

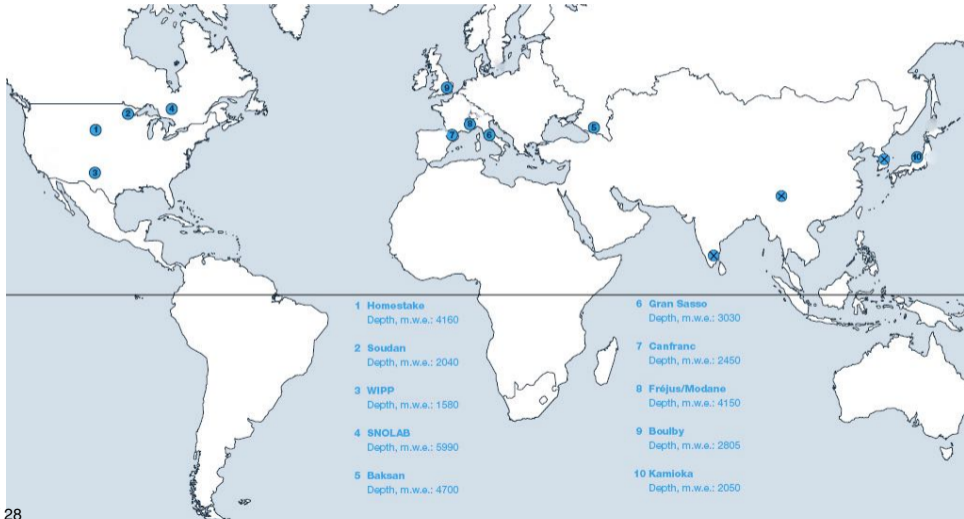
The ANDES underground laboratory in the south



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CNEA/CONICET

2nd World Summit on Exploring the Dark Side of the Universe
Guadeloupe islands - June 27, 2018

World map of underground laboratories

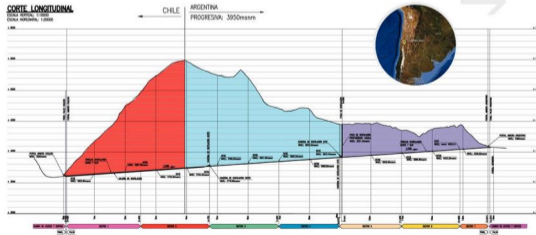


Updated world map of underground laboratories



The Agua Negra tunnel (Coquimbo - San Juan)

- Strategic crossing of the Andes to link productive areas to the Asian market
- 2 tunnels, 12 m \varnothing each, 60 m one from another, \approx 14 km
- Deepest point at \approx 1750 m depth
- Portals at 3650-3800 masl



The Agua Negra tunnel recent history

- Pre-feasibility study done in 2005, feasibility in 2008
- Presidents signed a Bi-National Integration treaty, including the San Juan - Coquimbo option, in October 2009, voted later on by both countries
- August 2010 MERCOSUR meeting in San Juan with strong support for Agua Negra
- Since 2011 the Argentine congress votes every year a 800 MU\$D guarantee fund
- In March 2012, Presidents signed an agreement to start the international tender
- 2013: new conceptual design and budget review
- 2014: detailed engineering design completed and construction protocol agreed upon
- In 2015, the IDB accepted to finance the project
- In December 2016, the first 40M\$ from IDB were received
- In October 2017, 280M\$ more from IDB were received
- Total cost estimated to 1.25 BU\$D, construction period 2019-2027

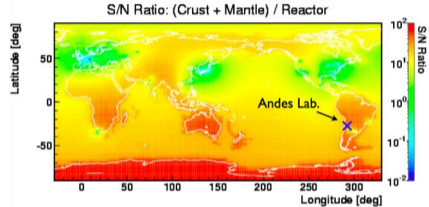


A scientific opportunity in the south?

- Opportunity for a big AND deep laboratory
- Located in the south
 - opposite weather modulation (dark matter)
 - complementary for supernovae neutrinos
- Geoneutrinos
(Low neutrino flux from nuclear power plants)
- Geoactive region
 - Underground geophysics laboratory

Manage it from an international consortium

- Opportunity to have not only international experiments but an international laboratory
- The consortium would be the seed of a “CERN” focused on underground science (high energies, geology, biology, technology...)
- International consortium structure similar to “SESAME”?

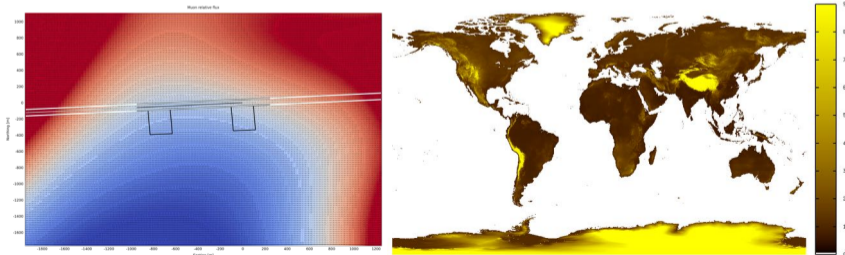


Background studies for ANDES

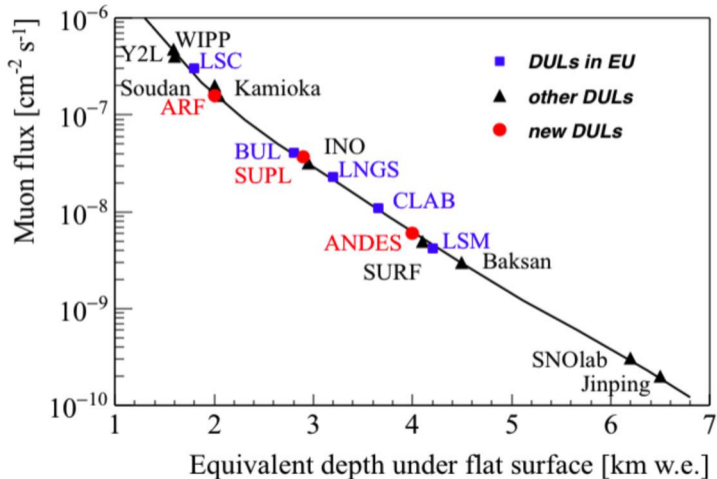
- 600 m deep rock samples measured for natural radioactivity (LAAN, M. Arribere)

(Bq/kg)	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

- Depth, muon flux and neutron activation calculations



Expected Muon Flux (Aldo Ianni - TAUP 2017)



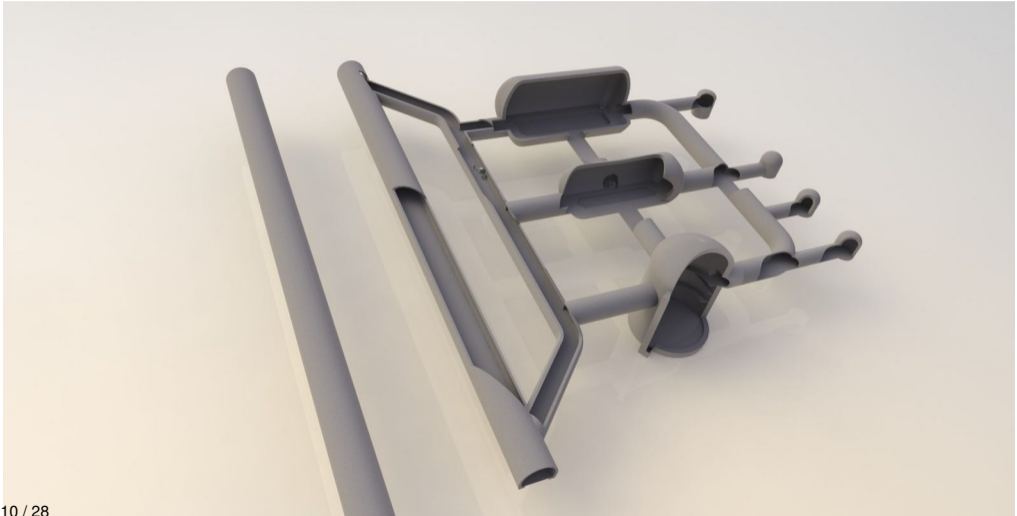
Original scientific programme for ANDES

- Neutrino
 - host a double beta decay experiment
 - build a large neutrino detector as a flagship experiment
 - similar to KamLAND/Borexino?
 - focused on low energies
 - solar/supernovae/geo-neutrinos
- Dark Matter
 - modulation measurements
 - 4th generation
 - new technologies
- Geophysics
 - Natural link of seismograph networks
 - “flat slab” study
- Biology
- Low radiation measurements
- Accelerator
 - Nuclear astrophysics
 - DAR neutrino beam?

“Typical” scientific programme for an underground laboratory

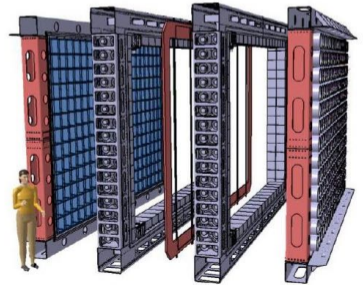
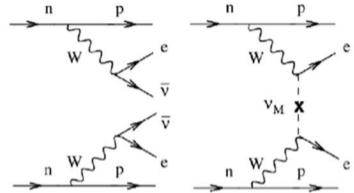


First proposal for the ANDES laboratory (2011)



SuperNEMO: double beta decay experiment

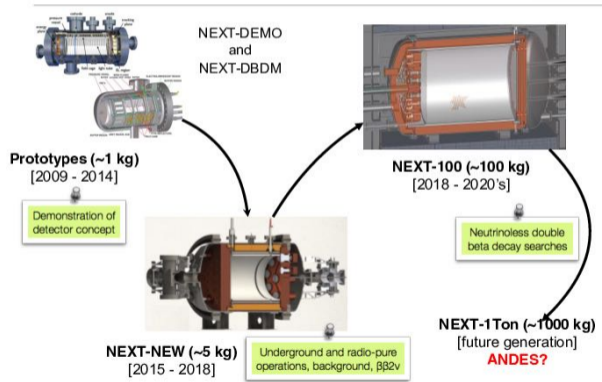
- based on NEMO-NEMO3 expertise (LSM)
- 100 – 200 kg of ^{82}Se
- sensitive to a neutrino mass of $\approx 0.05 - 0.1 \text{ eV}$
- modular design: ≈ 20 modules
- Status in 2027?



NEXT: double beta decay Xenon TPC

- NEXT at Canfranc
- Xenon TPC
- Background rejection by looking at blobs at both ends on trace
- Timescale ANDES compatible
- Discussed at 5th ANDES Workshop (June 2017)

DEVELOPING NEXT-100

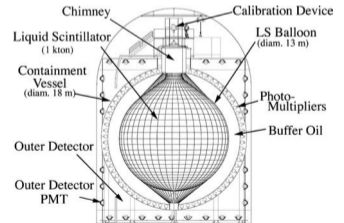
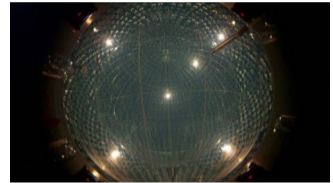


Large Neutrino Detector

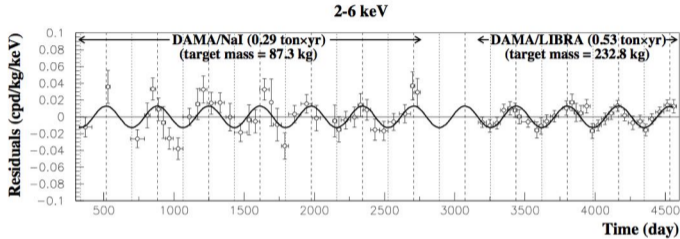
- design similar to Borexino and KamLAND?
 - 3 – 10 kton of scintillator
- interesting site for geoneutrinos
- complementary for supernovae neutrino measurements

(arXiv:1207.5454, arXiv:1305.4430)

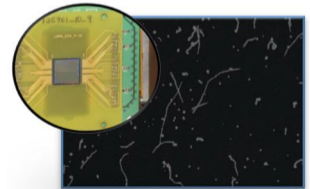
→ Have a large pit foreseen for the detector



Dark Matter in ANDES



- host a copy of an experiment observing a modulation
- host a 4th generation experiment
- work on new technologies (actively evolving area)
 - ex: DAMIC (Dark Matter Identification with CCD)



Dark Side: Argon TPC

- Argon community joined on Dark Side
- Timescale ANDES compatible
- Discussed at 5th ANDES Workshop (June 2017)

(New) Argon Collaboration

Researchers from

- DarkSide
- DEAP
- ArDM
- MiniCLEAN

DS-20K → multi-100-T

planning to collaborate on future program:

- Completion of current science and R&D programs by each collaboration (DS-50, DEAP-3600, MiniCLEAN, ArDM)
- Joint collaboration on DS-20K at LNGS, including Low Radioactivity Argon (operation starting 2021) and SiPM photodetectors
- Joint collaboration on future multi-hundred-tonne LAr detector, site TBD (mid-2020's)

Mark Boulay 3/23/2017

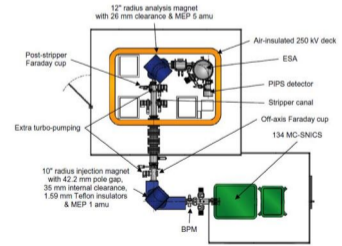


Nuclear astrophysics

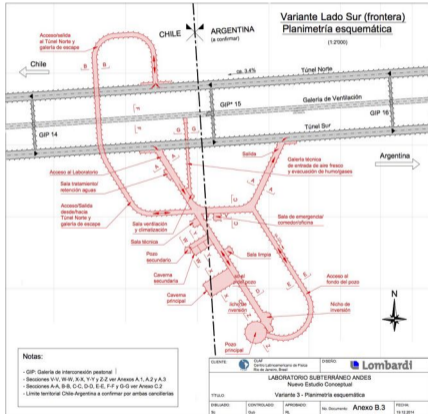
LUNA: Laboratory for Underground Nuclear Astrophysics

- installed at LNGS (Gran Sasso)
- 50 kV accelerator
- 400 kV (LUNA II)
 - study nuclear reactions at low energies, relevant in astrophysics (Gamow peak)
 - ex: ${}^3\text{He}({}^3\text{He}, 2p){}^4\text{He}$ below 21 keV

Proposal for a 300 kV high intensity platform for ANDES



Conceptual design for the ANDES laboratory (January 2016)

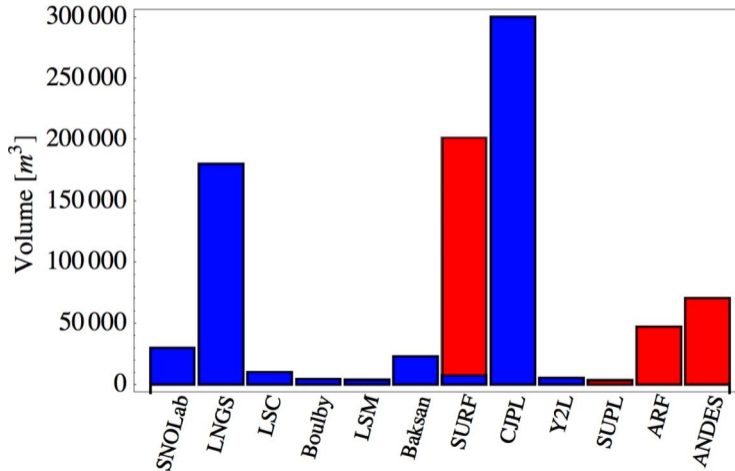


- main hall:
(21×23×50) m³
- secondary hall:
(16×14×40) m³
- small halls (office, workshop, clean room, ...):
total 340 m²
- ultra-low radiation pit: ∅9 m, 9 m depth
- single experiment pit: ∅30 m, 30 m depth

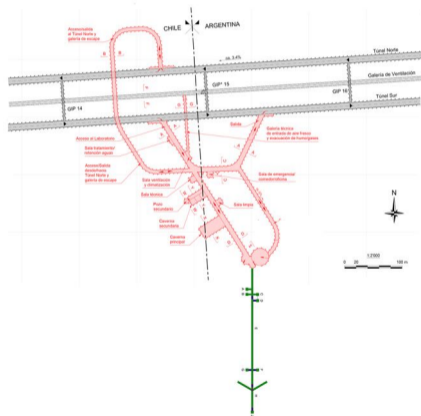
Total civil work cost: 38.1M\$
< 2.5 % of tunnel cost



ANDES size (Aldo Ianni, TAUP 2017)



Last minute details



- Add GEO portion (inspired by BFO, Germany)
- Add BIO independent laboratory
- Reorder small rooms
- Add Accelerator room?
- Keep cost close to 40M\$ while adding multidisciplinary platforms



Two support laboratories



- At La Serena (Chile) and Rodeo? (Argentina)
- Workshops for the underground activities
- Integration with local universities (academic activity)
- Visitor centres



International and institutional support

- Memorandum of Understanding signed during the first ANDES workshop (includes the signatures of the director of Modane, the emeritus director of Homestake, the spokespersons of SuperNEMO and Edelweiss II).
- EBITAN (Entidad Binacional Túnel Agua Negra), supported the ANDES laboratory in its Xth meeting and agreed on including it in the Agua Negra tunnel project in its XXXVth meeting
- Support and interest by latin american institutions:
 - CONICET, Argentina
 - MinCyT, Argentina
 - Universidad de La Plata, Argentina
 - Universidad de San Juan, Argentina
 - ANDES Unit in CLAF
 - Universidad La Serena, Chile
 - Gobierno de la provincia de San Juan, Argentina
 - CONICYT, Chile
 - Gobierno de la provincia de Elqui, Chile
 - Gobierno de la región de Coquimbo, Chile
 - CCHEN, Chile
 - MinRel, Chile
- Support and interest by representatives of latin american scientists and institutions:
 - Claudio Dib, representing groups from 4 Chilean universities
 - Juan Carlos D'Olivo, High Energy Physics Network, Mexico
 - Ronald Shellard, CBPF and SBF vice director, Brazil
 - Eduardo Charreau, ANCEFAN president, Argentina
 - Francisco Tamarit, AFA president, Argentina
- 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



Manifested interest in contributing to ANDES

- interest for collaboration and instrument installation in ANDES:

- Jennifer Thomas, SuperNEMO CB Chair
- Daniel Santos, MIMAC Spokesperson
- Kai Zuber, COBRA Spokesperson
- J. Conrad, M. Shaevitz, DAEDALUS Spokespersons
- A. Galindo-Uribarri et al., ORNL

Interest in collaborating to the construction and operation of the ANDES laboratory by latin american groups:

- 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 timeline

- Project started in July 2010
 - First 3 ANDES workshops in Buenos Aires, Argentina, April 2011, Rio de Janeiro, Brazil, June 2011, Valparaíso, Chile, January 2012
 - approved by the Argentine MinCyT (CAGICyT) and EBITAN, March 2012
 - Fourth workshop in Mexico City, Mexico, January 2014
 - ANDES Unit in CLAF created, January 2014
 - Laboratory New Conceptual Design ready, January 2016
 - Fifth ANDES workshop in Buenos Aires, Argentina, June 2017
 - ANDES approved into the TAN civil work by EBITAN, July 2017
-
- ▷ Detailed engineering study (0.5 MU\$D) started 2 weeks ago
 - ▷ Construction together with tunnel 2019-2027 (2021-2025)



Next ANDES workshop: join now!



ICTP SAIFR International Centre for Theoretical Physics South American Institute for Fundamental Research

CLAF

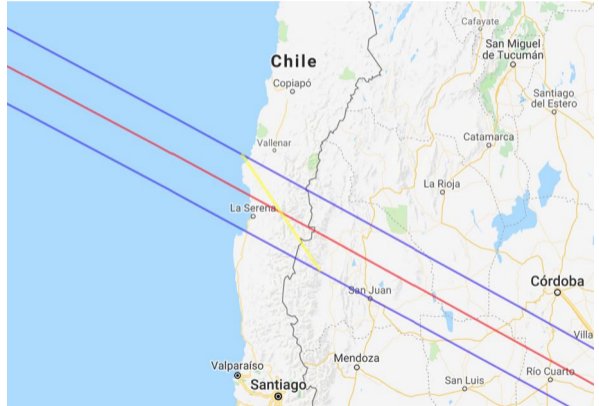
6TH INTERNATIONAL WORKSHOP FOR THE DESIGN OF THE ANDES UNDERGROUND LABORATORY

August 4-6, 2018
at Instituto de Física Teórica - UNESP, São Paulo, Brazil



Next Next ANDES workshop

- La Serena, Chile
- Around July 2, 2019



Next Next Next ANDES workshop

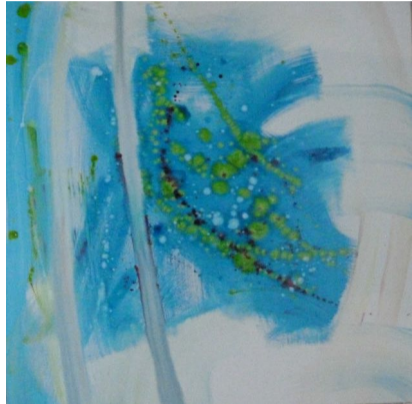
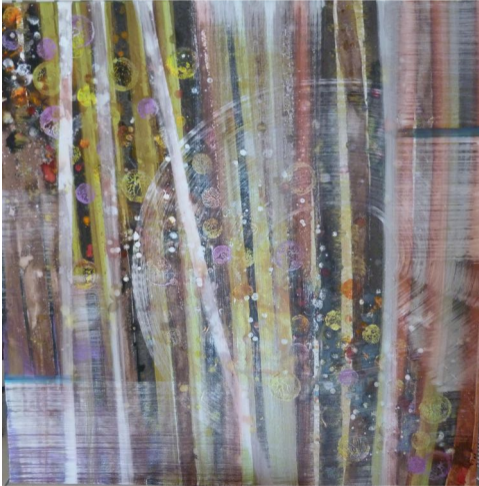
- Las Grutas, Argentina
- Around December 14, 2020



This is a unique opportunity to build a world class deep underground laboratory, one of a kind in the southern hemisphere, operated by an international consortium



Thank you!



Neutrino search
(*Kay Quattrocchi, 2012*)

