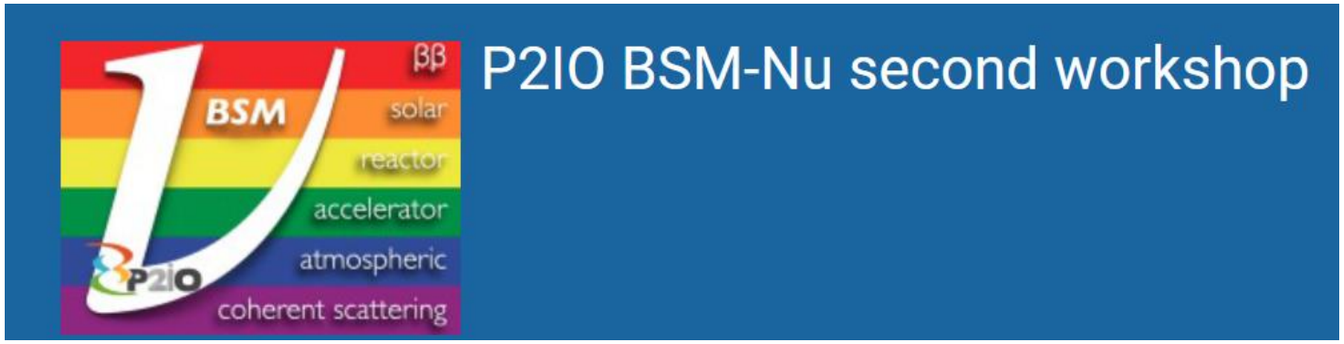


P2IO BSM-Nu second workshop

11 avril 2022
IJCLab (Orsay)

IJCLab
Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

Status of the BSM-Nu project

S. Bolognesi (IRFU) and A. Giuliani (IJCLab)

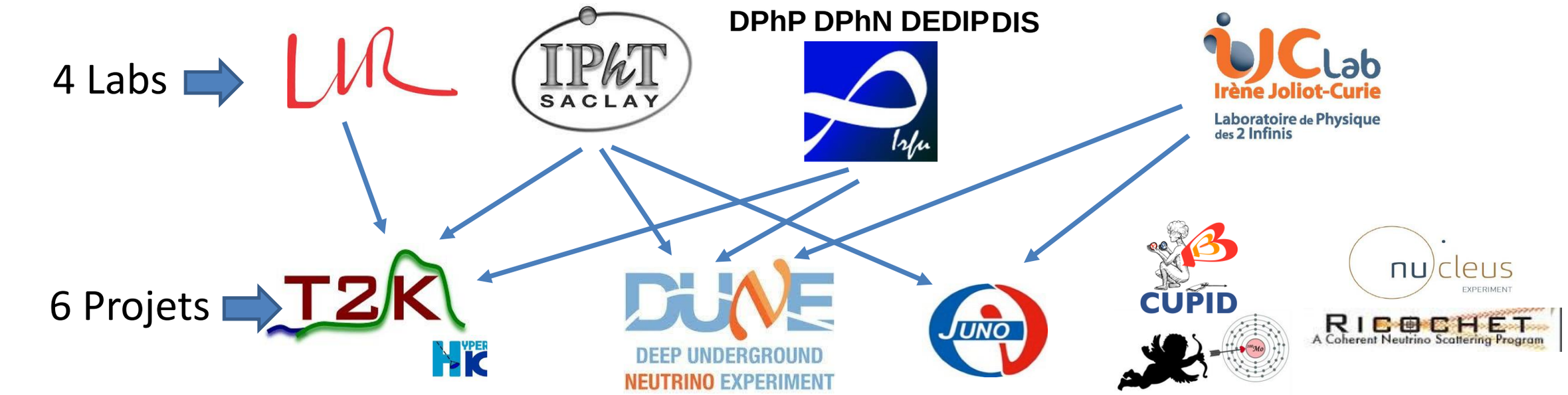
on behalf of the BSM-Nu group (IJCLab, IPhT, IRFU, LLR)

Overview of the BSM-Nu project (1)

4 Labs ➡

6 Projets ➡

DPhP DPhN DEDIP DIS

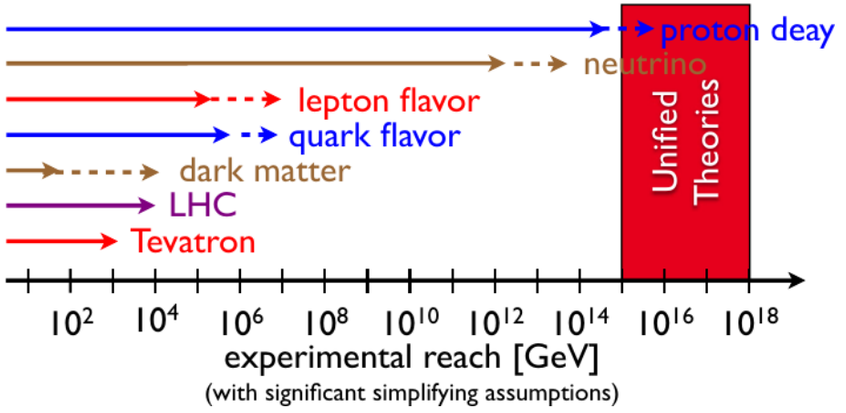


- **Neutrino oscillations** ~ interferometry effect sensitive to small effects induced by New Physics at very large energy scale

→ **Discovery of CP-violation** in the leptonic sector

→ **New Symmetry hidden behind the mass and flavour mixing**
PMNS unitarity? Mass Hierarchy in vacuum and matter?

H.Murayama @ Higgs workshop 2013(arXiv:1401.0966)



Overview of the BSM-Nu project (2)

4 Labs ➡ LPC, IPhT SACLAY, DPhP DPhN DEDIP DIS, Irfu, IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

6 Projets ➡ T2K, HYPER HK, DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT, JUNO, CUPID, nucleus EXPERIMENT, RICOCHET A Coherent Neutrino Scattering Program

→ *Franceso Vissani, this workshop*

❑ **Neutrino (Majorana!) mass** is necessarily the first order effect of BSM physics

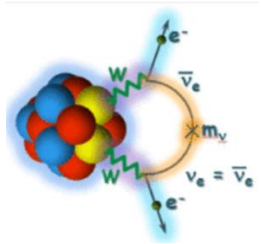
$$\mathcal{L} = \mathcal{L}_{SM} + \frac{1}{\Lambda_{UV}}\mathcal{L}_5 + \ \bullet\bullet\bullet \qquad \frac{1}{\Lambda_{UV}}\mathcal{L}_5 = \frac{v^2}{\Lambda_{UV}}\nu\nu.$$

The only possible 5th order operator according to fundamental symmetries

→ **Lepton number violation** (accidental symmetry in the SM)

→ **New fundamental type of particle** (the only fermion coincident with its anti-particle)

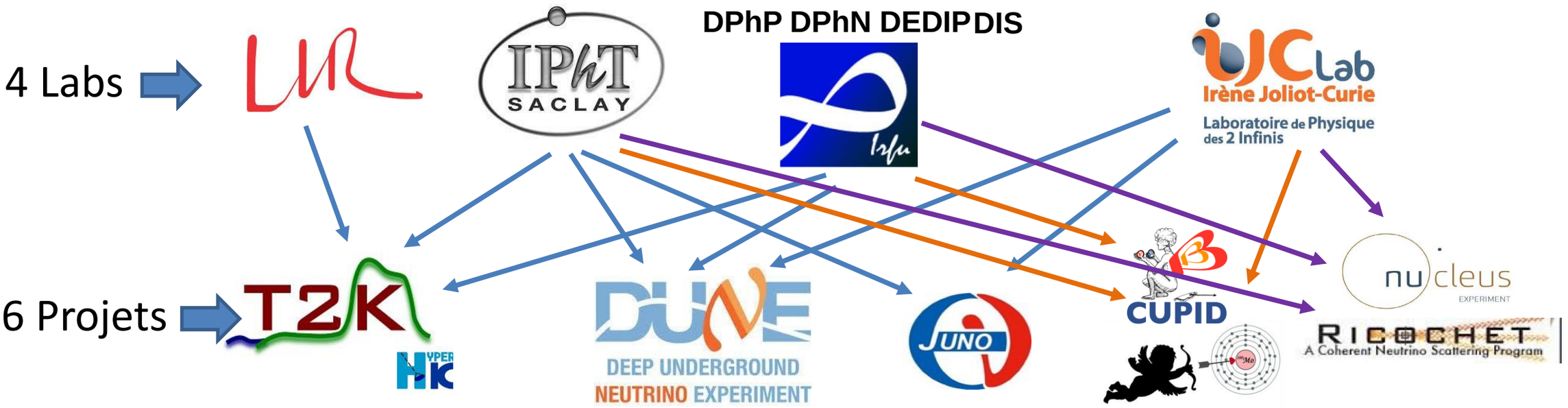
Search for $0\nu\beta\beta$ decay



Mass Hierarchy, from oscillation experiments, define the available “parameter space”

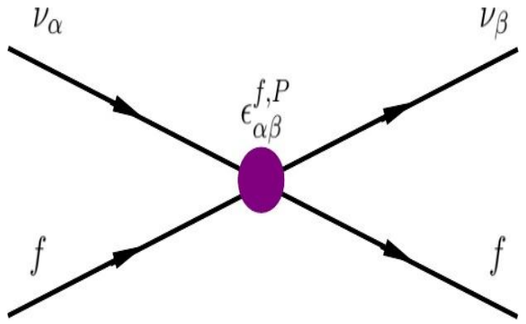
LNV + CP-violation are fundamental ingredients of Seesaw models able to give ‘naturally’ mass to ν and explain matter/antimetter asymmetry

Overview of the BSM-Nu project (3)



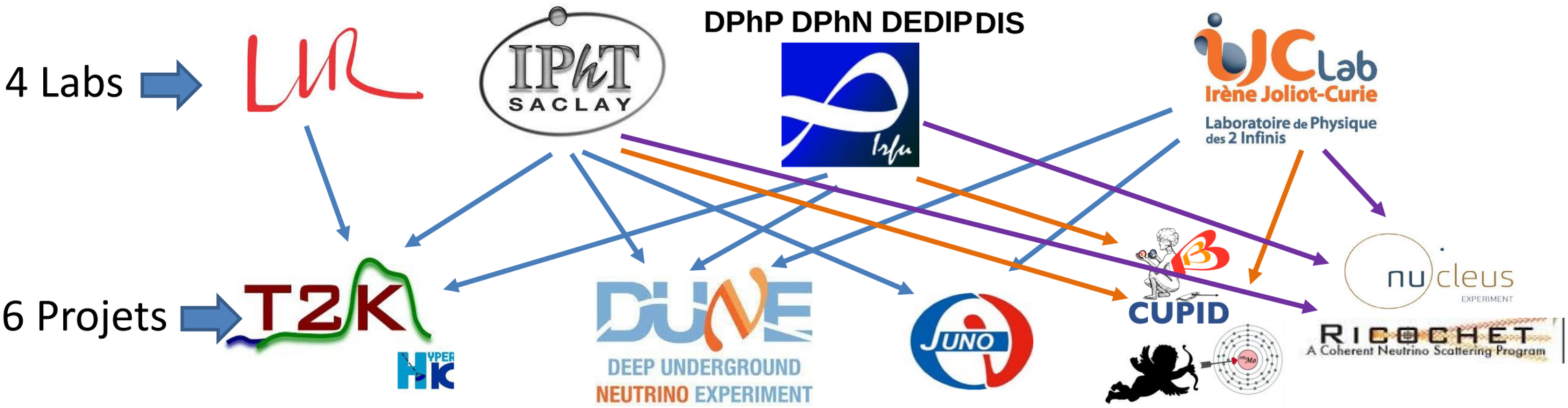
- Peculiar nature of ν and being in direct contact with Λ_{UV}: natural to expect **new type of interactions for neutrinos: Non Standard Interactions (NSI)**

  → **NSI** can be studied with **coherent elastic neutrino-nucleus scattering at reactors** and at long-baseline experiments (eg: additional source of CP-violation)



$$G_F \epsilon_{NSI} (\bar{\nu}\nu)(\bar{f}f)$$

Overview of the BSM-Nu project (4)



- **Development of highly capable detectors**
  - → New generation of near detectors for oscillation measurements:
    Time Projection Chambers (resistive Micromegas) and scintillating targets (“pixeled”)
  - → Cutting-edge technological developments in bolometers for $0\nu\beta\beta$ and coherent neutrino-scattering

Reports and meetings

Internal Meetings

- Internal meeting 13 Jan 2020
- Internal meeting 13 March 2020
- Internal meeting 22 May 2020
- Internal meeting 22 June 2020
- Internal meeting 29 Oct 2020
- Internal meeting 4 Dec 2020
- Internal meeting 19 July 2021
- Internal meeting 8 October 2021
- Internal meeting 11 February 2022

Meetings with P2IO CODIR

- Meeting with P2IO CODIR 17 Jan 2020
- Meeting with P2IO CODIR 3rd Nov 2020
- Meeting with P2IO CSI October 2021

Seminars

3 seminars in P2IO laboratories

- LLR - Jan2021 - **BSM physics with neutrinos** - Andrea De Gouvea
- IRFU - March 2022 (postponed) - **Low radioactivity bolometers development**
- IJCLab - April 2023 - **Nuclear physics for neutrino experiments**

Seminars at P2I days

- 23 Jan 2020 - **Baryo-leptogenesis**
  S. Lavignac
- 23 Jan 2020 - **Status and challenges of neutrino physics**
  S. Bolognesi
- 27 Nov 2020 - **The likely First Resolution of the Neutrino Mass Order**
  A. Cabrera

Workshops

Dates to be discussed (notably now the project end in 2024!): \

Fully online
~70 participants

- Feb 2021: P2IO BSMNu first workshop
- April 2022: P2IO BSMNu second workshop
- April 2023, May 2024, October 2025 (conclusions)

https://gitlab.in2p3.fr/bsm-nu/bsm-nu/-/wikis/home

Current workshop

Meeting Agenda

09:00

Welcome and introduction
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 09:30 - 10:00

10:00

Role of near detectors in present and future long-baseline experiments *Ciro Riccio*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 10:00 - 10:35

ND280 upgrade design and resistive Micromegas *David Henafl*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 10:35 - 11:05

11:00

New constraints on nuclear models from ND280 upgrade *Jaafar Chakrani*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 11:05 - 11:30

New nuclear models to exploit the capabilities of new near detectors *Anna Ershova*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 11:30 - 11:55

WP2

12:00

Lunch
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 12:00 - 13:00

13:00

Bolometric detection of CENNS: concept, status and prospects *Julien Billard*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 13:00 - 13:30

Results on bolometers developements: background model (TBC) *Leonard Imbert*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 13:30 - 14:00

14:00

Status of CUPID and its demonstrator *Anastasiia Zolotarova*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 14:00 - 14:30

Cryogenic active shielding for double beta decay experiments *Giovanni Benato*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 14:30 - 15:00

WP4

15:00

Break
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 15:00 - 15:30

Why is the neutrino mass important? *Francesco Vissani*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 15:30 - 16:05

16:00

Neutrino Mass Order Detecting by the Next Generation of Experiments and their Synergies *Anatael Cabrera*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 16:05 - 16:40

Precision oscillation physics with JUNO *Diana NAVAS NICOLAS*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 16:40 - 17:05

17:00

NSI in combination of long baseline experiments *Sabya Sachi Chatterjee*
100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay) 17:05 - 17:30

WP3

Organization and milestones

❑ **WP1** [Sara Bolognesi (IRFU), Andrea Giuliani (IJCLab)]

Management: reporting/wiki, organization of workshop, seminars

❑ **WP2** [Samira Hassani (IRFU), Margherita Buizza-Avanzini (LLR)]

Neutrino-nucleus scattering and near-detector design for long baseline

- Estimation of the sensitivity of new near detector design for the main systematics of neutrino oscillation measurements
- Prototypes test-beam and cosmics and X-ray test benches

→ *(publications and conferences)*

❑ **WP3** [Stéphane Lavignac (IPhT), Laurent Simard (IJCLab)]

Combination of experiments

- Mass-hierarchy sensitivity with present and medium-term experiments → *(publications and seminars)*
- Phenomenology beyond PMNS

❑ **WP4** [Claudia Nones (IRFU), Stefanos Marnieros (IJCLab)]

Low-background bolometers for CEνNS and $0\nu\beta\beta$

- Results and background model in tbe CUPID-Mo demonstrator → *(publications and conferences)*
- R&D on low-threshold TES sensors and Cryogenic Vetos

Working Package 2

Neutrino-nucleus scattering and Near Detector design for long-baseline experiments

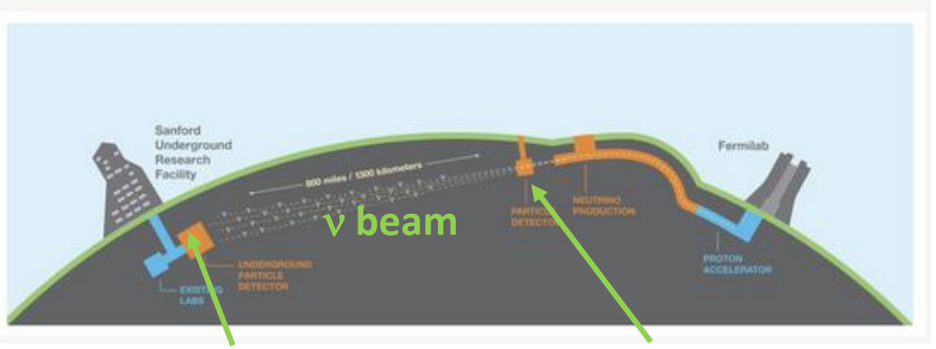
10:00	**Role of near detectors in present and future long-baseline experiments** — *Ciro Riccio* *100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)* — 10:00 - 10:35	
	ND280 upgrade design and resistive Micromegas — *David Henaff* *100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)* — 10:35 - 11:05	
11:00	**New constraints on nuclear models from ND280 upgrade** — *Jaafar Chakrani* *100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)* — 11:05 - 11:30	
	New nuclear models to exploit the capabilities of new near detectors — *Anna Ershova* *100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)* — 11:30 - 11:55	

Oscillations at long baseline experiments

ND measures rate vs neutrino energy before oscillation
→ characterize flux and xsec

$$R_{ND}^{n'} = \int \Phi^{n}(E_n)\frac{d\sigma^{n'}}{dE_n} dE_n$$

$$R_{FD}^{n'} = \int \Phi^{n}(E_n) P_{osc}^{n\to n'}(E_n) \frac{d\sigma^{n'}}{dE_n} dE_r$$



Far Detector (FD) Near Detector (ND)

~same flux at ND and FD

what we want to measure: oscillation probability

cross-section must be extrapolated from ND to FD:
- different neutrino energy distribution
- ND measure flux times xsec

→ **Need nuclear theory models!**

→ ***Ciro Riccio, this workshop***

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ND measures rate vs neutrino energy before oscillation
→ characterize flux and xsec

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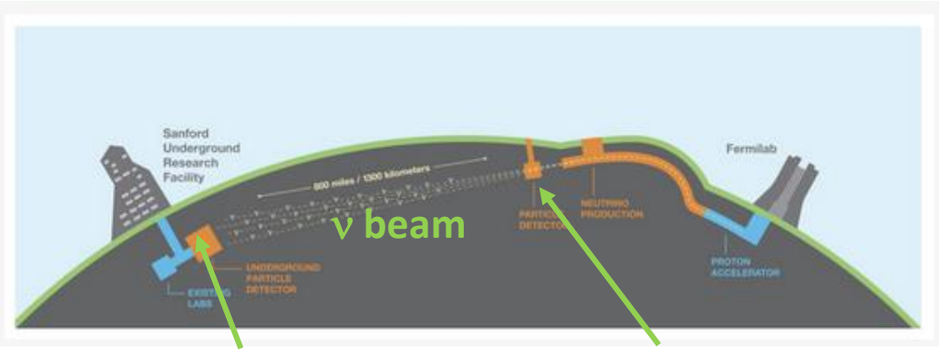

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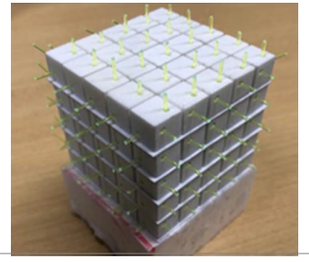
→ Need nuclear theory models!

→ Ciro Riccio, this workshop

Core of the problem: reconstruct neutrino energy from final state particles
→ new generation of near detectors:

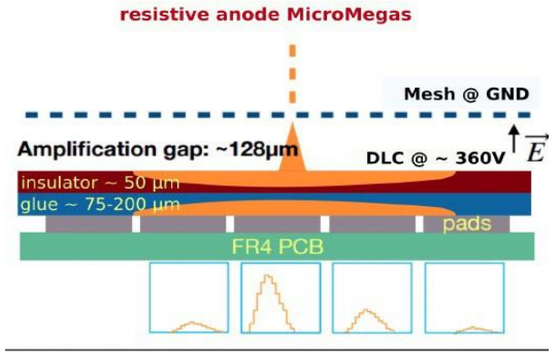
"Pixeled" scintillator with 3D track reconstruction capabilities



→ low threshold on proton, pion momentum

→ measurement of neutrons with ToF

Time Projection Chambers for tracking and ID of escaping particles



Resistive Micromegas technology to cope with needs of increased momentum resolution

Complete evaluation of sensitivity of new Near Detector design

Led by P2IO people and strong contribution from P2IO hired students

Phys. Rev. D 105 (2002) 032010

https://doi.org/10.1103/PhysRevD.105.032010

Open Access

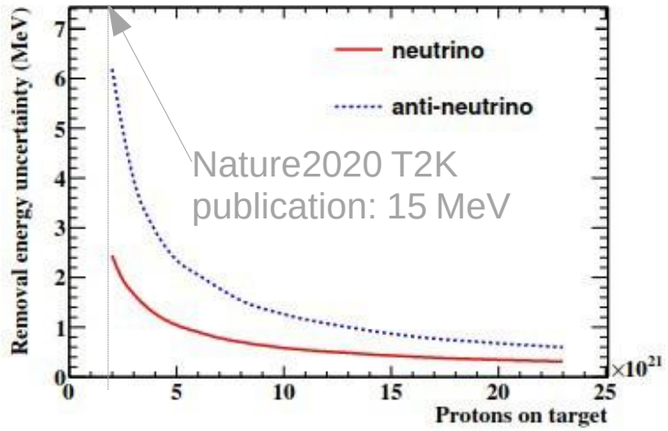
Sensitivity of the upgraded T2K Near Detector to constrain neutrino and antineutrino interactions with no mesons in the final state by exploiting nucleon-lepton correlations

S. Dolan, V. Q. Nguyen, A. Blanchet, S. Bolognesi, M. Buizza Avanzini, J. Chakrani, A. Ershova, C. Giganti, Y. Kudenko, M. Lamoureux, A. Letourneau, M. Martini, C. McGrew, L. Munteanu, B. Popov, D. Sgalaberna, S. Suvorov, and X. Y. Zhao

Phys. Rev. D **105**, 032010 – Published 28 February 2022

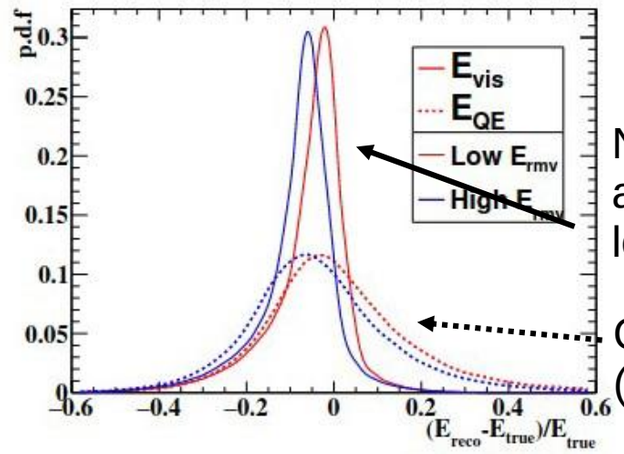
→ ***Jaafar Chakrani, this workshop***
P2IO student

Bias on energy resolution



1σ sensitivity to the nuclear removal energy shift parameter

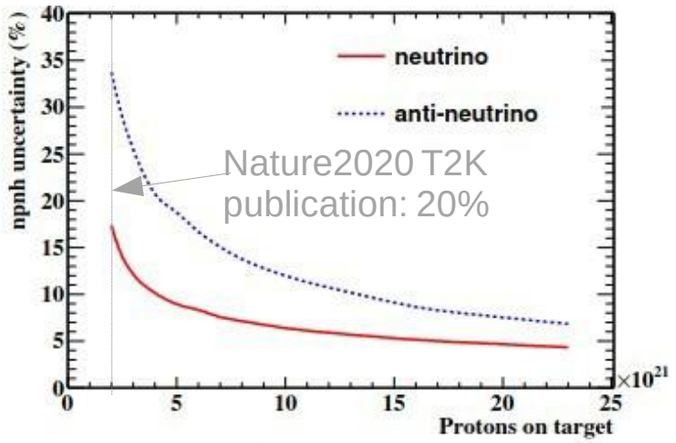
Energy resolution for final state w/o pions



New approach lepton+proton

Old approach (lepton only)

Normalization of left tail of energy resolution



1σ sensitivity to the npnh cross-section normalization

Fostering crucial improvements in T2K and beyond

2 ingredients for improved sensitivity: **+ improved nuclear model**

+ improved detector

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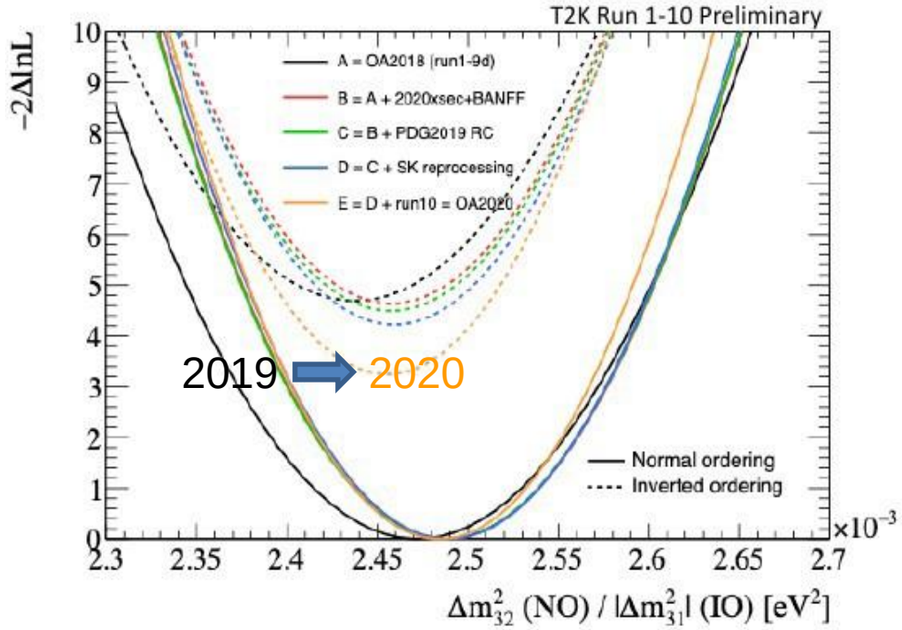
→ 30% improved precision of Δm^2 measurement!



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- **Next step: improvement of nuclear model** for final state re-interactions of protons, neutrons with nucleus. P2IO group is bringing a much more sophisticated treatment (INCL code from DPhN) into neutrino simulations!

→ **new paper led by P2IO group**

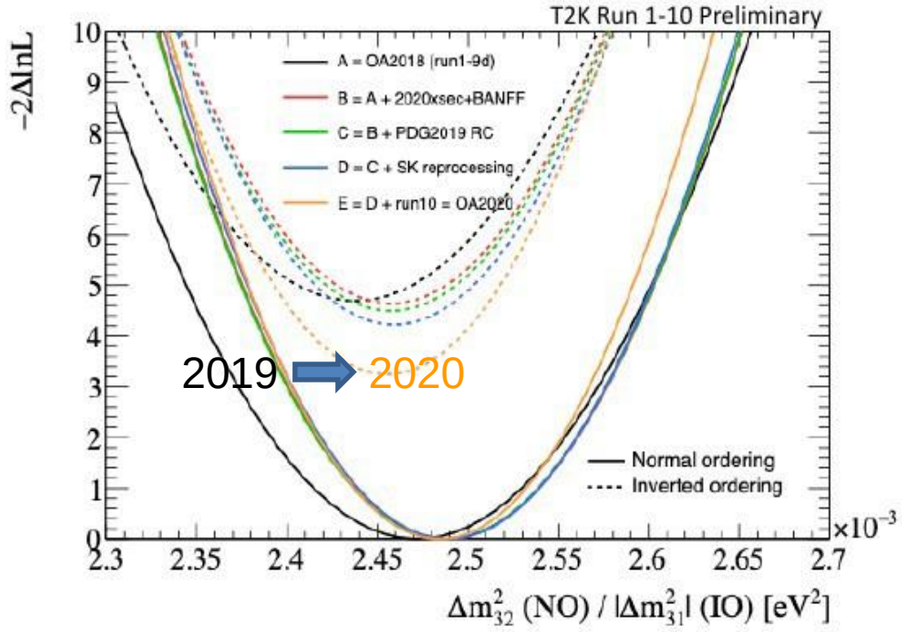
https://inspirehep.net/literature/2035691

Study of final-state interactions of protons in neutrino-nucleus scattering with INCL and NuWro cascade models

A. Ershova (IRFU, Saclay), S. Bolognesi (IRFU, Saclay), A. Letourneau (IRFU, Saclay), J.-C. David (IRFU, Saclay), S. Dolan (CERN) Show All(19)

Feb 21, 2022

→ ***Anna Ershova, this workshop***
P2IO student



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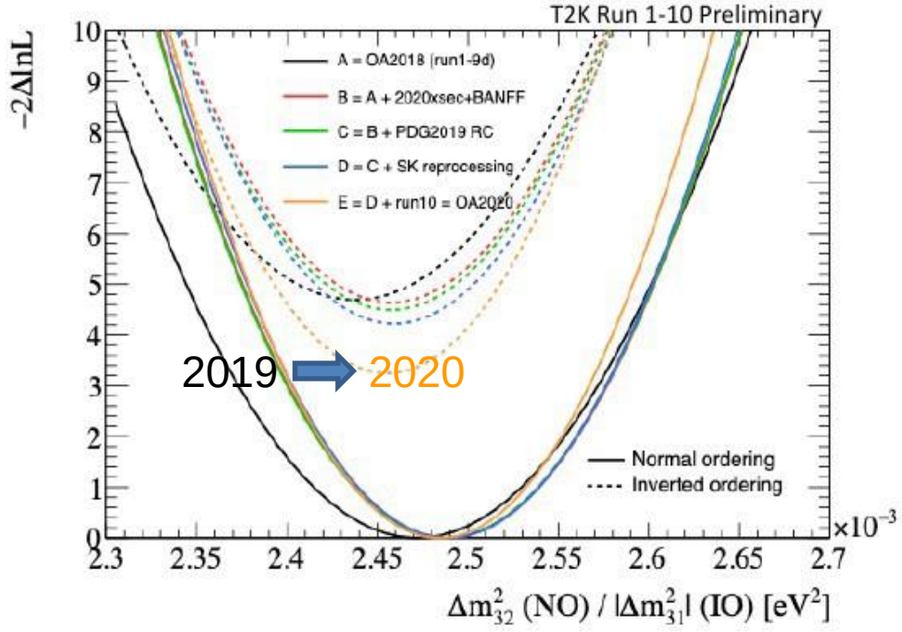

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Feb 21, 2022

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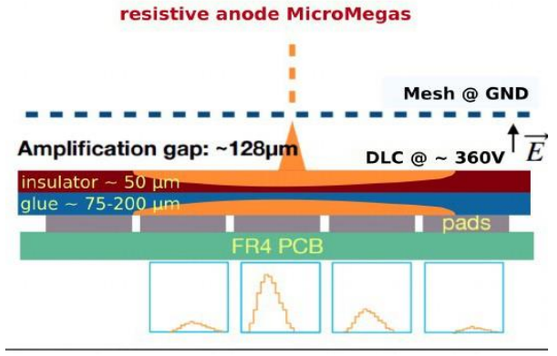
P2IO student

- **Improved detector**: notably, need improved resolution on lepton measurement in TPCs. Increased granularity of readout plane would explode the number of channels (and the cost)

→ induce charge spreading over multiple pads and make a 'weighted' reconstruction of charge to measure hit position with better resolution than pad size

(→ development of complex reconstruction algorithms)



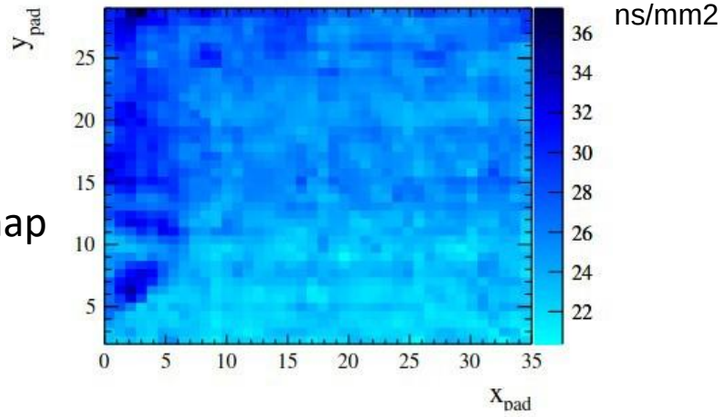
Development of TPC

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
Volume 1025, 11 February 2022, 166109

- Analysis of 2019 DESY test beam data: paper led by P2IO people *(WP2 convener is main editor)*

First map of Micromegas resistivity foil from data!

RC map



Characterization of resistive Micromegas detectors for the upgrade of the T2K Near Detector Time Projection Chambers

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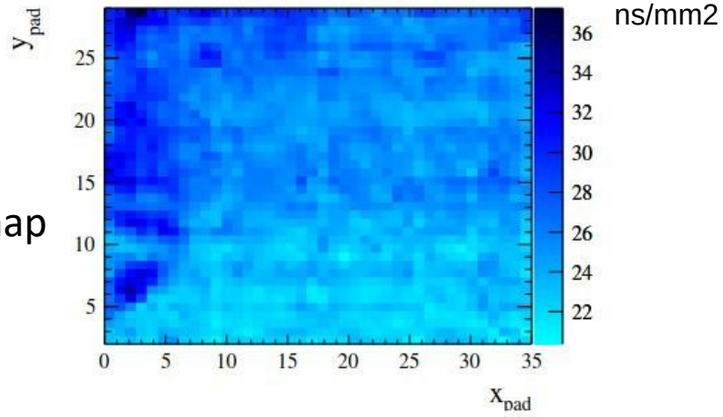

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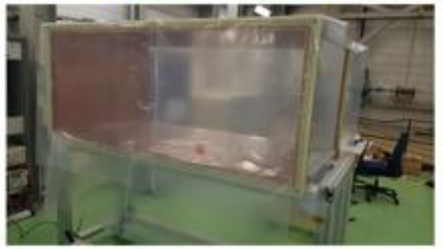
- **Test beam** at DESY in July 2021 with, for the first time, large field cage prototype
P2IO student is analyzing the ExB effect (new!) – **Data analysis ongoing**
- New test beam at CERN in May 2022 – Final first half TPC and 8 readout ERAM modules

First ½ TPC cage



½ TPC mock-up

Development of TPC

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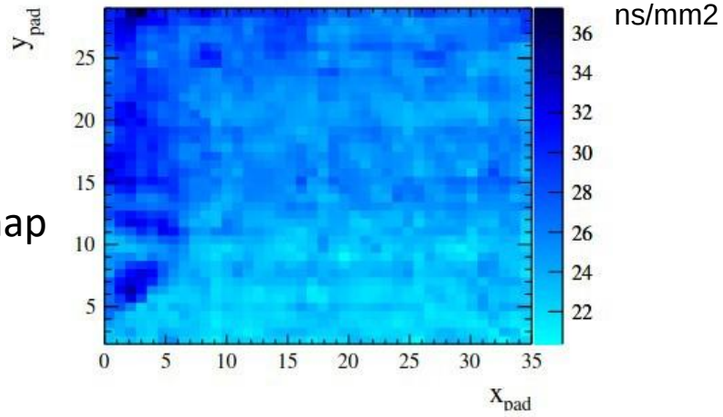

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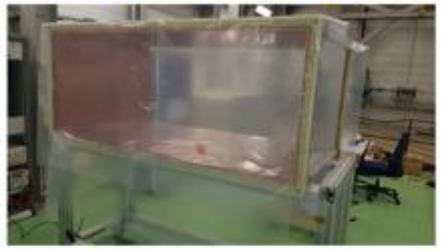
D. Attié [a], M. Batkiewicz-Kwasniak [b], P. Billoir [c], A. Blanchet [c], A. Blondel [c], S. Bolognesi [c], D. Calvet [a], M.G. Catanesi [d], M. Cicerchia [e], G. Cogo [f], P. Colas [a], G. Collazuol [e], A. Delbart [a], J. Dumarchez [c], S. Emery-Schrenk [a], M. Feltre [f], C. Giganti [c], F. Gramegna [e], M. Grassi [f], M. Guigue [c], P. Hamacher-Baumann [g], S. Hassani [a] ✉, F. Iacob [f], C. Jesús-Valls [h], R. Kurjata [i], M. Lamoureux [f], M. Lehuraux [a], A.

- **Test beam** at DESY in July 2021 with, for the first time, large field cage prototype
P2IO student is analyzing the ExB effect (new!) – **Data analysis ongoing**
- New test beam at CERN in May 2022 – Final first half TPC and 8 readout ERAM modules

First ½ TPC cage

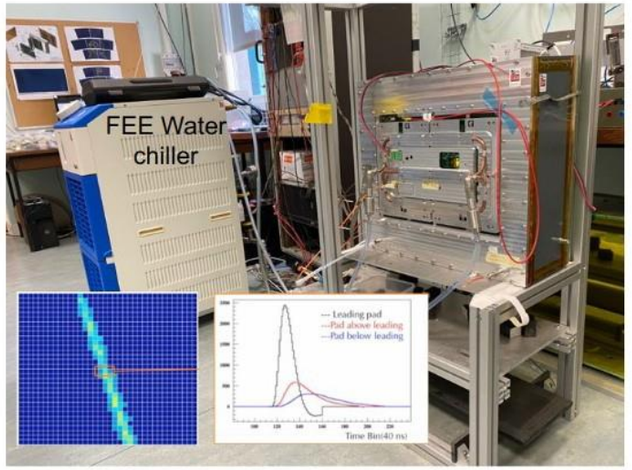


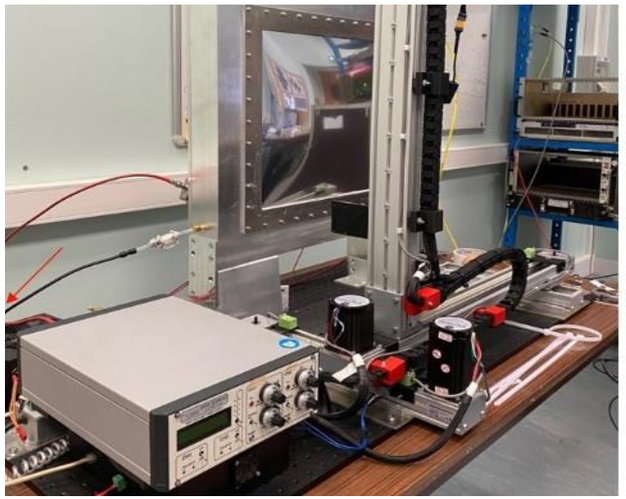
½ TPC mock-up

-Full characterization of new modules on-going with **test bench with cosmics and X- ray at Saclay**
→ P2IO financing an upgrade of them
(better control of conditions: gas flow, temperature, ...)

David Henaff: New P2IO BSMNu postdoc has arrived in WP2 (Oct 2021)

→ David Henaff, this workshop





Working Package 3

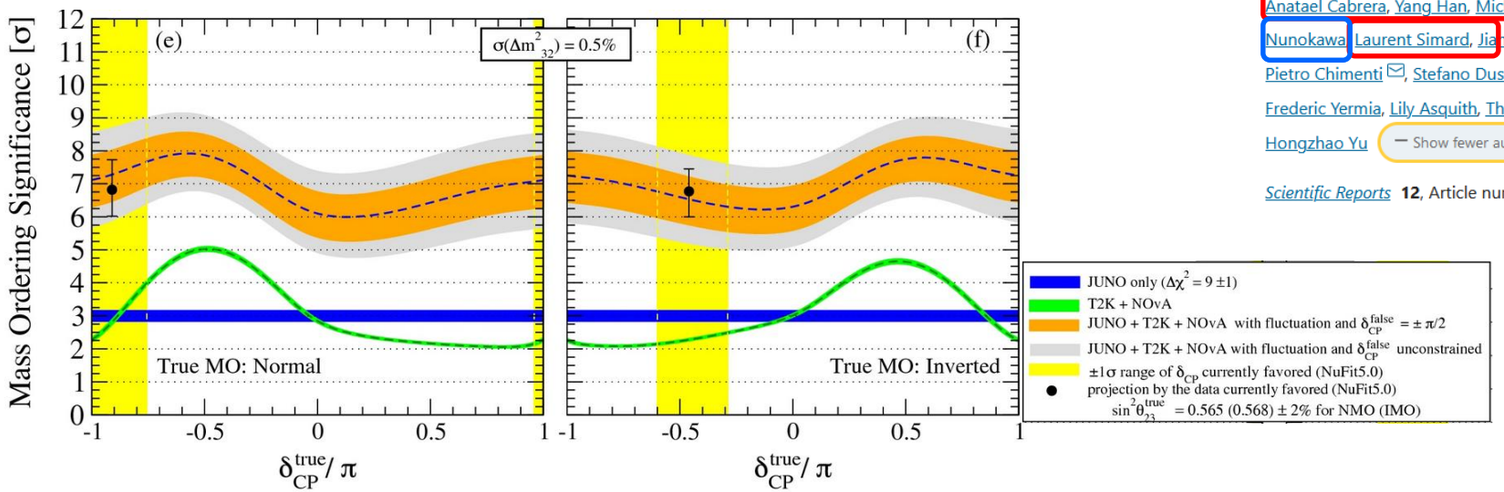
Combination of experiments

	Why is the neutrino mass important?	*Francesco Vissani*
	ZOOM	15:30 - 16:05
16:00	**Neutrino Mass Order Detecting by the Next Generation of Experiments and their Synergies**	*Anatael Cabrera*
	ZOOM	16:05 - 16:40
	Precision oscillation physics with JUNO	*Diana NAVAS NICOLAS*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	16:40 - 17:05
17:00	**NSI in combination of long baseline experiments**	*Sabya Sachi Chatterjee*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	17:05 - 17:30

Sensitivity to Mass Hierarchy

P2IO members led a milestone paper

https://www.nature.com/articles/s41598-022-09111-1



nature › scientific reports › articles › article

Article | Open Access | Published: 30 March 2022

P2IO members (+ sabbatical)

Synergies and prospects for early resolution of the neutrino mass ordering

Anatael Cabrera, Yang Han, Michel Obolensky, Fabien Cavalier, João Coelho, Diana Navas-Nicolás, Hiroshi Nunokawa, Laurent Simard, Jianming Bian, Nitish Nayak, Juan Pedro Ochoa-Ricoux, Bedřich Roskovec, Pietro Chimenti, Stefano Dusini, Mathieu Bongrand, Rebin Karaparambil, Victor Lebrin, Benoit Viaud, Frederic Yermia, Lily Asquith, Thiago J. C. Bezerra, Jeff Hartnell, Pierre Lasorak, Jiajie Ling, Jiajun Liao & Hongzhao Yu — Show fewer authors

Scientific Reports **12**, Article number: 5393 (2022) | Cite this article

→ ***Anatael Cabrera, this workshop***

JUNO+T2K/NOVA

Different parameters are entangled in one experiment but the constraints from another experiment could solve the degeneracy and boost the sensitivity

Notably, **MH sensitivity can be strongly enhanced by precision measurement of Δm^2_{32}**

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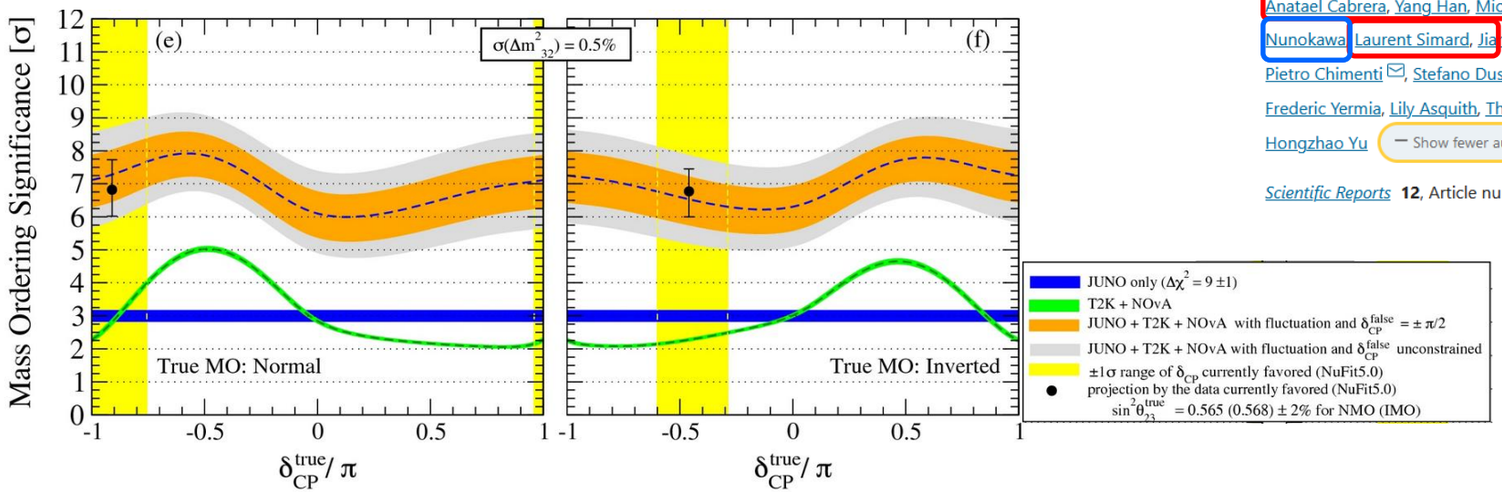

nature › scientific reports › articles › article

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JUNO+T2K/NOVA

Different parameters are entangled in one experiment but the constraints from another experiment could solve the degeneracy and boost the sensitivity

Notably, **MH sensitivity can be strongly enhanced by precision measurement of Δm^2_{32}**

Same paradigm exploited by a following crucial paper from **ORCA+JUNO** collaborations

arXiv:2108.06293 [hep-ex]

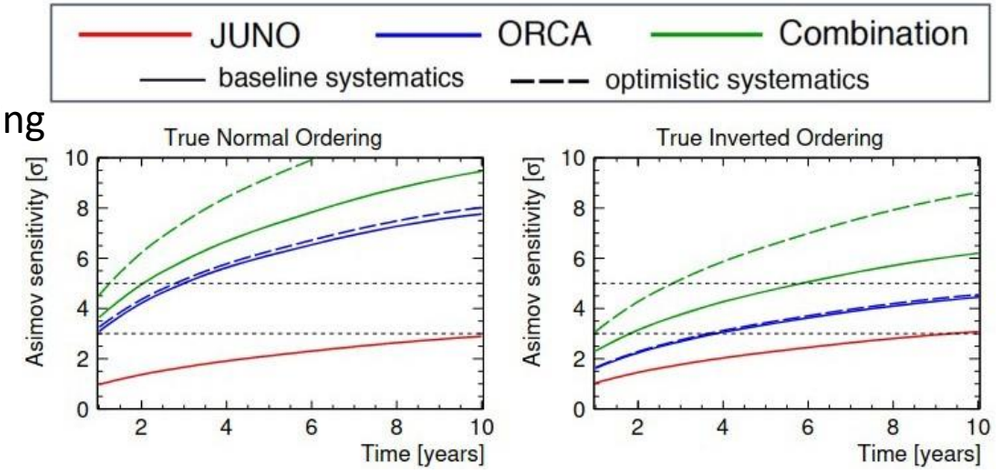
→ important **consequences on T2K targets and HK/DUNE design**

P2IO is taking part to shape the future of the discipline!

Overview of JUNO physics → ***Diana Navas Nicolas, this workshop***

Diana Navas: New P2IO BSMNu postdoc arriving in WP3 (Feb 2022)

ν Mass Ordering sensitivity



Next steps

The ‘standard’ oscillation paradigm (PMNS-based) is very strict and not motivated by fundamental symmetries (mixing angles and neutrino masses are ‘accidental’ numbers).

In particular it assumes
- minimal 3-flavour scenario
- standard neutrino interactions for production and detection
- standard matter effects along propagation

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Combination of long-baseline experiments beyond the PMNS paradigm (notably HK and DUNE + JUNO)

- bounds on New Physics (eg, non standard interactions)

- effects of New Physics on ‘standard’ PMNS paradigm: possible degeneracies, and apparent disagreement between experiments

A rehearsal: T2K+NOVA combination (already showing tension, but limited by statistics)

New (Oct 2021) P2IO BSM-Nu postdoc (Sabya Sachi Chatterjee) to work on the topic

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→ Sabya Sachi Chateerjee, this workshop

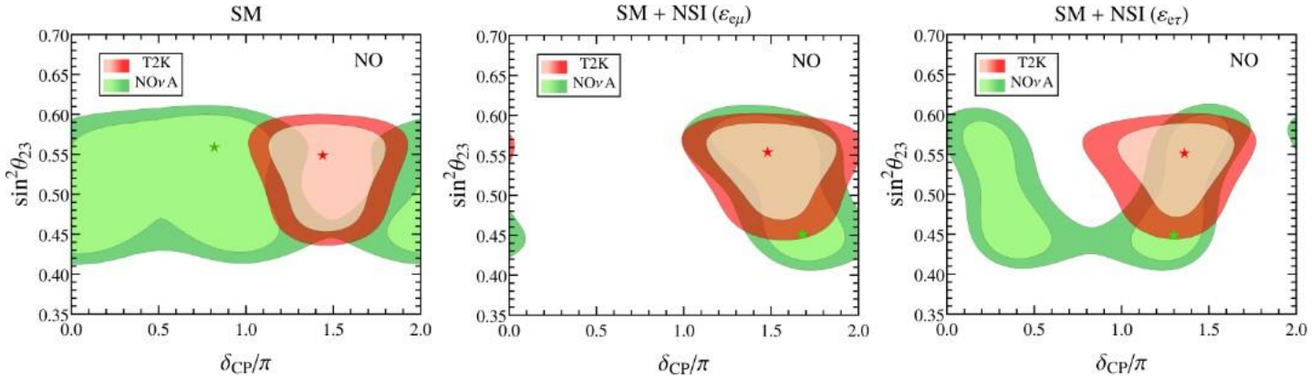
NSI

Phys.Rev.Lett. 126 (2021) 5, 051802

Non-standard neutrino interactions as a solution to the NOνA and T2K discrepancy

Sabya Sachi Chatterjee[1] * and Antonio Palazzo[2,3] †

[1] Institute for Particle Physics Phenomenology, Department of Physics, Durham University, Durham, DH1 3LE, UK
[2] Dipartimento Interateneo di Fisica "Michelangelo Merlin," Via Amendola 173, 70126 Bari, Italy
[3] Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Via Orabona 4, 70126 Bari, Italy

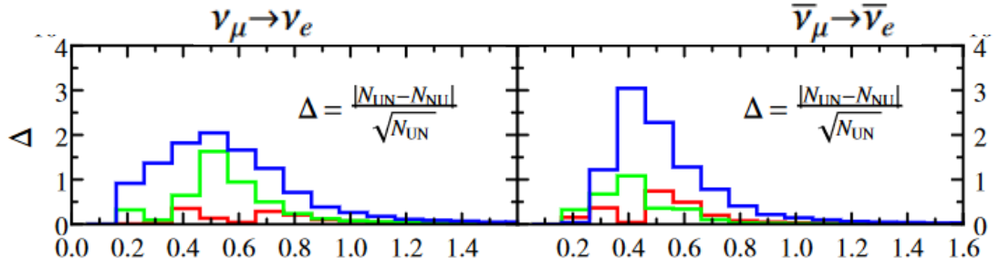


PSM Non Unitarity

arXiv:2111.08673v1 [hep-ph]

Non-Unitarity of the lepton mixing matrix at the European spallation source

Sabya Sachi Chatterjee,[1,2,*] O. G. Miranda,[3,†] M. Tórtola,[4,5,‡] and J. W. F. Valle[5,§]



absolute difference in the appearance events (UN – NU)

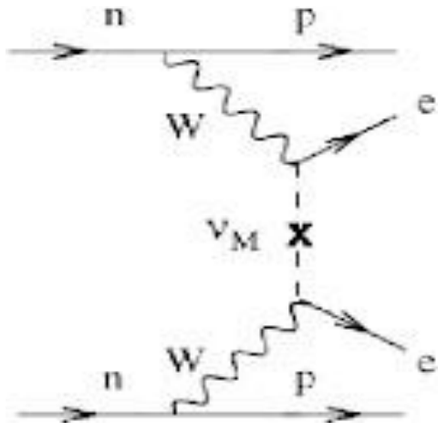
Working Package 4

Low-background bolometers for CEνNS and 0νββ

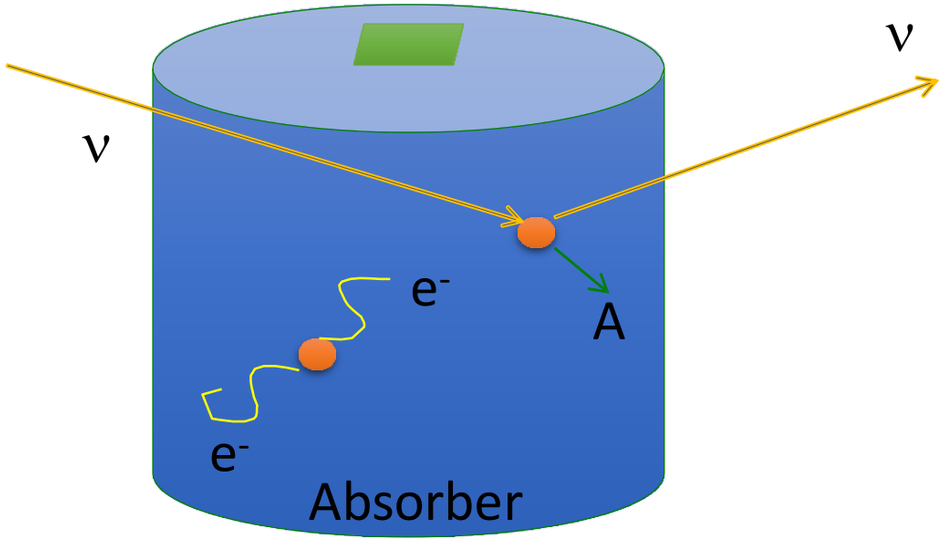
13:00	**Bolometric detection of CENNS: concept, status and prospects**	*Julien Billard*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	13:00 - 13:30
	Results on bolometers developements: background model (TBC)	*Leonard Imbert*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	13:30 - 14:00
14:00	**Status of CUPID and its demonstrator**	*Anastasiia Zolotarova*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	14:00 - 14:30
	Cryogenic active shielding for double beta decay experiments	*Giovanni Benato*
	100/-1-A900 - Auditorium Joliot Curie, IJCLab (Orsay)	14:30 - 15:00

Bolometers for 0νββ search and CEνNS detection

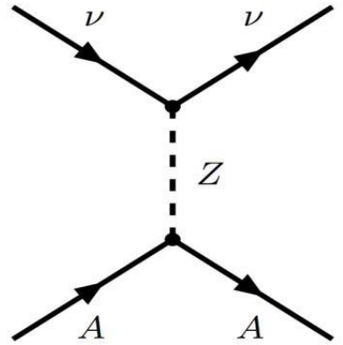
Neutrinoless double beta decay



Involved experiments:
CUPID-Mo → CUPID



Coherent elastic neutrino-nucleus scattering



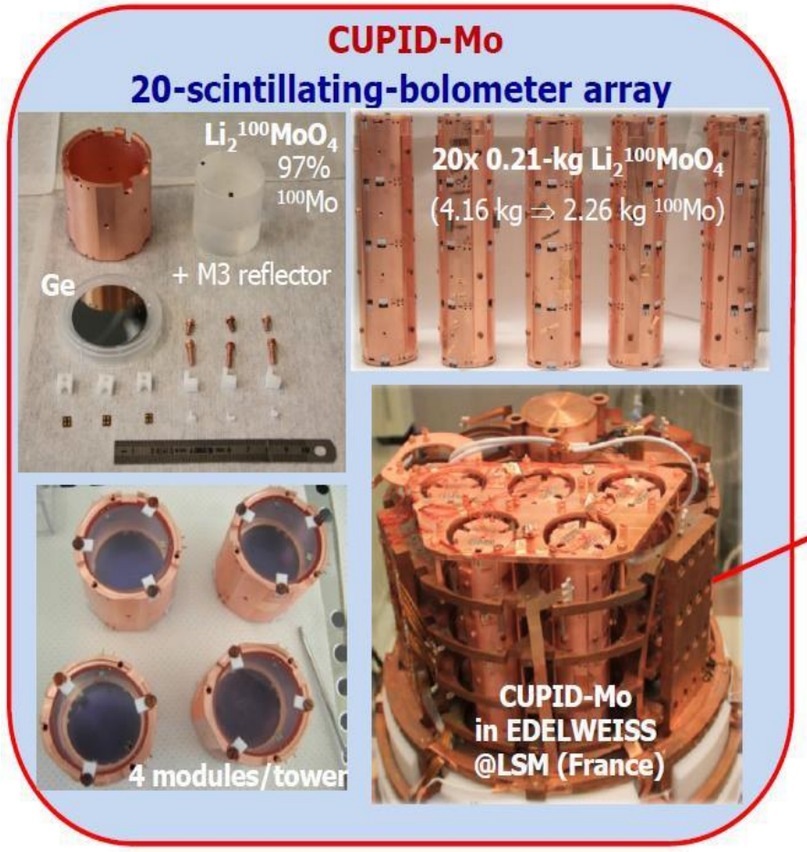
Involved experiments:
NUCLEUS
RICOCHET

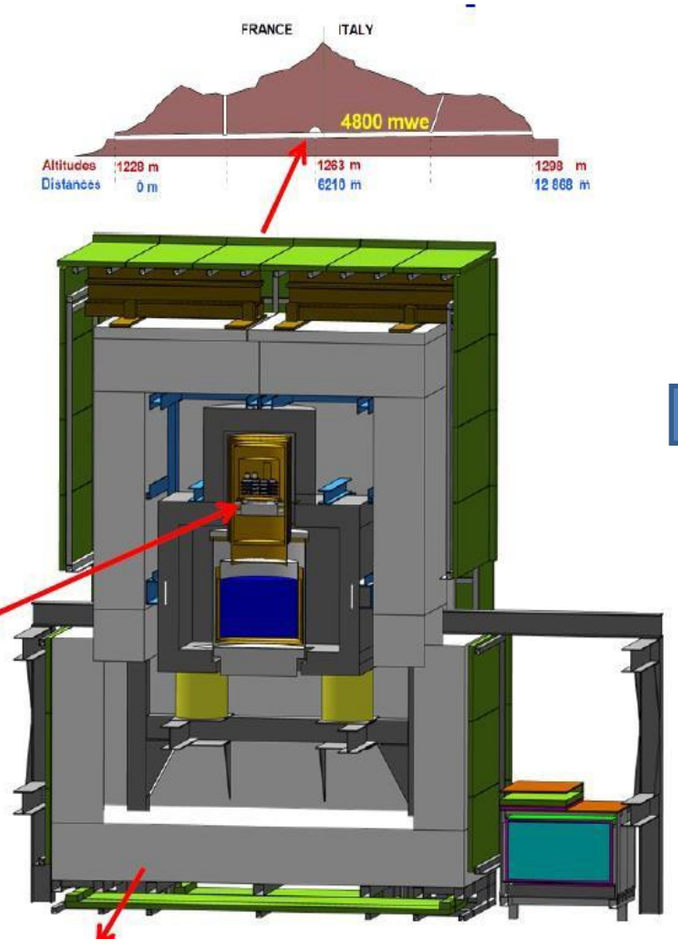
→ *Julien Billard, this workshop*

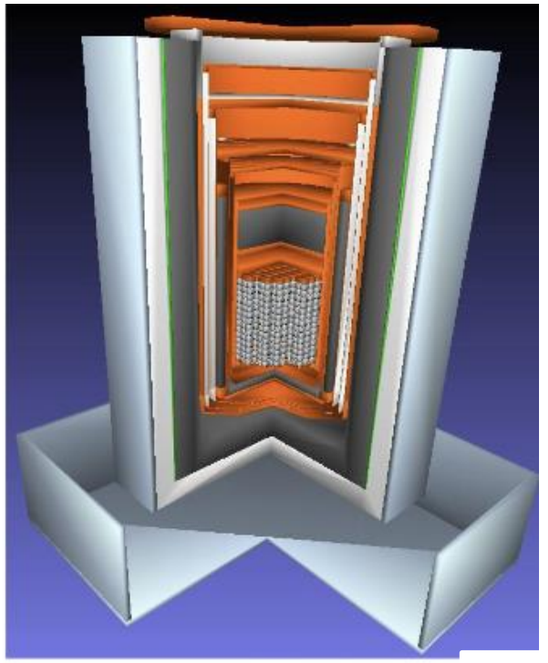
Neutrino nature: Dirac or Majorana?
Lepton number violation → *Francesco Vissani, this workshop*
Majorana phases

Precision test of standard model
Non-standard neutrino interactions
Table-top neutrino detectors

CUPID-Mo → CUPID







Detector Array

~240 kg of ^{100}Mo with >95% enrichment

~$1.6.10^{27}$ ^{100}Mo atoms

57 towers of 14 floors with 2 crystals each, 1596 crystals

CUPID – LNGS – CUORE cryostat

New (Oct 2021) P2IO BSM-Nu post-doc
Anastasiia Zolotarova

CUPID-Mo – LSM – EDELWEISS cryostat

→ ***Leonard Imbert, this workshop***
P2IO student

→ ***Anastasiia Zolotarova, this workshop***

CUPID-Mo – New 0νββ result – background model

New world leading limit on 0νββ of ^{100}Mo

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.126.181802

New Limit for Neutrinoless Double-Beta Decay of ^{100}Mo from the CUPID-Mo Experiment

E. Armengaud *et al.* (CUPID-Mo Collaboration)
Phys. Rev. Lett. **126**, 181802 – Published 3 May 2021

$T^{0\nu}_{1/2} > 1.5 \times 10^{24}$ yr, 90% c.i.

With only 1 year of data and ~2 kg of ^{100}Mo CUPID-Mo is able to set a limit of
$m_{\beta\beta} <$ (0.31-0.54) eV 90% c.i.

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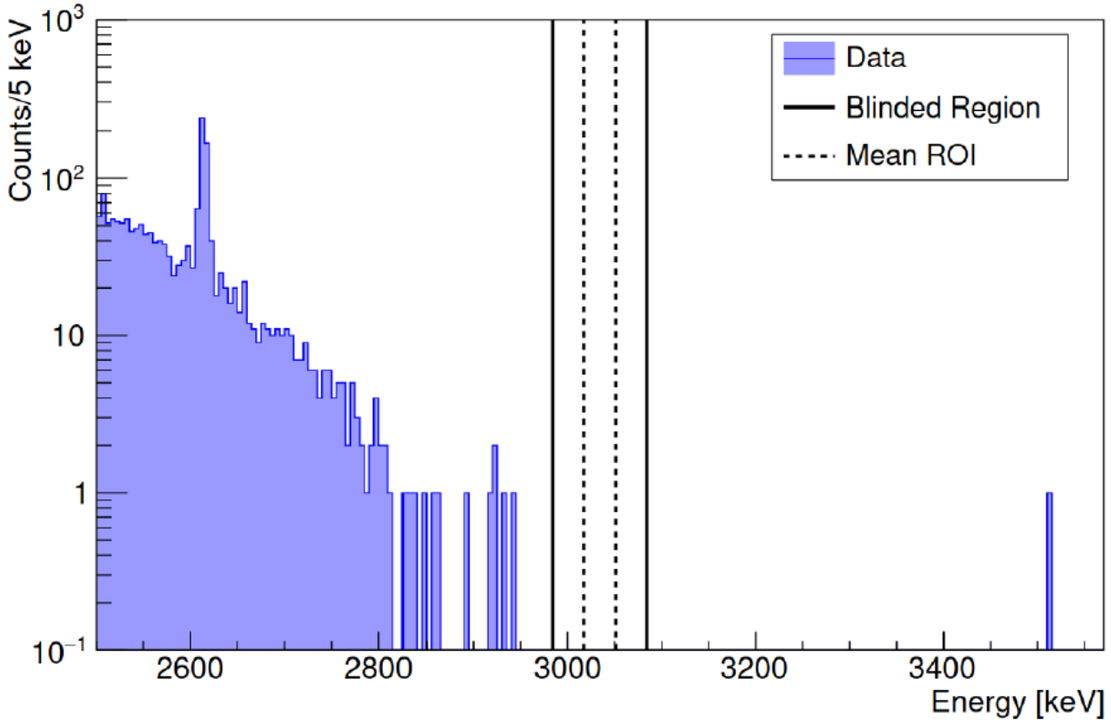
$T^{0\nu}_{1/2} > 1.5 \times 10^{24}$ yr, 90% c.i.

With only 1 year of data and ~2 kg of ^{100}Mo CUPID-Mo is able to set a limit of
$m_{bb} <$ (0.31-0.54) eV 90% c.i.

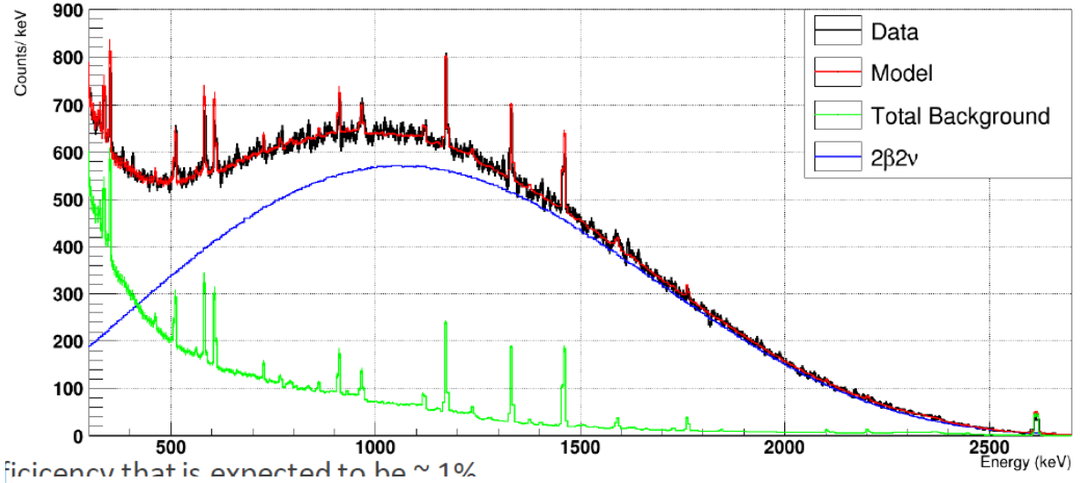
Upgraded limit with full statistics **$T^{0\nu}_{1/2} > 1.8 \times 10^{24}$ yr, 90% c.i.** **$m_{\beta\beta} <$ (280 - 490) meV**

arXiv:2202.08716v1[nucl-ex] – submitted to EPJC



Robust background model
Many exciting physics results expected

Most precise ever 2ν2β decay measurement



→ *Leonard Imbert, this workshop*
P2IO student

Low threshold TES sensors

High impedance TES based on NbSi thin films

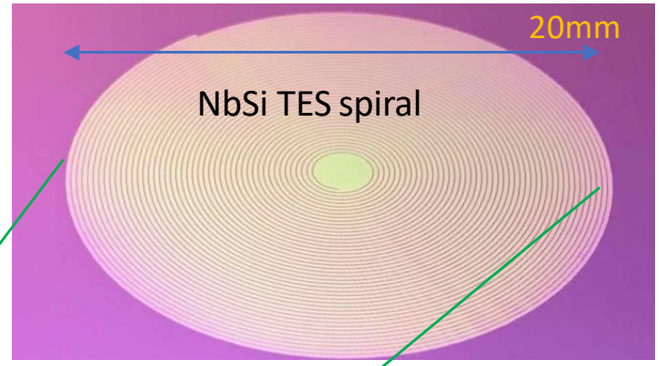
Spiral or meander geometry

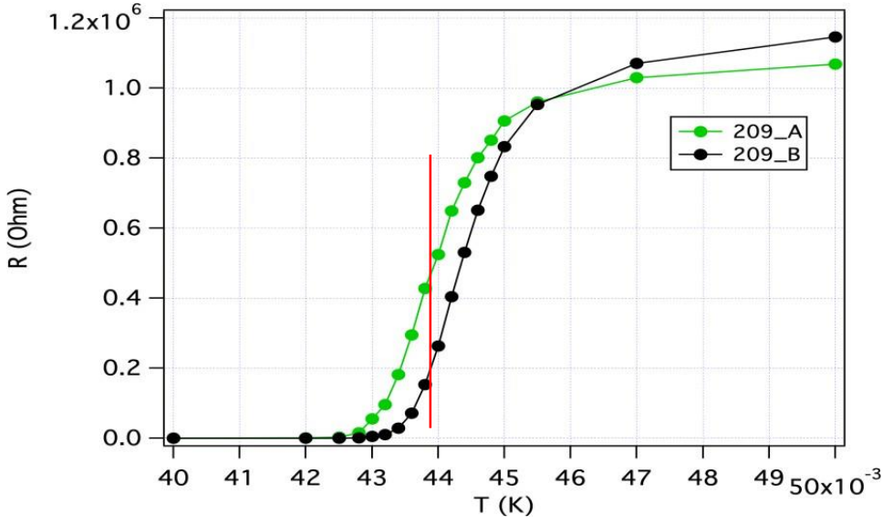
→ ***Julien Billard, this workshop***

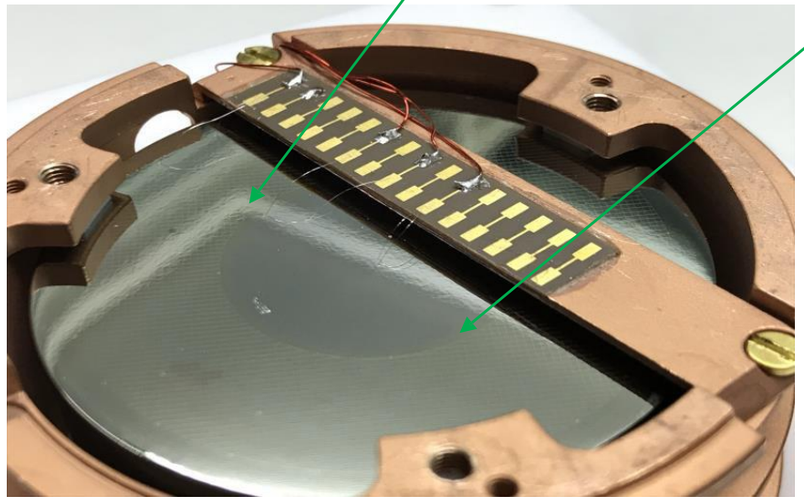
RICOCHET-CEνNS experiment : 35 g Ge detector < 20 mK

Simultaneous ionization + heat detection

Goal : heat sensor with threshold < 100 eV







Preliminary test on
200 g Ge detector
500 eV threshold

Preliminary test on
35 g Ge detector
250 eV threshold

NbSi TES is sensitive to “out-of-equilibrium phonons” : transient thermal regime of the detector before thermalization of the deposited energy.

Cryogenic vetos

Construction and the operation, for the first time, of **active shields** in bolometric experiments **directly facing the bolometric arrays** inside the experimental space at **millikelvin temperatures**

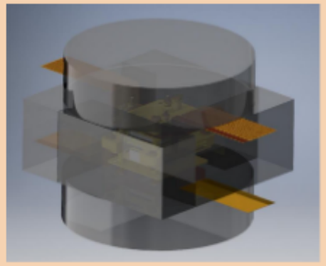
Shielding detectors will not use phonons as detection mediators, but, more conventionally:

- **electron-hole pairs** (for CEνNS)
- **scintillation light** (for 0νββ)

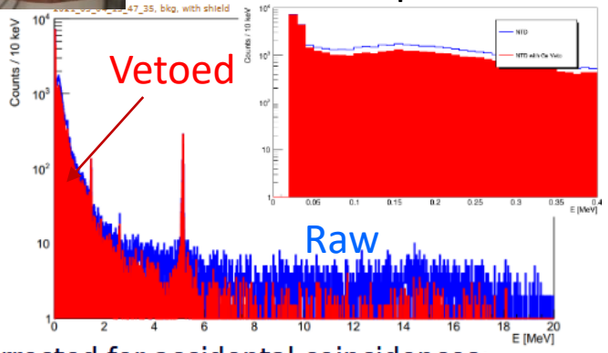
→ *Giovanni Benato, this workshop*

Ge ionization detectors
(EDELWEISS-like)

Final configuration:

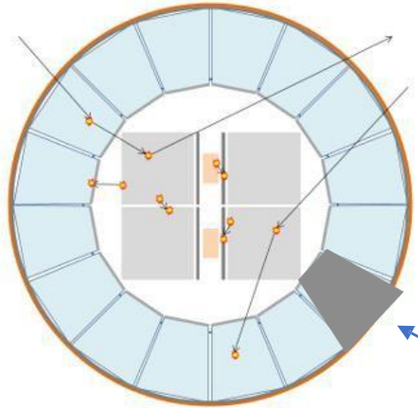


- 2 cylinders (ϕ = 100 mm, h = 25 mm)
- 4 paralleled-shaped (50 mm x 74.5 mm x 25 mm)

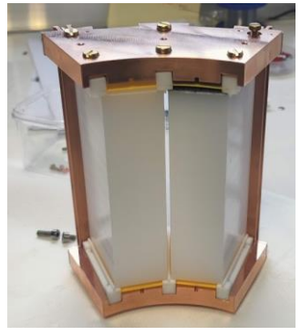


- Corrected for accidental coincidences:
- Veto rejection (full range)~ 23% (> 0.8%)
- Veto rejection (0-100 keV)~ 11%

NuCLEUS



BGO or $ZnWO_4$ scintillators



First prototype to be tested in a few weeks
BINGO

Read-out by Neganov-Luke Bolometric Ge light detectors

Conclusions

P2IO support allowed:

- the enrollment of **3 students + 4 post-docs**

  + collaborative papers led by P2IO physicists with strong participation from such students

  + few authors, not collaboration-wide paper → **BSM-Nu is fostering new collaborations efforts**

- the purchase of crucial hardware for the development of cutting edge technology

  + CUPID-Mo data taking → **best $0\nu\beta\beta$ results on Mo!**

  + Development and detailed characterization of **resistive Micromegas technology for TPCs**

  + Crystals for cryogenic vetos → **encouraging preliminary results**

- high-level workshops and seminars

-Leverage to increase visibility of P2IO community: already crucial role in improving present results (T2K, bolometers, ...)

Exciting workshop today!

first face-to-face meeting after COVID!!!