

CPM Parallel Session #61

Energy and Power and Time structure goals for Neutrino Frontier programs

Snowmass CPM Meeting

October 6 2020

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NF07/Targets & Sources Charlotte Barbier, Frederique Pellemoine, Yin-E Sun

Welcome to CPM Parallel Session #61

- Welcome and thanks for attending this parallel session!

Energy, Power and Time structure goals for the Neutrino Frontier Programs

- It is jointly organized by three Snowmass Topical groups:

NF09: Artificial Neutrino Sources

AF02: Accelerators for Neutrinos

AF07: Accelerator Technology: Targets/Sources

- AF02 has asked NF09 to outline what the energy, power, and time requirements for proposed neutrino frontier activities. This is the focus of this session.
- The plan for this session: each group will present the status of where they are in the process of digesting letters of intent / planning for our reports, focusing on the interface between neutrinos and accelerators

DPF Core Principles and Community Guidelines (CP&CG)

- By participating in this meeting, we all agree to adhere to the CP&CG
 - **Respect and support community members**
 - **Commit to constructive dialogue and take initiative**
- Details of what this means, expectations for behavior, and accountability procedures are provided in the CP&CG document linked at:
<https://snowmass21.org/cpcg/start>
- Everyone is invited to invoke the CP&CG as needed to encourage constructive and supportive collaboration
- The conveners of this meeting ([Laura Fields](#) and [Bob Zwaska](#)) are your recommended first point of contact for reports of CP&CG violations occurring here
 - The conveners have received training in the CP&CG and how to handle reports
 - The CP&CG accountability procedure is designed to encourage early intervention and is flexible enough to appropriately address issues ranging from the discourteous to the egregious

Please do not hesitate to contact us!

Snowmass is most successful when everyone's voice can be heard!

NF09 - Artificial Neutrino Sources

Snowmass CPM Meeting

Parallel Session #61

October 5-7 2020

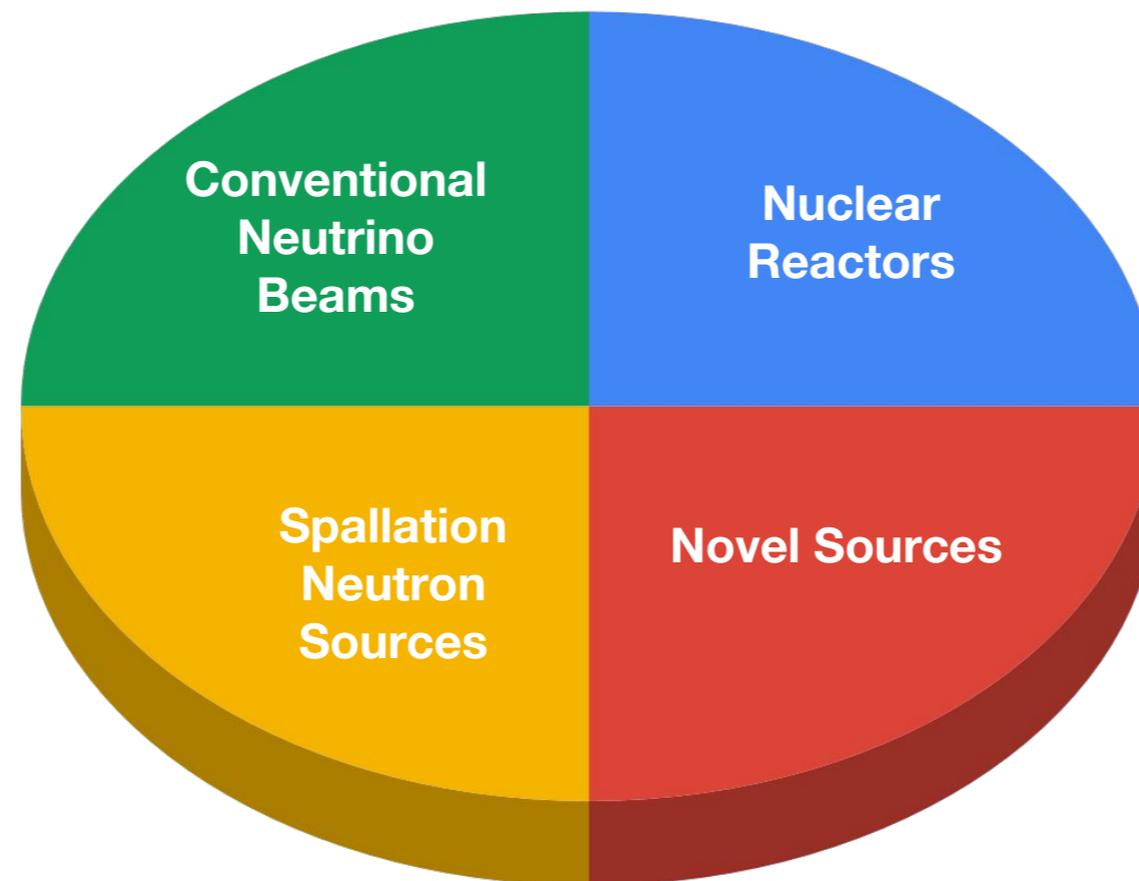
[L. Fields](#), [A. Marino](#), [P. Ochoa](#), [J. Spitz](#)

Welcome to CPM Parallel Session #61

- Report from NF02:
 - What our group covers
 - Summary of LOIs relevant to our group
 - Preliminary outline of report
 - We attempt to highlight missing pieces, ie artificial neutrino source topics that we think are important to the Snowmass process, but that were not covered in LOIs
 - First draft table of accelerator requirements for neutrino programs
 - NF02 plans going forward

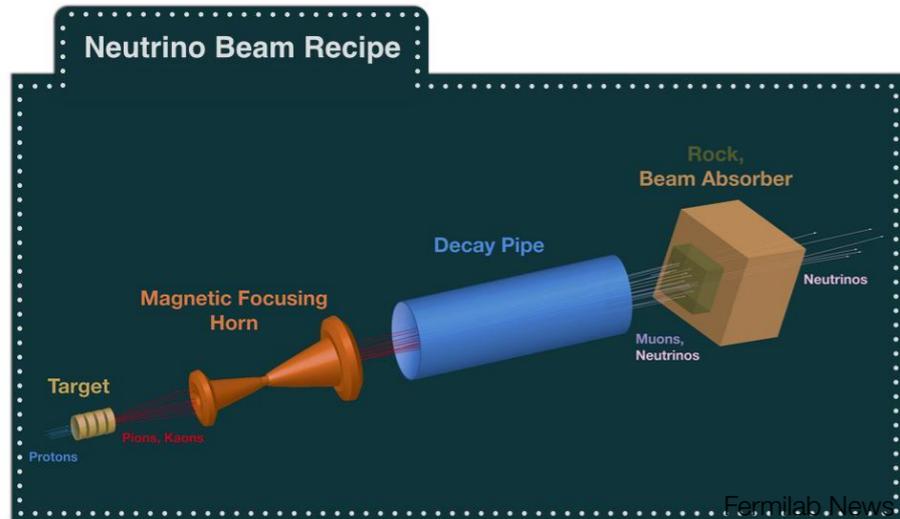
Intro to NF09: Artificial Neutrino Sources

Our group covers the development of new or upgraded artificial neutrino sources, as well as efforts to characterize/understand these sources.

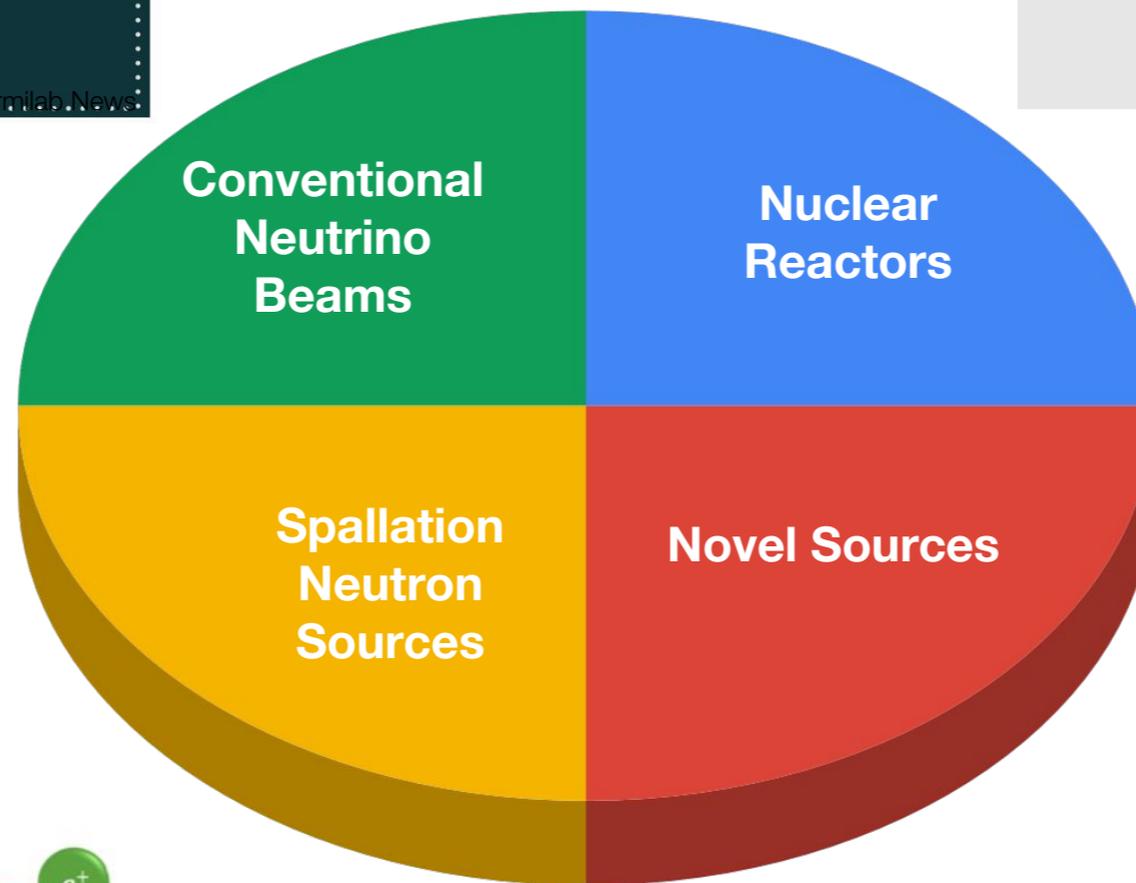
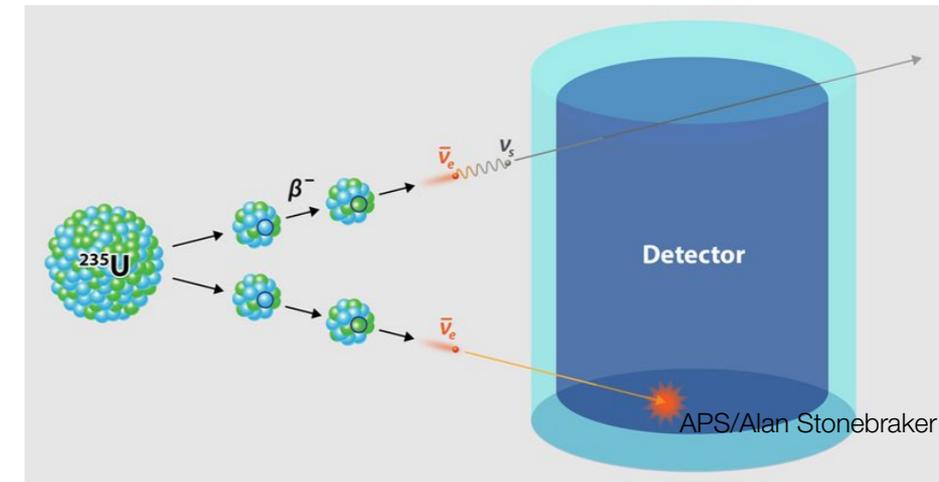


Intro to NF09: Artificial Neutrino Sources

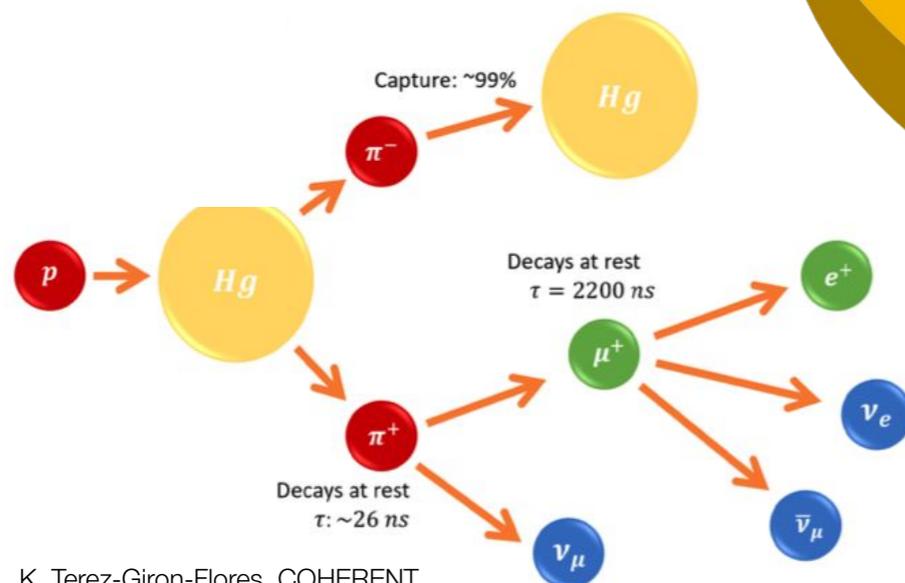
GeV-scale proton beams on fixed targets + hadron focusing and decay volumes



Beta decay of neutron-rich fission fragments at nuclear power plants.



Neutrino by-products of spallation neutron production



Everything else

Electron capture sources, beta beams, neutrino factories, etc

Landscape of Artificial Neutrino Sources in ~2024

Precision measurements of 3-flavor oscillations (including θ_{CP}), mass ordering, searches for sterile neutrinos and other BSM, neutrino interactions

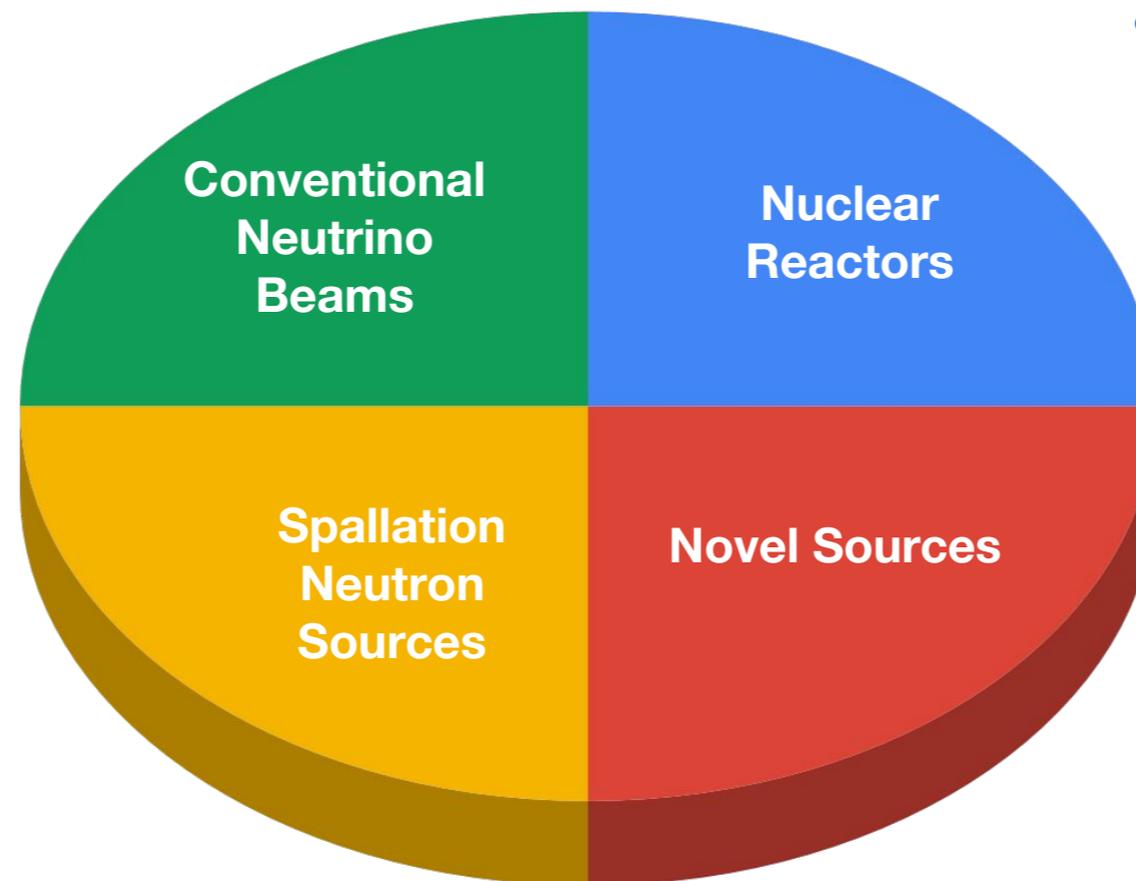
- NuMI at Fermilab
- BNB at Fermilab
- LBNF (under construction at Fermilab)
- T2K Beamline at JPARC

Coherent neutrino-nuclear scattering; cross sections for supernovae, tests of electro-weak theory

- SNS at Oak Ridge
- LANSCE at Los Alamos
- JSNS in Japan
- ESS in Sweden
- ISIS in the UK
- SINQ in Switzerland
- CSNS in China

Precision measurements of 3-flavor oscillations, mass ordering, searches for sterile neutrinos and other BSM, reactor flux characterization

- Daya Bay (China)
- JUNO and JUNO-TAO (China)
- WATCHMAN (UK)
- PROSPECT (US)



- BEST in Russia
- ???

NF09 is focusing on upgrades to these facilities, new sources beyond what is currently under construction, and characterization of new and existing sources

Letters of Interest Received

- A total of 69 LOIs fell under our group's purview:
 - We are the **primary** group within the NF for **15** of them:

Unique ID	Title	Subcategory
AF092	<i>Versatile Multi-MW Proton Facility with Synchrotron Upgrade of Fermilab Proton Complex</i>	Conventional neutrino beams
AF025	<i>The Need for Research into Early Conceptual Integration and Optimization, and Maturity evaluation of Future Accelerators</i>	Conventional neutrino beams
NF116	<i>The use of Precision Beam Timing in LBNF/DUNE.</i>	Conventional neutrino beams
NF173	<i>The EMPHATIC Table-Top Spectrometer: Enabling Hadron Scattering and Production Measurements for Improved Beam Simulations</i>	Hadron production and ancillary measurements
NF069	<i>The future NA61/SHINE program on hadron production</i>	Hadron production and ancillary measurements

(Unique ID numbers link to the LOI pdf)

- NF09 topical group **primary** LOIs, continued:

Unique ID	Title	Subcategory
NF062	<i>The ESS neutrino Super Beam Design Study (ESSnuSB) and the High Intensity Frontier Initiative (HIFI)</i>	Spallation neutron sources
NF108	<i>ORNL Neutrino Sources for Future Experiments</i>	Spallation neutron sources and Reactor Sources
NF140	<i>High-Resolution Multiphysics Reactor Modeling for the Antineutrino Source Term</i>	Nuclear Reactors
NF117	<i>Prediction and Measurement of the Reactor Neutrino Flux and Spectrum</i>	Nuclear Reactors
NF035	<i>The JUNO-TAO Experiment</i>	Nuclear Reactors
NF086	<i>Legacy of the Daya Bay Reactor Antineutrino Experiment</i>	Nuclear Reactors
AF121	<i>Progress with the IsoDAR Cyclotron</i>	Novel sources
AF081	<i>Tau neutrino Production at a Multi-TeV Lepton Collider</i>	Novel sources
NF047	<i>The IsoDAR (Isotope Decay At Rest) ν-e-bar source</i>	Novel sources
NF038	<i>Physics with Electron Capture Neutrino Sources</i>	Novel sources

(Unique ID numbers link to the LOI pdf)

- There are several other LOIs involving the development of artificial sources and/or their characterization that are also very high on our radar:

Unique ID	Title	Subcategory	Relevance to NF09
NF187	<i>The Hyper-Kamiokande Experiment</i>	Conventional neutrino beams	uses J-PARC beam
NF145	<i>The NOvA Physics Program through 2025</i>	Conventional neutrino beams	discusses NuMI beam upgrades
NF130	<i>T2K Experiment: future plans and capabilities</i>	Conventional neutrino beams	discusses T2K beam upgrades
RF099	<i>Fixed-Target Searches for New Physics with O(1 GeV) Proton Beams at Fermi National Accelerator Laboratory</i>	Conventional neutrino beams	possible beam dump facility at Fermilab
IF095	<i>Coherent LOI 5: Instrumentation Development</i>	Hadron production and ancillary measurements	includes D20 detector to determine neutrino flux
NF118	<i>3D-projection Scintillator Tracker (3DST) in SAND, a DUNE Near Detector Subsystem</i>	Hadron production and ancillary measurements	Instrumentation to monitor neutrino beam
EF038	<i>FASER 2: Forward Search Experiment at the HL LHC</i>	Novel sources	LHC as a source for TeV neutrinos
NF126	<i>Tau Neutrino Physics</i>	Novel sources	new sources for tau neutrino physics?
NF080	<i>Neutrino Physics with IsoDAR</i>	Novel sources	us of proposed novel source (IsoDAR)
NF082	<i>Neutrinos from stored muons; nuSTORM</i>	Novel sources	stored muon ring source

(Unique ID numbers link to the LOI pdf)

- LOIs high on NF09's radar, continued:

Unique ID	Title	Subcategory	Relevance to NF09
AF215	<i>LANSCCE-PSR Short-Pulse Upgrade for Improved Dark Matter and Sterile Neutrino Searches</i>	Spallation neutron sources	possible beam upgrade to search for steriles and dark matter
NF128	<i>The JSNS² Experiment</i>	Spallation neutron sources	use of spallation neutron source
NF095	<i>Future COHERENT physics program at the SNS</i>	Spallation neutron sources	relies on potentially upgradable spallation neutron source
NF111	<i>COHERENT Sensitivity to Dark Matter</i>	Spallation neutron sources	relies on potentially upgradable spallation neutron source
NF067	<i>Far-Future COHERENT physics program at the SNS</i>	Spallation neutron sources	relies on potentially upgradable spallation neutron source
NF161	<i>Neutrino Opportunities at the ORNL Second Target Station</i>	Spallation neutron sources	potential offered by neutrino source

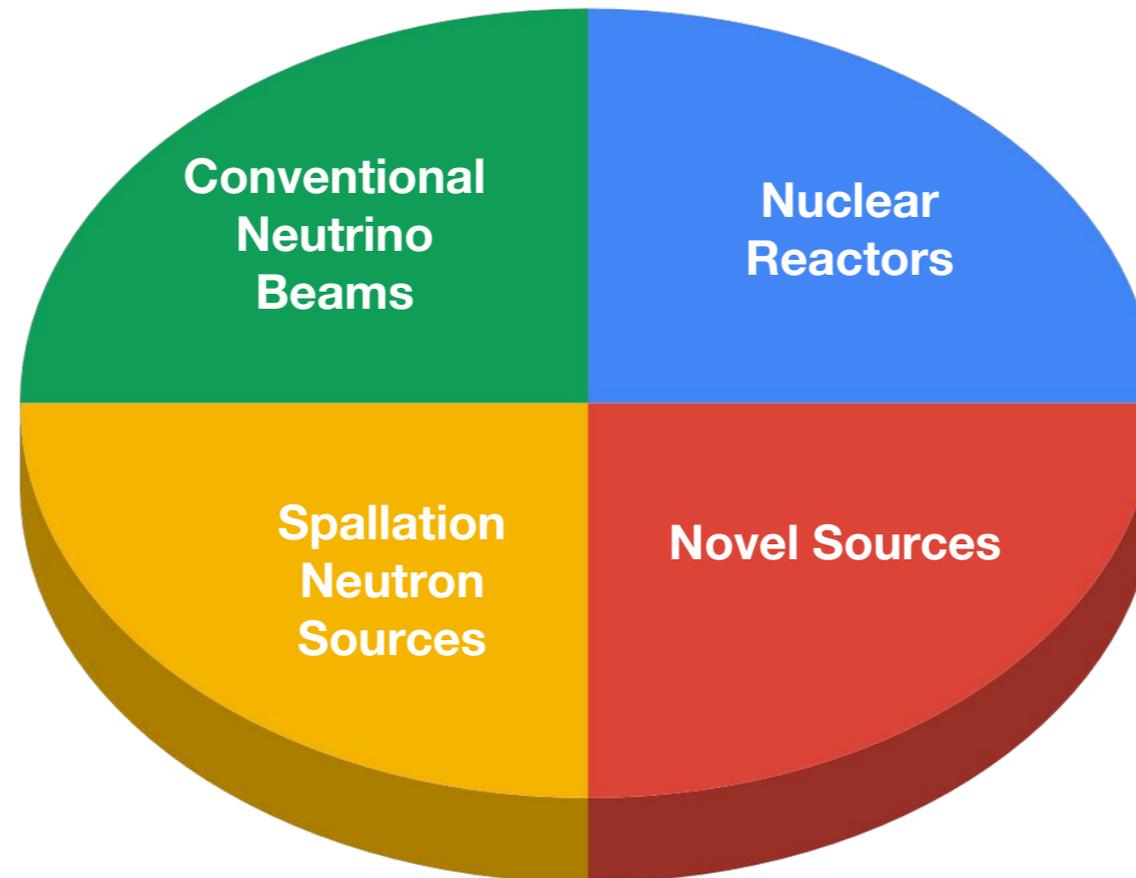
(Unique ID numbers link to the LOI pdf)

- LOIs high on NF09's radar, continued:

Unique ID	Title	Subcategory	Relevance to NF09
NF034	<i>The JUNO Experiment</i>	Nuclear reactors	Reactor physics at JUNO + possibility of cyclotron source
NF185	<i>Reactor and Geo Neutrinos at SNO+</i>	Nuclear reactors	Reactor antineutrino measurements at SNO+
NF075	CHANDLER: A Technology for Surface-level Reactor Neutrino Detection	Nuclear reactors	characterization of reactor antineutrino emission
NF168	<i>Forthcoming Science from the PROSPECT-I Data Set</i>	Nuclear reactors	characterization of reactor antineutrino emission
NF169	<i>The Expanded Physics Reach of PROSPECT-II</i>	Nuclear reactors	characterization of reactor antineutrino emission
NF128	<i>Mutual Benefits derived from the Application of Neutrino Physics to Nuclear Energy & Safeguards</i>	Nuclear reactors	characterization of reactor antineutrino emission
NF184	<i>ROADSTR: A Mobile Antineutrino Detector Platform for enabling Multi-Reactor Spectrum, Oscillation, and Application Measurements</i>	Nuclear reactors	characterization of reactor antineutrino emission

- Feel free to take a look if you are interested (click on the links)
- Let us know if you have feedback for us! (bear in mind that there are other “tertiary” LOIs in our radar not listed here)

Major Themes in NF09



- In the next few slides, we expand on each topic, highlighting LOIs for each
- This is essentially a draft outline of our summary report
 - Obviously subject to change based on further input
- Currently reaching out to community in areas where LOIs were not submitted
- We welcome your help in identifying topics missing from this outline

Tentative Outline: Conventional Beams

- Summary of existing sources and understanding of those sources (LOI: includes NF145, NF130)
- Source Development / Upgrades
 - Fermilab beam upgrade plans/possibilities (LOI: AF092 on beam upgrade path, but **physics case not detailed in LOIs**)
 - JPARC neutrino beam upgrade plans/possibilities (LOI: NF130, NF187)
 - Beams for tau neutrinos: (LOI: NF126 on physics, **No submissions on beam development**)
 - Time-bunched sources: (LOI: NF116)
 - Protvino to ORCA- P20: (**No submissions**)
- Neutrino flux determination and hadron production measurements
 - EMPHATIC (LOI: NF173)
 - NA61/SHINE (LOI: NF062)
 - SAND for DUNE (LOI: NF118)
 - ENubet (**No submissions**)

Tentative Outline: Nuclear Reactors

- Short summary of existing methods to predict flux and shape of reactor antineutrinos
- Importance of reactor antineutrino predictions
 - For basic science and reactor monitoring (LOI: NF117, NF140)
 - For nuclear physics (**No submissions**)
- Predictions vs. experiment: current status
 - PROSPECT-I (LOI:NF168)
 - Daya Bay - Legacy (LOI: NF086)
 - Other experiments (no submissions but can make a summary)
- Expected improvements in predictions:
 - High-resolution multiphysics reactor modeling (NF140)
 - Others (e.g. beta decay data)? (**No submissions**)
- Future experiments and reactors:
 - HIFR, PROSPECT-II (LOI: NF169, NF108)
 - JUNO (LOI: NF034)
 - JUNO-TAO (LOI: NF135)
 - SNO+ (LOI: NF185)
 - Others? Need more submissions
- Interplay between basic science and reactor monitoring:
 - CHANDLER (LOI: NF075)
 - ROADSTR (LOI: NF184)
 - Mutual benefits (LOI: NF128)

Tentative Outline: Neutrinos from Spallation Sources

- Spallation sources and development
 - Future and far-future COHERENT program (LOI: NF095, NF067, NF108)
 - ORNL Second target station (LOI: NF161)
 - ESSnu Superbeam (LOI: NF062)
 - JSNS² at J-PARC Spallation Source (LOI: NF128)
- Flux monitoring and hadron production
 - D2O flux monitor at SNS (LOI: IF095)
 - Low energy beam upgrade in NA61 to measure production on Hg targets (LOI: NF062)

Tentative Outline: Novel Sources

- Beta beams (**No submissions**)
- nuSTORM (LOI: NF082)
- Neutrino factories (**No submissions**)
- IsoDAR (LOI: AF121, NF047, NF080)
- Intense radioactive sources
 - Electron capture sources (LOI: NF038)
 - Radioactive source for BEST (no submissions, but data taking is now complete)
- Beam dump sources
 - LANSCE (LOI: AF215)
 - FNAL beam dump (LOI: RF099)
- Hadron and electron colliders
 - LHC/Faser2 (LOI: EF038)
 - FCC (LOI: EF017)
 - multi-TeV lepton collider as a tau neutrino source (LOI: AF081)
- In general, LOIs are **light on physics cases for major new facilities**
 - E.g. beams that could study ALL neutrino oscillation channels (e.g. $\nu_e \rightarrow \nu_x$)

Primary/secondary LOIs to NF09 and accelerator requirements

Experiment/accelerator	LOI(s)	Relevant beam params./comments
FNAL complex synchrotron upgrade	AF092,RF099	12 GeV, 1.15 MW; 120 GeV, 2.4 MW; Fixed-target 800 MeV-GeV-scale, 500 kW
Compact cyclotron (IsoDAR)	AF121,NF047, NF080	60 MeV H_2^+ , 600 kW
Multi-TeV muon collider (Dallavalle <i>et al.</i>)	AF081	Multi-TeV leptons
LBNF w/ tighter timing (Wetstein <i>et al.</i>)	NF116	100 ps proton bunches
ESSnuSB (Ekelof <i>et al.</i>)	NF062	2-2.5 GeV, 5 MW
FNAL test-beam (EMPHATIC)	NF173	beam exists
CERN test-beam (NA61/SHINE)	NF069	low-E (1-20 GeV) upgrade
ORNL SNS	NF108,NF095, NF111,NF067, NF161	1 GeV, 2 MW upgrade (w/ 2nd target)
LANL LANCSE w/ tighter timing	AF215	800 MeV, 100 kW (30 ns upgrade)
FASER 2 @ LHC, near ATLAS	EF038	LHC Run 3
J-PARC main-ring (T2K) upgrade	NF187,NF130	30 GeV, 1.3 MW
FNAL LBNF (vanilla)	NF118	60-120 GeV, 1.2-2.4 MW
FNAL NuMI upgrade	NF145	120 GeV, 900 kW
J-PARC SNS	NF128	3 GeV, 1 MW
NuSTORM	NF067	100 GeV protons w/ muon storage ring

Going Forward

- We plan to hold a workshop in early December:

- Three days: **December 2-4 (W-F)**
- Virtual, 3-4 hours per day, morning US time
- Organized around list of “big topics” (different colors) from previous lists
- Open to all, talks most likely by invitation only

nuclear reactor session
likely held jointly with
NF07 (applications)
group

details to be
announced soon

- Also plan to continue coordinating with the accelerator frontier (AF):

- Continue regular meetings with AF02 (accelerators for neutrinos) (add AF07?)
- Need to understand accelerator requirements associated with various neutrino physics goals

get in touch with us, even if you
did not submit an LOI

- Join the [SNOWMASS-NF09-ARTIFICIAL-SOURCES](#) list!

- Get in touch with us: ljf26@fnal.gov, amarino@colorado.edu,
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