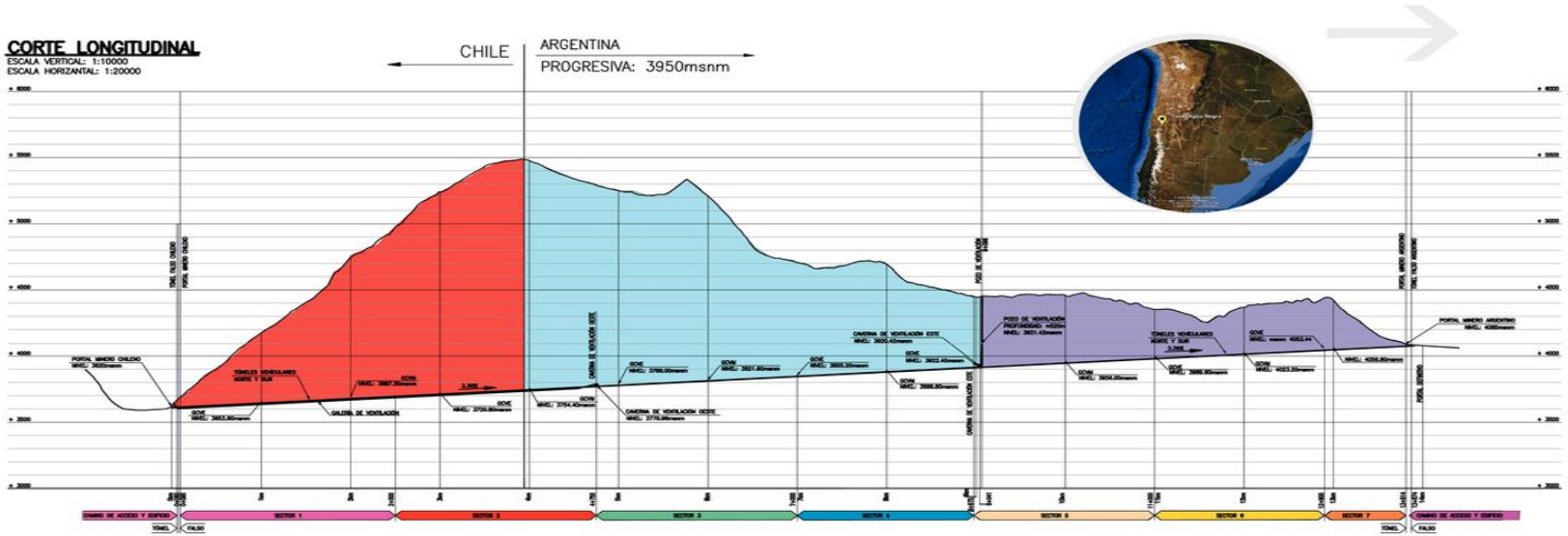
ANDES

Agua Negra Deep Experiment Site

Towards the first deep underground laboratory of the Southern hemisphere.



Xavier Bertou

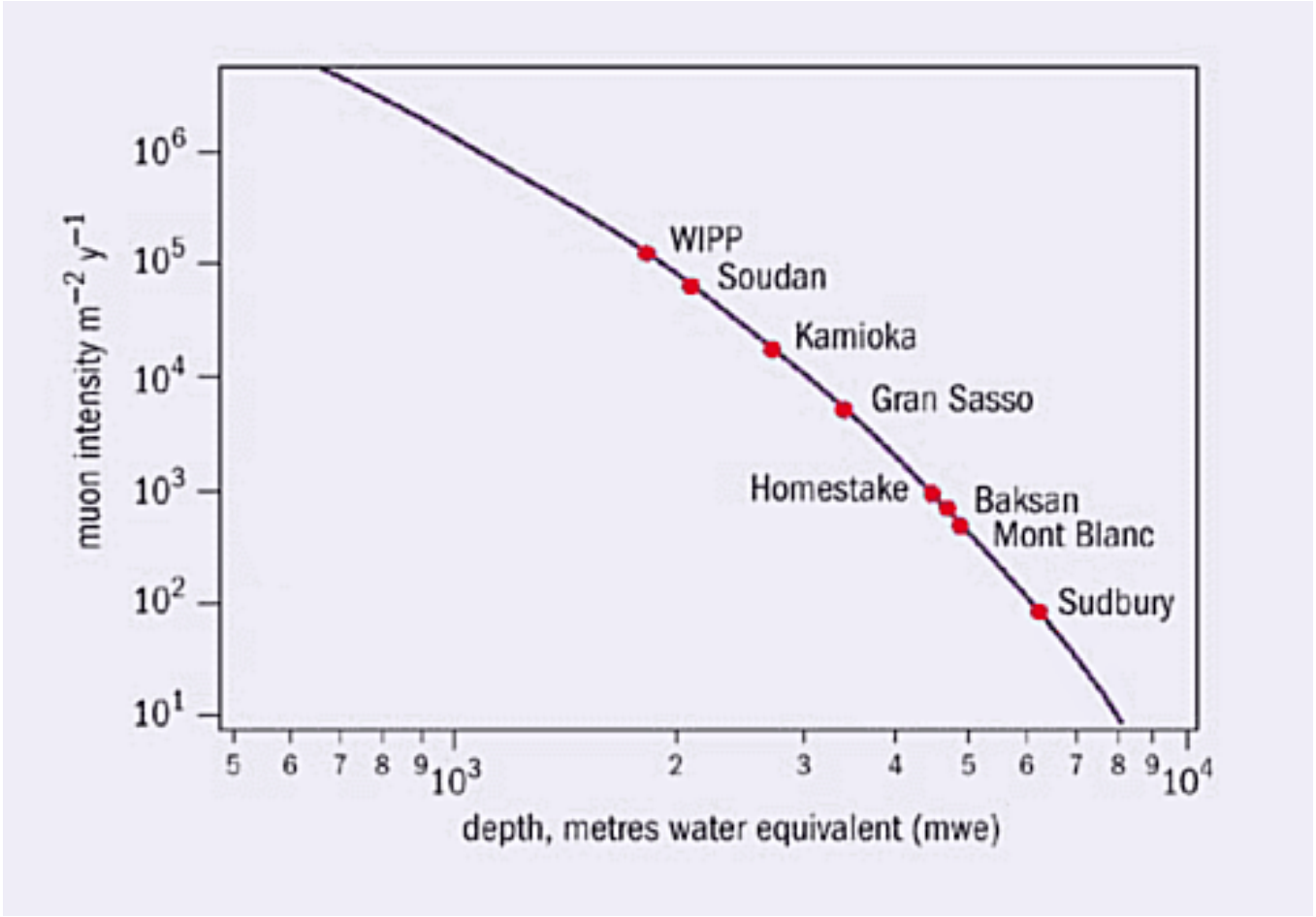
Centro Atómico Bariloche - CNEA/CONICET

CTA LINK - Buenos Aires - October 2012

Deep Underground Laboratories

Muon flux and overburden

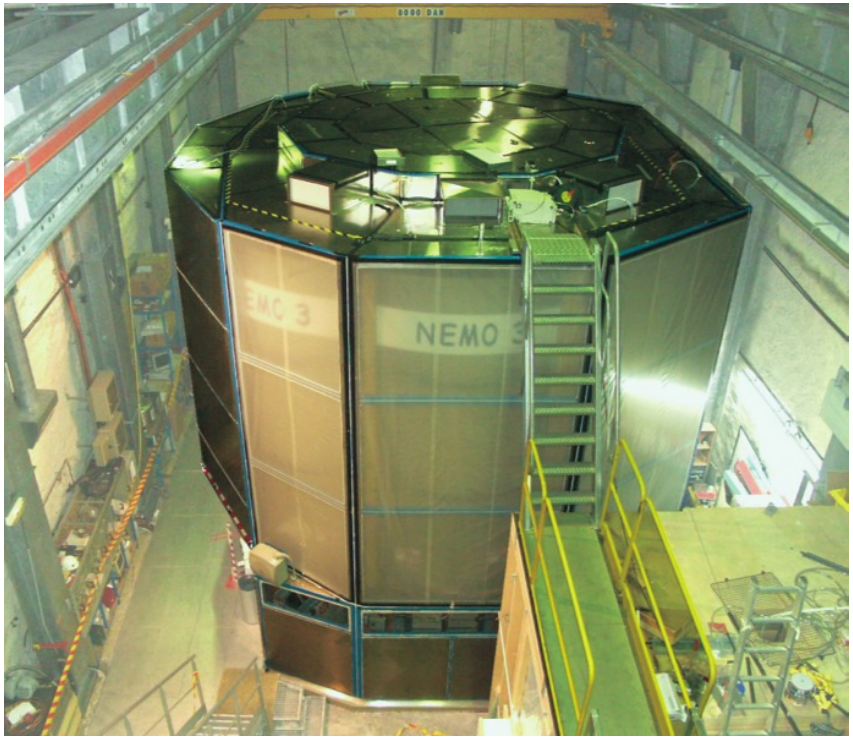
Muon flux at sea level: a few $100\,\mathrm{m}^{-2}\,\mathrm{s}^{-1}$



Muon flux 5000 mwe underground: $\approx 1\,\mathrm{m}^{-2}\,\mathrm{day}^{-1}$

Neutrino measurements

- nuclear reactor neutrinos
- particle accelerator neutrinos
- atmospheric neutrinos
- solar neutrinos
- extrasolar neutrinos
- geoneutrinos



- neutrino oscillation
- neutrino mass
- neutrino nature
- astrophysics/cosmology
- geophysics

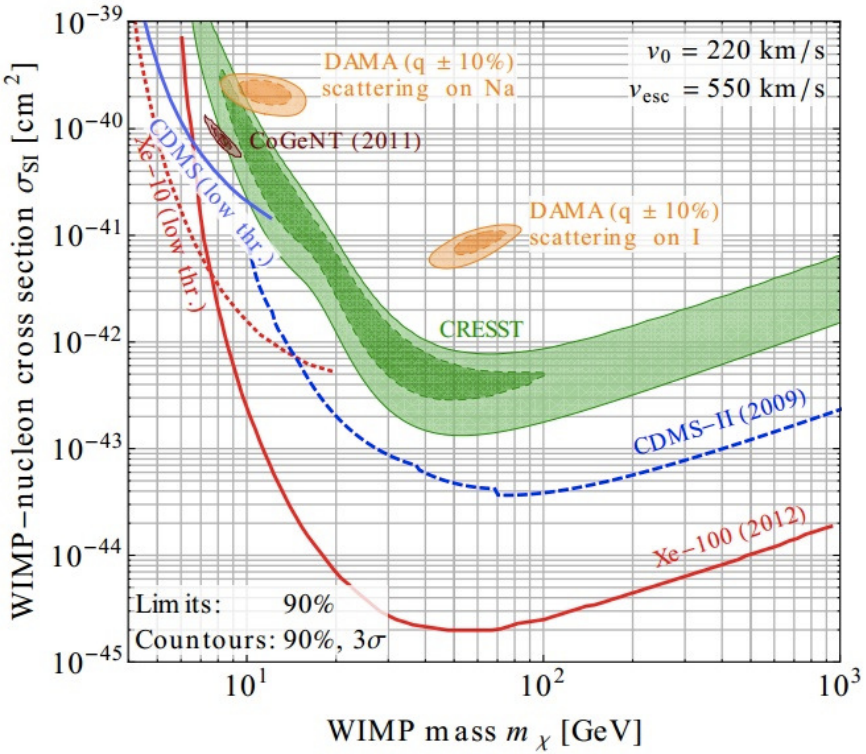
Experiments in underground laboratories - DM

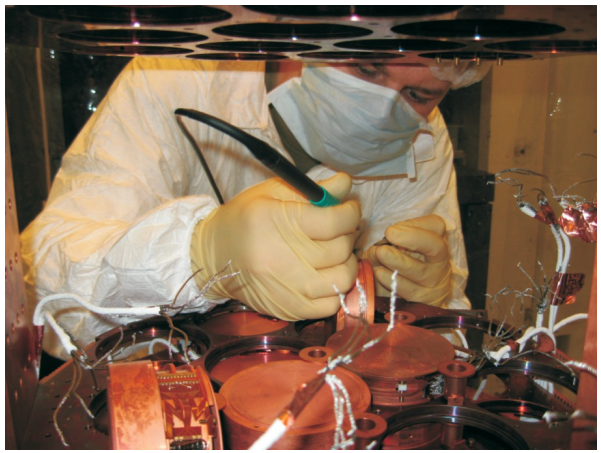
Dark Matter search

- 24% of Universe, 85% of matter

- different detector techniques (cryogenics, noble gas/liquids, ...)
- new ”exotic” techniques (bubble chambers, CCD, ...)

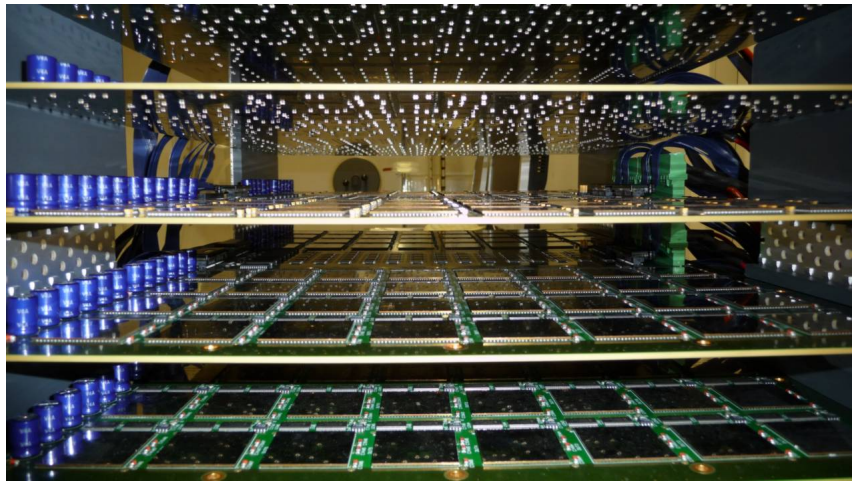
- direct detection
- indirect search (modulation)



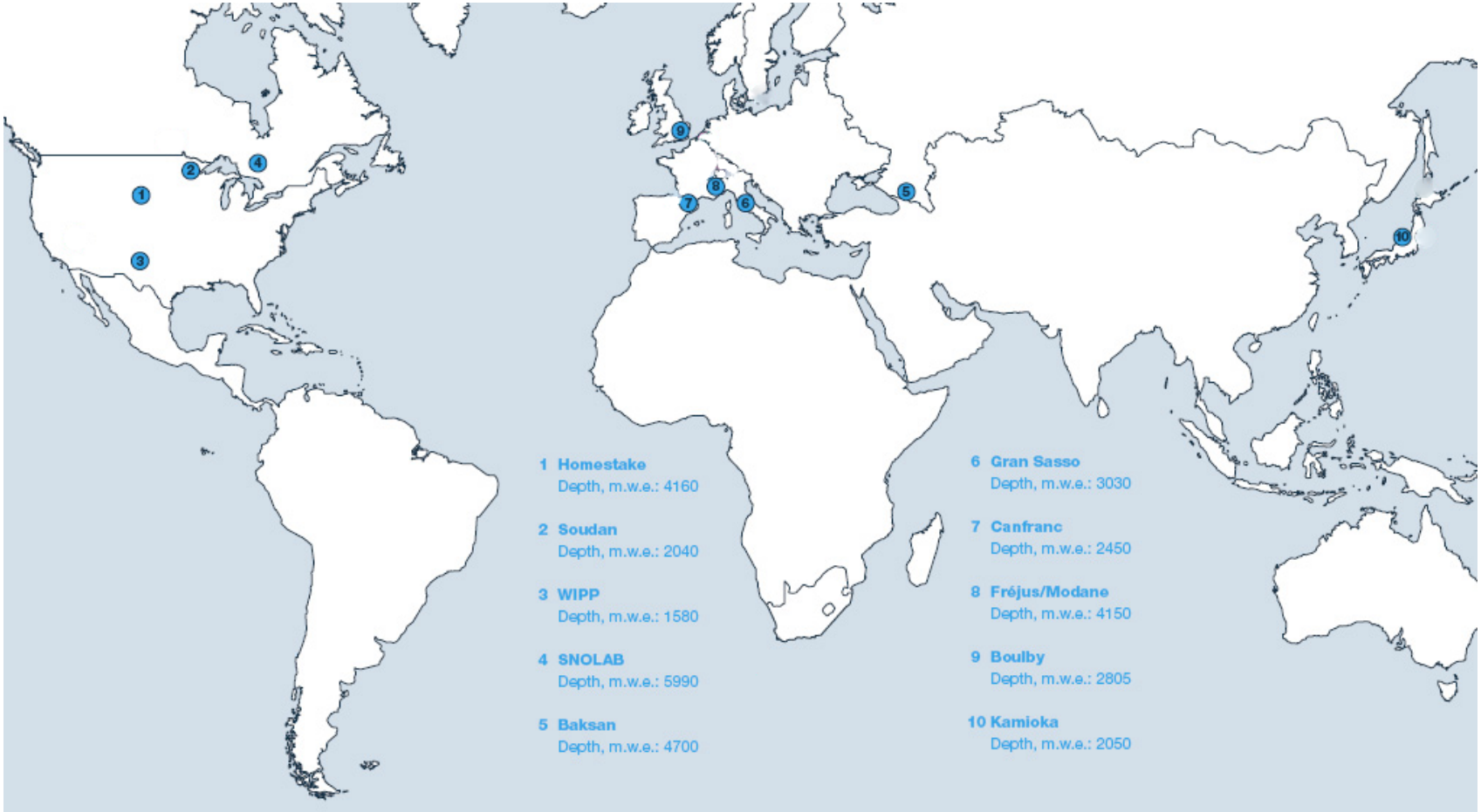


Experiments in underground laboratories - continued

- Geoscience
  - seismograph (low frequency)
  - geoneutrinos
- Low radiation measurements
  - material selection
  - climatology, environment
  - microelectronics
- Biology



Underground Laboratories



- \+ China, Korea, India
- mines (harder to work in), tunnels (harder to plan)
- None in the southern hemisphere

Southern hemisphere and Latin America?

South Africa

- First atmospheric neutrinos in 1965 (together with India)

South America

- Argentina: experiment at Sierra Grande mine (1000 wme)
  - Search for an annual modulation of dark-matter signals with a germanium spectrometer at the Sierra Grande laboratory Astropart.Phys. 10 (1999) 133-139
- Brazil: search for a mine by Lattes
- Chile: El Teniente mine prospected

Latin America

- Mexico: proposal of the multidisciplinary mexican underground laboratory (LSMM) for Mega Proyectos 2006

The Agua Negra tunnel and the ANDES laboratory

Andes crossing

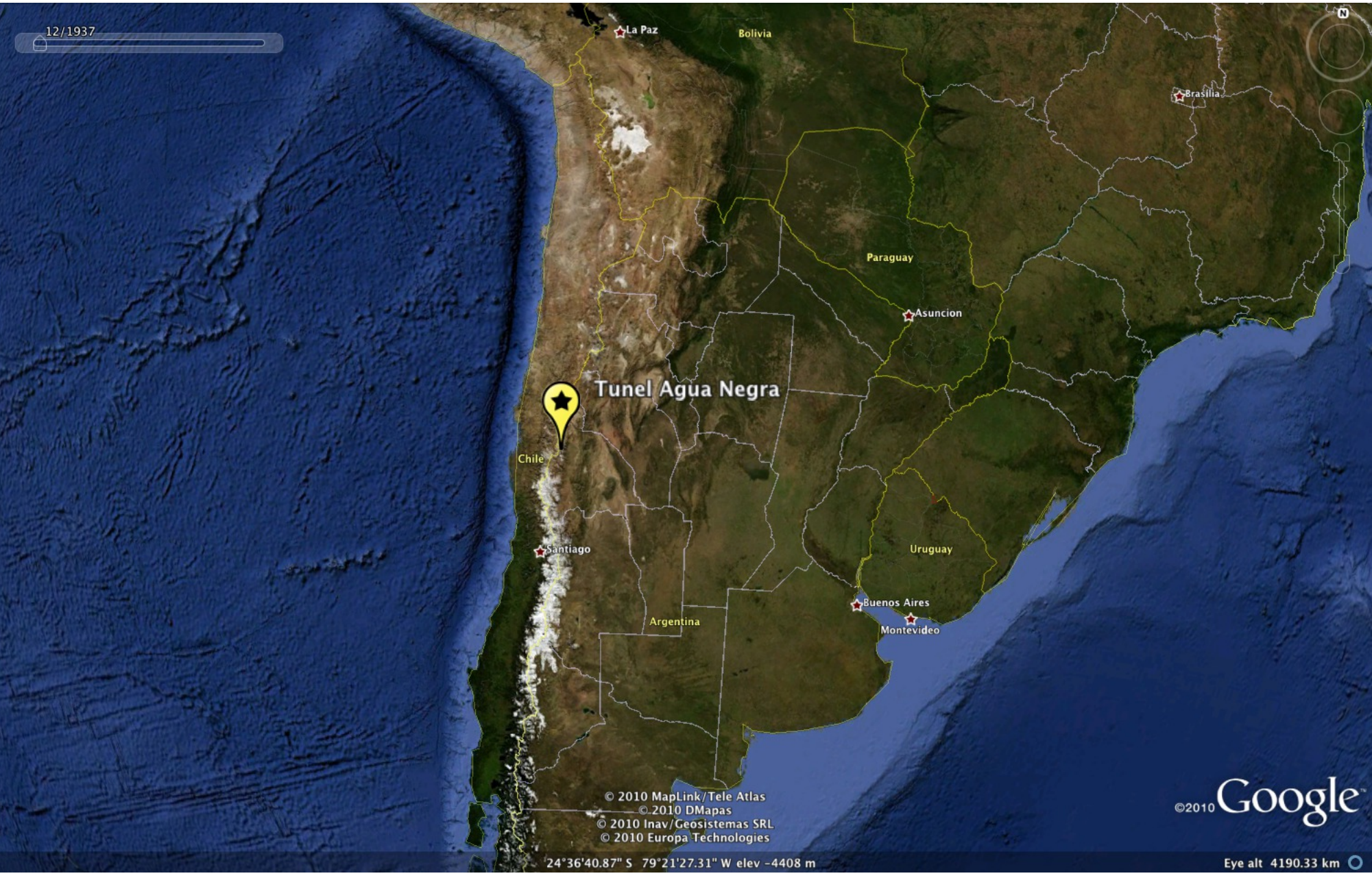
- It is of strategic importance for the region to increase exportation to the Asian market
- The natural way for Argentina and Brazil is to export by boat through Chile
- There are various passes. The main one, the Cristo Redentor tunnel from Mendoza to Santiago, cannot fulfil the increasing international demand, especially in winter when it has to close due to strong snows.

- Argentina, Brazil and Chile have been looking for years at complementary options
- There have been various proposals for Mendoza - Santiago (train tunnel, Las Leñas pass) and San Juan - Coquimbo (Agua Negra)
- Recently the San Juan - Coquimbo option has been favoured

The Agua Negra tunnel context

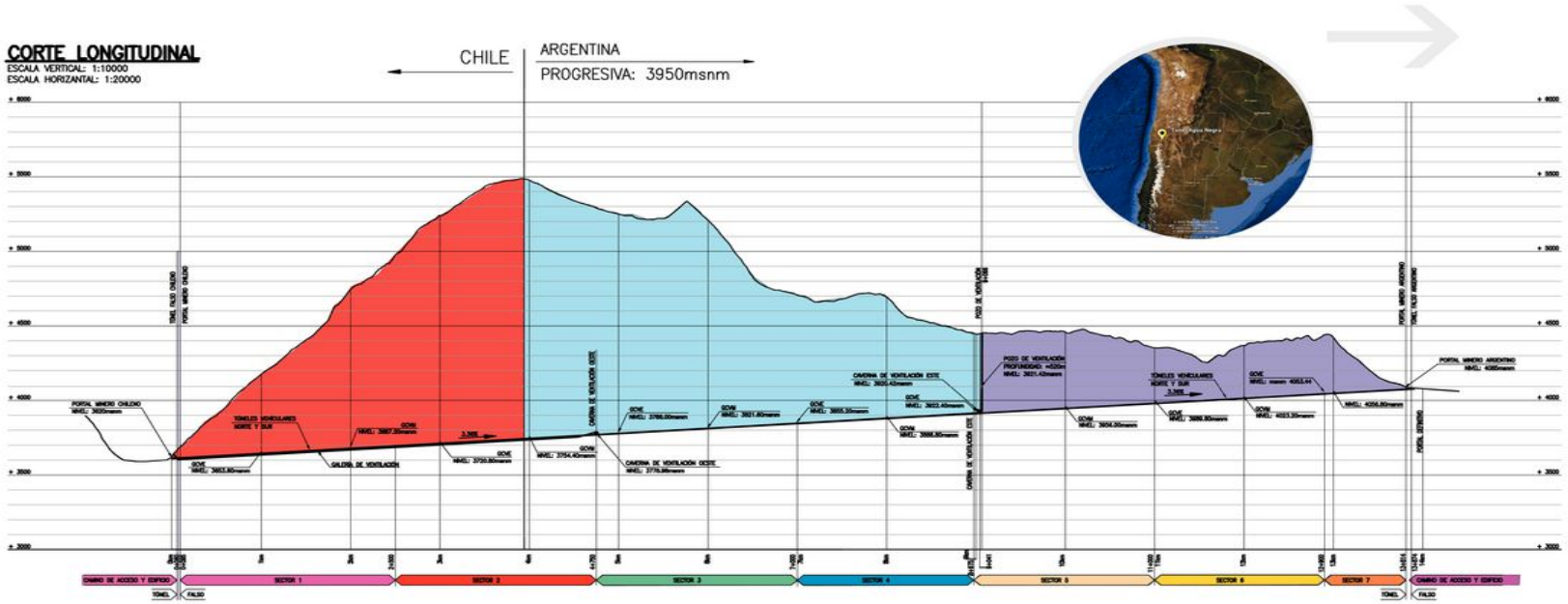
- Pre-feasibility study done in 2005, feasibility in 2008
- Cristina Fernández de Kirchner and Michelle Bachelet signed a Bi-National Integration treaty, including the San Juan - Coquimbo option, in October 2009, voted later on by both countries
- August 2010 MERCOSUR meeting was in San Juan and a strong support for the Agua Negra tunnel was given, with Luis Inácio Lula da Silva pushing for the tunnel tender
- In December 2011 the Argentine congress voted a 800 MU$D guarantee fund for the Agua Negra tunnel
- In March 2012, Cristina Fernández de Kirchner and Sebastián Piñera signed an international agreement asking for the tender of the tunnel
- Call for tender expected for December 6
- Total cost estimated to about 850 MU$D

Location of the Agua Negra pass



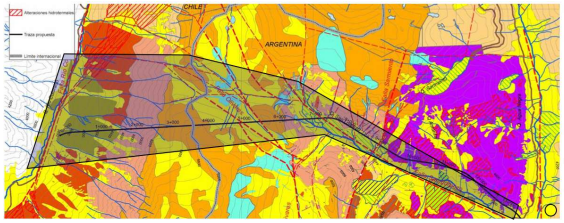
Tunnel proposed

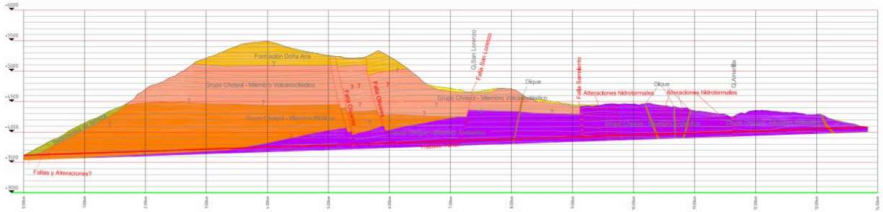
- 2 tunnels, 12 m $\varnothing$ each, separated by 60 m, $\approx$ 14 km long
- Argentine entry point at the Quebrada San Lorenzo, 4085 m a.s.l.
- Chilean entry point on a ridge, at $\approx$ 3600 m a.s.l.
- Internal connexion galleries every 500 m
- Deepest point at $\approx$ 1750 m depth
- Tender in 2013, Construction 2014-2020



Agua Negra Geology studies

- data from 8 main perforations of up to $\approx$ 600 m deep

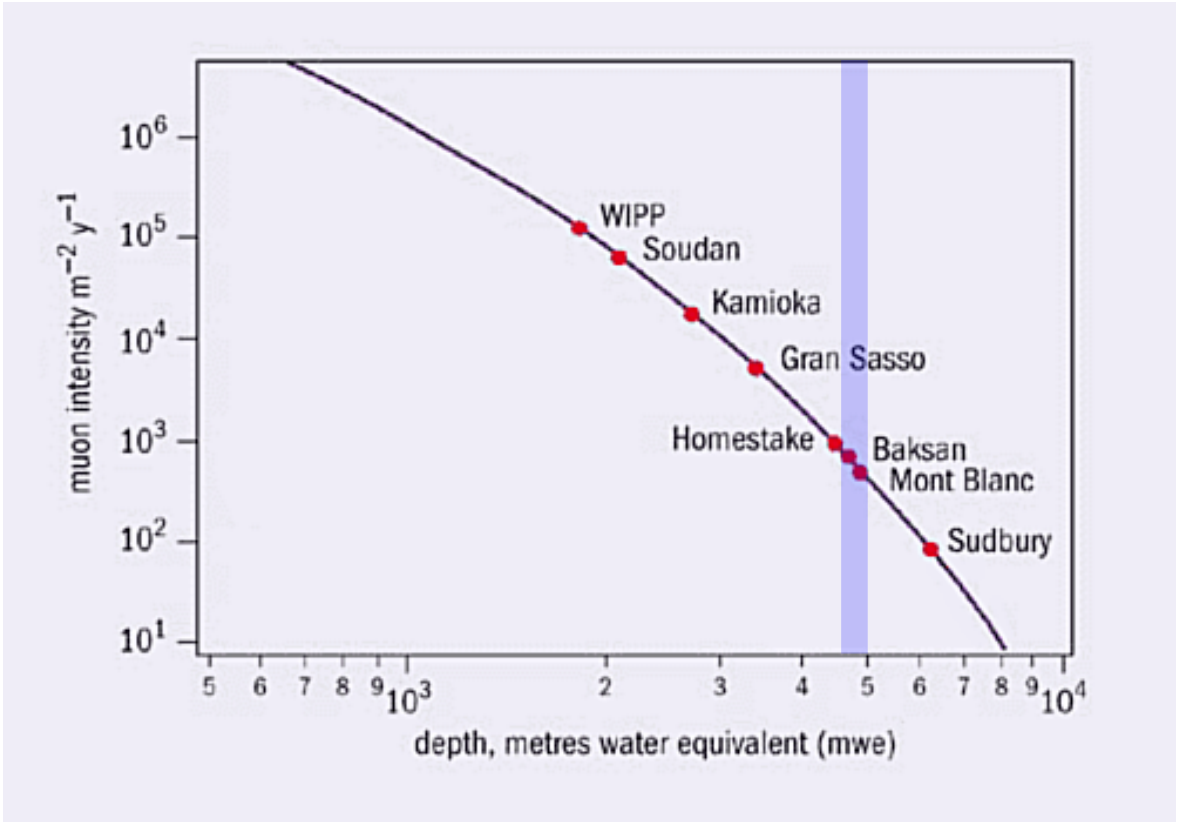




Main rocks

- Andesite
- Rhyolite
- Basalt
- Dacite
- Trachyte

1750 m depth:
4600-5000 mwe



Rock radioactivity measurements

- 9 samples, mostly from ≈ 600 m deep

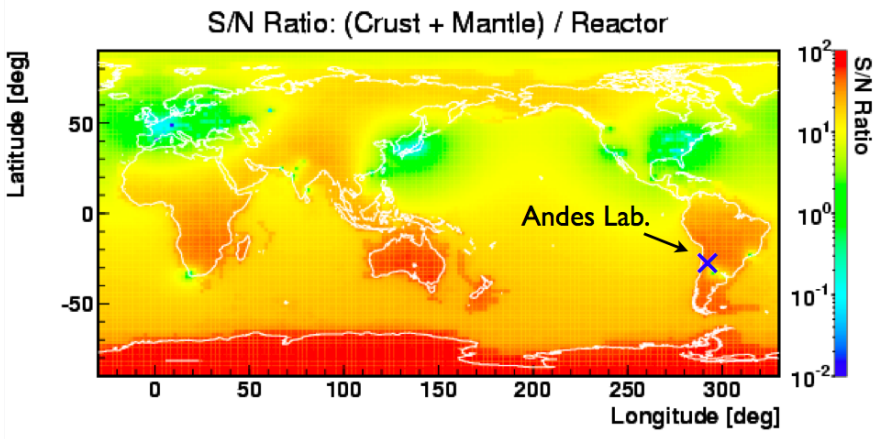
Radioactivity data (Bq/kg)

	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	$37 - 880$

What makes ANDES special?

(in addition to, for us, being in Latin America)

- Big AND Deep
- Only deep underground laboratory in the southern hemisphere
  - Opposite weather induced modulations
- Low reactor neutrino bkg
  - Embalse: 2.1 GWt, 560km
  - Atucha: 1.2 GWt, 1080km (Atucha II: 2.1 GWt)
- Geoactive region
  - geophysics underground laboratory
- Very long baselines?
  - CERN: 9920 km
  - Fermilab: 7640 km (“magic” baseline)
  - KEK: 12425 km (1500 km from Earth center)

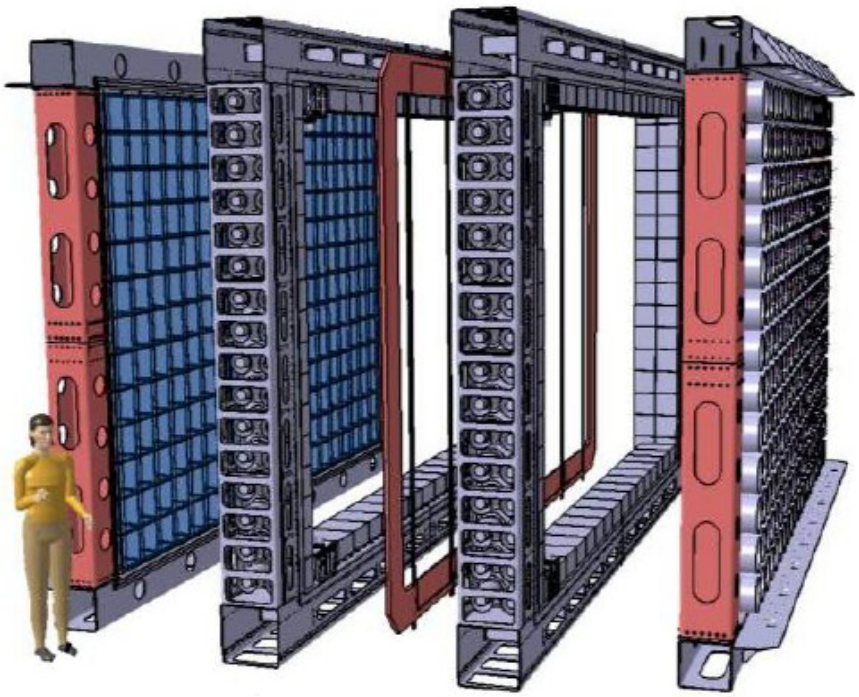


ANDES Initial Scientific Programme

- Neutrino
  - host double beta decay experiments
  - large Latinamerican neutrino detector
    - KamLAND/Borexino style
    - focus on low energy
    - solar/SN/geo neutrinos
- Dark Matter
  - modulation measurement
  - new technologies
- Geophysics
  - link Argentine and Chilean seismograph networks
- Biology
- Low Background measurements
- Accelerator
  - Nuclear Astrophysics
  - DAR neutrino beam?

SuperNEMO double beta decay experiment

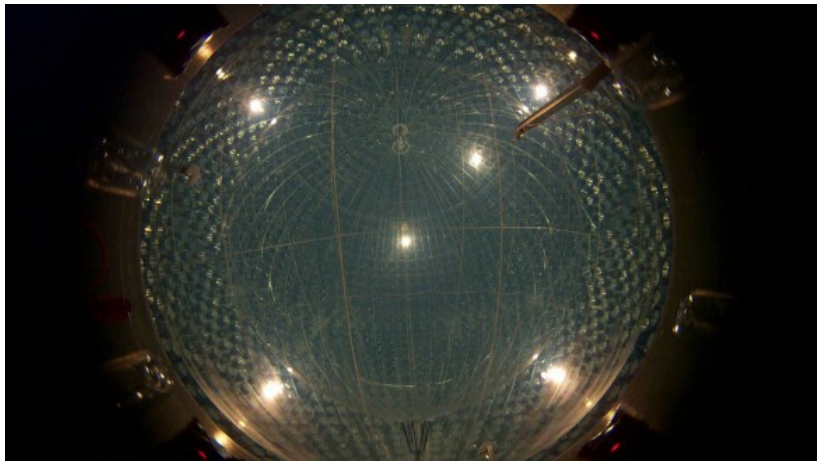
- based on NEMO-NEMO3 experience (LSM)
- $100 - 200\,\text{kg}$ of ^{82}Se
- neutrino mass sensitivity:
  $\approx 0.05 - 0.1\,\text{eV}$



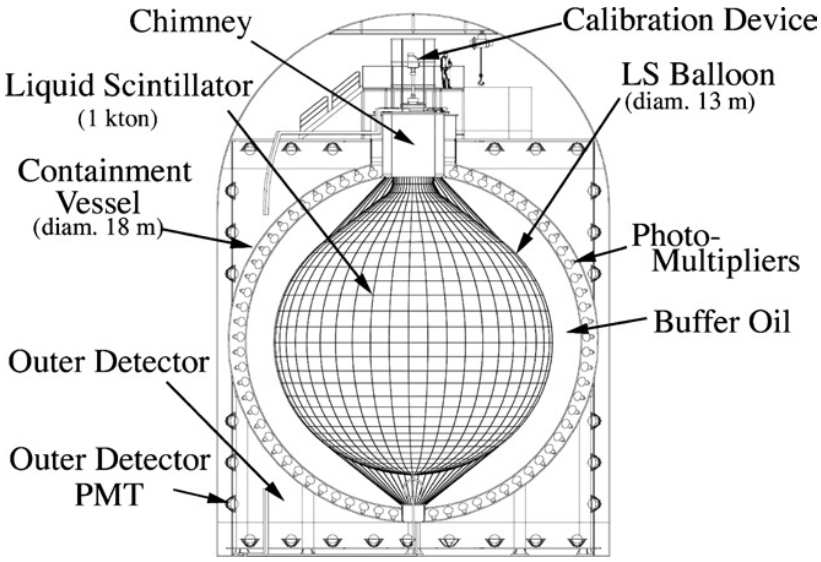
- modular design:
  ≈ 20 modules
- demostrator for 2013

  - design and schedule well adapted to ANDES
  - strong interest from SuperNEMO representatives

Large Latinamerican Neutrino Detector



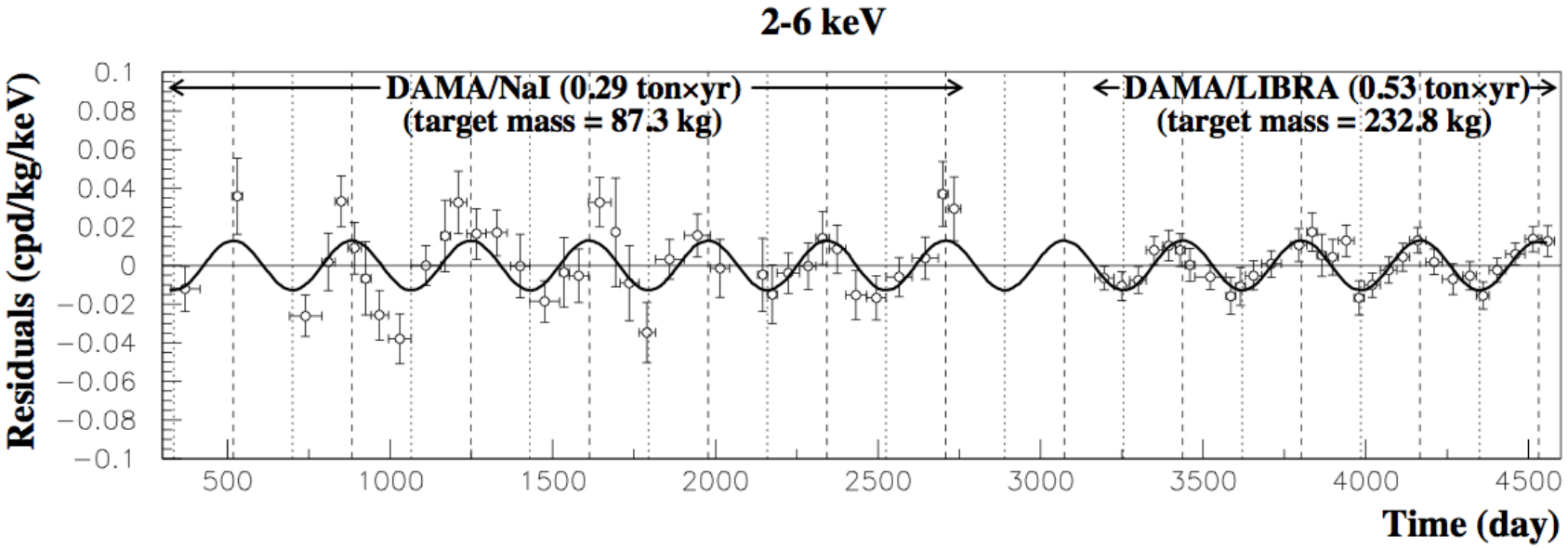
- similar design to Borexino and KamLAND
- $3 - 10$ kton of scintillator volume



- unique site for geoneutrinos
- complementarity for supernova neutrinos analysis arXiv:1027.5454

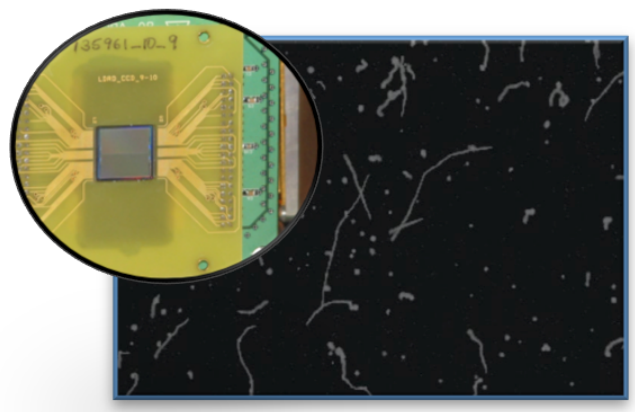
  - design under study
  - main topic of next ANDES Workshop

Dark Matter in ANDES



- host a copy of a DM experiment observing a modulation signal
- host a 3rd gen. DM experiment

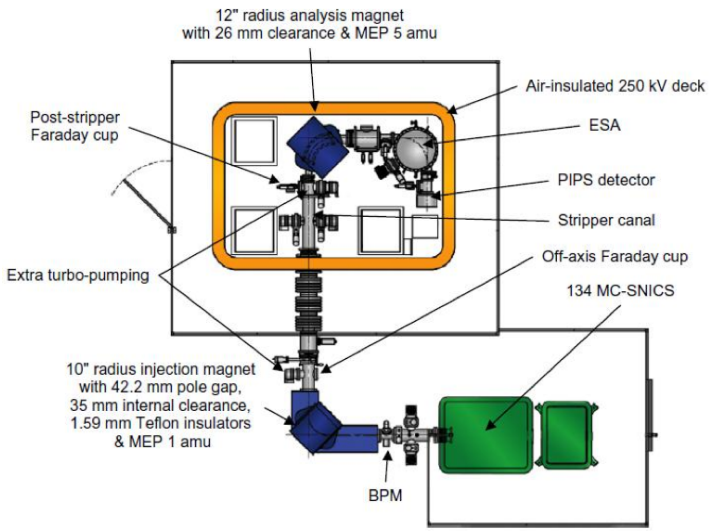
- work on new technologies (fast evolving topic)



LUNA: Laboratory for Underground Nuclear Astrophysics

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

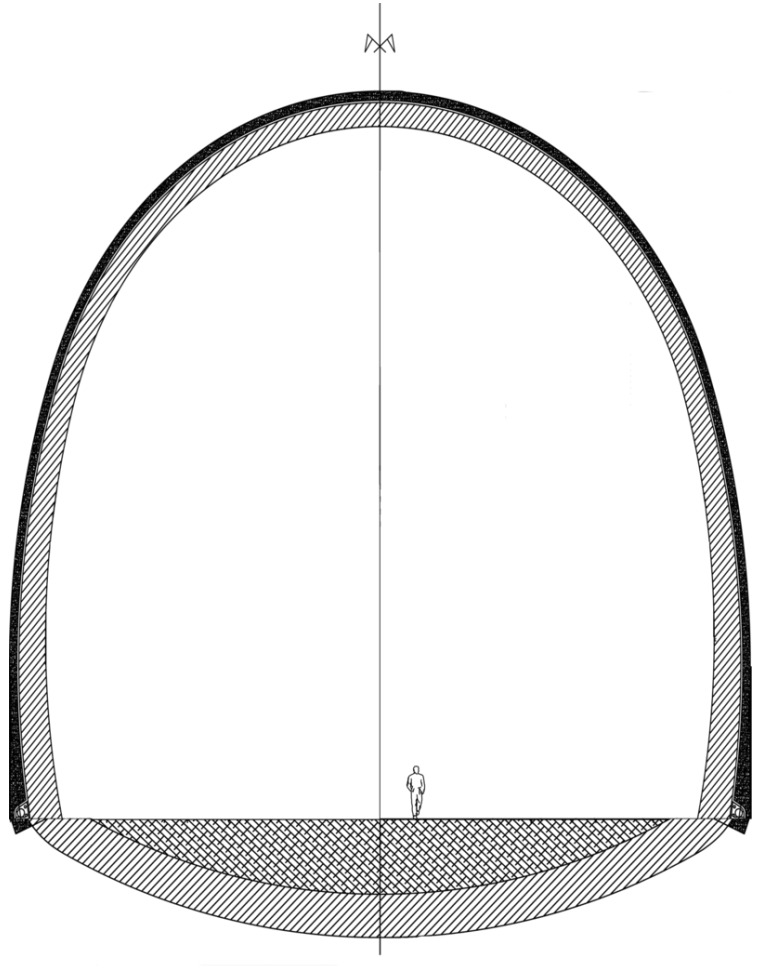
Proposal from Galindo-Uribarri, Padilla-Rodal and Vega for a 300 kV high intensity platform at ANDES



ANDES Laboratory proposal

Located at km 3.5-5

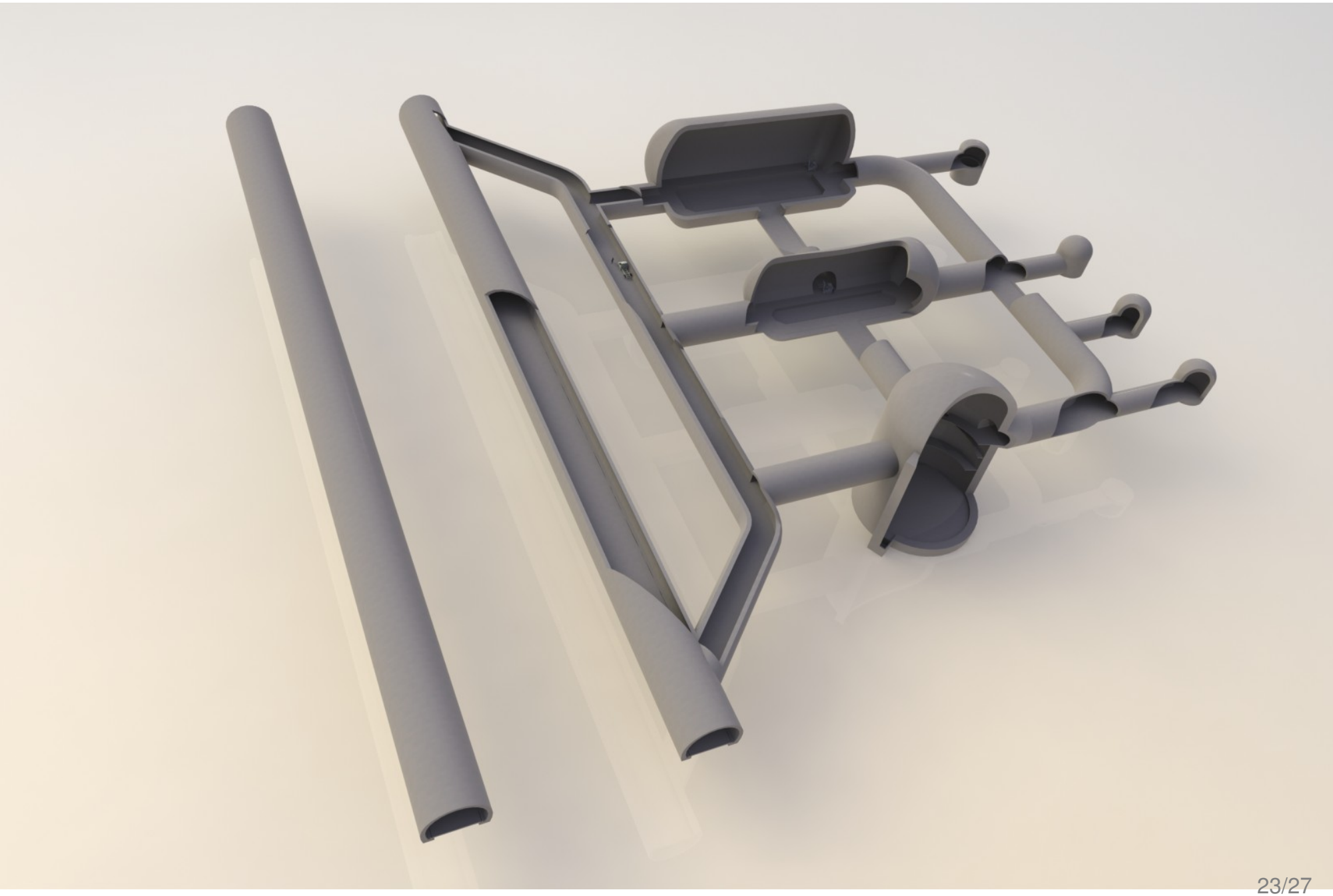
- main hall:
  $(21 \times 23 \times 50)\,\mathrm{m}^3$
- secondary hall:
  $(16 \times 14 \times 40)\,\mathrm{m}^3$
- multi-halls:
  $3 \times \varnothing 9\,\mathrm{m}$, $7\,\mathrm{m}$ tall
- ultra-low radiation pit:
  $\varnothing 8\,\mathrm{m}$, $9\,\mathrm{m}$ depth
- single experiment pit:
  $\varnothing 30\,\mathrm{m}$, $30\,\mathrm{m}$ depth



Total civil work cost:
$< 2\,\%$ of tunnel cost

- + scientific equipment cost
- + 2 external labs
- + experiments cost

ANDES Laboratory concept



Agua Negra surroundings

- Offices at the portals
  (for short stays)
- Two support labs, one in La Serena or Vicuña (Chile), the other one possibly in Rodeo (Argentina)
- Integration with local universities, host visitor centers...

El Consorcio Latinoamericano de Estudios Subterráneos

- Excellent opportunity to have an international laboratory, not only international experiments
- The MERCOSUR (UNASUR) aspect of the Agua Negra tunnel can be naturally extended to the ANDES laboratory
- The CLES would be our “seed” for a small CERN with respect of underground science (not only high energy: geology, biology, technology...)

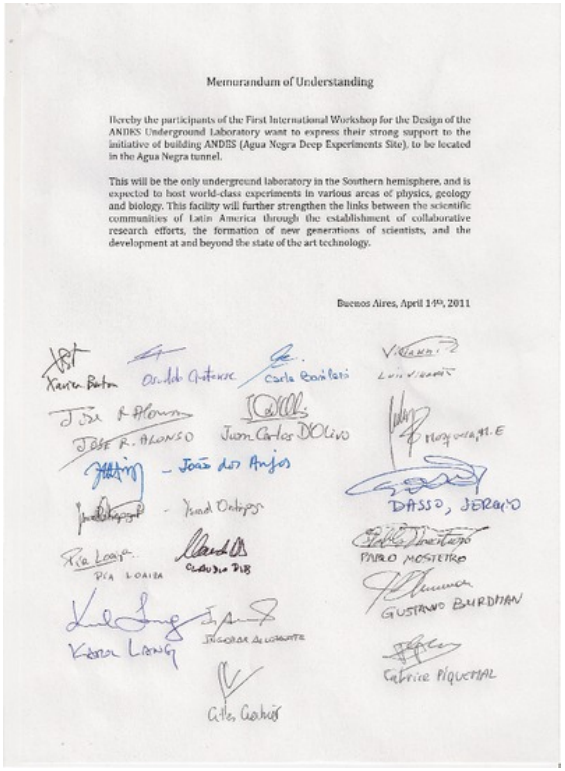
- Common participation for the ANDES laboratory operation and operating funds
- CLES manages the ANDES laboratory (with support from external international scientific advisory board)
- Initial participants: Argentina, Brazil, Chile, Mexico

Current Status

- International community support:
  - 20 support letters

    (underground lab directors, international projects spokespersons, national physics associations and academies...)
- Regional interest:
  - 26 letters from latinamerican groups
- First workshop in Buenos Aires, April 2011
- Second in Rio, June 2011
- Third in Valparaíso, January 2012
- Next in Mexico, March-April 2013
- Official support from Argentine MinCyT (Comisión Asesora Grandes Instrumentos)
- Official support from EBITAN (Entidad bi-nacional túnel Agua Negra)

Memorandum of Understanding (First workshop, Buenos Aires, April 2011)



Memorandum of Understanding

Hereby the participants of the First International Workshop for the Design of the ANDES Underground Laboratory want to express their strong support to the initiative of building ANDES (Agua Negra Deep Experiments Site), to be located in the Agua Negra tunnel.

This will be the only underground laboratory in the Southern hemisphere, and is expected to host world-class experiments in various areas of physics, geology and biology. This facility will further strengthen the links between the scientific communities of Latin America through the establishment of collaborative research efforts, the formation of new generations of scientists, and the development at and beyond the state of the art technology.

Buenos Aires, April 14th, 2011

Conclusions and prospects

Unique opportunity for a Latinamerican Consortium

- Argentina, Brazil, Chile, Mexico
- Shared contribution to the Operating Costs
- Latinamerican neutrino flag experiment

Open laboratory

- Natural integration with other labs/experiments
- Host large 3-gen double beta decay/dark matter exp.
- Students/posdocs formation phase for 8 years

Project status

- Scientific support
- Political support
- Currently working on:
  - Detailed engineering study of the laboratory
  - Include the laboratory in the tunnel tender
  - Produce science and laboratory white papers

Web page: http://andeslab.org/