Nucleon Polarizabilities from Low - Energy Compton Scattering*

TECHNISCHE UNIVERSITÄT DARMSTADT

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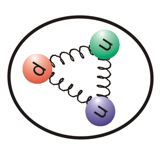
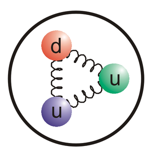
Nucleon Polarizability

$$\bar{\alpha} = 2\sum_{n\neq N} \frac{\left|\left\langle n\left|D_z\right|N\right\rangle\right|^2}{E_n - E_N} + \Delta\alpha$$





$$\bar{\beta} = 2\sum_{n\neq N} \frac{\left|\left\langle n\left|M_z\right|N\right\rangle\right|^2}{E_n - E_N} + \Delta\beta$$

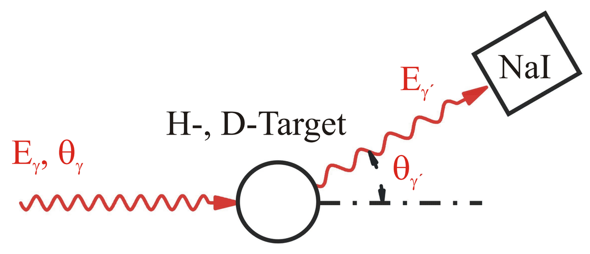
Low - Energy Theorem

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

$$\rho = \frac{e^2}{4\pi m_p}\left(\frac{E_{\gamma'}}{E_\gamma}\right)^2 (E_\gamma E_{\gamma'})\left[\frac{\bar{\alpha}+\bar{\beta}}{2}(1+\cos\theta)^2 + \frac{\bar{\alpha}-\bar{\beta}}{2}(1-\cos\theta)^2\right]$$

V.A. Petrunkin, Sov. J. Part. Nucl. **12** (1981) 278

Present Experimental Technique



Present Data

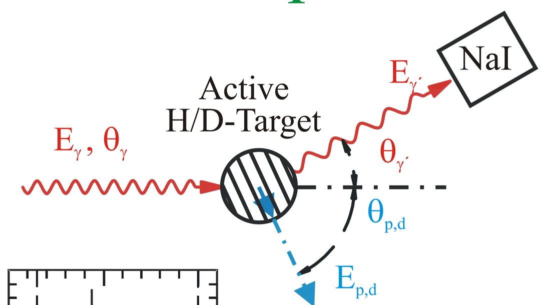
$$\bar{\alpha}_p = (11.9 \pm 0.5 \mp 1.3)\times 10^{-4}\,\mathrm{fm}^3$$
$$\bar{\beta}_p = (1.2 \pm 0.7 \mp 0.3)\times 10^{-4}\,\mathrm{fm}^3$$

V. Olmos de León et al., Eur. Phys. J. A **10** (2001) 207

$$\bar{\alpha}_n = (5.5 \pm 2.0)\times 10^{-4}\,\mathrm{fm}^3$$
$$\bar{\beta}_n = (10.3 \mp 2.0)\times 10^{-4}\,\mathrm{fm}^3$$

D.L. Hornidge et al., Phys. Rev. Lett. **84** (2000) 2334

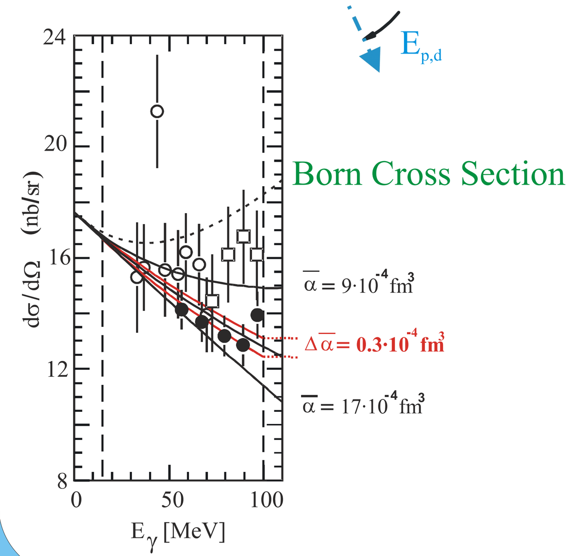
New Experimental Technique



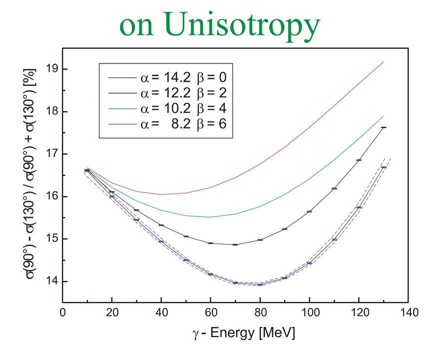
E_γ = 20 - 100 MeV
$E_{\gamma'}$ = 15 - 100 MeV

E_p = 0.4 - 8 MeV

Expected Accuracy
$\Delta\bar{\alpha}_p, \Delta\bar{\beta}_p \approx 0.3\times10^{-4}\,\mathrm{fm}^3$
$\Delta\bar{\alpha}_n, \Delta\bar{\beta}_n \approx 1\times10^{-4}\,\mathrm{fm}^3$



Energy Dependence on Unisotropy



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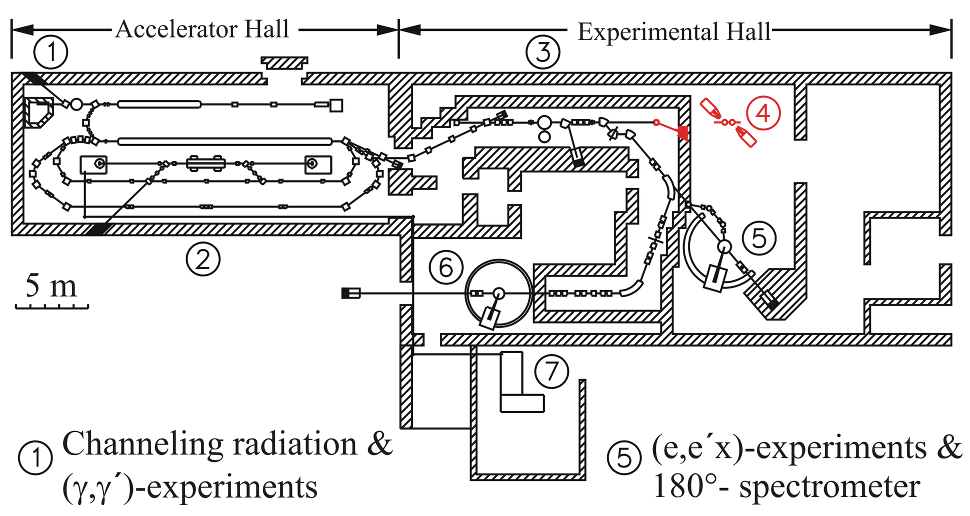
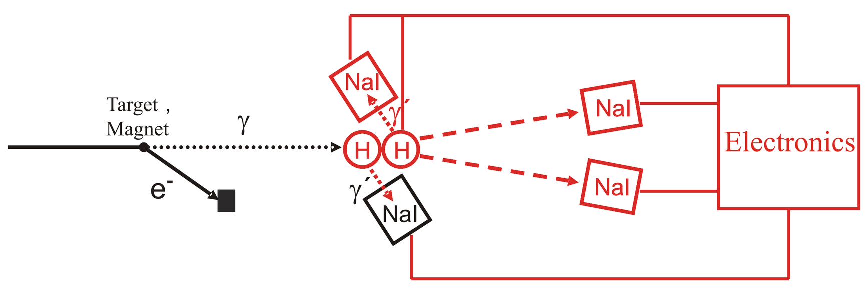


① Channeling radiation & (γ,γ´)-experiments
② Free - electron laser
③ High energy radiation physics
④ Compton scattering off the nucleon
⑤ (e,e´x)-experiments & 180°- spectrometer
⑥ (e,e´x)-experiments
⑦ Optics experiments

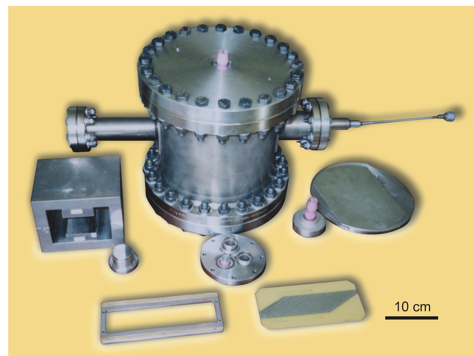
Experimental Setup



- Gamma beam 10^9 γ/MeV/s
- Test-chamber
- γ-spectrometer
- Background measurement

- Double chamber
- Read-out electronics
- γ-spectrometer with active shield

H/D High Pressure Ionisation Chamber



P = 100 bar

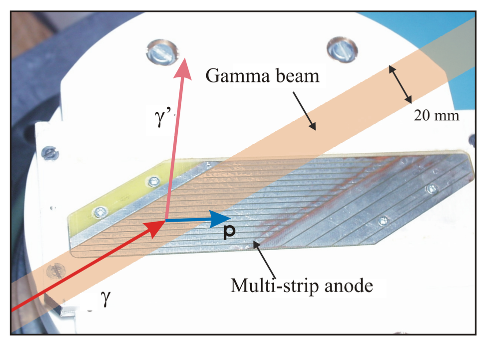
$\rho = 4\times10^{22}$ protons/cm^2

U_{cathod} = -60 kV

Be-window: 4 mm

100% Efficiency @ E_p = 0.4-8 MeV

Multi - Strip Anode

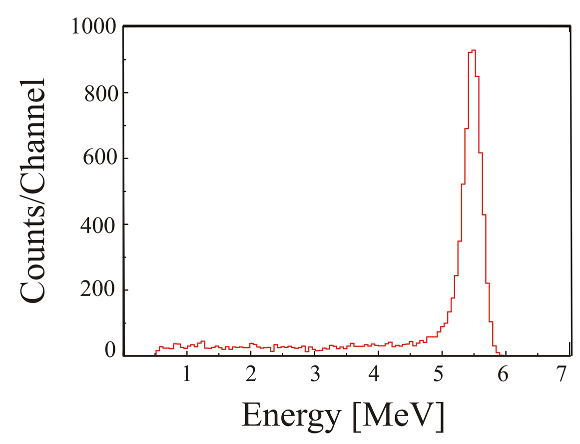


Special multi-strip anode:

16 strips

each 2.5 x 80 mm^2

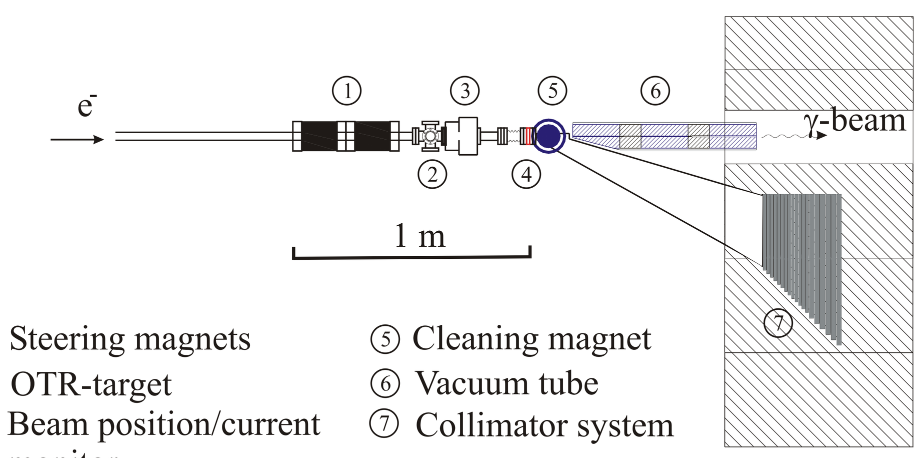
Energy Spectrum



^{241}Am as test-source inside the chamber

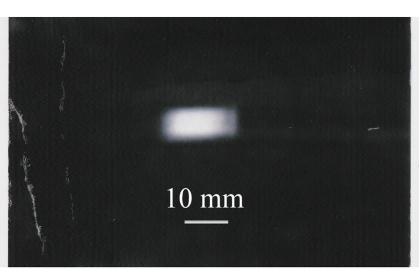
Gamma - Beam Production

E_{e^-}	< 130 MeV
I_{e^-}	< 10 µA
Target material	gold, 10% rad. length
Collimated gamma - beam	ca. 10x20 mm^2



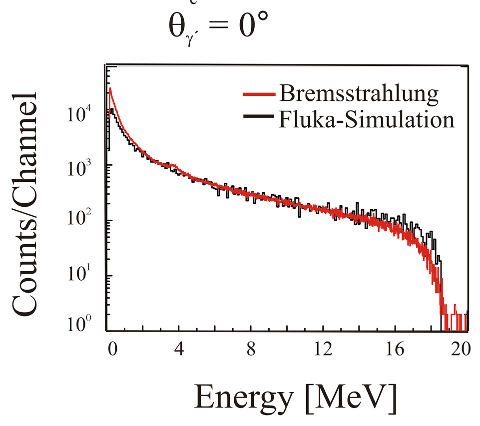
① Steering magnets
② OTR-target
③ Beam position/current monitor
④ Converter target
⑤ Cleaning magnet
⑥ Vacuum tube
⑦ Collimator system

Gamma - Beam Spot

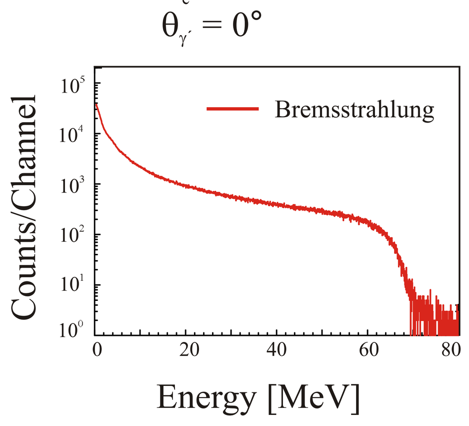


Gamma - Beam Spectrum

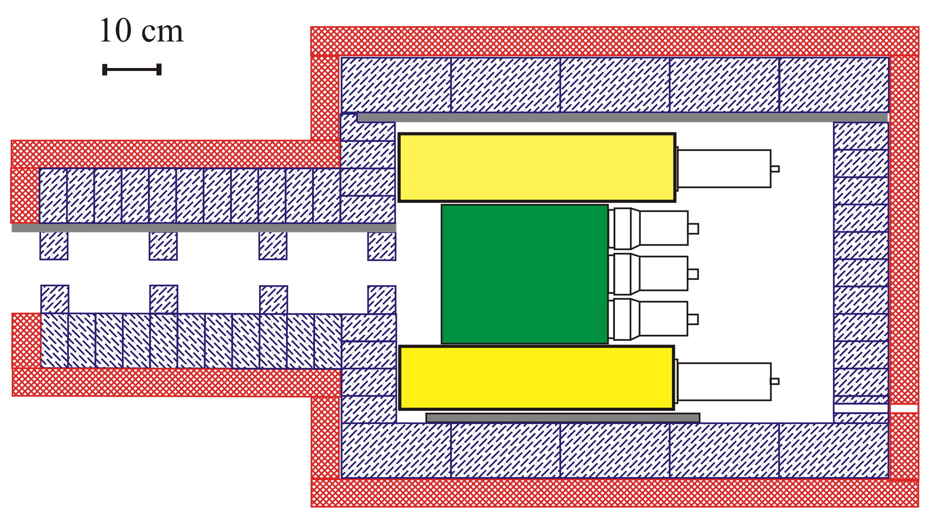
E_{e^-} = 19.5 MeV
θ_γ = 0°



E_{e^-} = 71.3 MeV
θ_γ = 0°



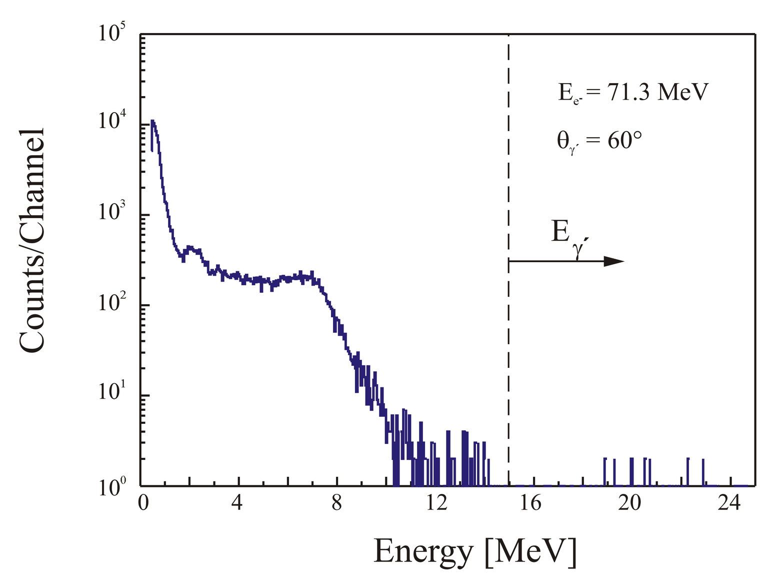
Gamma Spectrometer



- 10” x14” NaI(Tl)-crystal
- 200 mm plastic scintillators
- 100 mm lead
- 50 mm borated polyethylene
- steel

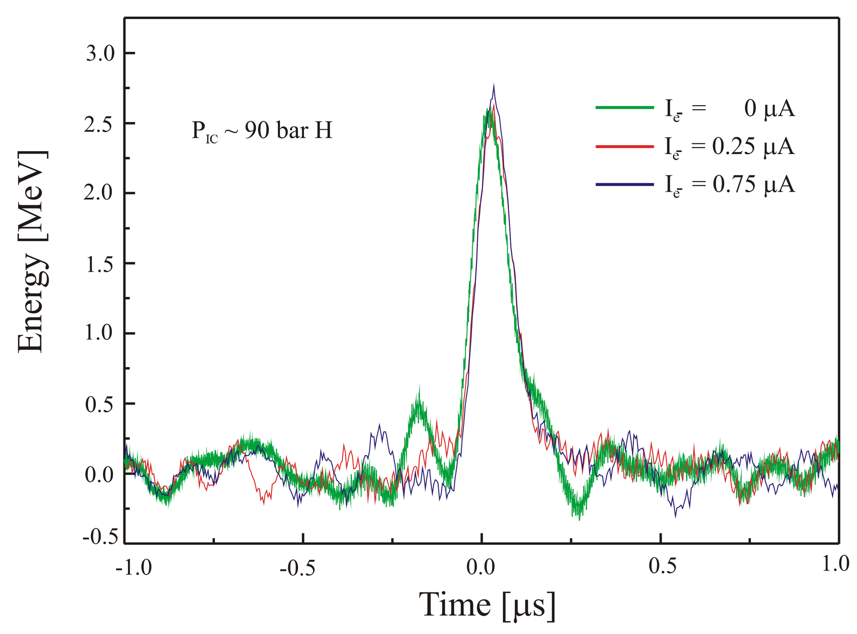
Solid angle 0.01sr

Background Spectrum



Test Measurement

Signals from ^{241}Am alpha source at different γ - fluxes



*Supported by the DFG under contract SFB 634