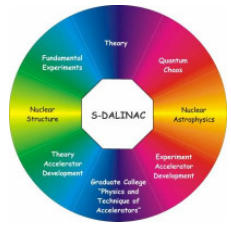
Polarizability of the Nucleon*

Olena Yevetska

TECHNISCHE UNIVERSITÄT DARMSTADT

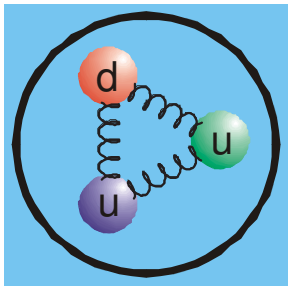
- Motivation
- Experimental setup
- Experiments and results
- Summary and outlook

SFB 634



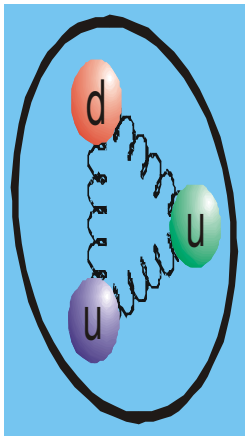
*Supported by the DFG within SFB 634

Motivation



α, β - electric and magnetic polarizabilities

$$\vec{d} = \alpha\vec{E} \qquad \vec{\mu} = \beta\vec{B}$$



$\vec{E}$
$\vec{B}$

describe the response of the nucleon internal structure to applied electric and magnetic fields

$$\overline{\alpha}_p = (11.9 \pm 0.5 \mp 1.3) \times 10^{-4}\ fm^3 \qquad \overline{\beta}_p = (1.2 \pm 0.7 \pm 0.3) \times 10^{-4}\ fm^3$$

V. Olmos de Leon *et al.*, Eur. Phys. J. **A10** (2001) 207

Goal: better accuracy of these constants

Motivation

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Low energy Compton scattering (E < 140 MeV)

Low Energy Theorem:

$$\frac{d\sigma(E_\gamma,\theta)}{d\Omega} = \left[\frac{d\sigma(E_\gamma,\theta)}{d\Omega}\right]_{Point} - \rho + 0(E_\gamma^4)$$

$\left[\frac{d\sigma(E_\gamma,\theta)}{d\Omega}\right]_{Point}$ Powell cross section for the point like proton with anomalous magnetic moment

$\rho \sim \left[\frac{\bar{\alpha}+\bar{\beta}}{2}(1+\cos\theta)^2 + \frac{\bar{\alpha}-\bar{\beta}}{2}(1-\cos\theta)^2\right]E_\gamma^2$ Structure term

$0(E_\gamma^4)$ Terms of higher order structure constants

V. Petrun'kin *et al.*, Sov. J. Part. Nucl. **12** (1981) 278

Experiment with Compton Scattering

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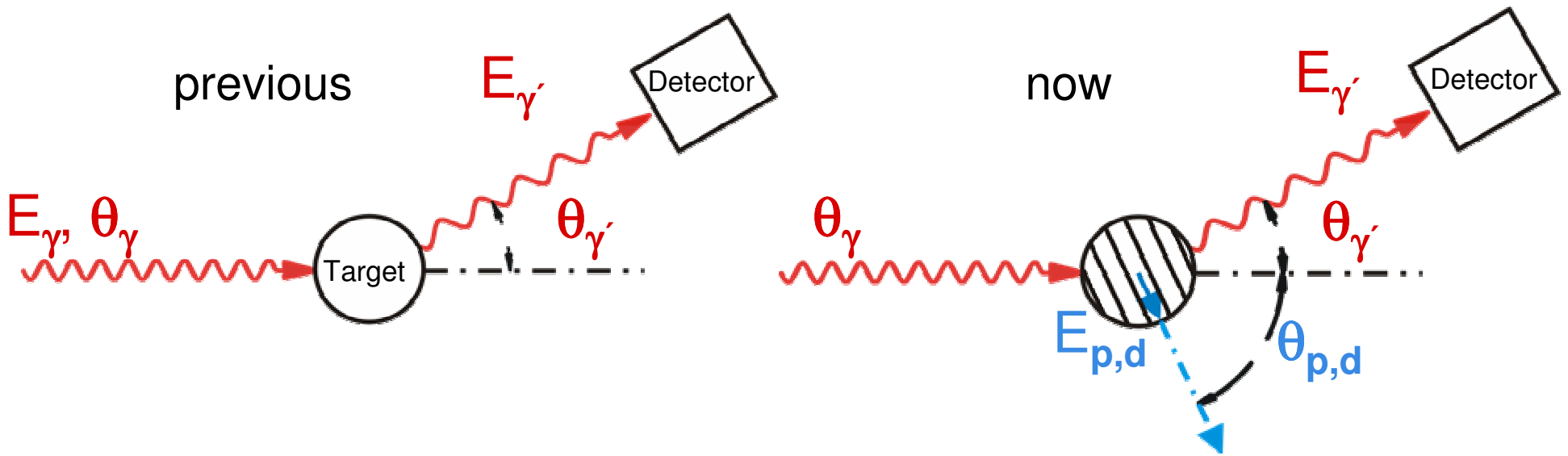

Liquid H/D-target

Active high pressure H/D-target

E_p = 0.4 – 8 MeV

- high luminosity:

10^6 γ/MeV/s 10^9 γ/MeV/s

- background suppression:

redundancy of kinematic values

- Bremsstrahlung spectrum has to be known

S-DALINAC

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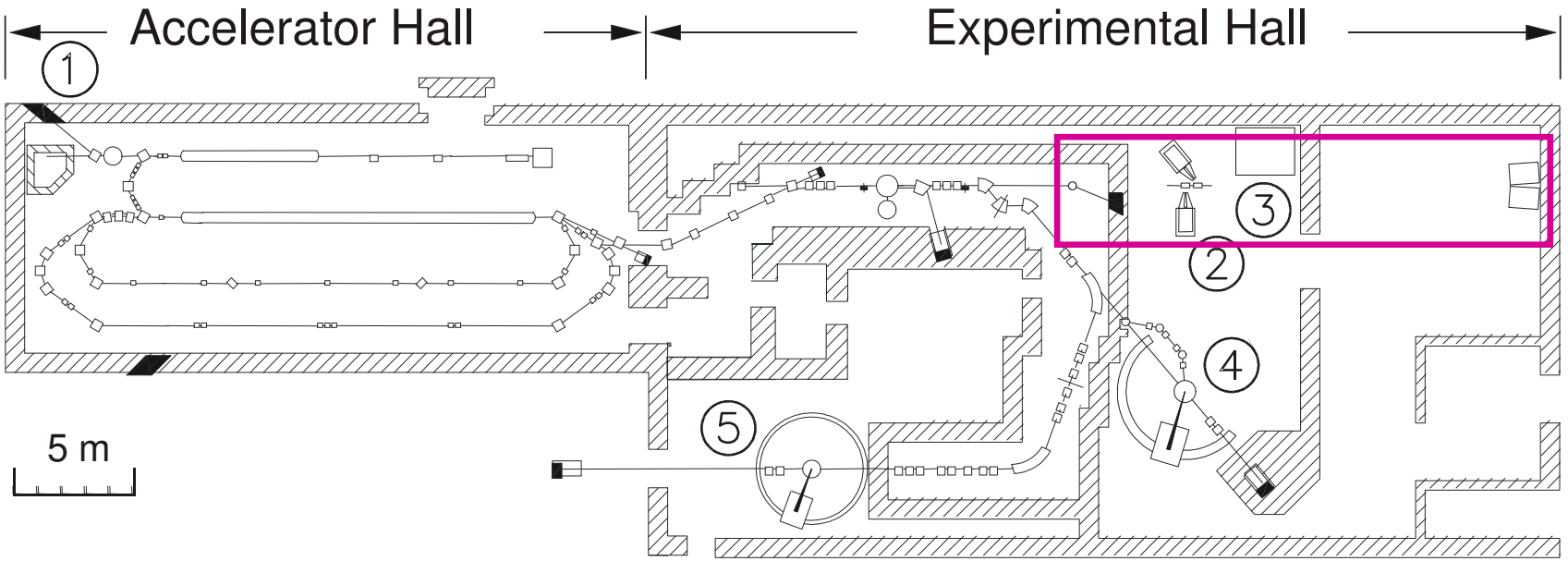

Design Parameters

Maximum energy:	130 MeV
Energy spread :	10^{-4}
Maximum current:	20 μA
Material:	Niobium
Temperature:	2K

1. (γ,γ´) & (γ,n) - Experiments
2. Compton Scattering on Nucleon
3. (γ,γx)- Experiments at NEPTUN Tagger
4. (e,e´x) & 180°- Experiments at QCLAM Spectrometer
5. (e,e´) - Experiments at Lintott Spectrometer

Experimental Setup

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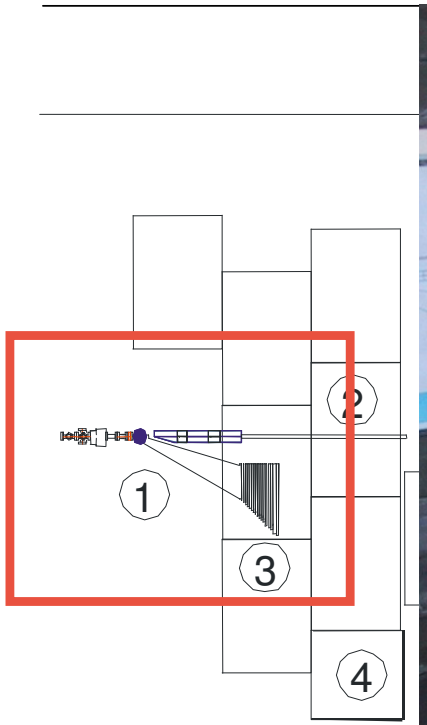

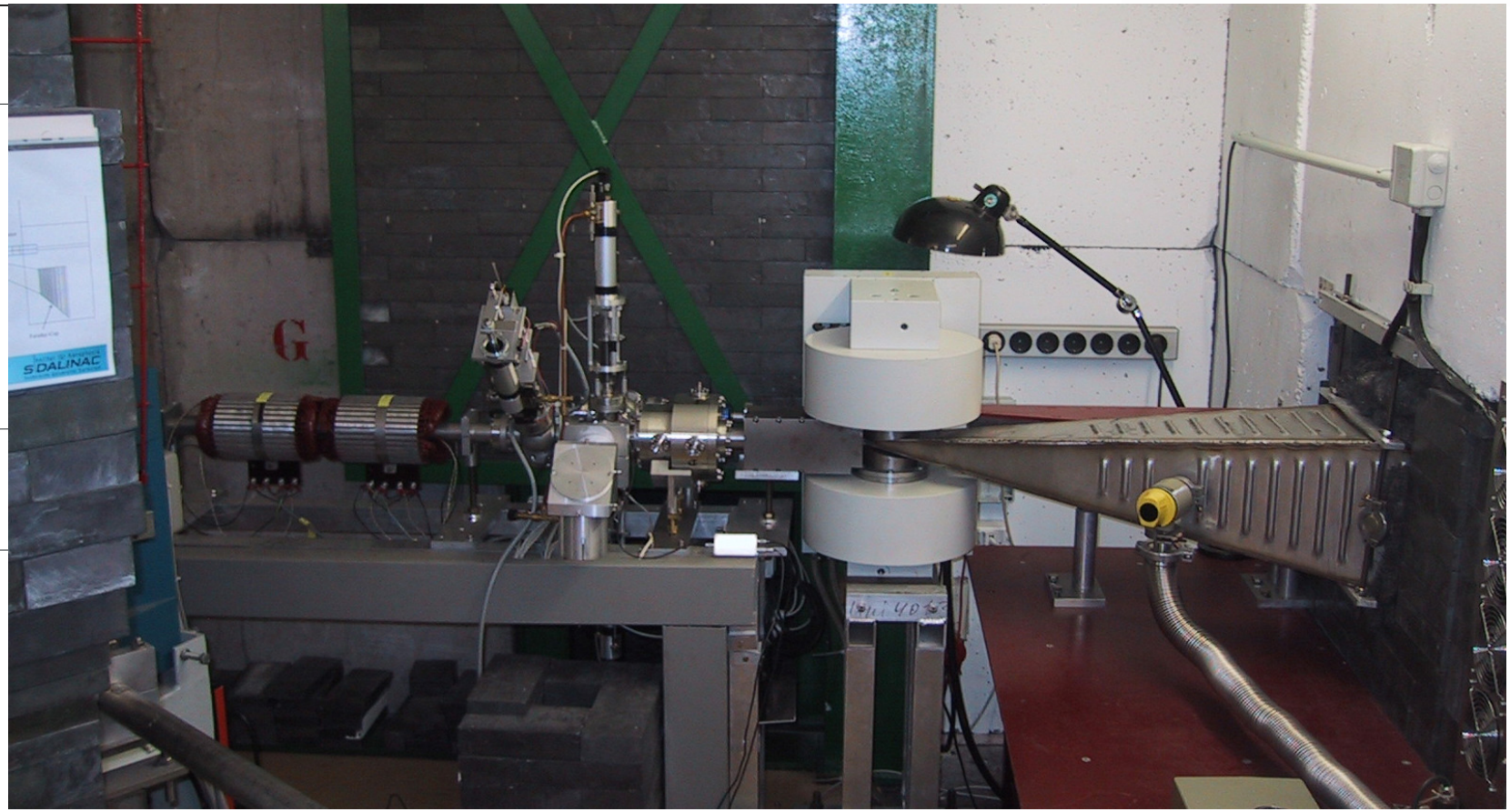

1 – Bremsstrahlung facility
2 – Collimator system
3 – Faraday cup
4 – Concrete shield

5 – High pressure ionisation cahmber
6 – NaI(Tl) spectrometer (10“x14“)
7 – Collimator system
8 – BPM, Quantameter
9 – NaI(Tl) spectrometer (10“x10“)

Experimental Setup

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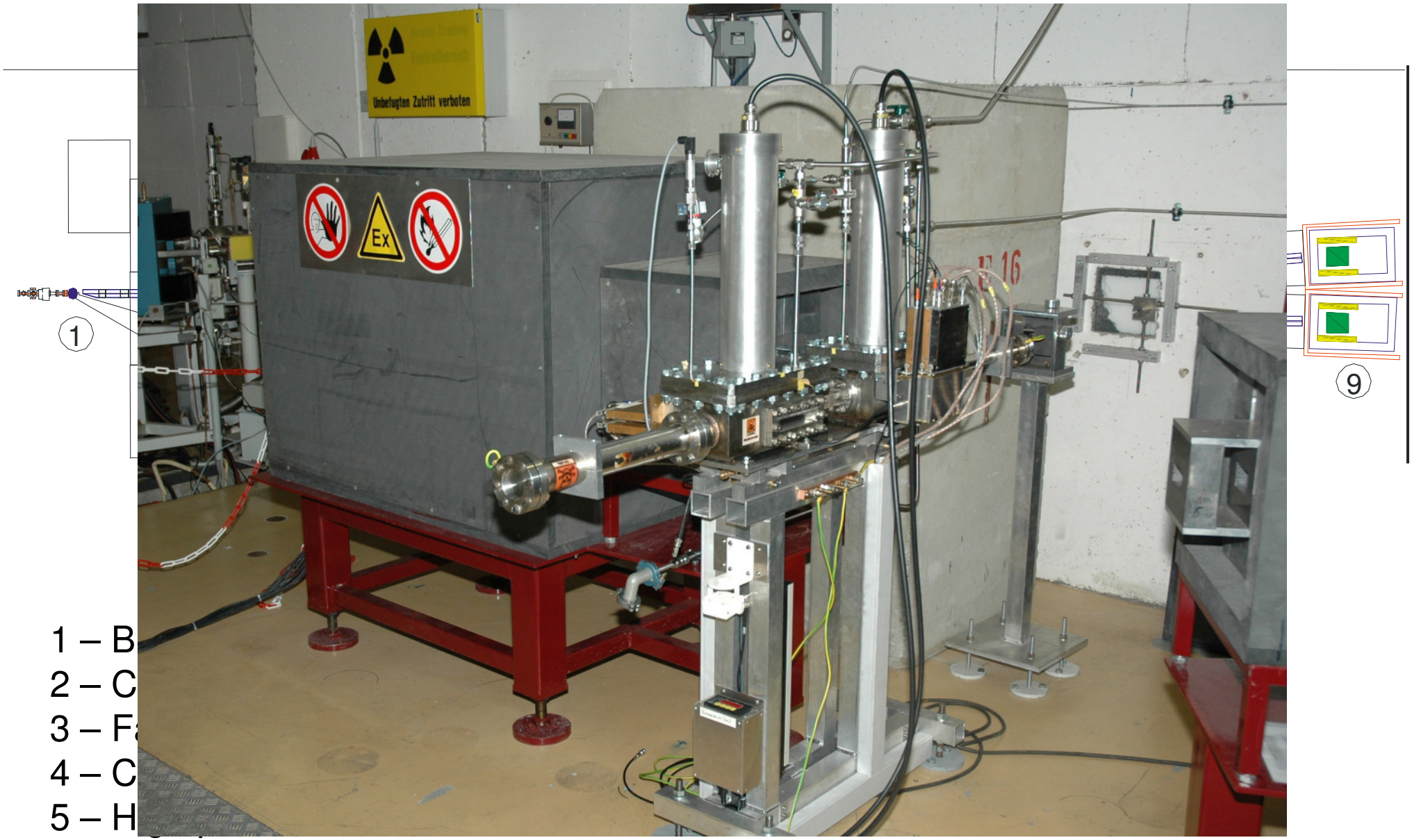

1 – B
2 – C
3 – F
4 – C
5 – H

High Pressure Ionisation Chamber

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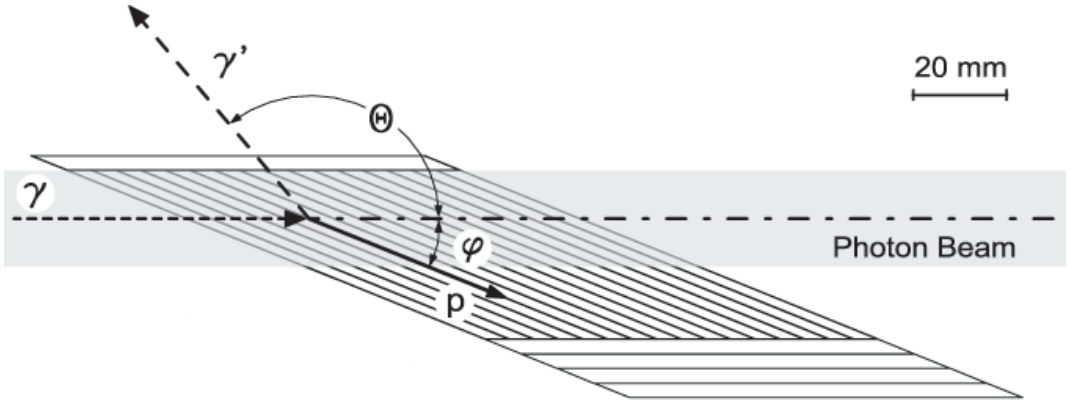
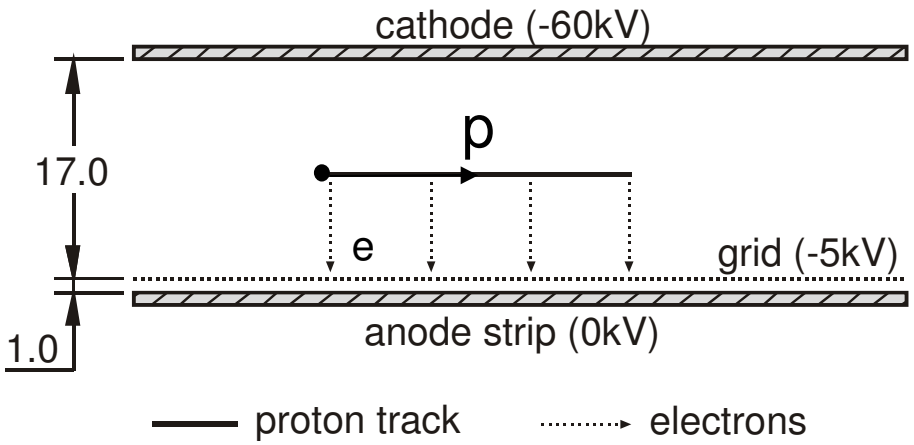
Determination of the energy and the position of the recoiled protons

Strips in the direction of the recoiled protons





$20\ \text{MeV} \leq E_\gamma \leq 90\ \text{MeV}$

$0.4\ \text{MeV} \leq E_p \leq 8\ \text{MeV}$

High Pressure Ionisation Chamber

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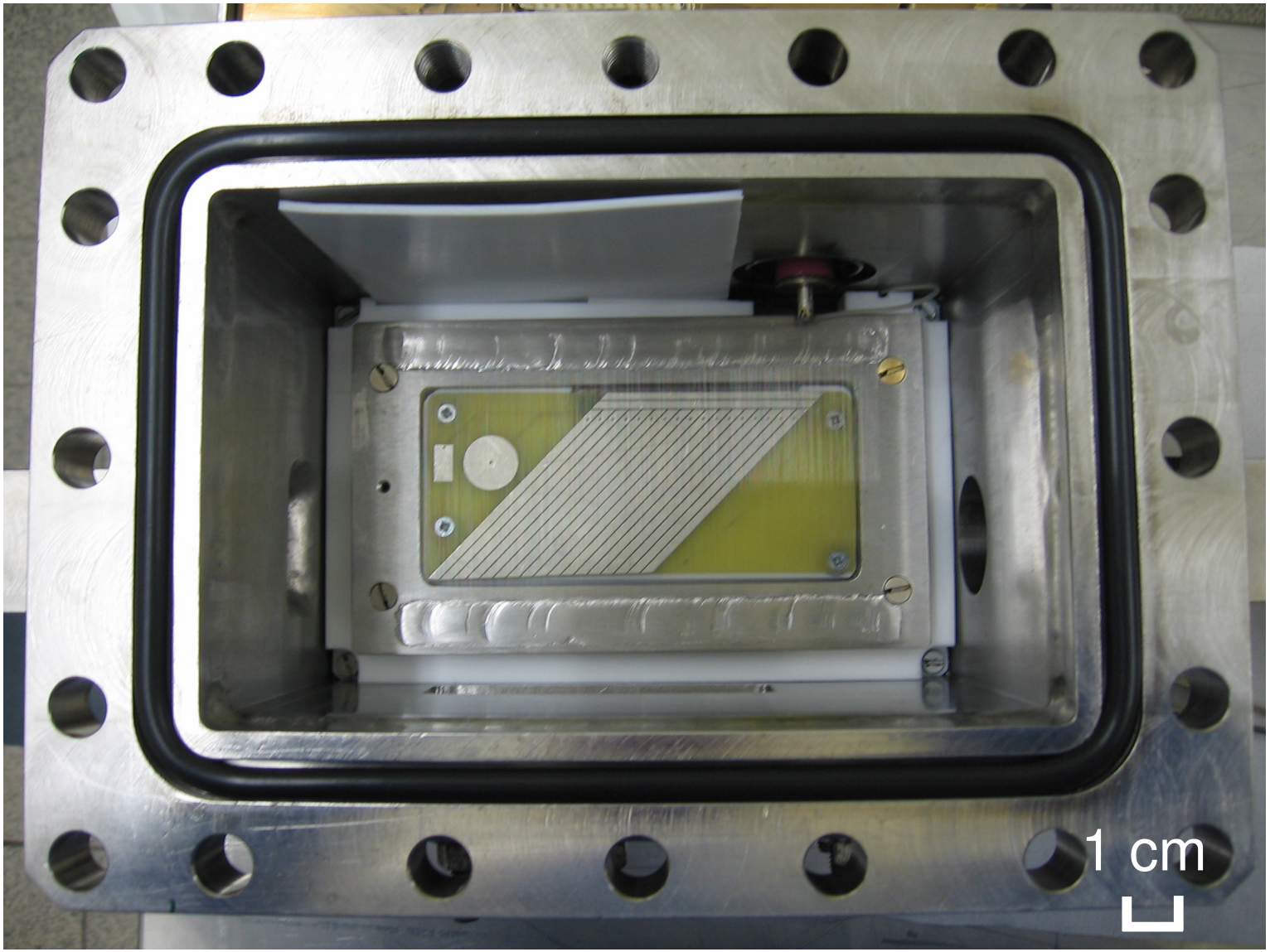

Proton Signals

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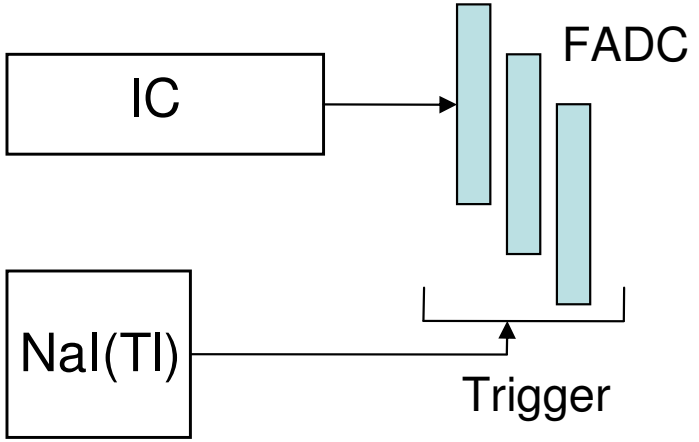
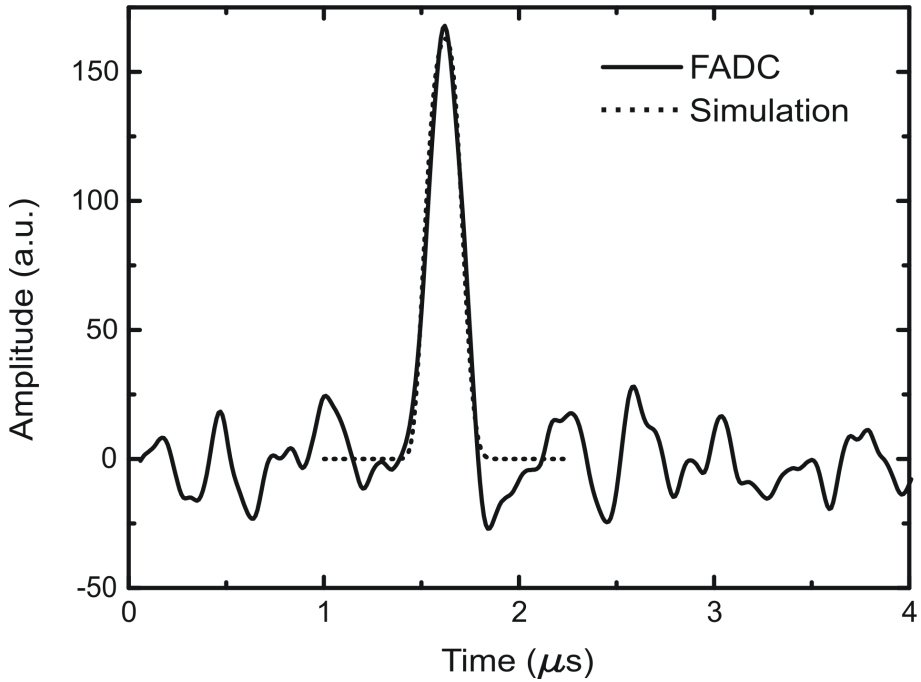
Flash ADC (FADC)

Sampling: 100 MHz, 10 ns
Time window: 4.5 μs





Experiments

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	August 2006	April-May 2007
Current I_0, μA	1-7	1-3* *pulsed beam
Energy E_0, MeV	60	79
Charge, μAh	1116.4	333.54
Pressure, bar	73.5	73.5
Voltage, kV	$V_C = 39$, $V_G = 3.5$	$V_C = 39$, $V_G = 3.5$

Signal Selection

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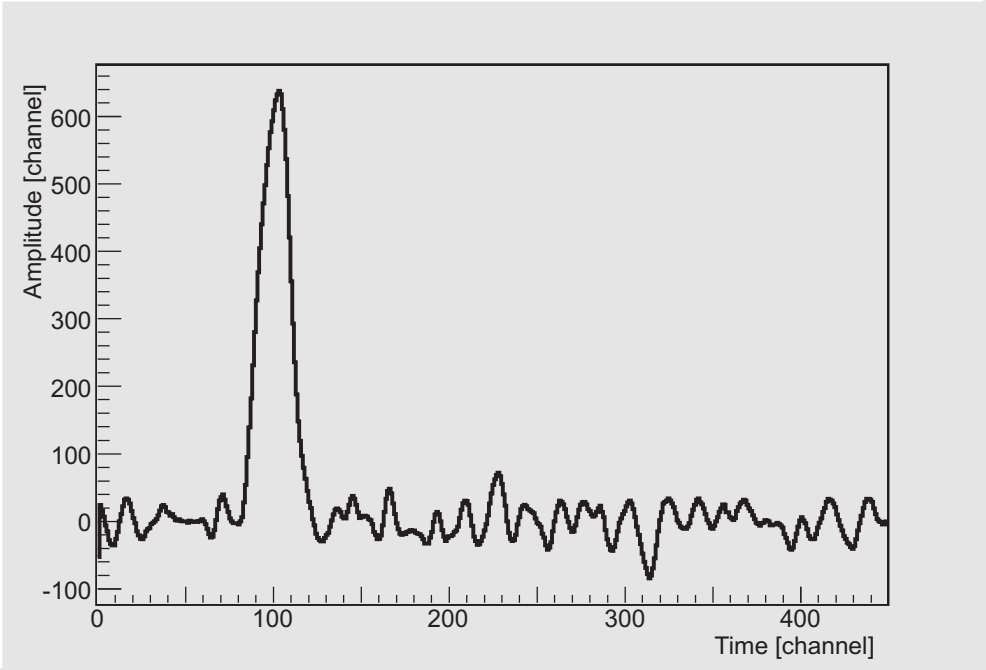

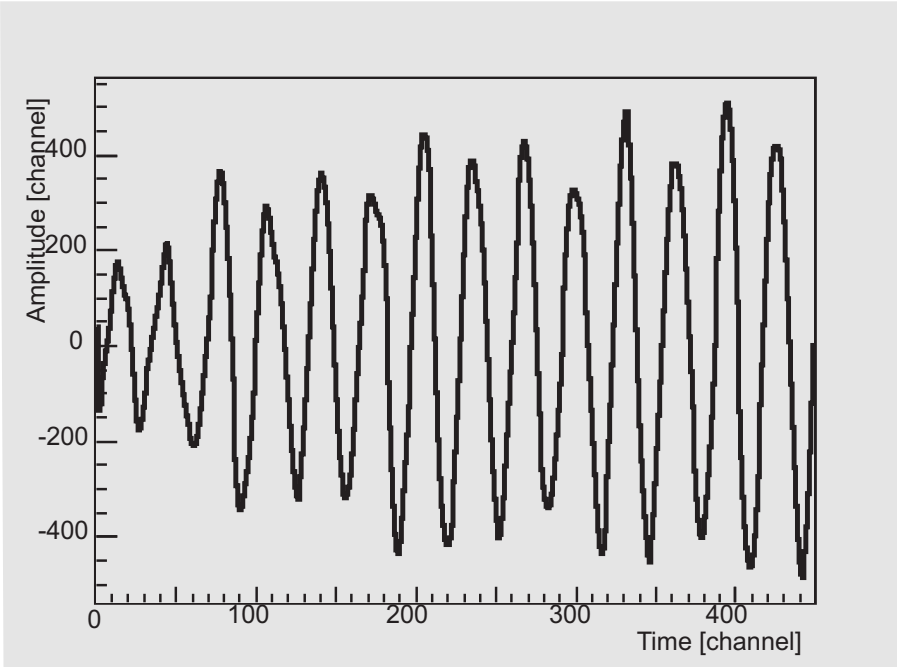

Correlation

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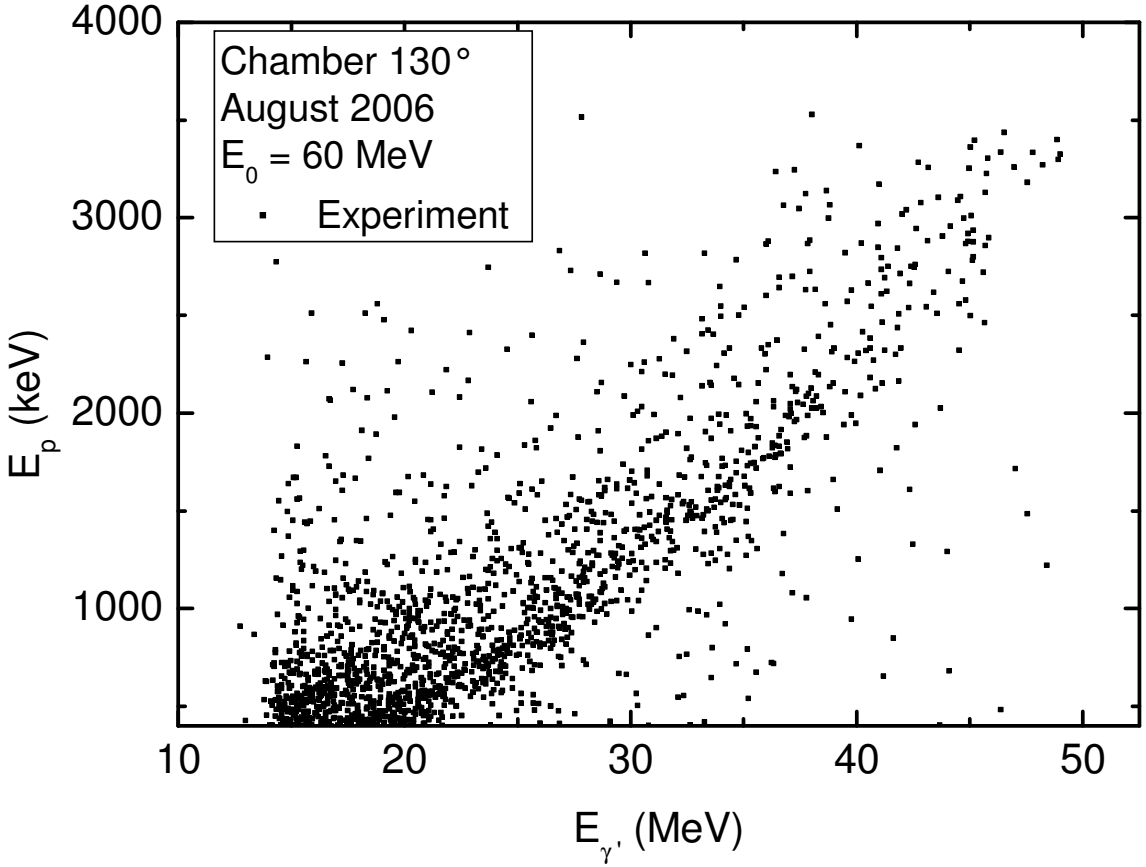

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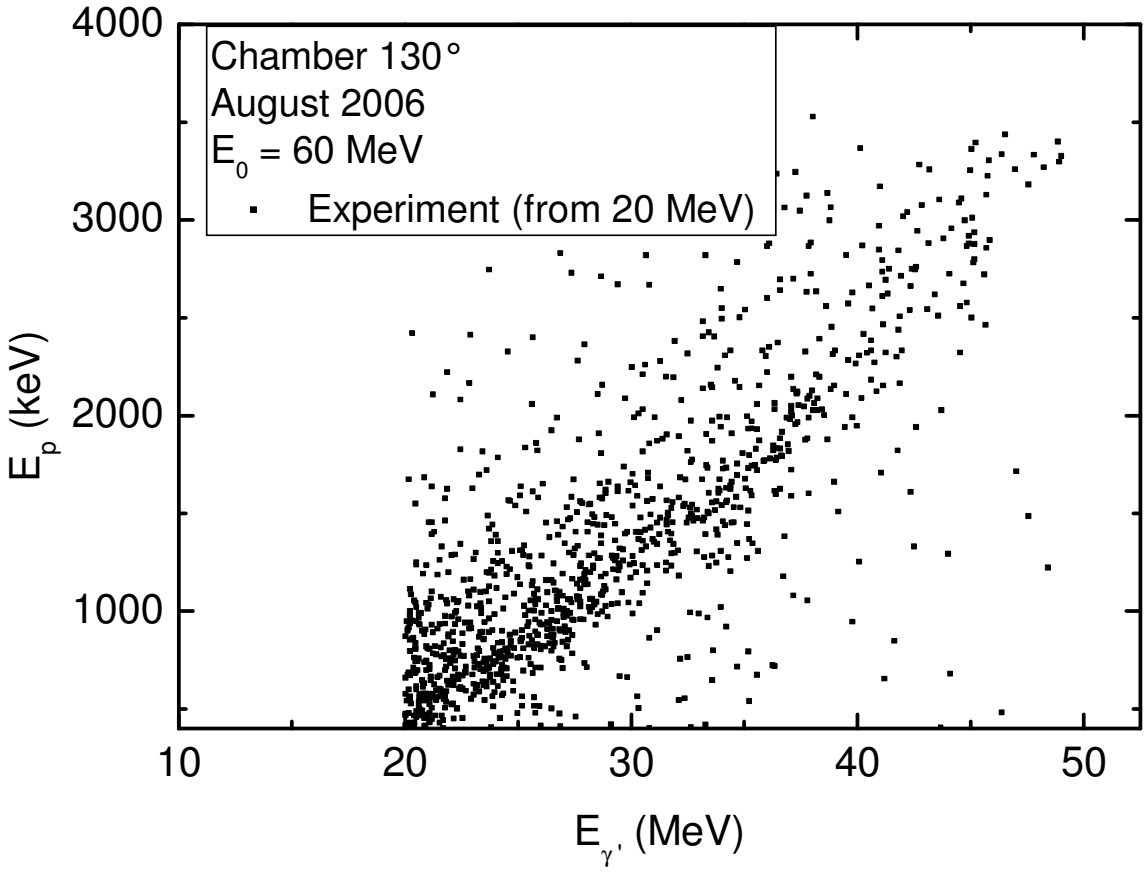

- Noise up to 20 MeV

High Pressure Ionisation Chamber

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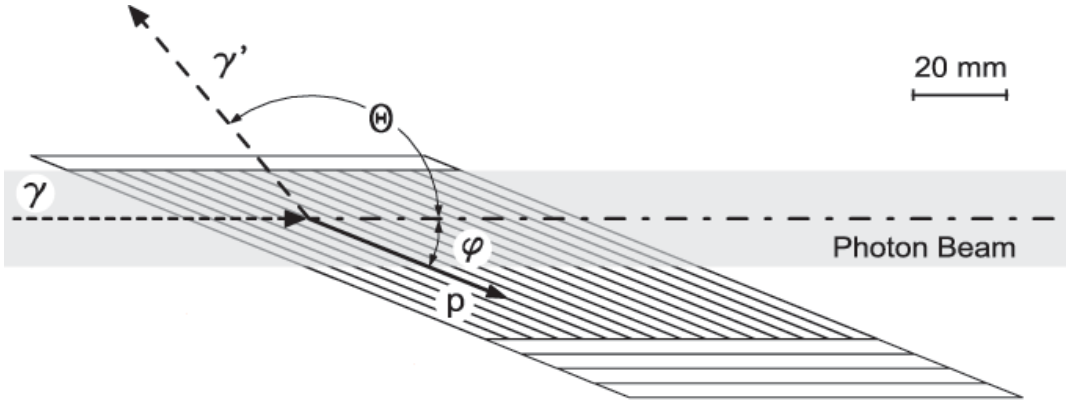
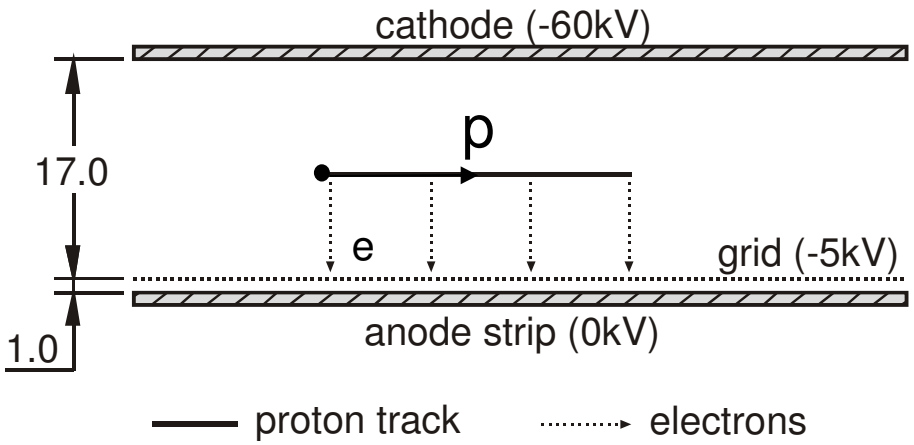
Determination of the energy and the position of the recoiled protons

Strips in the direction of the recoiled protons





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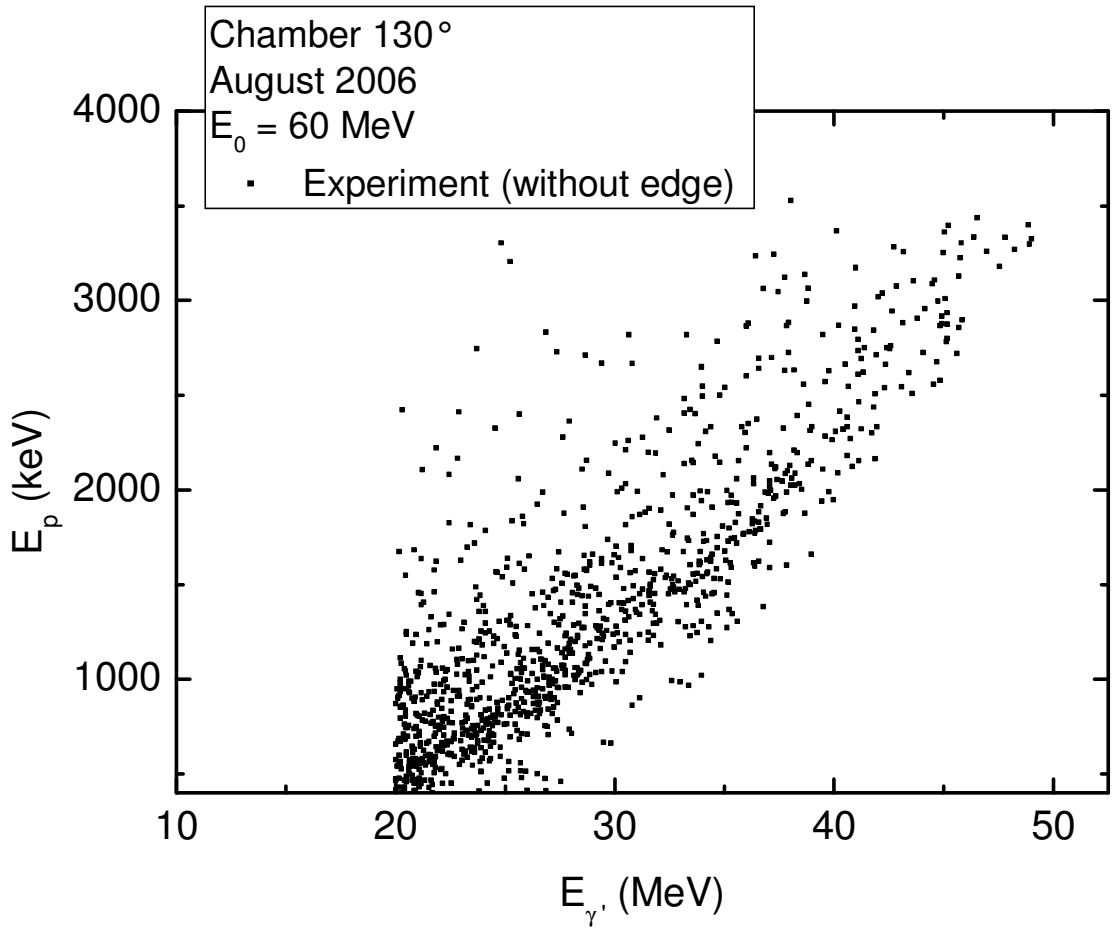
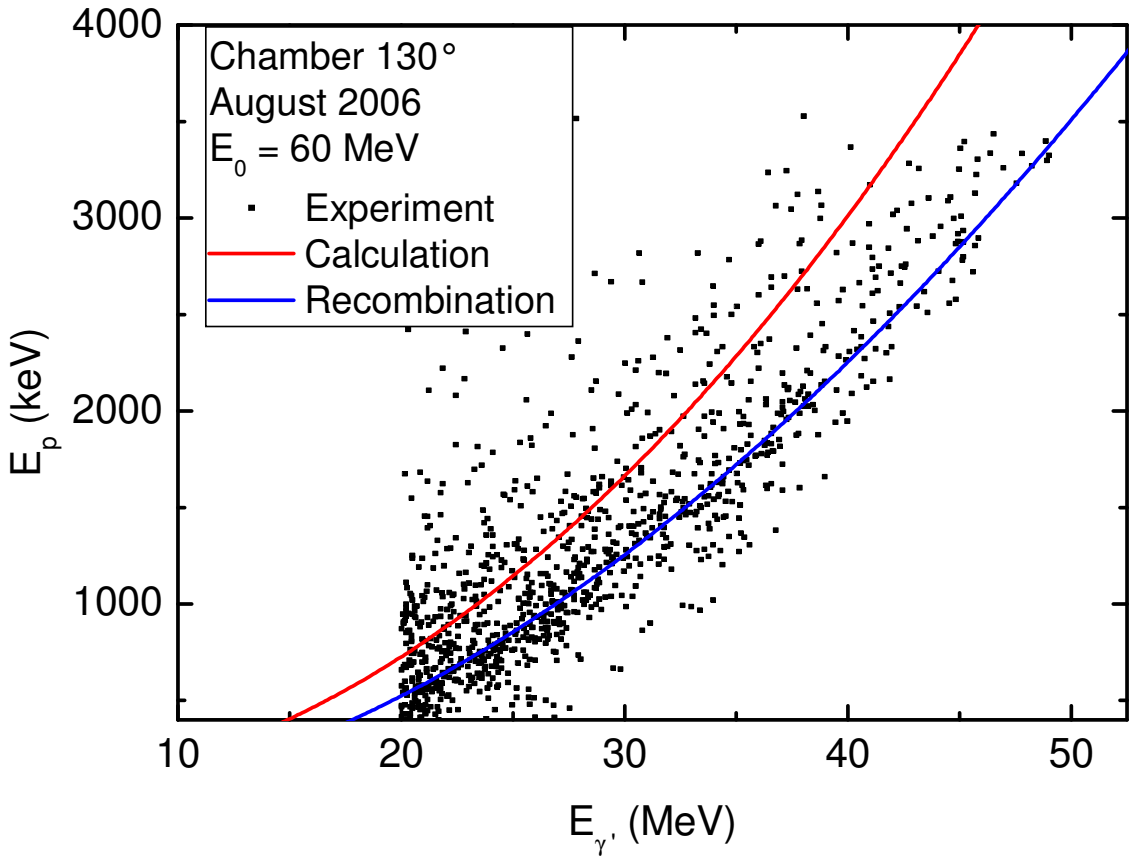
Correlation



- Noise up to 20 MeV
- Edge-strips
- Responce function

Correlation



$$E_{\gamma'} = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_p}(1 - \cos\theta)}$$

$$E_p^i = E_\gamma - E_{\gamma'}$$

$$E_p = 0.91 * (E_p^i - 150) * 0.95$$

First Results

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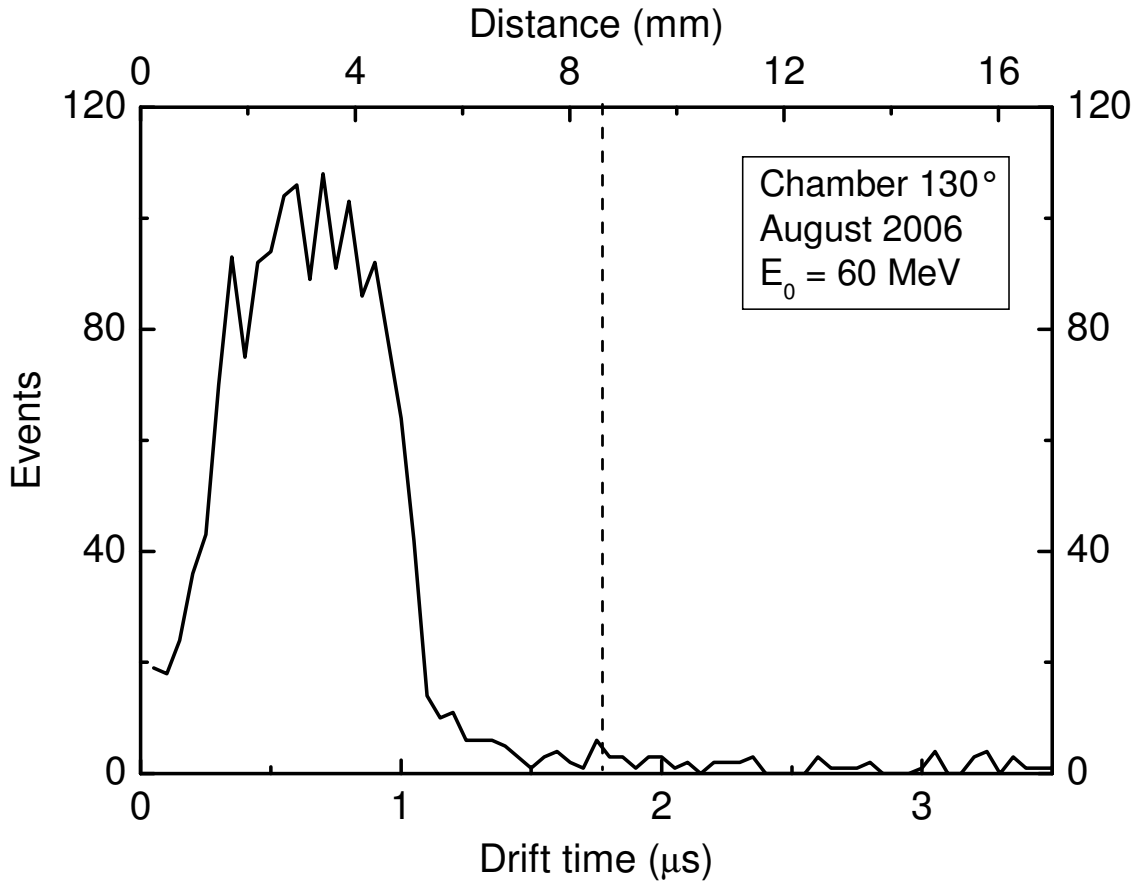

Problem with Electrons

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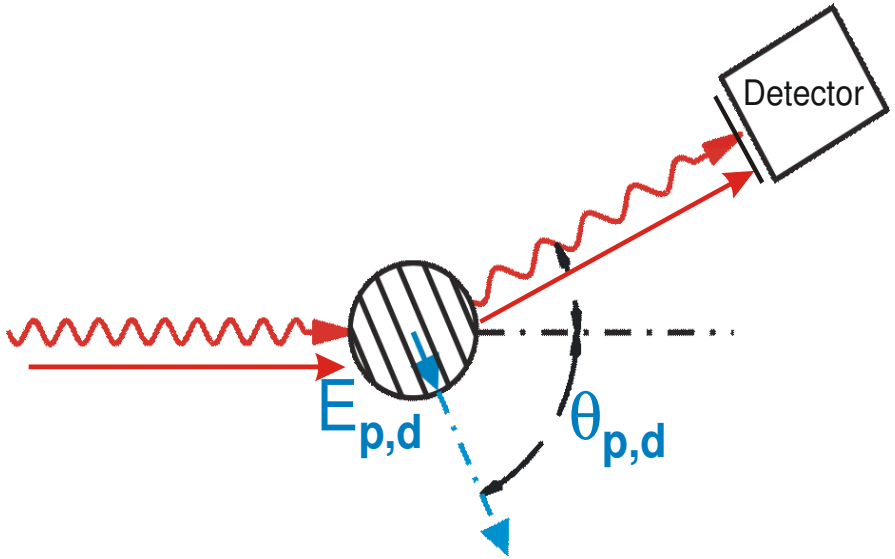
- Be-window $\longrightarrow$ e^- $\longrightarrow$ (e,p)-scattering
- $\sigma_{ep} \approx 100\sigma_{\gamma p}$, the same kinematics

$\}\longrightarrow$ signal in NaI(Tl)

Anticounter

plastic scintillator



Cross Section

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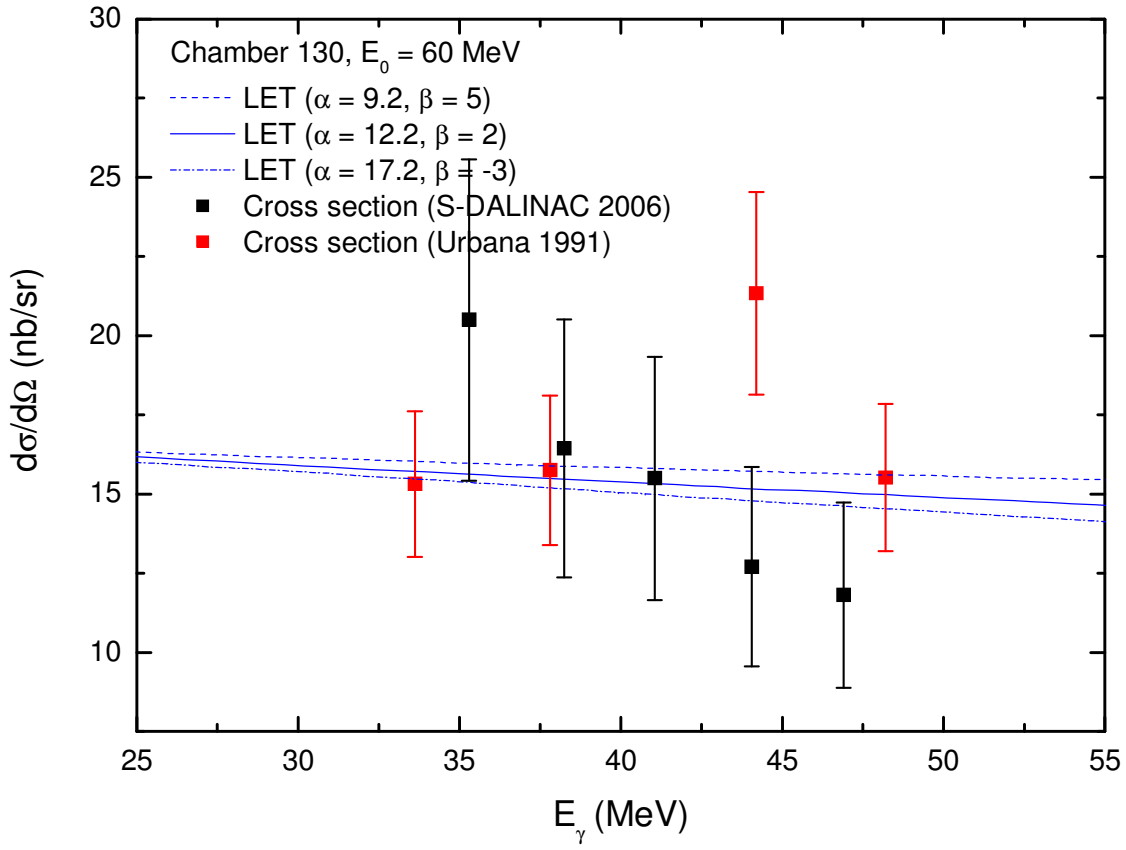

Summary

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- ✓ Experiments were performed
- ✓ Preliminary results were shown

- ✓ Lead shield
- ✓ Electronics for chamber

- ✓ Anticounters: scintillators, electronics, software

Outlook

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- Analysis is running
- Simulations with GEANT4

- Better statistics

- Experiment with deuteron

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