



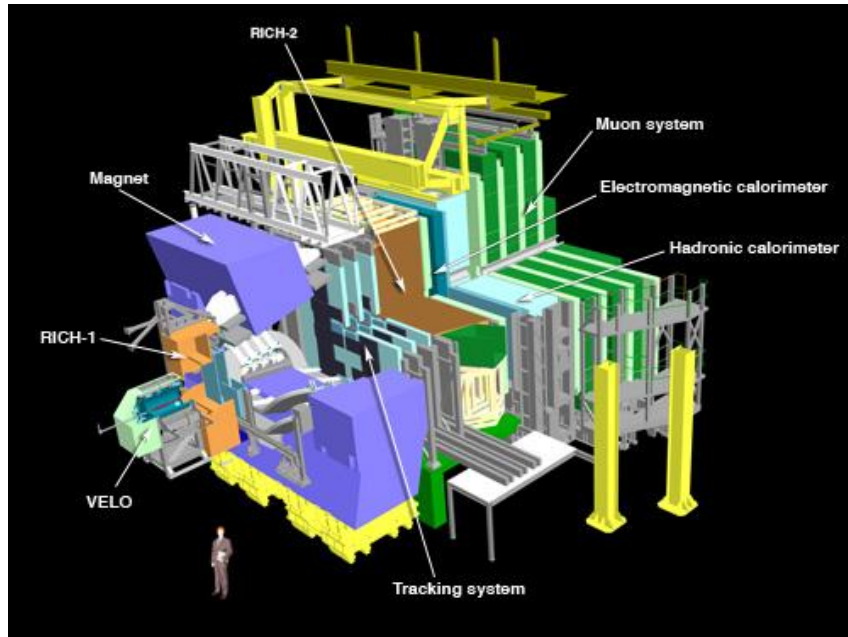
# Searching for Lepton Flavor Violation at LHCb

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# The LHCb Experiment



- 700 scientists from 52 institutions

- Indirect search for new physics
  - Matter/antimatter asymmetry
  - Measurement of rare decays

• **Lepton Flavor Violating Decays**



# Data Analysis



40 MHz

L0 Trigger

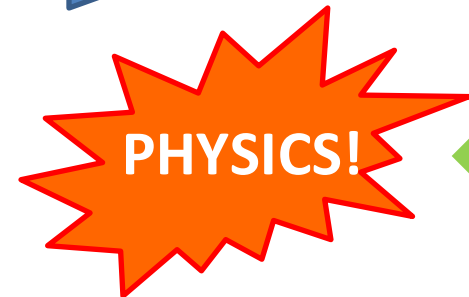
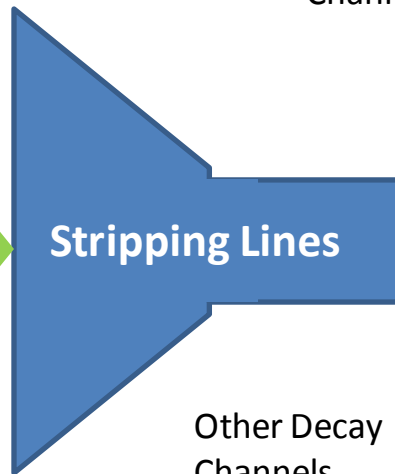
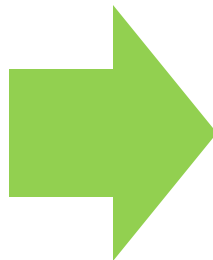
1 MHz

High Level  
Trigger

2 kHz

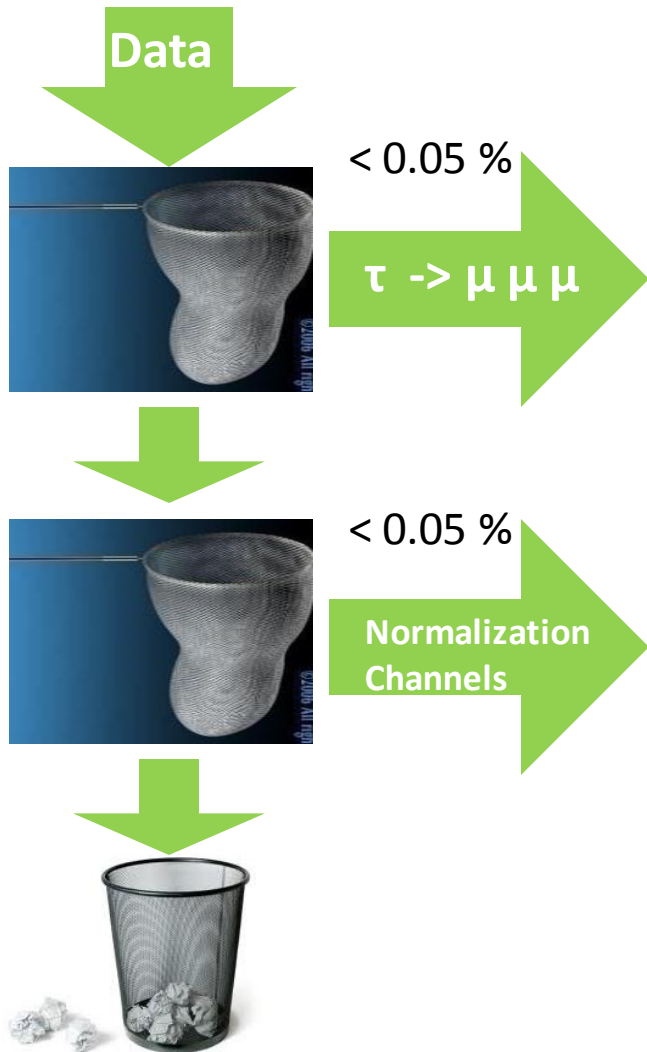
“Online” Analysis

“Offline” Analysis





# Step 1: Stripping



## Signal Monte Carlo Efficiency

Selection	$\epsilon_r (\tau \rightarrow \mu \mu \mu)$	$\epsilon_r (Ds \rightarrow \pi \pi \pi)$	$\epsilon_r (Ds \rightarrow \phi \pi)$
Proposed	<b>0.683</b>	<b>0.501</b>	<b>0.563</b>
Previous	0.623	0.116	0.234

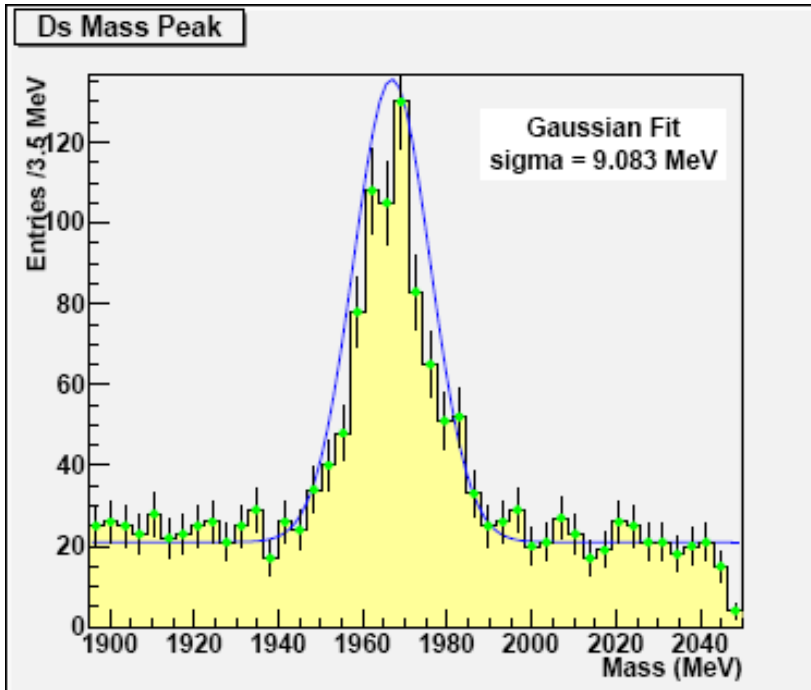
## Background Elimination – Remaining Events

Selection	$\epsilon_r (\tau \rightarrow \mu \mu \mu)$	$\epsilon_r (Ds \rightarrow \pi \pi \pi)$	$\epsilon_r (Ds \rightarrow \phi \pi)$
Proposed	<b>0.04%</b>	<b>0.21%</b> <i>(Prescale)</i>	<b>0.044%</b>

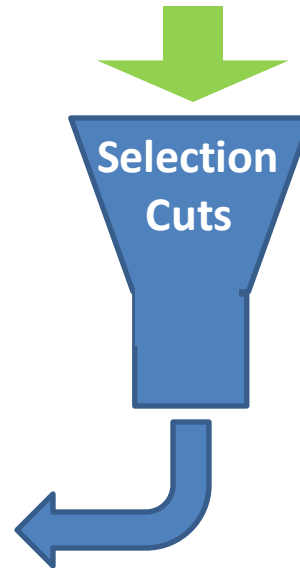




# Step 2: Selection



3 596 228 events



## Future Work

Optimize cuts to:

- 1) *Select signal channel more cleanly*
- 2) *Reject background more efficiently*

<u>Selection Cuts Efficiencies</u>	$\epsilon_r$ ( $\tau \rightarrow \mu\mu$ ) (Monte Carlo)	$\epsilon_r$ ( $Ds \rightarrow \pi\pi$ ) (Monte Carlo)	$\epsilon_r$ ( $Ds \rightarrow \phi\pi$ ) (Monte Carlo)	LHCb Real Data (Background)
Currently:	6.3 %	12.9%	11.5 %	0.00028 %

$$\text{Efficiency} = ( \# \text{ candidates after stripping + selection} ) / ( \# \text{ candidates after stripping} )$$



# Work Hard, Play Hard





## Previous Cuts

### Mother Cuts

- Mass Window =  $\pm 400$  MeV
- $V_{\text{chi2}} < 25$
- $c * \tau > 70 \mu\text{m}$
- **Child with  $P_t > 1$  GeV**

### Daughter Cuts (for all 3)

- $P_t > 300$  MeV
- mu track  $\chi^2 / \text{DoF} < 5$
- $(\text{Mu IPS})^2 > 6$

## Proposed Cuts

### Mother Cuts

- Mass Window =  $\pm 400$  MeV
- $V_{\text{chi2}} < 20$
- $c * \tau > 100 \mu\text{m}$
- $\tau \text{ IPS} < 15$

### Daughter Cuts (for all 3)

- $P_t > 300$  MeV
- mu track  $\chi^2 / \text{DoF} < 5$
- $(\text{Mu IPS})^2 > 9$





## Previous Cuts

### Mother Cuts

- Mass Window =  $\pm 250$  MeV  $\longrightarrow$
- $V_{chi2} < 25$   $\longrightarrow$
- $c * \tau > 200 \mu\text{m}$
- $D_s \text{ IPS} < 3$   $\longrightarrow$
- $P_t > 2 \text{ GeV}$   $\times$

### Daughter Cuts (for all 3)

- $P_t > 300 \text{ MeV}$
- $\mu \text{ track } \chi^2 / \text{DoF} < 5$
- $(\text{Mu IPS})^2 > 12$   $\longrightarrow$

## Proposed Cuts

### Mother Cuts

- Mass Window =  $\pm 80$  MeV
- $V_{chi2} < 20$
- $c * \tau > 200 \mu\text{m}$
- $D_s \text{ IPS} < 15$
- $D_s \rightarrow 3\pi$  required to be TIS

### Daughter Cuts (for all 3)

- $P_t > 300 \text{ MeV}$
- $\mu \text{ track } \chi^2 / \text{DoF} < 5$
- $(\text{Mu IPS})^2 > 9$



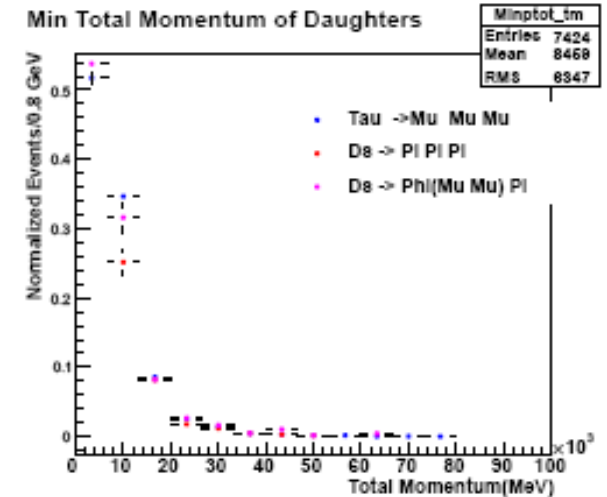
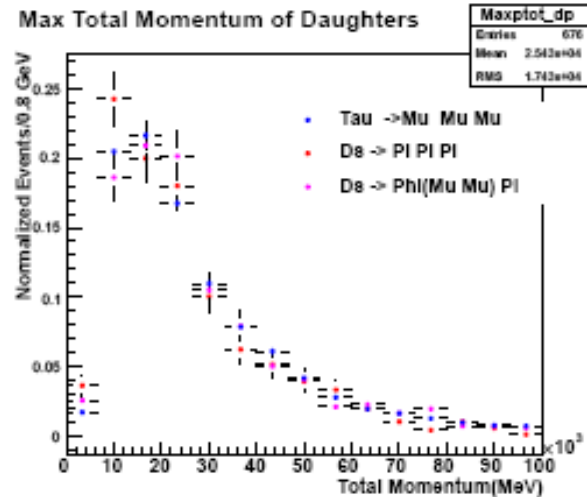
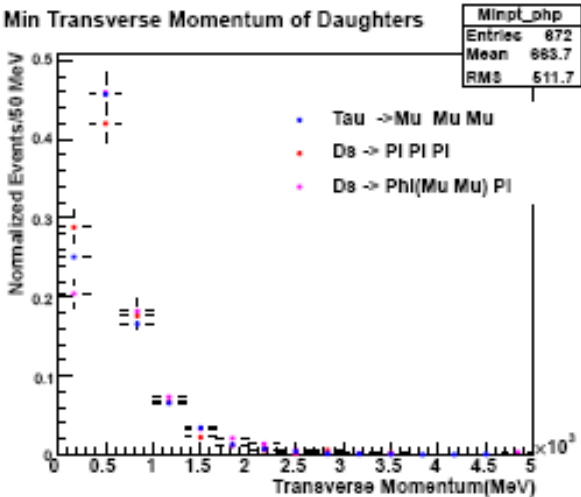
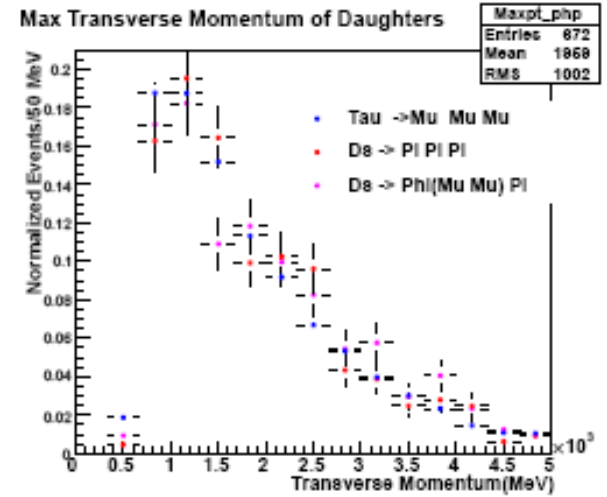
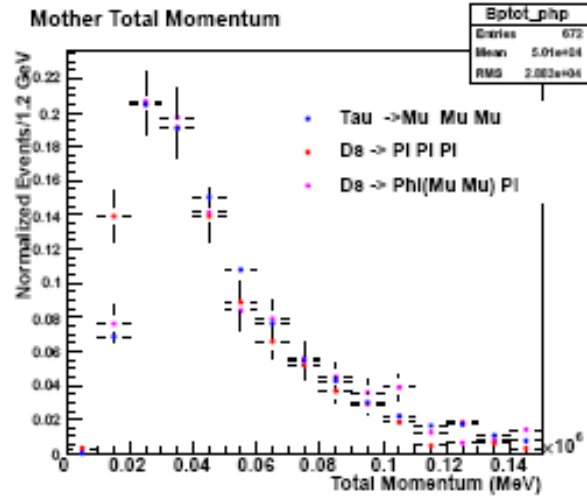
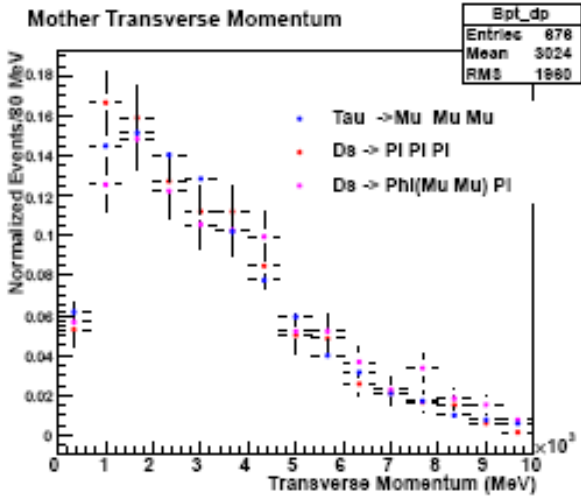


## Current Working Version of Selection Cuts

- 1) Mother Impact Parameter Significance (  $= \sqrt{\chi^2}$  )  $< 1.8$
- 2) Mother Vertex  $\chi^2 < 6$
- 3)  $\max$  ( Delta Log Likelihood( Pion - Kaon ) )  $< 0$
- 4)  $\max$  ( Daughter Track  $\chi^2$  )  $< 1.4$
- 5)  $\cos$  ( angle )  $> 0.999875$
- 6) Mother  $P_{\text{tot}} < 62$  GeV
- 7)  $\max$  ( Daughter  $P_{\text{tot}}$  )  $< 25$  GeV
- 8)  $\min$  ( Daughter  $P_{\text{tot}}$  )  $< 13.5$  GeV
- 9)  $\max$  ( Delta Log Likelihood( Pion - Proton ) )  $< 5$

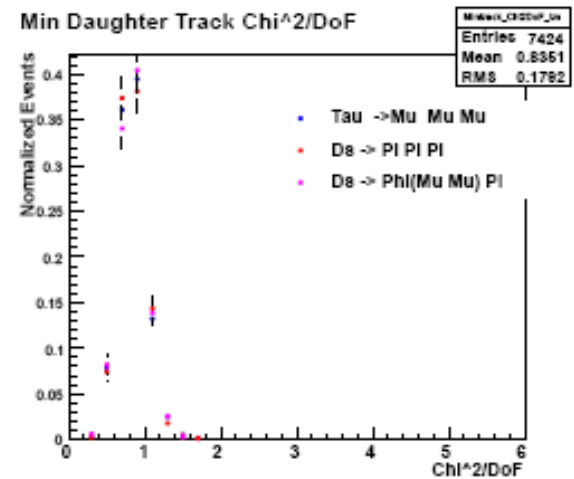
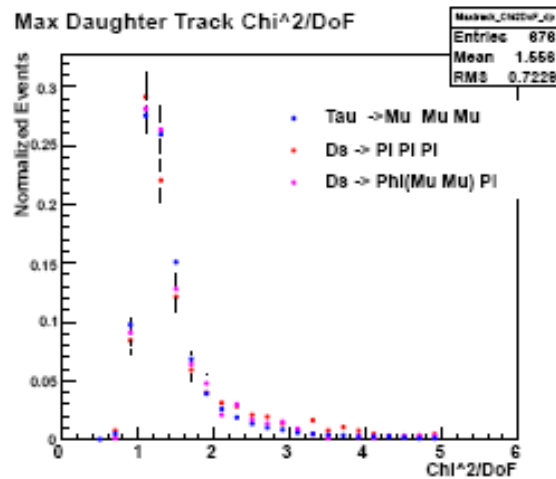
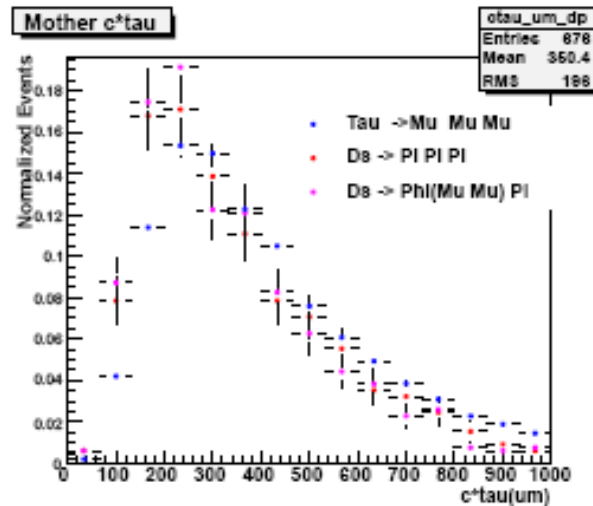
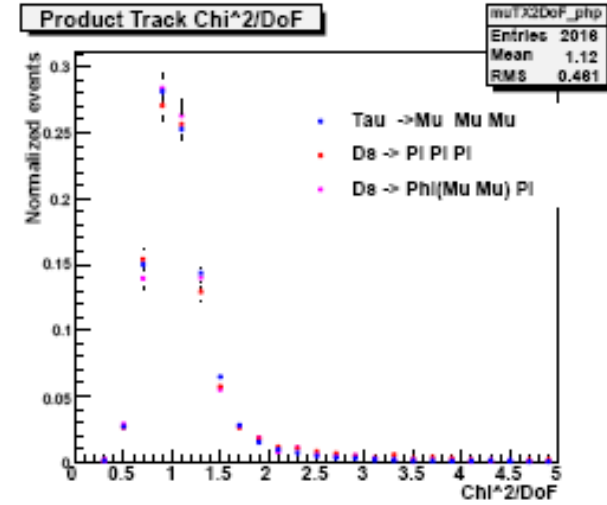
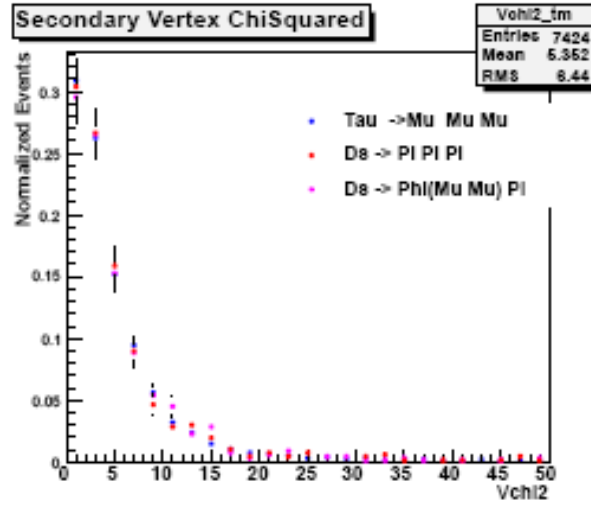
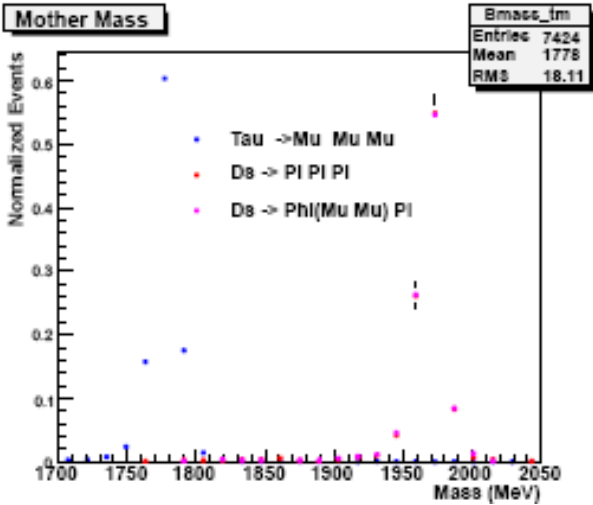


# Backup Slides - Kinematics Plots





# Backup Slides - More Plots



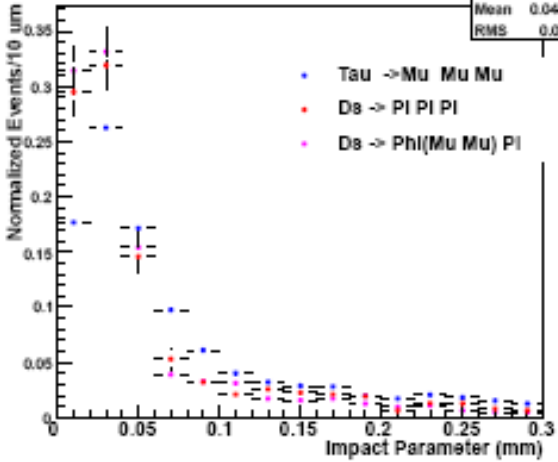


# Backup Slides - Flight/IPS Plots



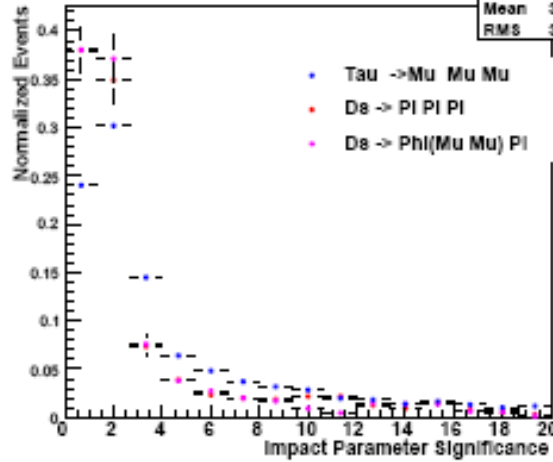
Mother Impact Parameter

Blep_php
Entries 872
Mean 0.04839
RMS 0.0537



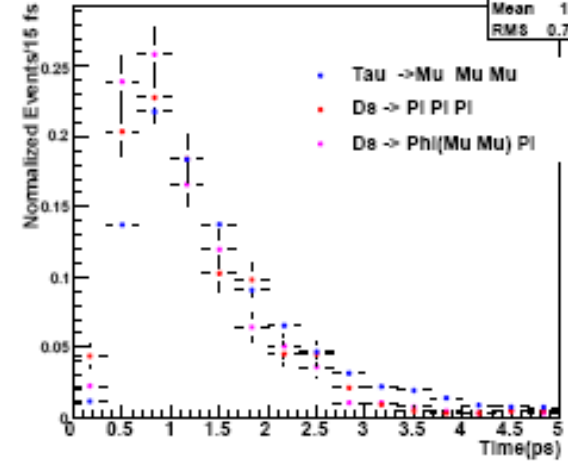
Mother IPS

Blep_dp
Entries 878
Mean 3.107
RMS 3.744



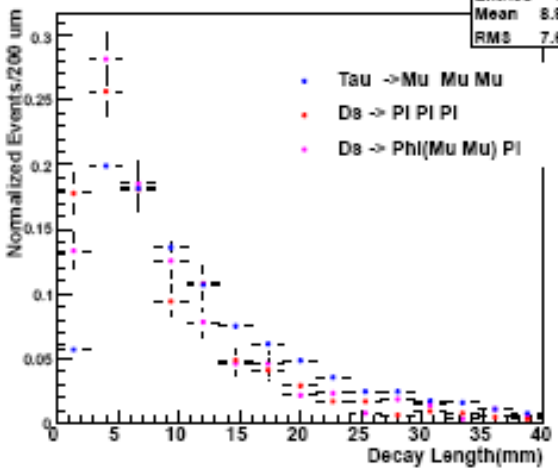
Mother Lifetime

Bllife_pc_php
Entries 872
Mean 1.181
RMS 0.7588



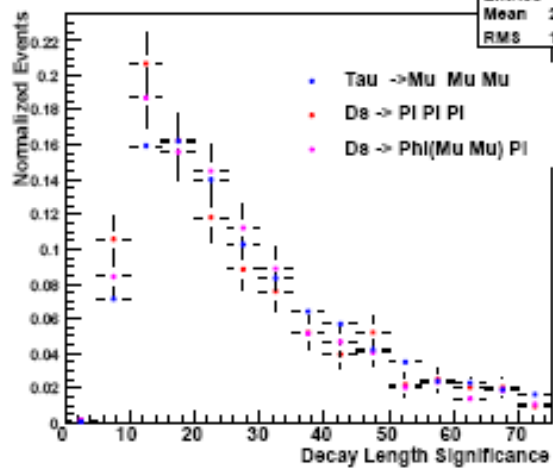
Mother Decay Length

Bdlc_php
Entries 872
Mean 8.838
RMS 7.823



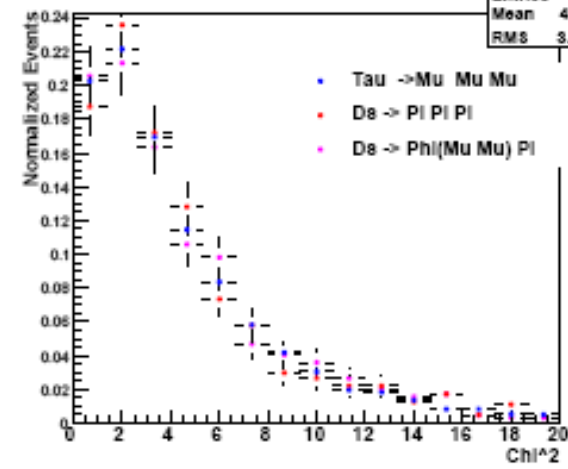
Mother Decay Length Significance

Bdlcslg_dp
Entries 878
Mean 25.78
RMS 15.84



Tau Decay Vertex Chi^2

Vchi2_php
Entries 872
Mean 4.481
RMS 3.888





# Backup Slides - More Plots

