Tracking efficiency at the LHCb experiment

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IC HEP 1st Year PhD

Outline

- LHCb Physics – overview
- The LHCb detector
  - Vertex locator
  - RICH
  - Trigger
- Relative tracking efficiency
  - LHCb Data 2009
  - k-Nearest-Neighbour algorithm
  - Kolmogorov-Smirnov test
- Future work

Figures taken from The LHCb Detector at the LHC, Journal of Instrumentation, Vol. 3, No. 08. (2008), pp. S08005-S08005

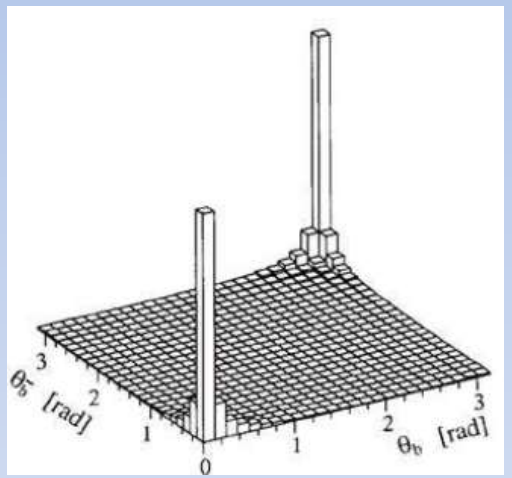
B-physics at the LHCb experiment

- Discover new physics
  - Measure suppressed final states
  - New physics in loop diagrams

- Measure CP violation in B,D mesons
  - SM doesn’t account for asymmetry in nature

Requirements for B Physics

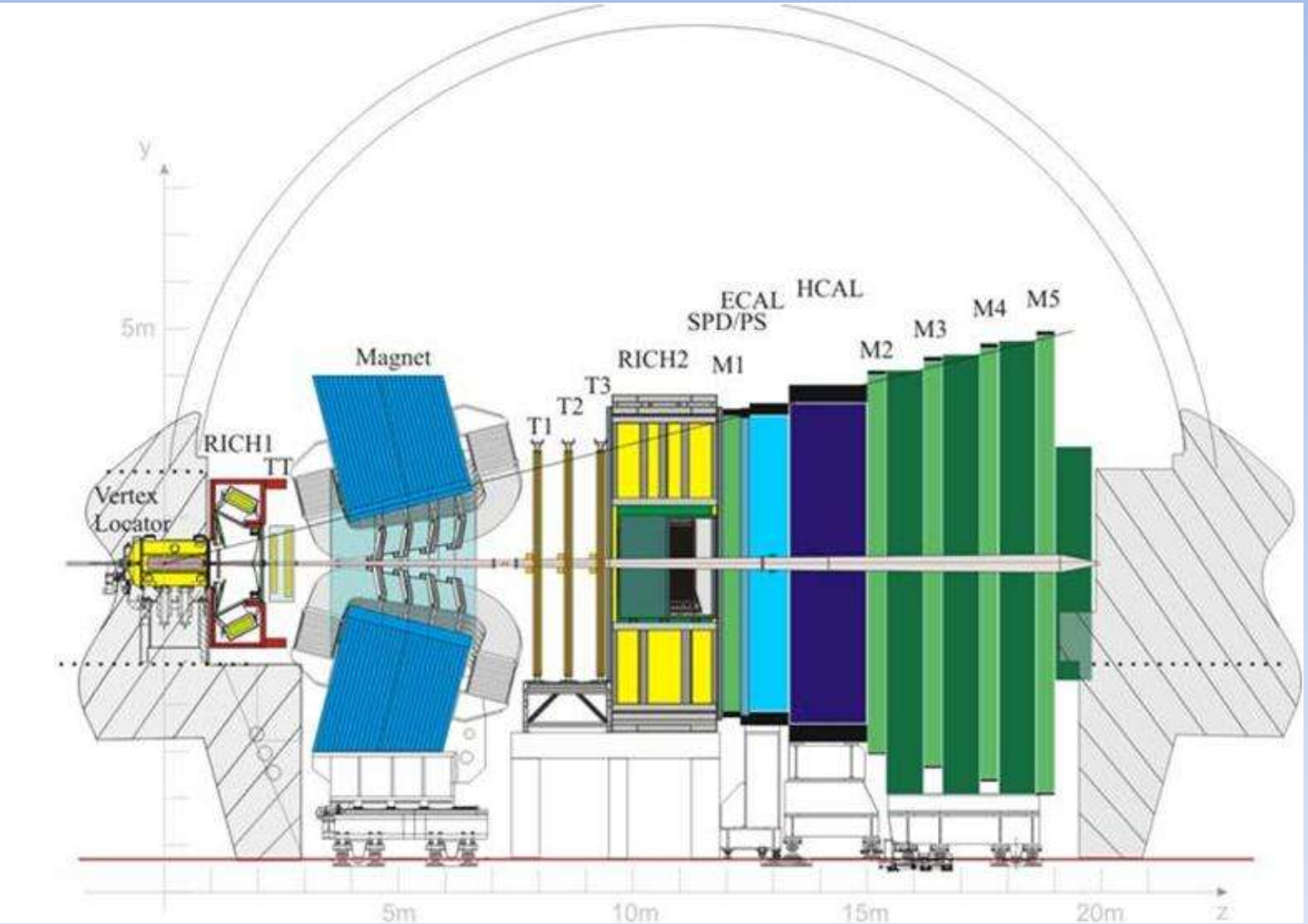
- B mesons produced at small polar angles



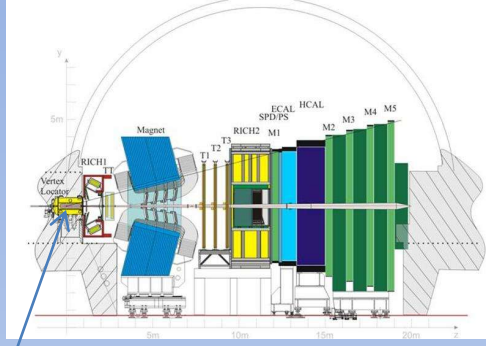
- Forward spectrometer to take advantage of this

- $\sigma_{bb} = 0.5\%\sigma_{Tot}$
  - require good signal/background separation
  - Particle ID / Trigger
- B flight distance
  - Only 7mm
  - Vertex resolution

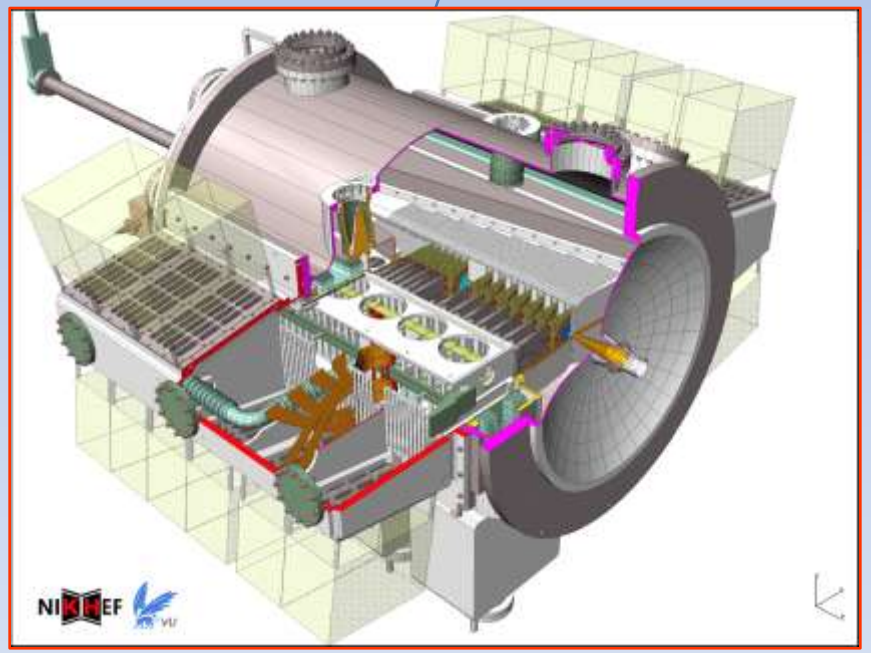
LHCb Detector



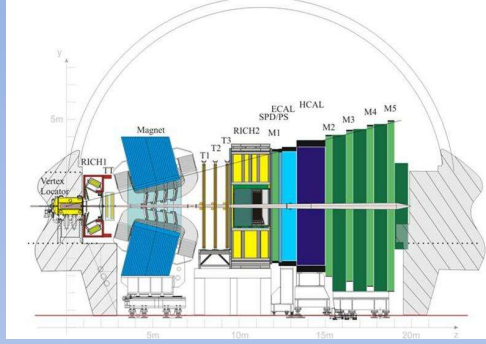
LHCb Detector: VErtex Locator (VELO)



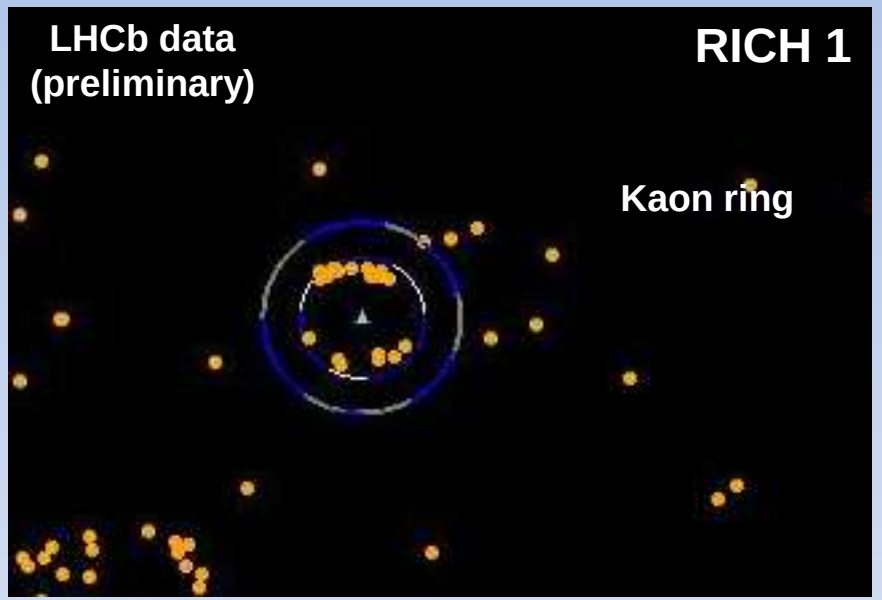
- Precise tracker
- Gives *r* and φ coordinate information
- Moveable
  - Position dependant on beam size
  - Insanely close when closed
- 50 fs lifetime resolution
  - B lifetime ~ 1000 fs



LHCb Detector: RICH (1&2)

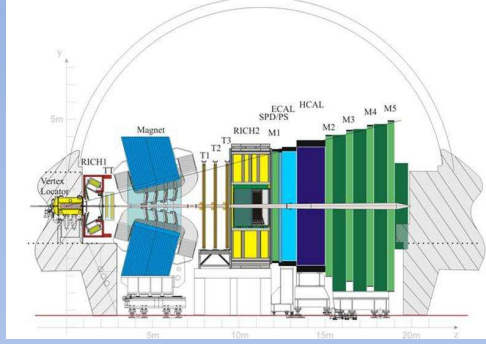


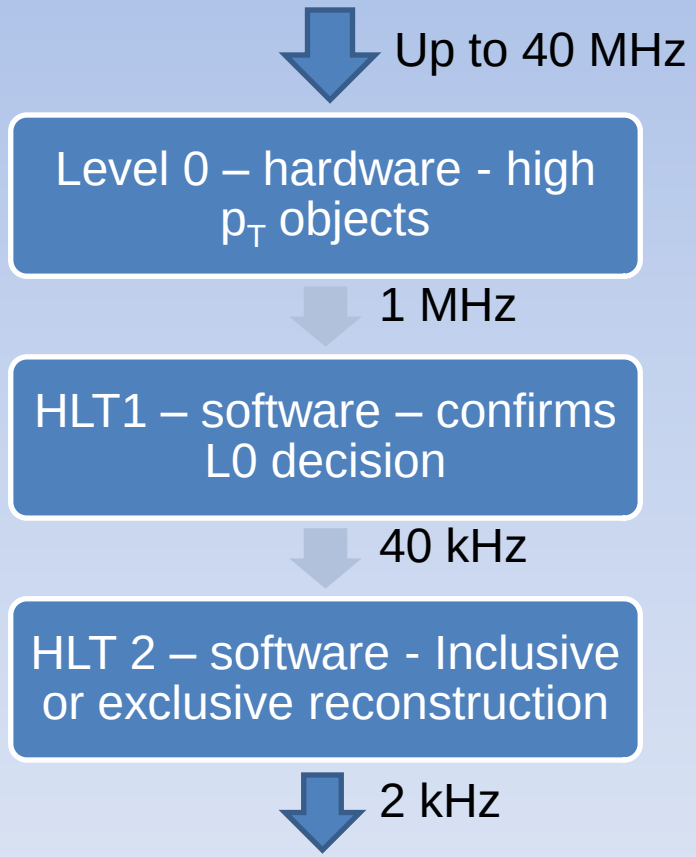
- Particle Identification using Cherenkov radiation
- ID from size of ring



Radiator	Momentum Range
Aerogel	Few GeV
C_4F_{10}	< 60 GeV/c
CF_4	15 GeV/c to beyond 100 GeV/c

LHCb Detector: Trigger

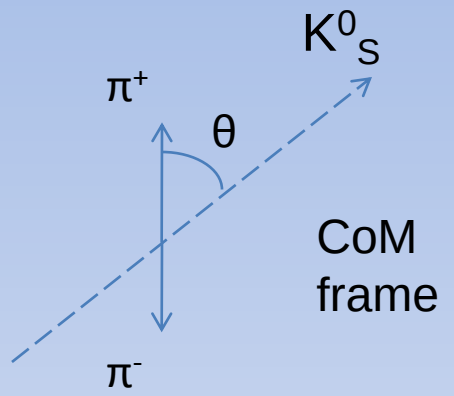


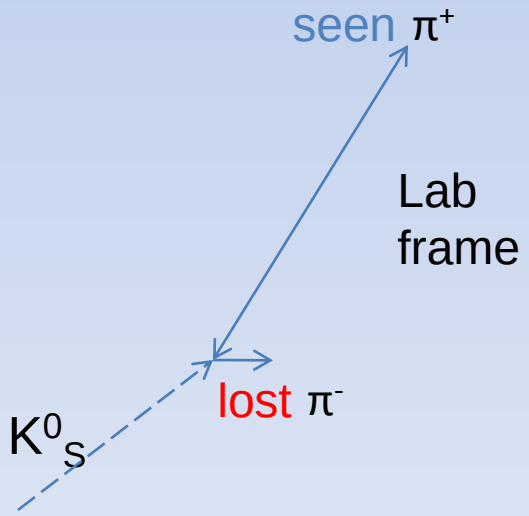


- Extract possible signal candidates from messy hadronic background
- Requires a farm of 2000 CPU cores for the software processing of each event

Pion relative tracking efficiency

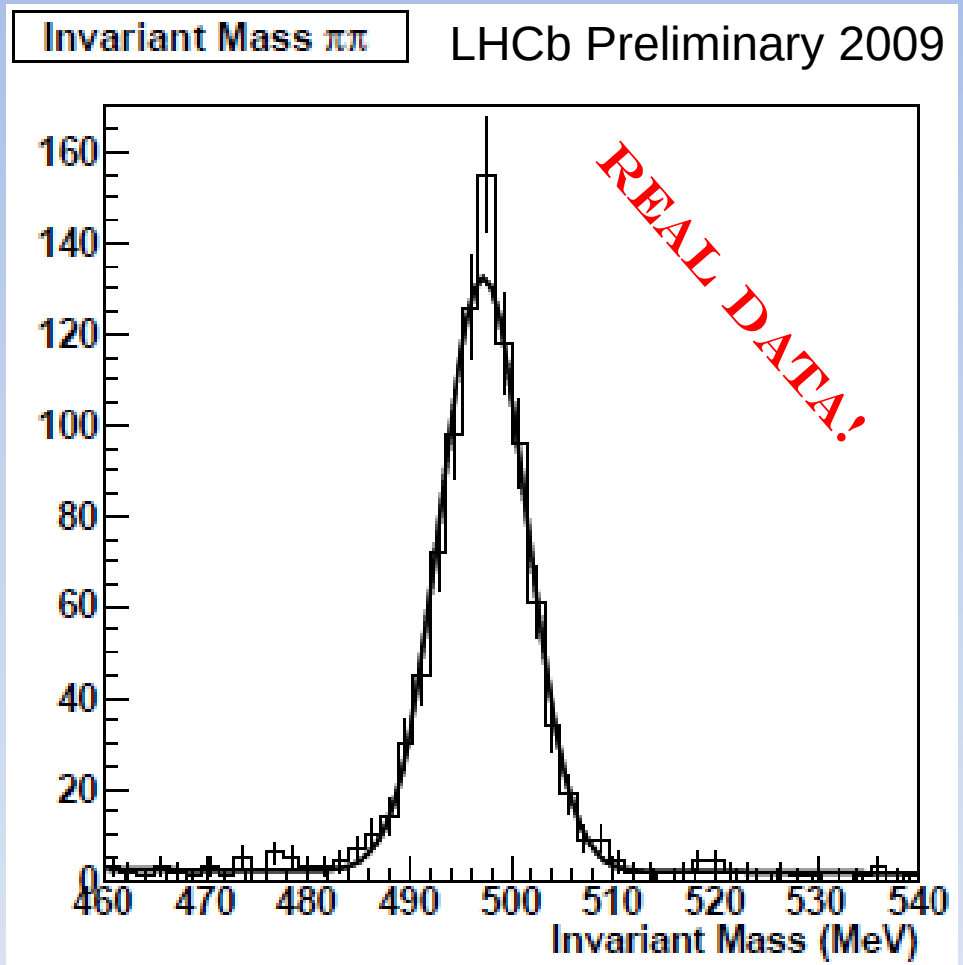
- Aim: To evaluate quality of the LHCb Monte Carlo reconstruction and compare with the data.
- Use $K^0_S \rightarrow \pi\pi$
  - Know physics
  - Don't know production cross section
  - k-nearest-neighbour method...
- Decay angle is sensitive to efficiency





LHCb data from 2009

- $\sqrt{s}$ = 900 GeV
- VELO at 15mm
- Very tight cuts to ensure pure K^0_S sample
- 1000 candidate decays
  - $K^0_S \rightarrow \pi\pi$
- (low statistics!)

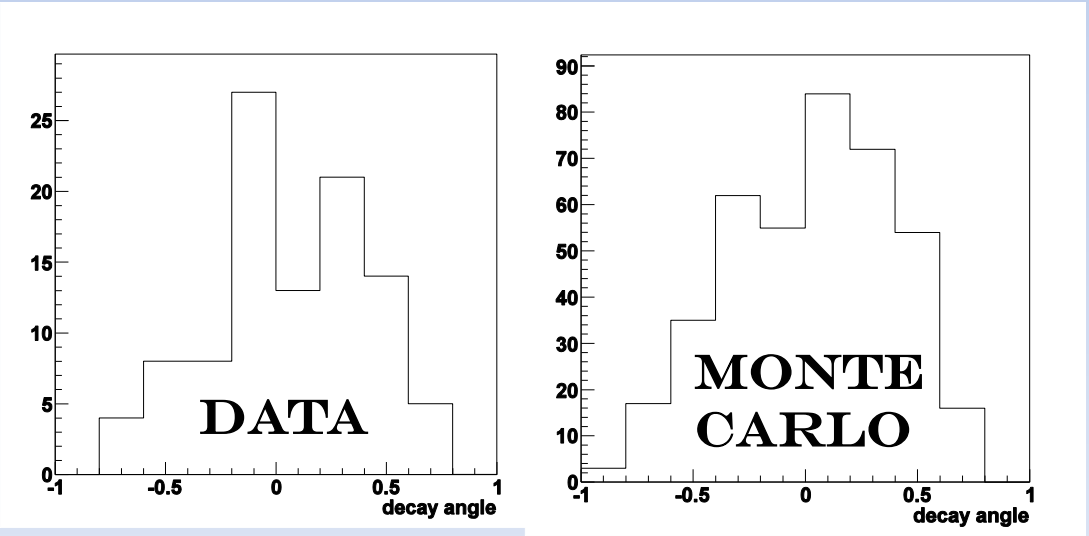


k-Nearest-Neighbour method

- Select decays with similar kinematics
- Choose events near each other in phase space
- For each event, compare data and MC neighbours
- Choose a candidate decay
- Select 100 events from data with lowest distance
- Select MC events within a 4-D hypersphere

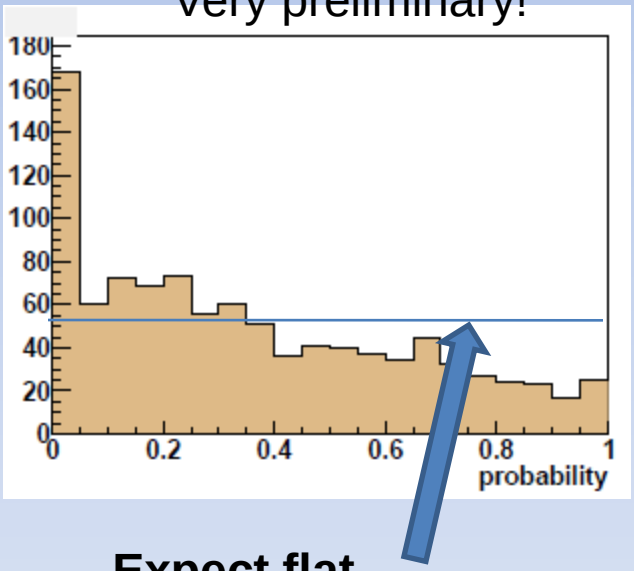
Comparing nearest neighbours

- Compare distribution of decay angle
- Kolmogorov-Smirnov test
- Example: the nearest neighbours of a random event
- Probability = 0.36



Plot the confidence level for all candidate decays

Very preliminary!



Expect flat distribution if the data agrees with Monte Carlo

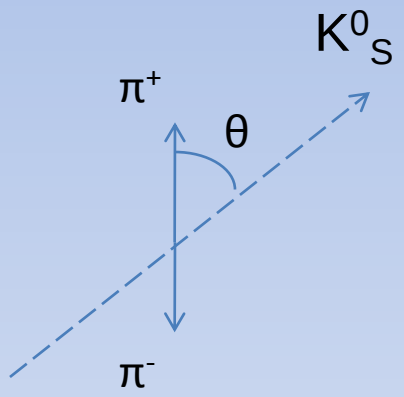
Future work

- Investigate the events with low Kolmogorov-Smirnov probabilities
  - as a function of kinematic variables
- More statistics ⇔ smaller region in phase space
  - Better comparison!
- Evaluate the quality of Monte Carlo simulation
- Expand the algorithm to other candidate decays
  - Such as Δ,D mesons
- Help discover new physics!

Backup

Decay angle

Polar angle of the pions in the rest frame of the K^0_S



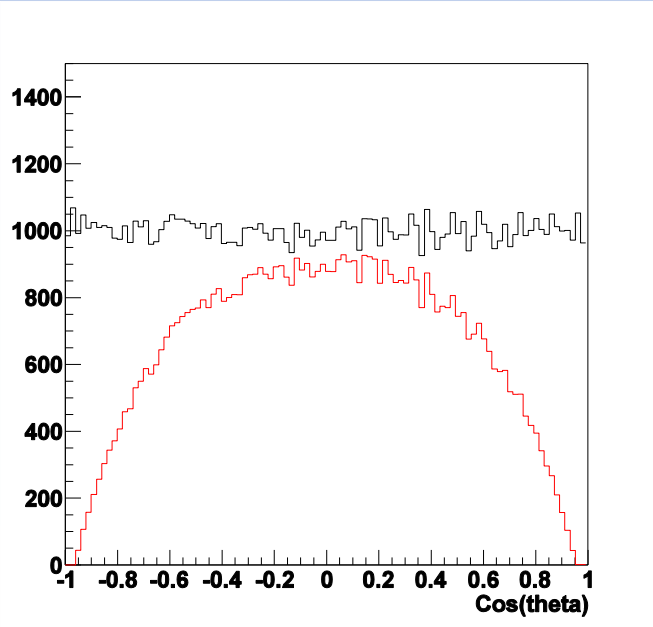
Spin-0 → Isotropic distribution

If relative efficiency varies with pion momenta
→
anisotropic distribution.

Toy Monte Carlo:

$$\epsilon_{rel} = 1 - e^{-0.37448(P_\pi - 2[GeV])}.$$

ε at (2 GeV) = 0
ε at (10 GeV) = 0.95



Black = total pions
Red = seen pions