BR & ACP of $B \rightarrow h^+h^-$ modes at CDF

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for the CDF collaboration

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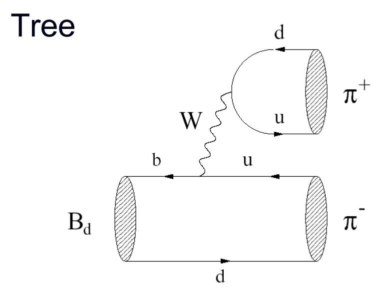
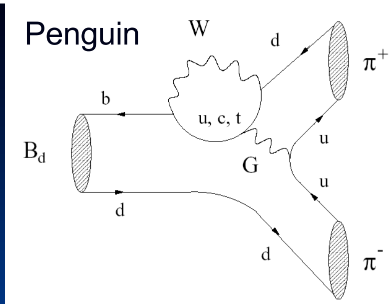


Outline



- Charmless B decays are a great tool to explore CKM and possible NP
- Single measurements hard to interpret: combination of multiple modes essential to understanding of data and comparison to theory
- Tevatron access to all b-hadrons and large Luminosity is a great opportunity for extending the range of available measurements.

- **This talk:** All modes into pairs of charged charmless hadrons:
  $(B_s / B^0 / \Lambda_b) \rightarrow h^+h'^-$ where $h = \pi$, K (or p for Λ_b)

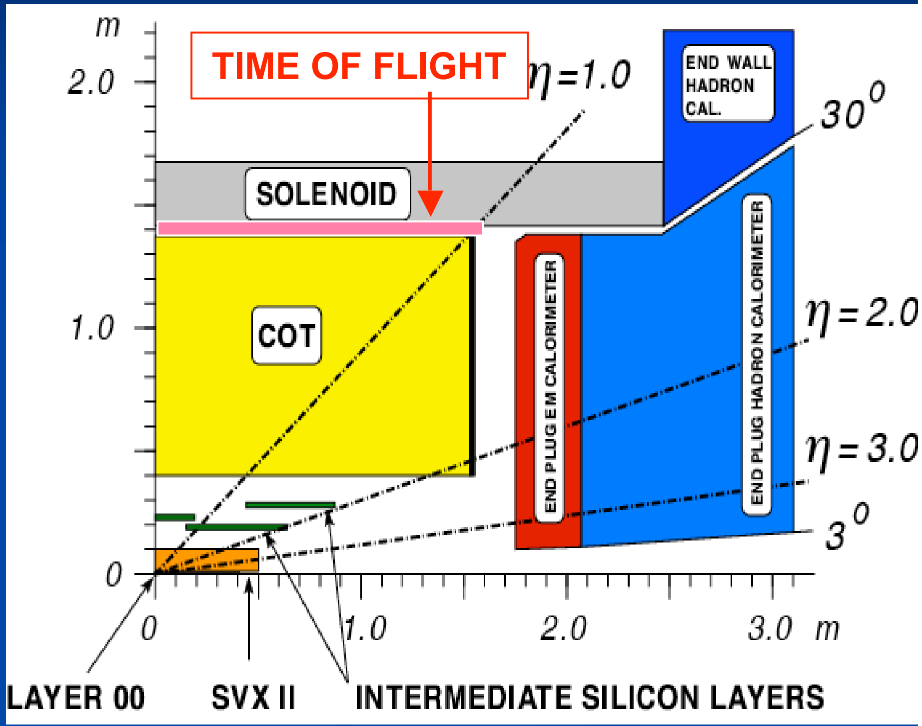
- Known modes (larger BR):
  - $B^0 \rightarrow K^+\pi^-$
  - $B^0 \rightarrow \pi^+\pi^-$
  - $B^0_s \rightarrow K^+K^-$ (observed by CDF)

- Yet unobserved modes:
  - $B^0_s \rightarrow K^-\pi^+$
  - $B^0 \rightarrow K^+K^-$
  - $B^0_s \rightarrow \pi^+\pi^-$
  - $\Lambda_b \rightarrow pK$
  - $\Lambda_b \rightarrow p\pi$

- CDF results with 1 fb^{-1} sample [CDF public note 8579]
  (Updates previous results with 180pb-1 or 360pb-1)

Important CDF features

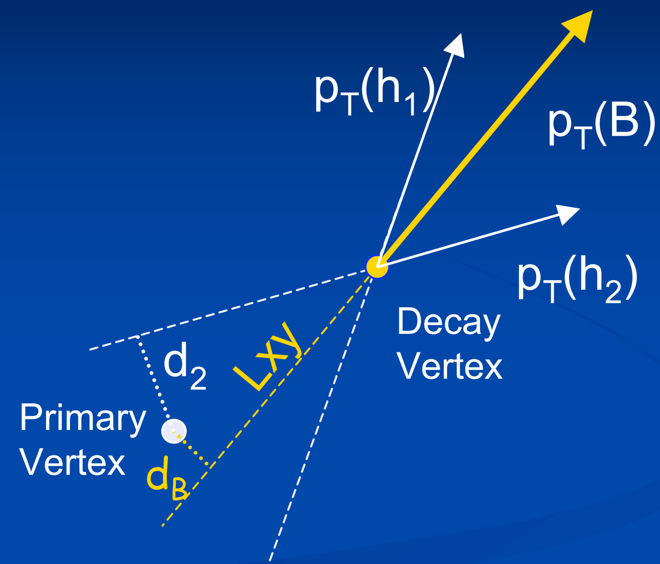
- Central Drift chamber in B field
  - $\sigma(p_T)/p_T^{\,2} \sim 0.1\%\ \mathrm{GeV}^{-1}$
  - dE/dx measurement (encoded in hit width)
- Silicon VerteX detector
  - I.P. resolution: 35μm@2GeV
- Time-of-Flight
  - Contol systematics from possible proton background asymmetry



- Tracking trigger:
  - XFT at L1: 2D tracks in COT, $p_T > 1.5\ \mathrm{GeV}/c^2$
  - SVT at L2: 2D tracks in COT+SVX $p_T > 2.0\ \mathrm{GeV}/c^2$
    - ☞ Impact parameter measurement

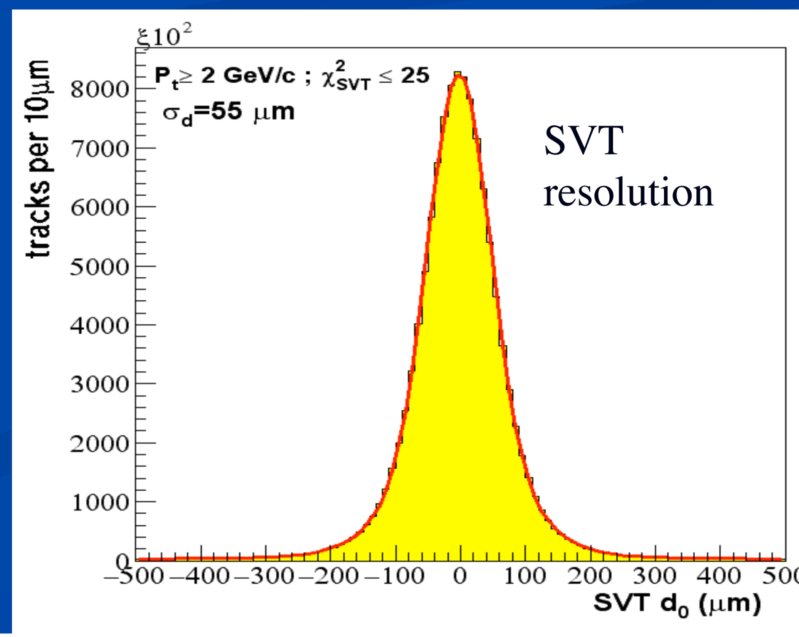
It all begins in the trigger

- Reject light-quark background
  - Two oppositely-charged tracks
  - Transverse opening angle [20°, 135°];
  - p_{T1} , p_{T2} > 2 GeV;
  - $p_{T1}+p_{T2}$ > 5.5 GeV.
- Long-lived candidate
  - Track impact parameters >100 μm;
  - Transverse decay length L> 200 μm;
- Reject multi-prongs and backgrounds
  - B impact parameter < 140 μm;

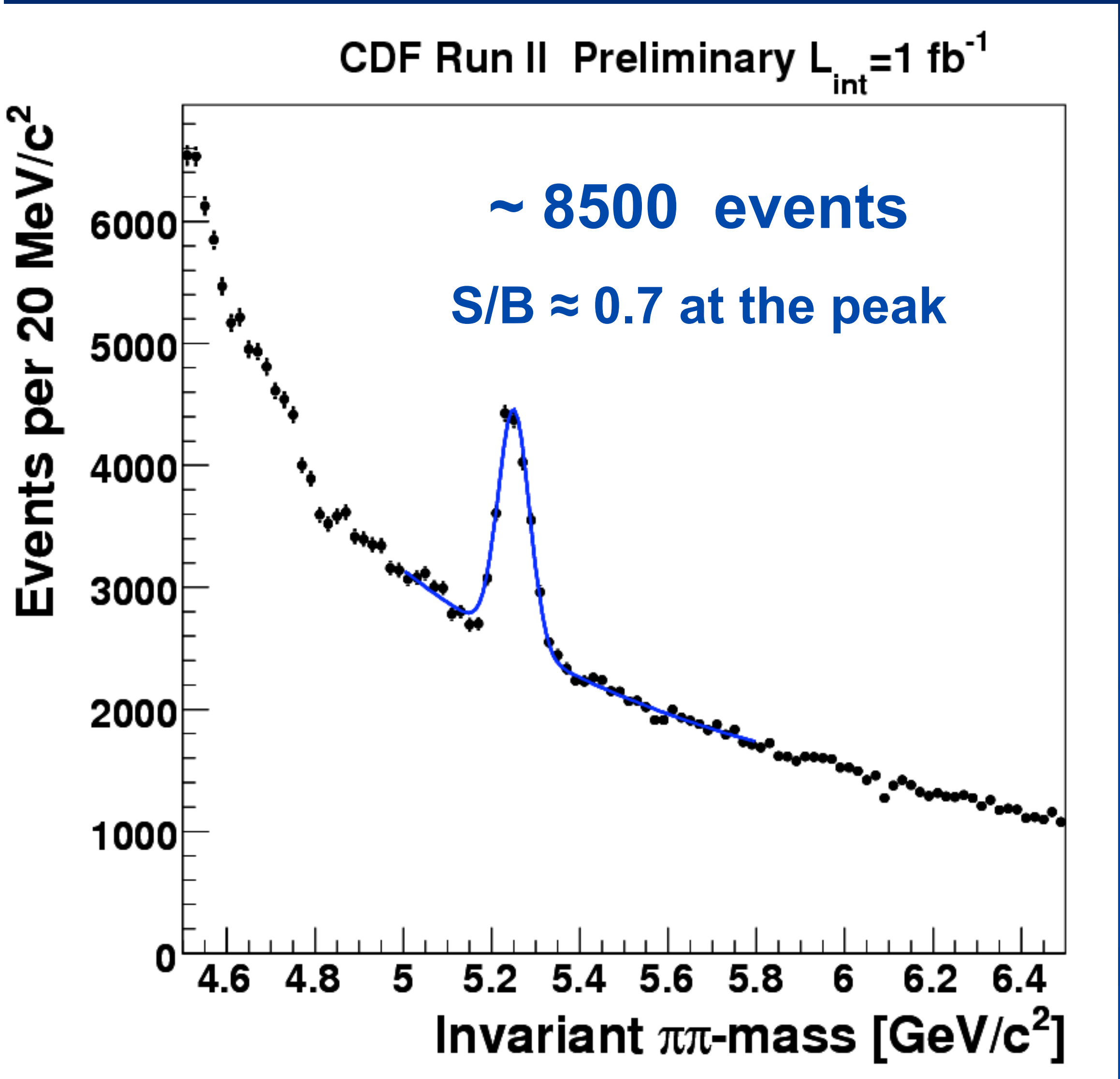


Trigger $\sigma(d_0) \approx$ offline:

48μm =35 [SVT] ⊕ 33 [beam-spot]



Signal with initial cuts



Signal (BR ~ 10^{-5}) clearly visible with just trigger cuts confirmation

Further observable used for offline analysis:

- 3D Vertex chi-square
- Isolation:

$$I(B) = \frac{Pt(B)}{Pt(B) + \Sigma_{cone} Pt_i}$$

- Isolation effective in reducing light-quark background, 85% efficient on signal (analog of event shape at e^+e^-)

Choice of cuts

Cuts individually optimized by minimizing the expected statistical uncertainty on the quantity of interest. Its expression $\sigma(S,B)$ is determined from actual uncertainties observed in analysis of MC samples, and parameterized by an analitically-inspired model.

Signal yield S is derived from MC simulation while the background B is estimated from mass sidebands on data.

In practice, only 2 sets of cuts were needed:

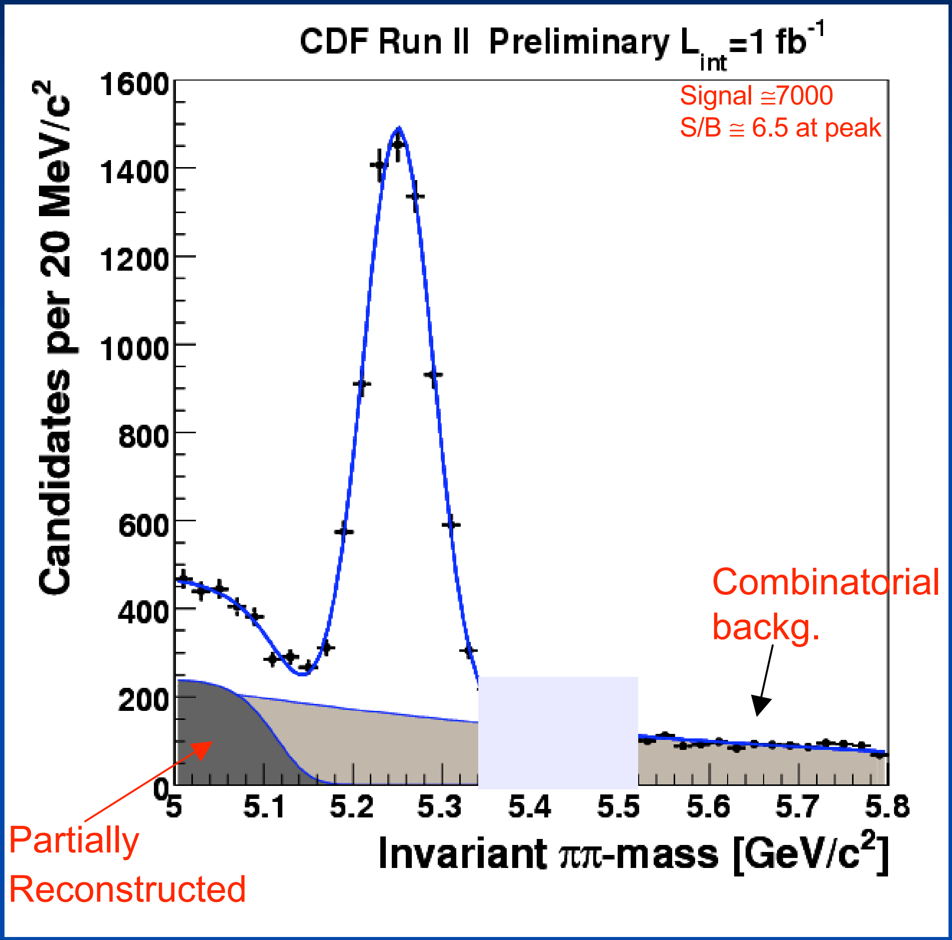
- (1) optimize on $A_{CP}(B^0 \to K^+\pi^-)$ => Loose cuts
    - good for all three "large modes" ($B^0 \to K^+\pi^-$, $B^0 \to \pi^+\pi^-$, $B^0_s \to K^+K^-$)
- (2) optimize on $B^0_s \to K^-\pi^+$ ***discovery/Limits*** [physics/0308063] $\Rightarrow$ tight cuts
    - good for all "rare modes"

When compared with $S/\sqrt{(S+B)}$:

~10% better on $A_{CP}(B^0 \to K^+\pi^-)$

~27% better on $BR(B^0_s \to K^-\pi^+)$

Offline signal (loose cuts)



Despite good mass resolution (≅22 MeV/c²), individual modes overlap in a single peak (width ~35 MeV/c²)

Note that the use of a single mass assignment (ππ) causes overlap even with perfect resolution

Blinded region of unobserved modes: $B^0_s \rightarrow K\pi$, $B^0_s \rightarrow \pi\pi$, $\Lambda^0_b \rightarrow p\pi/pK$.

Need to determine signal composition with a Likelihood fit, combining information from kinematics (mass and momenta) and particle ID (dE/dx).

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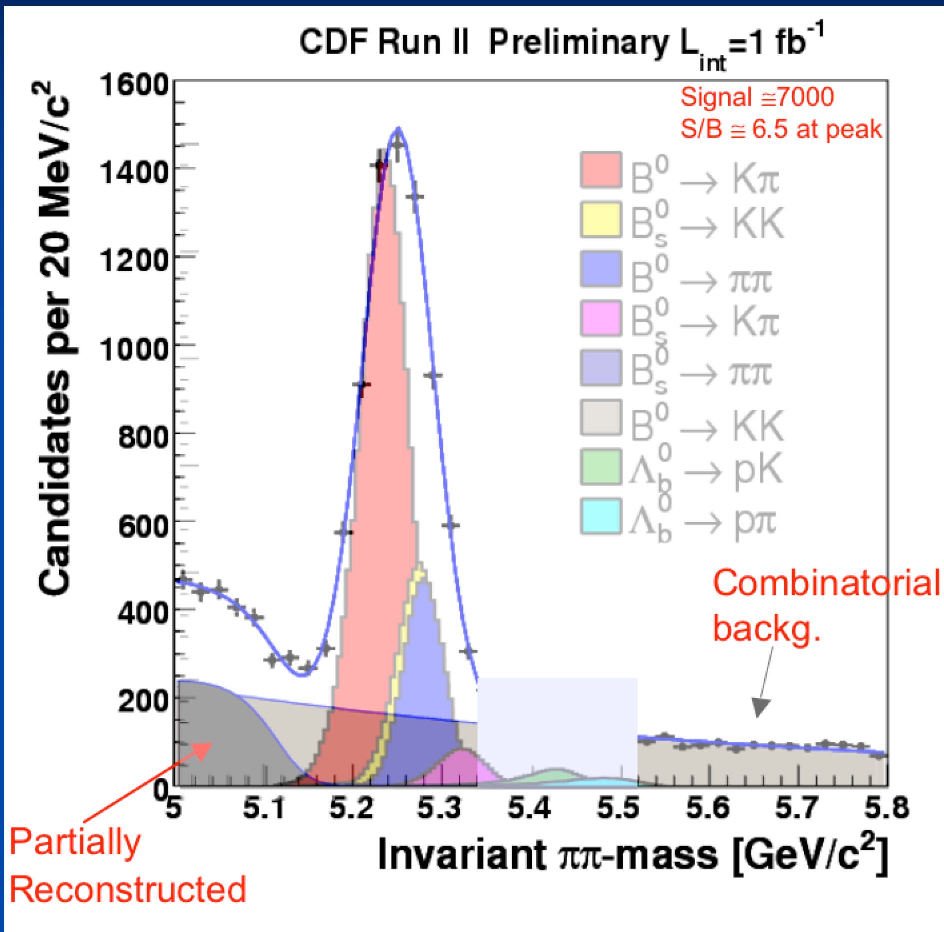

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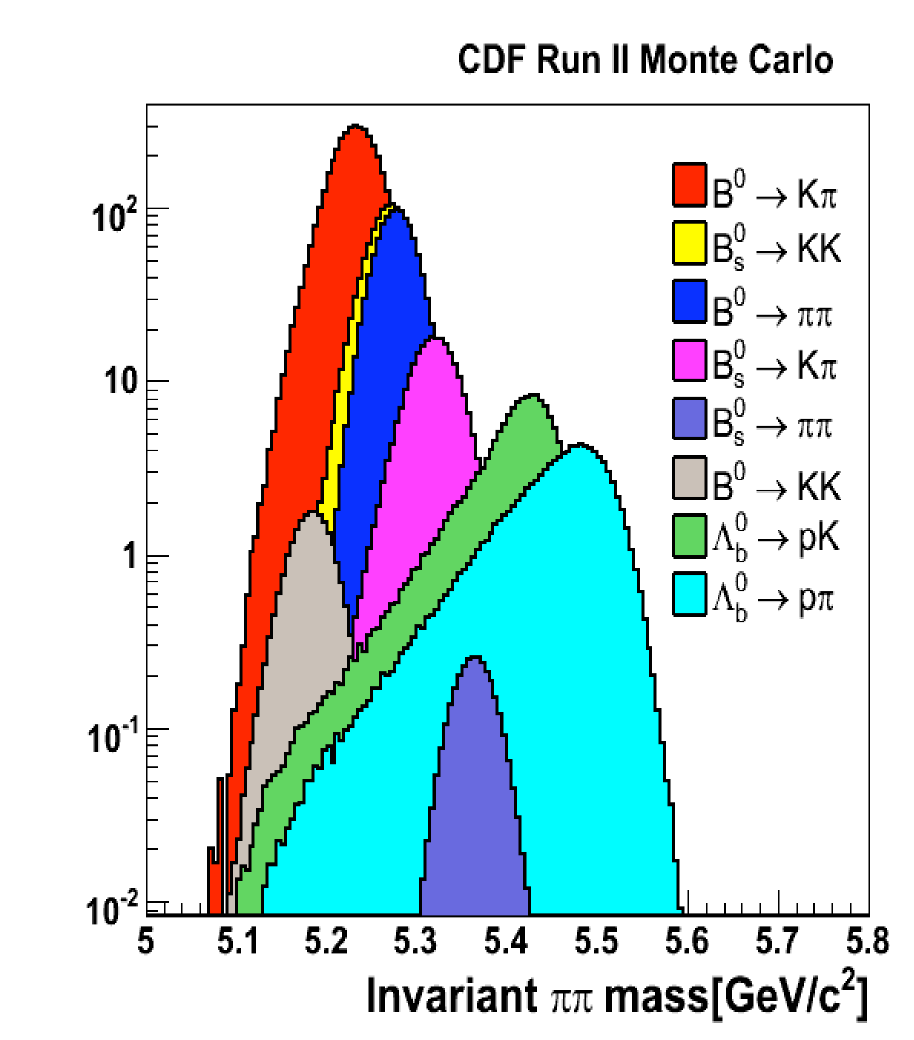
Handle 1:invariant mass

Different modes are somewhat separated in mass (~50 MeV between $B^0 \rightarrow Kpi$ and $B_s \rightarrow KK$)

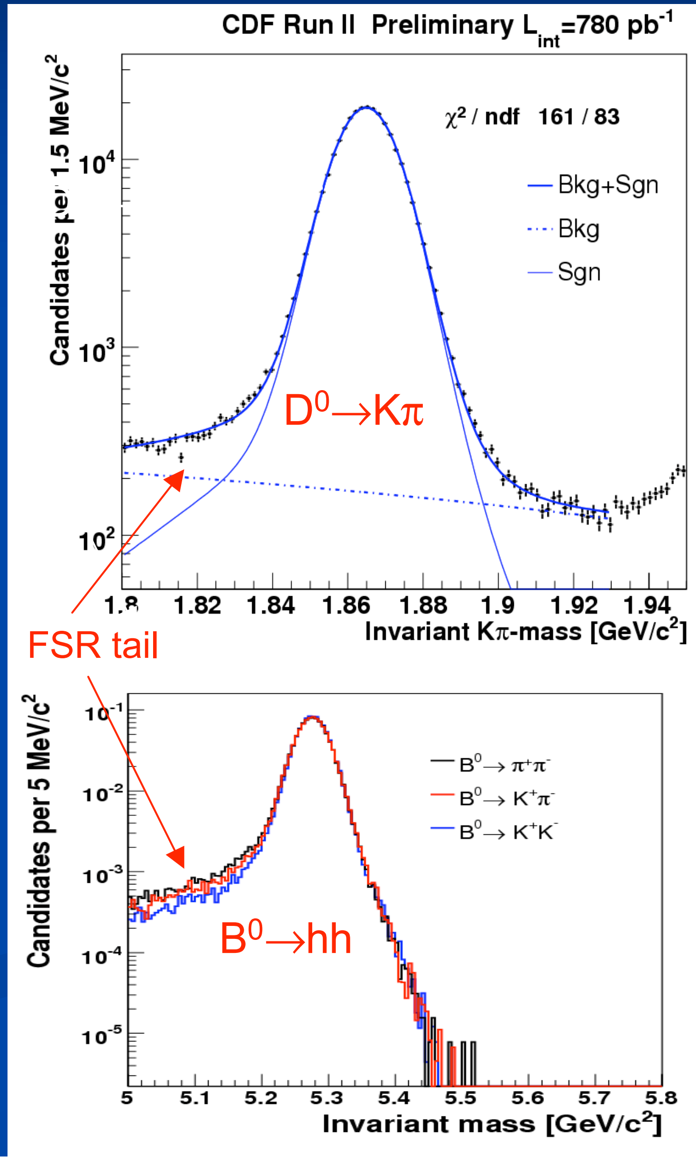
However, results depend on assumed mass resolution and details of the lineshape (rare modes confuse with the tails of larger modes)

Need good control of non–gaussian resolution tails and effects of Final State Radiation



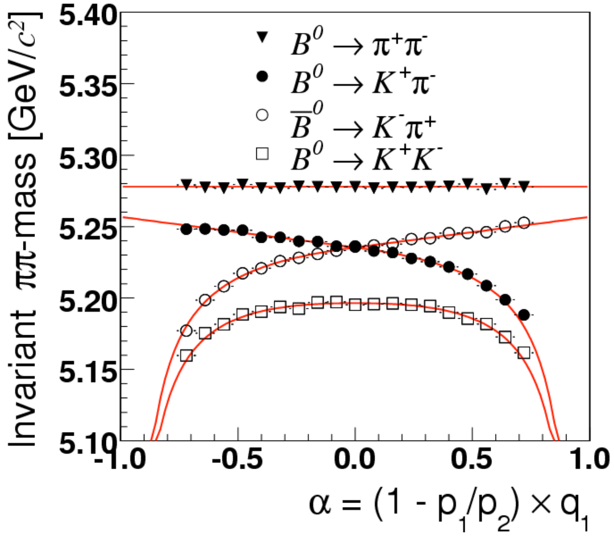
Calibrating Mass resolution and tails from the $D^0 \to$Kpi peak

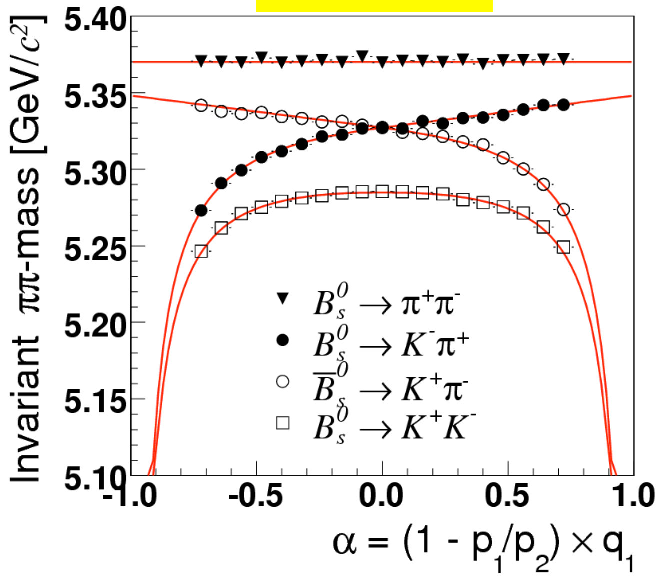
1. Accurate parameterization of *individual track parameters* resolution functions from full MC (including non-gaussian tails)
2. Add calculated QED radiation [Baracchini,Isidori PL B633:309-313,2006]
3. Generate mass lineshapes with a simple kinematical MC
4. Compare results with a huge sample of $D^0 \to K\pi$
   $\Rightarrow$ perfect match, no tuning necessary $\Rightarrow$ small systematics
5. Generate $B \to hh$ templates and use them in the Likelihood fit.

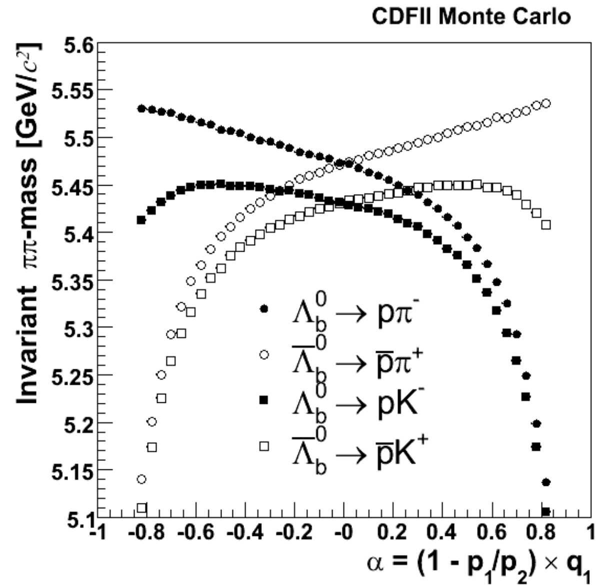


Handle 2: track momenta

CDF MC







Kinematic variables:

p_{min} (p_{max}) is the 3D track momentum with $p_{min} < p_{max}$

1) $M_{\pi\pi}$ invariant $\pi\pi$-mass
2) $\alpha = (1-p_{min}/p_{max})q_{min}$ signed p-imbalance
3) $p_{tot} = p_{min}+p_{max}$ scalar sum of 3-momenta

Each mode has an individual mass distribution $p(M_{\pi\pi}) = G(M_{\pi\pi} - F(\alpha, p_{tot}))$

This offers good discrimination amongst modes and between $K^+\pi^-$ / $K^-\pi^+$.

Handle 3: dE/dx

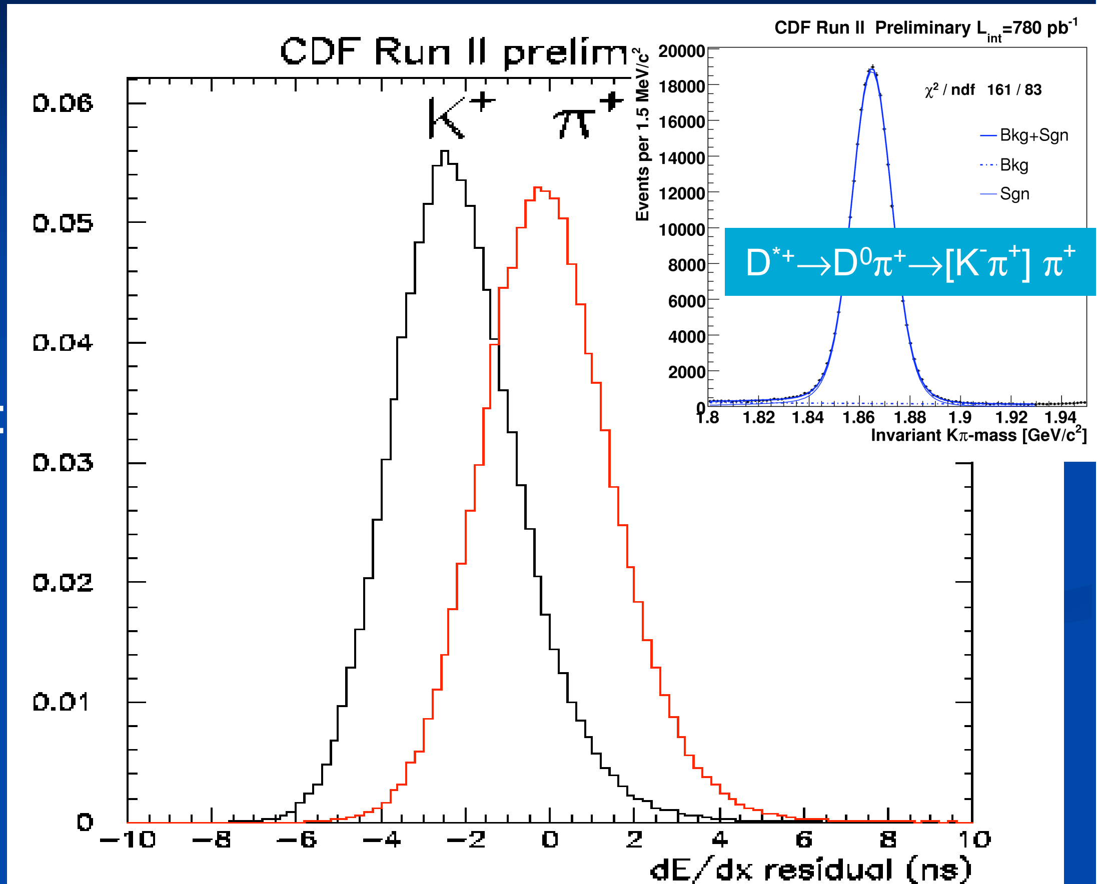
Calibrate on pure K and π samples from decay:
$D^{*+} \to D^0\pi^+ \to [K^-\pi^+]\,\pi^+$
(sign of D^{*+} pion tags D^0 sign)

Useful quantity to plot ('kaonness'):

$$\mathrm{ID(track)} = \frac{\left.\frac{dE}{dx}\right|_{meas}(\mathrm{track}) - \left.\frac{dE}{dx}\right|_{exp-\pi}(\mathrm{track})}{\left.\frac{dE}{dx}\right|_{exp-K}(\mathrm{track}) - \left.\frac{dE}{dx}\right|_{exp-\pi}(\mathrm{track})}.$$

<ID>(pion) = 0
<ID>(kaon) = 1

(independent of p)



dE/dx carefully calibrated over tracking volume and time.
Detailed model includes tails, momentum dependence, two-track correlations

1.4σ K/π separation for p>2GeV achieve a statistical uncertainty on separating classes of particles which is just 60% worse than 'perfect' PID

Putting it all together

NB:Only measure *relative* BRs and normalize to $B^0 \to K^+\pi^-$. (use HFAG06)

Unbinned ML fit based on 5 observables

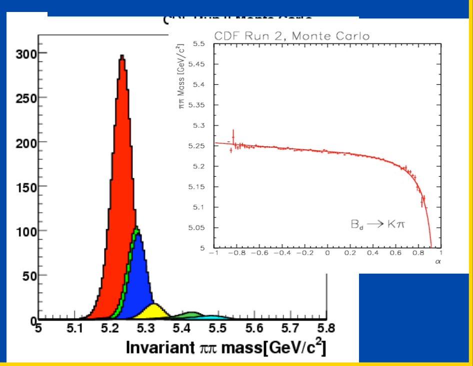
$$\mathscr{L}(\vec{\theta}) = \prod_{i=1}^{N} \mathscr{L}_i(\vec{\theta})$$

fraction of j[th] mode, to be determined by the fit

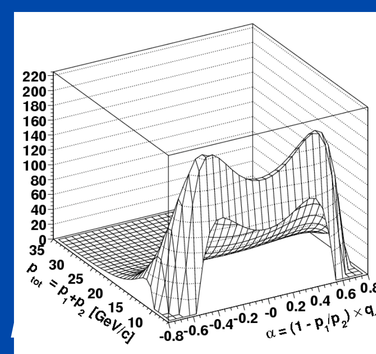
$$\mathscr{L}_i(\vec{\theta}) = (1-b)\sum_j f_j \mathscr{L}_j^{\text{sign}} + b\mathscr{L}^{\text{bckg}}$$

$$pdf_j^{\text{m}}(m_{\pi\pi}|\alpha, p_{tot};\vec{\theta}) \cdot pdf_j^{\text{p}}(\alpha, p_{tot};\vec{\theta}) \cdot pdf_j^{\text{PID}}(\text{ID}_1, \text{ID}_2|p_{tot}, \alpha;\vec{\theta})$$

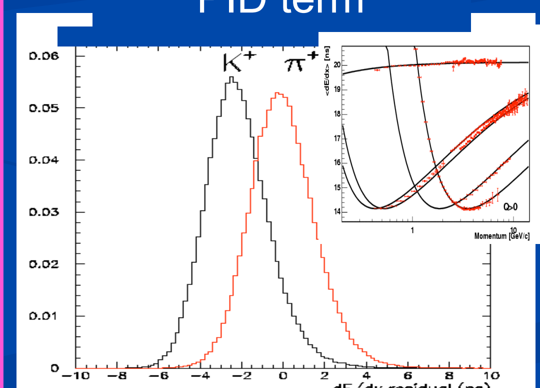
mass term



momentum term



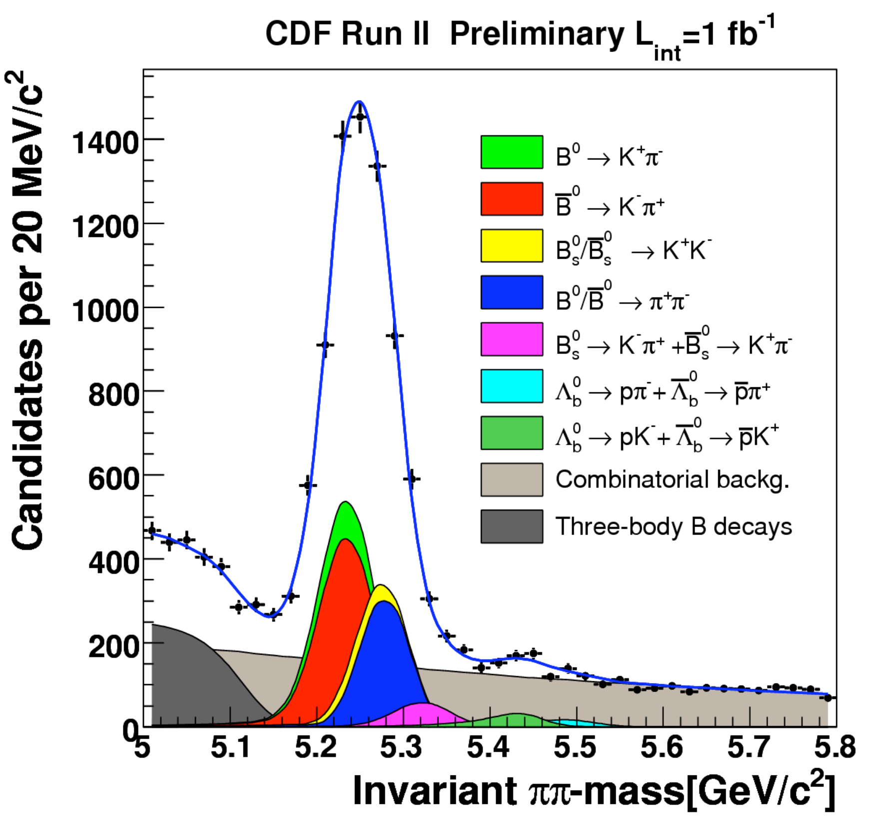
PID term



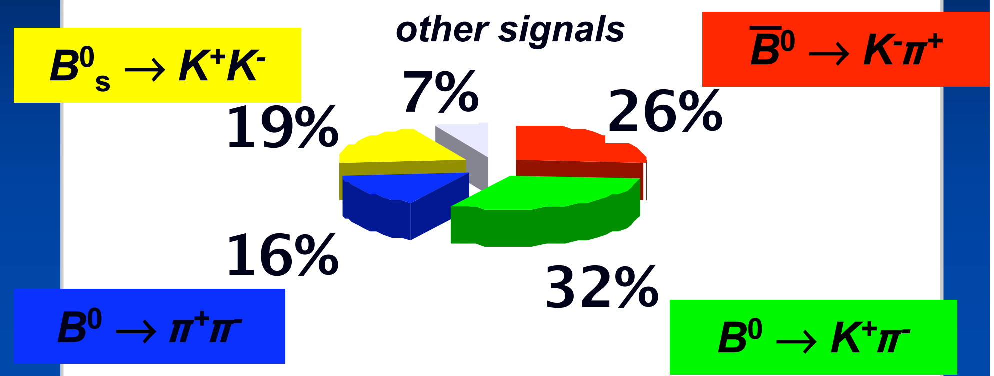
Signal shapes: from MC and analytic formula
Background shapes: from data sidebands

sign and bckg shapes from $D^0 \to K^-\pi^+$

Loose cuts, raw fit results



Uncorrected fractions

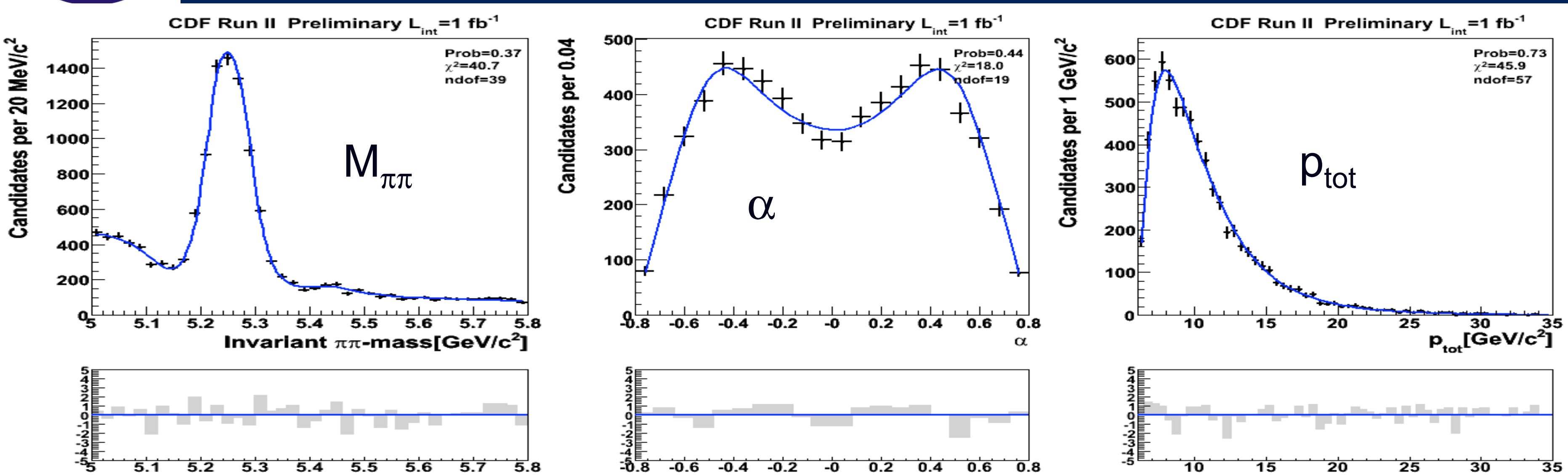


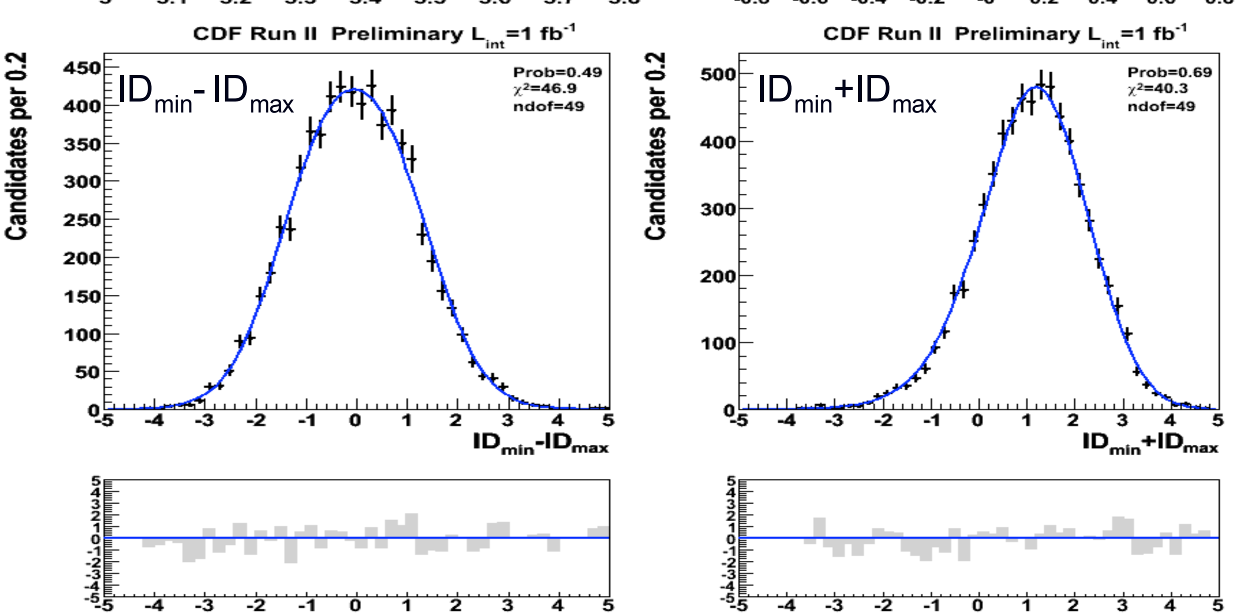
~7000 events total

- B^0 yields comparable to e^+e^-
- Large $B^0_s \to K^+K^-$ sample
- Good separation: compare to √N below

parameter	fraction	yield	σ/σ_{ideal}
$B^0 \to \pi^+\pi^-$ + c.c.	(0.160 ± 0.009)	1121 ± 63	1.8
$B^0 \to K^+\pi^-$ + c.c.	(0.577 ± 0.010)	4045 ± 84	1.3
$B^0_s \to K^+K^-$ + c.c.	(0.186 ± 0.009)	1307 ± 64	1.8

Fit projections





Many crosschecks:

-Gaussian fit pulls

-PID-less fit agrees with regular fit

- Free-mass-resolution fit agrees with standard fit

- Free-mass-scale fit agrees and returns mass shift

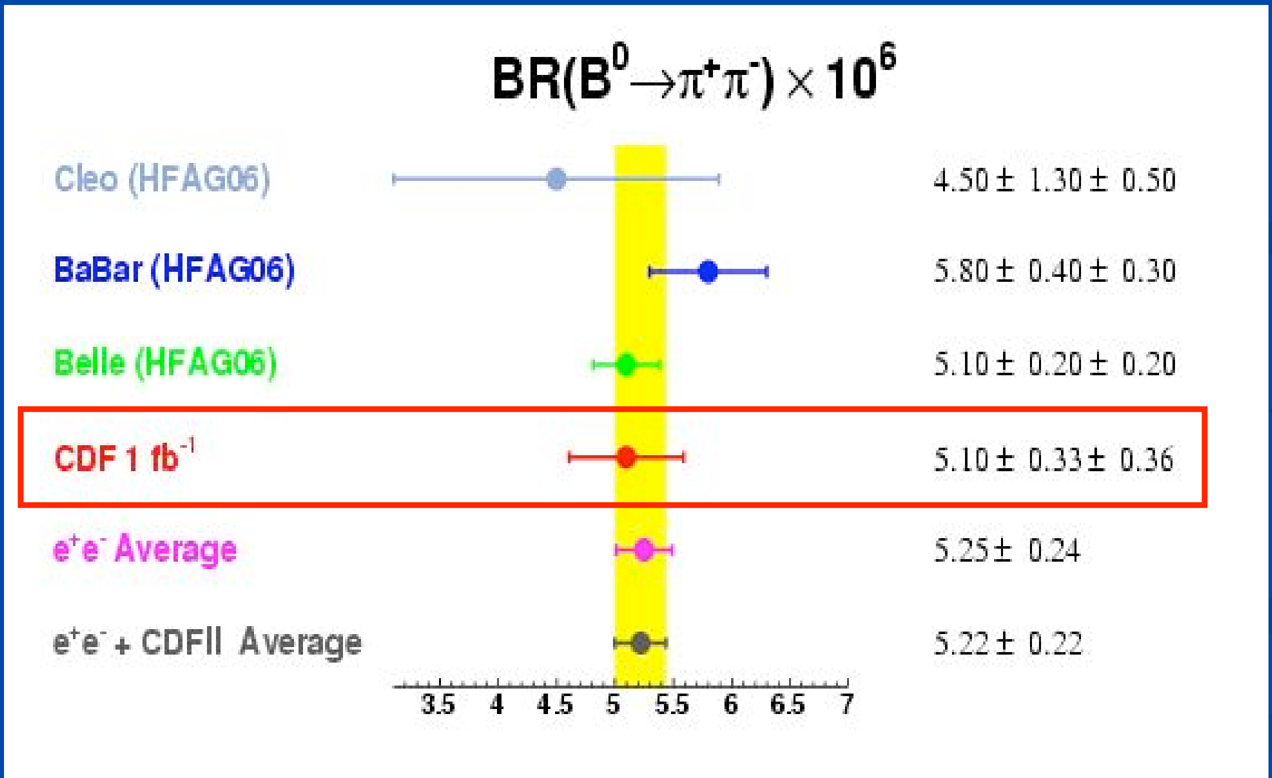
$\delta = 0.2 \pm 0.6$ MeV/c^2

Results for known modes

BR($B^0 \rightarrow \pi^+\pi^-$)

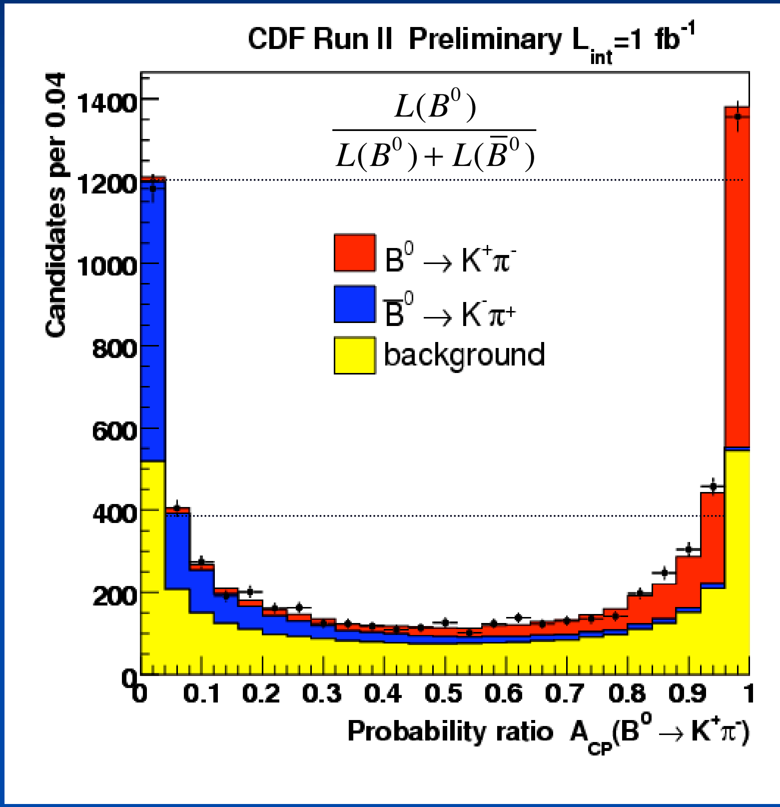
$$\frac{BR(B^0 \rightarrow \pi^+\pi^-)}{BR(B^0 \rightarrow K^+\pi^-)} = 0.259 \pm 0.017\ (stat.) \pm 0.016\ (syst.)$$

$$BR(B^0 \rightarrow \pi^+\pi^-) = (5.10 \pm 0.33\ (stat.) \pm 0.36\ (syst.)) \times 10^{-6}$$



- Precision measurements. systematic≅ statistics.
- Confirm previous results in a very different experimental setting
- Good yield, bright perspectives for time-dependent measurements: expect similar resolution to e+e- with full runII sample

Direct ACP ($B^0 \to K^+\pi^-$)



Large sample >4000 events allows measuring DCPV

Plot of $L(B^0)/[L(B^0)+L(\bar{B}^0)]$ shows good separation achieved between B^0 and $\bar{B}^0$ (mass, alpha, dE/dx)

Significant raw asymmetry, good resolution:

$$A_{CP}\Big|_{raw} = \frac{N_{raw}(\bar{B}^0 \to K^-\pi^+) - N_{raw}(B^0 \to K^+\pi^-)}{N_{raw}(\bar{B}^0 \to K^-\pi^+) + N_{raw}(B^0 \to K^+\pi^-)} = -0.092 \pm 0.023$$

Correcting the raw A_{CP}

$$A_{CP}(B^0 \to K^+\pi^-) = \frac{N_{raw}(\overline{B}^0 \to K^-\pi^+)\cdot\frac{\varepsilon(K^+\pi^-)}{\varepsilon(K^-\pi^+)} - N_{raw}(B^0 \to K^+\pi^-)}{N_{raw}(\overline{B}^0 \to K^-\pi^+)\cdot\frac{\varepsilon(K^+\pi^-)}{\varepsilon(K^-\pi^+)} + N_{raw}(B^0 \to K^+\pi^-)}$$

Only the different K^+/K^- interaction rate with material matters. K^- has a larger hadronic cross section than K^+.

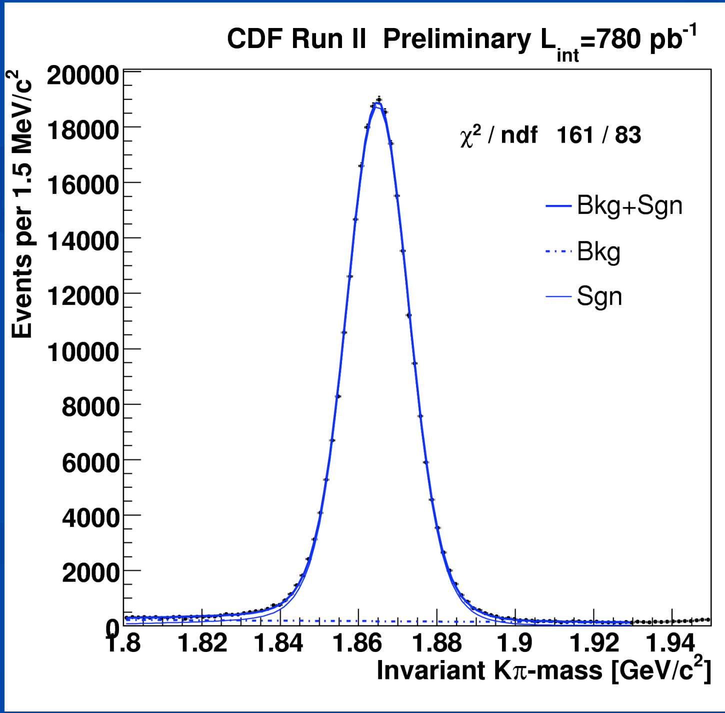
Huge sample of prompt $D^0 \to h^+h^-$ (15M).

Kinematic fit using the *same code* of the $B \to hh$ fit

Direct $A_{CP}(D^0 \to K\pi)$ very small:

$\Rightarrow$ extract from DATA correction for $\varepsilon(K^-\pi^+)/\varepsilon(K^+\pi^-)$ plus any other possible spurious asymmetries.

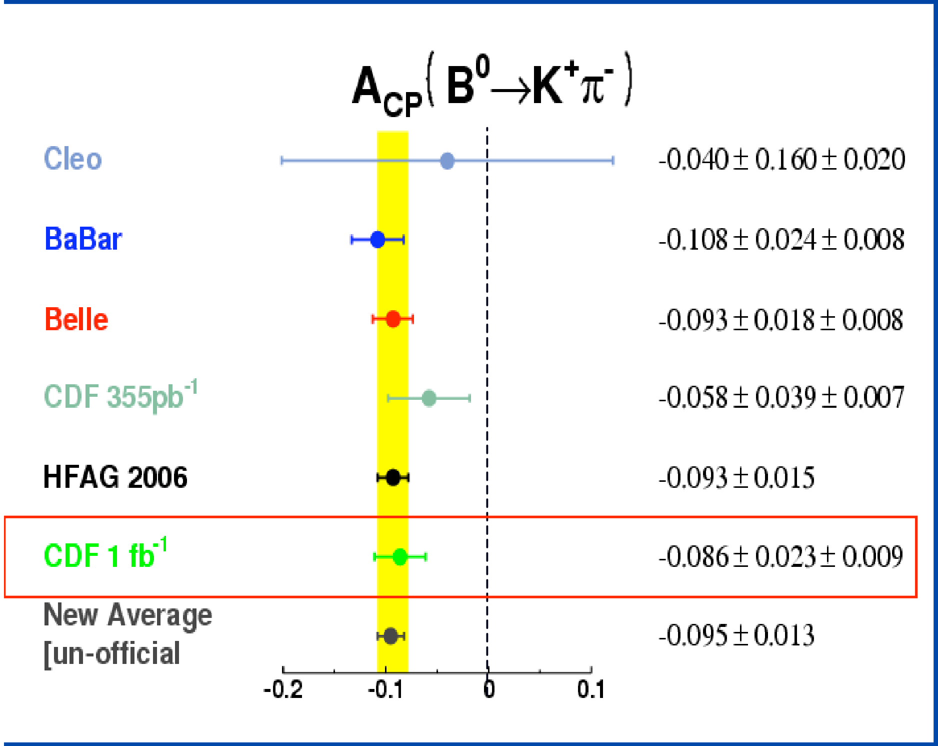
$$\frac{\epsilon(K^+\pi^-)}{\epsilon(K^-\pi^+)} = 1.0131 \pm 0.0028\ (stat.).$$



Small (~0.6%) correction. Agrees with indipendent evaluation from CDF simulation.

Results on $A_{CP}(B^0 \to K^+\pi^-)$

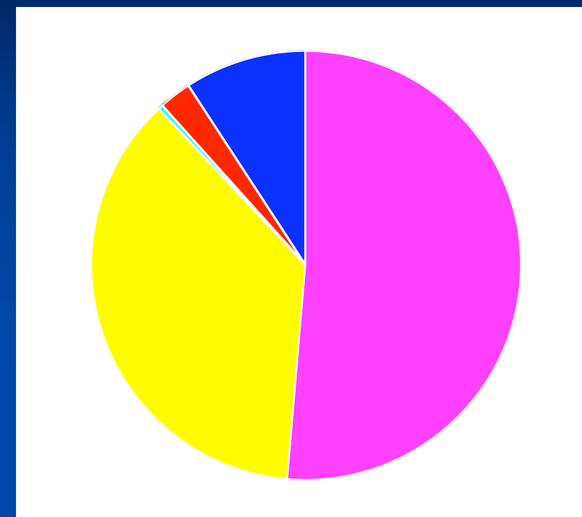
$$A_{CP} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.086 \pm 0.023\ (stat.) \pm 0.009\ (syst.)$$



- ✓CDF agrees with e^+e^- (**3.5σ** effect)
- ✓WA significance 6 σ →7 σ
- ✓Discrepancy with $A_{CP}(B^+ \to K^+\pi^0)$ now up to **4.9 σ**
- ✓Whether this really means new physics has been subject to debate.
- ✓CDF can help clarifying the issue by a much more robust test, based on $B_s \to K\pi$ (more on this shortly)

Systematics $A_{CP}(B^0 \to K^+\pi^-)$

- dE/dx model (±0.0064);
- Nominal *B*-meson masses (±0.005);
- Global mass scale;
- Charge-asymmetries (±0.0014);
- Background model (±0.003).



Total systematic uncertainty is 0.9%, compare with 2.3% statistical.

Largest effect (dE/dx) also verified with additional crosscheck:
measurement of $A_{CP}(D^0 \to K\pi)$ based on dE/dx-only.
Discrepancy with the kinematic fit (≅0.006) within quoted systematics.

Systematics can still decrease with larger calibration samples
Prospects for a runII CDF measurement with <1% uncertainty.

B_s

$BR(B^0_s \rightarrow K^+K^-)$

$$\frac{f_s \cdot BR(B^0_s \rightarrow K^+K^-)}{f_d \cdot BR(B^0 \rightarrow K^+\pi^-)} = 0.324 \pm 0.019\ (stat.) \pm 0.041\ (syst.)$$

$$BR(B^0_s \rightarrow K^+K^-) = (24.4 \pm 1.4\ (stat.) \pm 4.6\ (syst.)) \times 10^{-6}$$

Conservative systematics at the moment, expect syst$\cong$ stat for final result

Interesting comparison to predictions:

Naively : $BR(B^0_s \rightarrow K^+K^-) \cong BR(B^0 \rightarrow K^+\pi^-) \cong 20 \cdot 10^{-6}$

QCDF : BR $23\text{-}36 \cdot 10^{-6}$ [Beneke&Neubert NP B675, 333(2003)]

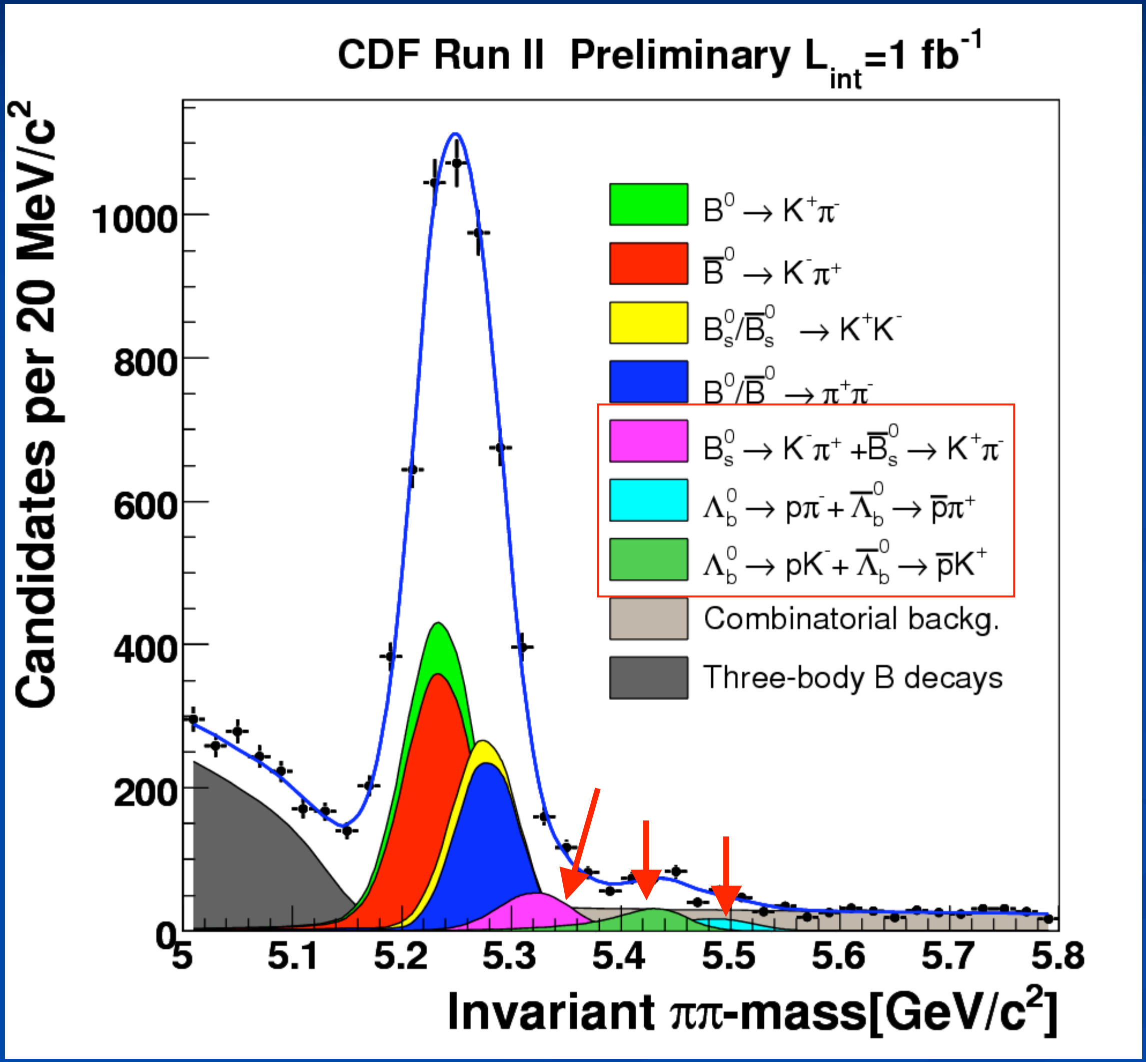
QCD sum rules predict large SU(3) breaking BR $\cong 35 \cdot 10^{-6}$
[Khodjamirian et al. PRD68:114007, 2003; Buras et al, Nucl. Phys. B697, 133,2004]

More recently, 1/mb corrections give lower values again: $BR=(20 \pm 9) \cdot 10^{-6}$
[Descotes-Genon et al. PRL97, 061801, 2006]

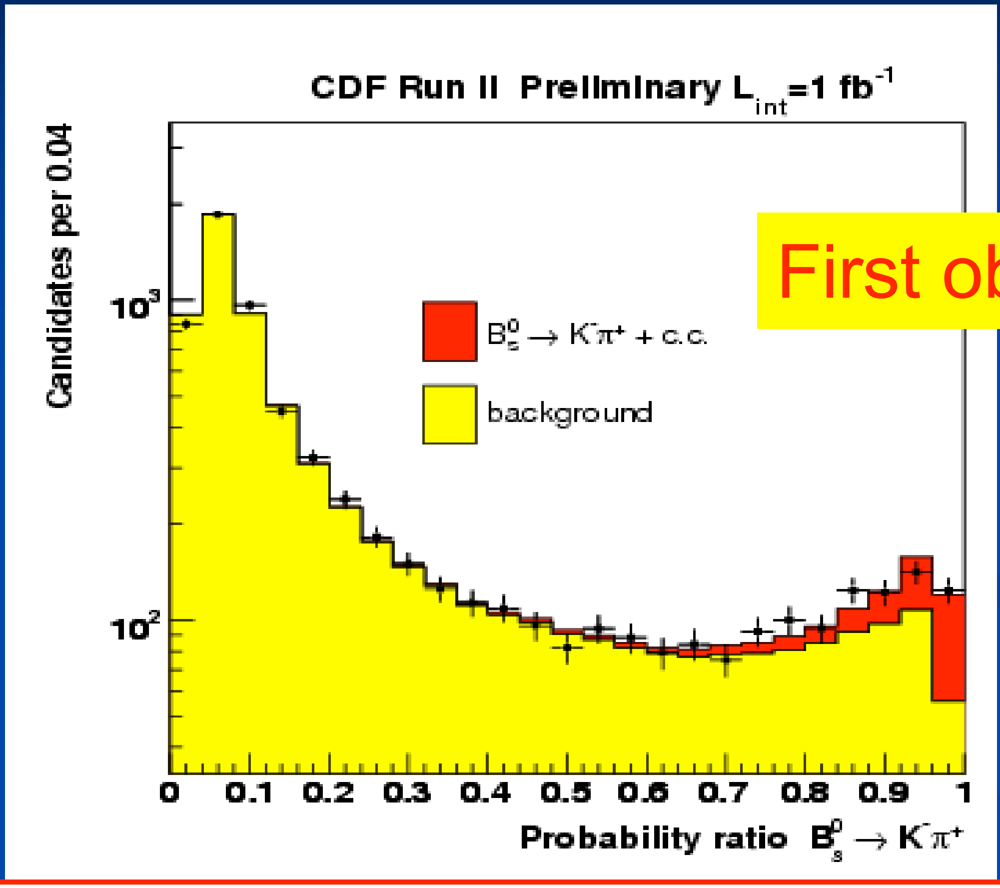
Further useful results expected from upcoming time-dependent measurements

Search for new modes

Rare modes search (tight cuts)



$B^0_s \to K^-\pi^+$



First observation(**8σ**)

$$N_{\rm raw}(B^0_s \to K^-\pi^+) \quad = \quad 230 \pm 34\ (stat.) \pm 16\ (syst.)$$

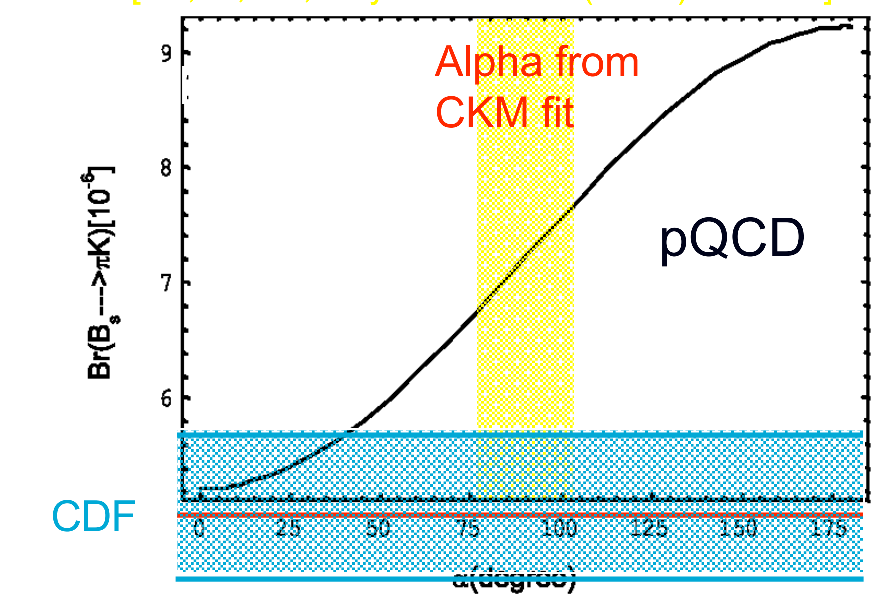
$BR(B^0_s \rightarrow K^-\pi^+)$

$$\frac{f_s \cdot BR(B^0_s \rightarrow K^-\pi^+)}{f_d \cdot BR(B^0 \rightarrow K^+\pi^-)} = 0.066 \pm 0.010\ (stat.) \pm 0.010\ (syst.)$$

$$BR(B^0_s \rightarrow K^-\pi^+) = (5.0 \pm 0.75\ (stat.) \pm 1.0\ (syst.)) \times 10^{-6}$$

Previous limit (CDF) < 5.4 @90% CL

[Yu, Li, Yu, Phys.Rev. D71 (2005) 074026]



Large sensitivity to angle α/ϕ_2

[Gronau, Rosner, Phys. Lett. B 482, 71 (2000)]

[Yu, Li, Yu, Phys.Rev. D71 (2005) 074026]

SOME PREDICTIONS:

QCDF $[7 \div 10] \cdot 10^{-6}$

[Beneke&Neubert NP B675, 333(2003)]

pQCD: $[6 \div 10] \cdot 10^{-6}$

[Yu, Li, Yu, PRD71: 074026 (2005)]

SCET: $(4.9 \pm 1.8) \cdot 10^{-6}$

[Williamson,Zupan:PRD74(2006)014003]

Results agree with recent lower estimates

DCPV $B^0_s \to K^-\pi^+$

Observation of this decay offers a unique opportunity of investigating the source of CP violation, and the reason for the discrepancy in B^0 vs B^+:

"Is observed direct CP violation in $B^0 \to K^+\pi^-$ due to new physics ?
Check standard Model prediction of equal violation in $B^0_s \to K^-\pi^+$ "

[Lipkin, Phys. Lett. B621:126, .2005] [Gronau Rosner Phys.Rev. D71 (2005) 074019]

$$|A(B_s \to \pi^+ K^-)|^2 - |A(\bar{B}_s \to \pi^- K^+)|^2 = |A(\bar{B}_d \to \pi^+ K^-)|^2 - |A(B_d \to \pi^- K^+)|^2$$

This comparison of $B^0 \to K^+\pi^-$ and $B^0_s \to K^-\pi^+$ is a probe of NP in CP violation based on really minimal assumption. Currently unique to CDF.

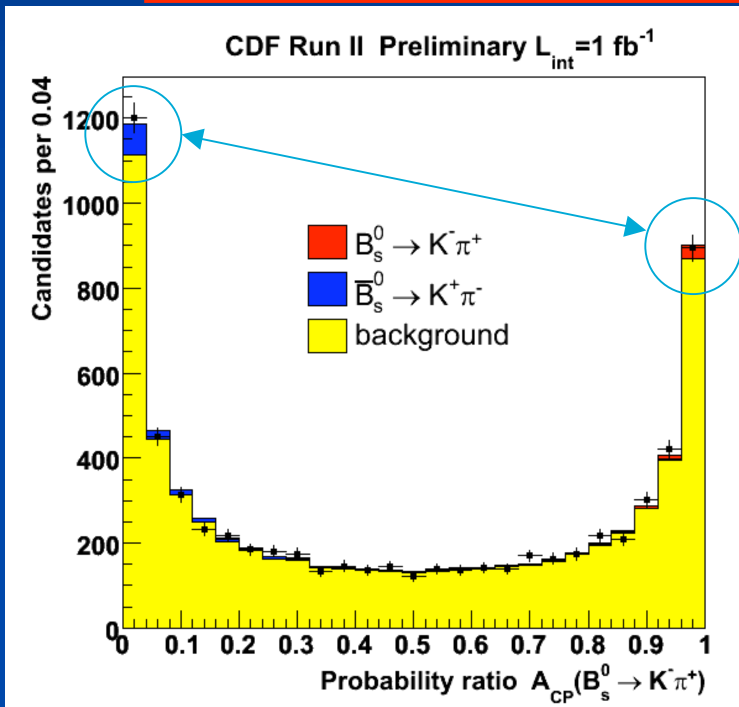
$$\frac{A_{CP}(B_s \to K^-\pi^+)}{A_{CP}(B_d \to K^+\pi^-)} = \frac{BR(B_d \to K^+\pi^-)}{BR(B_s \to K^-\pi^+)}$$

From our measured low BR, expect large asymmetry $\cong$ **37%**

DCPV $B^0_s \to K^-\pi^+$

$$A_{CP} = \frac{N(\overline{B}^0_s \to K^+\pi^-) - N(B^0_s \to K^-\pi^+)}{N(\overline{B}^0_s \to K^+\pi^-) + N(B^0_s \to K^-\pi^+)} = 0.39 \pm 0.15\ (stat.) \pm 0.08\ (syst.)$$

2.5 σ



$$\frac{|A(\bar{B}_d \to \pi^+ K^-)|^2 - |A(B_d \to \pi^- K^+)|^2}{|A(B_s \to \pi^+ K^-)|^2 - |A(\bar{B}_s \to \pi^- K^+)|^2}$$

= 0.84 ± 0.42(stat.) ± 0.15(syst.) (SM =1)

First measurement of DCPV in the Bs

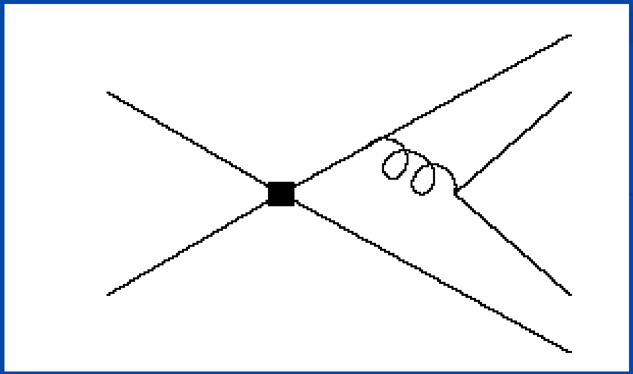
Sign and magnitude agree with SM predictions within errors

⇒ no evidence for exotic sources of CP violation (yet)

Exciting to pursue with more data

Even rarer modes:

Weak annihilation



Pure-annihilation modes

- All final-state quarks different from initial state quarks. ⇒only via annihilation-type diagrams
- Not yet observed. Small BR, with large uncertainties.
- Depends on hard-to-predict hadronic parameters ⇒ large source of uncertainty in calculations.
- CDF can look for $B_s \to \pi^+\pi^-$ in addition to $B_d \to K^+K^-$,

  B_s is expected larger by x3-x4.

• To extract annihilation hadronic parameters, need BOTH measurements:

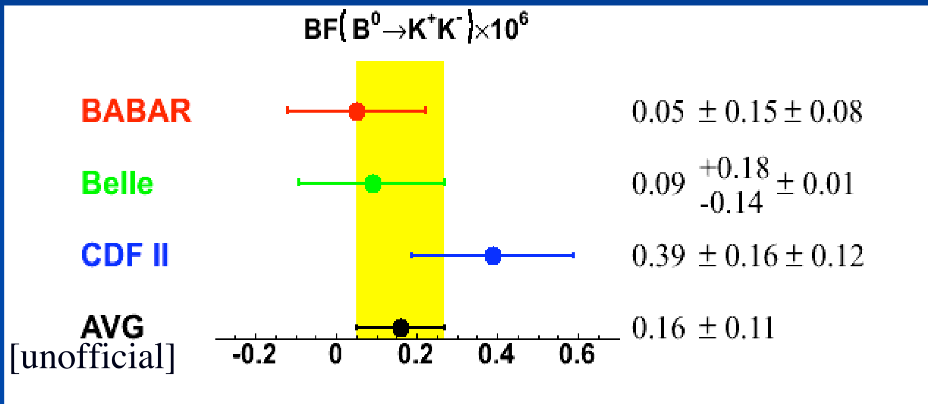
$$\frac{1}{\epsilon}\left[\frac{\mathrm{BR}(B_d \to K^+K^-)}{\mathrm{BR}(B_s \to \pi^+\pi^-)}\right]\frac{\tau_{B_s^0}}{\tau_{B_d^0}} = \frac{1 + 2\varrho_{\mathcal{PA}}\cos\vartheta_{\mathcal{PA}}\cos\gamma + \varrho_{\mathcal{PA}}^2}{\epsilon^2 - 2\epsilon\varrho_{\mathcal{PA}}\cos\vartheta_{\mathcal{PA}}\cos\gamma + \varrho_{\mathcal{PA}}^2}$$

[Buras et al., Nucl.Phys. B697 (2004) 133]

Results on $B^0_s \to \pi^+\pi^-$, $B^0 \to K^+K^-$

$$BR(B^0 \to K^+K^-) = (0.39 \pm 0.16\ (stat.) \pm 0.12\ (syst.)) \times 10^{-6}$$

($< 0.7 \cdot 10^{-6}$ @ 90% CL)



New WA : 0.16 ± 0.11 [speaker's calculation]

Expectations [0. 007 ÷ 0.08] $\cdot 10^{-6}$

[Beneke&Neubert NP B675, 333(2003)]

$\Rightarrow$ now in the region of interest

Best current limit

$$BR(B^0_s \to \pi^+\pi^-) = (0.53 \pm 0.31\ (stat.) \pm 0.40\ (syst.)) \times 10^{-6}$$

$<1.36 \cdot 10^{-6}$ @ 90% CL

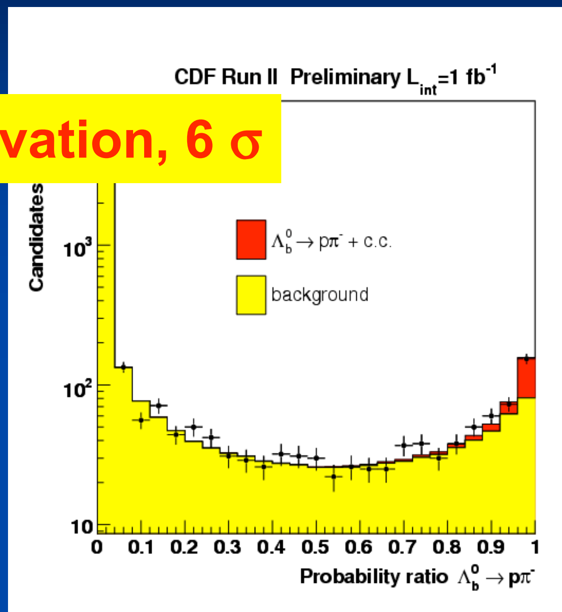
Expectations: [0.024 ÷ 0.16] $\cdot 10^{-6}$ [Beneke&Neubert NP B675, 333(2003)]

$0.42 \pm 0.06 \cdot 10^{-6}$ [Li et al. hep-ph/0404028]

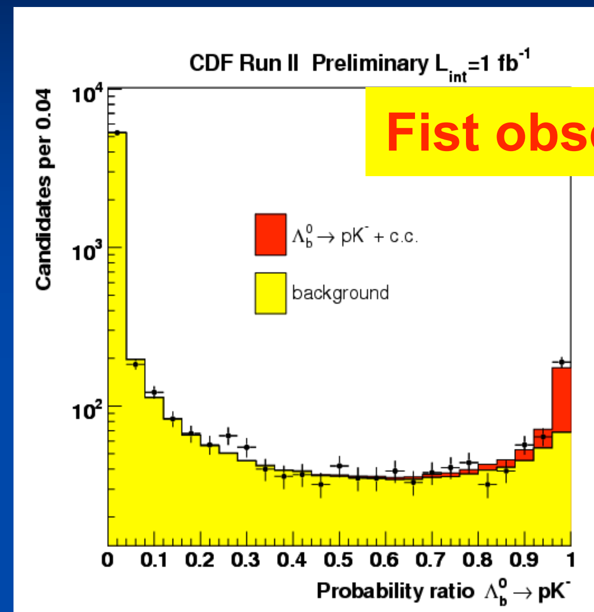
We have reached the interesting region for these channels.
A signal may be just around the corner.

$\Lambda^0_b \to p\pi^-$ and $\Lambda^0_b \to pK^-$

First observation, 6 σ



Fist observation, 11 σ



$$N_{\rm raw}(\Lambda_b^0 \to pK^-) = 156 \pm 20\ (stat.) \pm 11\ (syst.)$$

$$N_{\rm raw}(\Lambda_b^0 \to p\pi^-) = 110 \pm 18\ (stat.) \pm 16\ (syst.)$$

$$\frac{BR(\Lambda_b^0 \to p\pi^-)}{BR(\Lambda_b^0 \to pK^-)} = 0.66 \pm 0.14\ (stat.) \pm 0.08\ (syst.)$$

See for the first time a charmless decay of a B *barion*

Ratio of BR in agreement with predictions (0.60-0.62)

[Mohanta et al. Phys.Rev. D63 (2001) 074001]

Individual BR and ACP measurements in progress

Summary

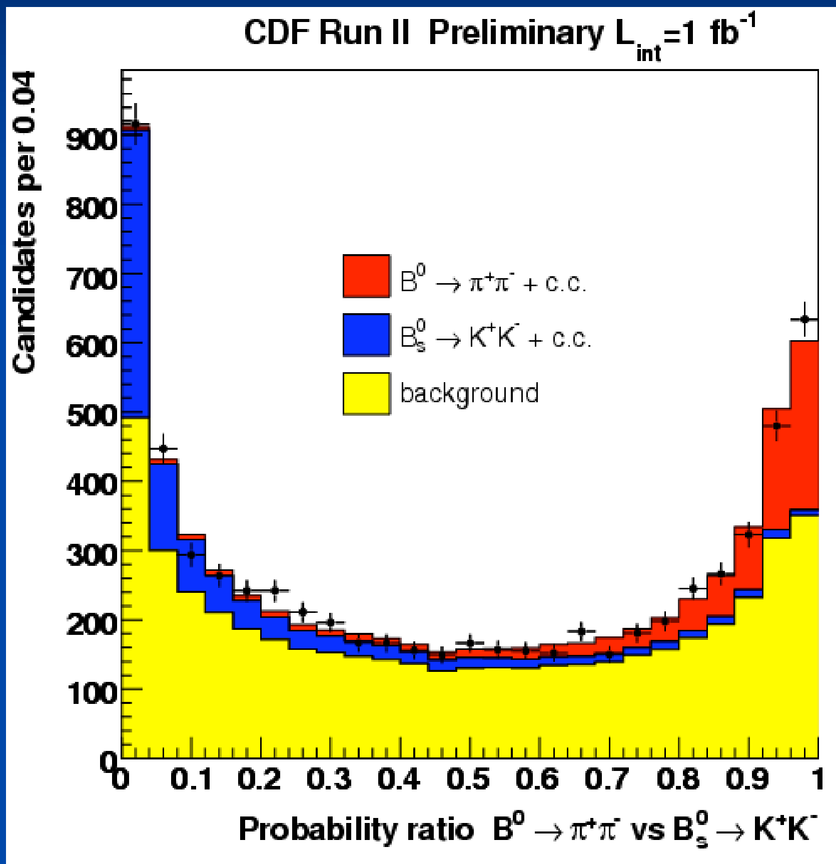
- First observation of $B^0_s \to K^- \pi^+$ mode
- First measurement of DCPV in B^0_s:
  $A_{CP}(B^0_s \to K^- \pi^+)$ at 2.5σ, in agreement with SM
- First observation of B-baryon modes $\Lambda_b \to pK$ / $p\pi$
- Precision $A_{CP}(B^0 \to K^+ \pi^-)$ confirms B-factories results. Increase significance of DCPV to 7σ, and discrepancy with B^+ to 4.9σ.
- Updated $BR(B^0_s \to K^+ K^-)$ agrees with latest predictions, no indication of large U-spin breaking.
- Improved results on annihilation: $B^0 \to K^+ K^-$ $B^0_s \to \pi^+ \pi^-$

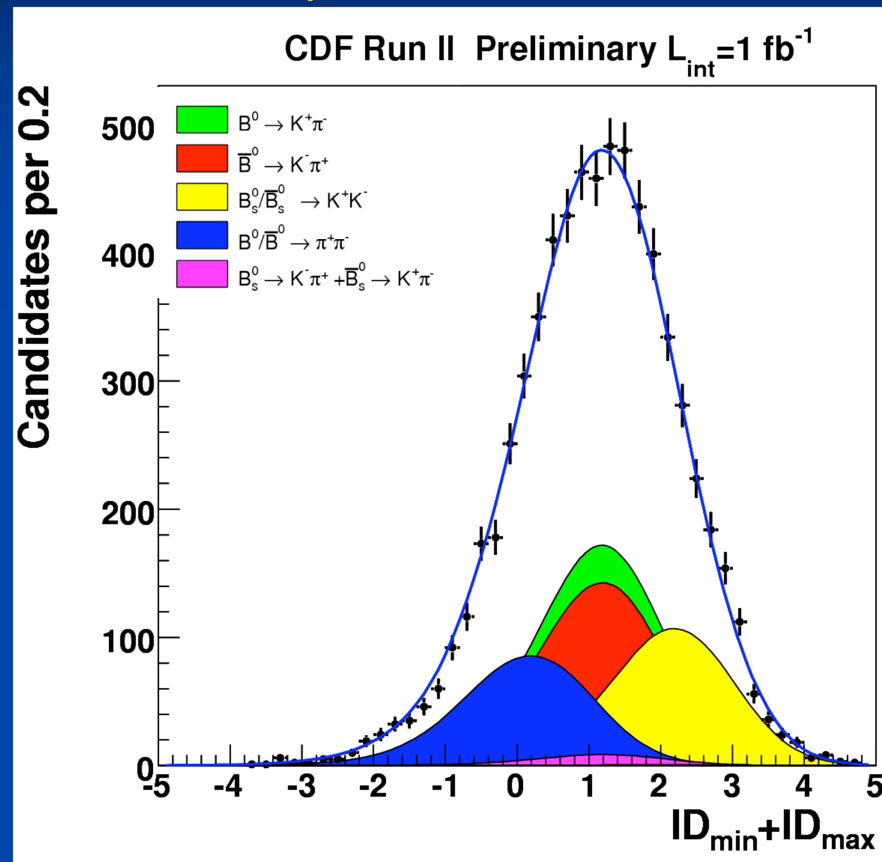
CDF has fresh new results in Charmless two-body decays of the B^0, plus unique results on B^0_s and baryons.
Now ready to start time-dependent measurements ($B^0 \to \pi^+ \pi^-$, $B^0_s \to K^+ K^-$)
Many more results expected with progressing of RunII.

Backup

Separating $B^0_s \to K^+K^-$ from $B^0 \to \pi^+\pi^-$

PID separation $\pi\pi/KK \cong 2\sigma$





Isolation cut efficiency

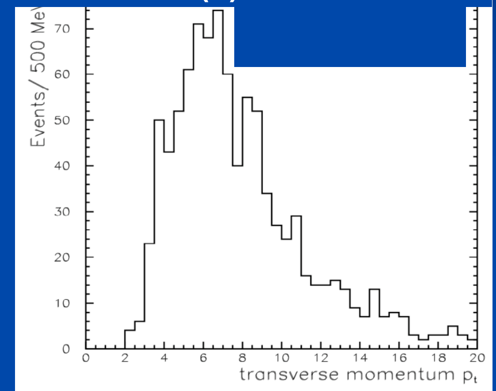
In order to normalize Bs Branching Fraction, need to know the relative efficiency.

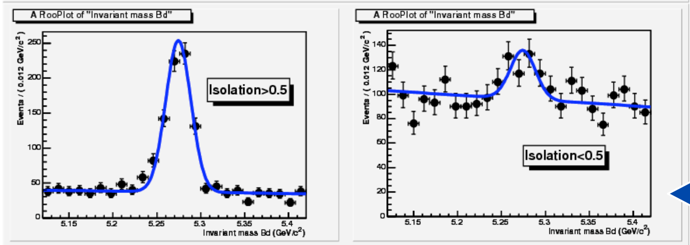
The Isolation cut may affect Bs and B0 differently. Use data to measure it (p_T – dependent)

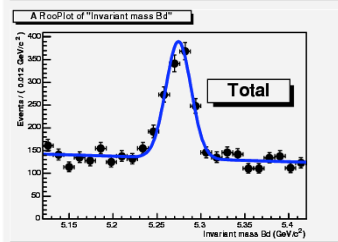
Need low-p_T samples: low edge of $p_T \sim$ 3 GeV

Maximum Likelihood fit of yields in exclusive modes.

$p_T(B^0_{(s)} \rightarrow h^+ h^{'-})$

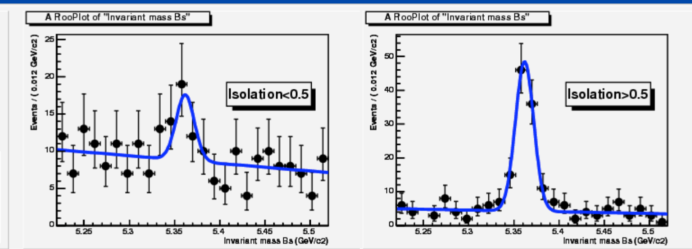


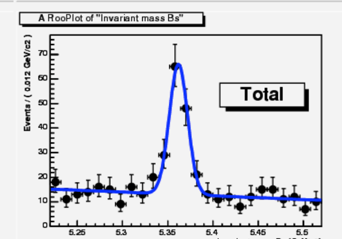




$B^0_s \rightarrow J/\psi\phi$

$B^0 \rightarrow J/\psi K^{*0}$





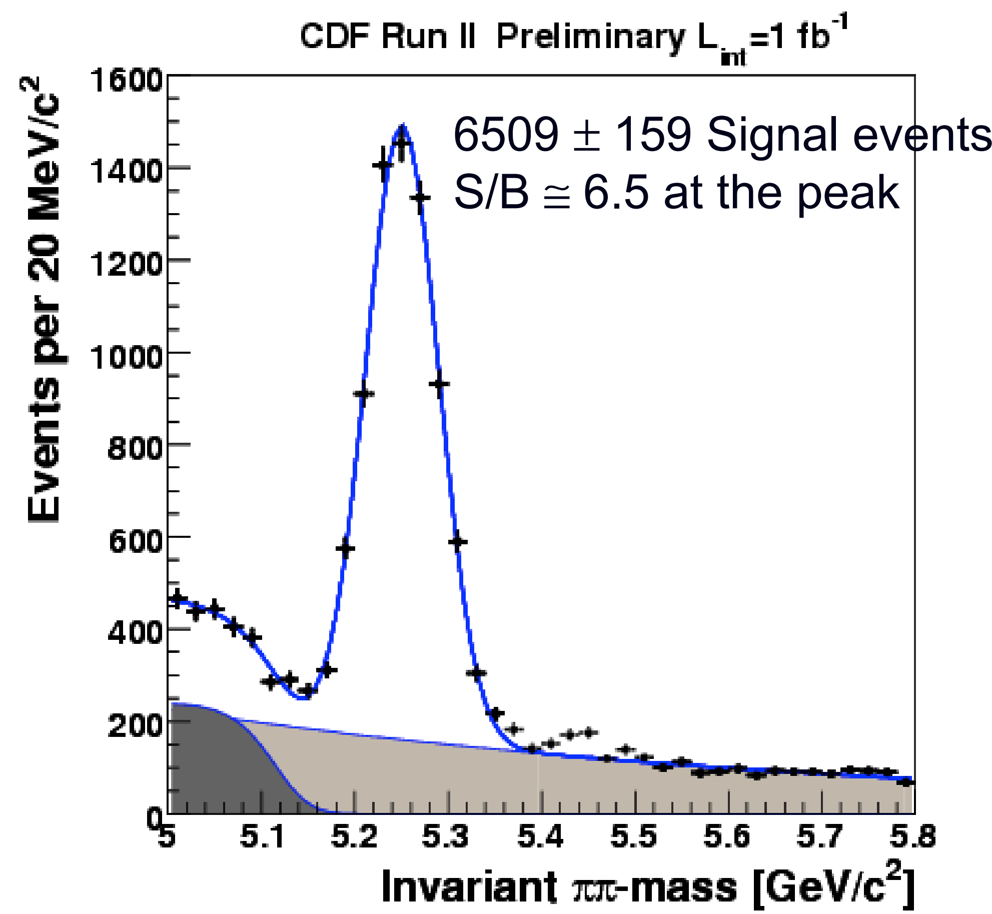
GeV/c	$\epsilon_{Iso}(B_d)$	$\epsilon_{Iso}(B_s)$	$\epsilon_{Iso}(B_d)/\epsilon_{Iso}(B_s)$
$p_T(B) < 6$	57.5±9.7	70.1±14.6	0.82±0.22
$6 < p_T(B) < 10$	84.6±2.4	84.8±5.7	1.00±0.08
$p_T(B) > 10$	93.8±1.2	90.4±2.8	1.04±0.03

DATA SAMPLE 1fb^{-1}

Cuts optimized for ACP(BdKpi)

variable	cut
# axial COT SL	$\geq$ 2(5 hits)
# stereo COT SL	$\geq$ 2(5 hits)
# $r-\phi$ SVXII hits	≥ 3
tracking algorithm	sil. r-ϕ and 90°z hits
$\mid \eta \mid$	≤ 1
p_T	$\geq$ 2 GeV/c
$p_T(1) + p_T(2)$	$\geq$ 5.5 GeV/c
$q(1) \cdot q(2)$	< 0
$\Delta\phi$	$\geq 20°$
$\Delta\phi$	$\leq 135°$
$\mid d_0 \mid$	$\geq 100\ \mu m$
$\mid d_0 \mid$	$\leq$ 1 mm
$d_0(1) \cdot d_0(2)$	$<0\ cm^2$

variable	cut
$\mid \eta(B) \mid$	≤ 1
$\mid d_0(B) \mid$	$\leq 80\ \mu m$
$L_{xy}(B)$	$\geq 300\ \mu m$
$\chi^2_{3D}(B)$	≤ 7
isolation $I_{R=1}$	≥ 0.5

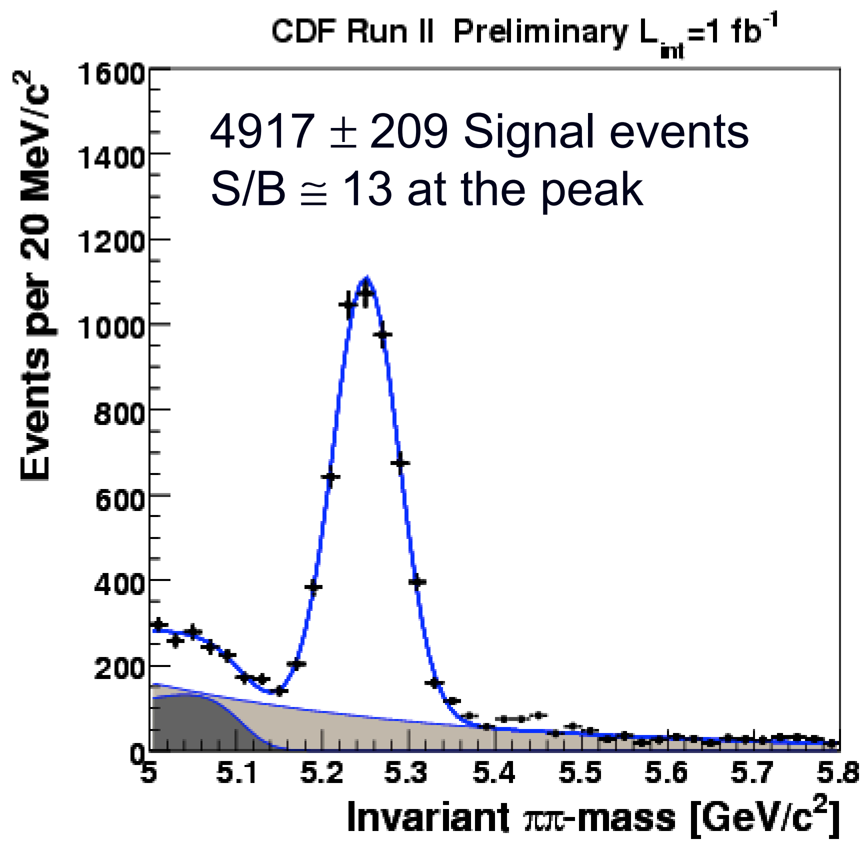


DATA SAMPLE 1fb^{-1}

Cuts optimized for rare modes

variable	cut
# axial COT SL	$\geq$ 2(5 hits)
# stereo COT SL	$\geq$ 2(5 hits)
# $r-\phi$ SVXII hits	$\geq$ 3
tracking algorithm	sil. r-ϕ and 90°z hits
$\mid \eta \mid$	$\leq$1
p_T	$\geq$ 2 GeV/c
$p_T(1) + p_T(2)$	$\geq$ 5.5 GeV/c
$q(1) \cdot q(2)$	$<$ 0
$\Delta\phi$	$\geq$20°
$\Delta\phi$	$\leq$135°
$\mid d_0 \mid$	$\geq$120 μm
$\mid d_0 \mid$	$\leq$ 1 mm
$d_0(1) \cdot d_0(2)$	$<$0 cm^2

variable	cut
$\mid \eta(B) \mid$	$\leq$ 1
$\mid d_0(B) \mid$	$\leq$ 60 μm
$L_{xy}(B)$	$\geq$ 350 μm
$\chi^2_{3D}(B)$	$\leq$ 5
isolation $I_{R=1}$	$\geq$ 0.525



ACP cuts: physical parameters

$$A_{\text{CP}} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.086 \pm 0.023\ (stat.) \pm 0.009\ (syst.)$$

$$\frac{BR(B^0 \to \pi^+\pi^-)}{BR(B^0 \to K^+\pi^-)} = 0.259 \pm 0.017\ (stat.) \pm 0.016\ (syst.)$$

$$\frac{f_s \cdot BR(B_s^0 \to K^+K^-)}{f_d \cdot BR(B^0 \to K^+\pi^-)} = 0.324 \pm 0.019\ (stat.) \pm 0.041\ (syst.)$$

With HFAG 2006:

$$BR(B^0 \to \pi^+\pi^-) = (5.10 \pm 0.33\ (stat.) \pm 0.36\ (syst.)) \times 10^{-6}$$

$$BR(B_s^0 \to K^+K^-) = (24.4 \pm 1.4\ (stat.) \pm 4.6\ (syst.)) \times 10^{-6}$$

BsKpi cuts: physical parameters (1)

$$A_{\mathrm{CP}} = \frac{N(\overline{B}_s^0 \to K^+\pi^-) - N(B_s^0 \to K^-\pi^+)}{N(\overline{B}_s^0 \to K^+\pi^-) + N(B_s^0 \to K^-\pi^+)} = 0.39 \pm 0.15\ (stat.) \pm 0.08\ (syst.)$$

$$\frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}_s^0 \to K^+\pi^-) - N(B_s^0 \to K^-\pi^+)} = -3.21 \pm 1.60\ (stat.) \pm 0.39 (sys.)$$

$$N_{\mathrm{raw}}(B_s^0 \to K^-\pi^+) = 230 \pm 34\ (stat.) \pm 16\ (syst.)$$

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

With HFAG 2006:

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

BsKpi cuts: physical parameters (2)

$$N_{\text{raw}}(B_s^0 \to \pi^+\pi^-) = 26 \pm 16\ (stat.) \pm 14\ (syst.)$$

$$N_{\text{raw}}(B^0 \to K^+K^-) = 61 \pm 25\ (stat.) \pm 35\ (syst.)$$

$$\frac{f_s \cdot BR(B_s^0 \to \pi^+\pi^-)}{f_d \cdot BR(B^0 \to K^+\pi^-)} = 0.007 \pm 0.004\ (stat.) \pm 0.005\ (syst.)$$

$$\frac{BR(B^0 \to K^+K^-)}{BR(B^0 \to K^+\pi^-)} = 0.020 \pm 0.008\ (stat.) \pm 0.006\ (syst.)$$

With HFAG 2006:

$$BR(B^0 \to K^+K^-) = (0.39 \pm 0.16\ (stat.) \pm 0.12\ (syst.)) \times 10^{-6}$$

$$BR(B^0 \to K^+K^-) \in [0.1 - 0.7] \cdot 10^{-6} \text{ @ } 90\%\ C.L.$$

$$BR(B_s^0 \to \pi^+\pi^-) = (0.53 \pm 0.31\ (stat.) \pm 0.40\ (syst.)) \times 10^{-6}$$

$$BR(B_s^0 \to \pi^+\pi^-) < 1.36 \cdot 10^{-6} \text{ @ } 90\%\ C.L.$$

BsKpi cuts: physical parameters (3)

$$N_{\rm raw}(\Lambda_b^0 \to pK^-) = 156 \pm 20\ (stat.) \pm 11\ (syst.)$$

$$N_{\rm raw}(\Lambda_b^0 \to p\pi^-) = 110 \pm 18\ (stat.) \pm 16\ (syst.)$$

$$\frac{BR(\Lambda_b^0 \to p\pi^-)}{BR(\Lambda_b^0 \to pK^-)} = 0.66 \pm 0.14\ (stat.) \pm 0.08\ (syst.)$$

Systematics: $A_{CP}(B^0 \rightarrow K^+\pi^-)$

source	shift wrt central fit
mass scale	0.0004
asymmetric momentum-p.d.f	0.0001
dE/dx	0.0064
input masses	0.0054
combinatorial background model	0.0027
momentum background model	0.0007
MC statistics	–
charge asymmetry	0.0014
$\Delta\Gamma_s/\Gamma_s$ Standard Model	–
lifetime	–
isolation efficiency	–
XFT-bias correction	–
TOTAL (sum in quadrature)	**0.009**

Systematics

$B^0 \to \pi^+\pi^-$ and $B^0_s \to K^+K^-$

source	shift wrt central fit $\frac{BR(B^0 \to \pi^+\pi^-)}{BR(B^0 \to K^+\pi^-)}$	shift wrt central fit $\frac{f_s \cdot BR(B^0_s \to K^+K^-)}{f_d \cdot BR(B^0 \to K^+\pi^-)}$
mass scale	0.0036	0.0034
asymmetric momentum-p.d.f	0.0006	0.0030
dE/dx	0.0129	0.0107
input masses	0.0050	0.0050
combinatorial background model	0.0020	0.0020
momentum background model	0.0010	0.0060
MC statistics	0.0011	0.0012
charge asymmetry	–	–
$\Delta\Gamma_s/\Gamma_s$ **Standard Model**	–	0.0060
lifetime	–	0.0060
isolation efficiency	–	0.0370
XFT-bias correction	0.0050	0.0080
TOTAL (sum in quadrature)	**0.0165**	**0.0413**

Isolation efficiency $\varepsilon(B^0)/\varepsilon(B^0_s)$ from the data using 180 pb^{-1}

$A_{CP}(B^0 \to K^+\pi^-)$ cuts: other fit parameters

Combinatorial background

parameter	value
f_{π^+} (combinatorial)	0.545 ± 0.017
f_{e^+} (combinatorial)	0.036 ± 0.005
f_p (combinatorial)	0.080 ± 0.025
f_{K^+} (combinatorial)	0.337 ± 0.031
f_{π^-} (combinatorial)	0.533 ± 0.018
f_{e^-} (combinatorial)	0.030 ± 0.005
$f_{\bar{p}}$ (combinatorial)	0.132 ± 0.027
f_{K^-} (combinatorial)	0.304 ± 0.033

$B \to 3$body background

fraction of physics bckg (ARGUS norm.)	0.197 ± 0.016
ARGUS cut-off [GeV/c^2]	5.135 ± 0.001
ARGUS shape	8.467 ± 3.45
f_π (ARGUS)	0.728 ± 0.027
f_K (ARGUS)	0.272 ± 0.027
background fraction	0.481 ± 0.008
c_1 (background shape)	-1.221 ± 0.124

Significance Table

(Statistical + systematic)

raw yield ± stat. from fit on data

systematic error

mode	yield	TOY stat. ($f = 0$)	syst.	Sign.(TOY stat.($f = 0$) + syst.)
$B^0 \to K^+K^-$	61±25	21	35	1.5σ
$B_s^0 \to \pi^+\pi^-$	26±16	11	14	1.5σ
$B_s^0 \to K^-\pi^+$	230±34	23	16	8.2σ
$\Lambda_b^0 \to p\pi^-$	110±18	9	16	5.9σ
$\Lambda_b^0 \to pK^-$	156±20	8	11	11.5σ

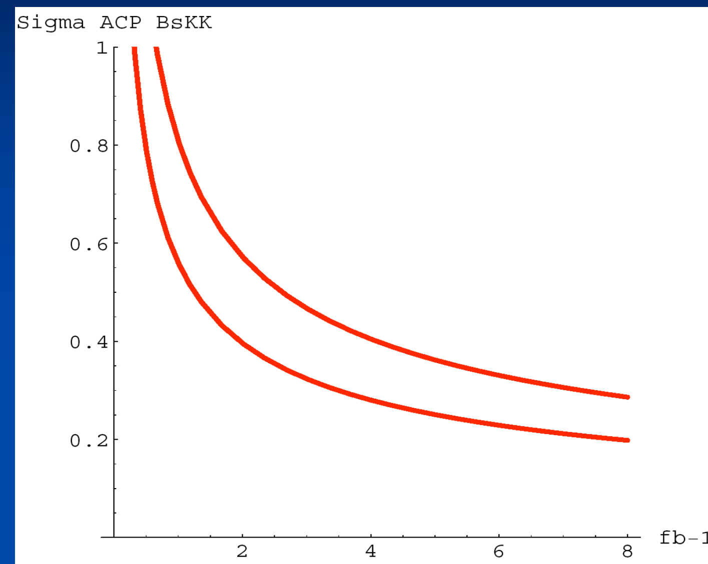
statistical uncertainty from pseudo experiments where the fractions of rare modes are fixed =0.

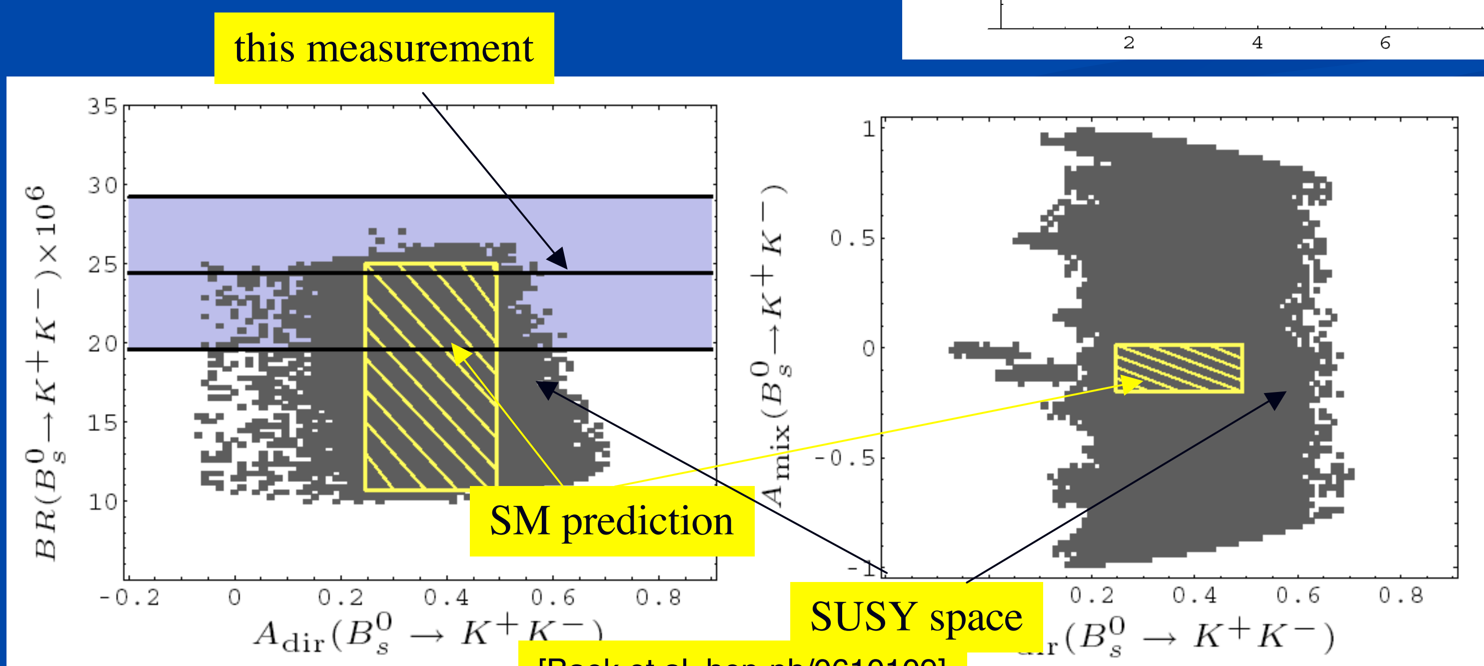
statistical error from the pseudo-experiment + systematic error. (Sum in quadrature).

Prospects for $A_{CP}(B^0_s \rightarrow K^+K^-)$

The large available sample allows expecting $\sigma(A_{CP})$ ~0.2 with runII sample

This allows searches for new physics. See below a recent work quoting the present measurement about SUSY search





[Baek et al, hep-ph/0610109]