B_s lifetimes in hadronic decays at CDF

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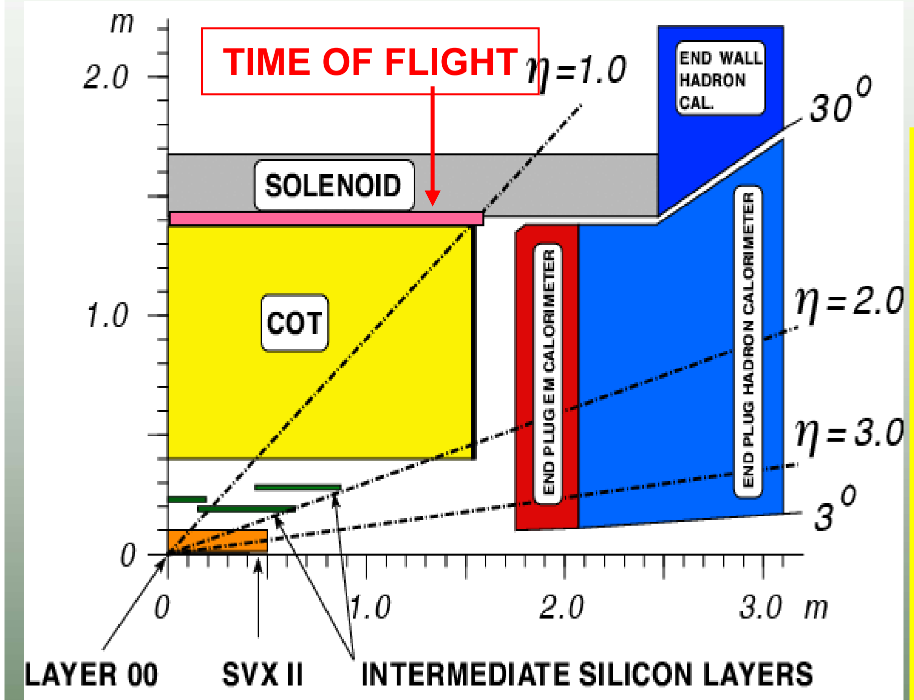
on behalf of the CDF collaboration

Outline

- CDF II detector
- Trigger on fully hadronic B decays
- Trigger shaping
- Correct for the trigger shaping
- Results

CDF II – subdetectors used for these analyses



B =1.4 T

COT: large radius (1.4 m) Drift Chamber

- 96 layers, 200ns drift time
- Precise P_T above 400 MeV/c
- Precise 3D tracking in $|\eta|<1$

$\sigma(1/P_T) \sim 0.1\% GeV^{-1}$; $\sigma(hit) \sim 150 \mu m$

- dE/dx info provides >1.4 sigma K/π separation above 2 GeV/c

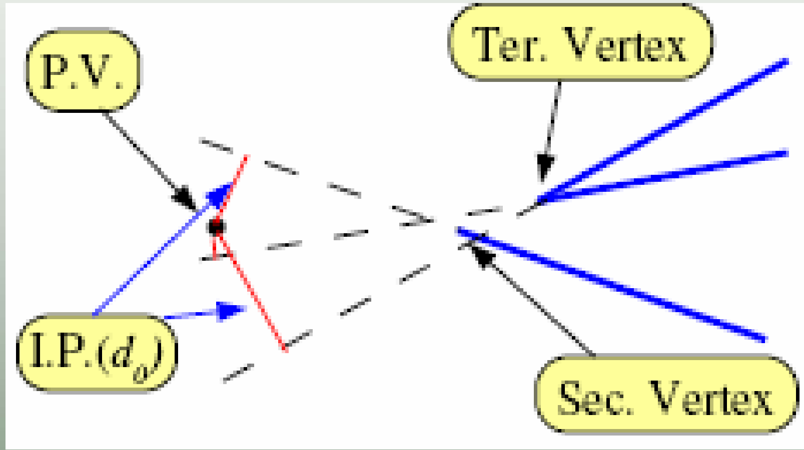
SVX-II + ISL: 5 + 1 (2) layers of double-side silicon (3cm < R < 30cm)

- Standalone 3D tracking up to $|\eta|= 2$
- Very good I.P. resolution: ~30μm (~20 μm with Layer00)

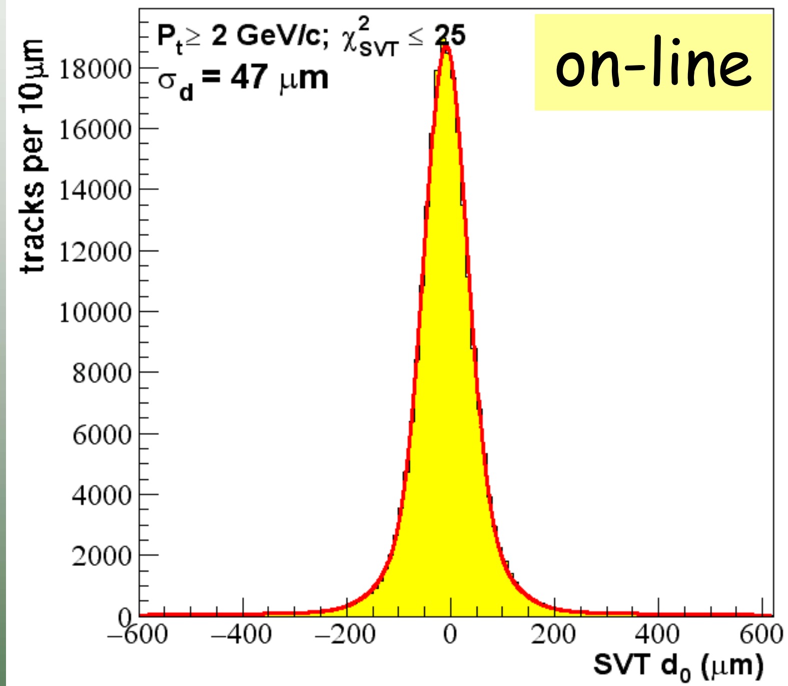
LAYER 00: 1 layer of radiation-hard silicon at very small radius (1.5 cm)

Silicon Vertex Trigger

Fully hadronic B decays



- Pt(trk) >2 GeV/c
- ΣPt >5.5 GeV/c
- 100 μm<IP(trk)<1 mm
- |η| <1



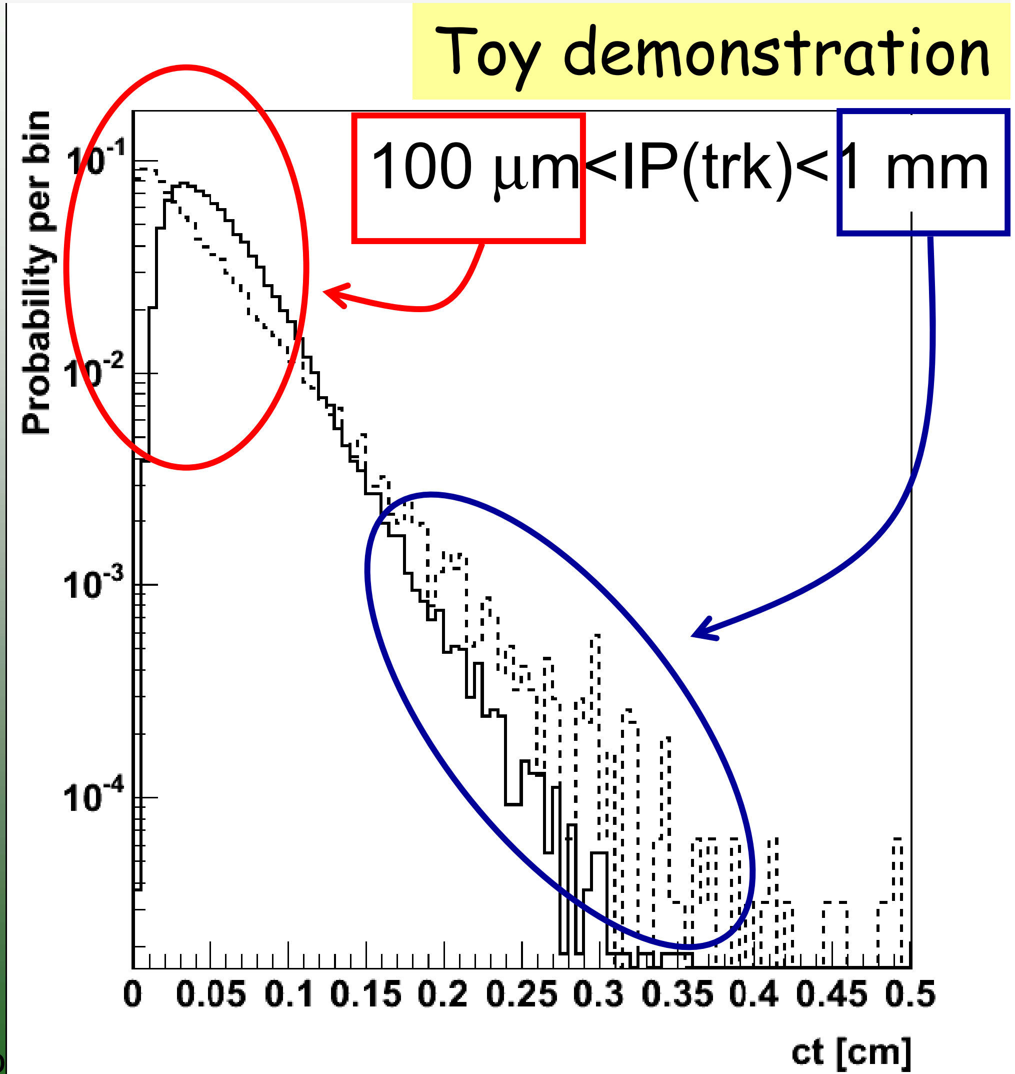
σ = 35 μm ⊕ 33 μm ≈47 μm
(resolution ⊕ beam)

Trigger bias - features

SVT = high purity b-samples

but…there's a price to pay:

- proper time distribution is distorted



Dashed = before trigger
Solid = after trigger

Trigger shaping - correction

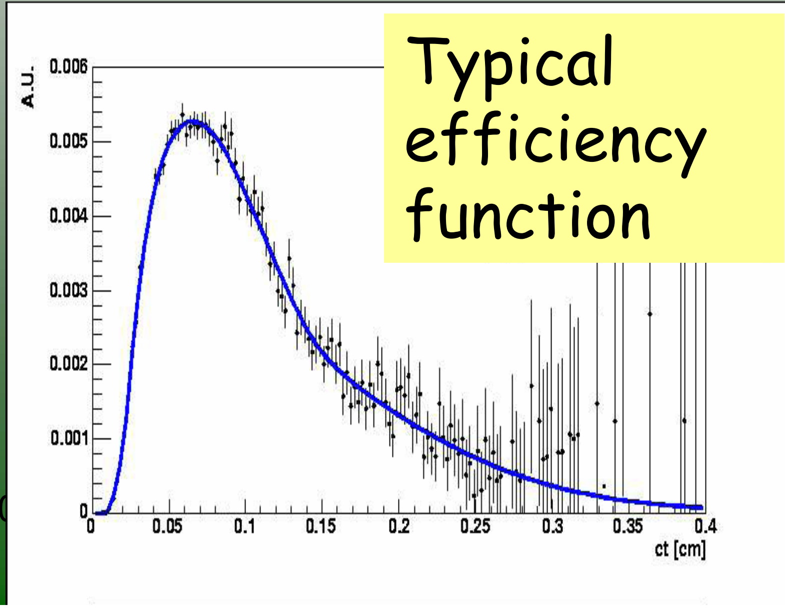
$$L_{sig}(ct) = [\exp(ct, c\tau) \otimes G(ct, 0, \sigma_{ct})] \times \varepsilon_{TTT}(ct)$$

- $L_{sig}(ct)$: Likelihood
- $\exp(ct, c\tau)$: decay
- $G(ct, 0, \sigma_{ct})$: detector smearing
- $\varepsilon_{TTT}(ct)$: efficiency function

Monte Carlo

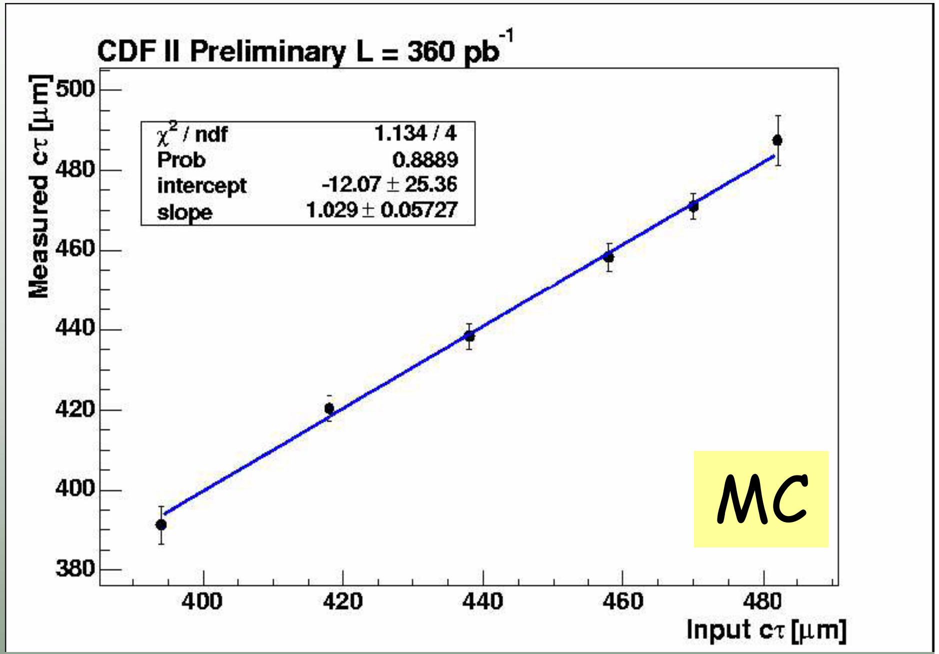
$$\epsilon_{TTT}(ct) = \frac{hist^{TTT}(ct)}{\Sigma_i \exp(ct^i, c\tau^{MC}) \otimes Gauss(\sigma^i)}$$

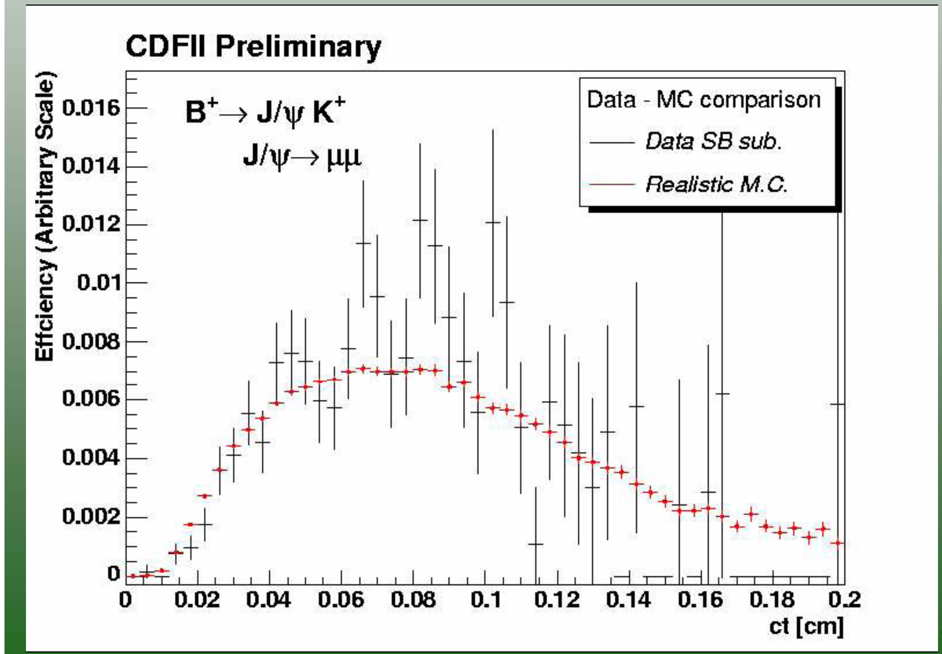
event by event resolution



Tests:

MC – data proper time distribution:
Check the SVT decision on the $B^+ \rightarrow J/\psi\ K^+$ unbiased sample and compare the proper time distributions





Check the range of validity of the efficiency function

Charmed Signals

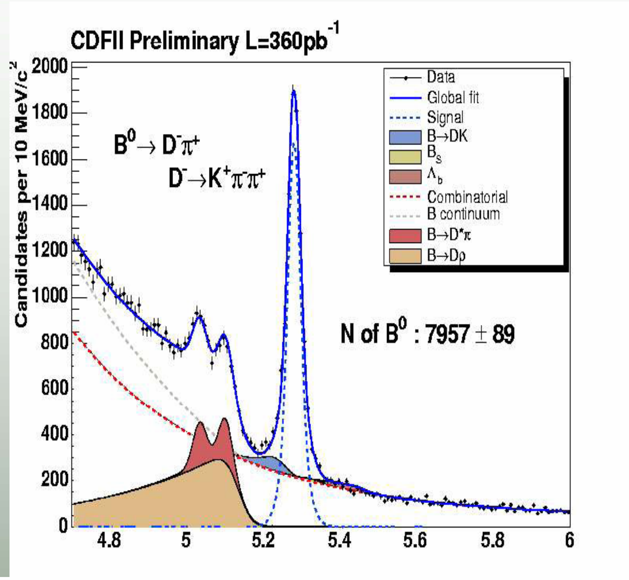
$B^{\pm} \rightarrow D^0 \pi^{\pm}$ $(D^0 \rightarrow K^- \pi^+)$

$B^0 \rightarrow D^{\pm} \pi^{\pm}$ $(D^- \rightarrow K^+ \pi^- \pi^-)$

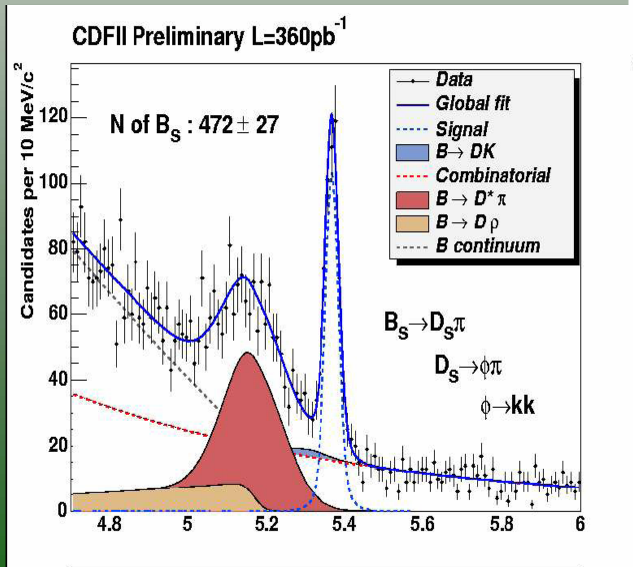
$B^0 \rightarrow D^{\pm} 3\pi^{\pm}$ $(D^- \rightarrow K^+ \pi^- \pi^-)$

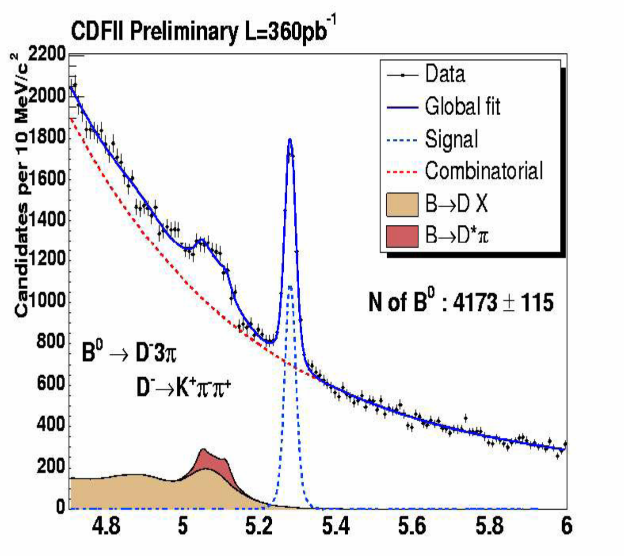
$B_S \rightarrow D_S{}^{\pm} \pi^{\pm}$ $(D_S{}^- \rightarrow \Phi \pi^-)$ $(\Phi \rightarrow K^+ K^-)$

$B_S \rightarrow D_S{}^{\pm} 3\pi^{\pm}$ $(D_S{}^- \rightarrow \Phi \pi^-)$ $(\Phi \rightarrow K^+ K^-)$



L = 360 pb^{-1}





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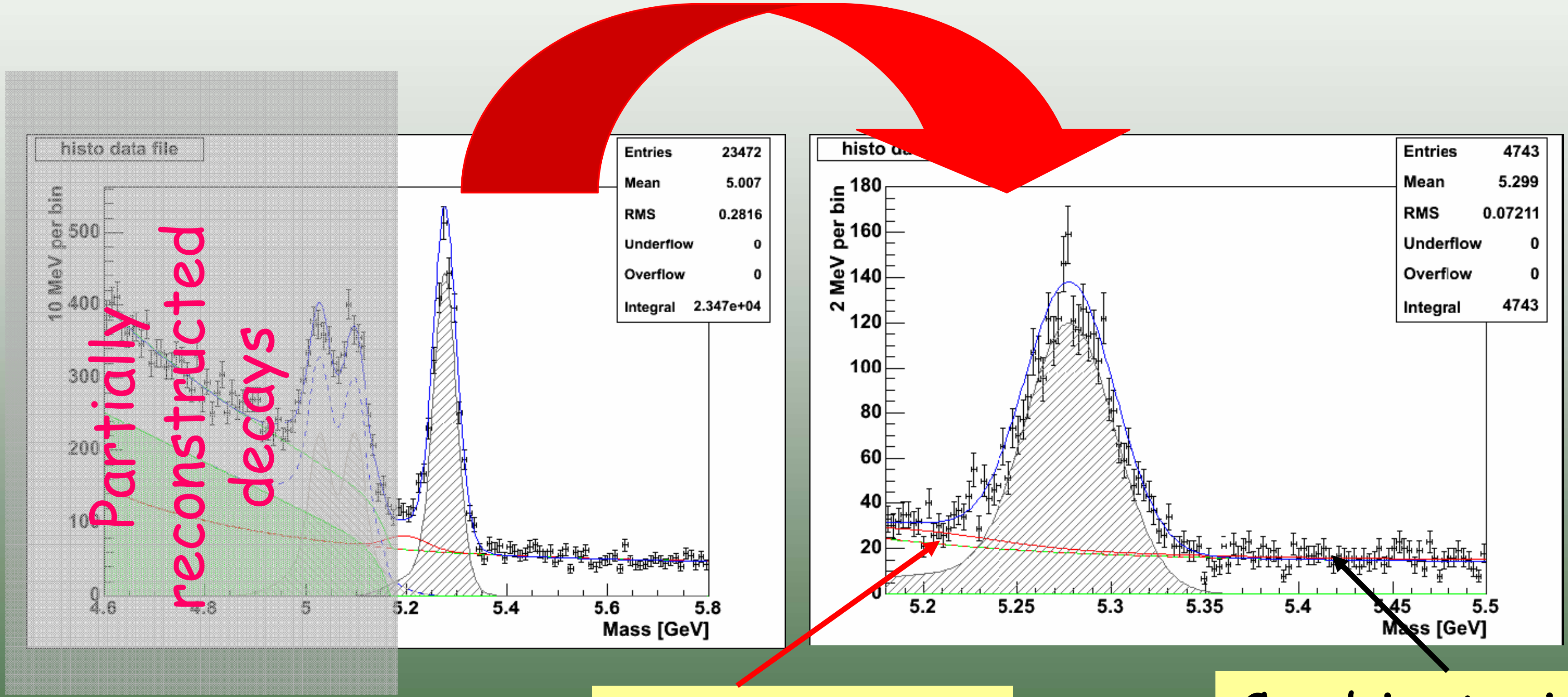
Typical B-mass Distribution for hadronic final states

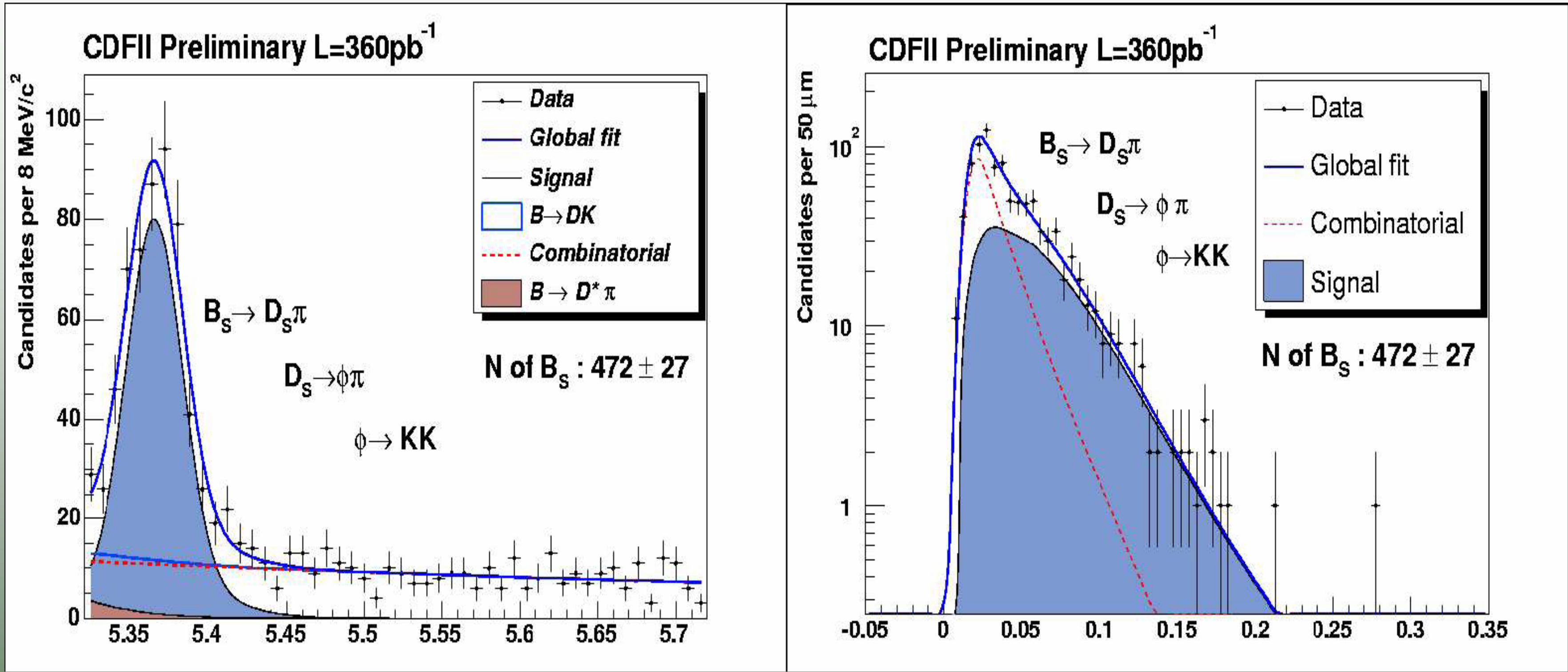


Less than 0.1% contamination in the signal region

Cabibbo suppressed mode

Combinatorial background

Simultaneous Mass-Lifetime fit



$B_S \rightarrow D_S{}^{\pm} \pi^{\pm}$
$(D_S{}^{-} \rightarrow \Phi\pi^{-})$
$(\Phi \rightarrow K^{+}K^{-})$

$c\tau = 479 \pm 32\ \mu m$
$Mass = 5365.2 \pm 1.1\ MeV/c^2$
$\sigma = 17.8 \pm 1.1\ MeV/c^2$

Fit Results

$$c\tau(B^+) = 498 \pm 8(stat) \pm 4(syst)\ \mu m,$$
$$c\tau(B^0) = 453 \pm 7(stat) \pm 4(syst)\ \mu m,$$
$$c\tau(B_s) = 479 \pm 29(stat) \pm 5(syst)\ \mu m.$$

$$\tau(B^+) = 1.66 \pm 0.03(stat) \pm 0.01(syst) ps,$$
$$\tau(B^0) = 1.51 \pm 0.02(stat) \pm 0.01(syst) ps,$$
$$\tau(B_s) = 1.60 \pm 0.10(stat) \pm 0.02(syst) ps.$$

Systematic errors

Effect	Variation(μm)	Variation(μm)
	$B^0\ B^\pm$	B_s
MC input $c\tau$	negligible	negligible
p_T re-weight	1.9	1.9
Scale Factor	negligible	negligible
Kg ct description	1.1	1.1
Bkg fraction	2.0	2.0
I.P. correlation	1.0	1.0
Eff. parameterization	1.5	1.5
L_{xy} significance	negligible	2
$\Delta\Gamma_s$	-	1.0
Alignm. + others	2.4	2.4
Total	4.2	4.7

World Averages

τ (B^+) = 1.643 ± 0.010 ps
τ (B^0) = 1.528 ± 0.009 ps
τ (B^s) = 1.479 ± 0.044 ps

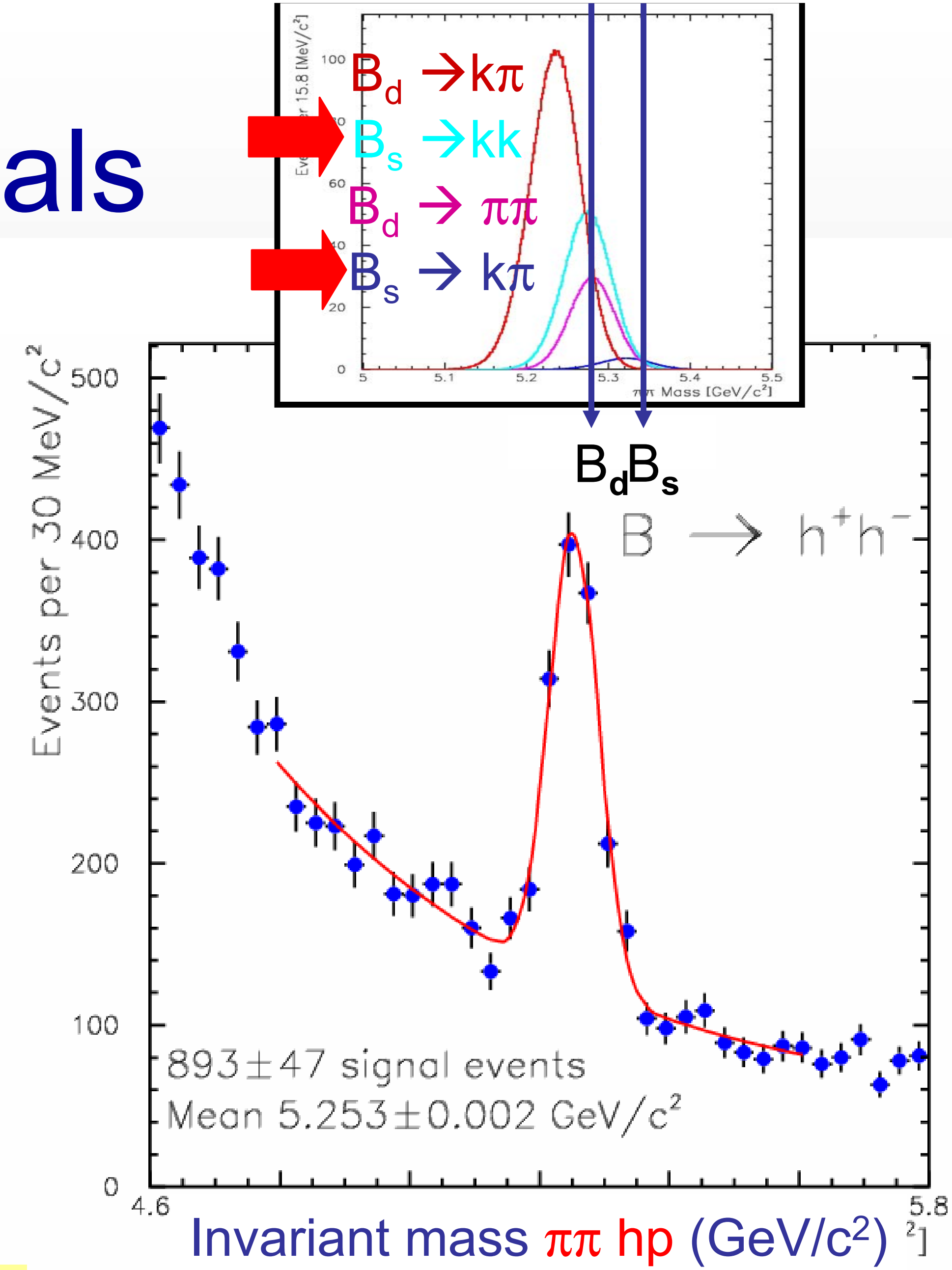
HFAG Winter 2005

Charmless Signals

$B_s \rightarrow kk$:
- almost pure *CP* even state
- $\Delta\Gamma_s$

Unbinned maximum likelihood fit variables:

- Invariant mass
- $\alpha = q_1(1-p_1/p_2)$
- $$\mathrm{ID}(track) = \frac{\frac{dE}{dx}_{meas}(track) - \frac{dE}{dx}_{exp-\pi}(track)}{\frac{dE}{dx}_{exp-K}(track) - \frac{dE}{dx}_{exp-\pi}(track)}$$



L = 180pb^{-1} (360 pb^{-1} underway)

893±47 B→hh' events

$$\mathcal{L}_i = b\cdot\mathcal{L}^{bckg} + (1-b)\cdot\mathcal{L}^{sign}$$

$$\mathcal{L} = \prod_{i=1}^{N_{events}} \mathcal{L}_i$$

Sum over the 4 channels

BKG Likelihood

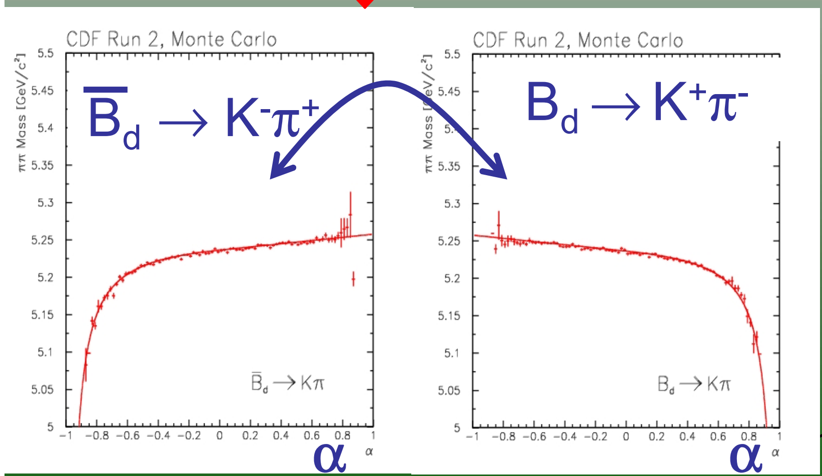
BKG fraction (float)

$$\mathcal{L}_j = pdf(M_{\pi\pi}|\alpha)\cdot pdf(\mathrm{ID}_1,\mathrm{ID}_2|\alpha,\Sigma p)\cdot pdf(\alpha,\Sigma p)\; T(ct,\sigma_{ct})$$

Kinematics

Particle Identification

Unbalance Momentum P(A|B)P(B)



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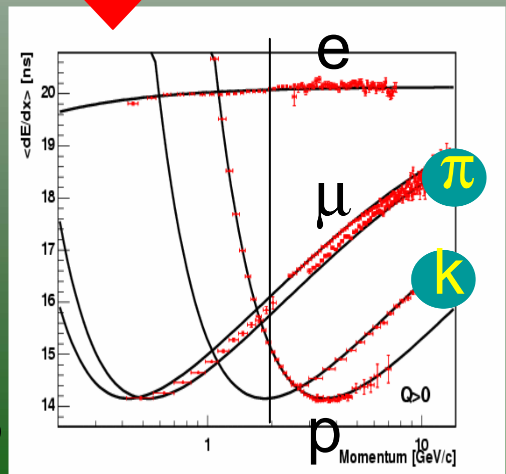
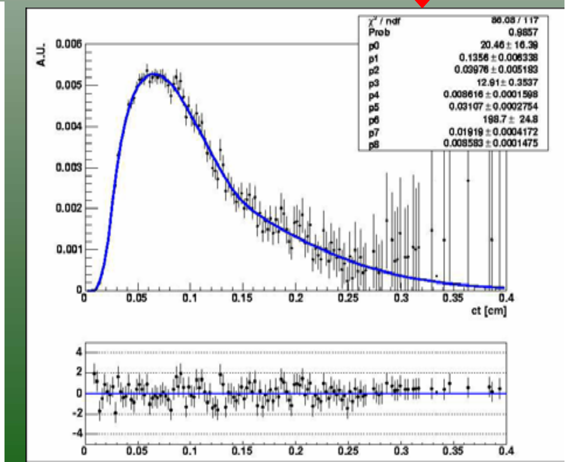




Conclusions

- The capability of measuring lifetime in fully reconstructed hadronic B decays at CDF has been demonstrated

- A Monte Carlo based way to correct for the trigger bias has been developed (and a MC independent one is well under development)

- All the measurements agree with World Averages:

$\tau(B^{\pm})$ = 1.66 ± 0.03 ± 0.01 ps (W.A. 1.643 ± 0.010 ps)

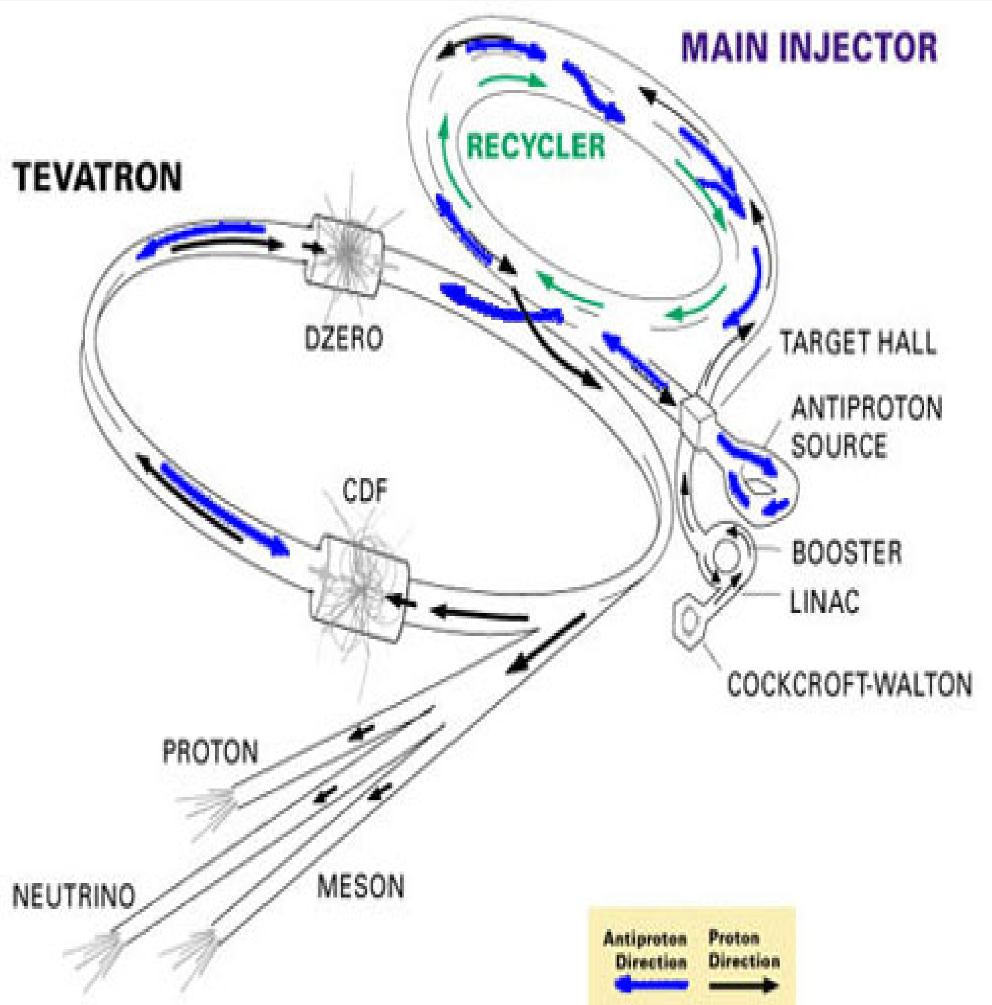
$\tau(B^{0})$ = 1.51 ± 0.02 ± 0.01 ps (W.A. 1.528 ± 0.009 ps)

$\tau(B_{S})$ = 1.60 ± 0.10 ± 0.02 ps (W.A. 1.479 ± 0.044 ps)

$B_s \to K^+K^-$ important to get to $\Delta\Gamma_s$

BACKUP

TeVatron



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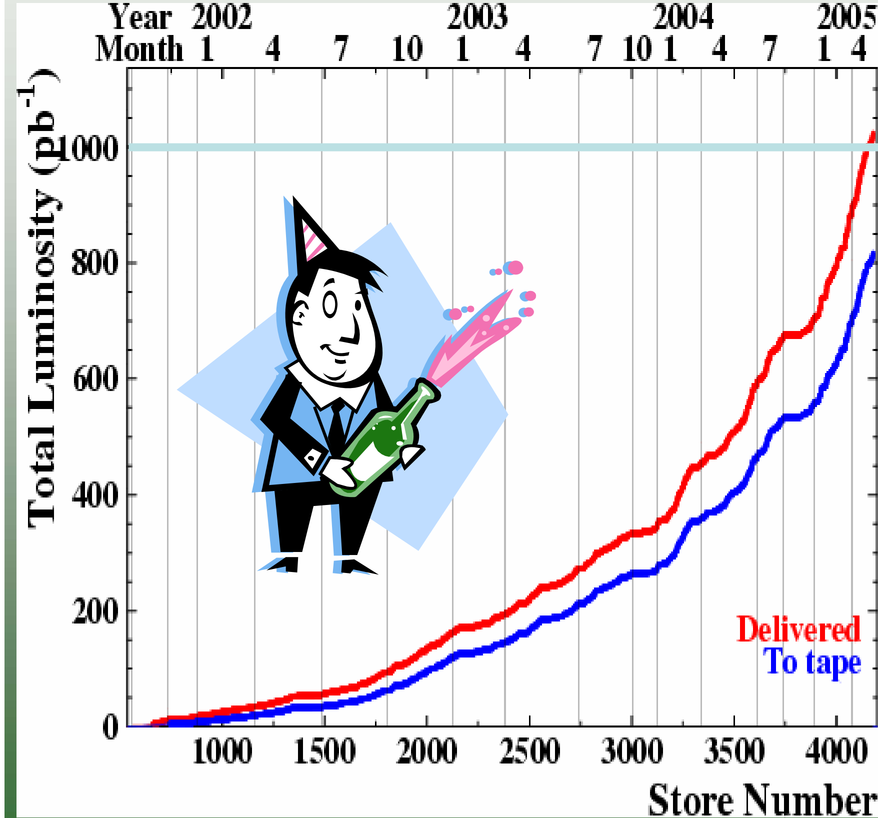
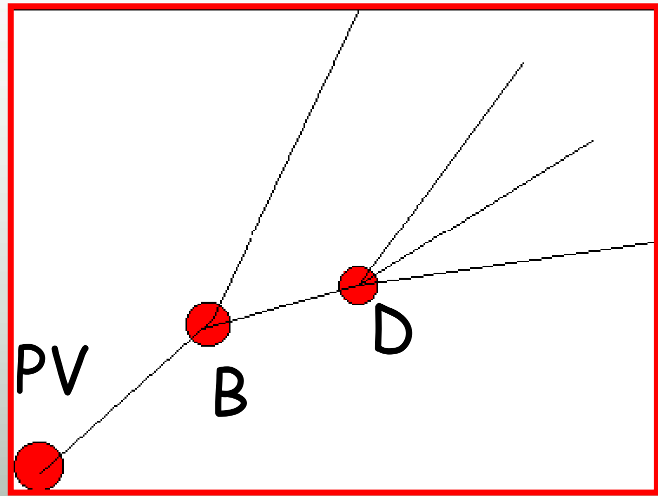


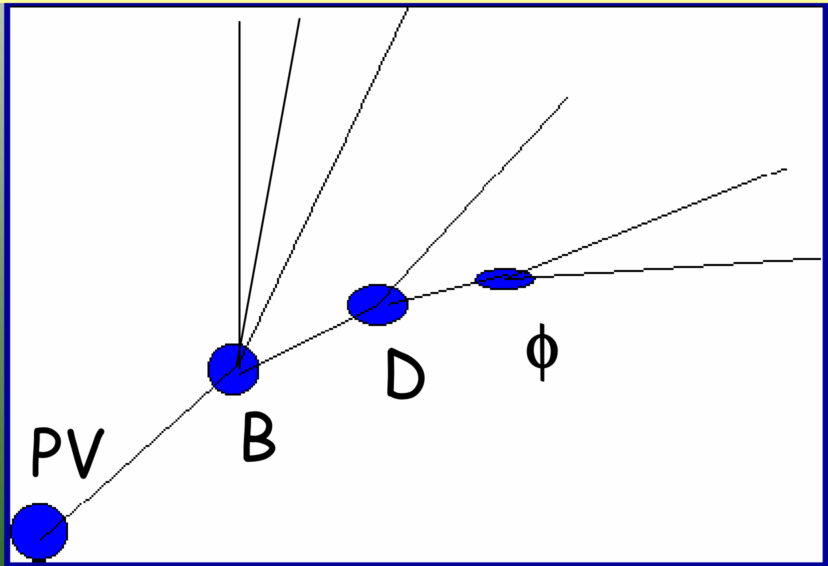
Decays topology

- Intermediate states are reconstructed
- B and D meson vertexes decay reconstructed
- Primary vertex from Beamline information
- $ct = M_B * L_{XY}/p_T$

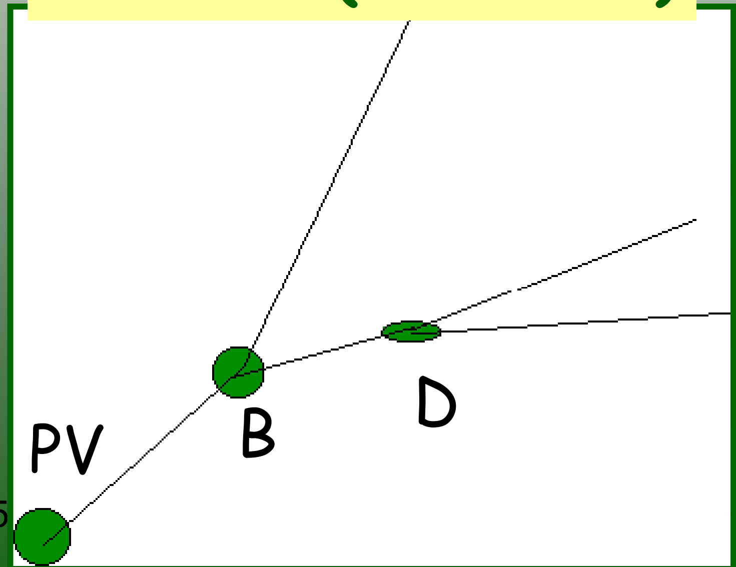
$B^0 \rightarrow D^{\pm} \pi^{\pm} (D^- \rightarrow K^+ \pi^- \pi^-)$



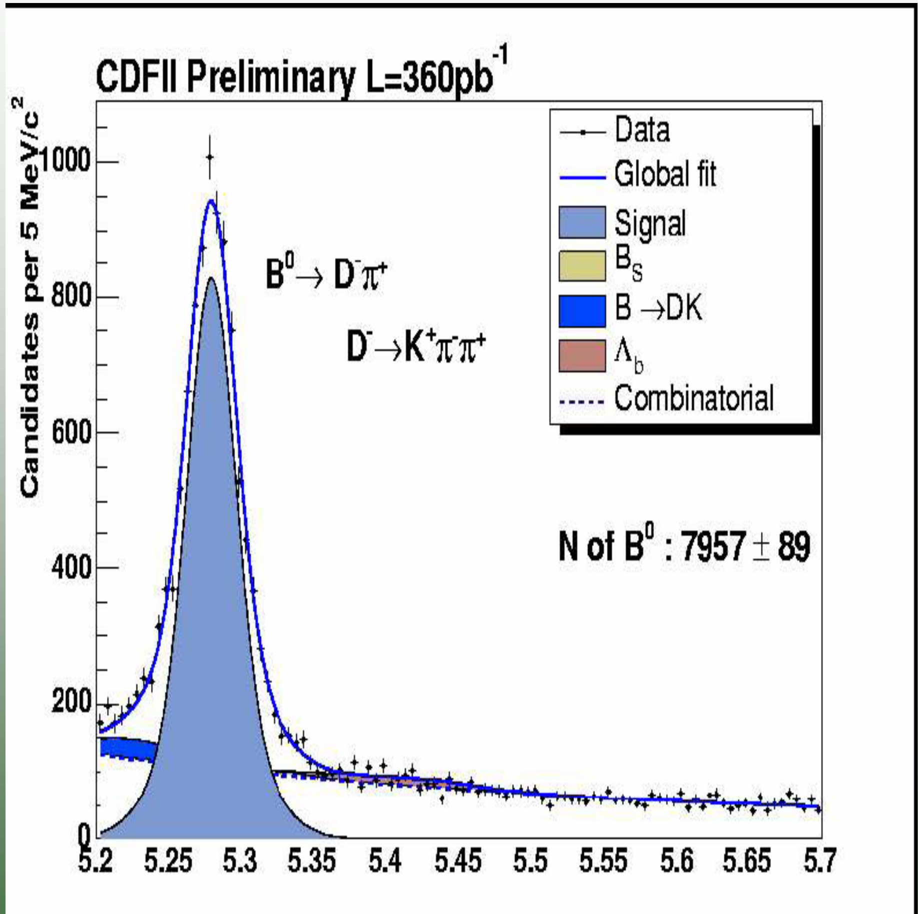
$B_S \rightarrow D_S^{\pm} 3\pi^{\pm} (D_S^- \rightarrow \Phi\pi^-) (\Phi \rightarrow K^+K^-)$

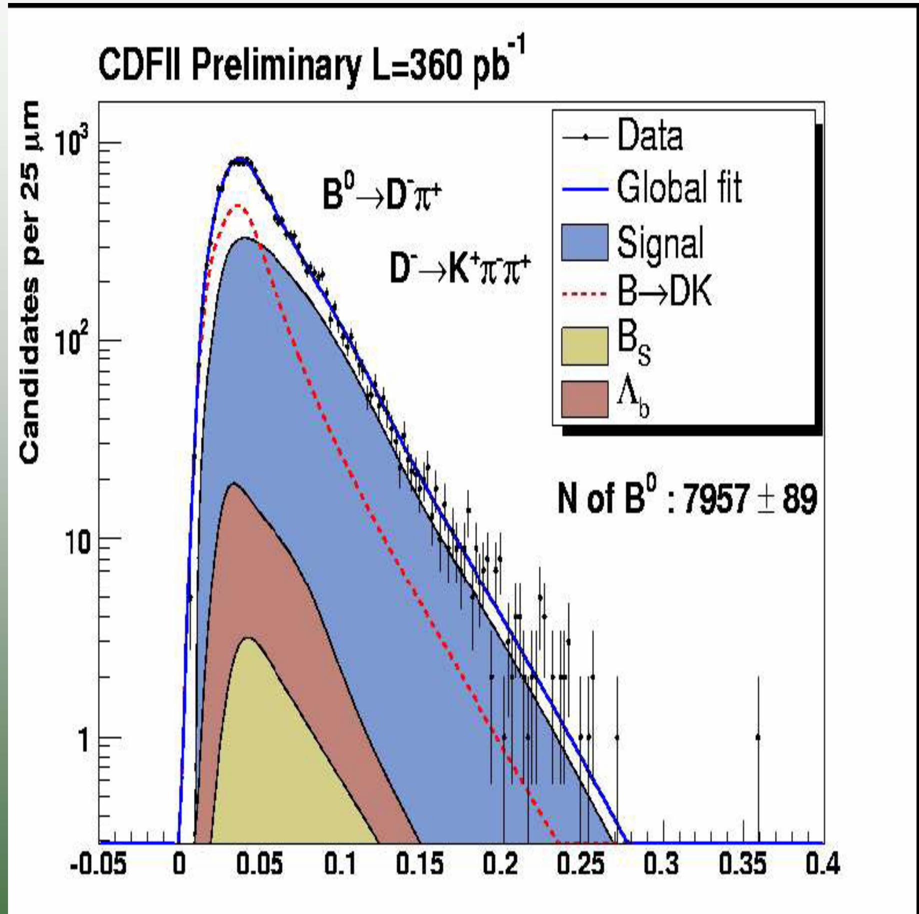


$B^{\pm} \rightarrow D^0\pi^{\pm} (D^0 \rightarrow K^- \pi^+)$

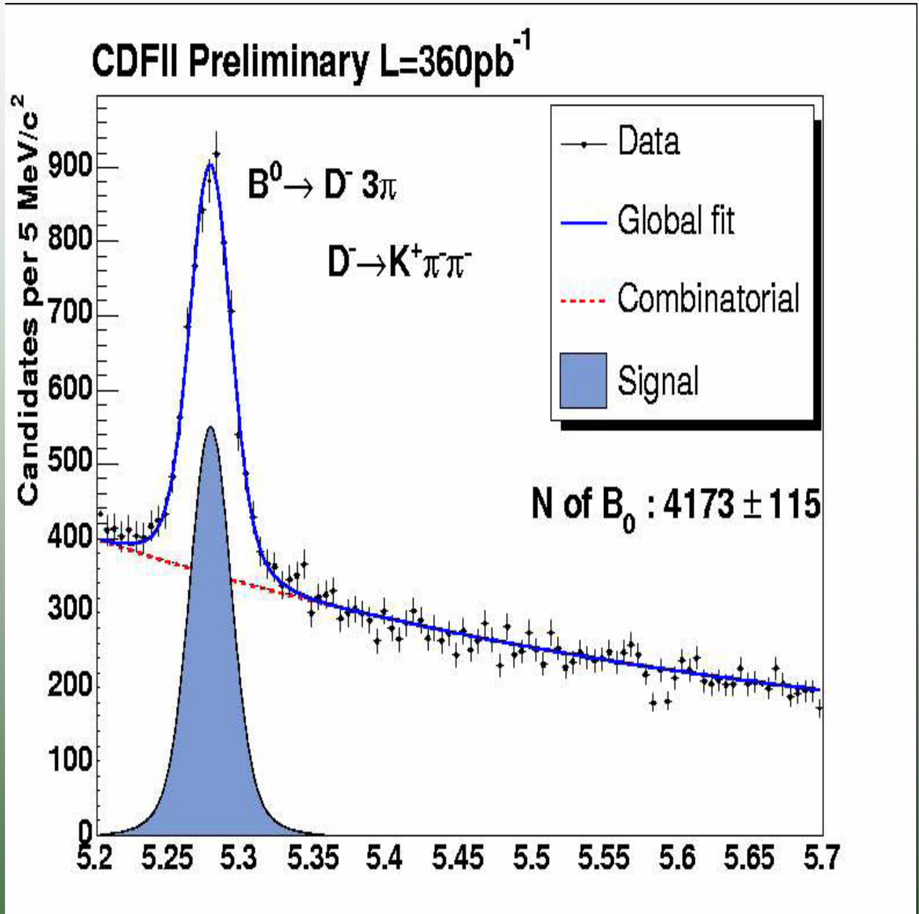


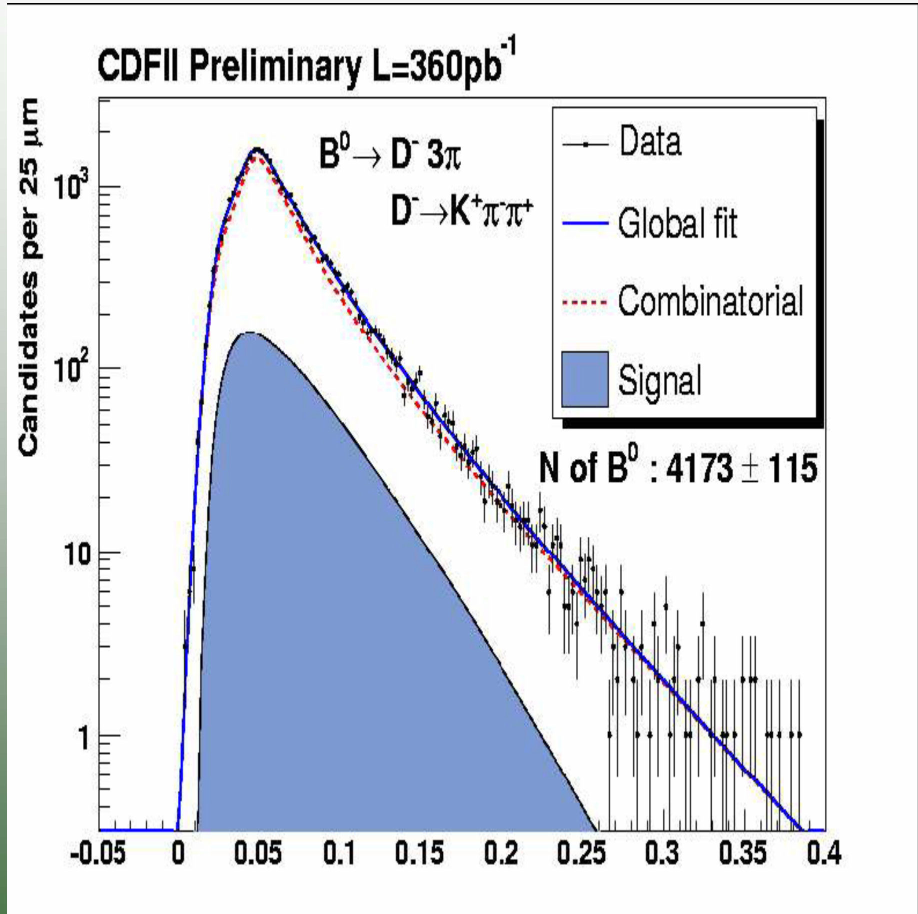
$B^0 \rightarrow D^{\pm}\pi^{\pm}$ ($D^- \rightarrow K^+ \pi^- \pi^-$)



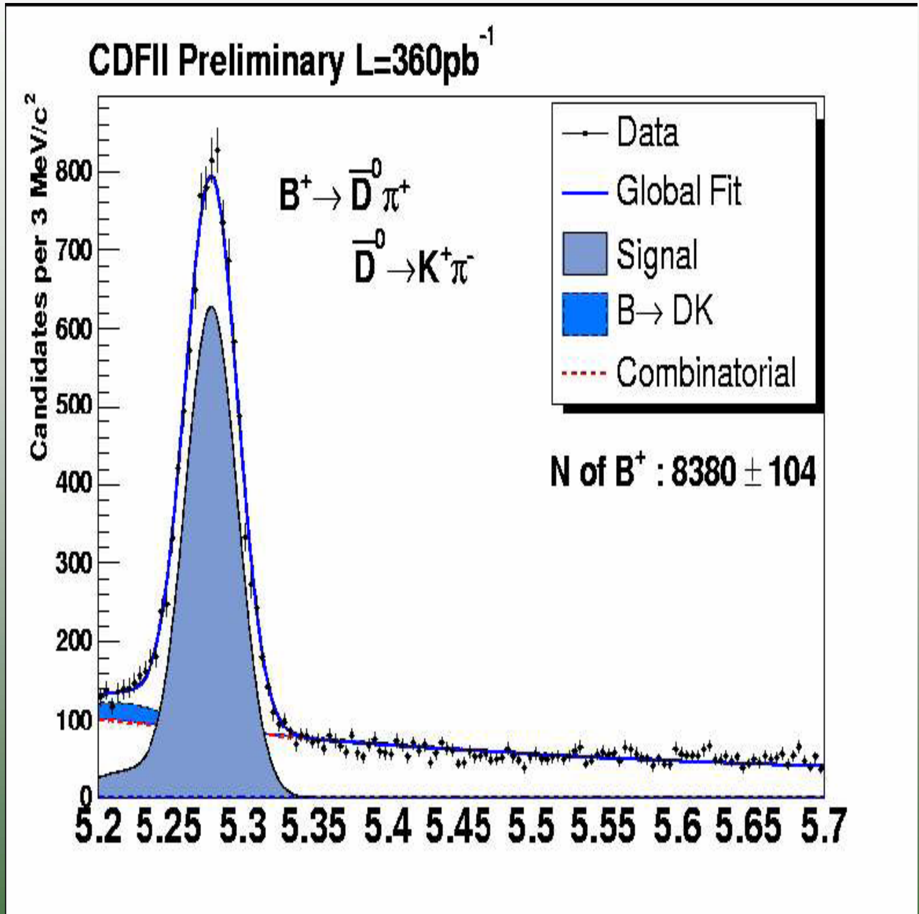


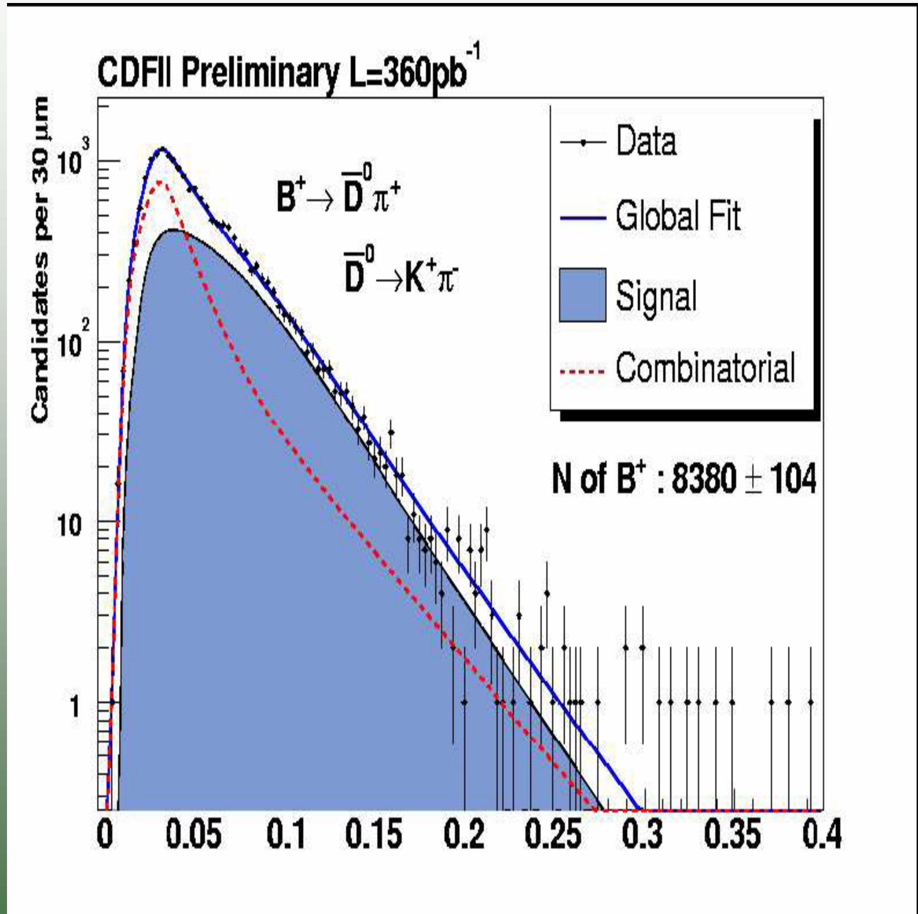
$B^0 \rightarrow D^{\pm}3\pi^{\pm}$ $(D^- \rightarrow K^+ \pi^- \pi^-)$





$B^{\pm} \to D^0 \pi^{\pm}$ ($D^0 \to K^- \pi^+$)





$B_S \rightarrow D_S^{\pm} 3\pi^{\pm}$ $(D_S^{-} \rightarrow \Phi\, \pi^{-})$ $(\Phi \rightarrow K^{+}K^{-})$