



LHAASO status and the first observational results

Zhen Cao for LHAASO Coll.

Institute of High Energy Physics, Beijing

CTA-Japan Workshop, ICRR, Tokyo, Dec. 2020

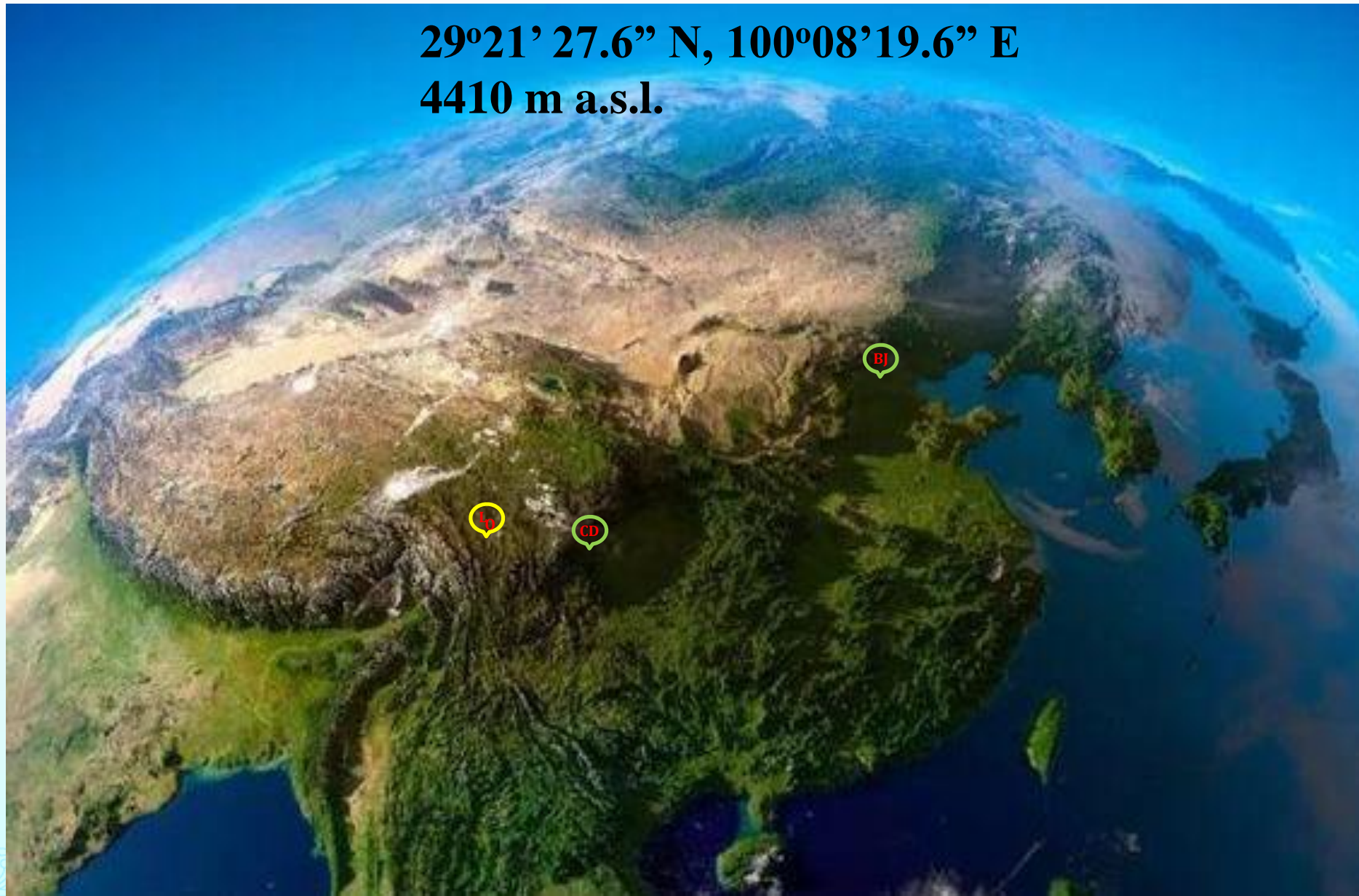


Content

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

LHAASO Geographic Location

$29^{\circ}21'27.6''$ N, $100^{\circ}08'19.6''$ E
4410 m a.s.l.





LHAASO Collaboration

Scientists: 260

Institutions: 27

The LHAASO Collaboration

Zhen Cao

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list of institutions waiting : Adelaide U., Australia

for membership: APS, France

Nankai U., China

Xinjiang Observatory, China

LHAASO Collaboration

U. Geneva, Switzerland
VHE gamma astro.

PAS, France
VHE Gamma Astro.
and CR phys.

(by country)

RAS NPR, Russia
CR phys.

24 Chinese
institutions

LHAASO

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

Adelaide U. Australia
CR phys.
VHE Gamma Astro.



LHAASO Coll. Chinese institutions

Xinjiang AO

乌鲁木齐

24 Chinese institutions

LHAASO

Tibet U

拉萨

Tsinghua U

Pekin U

IHEP

Nankai U

NSSC

NAO

Shandong U

Hebei Norm. U

Zhengzhou U

Sichuan U

Northwest J. U

USTC

PAO

Shanghai AO

Nanjing U

Shanghai J. U

CAS Chengdu Divi.

Wuhan U

Yunnan AO

Yunnan U

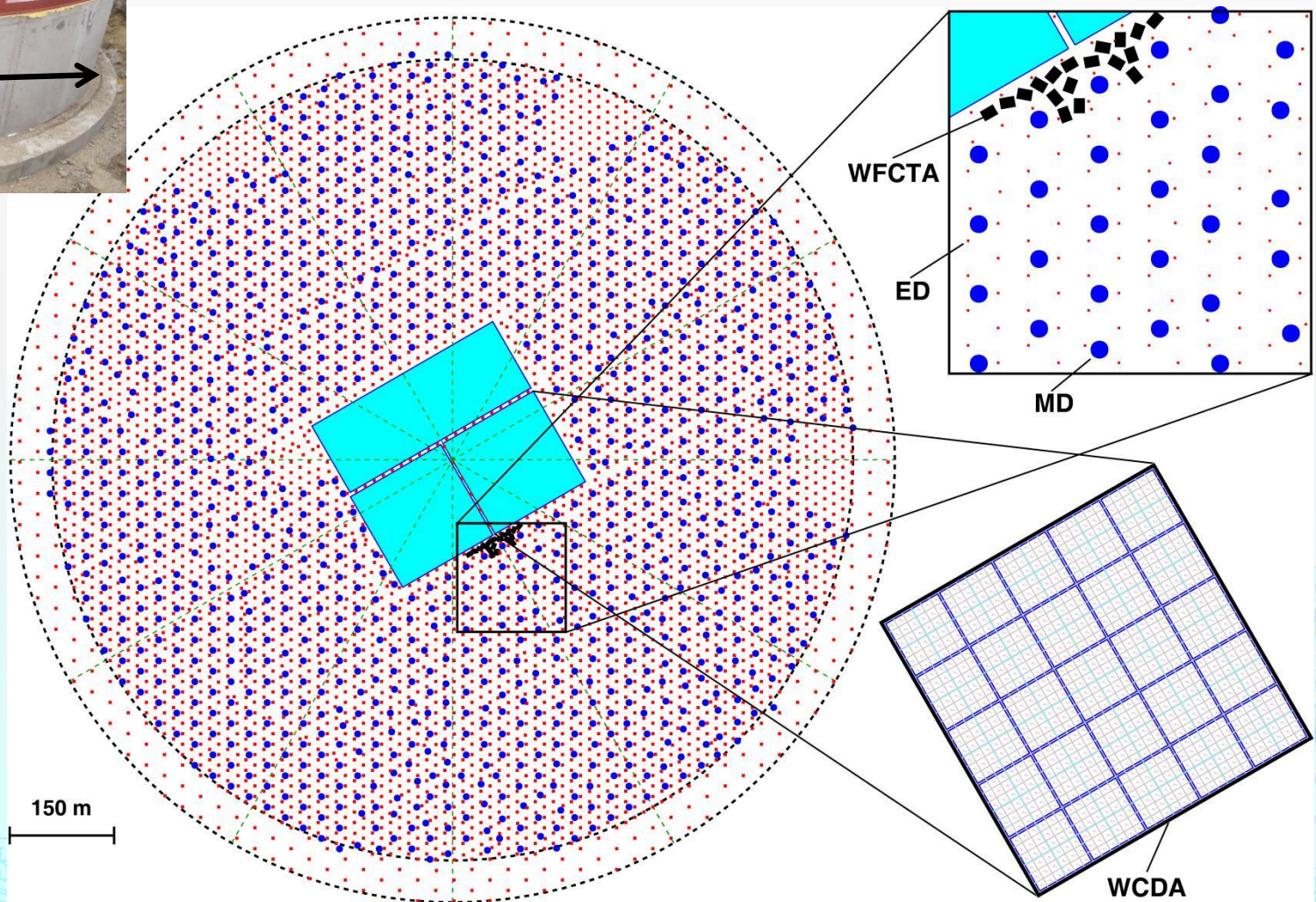
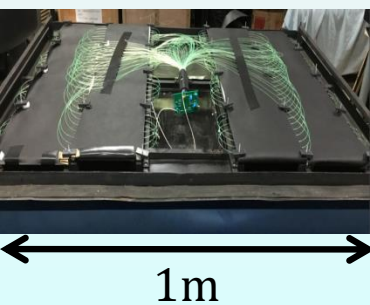
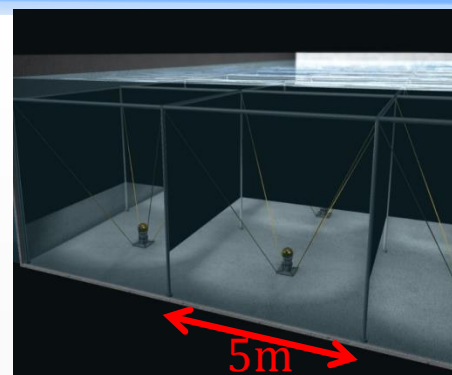
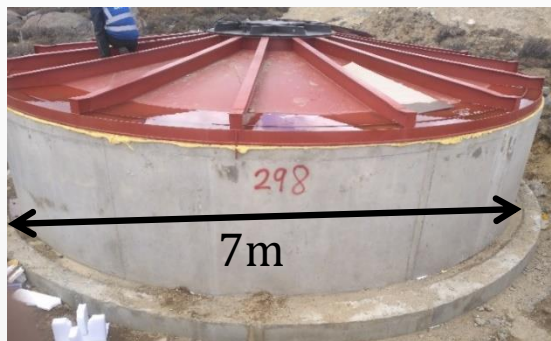
Guangzhou U

Guangxi U

SYSU

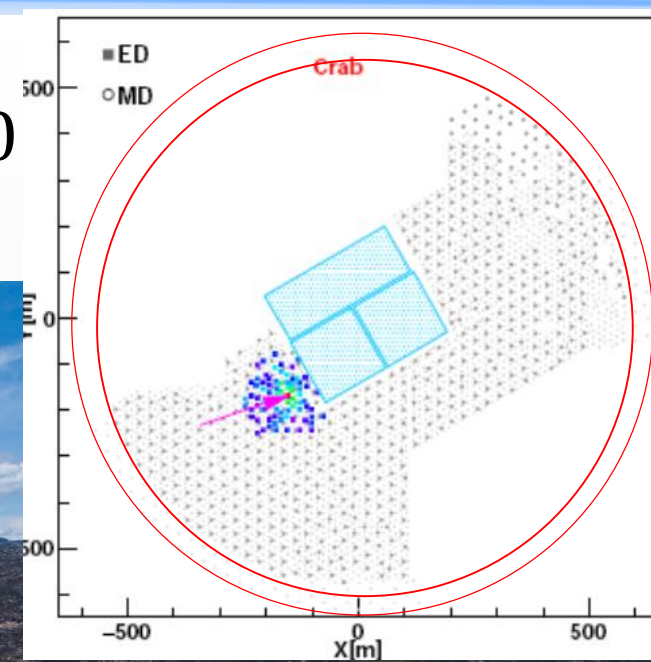
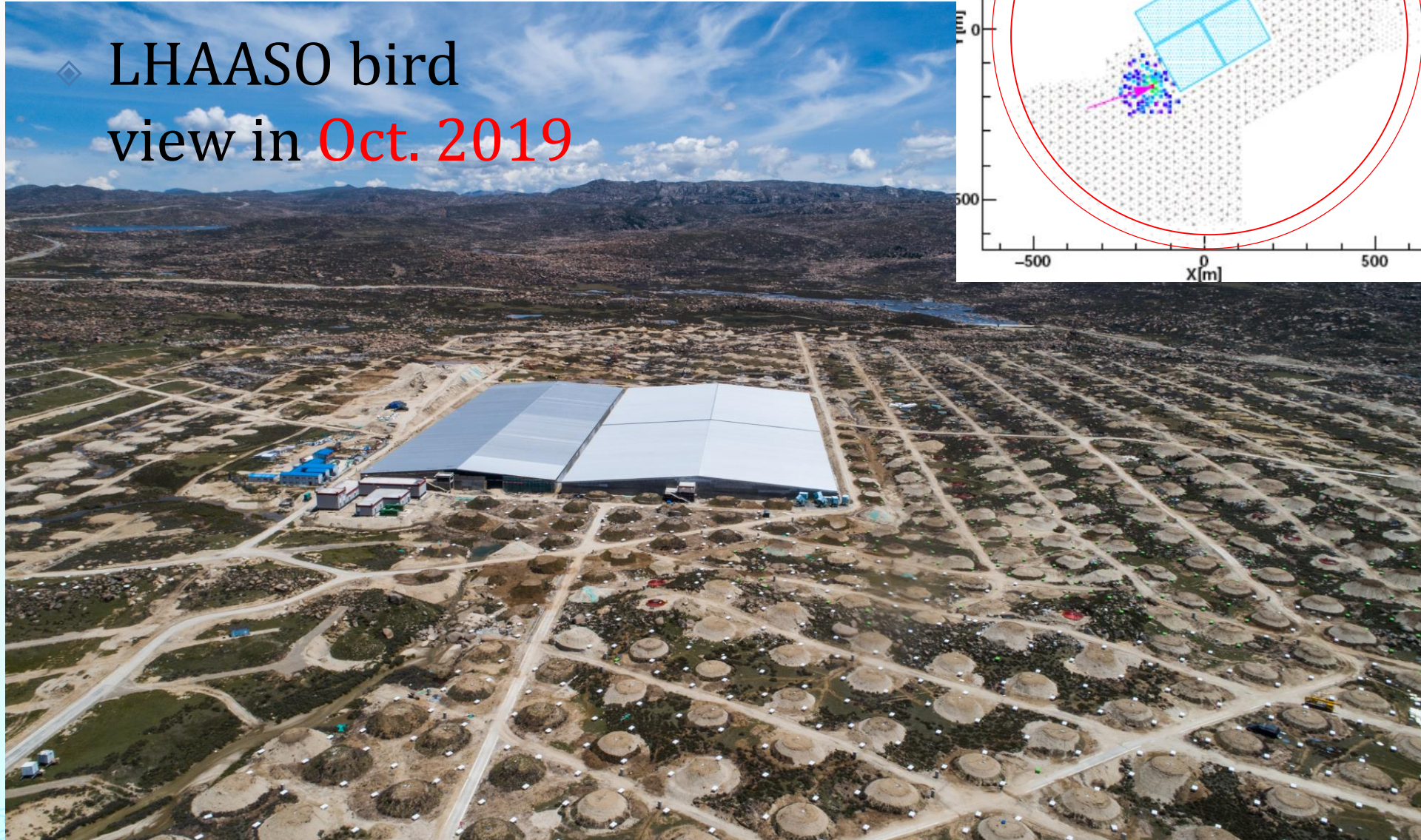
图例
● 首都
○ 省级行政中心
— 国界
— 省、自治区、直辖市界
-- 特别行政区界

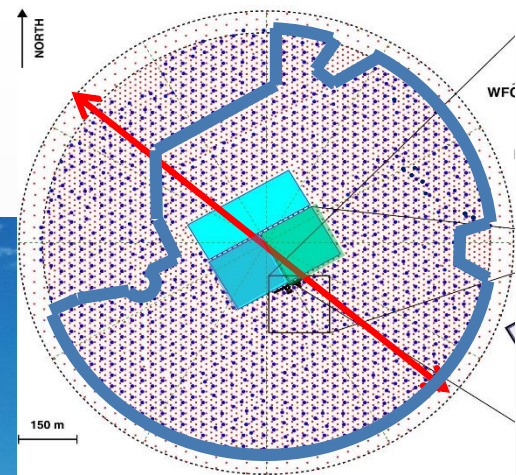
Detector Layout in LHAASO



Eastern view

◆ LHAASO bird
view in **Oct. 2019**





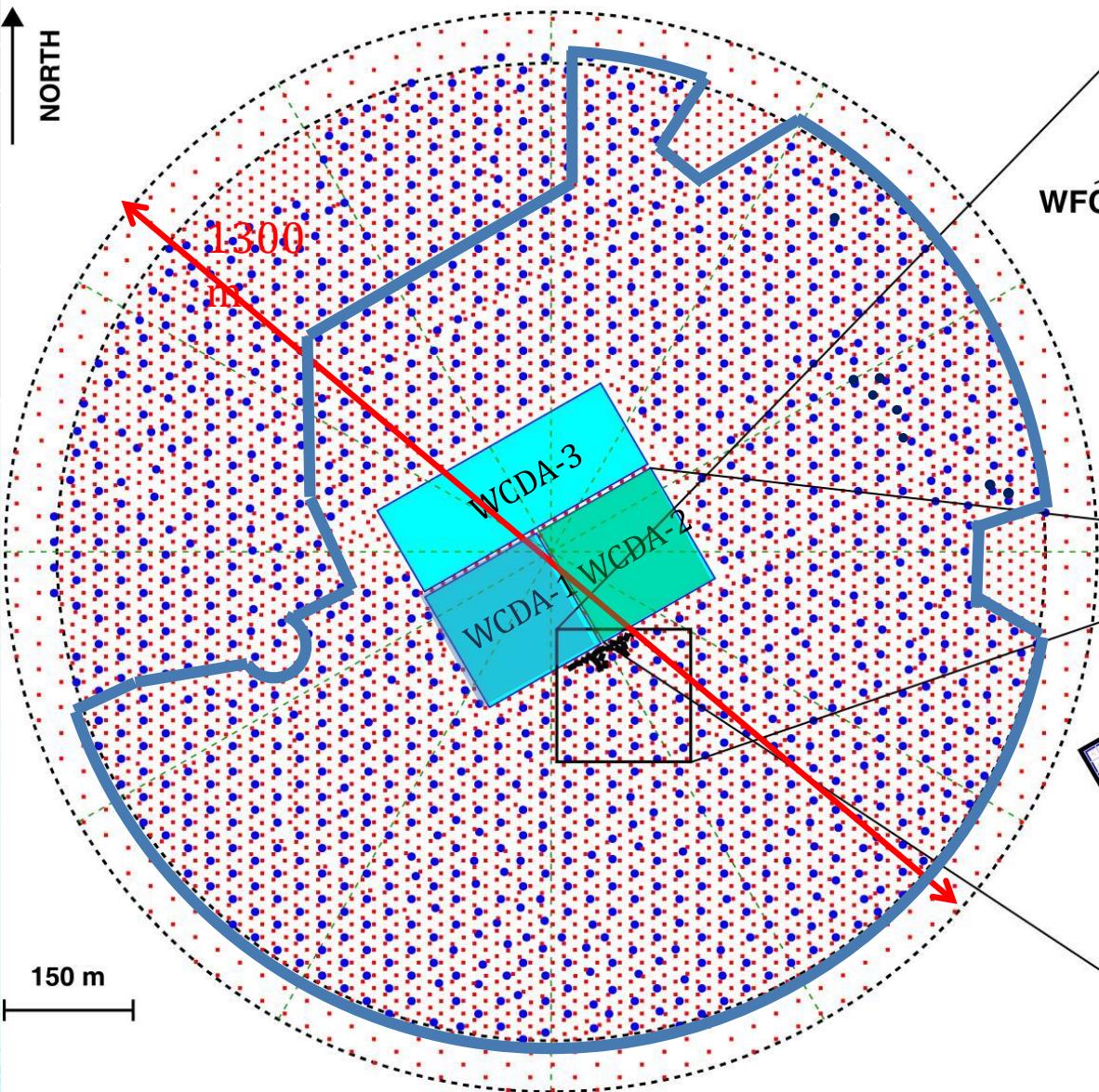
LHAASO bird view
Aug. 13, 2020



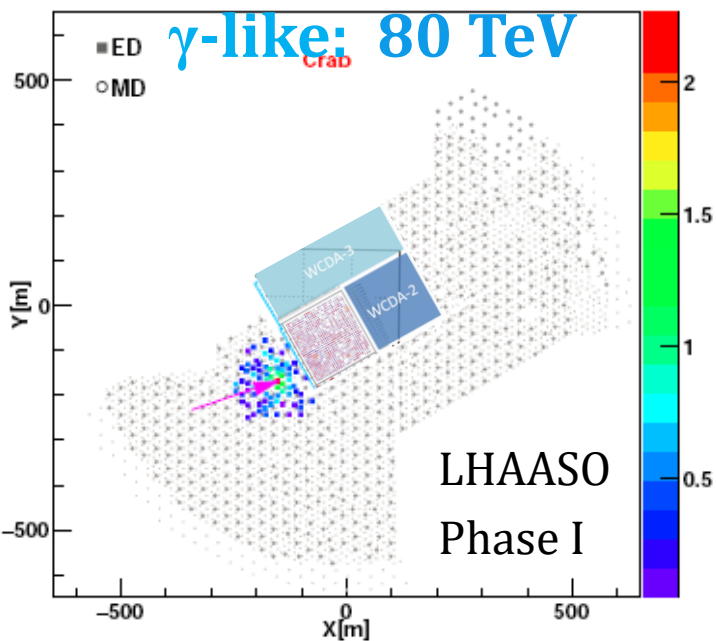
LHAASO Phase-II: Dec, 2020—

| 2019-12-12 | Muon Counter | Scintillator Detector |
|------------------------------------|--------------|-----------------------|
| operating | 594 | 2514 |
| 2010-11-30 | | |
| operating | 917 | 3978 |
| Percentage of designed sensitivity | 88% | |

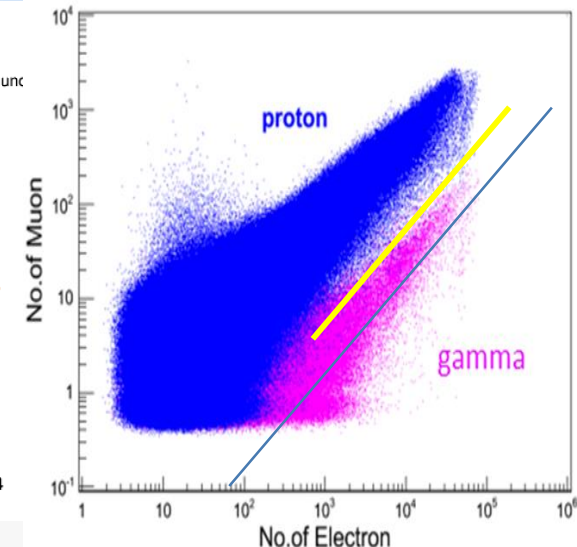
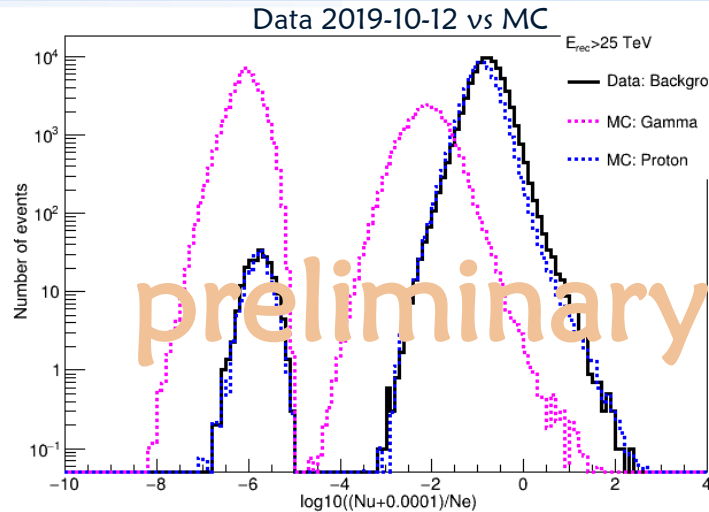
NORTH ↑



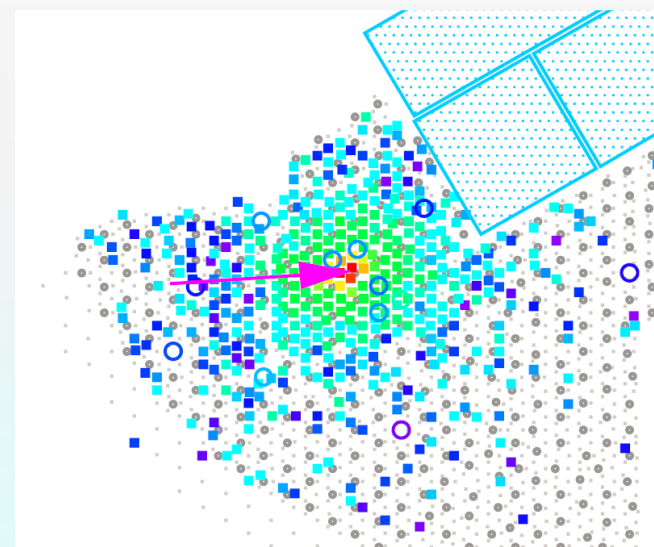
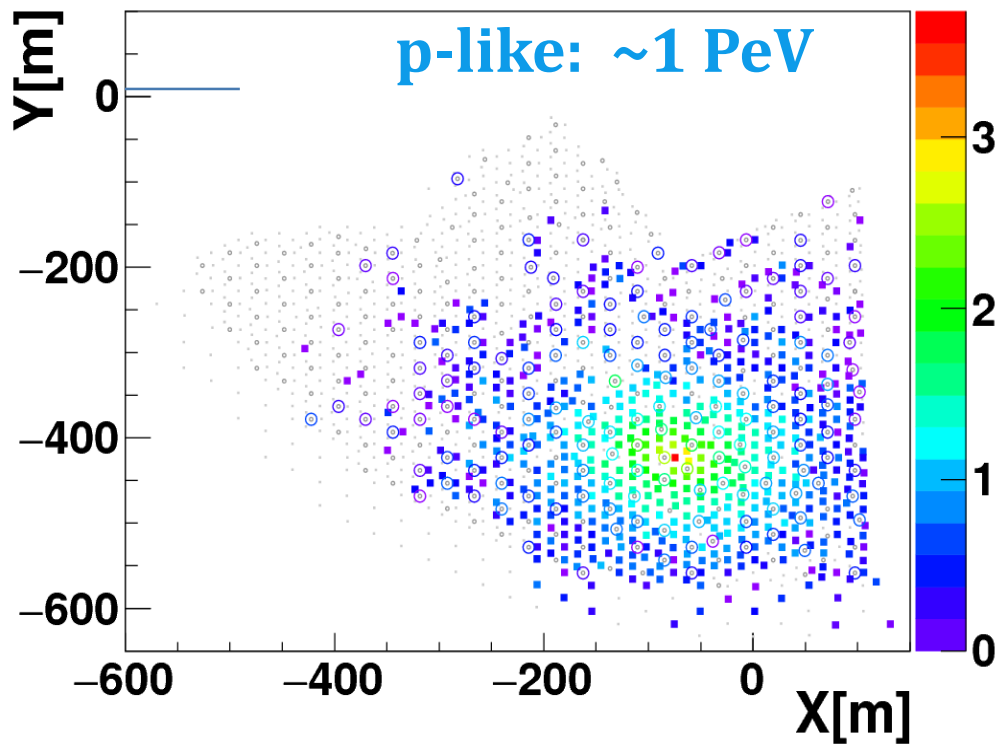
MJD : 58908.57, Ne : 465.8, Nu : 0.0, E_{hit} : 99.0TeV, E_{pc} : 80.9TeV



γ /proton Separation: μ -content

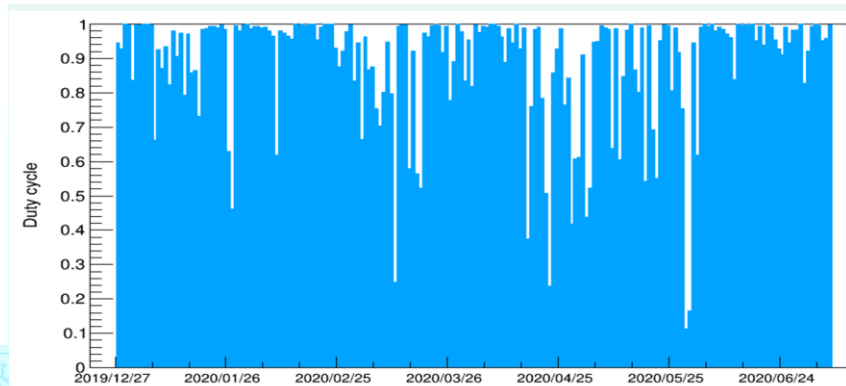
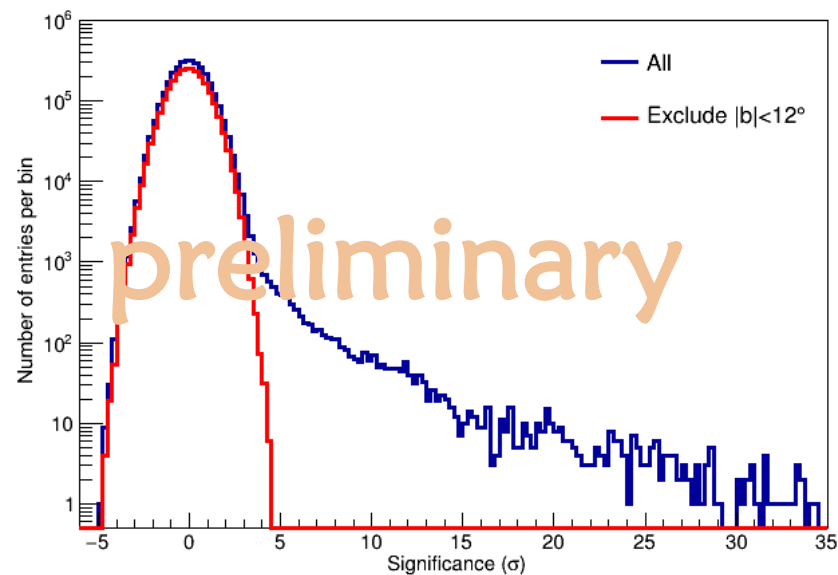
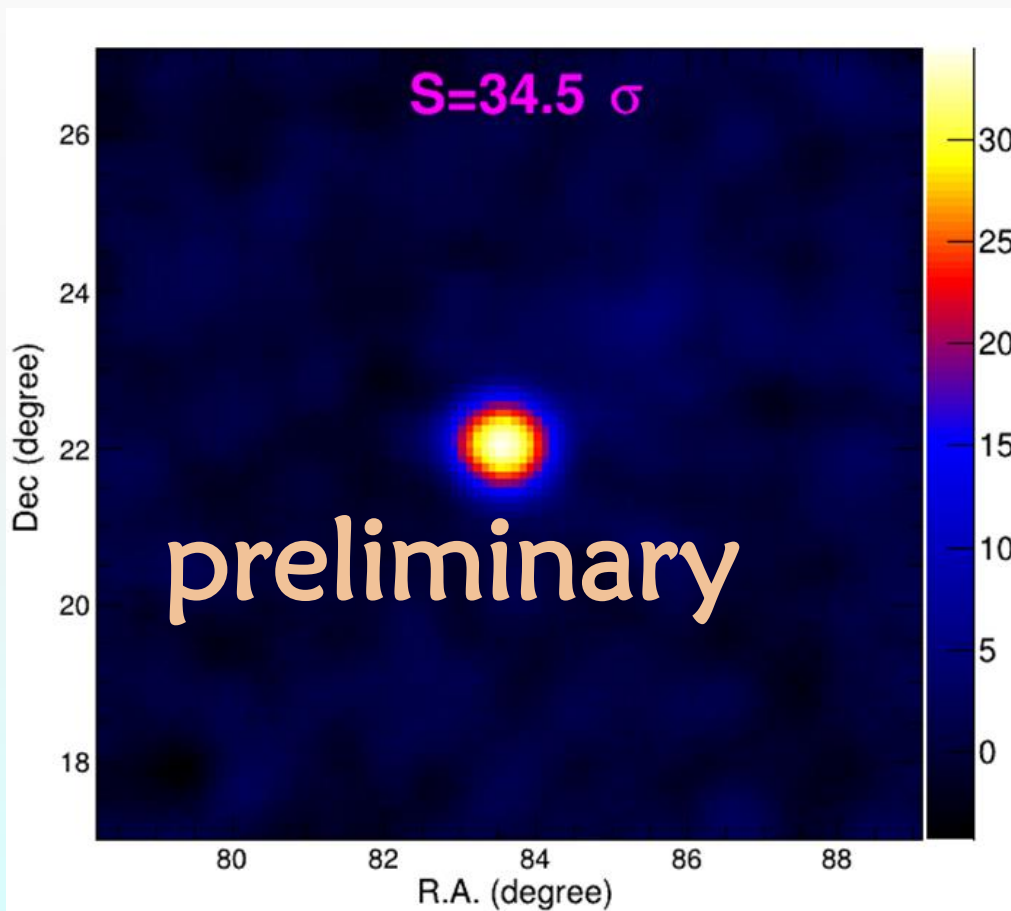


MJD:58788, NHitE:656, NHitM:154, Theta:31.2deg, Phi:284.0deg



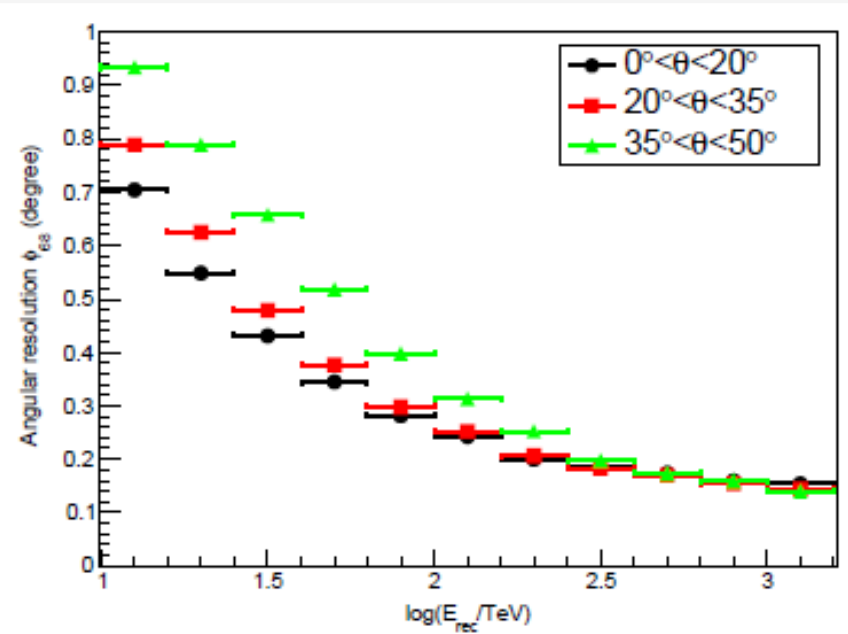
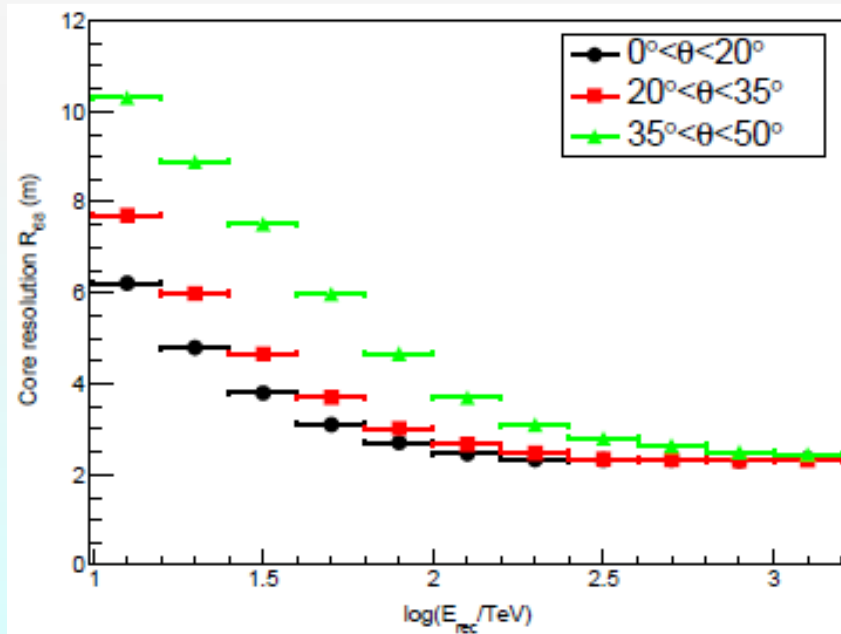
Standard Candle

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



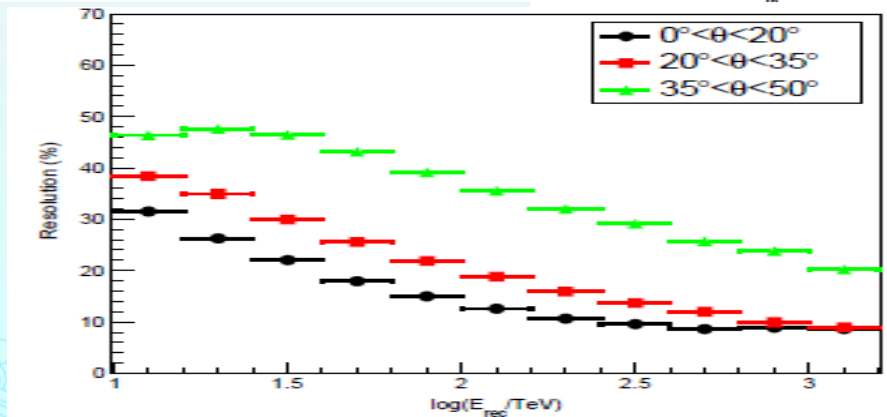
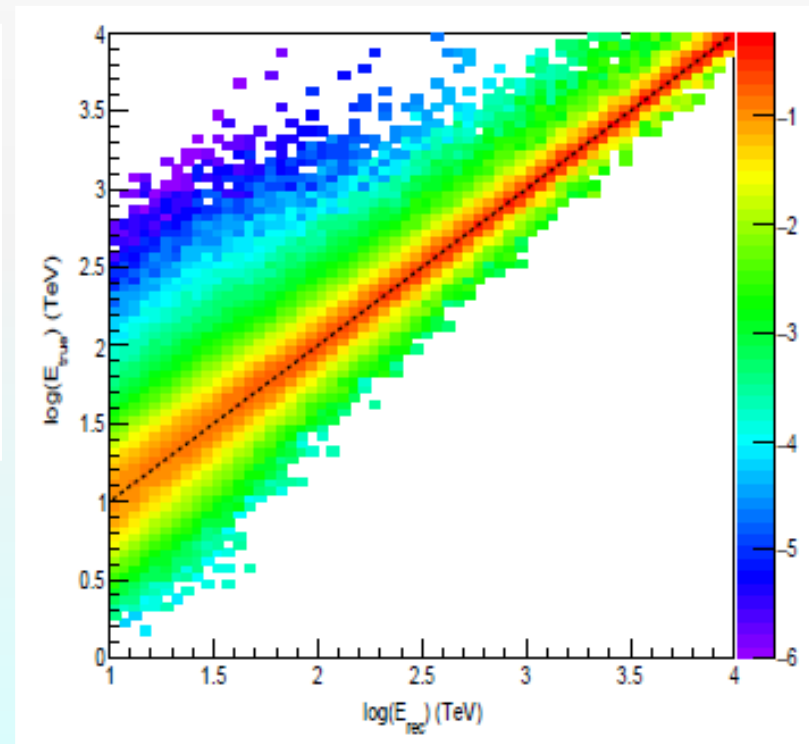
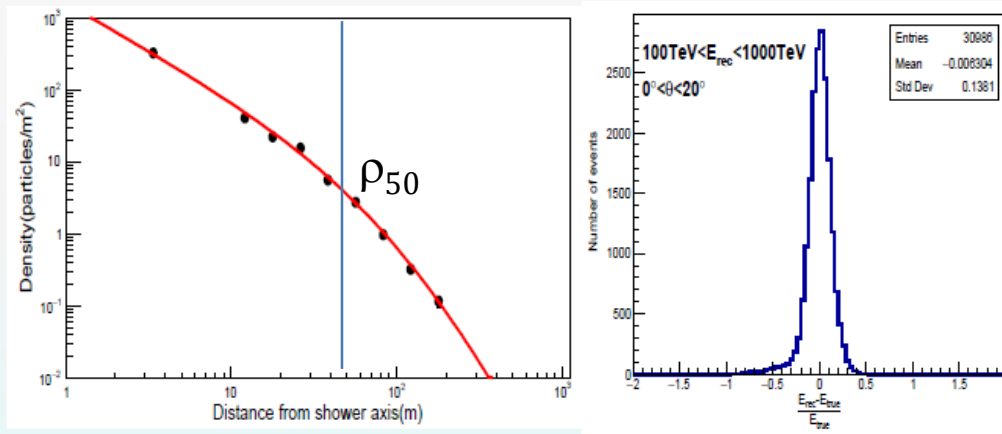
KM2A performances

- ◆ 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



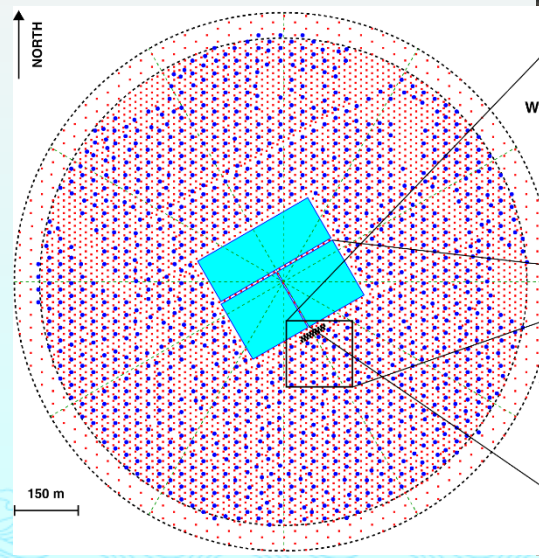
Water Cherenkov Detector Array

3 Arrays

1: 22,500 m² 8" PMTs

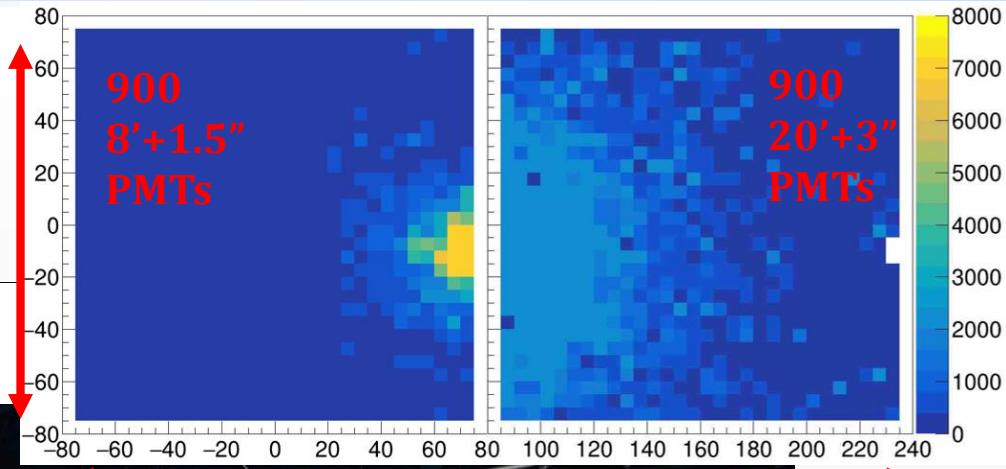
2: 22,500 m² 20" PMTs

3: 33,000 m² 20" PMTs

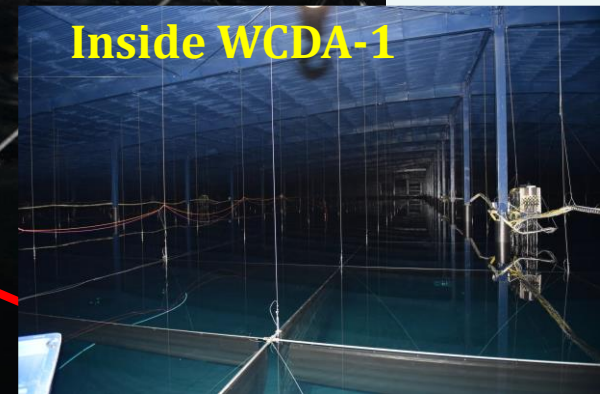


Inside WCDA-3

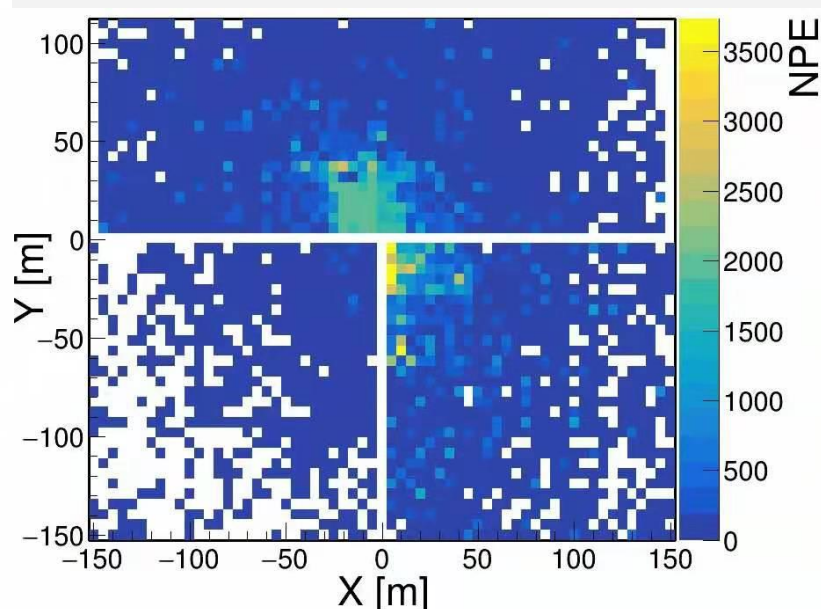
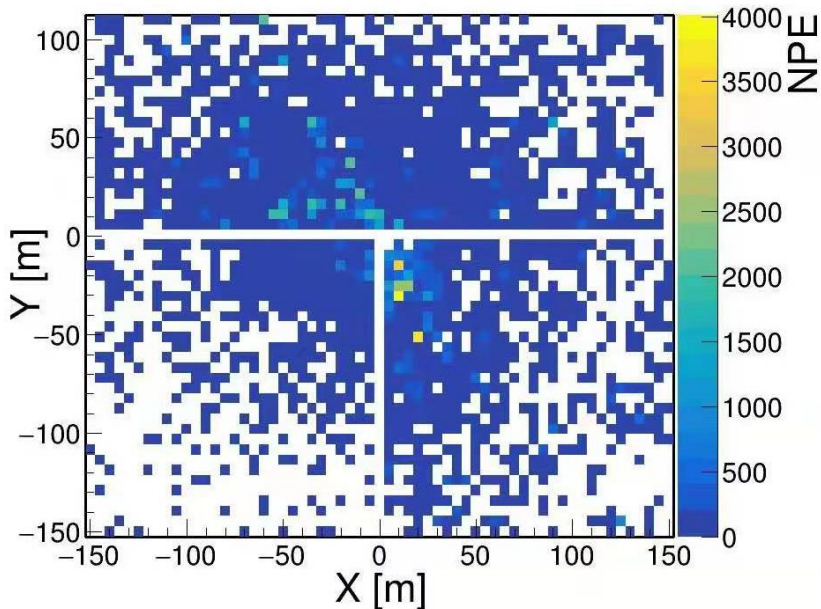
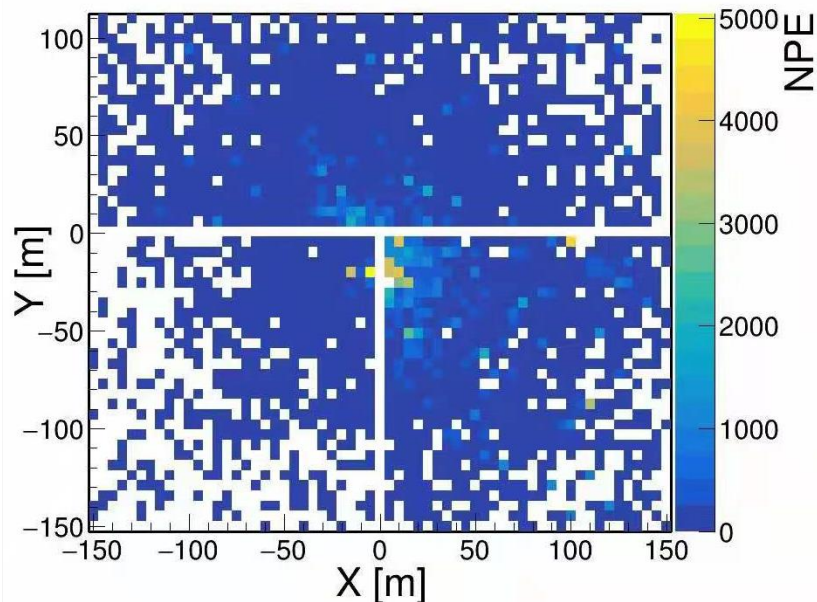
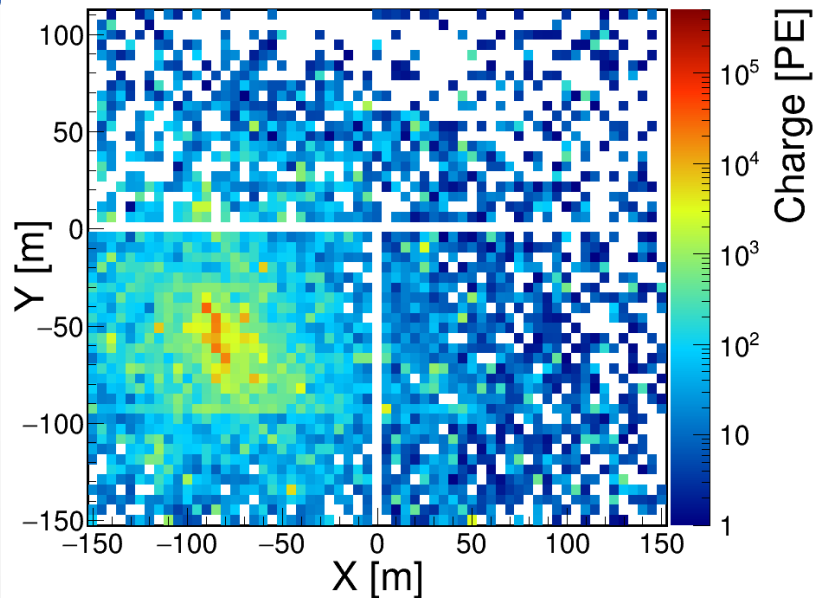
150 m



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

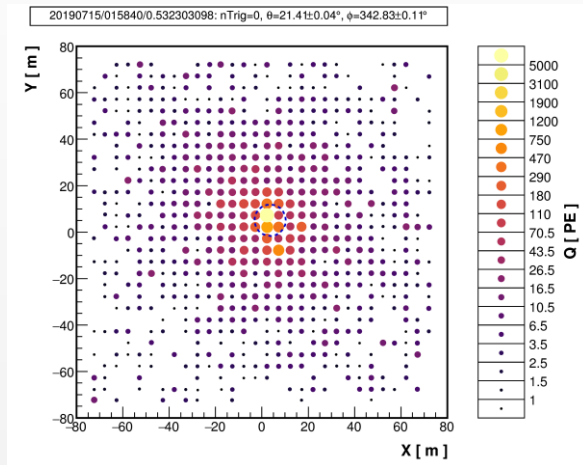


“Typical” Large Events in WCDA

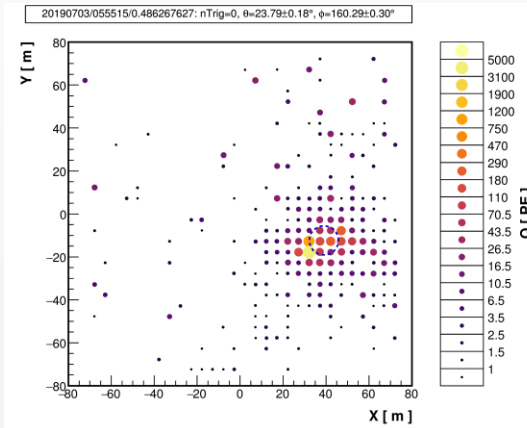


Pure Gamma Event Set!

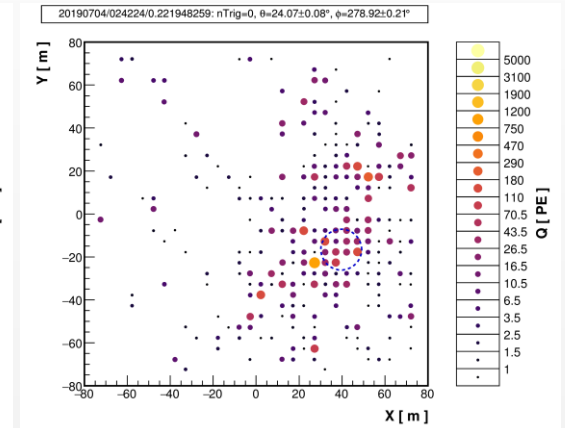
Data



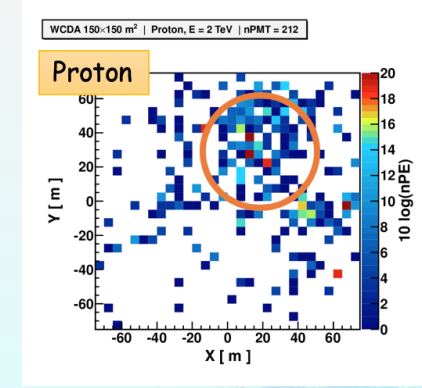
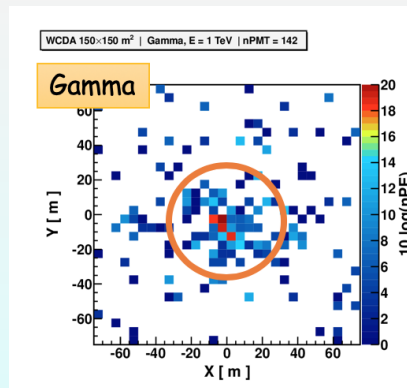
γ -like, $N_{hit}=236$



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

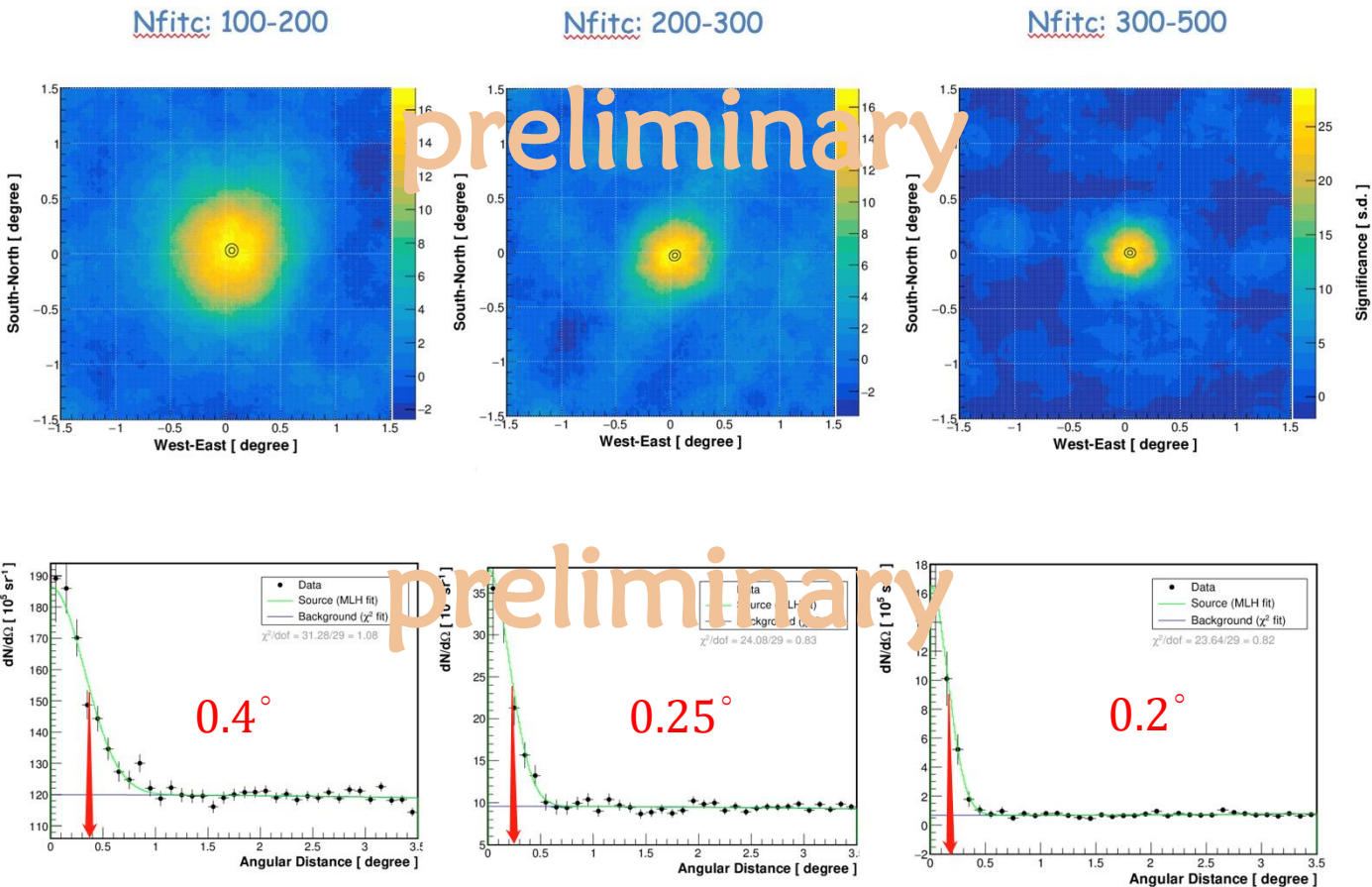


MC



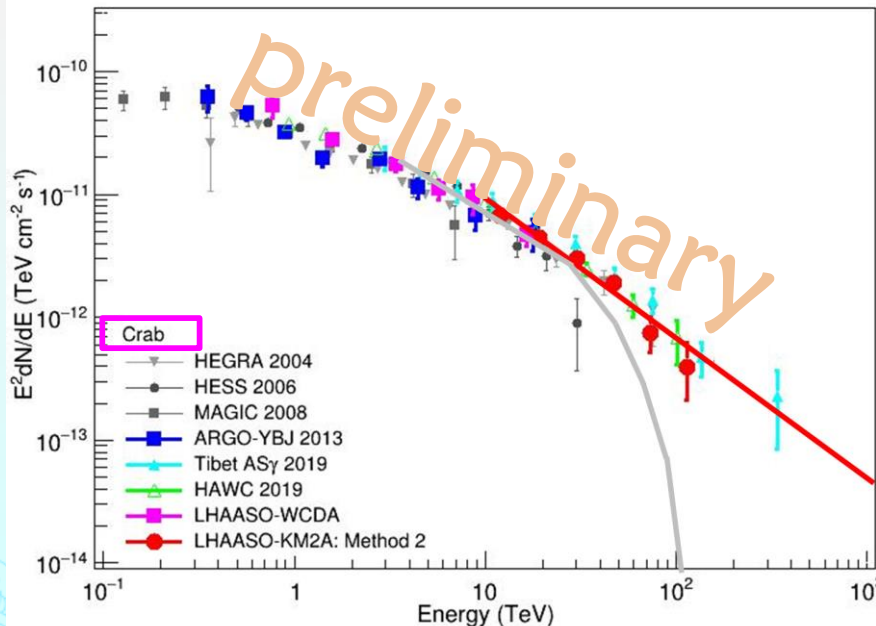
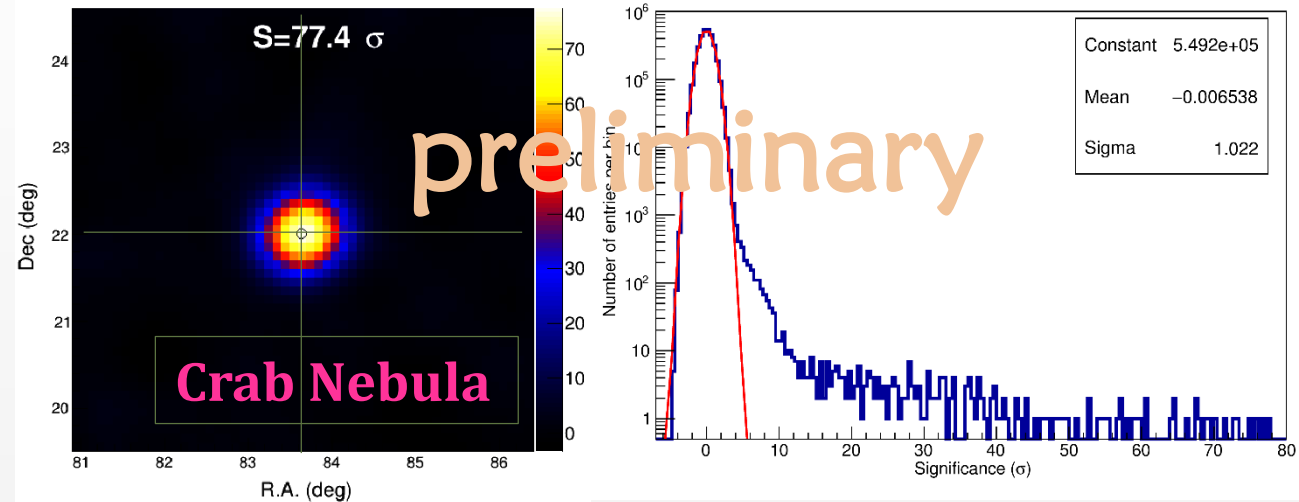
Pointing and Resolution

- 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

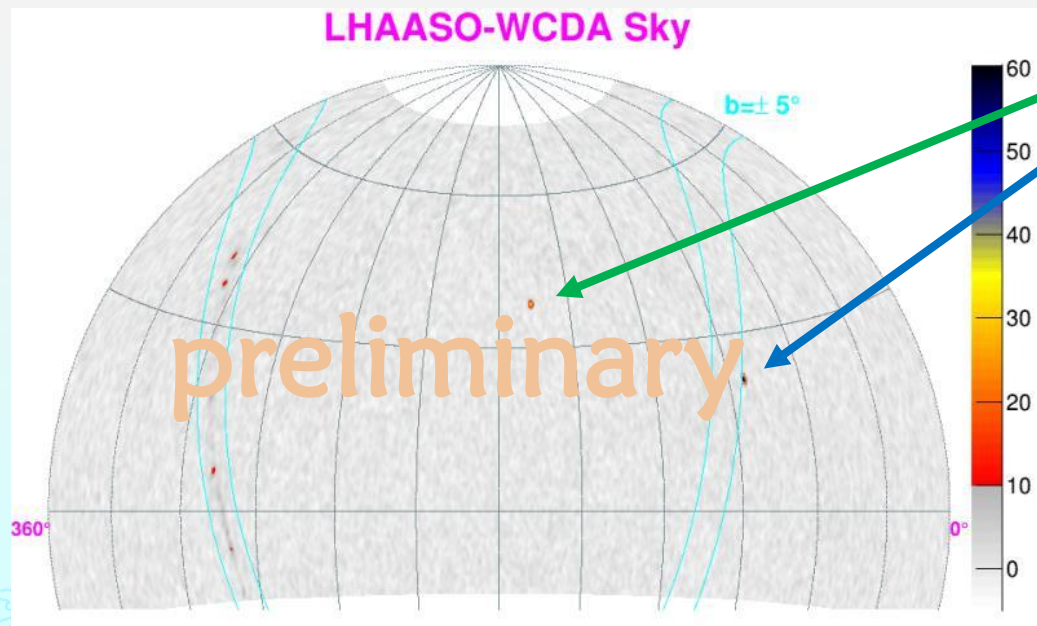
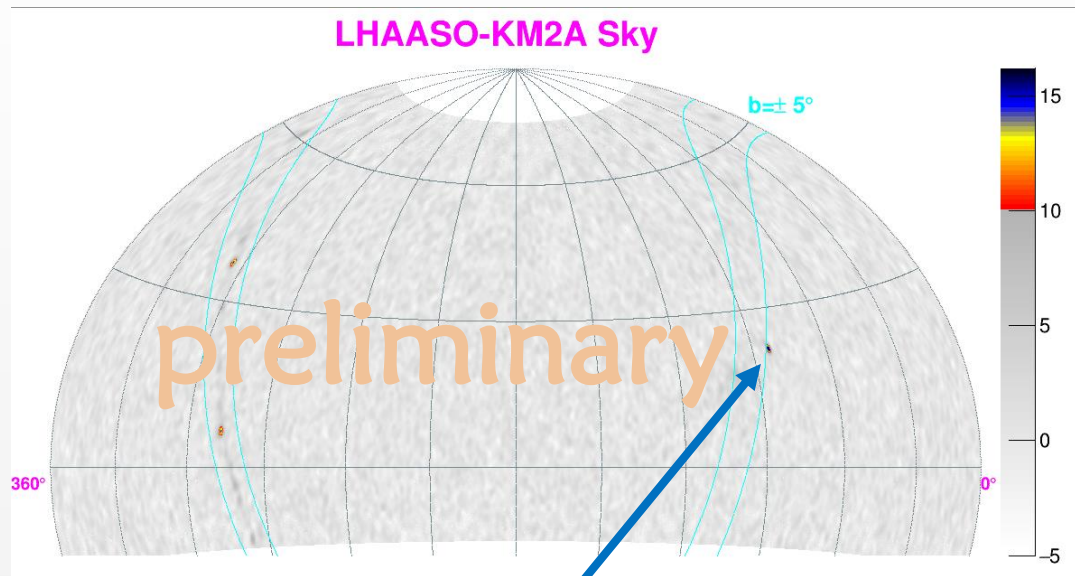
- Up to March 2020
- Crab 77σ ($E > 1$ TeV) by WCDA-1
- Pointing error $< 0.1^\circ$



- 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

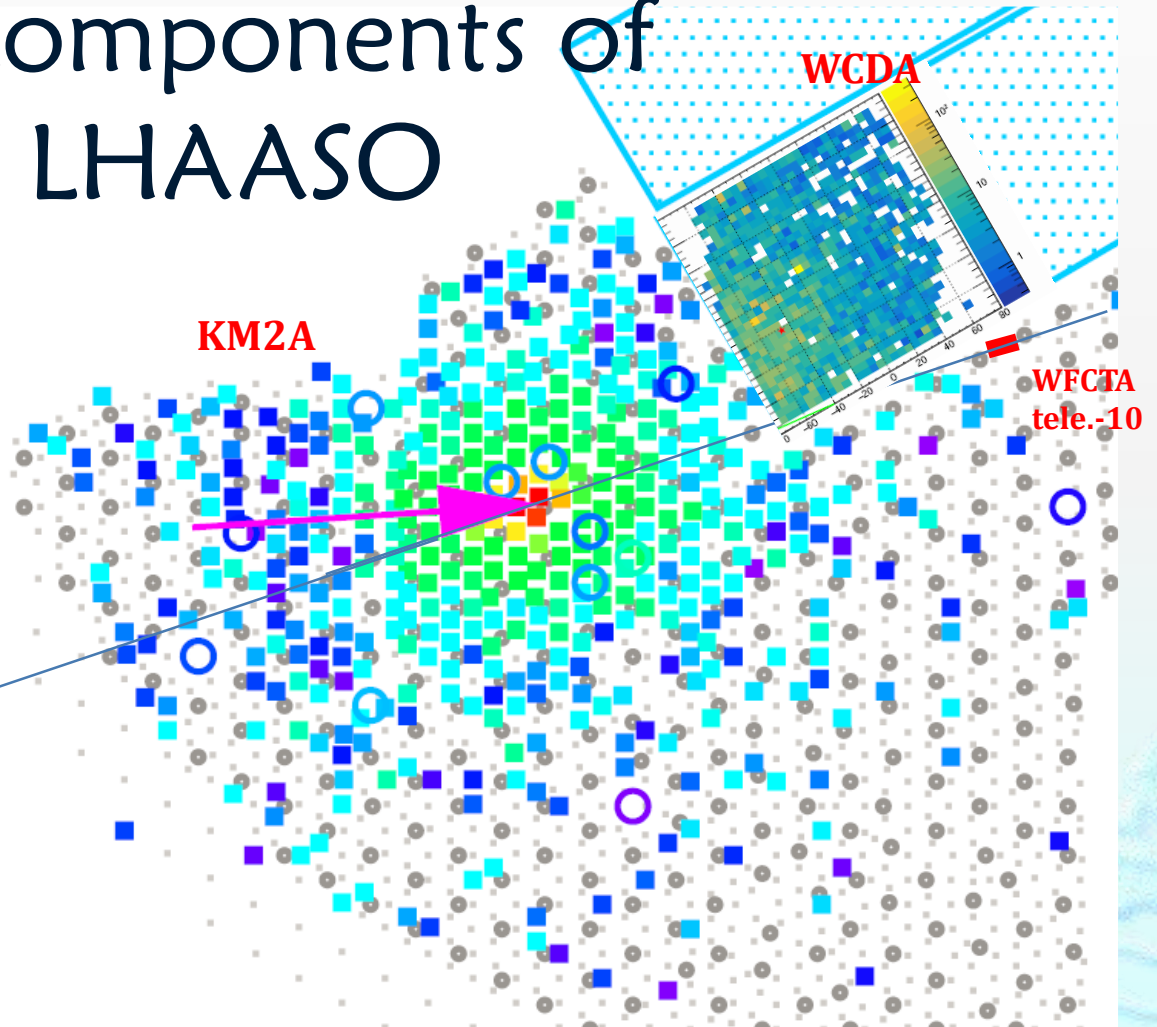
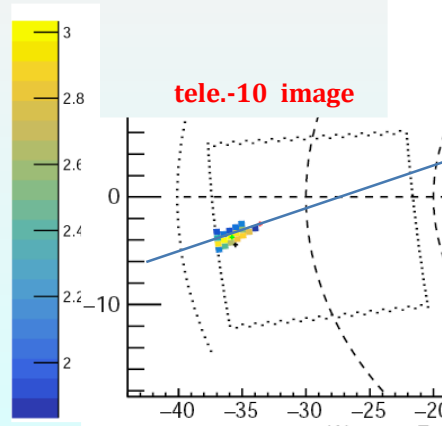


Mkr 421
Crab Nebula

above **100TeV** by KM2A-1/2
 Sensitivity: **0.1** C.U.
 PSF: **0.26°**
 Survey for 259 days :
4 sources >10σ

~1 PeV gamma detected by all components of LHAASO

- ◆ **WFCTA**: very slim image, $L/W \sim 2.6$, $N_{pe} \sim 9100$,
- ◆ 1.2 ± 0.3 PeV (assuming proton),
 0.9 ± 0.2 PeV (assuming gamma)
- ◆ **KM2A**: $N_{detector} \sim 395$, $N_{particle} \sim 4996$,
 $E \sim 0.9$ PeV
- ◆ Chance probability: $< 0.1\%$
(15 μ 's detected in 11 MDs)



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



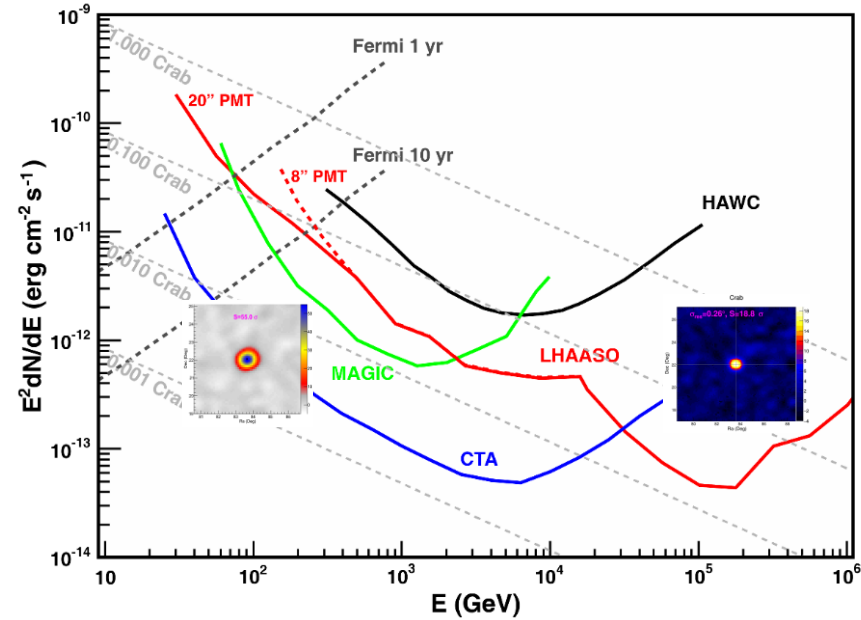
Phase-II:
Oct. 2020 —
14 telescopes
in operation



LHAASO: Large High Altitude Air Shower Observatory

Physics Topics

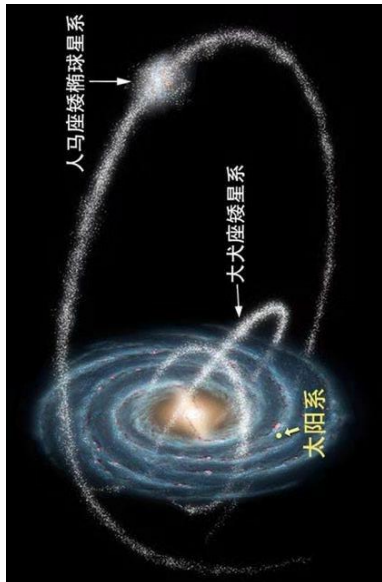
- Gamma Ray Astronomy
- Charged CR Spectra
- New Physics Frontier



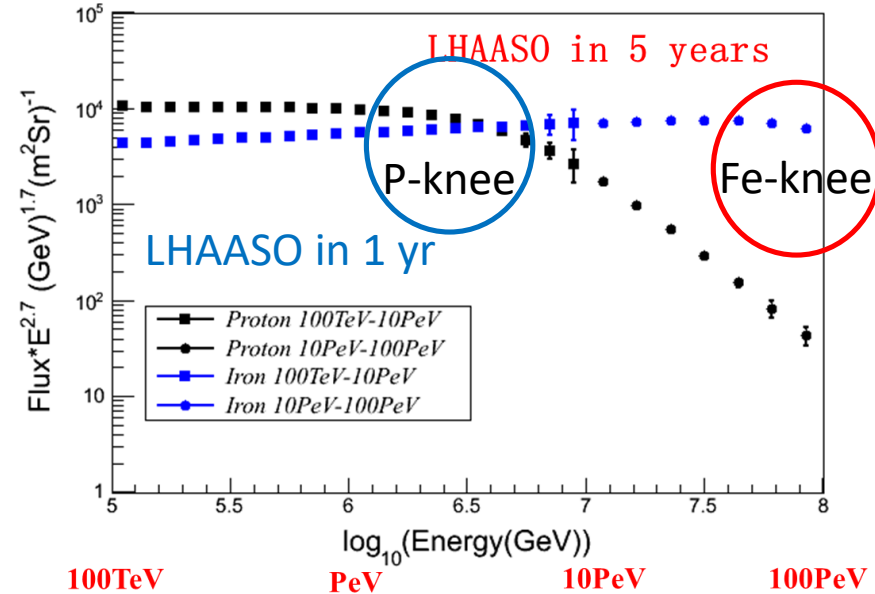
Pevatron searching



DM searching



GRB searching



100TeV

PeV

10PeV

100PeV

Summary

- ◇ 1/2-LHAASO has been operated for 259 days
- ◇ 3/4-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 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