International Centre for Theoretical Physics South American Institute for Fundamental Research
ICTP SAIFR

II ICTP-SAIFR LATIN AMERICAN STRATEGY FORUM FOR RESEARCH INFRASTRUCTURE: AN OPEN SYMPOSIUM FOR HECAP

NEUTRINO PHYSICS WG REPORT

LASF4RI PREPARATORY GROUP

H. Yepes-Ramirez, J. Molina, A. Aranda

July 6-10, 2020
(by videoconference)

OUTLINE

1. WHITE PAPERS SUBMITTED.
2. NEUTRINO PHYSICS SESSION IN THIS SYMPOSIUM.
3. THE GLOBAL NEUTRINO PHYSICS CONTEXT AND CHALLENGES.
4. CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY (LATINAMERICA).
5. SUMMARY (IDENTIFIED).
6. DISCUSSION AND RECOMMENDATIONS (NEUTRINO PHYSICS WG).

WHITE PAPERS SUBMITTED

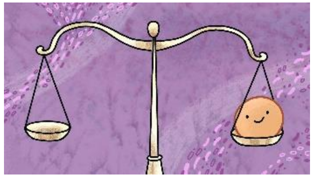
You're out there somewhere neutrino physicists ... and we'll find you !

NUMBER OF WHITE PAPERS FOR NEUTRINO PHYSICS PER COUNTRY

Country	Experimental [Exp]	Theory [The]	Total [Exp+The]
Argentina	3	0	3
Colombia	2	1	3
Ecuador	1	0	1
Brazil	6	1	7
Peru	1	0	1
		Total	15

- Total countries in Latinamerica: 20
- Latinamerica countries represented in LASF4RI (neutrinos): 5+1+1+1
- Ratio (representation): 0.4 (40%)

- Total neutrino white papers submitted to LASF4RI: 15
- Total of experimental white papers: 13 (86.6%)
- Total of theory white papers: 2 (13.3%)



WHITE PAPERS SUBMITTED

The ANDES Deep Underground Laboratory

Thematic areas:

- Neutrino Physics -
- Dark Matter -
- Astroparticle Physics -

Contact person: X. Bertou (bertou@cab.cnea.gov.ar)
International coordinator of the ANDES CLAF Unit

Dark Matter and Neutrino Physics

Contribution from Buenos Aires to the Latin American Strategy Forum for Research Infrastructure

Short baseline neutrino experiment in nuclear reactors in Argentina

Contribution to the Latin American Strategy Forum for Research Infrastructure

Draft version

Thematic areas: Neutrino Physics, Beyond Standard Model, Instrumentation and Computing

Primary authors: Guillermo Fernandez Moroni[1], Dario Rodrigues F. Maltez[2,3], Miguel Sofo Haro[4], Carla Bonifazi[5,6], Ivan Sidelnik[3,4], Jeronimo Blostein[3,4], Pedro Machado[7], Gustavo Cancelo[7], Fernando Chierchie[1], Federico Izraelevitch[3,8], Leandro Stefanazzi[1]

[1] Instituto de Investigaciones en Ingeniería Eléctrica "Alfredo Desages", Bahía Blanca, Argentina.
[2] Departamento de Física, UBA, Argentina
[3] Consejo Nacional de Investigaciones Cientificas y Tecnicas, Argentina.
[4] Instituto Balseiro - Centro Atómico Bariloche, UNCUYO-CNEA, Argentina.
[5] Instituto de Física - Universidade Federal do Rio de Janeiro, Brazil.
[6] International Center for Advanced Studies, UNSAM, Argentina.
[7] Fermilab, USA.
[8] Dan Beninson, UnSam, Argentina.

Contact persons:

Dr. Guillermo Fernandez Moroni, email: gfmoroni@fnal.gov
Dr. Dario P. Rodrigues F. Maltez, email: rodriguesfm@df.uba.ar

Colombian Network on High Energy Physics Input on Experimental HEP

Colombian Network on High Energy Physics Input on Theoretical HEP

DUNE IN THE CONTEXT OF LAS4RI. THE COLOMBIAN CASE

Thematic Areas

Neutrino physics, Instrumentation and computing and Beyond the Standard Model physics.

Primary Authors

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Contact Person

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Ecuadorian HECAP Groups Input to the Latin American Strategy Forum for Research Infrastructure (LASF4RI)

Thematic Area: Other (National road map)

Edgar Carrera*[1] and H. Yepes-Ramirez[2]

[1]Physics Department, Universidad San Francisco de Quito, Quito-Ecuador.
[2]Yachay Tech University - School of Physical Sciences and Nanotechnology, Hacienda San José S/N y Proyecto Yachay, 100119 Urcuquí, Ecuador.

The Giant Radio Array for Neutrino Detection (GRAND)

Primary authors: Rafael Alves Batista, Rogerio Menezes de Almeida, João Torres de Mello Neto, Bruno Lago, Márcio Müller

Co-authors: Jaime Alvarez-Muñiz, Aswathi Balagopal V., Julien Bolmont, Mauricio Bustamante, Washington Carvalho Jr., Didier Charrier, Ling-Mei Cheng, Ismaël Cognard, Zigao Dai, Valentin Decoene, Sijbrand De Jong, Peter B. Denton, Krijn D. De Vries, Ralph Engel, Ke Fang, Stefano Gabici, QuanBu Gou, Junhua Gu, Claire Guépin, Li Guo, Rene Habraken, Andreas Haungs, Hongbo Hu, Yan Huang, Kumiko Kotera, Sandra Le Coz, Jean-Philippe Lenain, KuanJun Li, Ruoyu Liu, Olivier Martineau-Huynh, Miguel Mostafá, Fabrice Mottez, Jean Mouette, Kohta Murase, Valentin Niess, Foteini Oikonomou, Tanguy Pierog, Simon Prunet, Xiangli Qian, Bo Qin, Markus Roth, Frank G. Schröder, Fabian Schüssler, Cyril Tasse, Charles Timmermans, Matias Tueros, Xiangyu Wang, Xiangping Wu, Lili Yang, Philippe Zarka, Andreas Zech, B. Theodore Zhang, Jianli Zhang, Pengfei Zhang, Yi Zhang, Qian Zheng, Anne Zilles

Coherent Neutrino-Nucleus Scattering Experiment (CONNIE)

Areas: Neutrino physics, Instrumentation

Primary authors: CONNIE collaboration (list of interested scientists later in the text)

Contact person: Irina Nasteva (irina@if.ufrj.br)

Hyper-Kamiokande: Possible Contributions from Latin America

Thematic Areas: Neutrino Physics, Beyond Standard Model, Astroparticle Physics

Arman Esmaili and Hiroshi Nunokawa[1]

Pontifícia Universidade Católica do Rio de Janeiro, 22452-970, Rio de Janeiro, Brazil

Latin American Contribution to JUNO

Angel Abusleme[1], Giancarlo Troni[1], Hiroshi Nunokawa[2], and Pietro Chimenti * [3]

[1]Pontificia Universidad Católica de Chile, Santiago, Chile
[2]Pontifícia Universidade Catolica do Rio de Janeiro, Rio, Brazil
[3]Universidade Estadual de Londrina, Londrina, Brazil

Brazilian Community Report on Neutrino Physics

A. A. Machado[1], E. Segreto[1], O. L. G. Peres[1], M. M. Guzzo[1], P. C. de Holanda[1], E. Kemp[1], L. Paulucci[3], C. A. Moura[3], F. Marinho[4], V. L. Pimentel[2], M. C. Q. Bazetto[2], C. Bonifazi[5], H. da Motta[5], J. dos Anjos[5], H. Lima[5], G. Valdiviesso[6], R. A. Gomes[7], J. Torres[8], A. Barros[9], A. Lisboa[9], L. Hirsch[9], M. Antoniassi[9], M. Ribas[9], M. Adames[9], F. Ganacim[9], R. N/"obrega[10], and D. Gratieri[11]

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[10]Universidade Federal de Juiz de Fora, 36036-900, Juiz de Fora, MG, Brazil
[11]Universidade Federal Fluminense, 27213-145, Volta Redonda, RJ, Brazil

Brazilian Report on Safeguards Application of Reactor Neutrinos

[1]E. Kemp*, [2]J. A. M. Alfonzo, [3]J. C. Anjos, [3]G. Cernicchiaro, [4]P. Chimenti, [5]I. A. Costa, [2]P. C. M. A. Farias, [5]A. Fernandes Jr., [6]G. P. Guedes, [1]L. F. G. Gonzalez, [3]H. P. Lima Jr., [5]A. S. Lopes Jr., [2]J. Marcelo, [5]M. L. Migliorini, [5]R. A. Nóbrega, [2]I. M. Pepe, [2]D. B. S. Ribeiro, [1]W. V. Santos, [2]D. M. Souza, [2]L. R. Teixeira, and [4]A. M. Trzeciak

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[5]*Universidade Federal de Juiz de Fora, Juiz de Fora, MG, Brazil and*
[6]*Universidade Estadual de Feira de Santana, Feira de Santana, BA, Brazil*

White paper on Nuclear Science in Brazil

Contribution to the Latin American Strategy Forum for Research Infrastructure

Alinka Lépine-Szily for

INCT-FNA

An Andean Deep-Valley Detector for High-Energy Tau Neutrinos

Thematic Areas: astroparticle physics, neutrino physics, astronomy & astrophysics

Authors: Andres Romero-Wolf[1,†], Jaime Alvarez-Muñiz[2], Washington R. Carvalho Jr.[3], Austin Cummings[4], Harm Schoorlemmer[5], Stephanie Wissel[6], Enrique Zas[2], Carlos Argüelles[7], Horacio Barreda (VRI)[8], Jose Bazo[9], Jose Bellido[10], Mauricio Bustamante[11], Alberto Gago[9], Rolando Perca[8]

[1]Jet Propulsion Laboratory, California Institute of Technology, [2]Universidade Santiago de Compostela, [3]Universidade de São Paulo, [4]Gran Sasso Science Institute, [5]Max-Planck-Institut für Kernphysik, [6]California Polytechnic State University, San Luis Obispo, [7]Massachussets Institute of Technology, [8]Universidad Nacional San Agustin de Arequipa, Peru, [9]Pontifica Universidad Catolica del Peru, [10]University of Adelaide, Australia, [11]Niels Bohr Institute, University of Copenhagen

EC: undeclared but "adjustable"

BR: declared but do not "adjustable"

NEUTRINO PHYSICS SESSION IN THIS SYMPOSIUM

Tuesday July 7 Chair: R. Rosenfeld

10:30-11:00 **Plenary II: Neutrinos (Yepes)**

11:00-11:10 Hyper-Kamiokande: Possible Contributions from Latin America, H. Nunokawa
11:10-11:20 An Andean Deep-Valley Detector for High-Energy Tau Neutrinos, A. Romero-Wolf.

11:20-11:30 Coherent Neutrino-Nucleus Scattering Experiment (CONNIE), I.Nasteva.

11:30-11:40 DUNE in the Report on LASF4RI: the Colombian case, D. Moreno.

11:40-11:50 Latin America Contribution to JUNO, P. Chimenti.

11:50-12:00 Short baseline neutrino experiment in nuclear reactors in Argentina, G. Moroni.

12:00-12:10 The ANDES Deep Underground Laboratory, X. Bertou

12:10-12:20 Neutrino White Paper, E. Segreto.

12:20-13:05 Discussion

Ample time for a global-joint discussion at the end of the session ☺

THE GLOBAL NEUTRINO PHYSICS CONTEXT AND CHALLENGES

NEUTRINO PROPERTIES (BASICS):

CREDITS → JONATHAN LINK, CENTER FOR NEUTRINO PHYSICS, VIRGINIA TECH

Neutrino mixing is governed by the PMNS mixing matrix which relates the mass eigenstates to the flavor eigenstates:

Flavor Eigenstates

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

Mass Eigenstates

PMNS Mixing Matrix

In the simplest approximation, the probability that a neutrino, which started out as a ν_α, is detected as a ν_β is given by:

$$P(\nu_\alpha \to \nu_\beta) = \sin^2 2\theta \sin^2\left(\Delta m_{ij}^2 L/4E_\nu\right)^* \qquad \Delta m_{ij}^2 = m_i^2 - m_j^2$$

* This two neutrino approximation gives a serviceable representation of the data that we have so far, but going forward it will no longer be a sufficient.

THE GLOBAL NEUTRINO PHYSICS CONTEXT AND CHALLENGES

CREDITS → JONATHAN LINK, CENTER FOR NEUTRINO PHYSICS, VIRGINIA TECH

The PMNS mixing matrix is constructed as the product of three independent rotations (a unitary matrix with three mixing angles and one phase):

$$\mathrm{U}_{\mathrm{PMNS}} = \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}}_{\text{Atmospheric}} \underbrace{\begin{pmatrix} \cos\theta_{13} & 0 & e^{i\delta}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix}}_{\text{Reactor}} \underbrace{\begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{Solar}}$$

Such that:

$$\mathrm{U}_{\mathrm{PMNS}} = \begin{pmatrix} c_{12}c_{13} & s_{12}c_{13} & e^{i\delta}s_{13} \\ -s_{12}c_{23} - e^{i\delta}s_{13}c_{12}s_{23} & c_{12}c_{23} - e^{i\delta}s_{13}s_{12}s_{23} & s_{23}c_{13} \\ s_{12}s_{23} - e^{i\delta}s_{13}c_{12}c_{23} & -c_{12}s_{23} - e^{i\delta}s_{13}s_{12}c_{23} & c_{23}c_{13} \end{pmatrix}$$

The three mixing angles have all been measured, but the CP violating phase, δ, is still unknown

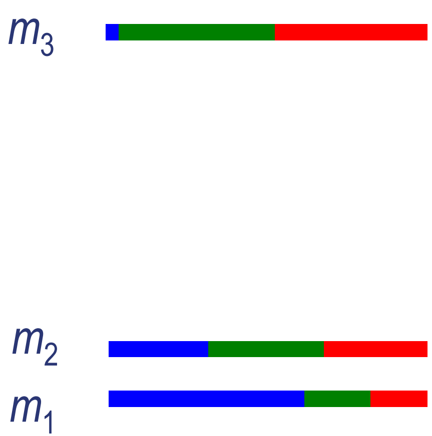
THE GLOBAL NEUTRINO PHYSICS CONTEXT AND CHALLENGES

CREDITS → JONATHAN LINK, CENTER FOR NEUTRINO PHYSICS, VIRGINIA TECH

In addition to the four mixing matrix parameters, there are two independent Δm^2 scales (Δm^2_{21} and Δm^2_{32})

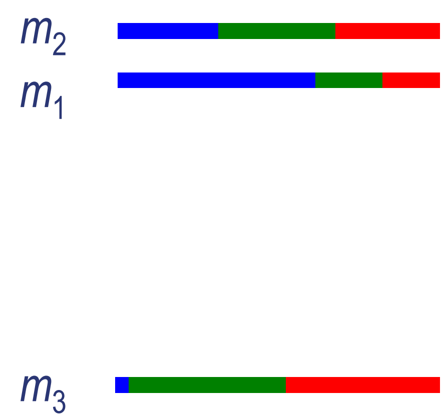
$$\Delta m^2_{31} = m^2_{32} + m^2_{21}$$

$$\Delta m^2_{31} = m^2_{32} - m^2_{21}$$



Normal Hierarchy

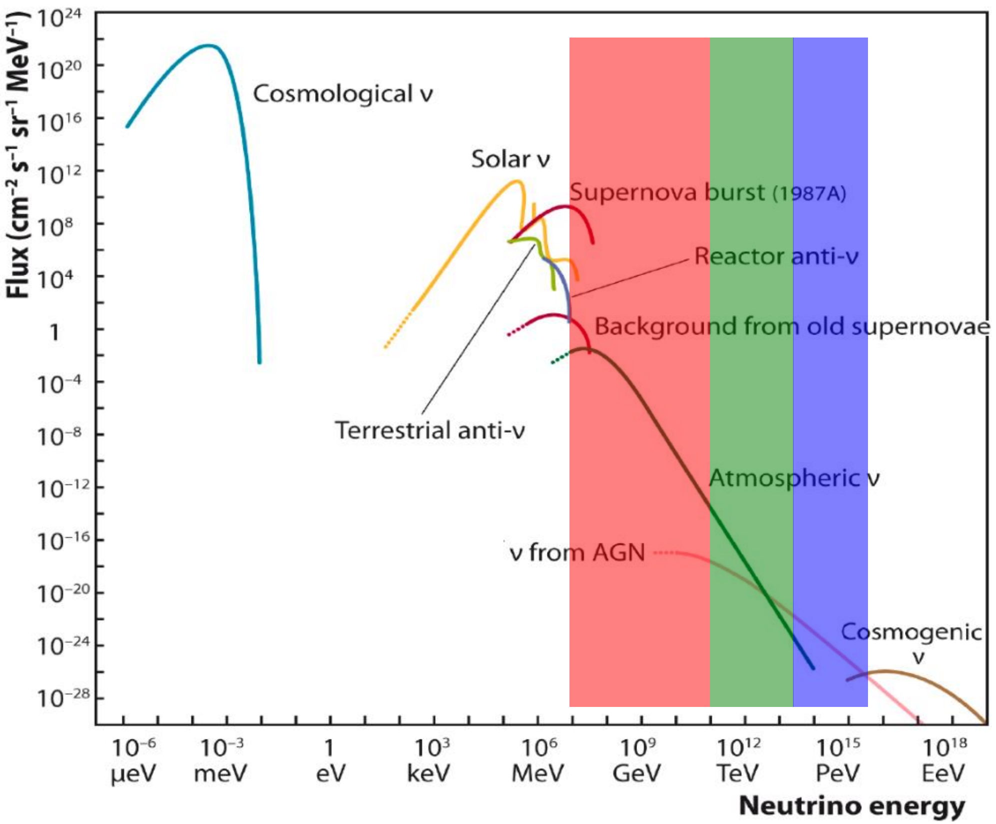
Or



Inverted Hierarchy

In the Inverted Hierarchy both Δm^2_{31} and Δm^2_{32} are negative.

THE GLOBAL NEUTRINO PHYSICS CONTEXT AND CHALLENGES



NEUTRINO SOURCES (BASICS):

NEUTRINO ENERGIES

~ MeV – 100 GeV
NMH with atmospheric flux

100 GeV - 30 TeV
Several galactic (gamma) sources

30 TeV – 3 PeV
IceCube signal (astrophysical flux)

Other fluxes and energies?

ν_{atm} oscillation experiments | **ν-astronomy (+astrophysics)** ← PHYSICS

higher densities | **larger volumes** ← DETECTOR REQUIREMENTS

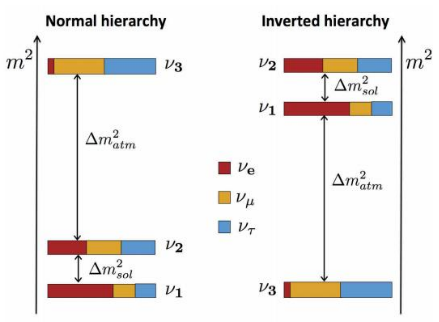
CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

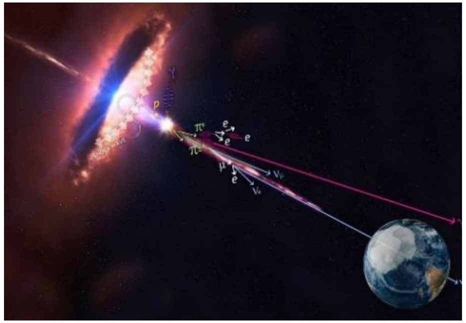
WHAT IS THE BEST WAY FOR ADDRESSING THIS PROPERLY?

1. **Neutrino Science open <u>questions</u>** → Phenomenology.

Two Approaches

Neutrino Properties	**Neutrino as a Probe**
Hierarchy and Masses of Neutrinos	Parton Distribution Function
Neutrino Oscillations	Precision Electroweak Physics
Nature of Neutrinos	Neutrino Astrophysics, etc.





- Neutrino Mass Hierarchy (NMH): Normal or Inverted?
- Is there CP-violation in neutrino mixing?
- Are neutrinos their own antiparticle? (Dirac Vs Majorana)
- How many neutrinos are there? (Sterile neutrinos?)
- What is the absolute neutrino mass scale?
- Astrophysical neutrinos?

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

WHAT IS THE BEST WAY FOR ADDRESSING THIS PROPERLY?

2. Neutrino Science open <u>solutions</u> → Experiments (running, CDR's, TDRs).

Neutrino Oscillations:
NMH, CP-violation, Sterile Neutrinos

Neutrinoless Double Beta Decay: [*]
Dirac Vs Majorana, NMH, Absolute Neutrino Mass

Direct Mass Measurements: [*]
Absolute Neutrino Mass

Neutrino Telescopes:
Astrophysical Neutrinos

Neutrino Cross Section:
Natural and artificial neutrino factories

JUNO · DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT · NOvA · KM3NeT · Hyper-K

An Andean Deep-Valley Detector for High-Energy Tau Neutrinos

GRAND

CONνNIE

Small scale projects (no flagship large-scale)

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

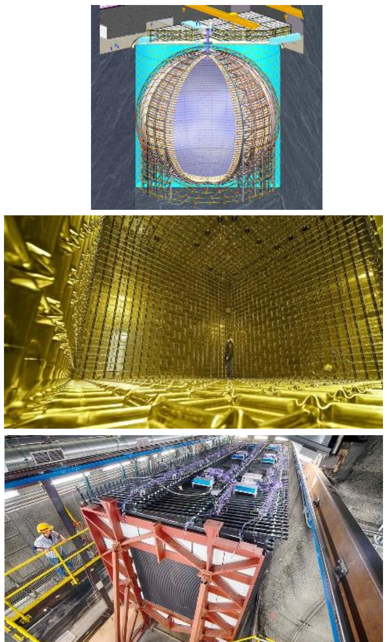
WHAT IS THE BEST WAY FOR ADDRESSING THIS PROPERLY?

3. **Neutrino Technology and Instrumentation** → Experimental techniques.

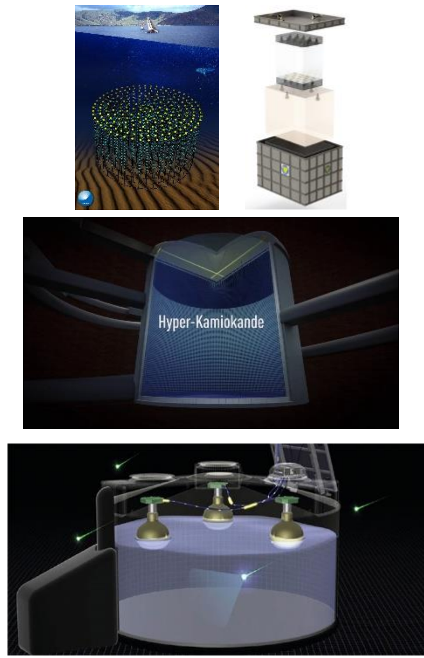
This Report

Neutrino Hunting by LA:

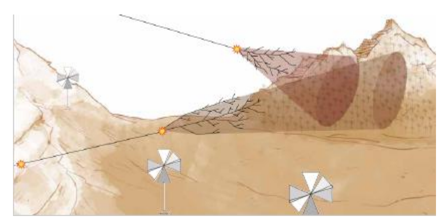
FOUR experimental techniques for addressing most of the scientific questions in Neutrino Science



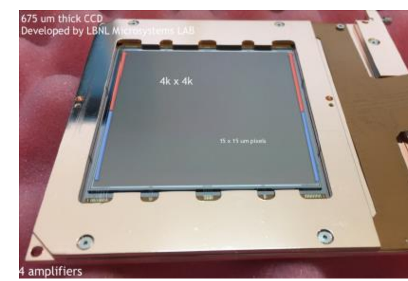
Scintillation and Hybrid Detectors



Water Cherenkov Detectors



Radio Cherenkov Detectors



Silicon Pixelated Detectors

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

WHAT IS THE BEST WAY FOR ADDRESSING THIS PROPERLY?

4. **Neutrino S&T coupling to global strategies** → e.g., LA – US – EU.

LASF4RI

Latin American Strategy Forum for Research Infrastructure

Developing a strategy to strengthen Latin American Scientific Collaborations and their impact.

1. Accelerators and Detectors: A. Sanchez, L de Paula, H. Aihara
2. Astroparticles: M. Subieta, F. Sanchez, J.C. D'Olivo
3. Instrumentation and Computing: H. Wahlberg, R. Camacho
4. Electroweak Physics (including Higgs Physics, CP violation, Flavor Physics): E. Carrera, M. Cambiaso, M. Mulders
5. Neutrino Physics: A. Aranda, J. Molina, H. Yepes
6. Strong Interactions: G. Herrera, A. Gago,
7. Beyond the Standard Model: R. Rosenfeld, A. Zerwekh
8. Dark Matter: M. Carena, D. Restrepo
9. Cosmology : Thiago S. Goncalves, D. Lopez, M. Soares, L. Boubeker

https://lasf4ri.org/

Latin America (LA)

SnowMass2021

Snowmass Frontiers

- ENERGY FRONTIER
- NEUTRINO PHYSICS FRONTIER
- RARE PROCESSES AND PRECISION
- COSMIC FRONTIER
- THEORY FRONTIER
- ACCELERATOR FRONTIER
- INSTRUMENTATION FRONTIER
- COMPUTATIONAL FRONTIER
- UNDERGROUND FACILITIES
- COMMUNITY ENGAGEMENT FRONTIER

Topical groups

- NF01: Neutrino Oscillations
- NF02: Sterile Neutrinos
- NF03: BSM
- NF04: Neutrinos from natural sources
- NF05: Neutrino properties
- NF06: Neutrino Interaction Cross Sections
  - letters
    - inviteloi
- NF07: Applications
- NF08: Theory of Neutrino Physics
- NF09: Artificial Neutrino Sources
- NF10: Neutrino Detectors

https://snowmass21.org/start

United States (US)

European Strategy Update

The highest scientific priorities identified in this update are the study of the Higgs boson - a unique particle that raises scientific profound questions about the fundamental laws of nature - and the exploration of the high-energy frontier. These are two crucial and complementary ways to address the open questions in particle physics.

The successful completion of the High-Luminosity LHC in the coming decade, for which upgrade work is currently in progress at CERN, should remain the focal point of European particle physics. The strategy emphasises the importance of ramping up research and development (R&D) for advanced accelerator, detector and computing technologies, as a necessary prerequisite for all future projects. Delivering the near and long-term future research programme envisaged in this Strategy update requires both focused and transformational R&D, which also has many potential benefits to society.

The document also highlights the need to pursue an electron-positron collider acting as a "Higgs factory" as the highest-priority facility after the Large Hadron Collider (LHC). The Higgs boson was discovered at CERN in 2012 by scientists working on the LHC, and is expected to be a powerful tool to look for physics beyond the Standard Model. Such a machine would produce copious amounts of Higgs bosons in a very clean environment, would make dramatic progress in mapping the diverse interactions of the Higgs boson with other particles and would form an essential part of a rich research programme, allowing measurements of extremely high precision. Operation of this future collider at CERN could begin within a timescale of less than 10 years after the full exploitation of the High-Luminosity LHC, which is expected to complete operations in 2038.

The exploration of significantly higher energies than the LHC will allow new discoveries to be made and the answers to existing mysteries, such as the nature of dark matter, to potentially be found. In acknowledgement of the fact that the particle physics community is ready to prepare for the next step towards even higher energies and smaller scales, another significant recommendation of the Strategy is that Europe, in collaboration with the worldwide community, should undertake a technical and financial feasibility study for a next-generation hadron collider at the highest achievable energy, with an electron-positron collider as a possible first stage.

It is further recommended that Europe continue to support neutrino projects in Japan and the US. Cooperation with neighbouring fields is also important, such as astroparticle and nuclear physics, as well as continued collaboration with non-European countries.

https://home.cern/news/news/physics/particle-physicists-update-strategy-future-field-europe

European Union (EU)

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

THE BEST WAY FOR ADDRESSING THIS SHOULD FOLLOW, INTEGRALLY:

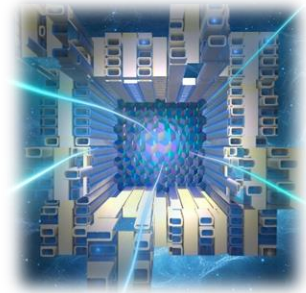
Technological Applications. Society, Human Capital and Environment Impact:

- Accelerators.
- Detectors.
- Computing.
- Open Science.
- Partnerships.

Neutrino S&T coupling to global strategies

Neutrino Science open questions

Neutrino Science open solutions



Neutrino Technology and Instrumentation

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

LA SCIENTIFIC AND TECHNICAL IDENTIFIED CAPABILITIES:

Scintillation and Hybrid Detectors

- Scintillation Detectors → Noble elements: gas, liquid, solid, dual phase.
- Hybrid Detectors → e.g., Scintillation + Cherenkov, as in NOνA.

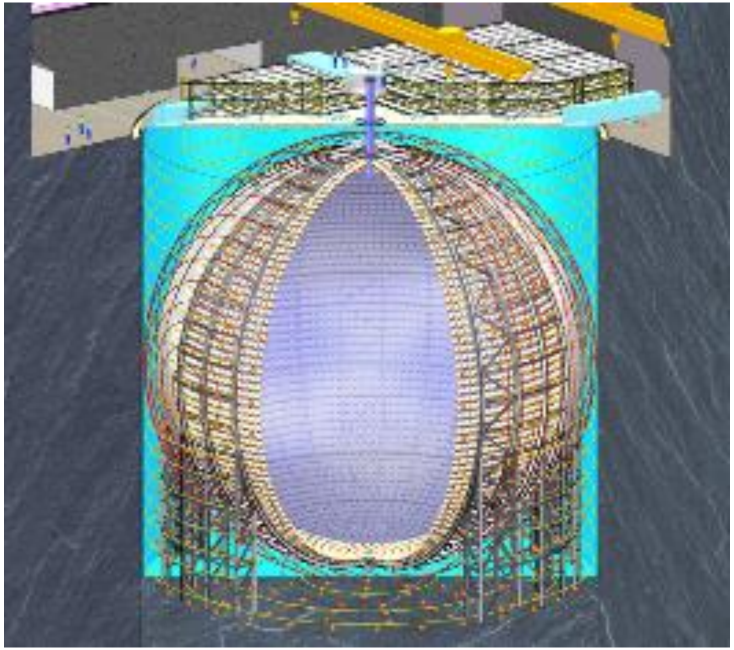
The light/charge readout as result of the light/charge response of the detection medium (LAr, GXe, C_xH_y compounds, sea water, purified water, ice, salt, air, etc.), is performed by a synchronized performance of SiPMs, PMTs, WLS, electronics, etc.

JUNO – Jiangmen Underground Neutrino Observatory:

- Underground Liquid Scintillator (Linear Alkyl Benzen), ~ 20 kton of active mass.
- Located 53 km away from two of the ten nuclear reactor units of the Yangjiang (4 cores) and Taishan (6 cores) nuclear facilities (35.8 MW thermal power in total) in Southern China (Kaiping, Jiangmen).

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

JUNO Status. Yue Meng. Neutrino 2020. June 22 - July 02.



Physics program (in a nutshell):

- NMH determination.
- Precision of oscillation parameters (θ_{12} and Δm^2_{21}, solar).
- Supernova neutrinos.
- Solar neutrinos.
- Geo neutrinos.
- BSM processes: proton decay.

LA contributions: aimed to provide a better control on the systematic uncertainties on energy measurements.

Hardware:
- sPMT (~25k 3-inches small PMTs) subsystem.
- Under Water Boxes "UWB".
- High-Voltage Splitters "HVS".

Software :
- ABC board simulation.
- Data analysis.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

DUNE: Progress and Physics. Mooney, Michael. Neutrino 2020. June 22 - July 02.

DUNE – Deep Underground Neutrino Experiment:

- 1300 km baseline (FERMILAB-to-SURF).
- Large (70 kton) LAr TPC Far Detector (FD) 1.5 km underground.
- Near Detector (ND) with LAr component.

Physics program (in a nutshell):

- Oscillations ($\nu_\mu/\bar{\nu}_\mu$ disappearance, $\nu_e/\bar{\nu}_e$ appearance): δ_{CP}, θ_{23} , θ_{13} and NMO.
- Supernova neutrinos
- BSM processes: baryon number violation, NSI, etc.

LA contributions: aimed to PDS, MC and SM-BSM.

Hardware:

- PDS of the DUNE FD (X-ARAPUCA).
- Readout electronics (DAPHNE) for SiPM.

Software :

MC simulations for DUNE and SBND (light production and propagation).

Physics :

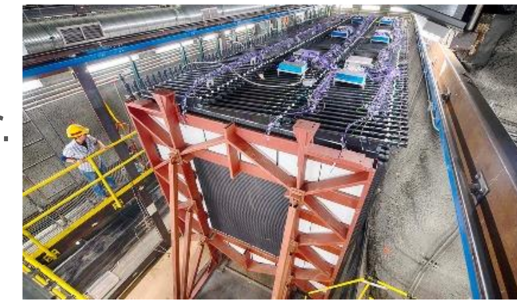
BSM, NSI, Dark Matter and Supernova Neutrinos.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

Cross-section measurements with NOvA. Cremonesi, Linda. Neutrino 2020. June 22 - July 02.

NOVA – NuMI Off-axis ν_e Appearance:

- 810 km baseline (FERMILAB-to-Minnesota).
- 300 metric-ton ND (1 km from NuMI beam) and 14 metric-kiloton FD.
- Detectors made up of 344k cells of plastic PVC filled with liquid scintillator.



Physics program (in a nutshell):

- Cross-sections in neutrino or antineutrino-mode (inclusive and exclusive channels).
- Oscillations ($\nu_\mu \rightarrow \nu_e$): detectors provide excellent imaging of both ν_μ and ν_e CC events: NMH, δ_{CP}, and precise determination of θ_{23} and Δm^2_{32}.

LA contributions: aimed to Cross-sections and Oscillations data.

Physics:

Data analysis and reduction of uncertainties: axial masses, final state interactions, random phase approximation and the 2p2h model.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

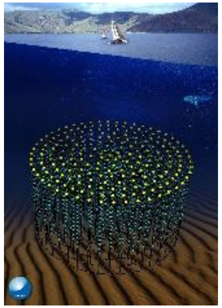
LA SCIENTIFIC AND TECHNICAL IDENTIFIED CAPABILITIES:

Water Cherenkov Detectors

Neutrinos in the Mediterranean Sea. Samtleben, Dorothea. Neutrino 2020. June 22 - July 02.

KM3NeT – KM^3 Neutrino Telescope:

- Multidisciplinary Neutrino Observatory at the abyss of the Mediterranean Sea.
- Two locations (FR, IT), two detector layouts, same technology: ARCA (sparser, Astrophysical Neutrinos) and ORCA (denser, Atmospheric Neutrinos).
- Ongoing scaling: 31 PMTs / DOM, 18 DOMs / DU, 2x115 – 1x115 DUs.



Physics program (in a nutshell):

- Discovery and subsequent study of medium/high-energy cosmic neutrino sources.
- NMH, Oscillation Parameters (θ_{23} and Δm^2_{32}), δ_{CP}, tau-neutrino appearance, BSM, NSI, tomography.

LA contributions: aimed to calibration and physics data analysis (astrophysical, atmospherics).

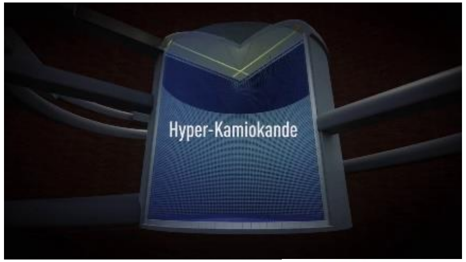
Calibration: positioning (digital compasses, acoustic positioning system), time/optical (PMTs, light sources).
Physics: sources (TXS 0506+056 Blazar), oscillations (Neutrino Tomography).

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

Hyper-Kamiokande. Ishitsuka, Masaki. Neutrino 2020. June 22 - July 02.

Hyper KamiokaNDE – Hyper Kamioka Nucleon Decay Experiment:

- Evolution of Super-Kamiokande (discovery of neutrino oscillations) + JPARC.
- Well established technology and atmospheric / solar / LBL searches.
- Under construction: running starting at 2027.



Physics program (in a nutshell):

- Extended search for proton decay (Super Kamiokande world best limits).
- Neutrino astrophysics (Sun, Supernovaes).
- Precision of oscillation parameters (all mixing angles and Δm^2_s, θ_{23} and Δm^2_{32}), δ_{CP}, NMH, BSM.

LA contributions: aimed to theoretical contributions

Physics:

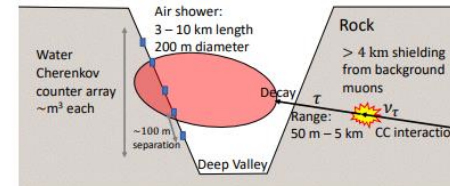
Neutrino oscillation phenomenology and astrophysics, BSM, sterile, NSI, neutrino decay scenarios.

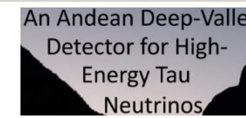
CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

An Andean Deep-Valley Detector for High-Energy Tau Neutrinos. Andres Romero-Wolf et al. https://arxiv.org/abs/2002.06475.

An Andean Deep-Valley Detector for HighEnergy Tau Neutrinos (TAMBO):

- Innovative concept for Tau Neutrino astronomy based on EAS.
- Array of small Detectors (~22k), each of ~1 m^3 volume, distanced by ~100 m on the mountain slope. Well established technology.
- Increased sensitivity: still angular uncertainty for flat ground arrays is rather large. Challenge: separation between components of the two cascades.





Physics program (in a nutshell):

- Determine whether high-energy neutrino sources continue to accelerate particles above 10 PeV.
- Characterize the astrophysical sources of the ν-flux between 1-10 PeV by measuring the τ component.
- Constrain the particle acceleration potential of point source transients observed with MM probes.

LA contributions: aimed to construction, subsequent roles do not defined yet

Hardware and Software: construction and commissioning. Physics: TBD.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

Neutrinos Angra experiment: commissioning and first operational measurements. H.P. Lima Jr et al. 2019 JINST 14 P06010.

ν-Angra Experiment – Neutrinos Angra Experiment:

- A remarkable application of neutrino technology in the region: practical roles for neutrinos in nuclear security and safeguards systems (IAEA roadmap, STR-361).
- Detector (~1 ton) located in the Angra dos Reis nuclear power plant (as CONNIE), aimed to use electron antineutrinos flux (β-decay) produced while burnout of the fuel to demonstrate the feasibility of monitoring the reactor dynamics. Distanced ~25 m from reactor's core.
- Reliability and cost-effective technology: (significantly lower if implemented in the operational budget of the plant).

Physics program (in a nutshell):

Antineutrino remote monitoring of reactors: reduces exposure and dose in the staff requiring for operation, maintenance, and inspection of the nuclear power plant (international standards).

LA contributions: aimed to non-proliferation and against nuclear threats

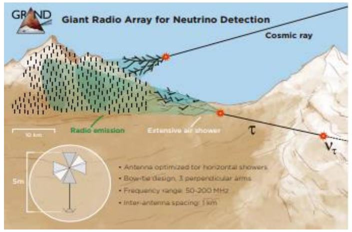
- Hardware: scaling and operating of prototypes.
- Physics: nuclear reactor monitoring.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

LA SCIENTIFIC AND TECHNICAL IDENTIFIED CAPABILITIES: Radio Cherenkov Detectors

GRAND, a Giant Radio Array for Neutrino Detection: Objectives, design and current status. Matias Tueros. EPJ Web of Conferences 216, 01006 (2019).

GRAND - Giant Radio Array for Neutrino Detection:



- Array of antennas for detection of radio emission from EAS triggered by cosmic-rays, gamma rays and neutrinos interactions with atmosphere.
- Under construction: GRANDProto300 - GRAND10k - GRAND200k.

Physics program (in a nutshell):

- GZK neutrinos, neutrino physics, EeV neutrino astronomy.
- UHE gamma rays, fast radio bursts, giant radio pulses, epoch of reionization, UHE cosmic rays.

LA contributions: aimed to calibration and optimization studies, computing and physics

- Calibration: signal processing techniques (improvement of signal-to-noise ratio, filters, wavelets).
- Computing: high performance computing.
- Physics: energy estimations of the primary from antennas data. Shower libraries. Cosmic ray physics.

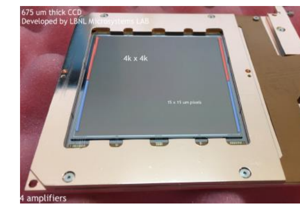
CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

LA SCIENTIFIC AND TECHNICAL IDENTIFIED CAPABILITIES:

Silicon Pixelated Detectors

Skipper-CCD and reactor neutrinos in Argentina. Guillermo Fernandez Moroni. COFI, Puerto Rico. February 5, 2020.

SENSEI – Sub-Electron Noise Skipper CCD Experimental Instrument:



- Dark Matter searches R&D via ultra-low threshold based on Skipper-CCD technology. Pioneering technology of FERMILAB known from the SENSEI experiments with Argentina's starring role.
- Under Planning: prototype expected to be built between 2020-2021.
- Reactor experiment: Atucha Nuclear Reactor (candidate). Detection array to be placed 12 m away the core and inside the dome.

Physics program (in a nutshell):

- Direct Dark Matter Searches in the MeV-GeV range and neutrino connection.
- Coherent neutrino-nucleus interaction cross sections.
- At low E: quantification of high intensity ν-fluxes while fuel burnout from a nuclear reactor. SBL Oscillations.

LA contributions: aimed to theoretical, computational and experimental/instrumentation contributions

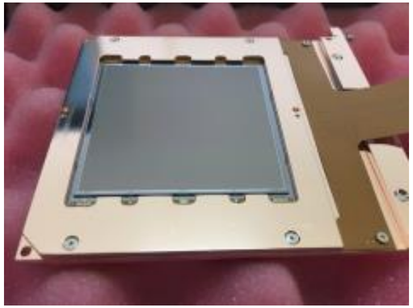
- Hardware: Skipper CCD and associated technology. Physics: Direct Dark Matter Searches. SBL. Reactor Monitoring.

CAPABILITIES ON NEUTRINO PHYSICS AND TECHNOLOGY

Exploring low-energy neutrino physics with the Coherent Neutrino Nucleus Interaction Experiment. Alexis Aguilar-Arevalo et al. Phys. Rev. D 100, 092005.

CONNIE – Coherent Neutrino-Nucleus Interaction Experiment:

- Sharing hut with ν-Angra experiment at Angra dos Reis Nuclear Power Plant.
- Also using CCD technology (low-noise fully depleted): 12 CCDs (~73 g).
- Already running since 2016, ~30 m away the core of Angra's 2 Nuclear Reactor.



Physics program (in a nutshell):

- Coherent neutral current neutrino-nucleus scattering cross sections.
- Limits for NSI from nuclear reactor antineutrinos (including sterile neutrinos searched from anomalies in reactor-based SBL experiments).
- Reactor monitoring.

LA contributions: aimed to hardware developments and physics.

Hardware: upgrades to Skipper-CCD and associated technology. Upgrade in active mass (~100 g).
Physics: coherent neutrino-nucleus interaction cross sections (SM prediction but never measured). Limits NSI. Nuclear reactor monitoring.

SUMMARY (IDENTIFIED)

Experiment	Scale	Capacity Building	R&D	Delivering Instrumentation	Multiple regional involvement
ANDES	Large	Yes	Yes	Yes	Yes
JUNO	Large	No	No	Yes	Yes
DUNE	Large	No	Yes	Yes	Yes
NOvA	Large	Yes	No	No	No
KM3NeT	Large	Yes	Yes	Yes	No
HYPER-K	Large	Yes	No	No	No
DEEP VALLEY	Large	No	Yes	Yes	Yes
Nu-ANGRA	Small	No	No	Yes	No
GRAND	Large	No	Yes	Yes	Yes
SENSEI	Small	Yes	Yes	Yes	No
CONNIE	Small	Yes	Yes	Yes	No
		[relative focus]		[including upgrades]	[already?]

DISCUSSION AND RECOMMENDATIONS

DISCUSSION ROUNDTABLE (only an “appetizer”!)

What are the main issues and needs of each of the projects in the most immediate future (~ 5 yrs)?

Can we develop more synergies in the region?

What are / should be the scientific priorities of the region for the next decade?

Which are the connections with neighboring fields?

Which areas could be strengthened per country?

How does our science contribute to knowledge and technology transfer?

How can we impact and benefit society?

DISCUSSION AND RECOMMENDATIONS

RECOMMENDATIONS FROM NEUTRINO PHYSICS WG:

(at closing of the event)