



# Evolution of the Landau spectral peak produced by 50 GeV protons and 7 GeV electrons in Si detector at rotation of the detector

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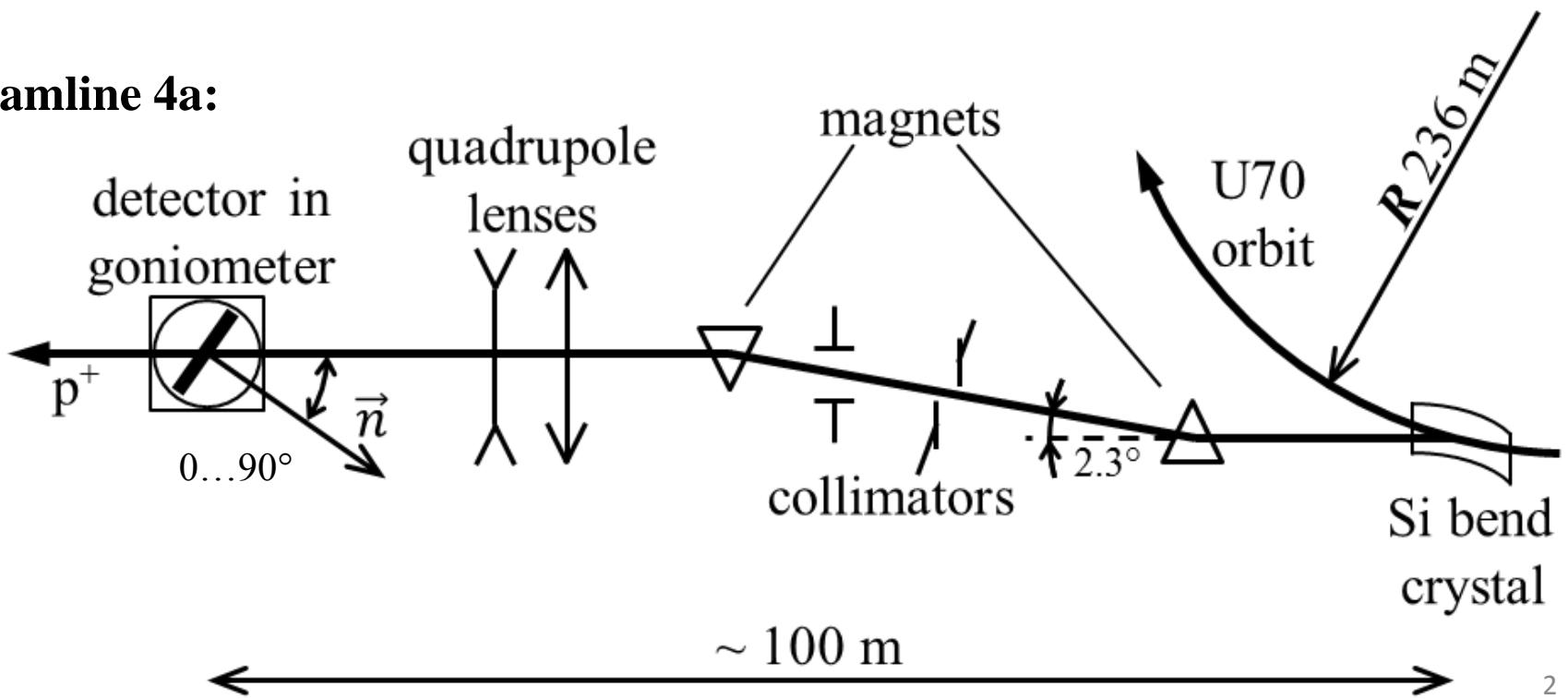
# Accelerator U70 at IHEP (Protvino, Russia)



p <sup>+</sup> energy	50 GeV
p <sup>+</sup> per spill	~ 10 <sup>6</sup>
Spill duration	~ 0.2 s
Spill periodicity	8.6 s
Beam divergence	100 μrad (21")



## Beamline 4a:



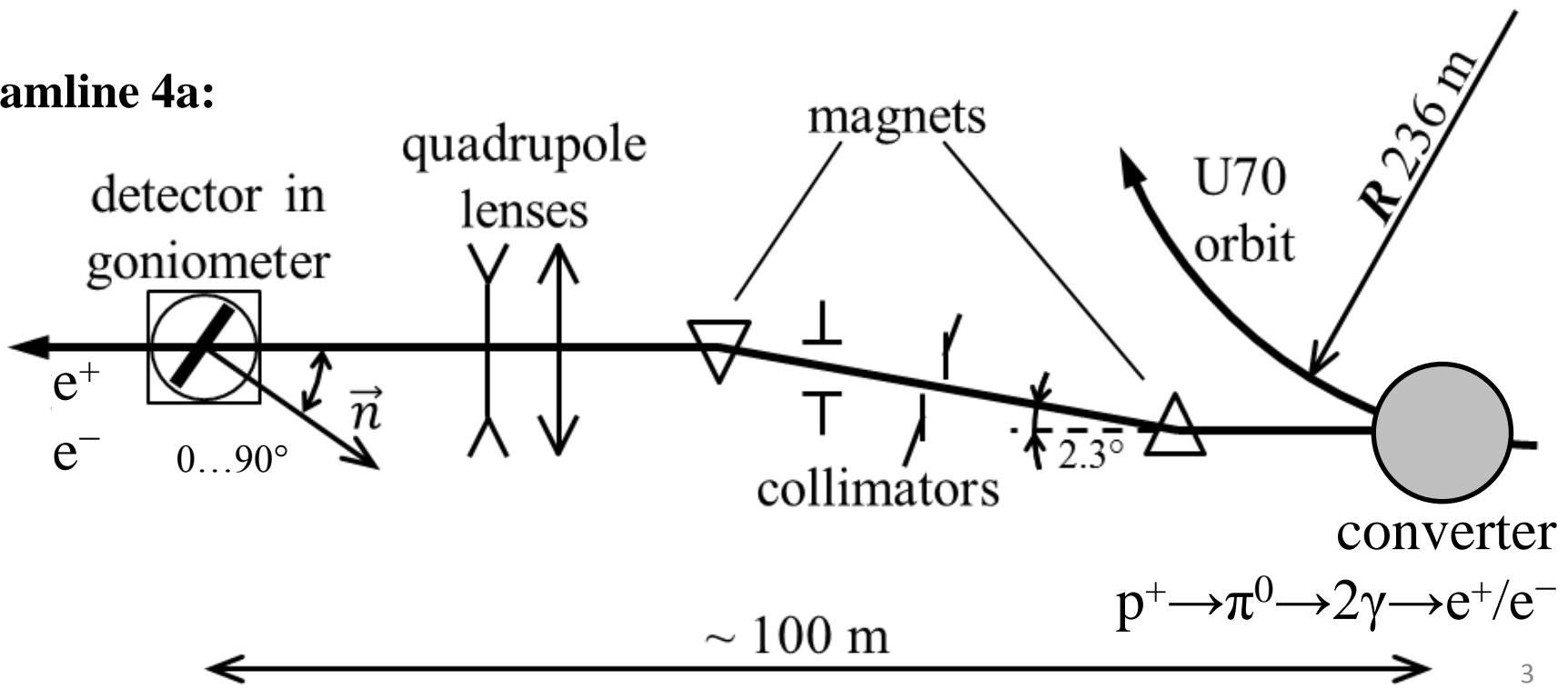
# Accelerator U70 at IHEP (Protvino, Russia)



e <sup>+</sup> /e <sup>-</sup> energy	7 GeV
e <sup>+</sup> /e <sup>-</sup> per spill	$10^4 - 10^5$
Spill duration	~ 0.2 s
Spill periodicity	8.6 s
Beam divergence	2.5 mrad (8.3')



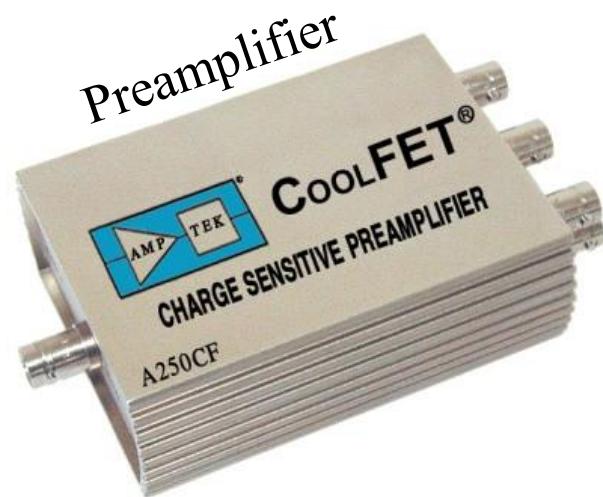
## Beamline 4a:



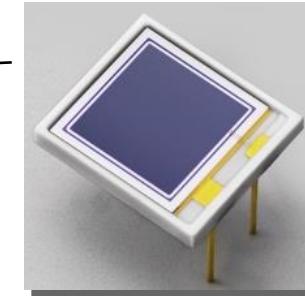
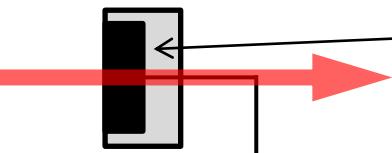
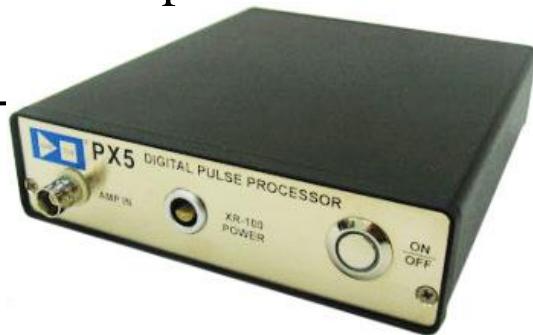
# Spectroscopy system

$p^+$  50 GeV

$e^+e^-$  7 GeV



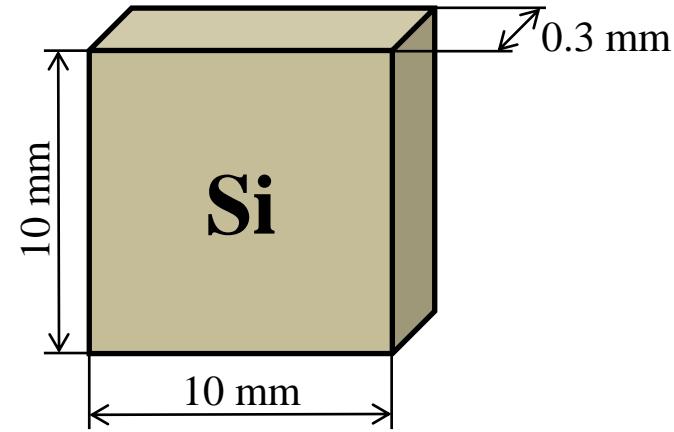
Spectrometer



**Hamamatsu Si PIN S3590-18**

area:  $1 \text{ cm}^2$

depleted layer: 0.3 mm

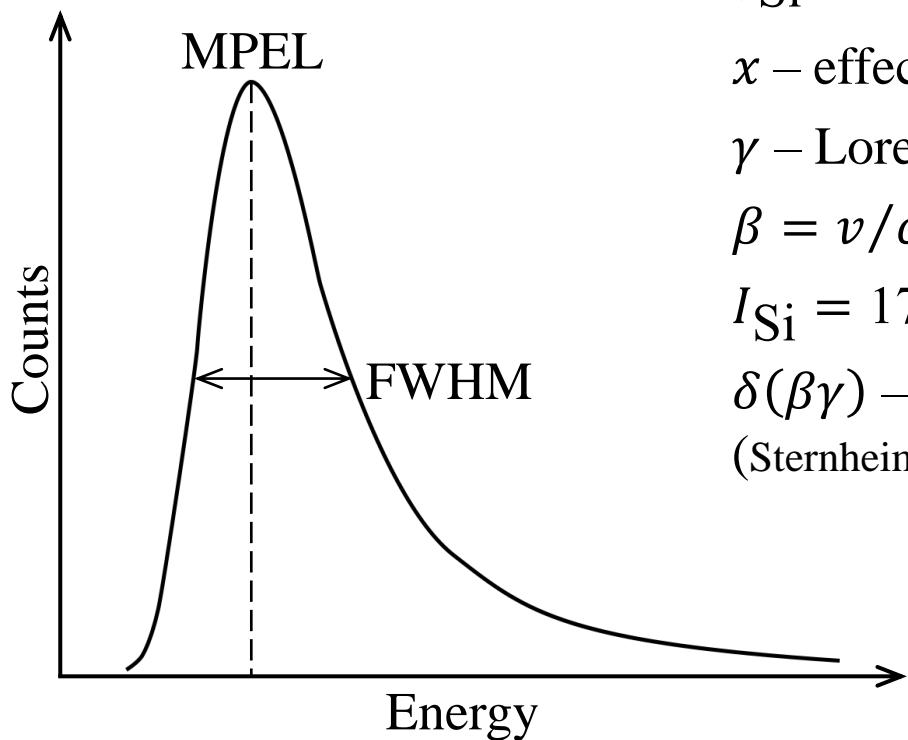


# Landau distribution for ionization energy loss

Most probably energy loss (MPEL):

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

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



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

$x$  – effective detector thickness

$\gamma$  – Lorentz factor

$$\beta = v/c$$

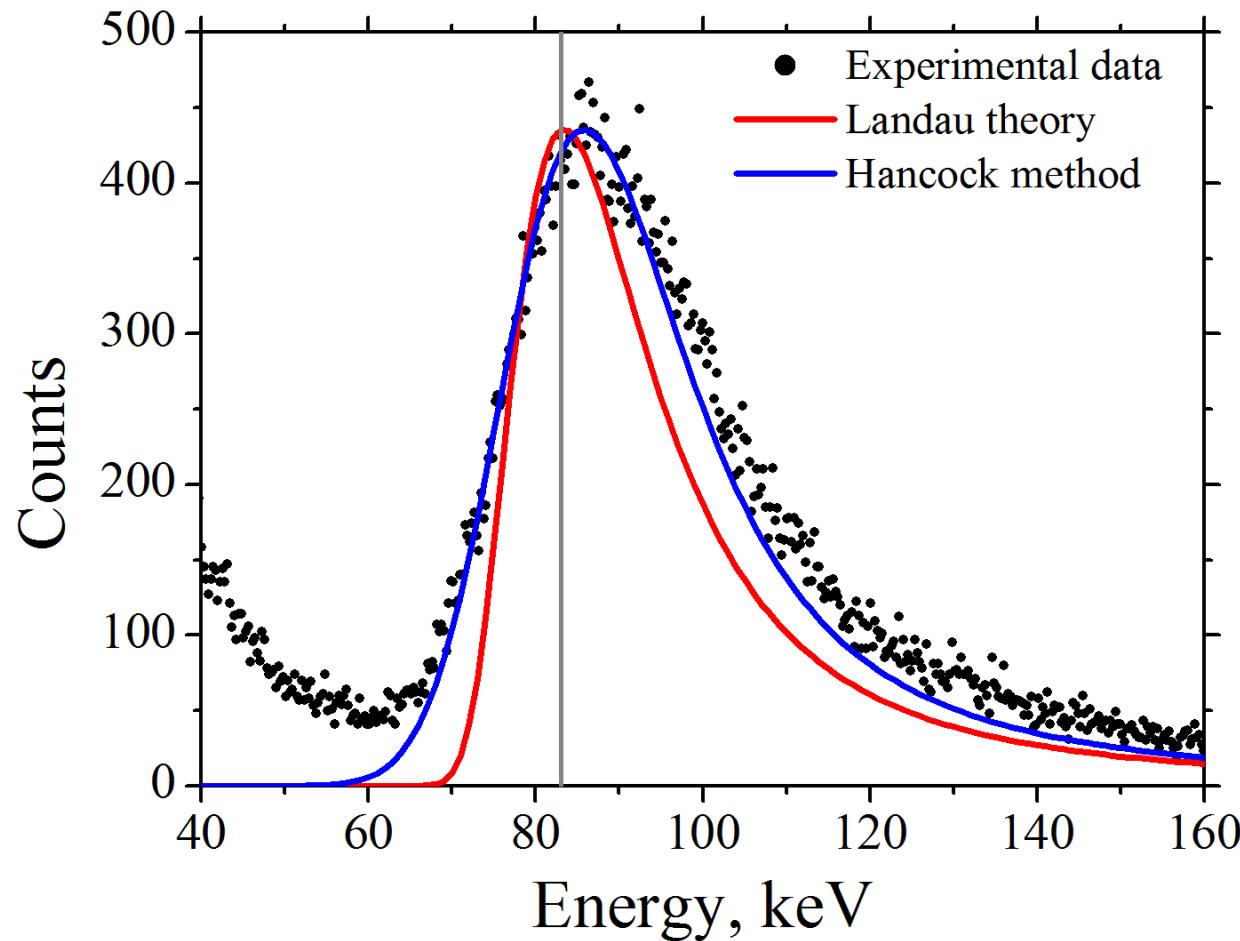
$I_{\text{Si}} = 173 \text{ eV}$  (mean excitation energy)

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

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

# Ionization loss of charged particles

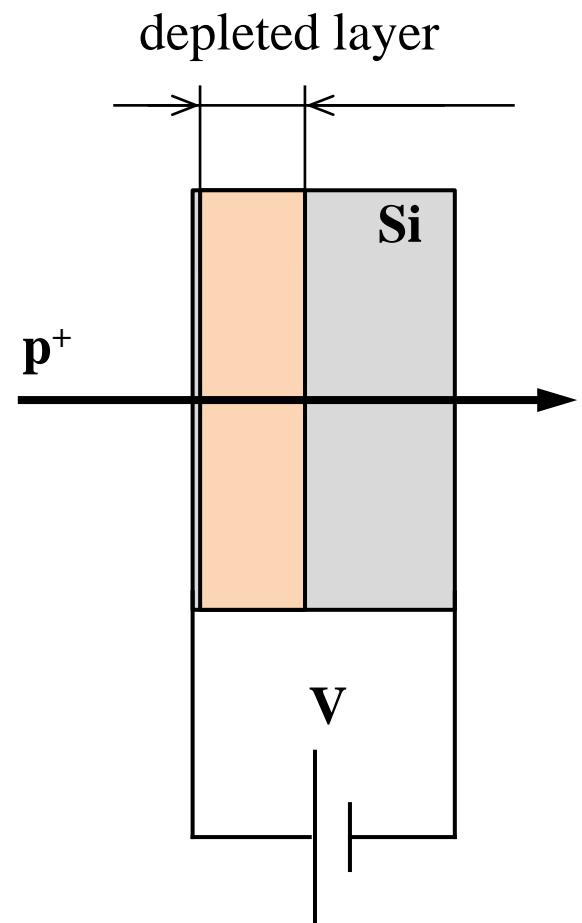
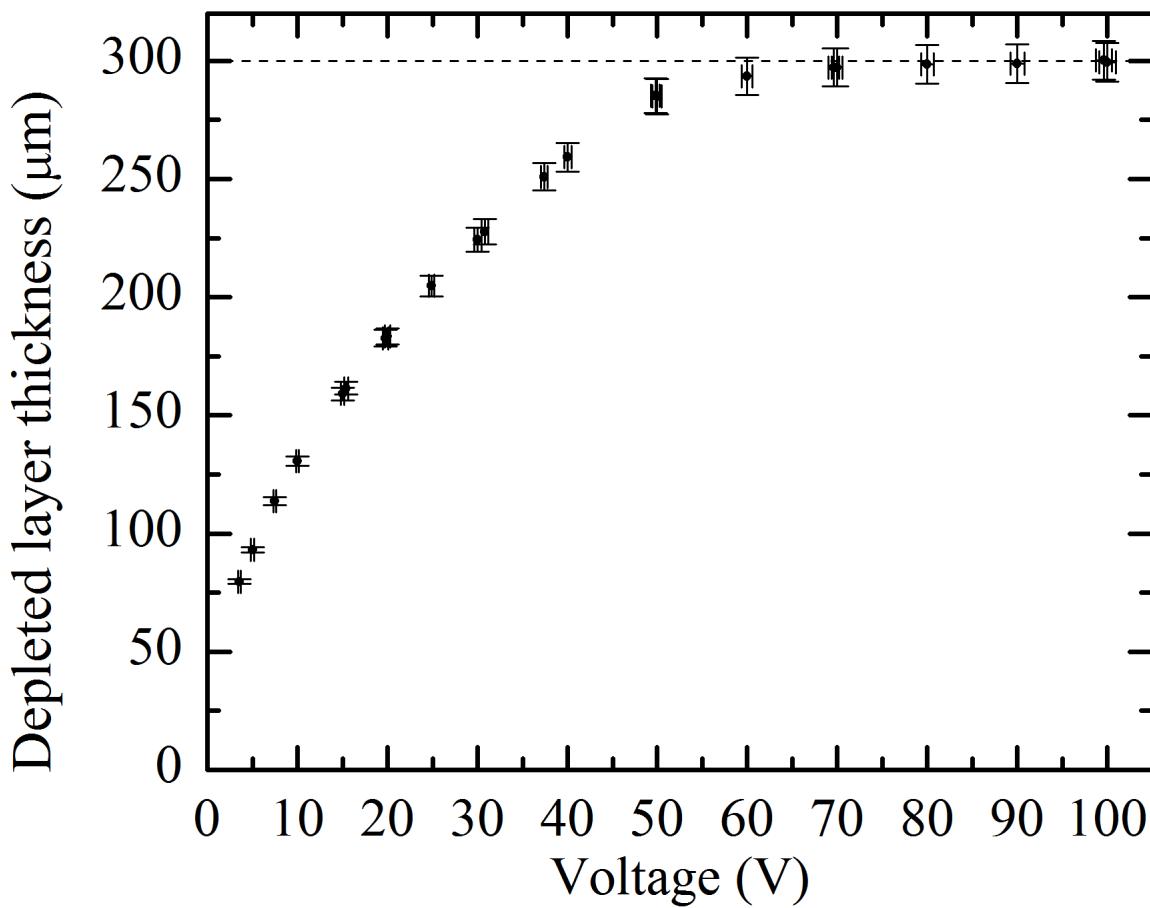
Energy loss of 50 GeV protons in 300  $\mu\text{m}$  thick silicon



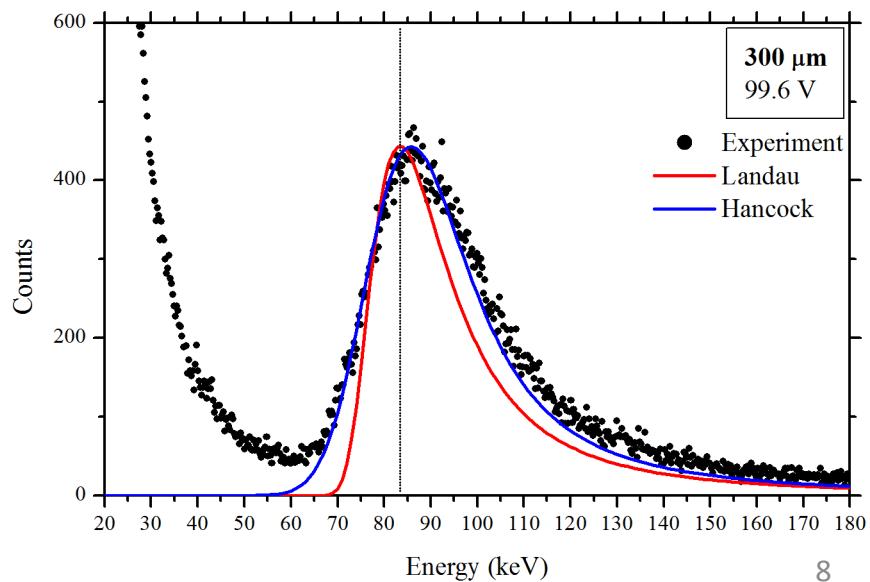
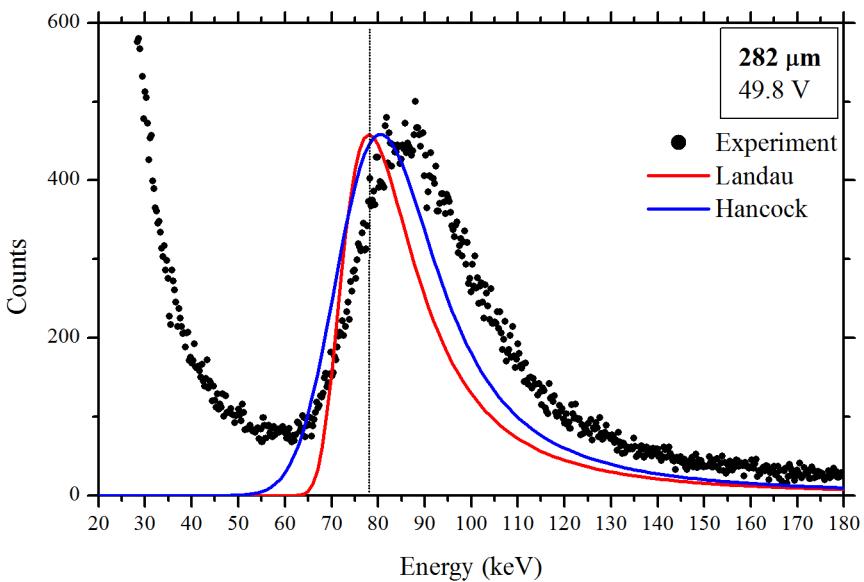
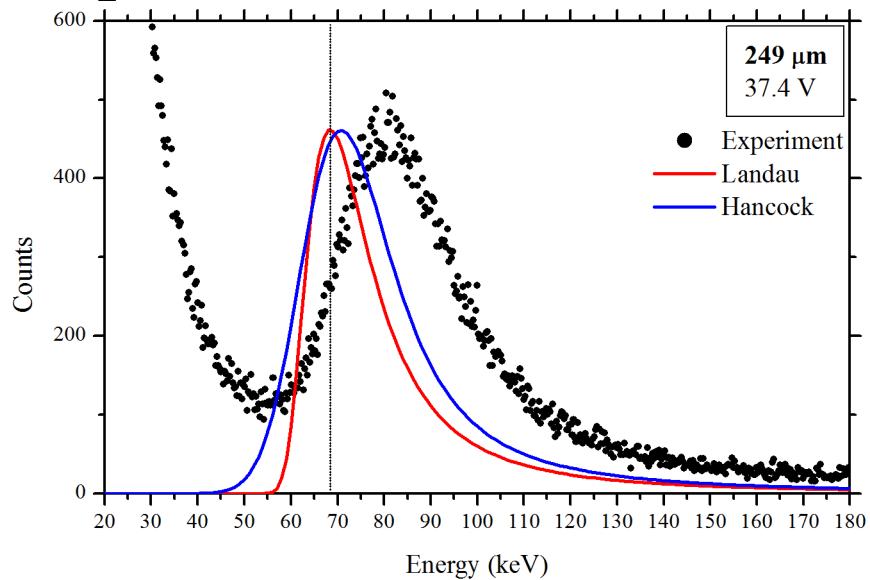
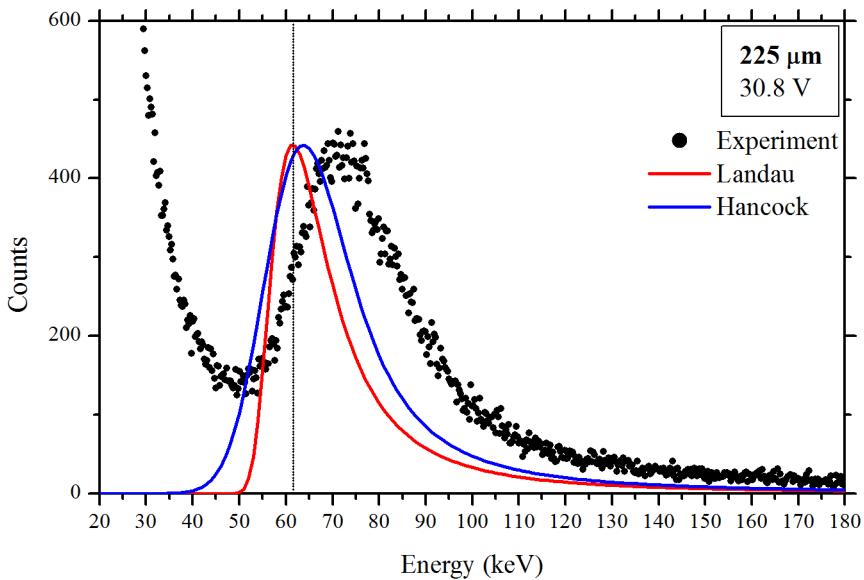
L.D. Landau // J. Phys. USSR, 1944, 8, 201.

S. Hancock, F. James // Phys. Rev. A, 1983, 28, 615–620.

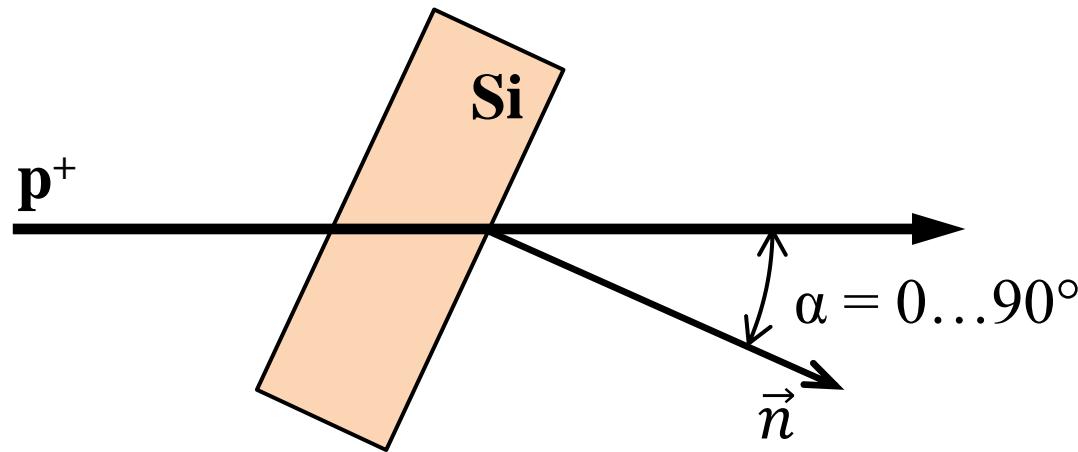
# Depleted layer thickness of the detector



# Influence of the detector power supply voltage on the spectra of ionization loss of 50 GeV protons in silicon

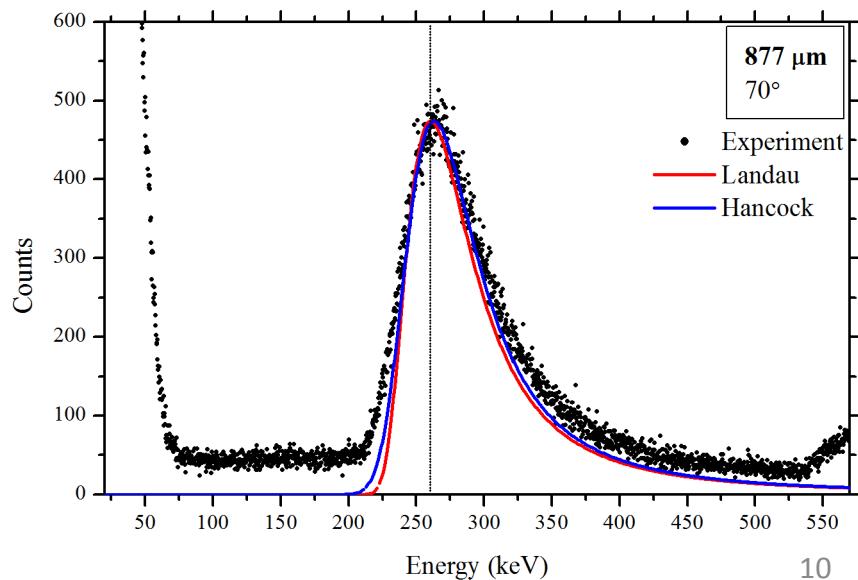
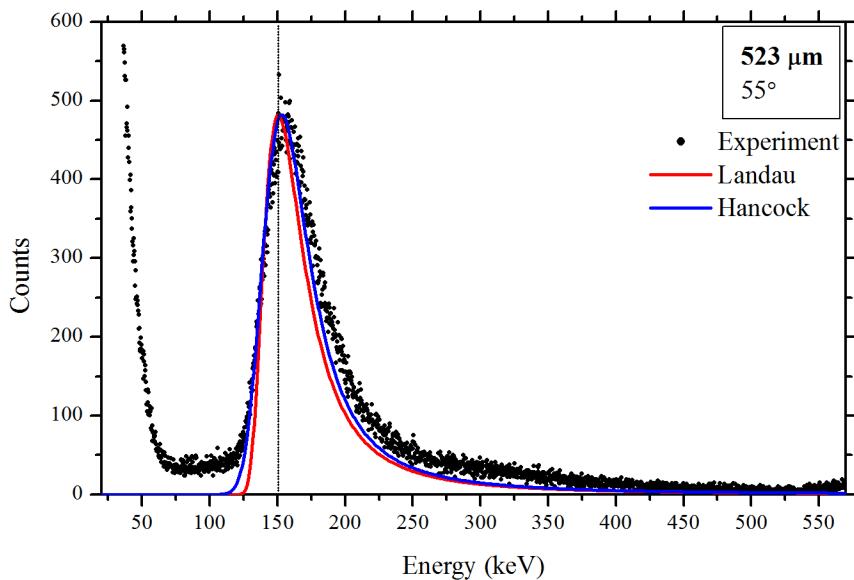
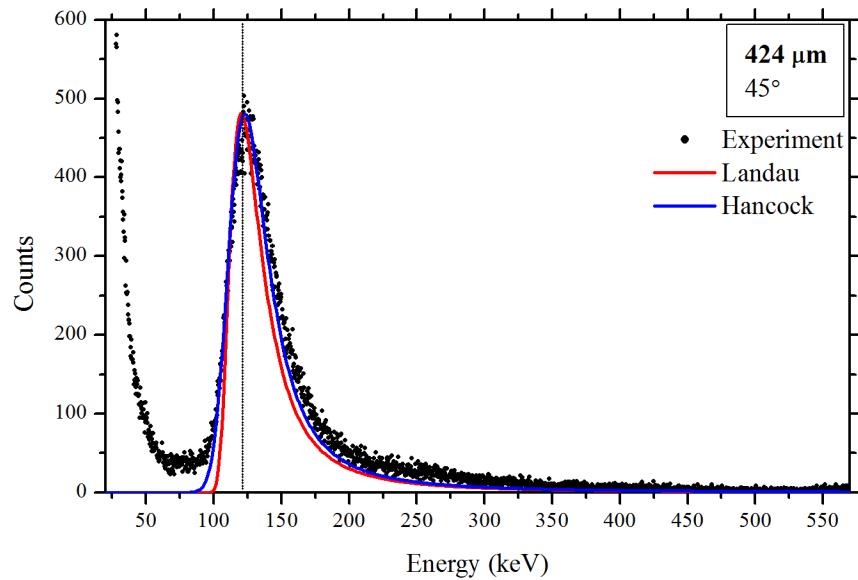
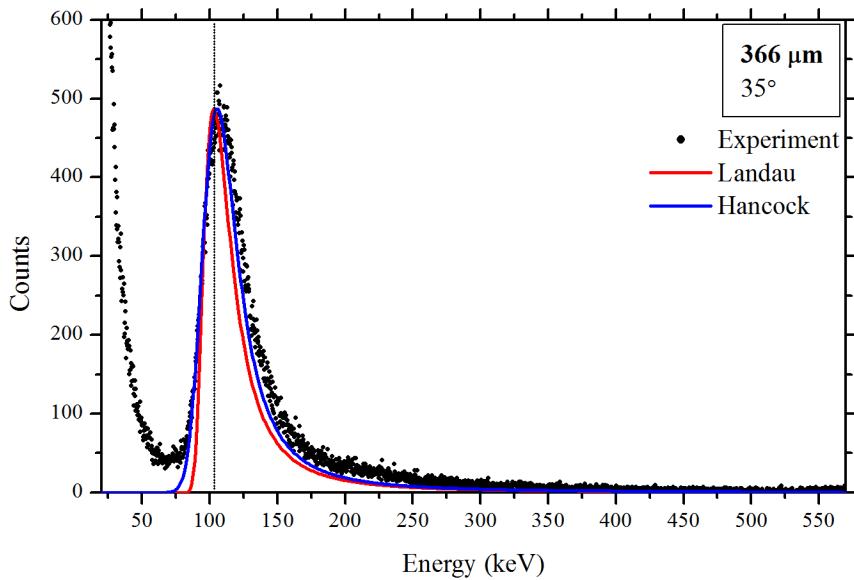


# Rotation of the detector

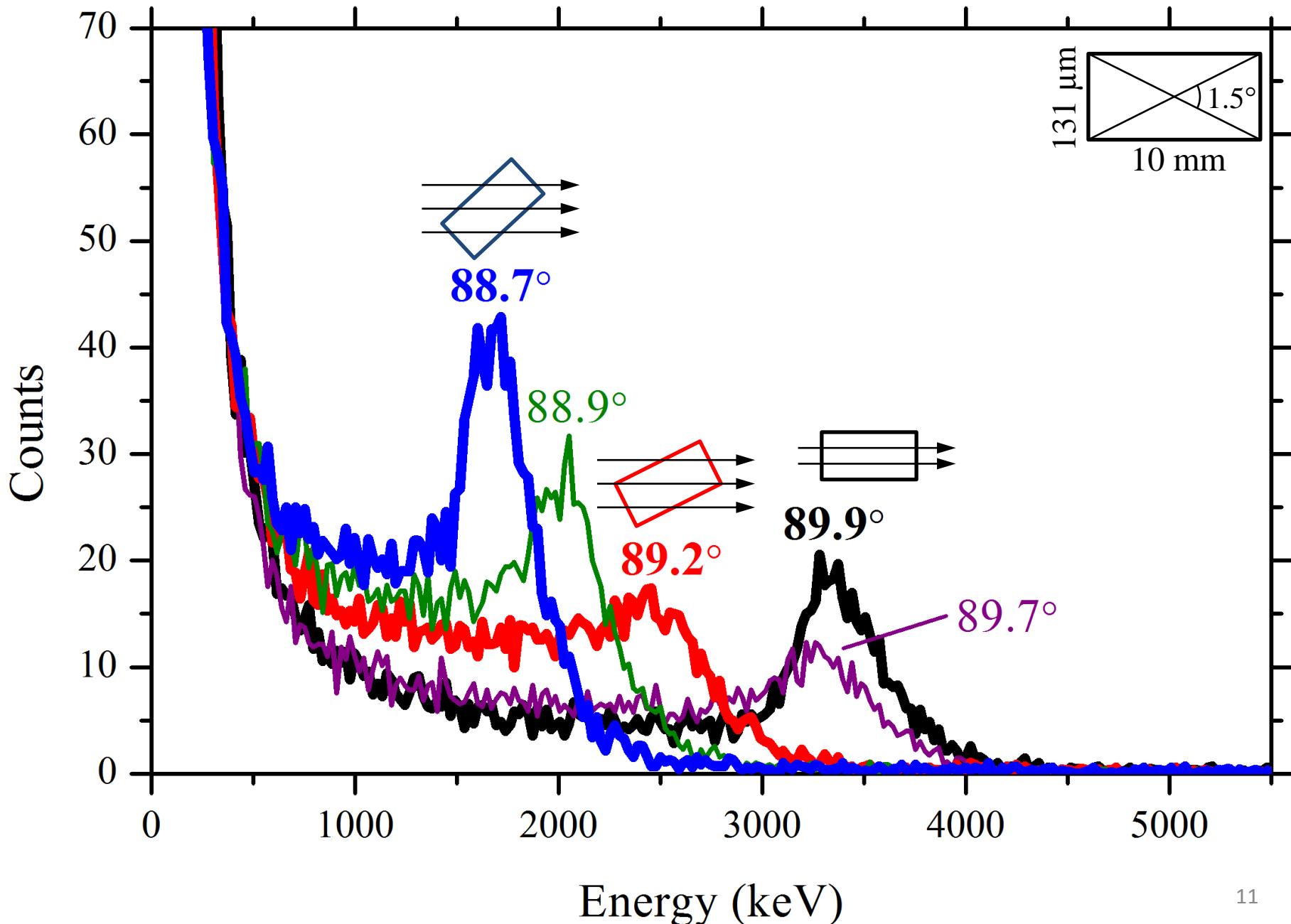


Effective thickness of Si crystal: **300  $\mu\text{m}$  ... 10 mm**

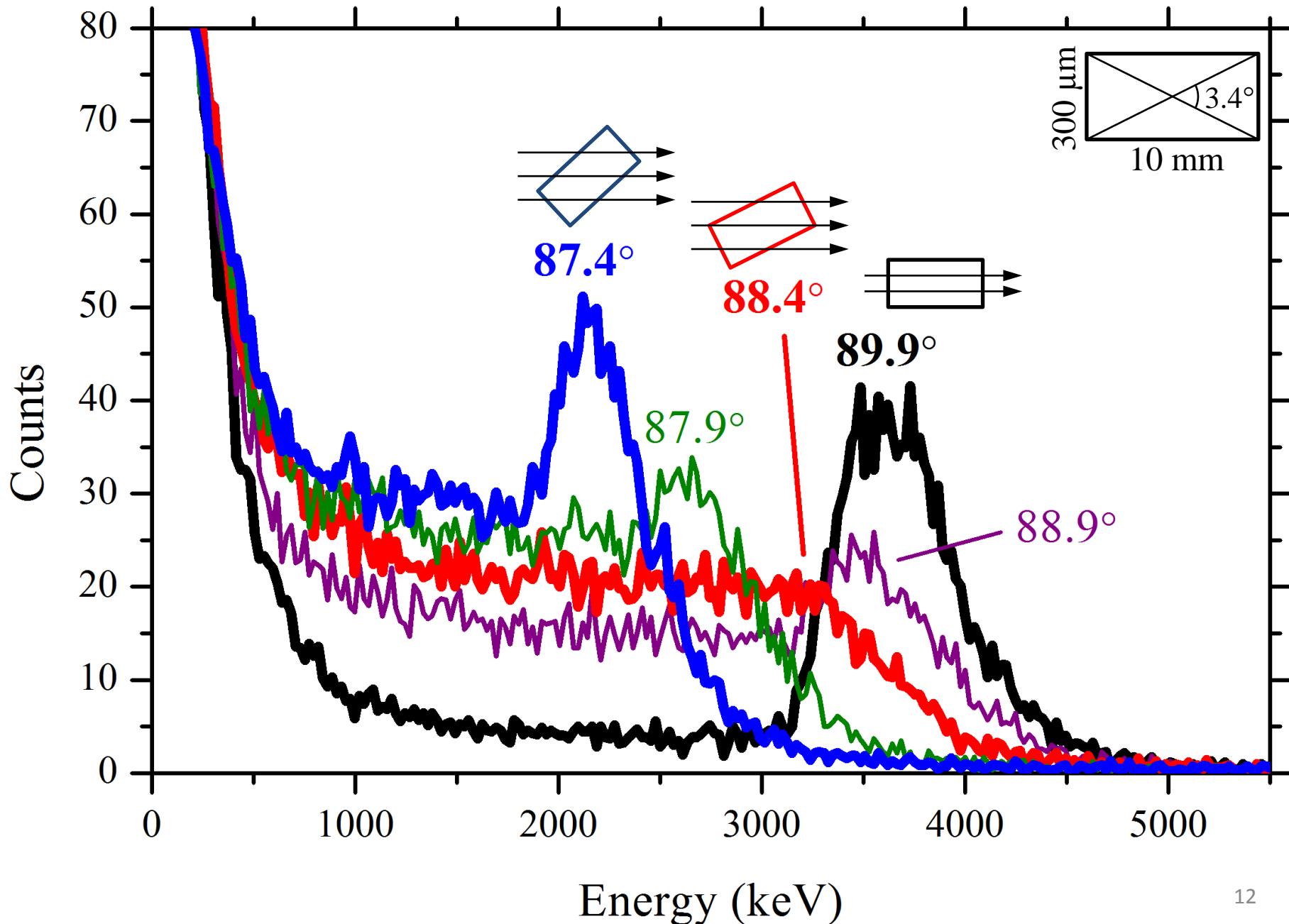
# Energy loss spectra produced by 50 GeV protons in Si detector at different orientations



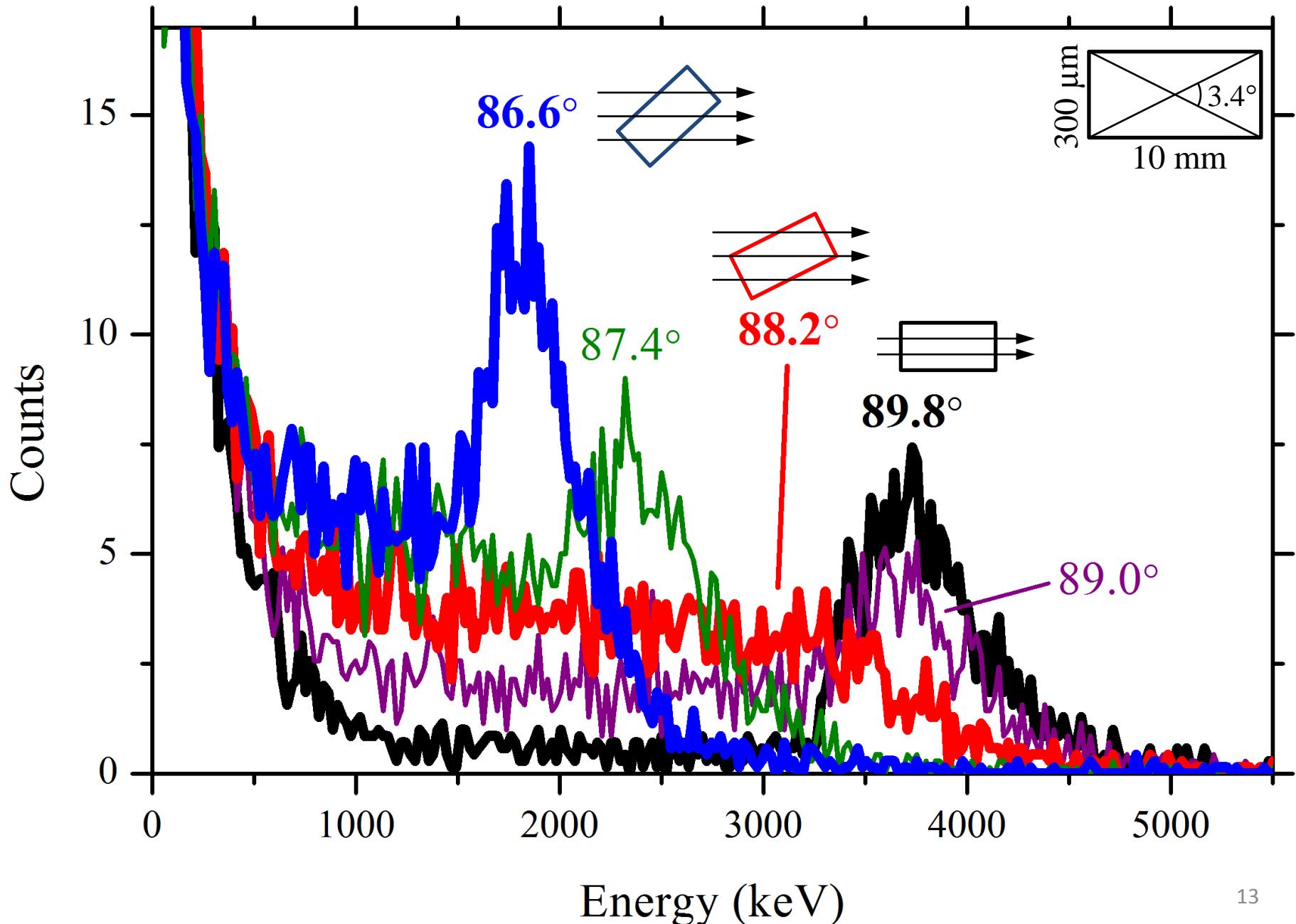
# The disappearance of the ionization loss peak of 50 GeV protons



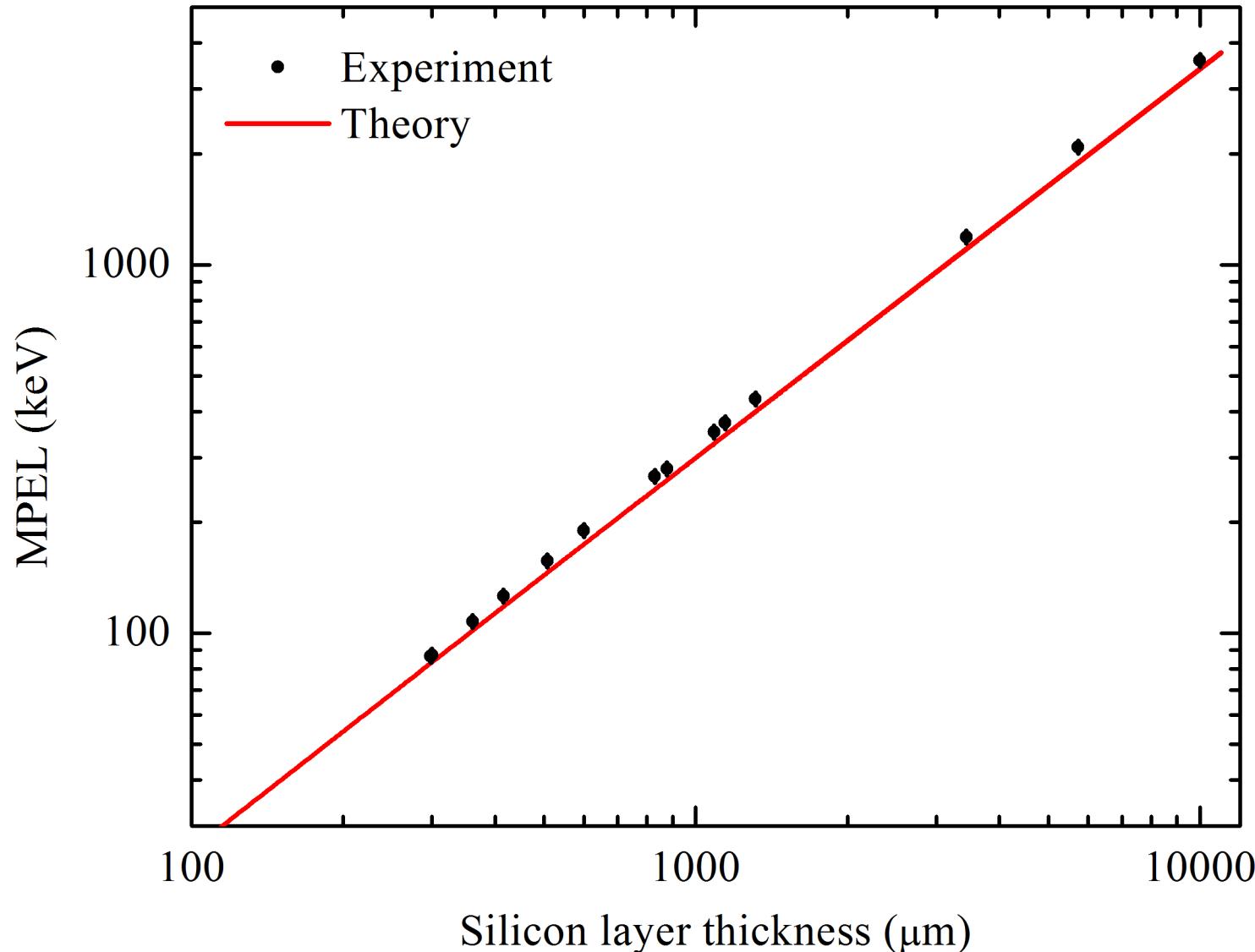
# The disappearance of the ionization loss peak of 50 GeV protons



# The disappearance of the ionization loss peak of 7 GeV electrons



# Most probable energy loss of 50 GeV protons in silicon



# Conclusion

- Experimental data on the ionization loss of 50 GeV protons in silicon with a thickness of 0.3 to 10 mm are obtained.
- The experimental data are compared with the theory.
- A method is proposed for aligning the targets along the axis of charged high-energy particle beams by measuring ionization loss spectra.

**Thank you for attention!**