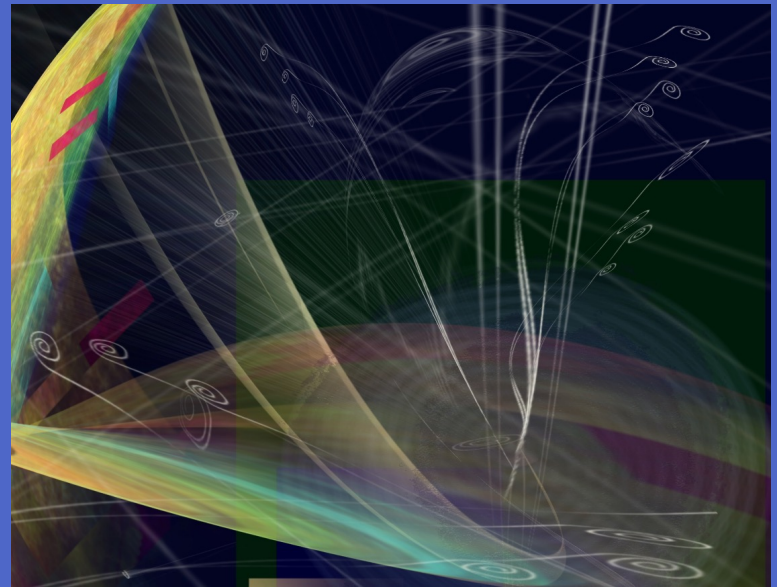


NEUTRINO FRONTIER: COMMUNITY SUMMER STUDY WORK PLAN

PATRICK HUBER, KATE SCHOLBERG, **ELIZABETH WORCESTER***

JULY 17, 2022



Robin A Giacomini, "Dall'Oscurita", 15x15, Digital Painting

* I am a collaborator on SBND, ICARUS, and DUNE

NEUTRINO FRONTIER ORGANIZATION

■ Conveners:

- Patrick Huber (Virginia Tech)
- Kate Scholberg (Duke)
- Elizabeth Worcester (BNL)



■ Topical Groups

- NF01: Neutrino Oscillations
- NF02: Understanding Experimental Neutrino Anomalies
- NF03: Beyond the SM
- NF04: Neutrinos from Natural Sources
- NF05: Neutrino Properties
- NF06: Neutrino Interaction Cross Sections
- NF07: Applications
- NF08→TFI I: Neutrino Theory
- NF09: Artificial Neutrino Sources
- NF10: Neutrino Detectors
- +liaisons to all other frontiers & SEC

See NF wiki – <https://snowmass21.org/neutrino/start> – for names of topical group conveners, names of liaisons, report drafts, and all things NF

MAJOR THEMES IN NEUTRINO FRONTIER

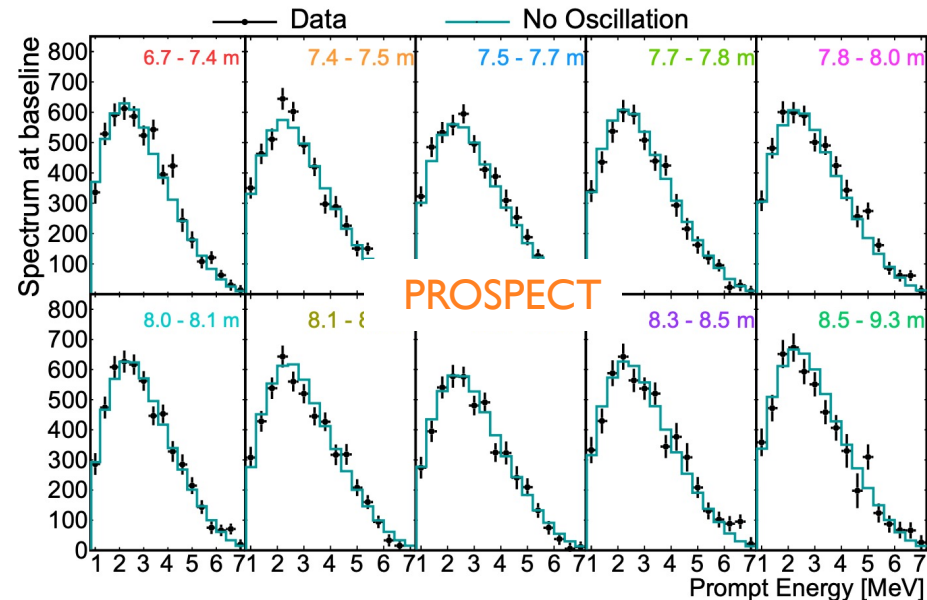
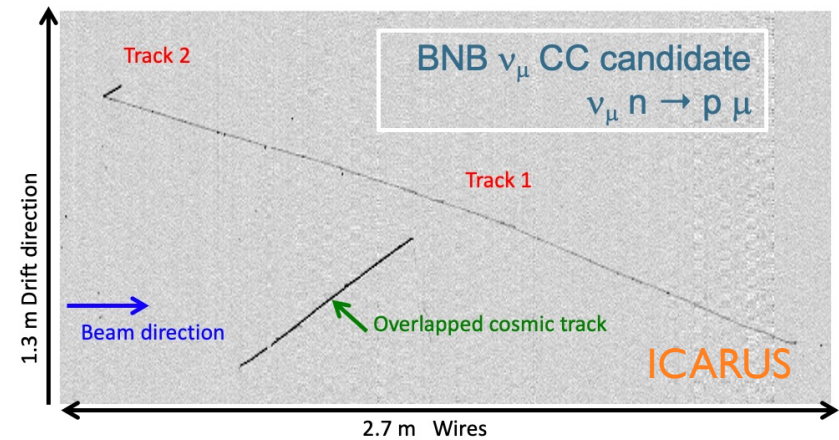
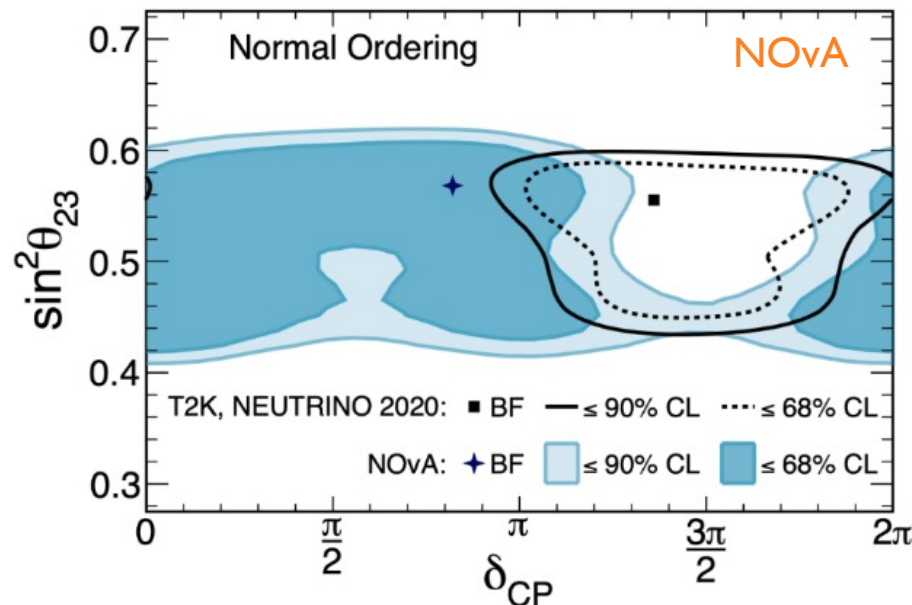
- A defining and somewhat unique aspect of NF is breadth and balance of effort across a wide range of physics topics, timescales, sizes, and costs, with significant need for collaboration with other frontiers and across boundaries of what is typically considered particle physics
- Physics beyond the (3-neutrino) Standard Model is emerging as a major focus of NF – this includes investigation of anomalies in neutrino oscillation measurements, precision measurements of neutrino oscillation that are sensitive to new particles and interactions, and use of neutrino experiments to search for other new physics, such as dark matter
- Use of neutrinos as messengers carrying information about otherwise inaccessible systems, particularly as participants in multi-messenger astronomy, is a growing area of interest in NF

MAJOR THEMES IN NEUTRINO FRONTIER

- DUNE/LBNF is the largest project in the NF portfolio, with extensive investment from the US and international partners to make precision neutrino oscillation measurements as well as a broad program of astrophysics topics and BSM searches. Snowmass/P5 will be particularly focused on the 2nd phase of DUNE, which is necessary to achieve the full DUNE physics scope, and which also offers opportunities to expand the physics scope beyond that initially envisioned
- There is significant synergy with other frontiers/fields in detector, accelerator, and computing development
- Community engagement is critical for the success of NF
- Early career scientists are central to all of the ongoing and planned research in NF

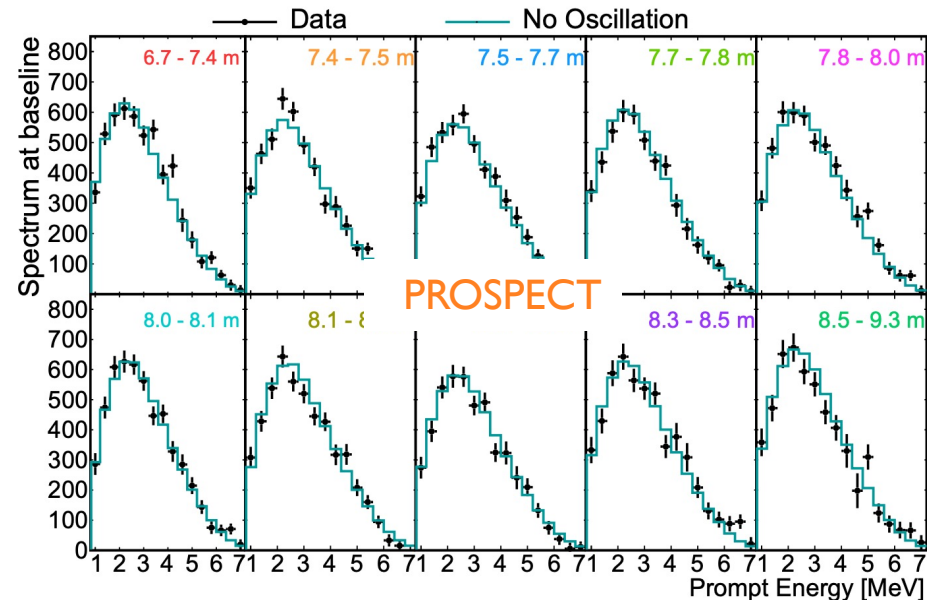
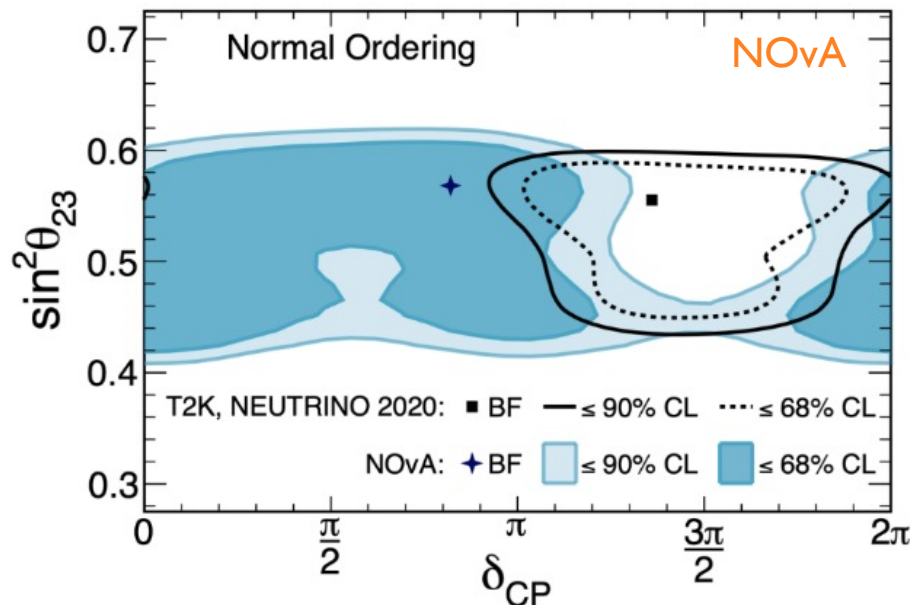
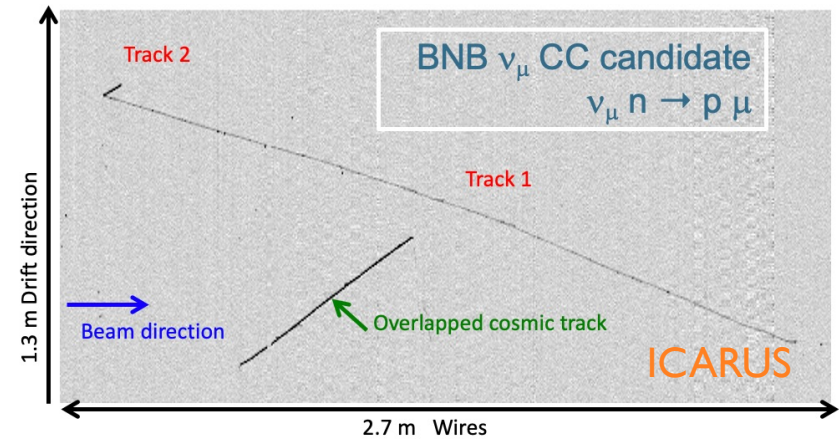
NF GENERAL MEETING (MONDAY 7/18)

To set the context for future plans, we will hear brief summaries of the major US initiatives in the vibrant, ongoing neutrino program at our general meeting.



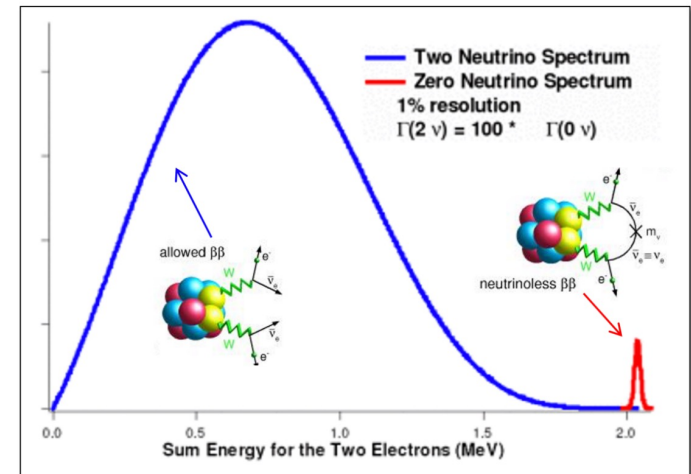
NF GENERAL MEETING (MONDAY 7/18)

- Agenda for general meeting:
 - Frontier business and logistics
 - Current program: SBN, NOvA, Low-energy Neutrinos
 - DUNE: Report from CD IRR, DUNE Overview
 - Town Hall (open discussion)



NUCLEAR PHYSICS IN NF

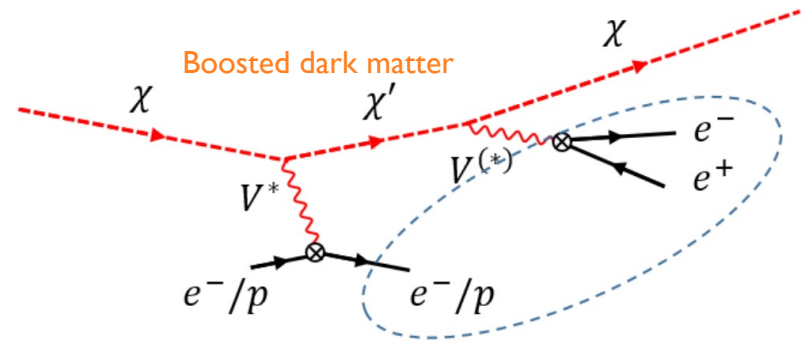
Some core aspects of the NF science drivers are traditionally outside the scope of particle physics. For example, the DOE Office of Nuclear Physics is stewarding the next phase of $0\nu\beta\beta$ experiments. From a scientific perspective, we feel it's important to consider all aspects of neutrinos together, so neutrino physics that is considered part of NP is included in our sessions and reports.



- Parallel sessions on neutrino properties
 - UF-NF-RF Facilities for measurements of $0\nu\beta\beta$ and neutrinos from natural sources (7/19)
 - NF-CF Neutrino mass scale with beta decay kinematics, double beta decay, and cosmology (7/22??)
 - NF: Beyond neutrino mass physics reach of precision beta-decay experiments (7/24)
- Parallel session on strategy:
 - NF: Optimizing Among Funding Agencies (7/22)

PHYSICS BEYOND THE STANDARD MODEL

Neutrino mass remains the only laboratory demonstration of non-SM physics and (further) BSM physics is emerging as a major focus of NF, thanks to anomalous measurements, large sensitive detectors, and creative theorists!



- Parallel sessions on BSM and Theory
 - NF: DUNE P5 Strategy: BSM Physics (7/19)
 - NF: DUNE P5 Strategy: Expanded Physics Scope in Phase II (7/20)
 - NF: Experimental Neutrino Anomalies (7/21)
 - NF-EF Cross-cutting issues (7/22)
 - NF: BSM/Dark Sectors & Reactor Neutrinos – Early Career Presentations (7/23)
 - NF-TF Neutrino Theory Network (7/23)
 - NF-CF-IF Dark matter detector (7/23)
 - NF: Beyond neutrino mass physics reach of precision beta-decay experiments (7/24)
 - RF-NF RF5 CLFV and neutrinos (7/24)

ASTROPHYSICS & COSMOLOGY

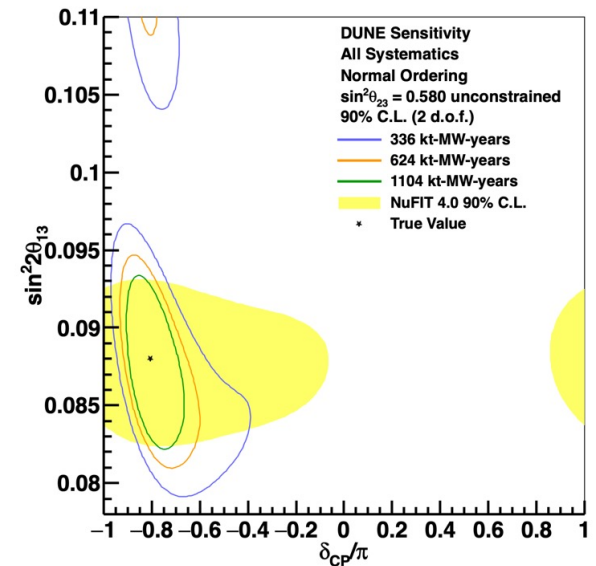
Studying neutrinos allows us to learn about a wide range of environments, like stellar fusion processes, supernova explosions, nucleosynthesis, and the origin of the highest-energy particles ever observed. Cosmology is sensitive to the number of neutrinos, the sum of their masses, and to potential new neutrino interactions.



- Parallel sessions on astrophysics, cosmology, and multi-messenger astronomy
 - NF: DUNE P5 Strategy: Low Energy and BSM Physics (7/19)
 - NF: DUNE P5 Strategy: Expanded Physics Scope in Phase II (7/20)
 - NF-CF Neutrino mass scale with beta decay kinematics, double beta decay, and cosmology (7/22??)
 - NF-CF-IF Dark matter detector (7/23)
 - NF-CF-TF High energy and ultrahigh energy astrophysical neutrinos (7/24)

DUNE

Deep Underground Neutrino Experiment (DUNE) will address many of the outstanding questions in neutrino physics by precisely measuring the parameters governing long-baseline neutrino oscillation in a single experiment. DUNE also has a broad physics program beyond three-flavor oscillation physics that includes multi-messenger astronomy and astrophysics, searches for a wide variety of BSM signatures, and precision SM measurements.



- Parallel sessions on DUNE
 - NF DUNE P5 Strategy: Oscillation Physics (7/19)
 - NF: DUNE P5 Strategy: Low Energy and BSM Physics (7/19)
 - NF: DUNE P5 Strategy: Expanded Physics Scope in Phase II (7/20)
 - NF: DUNE P5 Strategy: Phase II Detector R&D (7/20)
 - DUNE & Neutrino Interactions – Early Career Presentations (7/23)

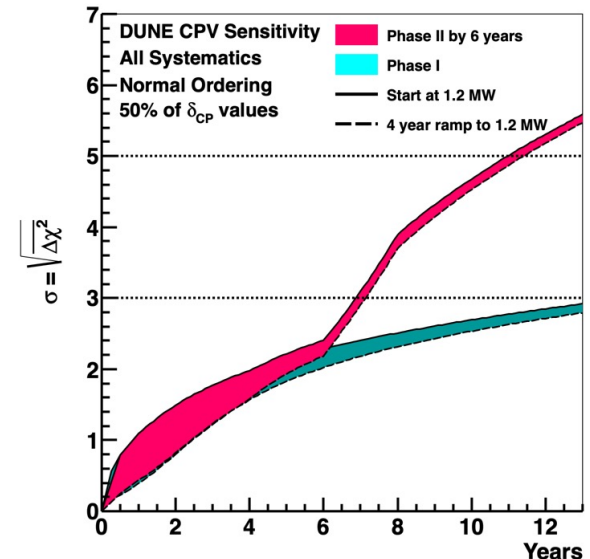
DUNE

DUNE will be built in two phases.

- Phase I (2 far detector modules, 1.2 MW beam, minimal near detector): mass ordering, measurement of δ_{CP} and other oscillation parameters
- Phase II (4 total far detector modules, 2.4 MW beam, upgraded near detector): necessary to achieve precision measurement goals, potential to expand physics scope as part of upgrades
- Phase II is a focus of the NF in Snowmass

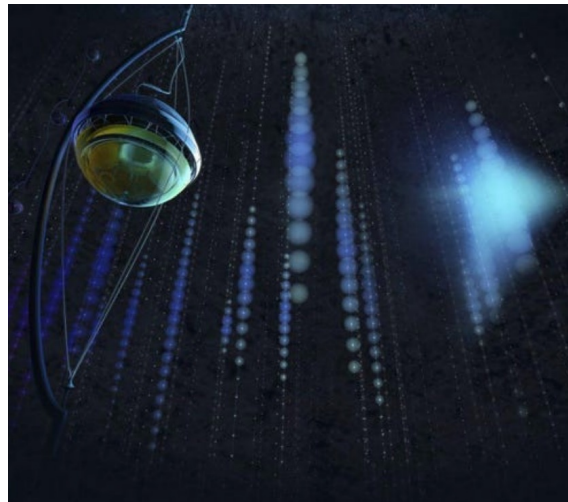
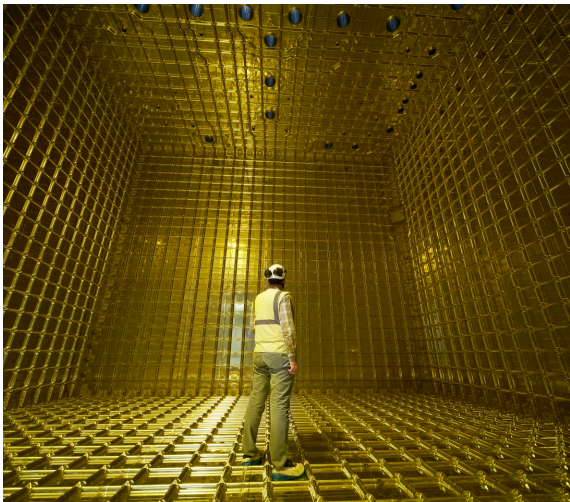
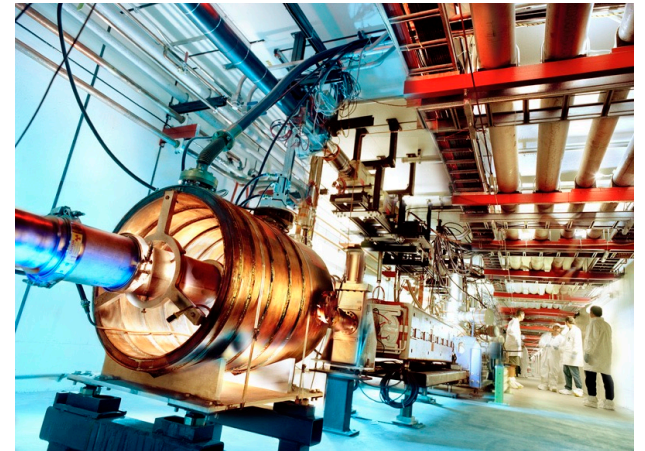
■ Parallel sessions on DUNE

- NF DUNE P5 Strategy: Oscillation Physics (7/19)
- NF: DUNE P5 Strategy: BSM Physics (7/19)
- NF: DUNE P5 Strategy: Expanded Physics Scope in Phase II (7/20)
- NF: DUNE P5 Strategy: Phase II Detector R&D (7/20)
- DUNE & Neutrino Interactions – Early Career Presentations (7/23)



DETECTOR/ACCELERATOR/FACILITIES DEVELOPMENT

Over the past decade there has been an explosion of new techniques and technologies for producing and observing neutrinos. These technological developments will likely impact other fields directly – there are particularly strong synergies with dark matter detection. Developments in accelerators and underground facilities are other areas with significant cross-frontier synergies.



DETECTOR/ACCELERATOR/FACILITIES DEVELOPMENT

- Parallel sessions on detector or accelerator development
 - UF-NF-RF: Facilities for measurements of 0nbb and neutrinos from natural sources (7/19)
 - NF: DUNE P5 Strategy: Phase II Detector R&D (7/20)
 - AF-NF: Booster Replacement Options (7/20)
 - NF: Blue Sky/Very Long Term Ideas (7/21)
 - UF-NF: Long Baseline Neutrinos and Underground Facilities for the Neutrino Frontier (7/21)
 - IF-NF: Instrumentation for Neutrino Experiments (7/23)
 - NF-CF-IF: Dark matter detector (7/23)
 - NF: New Opportunities in Neutrinos – Early Career Presentations (7/24)
 - NF: The Future is Now – Early Career Presentations (7/24)

COMMUNITY ENGAGEMENT

Discourse with other scientific disciplines, a diverse and welcoming environment within HEP, and education and outreach all facilitate collaborations necessary for NF success. A cohesive, HEP-wide strategic plan to address issues of diversity, equity and inclusion is critical.



01	02	03	04
Employment Security and Agency for all Black Scientists	Hire Black People with an Intersectional Lens	Restructure Leadership and Decision-making Entities	Commit to Accountability and Transparency
https://changenowphysics.com/			
05	06	07	
Education and Training	Invest in Black Communities	Make Commitments and Accountability Public	



- Parallel sessions on community engagement:
 - CEF-EF-NF-RF-CF-TF-AF-IF-CompF-UF: CEF Feedback (7/18)
 - NF: Community Engagement Success Stories in the Neutrino Frontier (7/24)

EARLY CAREER PRESENTATIONS

Most NF parallel sessions are focused on strategic planning as we did not feel it was appropriate or realistic to try to reproduce a neutrino physics conference here at CSS. The early-career presentations represent the only opportunity at CSS in the NF for contributed physics talks. Thank you to Jacob Zettlemoyer for leading this effort and to all the early career members who curated abstracts and will be chairing these sessions!



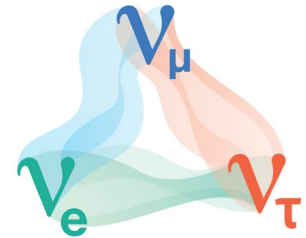
Photos from New Perspectives

- Parallel sessions for early career scientific presentations
 - NF: BSM/Dark Sectors & Reactor Neutrinos – Early Career Presentations (7/23)
 - NF: DUNE & Neutrino Interactions – Early Career Presentations (7/23)
 - NF: New Opportunities in Neutrinos – Early Career Presentations (7/24)
 - NF: The Future is Now – Early Career Presentations (7/24)

NF AFTERNOON PLENARY SESSIONS

■ Neutrino Frontier Colloquia: Big Picture Neutrino Science (7/22)

- Oscillation Physics: Three Flavor and Beyond (Mark Messier)
- BSM at Neutrino Experiments (André de Gouvêa)
- Neutrinos and Astrophysics (Kate Scholberg)



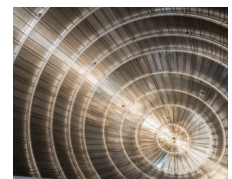
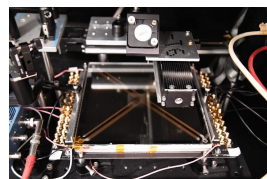
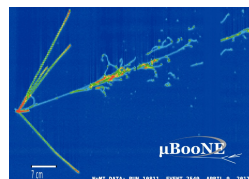
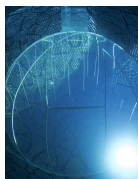
■ Neutrino Frontier Connections, Progress, and Plans (7/20)

■ Neutrino Connections:

- $0\nu\beta\beta$ Decay and Neutrino Mass (Joe Formaggio)
- Neutrino Interactions (Kendall Mahn)
- Beams and Instrumentation (Josh Klein)

■ Projects and Plans: Panel Discussion

- Overview of NF Projects (Joe Lykken)
- Sergio Bertolucci, Joe Lykken, Reina Maruyama, Lia Merminga, Jason Newby, J. Pedro Ochoa, Ron Ray



MORE INFORMATION & INPUT OPPORTUNITIES

- NF colloquium series in April-May provides an excellent summary of the physics of and with neutrinos. Recordings available and well worth your time:
 - Neutrinos in the Three Flavor Paradigm: <https://indico.fnal.gov/event/52707/>
 - Neutrinos & Beyond the Standard Model: <https://indico.fnal.gov/event/52708/>
 - Neutrinos & Nuclear Physics: <https://indico.fnal.gov/event/52709/>
 - Connections with Astrophysics & Astronomy; New Accelerator Facilities: <https://indico.fnal.gov/event/52706/>
- NF Town Hall tomorrow will be an open mic – please feel free to share any questions, comments, concerns, suggestions, words of wisdom, ...
- Neutrino Frontier Report
 - Draft executive summary, with feedback spreadsheet: <https://snowmass21.org/neutrino/start/drafts/execsumm>
 - Work-in-progress draft of NF report, with feedback spreadsheet (available later this week): <https://snowmass21.org/neutrino/start/drafts/nfreport>
 - Drafts of topical group reports, with feedback spreadsheets: <https://snowmass21.org/neutrino:start:drafts>

REMARKS

- Huge thank you to the topical group conveners, frontier liaisons, early career participants and liaisons, CSS local organizers, and everyone who has worked so hard to prepare for this meeting!
- While we have a very full slate of NF-organized sessions, we are very much looking forward to attending other frontiers' sessions and encourage NF'ers to do this as much as possible. The sessions we have planned for NF are generally not overly technical and we welcome attendance, input, and discussion from all the other frontiers at any of our sessions.
- We're excited about the physics of neutrinos and the many connections we have identified to other areas of particle physics and the larger scientific community. Looking forward to spending this time together as a community to develop a common message!