Using Geant4 in the BaBar Simulation

CHEP03

25 March 2003

Dennis Wright (SLAC)

on behalf of the BaBar computing group

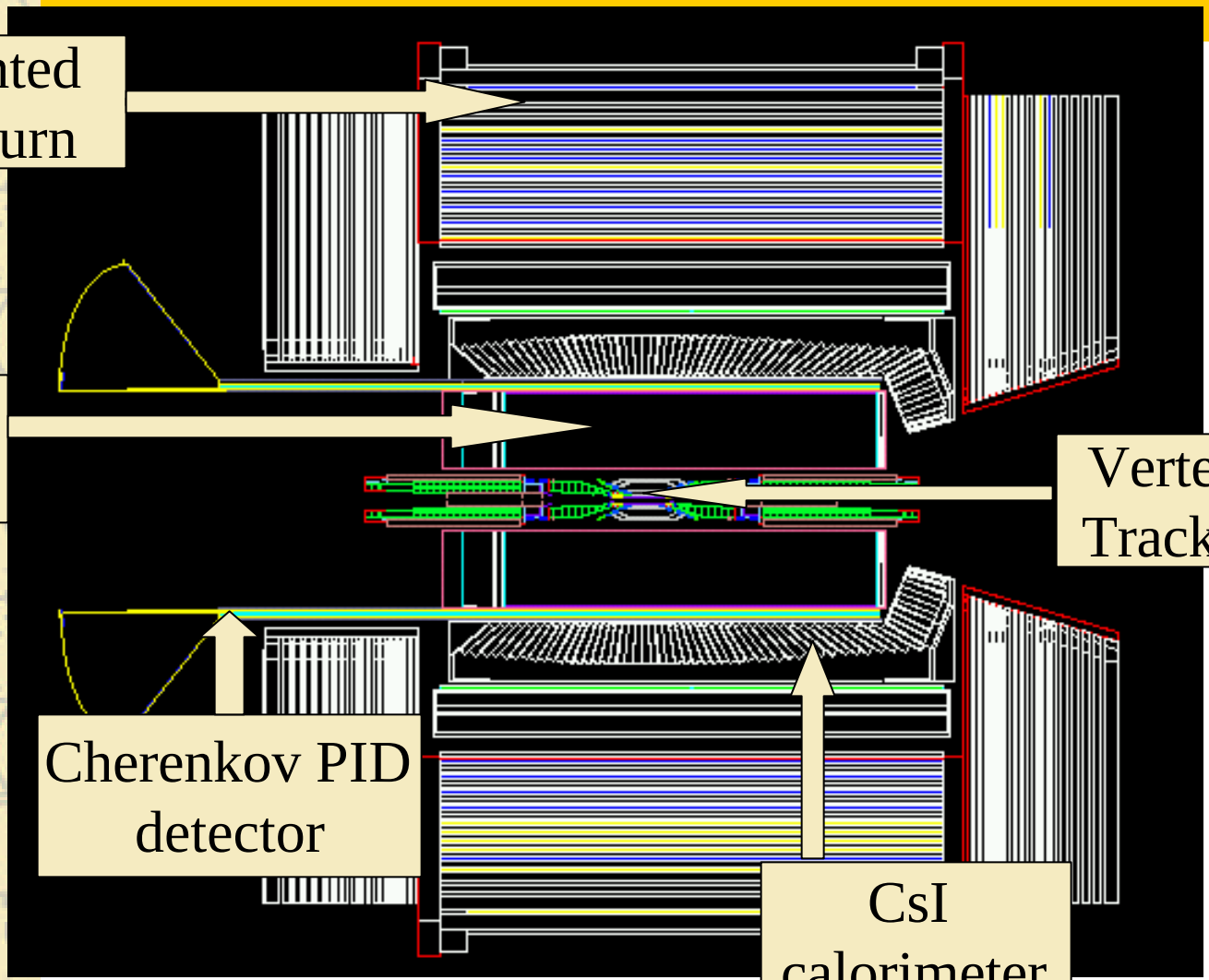
Outline

- BaBar overview
  - physics
  - building a Geant4-based simulation
- MC/data comparison
  - EM process validation
  - hadronic process validation
- Performance

BaBar Physics

- CP violation in B0B0bar system
- EM interactions
  - must reconstruct B0 → J/ψ K_s, J/ψ K*, D+D-, …
  - typical decay product energies:
    - lepton pairs 0.3 < p < 2.3 GeV/c
    - π^0 0.3 < E < 2.5 GeV
    - γ 0.1 < E < 4.5 GeV
- hadronic interactions
  - charged π s and K s interacting in beam pipe, calorimeters
    - p < 4 GeV/c, most < 1 GeV/c

The BaBar Detector

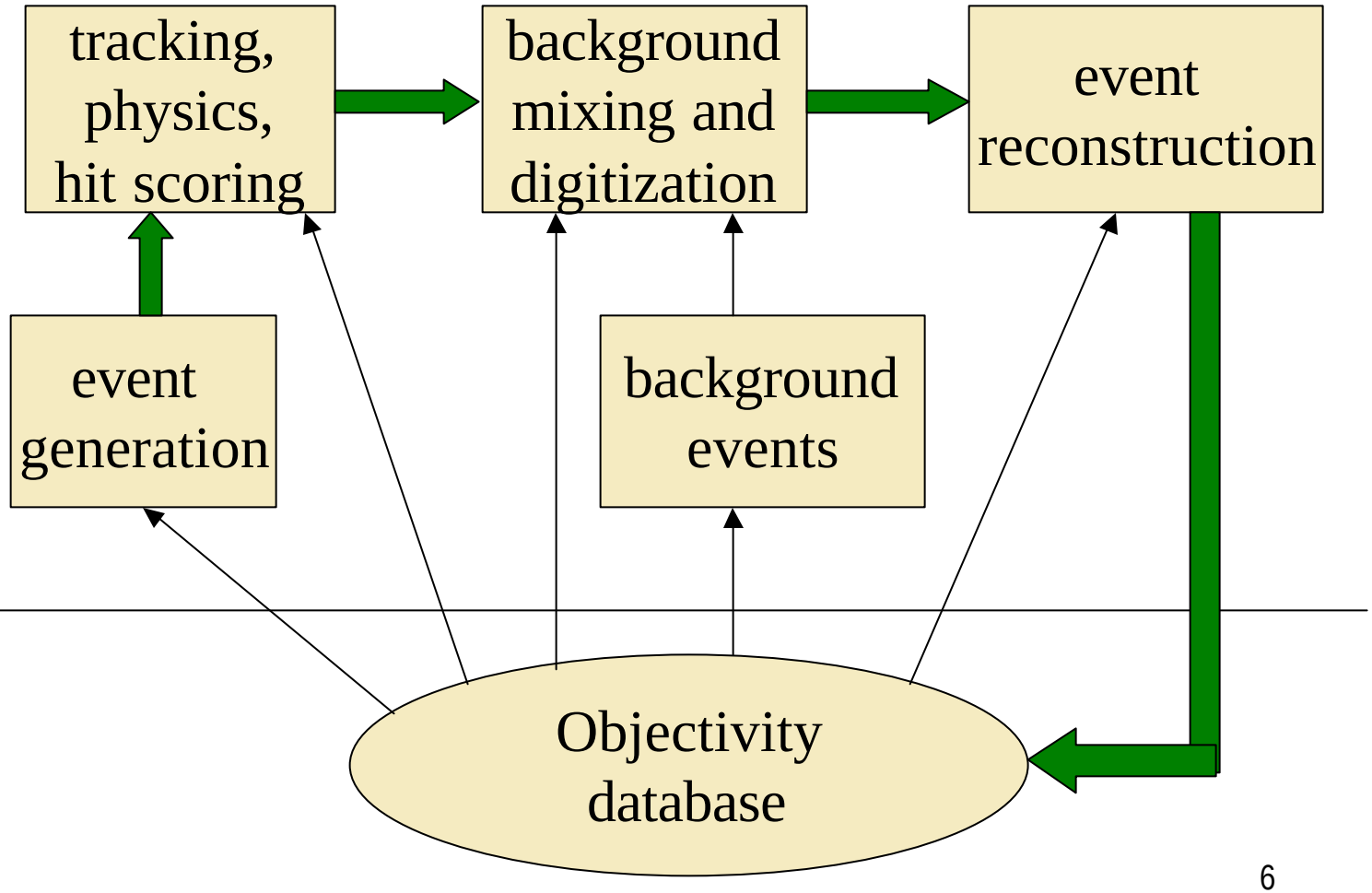


Simulation Design Requirements

- Simulation must run in BaBar Framework
  - tracking, physics, hit scoring (GEANT4) implemented as a Framework module
  - Geant4 must give up run control to the Framework
- Work with existing event generators, detector response and reconstruction codes
- Use Objectivity database for persistence
  - even though Geant4 does provide persistence
- Simulation must be detailed but fast enough to keep up with high-luminosity production

BaBar Simulation Overview

Framework



Use of Geant4 in BaBar

- BaBar uses:
  - Geometry
  - Hit-scoring
  - Decay processes
  - EM physics processes (< 10 GeV)
  - Low energy hadronic processes (< 10 GeV)
- BaBar does not use:
  - Detector response
  - Persistence
  - Standard particle transport/navigation

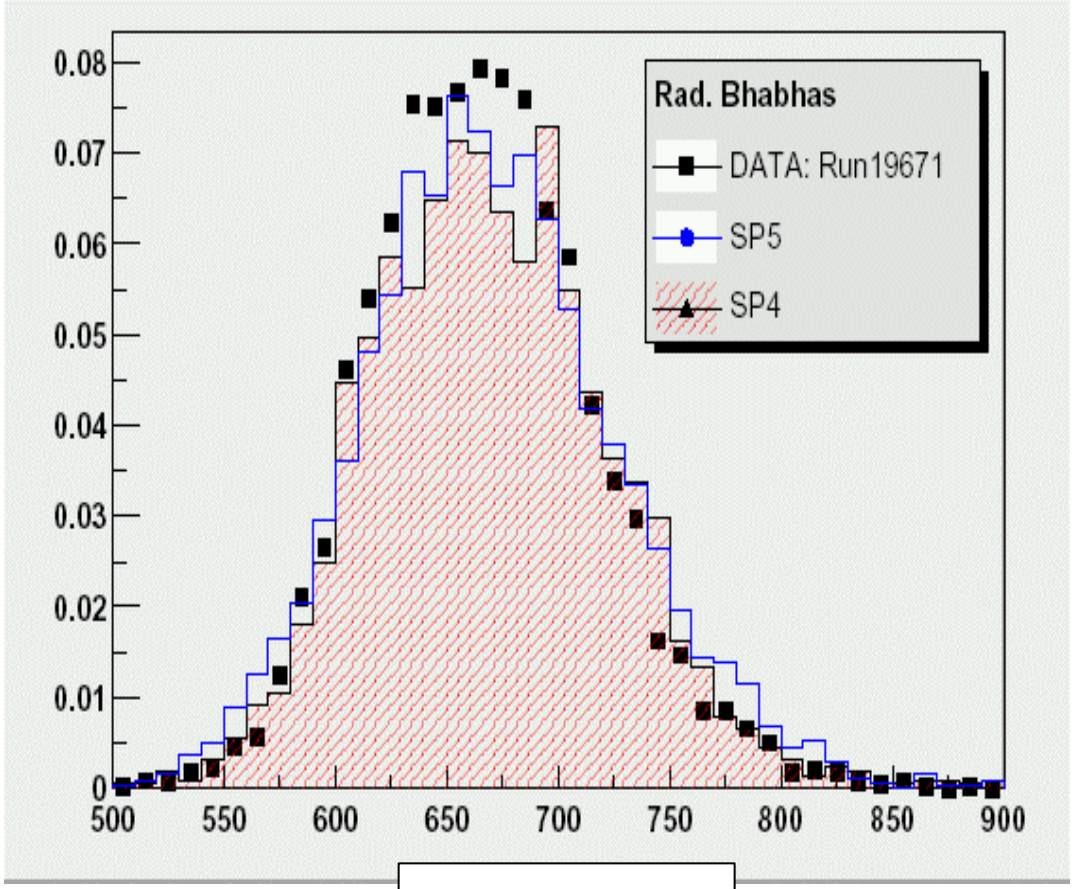
BaBar/Geant4 Validation

- Since October 2000, several validation test runs generated, compared to data
  - total of 20 million events
  - 25 different event types: B0B0bar, bhabhas, dimuons

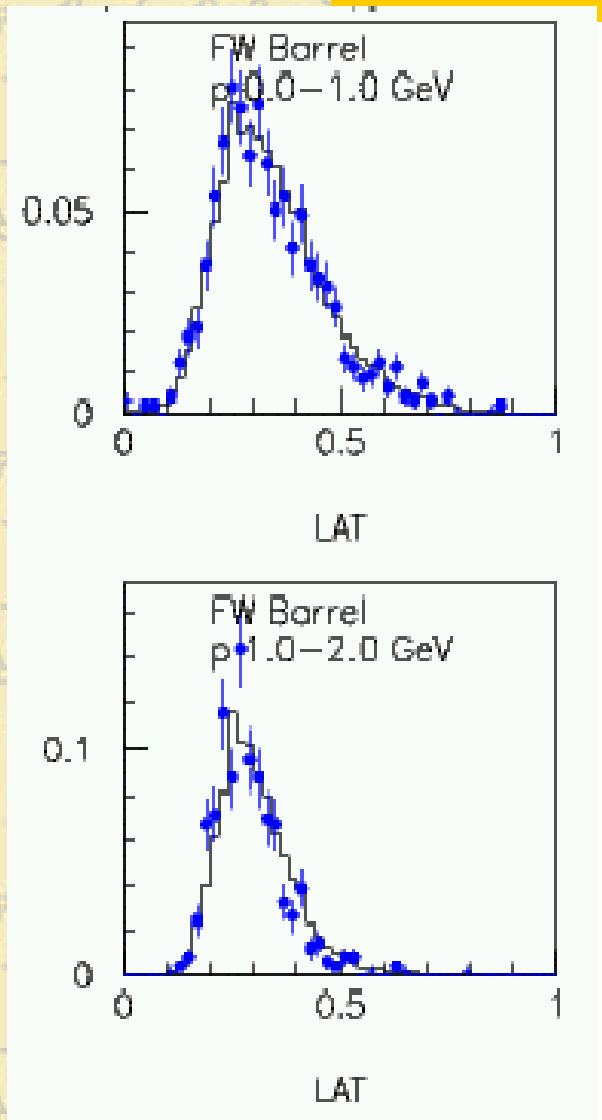
- Examined:
  - Detector material model
  - Tracking, resolution, reconstruction
  - Particle ID
  - EM processes
  - Hadronic processes
  - performance/robustness

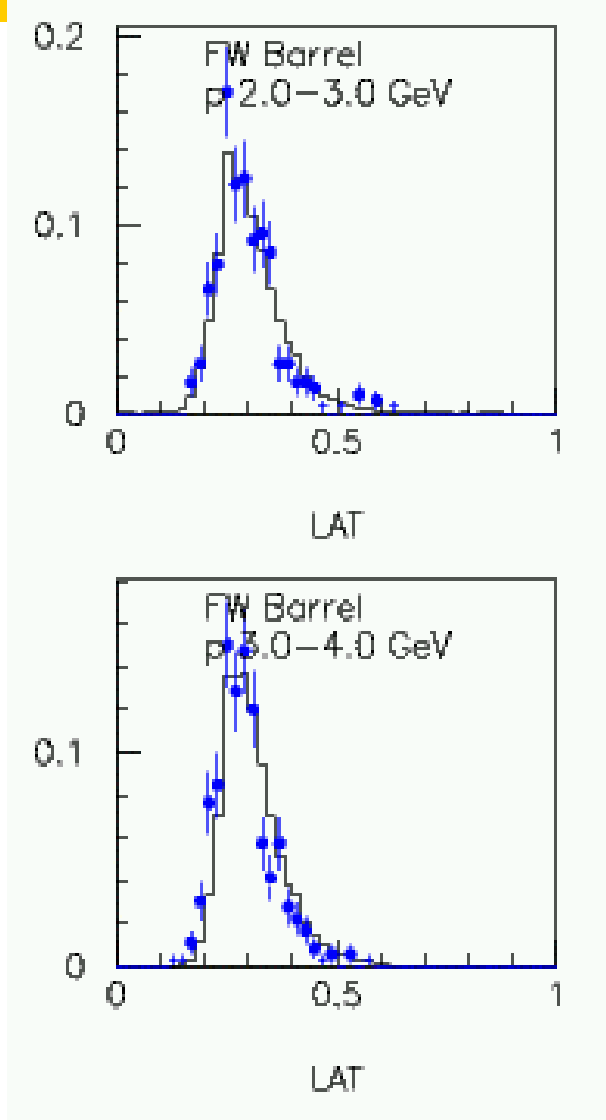
EM Process Validation: dE/dx

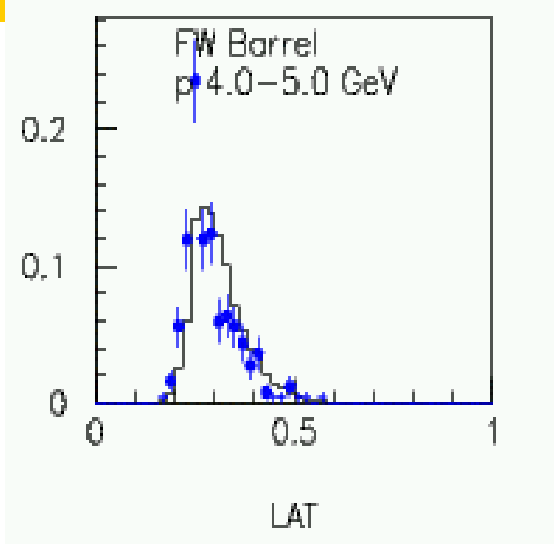
- Min. ionizing e+,e- from rad. Bhabhas ($0.2 < p < 8$ GeV/c)
  - mean energy loss in He-ISO gas reproduced
  - widths agree → fluctuations are reproduced



EM Validation: shower shapes





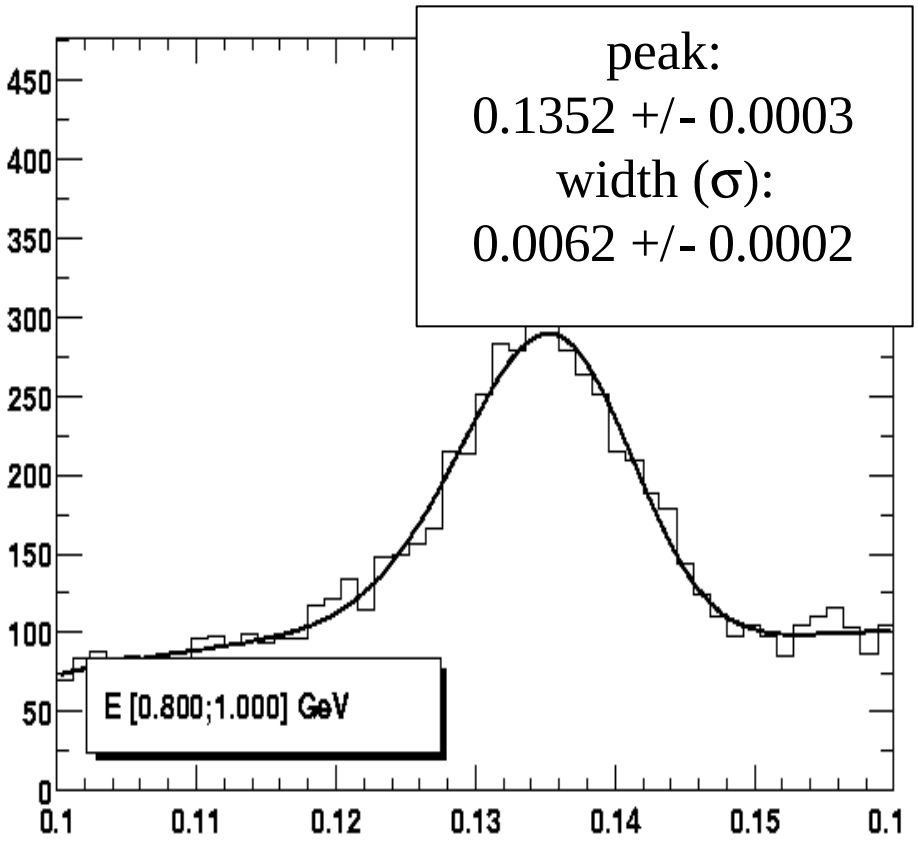


EM Validation: π^0 Reconstruction

- π^0 mass – test of tracking, energy scale, containment in calorimeter
- π^0 width – depends on shower simulation, detector response to photons
- Looked at π^0 s with energies 0.3 to 2.1 GeV from $K_s \rightarrow \pi^0 \pi^0$

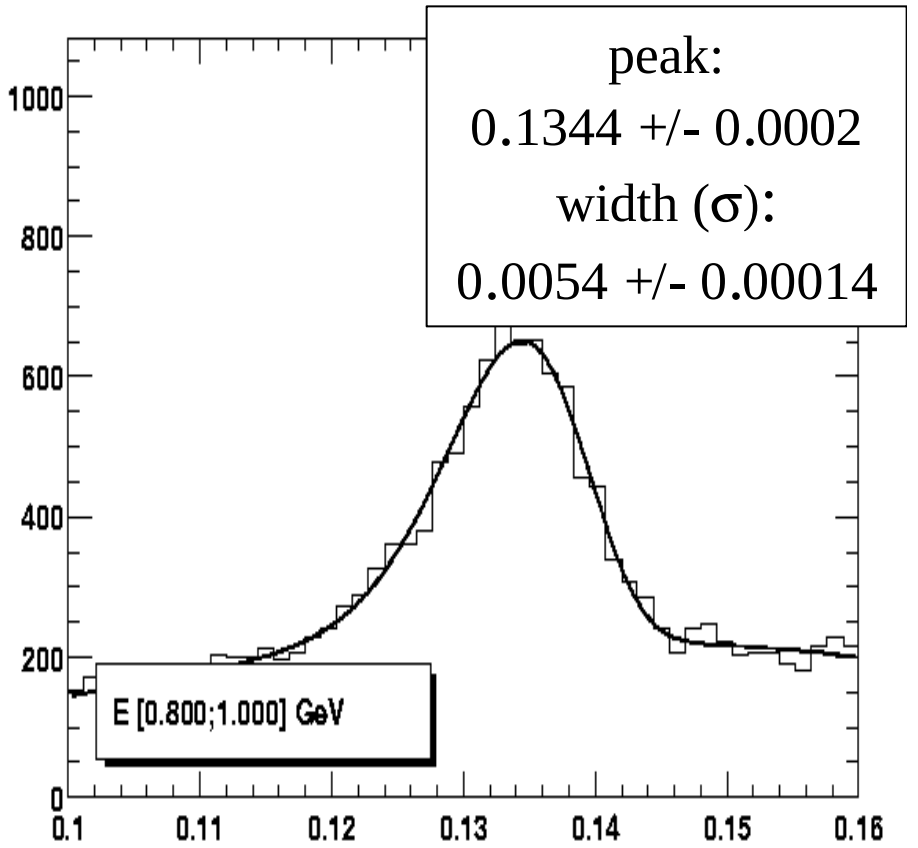
EM Validation: π^0 Reconstruction

data



GeV

MC

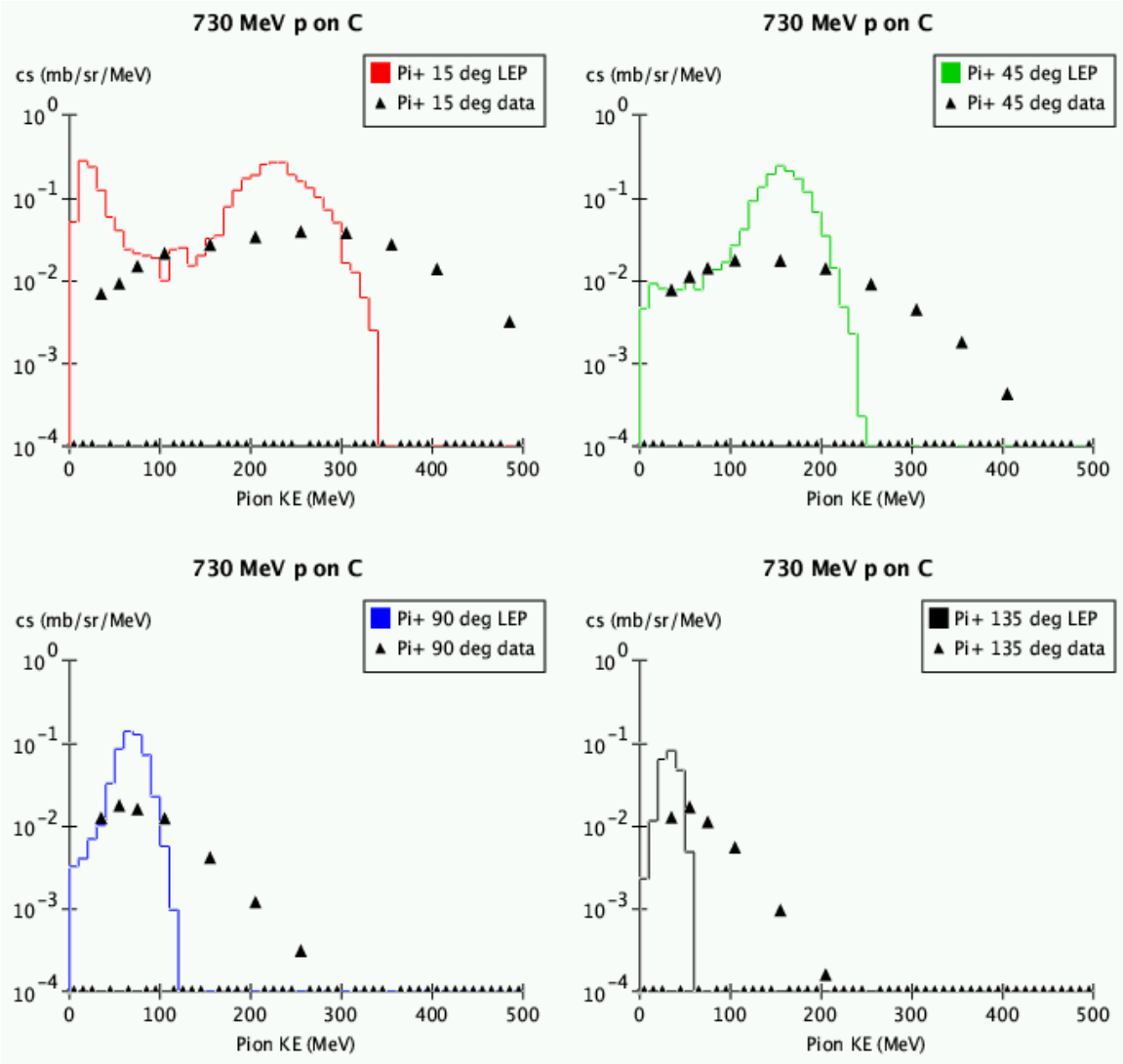


GeV

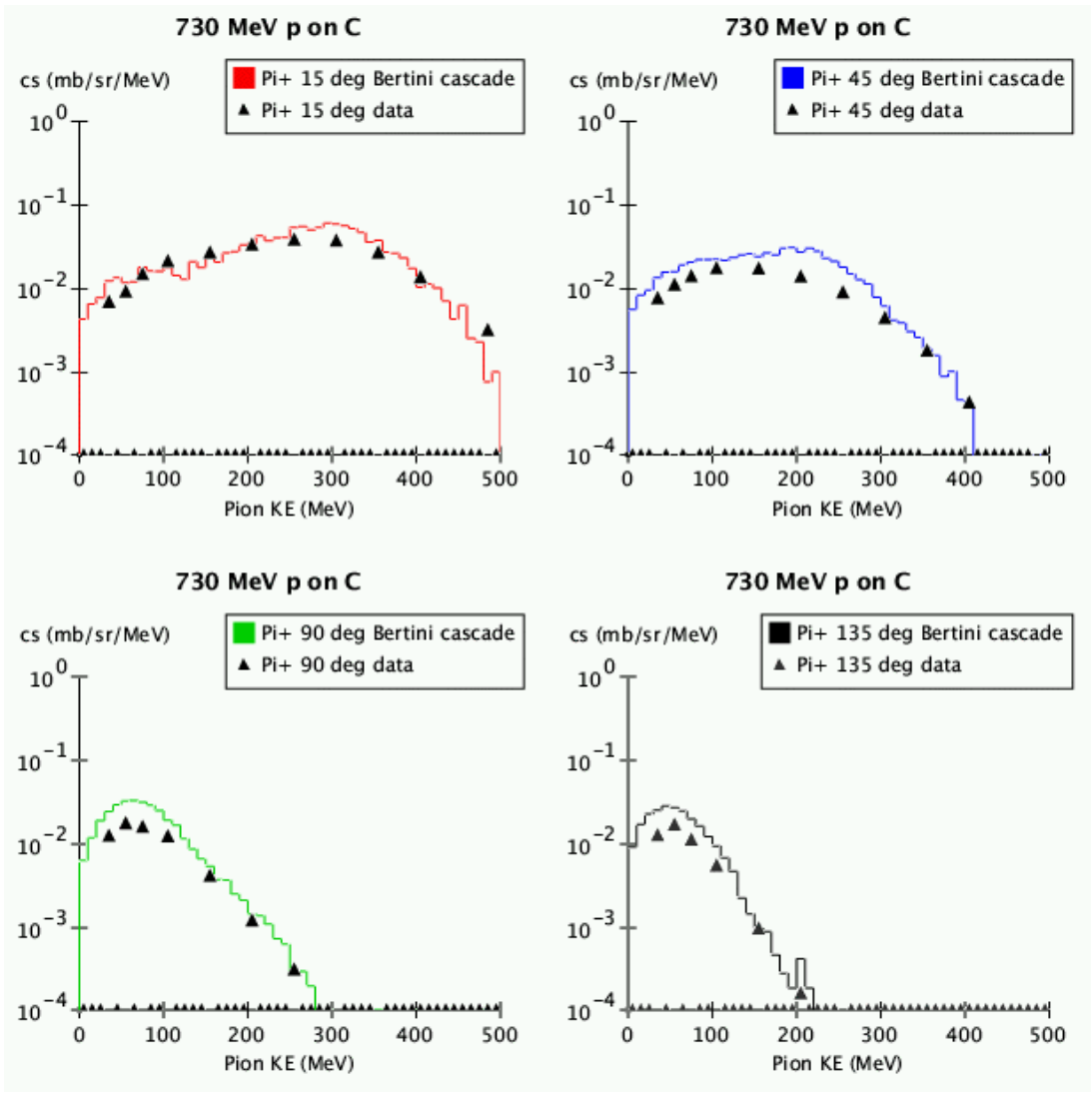
Hadronic Validation

- Currently using low energy parameterized (LEP) model
  - re-engineered version of GHEISHA
  - not especially appropriate for BaBar energies (50MeV – 5 GeV)
- Cascade models now being tested as alternatives
  - binary cascade
  - Bertini cascade looks promising
- Thin target tests used for validation
  - using BaBar data
  - using other data

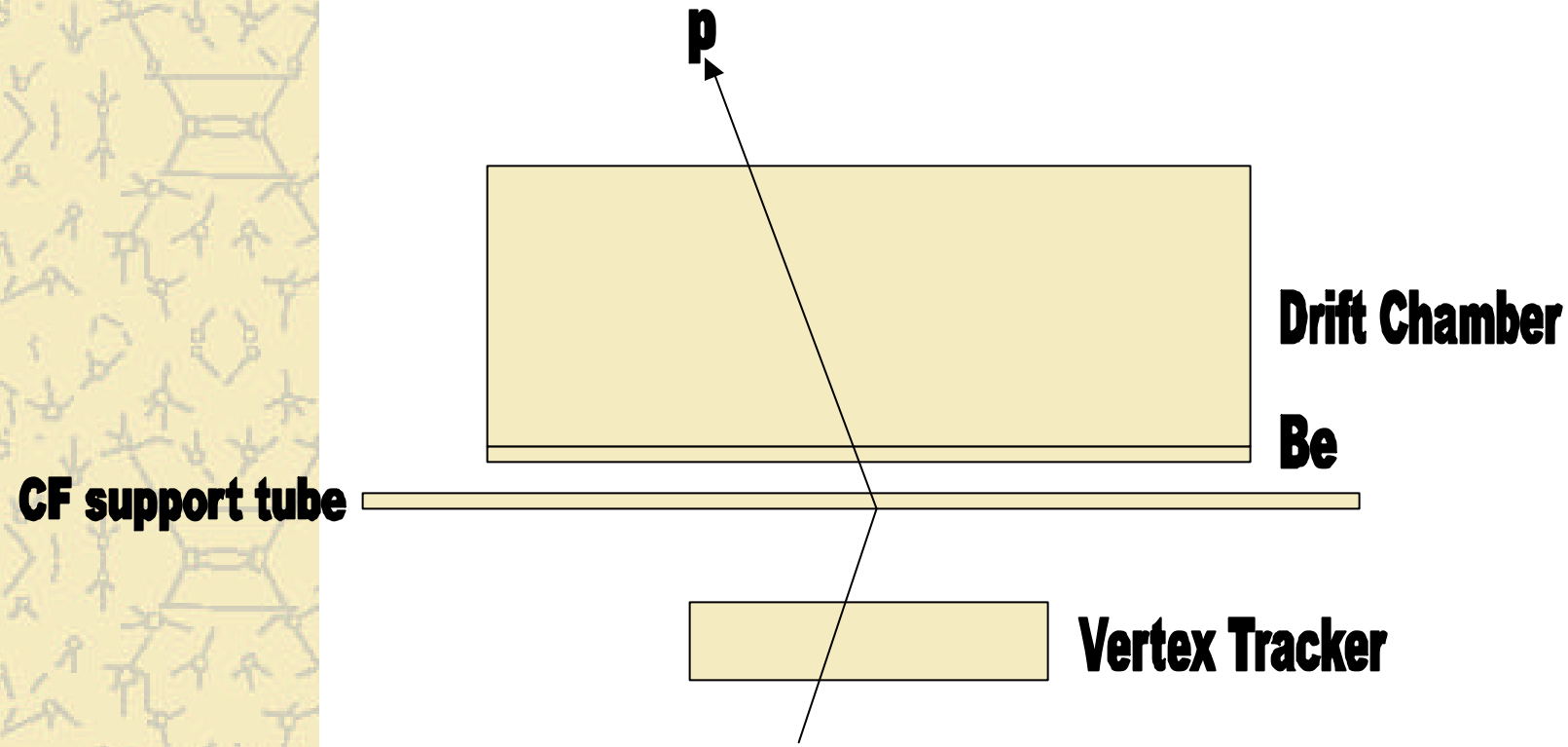
Hadronic Validation: Models



Hadronic Validation: Models



BaBar “Thin Target” Hadronic Tests



Performance

- Simulation stage of generic B0-B0bar event includes event generator, tracking, hit-scoring
  - On 866 MHz PIII takes 5.0 s/evt
  - Used Geant4 4.0
- Currently running MC production at ~20 sites (1440 M events so far)
- Run failures due to Geant4 getting rare
  - < 1 per million events

Conclusions

- BaBar is the first large experiment to develop and use a Geant4-based simulation
- EM validation well in hand
  - Some differences between MC and data but so far probably due to detector response simulation
- Hadronic validation beginning in earnest
  - Testing low energy parameterized, binary cascade, Bertini cascade models
  - BaBar thin target tests just beginning
- Simulation is robust and reasonably fast