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U.S. DEPARTMENT OF ENERGY
Office of Science

Neutrinos for Nonproliferation

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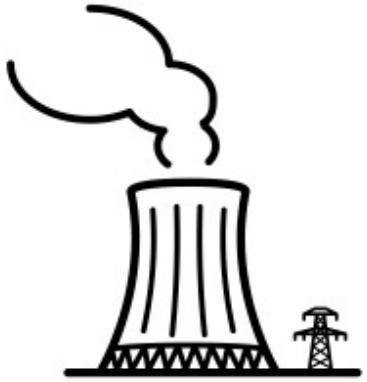
- **DNN Mission**: Develop and implement policy and technical solutions to eliminate proliferation sensitive materials and limit or prevent the spread of materials, technology, and expertise related to nuclear and radiological weapons and programs around the world.

REVIEWS OF MODERN PHYSICS, VOLUME 92, JANUARY–MARCH 2020

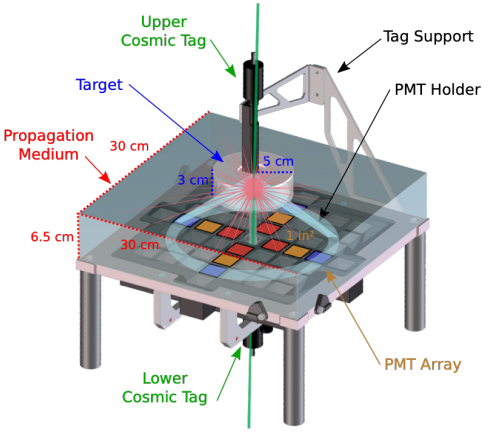
***Colloquium*: Neutrino detectors as tools for nuclear security**

Technology exists now to support the first on-the-ground applications for neutrinos in the detection, localization, and/or characterization of fuel for plutonium production



R&D Program at LBNL

Microphysical parameter measurement at CHESS (Orebi Gann)

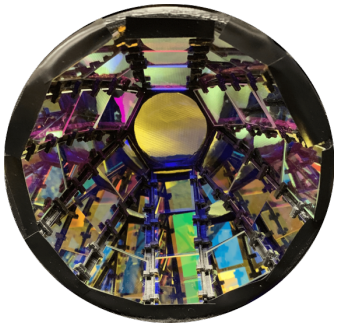


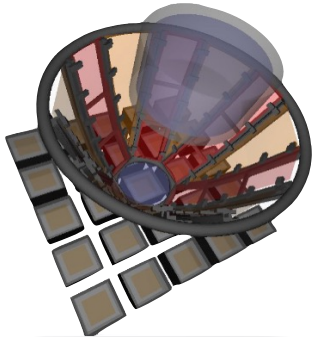
Microphysical extraction of intrinsic light yield and time profile; ring imaging; demonstration of C/S separation via timing and topology

*Phys. Rev. C **95** 055801 (2017)*
*Eur. Phys. Jour. C **77** 811 (2017)*
*Eur. Phys. Jour. C **80** 867 (2020)*

LAPPD deployment at CHESS (Orebi Gann)

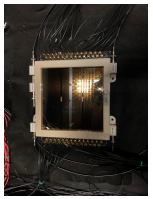
High precision fast timing (70ps) photon detection yields excellent Cherenkov/scintillation separation based on photon hit time

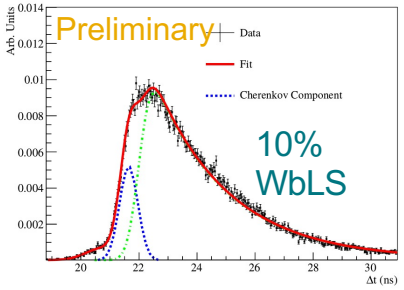




Chromatic quantum sensing at CHESS (Orebi Gann)

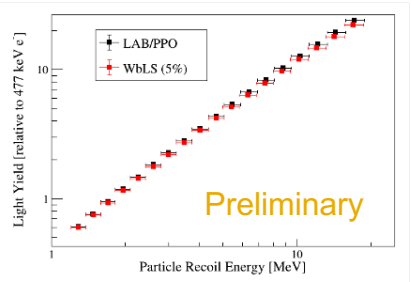
Dichroic filters allow spectral sorting of individual photons, which provides another dimension for separation of Cherenkov and scintillation populations





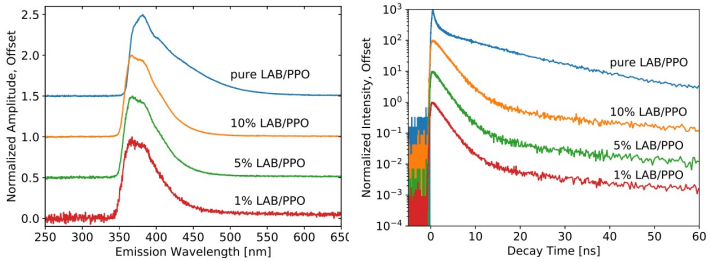
Proton light yield at the 88-Inch (Goldblum)

Double time-of-flight method using broad-spectrum pulsed neutron source and PSD-capable observation detector array



X-ray & optical excitation (Bourret)

50 kV x-ray luminescence for pure scintillation characterization allows independent check of CHESS MeV-scale physics events; optical excitation produced emission spectra



*Mat. Adv. **1** 71 (2020)*

Nu Tools: Exploring Practical Roles For Neutrinos In Nuclear Energy And Security

In FY20, a committee of US DOE National Lab scientists and academics were charged by the DOE NNSA Office of Defense Nuclear Nonproliferation Research and Development:

> *"...to facilitate broad engagement with interested communities on the topic of antineutrino-based monitoring of nuclear reactors and associated post-irradiation fuel cycle activities. The particular focus... should be on the* ***potential utility of antineutrino detection technologies****… in the context of existing or potential policy needs."*

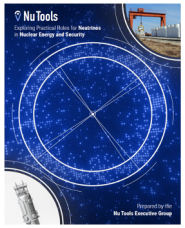
Stakeholders interviewed across multiple sectors:

+Mini-Workshop with the neutrino community:

- 21 presenters
- >100 more attendees

Covers issues related to:

- End-user engagement
- Technical readiness
- Neutrino system siting
- Current IAEA safeguards
- Advanced reactors
- Instrumentation for reactor operations
- Post-accident response
- Spent nuclear fuel
- Future nuclear deals
- Non-cooperative reactor monitoring



Final Report available at https://nutools.ornl.gov/

Key Findings from Nu Tools Study

- **Advanced reactors present novel safeguards challenges that represent possible use cases for neutrino monitoring.**
  - Limitations posed by traditional toolset
  - Neutrino signal proportional to power & fissioning isotope
  - Detection technology requires high sensitivity & low backgrounds for fission content determination
  - Cost and size pose implementation constraints

- **There is interest in the policy community in neutrino detection as a possible element of future nuclear deals.**
  - Desire to increase technical verification toolset for negotiators
  - Neutrino signal will depend upon siting (easy: verify operational status, hard: estimate fissile content)
  - Siting requires a balance between intrusiveness and technical considerations
  - Demonstration needed at appropriate TRL

WoNDRAM: Workshop on Nuclear Data for Reactor Antineutrino Monitoring

June 21-24, 2021 | Contact: Cathy Romano @ IB3 Global

WoNDRAM is a mini-workshop organized by the Nuclear Data Working Group to address the impact of nuclear data on reactor antineutrino measurements.

The goals of the workshop were to:

- **Identify nuclear data needs** for the reactor source term, the antineutrino spectrum calculation and the detector response that impact the fundamental research and applications of reactor antineutrino measurement systems.
- **Recommend solutions** to the identified nuclear data needs.
- **Bring together the various communities** involved in reactor antineutrino measurements along with the nuclear data community to enhance communication and understanding.

Expected Outcome:

Roadmap to Nuclear Data Interagency Working Group (DOE-SC, DOE-IP, NNSA DNN) to guide decision making on future funding opportunities

The workshop consisted of a plenary and three topical discussion sessions:

- Nuclear Data for **Reactor Source Term** Calculations
- Nuclear Data for **Antineutrino Spectrum** Calculations
- Nuclear Data for **Detector Response** Calculations