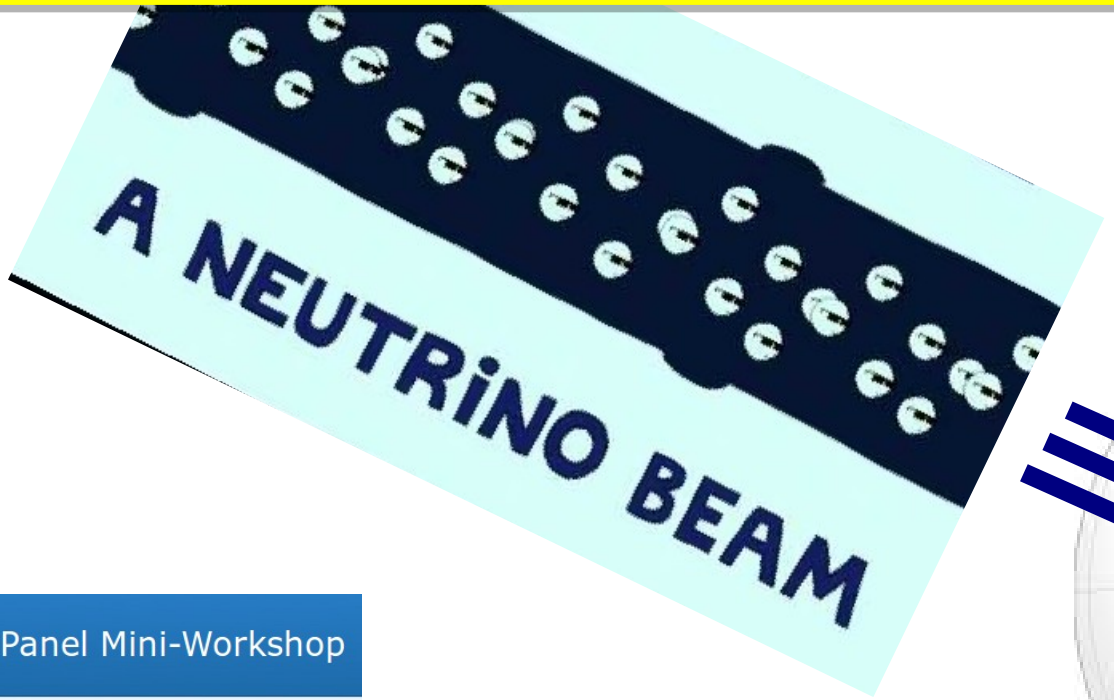
Perspective from Latin America



ICFA Neutrino Panel Mini-Workshop

30-31 January 2014

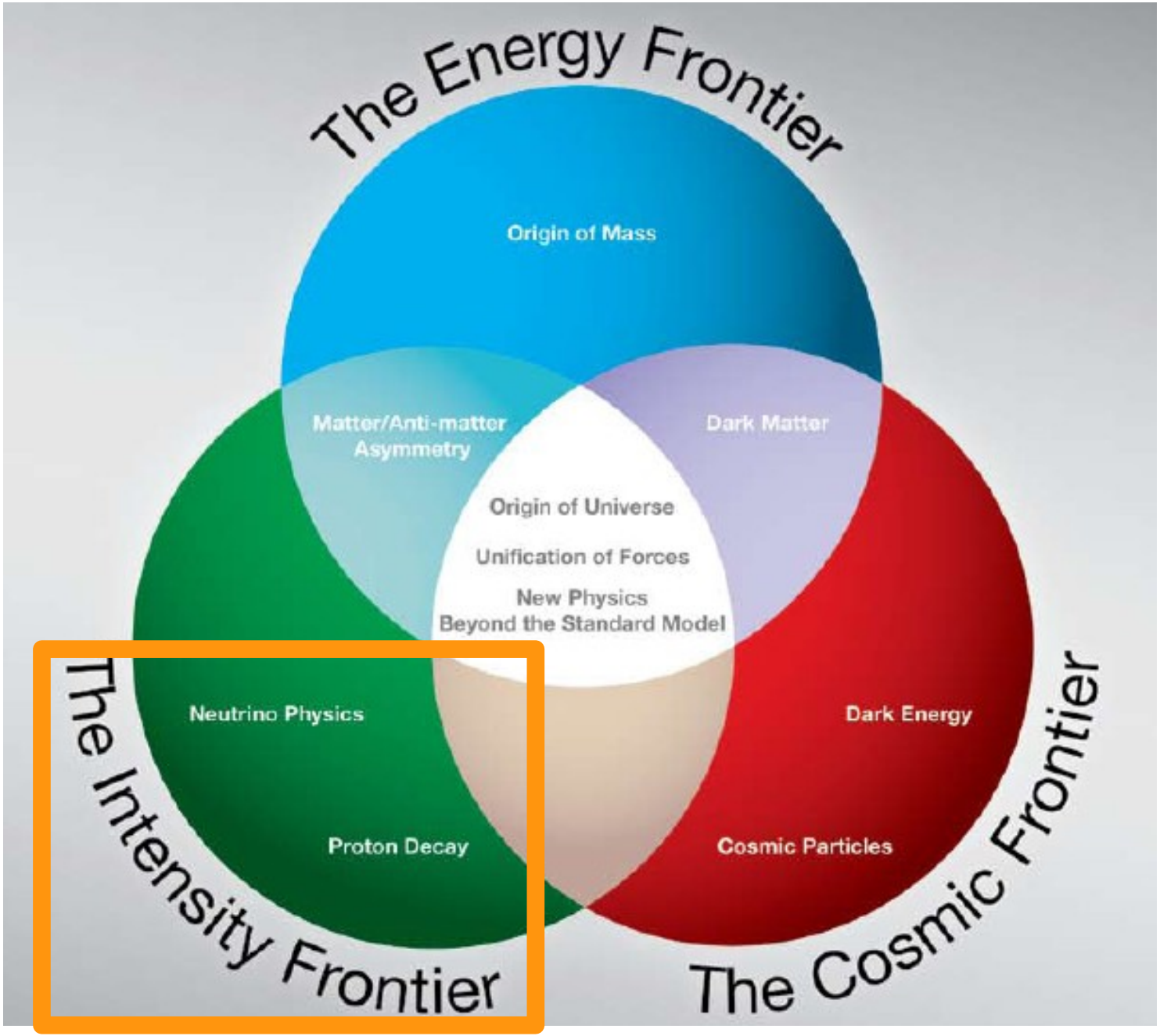
Ernesto Kemp
kemp@ifi.unicamp.br

University of Campinas – UNICAMP

Outline

- Physics Challenges
  - The context of neutrino experiments in the frontier of Physics
- LA neutrino community activities
  - Figures about Brazilian HEP community
  - Where are the Brazilians researchers/institutions within this scenario?
    - Experiments
    - Theoretical work
  - Extending the horizons: in the Latin-American wider scope
- Future and perspectives
- Conclusion

Physics Challenges



Physics Challenges: P5 report (2008)

- **The Intensity Frontier**
  - *"Measurements of the mass and other properties of neutrinos are fundamental to understanding physics beyond the Standard Model and have profound consequences for the understanding of the evolution of the universe."* (PG. 3)
  - *"Recent striking discoveries make the study of the properties of neutrinos a vitally important area of research. Measurements of the properties of neutrinos are fundamental to understanding physics beyond the Standard Model and have profound consequences for the evolution of the universe. The latest developments in accelerator and detector technology make possible promising new scientific opportunities in neutrino science as well as in experiments to measure rare processes."* (PG. 10)

The panel recommends a world-class neutrino program as a core component of the US program (PG. 3)

Physics Chalenges:
Focus on the question Not the answer

- The number 42 is the answer to the Ultimate Question of 'Life, the Universe, and Everything'. This answer was first discovered by the computer Deep Thought after seven and a half million years of calculation. The result of this shocking answer was the construction of an even bigger computer the task of which was to determine just what this 'Ultimate Question' was really asking in the first place.
  - Further details:
    - chapters 3, 6 and 9 of Joll ed., Philosophy and The Hitchhiker's Guide to the Galaxy (Palgrave Macmillan, 2012).

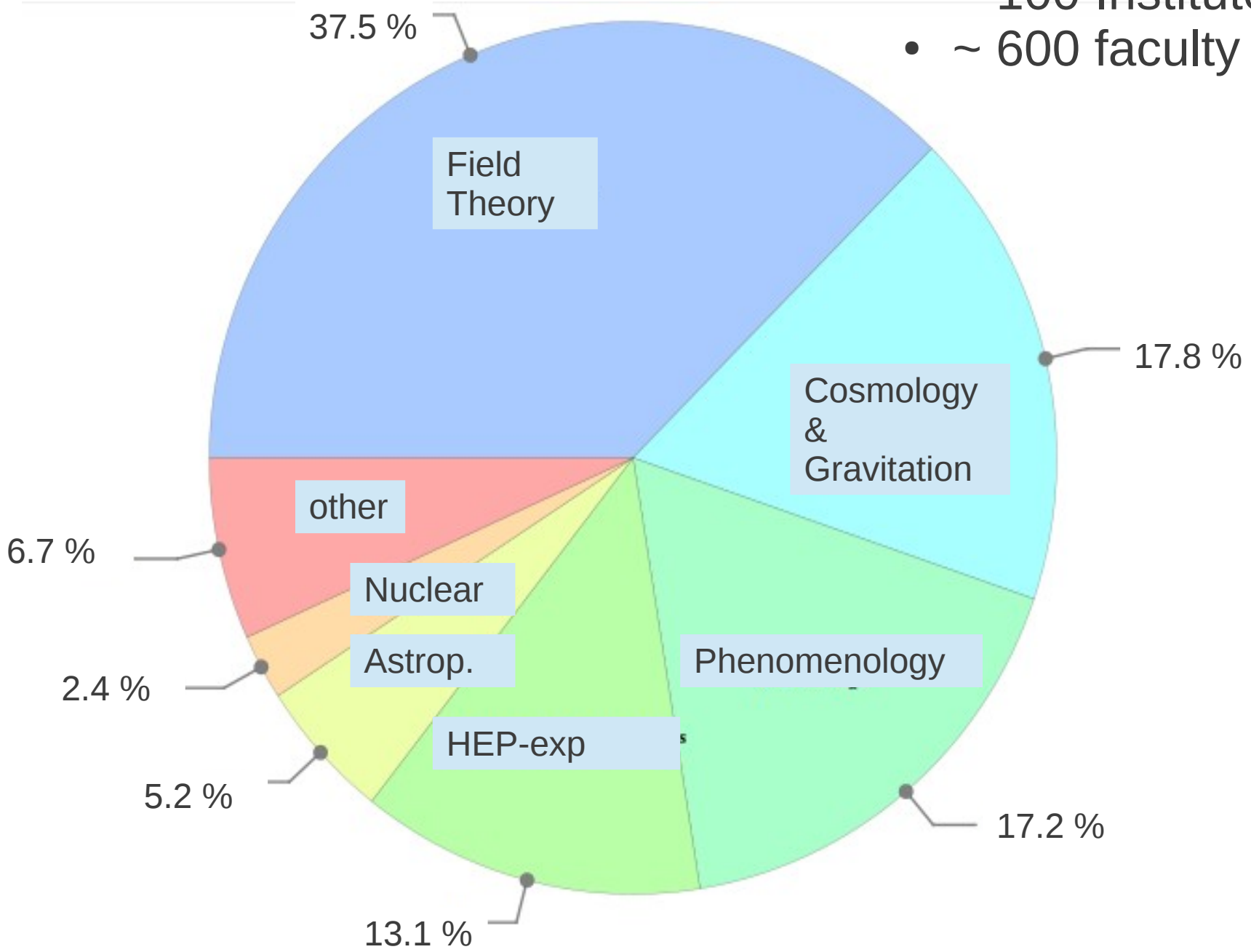
Physics Challenges: scientific policies

- Neutrino Physics is one of the most active field in the advanced frontier of “Big Science”
- Offers an unique opportunity to stay tuned with technological and scientific progress in worldwide scale
  - Sure LA countries are interested in be part of it

    .

Figures about BR-HEP

- ~ 100 Institutes
- ~ 600 faculty



Figures about BR-HEP: by subarea

- hep-exp
  - 5800 papers
  - 242 technological products
  - 211 supervision works in progress
  - 1080 concluded
- cosmology
  - 3000 papers
  - 308 technological products
  - 318 supervision works in progress
  - 1352 concluded
- Particle Physics
  - 3900 papers
  - 218 technological products
  - 259 supervision works in progress
  - 1379 concluded
- Field Theory
  - 6800 papers
  - 375 technological products
  - 534 supervision works in progress
  - 3476 concluded

- Lattes data base (from CNPq)
- Sampled from last ENFPC (2013)
- Caution: there are “ contaminations”

Who ? : the Brazilian neutrino community

- Among these people there are those interested in neutrinos

  (obs.: only main research interest, not accounted researchers working occasionally with neutrinos)

  - 24 (faculty) = 13 (exp) + 11 (theo)
- 11 Institutions:4
  - UNICAMP (4), USP (2), UFABC (3), IFT (2) (SP state)
  - UFG (1) (GO state)
  - CBPF (3), UFRJ (1) , PUC-Rio (1) (RJ state)
  - UFAL (1), UFJF (1) (MG state)
  - UFBA (2), UEFS (1) (BA state)
  - UFPR (1) (PR state)
  - UFPB (1) (PB state)

Where ? : Experiments with LA teams

- Neutrino Properties:
  - *oscillations*
    - LBNE
    - Double Chooz
    - NOvA
    - MINOS
      - MINOS+
  - 0νββ
    - NEXT
- Neutrino Interactions:
  - *nuclear scattering and NSI*
    - LBNE
    - MINERVA
    - CONNIE

- Astrophysical Neutrinos
  - LBNE
  - LVD
    - Xenon
  - Pierre Auger Observatory
- Neutrino Applied Physics
  - Neutrinos-ANGRA

- Special Remark: ANDES

Who ?: countries

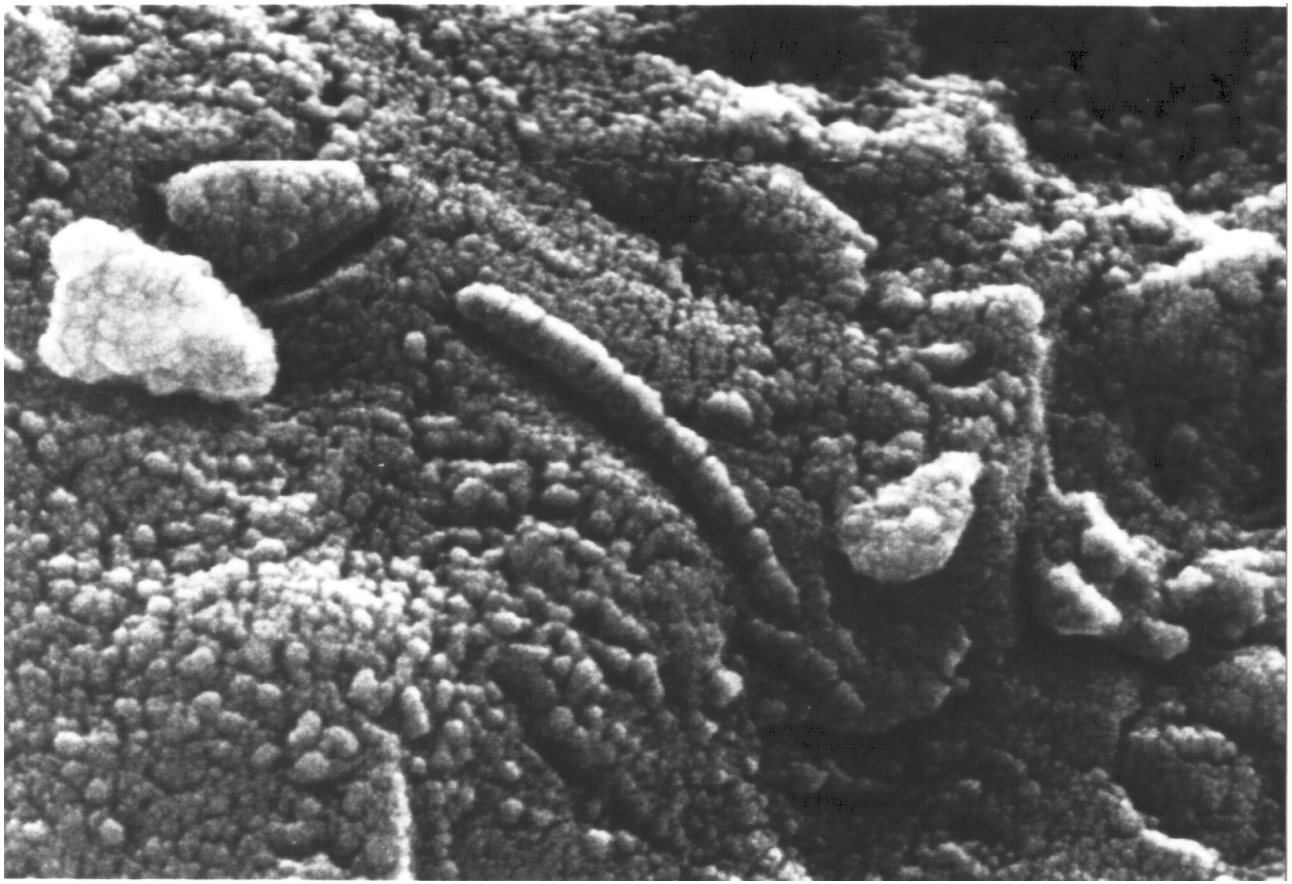
- Latin American Countries in neutrino experiments
  - Argentina : Auger,CONNIE, ANDES
  - Brazil: LBNE, DC, Auger, MINOS(+), NOvA, CONNIE, Nu-ANGRA, ANDES
  - Chile: ANDES
  - Colombia: NEXT
  - Paraguay: CONNIE
  - Peru: MINERvA
  - Mexico: Auger, MINERvA, ANDES

What ? : activities from LA teams

- Tasks – general overview
  - R&D
    - Detectors development, integration, prototype tests
  - Experiment construction
    - installation, commissioning
  - Monitoring
    - Data analysis for detector characterization (performance and systematics studies)
  - Data Analysis
  - Management
    - Scientific boards and task leading
    - Administrative boards and tasks

Who, Where, What ?:

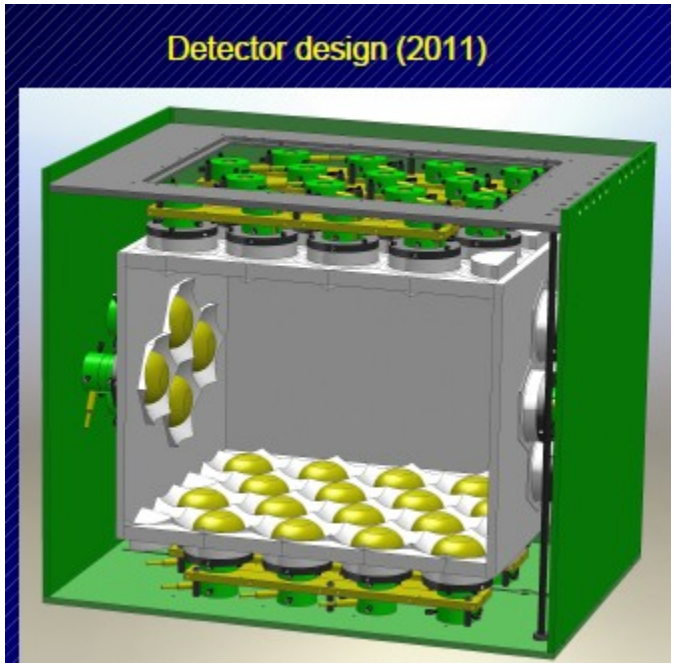
There is life outside very large international collaborations...

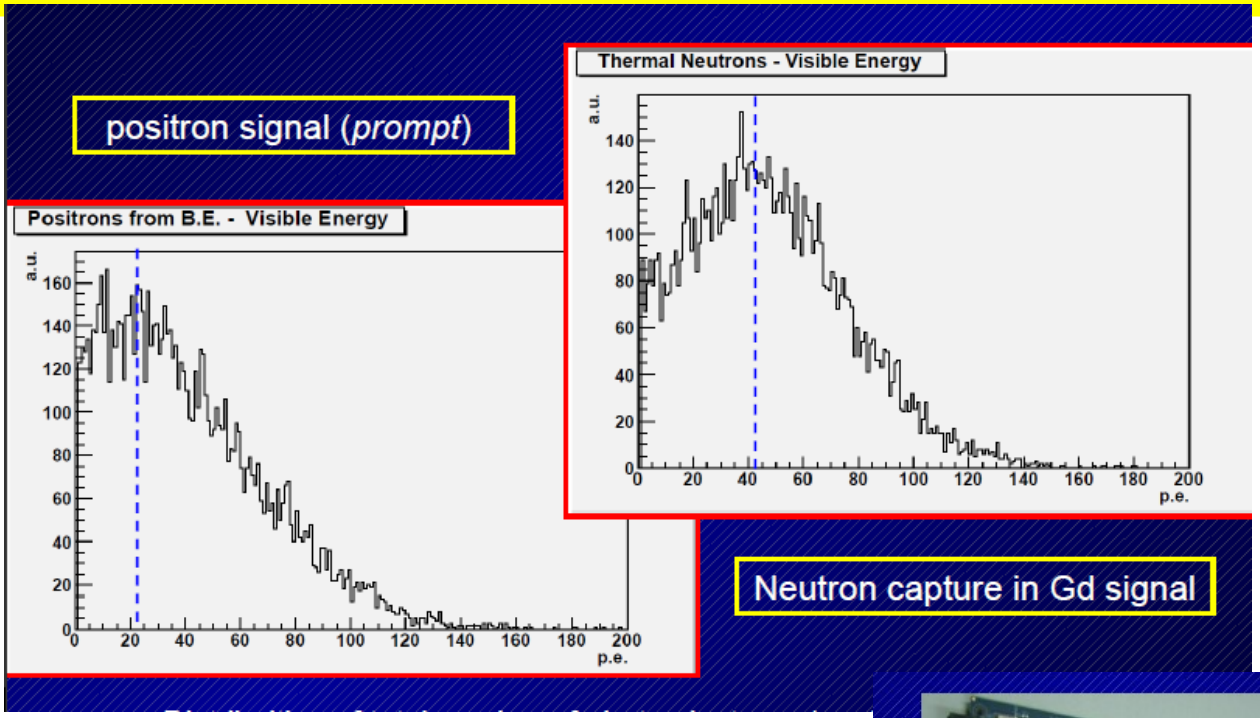


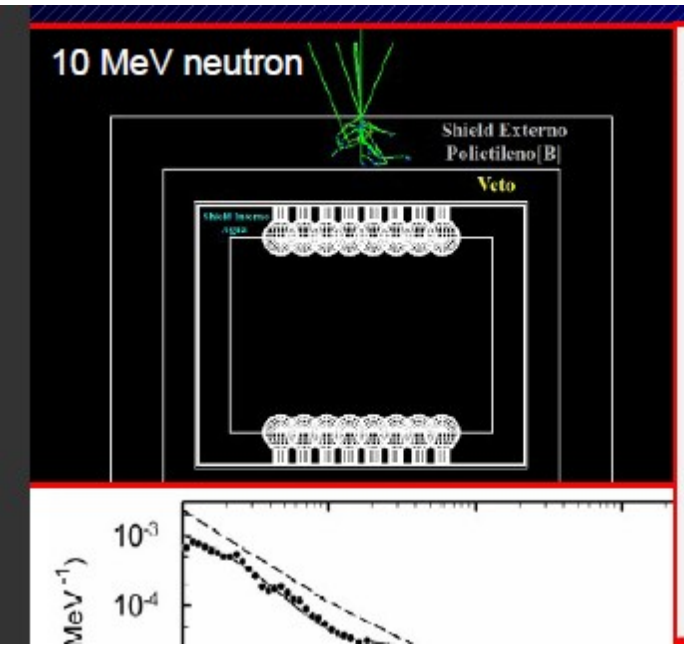
Experiments in BRAZIL: Neutrinos-ANGRA and CONNIE

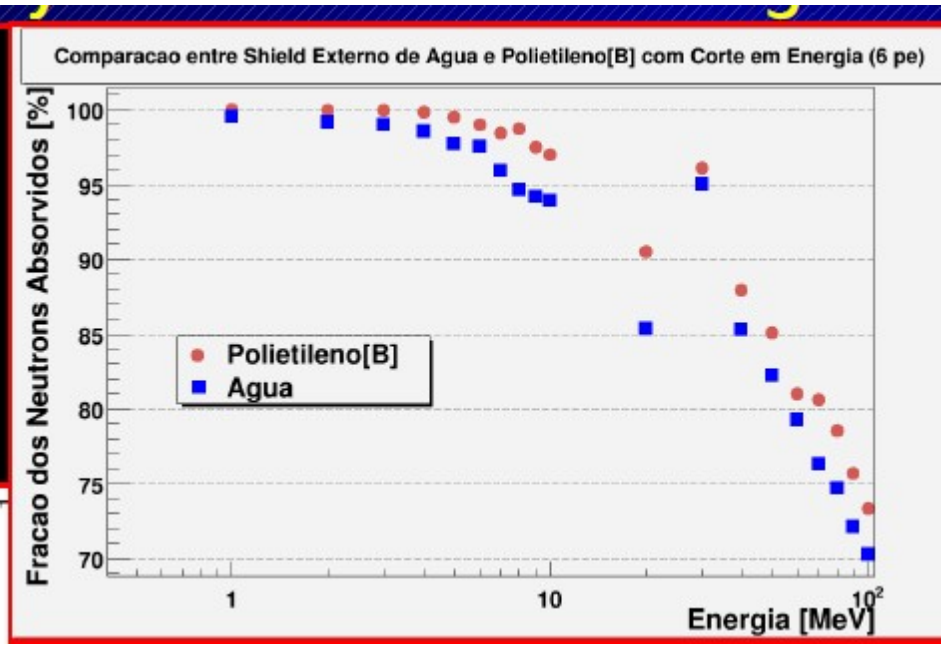
Experiments - BR: Neutrinos-ANGRA

Experiments - BR: Neutrinos-ANGRA





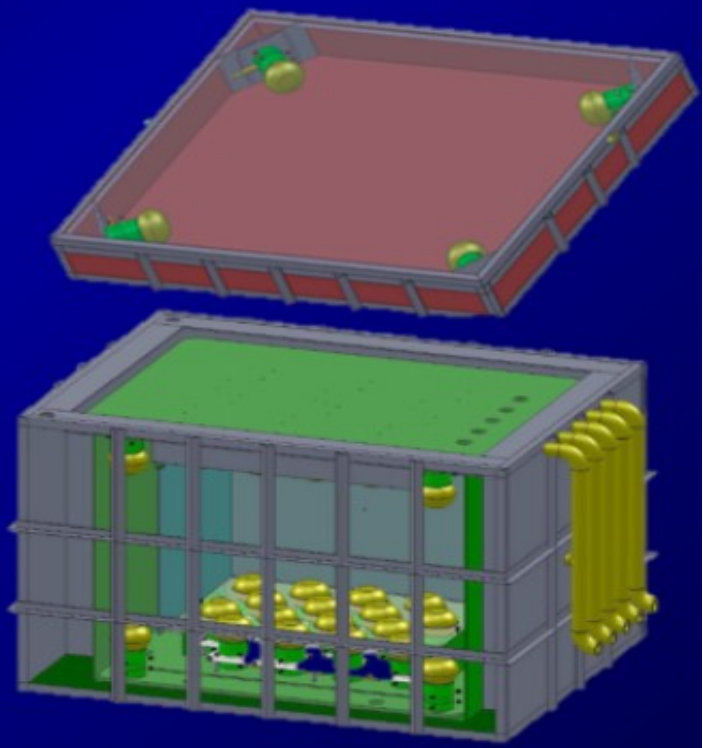




Experiments - BR: Neutrinos-ANGRA

Status of the Neutrinos ANGRA project

- New 40' High Cube container: **deployed** in Angra
- Geant4 simulation of detector response to signal and background events: **working**
- Neutrino signal extraction – **simulated**
- New detector design: **active water shield**
- Water shielding and target vessels: **built**
- Front-end electronics: **been tested**
- Electronics for DAQ: **ready**
- Data acquisition software: **ready**
- Detector test at CBPF: **Started July 2012**
- Deployment in Angra: middle **2014**

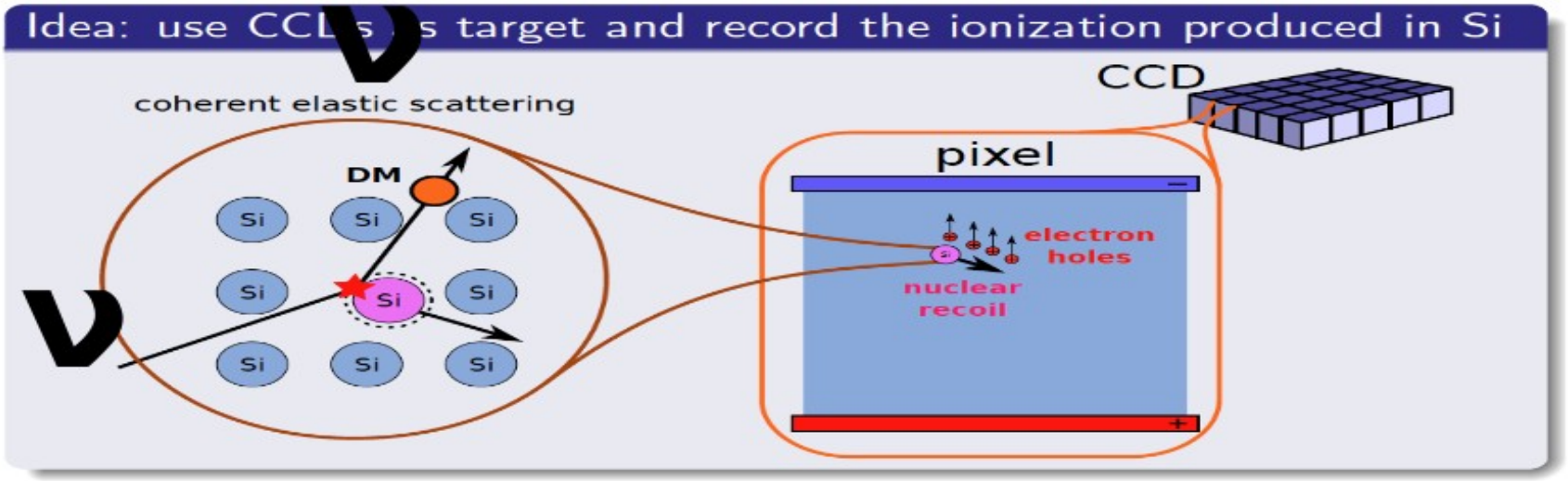


Experiments BR: CONNIE

Coherent Neutrino Nucleus Interaction Experiment (CONNIE)

Goal: lower the energy threshold in Si detectors

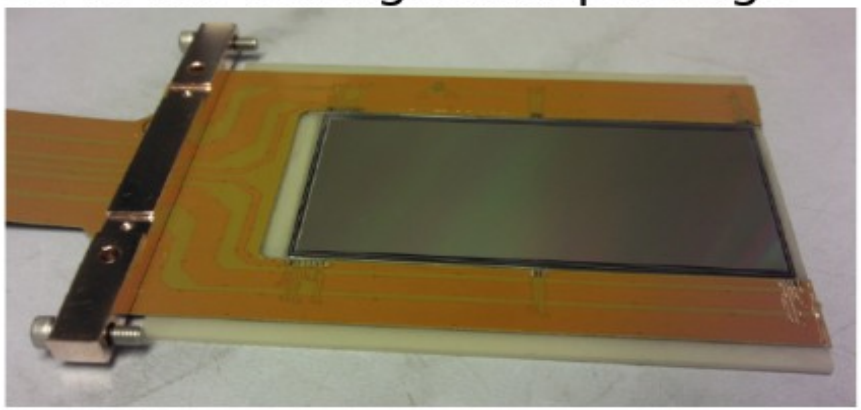
Look for coherent DM-nucleus interactions by measuring the ionization produced by the nuclear recoils



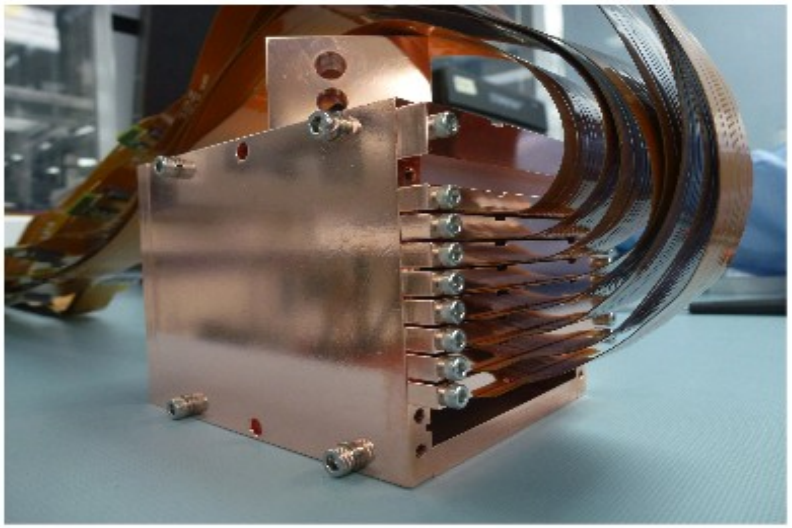
Using the technology developed for DM searches with CCDs. Low noise (~7.2eV RMS) and low background packages currently under test at SNOLAB.

Experiments BR: CONNIE

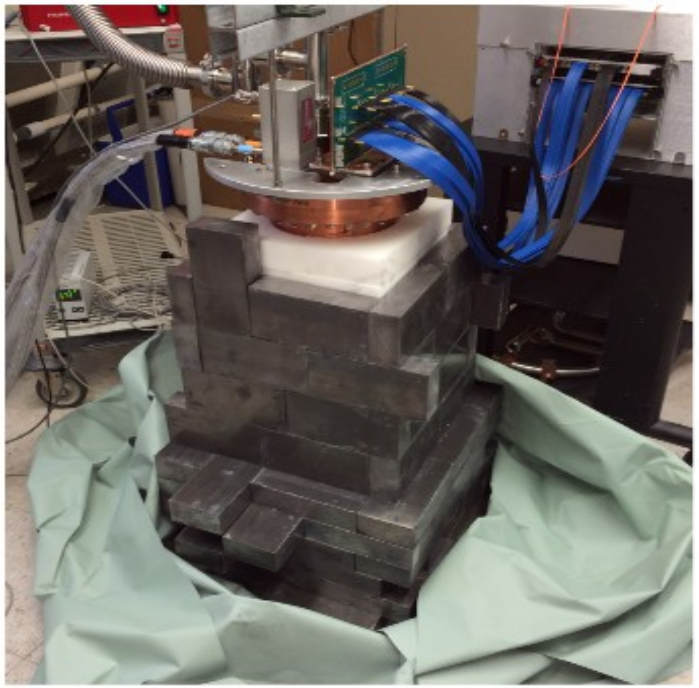
CCD in low background package



Vacuum vessell



Array of CCD in cold box to Operate at -150C



1/5 of the lead and poly shield being tested at FNAL (Jan-2014)

Other Experiments: NEXT

Experiments: NEXT

U. GIRONA • IFIC (VALENCIA) • U. SANTIAGO • U.P. VALENCIA • U. ZARAGOZA • U. A. MADRID

LBNL • TEXAS A&M • JOHNS HOPKINS U.

CEA (SACLAY)

U. COIMBRA • U. AVEIRO

JINR (DUBNA)

UAN (BOGOTÁ)

- 80 collaborators
- 14 institutions
- 6 countries

Experiments: NEXT

- SiPM plane construction and characterization
- Simulation and data analysis
- Contributions with qualified manpower, planning, logistic and budget
- 2 senior and 1 junior physicists, 1 electronic engineer, 3 PhD students and one technician
- 2014 will be increased with 1 senior electronic engineer and 1 physics postdoc

Experiments: NEXT – collaboration path

- Academic Cooperation Agreement between

  Universidad Antonio Nariño – Bogotá , Colombia

  +

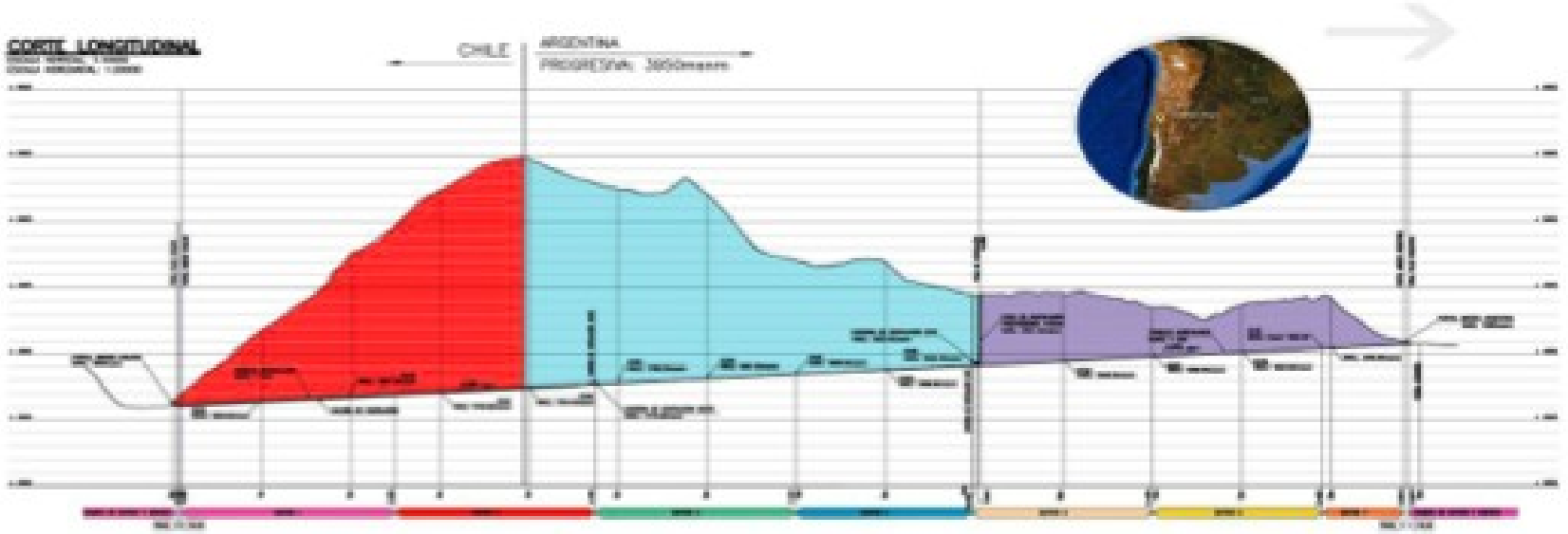
  UNICAMP

  already exists

Future Perspectives:

ANDES

The first deep underground laboratory
of the Southern hemisphere.



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

A Latin American project in the Agua Negra tunnel

Future Perspectives: ANDES

- Experimental facility in the tunnel connecting Argentina-Chile
  - Underground Physics
    - SN Neuttrinos
    - Geoneutrinos
    - Double-beta decay
    - Dark matter
- CLES: Centro Latino Americano de Estudos Subterraneos
  - A CERN-like consortium to manage the laboratory and drive the activities on all related fields in LA.

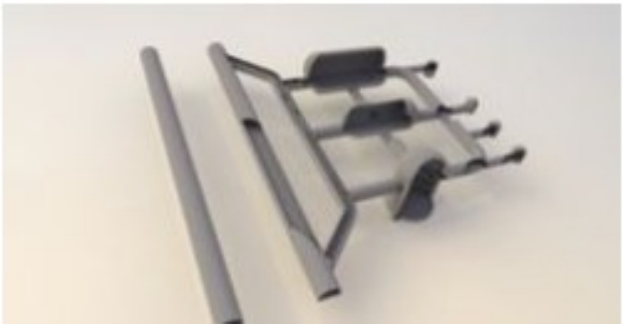
Future Perspectives: ANDES

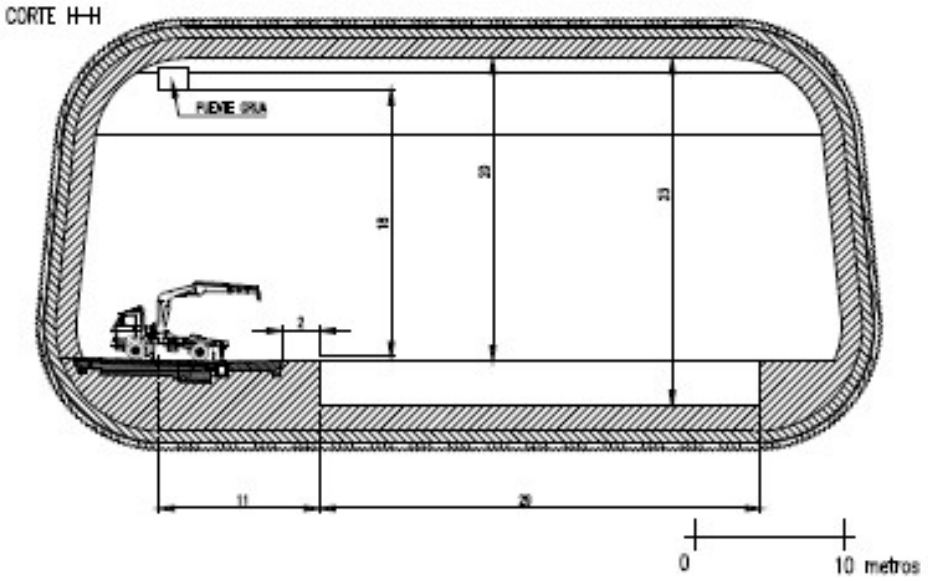
Future Perspectives: ANDES

Proposal for the ANDES laboratory

Located at km 3.5-5

- Main hall
  - $(21 \times 23 \times 50)\,m^3$
- Secundary hall
  - $(16 \times 14 \times 40)\,m^3$
- Offices and small laboratories
  - 3 halls of $100\,m^2$
- Low radiation pit
  - ⌀9 m, 9 m tall
- Large experimental pit
  - ⌀30 m, 30 m tall





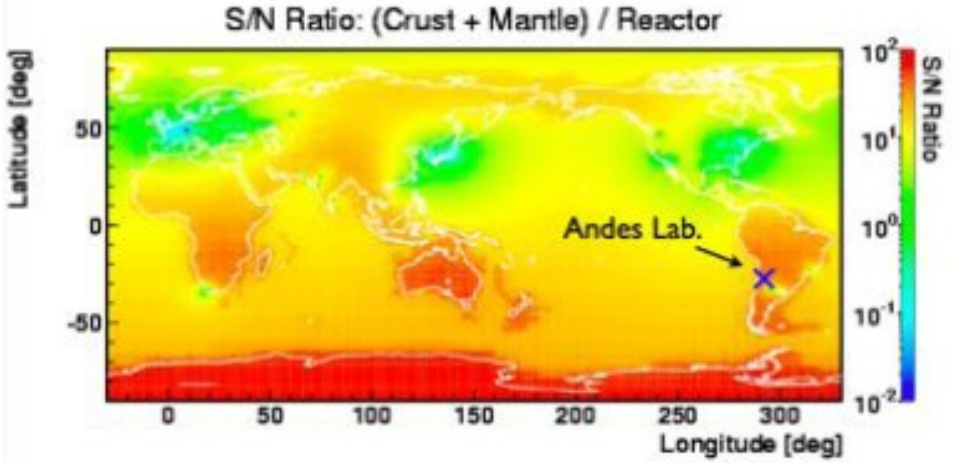
Civil work cost estimated < 2% of tunnel cost

- + Laboratory equipment
- + 2 support laboratories
- + Experiments

Future Perspectives: ANDES

A scientific opportunity in the south?

- Opportunity for a big AND deep laboratory
- only deep underground laboratory in the south
  - opposite weather modulation (dark matter)
  - complementary for supernovae neutrinos
- Geoneutrinos
  (Low neutrino flux from nuclear power plants)
- Geoactive region
  - Underground geophysics laboratory



The Consorcio Latinoamericano de Experimentos Subterráneos (CLES)

- Excellent opportunity to have an international laboratory
  expand the MERCOSUR (UNASUR) aspect of the tunnel to the ANDES laboratory
- The CLES would be the seed of a “CERN” focused on underground science (high energies, geology, biology, technology...)

Future Perspectives: ANDES

Current status (cont.)

March 2012

- approved by the MinCyT (CAGICyT) and EBITAN
  - ANDES will go as an "adicional de obra"

Tunnel tender process started in January 2013

- International call issued in June 2013
- Companies selected in October 2013
- Detailed engineering foreseen for March 2014

Next ANDES workshop

- Unidad de seminarios Ignacio Chavez, UNAM
  30-31 January 2014
- Work with CLAF for coordination
  - ANDES Unit in CLAF to be signed on next friday

Why so many what, where, who... ?

- Surely already happen to you to be in the middle of a conversation with someone and a curious person stopping to ask "what ?", "where ?", "why ?"," who ?" ;
- … and other things, trying to learn about the subject in discussion. It is a curious, nosy guy ... Someone from the corporate fauna everyone wants away because besides curious, it is often also gossip ...

Want to know all the other people's lives after spreading out in other rounds of conversation ...

5W2H

- But these little questions have another function in the Quality Management (administrative tool)

  … nothing to do with gossip or curiosity.

- It is a famous quality tool: 5W2H!
- the nosy guy is only doing a good management job

5W2H and this talk:

- ICFA-Americas neutrino panel
  - It is of uttermost importance try to have a consistent picture of scientists/students activities in LA to coordinate and consolidate their effective participation in the field of neutrino research.
  - The current scenario can give us the first hints in how to proceed, going further to have common benefits in “large scale”
    - This can be achieved by applying the ideas of 5W2H tool

How (much) ?: funding schema

- To be discussed tomorrow

Round Table Discussion: How to Increase Collaboration Across the Americas? Moderator: Jorge Morfin; Panelists: Carlos Escobar, Jean-Michel Poutissou, Arnulfo Zepeda

Wilson Hall - One West 09:20 - 10:00

Conclusions

- Brazilian/LA researchers on neutrino science are well inserted
- There are many opportunities both for new collaborators and students
- Future is also promising
- Perspective/suggestion:
  - 5W2H : systematic survey within LA-HEP community

GRACIAS

OBRIGADO

THANK YOU

BACKUP

Physics Challenges

- **The Intensity Frontier**
  - *"Measurements of the mass and other properties of neutrinos are fundamental to understanding physics beyond the Standard Model and have profound consequences for the understanding of the evolution of the universe."* (PG. 3)
  - *"Recent striking discoveries make the study of the properties of neutrinos a vitally important area of research. Measurements of the properties of neutrinos are fundamental to understanding physics beyond the Standard Model and have profound consequences for the evolution of the universe. The latest developments in accelerator and detector technology make possible promising new scientific opportunities in neutrino science as well as in experiments to measure rare processes."* (PG. 10)

The panel recommends a world-class neutrino program as a core component of the US program (PG. 3)

Physics Challenges

- **3 . 2 The Intensity Frontier : Neutrino Physics and Precision Measurements**

At the Intensity Frontier, precision measurements of the properties of leptons and quarks can lead the way to resolving some of the universe's deepest mysteries.

- **3 . 2 . 1 Neutrino physics**

Neutrino physics has had a long and distinguished history, … We outline an ambitious vision that builds on that strong scientific tradition to capture the unique scientific opportunities of neutrino science. Results of recent experiments have revolutionized and brought renewed excitement to this field.

They have shown that neutrinos have nonzero masses, mix with one another, and oscillate among the neutrino flavor states.

Cosmology tells us that the neutrino masses are very small, less than one millionth of the electron's mass.

Oscillation studies find tiny nonzero neutrino mass differences between generations, but large values of two of the three mixing angles, $\theta_{23} \sim 45^{o}$ and $\theta_{12} \sim 32^{o}$. Currently we only have an upper limit of about 10^{o} on the third angle, θ_{13}.

Collectively, these advances in neutrino physics have opened the first crack in the Standard Model of particle physics. They have significantly changed our view of neutrinos and the special role they play in elementary particle physics, astrophysics and cosmology.

In the coming years, neutrino physics presents exciting opportunities:

- the measurement of the mixing angle between the heaviest and lightest neutrinos,
- determination of the hierarchy of neutrino masses,
- the search for matter-antimatter asymmetry (CP violation) in neutrino mixing, and lepton number violation.

These opportunities are fundamental to the science of particle physics and have profound consequences for the understanding of the evolution of the universe.

Physics Challenges

- **Questions for the future**

The great progress in neutrino physics over the last few decades raises new questions and provides opportunities for major discoveries. Among the compelling issues today:

1) What is the value of θ_{13}, the mixing angle between first- and third-generation neutrinos for which, so far, experiments have only established limits? Determining the size of θ_{13} has critical importance not only because it is a fundamental parameter, but because its value will determine the tactics to best address many other questions in neutrino physics.

2) Do neutrino oscillations violate CP? If so, how can neutrino CP violation drive a matter-antimatter asymmetry among leptons in the early universe (leptogenesis)? What is the value of the CP violating phase, which is so far completely unknown? Is CP violation among neutrinos related to CP violation in the quark sector?

3) What are the relative masses of the three known neutrinos? Are they "normal," analogous to the quark sector, ($m_3 > m_2 > m_1$) or do they have a so-called "inverted" hierarchy ($m_2 > m_1 > m_3$)? Oscillation studies currently allow either ordering. The ordering has important consequences for interpreting the results of neutrinoless double beta decay experiments and for understanding the origin and pattern of masses in a more fundamental way, restricting possible theoretical models.

4) Is θ_{23} maximal (45^o)? if so, why? Will the pattern of neutrino mixing provide insights regarding unification of the fundamental forces? Will it indicate new symmetries or new selection rules?

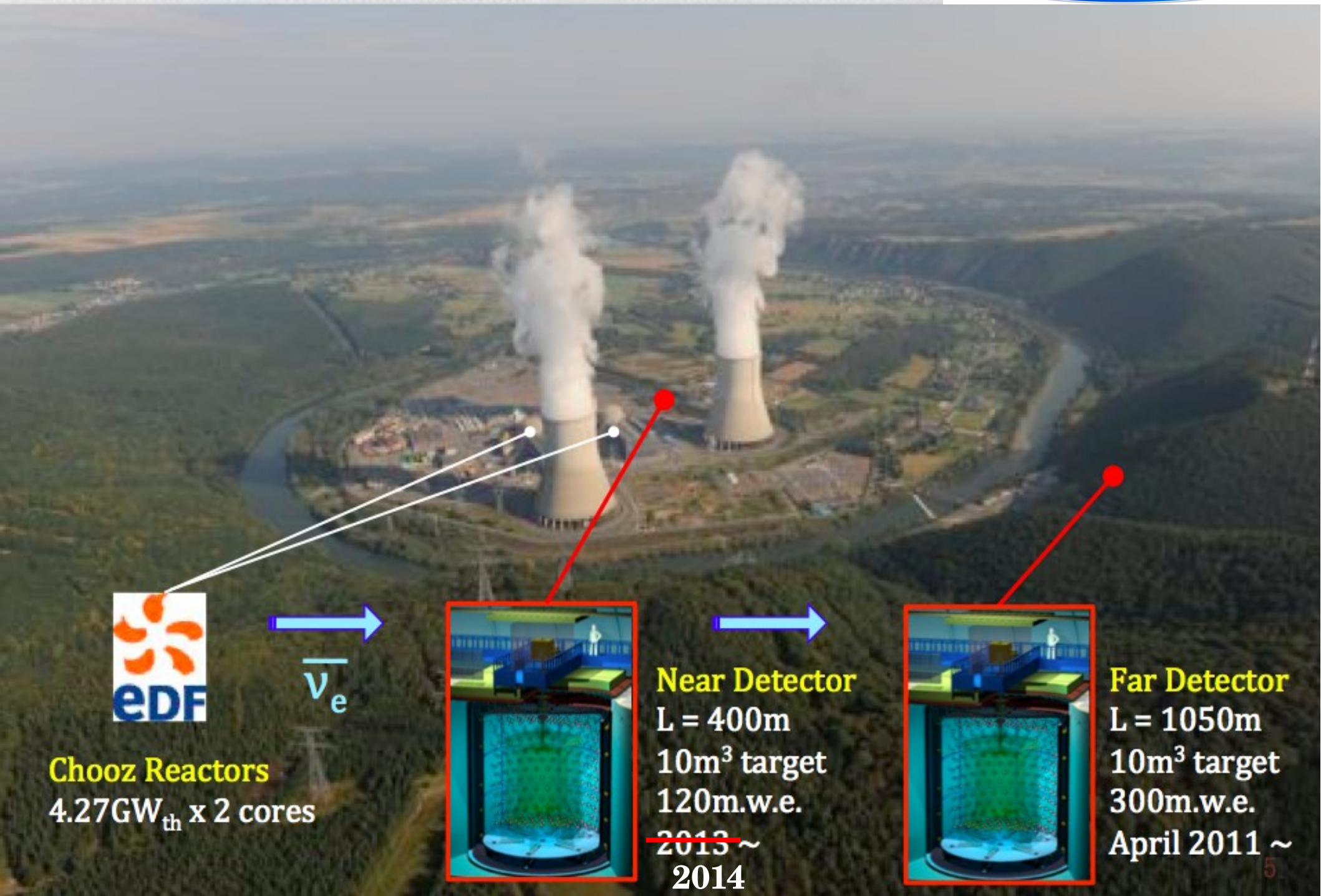
5) Are neutrinos their own antiparticles? Do they give rise to lepton number violation, or leptogenesis, in the early universe? Do they have observable laboratory consequences such as the sought-after neutrinoless double beta decay in nuclei?

6) What can we learn from observation of the intense flux of neutrinos from a supernova within our galaxy? Can we observe the neutrino remnants of all supernovae that have occurred since the beginning of time?

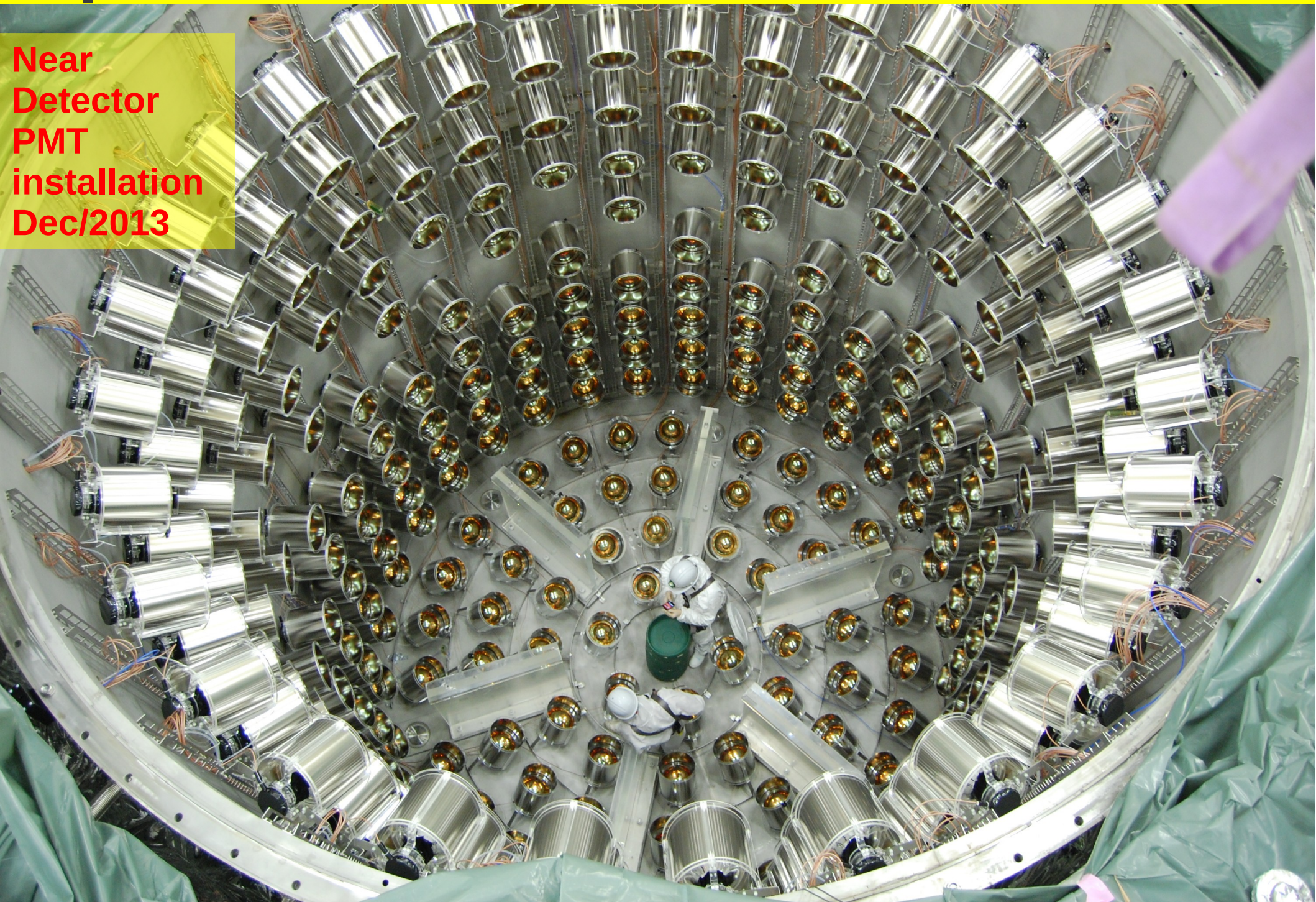
7) What can neutrinos reveal about other astrophysical phenomena? Will we find localized cosmic sources of very-high-energy neutrinos?

8) What can neutrinos tell us about new physics beyond the Standard Model, dark energy, extra dimensions? Do sterile neutrinos exist?

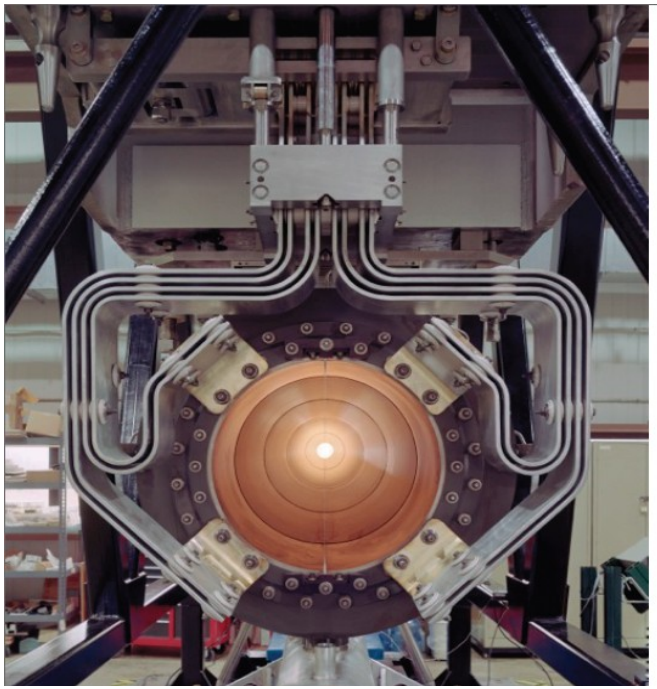
Double Chooz experiment

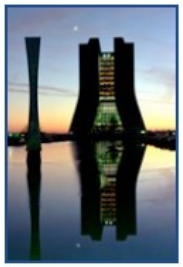


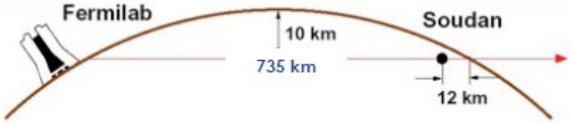
Experiments: Double Chooz



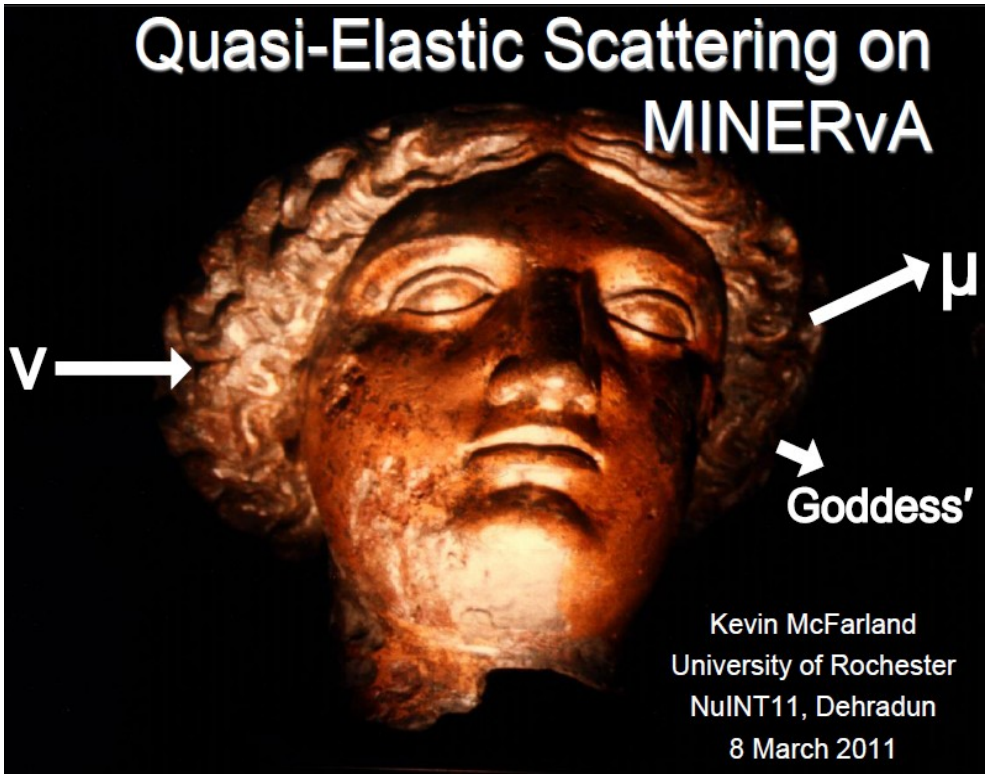
Experiments: MINOS

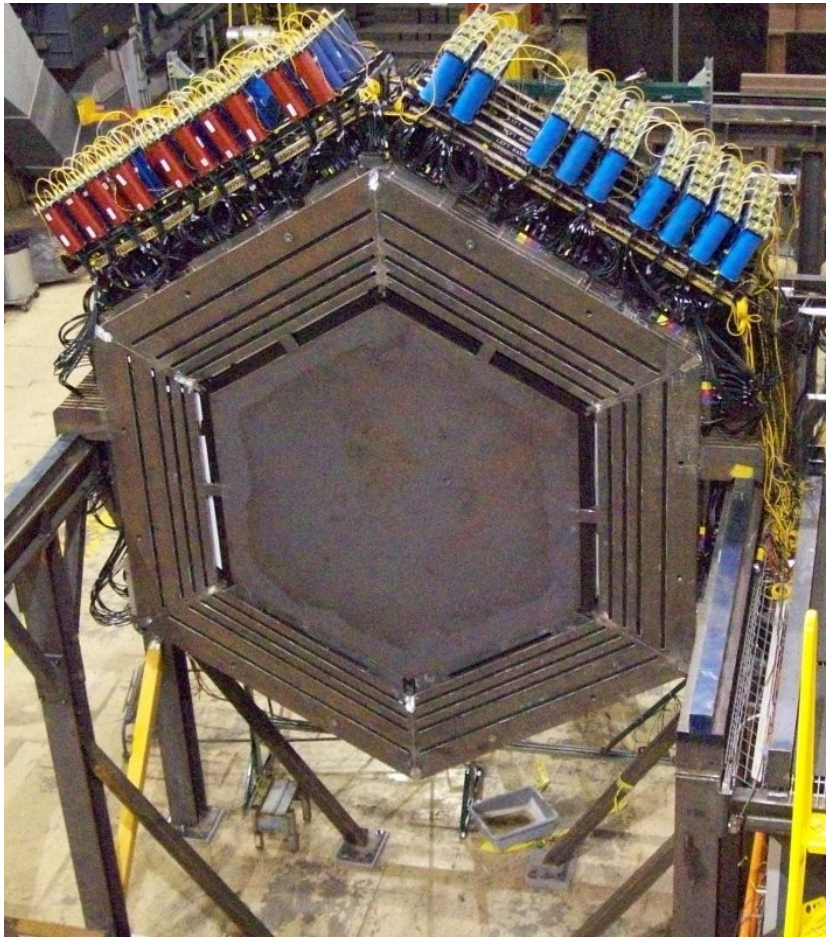




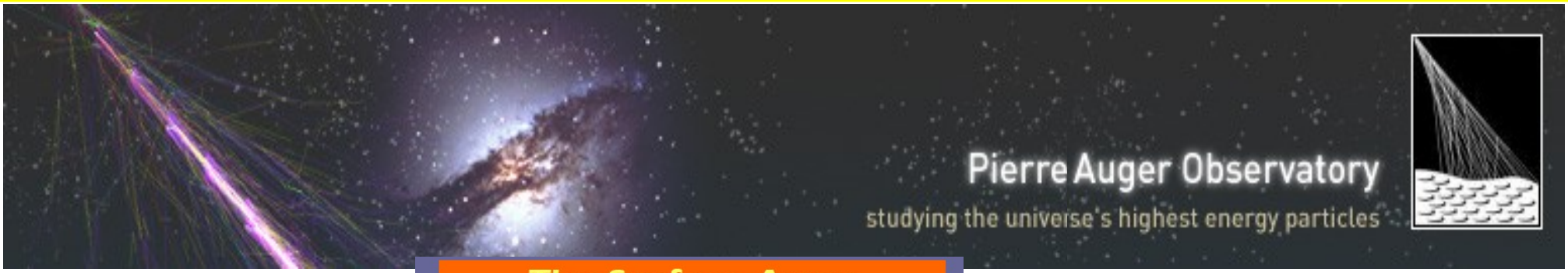


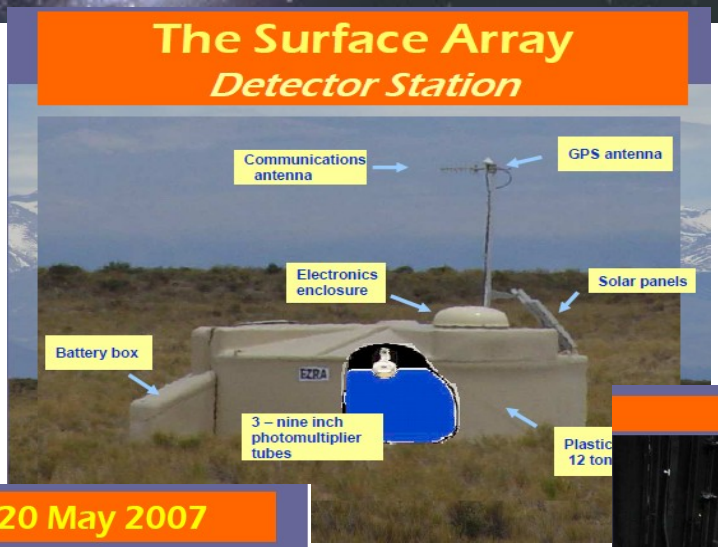
Experiments: MINERVA

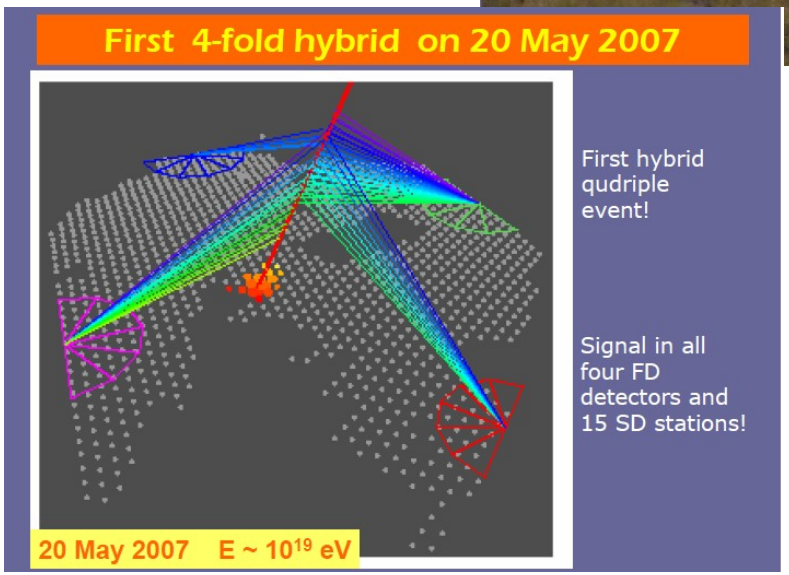


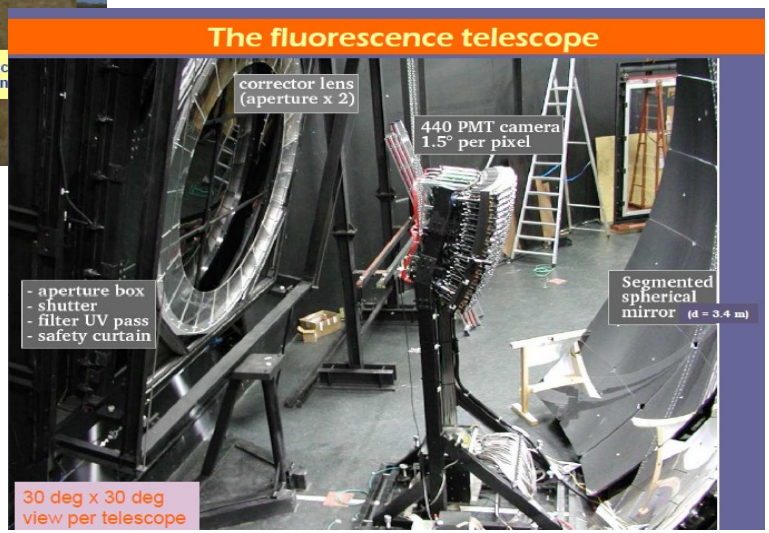


Experiments: Pierre Auger Observatory

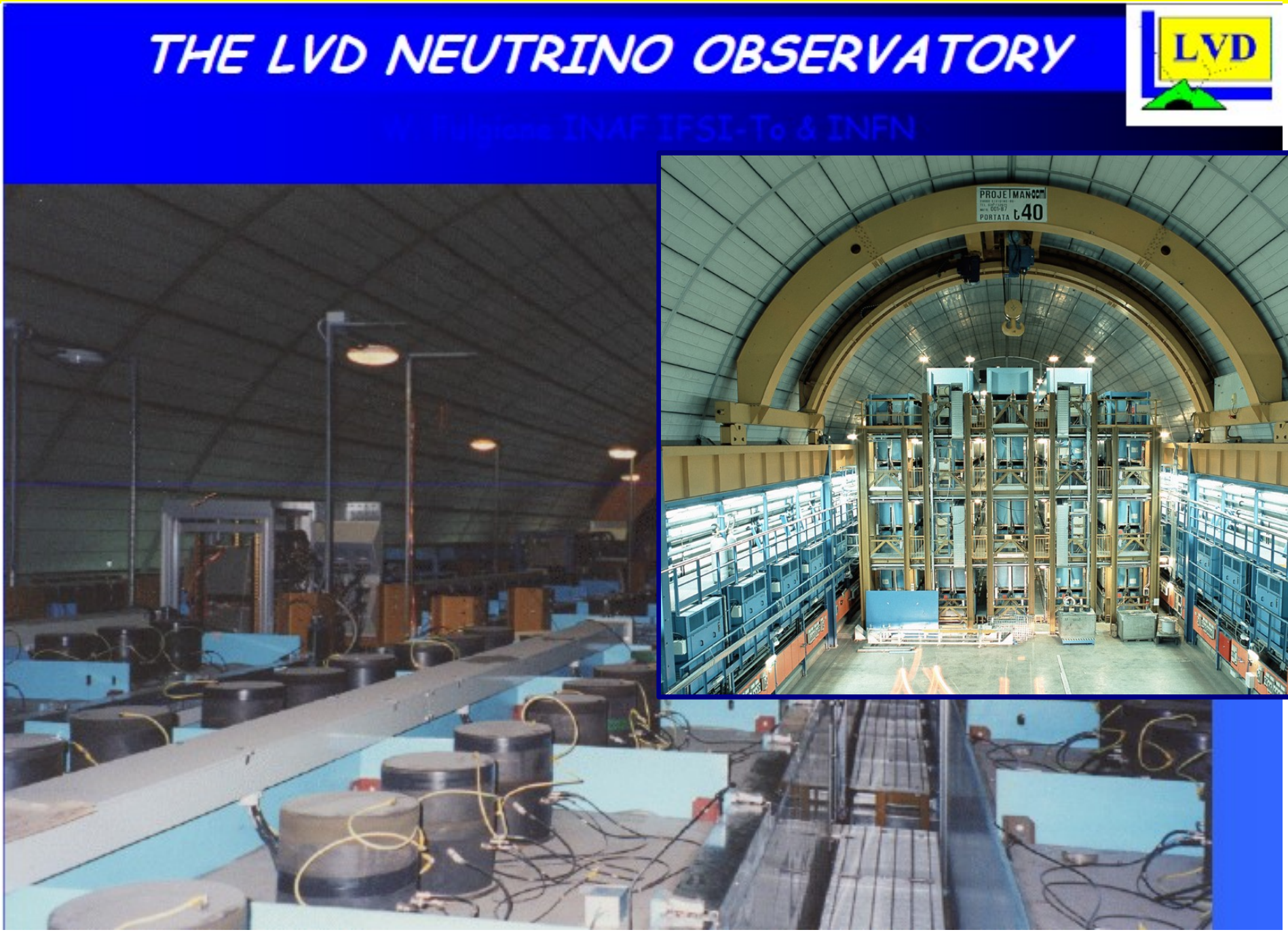








Experiments: Large Volume Detector - LVD



What ? : Double Chooz activities

- Institutions: CBPF, UFABC, UNICAMP
- Numbers
  - Researchers: 6
  - PosDoc: 1
  - PhD: 1
- Tasks:
  - PMT installation
  - Muon electronics, Muon system DAQ software
  - Trigger efficiency, detector response and energy resolution,
    muon tagging
  - Shift coordination
  - Analysis: cuts by event topology

What ? : MINOS activities

- Institutions: UNICAMP, UFG, USP
  - Faculty: 3
  - PosDoc: 1
  - PhD: 1
- Tasks:
  - Analysis: muon neutrino disappearing physics, high energy neutrinos

Experiments: Minerva

- Institution: CBPF
  - Faculty: 1
  - Pos-Doc: 1
  - PhD: 2
- Tasks:
  - Detector calibration, track reconstruction

What ? : LVD activities

- Institution: UNICAMP
  - Faculty: 1
  - Ph.D: 1

- Tasks:
  - SN monitoring methods, event display, muon tagging, doped scintillator development
  - Analysis: SN astrophysics (methods)

Special remark: since 1990, probably the first experimental activity in neutrinos from a BR Institution

What ?: Auger activities

- Institutes: CBPF, USP-SC, UNICAMP, USP, UEFS, UFBA, UFABC, UFRJ, UFF
  - Faculty: 18
  - Pos-Docs: 4
  - Ph.D: 5
- Tasks:
  - Surface detector performance studies, maintenance and trigger
  - Analyses: energy spectrum, anisotropy, galactic and extra-galactic magnetic fields, cosmic ray composition, solar physics
  - Co-task leader do Large Scale Anisotropy
  - Co-task leader do SD event selection, aperture and trigger
  - Collaboration Board chair
  - Member of the Publication Committee
  - Member of the Conference Committee
  - Member of Editorial Board

Experiments: Neutrinos-ANGRA

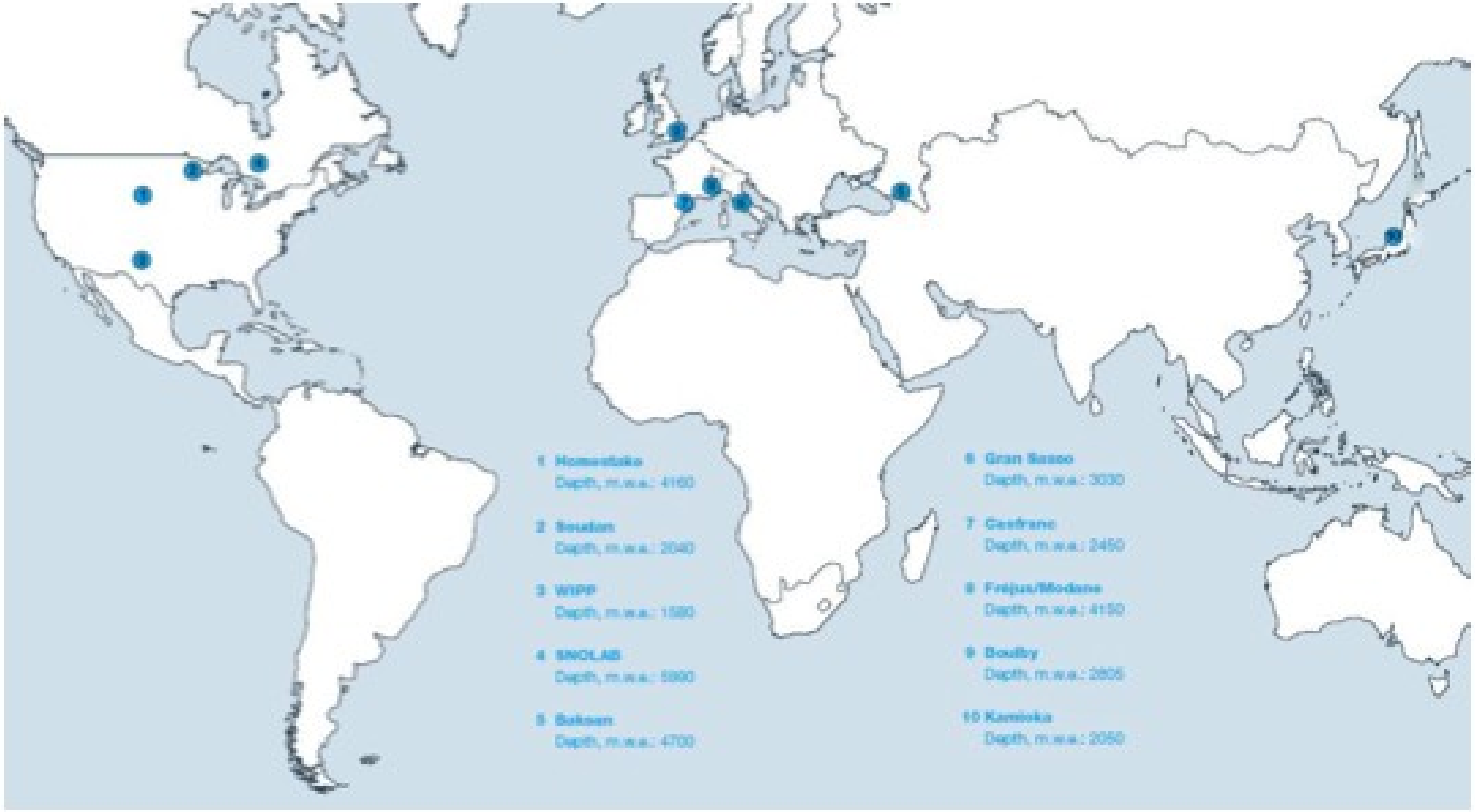
Neutrinos & Non-proliferation

IAEA.org
International Atomic Energy Agency

- ~ 438 reactors worldwide:
  The International Atomic Energy Agency - IAEA inspects nuclear installations under safeguards
- ~200kg plutonium produced in each fuel cycle (~ 1.5 years)
  ~90 tons of Plutonium produced every year worldwide
- IAEA is the verification authority of the Non Proliferation Treaty (NPT). IAEA has to keep track of all this material.

Future Perspectives: ANDES

Underground Laboratories



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