
P2IO BSMNu project

Neutrinos: a door to physics Beyond the Standard Model



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Neutrinos as door to New Physics

- **Neutrino oscillations** → evidence for neutrino masses: neutrino necessarily involved in BSM extension!

PMNS paradigm is well established as “easiest way” to extend SM (‘natural’ since based on CKM similarity)

Obvious first order questions we need to answer (in oscillation experiments):

→ Search of **CP violation in the leptonic sector** (related with matter/antimatter asymmetry in the Universe)

→ What is the **New Symmetry hidden behind the mass and flavour mixing?**
(Call for precision measurements of PMNS + is the mass order the same for neutral and charged leptons?)

→ is the **PMNS matrix unitary?**

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Some beyond-PMNS scenarios already theoretically established and under investigation:

- **sterile neutrinos**: many searches at different masses (reactor, SBL, and ND at LBL experiments)
- **Non-Standard-Interactions** (LBL experiments + CEvENS at reactors as in NUCLEUS and Ricochet)
- search for evidence of **Majorana nature through $0\nu\beta\beta$**
 - **New type of fundamental particle**
 - Discovery of **lepton number violation** (accidental conservation in SM: no symmetry supporting it)
 - Naturally emerging in **leptogenesis scenarios to create matter/antimatter asymmetry**

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More agnostic approach: characterization of neutrino particles given their very peculiar “BSM” nature + tool/door for BSM physics

Keep an open-mind approach (coherent and comprehensive view of neutrinos) + investigate new possibilities through combination between experiments

Some examples:

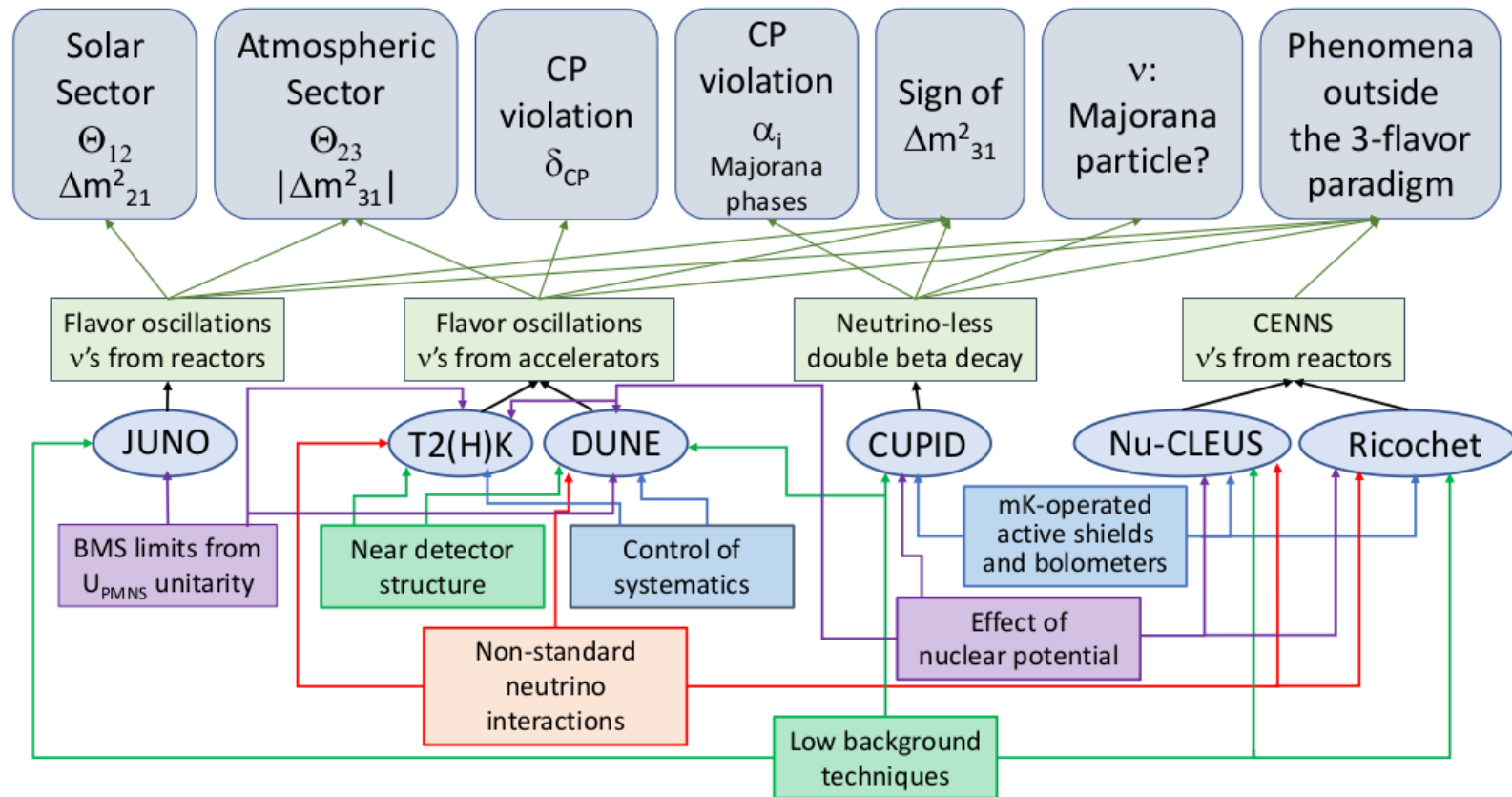
- LBL combination of experiments allow to model-independent search for T-violation (ie evidence of CP violation outside the strict paradigm of PMNS and standard propagation through matter)
- $0\nu\beta\beta$ as a tool to put limits on New Physics (eg on sterile neutrinos)
- R&D: develop of CEvNS detector as “large” statistics and reasonable size detector for measurement of unconventional neutrino properties (charge radius, magnetic moment...) ⁴

General objectives of BSM-Nu

Main objective federate all the actors of neutrino physics inside the P2IO perimeter to cope with challenges of:

- ① **Physics** – comprehensive view of neutrino physics beyond sectorial views dominated by Standard Model assumptions
- ② **Precision** – control of **systematic uncertainties** by combining measurements from different experiments and discussing together analysis strategies
- ③ **Detector advancement** – mutualizing R&D to **improve devices** and **develop new concepts** with a view to points ① and ②
- ④ **Critical mass** – **team building** inside the P2IO neutrino community
 - Enlargement of the neutrino physics community
 - Education of a new generation of physicists with a comprehensive view of the neutrino fieldDissemination: 3rd workshop + 2 seminars

BSM-Nu in a nutshell



Work package structure

WP 2 Neutrino-nucleus scattering and near-detector design for long baseline experiments

WP 3 Combination of experiments

WP 4 Low-background bolometers for CE ν NS and $0\nu\beta\beta$

Some of our results: more during the workshop!

- **LBL experiments:** development of more sophisticated near detectors, nuclear physics models to control neutrino-nucleus interactions and analysis tools
- **Study of combination** of JUNO+LBL and ORCA+JUNO
 - role of reactors for improved precision: new proposed SuperChooz experiment
- Phenomenology studies of T2K+NOVA and of DUNE+ESSnuB
 - road for NSI search (and more BSM physics)
- Crucial contribution to CUPID-Mo experiment providing new world leading limit on the half-life of $0\nu\beta\beta$ of ^{100}Mo and best worldwide limits on various ^{100}Mo 2β processes
- Development of **new detector concepts**
 - low-threshold Ge detectors equipped with TES
 - scintillator-based veto with bolometric light readout for CEvNS and $0\nu\beta\beta$ experiment

The project survived the COVID crisis (with actual great results!) and more to come!