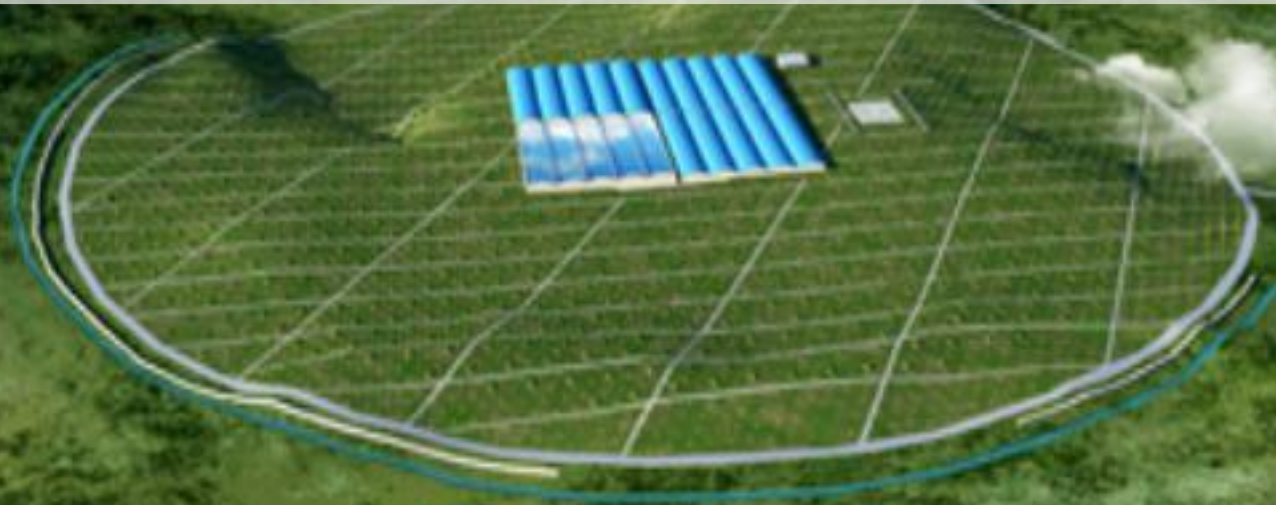


The LHAASO-KM2A detector array and physical expectations



Reporter: Sha Wu

Mentor: Huihai He and Songzhan Chen

Outline

- 1. Introduction
- 2. The KM2A Detector Array
- 3. Physical Expectations
 - 3.1 Sensitivity
 - 3.2 SNR
 - 3.3 Extended source Cygnus Cocoon
 - 3.4 Galactic plane diffuse gamma-ray
 - 3.5 Electron spectrum
 - 3.6 CME
- 4. Summary

1. High Energy Astrophysics

- Cosmic rays are energetic particles

Most of it: p^+ He^{2+}

Less than 1%: gamma and neutrino

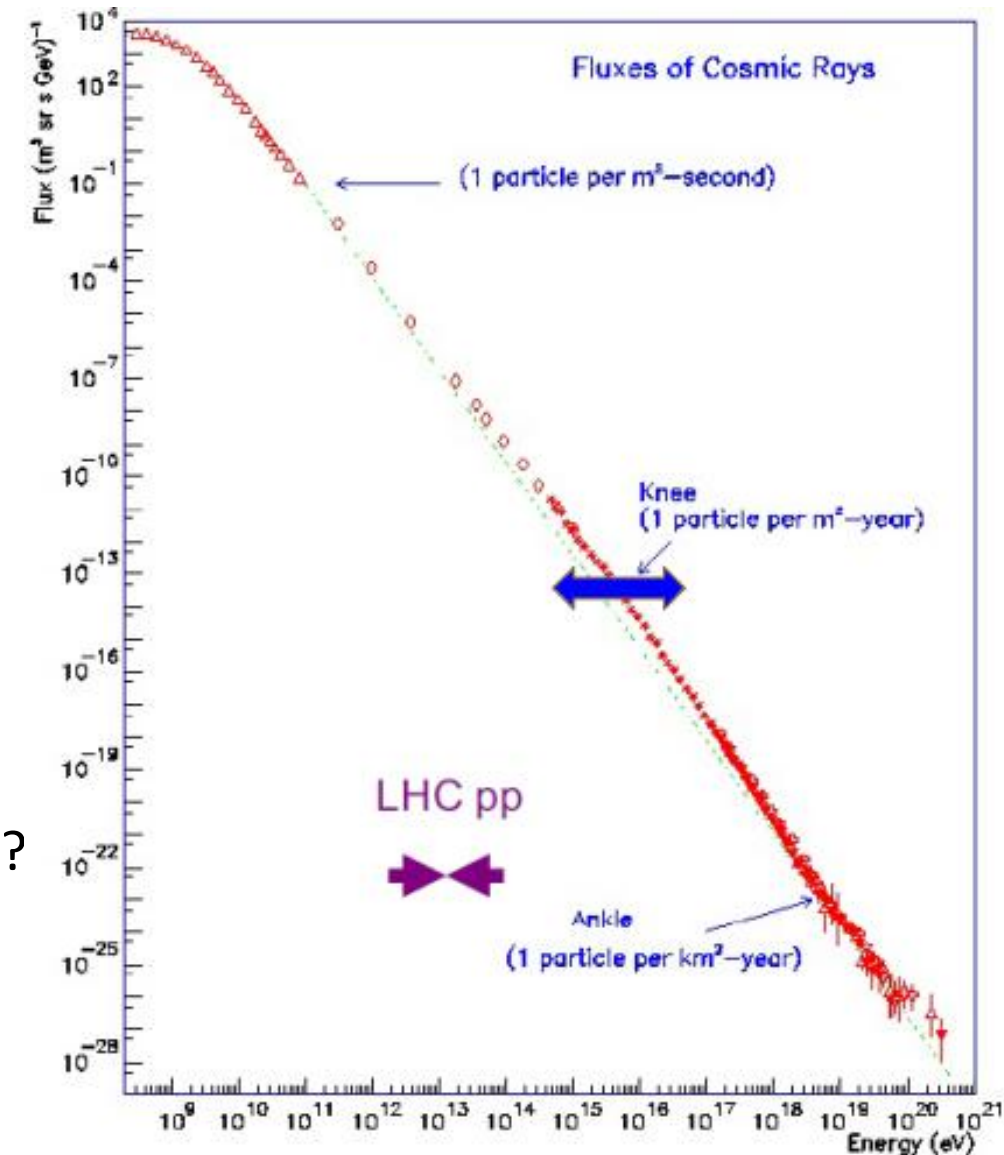
- What do we want to know?

What astrophysical sources accelerate particles?

How do astrophysical sources accelerate particles?

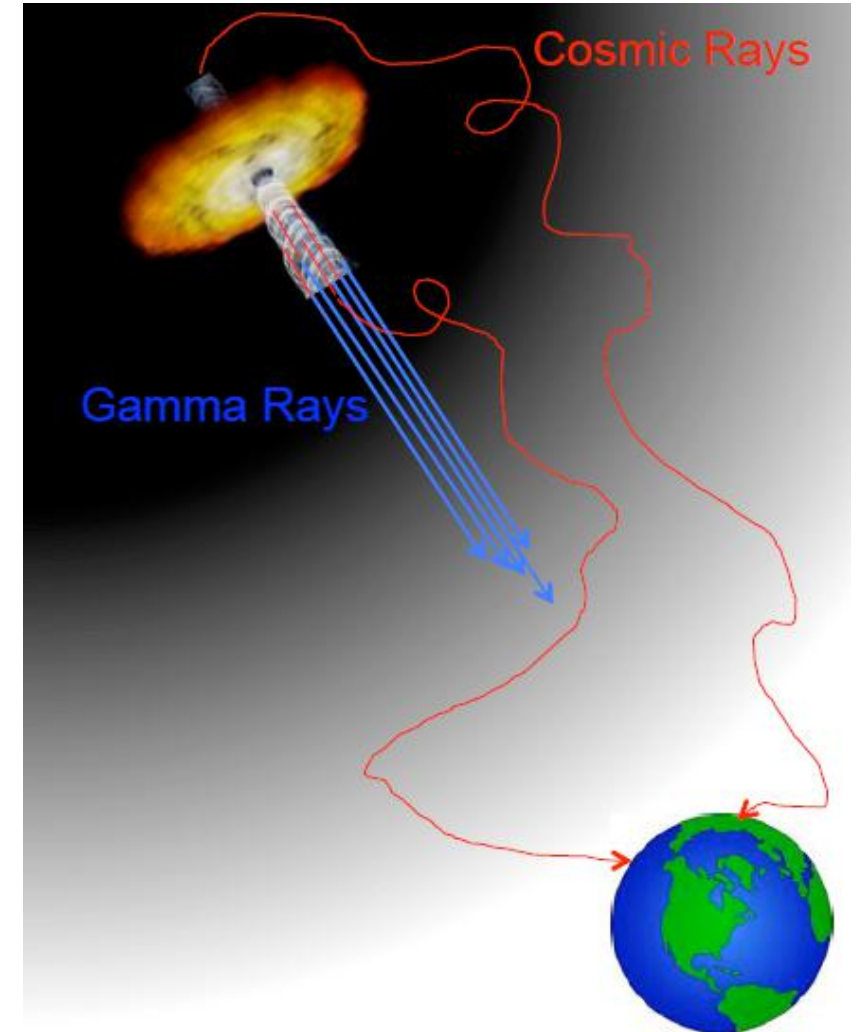
Why the Energy spectrum following a power law distribution?

.....



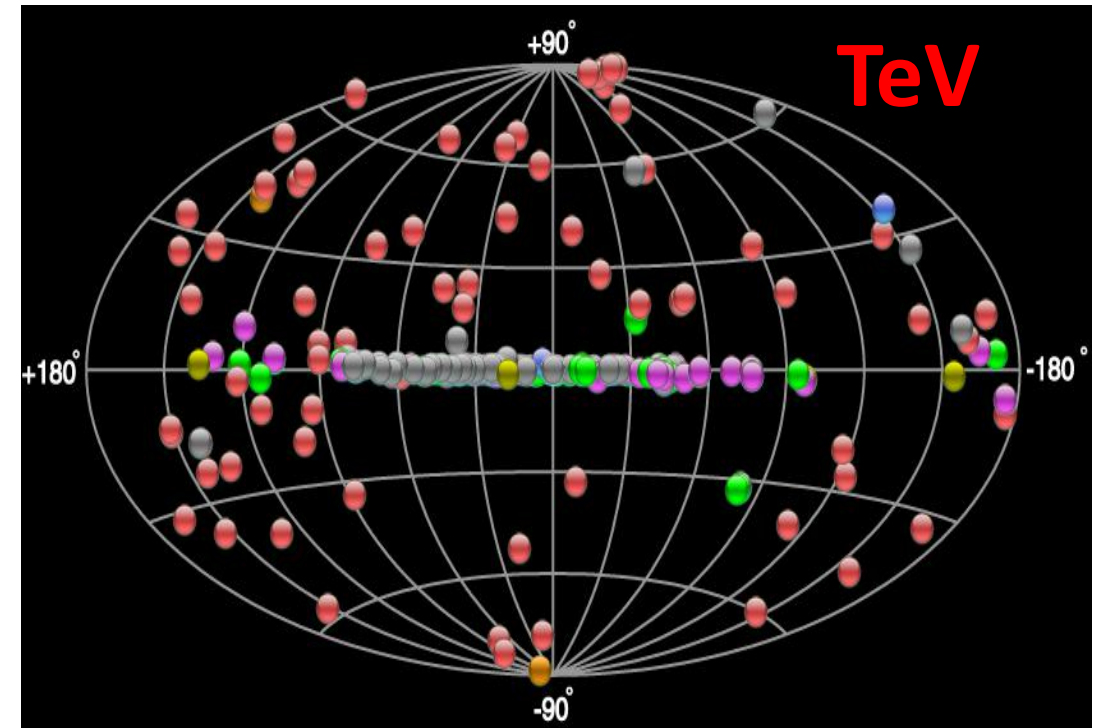
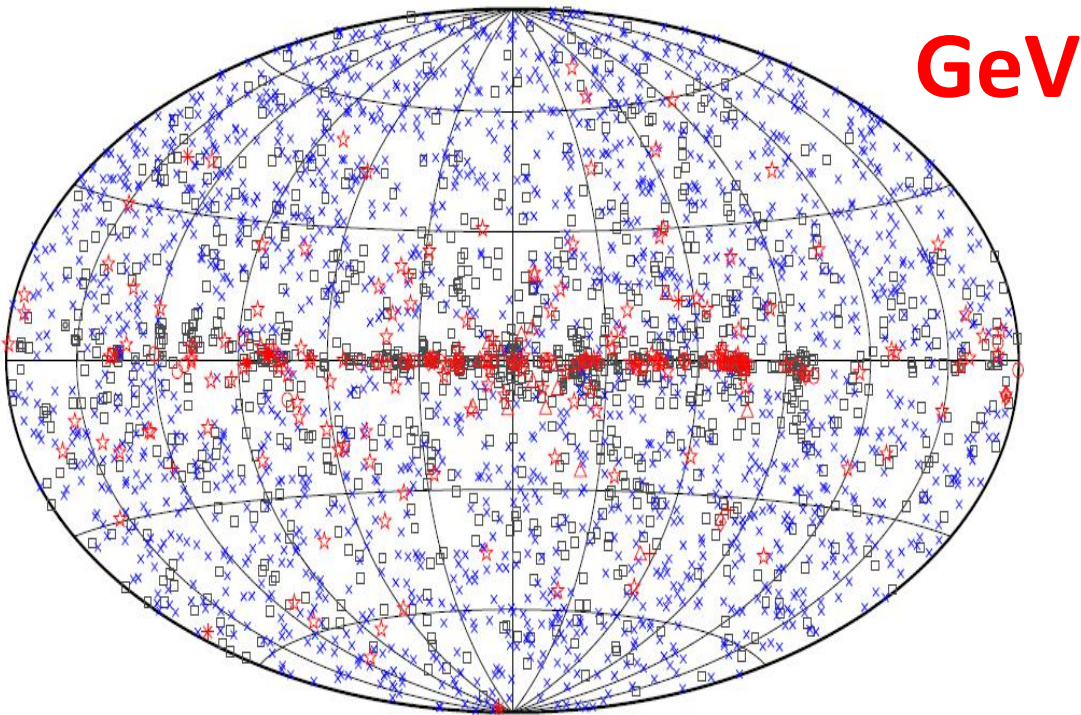
Gamma ray astronomy

- Cosmic rays' Directions are randomized by Magnetic Fields in the Universe
- Gamma rays are produced by cosmic rays near their accelerators
- Therefore, gamma rays are important probe of cosmic rays and their accelerators



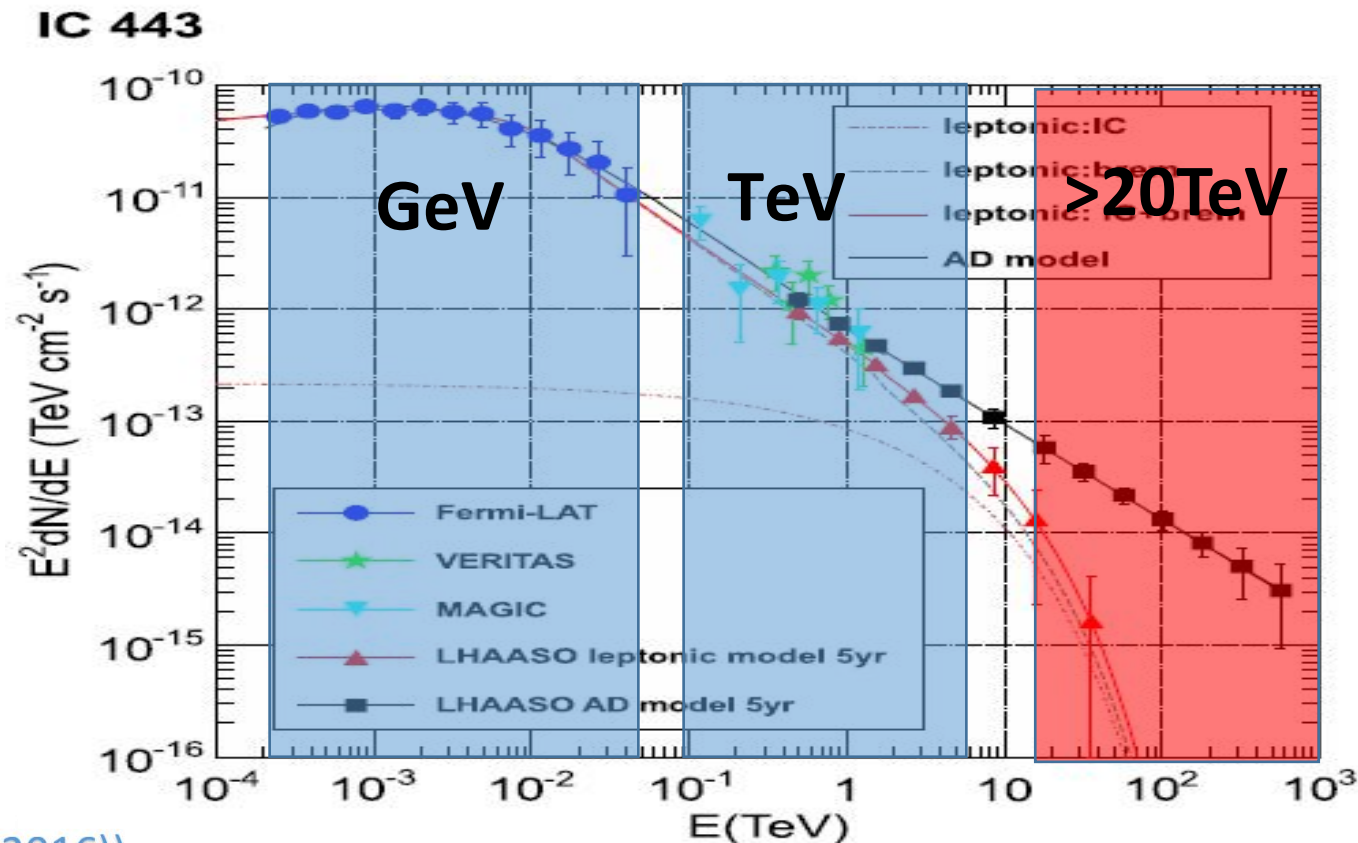
Gamma ray astronomy

Up to now, Fermi-LAT discovered over 3000 sources in GeV energies.
In TeV energies, more than 160 γ -ray sources have been firmly detected by the ground-based detectors.



Gamma ray astronomy

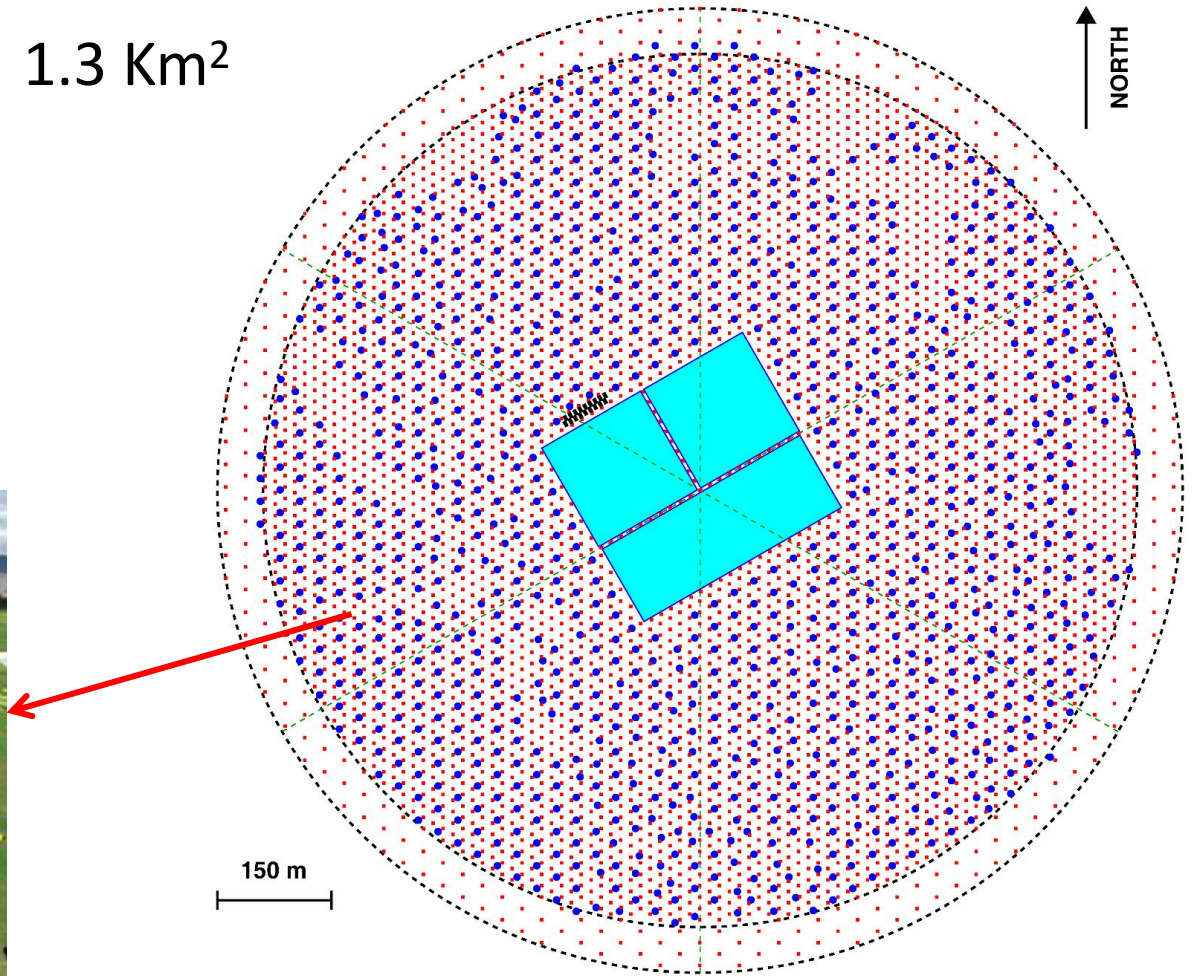
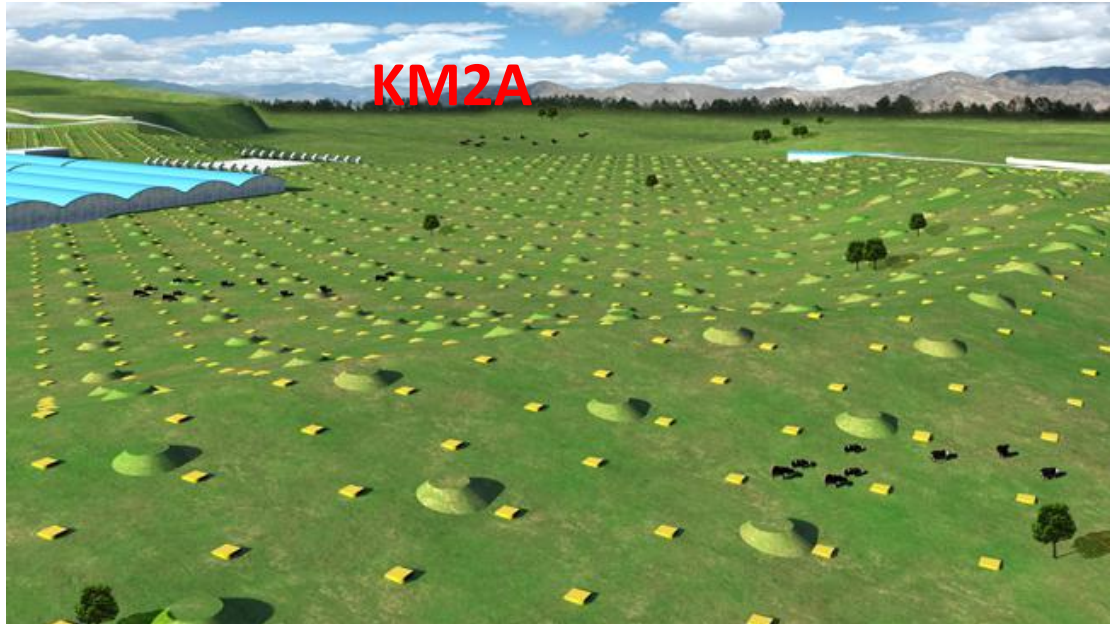
- The observations of very high energy (e.g., >100 TeV) γ -ray emission from SNRs will provide a complimentary test of the leptonic/hadronic origin of the γ -rays.



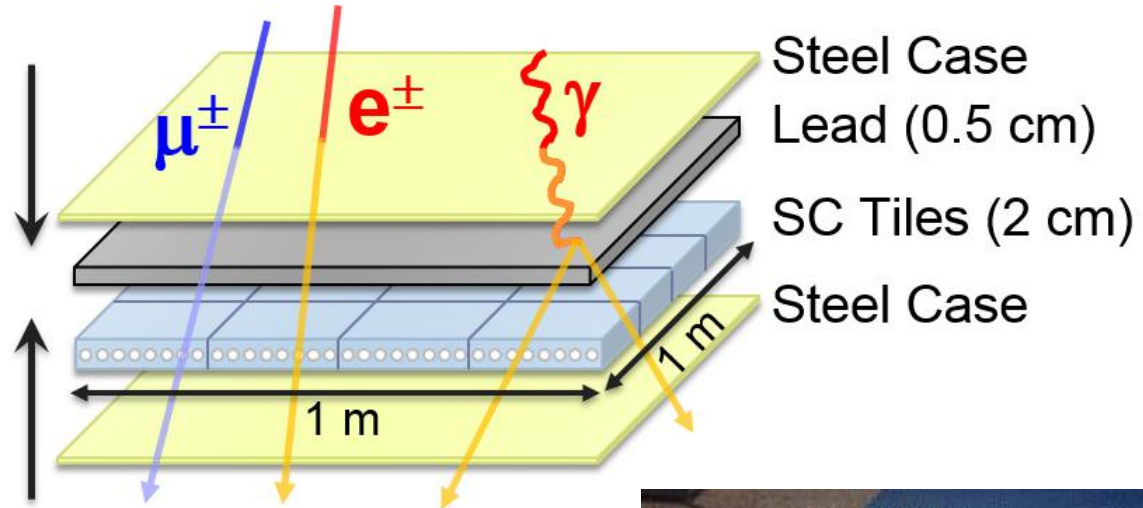
Leptonic?
Hadronic?

2. LHAASO-KM2A Detector Array

- Surrounding WCDA, KM2A cover an area of 1.3 Km^2
- 5246 EDs, 1 m^2 each, 15m spacing
- 1146 MDs, 36 m^2 each, 30m spacing



Electromagnetic Particle Detector

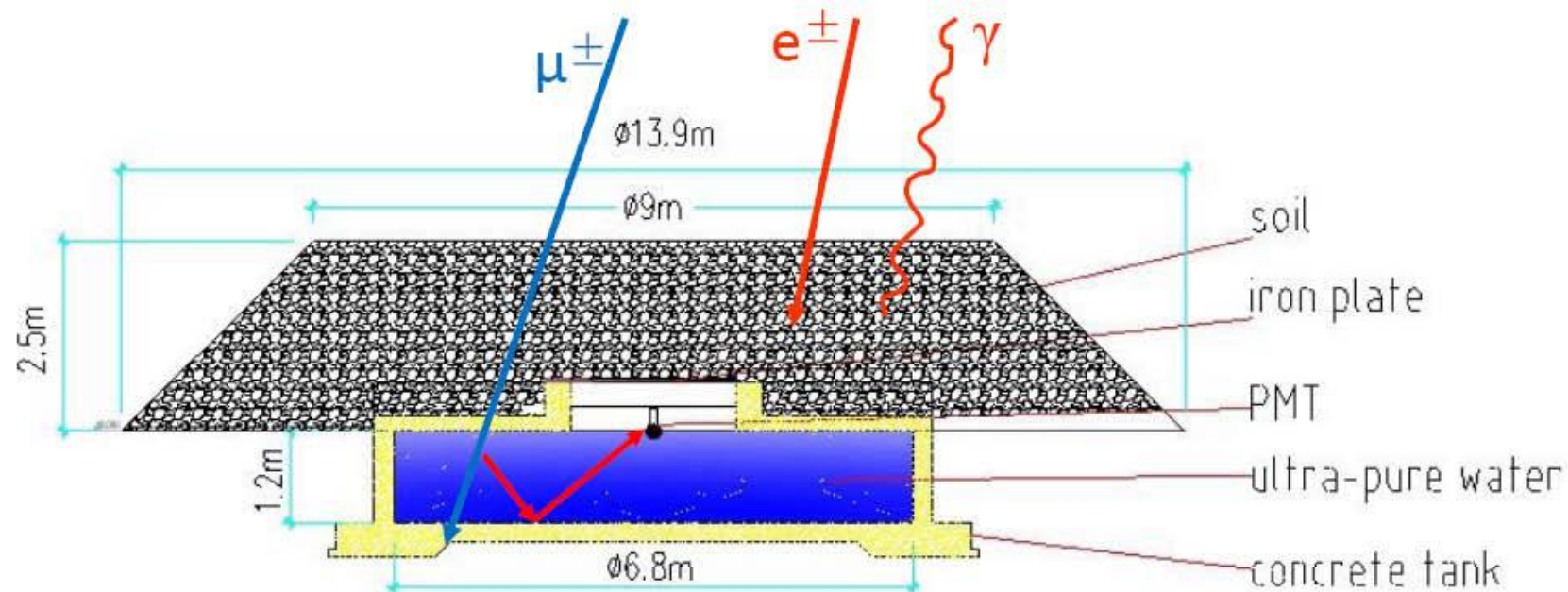


- **Uniformity for 5195 units: < 10%**
- **Stability with $\pm 25^\circ\text{C}$: $\pm 5\%$**



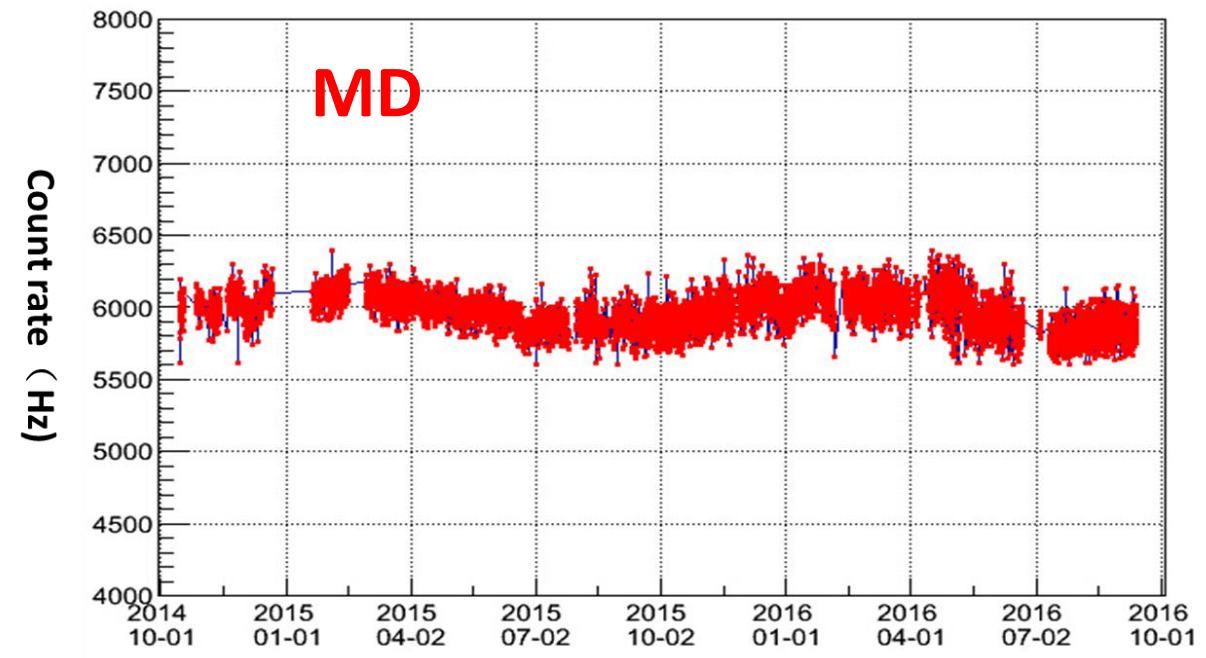
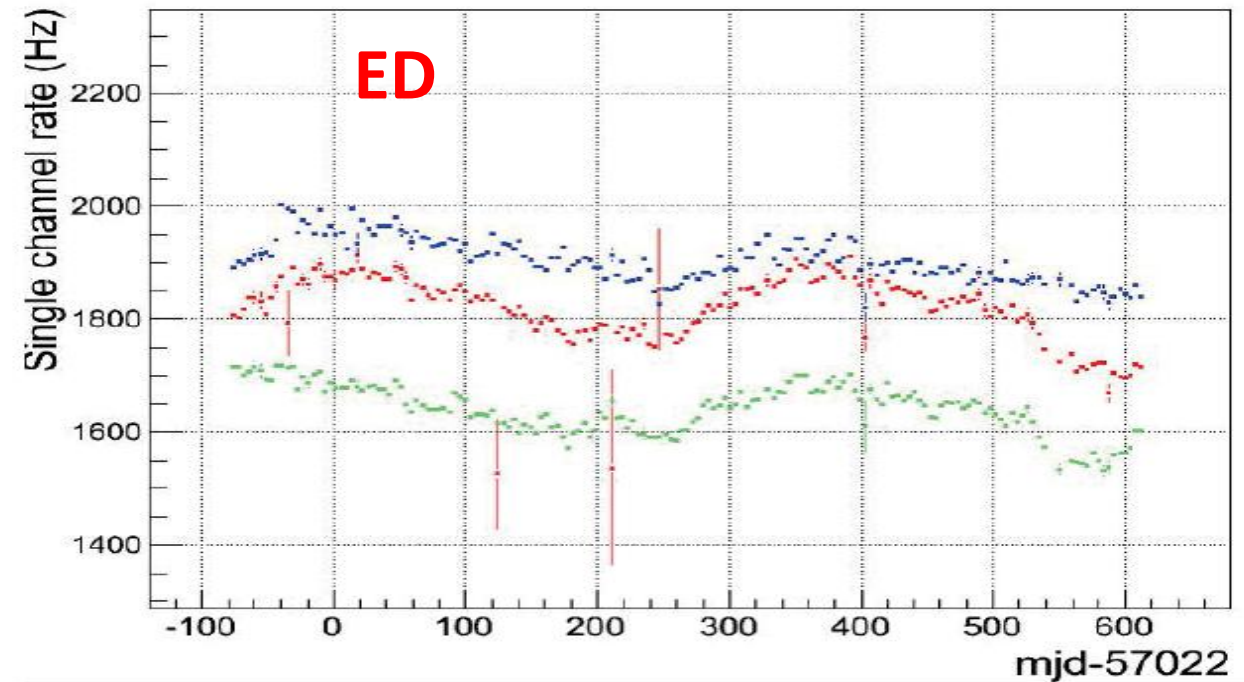
Muon Detector

Water Cherenkov detector underneath soil



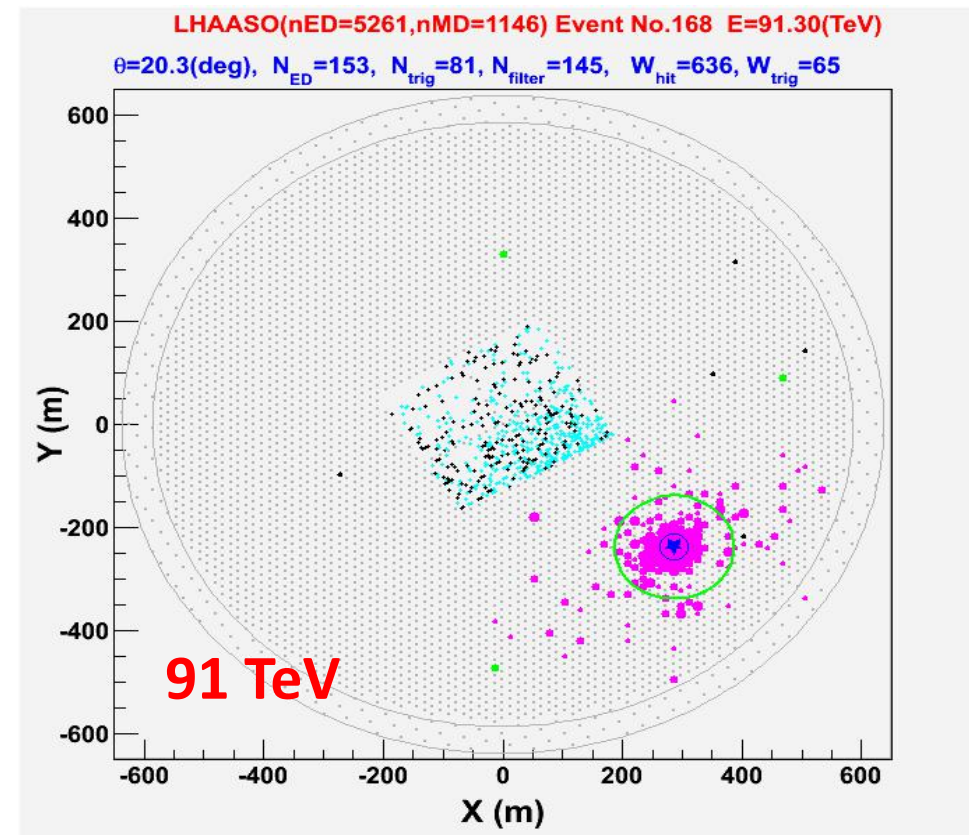
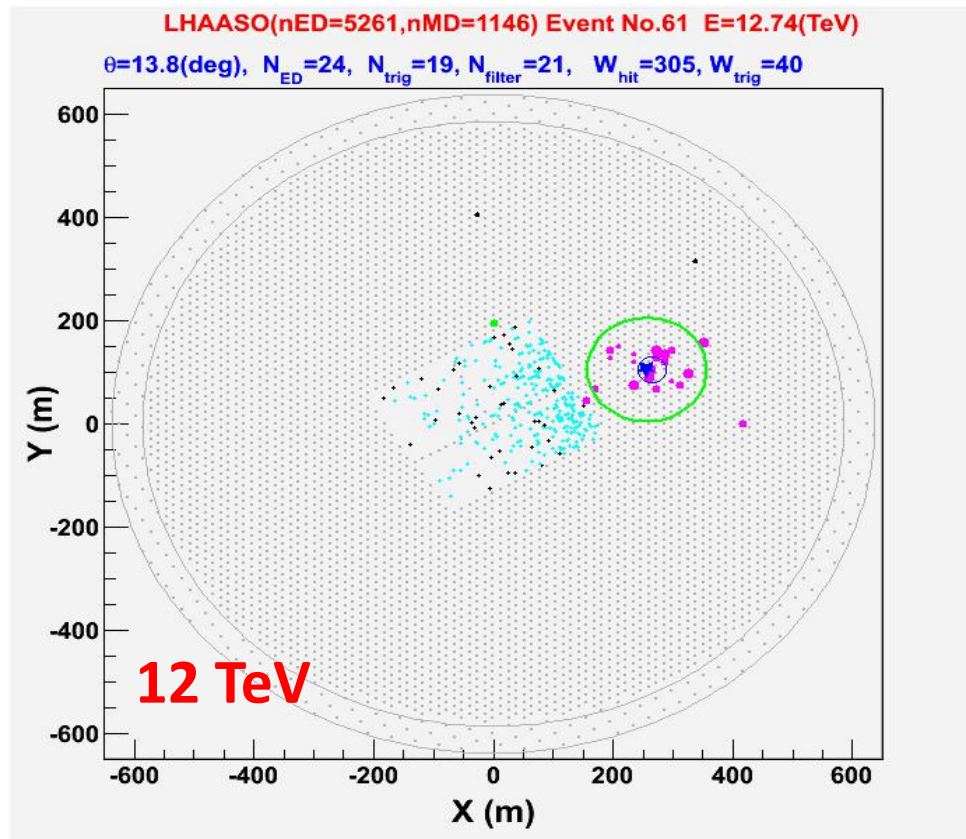
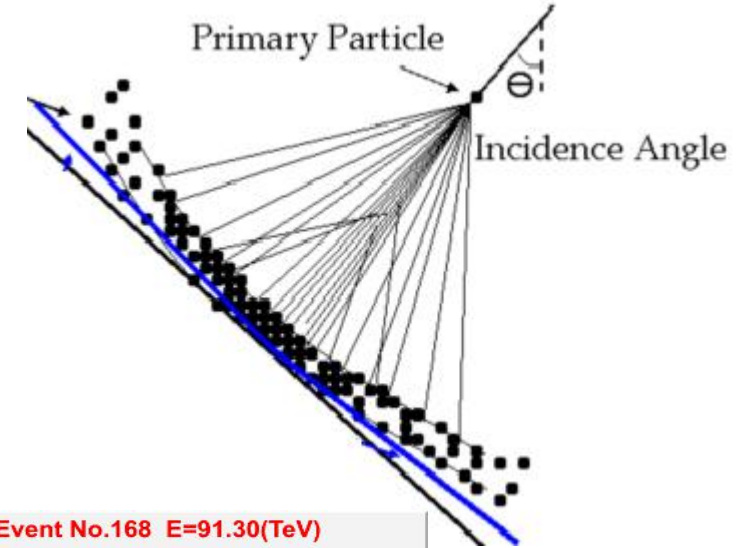
Engineer Array @YBJ

- ~1% of LHAASO-KM2A
 - 42 EDs, 2 MDs.
- Has been in operation for more than 2 years.



Study of KM2A Trigger Mode

- Both the **Time** and **Space** window are used for Trigger.



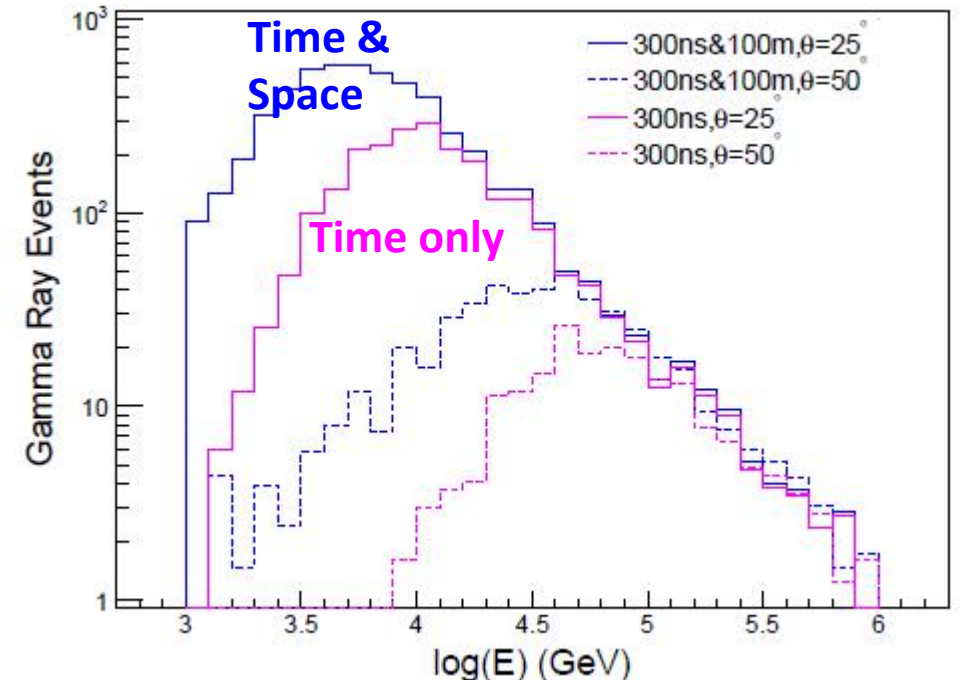
Study of KM2A Trigger Mode

- The estimated trigger rate is around 6.3 kHz
- The threshold energy is about 3.2 TeV ($\theta=25^\circ$) and 32 TeV ($\theta=50^\circ$)

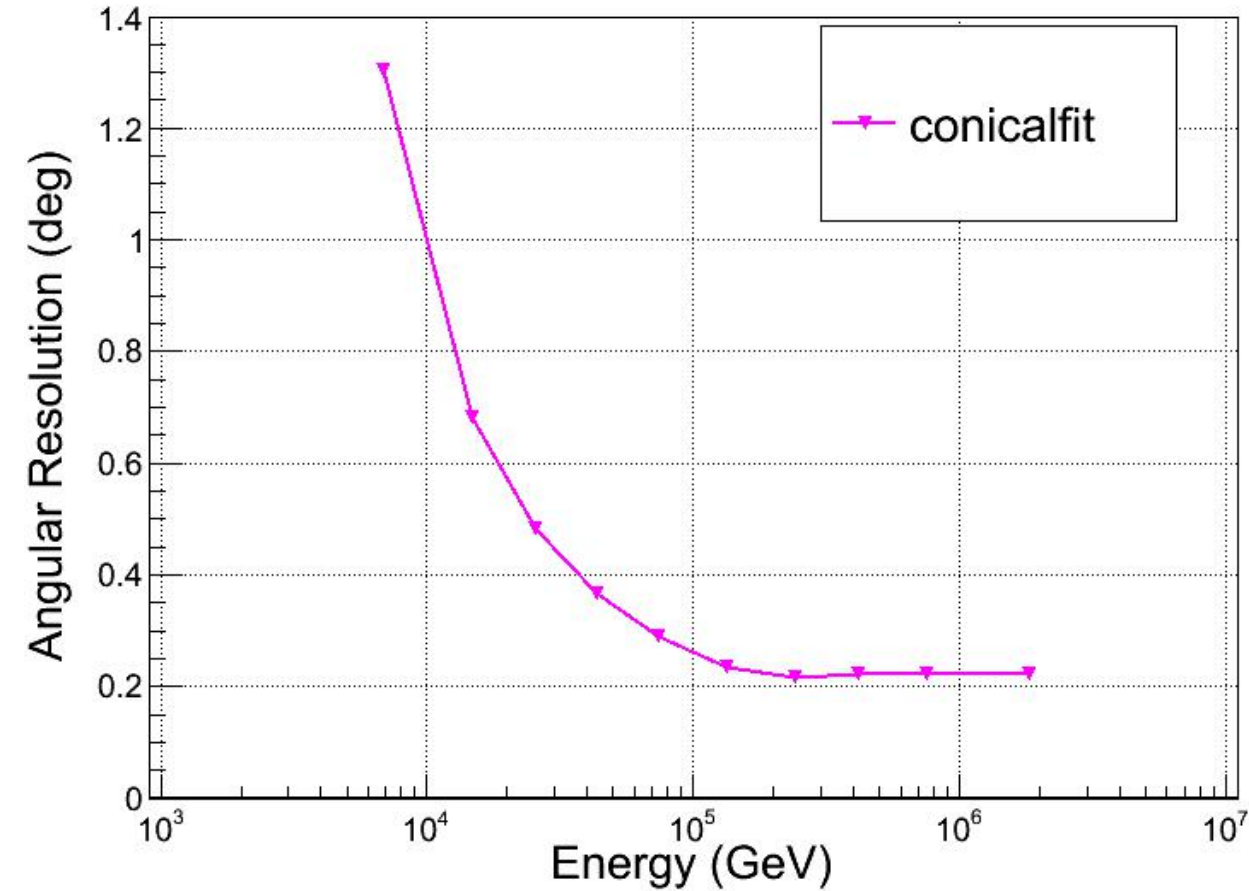
Group	Rate (Hz) for $T_{wind}=300\text{ns}, R_{wind}=100\text{m}$	Rate (Hz) for $T_{wind}=300\text{ns}$
P	3813 ± 9.61	1500 ± 4.45
He	1826 ± 5.02	878 ± 2.89
CNO	353 ± 1.16	194 ± 0.77
MgAlSi	118 ± 0.41	69 ± 0.28
Fe	150 ± 0.58	97 ± 0.47
Total	6260 ± 30	2738 ± 30

Time & Space

Time only

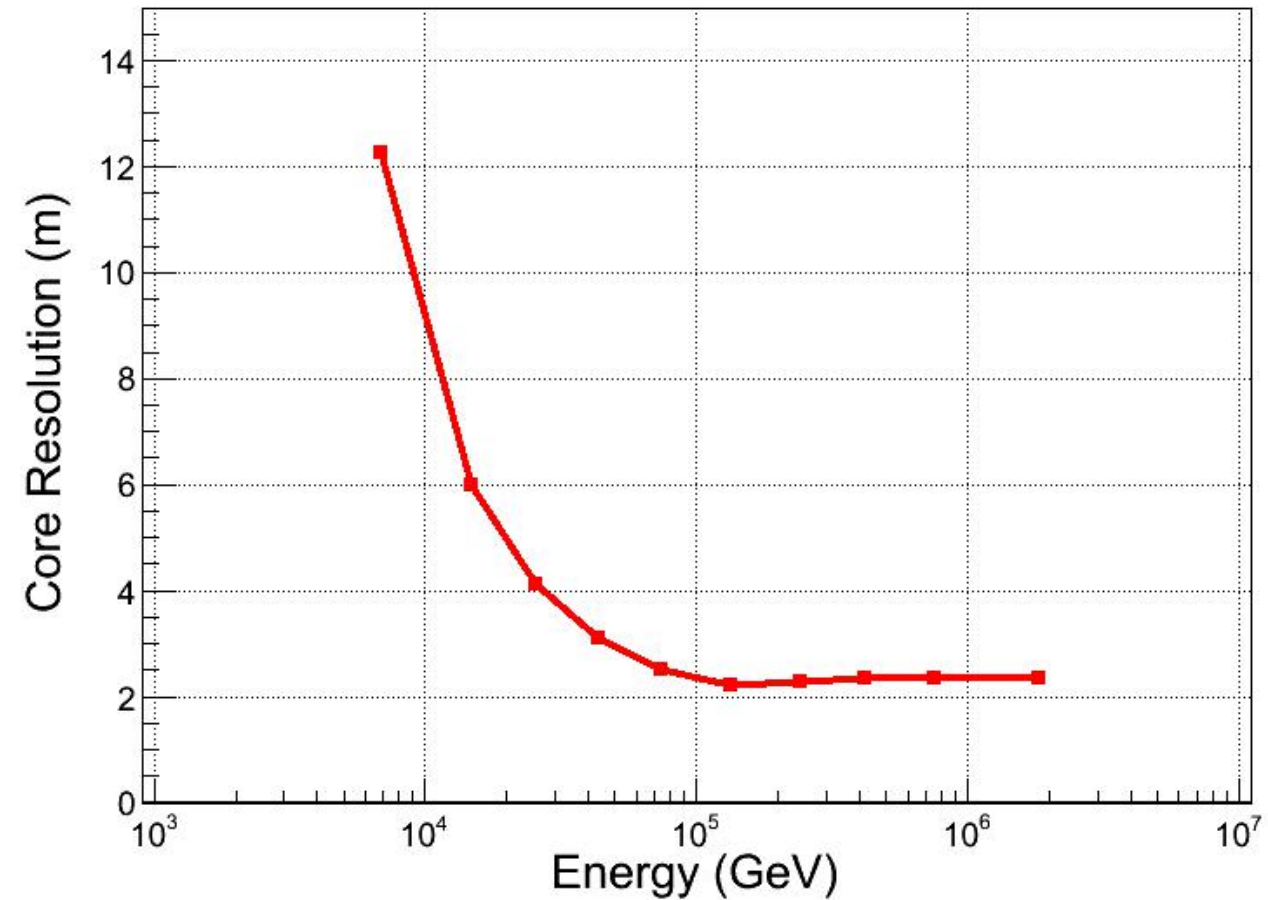


KM2A Events Reconstruction



~1°@10TeV

~0.2°@100TeV

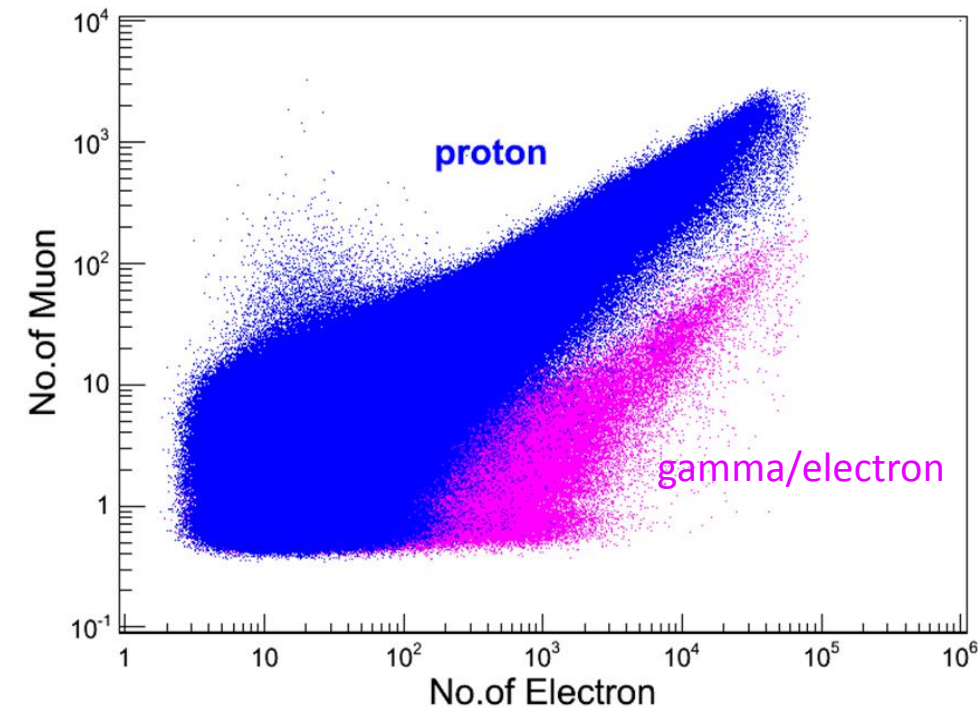
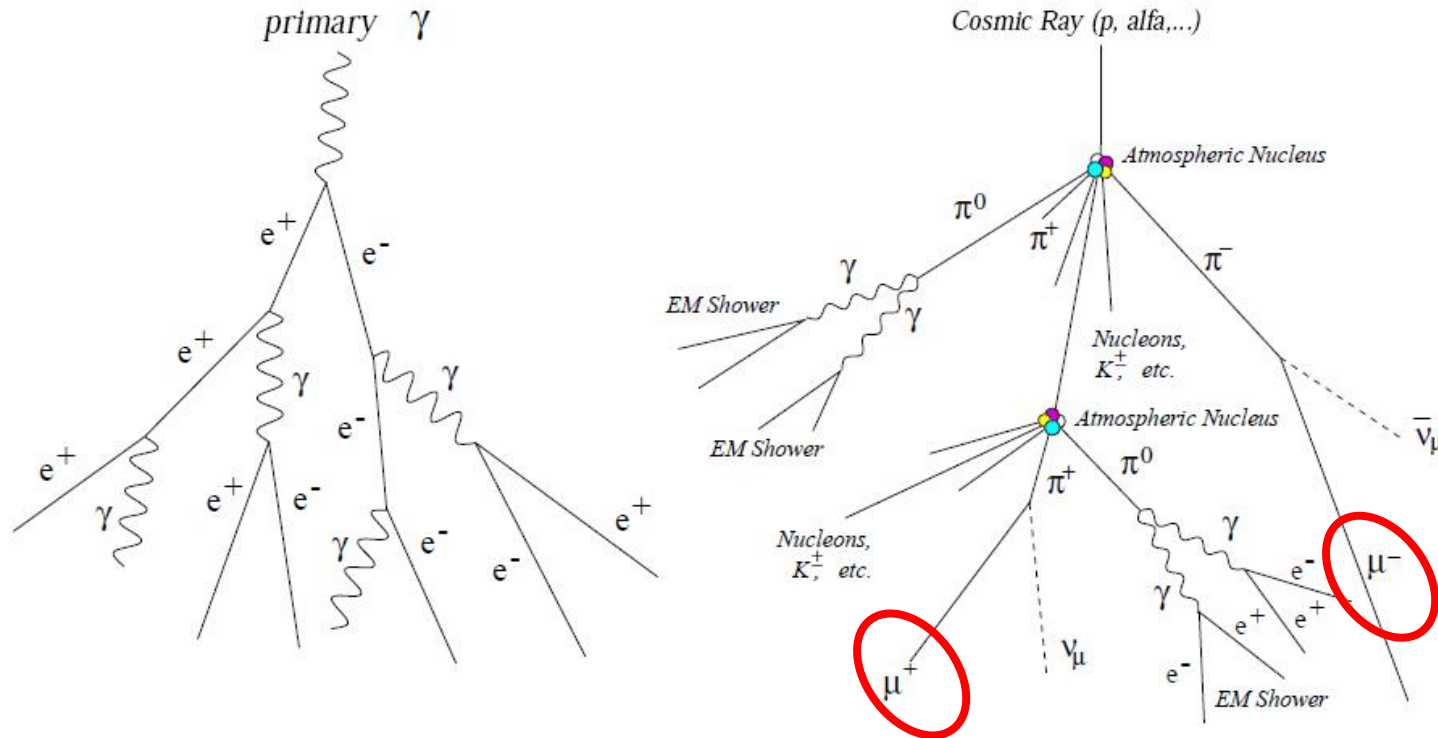


~9m@10TeV

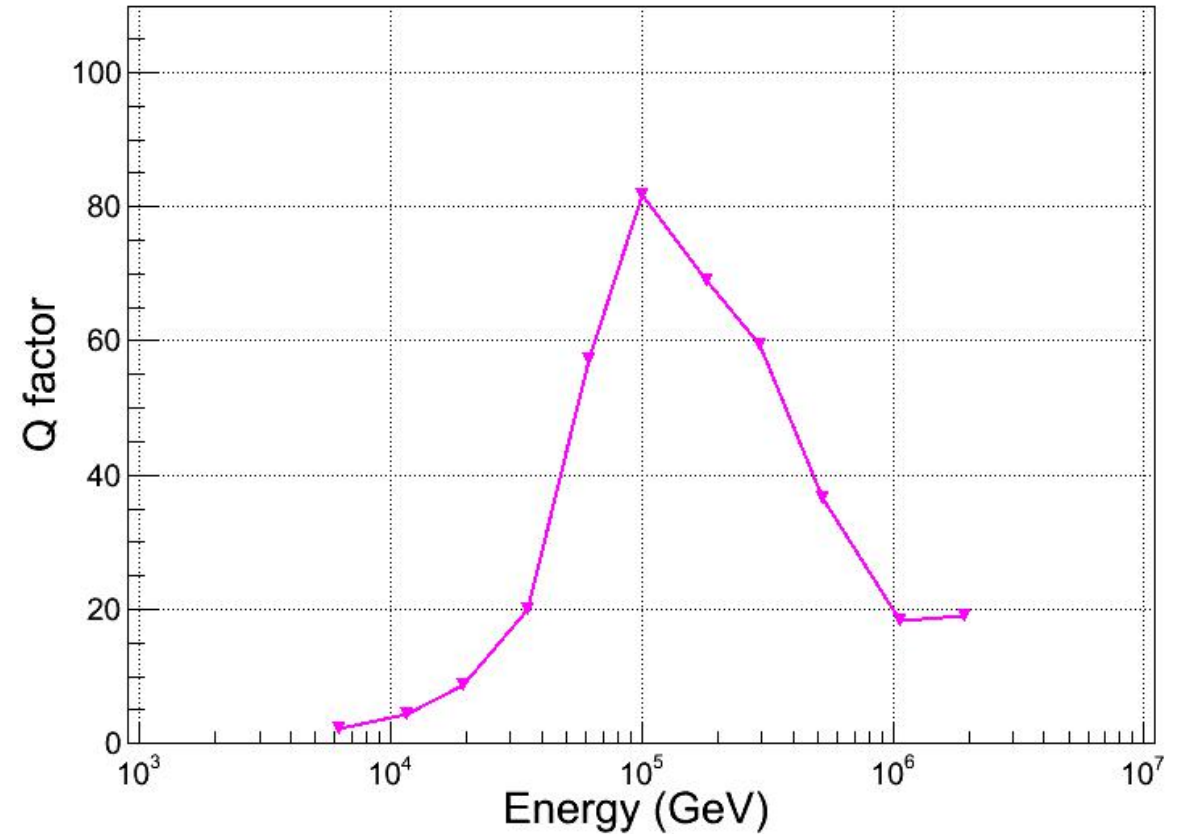
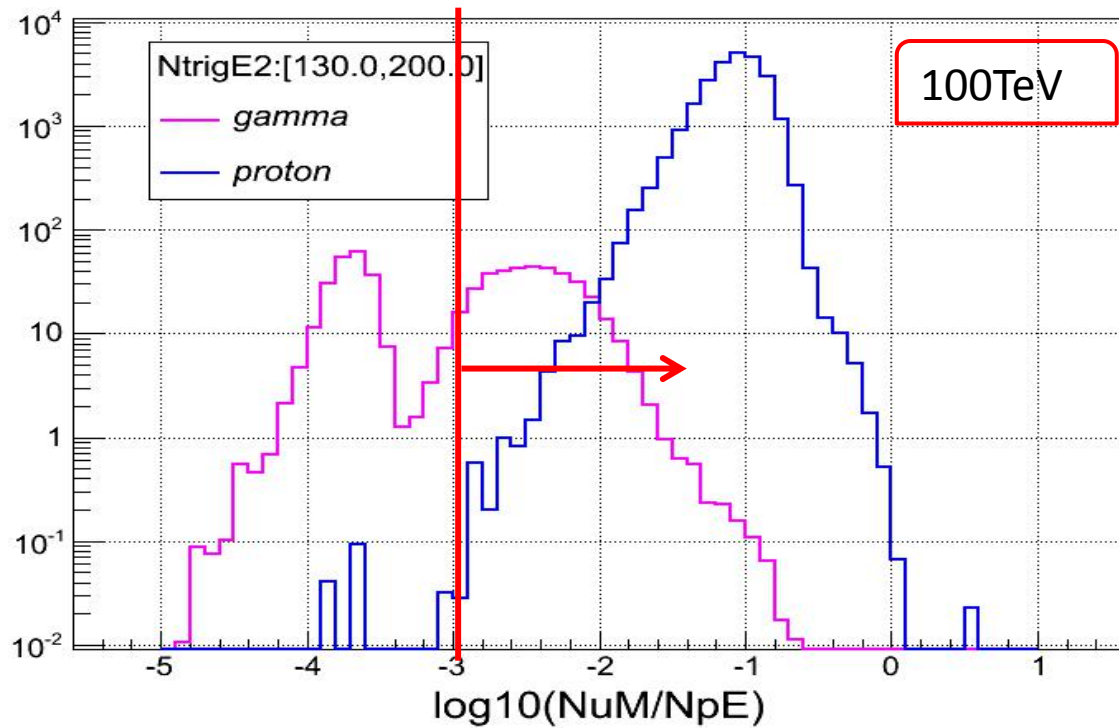
~2.5m@100TeV

Background rejection in KM2A

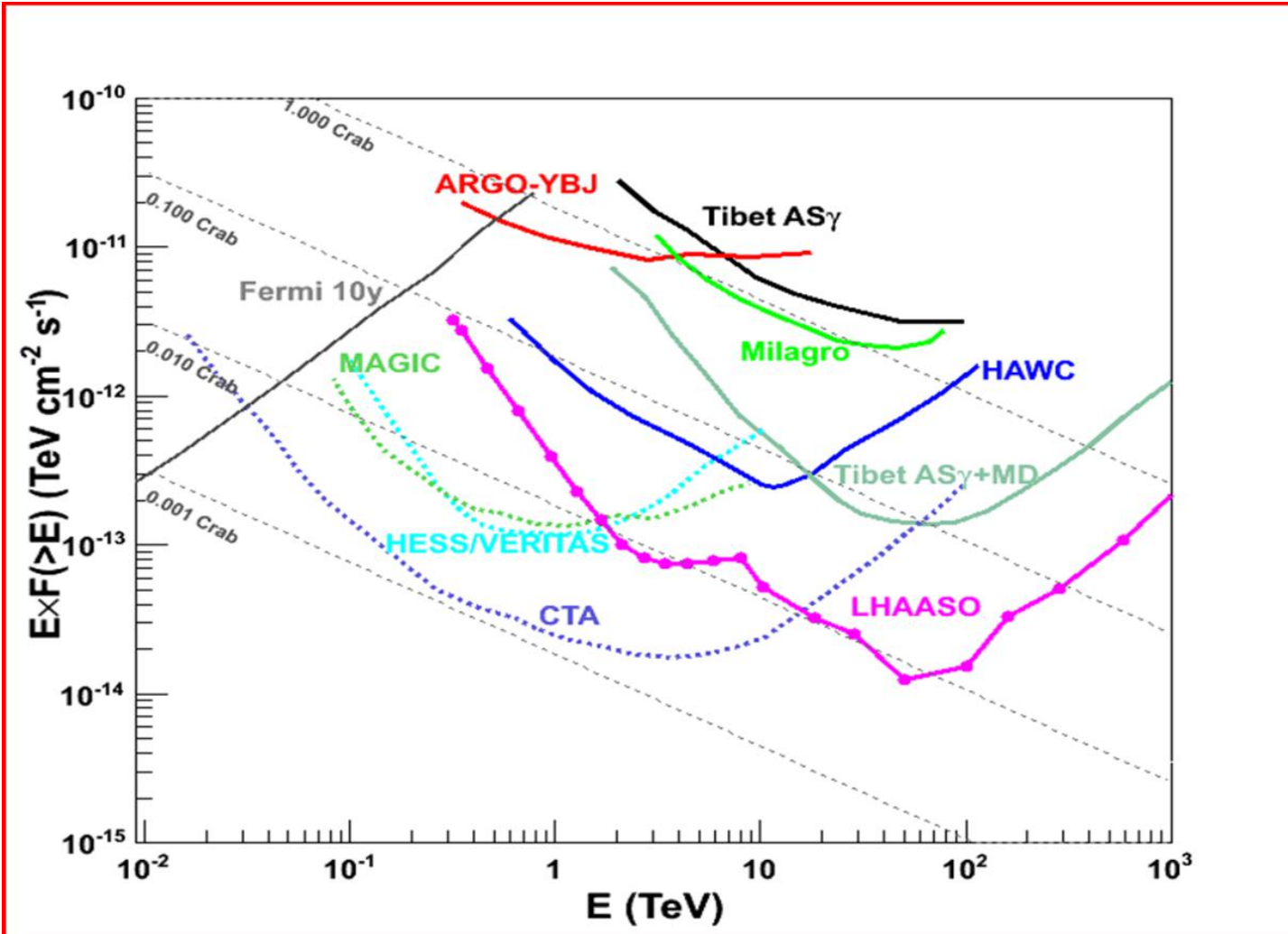
After the EAS process, Hadronic showers contain more Muon than electromagnetic showers



KM2A Background rejection

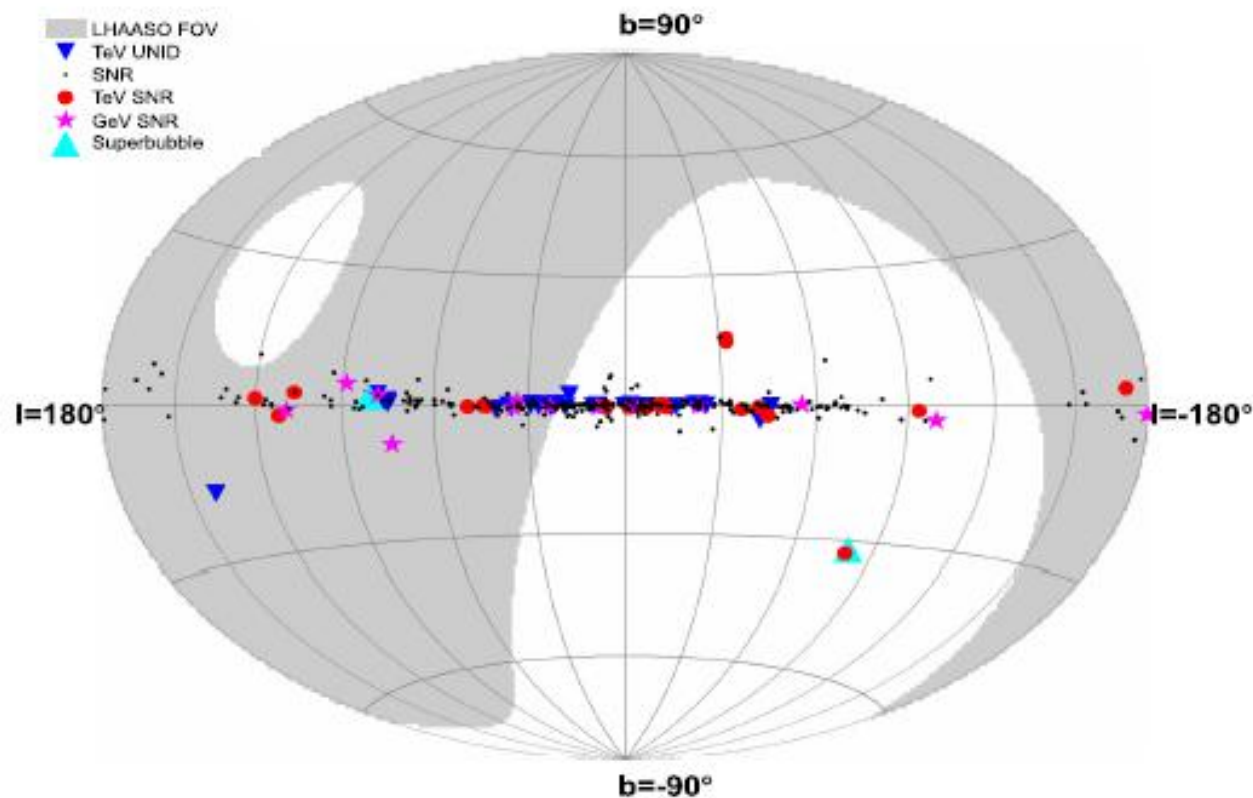


3.1 Crab sensitivity



The LHAASO sensitivity is sufficient to find new gamma ray source in to 100 TeV

3.2 SNR in LHAASO Sky Map



radio-TeV SNRs: 294, LHAASO can see 107

TeV UNID: 34, LHAASO can see 17

Supperbubble: 2, LHAASO can see 1

3.2 Significance of SNR and UNID TeV Sources

Table 1

Selection of Known GeV–TeV and TeV SNRs Shown with the Expected Significance above 10 TeV using 5 yr Monte Carlo Simulation Data of LHAASO, Assuming That the Sources Are Under the Specific Hypotheses for the Energy Spectrum

Name	Classification	R.A.	Decl.	α	J_0 ($\text{TeV}^{-1} \text{cm}^{-2} \text{s}^{-1}$)	σ ($E_{\text{cut}} = 100 \text{ TeV}$)	σ' ($E_{\text{cut}} = 30 \text{ TeV}$)	References
Tycho(a)	GeV–TeV	00 ^h 25 ^m 18 ^s	+64°09′	2.92 ± 0.46	2.2×10^{-13}	-	-	1
Tycho(b)	GeV–TeV	00 ^h 25 ^m 18 ^s	+64°09′	1.95 ± 0.51	1.70×10^{-13}	11.62	5.20	2
IC 443	GeV–TeV	06 ^h 17 ^m 00 ^s	+22°30′	2.99 ± 0.38	8.38×10^{-13}	5.46	-	3
W49B	GeV–TeV	19 ^h 11 ^m 08 ^s	+09°06′	3.1 ± 0.3	2.3×10^{-13}	-	-	4
HESS J1912-101	TeV	19 ^h 12 ^m 49 ^s	+10°09′	2.7 ± 0.2	3.5×10^{-12}	59.63	28.02	5
W51C	GeV–TeV	19 ^h 23 ^m 50 ^s	+14°06′	2.58 ± 0.07	9.7×10^{-13}	31.44	14.87	6
G106.3+2.7	TeV	22 ^h 27 ^m 59 ^s	+60°52′	2.29 ± 0.33	1.42×10^{-12}	57.43	21.10	7
Cassiopeia A	GeV–TeV	23 ^h 23 ^m 26 ^s	+58°48′	2.3 ± 0.2	7.3×10^{-13}	26.51	10.20	8

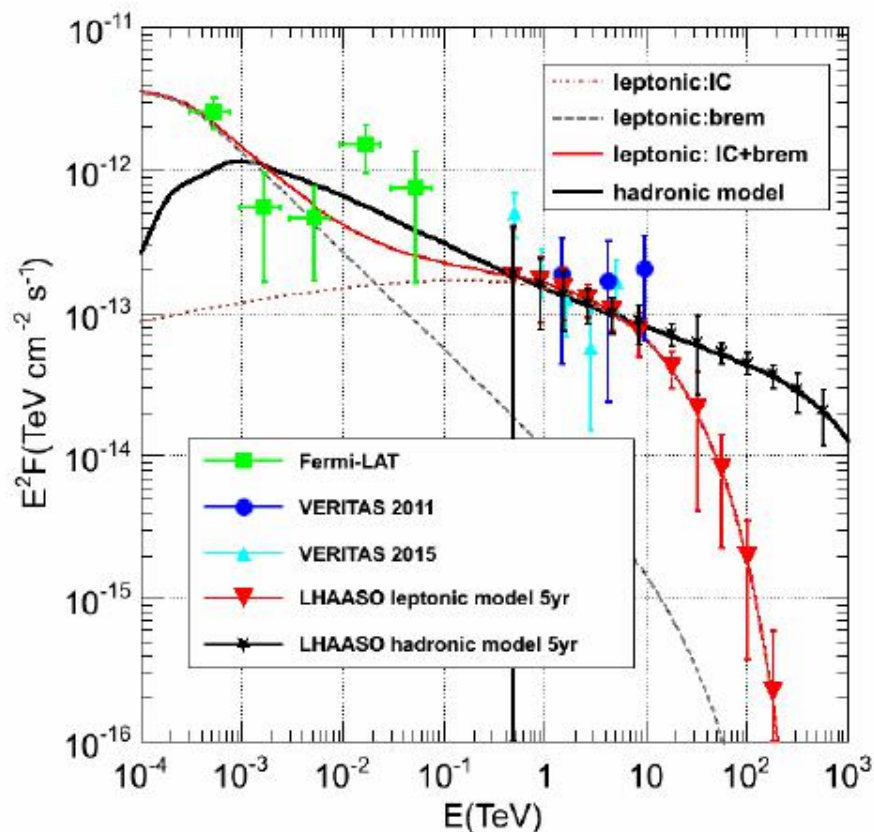
Table 4

Selection of Unidentified TeV γ -ray Sources and a Supperbubble (Cygnus Cocoon) Shown with the Expected Significance above 10 TeV using 5 yr Monte Carlo Simulation Data of LHAASO, Assuming That the Sources Are under the Specific Hypotheses for the Energy Spectrum

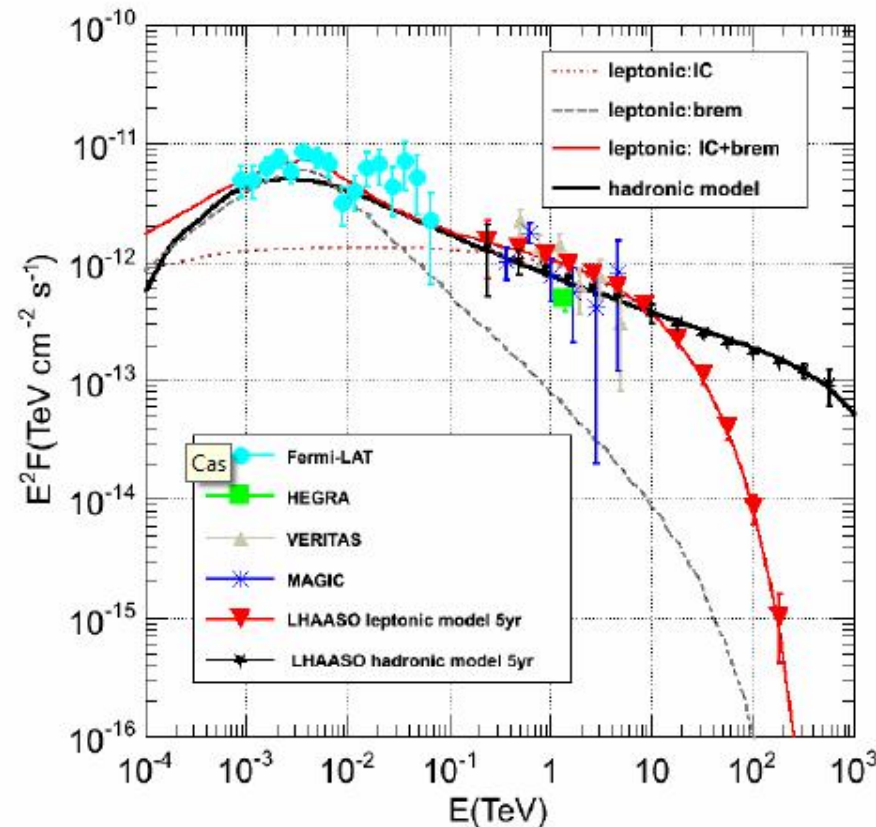
Name	R.A.	Decl.	α	J_0 ($\text{TeV}^{-1} \text{cm}^{-2} \text{s}^{-1}$)	σ_{ext} (°)	σ ($E_{\text{cut}} = 100 \text{ TeV}$)	σ' ($E_{\text{cut}} = 30 \text{ TeV}$)	References
MAGIC J0223+403	02 ^h 23 ^m 12 ^s	+43°00′	3.1 ± 0.31	4.07×10^{-13}	0	-	-	1
HESS J1832-093	18 ^h 32 ^m 50 ^s	−09°22′	2.6 ± 0.3	4.8×10^{-13}	0	15.27	5.15	2
HESS J1834-087	18 ^h 34 ^m 45 ^s .6	−08°45′	2.5 ± 0.2	3.7×10^{-12}	0.1	21.73	7.15	3
HESS J1841-055	18 ^h 40 ^m 55 ^s	−05°33′	2.32 ± 0.23	3.76×10^{-11}	0.4	699.27	234.89	4
HESS J1857+026	18 ^h 57 ^m 11 ^s	+02°40′	2.16 ± 0.07	5.37×10^{-12}	0.17	205.63	76.95	5
HESS J1858+020	18 ^h 58 ^m 20 ^s	+02°05′	2.17 ± 0.12	6.0×10^{-13}	0.08	20.10	7.45	6
MGRO J1908+06	19 ^h 07 ^m 54 ^s	+06°16′	2.54 ± 0.36	2.06×10^{-11}	0.49	220.80	97.13	7
VER J2016+371	20 ^h 16 ^m 02 ^s	+37°11′	2.3 ± 0.3	3.1×10^{-13}	0	9.76	5.00	8
VER J2019+368	20 ^h 19 ^m 25 ^s	+36°48′	1.75 ± 0.08	1.35×10^{-12}	2.0	58.36	22.40	9
VER J2019+407	20 ^h 20 ^m 04 ^s .8	+40°45′	2.37 ± 0.14	1.5×10^{-12}	0.23	38.74	17.89	10
ARGO J2031+4157	20 ^h 31 ^m 12 ^s	+42°30′	2.6 ± 0.3	3.05×10^{-12}	2.0	10.86	5.3	11

3.2 Expectant Energy Spectrum of SNR

Tycho



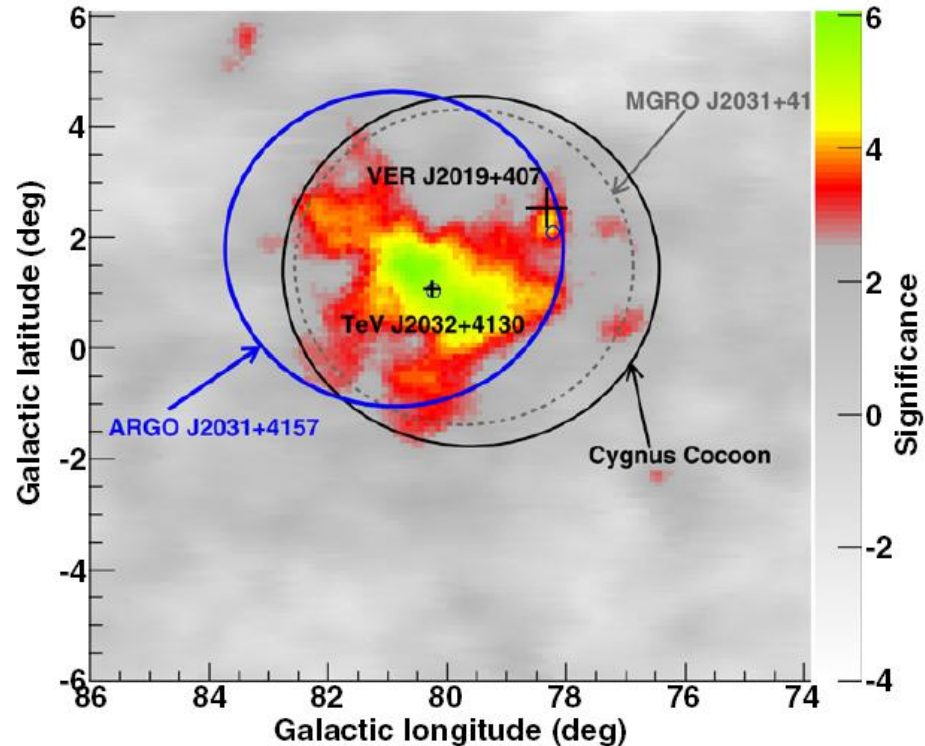
Cassiopeia A



The leptonic and hadronic model can obtain the effective tests by observation of LHAASO.

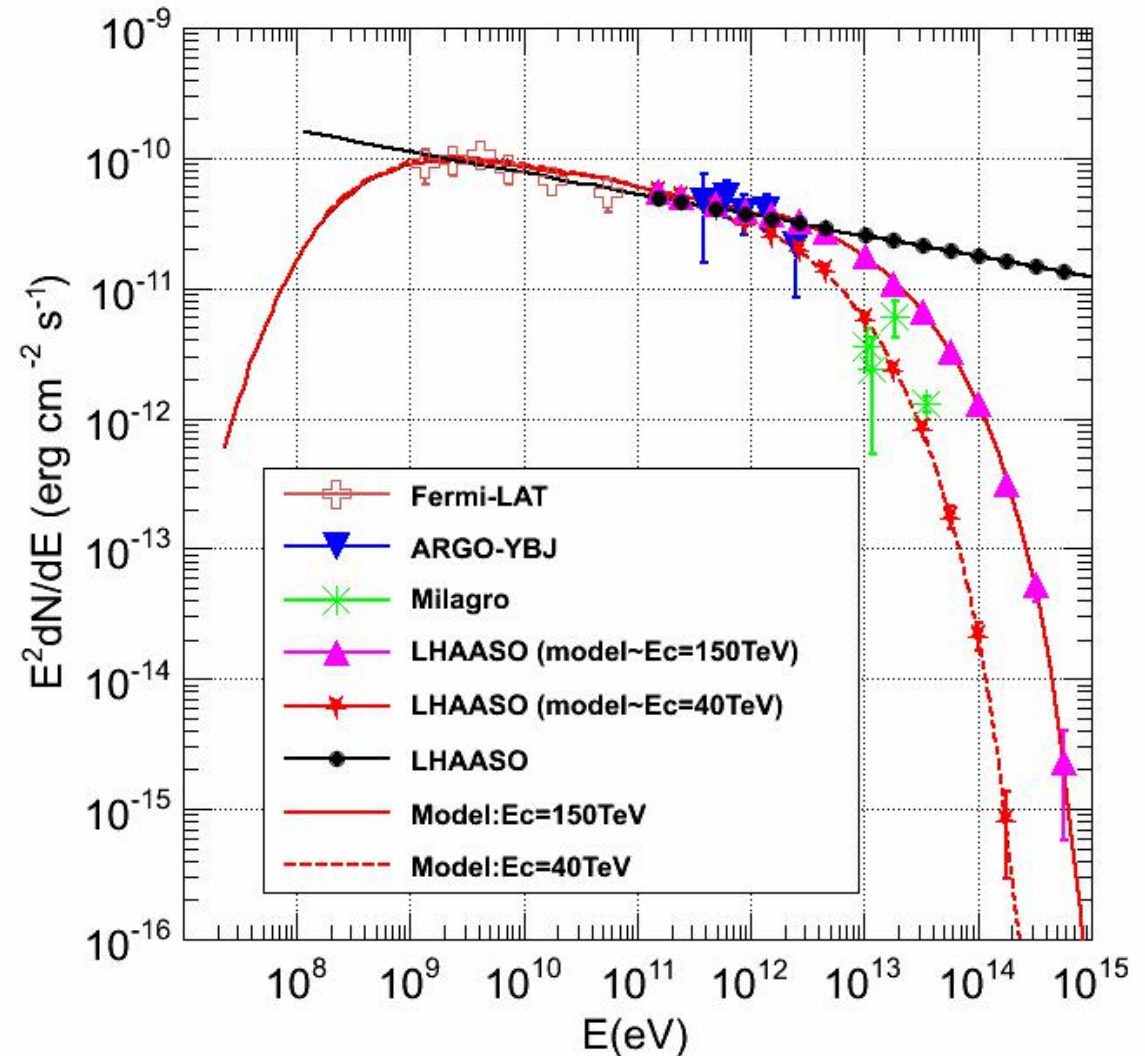
3.3 Expectant Energy Spectrum of Cygnus Cocoon

- LHAASO can give an accurate measurement for different situations.

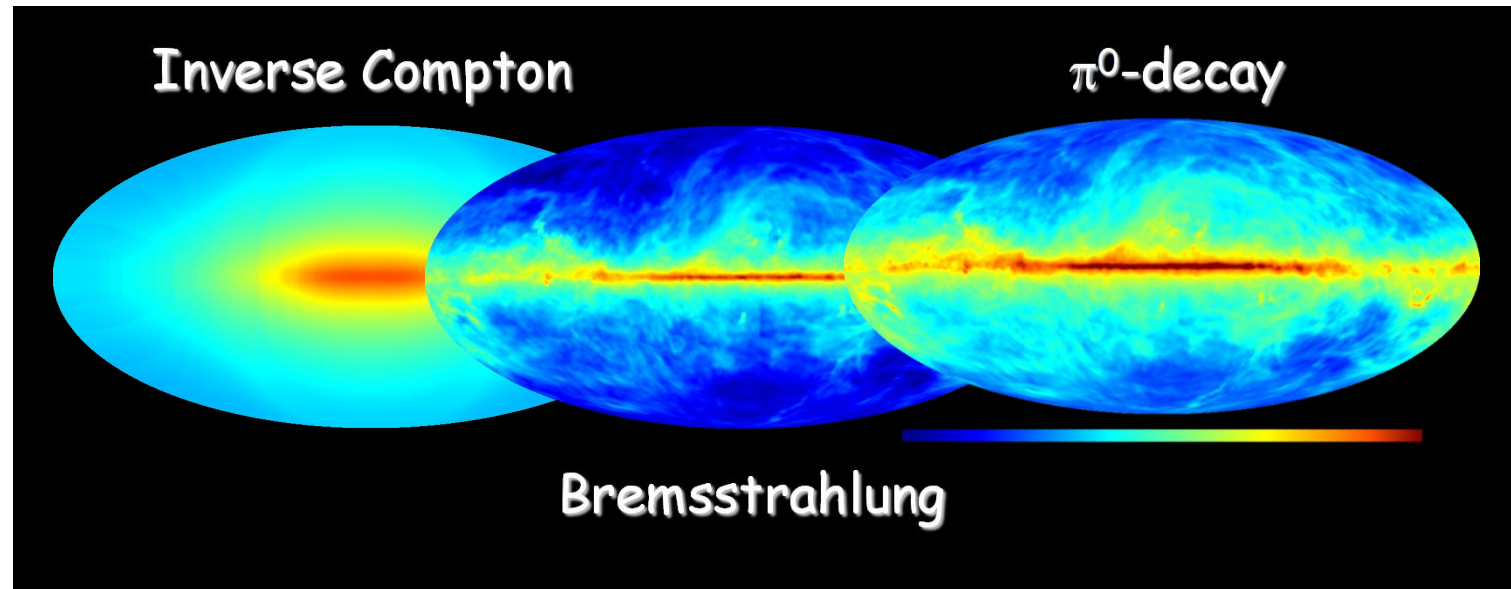


B. Bartoli, et al. 2014, APJ

Cygnus Cocoon



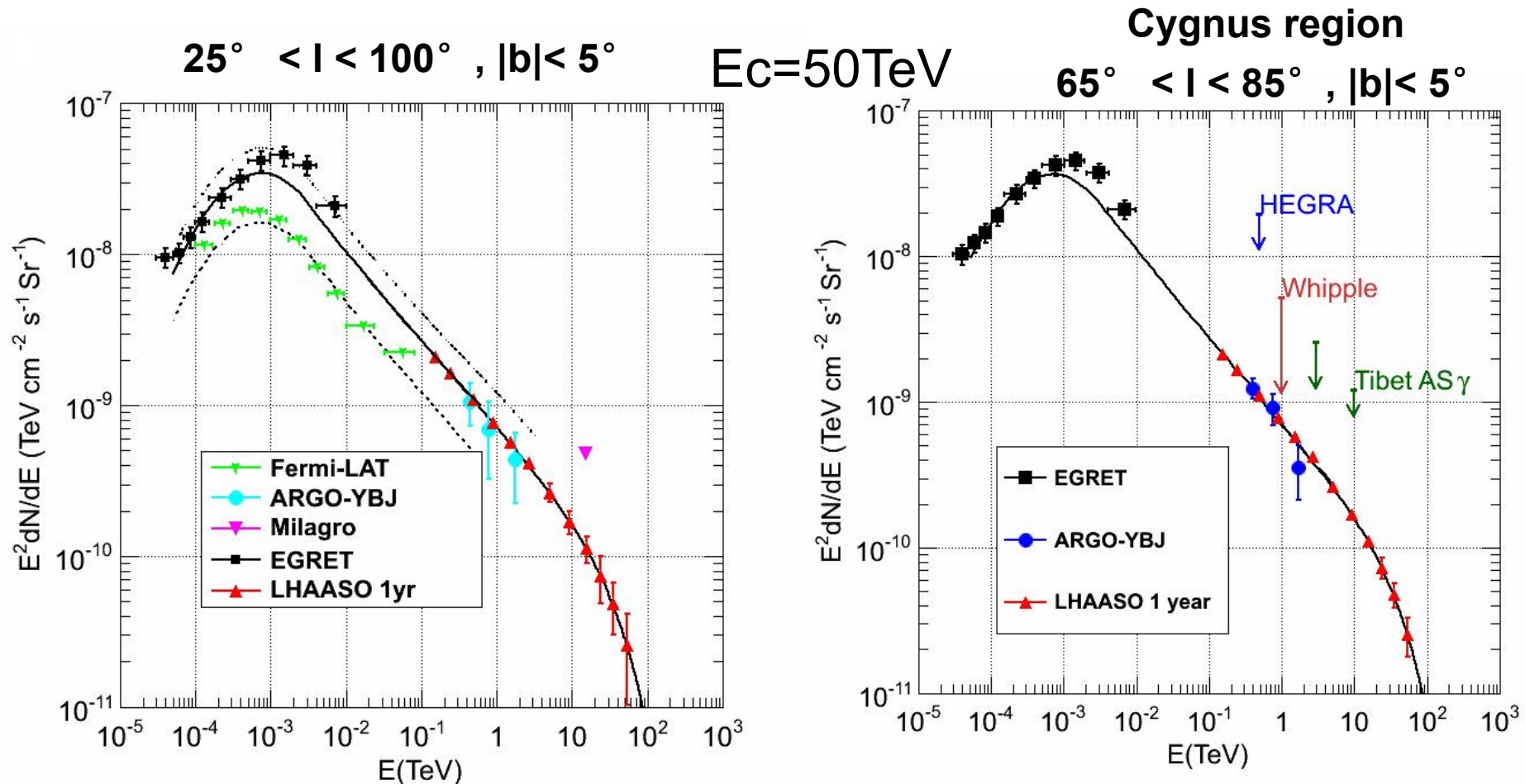
3.4 Galactic plane diffuse gamma-ray



- From interactions of cosmic rays with the interstellar gas and radiation fields. A tool to study **cosmic-ray origin and propagation, and the interstellar medium**.
- A way to search for **Dark Matter** Annihilation.

GCR spectrum and density:

global vs. local, diffuse emission as a probe
wide FOV is mandatory

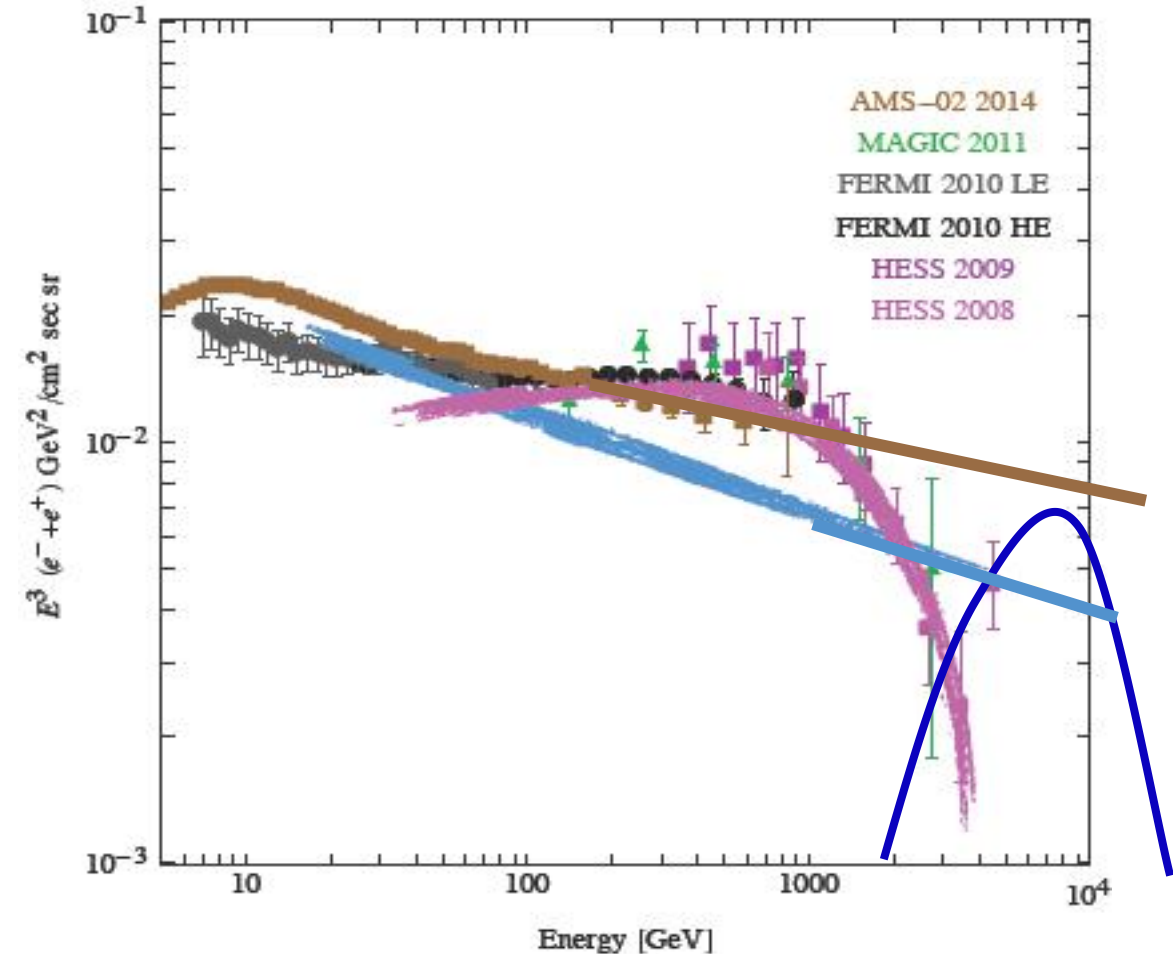


3.5 Expectation of electron spectrum

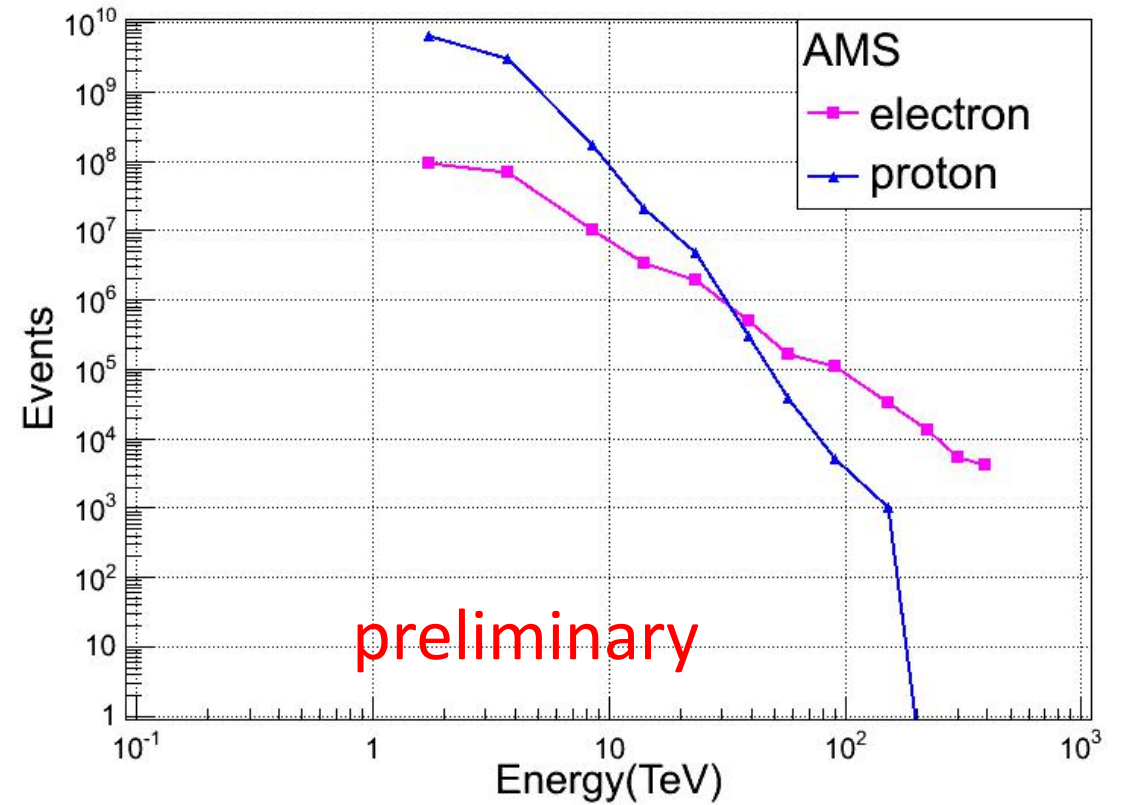
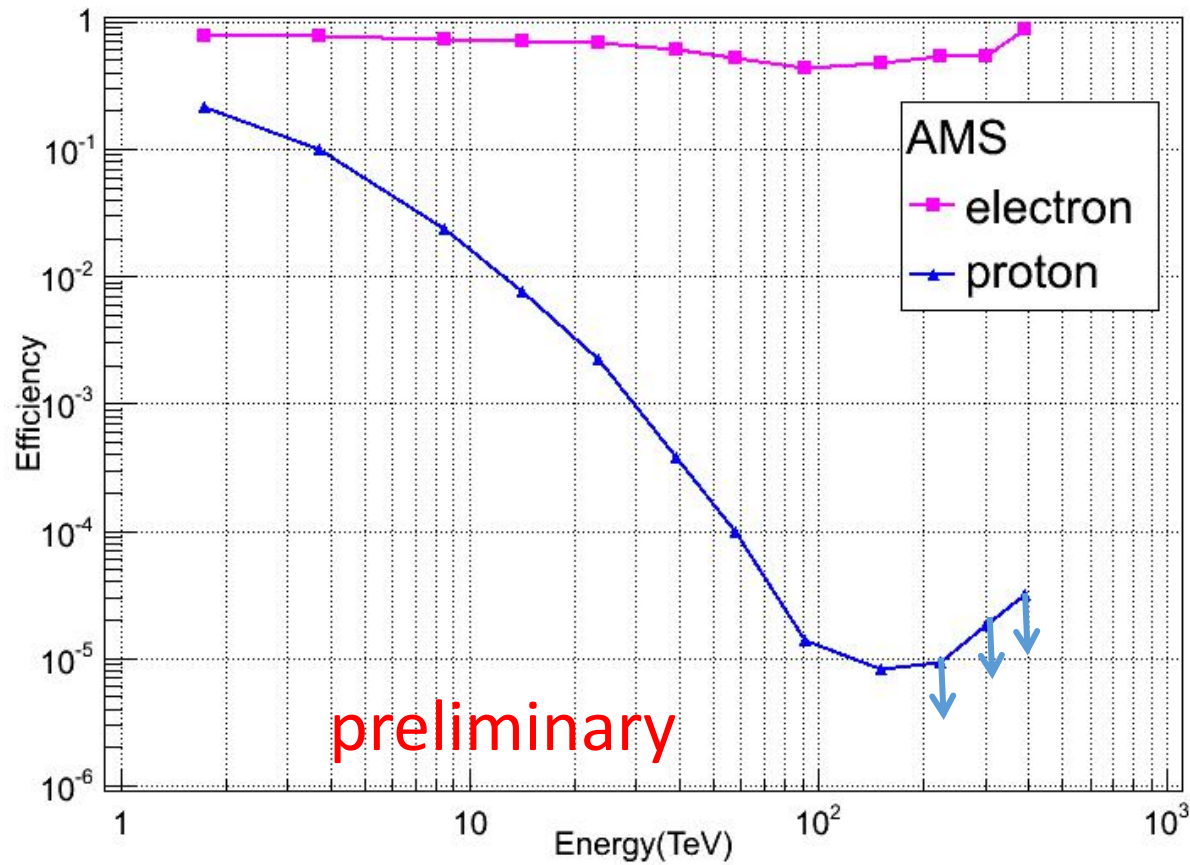
Electrons lose energy rapidly through synchrotron and inverse Compton processes which raises the possibility of seeing the contribution from individual nearby sources

The possible situation for electron spectrum more than 1 TeV:

- (1). AMS02~3.1
- (2). Hess~3.9
- (3). The result of propagation model
- (4). New structure: astrophysical object or darker matter annihilation



3.5 Expectation of electron

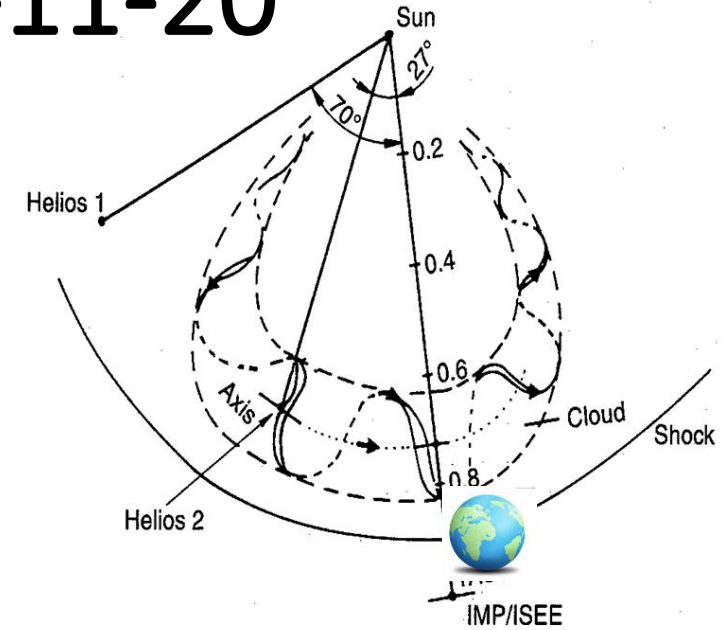
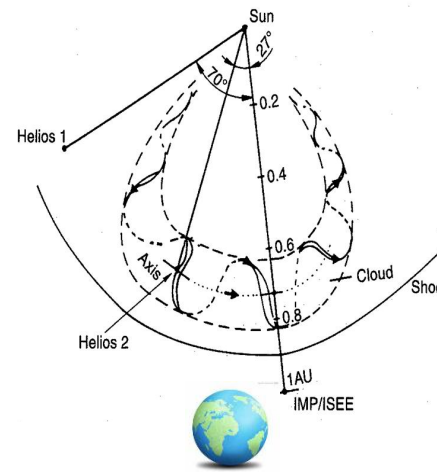
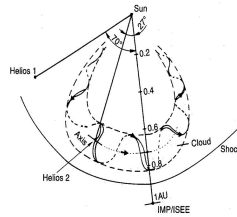


- In the energy above 30 TeV, KM2A Background remaining ratio can be 1.e-5

3.6 KM2A on for CME-ICME 2003-11-20



The KM2A solar shadow is related with the CME, can be used to research the magnetic field



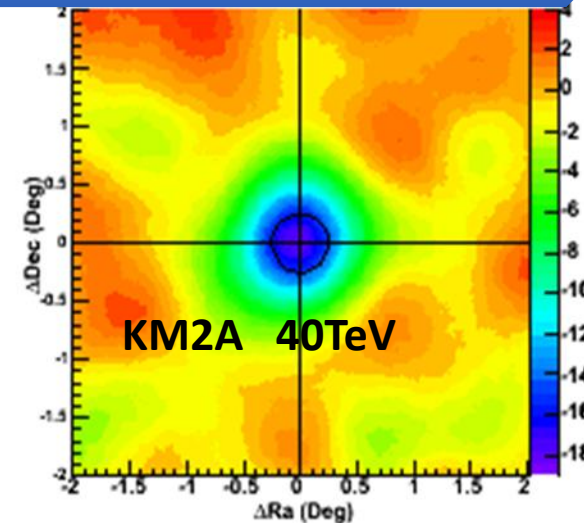
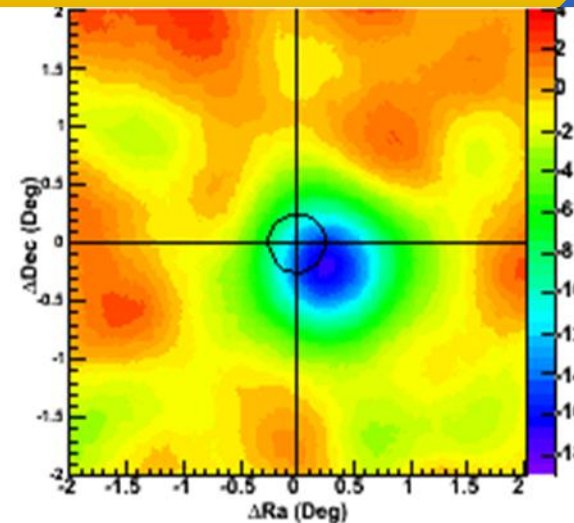
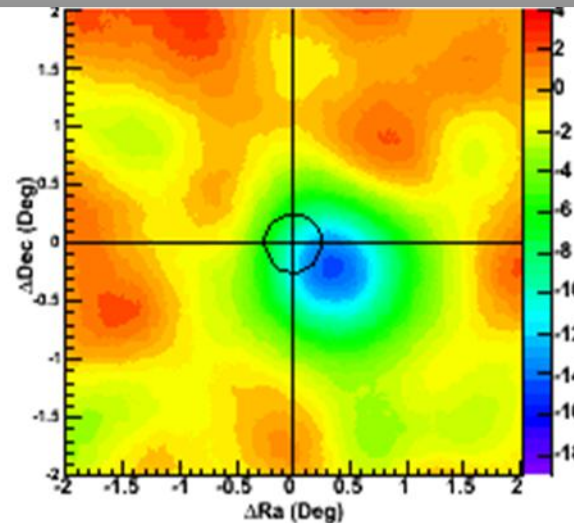
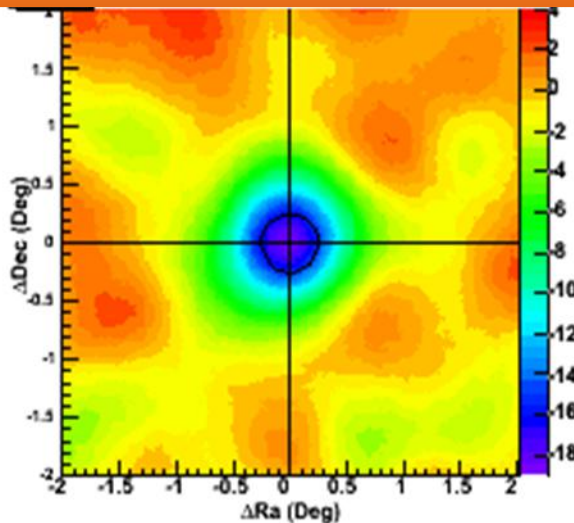
IMP/ISEE

Day 0

Day 1

Day 2

Day 3



4. Summary

- The KM2A Engineer Array has a good test of unit ED and MD
- The LHAASO-KM2A **can** extend the study of gamma-ray astronomy to the energy range **>20 TeV** with the unprecedented sensitivity
- LHAASO-KM2A can help us know more about the acceleration mechanism, the SNR ,Pulsar, Supperbubble,the solar magnetic field **and so on**

Thank you!