First observation of:
$B_s \to K\pi$, $\Lambda_b \to p\pi$, $\Lambda_b \to pK$
Decay modes

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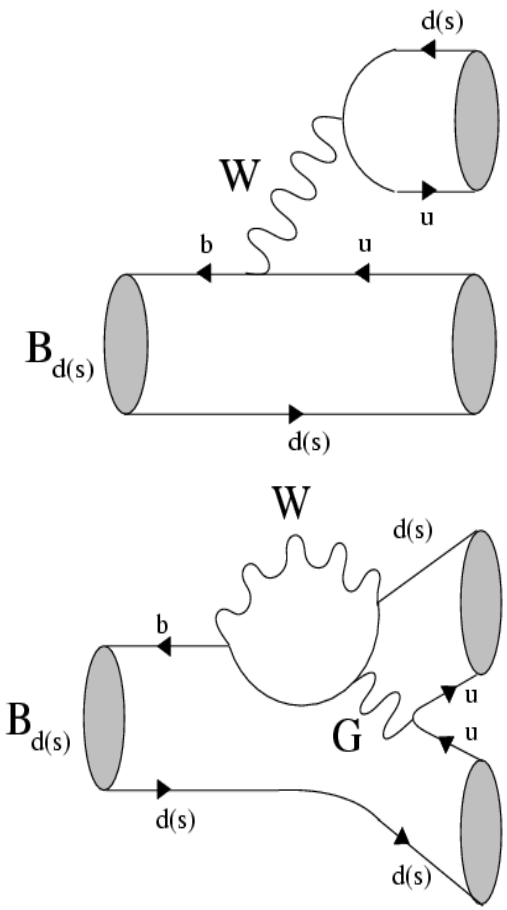
Jacksonville April 17, 2007

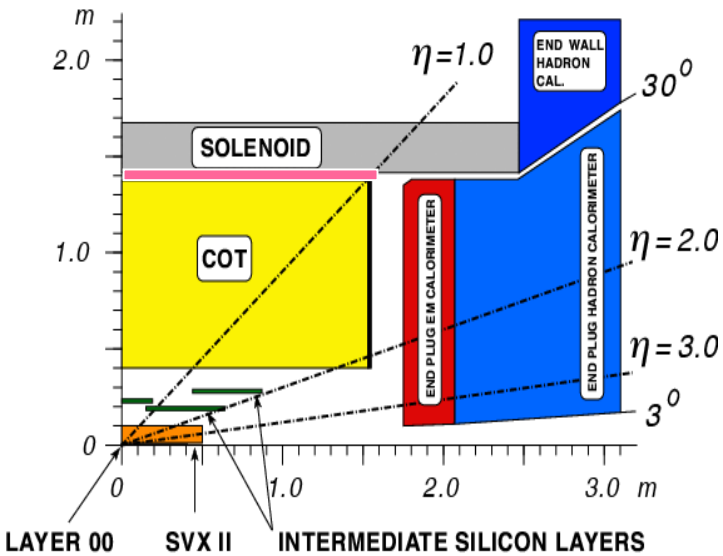
Outlines

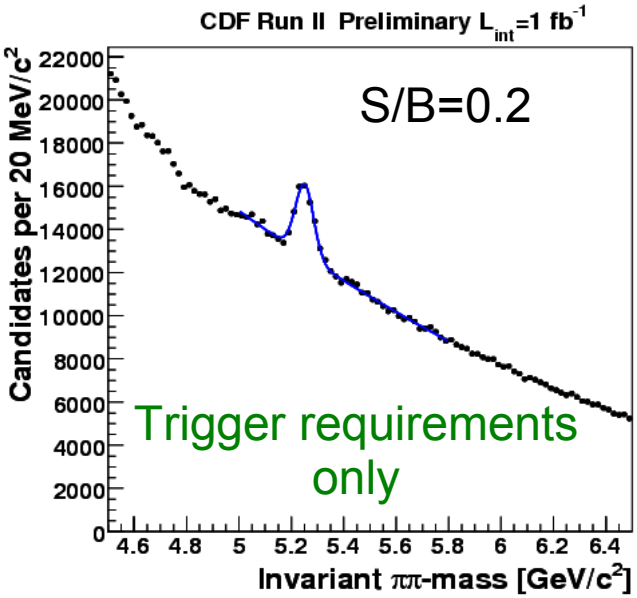
- 2 Body charmless decays of B/Bs mesons calculation involves contributions from Tree and Penguin diagrams.
- Measurement of BRs and ACPs aids to evaluate the magnitude of these diagrams
- Verifying which is the correct theoretical framework
- Sensitive to New Physics effects
- Simultaneous measurements Bd and Bs cancel out theoretical uncertainties



CDF Tracking and Trigger system

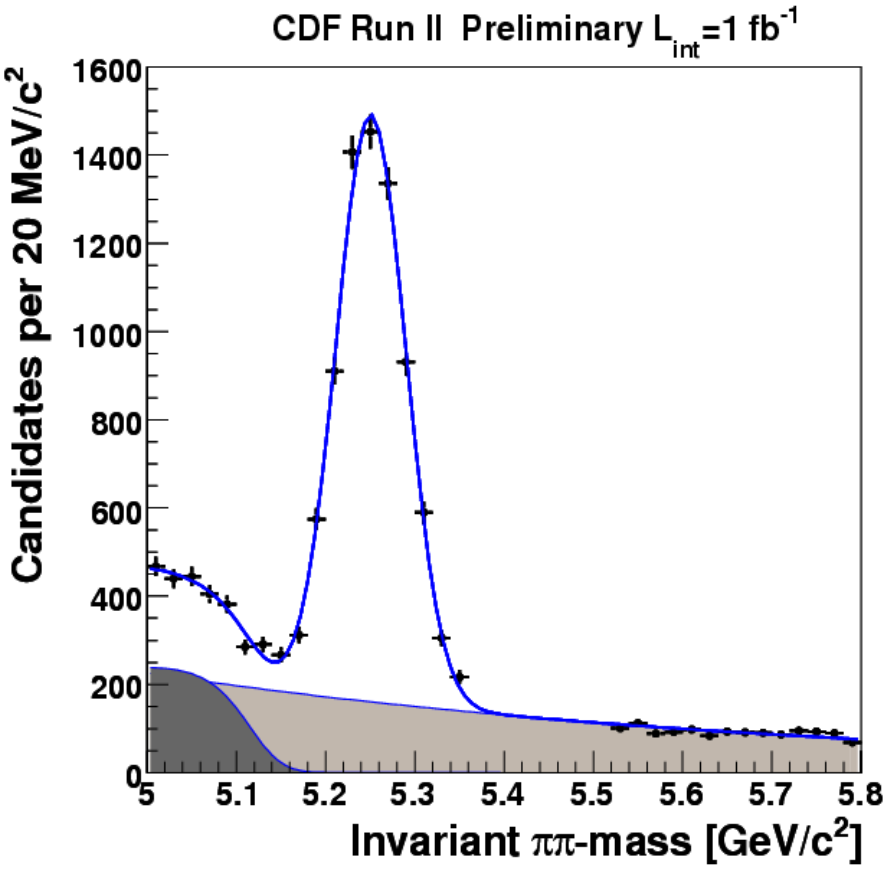
- Silicon VerteX detector
  - I.P. resolution: 35μm@2GeV
- Central Drift chamber in B field
  - $\sigma(p_T)/p_T^2 \sim 0.1\%\ GeV^{-1}$
  - dE/dx measurement
    - 1.4 σ K/π separation @ p_t>2GeV/c
- Trigger requirements:
  - opposite charge
  - p_t>2 GeV/c
  - $p_{t1}+p_{t2}$>5.5 GeV/c
  - 20°<Δφ<135°
  - Tracks Impact Parameter > 0.01cm
  - B IP < 0.08 cm
  - 0.02 cm < L_{xy} < 0.1 cm





Sample selection

- Analysis updated to 1 fb-1
  - [hep-ex/0612018]
- Large Bd/Bs sample
  - B yield comparable to B-factories
  - Sample of ~1300 B^0_s->KK
- Cuts optimized for the observation of B^0_s->Kpi decay
- Good mass resolution but not enough to separate the decays:
  - ML fit using: Mass, PID, momenta



Plot show the pion-pion invariant mass after the cuts.

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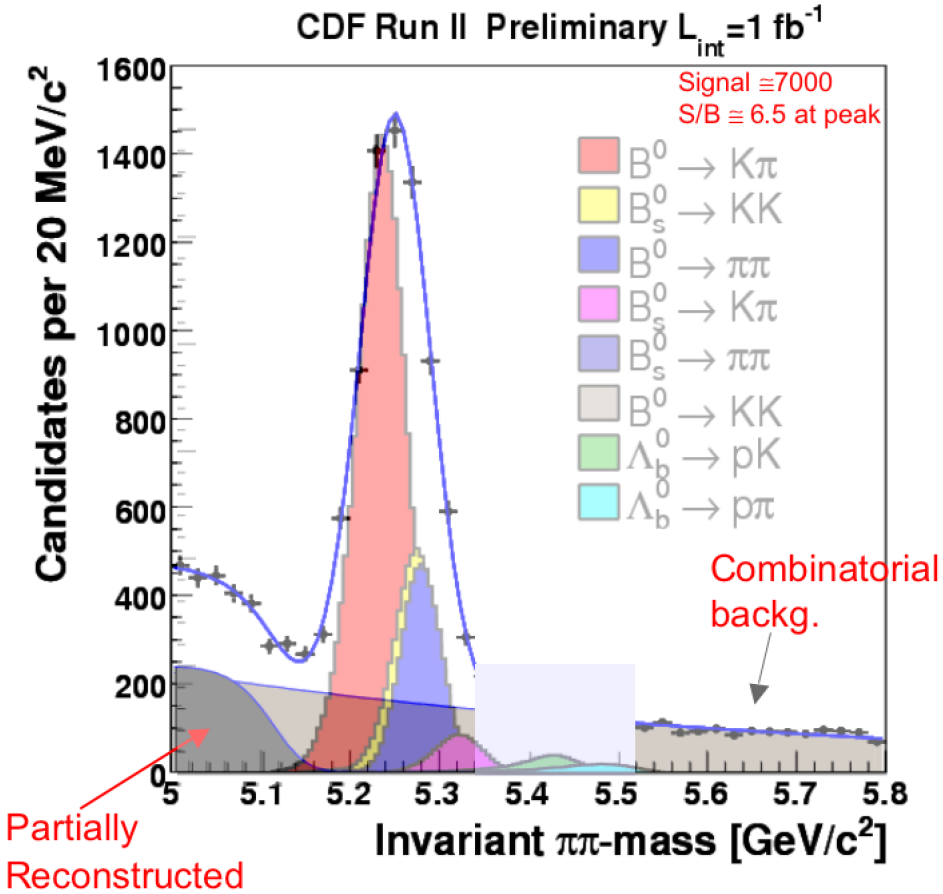
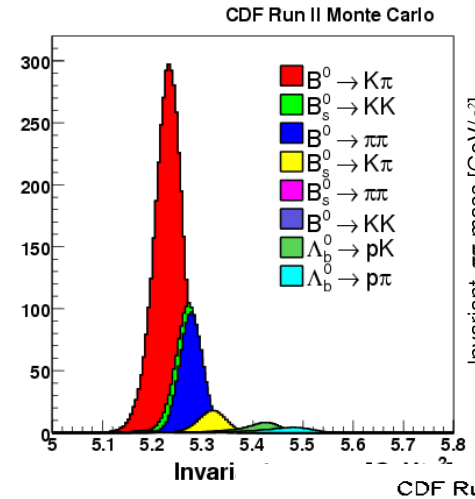


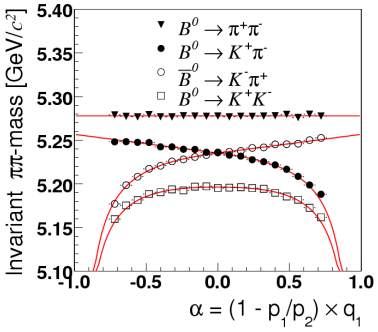
Plot show the pion-pion invariant mass after the cuts.

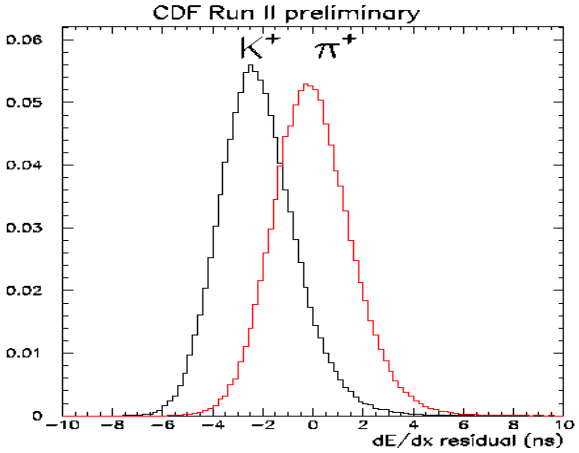
Expected contribution from different channels (CDF MC)

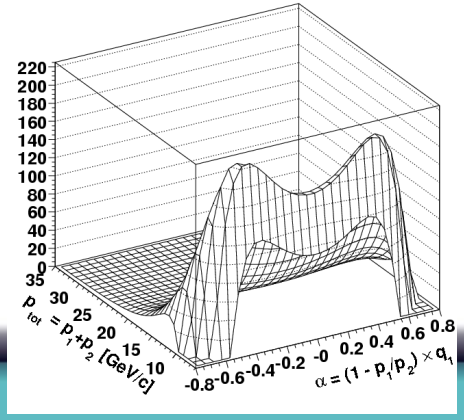
Channel separation: Likelihood

- 5 input variables:
  - 3 Kinematic:
    - alpha: momentum unbalance
    - ptot: sum of 3d momentum of tracks
    - Mass pi-pi
  - PID for both tracks
- Detailed documentation:
  - [hep-ex/0612018] M. Morello
- Mass shape model:
  - Detailed Mass shape parameterization
  - FSR effect included
    - Soft-photon emission produce an asymmetric tail that can hide rare decays
    - Reduce statistical uncertainties



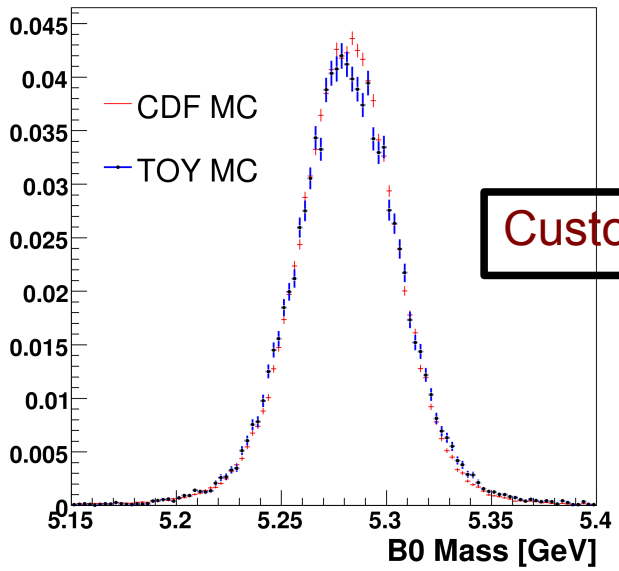




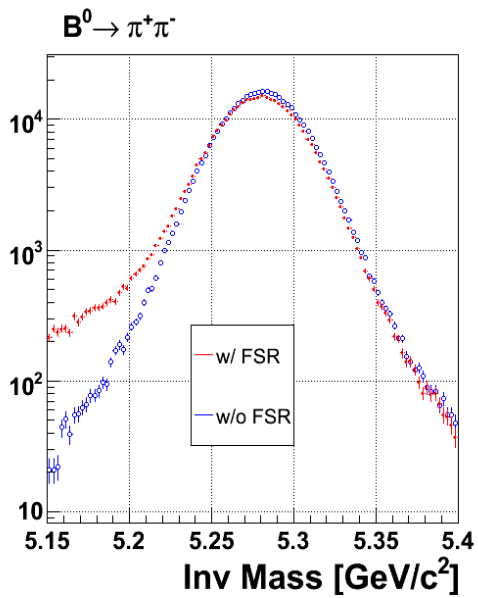


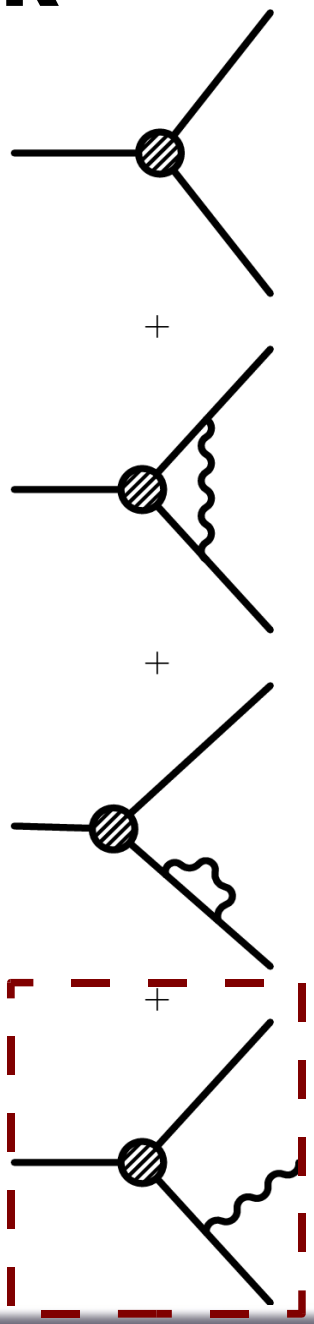
Mass shape template and FSR

- CDF MC can include FS with Photos
- We preferred to use analytical calculation by Baracchini and Isidori: Phys.Lett.B633:309-313,2006
- From CDF detailed MC we extracted the resolution on main track parameters:
  - Curvature, Cot(theta), phi, I.P.
- Wrote a custom 2-Body kinematic simulation.



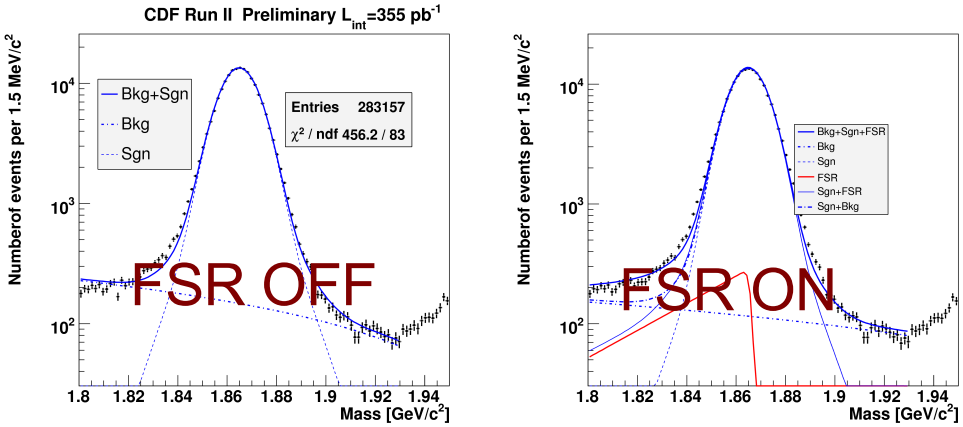
Custom MC

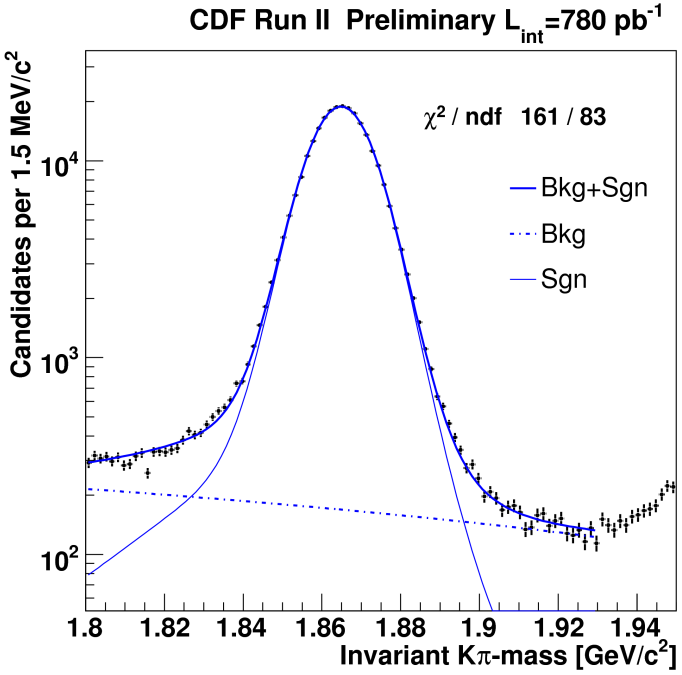




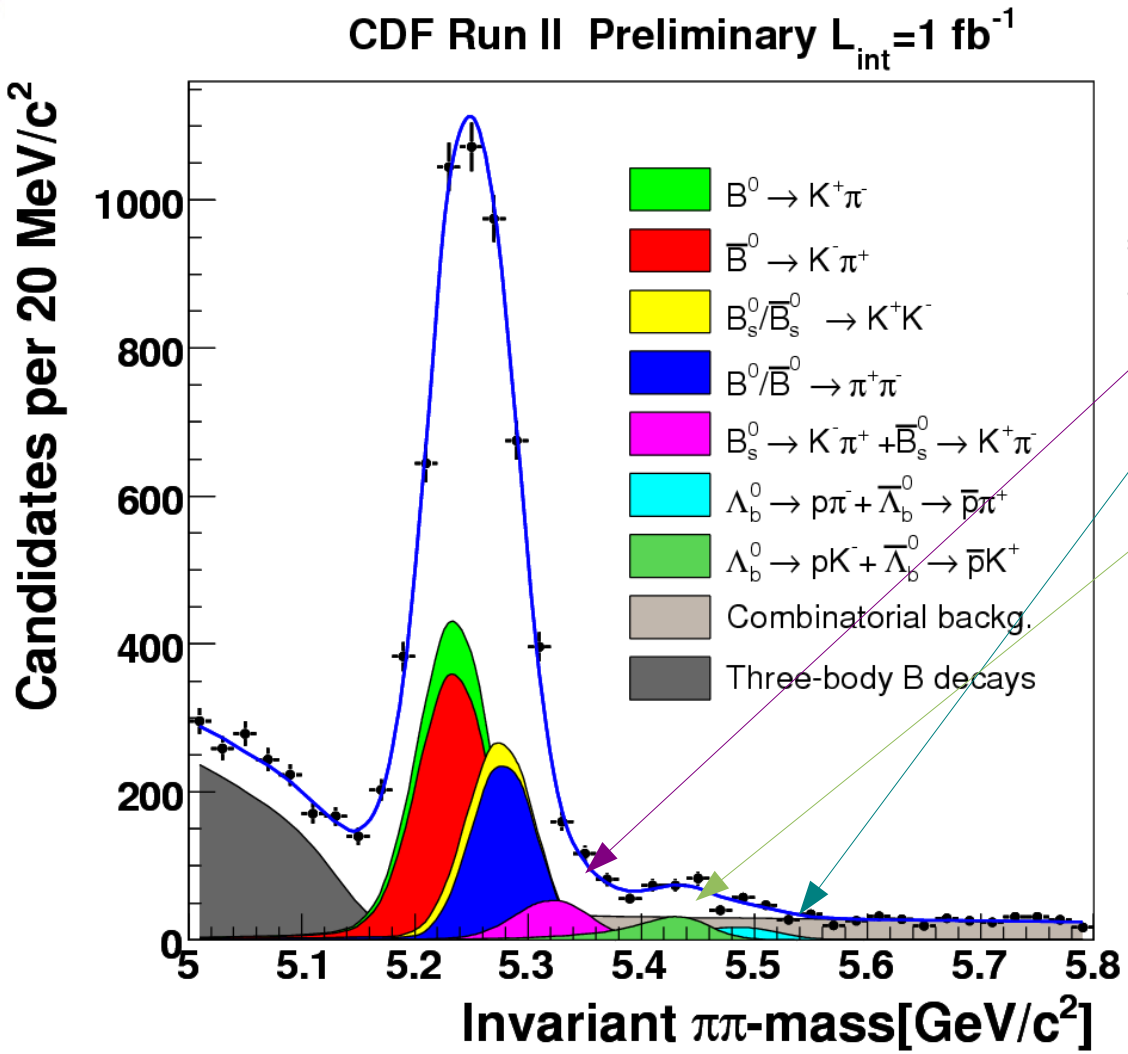
Mass shape test over D0 samples

- To test the method we used a sample of D0 mesons from D*
- We used the custom MonteCarlo simulation:
  - w/o FSR effect:
    - 2 Gaussian model for signal
    - Line for background
  - w/ FSR effect
    - 2 Gaussian+Erfc function
    - Linear background
- We have a very good agreement with FSR ON





Fit



parameter	fraction	yield
$B_s^0 \to K^-\pi^+ + \text{c.c.}$	(0.040 ± 0.006)	230 ± 34
$\Lambda_b^0 \to p\pi^- + \text{c.c.}$	(0.019 ± 0.003)	110 ± 18
$\Lambda_b^0 \to pK^- + \text{c.c.}$	(0.027 ± 0.003)	156 ± 20

Bs->Kπ measurements

- First measurement of Bs charmless decay:

$$\frac{f_s BR(B_s^0 \to K^- \pi^+)}{f_d BR(B^0 \to K^+ \pi^-)} = 0.066 \pm 0.010(stat) \pm 0.010(sys)$$

$$BR(B_s^0 \to K^- \pi^+) = (5.0 \pm 0.75(stat) \pm 1.0(sys)) \times 10^{-6}$$

11σ

- Direct ACP violation is expected large
- The SM predicts large ACP: 37%
- Our measurement is:

$$ACP(B_s^0 \to K^- \pi^+) = 0.39 \pm 0.15(stat) \pm 0.08(sys)$$

- We can evaluate the relation:

Using HFAG

$$\frac{|A(\bar{B}^0 \to K^- \pi^+)|^2 - |A(B^0 \to K^+ \pi^-)|^2}{|A(B_s^0 \to K^- \pi^+)|^2 - |A(\bar{B}_s^0 \to K^+ \pi^-)|^2} = 0.84 \pm 0.42(stat) \pm 0.15(sys)$$

SM=1 [Lipkin, Phys. Lett. B621:126, .2005]

Λb->pK and Λb->pπ measurement

- First observation for these 2 modes
- The ratio of BR agree with predictions
- ACP is expected large

- BR and ACP measurement for Λ_b are in progress
  - Measurements extracted from a fit optimized for Bs
  - New optimization is quite to finish
  - Expected resolutions for ACPs ~17%

$$N_{raw}(\Lambda_b \to pK) = 156 \pm 20(stat) \pm 11(sys) \rightarrow 11\sigma$$

$$N_{raw}(\Lambda_b \to p\pi) = 110 \pm 18(stat) \pm 16(sys) \rightarrow 6\,\sigma$$

$$\frac{BR(\Lambda_b \to p\pi)}{BR(\Lambda_b \to pK)} = 0.66 \pm 0.14(stat) \pm 0.08(sys)$$

Agrees with prediction: (0.60-0.62)
[Mohanta et al. Phys.Rev. D63 (2001) 074001]

Backup

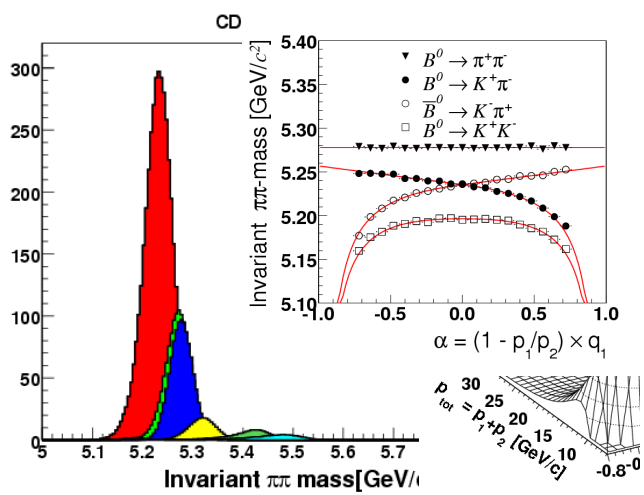
Channel separation: Likelihood

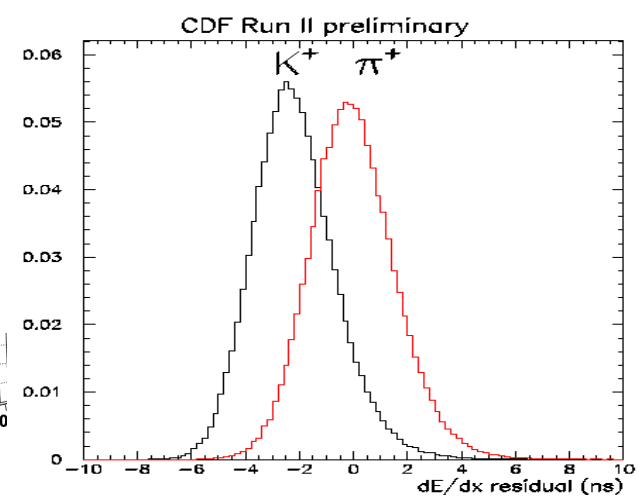
- 5 input parameters:
  - 3 Kinematic parameters:
    - alpha: momentum unbalance
    - ptot: sum of 3d momentum of tracks
    - Mass pi-pi
  - PID for both tracks

$$L=\prod_{i=1}^{N} pdf_i(\vec{x}|\vec{\theta})$$

$$pdf_i(\vec{x}|\vec{\theta})=(1-b)\cdot pdf_i^{sgn}(\vec{x}|\vec{\theta})+ +b\cdot pdf_i^{bkg}(\vec{x}|\vec{theta})$$

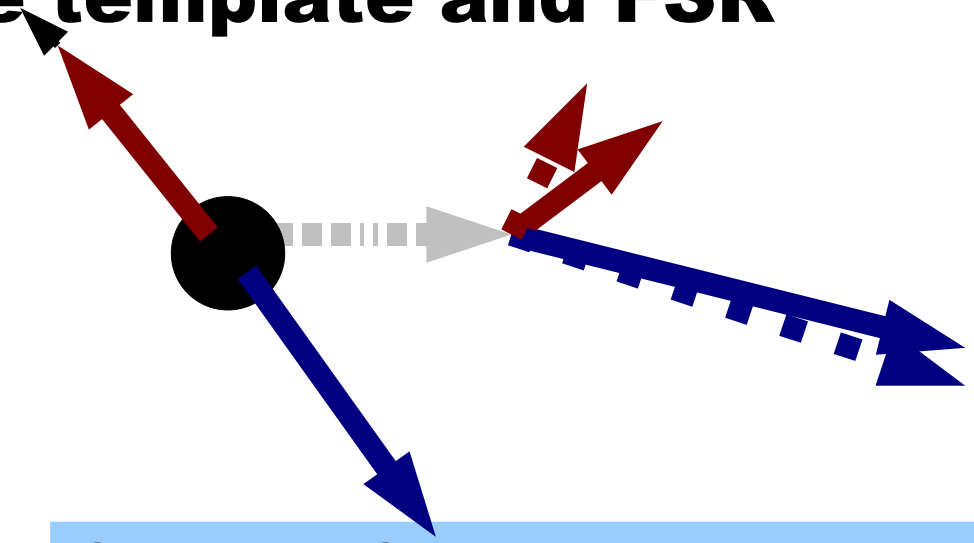
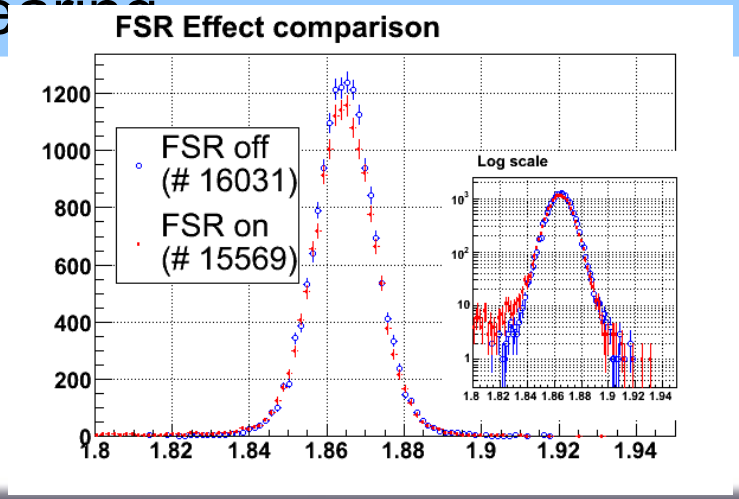
$$pdf_i^{XXX}(\vec{x}|\vec{theta})=pdf_{mass}(M_{\pi\pi},\alpha,p_{tot}|\vec{\theta})\cdot \cdot pdf_{PID}(ID_1,ID_2|\vec{\theta})\cdot \cdot pdf_{\alpha,p_{tot}}(\alpha,p_{tot}|\vec{\theta})$$





Mass shape template and FSR

- We need to take into account the effect of FSR on the mass line shape
- Use CDF detailed MC to extract the resolution on main track parameters:
  - Curvature
  - Cot(theta)
  - phi
  - IP
- Wrote a specific 2-Body kinematic simulation.
  - Decay contain photon emission according: hep-ex/??????



Custom MC steps:
- Decays generation in mass rest frame
- Boost
- Smearing