



The Large High Altitude Air Shower Observatory and the gamma ray detection

Isabelle LHENRY-YVON, IPN ORSAY
on behalf of the LHAASO collaboration

Contact person: Zhen CAO, IHEP, CHINA

OUTLINE

✓ Introduction

✓ LHAASO design

✓ LHAASO performances

✓ LHAASO and gamma ray astronomy

Major Scientific Goals

Study of VHE gamma rays and cosmic rays
measuring Air Showers at High Altitude

GAMMA RAY ASTRONOMY

- ✓ Survey in the Northern hemisphere for gamma ray sources
above 100 GeV
- ✓ Searching for GCR sources by measuring Spectral Energy Distribution
above 30TeV

COSMIC RAY PHYSICS

- ✓ Energy spectrum for individual compositions below 1EeV

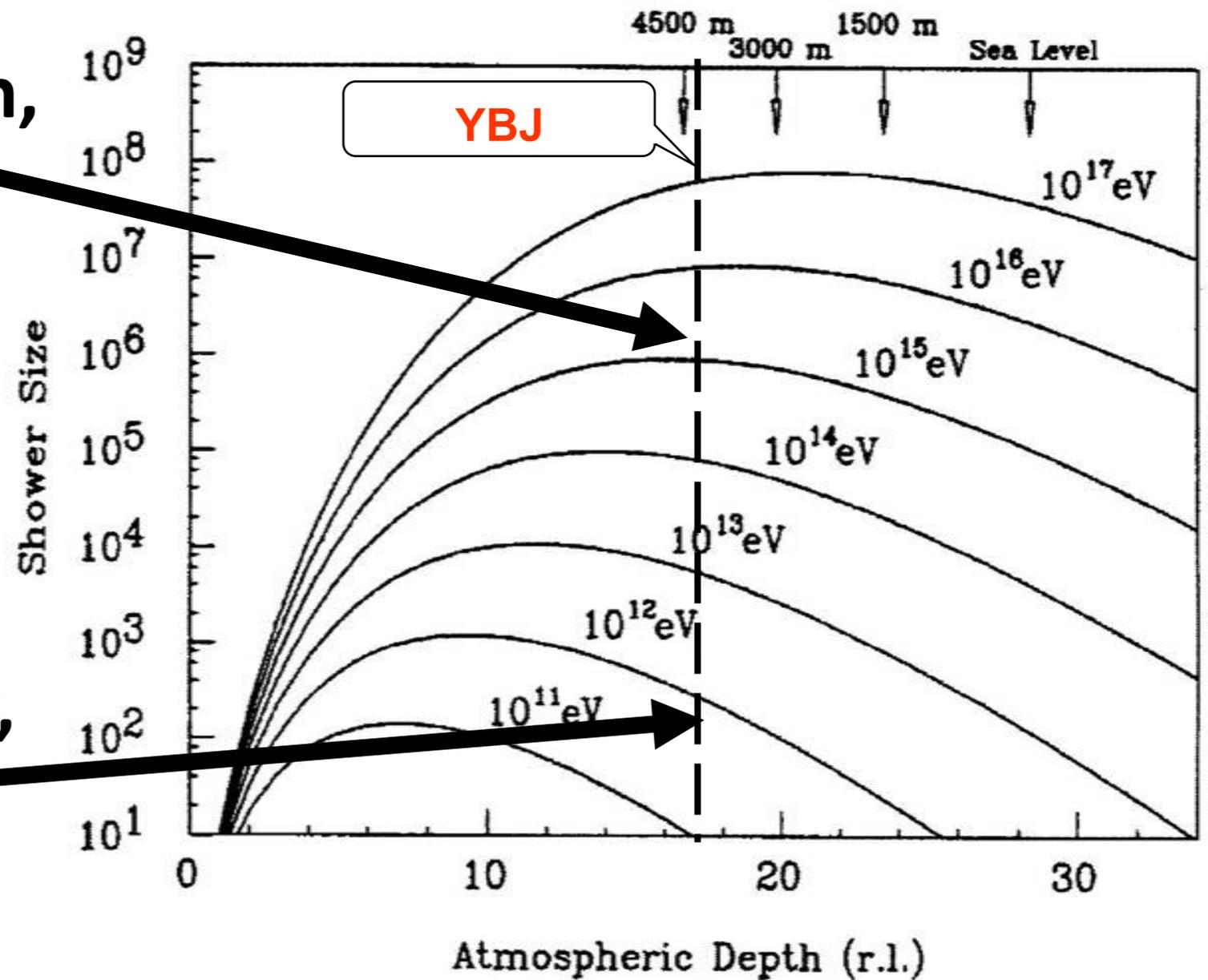
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Measurement of Air Showers at High Altitude

A large instantaneous field of view for VHE gamma rays (>100GeV)

- **HE: near Xmax**
→ lower fluctuation,
better σ_E

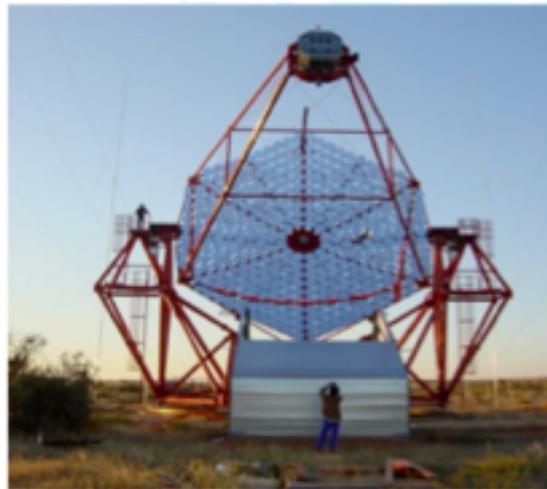
- **Lower E_{th} → deeper,**
more sources



Measurement of Air Showers at High Altitude

2 possible techniques

Cerenkov Imaging
of Gamma-ray showers (IACT)



Ex: HESS, MAGIC, VERITAS then CTA

- High sensitivity (γ -hadron separation)
- Good spatial resolution

BUT

- Low duty cycle
- Limited field of view

Detection at ground of gamma-ray showers



Ex: ARGO, MILAGRO, Tibet-AS γ , HAWC

- 100% duty cycle
- Large field of View

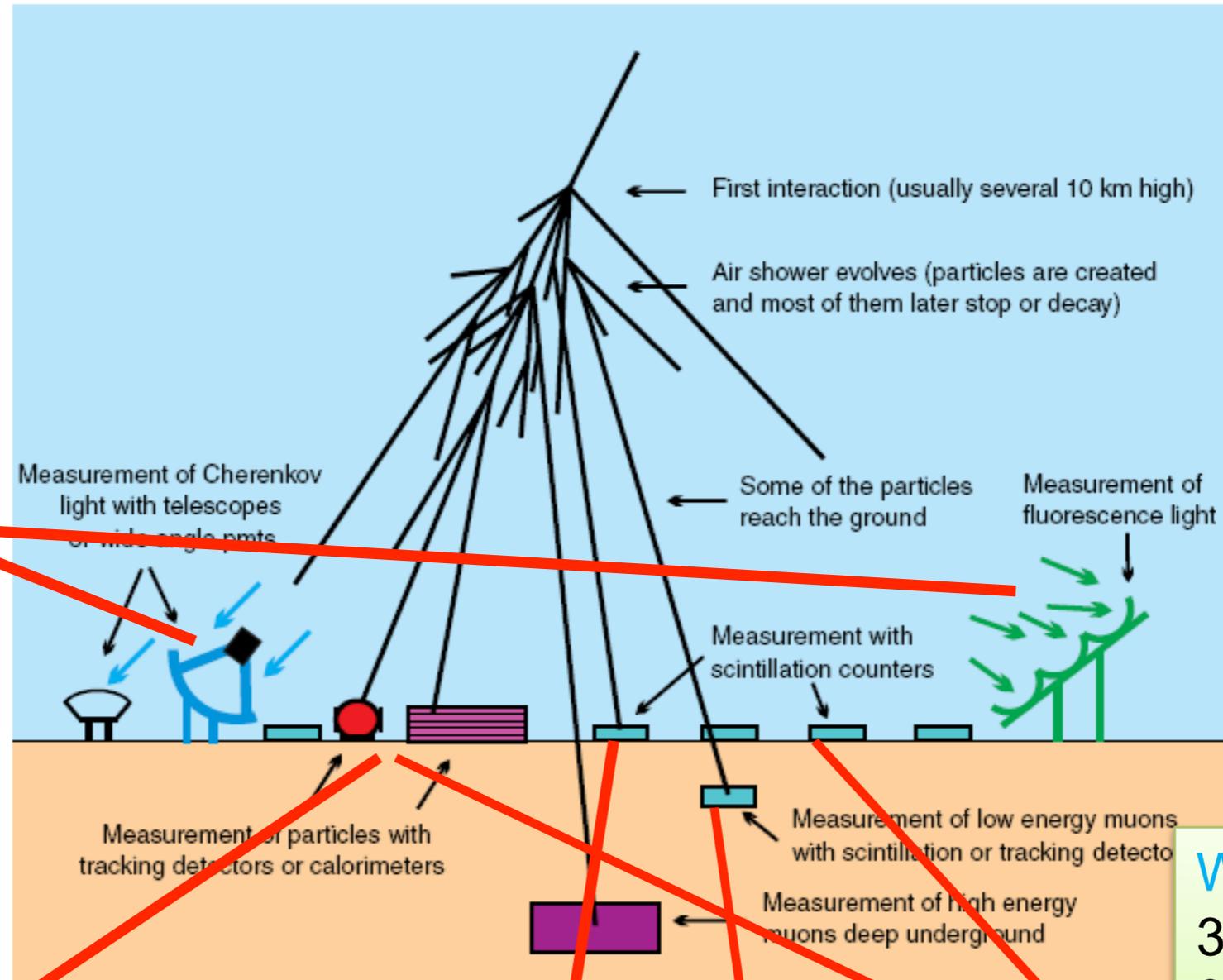
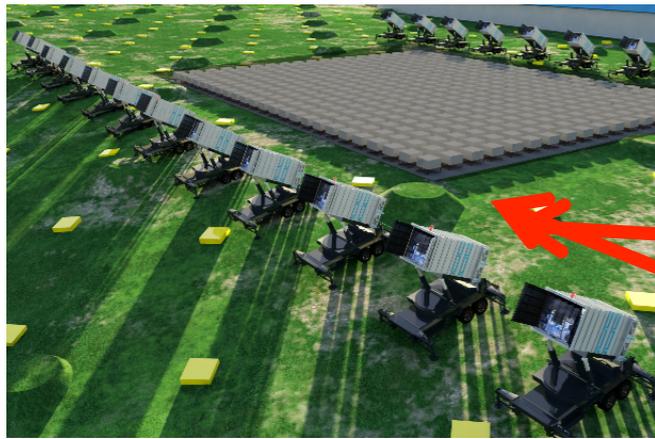
BUT

- Lower rejection power
- Lower resolutions

Hybrid Detection of Extensive Air Showers by LHAASO at 4400m

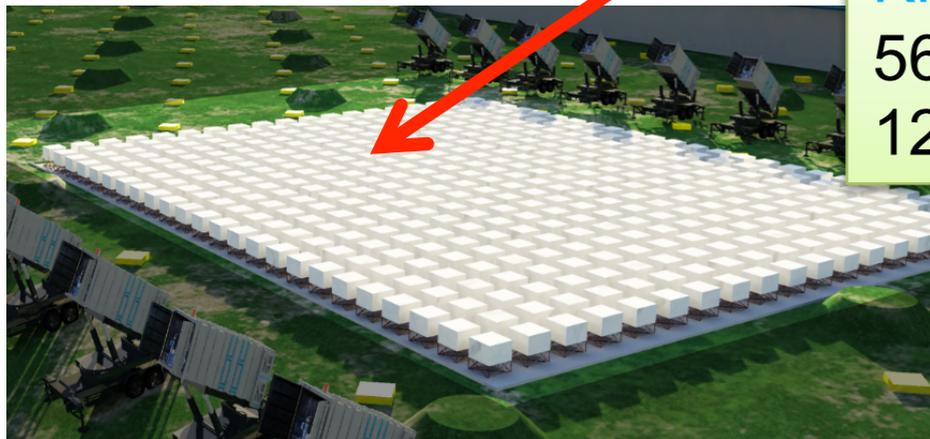
WFCTA:

24 telescopes
1024 pixels each



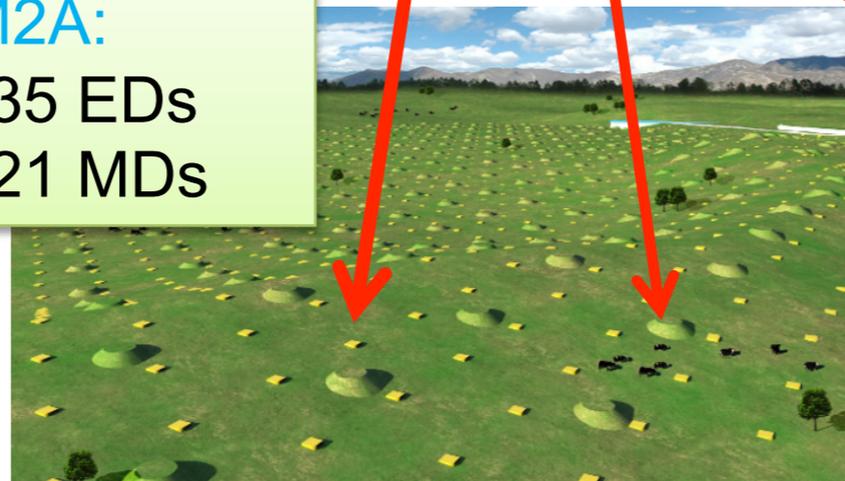
SCDA:

452 detectors



KM2A:

5635 EDs
1221 MDs



WCDA:

3600 cells
90,000 m²



OUTLINE

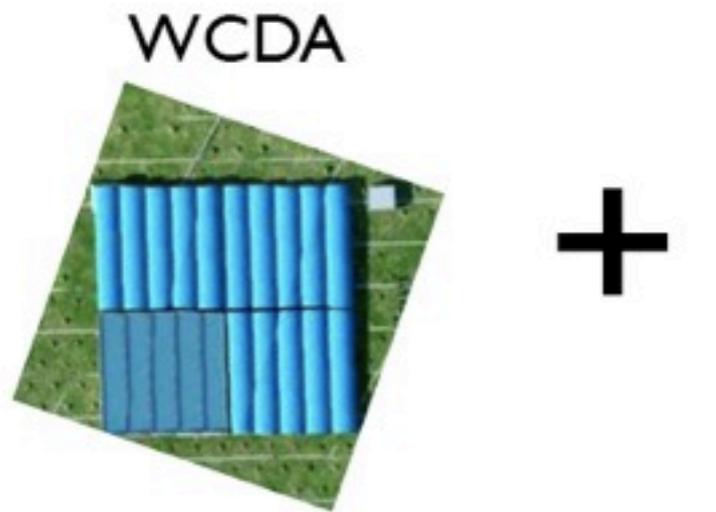
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- ✓ LHAASO performances
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LHAASO for Gamma Ray Astronomy

2 Gamma Ray Astronomy devices

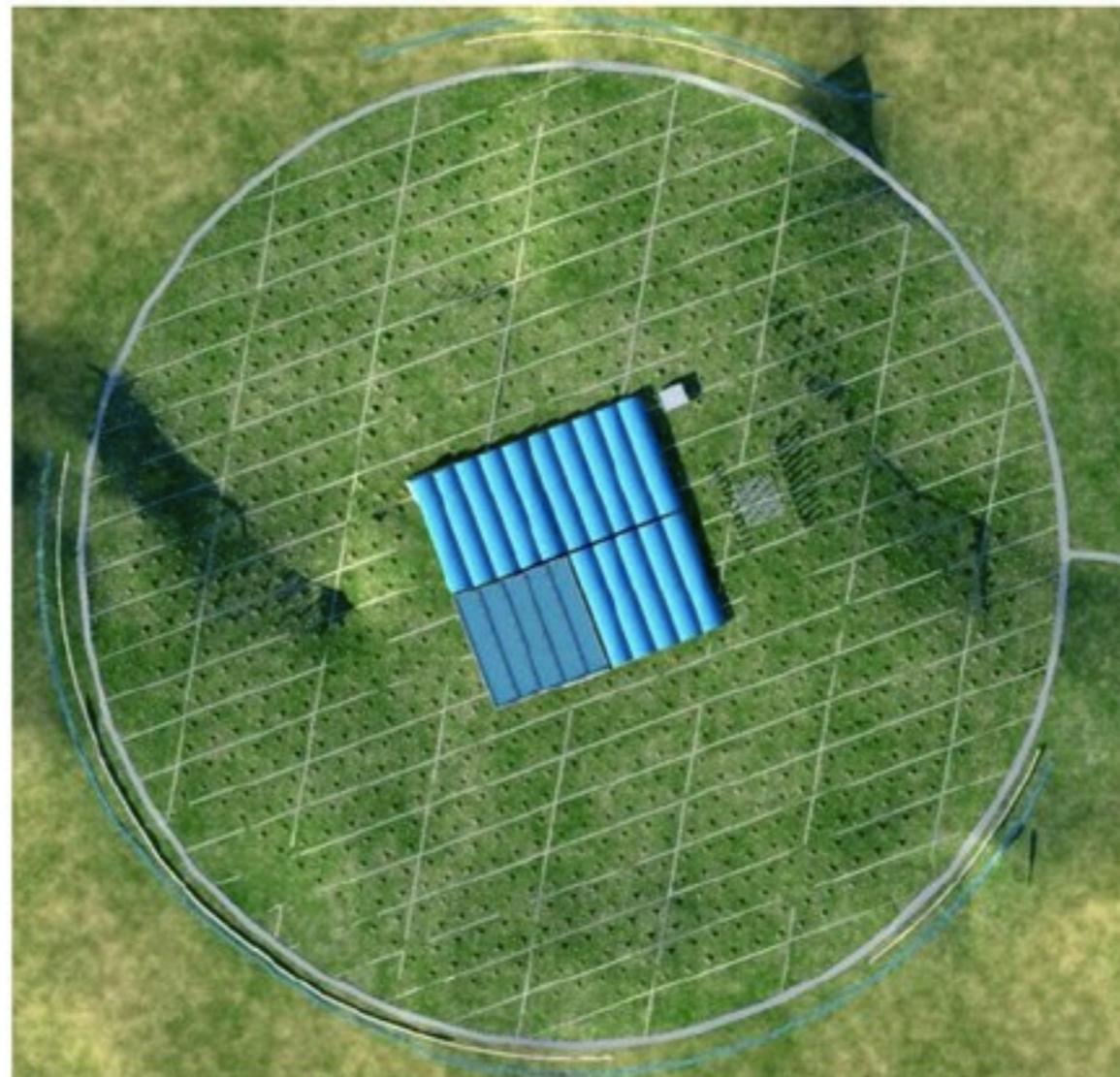
WCDA: Survey of the VHE gamma sky (>100 GeV)

KM2A : (ED+MD) GAMMA ray astronomy beyond 30 TeV



Water Cherenkov Detector
90000 m² (300m x 300m)

KM2A

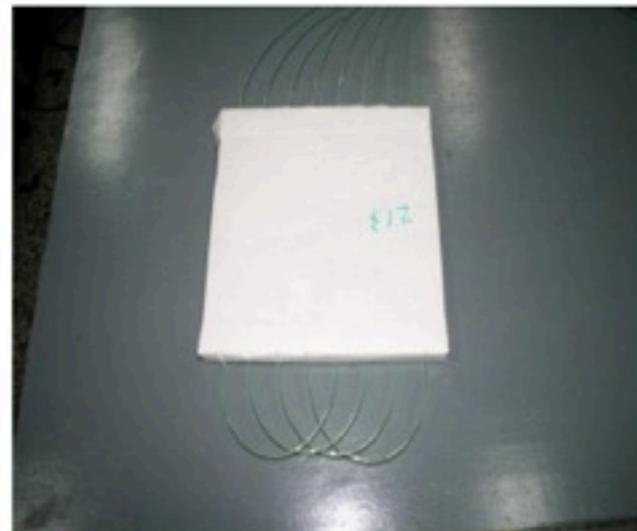
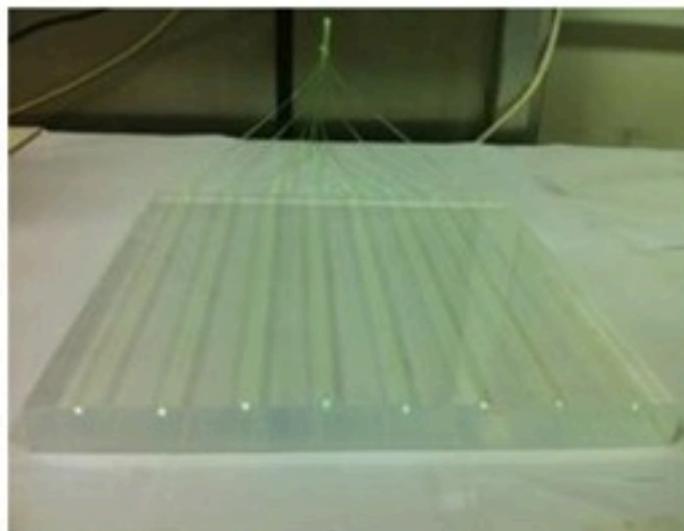
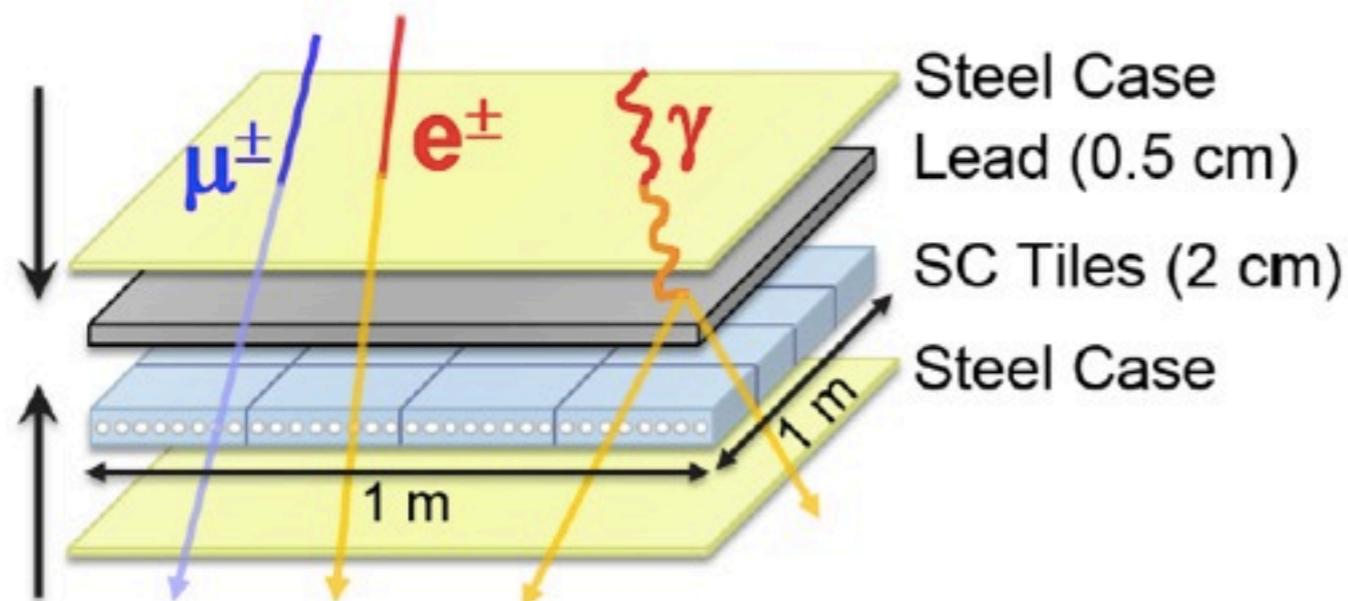


1-km² Array:
scintillator detectors
(ED) every 15 m
and
 μ -detectors (MD)
every 30 m

Electromagnetic Particle Detector (ED):

a 1km² array of 5635 1m² scintillators
with 15m spacing

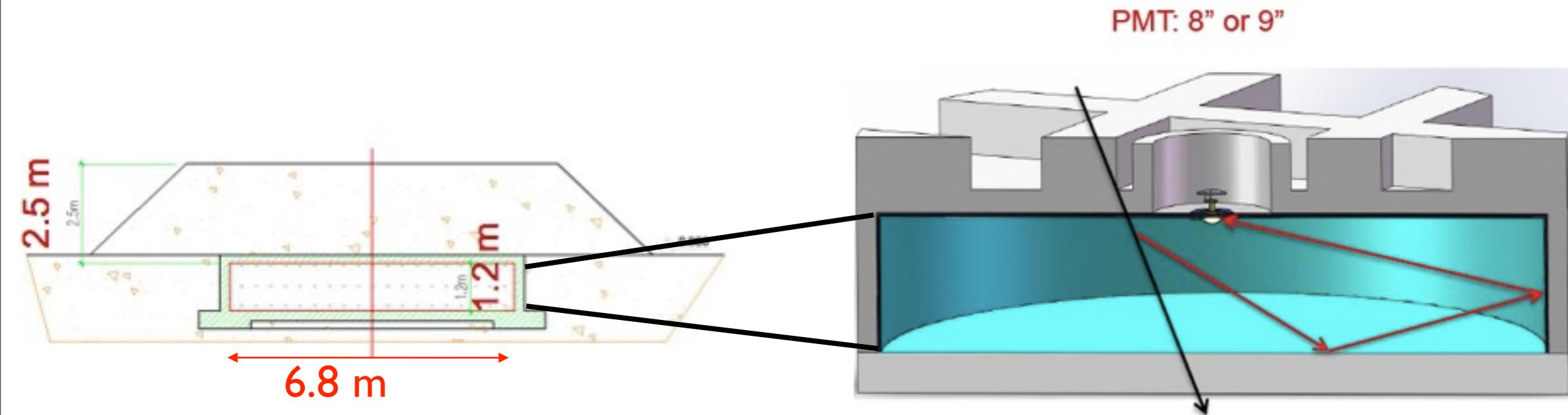
Direction, energy



Muon Detector (MD)

A 1km² array of 1212 Water Cherenkov Tanks with 30m spacing

γ /hadron discrimination



Water tanks very efficient for muons detection

Tanks burried under 2.5 m of dust

Almost pure muon content of showers

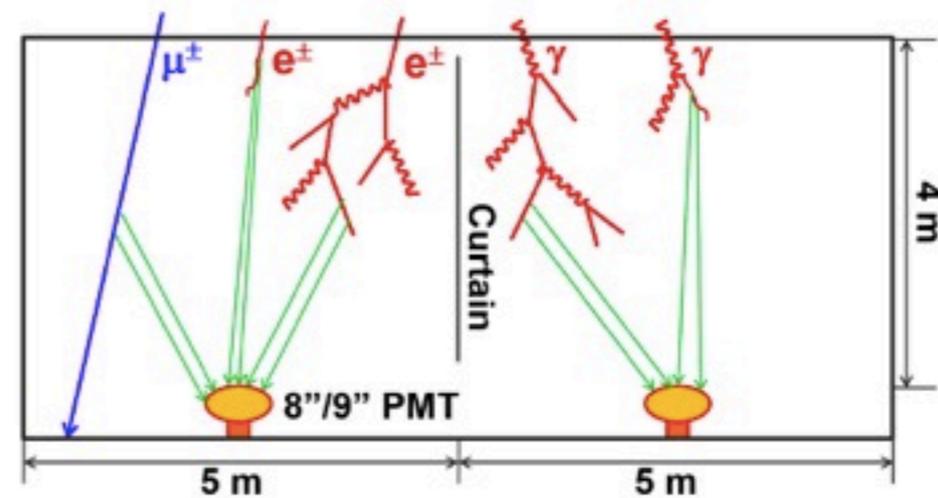
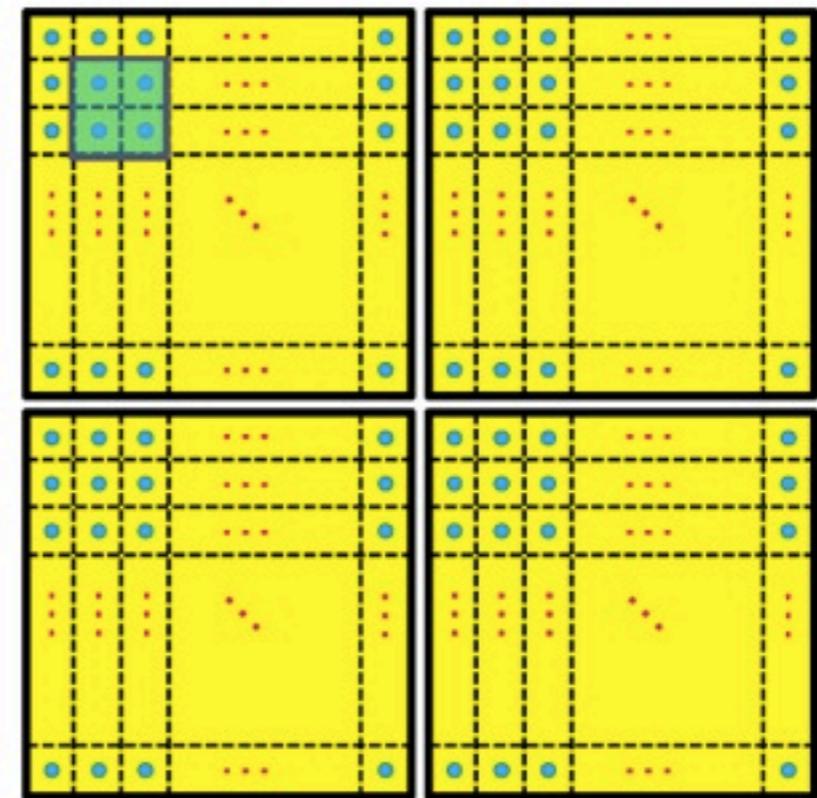
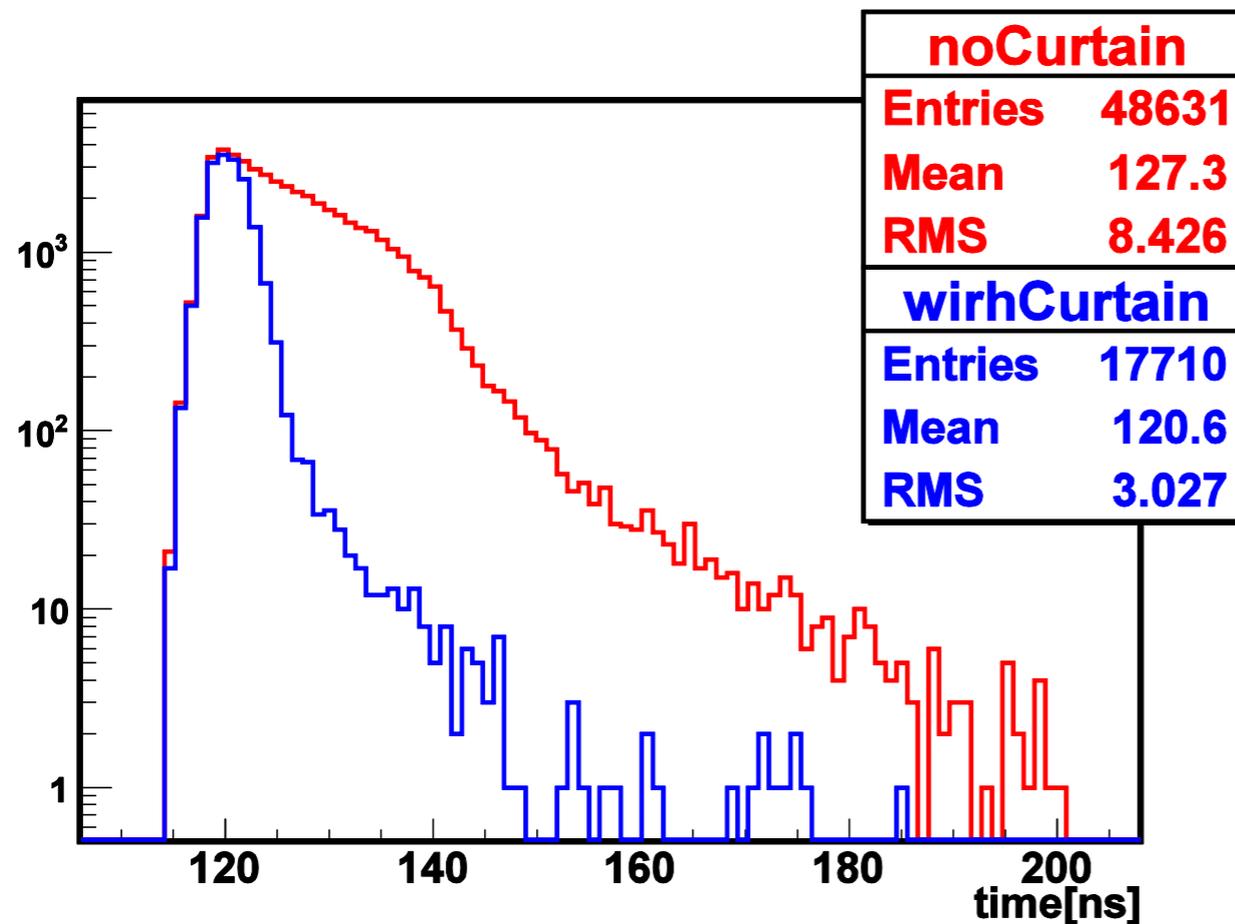
-> high γ /hadron discrimination power

Water Cerenkov Detector Array (WCDA)

«Milagro» like Water Cerenkov pond of 90000 m² in 3600 cells

direction, energy, and γ /hadron discrimination

Black curtain isolate each cell to limit cross-talk and improve γ /hadron discrimination

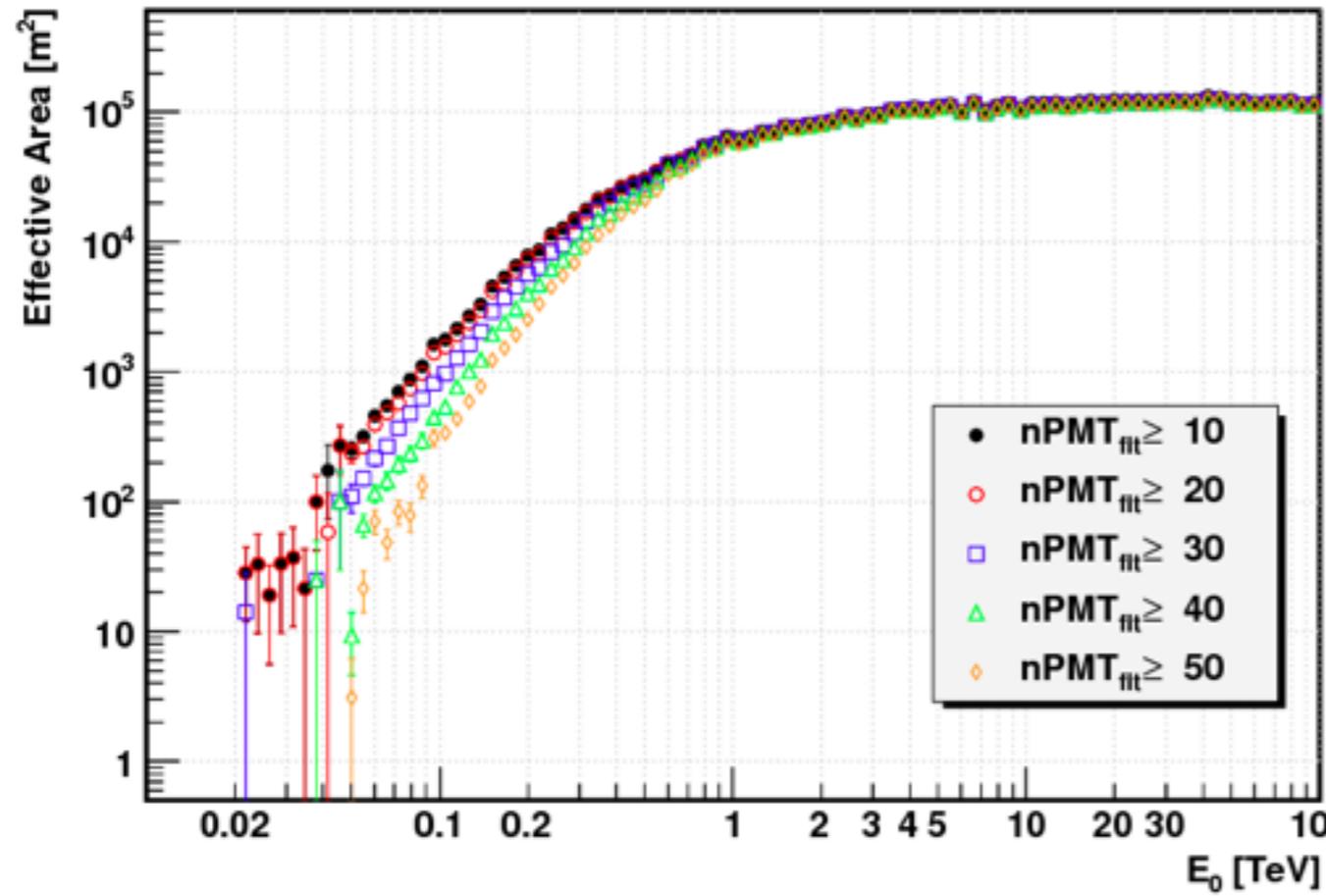


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Effective area

300×300 m²: Crab transit $\theta < 30^\circ$ && nPMT/cxPE > 5.0 && $\Delta\alpha < 1.00^\circ$

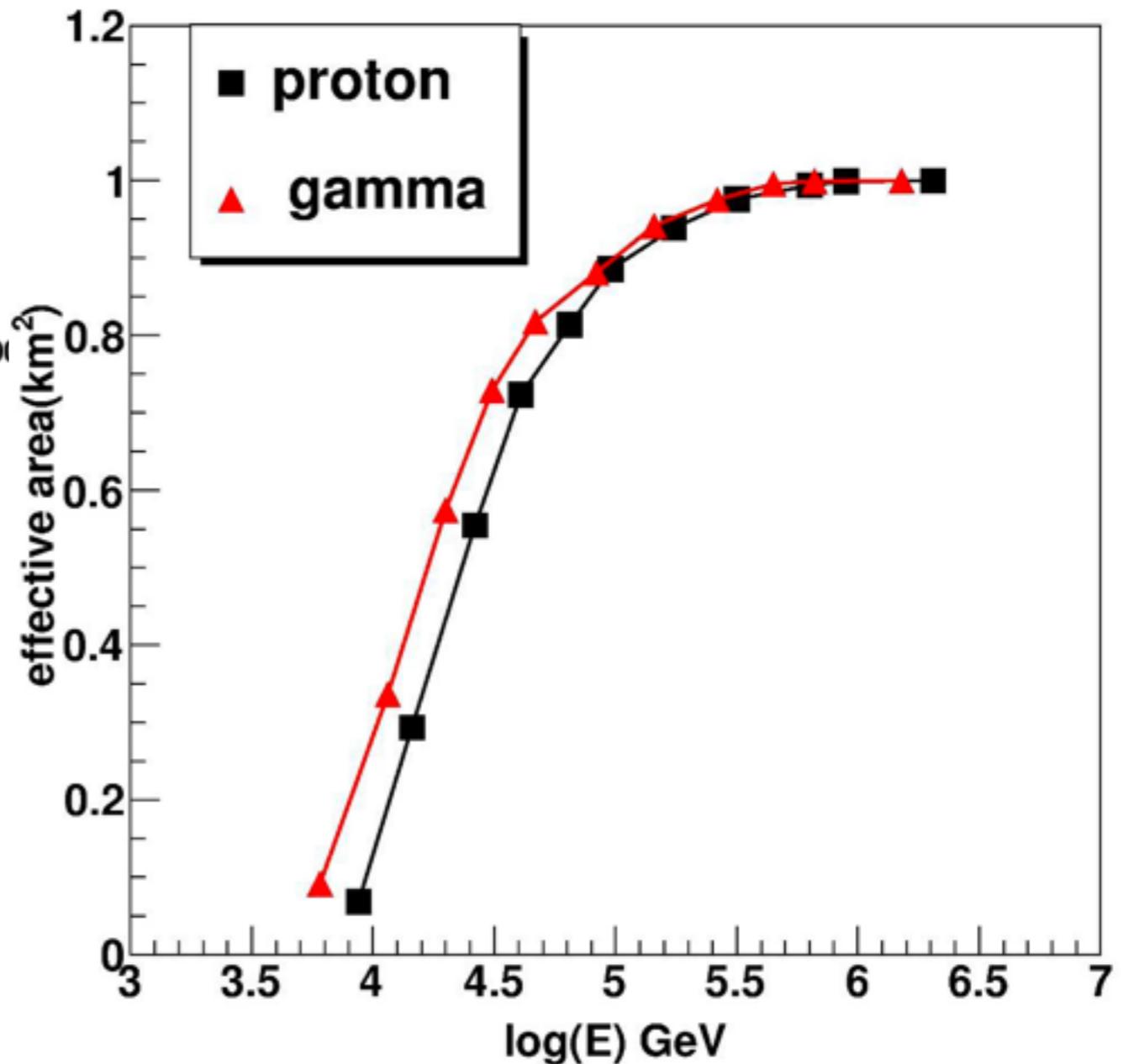


WCDA

90000m² > 1 TeV

1km² > 100 TeV

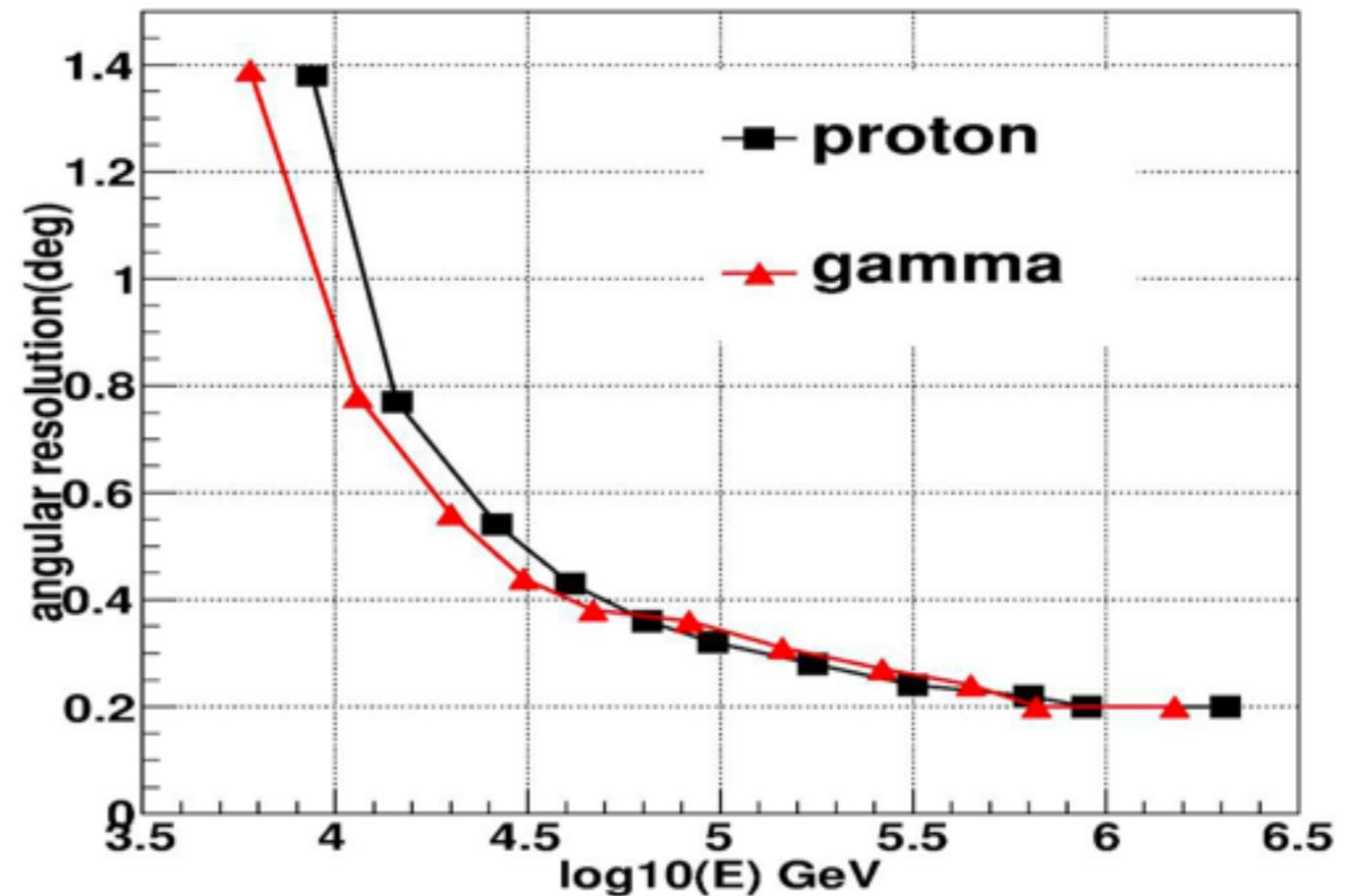
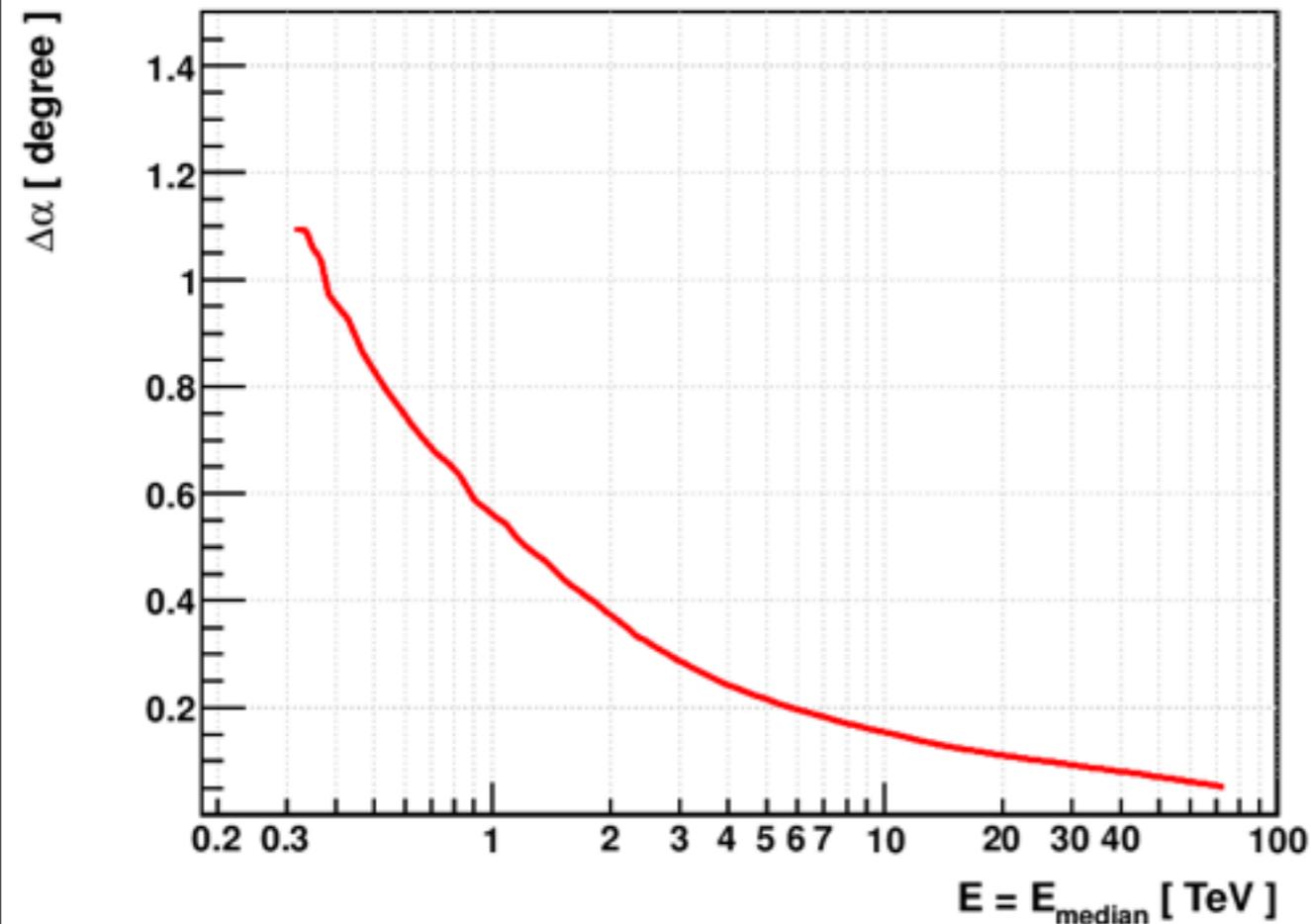
KM2A



ANGULAR RESOLUTION

WCDA

KM2A



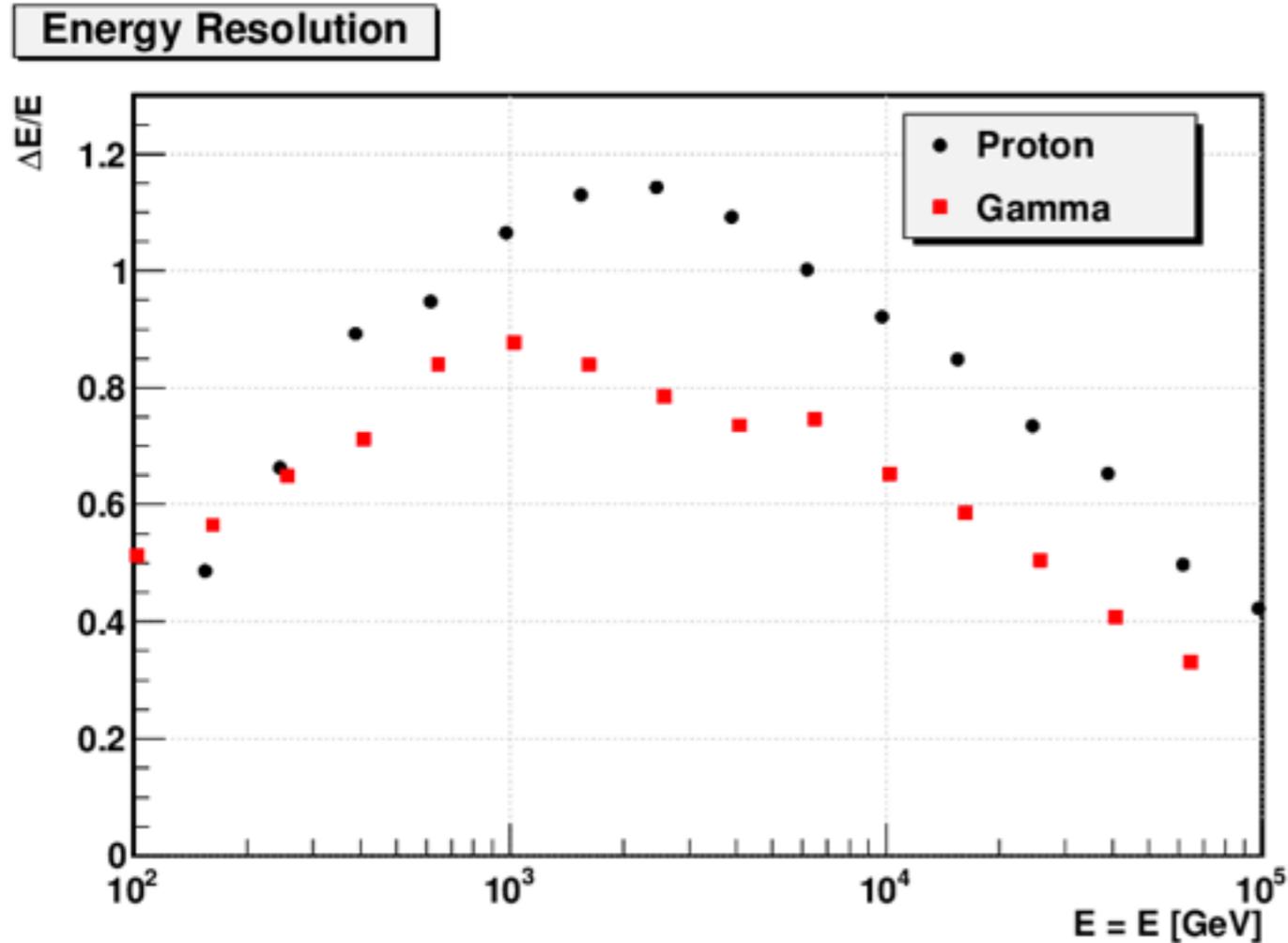
Below 0.2° from 50 TeV to 1 PeV

Need timing accuracy < 0.2 ns (WCDA) / 0.5 , s (KM2A)
and time jitter < 0.5 ns (WCDA) / 1 ns (KM2A)

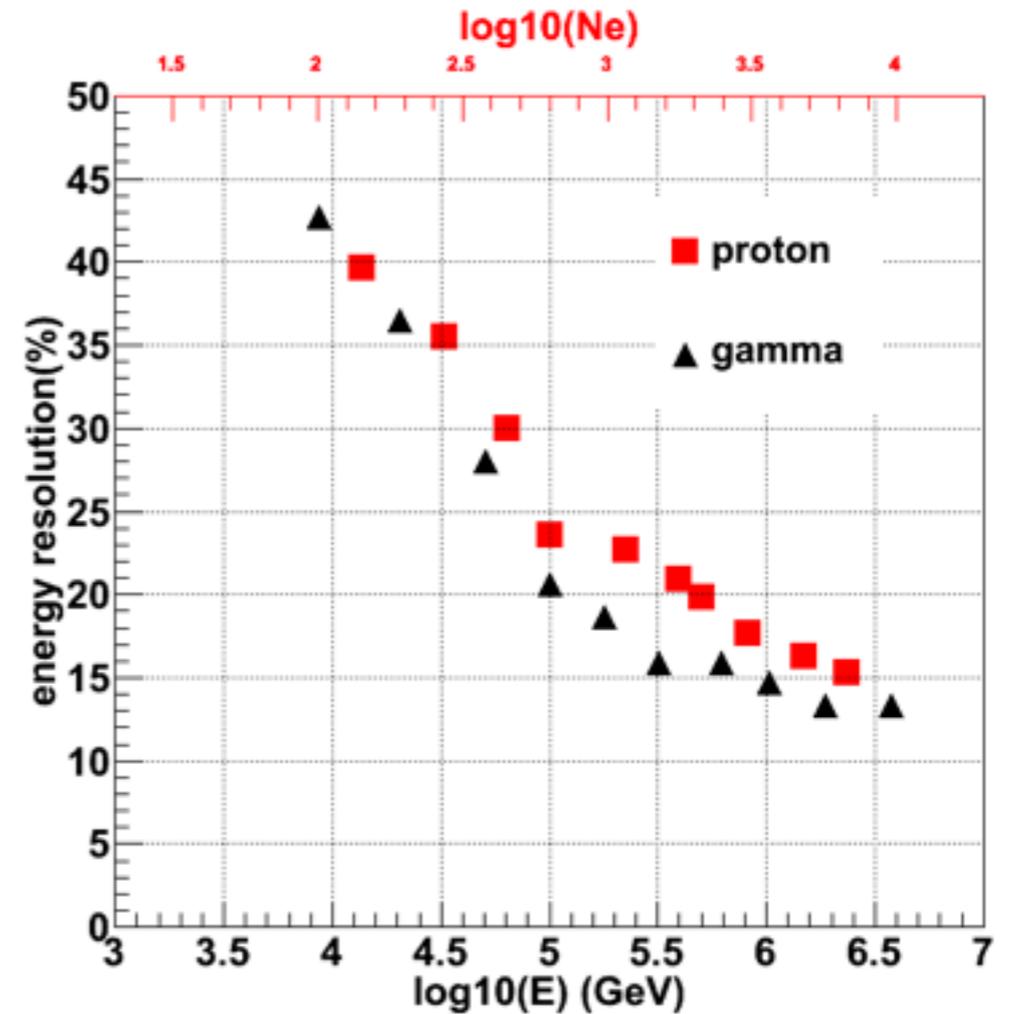
ENERGY RESOLUTION

WCDA

KM2A



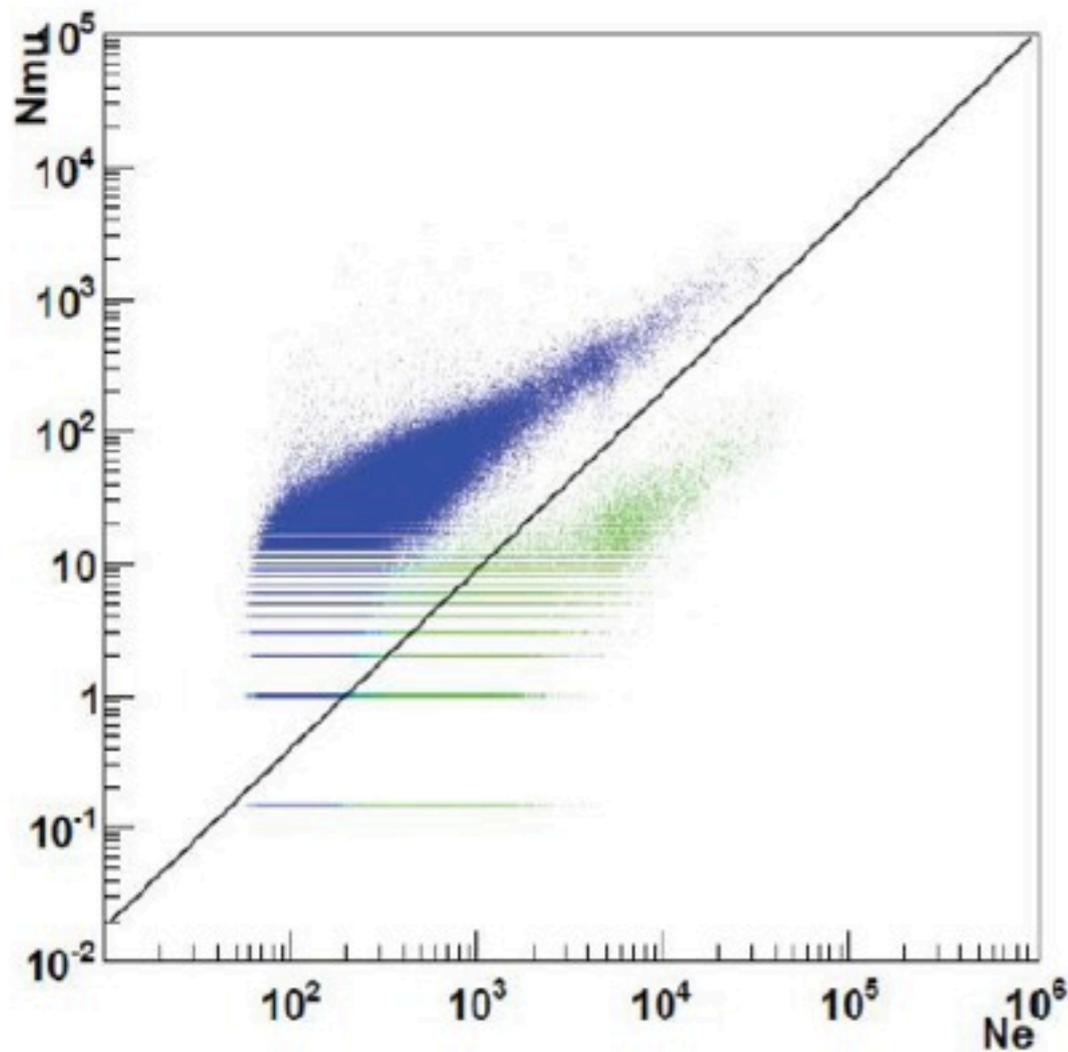
reach 20% > 100 GeV



background free > 100 TeV
-> gamma spectrum
can be measured within 10%

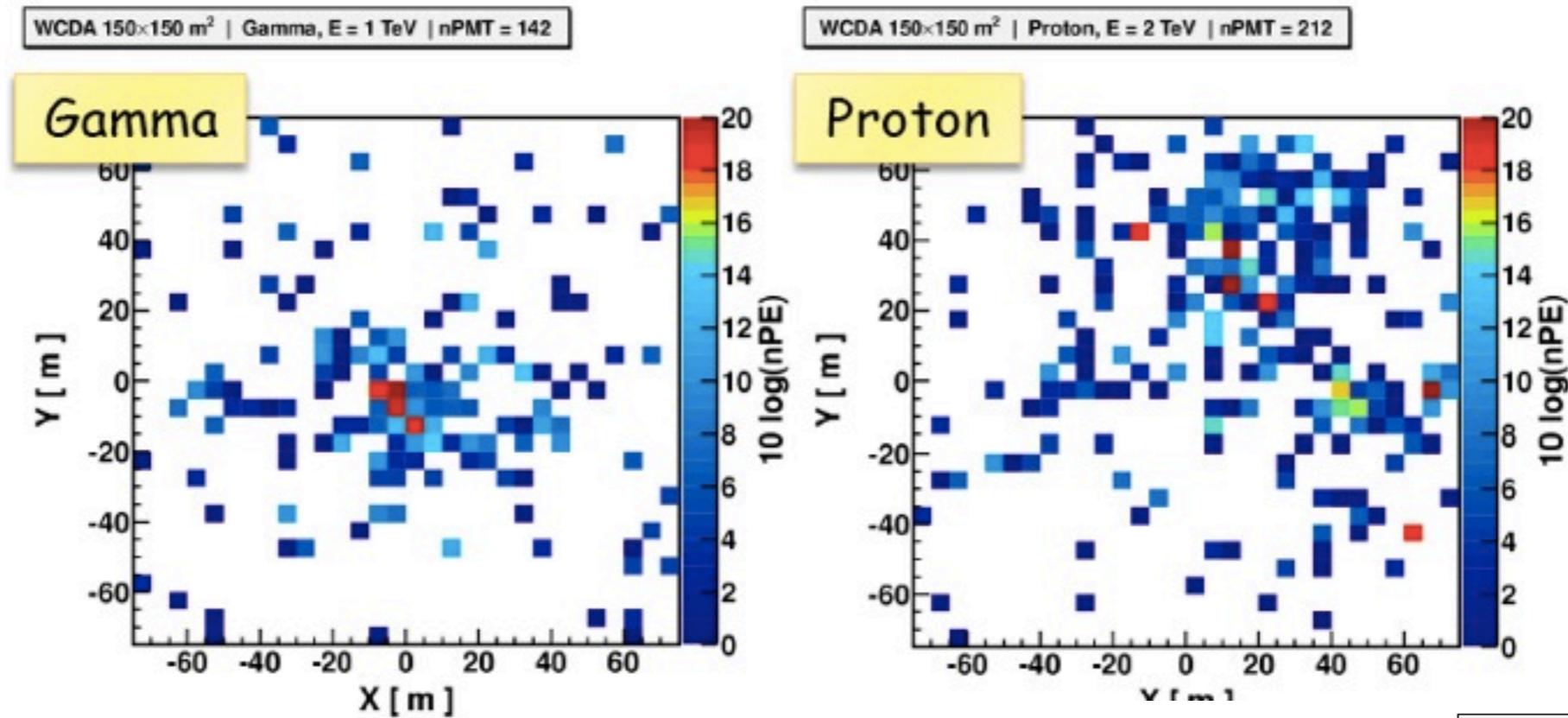
Gamma/proton discrimination (KMA2)

Discrimination power $Q = \epsilon_{\gamma} / \sqrt{1 - \epsilon_{CR}}$.

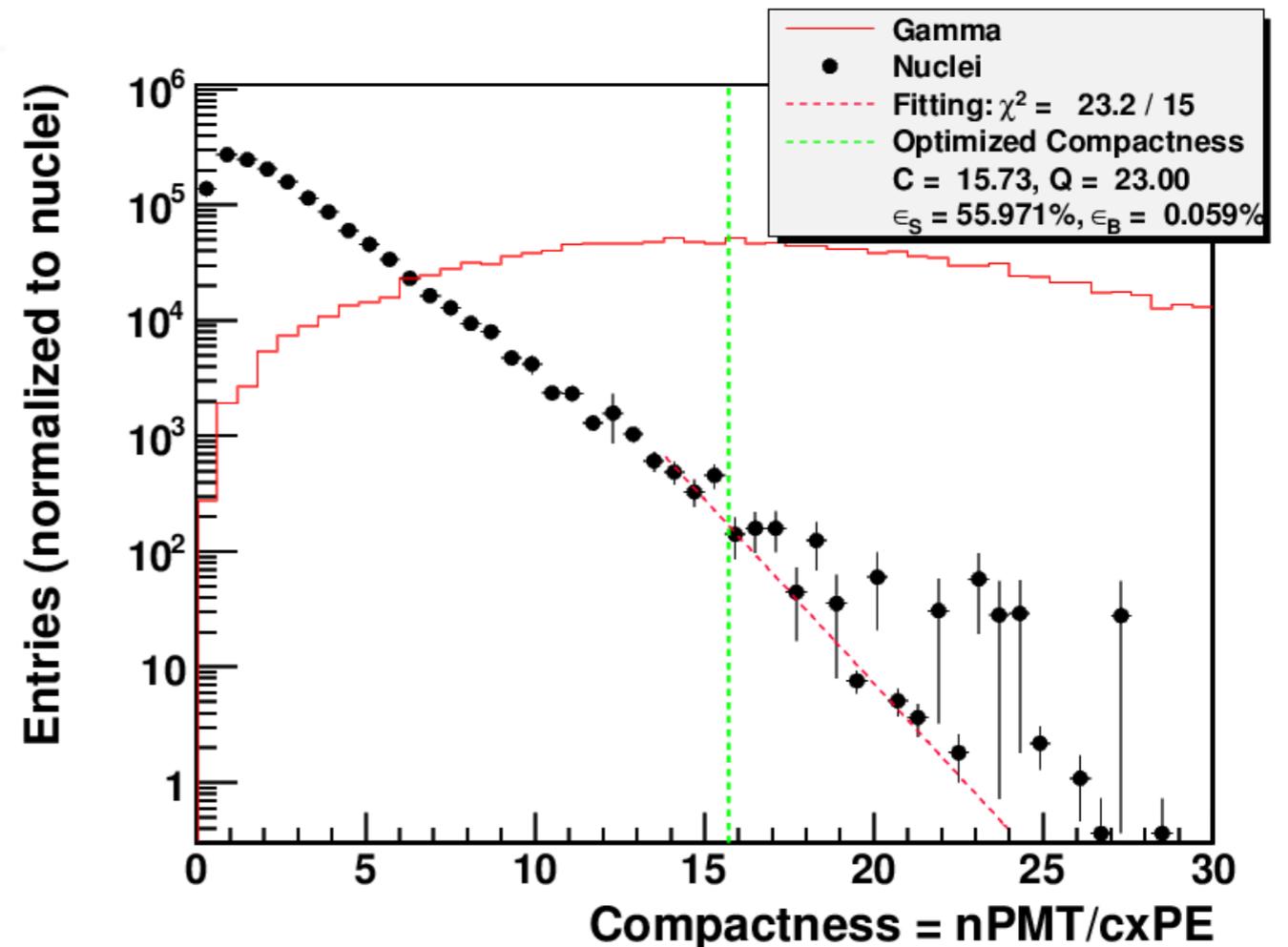


nHit	$\log_{10}(E)$ GeV	Q-factor
20-30	3.60	2.67
30-45	3.87	5.62
45-65	4.12	11.9
65-90	4.35	20.7
90-120	4.55	46.4
120-180	4.76	86.6
180-260	5.03	background free
260-360	5.28	background free
360-500	5.53	background free
500-700	5.82	background free
700-1000	6.11	background free

Gamma/proton discrimination by WCDA

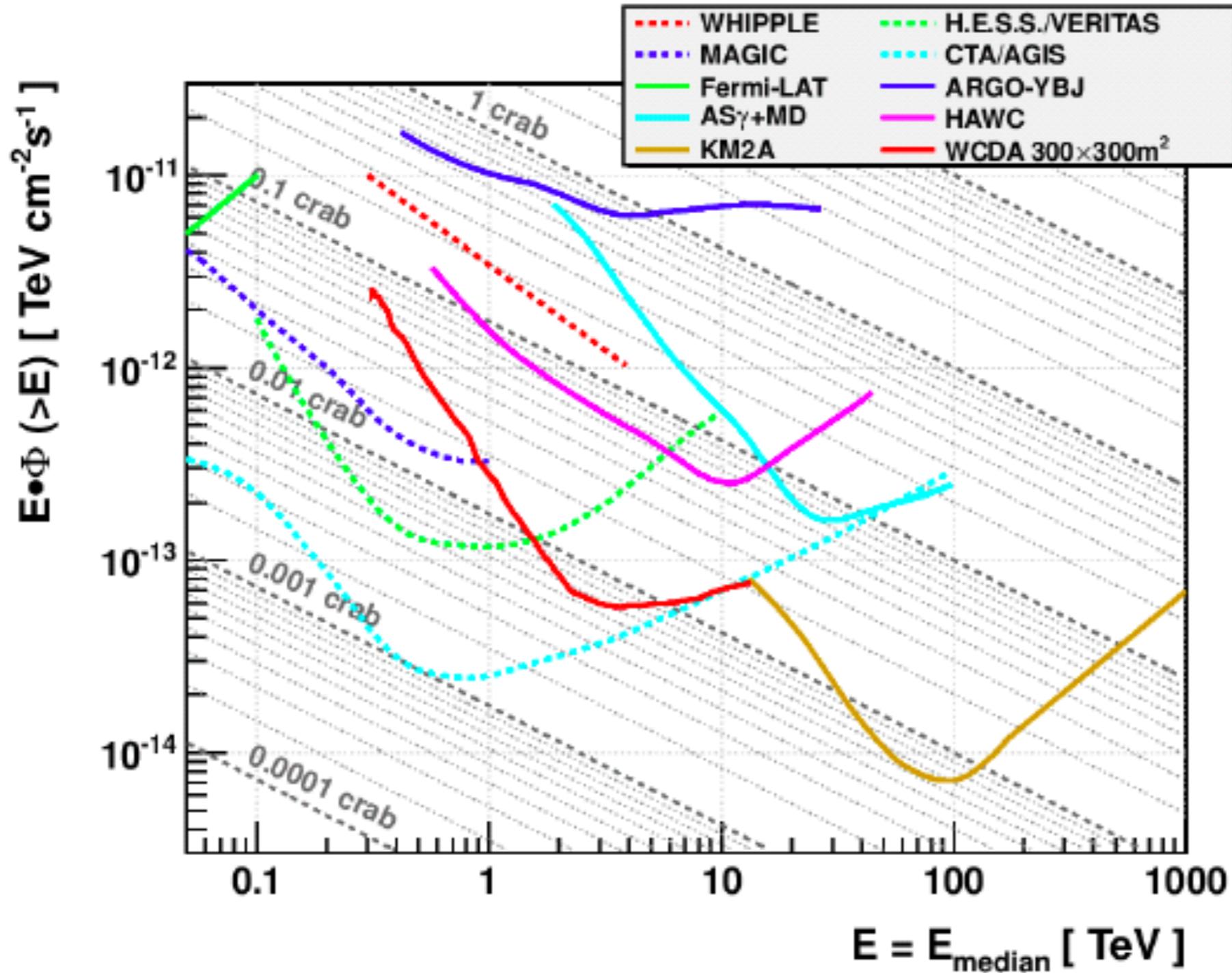


- Brightest «sub-core»
signal of the brightest PMT
outside the shower core region
- Compactness (nPMT/cxPE)
to reject cosmic ray



INTEGRAL SENSITIVITY

$$S(> E) = \frac{N_\gamma(> E)}{\sqrt{N_{\text{CR}}(> E)}} Q$$



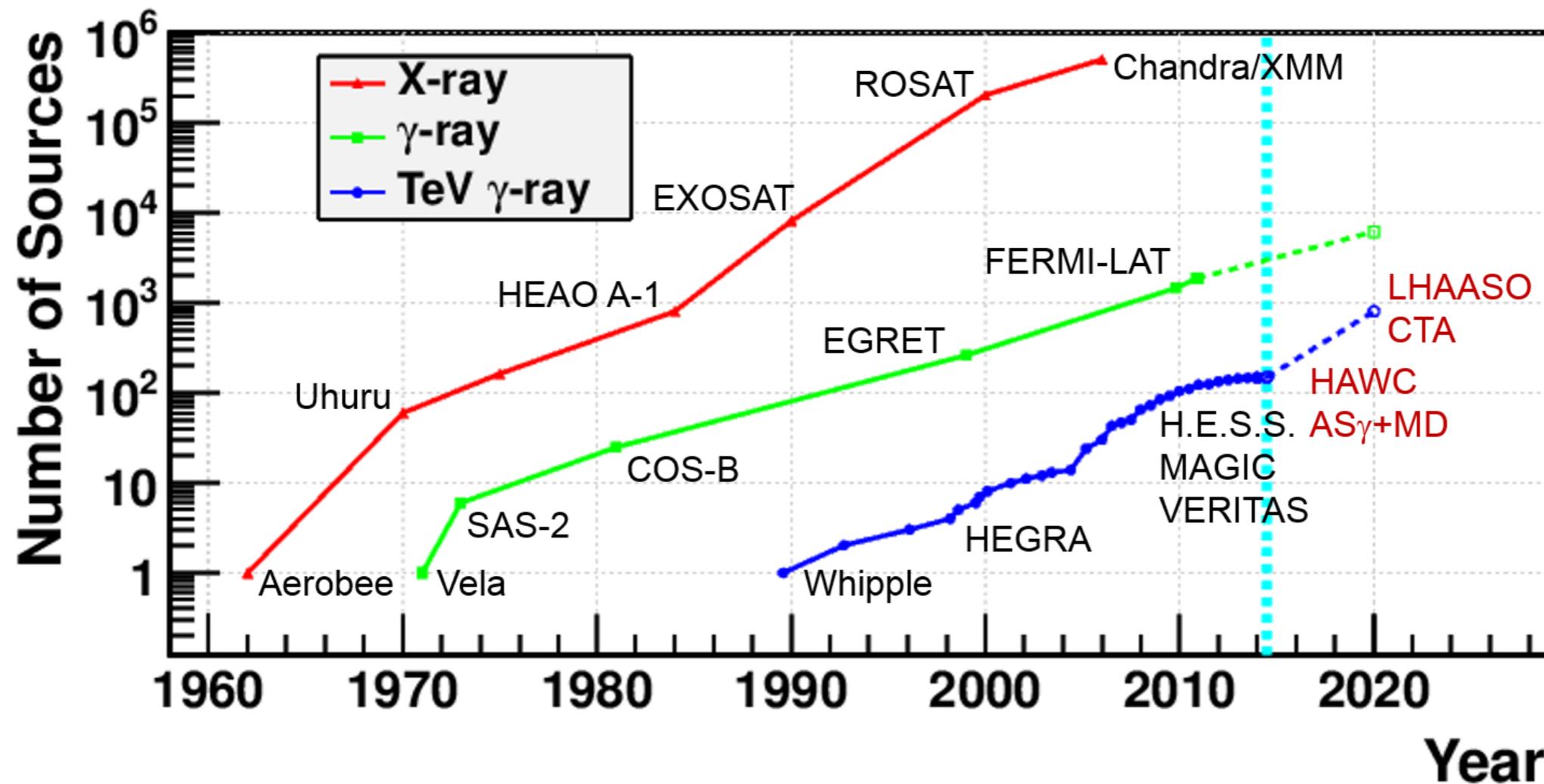
2% I_{Crab} (WCDA) /
1% I_{Crab} (KM2A)

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PHYSICS ON GAMMA RAY ASTRONOMY WITH LHAASO

- ▶ Large instantaneous effective area and field of view
- ▶ 100% duty cycle
- ▶ Good energy and angular resolution and sensitivity
- ➔ complementarity with CTA



PHYSICS ON GAMMA RAY ASTRONOMY WITH LHAASO

✓ Spectrum measurement at the high end:

Nature of the acceleration: leptonic or hadronic;

Origin of cosmic rays – 100 years' mystery.

✓ VHE gamma sky survey (100 GeV-1 PeV):

Galactic sources;

Extragalactic sources & flares;

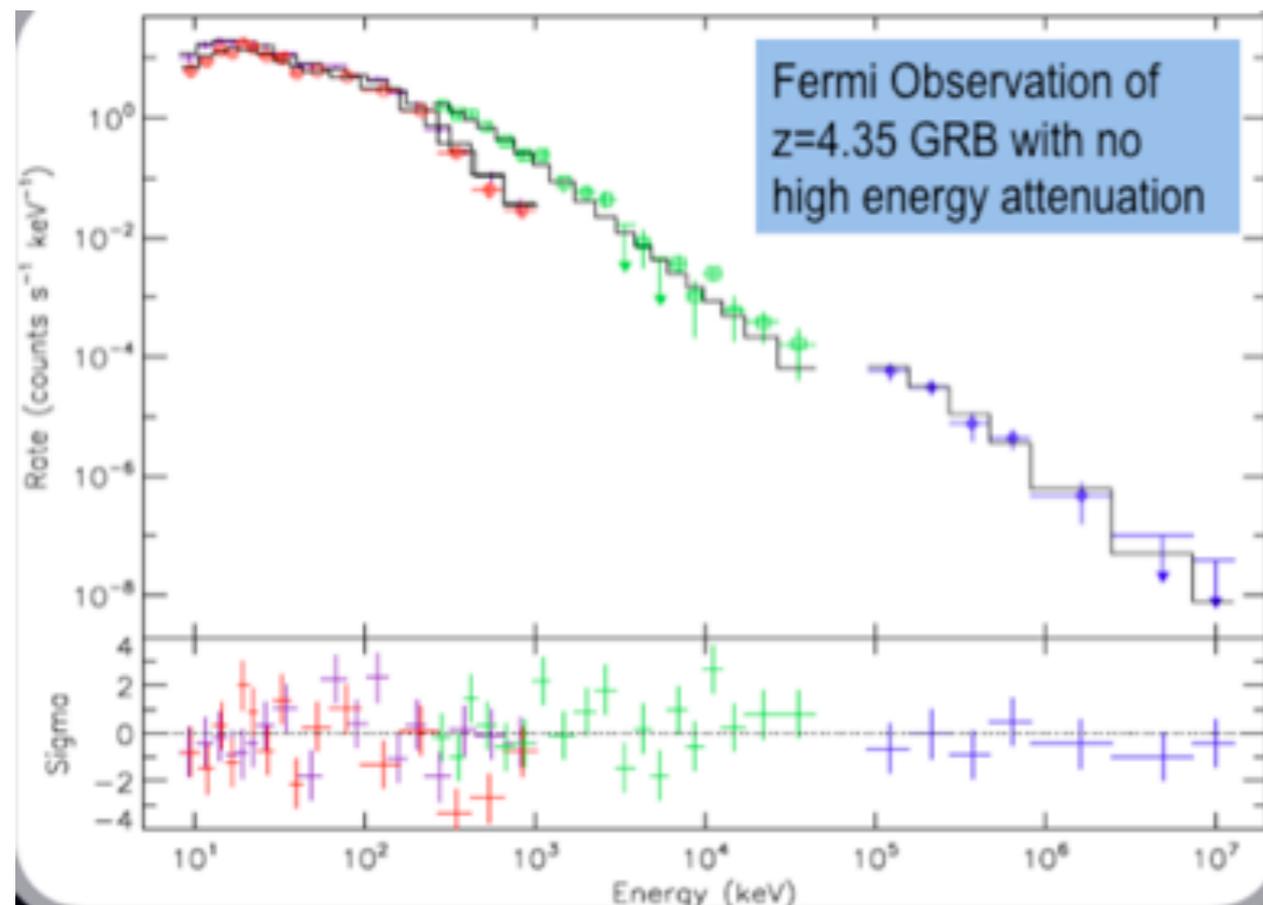
Integrated flux of extended sources

Long variability sources

VHE emission from Gamma Ray Bursts and other transient

VHE emission from Gamma Ray bursts

- High energy contribution up to 94 GeV observed in a few GRB by Fermi LAT
- Due to attenuation, the highest energies of gamma rays are likely to be in the 50 to 300 GeV range, depending on the redshift



LHAASO WCDA will be able to measure (if any) the high energy component of detected GRBs in its FOV (2sr)

- What fraction of GRBs emit GeV or even TeV gamma rays ?
- Cutoff energy due to EBL ?

Summary

LHAASO is fully funded by China and it is going to be built soon (starting in a year for 6 years) at Haizishan, Sichuan Province (site agreement should be signed in June with province)

Two detector arrays (KM2A & WCDA) of the LHAASO project will mainly focus on Gamma astronomy;

The sensitivity of the two arrays can reach 2 to 1% Crab flux at ~ 1 TeV and ~ 100 TeV, respectively;

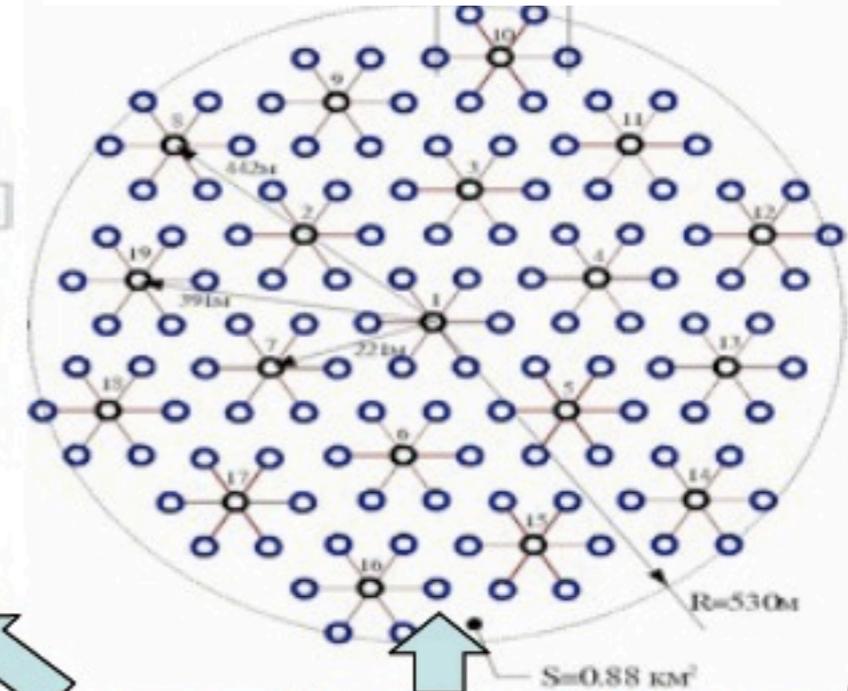
LHAASO will play an important role in surveying, detecting, observing and measuring various VHE Gamma ray sources.

LHAASO collaboration

ARGO and WCTA prototype hybrid analysis

IPNO / Omega ASIC electronics for LHAASO

PRISMA as Core detector and TUNKA on top of LHAASO-KM2 for high energy extension



Current and potential Collaborators

