Tracking Efficiency Study of Babar Detector

OUTLINE

- Motivation
- Accelerator
- DCH and SVT
- SVT-based efficiency
- Efficiency results
- Data/MC ratio results
- Conclusion

Motivation

- In physics analysis,

  Use MC simulation to model the rates of data

- But,

$$\text{Efficiency for Data} \neq \text{Efficiency for MC}$$

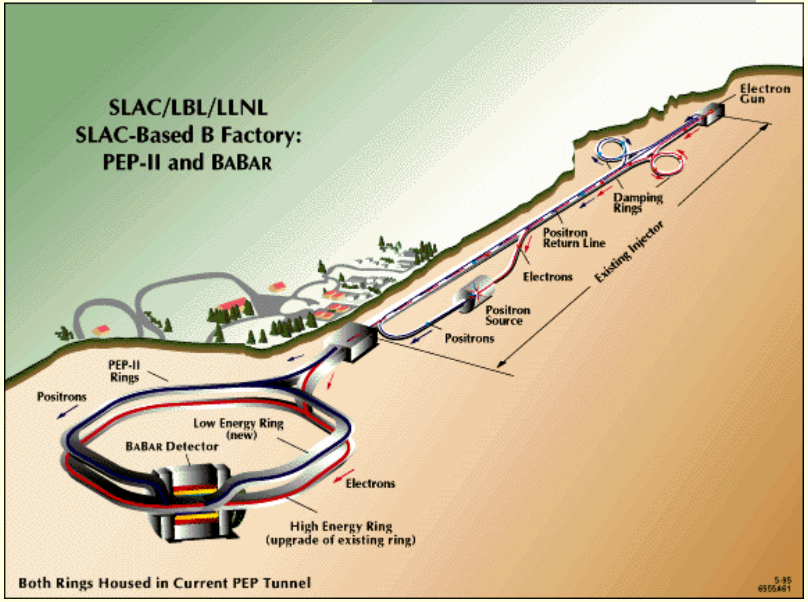
- Need to get correction factors

$$\text{Correction factor} = \frac{\text{Data efficiency}}{\text{MC efficiency}}$$

Accelerator

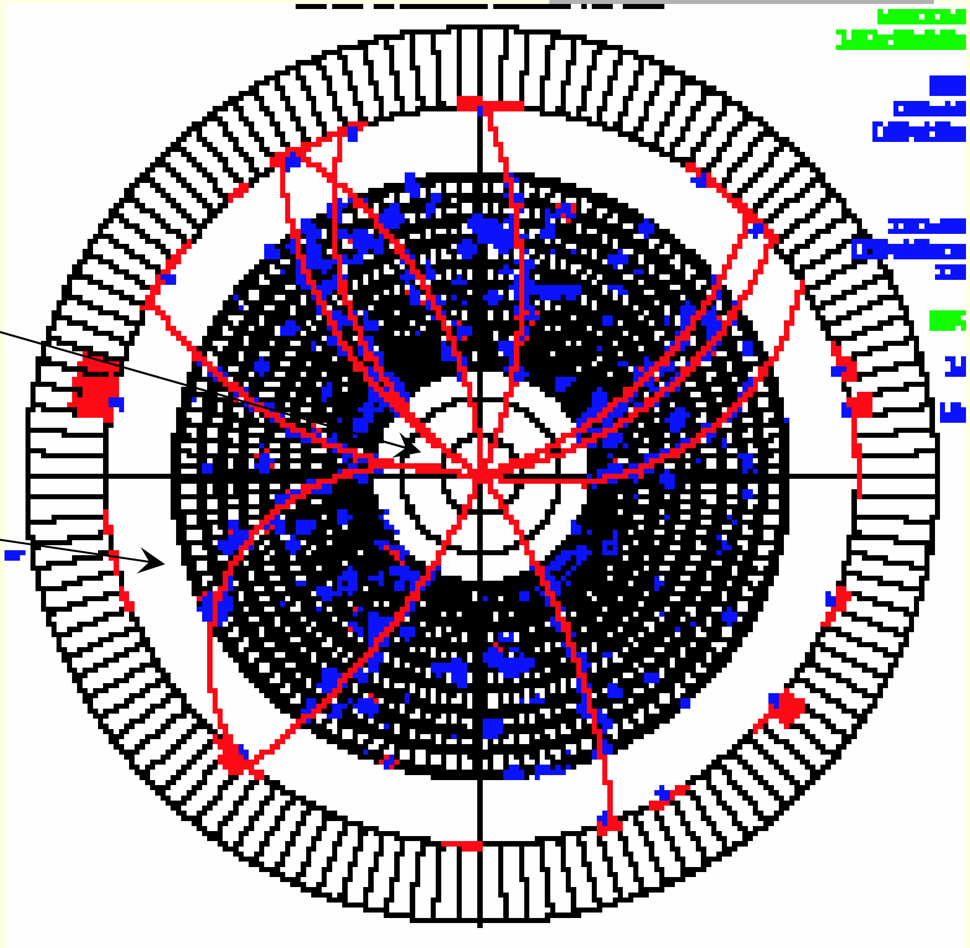
- Asymmetric electron positron collider
- Electron 9GeV

  Positron 3.1GeV
- Tuned to produce Y(4S) resonance, decaying into 2 B-mesons.



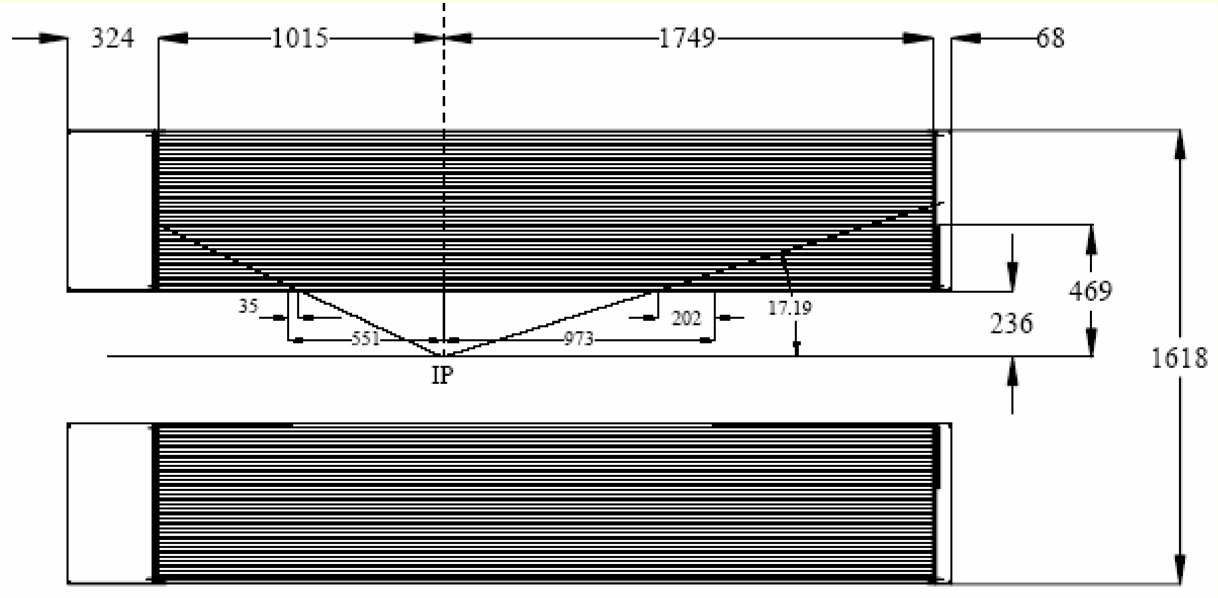
DCH and SVT

- Babar detector has two tracking devices.
  - SVT (Silicon Vertex Tracker)
  - DCH (Drift Chamber)
- 1.5T axial magnetic field



DCH (Drift Chamber)

- Main tracking device



cross section view along the beam line

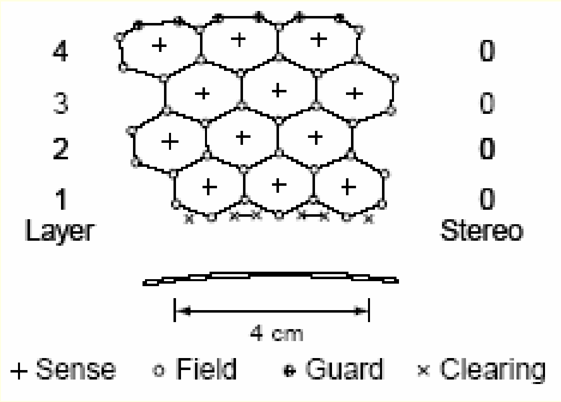
DCH (Drift Chamber)

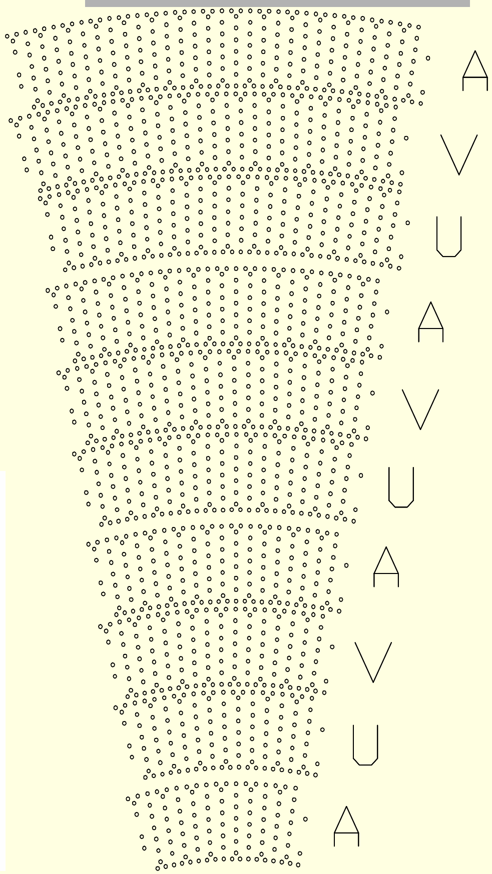
- 40-layer small-cell chamber
- Momentum resolution

$$\frac{\sigma_{P_T}}{P_T} = (0.13 \pm 0.01)\% \bullet p_T + (0.45 \pm 0.03)\%$$

0.97% for p_T=2GeV

p_T>100MeV

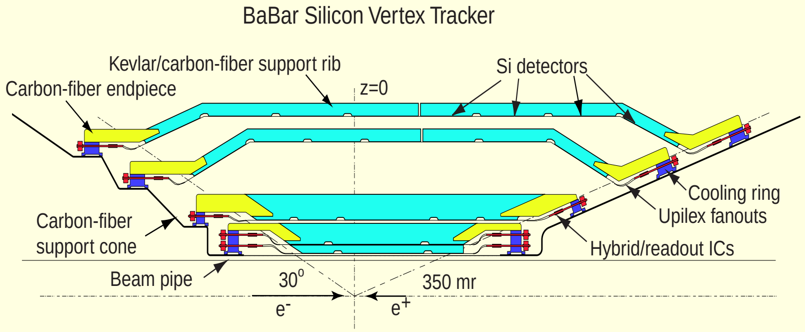


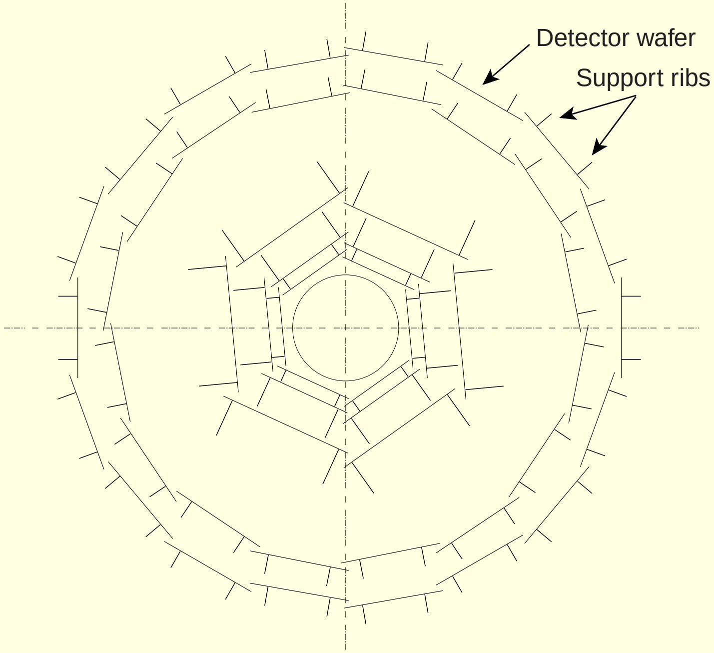


SVT (Silicon Vertex Tracker)

- 5 double layers $\left(r-\phi, r-z\right)$
  2 hits per layer
- Can reconstruct charged tracks.

(Typical SVT has only 2 or 3 single layers and cannot reconstruct tracks)





SVT-based Tracking Efficiency

- Use SVT to determine the efficiency of DCH

$$\varepsilon = \frac{\text{Number of (SVT + DCH) tracks}}{\text{Number of SVT tracks}}$$

- Compare efficiencies of Data and MC to produce correction table.
- This table will be widely used in Babar community.

SVT fake tracks

- Fake tracks

  tracks from a combination of noise hits.

- Rate of fake tracks is determined by well known Bhabha events (e+ e- → e+ e-)

$$\text{Fakes per event} = \frac{\text{Number of fake tracks}}{\text{Number of Bhabha events}}$$

- Number of fake tracks for multi-hadron events

$$\text{Fake tracks} = (\text{Fakes per event}) \times (\text{Number of multi hadron events})$$

Measured Efficiency

- Measured efficiency is given by

$$\varepsilon = \frac{\mathrm{DCH} + \mathrm{SVT\ tracks\ with\ 10\ SVT\ hits}}{\mathrm{SVT\ tracks\ with\ 10\ SVT\ hits\ \ -\ \ Fake\ tracks}}$$

- 10 SVT hits means the particle went through the SVT because SVT has 5 layers and a charged particle leave 2 hits per each layer.
- This doe not give an absolute efficiency.
- We are interested in Data/MC ratios.

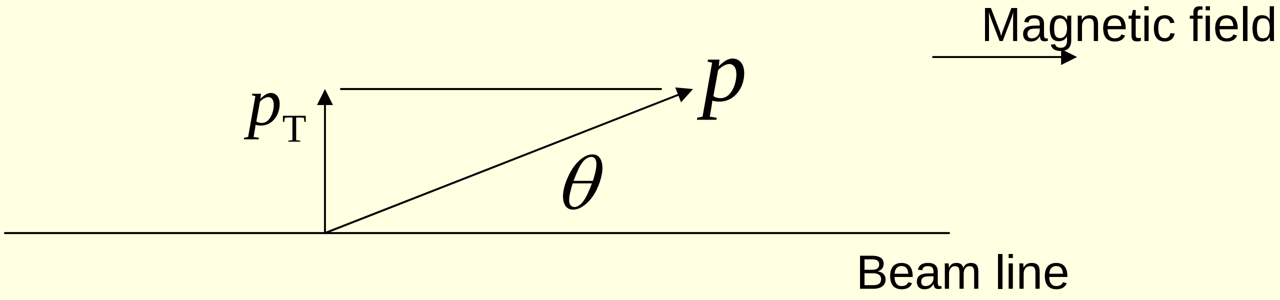
Data and MC(Monte Carlo)

- 100 pb^{-1} of data was used.
- This is less than one day data.
- Uncertainty is dominated by systematic error (~1%)
- Statistical error is the order of 0.1%

- 400 pb^{-1} of MC was used.

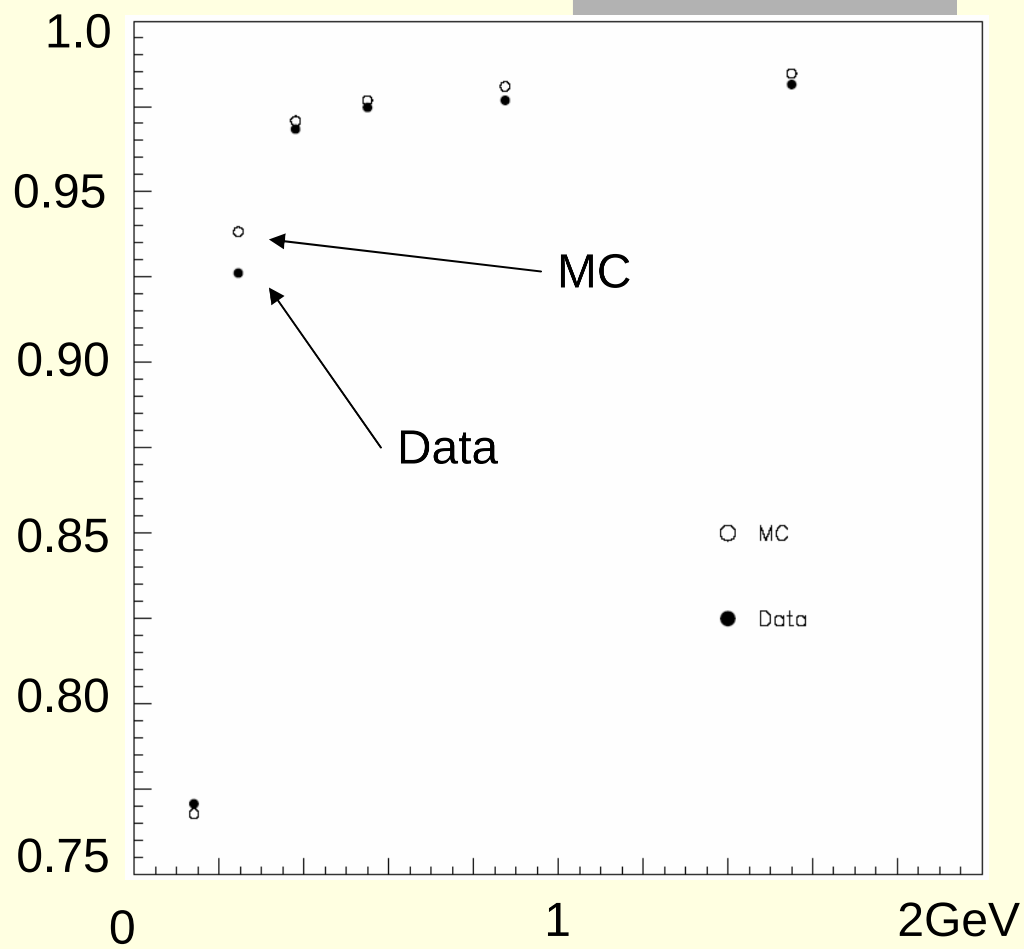
Kinematic variable dependence

- Efficiency would depend on
  - Transverse momentum: p_{T}
  - Angles: θ, ϕ
  - Multiplicity = number of tracks per event



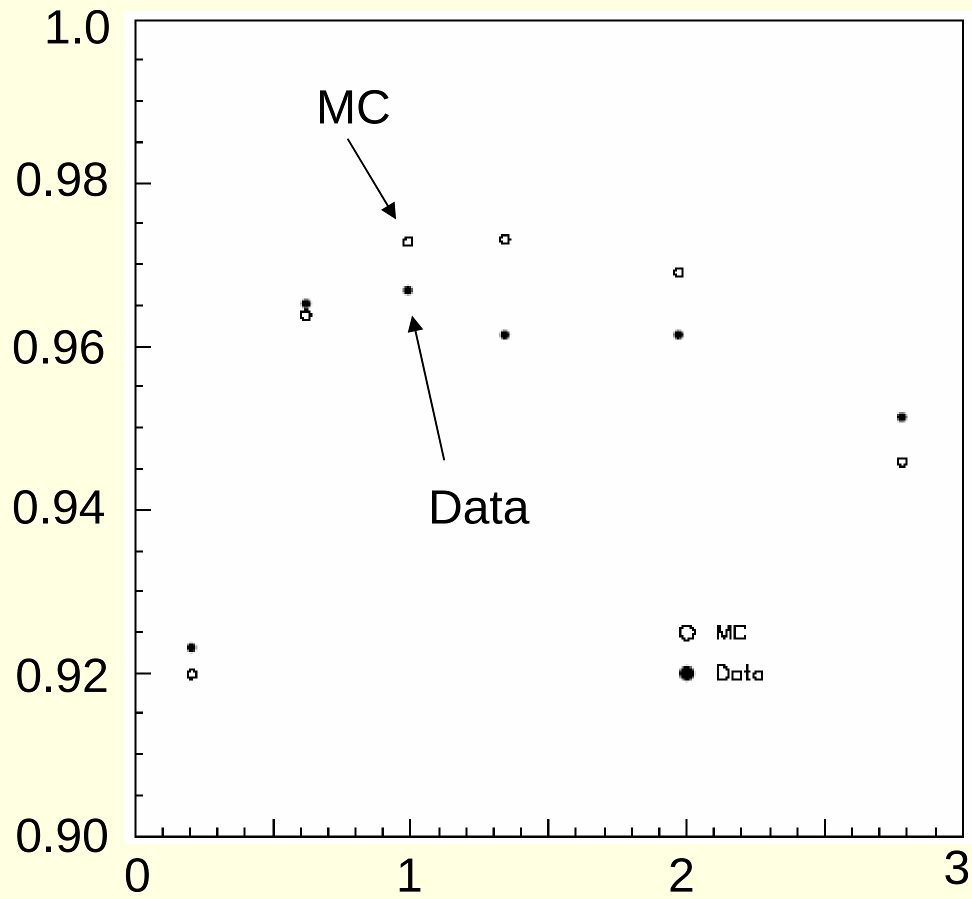
Efficiency vs p_T

- Data MC comparison
- p_T 6 bins (GeV)
  - 0.10 – 0.18
  - 0.18 – 0.31
  - 0.31 – 0.45
  - 0.45 – 0.65
  - 0.65 – 1.10
  - 1.10 –
- 0.41< θ <2.41



Efficiency vs Theta

- Data MC comparison
- θ 6 bins (rad)
  - 0.00 – 0.41
  - 0.41 – 0.83
  - 0.83 – 1.15
  - 1.15 – 1.53
  - 1.53 – 2.41
  - 2.41 – 3.14
- $p_T > 0.18$ GeV



Efficiency vs Phi

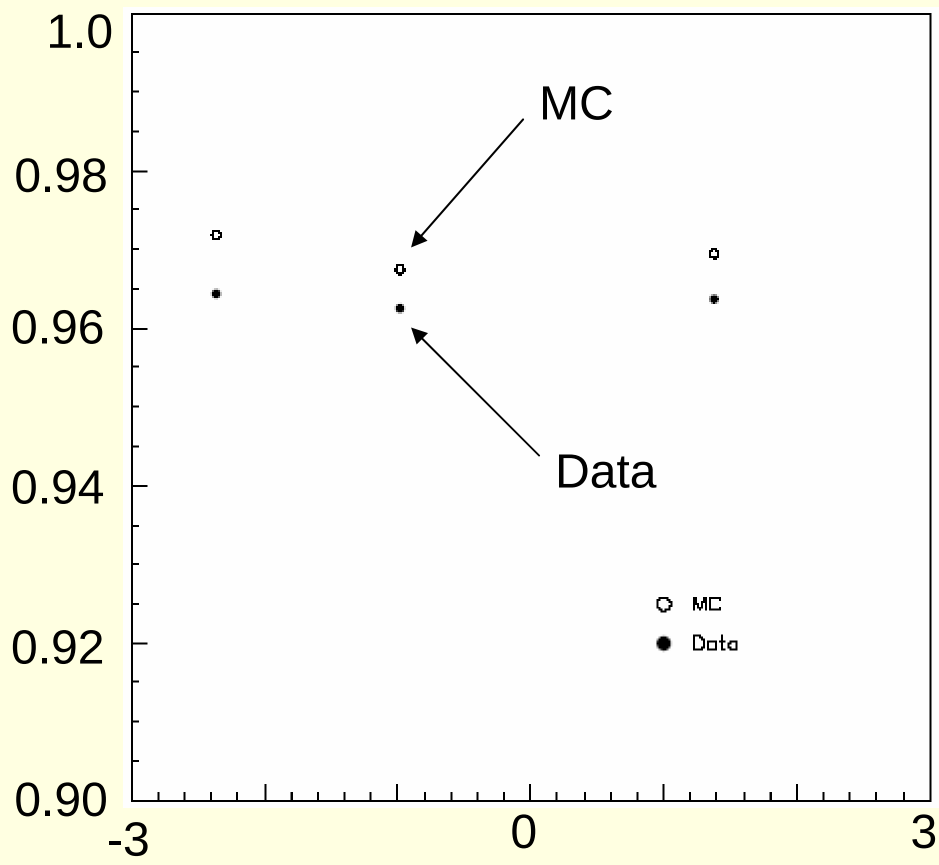
- Data MC comparison
- ϕ 3 bins (rad)

  -3.141 – -1.575

  -1.675 – -0.3937

  -0.3937 – 3.141
- $p_{\mathrm{T}} > 0.18$ GeV

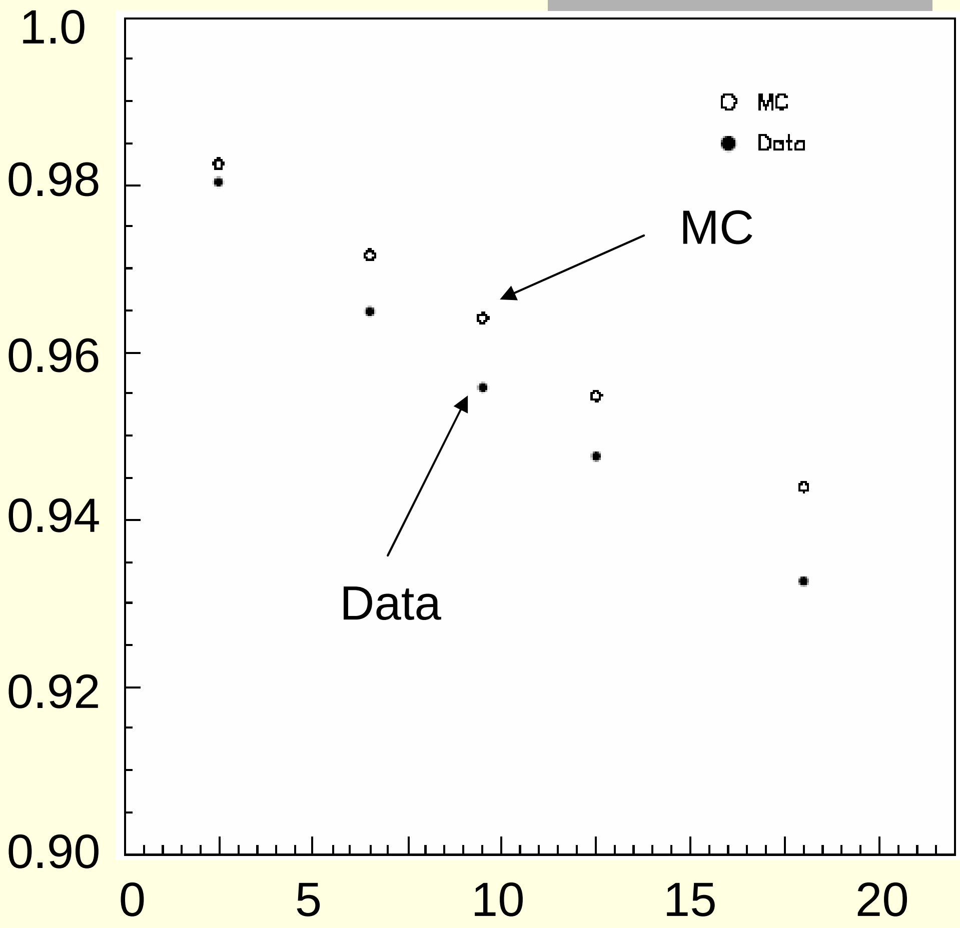
  $0.41 < \theta < 2.41$



Efficiency vs Multiplicity

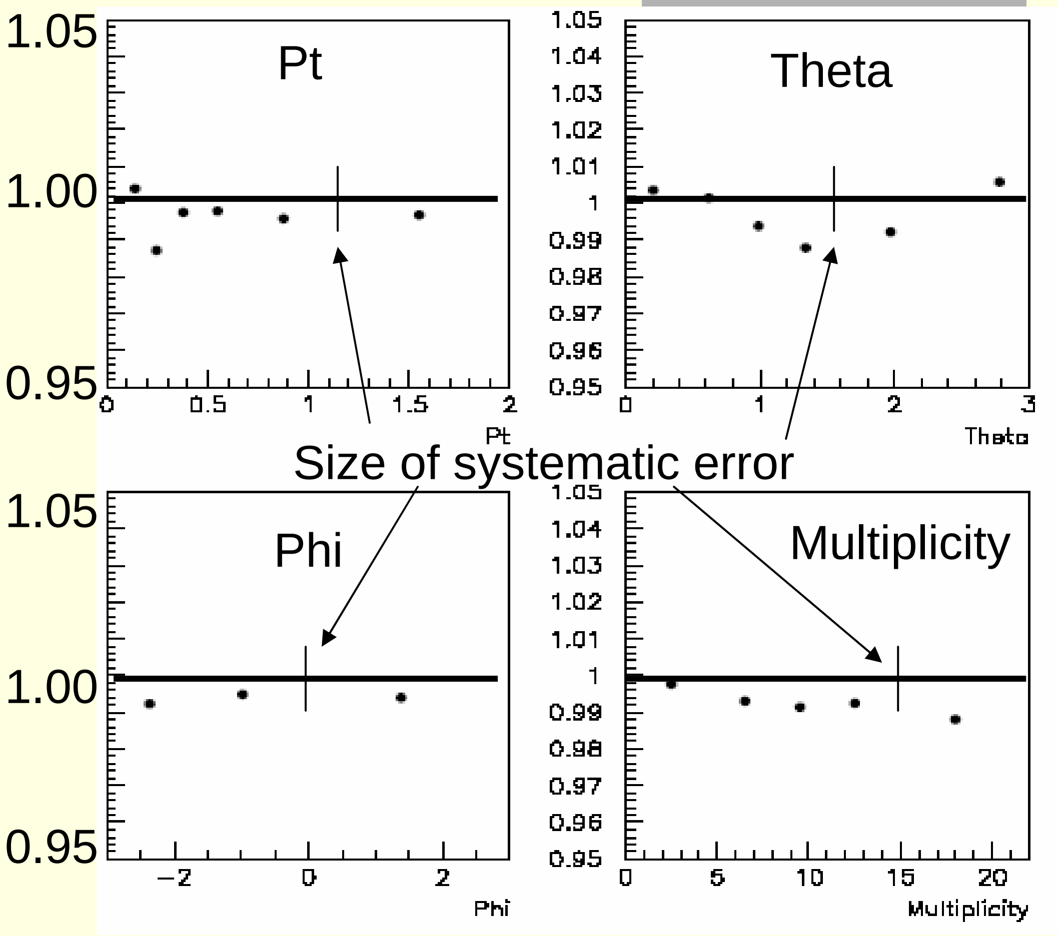
- Data MC comparison
- Multiplicity 5 bins
  - 0 – 5
  - 6 – 8
  - 9 – 11
  - 12 – 14
  - 15 –
- $p_T > 0.18$ GeV

  $0.41 < \theta < 2.41$



Data/MC Ratio Plots

- Data/MC ratios
- $p_T > 0.18\text{GeV}$
  $0.41 < \theta < 2.41$
- Good agreement
- Flat
- Statistical error is the size of the dots(~0.1%)
- Systematic error ~1%



Averaged Efficiencies and Ratio

- Efficiencies and Data/MC ratios averaged over bins

Efficiency of Data	96.37%
Efficiency of MC	96.95%
Data/MC ratio	99.40%

Conclusion

- Using SVT-based efficiency, Data/MC ratios were measured.
- Data/MC ratios were close to 1 and relatively flat against transverse momentum, theta, phi and multiplicity.
- Collection tables of Data/MC ratios were produced.
- Correction tables are going to be widely used in the Babar community.

Multiplicity dependence

- Could be the selection bias
- Cuts 1

  $p_T > 0.18\,\mathrm{GeV}$

  $0.41 < \theta < 2.41$
- Cuts 2

  $p_T > 0.31\,\mathrm{GeV}$

  $0.41 < \theta < 2.41$
- Specific bin

  $0.45 < p_T < 0.65$

  $0.83 < \theta < 1.15$