Status of NEOS II

10 -11 Oct
AAP2018@LLNL

Bo-Young Han (KAERI)
On behalf of NEOS Collaboration

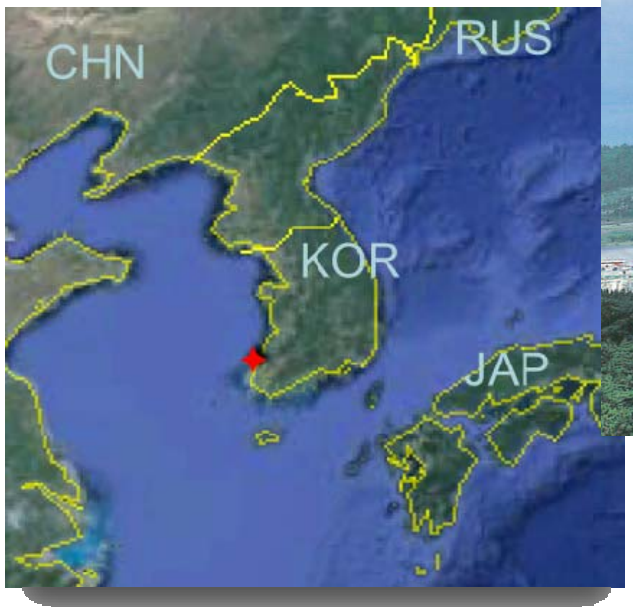
NEOS

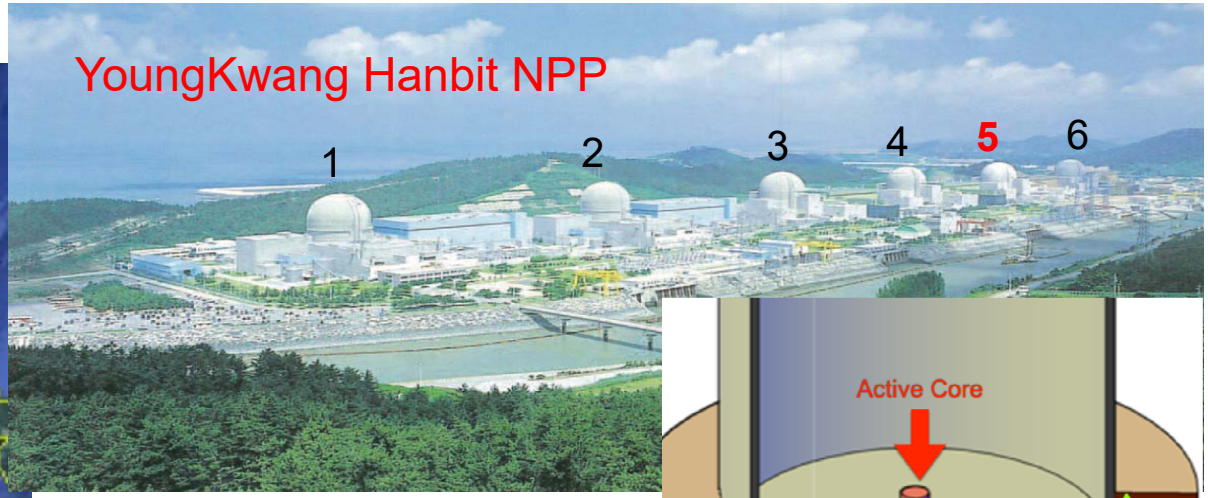
(Neutrino Experiment for Oscillation at Short baseline)

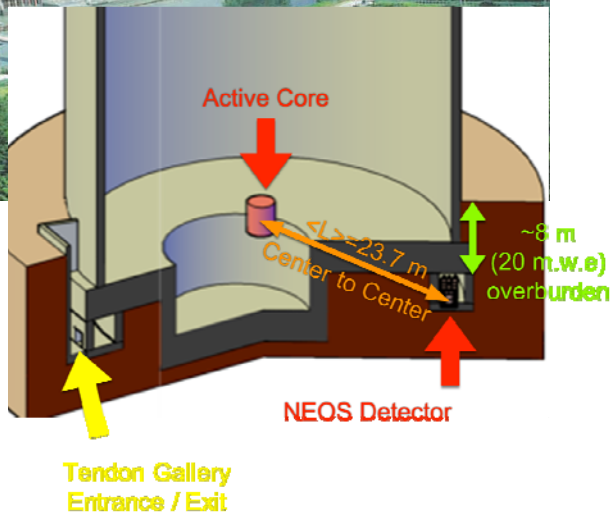
- To interpret reactor antineutrino anomaly, **"A search for sterile neutrino at a distance 24 m from reactor core"**
- NEOS Collaboration

  - 20 collaborators from 7 institutes in ROK
  - Project launched in 2012
  - Data taking from Summer 2015 to Spring 2016

Experimental Site

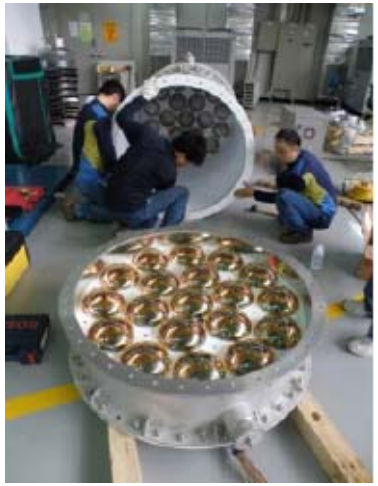


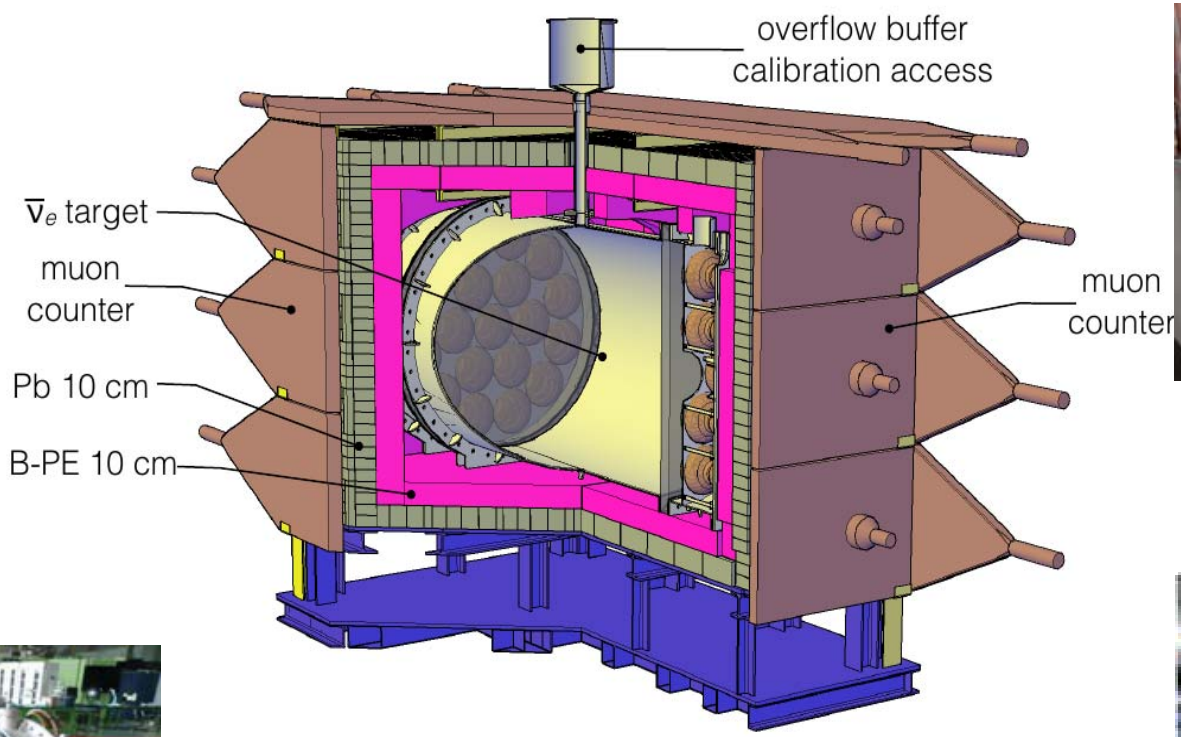




- The tendon tunnel of reactor Unit 5 at Hanbit nuclear power plant in ROK
- OPR-1000 reactor, 2815 MWt
- 177 fuel rods, low enriched (4.65%) uranium-235 (LEU) fuel
- Refueling by changing 1/3 of fuel rods for each burn-up cycle (~18 months)
- Active core size: 3.1 m (φ), 3.8 m (h)
- The distance to the closest neighboring reactor core is 256 m

NEOS detector

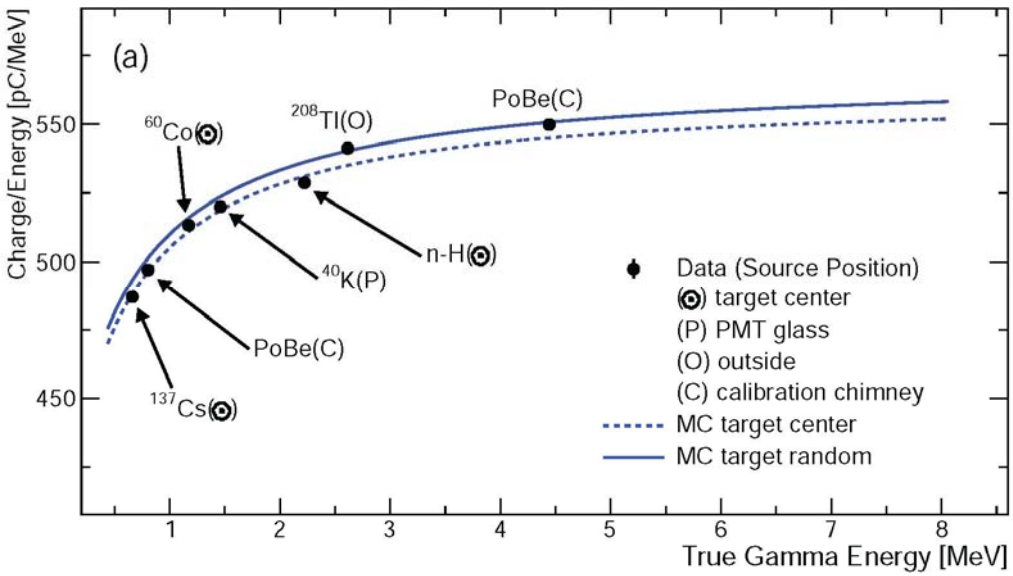


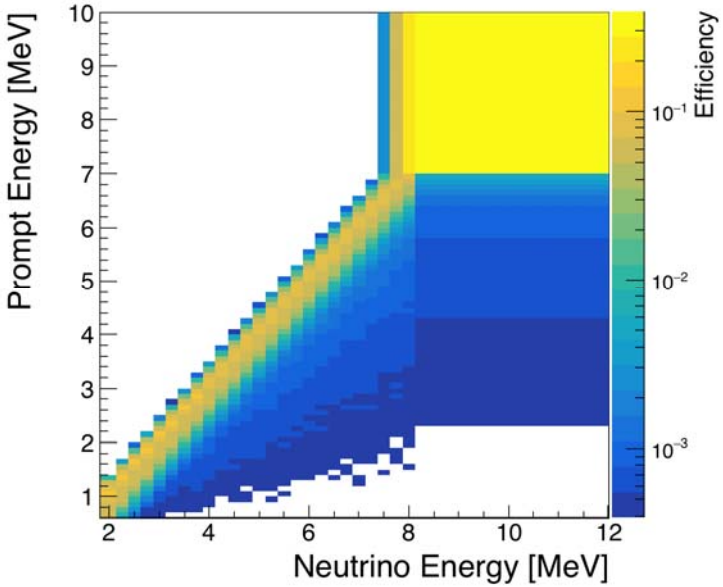


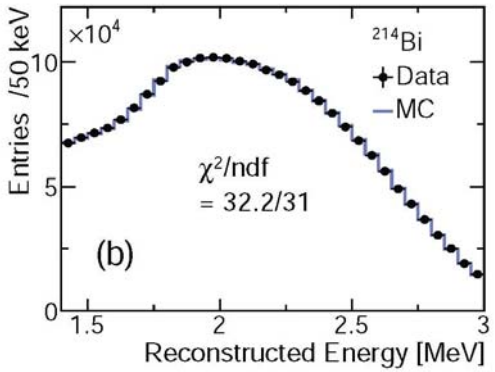
Active target (Liquid Scintillator, LS)
- Homogeneous, 1000 L volume
- 0.5% Gd-loaded LS
- LAB- and DIN-based LS (9:1)
- Cylindrical stainless steel tank with PTFE reflector

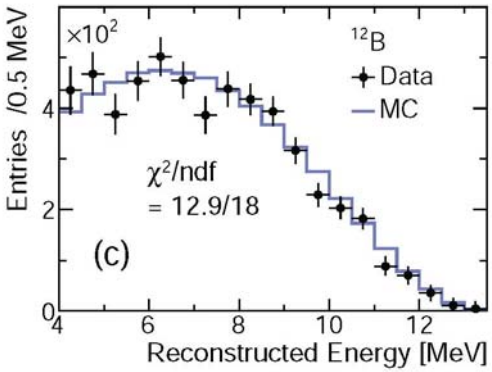
LAB: Linear Alkyl Benzene
DIN: Di-isopropylnaphthalene

Detector Response



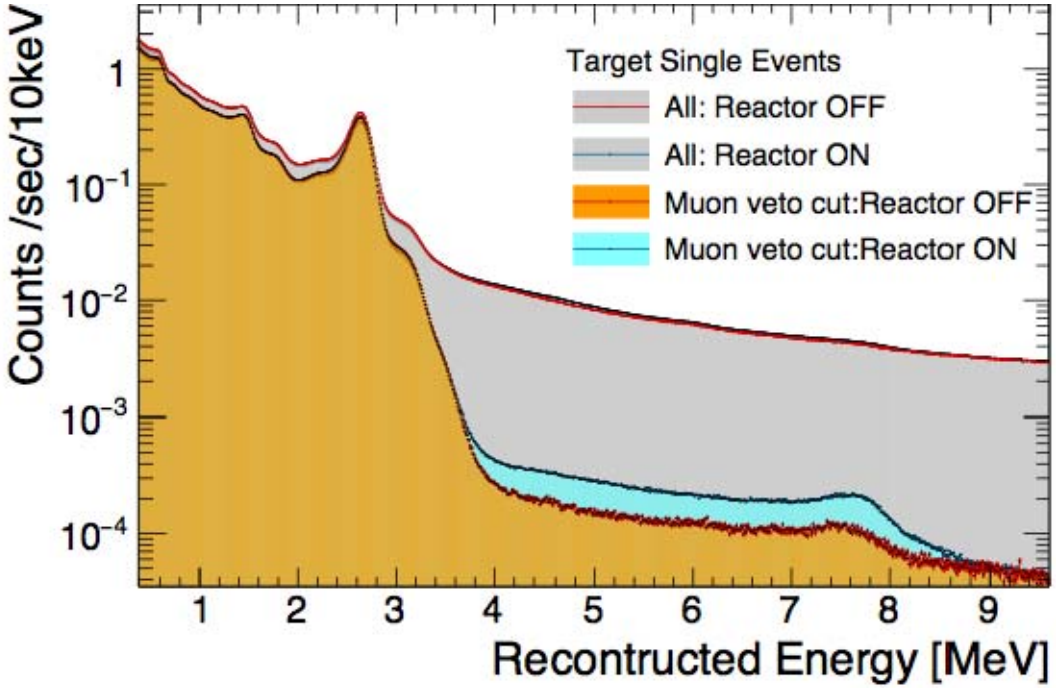




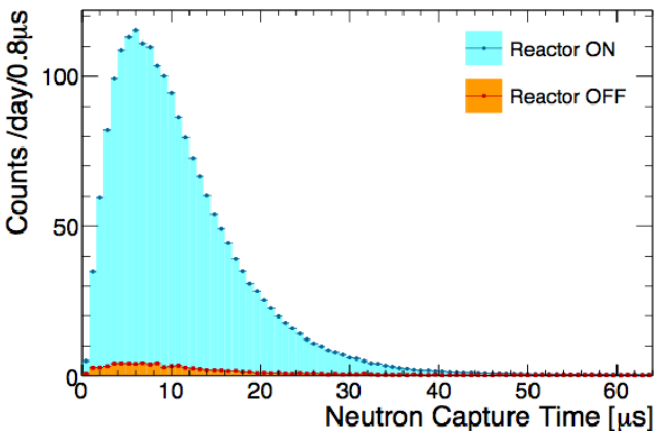


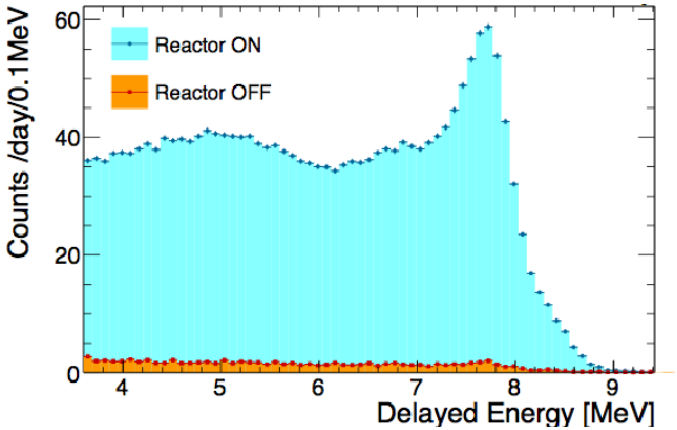
- **Energy Resolution : σ/E_γ ~5% at 1 MeV**
- **Nonlinear Q to E_γ response, reconstructed energy spectra for ^{214}Bi and ^{12}B are well reproduced**
- **The effects of escaping gamma rays**
- **The systematic error on the energy scale : 0.5%**

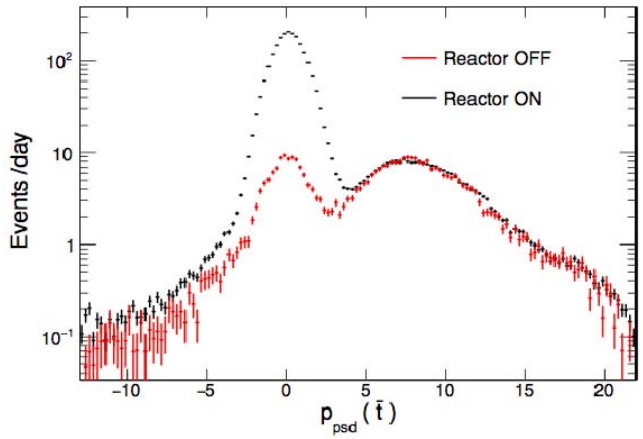
IBD event selection



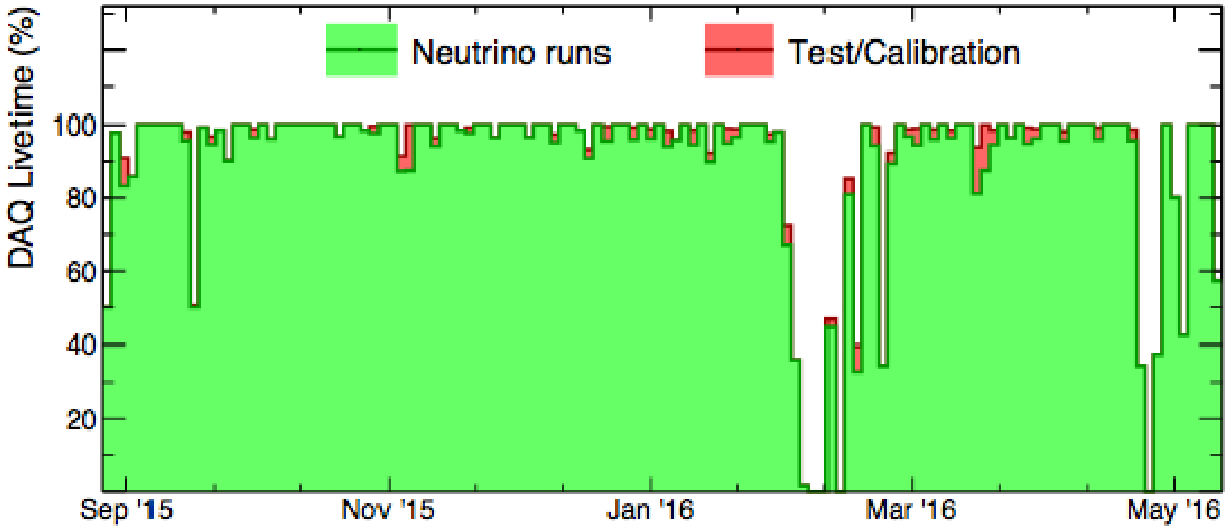
- neutron capture time:1~30 μs
- delayed energy: 4~10 MeV
- muon veto time: 150 μs (~240 Hz)
- multiplicity: no other event within 30 μs before / 150 μs after.
- pulse shape discrimination reduces 70% of background.

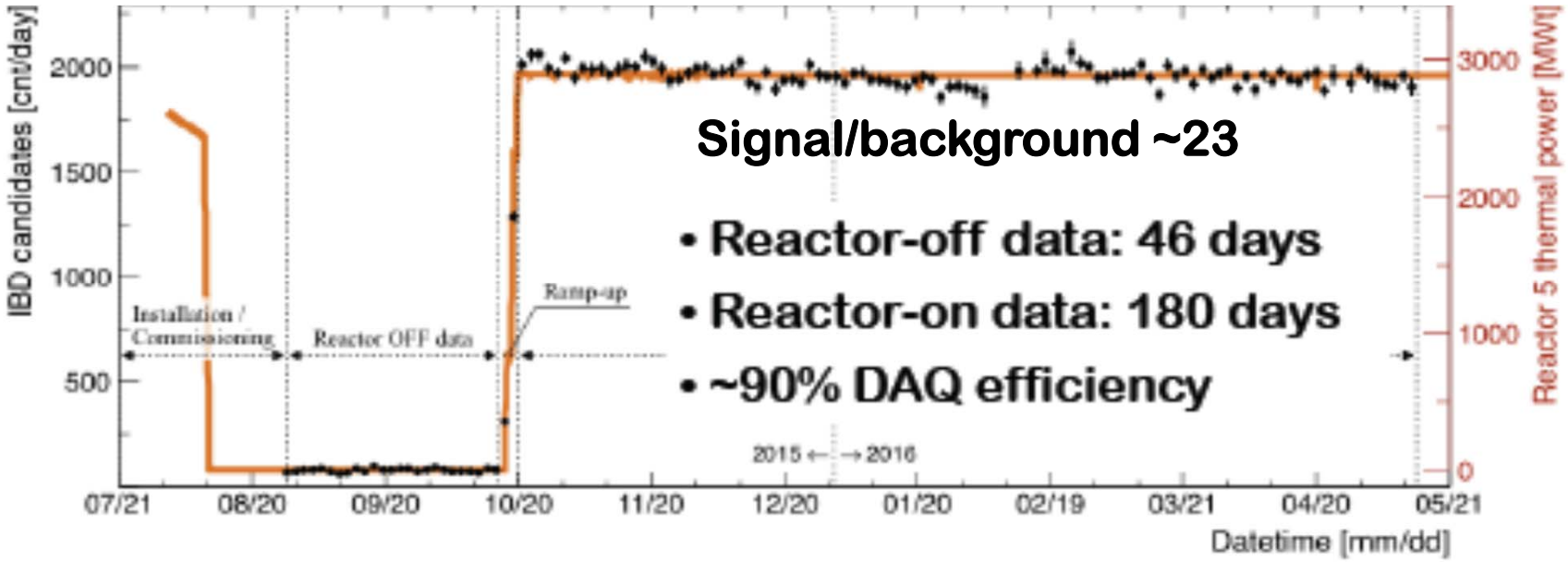






Operation (IBD event rate)

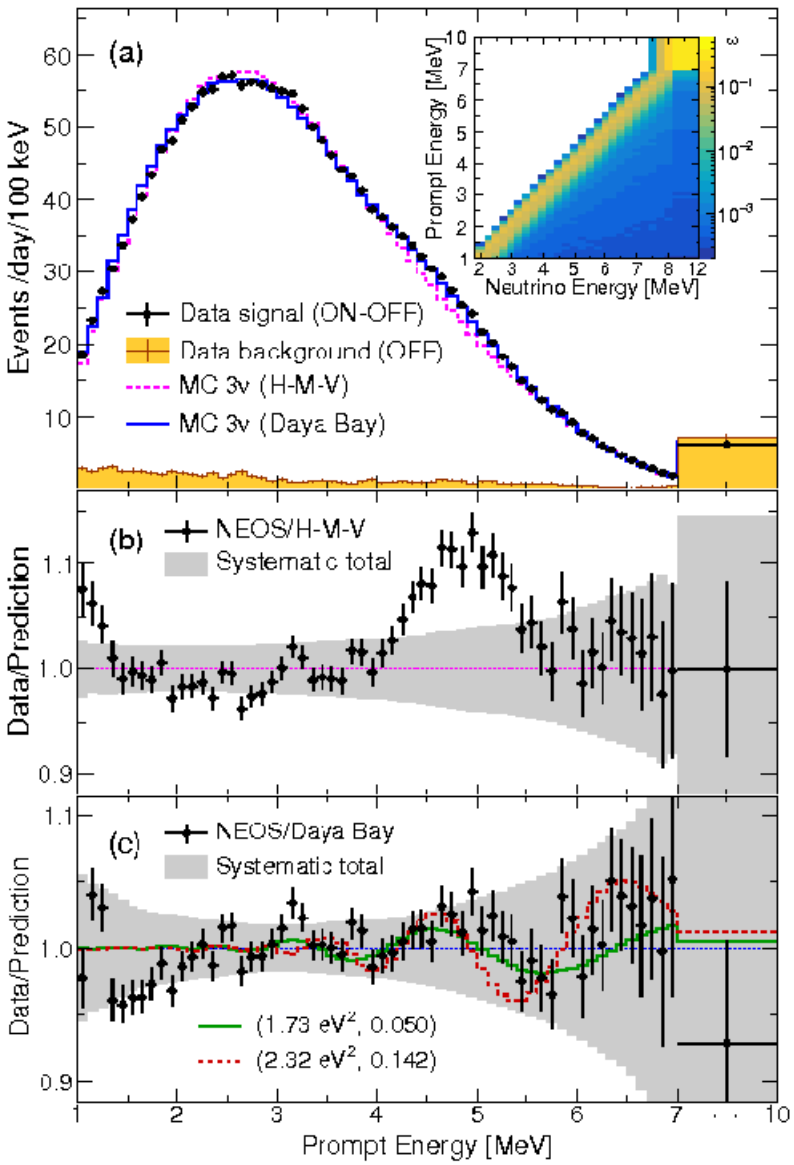


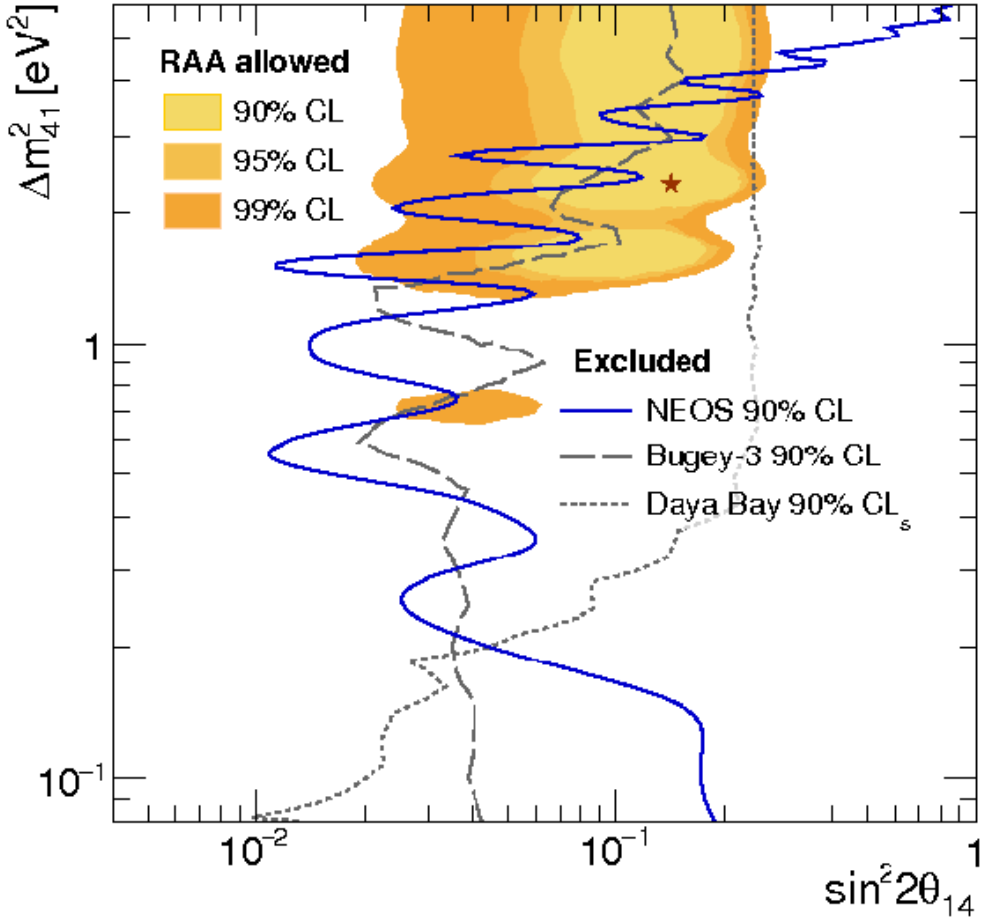


Signal/background ~23

- **Reactor-off data: 46 days**
- **Reactor-on data: 180 days**
- **~90% DAQ efficiency**

Results from NEOS I



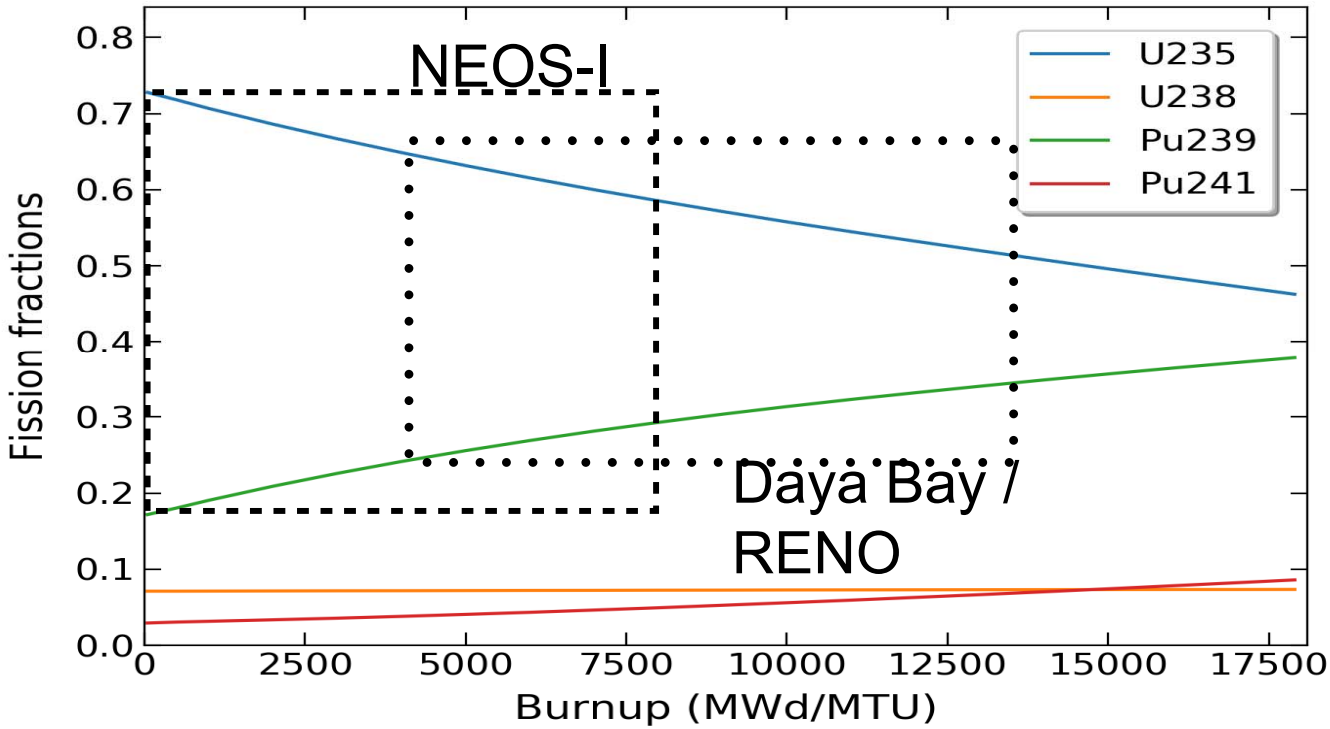


*Phys. Rev. Lett. 118, 121802 (2017)

- Errors in the reference antineutrino spectra are the main contributors to the total uncertainties.

New Phase (NEOS II)

- NEOS I detector was taken out in May 2016 due to regular maintenance in TG
- New phase (NEOS II) started in Sep. 2018
  - Replaced with new LS (same reactor, almost same detector)
  - Had no major changes but minor changes in detector structure
  - Will take data at least for one full fuel cycle (~500 days)



Installation of NEOS II

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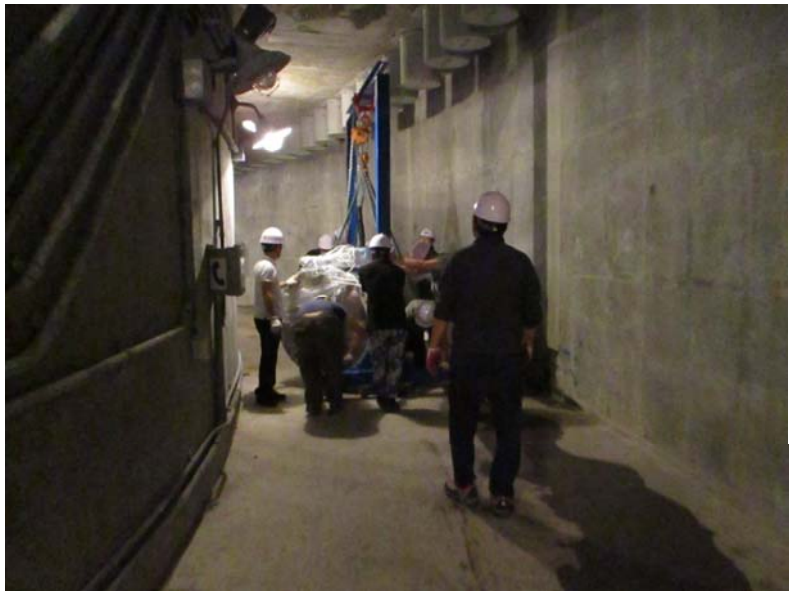

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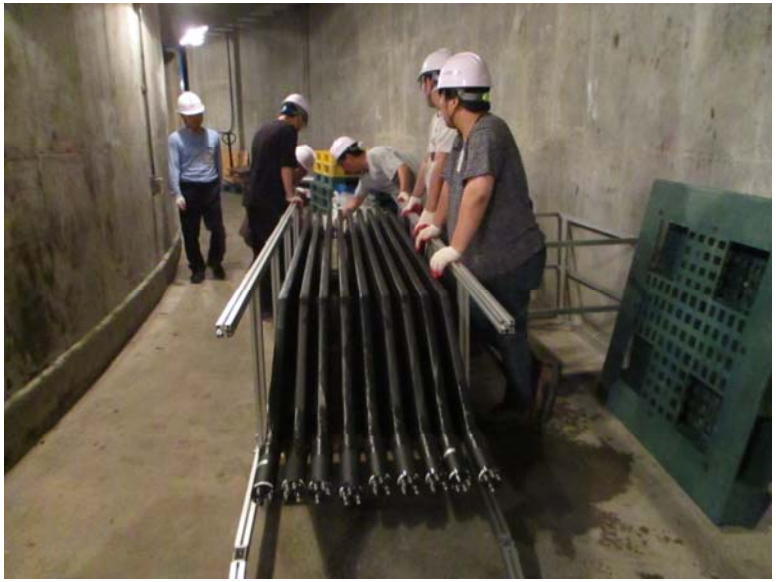
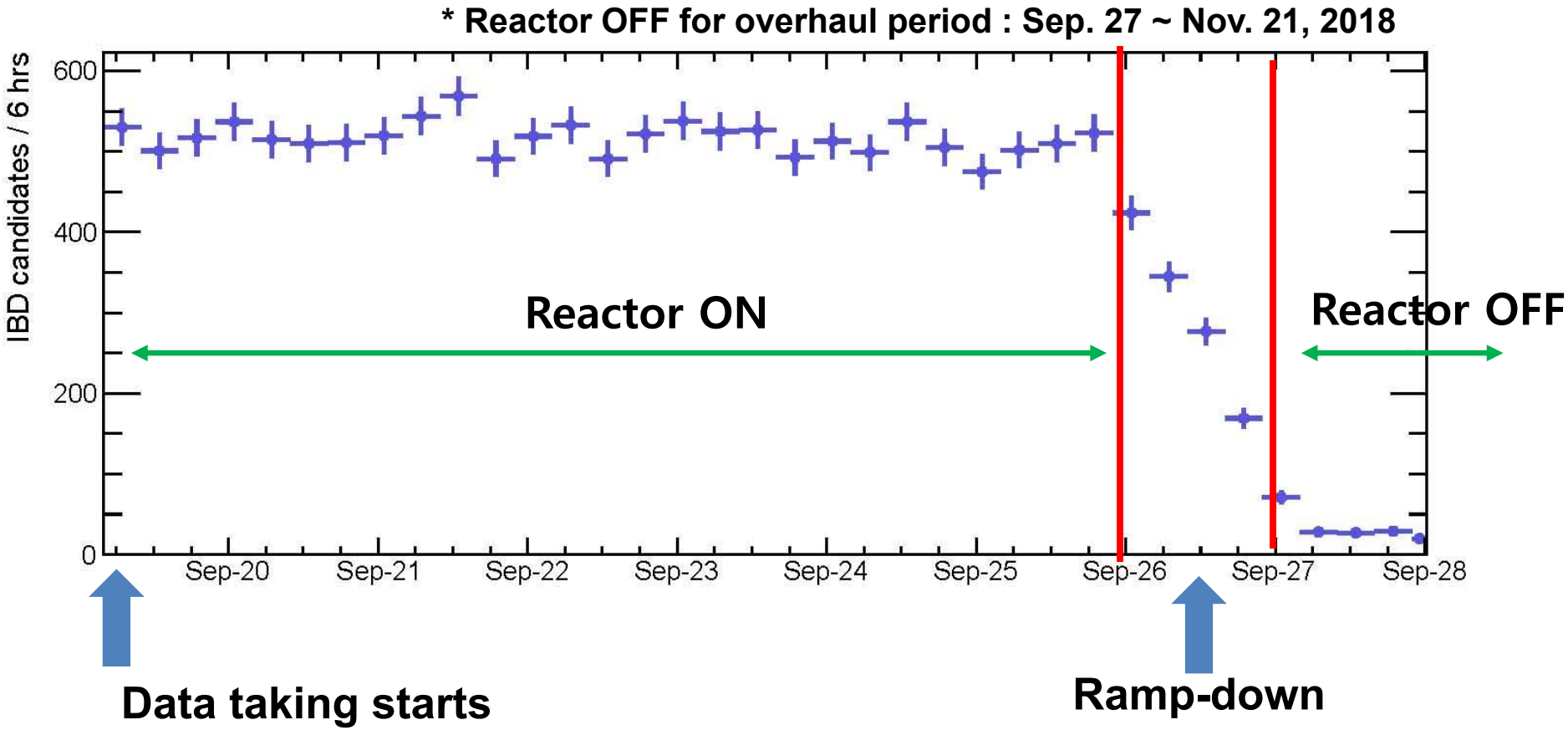
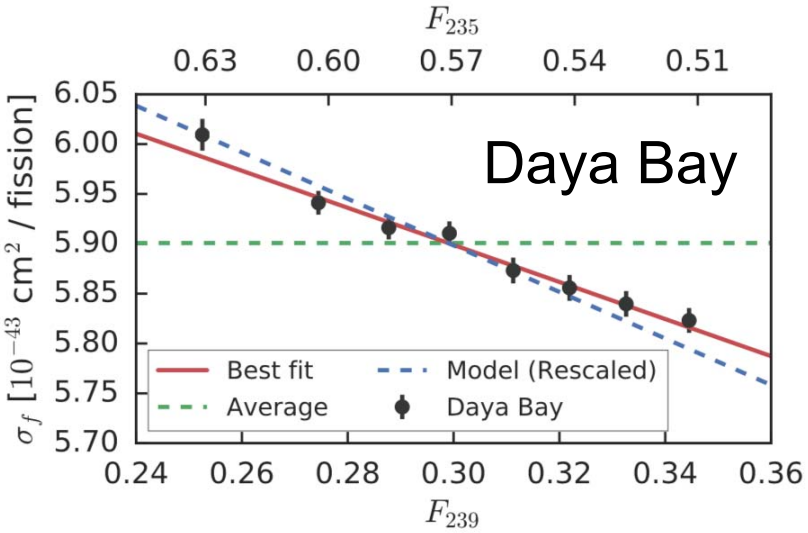


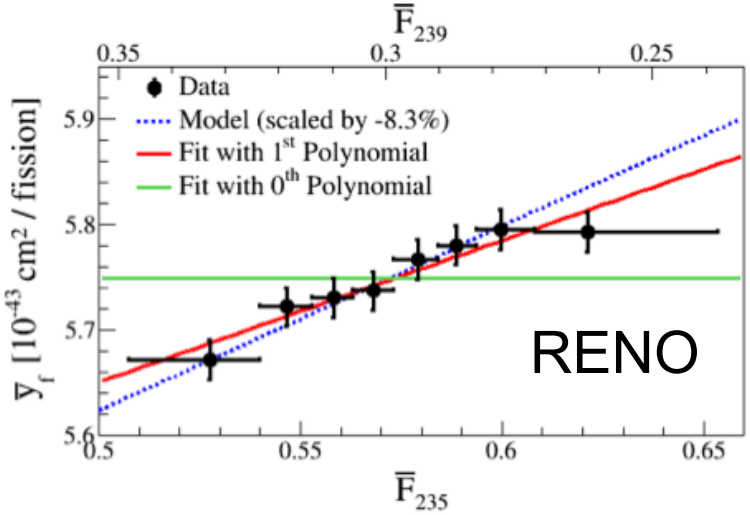
NEOS II measurement

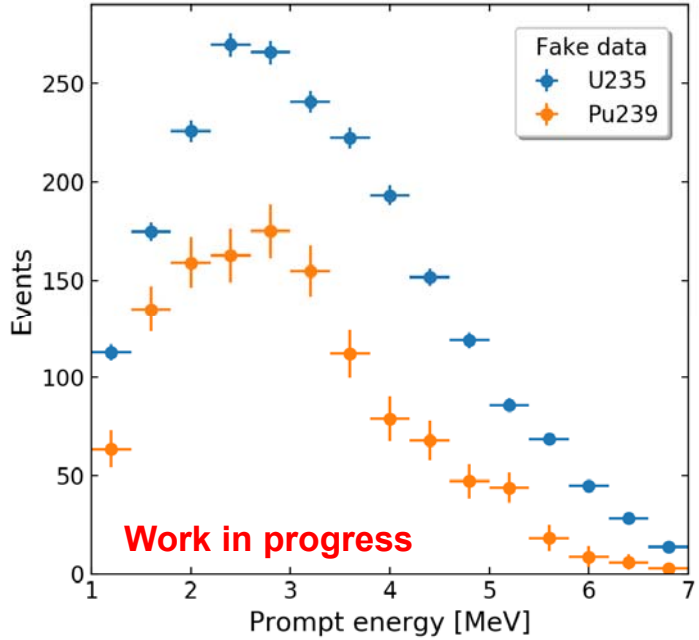
- Very preliminary IBD candidate rate



Spectrum evolution







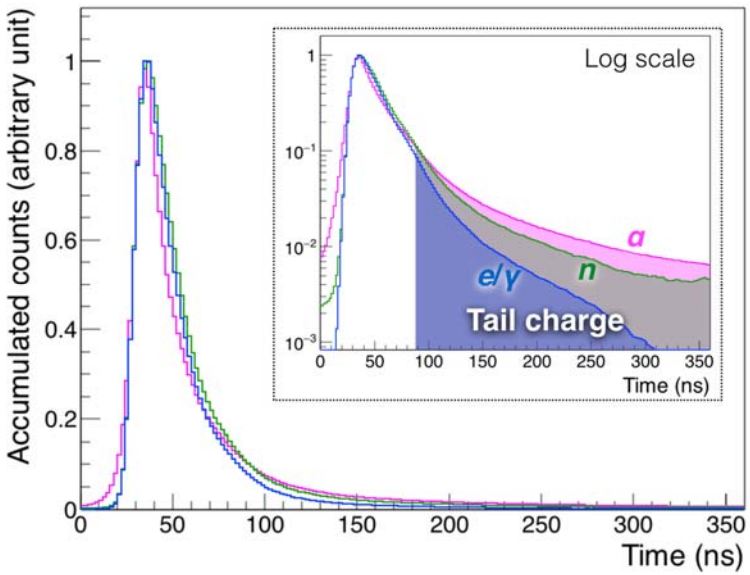
- Spectrum evolution with fuel compo nent changes.
  - from a single LEU core,
  - absolute spectrum measurement,
  - unfolding,
  - decomposing spectra for different elements.

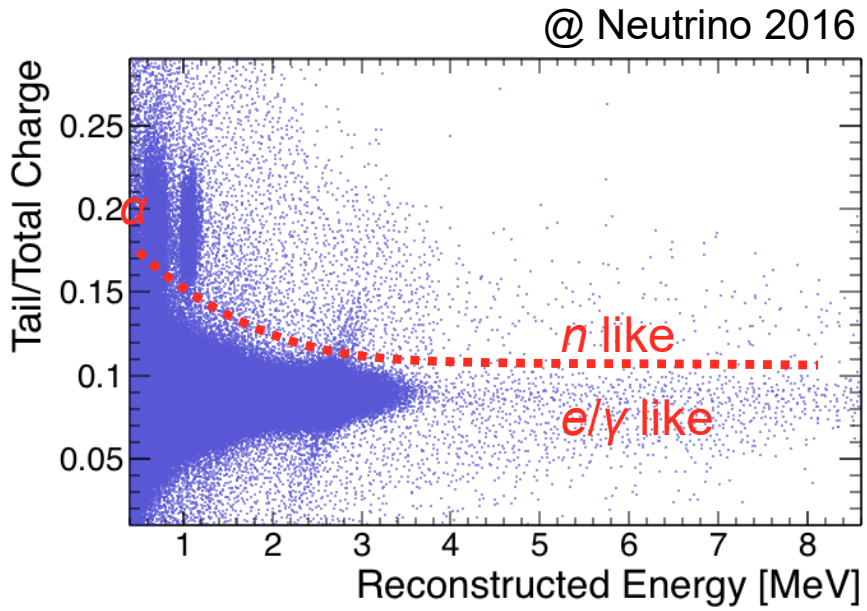
Summary & Plan

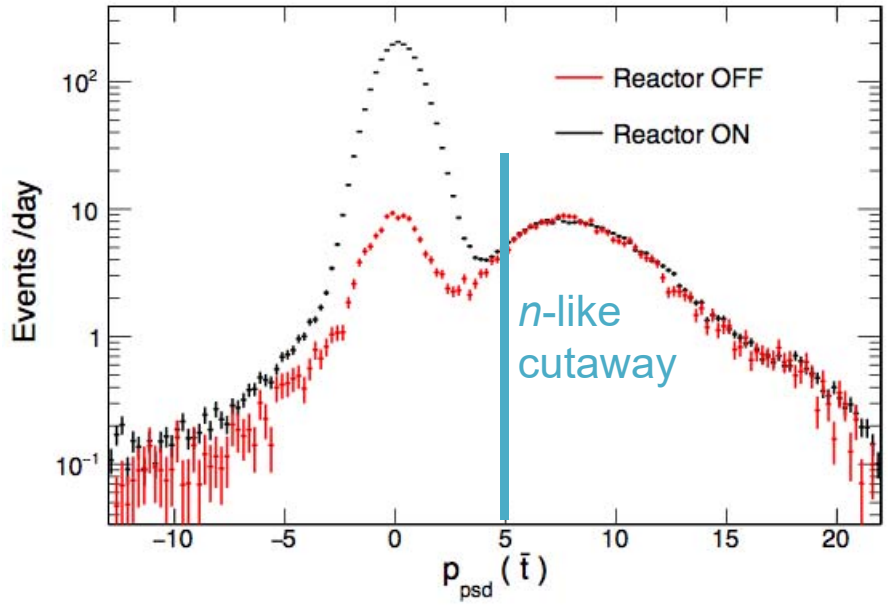
- NEOS phase I:
  - A ton of Gd-loaded LS detector was installed in a TG 24 m from the reactor core (2.8 GWt).
  - No strong sign of active-to-sterile neutrino oscillation for Δm^2~1 eV^2, $\sin^2 2\theta$ ~ 0.1.
  - An excess around the 5 MeV prompt energy range is observed as in mid-baseline experiments.
- NEOS phase II:
  - Resumed from Sep. 2018 with same detector & same reactor
  - The evolution of the reactor neutrino flux/spectrum will be studied according to the fuel component changes.

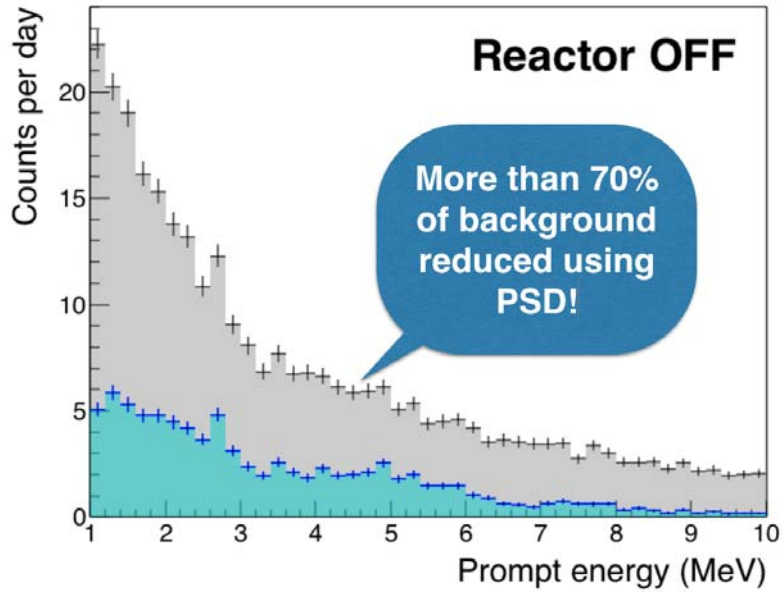
Back-up

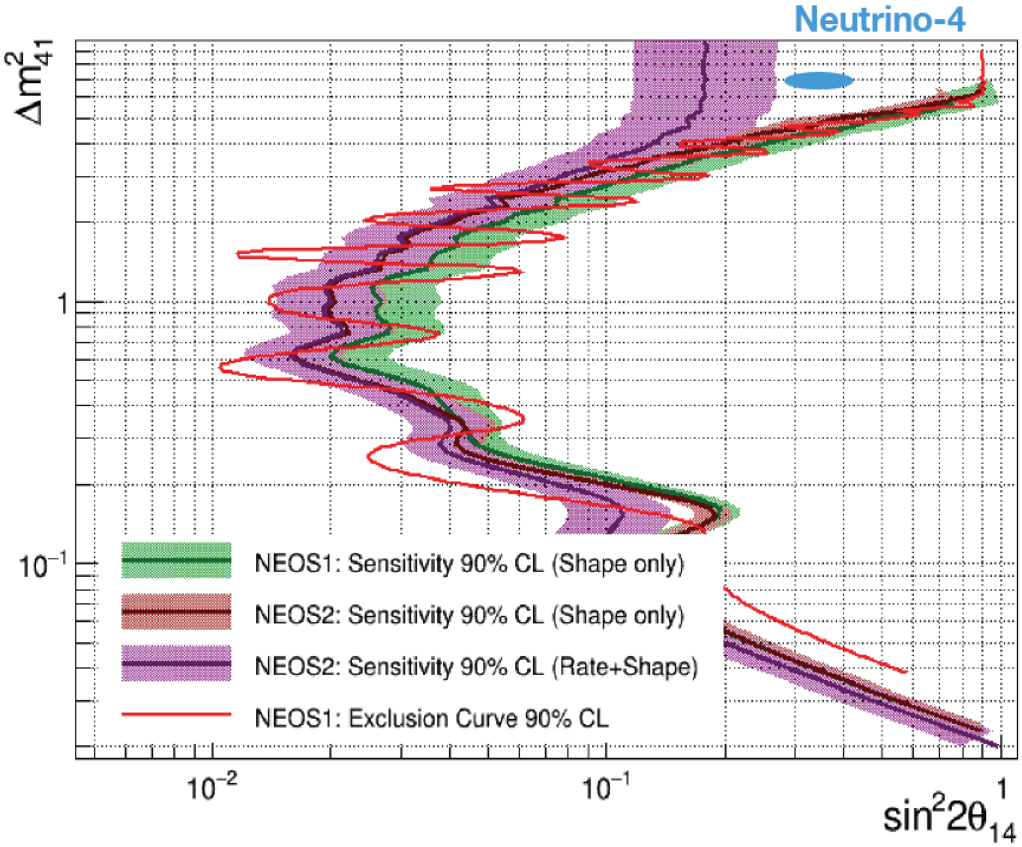
Pulse shape discrimination









Sensitivity study for NEOS II

- Flux model from Daya Bay
  - Different fission fraction b/w Phase 1 & 2
  - Correction w/ HM
- 1000 pseudo-datasets
  - (sig/bkg) statistics
  - (sig/bkg) normalization, energy scale
- 90/95% CL Sensitivity and 1σ band
- Assume 5% normalization for rate
- Systematics
  - flux, (sig/bkg) normalization, energy scale