



# **ANDES: A survey of the physics related to underground labs.**

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ANDES/CLES working group

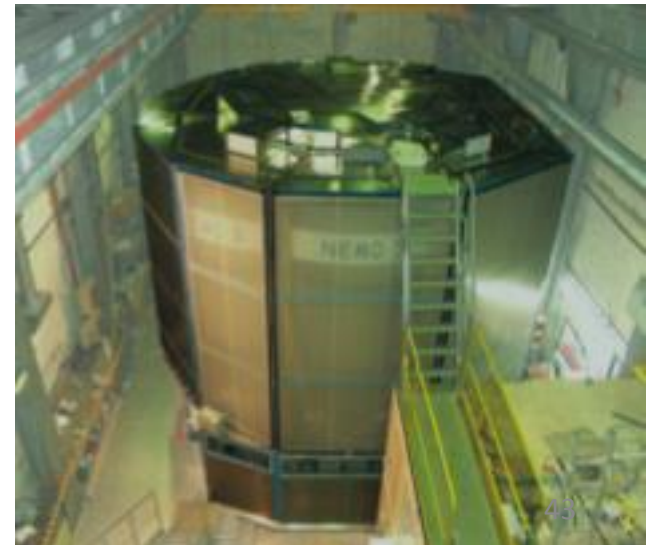
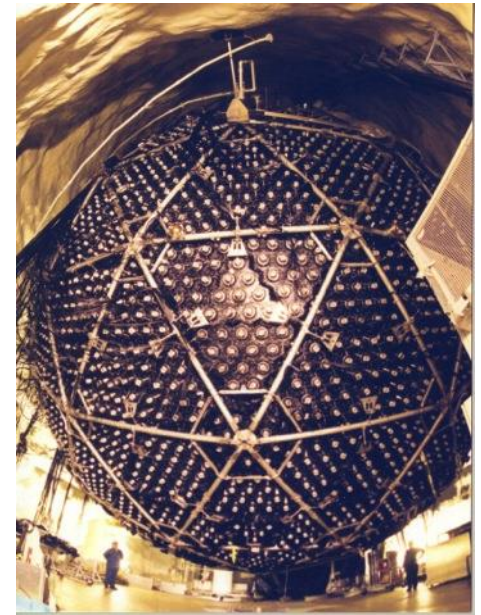
# The field in perspective



- How the matter in the Universe was (is) formed ?
- What is the composition of Dark matter?
- Neutrino physics: violation of fundamental symmetries?
- The atomic nucleus as a laboratory: exploring physics at large scale.

# Experiments in underground Labs:

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

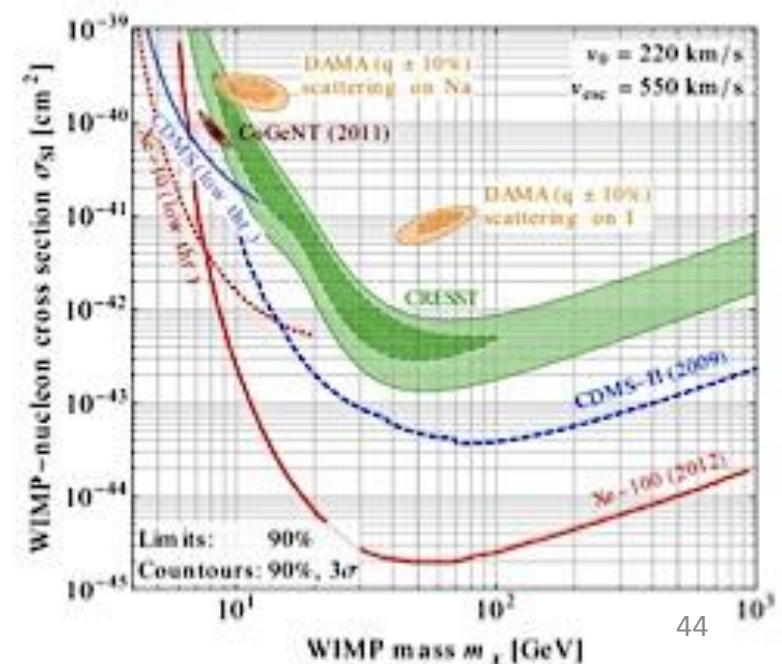


# Experiments in underground Labs:

- **Dark Matter search:**

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

- Direct Detection
- Yearly modulation



# Experiments in underground Labs:

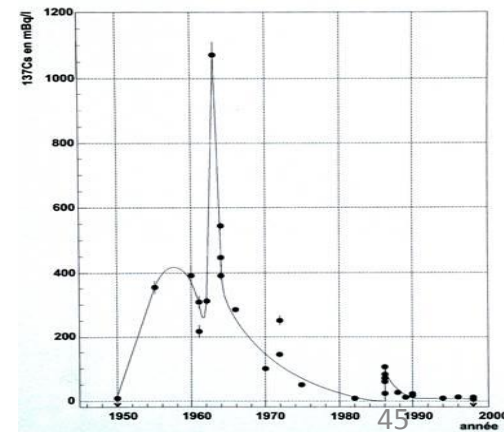
- **Geoscience**

- Low freq. Seismographs
- Radon measurements
- geoneutrinos

- **Low radiation measurements**

- Material selection
- Environment pollution
- microelectronics

- **Biology**

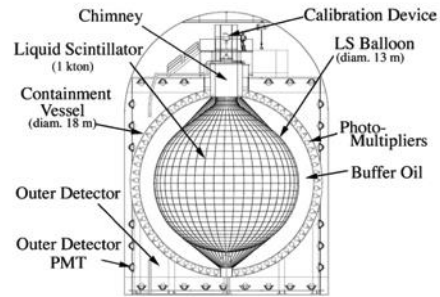


# ANDES initial Scientific Programme

- 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)

## Proposed Large Latinamerican Neutrino Detector

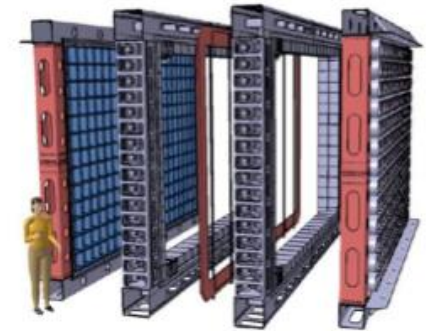
- 3 – 10 kton of liq. Scintillator
- arXiv:1027.5454



## Double Beta experiments:

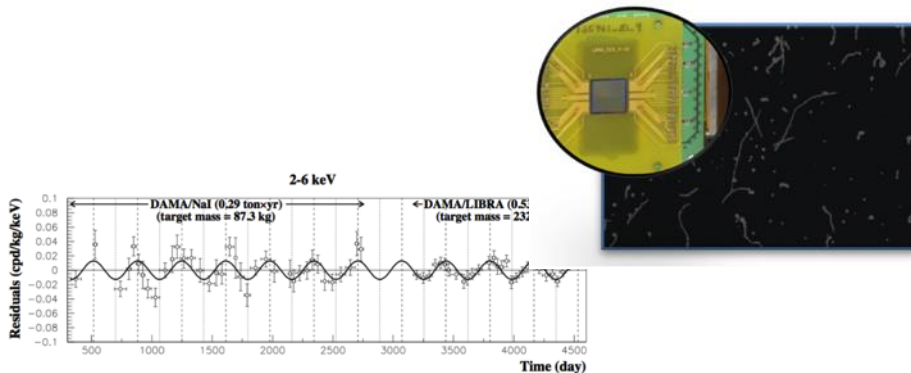
Manifested interest:

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



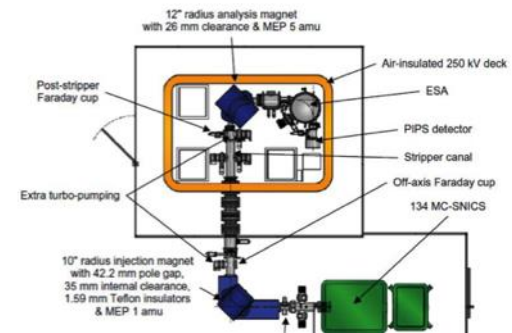
## Dark Matter:

- 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



## Open questions

- Lepton number non-conservation
- Nature of the neutrino: Majorana or Dirac
- Light/heavy mass ratio in the seesaw mechanism
- Absolute mass scale
- Mass hierarchy
- CP violation in the lepton sector
- Minimal extension of the Standard Model  $(SU(2)_R U(1)_{(B-L)})$
- Limits on the couplings to the singlet-scalar Majoron

This questions may be answered in the near future by the measurements of the Nuclear Double Beta Decay



## Present and future experiments: a short list

- Several double beta decay experiments have been taking data with quantities of enriched isotopes around or above 100 kg and plans are under way for tonne-scale experiments. These efforts revolve around several isotopes and use a broad array of detection techniques (KamLAND-ZEN, SNO+, EXO-200/nEXO, GERDA, CUORE, SuperNEMO, COBRA, Majorana) .
- Experiments of such scale make enormous demands on the progress and reliability of the nuclear matrix elements calculations.
- The research in the field of special modes of  $\beta^-\beta^-$ , such as  $\beta^+\beta^+$  or  $2\nu\text{ECEC}$  starts to be more and more interesting from experimental and theoretical points of view (e.g. COBRA, TGV)
- Further development of the theory of such processes is crucial for continuation of the experimental activities in this field.

## The research in ANDES: a view

- The neutrino puzzle is not yet solved and future experiments in ANDES may play an important role in the quest for the solutions.
- ANDES may host modulus of extended detectors, like Majorana and Super-Nemo, and in due time build its own Double Beta Decay Experiment. A good candidate will be the decay of  $^{128,130}\text{Te}$
- More refined measurements of the neutrino oscillation parameters in ANDES may be planned in view of the space available for large detectors.
- DAMA like experiments in ANDES may confirm the findings of experiments performed in the northern hemisphere. The location of ANDES is very convenient for it.
- The activities around ANDES, both in theory and experiments, will certainly give a great impulse to physics, astrophysics and detector-technology.
- ANDES should not be a repository but a generator of new and challenging experiments.

## ANDES: first steps (since 2010)

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- Time evolution of ANDES I.
  - Memorandum of understanding about the construction of the lab.
  - Discussions about the creation of the CLES.
  - Committees ANDES in Argentina, Brazil, Chile, Mexico
  - ANDES office in CLAF.
  - International support of the ANDES project.
  - Evaluation of ANDES in the Ministry of Science of Argentina.
  - Discussions with EBITAN and the formal inclusion of ANDES in the tunnel's complex.



## ANDES: first steps

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- Time evolution of ANDES II.
  - Discussions with Chilean authorities about ANDES
  - Workshops (Bs.As, Brazil, Mexico, Chile)
  - ANDES in several international conferences and papers about ANDES.
  - First scientific advisory committee.
  - Talks with members of the boards and directors of underground labs.
  - Design and fine details of the construction.



## From the drawings to reality: I

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- Basic:

- Construction and design of ANDES: technical committee, formal association with EBITAN from the start of the construction of the tunnels.
- Financing ANDES: who is paying and for what, how to channel and supervise the funds, international status of ANDES, diplomatic aspects, waivers and free circulation to and from the lab.
- Time table and accessories (networks, access, lodging, technical support)



## From the drawings to reality: II

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- Planning
  - Scientific branch
  - Administrative branch
  - Evaluation of ANDES activities, ANDES and the other underground labs.



## From the drawings to reality: III

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- Physics

- ANDES White paper
- Call for experiments
- Supporting the experiments, overheads.
- R and D in ANDES, detectors and acquisition systems
- Flag experiments



## From the drawings to reality: IV

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- Other than physics
  - Seismology and geology
  - New materials in low radiation environments.
  - Low radiation biology





## From the drawings to reality: V

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- Academic

- ANDES institute (modelled after the INT and the ECT).
- ANDES and the local universities (already discussed in San Juan, physics degree oriented towards ANDES).
- ANDES and the other labs: circulation of students, technicians and physicist.
- Programming ANDES workshops, formal contacts with ICTP as a regional partner.



## From the drawings to reality: VI

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- Social

- Propagate the news about ANDES among the regional governments, among official and private organizations and industries.
- Propagate idem in the media (ANDES news, perhaps, like NUPPEC news, CERN news, etc).

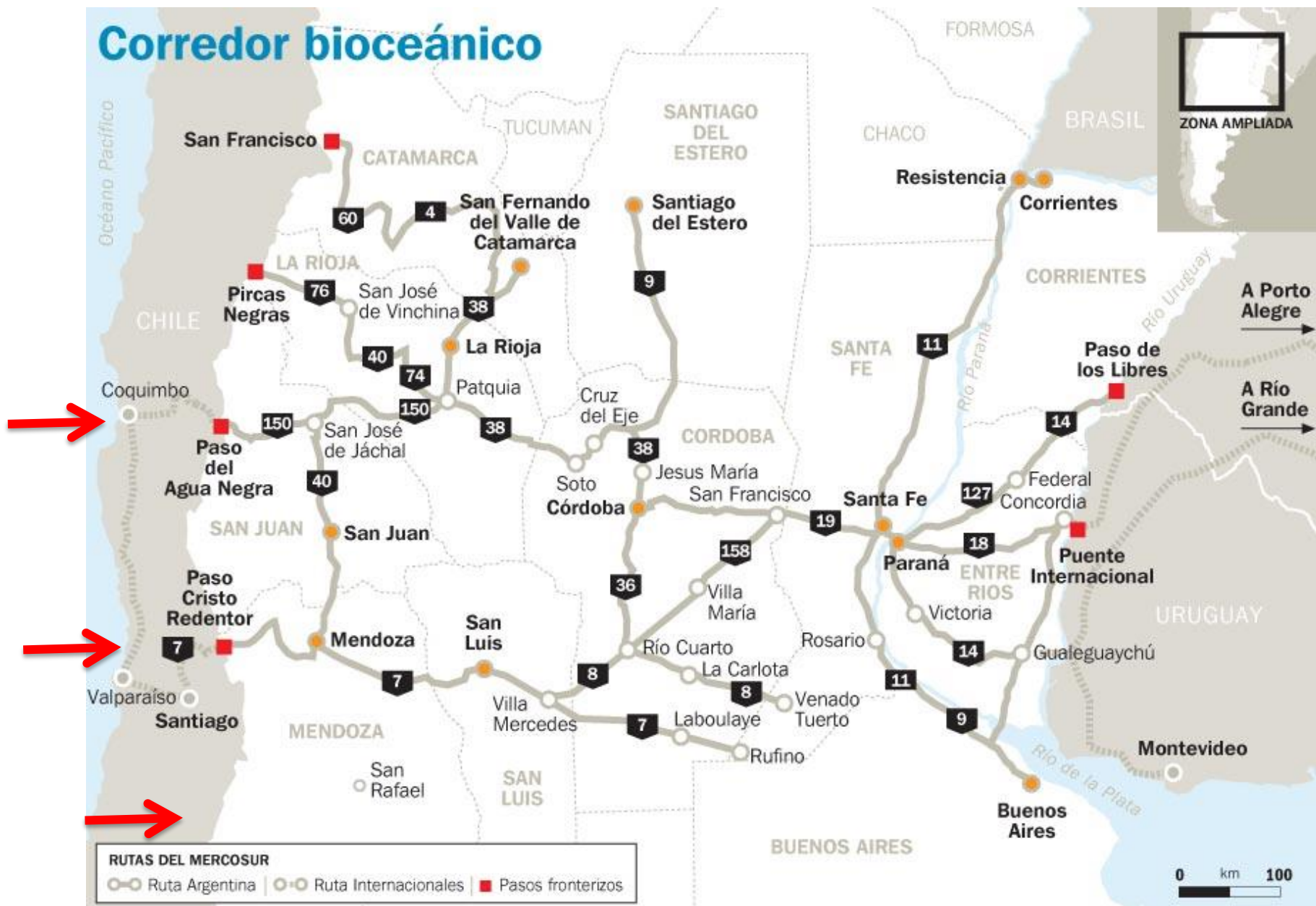
# The Tunnel Proposal

- 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

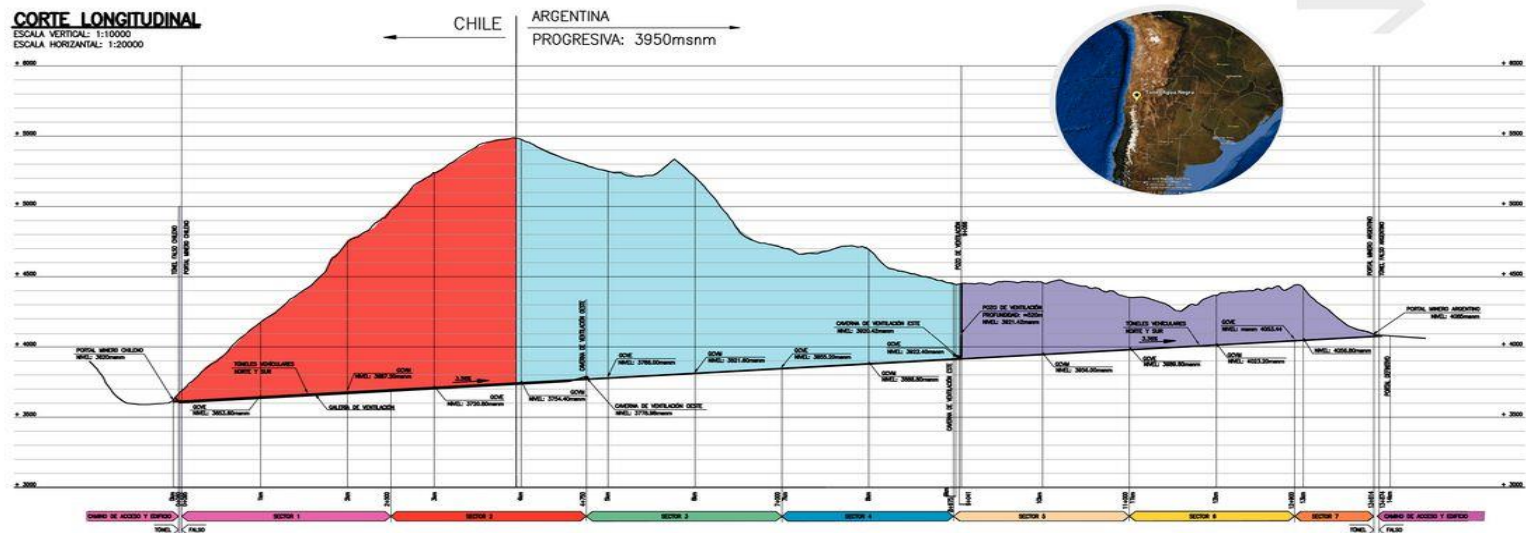


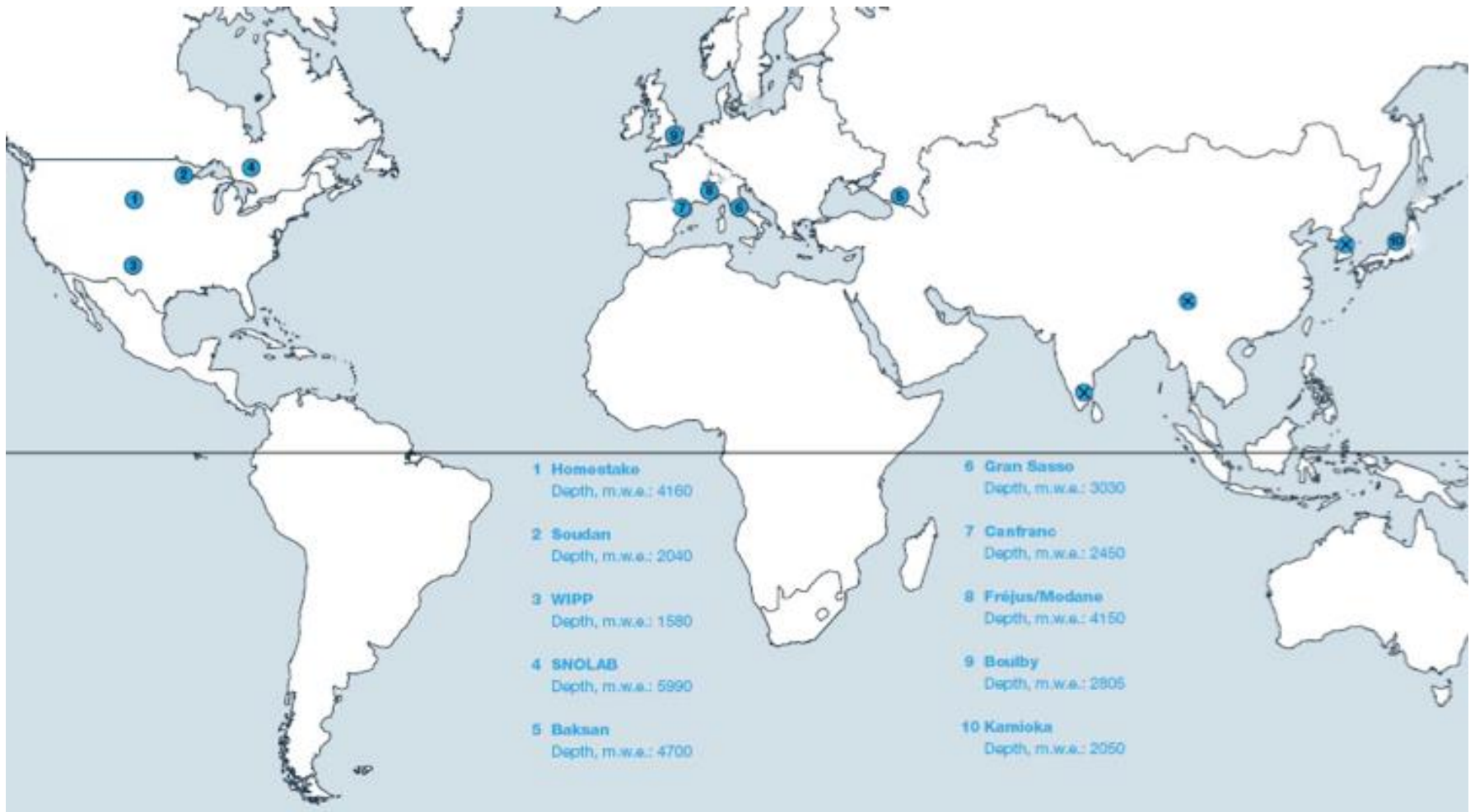
San Juan,  
Argentina



# 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).



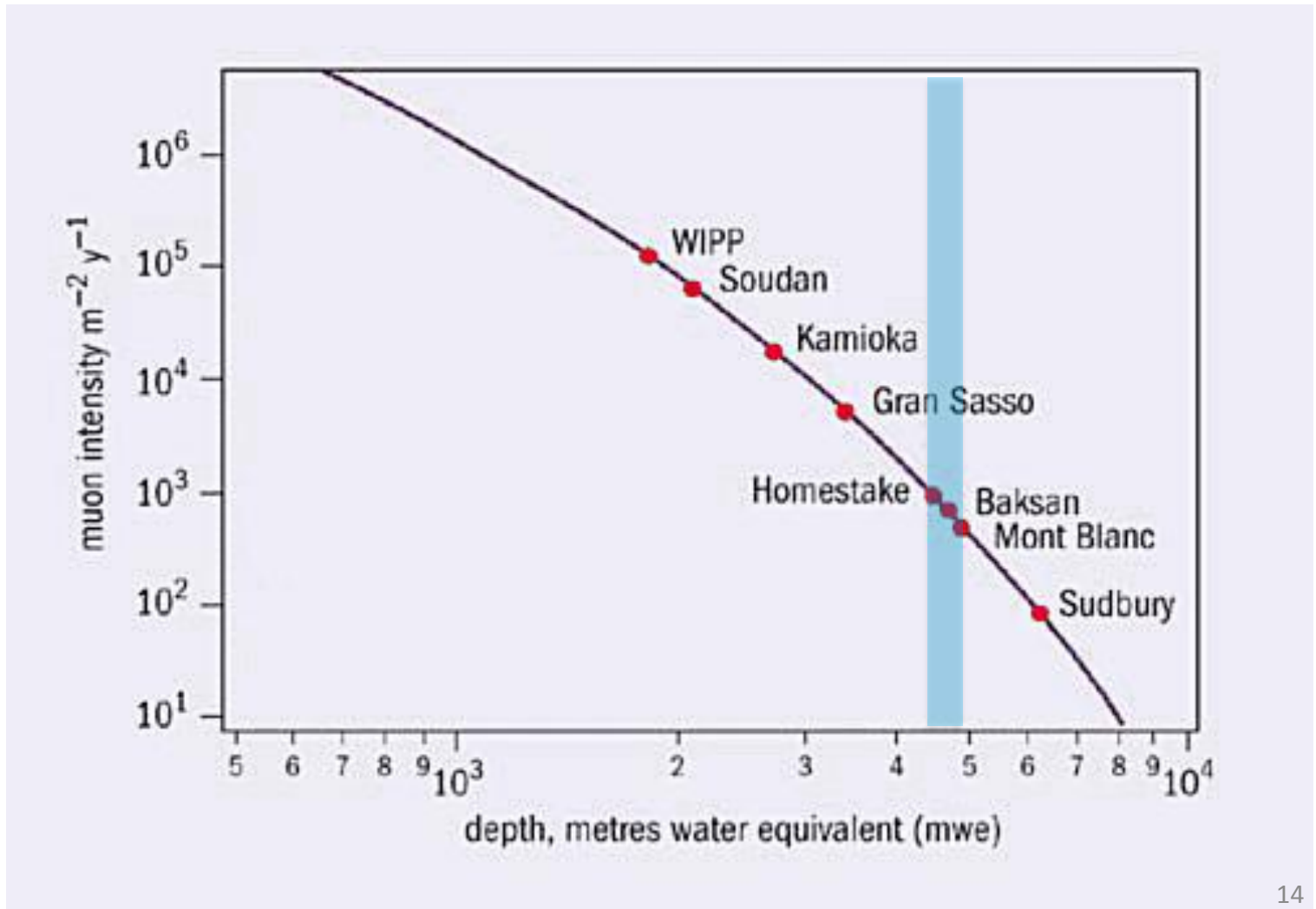


So far, all deep U. Labs are in the Northern Hemisphere.



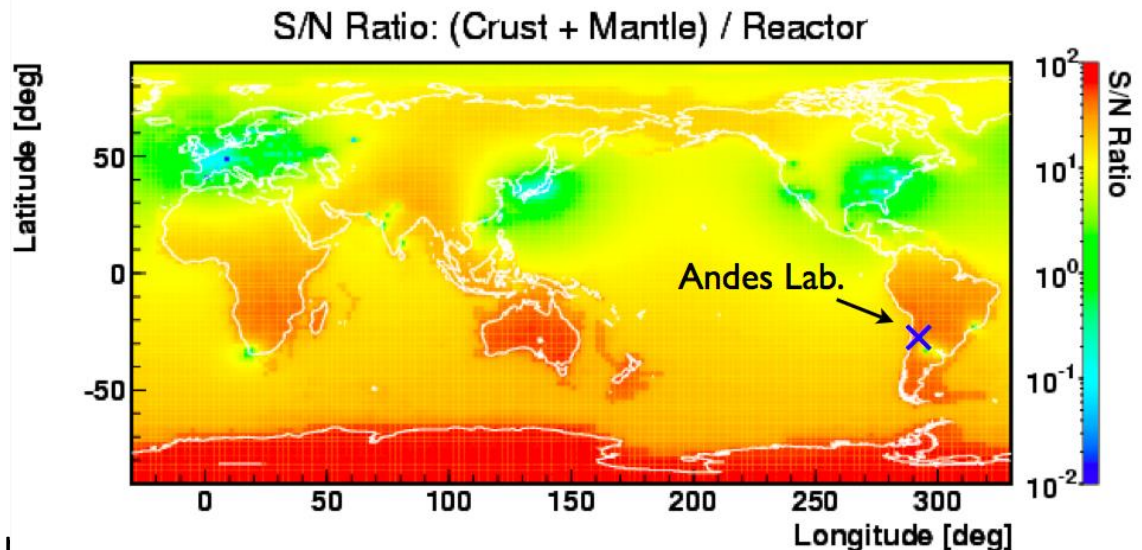
Flux at sea level  $\sim 100 / \text{m}^2 \text{ s}$

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...?



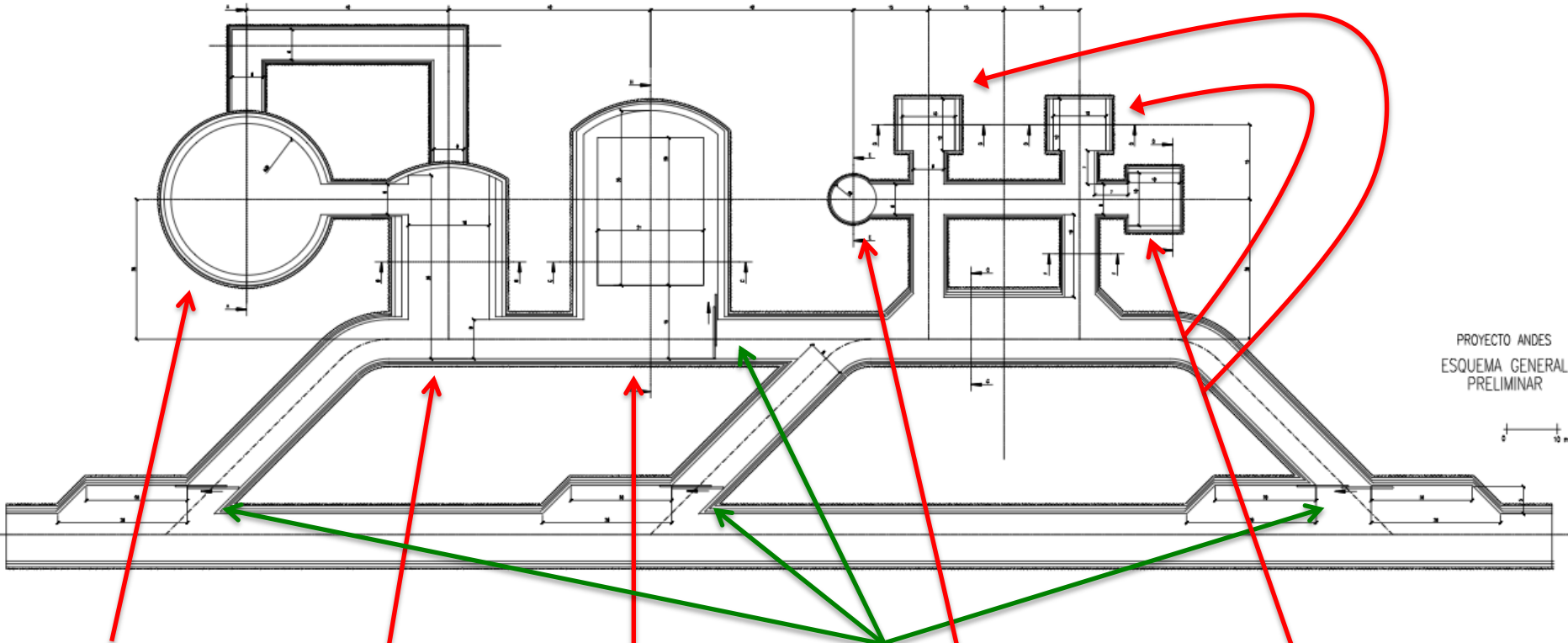
# ANDES proposed infrastructure

- **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

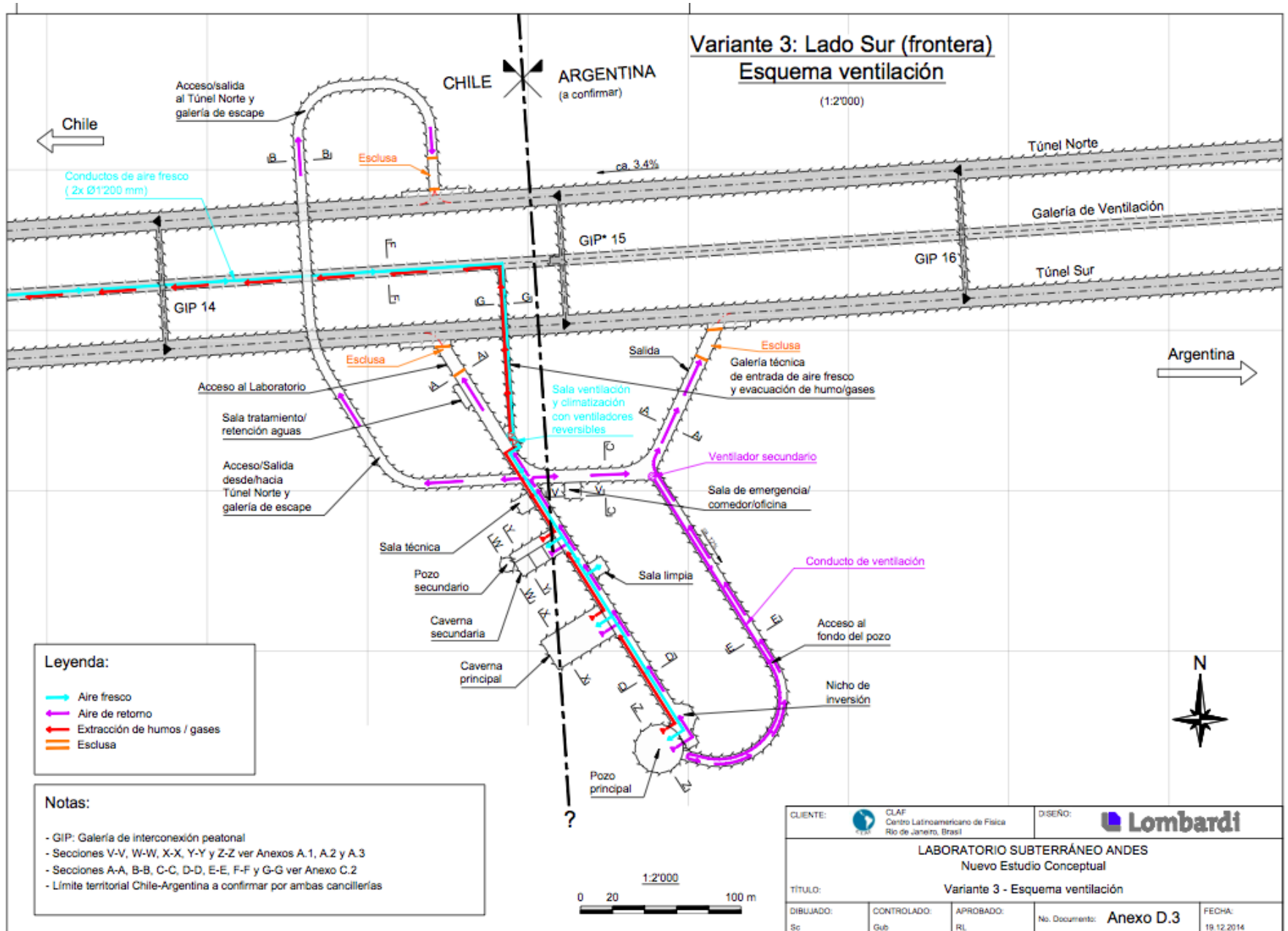
**Gates**

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

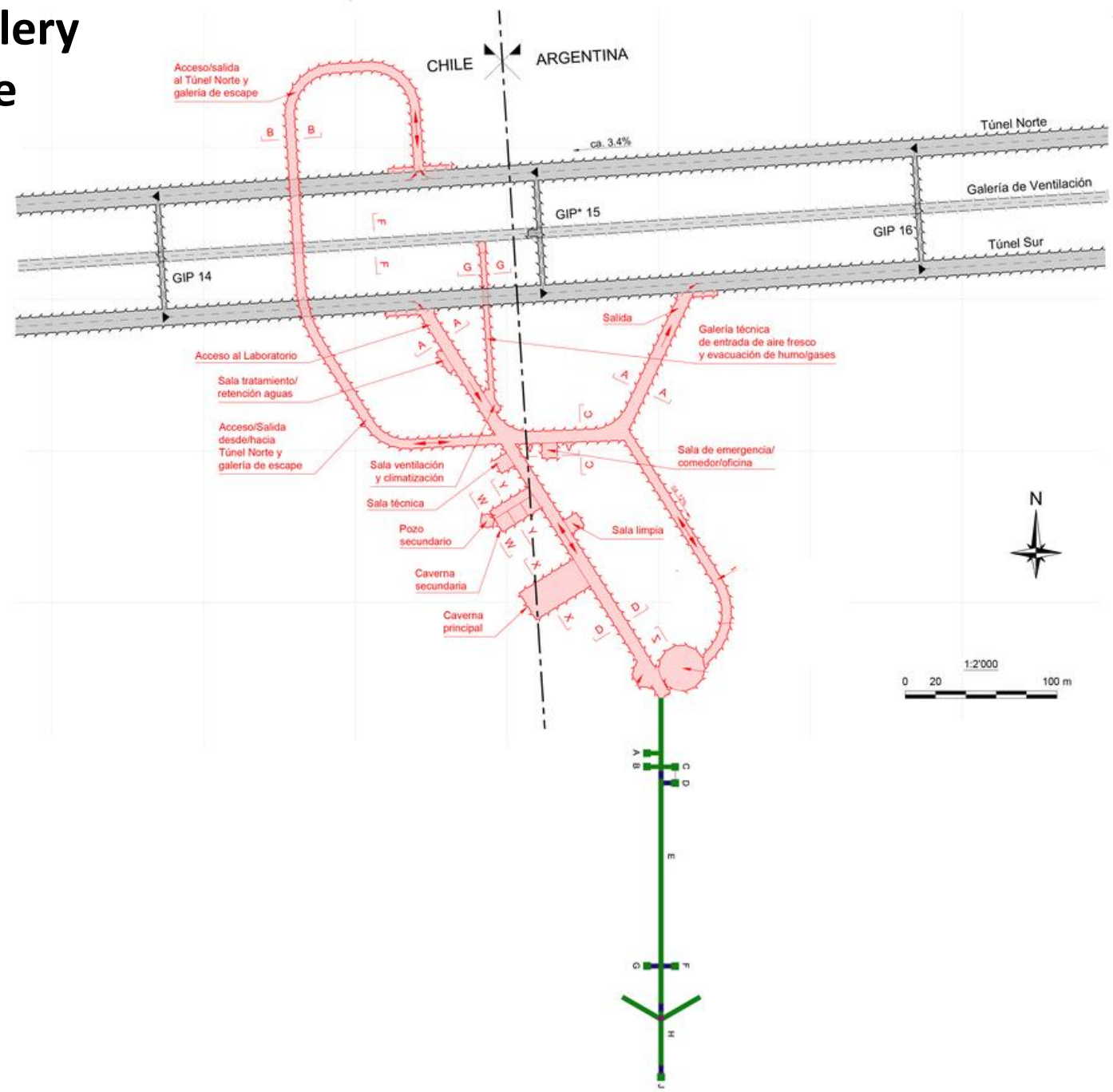
Access:  
At 10 m high and bottom

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

# Conceptual Design (by Lombardi): Ventilation



# Additional gallery for Geoscience



# Rock studies

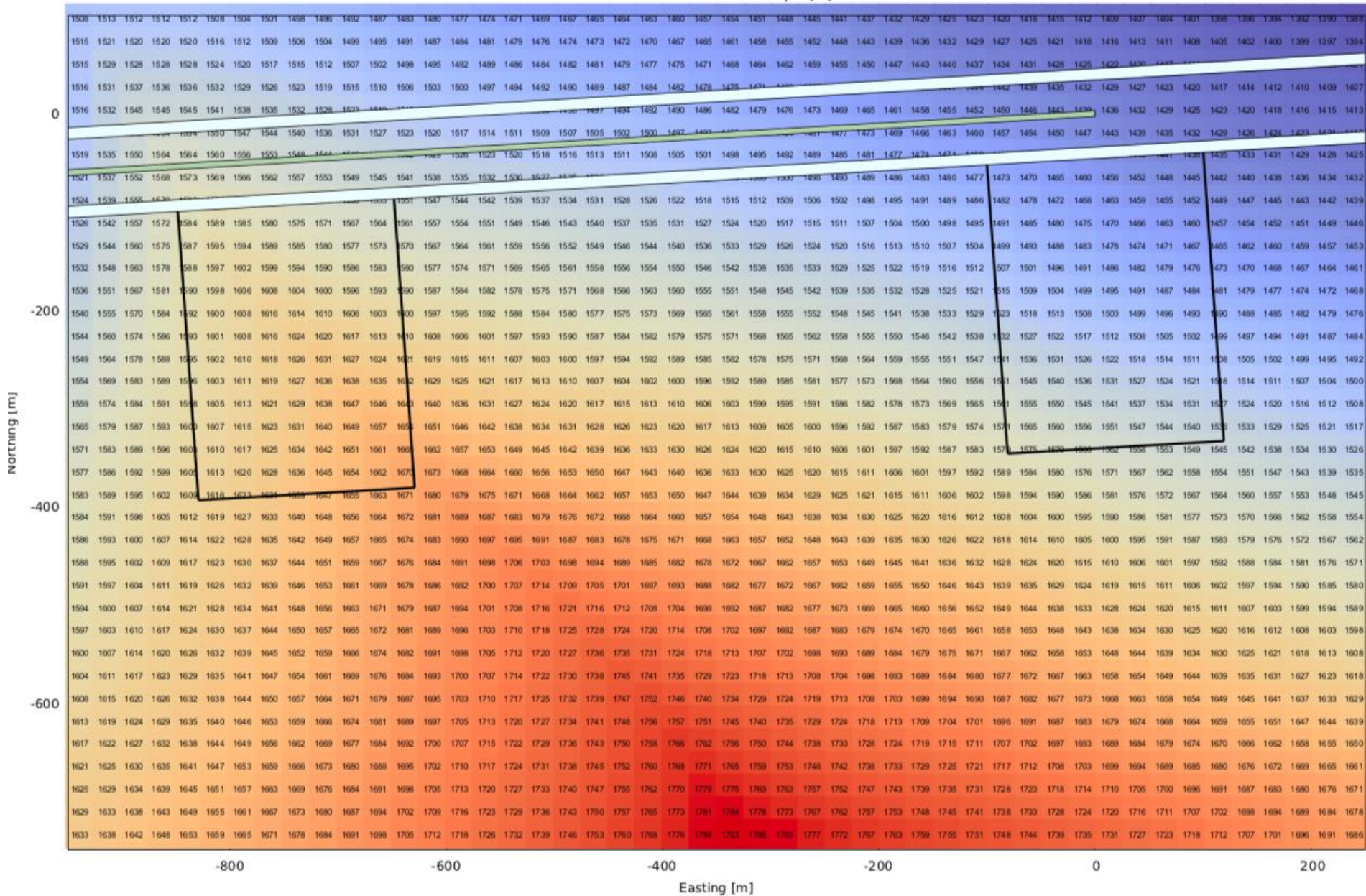
Main rock: - Andesite  
 variations: - rhyolite  
 - basalt  
 - dacite  
 - trachyte



9 samples from 8 perforations up to 600 m deep

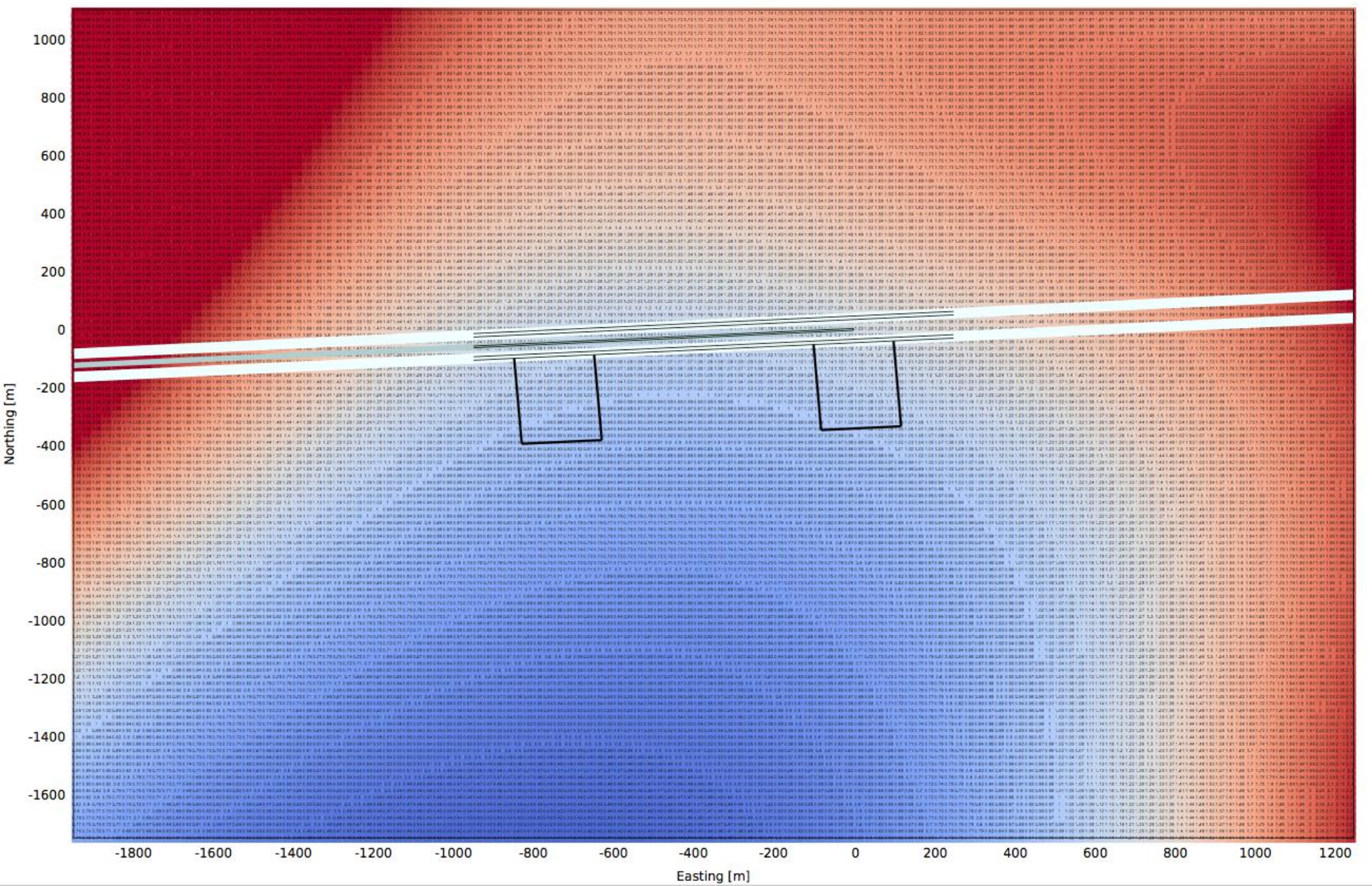
<b>(Bq/kg):</b>	<b>Andesite</b>	<b>Basalt</b>	<b>Rhyolite 1</b>	<b>Rhyolite 2</b>	<b>Canfranc</b>
U-238	$9.2 \pm 0.9$	$2.6 \pm 0.5$	$14.7 \pm 2.0$	$11.5 \pm 1.3$	4.5 -- 30
Th-232	$5.2 \pm 0.5$	$0.94 \pm 0.09$	$4.5 \pm 0.4$	$4.8 \pm 0.5$	8.5 -- 76
K-40	$47 \pm 3$	$50 \pm 3$	$57 \pm 3$	$52 \pm 3$	37 --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

Minimum omnidirectional depth [m]



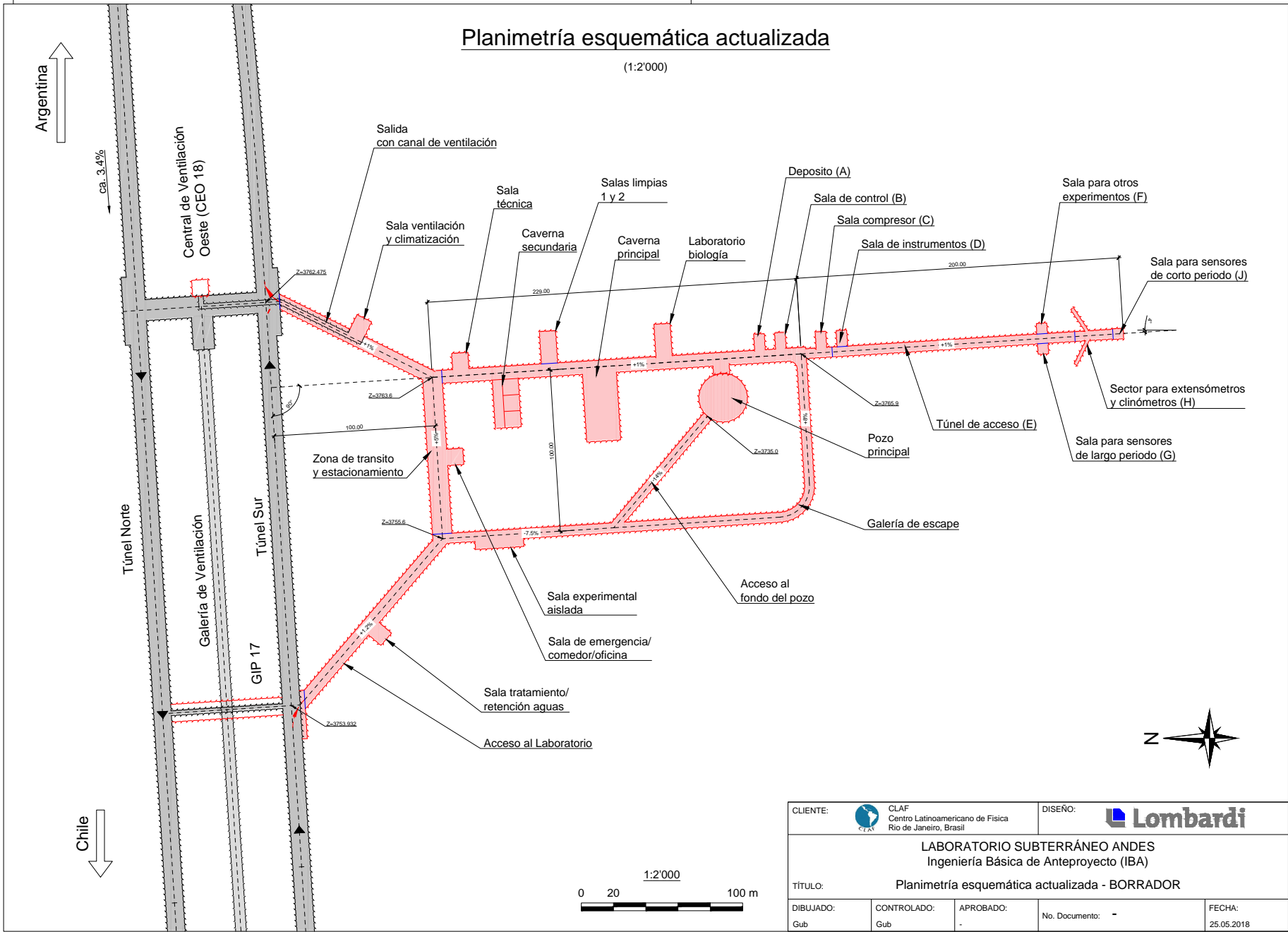




Muon relative flux

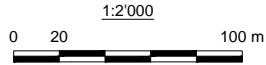


# Planimetría esquemática actualizada

(1:2'000)



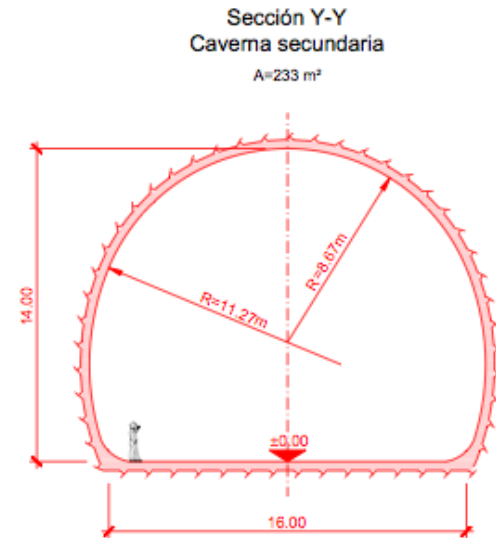
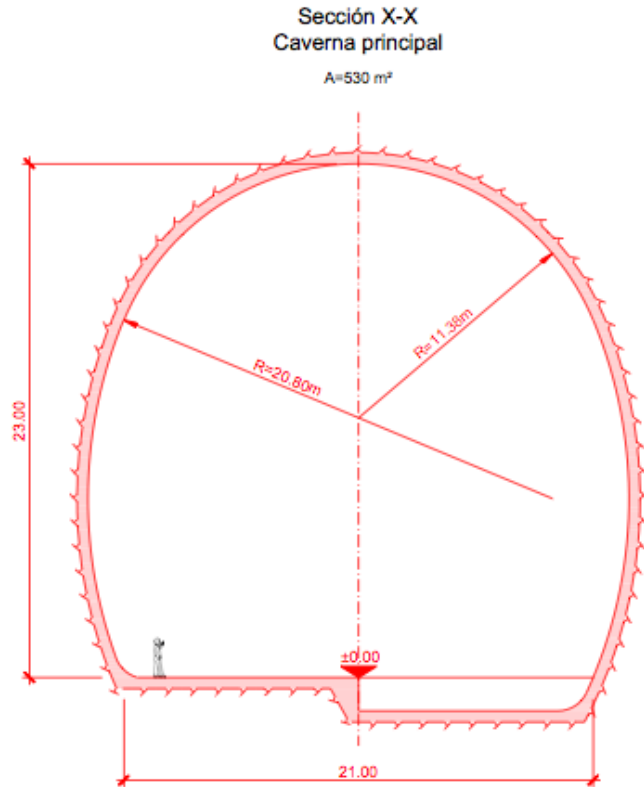
CLIENTE:	 CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	
<b>LABORATORIO SUBTERRÁNEO ANDES</b> Ingeniería Básica de Anteproyecto (IBA)			
TÍTULO:	Planimetría esquemática actualizada - BORRADOR		
DIBUJADO:	CONTROLADO:	APROBADO:	No. Documento: -
Gub	Gub	-	FECHA: 25.05.2018



# 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

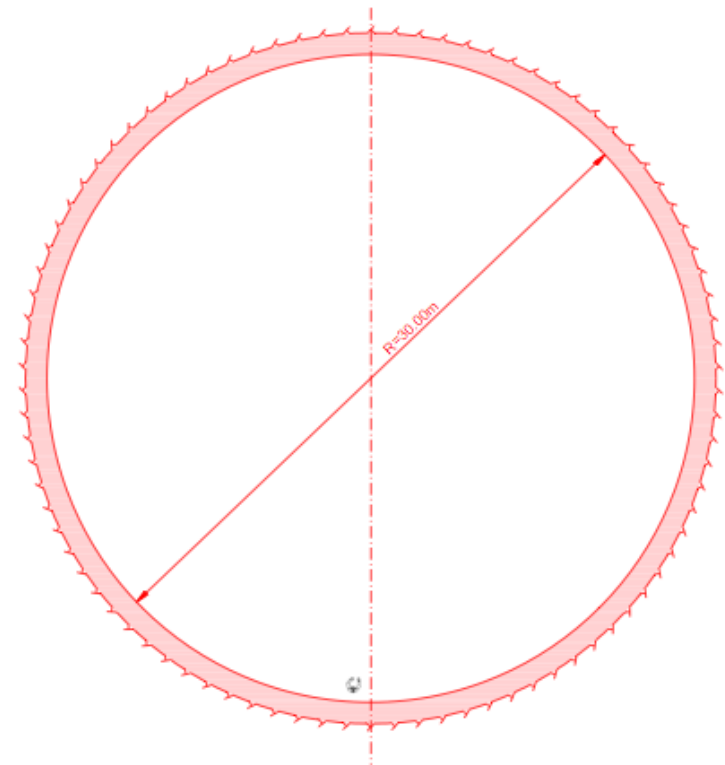
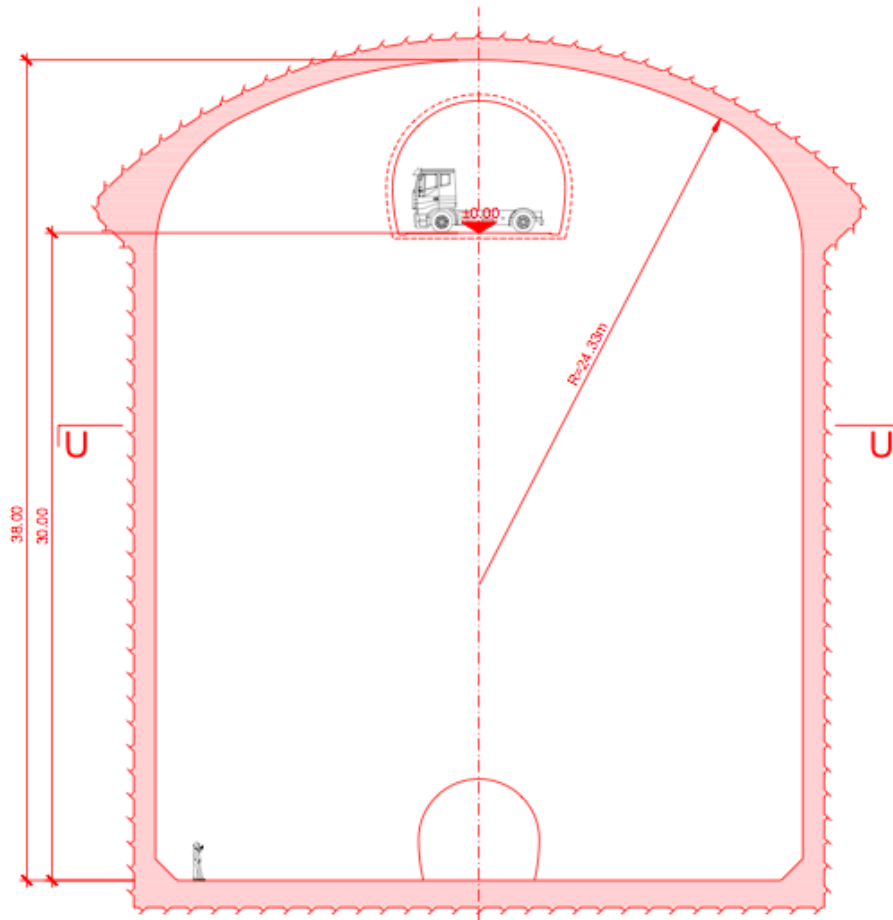
# Conceptual Design (by Lombardi): Main pit sections

## Pozo principal Secciones esquemáticas

(1:200)

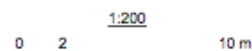
Sección Z-Z  
V=30'600 m<sup>3</sup>

Sección U-U  
A= 804 m<sup>2</sup>



### Notas:

- Planimetrías esquemáticas ver Anexo B



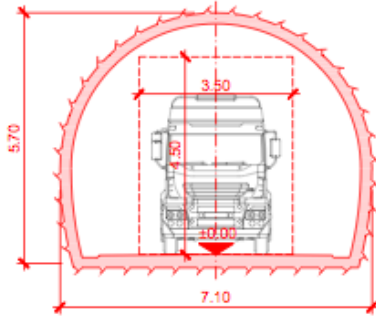
CUENTE:	CLAF Centro Latinoamericano de Física Rio de Janeiro, Brasil	DISEÑO:	Lombardi
LABORATORIO SUBTERRÁNEO ANDES Nuevo Estudio Conceptual			
TÍTULO: Pozo principal - Secciones esquemáticas			
DIBUJADO: Sc	CONTROLADO: Gub	APROBADO: RL	No. Documento: <b>Anexo A.2</b> FECHA: 19.12.2014

# Conceptual Design (by Lombardi): Access sections

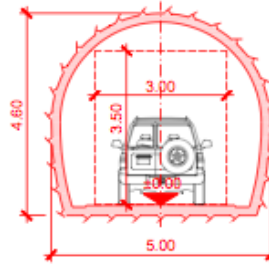
## Variante 3: Lado Sur, frontera / Variante 4: Lado Norte, frontera Secciones esquemáticas accesos

(1:100)

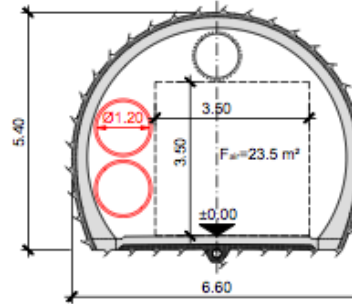
**Sección A-A**  
Galería de acceso/salida principal  
A= 35 m<sup>2</sup>



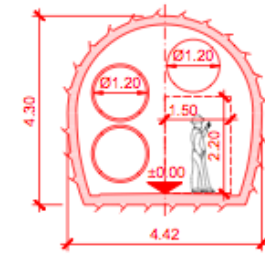
**Sección B-B**  
Galería de acceso/salida secundaria  
A= 20 m<sup>2</sup>



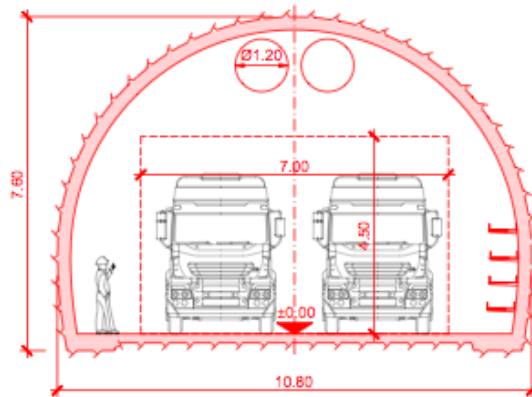
**Sección F-F**  
Galería de ventilación  
(Proyecto TAN)



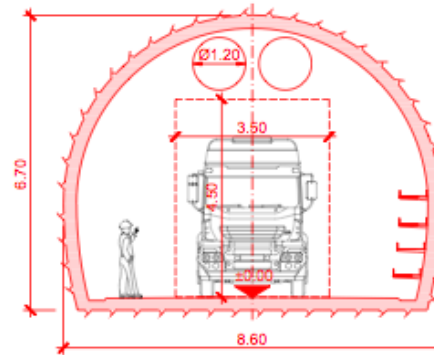
**Sección G-G**  
Galería técnica de ventilación  
A= 16 m<sup>2</sup>



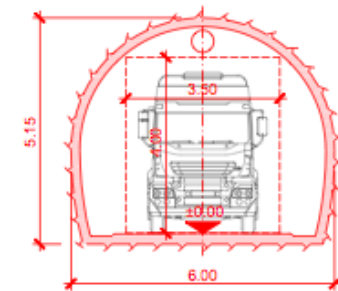
**Sección C-C**  
Zona de tránsito central  
A= 68 m<sup>2</sup>



**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



# 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...?



# 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>

**Thanks for your attention (and better start digging in!!)**





Thank you