2026 TeVPA, Tendo

Energy Reconstruction and Background Rejection for Cosmic-Ray Electron Observation above 10 TeV with the Tibet ASγ Array

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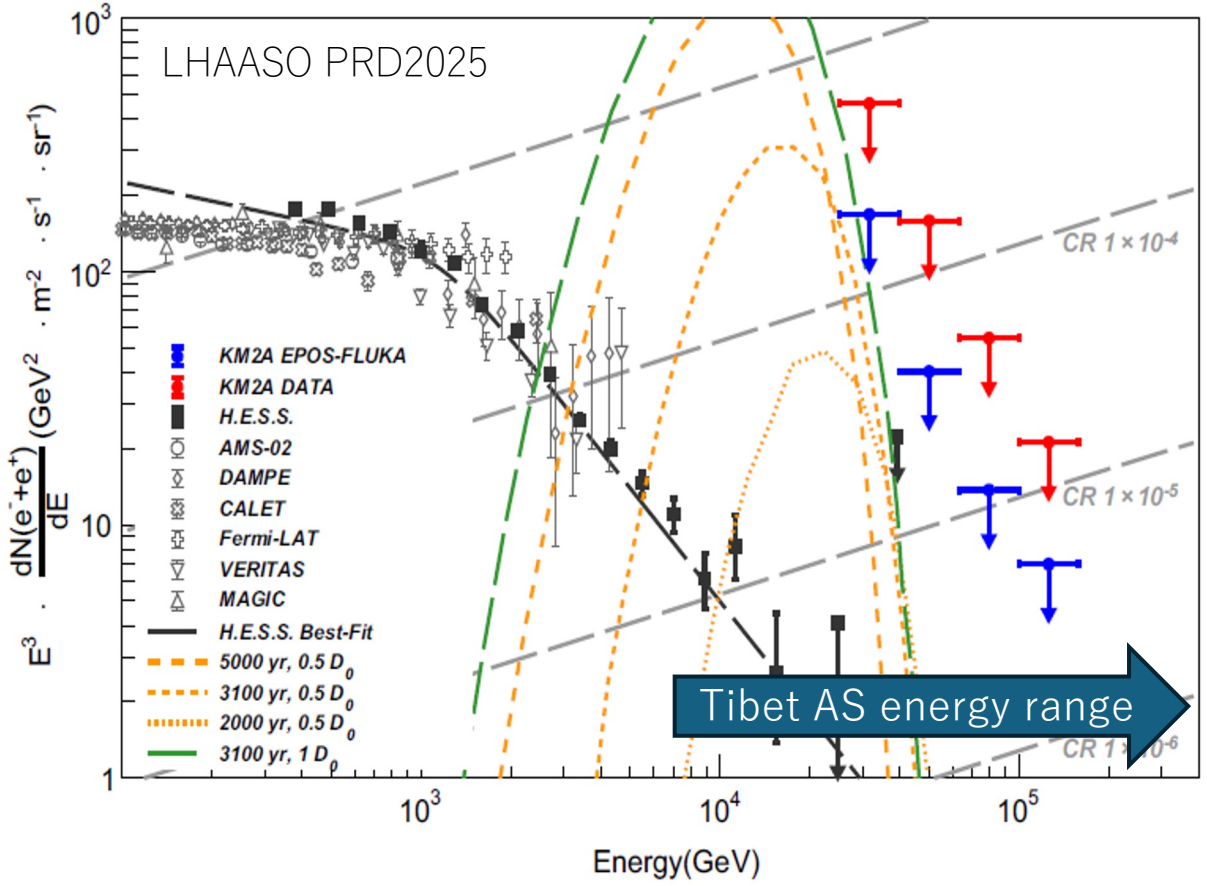
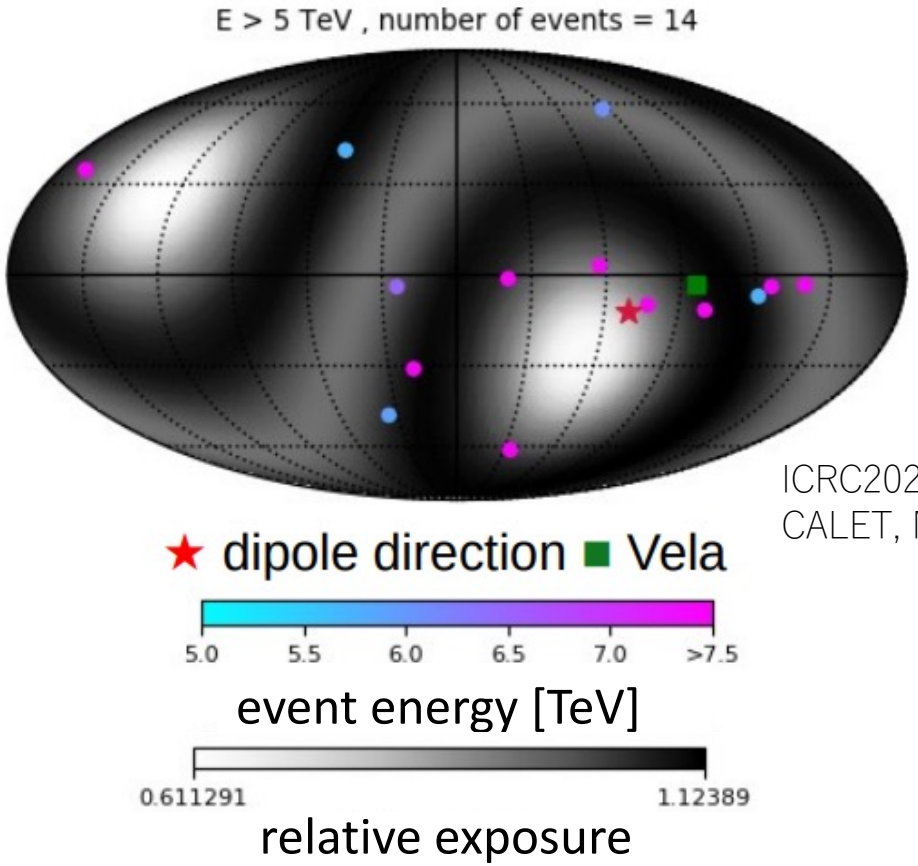
Cosmic ray electron beyond TeV

✓ TeV cosmic ray electrons provide a direct probe of nearby accelerators

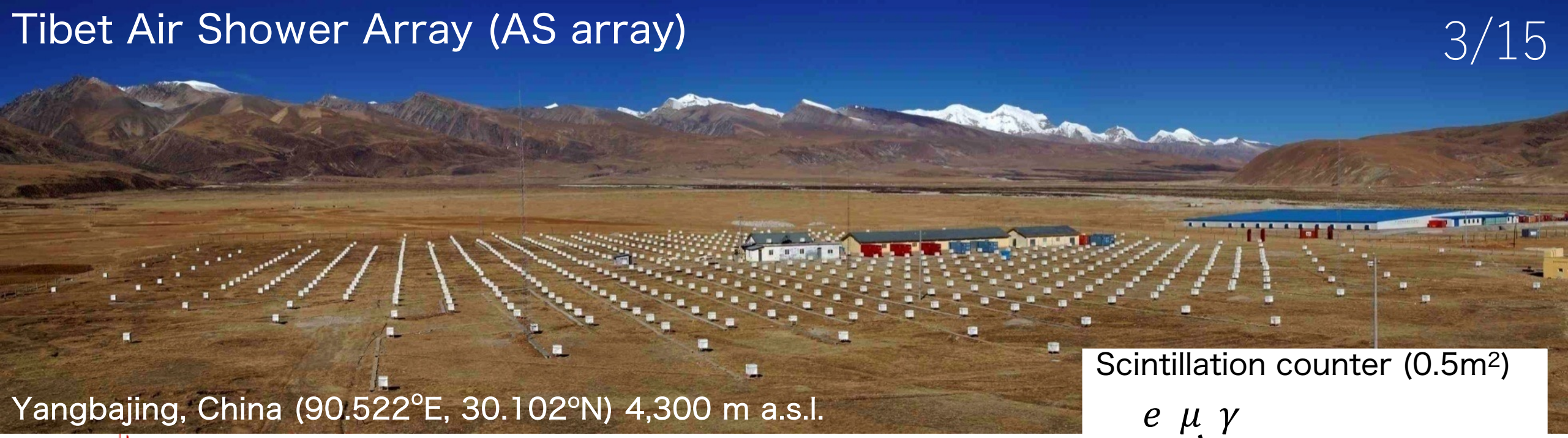




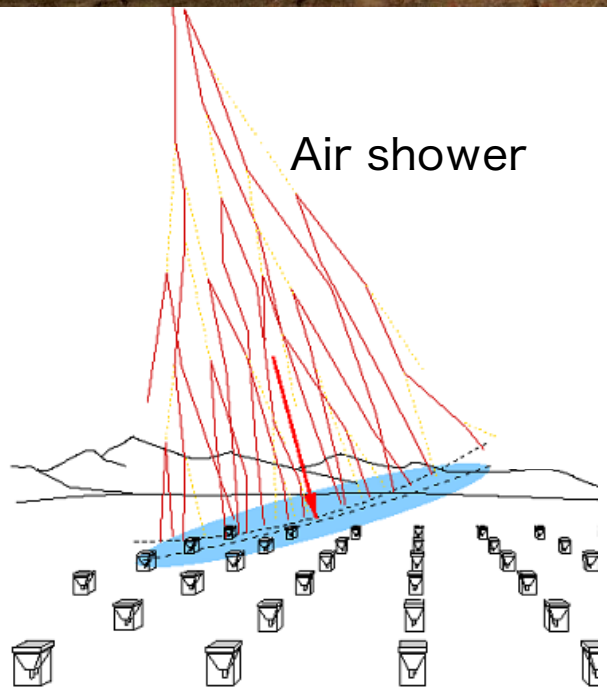
ICRC2025-100,
CALET, Motz et al.

The Tibet AS array offers large statistics(>1000@10TeV, 1yr), high background rejection, and a wide field of view
→ Search for potential spectral bump-like structures and anisotropy in the Northern Hemisphere

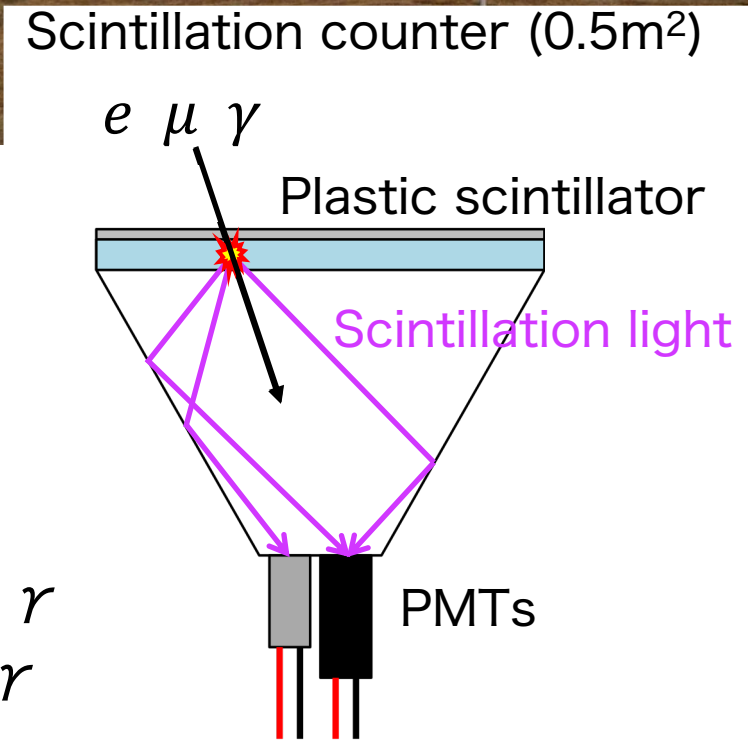
Tibet Air Shower Array (AS array)



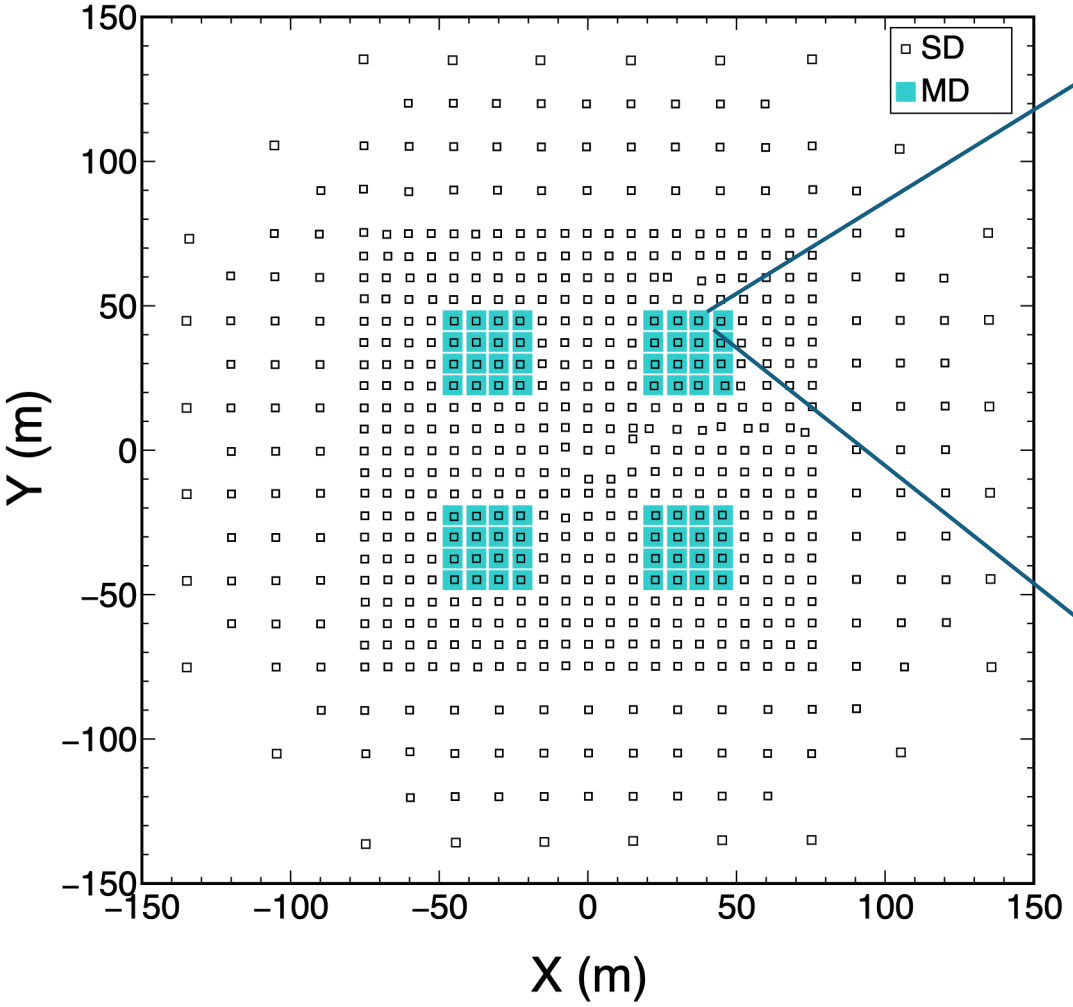
Yangbajing, China (90.522°E, 30.102°N) 4,300 m a.s.l.



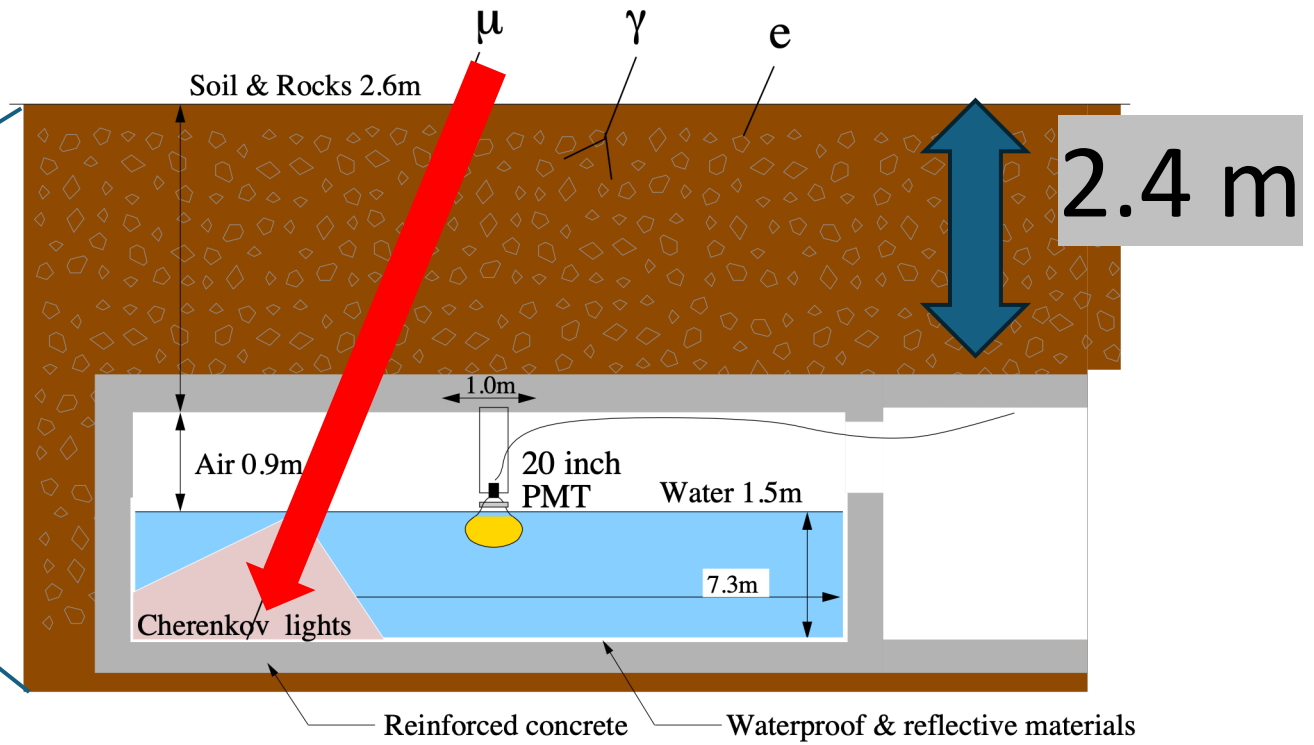
- ✓ Operating since 1990
- ✓ AS array 65,700 m²
  - 597 × 0.5 m² scintillation counter
  - Energy & direction reconstruction
- ✓ Angular resolution : ~0.2° @ 100TeV γ
- ✓ Energy resolution : ~20% @ 100TeV γ
- ✓ TeV-PeV CR, sub-PeV γ



Underground Muon Detectors (MDs)



Total area: ~3400 m^2



CRs: Large number of muons (ΣN_μ)
Gamma-rays, CR electrons: Small ΣN_μ

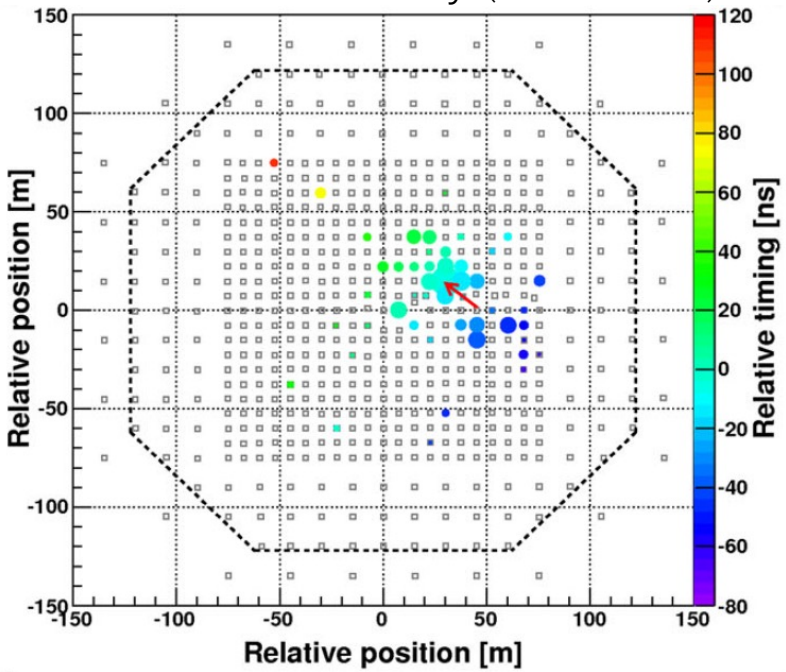
Rejection power for background CRs :
> 99.9% @ E > 100TeV

1, Energy reconstruction of CR electrons

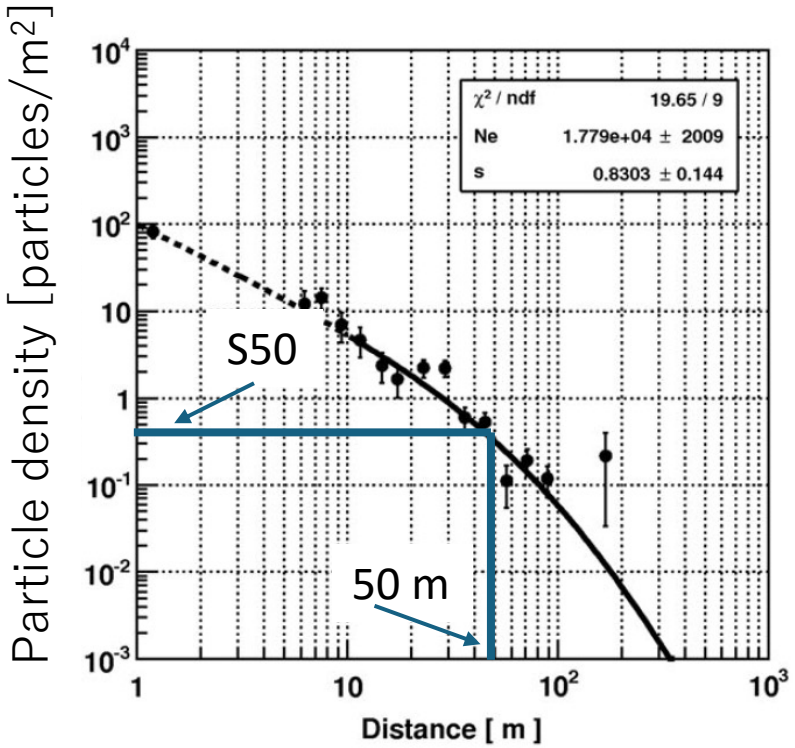
✓ Energy reconstruction for gamma-rays has been optimized in Tibet AS γ

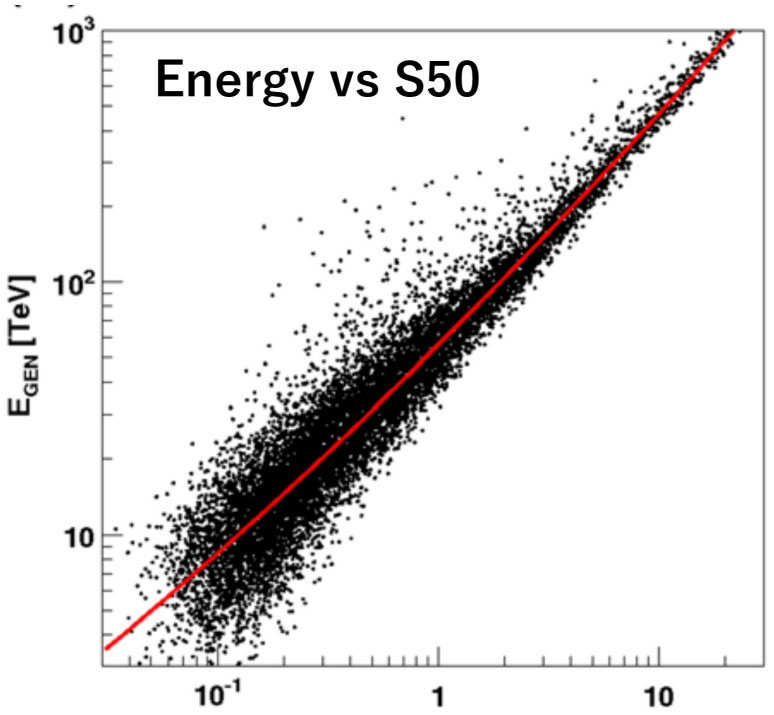
Particle distribution → **Lateral distribution** → **Energy reconstruction**

21 TeV Gamma-ray (Simulation)



Exp Astron (2017) 44:1–9, Kawata et al.





S50,Particle density at 50m [particles/m²]

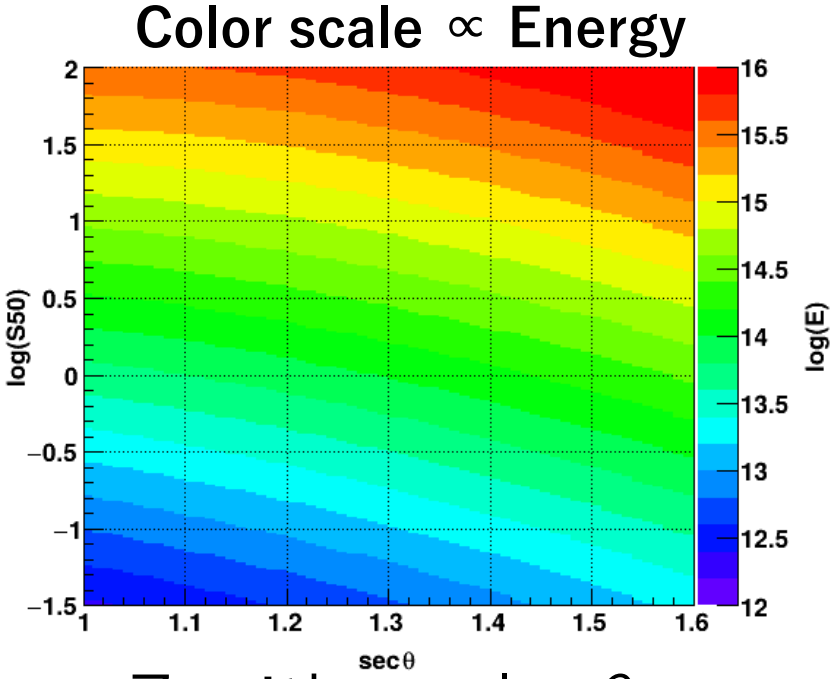
Due to the similarity between electron-induced AS and gamma-ray-induced AS, S50 is used as an energy estimator for electron-induced AS

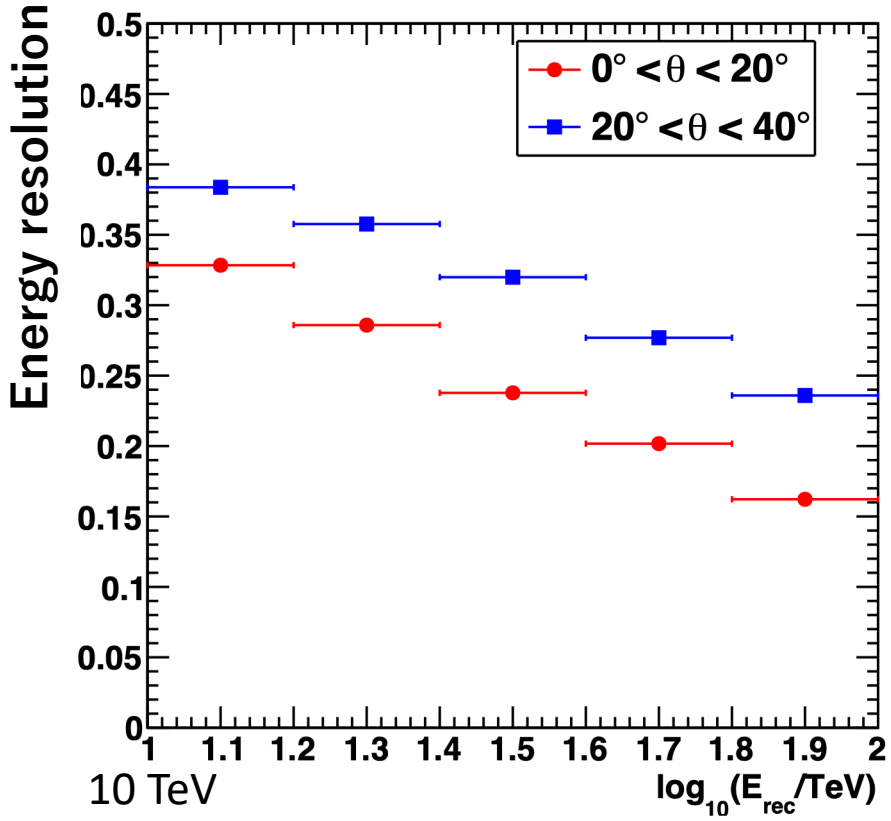
1, Energy reconstruction of CR electrons

✓ The energy lookup table was optimized using MC simulations of CR electrons

✓ MC condition

Primary: e^-
Energy range: 0.3 TeV - 10 PeV
Zenith: < 60 deg
Azimuth: 0-360 deg
Interaction model: EPOS-Fluka

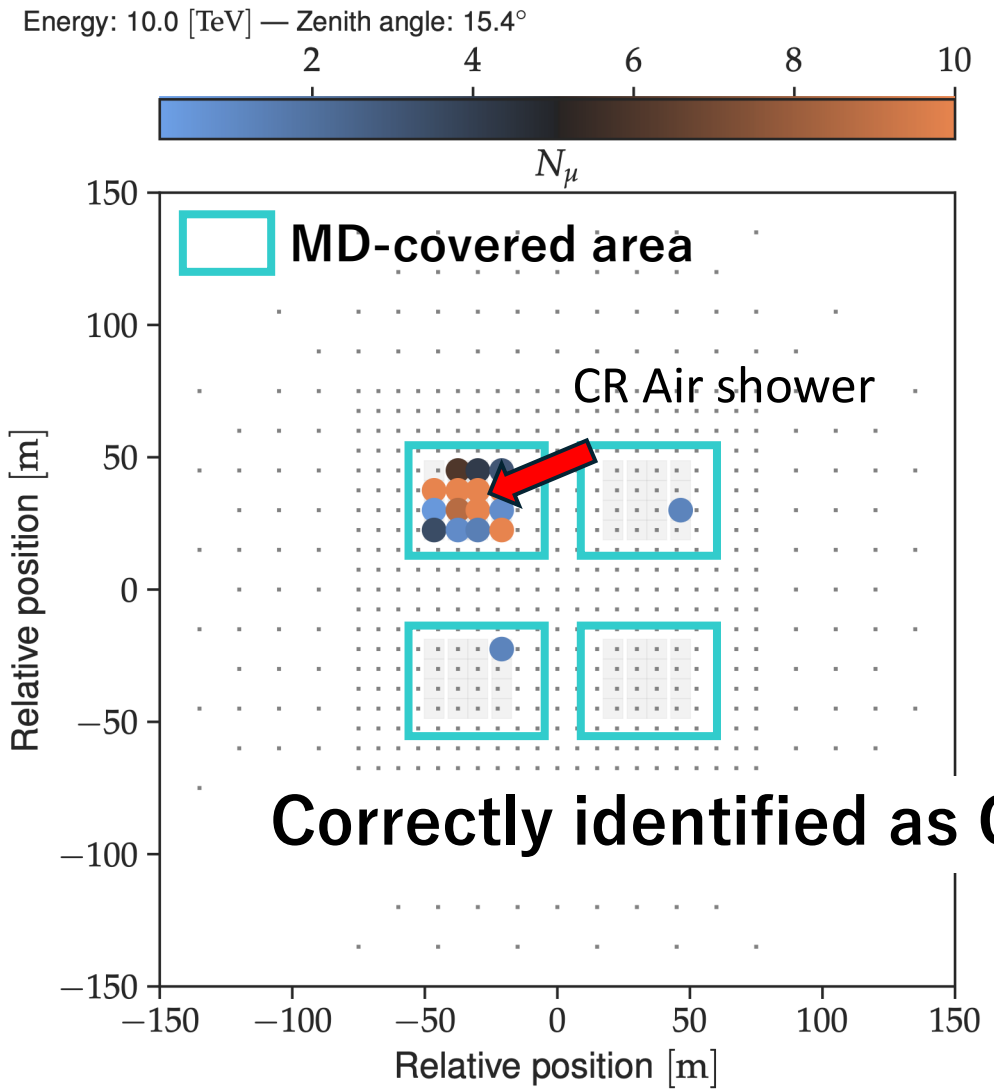


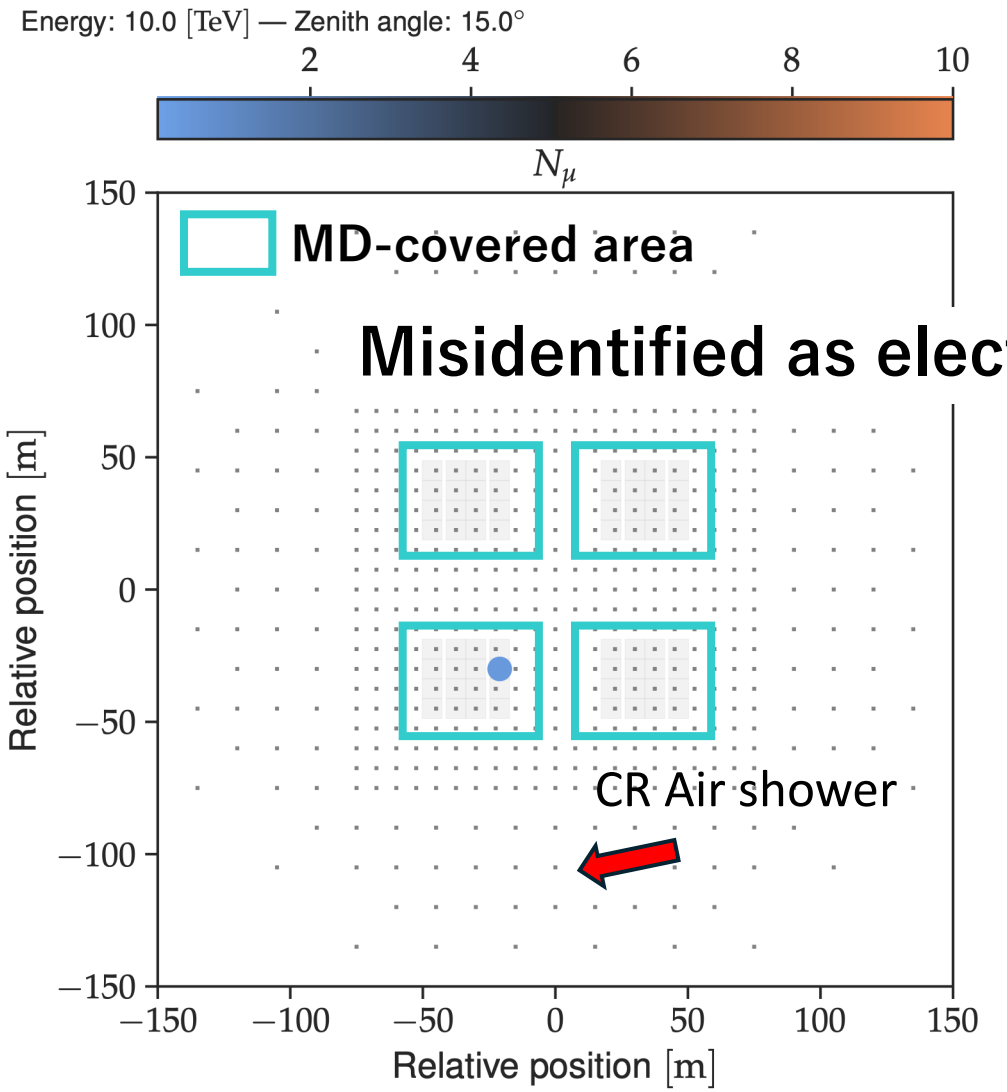


Energy resolution 40% at 10 TeV,
Bias < +-3 %, consistent with those obtained in gamma-rays reconstruction

2, Improvement of CR rejection rate at 10 TeV

10 TeV CR simulation (Zenith~15 deg), event map of measured muons





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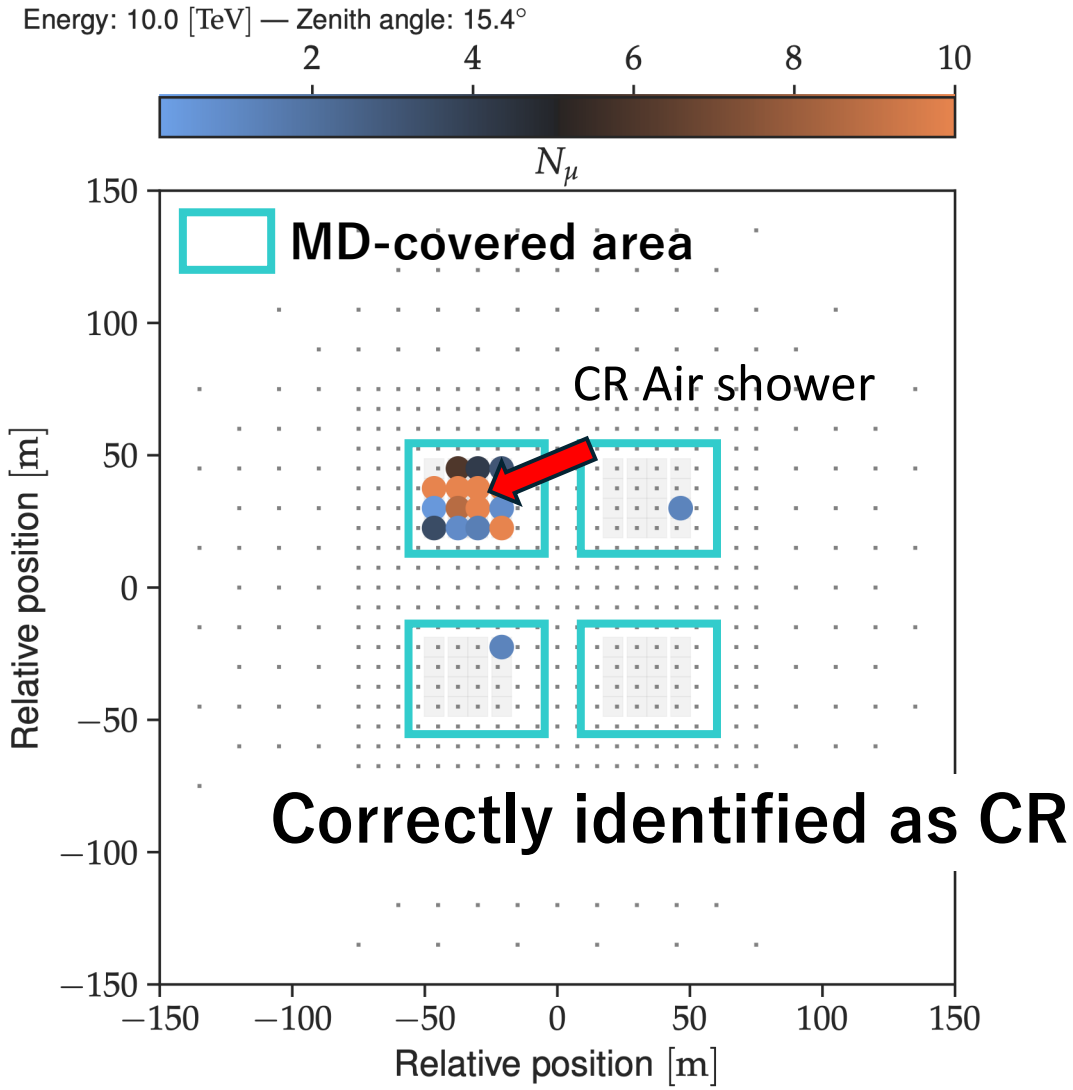
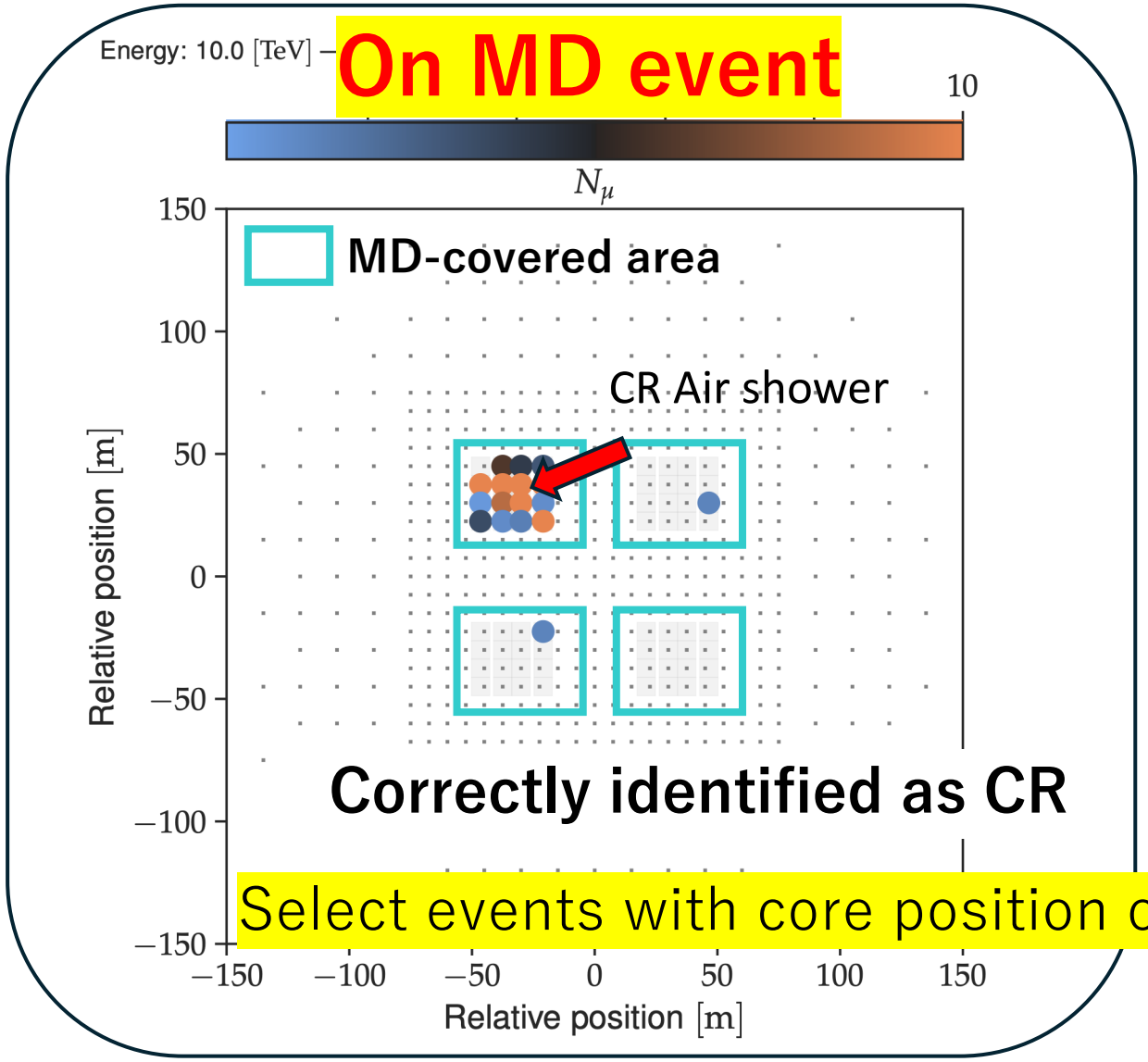


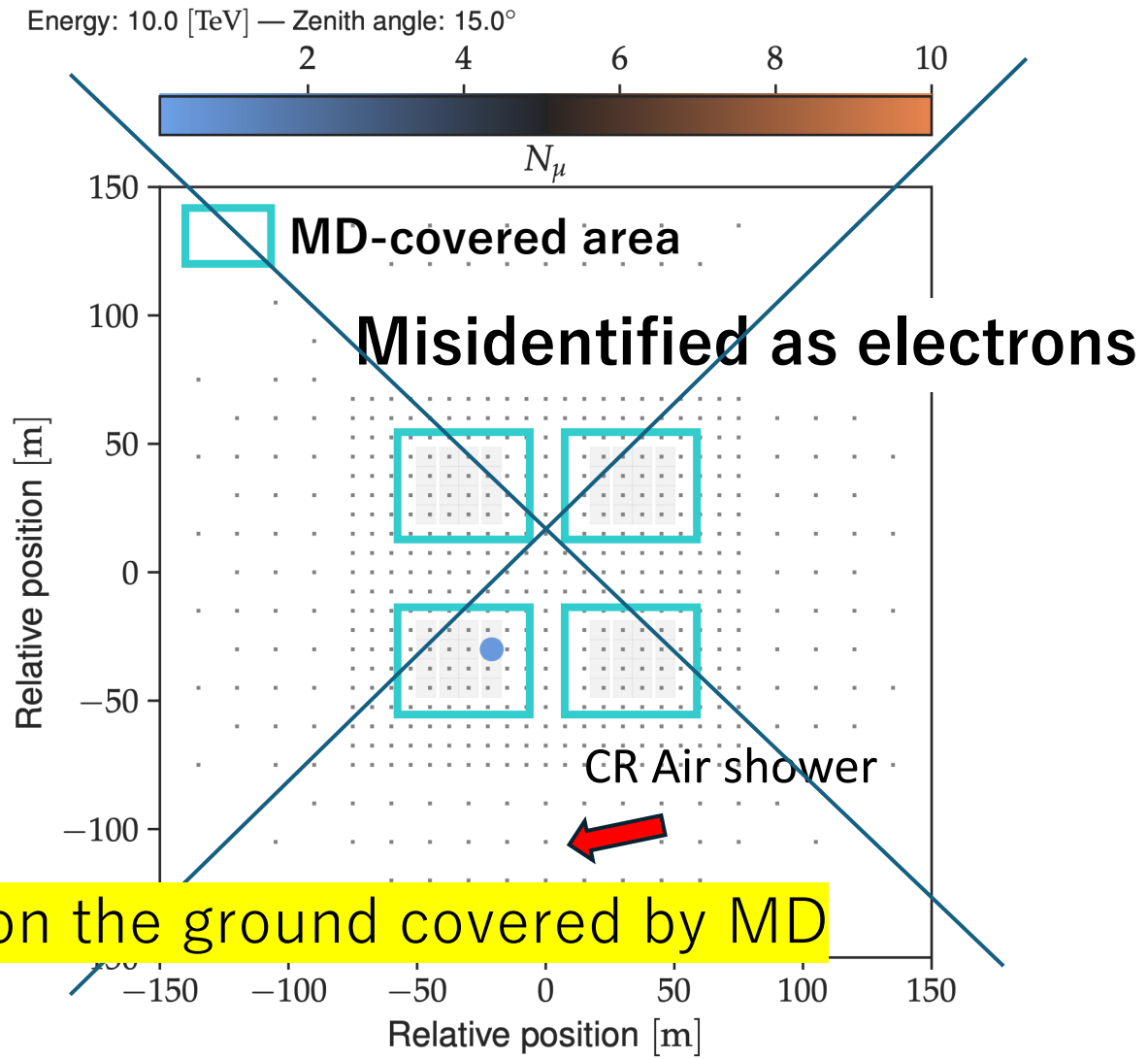
- Muon spread is smaller for 10 TeV CRs than for 100 TeV CRs
- Electron statistics are much larger than for gamma-rays, since electrons arrive from all directions

→ Background rejection can be improved even at the cost of effective area

2, Improvement of CR rejection rate at 10 TeV

10 TeV CR simulation (Zenith~15 deg), event map of measured muons



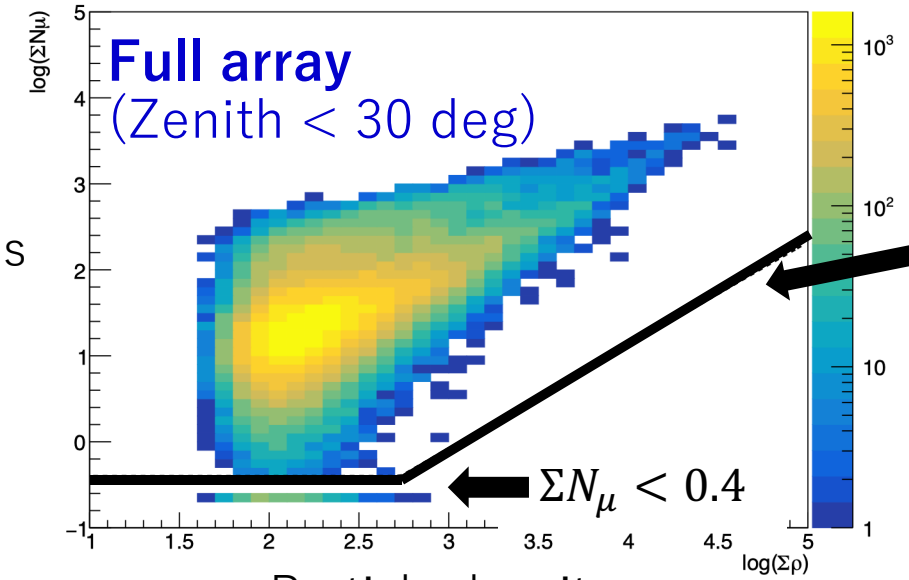


Select events with core position on the ground covered by MD

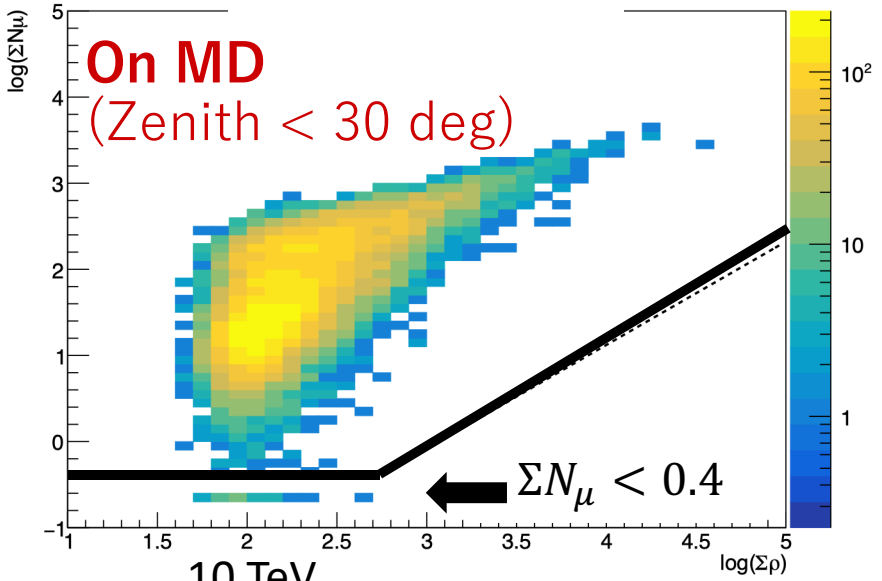
Distribution of particle density and number of muons

✓ MC CR (EPOS-LHC)

Number of muons



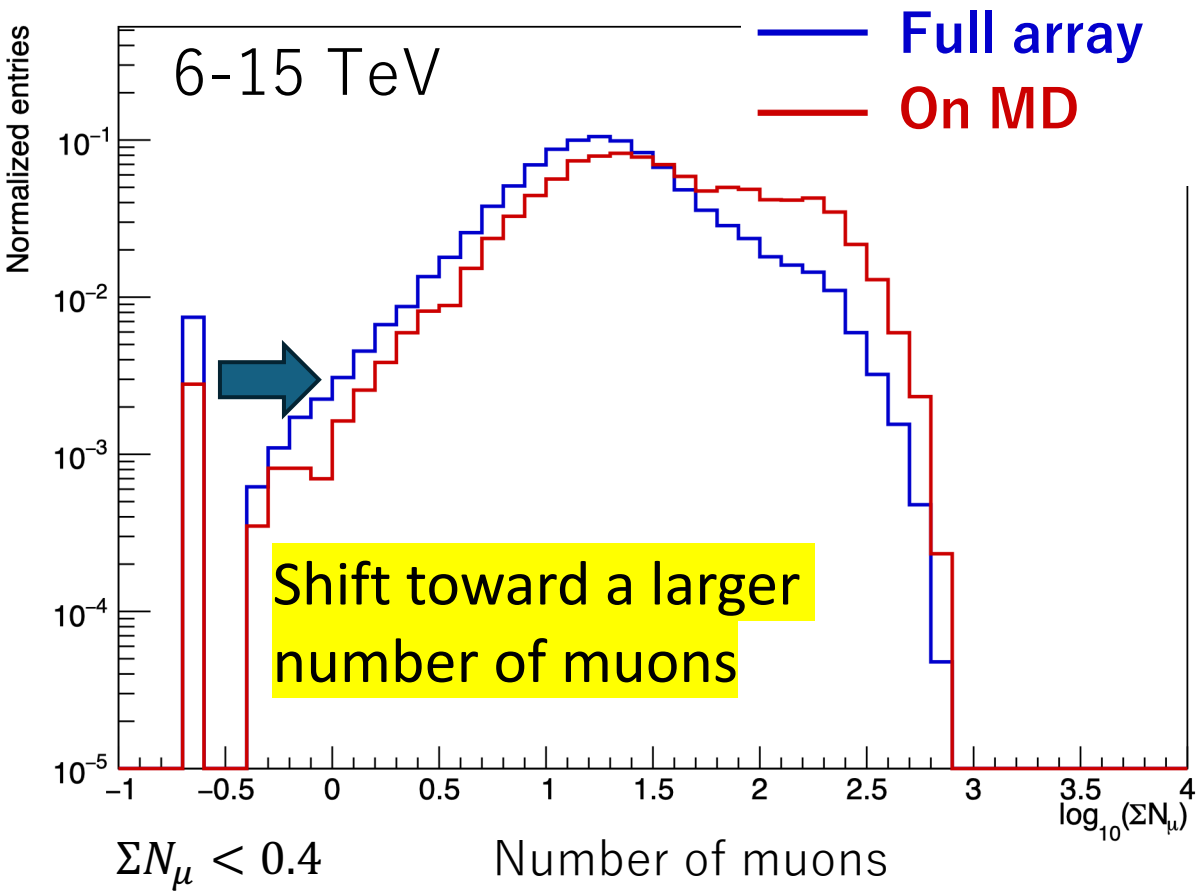
Particle density



10 TeV

Events with a large number of muons are rejected as background CRs

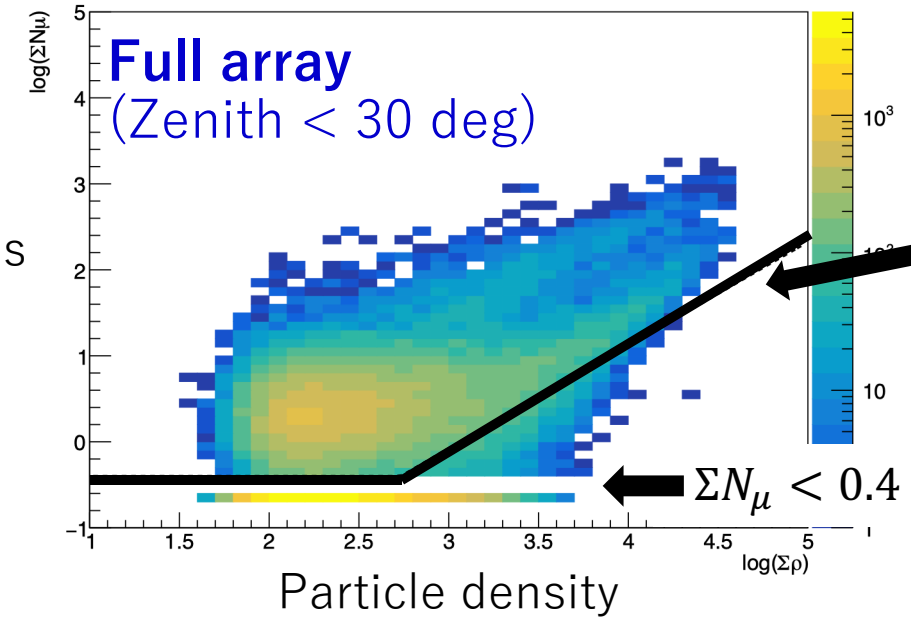
Muon cut: $\Sigma N_\mu < 2.1\times10^{-4}(\Sigma\rho)^{1.2}$ or $\Sigma N_\mu < 0.4$



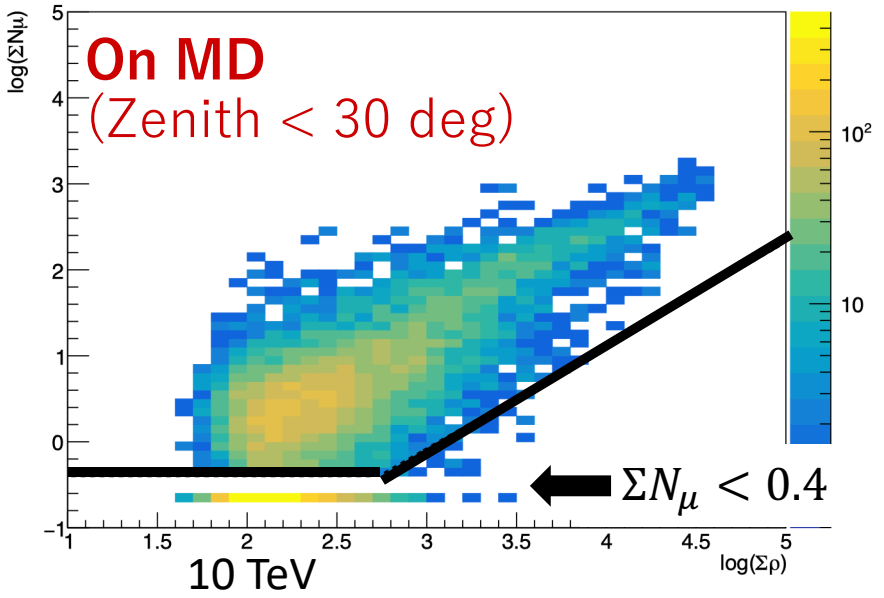
Distribution of particle density and number of muons

✓ MC Electron

Number of muons



Particle density



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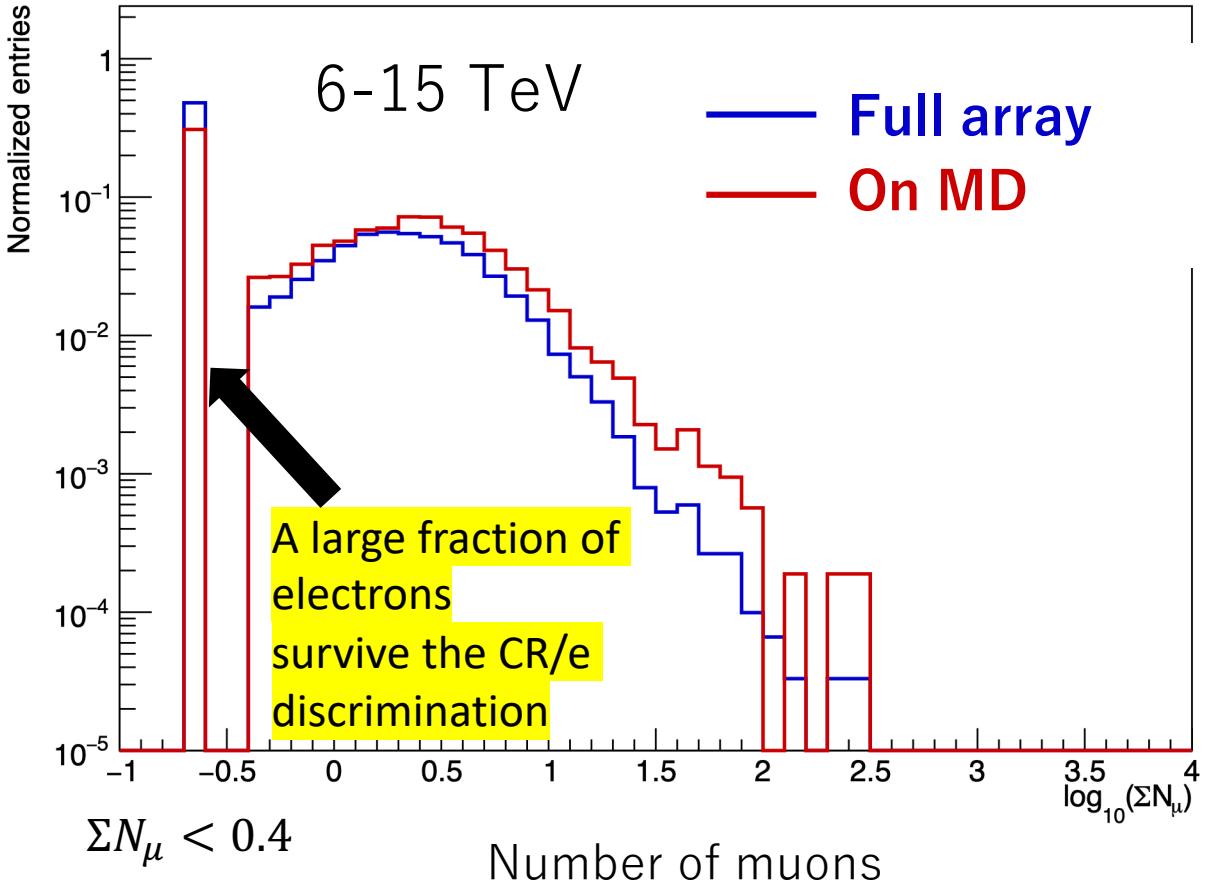


Number of muons

Survival ratio of CR/e discrimination

Analysis conditions

✓ Zenith < 30 deg

✓ Muon Cut

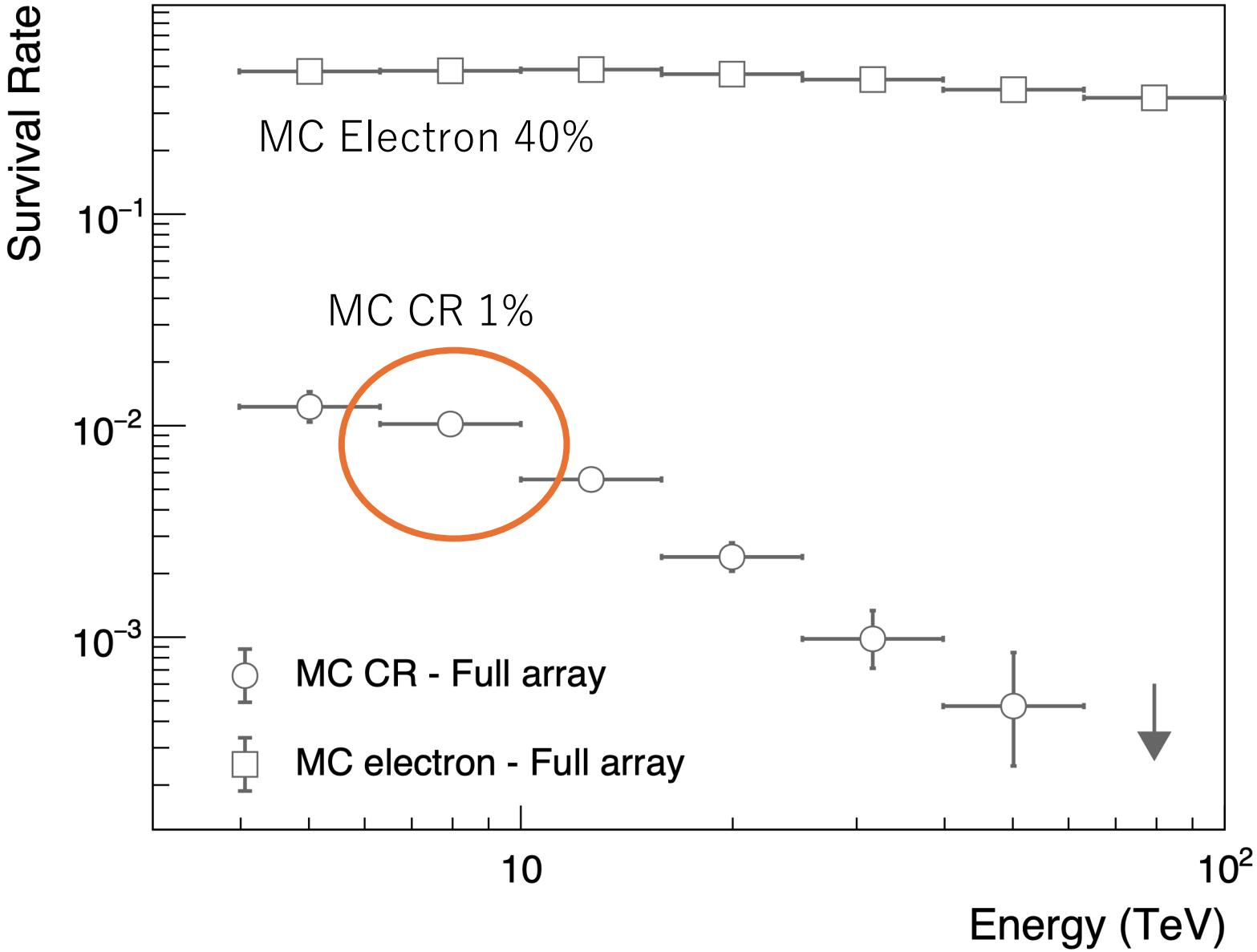
$$\Sigma N_\mu < 2.1\times10^{-4}(\Sigma\rho)^{1.2}$$

or $$\Sigma N_\mu < 0.4$$

✓ Core position

1. Full array

→ CR survival ratio ~1/100 at 10 TeV



Survival ratio of CR/e discrimination

Analysis conditions

✓Zenith < 30 deg

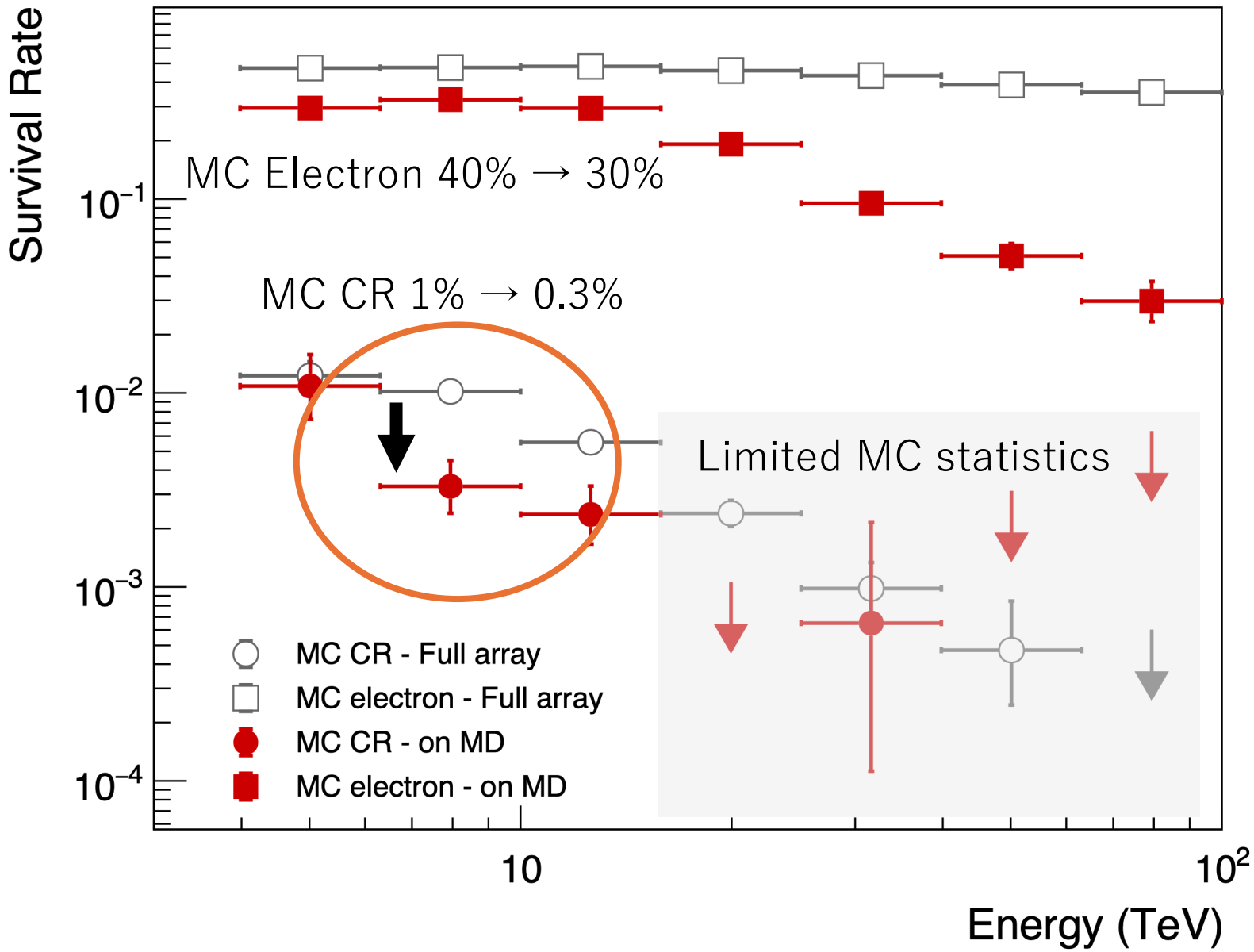
✓Muon Cut

$$\Sigma N_\mu < 2.1\times10^{-4}(\Sigma\rho)^{1.2}$$

or $$\Sigma N_\mu < 0.4$$

✓Core position

1. **Full array**
   → CR survival ratio ~1/100 at 10 TeV
2. **On MD**
   → CR survival ratio ~1/300 at 10 TeV (x3 improvement)



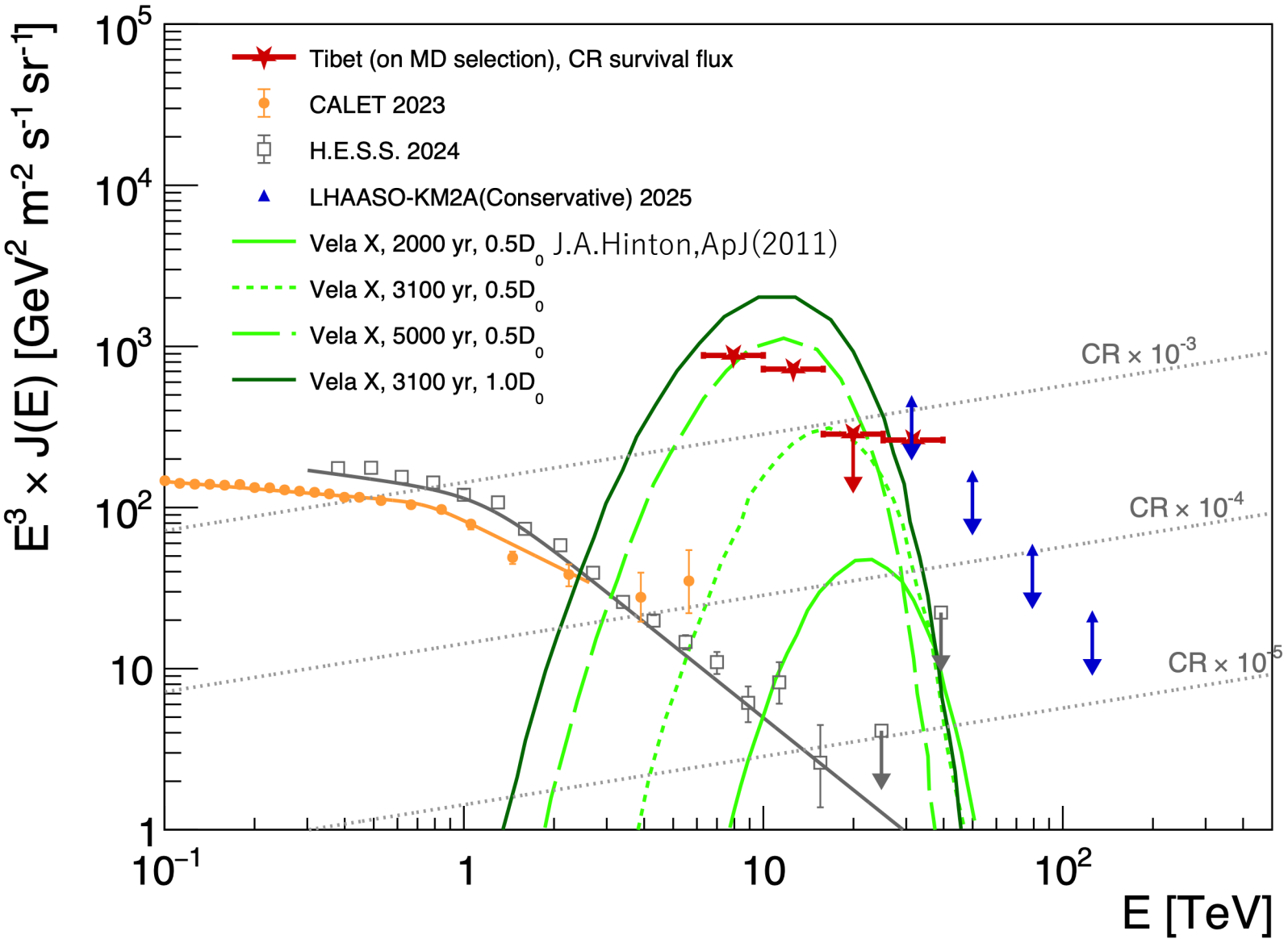
Background estimation

Survival BG CR flux

=

CR flux × CR survival ratio

- Electron excess over CR background expected for extreme models

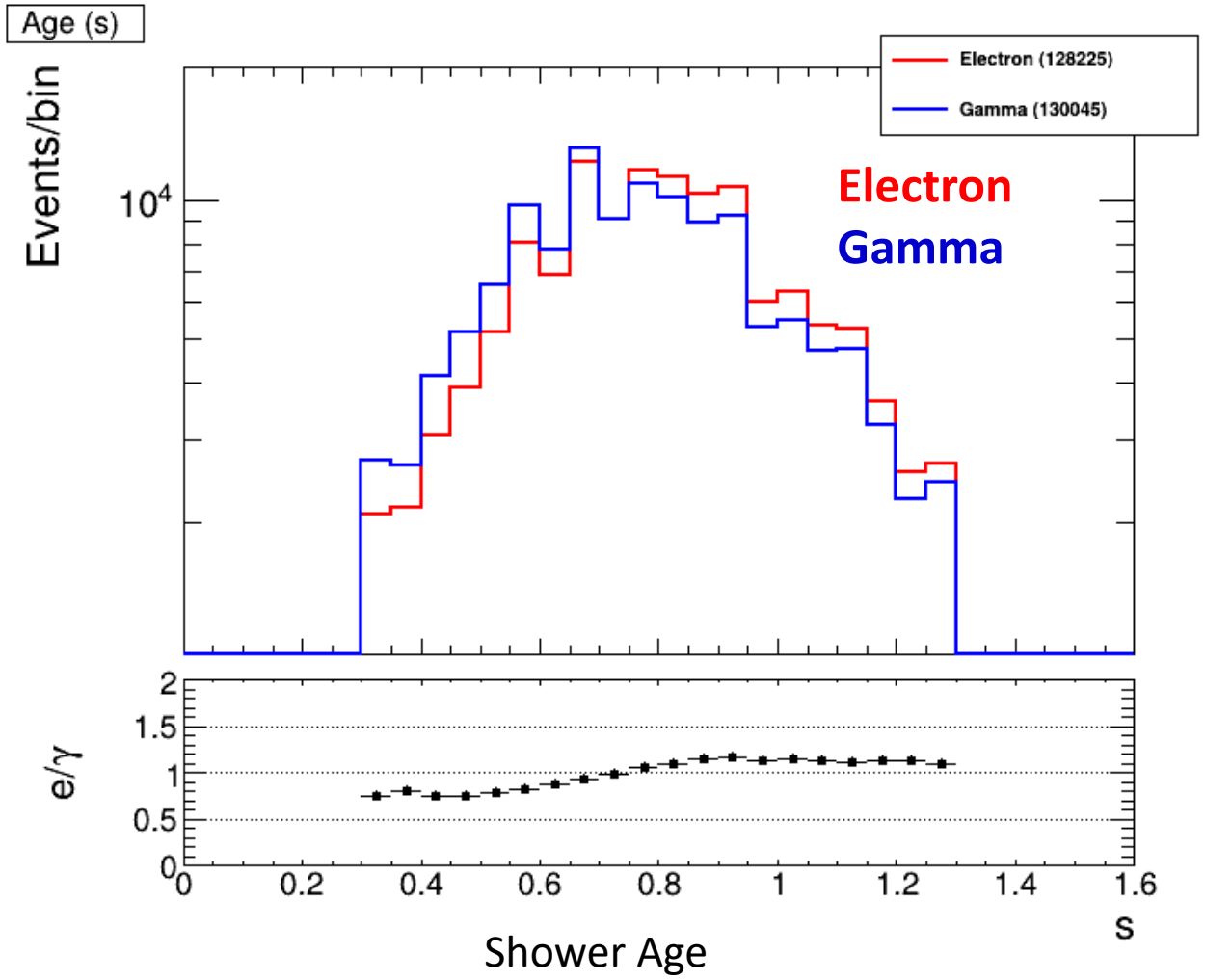


Summary

- Tibet air shower array offers a unique opportunity to study cosmic ray electrons above 10 TeV
- Dedicated energy reconstruction and background rejection techniques have been developed using MC simulation
- Experimental data analysis is ongoing

Back up

Electron/γ comparison



Shower Age