Development and prototyping of a new highly-segmented neutron detector
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**Background and Motivation**

Portal Monitor

- Look for highly-enriched uranium using fast neutron scattering as an alternative to looking for γ-rays that can easily be shielded
- Double scattering technique to pinpoint neutron source
- Alternative to He detectors that are only sensitive to thermal neutrons

**Potential Array Designs**

- Challenging, coupled issues with designing an array:
  - Necessary detector geometry / performance — driven by Physics requirements
  - Readout scheme with / cube-of-interaction (COI) sensitivity — use of SiPMs vs. PMTs as both have benefits and trade-offs

**Basic Nuclear Physics**

- Invariant mass spectroscopy with focus on 2n emission and p+n decay channels
- Missing mass experiments w/ neutron ejectiles — (d,n) or (3He,n)

These reactions are important in nuclear astrophysics and the structure of nuclei away from stability.

To benefit both basic science and applications, the goal is to build an array that has:

- Good efficiency ~10% of percent for 1- to 30-MeV neutrons
- Improved resolution & sensitivity relative to existing devices
- Fast timing
- Low thresholds
- n/y pulse-shape discrimination (PSD)
- ~1 cm position resolution

**Two-Neutron Decay**

- Correlated
- Uncorrelated

(above) The opening angle between emitted neutrons provides information on whether the neutrons are emitted simultaneously or sequentially, and whether they interact as they leave the nucleus.

**Parallel Efforts**

**Simulations to Inform Cube Size**

Simulation (GEANT4) work to inform detector design for various physics experiments:

- 2n decay of 9He11/2 [TAMU]
- 2n decay of 16O16/2 [NSCL/FRIB]
- Photo-disintegration of 3H [TUNL]

(above) Back-of-the-envelope simulation for He decay indicates cubes of ~1 cm3 would provide the desired resolution.

**SiPM Readout Scheme Testing**

Efforts to characterize PSD using SiPMs with different amplifier and chip configurations underway

- 249Co(α)γ and 249Co source with the following gating:
  - A gate: total 400ns wide
  - B gate: Fast 100ns wide

Gates precede signal by 40ns

**Expanded Multi-Cube Prototypes**

The next step in prototype designs includes an array of nine 1-cm3 cubes with PMTs coupled to WLS pieces in both the X and Y directions.

- The design is modular to build additional layers to ultimately include the Z direction.

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