Neutron Interrogation for Detection of Contraband in Cargo

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Introduction and Motivation

- Contraband (e.g., explosives) poses a security risk

Fig. 1: Shipment containers at the port of Los Angeles [1]

- Can be discriminated from benign cargo by detecting radiative capture reactions in HCNO
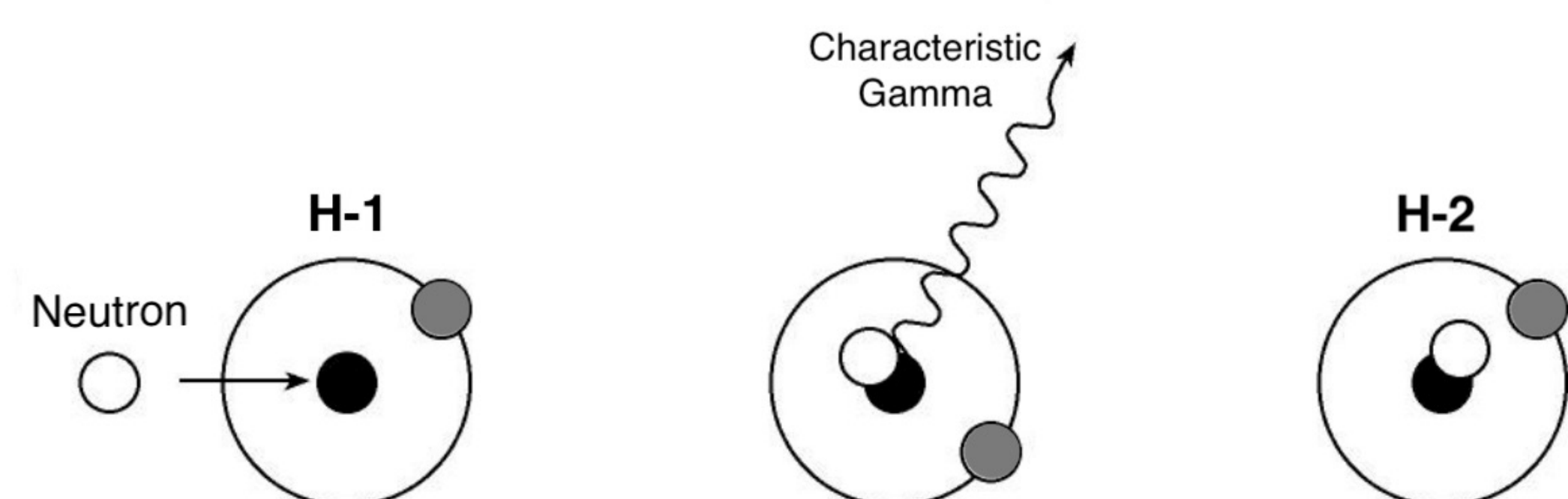

Fig. 2: Example radiative capture reaction with H-1 target [2]

- Neutron interrogation + gamma ray detection makes concealing contraband difficult

- **End application:** interrogate shielded cargo with a (D2O) neutron source to detect contraband
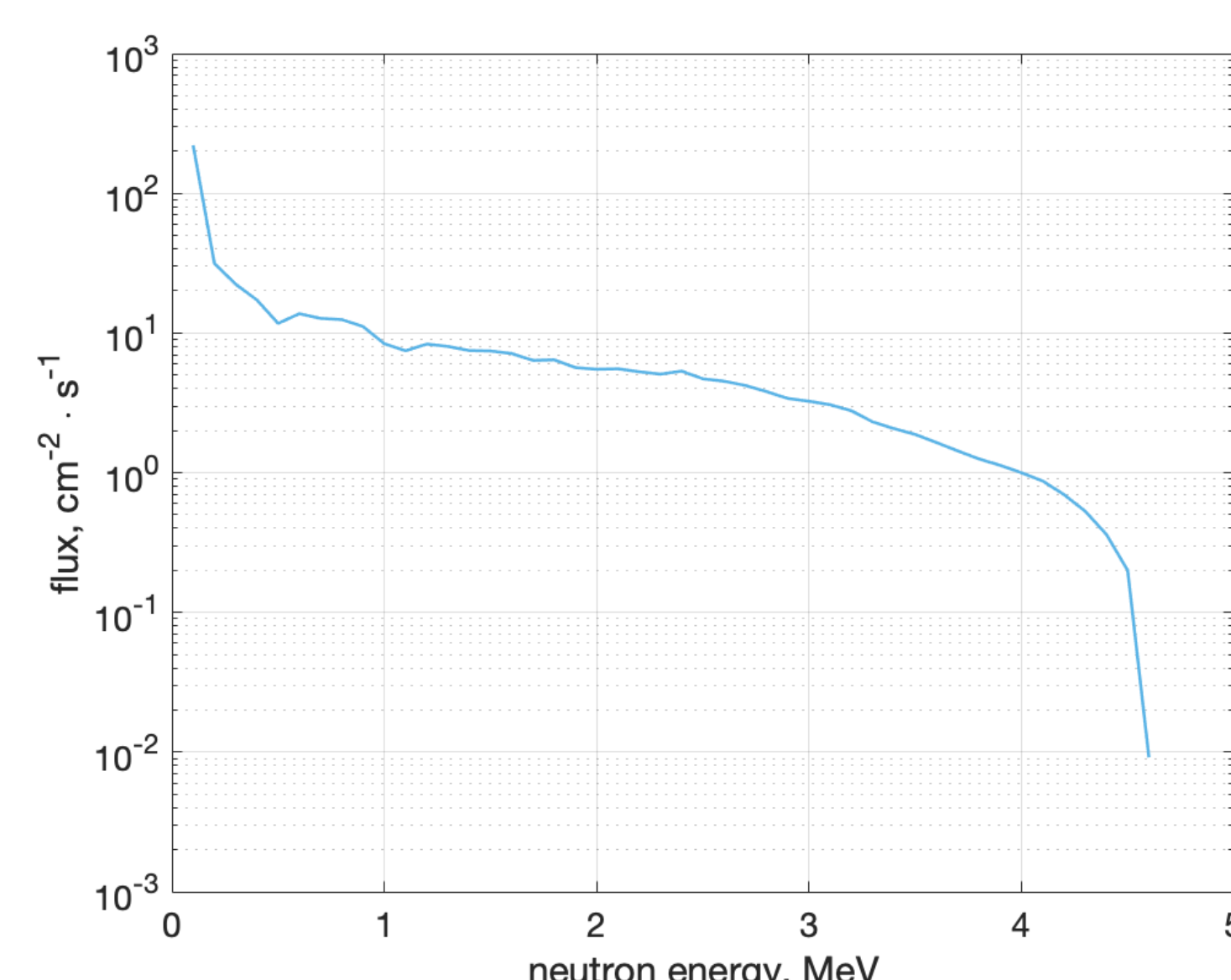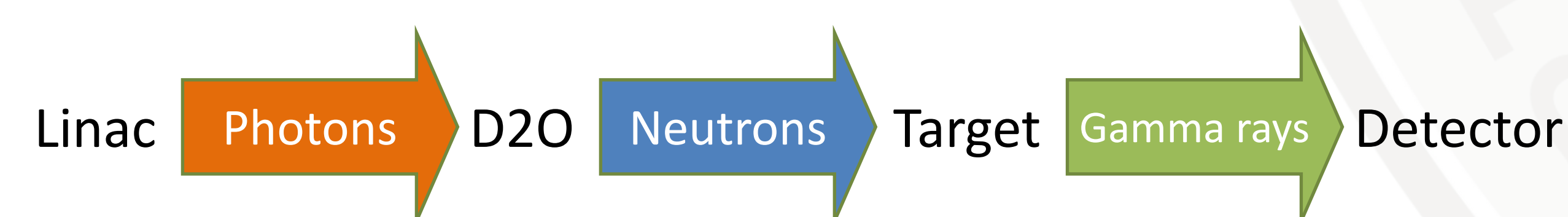
Linac → Photons → D2O → Neutrons → Target → Gamma rays → Detector

Fig. 3: Simulated D2O neutron energy spectrum when linac-driven

Technical Approach

Simulation

- Explosive simulant from ANSI Standard *[3]*
- Simulations conducted in MCNPX *[4]*

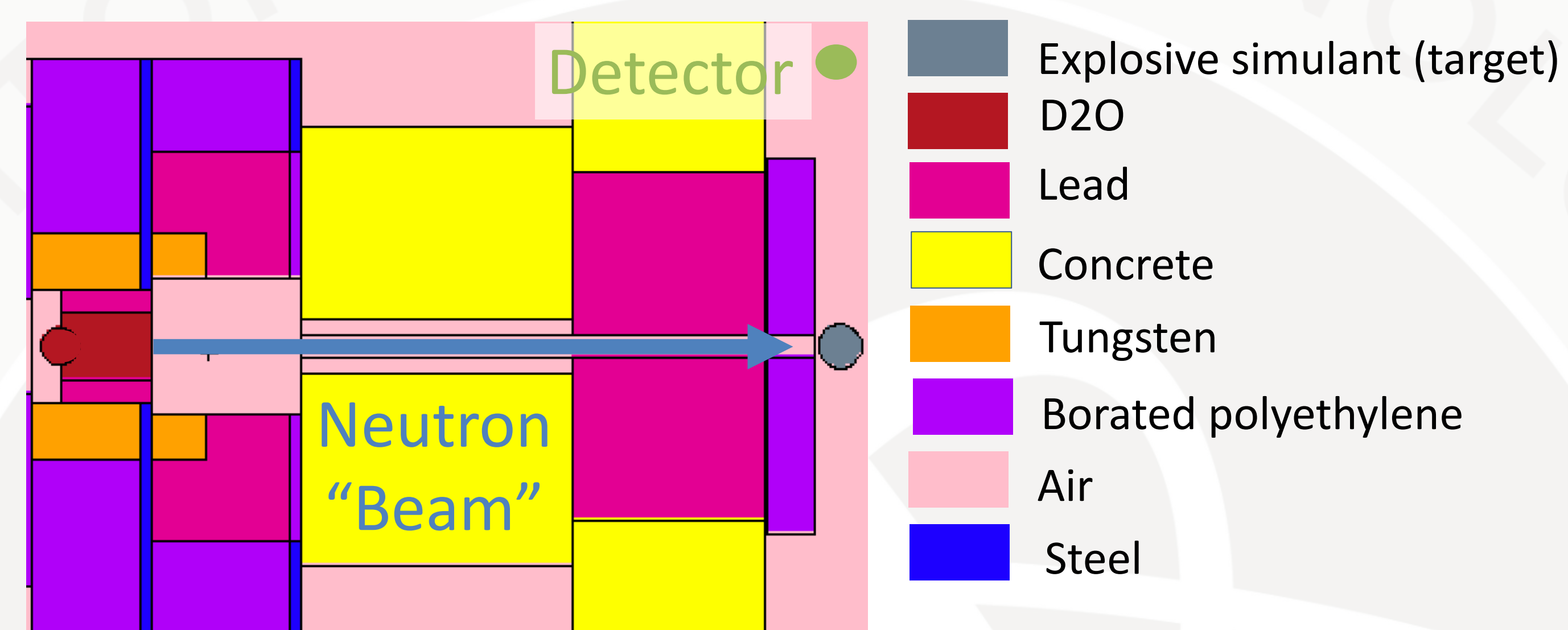|	
■ (grey)	Explosive simulant (target)
■ (dark red)	D2O
■ (magenta)	Lead
■ (yellow)	Concrete
■ (orange)	Tungsten
■ (purple)	Borated polyethylene
■ (pink)	Air
■ (blue)	Steel

Fig. 4: Top-down simulation geometry view in MCNPX

Measurement

- Irradiated plastic CH_4 target
  - Easily procured
  - 2 out of HCNO
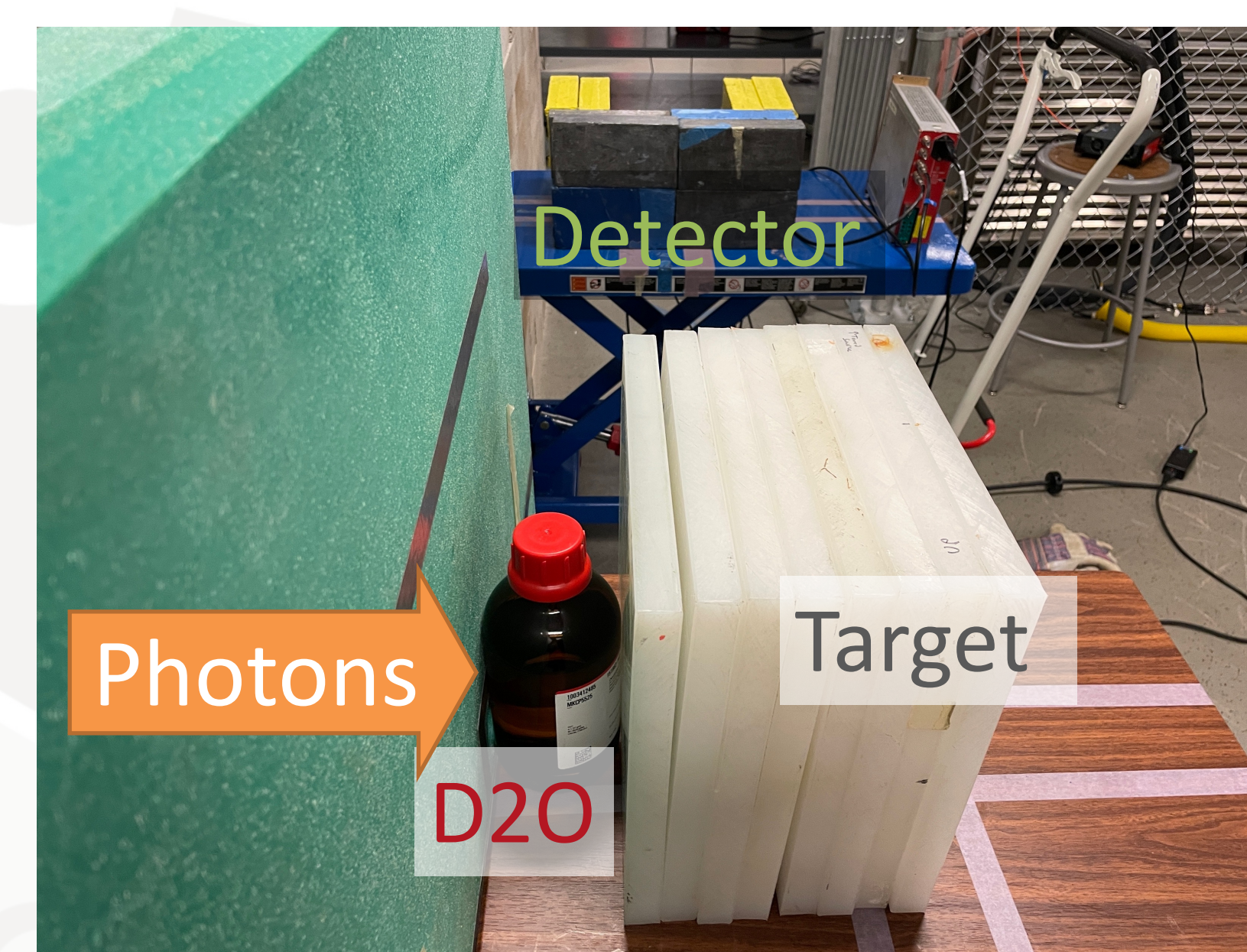- D2O mass lower than simulation for practicality

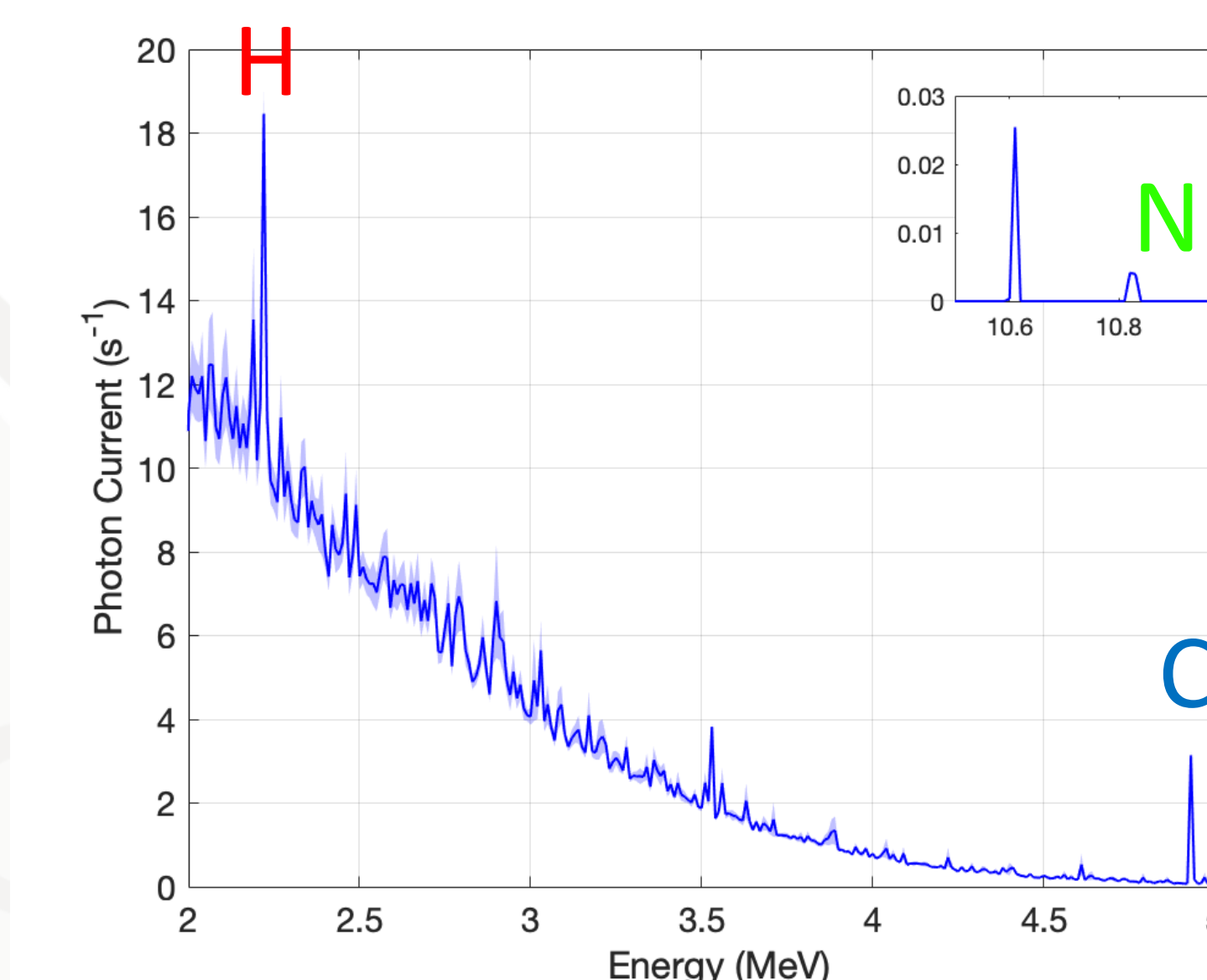*Fig. 5: Lab measurement setup*

Results

Simulation

Fig. 6: Simulated photon flux spectrum; Inset shows peak at ~10.8 MeV

Table 1: Net simulation photon fluxes

Element	Flux (cm^{-2} s^{-1})
H	0.175 ± 0.315
C	0.121 ± 0.000
N	0.004 ± 0.000

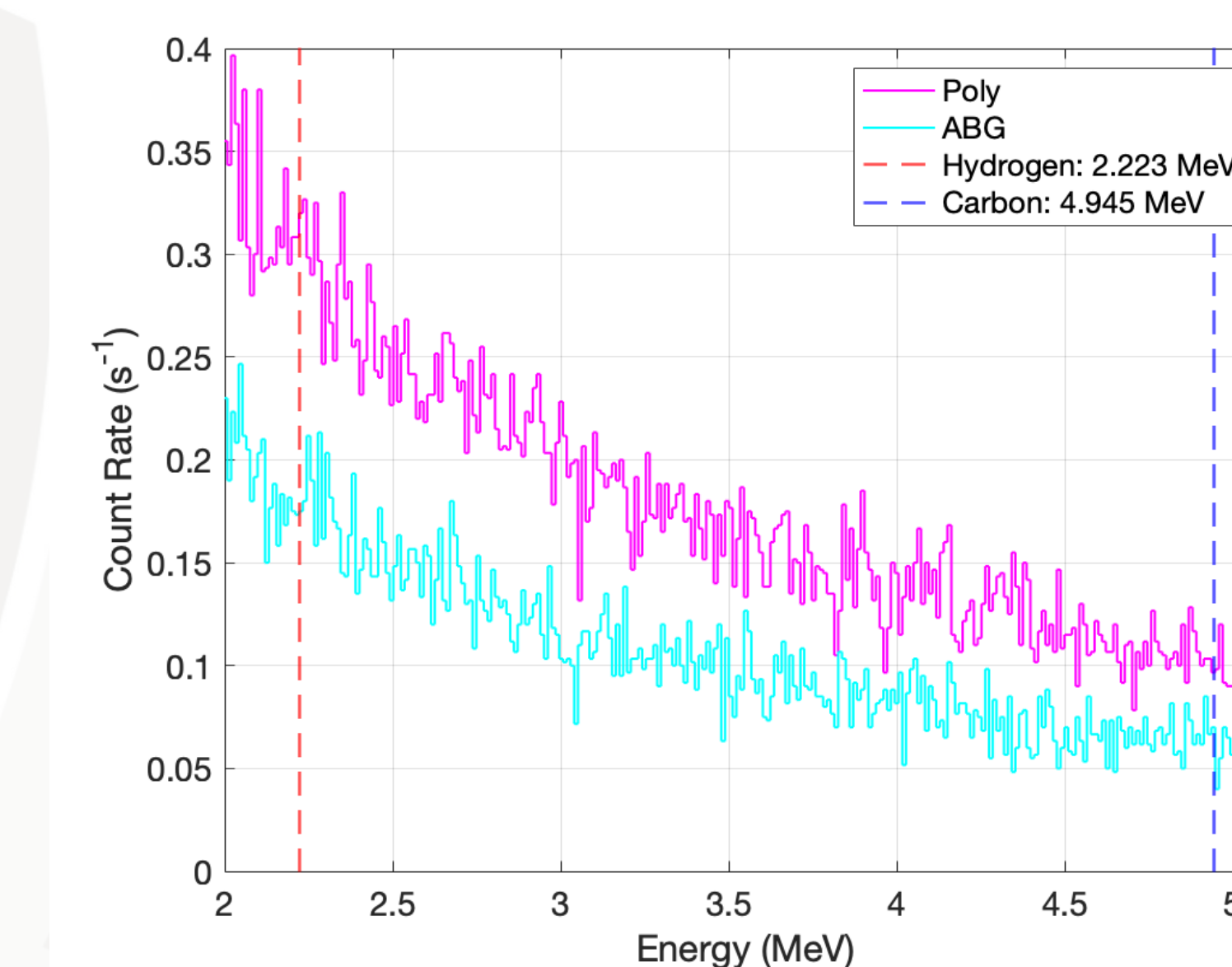- Net increase above background for HCN signatures

Measurement

Fig. 7: Net measured photon count rate

- No clear HC peaks
- 4.6% pile-up

Conclusion

- Simulated neutron interrogation produces unique HCNO gamma signatures
- In measurement, linac background prevents gamma peak identification
- Low pile-up rate is good for seeing target signal

Next Steps

- Increase shielding and detector distance to reduce noise
- Improve interrogation efficiency
- Define elemental ratio algorithm

References
[1] Everport Container Terminal. Port of Los Angeles. (n.d.). Retrieved November 30, 2022, from https://www.portoflosangeles.org/business/terminals/container/everport-terminal-services
[2] CanTeach. (n.d.). CANDU Fundamentals. Retrieved November 30, 2022, from https://sites.ifi.unicamp.br/mabernal/files/2014/09/NeutronInteractions.pdf
[3] American national standard minimum performance criteria for active interrogation systems used for Homeland Security. (2008). IEEE. https://doi.org/10.1109/ieeestd.2008.4453881
[4] MCNPX-Polimi [Computer software]. (2011). Radiation Safety Information Computational Center.