cube (gttscube)

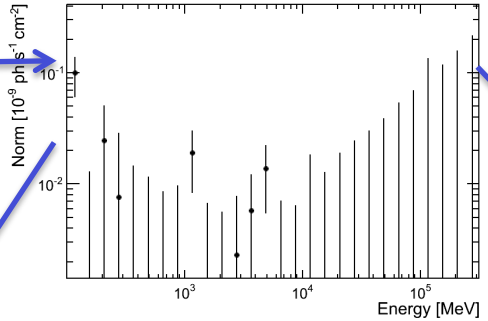
See Talk by Eric Charles

- **gttscube** will be a new ST application that enables fast computation of TS maps (~100x faster than gttsmap)
- Also stores at every location a likelihood profile vs. flux at each energy (the cube)

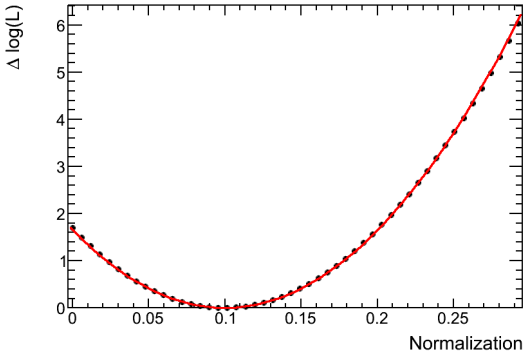
TS Map of 5° x 5° Region

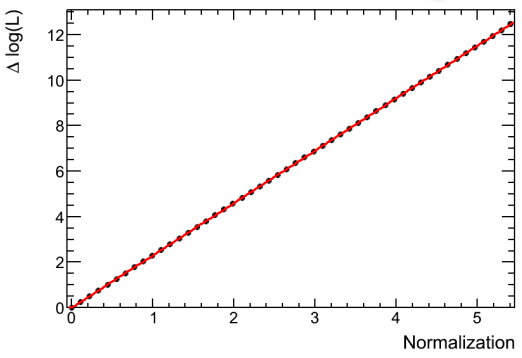


SED for test source a specific pixel



Likelihood v. Flux for each energy bin



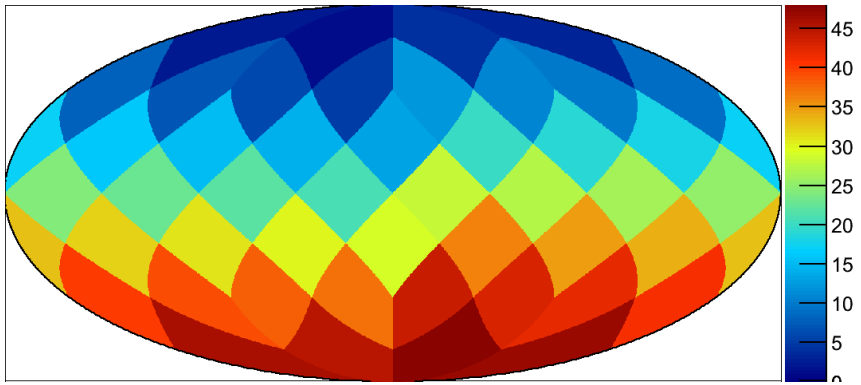


New ST Features: HEALPix-Based Likelihood Analysis

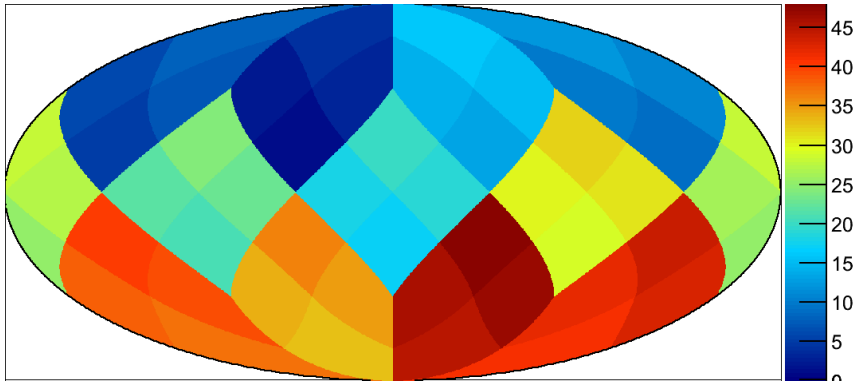
See Talk by Eric Charles

- Fermi STs currently only support binned likelihood analysis on local cartesian projections
- New functionality will allow binned likelihood fits to use HEALPix maps
  - Existing ST apps and tools will handle HEALPix maps transparently
  - Support for all- or partial-sky maps
  - PSF convolution handled efficiently with spherical harmonics
- HEALPix support should make it easier to perform large-scale diffuse analysis with the STs

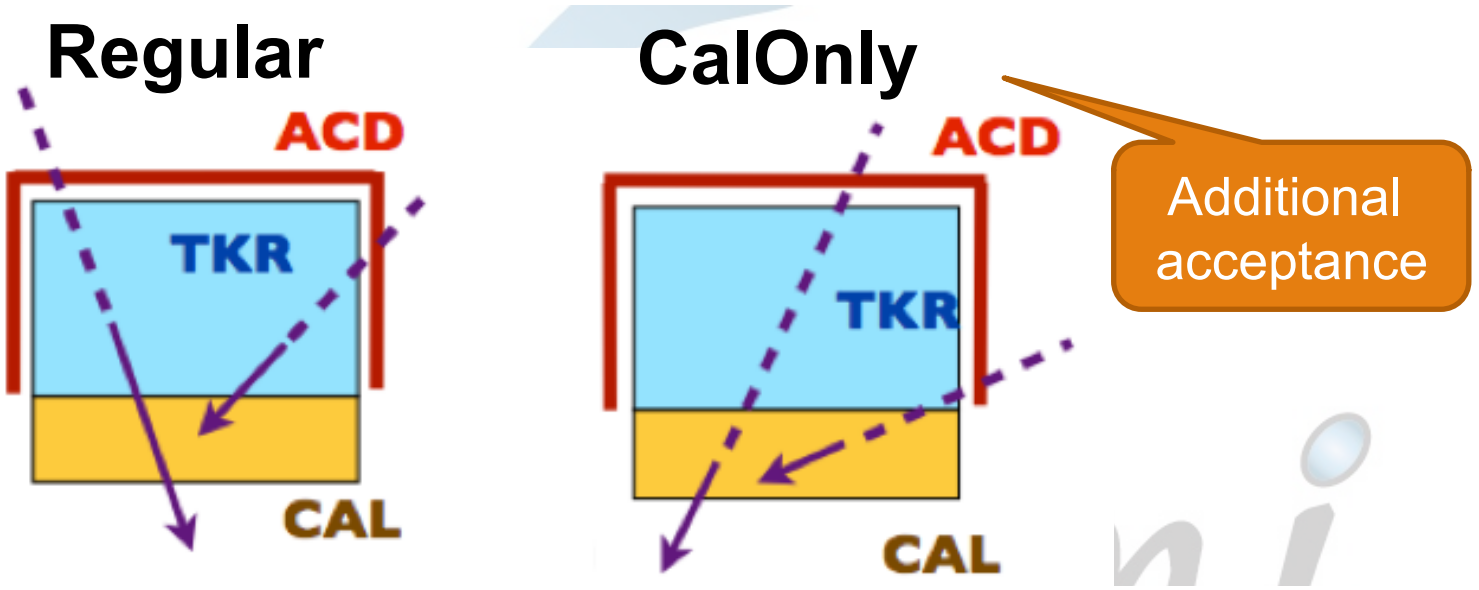
Pixel Index: RING scheme, nside=2



Pixel Index: NESTED scheme, nside=2



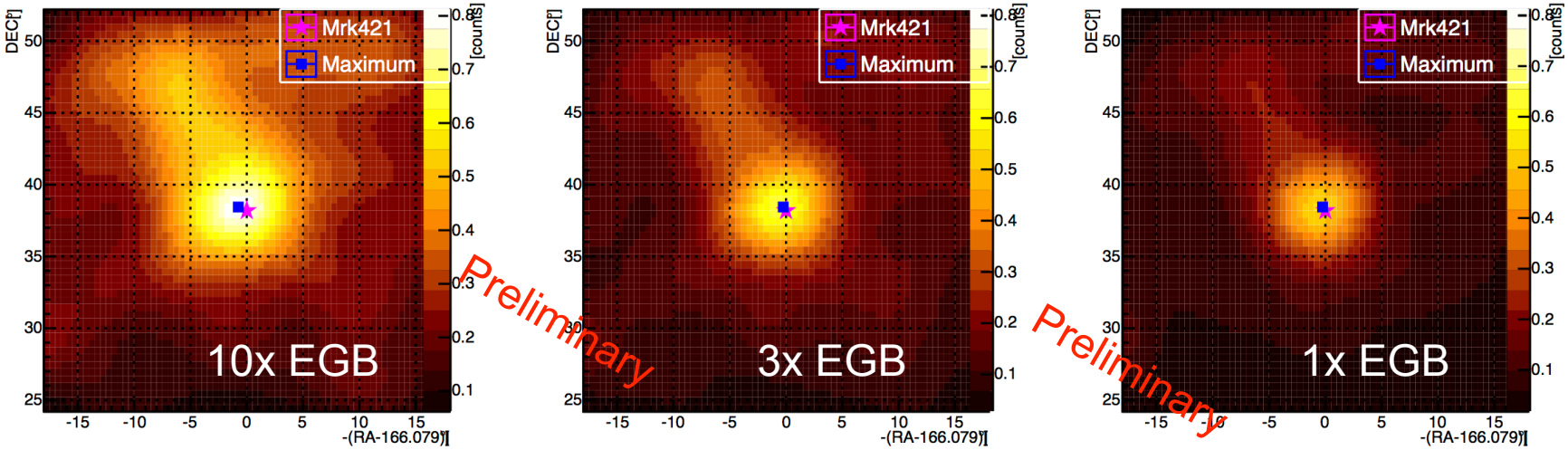
Cal-Only Event Class



- The CalOnly analysis can recover valuable gamma-ray events that are not converted in the TKR, *i.e.* side-entering or TKR-passing events
  - Provides an increase in acceptance above a few tens of GeV, where sensitivity is limited by photon statistics
  - CalOnly events are expected to have somewhat worse angular resolution (R_{68} = 2-3 deg) and signal/bkg separation

Cal-Only Class Performance: Mkn 421

Smoothed count map in 56.2-562GeV



CalOnly	CalOnly 10xEGB	CalOnly 3xEGB	CalOnly 1xEGB
Counts within 1.5σ PSF	150	120	95
Expected background	57.4	34.3	19.4
Regular	**TRANSIENT**	**SOURCE**	
Counts within 1.5σ PSF	190	178	
Expected background	0.41	0.03	

Summary and Plans

- Upcoming developments are focused on realizing the full potential of Pass 8
  - Reducing IRF systematics
  - Improving models for diffuse emission
  - Enabling analysis at very low energy (< 100 MeV)
  - Opening new capabilities at the highest energies (Cal-Only event class)

- Release Schedule
  - **Early-Mid 2016**: New IRFs and some ST Features
  - **Mid-2016 and later**: Earth Limb tool, Cal-Only Event Class, P8 Galactic Diffuse Model, Full HEALPix support in the STs

Pass 8 IRF Systematics

- Improvements to the accuracy of Pass 8 instrument simulation have reduced systematic uncertainties in the IRFs with respect to P7REP
  - Effective area systematics for FRONT/BACK are < 3% when enabling correction for energy dispersion (100 MeV – 100 GeV)
  - No significant discrepancy in the high-energy PSF
- Effective area of PSF and EDISP event types show slightly larger inconsistencies
  - PSF and EDISP Selections rely on CT variables that have poorer Data/MC agreement
  - Up to 5-10% systematic errors in the efficiency of each type with respect to the full class selection