Beamstrahlung background rejection based on cluster shapes in a pixel vertex detector
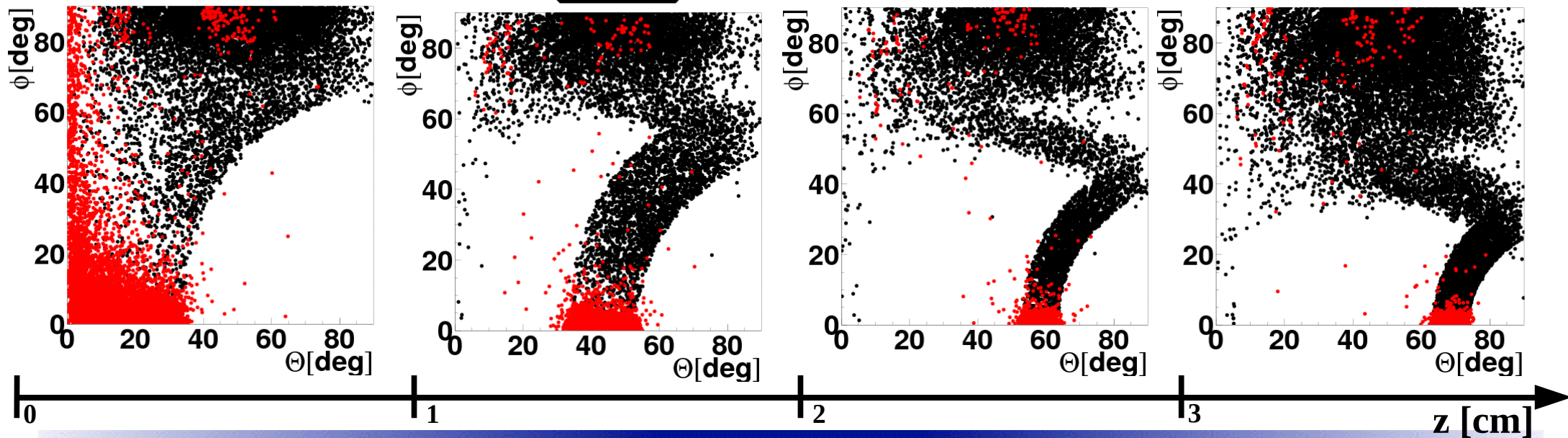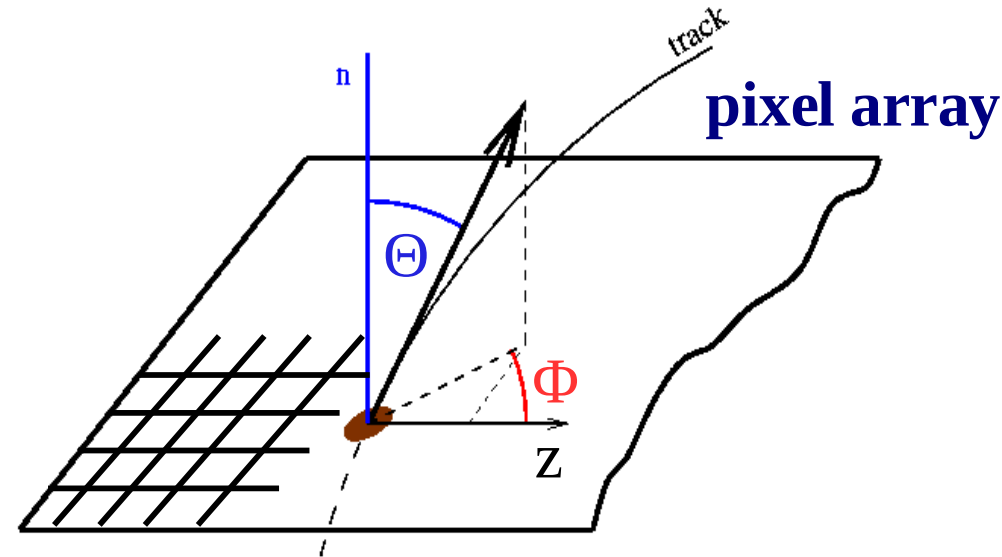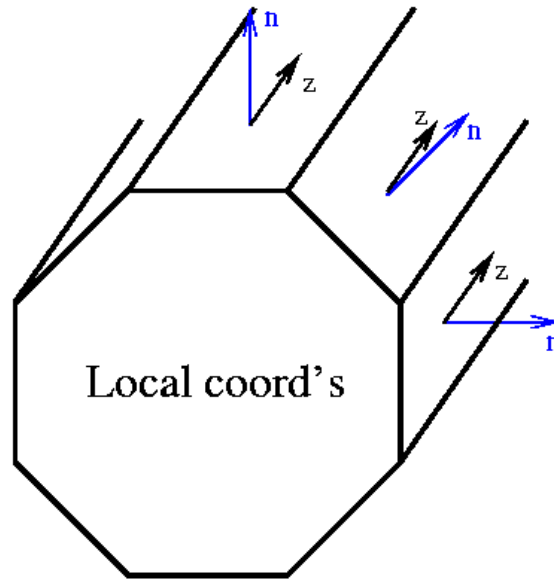
Ł. Mączewski [1], M. Adamus [2], J. Ciborowski [1], P. Łużniak [3]

[1] Warsaw University, [2] Institute for Nuclear Studies, [3] University of Lodz

Introduction

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

Hits in the first VTX layer r = 15 mm

pixel array

Local coord's

Dedicated measurements at DESY

- Beam tests at DESY – 6.5 GeV electrons

- Silicon strip telescope

- Measurements of MIMOSA5

  (MAPS device) response at

  different beam incident angles

  - Adjustable mounting
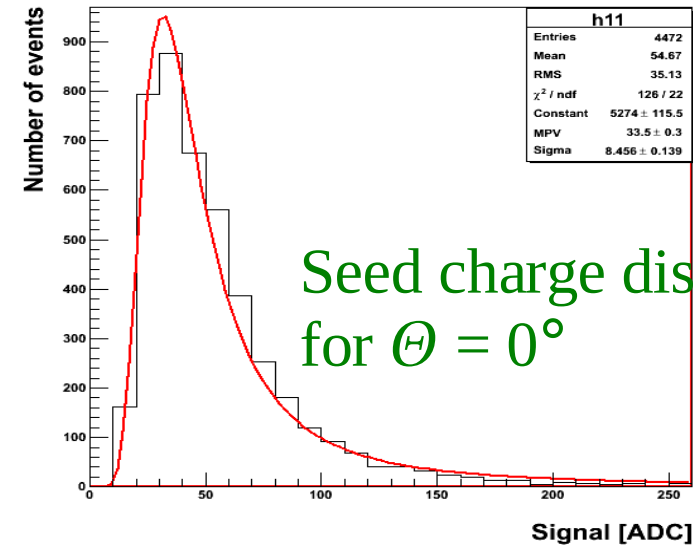 $\Theta \in (0°,80°)$

  **September 2007
  Preliminary results**
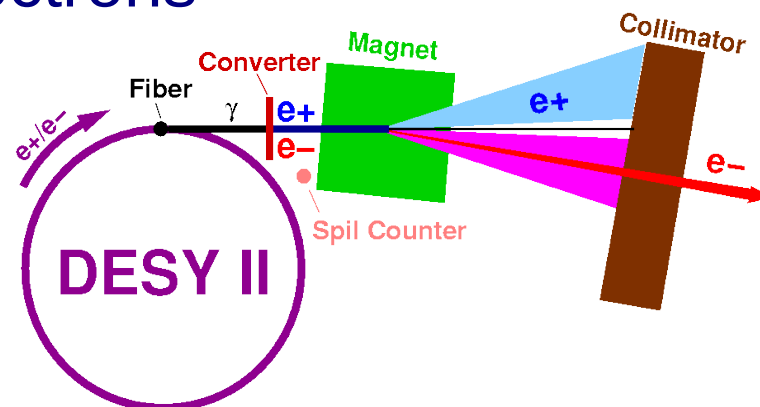
MIMOSA5 – a MAPS prototype

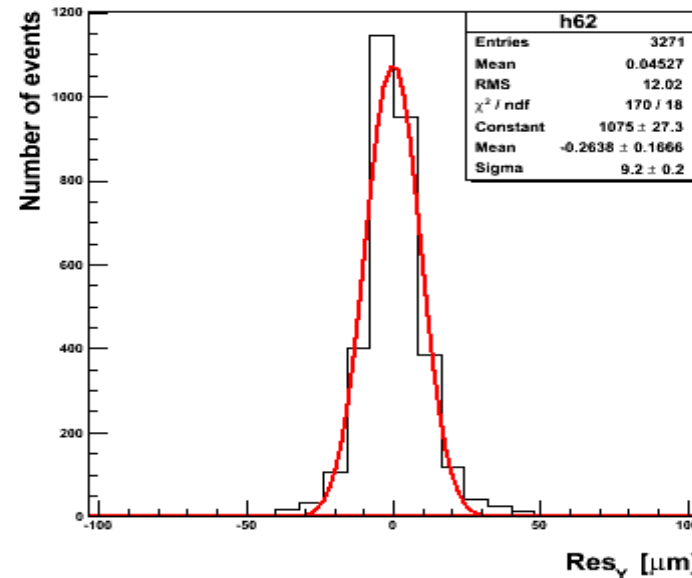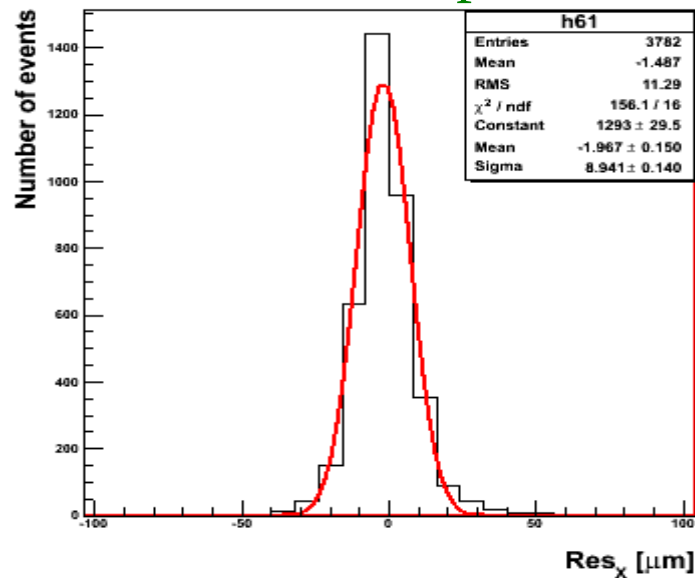- MIMOSA5 measurements

  - Pixel size: 17μm × 17μm

  - Epitaxial layer: 14μm

  - Thickness: 120μm

1 pixel clusters

Seed charge distribution for $\Theta = 0°$

Spatial resolution for $\Theta = 0°$

Mean cluster shapes - measurements

$\Theta = 0°$
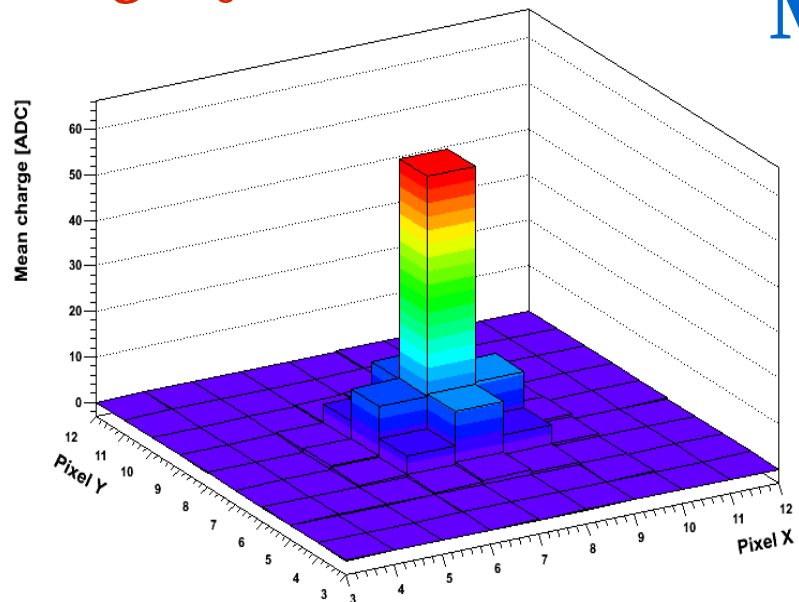
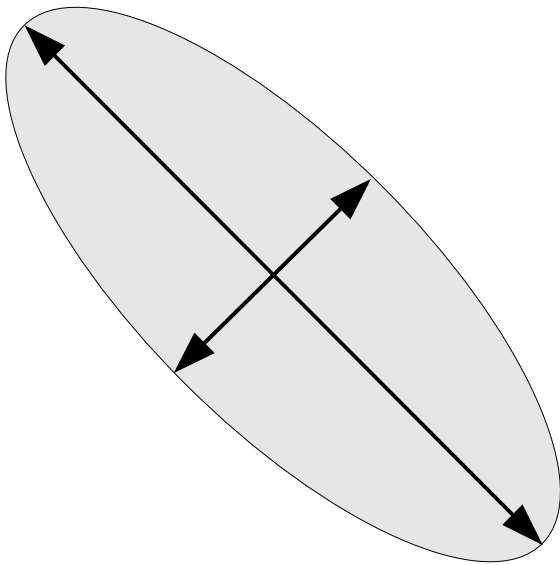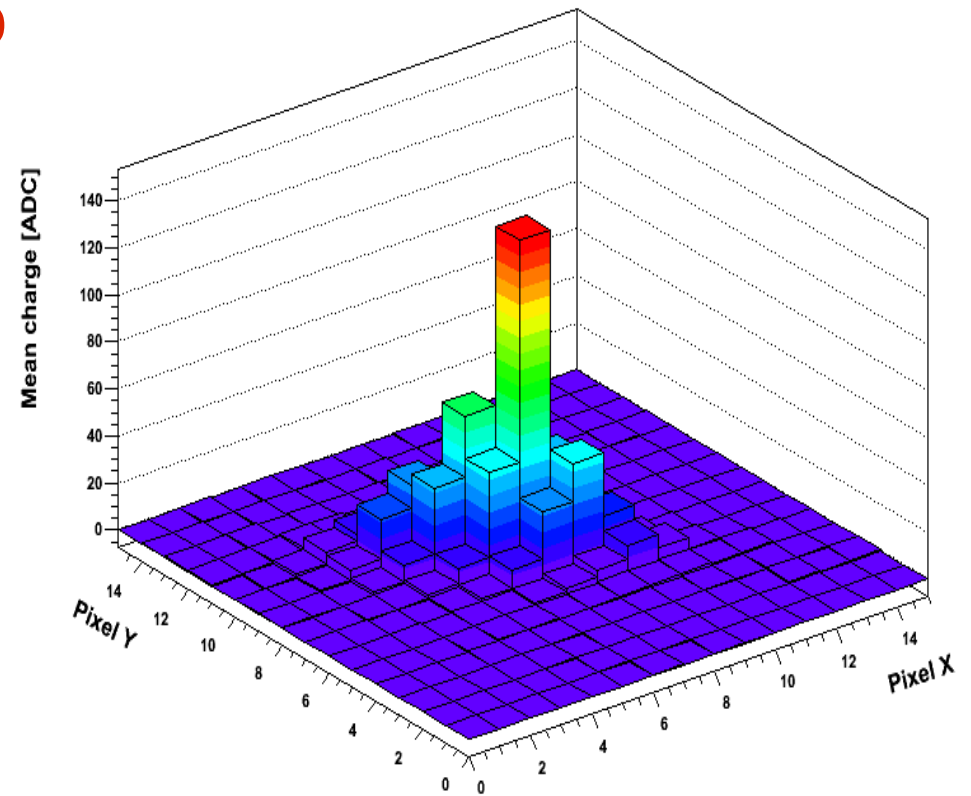**Mean clusters**
Φ = 0°

$\Theta = 60°$
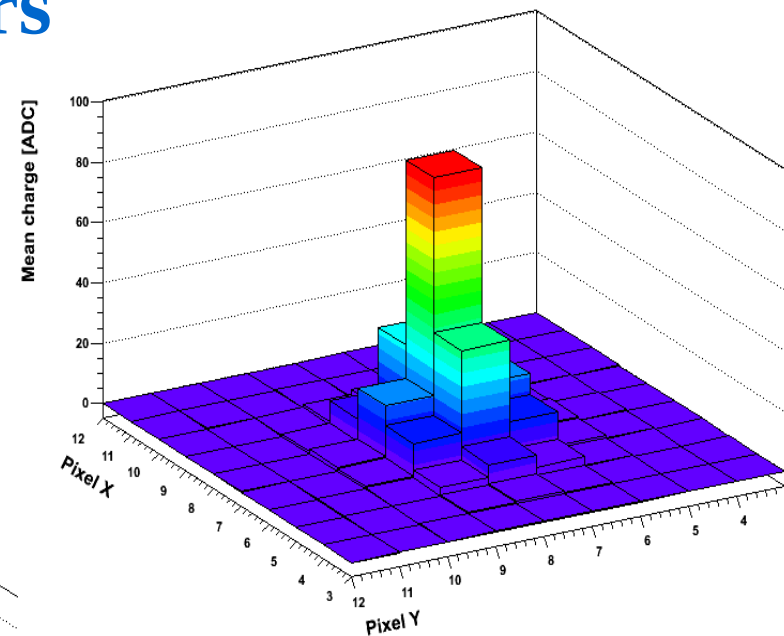
$\Theta = 75°$
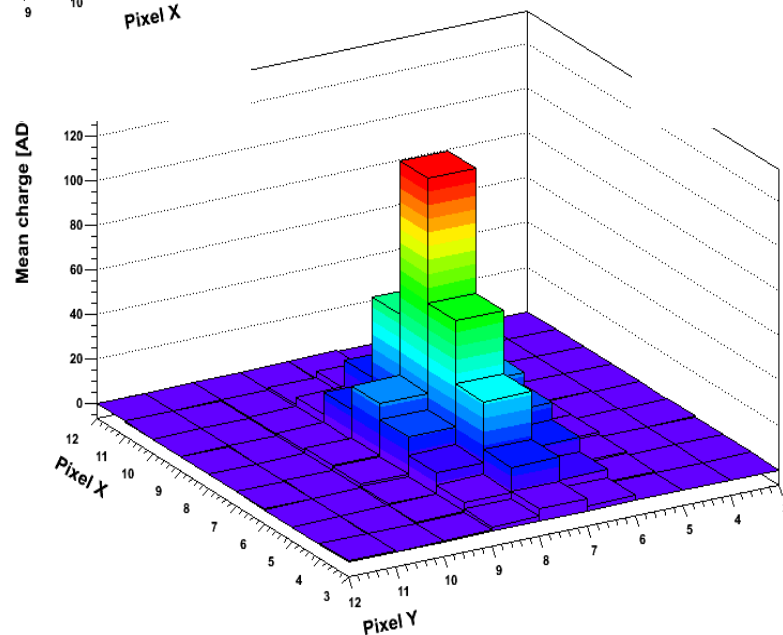
Cluster elongation depends on θ

Cluster parameters – reconstruction of angles

- Charge distribution matrix diagonalisation:
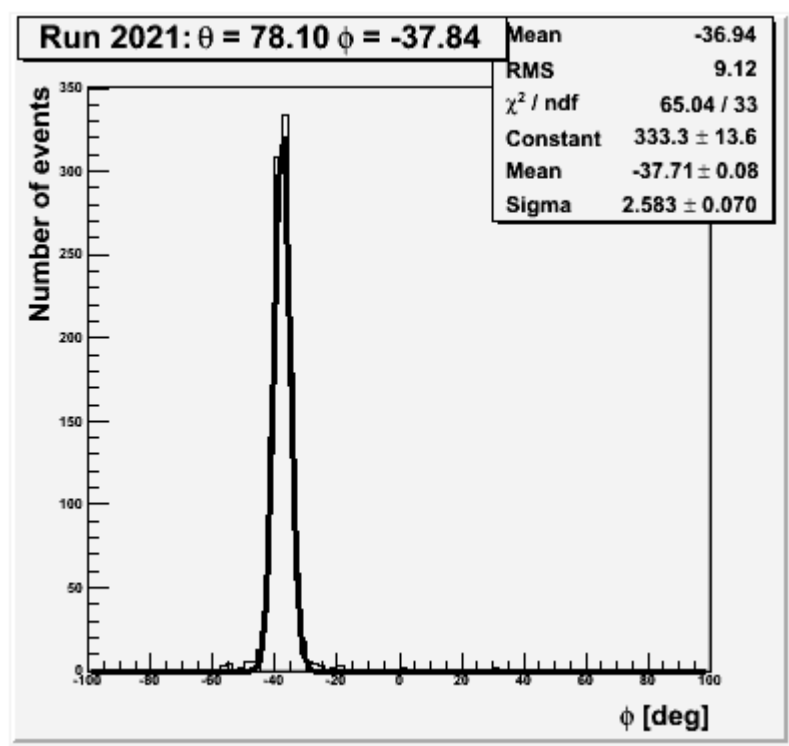
  - Eigenvalues → elongation → Θ

  - Eigenvectors → Φ

$\Theta = 78°$ $\Phi = -38°$

values determined by alignment

Mean cluster

Cluster orientation

Reconstructed Φ angle

Run 2021: θ = 78.10 φ = -37.84

Mean	-36.94
RMS	9.12
χ^2 / ndf	65.04 / 33
Constant	333.3 ± 13.6
Mean	-37.71 ± 0.08
Sigma	2.583 ± 0.070

$\Theta = 78°$ $\Phi = -38°$
values determined by alignment
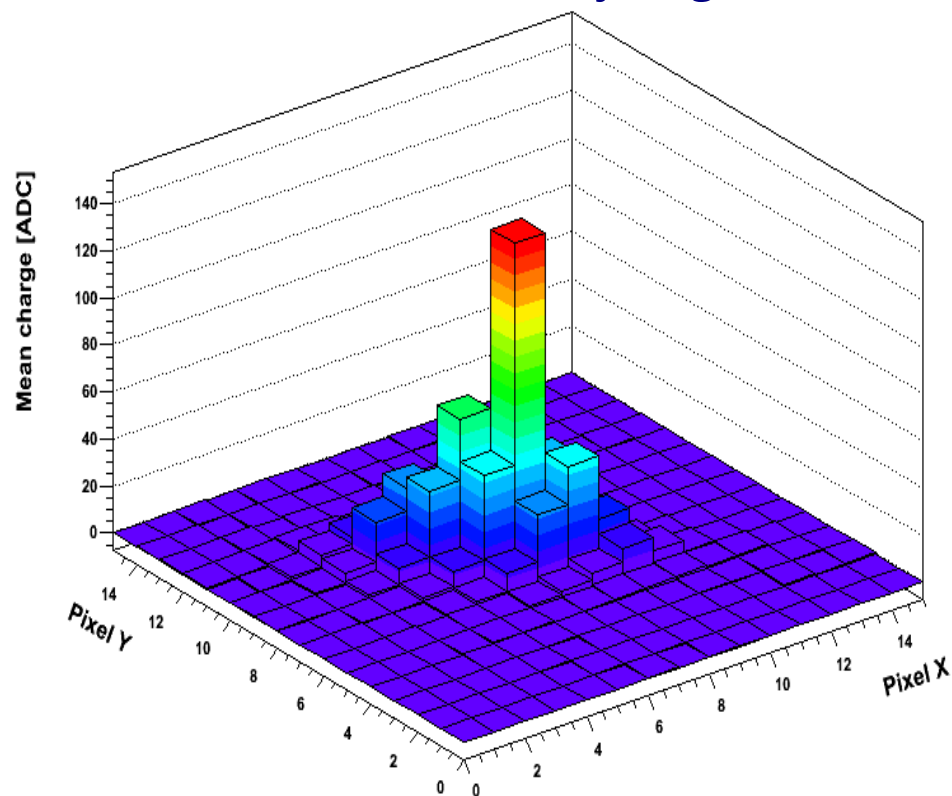
Mean cluster

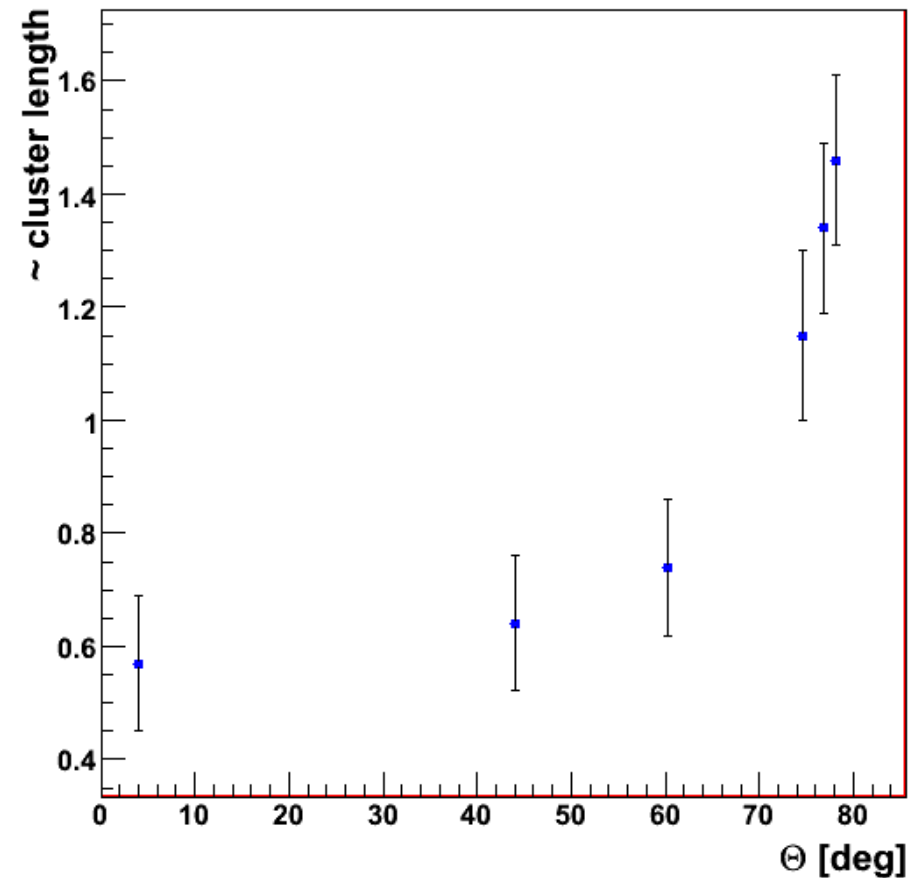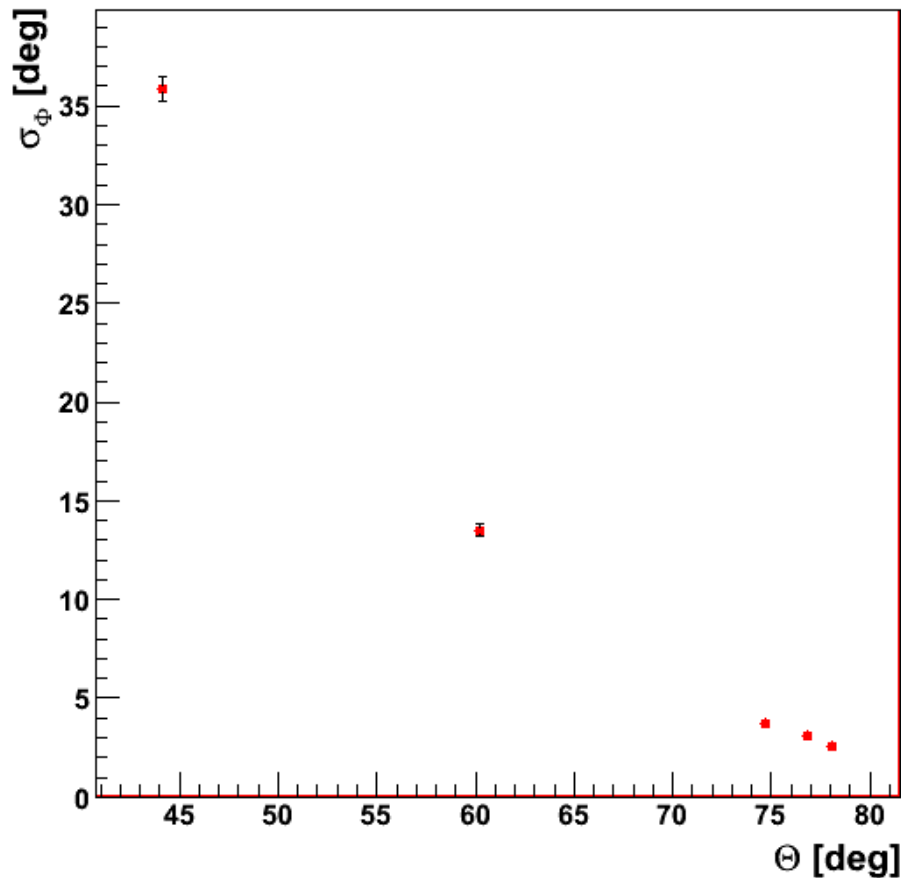# *Cluster parameters – reconstruction of angles*
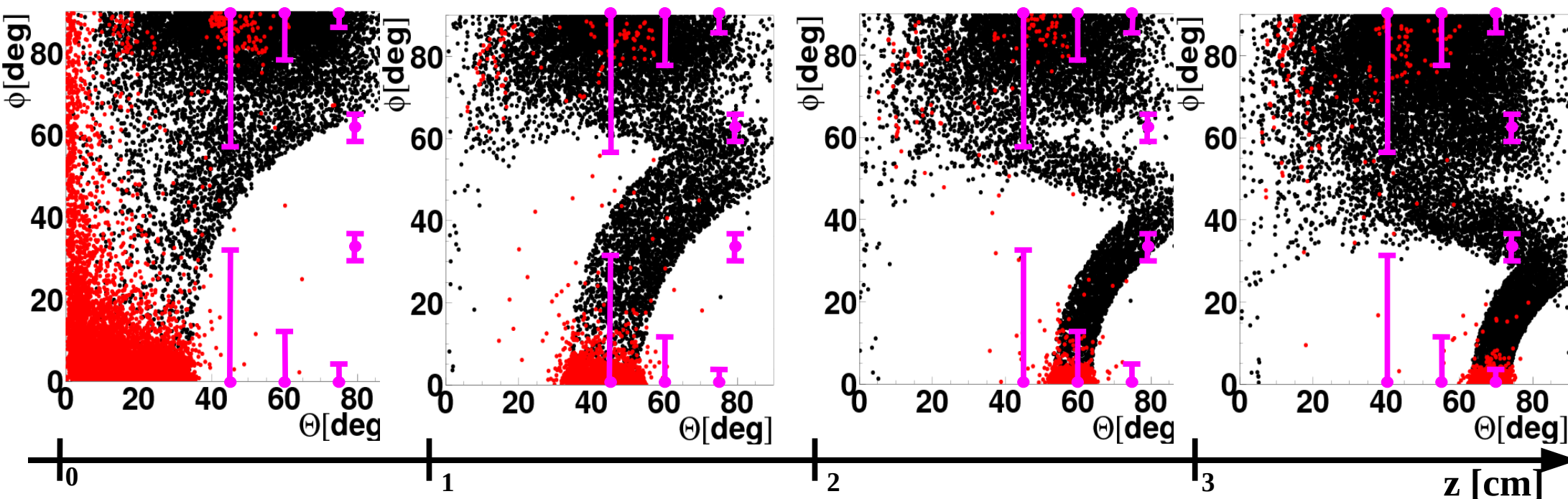

◆ Precision of Φ determination increases with Θ

Beamstrahlung background rejection

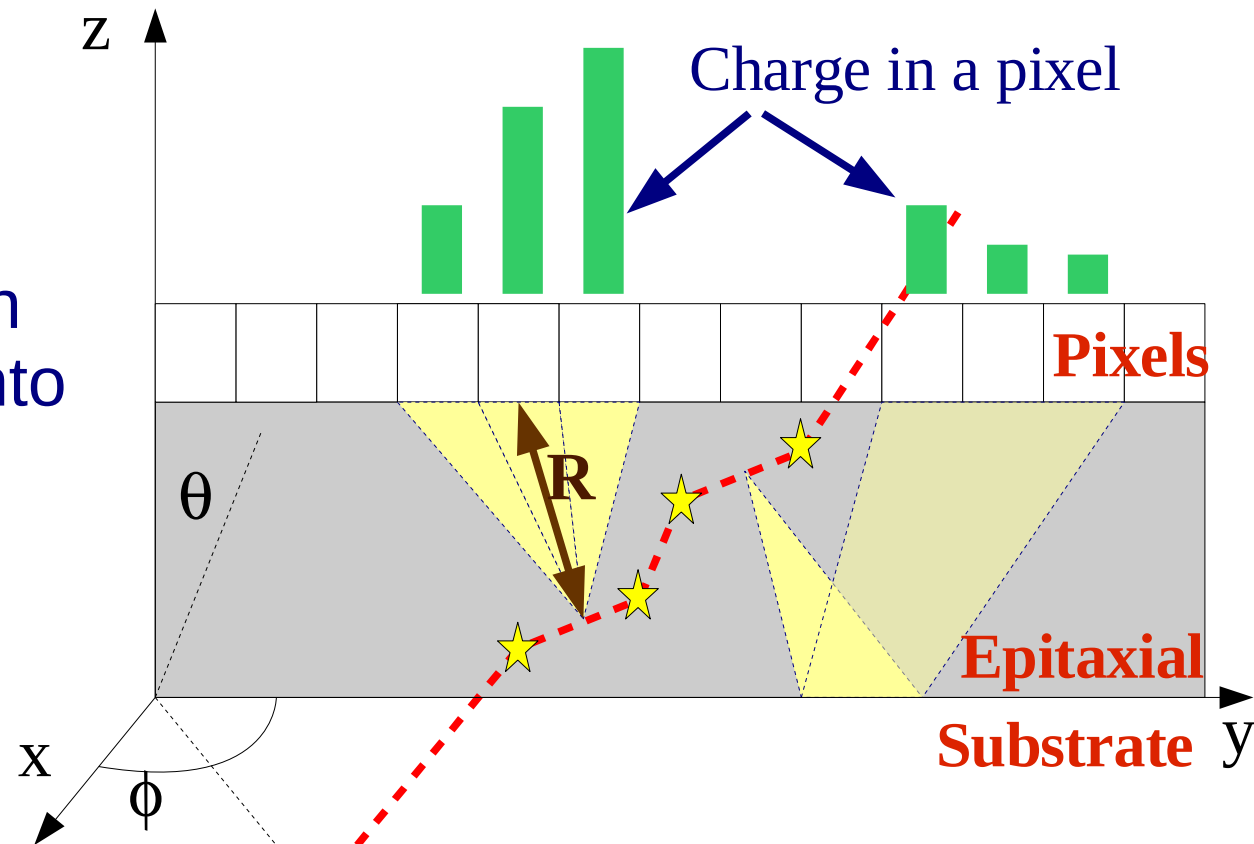## Partial preliminary results

- physics hits

Hits in the first VTX layer (r = 15 mm)

- beamstrahlung – e^+e^- pairs simulated by Guinea Pig @ 500GeV

A simple model of charge diffusion

- Isotropic thermal diffusion leads to charge spread into adjacent pixels – cluster formation

- Deposited energy is converted to charge (Q) and redistributed into pixels according to the formula:
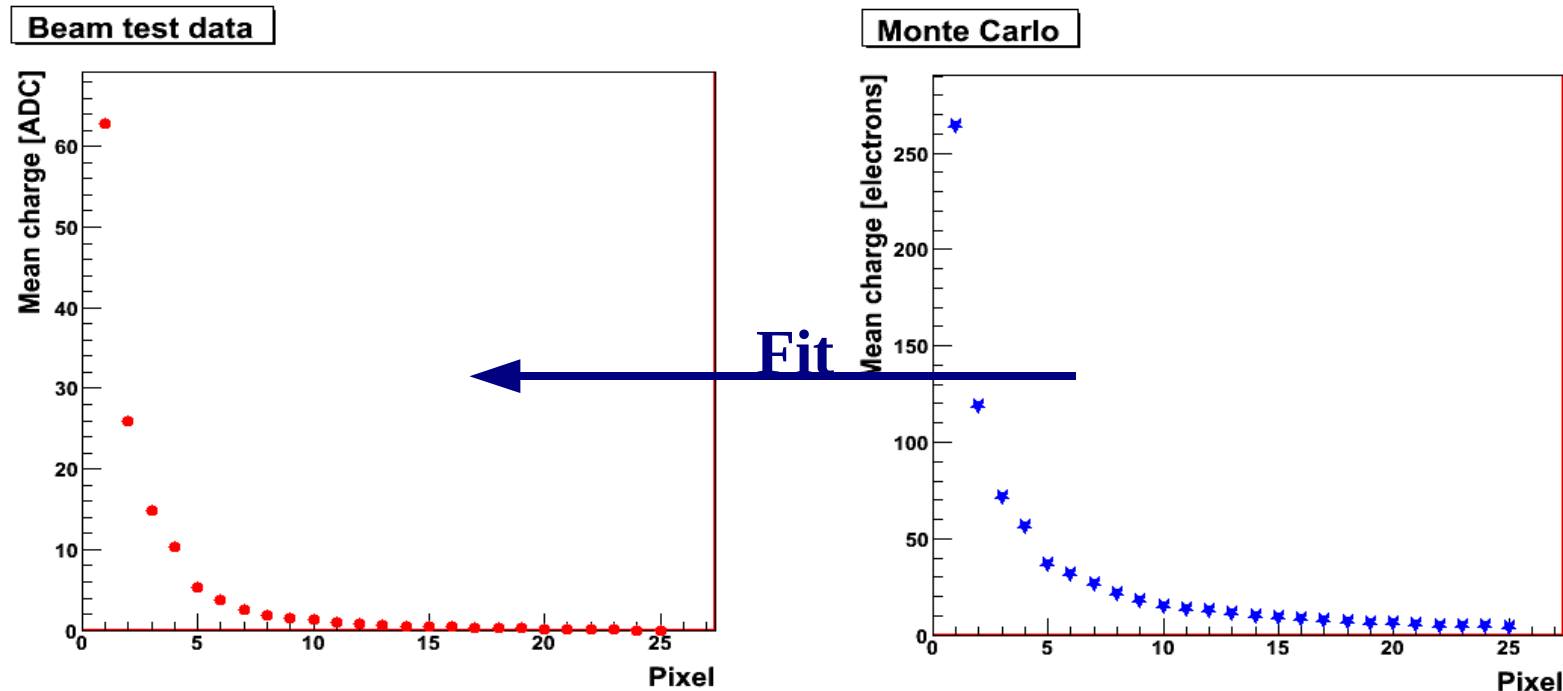
Isotropic diffusion

Attenuation term (λ – effective attenuation constant)

$$q(\mathbf{R}) = Q \frac{d\,\Omega}{(4\,\pi)} \exp\left(\frac{-\mathbf{R}}{\lambda}\right)$$

λ **to be determined**

Determining λ

- Also include: noise and conversion to ADC
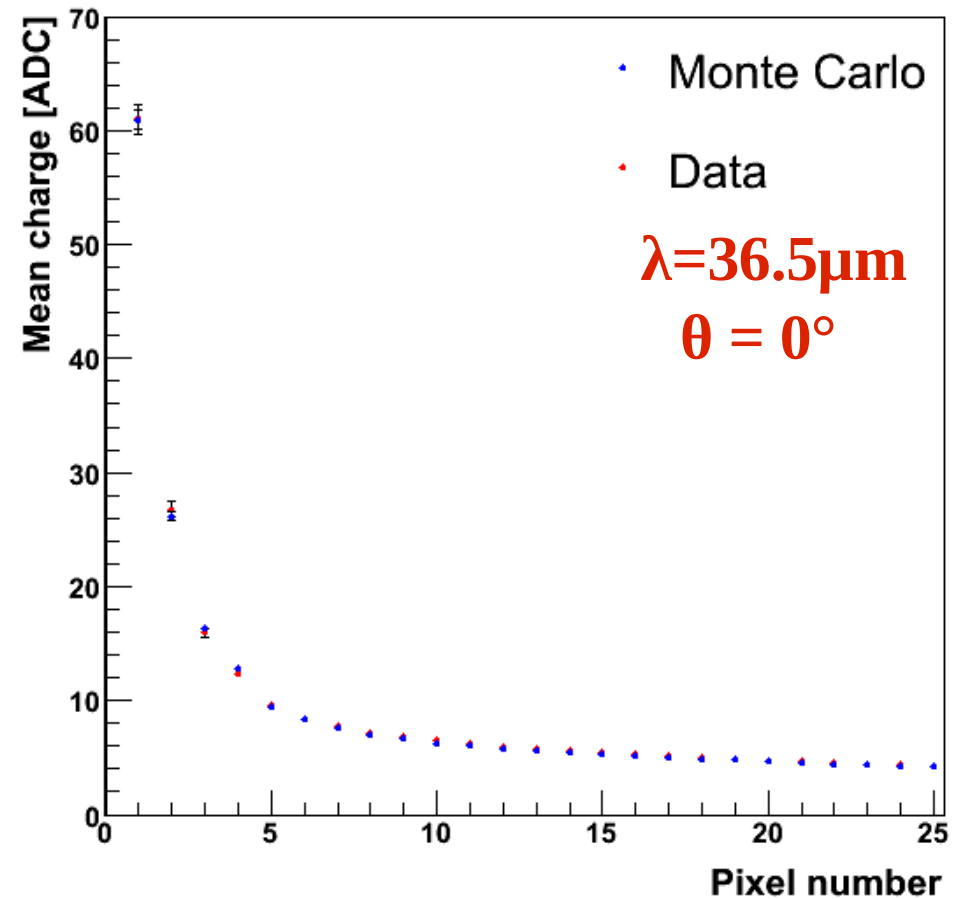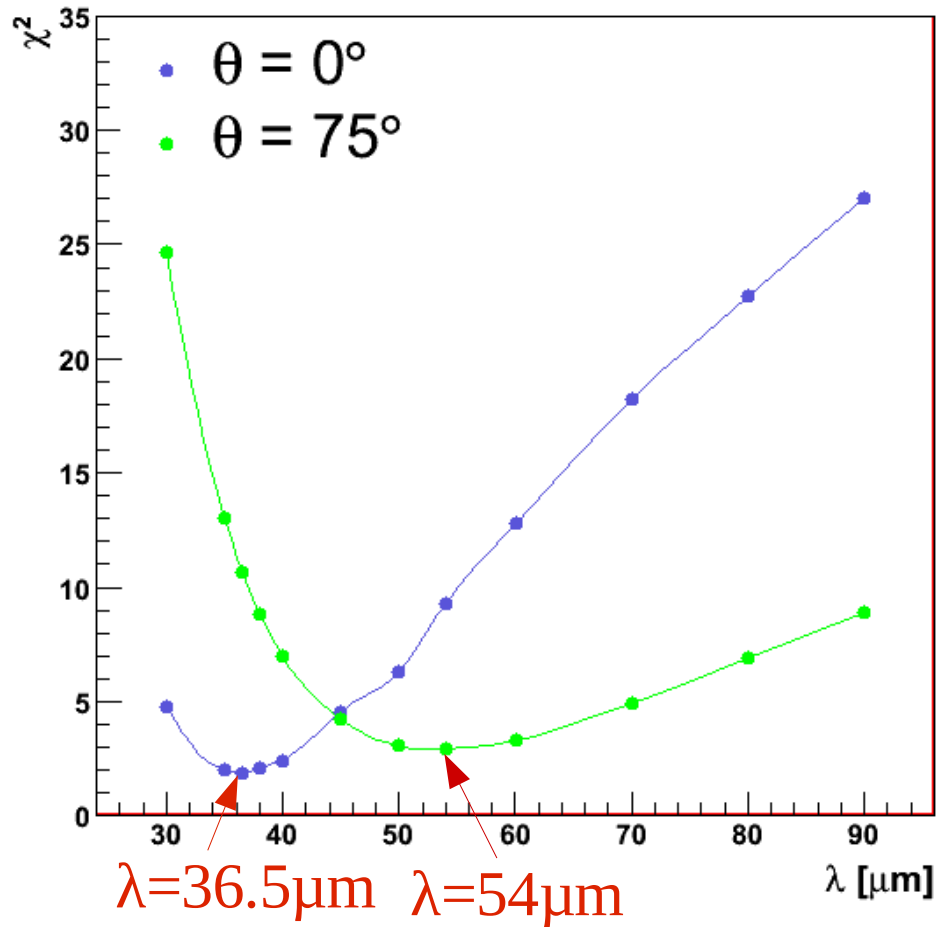

Beam test data — Monte Carlo
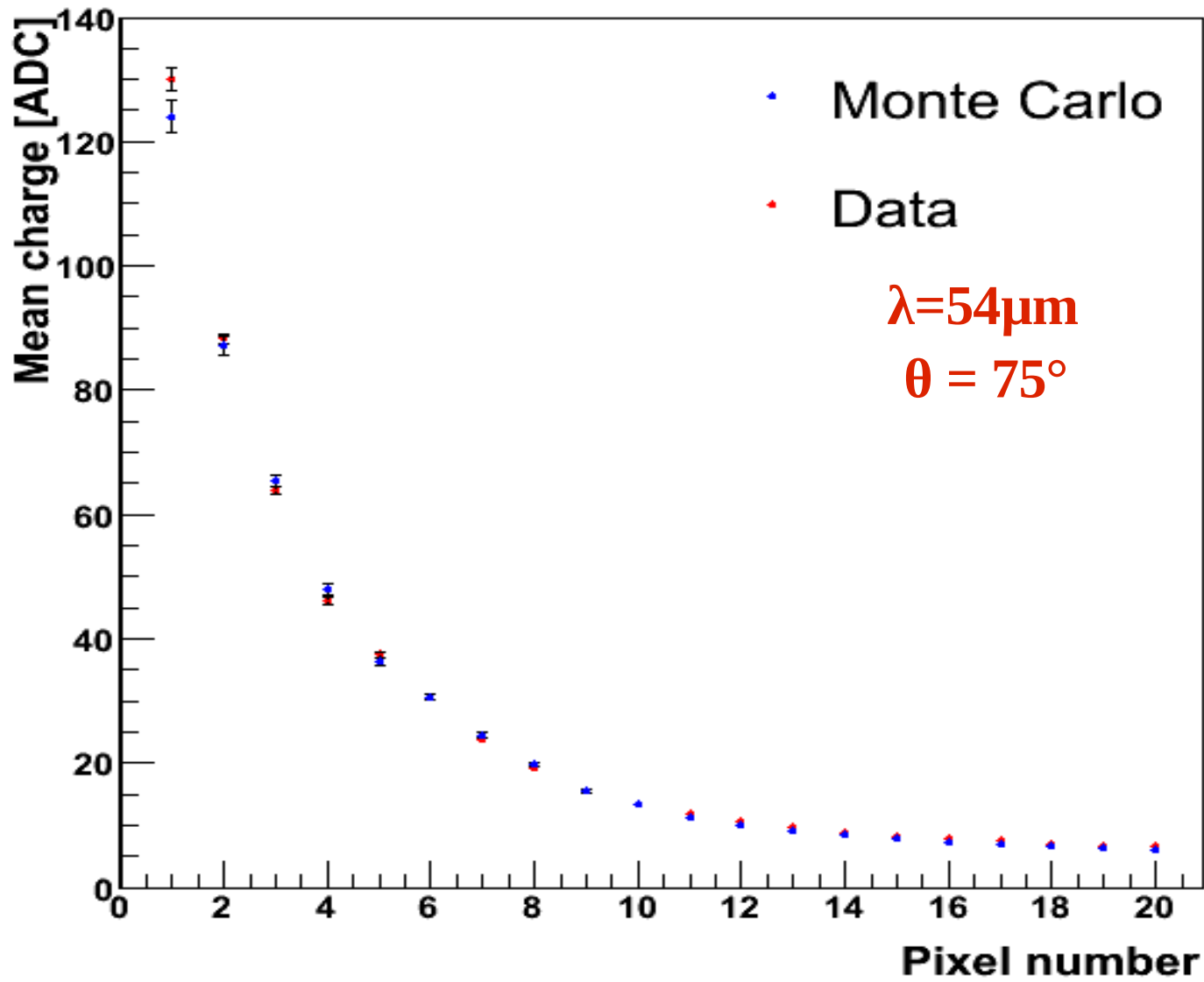
Fit

Monte Carlo

Determined from measurements

$$\text{Signal}_{\text{pixel}} = \text{int}\left(\alpha \cdot \text{Charge}_{\text{MC}}(\lambda)\right) + \text{Noise}$$

- α and λ to be determined from comparison Monte Carlo to data

Data versus MC

Data versus MC

Summary

- Measurements at different incident angles show cluster elongation

  - Significant cluster elongation for $\theta > 60°$ allows Φ and Θ determination

- Promising perspectives for beamstrahlung rejection

- Parametrisation of MAPS response presents good agreement with data, work in progres