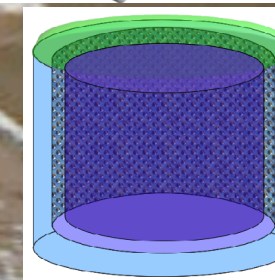
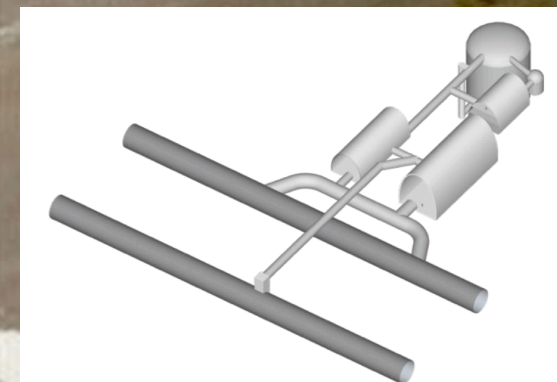
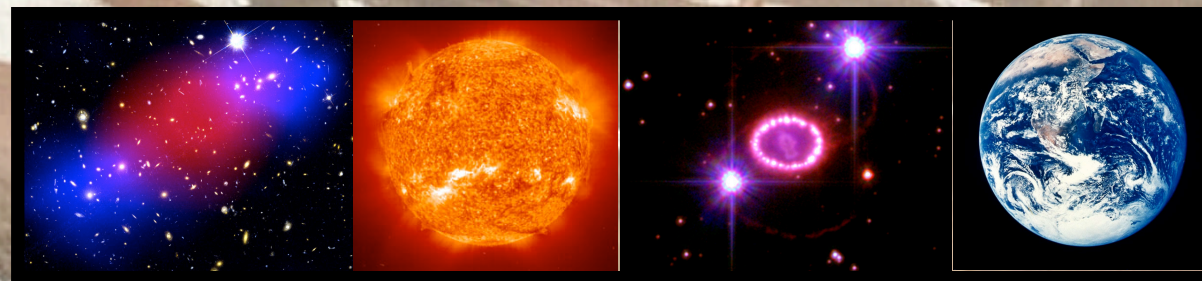


ANDES:

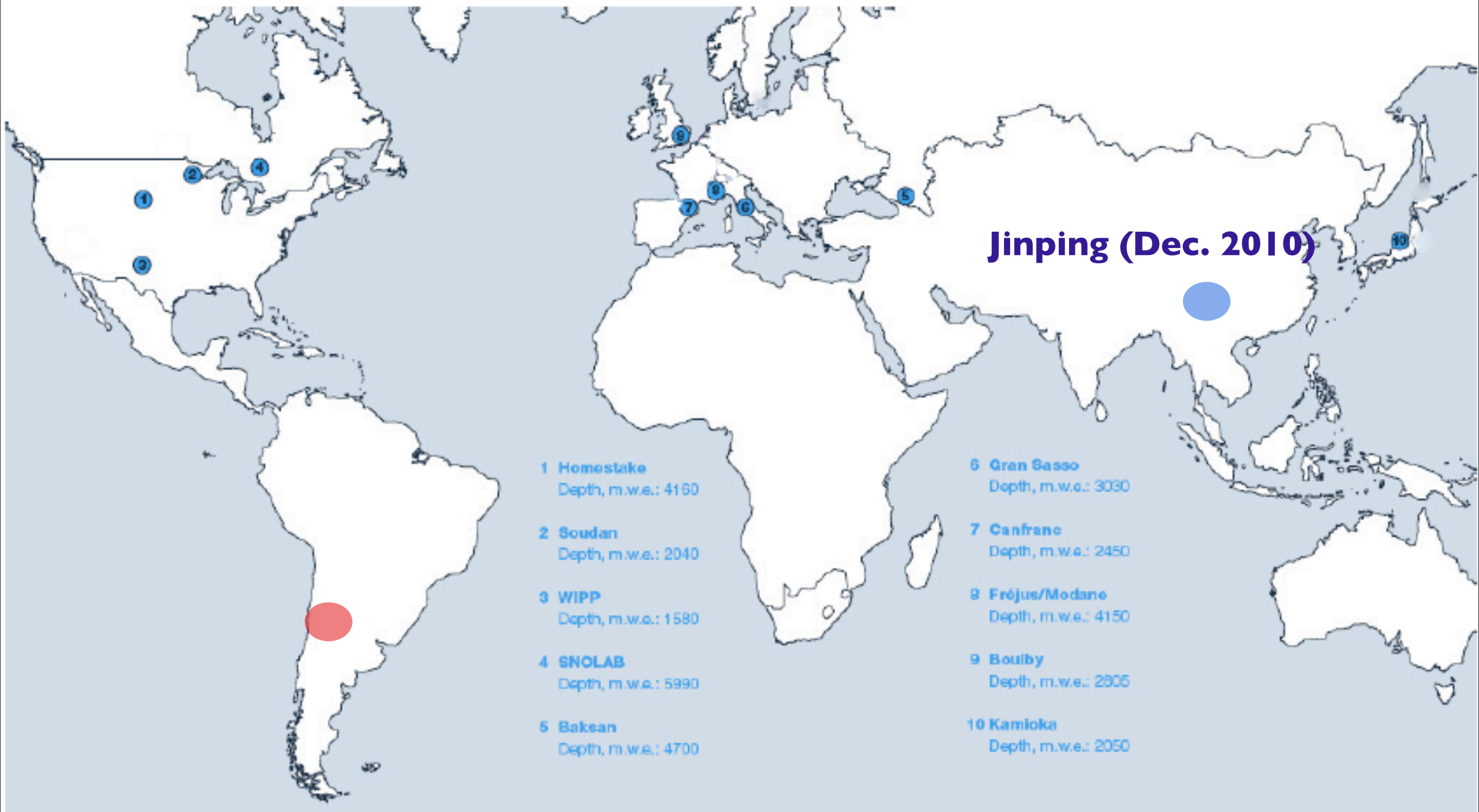
A Deep Underground Laboratory in the Southern Hemisphere



Renata Zukanovich Funchal
Instituto de Física, Universidade de São Paulo
KITP December 3, 2014

ANDES

Agua Negra Deep Experimental Site



Bi-oceanic Corridor

One of the axes for Integration of Regional Infrastructure in South America

Pacific Ocean

Atlantic Ocean



Paso de Agua Negra Tunnels



2 tunnels
14 km long
12 m of diameter each
separated by 60 m



Paso de Agua Negra Tunnels

construction 2015-23



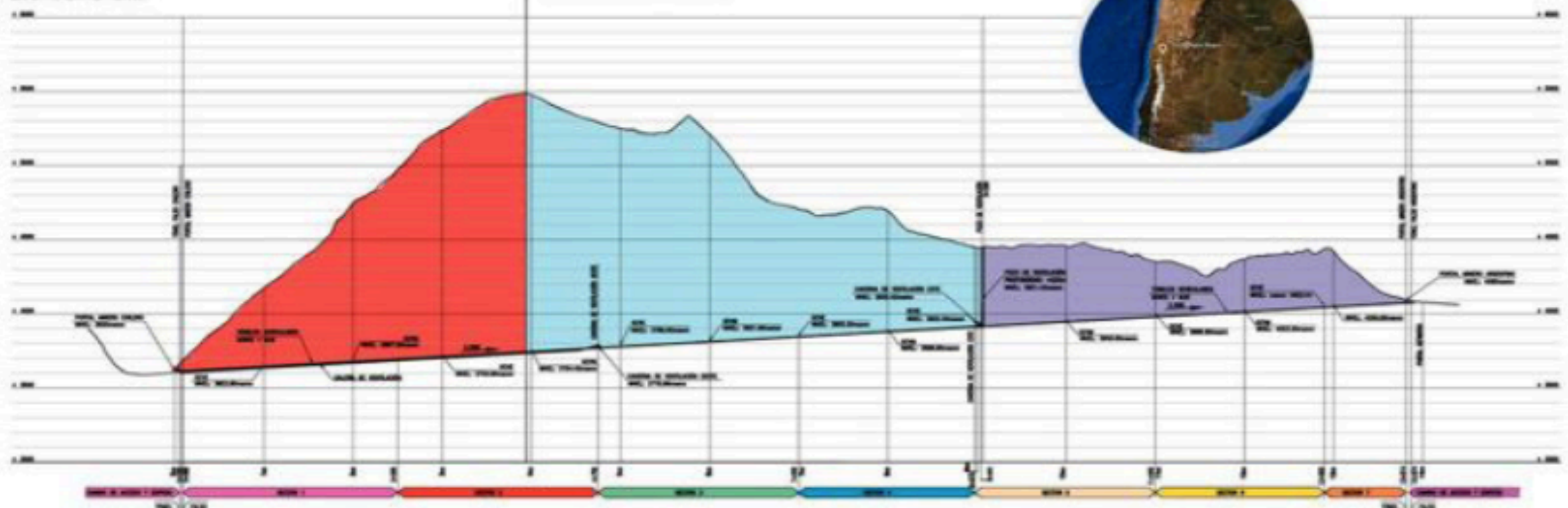
CORTE LONGITUDINAL

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

CHILE

ARGENTINA

PROGRESIVA: 3950msnm

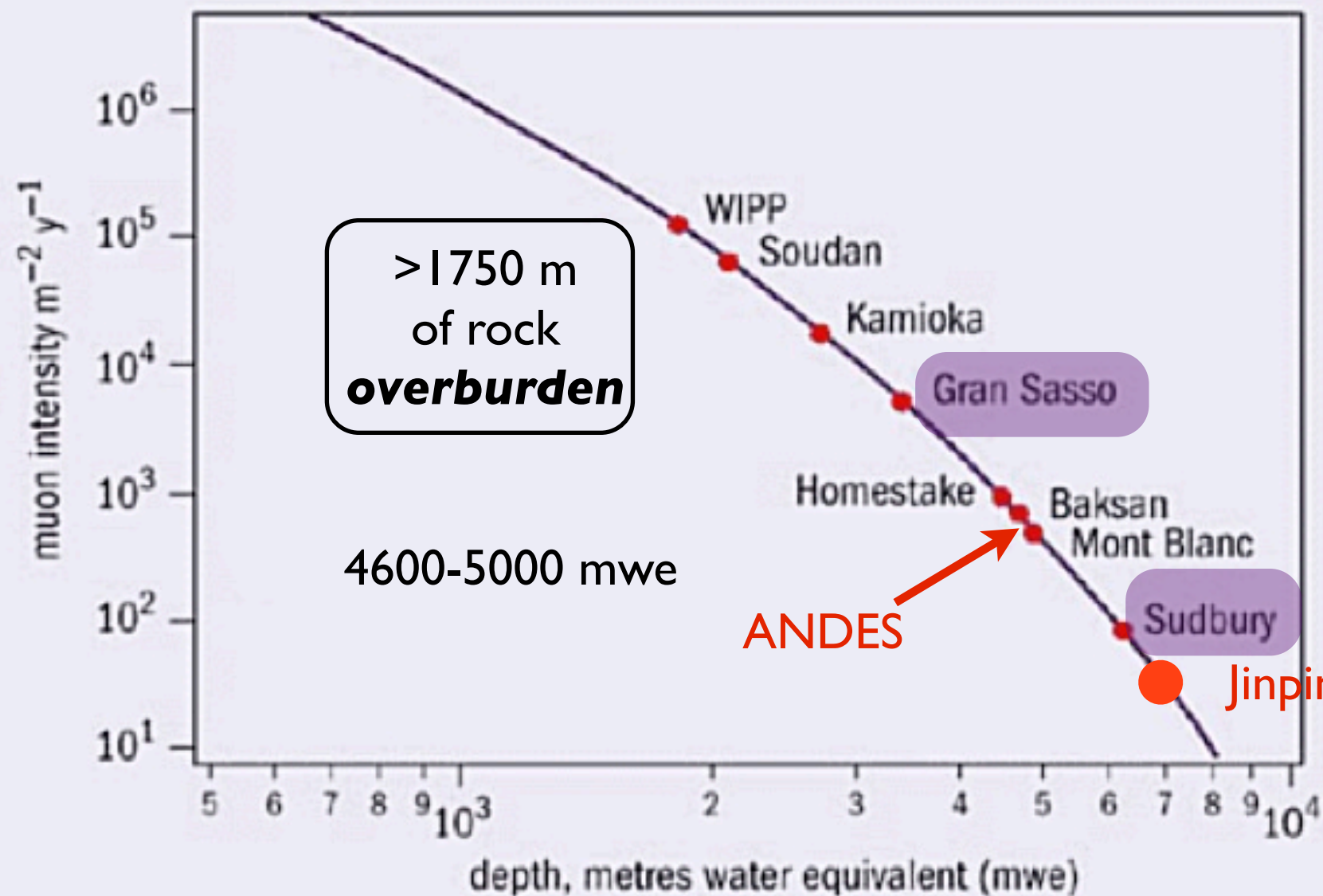




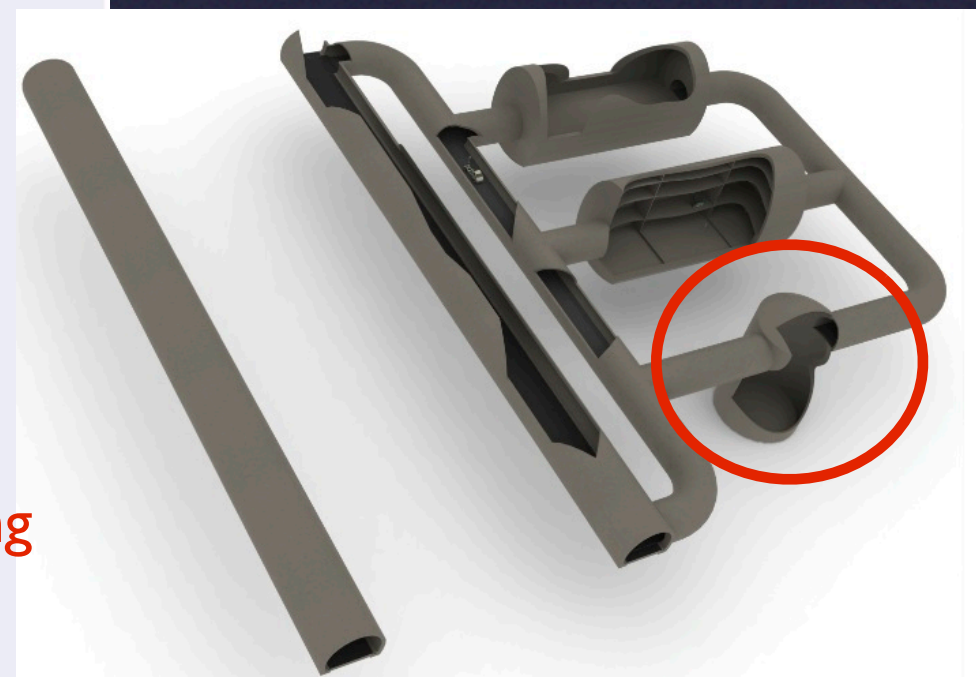
ANDES

Agua **N**egra **D**eep **E**xperimental **S**ite

👉 <http://andeslab.org/>



cost ~25-30 MU\$

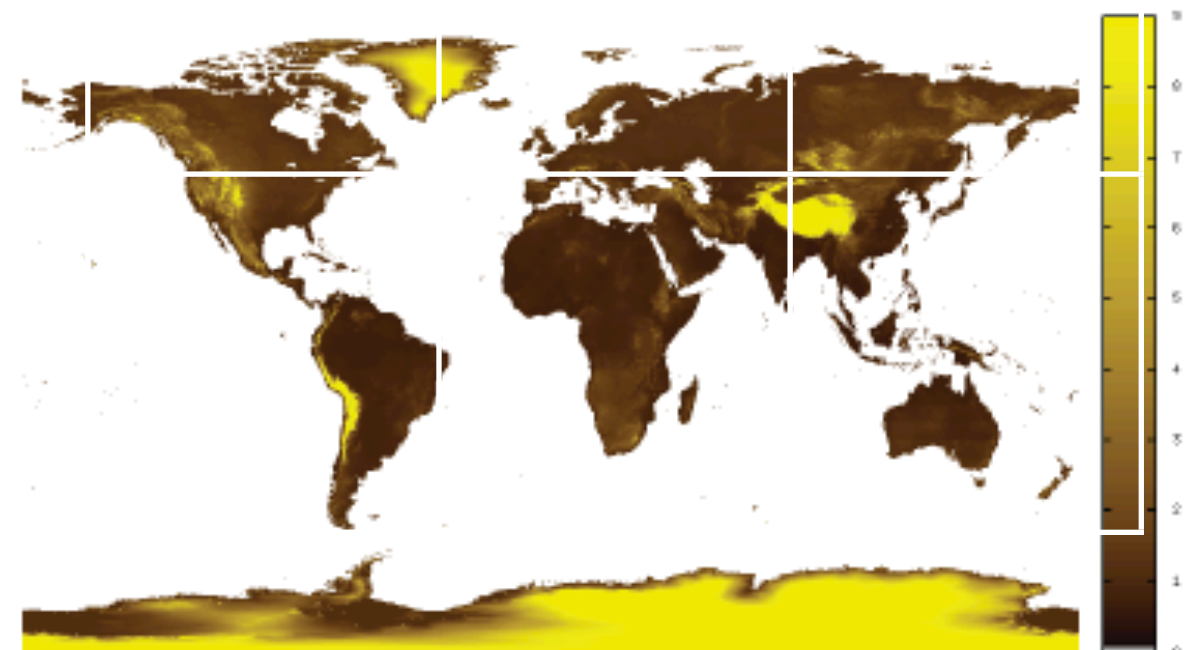
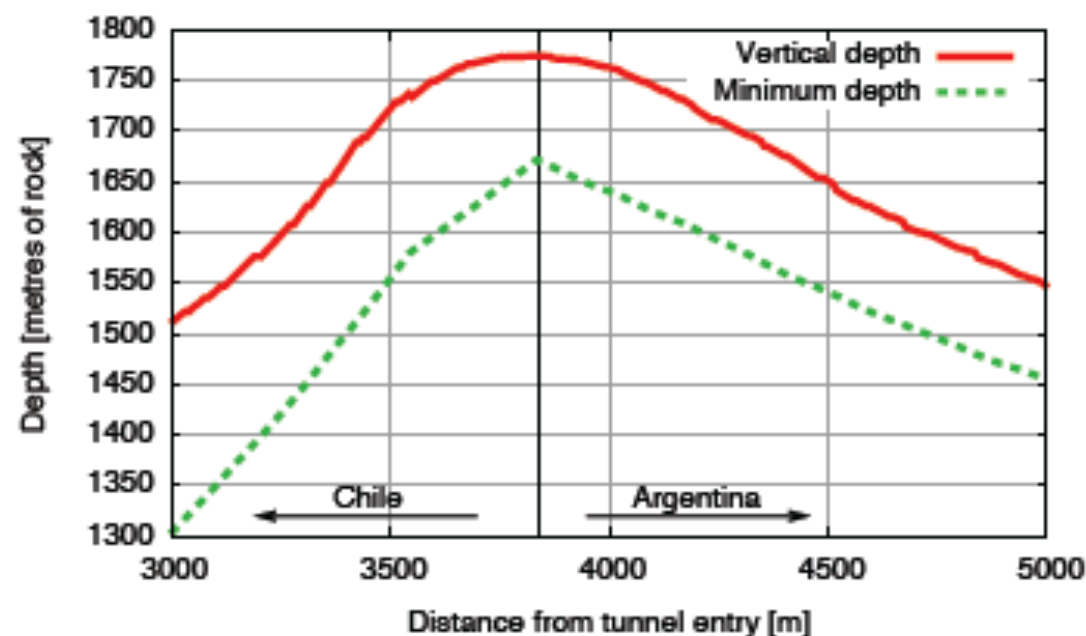


Background estimation

- 600 m deep rock samples measured for natural radioactivity

(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:

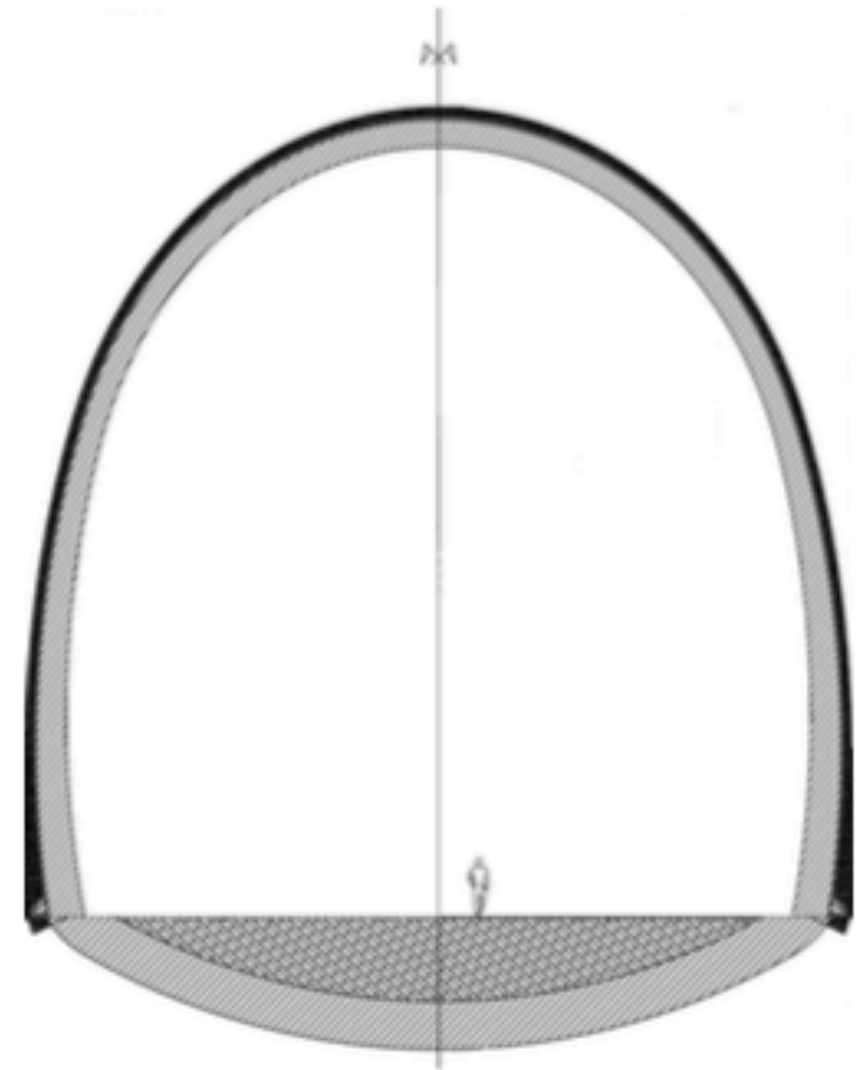


ANDES Laboratory proposal

Located at km 3.5-5

- main hall:
(21 × 23 × 50) m³
- secondary hall:
(16 × 14 × 40) m³
- multiple halls:
3 × (9 × 6 × 15) m³
- ultra-low radiation pit:
∅9 m, 9 m depth
- single experiment pit:
∅30 m, 30 m depth

Total civil work cost:
< 2% of tunnel cost



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



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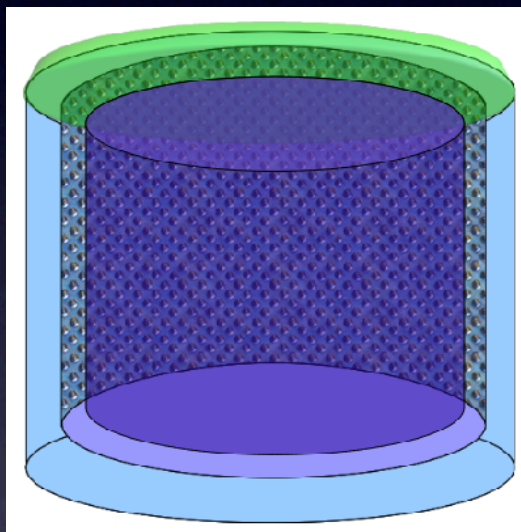
Scientific Program



ANDES

Agua **N**egra **D**eep **E**xperimental **S**ite

Scientific Program



Neutrinos:

Solar

Geoneutrinos

Supernova

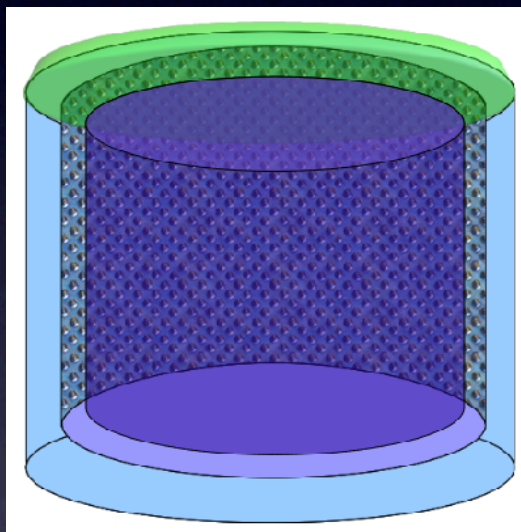
Neutrinoless Double Beta Decay



ANDES

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Scientific Program



Neutrinos:

Solar

Geoneutrinos

Supernova

Neutrinoless Double Beta Decay

Dark Matter

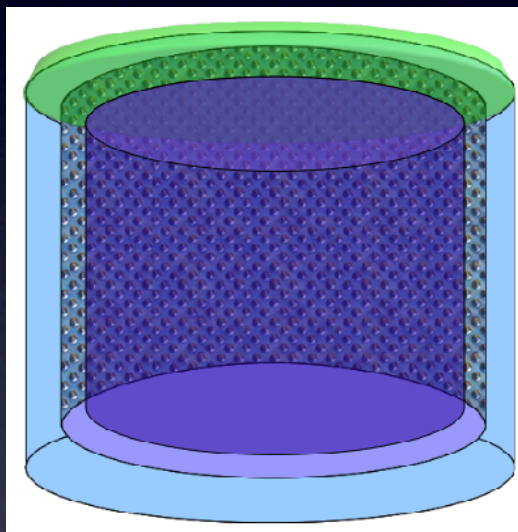




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Scientific Program



Neutrinos:

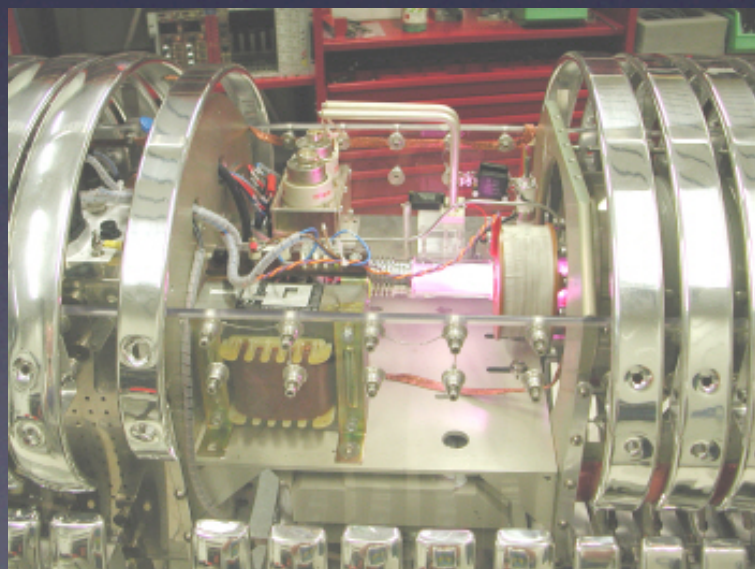
Solar

Geoneutrinos

Supernova

Neutrinoless Double Beta Decay

Dark Matter



Accelerator:

Nuclear Astrophysics

LBL Neutrino Beam

CERN: 9920 km

Fermilab: 7640 km (“magic” baseline)

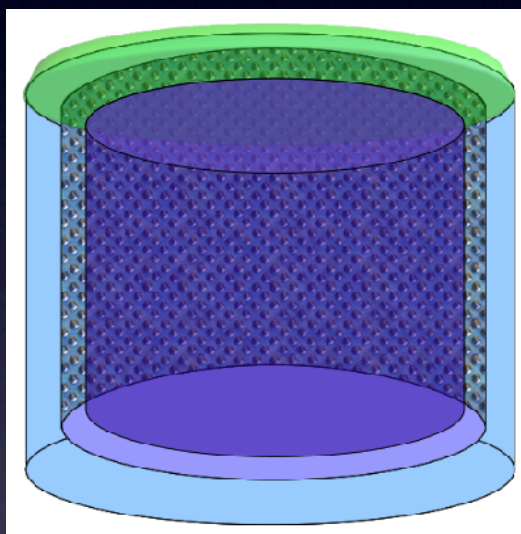
KEK: 12435 km



ANDES

Agua Negra Deep Experimental Site

Scientific Program



Neutrinos:

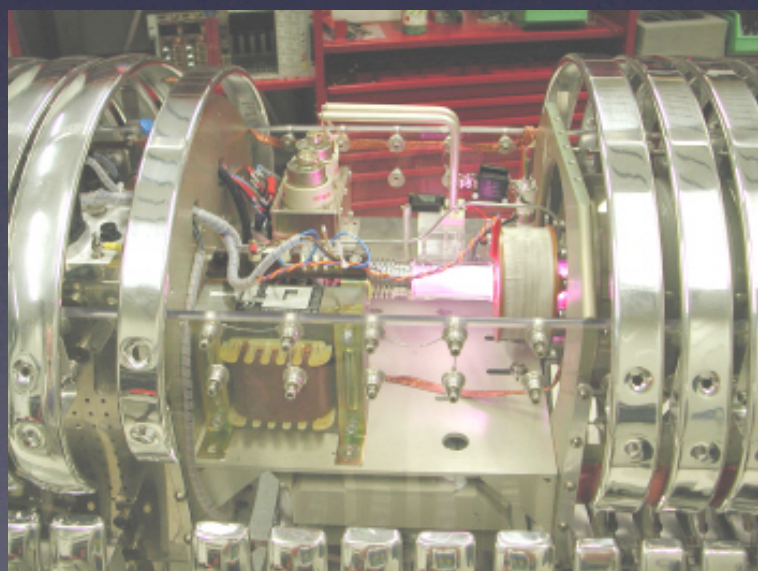
Solar

Geoneutrinos

Supernova

Neutrinoless Double Beta Decay

Dark Matter



Accelerator:

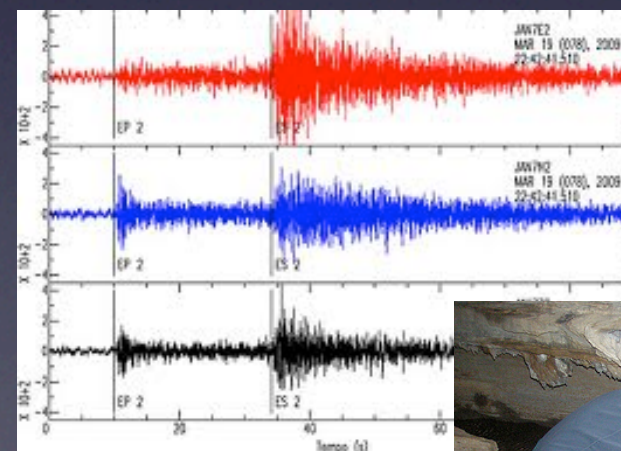
Nuclear Astrophysics

LBL Neutrino Beam

CERN: 9920 km

Fermilab: 7640 km ("magic" baseline)

KEK: 12435 km



Seismology
Geoscience
Microbiology



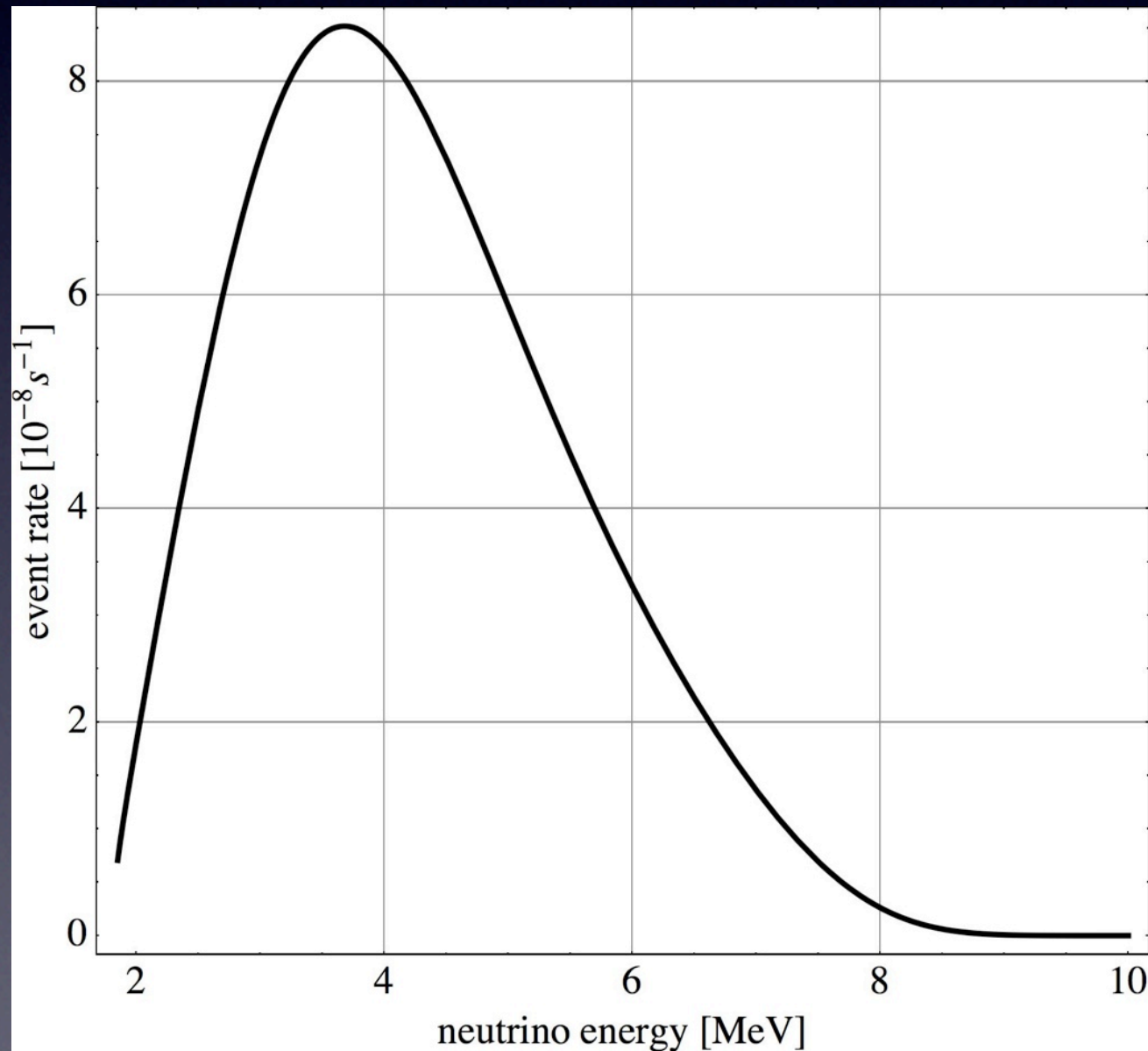


Advantage: few reactors in the vicinities



Embalse 2.1 GWt @ 560 km
Atucha I 1.2 GWt @ 1080 km
Atucha II 2.1 GWt @ 1080 km

Andes Lab



8.8 evts/yr/3 kton
2.2 evts/yr/3 kton for
low-energy geo- ν

Borexino:
5.7 evts/yr/100 tons

Expected number of events:

Location comparison assuming the same detector size, exposure and efficiency

For 1.7×10^{32} free protons, 1 year, 80% efficiency

- Kamioka : $N_U + N_{Th} = 75$
- Gran Sasso: $N_U + N_{Th} = 84$
- SNO : $N_U + N_{Th} = 98$
- Pyhasalmi : $N_U + N_{Th} = 102$
- Hawaii : $N_U + N_{Th} = 52$
- **Andes : $N_U + N_{Th} = 98$**

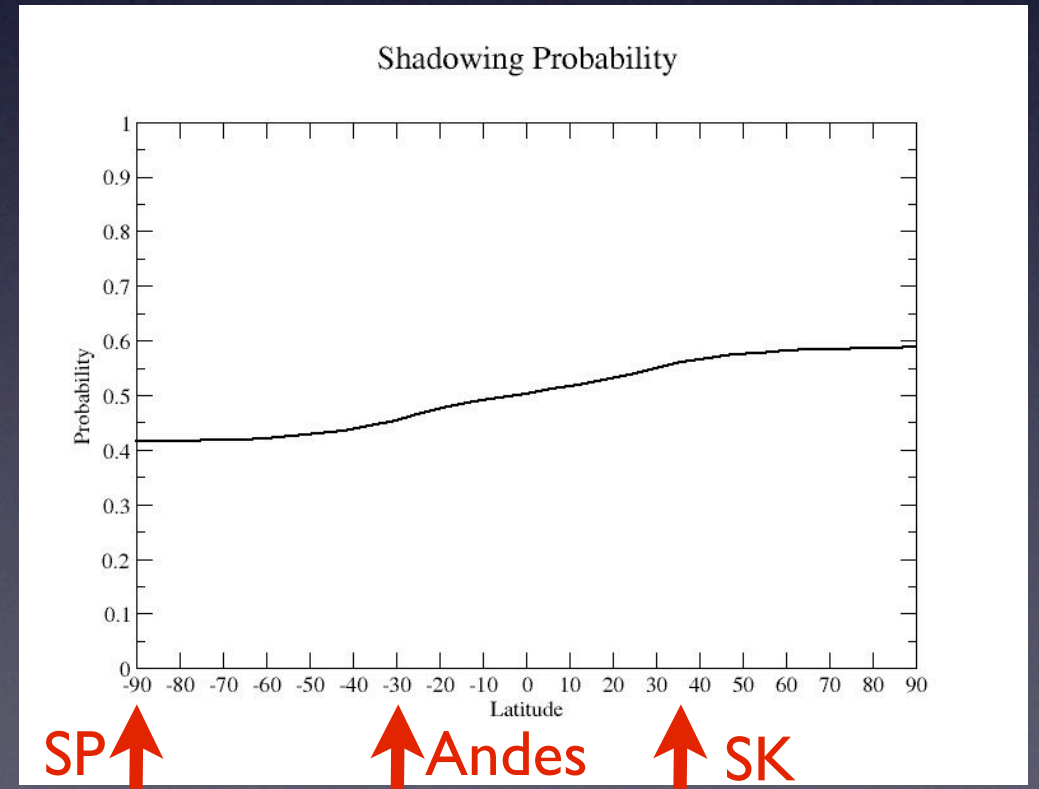
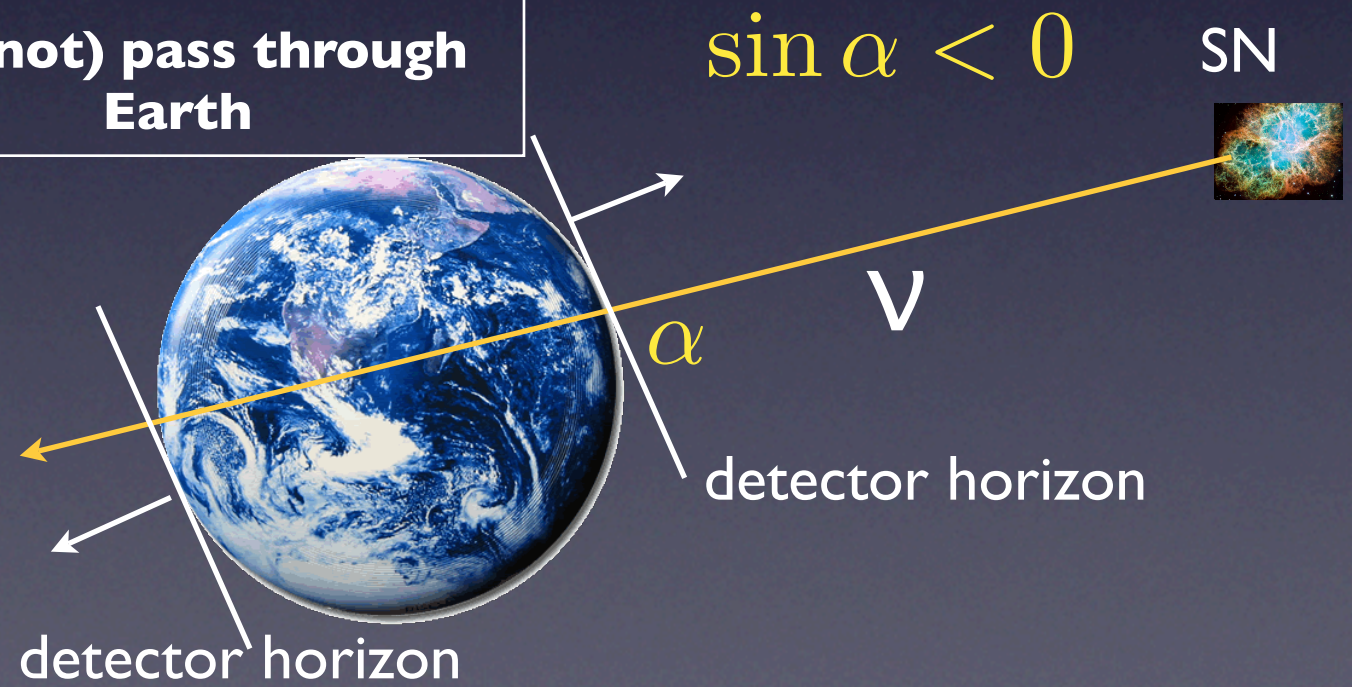
Preliminary

Probability of Earth Shadowing



Place	LATITUDE	LONGITUDE	Prob
Kamioka	36.27° N	137.3° E	0.56
Polo Sul	90° S	-	0.41
ANDES	30.25° S	68.88° W	0.45

(non) shadowed
≡
(do not) pass through Earth



based on A. Mirizzi, G.G. Raffelt and P.D. Serpico JCAP 0605, 012 (2006)

Presence of the Earth Matter Effect

Kamioka South Pole Probability

No	No	0.153
Yes	No	0.434
No	Yes	0.289
Yes	Yes	0.124

72% observe matter effect

@ least one shadowed + one non shadowed

Presence of the Earth Matter Effect

Kamioka South Pole **ANDES** Probability

No	No	No	0.022
Yes	No	No	0.390
No	Yes	No	0.037
No	No	Yes	0.131
Yes	Yes	No	0.108
No	Yes	Yes	0.252
Yes	No	Yes	0.044
Yes	Yes	Yes	0.016

96% observe matter effect