Study of galactic CR origin by using the ALPACA air shower array in Bolivia

ICRR-Inter-university research program
Tokyo, Japan Jan 29th 2025

Martin A. Subieta Vasquez (IIF, Universidad Mayor de San Andrés, La Paz-Bolivia) on behalf of ALPACA collaboration

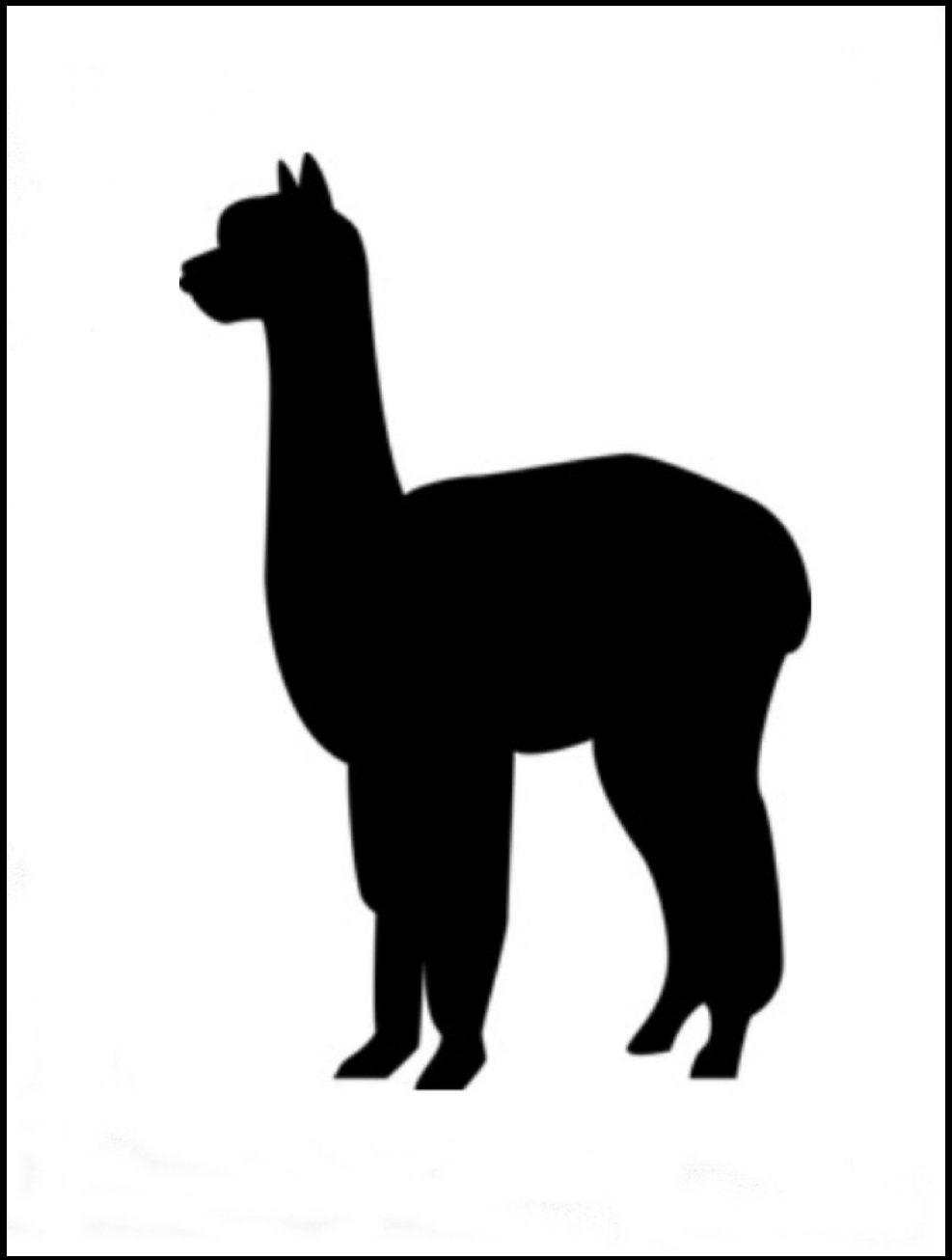
Outline

A brief introduction of ALPACA project

Status of the experiment

ALPACA physics

Outlooks



Andes

Large

area

PArticle

detector for

Cosmic ray

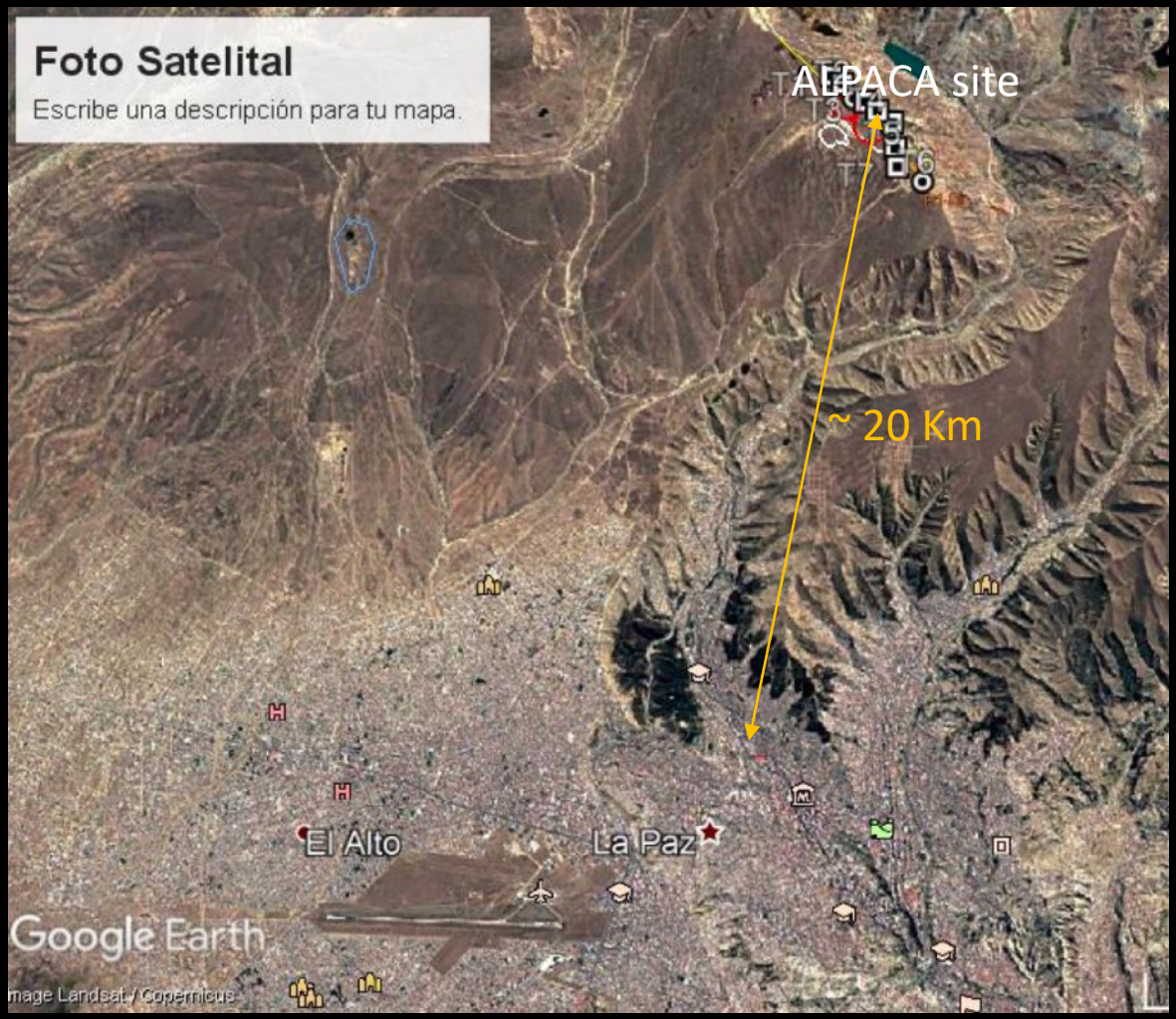
physics and

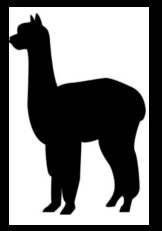
Astronomy

https://www.alpaca-experiment.org

Why in Bolivia?

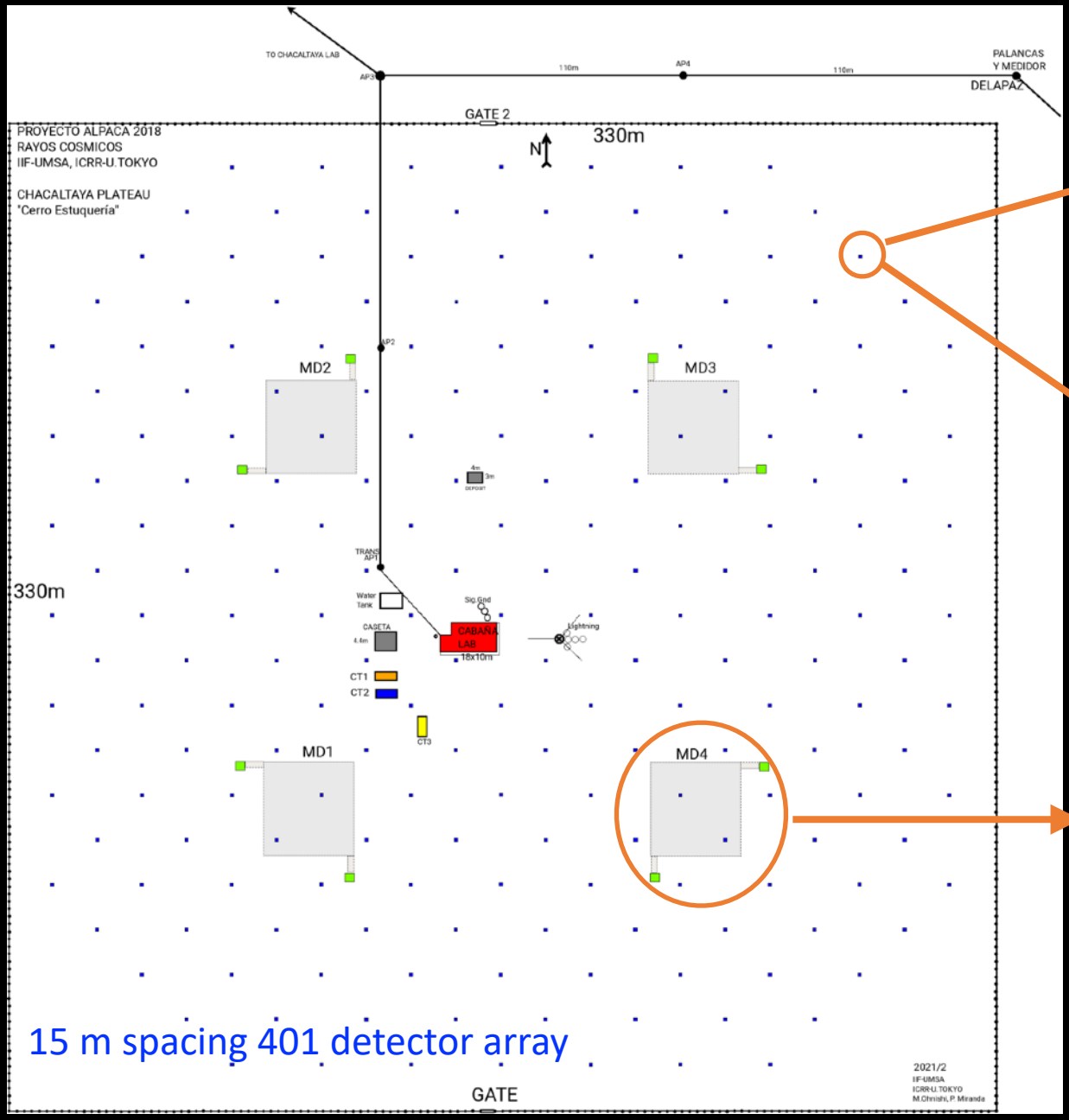
1. We can find feasible flat-land candidates above 4000 m a.s.l.
2. Observing sky form the southern hemisphere.
3. Long term scientific collaboration (cosmic rays field) between ICRR (Japan) and IIF (Bolivia) since 1961 (Chacaltaya observatory-BASJE).

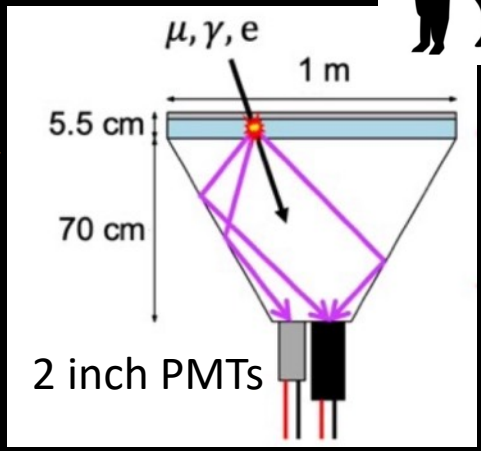


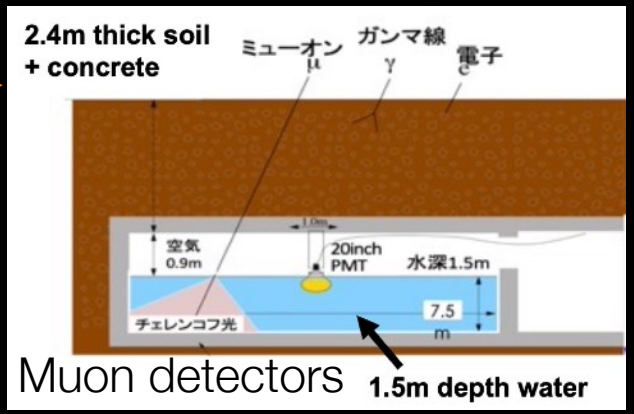


ALPACA current status

ALPACA's detectors layout goal





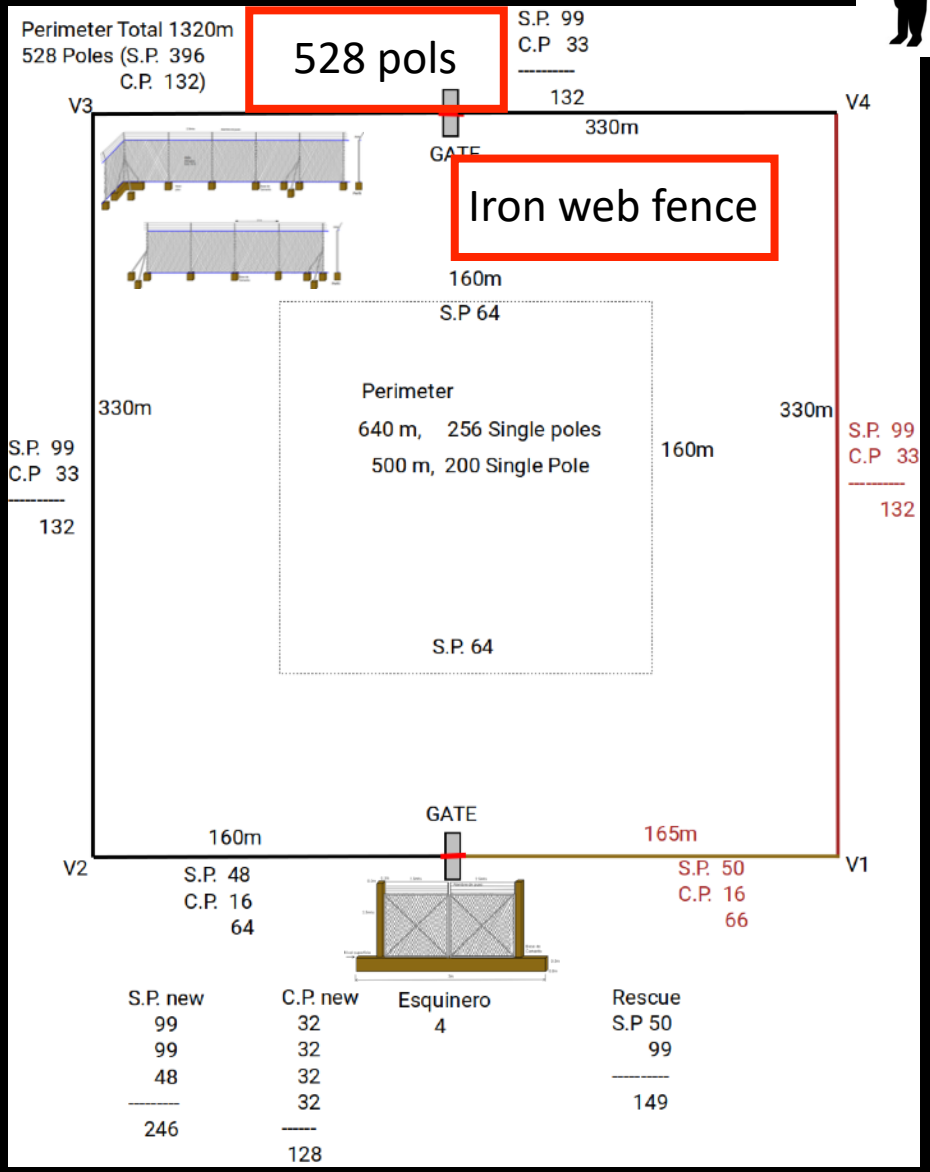


ALPAQUITA's detector deployment

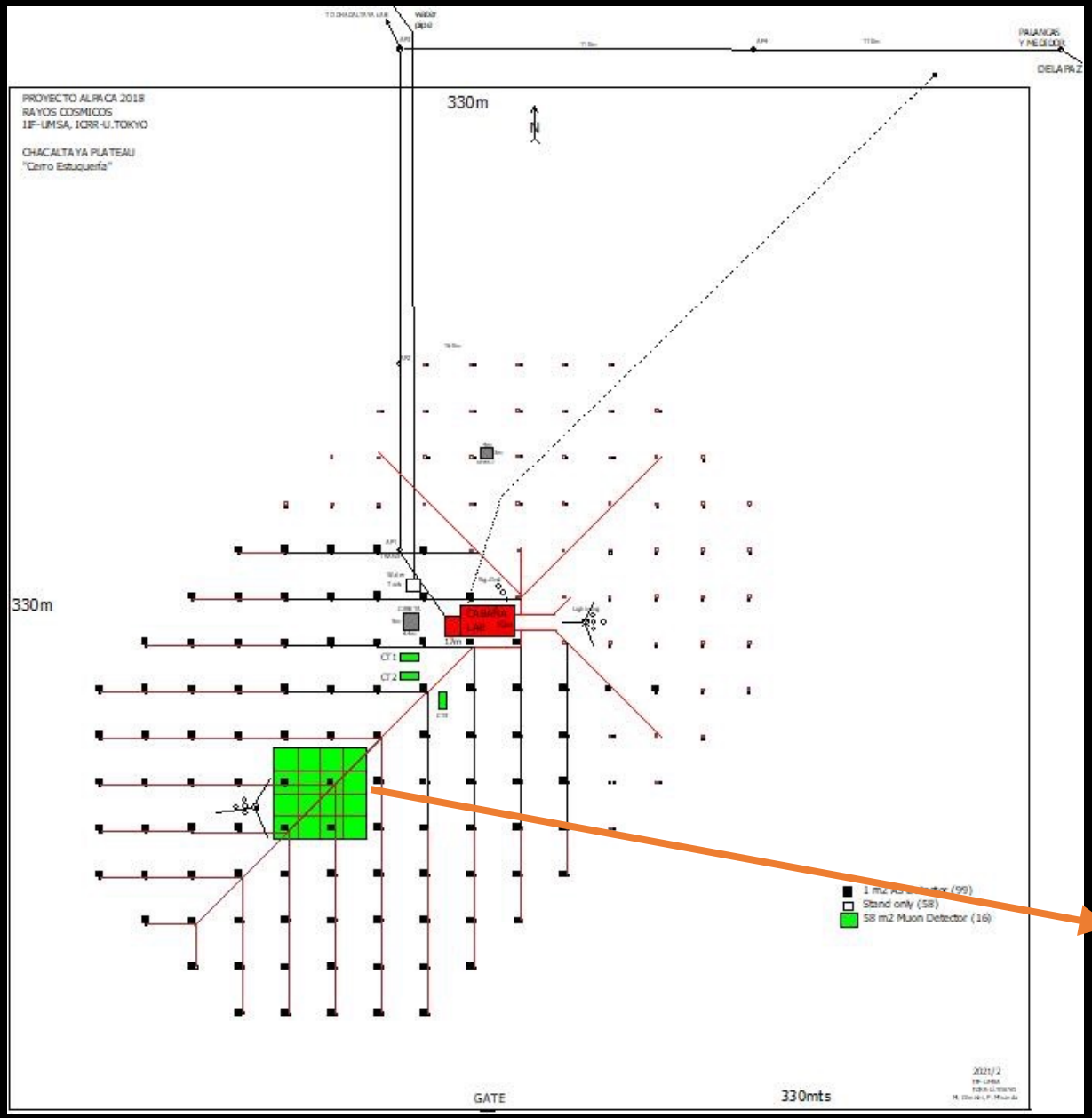
June 2022

- 97 scintillator detectors installed
- 15 m spacing array
- In September 2022 DAQ started taking data
- Covering area ~18,450 m^2

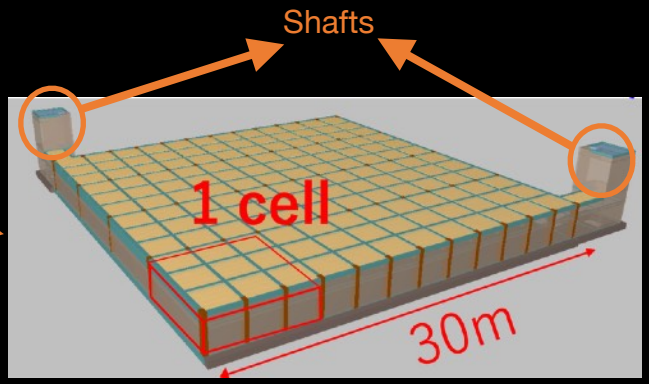
ALPACA Perimeter main wall (1320 m)

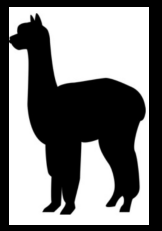


ALPAQUITA : Underground muon detector

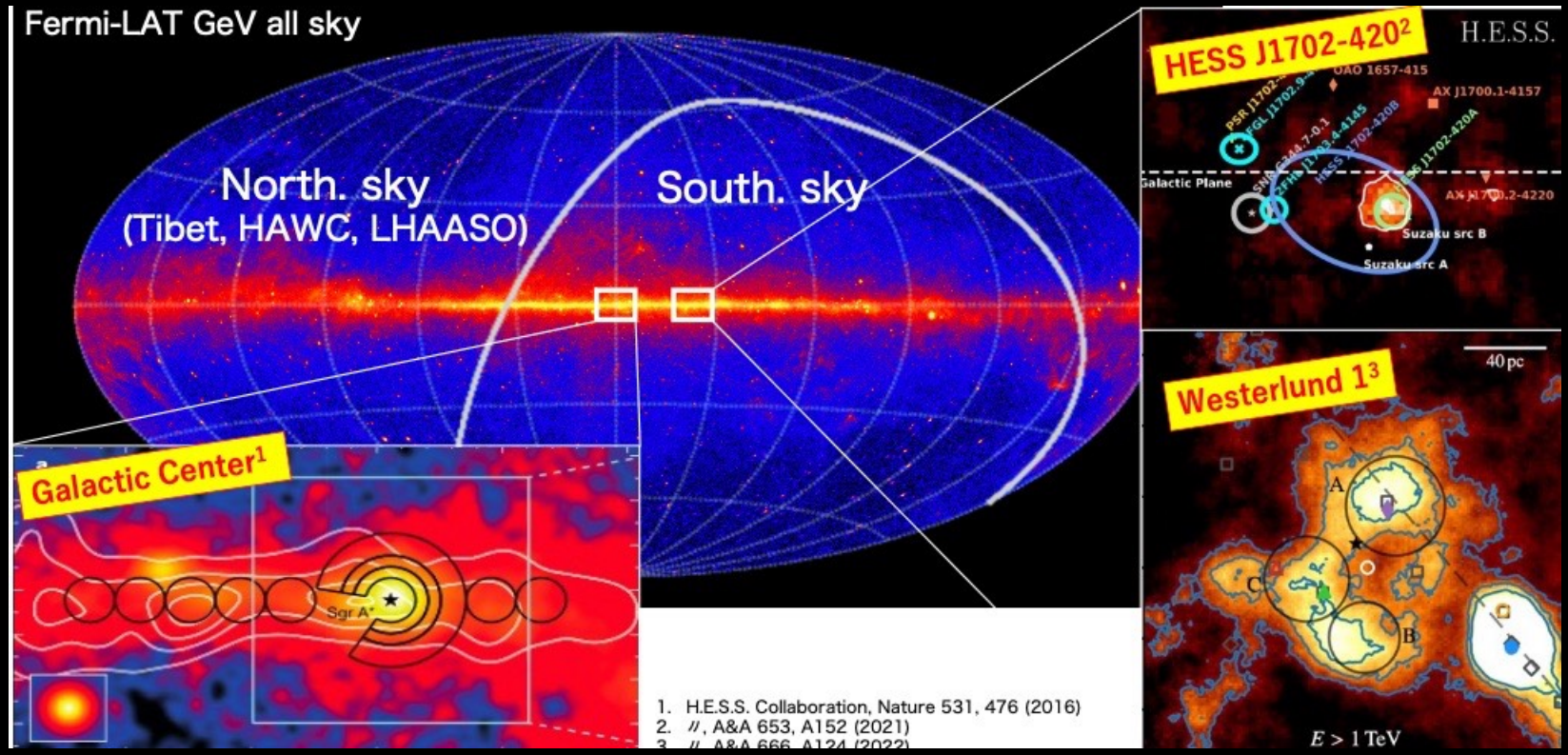


- In the coming months, the extension of the array and the construction of the first underground muon detector will begin (green square).
- Consist of an infrastructure based on concrete material known as the cell unit.
- Each cell unit will have an area of ~56 m^2
- 16 units covering an area of 900 m^2 Vol. (~1350 m^3)





ALPACA's physics pursuit



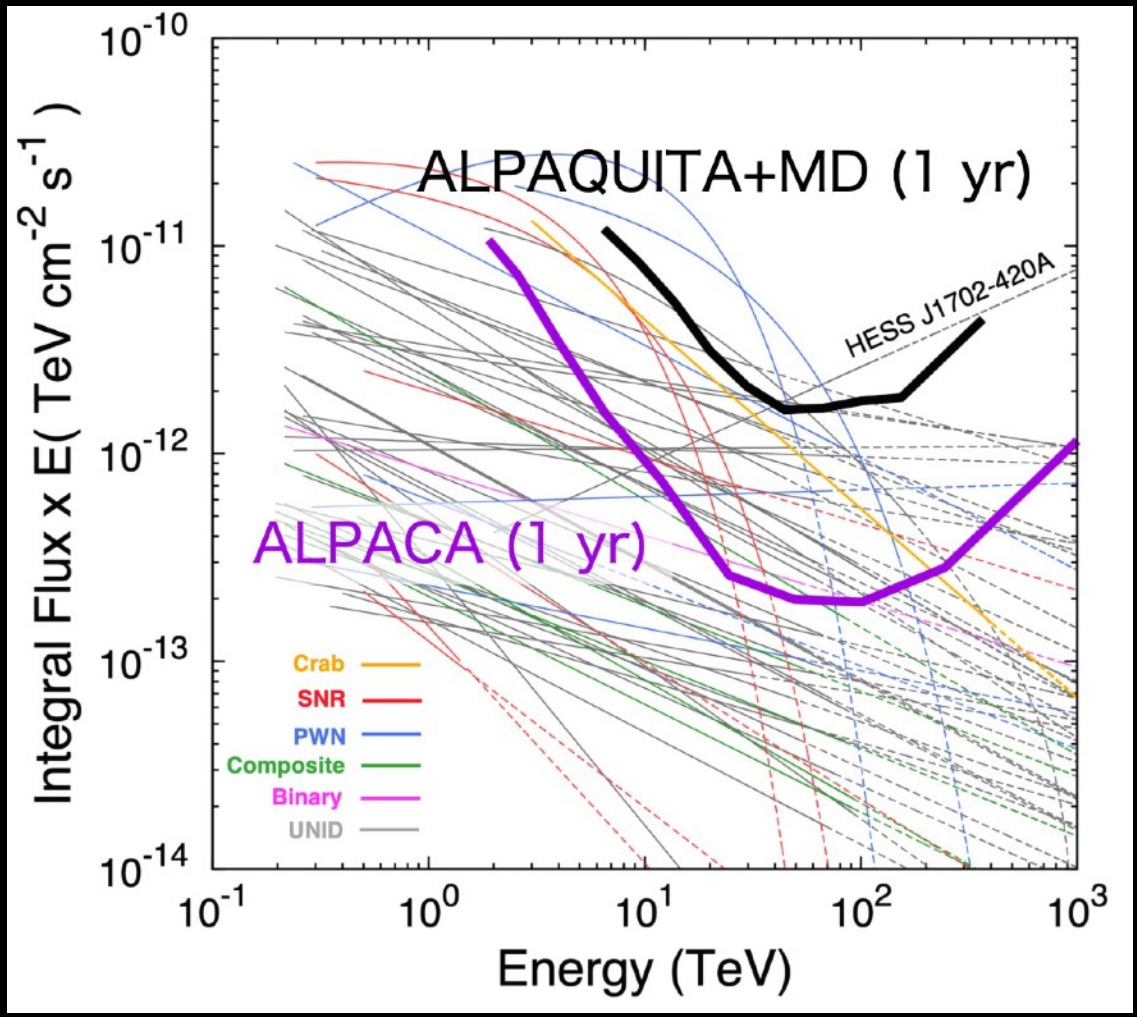
ALPACA	ALPAQUITA
Survey south-sky for Sub-PeV gamma-rays to search galactic PeVatrons	
AS array : 83000 m^2 4 MD : 3600 m^2	AS array : 18450 m^2 1 MD : 900 m^2
Energy resolution : 20 % @100 TeV Angular resolution : 0.2° @100 TeV	

1. ALPAQUITA gamma-ray sources will be equivalent to that of five gamma-ray sources observed by H.E.S.S. and HAWC in the TeV energy range [1].
2. ALPAQUITA will be excellent, achieving a 100% trigger efficiency above the 20 TeV energy range.
3. ALPAQUITA's gamma ray point source observations are predicted to detect sources above a 5 sigma significance level beyond the 10 TeV energy range within one year of observation.

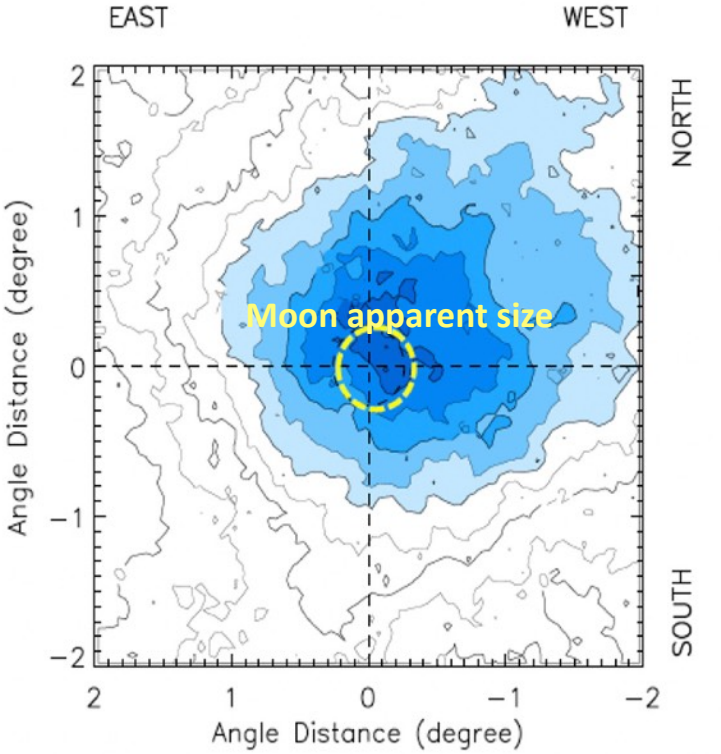
[1] S.Kato et al.,Detectability of southern gamma-ray sources beyond 100TeV with ALPAQUITA, the prototype experiment of ALPACA, Experimental Astronomy 52(2) (2021).

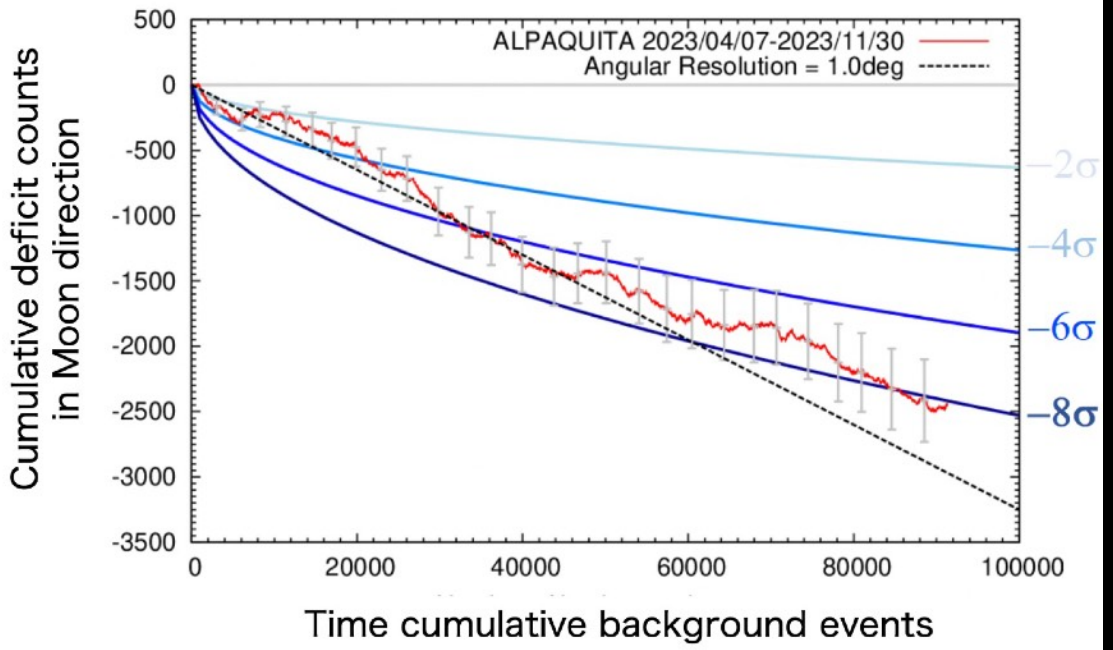
Important gamma ray observables

Candidate names	Distance from earth [pc]	Type	Period [ms]
Vela	293	Pulsar	89
Vela X	275,9	PWN	
Geminga	250	Pulsar	237
PSR J0953+0755	80	Pulsar	253
PSR J1932+1059	111	Pulsar	226,5
HESS J1825-137	4000	PWN	
HESS J1702-420A	?	?	

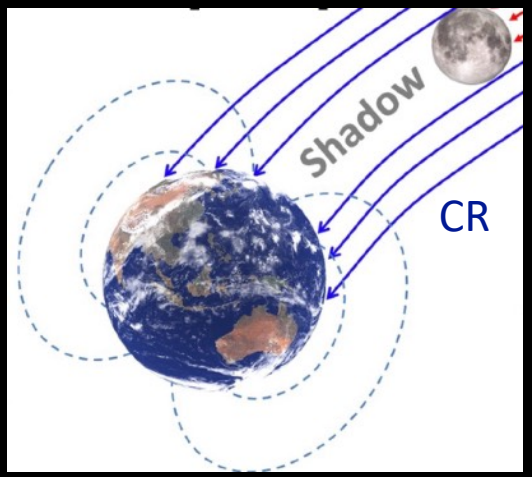


Moon shadow observed by ALPAQUITA



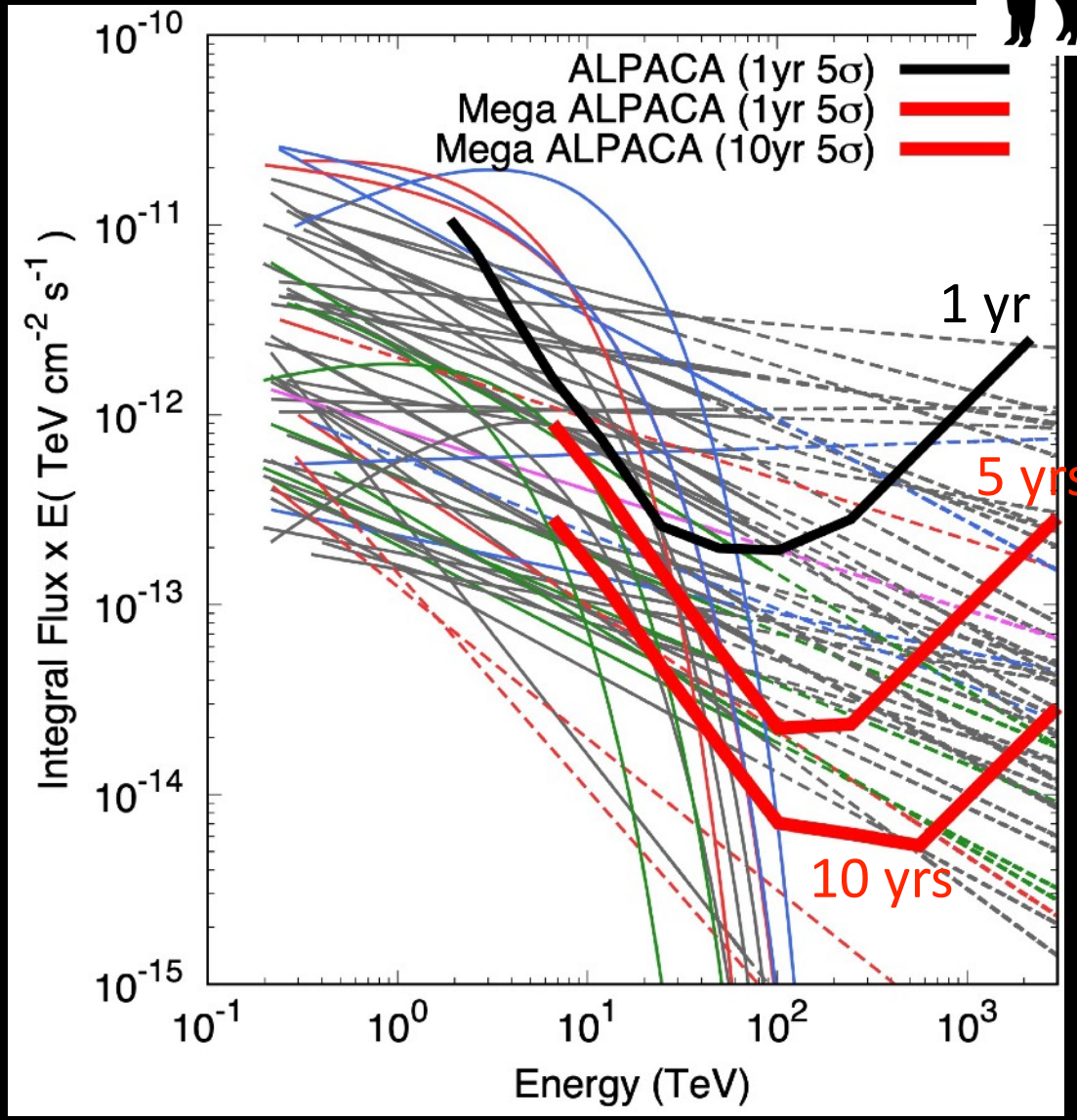


ALPAQUITA DATA ANALYSIS
Observation of the Cosmic rays (CR) Moon's shadow
0.2 degree westward shift of the CR Moon's shadow @ ~10 TeV
Angular resolution : $\sim 1^{\circ}$



Summary and outlooks

1. Full ALPAQUITA (+muon detector) will start collecting data late 2025.
2. The full-scale ALPACA experiment is expected to be operational by 2026-2027 (401 scintillator detectors + 4 muon detectors).
3. Since late 2022, the study to implement a surface Water Cherenkov Detectors array (WCDs) has begun.
4. By the end of this decade (2028-2030), there is a very promising idea to extend the ALPACA array up to 1,000,000 square meters (1500 scintillator detectors + 50 muon detectors (54000 m2) [2].



[2] Takashi Sako et al., ALPACA experiment: A new air shower array to explore the sub-PeV gamma-ray sky in the southern hemisphere. PoS(ICHEP2022) 414 (2022).

Thank you