AIT / WATCHMAN R&D
(and its relevance to THEIA)

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R&D Topics

Water-based liquid scintillator studies

– Current: Reactor monitoring sensitivities

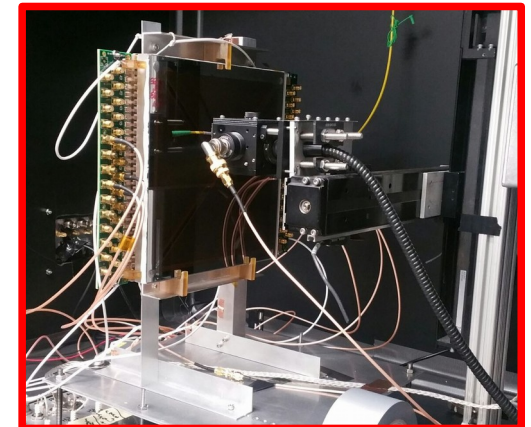– Future: Cherenkov / scintillation separation

PMT tests and comparisons

– Standard vs. ulta-low background glass

– Other PMT models? Suppliers?

Advanced photosensors for AIT

– Reconstruction with LAPPDs
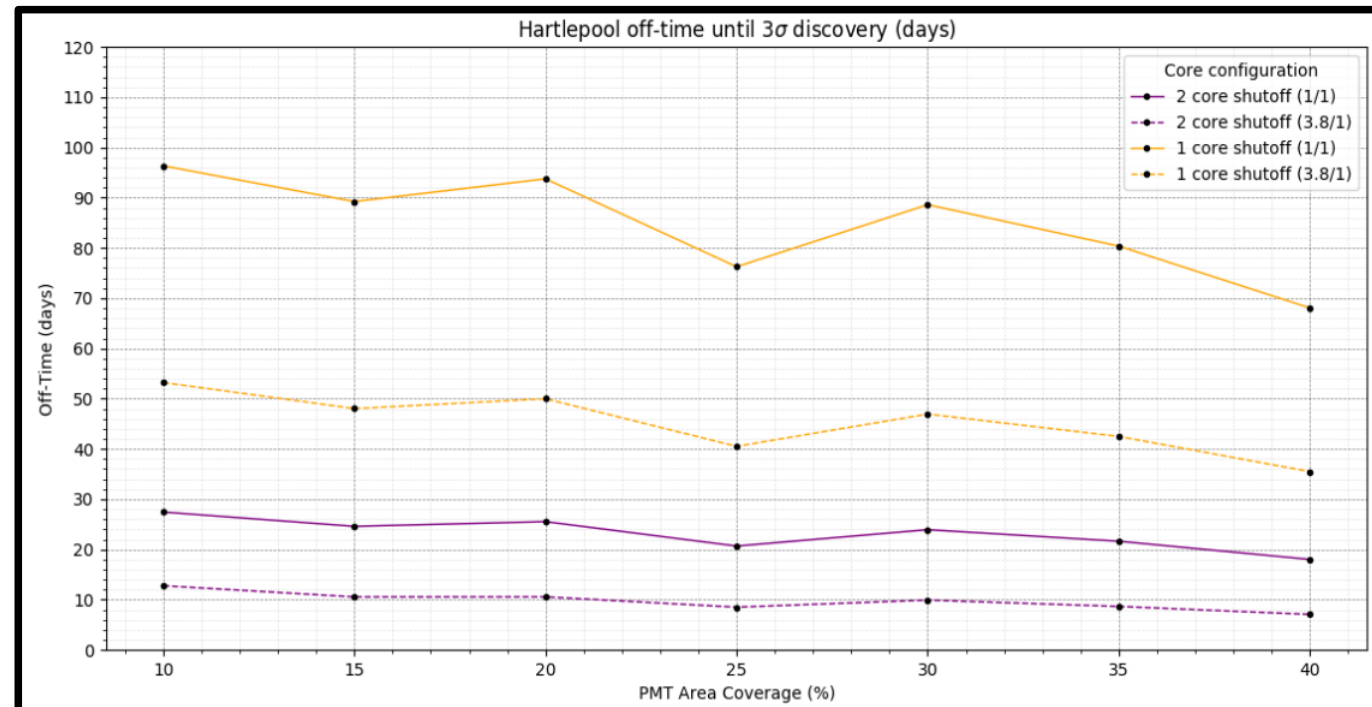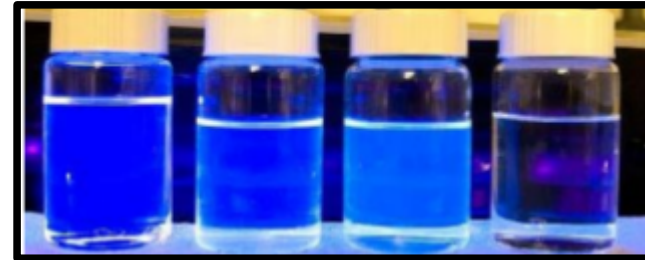
– Cherenkov / scintillation separation redux

Complementary near-field reactor studies
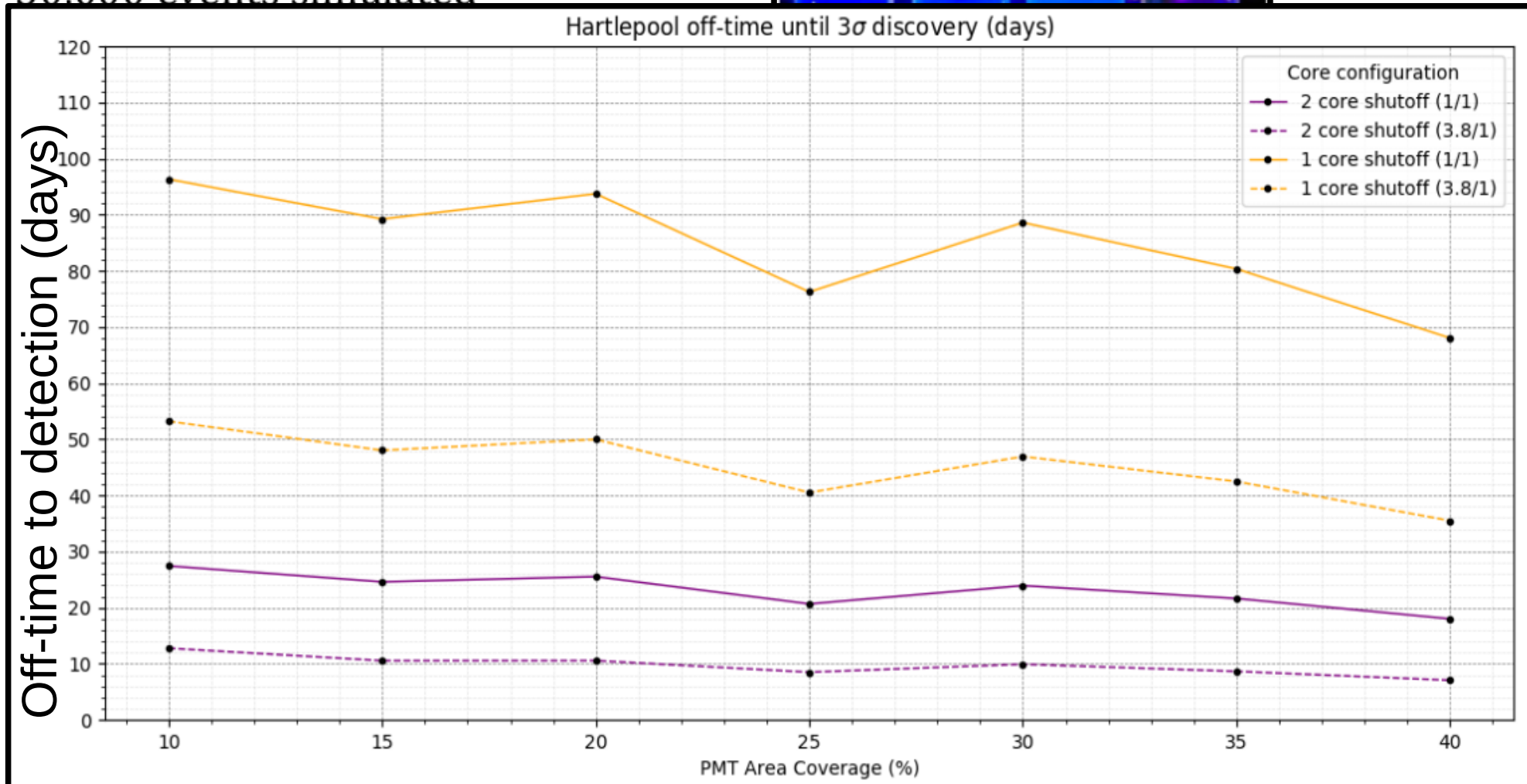
at Hartlepool

WbLS:

- 50,000 events simulated
- Average output (1900MWth)
- 2 (all) & 1 - core shutoff
- Nominal detector design – 1kT fiducial, 16m tank height
- ~160 days total time to detect 1 core (25%)
- ~13.7 IBDs per month (25%)
- IBD detection eff: ~48% (25%)

Hartlepool off-time until 3σ discovery (days)

Core configuration
- 2 core shutoff (1/1)
- 2 core shutoff (3.8/1)
- 1 core shutoff (1/1)
- 1 core shutoff (3.8/1)

WbLS:

- 50,000 events simulated

Hartlepool off-time until 3σ discovery (days)

Core configuration
- 2 core shutoff (1/1)
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- 1 core shutoff (1/1)
- 1 core shutoff (3.8/1)

Off-time to detection (days)

PMT Area Coverage (%)

Going The Distance

WATCHMAN (AIT Phase I): Uses **Hartlepool** (25 km) as $\bar{\nu}_e$ source

AIT Phase II: Can we see **Heysham** reactors (148 km)?
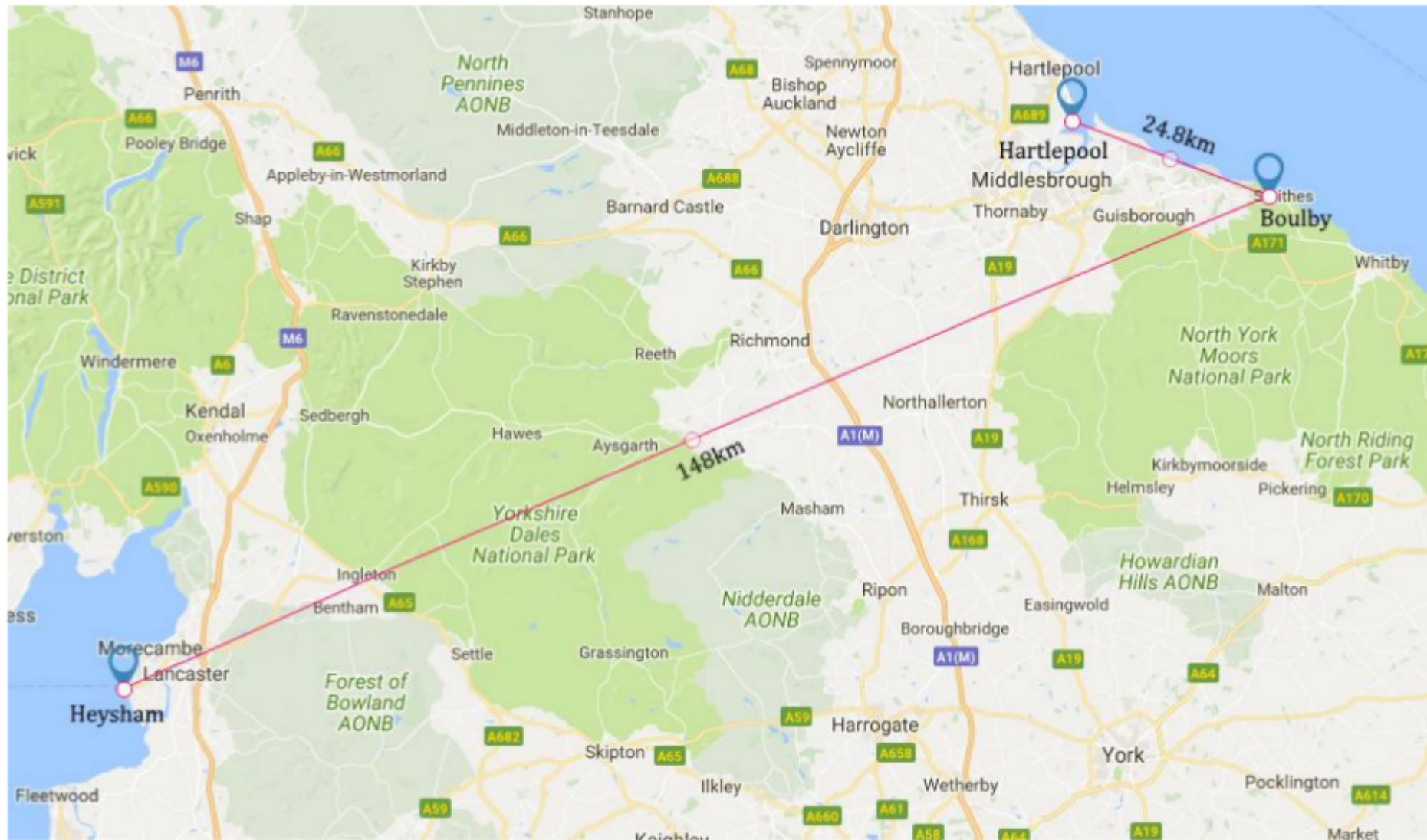
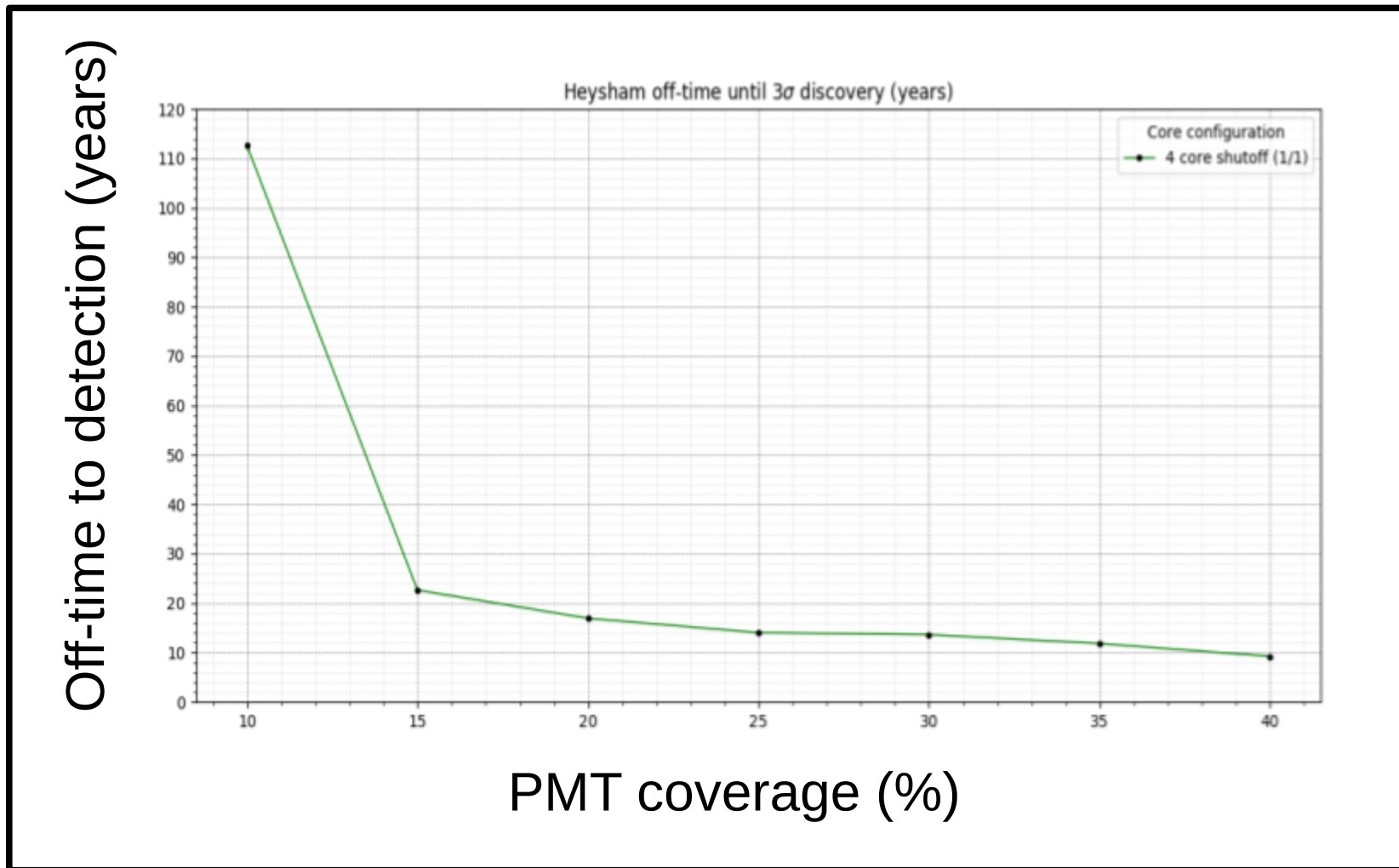# Going The Distance

Hartlepool

- ~25km standoff

- 1900MWth average output (max 3000MWth)

- 2 cores

- Reactor on/off ratio ~3.8

Heysham

- ~148km standoff

- 5000MWth average output (max 6100MWth)
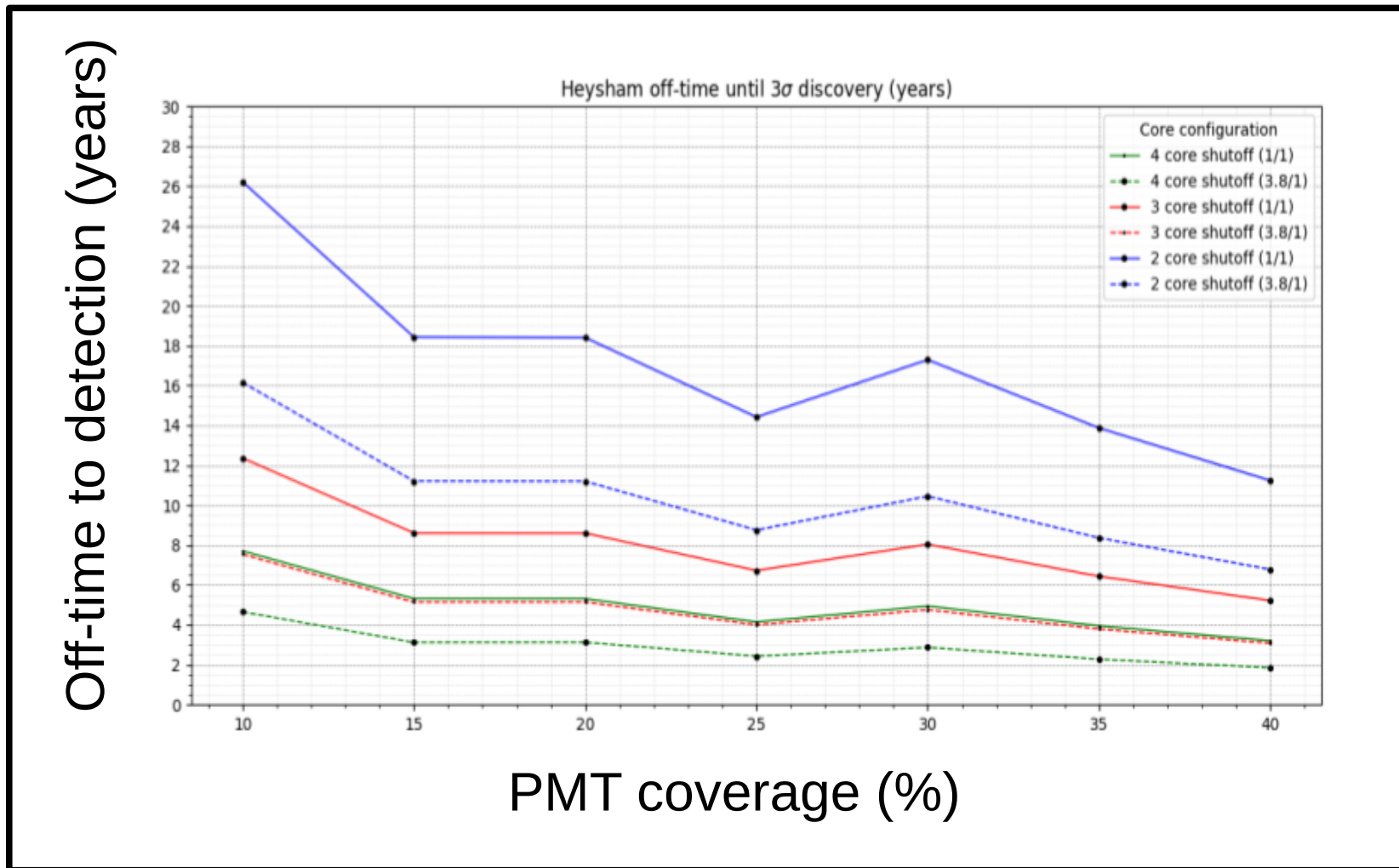
- 4 cores (2 stations w/ 2 cores)

Heysham: Water + Gd

Discovery time of ~20 years is completely unreasonable...

Discovery time of ~4 years is only _mostly_ unreasonable.
(This is first pass, with no Cherenkov / scintillation separation...)

PMT Tests & Comparisons

WATCHMAN PMT test bench currently under construction in UK.
→ Requirement is to test ~100 PMTs per month

- Comparison of PMTs options:

  - Hamamatsu R7801 (10" low-BG)

  - Hamamatsu R7801 (10" standard)
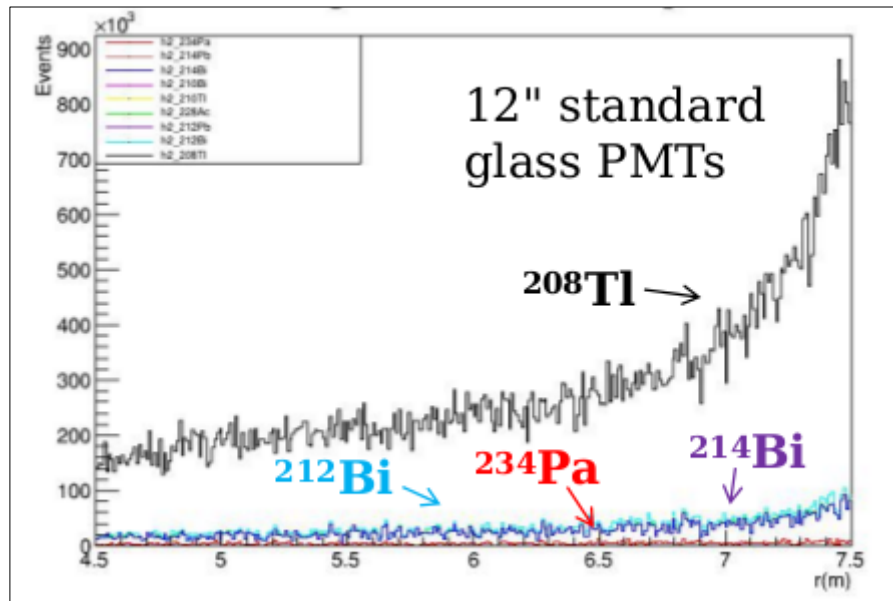
  - Hamamatsu R11780 (12" std glass)

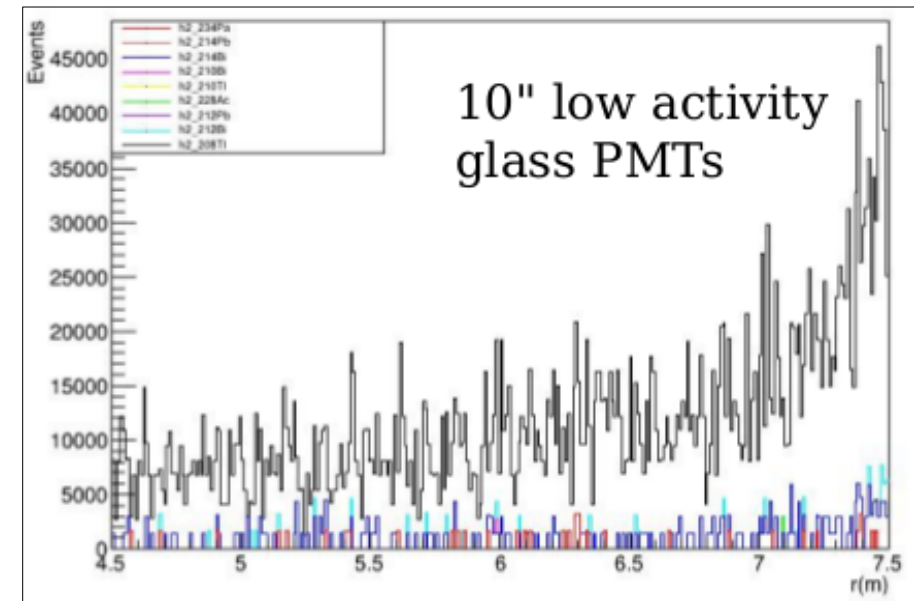- Evaluation of future PMT options:

  - ETEL D784KFLB (11" low-BG)

PMT testing last week
(Kamioka NOT Boulby)

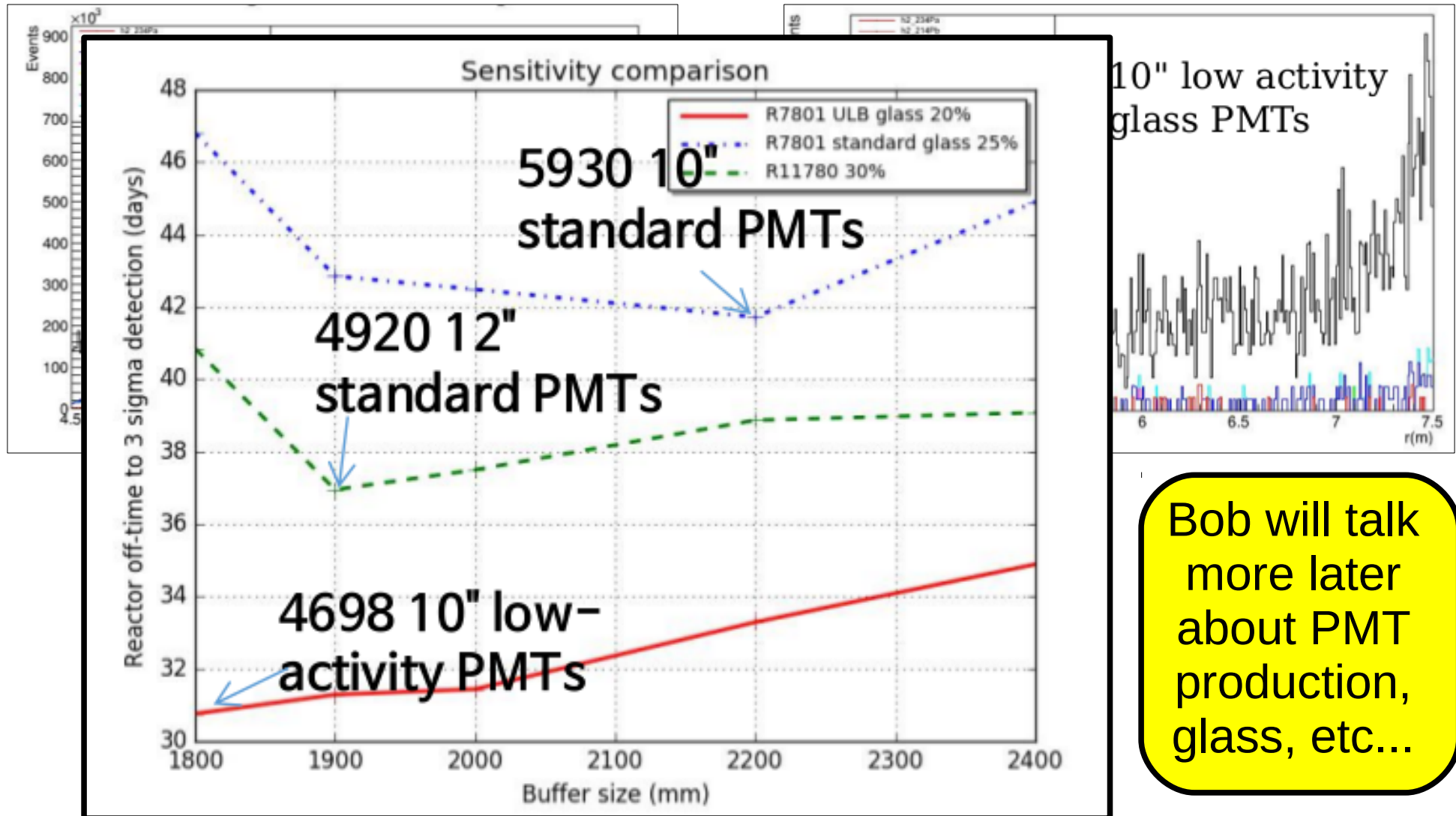# Do We NEED Low BG PMTs?

BG rates (per day) from R11780

BG rates (per day) from R7801 (Low-BG)

The University Of Sheffield.

BG rates (per day) from R11780

BG rates (per day) from R7801 (Low-BG)

Bob will talk more later about PMT production, glass, etc...

Advanced Photosensors

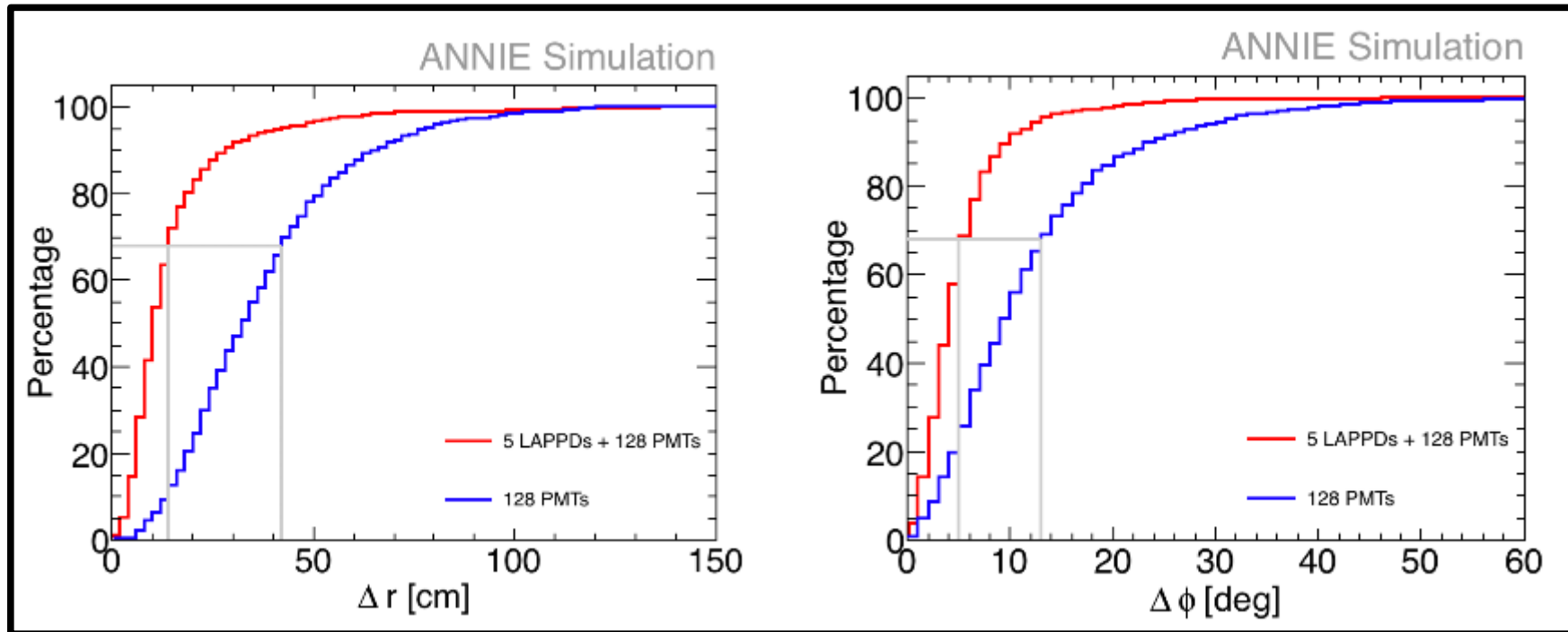AIT Phase II will look into other photosensor designs:
- mPMTs?
- LAPPDs?

LAPPDs: Now a reality!

First use of LAPPDs in a detector coming in ANNIE (next year!)
Larger-scale use *could* follow in AIT Phase II…
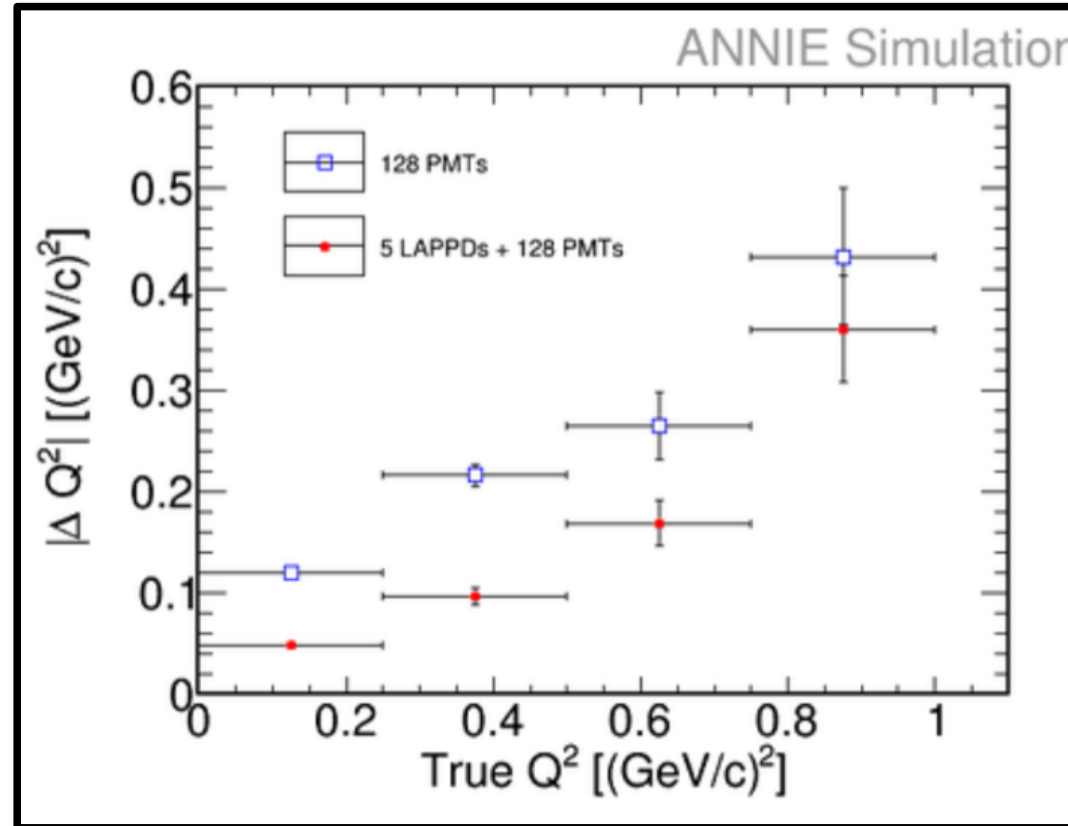
Initial reconstruction with LAPPDs has now been implemented in ANNIE.

Vertex and Direction

See Jingbo's
talk for more...

Resolution w/ LAPPDs (WC)

Momentum Transfer

Significant improvement in ANNIE (critical to success of experiment!)

Now looking into applying methodology to AIT Phase II (w/ WbLS)
→ Aim is to use C / S separation for directionality, increased range

Conclusions

- WATCHMAN is coming! ("proto-THEIA"?)

- So is ANNIE! ("proto-proto-THEIA"??)

- R&D ongoing at both are relevant to THEIA

- AIT work of interest includes

  – Attempts to boost range and distance with scintillator

  – Background tests of PMTs

  – Cherenkov / scintillation separation possibility

- Next talks will cover other interesting work, including:

  – Complementary measurements at Hartlepool (Sean)

  – ANNIE R&D efforts (Jonathan)