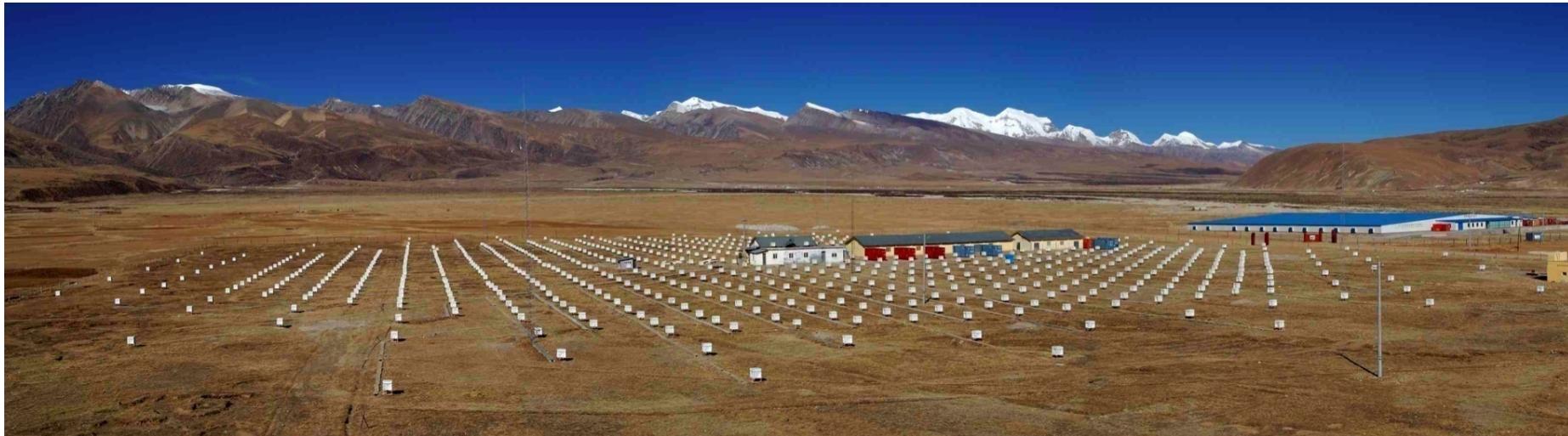
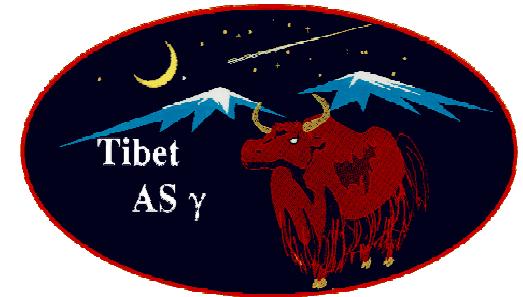


Observation of the Fermi bright galactic sources at TeV energies with the Tibet Air Shower experiment

UDO, Shigeharu
Kanagawa University
For the Tibet AS γ Collaboration



The Tibet ASg Collaboration



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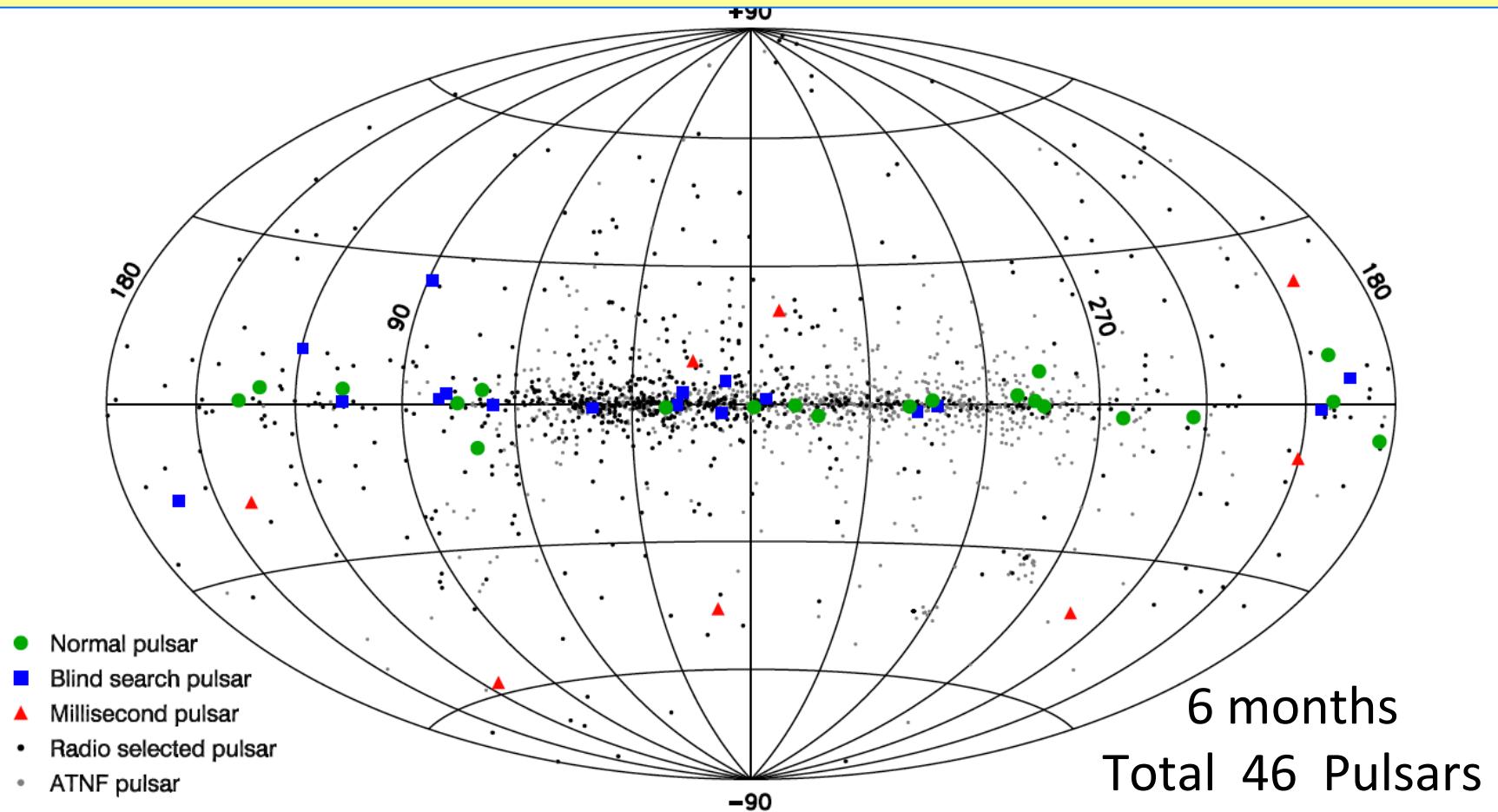
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Introduction

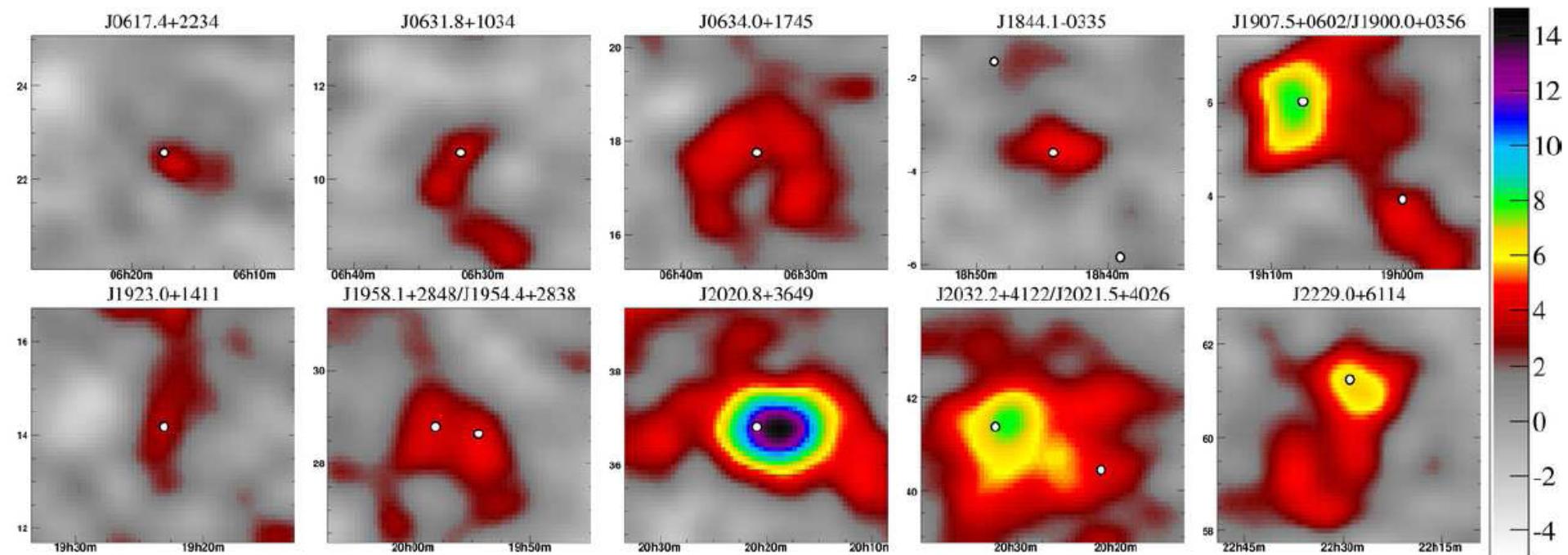
The First *Fermi* Large Area Telescope Catalog of Gamma-ray Pulsars
Abdo, A. A. et al. 2010, ApJS (arXiv: 0910.1608)

Search for **steady** TeV gamma rays around the *Fermi*-LAT pulsars



Milagro Results (\sim 35TeV)

Milagro Observation of TeV Emission from Galactic Sources
In the *Fermi* Bright Source List *Abdo, A. A. et al 2009, ApJ, 700, L127*



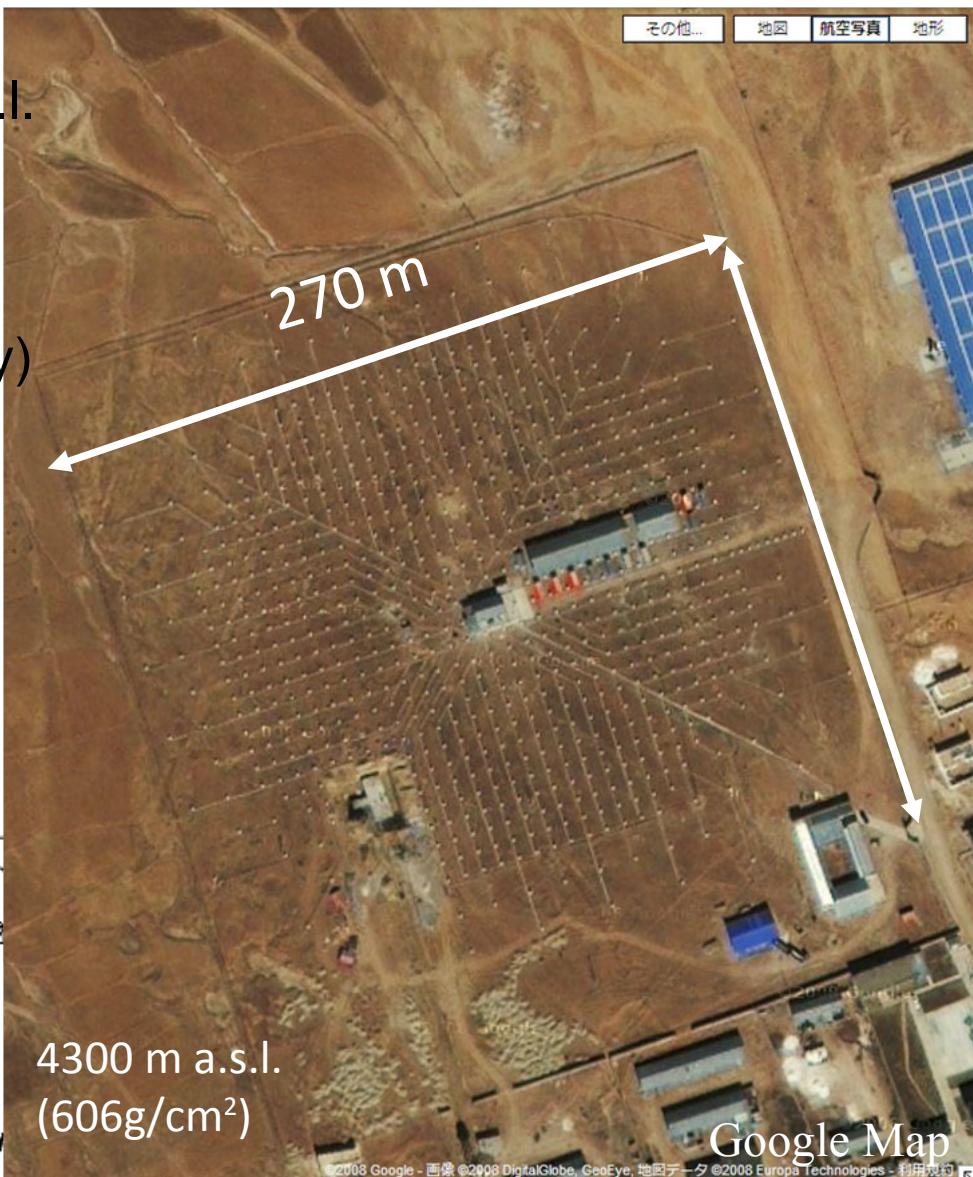
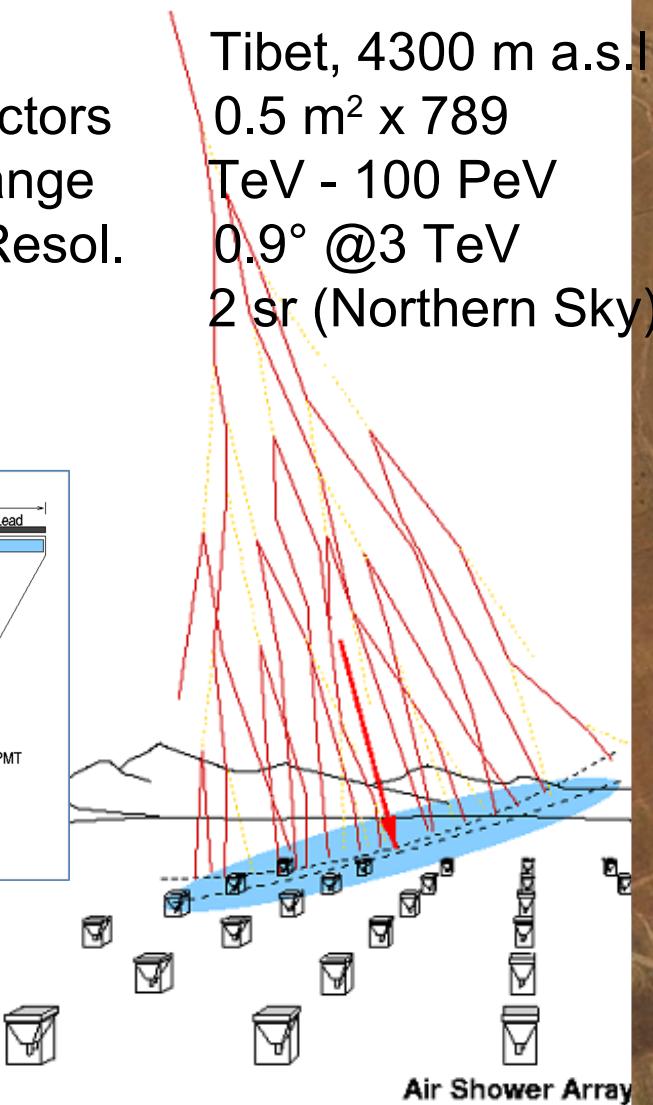
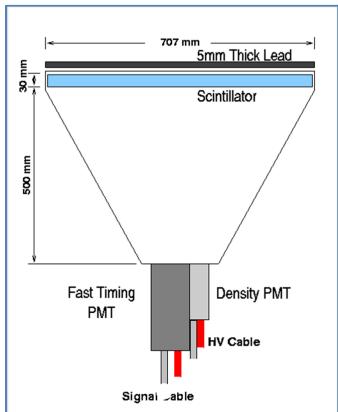
Fourteen $>3\sigma$ sources out of 34 Fermi sources
2D map - $5^\circ \times 5^\circ$ @ 35TeV

Geminga is extended?

Tibet Air Shower Array (Tibet-III)

- Location
- # of detectors
- Energy range
- Angular Resol.
- F.O.V

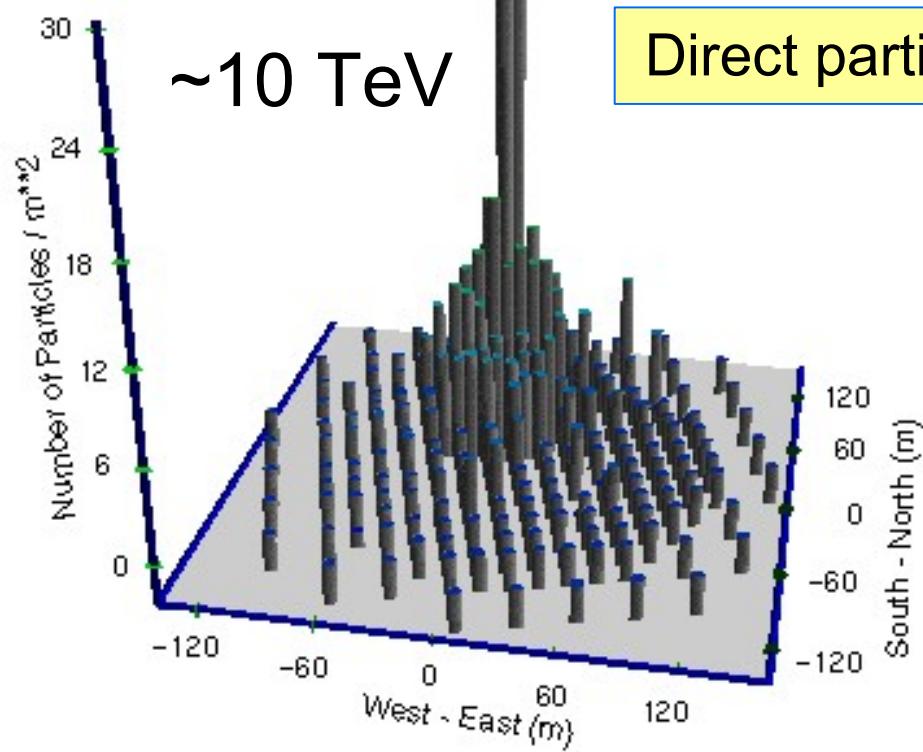
Tibet, 4300 m a.s.l.
0.5 m² x 789
TeV - 100 PeV
0.9° @3 TeV
2 sr (Northern Sky)



Air Shower Event Reconstruction

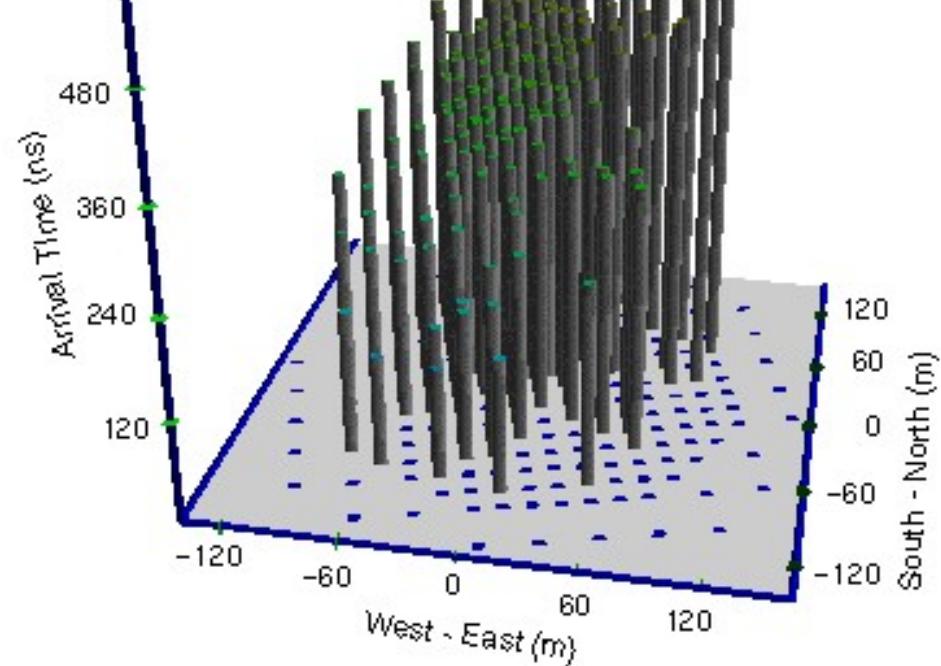
Secondary particle density

primary energy



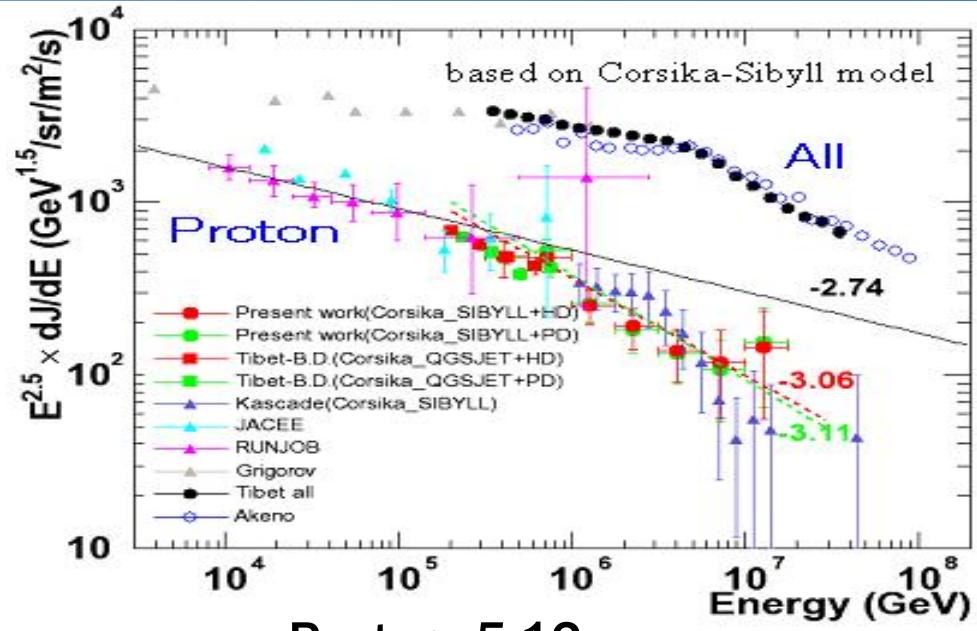
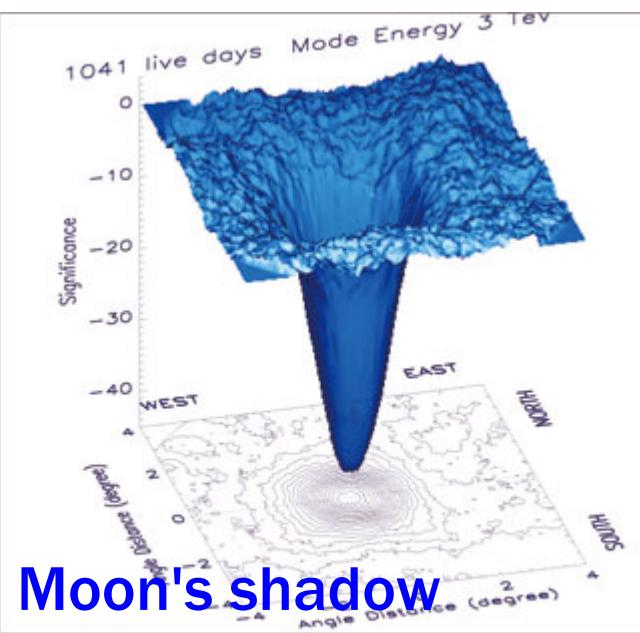
Secondary particle timing

primary direction



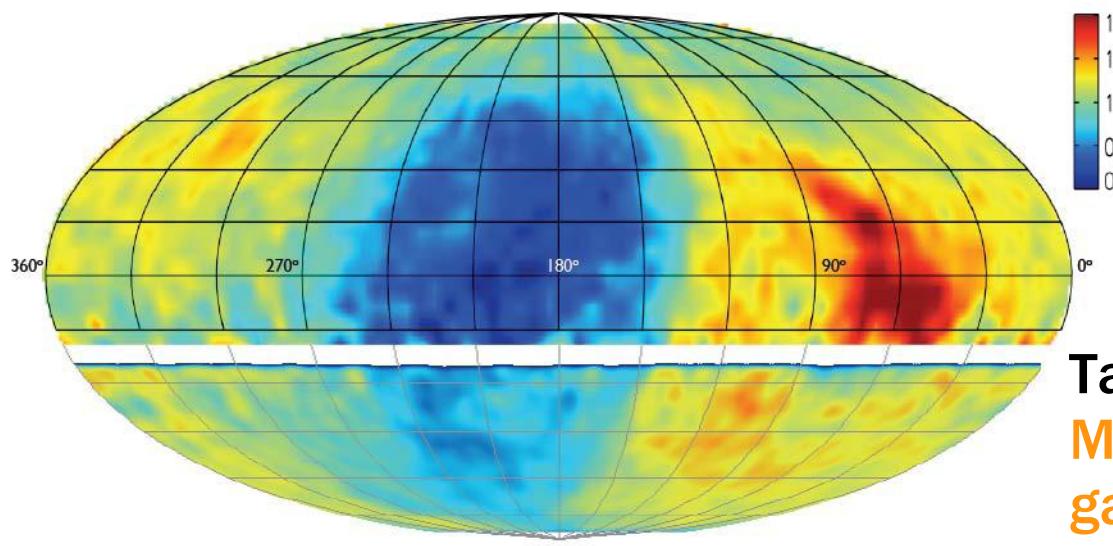
Wide field of view, regardless of day and night & weather.
No need to point the telescope at the star.

Poster Results of Tibet-III experiment



Poster : 5.12

Cosmic-ray energy spectrum
around the knee observed with
the Tibet air-shower experiment



JUST NOW!!

Talk : 1.16 (Today)
Modeling of the high-energy
galactic cosmic-ray anisotropy

Tibet-III Data

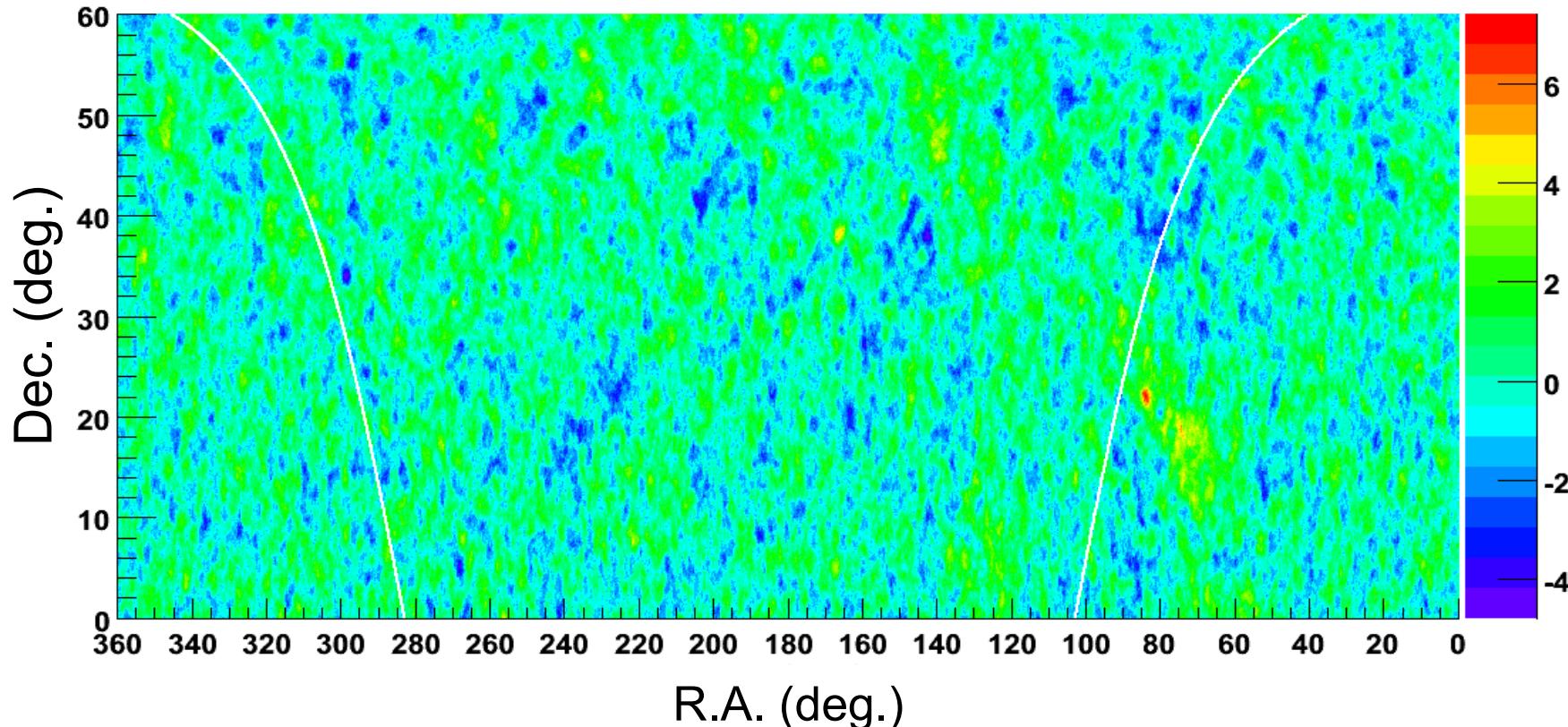
Period : Nov. 1999 – Dec. 2008 (live time : 1915.5 days)

F.O.V. : $0^\circ < \text{Declination} < 60^\circ$

Analysis : Equi-Zenith angle backgrounds

optimizing to point-like source

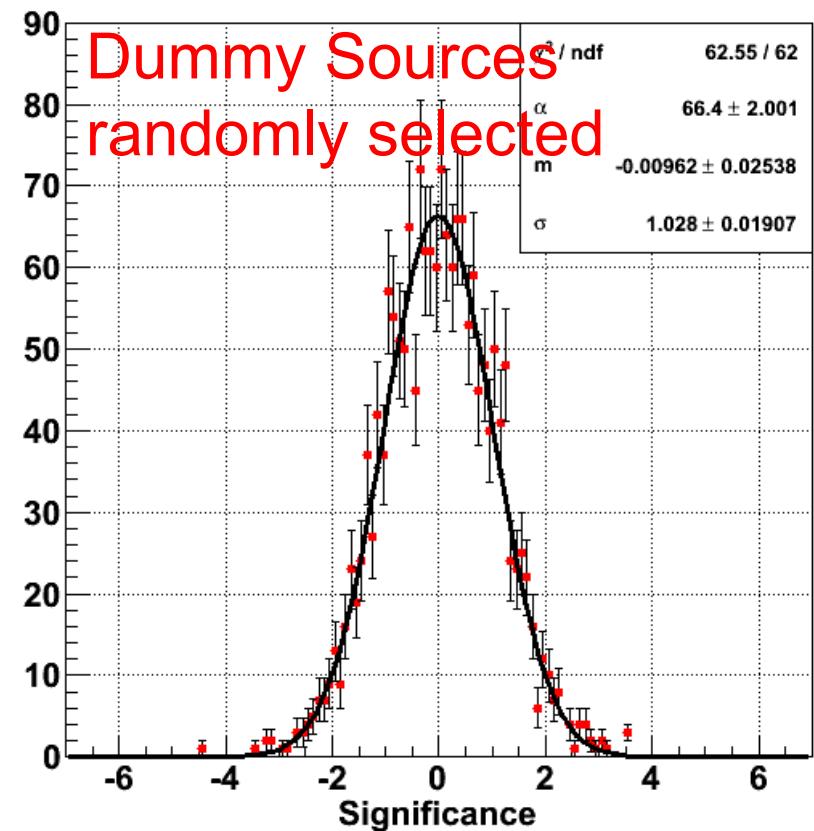
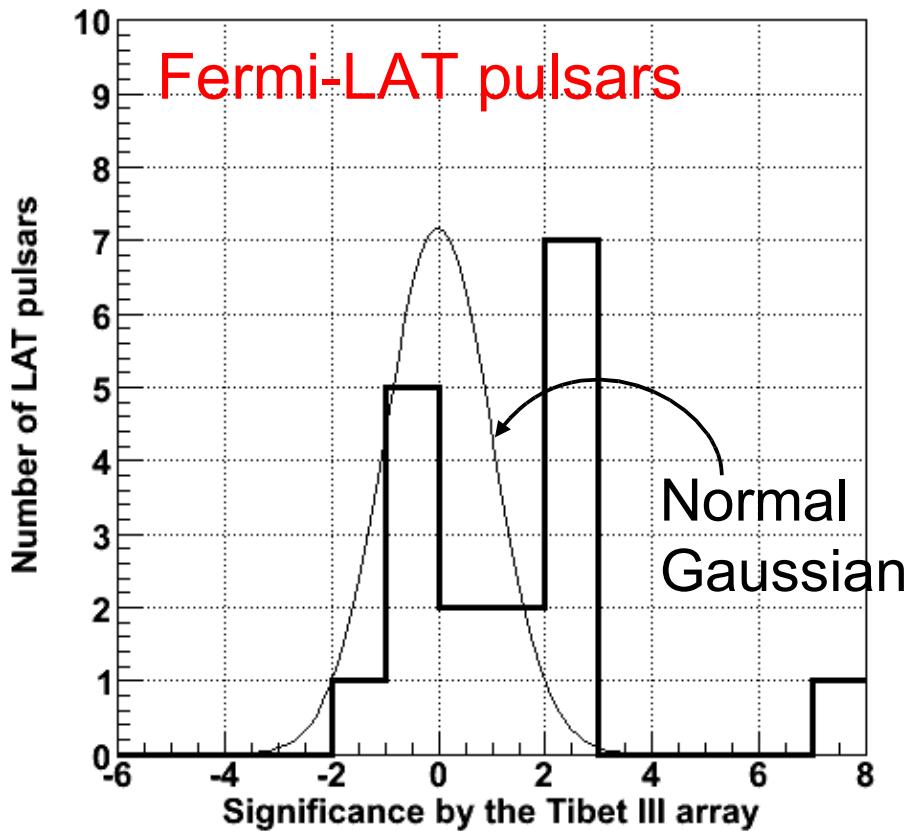
Energy : 3TeV ($20^\circ < \text{Dec.} < 40^\circ$), 6TeV(at Dec. = $0^\circ/60^\circ$)



18 LAT pulsars in Tibet-III F.O.V.

PSR	Period (ms)	Age (kyr)	LAT Discovery	Tibet-III (σ)
J0030+0451	4.9	7.7×10^6		1.6
J0218+4232	2.3	0.5×10^6		-0.2
J0357+32	444	590	✓	-1.2
J0534+2200	33.1	1		7.1 (Crab)
J0631+1036	288	44		-0.0
J0633+0632	297	59	✓	2.4
J0633+1746	237	340		2.3 (Geminga)
J0659+1414	385	110		0.7
J0751+1807	3.5	8.0×10^6		1.3
J1836+5925	173	1800	✓	-0.3
J1907+06	107	19	✓	2.6
J1952+3252	39.5	110		-0.2
J1958+2846	290	21	✓	0.1
J2021+3651	104	17		2.2
J2021+4026	265	77	✓	2.2
J2032+4127	143	120	✓	2.9
J2043+2740	96.1	1200		-0.1
J2238+59	163	26	✓	2.4

Tibet-III Results (~3TeV)



Chance probability

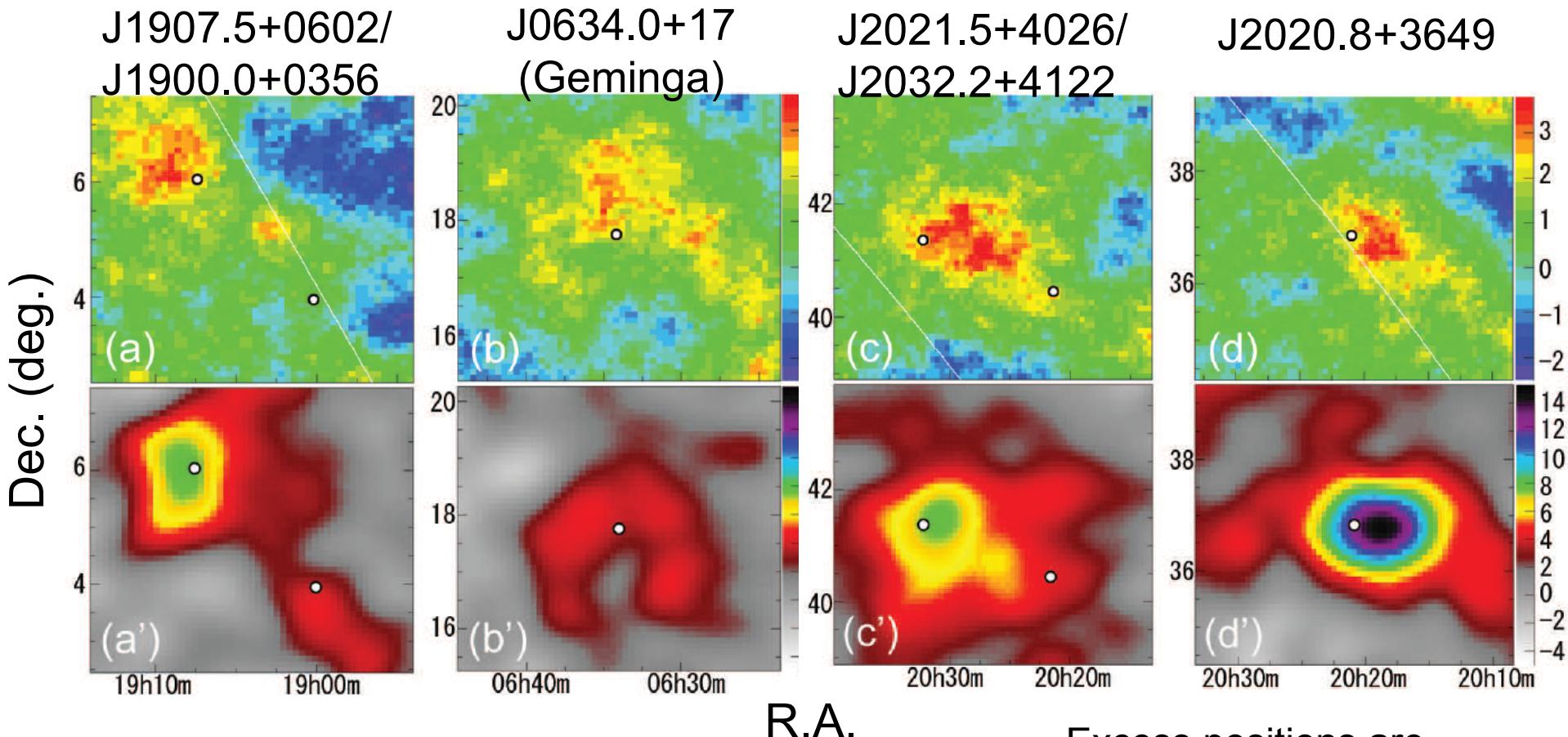
8 pulsars $>2\sigma$ in 18 LAT pulsars, expected = 0.41 (Poisson)

$\rightarrow 1.4 \times 10^{-8} = 5.6\sigma$ ($1.8 \times 10^{-7} = 5.0\sigma$ with Crab excluded)

Correlation between LAT pulsars and TeV excesses!

Significance Map around LAT pulsars

Upper: Tibet-III (~ 3 TeV)

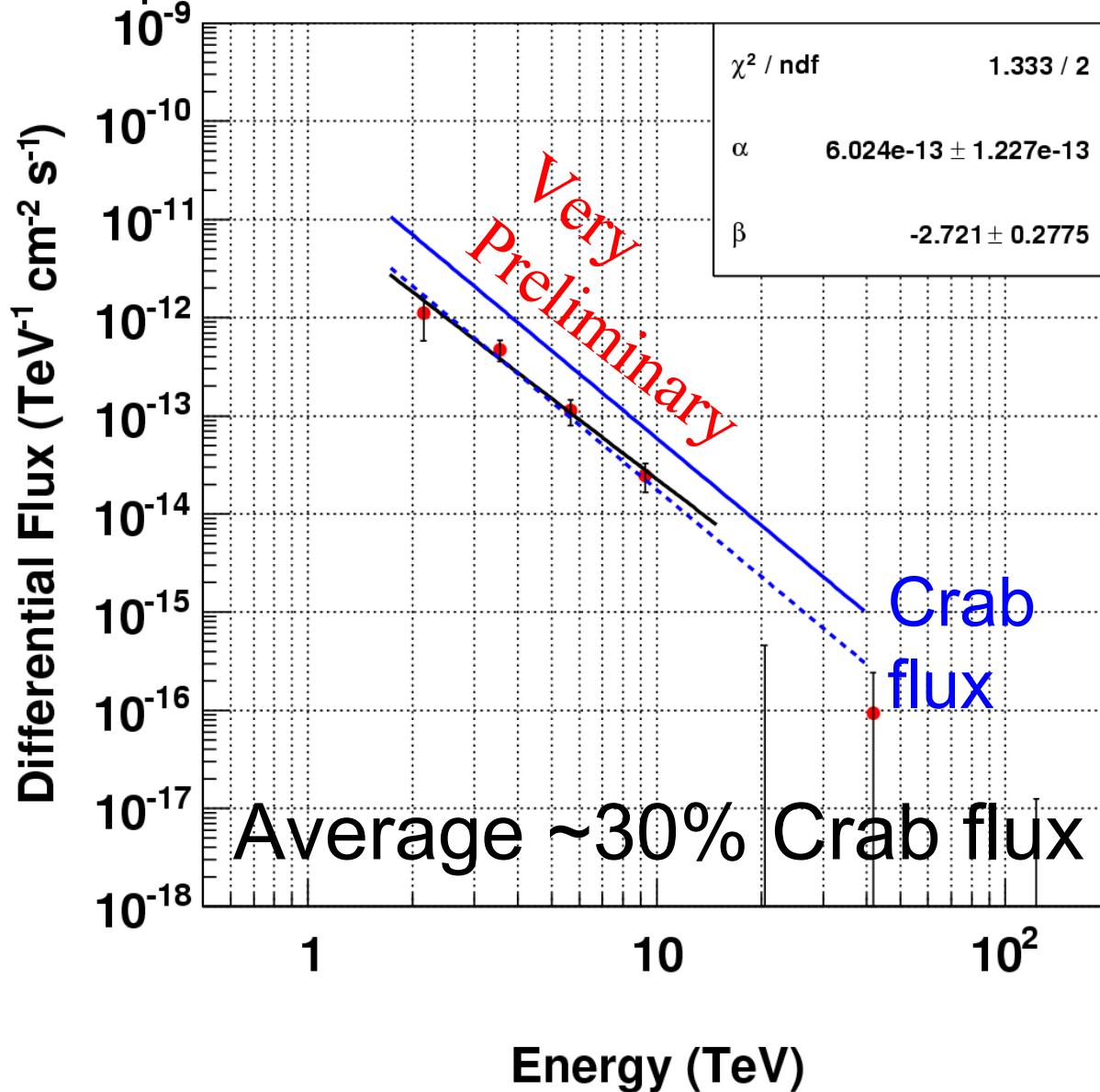


Lower: Milagro (~ 35 TeV)

Excess positions are
shifted from pulsars?
PWN?

Averaged Energy Spectrum (Crab excluded)

(summed up coincident sources between Tibet-III and Milagro)

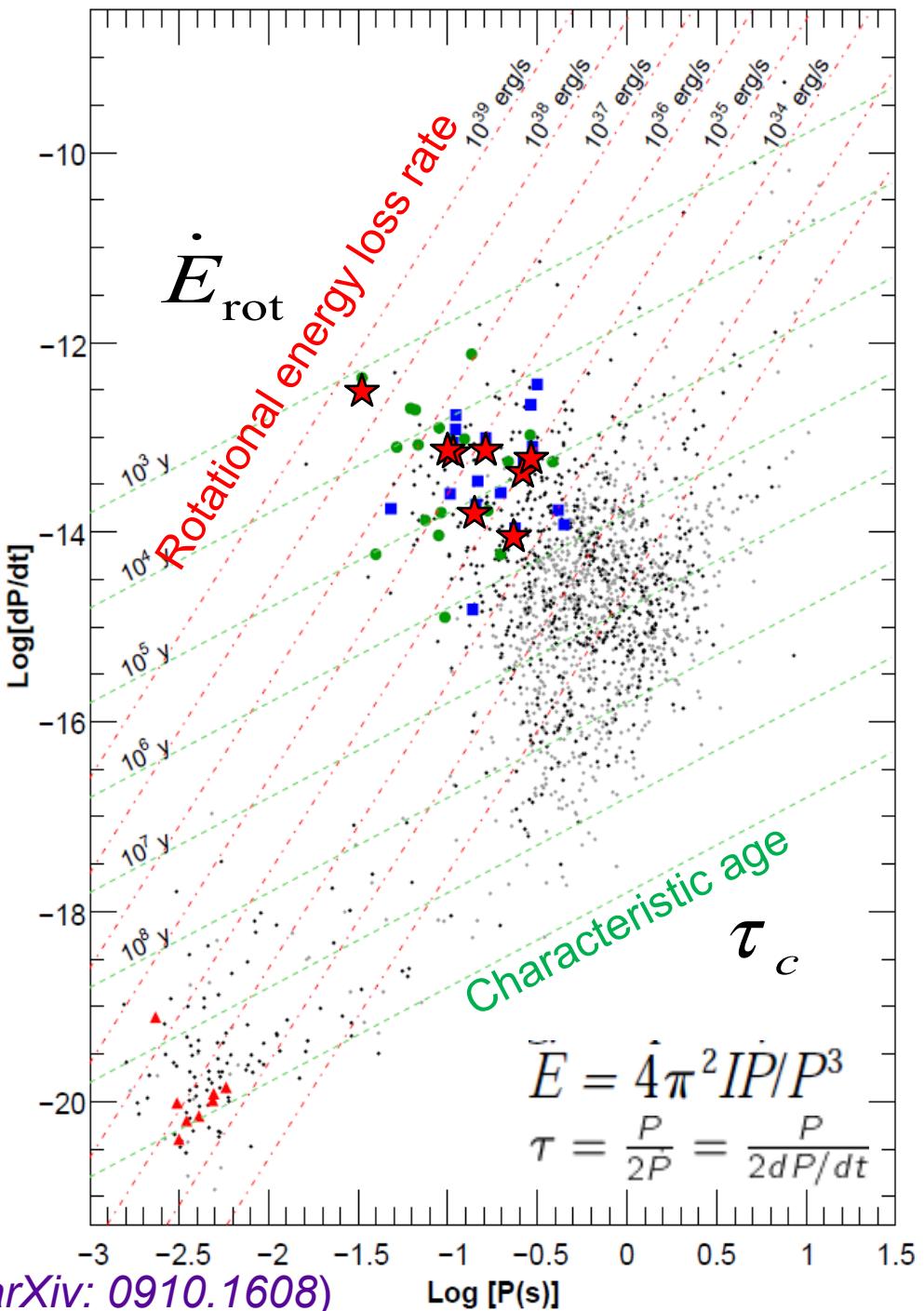


P-P Diagram

Colors : LAT pulsars

- Gamma-selected
- Radio-selected
- ▲ Milli second Pulsar
- ★ Tibet TeV Excess

High \dot{E}_{rot} → PWN?



Summary

See also : M.Amenomori, et al. 2010, ApJ, 709, L6

- We searched for steady TeV gamma rays from *Fermi*-LAT pulsars.
- We found 8 excesses at significance $>2\sigma$ out of 18 LAT pulsars in the Tibet-III F.O.V. This chance probability is $1.4 \times 10^{-8} = 5.6\sigma$ ($1.8 \times 10^{-7} = 5.0\sigma$ with excluded Crab). This clearly shows that the *Fermi*-LAT pulsars have correlations with TeV excesses.
- Seven of the 8 Tibet-III 2σ sources are associated with Milagro 3σ sources at 35 TeV.
- We are planning to add a 10,000m² water Cherenkov muon detector (Tibet MD). The Tibet MD will improve gamma-ray sensitivity by 1~2 orders of magnitude above 10 TeV.