Neutrino **E**xperiment for **O**scillation at **S**hort Baseline

July 4-9 @ ICHEP 2018, Seoul

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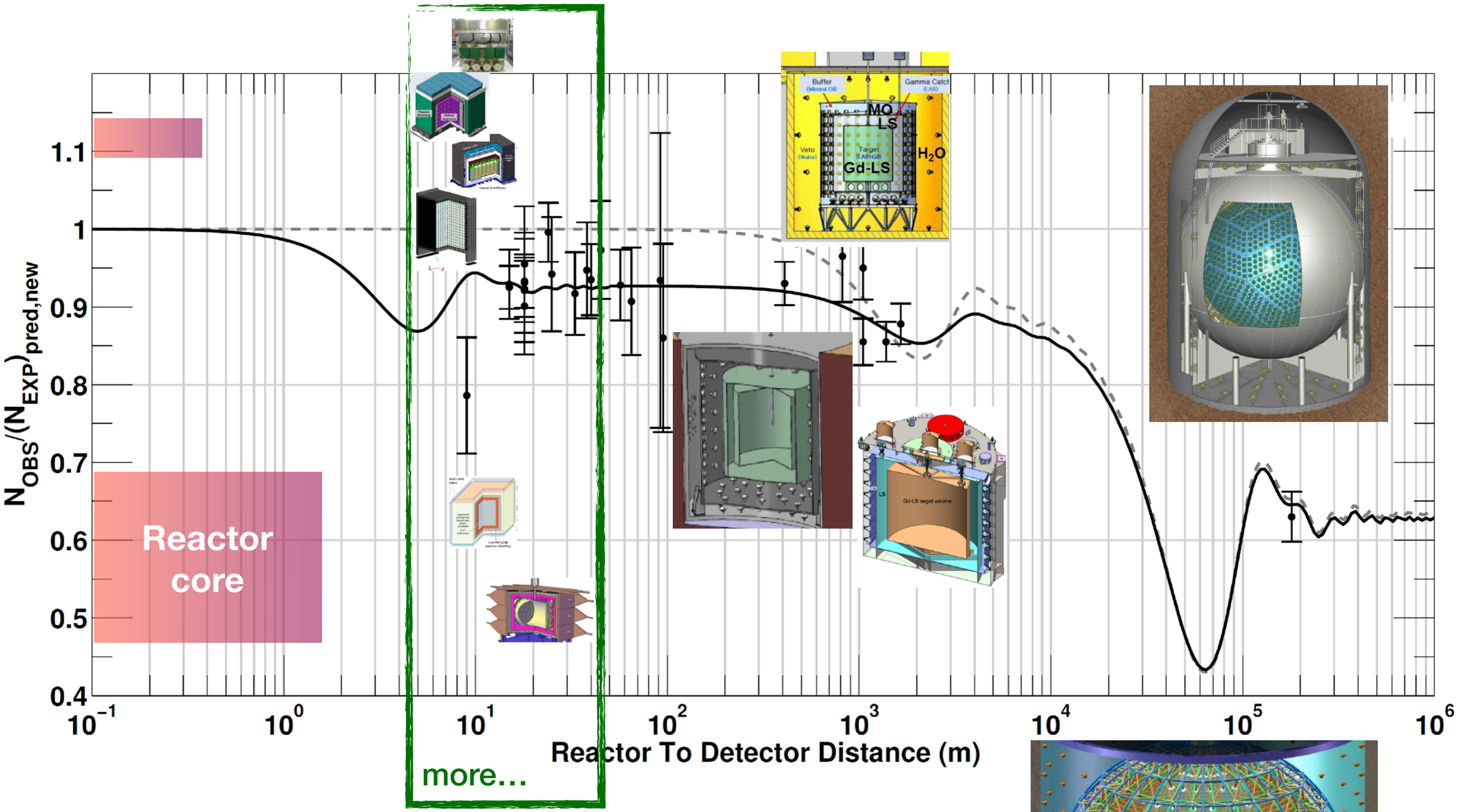
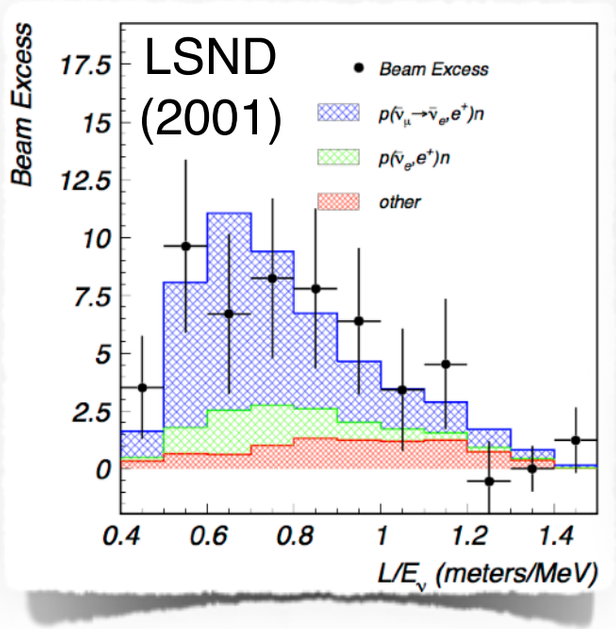
for the NEOS collaboraiton

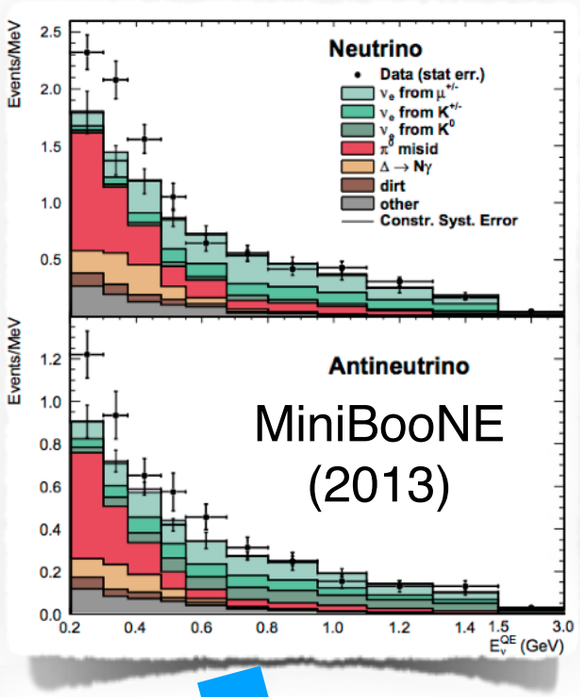
Center for Underground Physics ibs

Reactor neutrino experiments

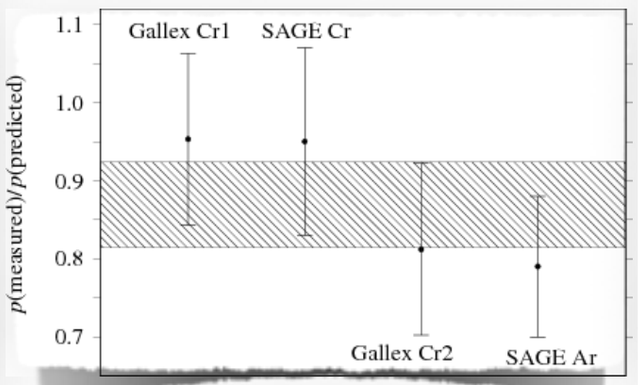


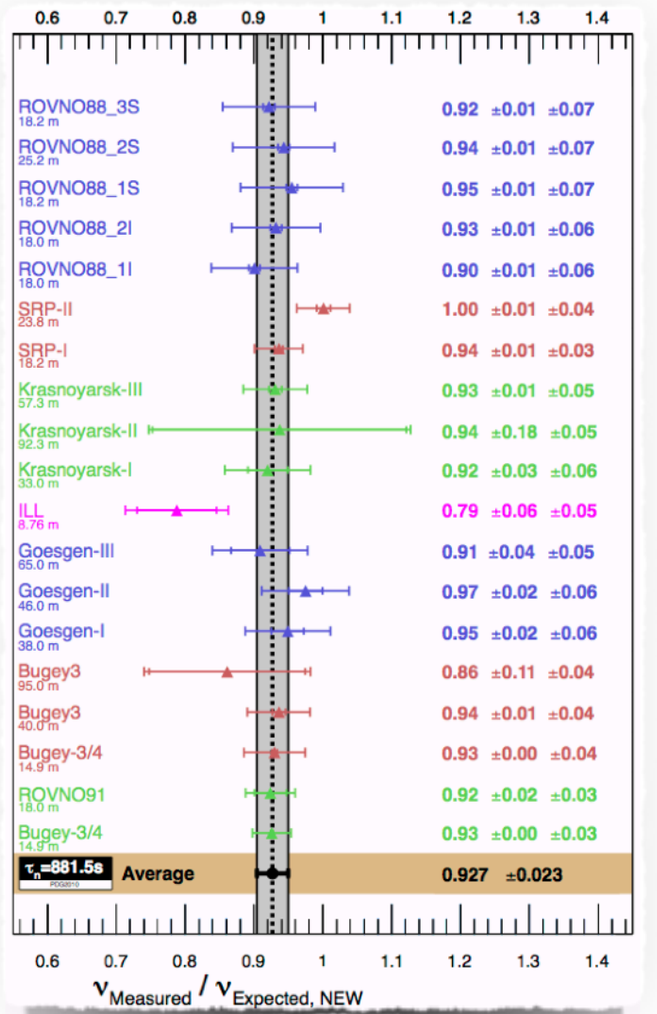
Motivation — anomalies





Gallex/SAGE
(2009)

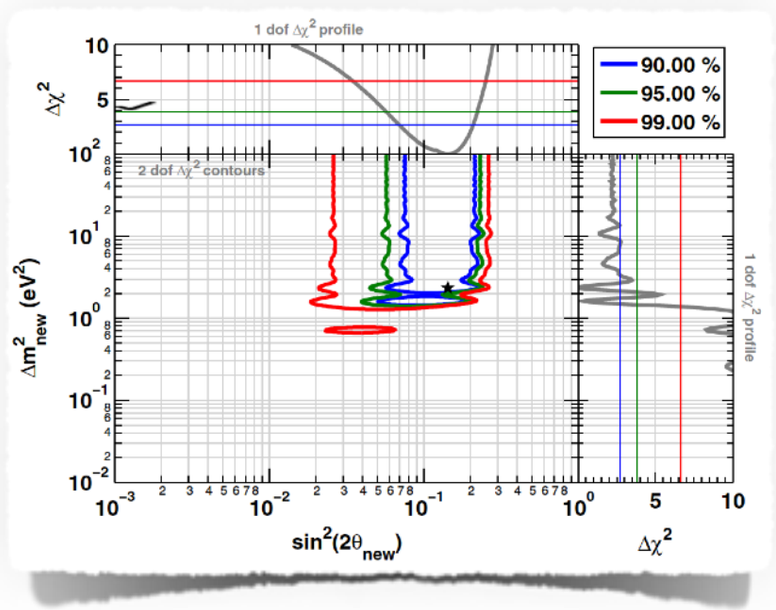


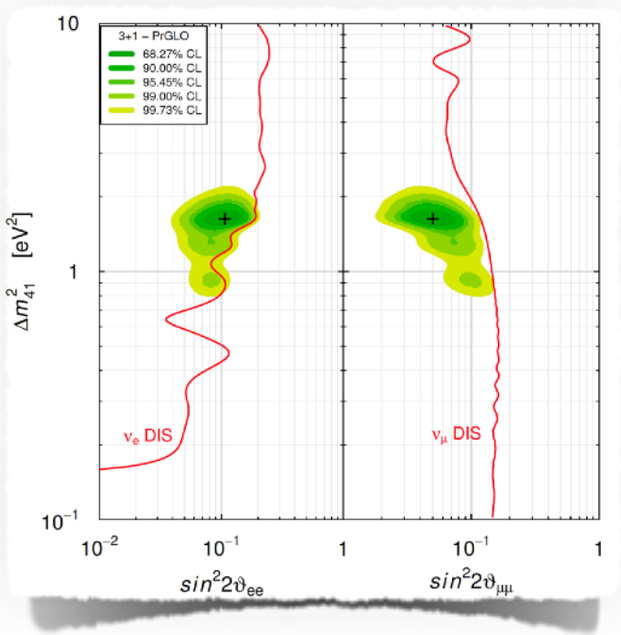


white paper
(2012)

~ 1eV sterile neutrino

Mention
(2011)

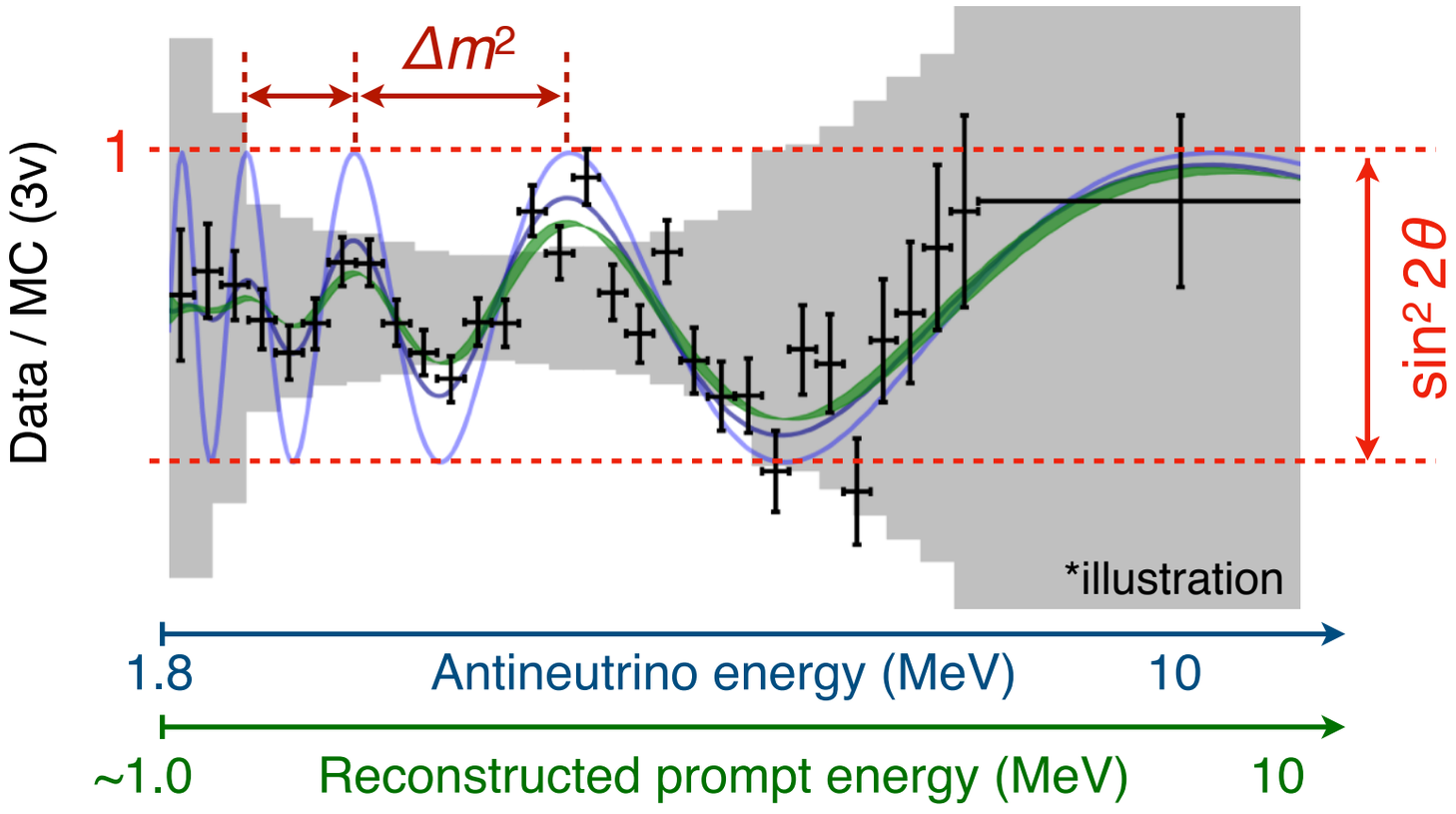




Gariazzo
(2016)

NEOS Sensitivity to 3+1ν oscillation

$$P(\bar{\nu}_e \to \bar{\nu}_e) \sim 1 - \sin^2 2\theta_{14} \sin^2\left(1.27 \frac{\Delta m^2 L}{E_\nu}\left[\frac{\mathrm{eV}^2 \cdot \mathrm{m}}{\mathrm{MeV}}\right]\right)$$



washed out by:

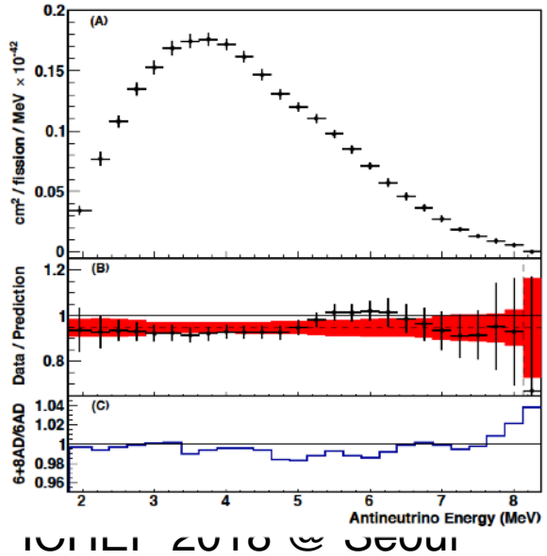
⊗ Baseline
size of reactor, detector

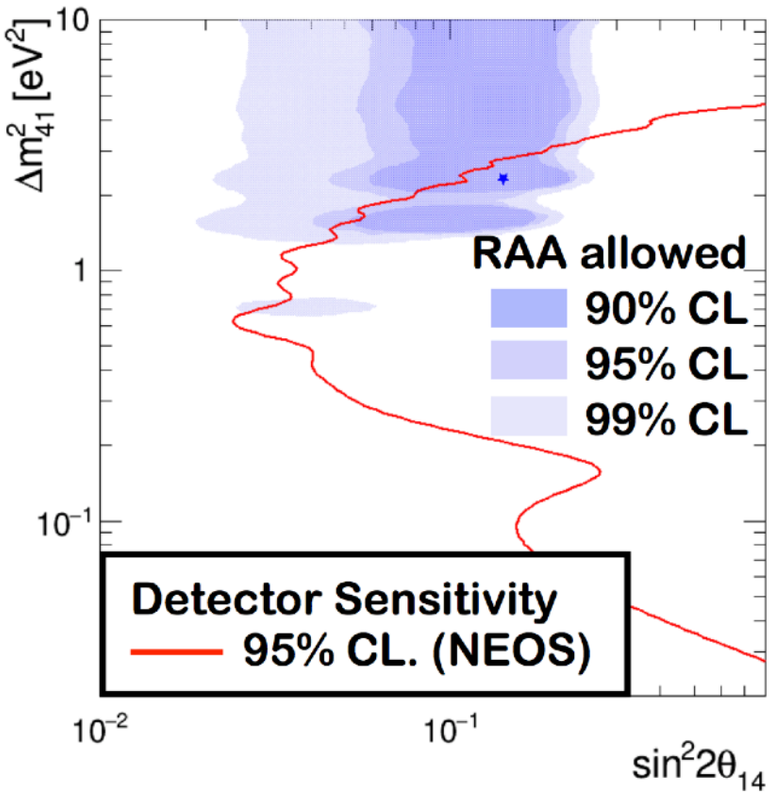
⊗ Detector
neutrino → prompt energy

⊗ Uncertainties in model
bin-to-bin (un)correlated

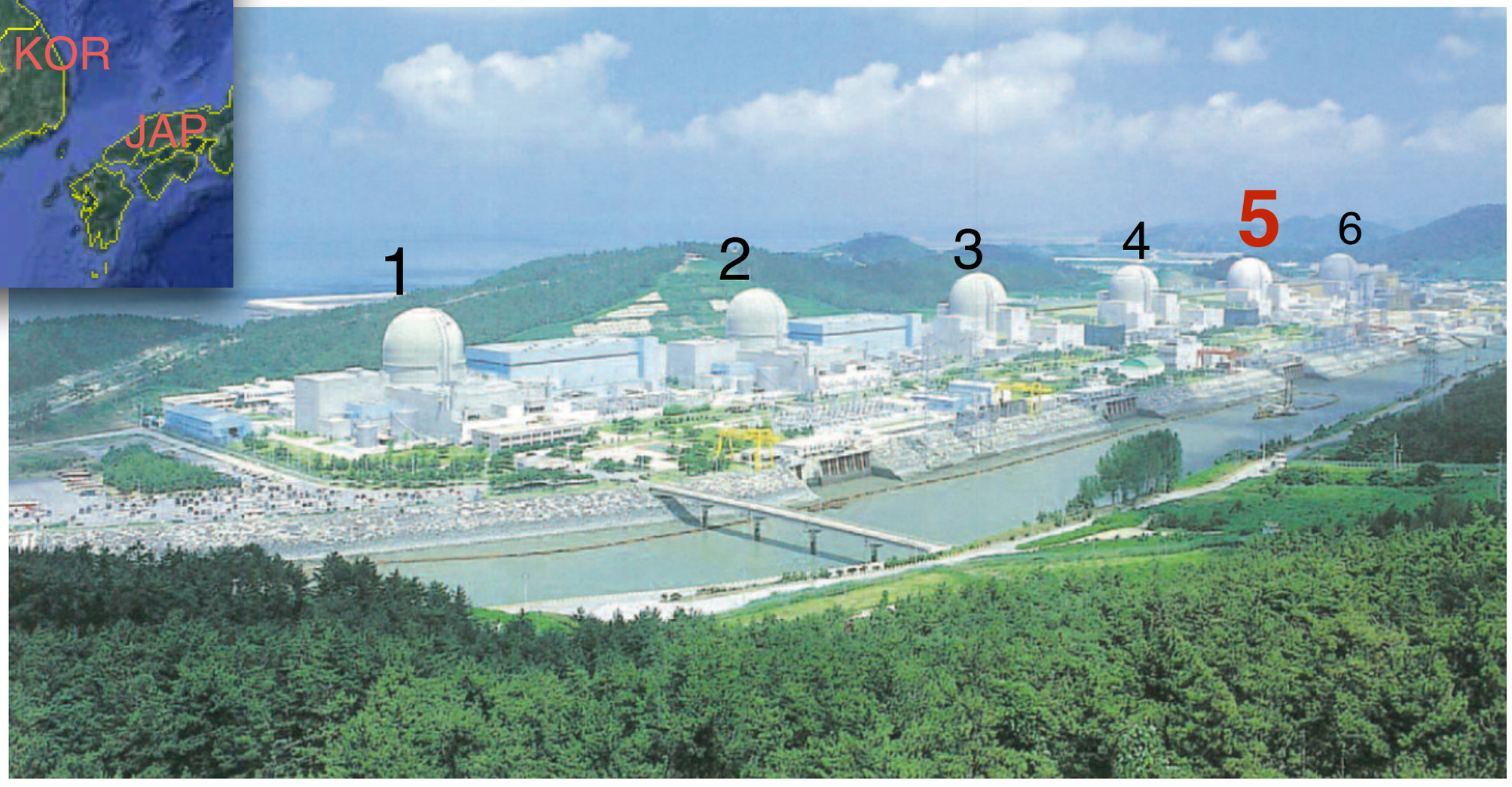
⊗ Statistics, background, …

Single detector experiment:
- a decent model spectrum,
- detector simulation



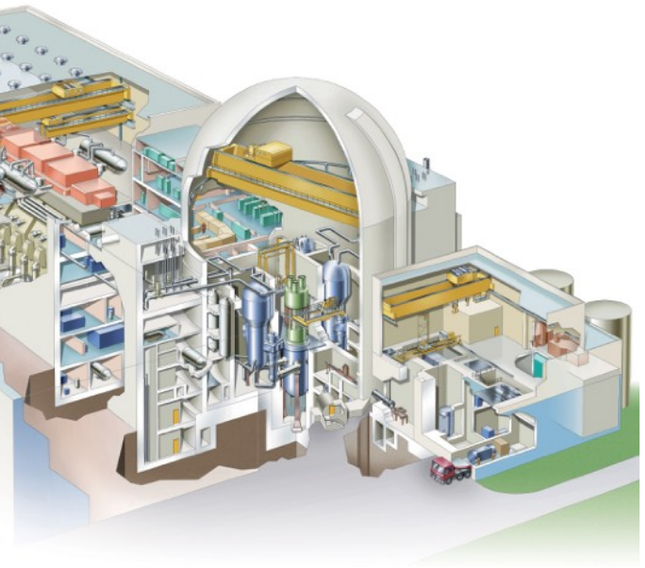


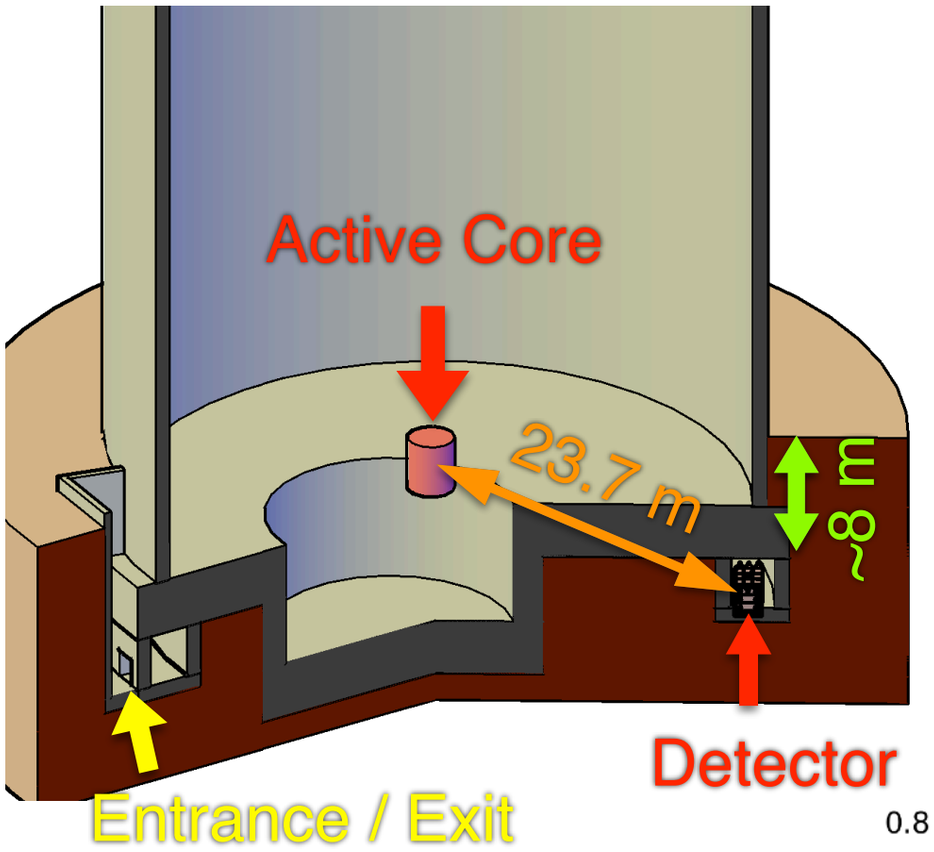
Experimental site

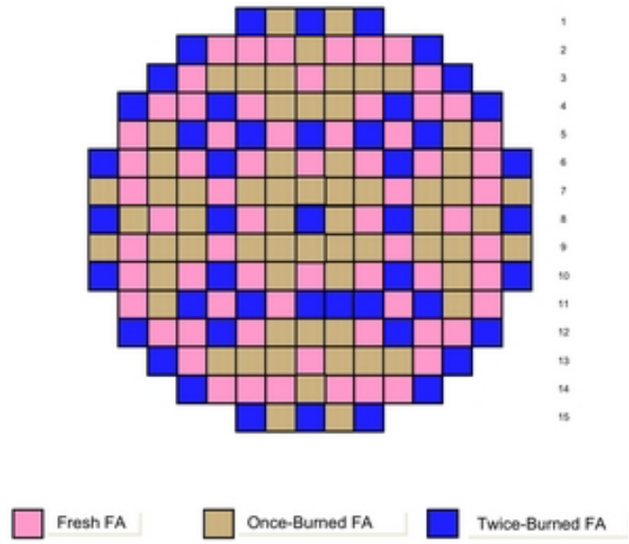


- Hanbit-5 reactor in Yeonggwang (靈光, ghost illumination), Korea
- Distance between neighboring reactor cores: 256 m
- Same reactor complex being used for the RENO experiment

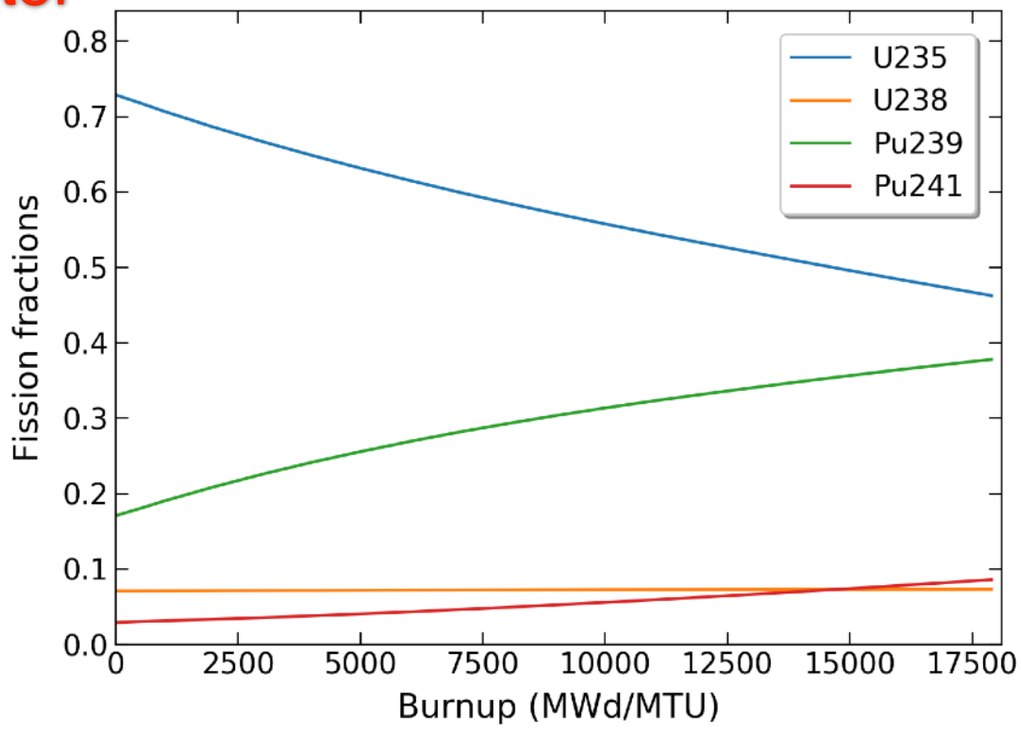
Hanbit-5 reactor and tendon gallery



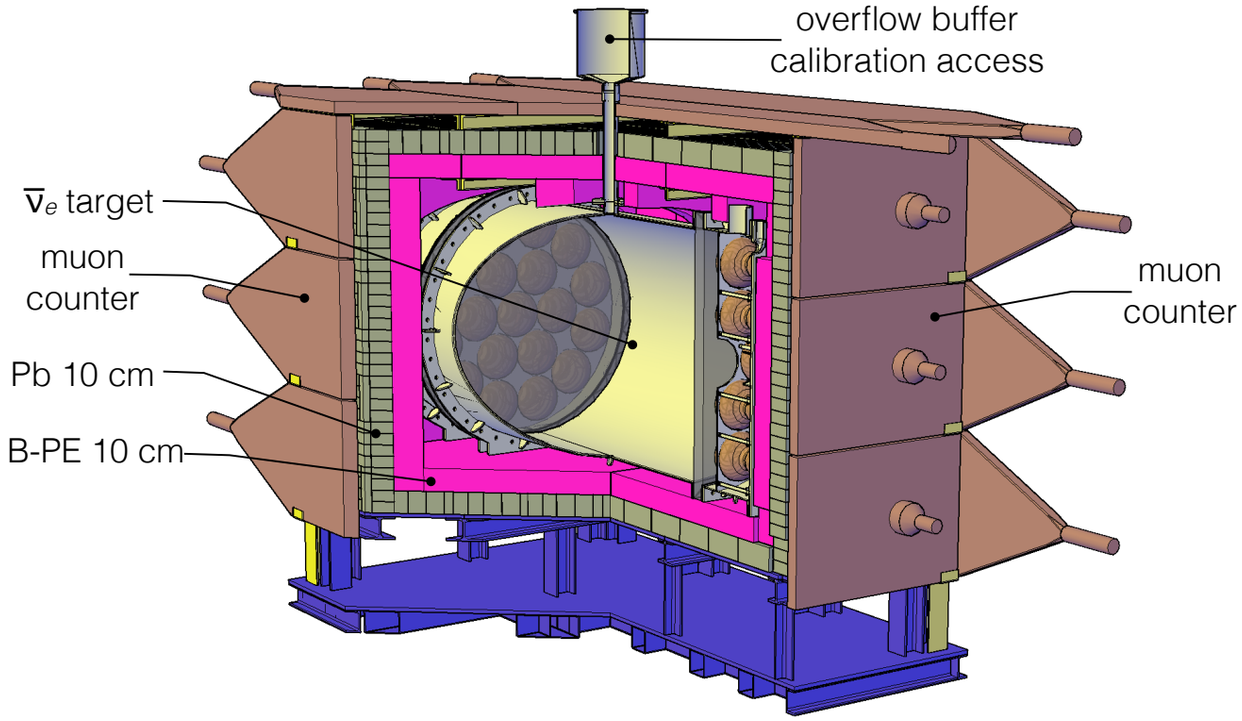




- OPR-1000, Thermal power: 2.8 GW
- Active core size: Φ 3.1 m, H 3.8 m
- 177 fuel rods, 1/3 changes after a cycle
- LEU fuel: ~4.x% U-235 enrichment
- Detector-core distance: 23.7 m
- Overburden > 20 m.w.e.

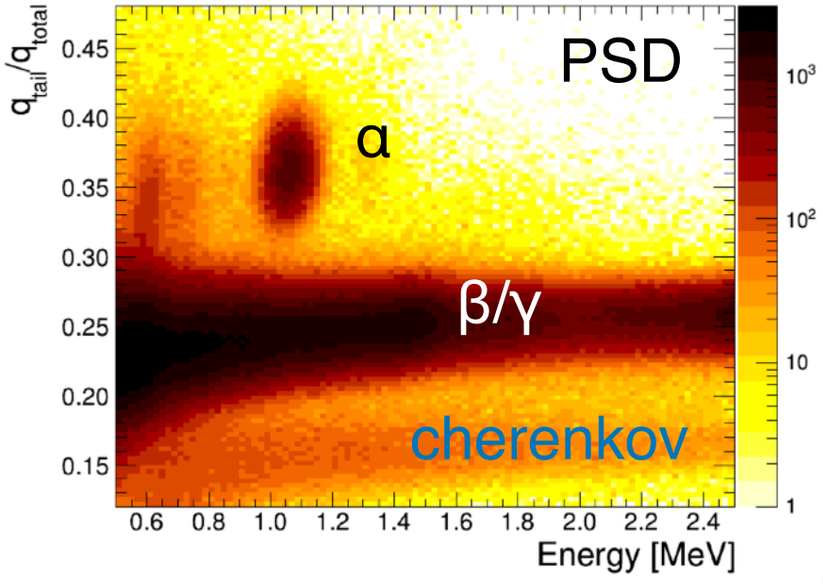


Detector design & construction

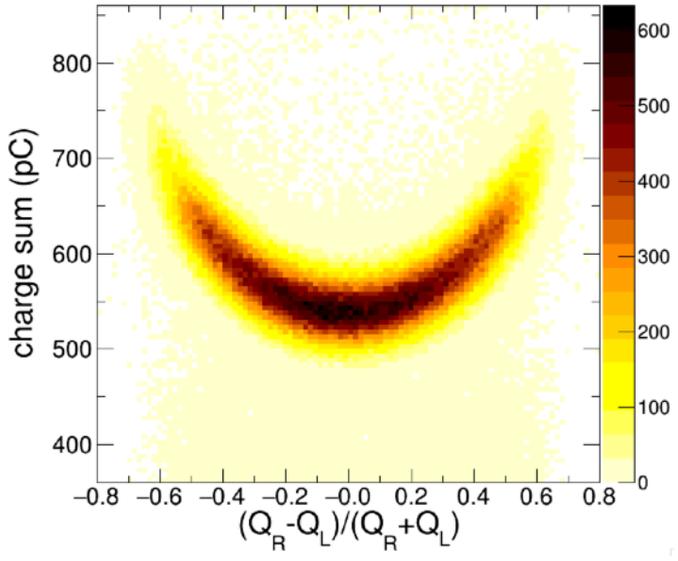


- Simple / compact / homogeneous.
  - efficiency, energy resolution.
- 1000L of 0.5% Gd loaded LS.
- 2 x 19 8-inch PMTs.
- No γ-catcher buffer layer.
- LAB:UG-F = 9:1 for PSD.
- Source calibration through chimney.
- FADC 500 MS/s for waveform analysis

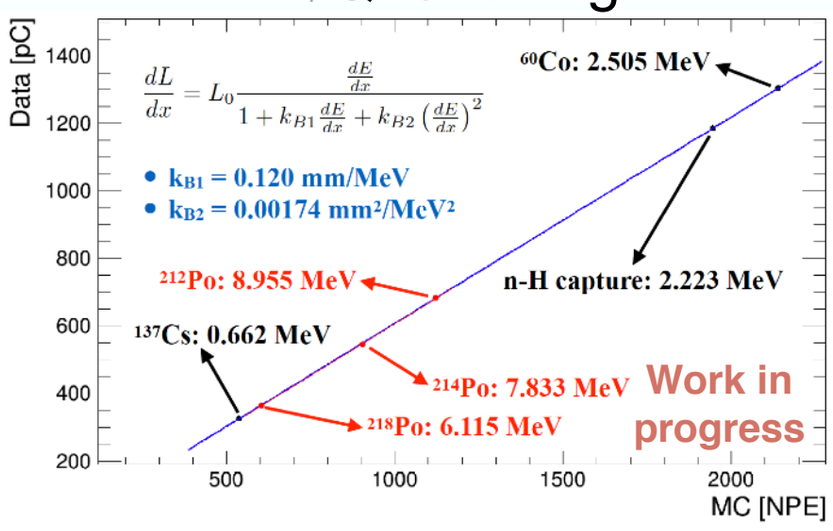
Detector responses & simulation

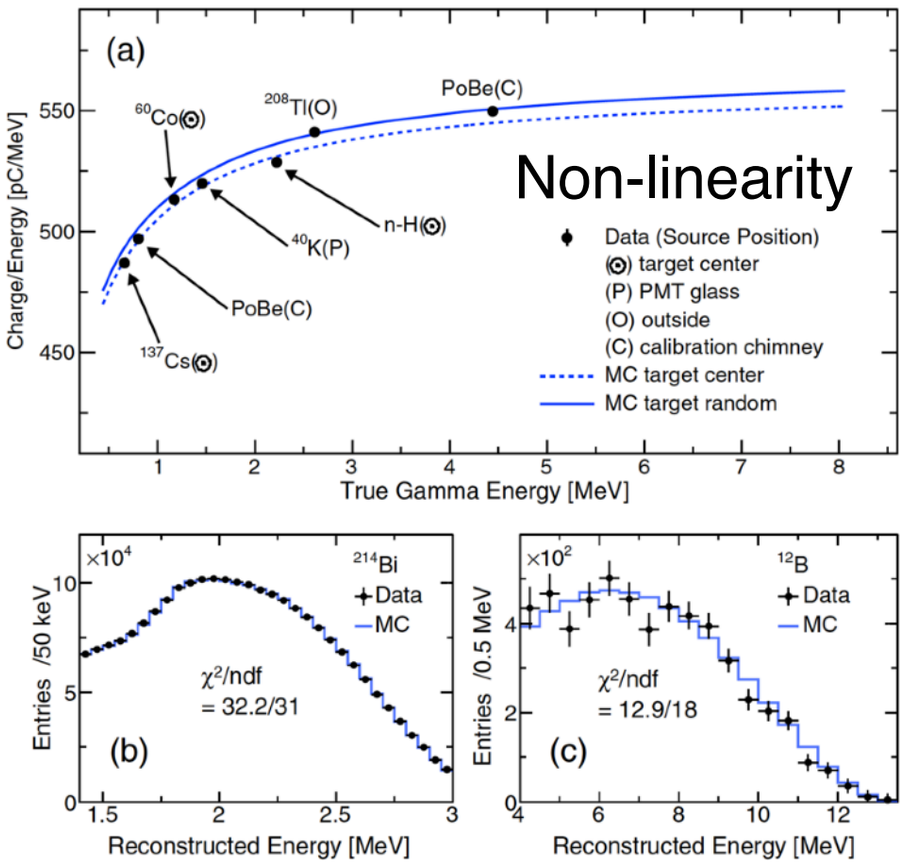


Non-uniformity

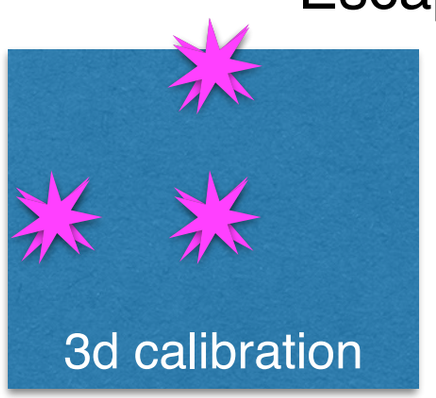


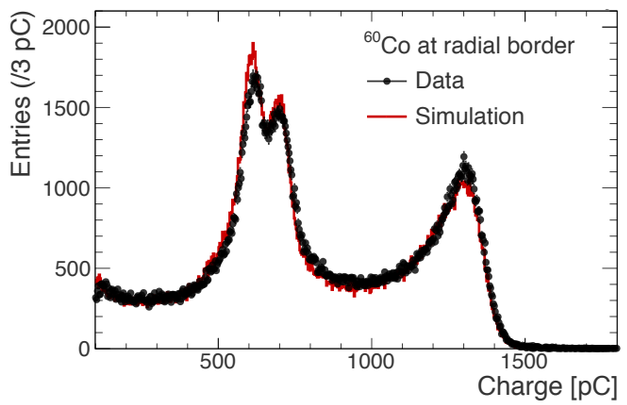
Quenching

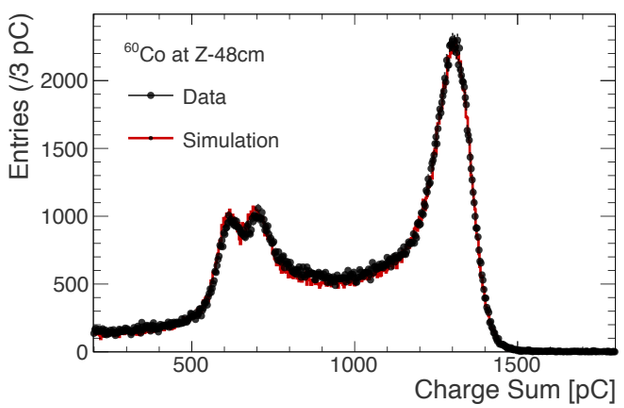


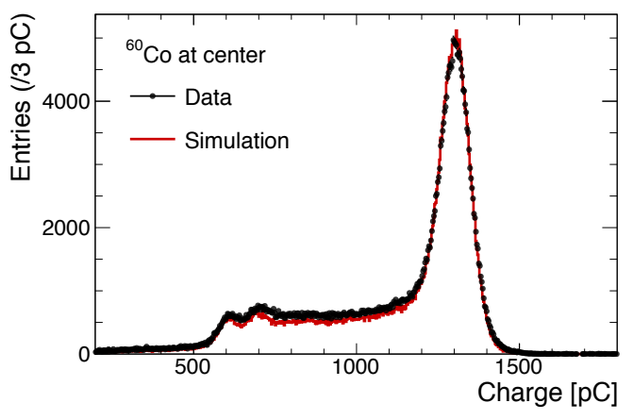


Escaping γ's

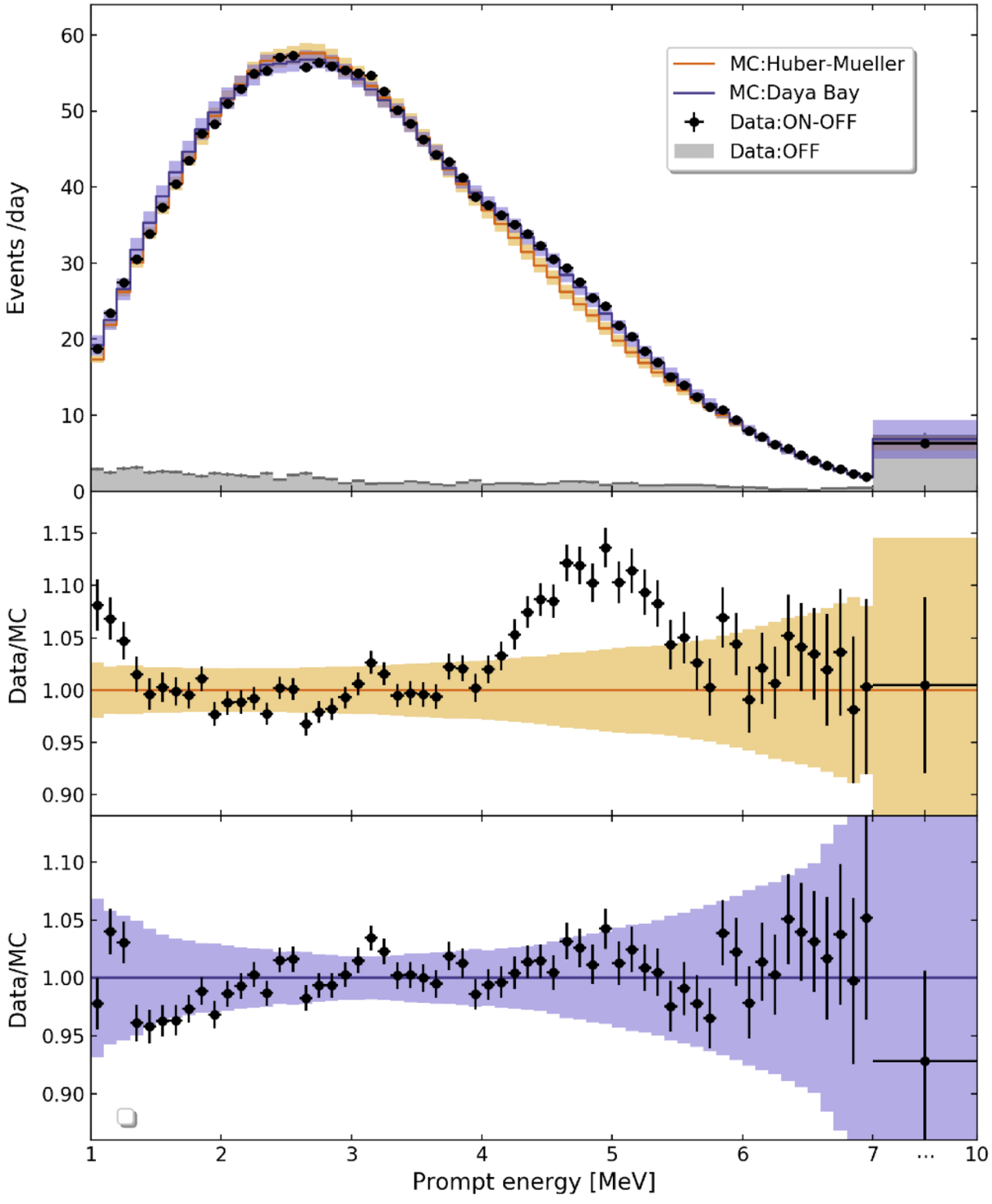




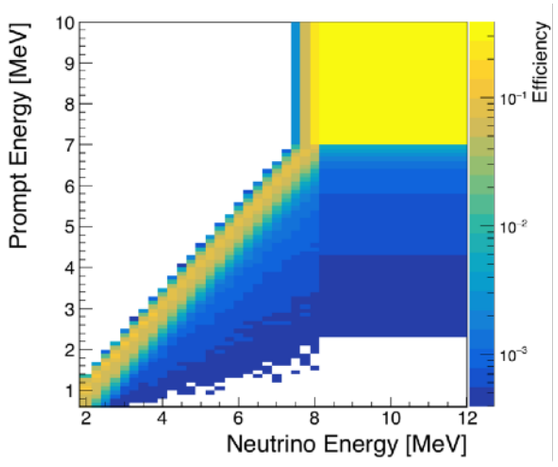


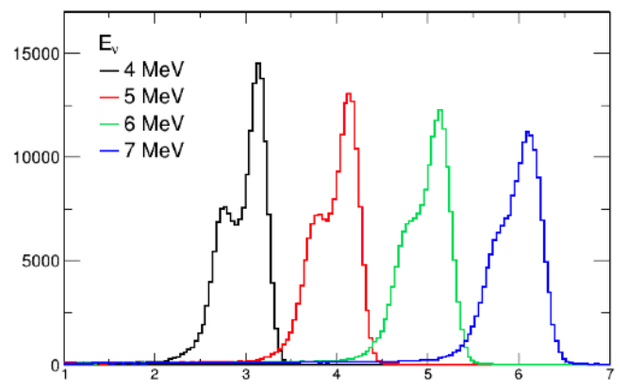


Prompt energy spectrum



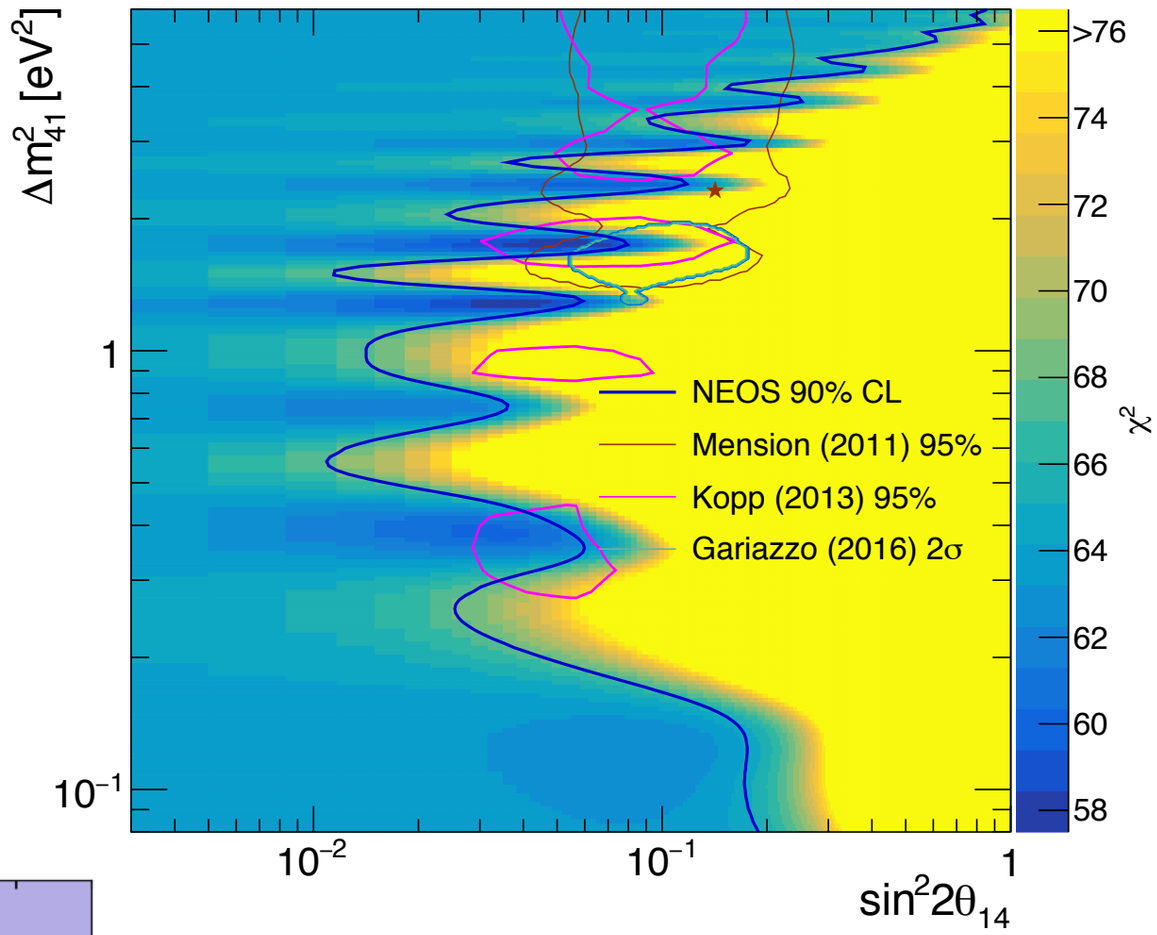
- 1976 IBD candidates/day (on), 85 /day (off); S/N~23.
- Negligible background change between on-off periods.
- Spectral anomaly observed (vs Huber-Mueller normalization).
- Small structural fluctuations.
- Reference spectra generated using detector response matrix,
  - energy escape due to detector size

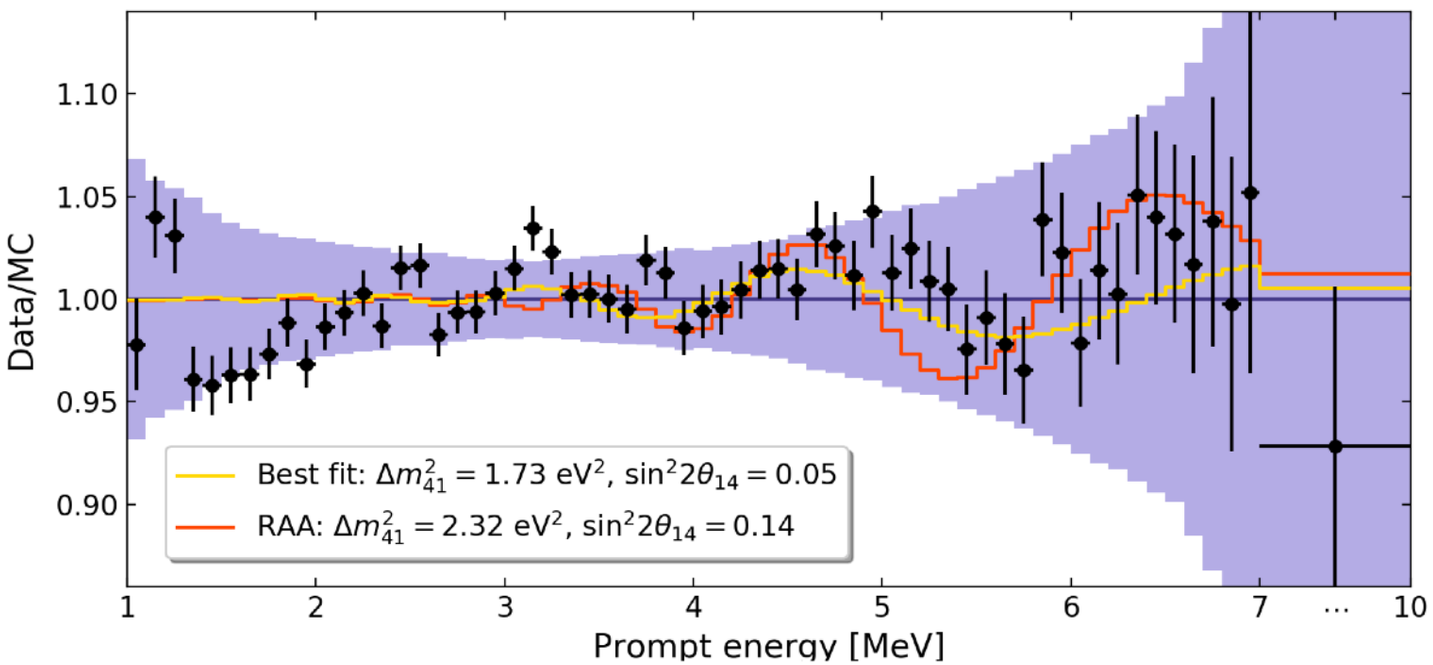


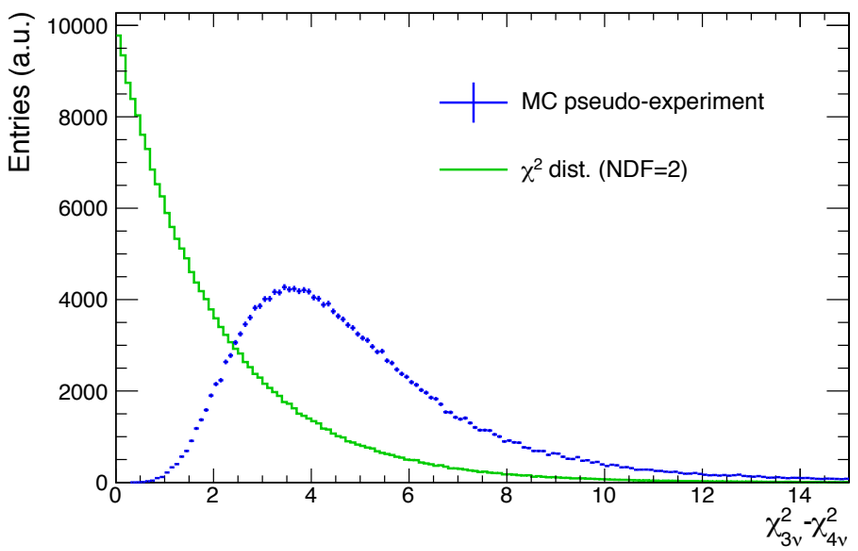


Active-to-sterile oscillation

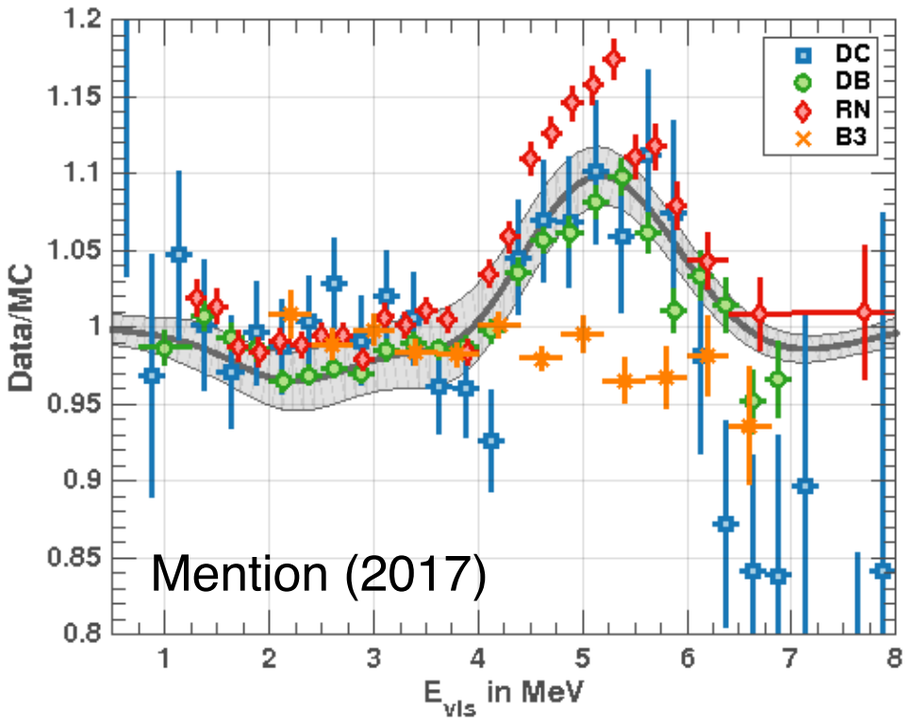
- Normalized with the Daya Bay shape
- Best fits at:
  (1.73 eV², 0.05), (1.30 eV², 0.04)
  with χ^2(3v)-χ^2(4v) = 6.5,
  p-value = 0.22
- Not a definitive answer for 3+1v oscillation or fine structures in reactor ν spectrum.

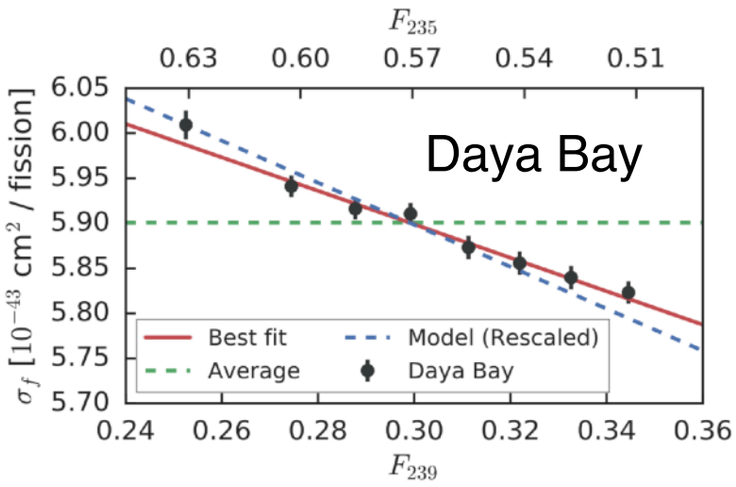


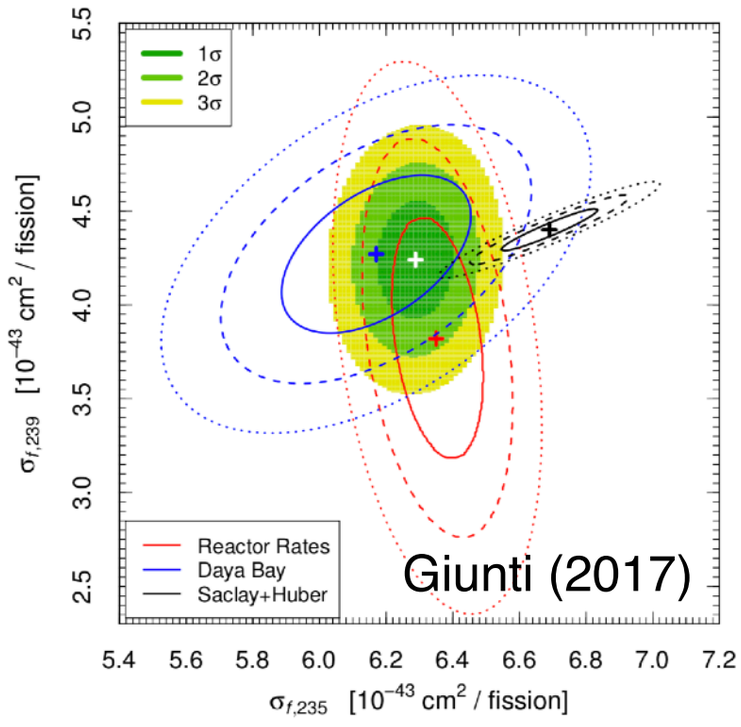




Recent Issues



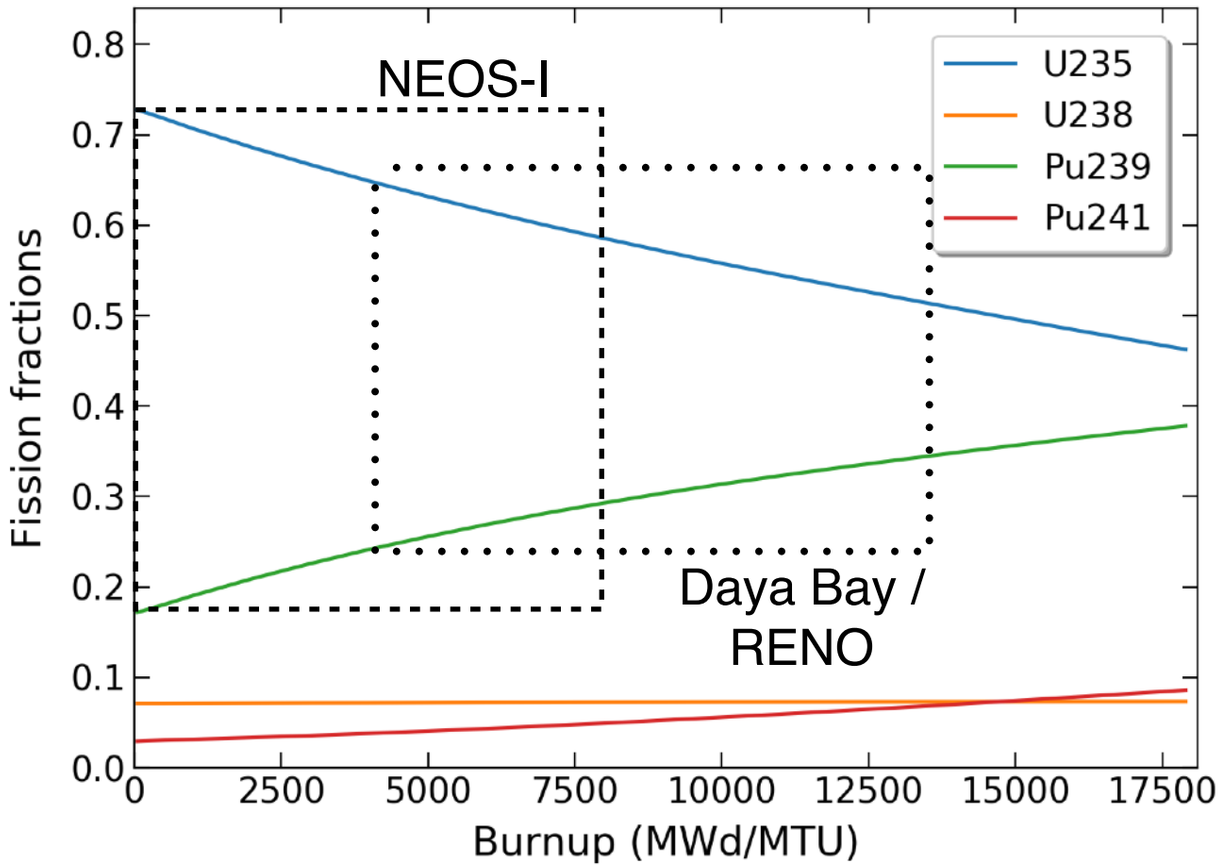


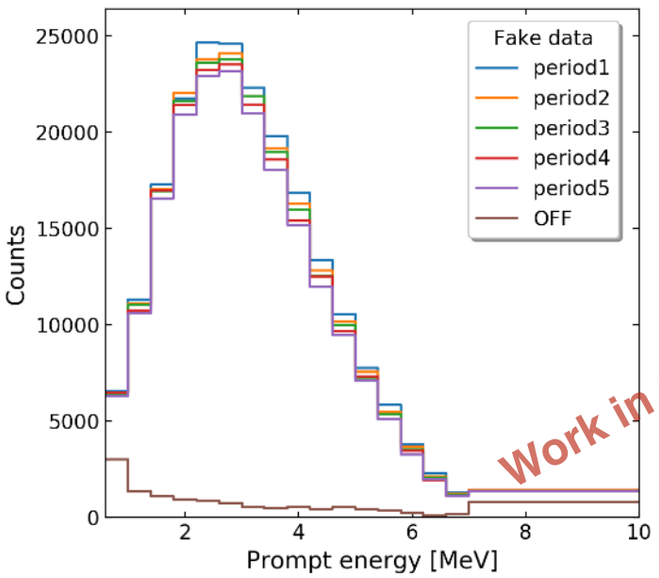


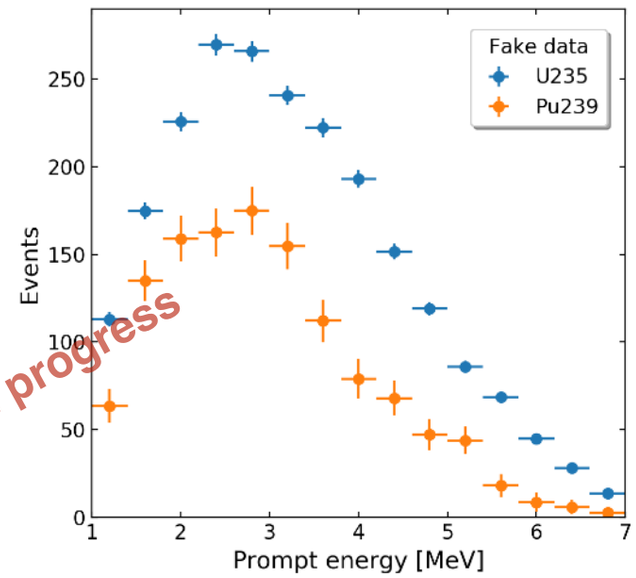
*"… sterile neutrino models **fail to simultaneously account** for **all** the $\nu_e \rightarrow \nu_e$ data, the $\nu_\mu \rightarrow \nu_e$ data and the $\nu_\mu \rightarrow \nu_\mu$ data. This conclusion is robust;"*
Maltoni @ v2018

+ fine structures in the flux spectrum > requires high resolution detector?

NEOS phase-II measurement

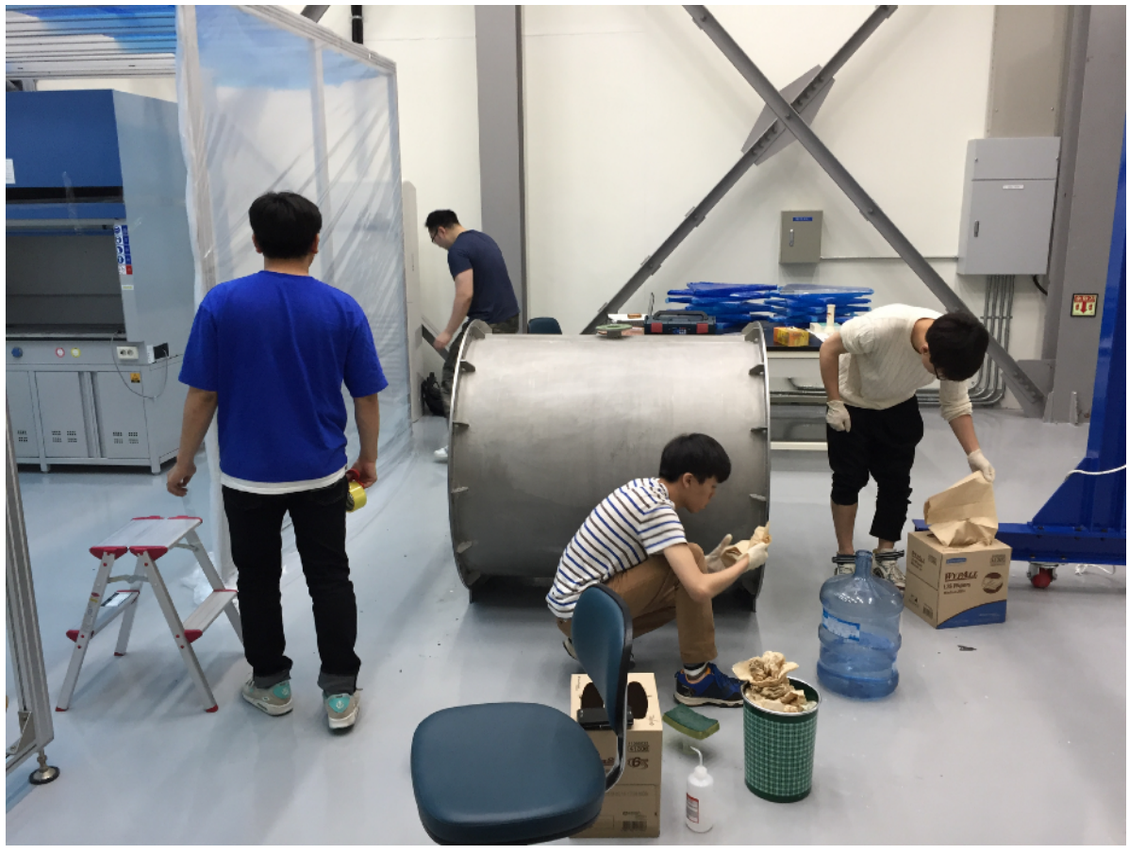






- Starts in September 2018:
  - one full burnup cycle (~500 days), plus two maintenance (off) periods (>100 days, contributions from spent fuels?)
  - expecting ~1 M IBD events.
  - same reactor, same detector.
- Spectrum evolution with fuel component changes.
  - from a single LEU core,
  - absolute spectrum measurement,
  - decomposing spectra for different elements.

Detector refurbishment and preparation



- To make more stable detector for longer data taking.
- Producing fresh Gd-LS and its QC.
- Upgrading slow control/monitoring system - temperature / PMT gain.
- MC simulation upgrade, e.g. GEANT4 versions, n-Gd data.

Summary

- IBD prompt energy spectral shape has been successfully measured, using 2.8 GWt commercial reactor at 24 m distance.
- No strong sign of active-to-sterile neutrino oscillation for $\Delta m^2 \sim 1$ eV^2, $\sin_2 2\theta \sim 0.1$.
- Similar spectral anomaly observed as mid-baseline experiments.
- Measurement will be resumed soon to see the evolution of the reactor neutrino flux/spectrum according to the fuel component changes.

Thank you.

B1. Recent limits