

NF05: Neutrino Properties

NF05 Conveners: Ben Jones, Lisa Kaufman, Carlo Giunti, Diana Parno

NF05 honorary co-conveners: Andrea Pocar (RF04), Julieta Gruszko

Group Scope

- **Neutrino Properties is a very broad term!**
- Early in Snowmass we defined our groups scope as the following topics not covered elsewhere:
 - **Direct neutrino mass measurements**
 - **Dirac vs Majorana nature**
 - **Electromagnetic properties**



- Input for the NF05 report was sought via:
 - 6 summer half-day workshops in Summer 2020
 - A workshop on the ton-scale future of Onubb in Dec 2020
 - Snowmass LOIs
 - A fairly small number of whitepapers (not all of them yet in our hands)
- Everything presented in one of these formats **that we have received** is covered in our report draft.

The screenshot shows a web interface for a "Mini Workshop: Onubb Experiment I" on August 5, 2020. The interface includes a search bar, a navigation menu with options like "Overview", "Timetable", "Contribution List", "My Conference", "My Contributions", and "Participant List", and a "Timetable" section. The timetable is for Wednesday, August 5, 2020, and lists various sessions with their times and speakers. The sessions are:

Time	Session Title	Speaker
09:30 - 09:35	Welcome and Introduction to Snowmass	Lisa Kaufman
09:35 - 09:50	Review of Onubb Theory Mini workshops	Carlo Giunti
09:50 - 10:05	KamLAND-Zen	Christopher Grant
10:05 - 10:20	SNO+ and Theia	Robert Svoboda
10:20 - 10:35	CUORE/CUPID	Danielle Speller
10:35 - 10:40	Break	
10:40 - 10:55	nEXO and LXe TPCs for Neutrinoless Double Beta Decay	David Moore
10:55 - 11:10	NEXT and GXe TPCs for Neutrinoless Double Beta Decay	Roxanne Guenette
11:10 - 11:25	Barium Tagging	William Fairbank
11:25 - 11:40	Neutrinoless Double Beta Decay with Germanium	Julieta Gruzsko
11:40 - 11:45	Plans for Mini Workshop: Onubb Experiment II	Benjamin Jones et al.
11:45 - 12:00	Group Discussion	

Report status

- Advanced draft in overleaf: 43 pages of text + 248 references.
- We have a few sections still to complete, expect it to top out around 46pages + 18pg of refs
- We have generally tried to be brief and where other white papers exist, or topic area is covered by another group, refer rather than rewrite.
- This means **topics that have white papers take less space in our report than ones without white papers.**
- We encourage readers not to equate length of text with importance of topic; instead consider it correlated to well-documented-elsewhere-ness.

The screenshot displays the Overleaf interface for a document titled "Snowmass NF05 Report". The left pane shows the LaTeX source code, and the right pane shows the rendered PDF. The source code includes a figure environment, a caption, and a paragraph discussing the CUORE Upgrade with Particle Identification (CUPID) project. The rendered PDF shows the title page with author information, a date of March 8, 2022, an abstract, and a table of contents. The table of contents lists sections such as "Direct neutrino-mass measurements", "Neutrinos double beta decay and Majorana Neutrinos", and "Open questions in $\nu\beta\beta$ theory".

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357 ~ \begin{figure}[b!]
358 ~ \begin{centering}
359 ~ \includegraphics[width=0.99\columnwidth]{Figs/CurrentGenPic
360 ~ s.png}
361 ~ \par\end{centering}
362 ~ \caption{Photos of some of the current generation of \nldb
363 ~ experiments described in this report.
364 ~ \label{fig:BaIonAtom}}
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366 ~ \end{figure}
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Snowmass NF05 Report: Neutrino Properties

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March 8, 2022

Abstract

Neutrinos are the most elusive among the known elementary particles, because of their feeble interactions with ordinary matter. This Topical Group focuses on neutrino properties that are not directly investigated in other Topical Groups of the Neutrino Frontier: in particular, the absolute value of the neutrino masses, the Dirac or Majorana nature of neutrinos, their electromagnetic properties, their lifetime, and hypothetical exotic properties.

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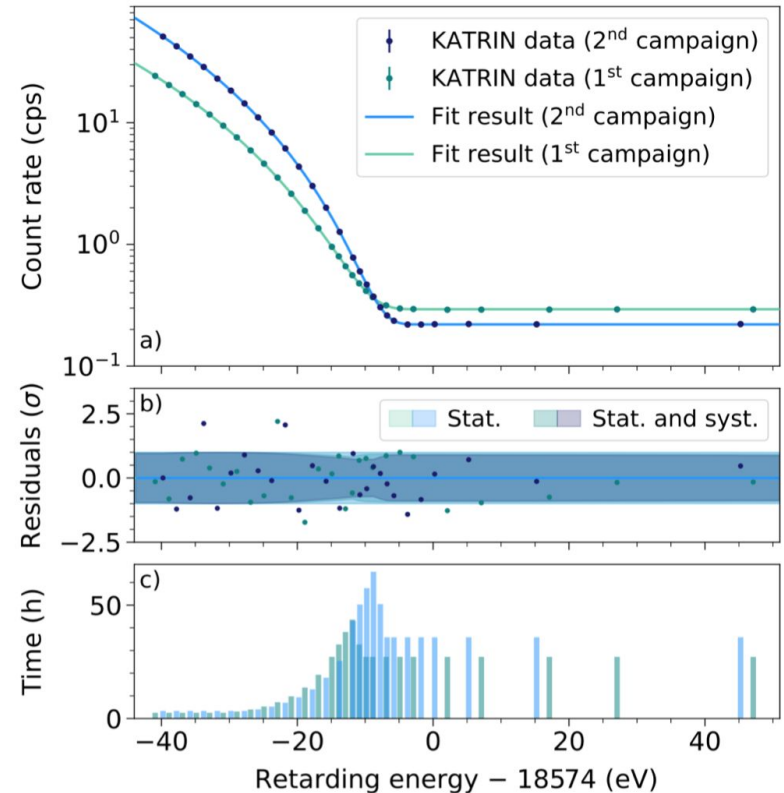
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Motivating considerations: Direct Neutrino Mass

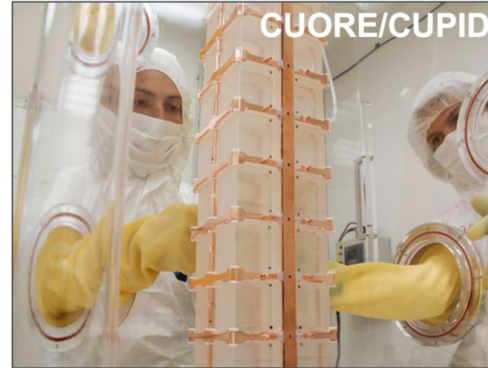
- Community is fairly unified in its vision for direct neutrino mass.
- Two main experiments in tritium:
 - KATRIN (present gen)
 - Project8 (next gen)
- Two main experiments in Holmium:
 - ECHO
 - HOLMES
- Plus connections to other BSM physics searches
- And brief mention of other approaches to this question (cosmology, etc)



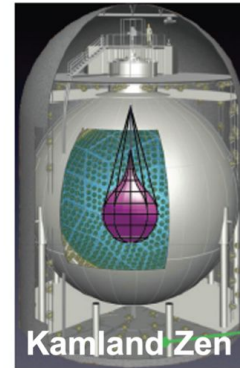
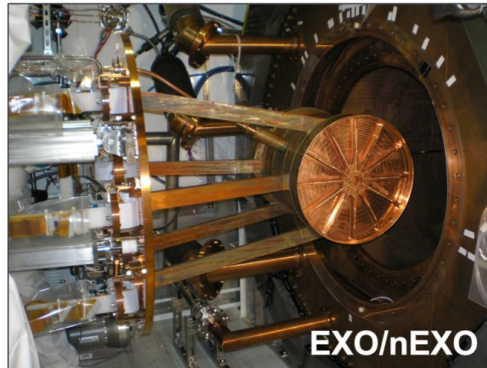
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Motivating considerations: Onubb

- On the contrary, a rather wider array of perspectives exists in Onubb.
- We have tried to ensure they are all represented
 - *Or at least, all the ones with US involvement!*

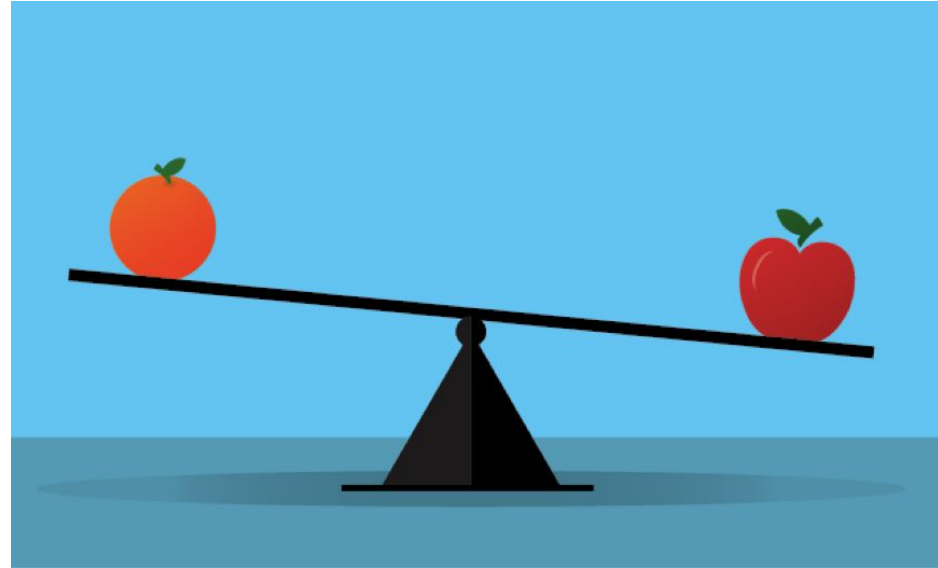


Current gen
experiments:



Motivating considerations: Onubb

- We have opted **not** to attempt to quantitatively compare different detectors yet to be built.
- While we can easily ask collaborations for the vital statistics of their future detector, we cannot correct for varying robustness of those projections.
- There seemed to us little value in an exercise comparing different levels of optimism in backgrounds of unbuilt detectors.



- There is an ongoing process within DOE NP concerning realization of at least one ton-scale $0\nu\beta\beta$ experiment, and ideally more than one, within the next decade.
- This process has been proceeding with potentially quite consequential steps during this Snowmass process.
- **We have endeavored not to interfere.**
- We briefly review current-gen and ton-scale in our report, but primarily focus on the possible beyond-ton-scale future.
- The main message to convey is that:
- **Searches for $0\nu\beta\beta$ are a critical pillar of the world neutrino physics program; continued investment is needed to realize both this generation and the next generation of experiments.**

North America - Europe Workshop on Future of Double Beta Decay

Sep 29, 2021, 2:00 PM → Oct 1, 2021, 9:30 PM Europe/Rome

'E. Fermi' auditorium (Gran Sasso National Laboratory (LNGS))

Description



The Majorana nature of neutrino and the possible contribution of neutrinos to explain the matter-antimatter asymmetry in the universe are among the most challenging physics goals in the next decade. The purpose of the North America-Europe workshop on Double Beta Decay is to stimulate the discussion between the North American and European double beta decay community and the corresponding funding agencies to consolidate strategy and define a path to the discovery of Majorana neutrinos. The discussion will focus on the upcoming generation of high sensitivity projects, their discovery potentials and the underground infrastructures.

INEN

The Workshop is jointly organized by INEN, INFN, and DOE

OFFICE OF SCIENCE

Ton-Scale Neutrinoless Double Beta Decay Perspectives

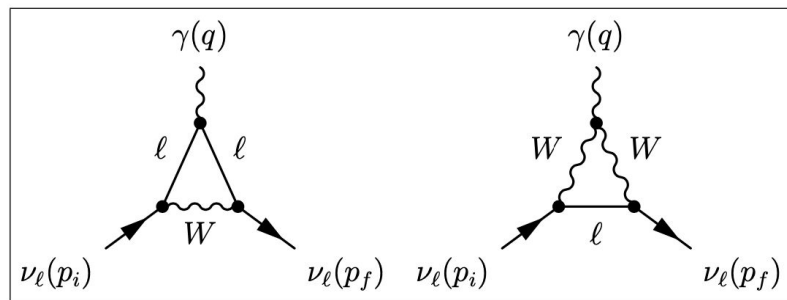
NSAC Meeting
November 16, 2021

U.S. DEPARTMENT OF ENERGY | Office of Science

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Motivating considerations: Electromagnetic Properties

- No major experiment in the US pursues electromagnetic properties as its primary goal.
- Nevertheless, they are important fundamental properties of neutrinos, accessible mainly through low energy neutrino scattering.
- A brief review of theoretical and experimental status is given.
- The most programmatically relevant aspect is probably connections to CEvNS, which is covered here in brief.



Method	Experiment	Limit [e]	CL	Year	Ref.
Neutrality of matter	Bressi et al. [220]	$Q_{\nu_e} \in (-3.8, 2.6) \times 10^{-21}$	68%	2014	[177]
Reactor $\bar{\nu}_e e^-$	TEXONO [221]	$ Q_{\nu_e} < 3.7 \times 10^{-12}$	90%	2006	[222]
	GEMMA [195]	$ Q_{\nu_e} < 1.5 \times 10^{-12}$	90%	2013	[223]
	TEXONO	$ Q_{\nu_e} < 1.0 \times 10^{-12}$	90%	2014	[224]
Accelerator ($\nu_\mu, \bar{\nu}_\mu$) e^-	LSND [181]	$ Q_{\nu_\mu} < 3 \times 10^{-9}$	90%	2020	[225]
Beam Dump	BEBC [196]	$ Q_{\nu_\tau} < 4 \times 10^{-4}$	90%	1993	[226]
Accelerator ($\nu_\tau, \bar{\nu}_\tau$) e^-	DONUT [198]	$ Q_{\nu_\mu} < 4 \times 10^{-6}$	90%	2020	[225]
CEvNS	COHERENT [185, 186]	$Q_{\nu_e} \in (-14, 34) \times 10^{-8}$	95%	2020	[187]
		$Q_{\nu_e} \in (-10, 12) \times 10^{-8}$			
		$ Q_{\nu_{e\mu}} < 17 \times 10^{-8}$			
	CONUS	$ Q_{\nu_{e\tau}} < 27 \times 10^{-8}$	90%	2022	[199]
		$ Q_{\nu_{\mu\tau}} < 20 \times 10^{-8}$			
Solar $\nu_e e^-$	XMASS-I	$ Q_{\nu_e} < 3.3 \times 10^{-12}$	90%	2020	[204]
		$ Q_{\nu_\mu} , Q_{\nu_\tau} < 1.1 \times 10^{-11}$			

Table 5: Experimental limits for the neutrino electric charges.

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Other.

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- Finally we make a very brief, passing reference to these two topics, though expect they mostly reside within the NF03 group purview.

What did we miss?

- We will circulate report draft soon. If we missed something tell us!
- If you don't like the text about your experiment, reach out with a replacement!
- Our main goal was inclusivity and to ensure nothing that was contributed to Snowmass was omitted, while presenting an organized view of a busy and active area.
- Your feedback welcome!

