The Lifetime of the Λ_b^0 Baryon

1. Introduction
2. Event Reconstruction
3. Lifetime Measurement
4. DØ Run II Measurement Studies

Wendy Taylor
SUNY, Stony Brook
February 24, 2000

Introduction

- Naïve spectator model predicts $\tau(\Lambda_b^0)/\tau(B^0) = 1$

- Experimentally, $\tau(\Lambda_b^0)/\tau(B^0) = 0.77 \pm 0.03$

- Theoretically,

  1. Lifetime difference reflects contributions from non-spectator diagrams (e.g., final state quark interference and W exchange)

  2. Baryon lifetime calculation more complicated and less reliable

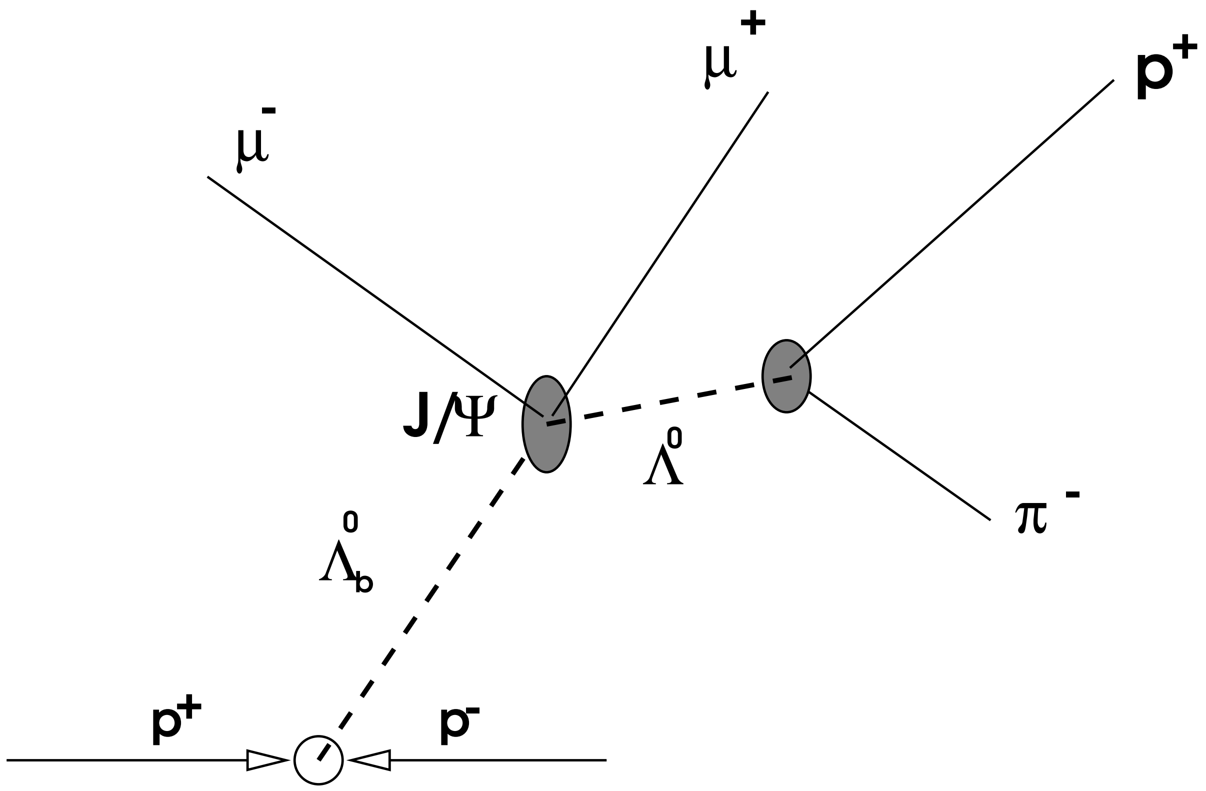
- Experimentally,

  1. $\mathrm{Br}(\Lambda_b^0 \to J/\psi \Lambda^0) = 5 \times 10^{-4}$

  2. Trigger on J/ψ dilepton (electron or muon)

  3. Reconstruct Λ^0 in J/ψ events

$\Lambda_b^0 \to J/\psi \Lambda^0$ Decay



1. Secondary vertex is Λ_b^0 decay (= J/ψ decay vertex)

2. Tertiary vertex is Λ^0 decay

$\boxed{\Lambda^0 \to p^+\pi^- \text{ Reconstruction}}$

1. Proton assigned to track with highest momentum
2. P_T cuts on the daughter candidates
3. P_T cut on Λ^0 candidate
4. Mass cut on Λ^0 candidate
5. Require the daughters to come from a common isolated vertex
6. Require the momentum of the Λ^0 candidate to point back to J/ψ decay vertex
7. CDF/Run I: particle ID (dE/dx) was useful for reducing combinatorial backgrounds

$\boxed{\Lambda_b^0 \text{ Lifetime Measurement}}$

- Proper decay length $X = L_{xy}M/P_T$

- Define upper and lower sideband regions to measure lifetime distribution of heavy flavour backgrounds under the signal

- Fit background decay length distribution to

  1. Gaussian distribution centered at zero
  2. Exponential for positive lifetime background
  3. Exponential for negative lifetime background

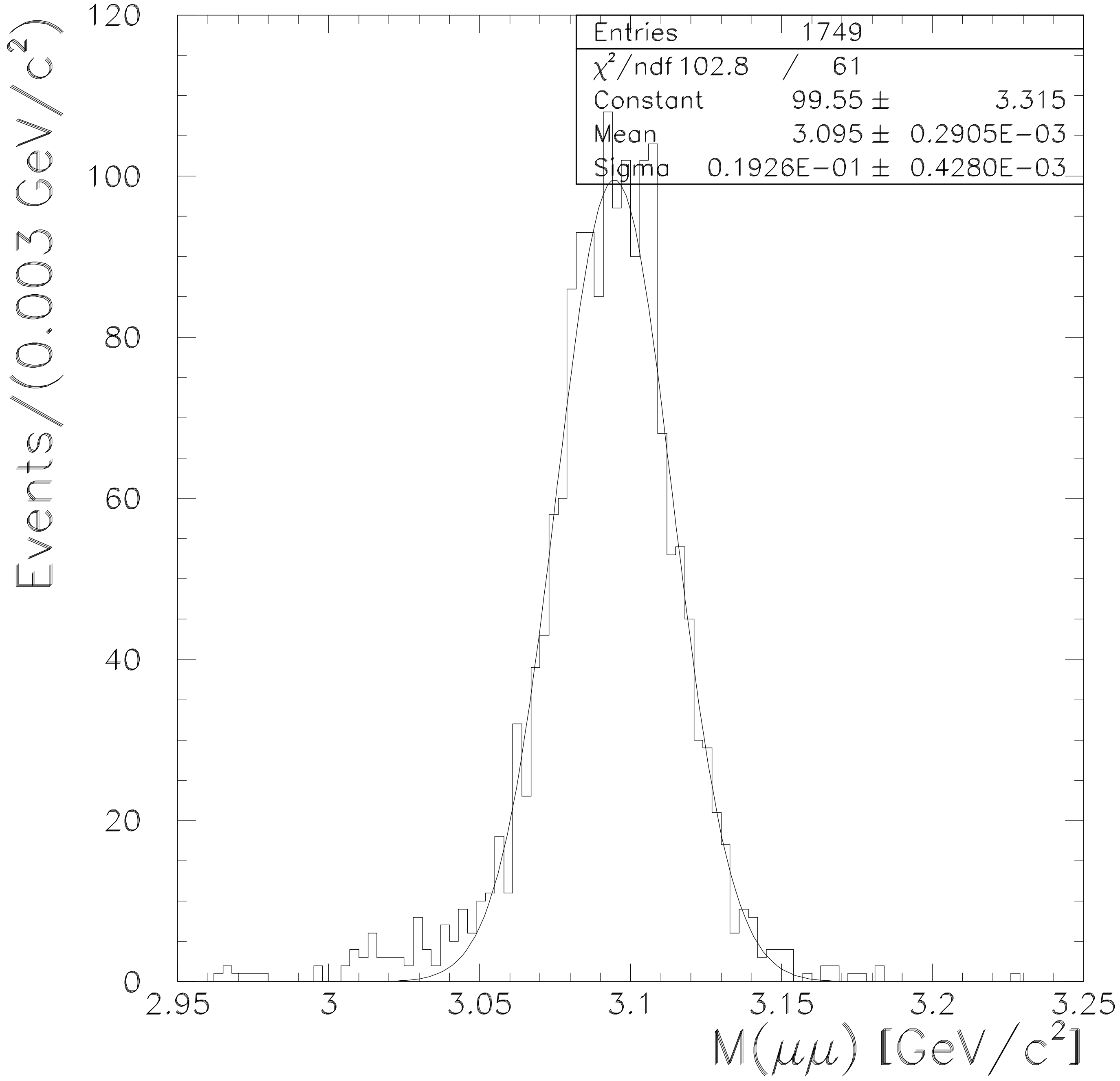
- Fit signal decay length distribution to a positive exponential

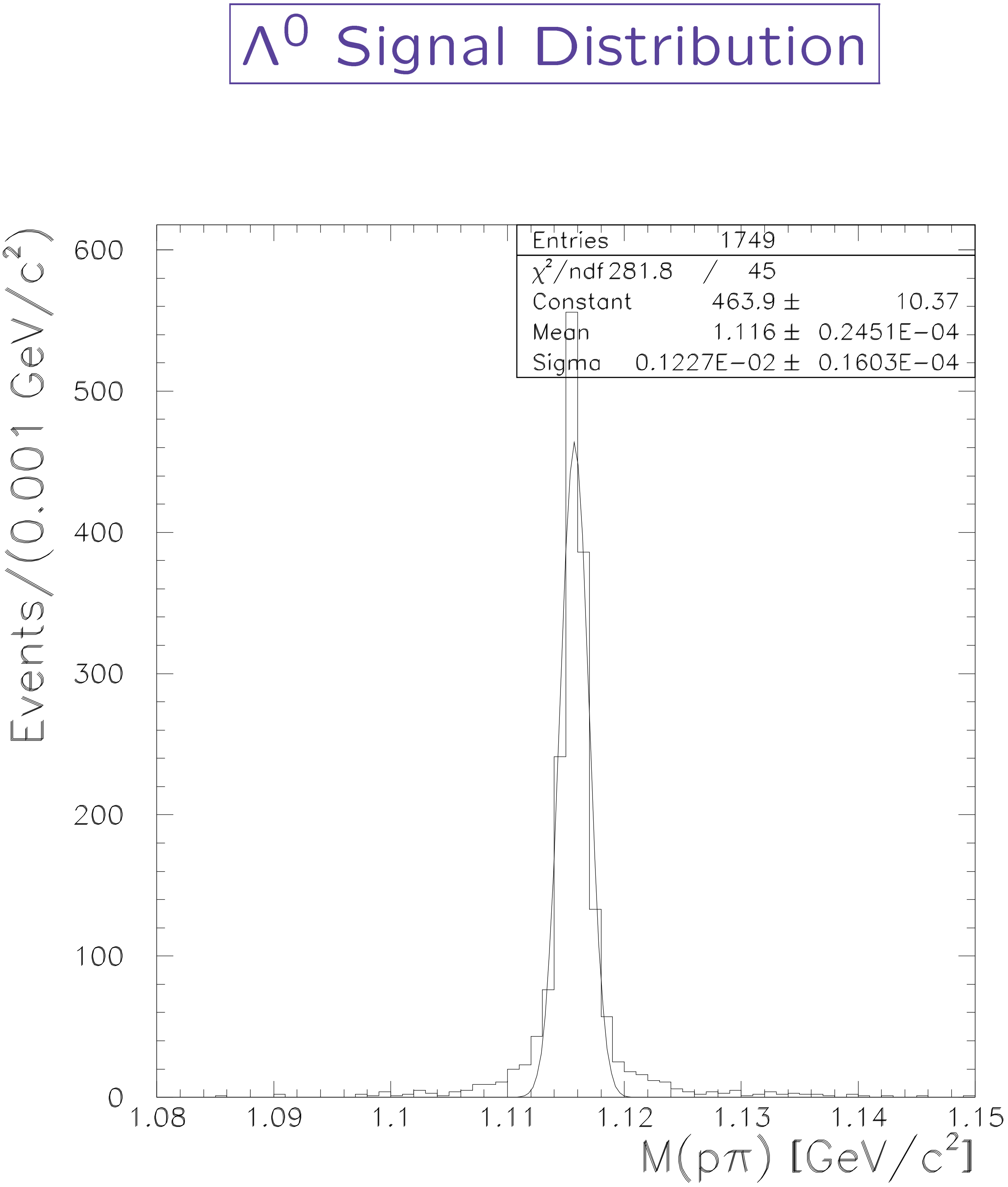
$\boxed{\text{DØ Run II Measurement Studies}}$

Simulate signal decays with MCFast to estimate

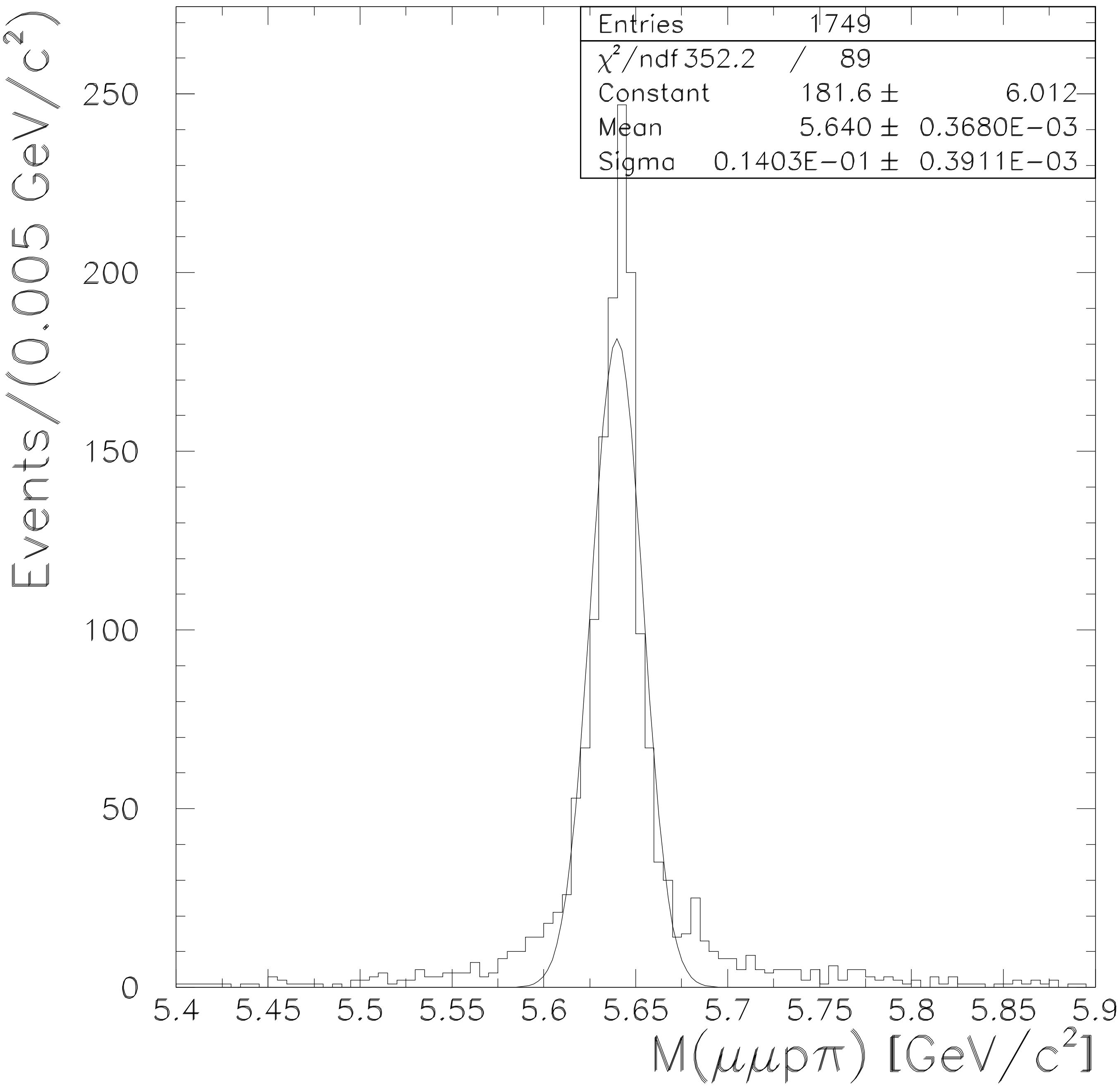
- Efficiency (including trigger)
  1. track quality cuts on muons
  2. $P_T(p) > 0.4$ GeV/c
  3. $P_T(\pi) > 0.15$ GeV/c
- Event yields for 2 fb^{-1}
- Mass resolution
- Lifetime resolution

J/ψ Signal Distribution

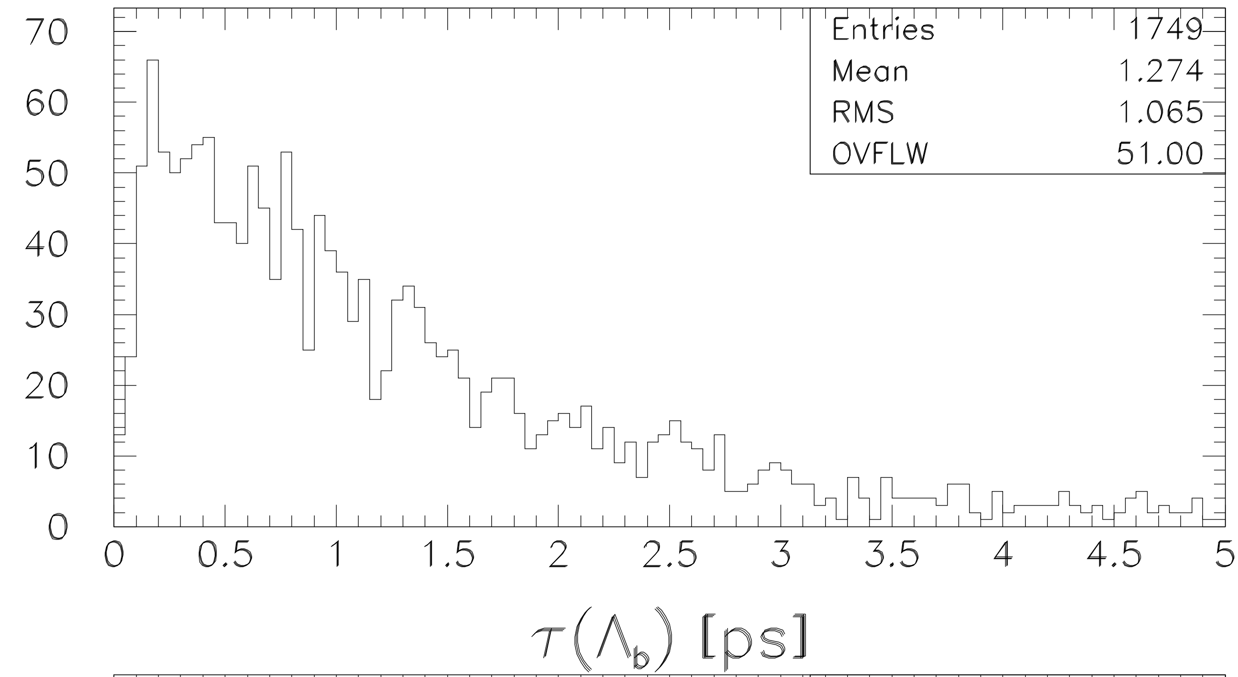


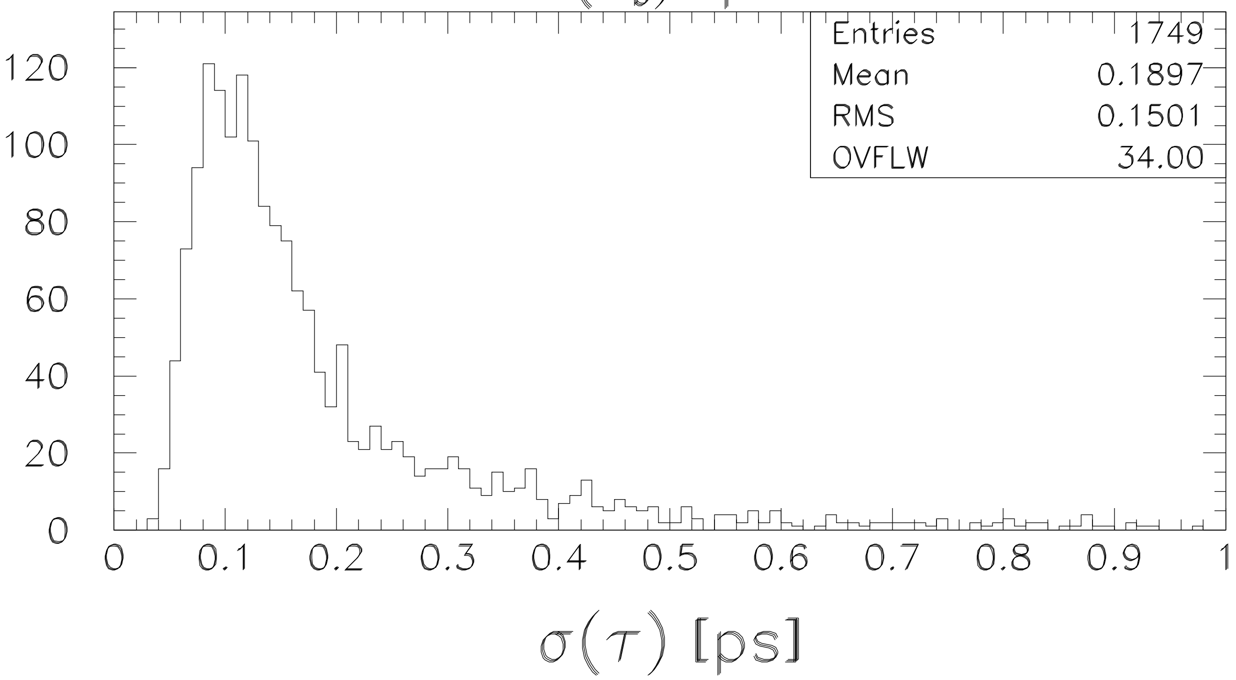

Λ0 Signal Distribution
Entries 1749
χ2/ndf 281.8 / 45
Constant 463.9 ± 10.37
Mean 1.116 ± 0.2451E−04
Sigma 0.1227E−02 ± 0.1603E−04
Events/(0.001 GeV/c2)
M(pπ) [GeV/c2]
0
100
200
300
400
500
600
1.08
1.09
1.1
1.11
1.12
1.13
1.14
1.15

Λ_b^0 Signal Distribution

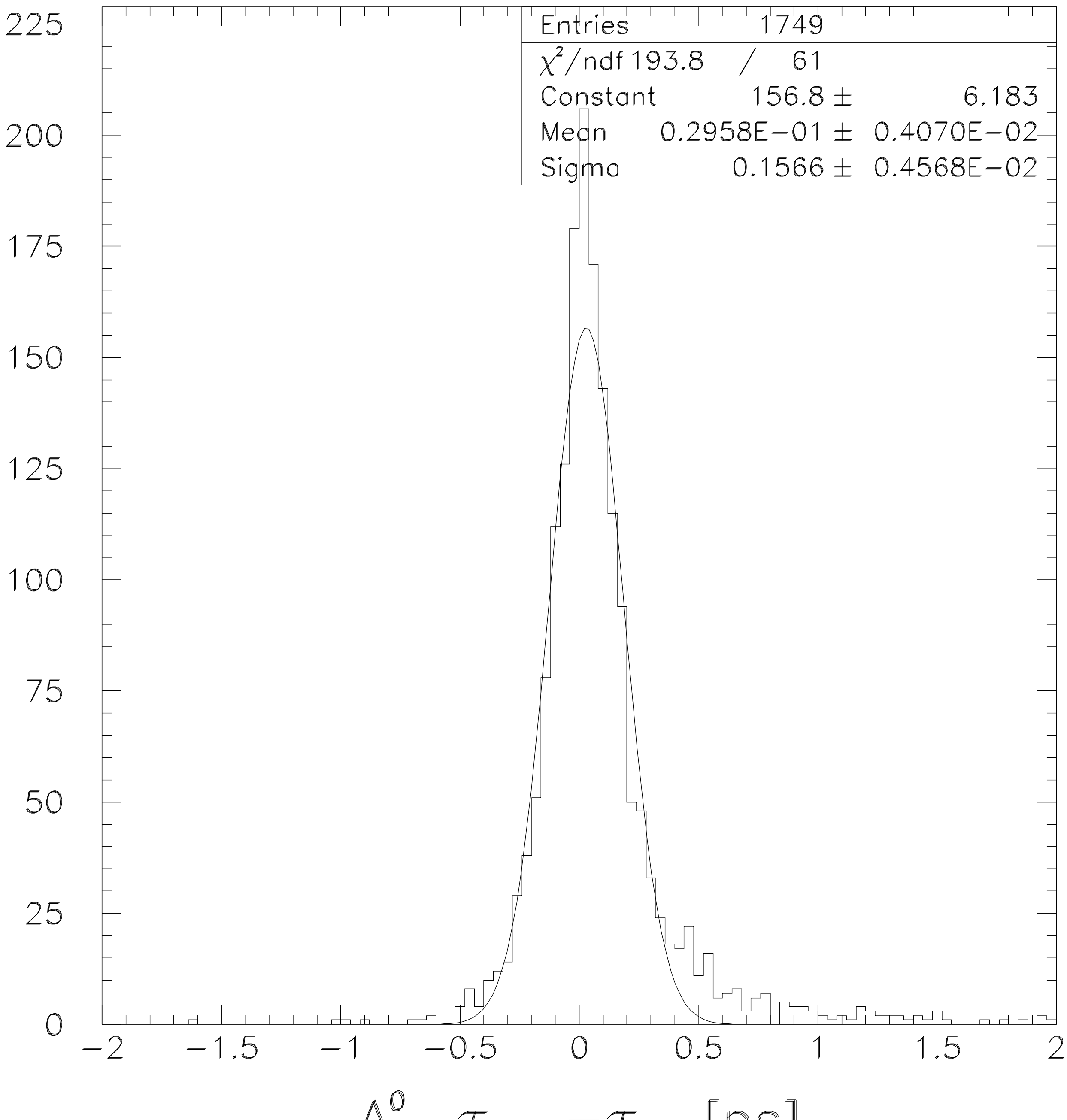


Λ_b^0 Lifetime Distributions





Λ_b^0 Lifetime Comparison



Expectations for 2 fb^{-1} of DØ Run II Data

- Preliminary results

  1. Efficiency (including trigger) = (2.5 - 7.0)%
  2. Event yield = 30 000 - 80 000
  3. Mass resolution = 14 MeV/c^2
  4. Lifetime resolution = 0.16 ps

- Further Studies

  1. Study background sources
  2. Optimize Λ^0 identification criteria for maximum signal to background ratio
  3. Examine possibility of using dE/dx for differentiating protons from kaons/pions