



# ANDES

## AGUA NEGRA DEEP EXPERIMENT SITE

Proposal for a Deep Underground Laboratory  
in the Southern Hemisphere  
(update)

Claudio Dib  
Universidad T. Federico Santa Maria, Valparaiso, Chile  
on behalf of ANDES Coord. Team.

**6th ANDES workshop, ICTP-SAIFR, IFT, Sao Paulo, Brazil 4-6 Aug 2018**

# Proposal:

- To build an Underground Lab in the AGUA NEGRA tunnel.

First **deep underground Lab** in the **Southern Hemisphere**.



# Content

- The Agua Negra Tunnel
- ANDES Lab proposal
  - Scientific programme (white paper?)
  - Design (update)
  - Conceptual design
  - Engineering design and documentation
  - Organization
  - Support (commitments?)



# 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.



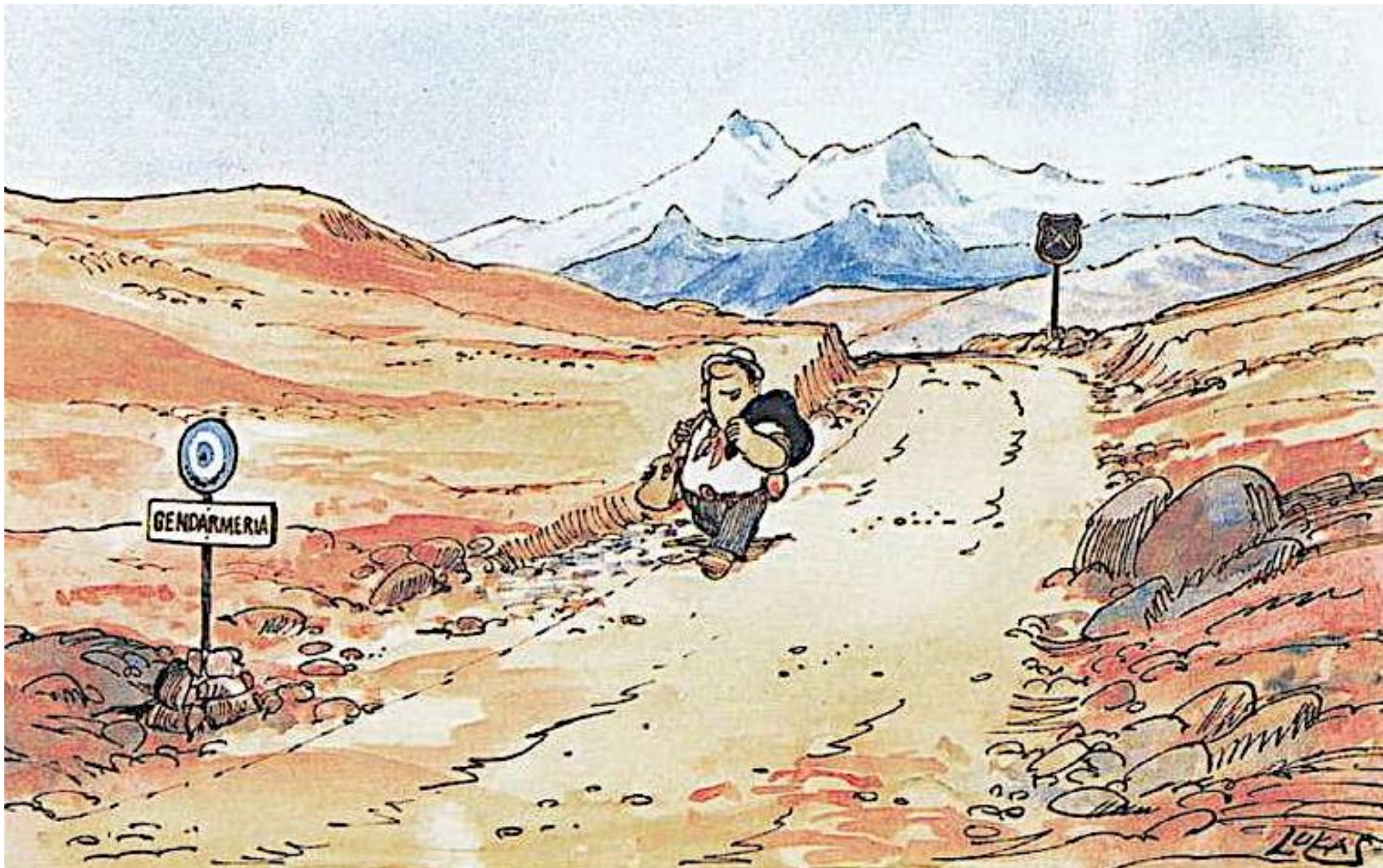
Views of the Agua Negra pass at 4780 m a.s.l.

# Corredor bioceánico



Tunnel approx. Coordinates: 30.19 South, 69.82 West







La Serena, Chile



Cerro Tololo  
Int. Am. Observatory



San Juan,  
Argentina

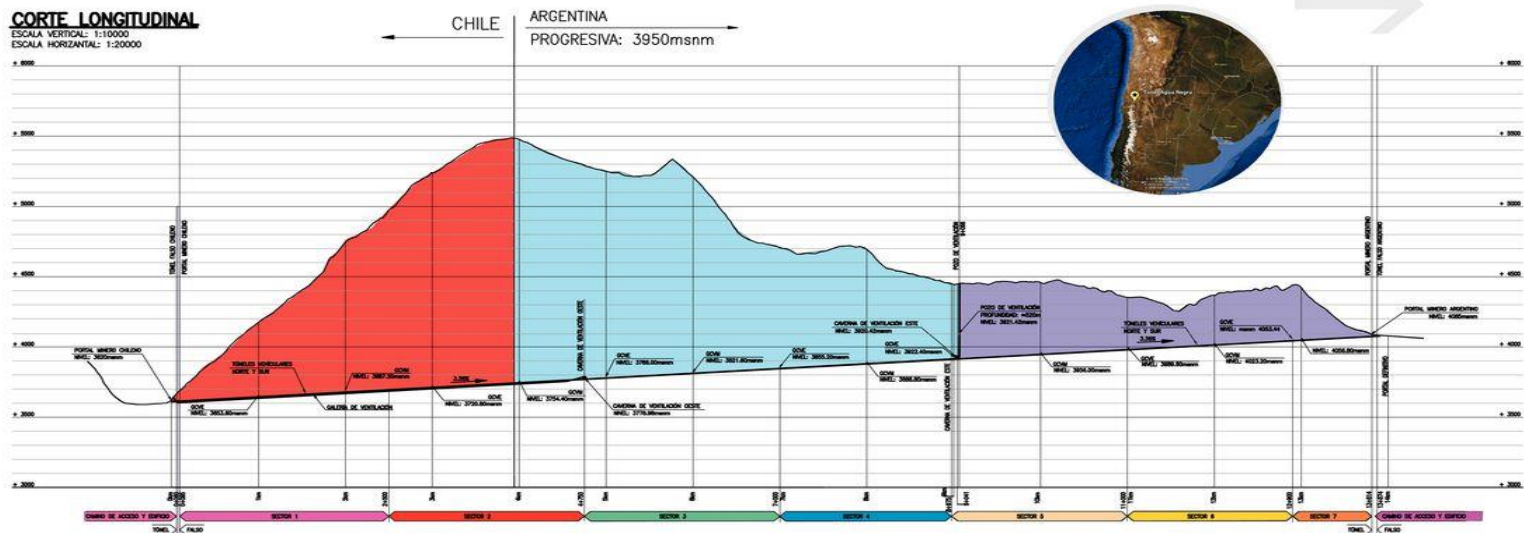


# Tunnel features

- Altitude: 3600 m asl (Chile), 4085 m asl (Argentina), slope  $\sim 3\%$
- Two parallel tunnels, 14 km long, 60 -100 m separation
- 12 m diameter (two lanes each), connecting galleries every 500 m.
- Deepest point: 1750 m depth.
- Forced ventilation (14.5 MW).

## CORTE LONGITUDINAL

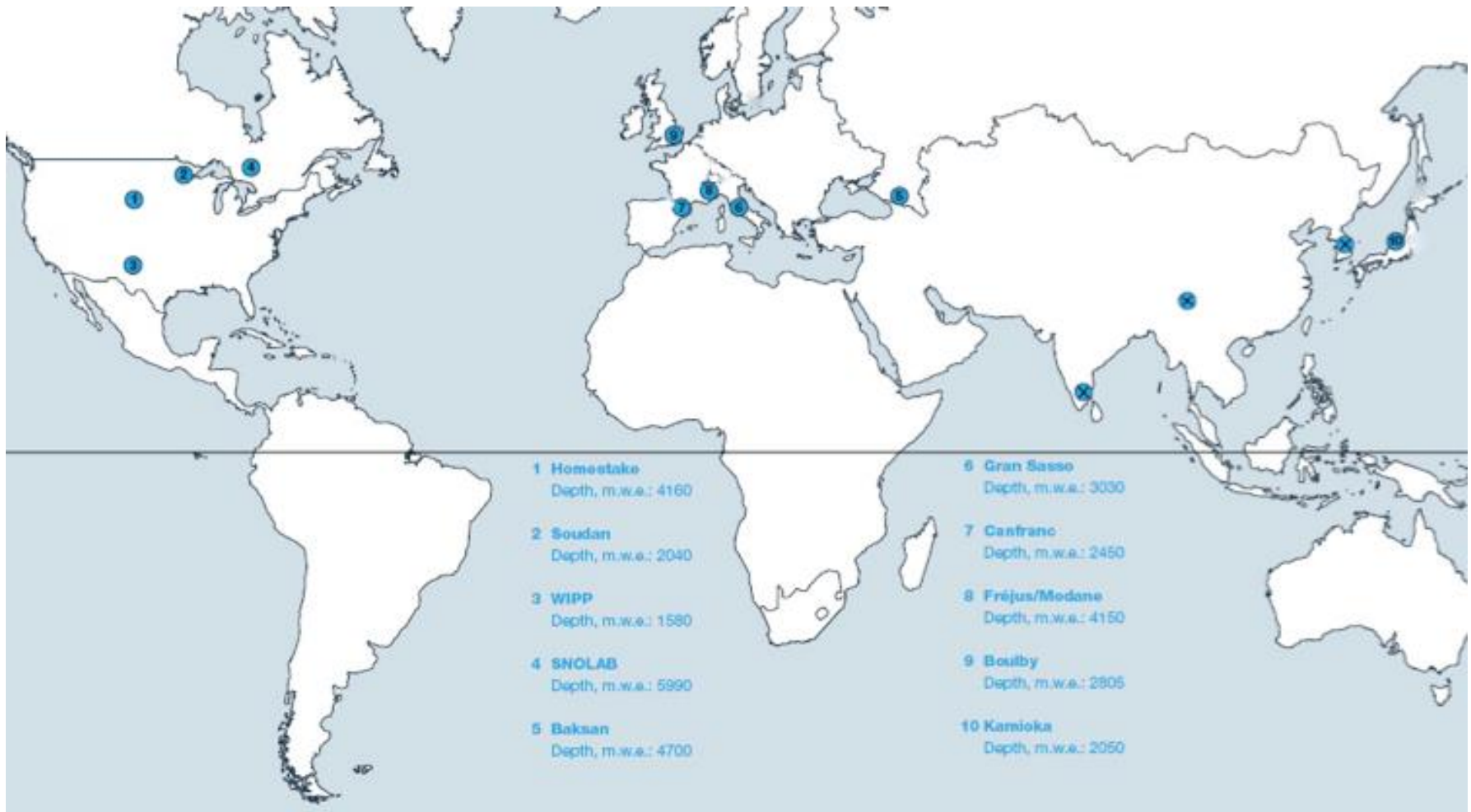
ESCALA VERTICAL: 1:10000  
ESCALA HORIZONTAL: 1:20000





# The ANDES Laboratory proposal

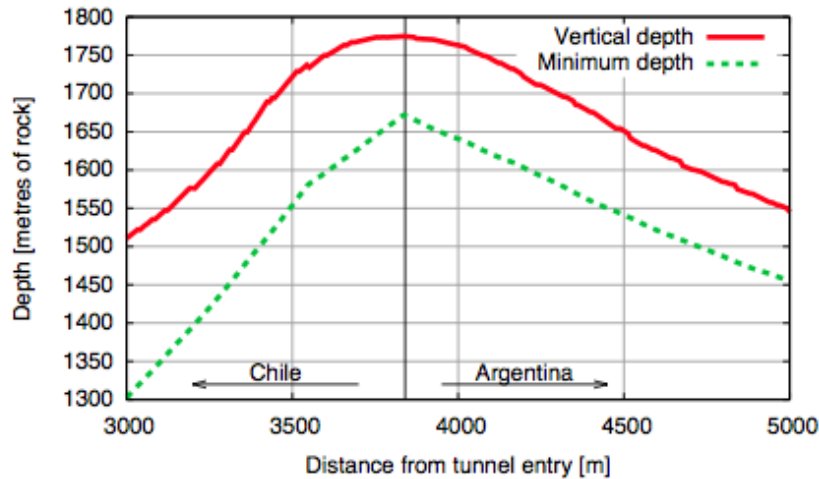
ANDES: **A**gua **N**egra **D**eep **E**xperiment **S**ite



So far, all deep U. Labs are in the Northern Hemisphere.

# The ANDES Lab proposal

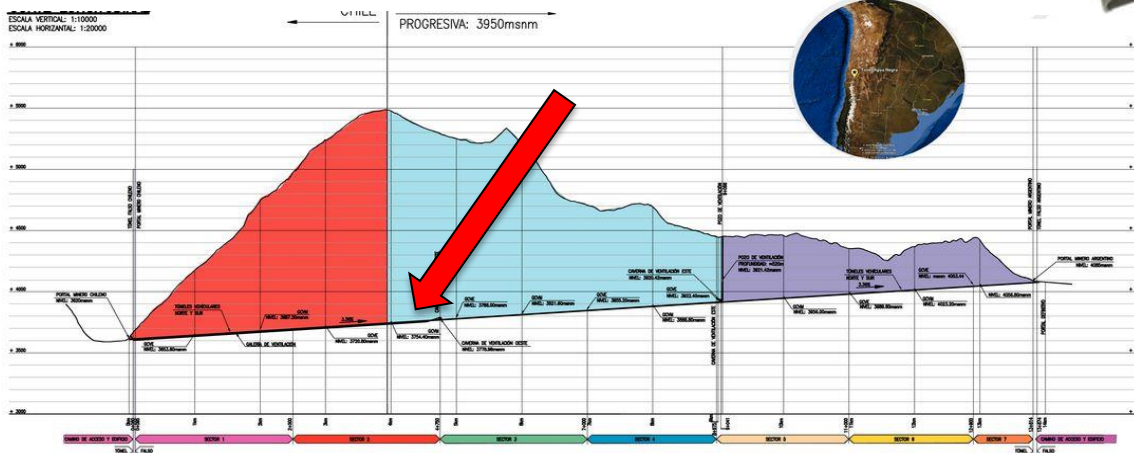
- Deepest point in tunnel (~ 1750 m deep)  
≈ 3.5 km to Chile entrance, 10 km to Argentina exit



Argentina

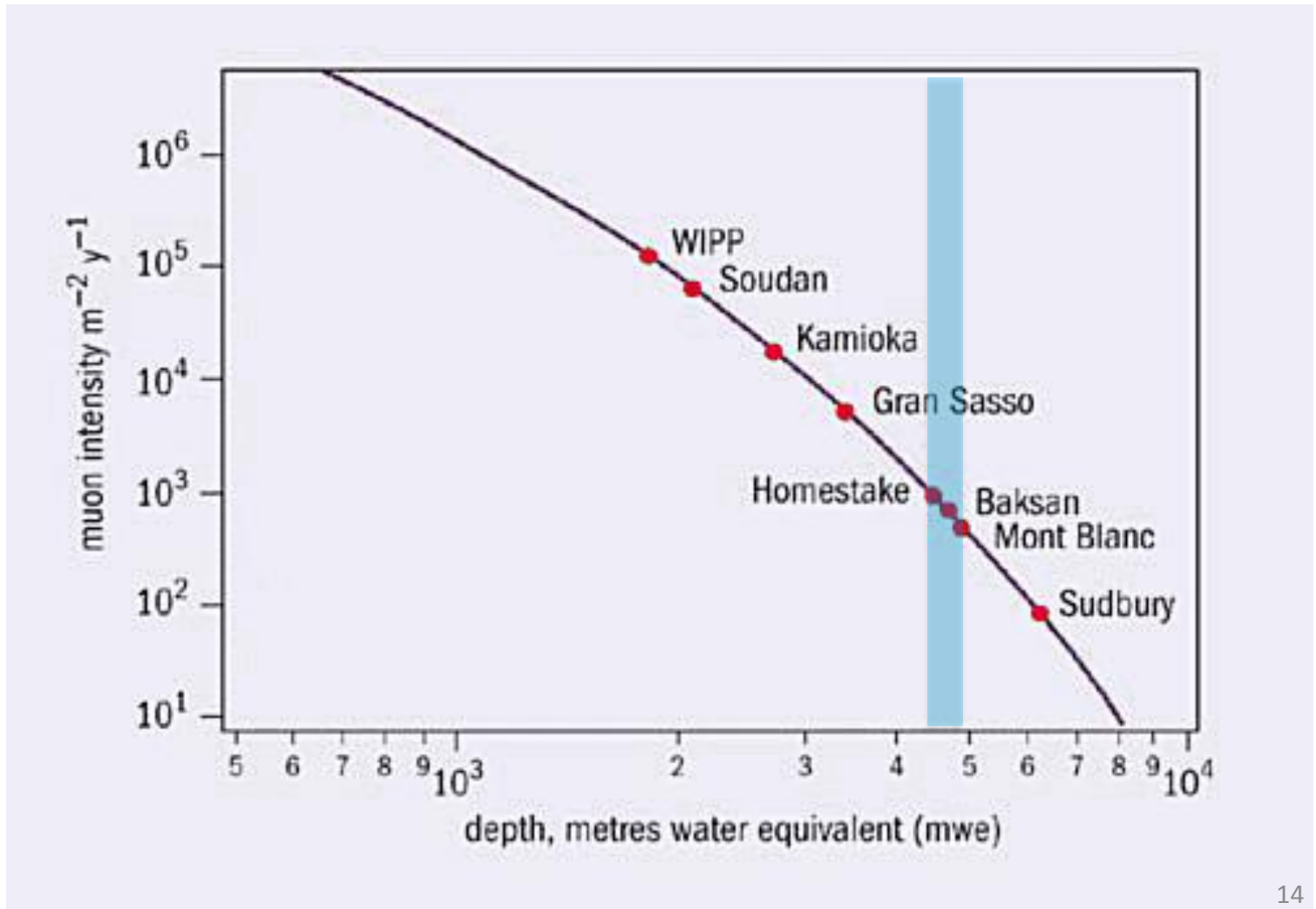


Chile



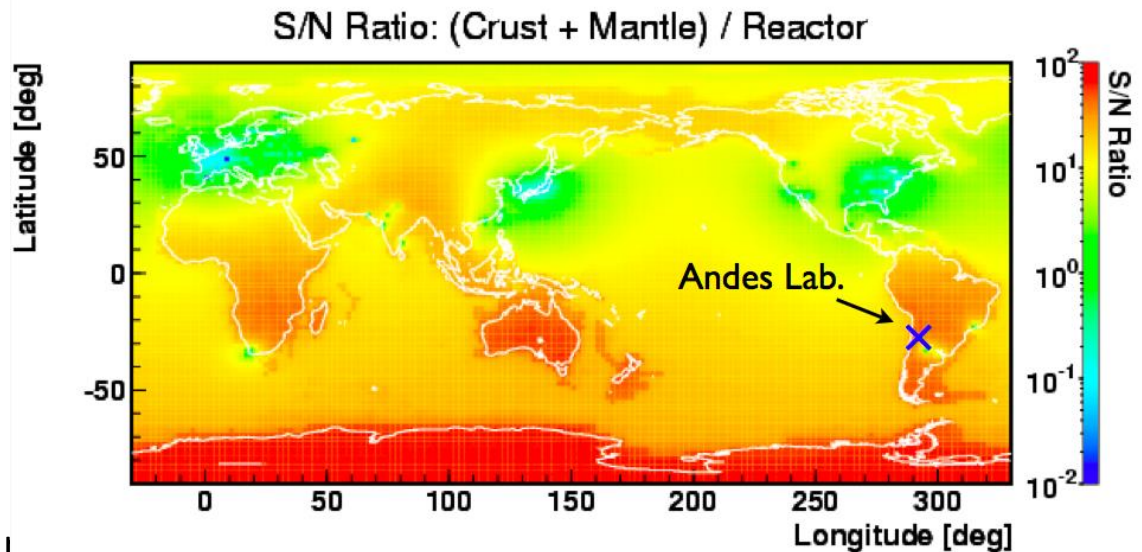
Flux at sea level  $\sim 100 / \text{m}^2 \text{ s}$

ANDES:  $\sim 4500 \text{ mwe}$ ; atn:  $10^{-7}$



# 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 ea
- Supernovae...?





**ANDES scientific programme**  
(tentative)  
(needs work... white paper?)

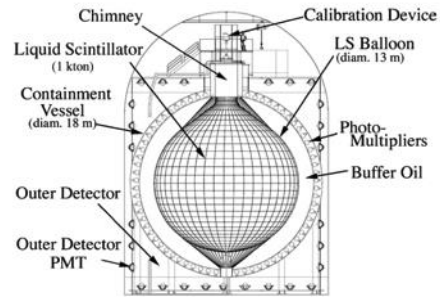


# ANDES initial Scientific Programme

- Neutrino physics:
  - host double beta decay experiments
  - large neutrino detector (similar to KamLAND / Borexino)
    - focused on low energies (solar / SN / geoneutrinos)
- Dark Matter
  - modulation measurements
  - new technologies
- Geophysics
  - link Chile-Argentina seismograph networks
- Biology
- Low radiation measurements
- Nuclear Astrophysics (low energy beams)

## Proposed Large Latinamerican Neutrino Detector

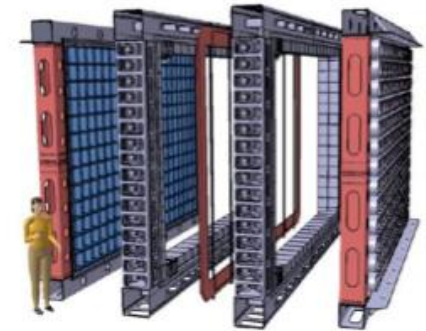
- 3 – 10 kton of liq. Scintillator
- arXiv:1027.5454



## Double Beta experiments:

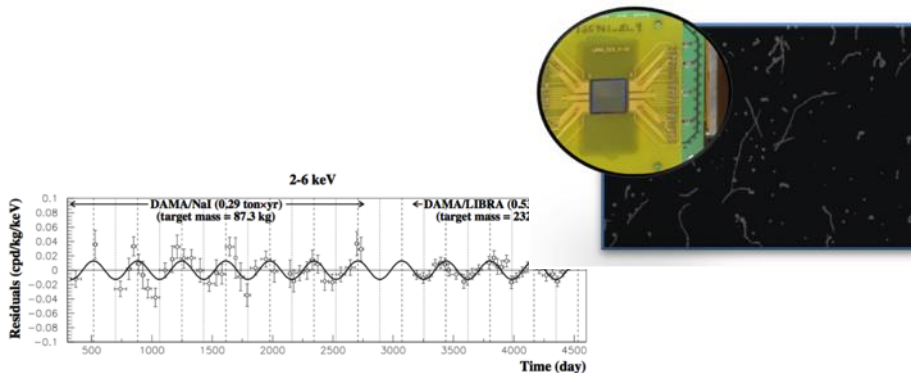
Manifested interest:

- NEXT
- SuperNEMO modules:  $\sim 100$  kg  $^{82}\text{Se}$



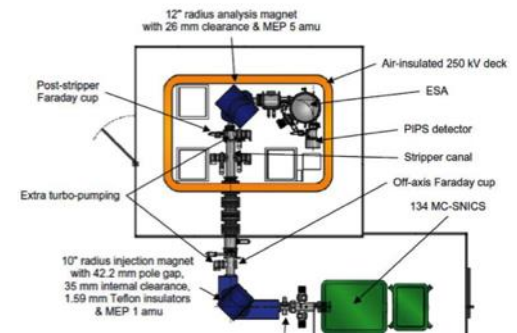
## Dark Matter:

- 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





# ANDES Conceptual Design

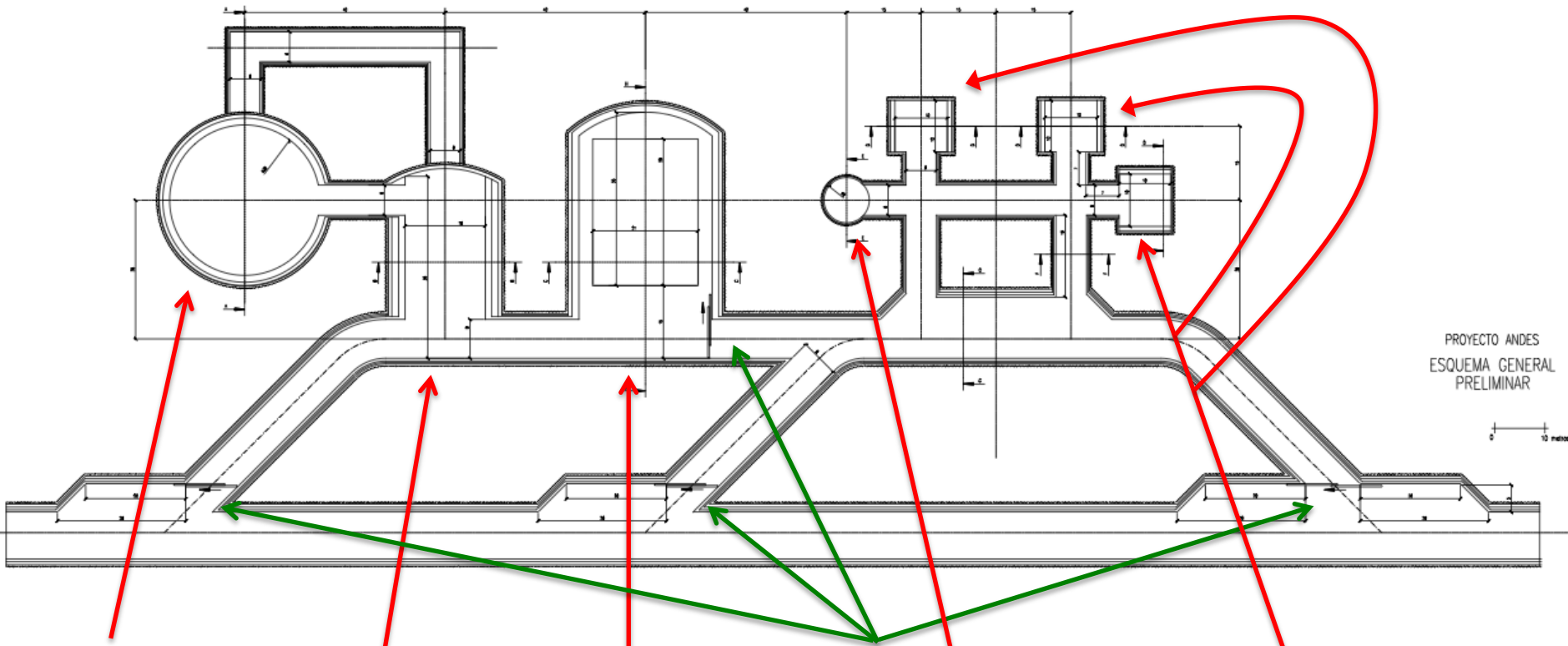
# ANDES proposed infrastructure

- **The underground Lab itself:**
  - 2 horizontal caverns, 1 large pit, 1 small pit, service room, access galleries.
- **Support Laboratories:**
  - One in Chile (La Serena), and one in Argentina (Rodeo)
  - To host Laboratories, administration, offices and an Outreach Center.
- **Lodging at the borders (portals).**
  - Office, bedrooms, storage

# Proposed schematic layout

PROYECTO ANDES  
ESQUEMA GENERAL  
PRELIMINAR

0 10 metros



**Large pit**  
30 m diam  
42 m deep

Access:  
at 30 m high  
and  
at bottom

**Service hall**  
40 m long  
16 m wide  
15 m high  
Oval section

**Main hall**  
50 m long  
21 m wide  
23 m high  
Oval section

**Gates**

**Ultra low  
radiation pit**  
9 m diam  
15 m deep

Access:  
At 10 m high and bottom

**3 secondary  
caverns**  
10 x 10 x 10 m



CLAF  
Centro Latinoamericano de Física  
Rio de Janeiro  
Brasil

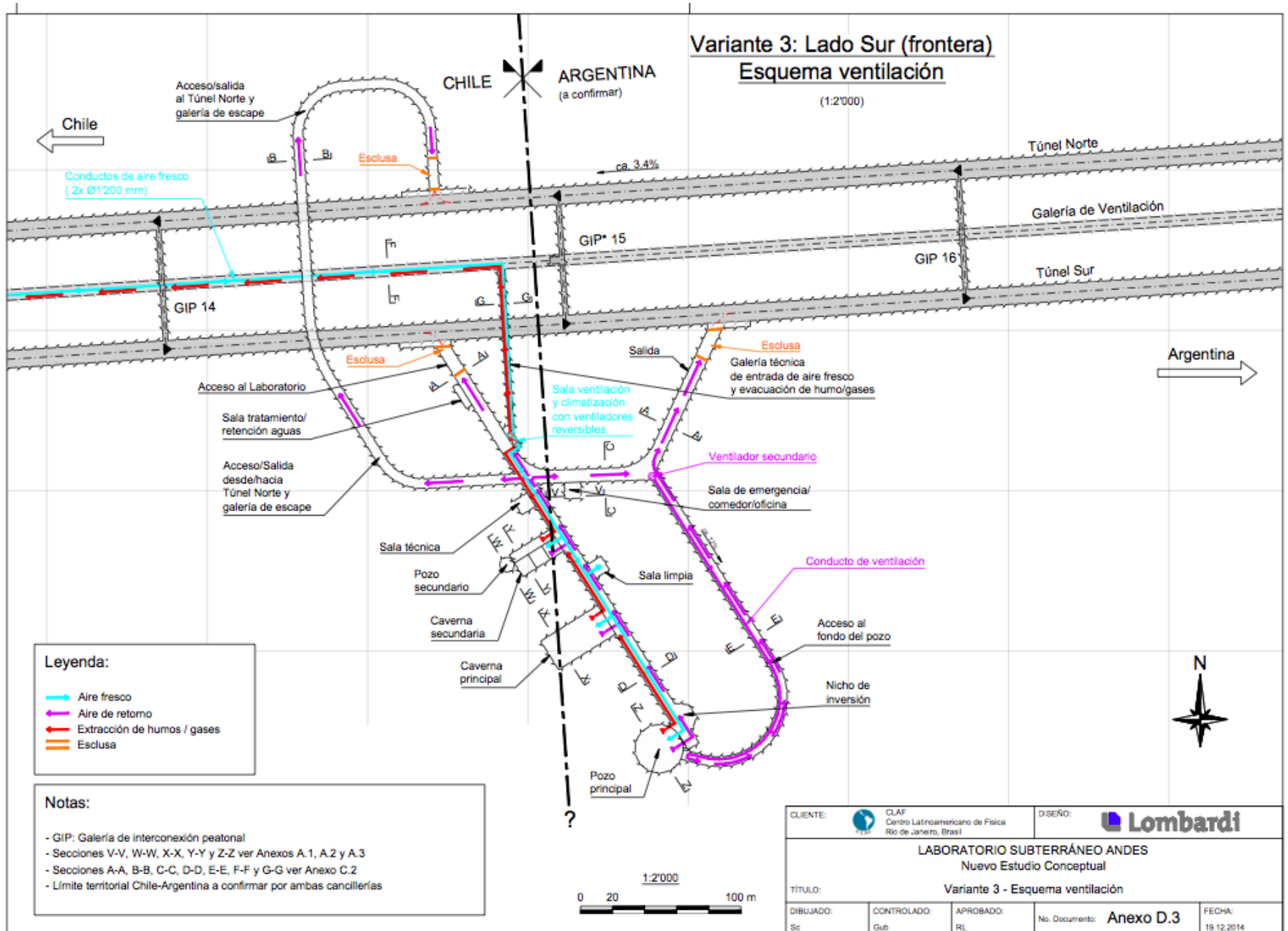
## LABORATORIO SUBTERRÁNEO ANDES

### Nuevo Estudio Conceptual

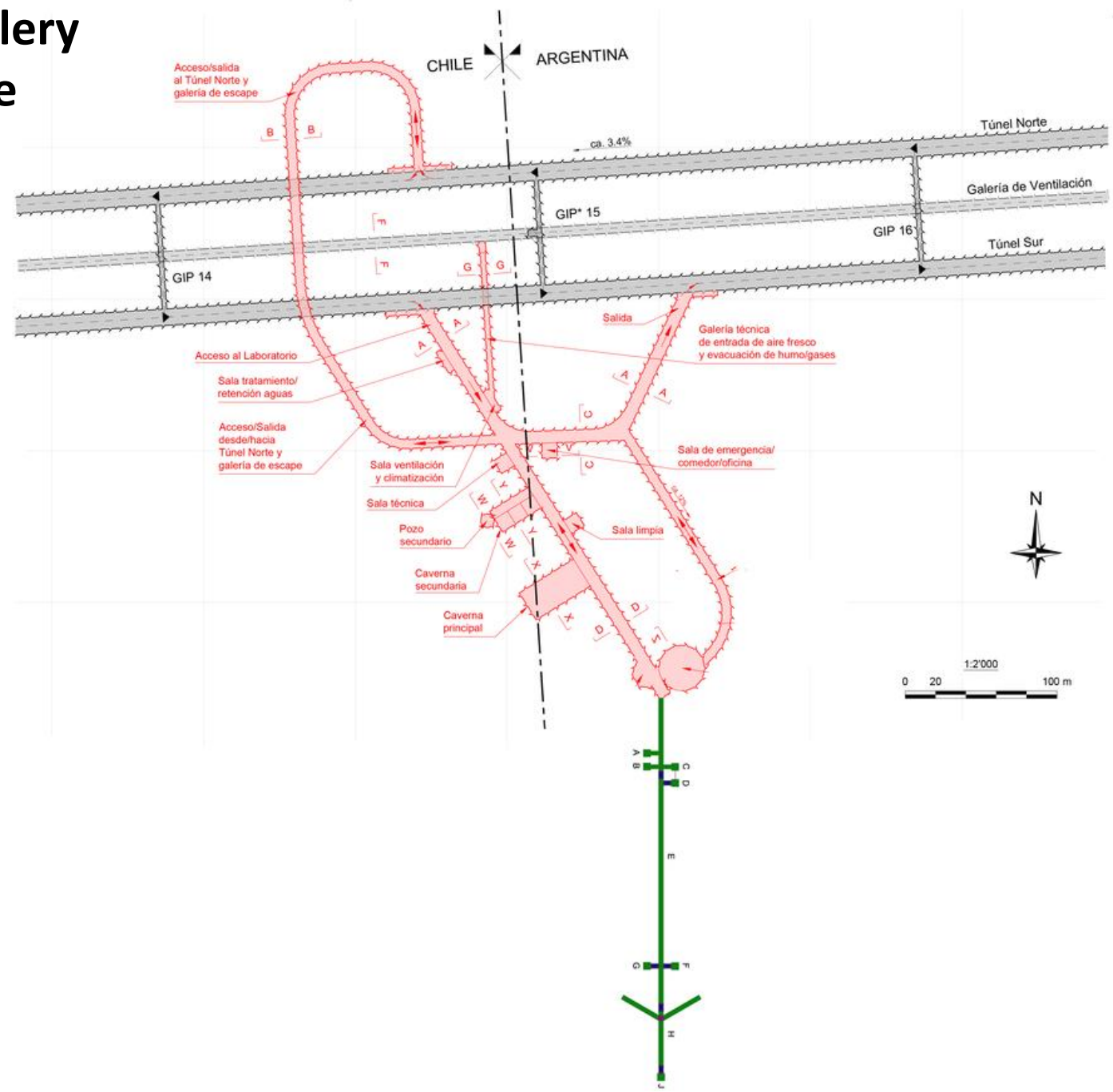


Informe Técnico

# Conceptual Design (by Lombardi): Ventilation



# Additional gallery for Geoscience

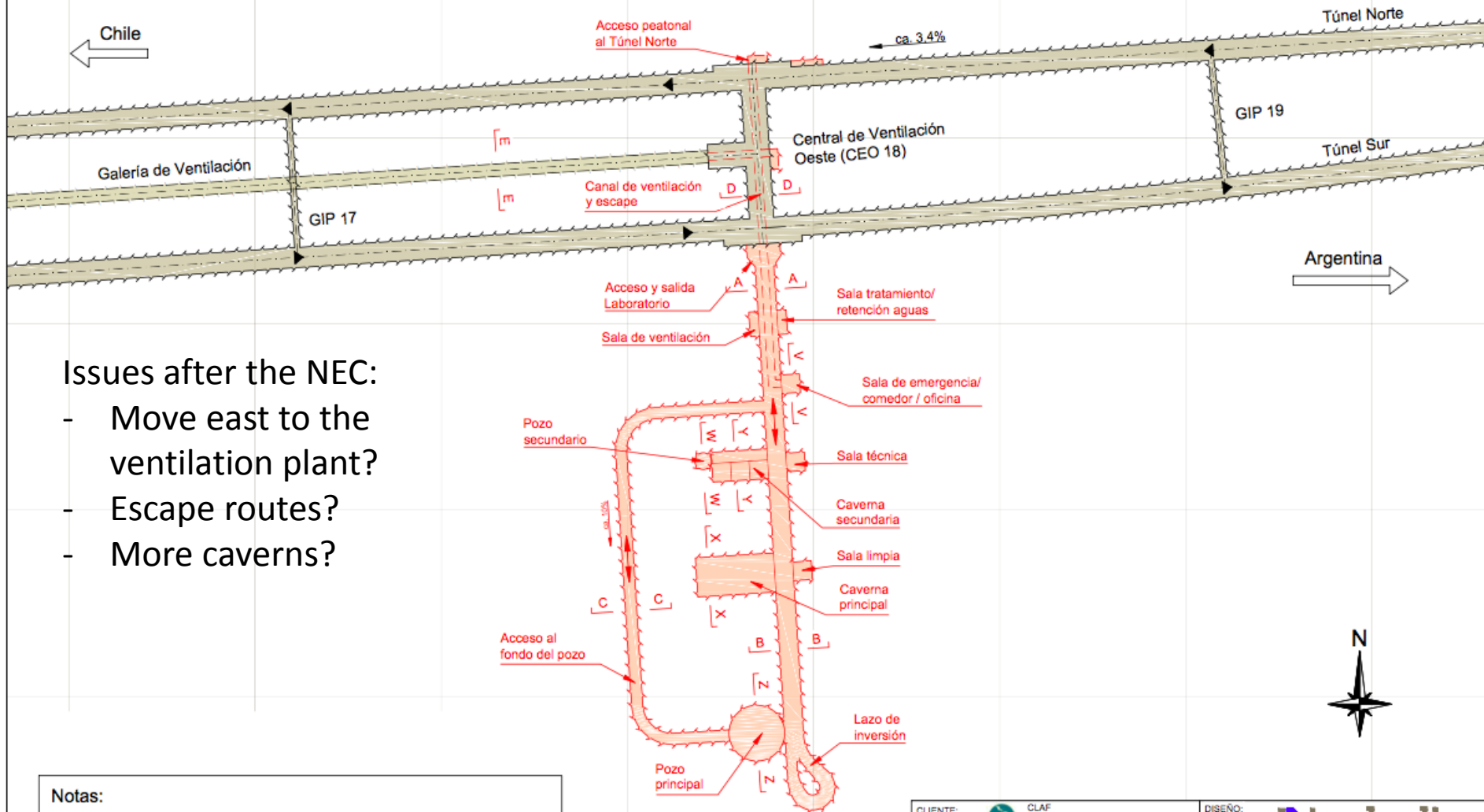




# Variante 5: Lado Sur (mínima)

## Planimetría esquemática

(1:2'000)



Issues after the NEC:

- Move east to the ventilation plant?
- Escape routes?
- More caverns?

### Notas:

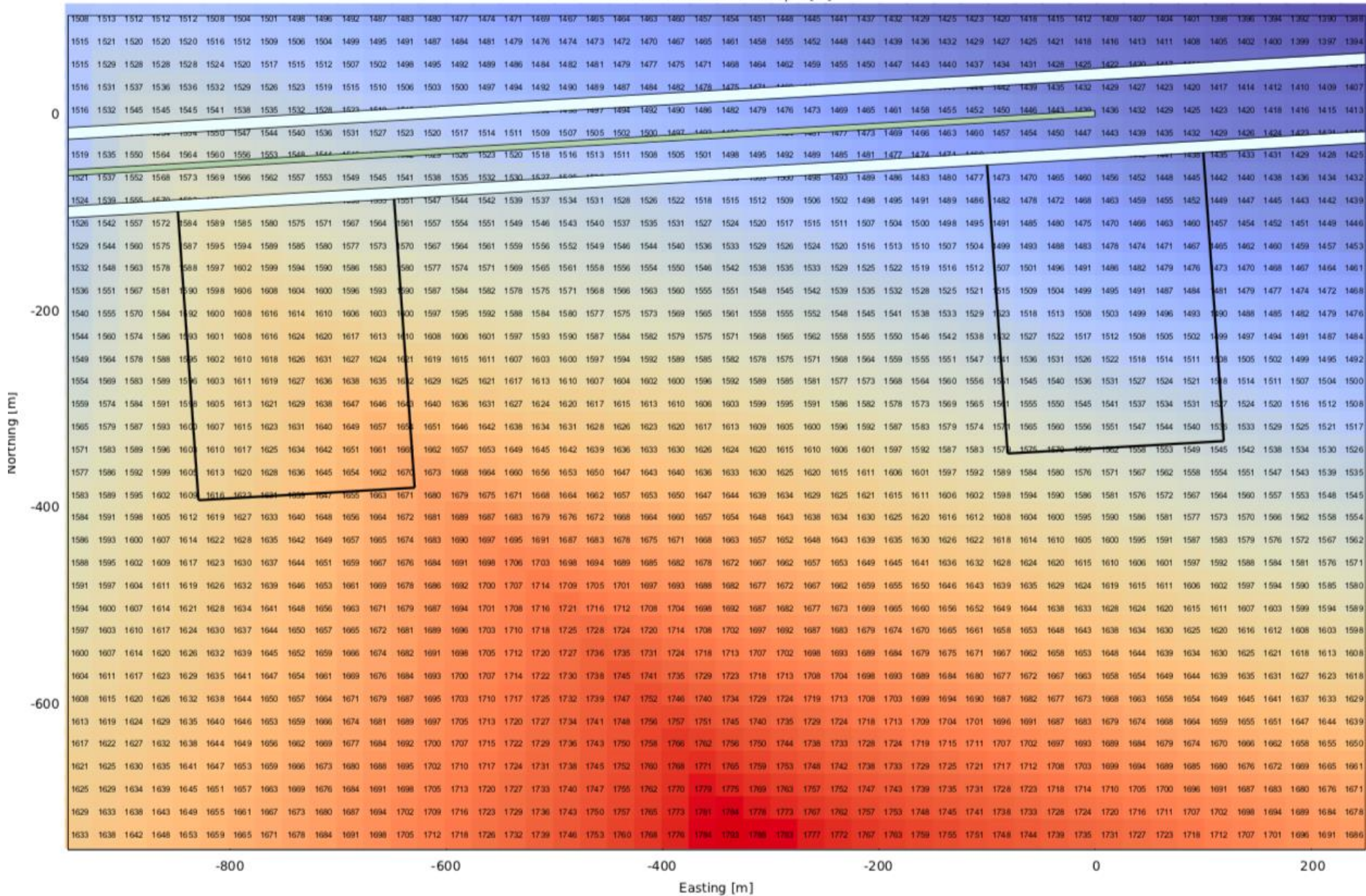
- GIP: Galería de interconexión peatonal
- Secciones V-V, W-W, X-X, Y-Y y Z-Z ver Anexos A.1, A.2 y A.3
- Secciones A-A, B-B, C-C, D-D y E-E ver Anexo C.3
- La misma solución puede ser realizada en el lado Norte

1:2'000

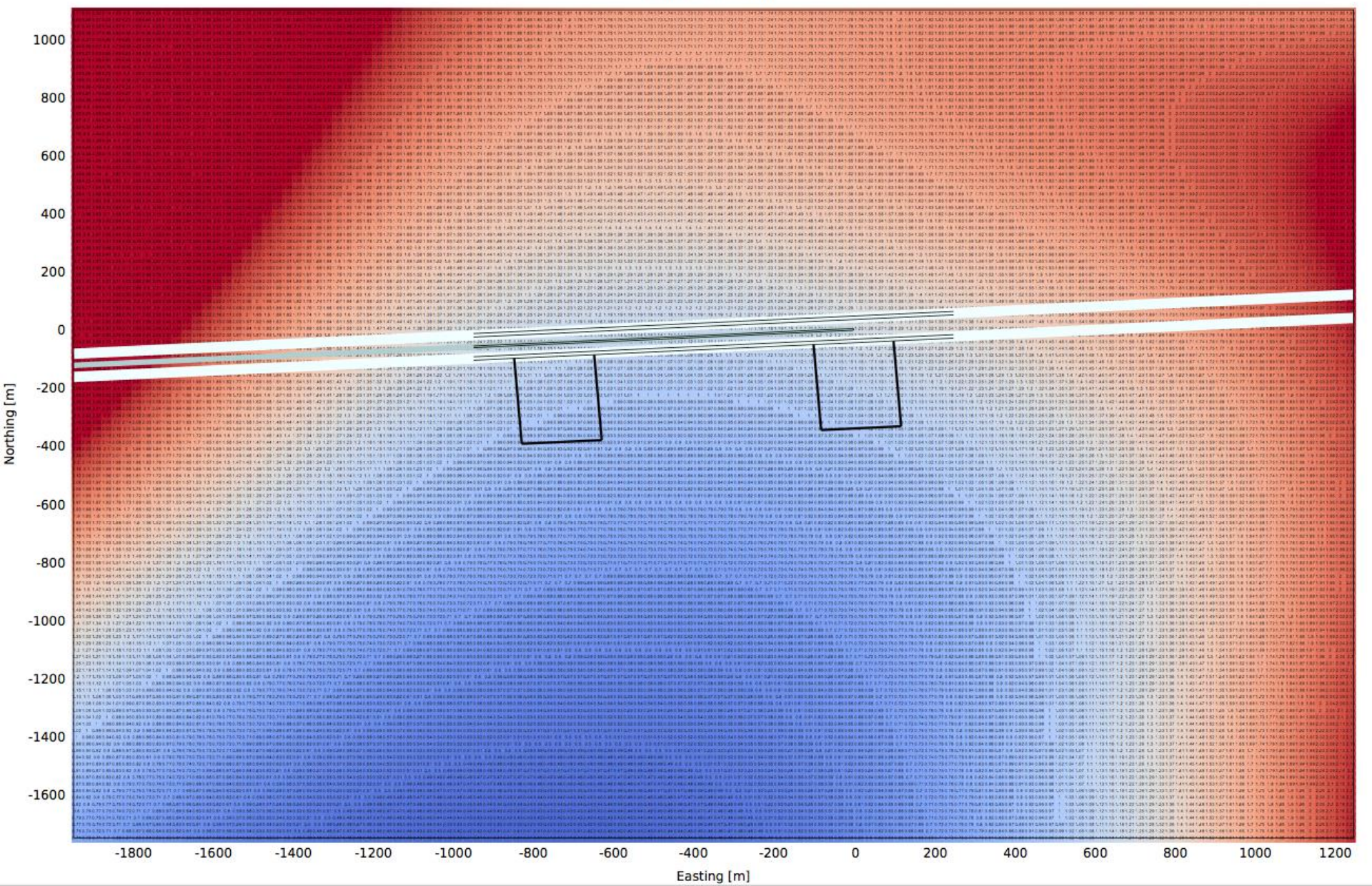
0 20 100 m

CUENTE:	CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	<b>Lombardi</b>	
<b>LABORATORIO SUBTERRÁNEO ANDES</b> Nuevo Estudio Conceptual				
TÍTULO: Variante 5 - Planimetría esquemática				
DIBUJADO:	CONTROLADO:	APROBADO:	No. Documento:	FECHA:
Sc	Gub	RL	Anexo B.5	19.12.2014

Minimum omnidirectional depth [m]



Muon relative flux

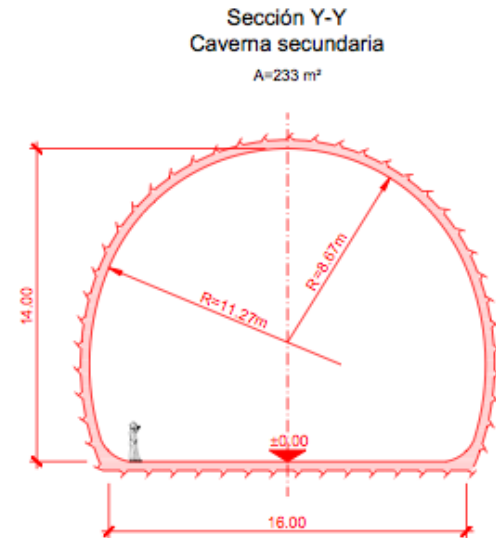
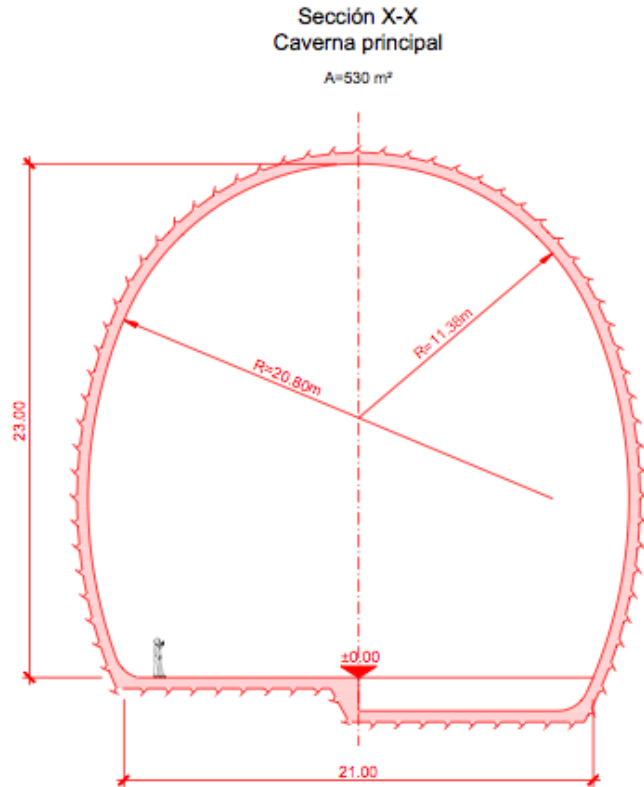




# Conceptual Design (by Lombardi): Cavern sections

## Caverna principal y caverna secundaria Secciones esquemáticas

(1:200)



### Notas:

- Planimetrías esquemáticas ver Anexo B



CUENTE:	CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	Lombardi
LABORATORIO SUBTERRÁNEO ANDES Nuevo Estudio Conceptual			
TÍTULO:	Caverna principal y secundaria - Secciones esquemáticas		
DIBUJADO:	CONTROLADO:	APROBADO:	No. Documento: Anexo A.1
Sc	Gub	RL	FECHA: 19.12.2014

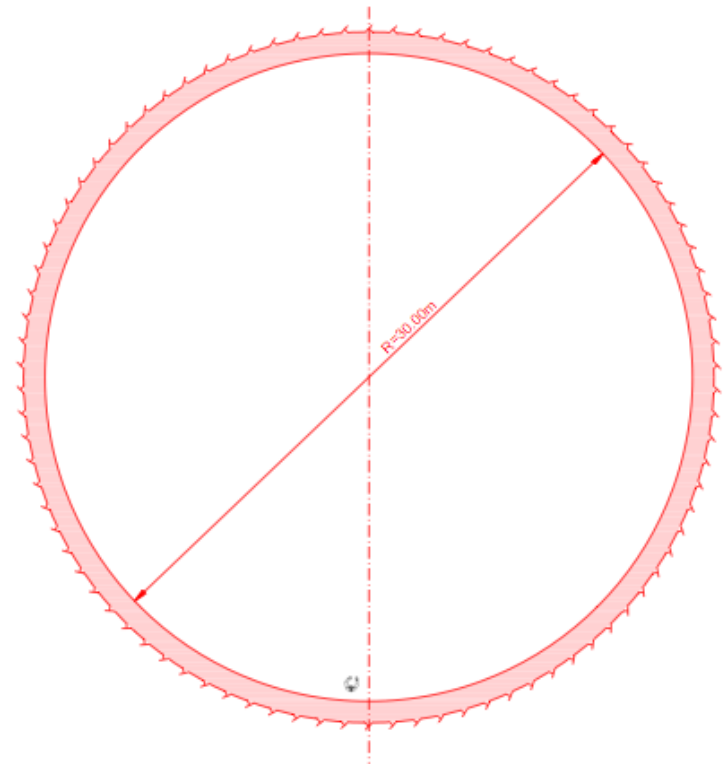
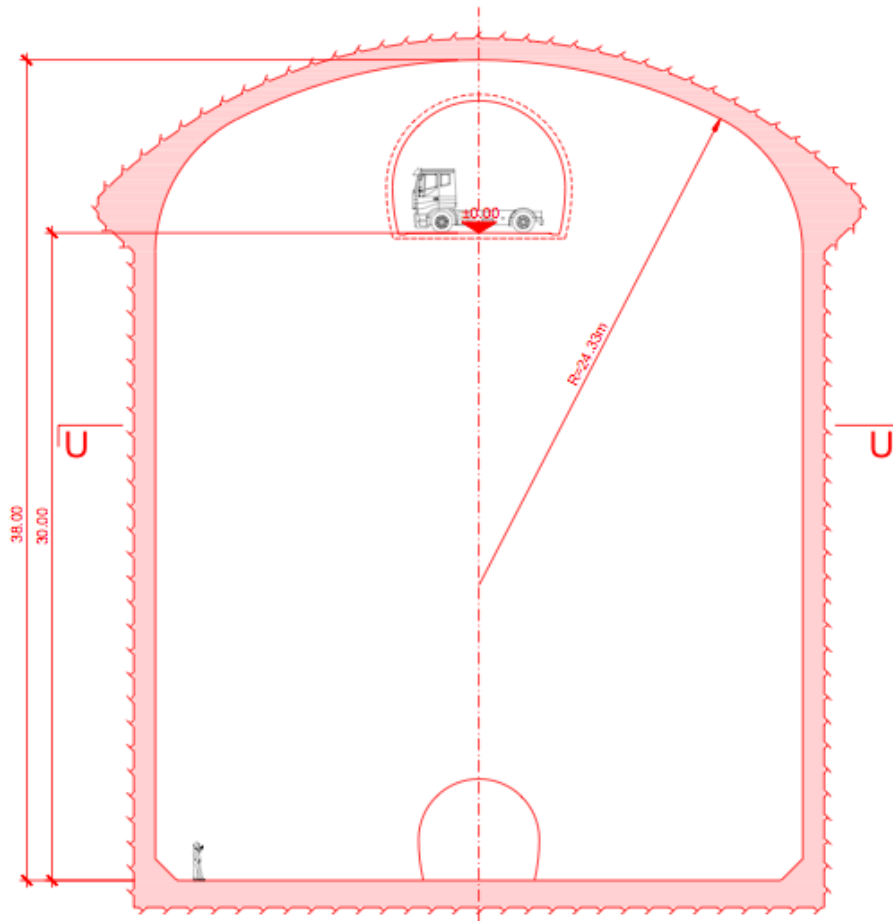
# Conceptual Design (by Lombardi): Main pit sections

## Pozo principal Secciones esquemáticas

(1:200)

Sección Z-Z  
V=30'600 m<sup>3</sup>

Sección U-U  
A= 804 m<sup>2</sup>



### Notas:

- Planimetrías esquemáticas ver Anexo B



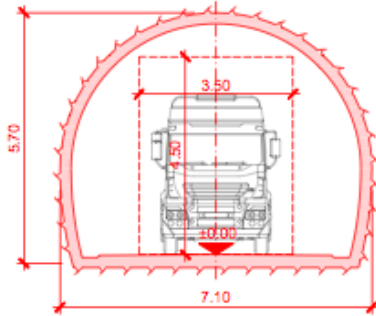
CUENTE:	CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	Lombardi
LABORATORIO SUBTERRÁNEO ANDES Nuevo Estudio Conceptual			
TÍTULO: Pozo principal - Secciones esquemáticas			
DIBUJADO: Sc	CONTROLADO: Gub	APROBADO: RL	No. Documento: <b>Anexo A.2</b> FECHA: 19.12.2014

# Conceptual Design (by Lombardi): Access sections

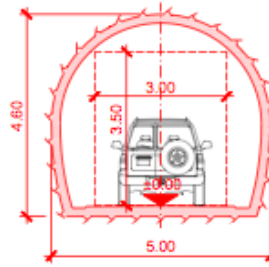
## Variante 3: Lado Sur, frontera / Variante 4: Lado Norte, frontera Secciones esquemáticas accesos

(1:100)

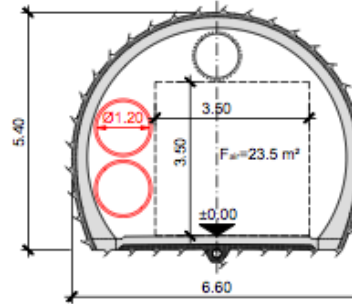
**Sección A-A**  
Galería de acceso/salida principal  
A= 35 m<sup>2</sup>



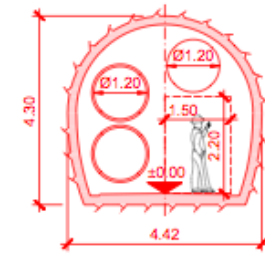
**Sección B-B**  
Galería de acceso/salida secundaria  
A= 20 m<sup>2</sup>



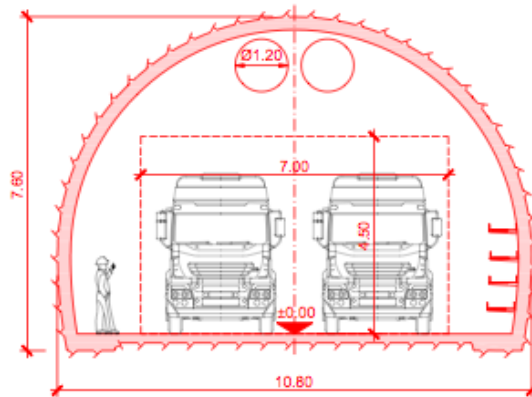
**Sección F-F**  
Galería de ventilación  
(Proyecto TAN)



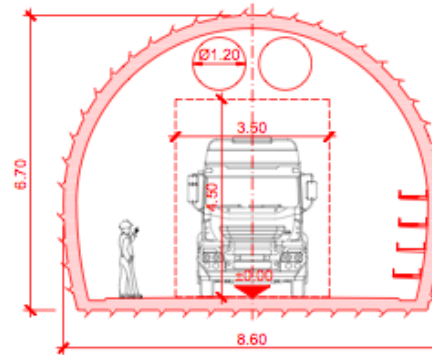
**Sección G-G**  
Galería técnica de ventilación  
A= 16 m<sup>2</sup>



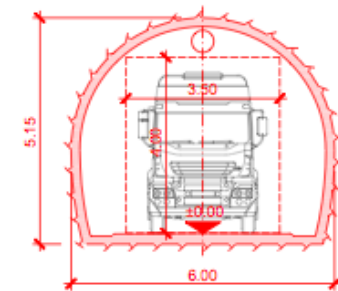
**Sección C-C**  
Zona de tránsito central  
A= 68 m<sup>2</sup>



**Sección D-D**  
Galería de conexión interna Laboratorio  
A= 49 m<sup>2</sup>

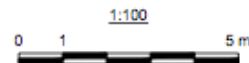


**Sección E-E**  
Galería de acceso al fondo del pozo  
A= 27 m<sup>2</sup>



### Notas:

- Planimetría esquemática variante 3 ver Anexo B.3
- Planimetría esquemática variante 4 ver Anexo B.4



CUENTE:	CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	Lombardi
LABORATORIO SUBTERRÁNEO ANDES Nuevo Estudio Conceptual			
TÍTULO: Variantes 3 y 4 - Secciones esquemáticas			
DIBUJADO: Se	CONTROLADO: Gub	APROBADO: RL	No. Documento: <b>Anexo C.2</b>
			FECHA: 19.12.2014

# Conceptual Design (by Lombardi): Dimensions

Objeto	Longitud [m]	Area sección [m2]	Volumen [m3]
<b>Espacios Laboratorio</b>			
Caverna principal	50	530	26'500
Pozo principal	-	-	30'600
Caverna secundaria	40	233	9'320
Pozo secundario	-	-	1'125
<b>Otros espacios</b>			
Sala emergencia, comedor, oficina	10	68	680
Sala limpia	10	68	680
Sala técnica	10	68	680
Sala tratamiento aguas	5	68	340
Sala ventilación	5	68	340
<b>Accesos y tránsito interno</b>			
Entrada principal	100	35	3'500
Salida principal	100	35	3'500
Zona central	80	68	5'440
Acceso/salida túnel opuesto/galería de escape	460	20	9'200
Acceso al fondo del pozo	250	27	6'750
Túnel de conexión laboratorio	195	49	9'555
<b>Otros objetos</b>			
Bahía salida principal	-	-	600
Bahía acceso principal	-	-	1'200
Bahía acceso/salida Túnel Norte/Sur	-	-	1'200
Galería técnica ventilación	100	16	1'600
<b>TOTAL parcial obra civil</b>			<b>112'810</b>



# 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

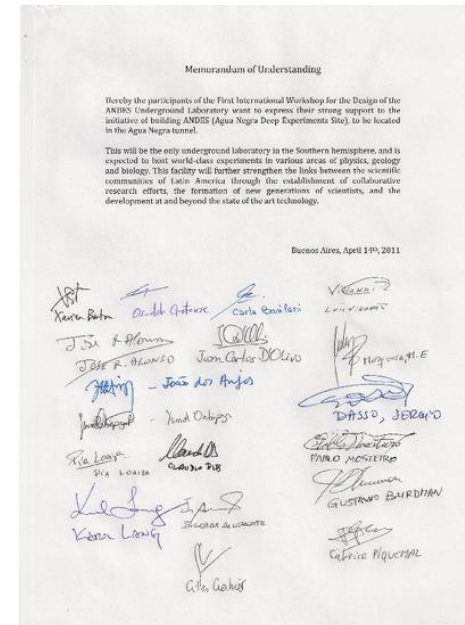
# Proposal for Organization:

## An international Consortium:

- will manage the ANDES Laboratory
  - With support from external international scientific advisory board.
  - call for experiment proposals of the intl' community.
  - have an operation budget from member nations.
  - e.g. SESAME...?

# International support

- > 20 support letters from International community (underground lab directors, intl. exp spokespersons, natl. physics associations and academies,...)
- Regional interest: 26 letters from latin american groups.
- Official support from MinCyT (Argentina) and EBITAN (Entidad Binacional Túnel Agua Negra).
- 5 workshops for the Lab design (Argentina, Brazil, Chile, Mexico).
- CLAF (Centro Latinoamericano de Fisica) created ANDES unit.
- Conceptual Design (NEC) (done by Lombardi S.A., paid 50/50 by Chile and Argentina)
- Basic Engineering and tech. doc. for tender (IBA+DTL) (ordered to Lombardi. Payment pending.)



# ANDES Coordination Team

- **General coordinator:**  
Xavier Bertou (Centro Atómico de Bariloche, Argentina)
- **Country coordinators:**
  - **Argentina:** Osvaldo Civitarese (IFLP, U. Nac. La Plata)
  - **Chile:** Claudio Dib (UTFSM, Valparaiso)
  - **Brasil:** Ron C. Shellard (CBPF)
  - **Mexico:** Luis Villaseñor (UNAM)
- Web site <http://andeslab.org>

# Summary

- ANDES is a unique opportunity for a deep and large underground lab in Southern Hemisphere.
- Needs political resolution from Chile and EBITAN
- Support/commitment from intl. Community
- Payment of IBA+DTL
- Final review current design:
  - Inclusion of Geoscience galleries, Biology Lab, Isolated Lab.
- White paper on the science



Thank you

# Backup slides



# Rock studies

Main rock: - Andesite  
 variations: - rhyolite  
 - basalt  
 - dacite  
 - trachyte



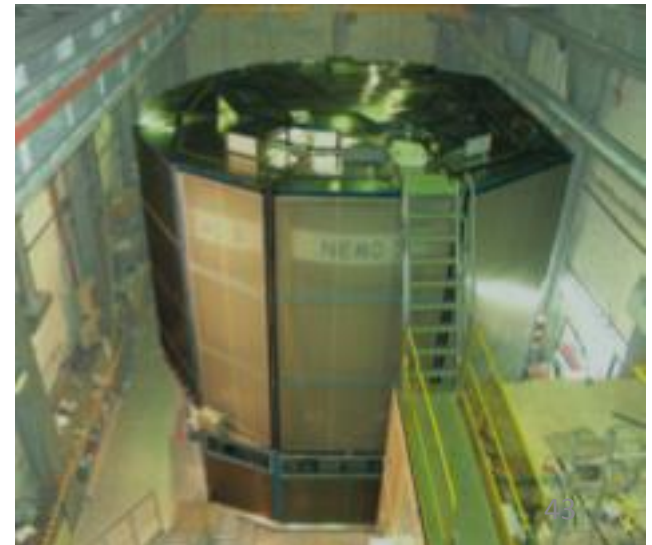
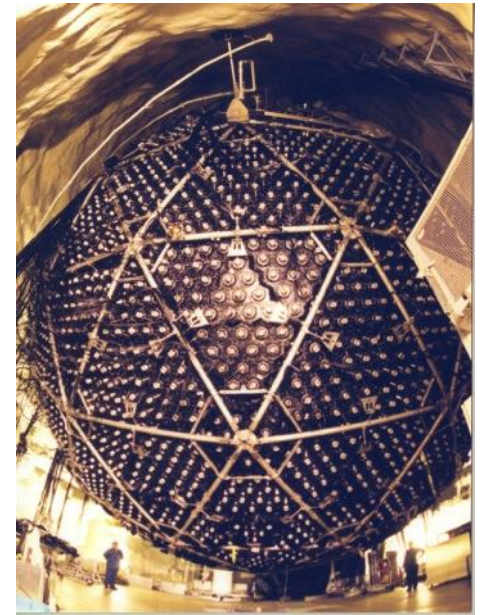
9 samples from 8 perforations up to 600 m deep

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

# 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

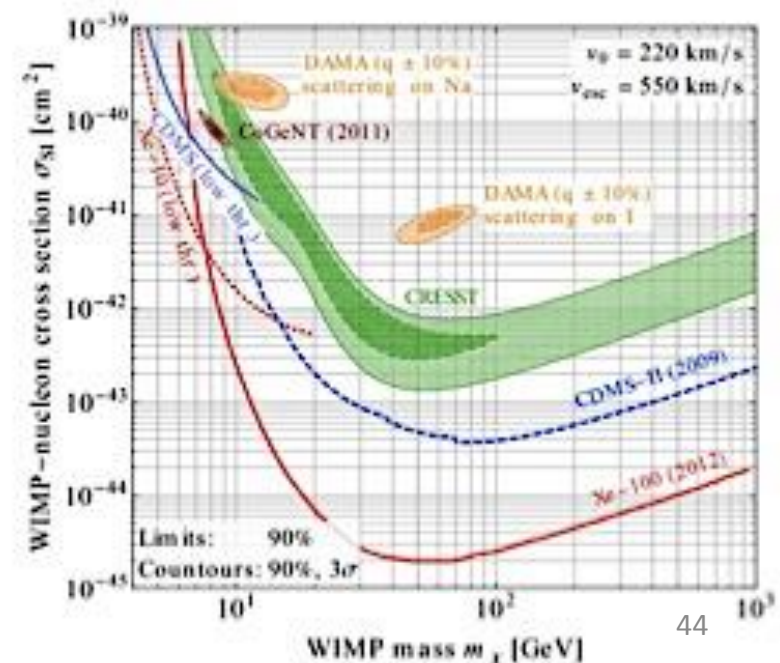


# Experiments in underground Labs:

- **Dark Matter search:**

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

- Direct Detection
- Yearly modulation



# Experiments in underground Labs:

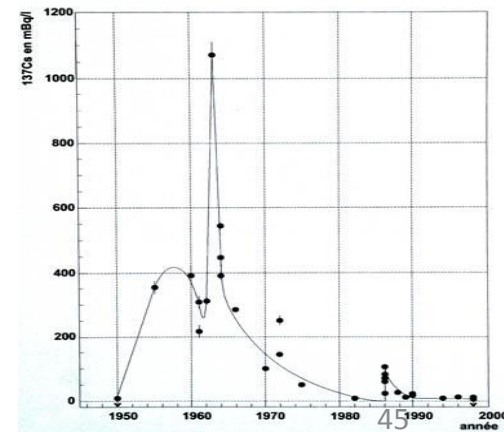
- **Geoscience**

- Low freq. Seismographs
- Radon measurements
- geoneutrinos

- **Low radiation measurements**

- Material selection
- Environment pollution
- microelectronics

- **Biology**



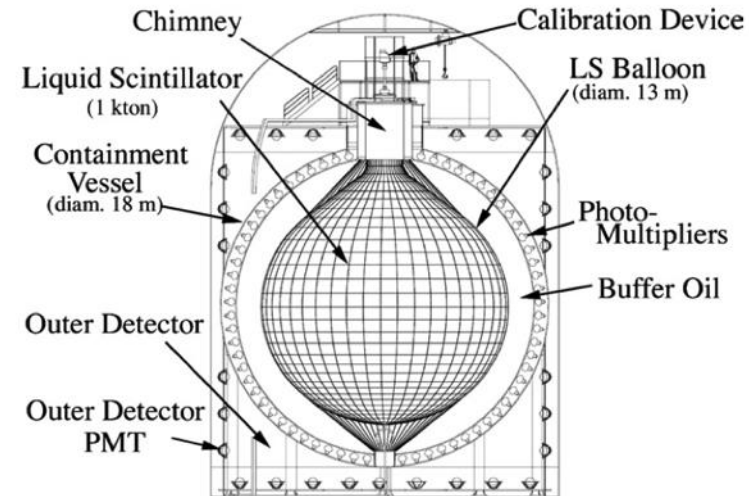
# Preliminary ANDES Science program

# ANDES initial Scientific Programme

- Neutrino physics:
  - host double beta decay experiments
  - large Latin American neutrino detector
    - KamLAND / Borexino style
    - focus on low energy
    - Solar / Supernova / Geo neutrinos
- Dark Matter
  - modulation measurements
  - new technologies
- Geophysics
  - link Chile-Argentina seismograph networks
- Biology
  - life in extreme and low radiation environments
- Low background measurements
- Nuclear Astrophysics (low energy beams)

# eg. Proposed Neutrino detector

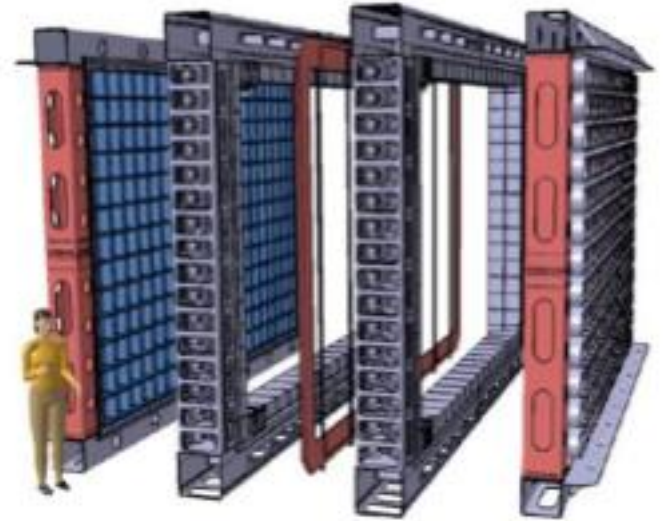
- 3 – 10 kton of liq. Scintillator
- similar to Borexino or KamLAND
- ANDES: unique site for geo  $\nu$ 's
- Can be used for Supernova  $\nu$ 's
- arXiv:1027.5454



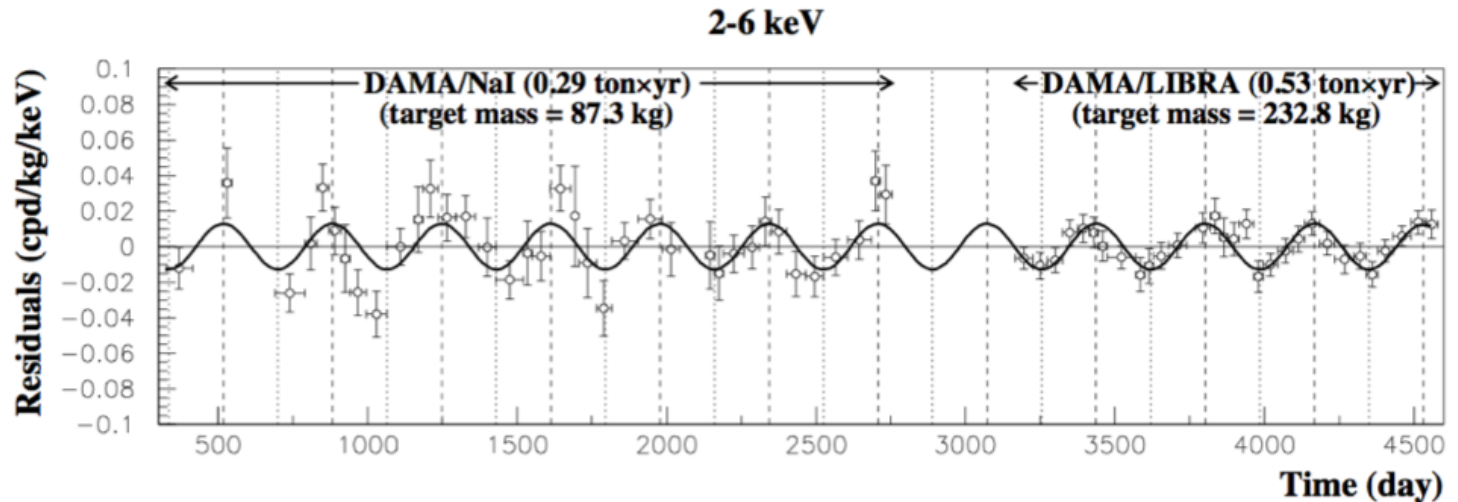


# Double beta decay experiments

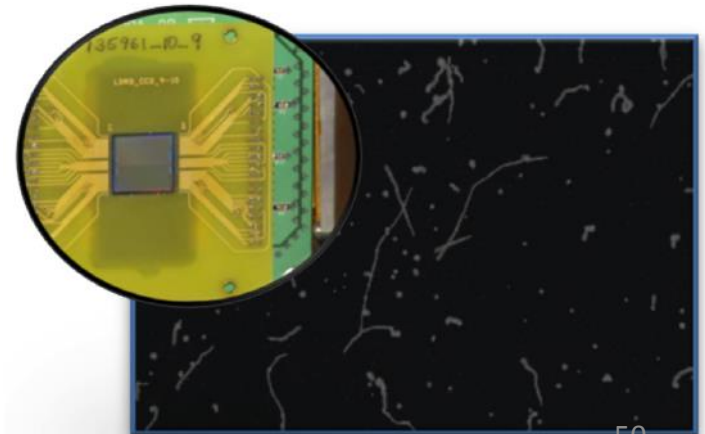
- eg. SuperNEMO:
  - 100 – 200 kg of  $^{82}\text{Se}$
  - Larger experiment, based on NEMO, NEMO3 (LSM).
  - Modular design  $\approx 20$  modules
  - Neutrino mass sensitivity  $\approx 0.05$  eV
  - Design and schedule fits ANDES
  - strong interest from SuperNEMO
- Also: NEXT.
- others



# 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.



# 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