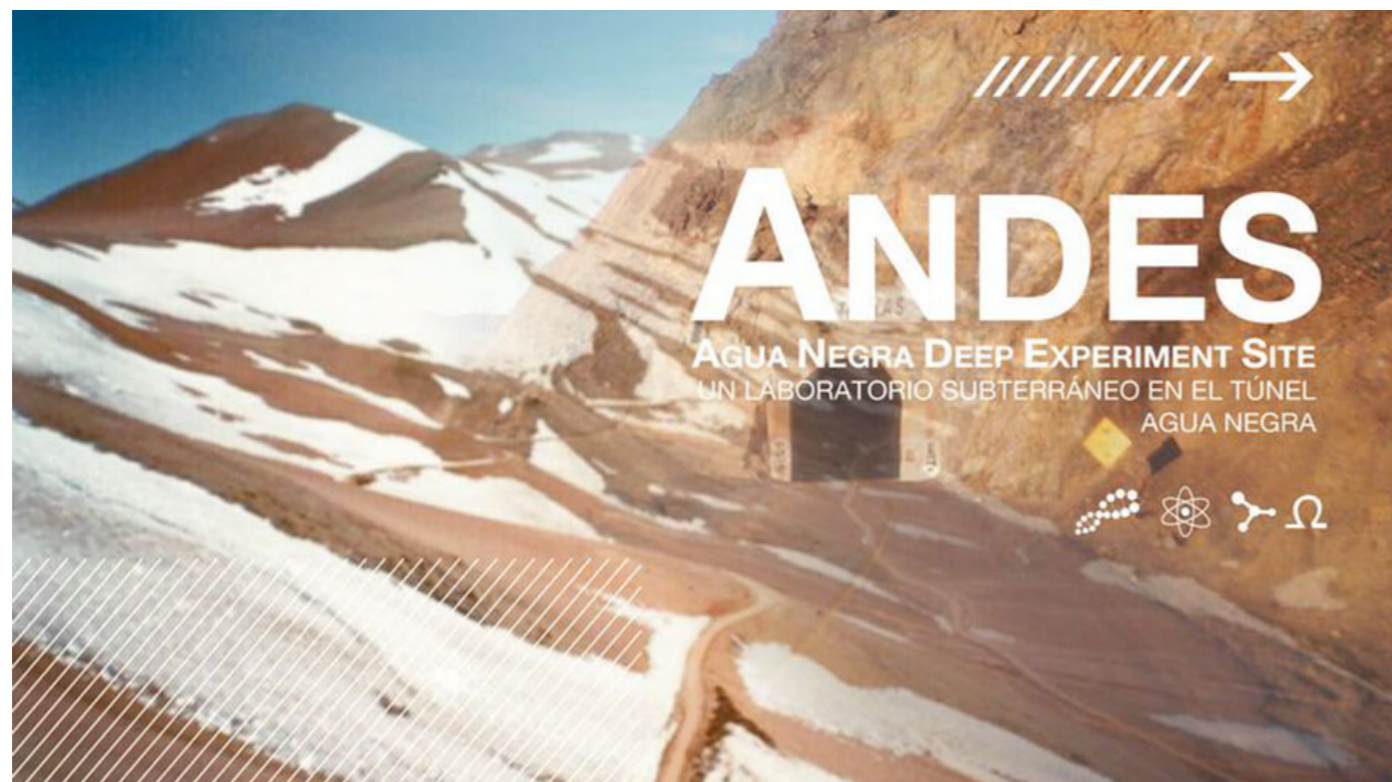


ANDES - the future South American Deep Underground Laboratory



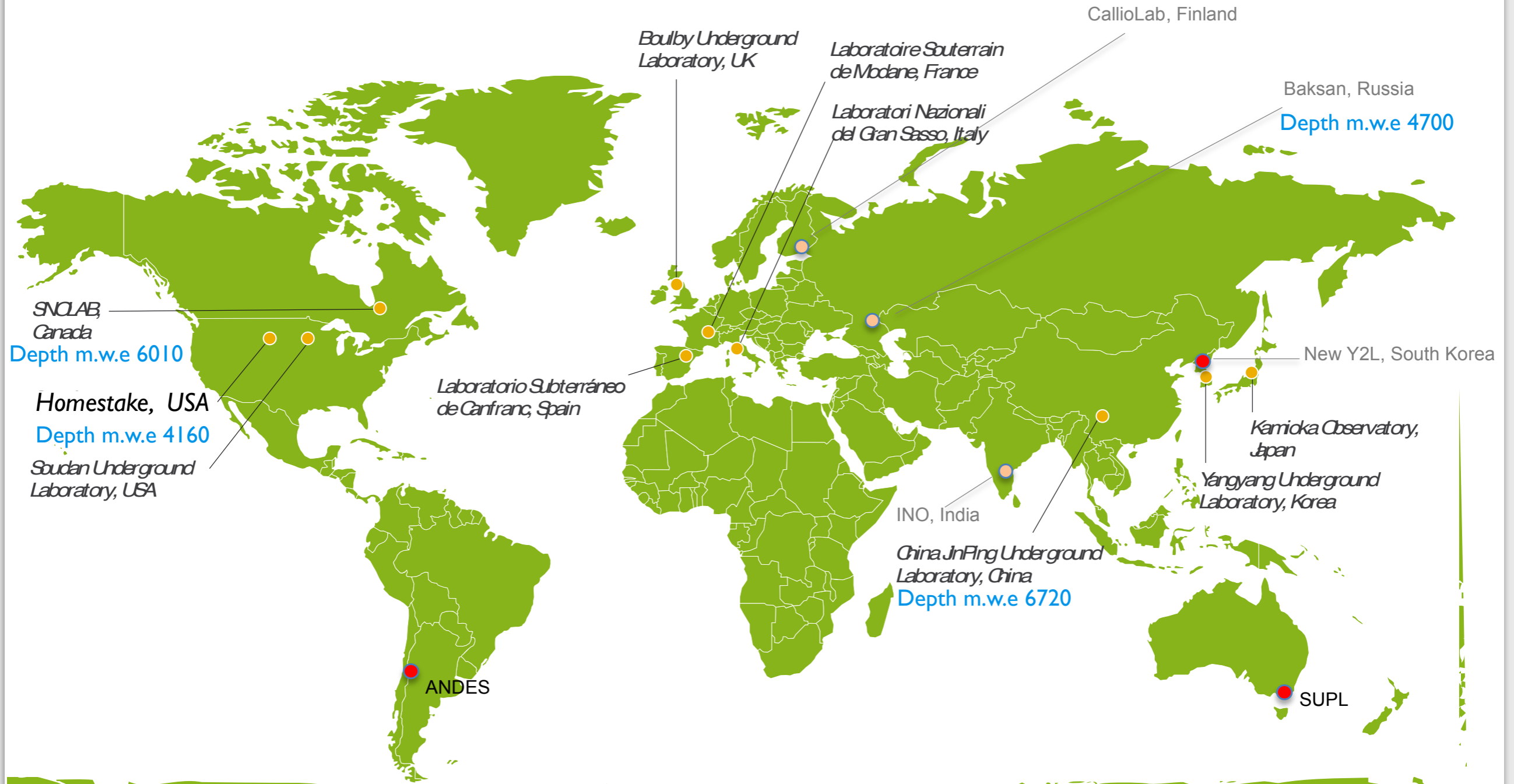
Taisiya Mineeva

Universidad Técnica Federico Santa María
Valparaíso, Chile

On behalf of ANDES collaboration, Chile



World map of deep underground laboratories



So far, all deep underground laboratories are in the Northern Hemisphere

Where underground laboratories are constructed?

- Existing mines

- advantage: can be constructed immediately
- disadvantages: interference with the mine
difficult access



Sanford Lab in Homestake mine, USA

- Tunnels

- advantage: easy access and operation
- disadvantage: contracted only with tunnel



Tunnel leading to Jinping laboratory, China



ANDES - Agua Negra Deep Experiment Site

Agua Negra Tunnel

- Growing trade of Argentina and Brazil with Asia
- Shipping through Chilean ports creates strategic importance to cross ANDES in order to connect Argentina and Brazil to Asian markets
- The mountain pass connecting Chile and Argentina suffers severe cuts in winter



View of the Agua Negra pass at 4780 m a.s.l.





ANDES - Agua Negra Deep Experiment Site

Agua Negra Tunnel Features

- Altitude: 3600m asl Chile, 4085m asl Argentina
- Two parallel tunnels: 14 km long, 60m separation
12 m diameter (2 lanes each)
- Deepest point: 1750 m depth. Slope 3%.





Cosmic radiation and underground laboratories

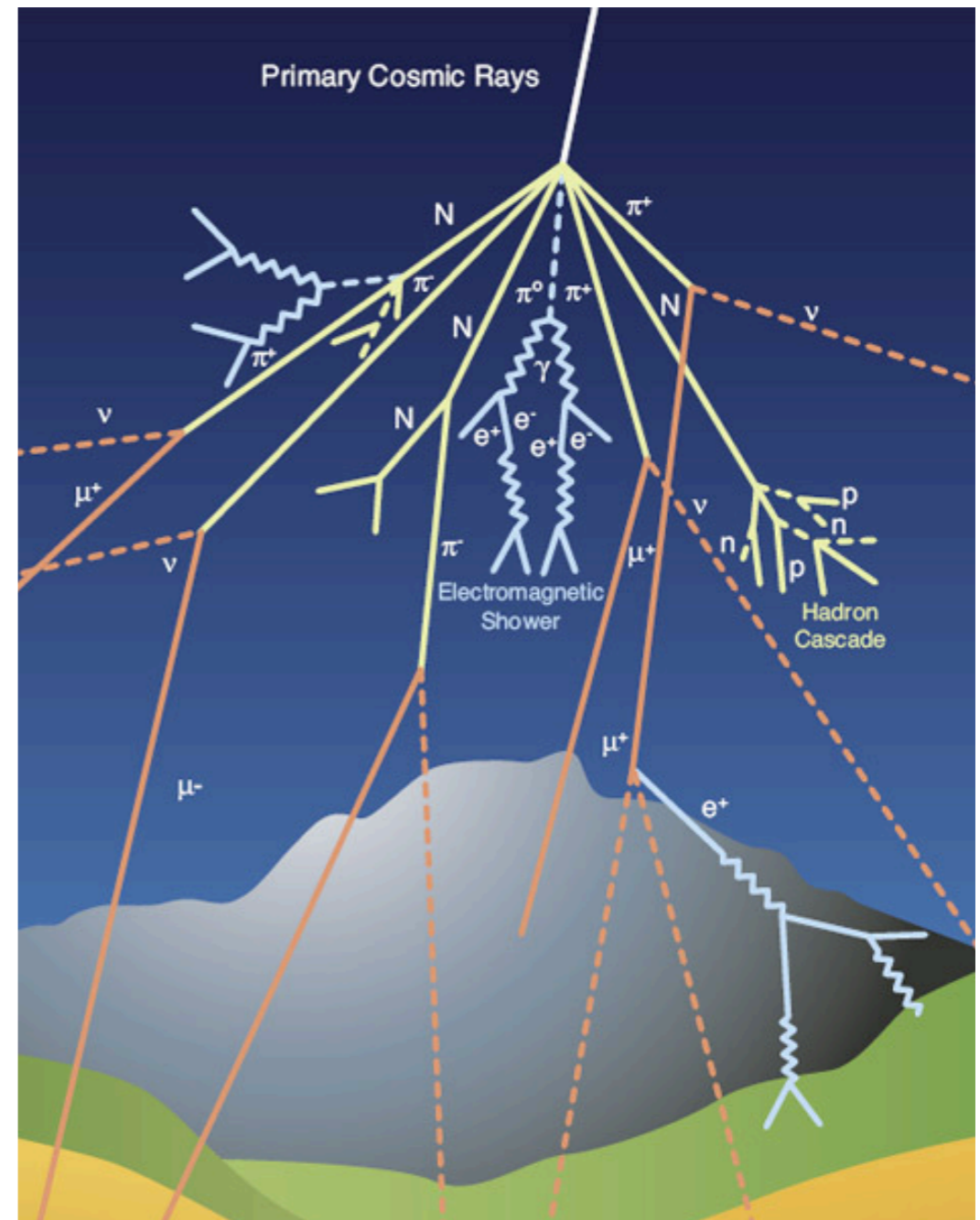
Cosmic radiation

- Primaries

- Protons
- Nuclei (He, O, HZE ions)
- Electrons
- Neutrons
- Gamma

- Secondaries

- Pions
- Neutrons
- Muons
- Electrons/positrons
- Gammas
- Neutrinos



Cosmic rays as noise

In a cubic meter of detector at ground level, one detects every day:

10^8 muons

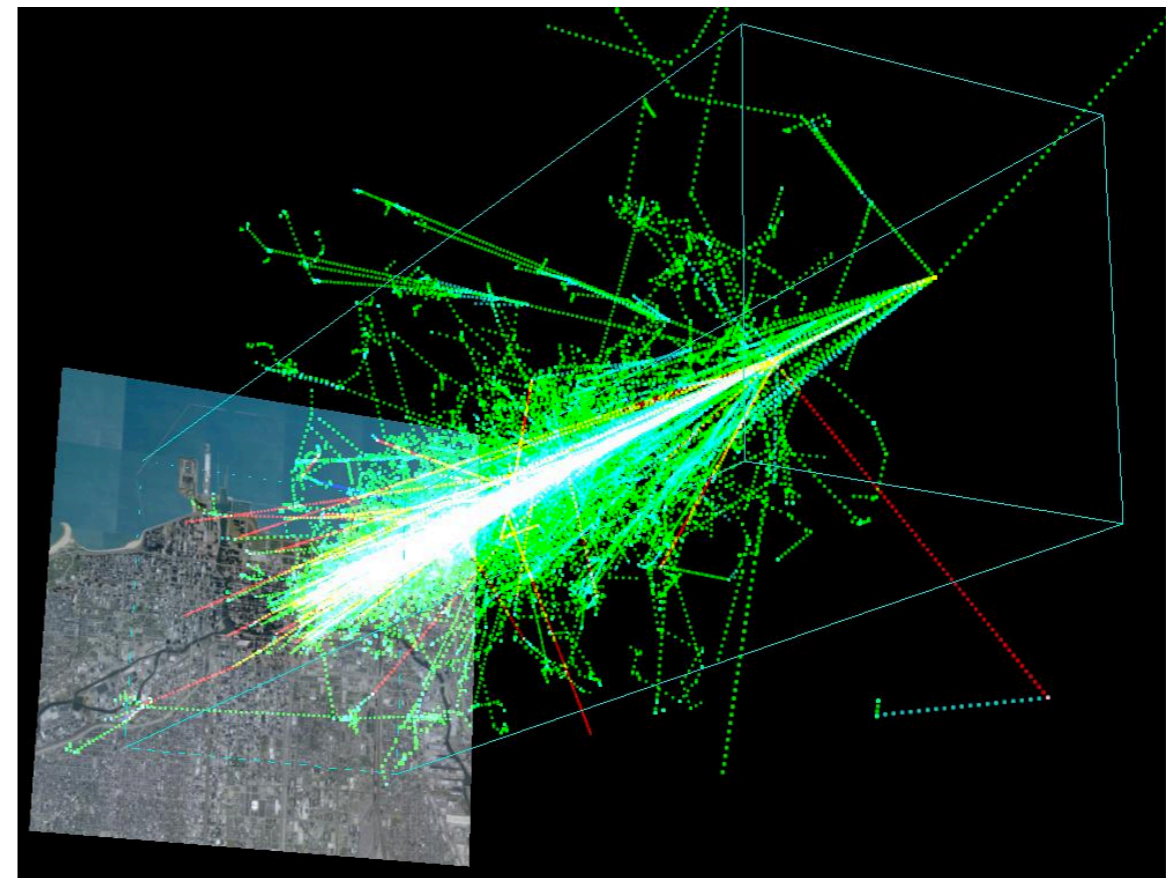
10^8 gammas/electrons/positrons

10^6 neutrons

10^{-3} neutrinos

maybe 100s of dark matter particles

from X.Bertou APS2017



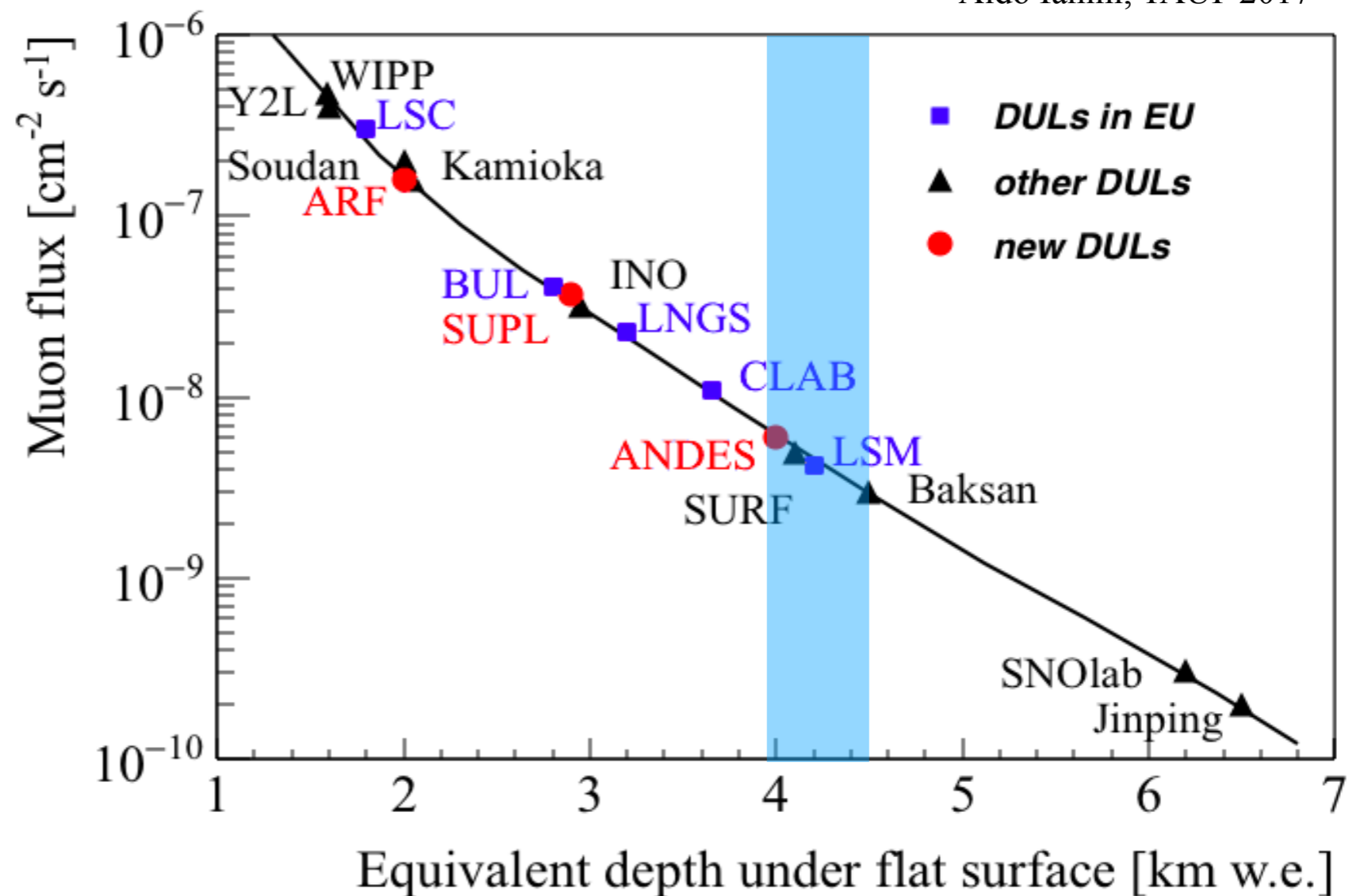
A simulation of an air shower from a proton collision
Image from COSMUS group at the university of Chicago

Muon flux vs depth

Muon flux at ground level: a few $100 \text{ m}^{-2} \text{ s}^{-1}$

Muon flux at 5 km.w.e. underground: $1 \text{ m}^{-2} \text{ day}^{-1}$

Aldo Ianini, TAUP 2017



Reactor Neutrino Background

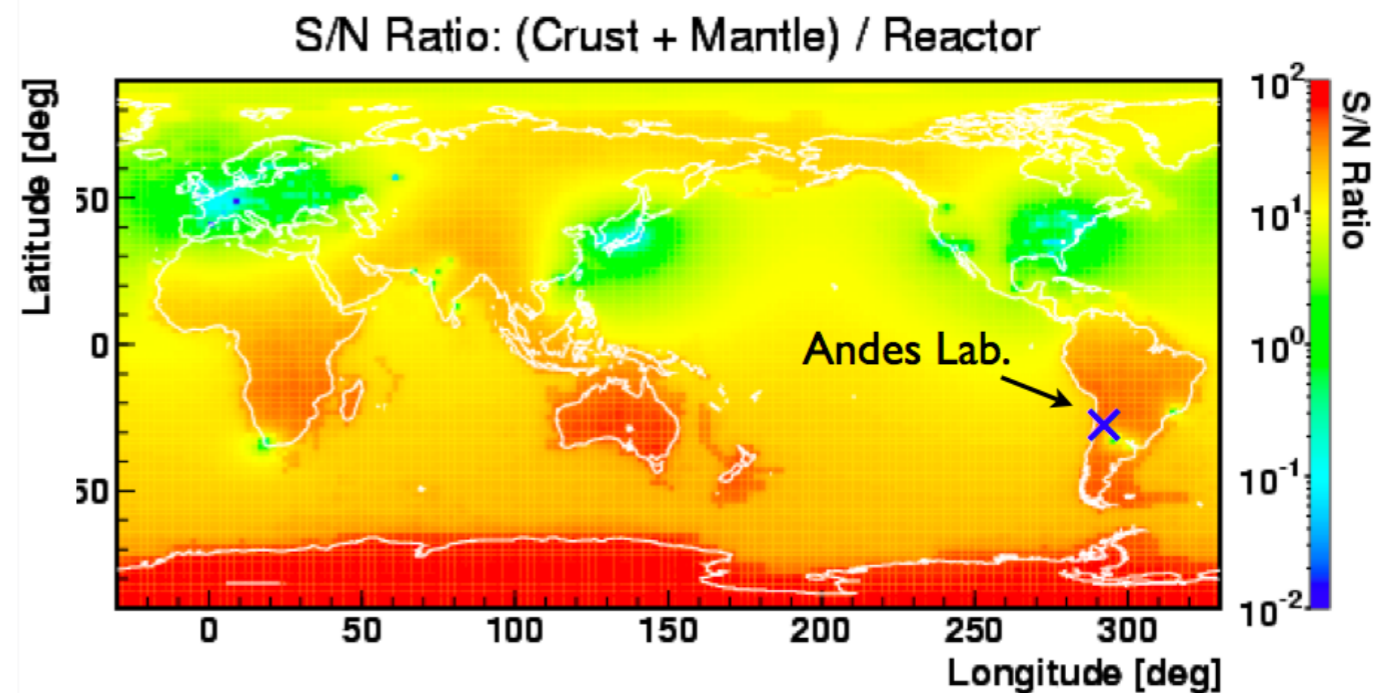
- ANDES: low reactor neutrino background

- Embalse: 2.1 GWth, 560 km
- Atucha: 1.2 GWth, 1100km
- Atucha II: 2.1 GWth

➔ access to geoneutrinos

- Very long baselines...?

- CERN: 9920 km.
- Fermilab: 7640 km.
- KEK: 12400 km (1500 km from earth center)





ANDES scientific program (tentative)

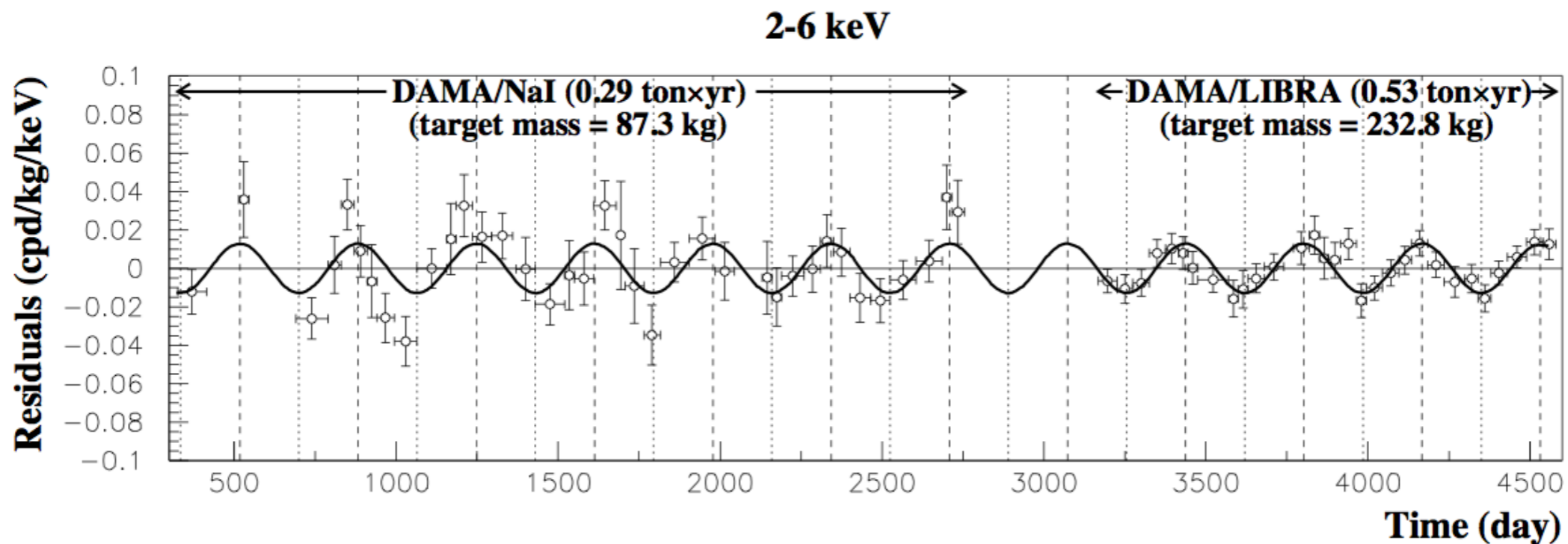
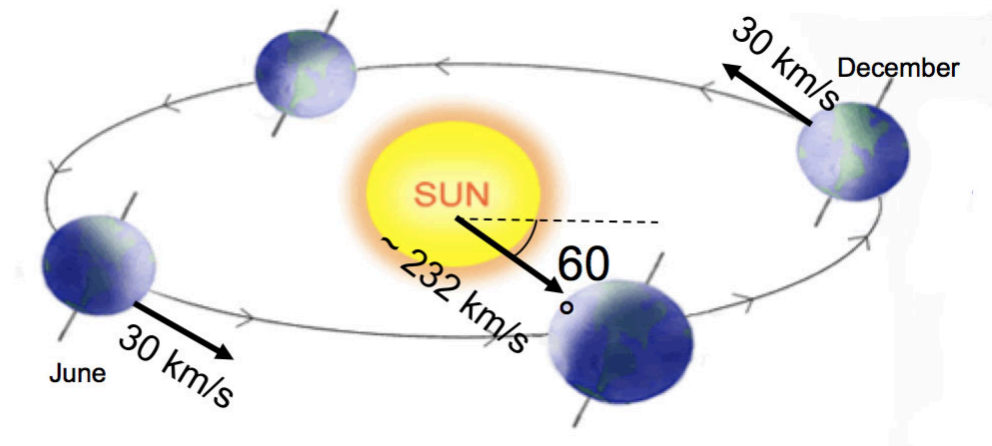
ANDES as multidisciplinary research facility

- Neutrino Physics
 - host double beta decay experiments
 - large neutrino detector (similar to KamLAND / Borexino)
 - focused on low energies (solar / SN / geoneutrinos)
- Dark Matter
 - opposite weather induced modulations
 - new detector technologies
- Nuclear Astrophysics
- Geophysics:
 - enhanced sensitivity to local and global events
 - link of seismograph networks (Chile-Argentina)
- Biology: low radiation measurements (see DULA Bio workshop 2015)

Dark matter modulation

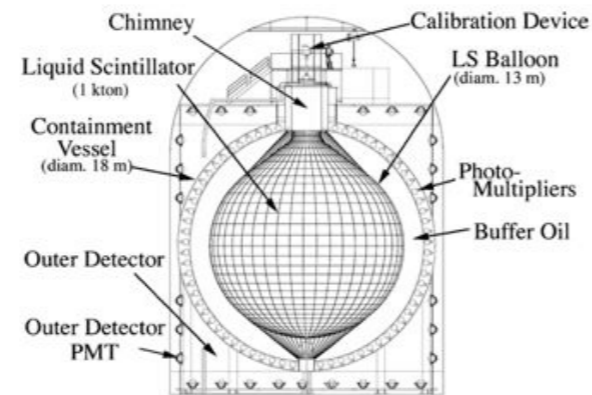
Southern Hemisphere: dark matter or opposite weather induced modulations?

Should the twin experiment observe an annual modulation shifted by 6 months of time, it would indicate the modulation is indeed of atmospheric origin



Proposed Large Latinamerican Neutrino Detector

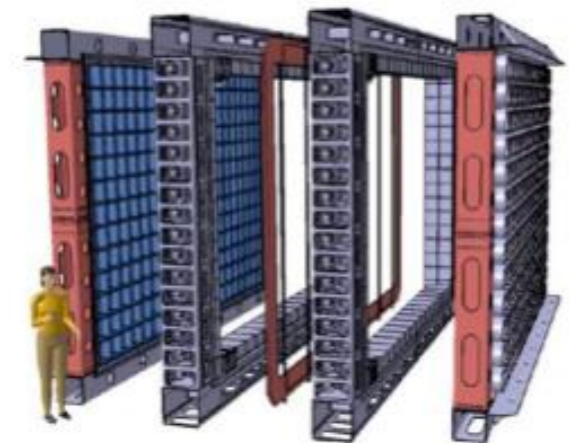
- 3 – 10 kton of liq. Scintillator
- arXiv:1027.5454
- Main topic for next ANDES workshop.



Double Beta experiments:

Manifested interest:

- NEXT
- SuperNEMO modules: ~ 100 kg ^{82}Se

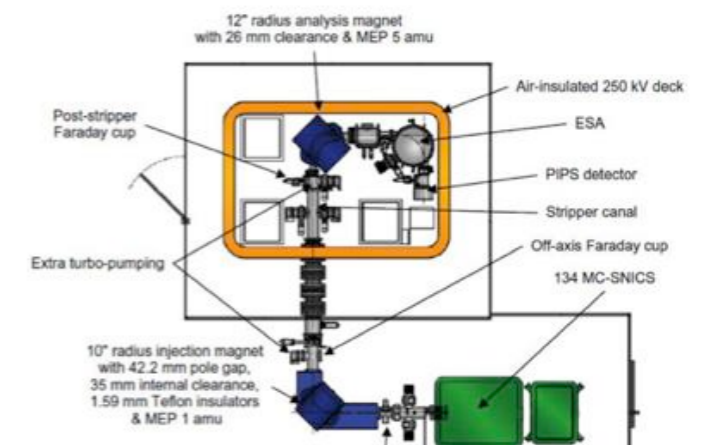
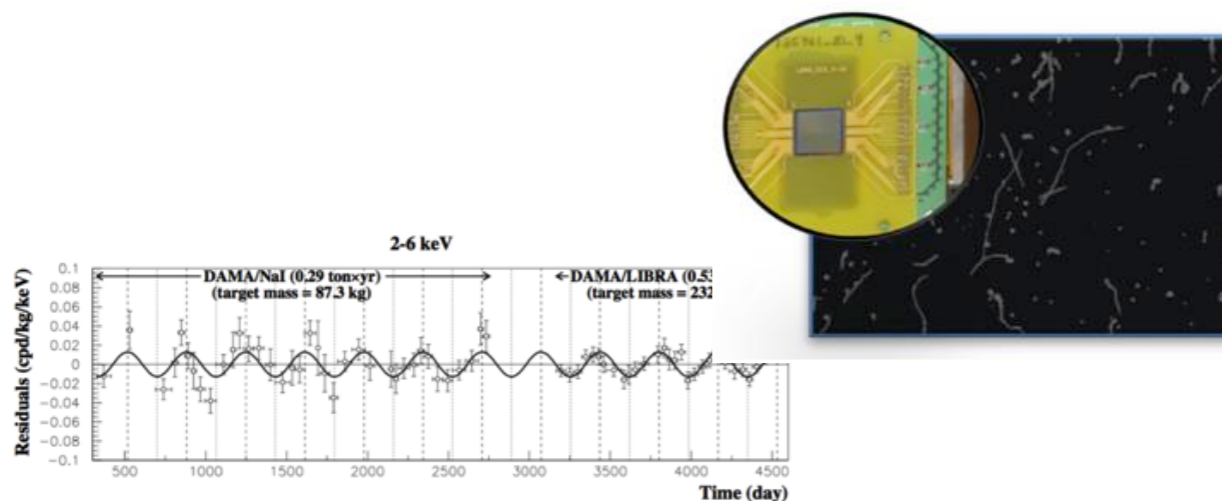


Dark Matter:

- Host a south copy of a DM experiment with modulation signal.
- Host a next gen. DM experiment.

Nuclear Astrophysics:

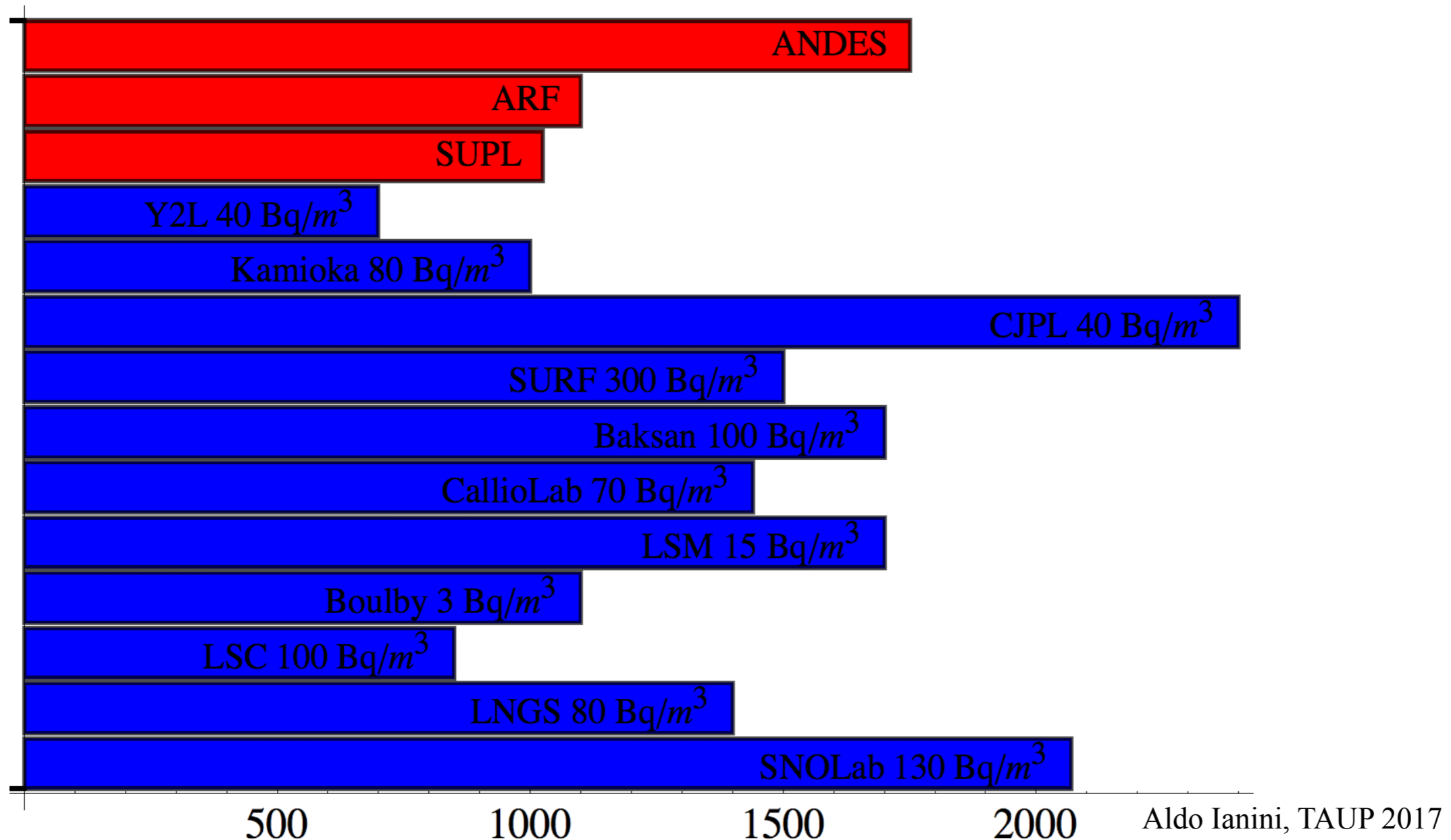
- proposal for a 300 keV high intensity ion beam (similar to LUNA)
- Study nuclear reactions of stars



Claudio Dib, HEP2018

What makes ANDES special?

- First deep underground site in Southern Hemisphere
- Third deepest in the world

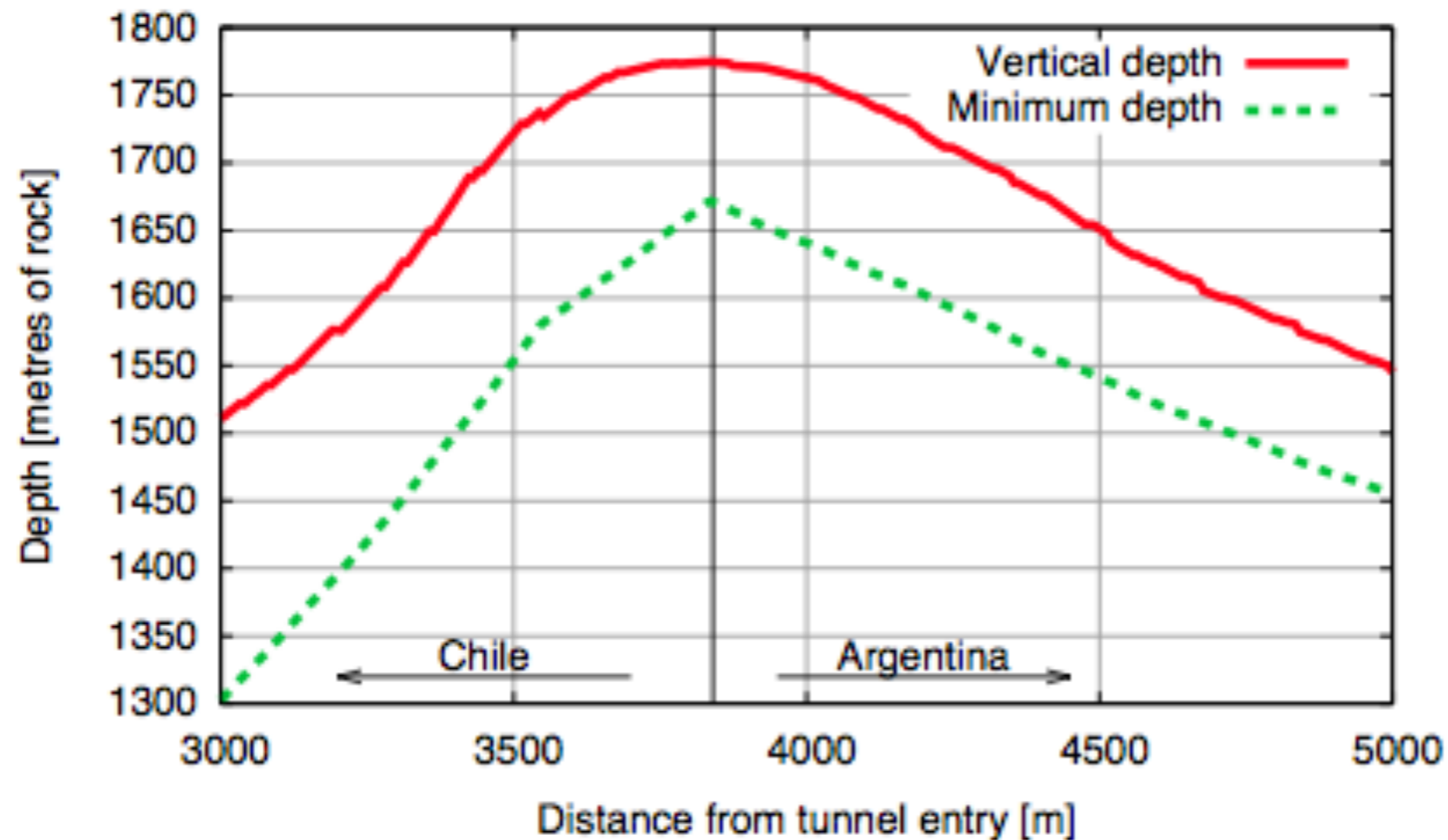




ANDES engineering design

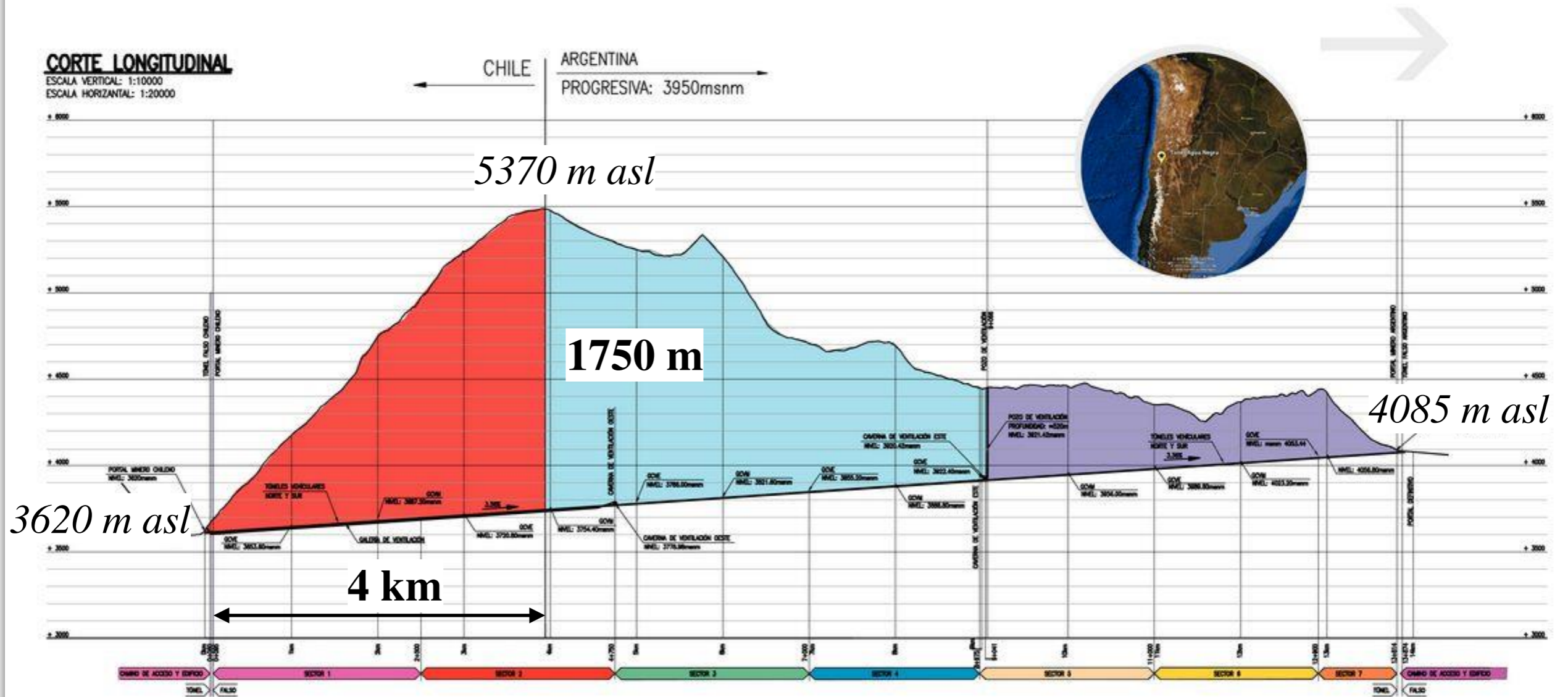
ANDES mountain profile

- Deepest point in tunnel (~ 1750 m deep)
3.5 km to Chile entrance, 10 km to Argentina exit

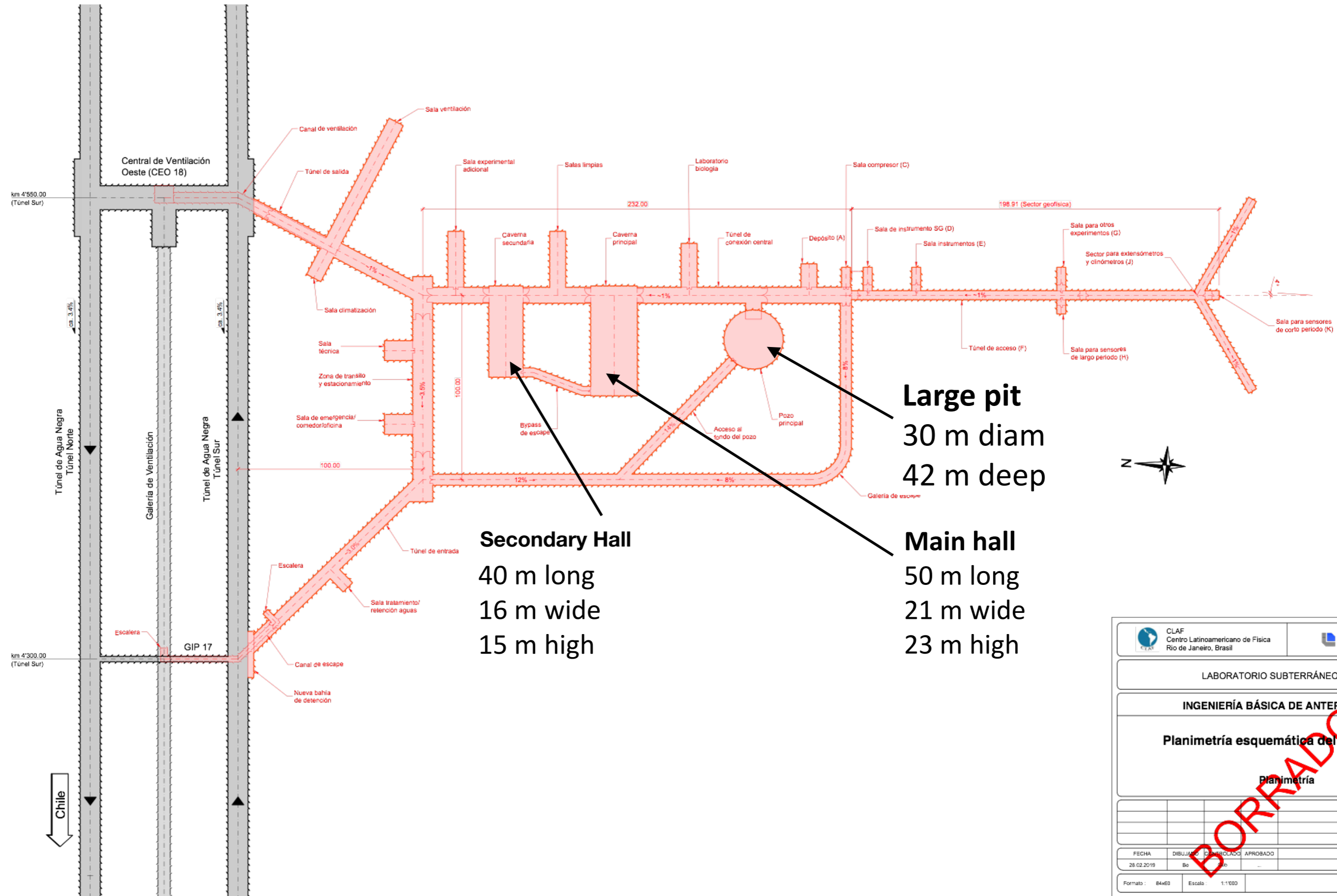


ANDES mountain profile

- Deepest point in tunnel (~ 1750 m deep)
3.5 km to Chile entrance, 10 km to Argentina exit



Basic engineering design of ANDES (by Lombardi S.A.)



Large pit
30 m diam
42 m deep

Secondary Hall
40 m long
16 m wide
15 m high

Main hall
50 m long
21 m wide
23 m high

CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil			
LABORATORIO SUBTERRÁNEO			
INGENIERÍA BÁSICA DE ANTES			
Planimetría esquemática del Planimetría			
FECHA	DIBUJADO	REVISADO	APROBADO
28.02.2019	Be		
Formato	84x60	Escala	1:1000

Chile

ANDES support laboratories



Two Support Labs (one on each side):

- Tentative sites: La Serena (Chile) , Rodeo (Argentina)
- Integration with local Universities (academic activities)
- Host a visitor center
- Workshops for underground experiments



ANDES status

ANDES: current status and milestones

- Official support from Ministry of Science MinCyT Argentina and Approval from EBITAN (Entidad Binational Agua Negra) (2012).
- CLAF (Centro Latinoamericano de Fisica) creates ANDES unit (2014).
- Detailed Engineering design of tunnel completed (2014)
- Conceptual design of laboratory by Lombardi S.A (paid 50/50 Chile-Arg).
- Basic Engineering design of ANDES completed (paid by Argentina).
- Chilean Ministry of Science created in 2018.
ANDES presented to Chilena Min. of Sc.
Approval suspended until tunnel costs agree between Chile-Arg (1.5b \$).
Chilean government requires further geological studies.

Proposal for organization

- ANDES is foreseen to be run by the Latin American Consortium for the Underground Experiments (CLEES)
 - installation and operation of ANDES laboratory
 - academic integration of scientific activities
- CLEES will manage ANDES laboratory with support of international advisory board
 - have an operation budget from member nations

International support

- Support from scientists and international experiments:
 - Stephen Adler, Princeton
 - M. Miller, A. Garcia, University of Washington
 - Bob Svoboda, LNBE Spokesperson
 - Nigel Smith, SNOLAB Director
 - Kunio Inoue, KamLAND Spokesperson
 - Hiro Ejiri, Former RCNP Director
 - Yoichiro Suzuki, Kamioka Director, Super Kamiokande Spokesperson
 - Takaaki Kajita, ICRR Director
 - P. Brink et al., DM modulation
 - D.A. Harris, K. McFarland, MINERvA Spokespersons
 - A.B. McDonald, Nobel Physics Laureate

*International: over 20 support letters
from communities worldwide*

- Argentina:
 - IFLP, UNLP
 - Neutrones y Reactores, CAB
 - Partículas y Campos, CAB
 - Bajas Temperaturas, CAB
 - Instituto Geofísico Sismológico Volponi, San Juan
 - ITeDA, CNEA-CAC
 - I&D - PNGRR, CNEA-CAC
 - Física Experimental Altas Energías, UBA
 - Instituto de Matemática Aplicada, San Luis
 - Empresa SOLYDES
- Brasil:
 - Rede Nacional de Física de Altas Energias
 - ICE, UFRJ
 - IFRW, UNICAMP
 - ICRA, CBPF
 - Neutrino Physics group, UFABC
 - HEP, PUC Rio
 - Instituto de Física, USP
- Chile:
 - CCTVAL, UTFSM
 - Pontificia Universidad Católica de Chile
 - Universidad de Santiago de Chile
 - Dpto Ciencias de la Tierra, Universidad de Concepción
 - ICFM, Universidad Austral
- Mexico:
 - Instituto de Biotecnología, UNAM
 - Instituto de Ciencias Nucleares, UNAM
 - Grupo Astropartículas, UMSNH
 - FCFM, BUAP

ANDES coordination team

- Coordinator: **Xavier Bertou** (CAB, CNEA/CONICET)
- Representatives of the countries:
 - Argentina: **Osvaldo Civitarese** (IFLP, UNLP/CONICET)
 - Brasil: **João Carlos Costa dos Anjos** (CBPF)
 - Chile: **Claudio Dib** (UTFSM)
 - México: **Luis Manuel Villaseñor** (IFM-UMich)

Summary

- ANDES is a unique opportunity for a deep and large underground laboratory in Southern Hemisphere
- International laboratory led by Latin American consortium (CLES)
- Interest and support from international community
- Needs political decision from Chilean government

ANDES website: <http://andeslab.org>



Thank you

Backup slides

Rock radioactivity

	Basalt	Andesite	Rhyolite 1	Rhyolite 2	Canfranc
^{238}U	2.6 ± 0.5	9.2 ± 0.9	14.7 ± 2.0	11.5 ± 1.3	4.5–30
^{232}Th	0.94 ± 0.09	5.2 ± 0.5	4.5 ± 0.4	4.8 ± 0.5	8.5–76
^{40}K	50 ± 3	47 ± 3	57 ± 3	52 ± 3	37–880

Perforations of up to 650 m deep were done, and the main rocks found were andesite, basalt and rhyolite. Of special interest is the Rhyolite as it may contain higher level of radioactive material, depending on how it was formed.

Neutron Activation

