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Two TGF populations Detected by AGILE?

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10th AGILE Workshop “Lightning, TGFs and meteorology”

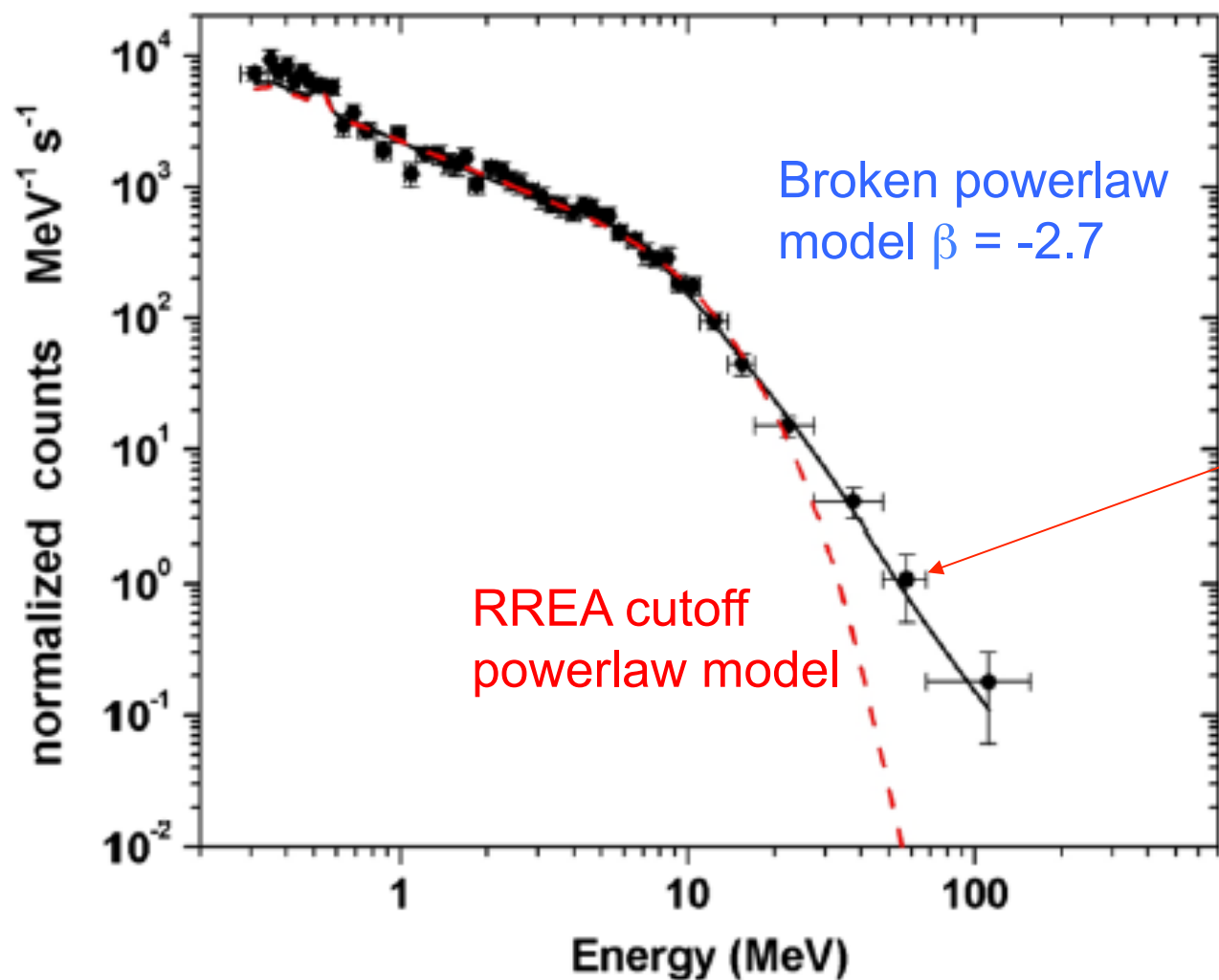
ESRIN Frascati, April 18 2012

TGF Cumulative spectrum



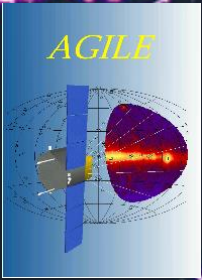
110 TGFs

1806 photons

142 γ $E > 10$ MeV26 γ $E > 20$ MeV

significant
detection of γ
>40 MeV
unexplained by
standard RREA
model: challenge
for emission
models

Tavani et al., Phys. Rev. Letters 106, 018501 (2011)

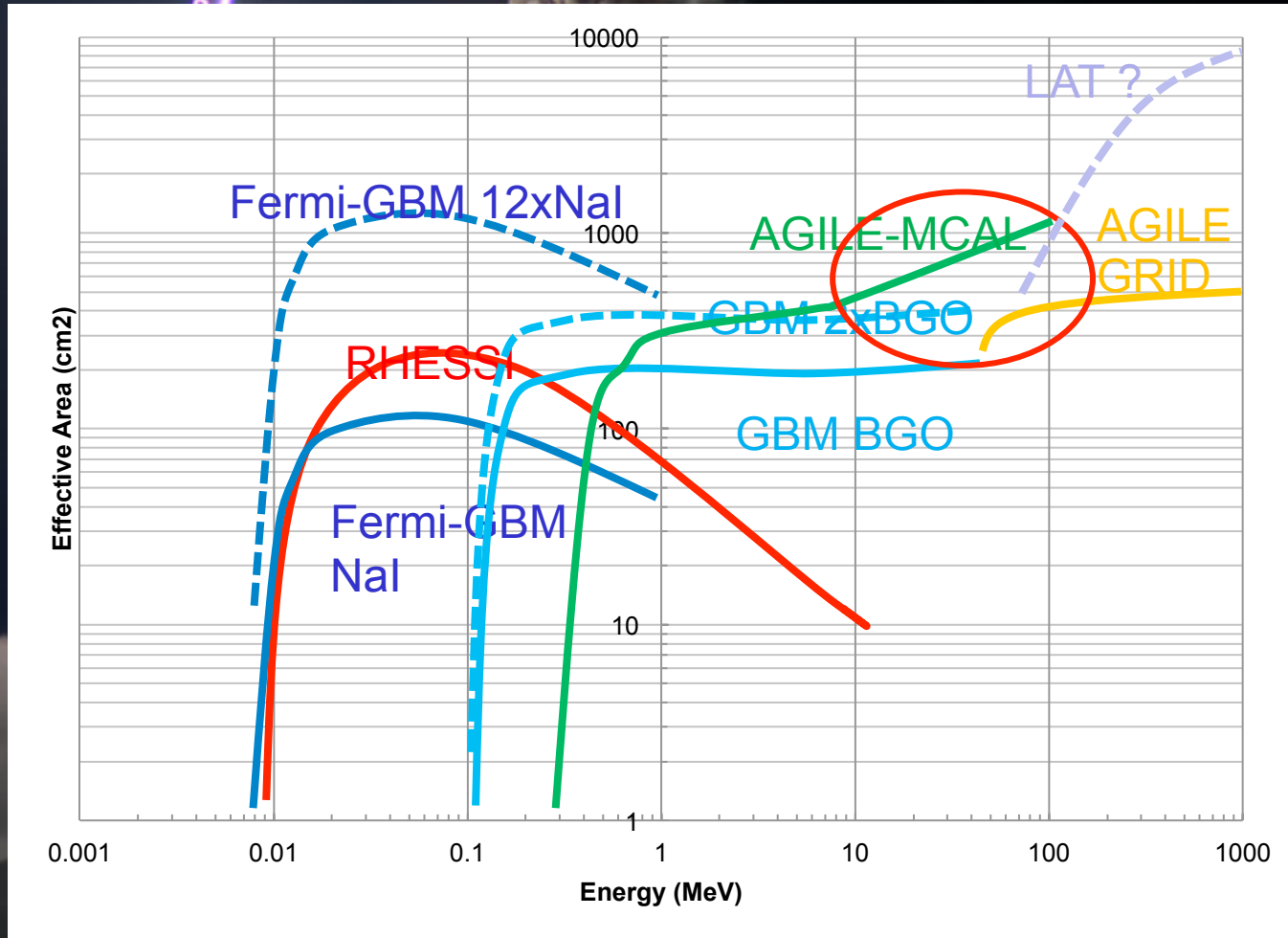


Operating TGF detectors



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Effective Area vs. Energy

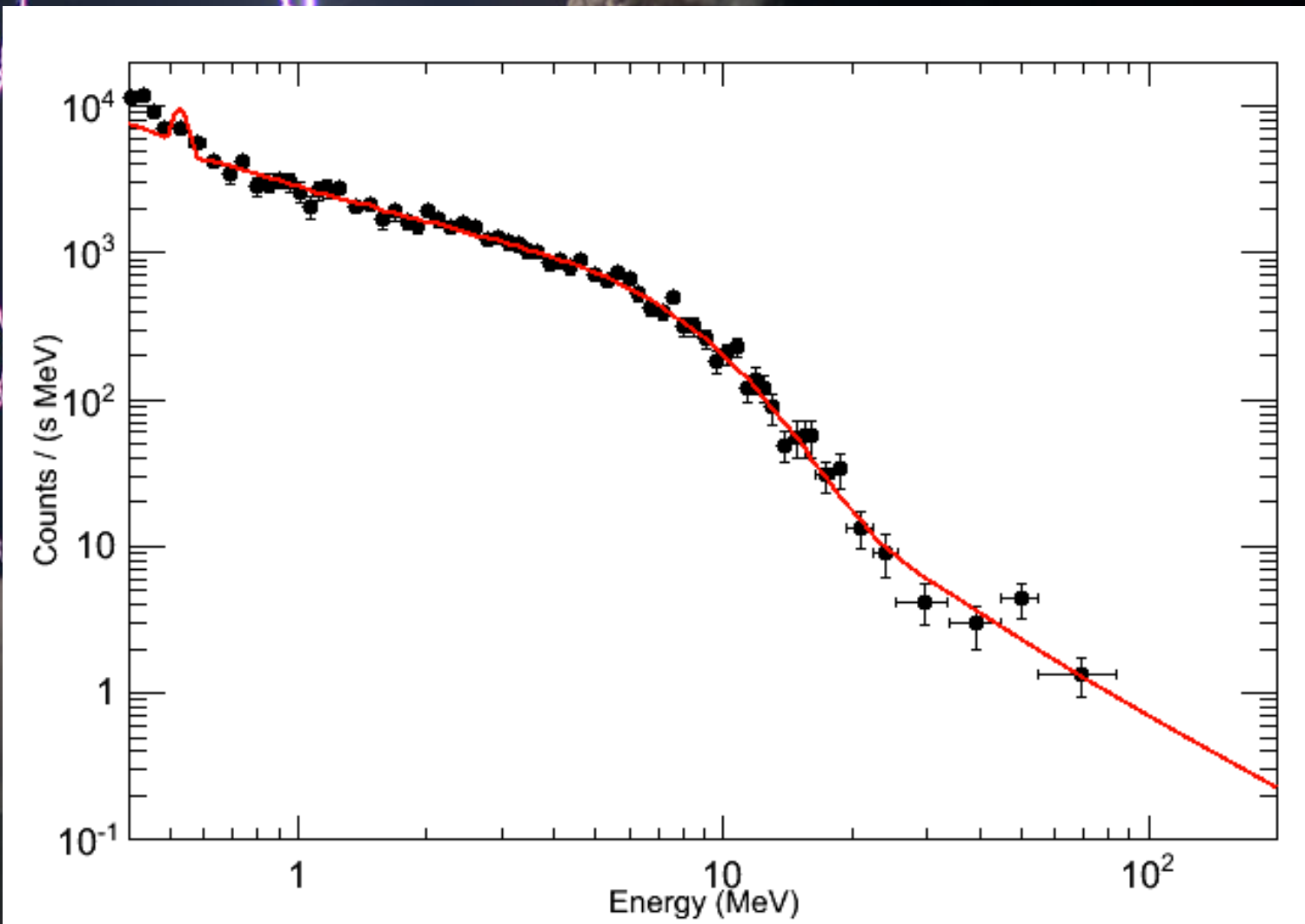


Data from: Smith et al. (2002), Meegan et al. (2009), Labanti et al. (2009), Tavani et al. (2009)

Cumulative spectrum

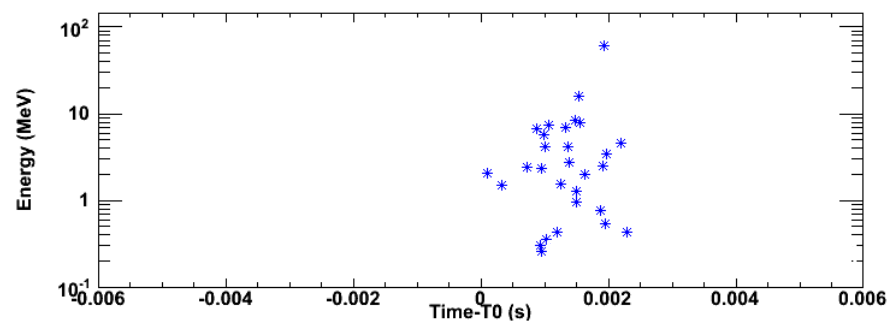
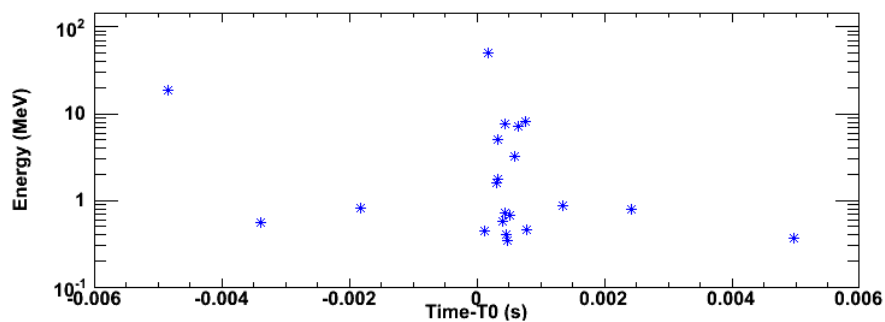
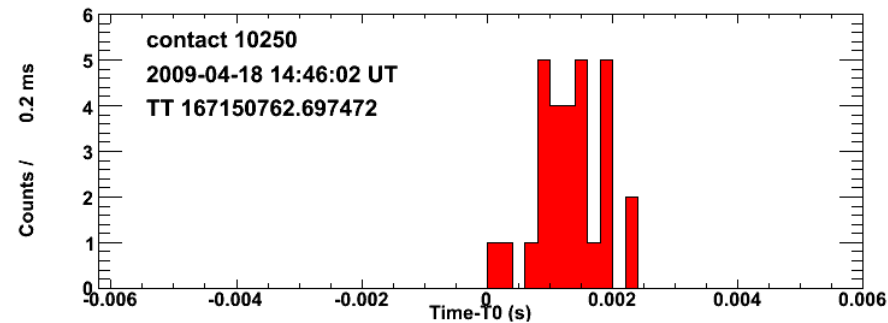
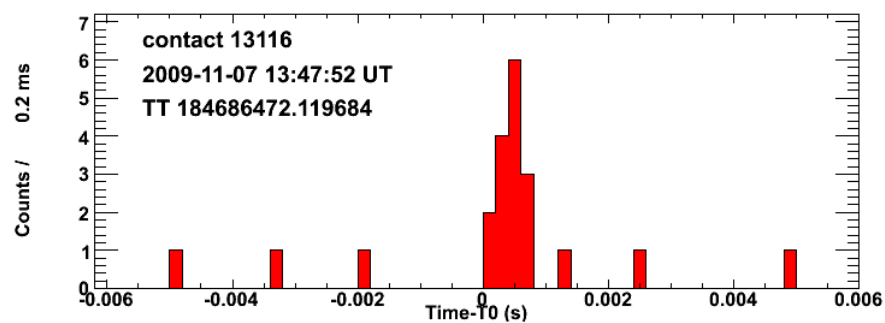
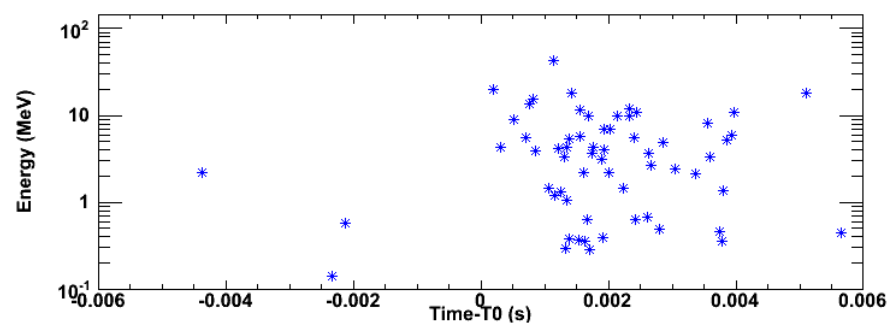
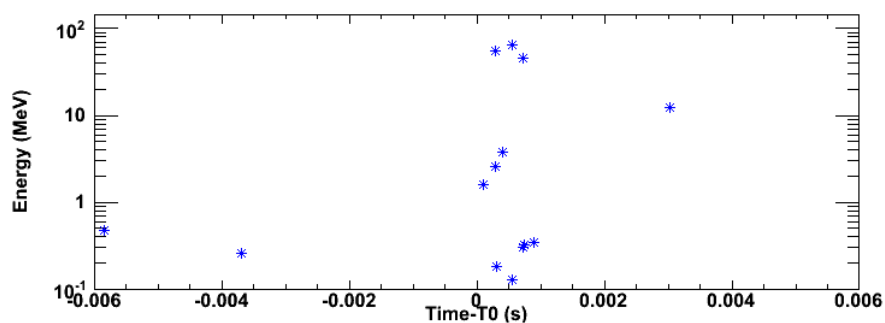
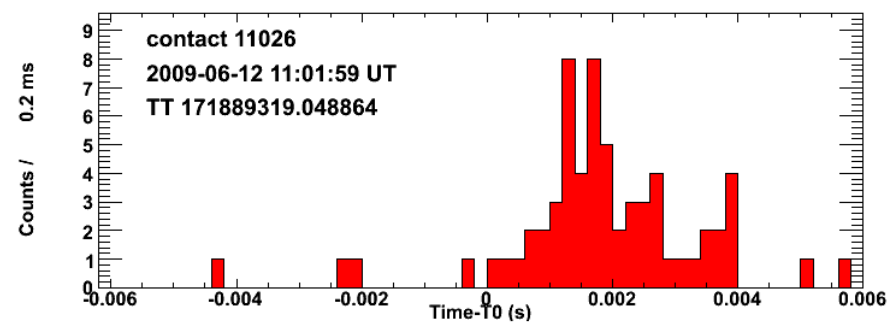
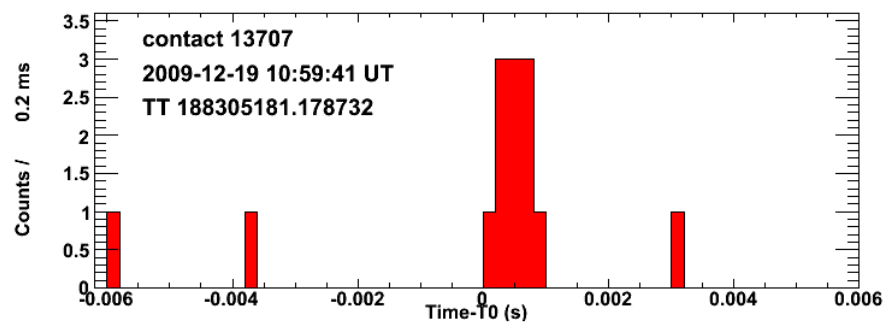


302 class A TGFs detected in the period Mar. 2009 – Nov. 2011
Model fit is cutoff powerlaw (low energy) + powerlaw (high energy)



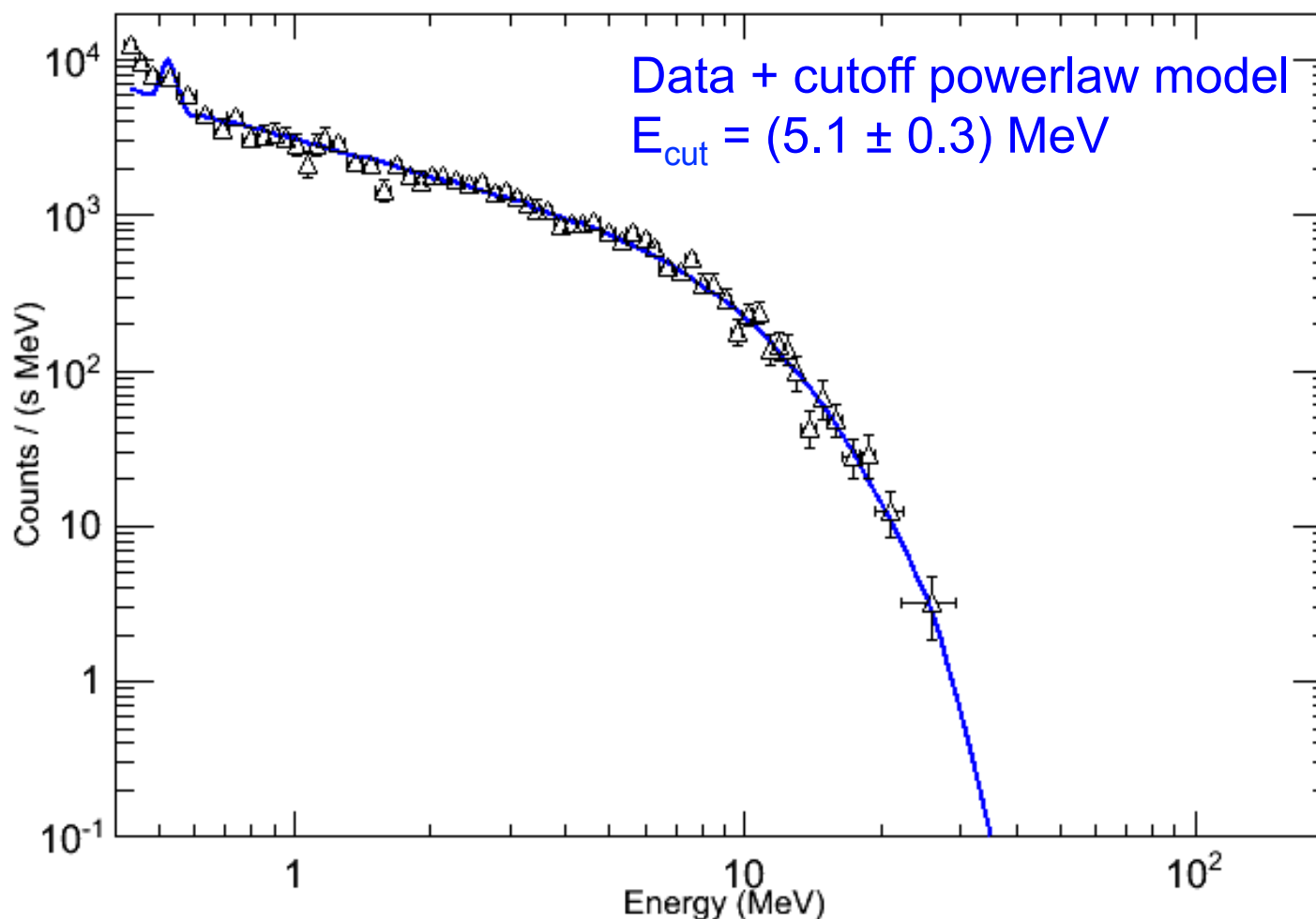


High energy TGFs



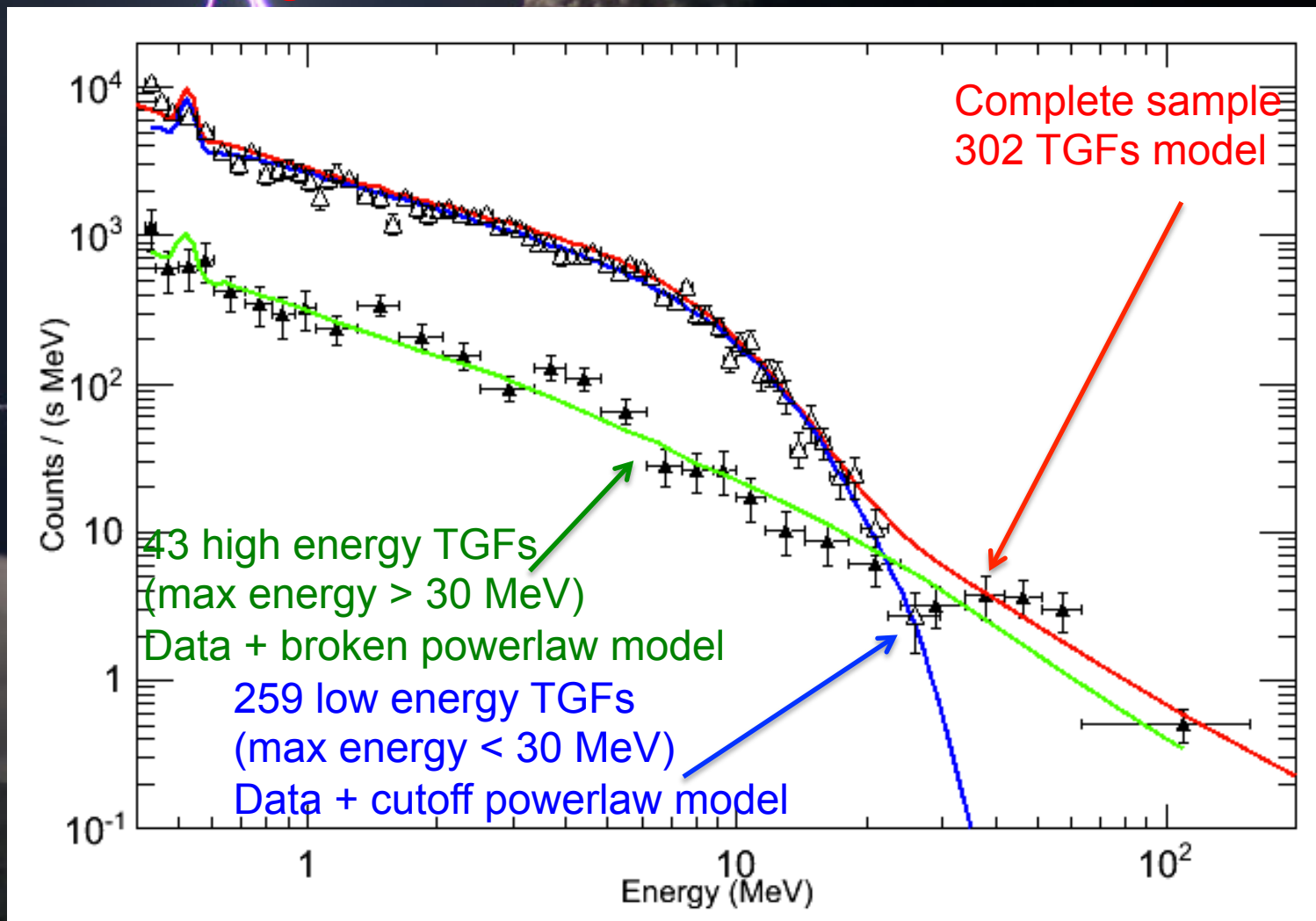
Low energy population cumulative spectrum

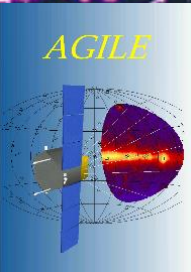
259 low energy TGFs (max energy < 30 MeV).
Normalized to total duration 277 ms



Cumulative spectrum: two different populations!

HE and LE samples are normalized to the complete sample duration (330 ms)
All spectra are background-subtracted





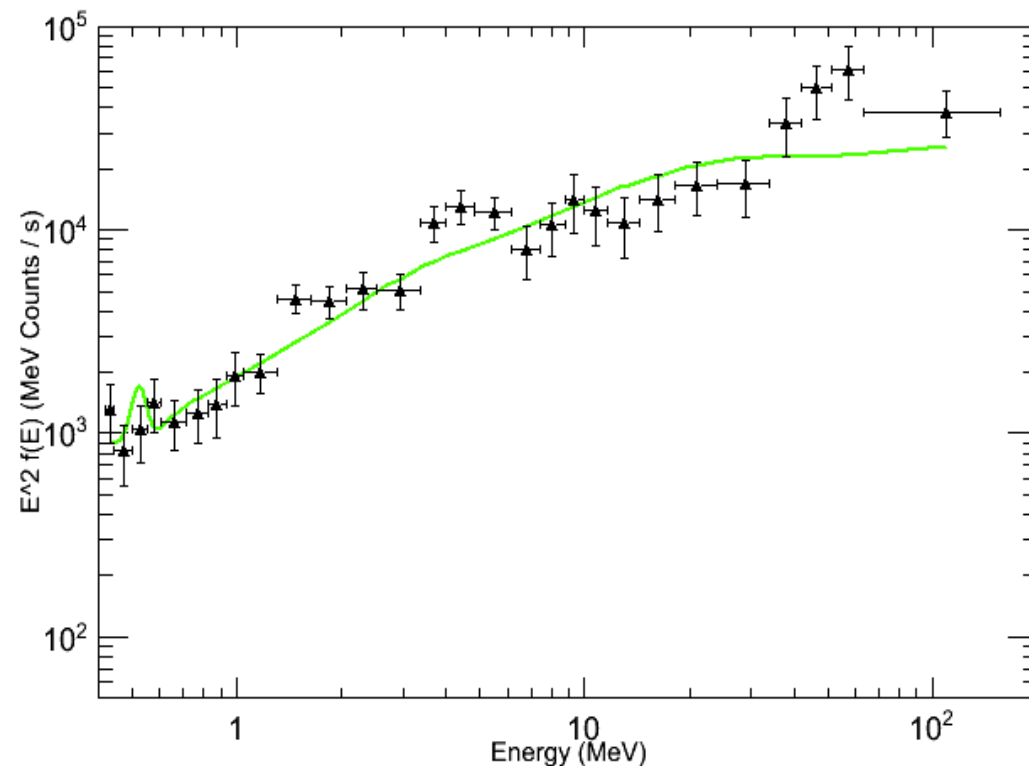
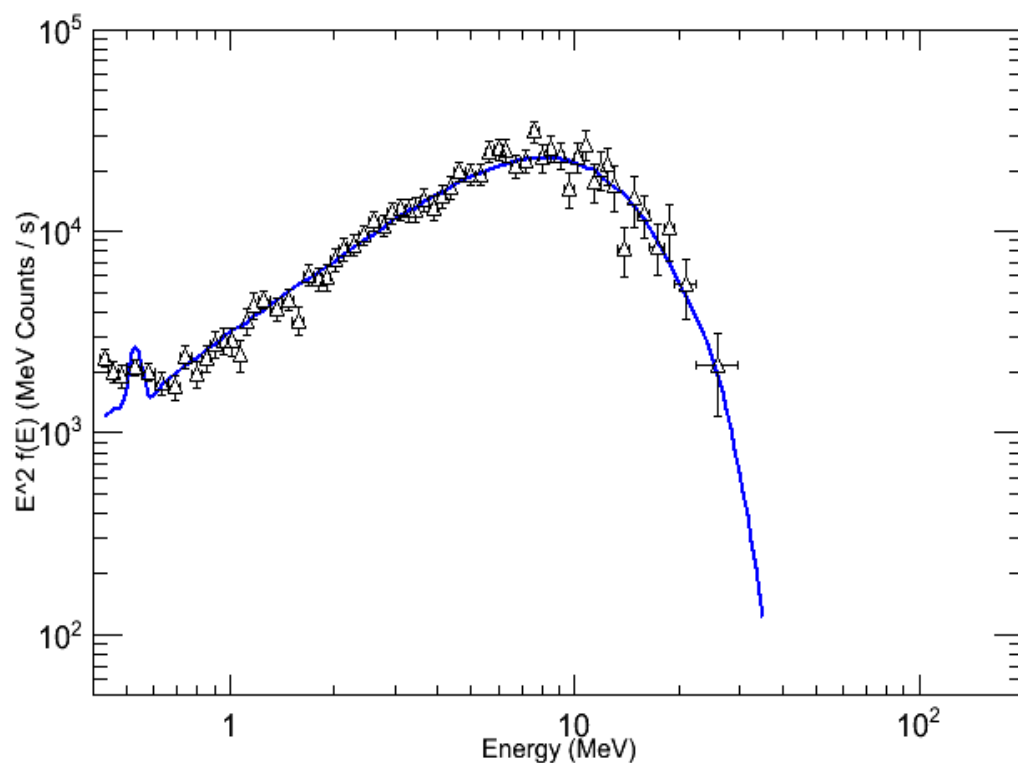
Low and high energy populations power spectral density $E^2 f(E)$



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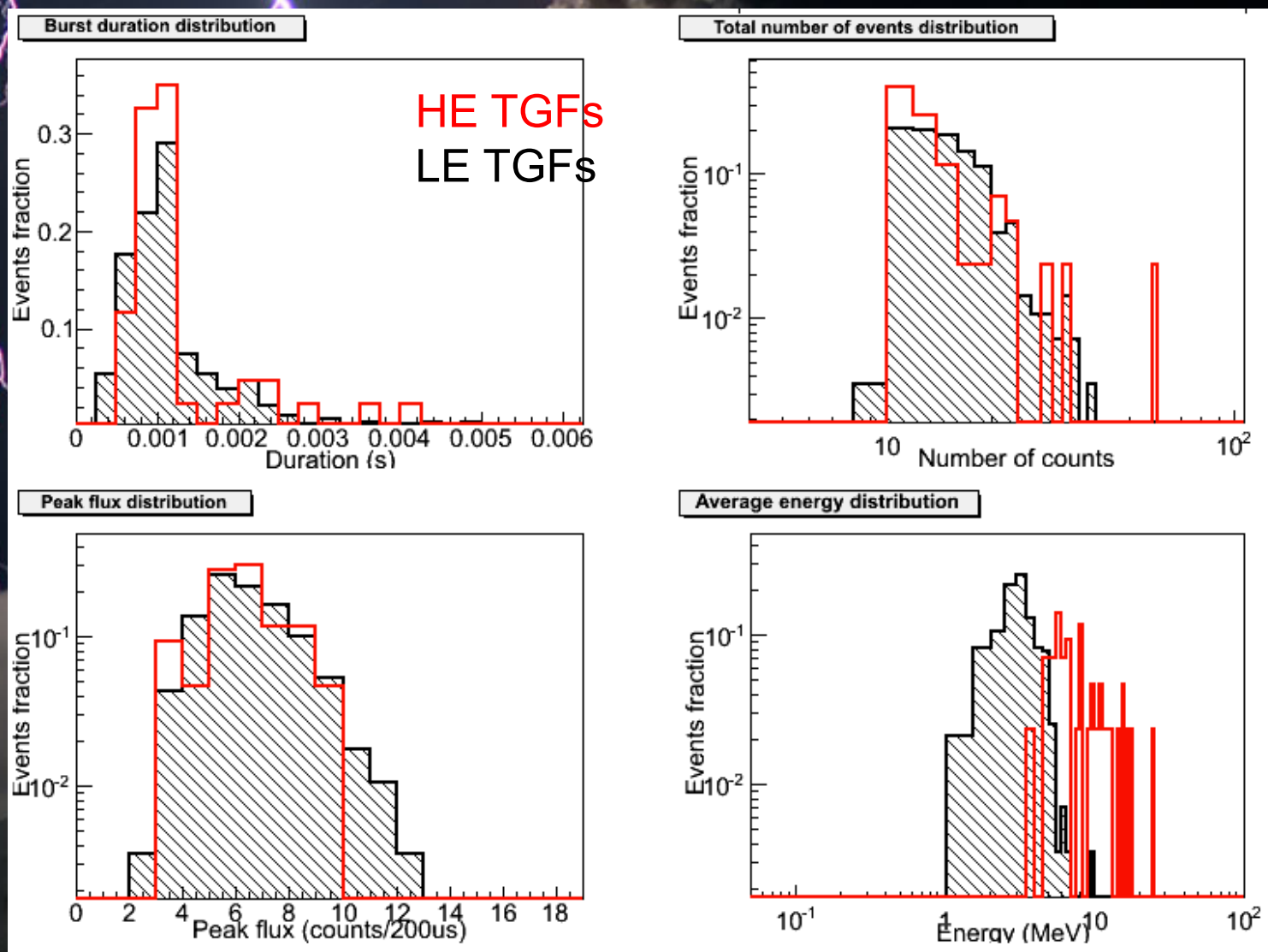
Low energy population

High energy population



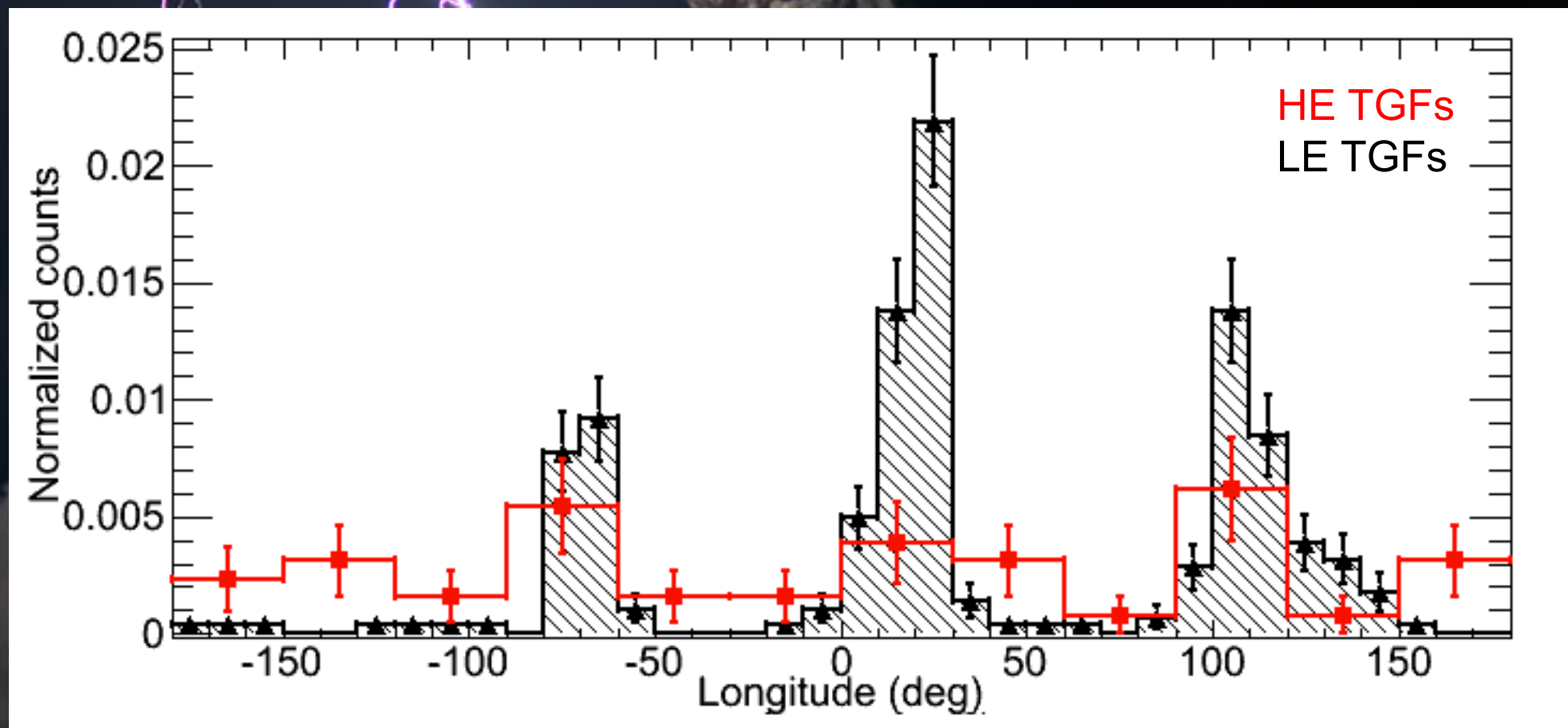
HE vs LE populations

Normalized parameter distributions



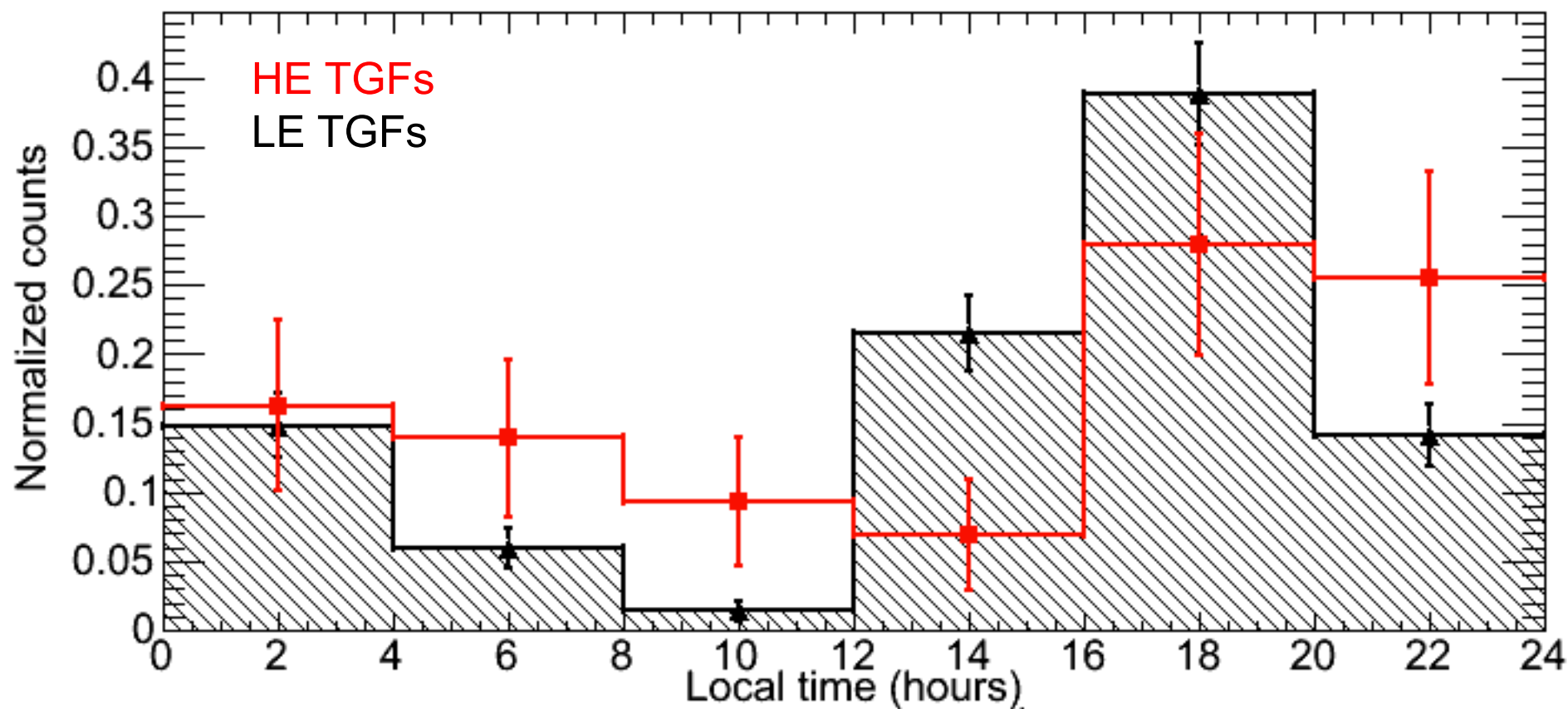
HE vs LE events: Geographical distribution

No clear geographical pattern as for low energy TGFs



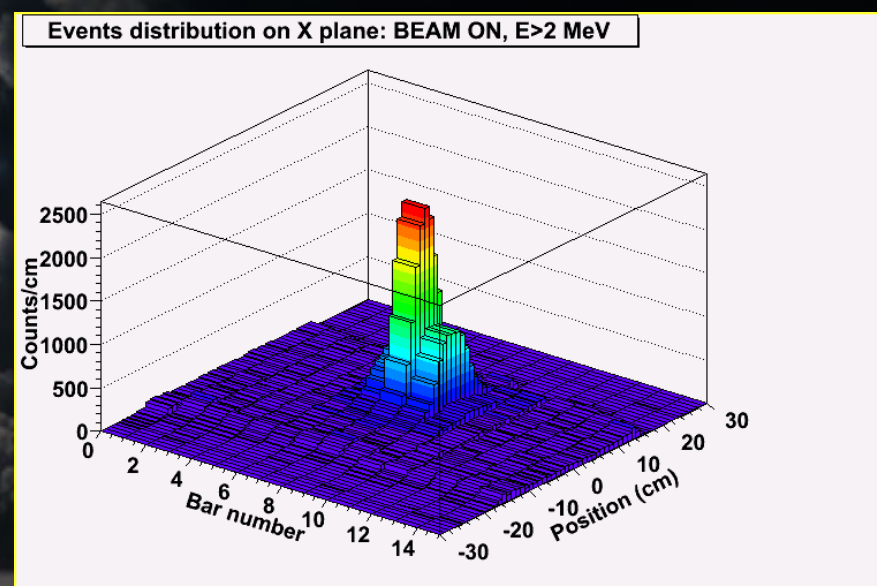
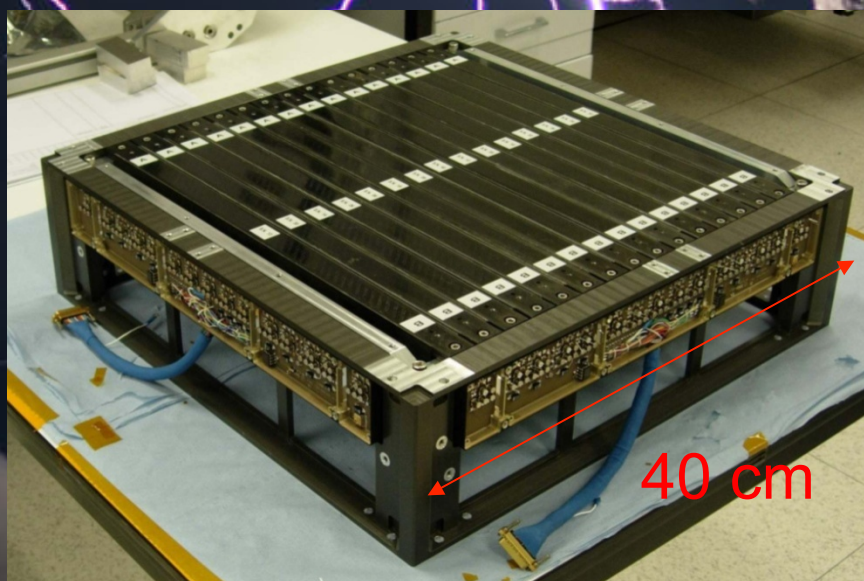
HE vs LE events: local time

No clear pattern: statistics too low

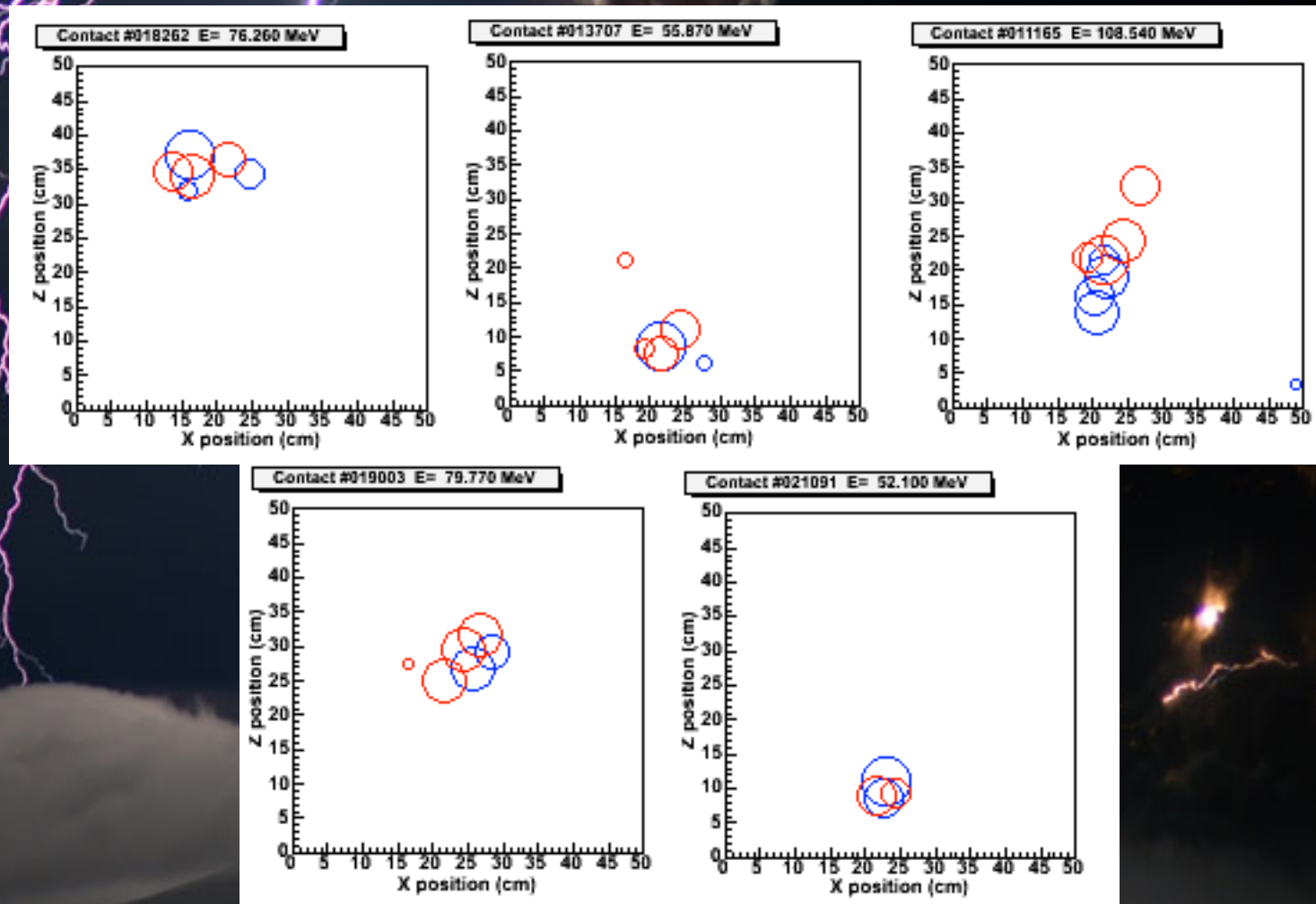


HE events topology: Can HE events be due to pile-up of many low energy events?

MCAL position reconstruction capabilities



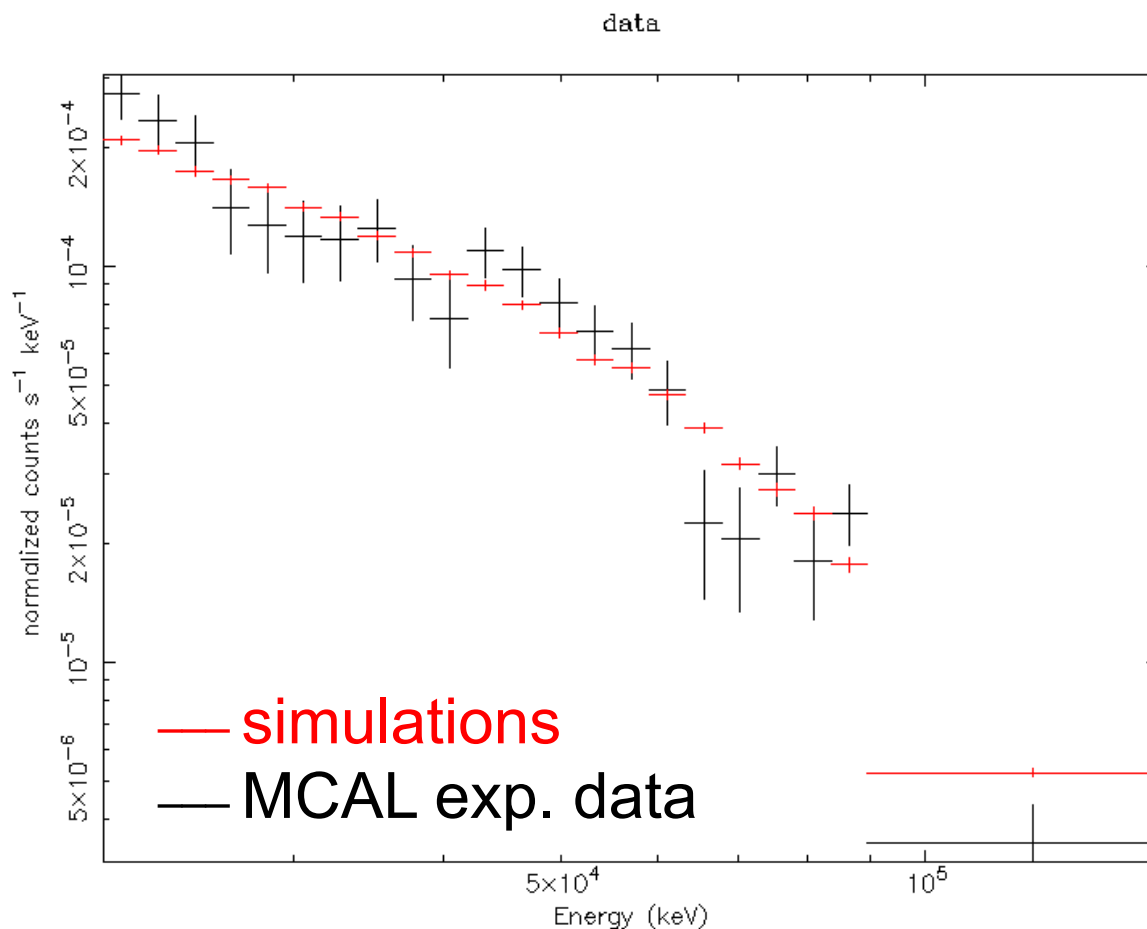
HE counts topology



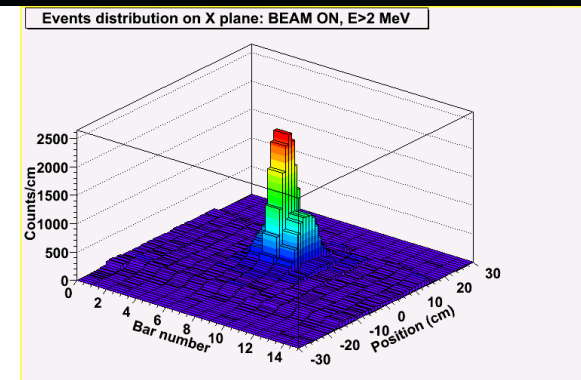
Spatial clustering in MCAL allows to exclude high-energy events being due to pile-up of low energy photons

MCAL high energy calibration

On ground

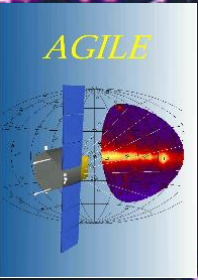


mccl 8-Jun-2010 17:16



Simulations by:
A. Rappoldi
P.W. Cattaneo
F. Longo
INFN Pv and Ts

AGILE on-ground calibration performed at INFN Beam Test Facility, Frascati, with Bremsstrahlung γ -rays by 460 MeV e^- on Si target



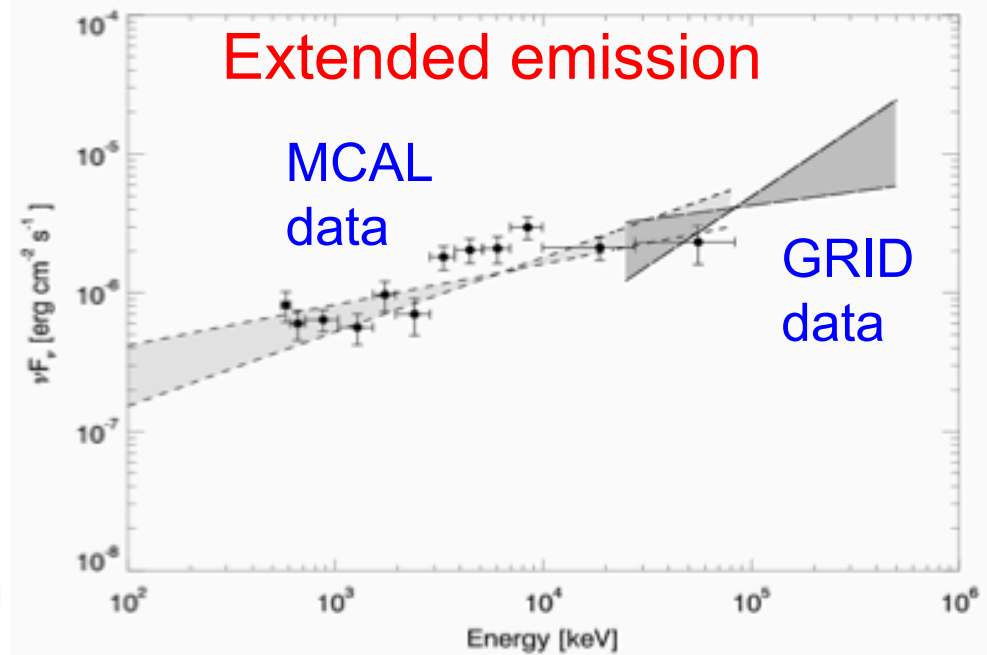
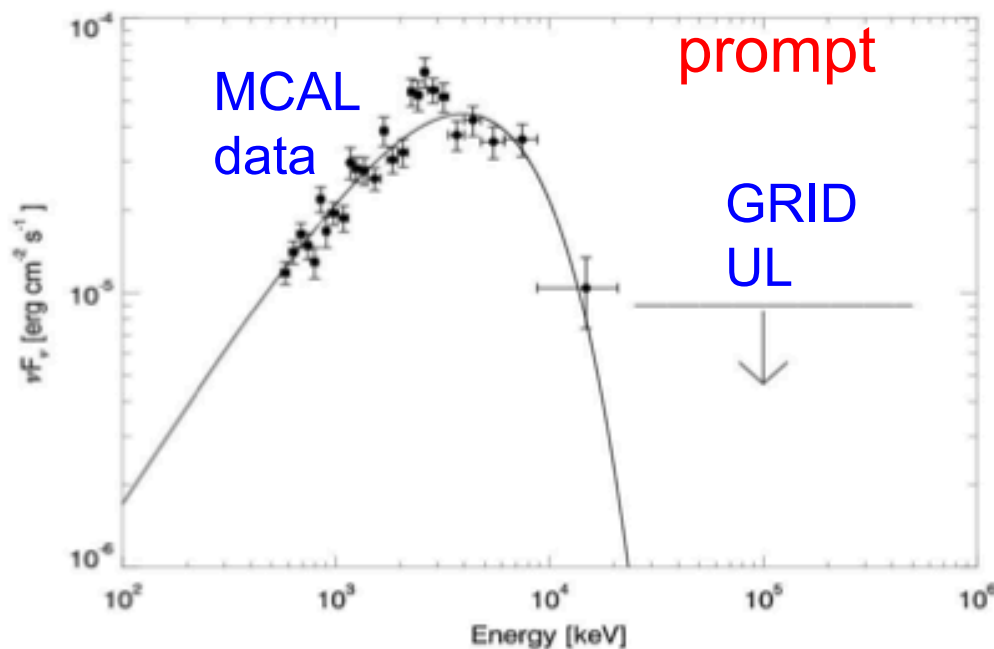
MCAL high energy calibration



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In flight

GRB 090510



Giuliani et al., ApJL 708 (2010) L84

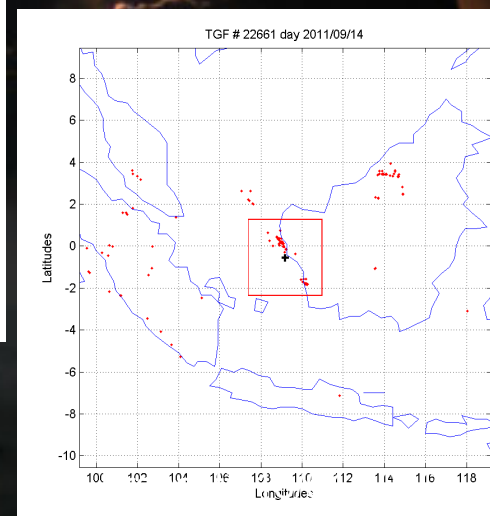
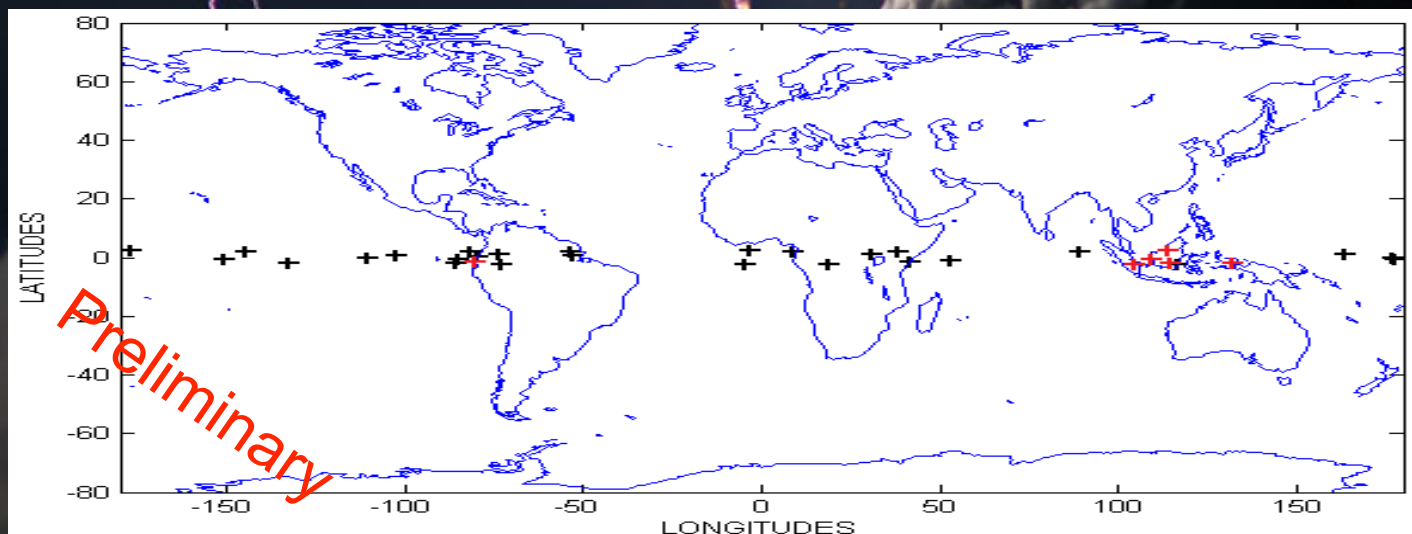
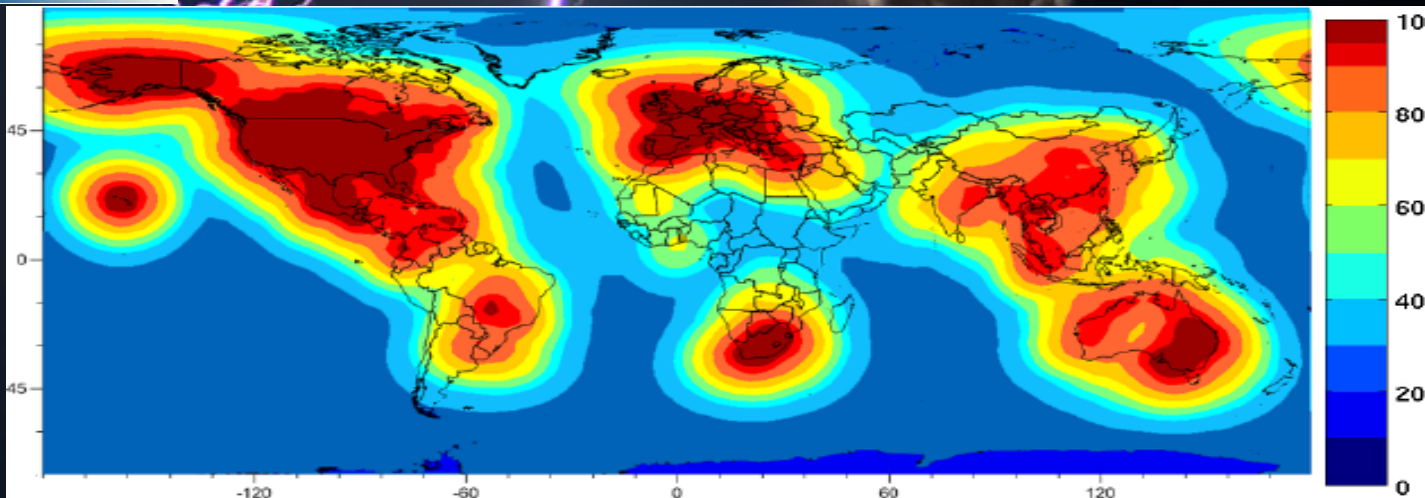
HE events: the lightning connection



GLN network: global coverage but inhomogeneous efficiency.

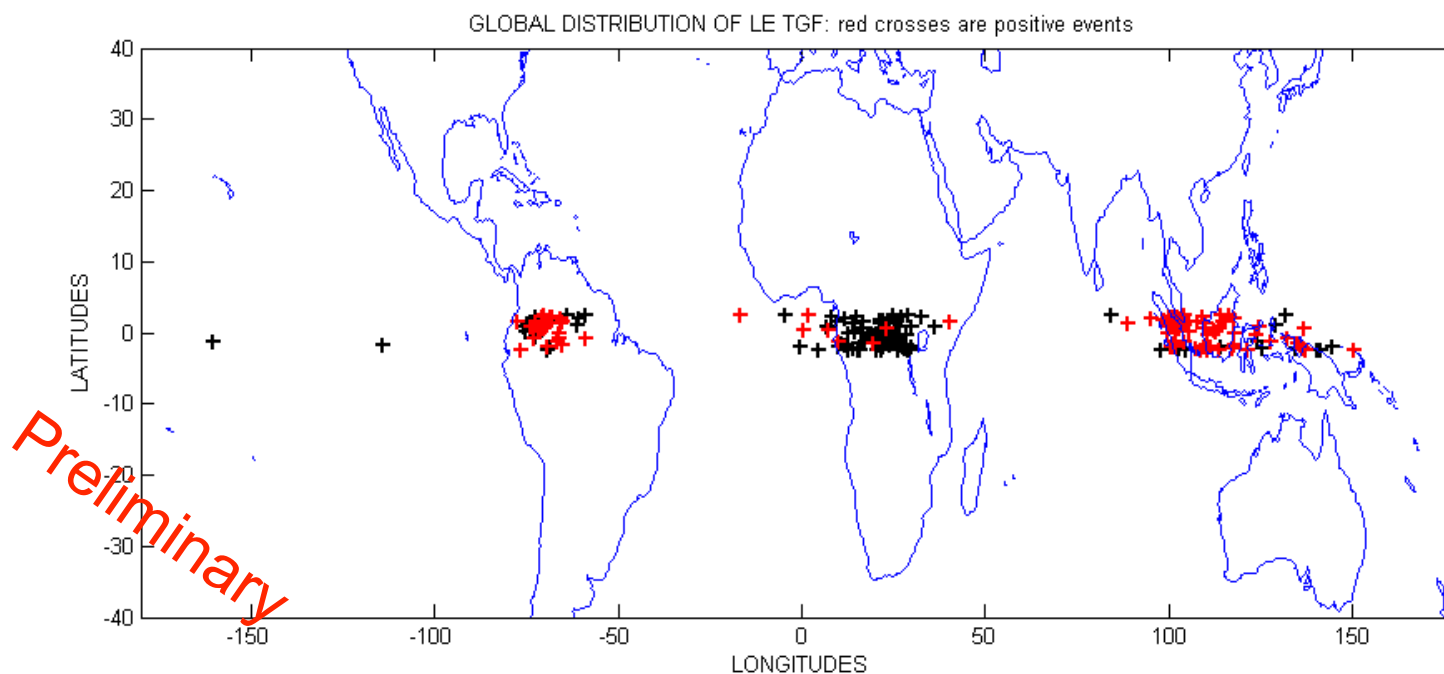
No one-to-one correlations.

200km side box, ± 5 min from TGF: 5/6 correlations above S.E. Asia. 18% global.



Benchmark: low-energy TGF lightning connection

201 AGILE low-energy TGFs, same algorithm



Central America:
66% match.
Non compliant with HE sample
5.9 expected, 1 observed

Africa:
10% match.
Compliant with HE
sample non detection

South East Asia:
81% match.
Compliant with
HE sample

Different lightning mechanisms at play? Results non conclusive yet.
Need for more efficient networks and one-to-one correlations.

Conclusion



- Evidence for two distinct populations in the AGILE TGF sample
- The low-energy population (90% of events, $E_{\text{MAX}} < 30 \text{ MeV}$) match standard TGF phenomenology: cutoff powerlaw spectrum, longitude and local time follow lightning distributions
- The high-energy population (10% of events, $E_{\text{MAX}} > 30 \text{ MeV}$):
 - Power law spectrum up to 100 MeV and above
 - Statistics is too low for a clear geographical and local time pattern, but many events above the oceans
- HE events are spatially clustered: not a pile-up effect
- High confidence on MCAL response at high energy
- Correlation to lightning detected on ground is not conclusive yet

AGILE

THANK YOU!

INAF



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Credit: Alan Stonebraker

