Neutrino Physics and R&D at ANNIE

The Accelerator Neutrino Neutron Interaction Experiment

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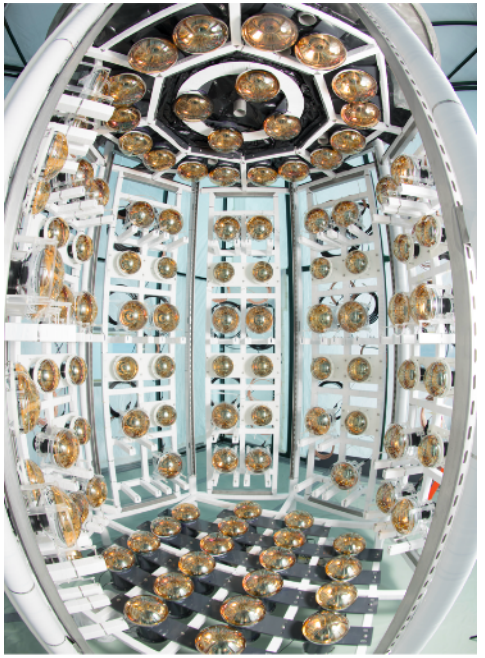
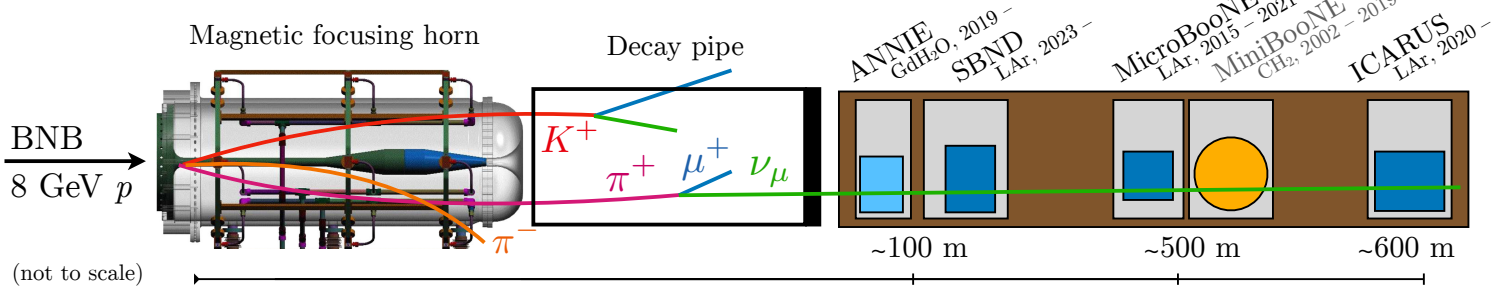
The ANNIE Detector

- **Located in a powerful GeV-scale accelerator neutrino beam**
  - Fermilab Booster Neutrino Beam (BNB): ~1 GeV ν_μ
  - Shared beamline with the Short-Baseline Neutrino (SBN) Program LArTPCs (SBND, MicroBooNE, ICARUS-T600)
- **A flexible, Gd-loaded water Cherenkov detector**
  - Water target loaded with Gadolinium
    - Excellent detection of neutrino-induced neutrons
    - Ability to deploy target sub-volumes (e.g. Water-based LS, GdWbLS) and various calibration sources
  - Light detection using PMTs and next-generation LAPPDs
  - Forward muon range detector for reconstructing high-momentum tracks, front veto to reject upstream activity

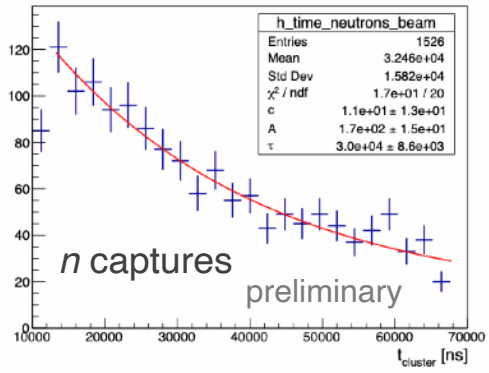


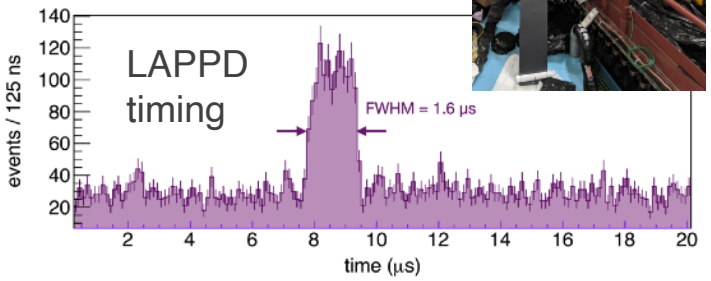


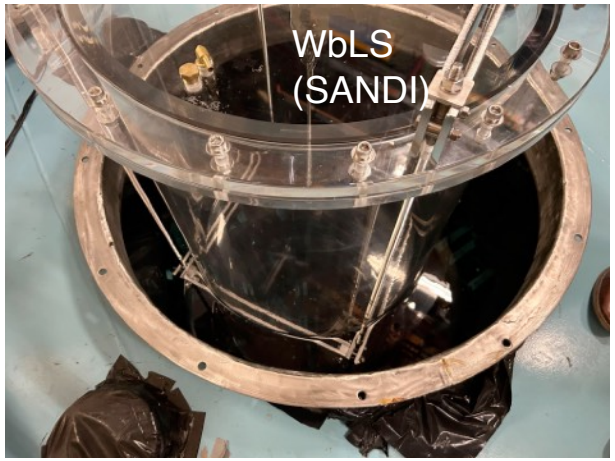
Fermilab

ANNIE in the broader program

- **A suite of targeted neutrino-nucleus interaction measurements**
  - Neutrino-induced neutron production
  - Characterizing backgrounds for future DSNB and proton decay searches
  - Leveraging BNB experiments for precision multi-target cross section measurements (argon/water)
    - Key cross section ratios and correlated hadron production constraints
  - Snowmass LoI: Physics Opportunities at ANNIE
- **A flexible R&D testbed for future large detectors**
  - Gd loading: 1st Gd-H_2O target in a neutrino beam
  - LAPPDs: First neutrinos on LAPPDs (2022)
    - Multiple LAPPDs deployed now, more coming
  - WbLS: Water-based LS sub-volume deployed now
    - Future plans for a full WbLS fill, opportunity to prototype e.g. Theia beam (LBL) physics
  - Snowmass LoI: ANNIE Detector R&D







Role of small-scale experiments

- Small-scale experiments offer clear benefits to the particle physics community
  - Targeted measurements (physics and R&D) inform the larger programs
  - Flexibility to address evolving needs
- Projects provide an ideal training ground for early career scientists
  - Experience all facets of experimental physics
  - Broad expertise for executing physics projects, skills the technical workforce
- **Realizing these benefits requires robust and predictable funding in the coming years**
  - Such projects have a high impact-to-cost ratio
  - Strong support enables creative, high-impact science and excellent training opportunities