The Third Fermi GBM Terrestrial Gamma-ray Flash (TGF) Catalog

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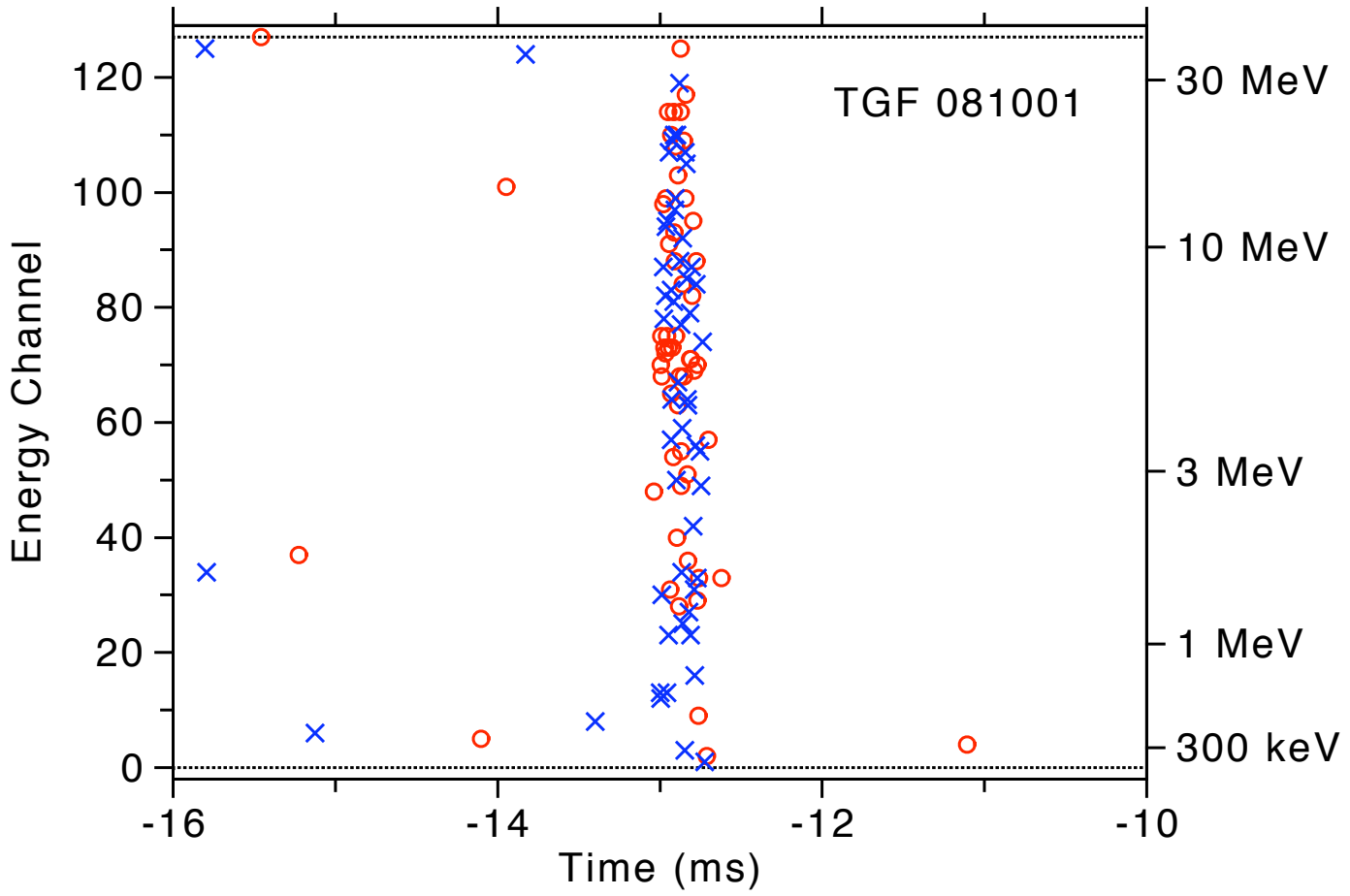
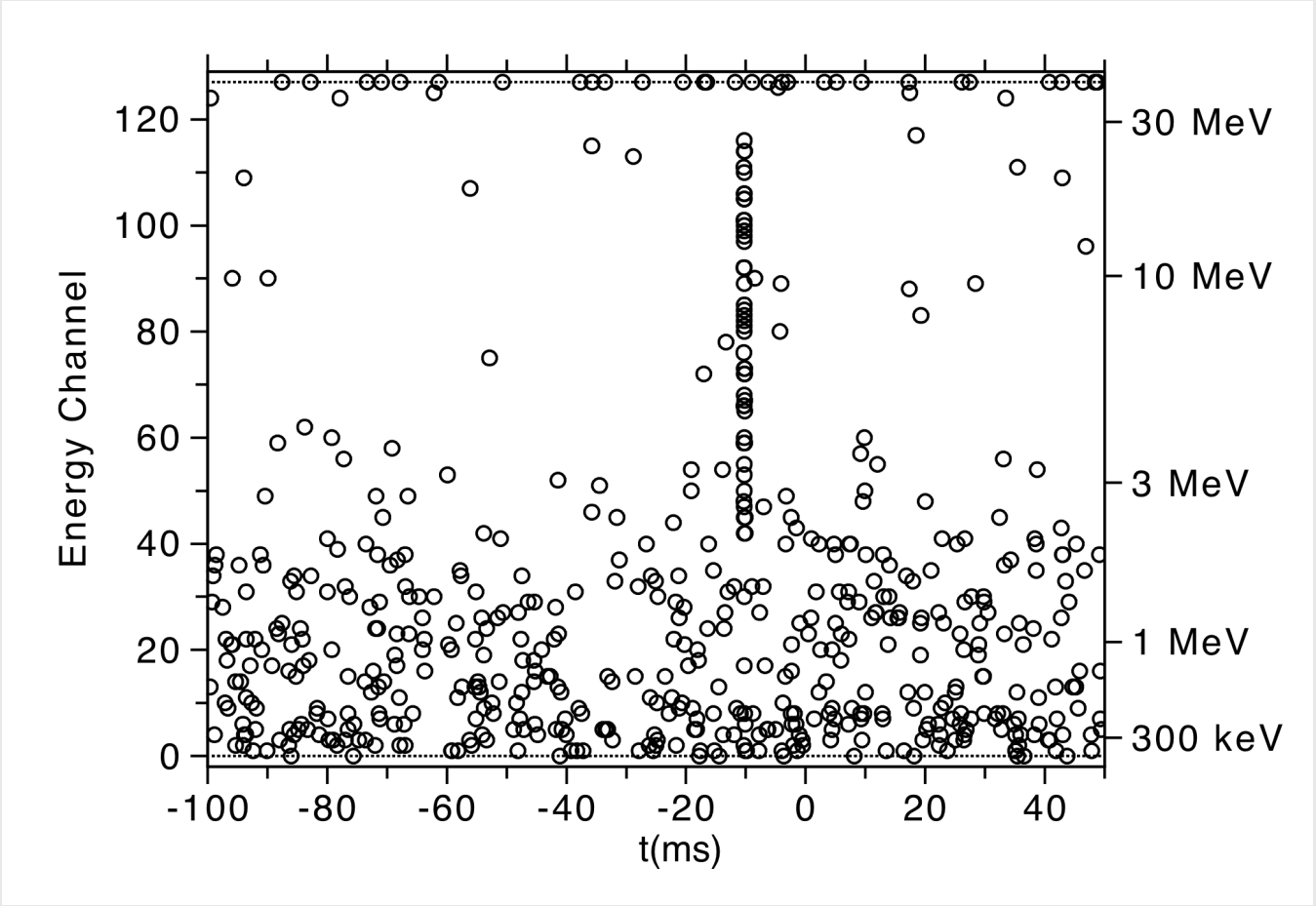
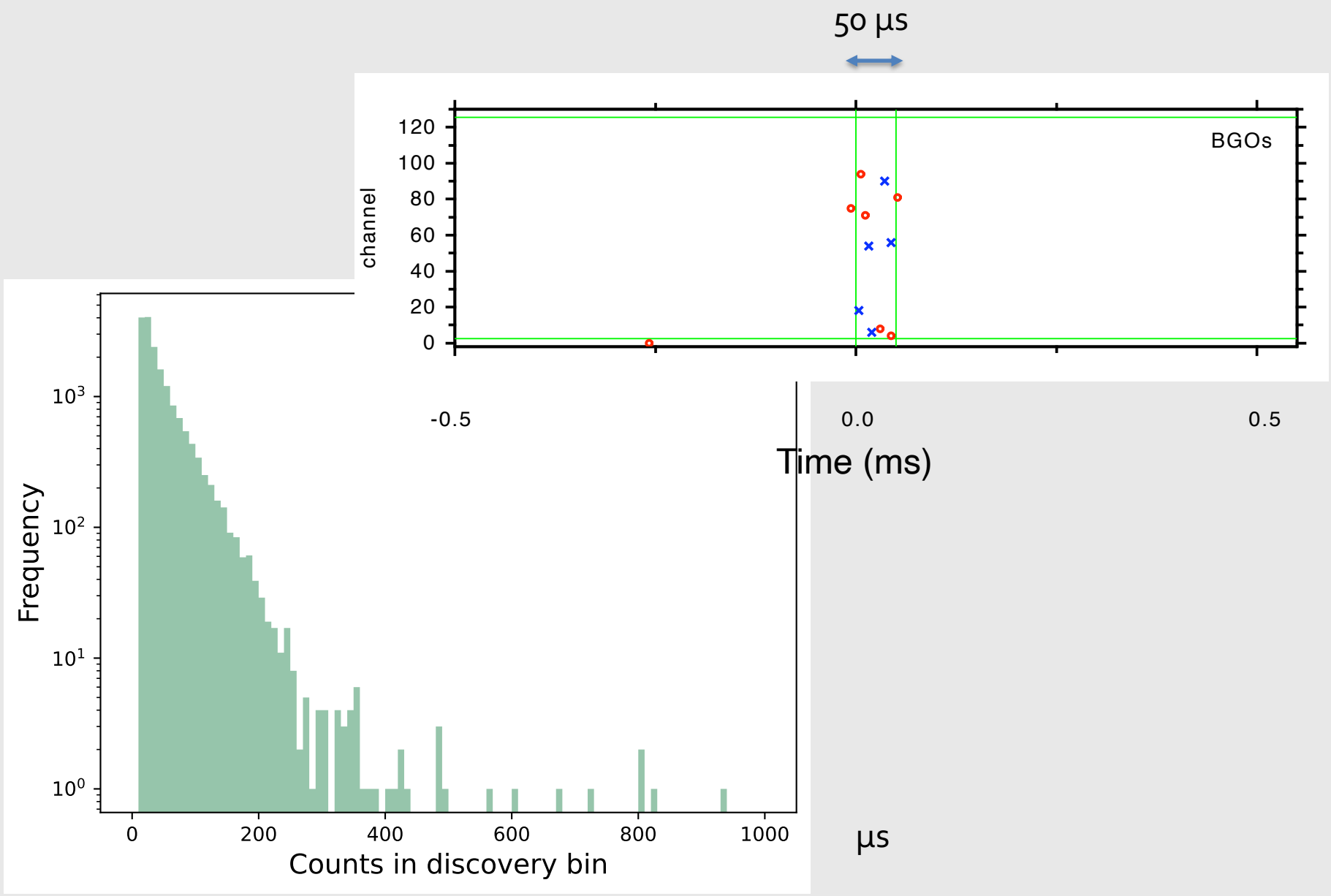

TGF 081001
Energy Channel
120
100
80
60
40
20
0
-16
-14
-12
-10
Time (ms)
30 MeV
10 MeV
3 MeV
1 MeV
300 keV

Fermi GBM advantages for TGF research:

- Covers energy range of TGFs,
- Orbit overflies tropics: high TGF rate,
- Continuous Time-Tagged Events (CTTE) enables high-sensitivity ground-based search,
- High-time accuracy (few μs) allows correlation with ground-based radio observations.
- Long dataset: CTTE from late Nov 2012.

150 ms of BGO data



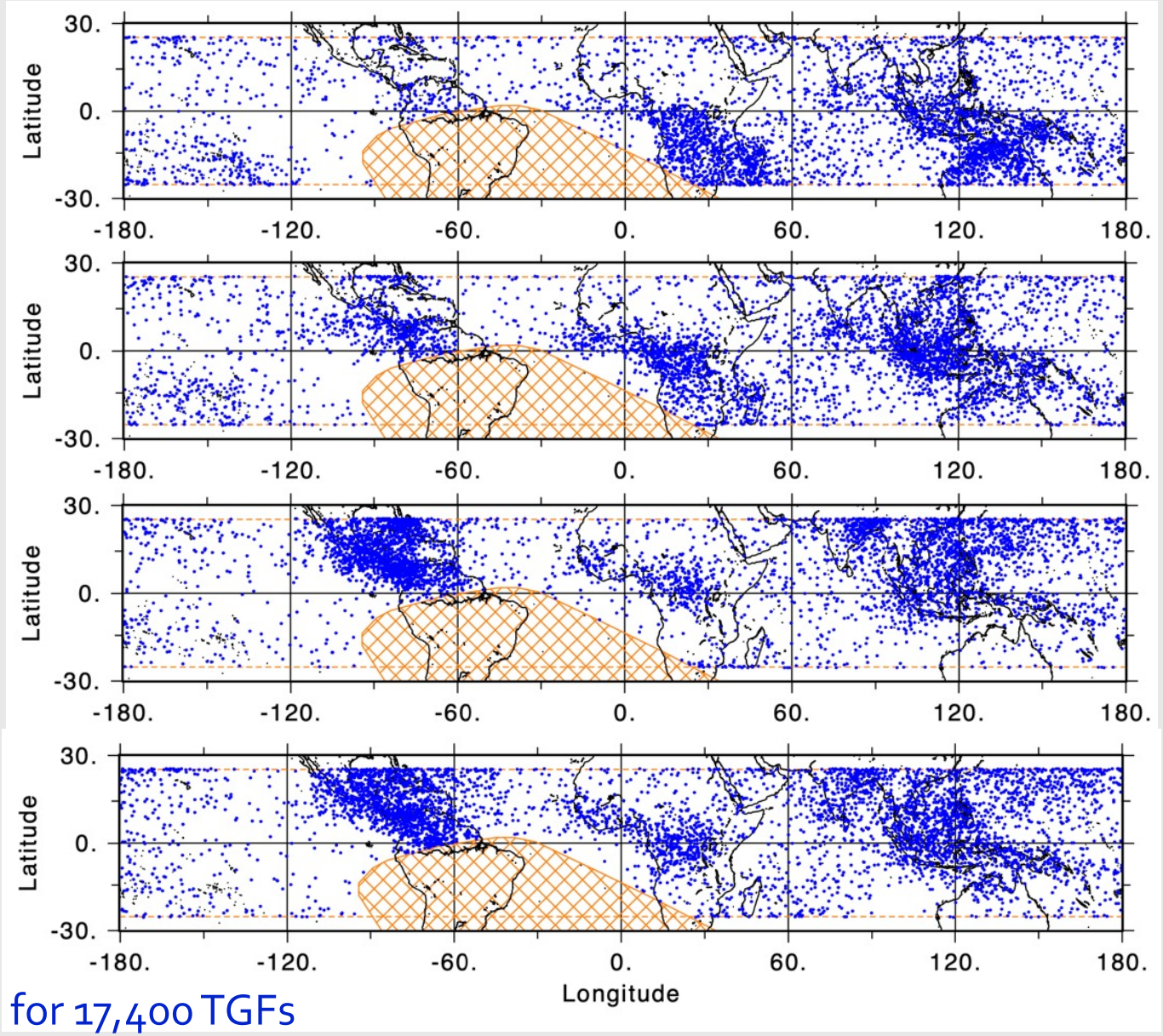

50 µs
BGOs
channel
120
100
80
60
40
20
0
-0.5
0.0
0.5
Time (ms)
Frequency
10^3
10^2
10^1
10^0
0
200
400
600
800
1000
Counts in discovery bin
µs

Dec/Jan/Feb

Mar/Apr/May

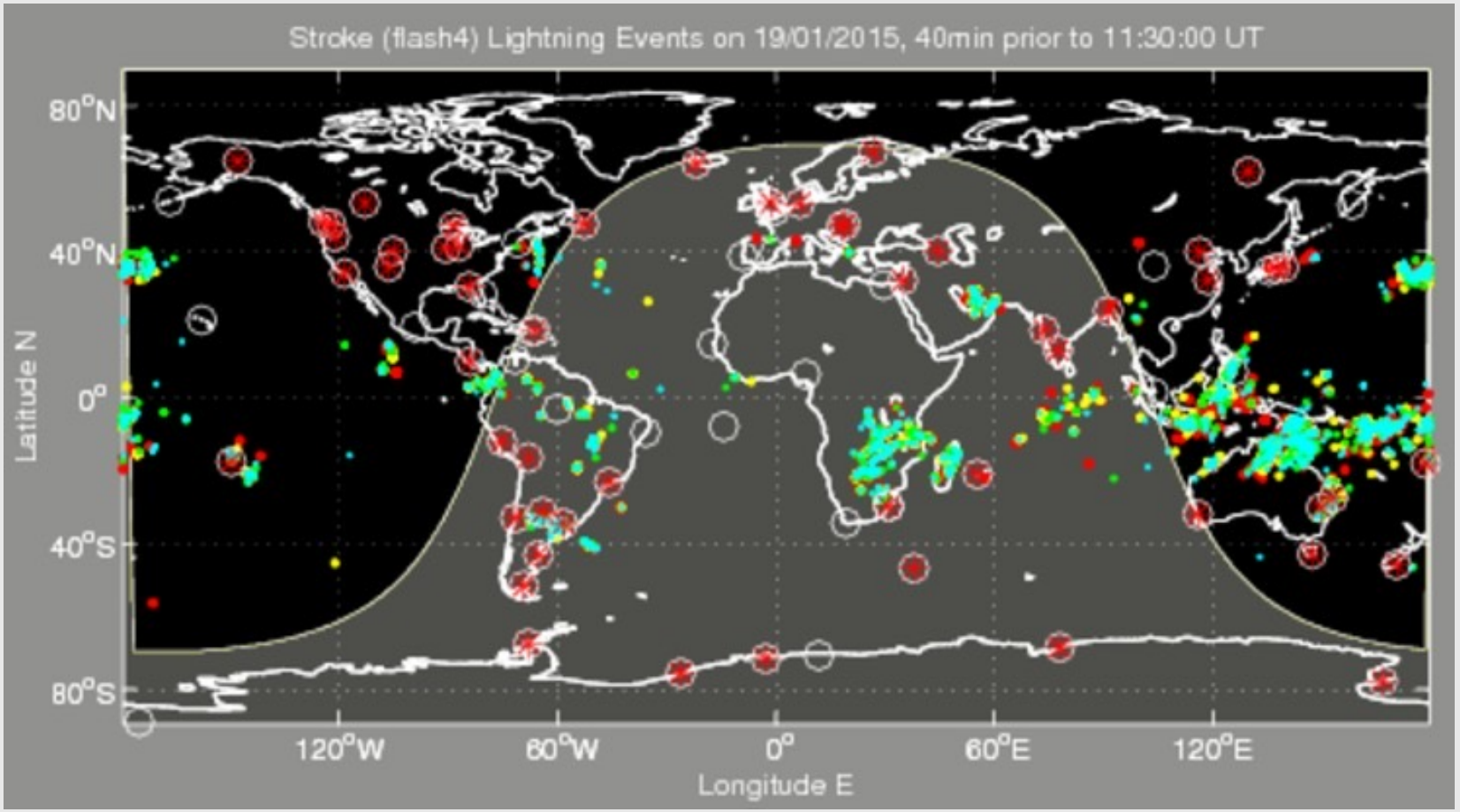
Jun/Jul/Aug

Sep/Oct/Nov

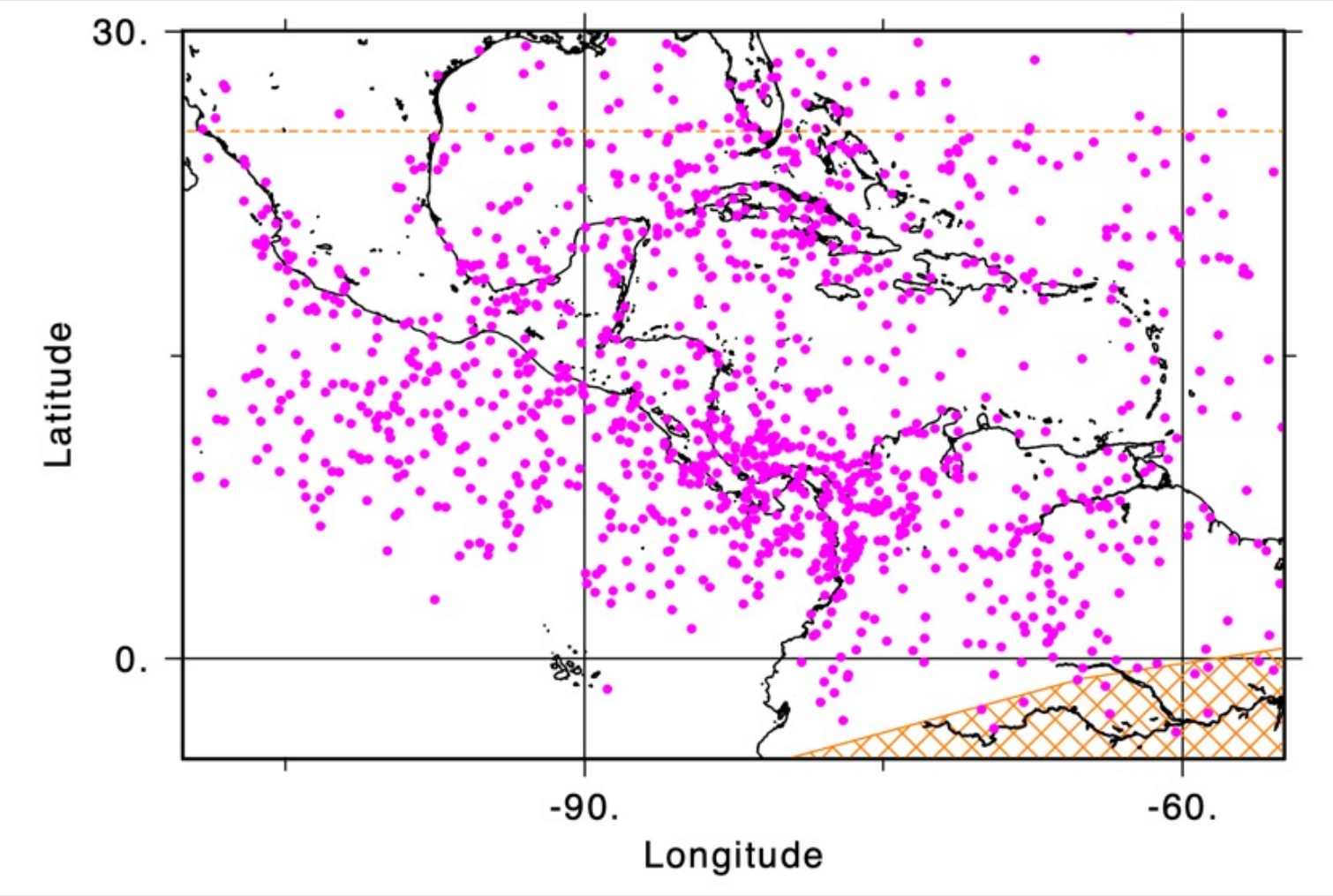


Location of Fermi for 17,400 TGFs

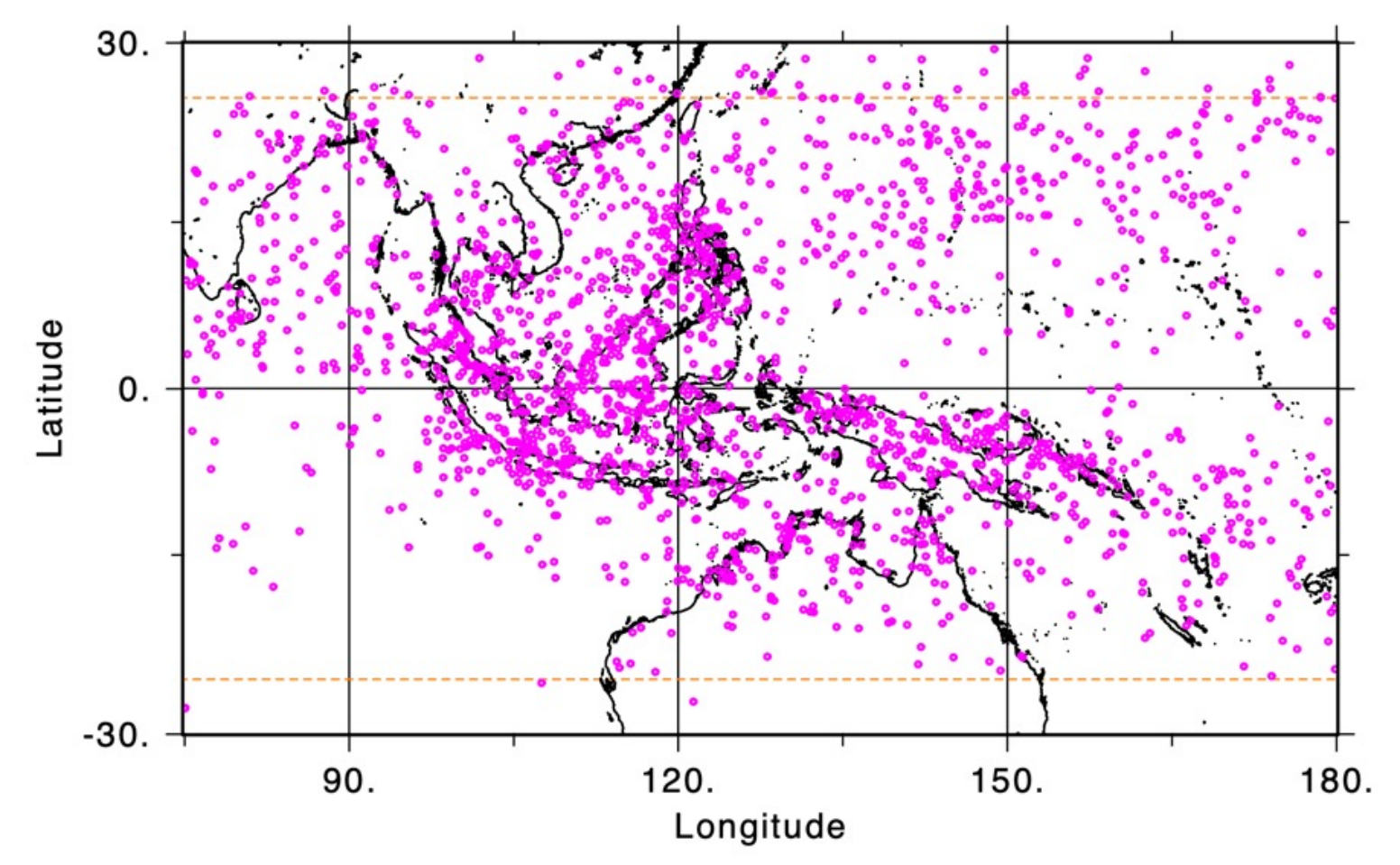
World-Wide Lightning Location Network (WWLLN)
Very Low Frequency (VLF) Radio



WWLLN localizations for TGFs



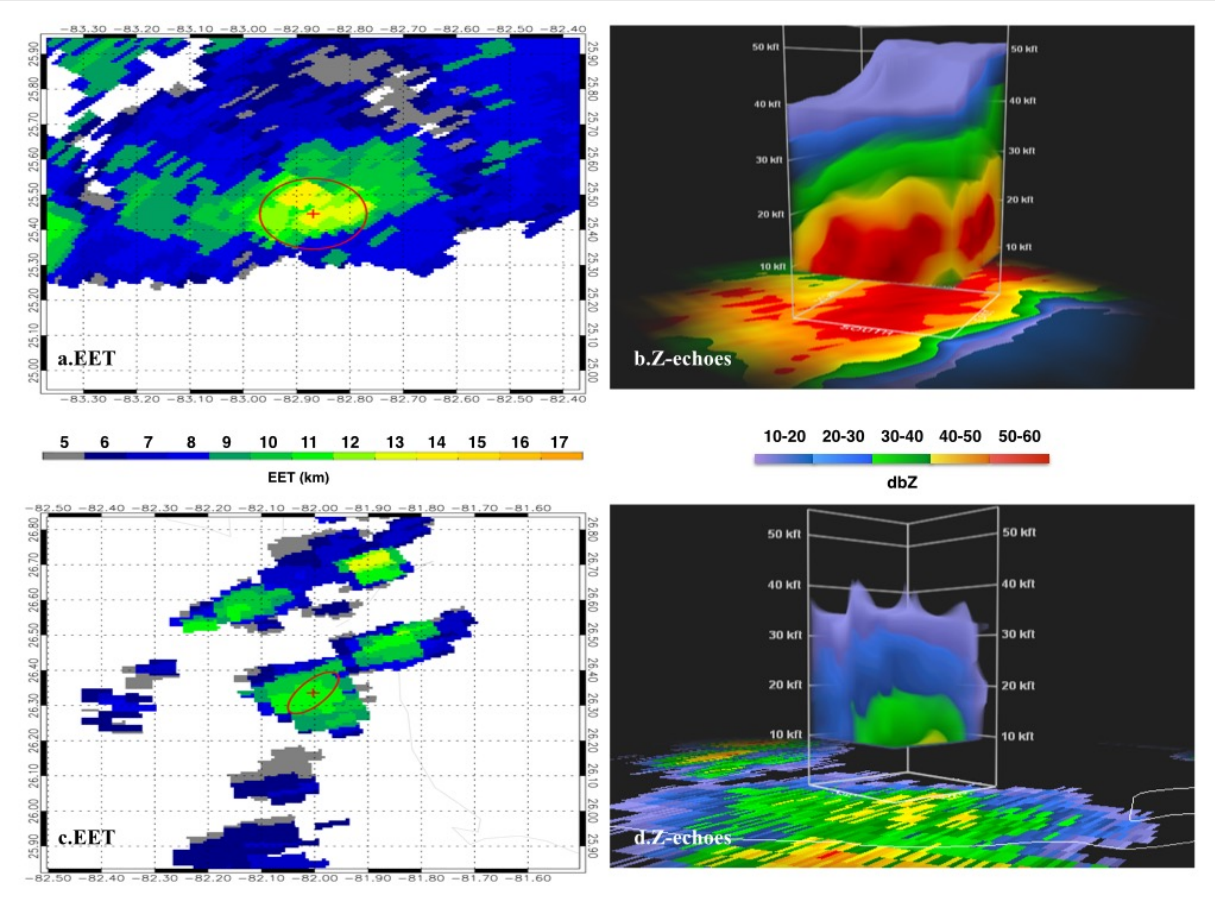
WWLLN localizations for TGFs



Third Fermi GBM TGF catalog

- The catalog will be made available at the FSSC in ~December.
- The 3rd Fermi GBM TGF catalog will be the largest TGF catalog with ~17,000 TGFs:
  - GBM has the highest TGF detection rate and the catalog covers 11 years.
- The 4280 TGFs with WWLLN associations have accurate locations and are particularly useful for correlating with meteorological observations.
- Outstanding questions:
  - Which thunderstorms make TGFs?
  - In which phase of storms are TGFs produced?
  - Are there any meteorological conditions favorable to TGF production?
  - Are there any differences between TGFs originating from ocean or land, or the ocean/land lightning making TGFs?
  - Are there differences in TGF production efficiency compared to lighting rate: land / ocean, geography, seasons, …

From an earlier sample: TGF producing storms observed by US weather radar. Chronis et al. (2016).



NEXRAD radar: Enhanced Echo Tops (EET) and radar reflectivity (dBZ)

From the previous Fermi GBM TGF catalog:
TGF rate as a function of distance from coastline.