Status of A Large High Altitude Air Shower Observatory Project

Min Zha

For the LHAASO Project

Institute of High Energy Physics, Beijing, China

3rd RICAP Workshop 2011, Roma

Outline

- Scientific goals
- Project overview: design of the complex experiment
  - Full-sky survey detector: WCDA
  - High energy γ ray detector: KM2A
  - Cosmic Ray Detector Array for CRs > 30 TeV
    - Wide FOV Cherenkov Telescope Array(WFCTA)
    - Shower Core Detector Array (SCDA) / PRISMA
  - Extension for low energy γ rays and high energy CRs
    - Extension using TUNKA-technique by Russian Collaborators
- Prototype detectors and engineer array
- Status

Scientific Problems and Possible Solutions

- TeV γ-ray observation has an opportunity of finding CR origin: 80+ sources discovered
  - 50+ galactic sources: γ at high energy (>30TeV) is crucial (high sensitivity and high energy resolution)
  - All-sky survey for γ source population is necessary (full duty cycle, wide FOV and sufficient sensitivity)
- PeV CR spectra of individual composition
  - Bridge between space/balloon borne measurements and ground based UHECR measurements
- Exploring for new physics frontier

A Tentative Design of A Complex Detector Array

Three major components:

- 90k m^2 water Cerenkov detector for γ>100GeV;
- 1km^2 complex array for γ + CR >30TeV:
  - Array of 5000 scintillation detectors ;
  - Array of 1200 μ detectors (buried water C detectors).
- Cosmic Ray Detector Array for CRs >30TeV:
  - Array of 24 C-telescopes ;
  - Shower Core Detector /PRISMA;
  - Extension using TUNKA-technique.

Project Overview

Charged Particle Array

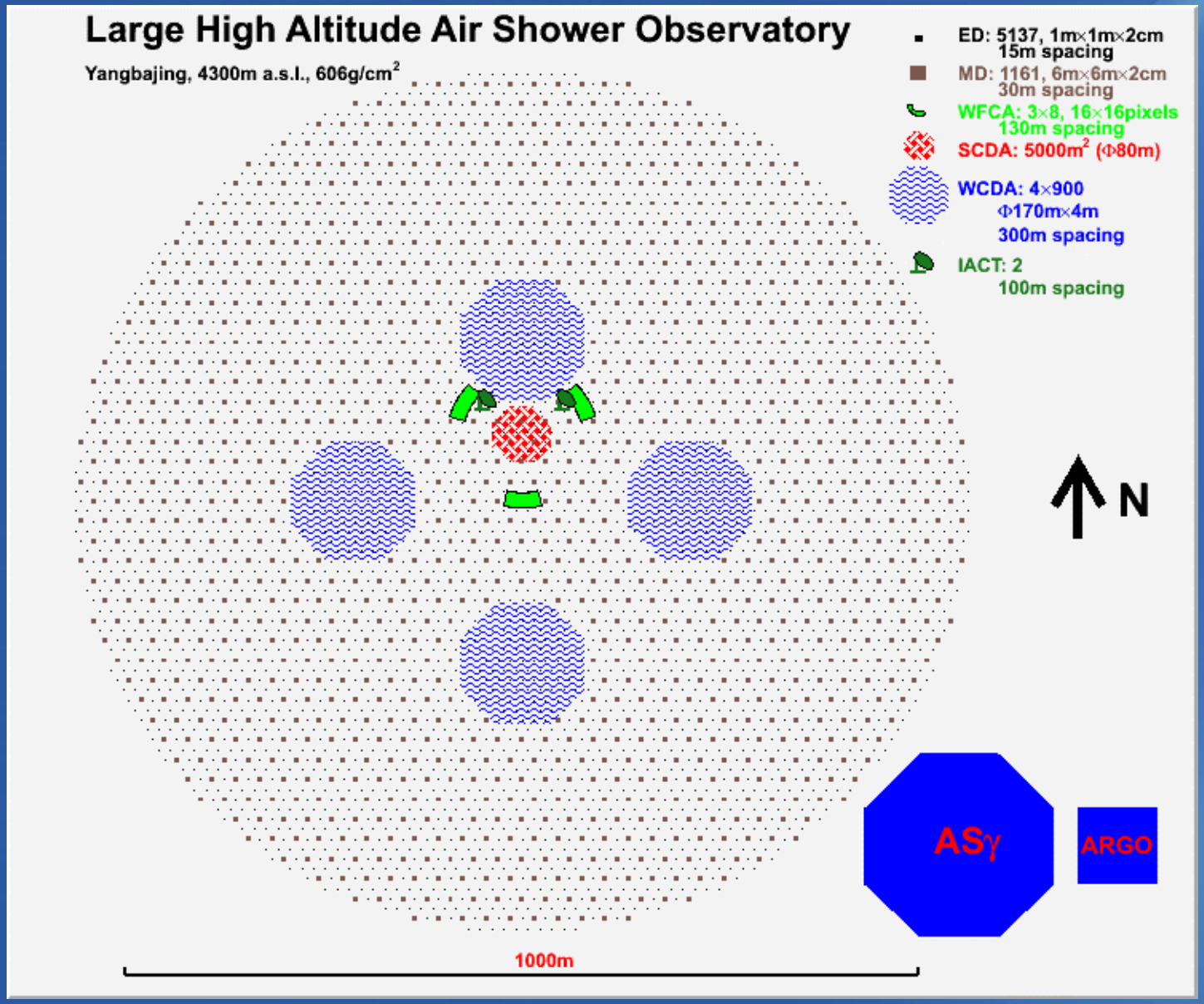
μ Detector Array

Water C Array

Wide FOV C-Telescope Array

&

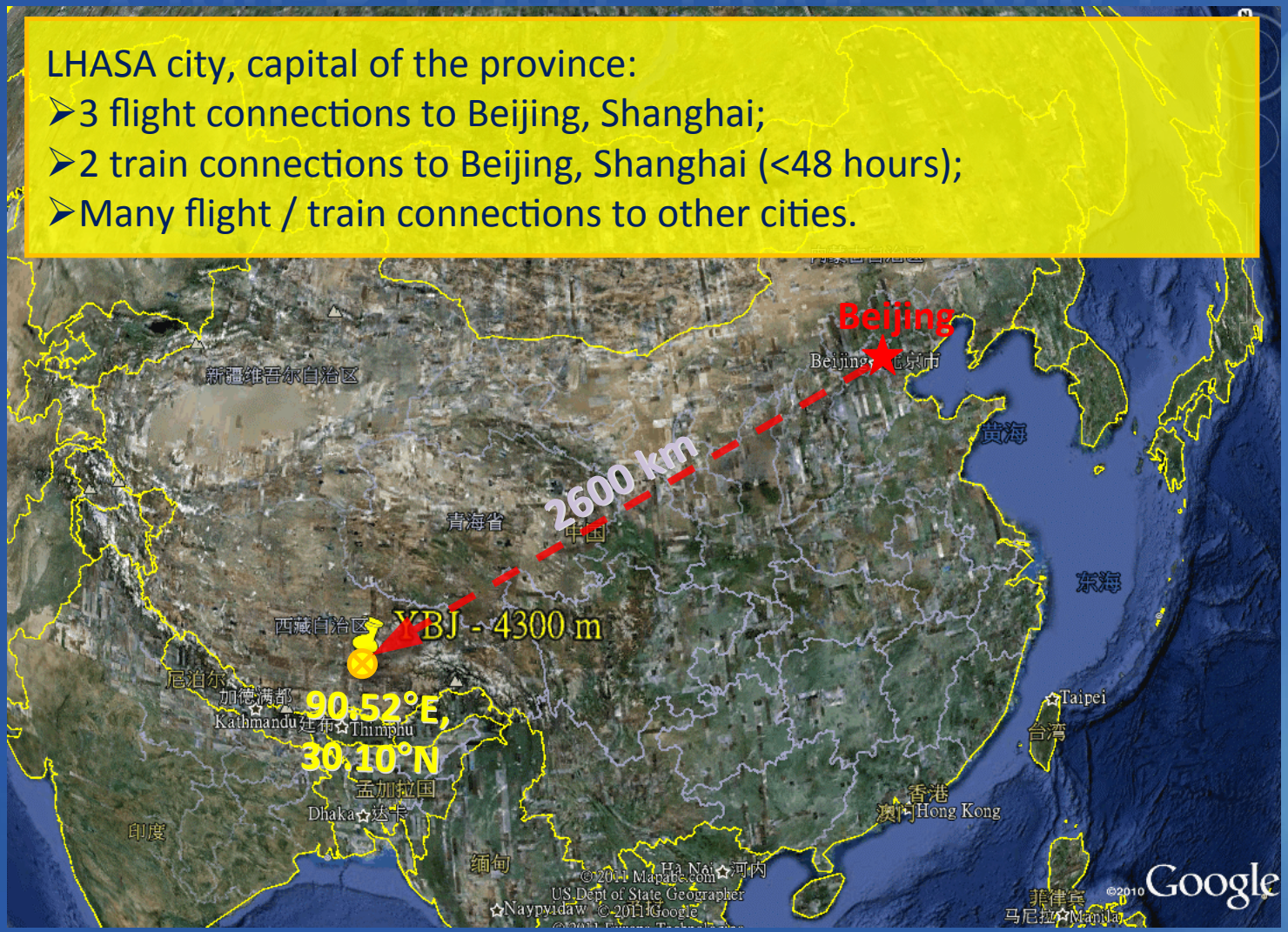
Core Detector Array



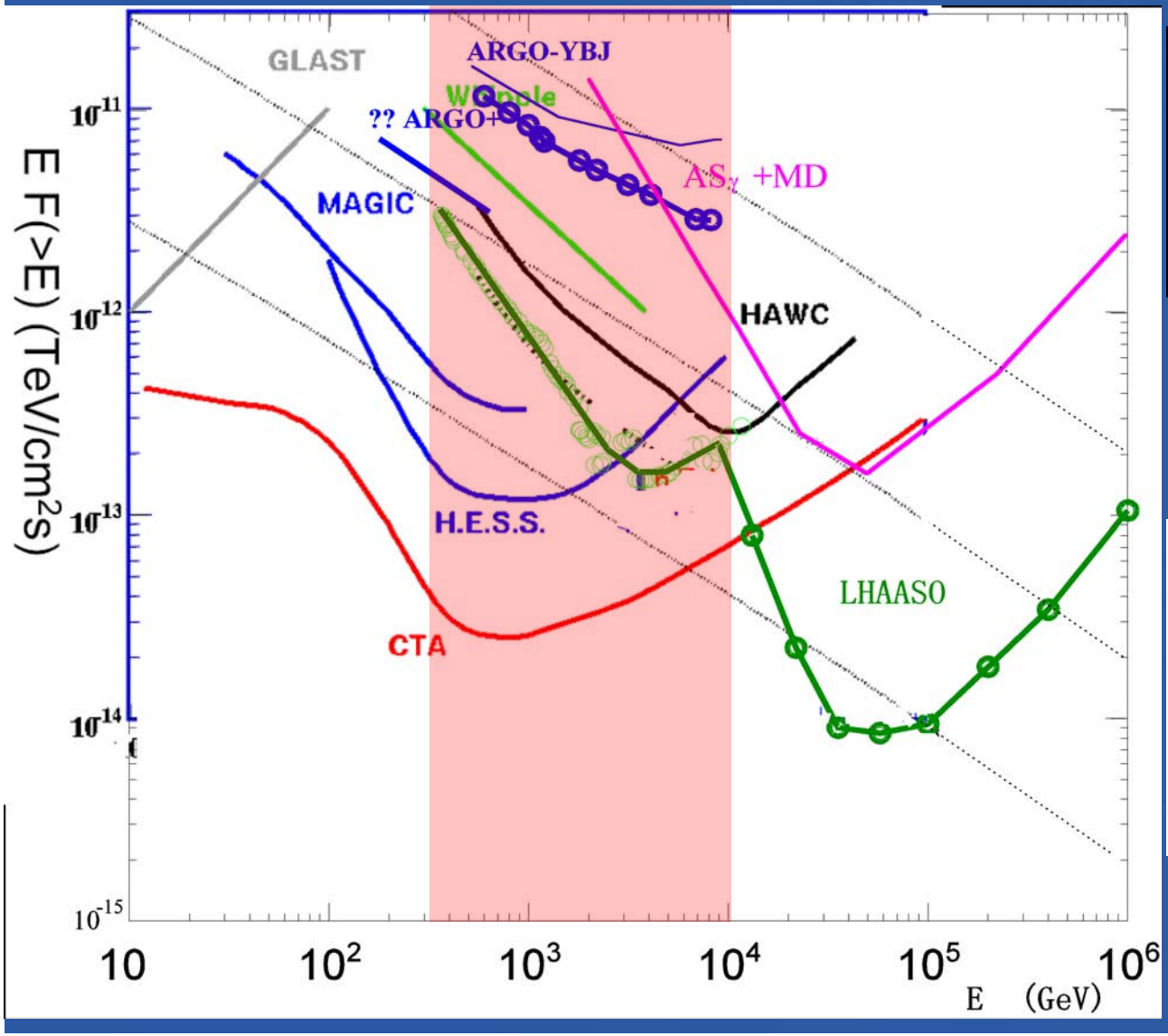
Yang-Ba-Jing, Tibet, China

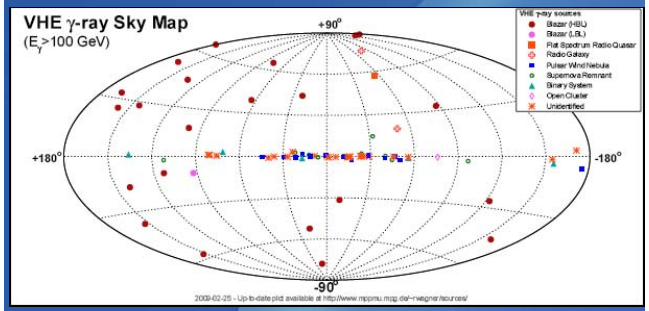
LHASA city, capital of the province:

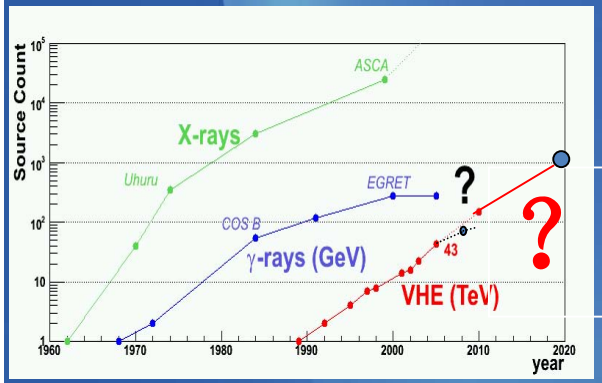
- 3 flight connections to Beijing, Shanghai;
- 2 train connections to Beijing, Shanghai (<48 hours);
- Many flight / train connections to other cities.



Survey for γ sources (extra-galactic)

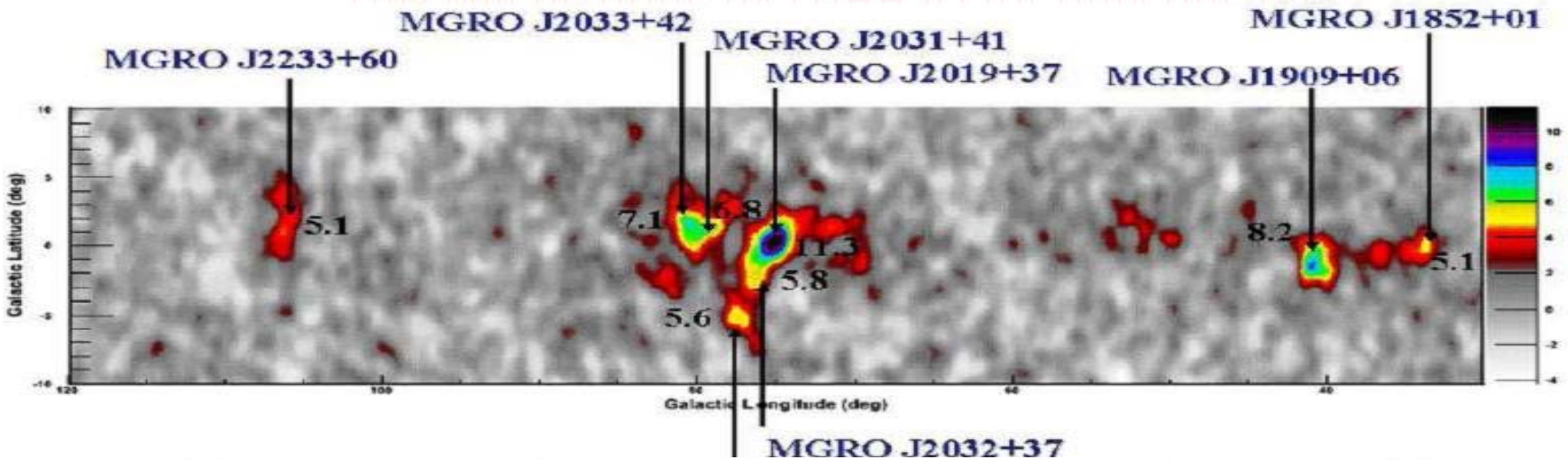






Milagro demonstrated that the technique works for source surveying

This will be done by LHAASO for only one day



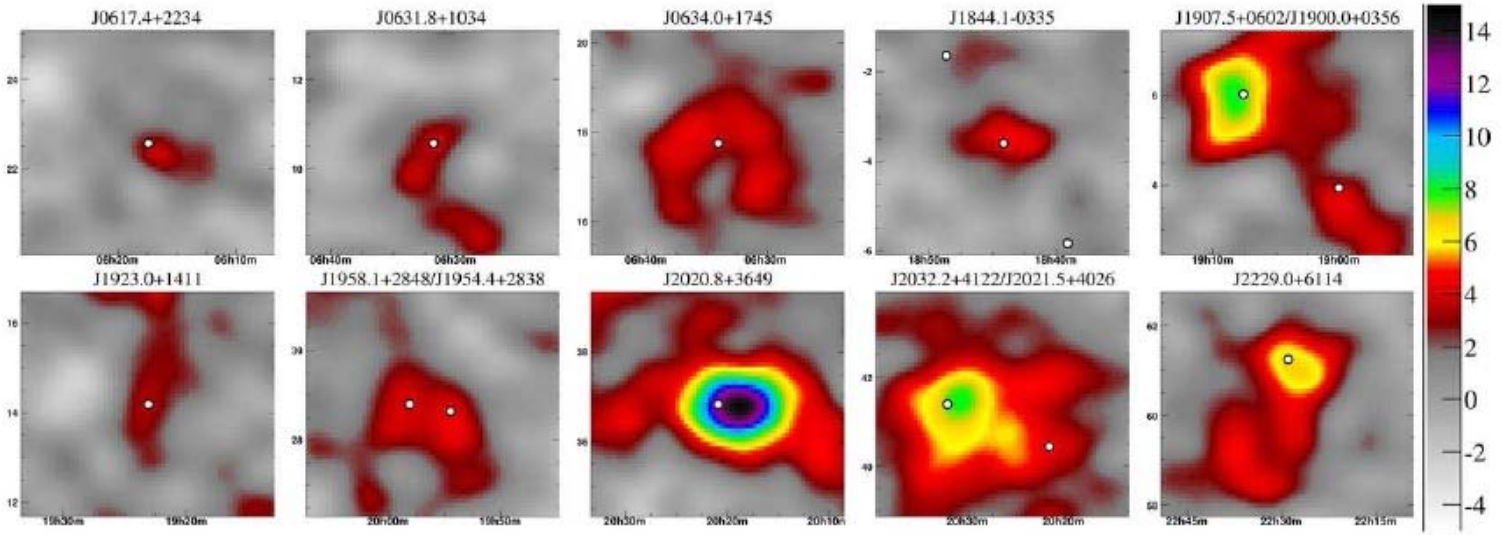
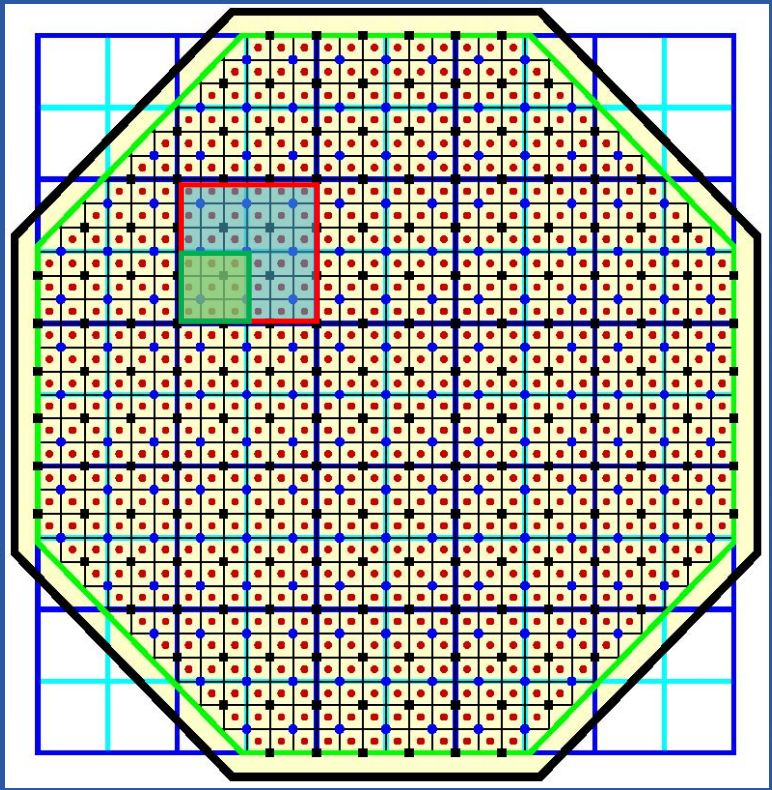
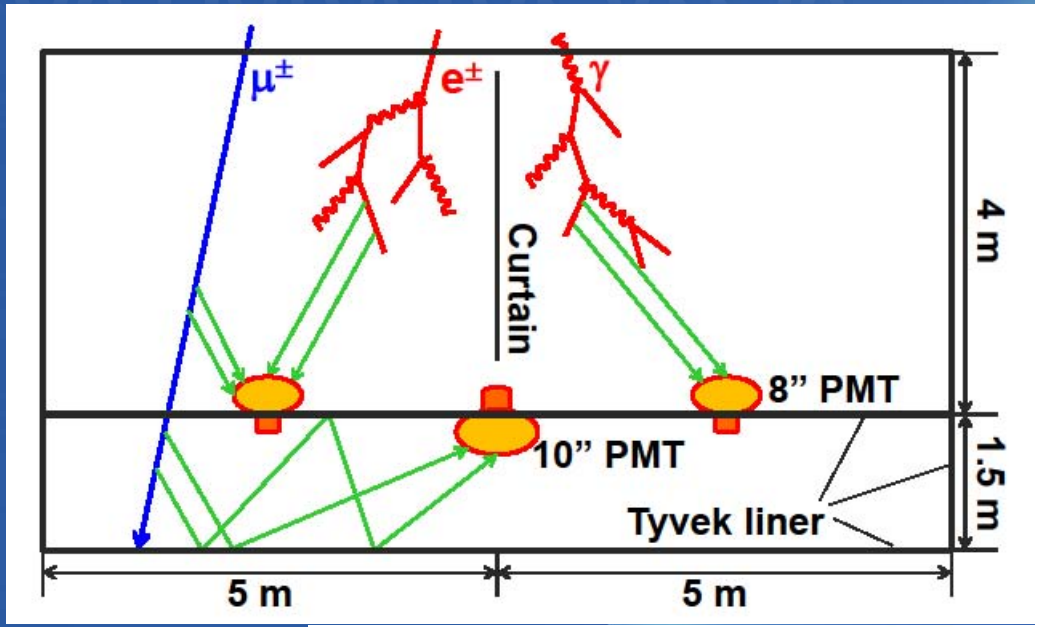
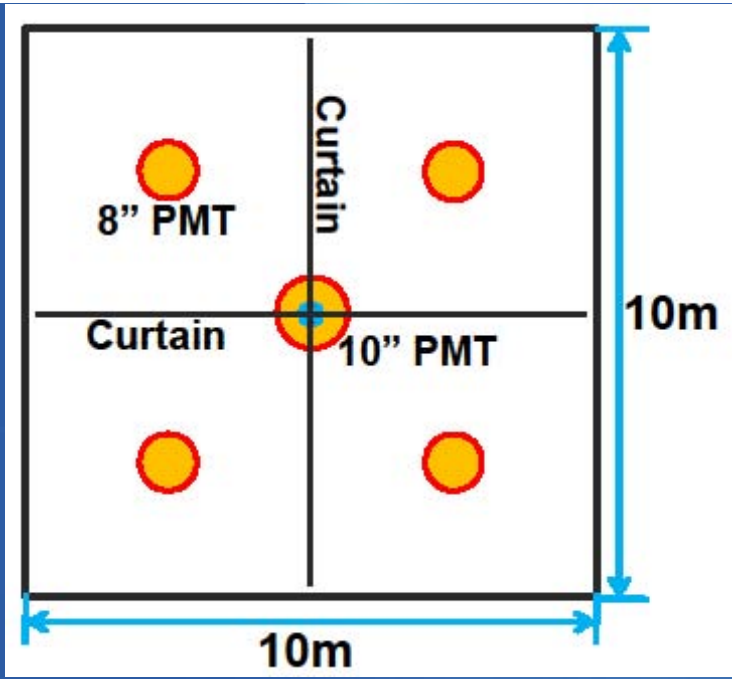


Figure 8. ach source.

Water Cherenkov Detector Array

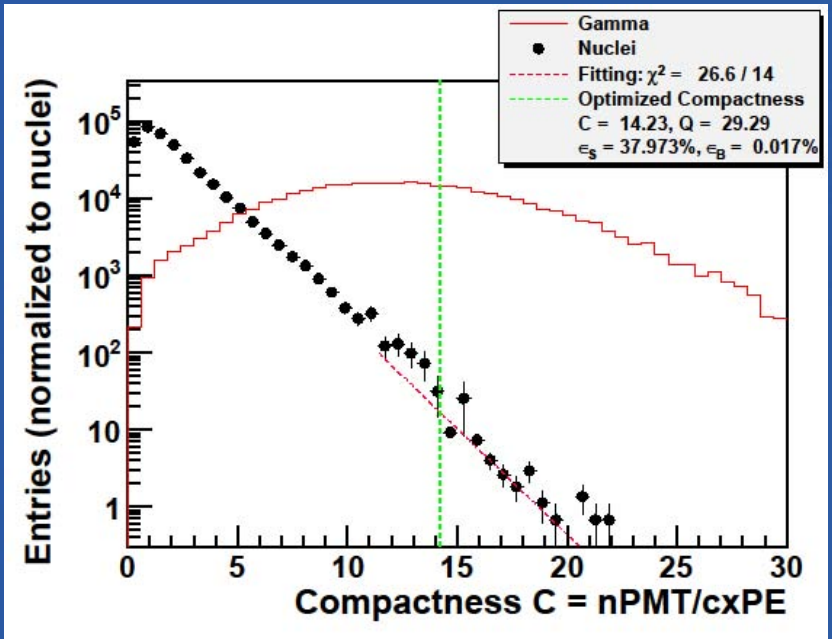


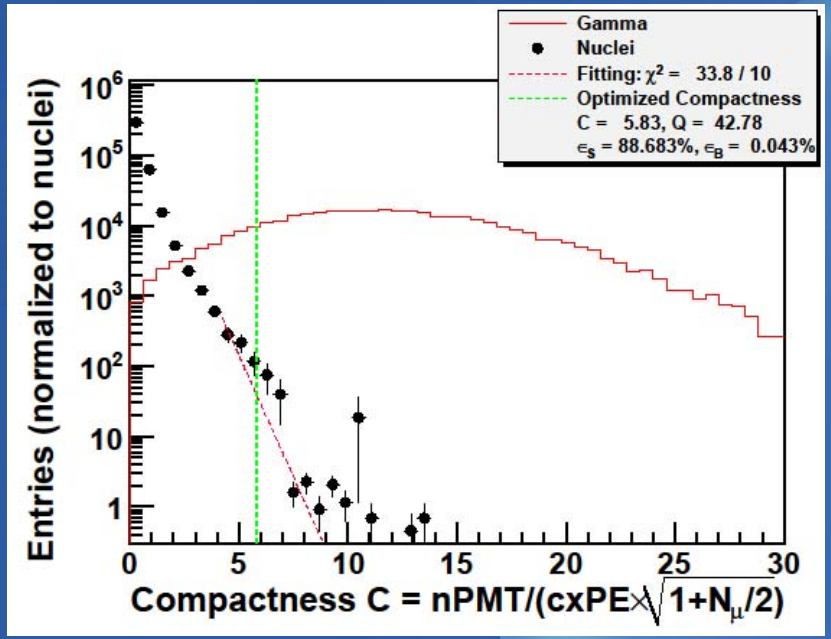


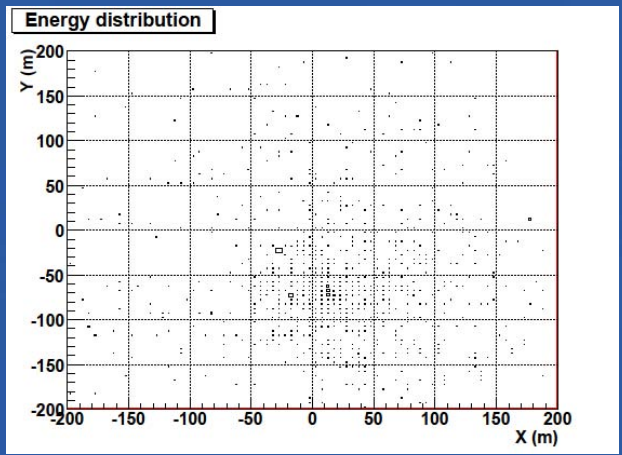


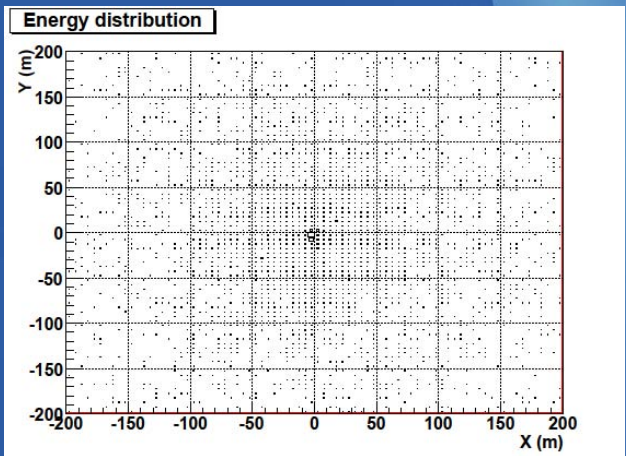
- 75000m^2
- 3700 PMTs.

Gamma / Proton Discrimination



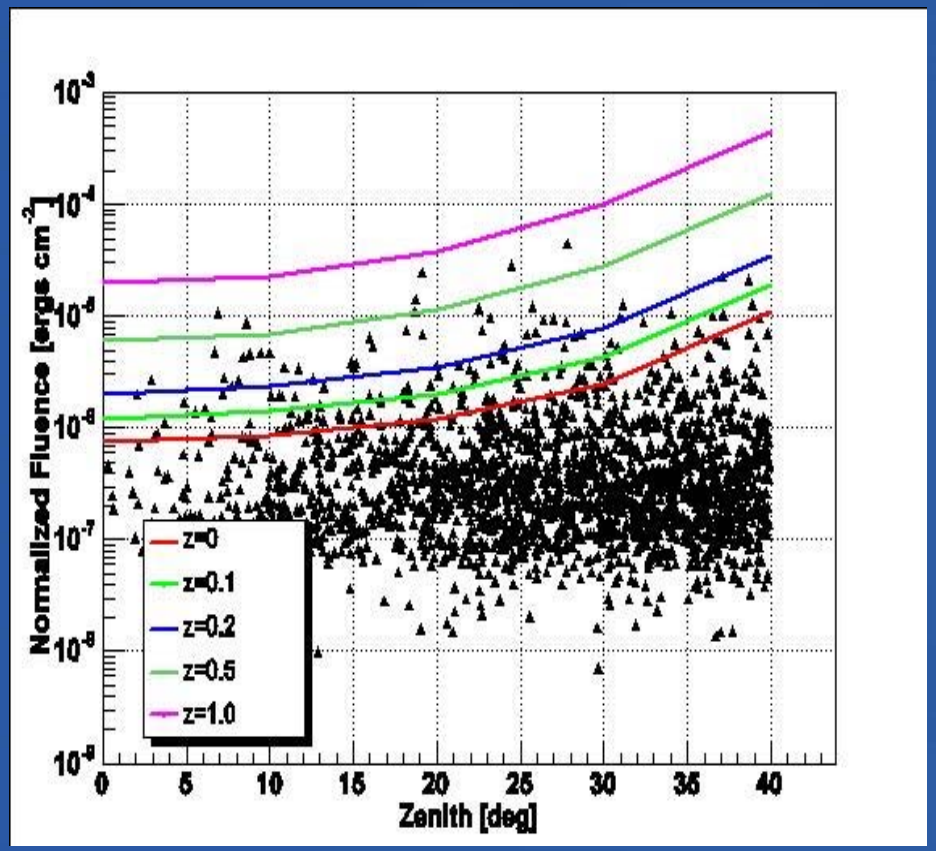


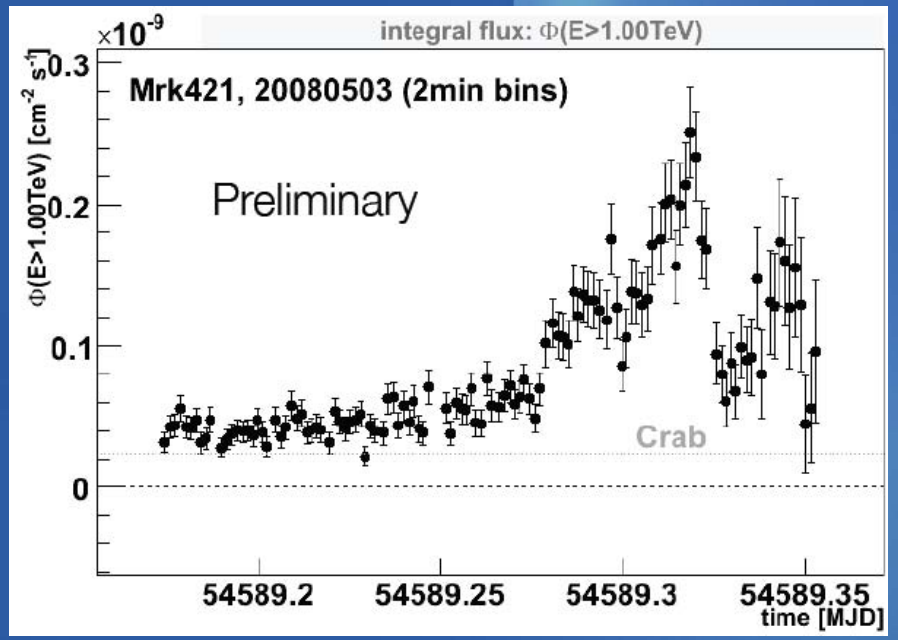




Monitoring for Transient Phenomena: GRBs and AGN Flares

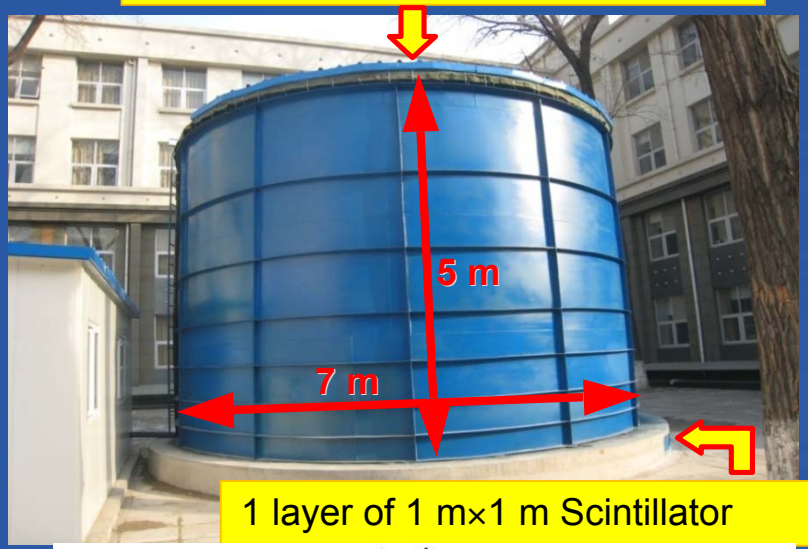
- GRB: ~2 per year;
- Light curves of AGN in bins of one minute.





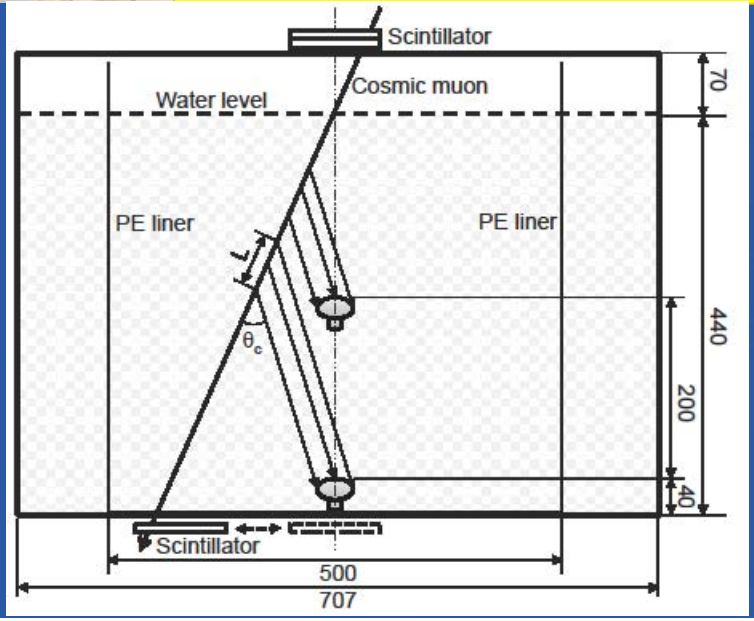
WCDA Prototype in IHEP

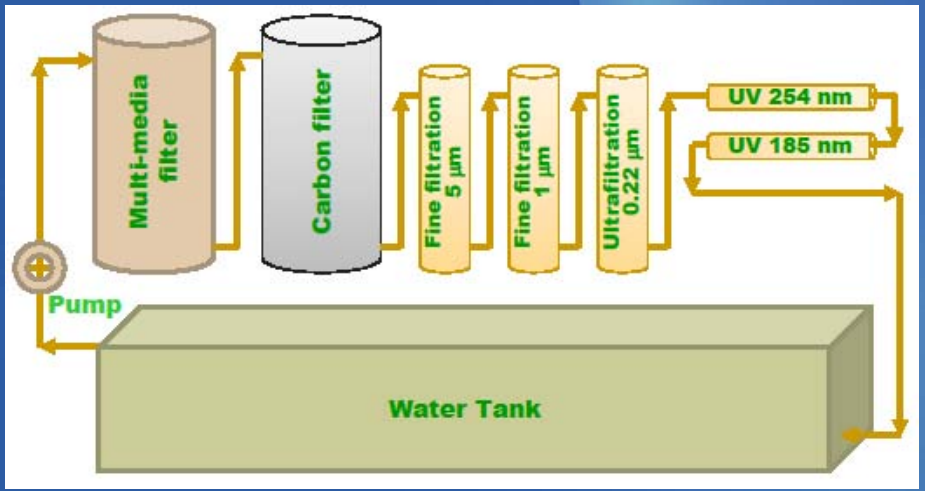
2 layers of 1 m×1 m Scintillators



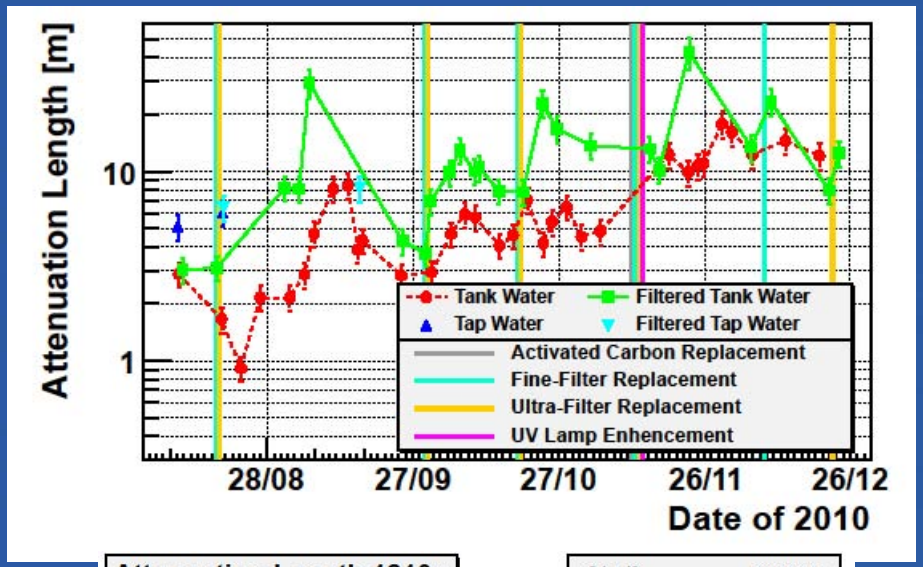
Setup in the very beginning

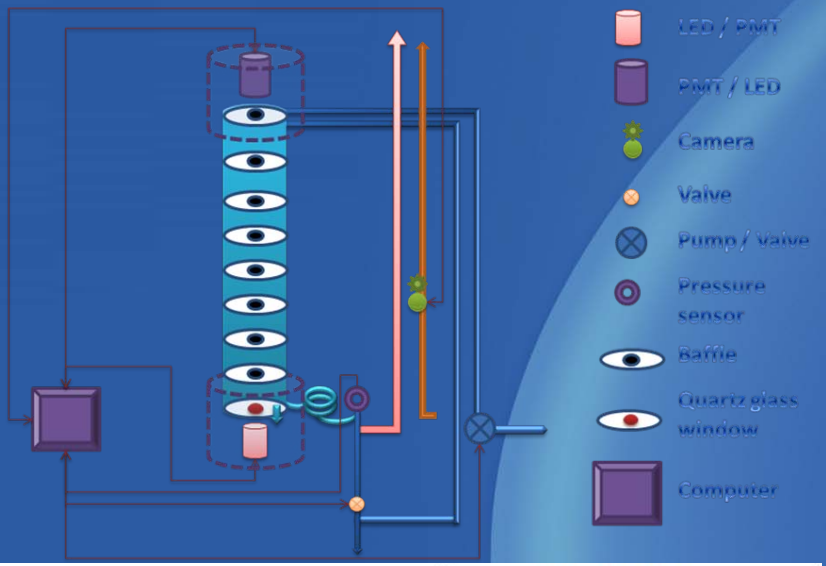
1 layer of 1 m×1 m Scintillator

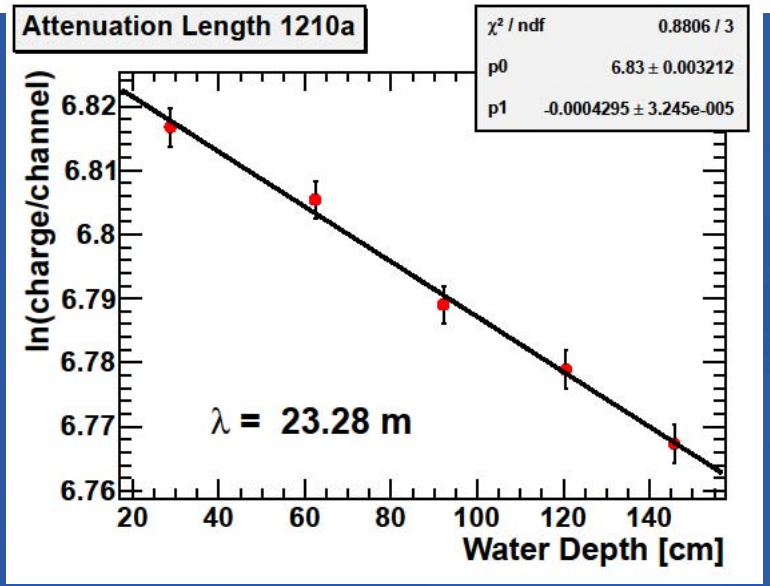


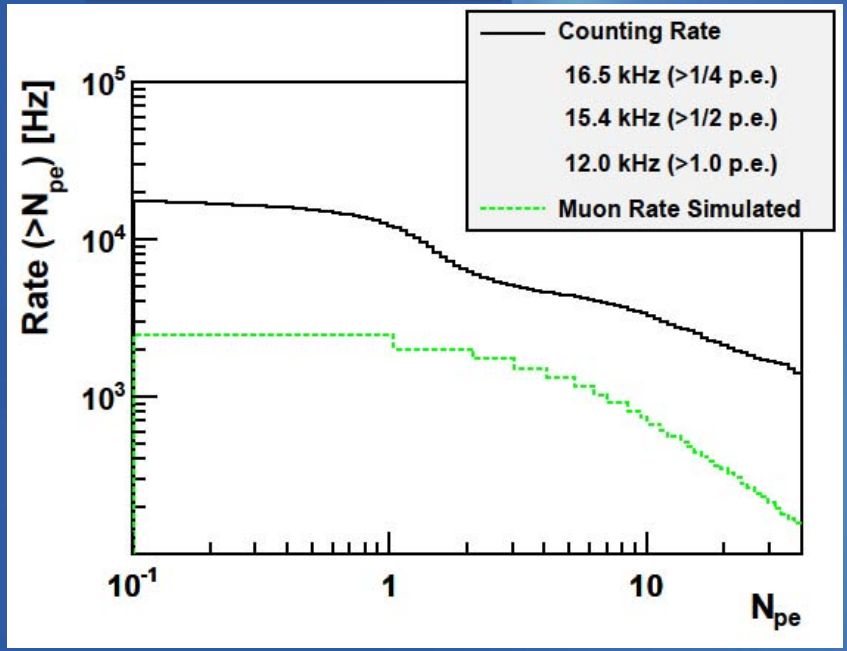


Results: Water & Rate

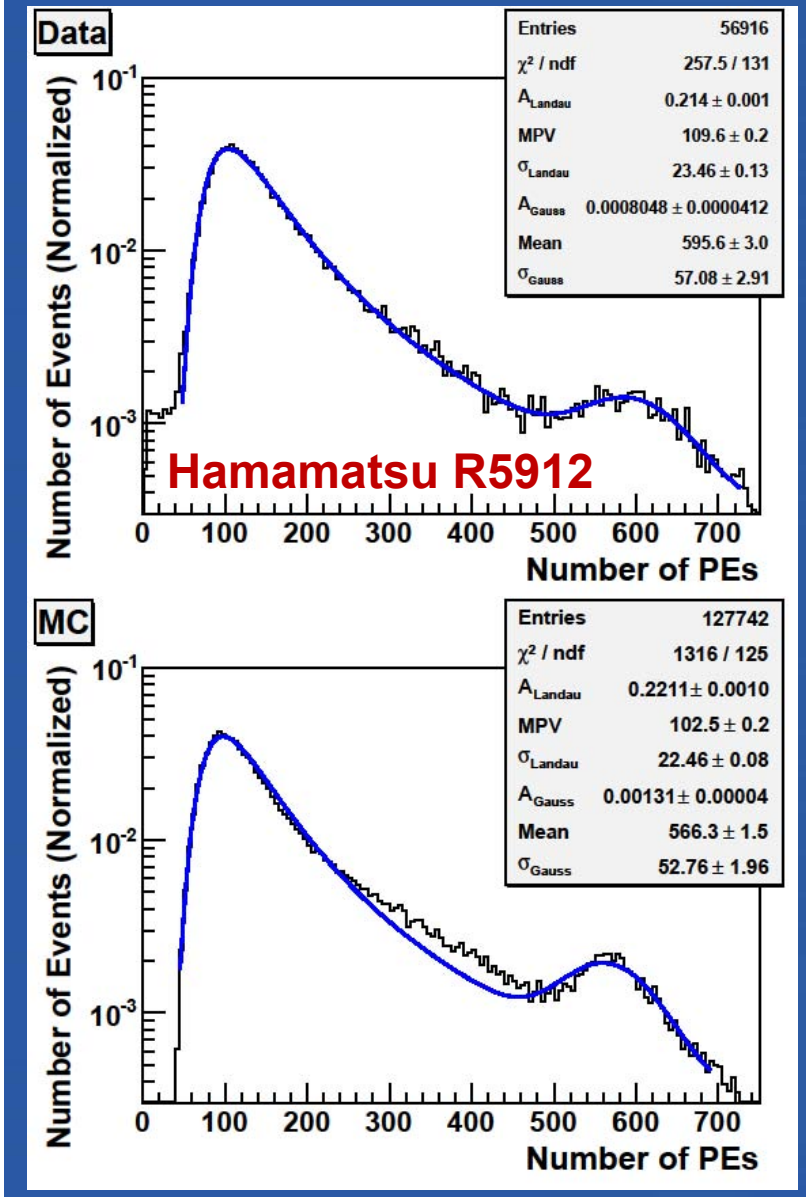


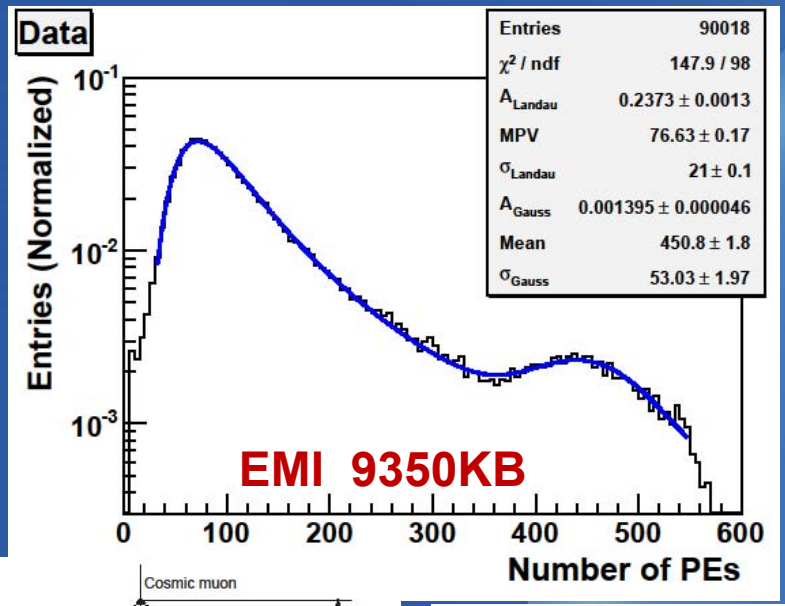


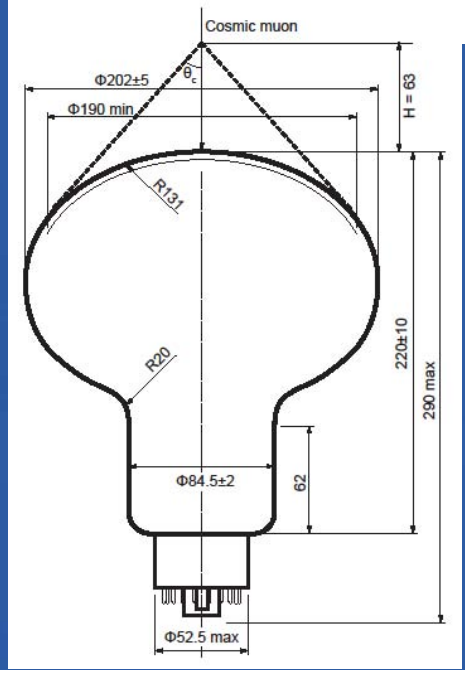


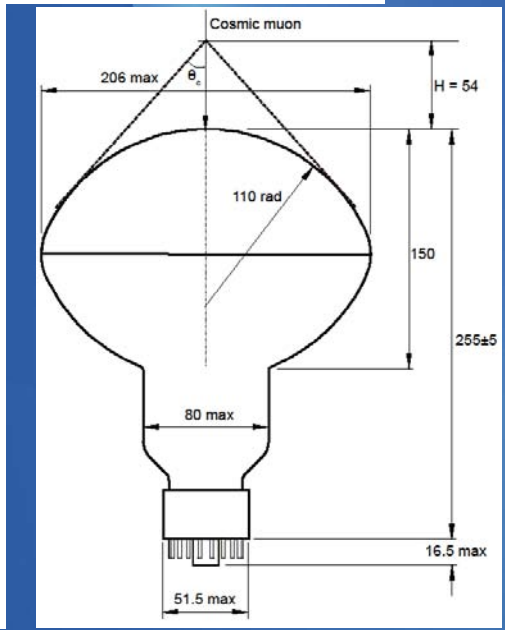


Results: Second Peak

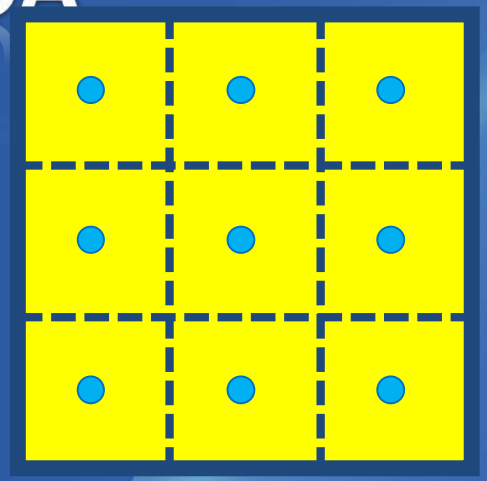


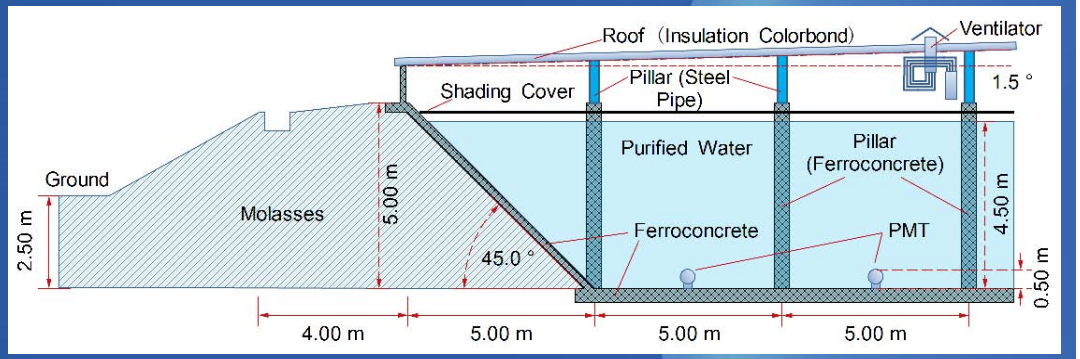






Engineering Array of WCDA

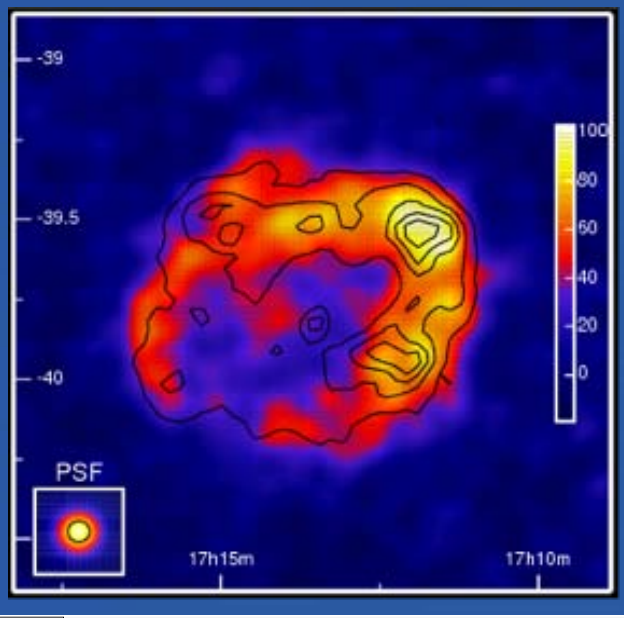


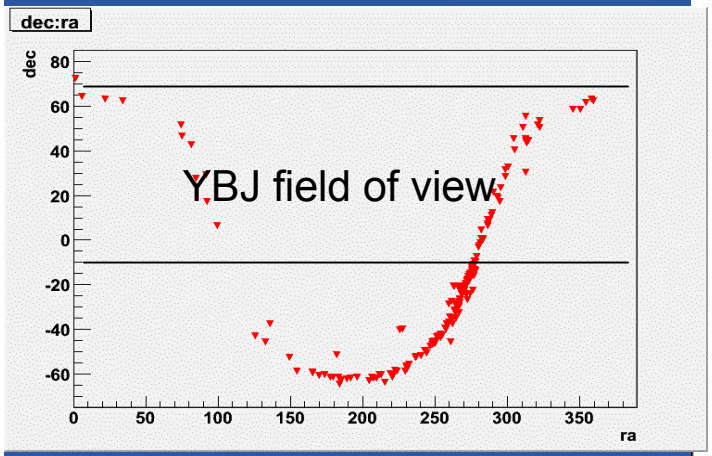


Status of WCDA Engineering Array

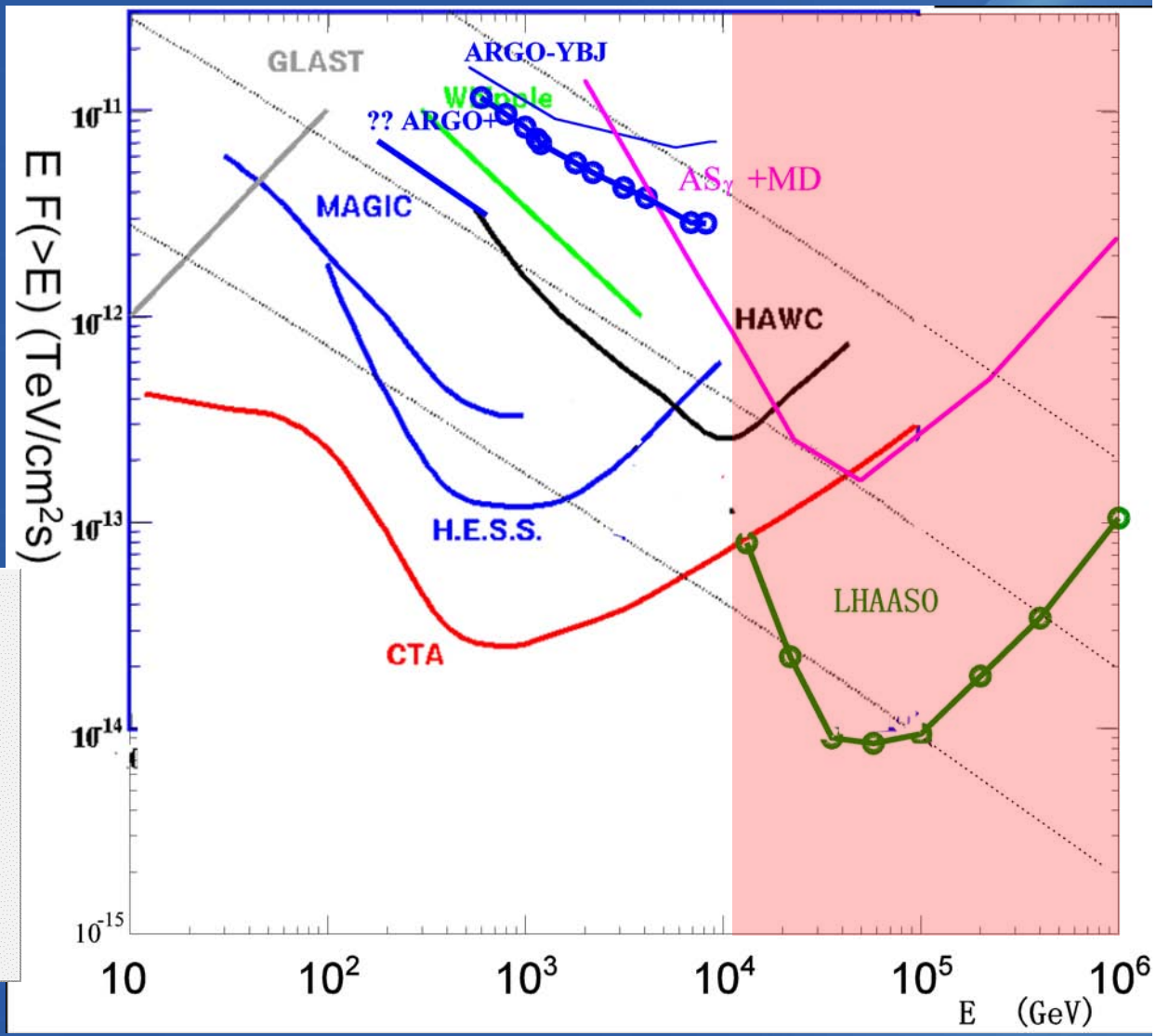
- The array consists of
  - 9 WCDs and 1 MD;
  - 4 scintillator modules surrounding the array;
  - A water purifier and circulating system;
  - An LED+fibers system for time calibration & SPE measurement;
  - A charge calibration system using cosmic muons.
- Status
  - Now it is in “dry run” mode;
  - Will start the real data-taking in June.

Sensitivities for 10TeV γ sky

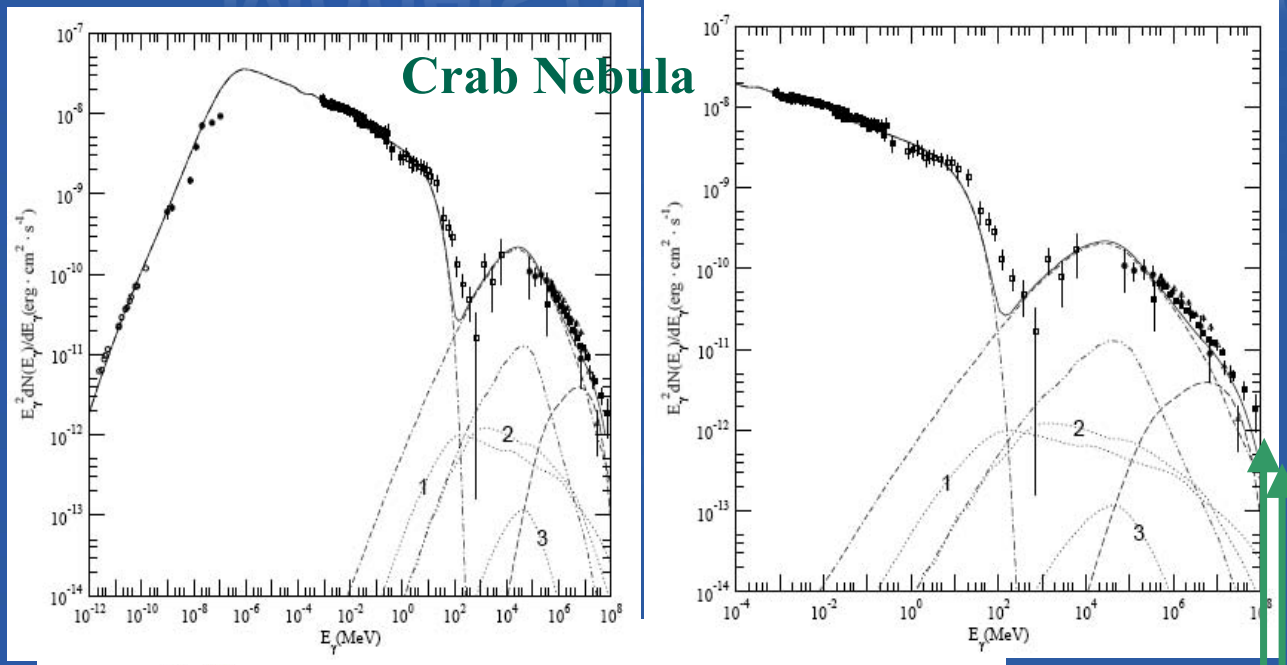




E-resolution 20%



Models of Gamma Ray Sources



Hadronic model?

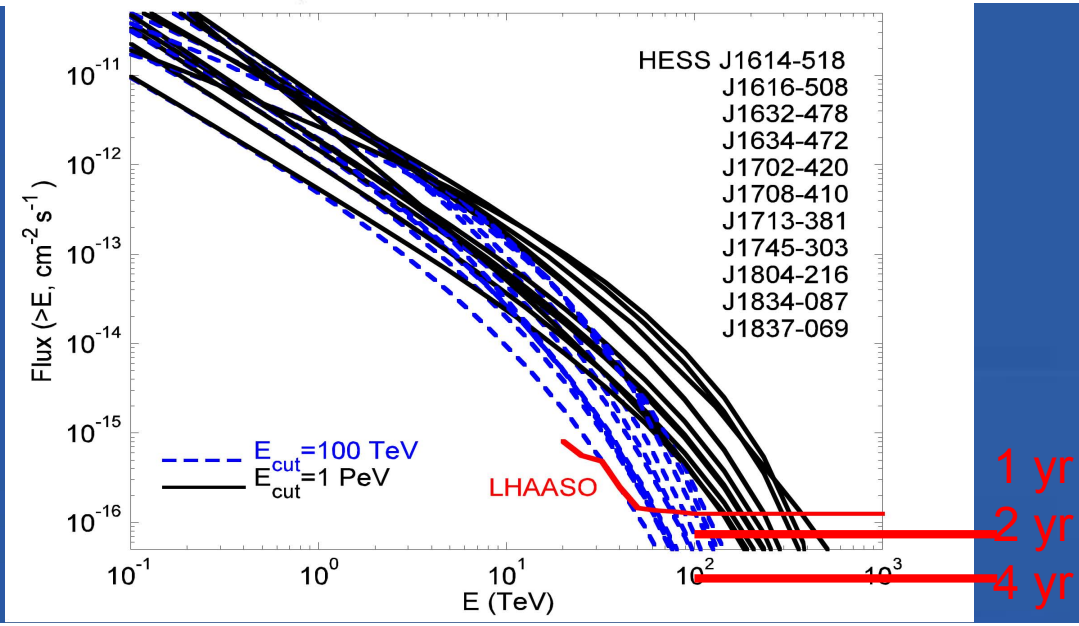
Leptonic model?

- SED @100 TeV
- SED @10 GeV

1000

200

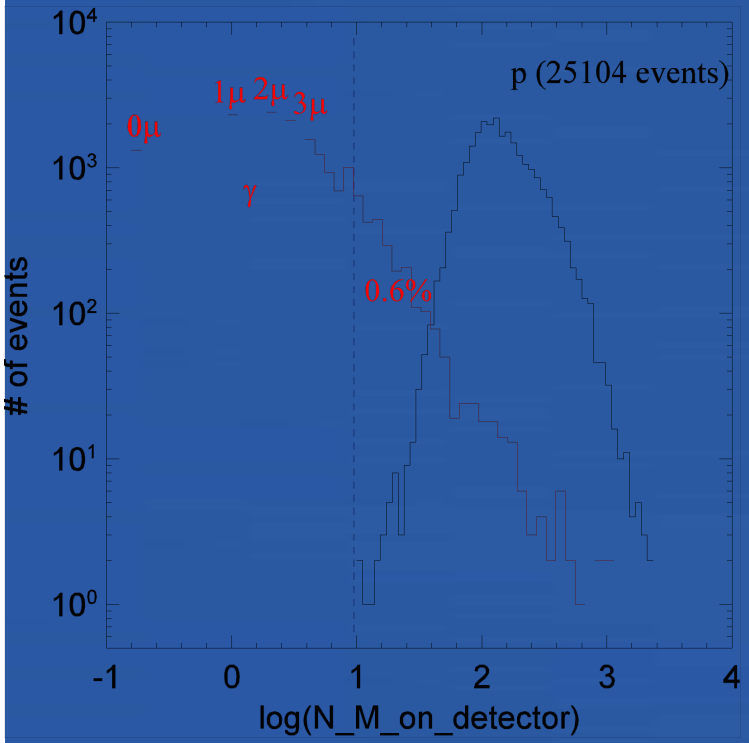
10

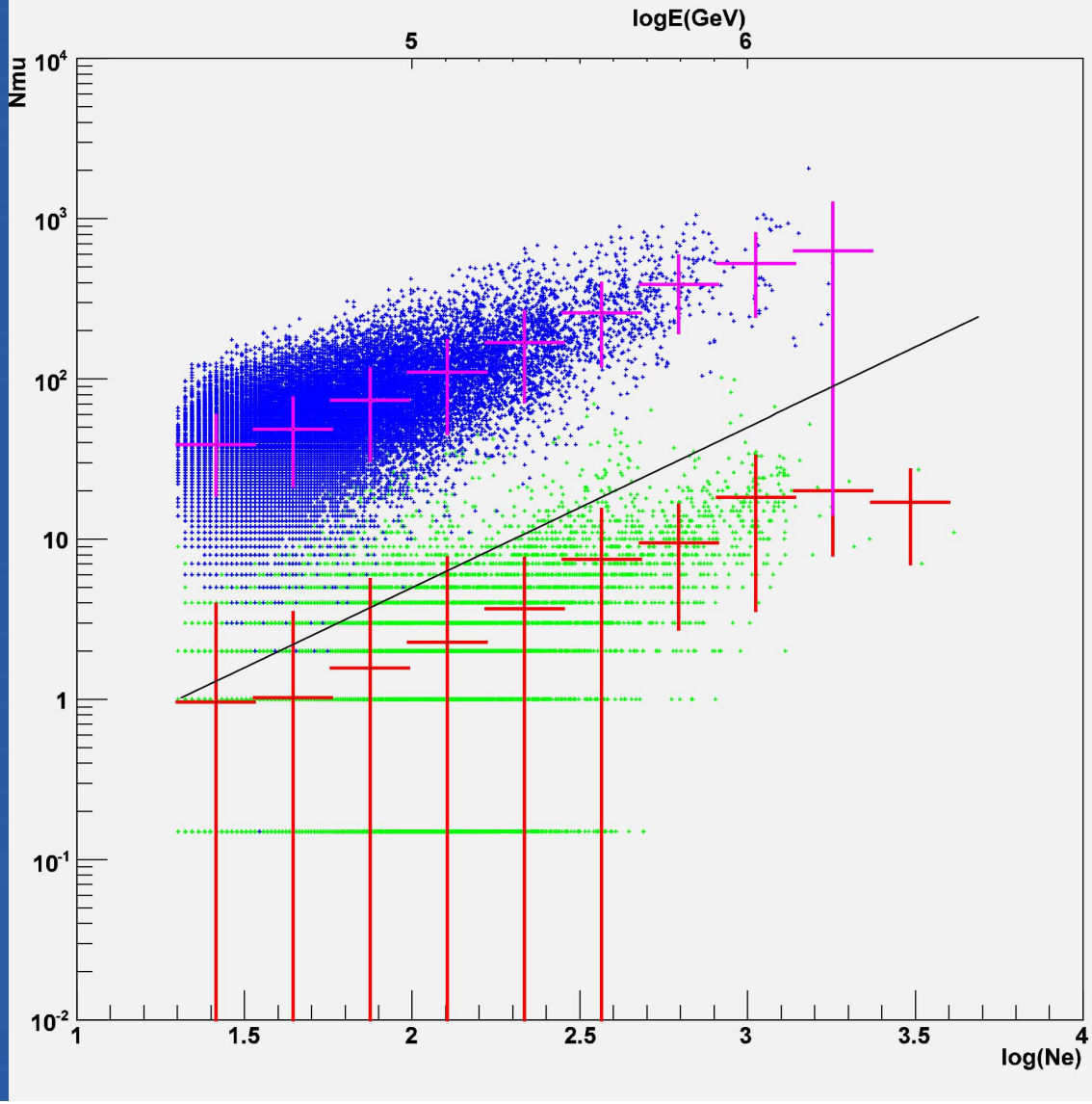


Expectation: if Hess sources are in the FOV

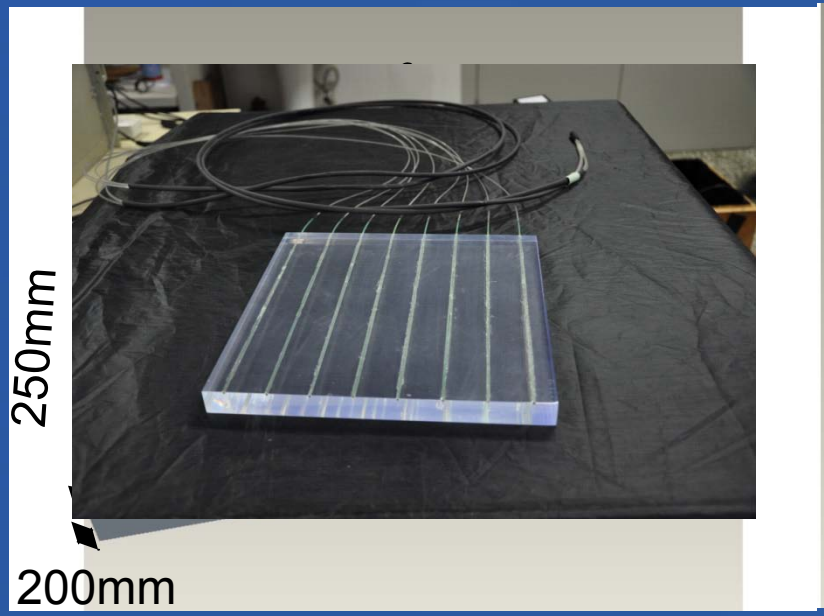
γ/p discrimination

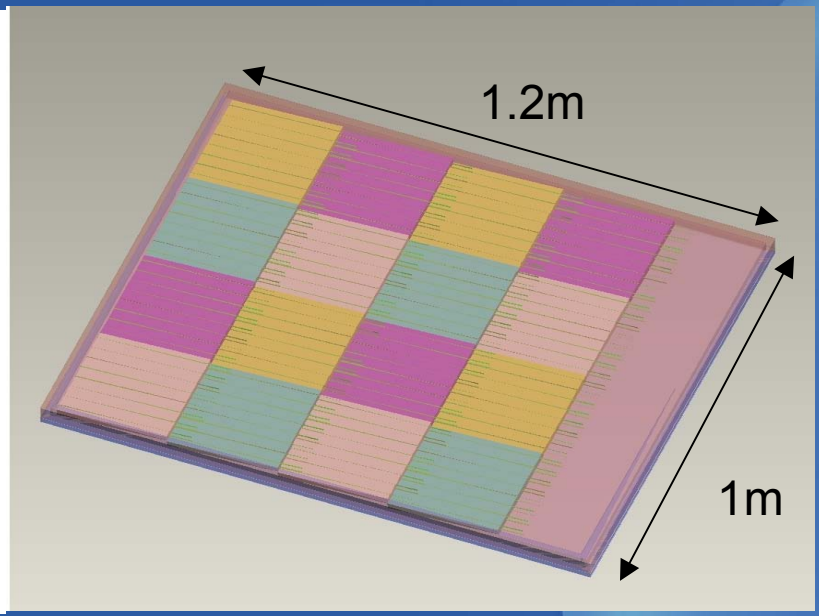
- CR BG-free(10^{-5})
- γ survival rate ~99%
- Angular resolution 0.5°above 60TeV

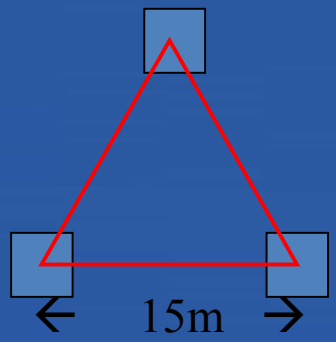




ED of KM2A

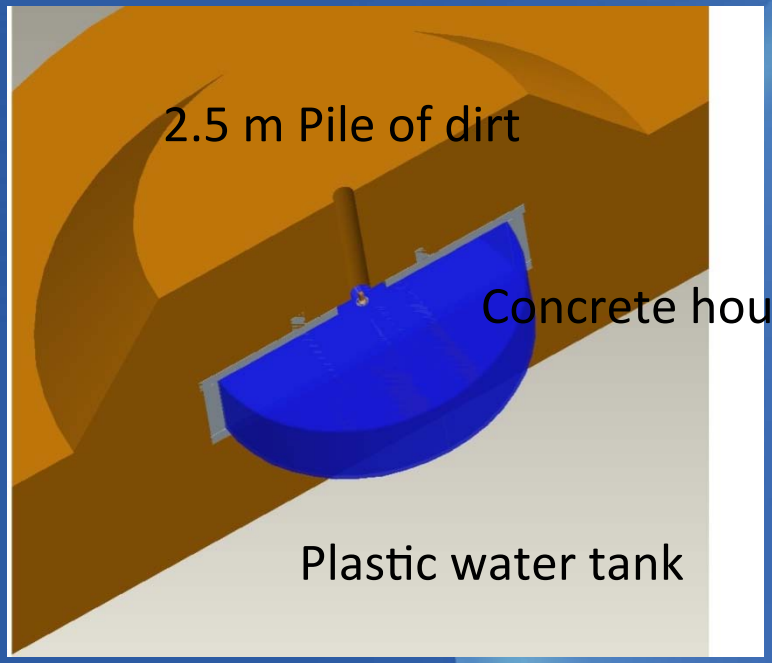


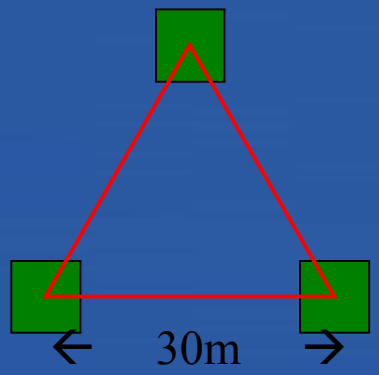




- Total 5137 cassettes, distributed in an area of 1 km^2.

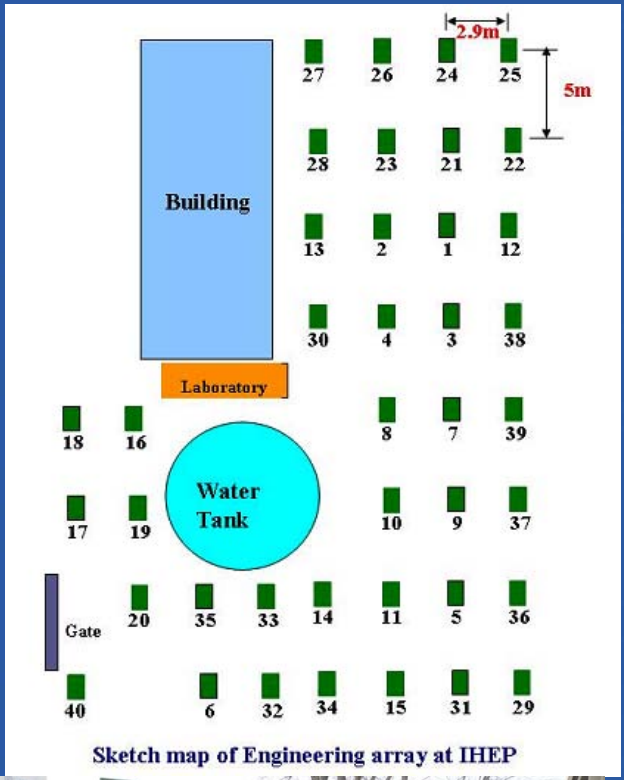
MD of KM2A





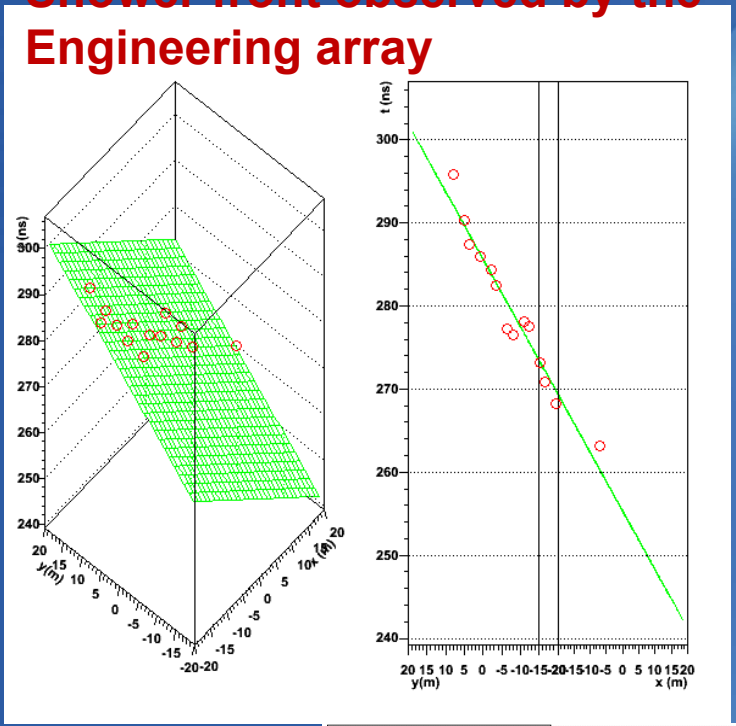
- Total 1161 tanks, distributed in an area of 1 km^2.
- MD prototype will be installed and run in this summer

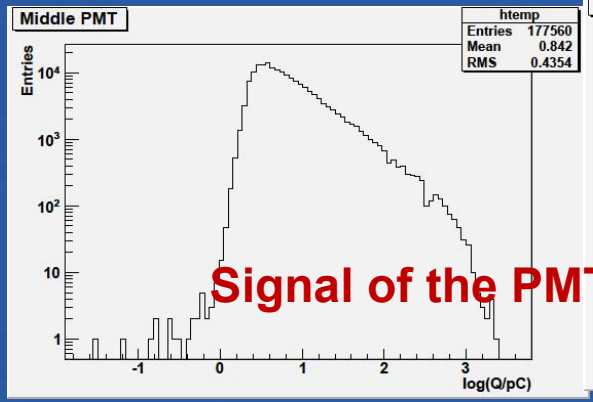
Engineering Array of KM2A at IHEP

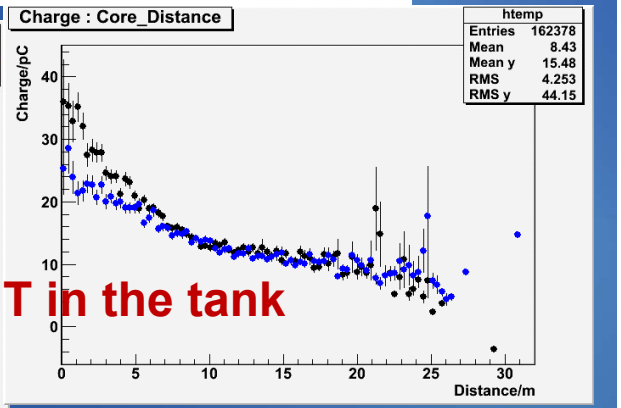


Sketch map of Engineering array at IHEP

Shower front observed by the Engineering array

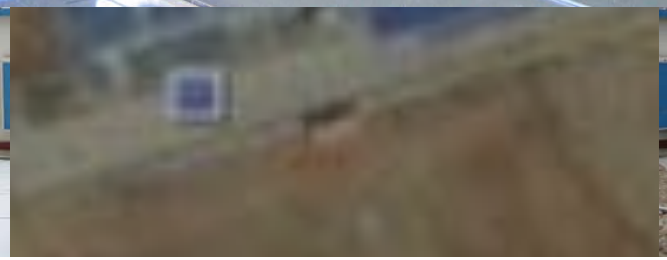


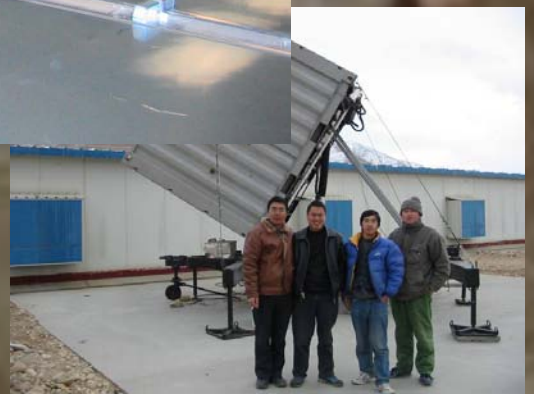


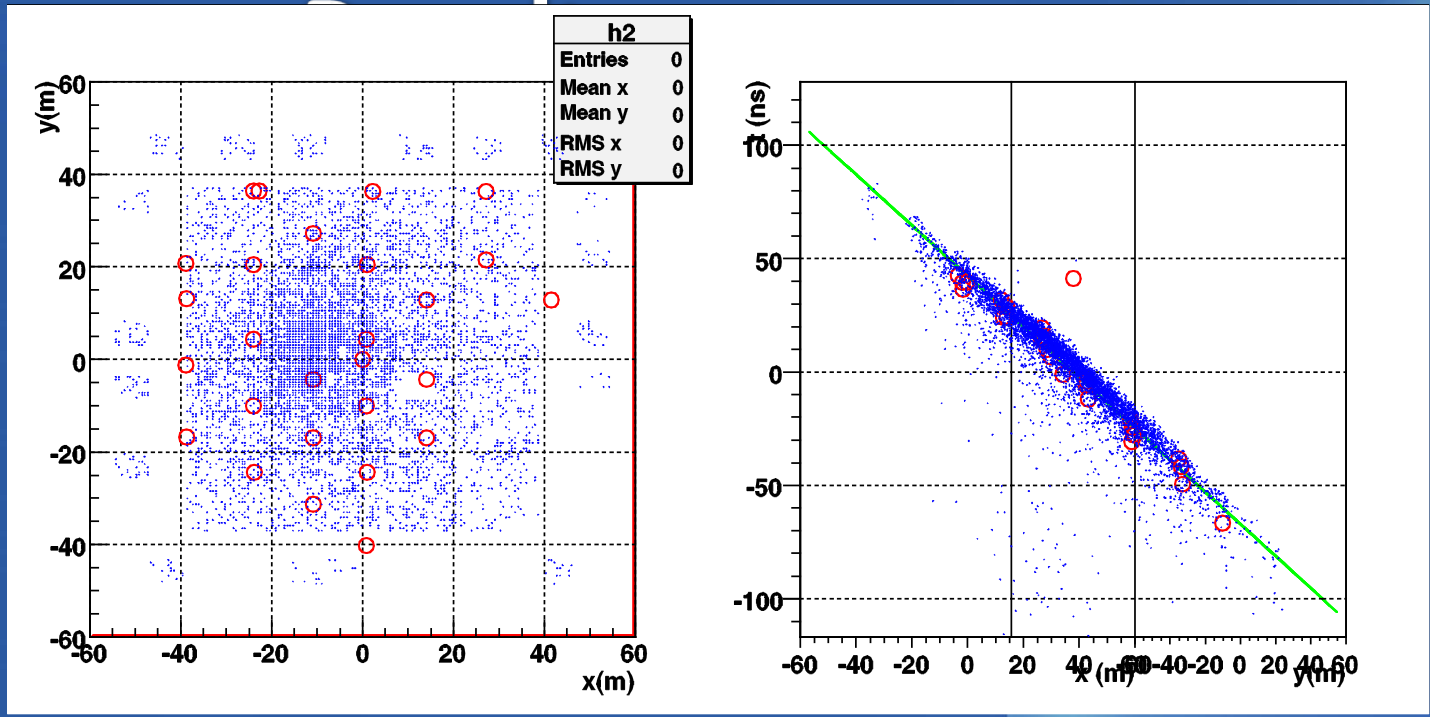


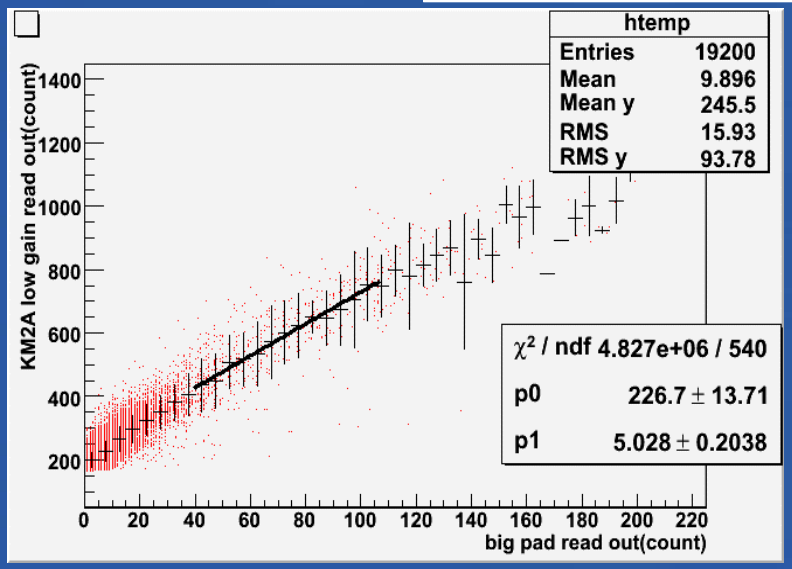
Signal of the PMT in the tank

Engineering Array of KM2A at YBJ







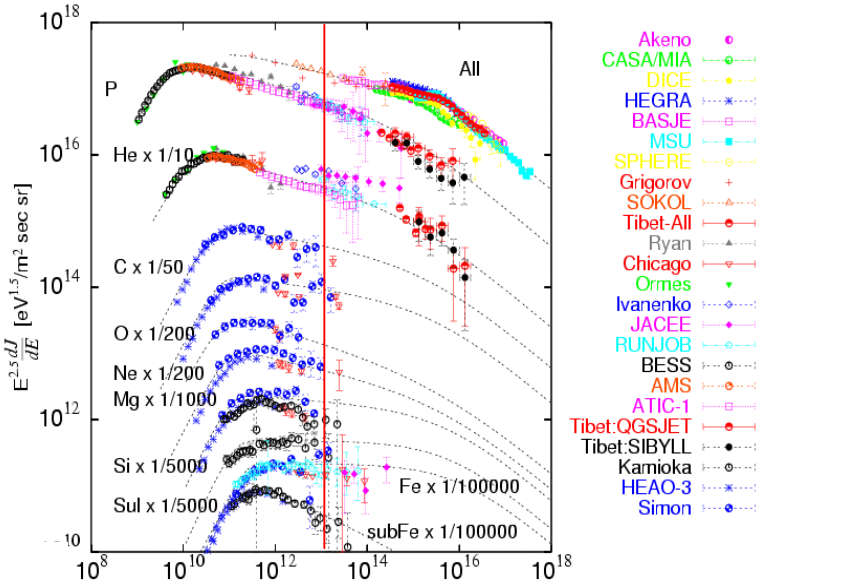


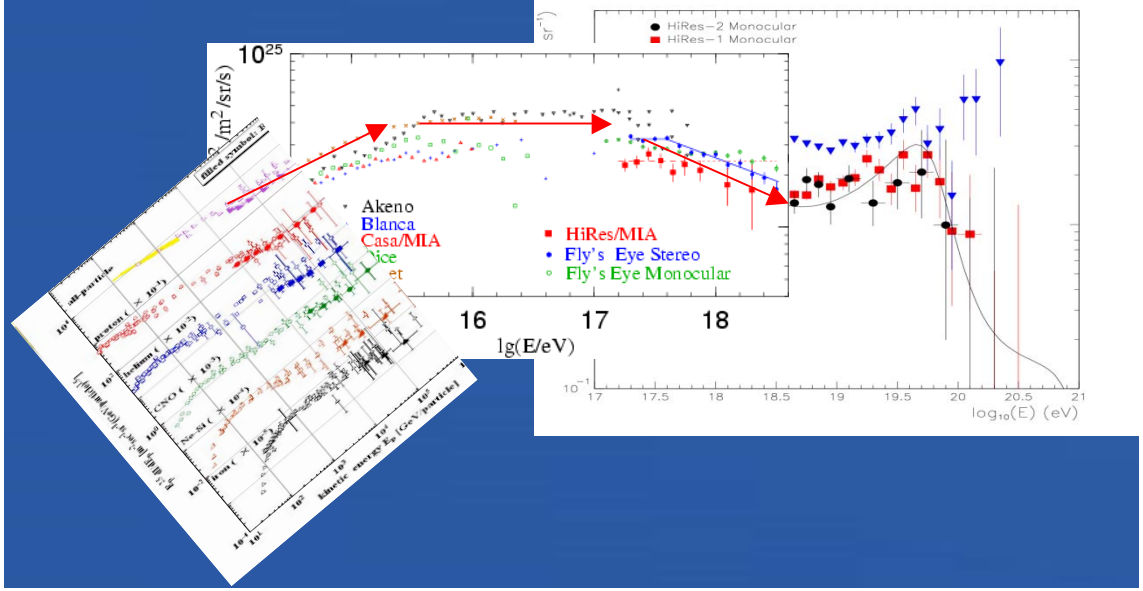
Lateral distribution and direction reconstruction for a shower event in ARGO & ED.

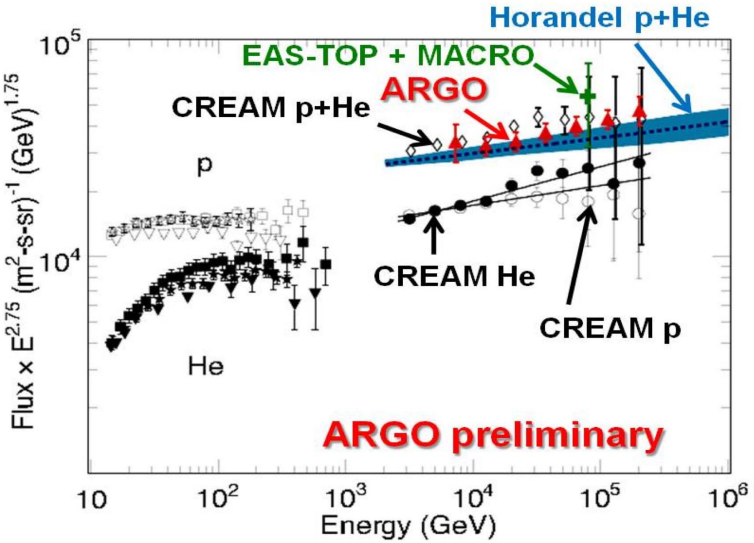
ARGO Bigpad charge readout vs. charge values of ED.

Scientific Problem: Cosmic Rays

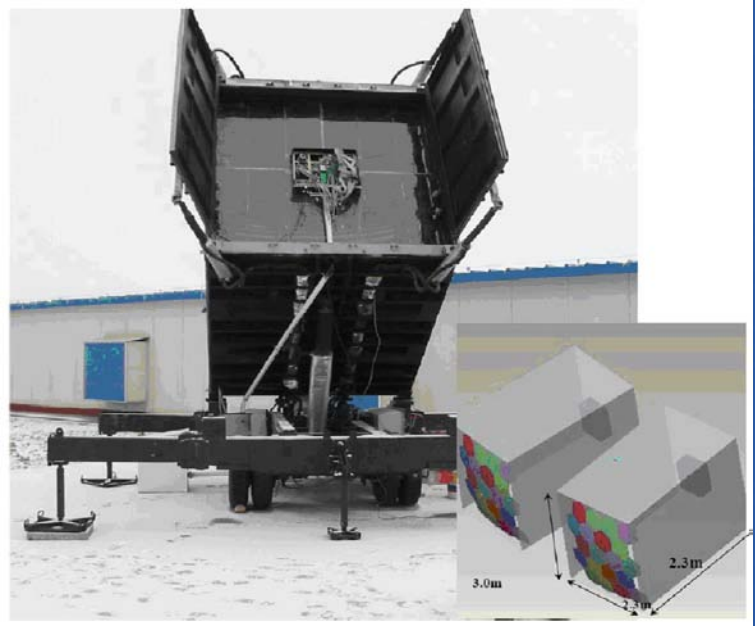
- Touch-down at 5TeV: connection with direct measurement;
- Absolute energy scale: Bottom-up scheme or T.Gaissor's "anchoring"
- Knee puzzle: mult-parameters



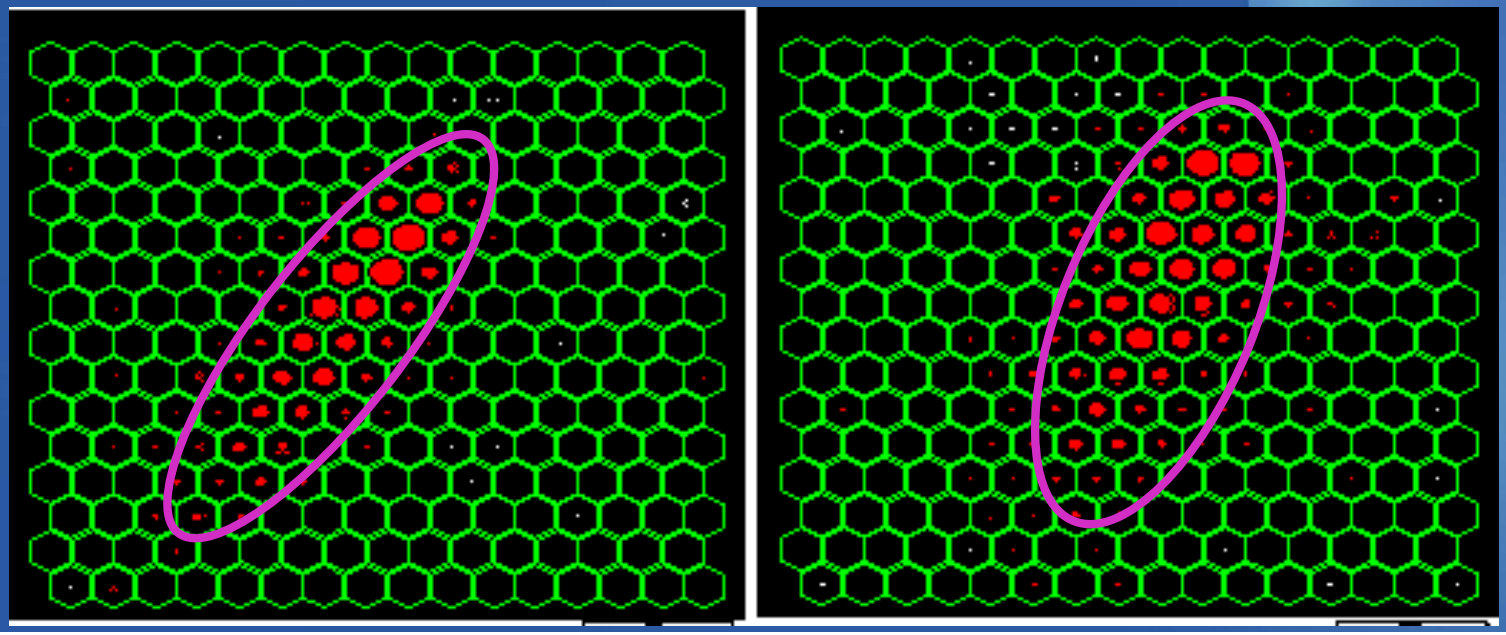




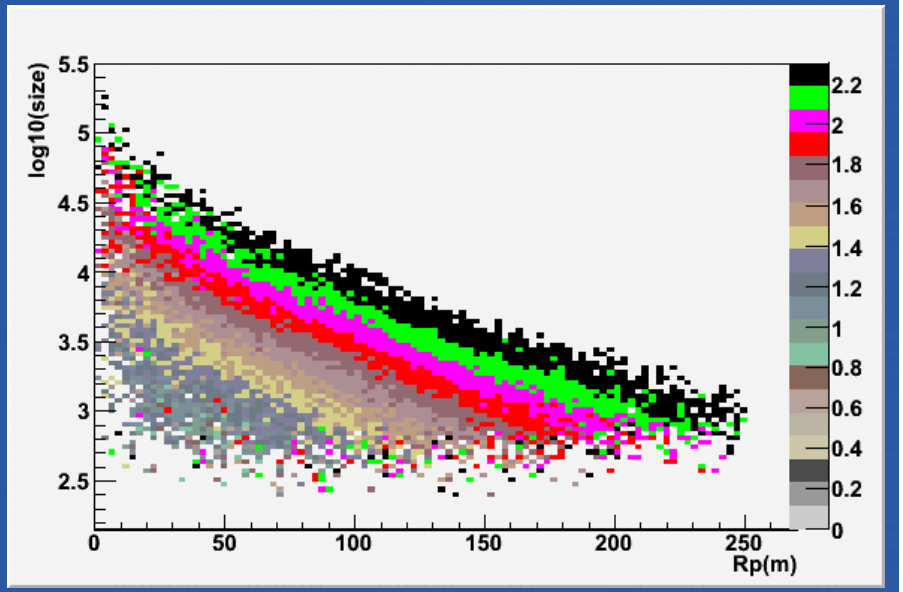
Wide Field of View Cherenkov Telescope Array (WFCTA)

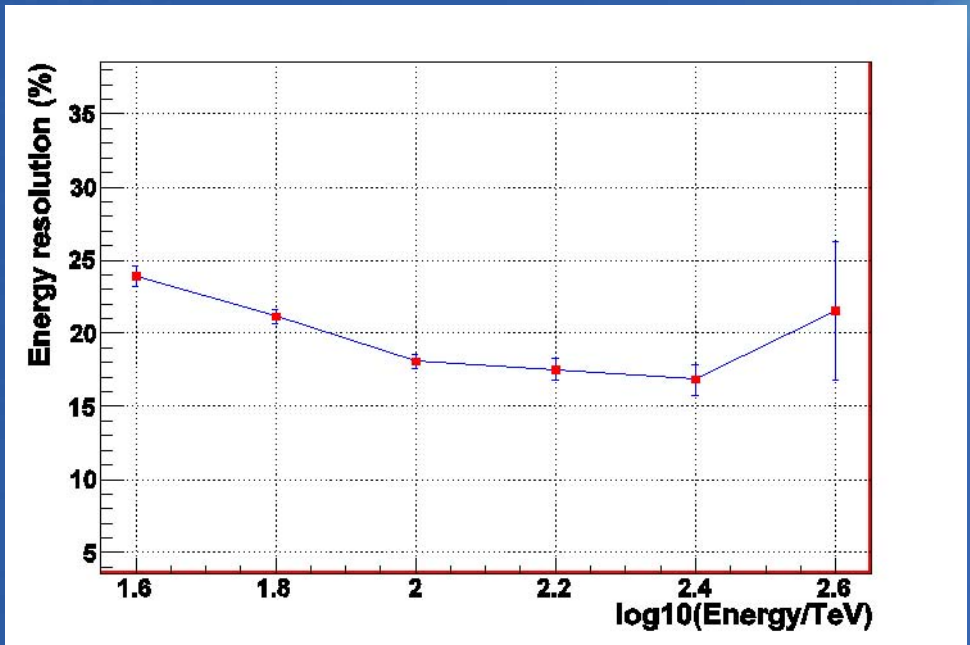


- 8×3 mirrors
- Mirror size: 4.7 m^2
- Camera:
  - 16×16 PMT array;
  - 1° pixel;
  - FOV 14°×16°;
- Electronics: 50Hz FADC (20ns/bin) .

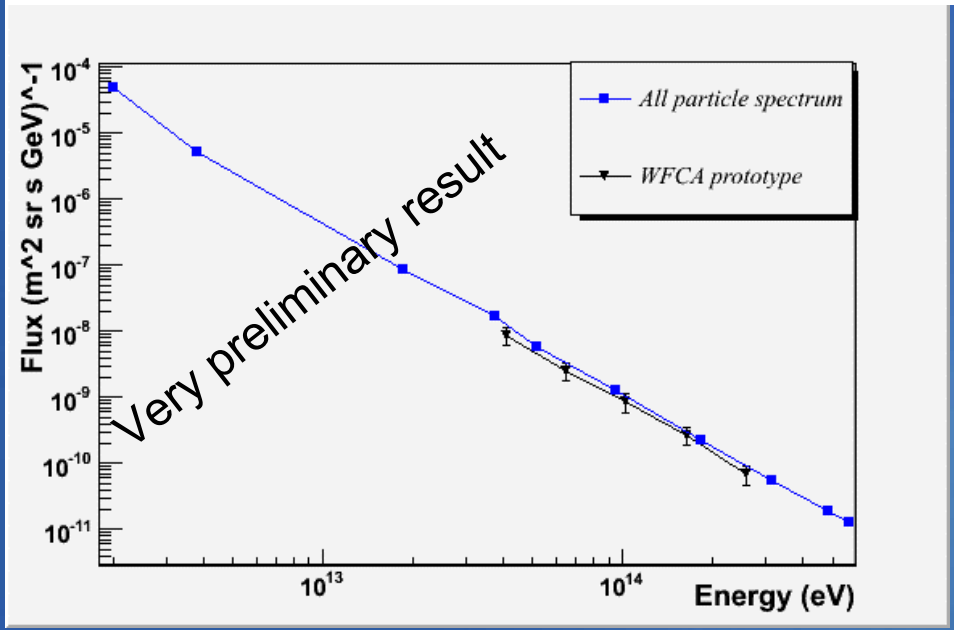


Results

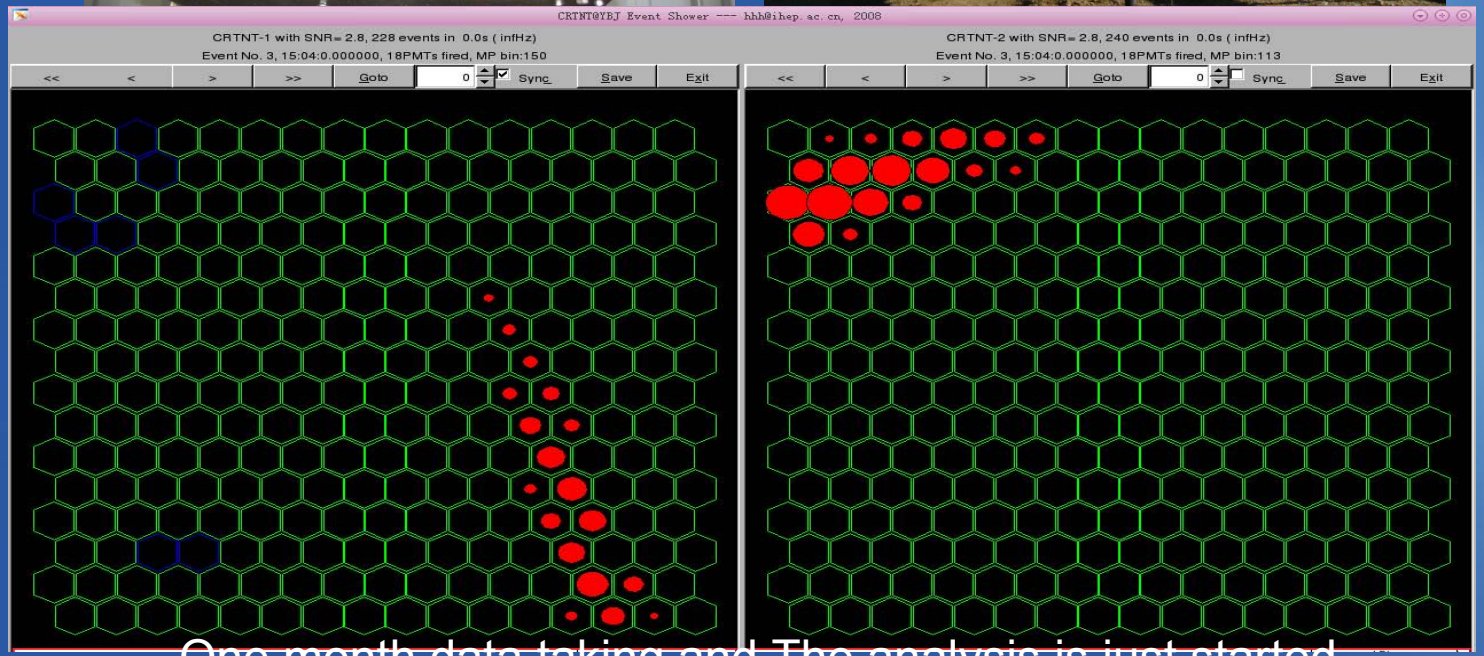




- 160 k events.
- Resolution < 15%, with bias<3%;
- Core resolution <1 m.

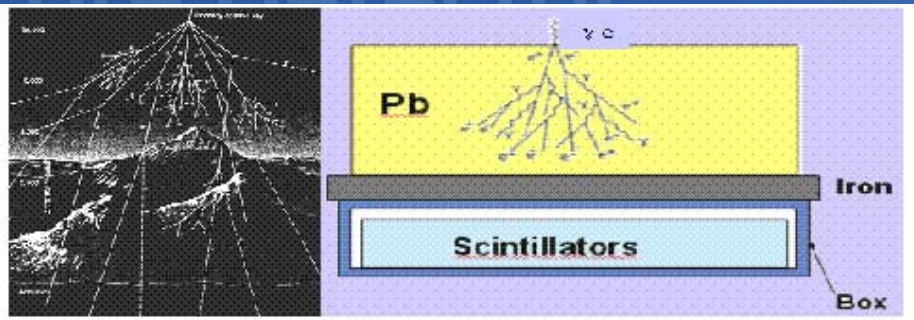


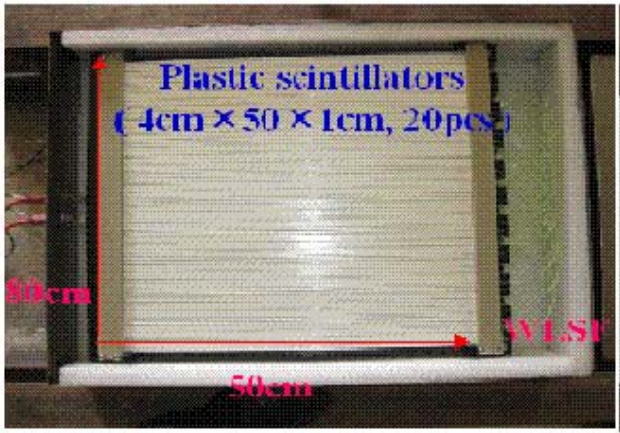
Laser calibration facility

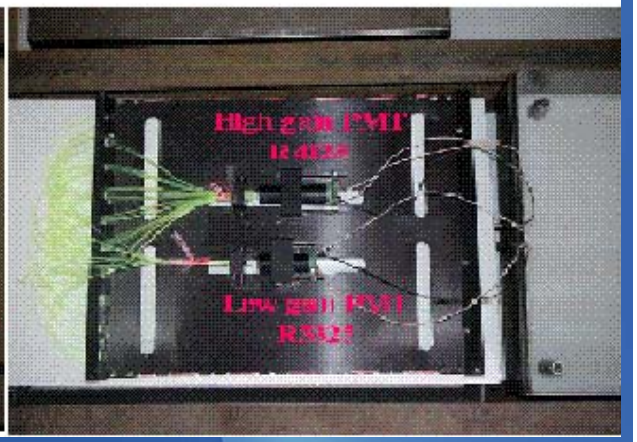


One month data taking and The analysis is just started

Shower Core Detector







- Total 5000 m^2, carpet, in the center of the array.
- A unit: 80 cm × 50 cm;
- Lead plate on top.
- Thickness of plastic SC: 1 cm;
- 2 PMTs to readout.

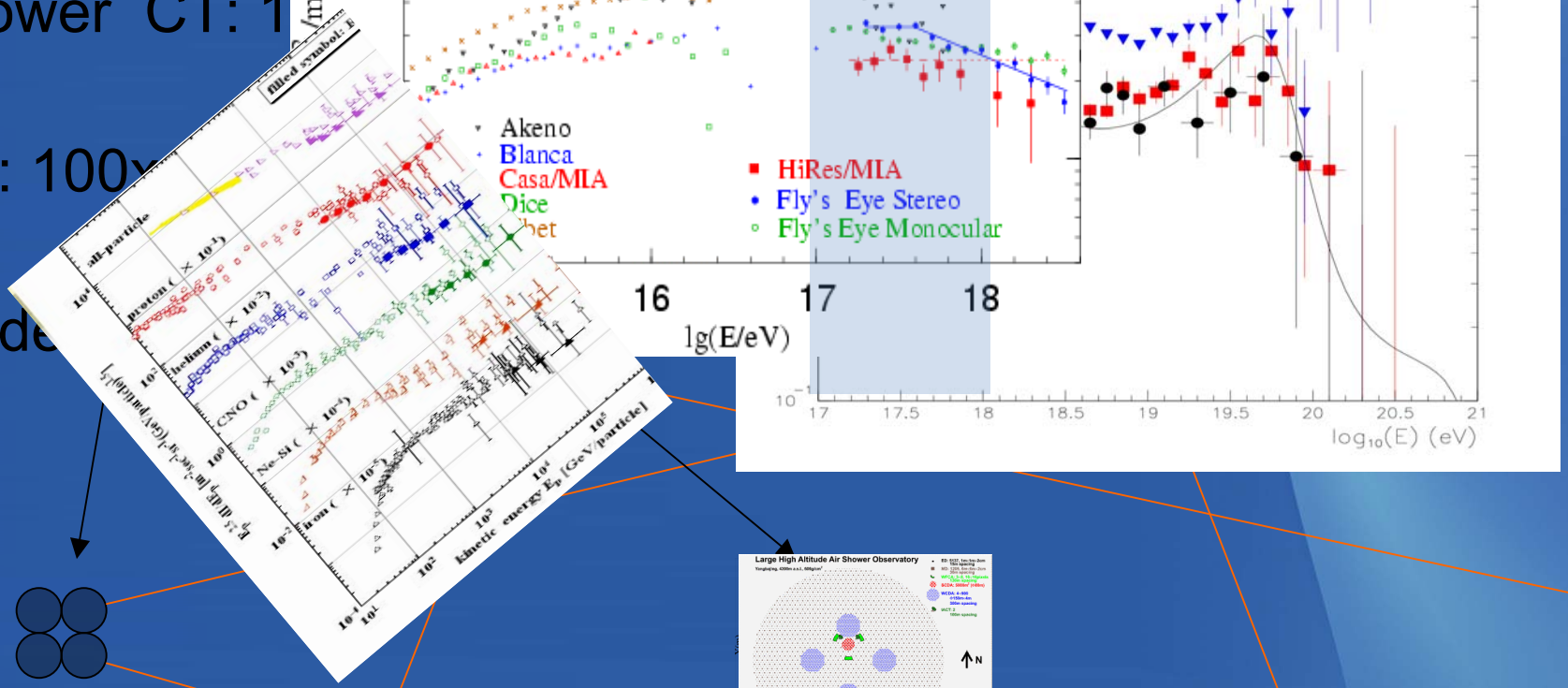
LHAASO Extension to 2nd Knee (Cost Free)

Re-Configuration

Tower CT: 1

μ : 100×

Side



LHAASO Extension to 2nd Knee with TUNKA

Charge Particle Array

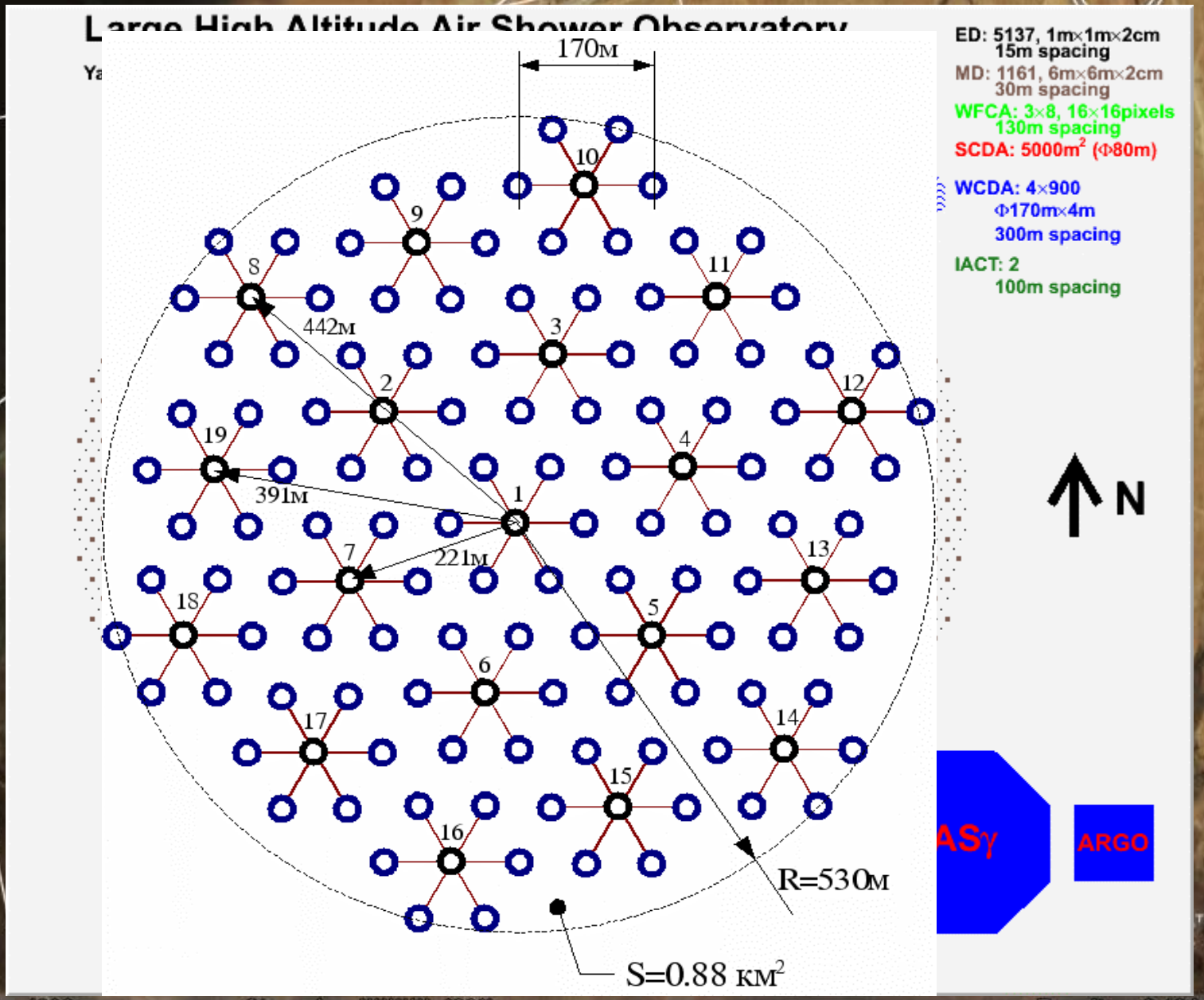
μ detector Array

Water C Array

Wide FOV C-Telescope Array

&

Core Detector Array



LHAASO Proje

PRISMA

Core Detector Array

ZnS(Ag) is a unique scintillator for heavy particles detection:

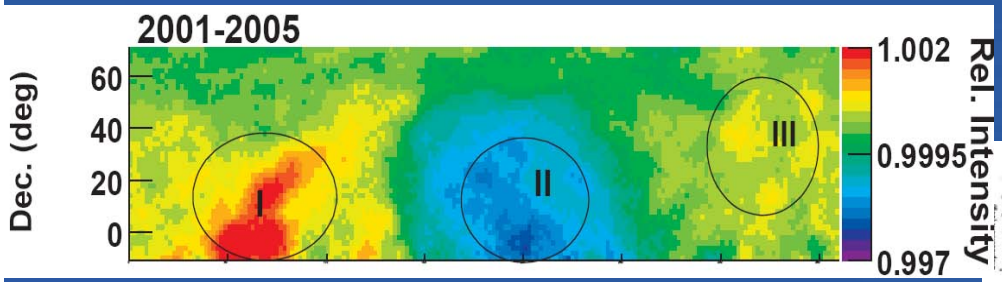
160,000 photons per capture

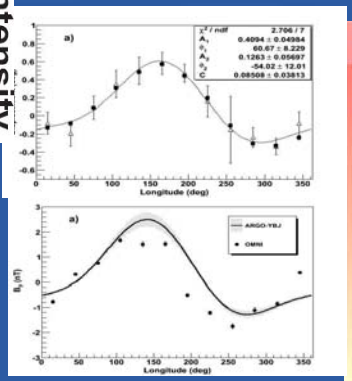
ASγ

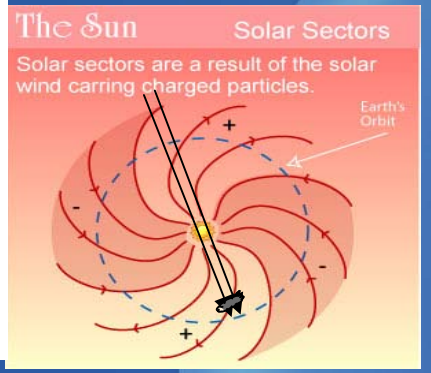
ARGO

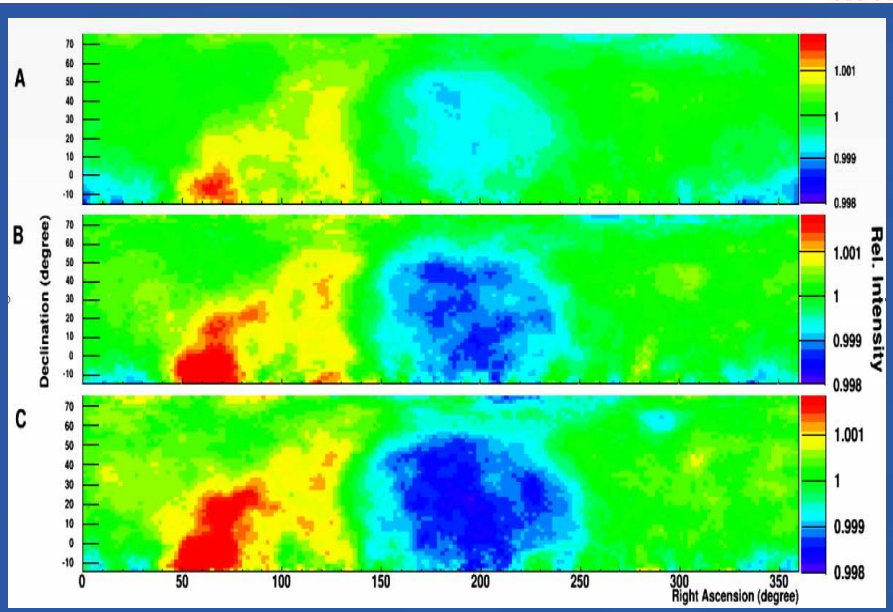
Other Topics

Solar activity : forecast magnetic storms

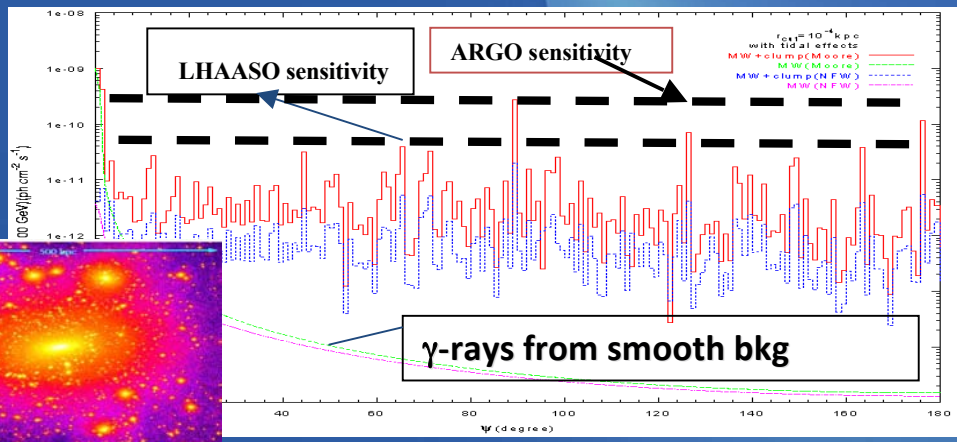








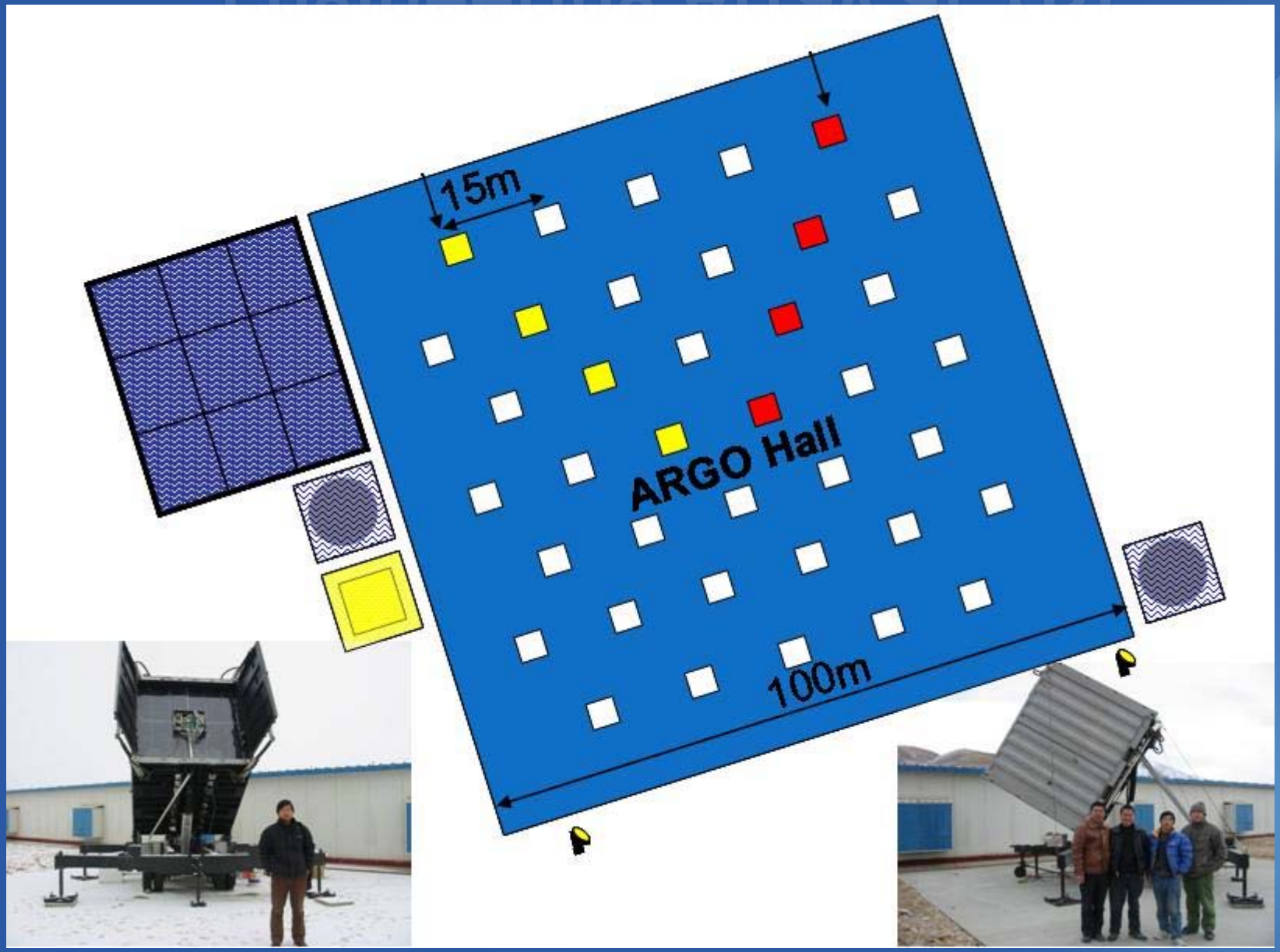
Dark matter –
gamma rays from the sub-halos



Proposing and current status

- In Nov. 2010, CCDR (Chinese Committee of Development and Reformation) reviewed all proposals in 7 groups and LHAASO was ranked as No. 1 in the group of HEP&NP;
- In Jan. 2011, CCDR reviewed 21 candidate projects and LHAASO was selected as one to be supported in next 5 years;
- Reviewing of LHAASO for its design and budget will start soon. The proposal is expected to be approved soon because of its readiness in terms of R/D and site preparation;
- It is planned for a construction of 5-6 years.
- Physics design report (PDR) is expected to release by end of 2011;
- Technical design report (TDR) is expected to release by mid of 2012.

Engineering Array at YBJ



BACKUP SLIDES

Collaboration

- Domestic collaboration
  - ARGO collaboration:
    - APC of IHEP
    - Tibet Univ.
    - SW Jiaotong Univ.
    - Yunnan Univ.
    - Shandong Univ.
    - Hebei Normal Univ.
  - New collaborators
    - EPC of IHEP
    - USTC
    - Tsinghua Univ.
    - PKU
    - IAP
    - CSSAR
    - NSMC
    - IMP
  - Communication Members (potential collaborators):
    - Shanghai Jiaotong Univ.
    - Eastern Institute of Science and Technology
    - Nanking Univ.
- International collaboration
  - ARGO collaboration:
    - Rome II Univ.
    - Napoli Univ.
    - Turino Univ.
  - France IN2P3
    - INPO
    - LAL
  - Russia Tunka
  - …..

YBJ Site


ASγ
ARGO-YBJ
Village
Hot Spring
Lhasa, 90 km
Power Plant
© 2011 Mapabc.com
Image © 2011 GeoEye
©2010 Google
4363 m
4342 m
LHAASO
1 km
Gradient <2.0°
4336 m
1 km
4323 m
ASγ
ARGO-YBJ
© 2011 Mapabc.com
Image © 2011 GeoEye
©2010 Google