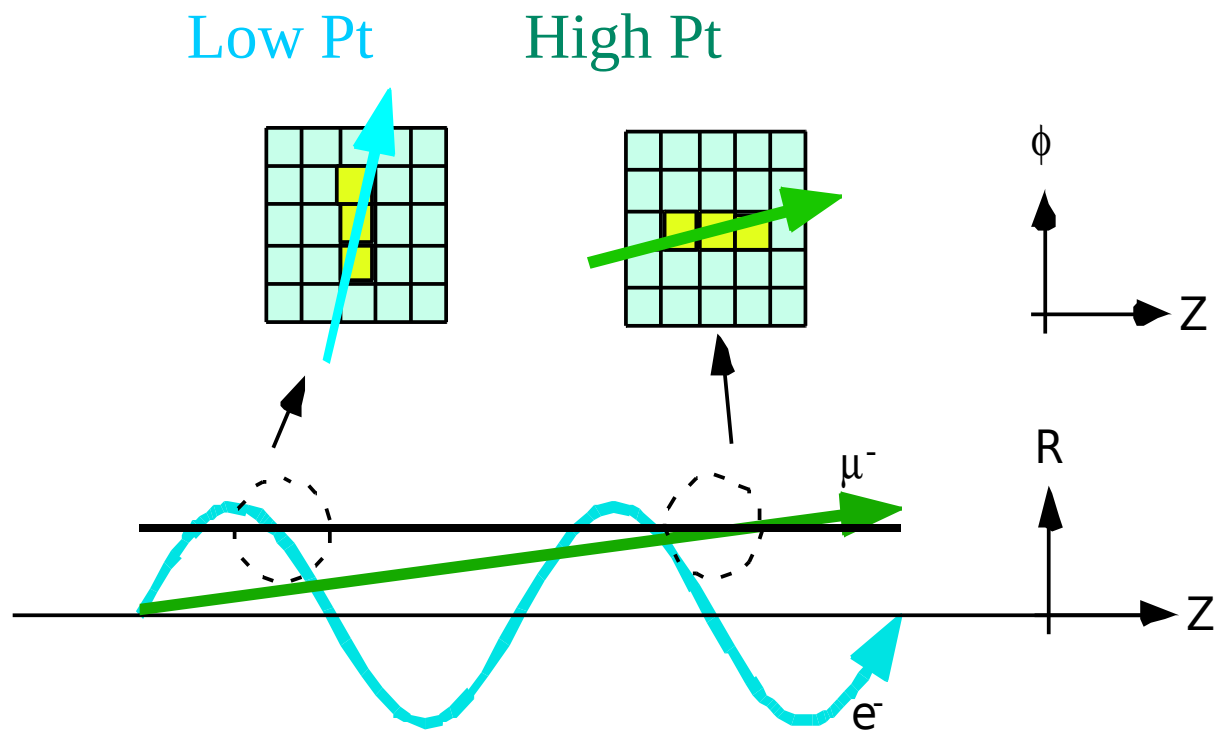


ILC Vertex Workshop
Como April 2008

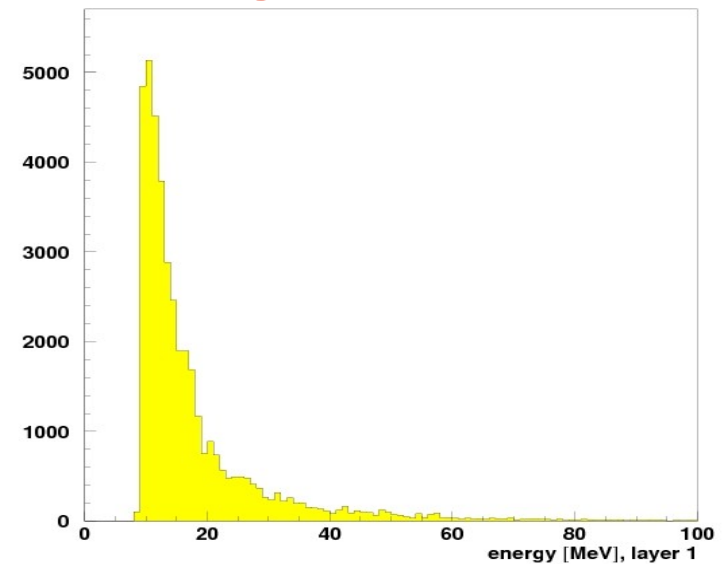
**Measurements of cluster shapes in MAPS
detectors – studies towards beamstrahlung
rejection in the ILC Vertex Detector**

Ł. Mączewski, M. Adamus, J. Ciborowski, P. Łuźniak

Introduction



Energy distribution of particles reaching the first VXD layer



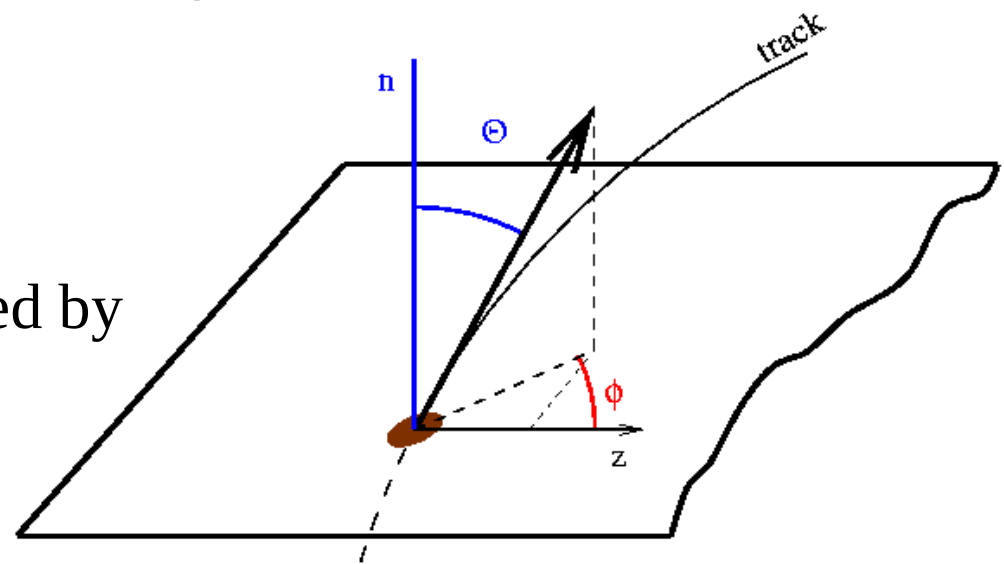
[Akiya Miyamoto, CIAW07]

- High beamstrahlung background – e^+e^- pairs with low P_t
- Electrons and positrons spiralling in the magnetic field
- Physics hits with high P_t

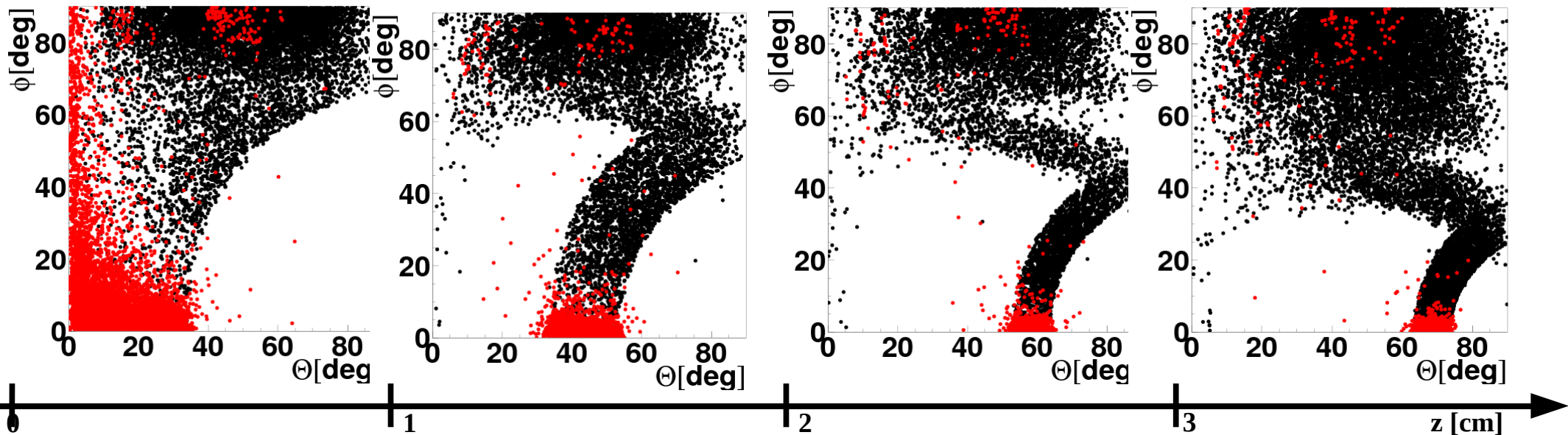
Introduction

- Discriminate between **beamstrahlung** and **physics hits** at ILC (simulation by P. Luzniak)

- physics hits
- beamstrahlung – e^+e^- pairs simulated by Guinea Pig (@ 500GeV)

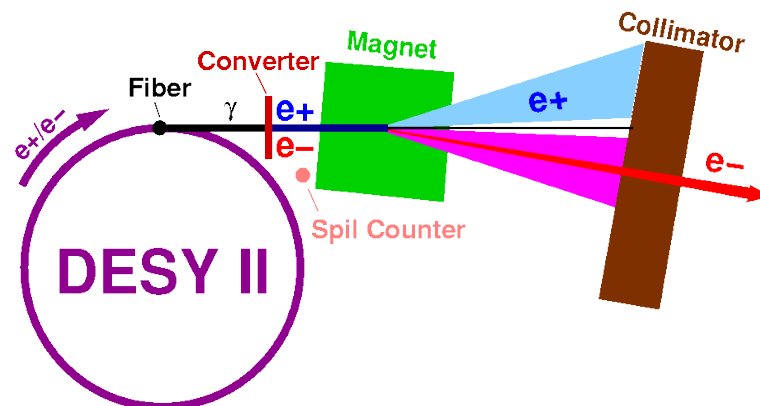


Hits in first VTX layer



Dedicated measurements at DESY

- Beam tests at DESY – 6.5 GeV electrons delivered by DESY II accelerator



- Measurements of MIMOSA5 and MIMOSA18 (MAPS devices) response at different incident angles

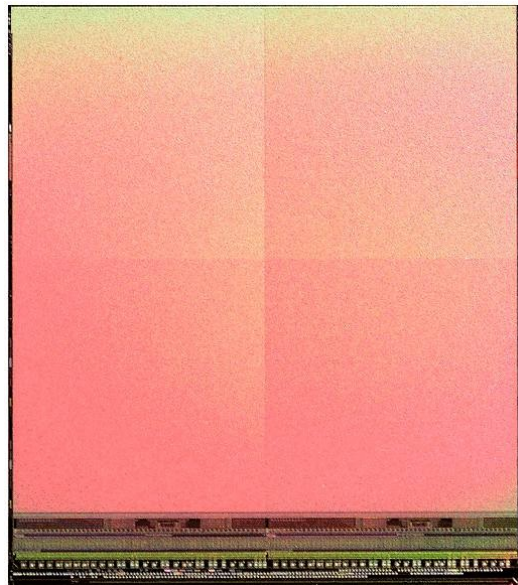
6.5 GeV electrons at several incident angles $\theta \in (0^\circ, 80^\circ)$



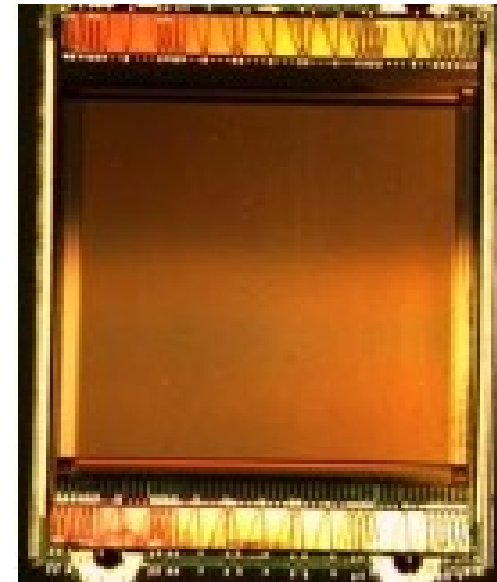
Tested MAPS prototype

- ◆ MIMOSA5 measurements
 - ◆ Pixel size: $17\mu\text{m} \times 17\mu\text{m}$
 - ◆ Epitaxial layer: $14\mu\text{m}$
 - ◆ Thickness: $120\mu\text{m}$
- ◆ MIMOSA18 measurements
 - ◆ Pixel size: $10\mu\text{m} \times 10\mu\text{m}$
 - ◆ Epitaxial layer: $14\mu\text{m}$
 - ◆ Thickness: $700\mu\text{m}$

Using DESY reference strip telescope



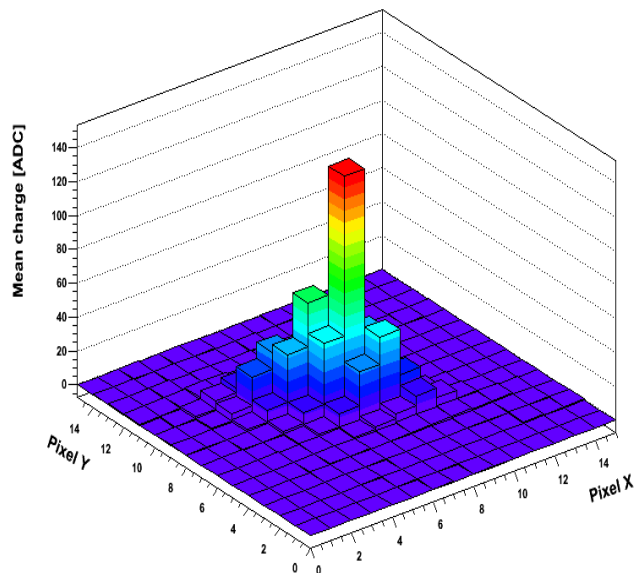
Without reference telescope



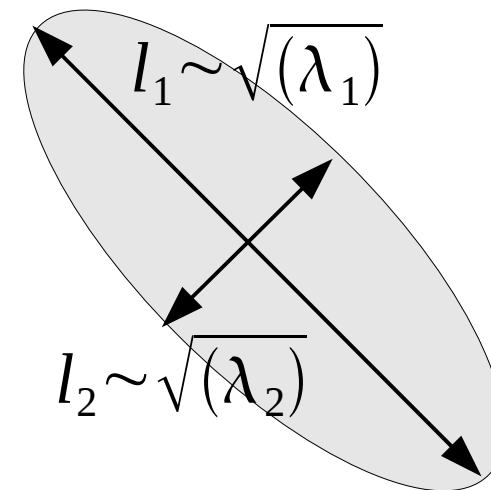
Cluster shapes – angles reconstruction

$$\theta = 78^\circ \quad \varphi = -38^\circ$$

values determined by alignment



Determination of main axes



Charge distribution matrix

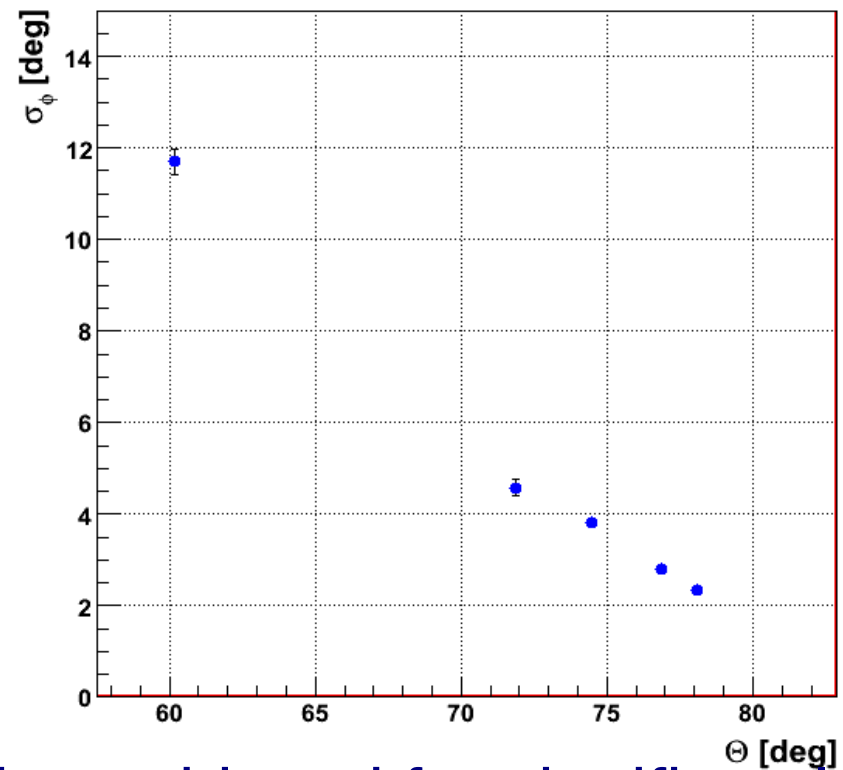
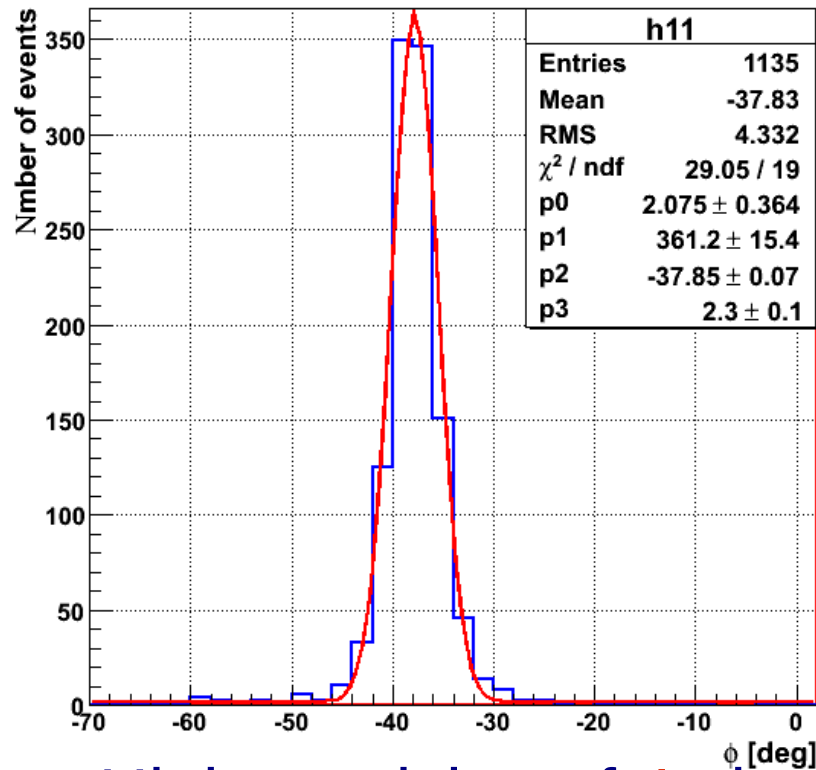
$$\begin{pmatrix} \sum_i \frac{q_i}{Q} (x_i - \bar{x})^2 & \sum_i \frac{q_i}{Q} (x_i - \bar{x})(y_i - \bar{y}) \\ \sum_i \frac{q_i}{Q} (x_i - \bar{x})(y_i - \bar{y}) & \sum_i \frac{q_i}{Q} (y_i - \bar{y})^2 \end{pmatrix} \xrightarrow{\text{diagonalisation}} \begin{matrix} \text{Eigenvalues } (\lambda_1 \lambda_2) \rightarrow \text{elongation} \rightarrow \theta \\ \text{Eigenvectors} \rightarrow \varphi \end{matrix}$$

where: q_i , x_i , y_i are charge and coordinates of the i -th pixel in a cluster, Q is a total cluster charge and \bar{x} , \bar{y} are the coordinates of the cluster symmetry centre

Reconstruction of cluster orientation **MIMOSA-5**

$$\theta = 78^\circ \quad \varphi = -38^\circ$$

values determined by alignment



- High precision of ϕ determination achieved for significantly elongated clusters – $\sigma_\phi < 15^\circ$ for $\theta > 60^\circ$

- Higher precision is expected for smaller pixels size -

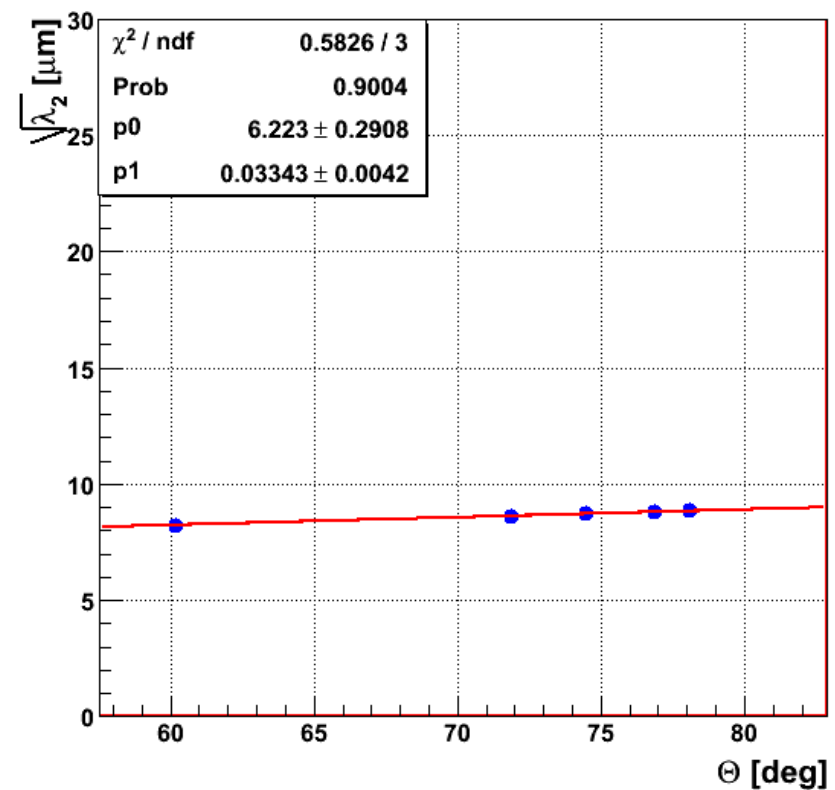
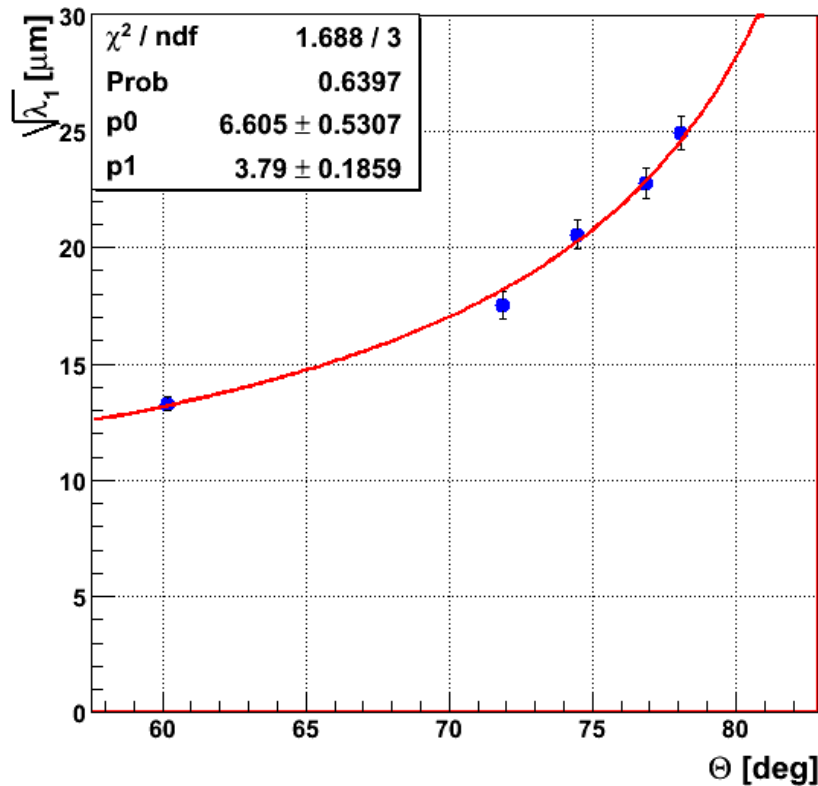
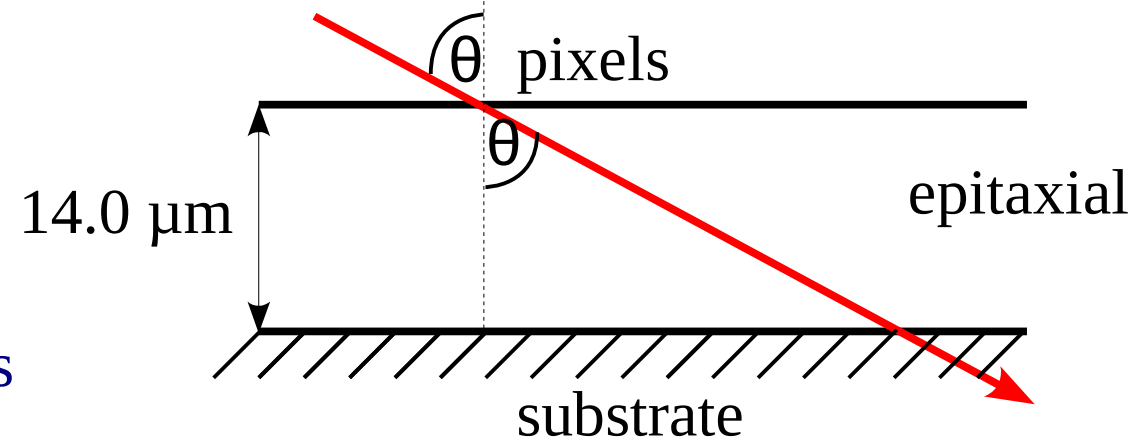
MIMOSA18

Reconstruction of cluster orientation **MIMOSA-5**

- Elongation along the particle path

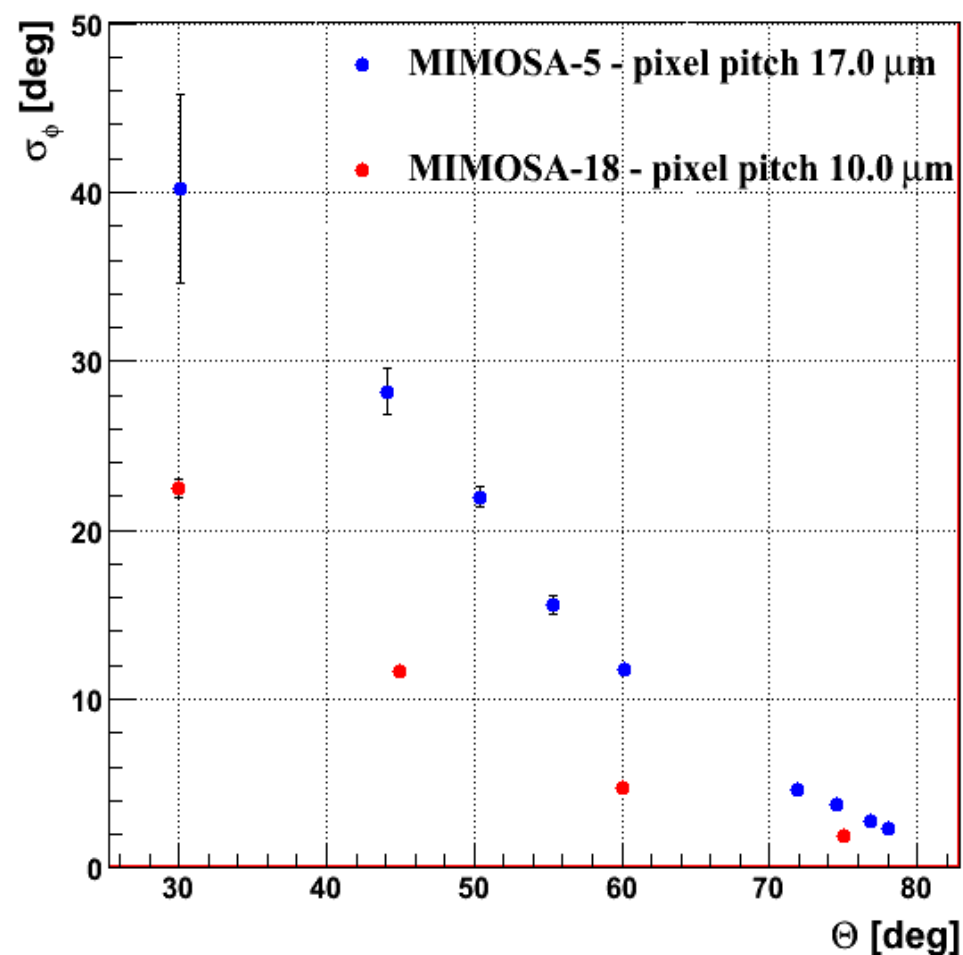
$$\sqrt{\lambda_1} = p0 + p1 \cdot \tan \theta$$

$p1$ – proportional to epitaxial thickness



Reconstruction of cluster orientation

- ◆ For smaller pixels size higher precision of ϕ is achieved
- ◆ In case of the $10\ \mu\text{m}$ pixel pitch, $\sigma_\phi < 15^\circ$ for $\theta > 40^\circ$
- ◆ To reject beamstrahlung more efficiently small pixels in the first layer of the VXD are recommended - $5\ \mu\text{m}$

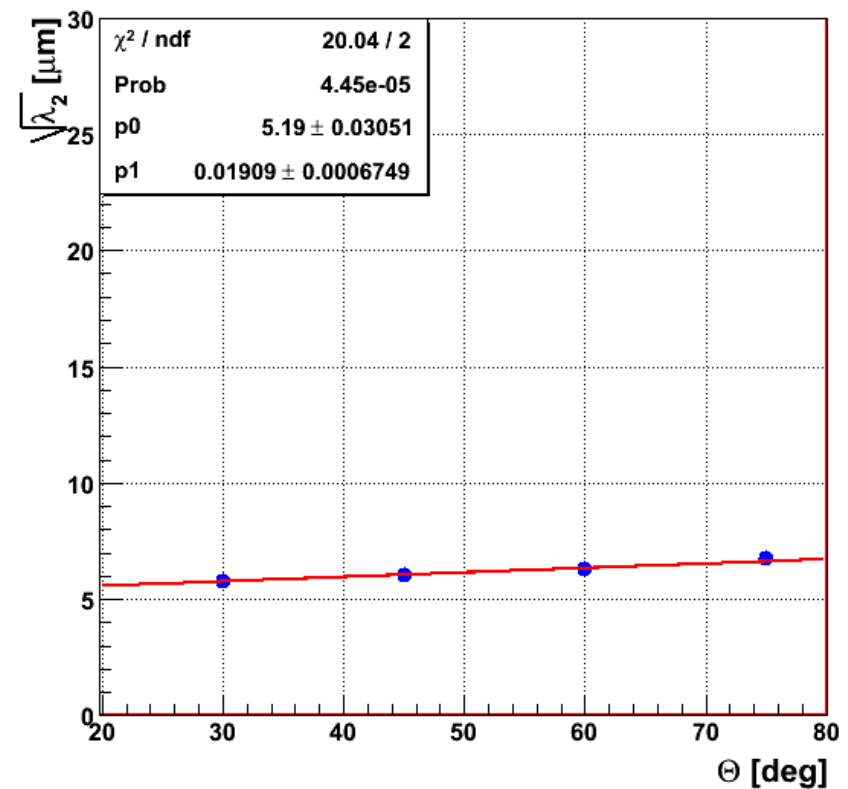
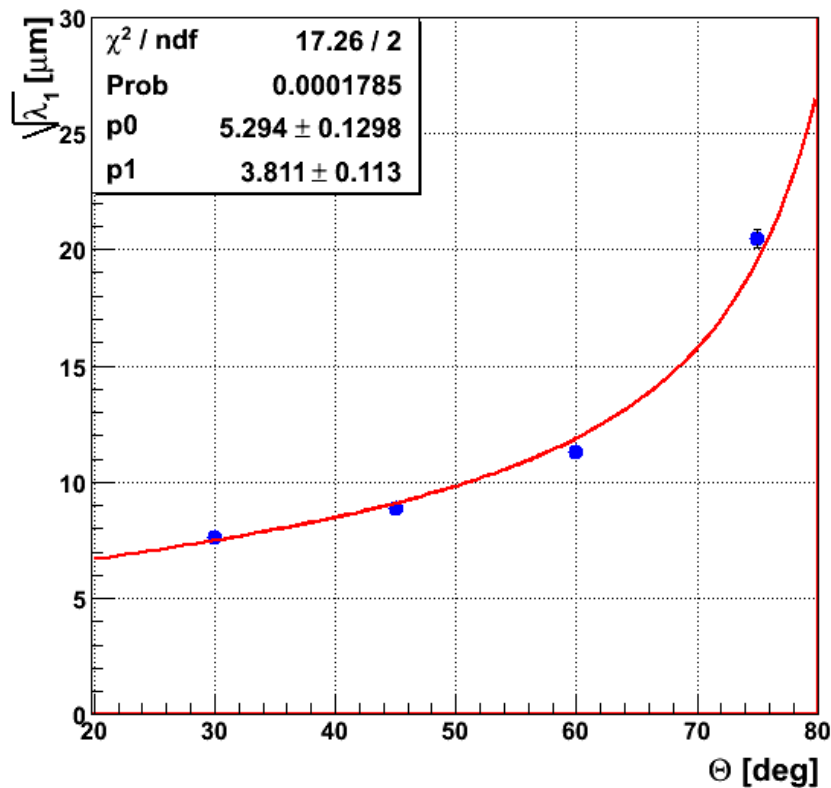
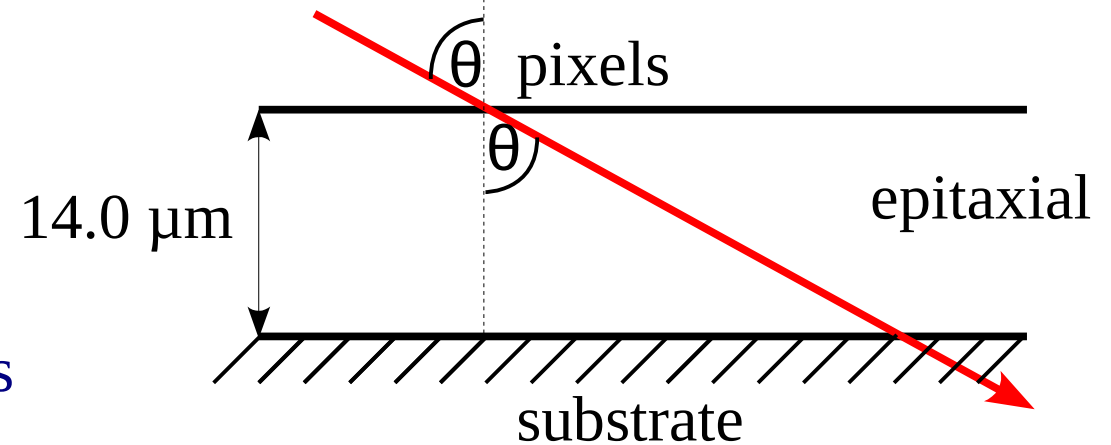


Reconstruction of cluster orientation **MIMOSA-18**

- ◆ Elongation along the particle path

$$\sqrt{\lambda_1} = p0 + p1 \cdot \tan \theta$$

$p1$ – proportional to epitaxial thickness



Summary

- ◆ Results are very promising in terms of distinguishing between beamstrahlung and physics hits:
 - ◆ Precision of presented method increases with decreasing pixel size
 - ◆ Tests with $\sim 10 - 100$ MeV electrons planned
- ◆ Dedicated Monte Carlo studies for beamstrahlung rejection efficiency are in progress:
 - ◆ Development of parametrisation of the MAPS detectors response