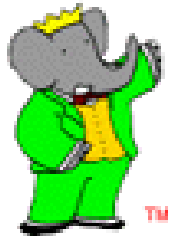
Usage of GEANT 4 versions: 6, 7 & 8 in *BABAR*



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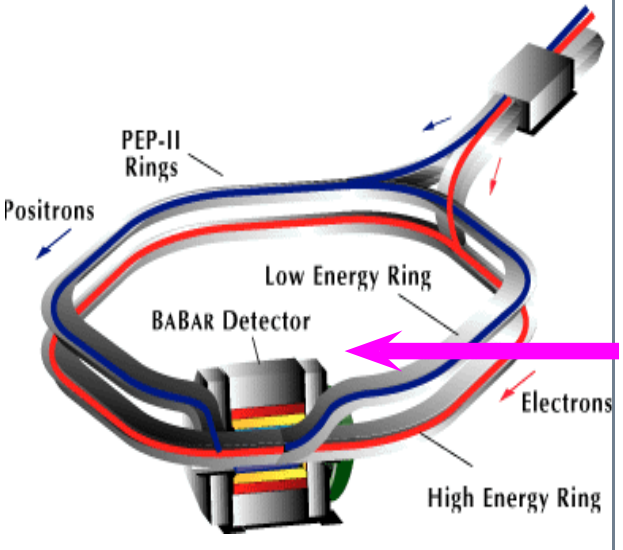
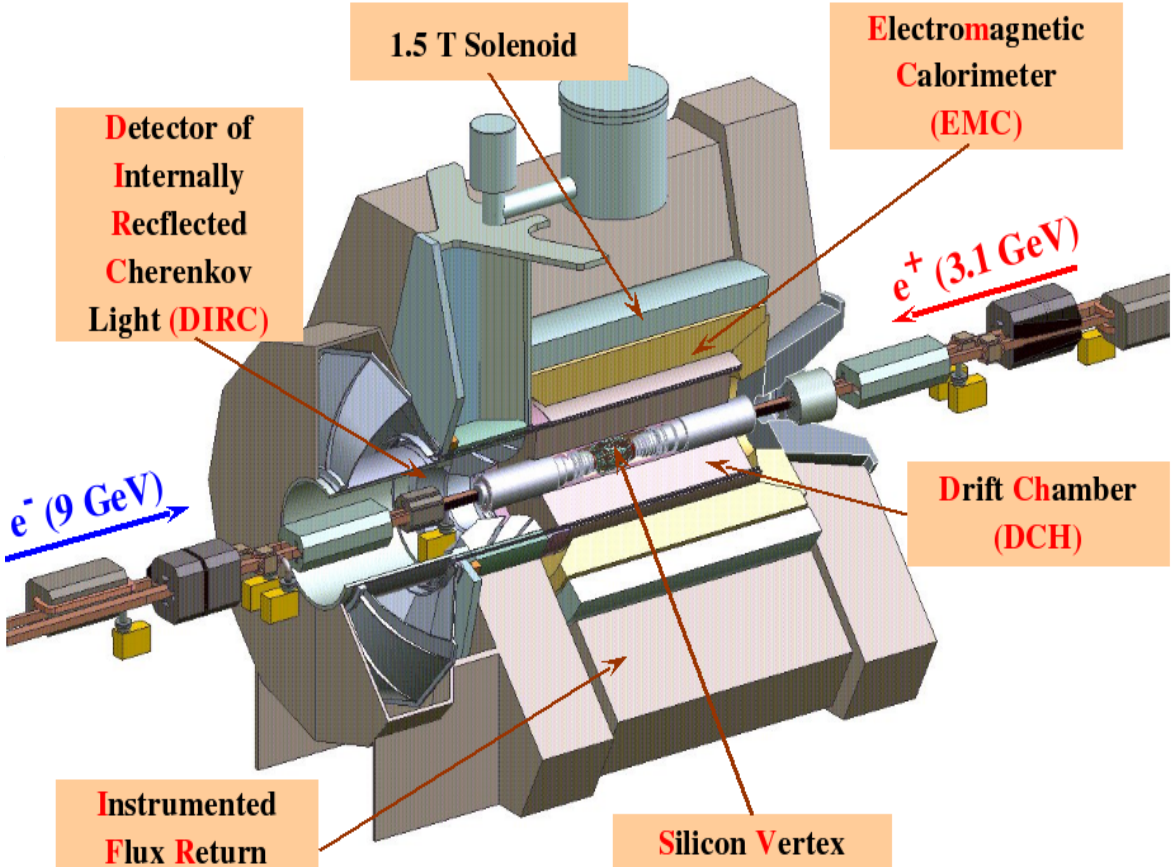
Computing in High Energy and Nuclear Physics (CHEP)

4 September 2007, Victoria.

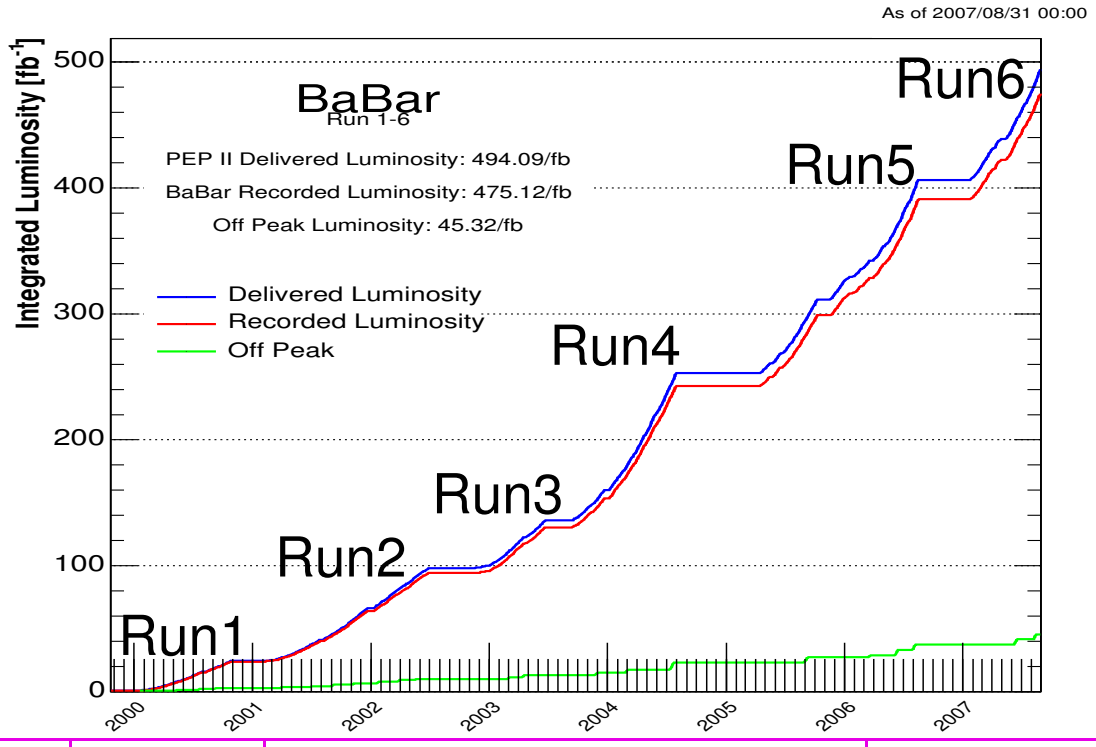
SLAC-Based B-Factory: PEP II & BABAR



The BABAR Detector:



Simulation Road Map



Year	Runs	Simulation Production	GEANT 4 version
1999-2006	1-5	SP8	6.1
2007	6	SP9	7.1
2008	7	SP10	8.3

Maybe, complete re-simulation (2008) for Runs 1-7 with GEANT 4.8.3

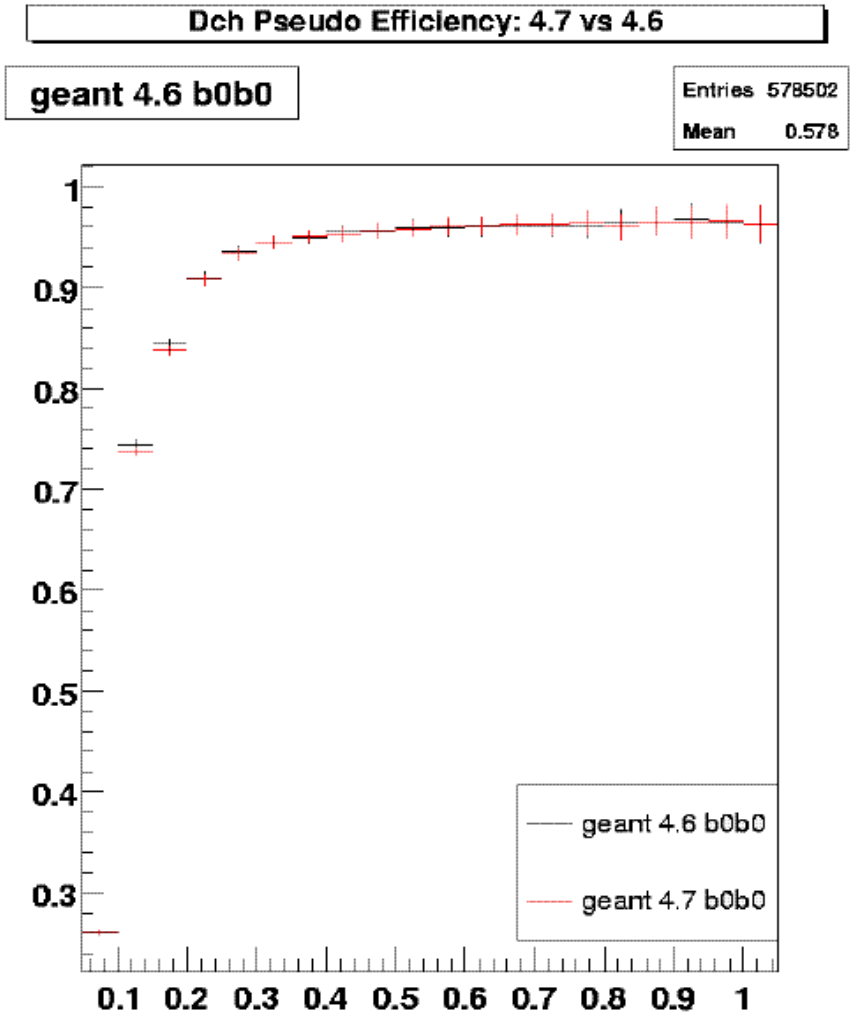
GEANT 4 v7 Highlights

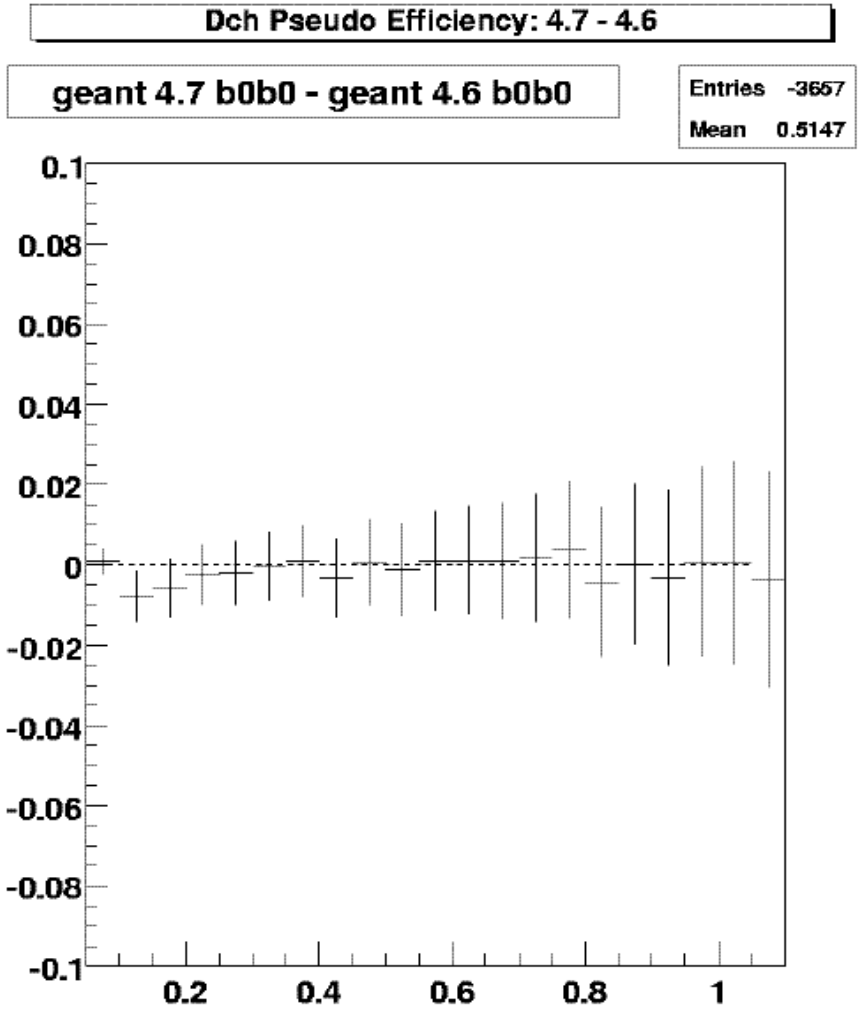
- Ionization step-size had bug in **GEANT** 4 v6.1 ~ 100 MeV
  - Ionization step-size increased in v6.1 ("G4Bug workaround")
  - In **GEANT** v7.1 "bug-fixed" by **GEANT** developers (Thanks!)
- Improvements to Multiple Scattering:
  - Modified Highland formula for the width of the central part
  - Changes in angular distribution of electromagnetic processes
- Corrections to muon ionization, cross-sections of pair production
- Hadronic Processes:
  - New implementation of high energy coherent elastic scattering
    - Substantial improvement of angular distributions for heavy materials and large scattering angles.
  - **Gheisha** $\rightarrow$ Bertini cascade model for k/Λ
    - "on average" parameterization $\rightarrow$ up to 7 body final state
  - Pion cross-sections used in v6.1 out-of-date: table updated from calorimeter beam tests

GEANT 4 v8 Highlights

- Optimized interfaces to Multiple Coulomb Scattering (no step limit)
- Improved mechanism for hard bremsstrahlung emission (electron recoil in the final state)
- EM shower shape wider: improve e/π discrimination, π^0 resolution
- Use improved MIP signature for μ and hadrons (max energy transfer to delta-electrons takes into account hadron size effects: important for ionization of very energetic hadrons)
- Cross sections of Hadronic Processes:
  - Changed scaling of interpolated pion cross sections from $Z^{2/3}$ to $A^{3/4}$ (slightly increase interpolated cross section values)
  - Uses improved fits to cross section data for elastic scattering
- Particle Conventions: updated encoding to match with PDG2006.
- $\geq$ **GEANT** 4 version 8: Requires CLHEP 1.9 or 2.0

Tracking: DCH Pseudo Efficiency



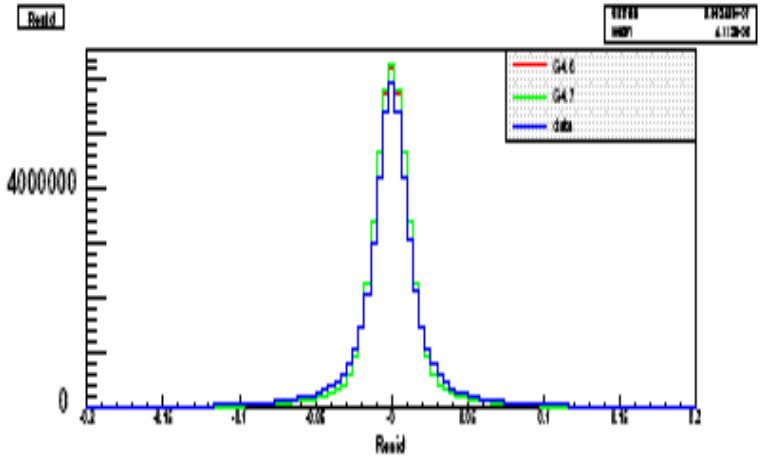


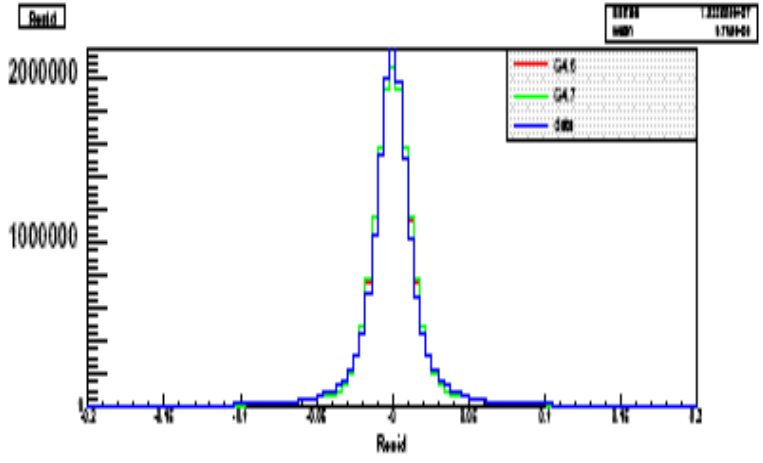
☞ Small change in PE around 100 MeV: effect of Ionization bug-fix

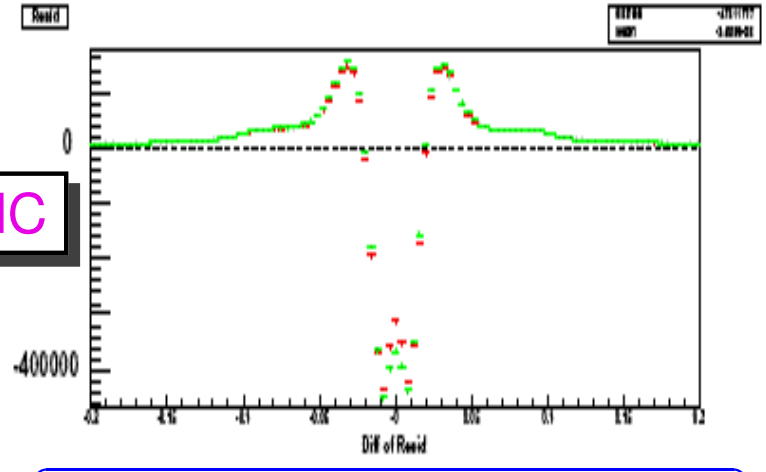
DCH hit residuals

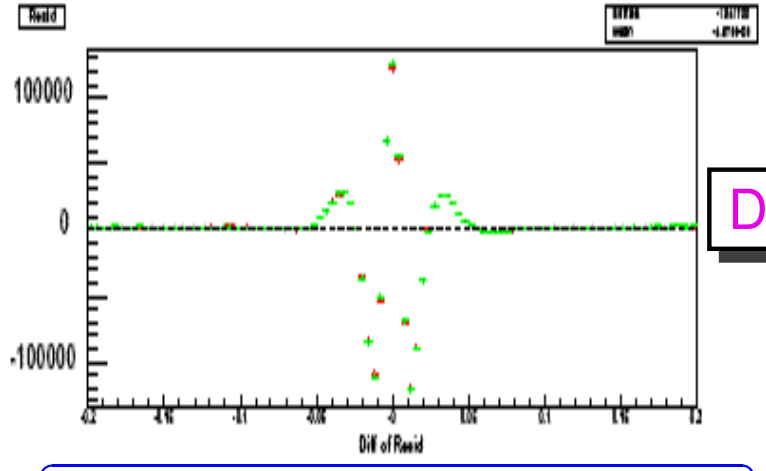
- **GEANT** 4.6: red, **GEANT** 4.7: green

☞ No significant change









Data-MC

Data-MC

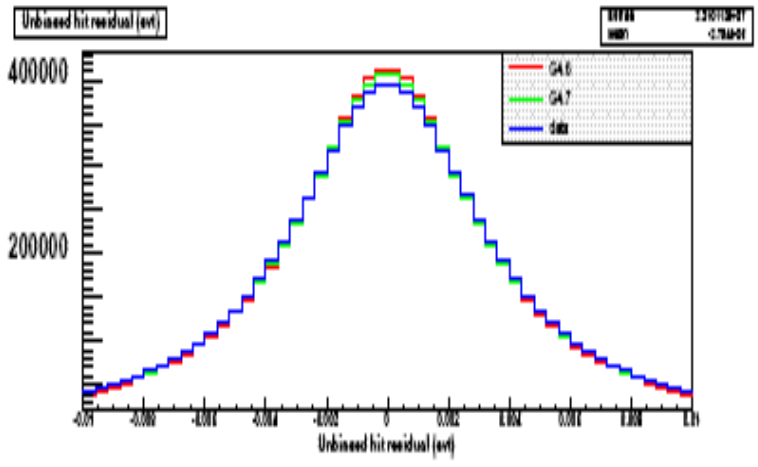
Residuals for Momentum $<$ 1 GeV

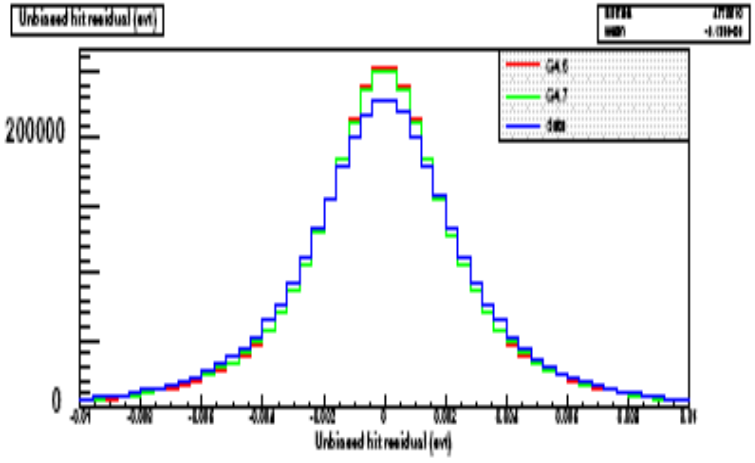
Rediduals for Momentum $>$ 1 GeV

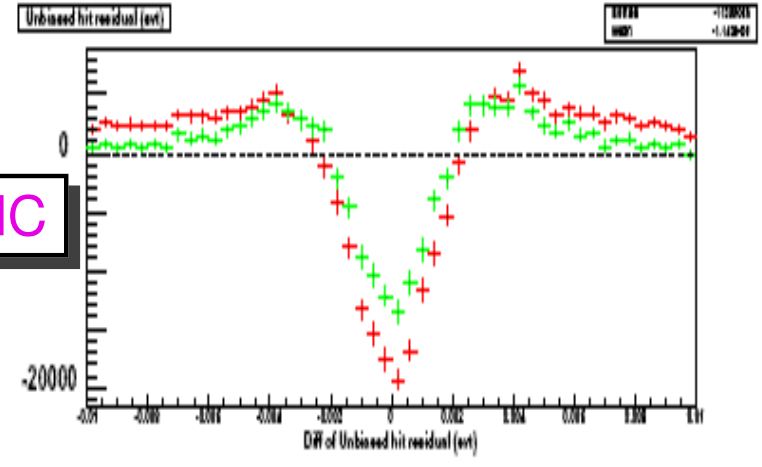
SVT hit residuals

- **GEANT** 4.6: red, **GEANT** 4.7: green

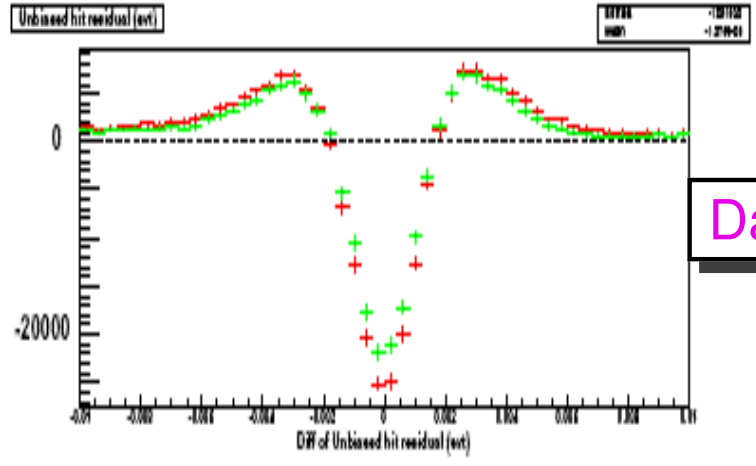
☞ Small improvements







Data-MC



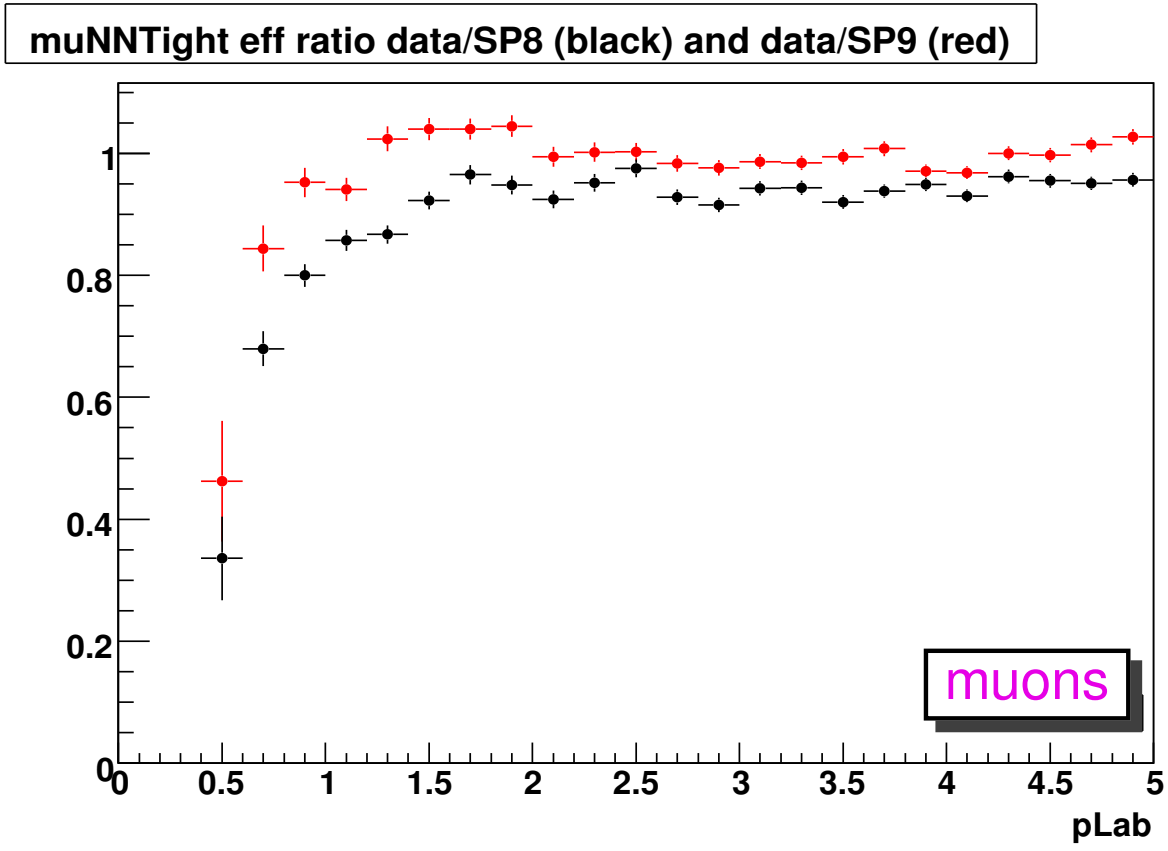
Data-MC

Residuals for Momentum < 1 GeV

Rediduals for Momentum > 1 GeV

μ identification efficiency

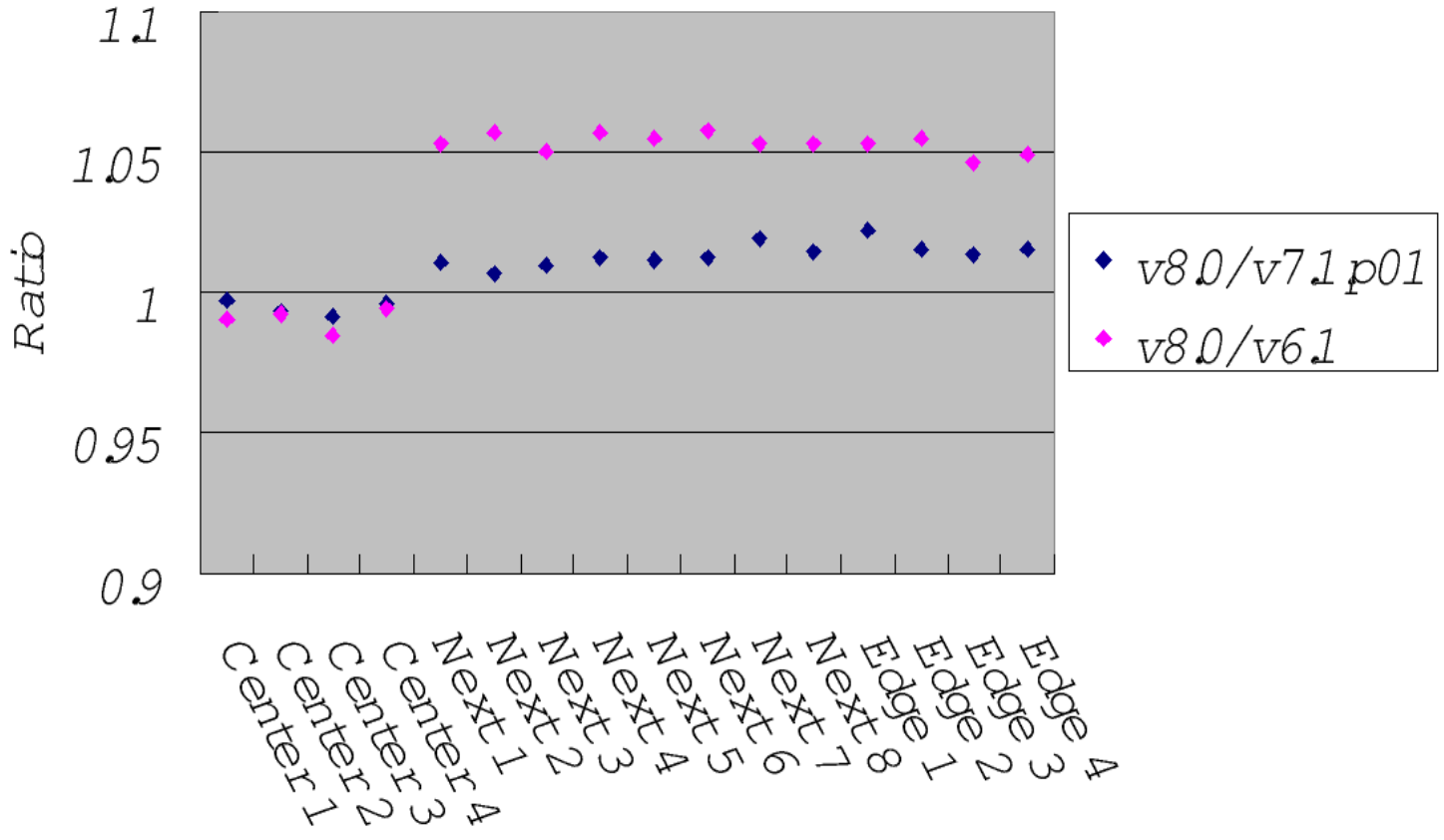
- Data/MC comparison of efficiency for μ selector with **GEANT** 4.6 (black) and **GEANT** 4.7 (red)



☞ Improvements due to updates in multiple scattering

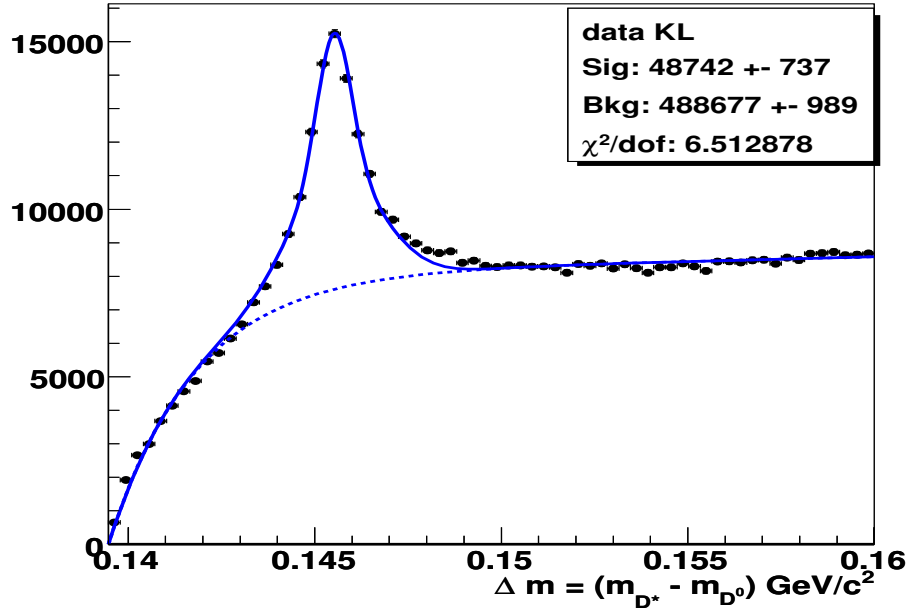
EMC Shower Shapes

- Standalone simulation with BaBar EMC Geometry (T. Koi, SLAC)
- Comparing average energy deposition with 1 GeV photon (normal incidence) of each CsI among **GEANT** 4 versions



Control Samples for Photons & KLongs

- Photon shower shape from $e^+e^- \to \mu^+\mu^-\gamma$ events
- K^0_L shower shape from $D^{\star+} \to D^0(\to K^0_L\pi^+\pi^-)\pi^+_{soft}$ decays



- N(IFR)/N(EMC) yeild of $B \to J/\psi K^0_L$:

GEANT 4 v6 : (0.51 ± 0.01)

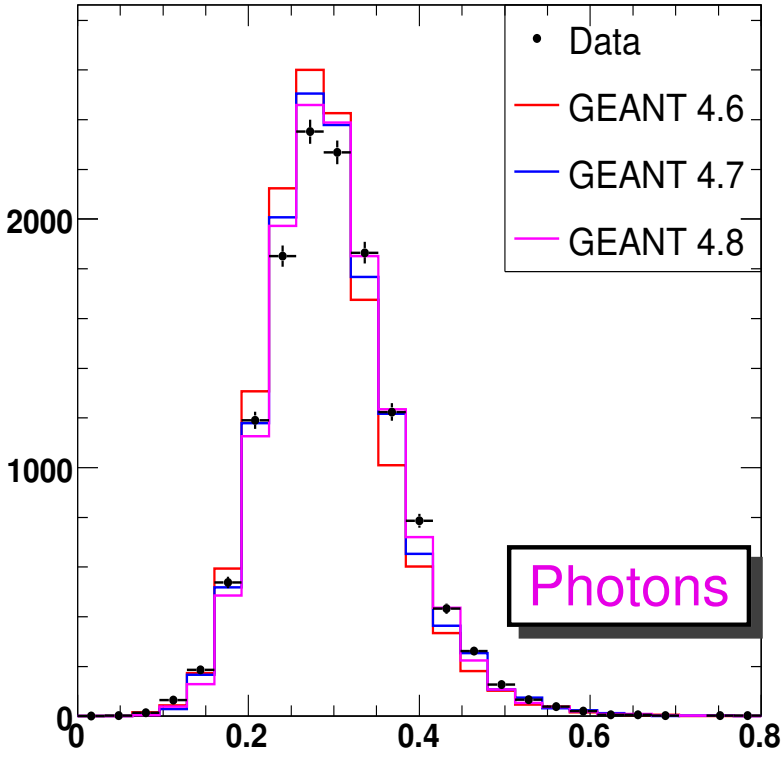
GEANT 4 v7 : (0.64 ± 0.01)

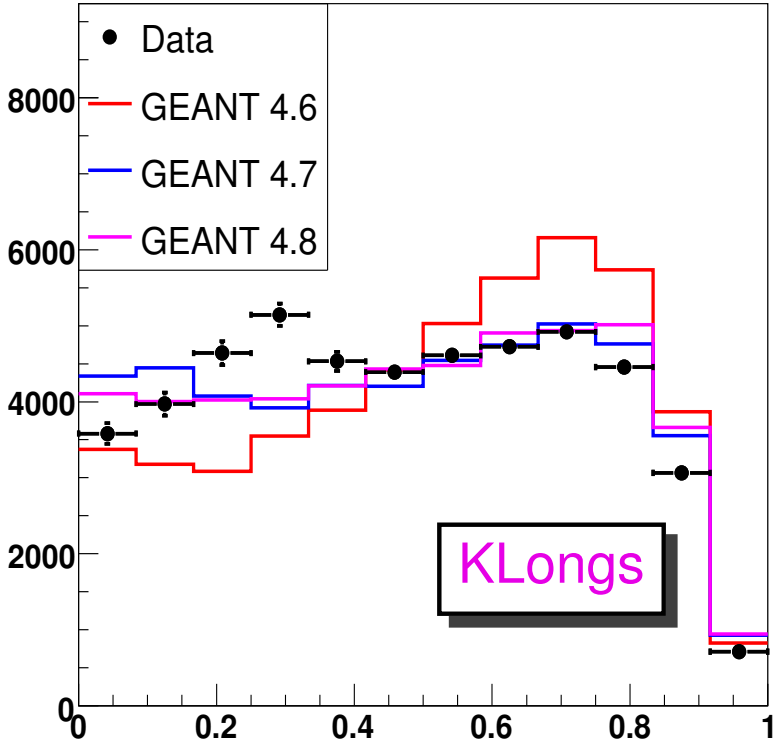
GEANT 4 v8 : (0.64 ± 0.01)

Data : (0.74 ± 0.02)

EMC Shower Shapes (Photons/KLongs)

- Lateral Moment:

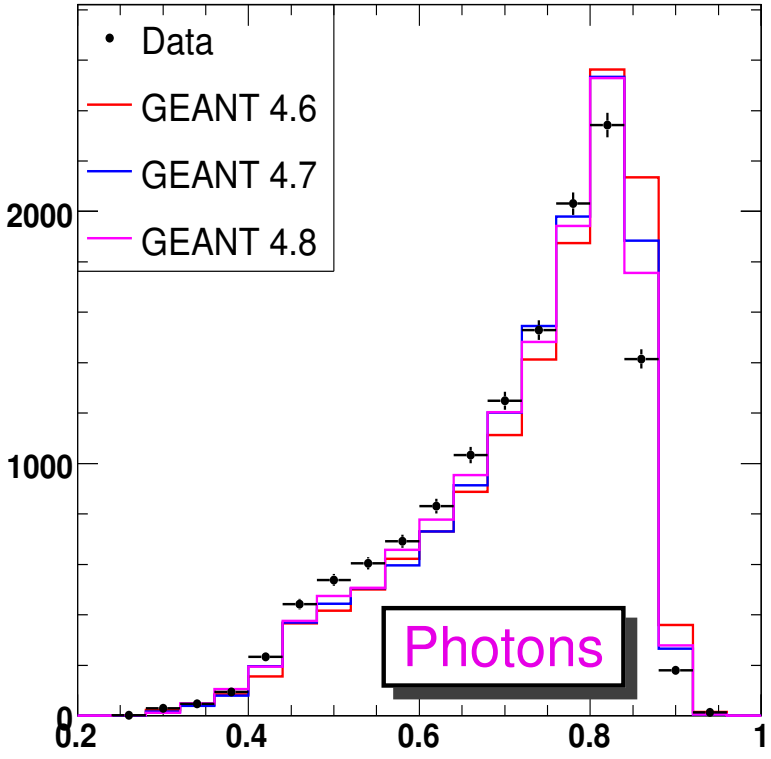


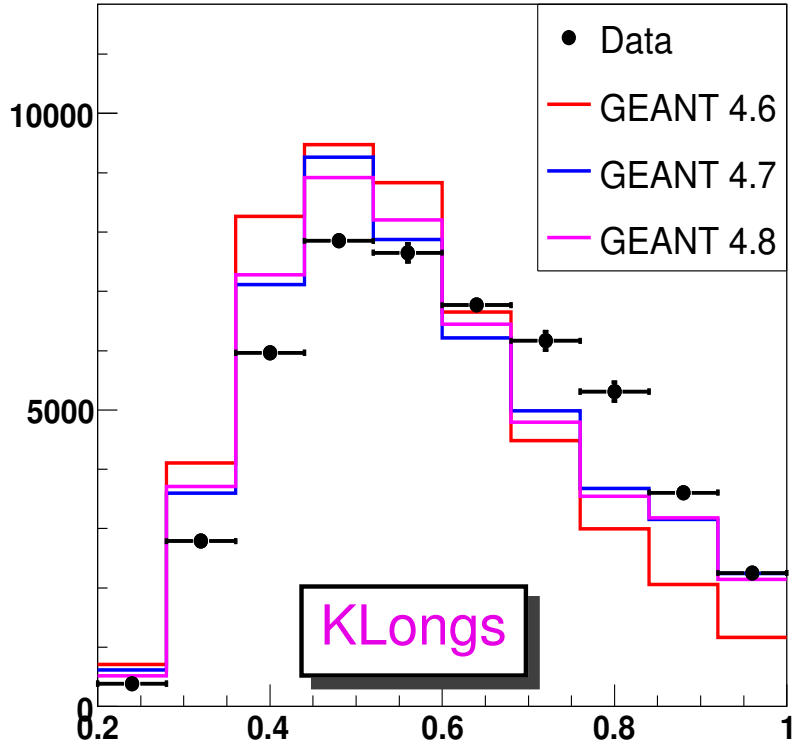


☞ **GEANT** 4 v7 (v8) is in better agreement with Data than **GEANT** 4 v6

EMC Shower Shapes (Photons/KLongs)

- Energy in 1 crystal / Energy in 3x3 matrix:

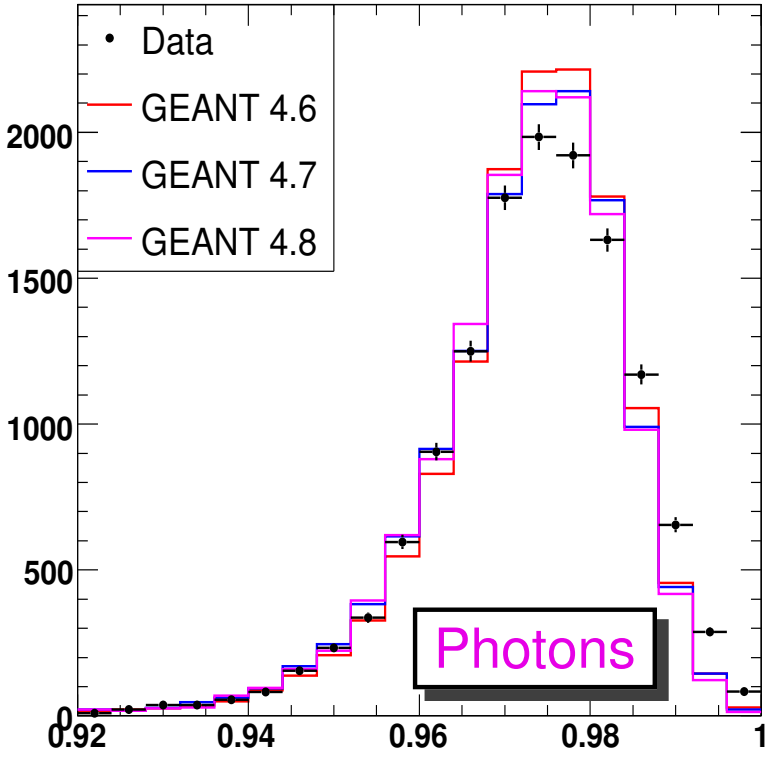


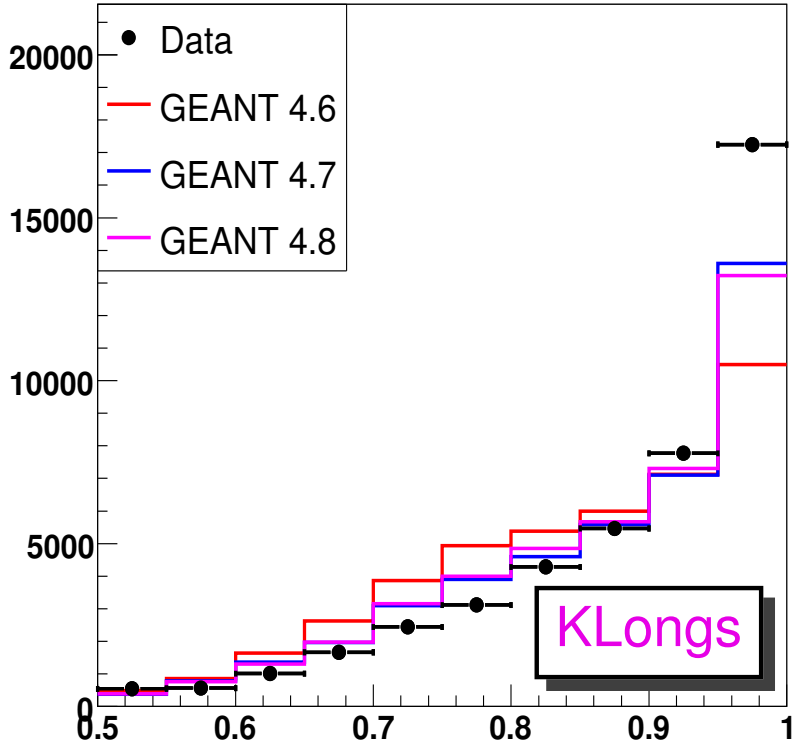


☞ **GEANT** 4 v7 (v8) has some improvement over **GEANT** 4.6

EMC Shower Shapes (Photons/KLongs)

- Energy in 3x3 matrix / Energy in 5x5 matrix:





☞ **GEANT** 4 v7 (v8) has some improvement over **GEANT** 4.6

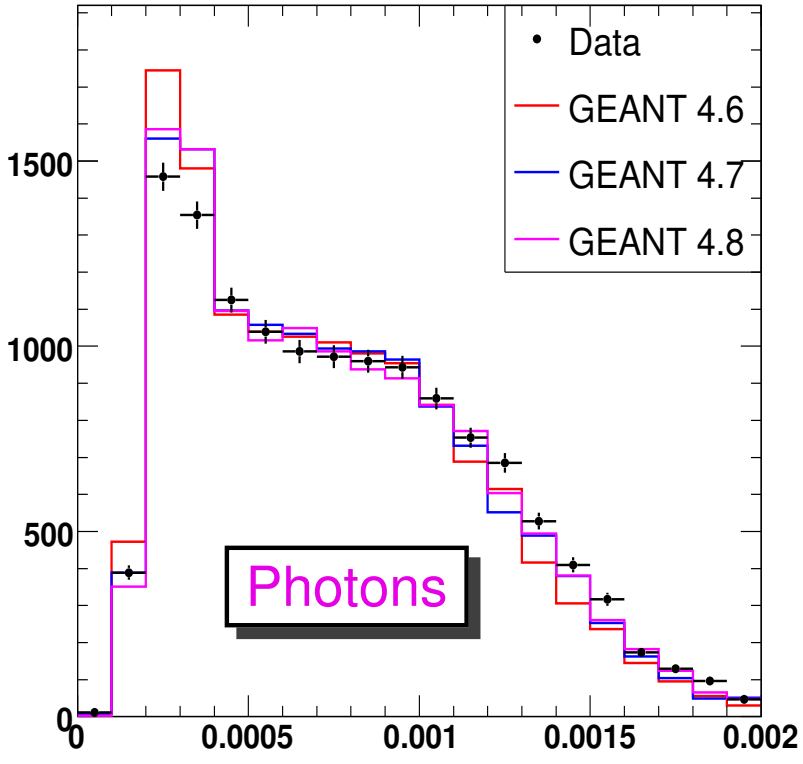
Summary and Outlook

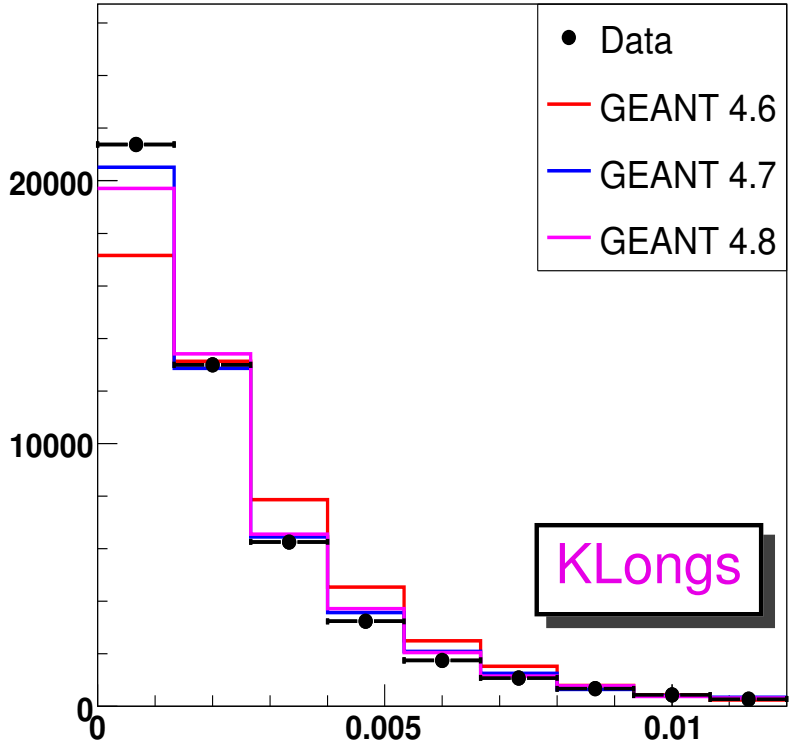
- Validation of **GEANT** 4 has taught us more than expected.
- Data/MC improvements noted in μ identification efficiency.
- Photon shower shape improvement already noted in **GEANT** 4 v7. More improvement in v8 from multiple scattering $\Rightarrow \pi^0$ efficiency.
- Bertini model for Kaons show improvement in **GEANT** 4 v7 from v6. Not much change in v8 as compared to v7.
- CLHEP 1.8 to 1.9 migration was necessary for **GEANT** 4 v8 tests.
- Re-simulation for Runs 1-7 with **GEANT** 4 v8 version hopeful.

Backup Slides

EMC Shower Shapes (Photons/KLongs)

- Second Moment:

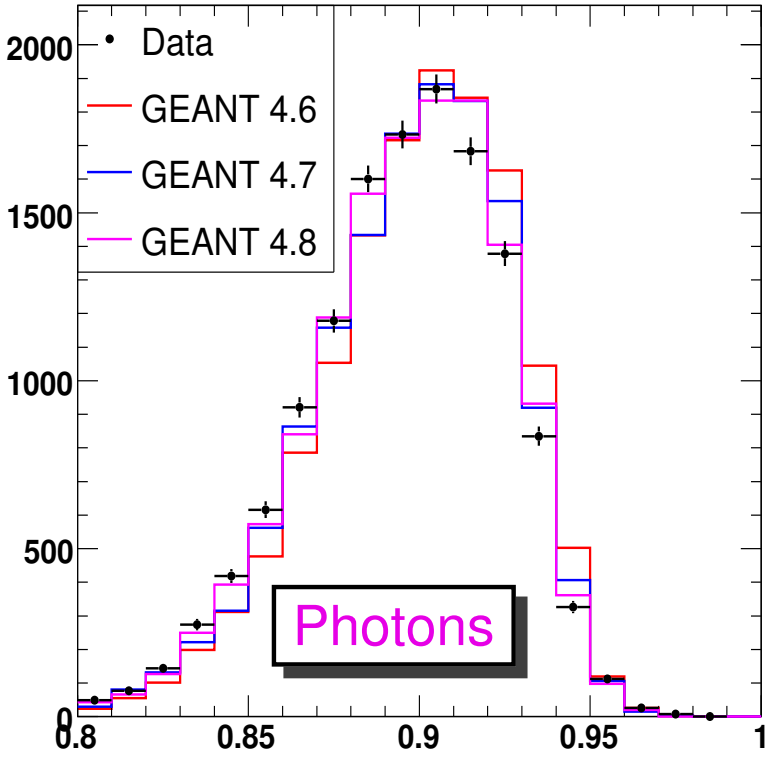


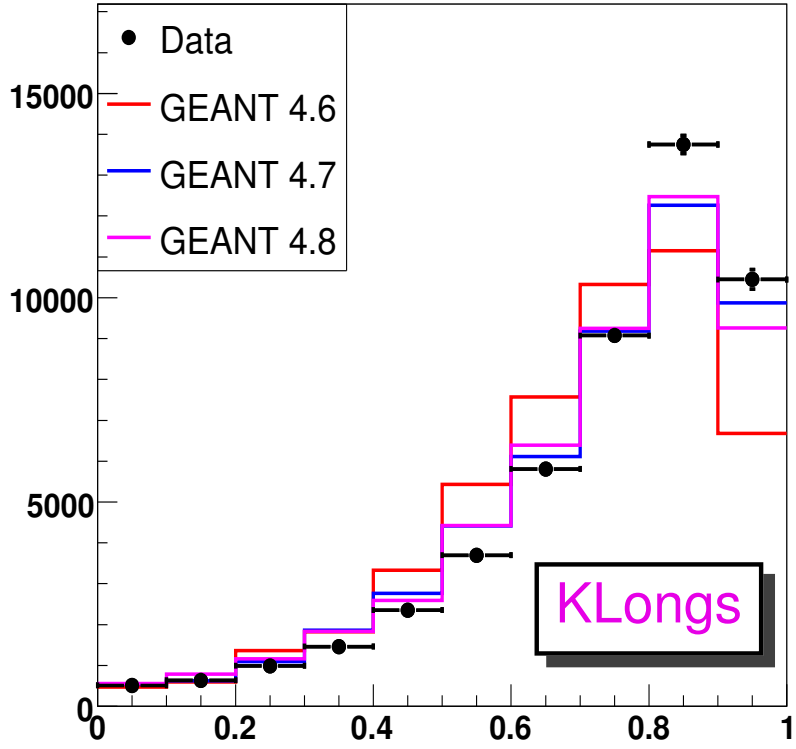


☞ **GEANT** 4 v7 (v8) has some improvement over **GEANT** 4.6

EMC Shower Shapes (Photons/KLongs)

- Zernike Moment 20:

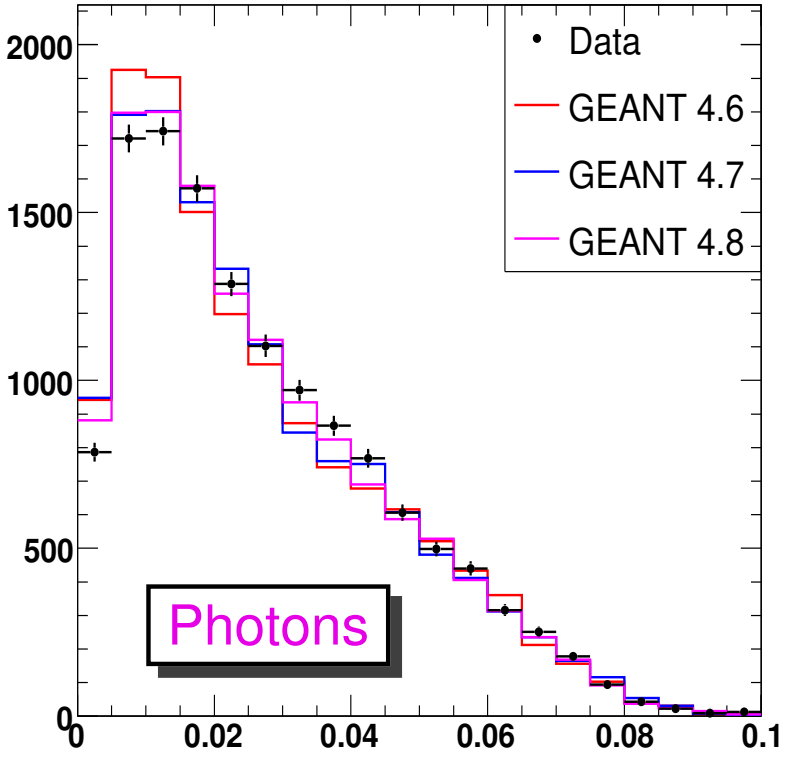


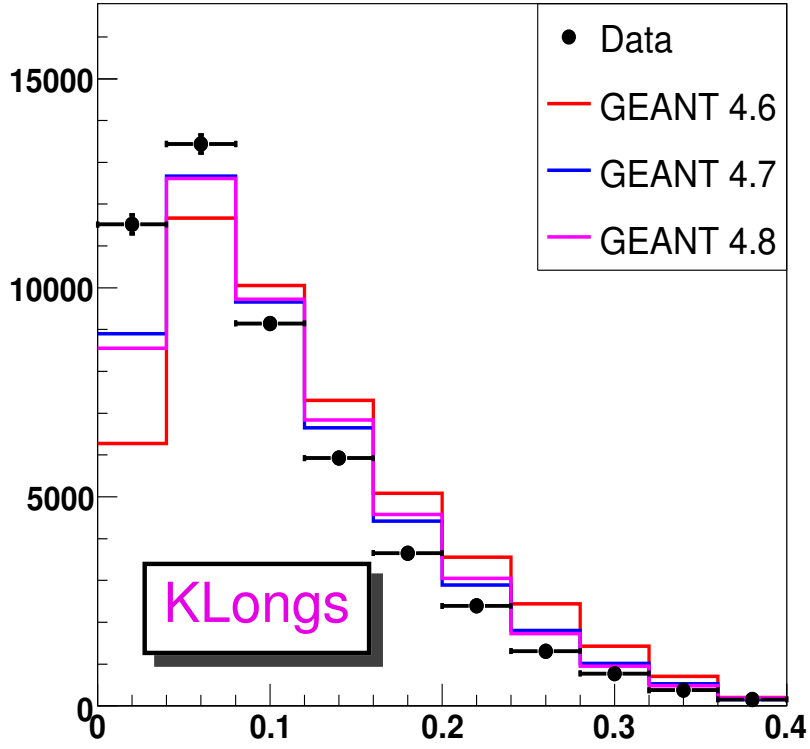


☞ **GEANT** 4 v7 (v8) has some improvement over **GEANT** 4.6

EMC Shower Shapes (Photons/KLongs)

- Zernike Moment 42:





☞ **GEANT** 4 v7 (v8) has some improvement over **GEANT** 4.6