The Compton Slope Parameter and the Compton and Two Photon Spectrometer

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Land Acknowledgement

I would like to acknowledge that we are located within the territory of the Stoney and Ktunaxa Nations and that the bulk of my research was completed within the territory of the Mi'kma'ki. As such, it is to be acknowledged that we have a responsibility to respect these Indigenous territories.

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The Compton Slope Parameter (CSP)

- Not well known for complex nuclei
- Introduces $\sim 20\%$ error in BNSSA
- Function of elastic energy from Compton scattering

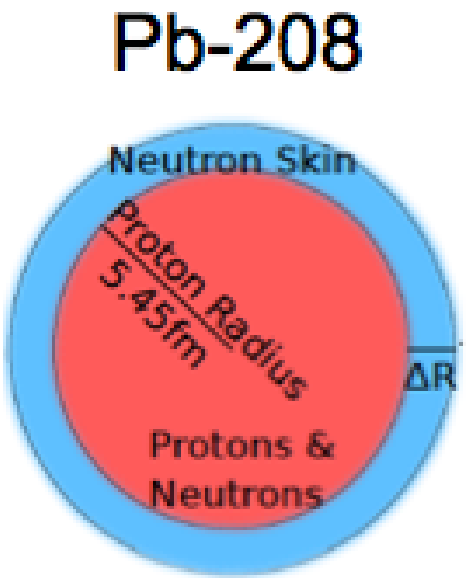
CSP $\longrightarrow$ CFF $\longrightarrow$ Beam-Normal Single-Spin Asymmetry (BNSSA)

$\longrightarrow$ Parity Violating Electron Scattering (PVES) $\longrightarrow$

Neutron Skin Thickness $\longrightarrow$ **Nuclear Equation of State (EOS)**

Neutron Skin Thickness

- Heavy atomic nuclei
- Neutrons wrap around nucleus
- Linear correlation with the slope of the symmetry energy, L (ε_{cost} in this talk)
- L constrains the Nuclear Equation of State (EOS)



Nuclear Equation of State (EOS)

- Describes relationship between nuclear matter in nuclei
- Applications to astrophysics
- Usually a function of pressure, density, temperature

$$\varepsilon(P, \rho, T) = \varepsilon_{symmetry} + \varepsilon_{cost}$$

$\therefore$ **The CSP is crucial for an accurate EOS!**

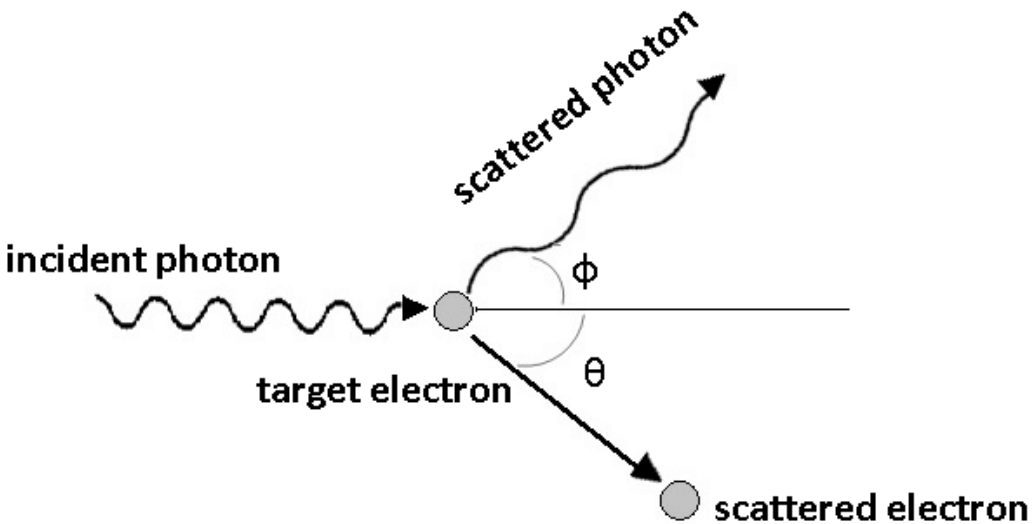
Compton Scattering

Elastic Scattering

- Incoming particle absorbed by target
- Target is propelled into specific direction
- New incoming particle re-emitted

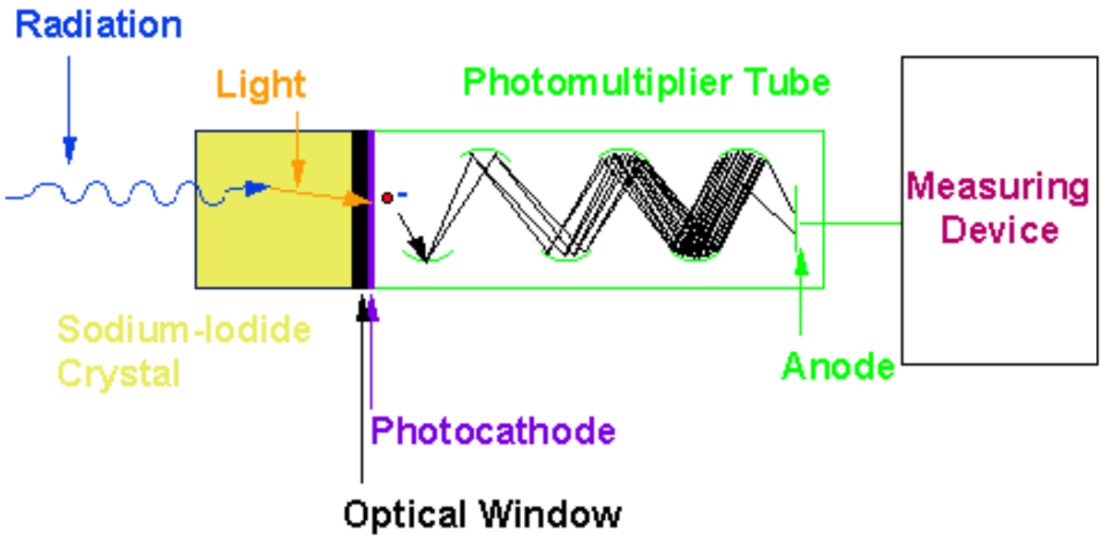
Inelastic Scattering

- Deposits energy into target
- Target reaches excited state
- Target de-excites, emitting a characteristic photon



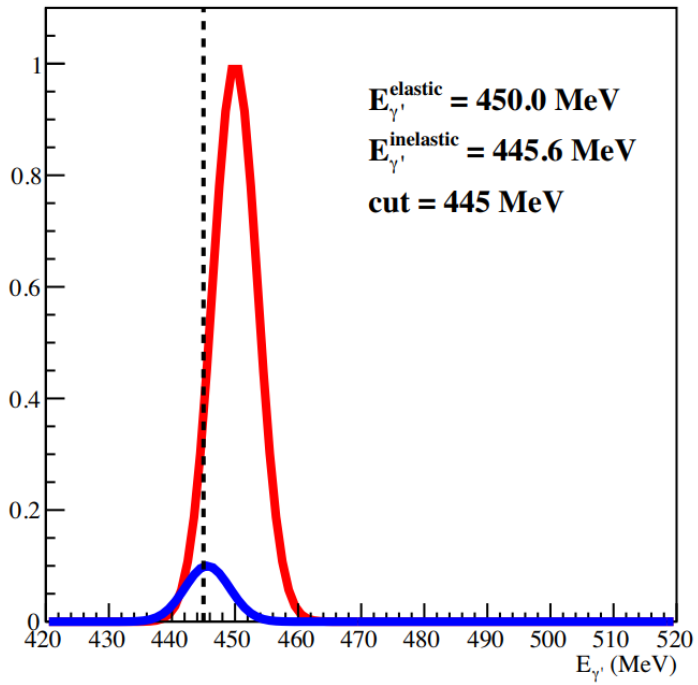
Scintillating Detectors

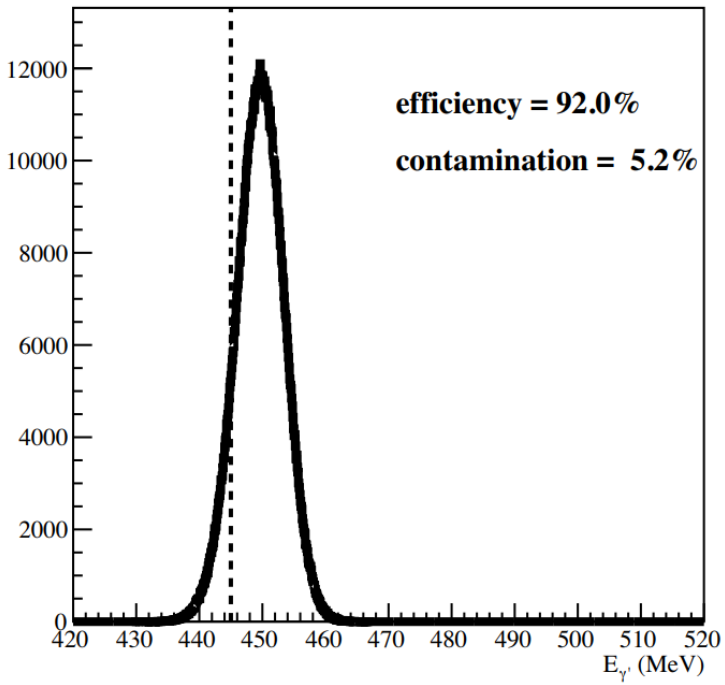
- Large NaI Detector
- Mainz, Germany
- Scintillation Crystal



G4CATS Simulation

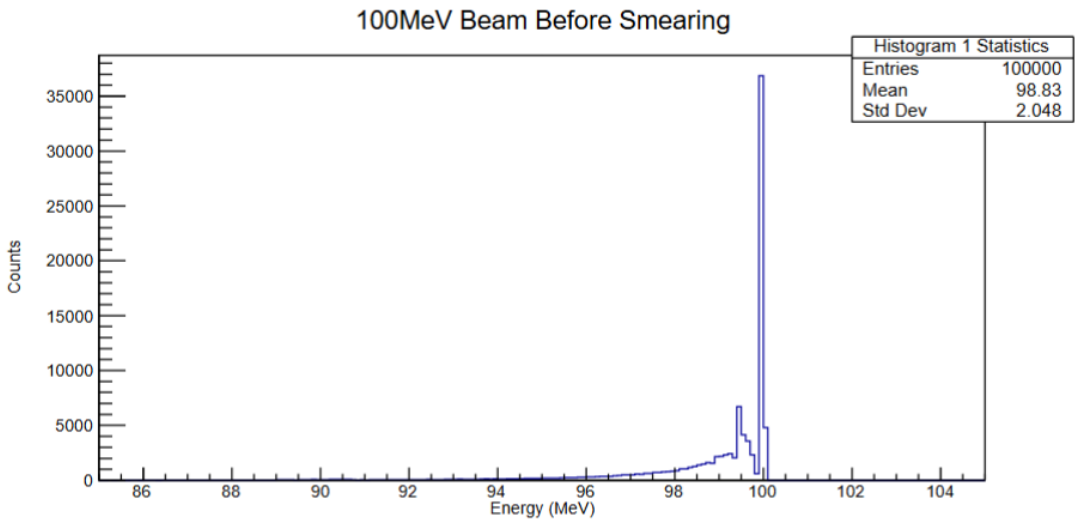
- Two Geant4 software simulations: A2Geant4 and G4CATS
- Analysis done for simulations using ROOT
- CATS has $\sim 2\%$ energy resolution; can discern between inelastic and elastic contributions

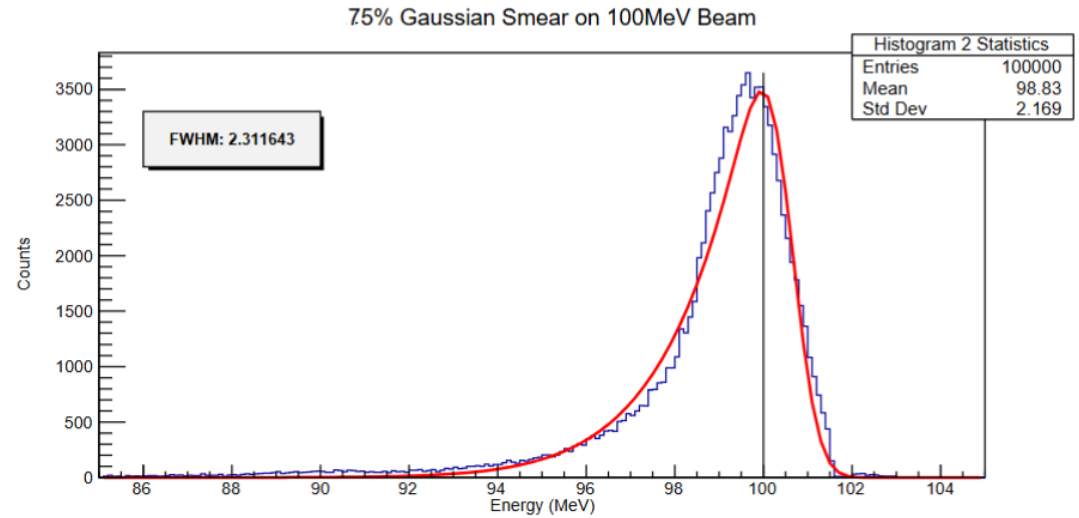




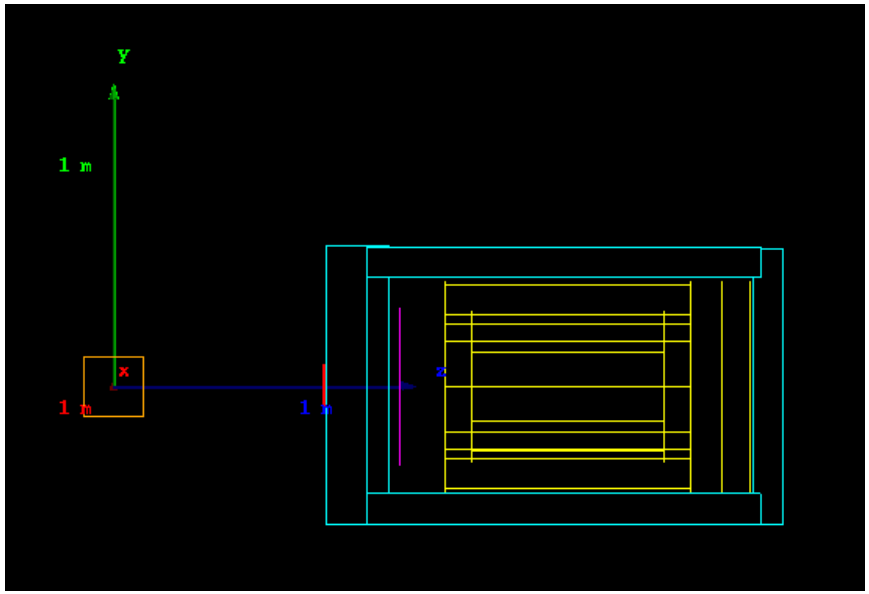
G4CATS Multiplication Smear

- Shooting 100MeV photons directly into CATS
- Smearing percentage (standard deviation) of 7.5%
- FWHM (Full-Width at Half-Maximum) corresponding to energy resolution

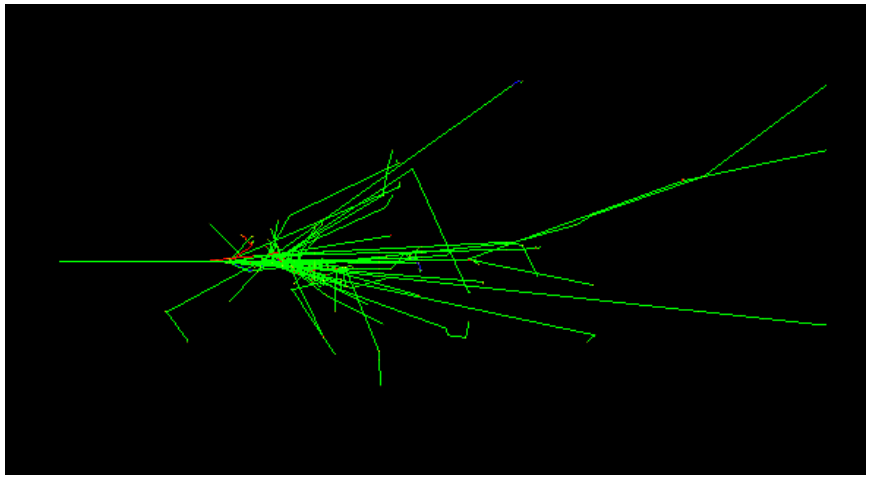




G4CATS Visualization



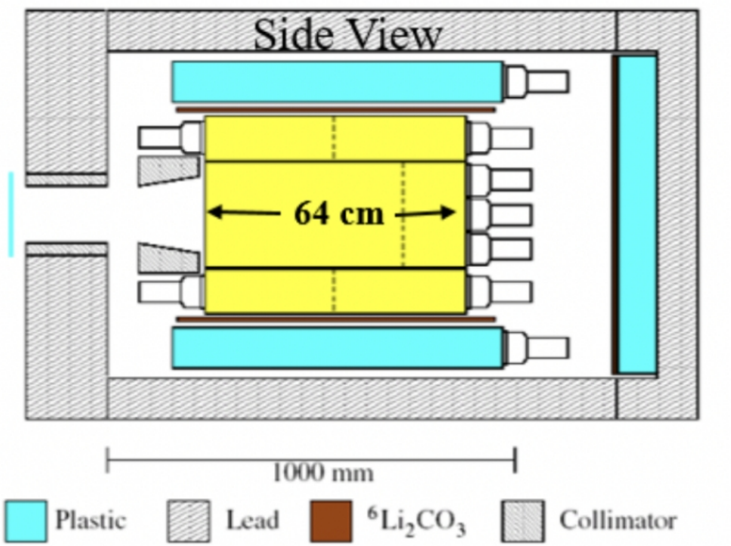
CATS detector with Carbon-12 target cube



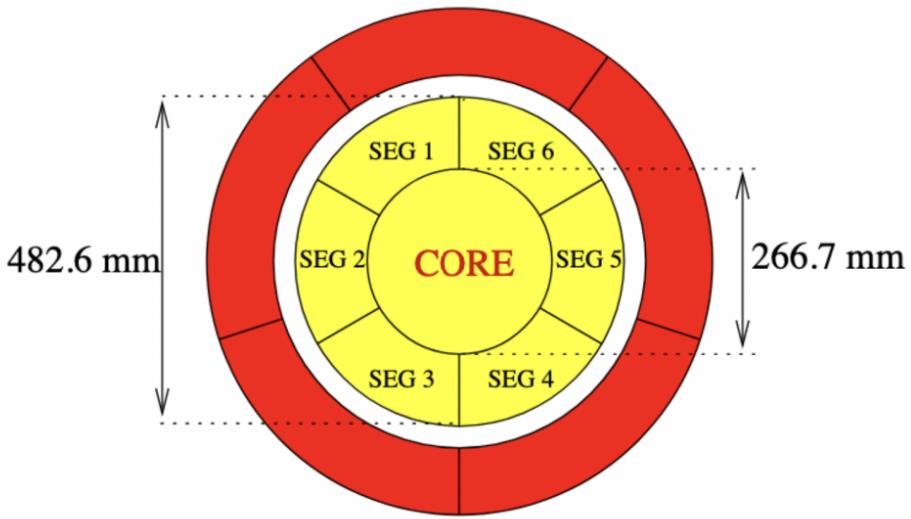
Electromagnetic shower in CATS from a 300MeV gamma particle

CATS Schematics

CATS Side View



Front of CATS



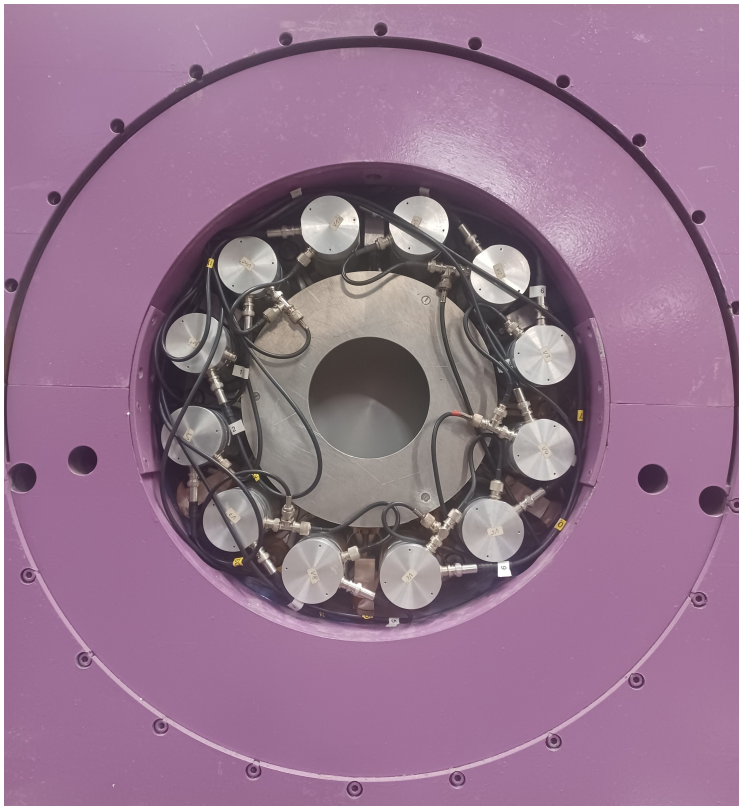
Pictures of CATS

Back Veto Cover

Pictures of CATS (cont.)

Back of CATS

Front of CATS



Future Work and Motivation

- Analyzing data taken in Germany (cosmic rays, in-beam, radioactive sources)
- Simulating cosmic rays in G4CATS simulation using CRY
- Comparing theoretical and experimental data to confirm detector energy resolution
- Taking C-12 Compton scattering data to confirm analysis techniques and extract C-12 CSP
- Replicate previous step with 4π detector, then with Pb-208
- **Extract Pb-208 CSP and calculate its neutron skin thickness**

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