Precision Measurement of the Proton Charge Radius with Elastic Electron Scattering

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- Motivation
- Experimental technique
- Measured spectra
- Preliminary results
- Outlook

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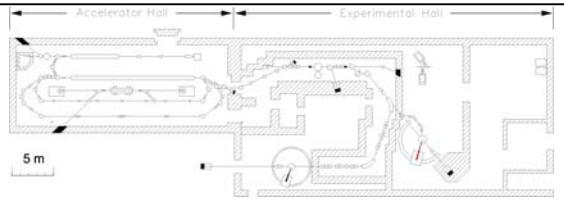


Motivation

- proton radius

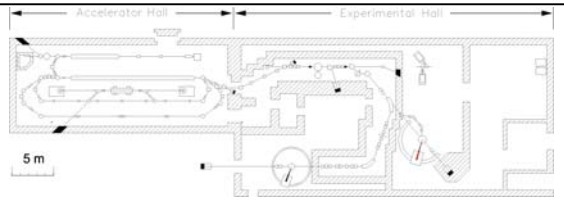
  ⟶ fundamental quantity in physics

  ⟶ important for nuclear theory

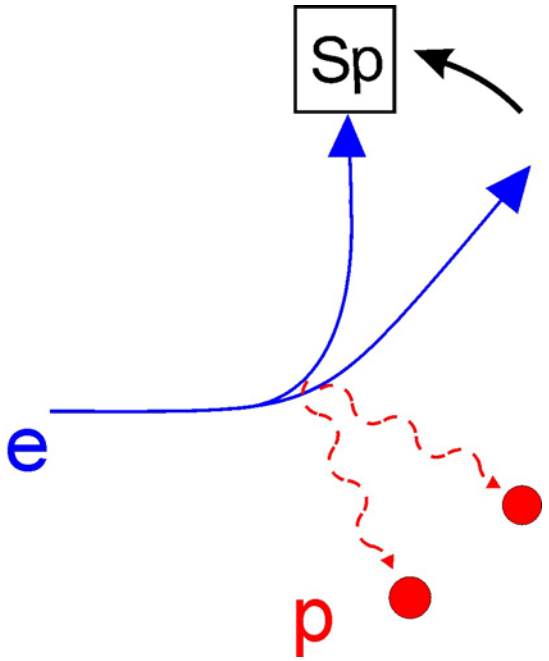
- recent Lamb shift measurements as a test of QED

  ⟶ theory limited by higher order corrections,

  which depend on R_p

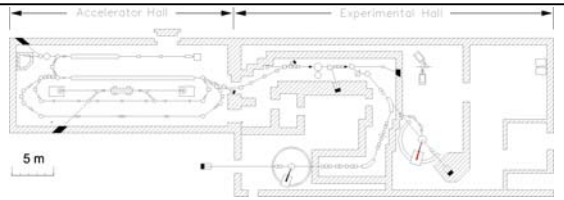


Measuring Method

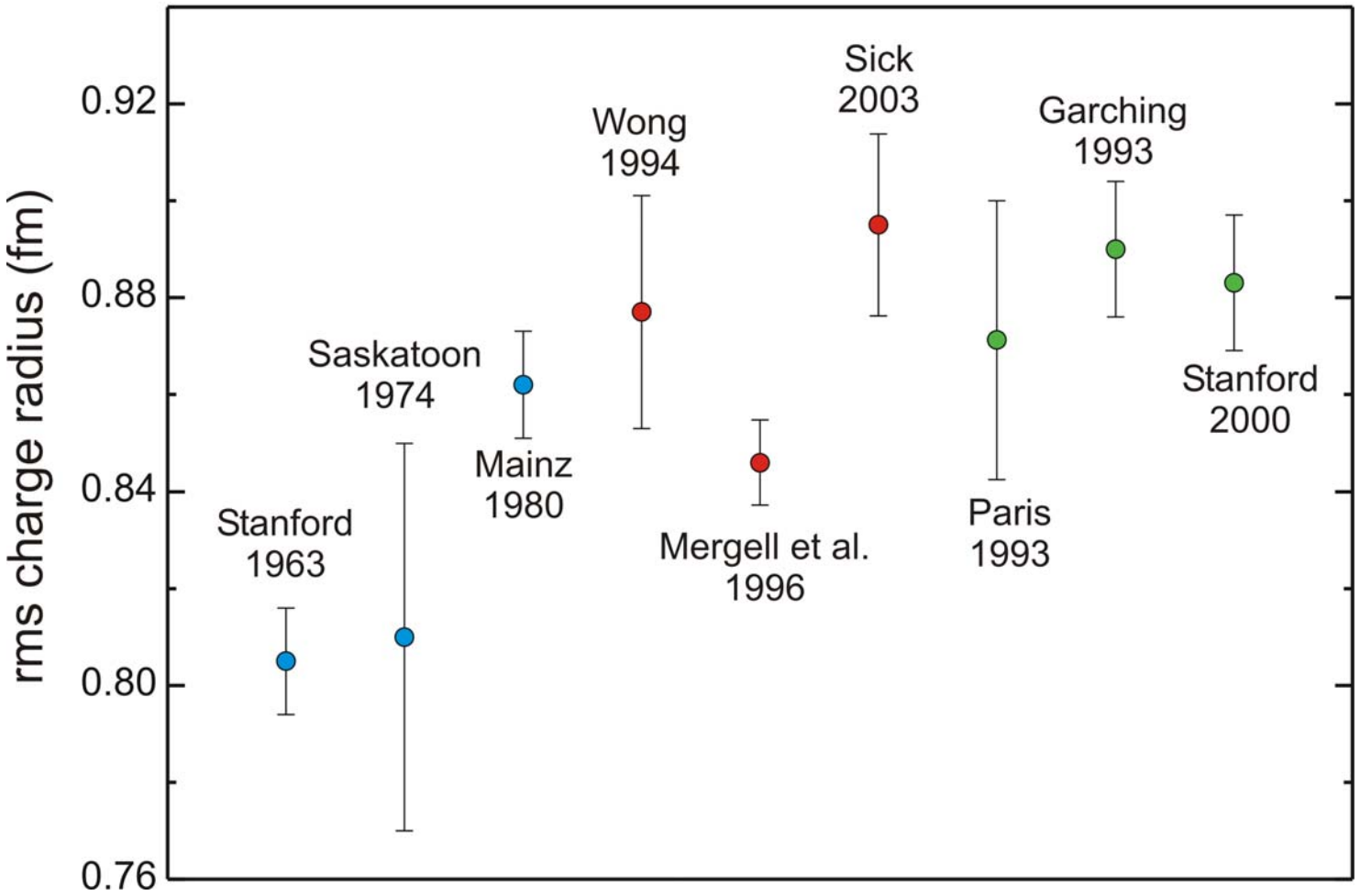


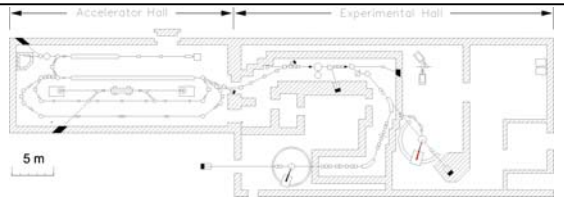
$$\frac{d\sigma}{d\Omega} = \left.\frac{d\sigma}{d\Omega}\right|_{Mott} \cdot \left(1 - \frac{\langle r^2 \rangle q^2}{3!} + \frac{\langle r^4 \rangle q^4}{5!} - \cdots\right)$$

$$\frac{\langle r^2 \rangle}{6} = -\left.\frac{dG_E^P(q^2)}{dq^2}\right|_{q \to 0}$$



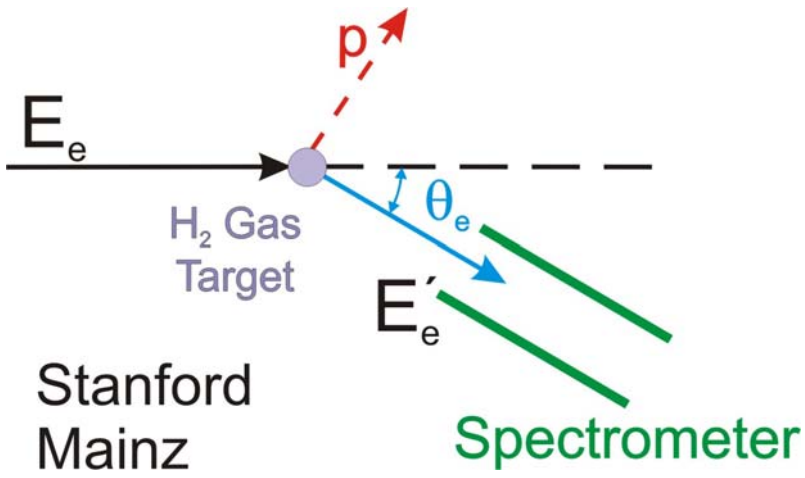
Previous Results



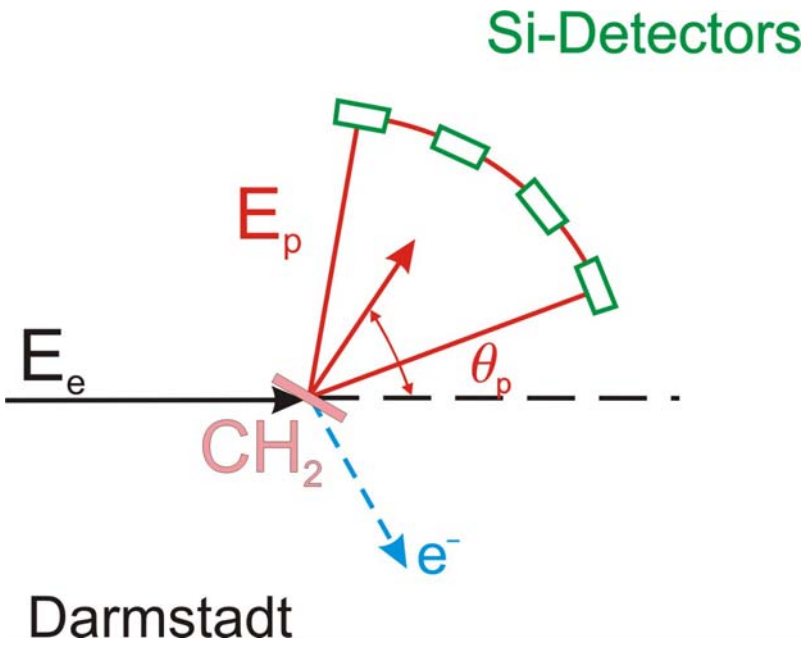


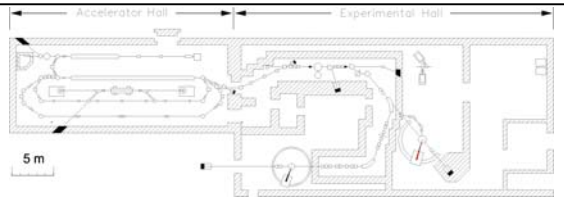
New Idea: Detect Protons and not Electrons!

Previous



Present





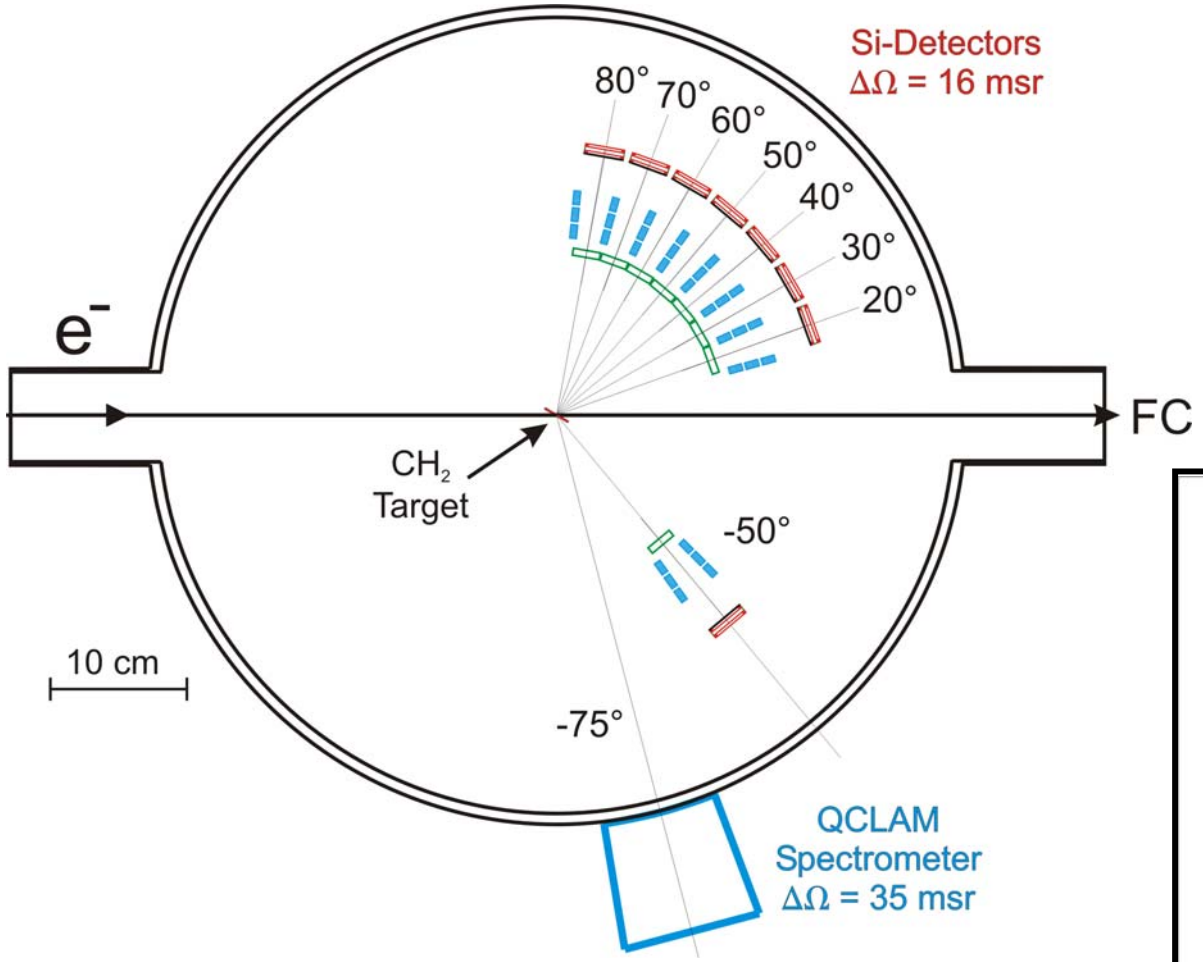
Advantages

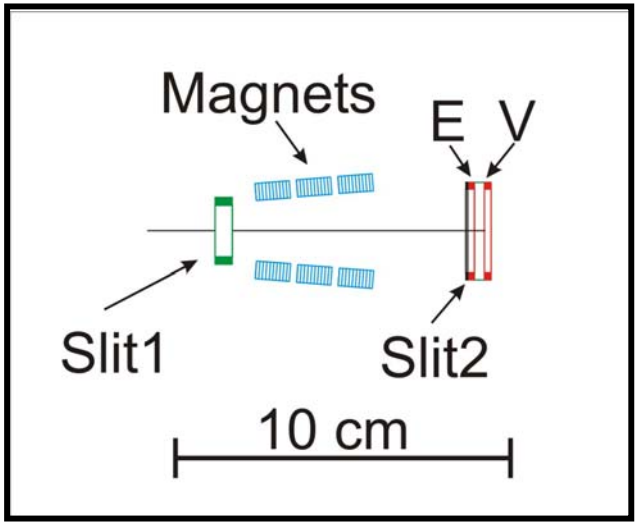
- complete angular distribution measured simultaneously

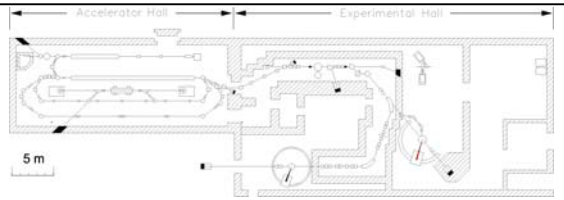
  ➡ q = 0.15 - 1 (fm^{-1}) in a single run

- avoid difficult normalization
- proton detection efficiency is ~1
- precise definition of solid angle
- Rosenbluth separation

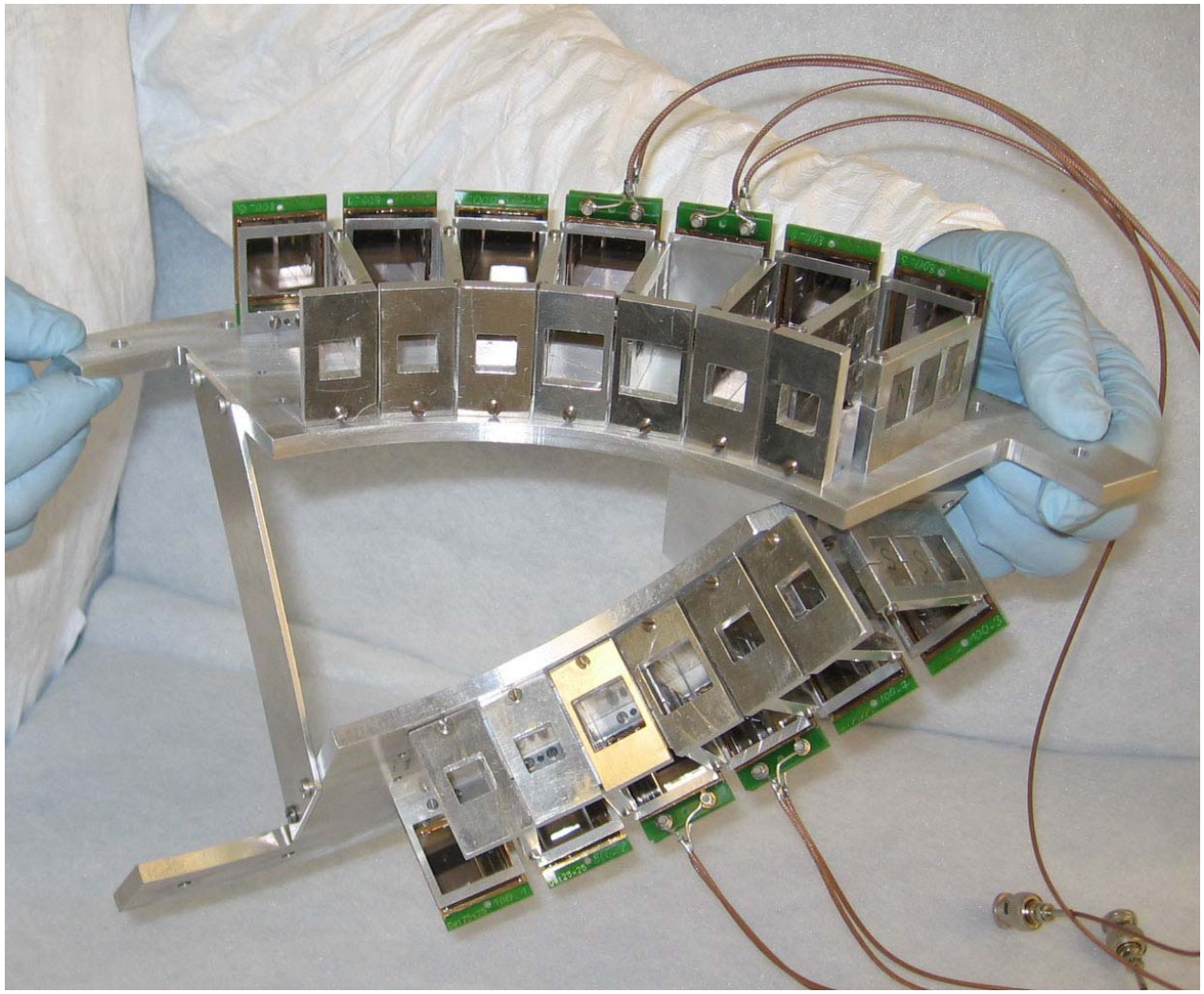
Experimental Setup

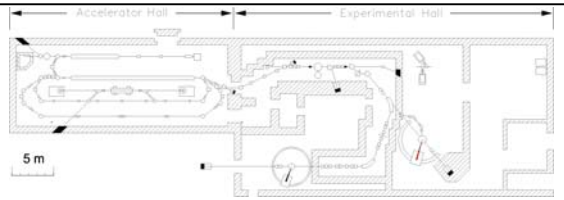




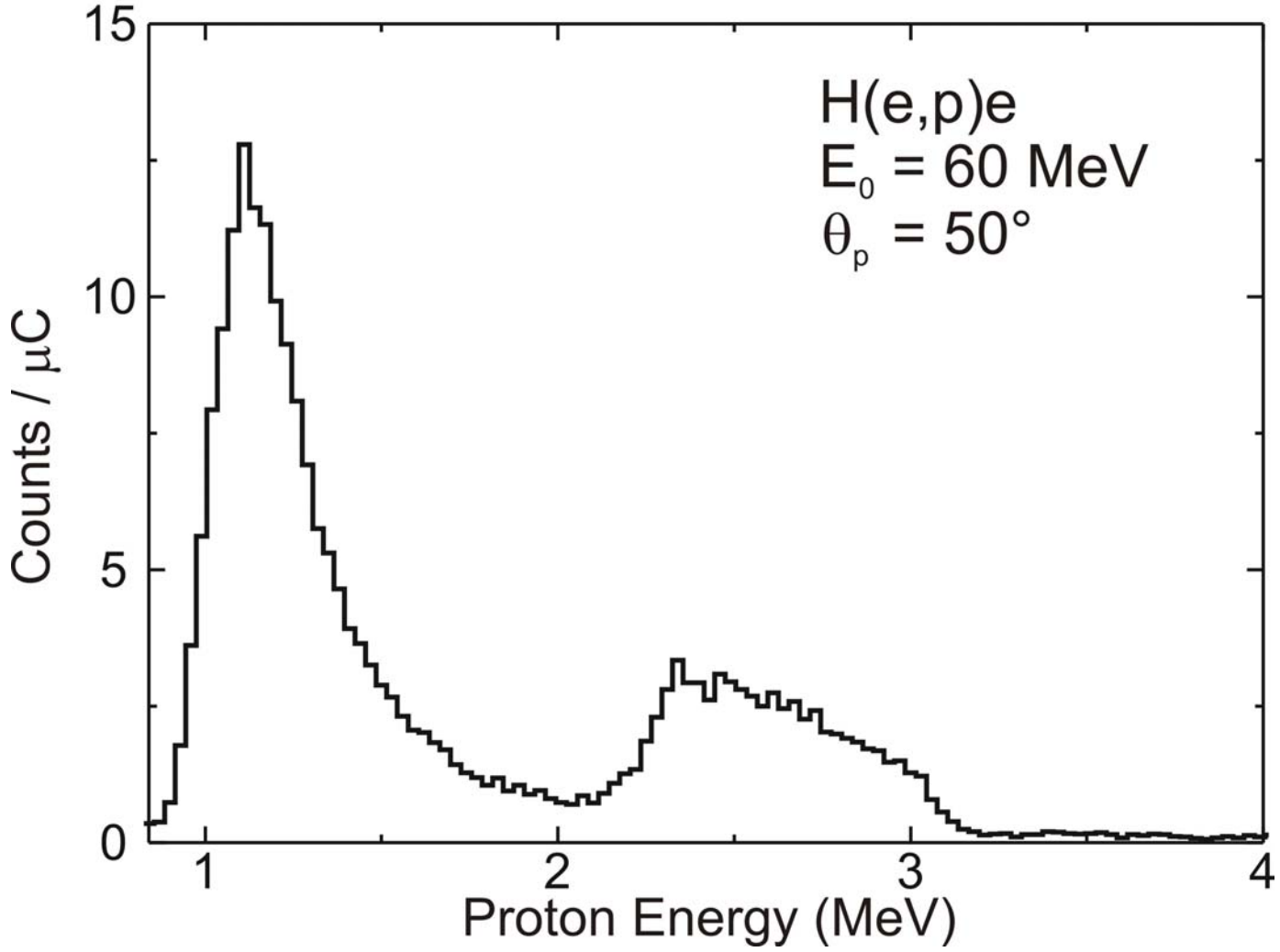


Experimental Setup





Measured Spectrum



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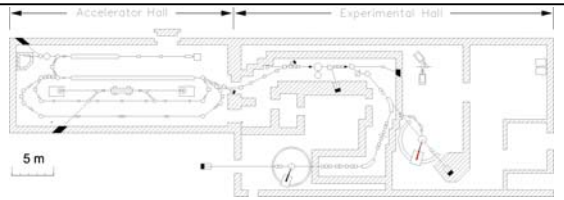
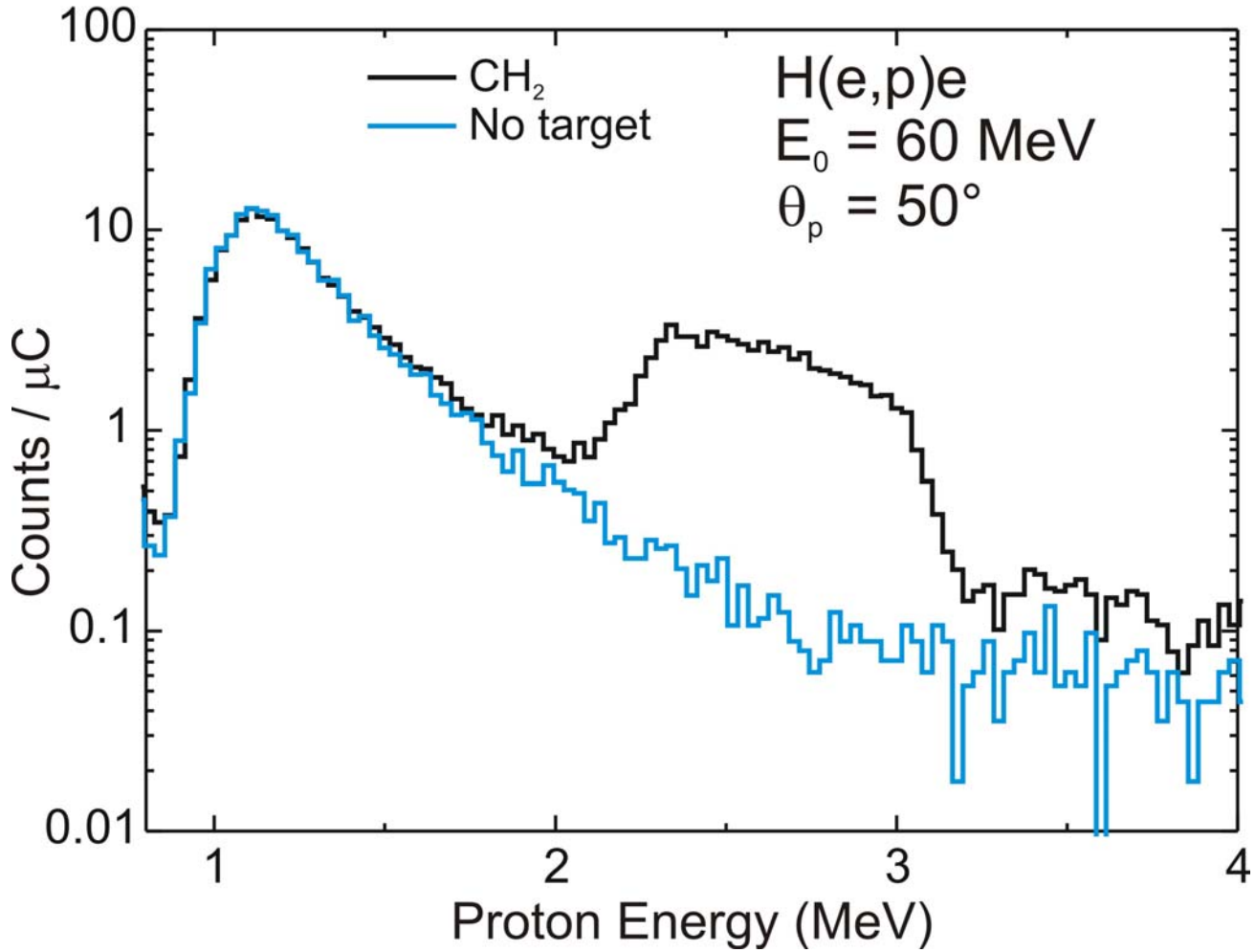
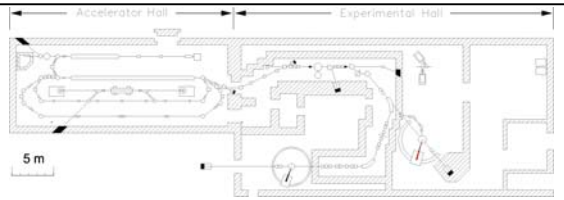
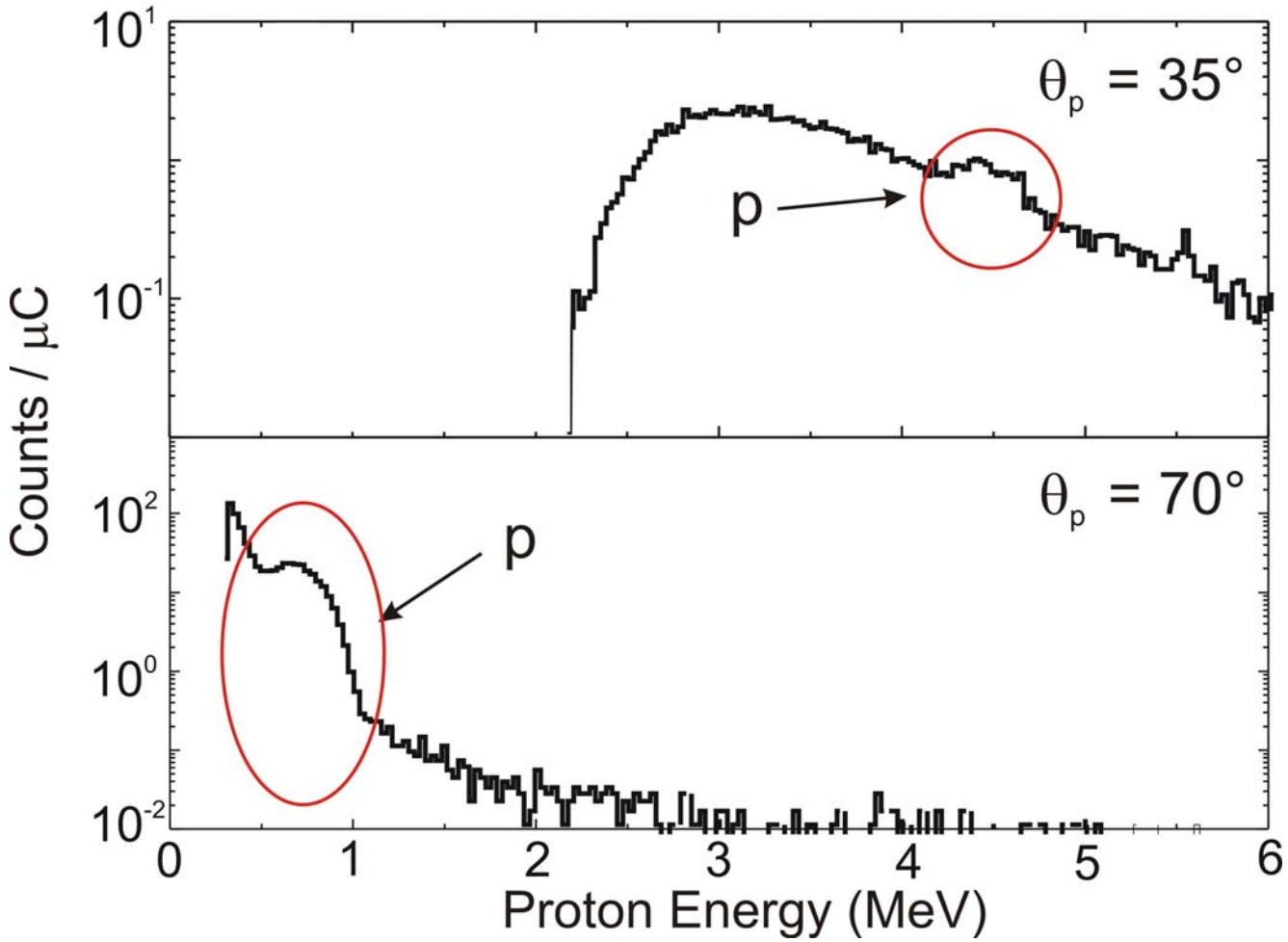


Background Contribution





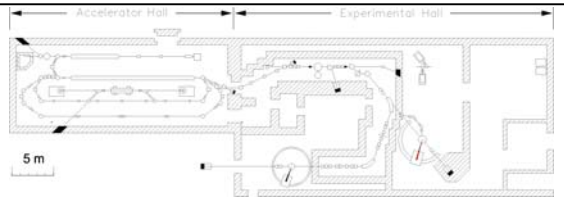
Background at Different Angles



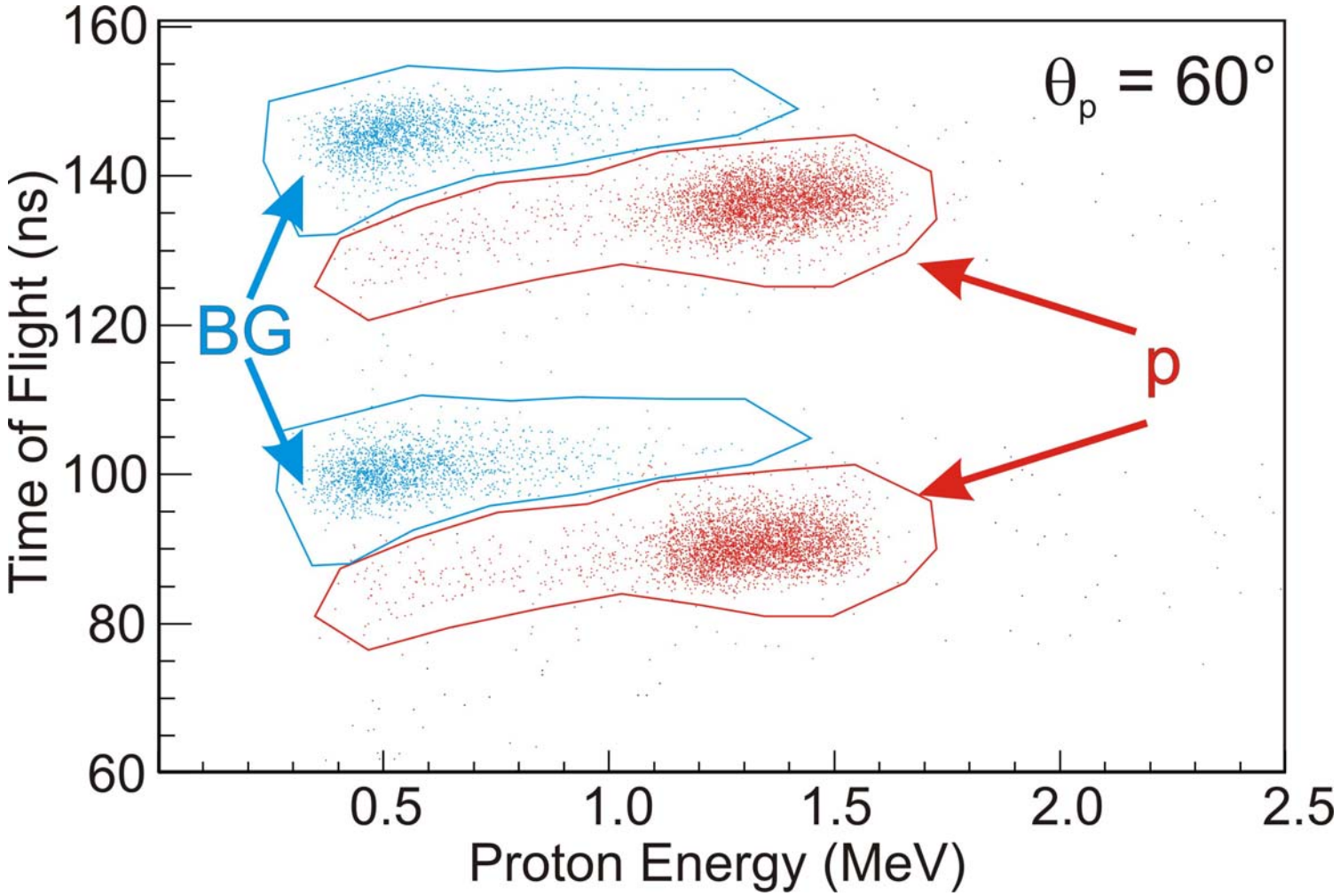
⇒ ΔE / E

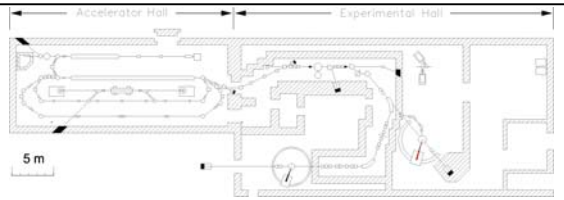
✓ TOF

Method

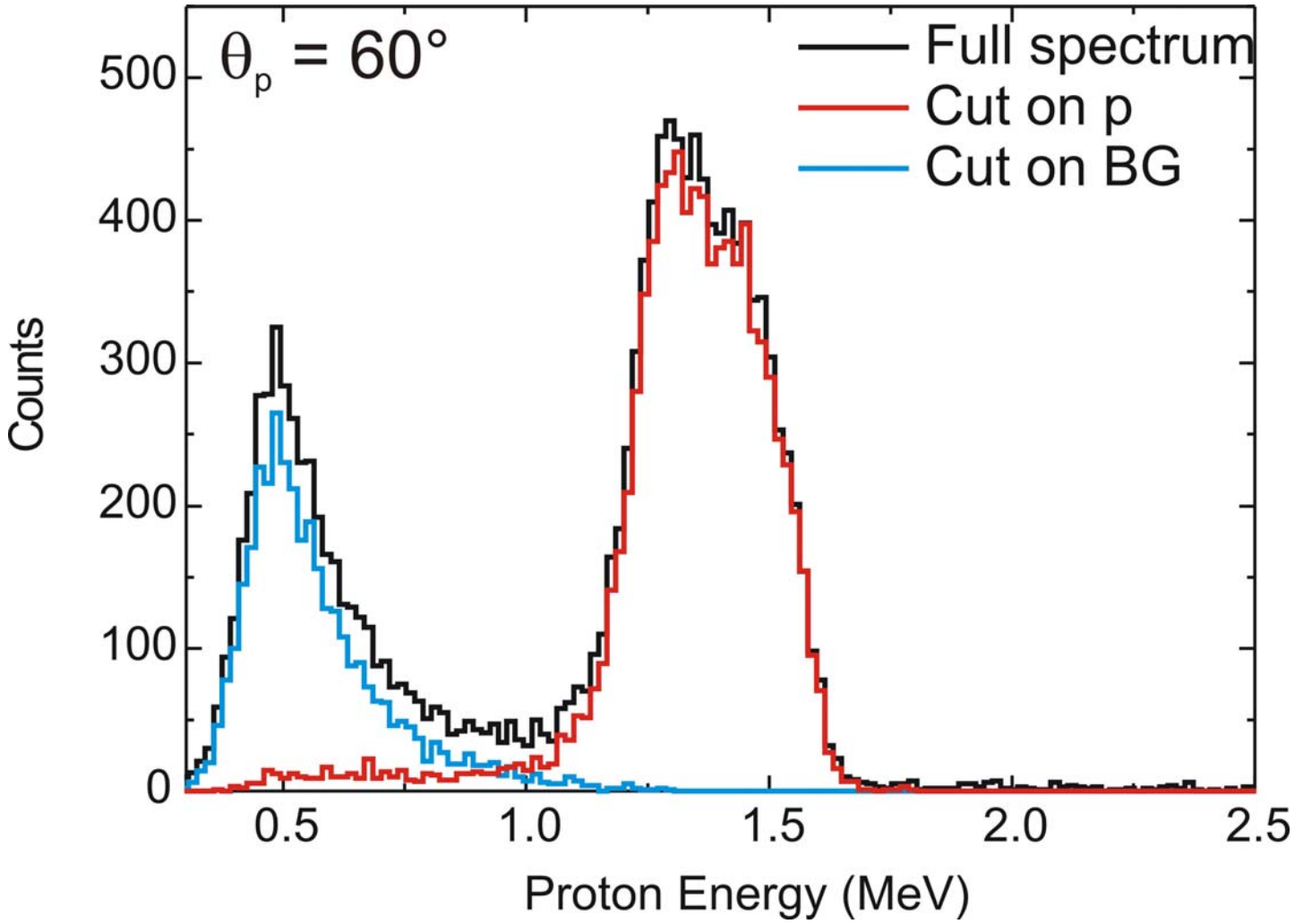


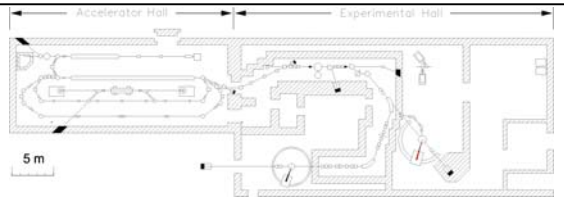
Background Subtraction by TOF Method



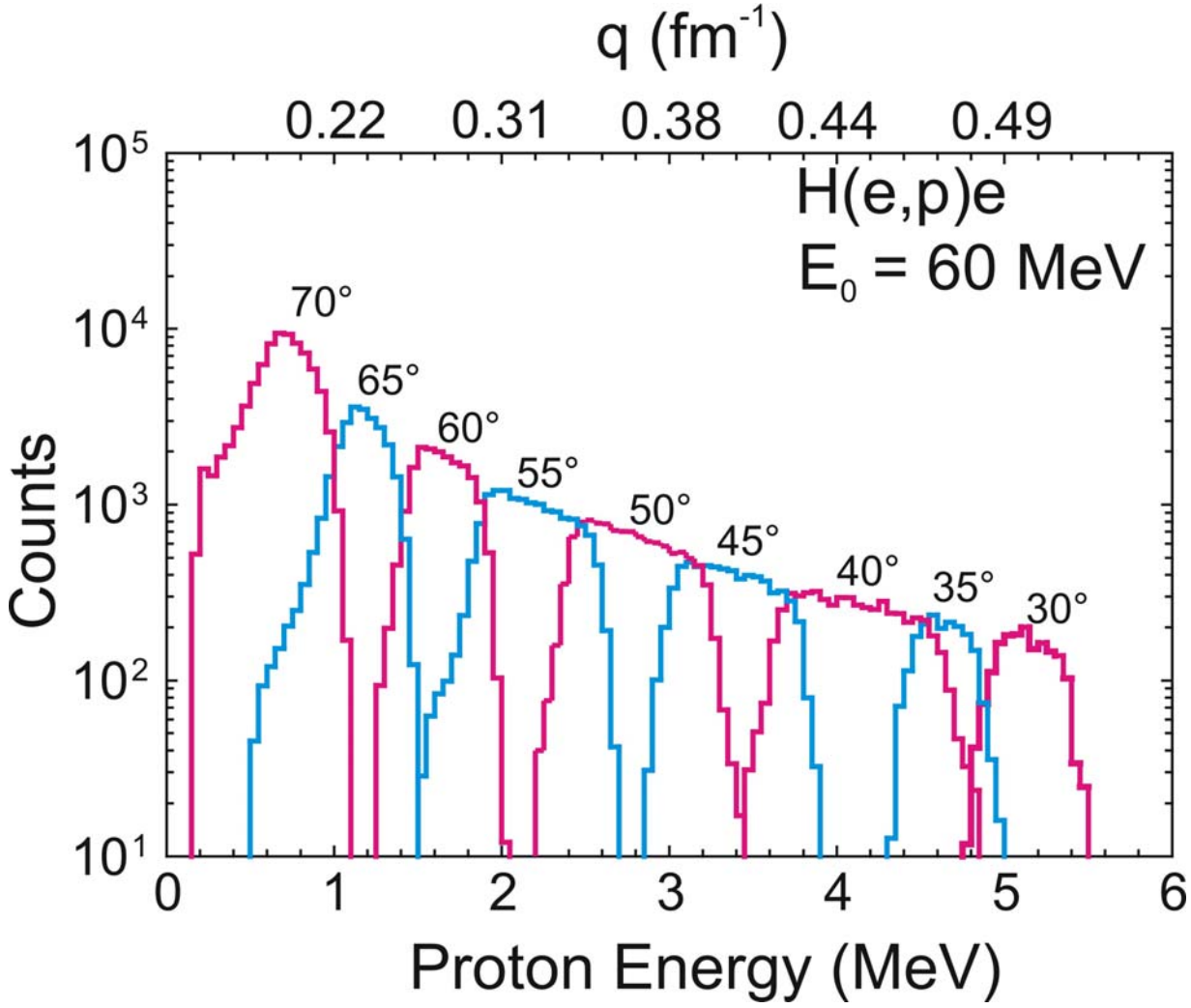


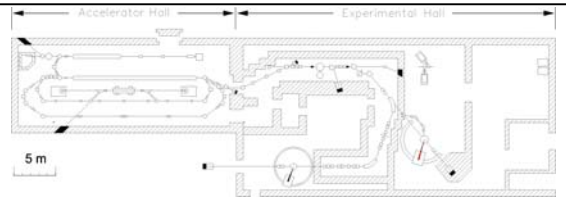
Projected Spectra





Measured Energy Spectra





Outlook

- **Final design**
  - ➡ setup with new detectors
- **New requirements**
  - ➡ adjustment of setup
  - ➡ backward angles ⟶ define q by angle definition
  - ➡ BG at forward angles ⟶ ΔE/E telescopes
- **Experiment**
  - ➡ first half 07
- **Different beam energies**
  - ➡ Rosenbluth separation ⟶ magnetic FF

Raduis Extraction

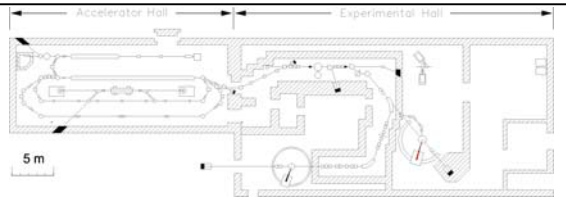
$$\frac{d\sigma}{d\Omega} = \left.\frac{d\sigma}{d\Omega}\right|_{Mott} \cdot F\left(q^2\right)$$

$$F\left(q^2\right) = \left\{\left(\frac{G_E^2 + \tau \cdot G_M^2}{1+\tau}\right) + 2\tau \cdot G_M^2 \tan^2\left(\theta/2\right)\right\}$$

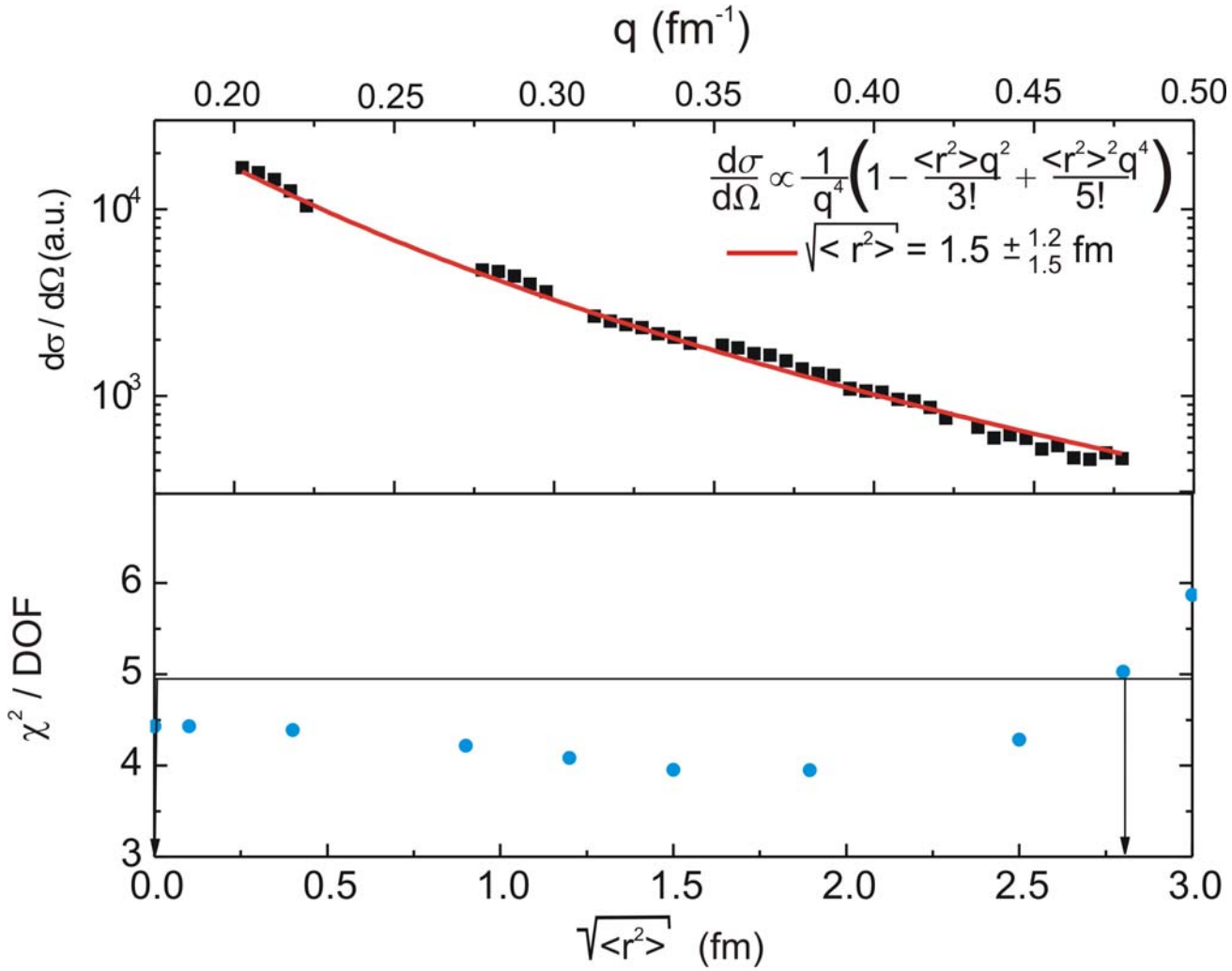
$$\tau = \frac{q^2}{4M^2} \qquad q \to 0 \qquad \tau = 0$$

$$\frac{d\sigma}{d\Omega} = \left.\frac{d\sigma}{d\Omega}\right|_{Mott} \cdot \left(1 - \frac{\left\langle r^2\right\rangle q^2}{3!} + \frac{\left\langle r^4\right\rangle q^4}{5!} - \cdots\right)$$

$$\frac{\left\langle r^2\right\rangle}{6} = -\left.\frac{dG_E^P\left(q^2\right)}{dq^2}\right|_{q\to 0}$$



Preliminary Results



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