The CDF Run II Detector:

The detector is fully commissioned and working well.

Lifetime Measurements:

Exclusive:
- J/ψ trigger
- clean • fully reconstructed
- lifetime unbiased
- low statistics

Semileptonic:
- lepton+displaced track trigger
- partially reconstructed • need MC to unfold ct
- lifetime biased • good statistics

- Reconstruct decay length by vertexing
- Measure p_T of decay products

• B decay not fully reconstructed
  → extract the J/ψ factor from Monte Carlo:

Extract lifetime from decay length:

\[ c \tau = \frac{L_m(B)}{p_T(B)} \]

Unbinned maximum likelihood fit to \( c \tau(B) \)

Define signal and background regions from mass peak:

- Background is parameterised by delta function and positive exp both convoluted with Gaussian resolution:

  \[ F_{bg} = (1 - f) B(t - \Delta_\tau) + f \exp \left( \frac{\Delta_\tau - t}{\epsilon} \right) \otimes G(t, \sigma_G) \]

  - Free parameters: \( \Delta_\tau \), \( \delta_\tau \), \( \epsilon \), \( \sigma_G \)

  - Signal: exp convoluted with Gaussian resolution, K factor distribution, P(K), and bias function, \( \epsilon \)

  \[ F_{sig} = N \frac{K}{c \tau} \exp \left( \frac{K \tau}{\epsilon} \right) \otimes G(t, \sigma_G) \otimes P(K) \]

- Maximum likelihood function:

  \[ L = \prod_{i=1}^{N} \left( \left( 1 - f_{sig} \right) F_{bg}^{i} + f_{sig} F_{sig}^{i} \right) \]

According to the spectator model all B mesons would have the same lifetime... but that is not the whole story!

The HQE predicts by how much the lifetimes differ.

Aim 1: Measure lifetimes accurately to inform theories

Aim 2: Prove the detector and triggers are working

Aim 3: Measure \( \Delta_\tau/B_\tau \)

Pair it with fully CP even or CP odd state (or use polarisation analysis) and measure \( \Delta_\tau/B_\tau \)

Fit Methodology:

Simultaneous fit of

\[ M(B) \rightarrow \text{signal fraction, define sidebands} \]

\[ c\tau(B) \rightarrow \text{lifetime} \]

Reconstructed channels:

\[ B^0 \rightarrow J/\psi K^0 \]

\[ B^+ \rightarrow J/\psi K^+ \]

\[ \Lambda_c \rightarrow J/\psi \Lambda \]

\[ B_{s}^+ \rightarrow J/\psi \phi \]

Fit to Data

The CDF Run II Detector:

\[ \text{Di-Muon (J/ψ)} (\text{conventional}) \]

\[ p_T(\mu) > 1.5 \text{ GeV/c} \]

\[ J/\psi \text{ modes at low } p_T, p_T(J/\psi) > 0 \text{ GeV/c} \]

\[ \text{Measure } x\text{-section} \]

\[ J/\psi \text{ Yield}=2 \times \text{Run I} \]

1 displaced track

\[ p_T(\text{trk}) > 4 \text{ GeV/c} \]

\[ p_T(\text{trk}) > 2 \text{ GeV/c} \]

Semileptonic modes

Lifetimes, flavour tagging

\[ 120 \mu \text{m} < d_{\text{trk}} < 1 \text{ mm} \]

B Yields 3x Run I

Two displaced tracks

\[ 120 \mu \text{m} < d_{\text{trk}} < 1 \text{ mm} \]

Hadronic modes

Charm Physics, \( B_{s}^0 \) mixing

Individually data samples of about 140 pb\(^{-1}\) accumulated

Exclusive Lifetime Measurements

Semileptonic Lifetime Measurements

pp collisions produce a wide spectrum of B hadrons in a challenging environment

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