



Observation of UHE γ -rays by the LHAASO experiment

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on behalf of the LHAASO collaboration



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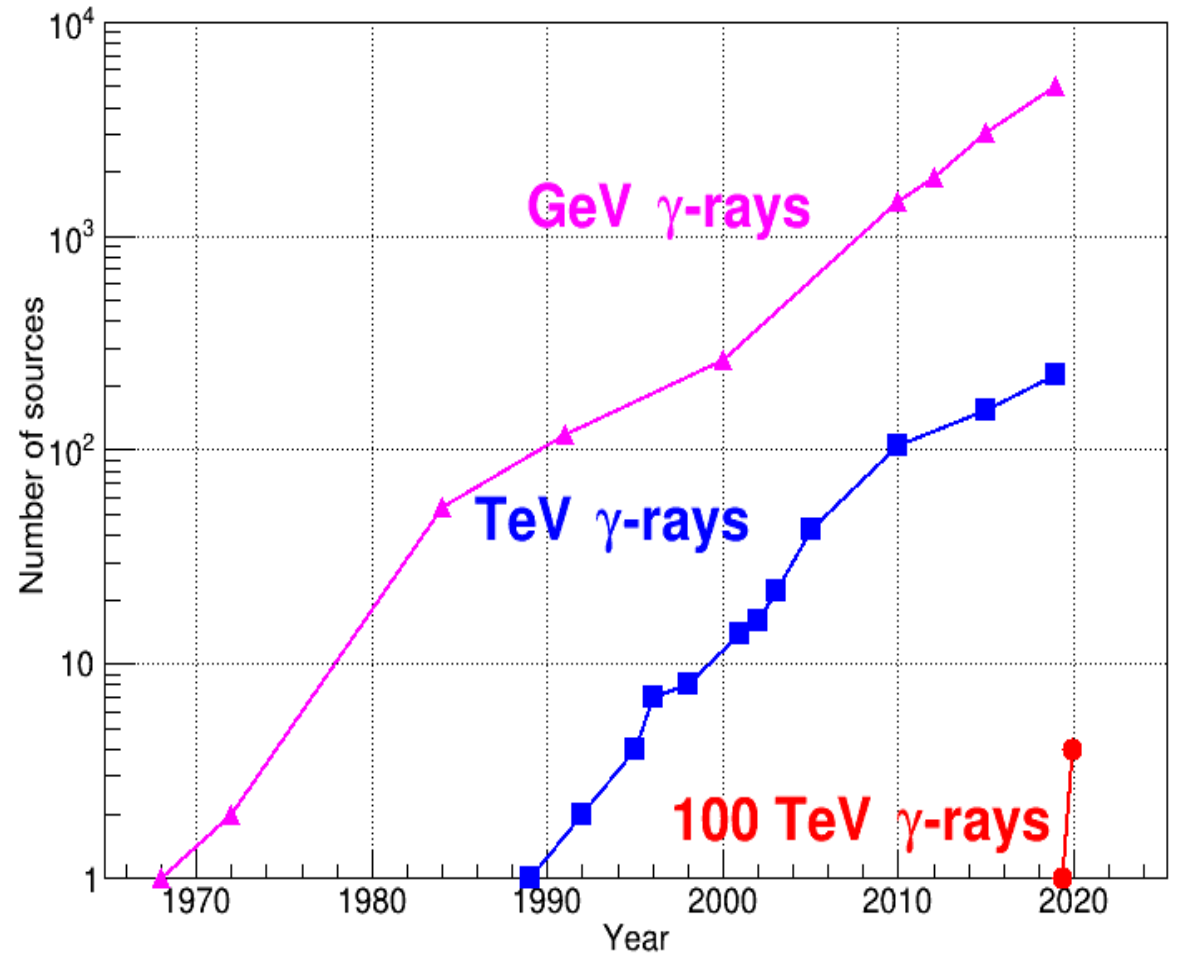
Outline

- 1. Introduction
- 2. LHAASO-KM2A detector
- 3. Preliminary result of UHE γ -ray observation
- 4. Summary

1. Introduction

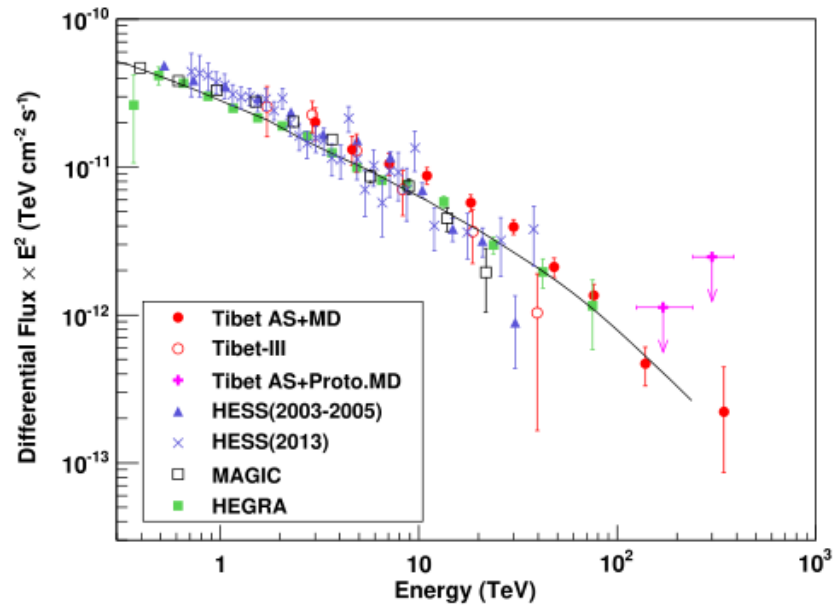
Gamma-ray astronomy

- **Great advance in the last 20 years:**
5000+ HE and 200+ VHE sources
- **Space:** Fermi-LAT
- **IAC:** HESS, MAGIC, VERITAS
- **EAS:** Milagro, ARGO-YBJ, HAWC,
Tibet ASy

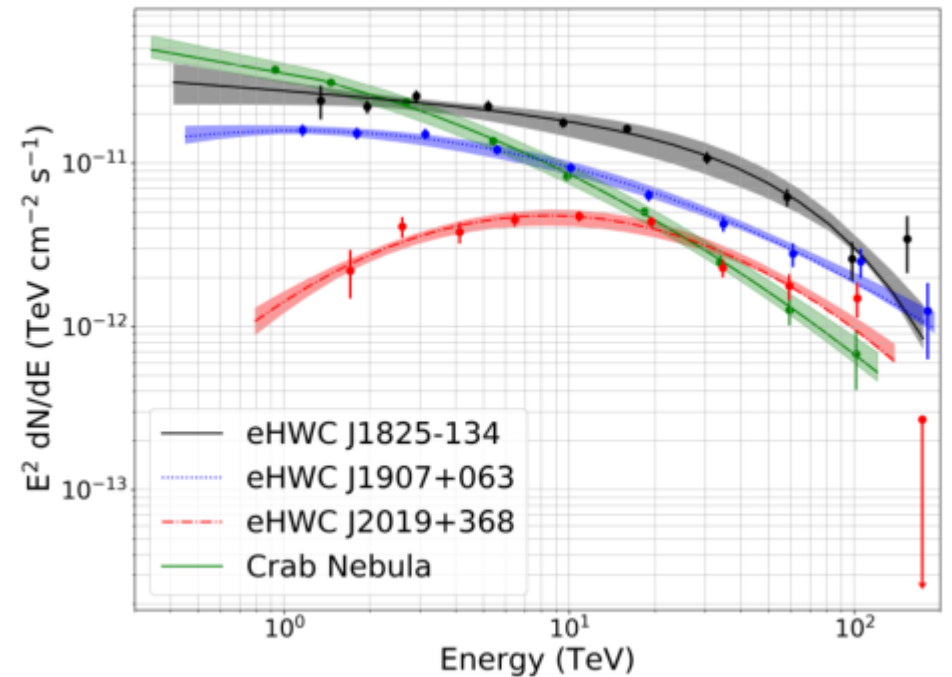


100 TeV γ -ray astronomy in 2019

- **Tibet ASy: Crab (5.6σ)**
- **HAWC: eHWC J1825-132 (7.3σ), eHWC J1908+065 (7.0σ), eHWC J2019+367 (5.4σ),**



Tibet ASy coll. 2019

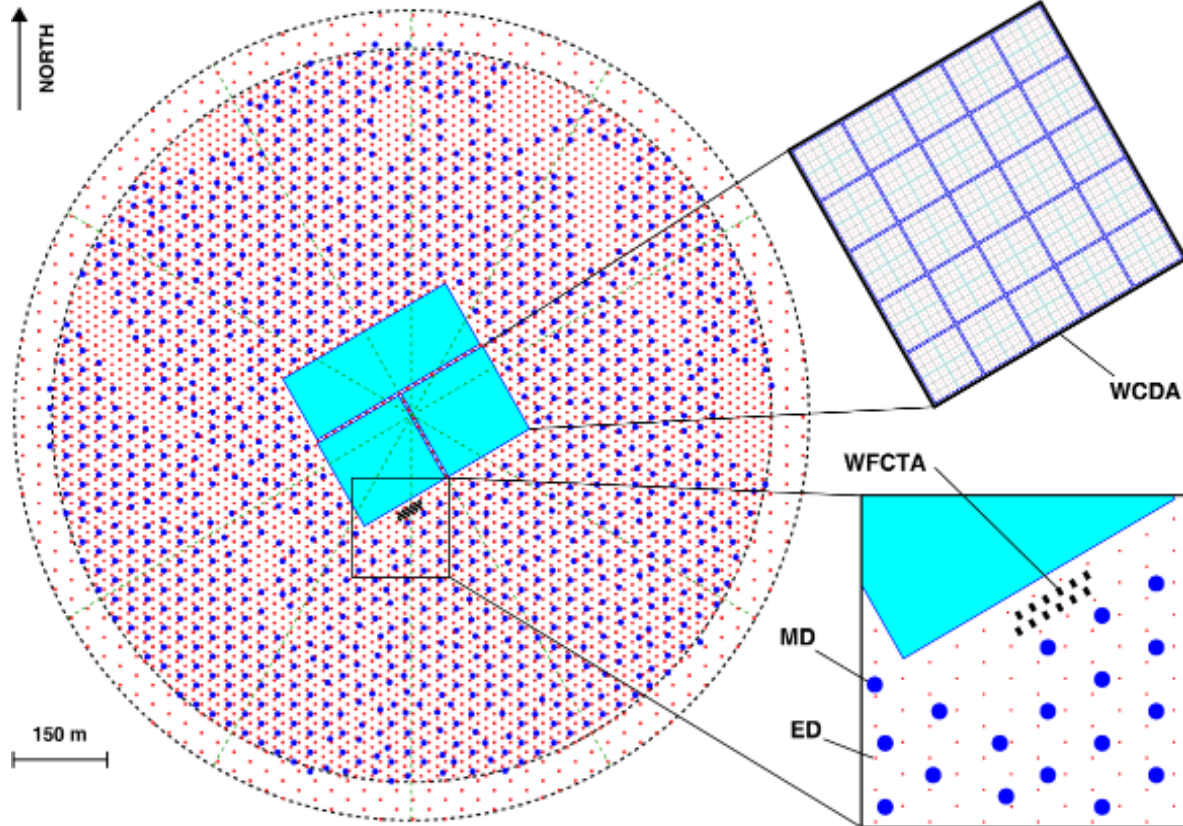


HAWC coll. 2019

Topics of UHE γ -ray astronomy

- **Maximum energy of particles acceleration within sources.**
- **Search for PeV cosmic ray source: PeVatrons.**
- **Probe the cosmic ray transport within Galaxy.**
- **New physics?**

LHAASO detectors



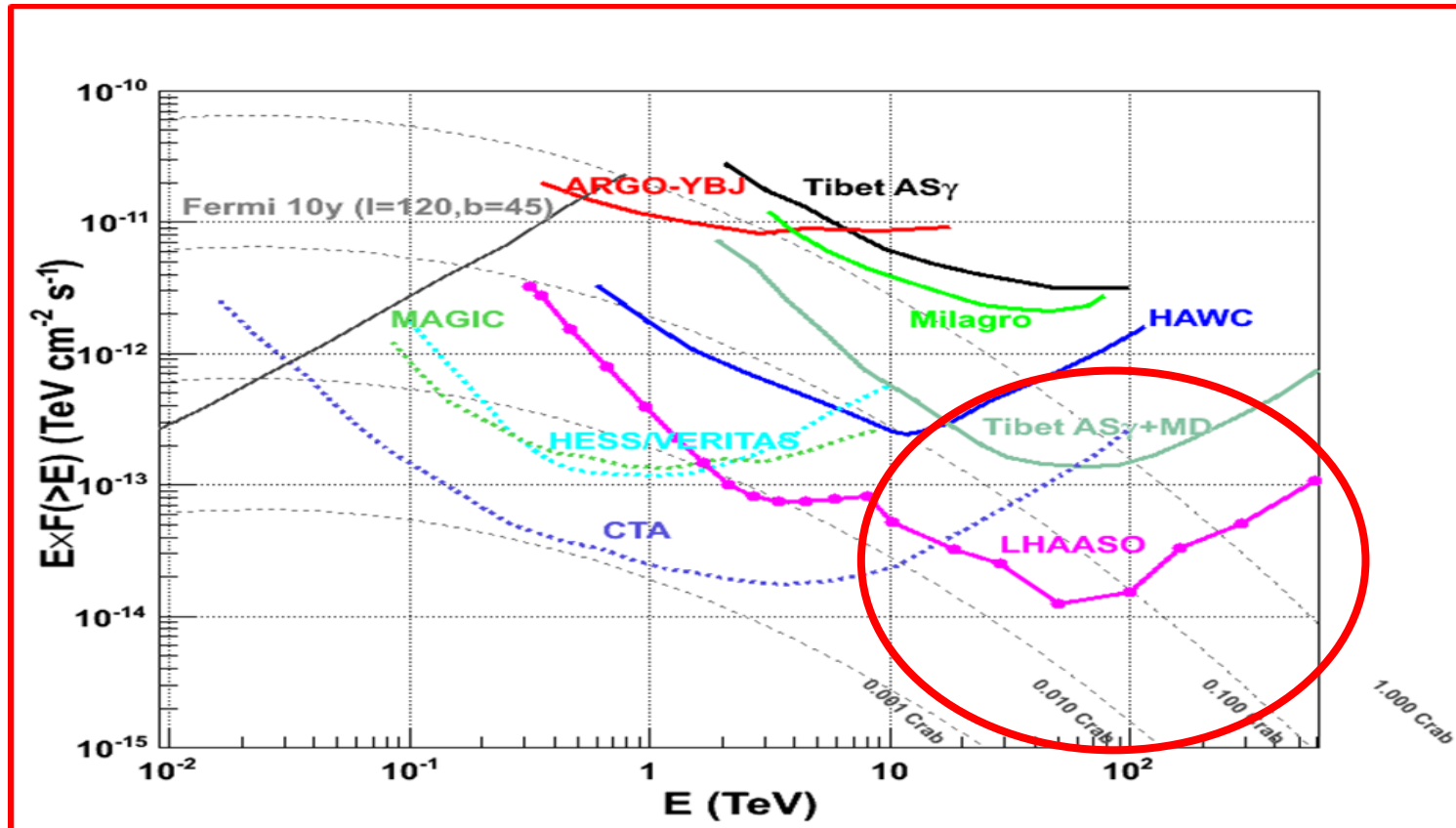
1.3 km²

- **5195 EDs**
 - 1 m² each
 - 15 m spacing
- **1171 MDs**
 - 36 m² each
 - 30 m spacing
- **3120 WCDs**
 - 25 m² each
- **12 WFCTs**

**KM2A:
UHE γ -rays
20 TeV-1 PeV**

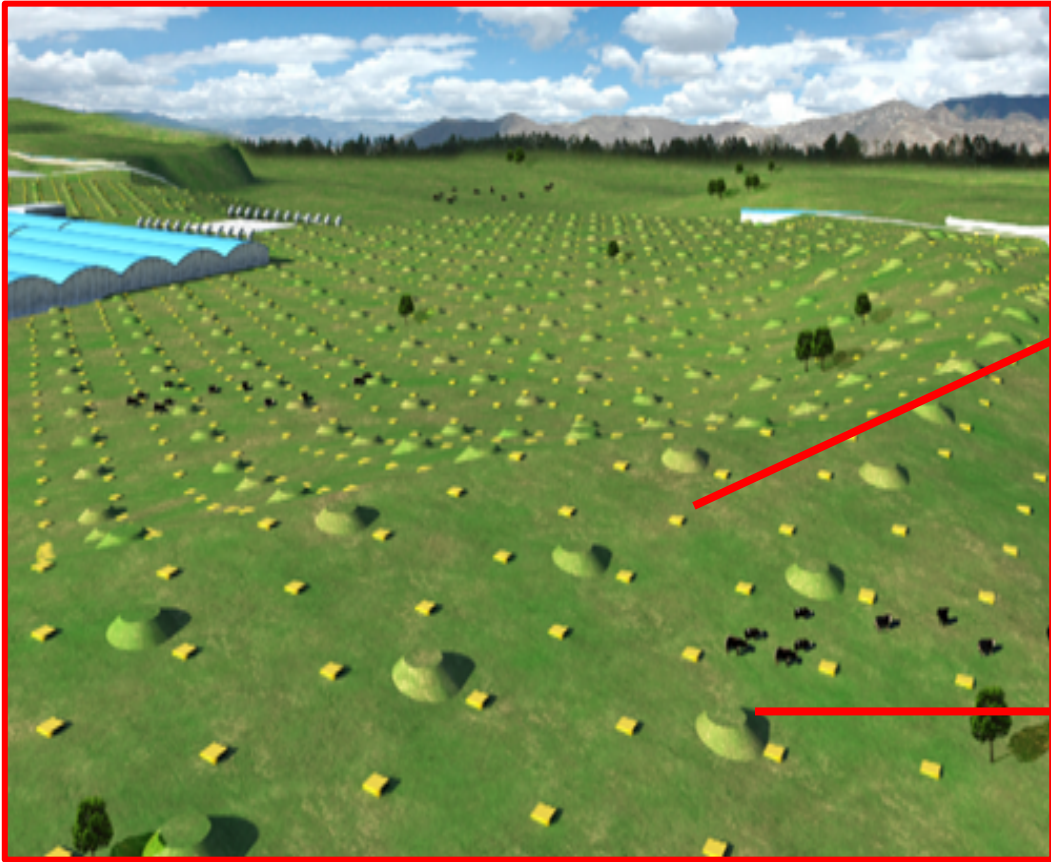
Sensitivity

- LHAASO-KM2A: Unprecedented sensitivity at energy above 20 TeV.

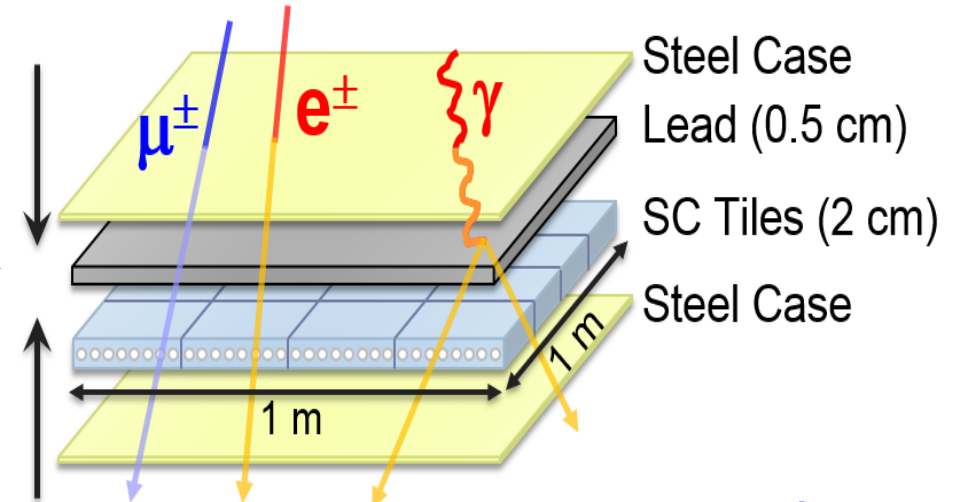


2. LHAASO-KM2A detector

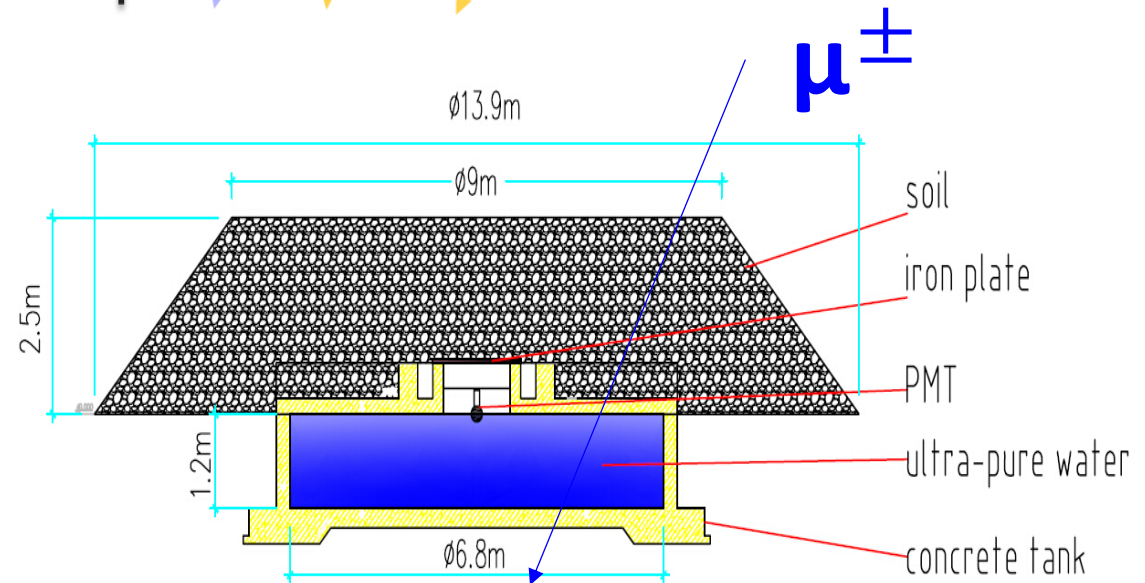
KM2A detector: ED + MD



ED



MD

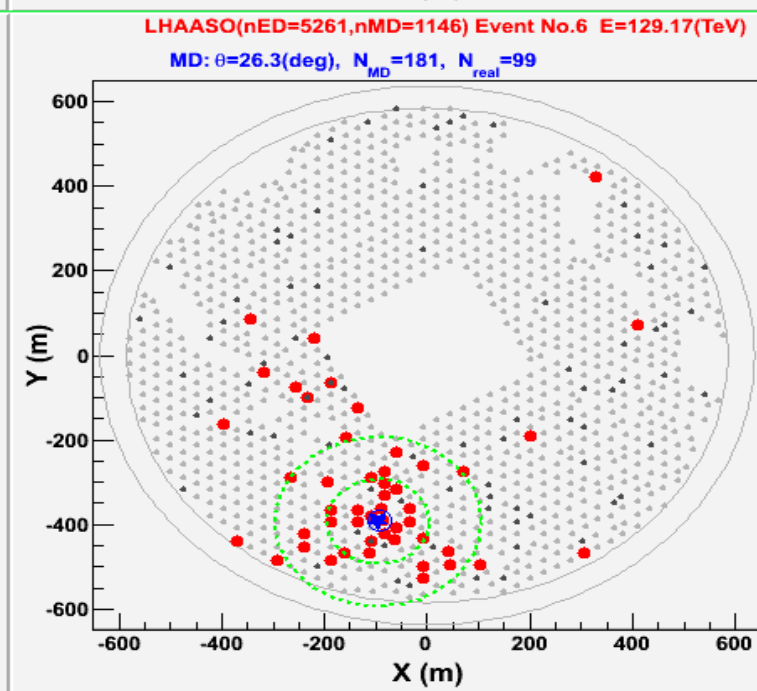
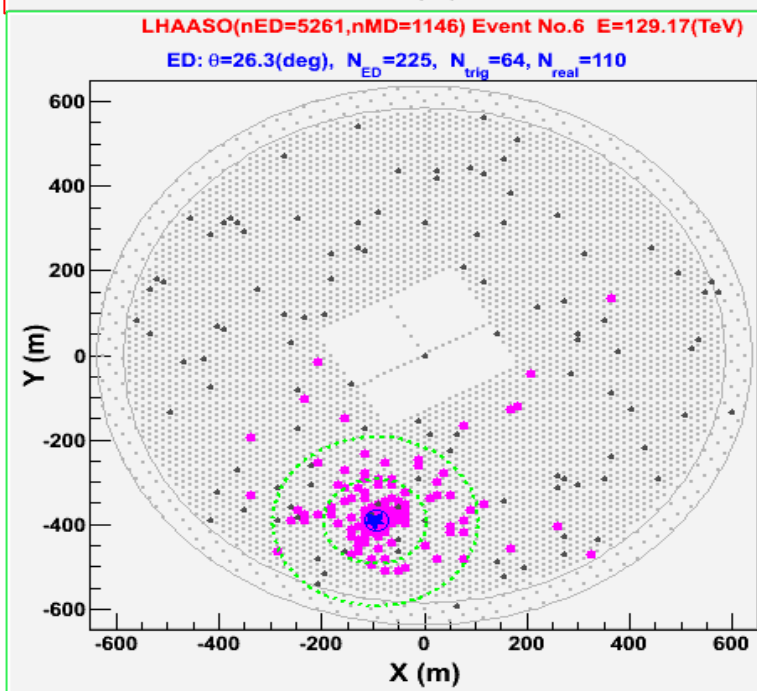
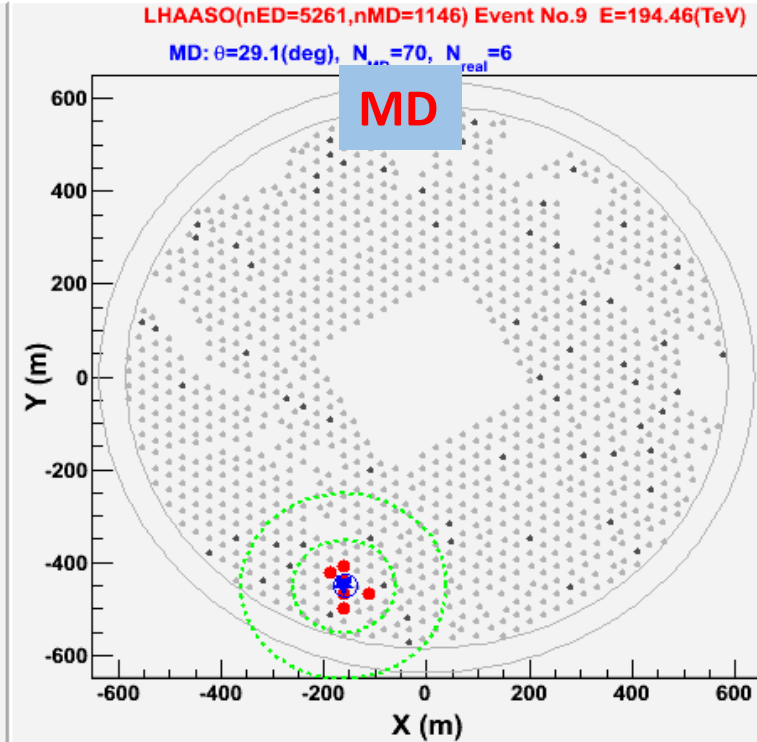
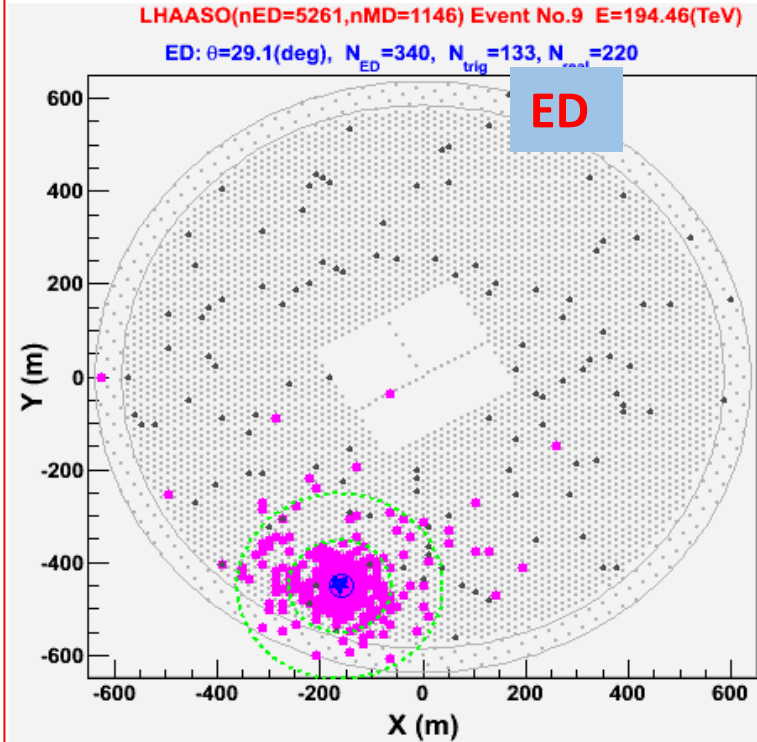


Gamma-ray E=194 TeV

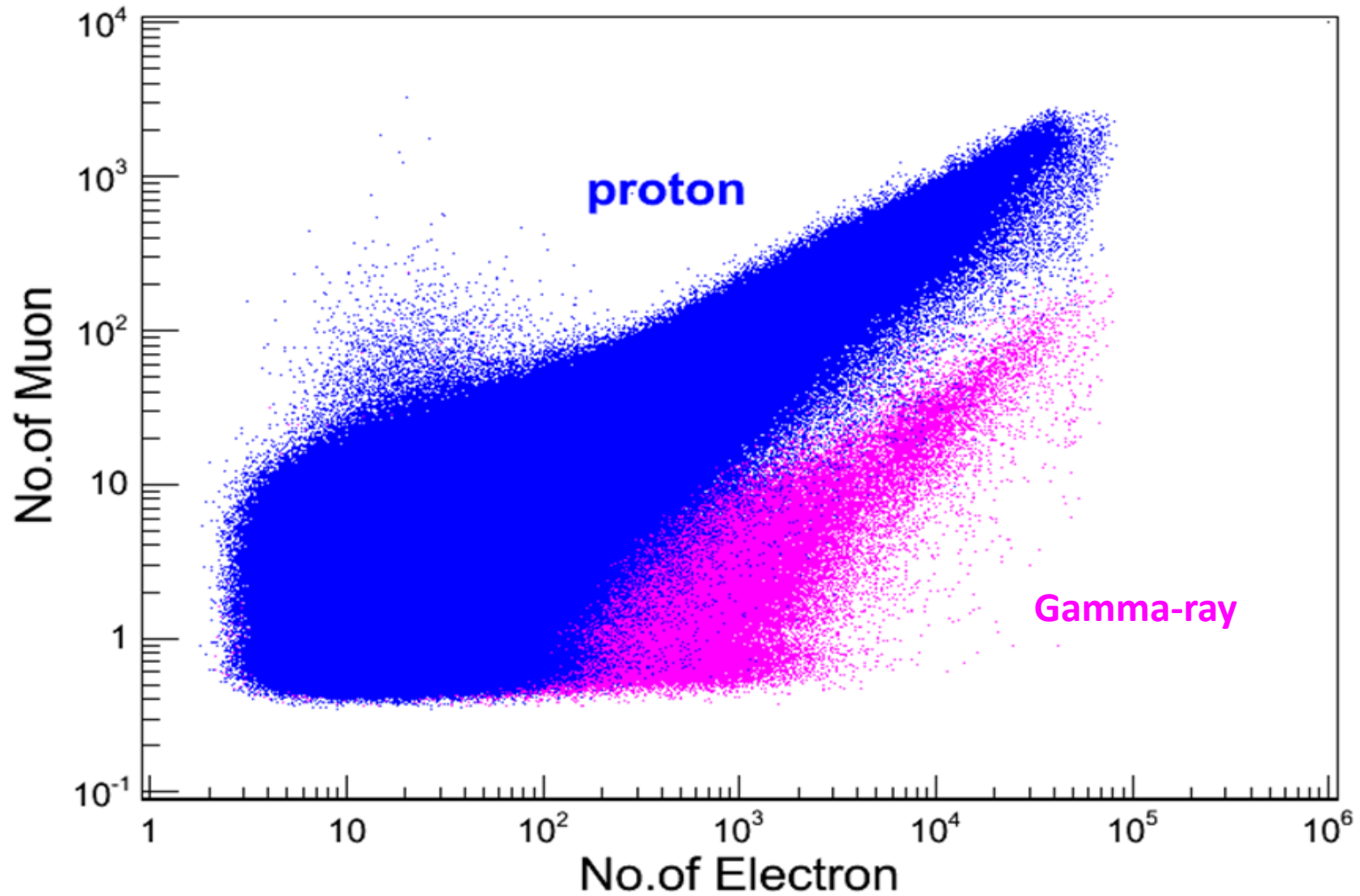
Geant4 based

γ/P discrimination

Proton E=129 TeV



γ/P discrimination



Progress of LHAASO-KM2A

1. 33EDs:

since 2018-02-03

2. 71EDs+10MDs:

since 2018-12-26

3. 99EDs+8MDs:

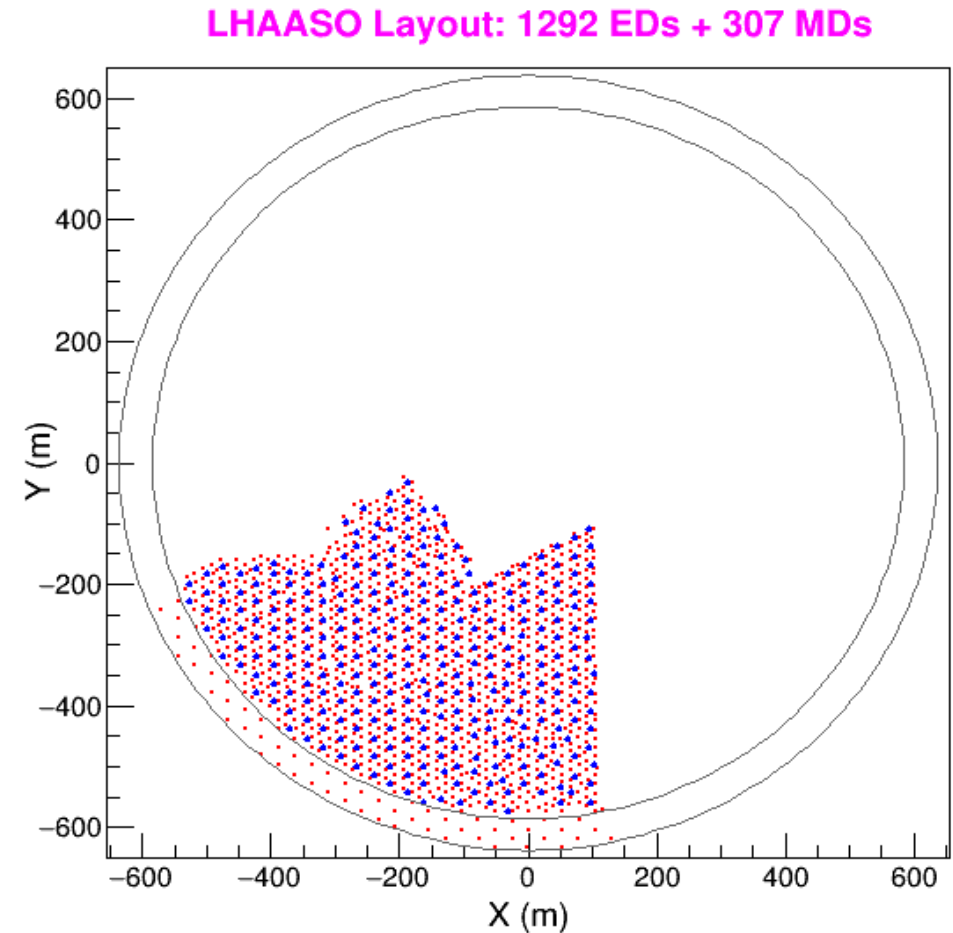
since 2019-04-26

4. $\frac{1}{4}$ KM2A: 1292EDs+307MDs:

since 2019-09-26

5. $\frac{1}{2}$ KM2A: 2390EDs+578MDs:

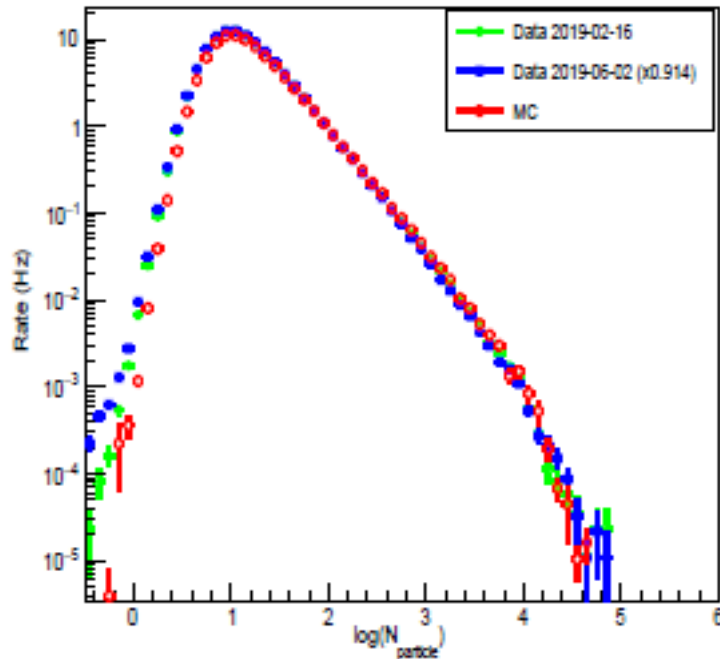
since 2019-12-26



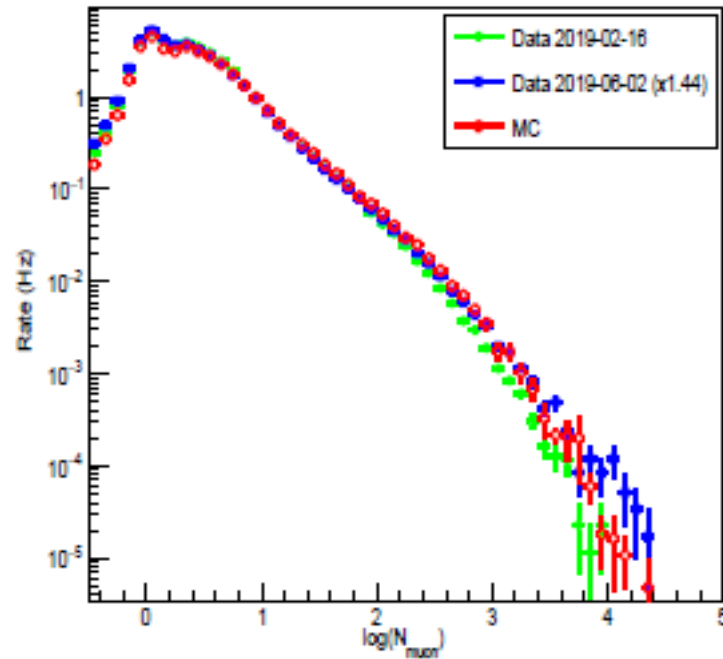
Only the $\frac{1}{4}$ KM2A data are used in this talk!

Data vs MC

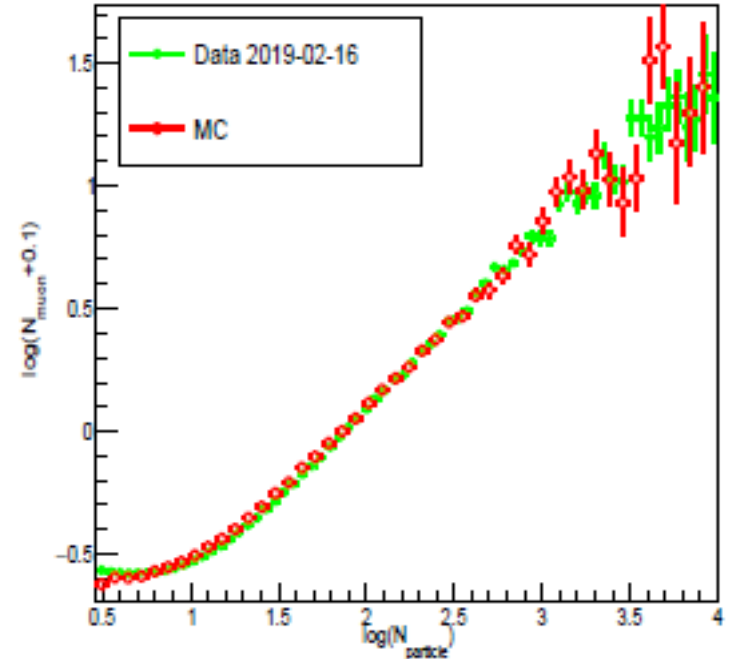
electromagnetic particles



Muon particles



Nu vs Ne



71EDs+10MDs

The number of detected particles is in agree with MC expectation.

3. Preliminary result of UHE γ -ray observation

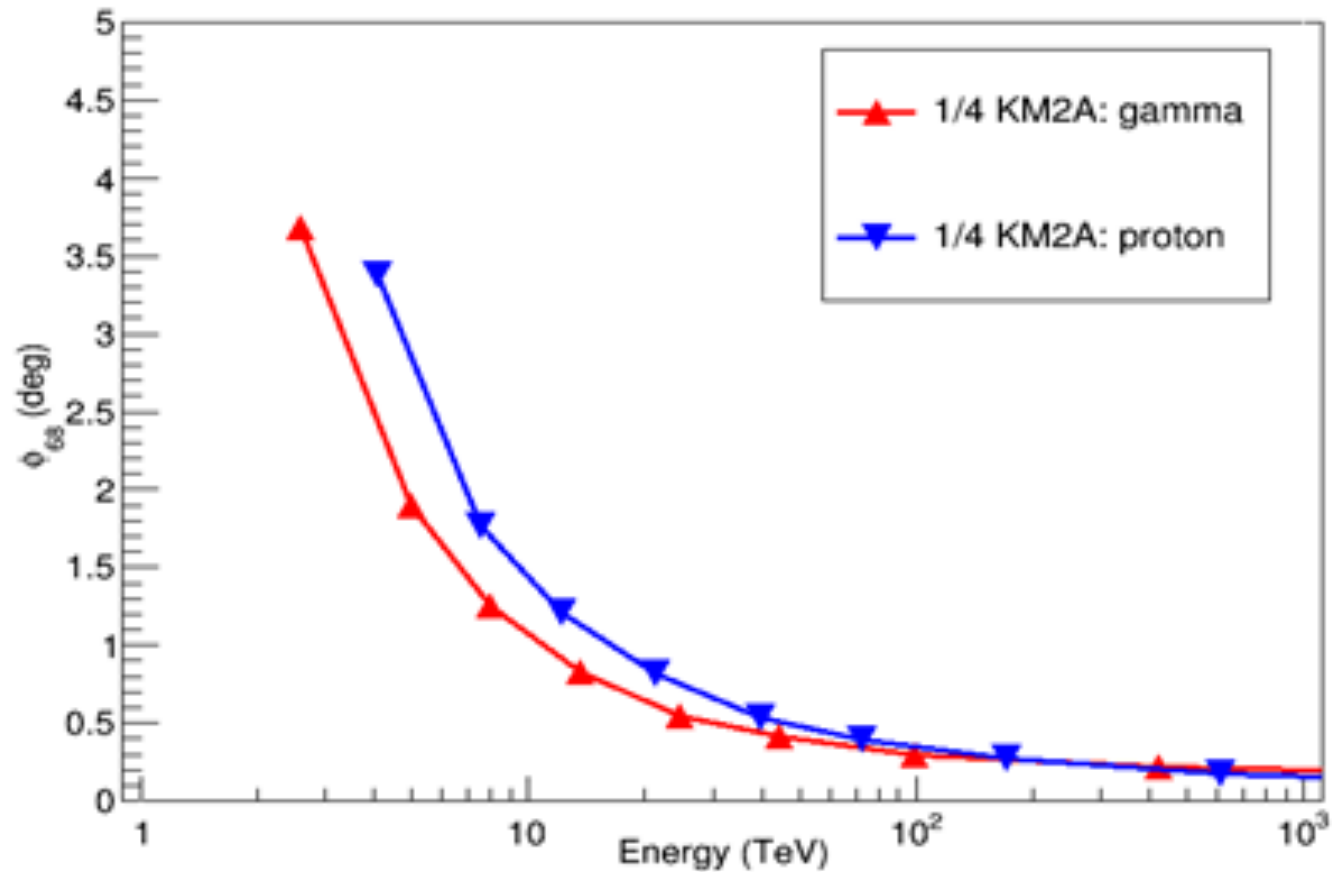
¼ KM2A Data

- From 2019-9-29 to 2019-12-31
- Trigger: 400ns, $N_{ED} > 15$
- Event rate: $\sim 700\text{Hz}$
- Life time: **38 days**



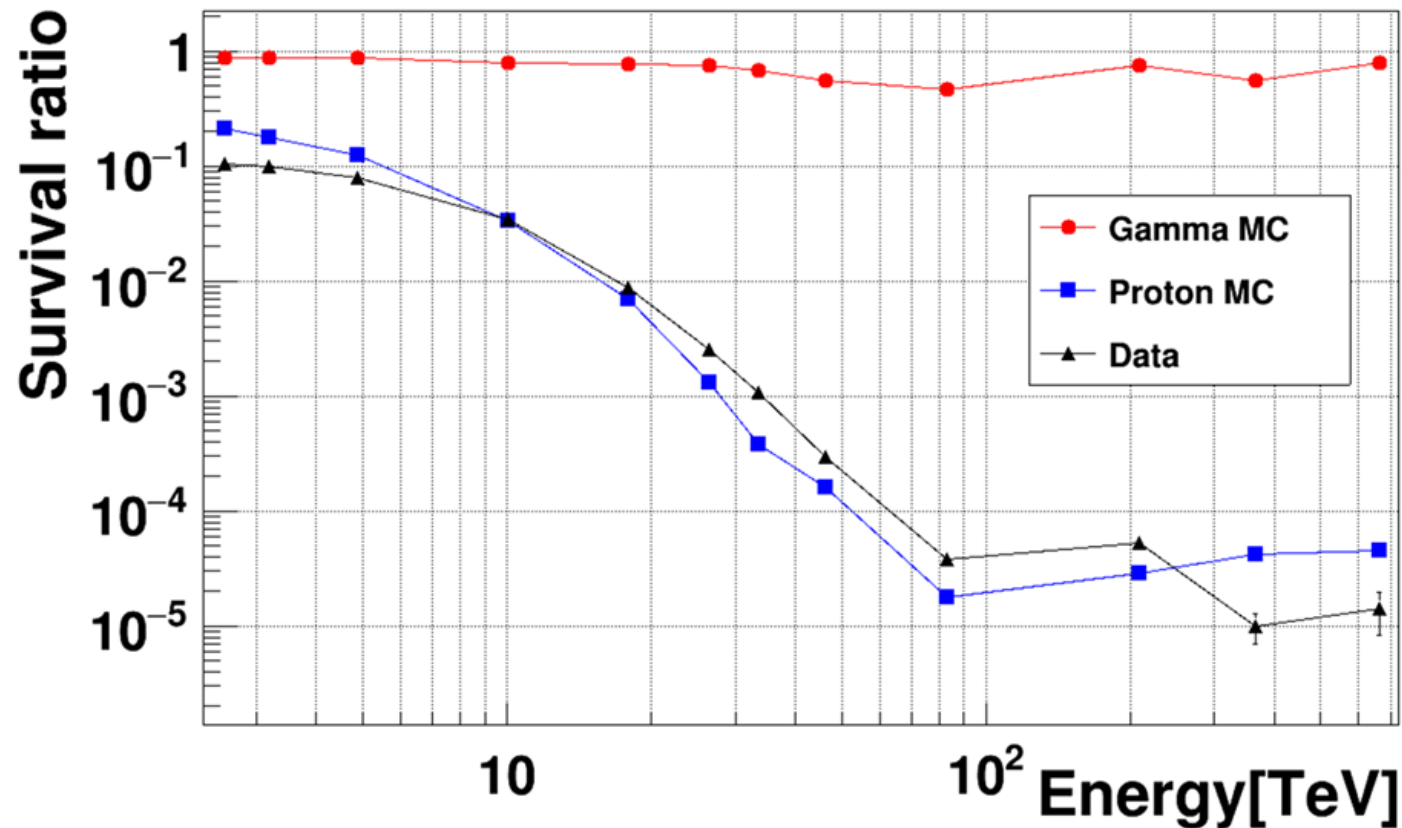
Angular resolution of $\frac{1}{4}$ KM2A

0.3°(68%) @100 TeV



γ/\mathbf{P} discrimination of $\frac{1}{4}$ KM2A

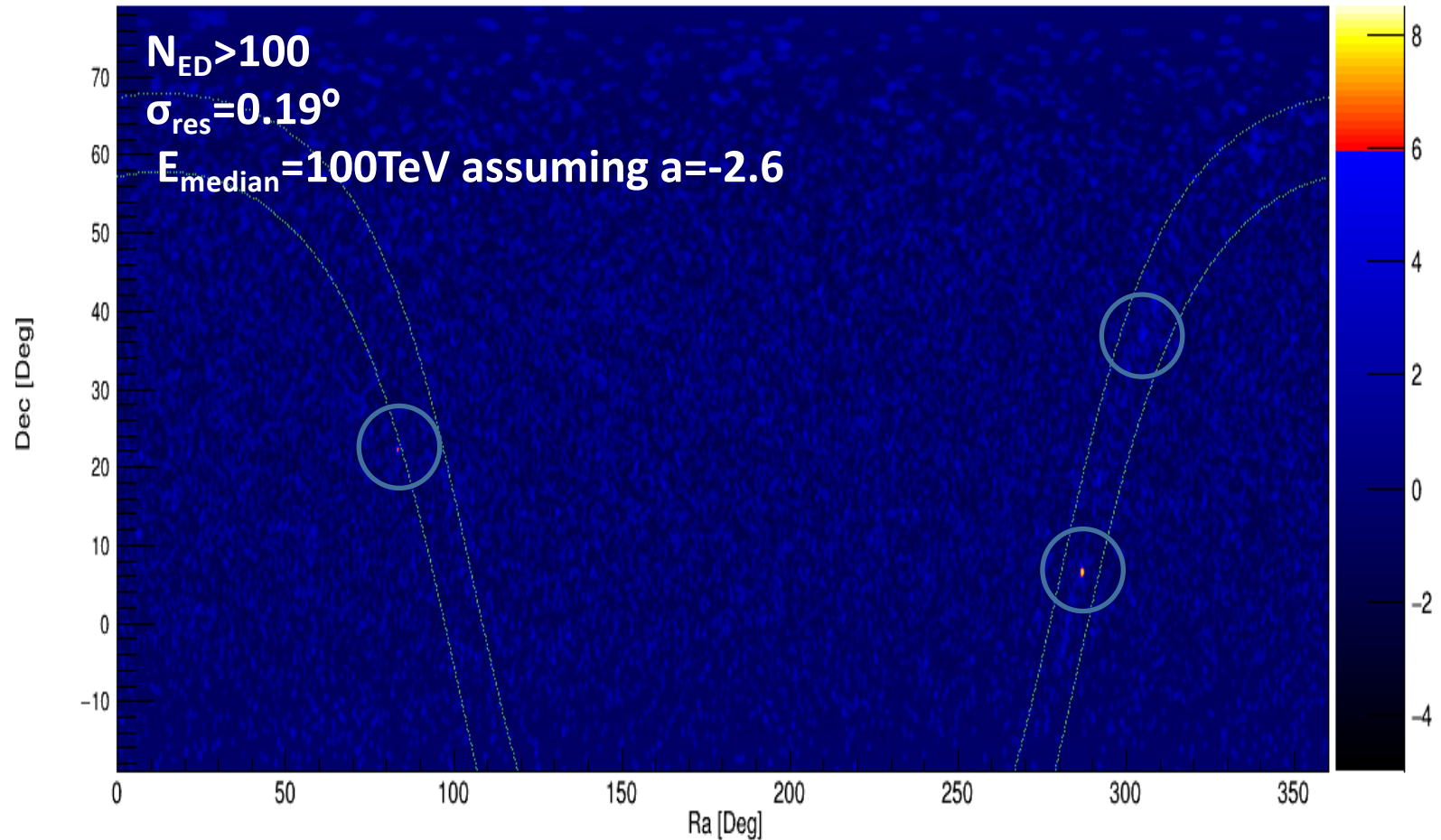
Background rejection $>10^4$ @ 100 TeV



100 TeV sky map

- 3 Source above 6 σ :

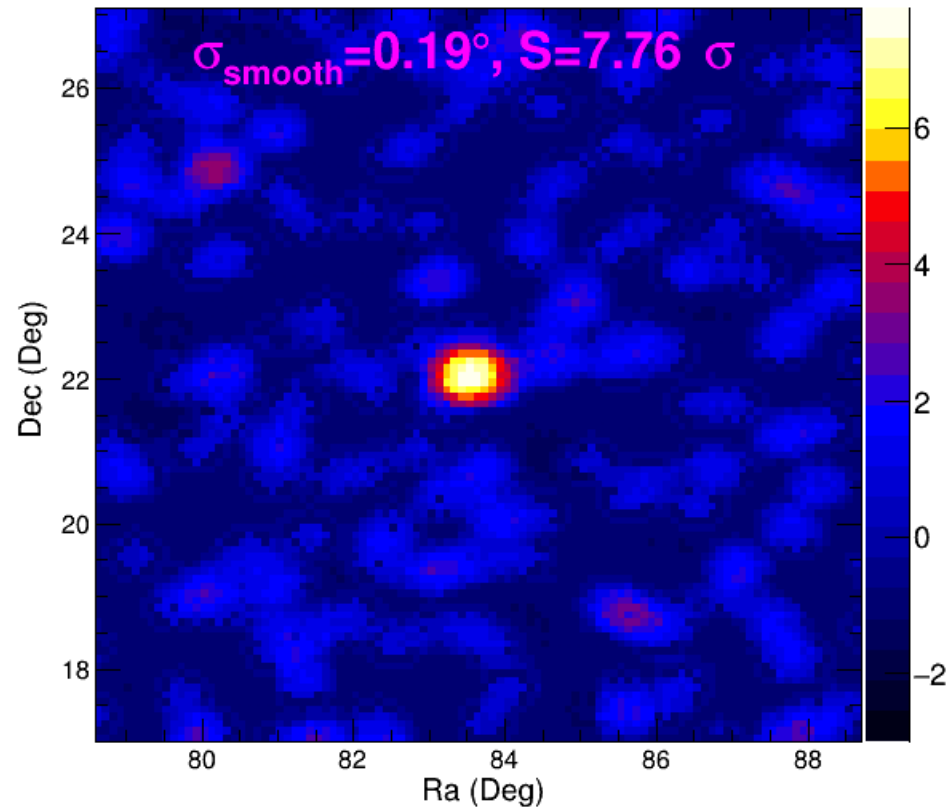
- Crab
- MGRO J1908+06
- MGRO J2019+37



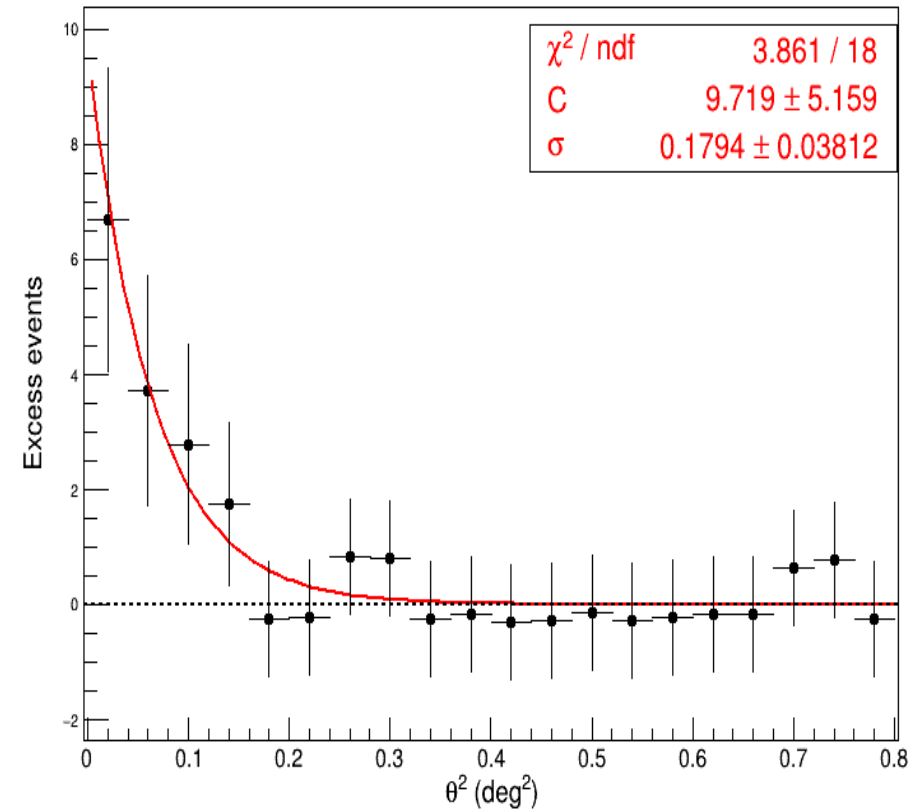
Crab @100TeV

Point error $<0.2^\circ$

Crab

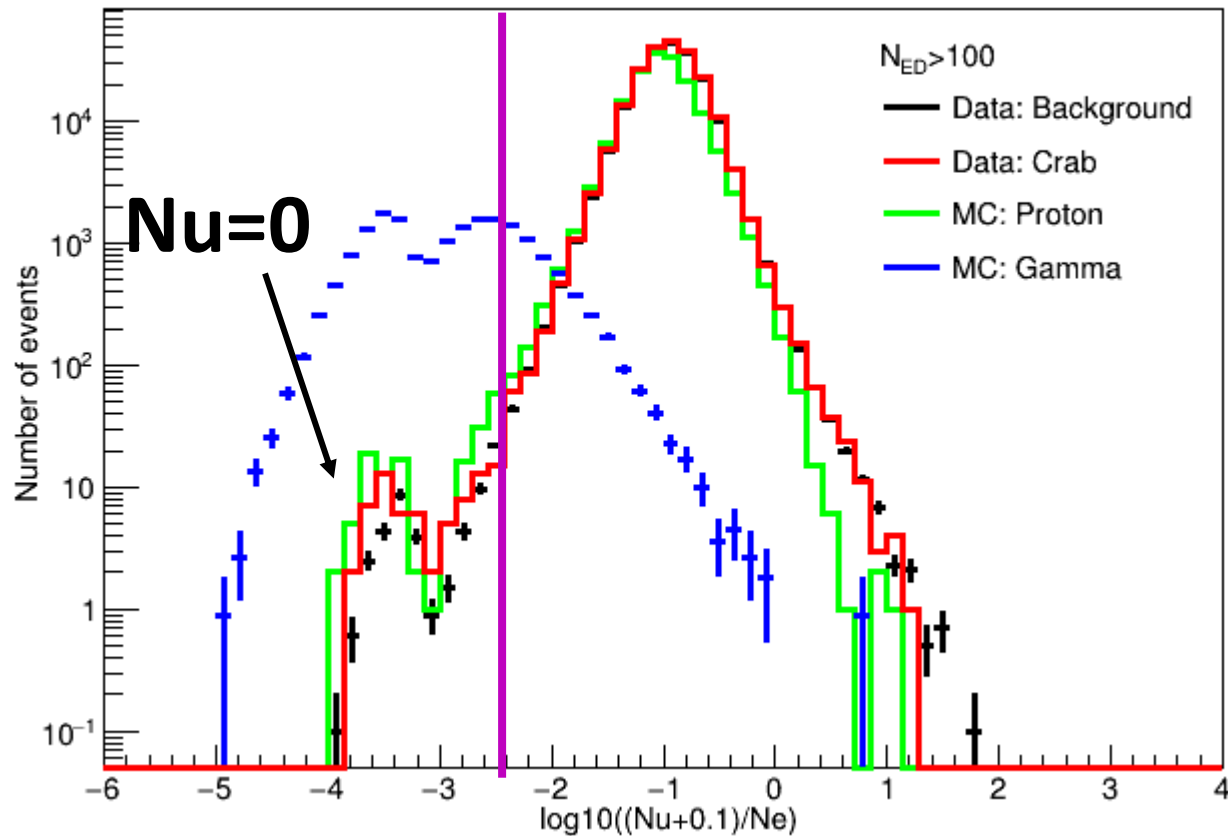


Angular resolution
 $0.18^\circ \pm 0.04^\circ$



Crab gamma-ray selection: MC vs Data

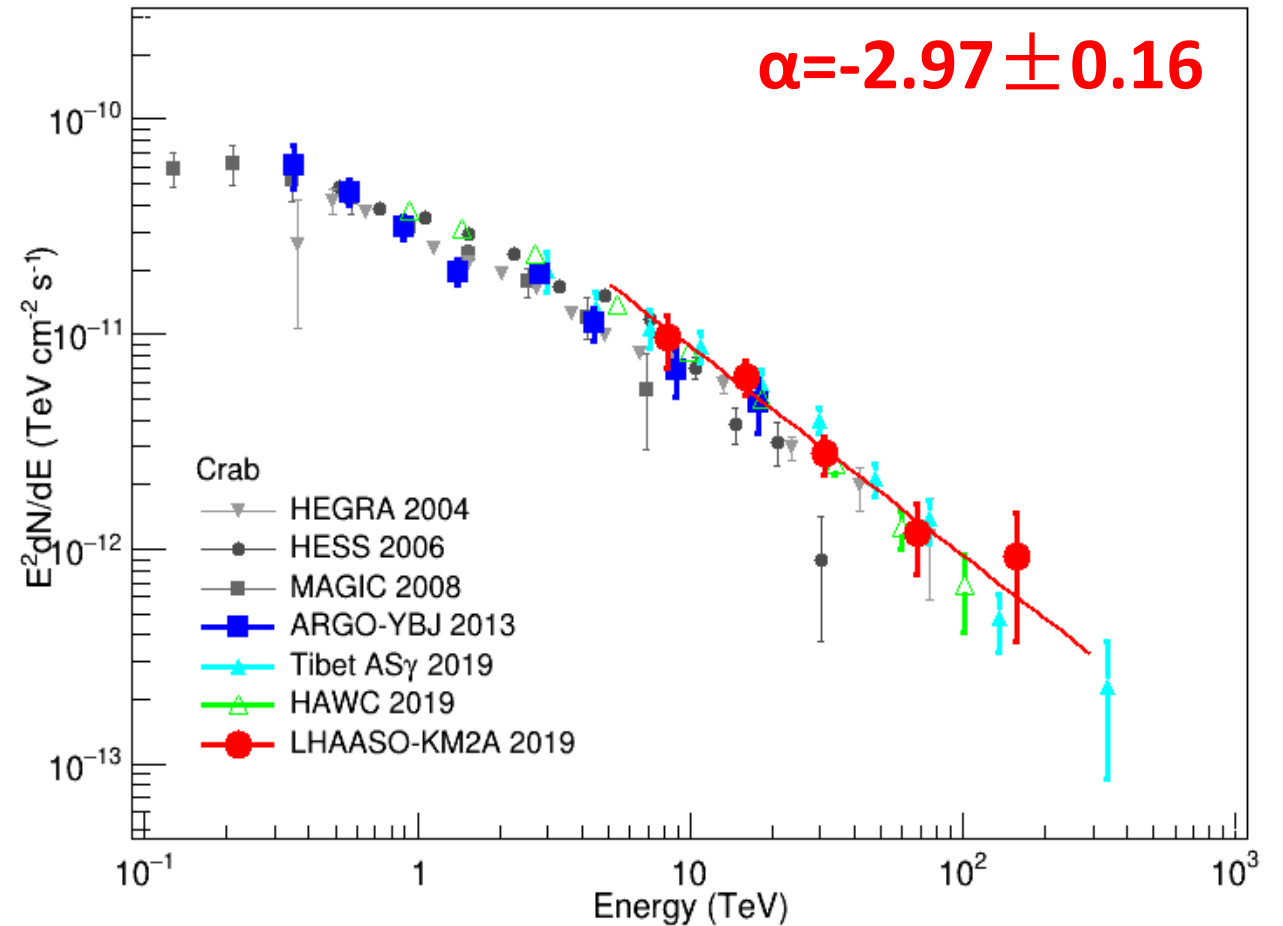
Nu/Ne distribution: MC is consist with data



Nu/Ne

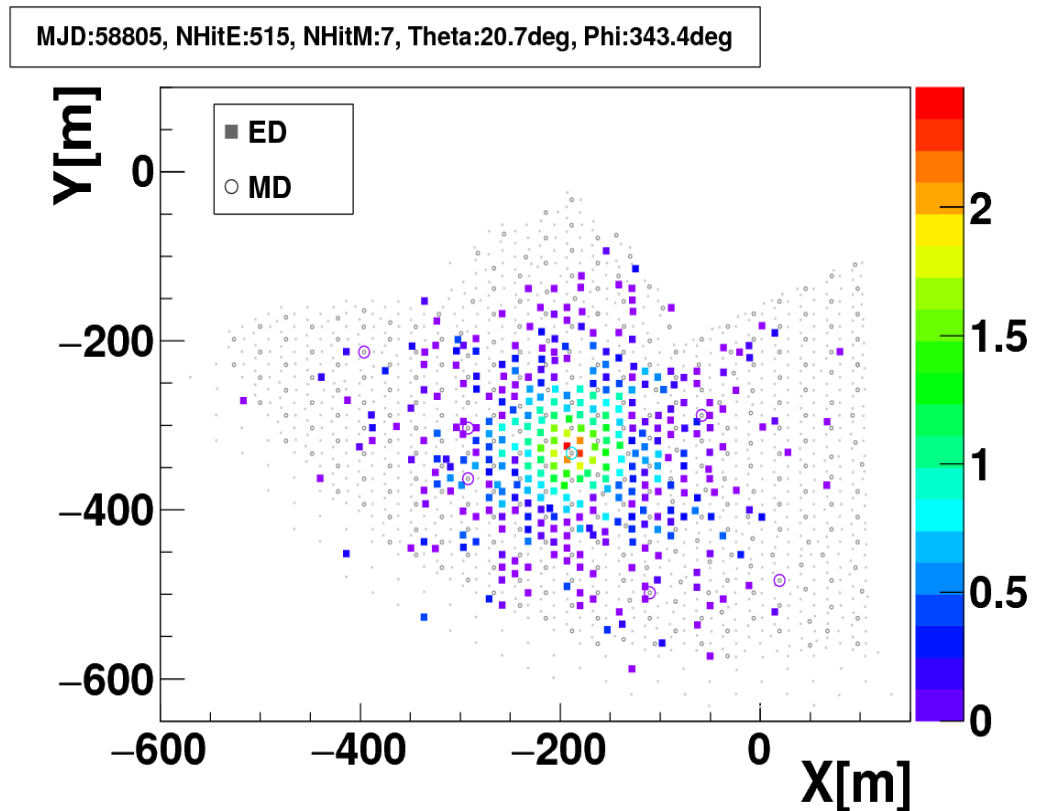
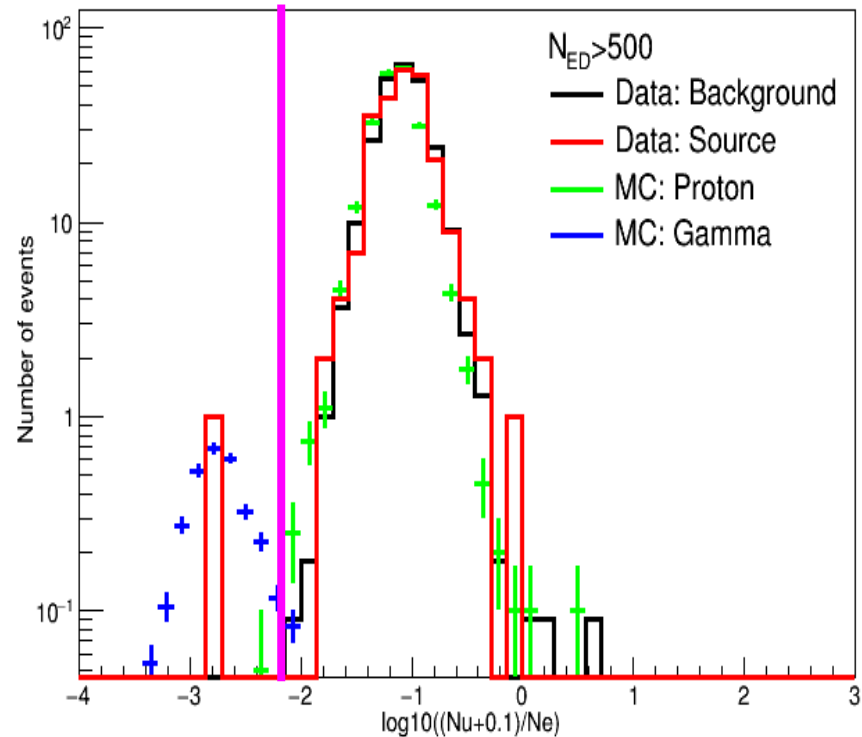
Crab SED

- Consistent with **ARGO-YBJ** at **10TeV**
- Consistent with **HEGRA, Tibet AS γ , HAWC** at **10-100TeV**
- **Maximum energy up to 200TeV**



Highest γ -ray event

- **~470 TeV**, detected in 2019-11-18!
- Possibility due to cosmic ray background is **0.023**.
- **This may hint for a PeVatron!**



Summary

- Using the 38 days data of ¼ KM2A, 3 γ -ray sources are detected around 100TeV with significance $>6\sigma$.
- According to analyses of the standard candle Crab Nebula, the point error is less than 0.2° , and the SED is consistent with previous experiment results.
- The highest energy gamma-ray detected up to now is ~ 470 TeV may hinting for PeVatron!
- ½ KM2A has been operating normally since December 26, 2019. It will bring the 100 TeV gamma-ray astronomy to a new level!

Thanks!