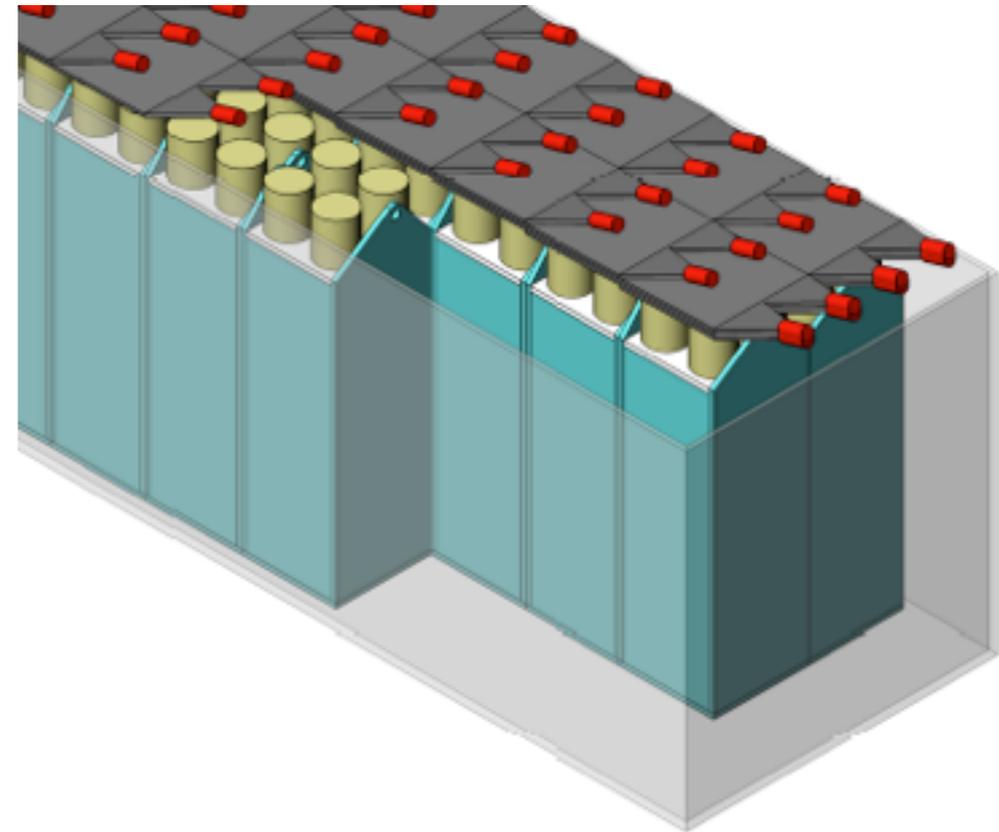
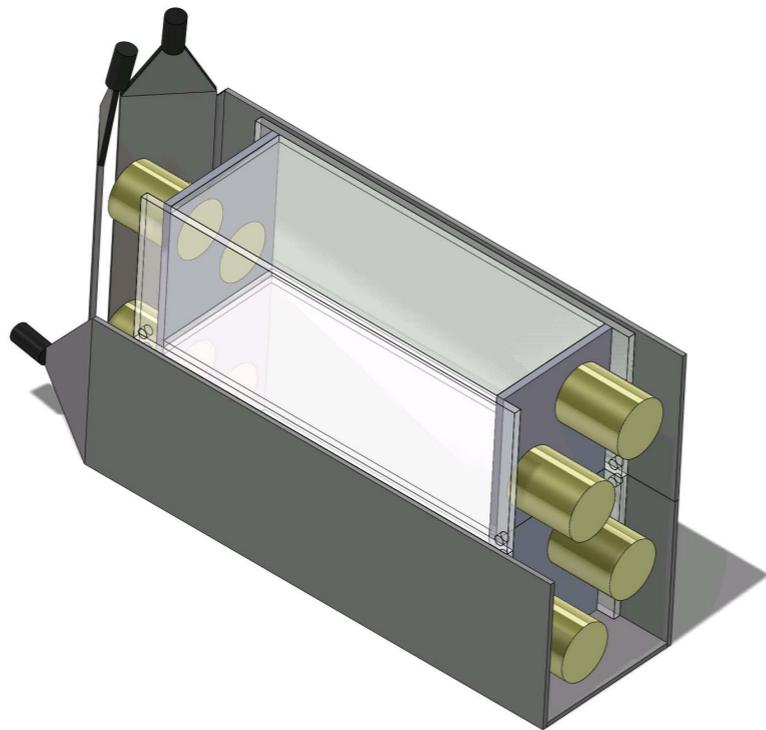

Segmented, Modular Detector Concepts

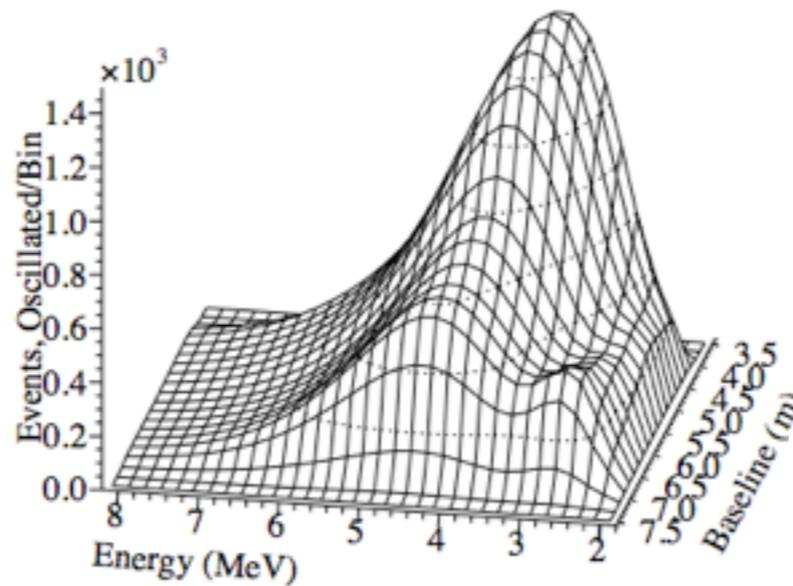
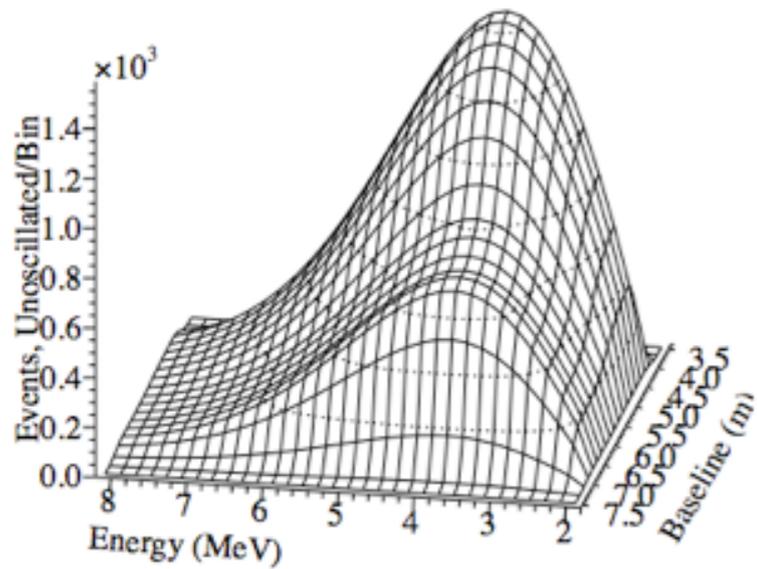
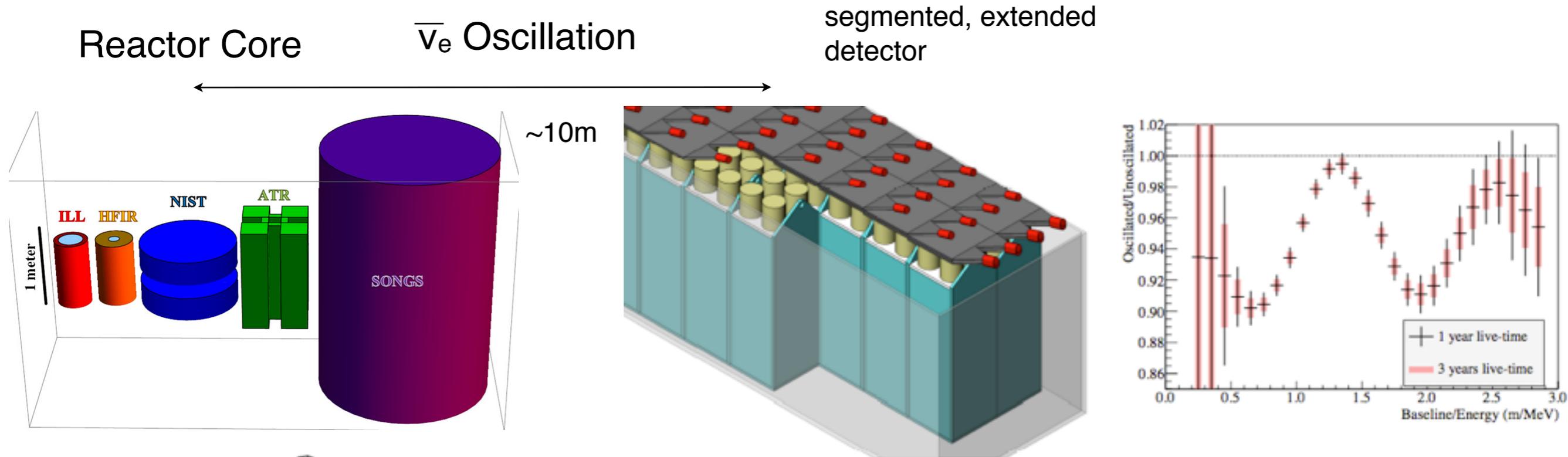


Jeff Cherwinka, Karsten Heeger, Pieter Mumm, Bryce Littlejohn
University of Wisconsin
NIST
University of Cincinnati

LLNL, December 11-12, 2012

Introduction

Segmented Detector for Position Resolution

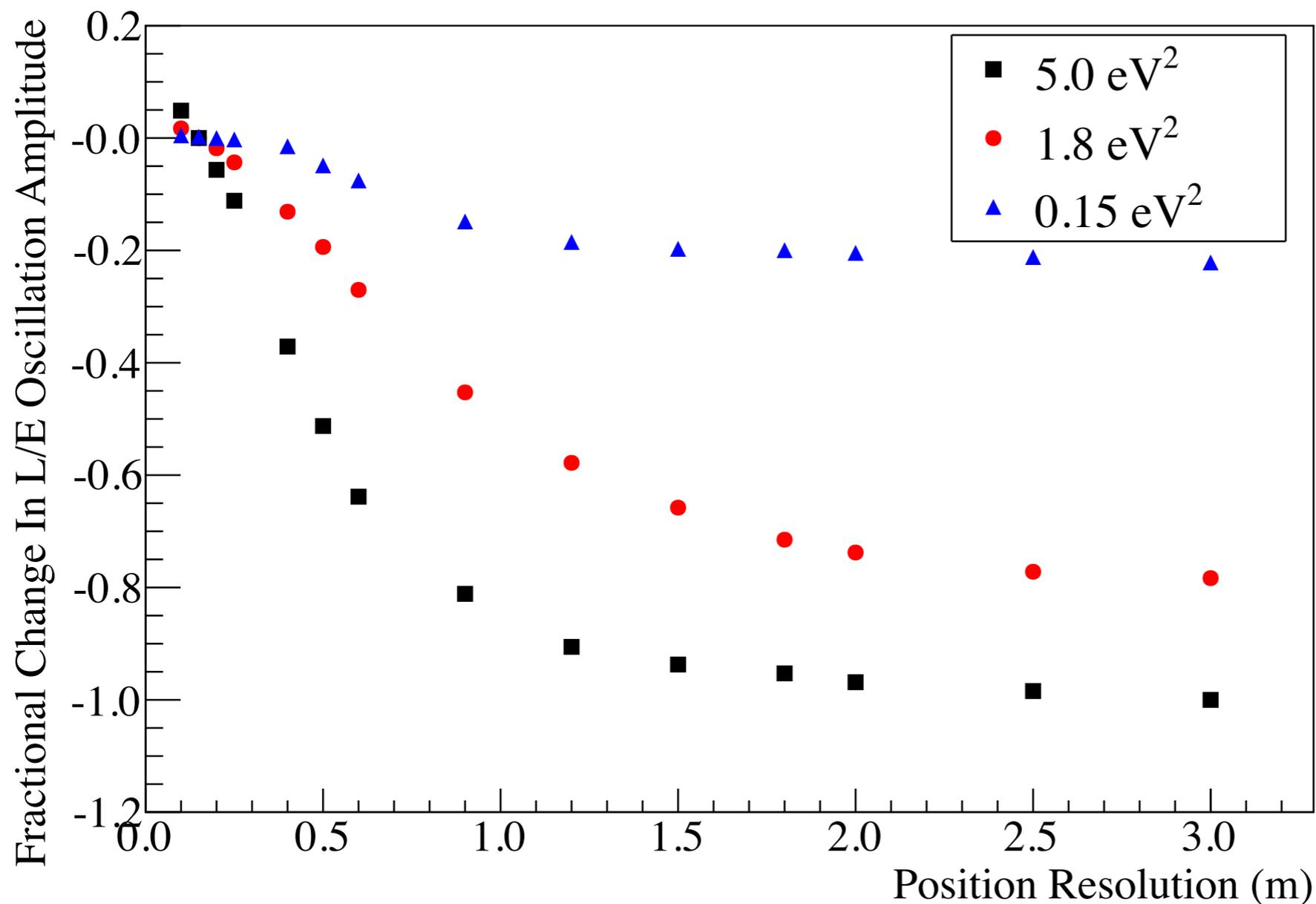


Littlejohn, Mumm, Tobin, KMH
arXiv:1212.2182

measure energy spectrum
map out oscillation as a function of distance & energy

Introduction

- Better position resolution = better oscillation sensitivity
 - Especially the case at high mass-squared splitting
 - Figure shows a particular reactor-detector experimental setup:

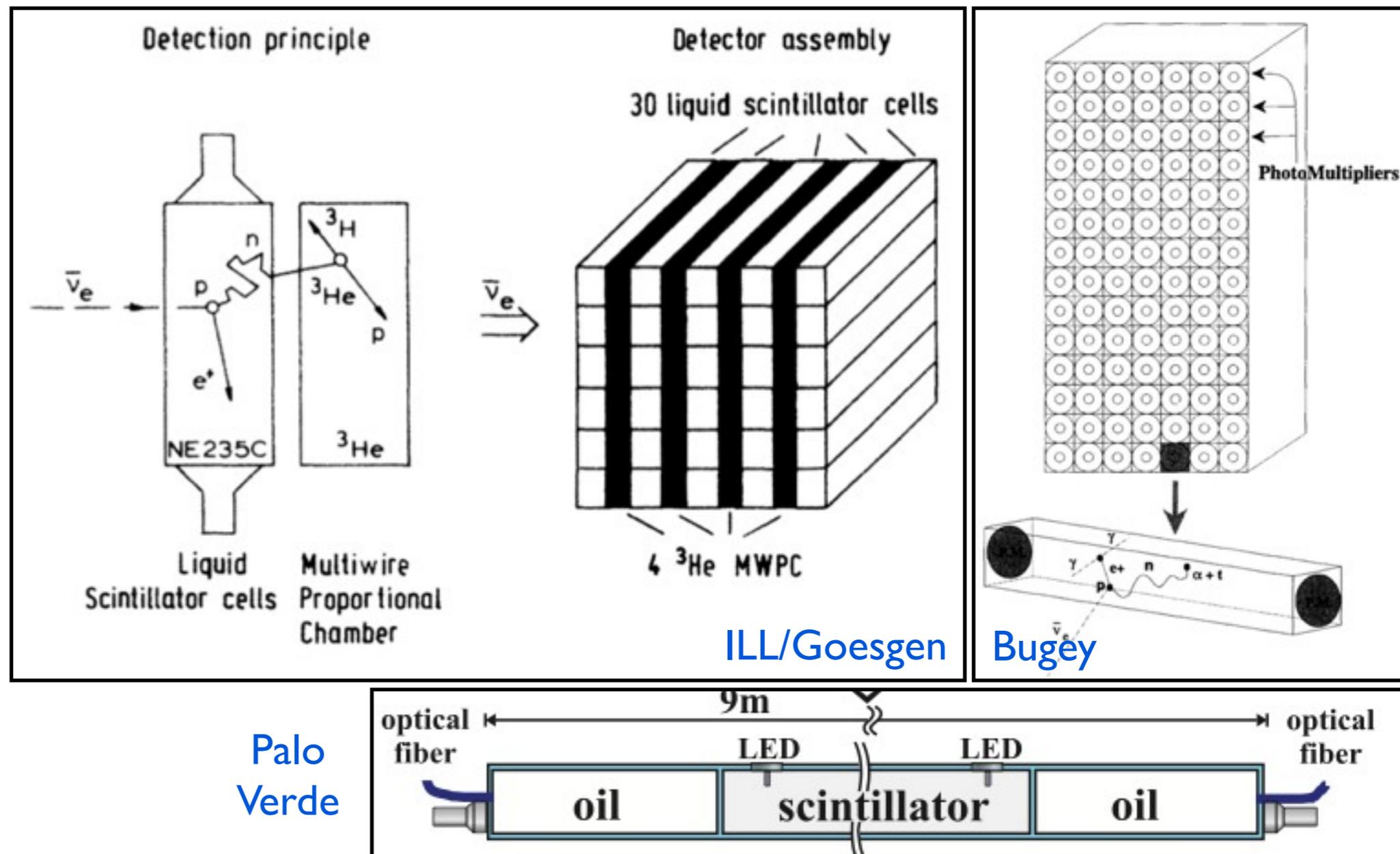


Littlejohn, Mumm, Tobin, KMH
arXiv:1212.2182

Detector Segmentation

- One way to achieve position resolution: segmentation
 - Detector target physically and optically separated into 'cells'
- Method utilized in many previous detectors/prototypes

- ILL
- Goesgen
- Rovno
- Bugey
- Krasnoyarsk
- Palo Verde
- LLNL/Sandia monitoring detector



Position Information

- Segmentation versus full-volume position reconstruction

- PRO: Position information is direct

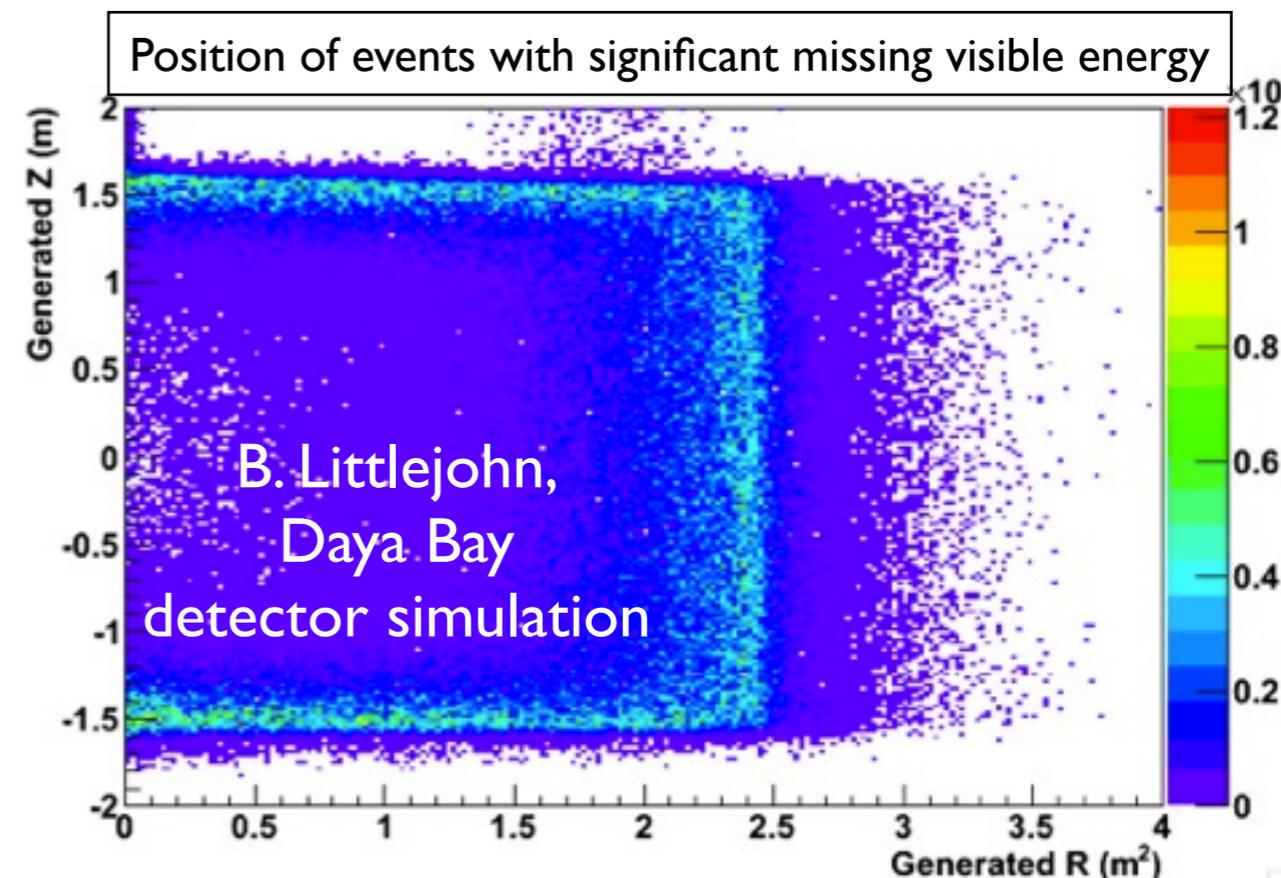
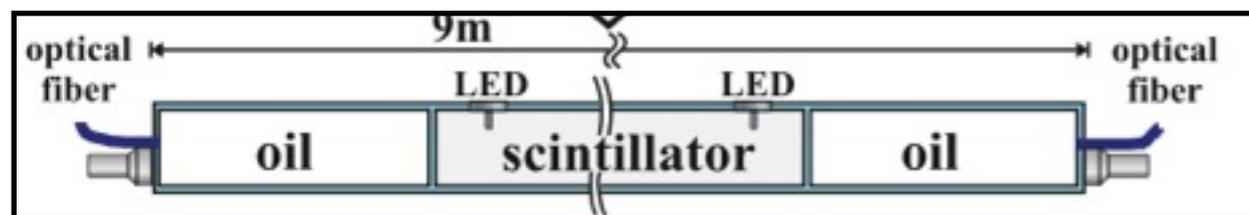
- Transformation from PMT signal to position coordinate is VERY direct
- “These two PMTs lit up, so the event took place here.”
- Avoids complexities, biases, systematics, and questions associated with full-volume calibration

- CON: Typically two-dimensional

- X and Y position can be known, but not Z, the position along a scintillator cell
- Can be worked around to some degree: alternating segment orientations, or utilizing ‘opaque’ scintillator

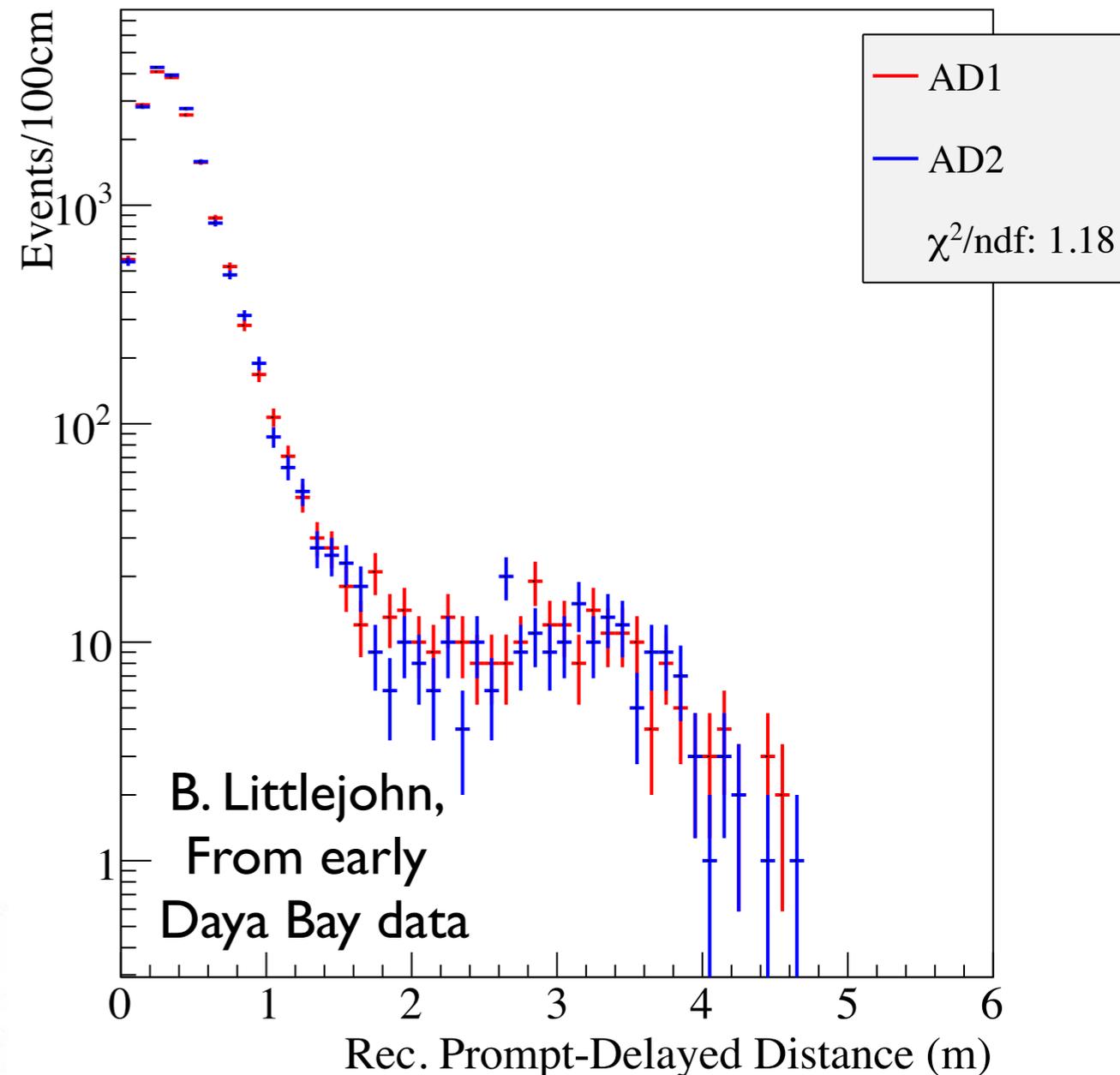
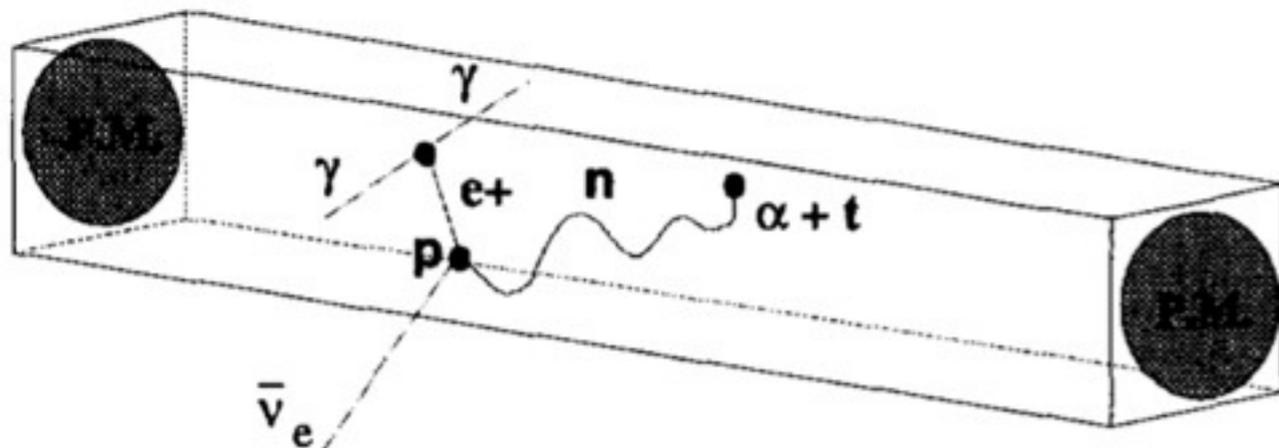
- CON: Reduced detection efficiency

- Positrons, neutrons deposit energy in non-scintillating regions
- Detector simulation for precise efficiency estimate



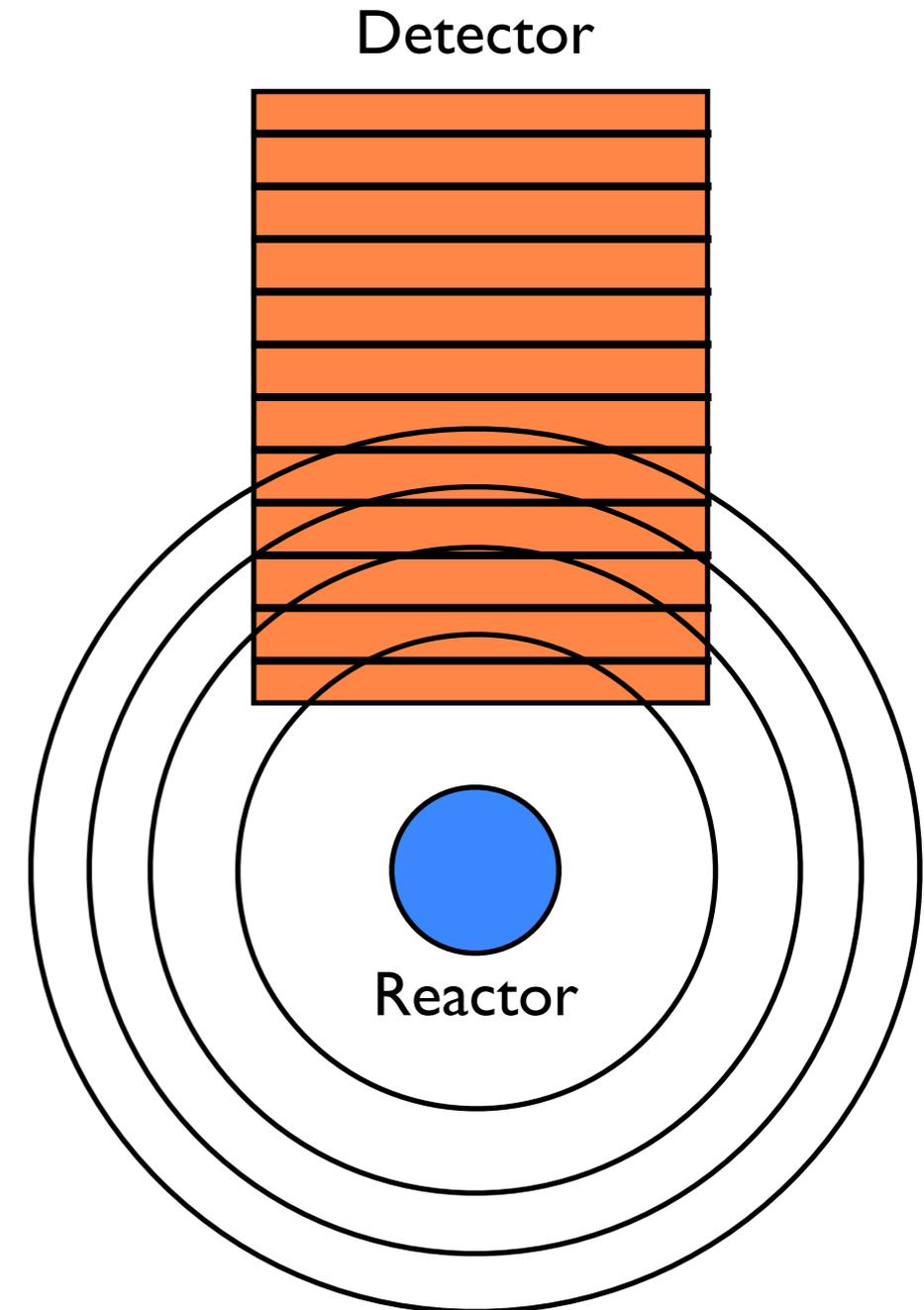
Background Reduction

- Other major advantage: background reduction
- Very straightforward event topology cut:
 - Prompt and delayed signals must occur in the same or adjacent cells
 - Most accidentals, fast neutrons will not follow pass this cut
 - Can do similar thing with open-volume detector, but must have a good method of reconstructing position
 - Will segmentation result in lower cut systematics than full-volume for similar level of background reduction?



Other Detector Considerations

- **Detector cross-section**
 - The wider the detector, the larger the range of baselines present in each detector segment
 - Washes out some position information
 - Further calculations necessary to determine degree of washing-out and its effects on sensitivity
 - Could consider more complex shapes to segmentation to avoid this.....
- **Contrast with full-volume: bigger is better!**
 - Larger variations in charge topology if PMTs are farther apart



Reactor Site Considerations

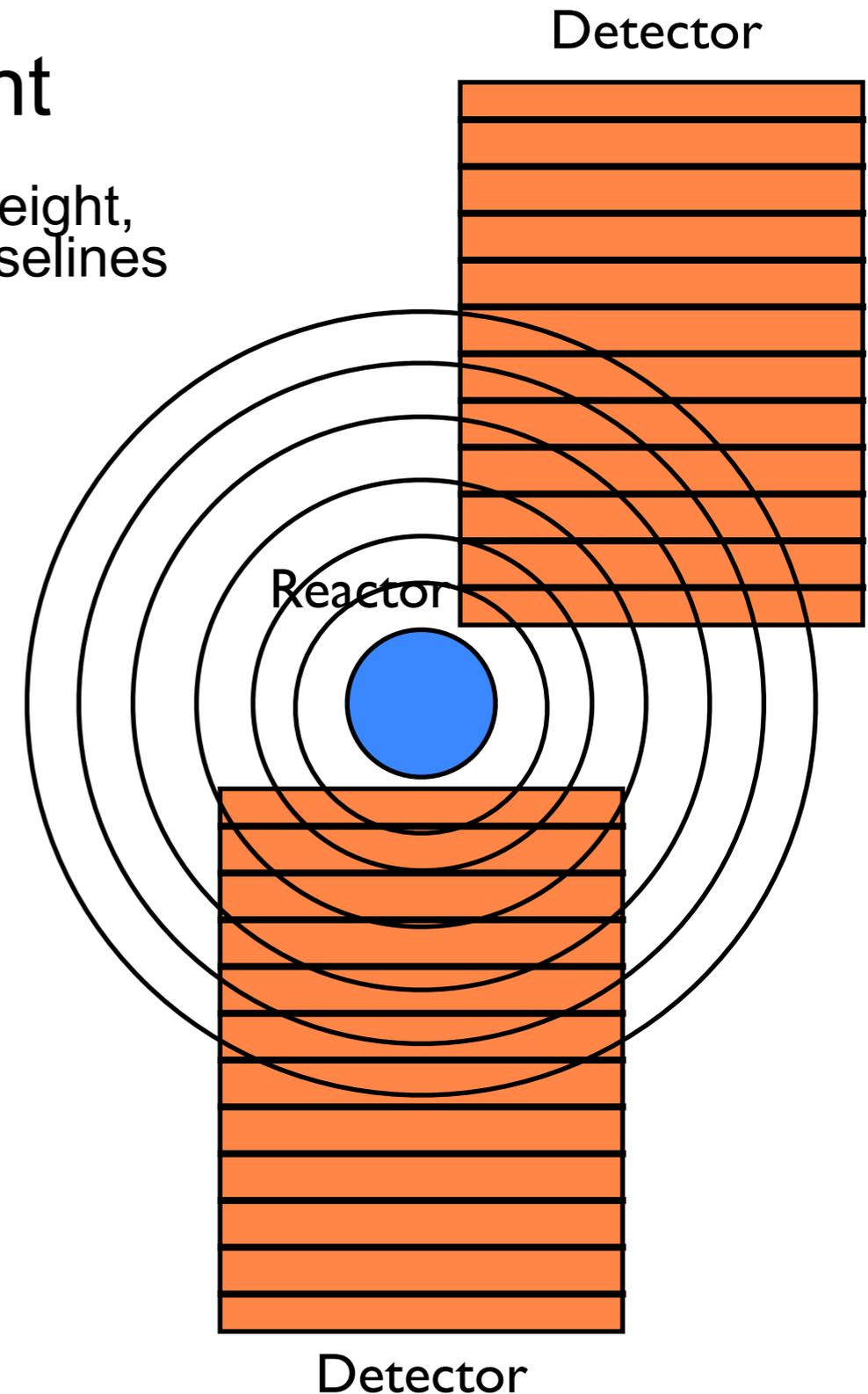
- **Vertical core-detector displacement**

- If detector is significantly above or below core height, vertical segments will sample many different baselines
- Will also wash out position information
- Could consider, i.e. diagonal segmentation to reduce wash-out.....

- **Core-detector distance**

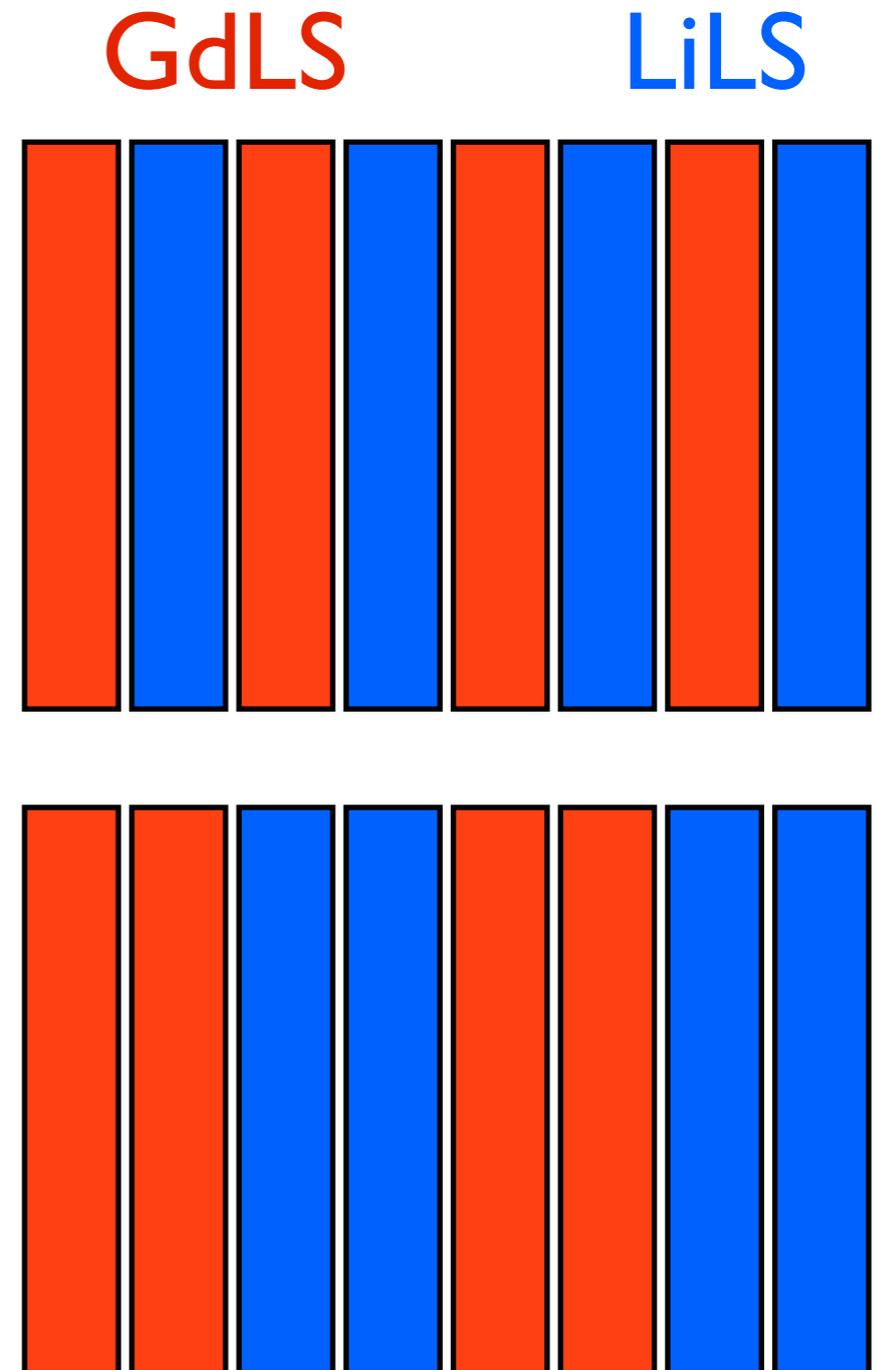
- Baseline 'isobars' are rounder at low core-detector distance
- Washing-out will be greatest at small core-detector distance

- **Further calculations necessary here, as well.**

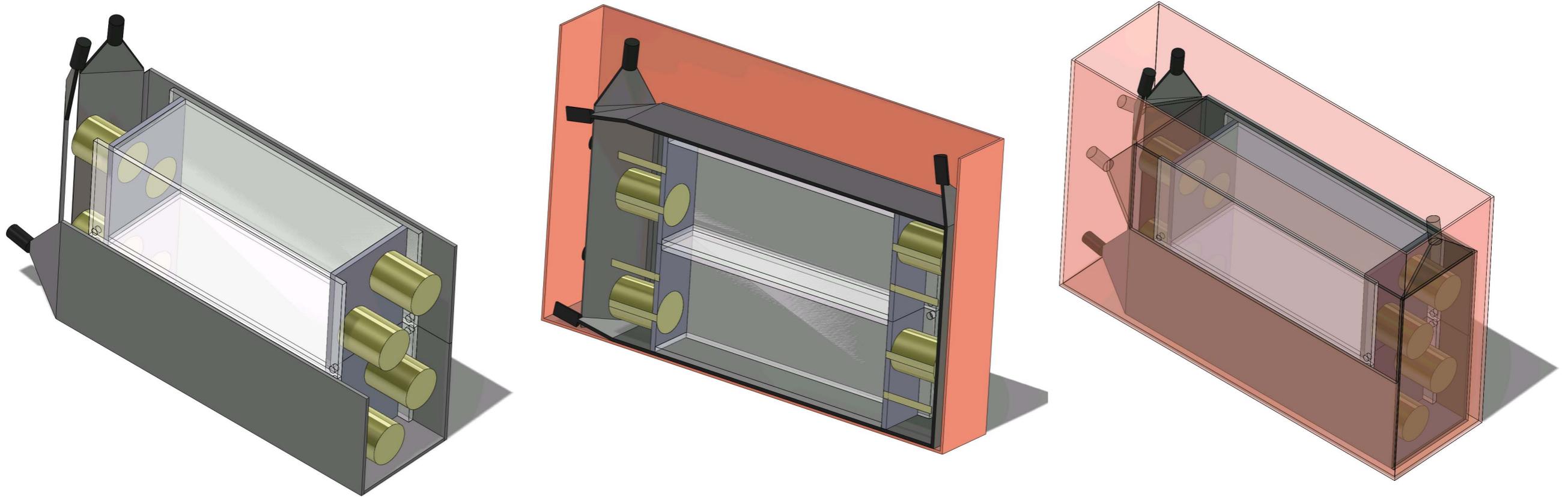


Refillable Isolated Segments

- Can test multiple detection methods in one detector
 - Lithium-loaded scintillator
 - Gd-loaded scintillator
 - Gd-loaded water
 - Others?
- Can compare results between detection methods for confident probing of reactor anomaly
- Can 'swap' by emptying and re-filling segments with different liquids



Segmented, Modular Detector Concept



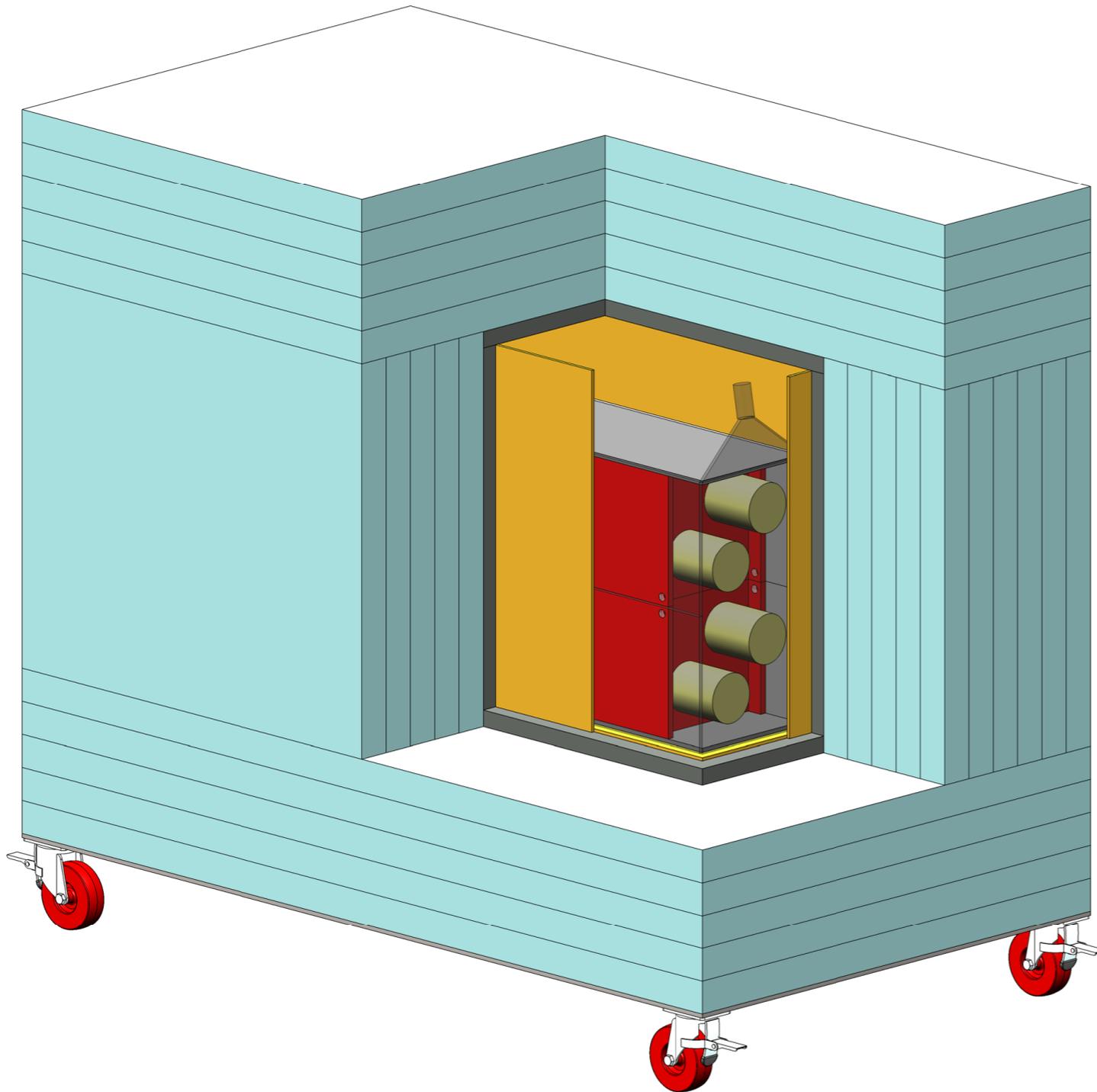
modular detector

each module:

- acrylic tank with liquid scintillator
- double ended PMT readout
- dimensions of module determine position resolution

image shows prototype detector module with plastic scintillator around it and spill containment

Passive Shielding Around Prototype Module



prototype module is a validation of concept

full-size detector can be built up in phases

modules can be optimized for space constraints at facility

Summary

- Segmentation defines position resolution in radial direction
- Segmentation allows for natural path from prototype development to full-scale detector
- Detector modules can be filled with different detection liquids; allows for systematic checks, scintillator R&D