



ANDES AGUA NEGRA DEEP EXPERIMENT SITE

Proposal for a Deep Underground Laboratory in the Southern Hemisphere





DDAp & HIRSAP 2020 (nov 25-27, 2020)





Proposal:

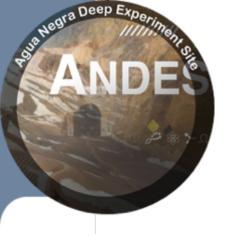
To build an Underground Lab in the AGUA NEGRA tunnel.

First deep underground Lab in S. America (S. Hemisphere).



Content

- The Agua Negra Tunnel
- ANDES Lab proposal
 - Tentative Scientific programme
 - Current Design (IBA)
- Proposed Organization
- Current status



The Agua Negra Tunnel

The Tunnel Proposal

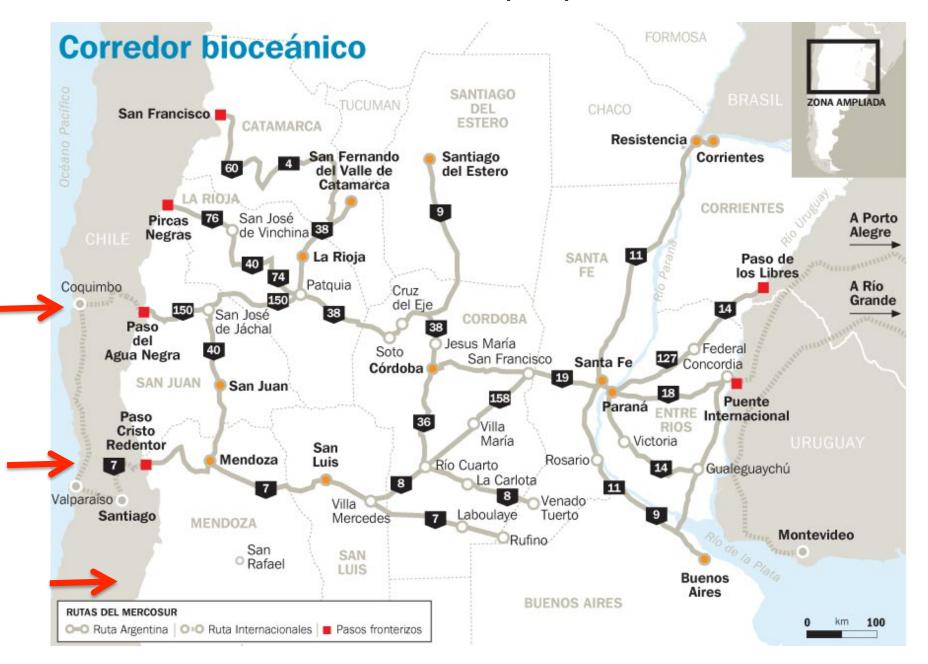
- Why a Road tunnel: growing trade of Argentina and Brazil with Asia.
- Shipping through Chilean ports

 to cross the Andes.
- The mountain Pass suffers severe cuts in winter.





Several tunnel proposals



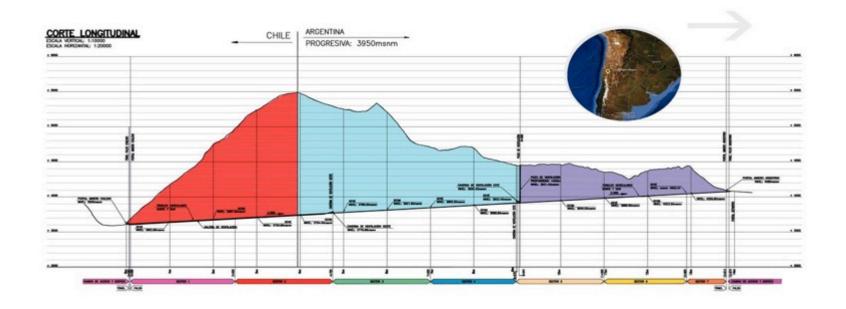
Tunnel approx. Coordinates: 30.19 South, 69.82 West



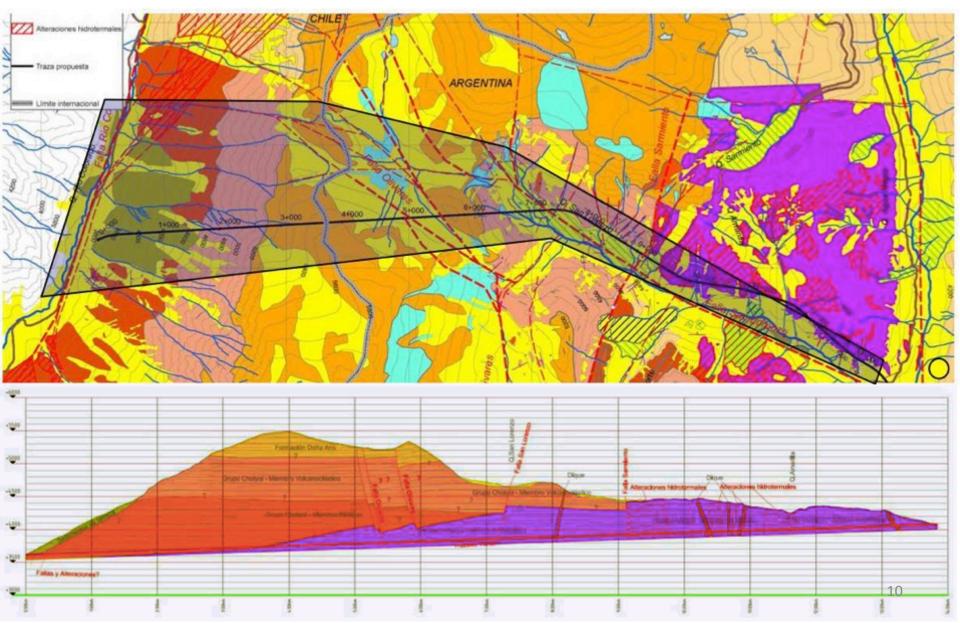


Tunnel features

- Altitude: 3600 m asl (Chile), 4085 m asl (Argentina), slope ~ 3%
- Two parallel tunnels, 14 km long, 60 m separation
- 12 m diameter (two lanes each), connecting galleries every 500 m.
- Deepest point: 1750 m depth.
- Forced ventilation (14.5 MW).



Agua Negra geology



Rock studies

Main rock: - Andesite

variations: - rhyolite

- basalt

- dacite

- trachyte



9 samples from 8 perforations up to 600 m deep

(Bq/kg):	Andesite	Basalt	Rhyolite 1	Rhyolite 2	Canfranc
U-238	9.2 ± 0.9	2.6 ± 0.5	14.7 ± 2.0	11.5 ± 1.3	4.5 30
Th-232	5.2 ± 0.5	0.94 ± 0.09	4.5 ± 0.4	4.8 ± 0.5	8.5 76
K-40	47 ± 3	50 ± 3	57 ± 3	52 ± 3	37 880

Tunnel status

- Bi-national Entity to manage the tunnel project:
 EBITAN (Entidad Binacional Tunel Agua Negra) since 2009.
- Engineering Design completed, call for tender in process.
- Interamerican Development Bank (BID) will lend the 1.5 billion USD for the tunnel construction, to be paid by Chile/Argentina.
- Economic review, geological studies, environmental impact, etc.
- Construction pending.



The ANDES Laboratory proposal

ANDES: Agua Negra Deep Experiment Site

ANDES Proposal:

- Underground site at deepest point inside the Agua Negra Tunnel (border ~ 4 km from Chile entrance).
 - 2 large horizontal caverns + 1 large pit.
 - Other isolated rooms, clean rooms, ...

2 Support Labs at the surface:

La Serena (Chile); Rodeo (Argentina):
 Administration, tech. workshops,
 and Visitor Center.

Sites at the portals:

Lodging, office, storage.



Gentileza: Lab. Gran Sasso, Italia





Gentileza: : Lab. Apoyo y Centro de Difusión, Modane, Francia

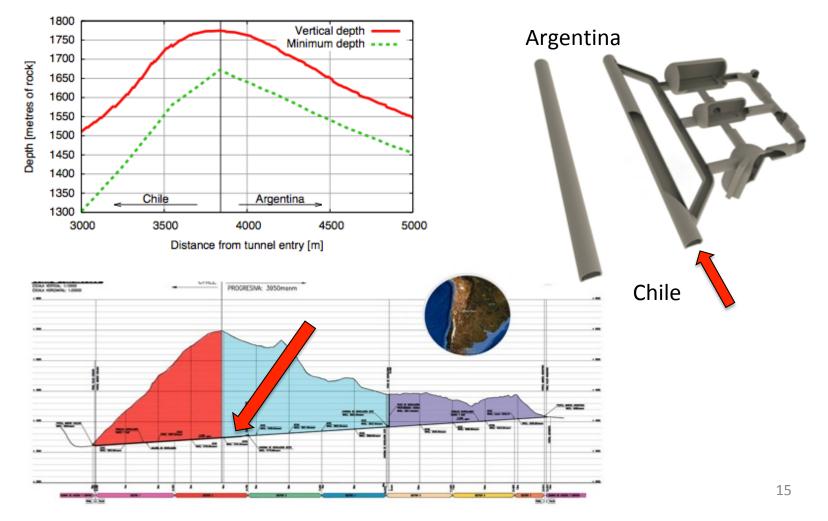


Gentileza: Paso Pino Hachado, Chile

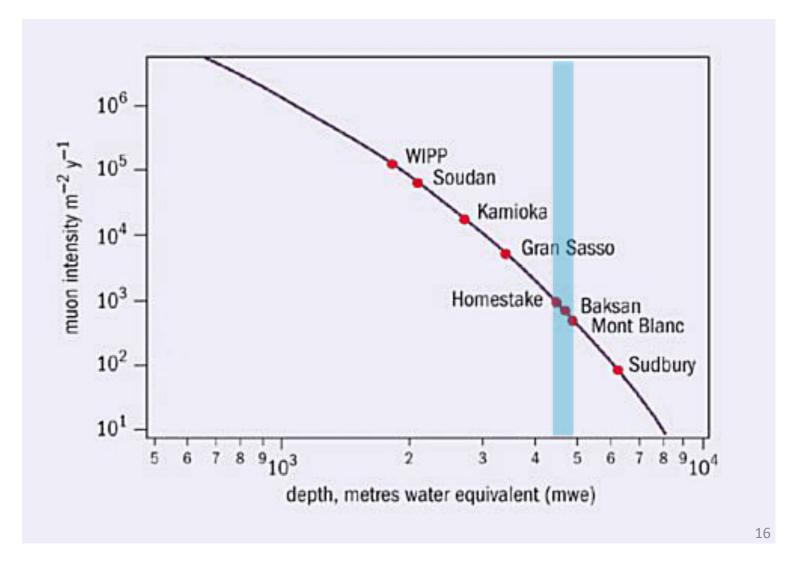
The ANDES Lab proposal

Deepest point in tunnel (~ 1750 m deep)

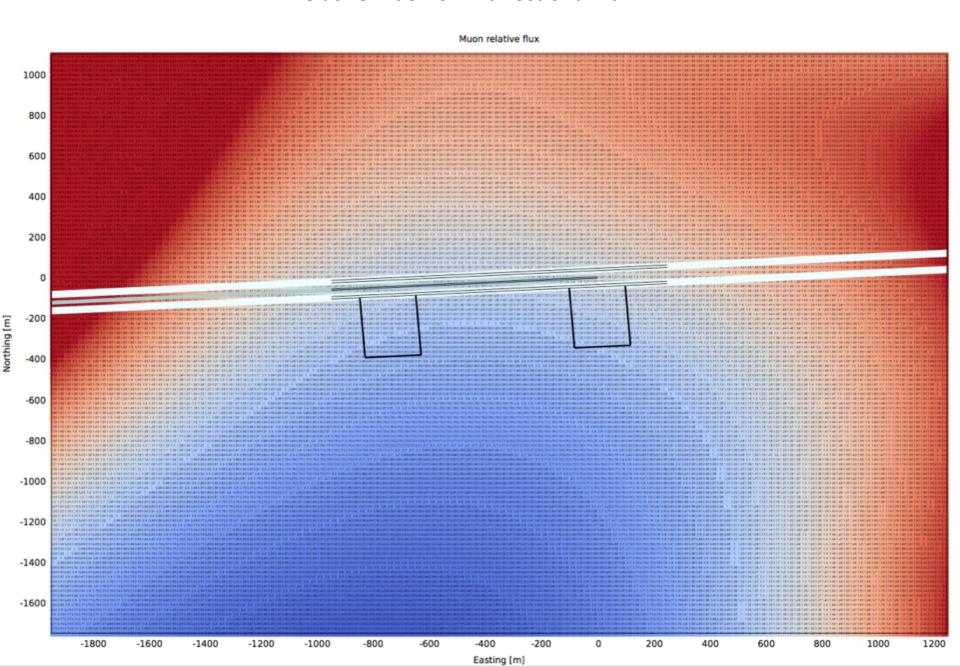
≈ 4 km to Chile entrance, ~ 10 km to Argentina exit

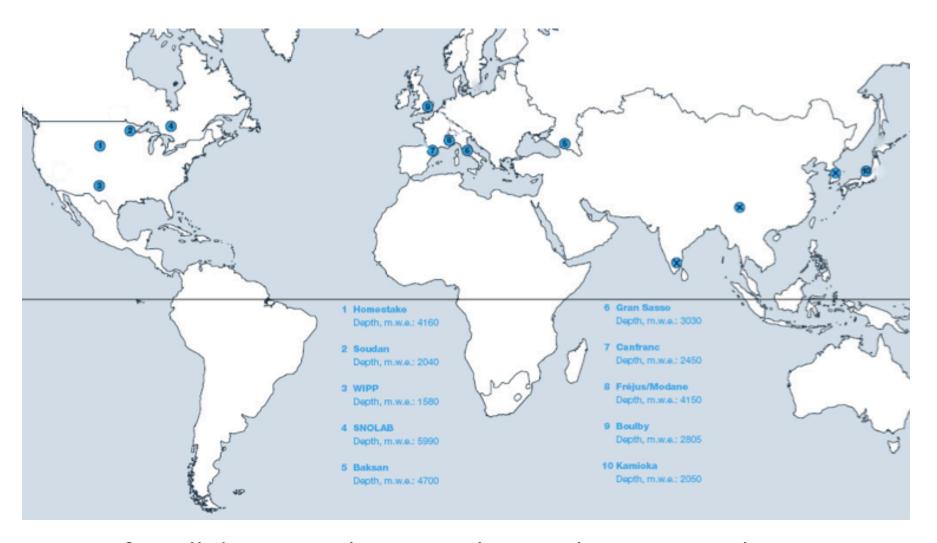


Flux at sea level $\sim 100 \, / \text{m}^2 \, \text{s}$ ANDES: $\sim 4500 \, \text{mwe}$; atn: 10^{-7}



Relative muon omnidirectional flux

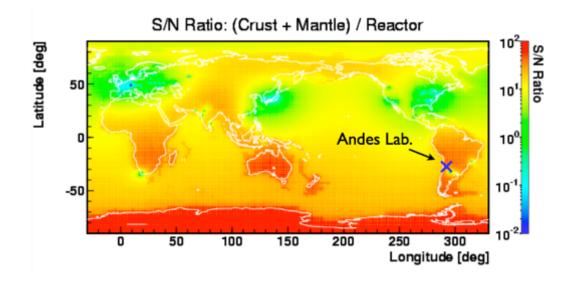


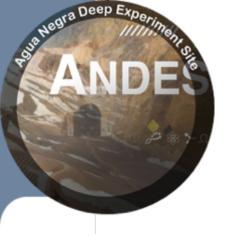


So far, all deep U. Labs are in the Northern Hemisphere (and Stawell Underground Physics Lab. currently under construction in Australia)

What makes ANDES special?

- Third deepest Lab in the world.
- First in the southern hemisphere
 - Opposite weather-induced modulations
- Low reactor neutrino bkg
 - Embalse: 2.1 GWth, 560 km
 - Atucha: 1.2 GWth, 1080 km
 - Atucha II: 2.1 GWth
- Geoactive Region
 - Geophysics experiments
- Very long baselines...?
 - CERN: 9920 km.
 - Fermilab: 7640 km.
 - KEK: 12400 km (1500 km from earth center)





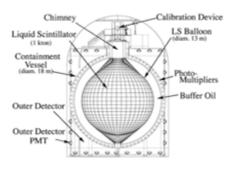
ANDES scientific programme (tentative)

ANDES initial Scientific Programme

- Neutrino physics:
 - Neutrinoless double beta decays
 - large neutrino detector
 - focus on low energies? (solar / SN / geoneutrinos)
- Dark Matter
 - modulation measurements
 - going for low mass WIMPS, new technologies
- Nuclear Astrophysics
 - low energy beams
- Geophysics
 - seismograph networks, rock studies
- Biology
- Low radiation measurements

Large Neutrino Detector:

- 3 10 kton of liq. Scintillator?
- arXiv:1027.5454



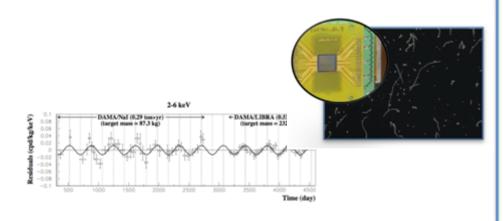
Double Beta experiments:

- NEXT (high pressure Xe)
- SuperNEMO modules: ~ 100 kg 82Se



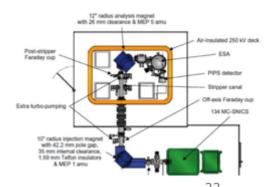
Dark Matter:

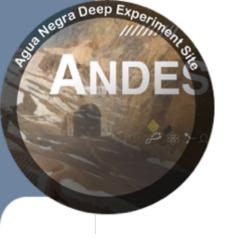
- South modulation experiments?
- Next gen. DM experiments: aim at smaller WIMP masses?



Nuclear Astrophysics:

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





ANDES Design

Conceptual Design (by Lombardi, 2015)



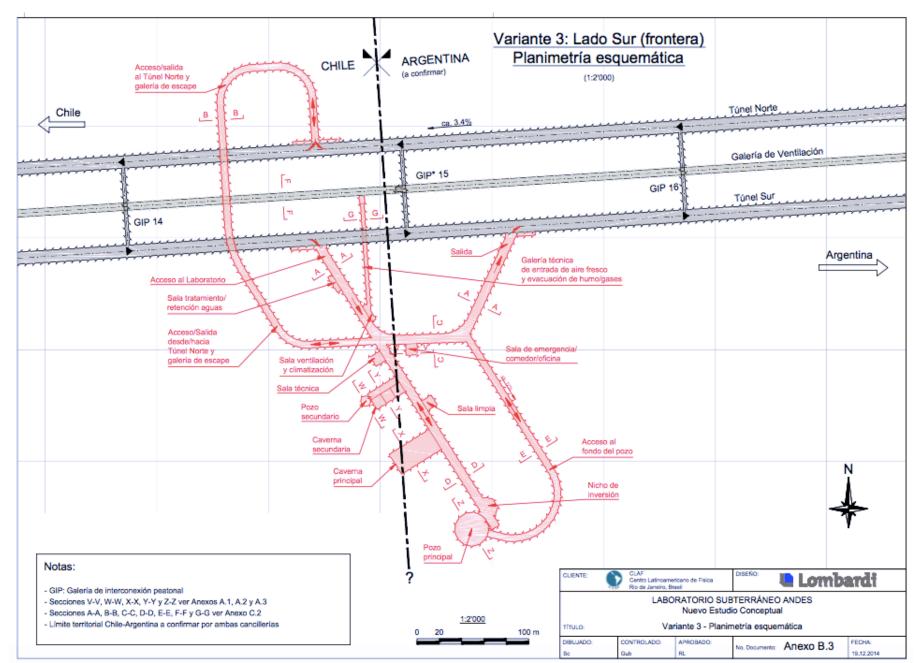
LABORATORIO SUBTERRÁNEO ANDES

Nuevo Estudio Conceptual

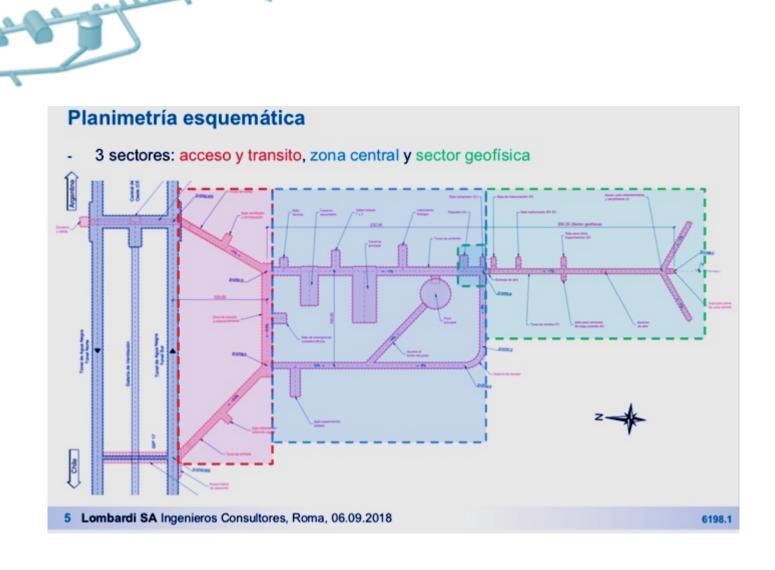


Informe Técnico

Conceptual Design (Layout 2015 by Lombardi)



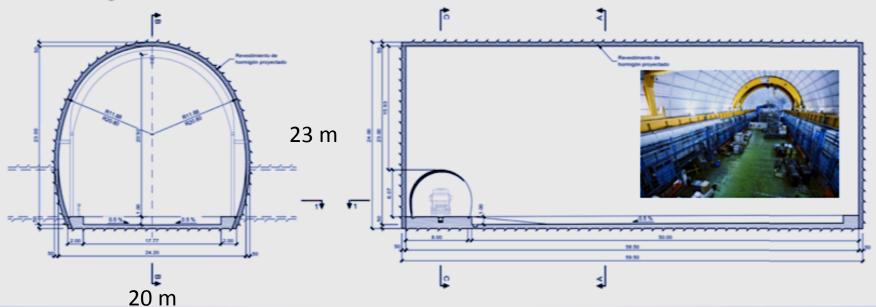
Basic Engineering (IBA) by Lombardi 2018.



Main cavern

2.3 Caverna principal

- Sala experimental principal
- Taller mecánico para soldaduras o similares.
- Una cubeta de retención con un volumen de 500 m3 para contener un eventual derrame de líquidos
- Canaletas técnicas en la solera o bandejas portacables
- Puente grúa curvo de 40 t



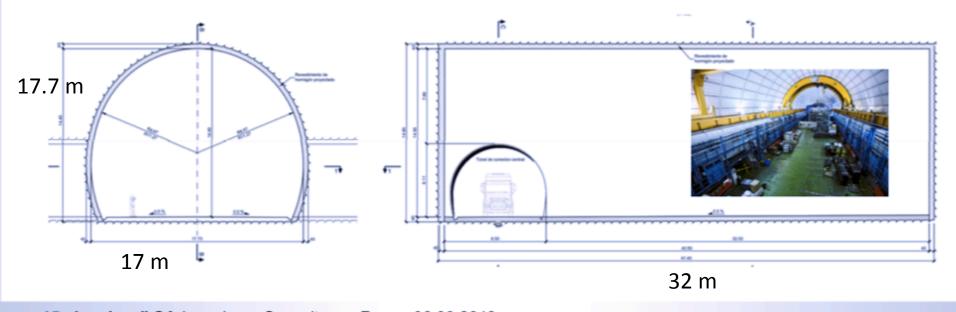


Secondary cavern

2.5 Caverna secundaria

- Espacio para experimentos de tamaño menor, oficinas e instalaciones secundarias
- Puente grúa principal de 40 t de capacidad?
- Cubeta de retención?

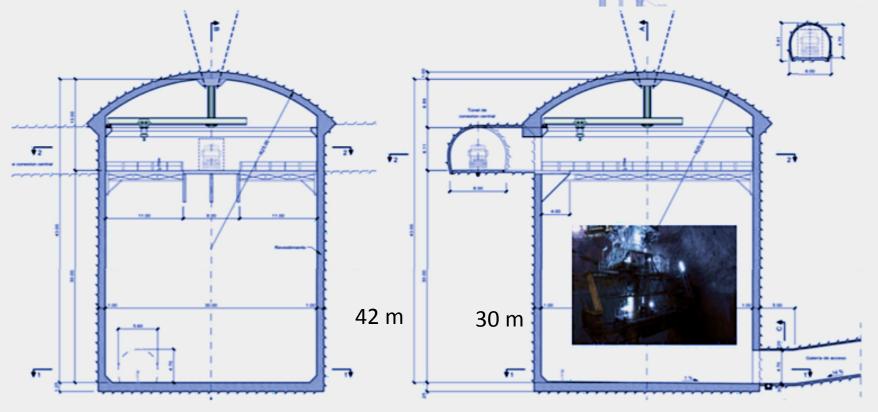




Main Pit (the only pit)

2.4 Pozo principal

- Espacio para experimentos de gran tamaño
- Aparejo central de 40 t de capacidad
- Revestimiento del pozo impermeable

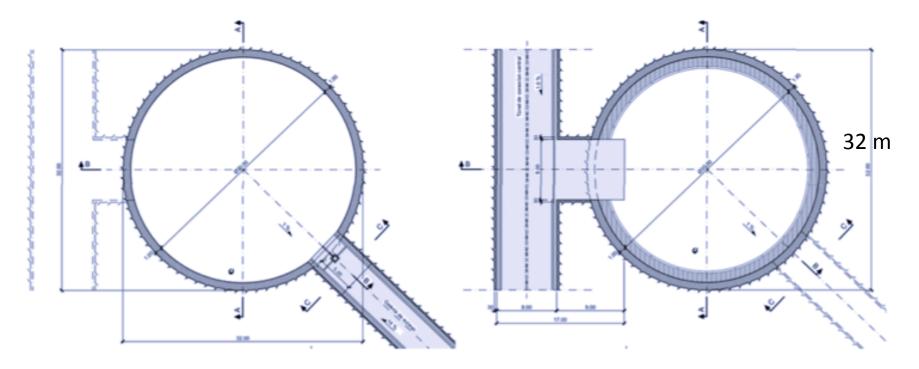


Main Pit

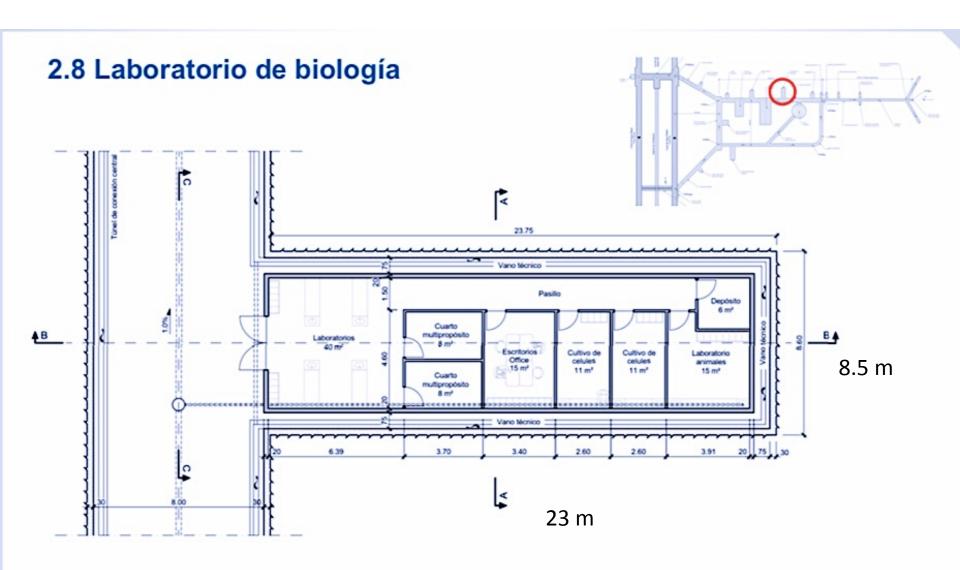
2.4 Pozo principal

- Andamio perimetral
- Entrada con plataforma voladiza
- Puerta estanca al fondo del pozo





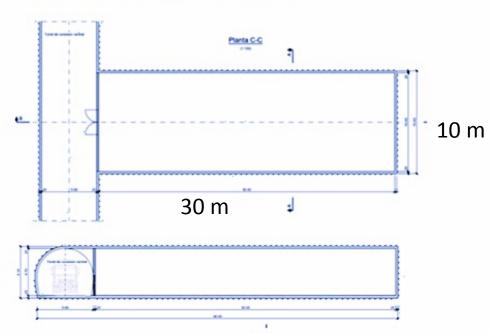
Biology Lab

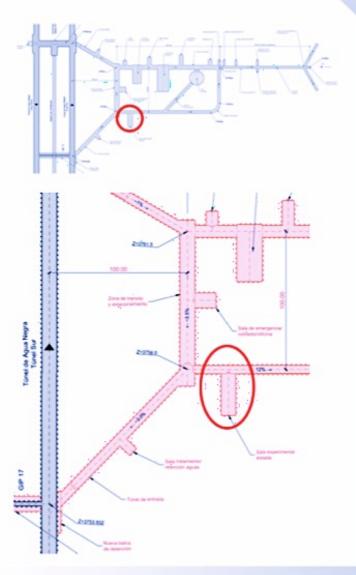


Isolated room (Nuclear Astrophysics)

2.9 Sala experimental aislada

- Espacio para experimentos aislados
- Posición alejada
- Acceso en bajada con pendiente 12% y galibo reducido
- Posible reubicación, dimensiones?





Clean rooms

2.7 Salas limpias

Exigencia:

- 2 salas separadas con espacio libre interno de 10 m de ancho y 10 m de largo
- Las salas limpias deberán cumplir la norma ISO Class 6 o Federal Standard Class 1000 con presión positiva.

Propuesta:

- Preparación de una caverna con impermeabilización y revestimiento interno
- Dimensionamiento conexiones de ventilación y equipamientos
- Salas limpias construida con sistema modular según exigencias especificas





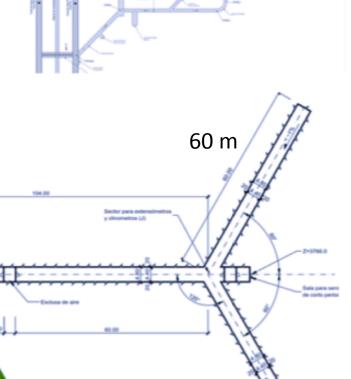
Geoscience sector

2.12 Sector geofísica

- Sector específico destinado para experimentos y mediciones en el ámbito de la geofísica.
- Exigencia diferentes (temperatura y presión constante, etc.).
- Acceso restringido.









Support Labs



- Two Support Labs (one on each side):
 - Tentative sites: La Serena (Chile), Rodeo (Argentina)
 - Integration with local Universities
 - Host a visitor center





Organization

ANDES International Consortium (tentative):

Organizational structure:

- 1. The Council (governing body of ANDES)
 Representatives of the participating nations, which are
 Members and Observers.
- 2. A Scientific Advisory Committee to the Council
- 3. The Executives: Director, Directorate and Staff.

ANDES International Consortium (tentative):

Operation:

- Member countries of the Consortium would be the owners of the infrastructure.
 - The Consortium calls for experiments to be installed at ANDES.
- Major experiments are international collaborations who should build and operate their own detectors.
- Member countries will have participation privileges in all steps of the experiments.

ANDES estimated costs:

- Infraestructure (financed by Chile/Argentina):
 - Underground site: 40 M USD (2% of Tunnel cost).
 - Support Lab: 2 M USD.
- Yearly Operation (financed by the Consortium):
 - 2 M USD/yr (with lab full).
- Experiments:
 - Property of each collaboration (not cost of the lab).
 Estimated capital when full: 500 MUSD.
 - Large experiments pay lab services.

Current support and status

- > 40 support letters from International community
 (underground lab directors, intl. exp spokespersons,
 Physics associations, Universities etc., including 2 Nobel laureates,
 and 30 letters from latin american groups.
- Official support from MinCyT, Argentina (2012).
- 6 workshops for the Lab design (Argentina, Brazil, Chile, Mexico).
- CLAF (Centro Latinoamericano de Fisica) creates ANDES unit (2014).
- Technical assessment of the proposal, led by T. Noble, former SNO Lab Director (2014).
- ANDES Conceptual Design, by Lombardi S.A., paid 50/50 by Chile and Argentina (2015).

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Current support and status

- CONICYT (Chile) creates Committee to present proposal to Government (2017).
- Design of Geoscience sector, in coll. with Karlsruhe and Heidelberg (2018).
- Design of Biology sector, in coll. with ISS, Rome (2018).
- First ANDES Geoscience Workshop (San Juan, Arg., Nov 2018)
- Government of San Juan (Argentina) commits full funds for the Basic Engineering Design (IBA), 2018.
- Engineering Design (IBA) by Lombardi December 2018.
- Government of Coquimbo (Chile) proposed to reserve FNDR funds to cover 50% IBA (2018).
- Construction pending.

Current support and status

- Collaboration agreements, current and in progress:
 - MoU for IRLA (Inst. Regional Latinam. Astropart.) Brazil-Argentina.
 - CNEA, Argentina INFN, Italy: for ANDES LNGS on Astroparticles.
 - CNEA, Arg. KIT, Germany: for detector technologies.
 - UNSAM, Arg. KIT, Germany: joint graduation Astropart. & Tech.
 - CNEA-MinCyT-CONICET-Gob. San Juan: for the development of ANDES.
 - USM, Chile KIT, Germany: exchange program for students and scientists.
 - Chilean Univ. Consortium for the development of ANDES (pending).

Extracts from T. Kajita's letter of support (2011):



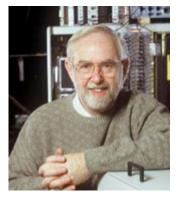
"...underground laboratories will be one of the most important infrastructures for basic science in the next decades..."

"...The underground lab in Kamioka, Japan, is still growing with more experiments in the areas of dark matter search, double beta decay, gravitational wave detection, etc."

"There are several underground labs in the world, however they are all in the northern hemisphere. It will be extremely important to have an underground lab in the southern hemisphere. I mention two examples: ..."

"...from the experience and reasons mentioned above, I strongly support the proposal of the ANDES Underground lab. If you want to hear more, please do not hesitate to ask me. I am very happy to write more."

Extracts from Art McDonald's letter to Chilean Minister of Education (August 2016)



"The world-wide interest in experiments performed in an environment such as will be achieved at ANDES is increasing at a high rate."

"As we have observed with SNOLAB, this provides major opportunities for our Canadian university faculty and students to work with the best scientists in the world ..."

"As Ministra de Educacion, I urge you to approve this laboratory as a major educational opportunity for Chile that will develop new generations of students working side by side with the best scientists in the world and developing skills that will be of substantial value to Chile in the longer term."

"There are international advisors who have been providing expert reviews of the plans for this laboratory, including my colleague Professor A. J. Noble from Queen's University, former Director of SNOLAB..."

ANDES Coordination Team

- General coordinator:
 - Xavier Bertou (CAB)
- Country coordinators:
 - Argentina: Osvaldo Civitarese, UNLP (Alberto Etchegoyen, UNSAM)
 - Chile: Claudio Dib (USM) (Juan Carlos Helo, ULS)
 - Brasil: Ronald C. Shellard (CBPF) (Joao dos Anjos, id.)
 - Mexico: Juan Carlos D'Olivo (UNAM) (Luis Villaseñor, UMSNH.)
- Web site http://andeslab.org

Summary

- ANDES is a unique opportunity for a deep and large underground lab in Southern Hemisphere:
 - To educate new scientists within Latinamerica.
 - To establish international collaboration in many sciences.
 - To integrate Latin American nations around science objectives.
- International support, interest from world exp. Collaborations.
- Tunnel call for tender and ANDES inclusion in progress (expected completion within 8 years).
- More info at http://andeslab.org



Thank you

Backup slides

Experiments in U Labs

Experiments in underground Labs:

Neutrinos:

- from nuclear reactors
- from accelerators
- from the atmosphere
- from the Sun
- cosmic and Supernovae
- from inside the Earth





Experiments in underground Labs:

Geoscience

- Low frec. Seismographs
- Radon measurements
- geoneutrinos

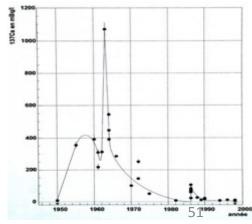
Low radiation measurements

- Material selection
- Environment pollution
- microelectronics

Biology



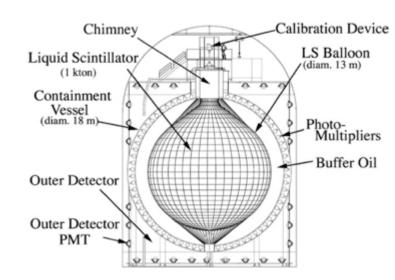




Preliminary ANDES Science program

eg. Proposed Neutrino detector

- 3 10 kton of liq. Scintillator
- similar to Borexino or KamLAND
- ANDES: unique site for geo nu's
- Can be used for Supernova nu's
- arXiv:1027.5454



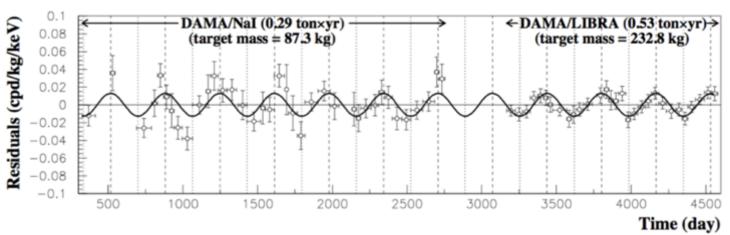
Double beta decay experiments

- eg. SuperNEMO:
 - $-100 200 \text{ kg of } ^{82}\text{Se}$
 - Larger experiment,
 based on NEMO, NEMO3 (LSM).
 - Modular design ≈ 20 modules
 - Neutrino mass sensitivity ≈ 0.05 eV
 - Design and schedule fits ANDES
 - strong interest from SuperNEMO

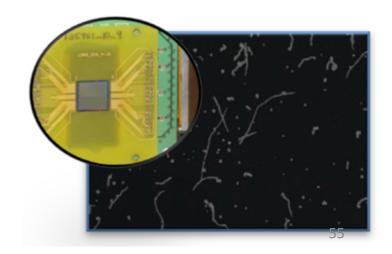


Dark Matter at ANDES





- To host copy of northern DM modulation exp.
- Host a 3rd generation DM exp.
- Work on new techniques...
 - e.g. CCD's, DNA chains, et c.



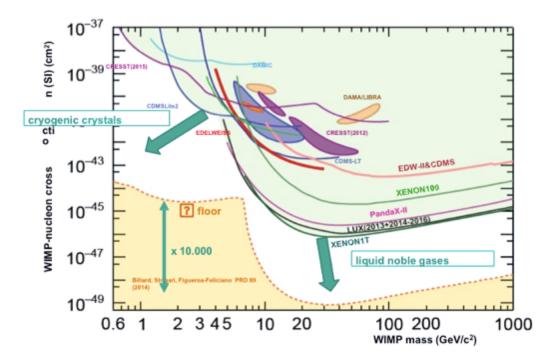
Experiments in underground Labs:

Dark Matter search:

- Needs different detector techniques (noble gas/liquid, ...)
- New techniques
 (bubble chambers, CCD, ...)



- Direct Detection
- Yearly modulation?



Nuclear reactions for Astrophysics

- LUNA (Laboratory for Underground Nuclear Astrophysics).
- installed at Gran Sasso
- 50 kV accelerator
- LUNA II: 400 kV
- Study low energy nuclear reactions in stars (Gamow peak)
- Proposal for a 300 kV, high intensity setup at ANDES