Precision Measurement of the Proton Charge Radius with Elastic Electron Scattering *

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- **Motivation**
- **Experimental Technique**
- **Test Experiment**
- **Outlook**

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Extraction of the Mean Squared Charge Radius

$$\frac{d\sigma}{d\Omega}(E_0,\theta) = \sigma_{NS}\left[F1(q^2) + F2(q^2)\tan^2(\theta/2)\right]$$

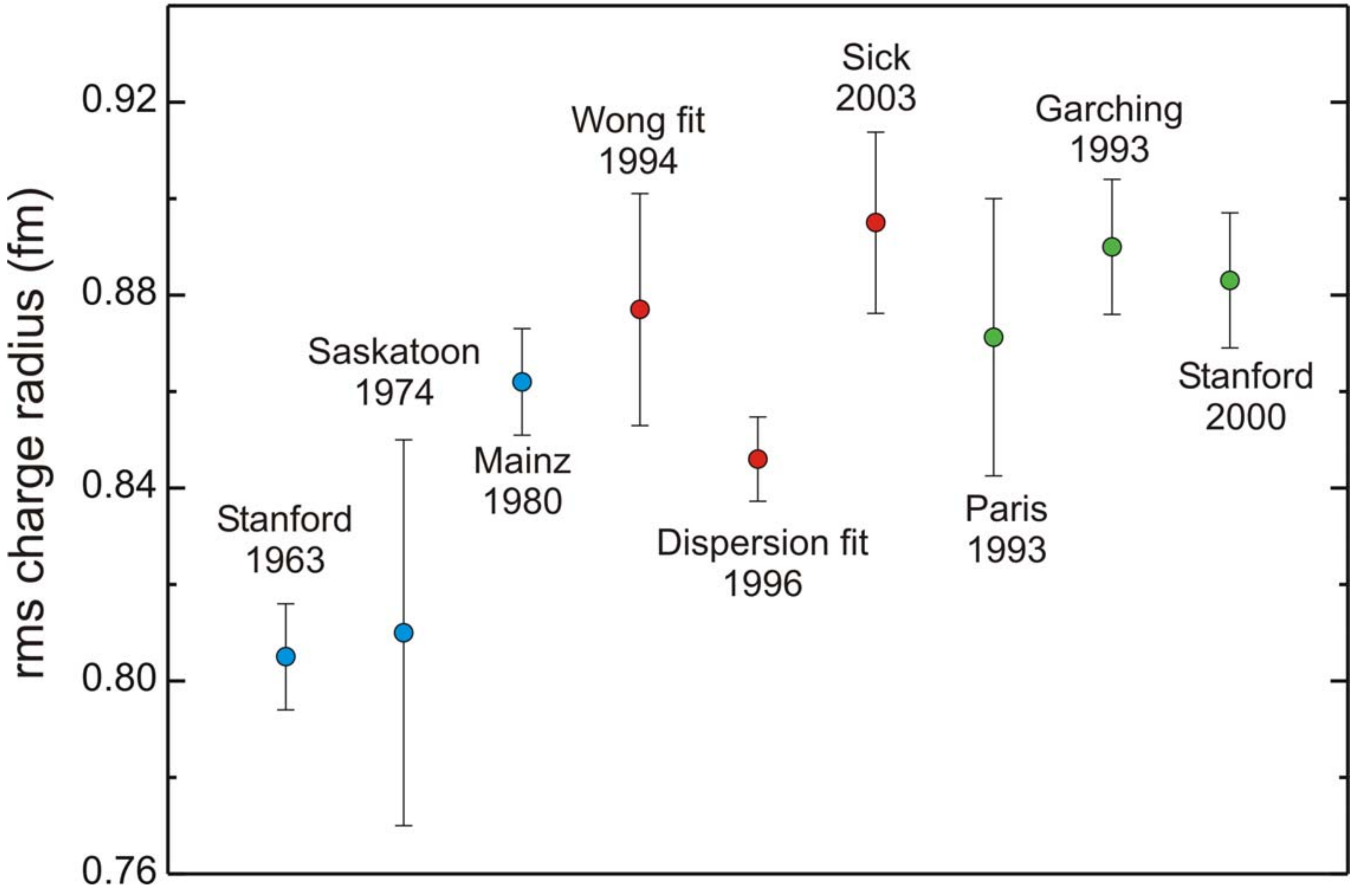
$$F1(q^2) = \left[G_E^{P^2}(q^2) + \tau \cdot G_M^{P^2}(q^2)\right] \Big/ (1+\tau)$$

$$F2(q^2) = 2\tau \cdot G_M^{P^2}(q^2)$$

$$\tau = \frac{q^2}{4M_p^2}$$

$$\frac{\langle r^2 \rangle}{3!} = \left. \frac{d\, G_E^{P^2}(q^2)}{dq^2} \right|_{q^2=0}$$

Previous Results



Motivation

- resolve the discrepancy between

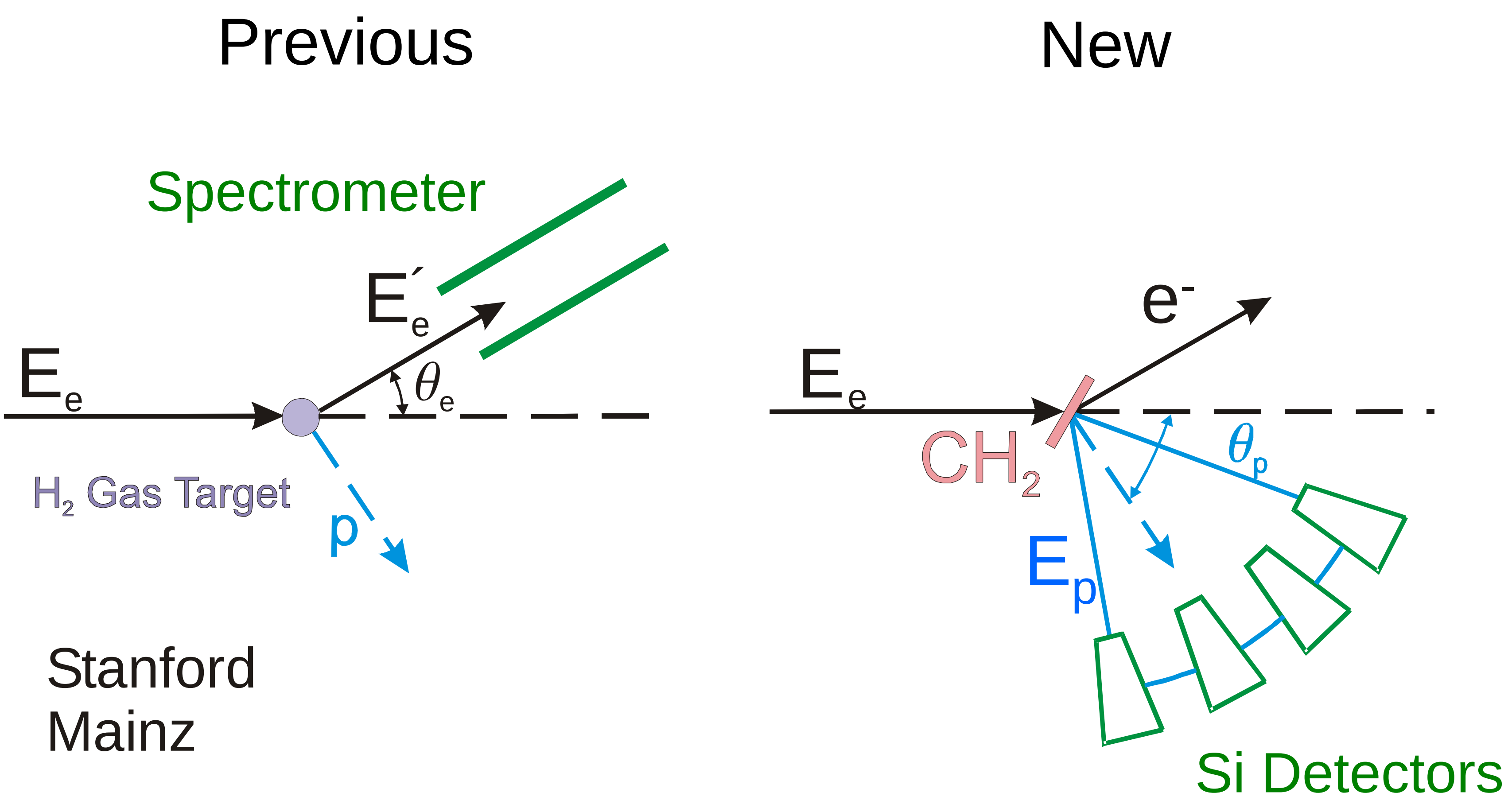
  different results

- recent Lamb shift measurements

  → QED predictions need $<r^2>$

- a new method: measure recoil protons,
  not electrons

New Idea: Detect Protons and not Electrons!



Advantages

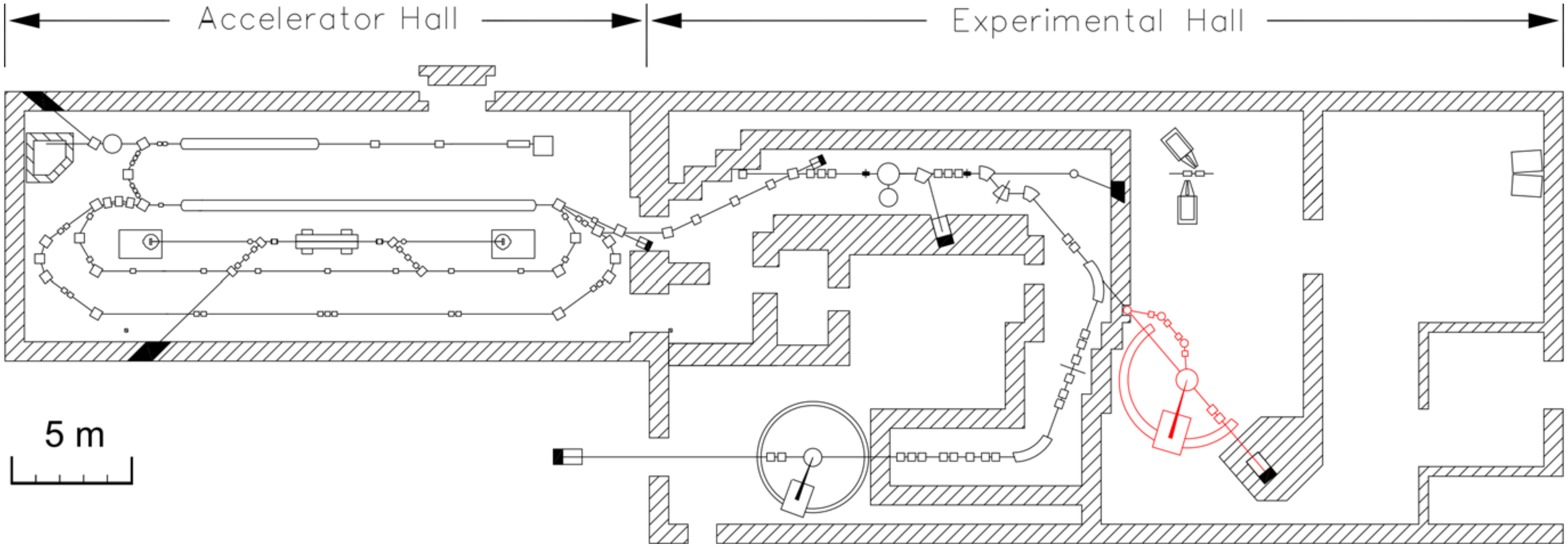
- complete angular distribution measured simultaneously

  ⇒ large momentum transfer range

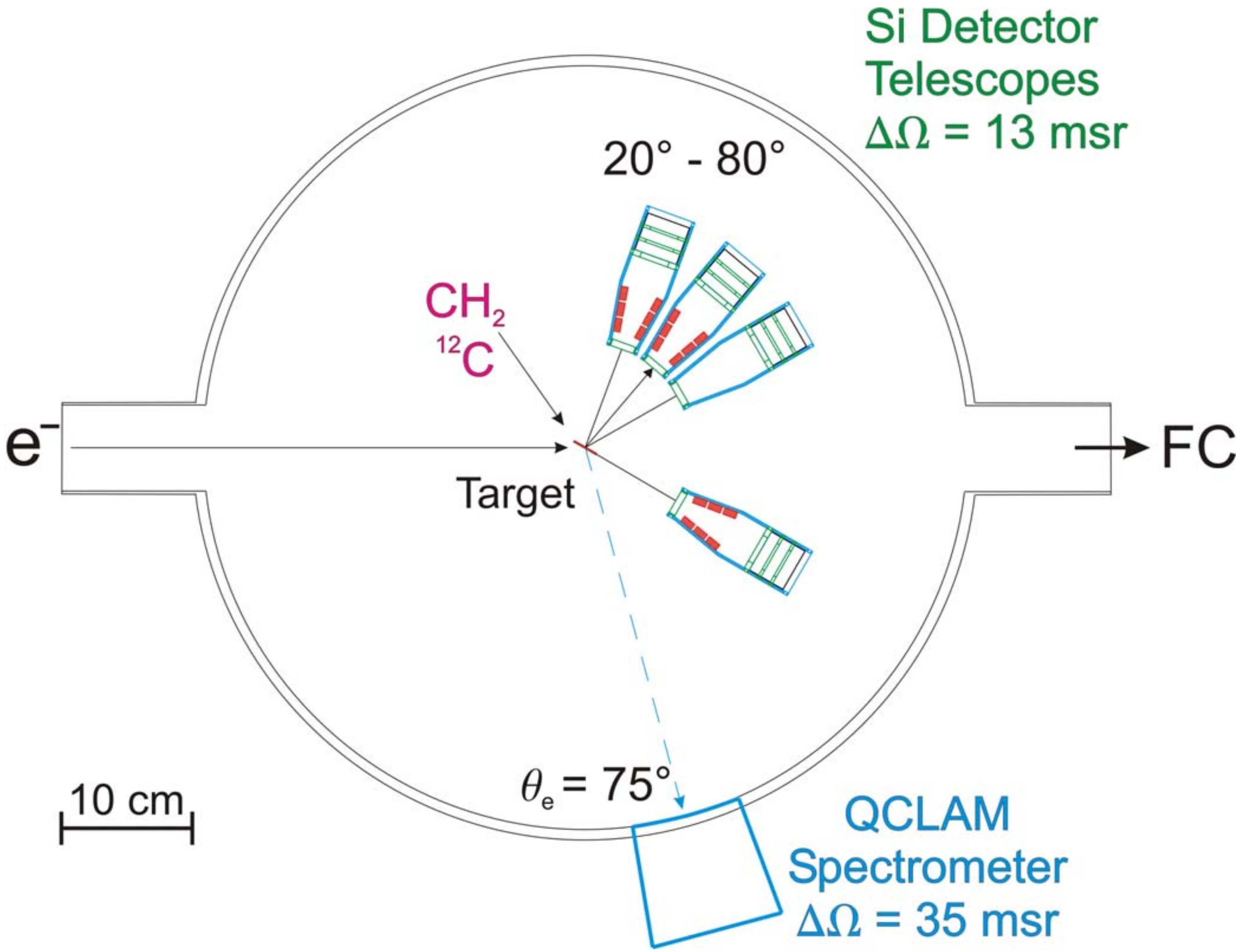
  in a single run (0.15 - 1 fm^{-1})

- avoid difficult normalization
- proton detection efficiency is ~1
- precise definition of solid angle
- same momentum transfer range with different beam energies (Rosenbluth separation)

S-DALINAC



Test Experiment



Aim of the Test Experiment

- Background sources

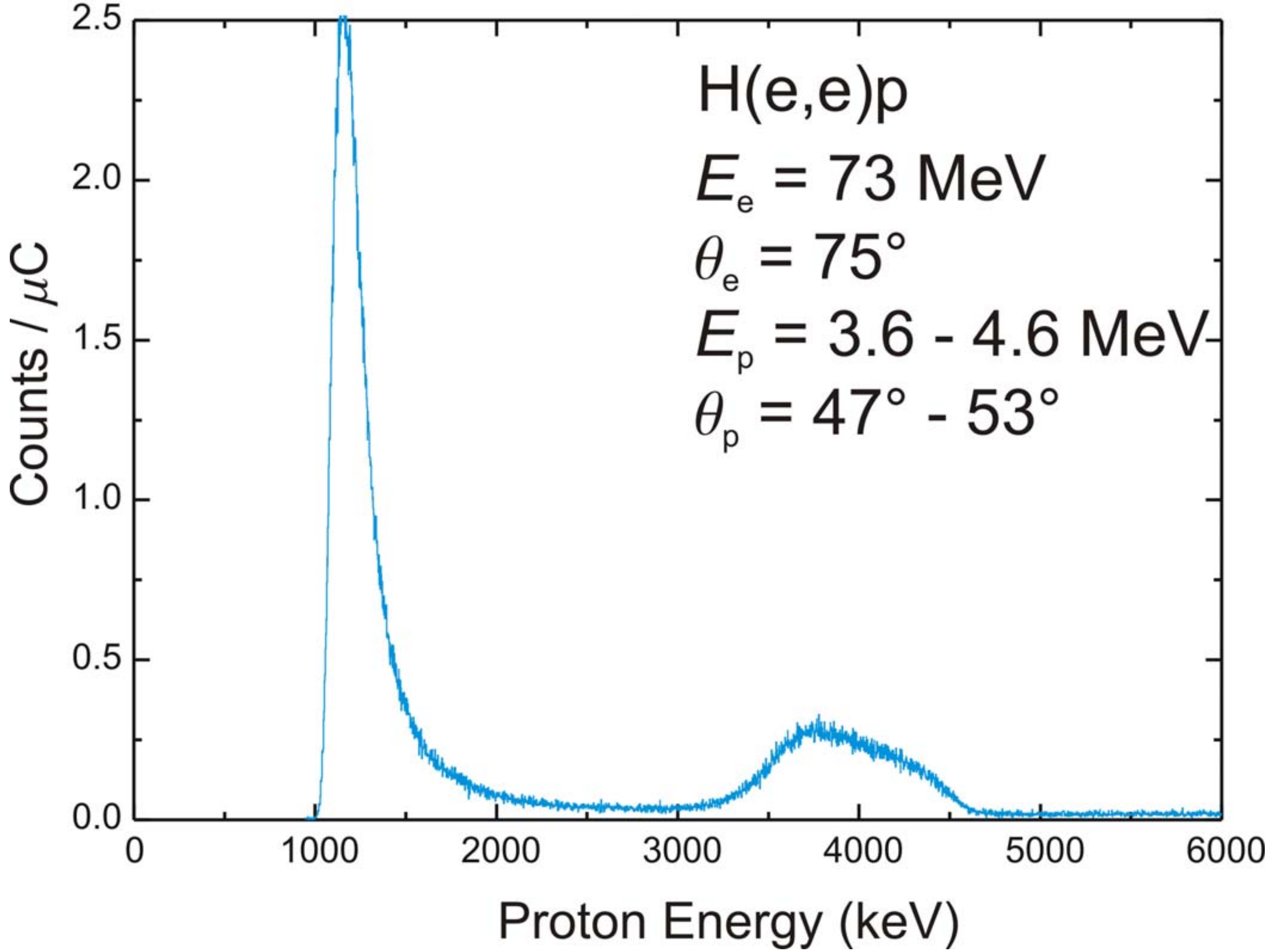
- Kinematic coincidence

  → role of the radiation tail

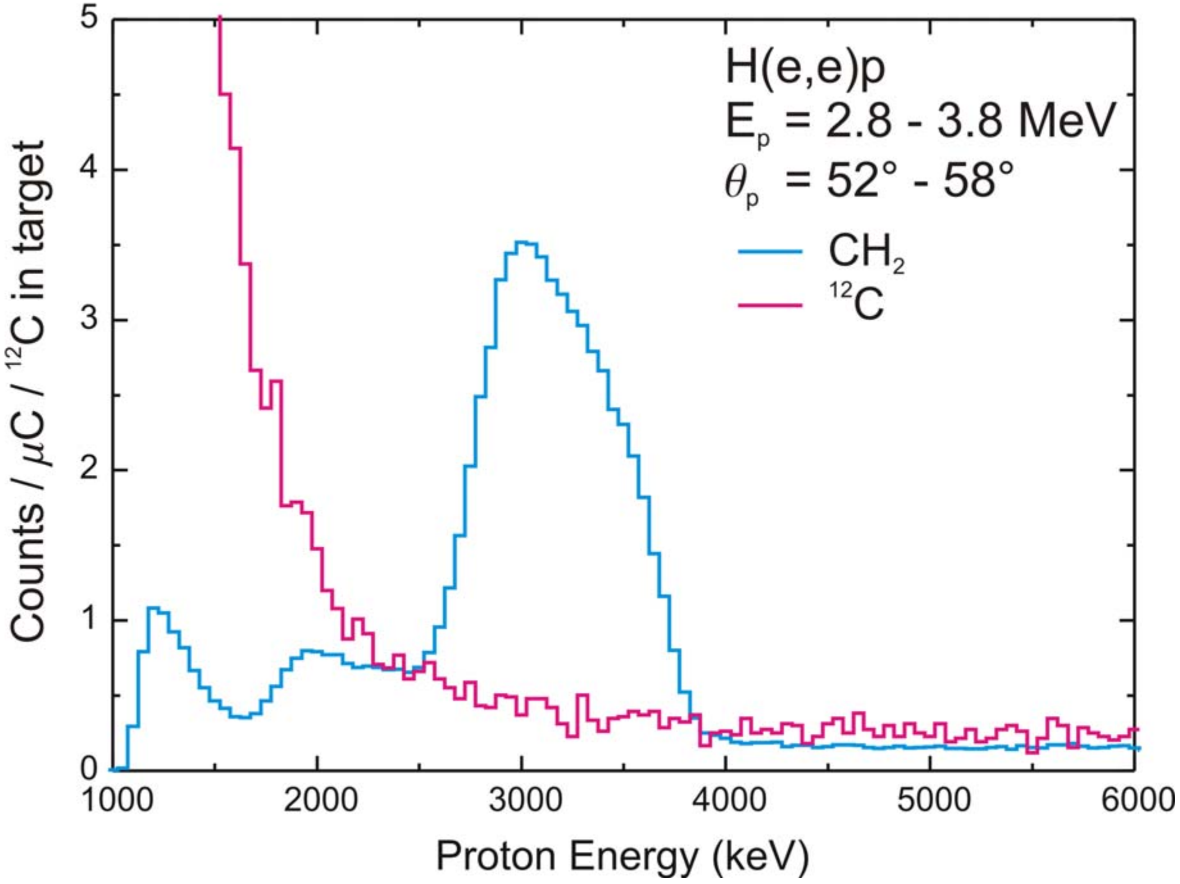
- Determination of momentum transfer

  → from proton energy or angle ?

Measured Spectrum

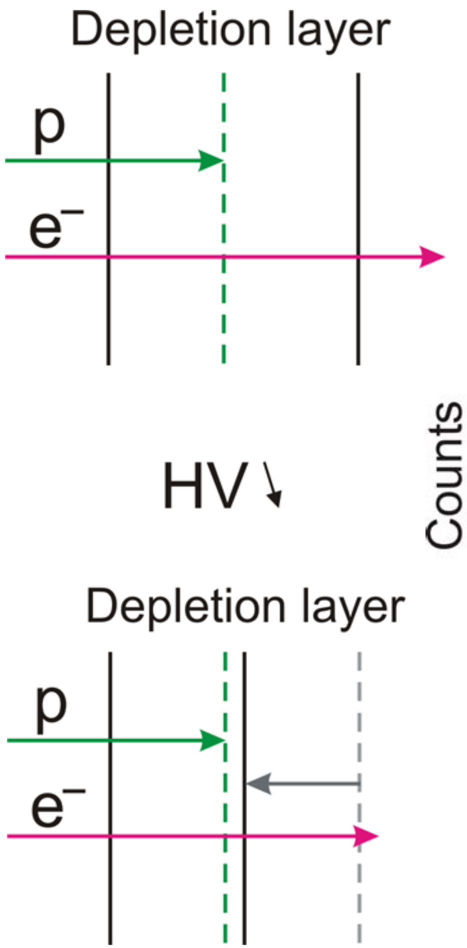


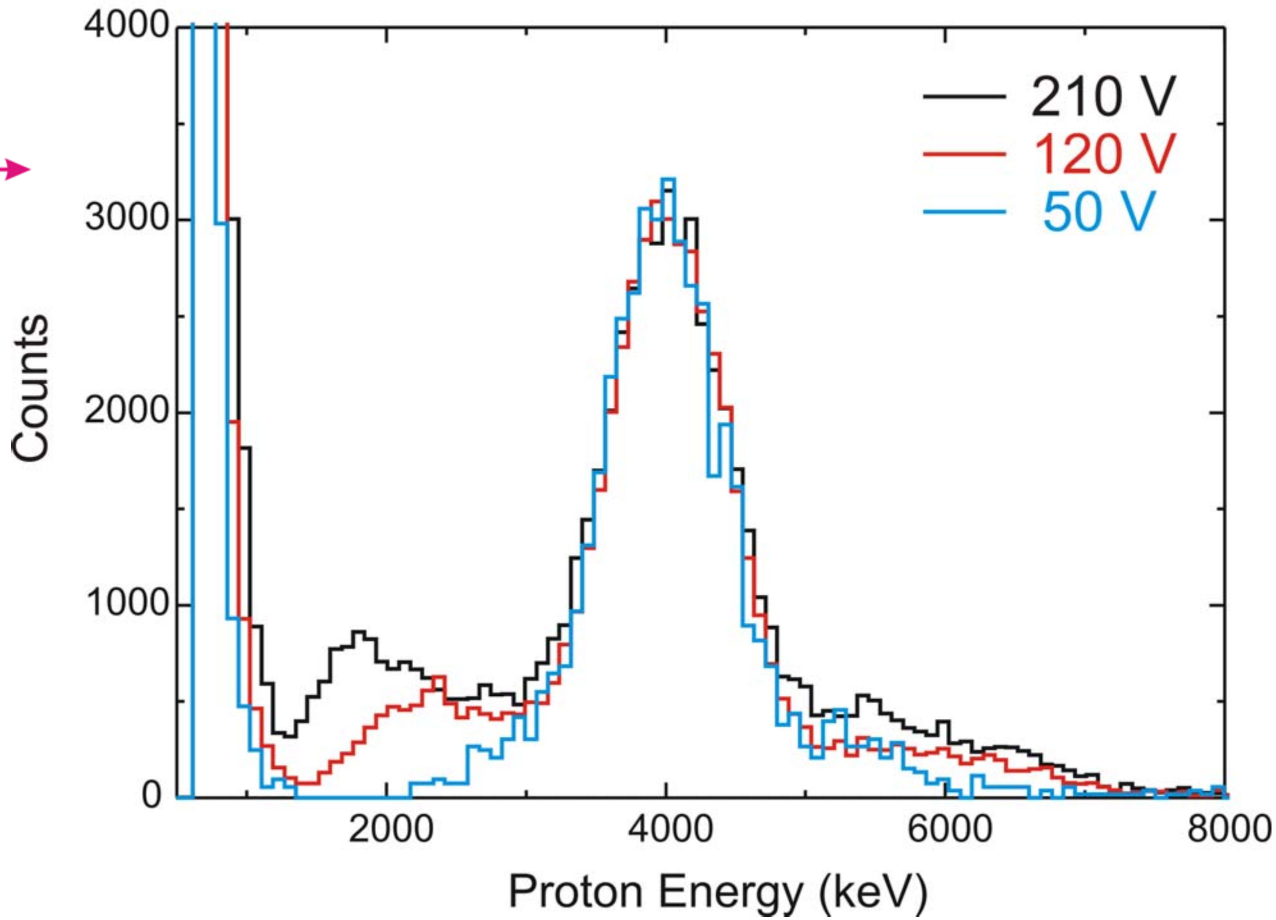
Target Background



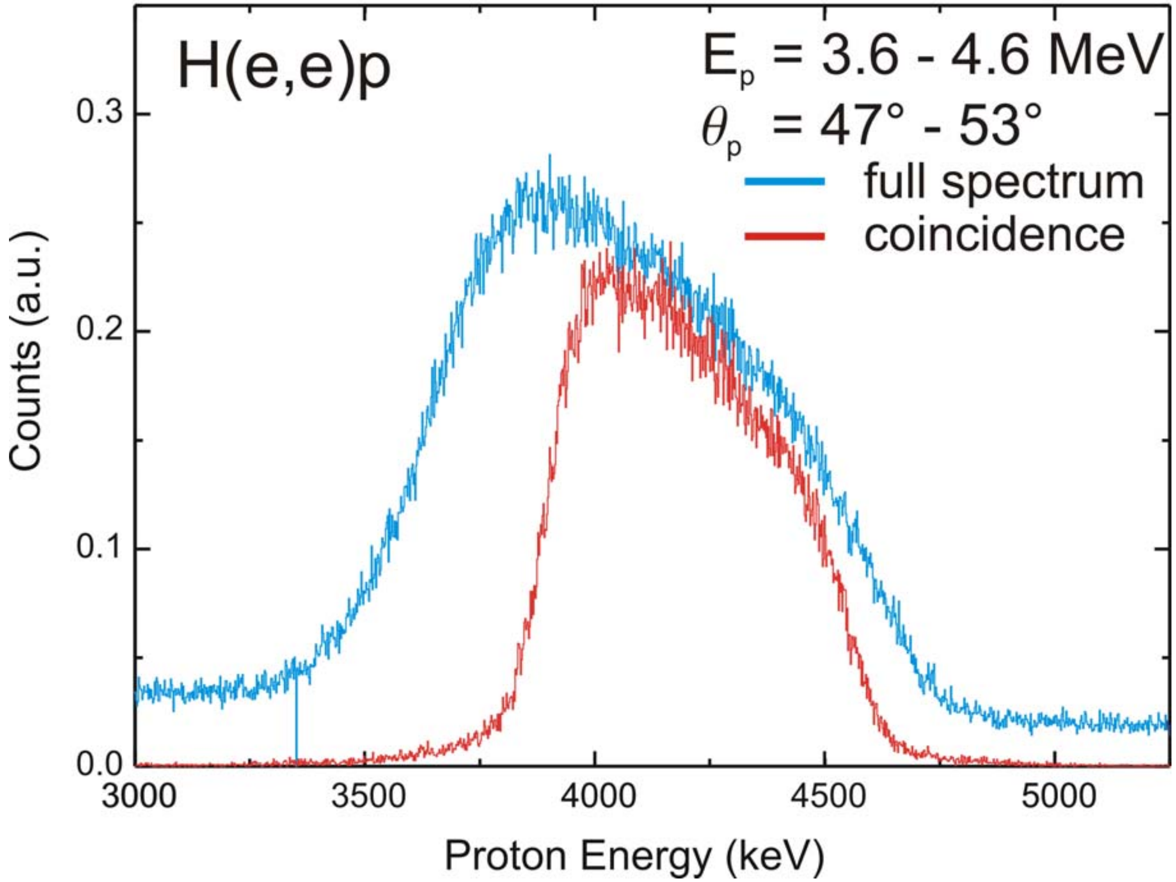
- Same background

Bias Voltage → Improve Background





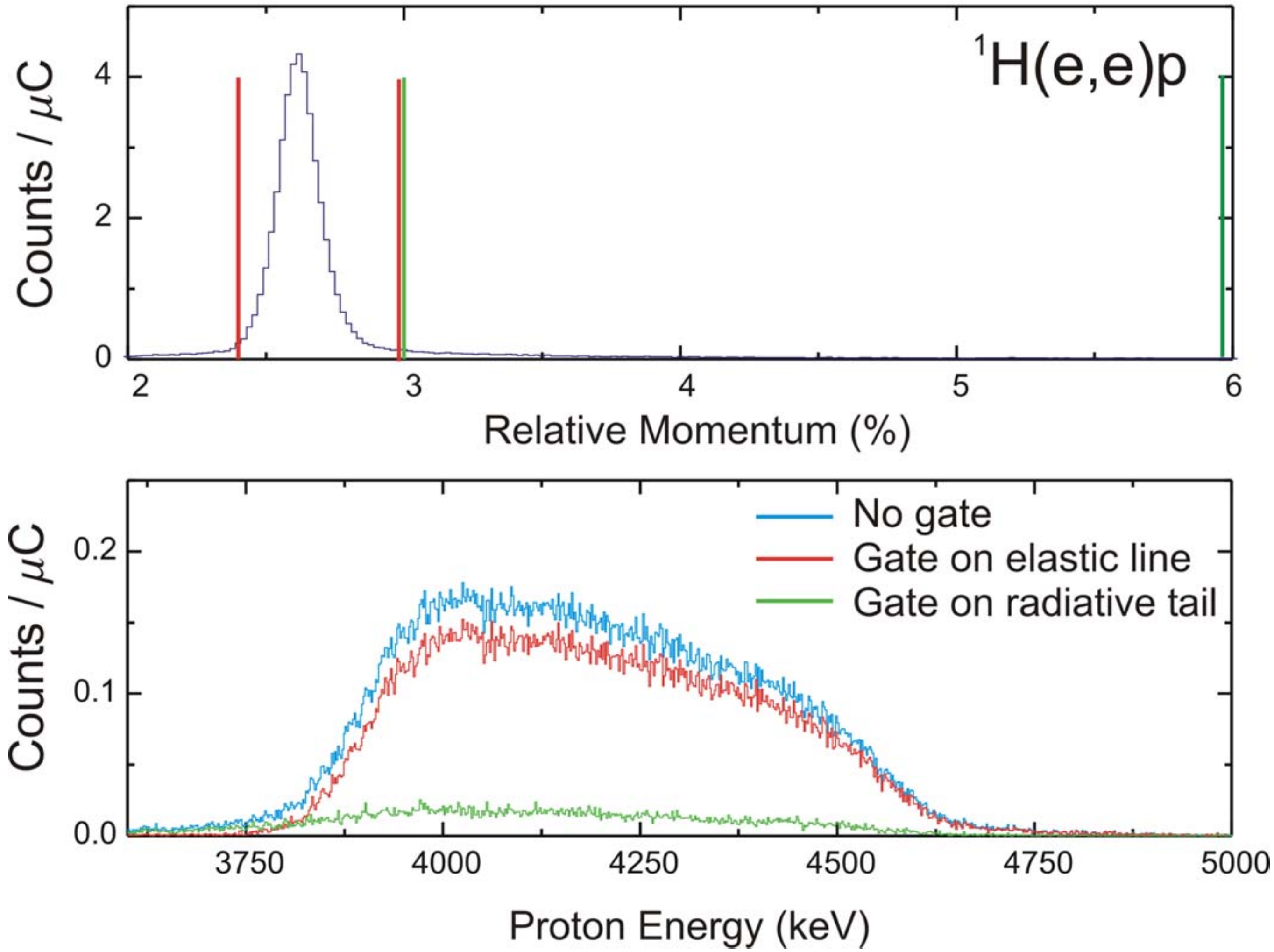
Coincidence



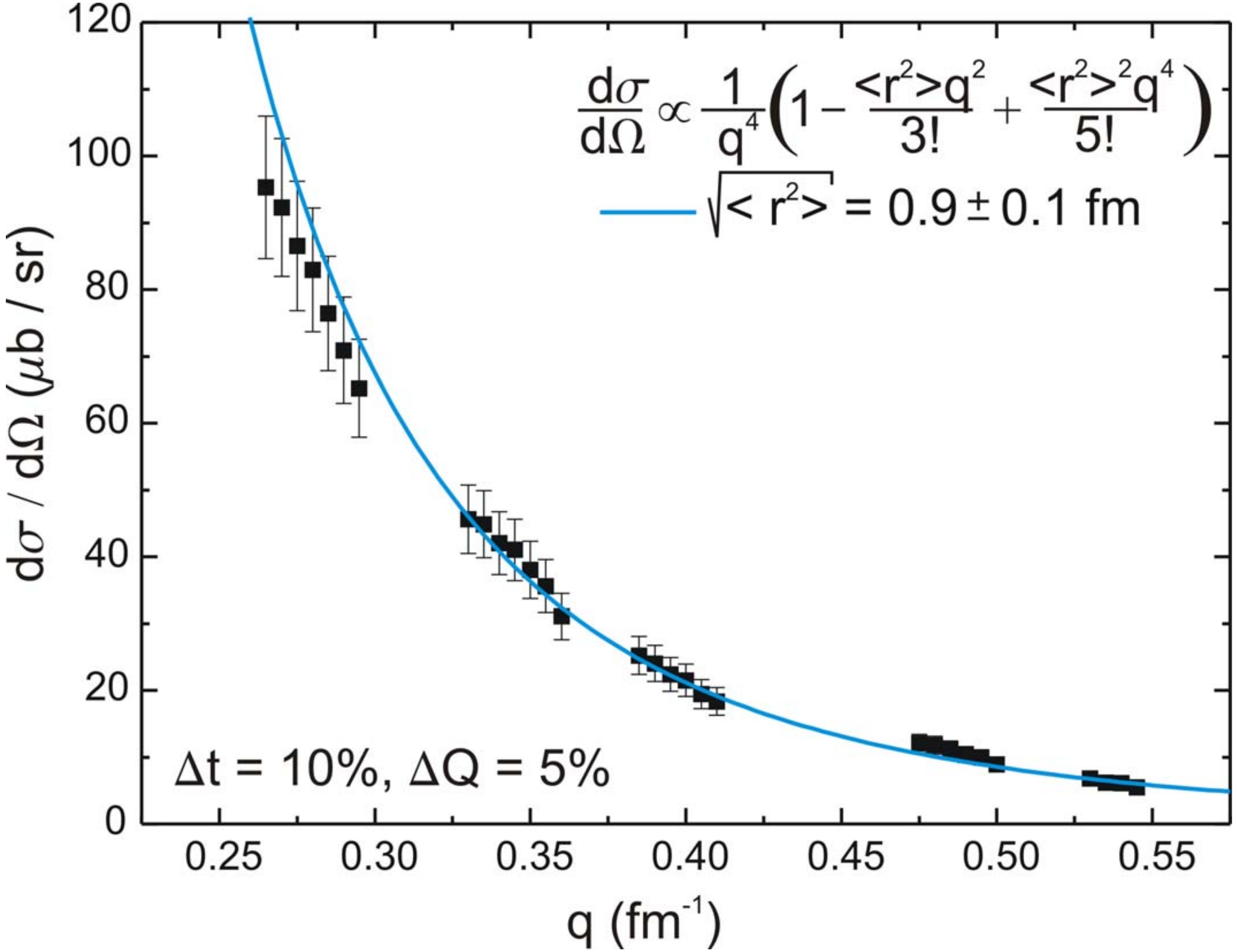
- **Coincidence measurements**

  → good correspondence after background subtraction

Background from Radiative Tail



Preliminary Results



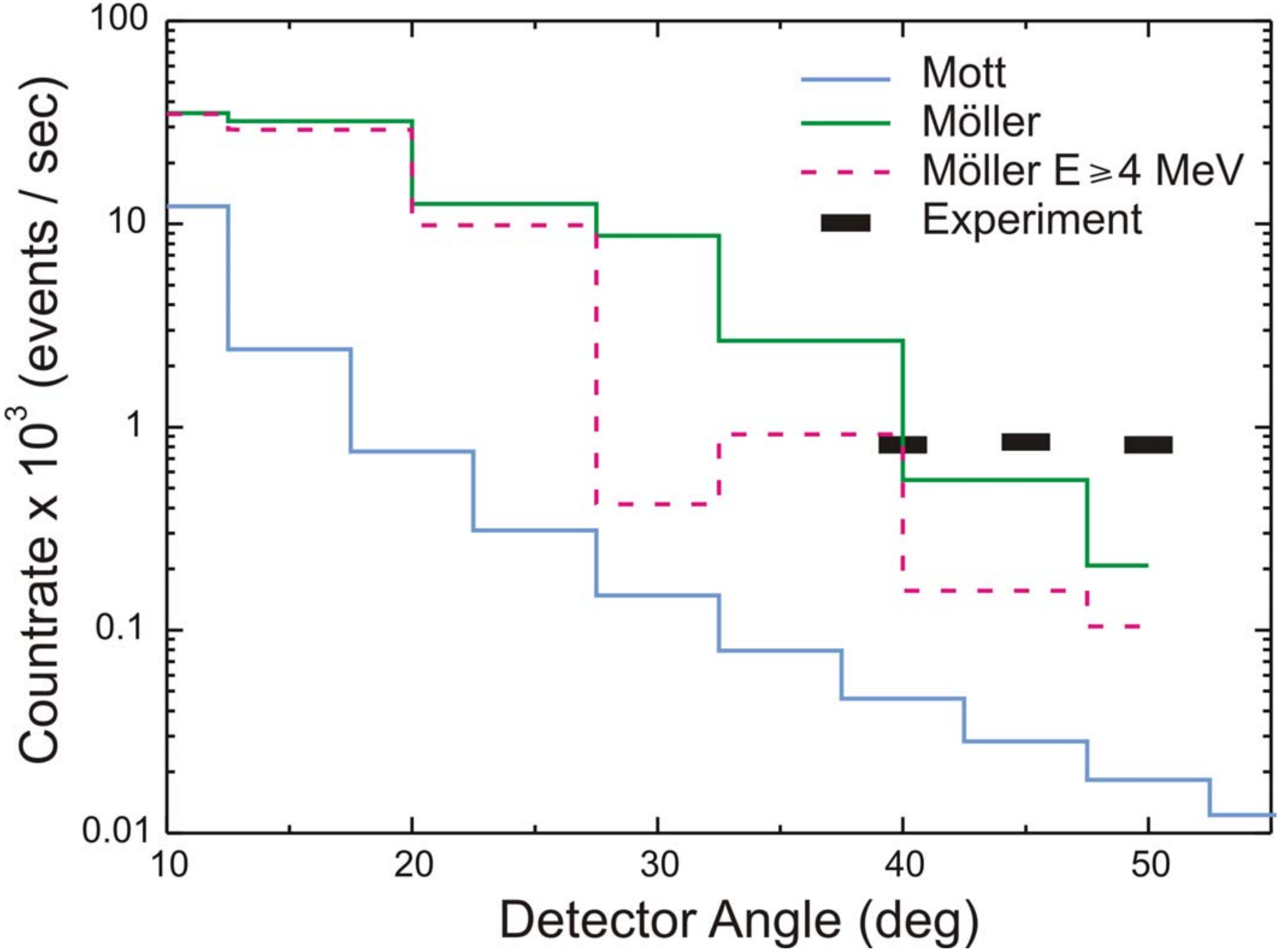
Summary

- **Test experiment**
  - → shows the feasibility
- **Investigations of background**
  - → Mott → lower count rate
  - → Möller ? → Geant4 simulations
- **Suppression of possible background sources**
  - → bias optimization
  - → thinner detectors for larger angles
  - → pulsed beam → TOF difference

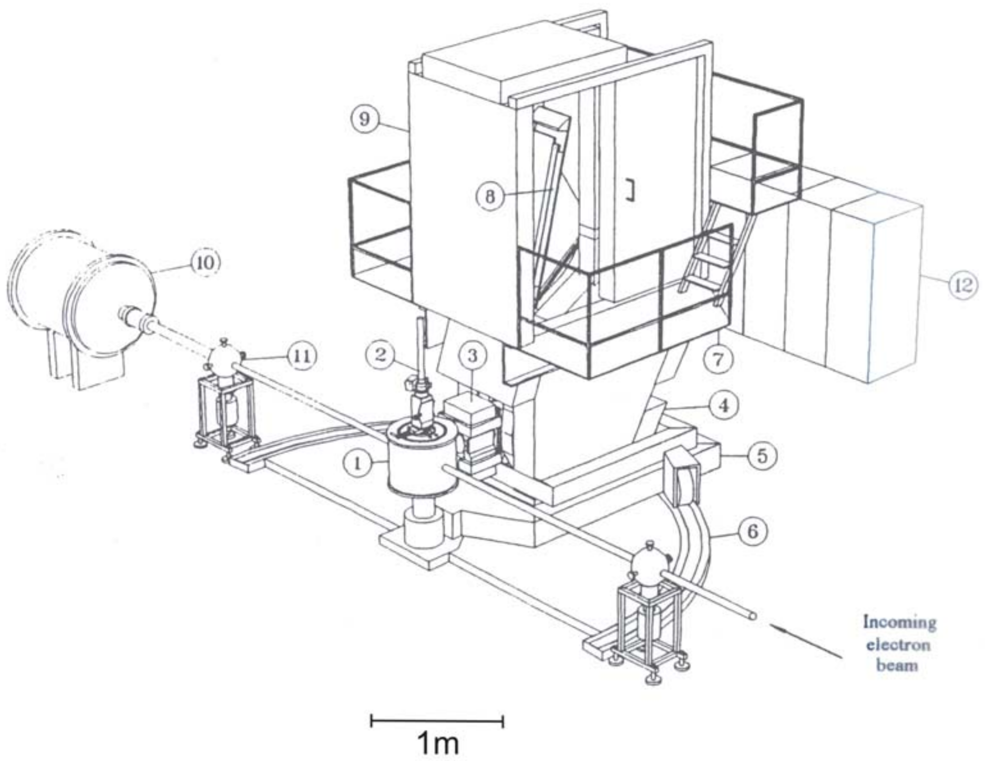
Outlook

- **Final Design**
  - ⇒ make detectors
  - ⇒ modify telescopes
- **Measurements**
  - ⇒ Spring 2006

Geant4 Simulations for Carbon Target

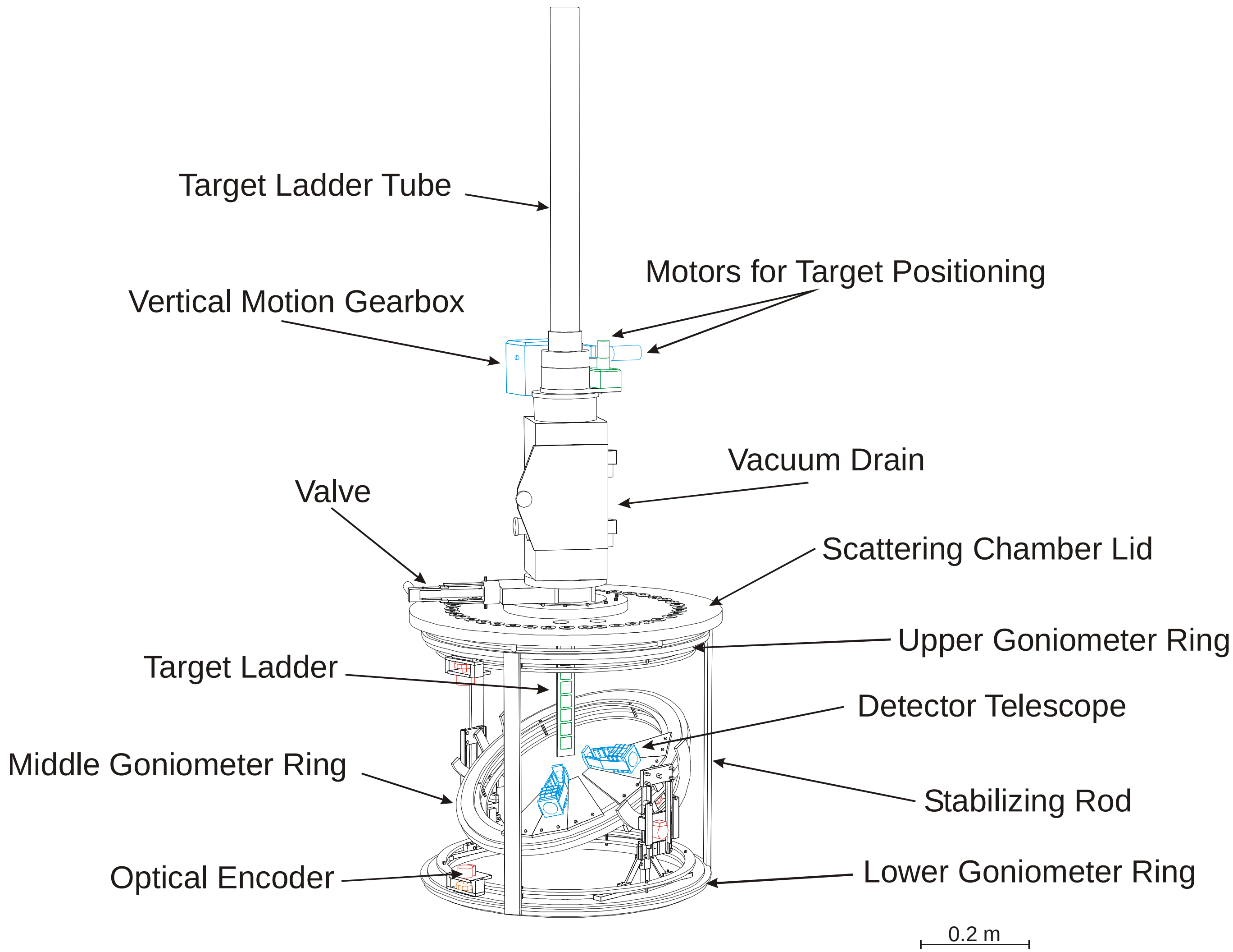


QCLAM - Spectrometer



1 - Scattering Chamber
2 - Target Ladder
3 - Quadrupole Magnet
4 - Dipole Magnet
5 - Rotational Platform
6 - Slide Rail
7 - Working Platform
8 - Detector System
9 - Lead Shielding
10 - Faraday Cup
11 - Vacuum and Pumping Station
12 - Electric Power Supply for Magnets

Goniometer


Target Ladder Tube
Motors for Target Positioning
Vertical Motion Gearbox
Vacuum Drain
Valve
Scattering Chamber Lid
Upper Goniometer Ring
Target Ladder
Detector Telescope
Middle Goniometer Ring
Stabilizing Rod
Optical Encoder
Lower Goniometer Ring
0.2 m

χ^2 -Distrubution