超高エネルギーガンマ線天体の探索ーALPACA実験

Kato Sei (ICRR)

ABOUT ME

- Belong to ICRR, Tibet ASγ experiment
- Got a Bachelor of Engineering (reseach field : Fusion Plasma)
- My hobby : Training, and singing
- My recent trend : Greek Orthodox Chant

The ALPACA Experiment

Andes Large area

PArticle detector for

Cosmic ray physics and

Astronomy

The ALPACA experiment

★ A New Project in Southern Hemisphere (Bolivia)

Bolivia side 5 members
UMSA (Universidad Mayor de San Andrés)
Japan side 32 members
(Some members from BASJE + GRAPES-3 + Tibet ASγ)

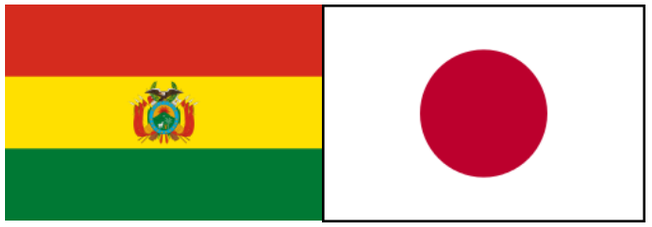
★ Targets

10 - 1000 TeV gamma-ray astronomy (Southern sky)
Cosmic-ray anisotropy
Sun shadow
Chemical composition at Knee region

★ Site and Detectors

Halfway up Mt. Chacaltaya, Bolivia	4,740 m a.s.l.
Surface air shower array	~83,000 m^2
Underground muon detector array	~5,400 m^2

The ALPACA Collaboration



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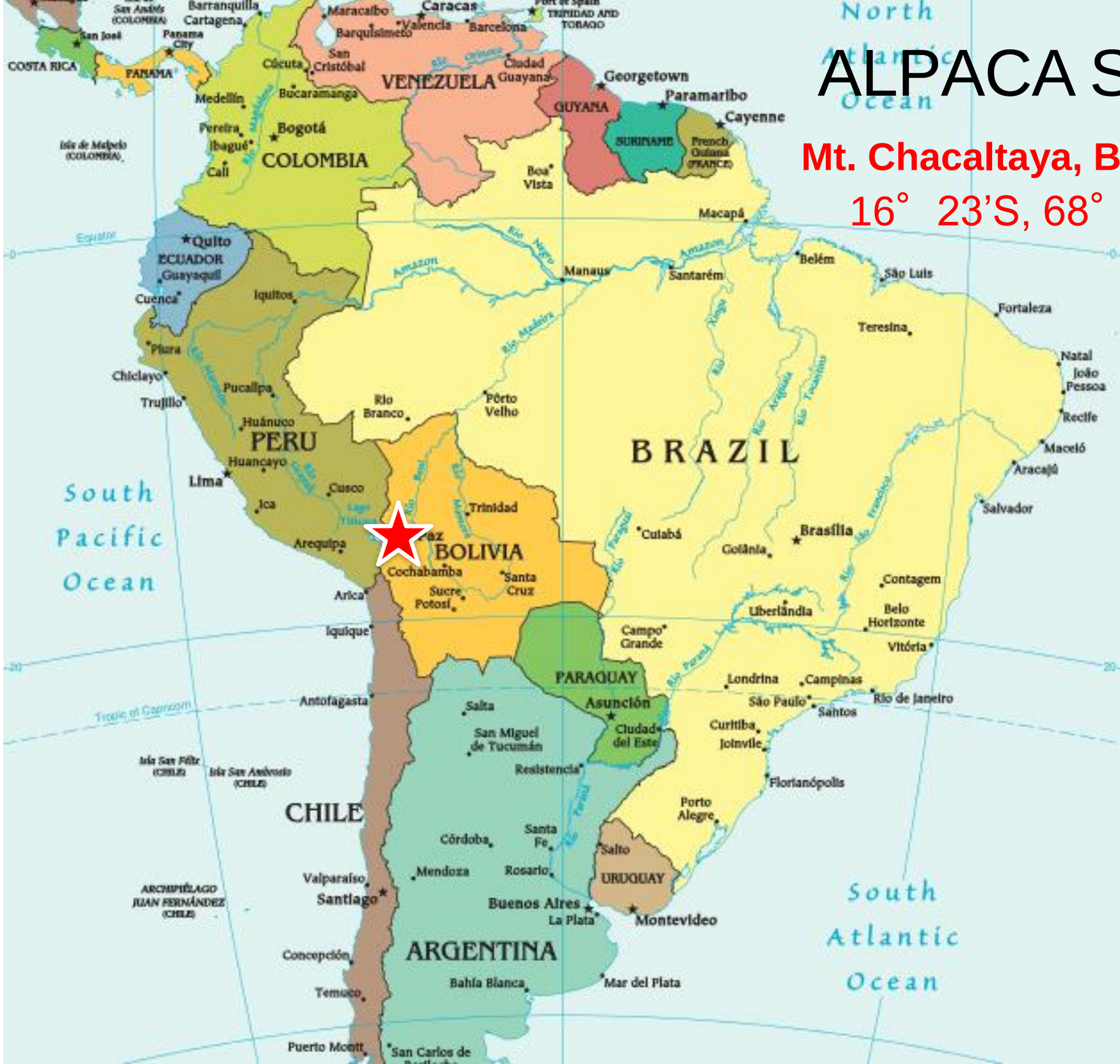
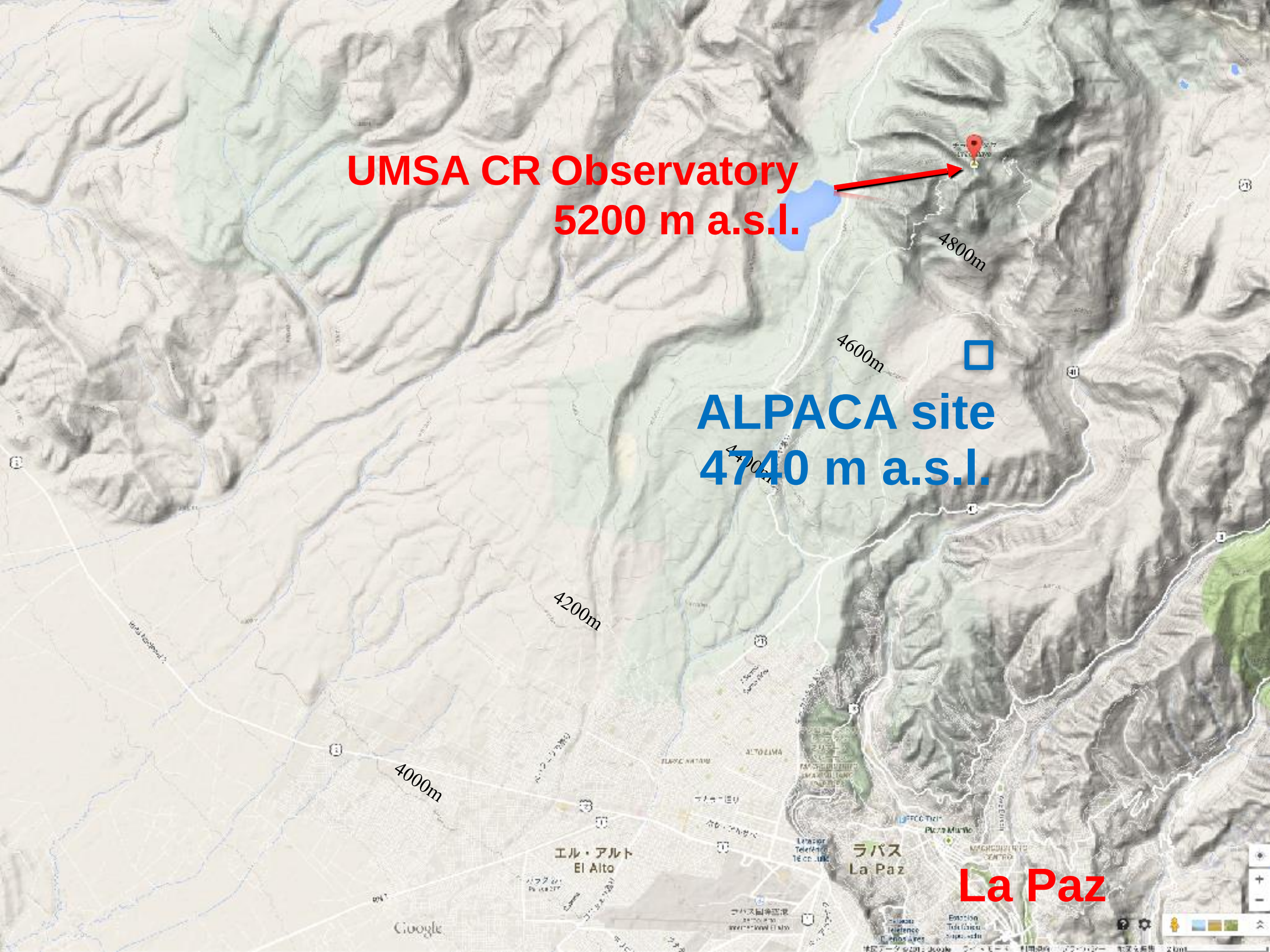
ALPACA Site

Mt. Chacaltaya, Bolivia

16° 23'S, 68° 08'W



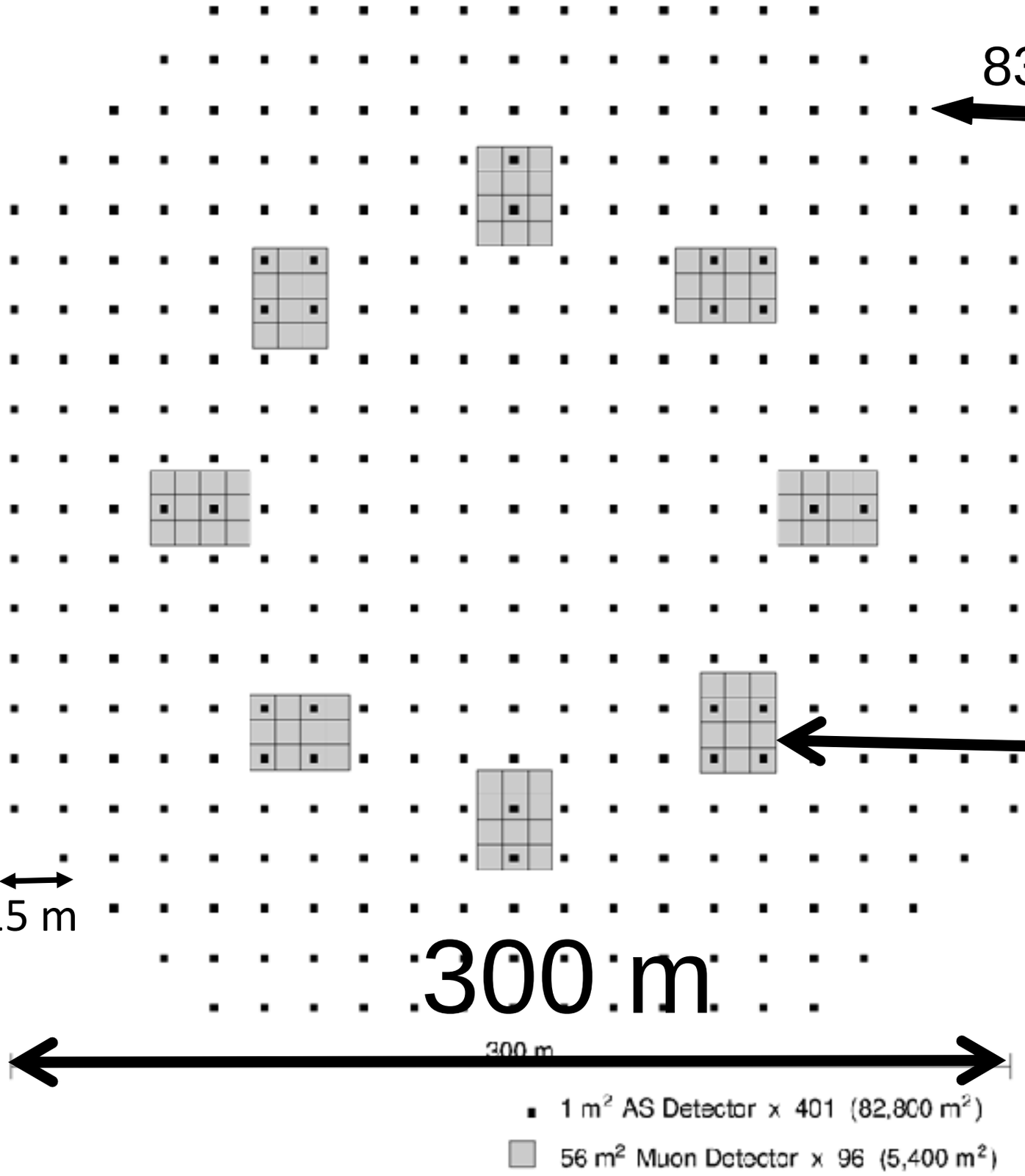

UMSA CR Observatory
5200 m a.s.l.
4800m
4600m
ALPACA site
4740 m a.s.l.
4400m
4200m
4000m
エル・アルト
El Alto
ラパス
La Paz
La Paz
Google

Observation Cite: **Chacaltaya Hill**

500 m × 500 m flat within ± 1°

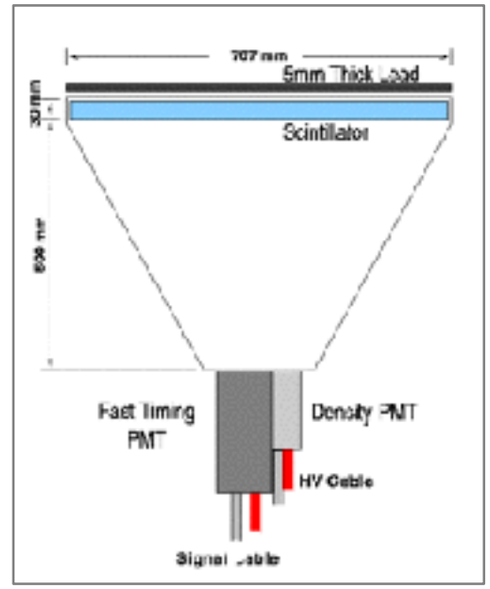
4,740 m above sea level (16° 23’ S, 68° 08’ W)

Schematic view of ALPACA



83,000 m²

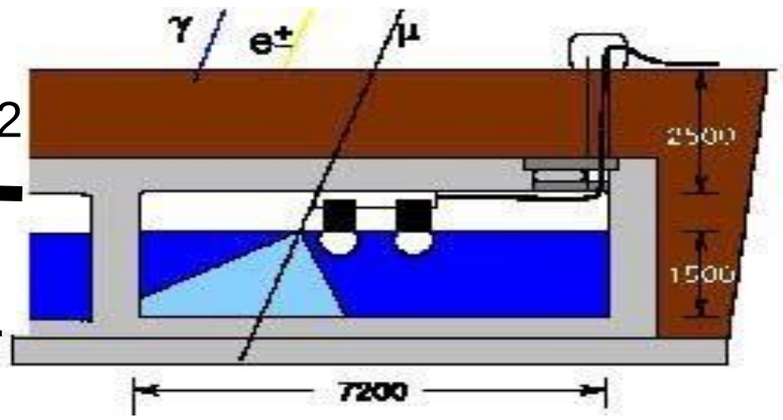
Air Shower Array



1m² plastic scintillation detector

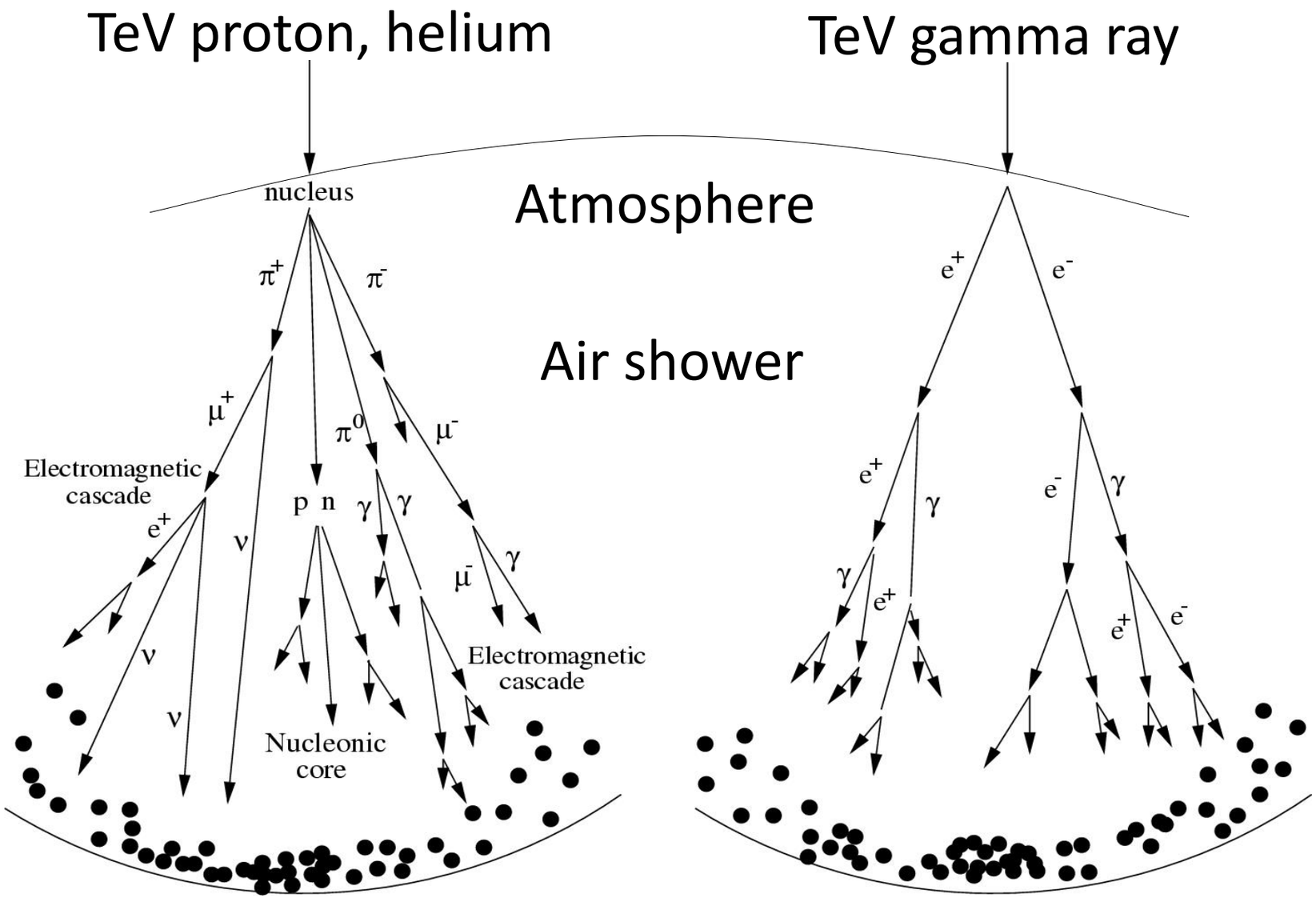
5,400 m²

Muon Detector Array



Underground water Cherenkov muon detector (56 m² / unit)

p/γ discrimination by counting # of muons

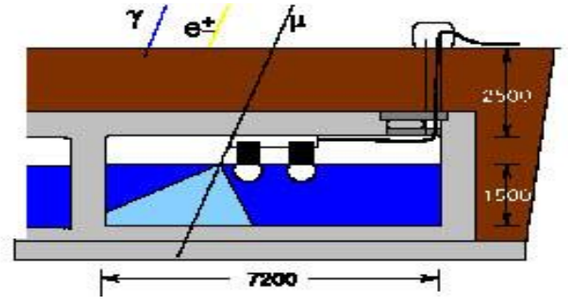


Number of muons within <100m from air-shower core

~50 μ for 100 TeV proton

~1 μ for 100 TeV γ

Muon detector unit

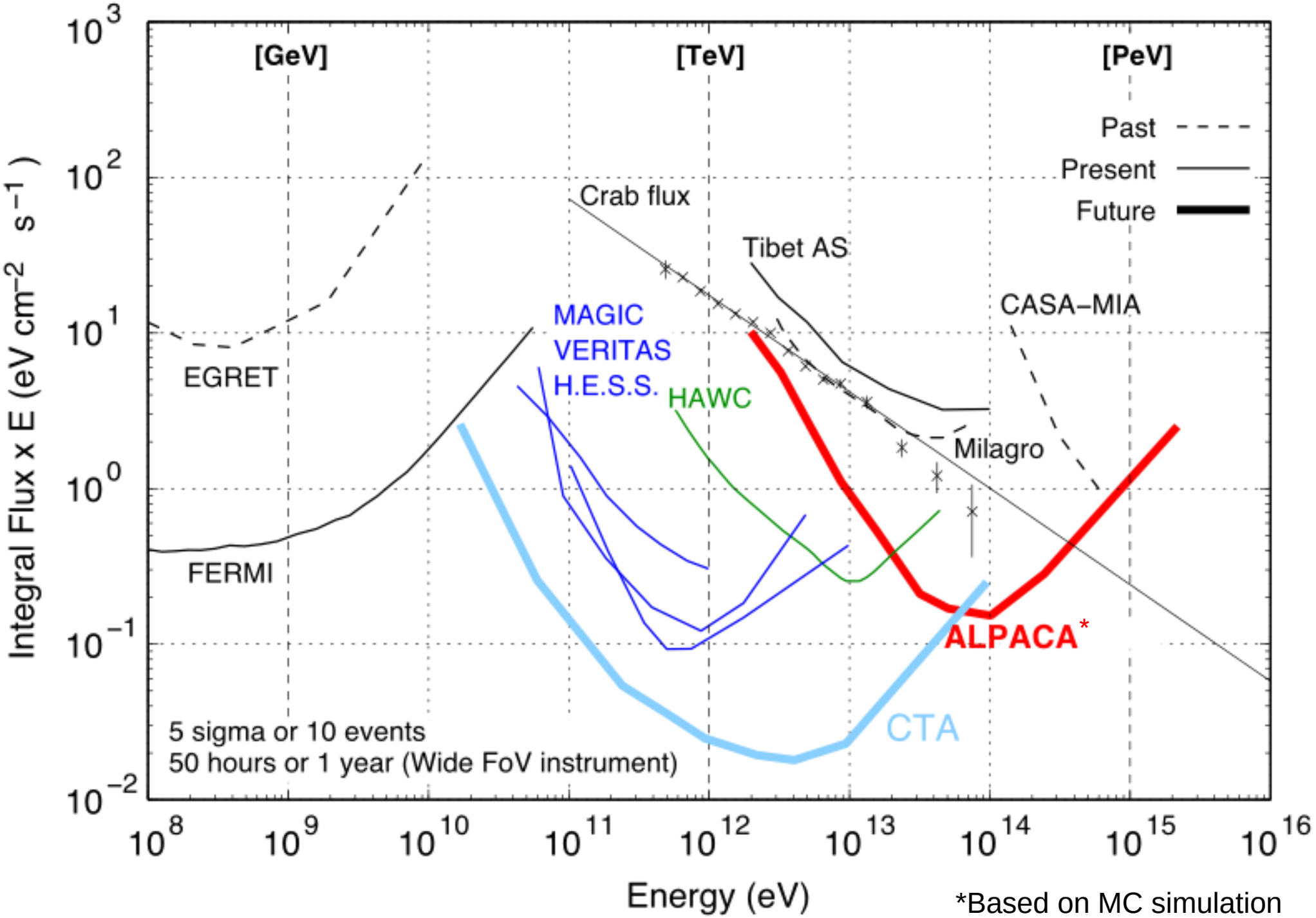


Expected performance of ALPACA

Location: 4,740 m above sea level (16˚23’ S, 68˚08’ W)

# of scintillation detectors	1.0 m^2 × 401 detectors
Effective area of	~83,000 m^2
Modal energy	~5 TeV
Angular resolution	~0.2˚ @ 100 TeV
Energy resolution	~20% @ 100 TeV γ-rays
Field of view	~2 sr
Duty cycle	>90%
CR rejection power	>99.9%@100TeV (γ ray efficiency ~90%)

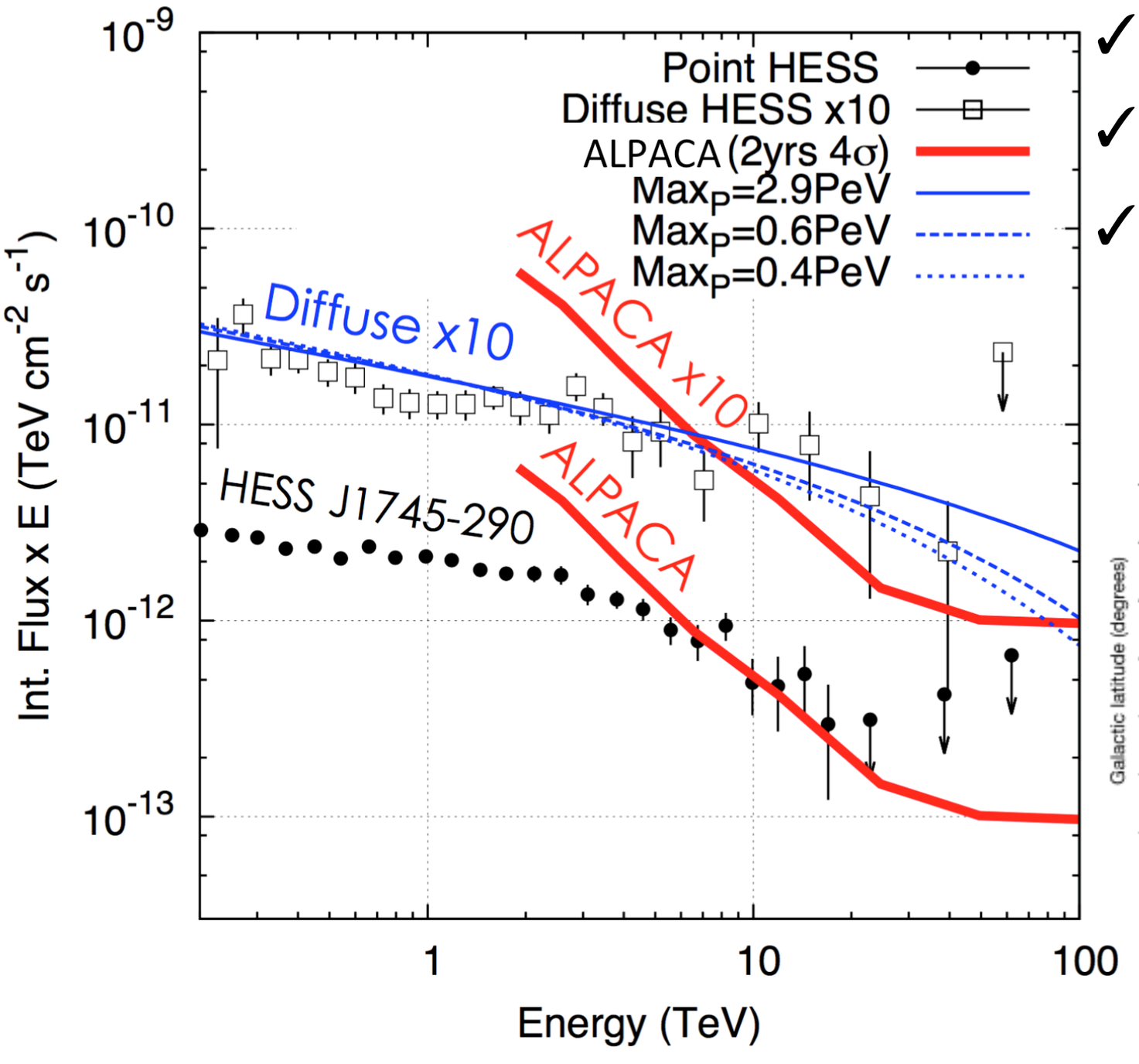
Sensitivity to γ-ray Point Source



*Based on MC simulation for the Tibet AS+MD

CTA Review by Kubo (JPS 2015)
M. Daniel, Proc. of 28th Texas Sympo. (2015)

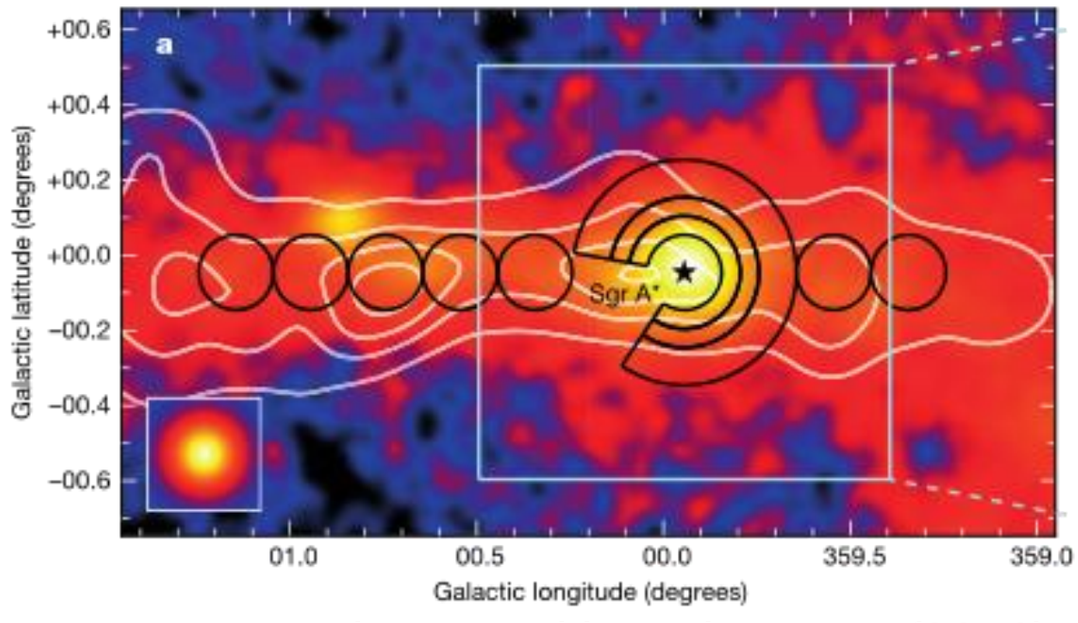
Galactic Center as PeVatron?



✓ Detection of diffuse component

✓ sub-PeV γ-rays expected

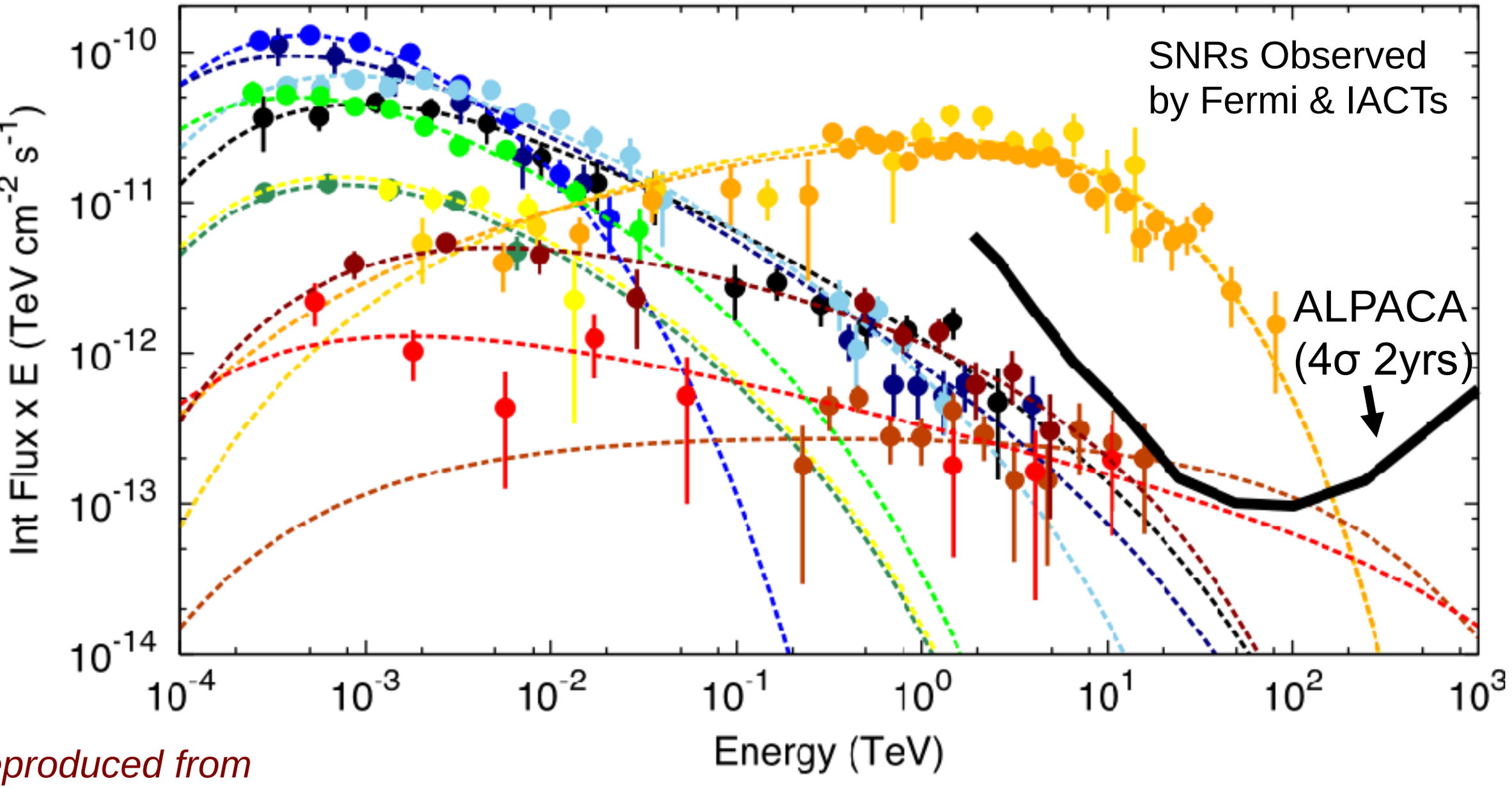
✓ Promising candidate for PeVatron



Abramowski, et al, Nature (2016)

$\delta \sim -29^\circ$

Young SNRs

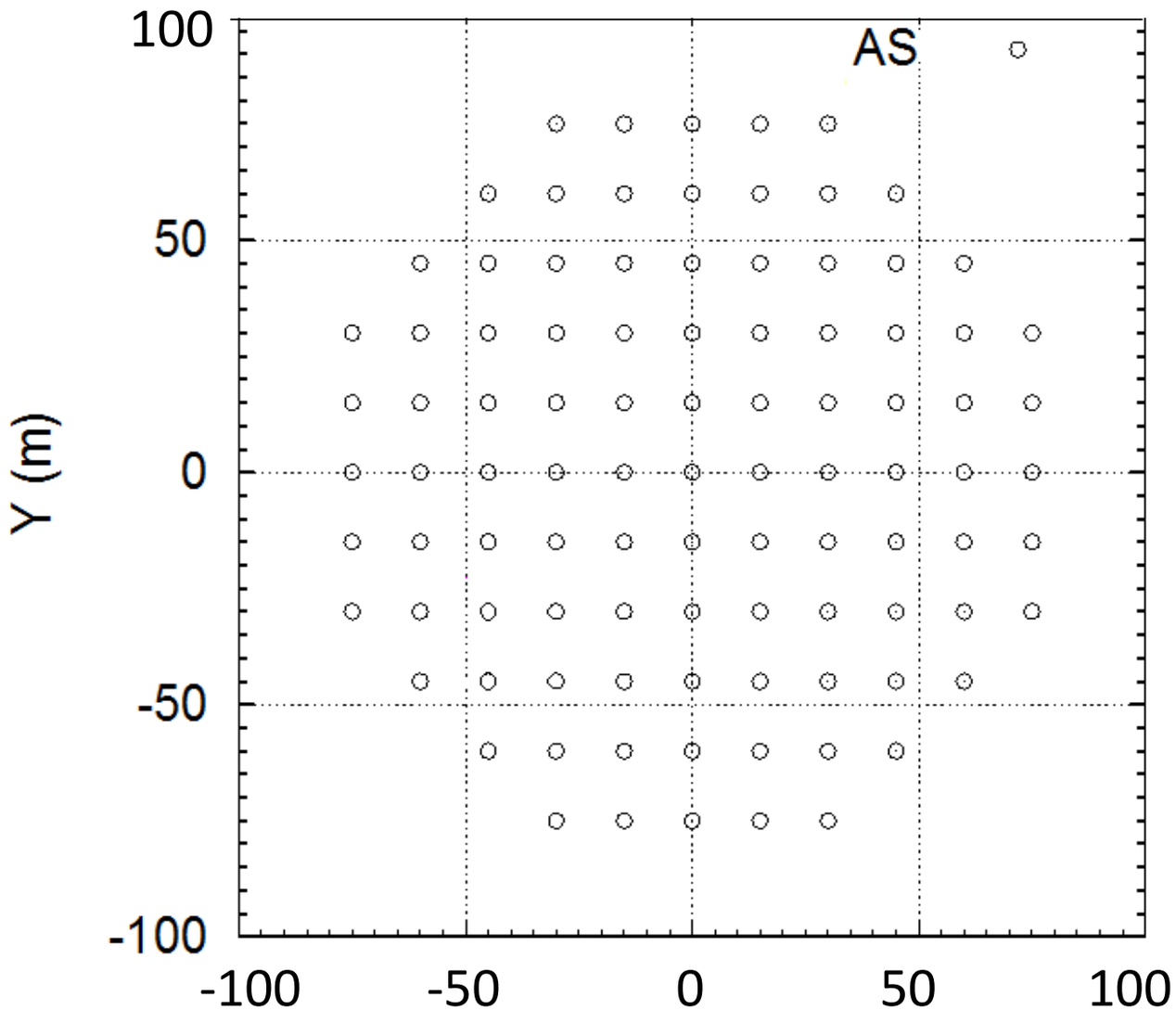


Reproduced from slides presented by S. Funk (TeVPA 2011)

W51C (35k yrs)
W28 (30k yrs)
W44 (20k yrs)
IC443 (10k yrs)
Cyg Loop (5.0k yrs)
W49B (4.0k yrs)
PuppisA (3.7k yrs)
RXJ0852 (2.5k yrs)
RXJ1713 (2.0k yrs)
SN1006 (1.0k yrs)
Tycho (0.4k yrs)
CasA (0.3k yrs)

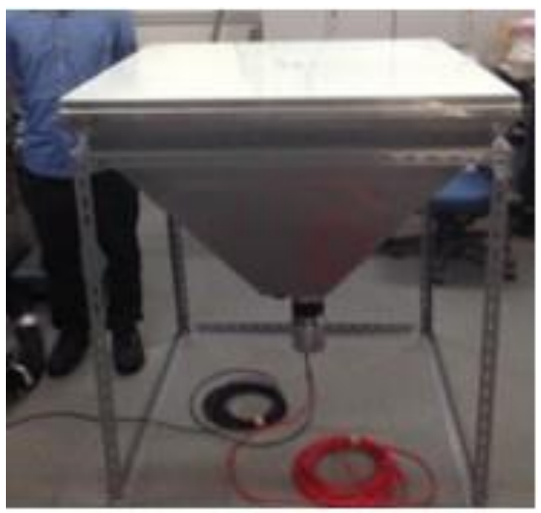
ALPAQUITA: prototype AS array

# of scintillation detectors	1.0 m^2 × 97 detectors
Effective area	~12,600 m^2
Construction	2019 Spring？



← Detector deployment

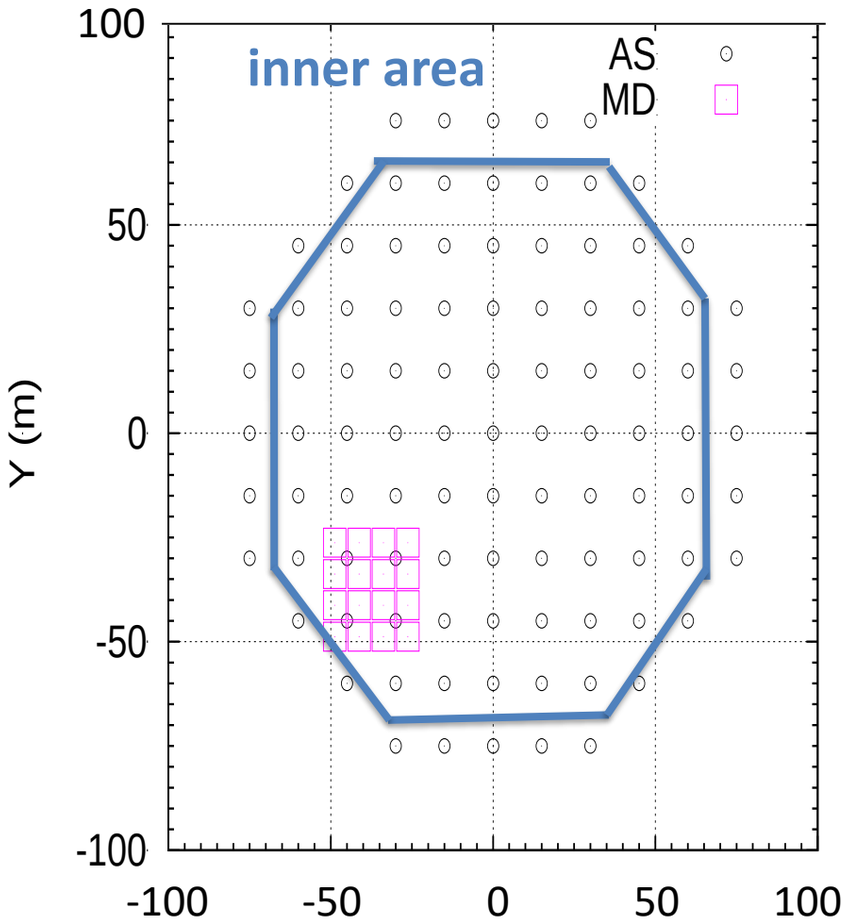
↓ 1m^2 Detector



MC settings

Primary: gamma rays, 10^7 events
all-sky ($0^\circ < \theta < 60^\circ$)
Energy range: > 300GeV
Spectrum: $\propto E^{-2.0}$

Observation level: 4,740 m
AS array: 97 scintillators ($1m^2$ x 97)
1 ptcl ≡ 9.4 MeV (temporary)
Trigger condition = 1 ptcl any 4
Air-shower cores random within 200m from array center
MD array: 16 cells (7.2m x 7.2m x 16 ~ 800 m^2)

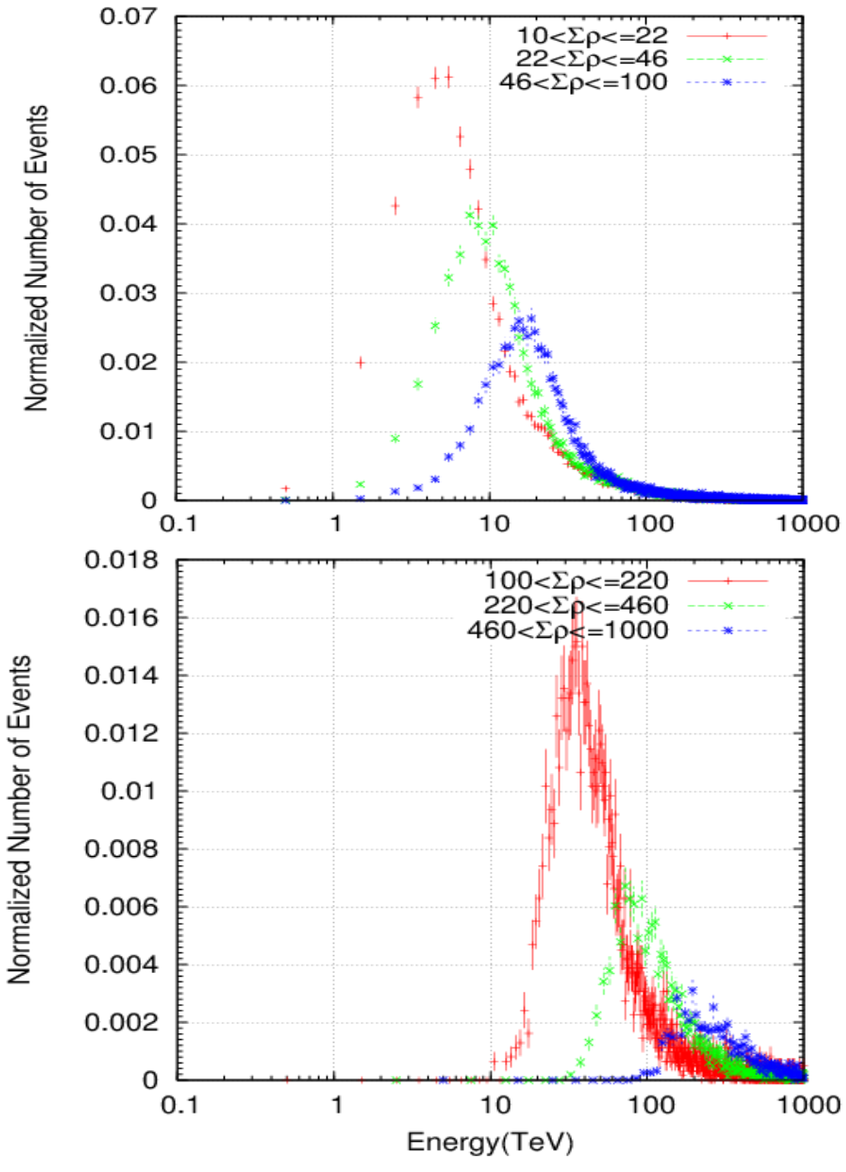


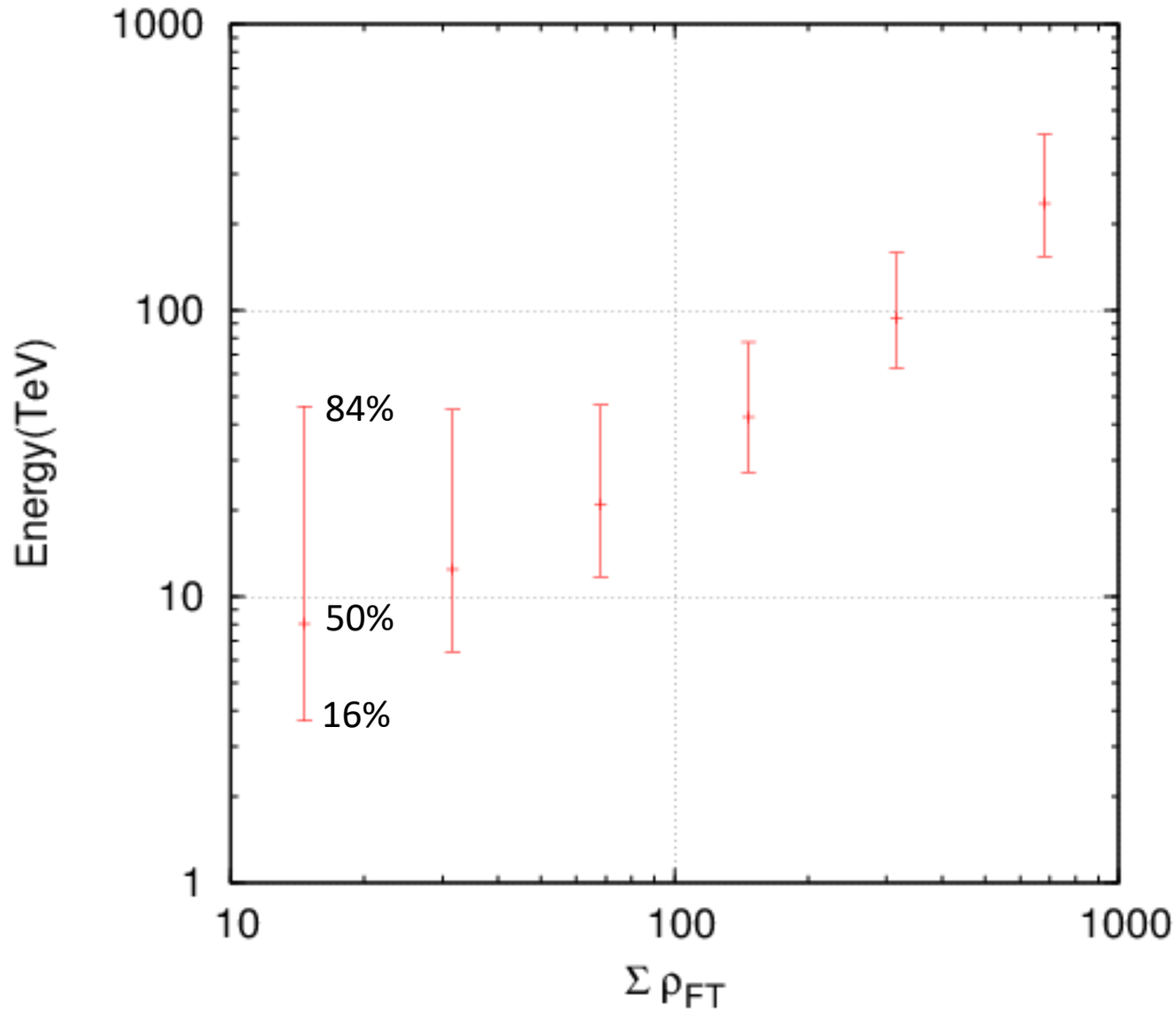
Event selection: "IN" events (5 out of 6 hottest detectors located in inner area) 1.2 ptcl any 4

AS	18,450 m^2 (inner area 12,600 m^2)
MD	800 m^2

Simulation Results (1)

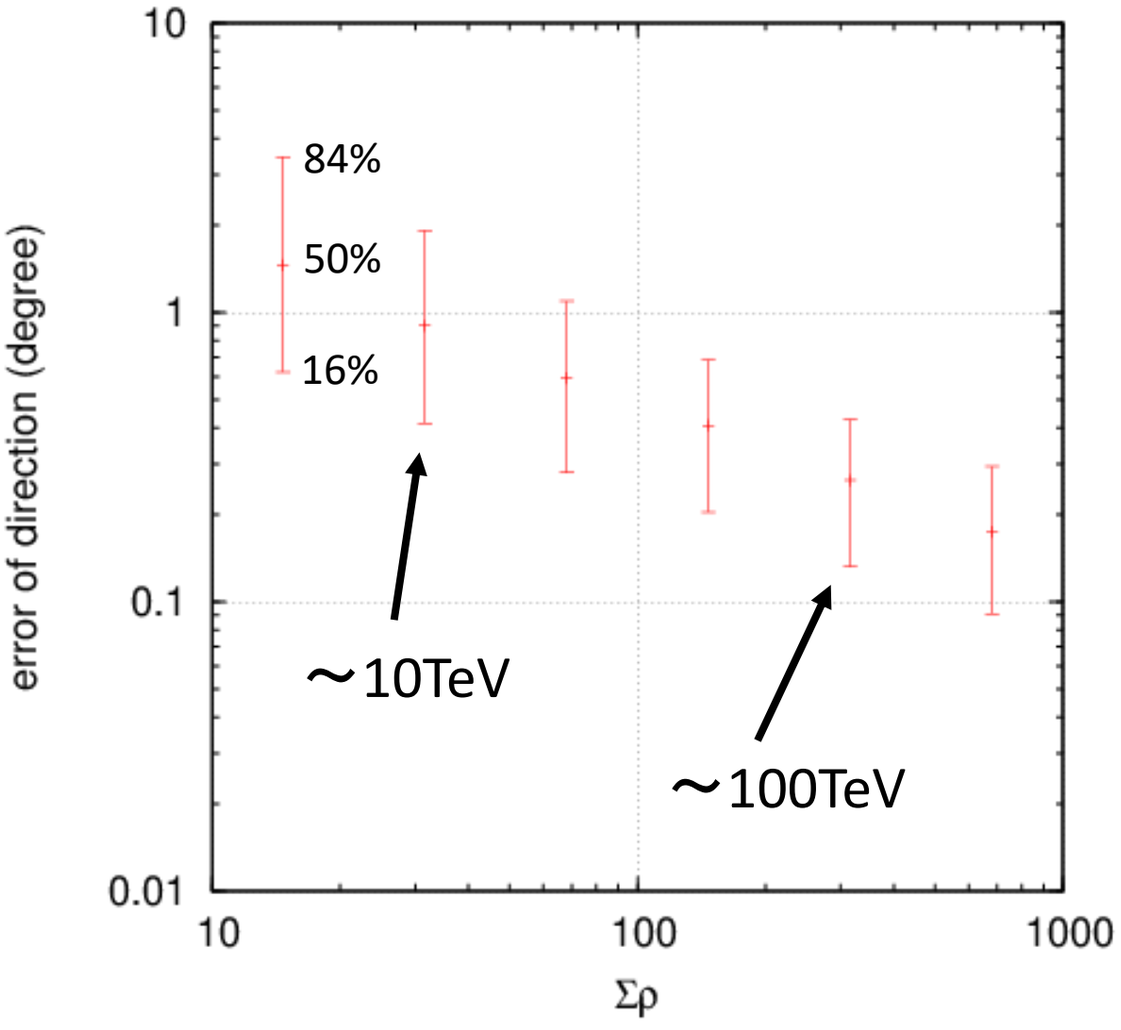
Energy Resolution



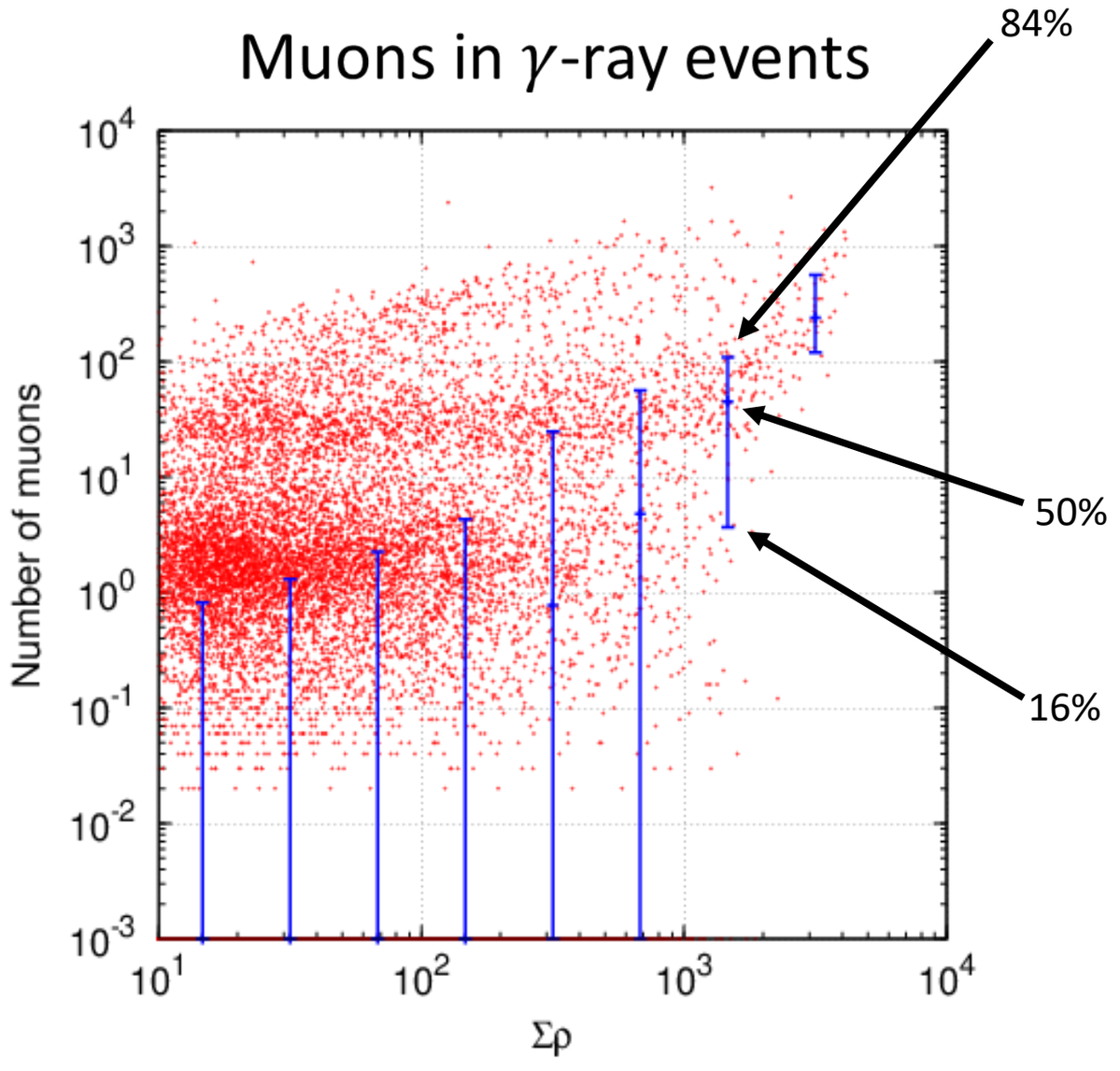


Simulation Results (2)

Angular Resolution



Muons in γ-ray events



ALPAQUITA Simulation
Future Prospects

- ALPAQUITA AS array
  - Optimize reconstruction of AS arrival direction
  - Lateral fit (using NKG function) → Improve E resolution

- ALPAQUITA γ-ray sensitivity by MD
  - Assume a specific bright source (e.g. RXJ1713)
  - BG/γ discrimination by MD
  - Optimize muon-cut condition

Summary

★ new project **ALPACA** in southern hemisphere

Halfway up Mt. Chacaltaya, Bolivia	4,740 m a.s.l.
Surface air shower array	~83,000 m^2
Underground muon detector array	~5,400 m^2

★ Targets

10 - 1000 TeV gamma-ray astronomy (Southern sky)

Cosmic-ray anisotropy

Sun shadow

Chemical composition at Knee region

★ ALPAQUITA: prototype AS array

97 x 1.0 m^2 scintillation detectors (~12,600 m^2)

Thank you
for your attention!