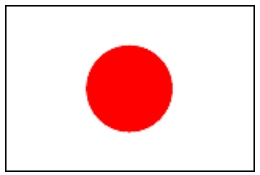
ICRC2021; ID777

Current status of ALPACA for exploring sub-PeV gamma-ray sky in Bolivia

Takashi Sako (ICRR, University of Tokyo)
for the ALPACA Collaboration

The ALPACA Collaboration



F. Aceves de la Cruz[1], S. Asano[2], C. A. H. Condori[3], E. de la Fuente[1,4], J. L. Garcia-Luna[1], A. Gomi[5], K. Hibino[6], N. Hotta[7], A. Jimenez-Meza[8], Y. Katayose[9], C. Kato[2], S. Kato[10], T. Kawashima[10], K. Kawata[10], T. Koi[11], H. Kojima[12], D. Kurashige[5], J. Lozoya[13], R. Mayta[14,15], P. Miranda[3], K. Munakata[2], K. Nagaya[5], Y. Nakamura[10], Y. Nakazawa[16], C. Nina[3], M. Nishizawa[17], S. Ogio[14,15], M. Ohnishi[10], S. Okukawa[5], F. Orozco[4], A. Oshima[11], M. Raljevich[3], H. Rivera[3], T. Saito[18], Y. Sakakibara[5], T. Sako[10], T. K. Sako[10], S. Shibata[12], A. Shiomi[16], M. Subieta[3], N. Tajima[19], W. Takano[6], M. Takita[10], Y. Tameda[20], K. Tanaka[21], R. Ticona[3], I. Toledano-Juarez[22,23], H. Tsuchiya[24], Y. Tsunesada[14,15], S. Udo[6], K. Yamazaki[11] and Y. Yokoe[10]

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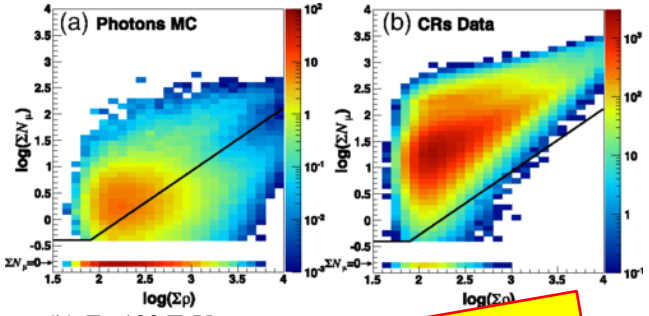
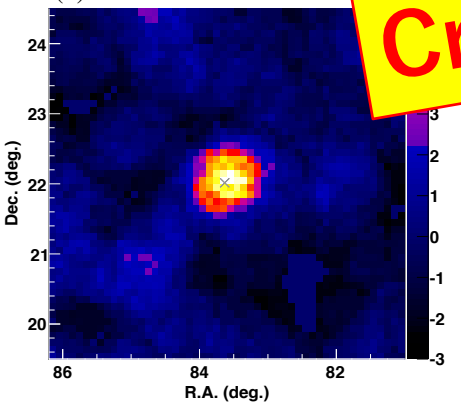
Dawn of sub-PeV gamma-ray astronomy

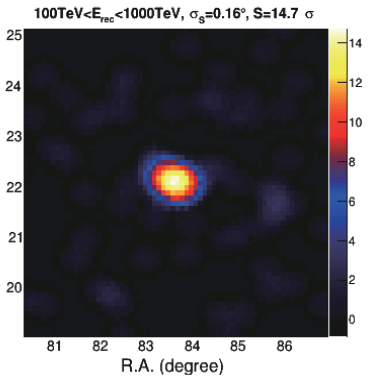


(b) E >100 TeV

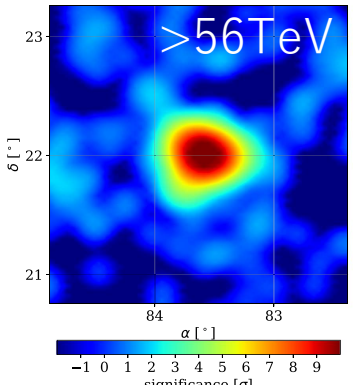
Crab



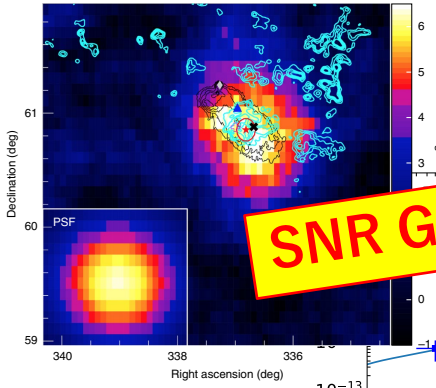
Tibet AS γ Collaboration,
PRL 123, 051101 (2019)



LHAASO Collaboration,
Chin. Phys. C45, 023002 (2021)

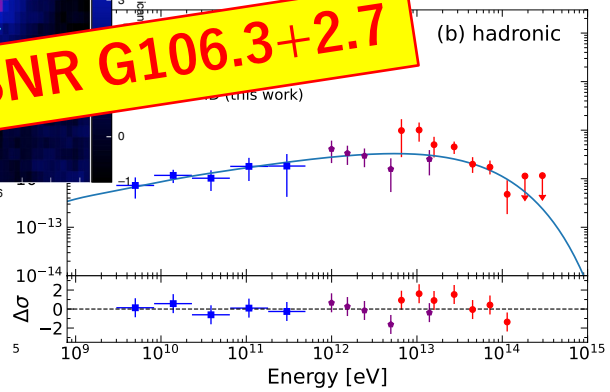


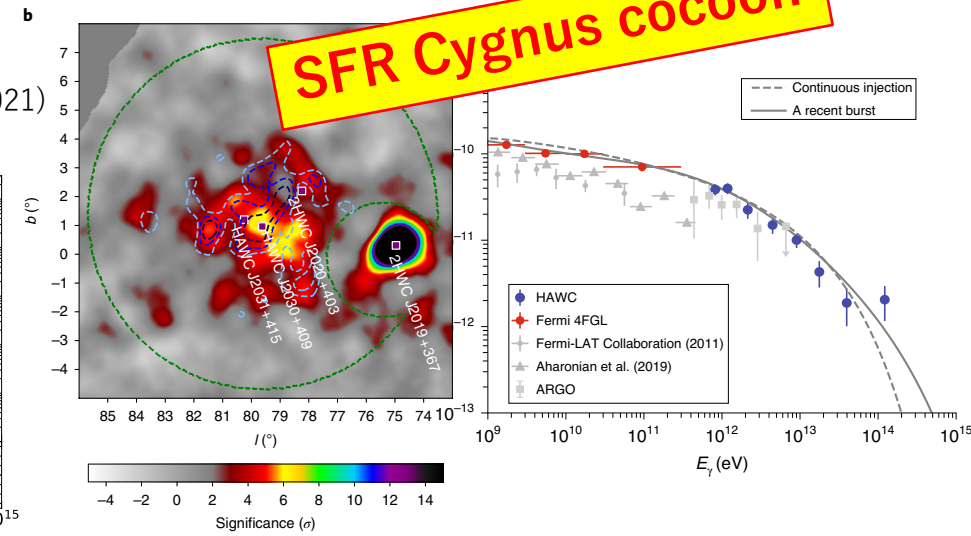
HAWC Collaboration,
ApJ 881:134 (2019)



Tibet AS γ Collaboration,
Nature Astron., 5, 460-464 (2021)

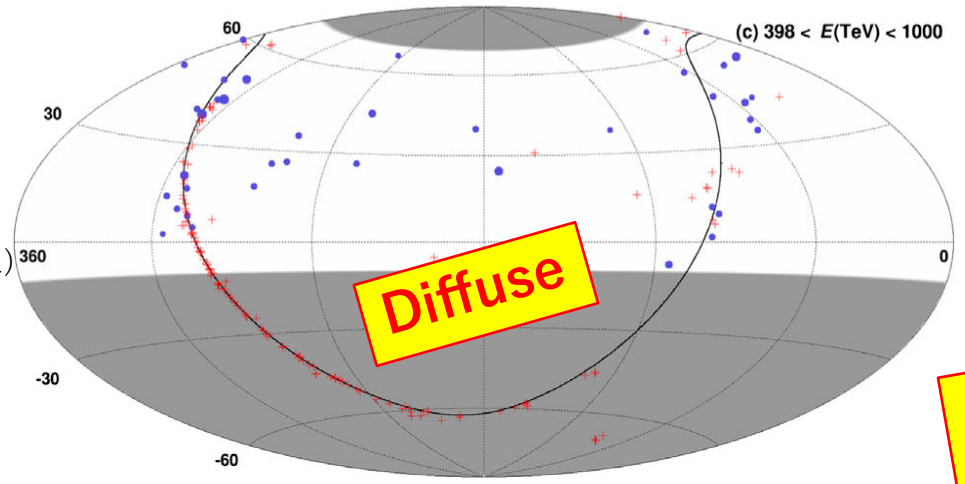
SNR G106.3+2.7





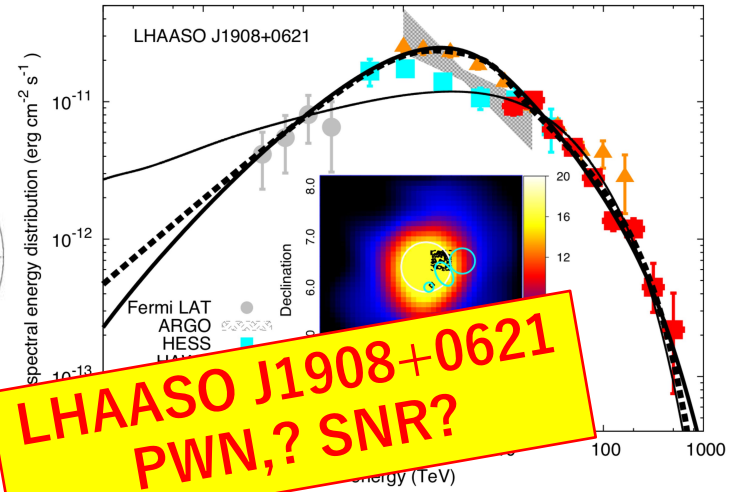
SFR Cygnus cocoon

HAWC Collaboration, Nature Astron., 5, 465-471 (2021)



Diffuse

Tibet AS γ Collaboration, PRL 126, 141101 (2021)

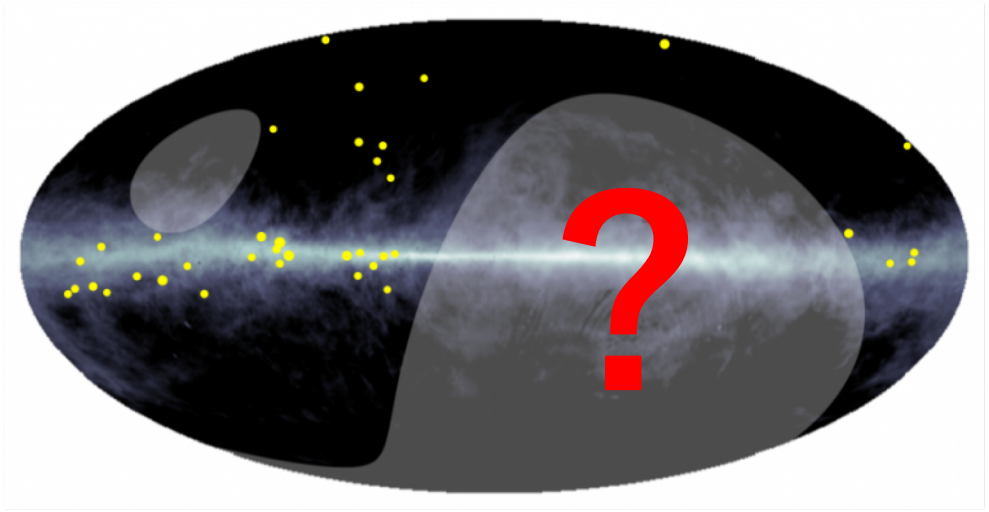


LHAASO J1908+0621
PWN,? SNR?

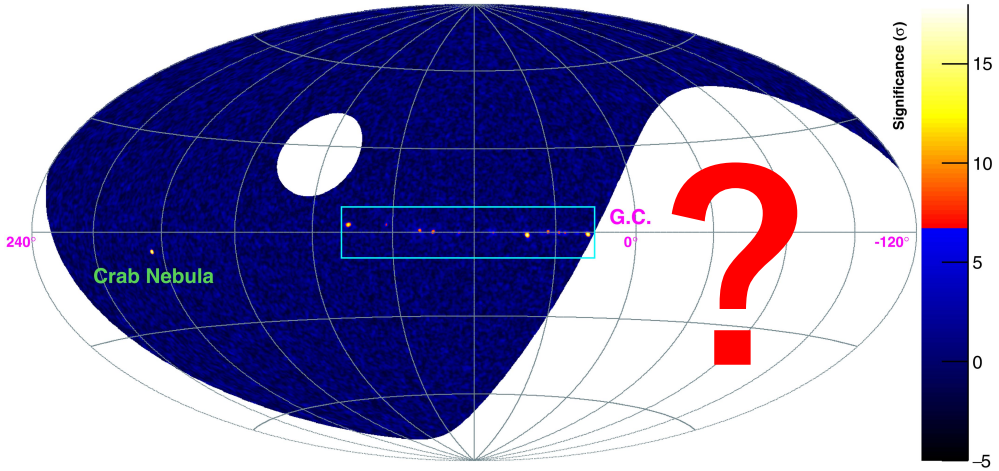
LHAASO Collaboration,
Nature, 594, 33-36 (2021)

Let us go to south!

Tibet ASγ >100TeV diffuse γ

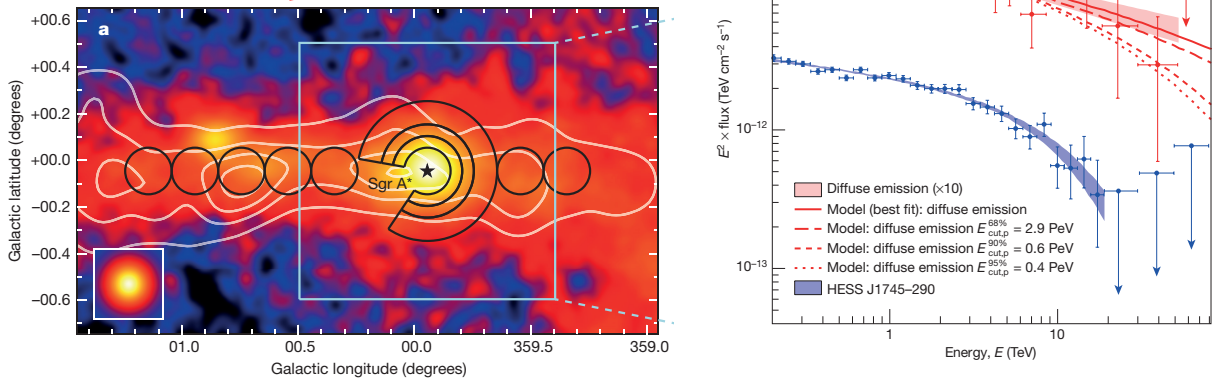


LHAASO Sky @ >100 TeV



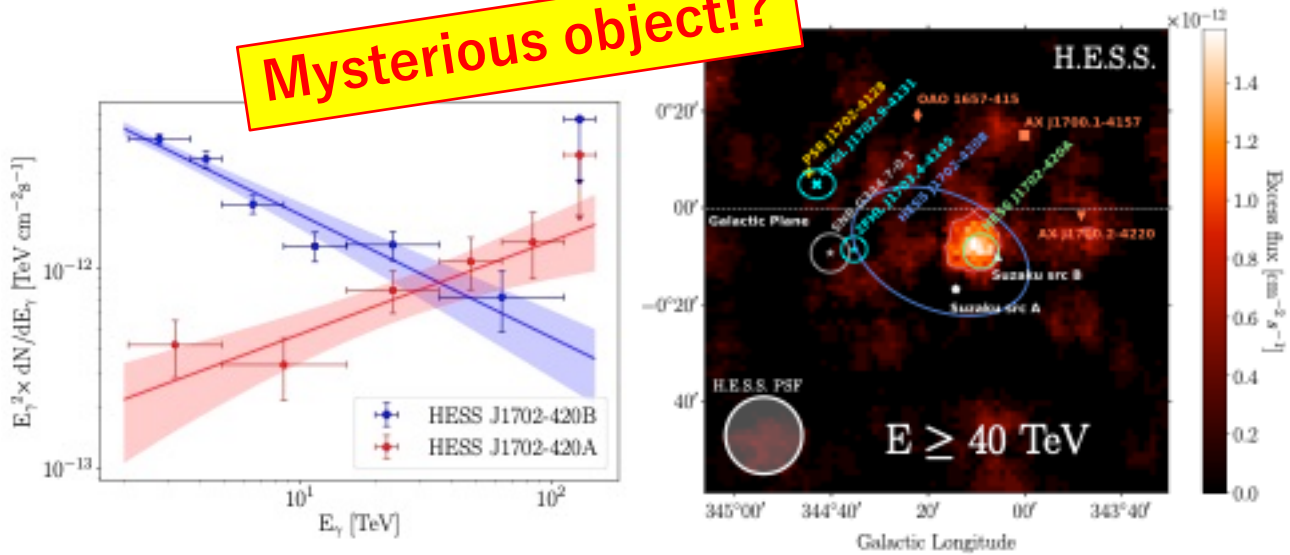
LHAASO Collaboration, Nature, 594, 33-36 (2021)

Galactic center



HESS Collaboration, Nature, 531, 476-479 (2016)

Mysterious object!?



HESS Collaboration, arXiv:2106.06405 (2021)

ALPACA

(Andes Large area PArticle detector for Cosmic ray physics and Astronomy)

Mt. Chacaltaya, Bolivia

UMSA CR Observatory
5200 m a.s.l.

4600m

4400m

ALPACA site
4740 m a.s.l.

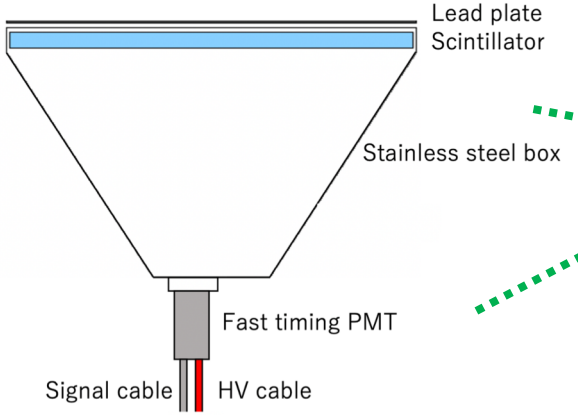
4,740 m above sea level
(16° 23′ S, 68° 08′ W)

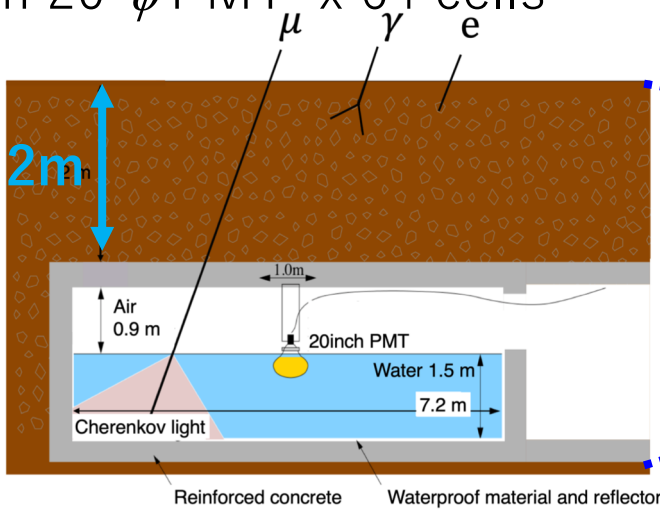
La Paz

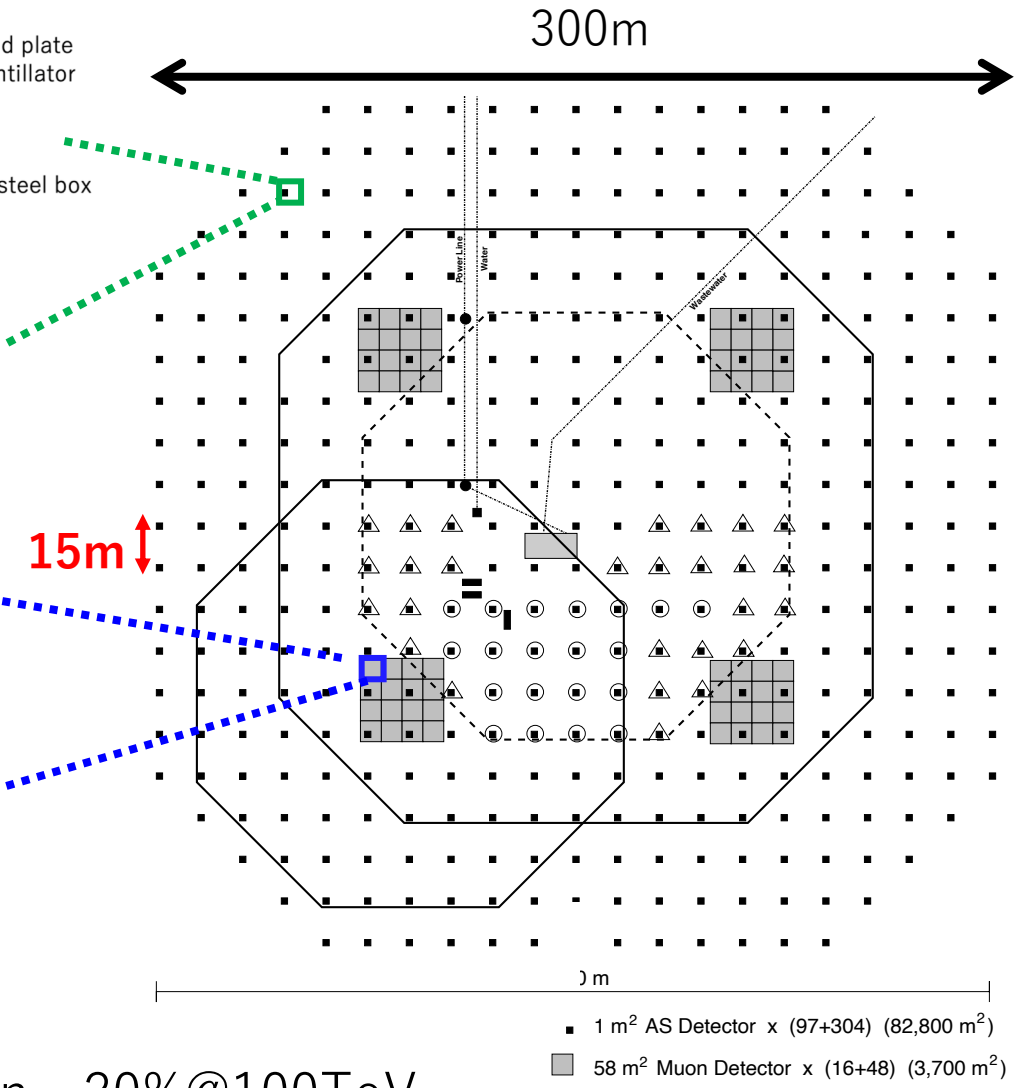
Original ALPACA design

1. **Array coverage 82,800m²**
   = 401 x 1m² plastic scintillators

2. **Underground water Cherenkov muon detector (MD) 3700m²**
   Soil over 2m (~16X_0)
   = 58m² with 20"ϕ PMT x 64 cells

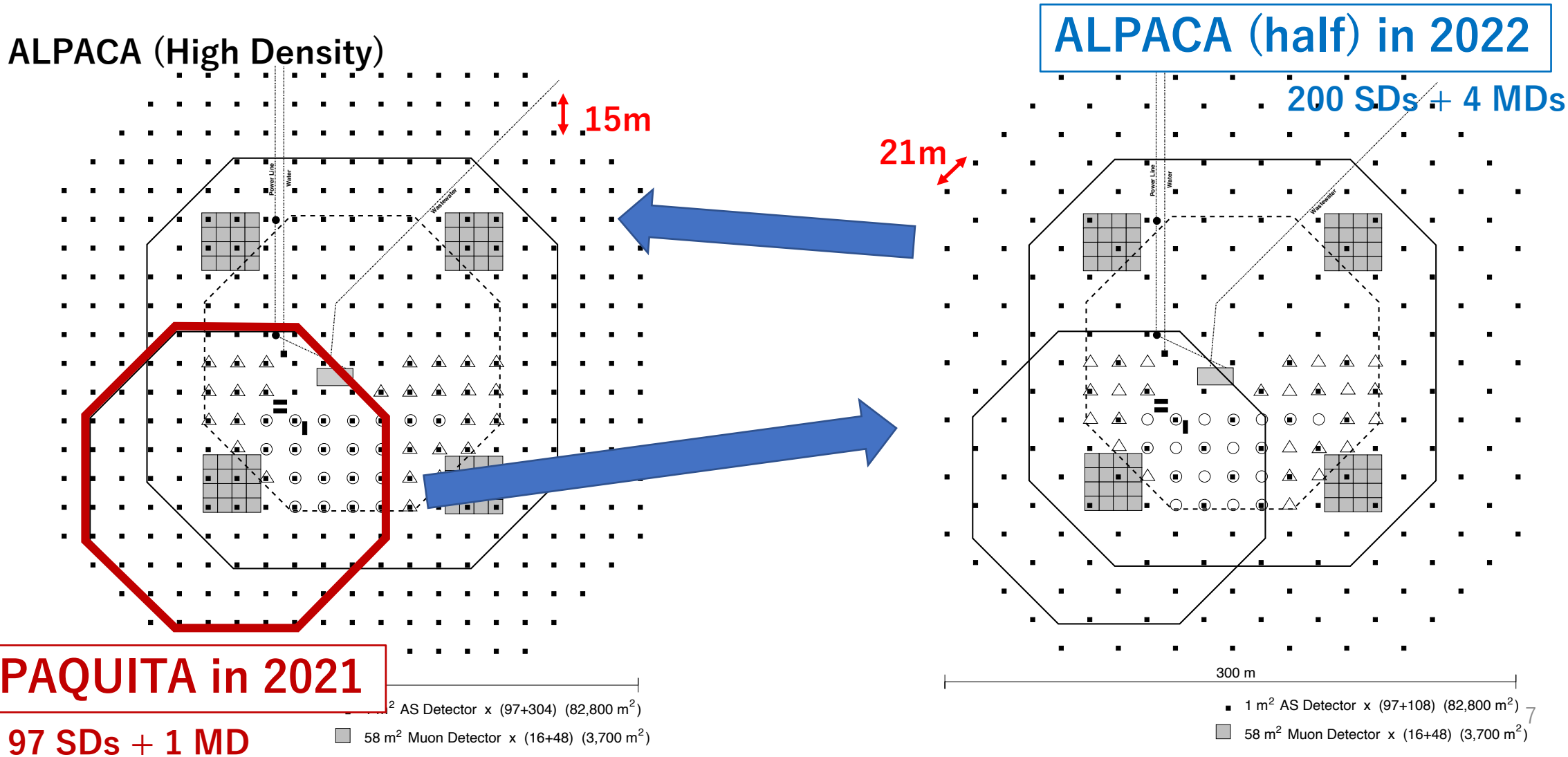






- ✓ Cosmic-ray BG rejection power >99.9% @100TeV.
- ✓ Angular resolution ~0.2° @100TeV, Energy resolution ~20%@100TeV
- ✓ 100% duty cycle, FOV θ_{zen}<40° (well studied), θ_{zen}<60° (in study)

ALPACA staging



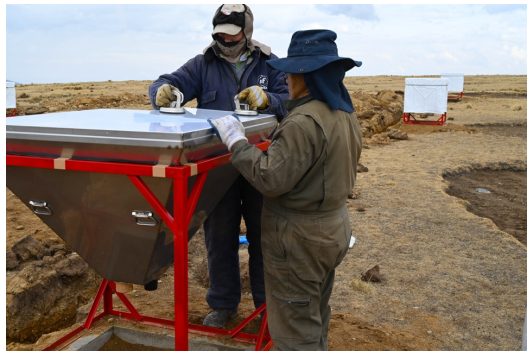
ALPAQUITA
(little ALPACA)

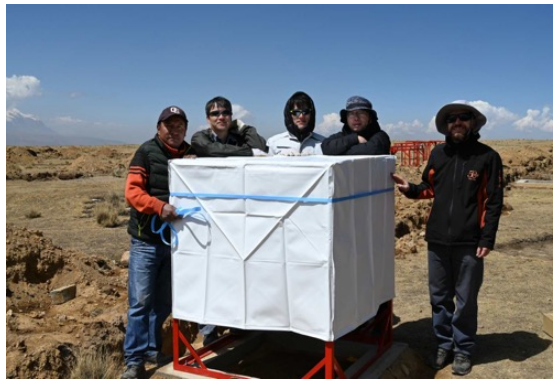
- Prototype array of 25% ALPACA area coverage
  - 97 surface detectors
  - 1 MD

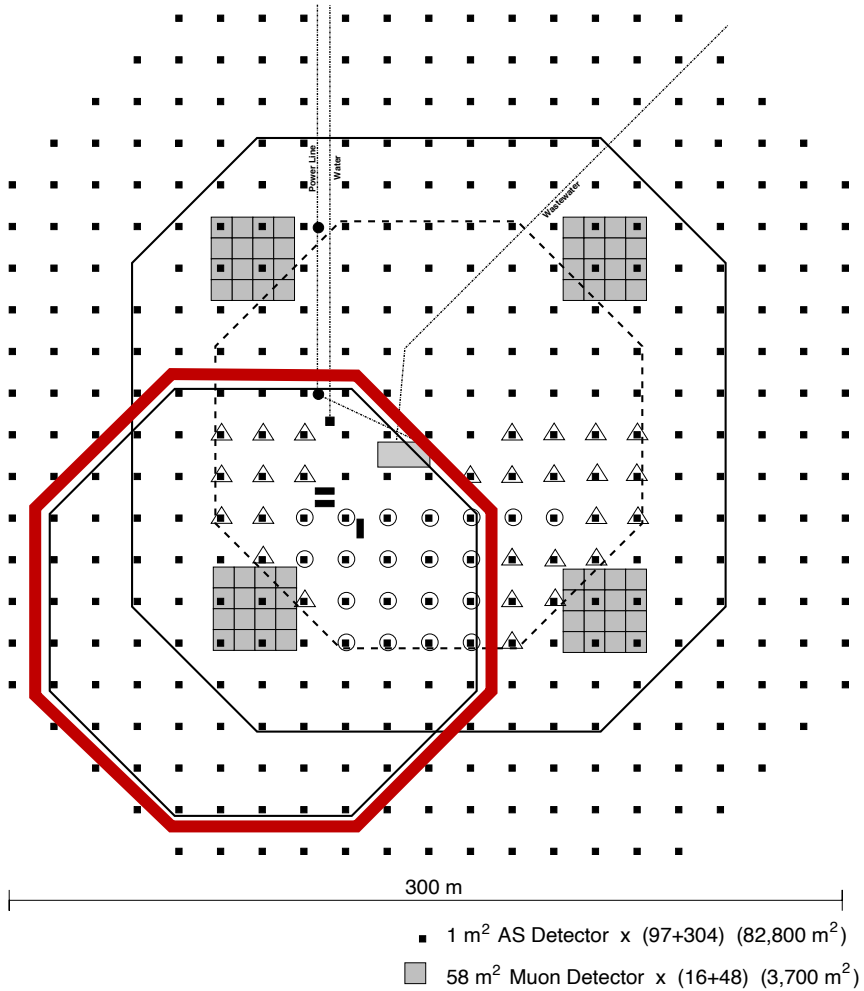
- Targets
  - **Start operation in 2021**
  - Infrastructure establishment
  - A few bright >100TeV sources
  - CR anisotropy

S. Kato ID:857

T.K. Sako ID:722 (north observation)

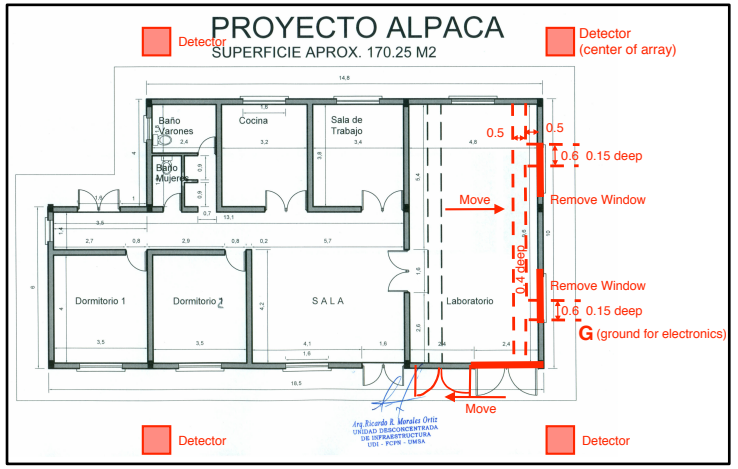


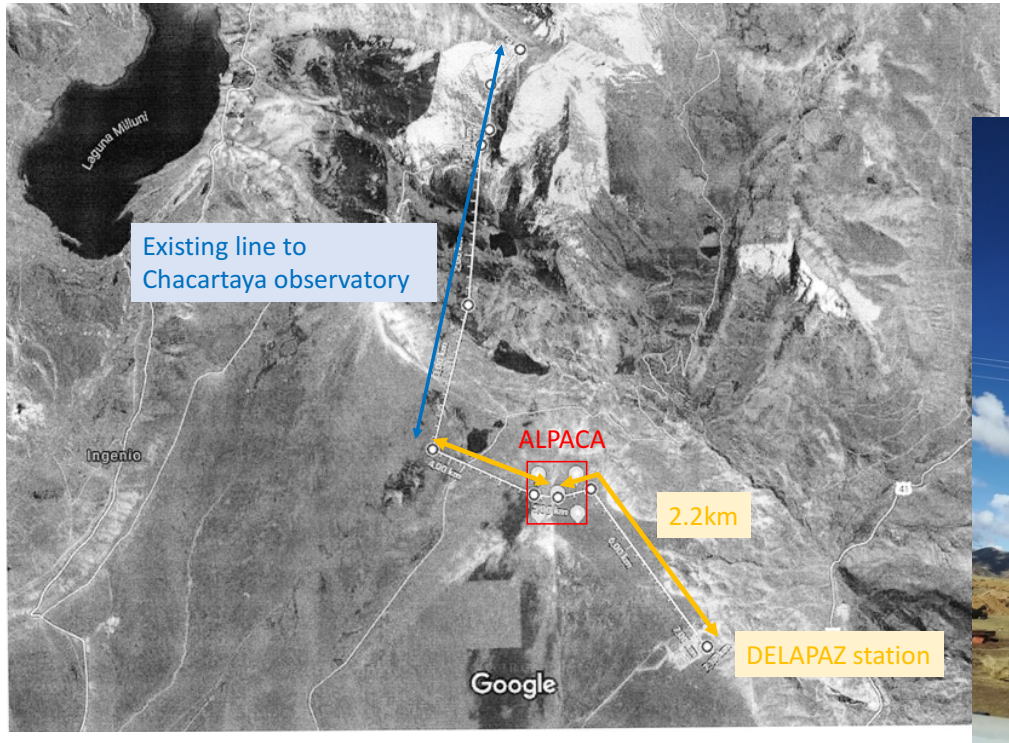




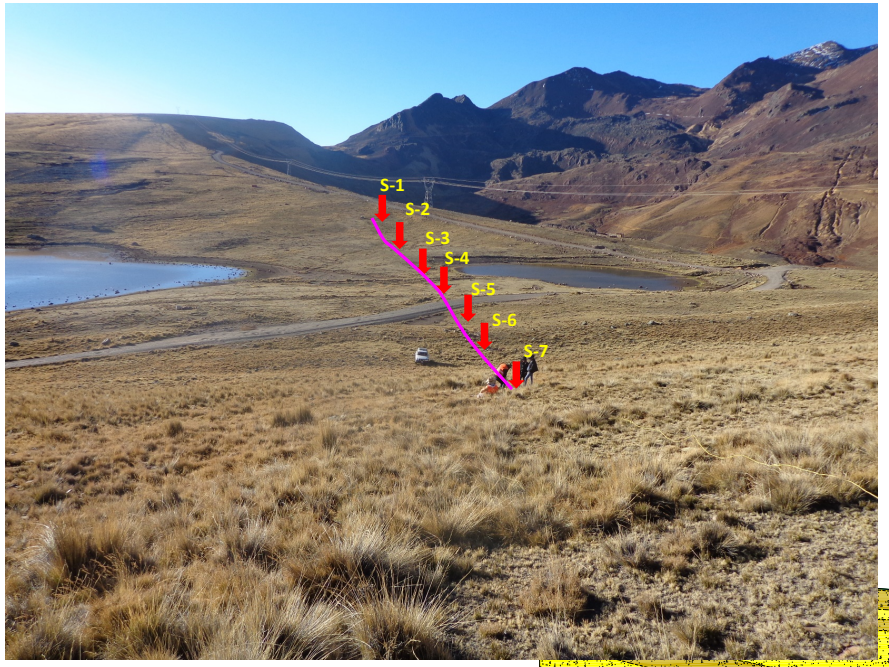
ALPAQUITA & infrastructure

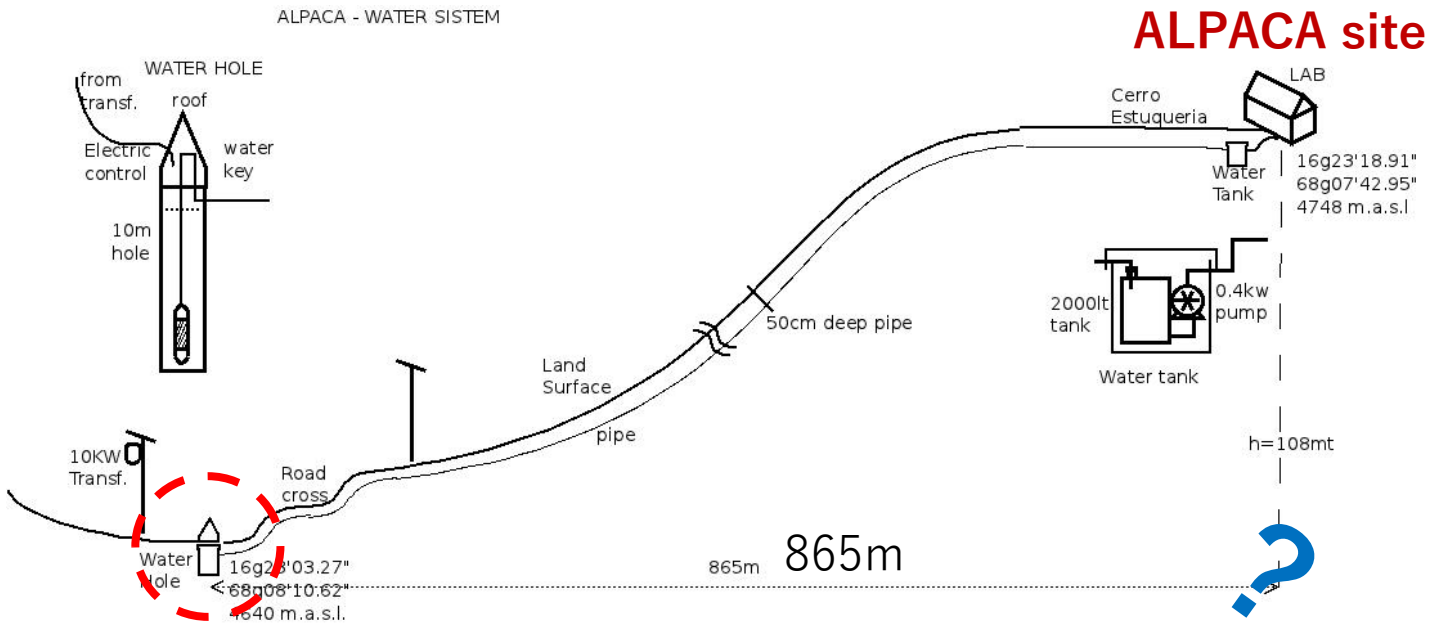
- Central electronics hut
- Perimeters
- Powerline (branch from the substation-Chacaltaya observatory line)
- Cable drains
- Lightning rods
- Long distance Wifi
- Water system




Laguna Milluni
Existing line to
Chacartaya observatory
Ingenio
ALPACA
2.2km
DELAPAZ station
Google

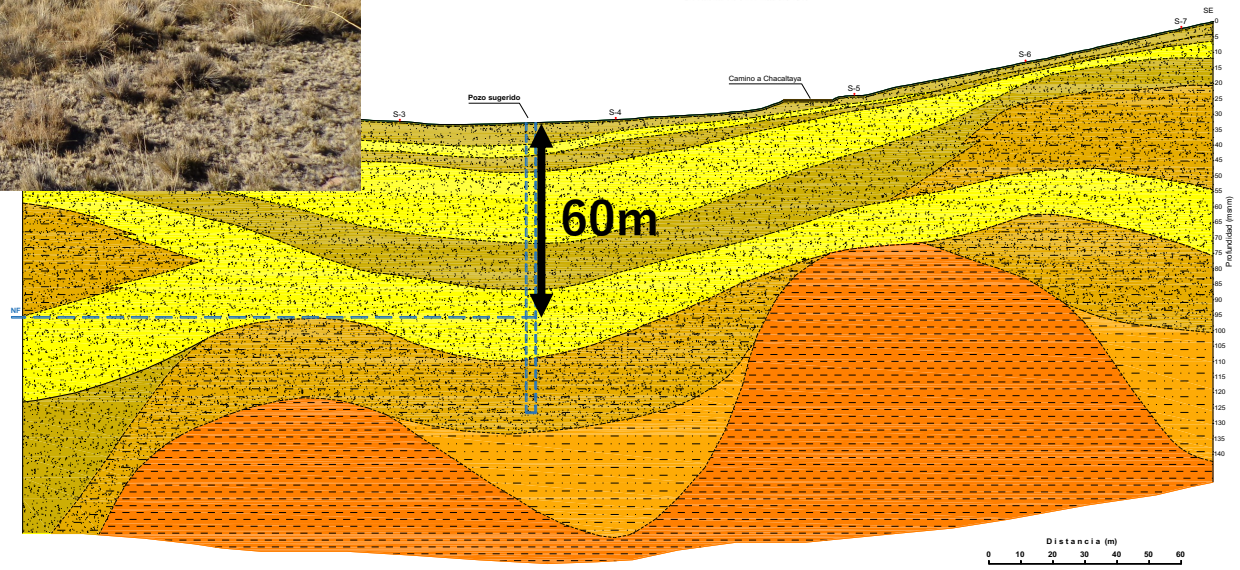
Survey for underground water



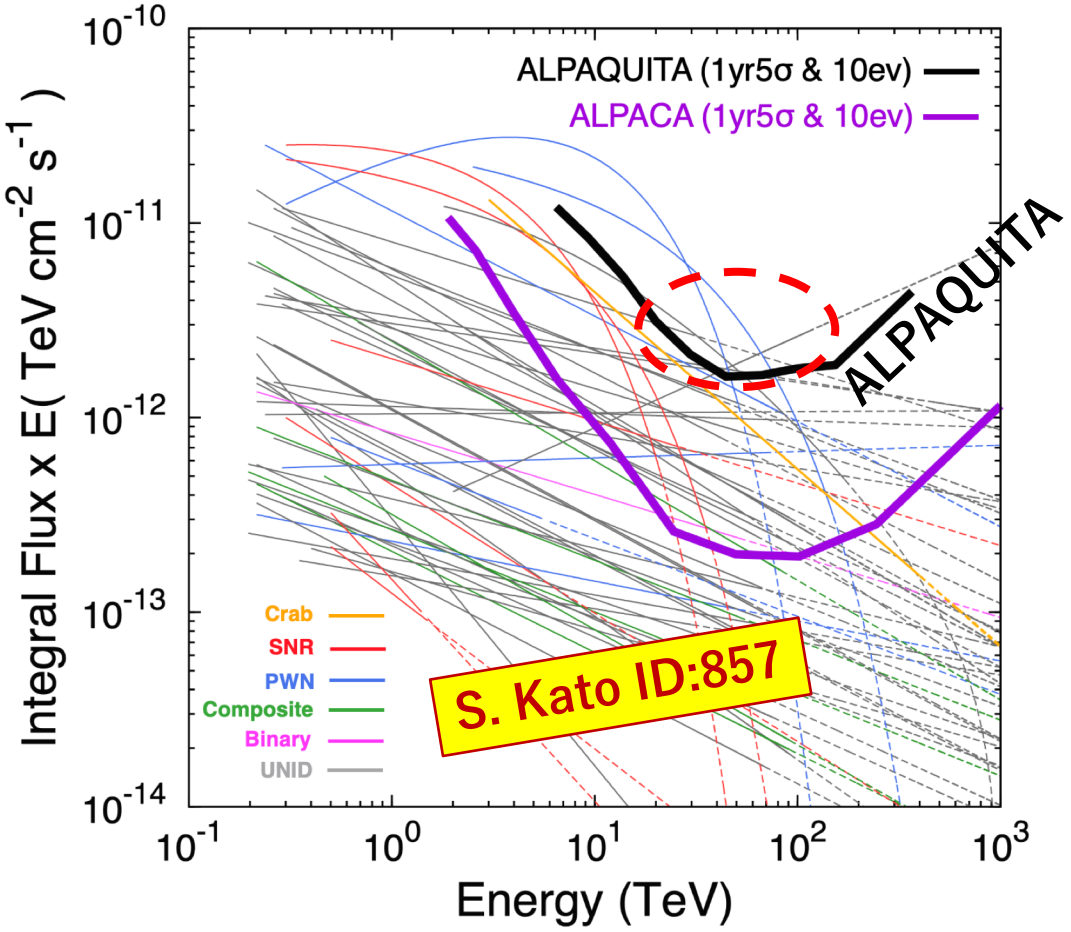


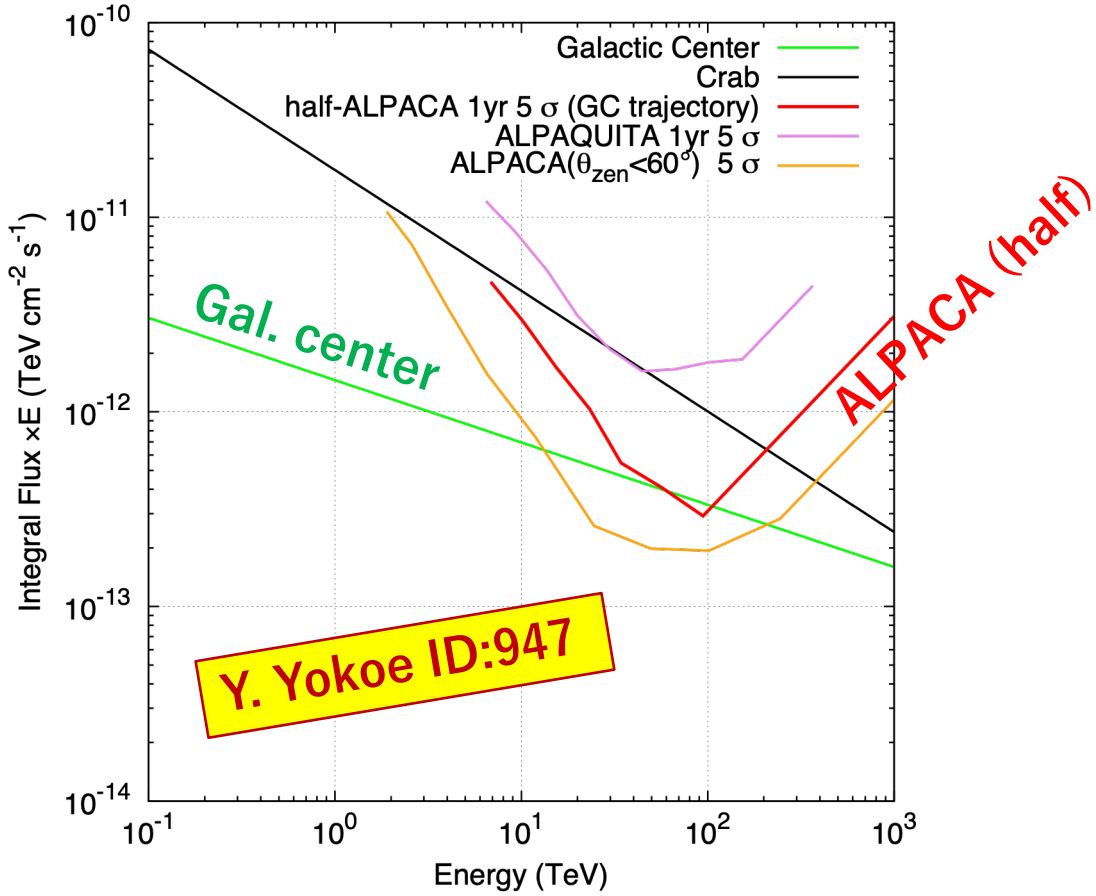
ALPACA site

under survey



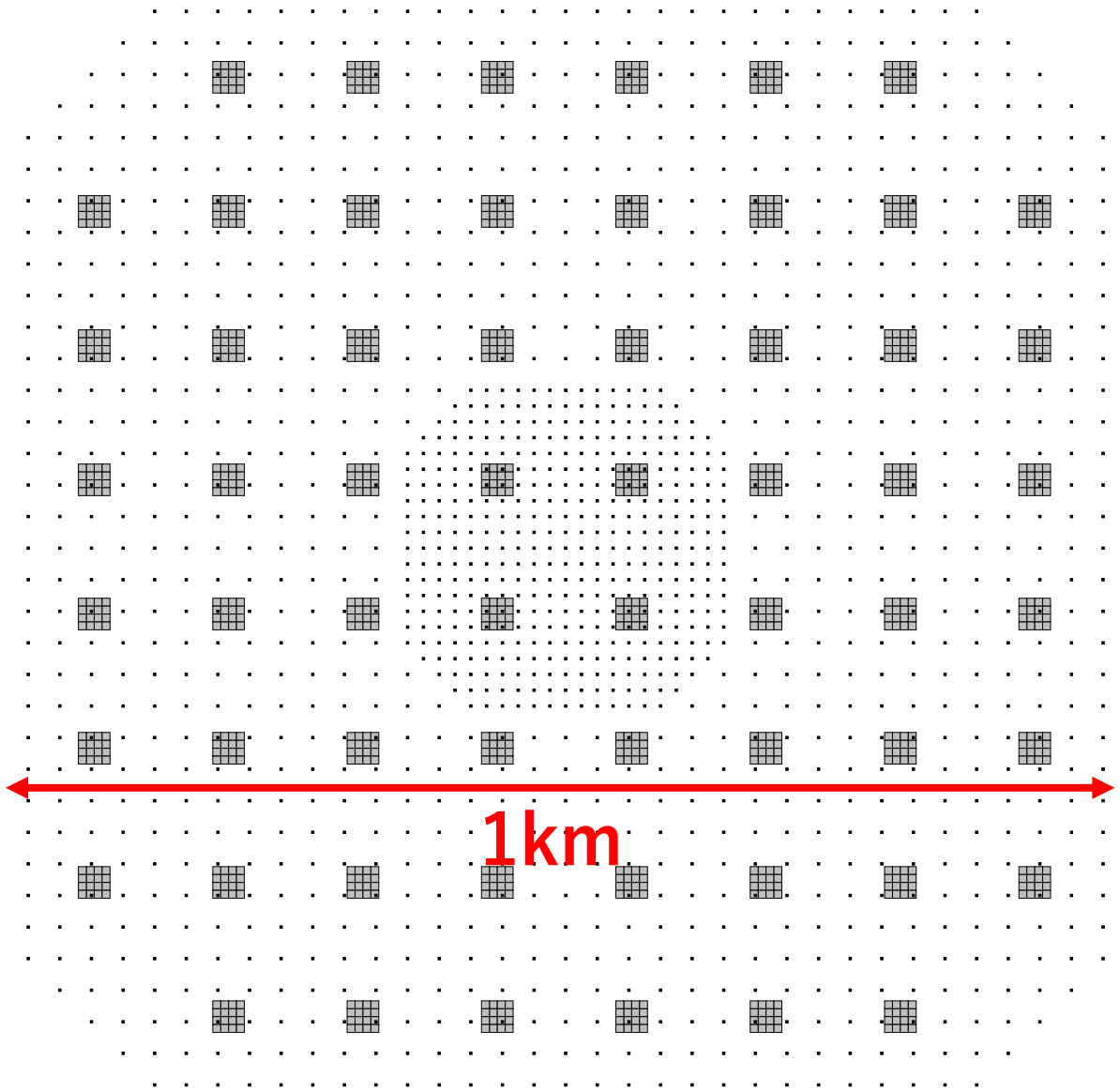
Sensitivities of ALPAQUITA, ALPACA (half) and ALPACA (HD)

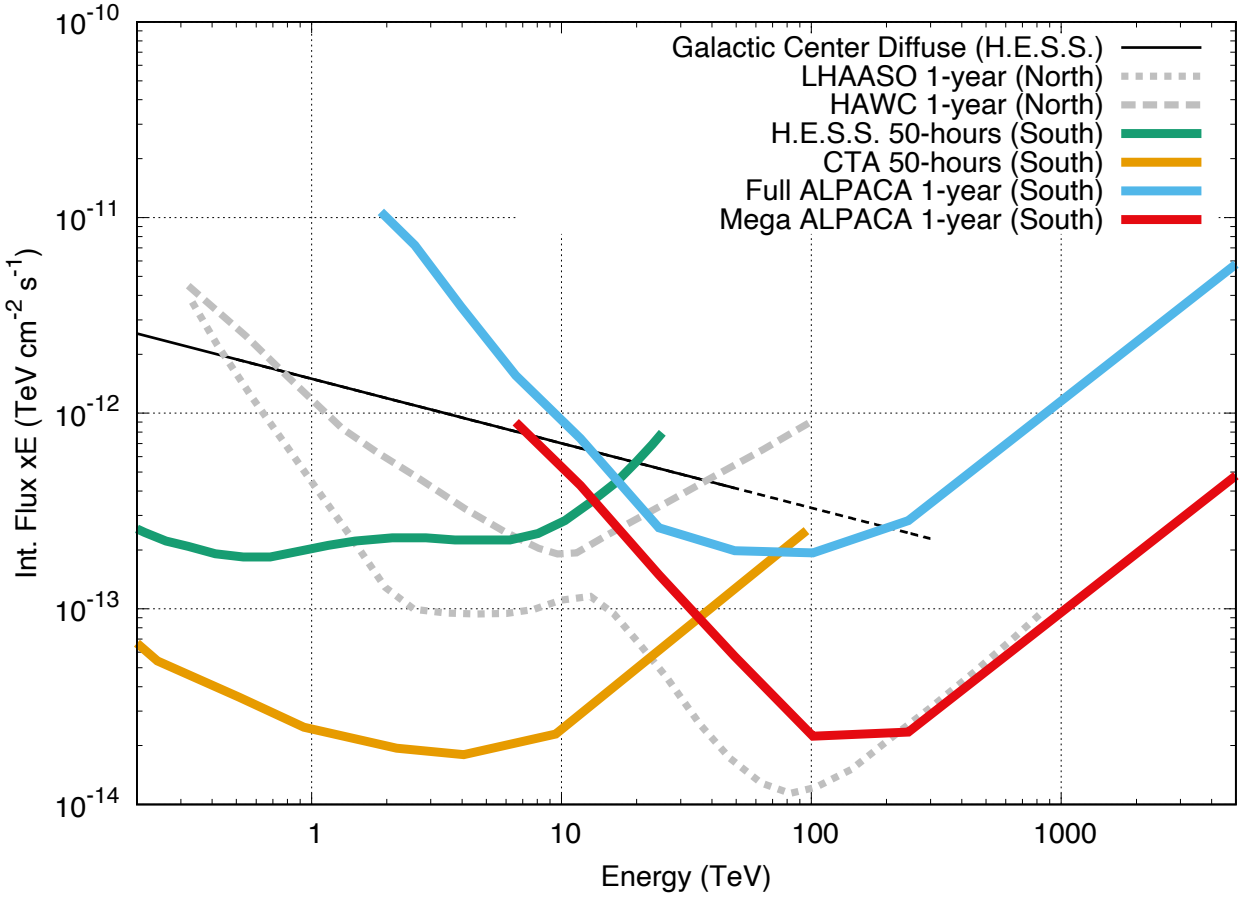




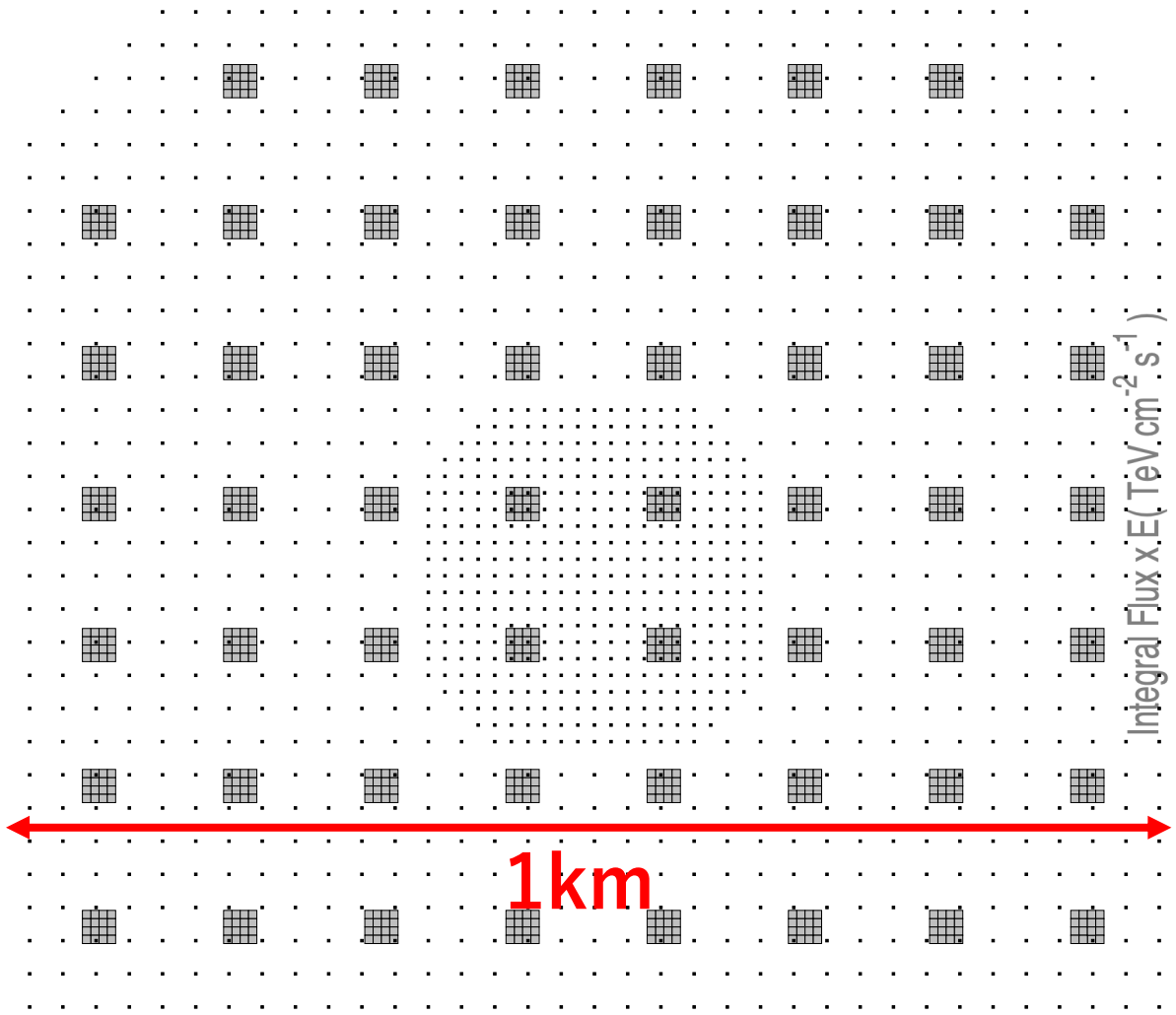
- ALPAQUITA can detect some sources in 1 year
- ALPACA (half) can touch the Galactic center flux in 1 year

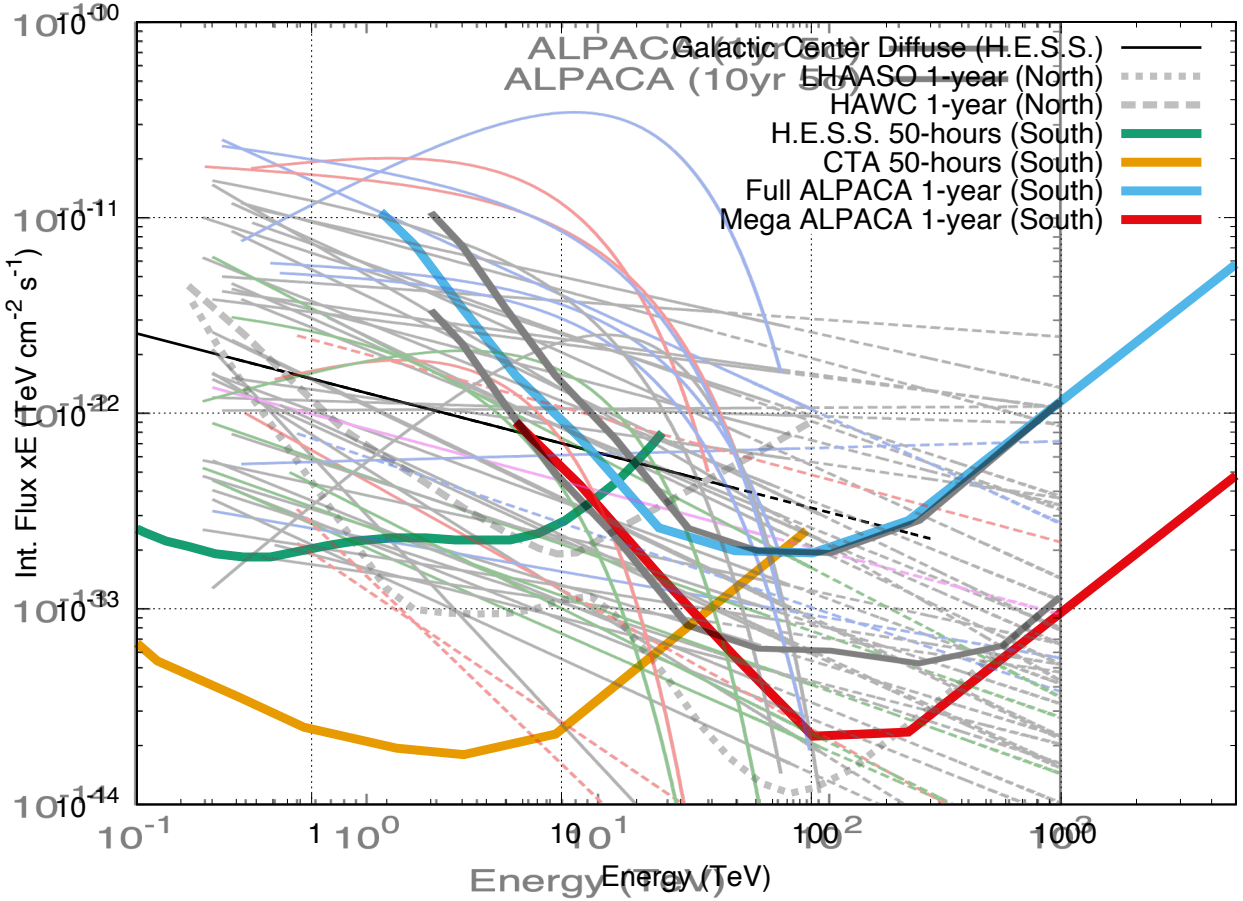
Beyond PeV – Mega (m^2) ALPACA





Beyond PeV – Mega (m^2) ALPACA





Where is the highest energy accelerator in our Galaxy?

Summary

- ✓ **Sub-PeV gamma-ray astronomy is crucial to identify the PeV particle accelerators, PeVatrons**
  - Recent successes by Tibet ASγ, HAWC and LHAASO open a sub-PeV window in the northern sky
  - New experiment in the southern hemisphere is desired
  - Rich targets in south thanks to HESS up to 10TeV
- ✓ **ALPACA explores southern sky in Bolivia first time with the technic established by Tibet ASγ**
- ✓ **ALPAQUITA will start operation in 2021**
- ✓ **ALPACA (half) will start operation in 2022, and eventually upgraded to ALPACA (HD)**
- ✓ **Mega ALPACA is discussed as a future plan to explore PeV energy range**

S. Kato ID:857

Y. Yokoe ID:947

Current status of ALPACA for exploring sub-PeV gamma-ray sky in Bolivia

T. Sako (ICRR, University of Tokyo) for the ALPACA Collaboration

One page executive summary

- What is this contribution about?

  Status of a new air shower array project in Bolivia, ALPACA, is presented.

- Why is it relevant / interesting?

  Sub-PeV gamma-ray astronomy is important to know the origin of the galactic cosmic rays. Recent success in the Northern hemisphere naturally calls our interest to the observations in the Southern hemisphere.

- What have we done?

  To realize ALPACA, some construction stages are defined and their sensitivities are studied. Infrastructure is ready and the prototype array ALPAQUITA is under construction.

- What is the result?

  ALPAQUITA will start operation in 2021 followed by an extension to ALPACA (half) in 2022. Eventual extension to ALPACA (HD) and future Mega ALPACA plan are also being studied.