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Title: LDRD Final Review: Radiation Transport Calculations

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LDRD Final Review: Radiation Transport Calculations

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June 8, 2017

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Presentation

- Background
  - Role of simulation
  - Calculated Impulse response -> Pulse
  - NDSE Signals: Same k_{eff}, different α!
- Surrogate Object (B4C) table top & Area 11
  - Covered in Mid-Term LDRD review
- Area 11: Object I & II Families of targets
- DAF: Object I & II
- Impacts from different Nuclear Data
- Continued improvements to facility from simulation
- Summary

Presentation

- Role of simulations:
  - Understand neutron and photon reactions in various shielding / collimation and target objects through integral radiation transport relying on evaluated nuclear data.
  - Understand contributions to energy deposition events in the detectors from shielding / collimation (background) and target objects.
  - Use these concepts to guide construction of facility & design experiments.
    - Move Liquid-VI detector from 15m to 20m
    - Understand late-time tails (add collimators)
- Once data is collected, use the measurements to validate the simulations, and gain confidence in simulations of more complicated objects in more complicated facilities.

Same k_{eff}!

Rocky Flats Shells Configurations, all with k_{eff} 0.949 +/- 0.001

5mm Al contamination barrier around SNM & 1 m above ground

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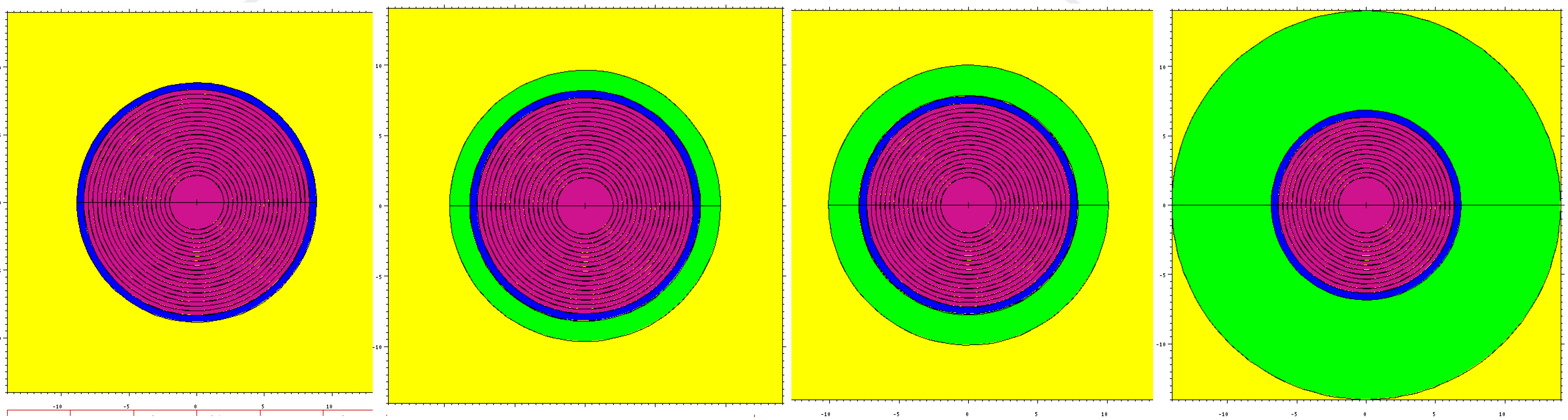


RF Parts	1-40	1-36	1-34	1-28
SNM mass	43.87	34.14	29.88	19.20
SNM OD	8.33	7.67	7.33	6.33
HDPE Δ	0	1.43	2.18	7.67
HDPE OD	NA	9.63	10.08	14.0
k_{eff}	0.94977 +/- 0.00008	0.94993 +/- 0.00010	0.95004 +/- 0.00010	0.94955 +/- 0.00011

1-26 not possible, highest k_{eff} was 0.940

Same keff, but different neutron lifetimes

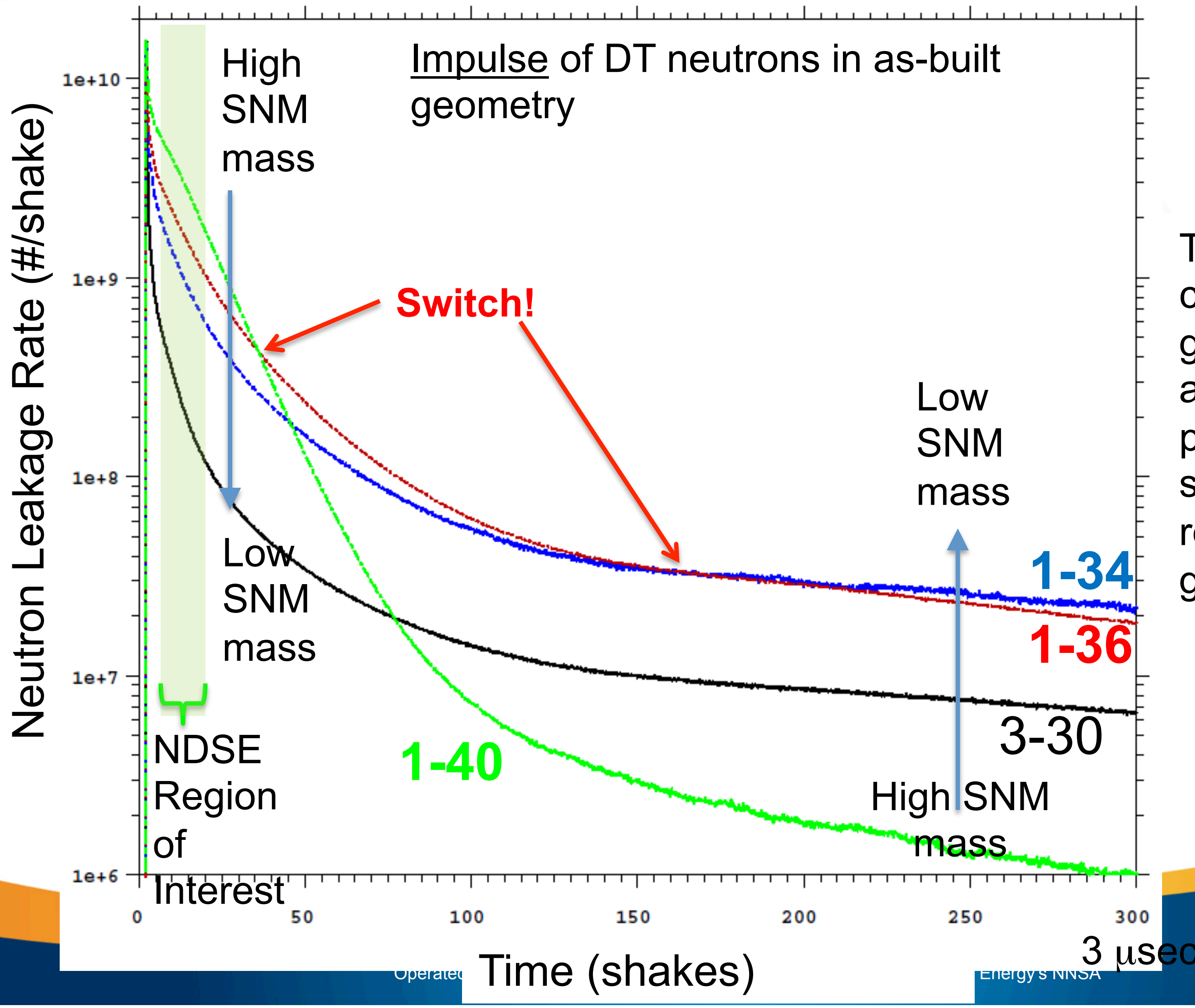
k_{eff} 0.949 +/- 0.001 (total nubar)

RF Part #	SNM Mass (kg)	SNM Radius (cm)	Poly Δ (cm)	Poly Outer Radius (cm)	Generation Time (Λ) (nsec)	
1-40	43.87	8.33	0	NA	59	Bare
1-36	34.14	7.67	1.43	9.63	128	
1-34	29.88	7.33	2.18	10.08	595	Object II
15-34	25.07	7.33	5.00*	11.4	5730 = 5μs	
3-30	21.83	6.67	6.30	13.5	7830 = 8μs	Object I
1-28	19.20	6.33	7.67	14.0	9400 = 9μs	

How far does a 1 MeV neutron travel in 64 ns? About the diameter of the SNM.
The neutron generation time is the mean time per unit neutron importance between the production of fission neutrons. Spriggs et al. LA-UR-97-1073

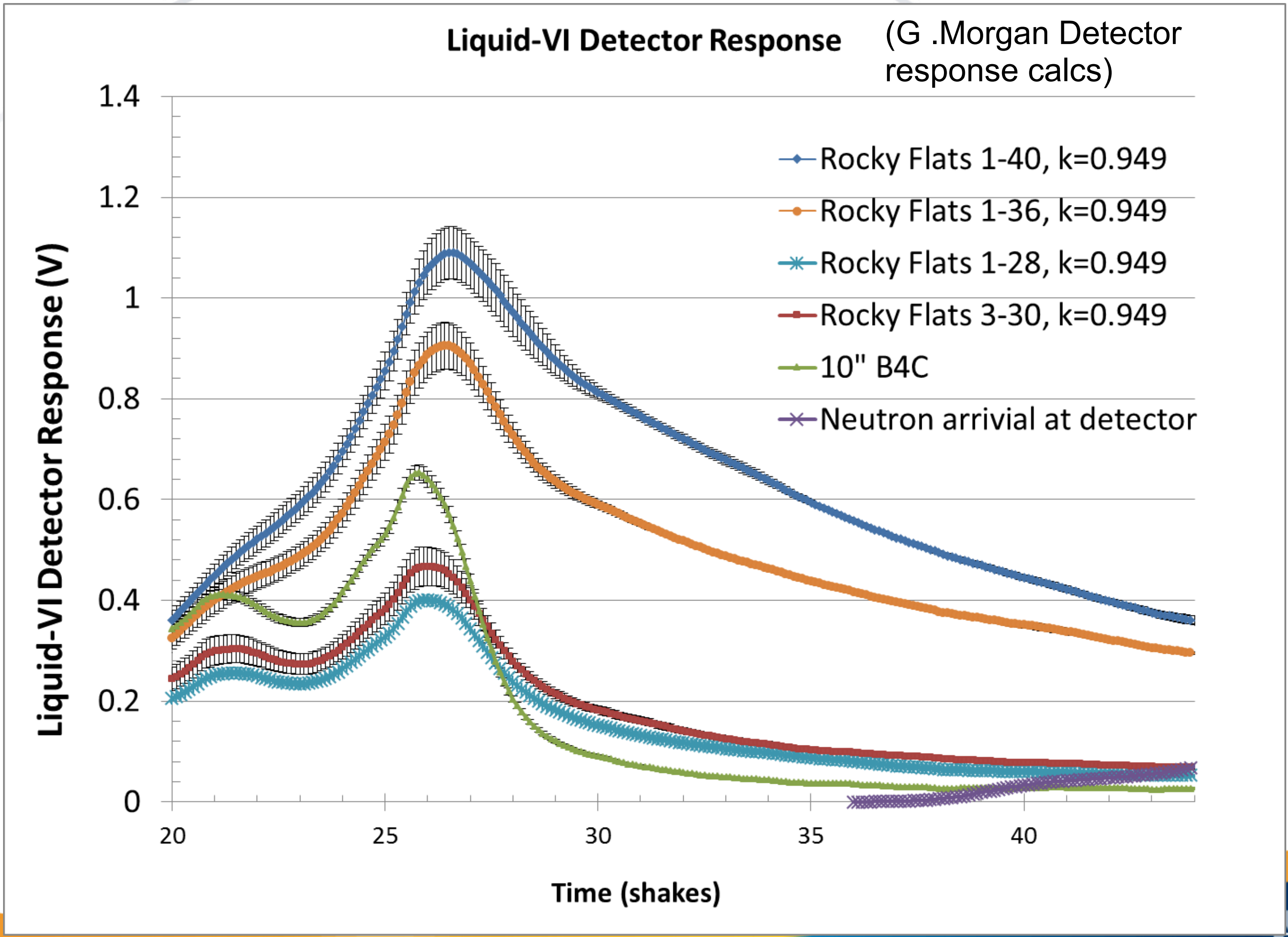
Different NDSE signals (alphas)

All configurations have k_{eff} = 0.949 +/- 0.001

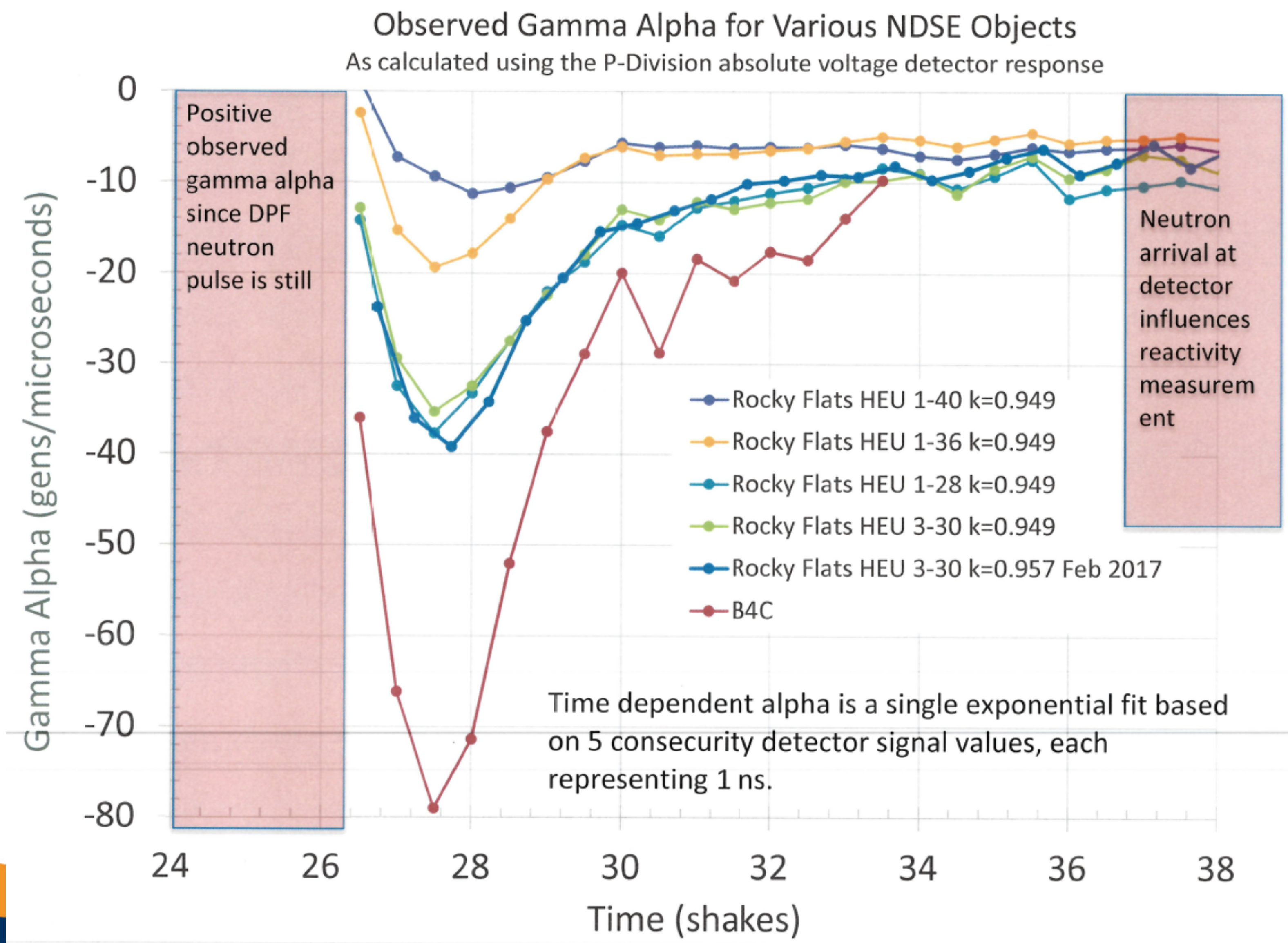


These impulse calculations then get convolved with a specific DPF pulse to generate simulated detector response for a given experiment.

Convolve ϕ @ detector w/ specific DPF pulse & generate Liquid-VI response



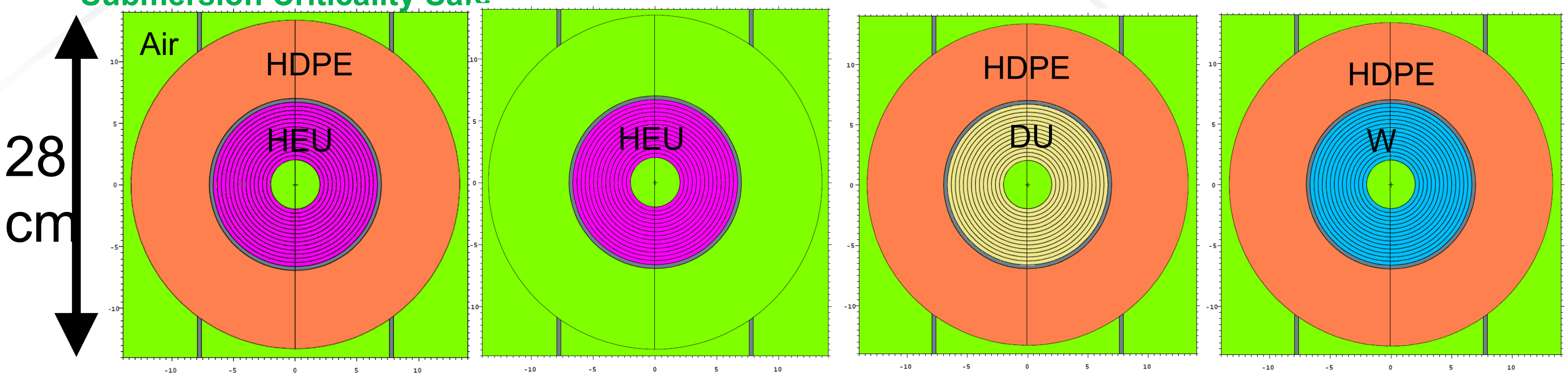
Different time-dependent alphas



Object I family

+ Graphite Ball

Submersion Criticality Safe



RF Parts	Object I: 3-30 (Feb 2017)	Object I (no HDPE)	Object I DU Surrogate mass, radius* match to 3-30	Object I W Surrogate
Total SNM mass	21.73	21.73	21.73	NA
SNM OR (cm)	6.6707	6.6707	6.6707	NA
HDPE Δ (cm)	6.66	0	6.66	6.66
HDPE OR (cm)	13.335	0	13.335	13.335
k_{eff}	0.9549 +/- 0.0006	0.7359 +/- 0.0004	0.2352 +/- 0.0002	NA

Object I Family

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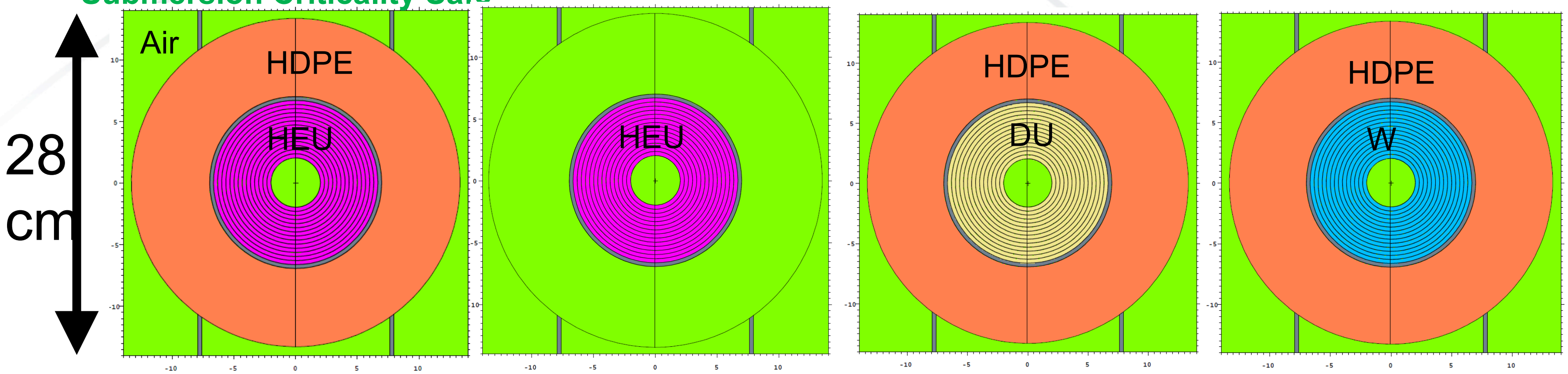
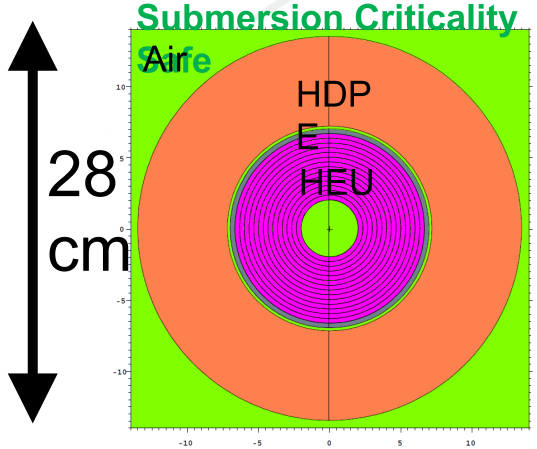
+ Graphite Ball

Submersion Criticality Safe

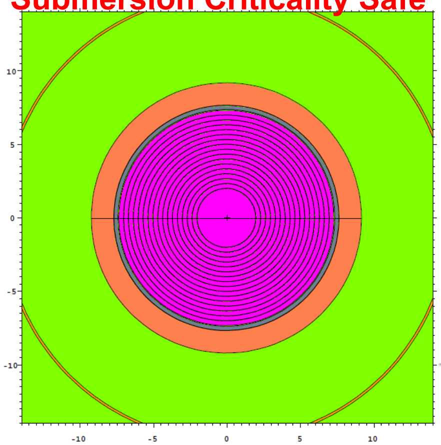


RF Parts	Object I: 3-30 + HDPE (Feb 2017)	Object I (no HDPE)	Object I DU Surrogate mass, radius* match to 3-30	Object I W Surrogate
% thermal n causing fission	16.6	0.05	40.92	NA
% epithermal n	16.6	4.6	3.2	NA
% fast n causing	66.8	95.3	55.9	NA
Generation time	8,917 ns	169 ns	132,000 ns	NA
k_{eff}	0.9549 +/- 0.0006	0.7359 +/- 0.0004	0.2408 +/- 0.0002	NA

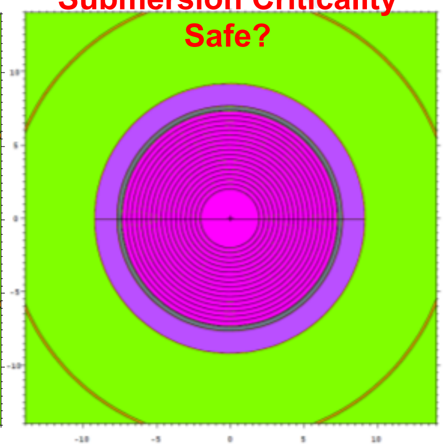
Object II Family Design



Needs Container to be Submersion Criticality Safe



Needs Container to be Submersion Criticality Safe?



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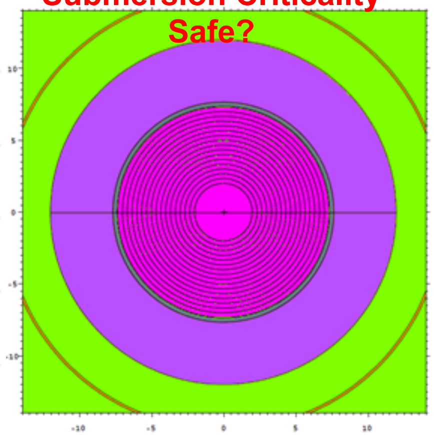
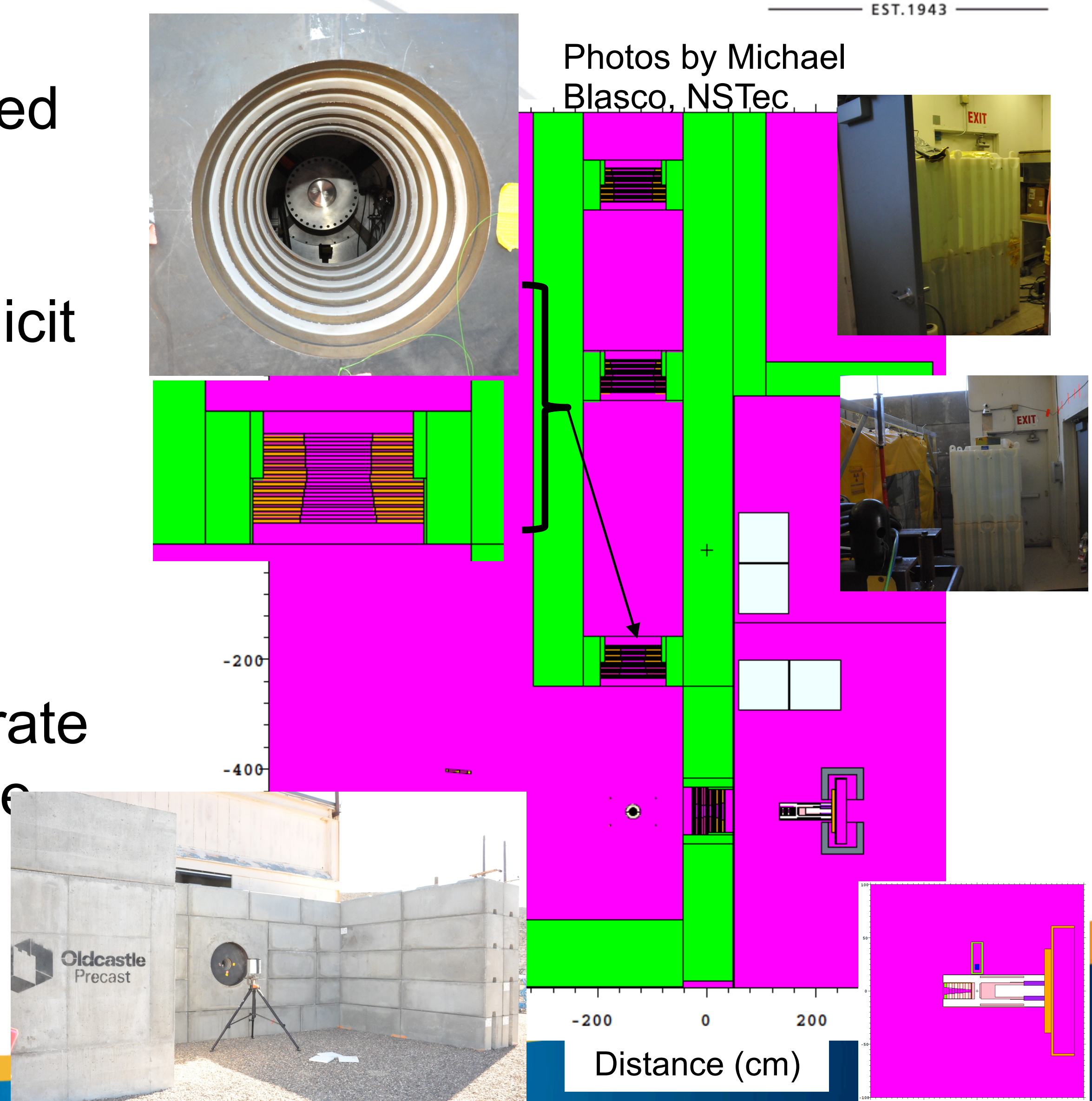


RF Parts	3-30 (Feb 2017)	1-34	1-34 Li HDPE I	1-34 Li HDPE II
Total SNM mass	21.73	29.88	29.88	29.88
SNM OR (cm)	6.6707	7.33	7.33	7.33
HDPE Δ (cm)	6.66	1.87	1.87	4.67
HDPE OR (cm)	13.335	9.20	9.20	12.0
k_{eff}	0.9549 +/- 0.0006	0.9500 +/- 0.0003	**0.8985 +/- 0.0005**	0.9535 +/- 0.0005

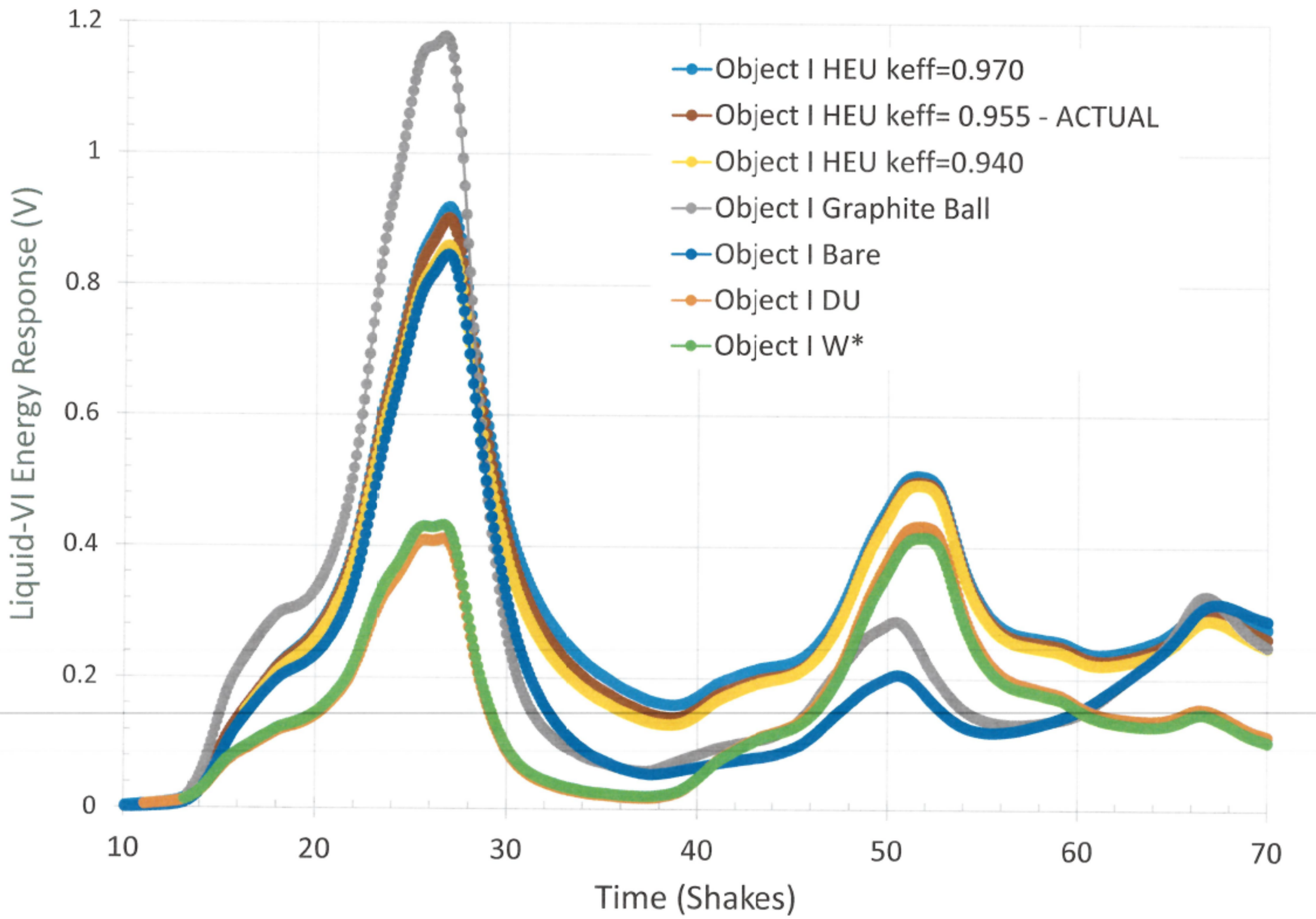
Area 11 Facility Model

- Models contain detailed DPF description, combined DD & DT fusion spectra, & explicit dual-angle collimated plates.
- Run
- Results can be post-processed to incorporate detector energy & time response.

Photos by Michael Blasco, NSTec

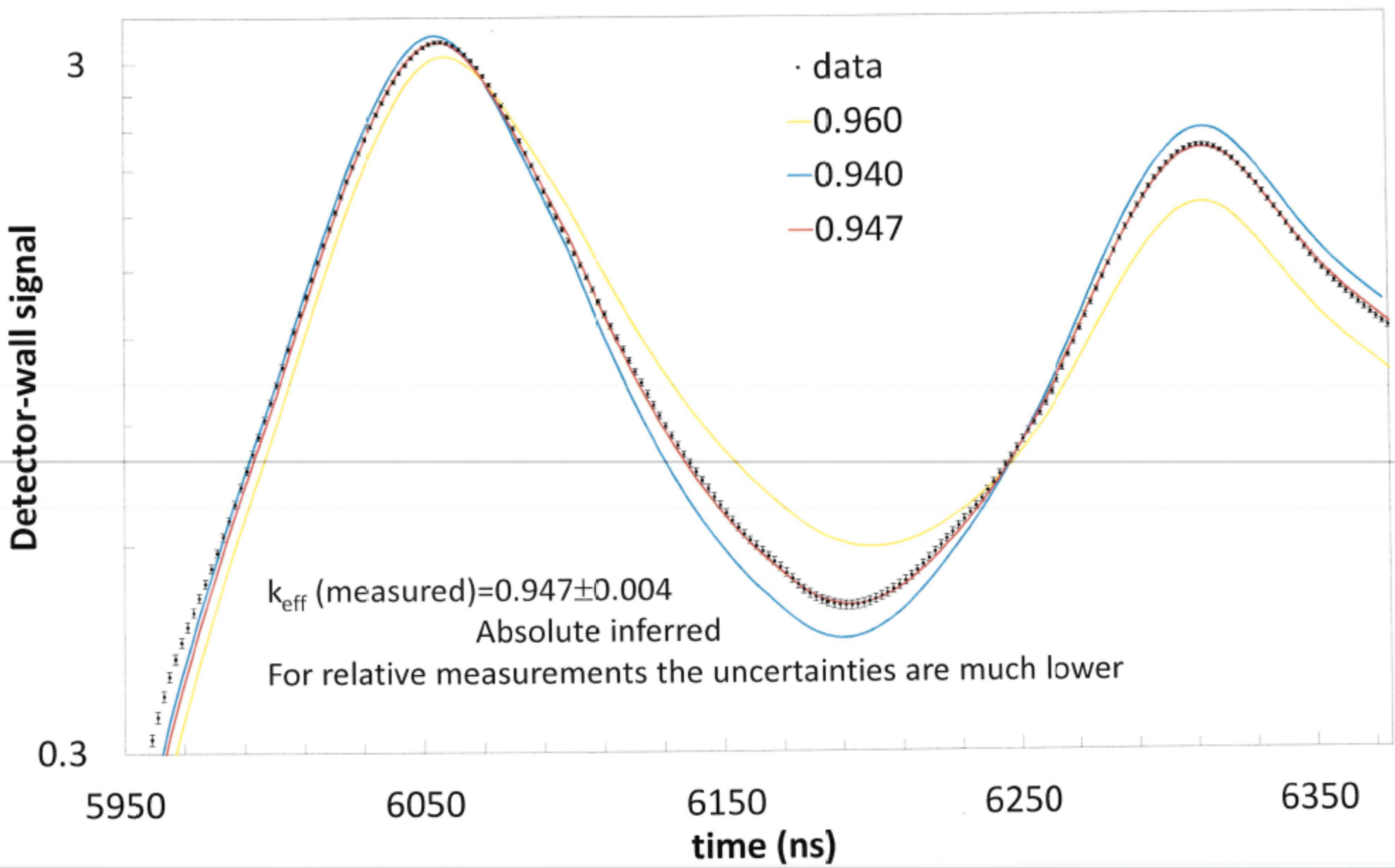


Object I family signal pre/post dictions



Lestone's sensitivity analysis

Big hammer simulations : Tweezer DPF shots on HEU/poly object 1 k_{eff}=0.950 (MCNP), bias corrected to 0.947



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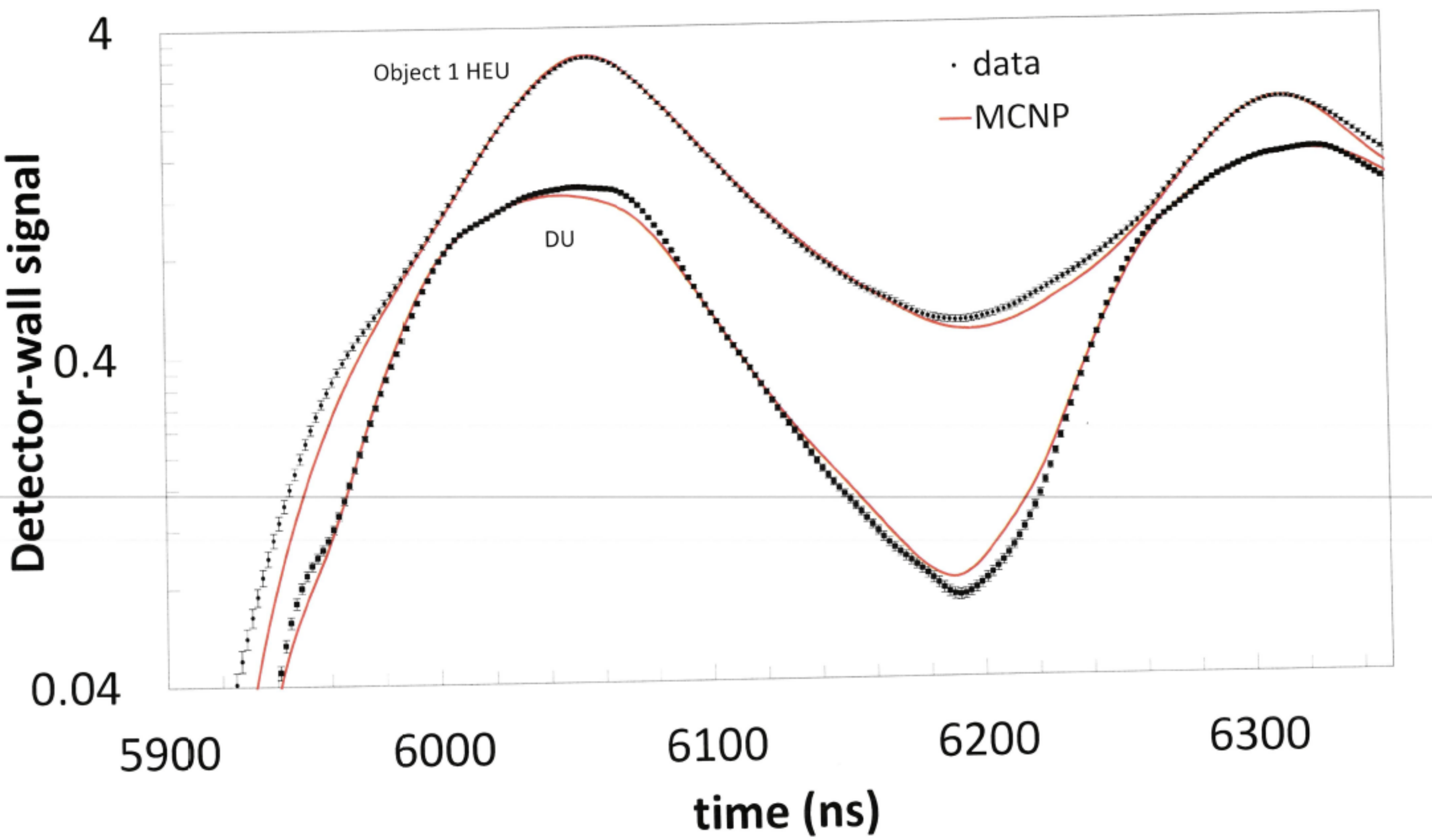
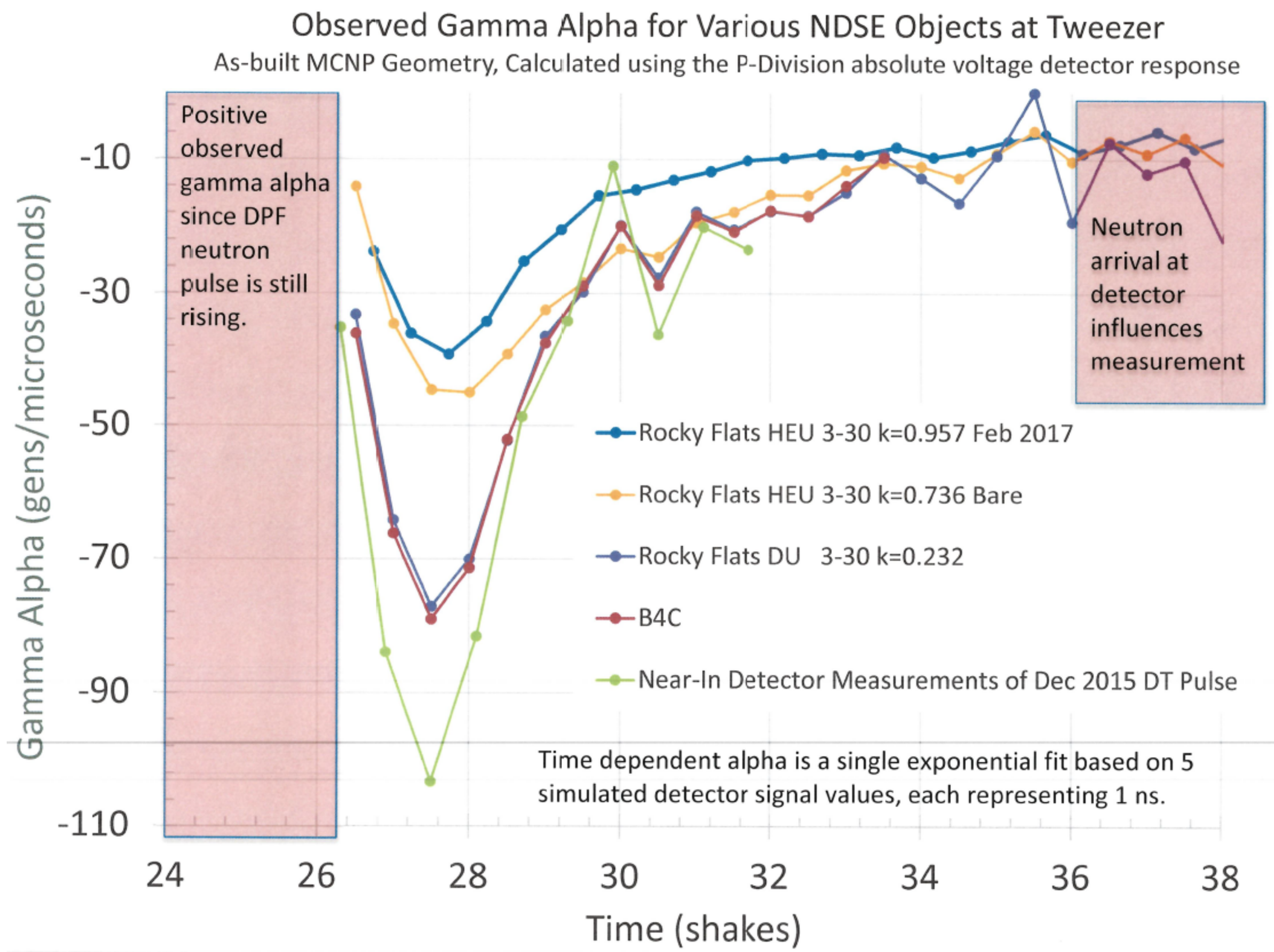
Using DU results to correctly predict absolute intensity & shape of HEU signal



Object I family gamma alphas



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Independent Confirmation

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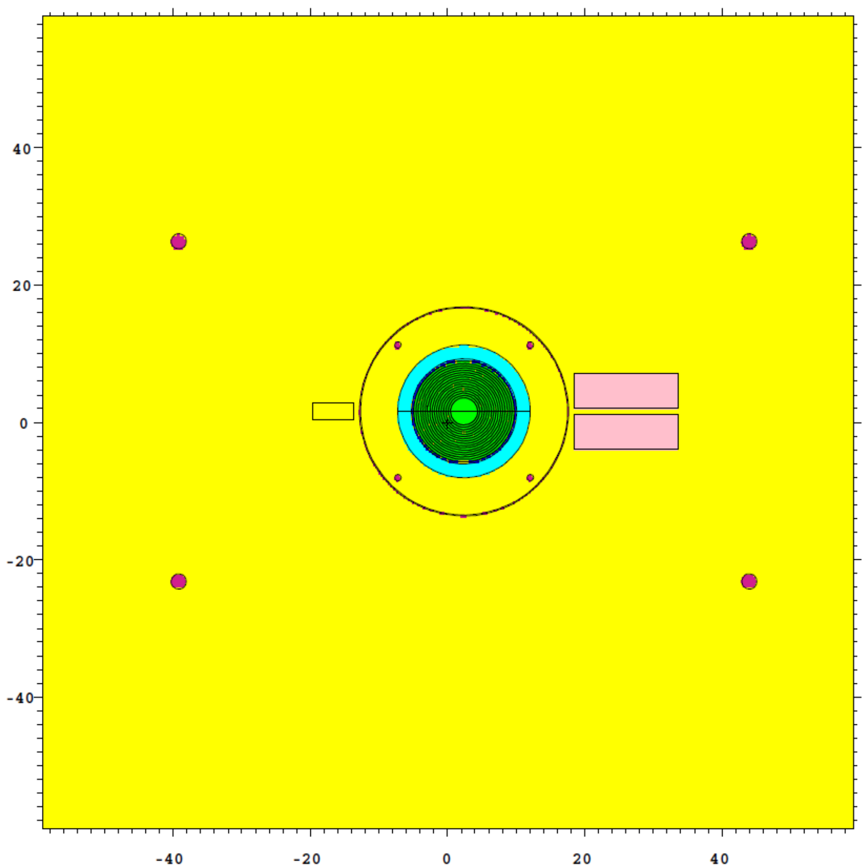
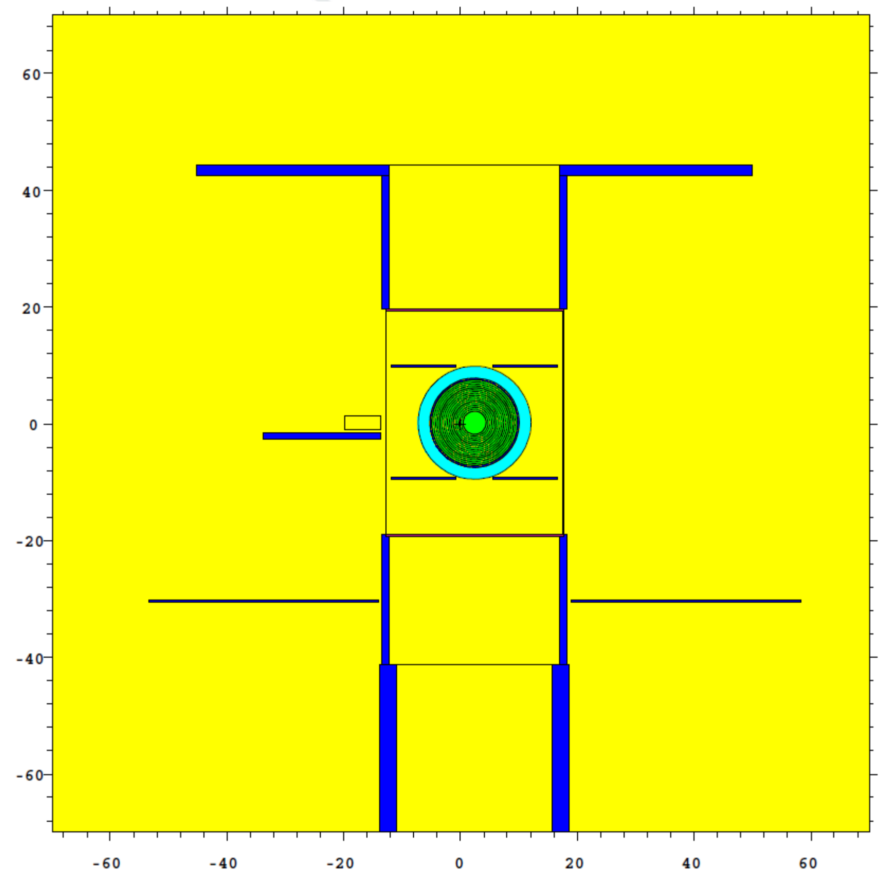
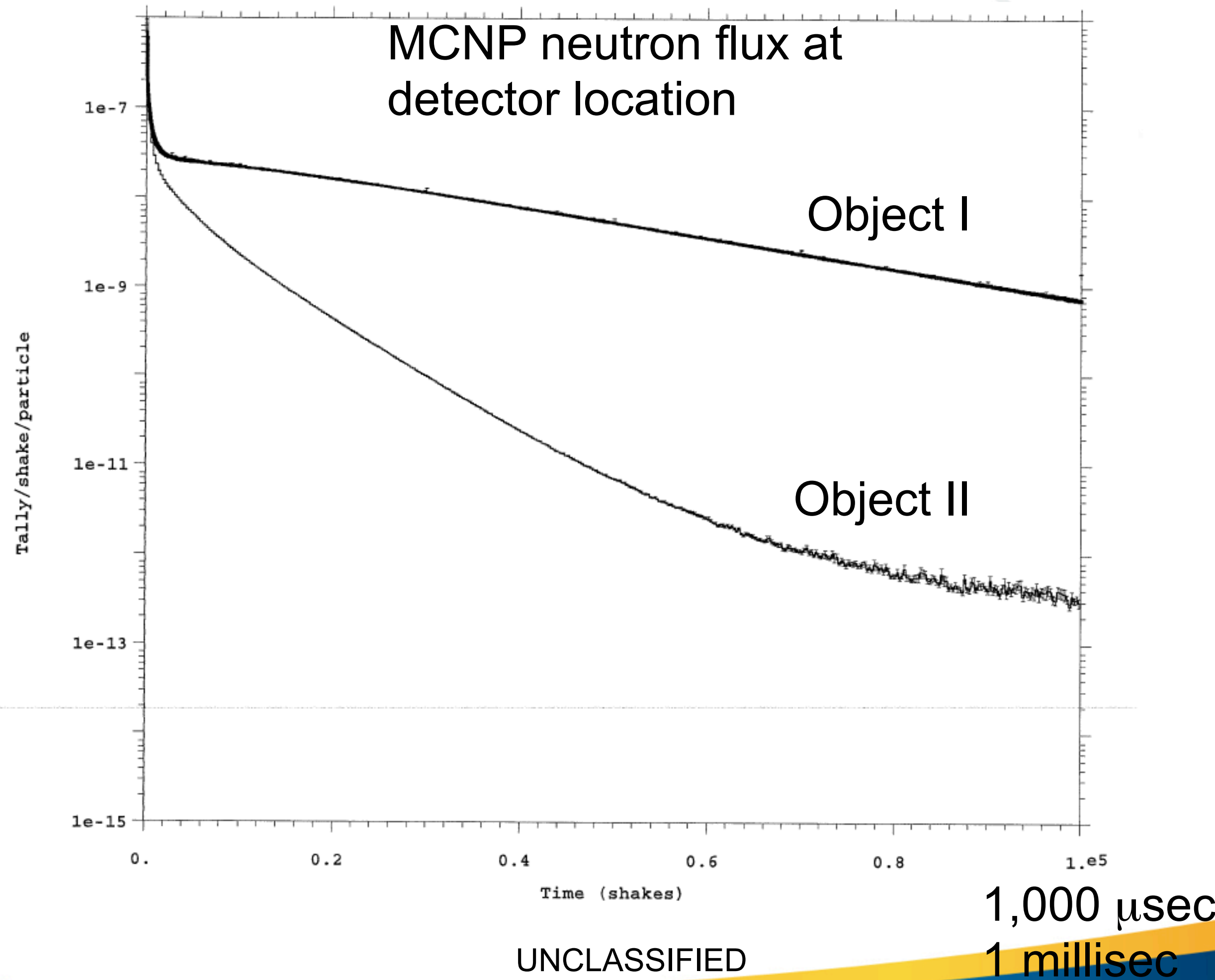
- We wanted an intendent methodology to assess SNM characteristics (that are sensitive to mass & ultimately k_{eff}) to match to simulations to gain confidence in what we are seeing with the DPF.
- Thus we (NEN-2) fielded a set of die-away measurements at the DAF

DAF geometry model:
Room, stand, convenience can, detectors, source





DAF Die away comparison



Effects from Nuclear Data from nubar and gamma production

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- What is the Object I k_{eff}?

ENDF/B-VII.1 (.80c for most isotopes): 0.95449 +/- 0.00057

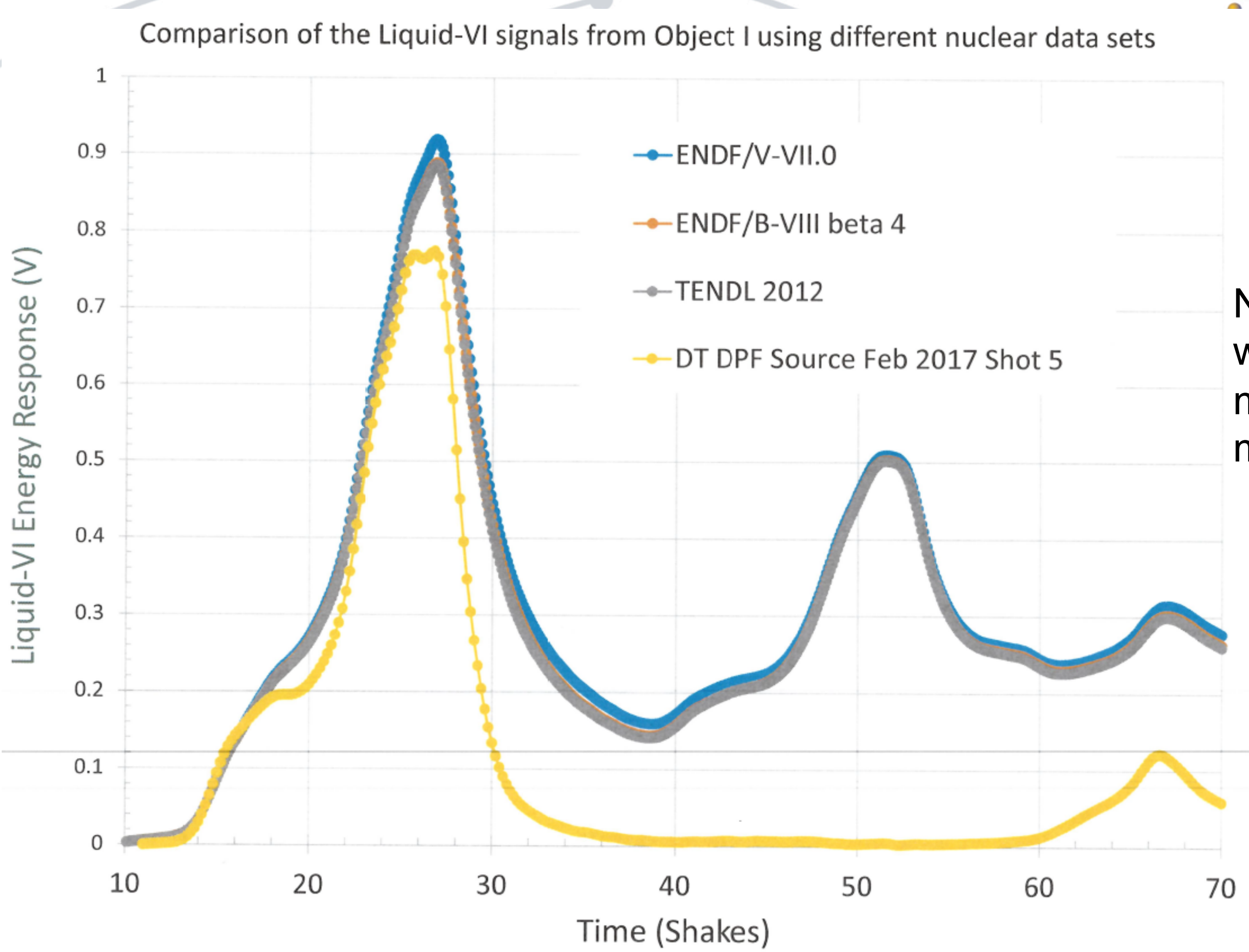
ENDF/B-VIII beta 4 (changing U235 & U238 only) : 0.95347 +/- 0.00033

TENDL 2012 release: (changing U235& U238 only): 0.95399 +/- 0.00047

TENDL 2012 release: (changing U234, U235, U236 & U238 only): 0.95801 +/- 0.00030

- What is the absolute change in signal & slope?

	ENDF 7.0	ENDF 8 Beta 4	TENDL
# photons per fission (MT 18)	6.86	8.60	7.01
# photons per inelastic scatter (MT 4)	1.98	0.00	1.97
# photons per capture (MT 102)	3.69	3.66	3.73
# Photons per any nuclear interaction (including elastic scatter, MT 1)	1.82	2.01	1.86
# Photons per non-elastic nuclear interaction (MT 4)	6.46	7.82	6.61



Not ready to say which is a better match to measured data.

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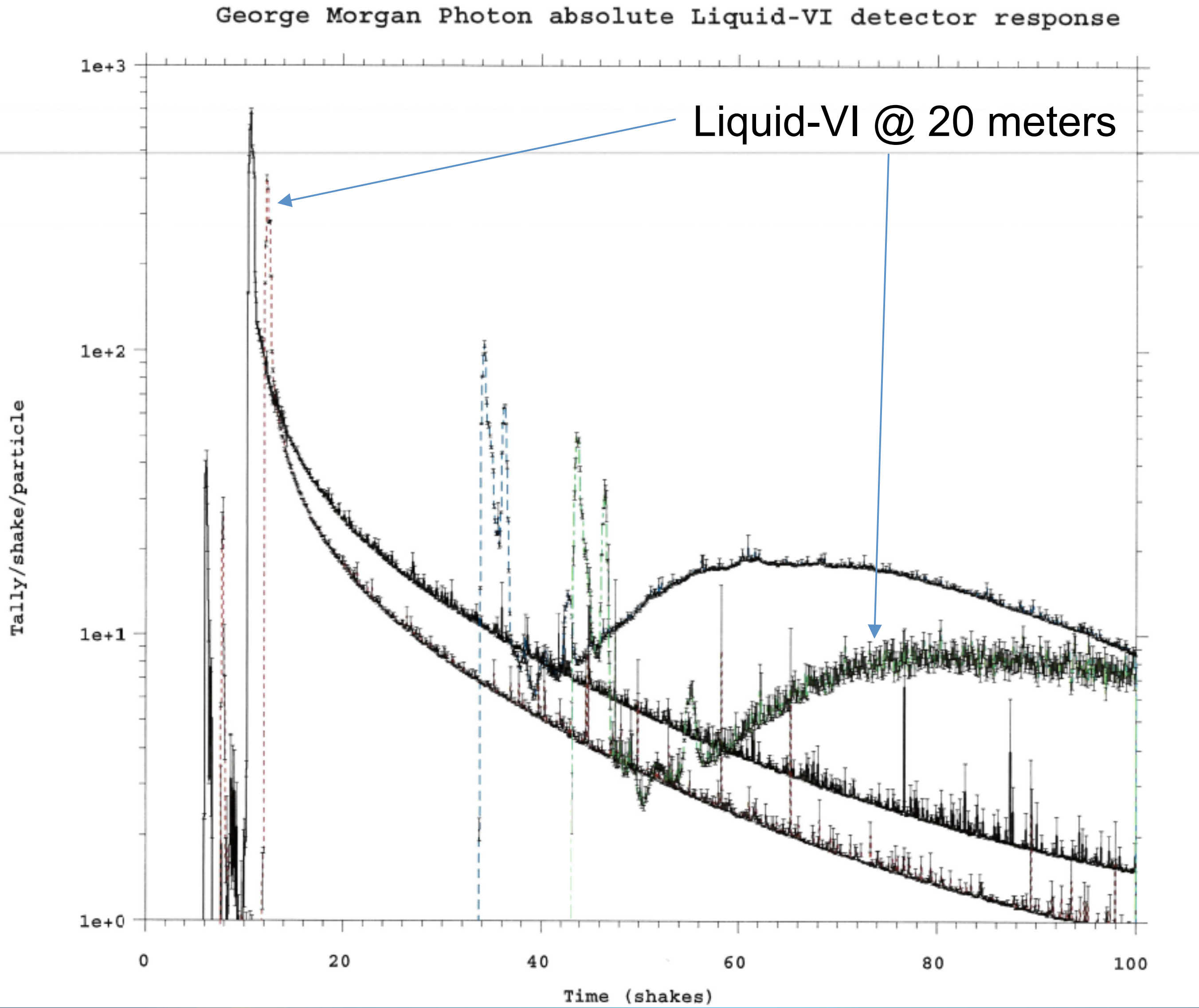
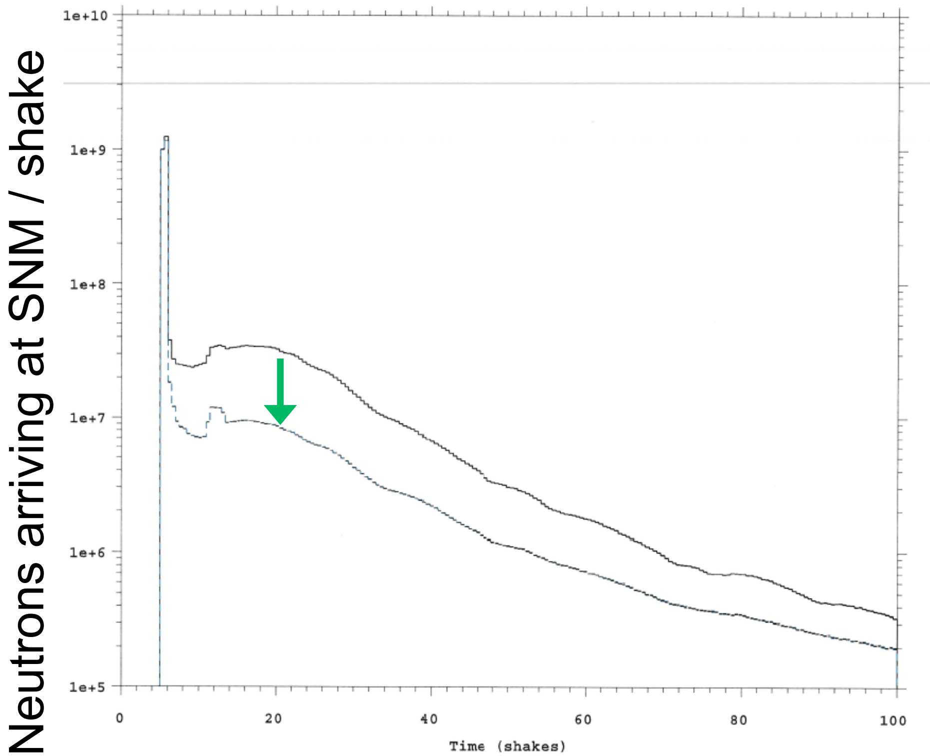
Area 11: 15m or 20m?



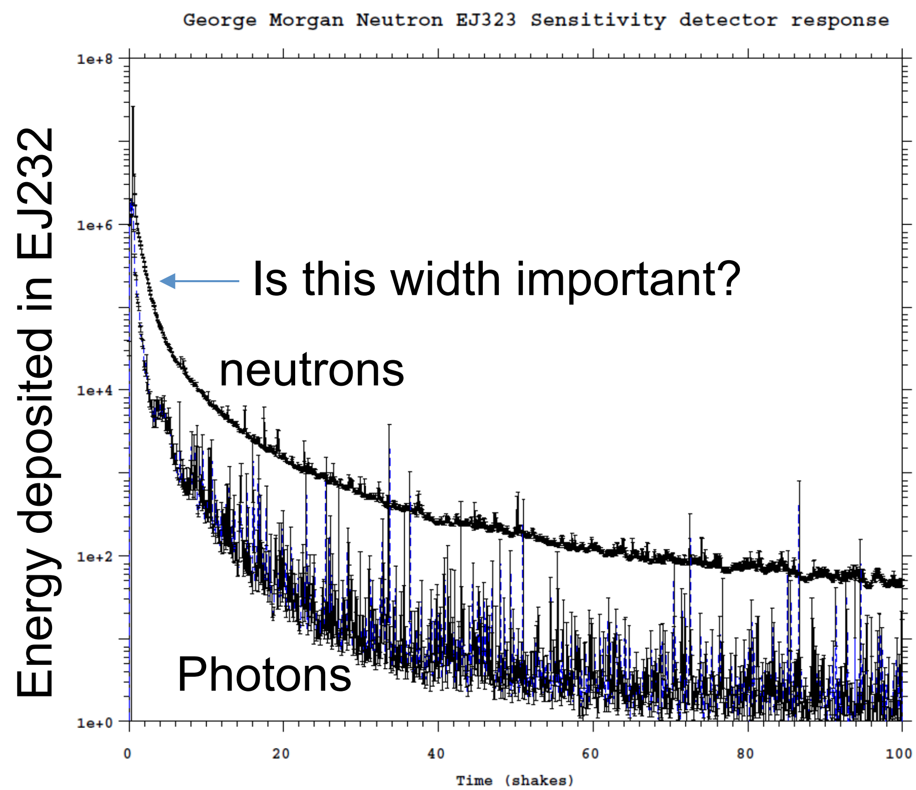
Help predict signal intensity and shape if the Liquid-VI wall is moved back

Improve NDSE measurements:
minimized late-time tails

Recognize inelastic n scattering causing late-time tail of neutrons to arrive at SNM; P-Div added “inny collimator” this plot shows the reduction in the late-time tail



Similarly, the inelastic scattered neutrons arriving at the near-in detector are “smearing out” that signal, add another collimator?



Summary

- Both high-fidelity & toy simulations are being used to understand measured signals and improve the Area 11 NDSE diagnostic.
- We continue to gain more and more confidence in the ability for MCNP to simulate neutron and photon transport from source to radiation detector.
- We are not done, still more analysis (and Object II results).
- I am encouraged by the results so far.