

2026/04/17

Improving Neutron Flux Characterization Through Cadmium- Filtered Measurements

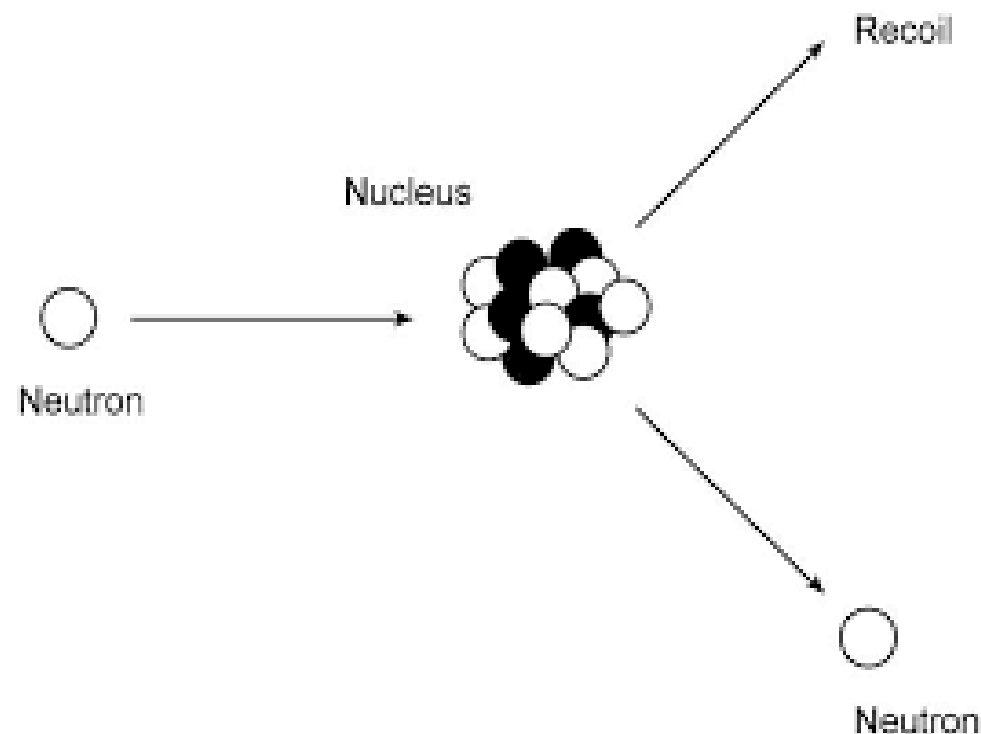
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Why study neutrons?

- Background source
- Both neutrons and WIMPS produce nuclear recoils
- Accurate neutron characterization is essential for background suppression in dark-matter experiments



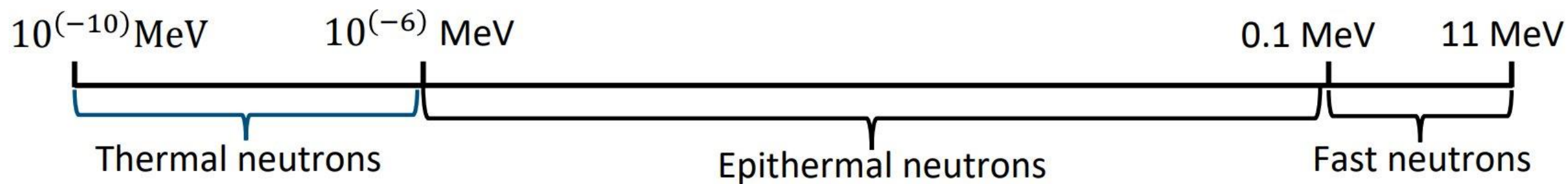
Source: CANTEACH, "Neutrons and Neutron Interactions"

Where do neutrons come from?

- **(α ,n) reactions** in surrounding rock from U/Th decay chains
- **Cosmogenic neutrons** from muons penetrating deep underground
- These neutrons are fast & hard to detect!



Source: SNOLAB, "SNOLAB 10-Year Anniversary"



Detector Setup

Materials

Polyethylene (Moderator)

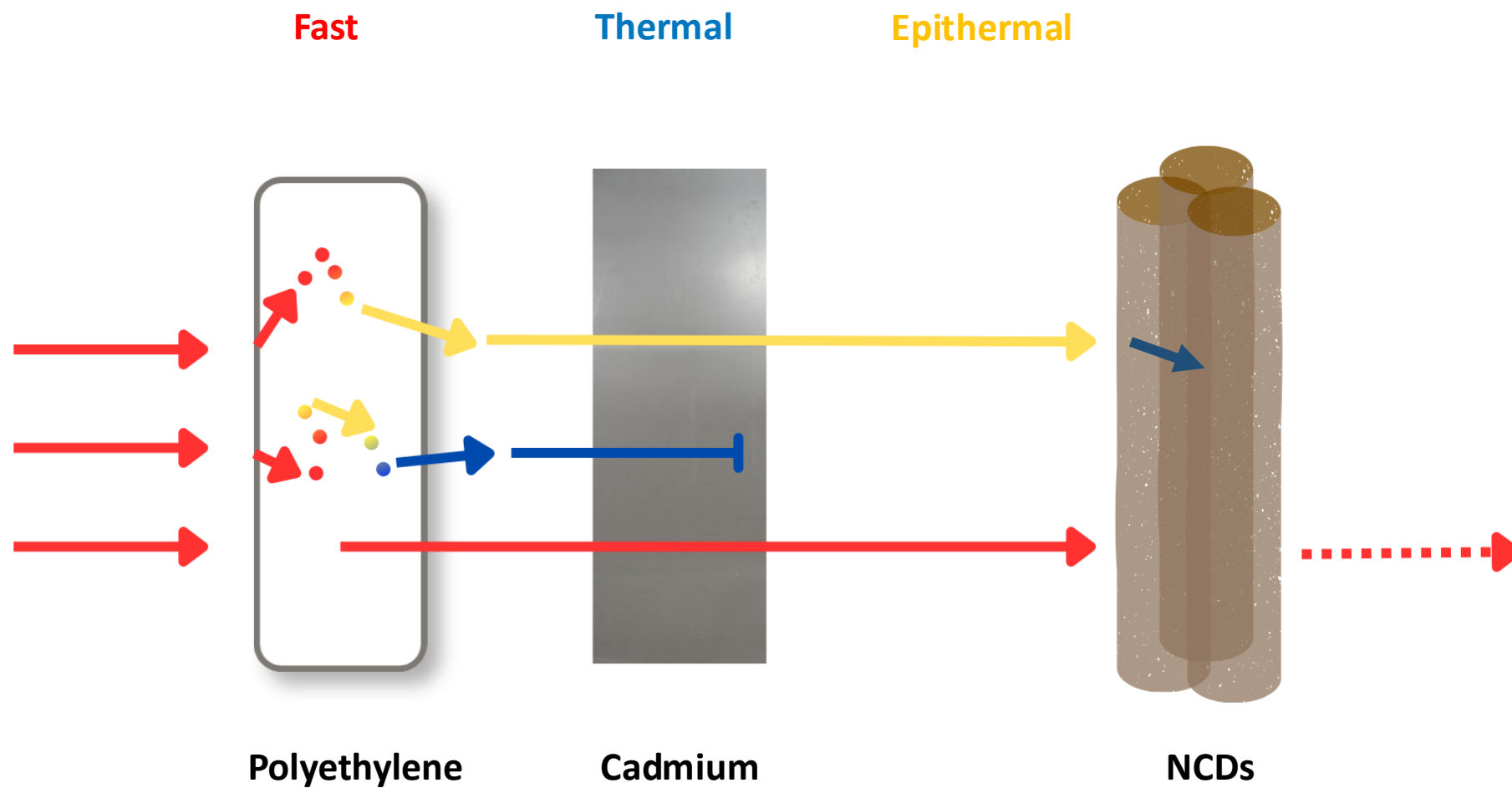
- Slows fast neutrons
- Converts fast -> thermal neutrons

Cadmium

- Strong absorber of thermal neutrons
- Isolates epithermal/fast neutrons

Polyethylene & Cadmium

- Probes fast to epithermal conversion





Cd shielding



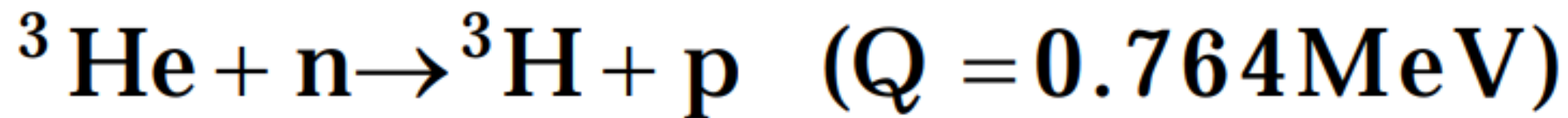
1" Polyethylene



2" Polyethylene

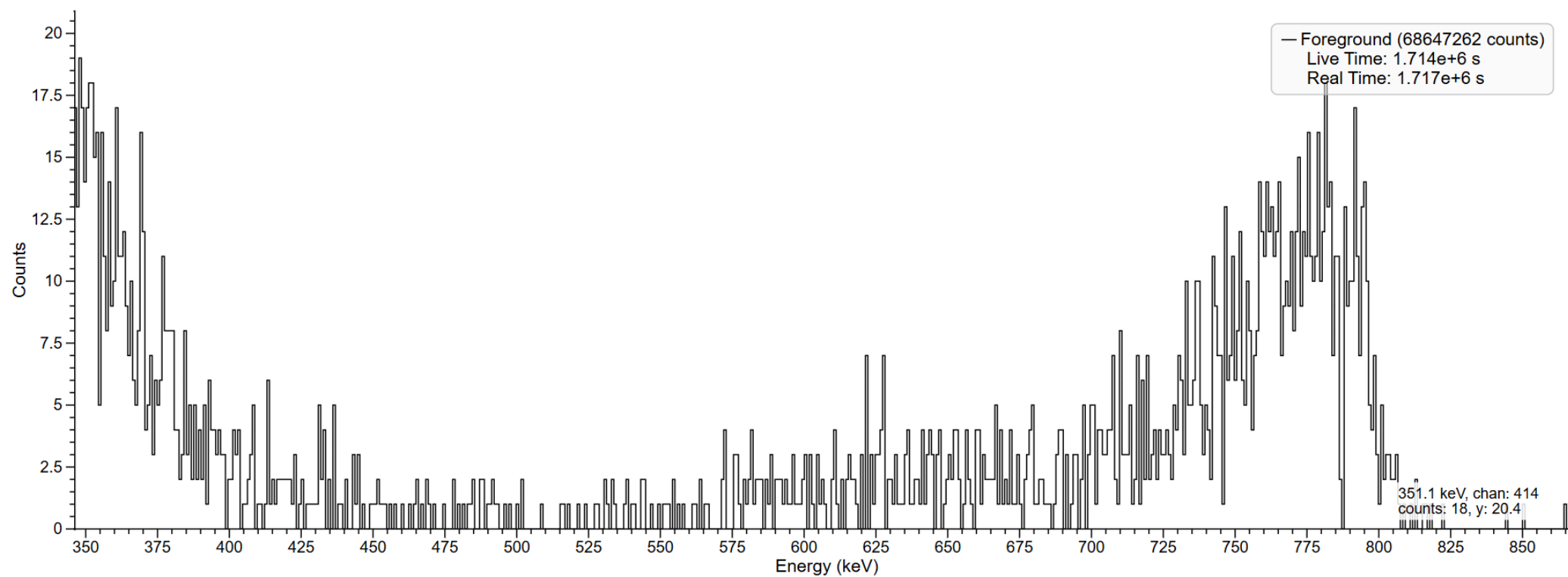
NCDs (Neutral Current Detectors)

- NCD = ^3He proportional counter

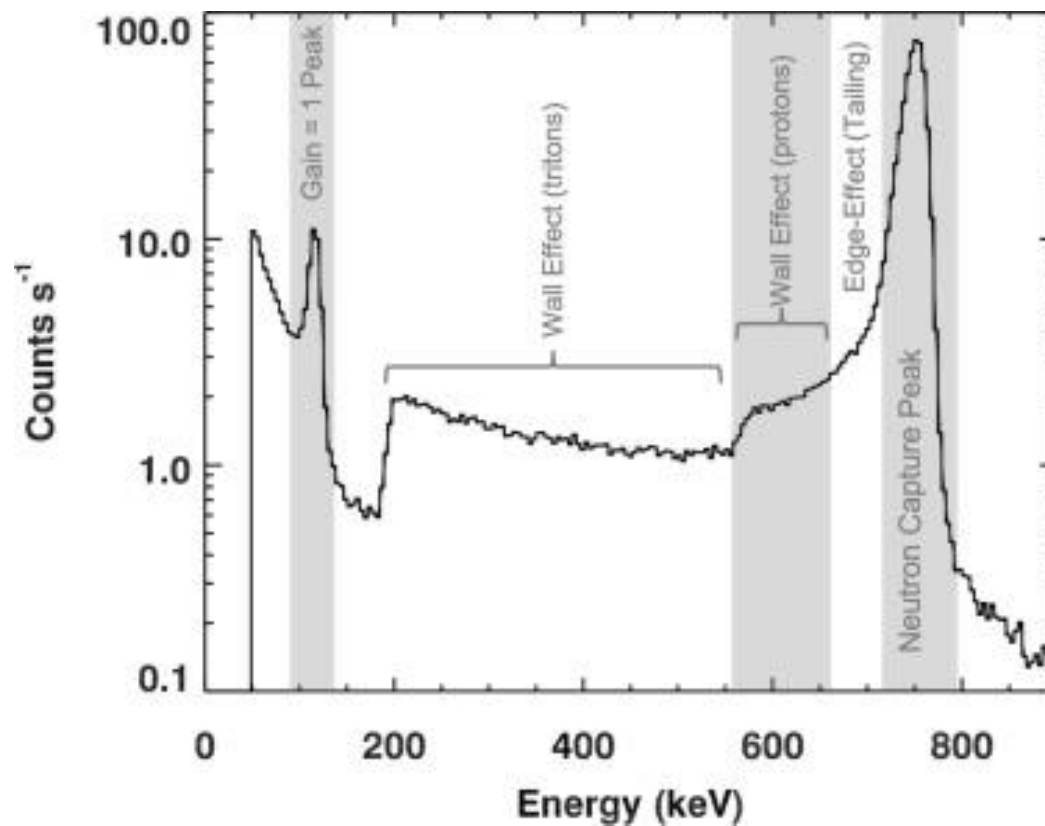


 tritium

Raw Detector Data

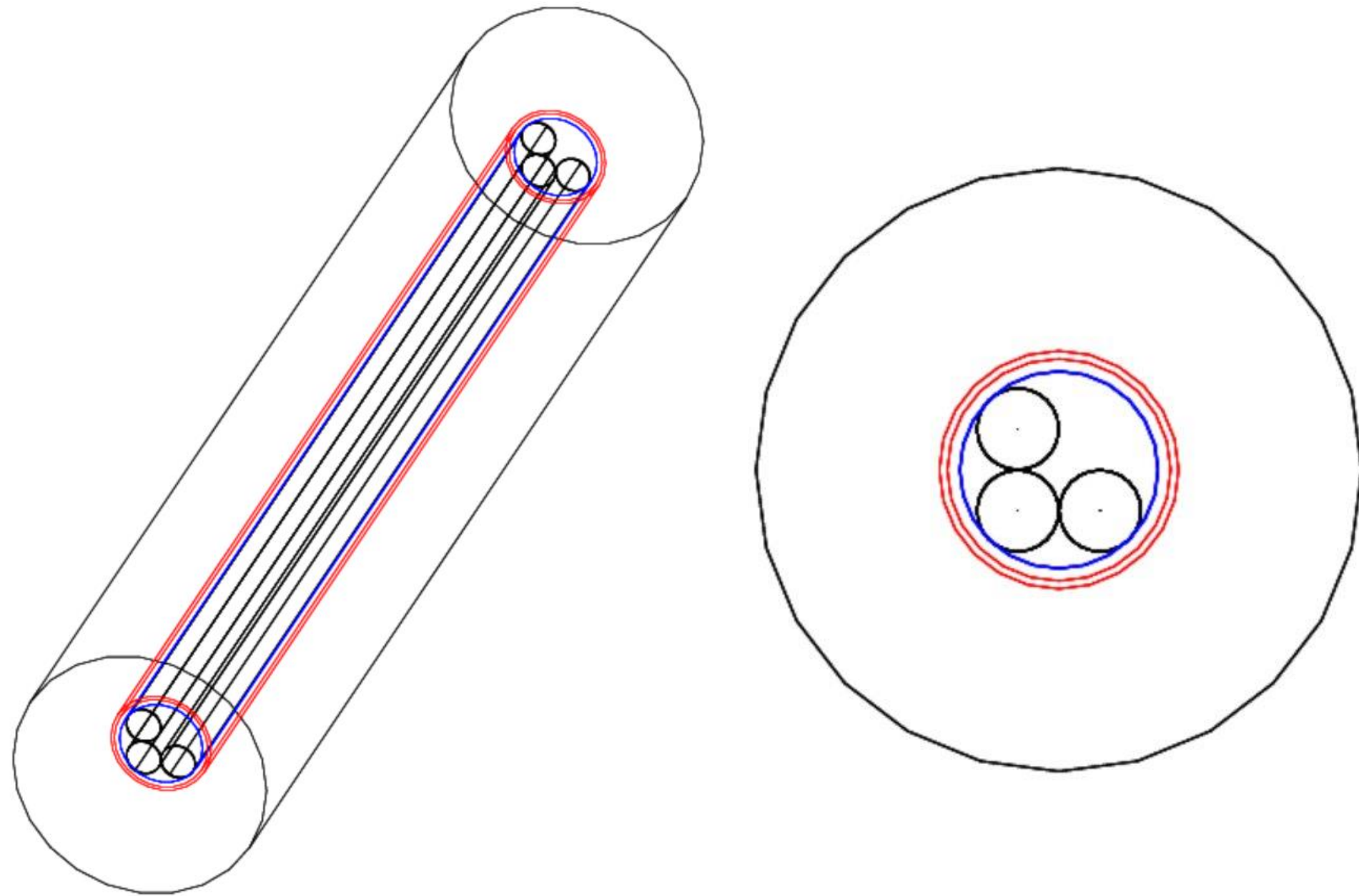


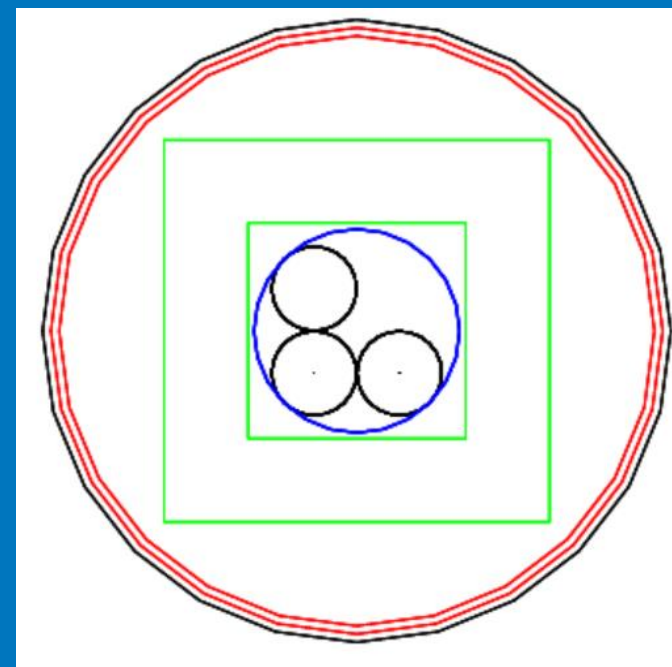
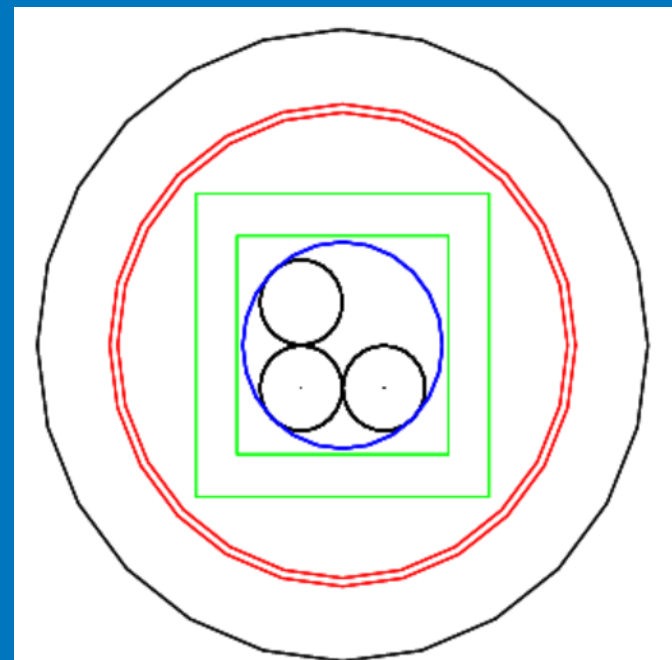
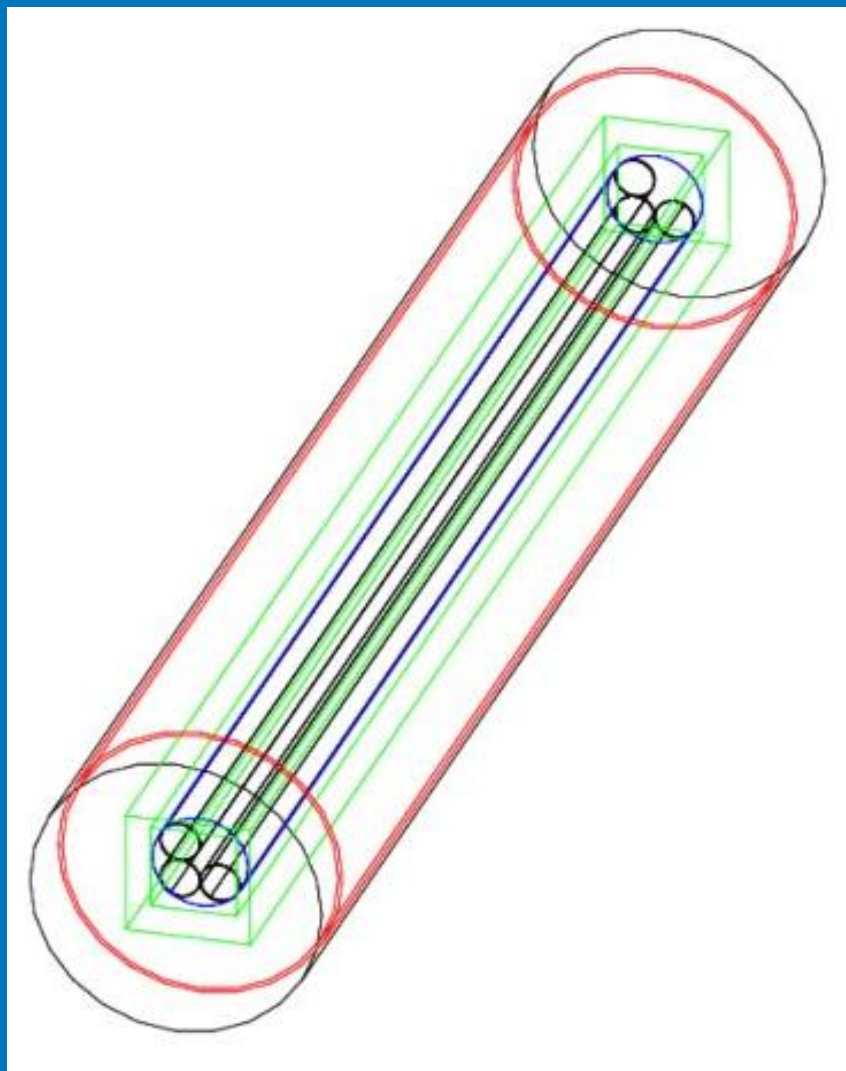
The "Wall-Effect"



Source: Elsevier, Nuclear Instruments and Methods A (2020)

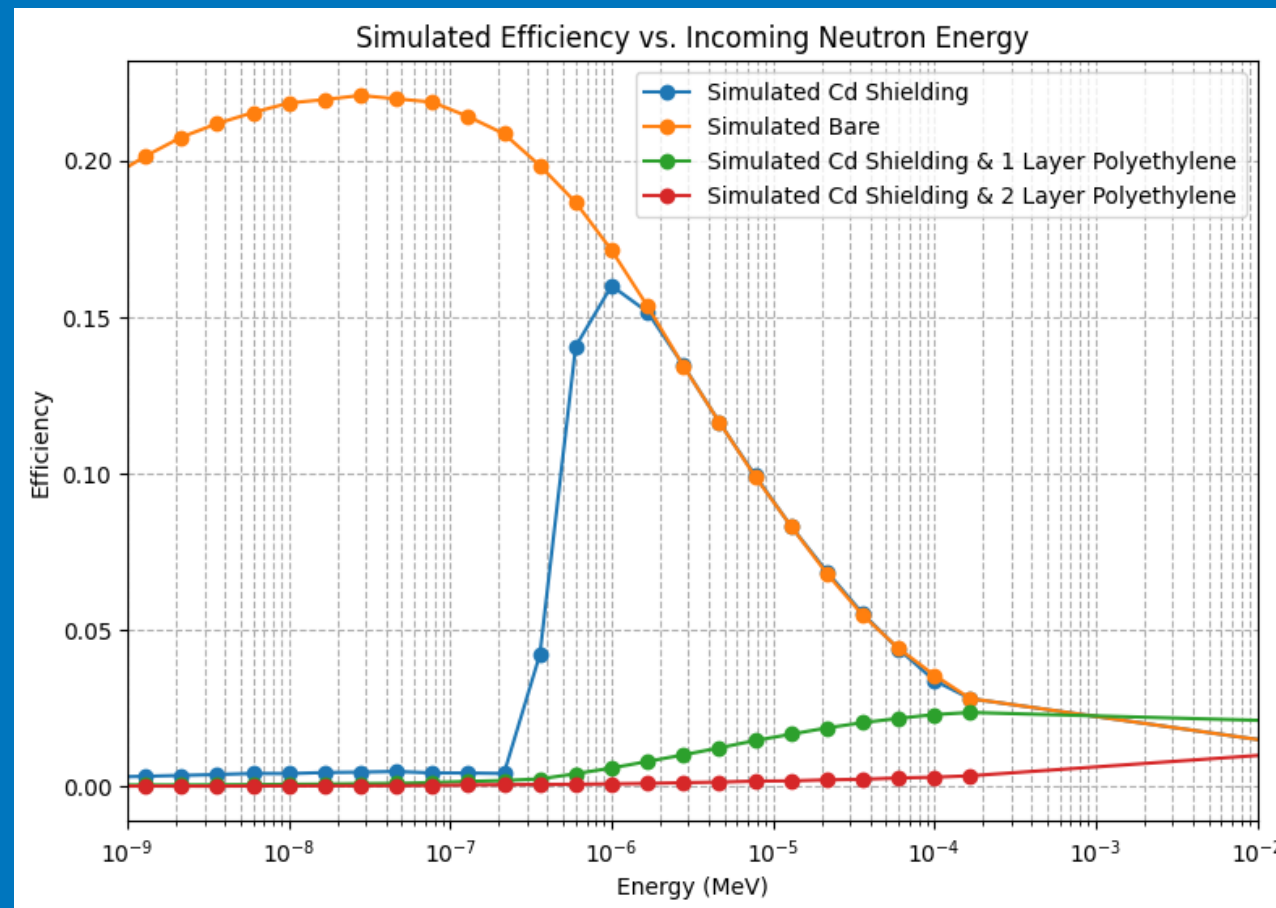
GEANT4 Simulations





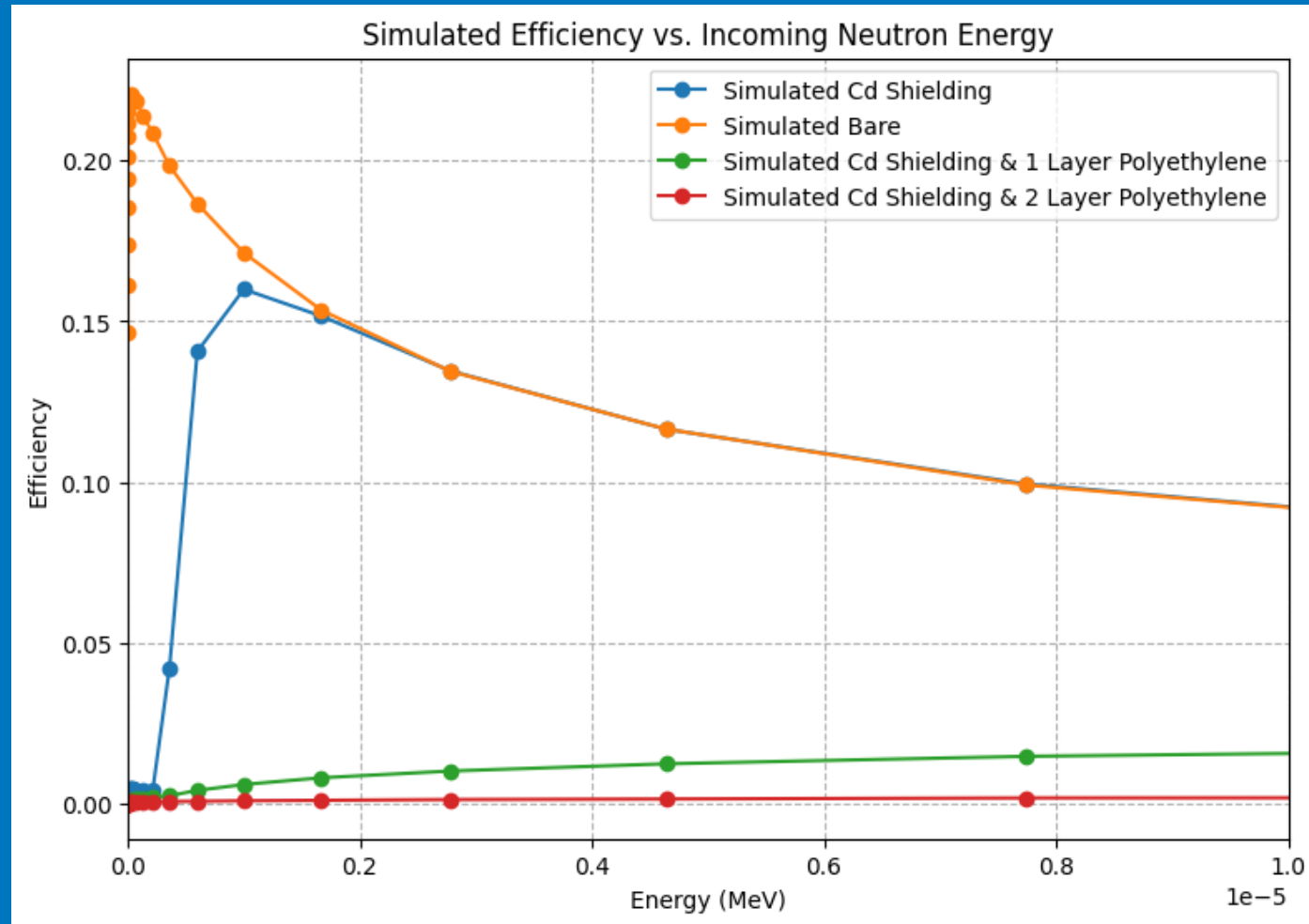
Simulation Plot

Bare – Cadmium = Thermal Contribution



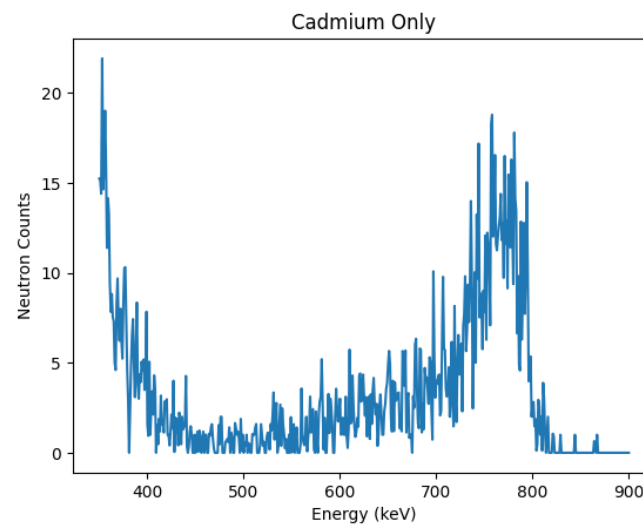
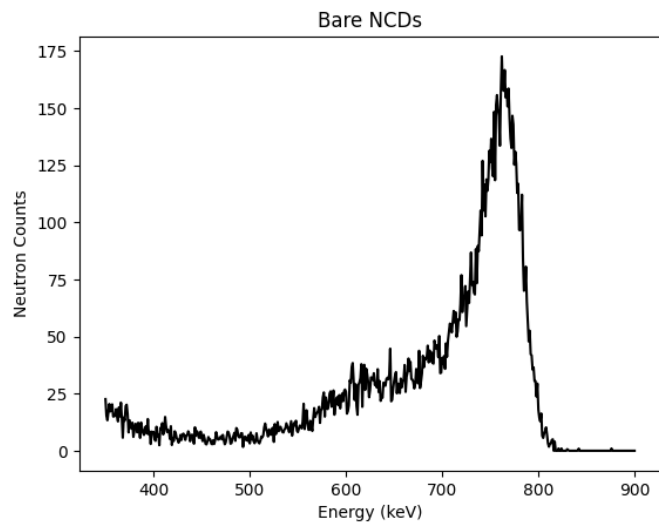
At higher energies, polyethylene has a greater efficiency than bare

Simulation Plot



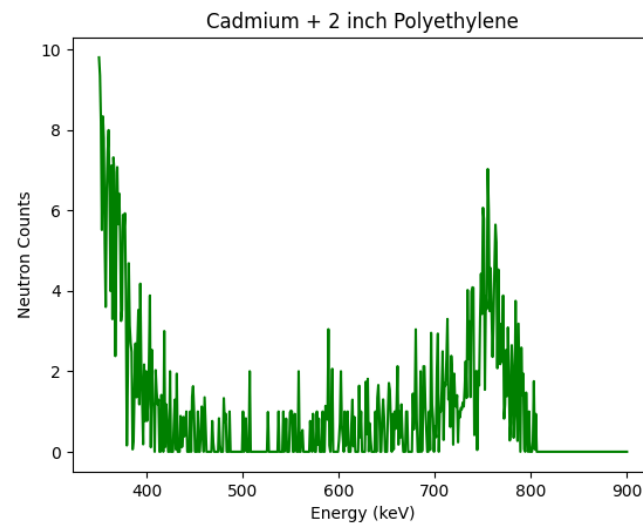
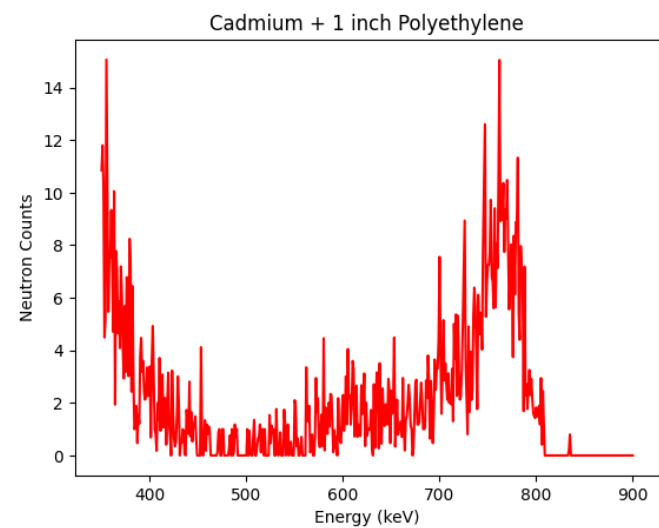
Experimental Data

713.7 counts/day



86.9 counts/day

56.8 counts/day



19.2 counts/day



Thank you!

Special Thanks To:

Ian Lawson, Steffon Luoma, Dimpal Chauhan, Thomas Sonley

Supplementary Material

How do neutrons interact with matter?

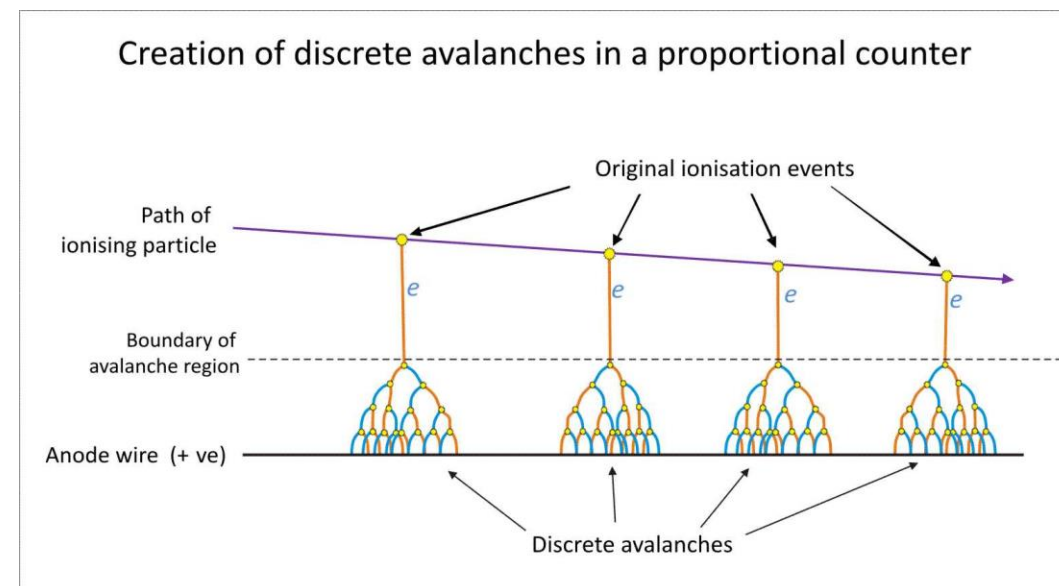
- Neutrons have no charge
 - Do not interact with electrons
- In polyethylene:
 - Elastic scattering
 - Neutron bounces off a nucleus and loses some of its energy
- In detector:
 - Absorption (capture)
 - Neutron is captured by Helium-3 nucleus -> nucleus transforms into proton and triton

Why are we interested in multiple energy ranges?

- In most environments, neutrons are initially produced at high energies
- As they travel through materials, they collide with nuclei and lose energy
 - Creates a range of neutron energies from fast to thermal

How do gas detectors work?

- Gas-filled detectors with applied electric field
- Neutron interaction produces charged particles (triton and proton)
- Charged particles will move through gas and ionize it
- Creates electron-ion pairs
- Electrons drift toward central wire
- Electron multiplication
- Measurable electrical signal



Source: Wikipedia, "Proportional Counter"

Why do we have 3 detectors?

- Originally 4 NCD detectors in the setup
 - One broke :(
- Each detector can detect $\sim 30\text{-}50\%$ neutron interactions