Study of Belle Silicon Vertex Detector Intrinsic Resolution

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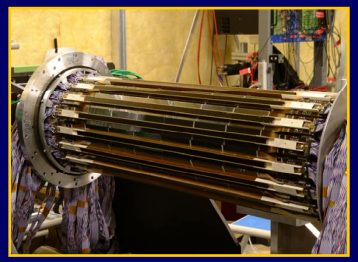
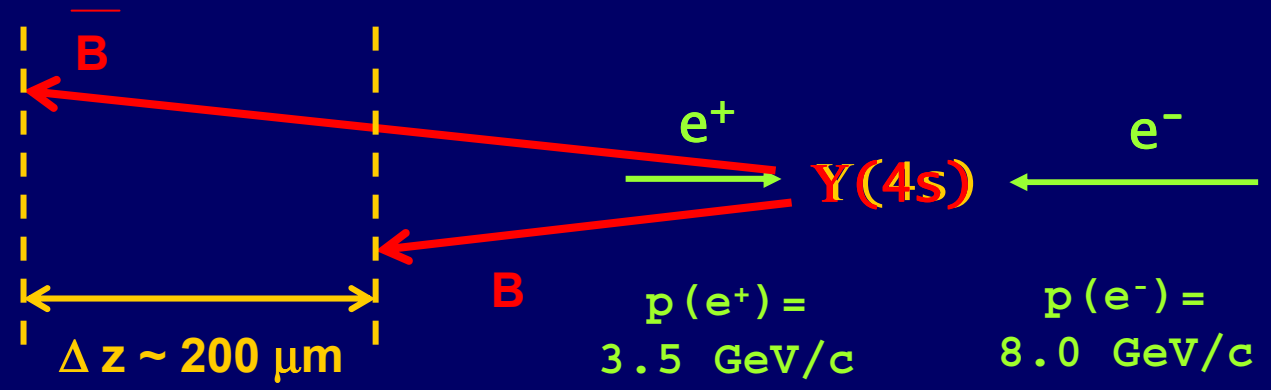
Outline of the talk

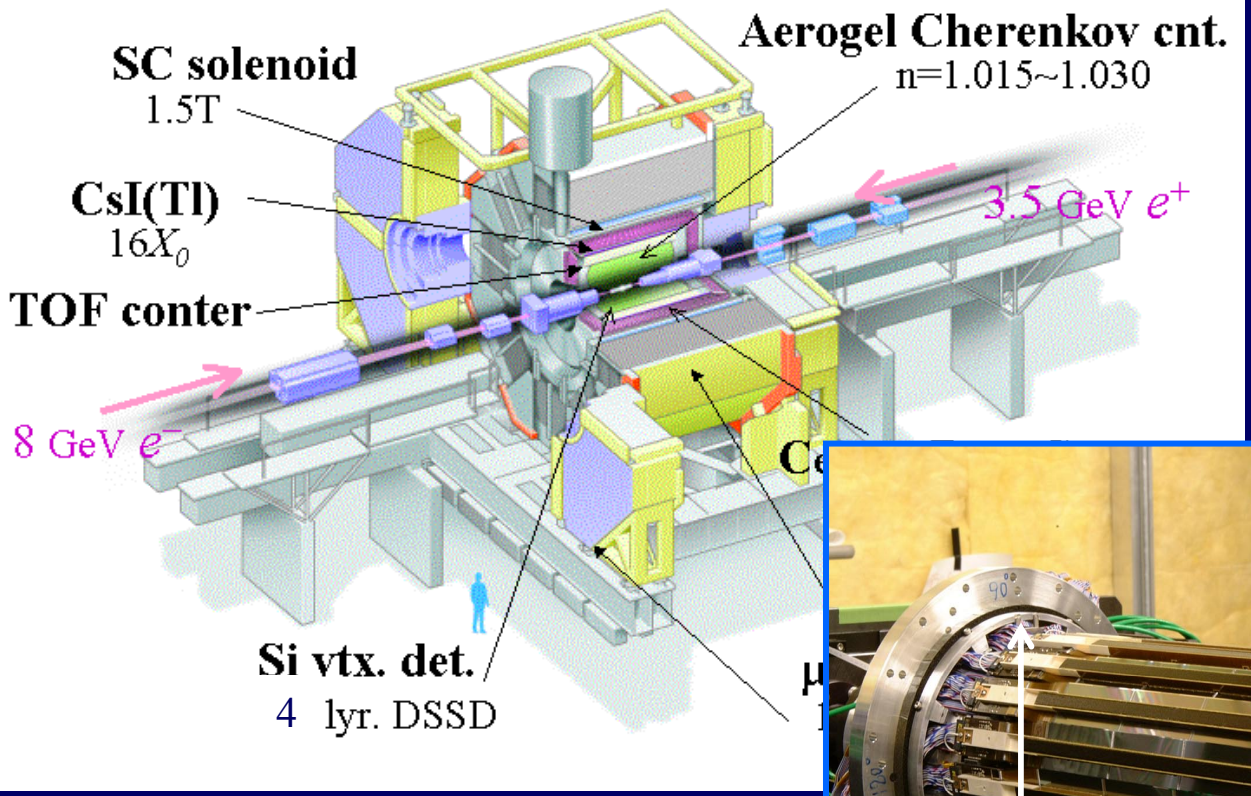
- Belle experiment
- Silicon vertex detector (SVD)
- Intrinsic resolution: study and results

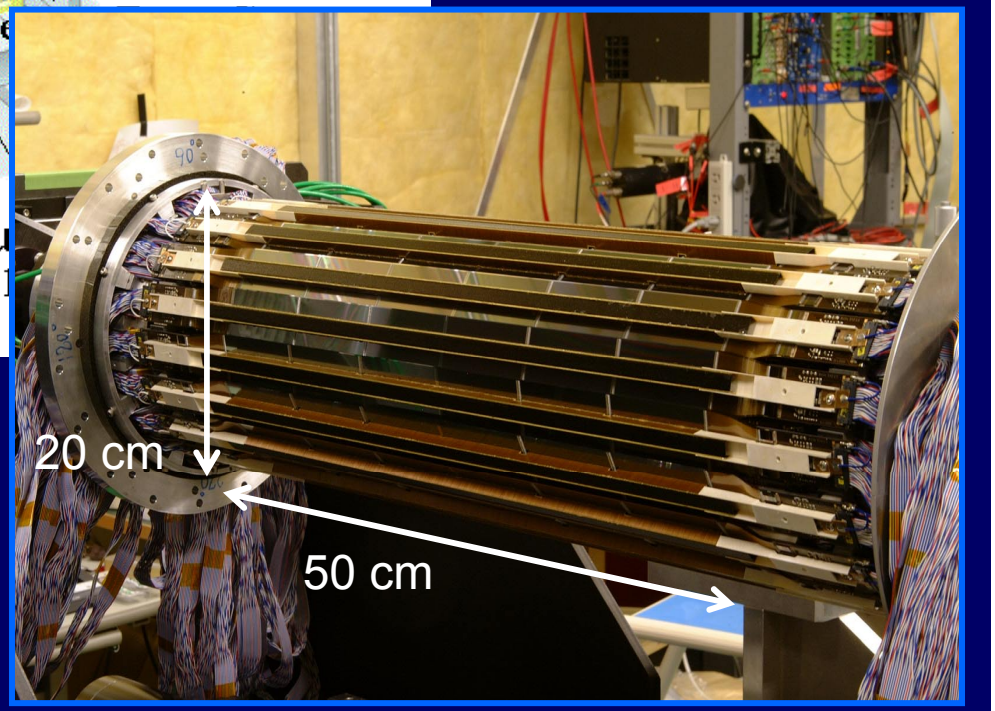


Main goal of Belle experiment: study of CP violation in B-meson system



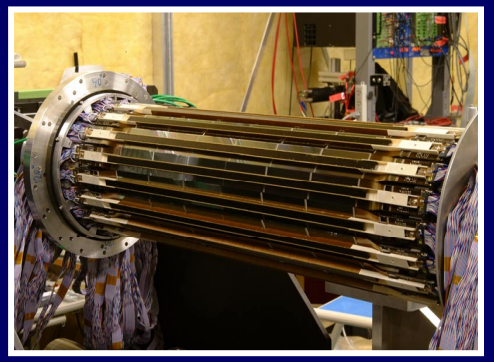
Belle Detector

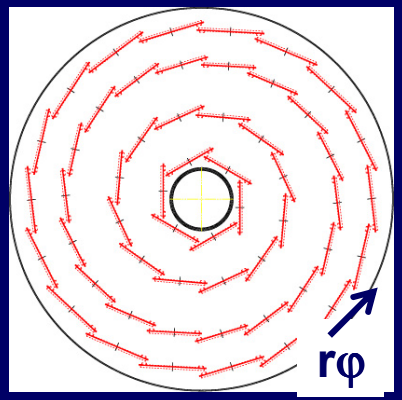


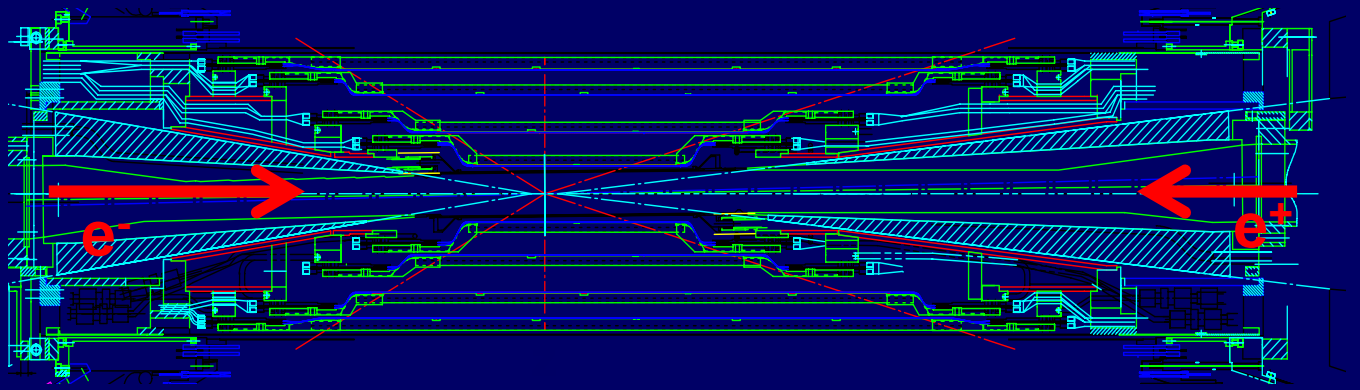


BELLE

silicon vertex detector (SVD)



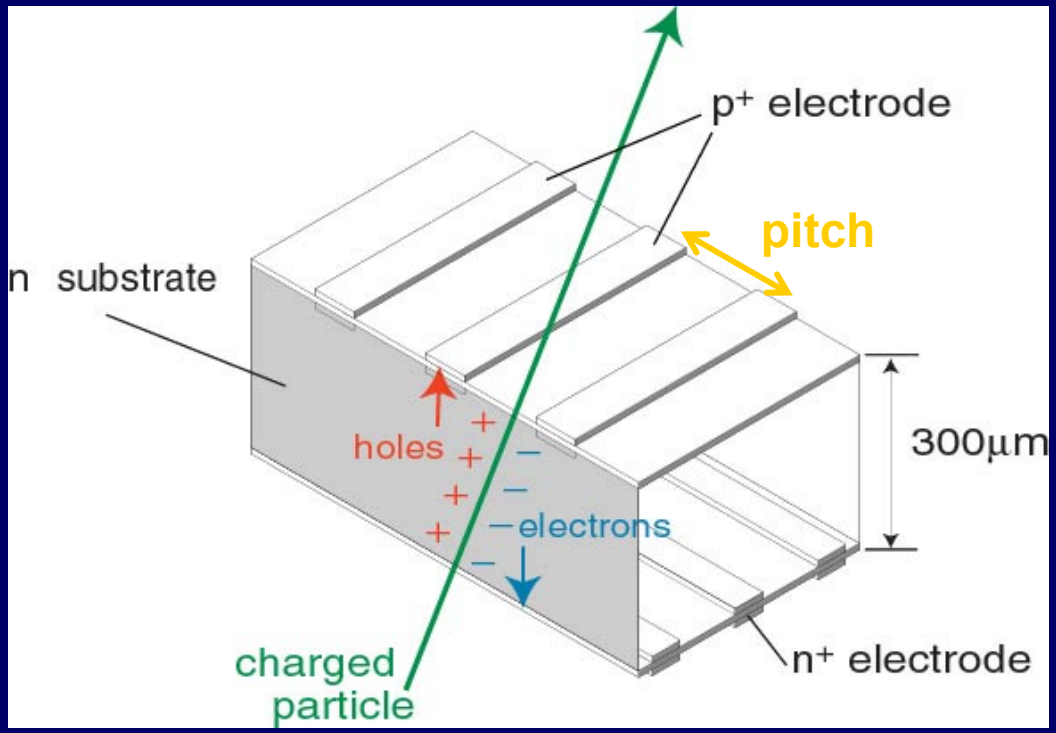




4 layers

covering polar angle from 17 to 150 degrees

basic SVD unit:
Double Sided Strip Detector (DSSD)

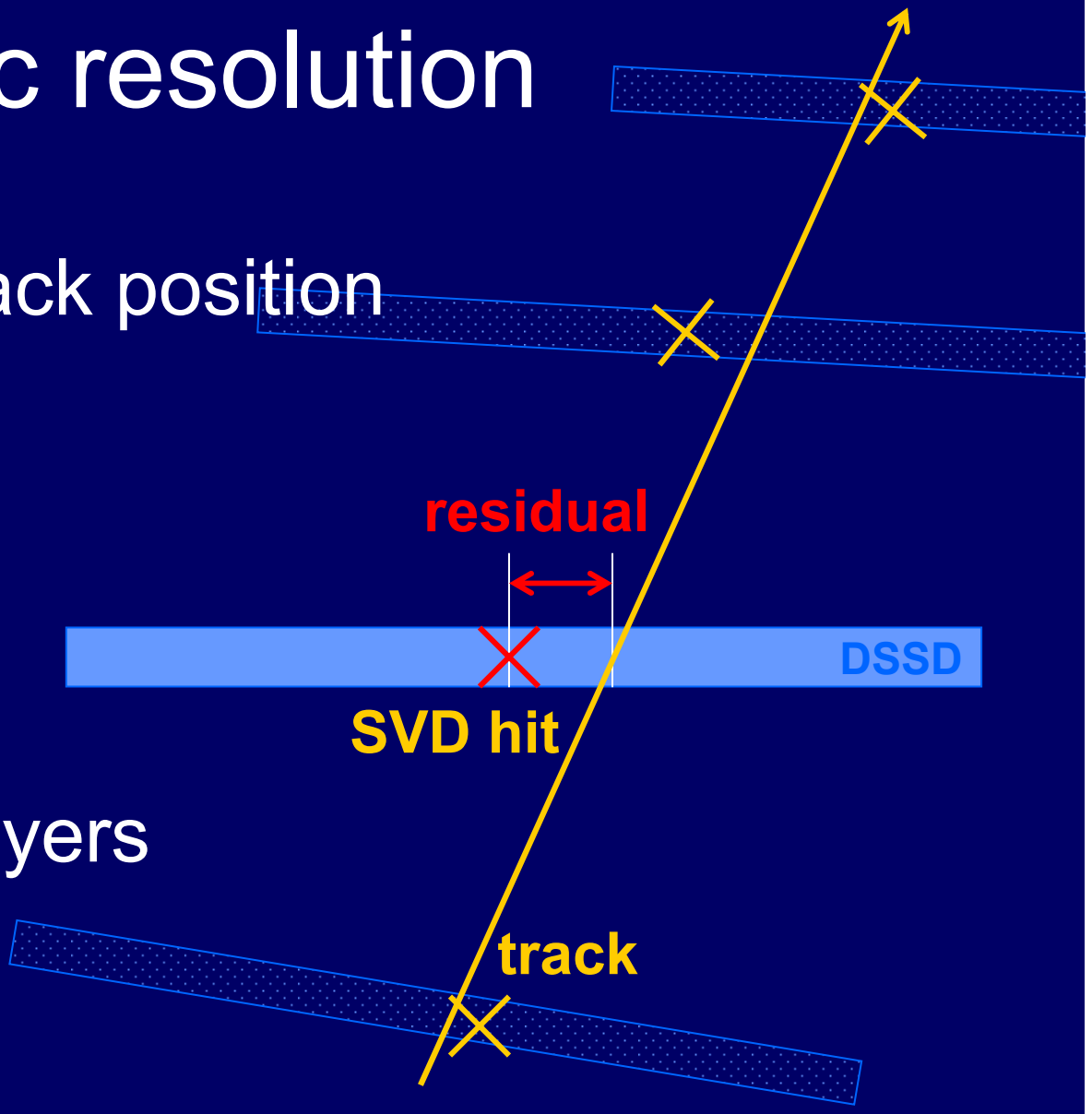


separate measurement of rφ and z coordinate

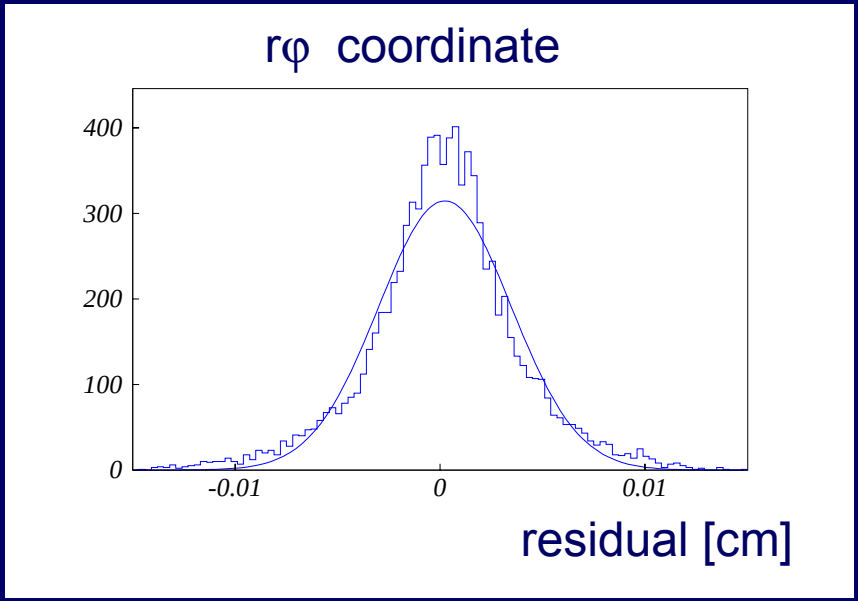
strip pitch:
50 and 75 μm for rφ and z coordinate, respectively

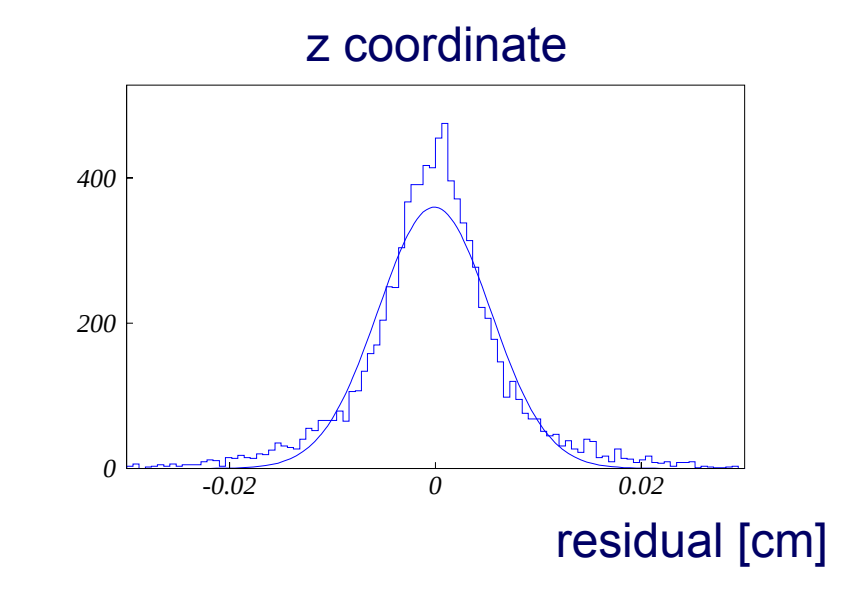
SVD intrinsic resolution

- Error on the track position measurement
- Track position is determined from the SVD hits on other layers



Typical residual distributions

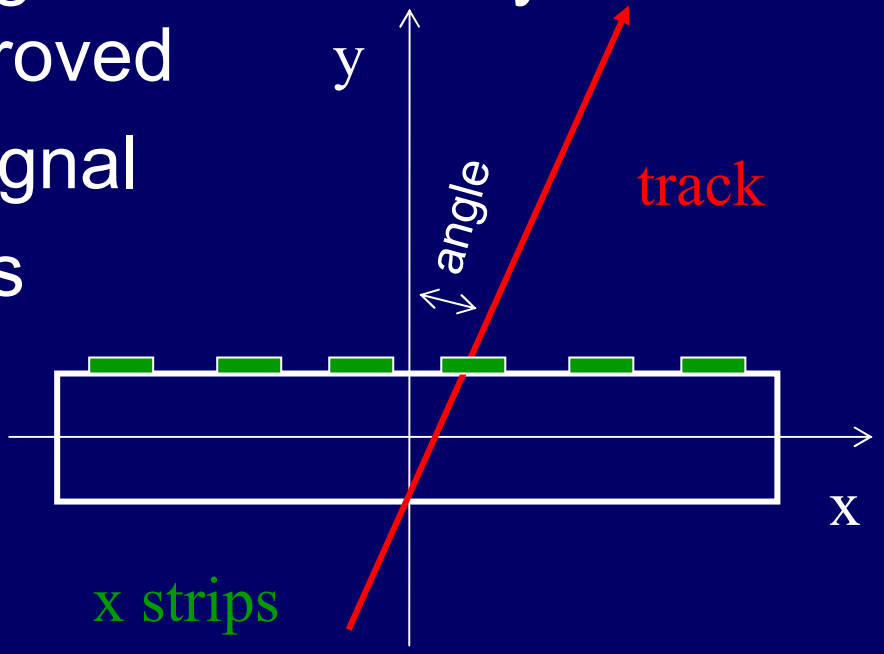




- Intrinsic resolution is determined from the width of the residual distribution:
  - σ_i = 10 μm, RMS = 12-15 μm for rφ and
  - σ_i = 25 μm, RMS = 30 μm for z coordinate

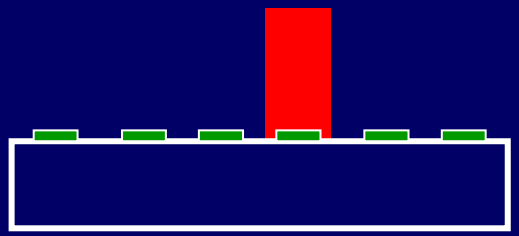
Incident angle dependence

- Simple estimate for the perpendicular tracks: signal collected by single strip → resolution ≈ strip pitch / $\sqrt{12}$
- Small incident angle: signal collected by few strips → resolution improved
- Large incident angle: signal collected by many strips → resolution gets worse due to smaller signal to noise ratio

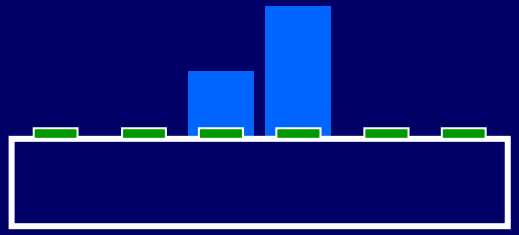


Perpendicular incidence

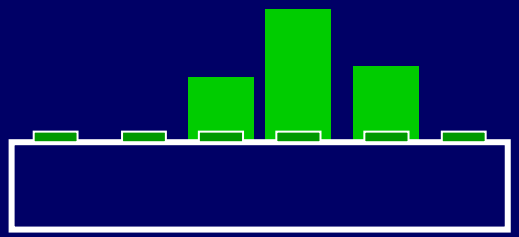
Relative number of tracks with cluster size



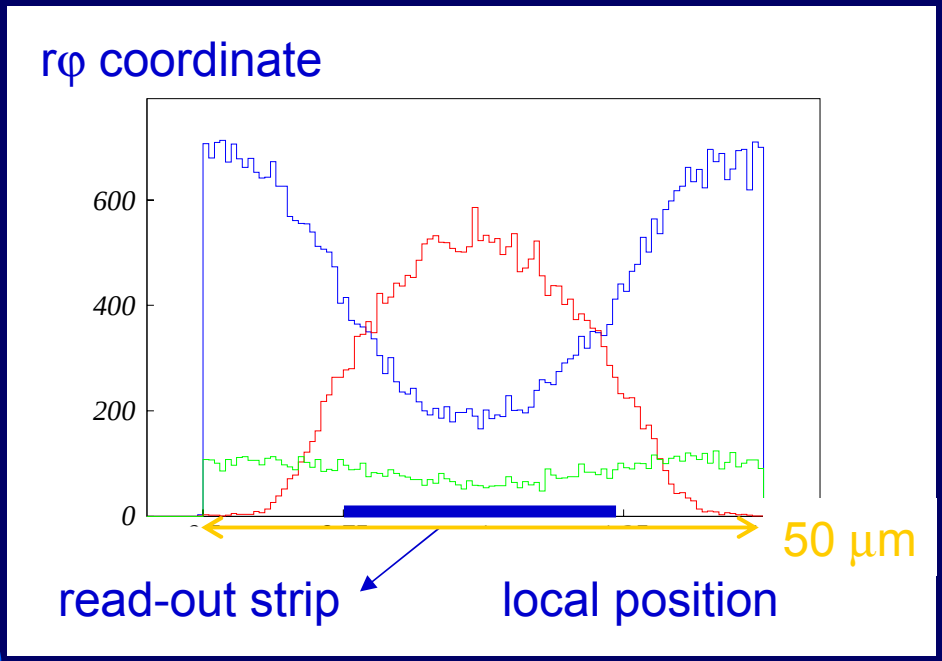
1 strip (red),



2 strips (blue)



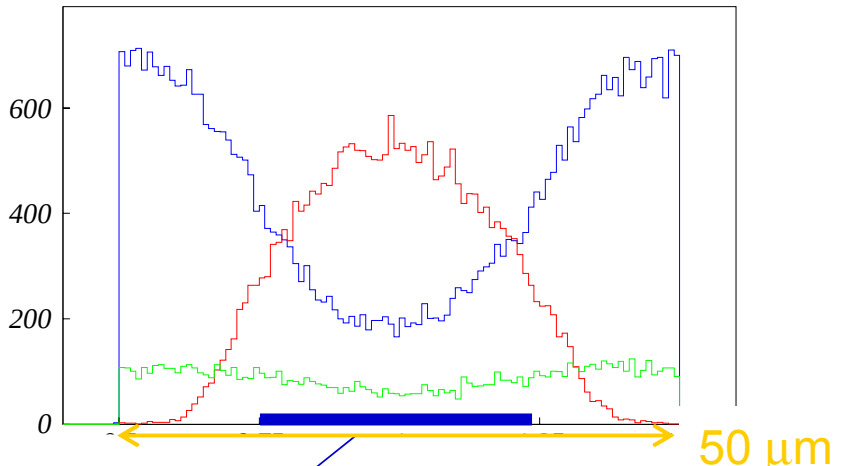
and
3 strips (green)



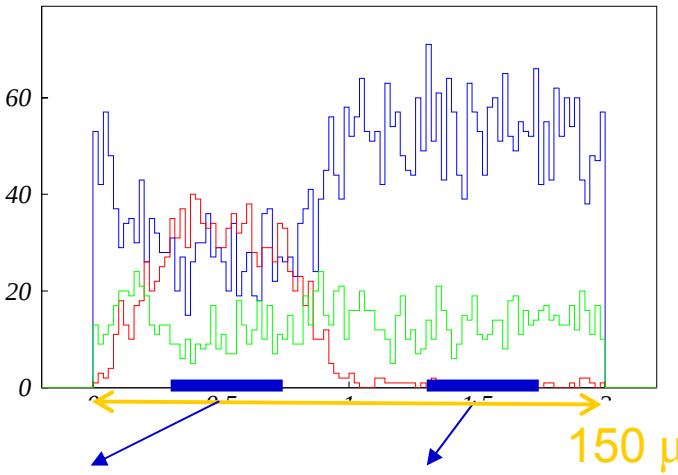
Due to charge diffusion, only about 30% of the SVD hits at perpendicular incidence have cluster size 1 strip

Perpendicular incidence

rφ coordinate



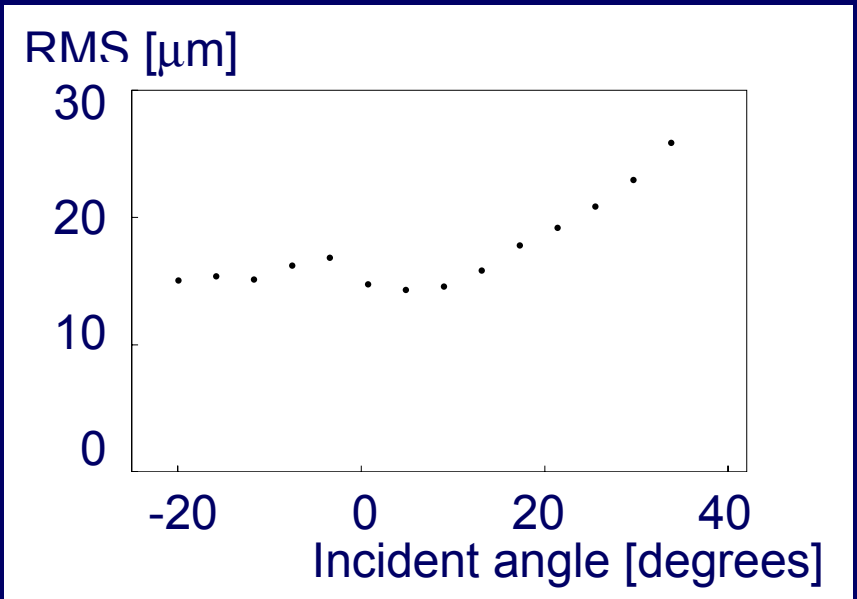
same for z coordinate



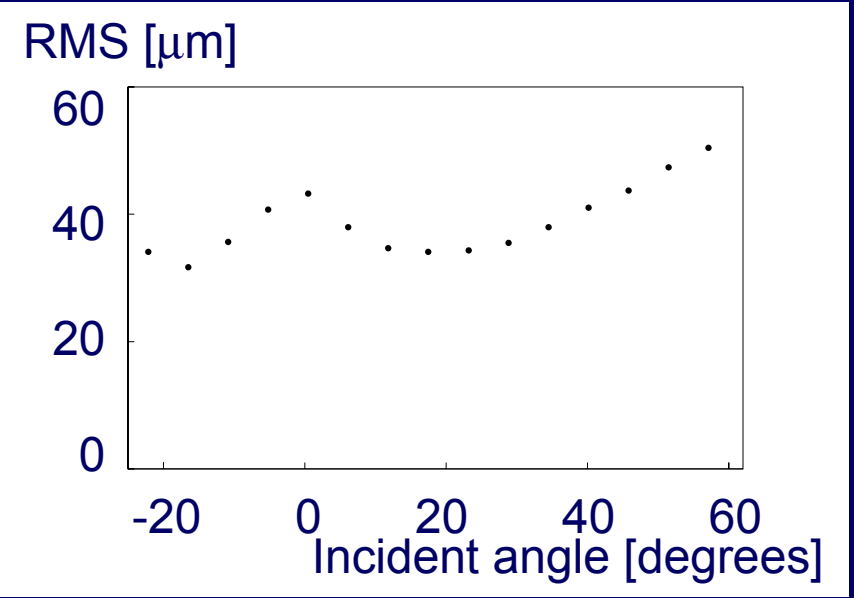
Due to charge diffusion, only about 30% of the SVD hits at perpendicular incidence have cluster size 1 strip

Incident angle dependence: result

rφ coordinate



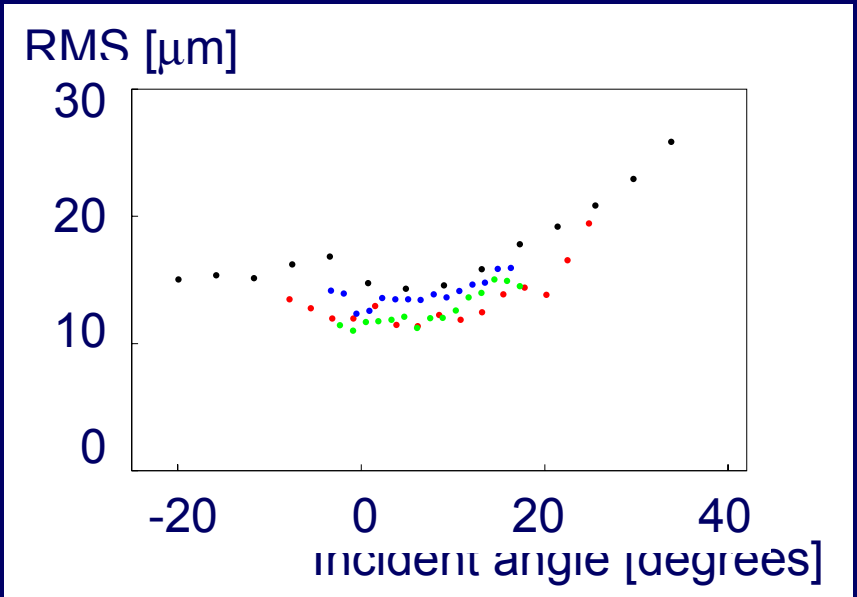
z coordinate



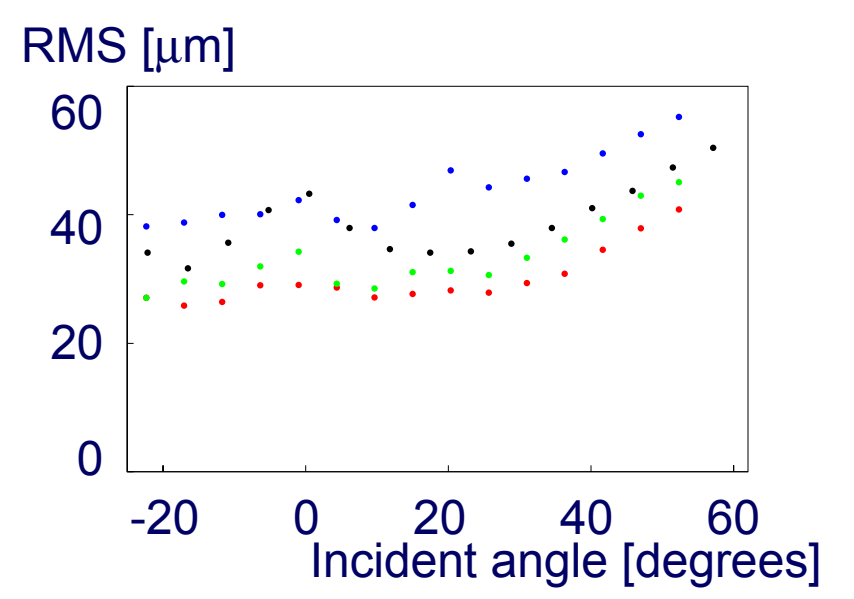
Innermost layer

Incident angle dependence: result

rφ coordinate



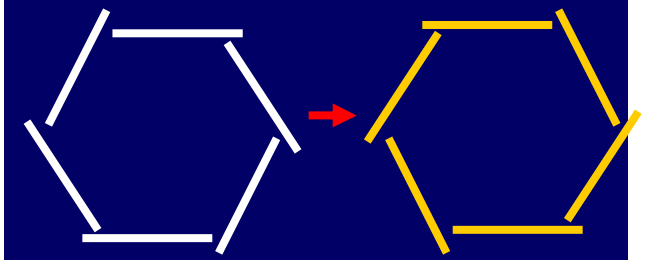
z coordinate

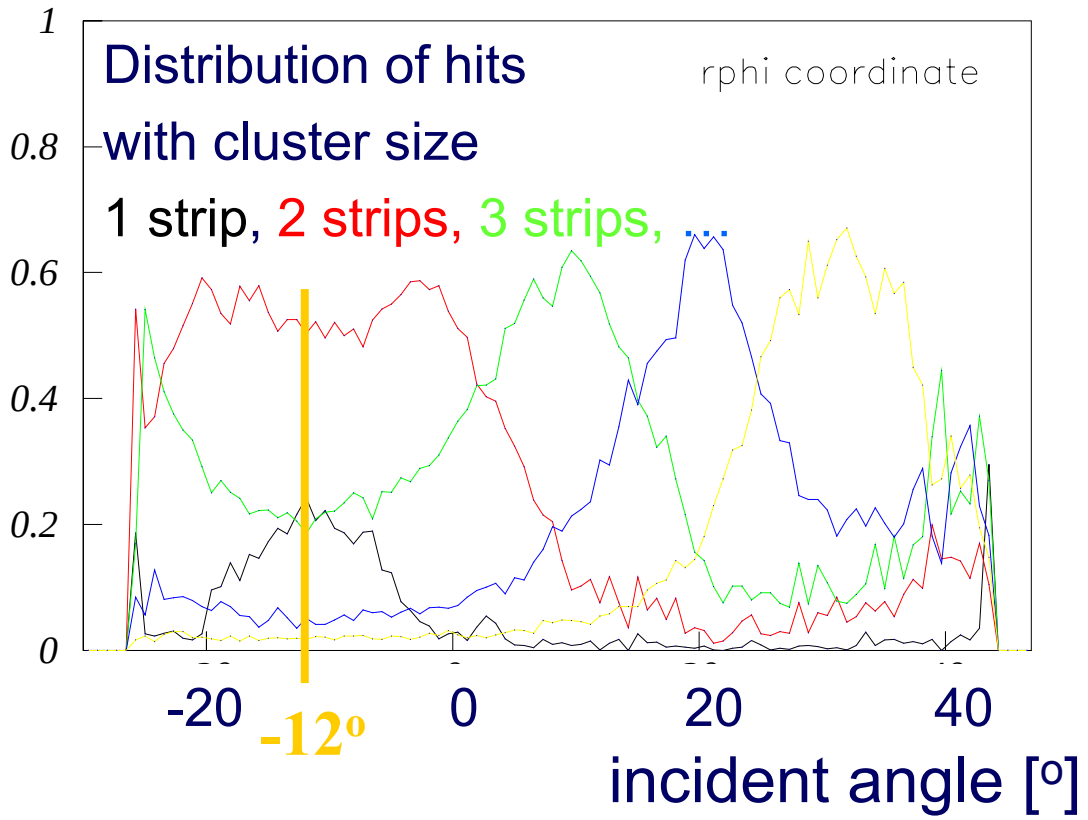


Different colors show the result for all four layers:
black, red, green and blue for the innermost, second, third and outermost layer.

Magnetic Field Effect

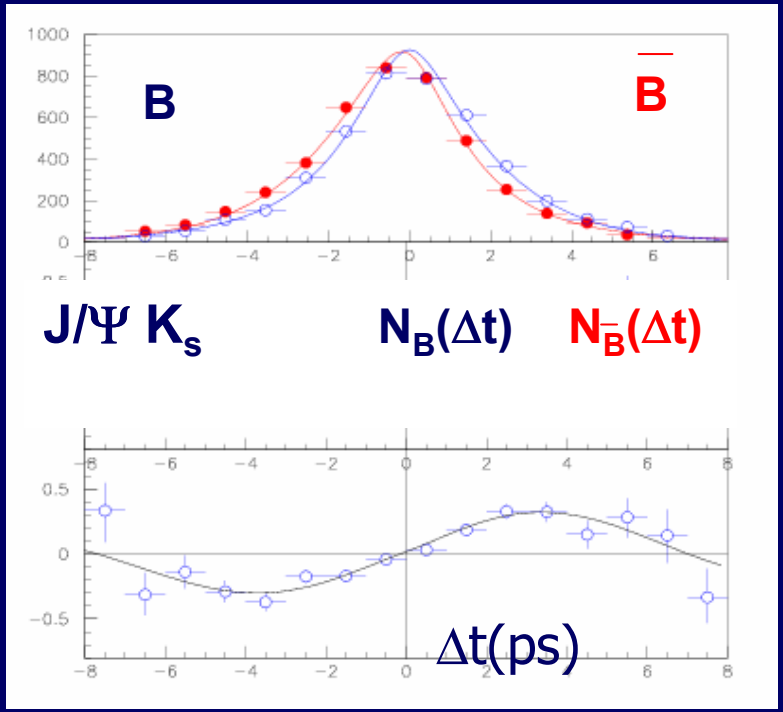
- Intrinsic resolution is not symmetric with respect to perpendicular incident angle
- Reason: magnetic field, confirmed by the plot of hit cluster size
- next SVD:





Conclusions

- Best resolution (RMS) at small track incident angle is found to be 20 and 30 μm for rφ and z coordinate, respectively.
- Intrinsic resolution is worse for larger incident angles and approximately constant for angles smaller than 20 degrees
- Intrinsic resolution of 30 μm enables measurement of B meson vertex with the accuracy of ~ 100 μm, which allows to measure CP violation in B meson system (differences between the decays of B and $\overline{B}$ mesons)



Back up slides

Interpretation of results

- Intrinsic resolution is the width of residual distribution if position of track is exactly known

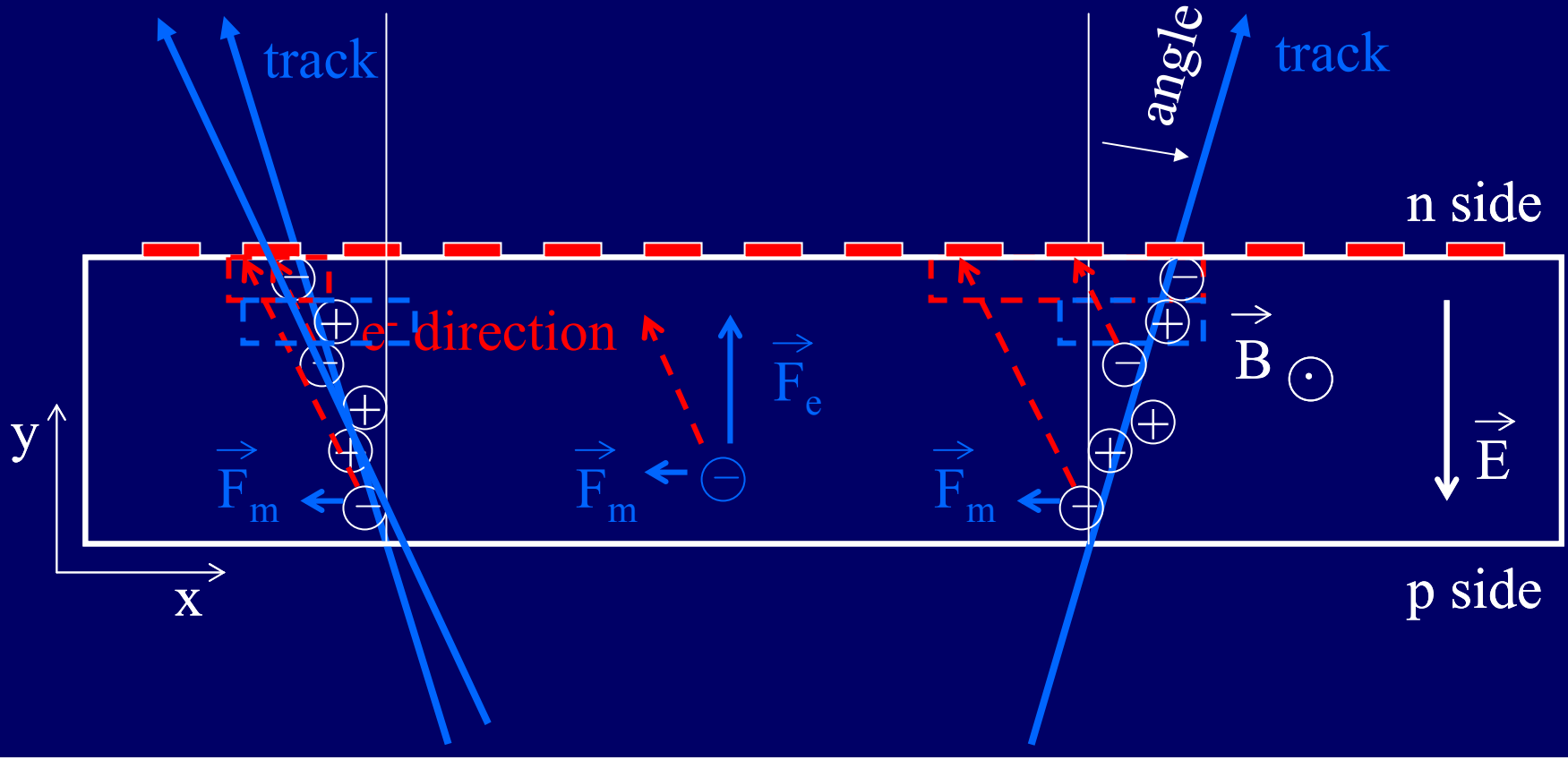
$$\sigma^2_{\text{residual}} = \sigma^2_{\text{intrinsic}} + \sigma^2_{\text{track}}$$

- $\sigma^2_{\text{track}} > 0 \Rightarrow$ layer scale factor used to determine intrinsic resolution from the width of residual distribution

  ($\sigma_r \sim 1.8\ \sigma_i$ for innermost and outermost layer and $\sigma_r \sim 1.4\ \sigma_i$ for the other two layers)

Magnetic field effect

- Negative angle: smaller cluster size
- Positive angle: bigger cluster size



Assembly of the detector