Charmless B decays at CDF

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on behalf of the CDF collaboration

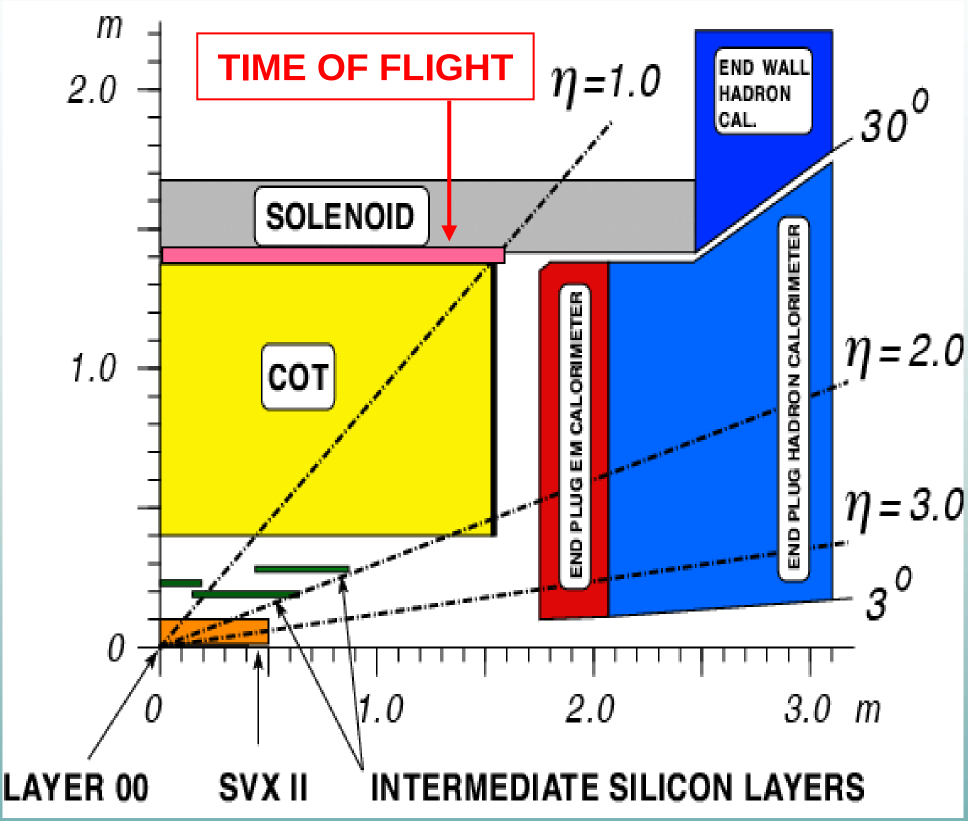
Outline

Lot of Charmless B results…

…in this talk:

- $B \rightarrow hh'$ ($B \rightarrow PP$)
  - BR and Acp: $B_d \rightarrow K\pi$
  - BR: $B_d \rightarrow \pi\pi$ $B_s \rightarrow KK$
- $B \rightarrow VV$
  - BR **first evidence**: $B_s \rightarrow \phi\phi$
- $B \rightarrow PV$
  - BR and Acp $B^{\pm} \rightarrow \phi K^{\pm}$

CDF



B =1.4 T

TOF: ~100ps resolution, 2sigmaK/π separation for tracks below 1.6 GeV/c (significant improvement of B_s flavor tag effectiveness)

COT: large radius (1.4 m) Drift C.

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

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

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

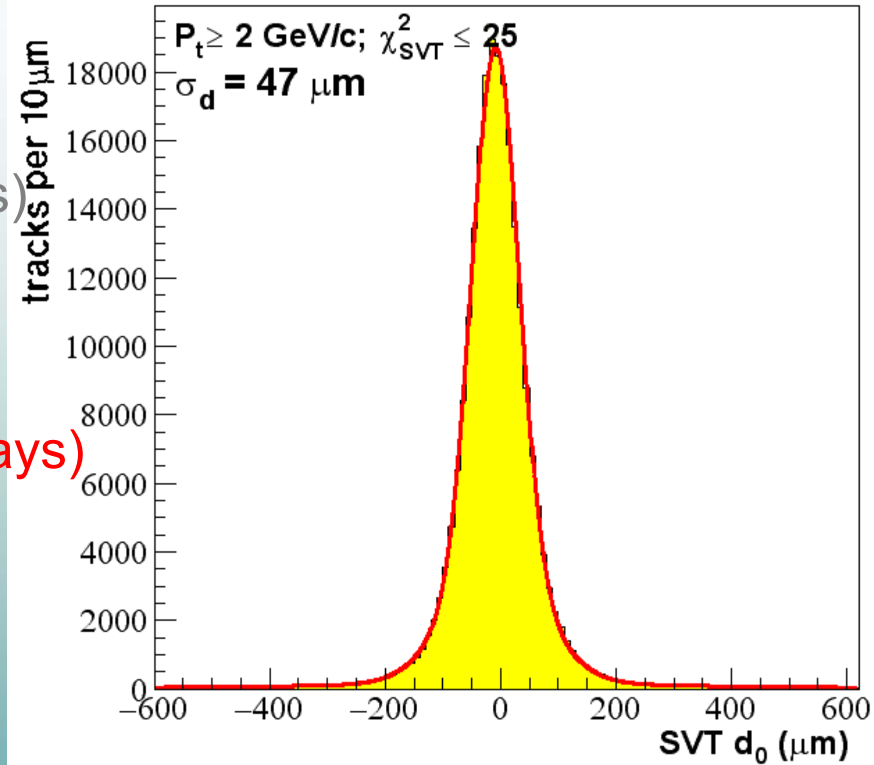
SVX-II + ISL: 5 + 1 (2) layers of double-side silicon (3cm < R < 30cm)

- 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) (expected 50 fs proper time resolution in $B_s \to D_s \pi$)

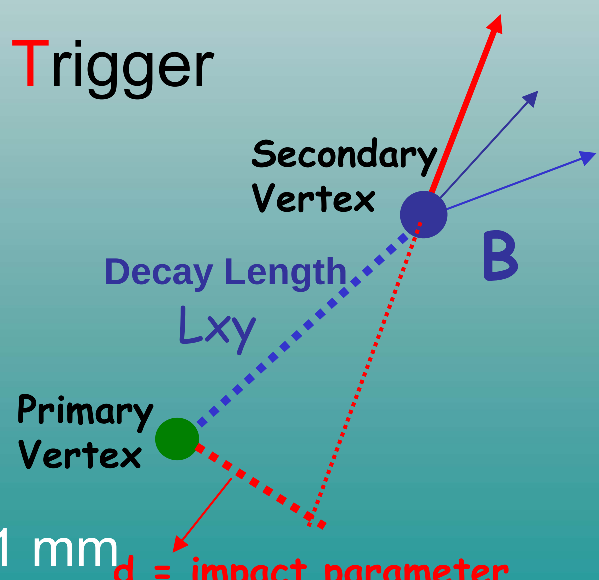
Silicon Vertex Trigger

B physics @ hadron collider :
- 2 leptons
  (rare decays, charmonium decays)
- 1 lepton + <u>1 displaced track</u>
  (semileptonic decays)
- **<u>2 displaced tracks</u>** :
  (two-body decays, multibody decays)



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

Silicon Vertex Trigger



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

B→hh' at CDF

CDF is the first experiment to be sensitive to Bs→hh' decays

TeVatron →all b-hadrons (B_d, B_s, Λ_b…)

Both B_s→hh' processes and B_d→hh'

Physics opportunities:

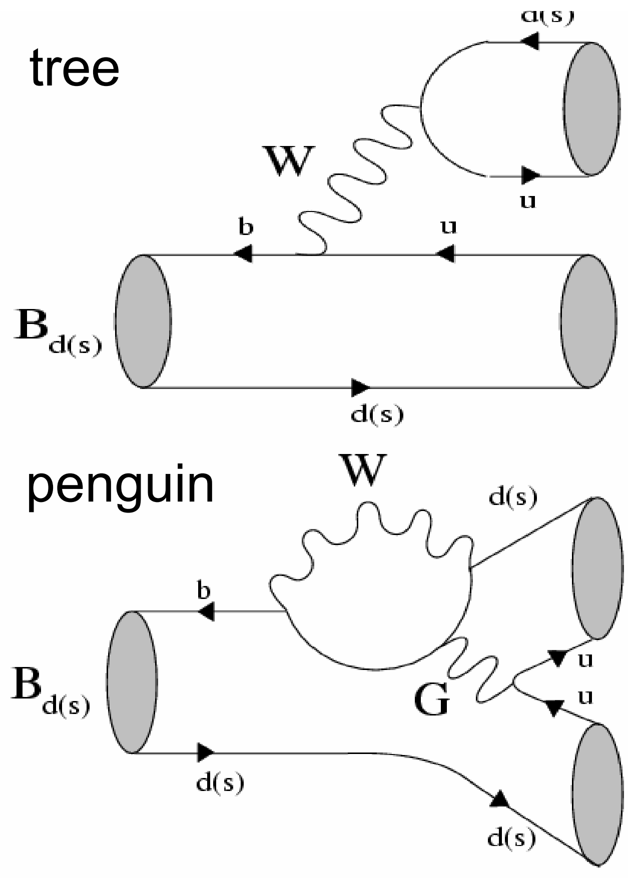
Counting experiments:

$B_d \to K^+\pi^-$

- Branching Ratio
- Direct CP asymmetry

- With higher statistics $B_s \to K^-\pi^+$
  - Branching Ratio
  - Direct CP asymmetry

Contributions from both:



$B \rightarrow hh'$ at CDF

More than counting:

- $B_s \rightarrow K^+K^-$:
  - Lifetime measurement
    - sample sensitive to Γ_L
    - Combined with other lifetime measurements $\rightarrow \Delta\Gamma_s$

… in the future

- $B_d \rightarrow \pi^+\pi^-$ $\rightarrow \alpha$
- $B_d \rightarrow K^+\pi^-$ $\rightarrow \gamma$

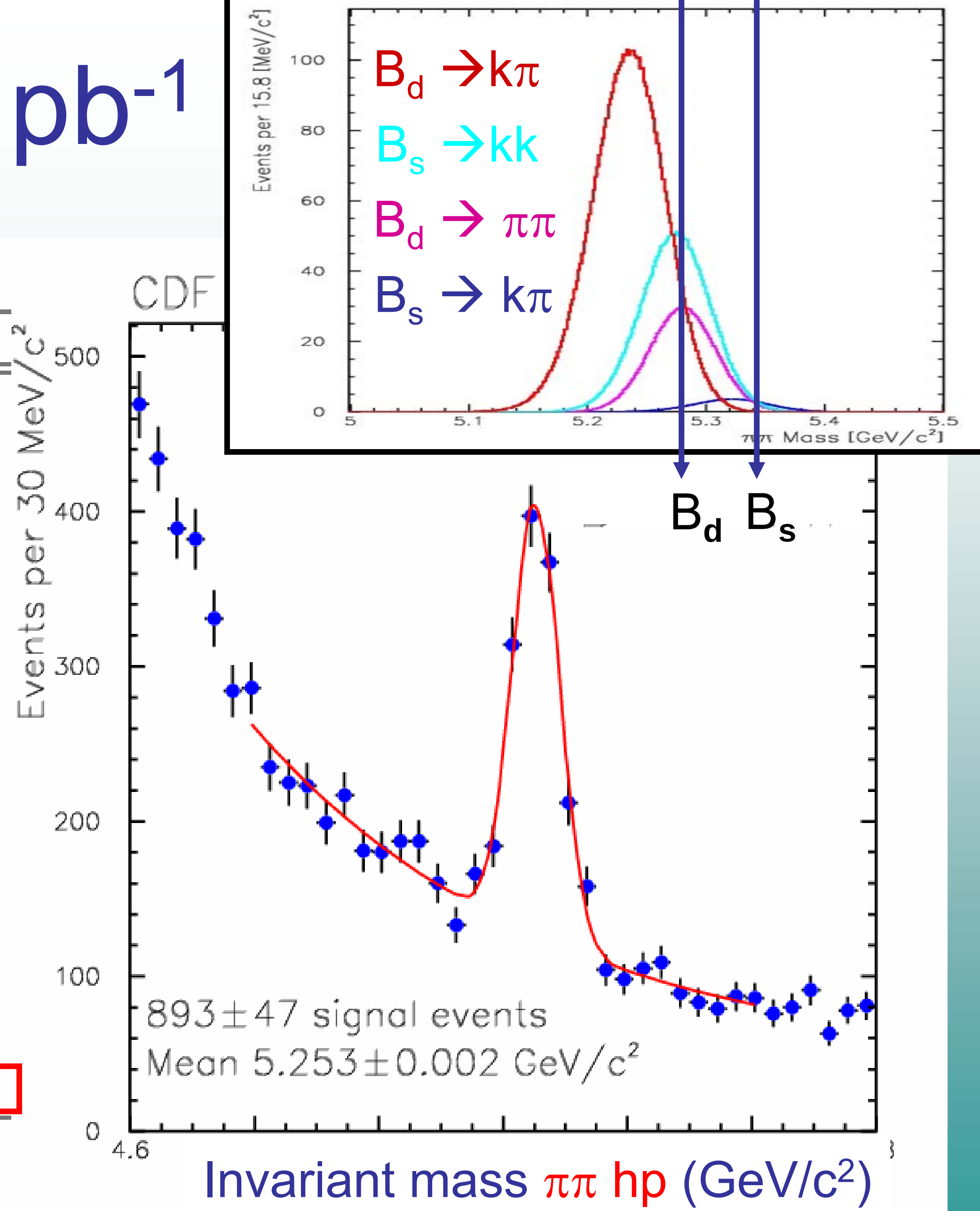
Time dependent CP asymmetry requires b-flavor tagging and more statistics !

B→hh' in 180 pb^{-1}

Selection cuts

Parameter	value
# axial COT hits	≥ 20
# stereo COT hits	≥ 20
# axial SVXII hits	≥ 3
$\max(\lvert\eta(\pi_1)\rvert, \lvert\eta(\pi_2)\rvert)$	≤ 1
$\min(p_T(\pi_1), p_T(\pi_2))$	≥ 2 GeV/c
$p_T(\pi_1) + p_T(\pi_2)$	≥ 5.5 GeV/c
$q(\pi_1) \cdot q(\pi_2)$	< 0
$\Delta\phi(\pi_1, \pi_2)$	$[20°, 135°]$
$\min(\lvert d_0(\pi_1)\rvert, \lvert d_0(\pi_2)\rvert)$	≥ 0.0150 cm
$\max(\lvert d_0(\pi_1)\rvert, \lvert d_0(\pi_2)\rvert)$	≤ 0.1000 cm
$d_0(\pi_1) \cdot d_0(\pi_2)$	< 0
$\lvert\eta(B)\rvert$	≤ 1
$\lvert d_0(B)\rvert$	≤ 0.0080 cm
$L_{xy}(B)$	≥ 0.0300 cm
B isolation	≥ 0.5

The only significant cut
not already present in the trigger



893±47 B→hh' events

Unbinned Maximum Likelihood Fit

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

Sum over the 4 channels

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

BKG Likelihood

BKG fraction (float)

Likelihood variables:

$M_{\pi\pi}$ = invariant mass

$\alpha = q(1) \cdot [1 - \frac{p(1)}{p(2)}]$ momentum imbalance(where $p_1 < p_2$)

$$\text{ID}(track) = \frac{\frac{dE}{dx}_{meas}(track) - \frac{dE}{dx}_{exp-\pi}(track)}{\frac{dE}{dx}_{exp-K}(track) - \frac{dE}{dx}_{exp-\pi}(track)}$$

$$\sigma^*(track) = \frac{\sigma_{dE/dx}(track)}{\frac{dE}{dx}_{exp-K}(track) - \frac{dE}{dx}_{exp-\pi}(track)}$$

Likelihood in detail

$$\mathcal{L}^{sig} = \sum_j f_j \, \mathcal{L}_j$$

Signal likelihood

f_j → fraction of events of the jth mode

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

- $pdf(M_{\pi\pi}|\alpha)$: Kinematics
- $pdf(\mathrm{ID}_1, \mathrm{ID}_2|\alpha, \Sigma p)$: Particle Identification
- $pdf(\alpha, \Sigma p)$: Unbalance Momentum

P(A|B)P(B)

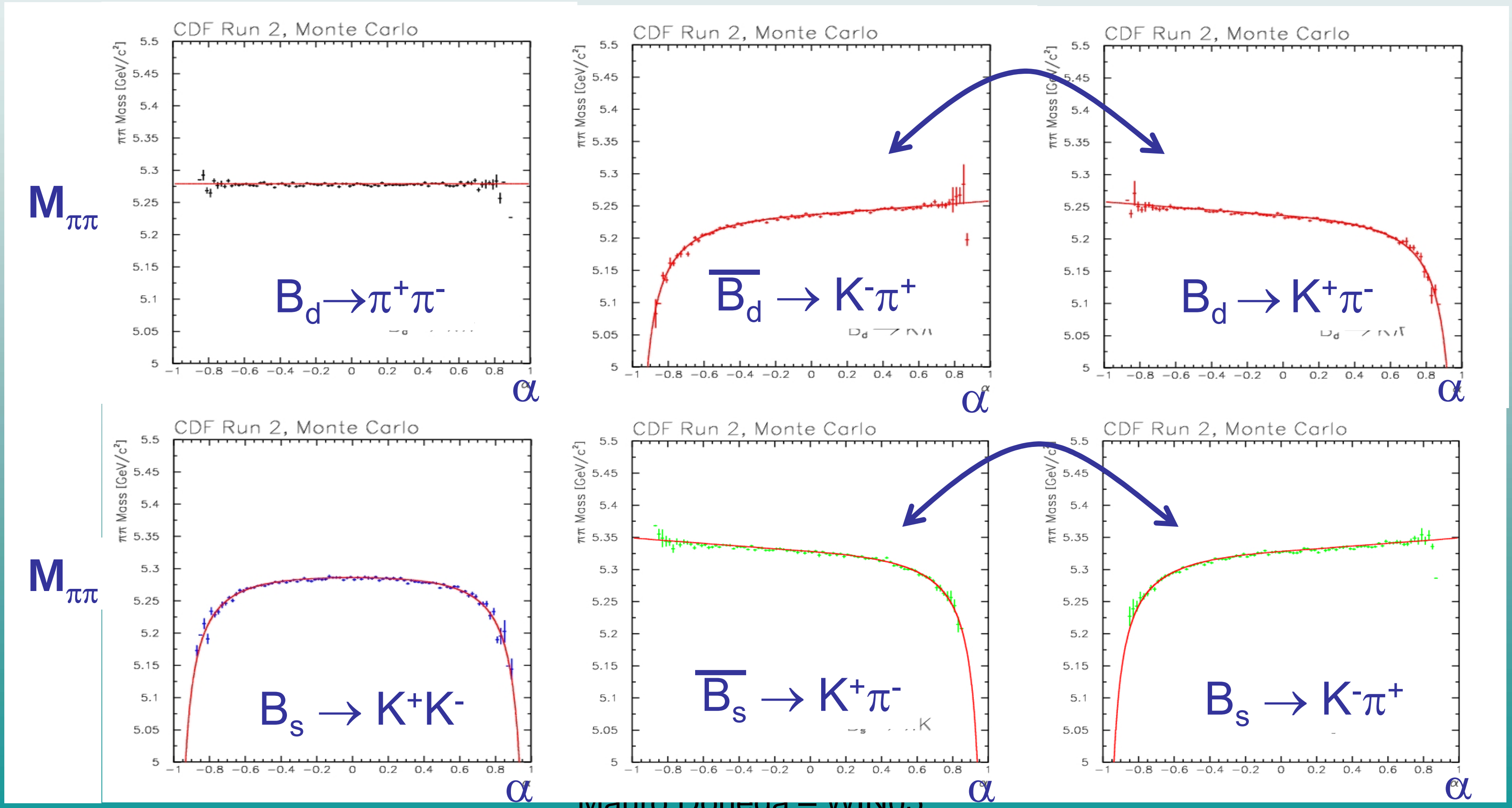
Background likelihood same structure as the signal

Kinematics

Invariant mass (π hypothesis) vs unbalance

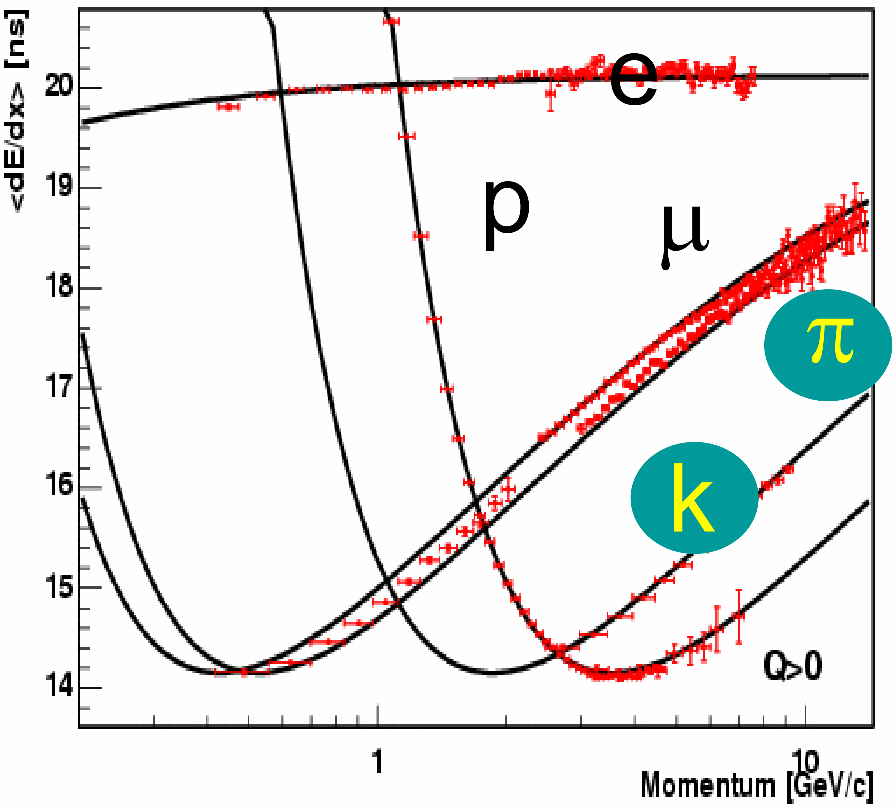
Def: α=**[1–p1/p2] q1**

Helps to disentangle the $B_d \to K^+\pi^-$ from $B_s \to K^-\pi^+$



Particle Identification

Helps to disentangle $B_d \to \pi^+\pi^-$ **from** $B_s \to K^+K^-$



- K/π separation:

  1.4σ @P_T>2 GeV/c

…no ev/ev PID separation

- This PID performance implies statistical separation of K-pi with resolution 60% of a "perfect" PID
- Background composition:

  (ad-hoc study)

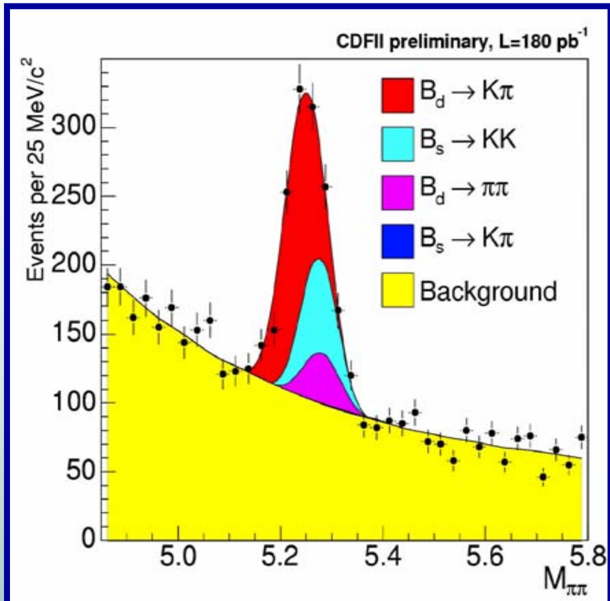
  kaons &

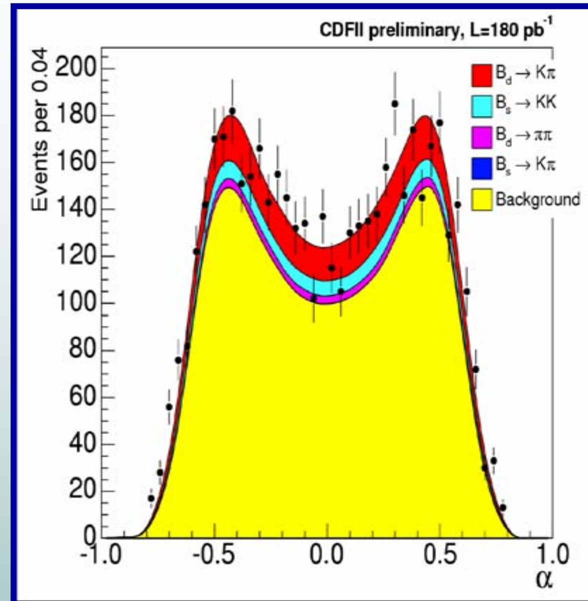
  pions (muons)&

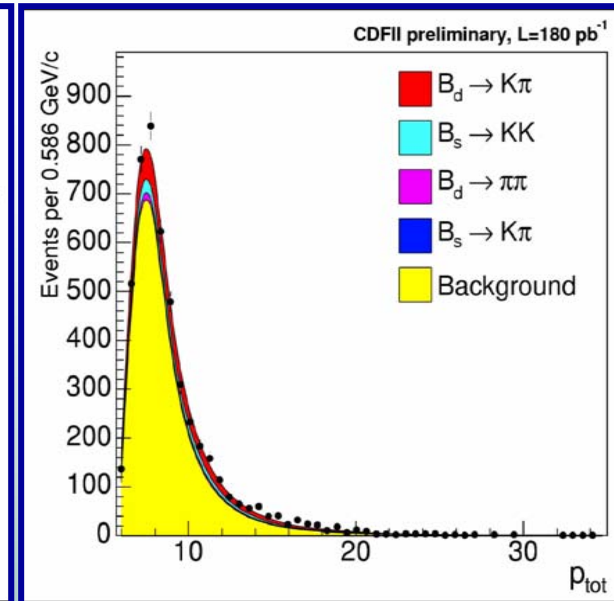
  protons &

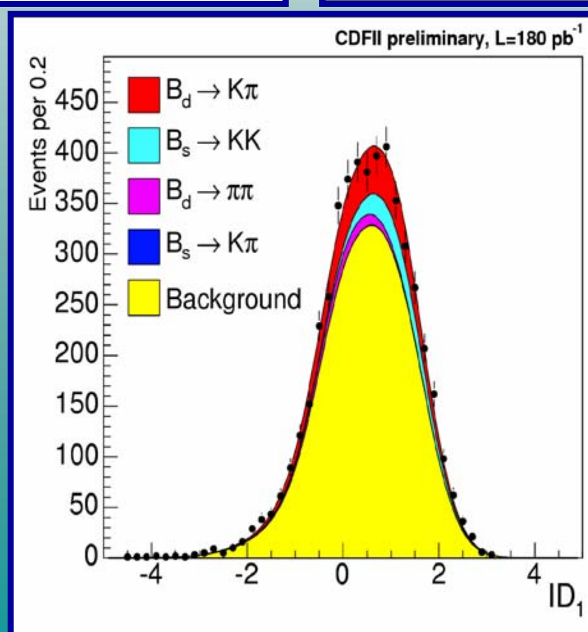
  electrons

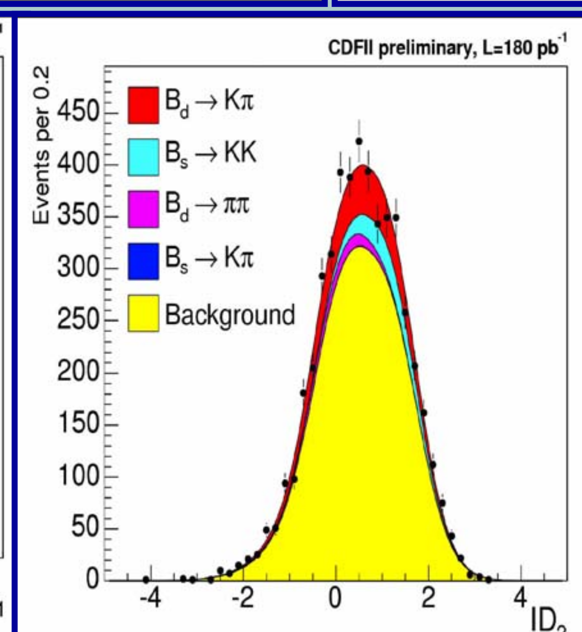
Fit Projections











B→hh' results BR and Acp

Analyzed Luminosity =180 pb^{-1}

$$\frac{BR(B^0 \to \pi^+\pi^-)}{BR(B^0 \to K^+\pi^-)} = 0.21 \pm 0.05\ (stat.) \pm 0.019\ (syst.)$$

$$A_{CP} = \frac{N(\overline{B}^0 \to K^-\pi^+) - N(B^0 \to K^+\pi^-)}{N(\overline{B}^0 \to K^-\pi^+) + N(B^0 \to K^+\pi^-)} = -0.022 \pm 0.078\ (stat.) \pm 0.012\ (syst.)$$

$$\frac{f_d \cdot BR(B^0 \to \pi^+\pi^-)}{f_s \cdot BR(B_s^0 \to K^+K^-)} = 0.45 \pm 0.13\ (stat.) \pm 0.054\ (syst.)$$

$$\frac{f_s \cdot BR(B_s^0 \to K^+K^-)}{f_d \cdot BR(B^0 \to K^+\pi^-)} = 0.46 \pm 0.08\ (stat.) \pm 0.063\ (syst.)$$

Systematic uncertainties

source	$\frac{f_s}{f_d} \cdot \frac{BR(B^0_s \to KK)}{BR(B^0 \to K\pi)}$	$A_{CP}(B^0 \to K\pi)$	$\frac{BR(B^0 \to \pi\pi)}{BR(B^0 \to K\pi)}$	$\frac{f_d}{f_s} \cdot \frac{BR(B^0 \to \pi\pi)}{BR(B^0_s \to KK)}$
mass resolution	0.003783	0.001522	0.001664	0.0037
dE/dx **correlation:**	0.024462	0.001566	0.01272	0.003695
dE/dx **residual**	0.00082	0.00034	0.00020	0.00037
input masses	0.02257	0.0033	0.0105	0.0097
background model	0.0106	0.002234	0.00308	0.00357
p **spectra of background**	0.00116	0.00047	0.00008	0.0009
lifetime	0.00373	-	-	0.0037
isolation efficiency	0.04755	-	-	0.0464
MC statistics	0.00373	0.000454(*)	0.0026	0.00556
charge asymmetry	-	0.0009	-	-
XFT-bias correction	0.0093	-	0.0035	0.014
$p_T(B)$ **spectrum**	0.0065	-	-	0.0065
$\Delta\Gamma_s/\Gamma_s$ **Standard Model**	0.0065	-	-	0.00556
TOTAL	±0.063	± 0.012	±0.019	±0.054

will decrease with statistics

Upper Limits

$$\frac{f_s \cdot BR(B_s^0 \to K^-\pi^+)}{f_d \cdot BR(B^0 \to K^+\pi^-)} < 0.08 \text{ @ } 90\% \ C.L.$$

$$\frac{BR(B_s^0 \to \pi^+\pi^-)}{BR(B_s^0 \to K^+K^-)} < 0.05 \text{ @ } 90\% \ C.L.$$

$$\frac{BR(B^0 \to K^+K^-)}{BR(B^0 \to K^+\pi^-)} < 0.10 \text{ @ } 90\% \ C.L.$$

- $\Delta\Gamma_s/\Gamma_s = 0.12$ (Standard Model)
- $B_s \to KK$ = 100% short eigenstate
- (HFAG2005) $BR(B_d \to K\pi) = 18.2 \times 10^{-6}$
- (PDG 2004) $f_s = 0.107$ $f_d = 0.397$

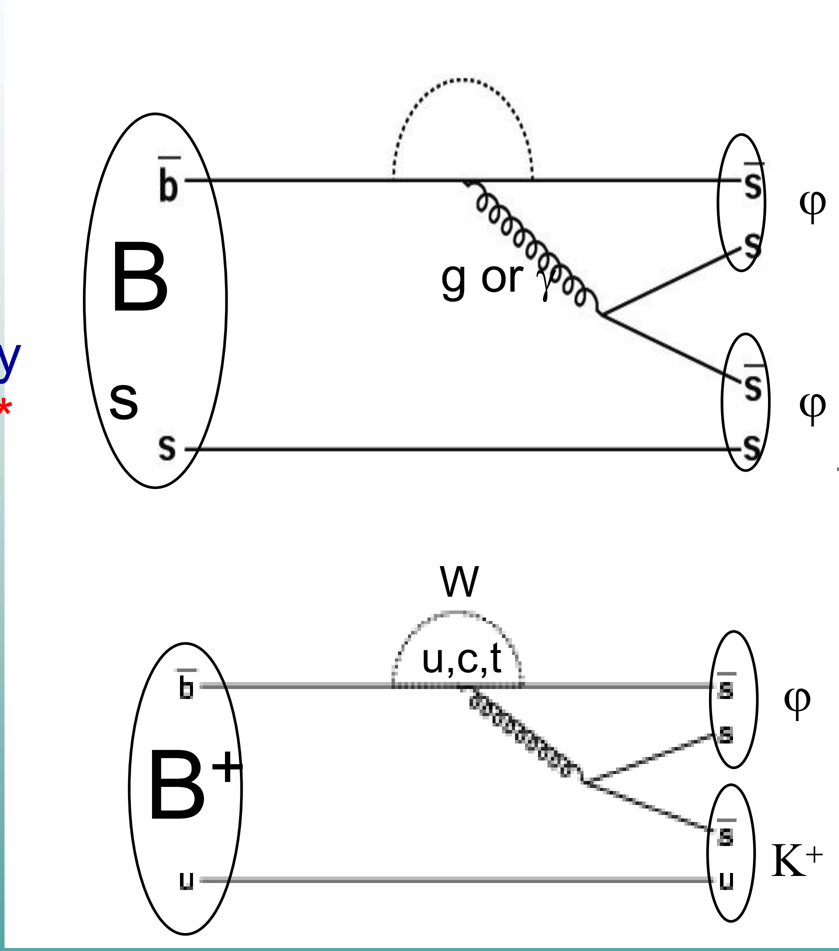
measurement	this analysis	world best	theory
$BR(B_s^0 \to \pi^+\pi^-)$	< 1.6	< 170	0.03–0.42
$BR(B_s^0 \to K^-\pi^+)$	< 5.4	< 210	7–10
$BR(B^0 \to K^+K^-)$	< 1.82	< 0.6	0.01–0.20

$B \to VV$ $B \to PV$

- b->$s\bar{s}s$ pure penguin amplitude
  $B_s \to \phi\ \phi$
  $B^{\pm} \to \phi K^{\pm}$

- New Physics has a chance to compete!
  ($B \to \phi K^*$: "$B \to \phi K^*$ polarization discrepancy
  $B_s \to \varphi\ \varphi$ is the B_s counterpart of $B_d \to \phi K^*$
  Unexpected result (3σ effect) from sin(2β) measure from penguin dominated modes)
  $(b \to s\bar{s}s$ and other $b \to s)$

- Measuring angular distribution of decay products determine polarization amplitudes and their relative phases through interference effects:
  - CP violation
  - $\Delta\Gamma_s$
  - …



$B_s \rightarrow \phi\ \phi$

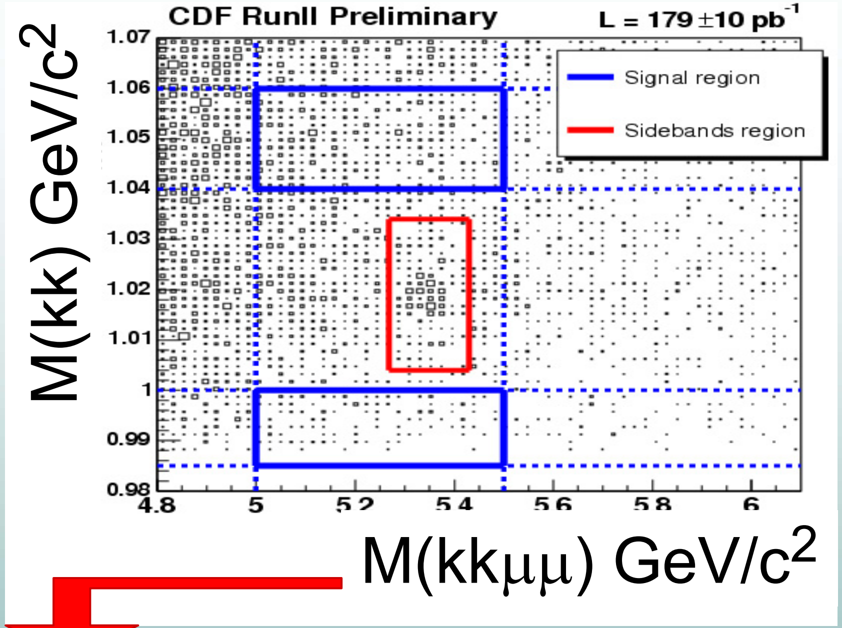
A blind analysis was performed in anticipation of a small signal rate.

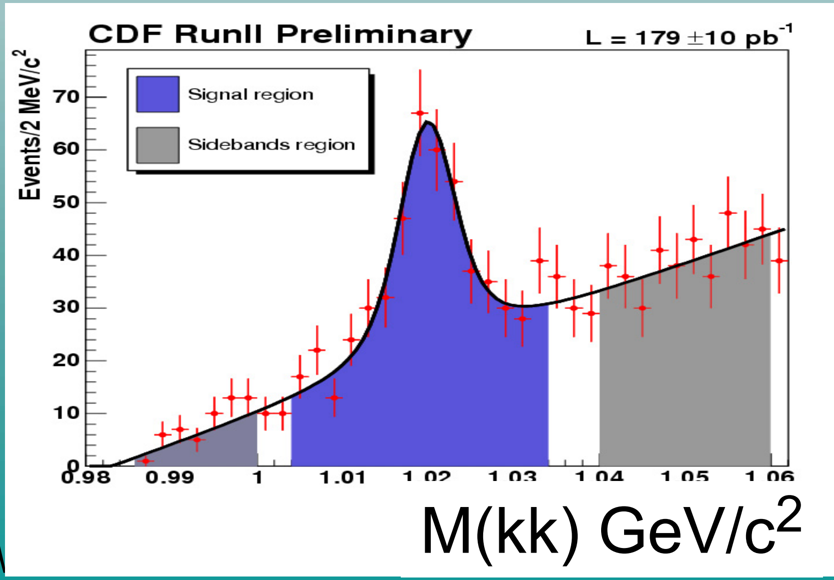
Normalize rate using another $B_s \rightarrow VV$ decay: $B_s \rightarrow J/\psi\ \phi$:

- NO production ratio of B_s vs B_d (f_s/f_d)
- one $\phi \rightarrow K^+K^-$ in the final state
- some systematic on efficiency cancel
- sizeable rate

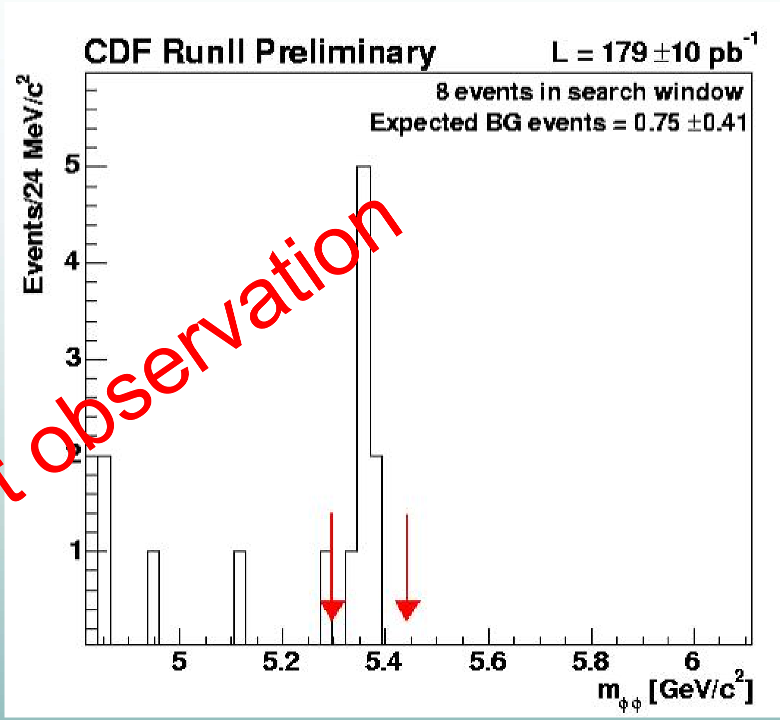
Separate optimization for Signal and Normalization sample

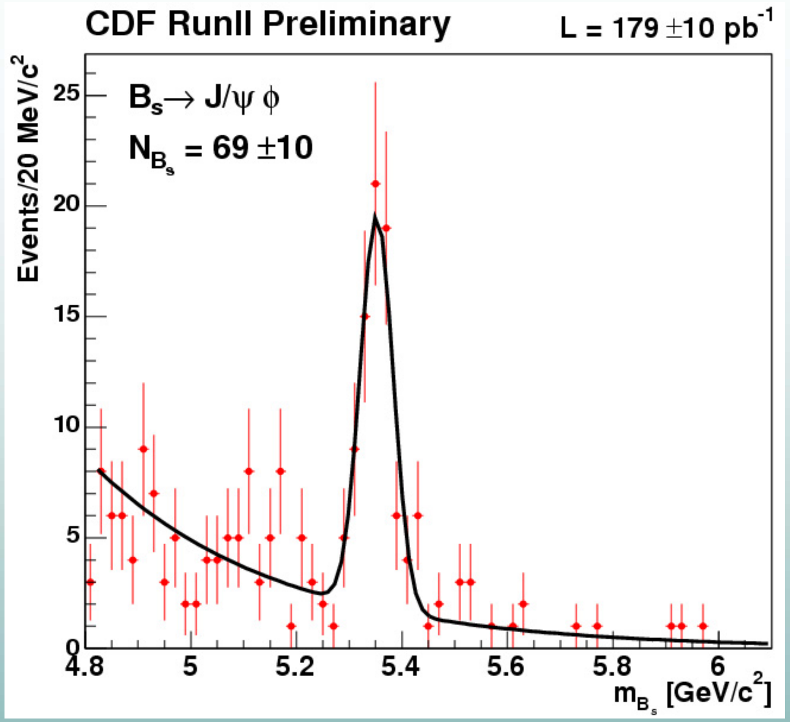
Cuts optimized checking which of The tracks fired the trigger





$B_s \to \phi\ \phi$ signal





$$\frac{BR(B_s^0 \to \varphi\varphi)}{BR(B_s^0 \to J/\psi\varphi)} = \frac{N(B_s^0 \to \varphi\varphi)}{N(B_s^0 \to J/\psi\varphi)} \cdot \frac{BR(J/\psi \to \mu^+\mu^-)}{BR(\varphi \to K^+K^-)} \cdot \frac{\varepsilon_{\varphi\varphi}}{\varepsilon_{J/\psi\varphi}} \cdot < \varepsilon^{\mu}_{J/\psi\varphi} >$$

From Data

From PDG *

From MC

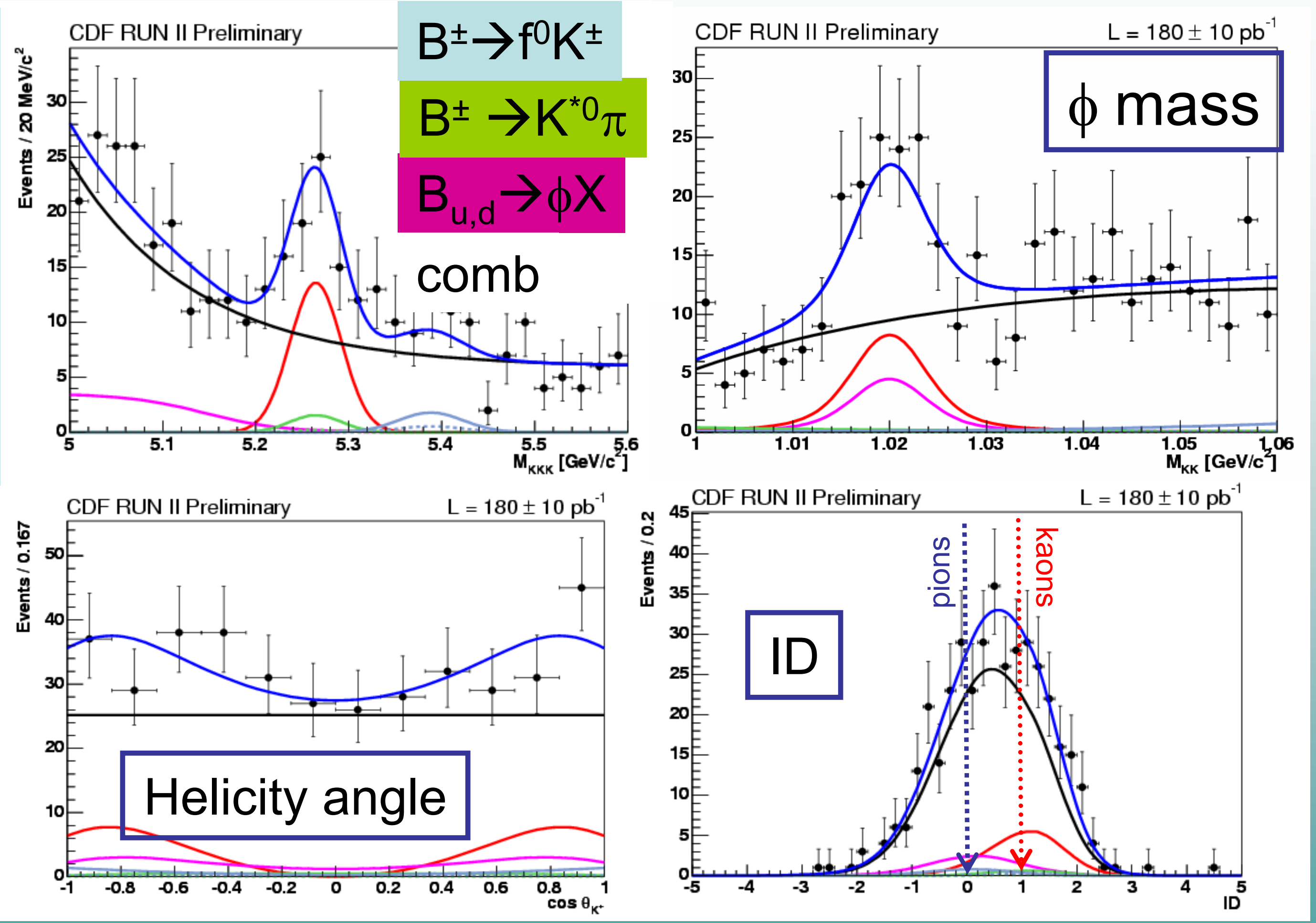
BR = (14 +6 -5 (stat) ± 2(syst) ± 5 (BR)) × 10^{-5}

* BR(ψϕ) needs to be rescaled for f_s/f_d

Yield and A_{CP} ($B^{\pm} \rightarrow \phi K^{\pm}$)

Extended unbinned maximum likelihood fit to :

- M_{KKK}
- $M\phi$
- helicity angle
- dE/dx from COT



Measure at the same time:

$N(B^{\pm} \rightarrow \phi K^{\pm})$

$A_{CP}(B^{\pm} \rightarrow \phi K^{\pm})$

+ disentangle signal from $B^{\pm} \rightarrow f^0 K^{\pm}$, $B^{\pm} \rightarrow K^{*0}\pi$, $B_{u,d} \rightarrow \phi X$ and combinatorial background

Normalization: $B^{\pm} \rightarrow J/\Psi K^{\pm}$

Extended unbinned maximum L

$M\mu\mu$ $M\mu\mu k$

$B^\pm \rightarrow \varphi K^\pm$ Results

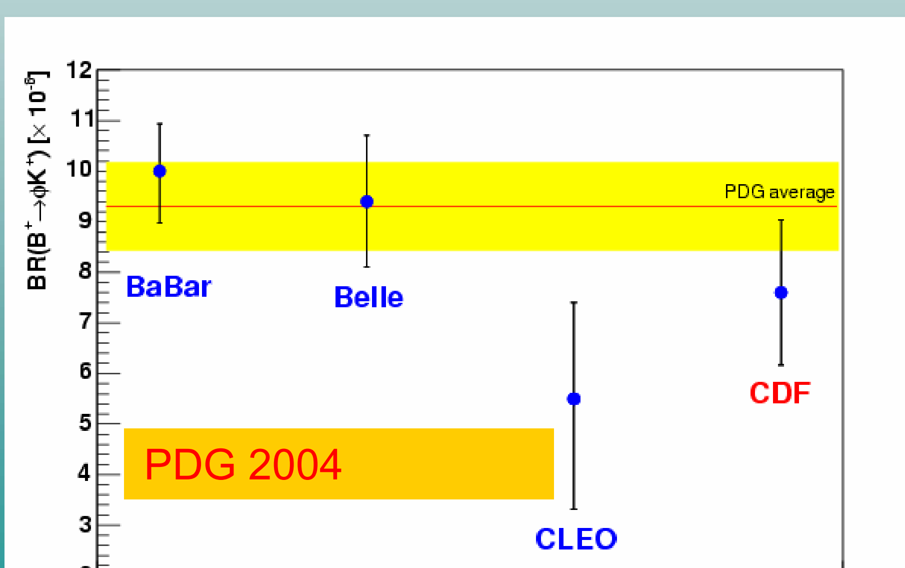
	$B^\pm \rightarrow J/\Psi K^\pm$	$B^\pm \rightarrow \varphi K^\pm$
N_B	439 ± 22	47.0 ± 8.4

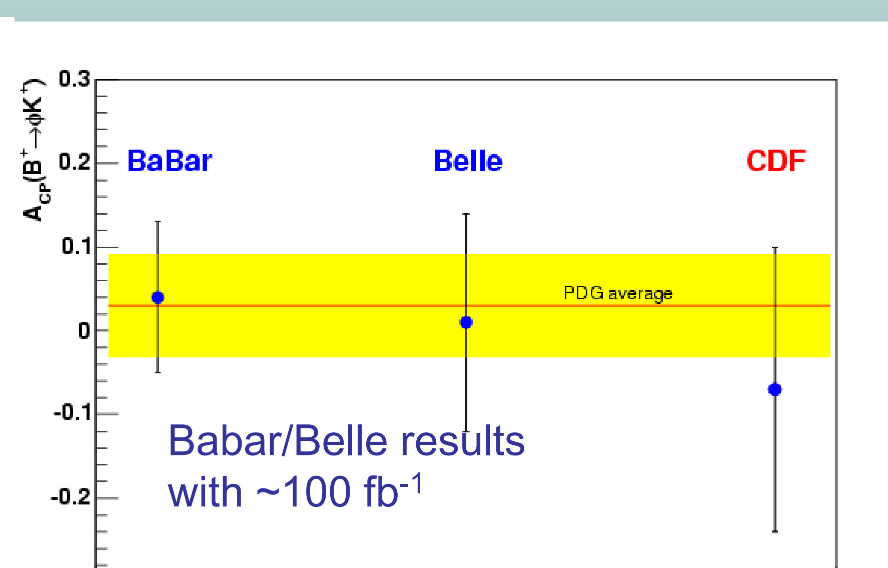
+PDG

$BR(B^\pm \rightarrow J/\Psi K^\pm)$

$$BR(B^\pm \rightarrow \varphi K^\pm) = (7.6 \pm 1.3(stat.) \pm 0.7(syst.)) \cdot 10^{-6}$$

$$A_{CP}(B^\pm \rightarrow \varphi K^\pm) = \frac{N(B^- \rightarrow \varphi K^-) - N(B^+ \rightarrow \varphi K^+)}{N(B^- \rightarrow \varphi K^-) + N(B^+ \rightarrow \varphi K^+)} = -0.07 \pm 0.17(stat.)^{+0.03}_{-0.02}(syst.)$$

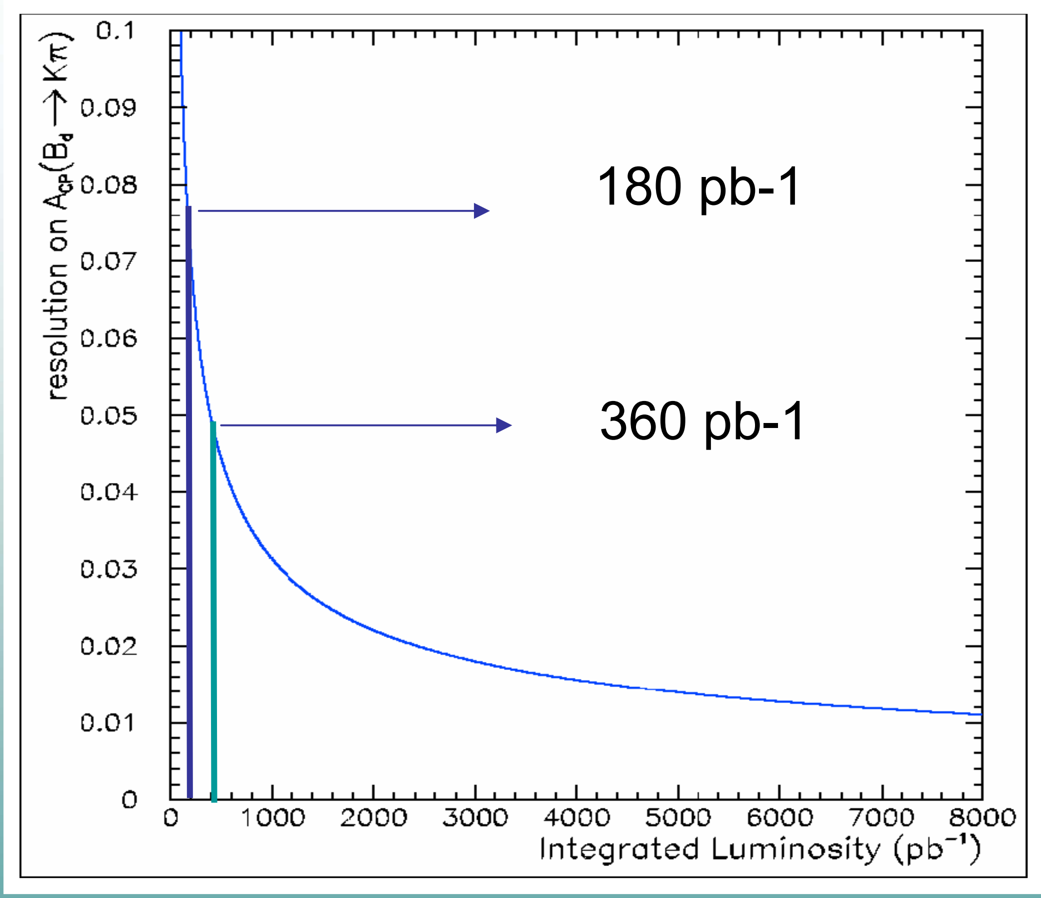




Analyzed L =180 pb^{-1}

B→hh' perspectives

CDF "the present":
- Next round with ~360 pb^{-1}
- Better tracking
- Improved PID



B→hh' the future:
- Higher precision BR(B_s→KK)
- B_s→ KK lifetime: $\Delta\Gamma_s$

- Precision Acp(B_d →Kπ)
  (eventually1%)

- B_s → Kπ BR and direct Acp

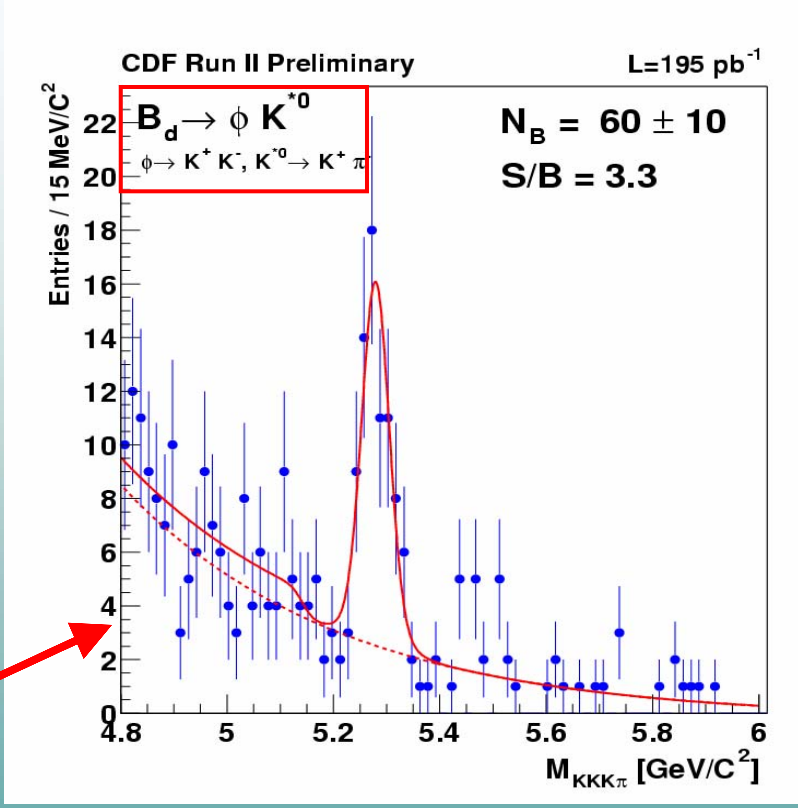
- Tagged time-dependent measurements further ahead:
  Acp parameters for B_d and B_s

B →VV perspective

With dataset now on tape new B_s modes should be visible ($B_s \to K^{*0}K^{*0}$, $B_s \to \phi\rho$):

Need significantly more statistics to perform CP measurements
(…full Run II)

Measure "untagged" quantities with $B_s \to \phi\phi$ and $B_d \to \phi K^*$events:



And other charmless decays are currently under study:

- $B_{d(s)} \to K^{*+}\pi^-(K^-)$
- ϕV^0 (as $\Lambda_b \to \phi\Lambda_0$)

Conclusions

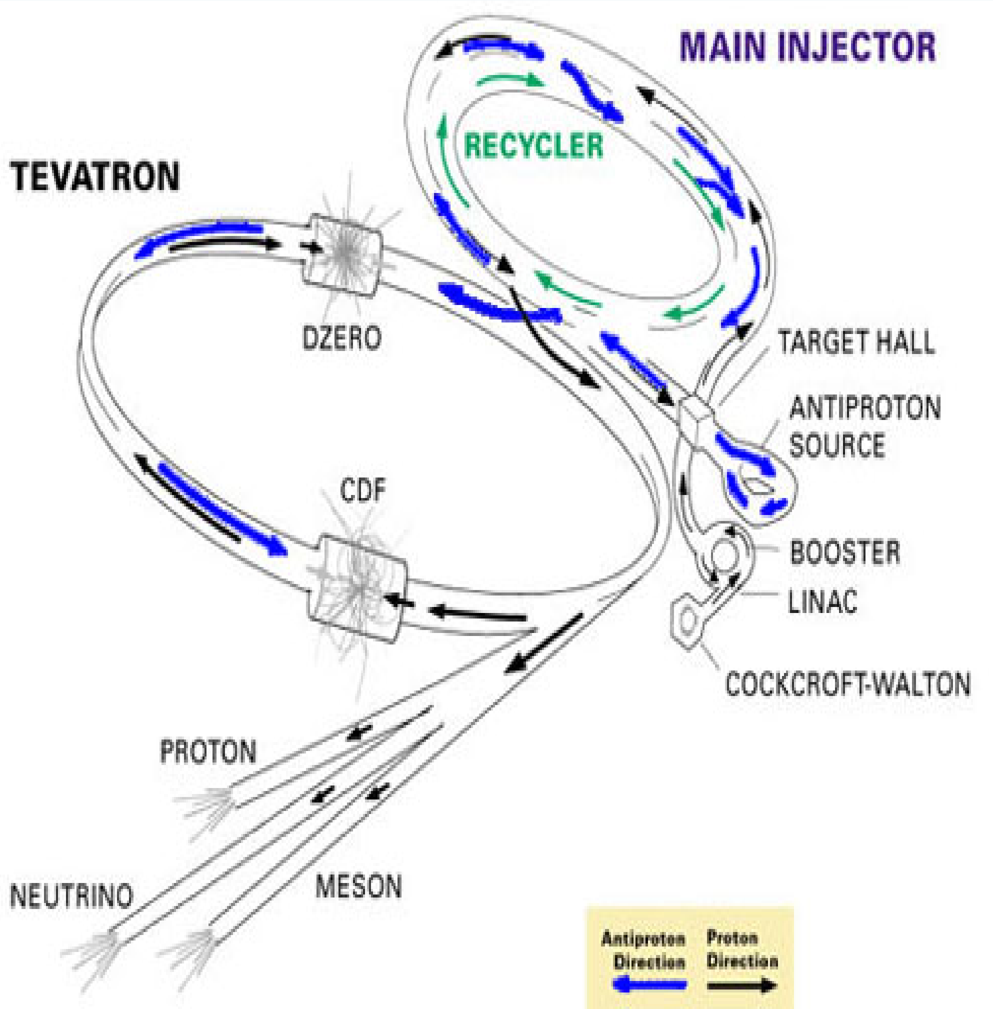
- CDF is giving important contribution in the field of the charmless B decays and remains the only player in the B_s fully hadronic decays
- New analysis with improved tracking and PID are already in the pipeline
- Significant improvement of the TeVatron performance

  Mon, 23 May 2005 first fb^{-1} was exceeded

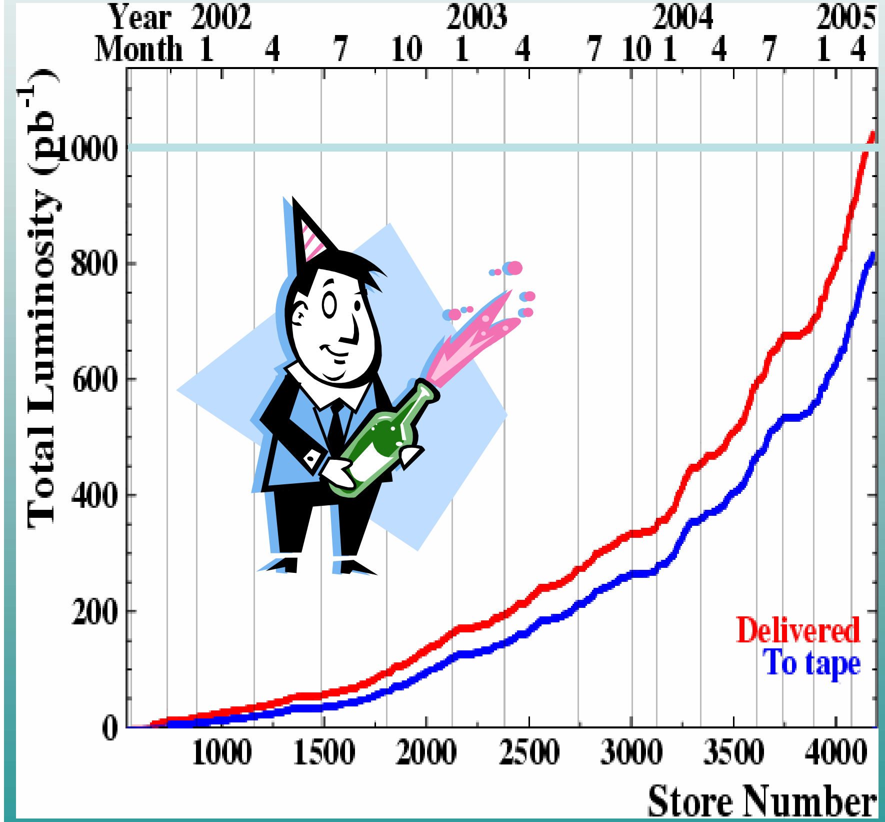
  (delivered luminosity ~600 pb^{-1} on tape)
- Higher level of precision is at the door !

BACKUP

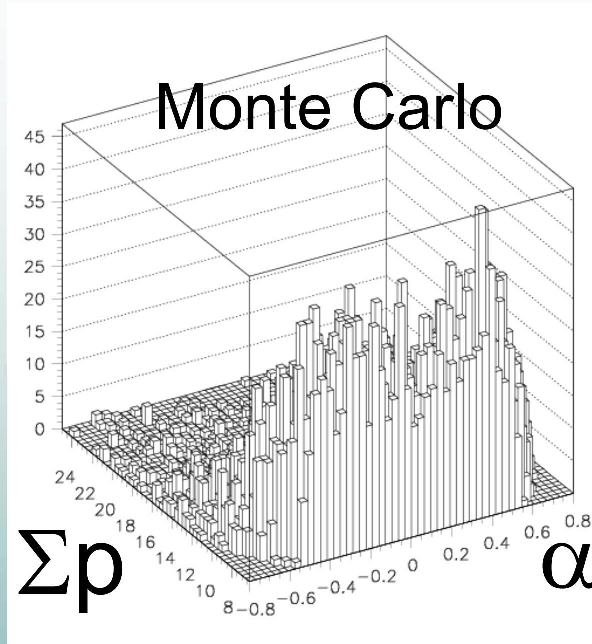
TeVatron

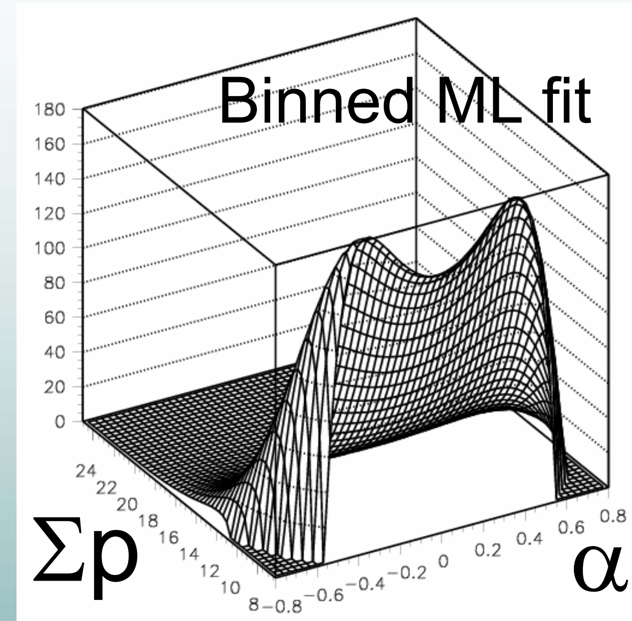


1 fb^{-1} delivered



Imbalance - Momentum





Signal

$$pdf\,(\alpha, p_{tot}) = \frac{1}{\text{norm}} \times e^{a_5 \times p_{tot}} \times \sum_{i=0}^{4}(a_i \times p_{tot}^{i}) \times \sum_{j=0}^{6} b_j \times \left(\alpha \times \frac{p_{tot}-2}{p_{tot}-4}\right)^{j}$$

BCKG

$$pdf\,(\alpha, p_{tot}) = \frac{1}{\text{norm}} \times \left[1 + \left(\frac{p_{tot}-\lambda}{a}\right)^{-m}\right] exp\left[-\nu \times \tan^{-1}\left(\frac{p_{tot}-\lambda}{a}\right)\right] \sum_{j=0}^{6} b_j \times \left(\alpha \times \frac{p_{tot}-2}{p_{tot}-4}\right)^{j}$$

Systematics

a) Mass resolution: the mass resolution is input from MC. It is rescaled to match the D^0 resolution on data, vary the the rescale factor of ±10% and repeat the fit.

b) dE/dx correlation: repeat the fit using the correlation shape extracted in the sample of kaons and pions from "mixed-events": e.g. one meson from an event, the other from the subsequent event. Quote the difference wrt the central value.

c) dE/dx shapes for e and p: repeat the fit assigning to the electrons and protons all 4 combinations of dE/dx shapes (ep)= ($\pi\pi$/πK/KK/Kπ). Quote the maximum difference wrt the central fit.

Systematics (cont'd)

d) input masses: the fit is done on data in which the recipe used for mass measurement at CDF II was applied. Input masses in the kinematics pdf are those measured by CDF II. Repeat the fit varying $M(B_d)$ and $M(B_s)$ within their statistical uncertainties (0.92 and 1.29 MeV/c^2). Quote the differences wrt the central fit

e) Background model: the fit assumes mass spectrum of bckg = exp + C. Repeat the fit with p_1,p_2,p_3 and quote the difference wrt central value

Systematics (cont'd)

f) Different p-spectra for bckg components: central fit assumes the same momentum distribution for e/pi/K/p of background. Reweight each term of the bckg p.d.f. according to linear fits of populations vs momentum plots.

Systematics (cont'd)

g) B lifetimes: relative kinematics efficiencies depend on the lifetime assumed in MC. Re-evaluate efficiencies after simultaneous shift of B_s lifetime (+1σ) and B_d (-1σ) and viceversa. σ is the PDG2004 uncertainty. Quote difference wrt central value

h) Isolation efficiency: has a ~ 10% from measurement on data. Re-evaluate the efficiency at +/- 1 σ and quote difference wrt central value

i) MC statistics: kinematics efficiencies have statistical error. Re-evaluate them at +/- 1 σ and quote difference wrt the central fit.

Systematics (cont'd)

l) Charge asymmetry: assess +/-25% of the 10% charge-asymmetry effect studied in the published D^0 analysis

m) XFT bias correction: the correction function have uncertainties. Stretch (push) K/π discrepancy shifting simultaneously the correction coefficients by 1 σ, reevaluate the correction, and quote differences wrt the central fit

n) $p_T(B)$ spectrum: B_s and B_d spectra are different, in principle, but use MC with an "average" spectrum. Created an additional "shrunk" spectrum by shifting by –1% each entry in the $p_T(B)$ histogram used in central fit. Extract weights from the ratio of the two spectra, apply to MC events; re-evaluate the relative efficiencies.

Systematics (cont'd)

o) $\Delta\Gamma_s/\Gamma_s$: Standard Model predicts ~ 0.12±0.06 and $B_s \to K^+K^-$ to be dominated by the short-lived component. We derive the systematic uncertainties from these assumptions by varying $\Delta\Gamma s/\Gamma s$ from 0.06 to 0.18 , re-evaluating the relative efficiencies and quoting the differences wrt the central fit.

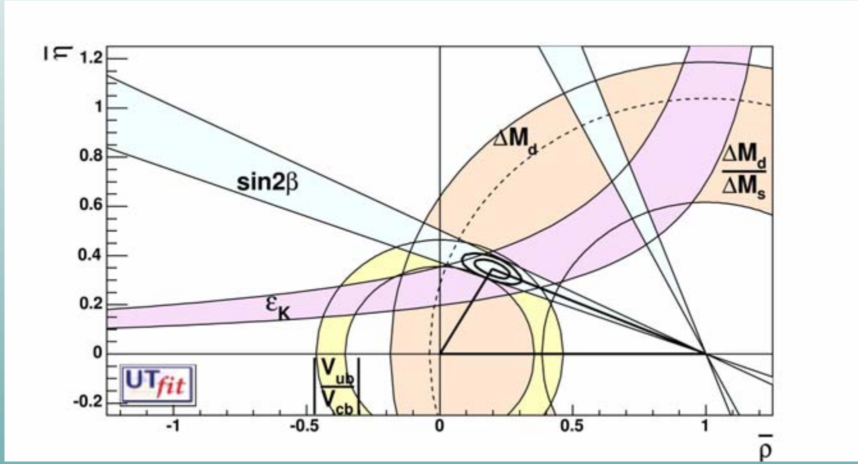
Systematic uncertainties

source	$\frac{f_s}{f_d} \cdot \frac{BR(B_s^0 \to KK)}{BR(B^0 \to K\pi)}$	$A_{CP}(B^0 \to K\pi)$	$\frac{BR(B^0 \to \pi\pi)}{BR(B^0 \to K\pi)}$	$\frac{f_d}{f_s} \cdot \frac{BR(B^0 \to \pi\pi)}{BR(B_s^0 \to KK)}$
mass resolution	0.003783	0.001522	0.001664	0.0037
dE/dx **correlation:**	0.024462	0.001566	0.01272	0.003695
dE/dx **residual**	0.00082	0.00034	0.00020	0.00037
input masses	0.02257	0.0033	0.0105	0.0097
background model	0.0106	0.002234	0.00308	0.00357
p **spectra of background**	0.00116	0.00047	0.00008	0.0009
lifetime	0.00373	-	-	0.0037
isolation efficiency	0.04755	-	-	0.0464
MC statistics	0.00373	0.000454(*)	0.0026	0.00556
charge asymmetry	-	0.0009	-	-
XFT-bias correction	0.0093	-	0.0035	0.014
$p_T(B)$ **spectrum**	0.0065	-	-	0.0065
$\Delta\Gamma_s/\Gamma_s$ **Standard Model**	0.0065	-	-	0.00556
TOTAL	**±0.0609**	**±0.0046**	**±0.0174**	**±0.0510**

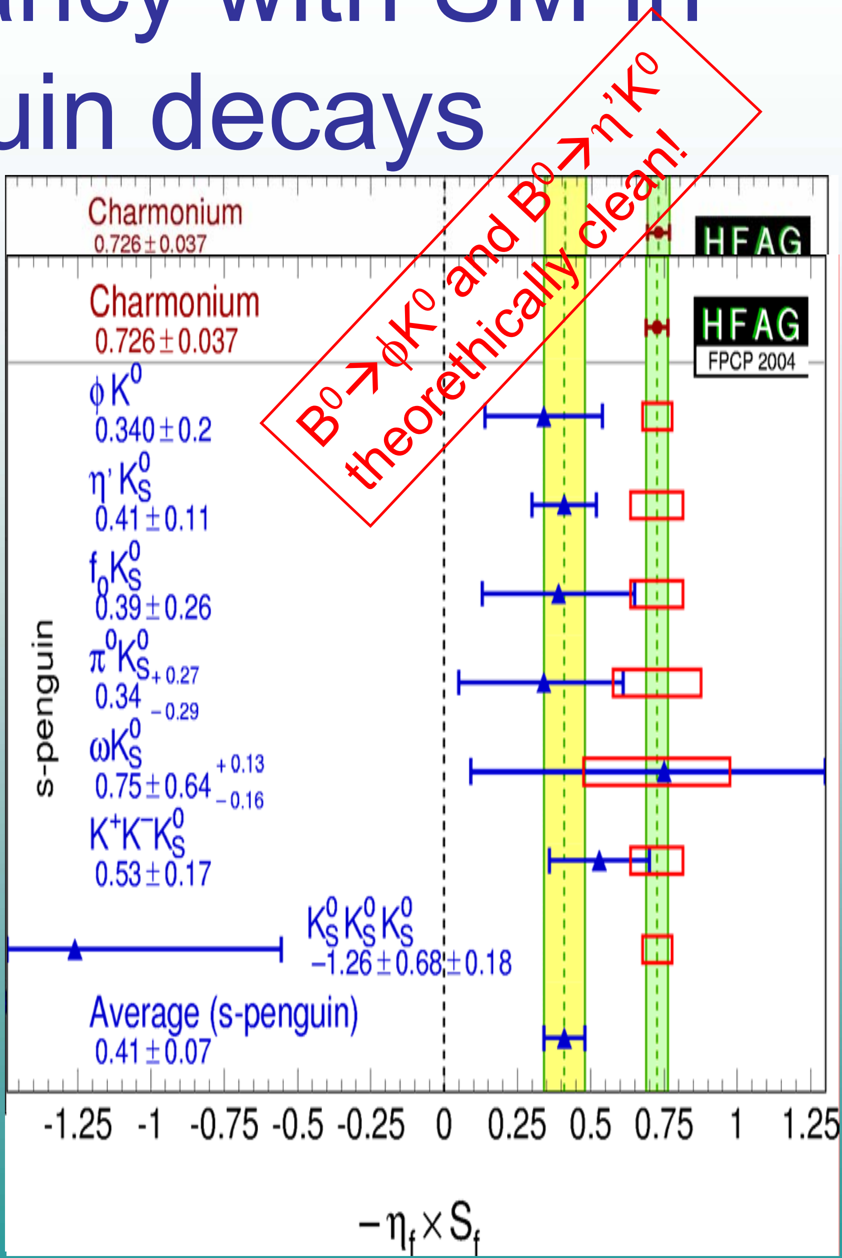
will decrease with statistics

Hint of discrepancy with SM in b→s penguin decays

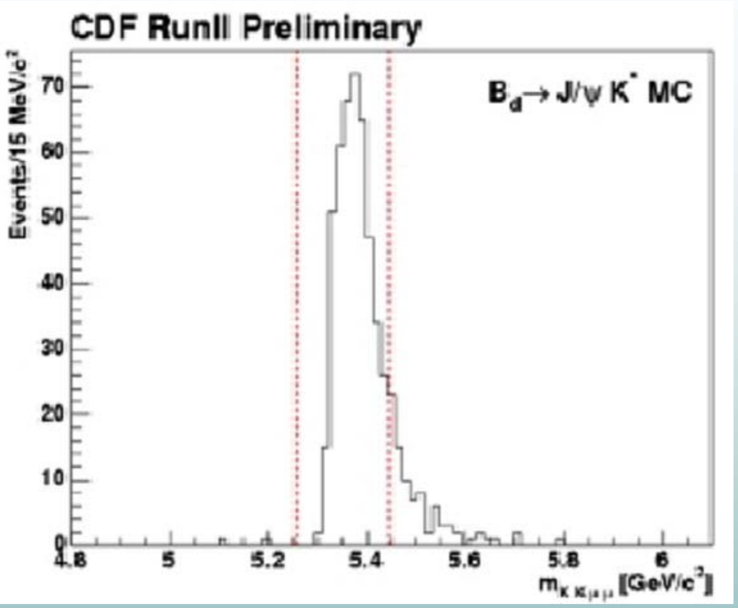
- Measure sin(2β) using golden charmonium modes $(b \to c\bar{c}s)$ (i.e. $B_d \to J/\psi K_S^0$) from mixing induced time dependent CP asymmetry

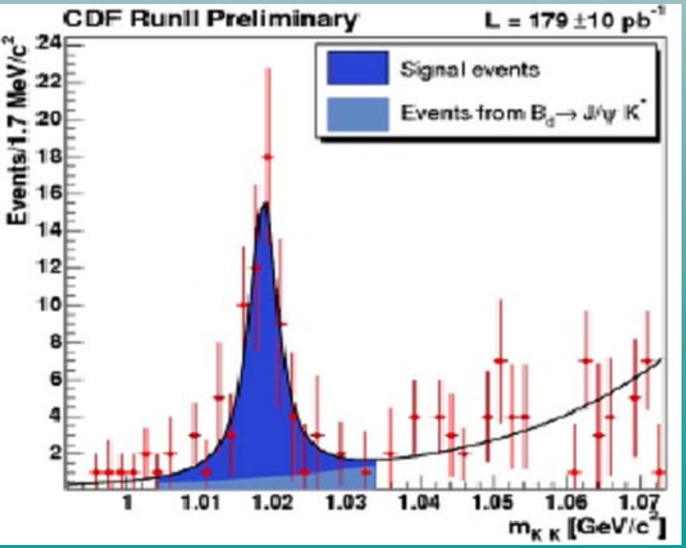


- Unexpected result (3σ effect) when measuring sin(2β) from penguin dominated modes $(b \to s\bar{s}s$ and other $b \to s)$



$B \rightarrow \phi\phi$ background





Due to the large width of K* and to its value close to mφ we get in our Bs signal window a reflection from Bd→J/ψ K* for Bs→J/ψ φ and from Bd→φ K* for Bs→φφ
We get an estimate of this contribution by evaluating from MC the efficiency of reconstructing a Bd→J/ψ K* event as Bs→J/ψ φ and from the measured BRs and fs/fd.
As a cross-check we can evaluate the contribution from the sidebands subtracted mass spectrum of the φ meson, in which the only remaining source of background comes from the Bd→J/ψ K* reflection that doesn't enter the Bs sidebands region

BR($B_s \rightarrow \varphi\varphi$) systematics

- Systematic error dominated by normalization mode BR uncertainty and already similar in size to the statistical error
- Theory uncertainty on polarization very conservative (vary longitudinal fraction in 20 % to 80% range as suggested by A. Kagan)
- $\Delta\Gamma_s$ uncertainty based on the preferred theory value of: $\Delta\Gamma_s/\Gamma_s = 0.12 \pm 0.06$
- BR is rather on the low side respect to QCDF (2.5 σ) 1.4 vs 3.7 E-5

Source	Relative error on BR
Trigger efficiency	3.3 %
J/$\psi\phi$ yield and effici	8.4%
Background subtraction	5.4%
$B_s \rightarrow \phi\phi$ polarization	3.8%
$B_s \rightarrow J/\psi\phi$ polarization	1.4%
$\Delta\Gamma_s$ uncertainty	0.6%
J/ψ and ϕ BR	2.1%
Sub Total	11 %
BR(J/$\psi\phi$)	35%
Total	37%

BR($B^\pm \rightarrow \varphi K^\pm$) systematics

- Systematic error on BR dominated by fit uncertainty and acceptance correction, largely below statistical uncertainty
- A_{CP} systematic is largely statistical in nature, intrinsic systematic below 0.01
- Comparable to B-factory experiments

Source	Relative error on BR
Trigger efficiency	3.3 %
$J/\psi K$ yield and eff.	4.0%
Efficiency Ratio	3.6%
$B^\pm \rightarrow \varphi K^\pm$ fit syst.	3.0%
J/ψ and ϕ BR	2.1%
$B^\pm \rightarrow \varphi K^\pm$ BR	0.4%
Total	7.4 %

Source	error on Acp
$B^\pm \rightarrow \varphi K^\pm$ fit syst.	+0.034 -0.020
Charge asymmetry	±0.005

Further B_s modes

- Rich harvest of interesting $B_s \to VV$ decays
  (Li,Lu,Yang hep-ph/0309136)
- Only the π^0-less shown in the table here
- Measure them all!
  - $K^{*+}K^{*-}/K^{*0}$anti-K^{*0} untagged angular analysis gives γ (with SU(2) assumptions)
  (Fleisher,Duniets)
  - $\phi\rho^0$ dominated by Electro Weak Penguin (insight in to the $B\to\pi K$ puzzle!)

Decay	BR(10^{-6})	BR/BR($\phi\phi$) (including daugher BR)
$K^{*0}\rho^0$ (b→d)	0.53	0.11
$K^{*+}K^{*-}$ (b→s)	1.94	0.008
$\rho^0\phi$ (b→s)	1.03	0.16
K^{*0} anti-K^{*0} (Pure penguin)	2.61	0.35
$K^{*0}\phi$ (Pure penguin)	0.14	0.014
$\phi\phi$ (Pure penguin)	13.1	1

Trigger efficiency not included
(but expected very similar)