

# AN OVERVIEW OF ANDES

## AGUA NEGRA DEEP EXPERIMENT SITE

Workshop de  
Infraestructura  
Astronómica  
Argentina

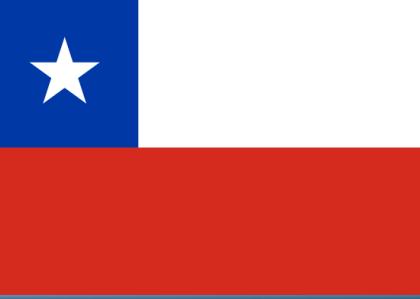
Acerca de... Comités Programa Circulares Inscripción

Córdoba - 8 al 10 de mayo de 2019



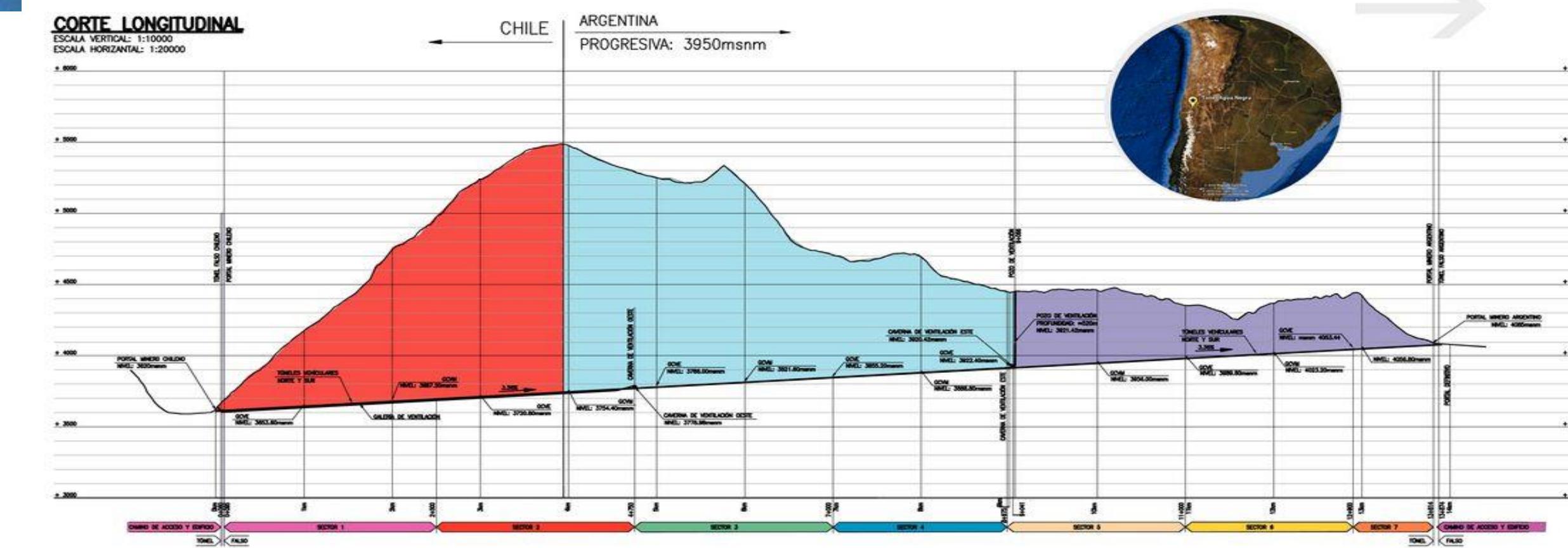


# The Agua Negra Tunnel (TAN)



- Porto Alegre-Coquimbo bioceanic corridor, regional integration artery for the south of the continent;
- Pacific Chilean ports: growing commerce with Asia (China, India, Japan,...)

- 1750 m deep at the frontier
- Slope ~ 3%
- Two parallel tunnels, 14 km long, 60 m separation
- 12 m diameter (two lanes each), connecting galleries every 500 m.



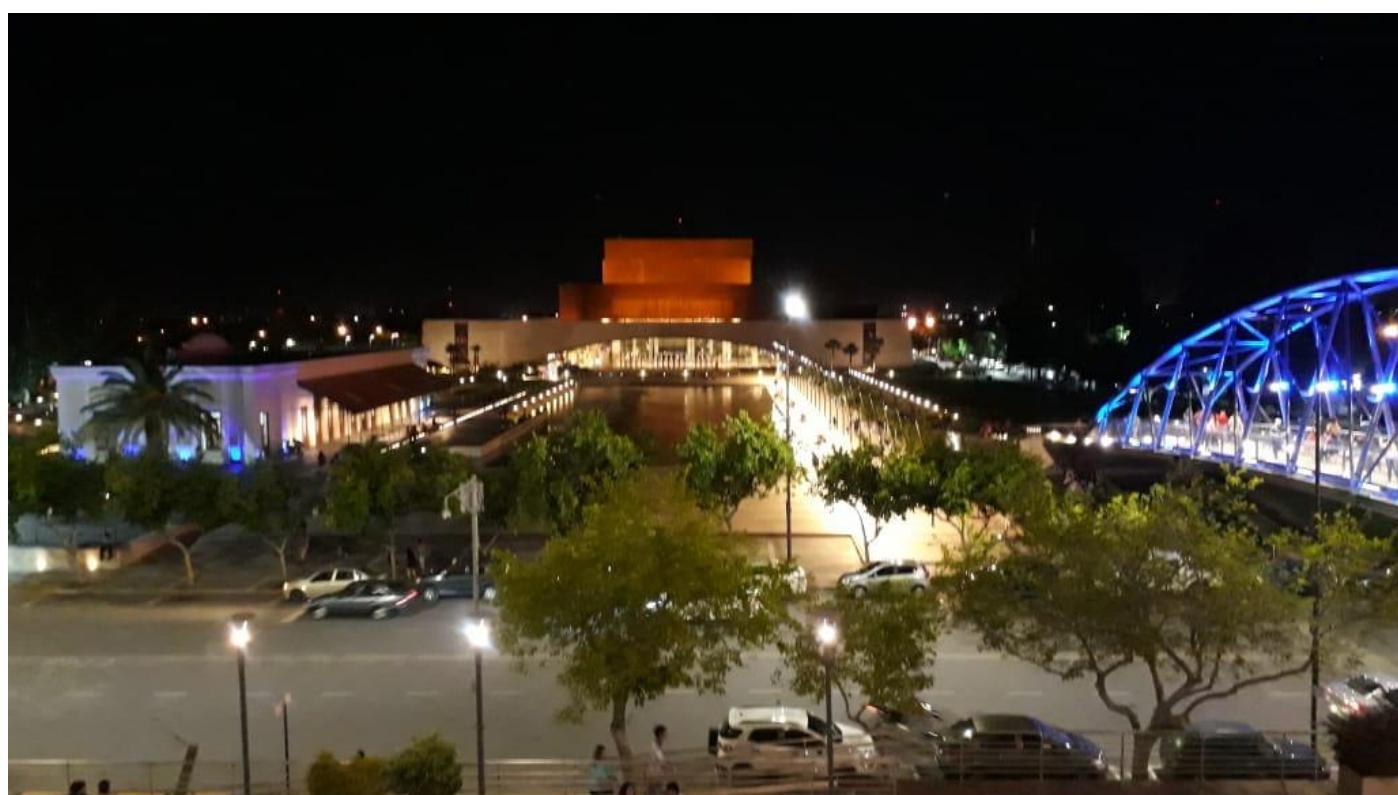
# First Deep Underground Laboratory in the Southern Hemisphere

## La Serena, Chile



Región Cuarta (Región de Coquimbo)  
Capital La Serena

## San Juan, Argentina



# Visit to TAN Area

First International ANDES-GEO Workshop

14 to 16 November 2018

San Juan, Argentina

<https://andesgeo2018.com/>

ANDES website <http://andeslab.org>

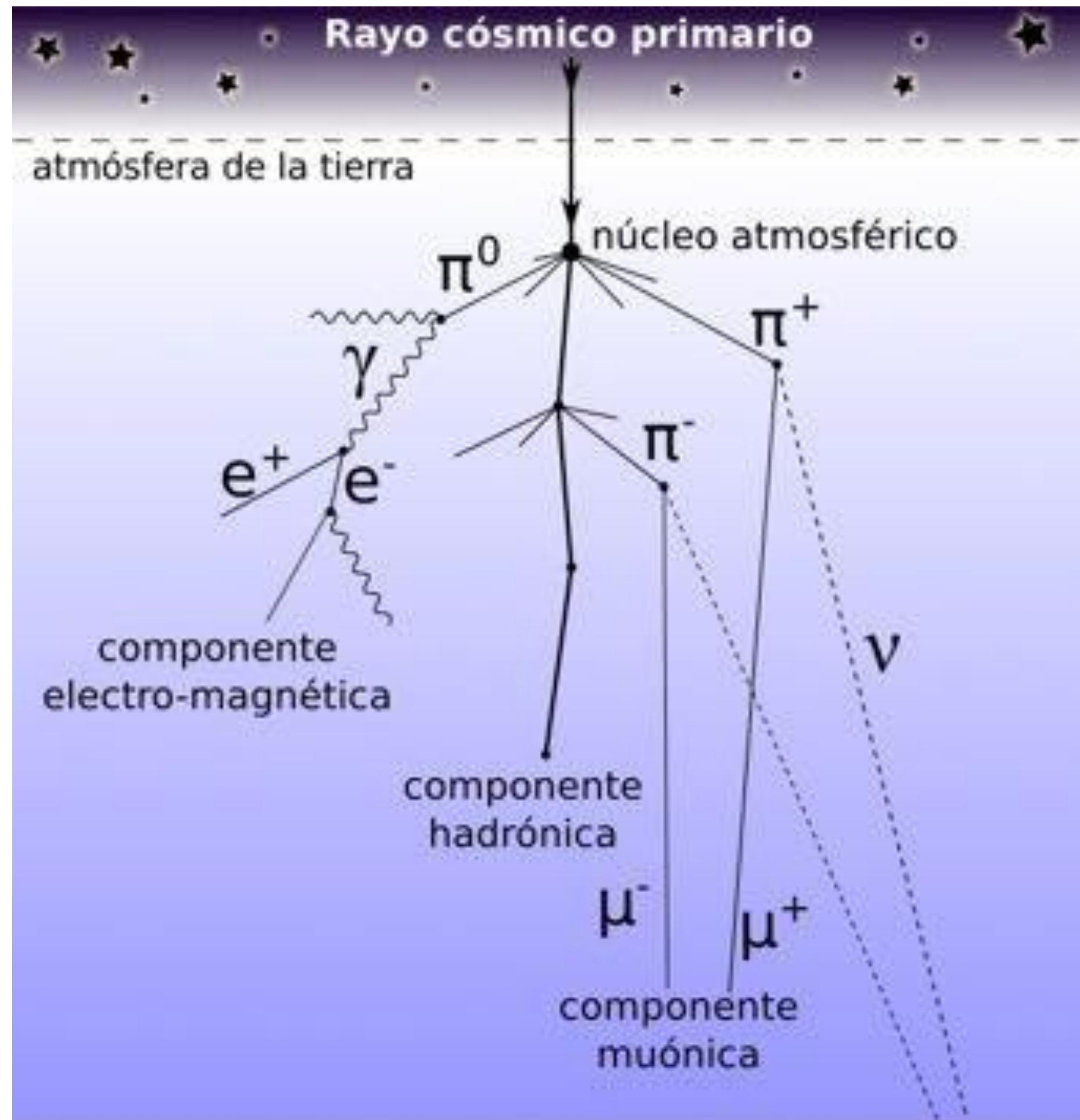


# Next Steps

## GOALS

- 1. Science**
- 2. Technology (detection systems)**
- 3. Human Resources in astrophysics and engineering**
- 4. Outreach**

# Noise: Cosmic Rays



In a cubic meter of detector at ground level, one detects every day:

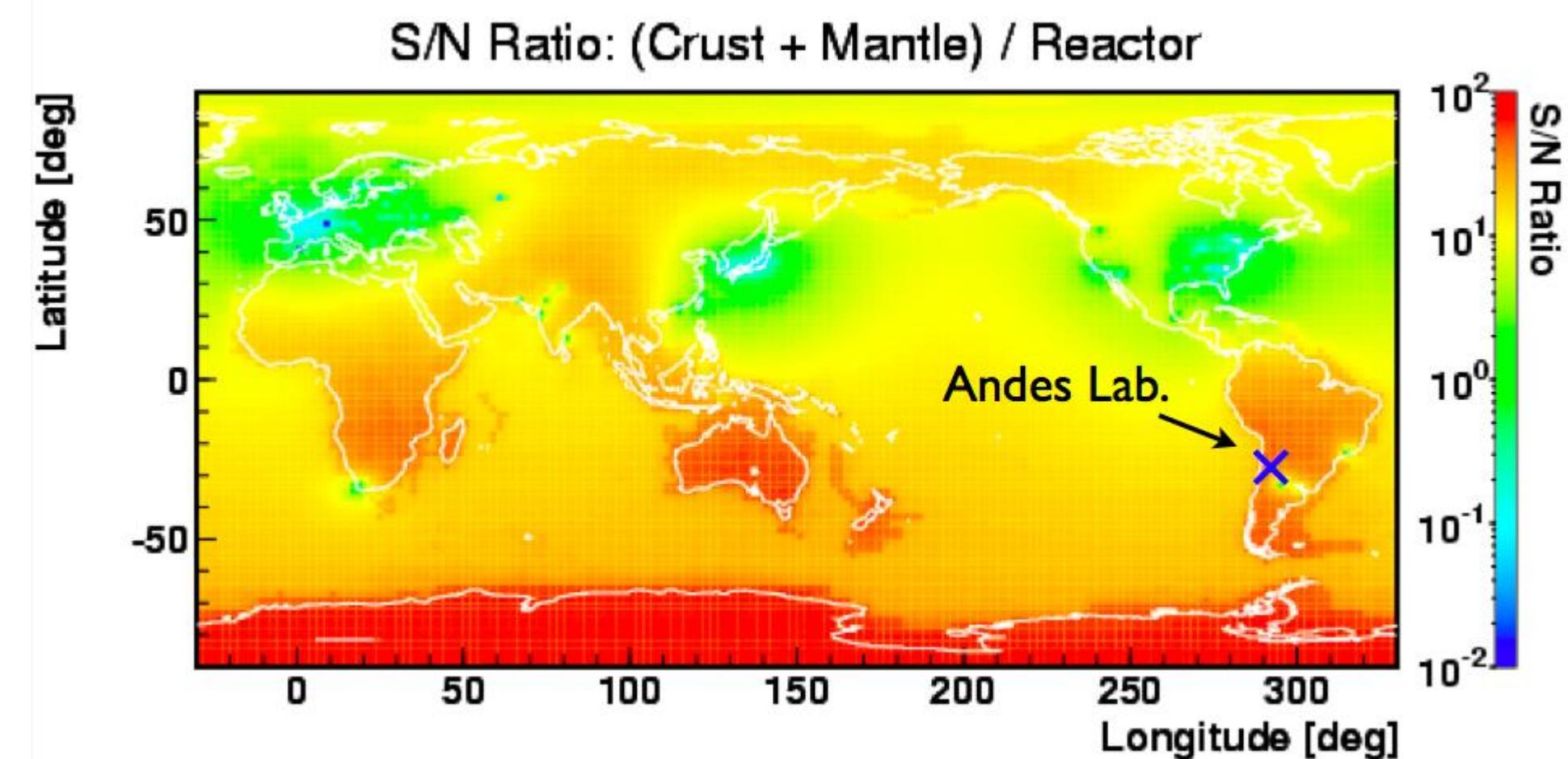
- $10^8$  muons
- $10^8$  gammas/electrons/positrons
- $10^6$  neutrons
- $10^{-3}$  neutrinos
- $10^{-7}$  supernova neutrinos
- maybe 100s of dark matter particles

} Weakly interacting



# ANDES Location

- 1.- First in Southern Hemisphere**  
7 in North America, 6 in Europe, and 2 in Asia
- 2.- Very low neutrino background**
- 3.- Third deepest in the world**
- 4.- Geoscience of the Cordillera de los Andes**



**Geo-neutrino signal / neutrino background**  
Reactors in Argentina and Brazil too far away,  
make no impact on ANDES

# ANDES Scientific Programme

## 1. - Astrophysics

### 1.1) Neutrino physics:

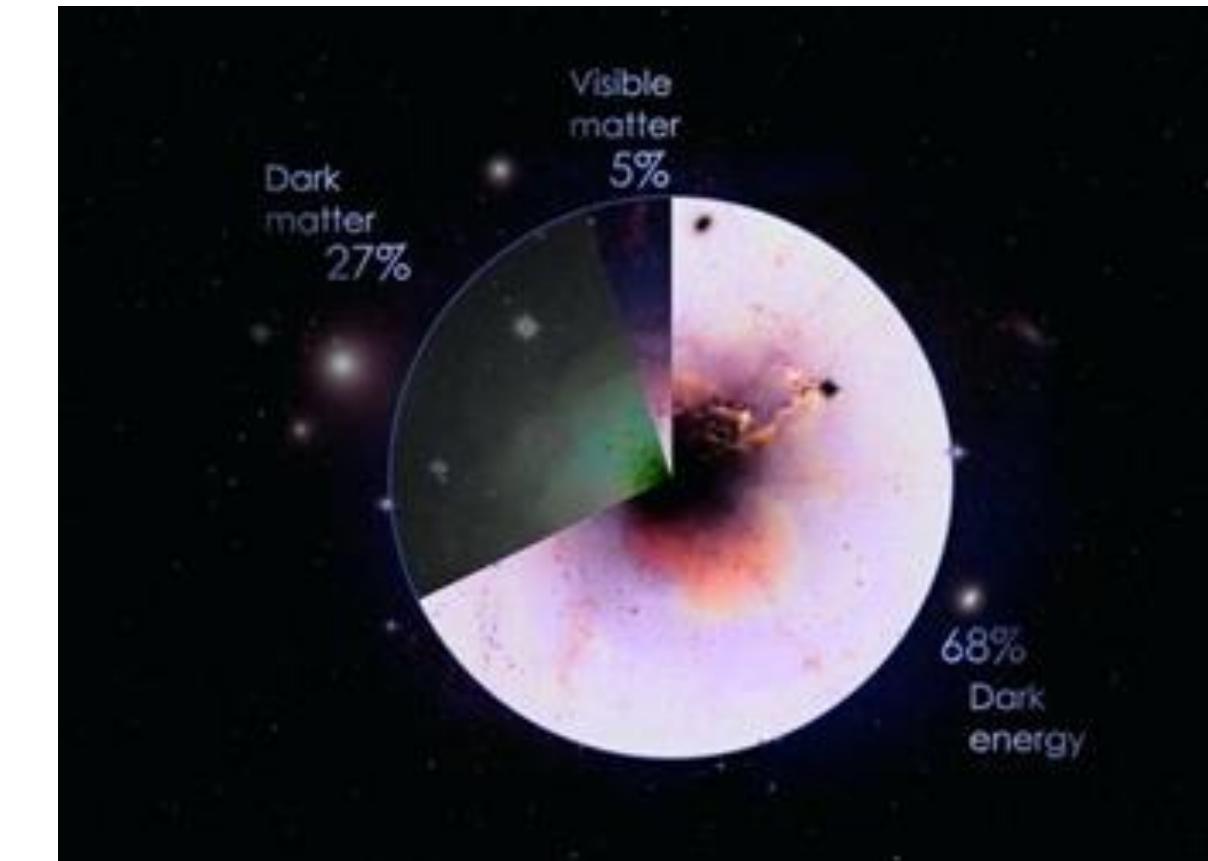
- host double beta decay experiments (Dirac vs. Majorana)
- neutrino mass (outside standard model)
- solar neutrinos (understand energy generation in sun)
- geoneutrinos: Earth abundances and spatial distribution of father elements
- do more (sterile) neutrinos exist?
- do neutrinos violate CP?

### 1.2) Dark Matter

- modulation measurements
- new technologies

## 2) Biology

*Low radiation measurements (cell mutations)*



## 3) Geoscience

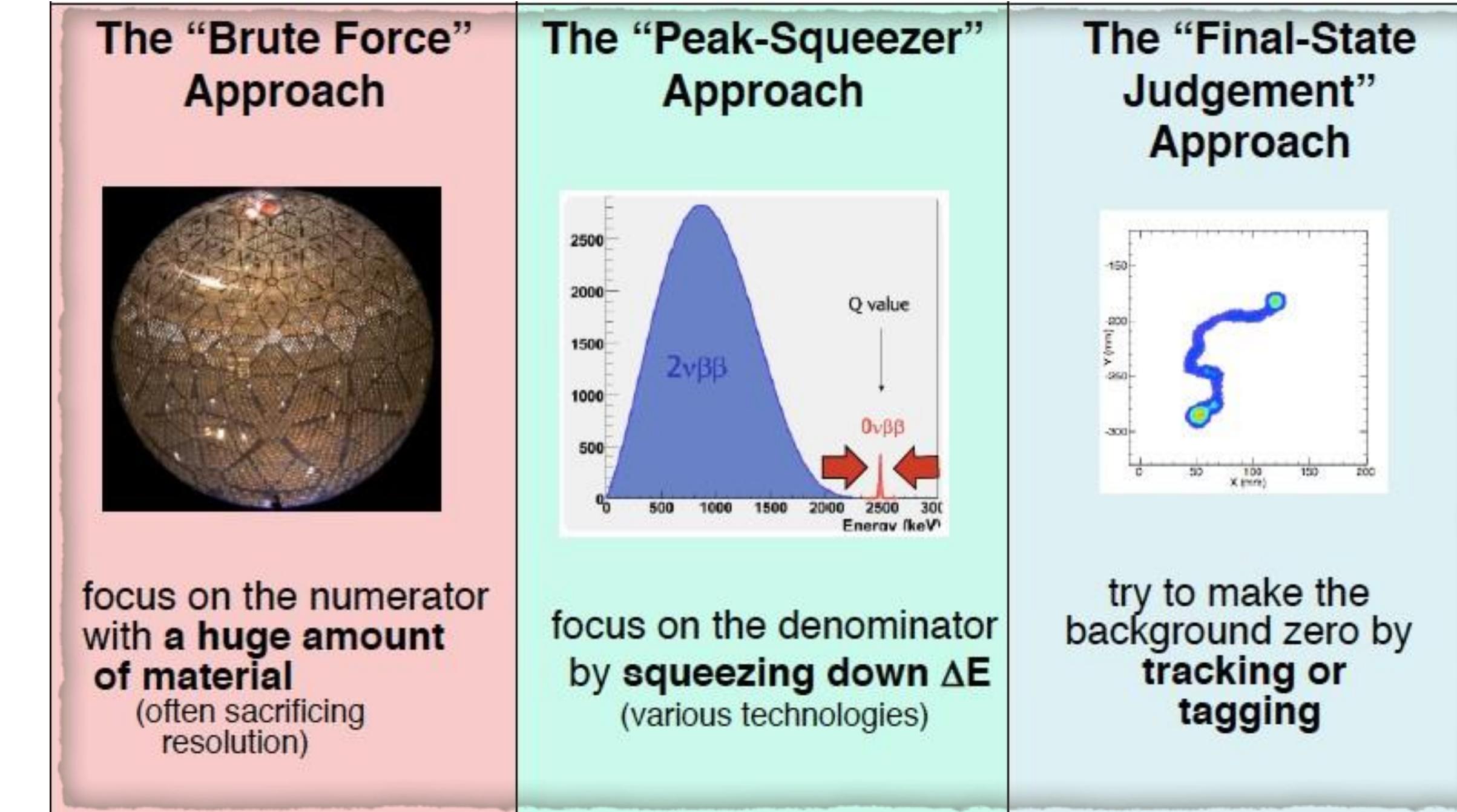
*seismology; thermochronology; Andean orogen; lithographic mapping, microdeformation and thermoelasticity*

## 4) Nuclear Astrophysics

- tests of general relativity and quantum mechanics
- nucleosynthesis of elements in the earliest universe and in all the objects (stars) formed thereafter

# Neutrinoless Double- $\beta$ decay

→  $\beta\beta 0\nu$ : kinetic energies of the two released electrons is equal to the Q value:  $Q_{\beta\beta}$



Electrons travel on average 15 cm each (a few ns). Observe the two stopping electron tracks emitted from common vertex, characteristic of double beta decays

**Best: use three techniques**  
**Cryogenic detection for background zero**  
**Is neutrino its own antiparticle?**  
**1 ton experiments, right momento for ANDES**

# Direct Dark Matter Searches

**Basic idea:** Dark matter particle interacts with a nucleus, transferring energy to it, which is then measured

Again, the idea is to built larger detectors with zero background (veto noise particles):

1. i) Dark Side 20Kg of liquid Argon (2021)  
ii) Argo, 300 Tons of liquid Argon (2027...), an ANDES candidate ...  
(SiPMs replace PMTs, same as performed by us in AMIGA/Auger muon detectors)
  
2. i) XENON1T, 1 Ton Liquid Xenon  
ii) PANDAX-4T, 4 Ton Liquid Xenon to start building 2019 ...

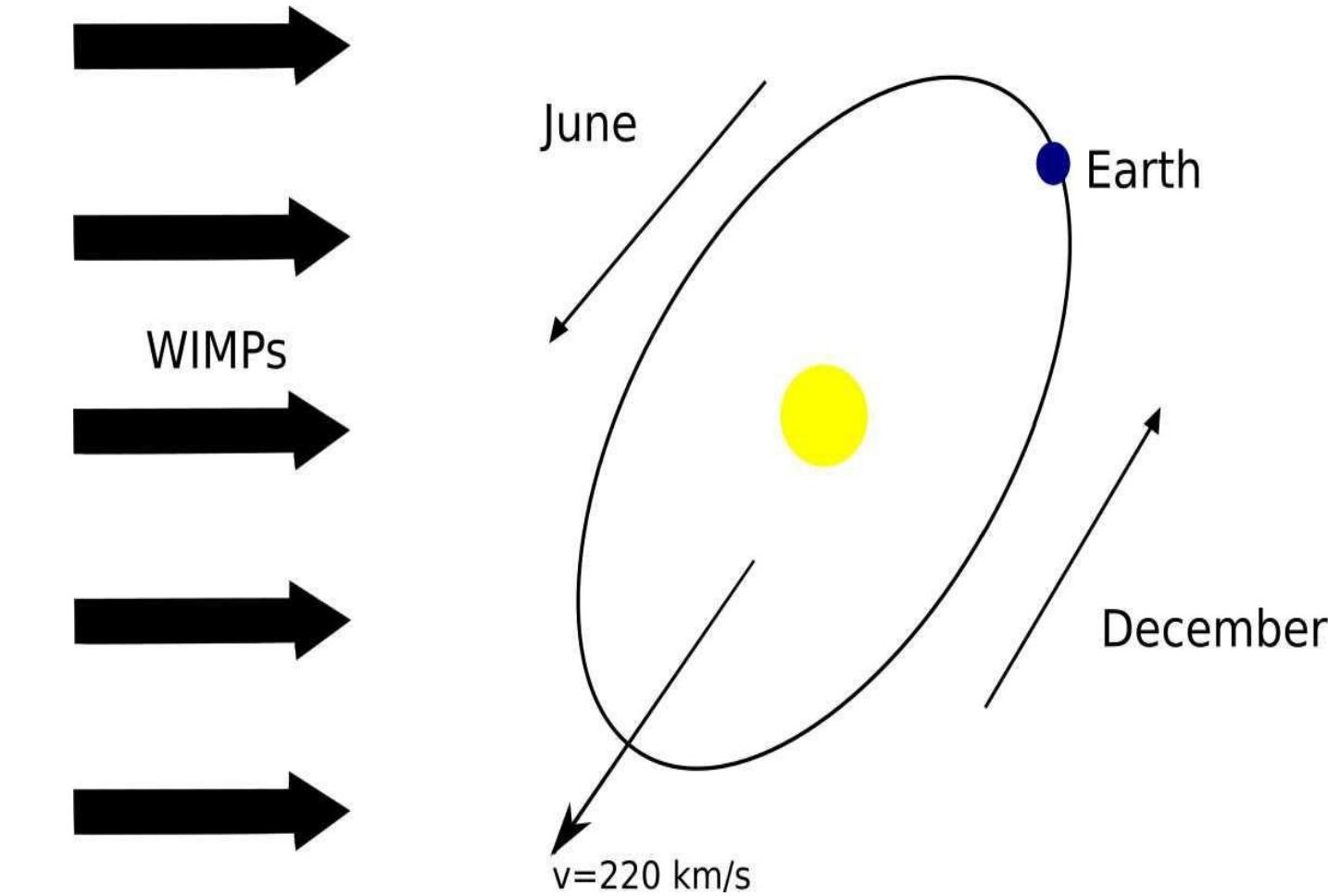
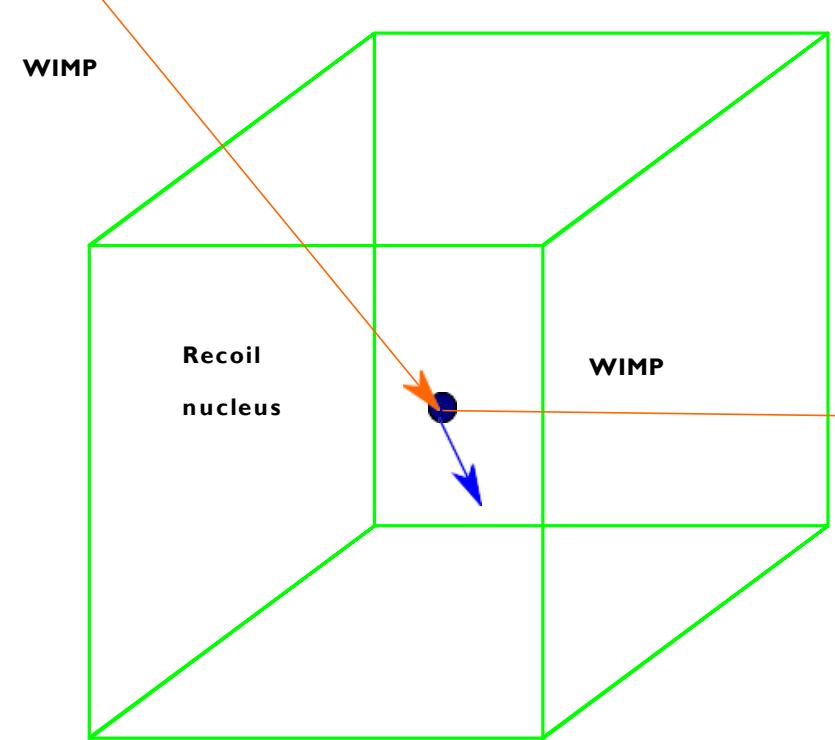
Further size upgrades will lead to the “neutrino floor”, rendering the detector system not viable for dark matter searches →

**improve detection technique (e.g. directional dark matter, signal pointing to Cygnus constellation, background less important)**



XENON1T

# Modulation - Dark Matter Detection



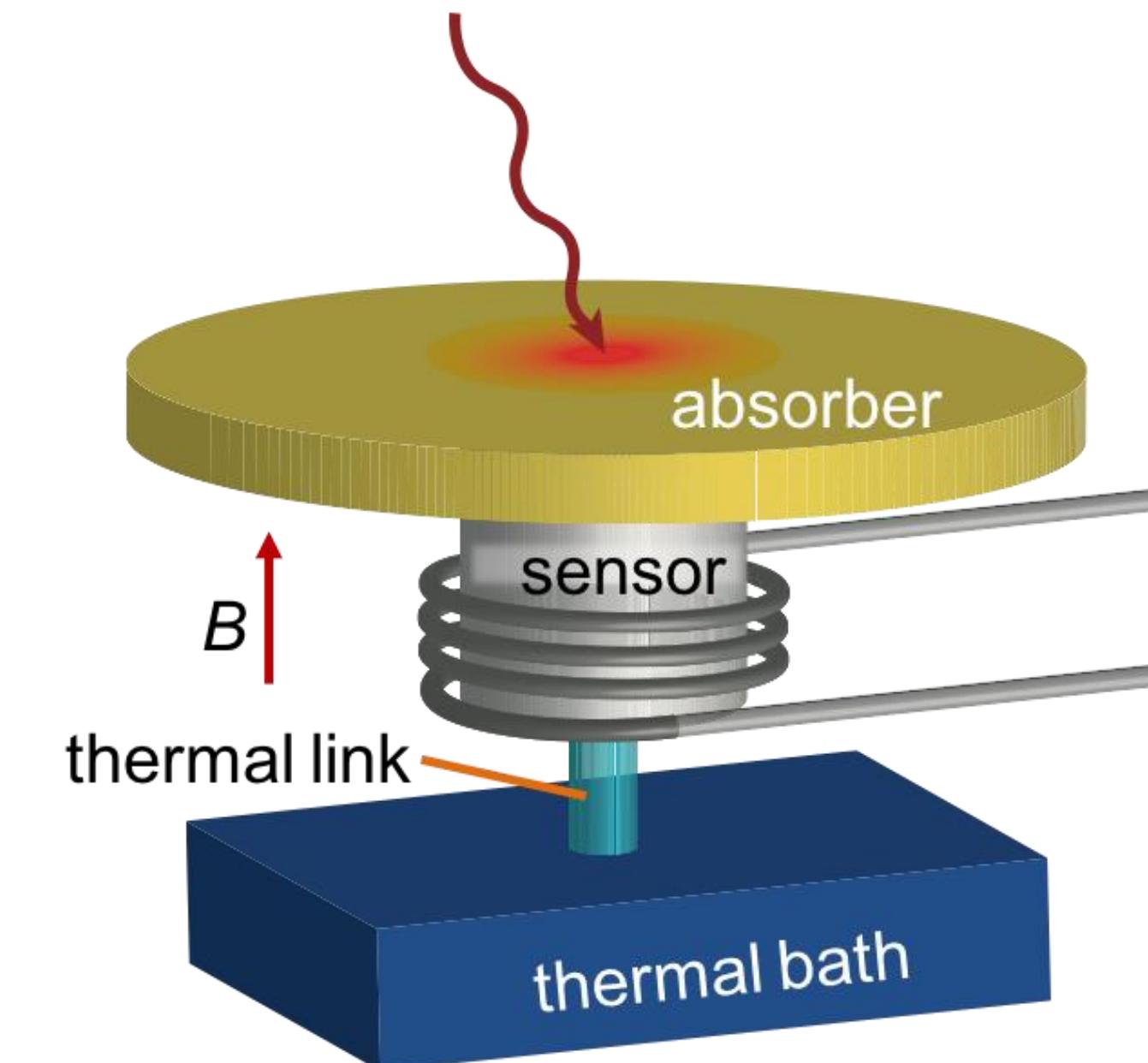
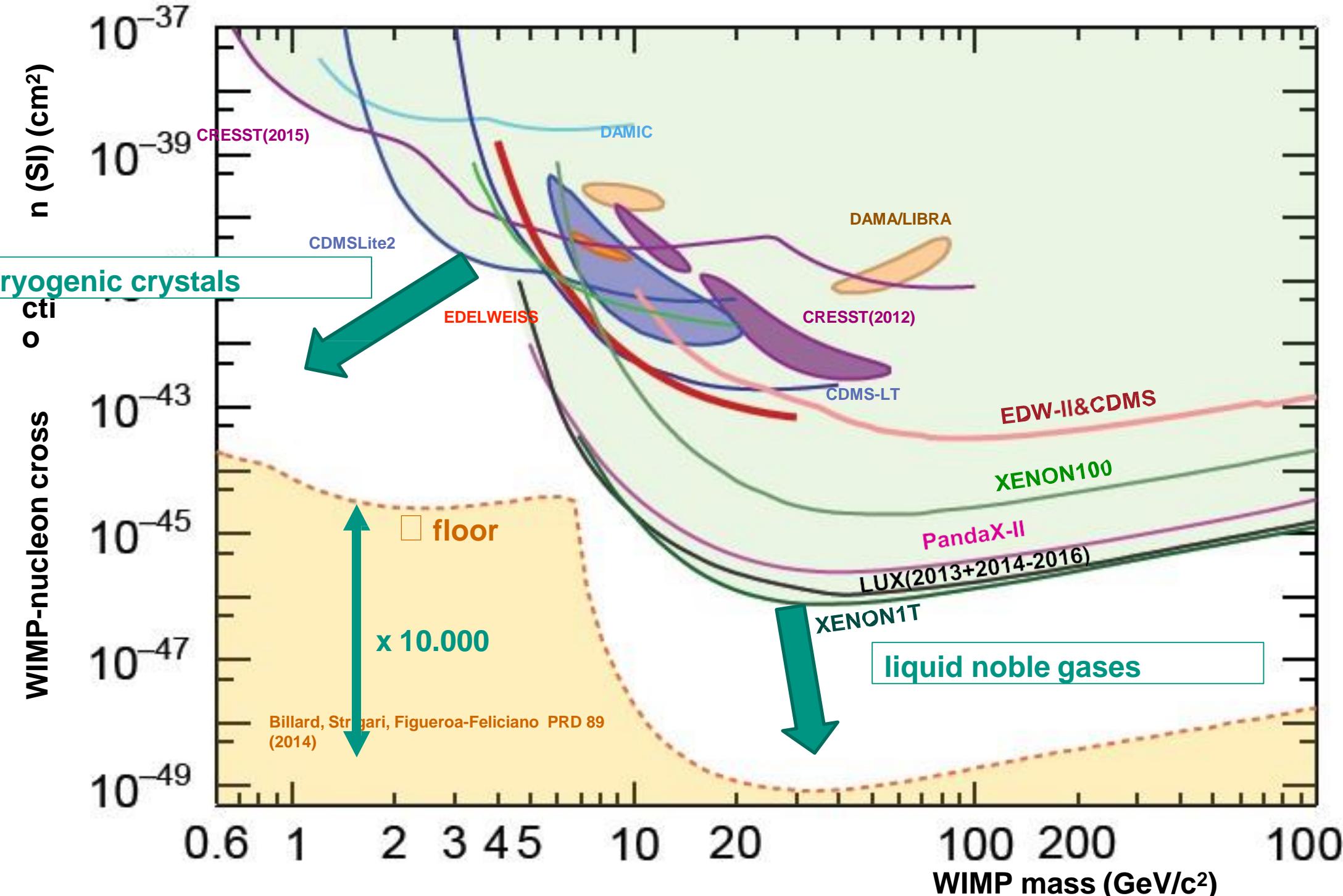
**Direct detection:** Search the energy deposited in a detector of low threshold, when the WIMP is scattered by a nucleus.

The flux of the dark matter should vary annually.  
Measurement of northern and southern laboratories will help to refine parameters of DM

**Modulation due:**

- i) Relative motion WIMP- galactic plane → same modulation northern and southern hemispheres
- ii) Relative motion Earth-Sun → different modulations northern and southern hemispheres (no WIMP)

# Going to Lower Masses



Experienced in ITeDA , CNEA and CONICET

# Biology Research

Underground laboratories represent a unique opportunity for investigating the response of biological systems to very low radiation doses

*Relevant scenario for both basic and applied science*

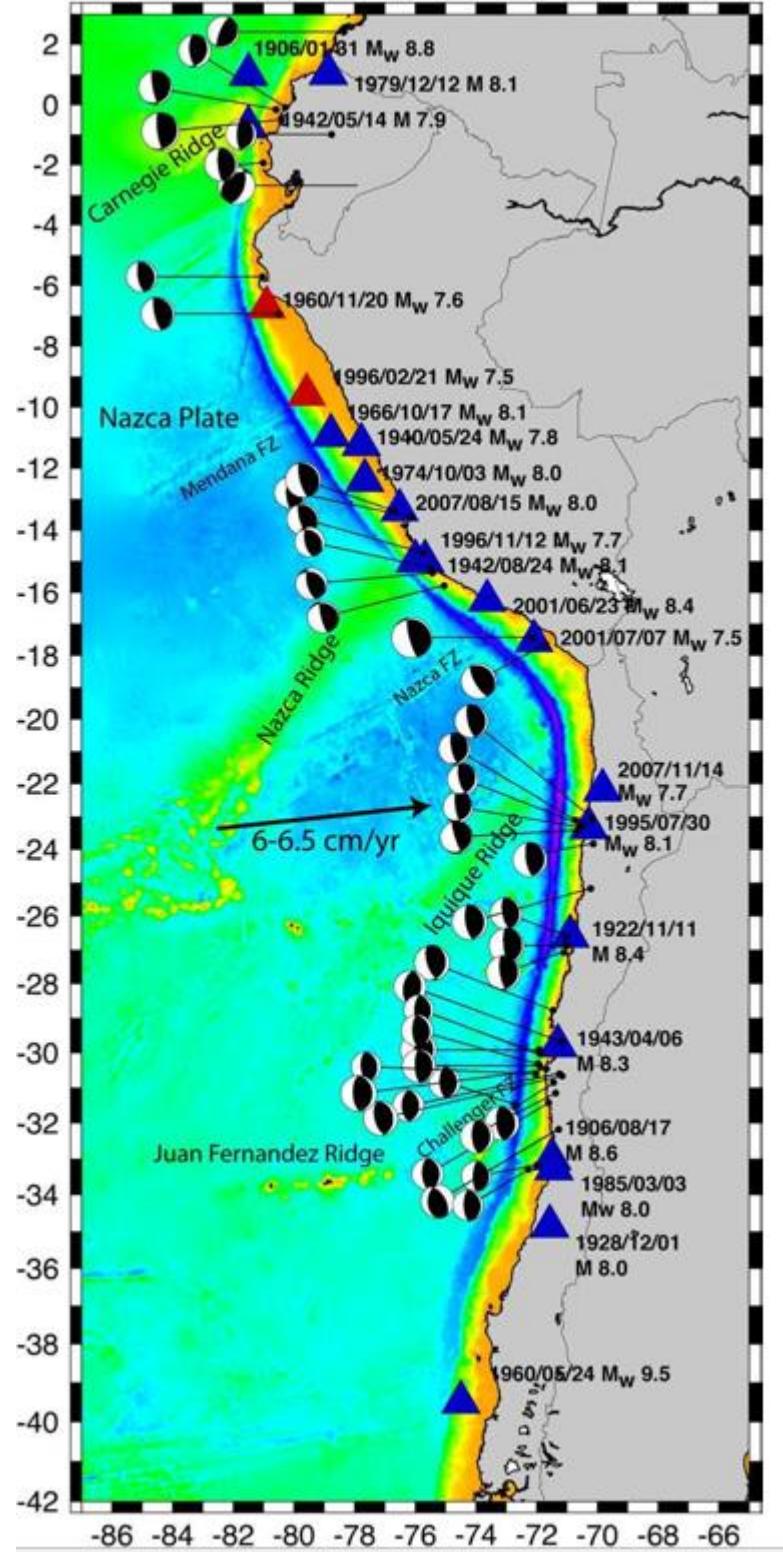
- All living organisms have to cope with the natural level of radioactivity on the Earth as well as with cosmic rays. Natural variations of background radiation likely played a critical role during the evolution and contributed to the development of still poorly characterized defense mechanisms to minimize genotoxic damage
- The basic assumption in radiation protection is that stochastic risk is directly proportional to dose. Underground laboratories give the opportunity to test the linear no-threshold (LNT) model for which below the average natural environmental background no detriment is expected

**SET UP OF PARALLEL EXPERIMENTS UNDER DIFFERENT RADIATION ENVIRONMENTS (ground and underground)**

# GeoScience Research

## 1.- Science topics

- i) Seismological experiments
  - ii) Thermo-chronology: Close cooperation with the regional geologist from San Juan and Mendoza. Heidelberg Univ. came in February 2019 to continue discussion and perform a first joint field work with geologists from Mendoza and San Juan
  - iii) Geodynamic model for the Andean orogen at  $30^{\circ}$  S
  - iv) General lithological and structural mapping along the tunnel (starting in Feb 2019).
  - v) During 2019 possible installation at 4500 msl/m an Acoustic Emission equipment to measure the mountain microdeformation and termoelasticity.
  - vi) Material Research in the underground laboratory. Possible cooperation partners in Argentina to discuss joint possibilities for material research without or better reduced influence of cosmic rays and spallation products
  - vii) Gas chemistry: possible cooperation partners in Argentina.
- 
- 2.- There is a strong desire to start with double doctoral degrees in geo sciences. The idea is to make an effort to include the host universities, like San Juan-Argentina and Region de Coquimbo-Chile; however other universities are not excluded and are very welcome to join.
  - 3.- An international Congress to be performed every year. In 2018 it was performed in San Juan and in 2019 in La Serena, Chile



## South-American Subduction zone:

- Ocean-Continent collision
- Nazca plates subducts beneath the South American continent

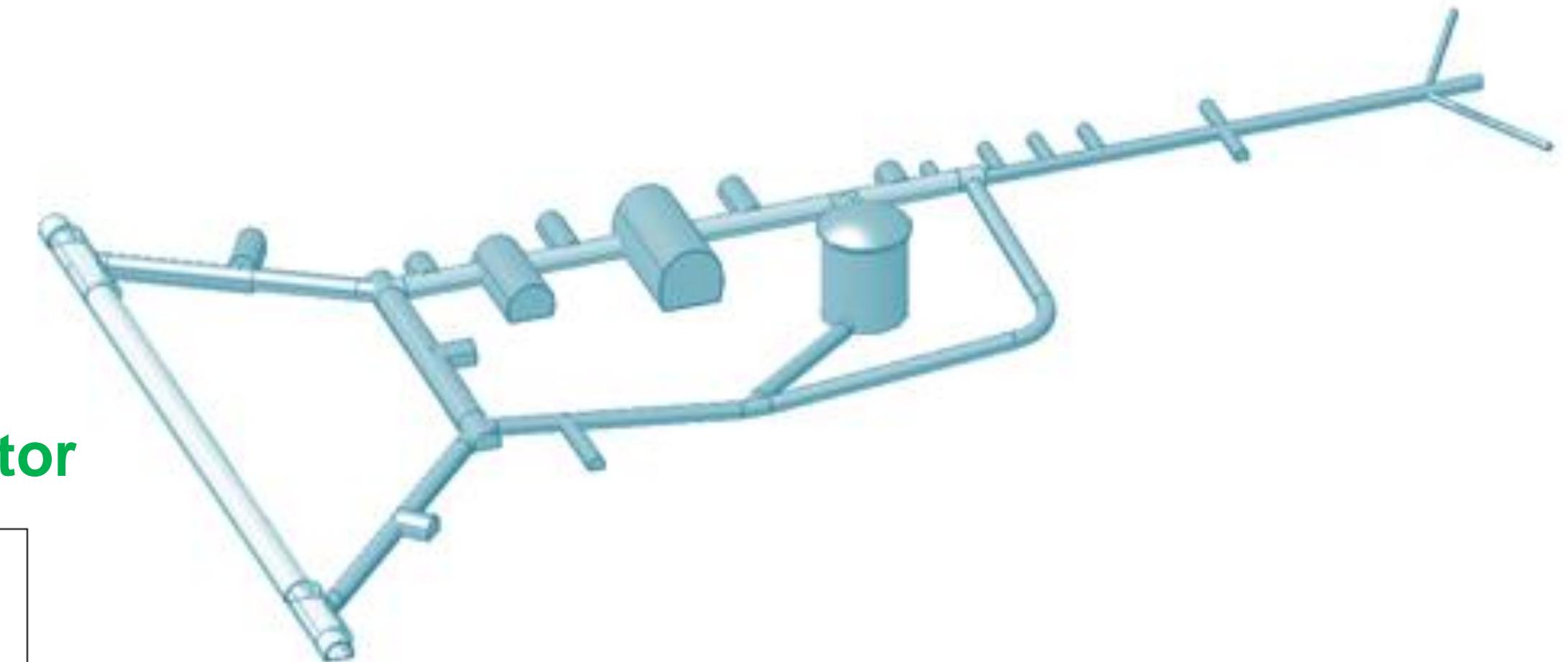
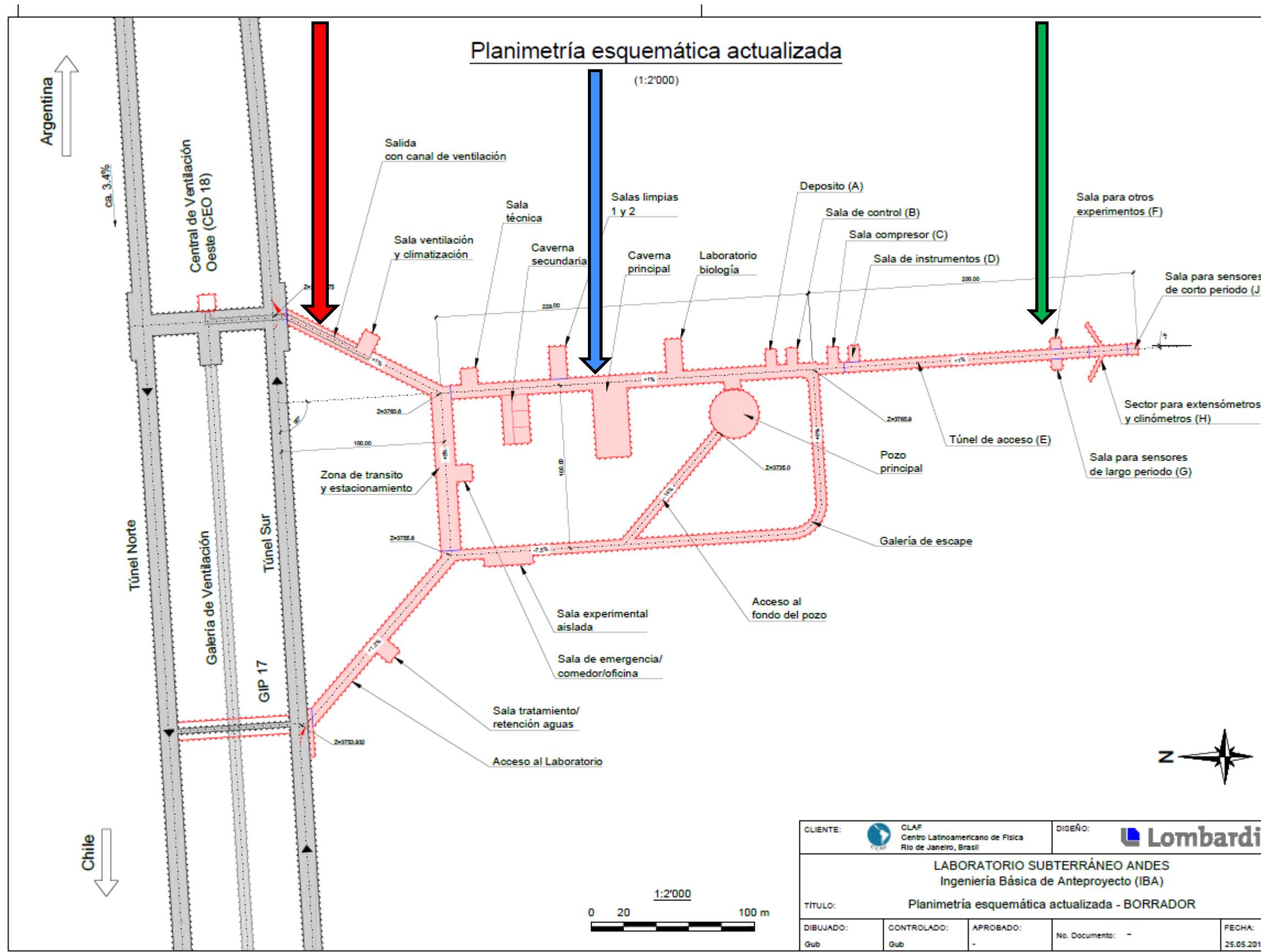
2<sup>nd</sup> highest mountain range in the world, largest ever instrumentally recorded earthquake: 1960 Valdivia earthquake  $M_w$  9.5

# ANDES Layout

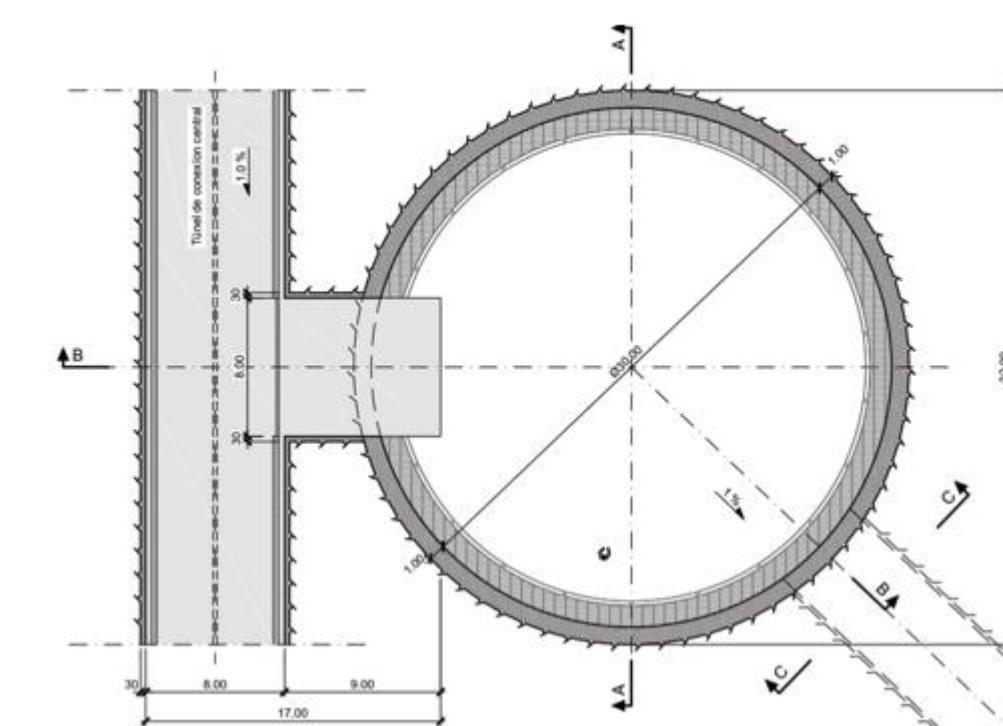
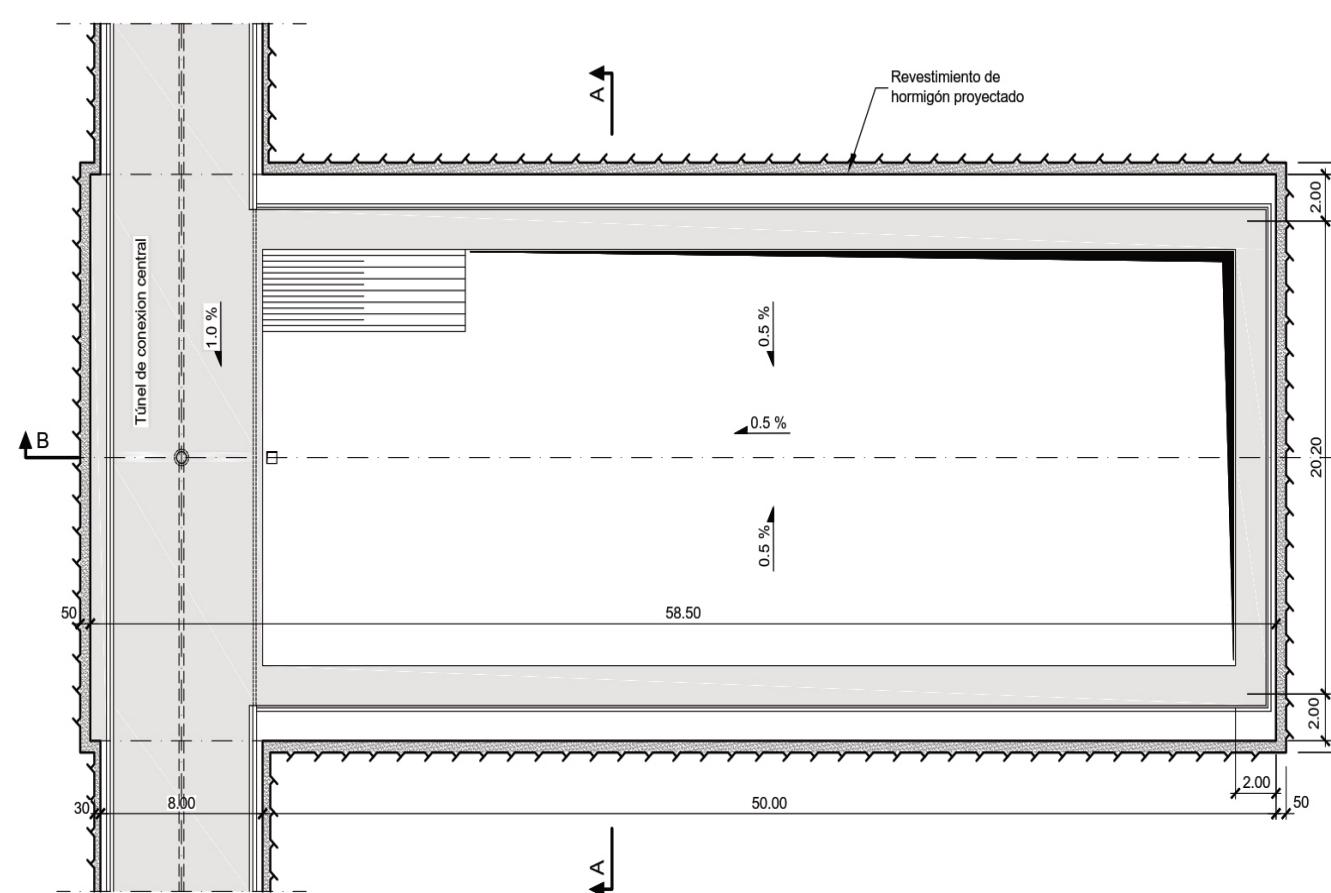
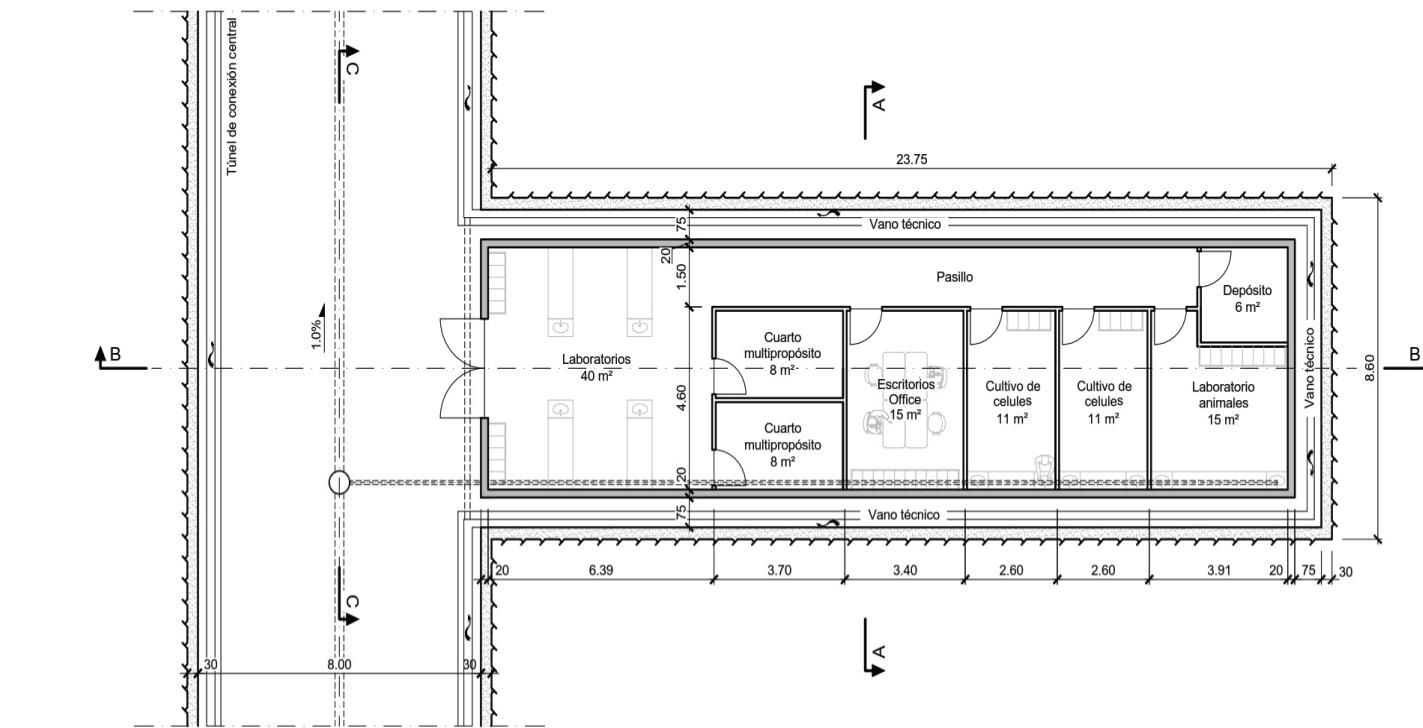
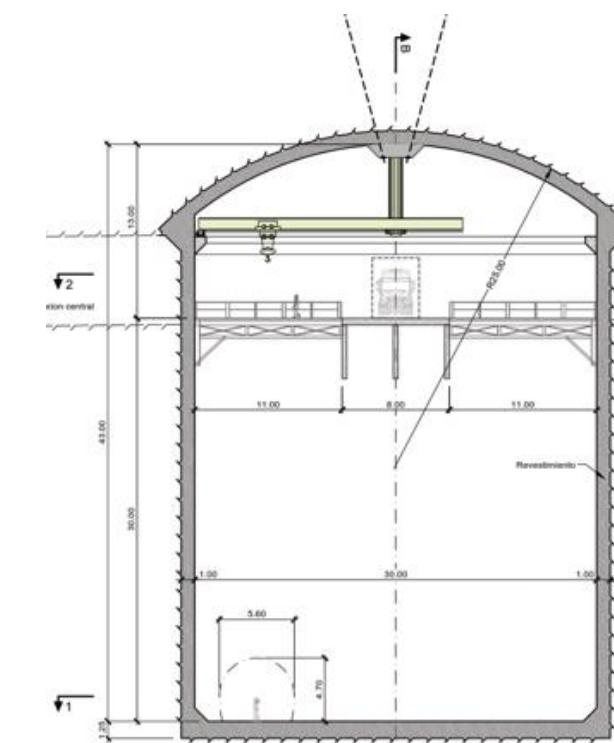
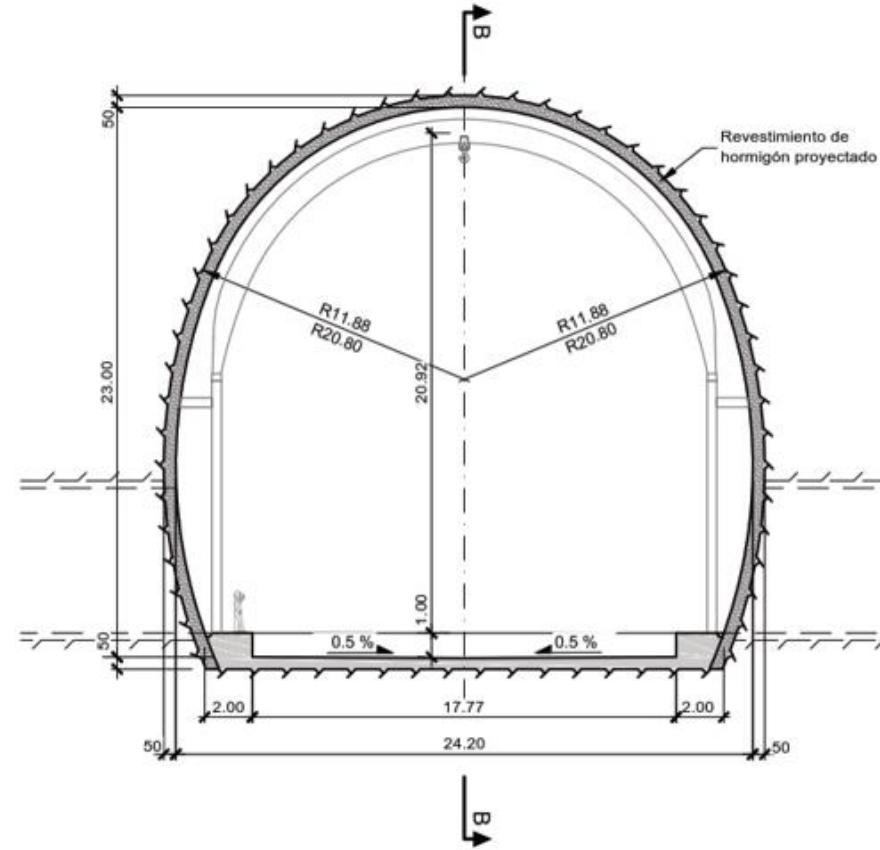
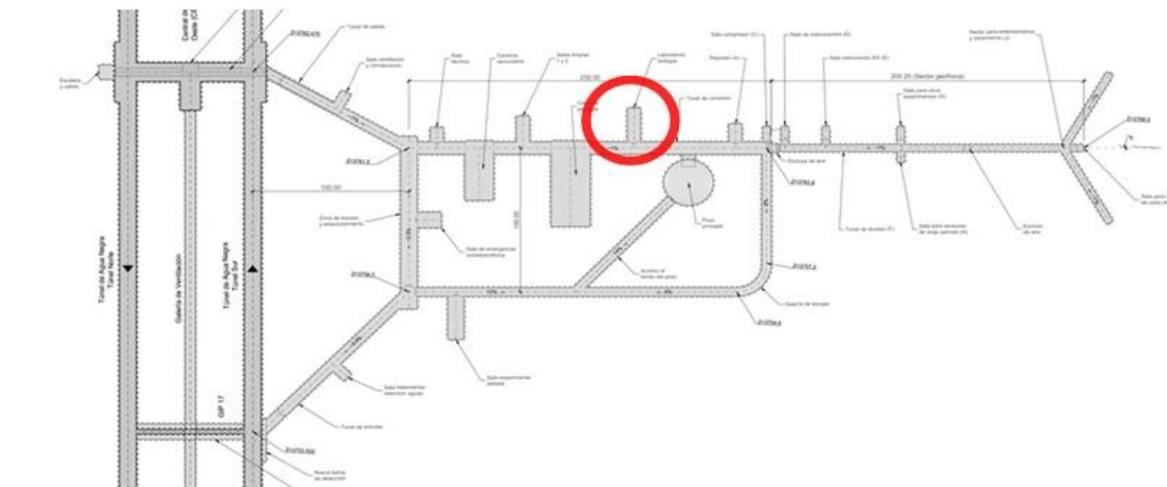
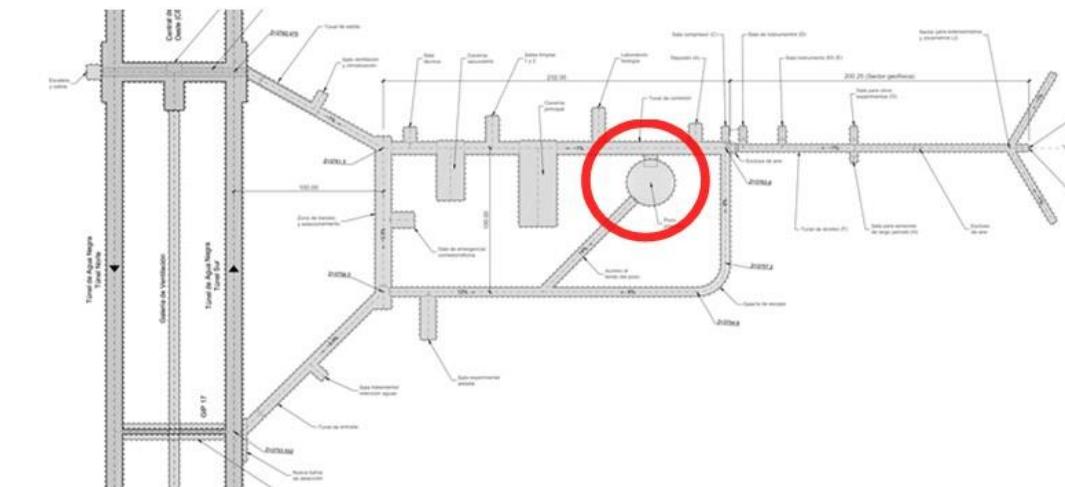
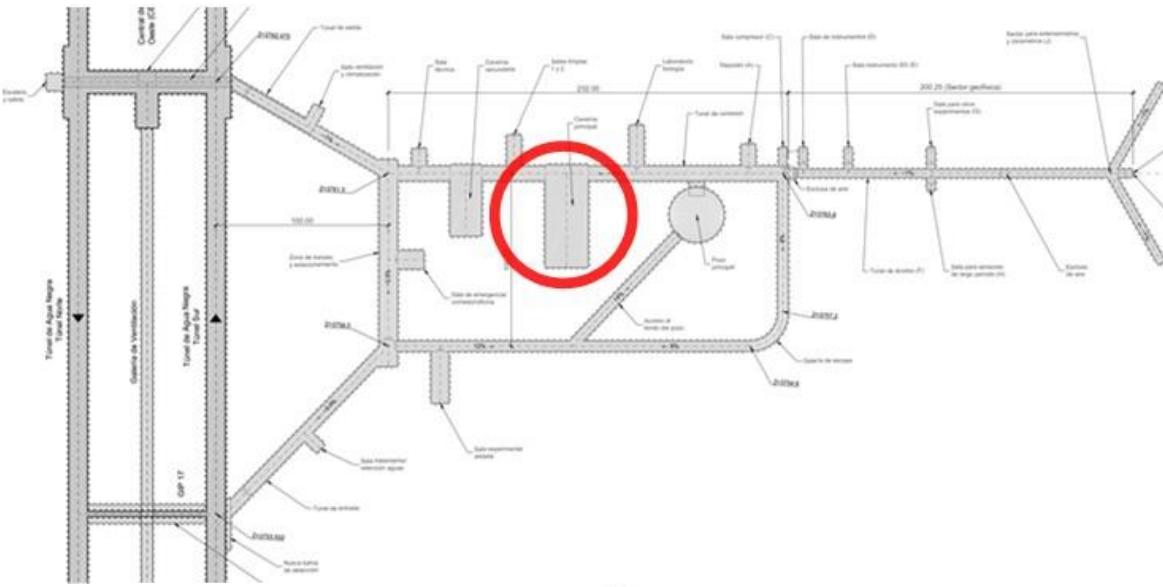
ANDES placement at:

- 1.- West Ventilation Central
- 2.- Argentina-Chile Frontier

3 sectors: **Access and transit, central zone and geoscience sector**



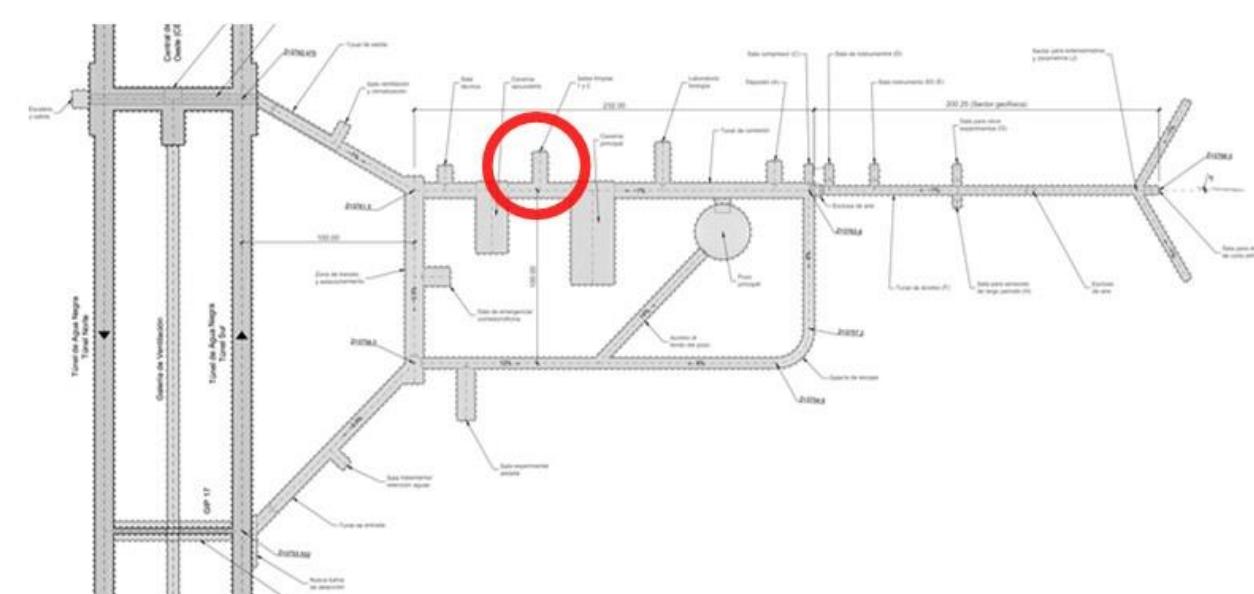
# Main Laboratories



**Main Cave**  $50 \times 24 \times 23 \text{ m}^3$

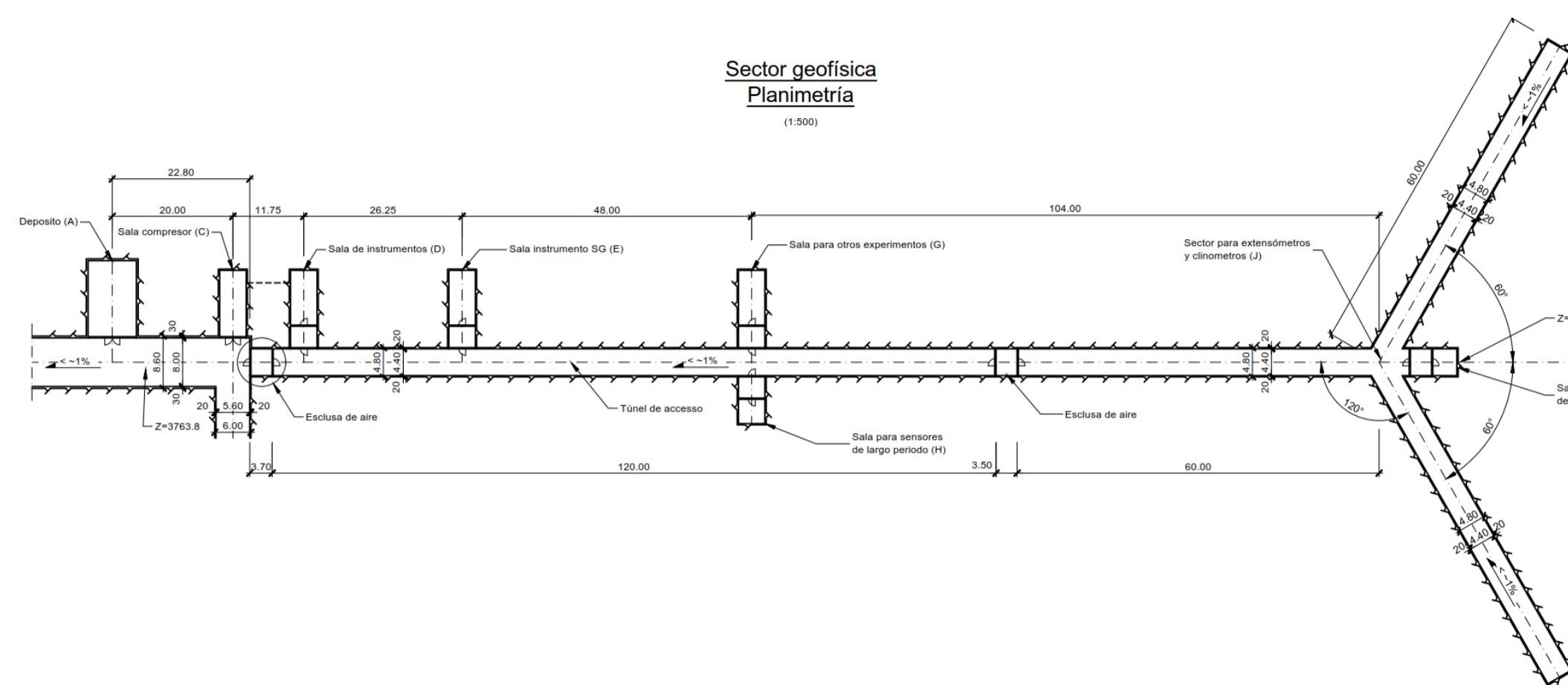
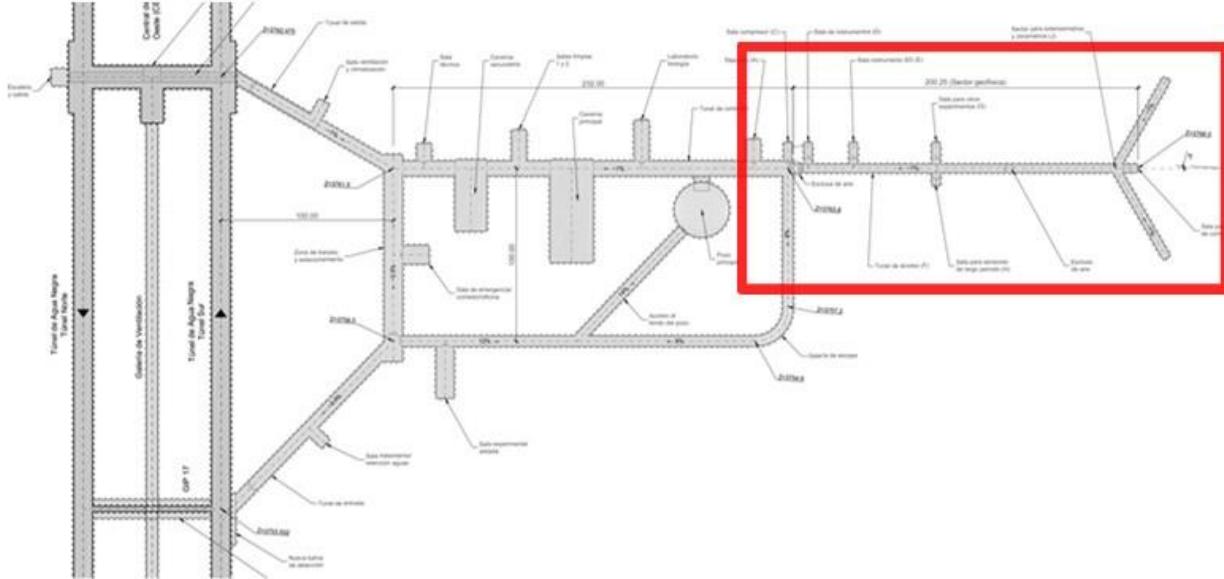
**Main Well**  $43 \text{ m} \times 30 \text{ m}$

**Biology Laboratory (100 m<sup>2</sup>)**



**Clean Rooms Class 1000**

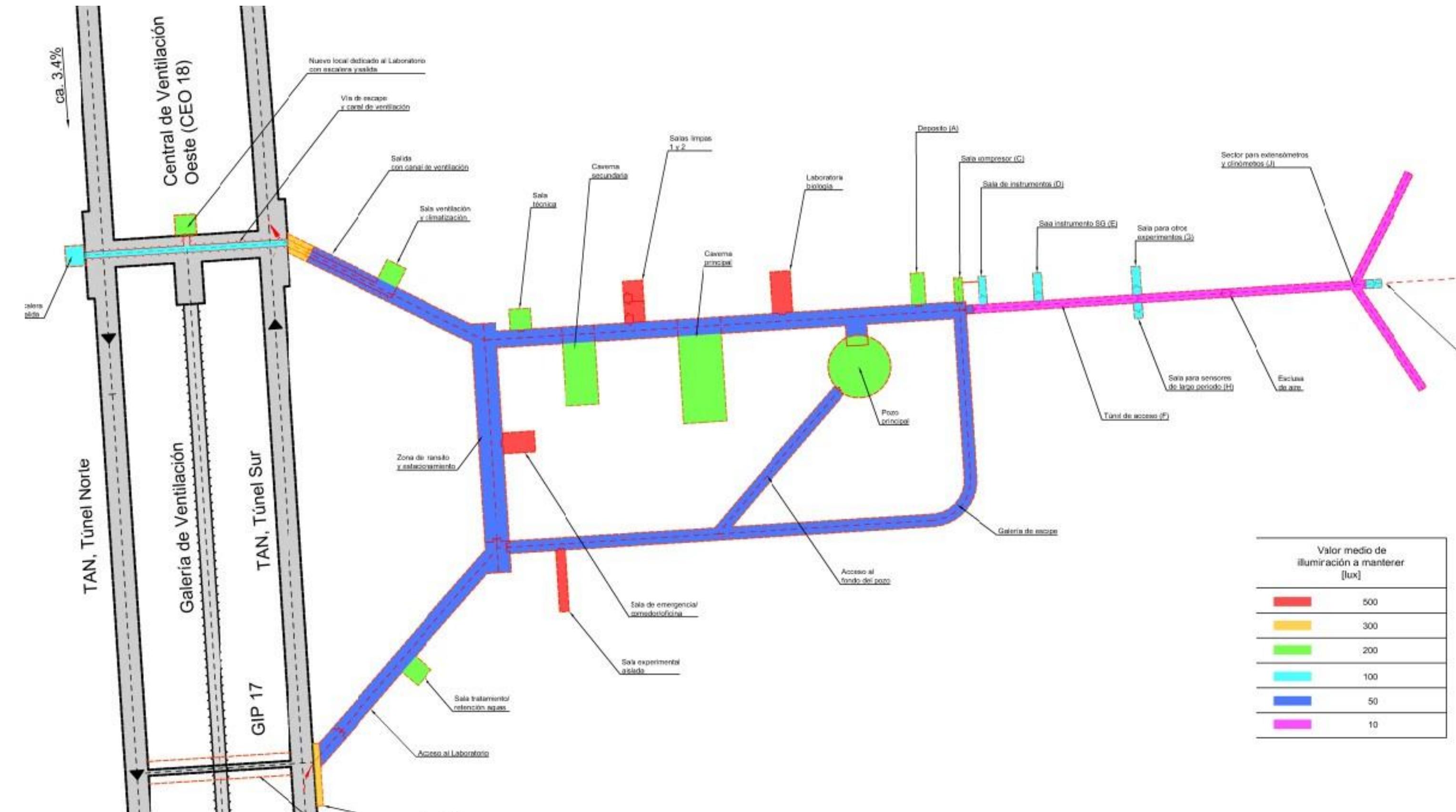
# Geoscience and Isolated (Nuclear Astrophysics) Laboratories



**Geoscience Laboratories  
(INGV/Italy and KIT/Germany)**

**Nuclear Astrophysics Laboratories**

# Illumination Scheme



# Prototype Phase



**Precursor site: Minera Sierra Grande; available in 2018/19**

**Signed interest letter from MCC Sierra Grande President: 15/Aug/2018**

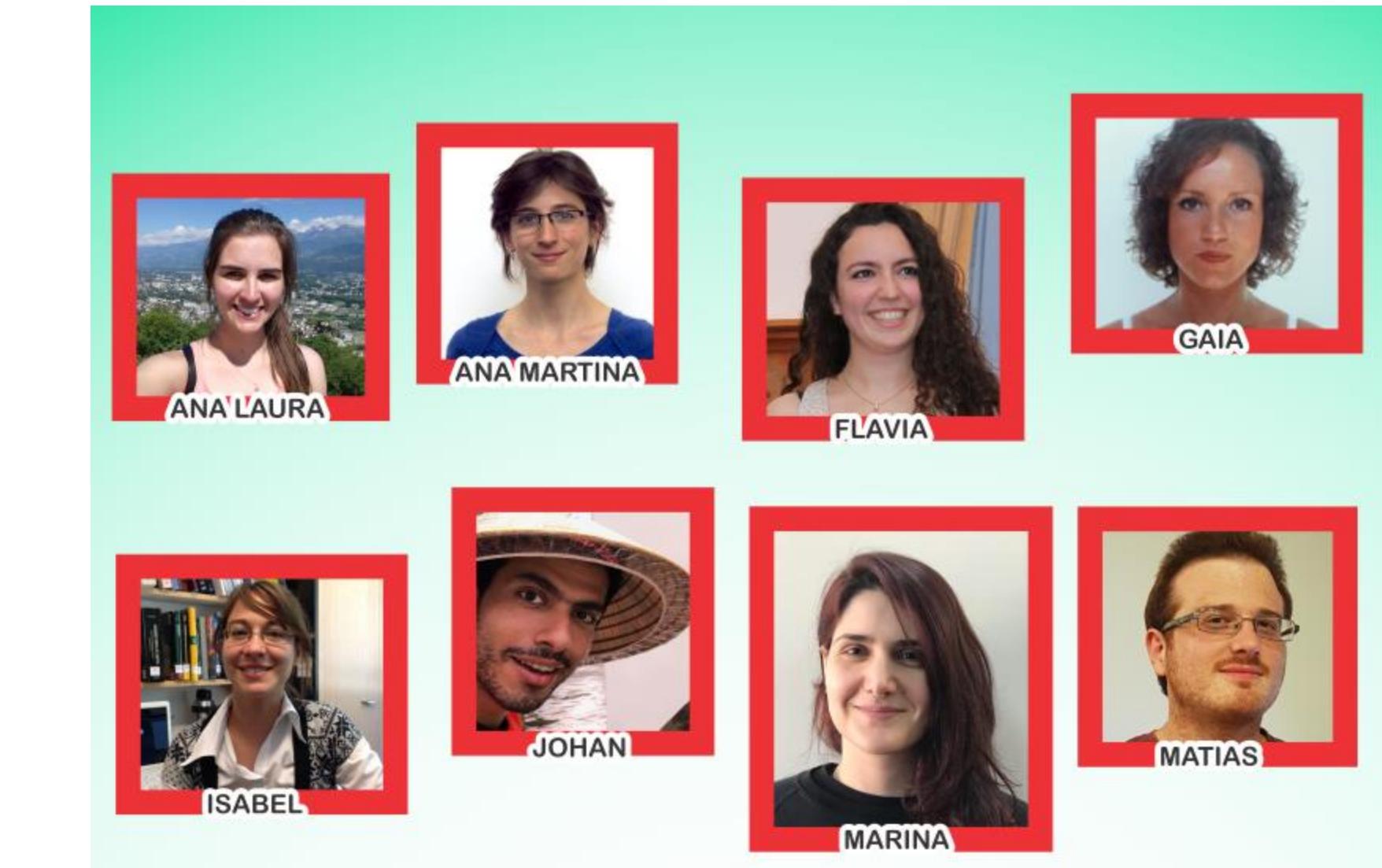
**Site already used for Astrophysics (1994-1999) (International Collaboration Spain-USA-Argentina (CNEA-CONICET group)) Cold Dark-Matter Search (looking for diurnal modulation effects)**

# PhD Training in Cotutelle KIT-UNSAM

- We created the Double Doctoral degree in Astrophysics (DDAp)
- We created the International Research School for Astroparticle Physics and Enabling Technologies.
- We use the majority of the funding for doctoral researchers, >1/3 of the time in the counterpart.



DDAp PhD Students



PhD physicists



J. Bonaparte



L. Ferreyro



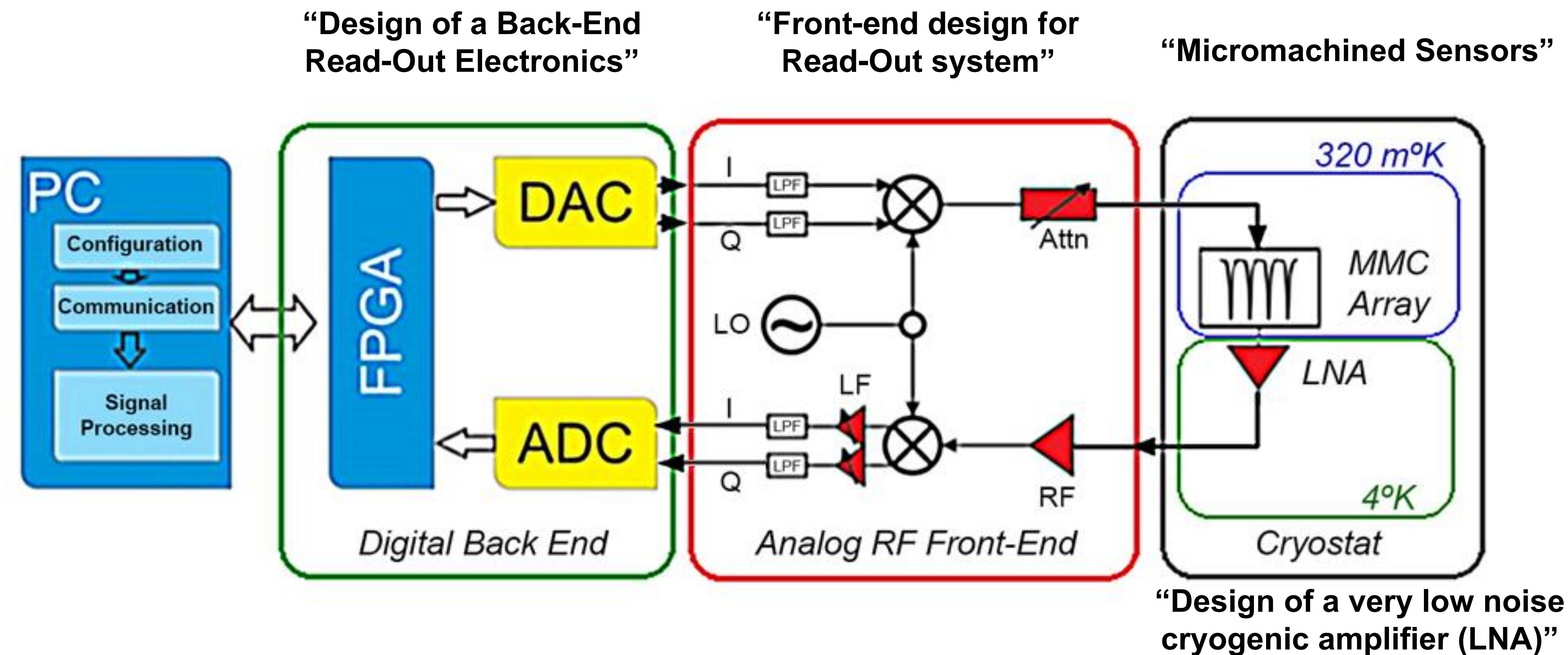
M. García Redondo



J. Salum

PhD electronics engineers

# Technology Innovation: Cryogenic Quantum Detectors



*The same application can be adapted for several astrophysics projects: ANDES, QUBIC, etc. Strongly working on it.*

# Human Resources and Outreach

- Two Support Labs (one on each side, San Juan and La Serena)
- Strong integration with local Universities
- Host a Visitor Centre

El MinCyT, la CNEA, y el CONICET en el Consejo Nacional se comprometen a impulsar y a gestionar ante el Poder Ejecutivo Nacional **la creación de un Instituto de excelencia en la Provincia de San Juan**, orientado a la ciencia y técnica relevante para el Laboratorio ANDES y sus tecnologías habilitantes, con formación de RRHH internacionales.

Signed by Gov. San Juan, MinCyT, CNEA, and CONICET



Inclusión: Planetario para Ciegos



Desfile científicos:  
todos los años, día de  
Malargüe



Feria de Ciencia  
Secundarios



1er Planetario  
profesional fijo



Centro de Visitantes  
(8000 visitantes/año)  
Malargüe

# ANDES Workshops



*Welcome ANDES International Congress  
(June 2017, UNSAM, Buenos Aires)*

*Presidente CNEA O.Calzetta, Ministro Infraestructura San Juan Ing. J.C. Ortiz Andino, Organizador A. Etchegoyen , Ministro MinCyT L. Barañao, Presidente INFN F. Ferroni, Rector UNSAM C. Ruta.*

*Welcome GeoCiencias ANDES International Congress  
(November 2018, San Juan)*

*Subsecretaria de CyT Nación P. Nahirñac; Ministro Infraestructura San Juan J.C. Ortiz Andino; Gobernador S. Uñac; Coordinador Técnico EBITANA Zini; Rector UNSJ*

*Representantes INFN/Italy G. Paparo and G. Saccorotti, D. Comte-Univ. Chile, A. Rietbrock-KIT/Germany*

# Institutional Support



**IDB granted a 1,500 MUSD loan  
to Argentina (60%) and Chile (40%)  
To pay for the tunnel construction**

**Gov. of San Juan Sergio Uñac and  
President IDB Luis Moreno**



**President IDB Luis Moreno and  
President Mauricio Macri**



**EBITAN: Ente Binacional del Túnel de Agua Negra**

# Institutional Support

## CONVENIO CUATRIPARTITO PARA LA EJECUCIÓN DEL PROGRAMA INTERINSTITUCIONAL DE DESARROLLO DEL PROYECTO LABORATORIO INTERNACIONAL ANDES

República Argentina, a los 12. días del mes de Abril de 2018.

Dr. S. M. UÑAC  
Gobierno de la Provincia de San Juan

Lic. O. CALZETTA LARRIEU  
Comisión Nacional de Energía Atómica

Dr. J. L. S. BARAIÑAO  
Ministerio de Ciencia, Tecnología e Innovación  
Productiva  
  
Dr. H. A. CECCATTO  
Consejo Nacional de Investigaciones Científicas  
y Técnicas

### EL GOBERNADOR DE LA PROVINCIA

#### DECRETA:

**ARTICULO 1º:** Ratífiquese en todas sus partes el Convenio de Transferencia de Fondos, celebrado entre el Gobierno de la Provincia de San Juan, por una parte, representado por el Sr. Gobernador Dr. Sergio UÑAC y el Centro Latinoamericano de Física, por otra parte, representado por el Sr. Coordinador de su Unidad ANDES, Dr. Xavier BERTOU, suscripto a los 10 días del mes de Julio de 2018, y su Anexo, Contrato suscripto entre el Centro Latinoamericano de Física y la Consultora Lombardi S.A., que forman palte del presente Decreto.

**ARTICULO 2º:** Apruébese un gasto por la suma de PESOS QUINIENTOS VEINTE MIL DOLARES ESTADOUNIDENSE CON 00/100 (USD 520.000,00), a fin de realizar la conversión a Pesos Argentinos, se utiliza el tipo de cambio vendedor del Banco Nación



**Auger, ANDES/Gran  
Sasso, QUBIC**

**60,000 €/año total**

### CONVENIO ESPECÍFICO EN ASTROPARTÍCULAS

Entre la COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, en adelante denominada "CNEA", representada en este acto por su Presidente Lic. Osvaldo CALZETTA LARRIEU, por una parte, y el INSTITUTO NACIONAL DE FÍSICA NUCLEAR, en adelante "INFN", representada por su Presidente Prof. Fernando FERRONI, por la otra, acuerdan celebrar el presente CONVENIO ESPECÍFICO encuadrado dentro del MEMORANDO DE ENTENDIMIENTO CIENTÍFICO, en adelante MoU, firmado entre las partes el 15 de noviembre de 2015 que se regirá por las siguientes cláusulas.

# Current Status: IBA + DTL

*“Contándose ya con el acuerdo de EBITAN de incorporar la construcción del Laboratorio ANDES dentro del Proyecto TAN, se conviene que tanto la elaboración de la Ingeniería Básica de Anteproyecto (IBA) , como su Proyecto Ejecutivo y Construcción se incluya dentro del Proyecto de la obra, en la medida con que se cuente el financiamiento correspondiente.”*

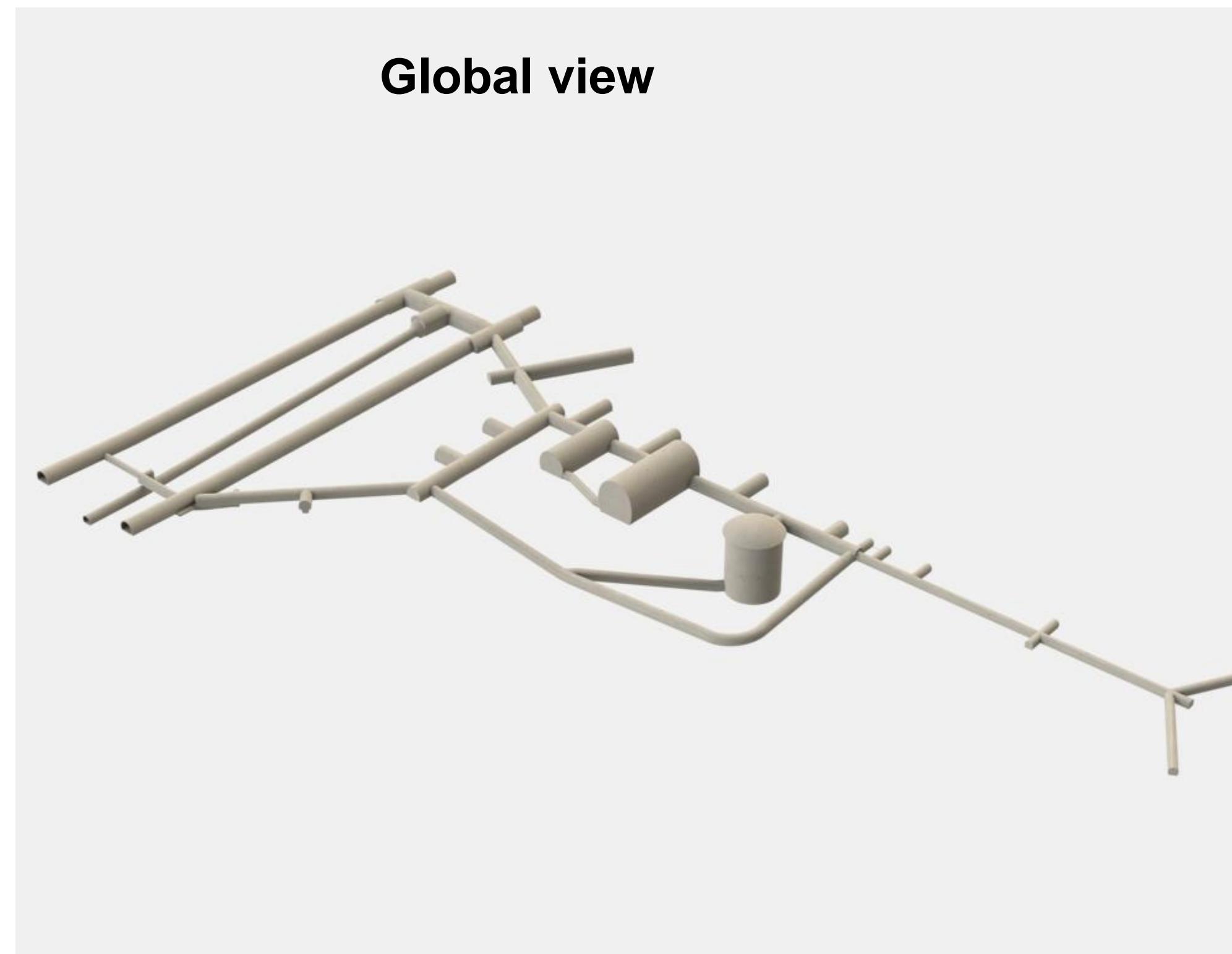
*(Acta de la XXXV reunión de EBITAN, Buenos Aires, 4 Julio 2017). ANDES costs: Caverns 40 MUSD, Experiments 500 MUSD*

**EBITAN: A cargo del túnel y de su construcción**  
**Entidad Binacional Túnel de Agua Negra**

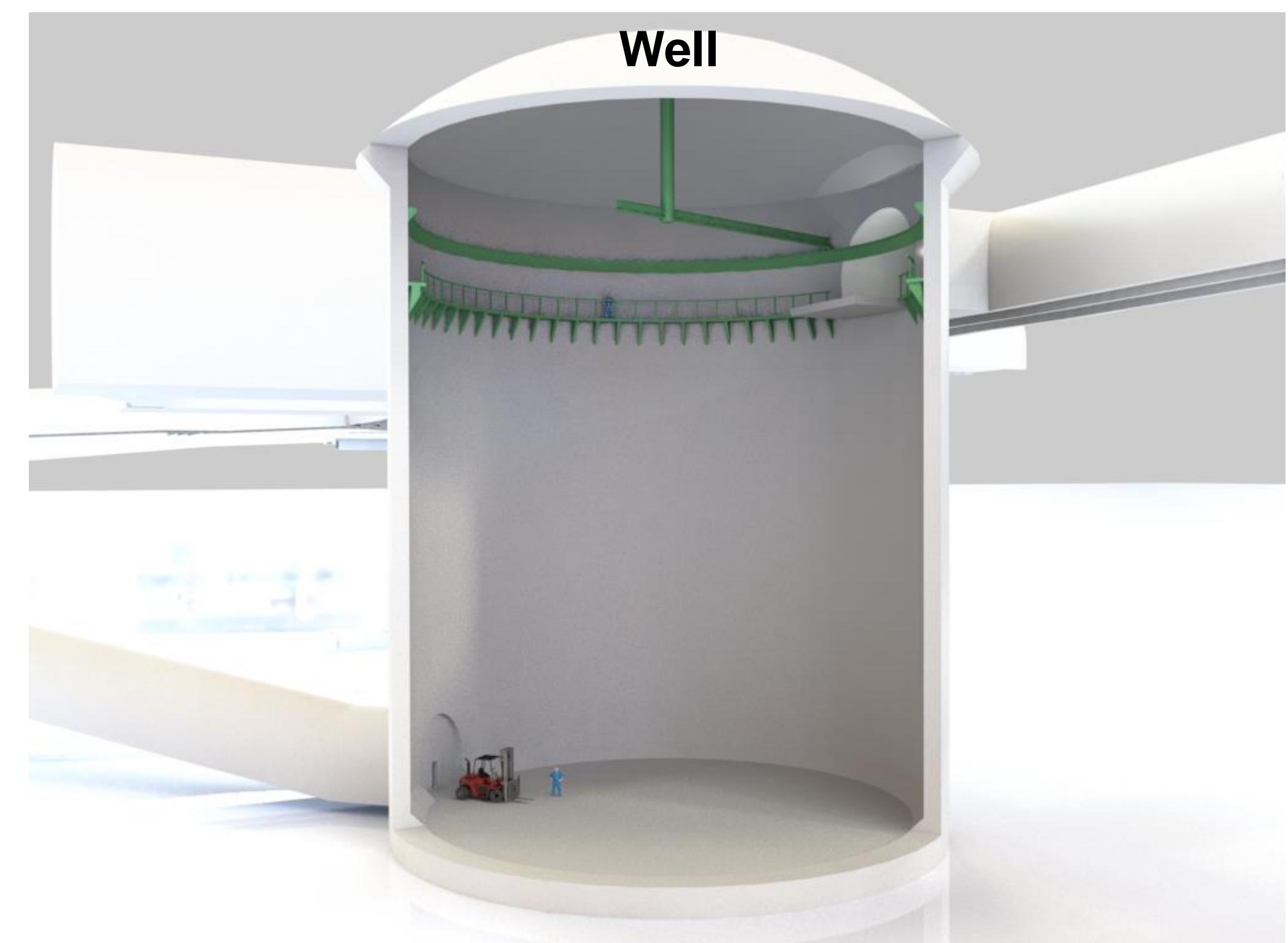
**IBA + DTL performed by Swiss Company Lombardi**  
**and paid by San Juan Province (520 KUSD)**

**ANDES 3D:**

**Global view**



**and**



# Underground Global Research Infrastructures (UG-GRI)

- **Proposed by LNGS and SNOLAB following an initiative by the Group of Senior Officers of G8+5**
- **UG-GRI will constitute for ANDES a great opportunity to take advantage from experience and best practices of existing UG RIs**

**Global distributed research facilities act in a synergic and coordinated way in a single network**

# Next Steps

- Develop human resources (PhDs astrophysics and engineering)
- Shape the International Collaboration
- Decide on the Equipment and Financing
- Start Prototyping

***The Future: Multi-Messenger Approach***

HE neutrinos (ANDES)  
HE cosmic rays (Auger)  
HE gamma rays (CTA)  
Gravitational waves (VIRGO, LIGO)



***Can only be performed via International Collaborations***