# Mid and Small Scale Experiments in the Neutrino Frontier

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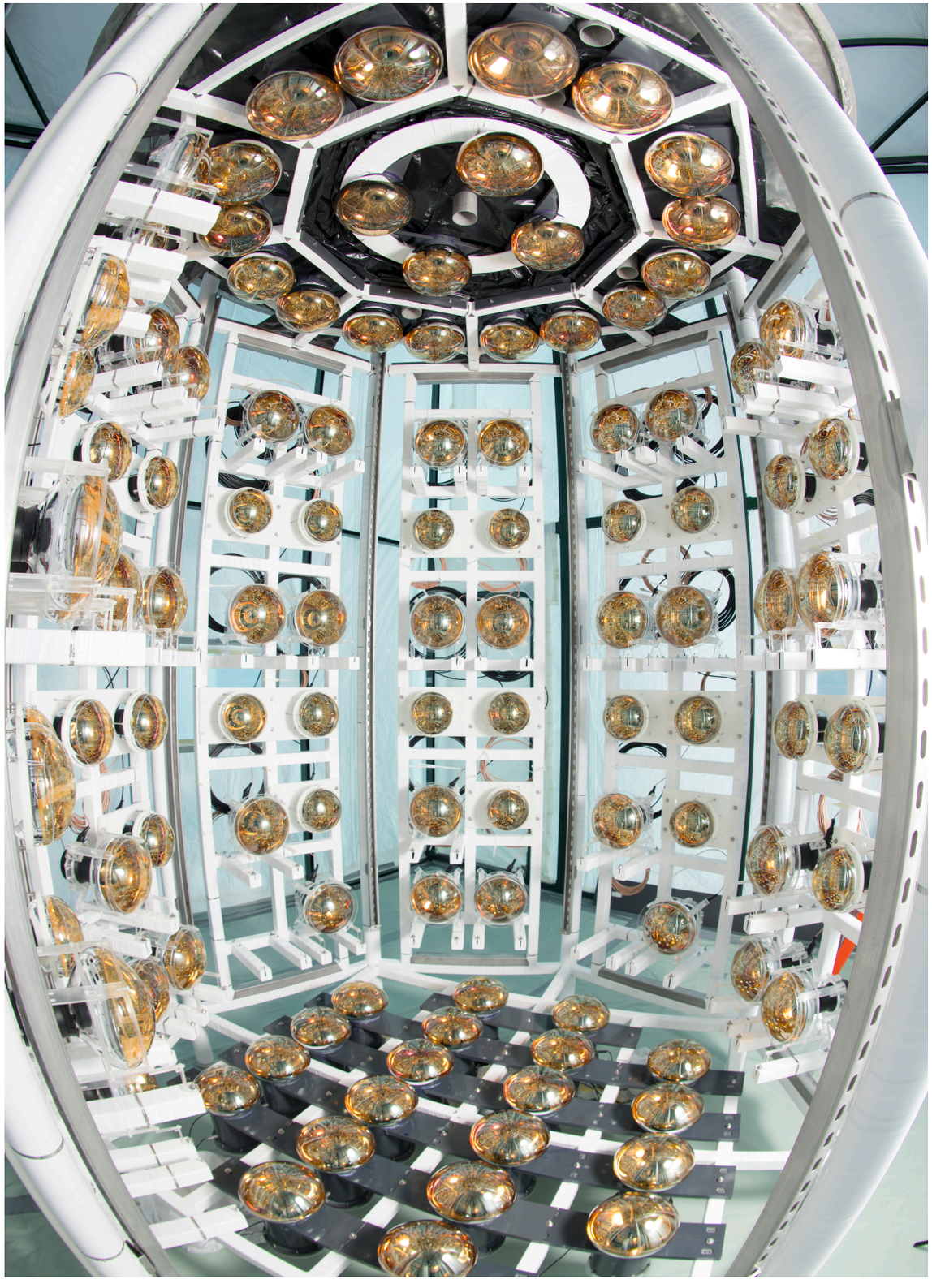


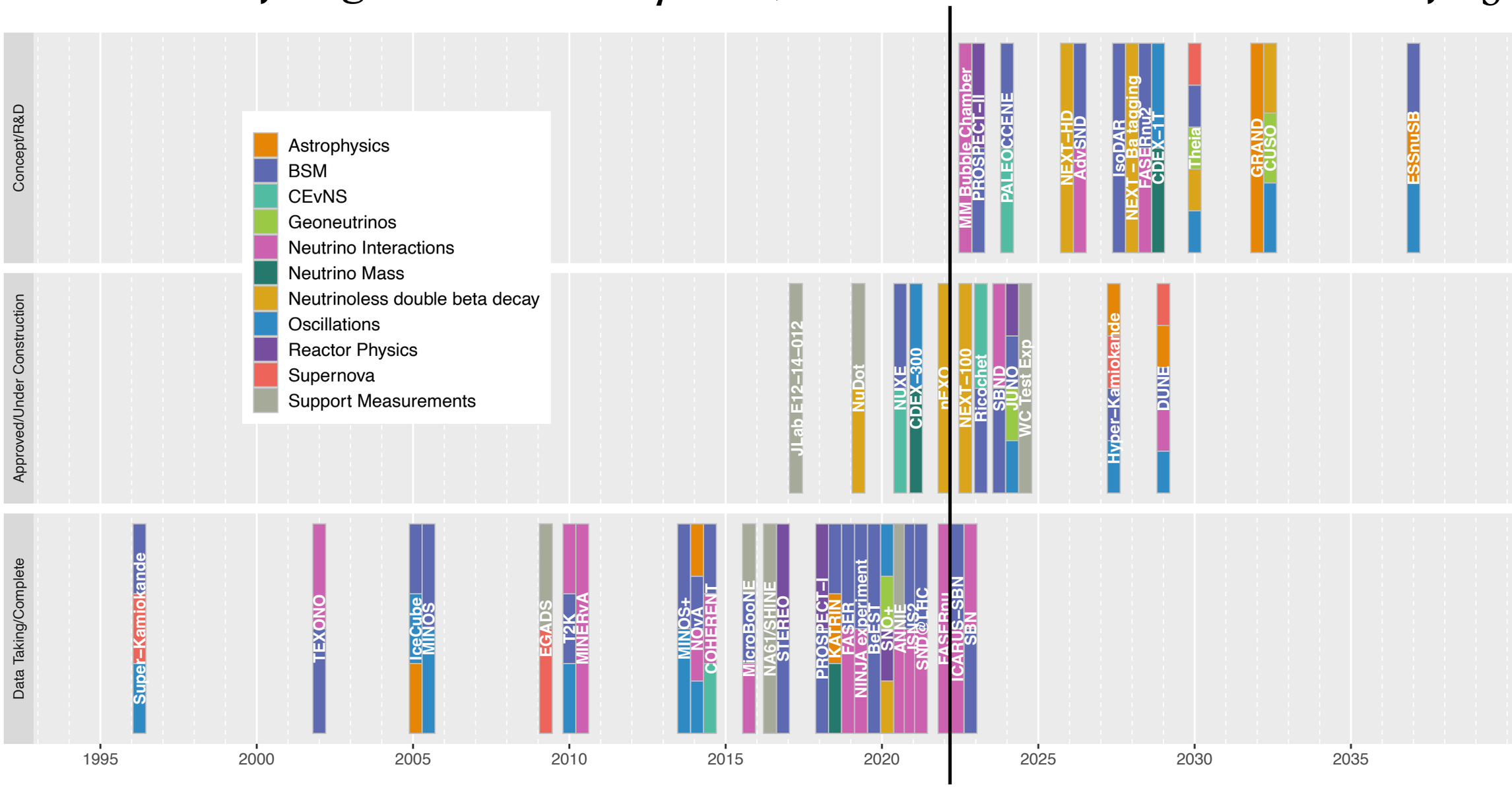
The ANNIE Experiment

captions go here

CSS SNOWMASS - July 26, 2022

# What is Mid and Small Scale in NF?

- ... not DUNE (or DUNE Phase II see previous panel)
- ... experiments below $500M total or in US contribution to large projects
- ... too many to go into detail in 7 mins; not all would be raise to review by P5

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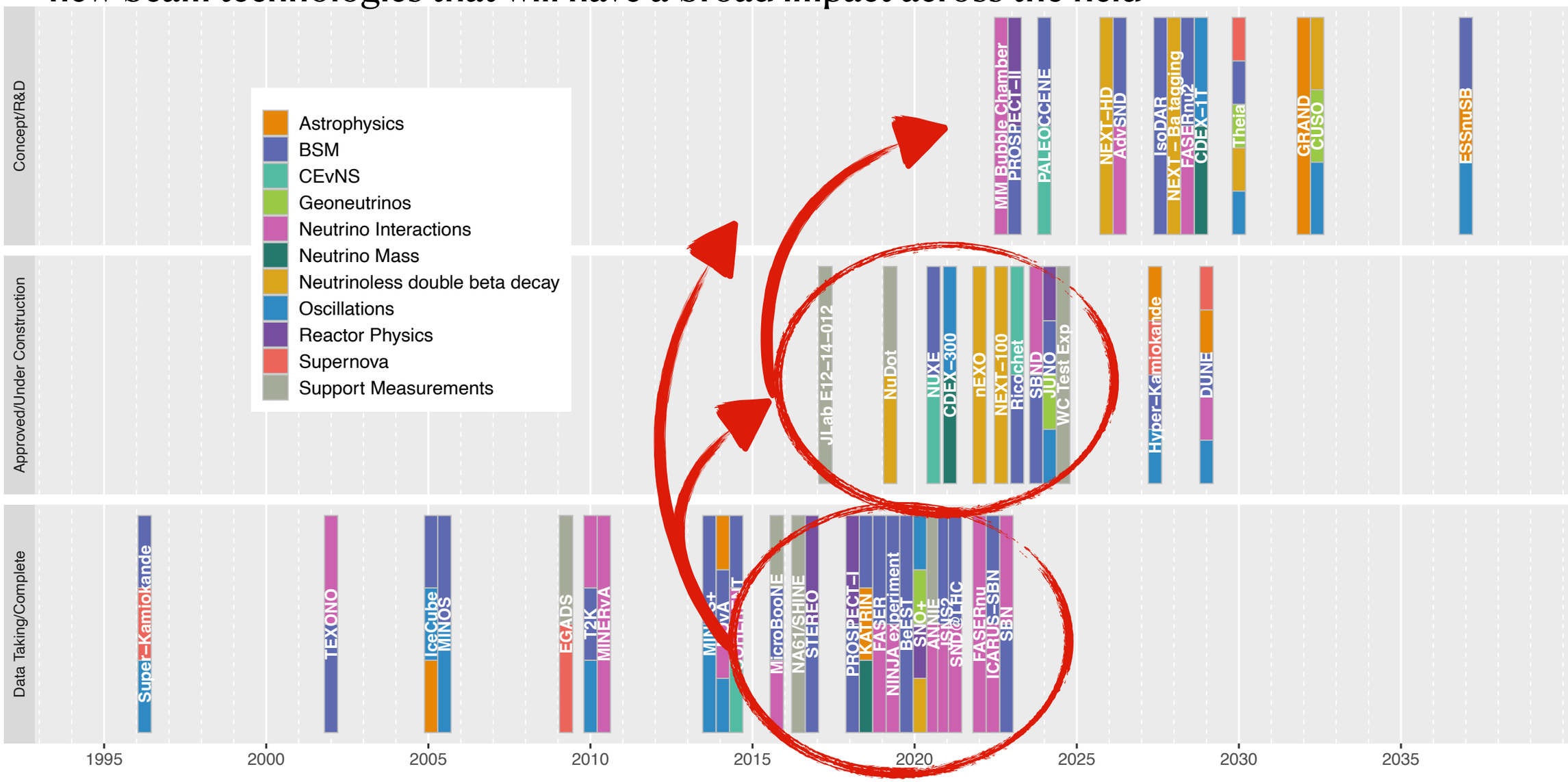
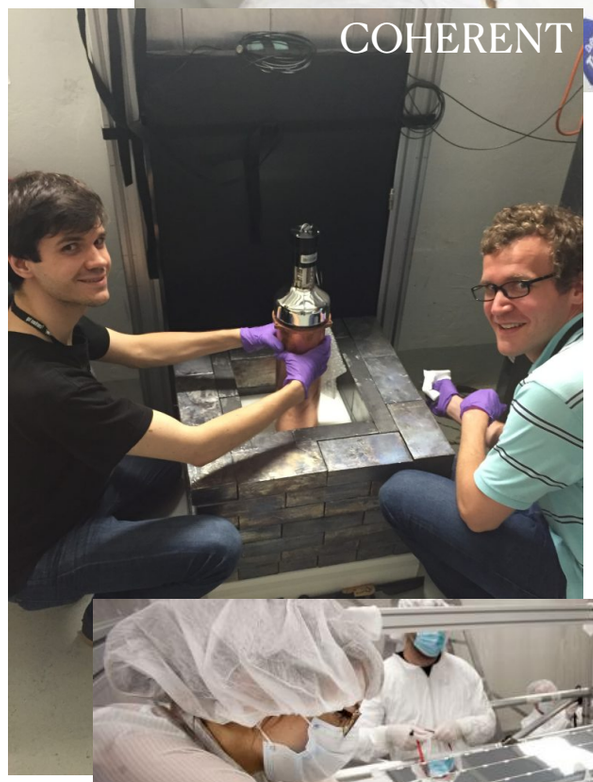
# What is Mid and Small Scale in NF?

- ... experiments that address many of relevant science and R&D questions in NF
- ... experiments that would exploit opportunities at accelerators, spallation sources, reactors, etc
- ... experiments that provide opportunities to explore and resolve existing and future neutrino-related anomalies, to support the future of the program and to develop instrumentation and new beam technologies that will have a broad impact across the field



# The case for Mid and Small Scale Experiments

- Mid- and Small Scale experiments **do discovery science!**
- Mid/small scale projects are **R&D platforms that enable future new science opportunities!**
- Long lead times of large projects leave space for exploring new ideas and science in the mid/small scale.
- Mid/small scale projects allow full cycle from planning to data taking to occur in shorter time periods.
- Provide essential **hands-on training for junior researchers** to acquire technical skills and experience a full experiment cycle.



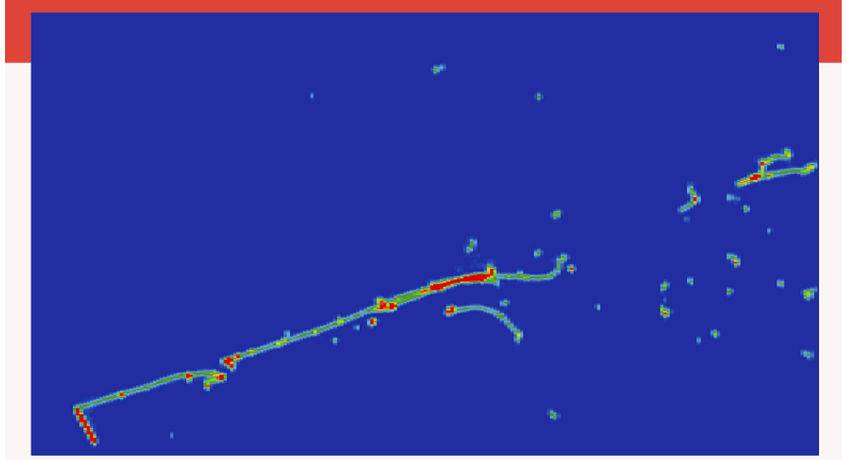
**Mid and Small scale experiments are a unique training ground for future leaders and technical personnel for the field**

# Mid and Small Scale in NF Examples

## MicroBooNE experiment's first results show no hint of a sterile neutrino

10/27/21

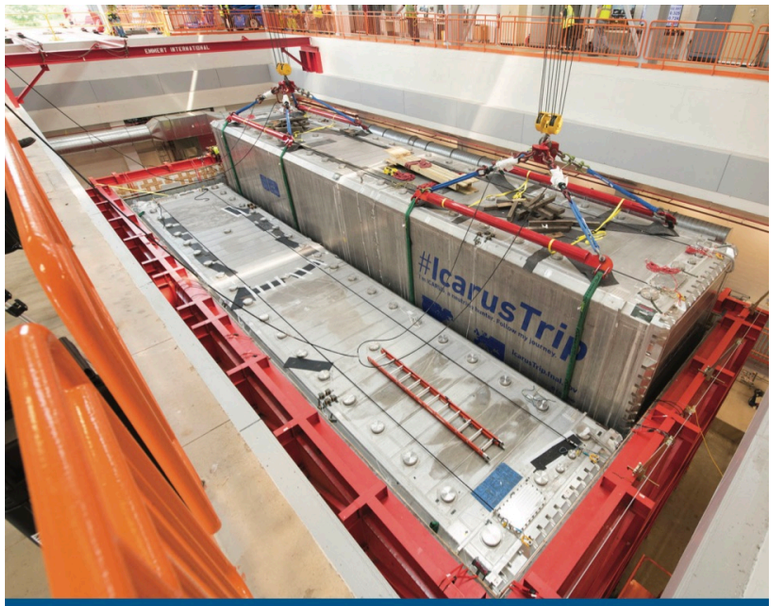
Four complementary analyses by Fermilab's MicroBooNE show no signs of a theorized fourth kind of neutrino.



Fermilab

## The search for a fourth neutrino

**An international research program at Fermilab will probe one of the enduring mysteries of science: Are there only three types of ghostly particles known as neutrinos, or is a fourth type waiting to be discovered?**




The ICARUS detector was installed in its Fermilab research hall in 2018.

## Anomaly Search by MicroBooNE

Measurement of the flux-averaged inclusive charged-current electron neutrino and antineutrino cross section on argon using the NuMI beam and the MicroBooNE detector

P. Abratenko *et al.* (MicroBooNE Collaboration)
Phys. Rev. D **104**, 052002 – Published 8 September 2021

## Cross sections on Argon by MicroBooNE

- Liquid Argon Detectors in the SBN program search for neutrino anomalies and also important measure crucial cross sections for the future of the NF program.

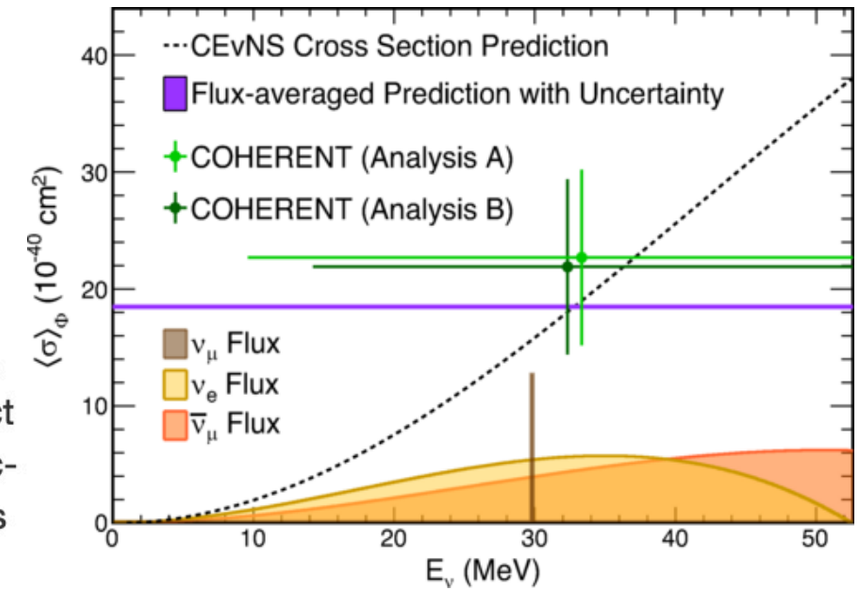
# Mid and Small Scale in NF Examples

## Compelling evidence of neutrino process opens physics possibilities

*Date:* January 26, 2021

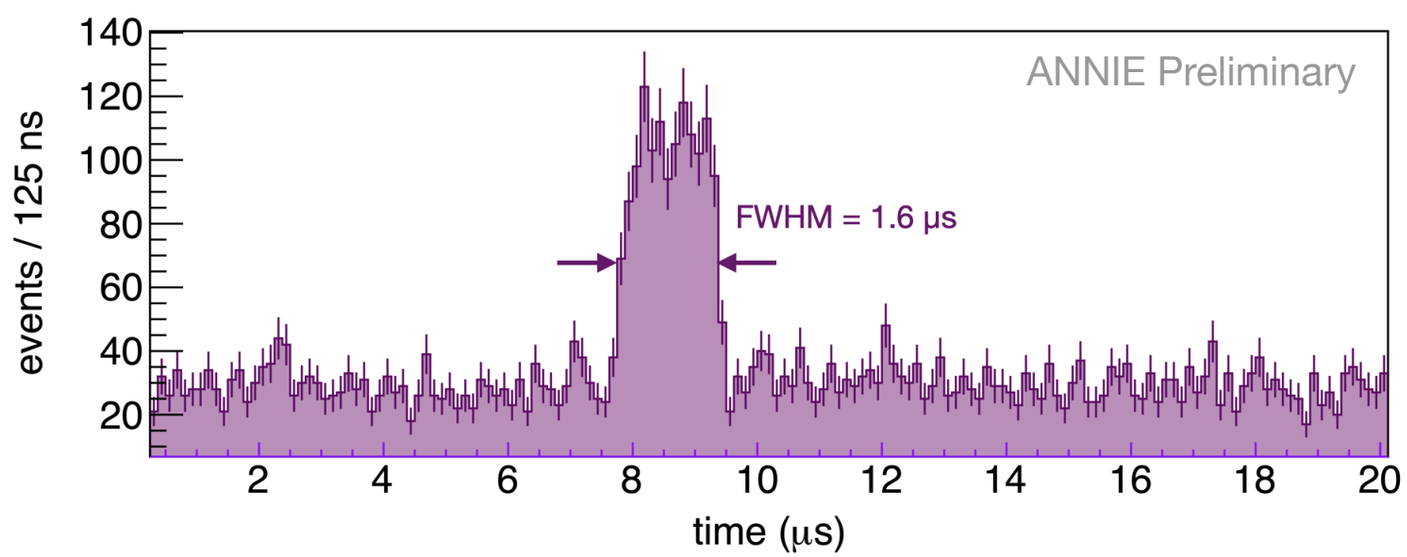
*Source:* DOE/Oak Ridge National Laboratory

*Summary:* The COHERENT particle physics experiment has firmly established the existence of a new kind of neutrino interaction. Because neutrinos are electrically neutral and interact only weakly with matter, the quest to observe this interaction drove advances in detector technology and has added new information to theories aiming to explain mysteries of the cosmos.




**Observation of a new neutrino interaction by COHERENT**

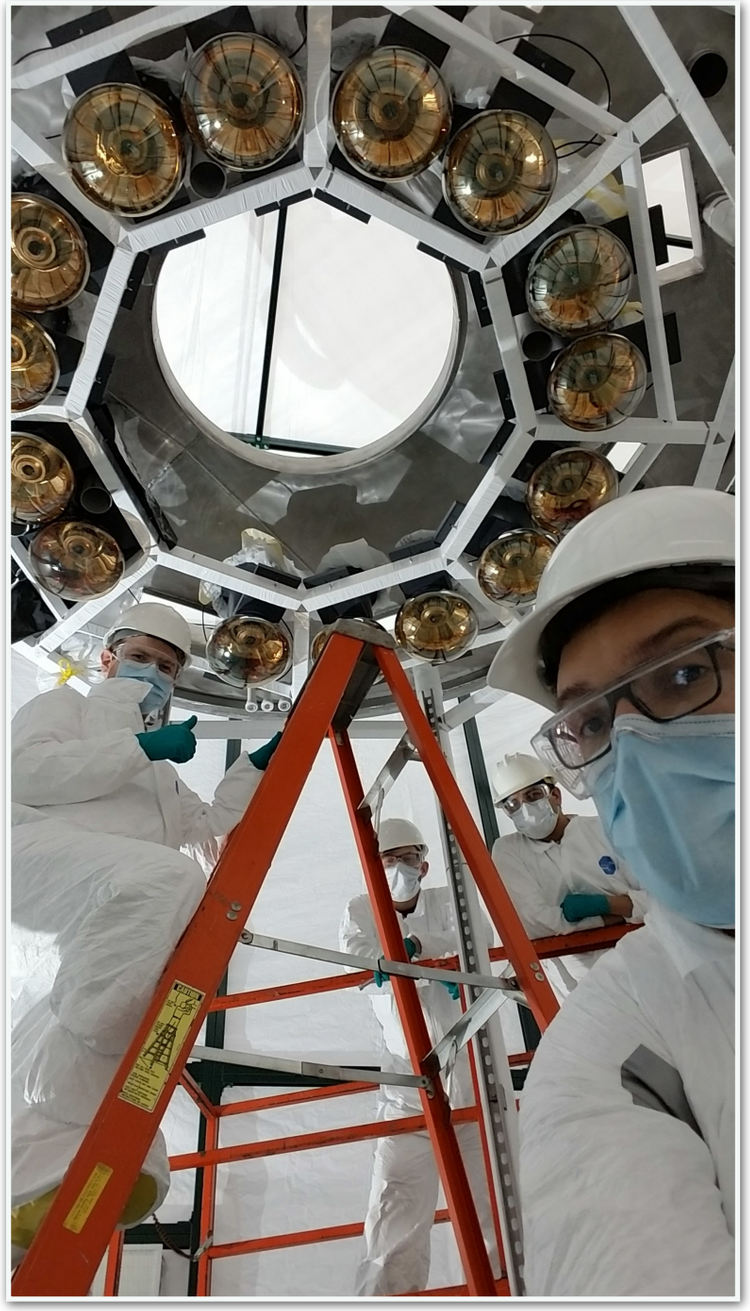
- Discovery of a new neutrino interaction in the COHERENT experiment and first HEP application of Large Area Picosecond Photodetectors in the ANNIE experiment.




**Neutrinos observed with LAPPD by ANNIE**

# Summary

- **A future program with a healthy breadth and balance of physics topics, experiment sizes, and timescales, supported via a dedicated, deliberate, and ongoing funding process, is highly desirable.**
  - A program incorporating breadth and diversity of efforts at different scales **increases the chances for major discoveries.**
  - It also provides **essential training opportunities** to ensure a capable workforce in the long term.
  - Such program **enables crucial R&D** to broaden the physics opportunities of DUNE (eg. Phase II) and other future experiments.
- The last P5 report recommended: **"Maintain a program of projects of all scales, from the largest international projects to mid- and small-scale projects".**
  - The Neutrino Frontier endorses continued and enhanced support of this recommendation.



The ANNIE Experiment