



## A catalog of flaring gamma-ray sources

Alice Allafort<sup>1</sup>

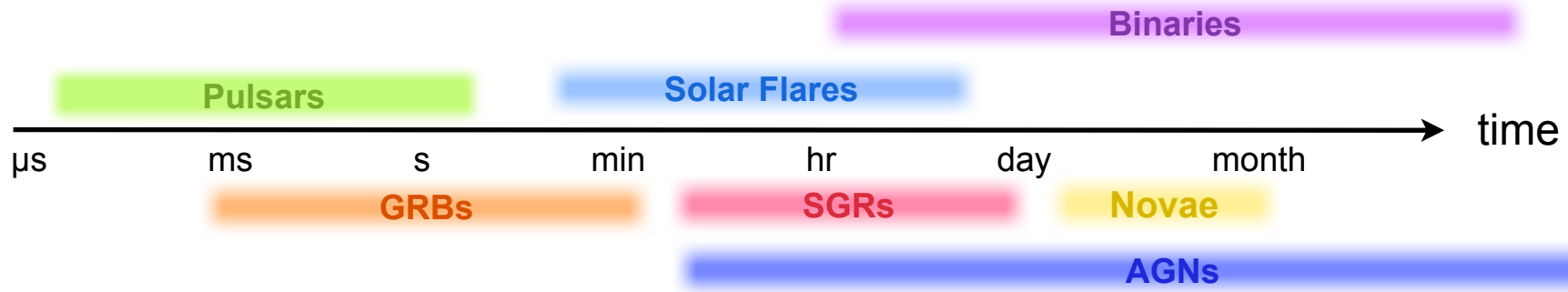
Rolf Buehler<sup>1</sup>, Marco Ajello<sup>1,2</sup>,  
Stefan Funk<sup>1</sup>,

on behalf of the *Fermi*-LAT  
Collaboration

<sup>1</sup>Stanford/SLAC/KIPAC, <sup>2</sup>UCB

4th Fermi Symposium -- Oct 28 - Nov 2, 2012

# Variability in gamma rays with *Fermi*



- New sources detected or identified through their variability
- *Fermi* continuous full-sky monitoring for the multi-wavelength community

- Current flaring monitoring with the *Fermi*-LAT
  - Automated Science Processing, based on daily peak finder and likelihood analysis
  - *Fermi* blog, Monitored sources light curves, ATels

**FERMI GAMMA-RAY SKY**

MONDAY, OCTOBER 29, 2012  
**Fermi LAT Weekly Report N. 228**

Covered period: 2012.October.15 - 2012.October.21  
 LAT Mission weeks: 228.57 - 229.57

- **PKS 1424-41** has been significantly detected almost every day in the first three weeks of October. This increase in activity was highlighted with an *Astronomer's Telegram* (#44527) on 2012 Oct 17 when its daily averaged flux reached  $(2.4 \pm 0.2) \times 10^{-6}$ .
- **S4 0918+35** remained very bright all week, with a daily averaged flux between  $(1.4 \pm 0.3) \times 10^{-6}$  and  $(2.8 \pm 0.4) \times 10^{-6}$ .
- **4C +38.41** was bright and detected every day this week with a daily averaged flux between  $(0.8 \pm 0.2) \times 10^{-6}$  and  $(1.4 \pm 0.2) \times 10^{-6}$ .
- **CTA 102** was bright and detected every day (except Oct 20) this week with a daily averaged flux between  $(1.1 \pm 0.3) \times 10^{-6}$  and  $(1.8 \pm 0.2) \times 10^{-6}$ .
- **NRAO 606** was bright and detected every day (except Oct 17) this week with a daily averaged flux between  $(1.3 \pm 0.4) \times 10^{-6}$  and  $(2.1 \pm 0.3) \times 10^{-6}$ .

**Fermi Science Support Center**

Home Observations Data Proposals Library HEASARC Help Site Map

**Data Monitored Source List Light Curves**

3C 454.3  
 (RA = 343.491, Dec = 16.1480)

- Daily Light Curve
- Daily Light Curve Fits File
- Weekly Light Curve
- Weekly Light Curve Fits File



*The Astronomer's Telegram*

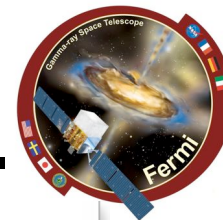
**Identification of the new gamma-ray blazar NRAO 676 through Swift follow-up observations**

ATel #4527: *Stefano Ciprini, Dario Gasparri, Sara Cutini (ASDC and INAF Rome, Italy) on behalf of the Fermi Large Area Telescope Collaboration*

on 29 Oct 2012; 16:18 UT  
 Credential Certification: Stefano Ciprini (stefano.ciprini@asdc.asi.it)

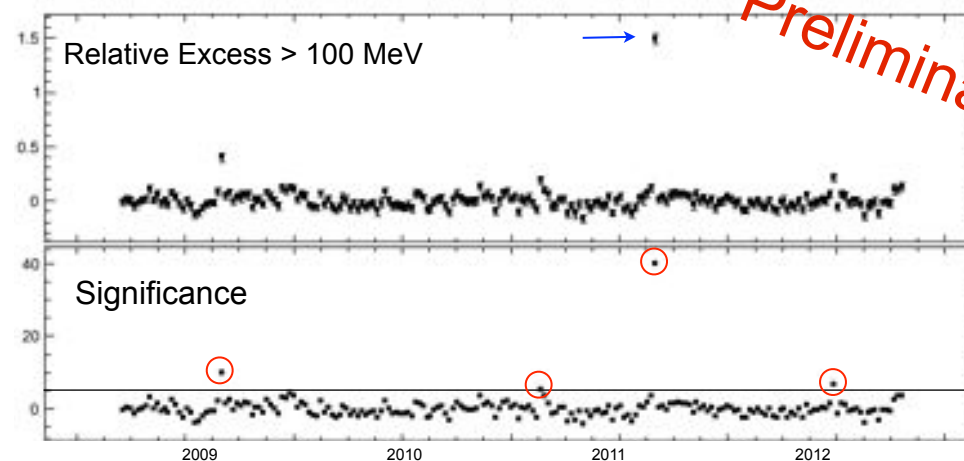
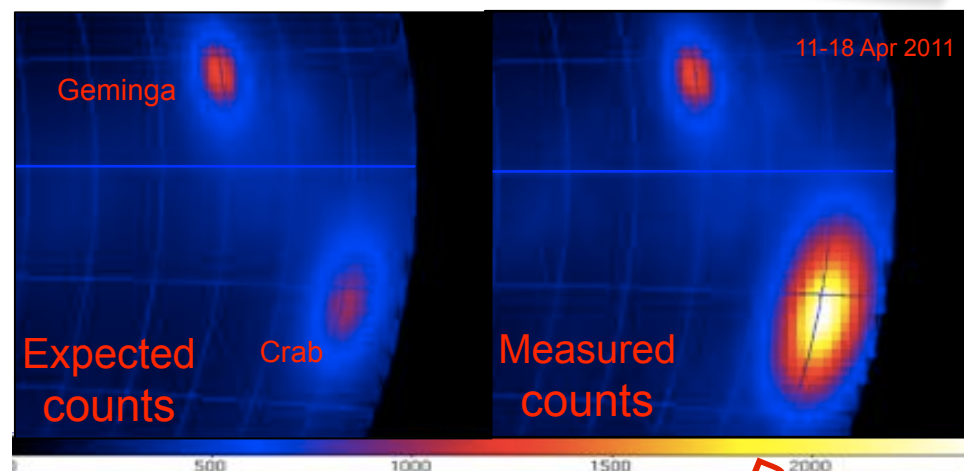
Alice Allafort - Stanford University /

# Principle

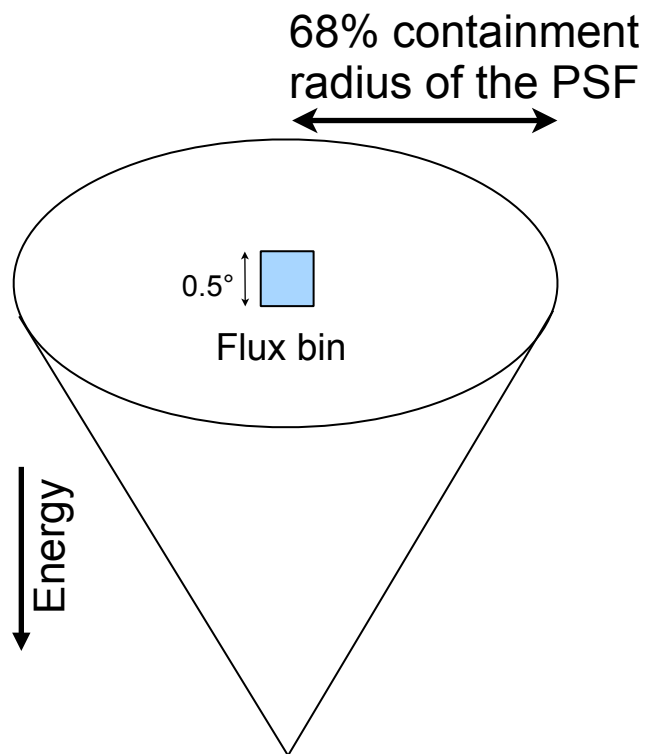


We compare the **observed** photon counts to the **expected** value from long-term average.

- Arbitrary time binning and energy range
- Simple and fast
- No systematics due to the modeling of the diffuse emission  
→ particularly suited for **plane transients**
- Unbiased view of the whole sky, including negative fluctuations



## Method

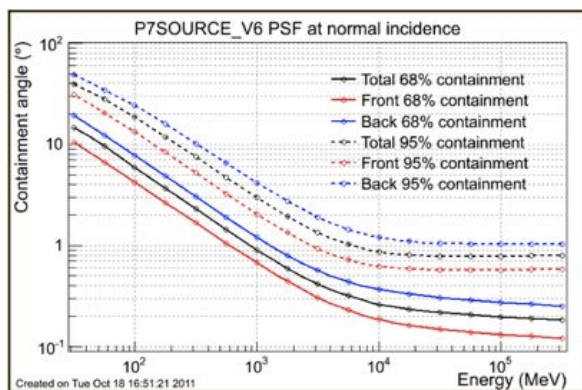


- **Observed** counts maps are generated by counting events within a 68% containment radius *as a function of Energy and Incidence angle ( $E, \theta$ )*
- An **expected** counts map is generated from:

$$N_{\text{expected}} = \sum_{E, \theta} N_{\text{total}} * \frac{\mathcal{E}_{\text{week}}}{\mathcal{E}_{\text{total}}}$$

$\mathcal{E}$ : exposure ( $E, \theta$ )

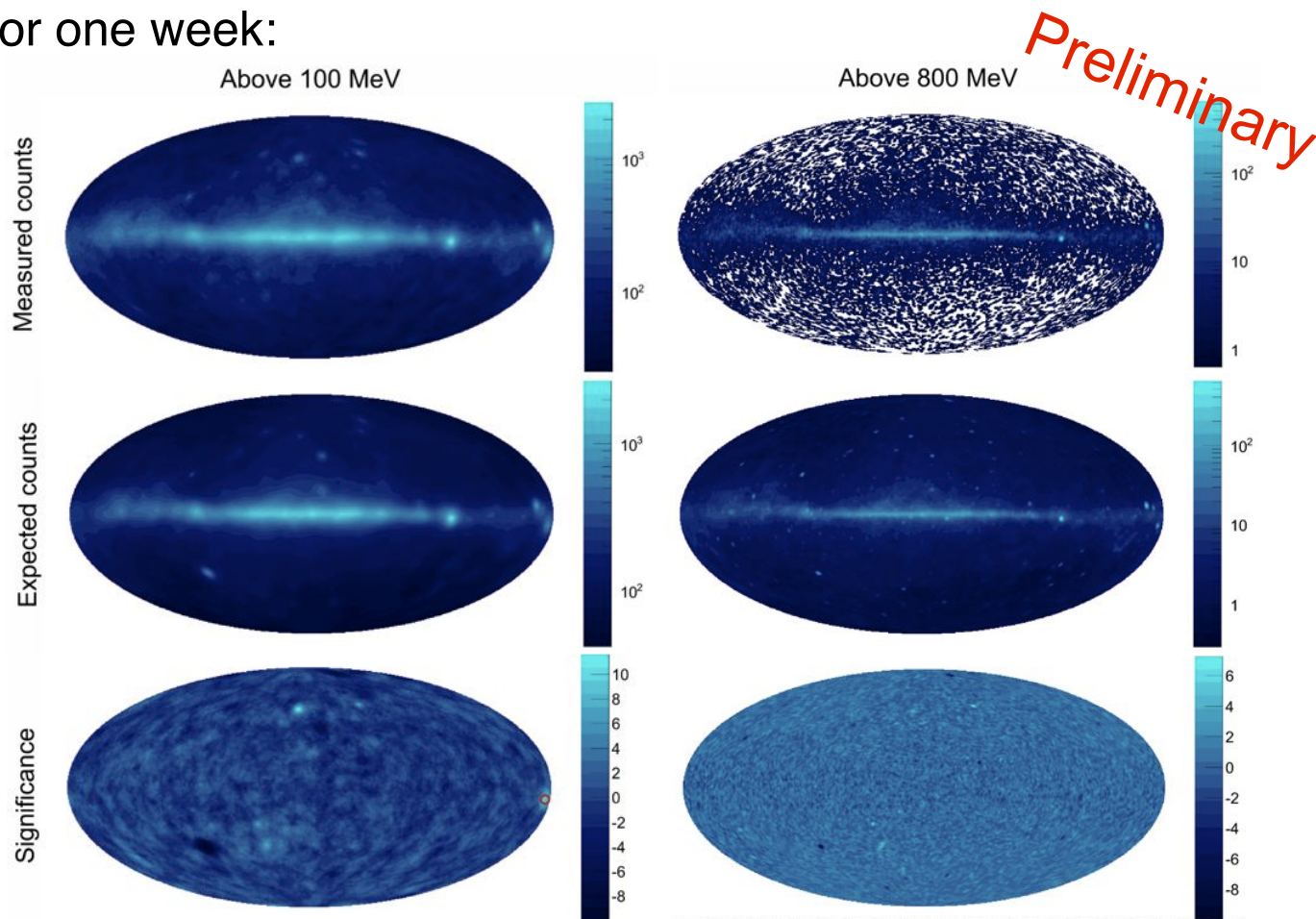
- Significance using Poisson statistics



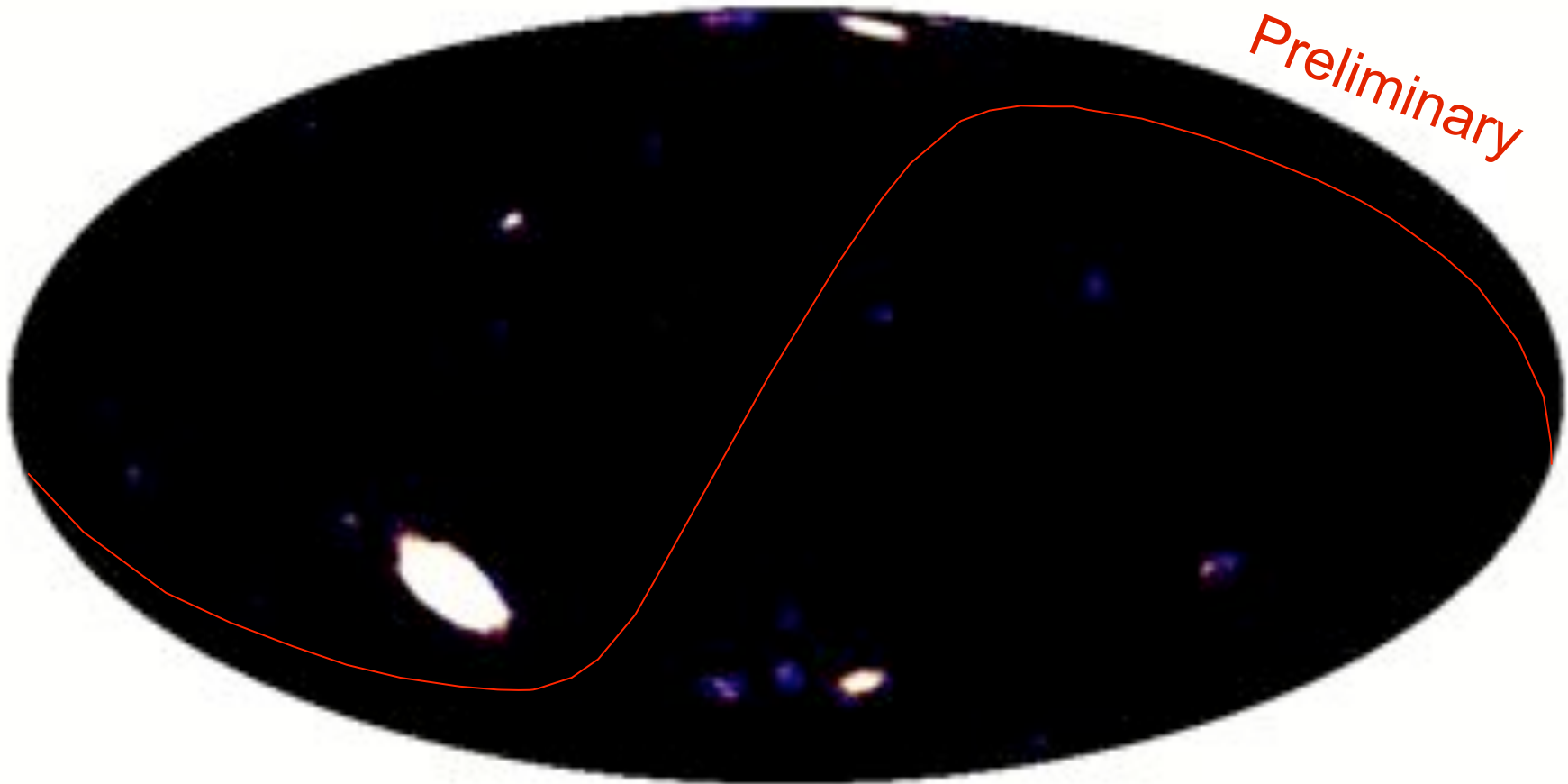




Example for one week:



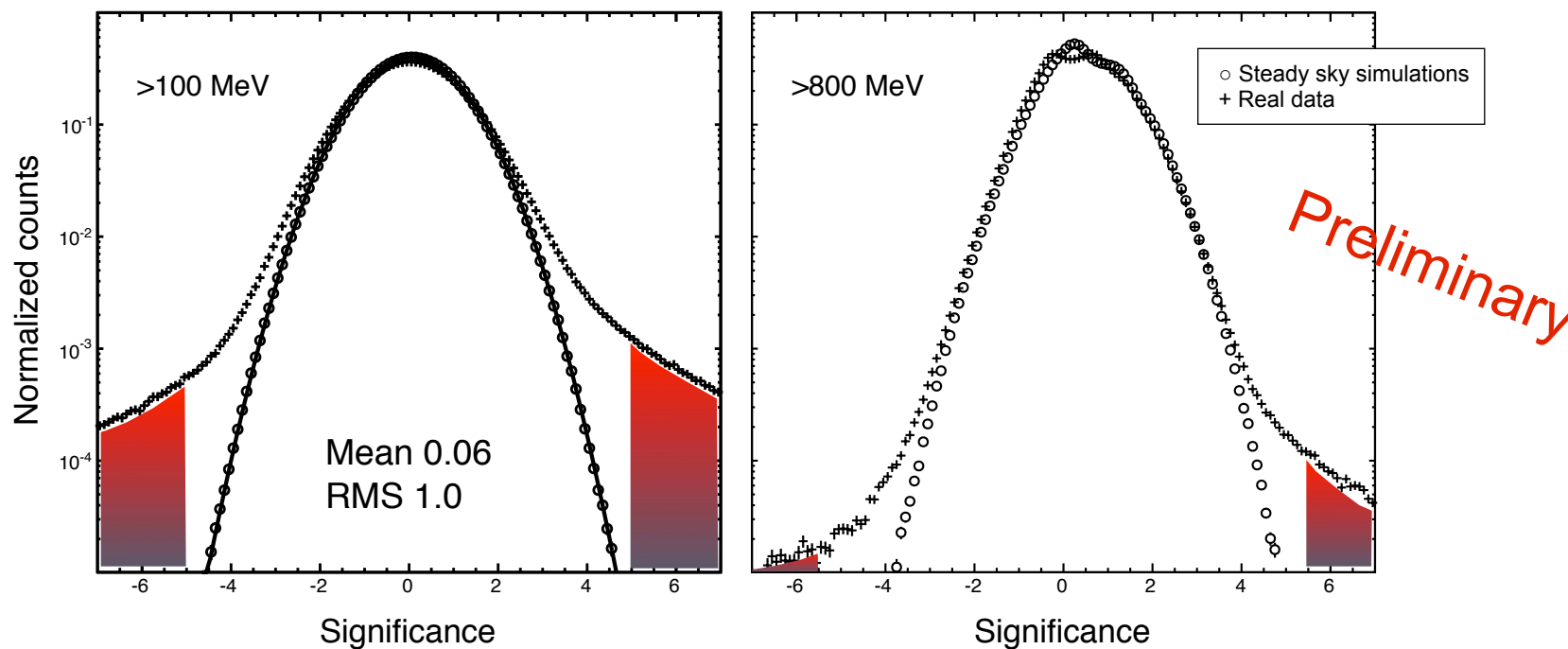
Extract peaks with significance  $>5\sigma$  above 100MeV or  $>5.5\sigma$  above 800MeV  
 → expect  $\sim 1$  false flare over entire sky and 206 weeks



Motion of the Sun: appears as variable source along ecliptic

- Exclude flares within  $15^\circ$  of the Sun.

# Validations



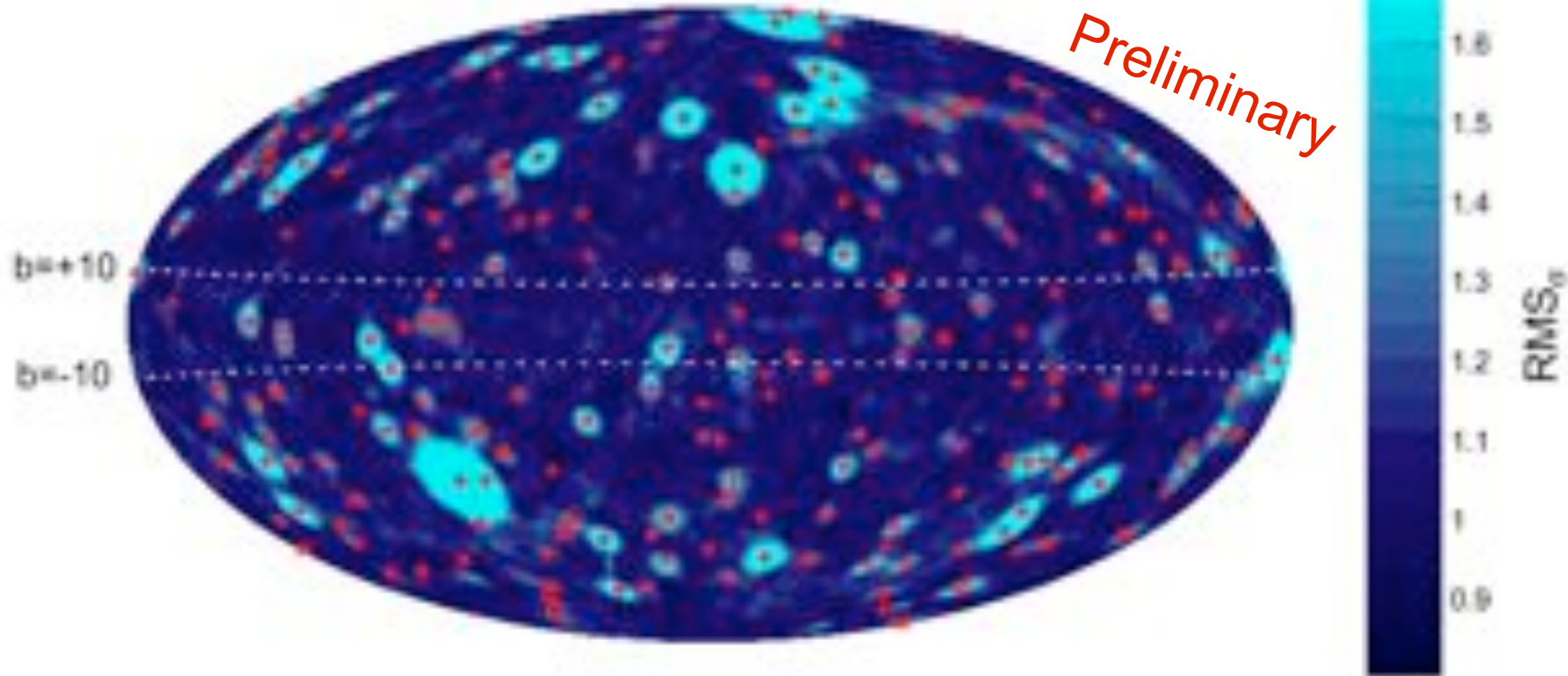
Tests with non-variable full-sky simulations for 36 months of data.

- ▶ method works: Significance follow a Gaussian distribution with RMS 1.0

Systematics errors on level similar to the 2% adopted for the variability analysis of the 2FGL catalog (Nolan et al. 2012)

- ▶ Vela and Geminga compatible with constant

# All sky catalog



- Weekly flares grouped using a Minimum Spanning Tree algorithm
- Built a catalog of 218 flaring sources

167 sources associated  
with 2FGL blazars

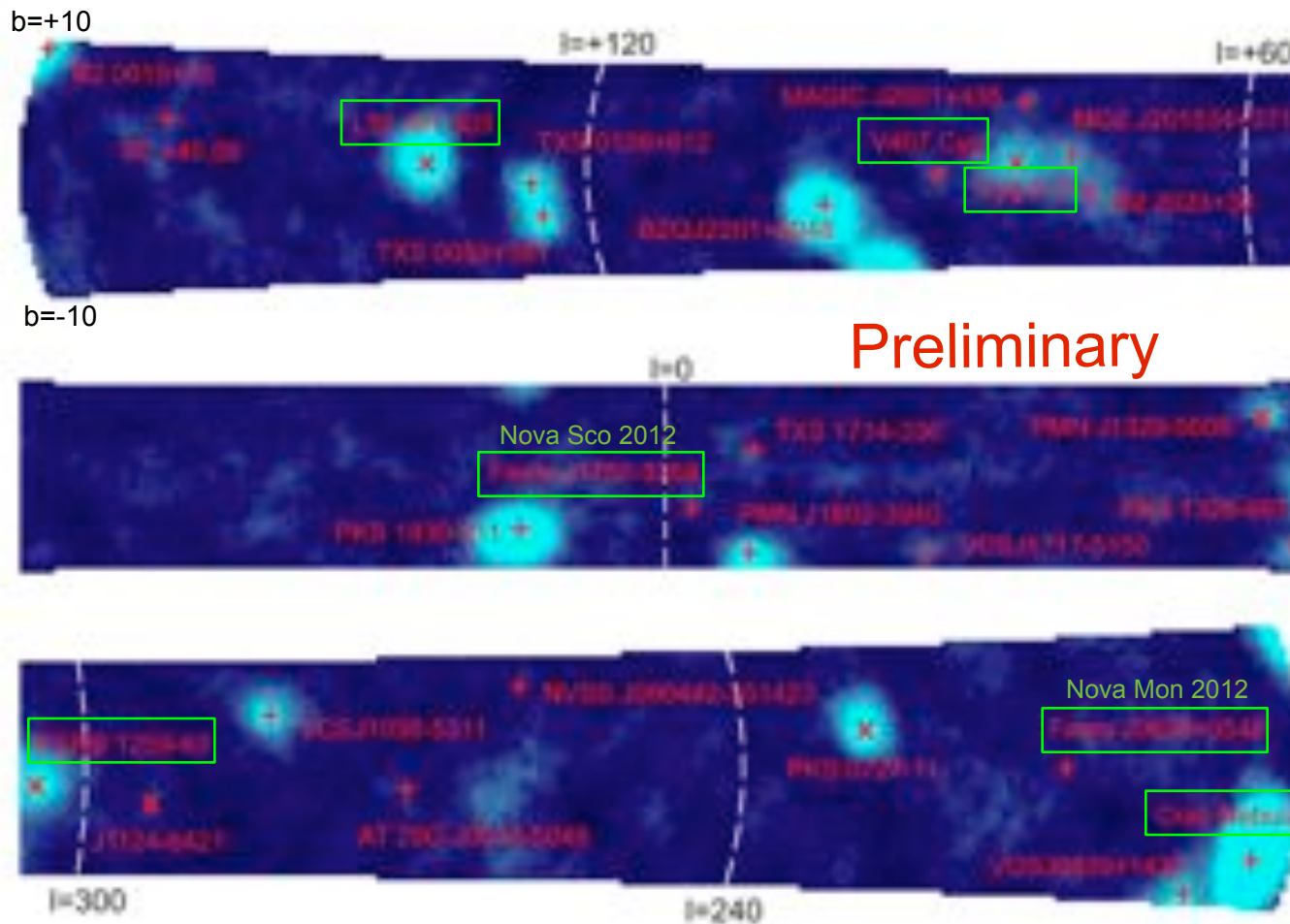
29 sources with no  
2FGL association

Find the 4 most fluent GRBs:

GRB080916C, GRB090510, GRB090902B,  
GRB090926A



# Galactic plane transients



Preliminary

Total of **27** Galactic plane transients.

7 of known Galactic origin:

- 3 Binary systems
- Crab Nebula
- 3 novae

(Talk by C. Cheung)

20 sources coincident with AGNs

From the AGN flare density in the extragalactic sky, we expect  $23 \pm 2$  flares in the Galactic plane.

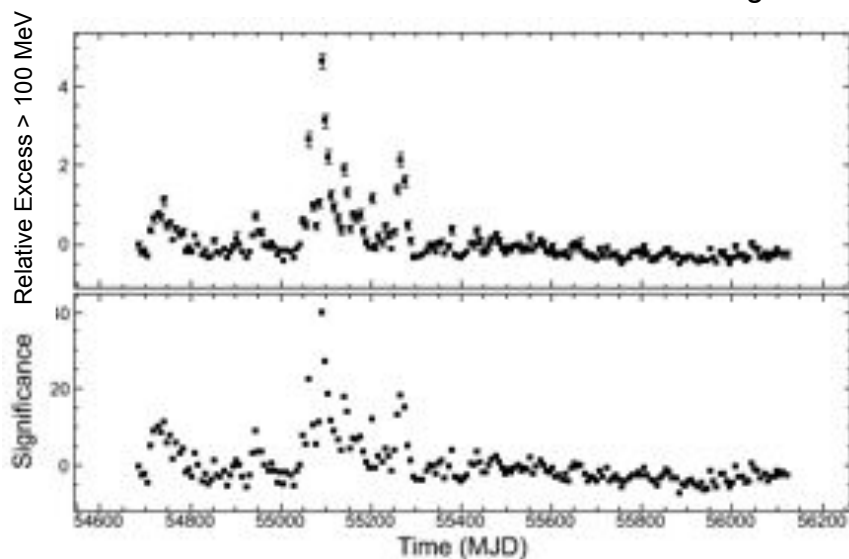
# AGN “Fractional Variability”



- Instantaneous access to lightcurve for any point in the sky
- Compare different AGN populations:

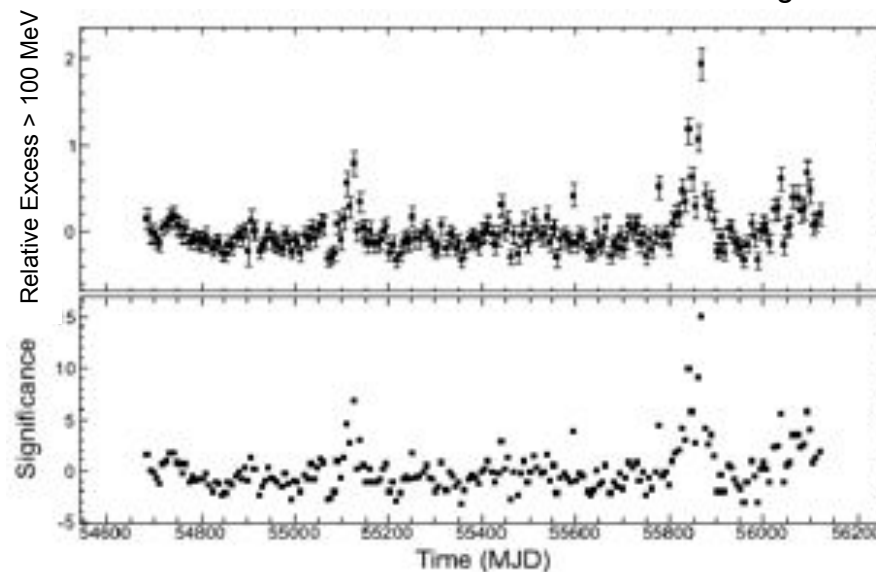
## FSRQs

ex: 3C 273 with 22 weeks flaring



## BL Lacs

ex: OJ 287 with 7 weeks flaring



Talk by B. Lott and others

## Conclusion



- **First all sky catalog of *Fermi*-LAT flaring sources: 218 detected on weekly timescales.**
- **Variable source populations:**
  - **Characterize AGN populations properties**
  - **New Galactic gamma-ray transient population: Novae**
  - **Other Galactic sources expected with known binaries and AGN density.**
- **Toward an exhaustive view of the variable sky**
- **Ongoing additional projects:**
  - **Real time online product available to the public**
  - **Testing on other time scales**





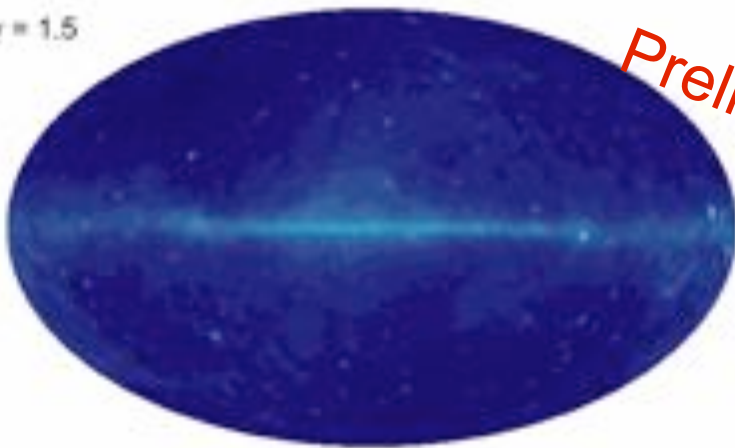
**Backup**



# Sensitivity

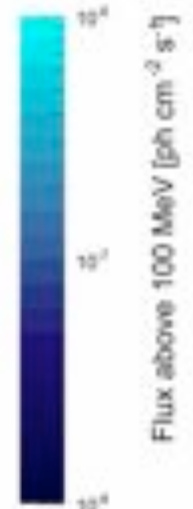
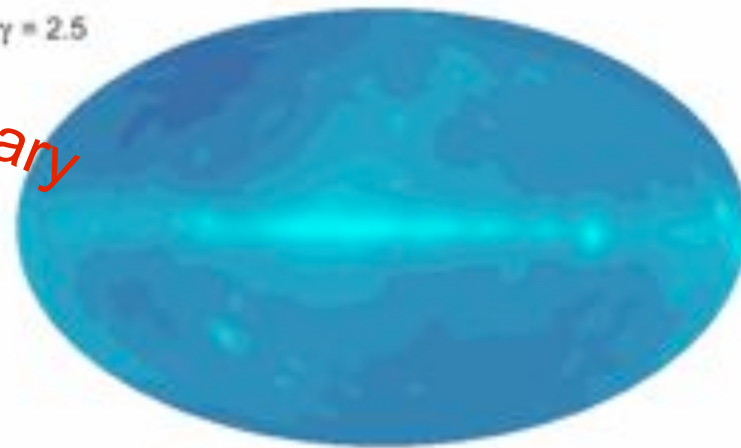


$\gamma = 1.5$



Preliminary

$\gamma = 2.5$



Average weekly flux required for catalog detection