Evolution of the Landau spectral peak produced by 50 GeV protons in Si detector with smoothly variable thickness

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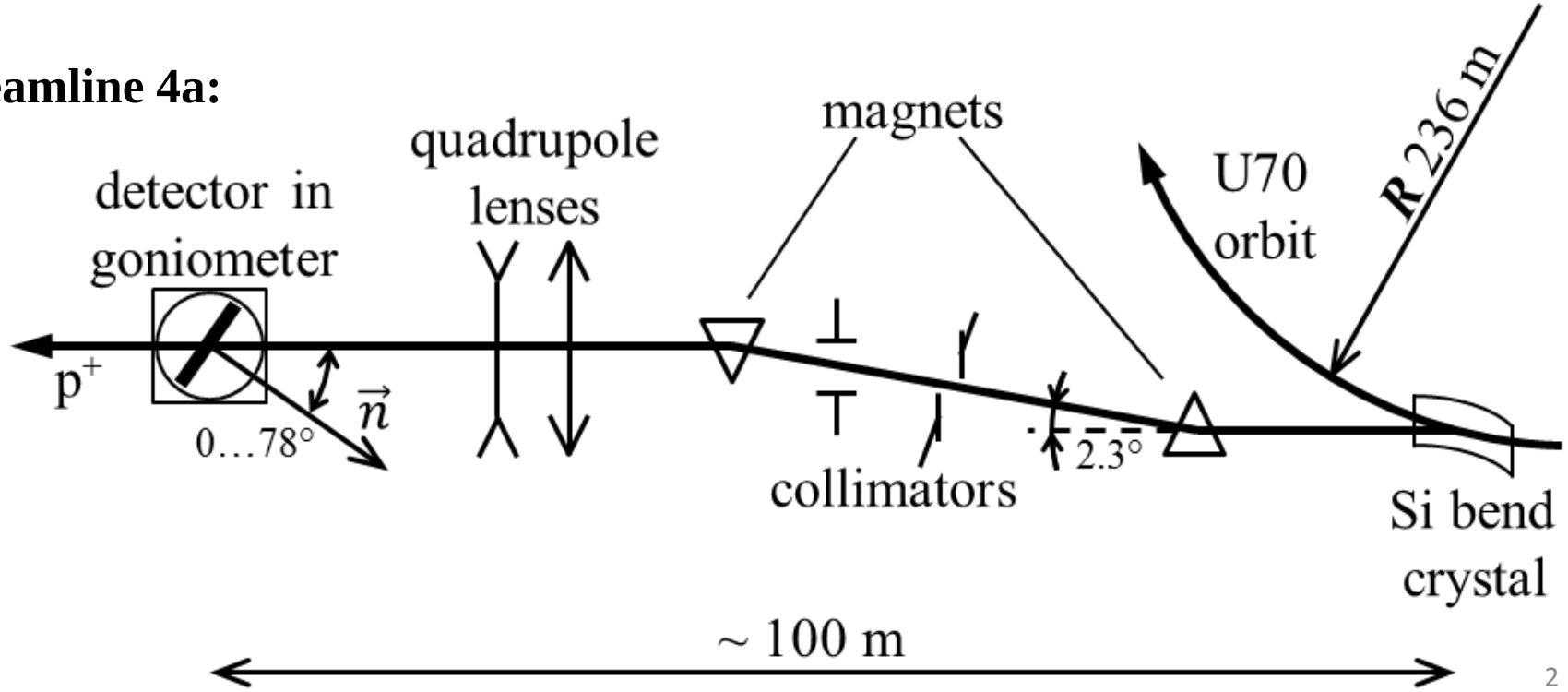
Accelerator U70 at IHEP (Protvino, Russia)

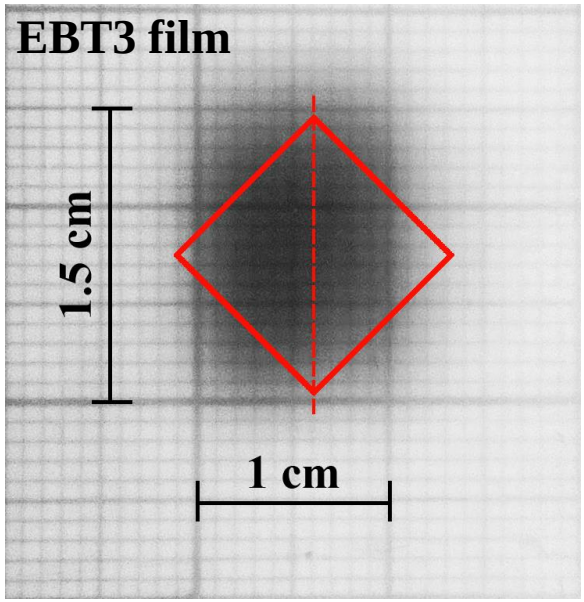
Proton energy	50 GeV
Protons per spill	100…300
Spill duration	150 ms
Spill periodicity	8.6 s
Beam divergence	21" (100 μrad)

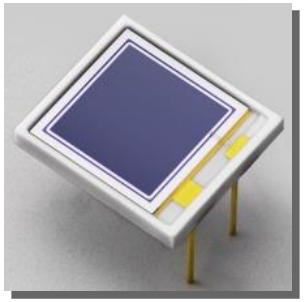
Beamline 4a:



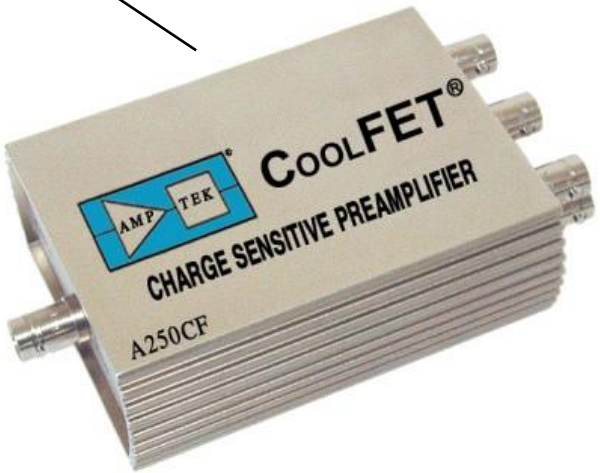
Experimental layout

p^+ 50 GeV





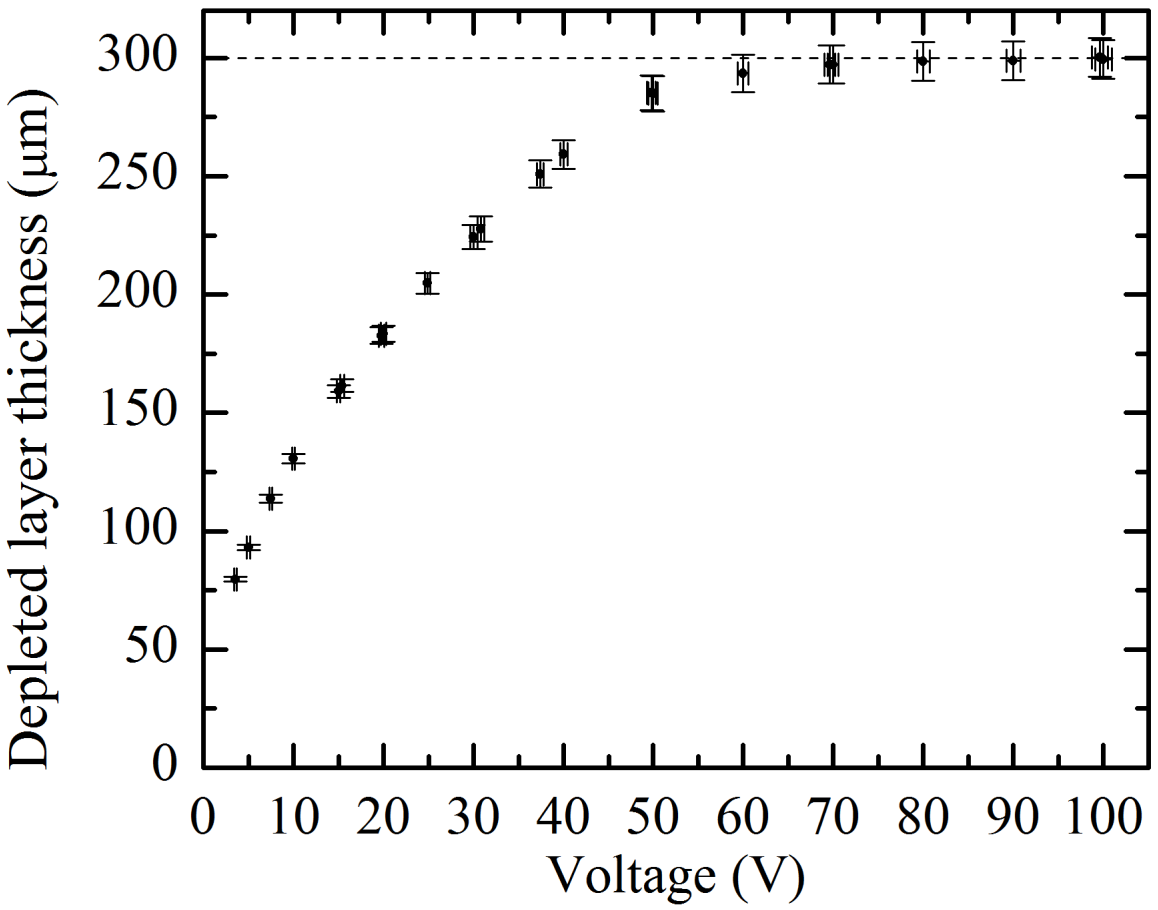
Hamamatsu Si PIN S3590-18
area: 1 cm^2
depleted layer: 0.3 mm

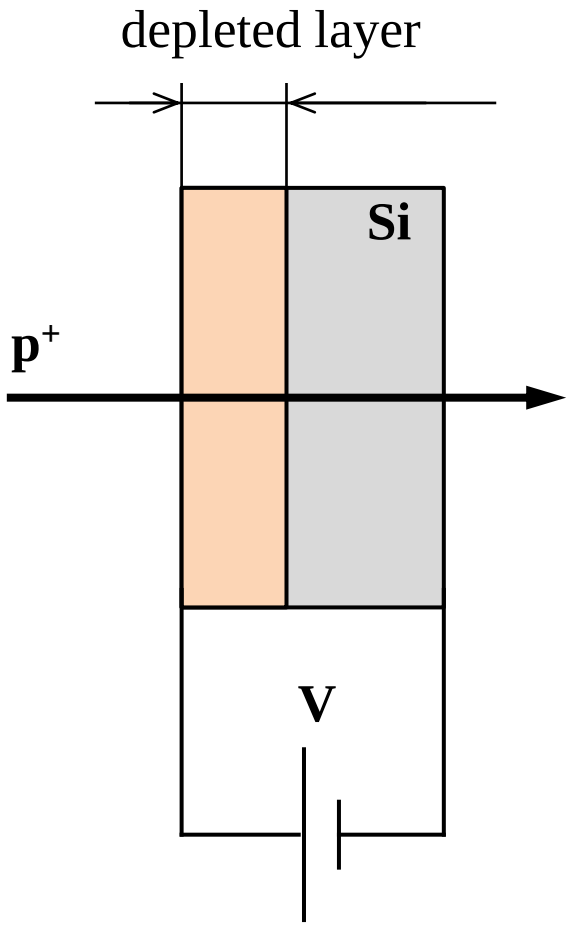


Spectrometer

Depleted layer thickness of the detector

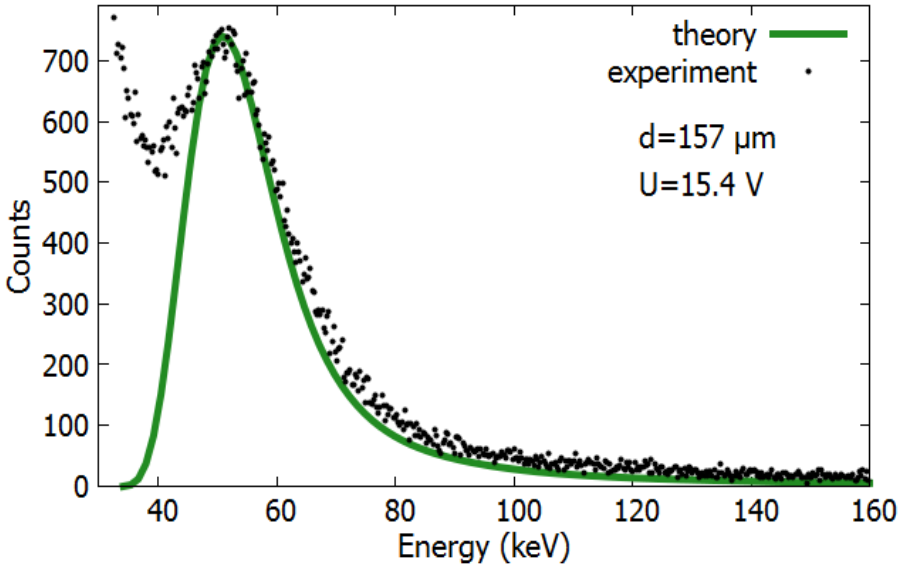
1st phase of the experiment

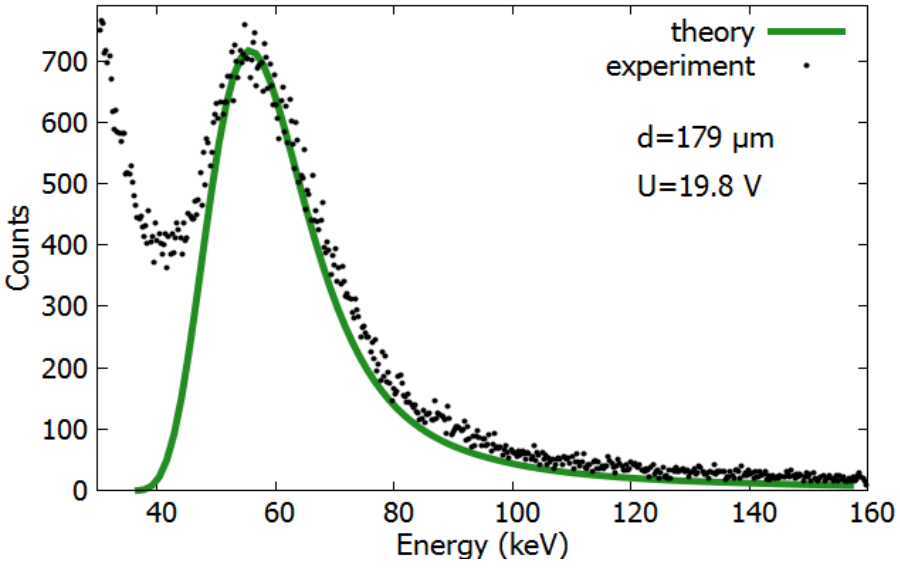


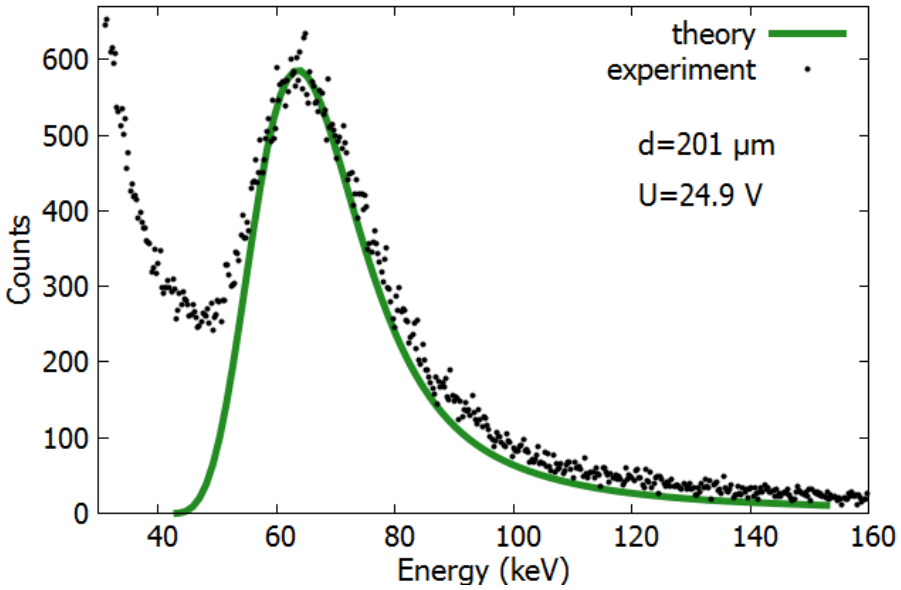


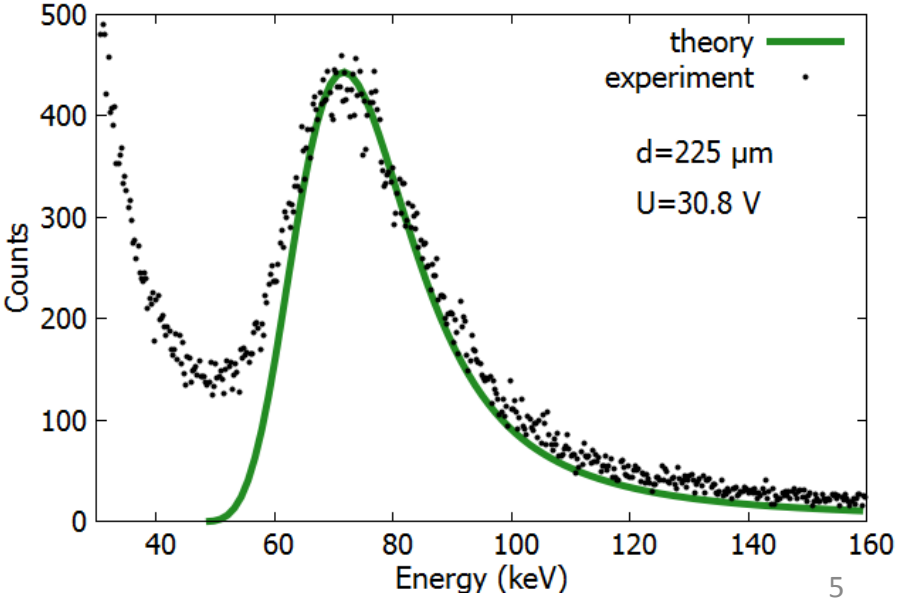
Effective thickness of Si crystal: **157…300 μm**

Energy loss spectra produced by 50 GeV protons in Si detector at different supply voltages









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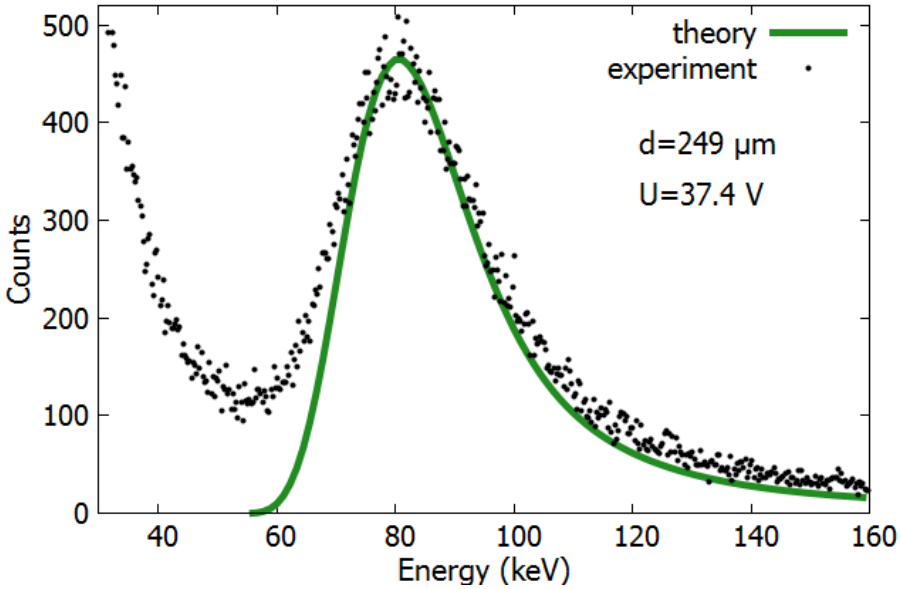
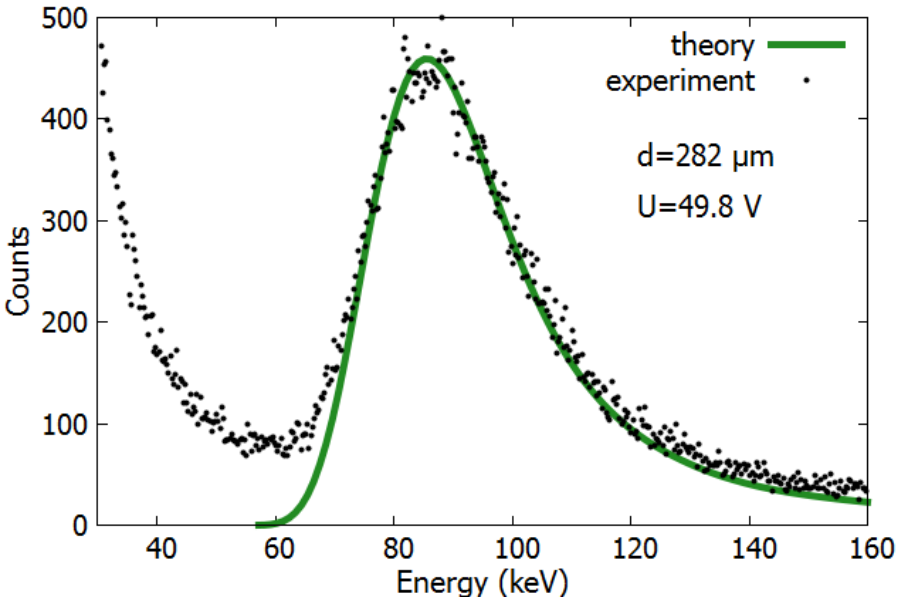
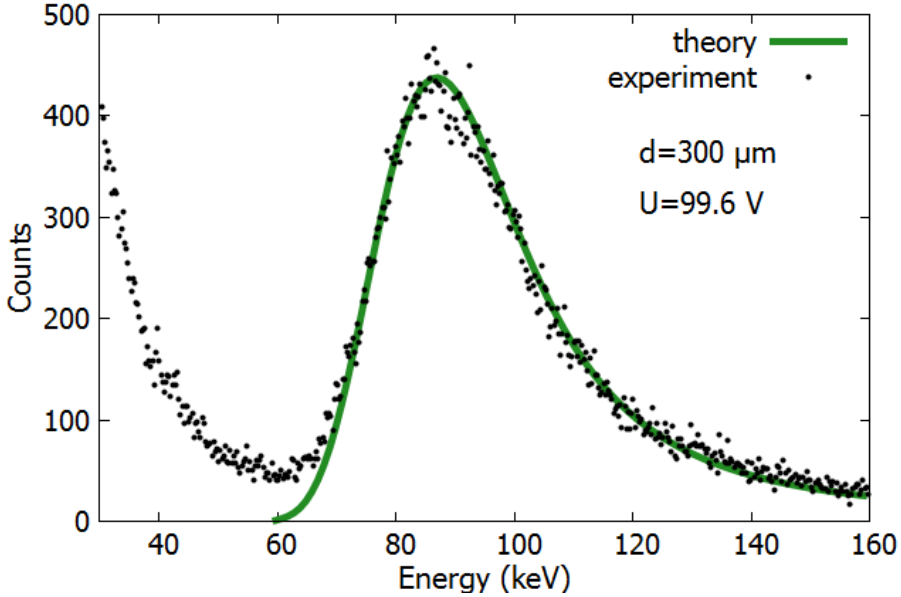
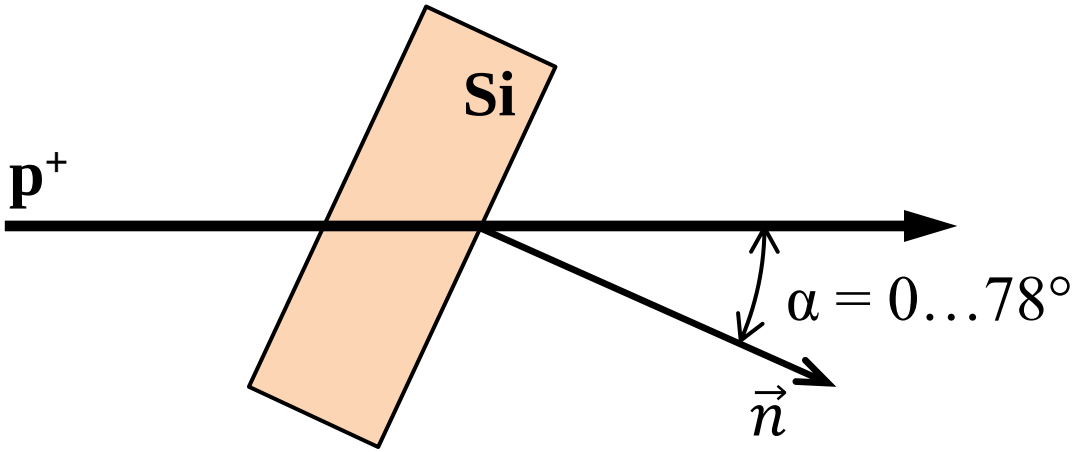






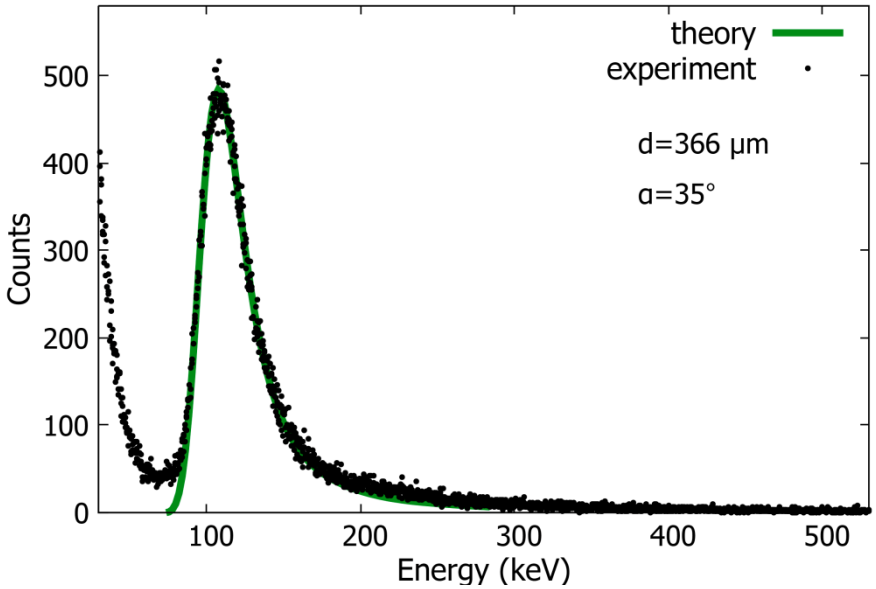
Rotation of the Hamamatsu S3590-18

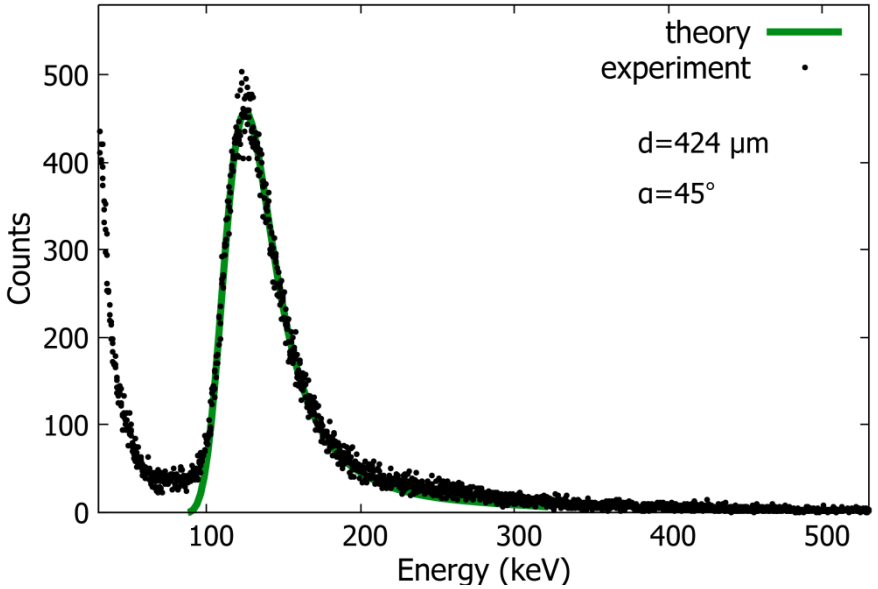
2nd phase of the experiment

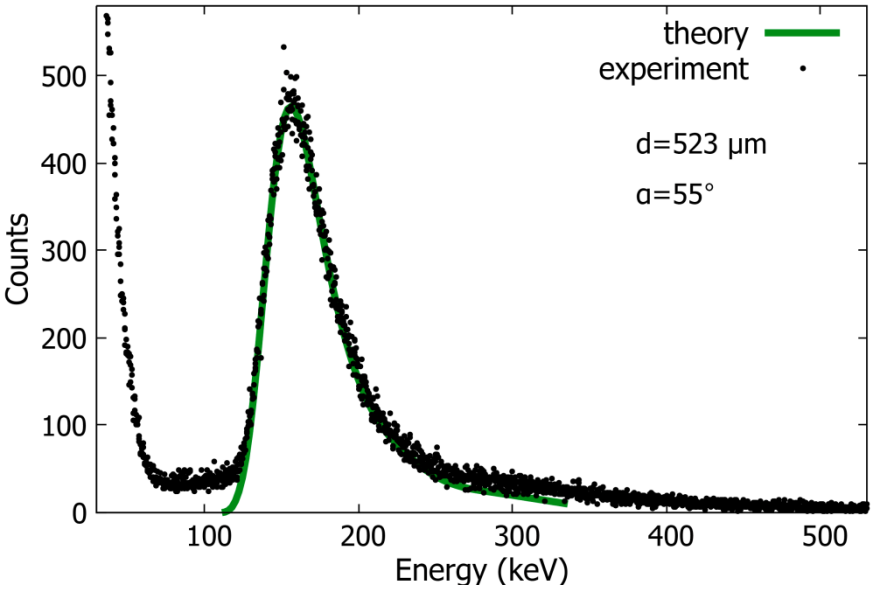


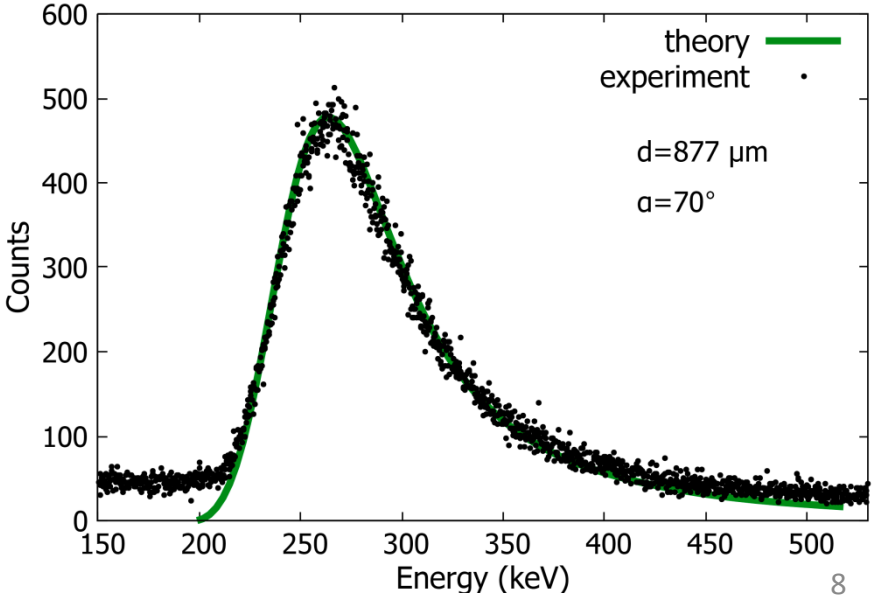
Effective thickness of Si crystal: **300…1443 μm**

Energy loss spectra produced by 50 GeV protons in Si detector at different orientations

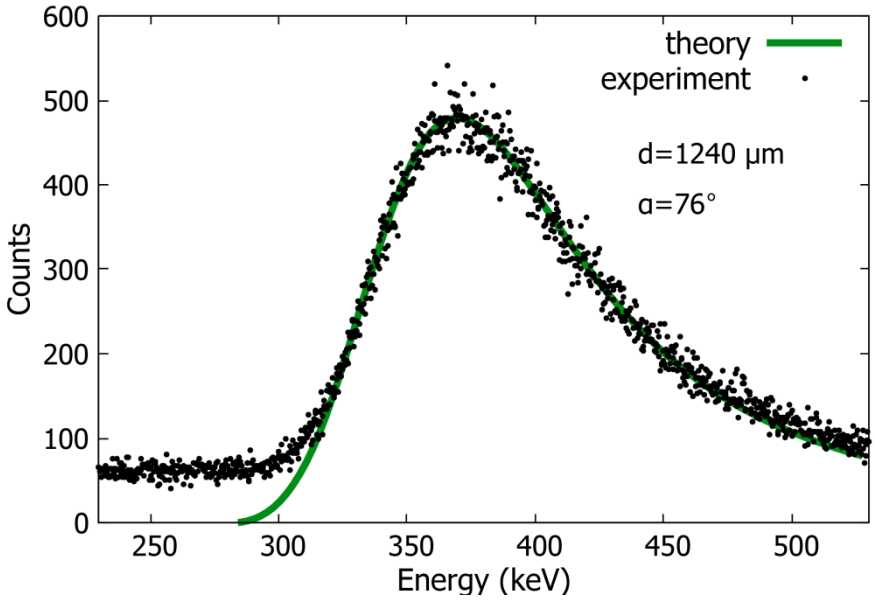


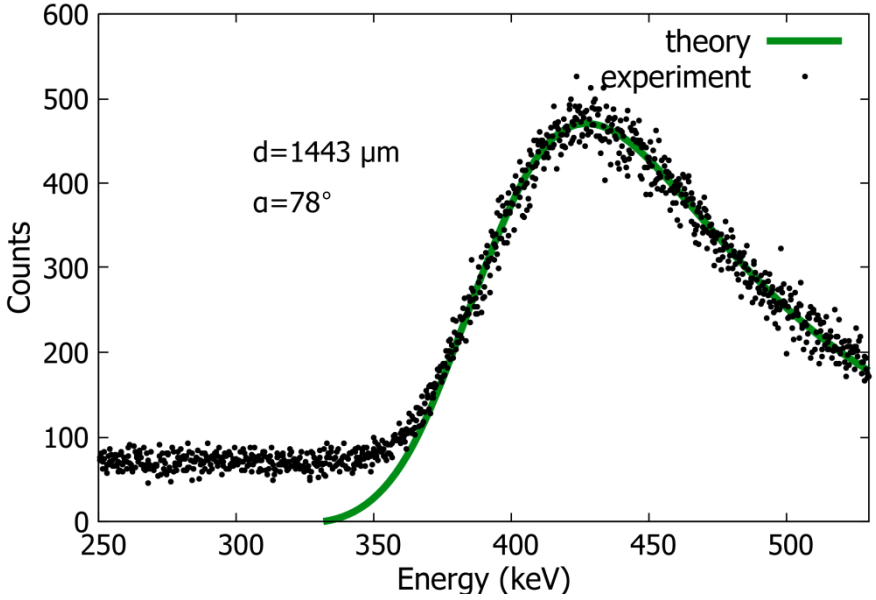






Energy loss spectra produced by 50 GeV protons in Si detector at different orientations





The theoretical energy loss functions (Landau peaks) were calculated with the use of convolution method proposed in

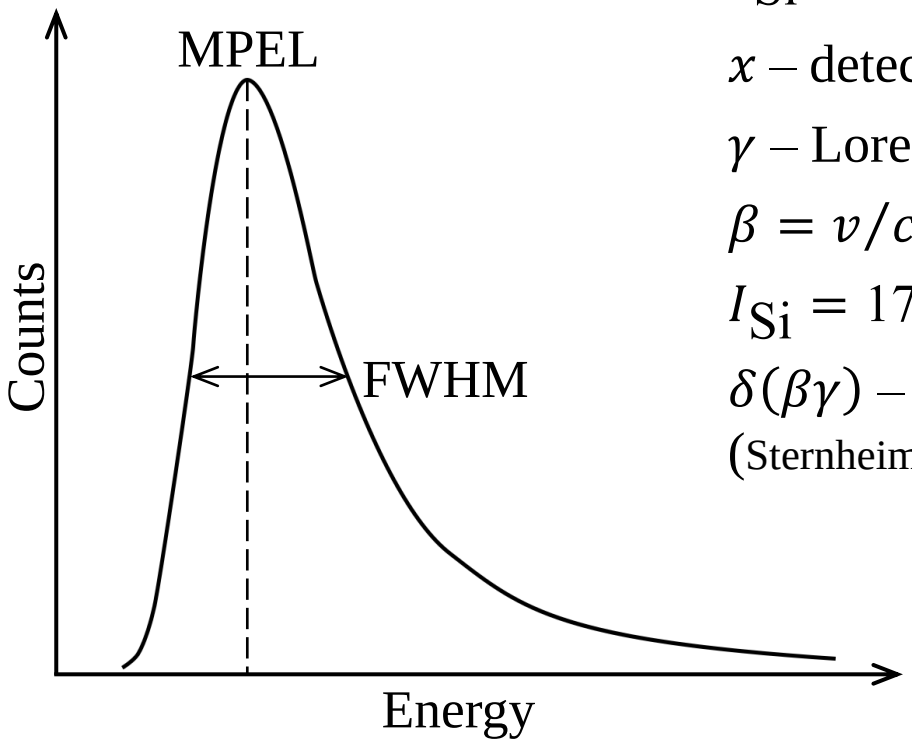
H. Bichsel, R.P. Saxon, Phys. Rev. A 11 (1975) 1286.

Landau distribution for ionization energy loss

Most probably energy loss (MPEL):

$$\mathrm{MPEL} = \xi\left[\ln\frac{2m_e c^2\beta^2\gamma^2}{I} + \ln\frac{\xi}{I} + 0.200 - \beta^2 - \delta(\beta\gamma)\right]$$

Bichsel H., Rev. Mod. Phys. 60, 663 (1988)



$\xi_{\mathrm{Si}}[\mathrm{MeV}] = 0.0765 \cdot x[\mathrm{g/cm^2}]/\beta^2$

x – detector thickness

γ – Lorentz factor

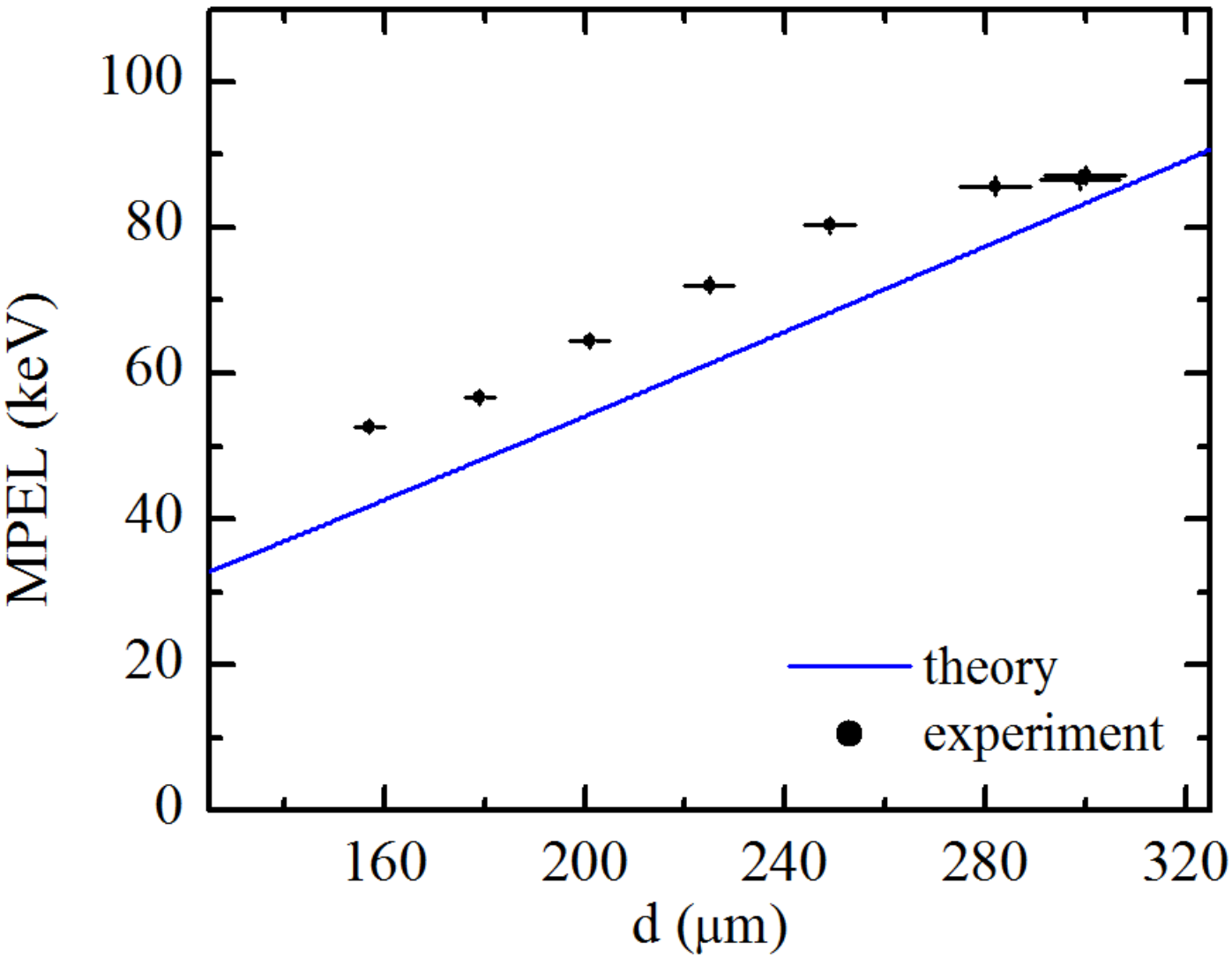
$\beta = v/c$

$I_{\mathrm{Si}} = 173$ eV (mean excitation energy)

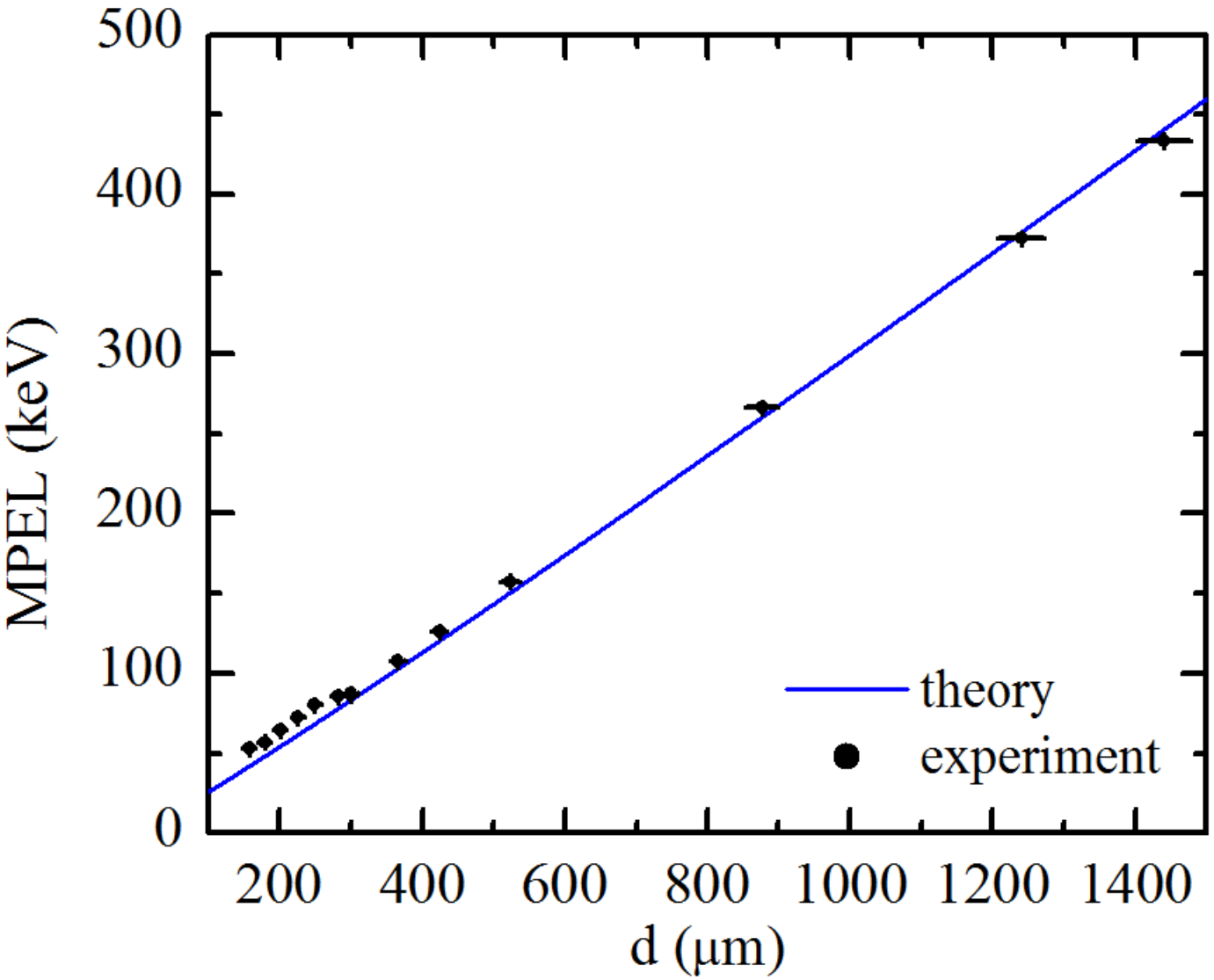
$\delta(\beta\gamma)$ – density correction

(Sternheimer R.M. et al, Phys. Rev. B, 26, 6067-6076 (1982))

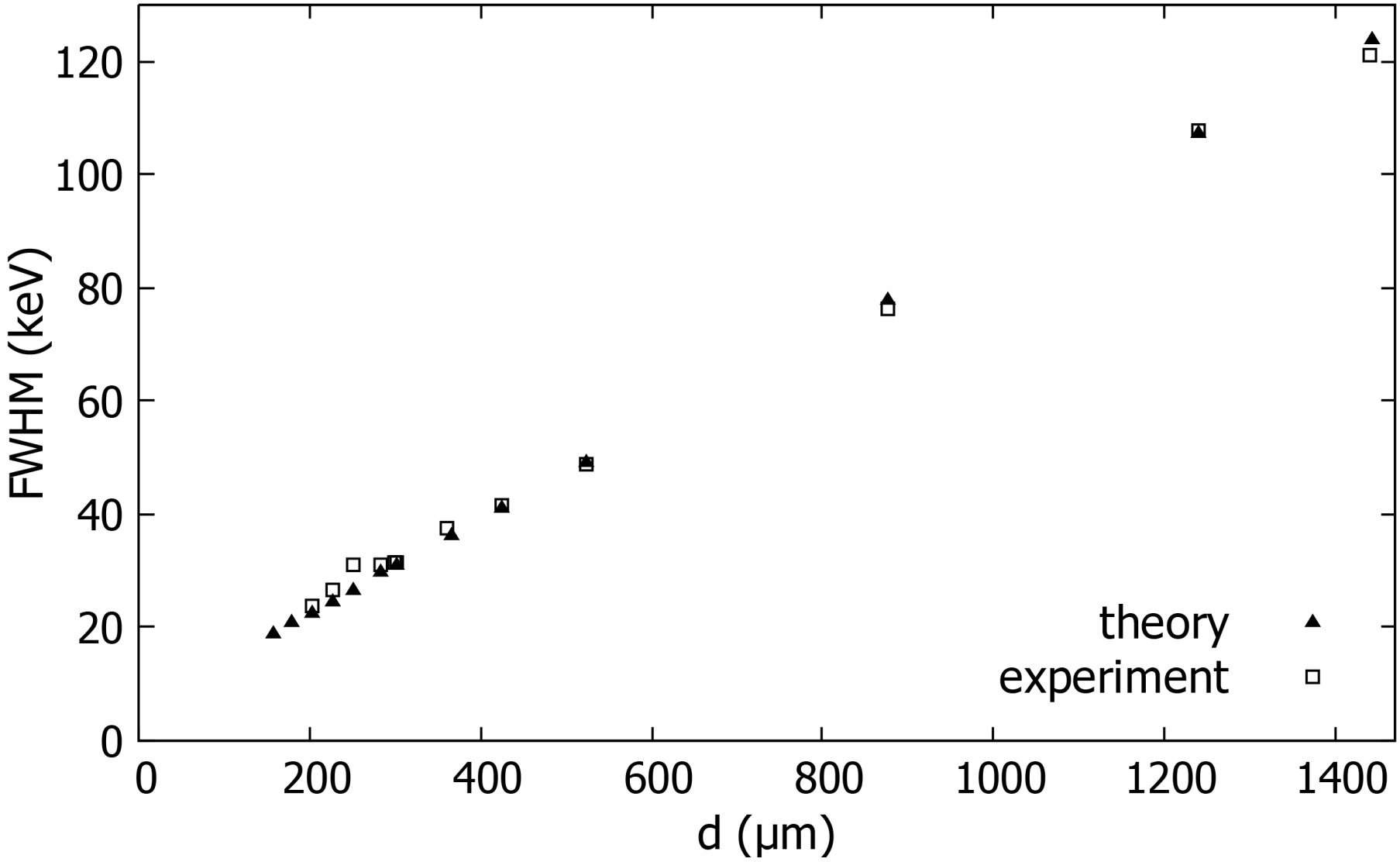
Most probably energy loss of 50 GeV protons in Si



Most probably energy loss of 50 GeV protons in Si



Width of the Landau spectral peaks



Conclusions

- The possibility of observation of gradual evolution of the Landau spectral peak with smooth turning of the effective semiconductor detector thickness was demonstrated.
- The experimental data are compared to results of calculations.

Thank you for your attention