



LHAASO status and the first observational results

Zhen Cao for LHAASO Coll.
Institute of High Energy Physics, Beijing

Cosmic Rays and Neutrinos in the
Multi-Messenger Era, APC, Paris, Dec. 2020





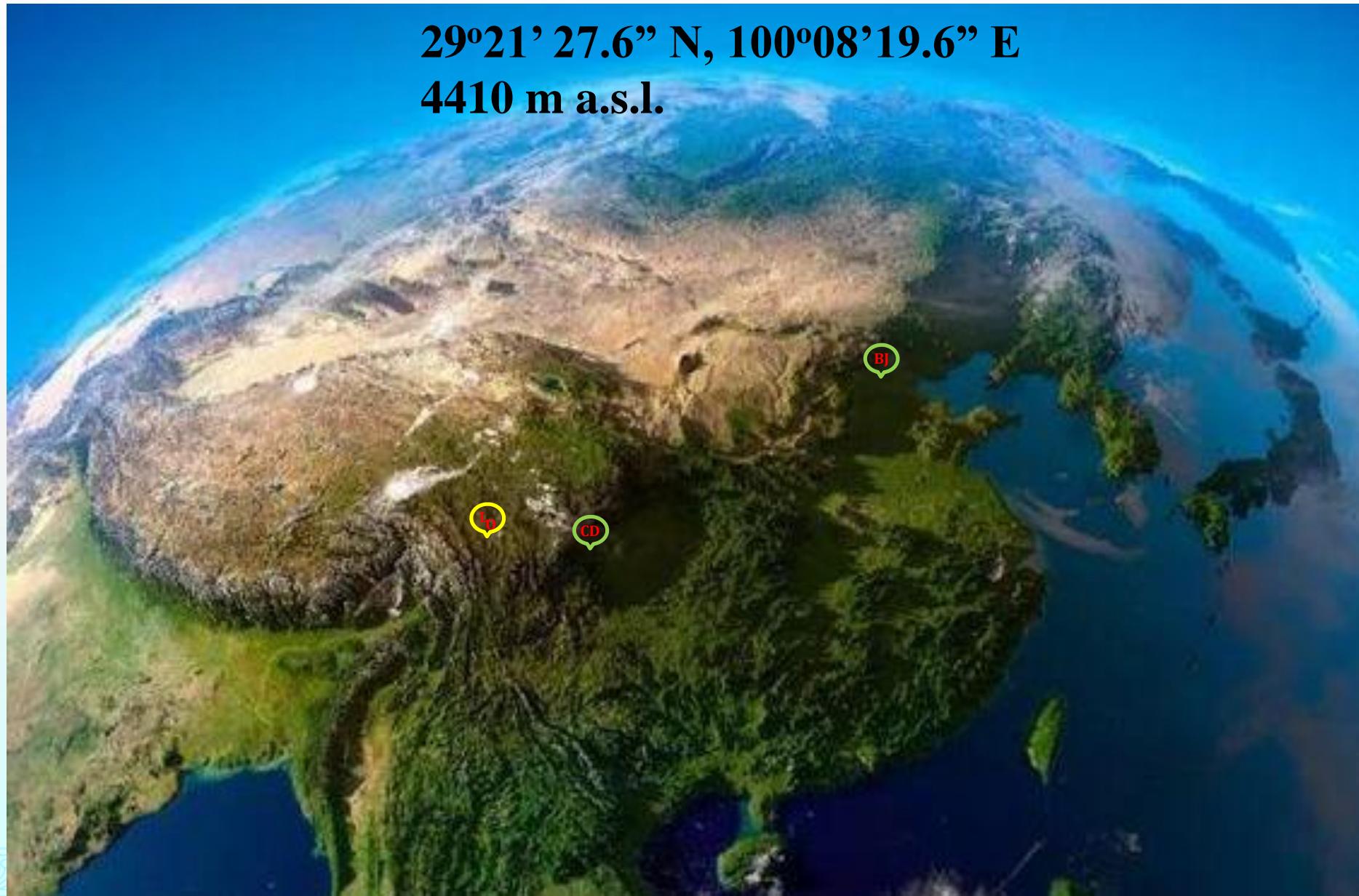
Content

- ❖ **Introduction of LHAASO**
- ❖ **Construction Status and Observational Results**
- ❖ **Summary**



LHAASO Geographic Location

**29°21' 27.6" N, 100°08'19.6" E
4410 m a.s.l.**





LHAASO Collaboration

Scientists: 260

Zhen Cao

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²⁴Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand

list of institutions waiting : Adelaide U, Australia

for membership: APS, France

Nankai U, China

Xinjiang Observatory, China



LHAASO Collaboration

(by country)

U. Geneva, Switzerland
VHE gamma astro.

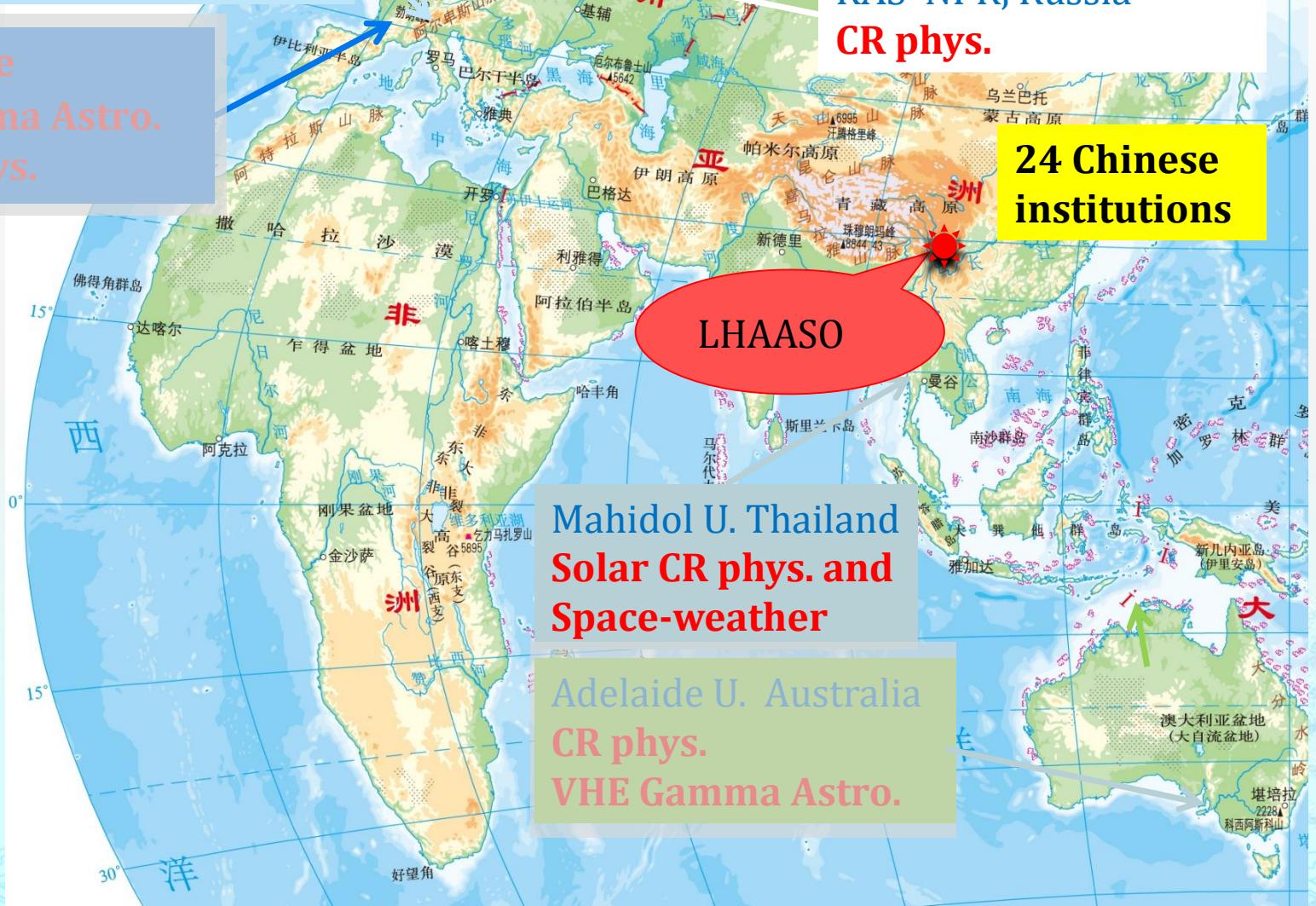
PAS, France
VHE Gamma Astro.
and CR phys.

RAS NPR, Russia
CR phys.

24 Chinese
institutions

Mahidol U. Thailand
Solar CR phys. and
Space-weather

Adelaide U. Australia
CR phys.
VHE Gamma Astro.



Xinjiang AO

乌鲁木齐

LHAASO Coll. Chinese institutions

24 Chinese
institutions

LHAASO

Tibet U

拉萨

Sichuan U

Northwest J. U

CAS Chengdu Divi.

Yunnan AO

Yunnan U

Guangxi U

Guangzhou U

SYSU

Tsinghua U

Pekin U

IHEP

Nankai U

Hebei Norm. U

Zhengzhou U

USTC

PAO

Shangdong U

Shanghai AO

Shanghai J. U

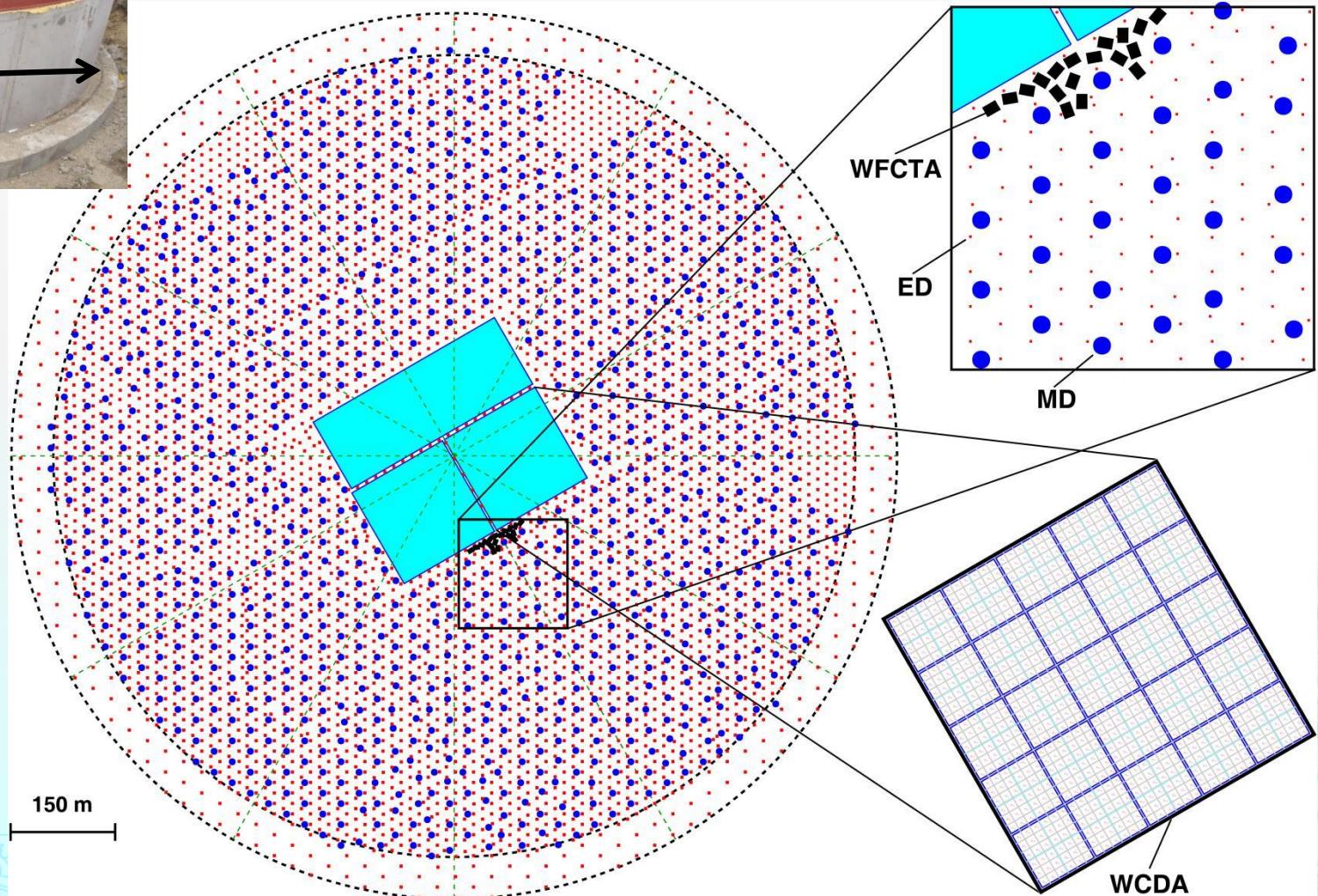
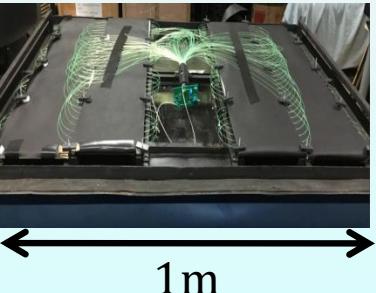
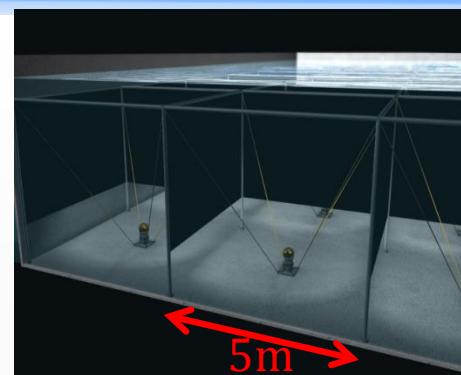
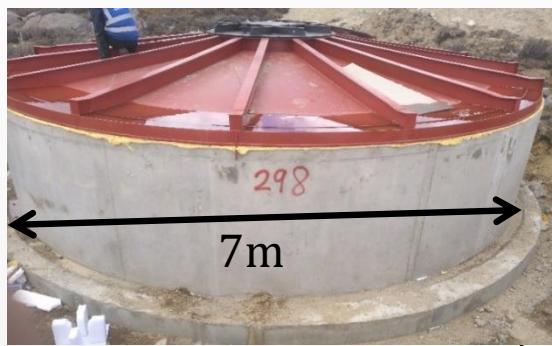
Wuhan U

SYSU

图例
首都
省级行政中心
国界
省、自治区、直辖市界
特别行政区界



Detector Layout in LHAASO

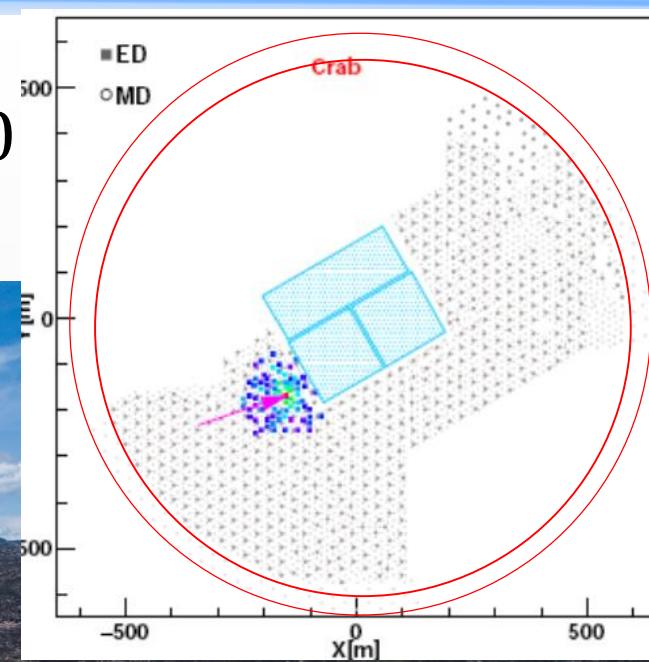




LHAASO Phase-I: Jan-Dec, 2020

Eastern view

- ◆ LHAASO bird view in Oct. 2019





LHAASO Phase-II: Dec,2020—



LHAASO Phase-II: Dec,2020—

2019-12-12

Muon Counter Scintillator Detector

operating

594

2514

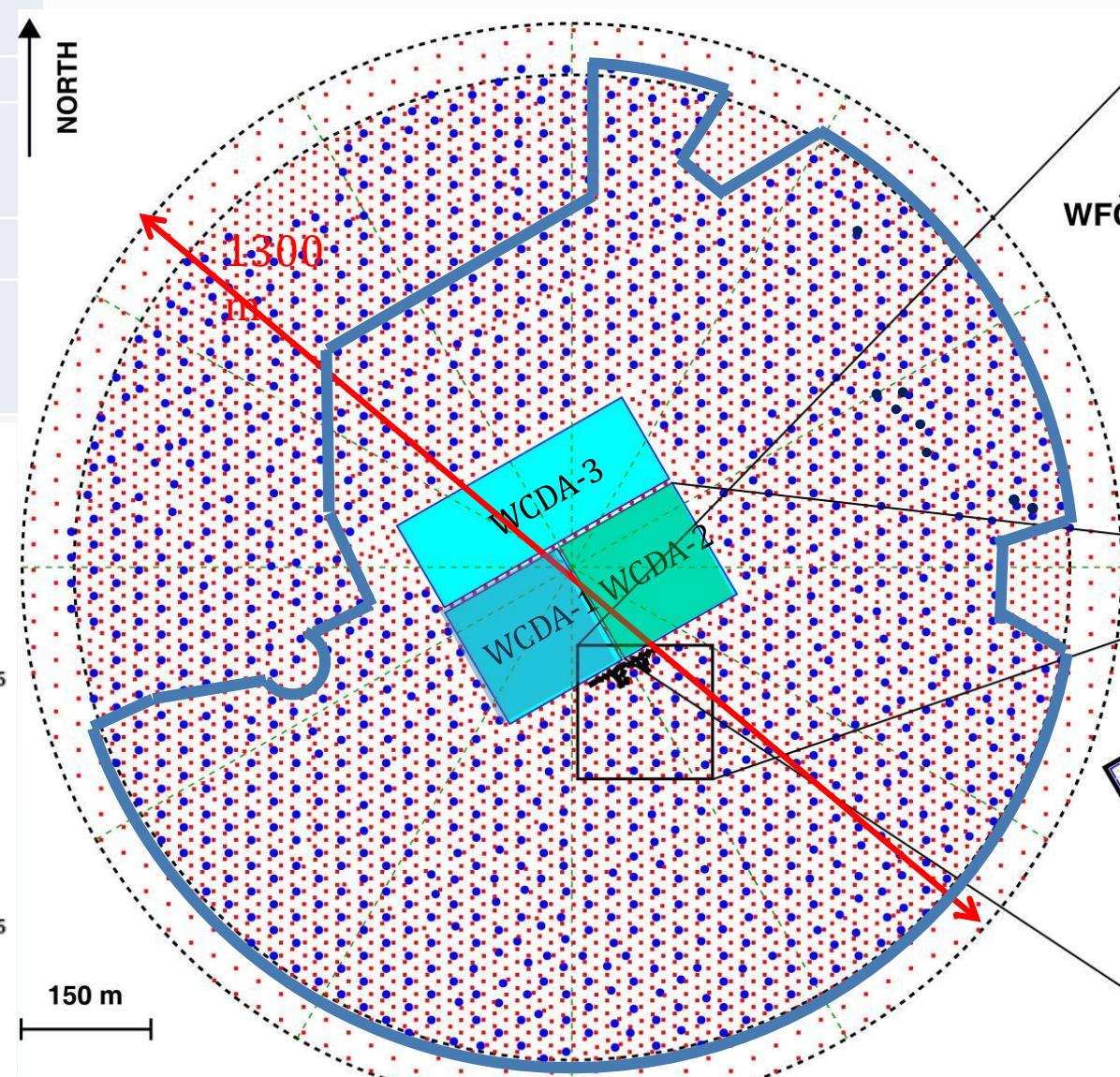
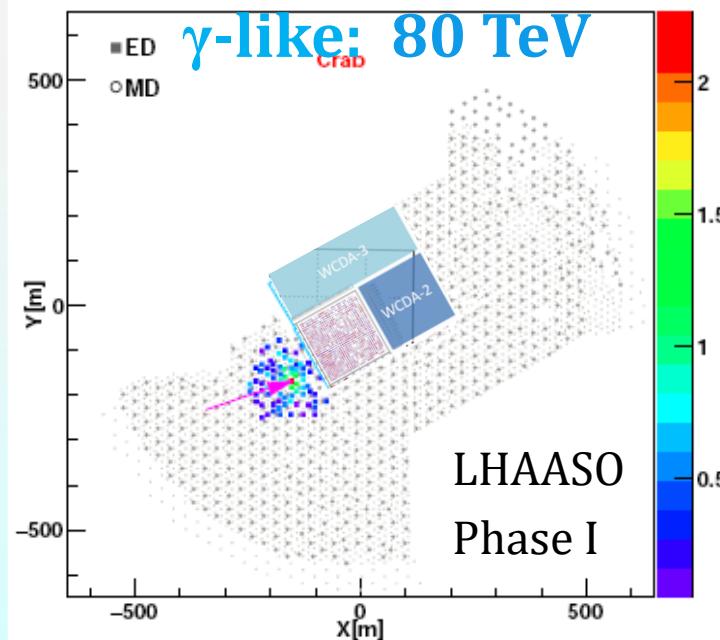
2010-11-30

operating

917
3978

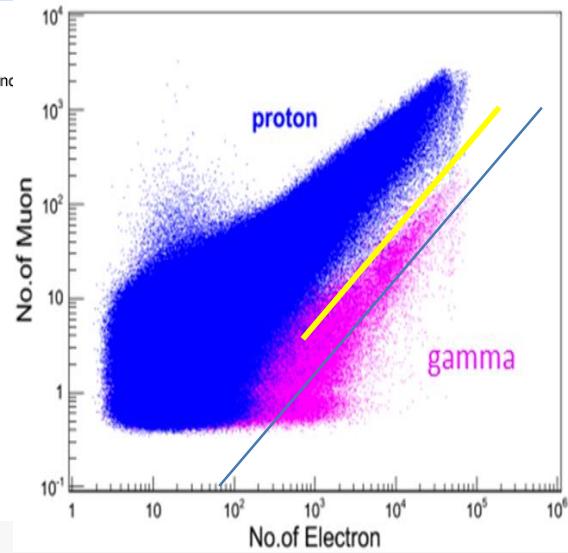
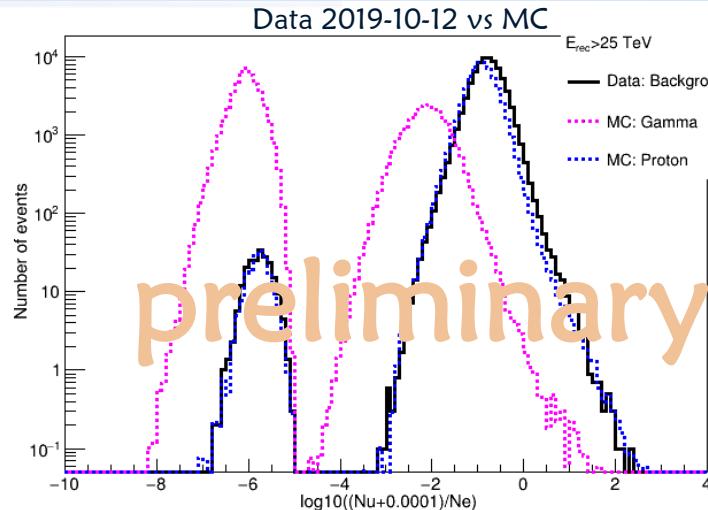
 Percentage
of designed
sensitivity

88%

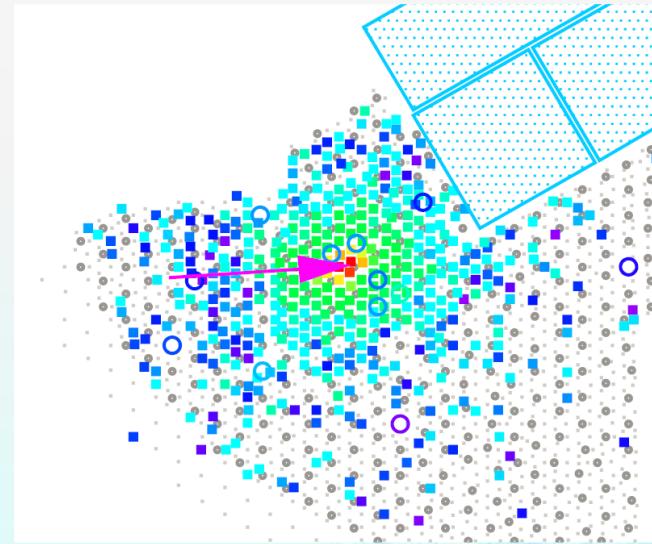
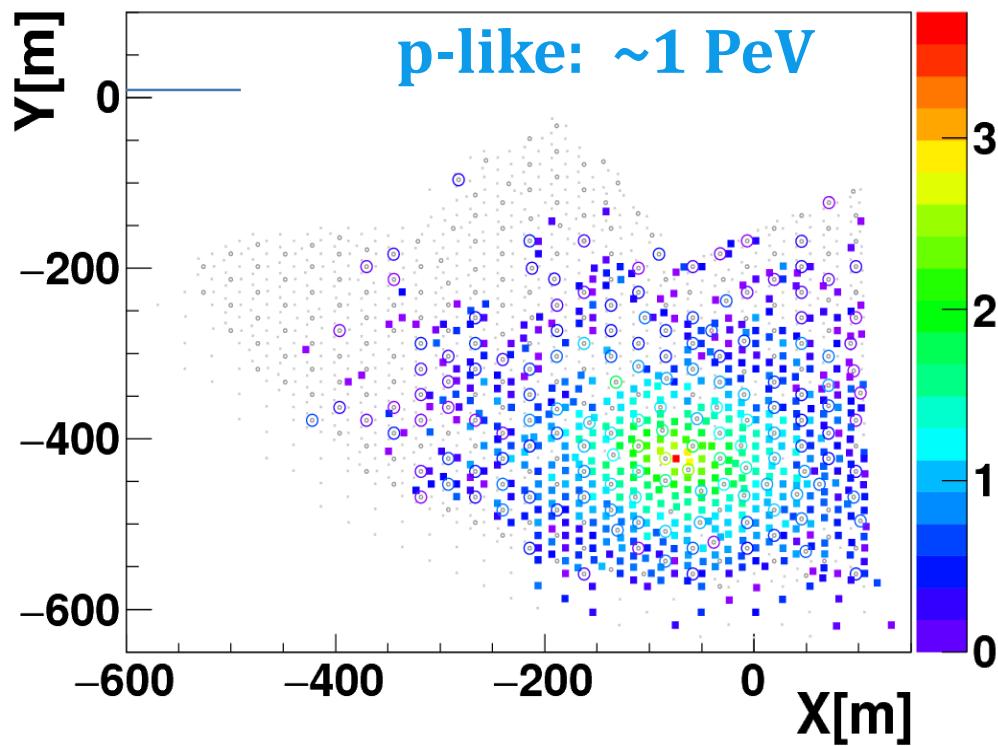
 MJD : 58908.57, Ne : 465.8, Nu : 0.0, E_{hit} : 99.0TeV, E_{pe} : 80.9TeV




γ /proton Separation: Separation: μ -content

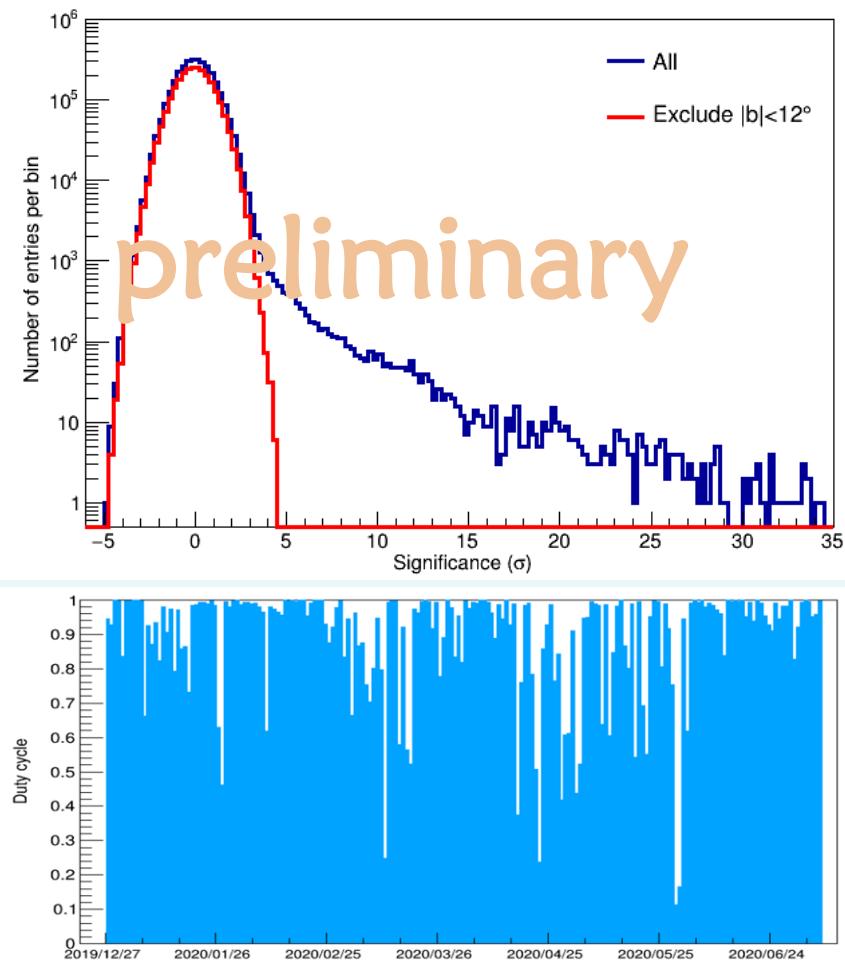
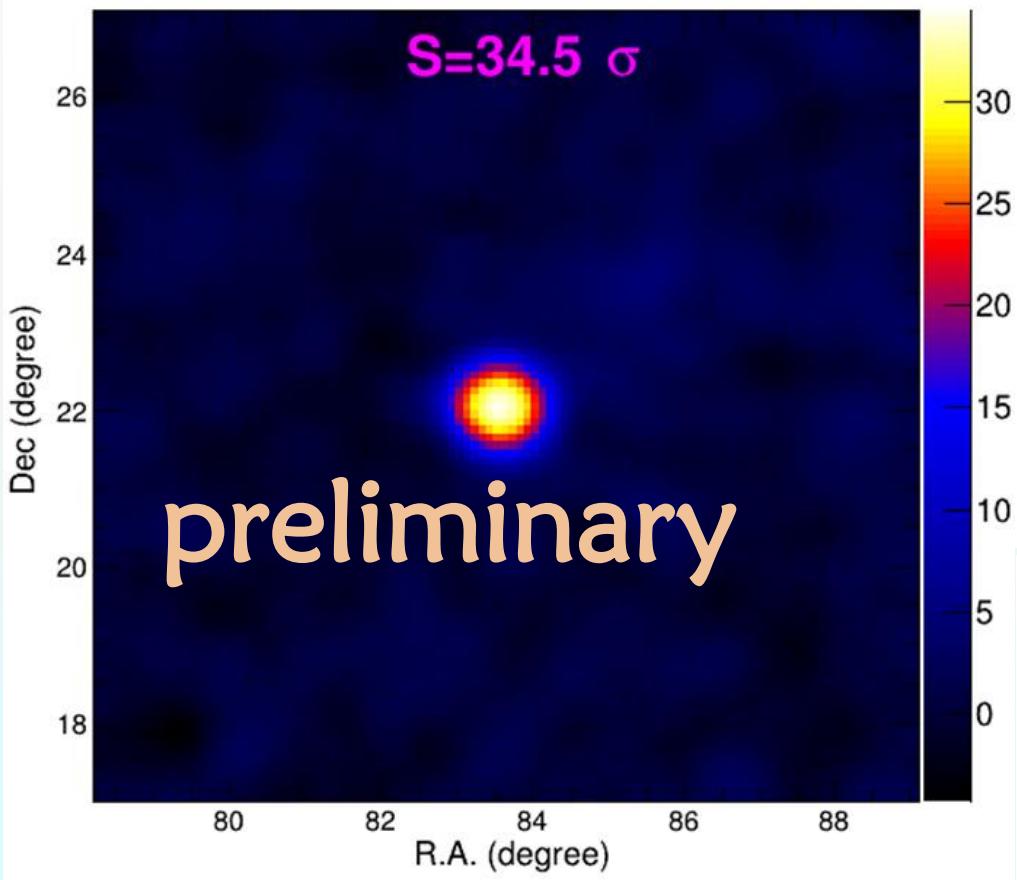


MJD:58788, NHitE:656, NHitM:154, Theta:31.2deg, Phi:284.0deg



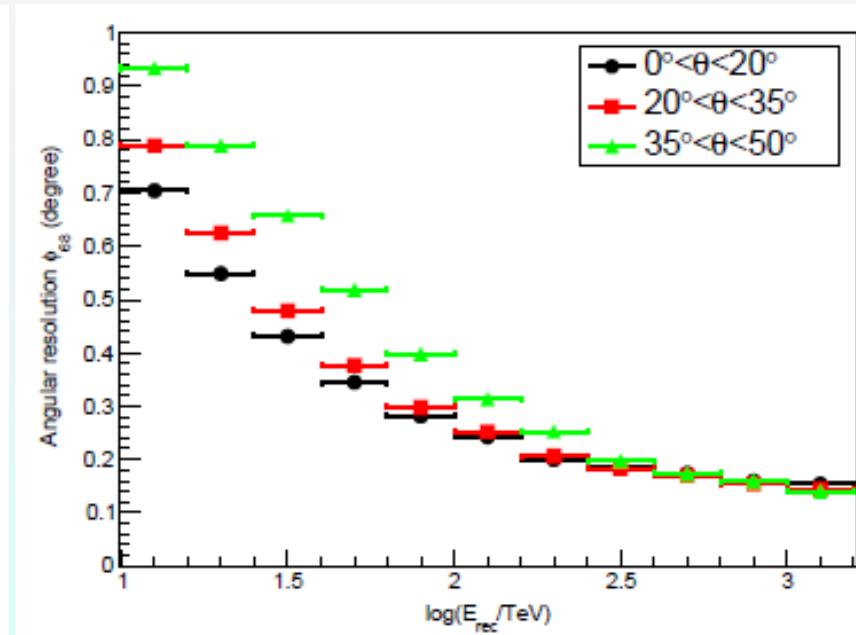
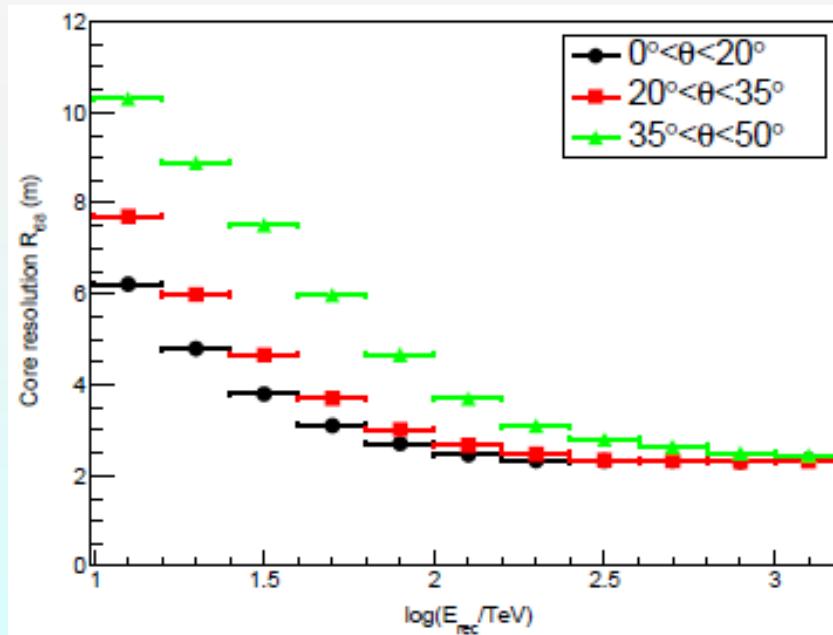
Standard Candle

- ◆ 2019-09-11 to 2020-07-07
- ◆ Pointing accuracy: $\sim 0.1^\circ$
- ◆ Angular resolution: 0.26°
- ◆ Significance: 35σ (> 25 TeV)



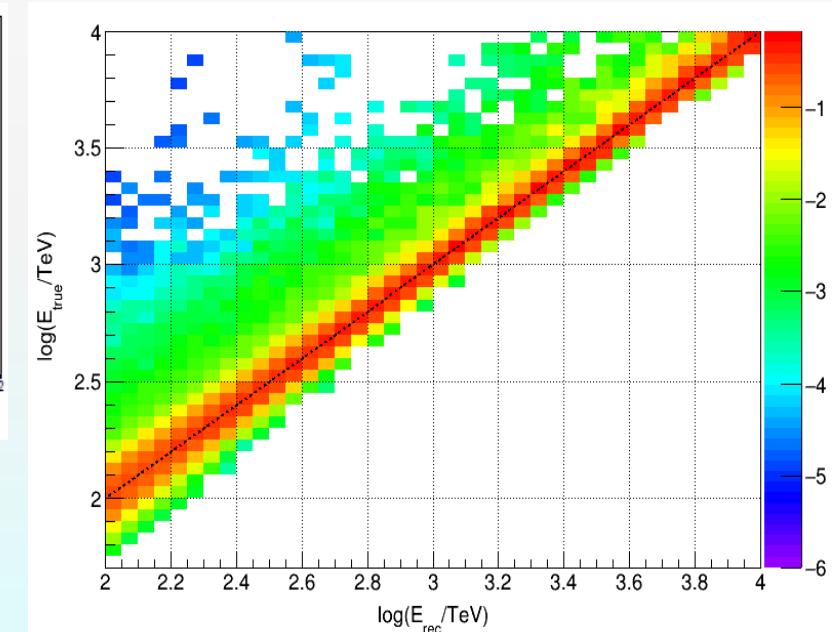
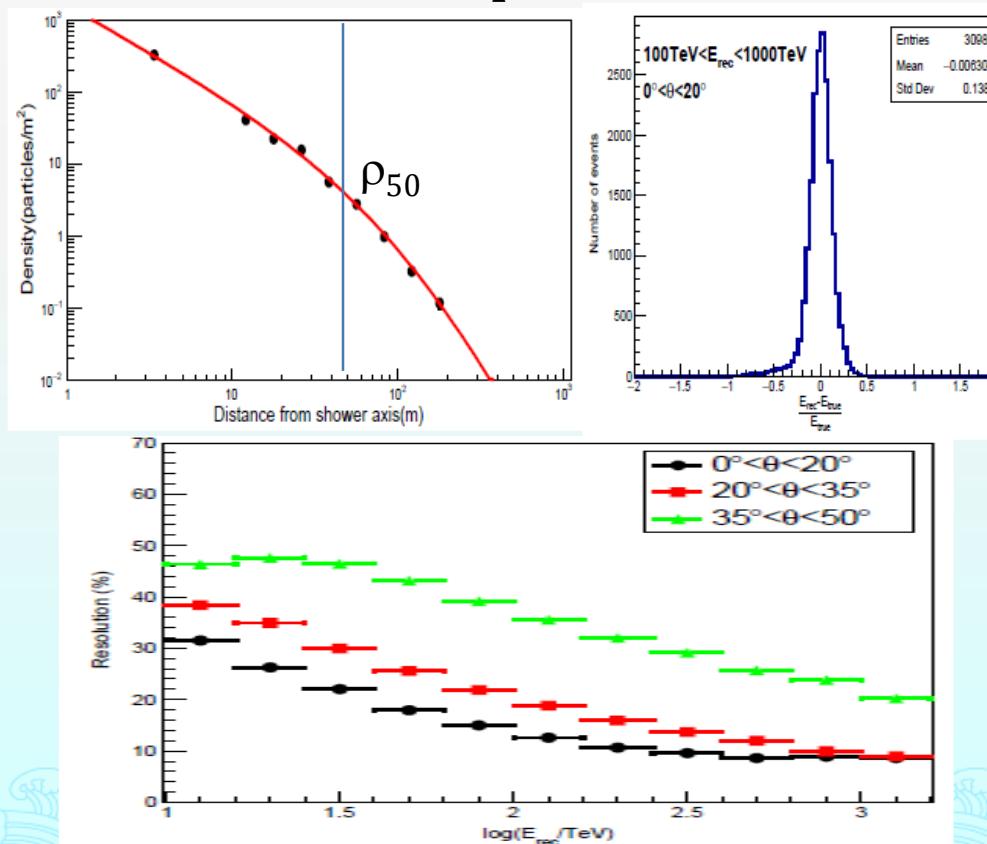
KM2A performances

- ◆ Shower geometrical reconstruction
 - ◆ Arrival direction: resolution of **0.3°** @100 TeV
 - ◆ Shower core location: resolution of **3 m** @100 TeV
 - ◆ Zenith angle effect



Shower Energy Reconstruction

- ❖ Lateral distribution: modified NKG function
- ❖ Energy estimator: ρ_{50} particle density @100 TeV
- ❖ Gaussian Resolution function >100 TeV: **14%**
- ❖ Linear response function





Water Cherenkov Detector Array

3 Arrays

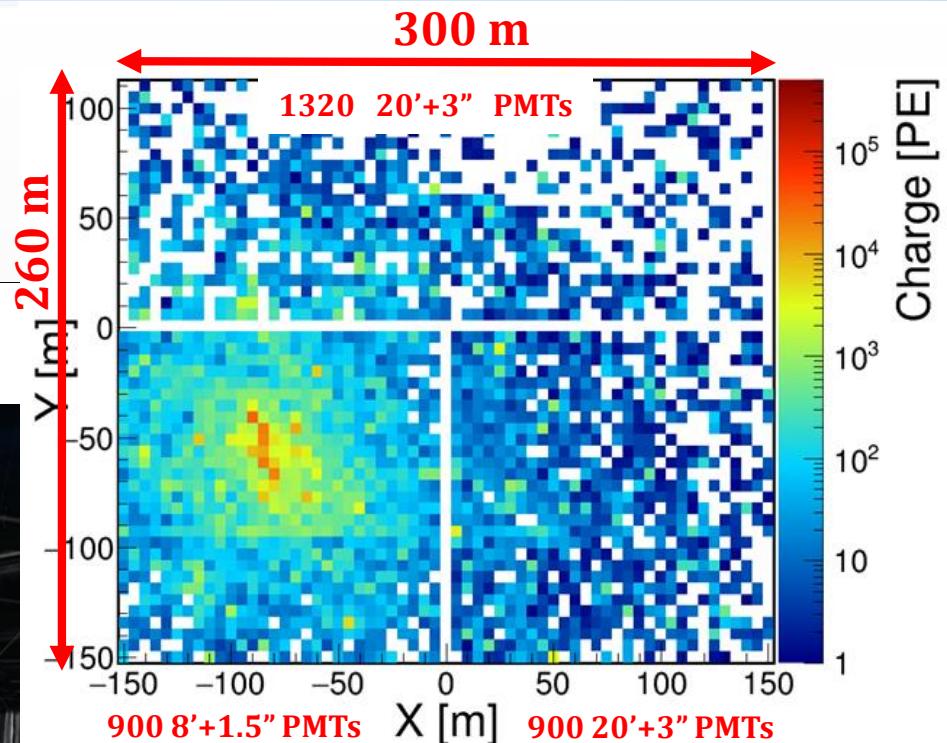
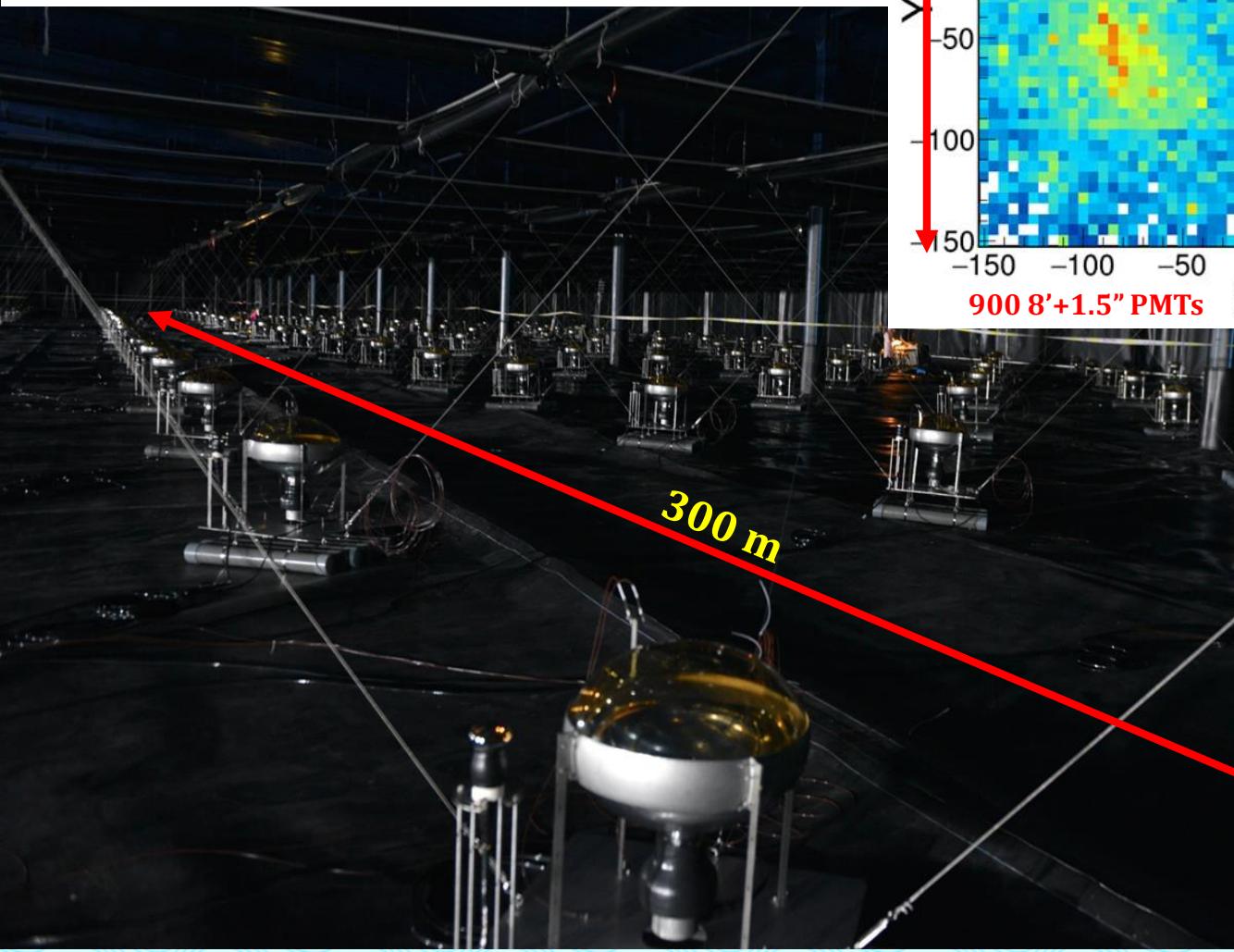
- 1: 22,500 m² 8"PMTs
- 2: 22,500 m² 20"PMTs
- 3: 33,000 m² 20"PMTs





Inside WCDA-3

- WCDA-1 started operating April 2019
- WCDA-2 started operating January 2020



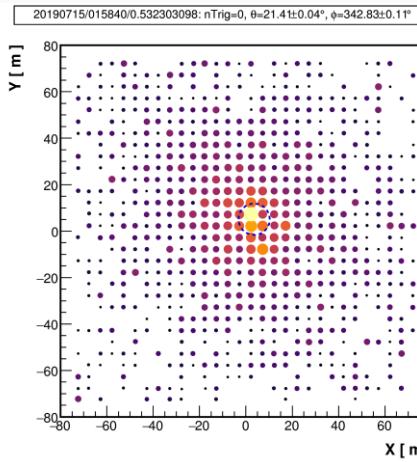
Inside WCDA-1



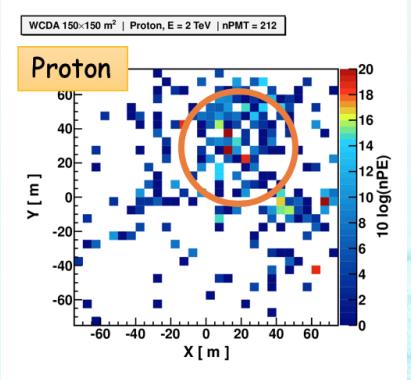
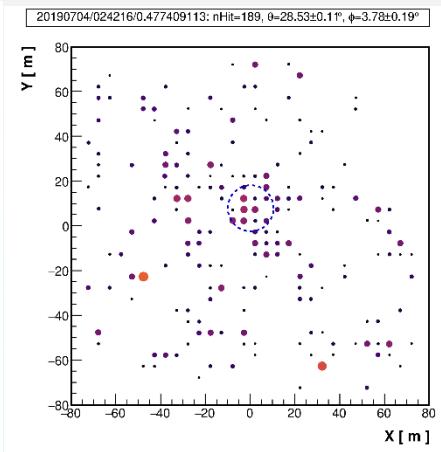
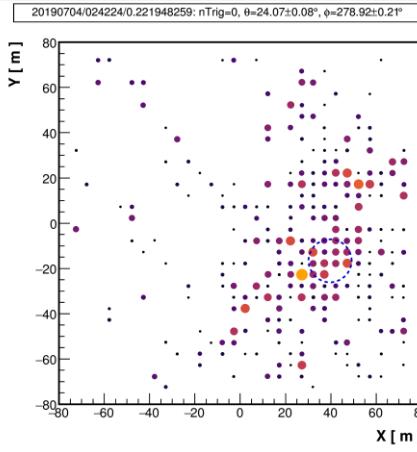
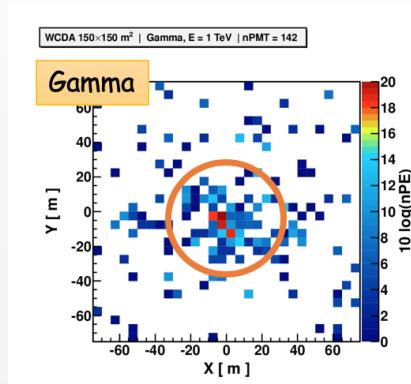
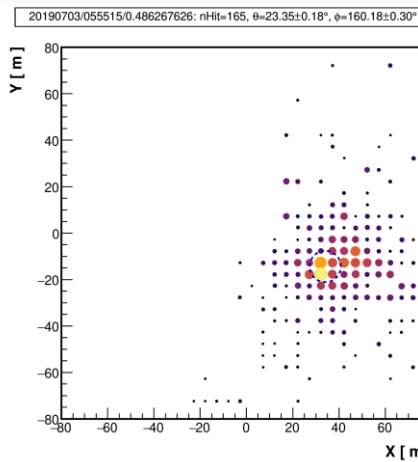
Pure Gamma Event Set!

Data MC

γ -like, $N_{\text{hit}}=168$



$N_{\text{hit}}=168$

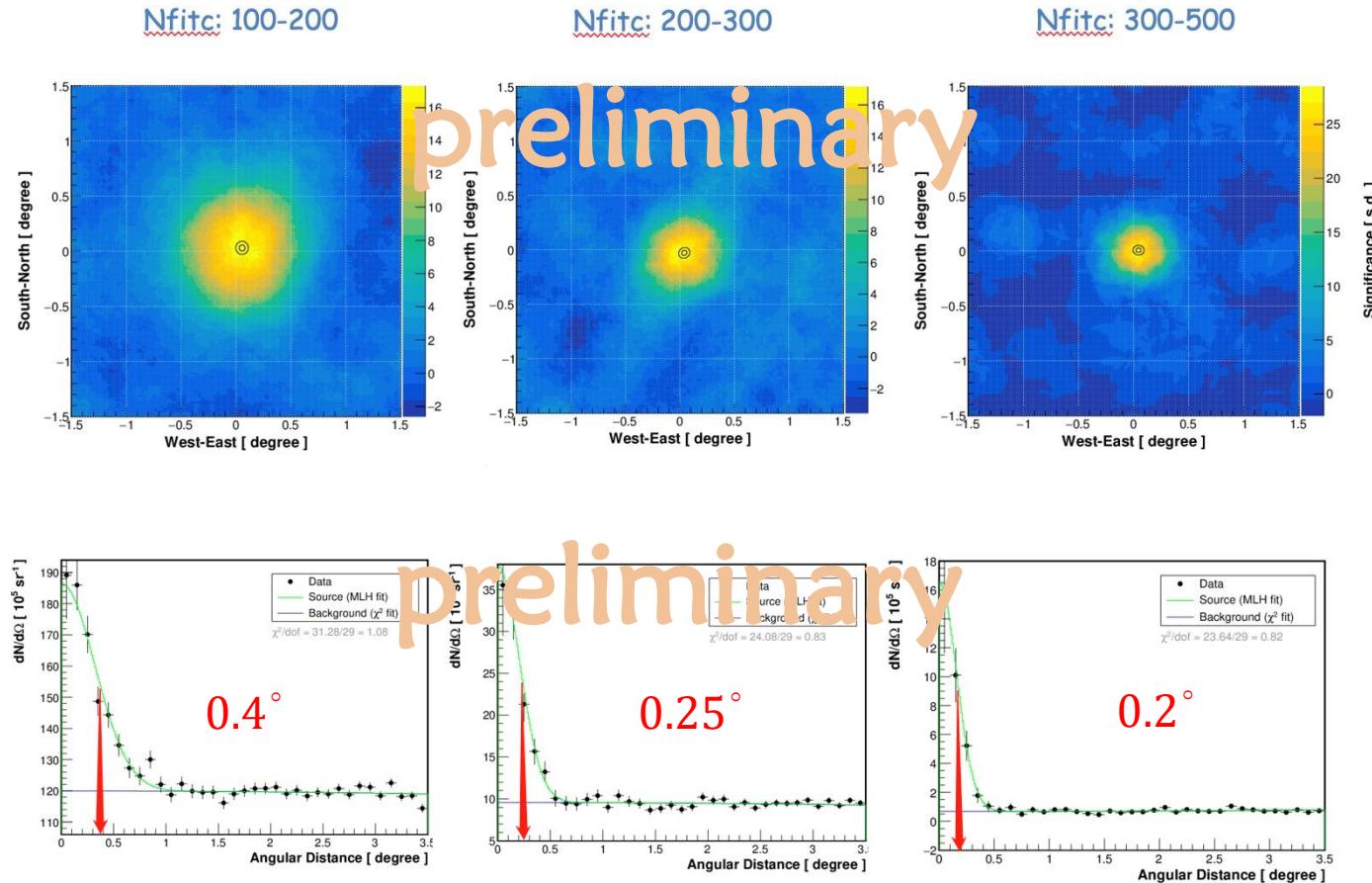


hadron-like, $N_{\text{hit}}=261$

$N_{\text{hit}}=189$

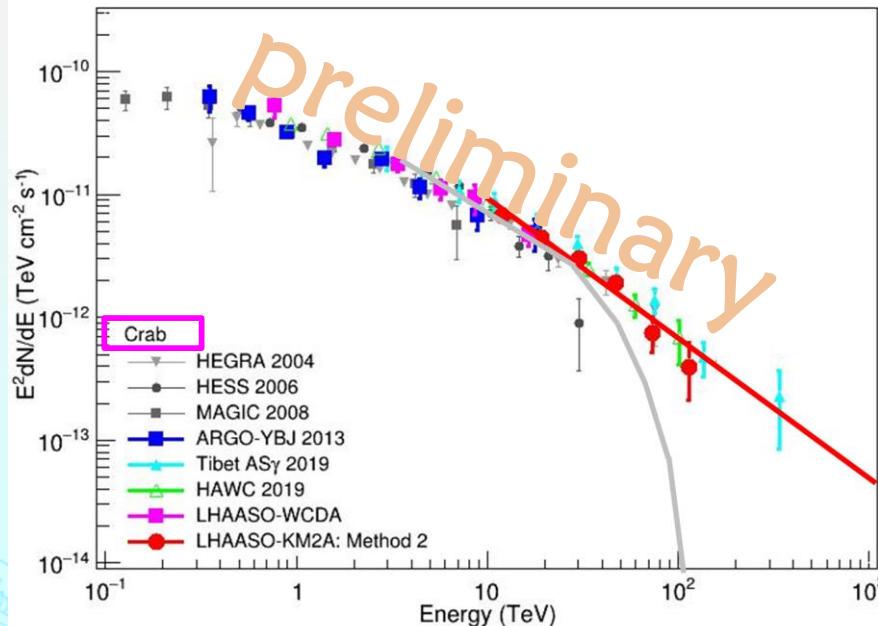
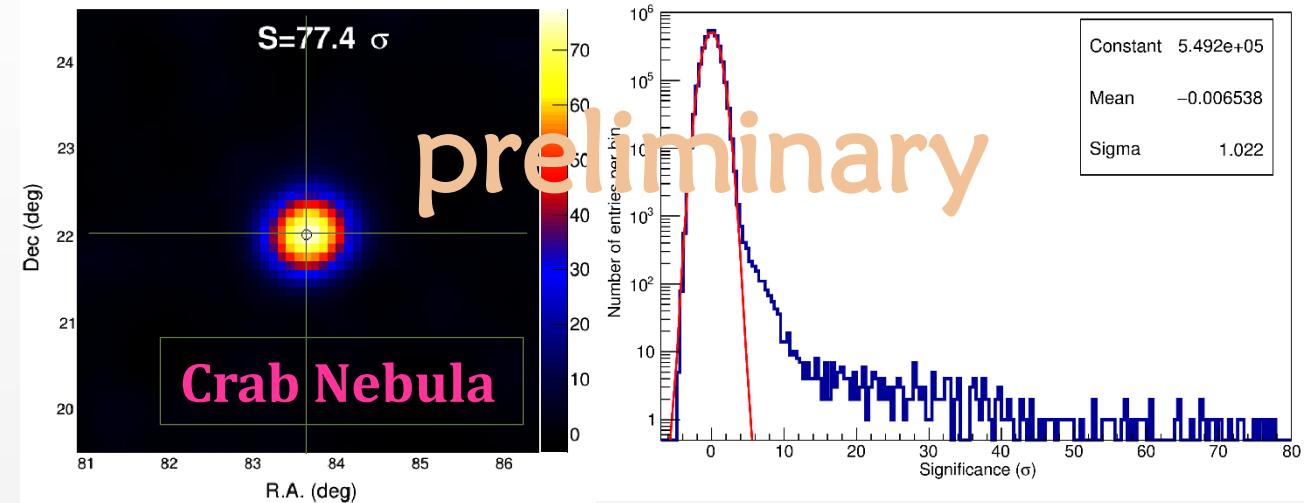
Pointing and Resolution

- ◆ Pointing accuracy is already good, though we still found the orientation of WCDA-1 29.45° towards west instead of 30.00° that results in an even better pointing



Standard Candle for WCDA & KM2A

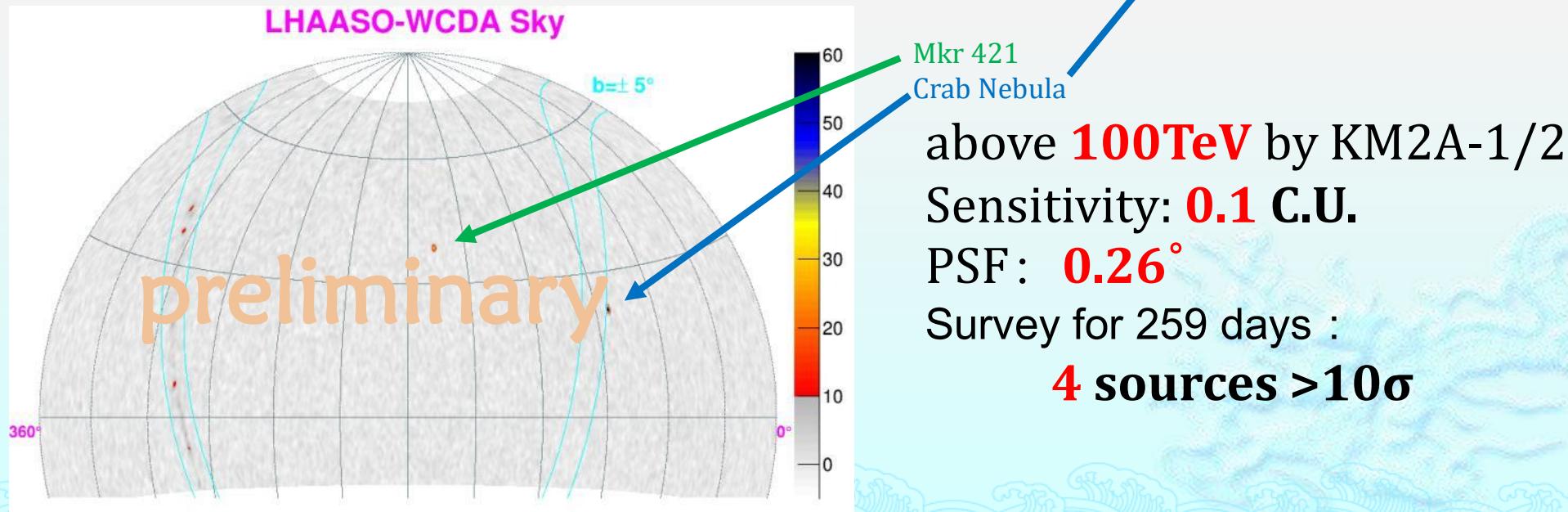
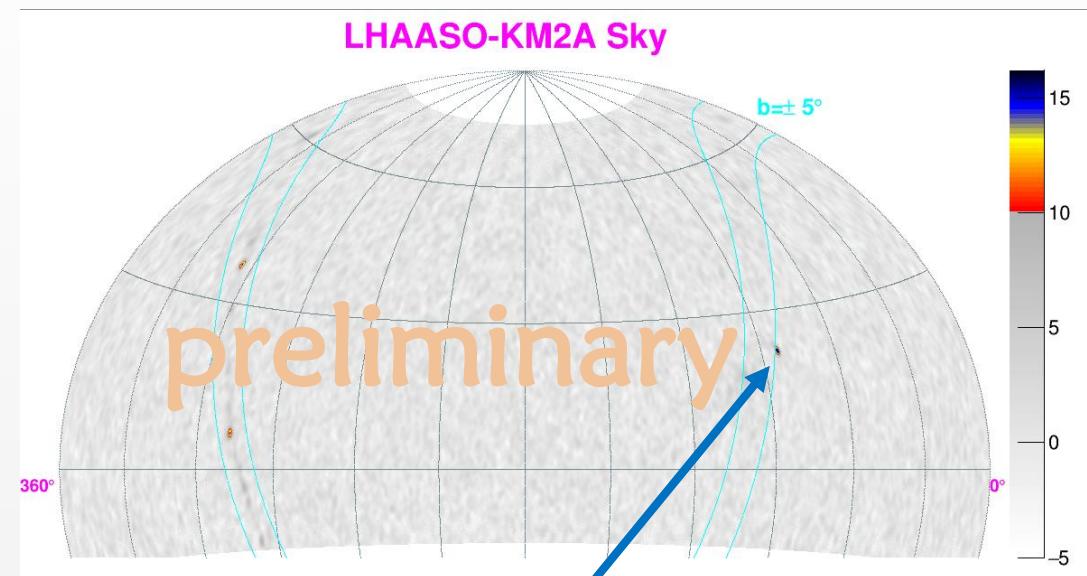
- Up to March 2020
- Crab 77σ ($E > 1$ TeV) by WCDA-1
- Pointing error $< 0.1^\circ$



- Not only for the Crab Nebula
- All sources have clear power law spectra in UHE region
- no indication of cut-off
- Posting challenges to models with limits of accelerating power of galactic sources

LHAASO: Full of PeVatrons in MW

Below 10TeV by WCDA-1
 Sensitivity: **60** mC.U.
 PSF: **0.26°**
 Survey for 300 days :
6 sources >10σ



WFCTA Phase-I:
Oct. 2019-
May 2020
had 6 telescopes
operated

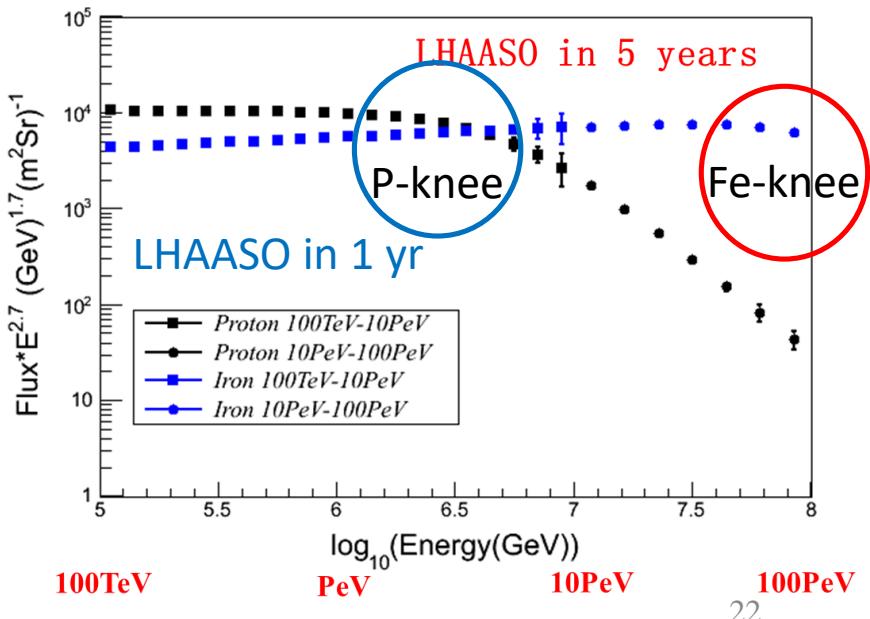
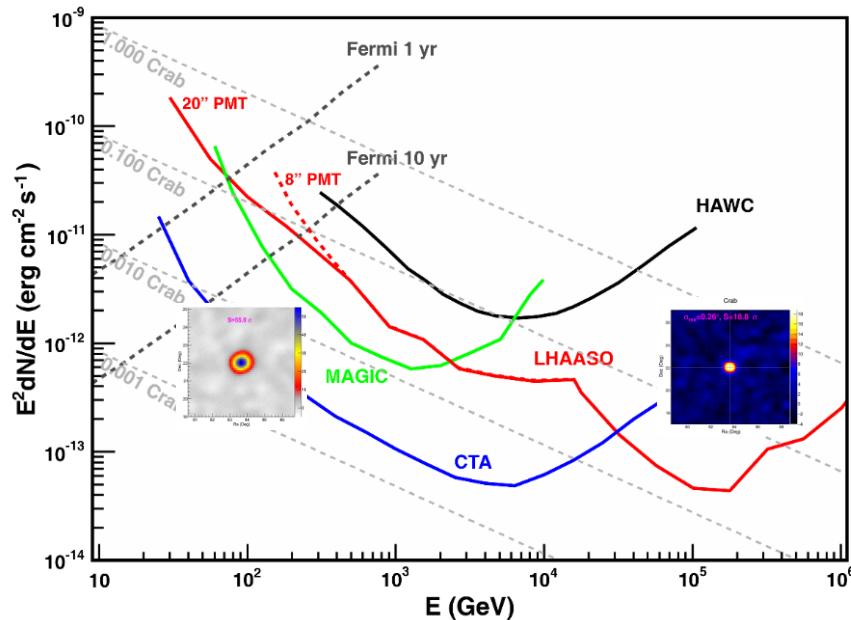
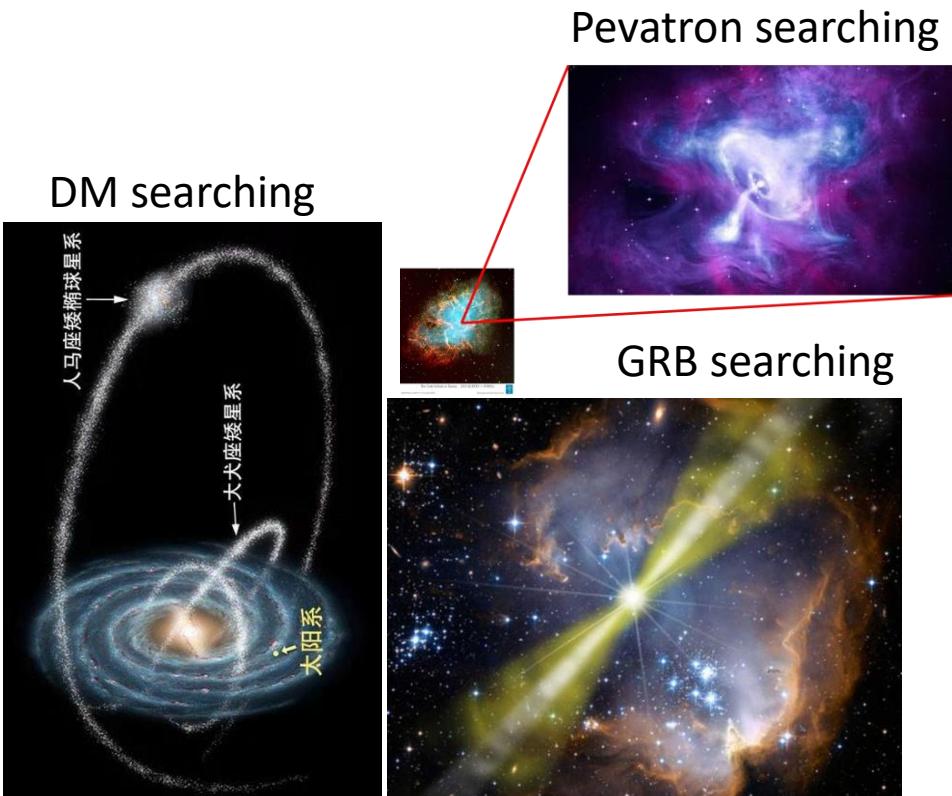
Phase-II:
Oct. 2020 —

14 telescopes
in operation



Physics Topics

- Gamma Ray Astronomy
- Charged CR Spectra
- New Physics Frontier





Summary

- ◆ ½-LHAASO has been operated for 259 days for phase-I
- ◆ ¾-LHAASO has been turned on for phase-II operation with 88% designed sensitivity now
- ◆ The entire array will be built up in 2021
- ◆ LHAASO observatory for gamma ray astronomy and CR phys.
 - ◆ Unique for UHE ($>0.1\text{PeV}$) γ -astronomy: full of **PeVatrons in the Milky Way** which are generating **super-PeV photons**
 - ◆ No indication of cut-off for most galactic sources:
opening the UHE γ -astronomy era
 - ◆ Evidences of hadronic origin of γ 's are expected
 - ◆ SED measurements covering a range of **0.1-1000 TeV** by LHAASO
 - ◆ Wide FOV monitoring for **transient phenomena** below 1 TeV
 - ◆ Precision measurements of E-spectra of CR species
- ◆ Big potential of discovery of Galactic CR origins