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Calibration of MUSE Scattered Particle Scintillators  
October 4, 2019  
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# Outline

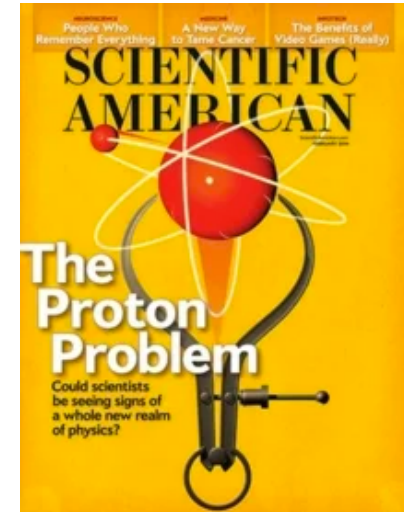
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Introduction to Muse

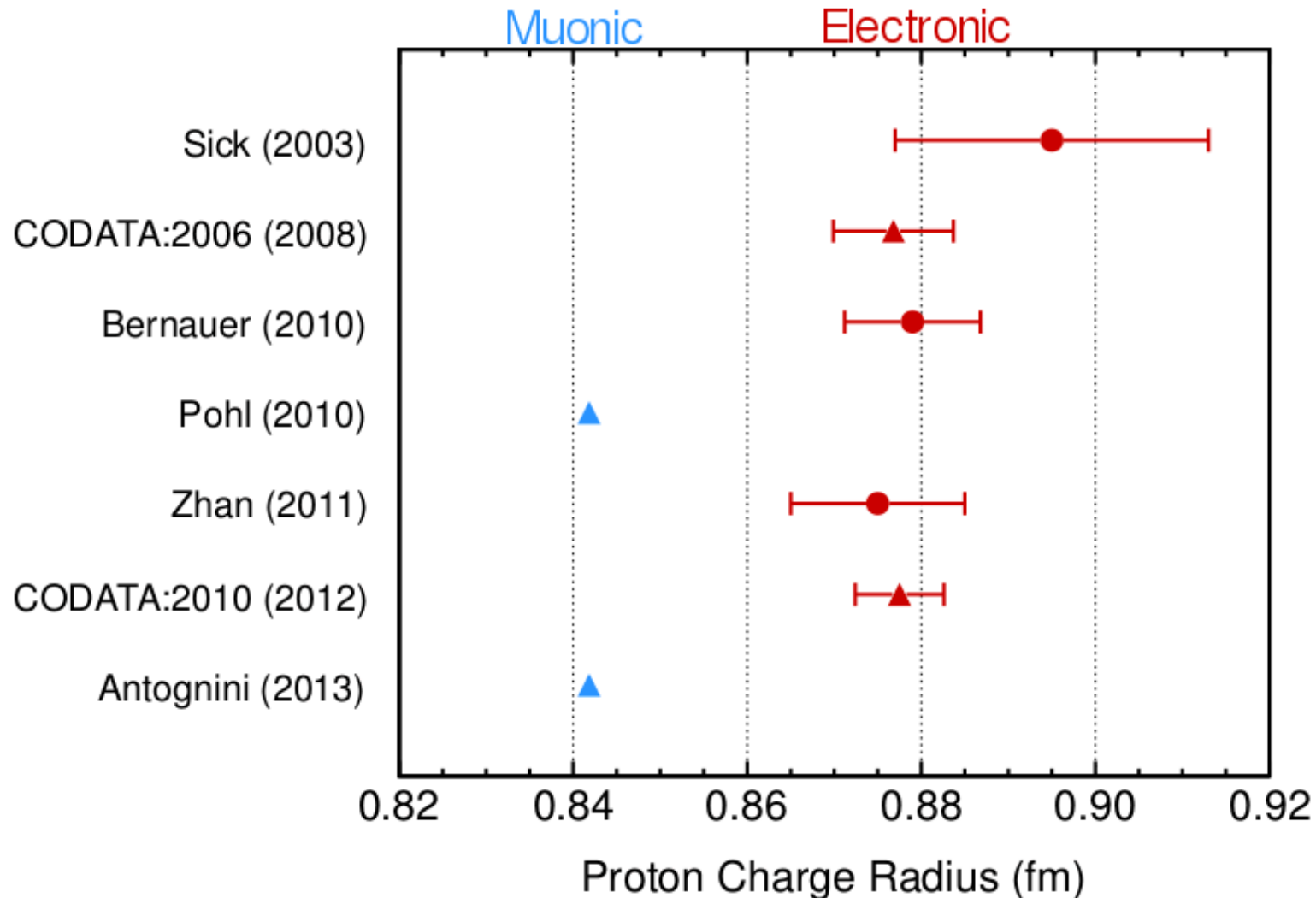
SPS Detectors Overview

Calibration of SPS

Concluding Statement



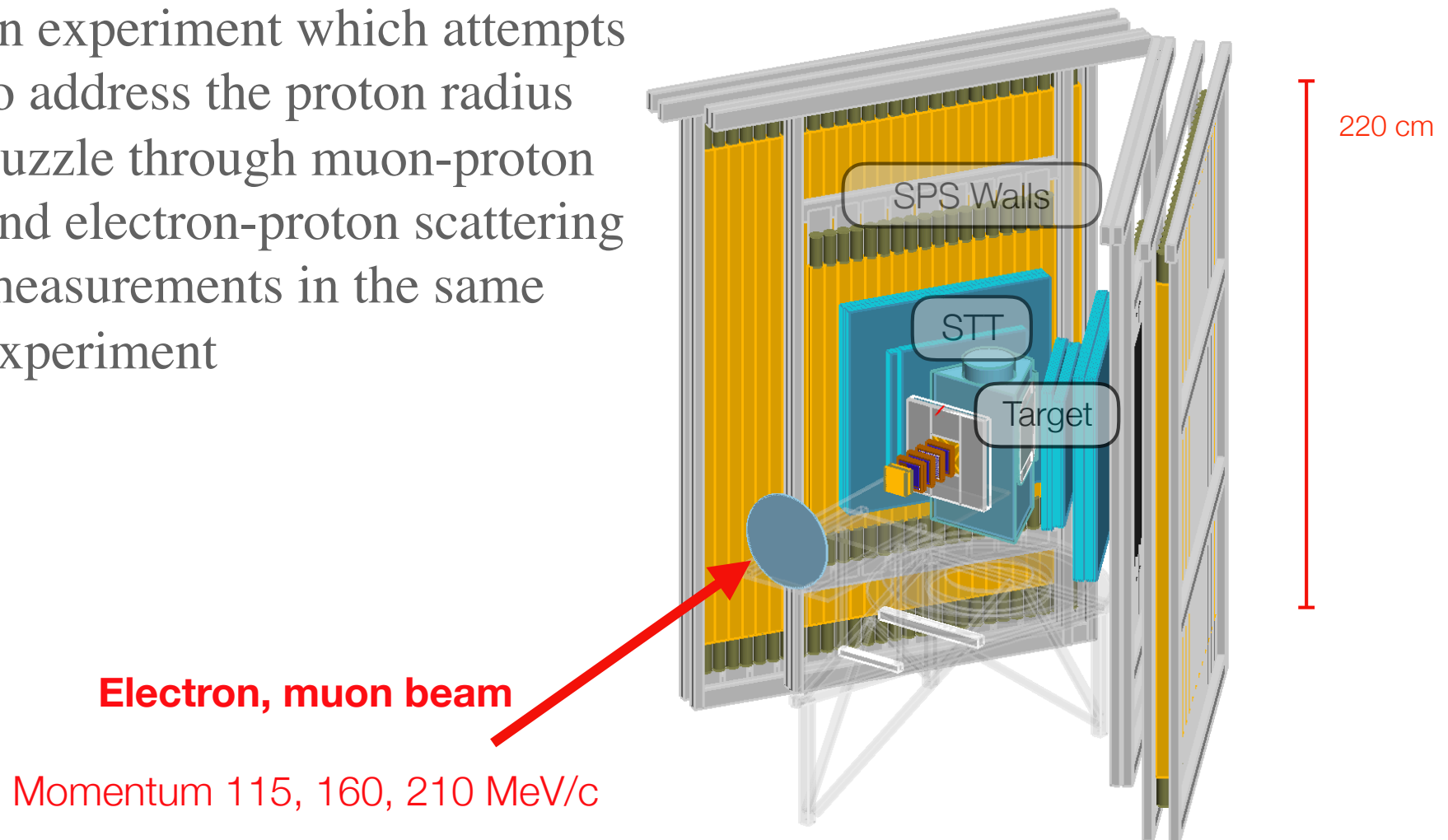
# What is the radius of the proton?



Mesick, Katherine. (2015). The MUSE Experiment: Studying the Proton Radius Puzzle with muon-proton Elastic Scattering. 091. DOI: 10.22323/1.226.0091.

## MUon Proton Scattering experiment

- an experiment which attempts to address the proton radius puzzle through muon-proton and electron-proton scattering measurements in the same experiment

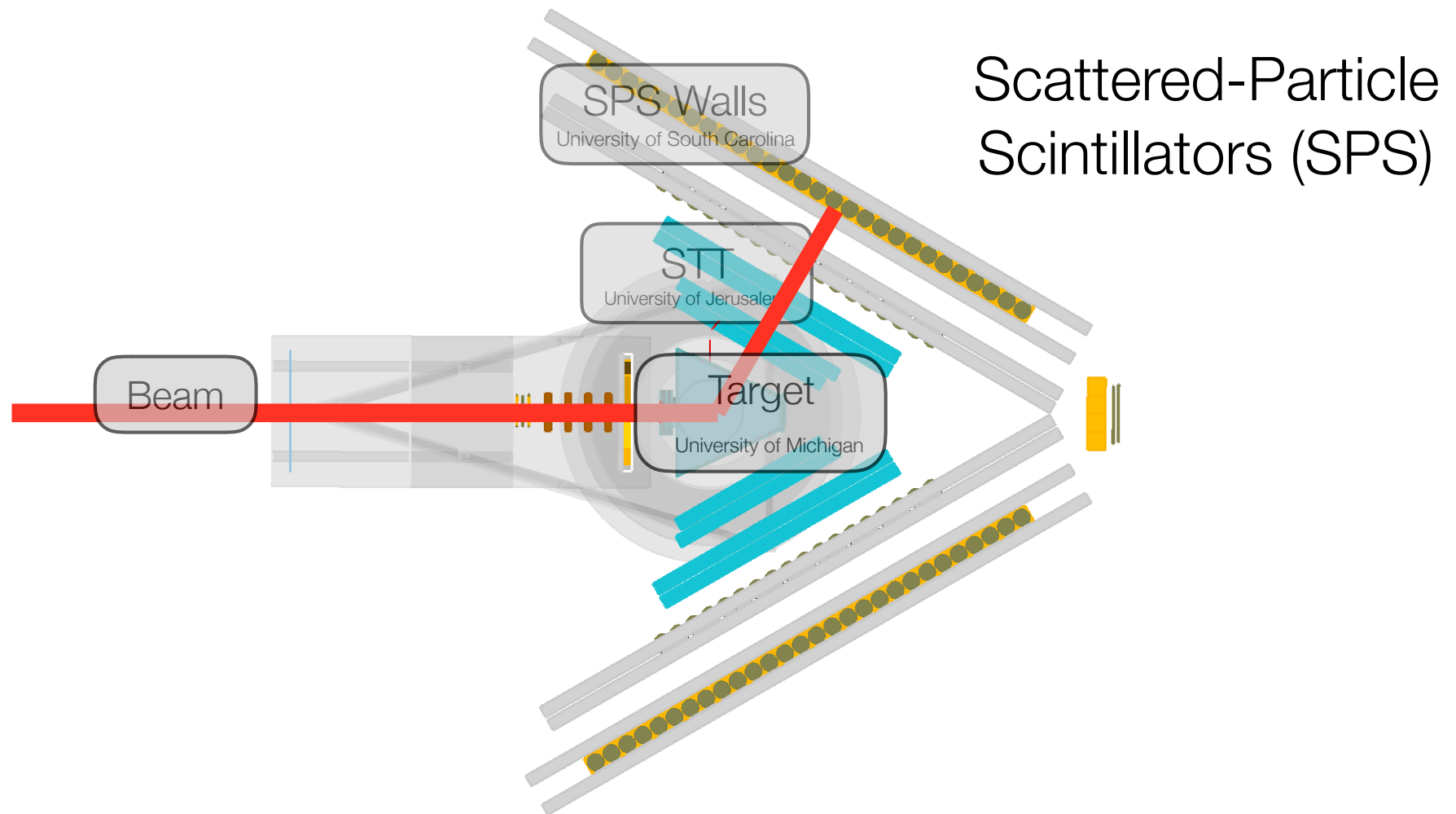


Momentum 115, 160, 210 MeV/c

Muse Setup

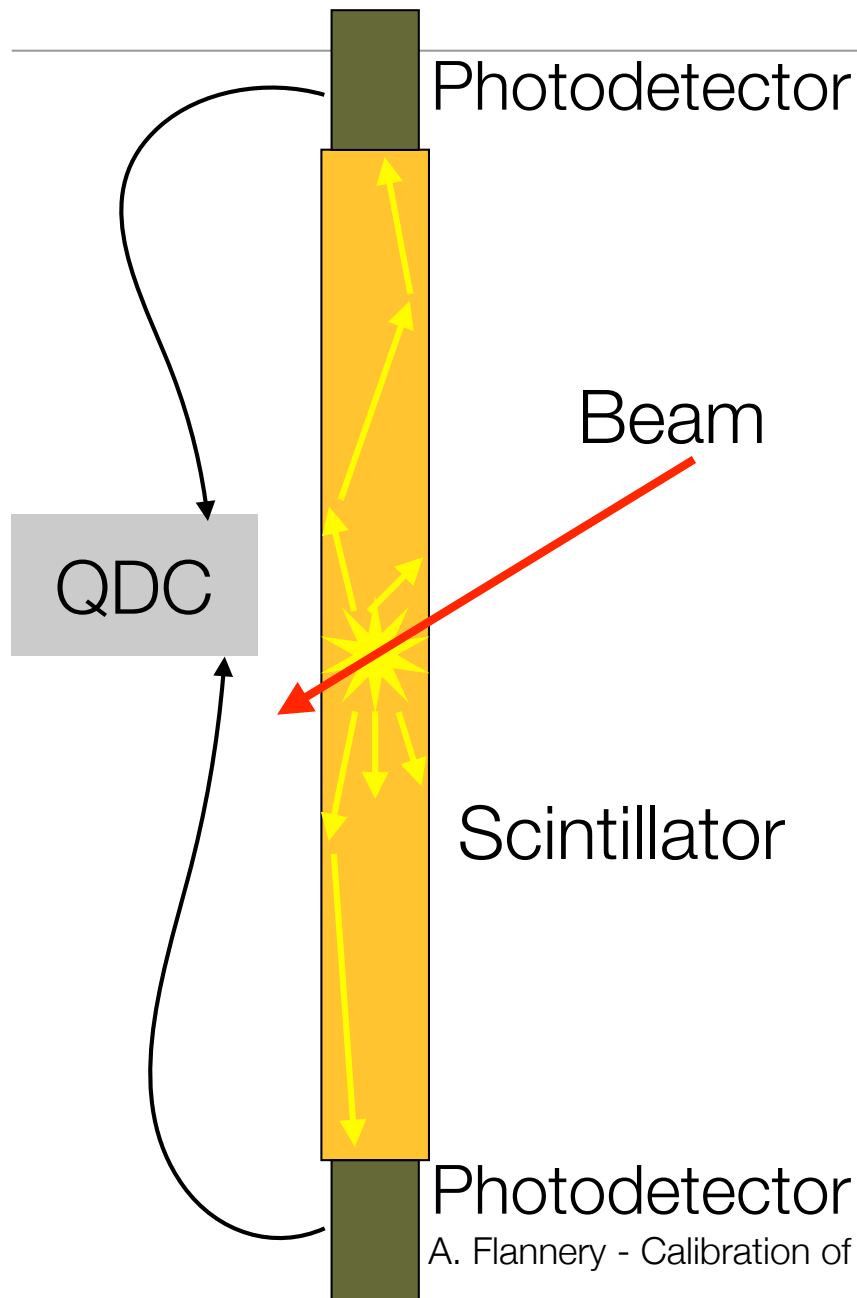
A. Flannery - Calibration of MUSE scattered-particle scintillators

## Path of the scattered particle



The SPS bars are fast timing detectors for the experiment

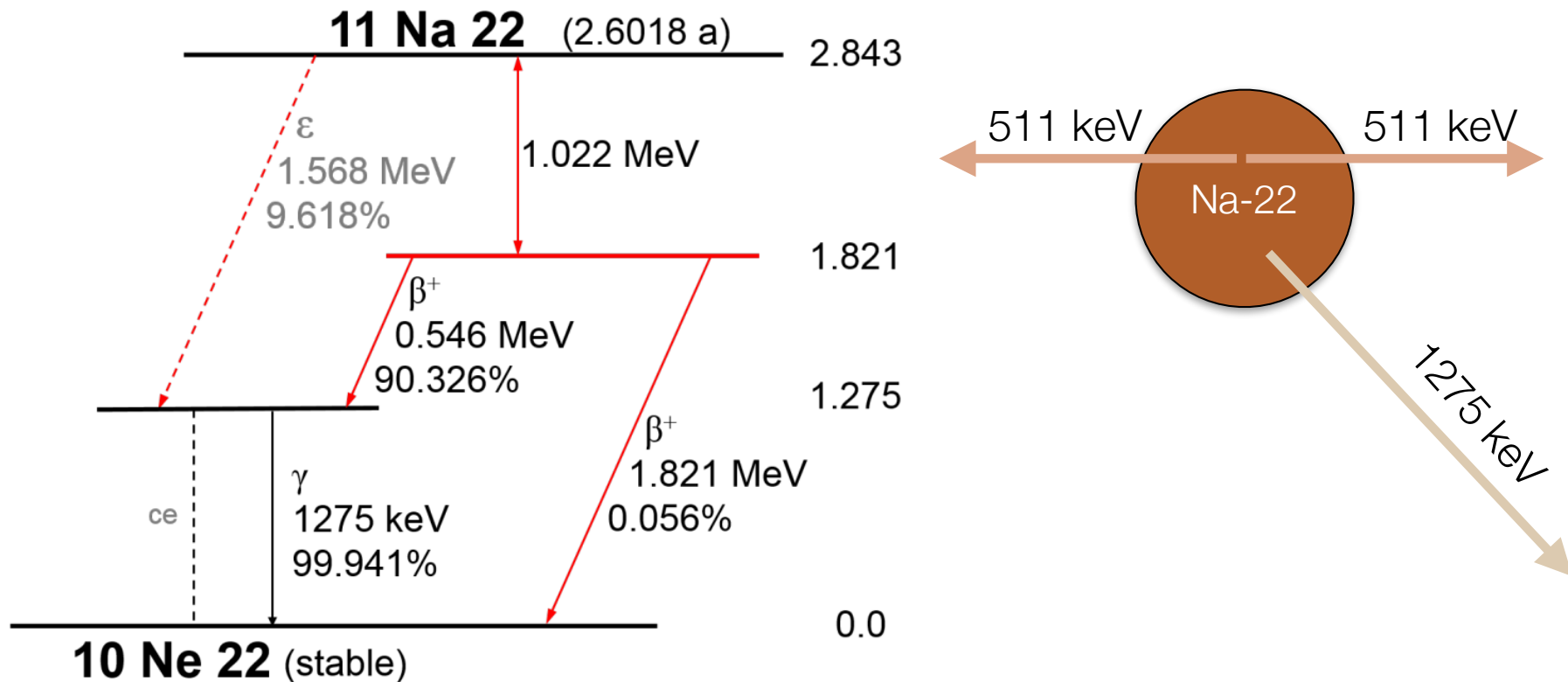
## How does a scintillator work?



- A charged particle passing through the bar deposits a certain amount of energy (minimum  $2 \text{ MeVg}^{-1}\text{cm}^2$ ), causing photon emission.
- A photodetector receives a signal whose strength is determined by the amount of energy deposited.
- The photodetector sends this signal to a charge to digital converter (QDC).

## Where does the signal go, and what does it mean?

- A Na-22 source is used instead of the beam in order to calibrate SPS bars.

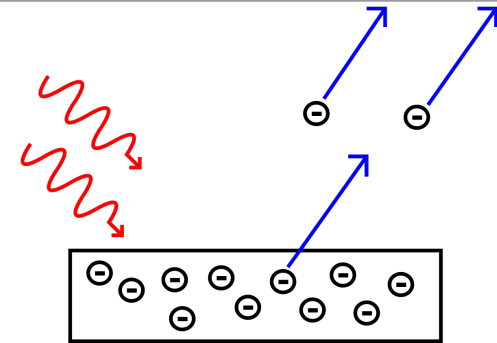


Na-22 Decay scheme

## Three kinds of light-matter interaction

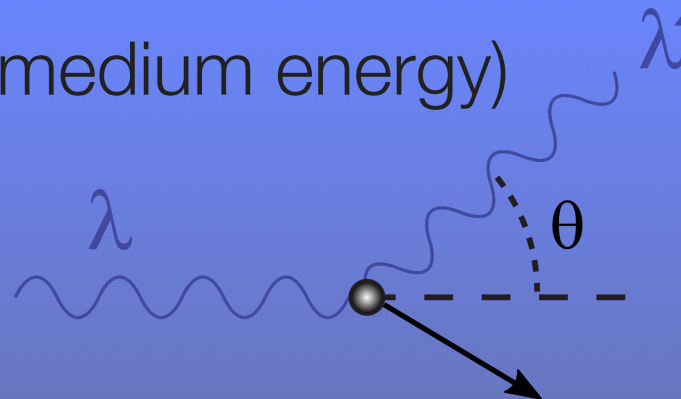
- Photoelectric effect (lowest energy)

*Unlikely*



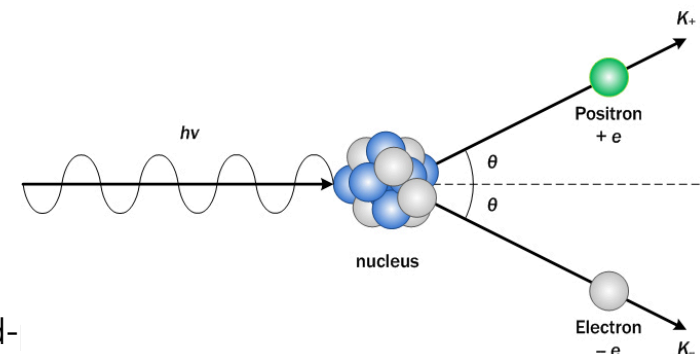
- Compton scattering (medium energy)

*We use Compton scattering for the calibration method discussed here*



- Pair-production (highest energy)

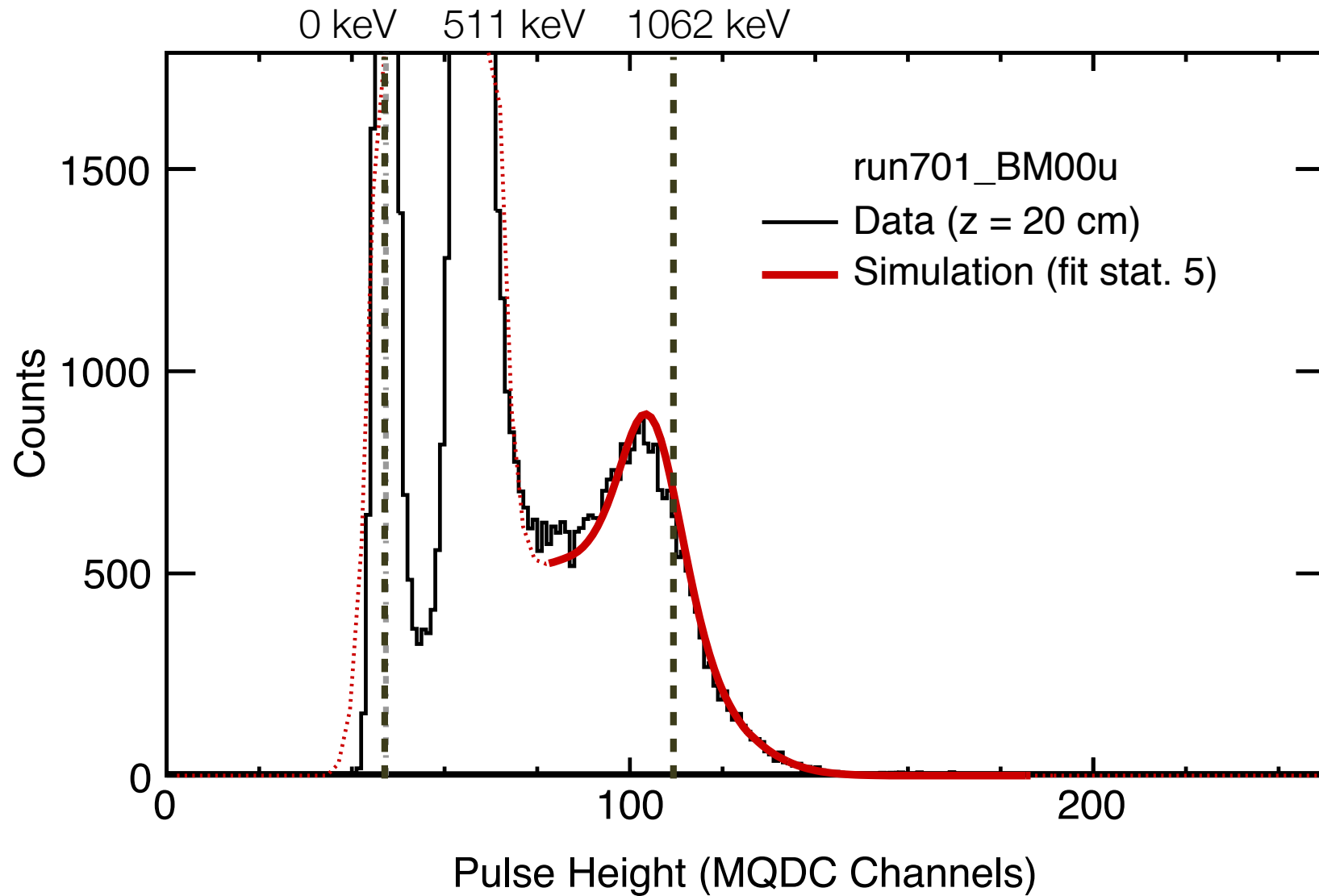
*Unlikely for 1275 KeV, and impossible for 511 KeV*



<http://electrons.wikidot.com/pair-production-and-annihilation>

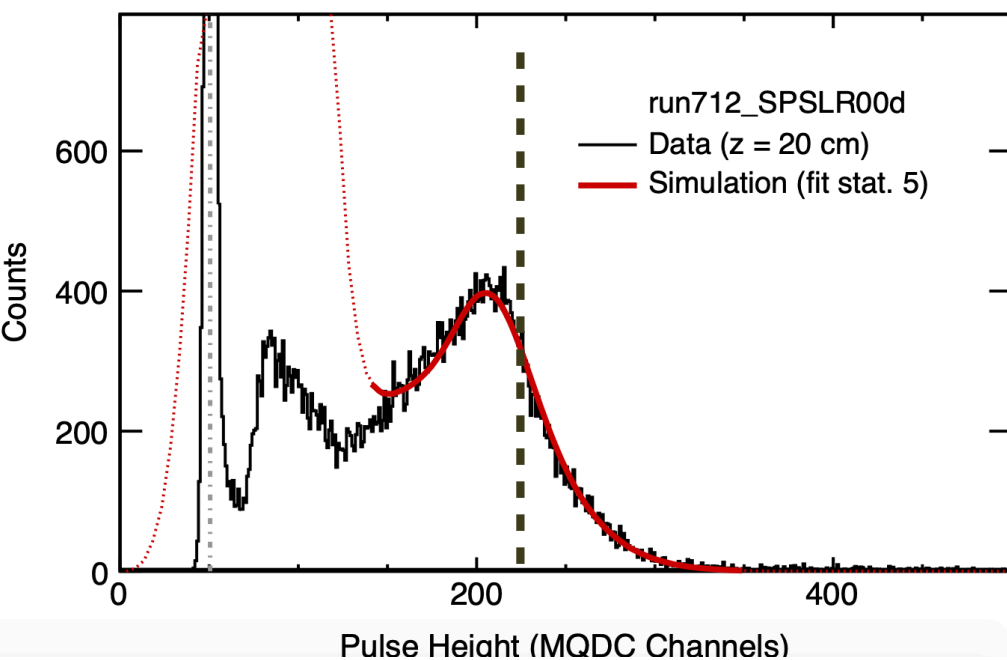


## Example Na-22 QDC Distribution

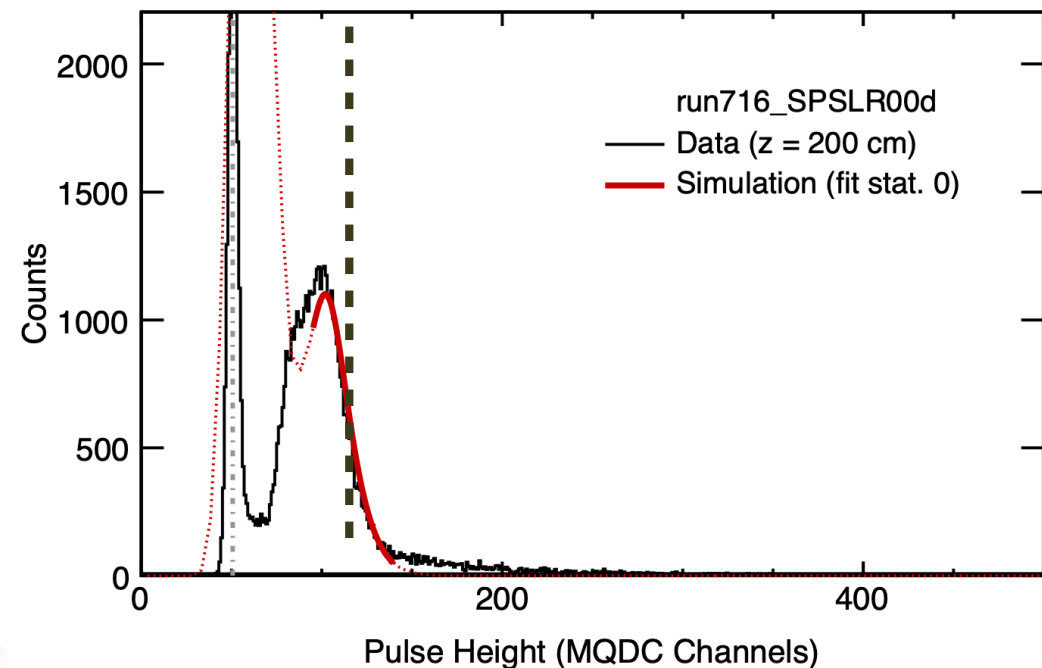


## Na-22 Calibration for the SPS Bars

- A Na-22 source was placed at varying heights along the bar, in 20cm increments. Since the PMTs were on both the top and bottom of the bar, signal strength lowered as Na-22 source became further from either the up or the down PMT.



Closer Na-22 source



Further Na-22 Source

## Concluding Statement

- Future calibration methods will include room background source, especially focusing on the Compton edge for Thallium 208, which is ever-present for all bars. The following graph shows a QDC histogram which is already pedestal subtracted.

