Development of a Teaching Laboratory for the Measurement of Prompt Neutrons from Californium 252 by Time-of-Flight Analysis

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Summer 2011

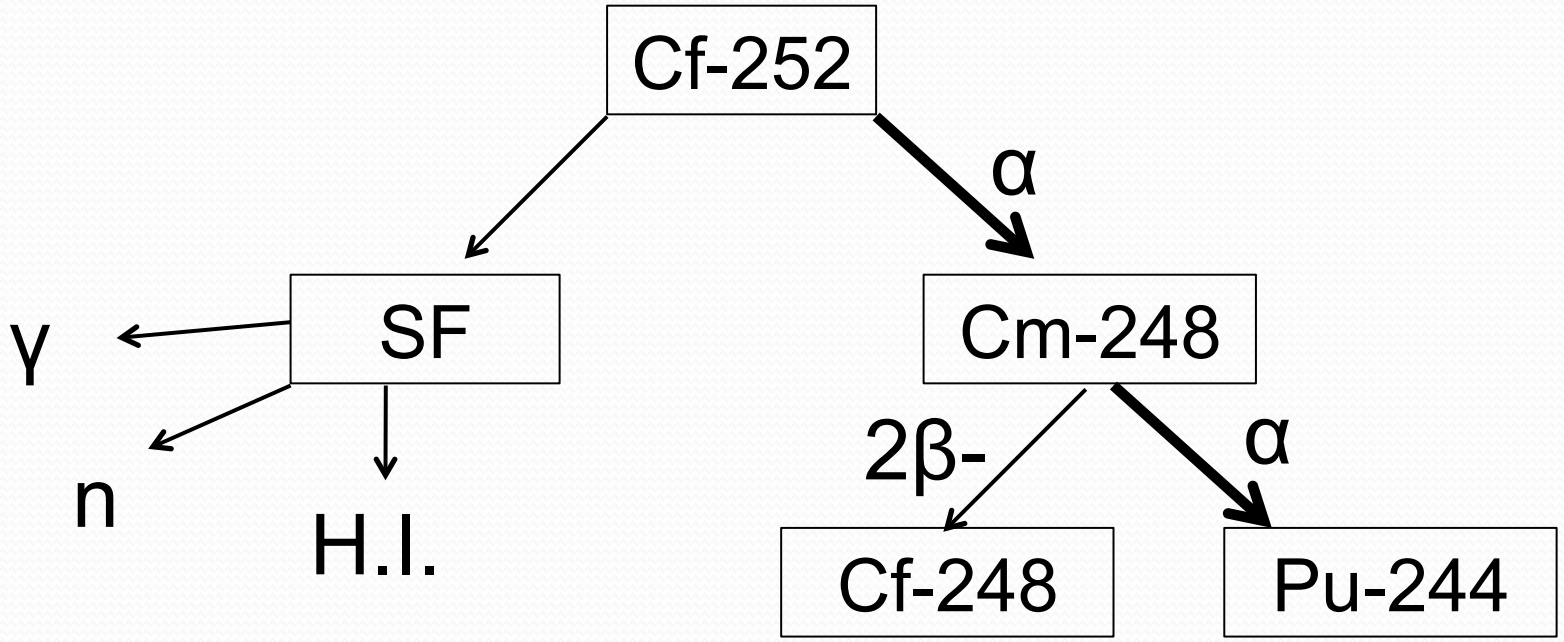


UM Nuclear Sciences Group

Overview

- Background
- Why
- Detectors
- Time of Flight
- Road Blocks
- Conclusion
- Main Side Project

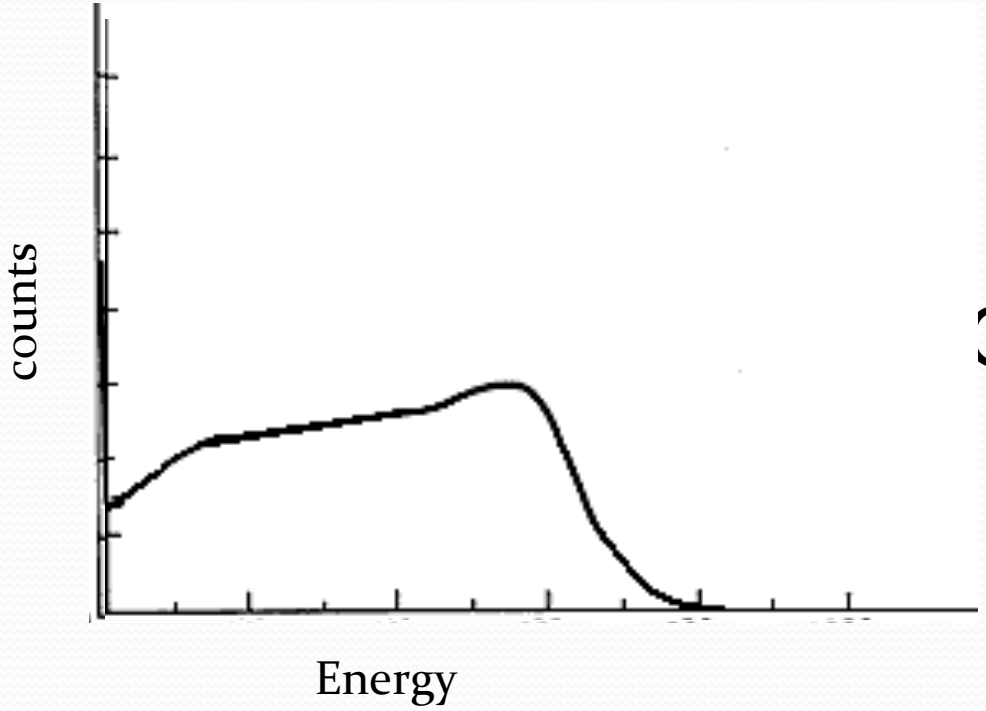
Californium 252 Fission Source



- High spontaneous fission branch[1] 3.09%
- 3.87 neutrons per fission[4]
- 50 uCi 5/15/05 - ~42,000 neutrons/sec (July 2011)

Background

- Neutron was detected in 1932 by James Chadwick with proton recoil methods
- Neutrons are harder to detect then gammas



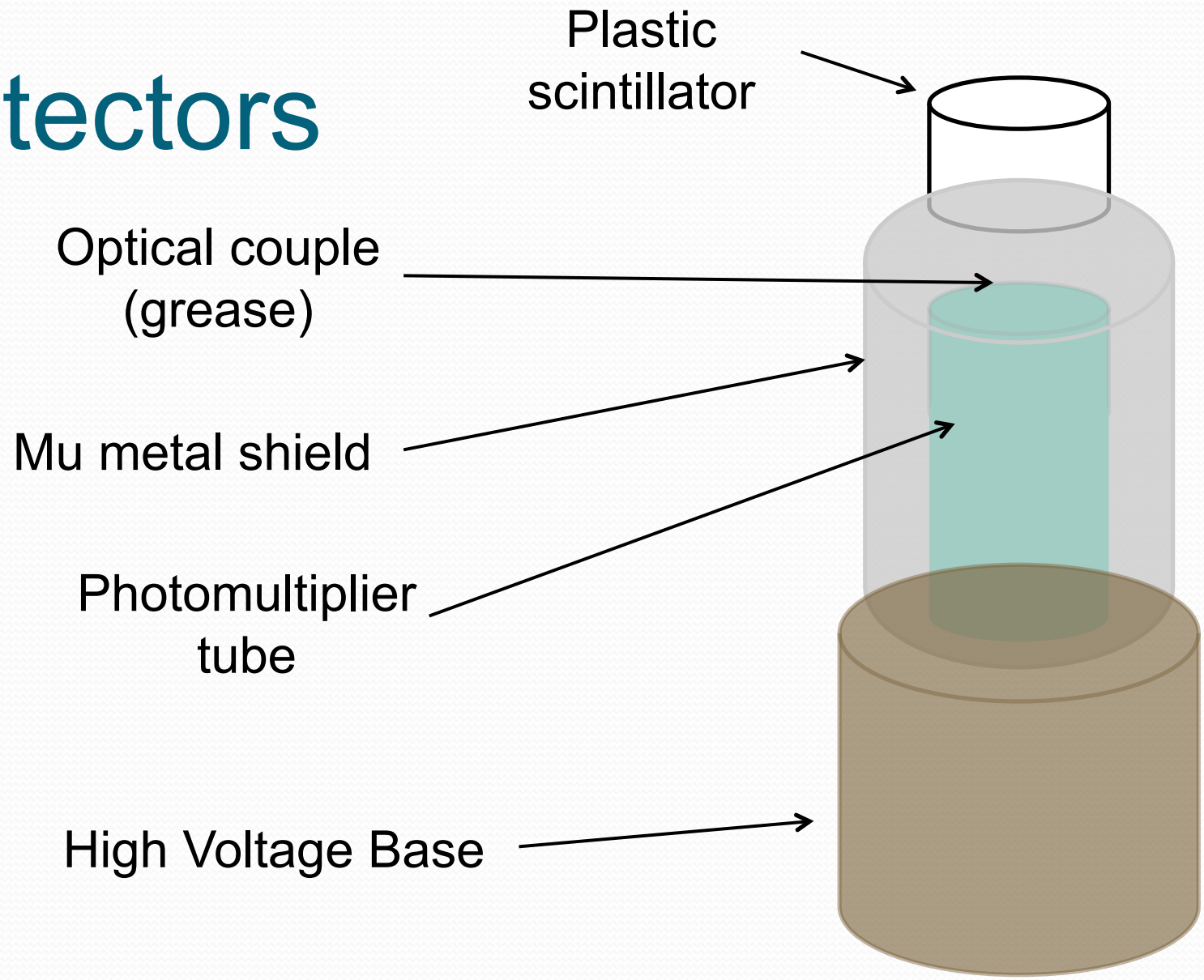
Neutron spectrum

http://www.oken.co.jp/o/eng_s/toku2.html

Why

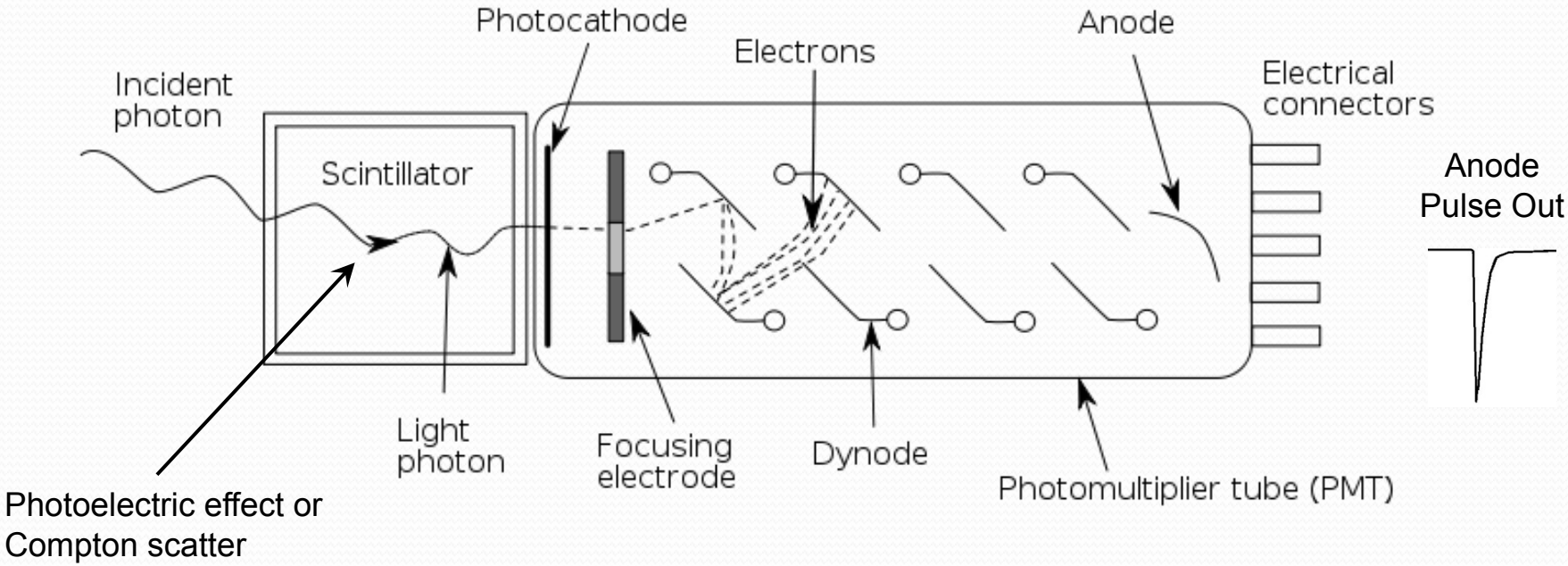
- Neutrons are important constituents of matter
- Neutrons are vital for analysis of many nuclear reactions
- Nuclear security- radioactive material
- Nuclear reactors- clean energy
- Develop an advanced lab for physics majors

Detectors


Plastic scintillator
Optical couple (grease)
Mu metal shield
Photomultiplier tube
High Voltage Base

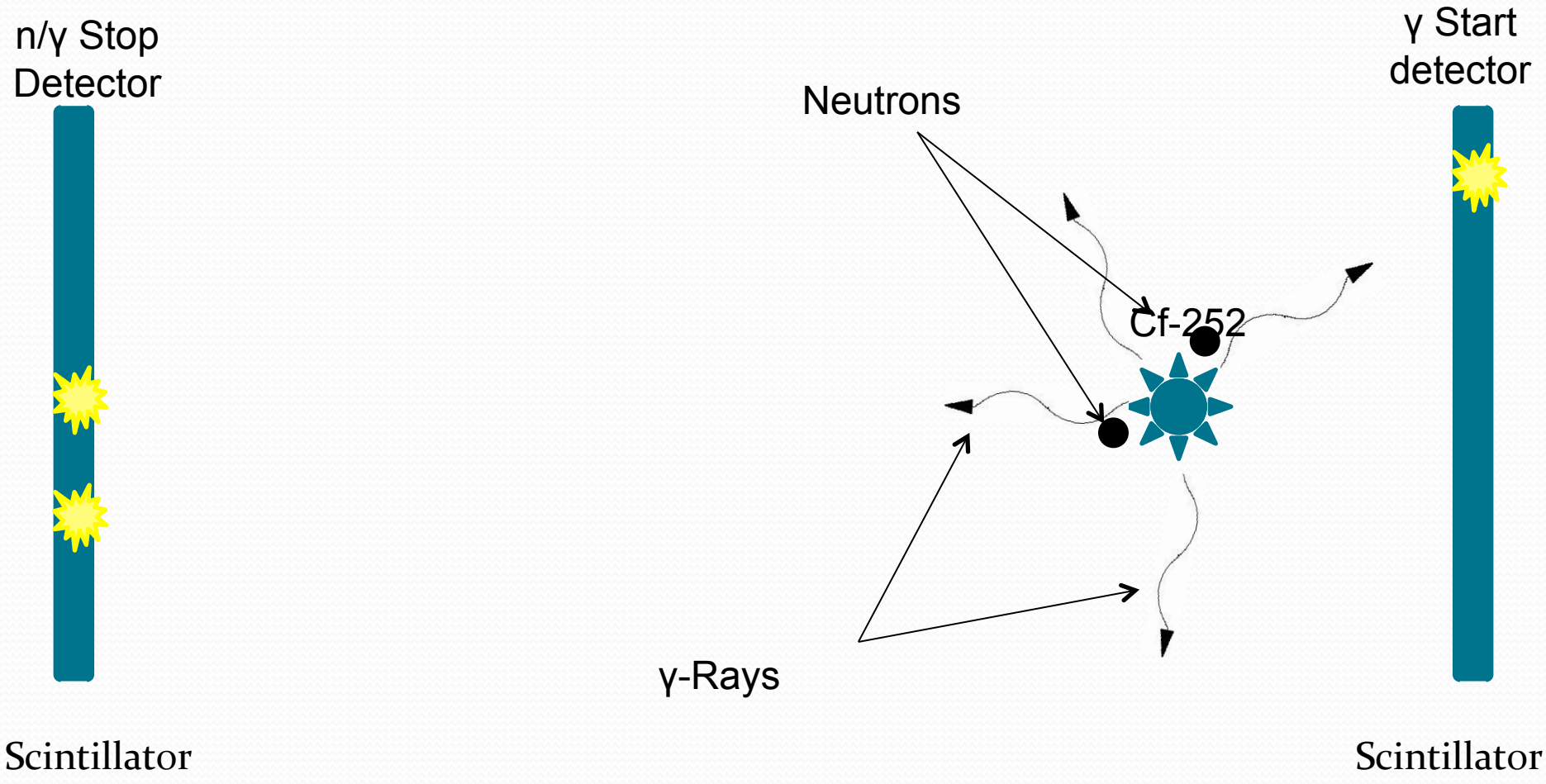
Photomultiplier tubes

Converts photons to a fast current pulse



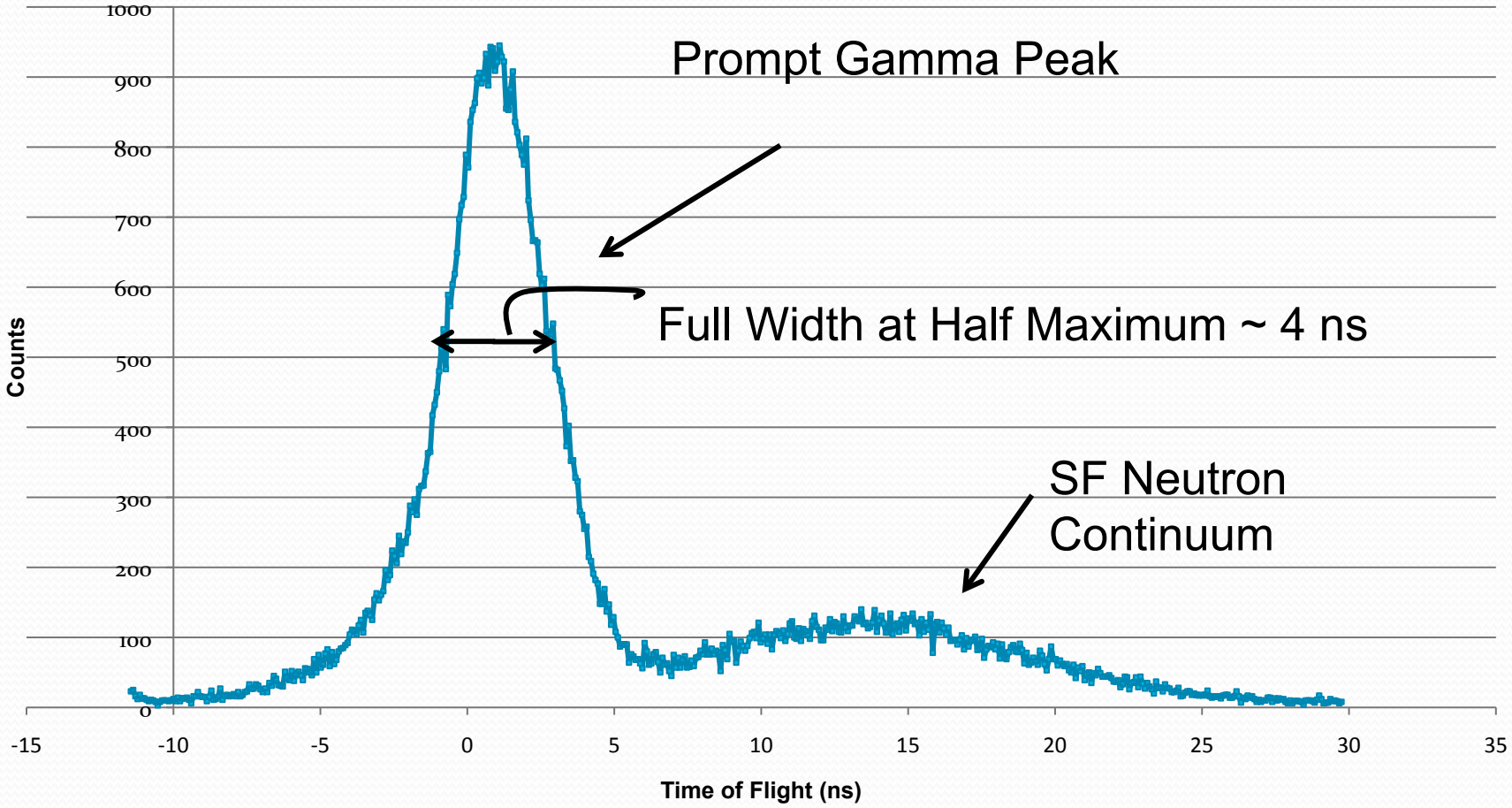
http://commons.wikimedia.org/wiki/File:Photomultipliertube.png

Time of Flight Method



Time-of-Flight Spectrum using Cf-252

Path length 30 cm



Triggers and Thresholds

Single Channel Analyzer (SCA)

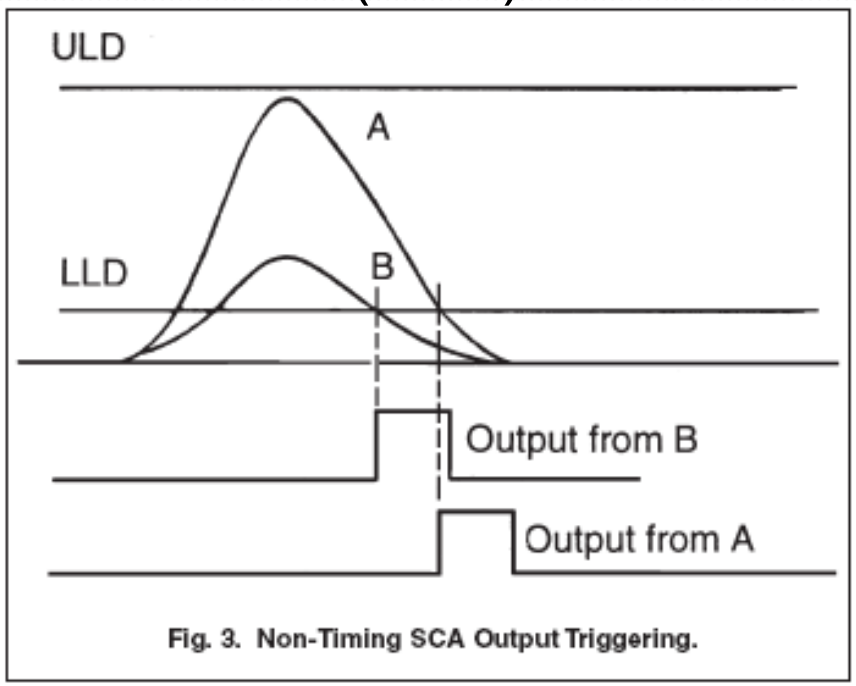


Fig. 3. Non-Timing SCA Output Triggering.

Constant Fraction Discriminator (CFD)

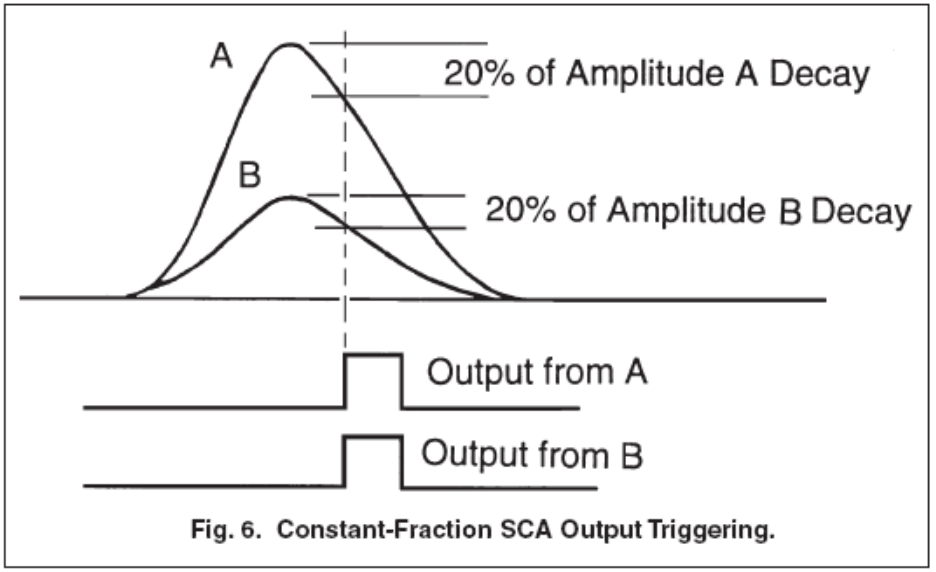
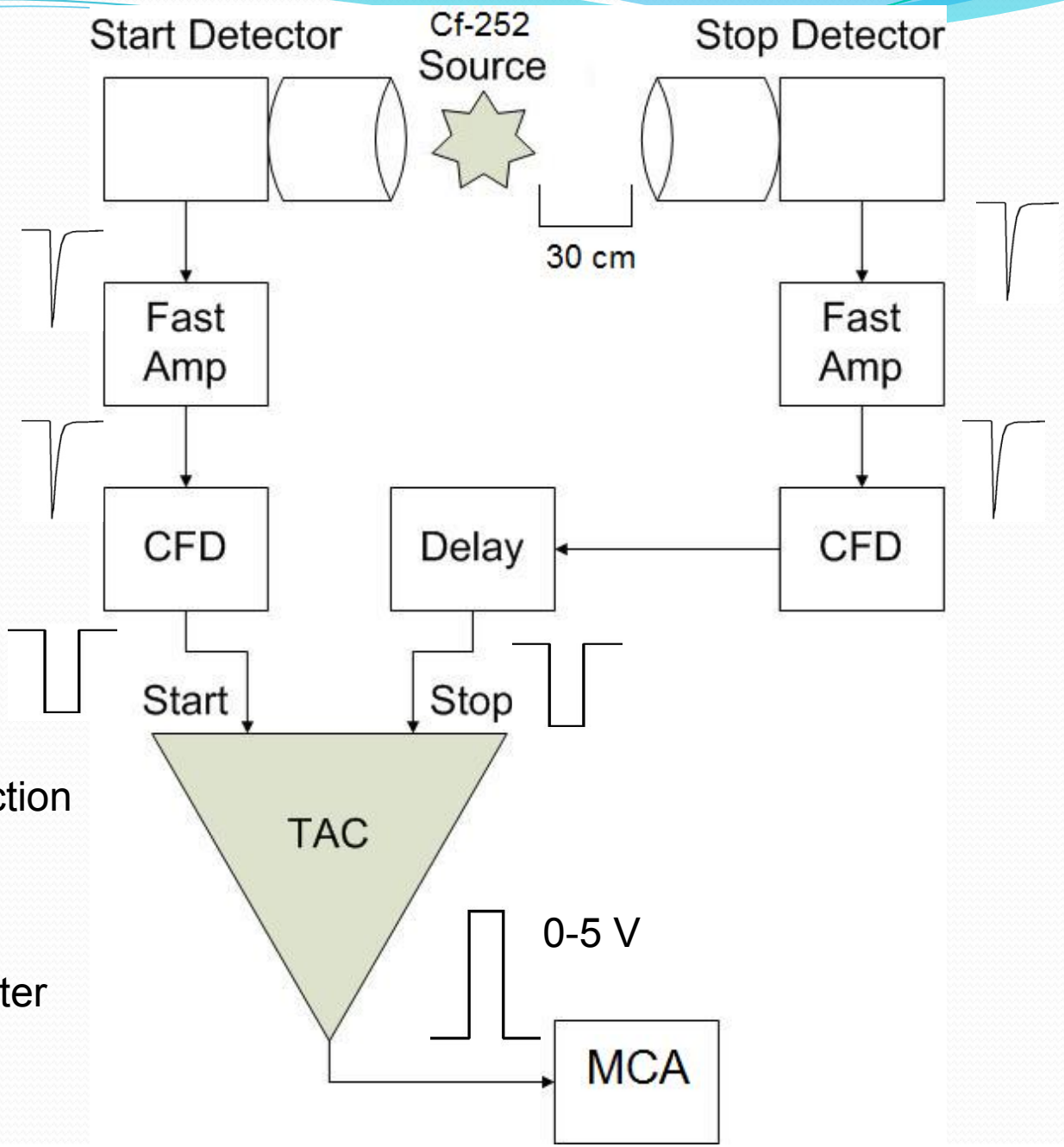


Fig. 6. Constant-Fraction SCA Output Triggering.

CFD Circuit

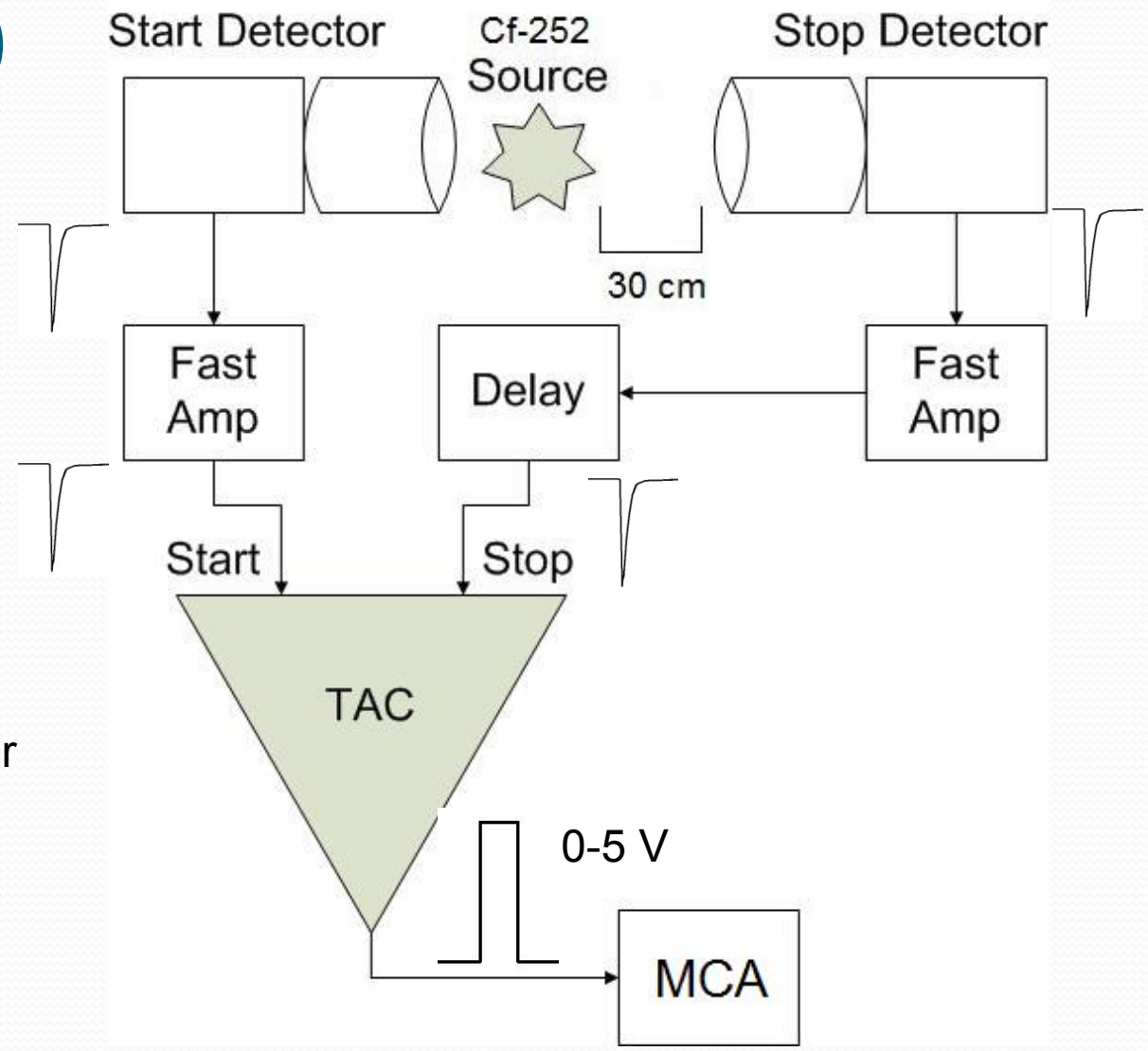


CFD - Constant Fraction Discriminator

TAC - Time to Pulse Height Converter

MCA - Multi Channel Analyzer

No CFD Circuit

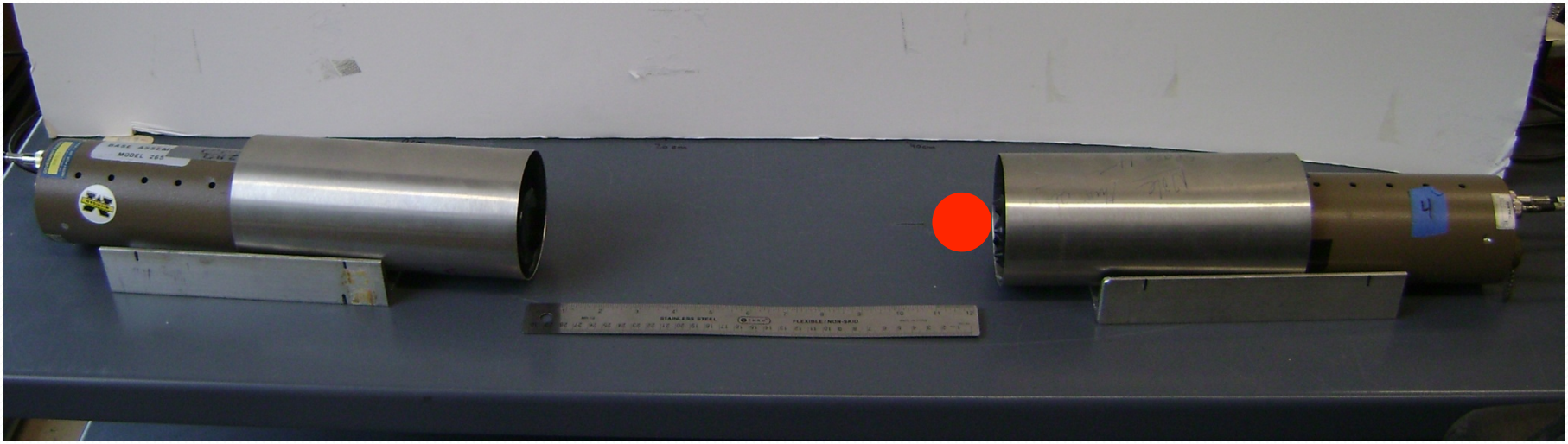


TAC - Time to Pulse Height Converter

MCA - Multi Channel Analyzer

The Apparatus





Stop detector

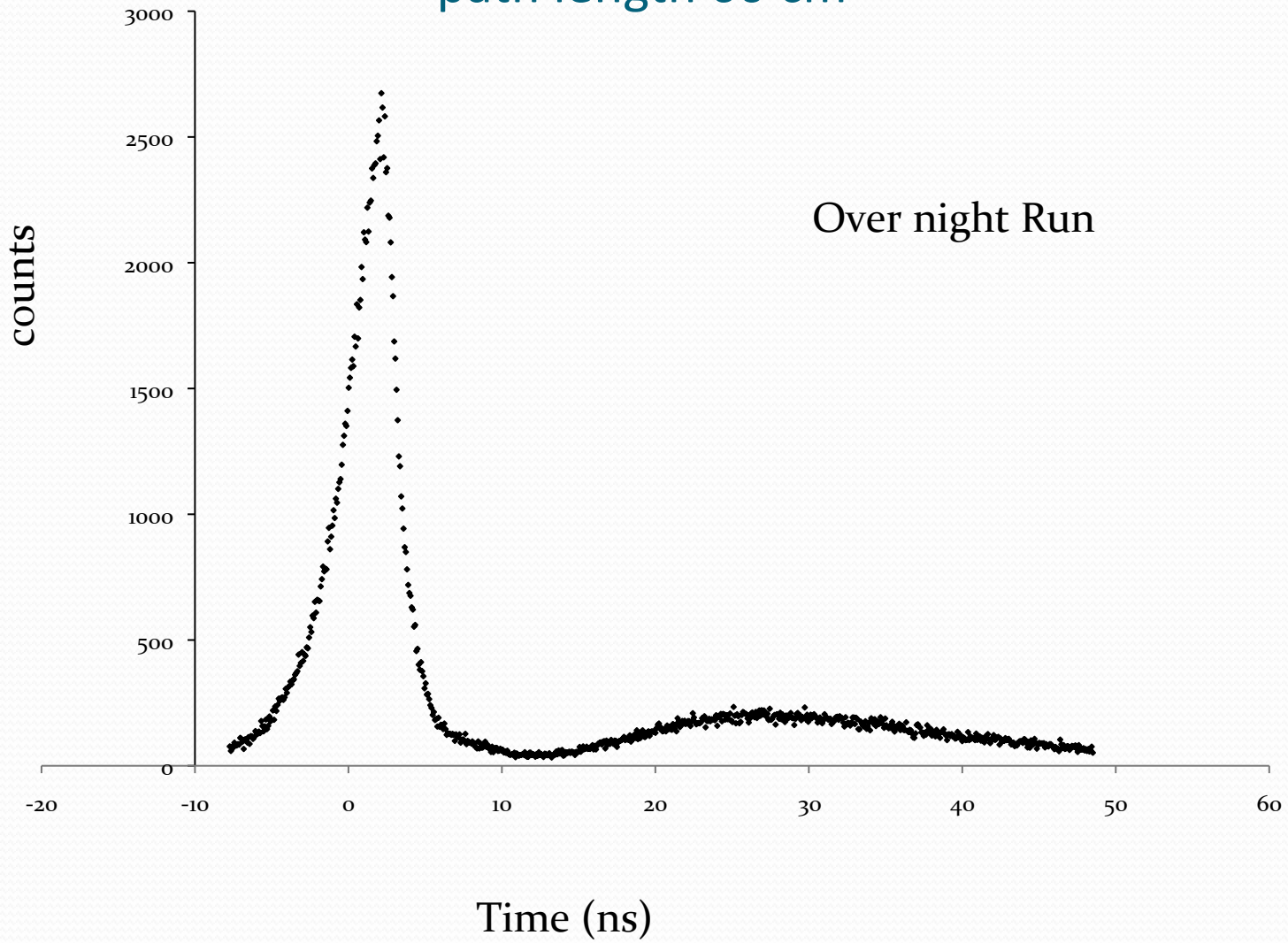
Start detector

Road Blocks

- Low Count Rate vs Separation
- Time Jitter
- Efficiency Correction

Time-of-Flight Spectrum

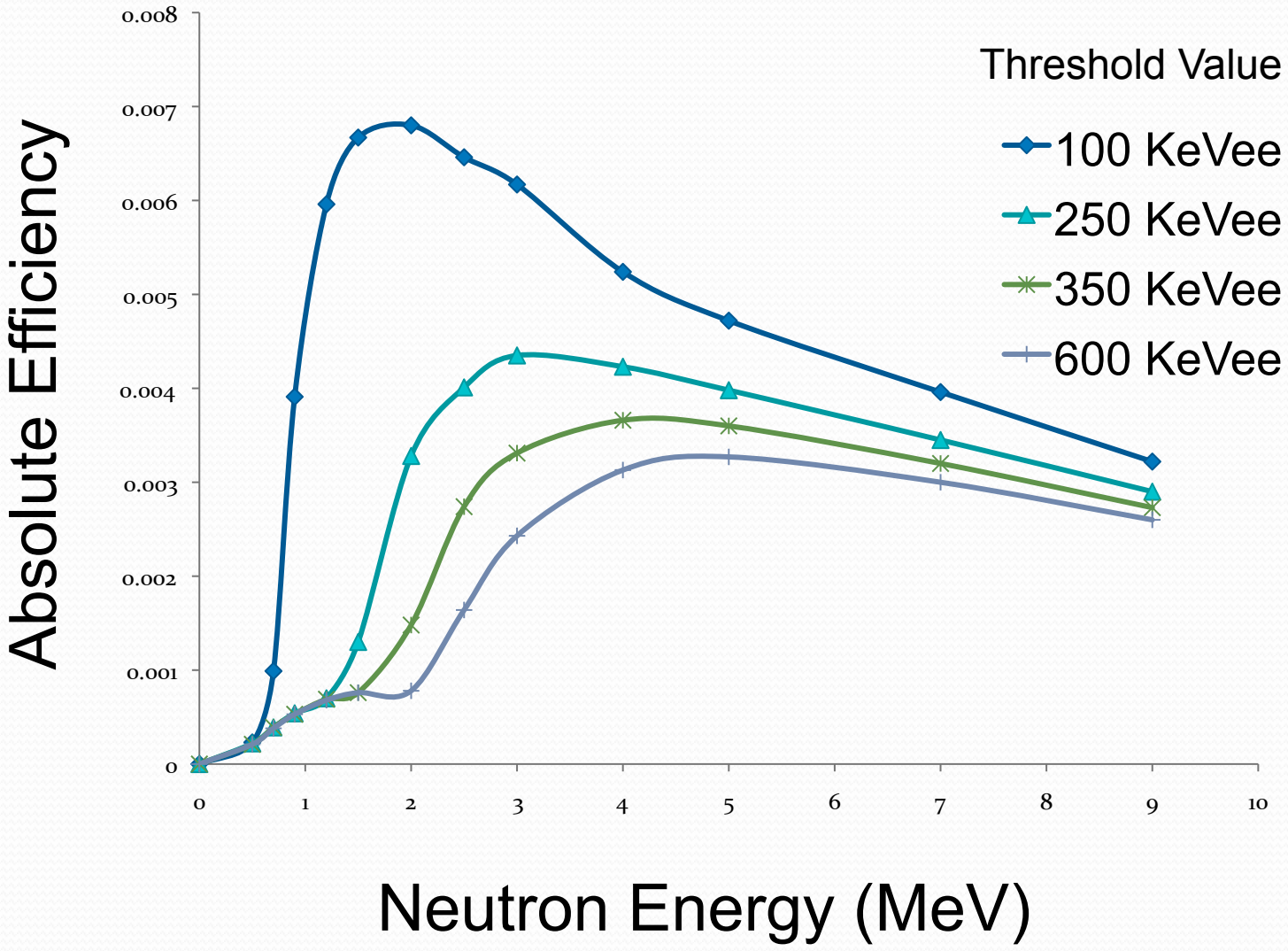
path length 60 cm



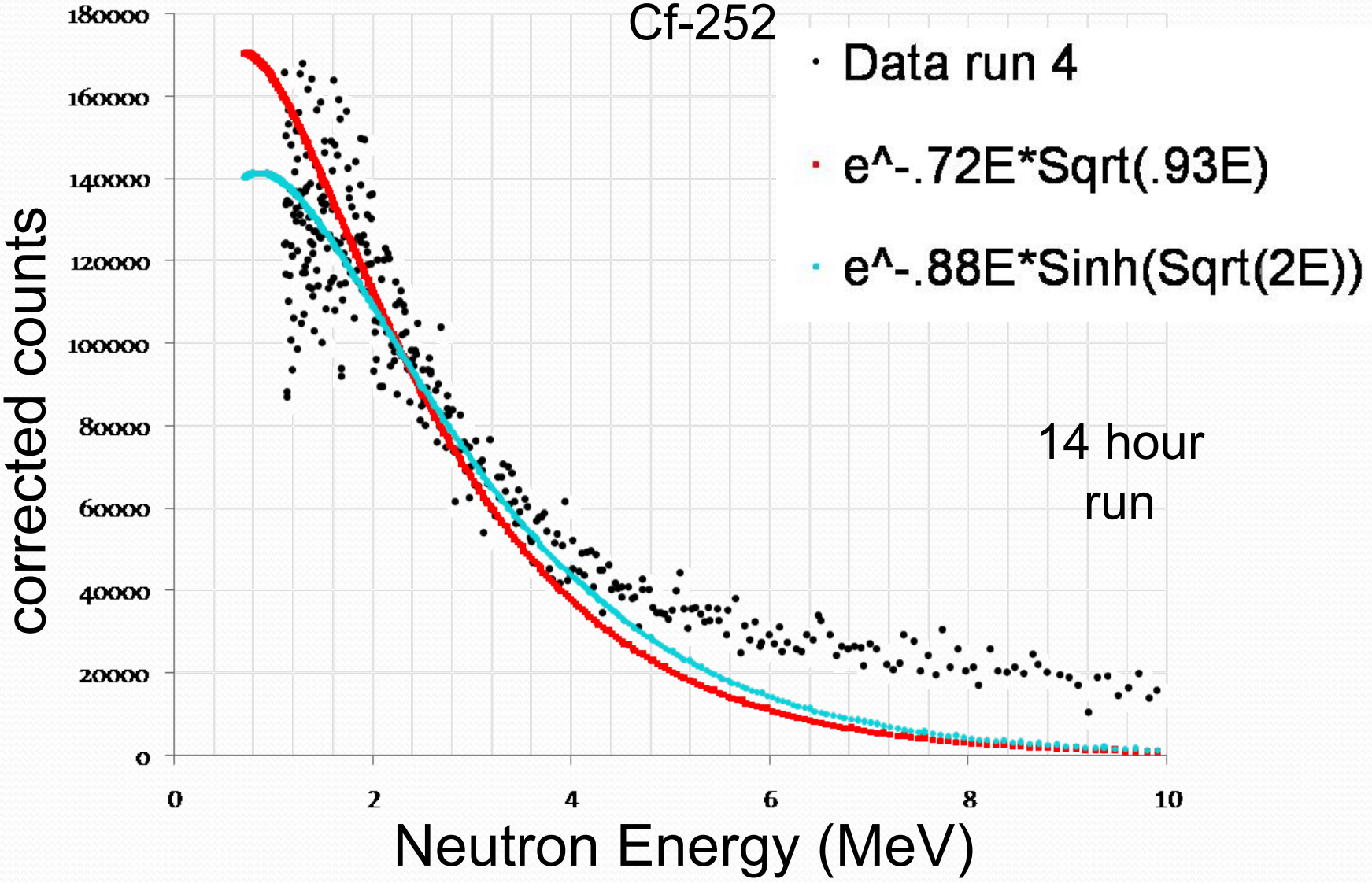
MCNP-Polimi Detector Simulation Code

- Timing Resolution of 4 ns
- Time Jitter
  - Dependent on the detector geometry
  - Trigger dependent

Detection Efficiency Calculations



Neutron Energy Spectrum Deduced

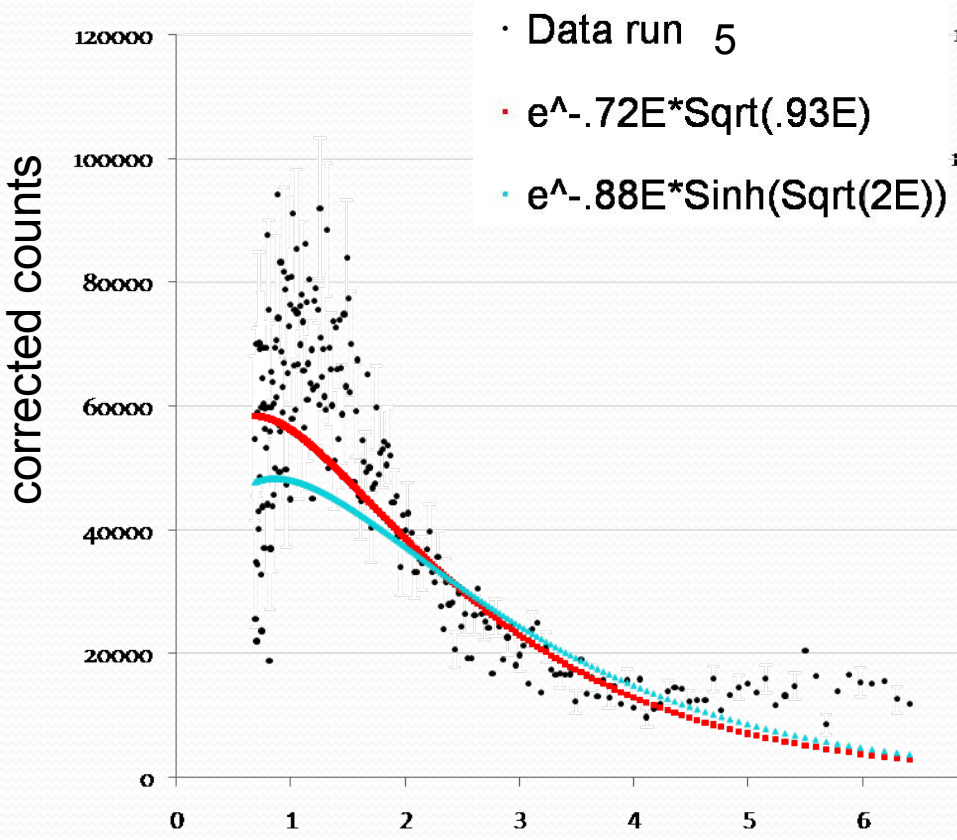


4,5,6

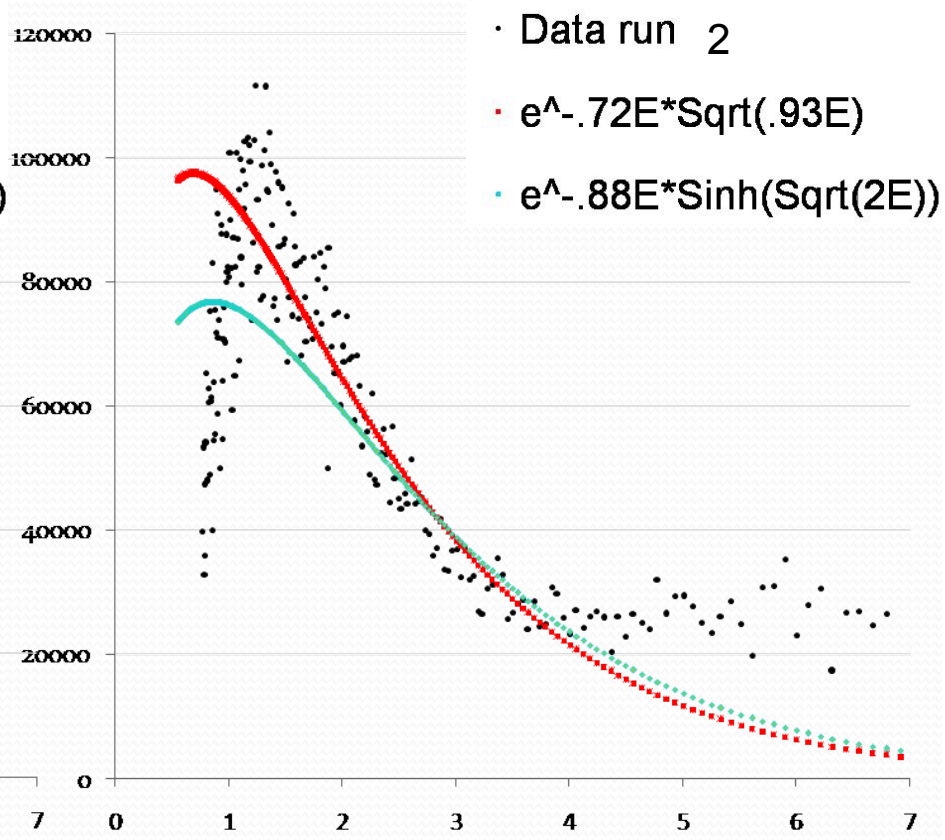
Neutron Energy Spectrum Deduced

Cf-252

Non-CFD



CFD



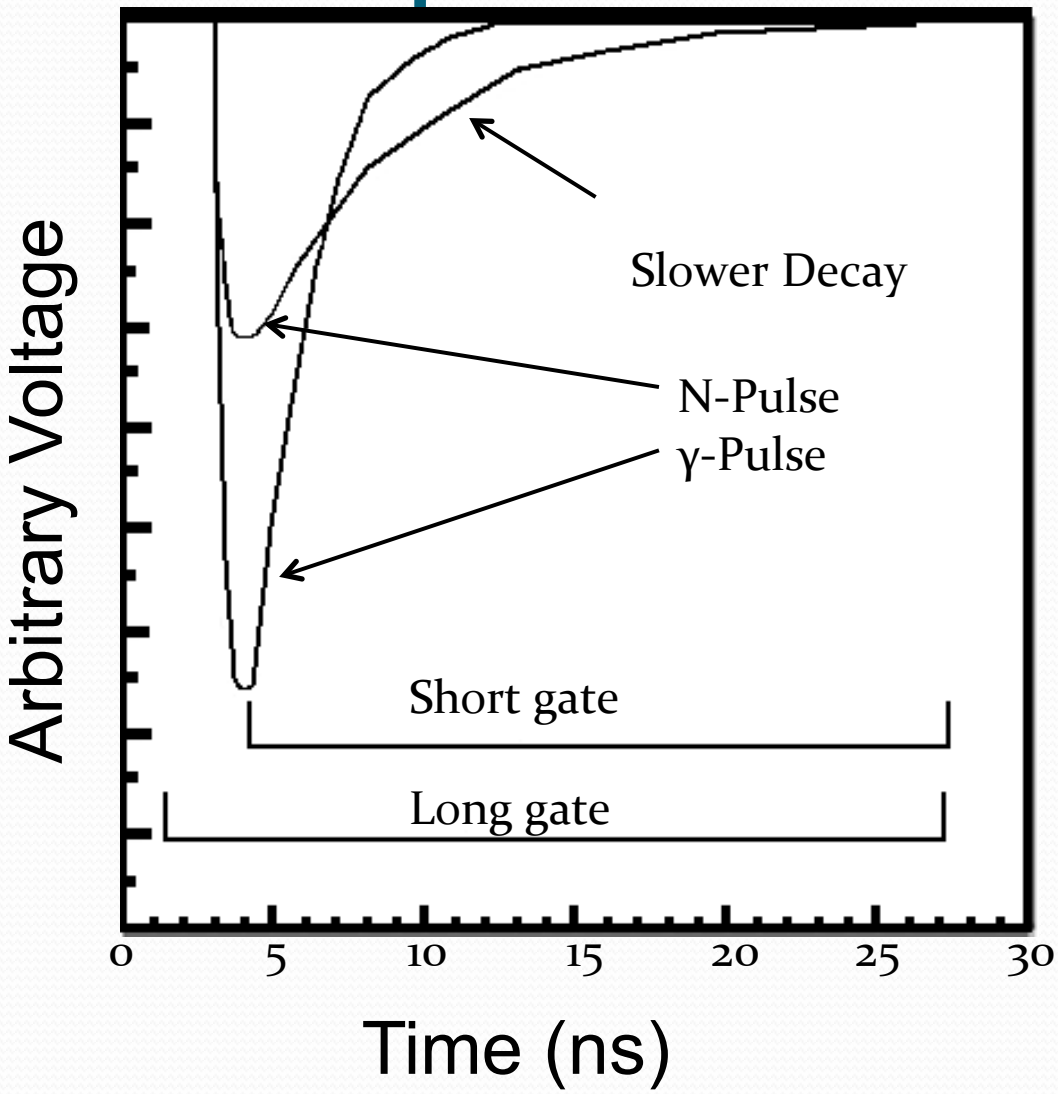
Neutron Energy (MeV)

4,5,6

Side Project

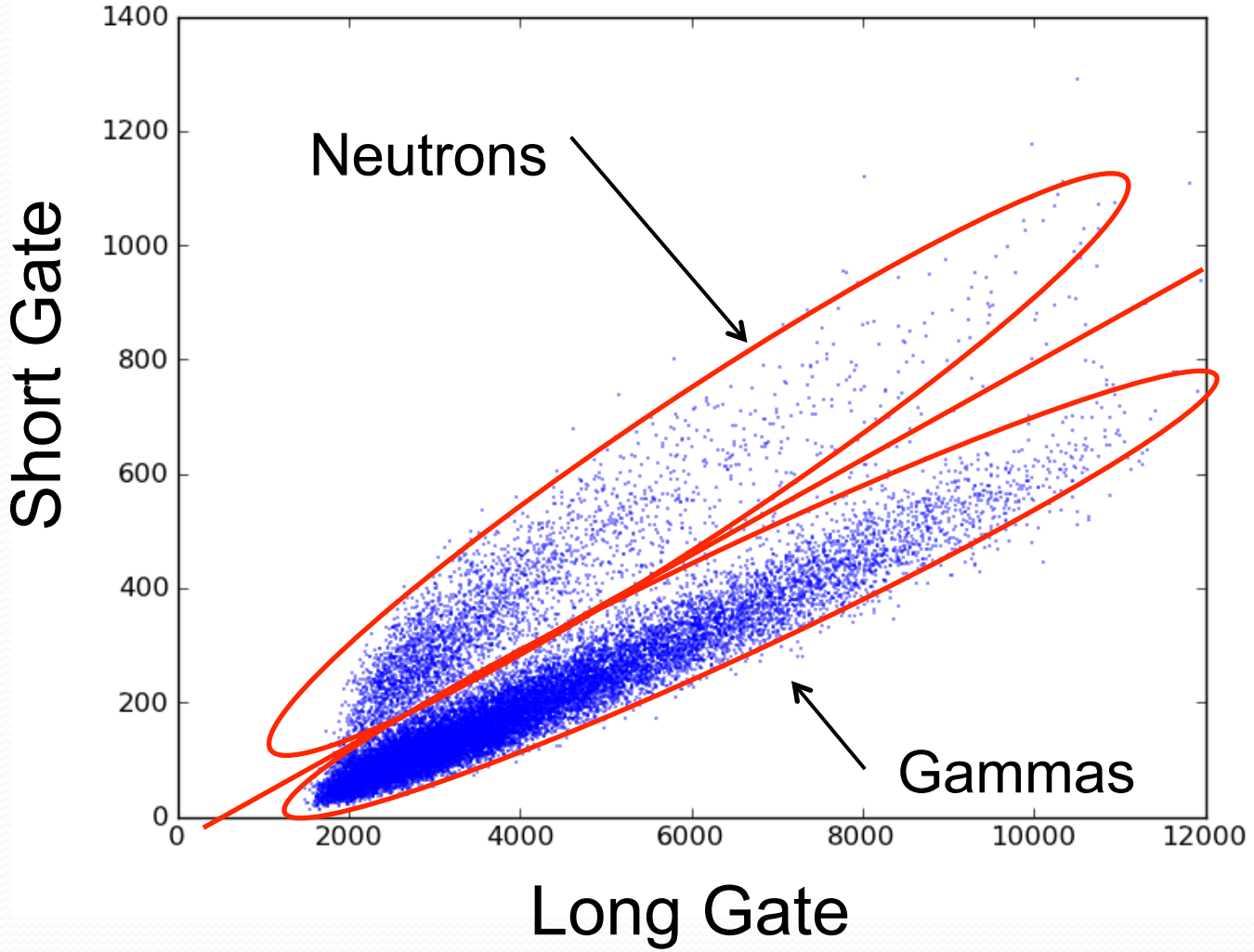
- Digitizer PSD work at the University of Notre Dame Accelerator Lab

Pulse Shape Discrimination

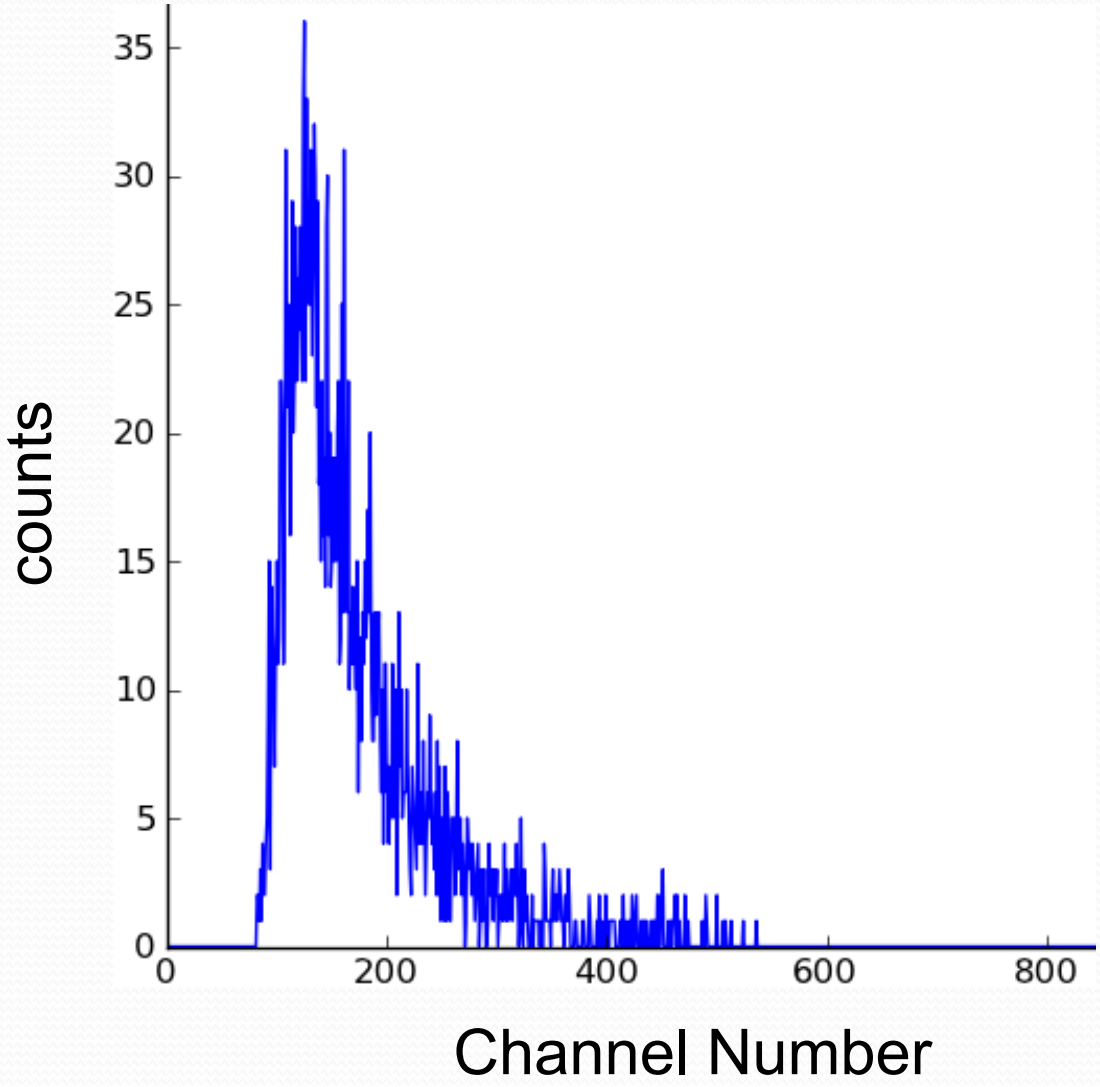


M. Ojaruega

PSD of Cf-252 using liquid scintillator



Uncalibrated Neutron Energy Spectrum



Digitizer

Pros:

- Can use 6-detector array
- Post processing flexibility
- High sample rate

Cons

- Large data files

Acknowledgements

- NSF REU program
- U of M
- Fred Becchetti
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- Ramón Torres-Isea

Works Cited

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