# Synergies and Differences between Near-Field Reactor Monitoring Applications & Short Baseline Neutrino Physics

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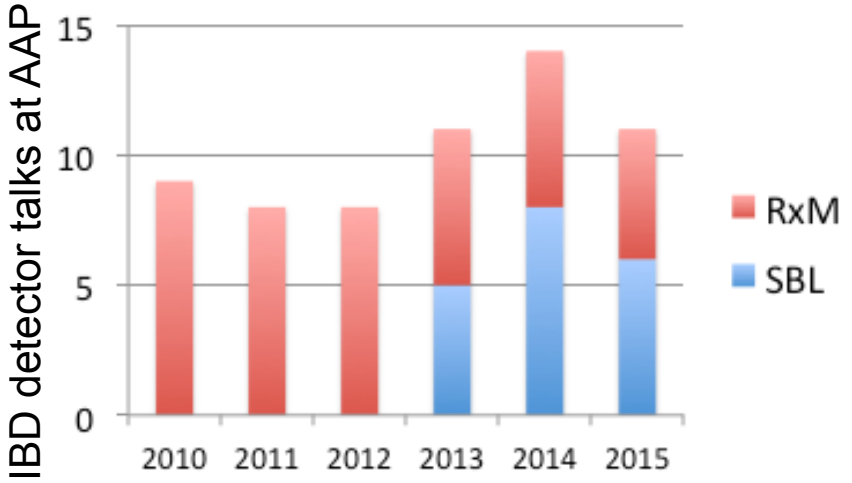
# Outline

- Short Baseline Neutrino Physics projects have become a major focus of this workshop
- This is natural given the considerable, but imperfect, overlap with Reactor Monitoring R&D

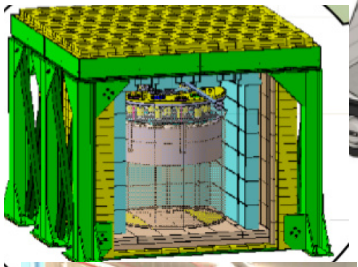



- This talk seeks to examine the similarities and differences, with the following goals:
  - providing background for AAP participants whose focus is mostly on a single of these topics
  - generating discussion within the AAP community on where boundaries fall and whether there are ‘synergies’ that can be further developed
- We will explore this topic through comparison of central features of each endeavour

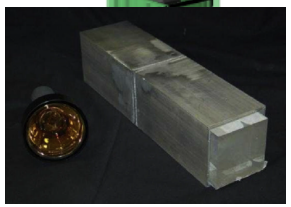
# Definitions

## Near Field Reactor Monitoring (RxM)

- Primary goal of technology development and demonstrations for monitoring applications

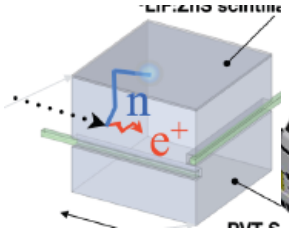


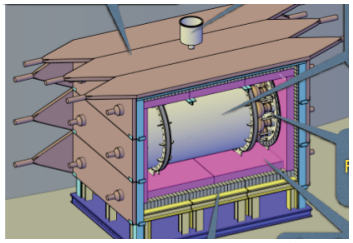
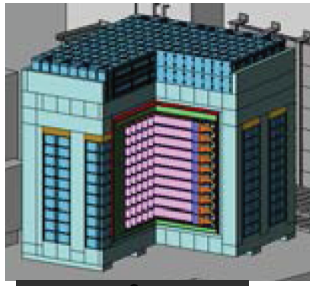
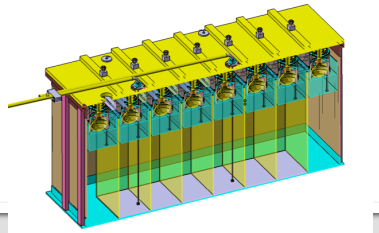
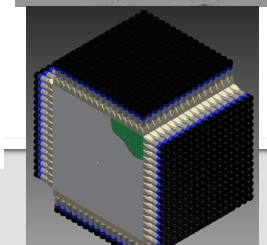




## Short Baseline Neutrino Physics (SBL)

- Primary goal of resolving the “Reactor Anomalies”
  - Sterile neutrino(s) at the 1eV mass scale?
  - Cause of discrepancies between predictions and measurements of flux and spectrum



# Deployment Location

## Common Features

- Must be non-intrusive – limited likelihood of site reconfiguration
  - deployment location probably determined by available space, with a preference for existing overburden if possible

### Reactor Monitoring

- Applications considered for commercial & research reactors, irradiated fuel
- no hard constraint on baseline, but closer is better

### SBL Physics

- Preference for compact core $^{235}U$ fuelled research reactors
- Little overburden – near-surface operation
- Access to both shortest practical baseline, and a broad baseline range, is highly advantageous

*SBL Physics prefers sites with challenging characteristics; if it can be done there, it can be done almost anywhere*

# Detector Performance

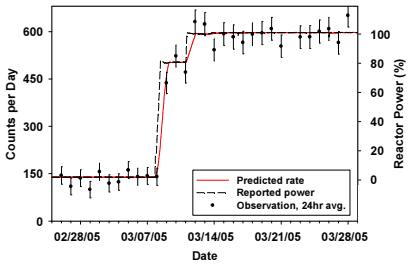
## Reactor Monitoring

- Requirements determined by specific application
  - Total Size / Footprint
  - Efficiency
  - Signal / Background
  - Energy Resolution, energy scale precision

combine to determine capability

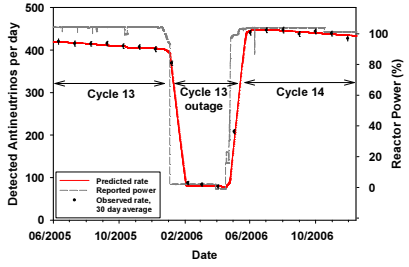
**Short-term rate**

**Verify Operational Status**



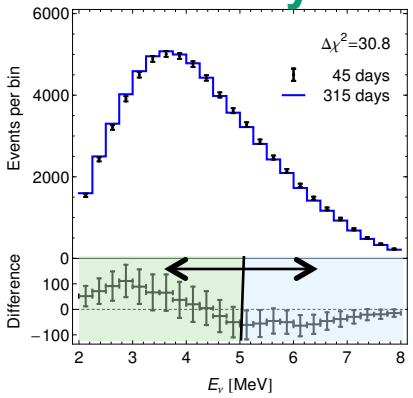

**Long-term rate**

**Constrain Operational Parameters**



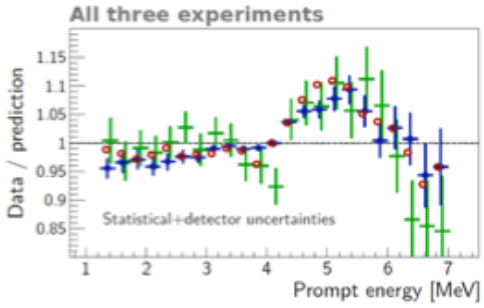

**Rate + shape ratio**

**Estimate fissile inventory**




**Rate + detailed shape**

**Improved fissile inventory estimate?**




**Size, Complexity, Signal:Background, Capability**

# Detector Performance

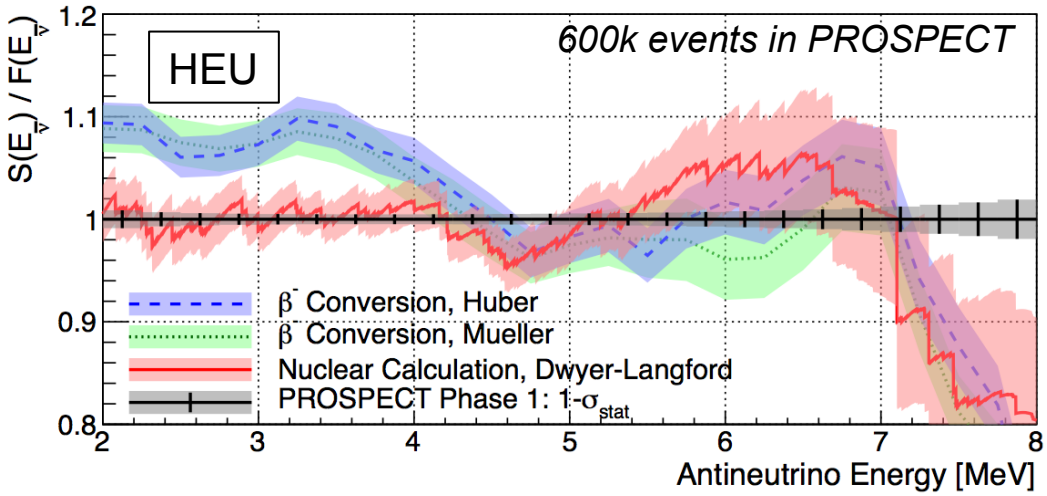
## SBL Physics

- Requirements determined by physics goals
  - Total Size / Footprint
  - Efficiency
  - Signal / Background > 1:1

  } combined, strongly influence osc. sensitivity

  - Energy Resolution better than $\theta_{13}$ expts, lower is better
  - Detailed understanding of energy scale

} Determine power of spectrum measurement



# Detector Performance

- *The requirements for SBL physics are the most stringent and would provide any presently envisioned monitoring capability*
- *SBL Physics will provide a wealth of knowledge and results that will aid reactor monitoring development*
  - *Detailed understanding of near-surface background and performance of mitigation strategies*
  - *Improved understanding of reactor antineutrino emissions*
- *A challenge for this community will be matching capabilities, and complexity, to particular monitoring applications*

# Scale of the Field

## Reactor Monitoring

- Depending on particular application:
  - maybe handful of ‘bespoke’ devices, or
  - devices at many facilities – a ‘mass-produced widget’

## SBL Physics

- suite of ‘bespoke’ devices

*SBL Physics will always use fairly unique instruments*

*This may also be true for reactor monitoring, but the path to widespread use should also be considered*

*The range of approaches being pursued in both RxM and SBL will be an advantage when assessing the requirements for a particular RxM application*

# Mode of Operation

## Reactor Monitoring

- Strong emphasis on automated /unattended operation

## SBL Physics

- Monitored operation to maintain high livetime is possible
- regular onsite calibration to develop and maintain understanding of energy scale is possible

*The monitoring and calibration intensity of a typical physics experiment is incompatible with non-intrusive operation and available personnel resources for reactor monitoring*

*It remains to be seen how the SBL expts will perform here – the highest priority must of course be the physics goals*

# Host Site Collaboration

## Common Features (for Reactor Monitoring *Demonstrations)*

- Operator likely to be deeply involved in project
  - detailed operational information
  - direct engagement in design and planning
  - workforce development and engagement a common motivation

## Reactor Monitoring *Applications*

- Collaboration and detailed information sharing cannot be assumed

*The relationship with a reactor operator in any actual application will be entirely different than any experienced by this community so far*

# Conclusions

- Short Baseline Neutrino Physics and Reactor Monitoring have many similarities but are by no means identical
- Significant differences include
  - tighter constraints on deployment location for SBL
  - application specific performance requirements and constraints for RxM
  - very different host relationship for actual RxM deployments
- SBL efforts will provide important capability demonstrations and data to inform what is possible for monitoring applications
- Our diverse technological approaches are a strength:
  - we will learn a great deal from careful comparisons of performance
  - a single approach is unlikely to be optimal for all reactor monitoring applications
  - will bolster strengthen scientific conclusions drawn from SBL