Calibration Strategies for a Spherical Gas Detector

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CAP Congress 2017
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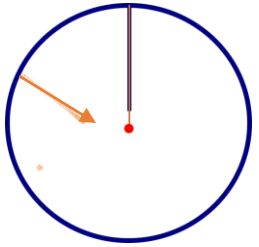
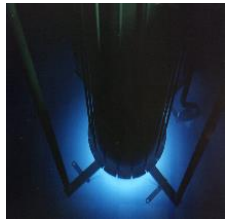
Overview

- Introduction to NEWS-G

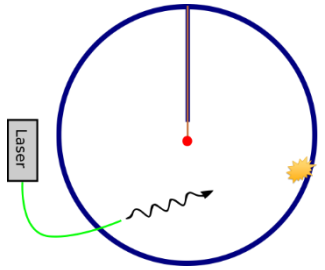
- Alpha particle calibration



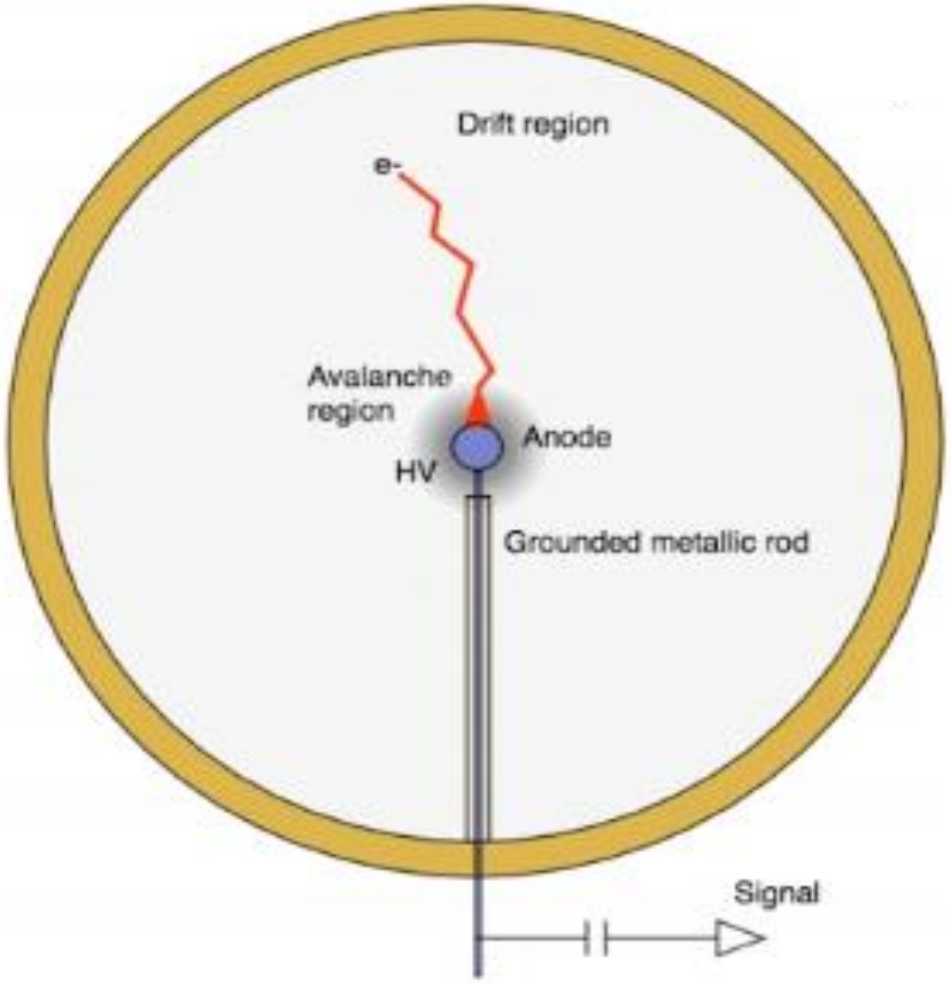
- Argon-37 calibration



- UV laser calibration

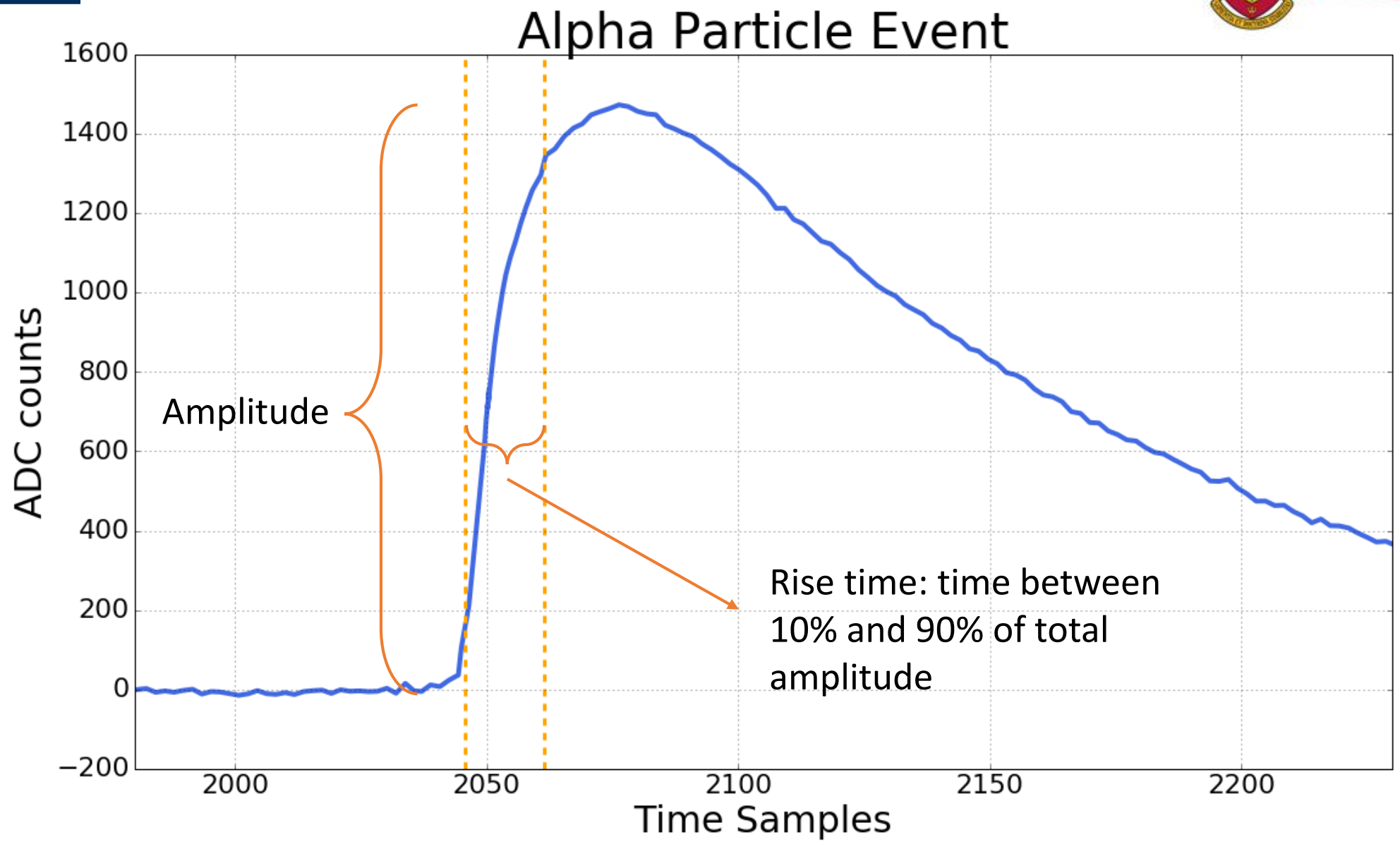


NEWS-G

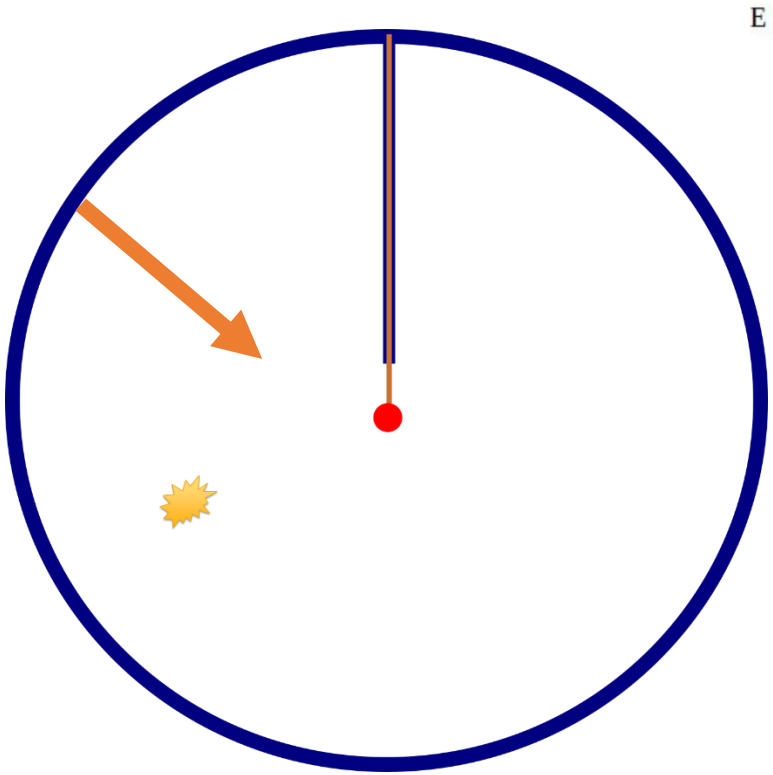


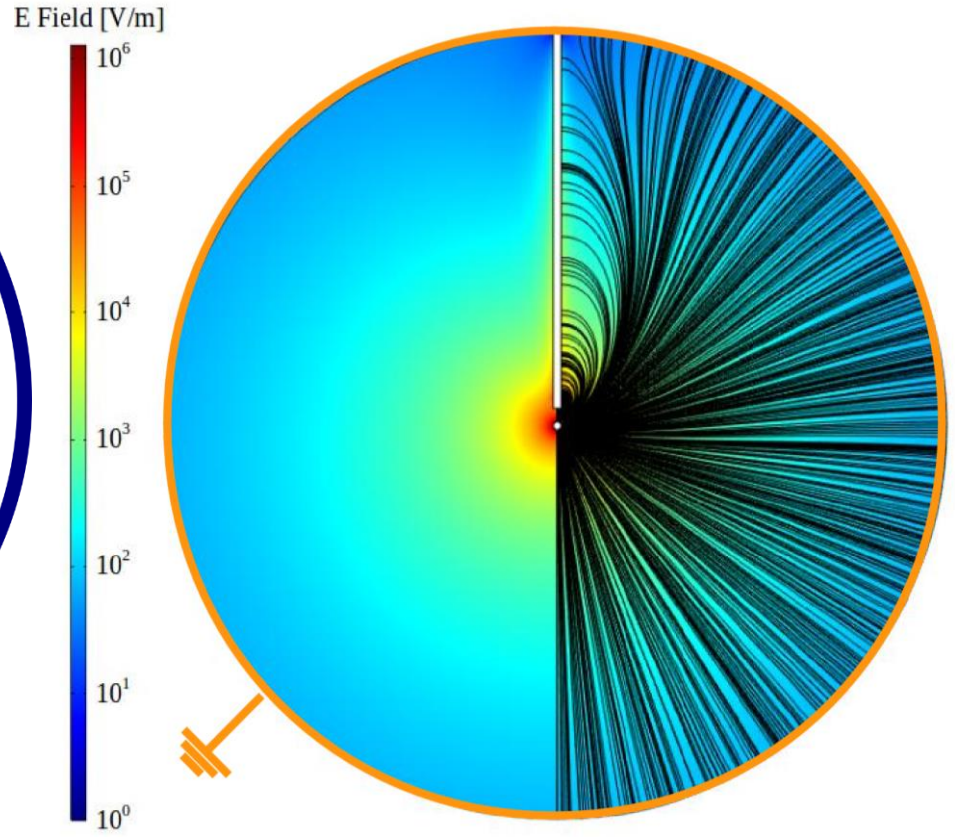
$$E = \frac{V_0 \rho}{r^2}, \qquad \frac{1}{\rho} = \frac{1}{r_{min}} - \frac{1}{r_{max}}$$

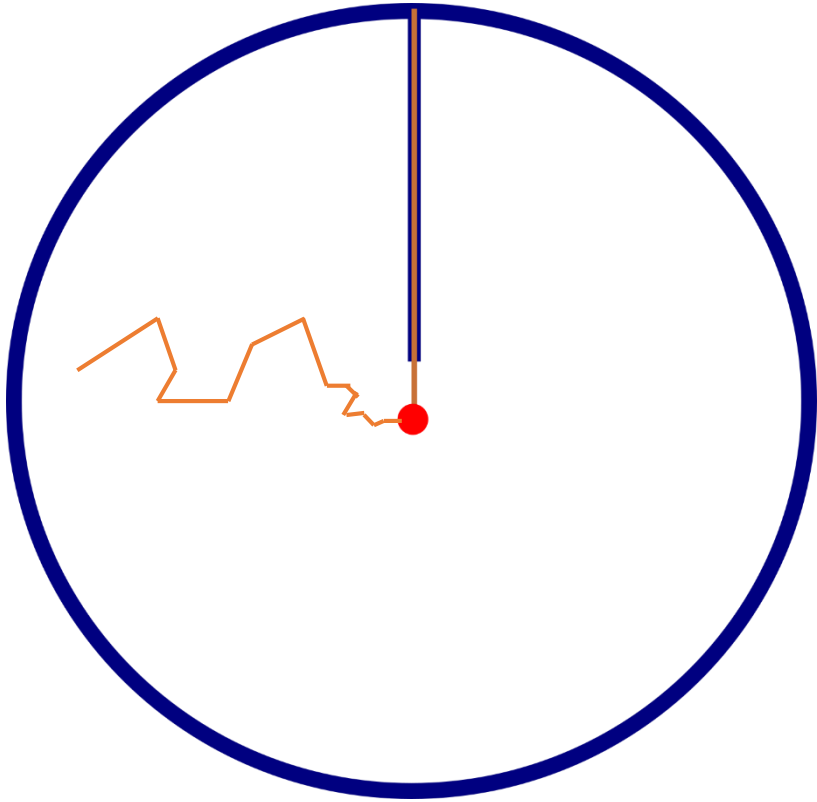
- Spherical gas-filled proportional chamber to search for WIMPs
- Looking for low-mass WIMPs
- Data is current pulse from electrode


Alpha Particle Event
ADC counts
Time Samples
Amplitude
Rise time: time between 10% and 90% of total amplitude
1600
1400
1200
1000
800
600
400
200
0
−200
2000
2050
2100
2150
2200

Lots of properties to understand!







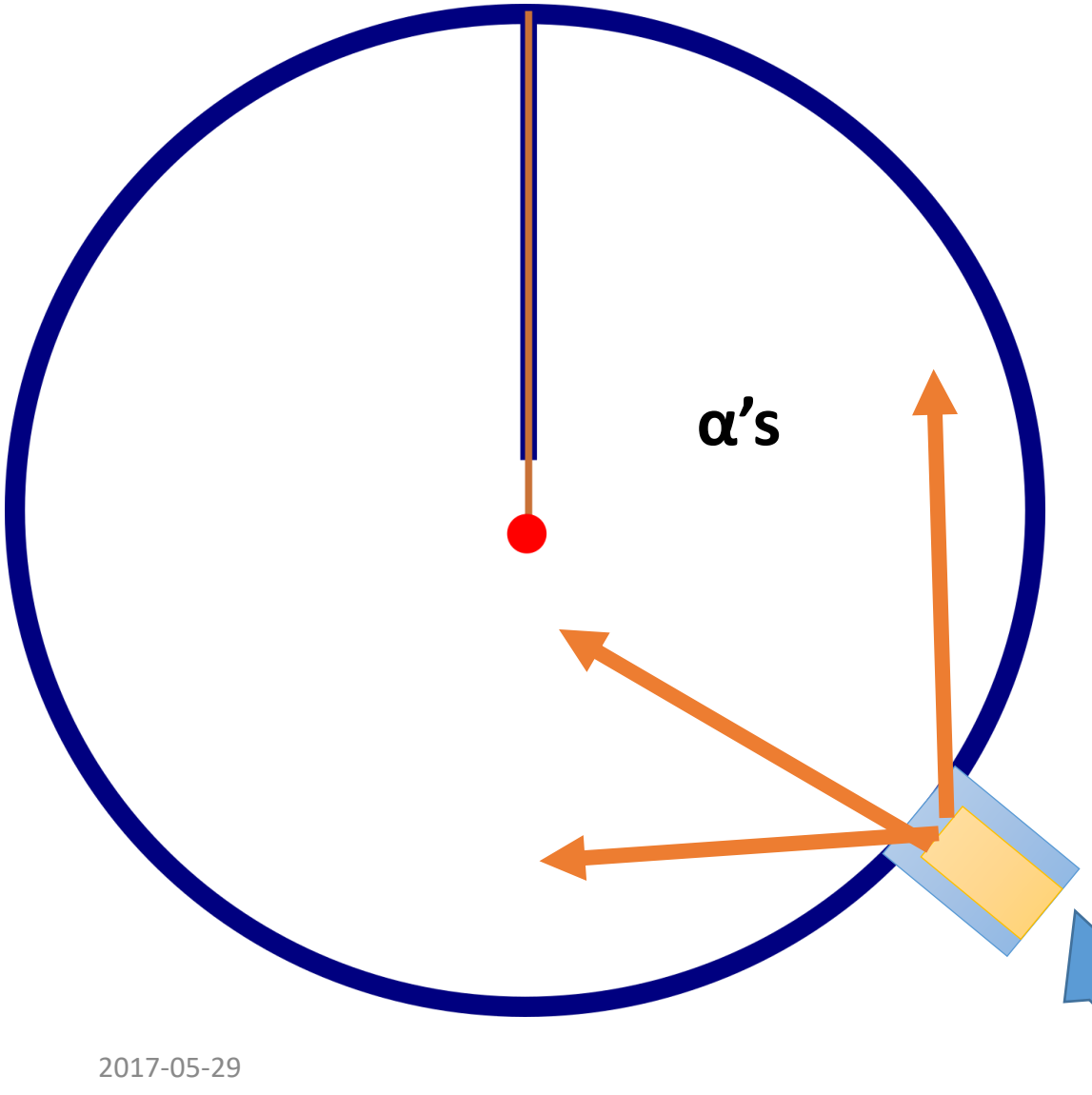
Q Arnaud

NEWS-G

- Energy calibration:
  - Ar37 gives 2 lines at 2.8 KeV and 0.27 KeV (important for linearity), volume calibration
- Drift time/diffusion calibration:
  - Can be done indirectly with alpha calibration (involves both drift times and diffusion)
  - Will be done with UV laser, moderate attenuation
  - AmBe fast neutron source allows for measurement of diffusion (risetime) vs energy for volume nuclear recoils events (WIMP-like events)
  - ^{22}Na allows for measurement of diffusion (risetime) vs energy for electron recoil events
- Stability of gain with time:
  - UV Laser with low attenuation, monitoring with photodiodes
- Calibration of single electron response (study of avalanche process):
  - UV Laser with high attenuation
- Response of nuclear recoils vs electron recoils/ "quenching factor":
  - Dedicated installation with electron and ion beam with COMIMAC at Grenoble (see talk by Philippe Di Stefano on Thursday)
  - Nuclear recoil measurement from neutron capture reactions on Hydrogen, Argon, Neon

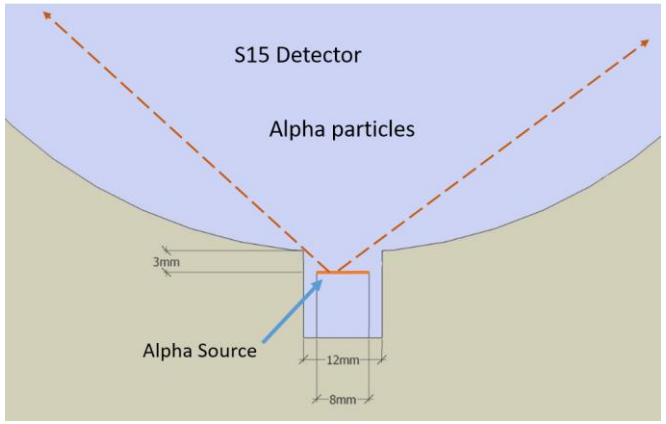
Alpha Particle Calibration

Alpha Particle Calibration

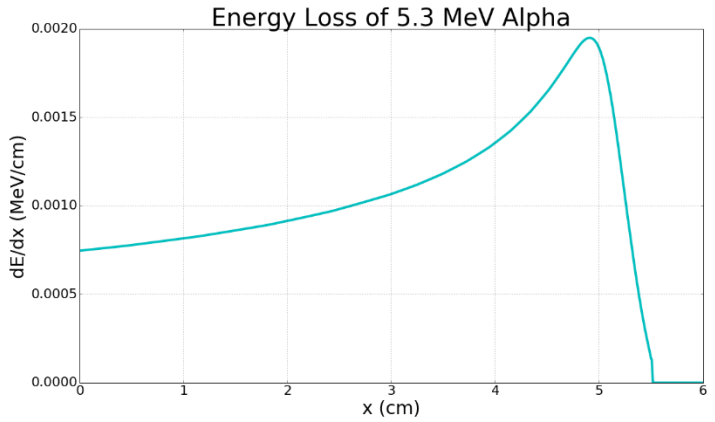


- Alpha particle simulation compared to calibration data to help understand track events
- Homemade ^{210}Po alpha source (Maurice Chapellier)

Alpha Particle Calibration



+



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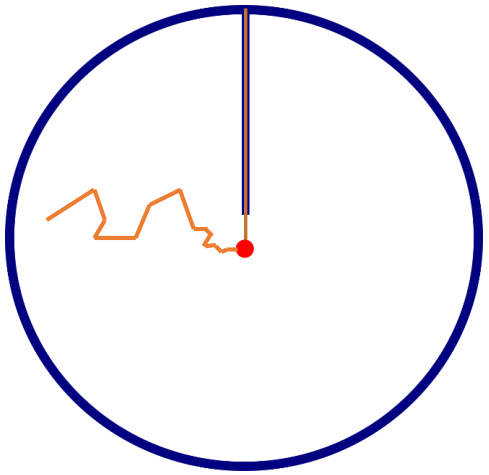
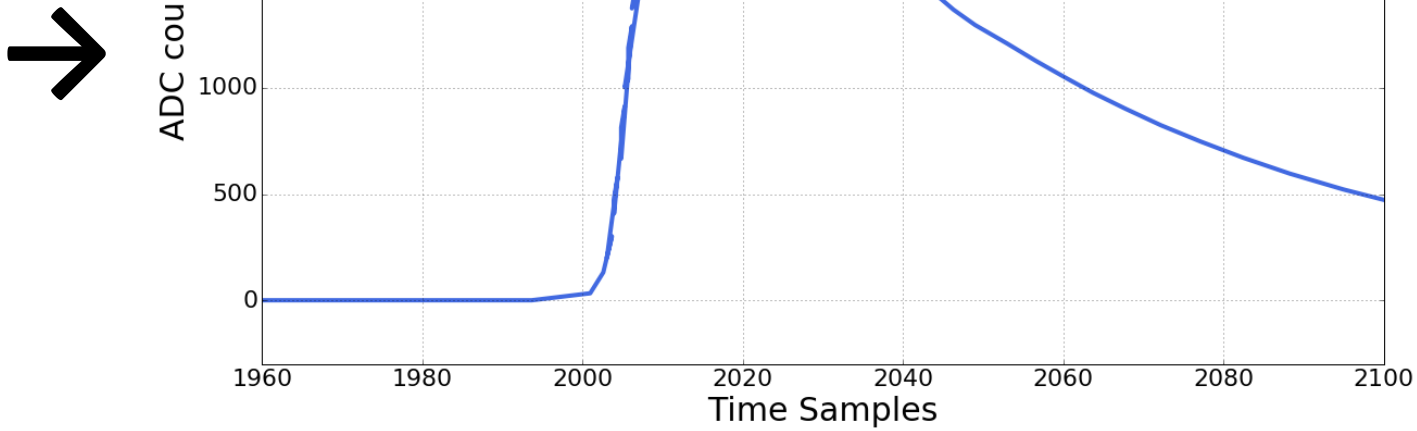
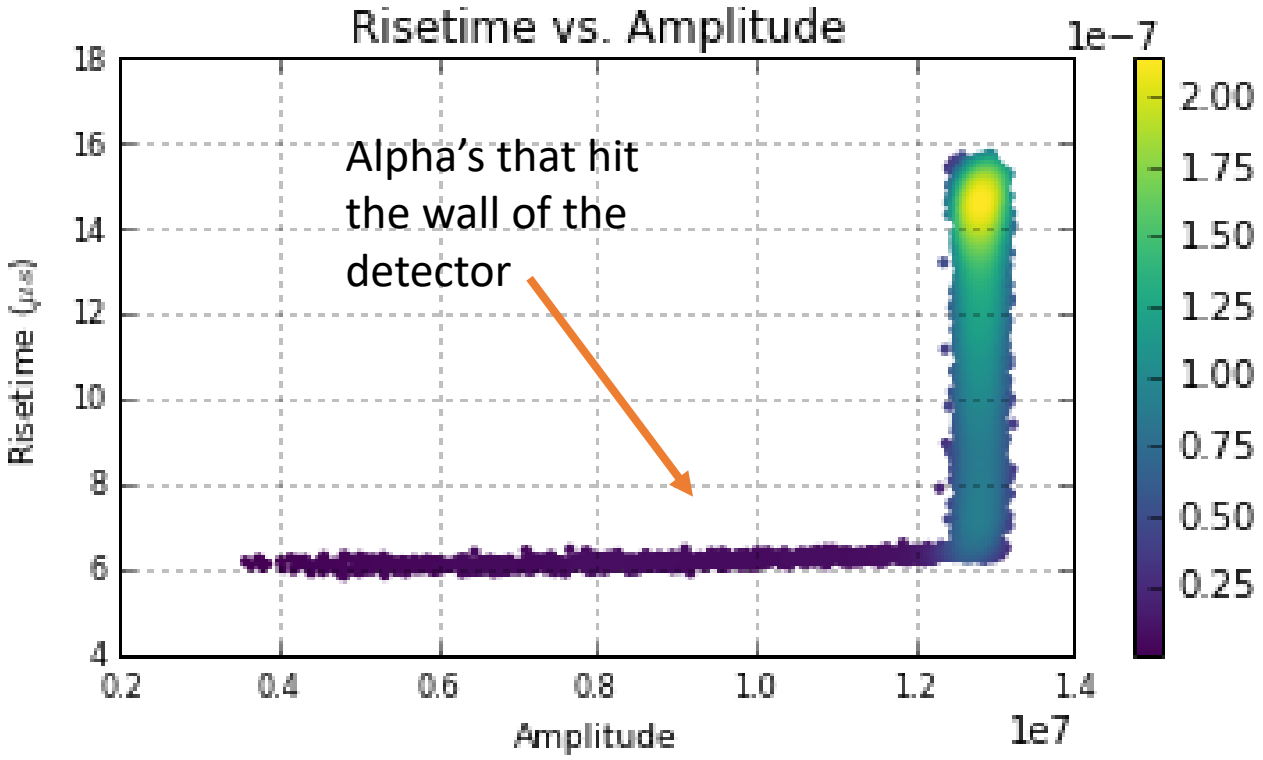
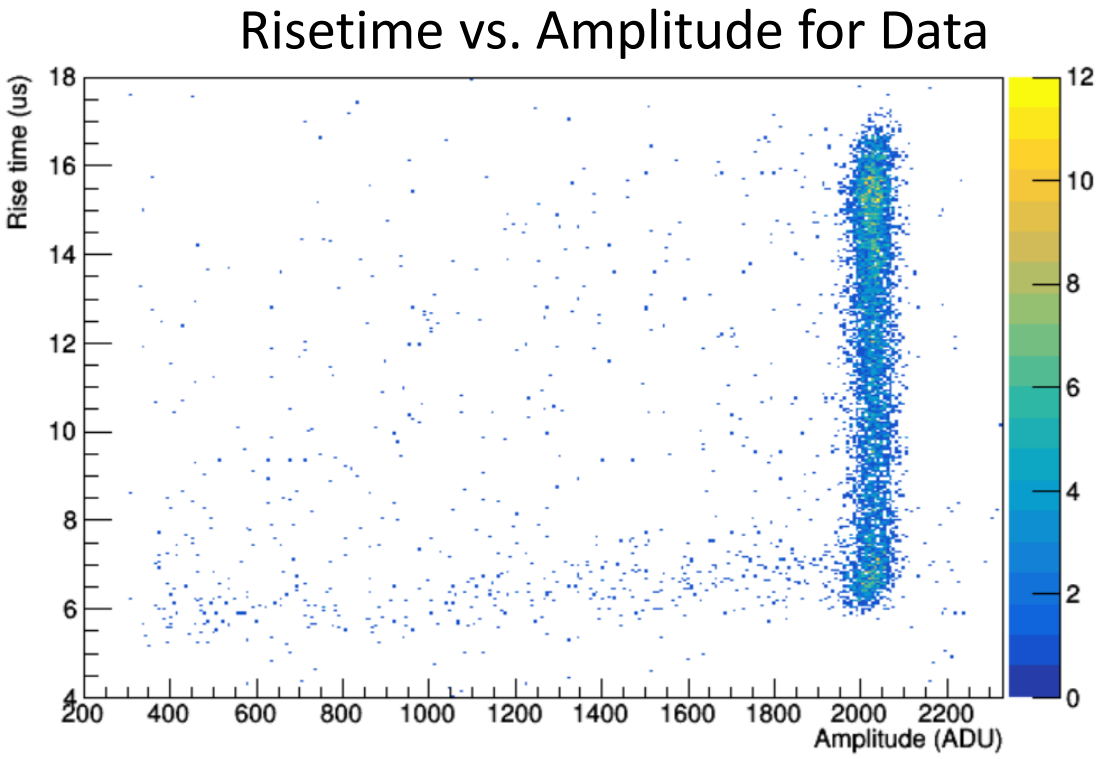




Alpha Particle Calibration

- Good agreement between Monte Carlo and data!





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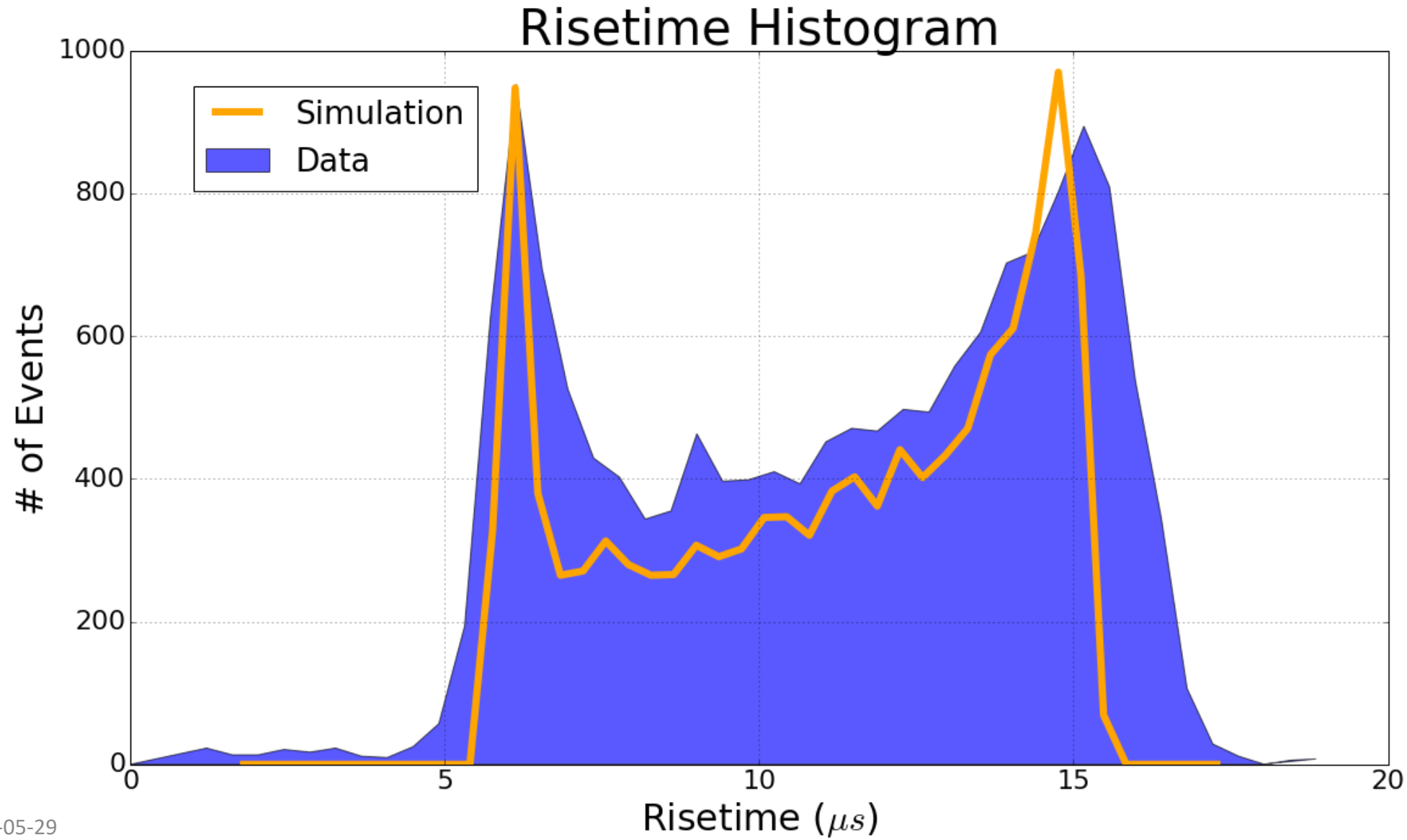
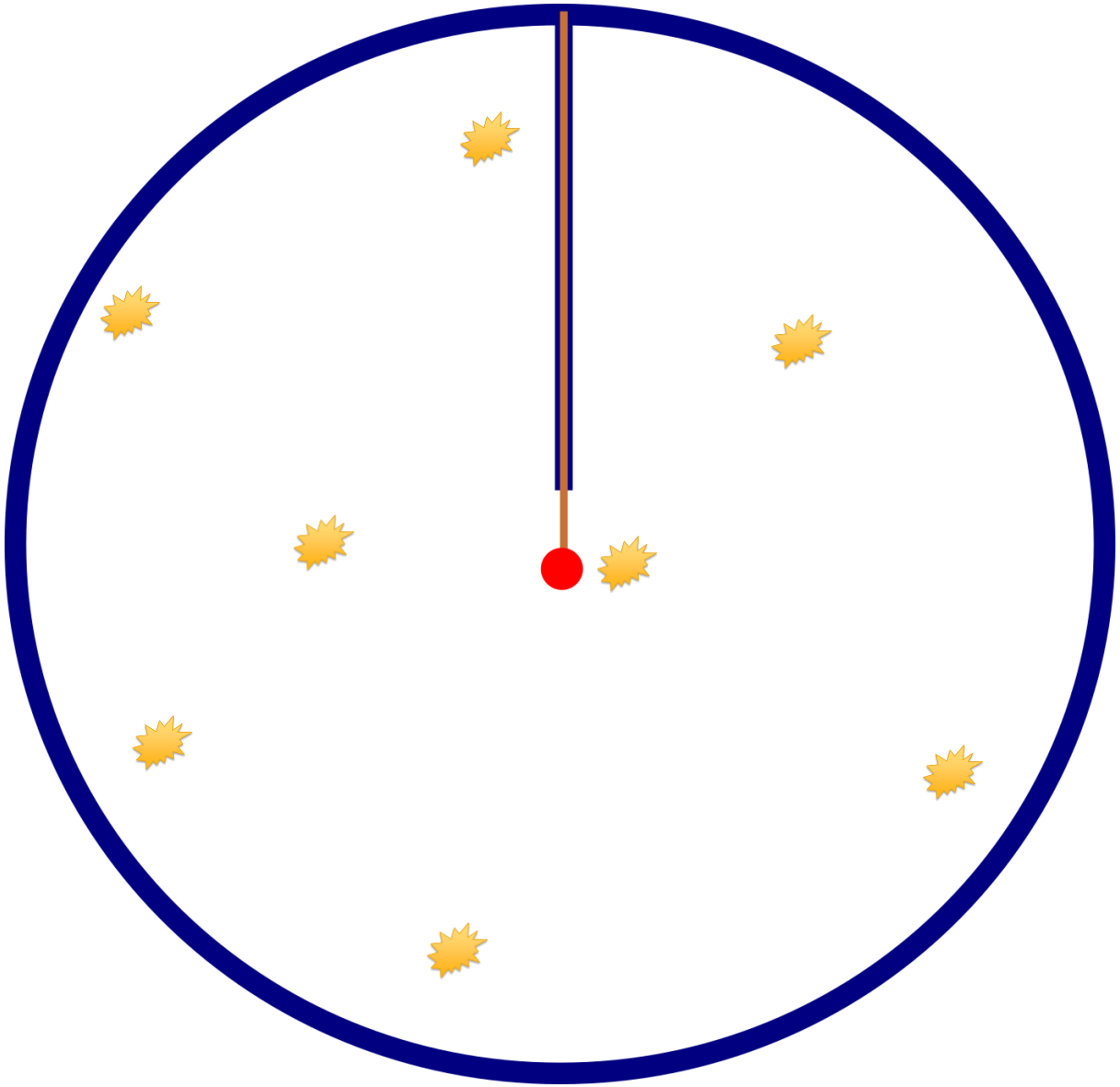


^{37}Ar Calibration

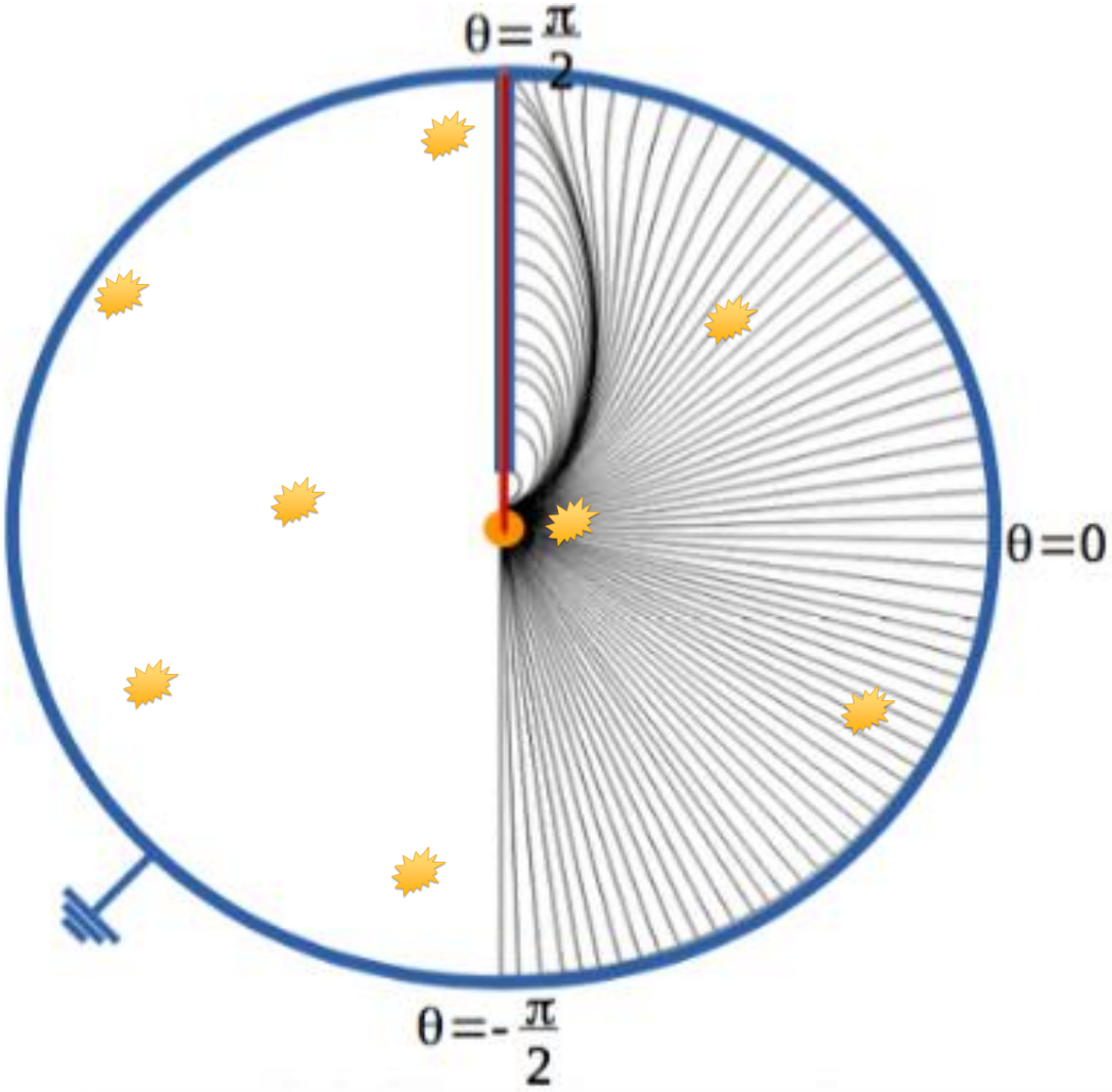
Argon-37



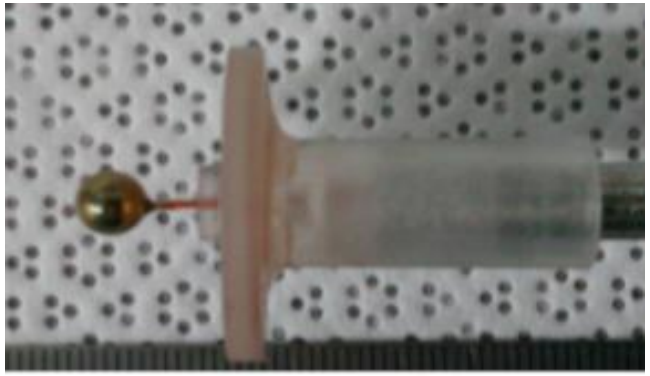
^{37}Ar:

- 2.8 KeV , 270eV x-rays
- 35 day half-life
- Volume events, activity can be varied

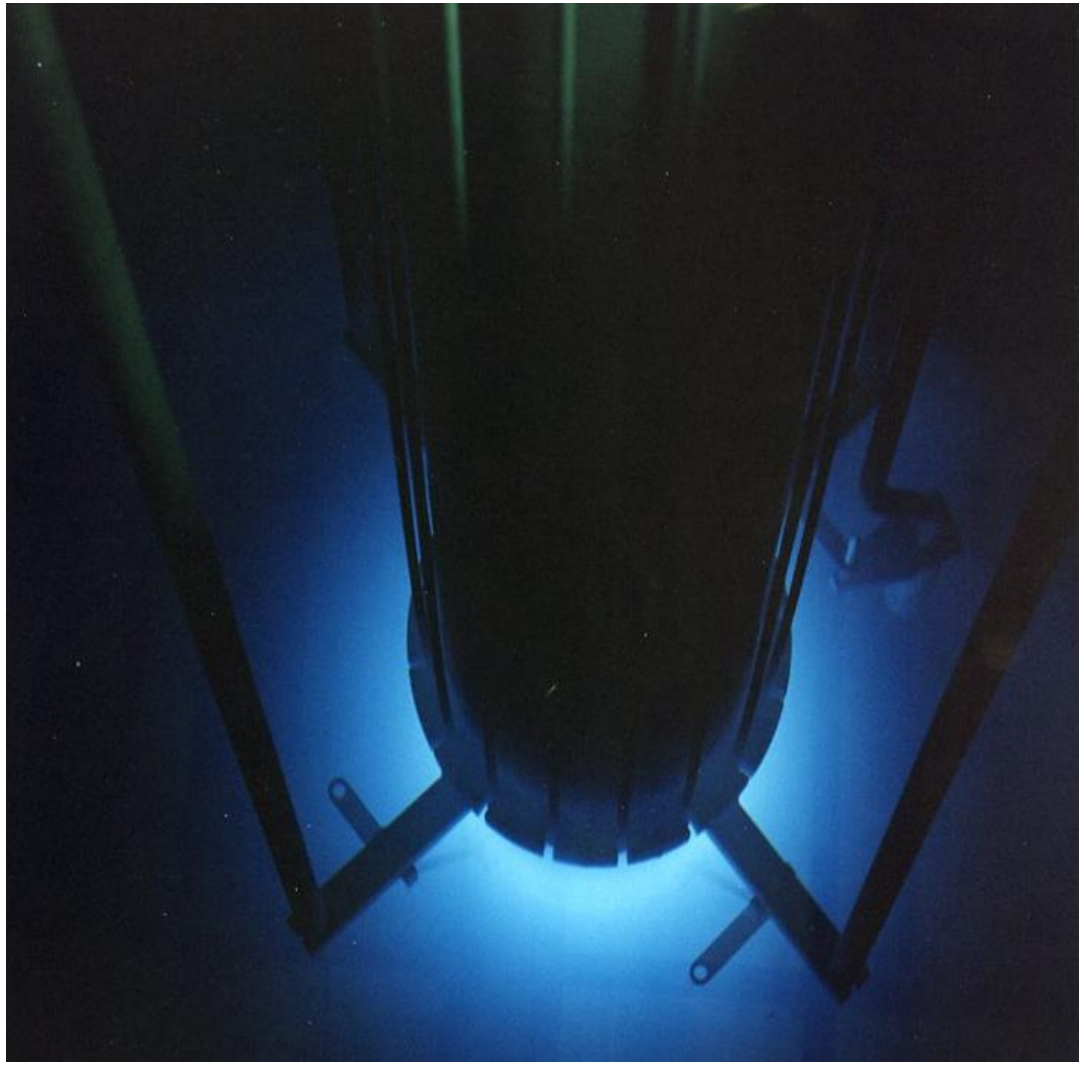
Argon-37



- Volume calibration sensitive to field inhomogeneity
- Testing of different sensors to correct field shape

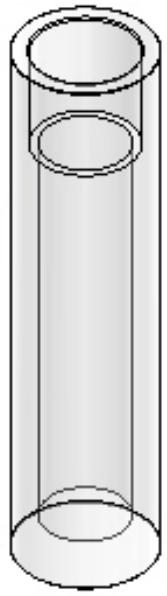


Argon-37

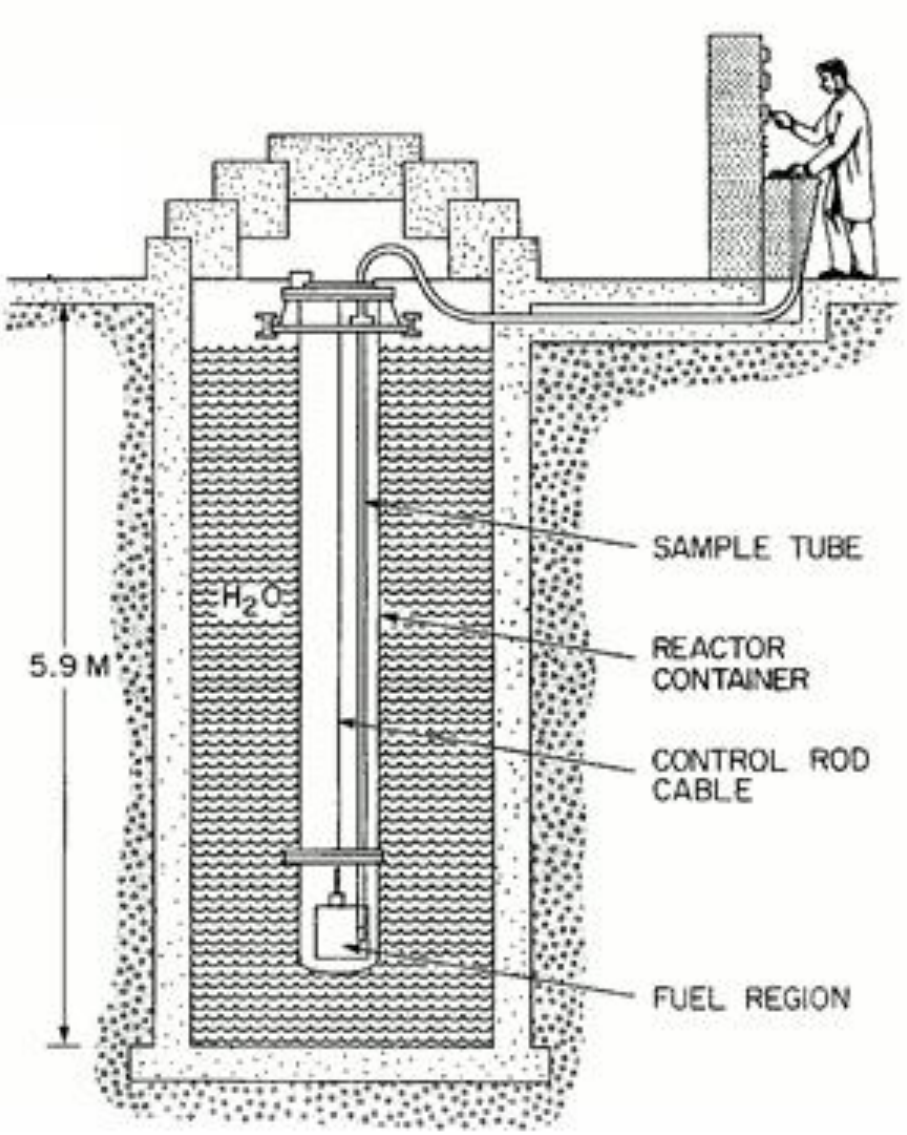


- Made at the Royal Military College of Canada (D. Kelly, E. Cocoran)
- Uses $^{40}Ca(n,\alpha)^{37}Ar$ reaction
- Custom irradiation vessel by RMCC (Clarence McEwen)

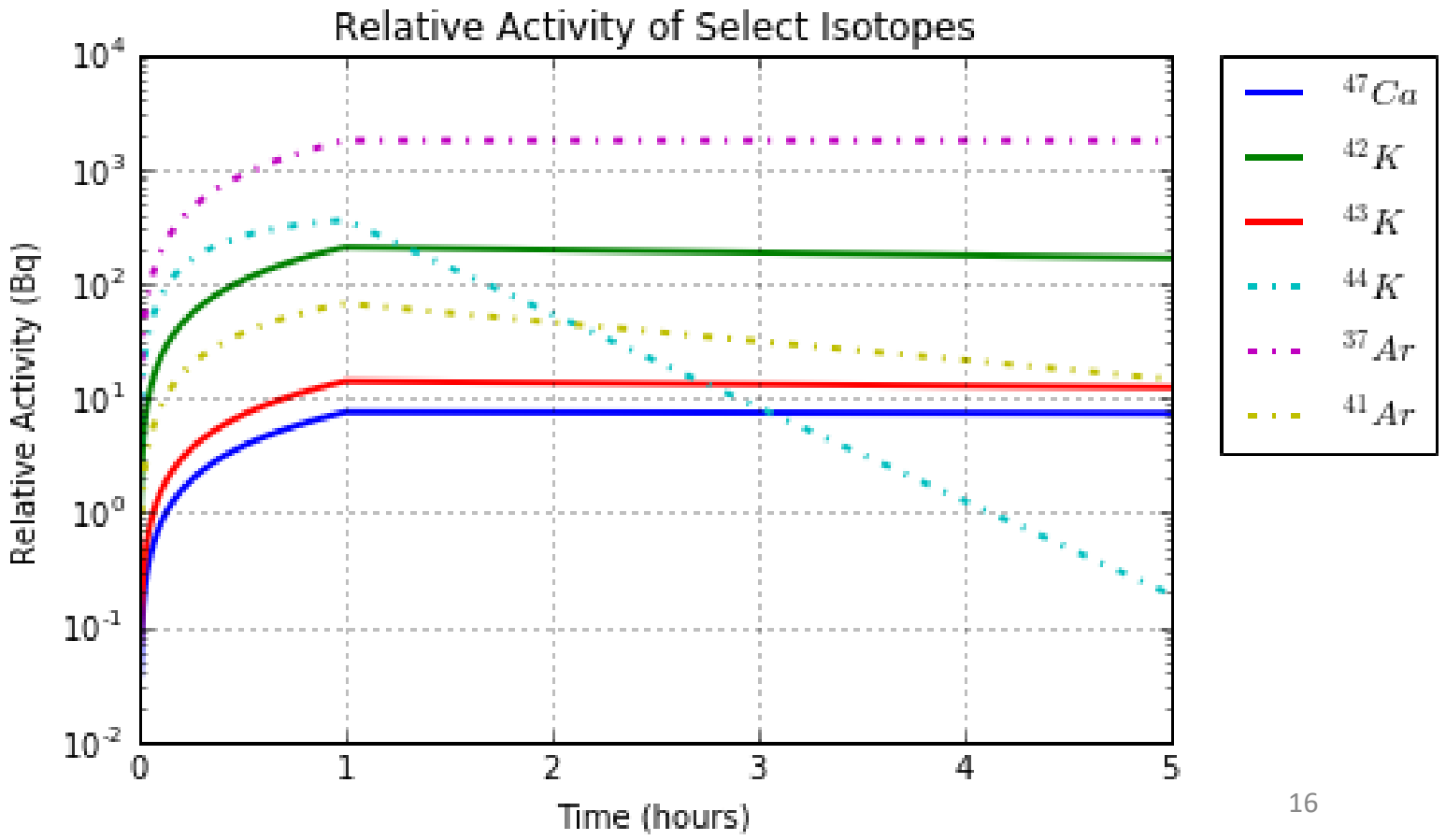
TRUTH · DUTY · VALOUR
VÉRITÉ · DEVOIR · VAILLANCE



Argon-37



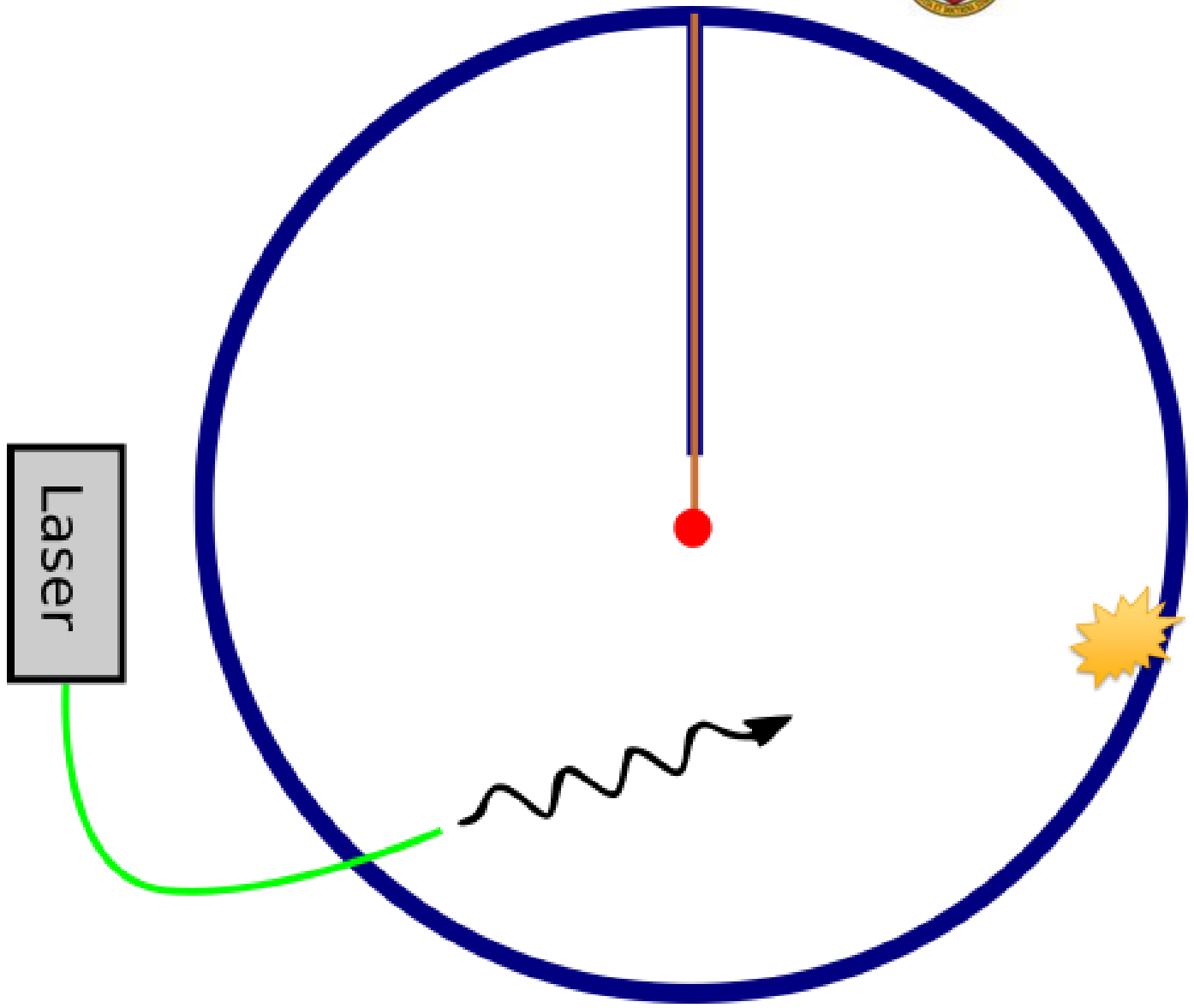
- Marker isotopes measured in germanium counter to verify activity



UV Laser Calibration

UV Laser Calibration

- Photoelectric effect of UV photons on vessel surface
- Low energy (down to 1 photoelectron) calibration
- Known starting position
- Important for measuring avalanche process, drift time…



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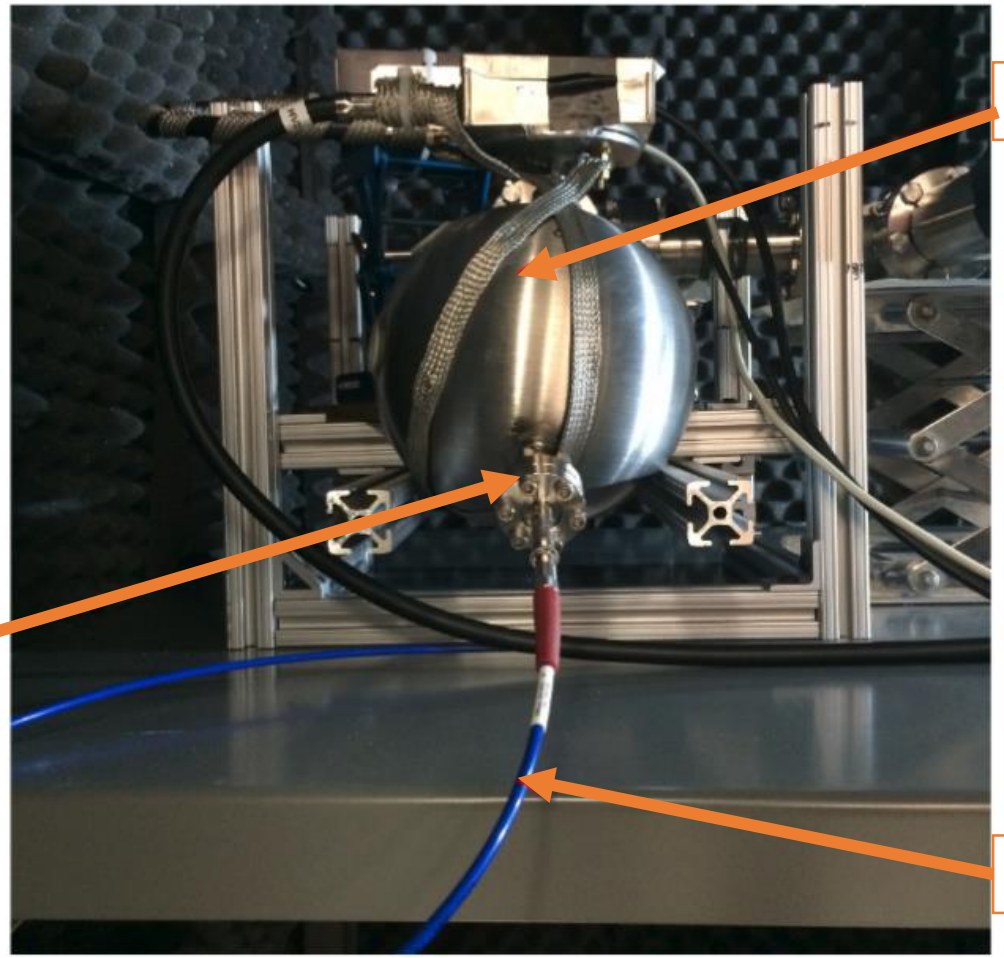
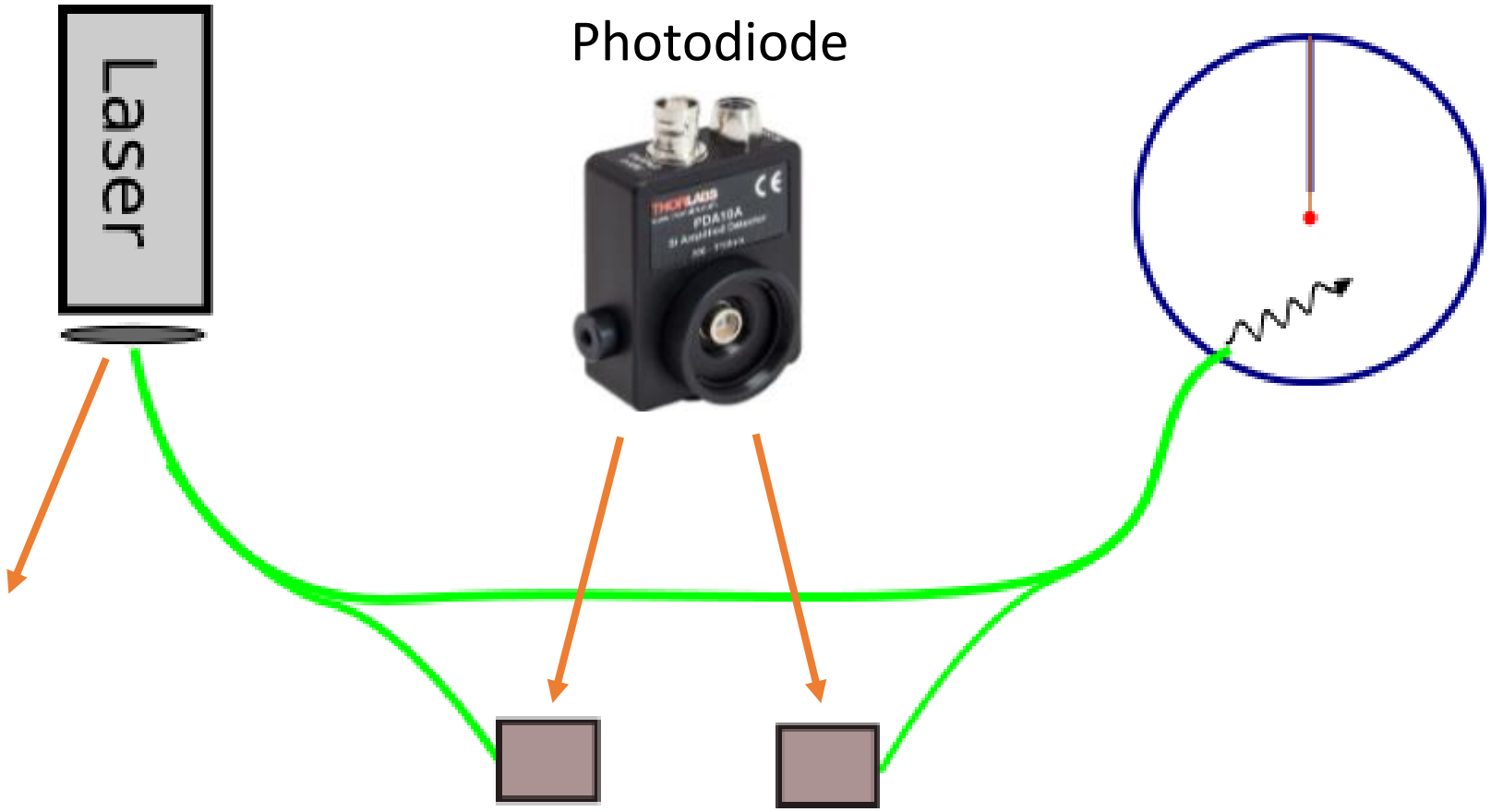


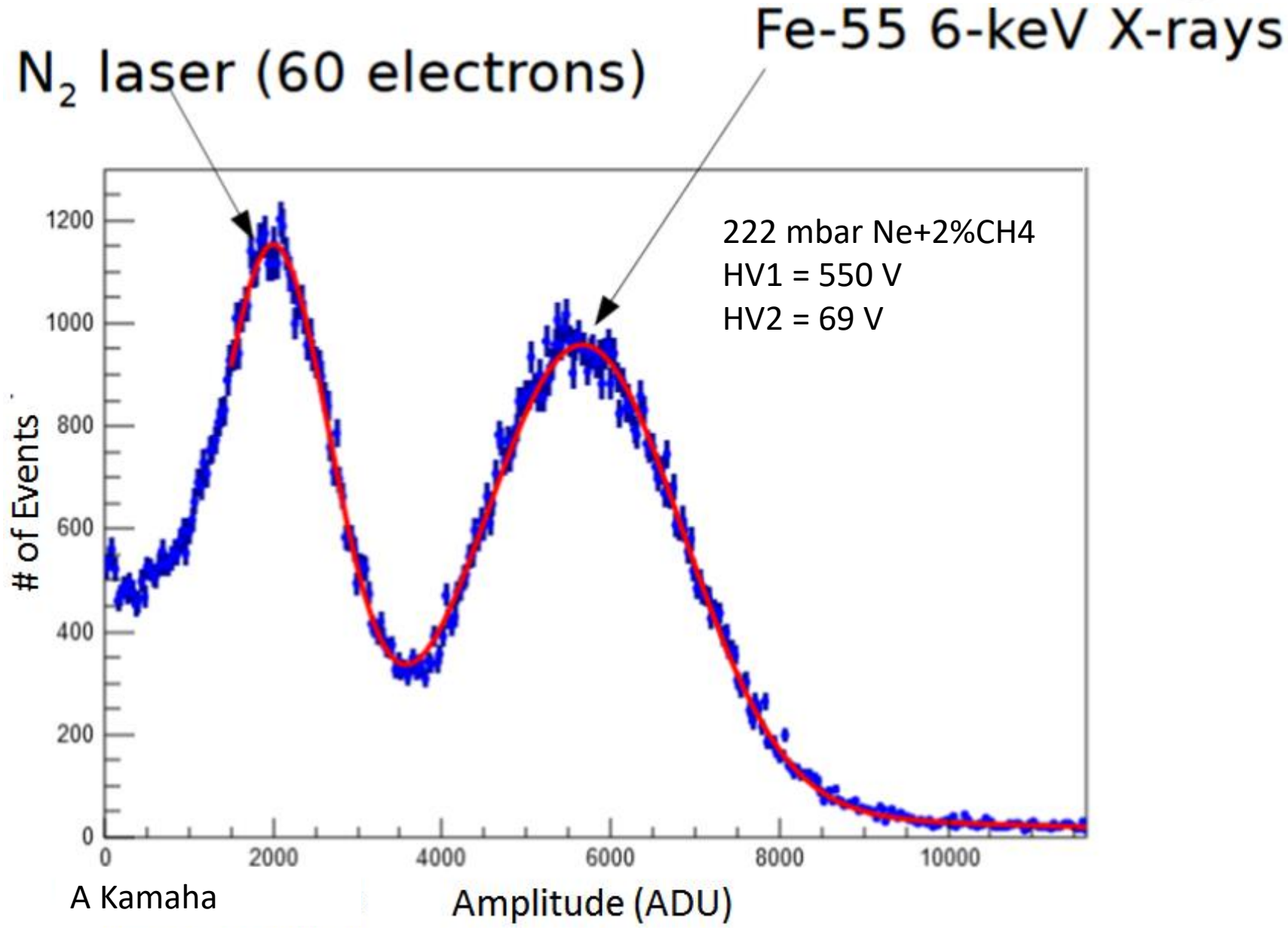
UV Laser Calibration

Changeable neutral density filters

A Kamaha



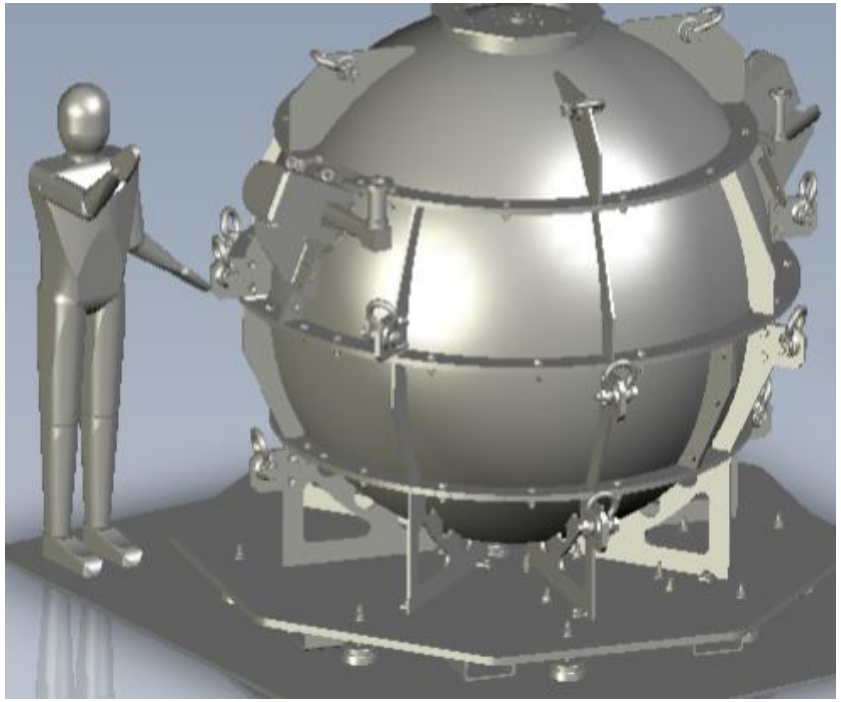
UV Laser Calibration

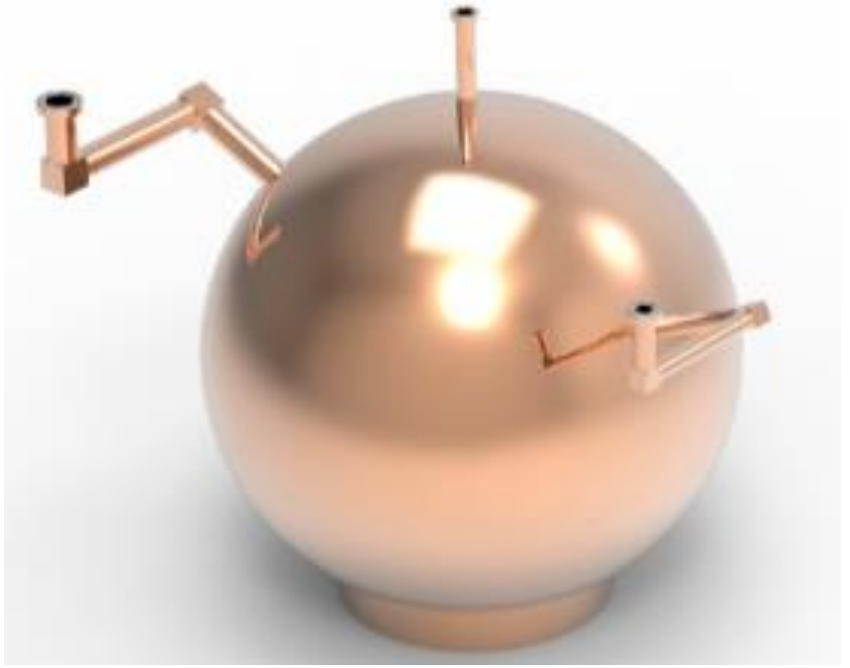


A Kamaha

Summary

- NEWS-G is at a very exciting phase of development
- Many novel calibration strategies being used successfully to understand our detectors
- Other calibration strategies (i.e. neutron capture calibration) being explored too!





Thank you!

Other NEWS-G Talks

Monday:
Quentin Arnaud: Final results on the search for low-mass WIMPs with the NEWS-G experiment.
Alexis Brossard: Sensor development for spherical gas detector for dark matter search
Thursday:
Gilles Gerbier: Status of NEWS-G experiment
Philippe Di Stefano: Quenching measurements for a spherical detector at the COMIMAC facility

Collaboration

Queen's University Kingston – G Gerbier**,** P di Stefano, R Martin, T Noble, D Durnford A Brossard, A Kamaha, P Vasquez dS, Q Arnaud, K Dering, J Mc Donald, M Clark, M Chapellier

- Copper vessel and gas set-up specifications, calibration, project management
- Gas characterization, laser calibration, on smaller scale prototype
- Simulations/Data analysis

IRFU (Institut de Recherches sur les Lois fondamentales de l'Univers)**/CEA Saclay** -I Giomataris, M Gros, C Nones, I Katsioulas, T Papaevangelou, JP Bard, JP Mols, XF Navick,

- Sensor/rod (low activity, optimization with 2 electrodes)
- Electronics (low noise preamps, digitization, stream mode)
- DAQ/soft

LSM (Laboratoire Souterrain de **Modane**), IN2P3, U of Chambéry - F Piquemal, M Zampaolo, A DastgheibiFard

- Low activity archeological lead
- Coordination for lead/PE shielding and copper sphere

Thessaloniki University – I Savvidis, A Leisos, S Tzamarias, C Elefteriadis, L Anastasios

- Simulations, neutron calibration
- Studies on sensor

LPSC (Laboratoire de Physique Subatomique et Cosmologie) **Grenoble** - D Santos, JF Muraz, O Guillaudin

- Quenching factor measurements at low energy with ion beams

Technical University Munich – A Ulrich, T Dandl

- Gas properties, ionization and scintillation process in gaz

Pacific National Northwest Lab– E Hoppe, D Asner

- Low activity measurements, Copper electroforming

RMCC (Royal Military College Canada**) Kingston –** D Kelly, E Corcoran

- 37 Ar source production, sample analysis

SNOLAB –Sudbury – P Gorel

- Calibration system/slow control

University of Birmingham– Kostas Nicolopoulos

- Simulations, analysis, R&D

Associated lab : TRIUMF - F Retiere

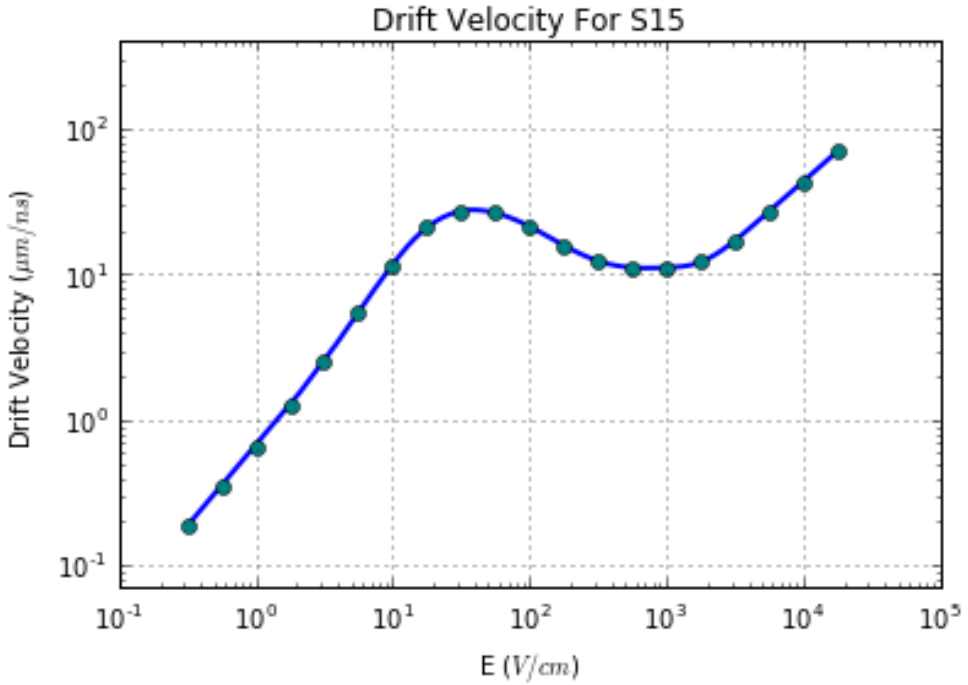
- Future R&D on light detection, sensor

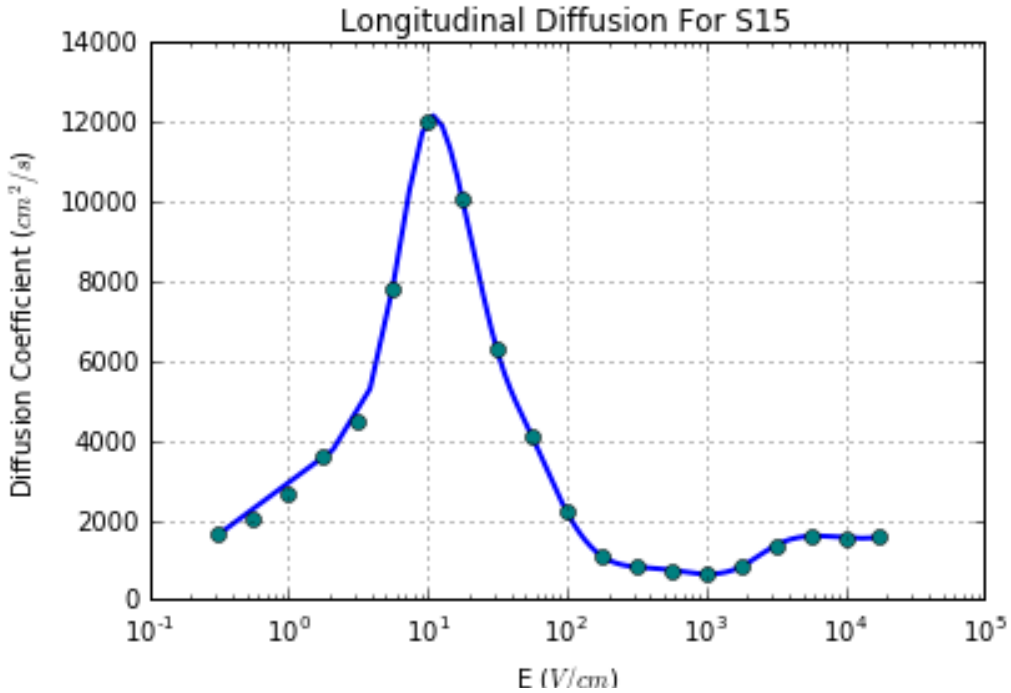
April 2017

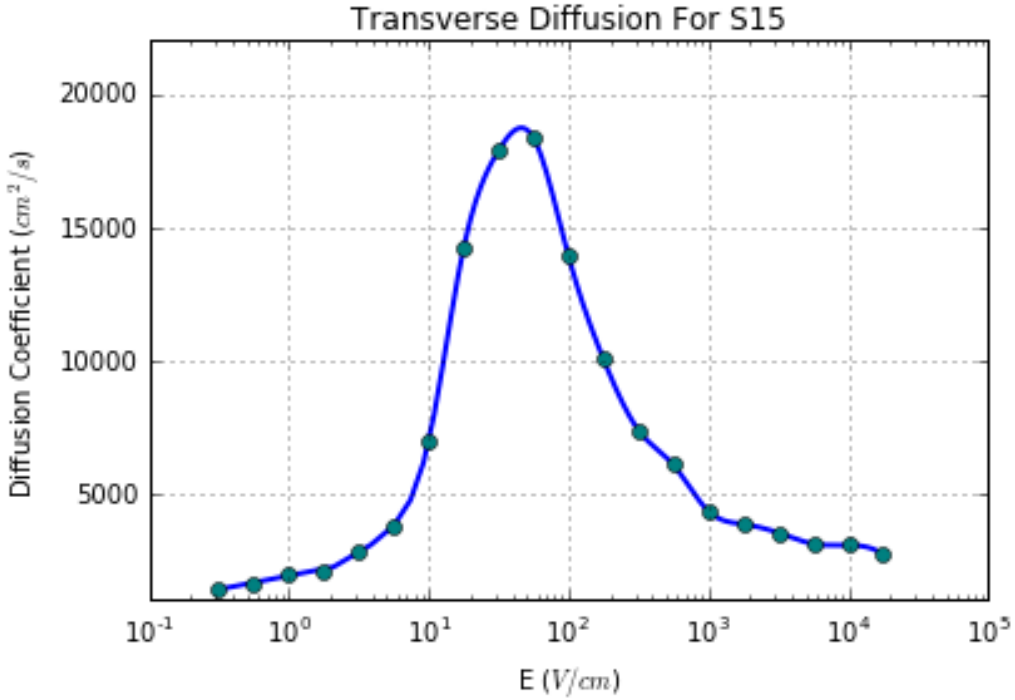
Extra Slides

Drift Time Modelling

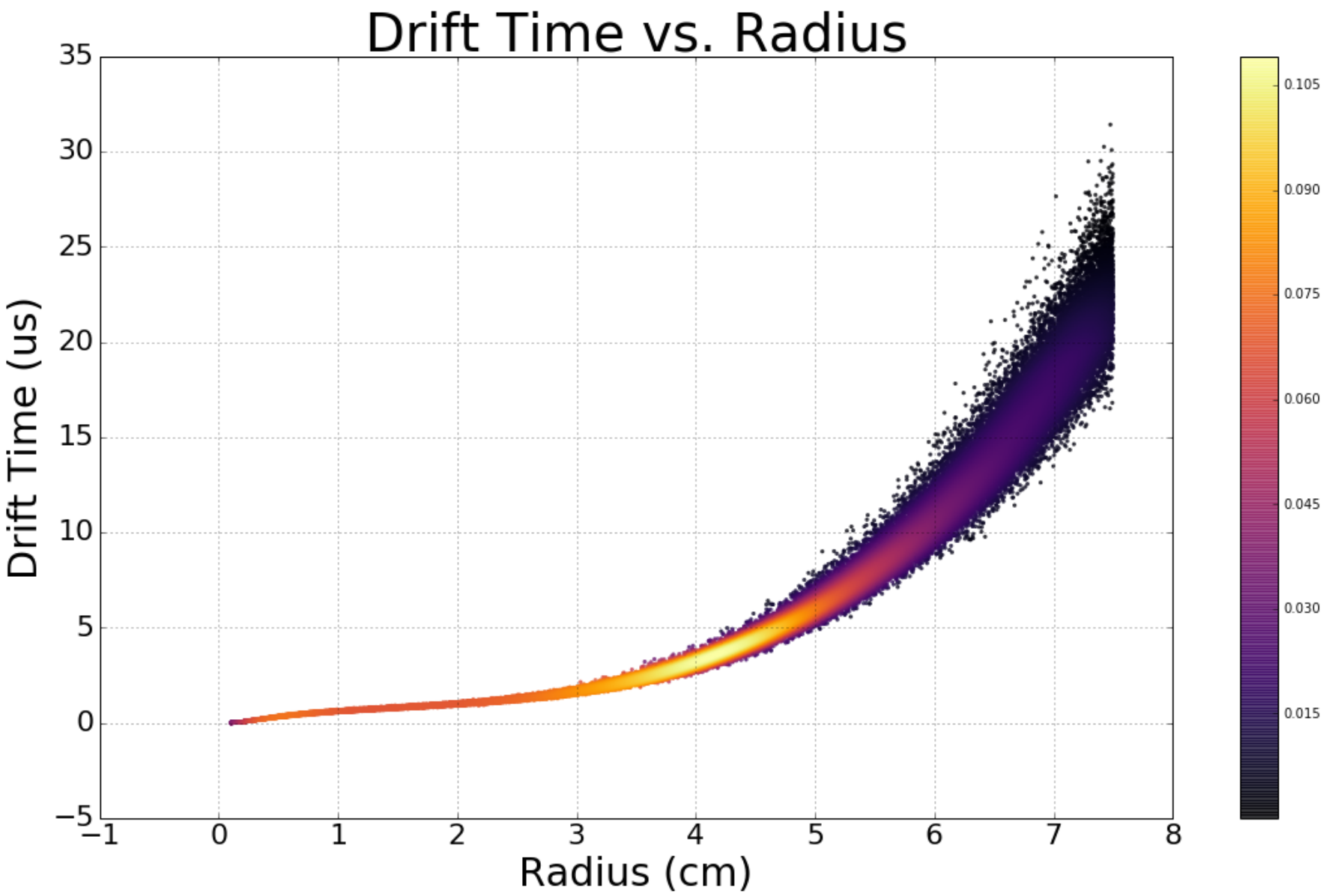
- Diffusion parameters and drift velocity of electrons calculated by Magboltz
- Solves the Boltzman Transport Equation for different conditions





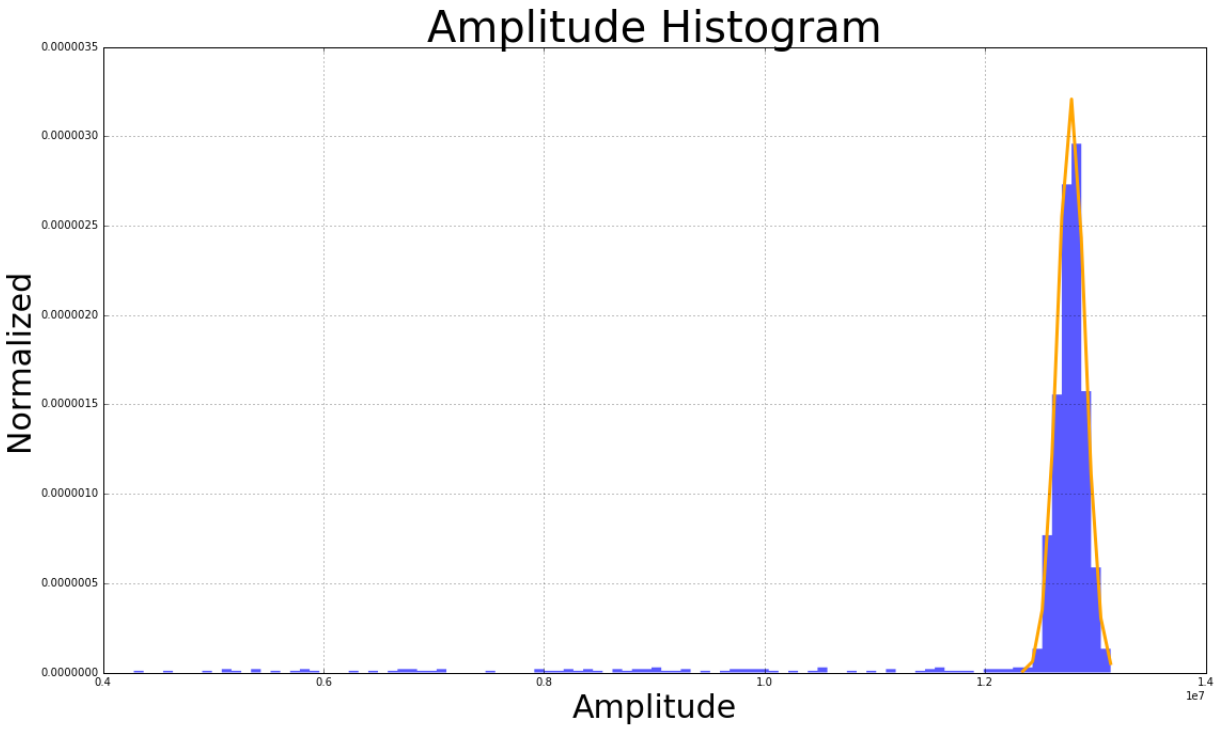


Drift Time Modelling

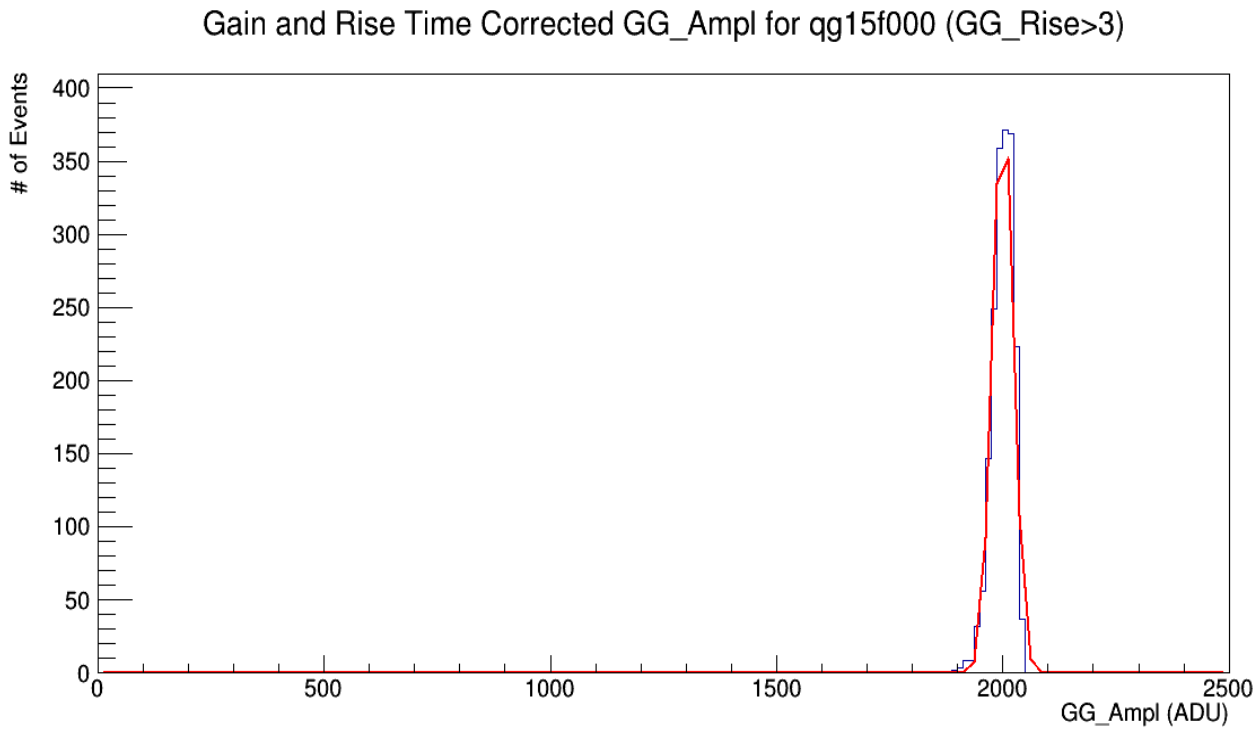


Alpha Particle Simulation

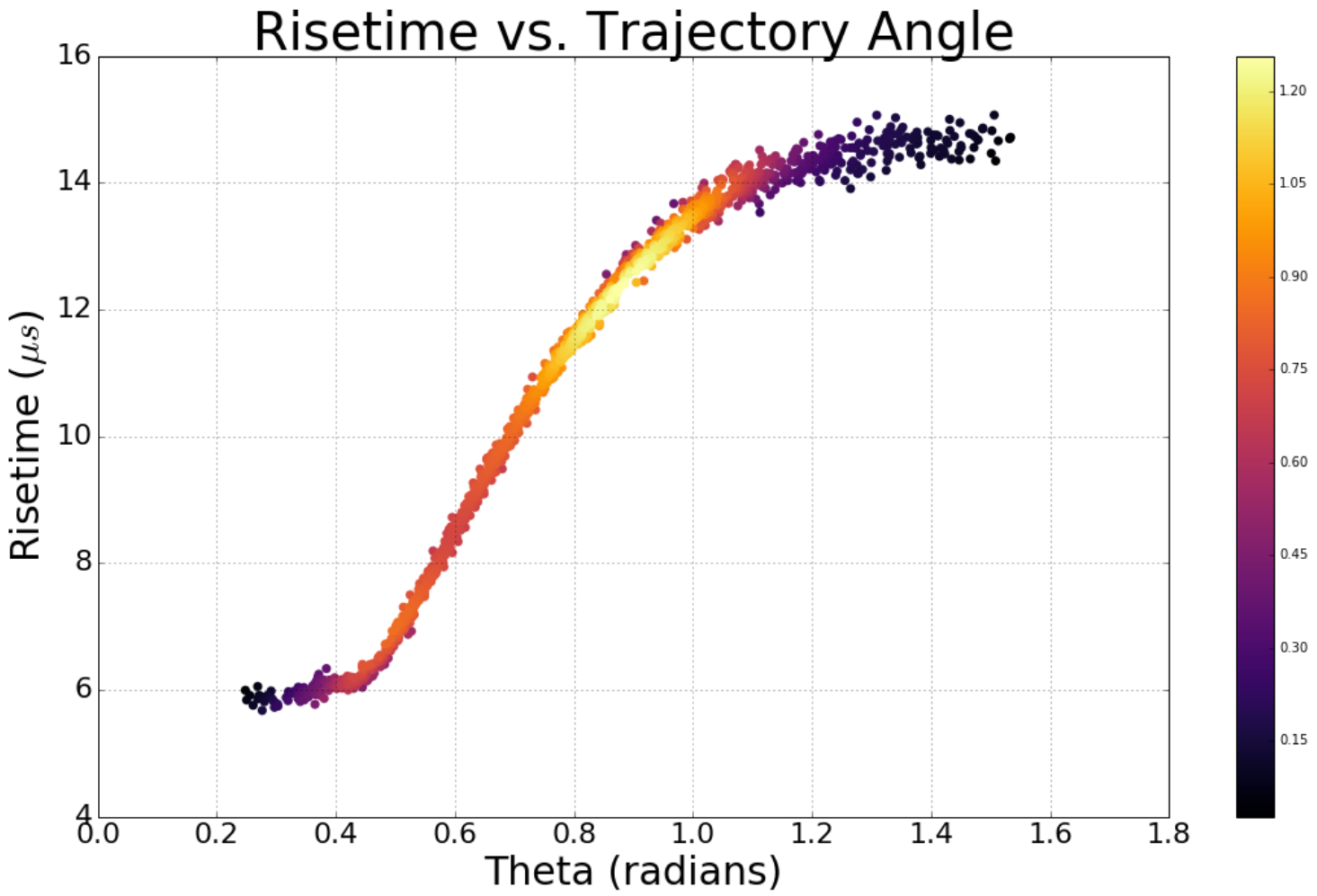
Simulation Resolution: 1.07 ± 0.01%



Data Resolution: 1.12 ± 0.03%

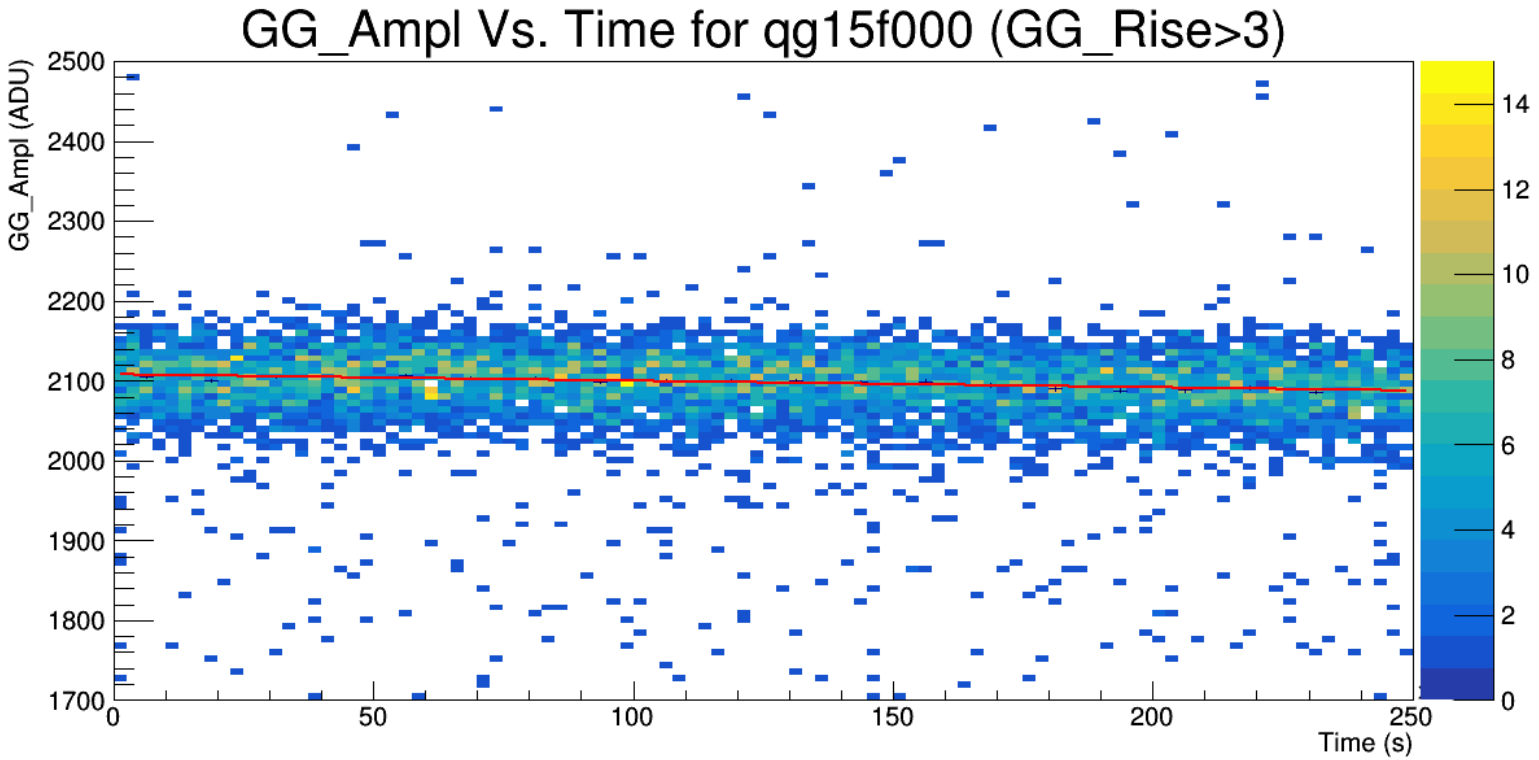


Alpha Particle Simulation



- Relationship between trajectory altitude and rise time makes sense for a track-like event: electrons from tracks that are perpendicular to the sensor will arrive more or less at the same time, therefore a lower rise time

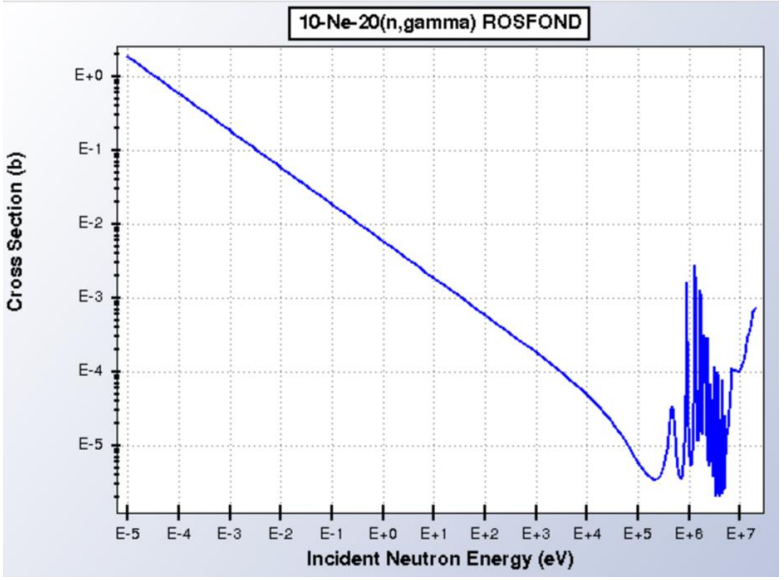
Alpha Particle Simulation

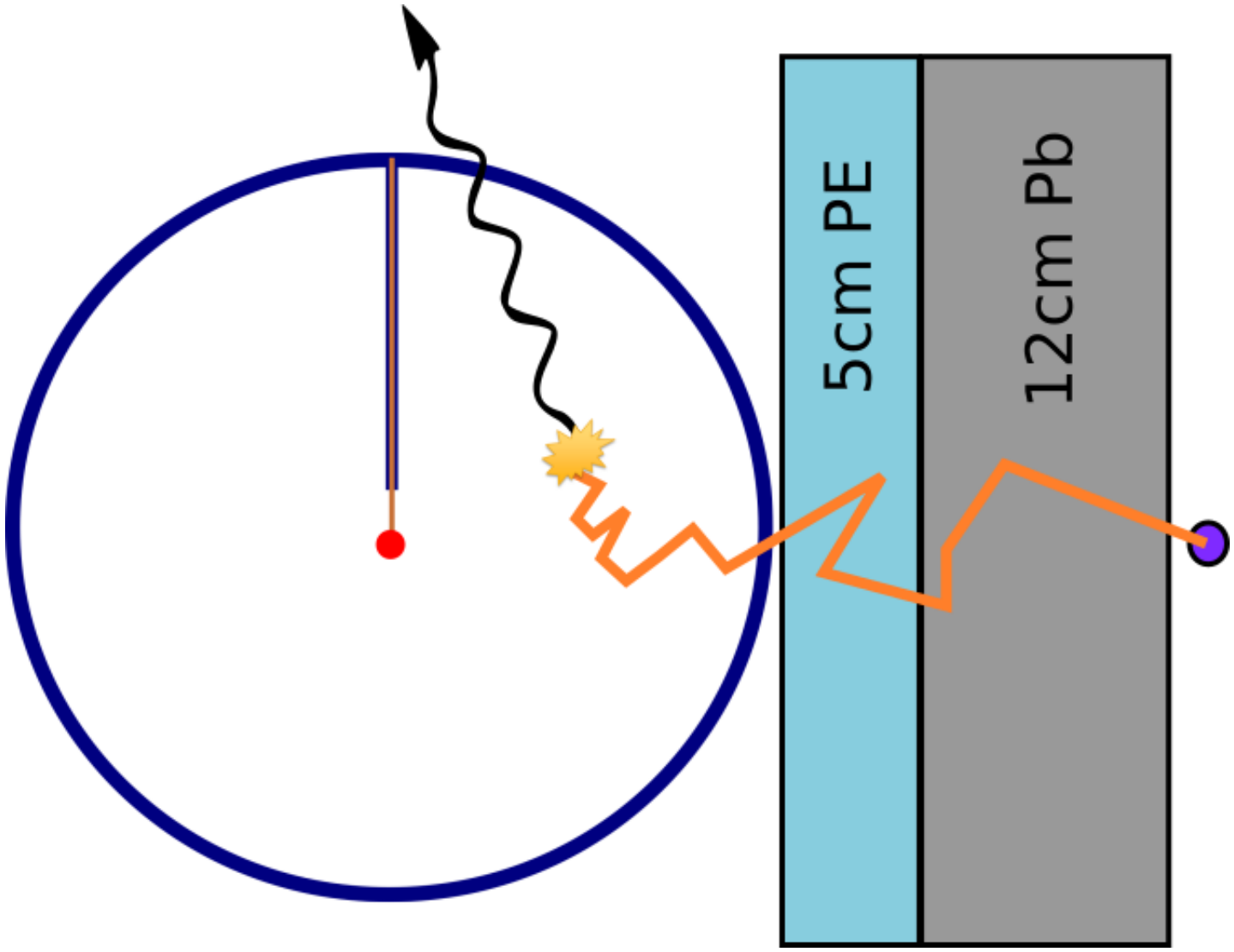


- Amplitude time dependency likely due to diminishing gas quality
- Corrected for in this analysis

Neutron Capture

- Nuclear recoil from X(n,γ)Y reaction
- Recoil energies on order of 100-1000eV





Sensitivity of NEWS-G -LSM to Spin Independent couplings WIMPS