Time-of-Flight corrections for Hadrons at BESIII

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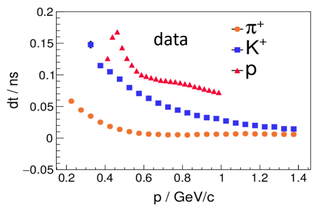
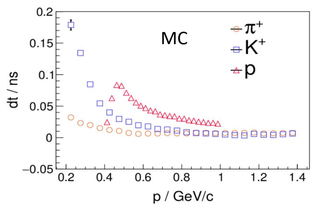
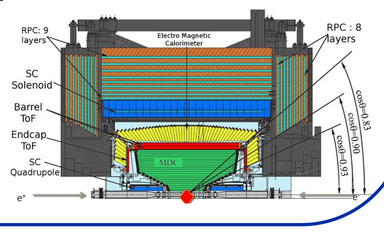
Introduction

- BESIII: study τ-charm physics with high precision and explore new physics
- Accurate and reliable particle identification (PID): enhances the signal-to-noise ratio significantly
- Time-of-flight (TOF) system based on plastic scintillation: pivotal in particle identification, especially for K/π separation
- Systematic deviation of Δt of charged hadrons observed in data and MC:
  - ➢ Universality: observed by all scintillation TOF detector
  - ➢ Systematic deviation → Unreasonable PID efficiency
  - ➢ Inconsistent offset for data and MC → Increase in systematic uncertainties







Correction for Hadrons

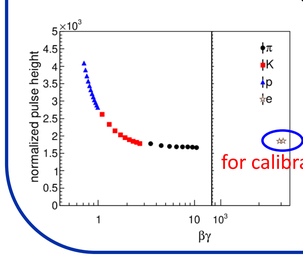
Possible reason for time deviation

$$\Delta t = t_{mea} - t^i_{exp},\ t_{mea} = TDC - t_0 - t_{cor}$$

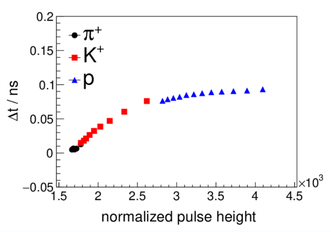
$$t_{cor} = P_0 + \frac{P_1 + P_2 \times z}{\sqrt{Q}} + \frac{P_3}{Q} + P_4 \times z + P_5 \times z^2 + P_6 \times z^3 \qquad t^i_{exp} = \frac{L}{c \cdot \beta_i}$$

time delay · time walk · equivalent speed

When calibration: using Bhabha events



for calibration



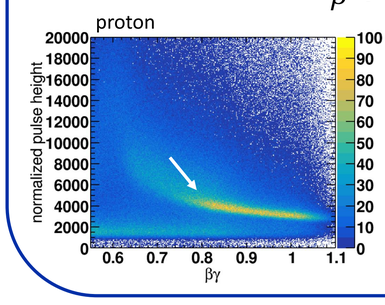
indicating → Time-walk term for electrons cannot describe that of hadrons well

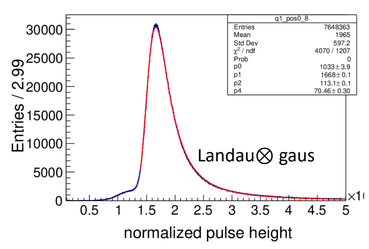
The pulse height (Q) calibration

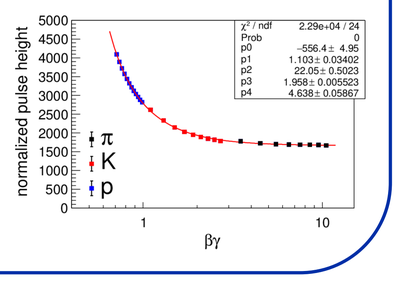
Briks' Law: $\frac{dL}{dx} = L_0 \frac{dE/dx}{1+\kappa_B\, dE/dx}$, κ_B is a small constant, Q_{peak} is proportional to dL/dx

➢ Fit the $Q_{peak}(\beta\gamma)$ with a Bethe-Bloch-like formula(NOT Bethe-Bloch)

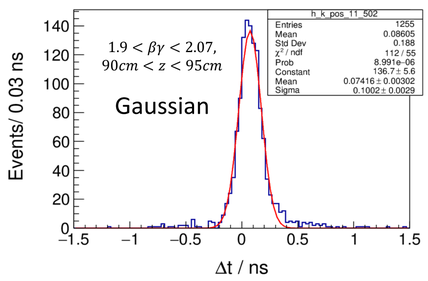
$$Q_{peak} = \frac{P_1}{\beta^{P_4}}\{P_2 - \beta^{P_4} - \log[P_3 + \left(\frac{1}{\beta\gamma}\right)^{P_5}]\}$$







The correction of time deviation and resolution

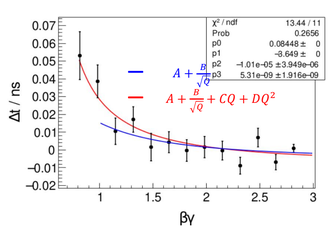


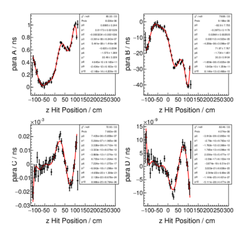
Binning in 2 dimensional(z , p), get the time deviation and time resolution

➢ Time deviation correction term for hadrons is

$$\Delta t = A(z) + \frac{B(z)}{\sqrt{Q}} + C(z)Q + D(z)Q^2$$

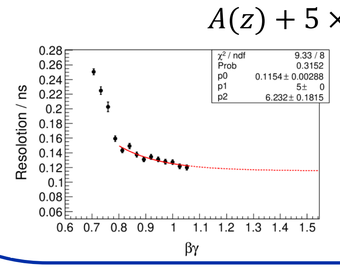
$A + \frac{B}{\sqrt{Q}}$ is the main term

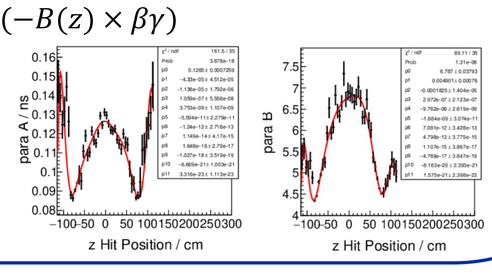




➢ Time resolution correction term for hadrons is

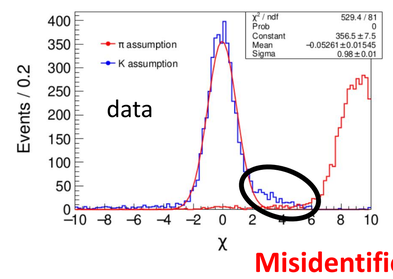
$$A(z) + 5 \times \exp(-B(z) \times \beta\gamma)$$

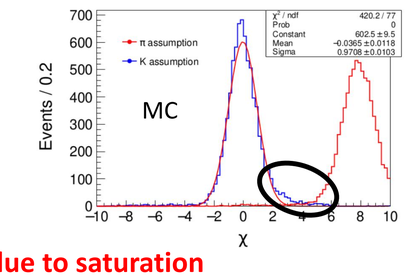




Correction for Hadrons

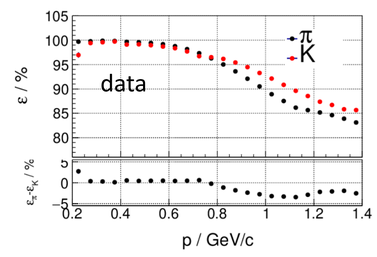
Fine tuning of Time resolution

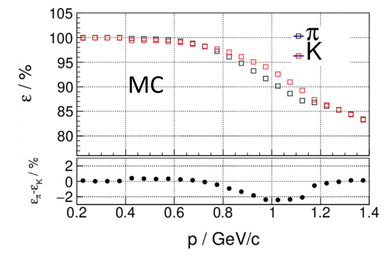




Misidentification due to saturation

Inconsitent PID efficiency for K/π, Misidentification from $\pi \rightarrow K$

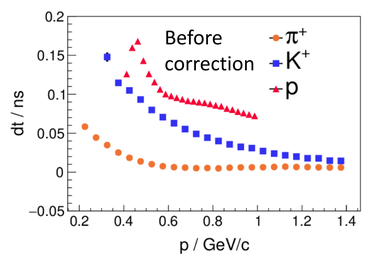


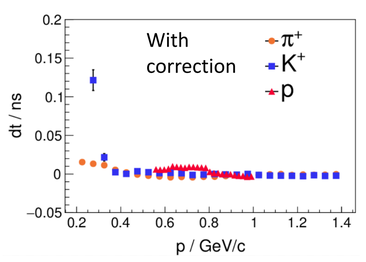


Fine tuning the time resolution according to momenta

Performance

Time deviation





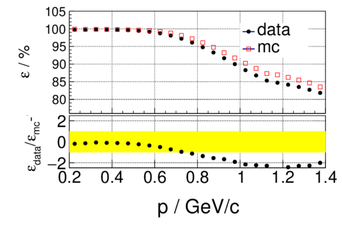
The systematic deviation of Δt has been reduced significantly

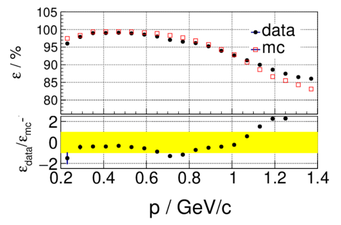
Particle Identification (PID) efficiencies and systematic uncertainties

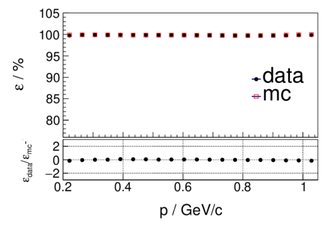
previous: TOF correction based on 09 and 12 J/ψ data

Pion · Kaon · Proton and Antiproton

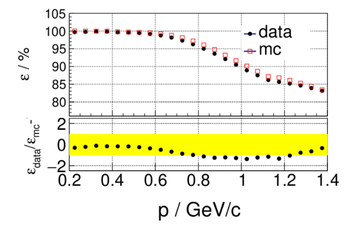
Previous:

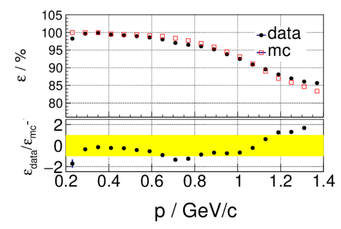


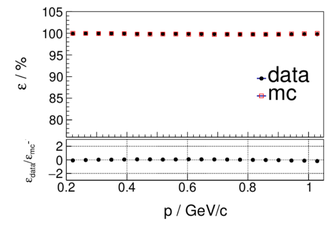




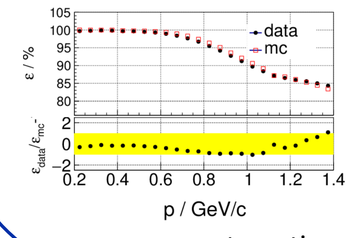
New & w/o tuning :

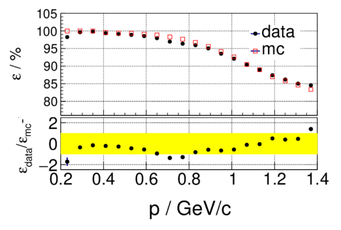


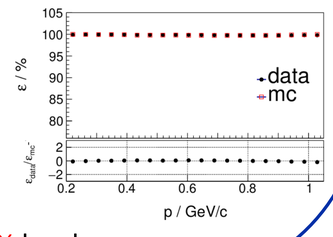




New & w/ tuning :







systematic uncertainty has been reduced to 1% level

Conclusions

- ☐ Correction formulas for time deviation and time resolution were constructed
- ☐ Performance of PID
  - ✓efficiency of PID becomes reasonable
  - ✓systematic uncertainty is reduced to 1%
- ☐ A valuable reference for experiments with scintillation TOF detector

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