B mass, lifetime, prospects for B-oscillations and CP-violation at CDF, including new Charm results.

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- CDF detector upgrades for Heavy Flavour physics.
- First Run II measurements overview.
- Prospects for B mixing and CP violation.
- Perspectives for Charm physics & CPV.
- Conclusions.

CDF upgrades for B-physics:

- New Silicon vertex detector SVX II (5 double layers) + ISL (2 additional layers) + extra silicon layer L00 on beam pipe (~2cm from I.P.) rad. hard for improving vertexing resolution.

- Silicon Vertex Tracker at L2 for triggering on high impact parameter tracks, combine tracks measured in the transverse plane at L1 by XFT with axial silicon information to measure I.P. with quasi-offline resolution.

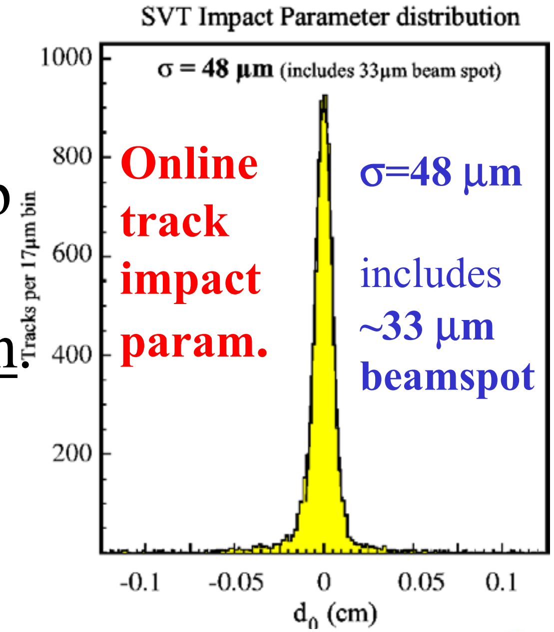
- Muon detector coverage extended to $\eta = 1.5$

- New Time of Flight detector at R=1.4 m, outside the drift chamber,made of 216 plastic scintillator bars, for PID oriented to improve B-tagging.

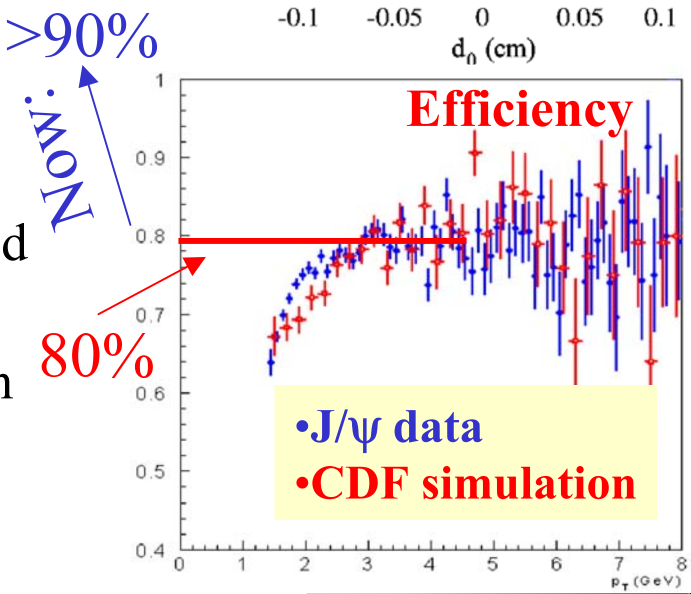
The new hadronic B trigger SVT:

~150 VME boards find & fit silicon tracks, with offline accuracy, in a 15 μs pipeline

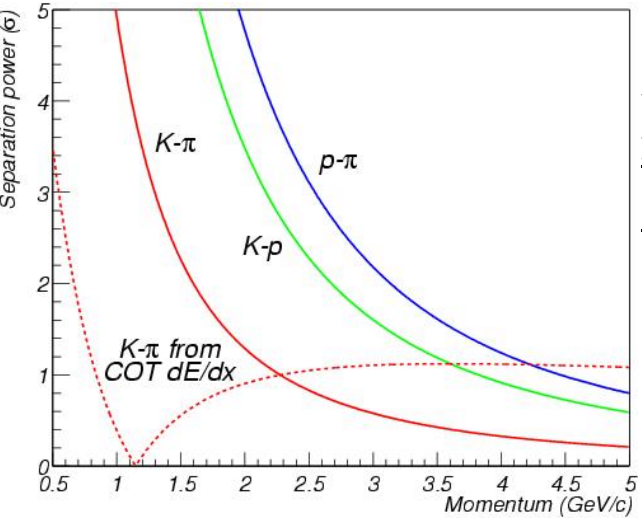
First time that B-physics ($\sigma \approx 0.1$mb) @ CDF, is done by rejecting p-antip background ($\sigma \approx 50$mb) without requiring a lepton.



- ❖ **S**econdary **V**ertex L2 **T**rigger
  - ➢ Impact Parameter resolution as planned
    - 48 μm (**33 μm** beam spot transverse size)
  - ➢ Online fit/subtraction of beam position
  - ➢ Rϕ only $\Rightarrow$ need beamline || silicon



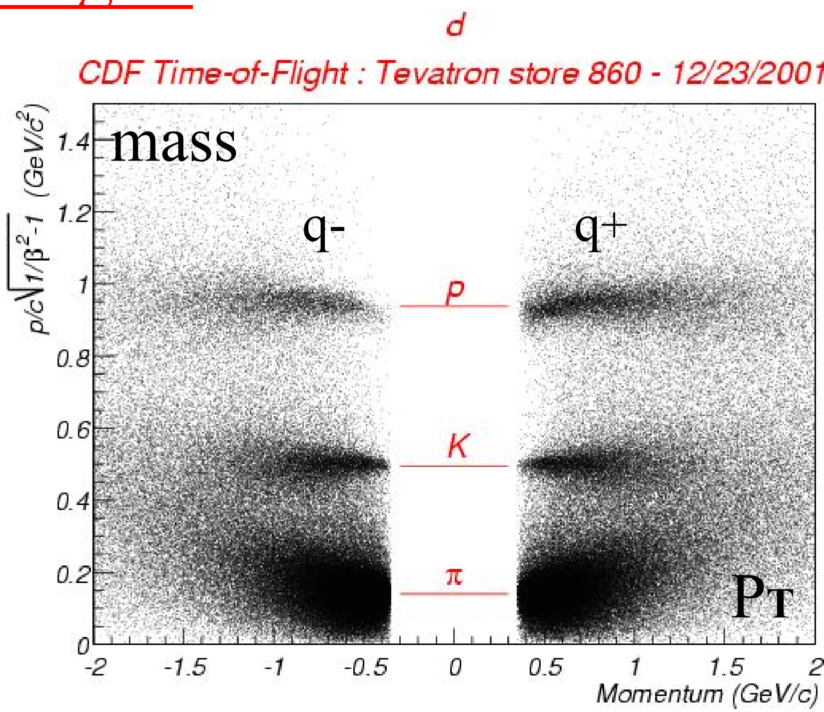
CDF Time of Flight:



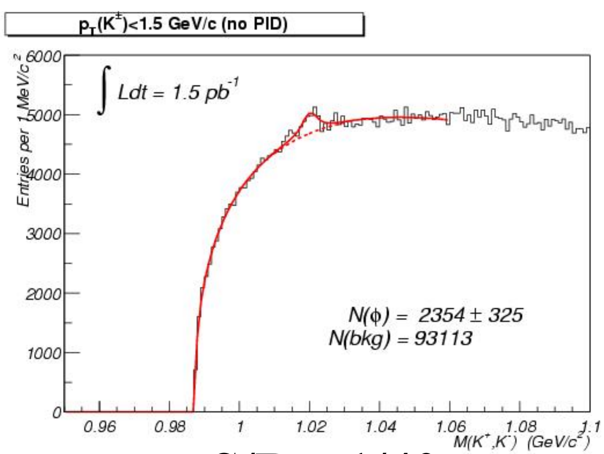
A very good timing resolution is needed: 100 ps to obtain a **K/π** separation at **2σ** for P_T<1.6 GeV.

…at present almost reached

⇒



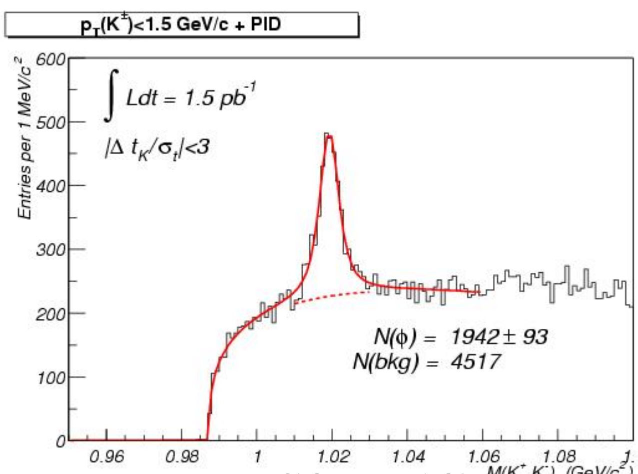
An example of application on background reduction on **φ→KK** :



S/B ~ 1/40

with TOF PID

⇒



S/B ~ 1/2

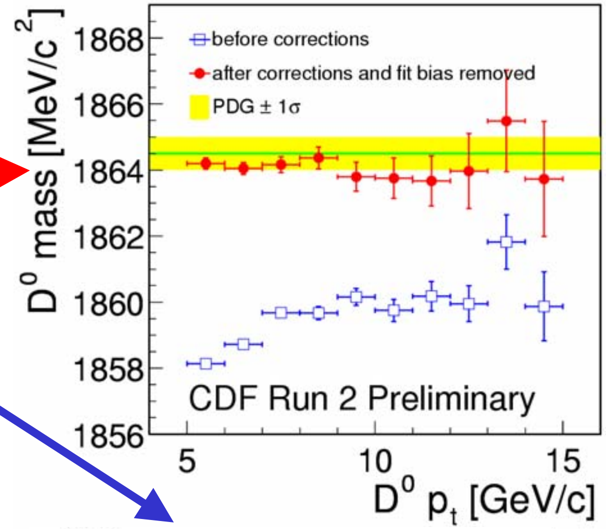
Lepton based sample

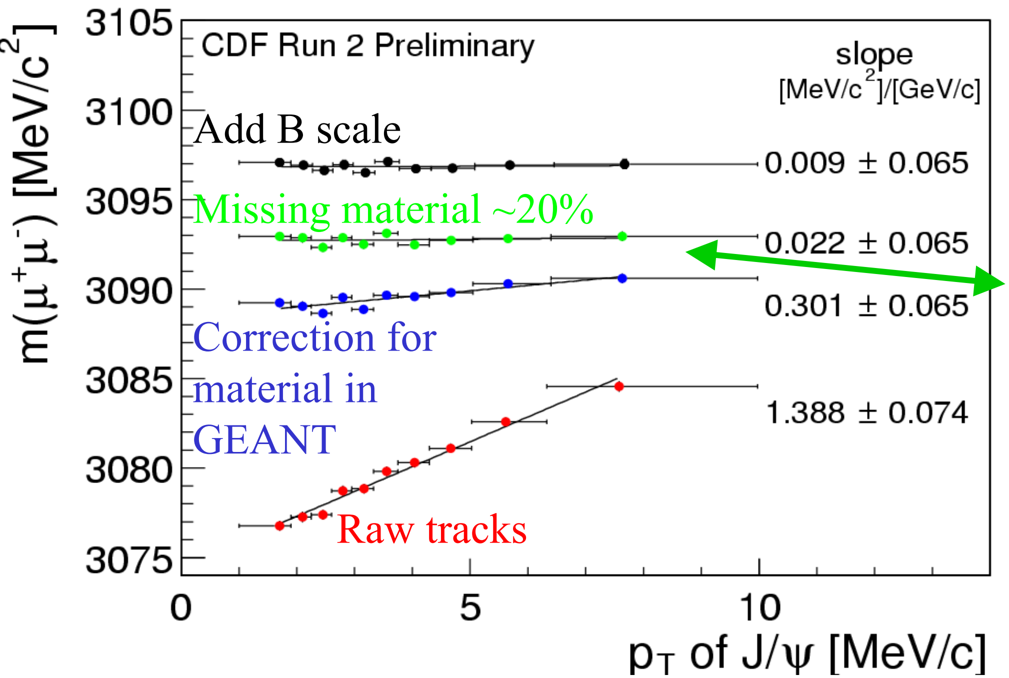
Momentum scale study from J/Ψ and D's:

- Use J/ψ's to understand E-loss and B-field corrections

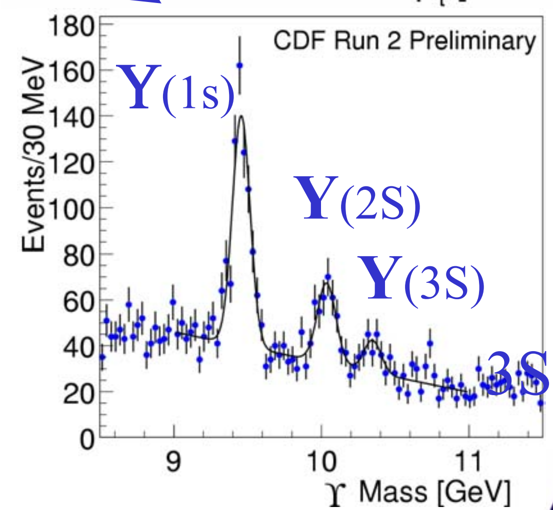
  σ(scale)/scale ~ 0.02% !
- **Check with other known signals**

D^0



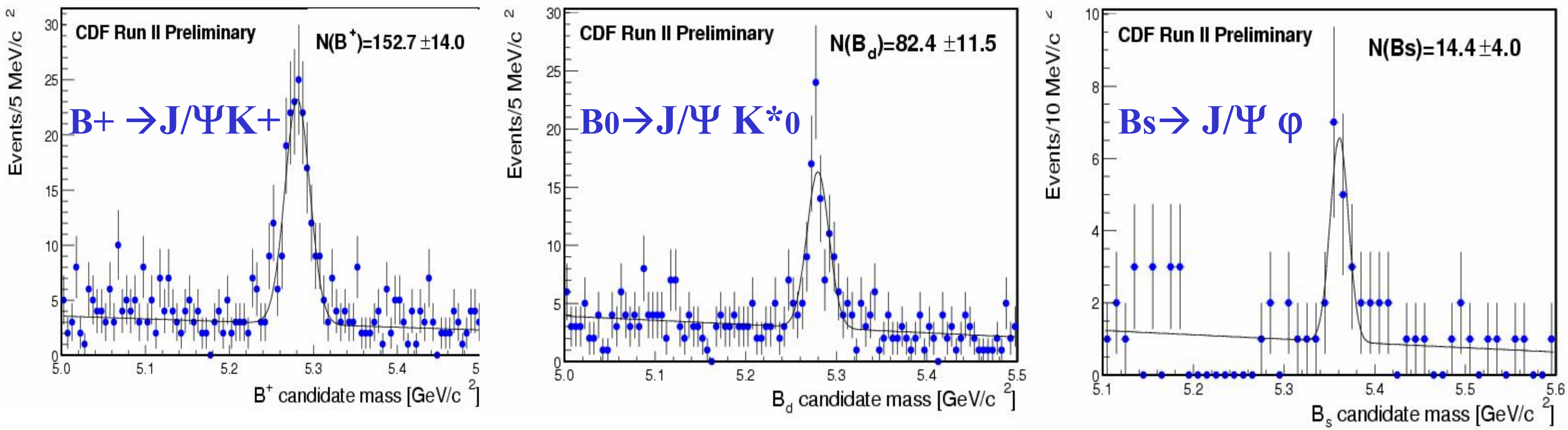


confirm with $\gamma \to ee$



Bo, B+, Bs masses in the exclusive J/Ψ channels

Relying on momentum scale calibration, B mesons masses as been measured using 18.4 pb-1 of integrated luminosity with the di-muon trigger.



•Very **low statistics** at present especially for Bs.

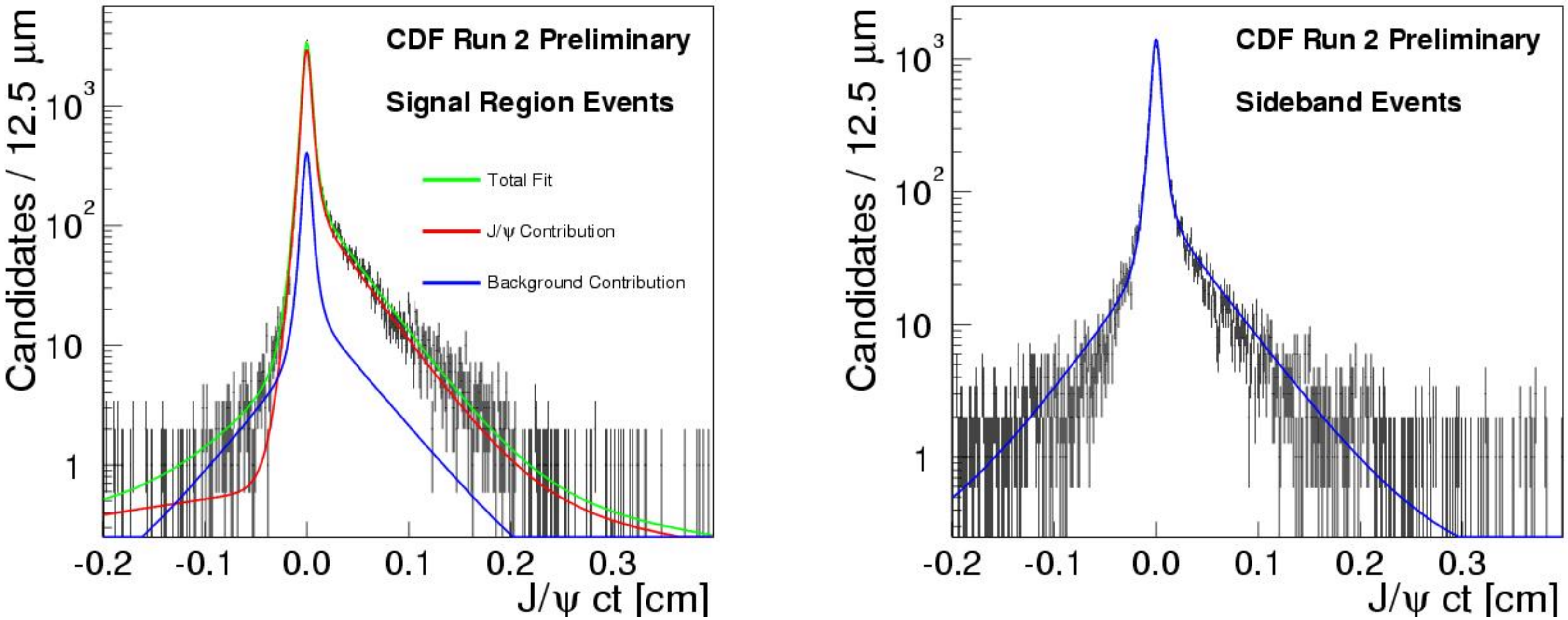
• Systematic from **tracking** drift chamber +Silicon extensively studied (Energy loss,alignments).

M(B+) = 5280.6 ± 1.7(stat) ± 1.1 (syst) MeV/c2
M(B0) = 5279.8 ± 1.9(stat) ± 1.4 (syst) MeV/c2
M(Bs) = 5360.3 ± 3.8(stat) +2.1/-2.9(syst) MeV/c2

•As an higher statistics monitor, the Ψ' mass from Ψ'→J/Ψ ππ was used.

M(Ψ') = 3686.43 ± 0.54(stat) MeV/c2

Inclusive B lifetime from B→ J/Ψ+X

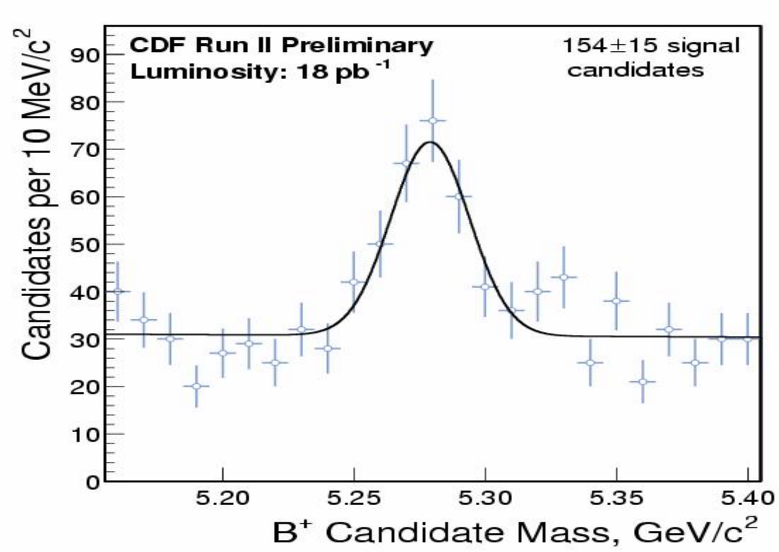


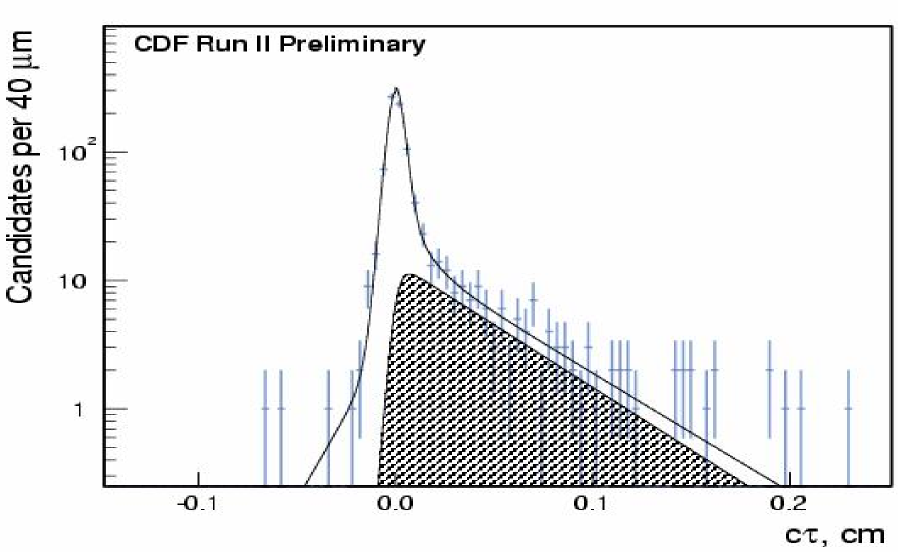
- From ~ 28K J/Ψ→μμ collected with di-muon trigger based on CMU (Central Muon System).
- There are a "prompt" (from direct pp production) and a "lifetime" component of J/Ψ's.
- Need to correct cτ measurement of J/ Ψ with MC, to account for the partially recon.decay
- Primary vertex J/Ψ's are used to study the resolution function.

$c\tau(B) = 458 \pm 10(stat) \pm 11(syst)\ \mu m$

$\tau(B) = 1.526 \pm 0.034(stat) \pm 0.035(syst)\ ps$

Exclusive B+ lifetime in B+→ J/Ψ K+





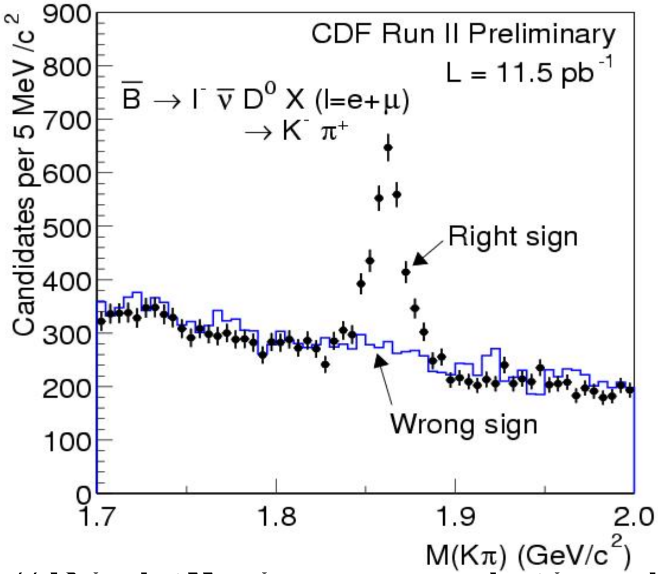
- Measure based on 18 pb-1 collected corresponding to ~150 reconstructed B+→ J/Ψ K+.
- The cτ distribution is modeled by the convolution of a long life exponential with a gaussian resolution function.
- Systematic uncertainties, mostly due to silicon alignment, model for resolution and selection cuts, is very well controlled. → Measure is statistically dominated for the time being.

cτ(B+) = 446 ± 43(stat) ± 13(syst) μm
τ(B+) = 1.49 ± 0.14(stat) ± 0.04(syst) ps

Semileptonic B decays:

Two optimized trigger paths:
- 4 GeV **electron** + **displaced track**(pT>2GeV; d0>120μm)
- **Muon** + **displaced track**(pT>2GeV; d0>120μm)

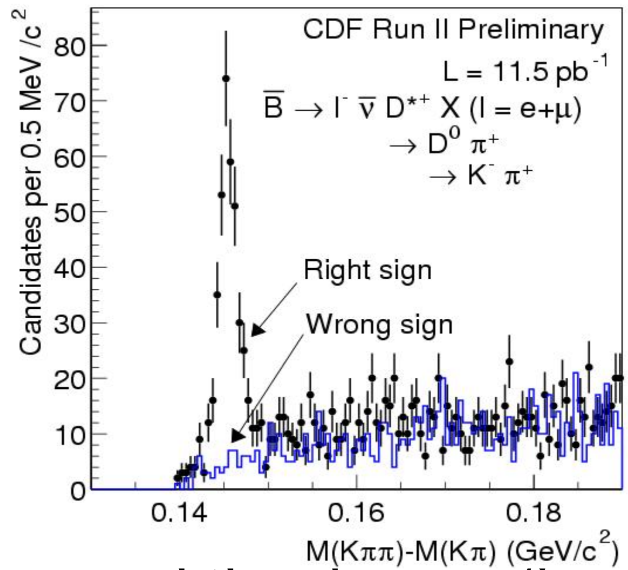
Best sample to measure **effective dilution** of tagging algorithm for **B mixing**



Lepton+D0, D0→Kπ
~2000 candidates
⇐

(10 pb-1)

Lepton+D*→D0π
(D0→Kπ)
~350 candidates



"Right" sign correlation between lepton charge and the charge of the Kaon from D meson is a tag for **B→lνD** decays.

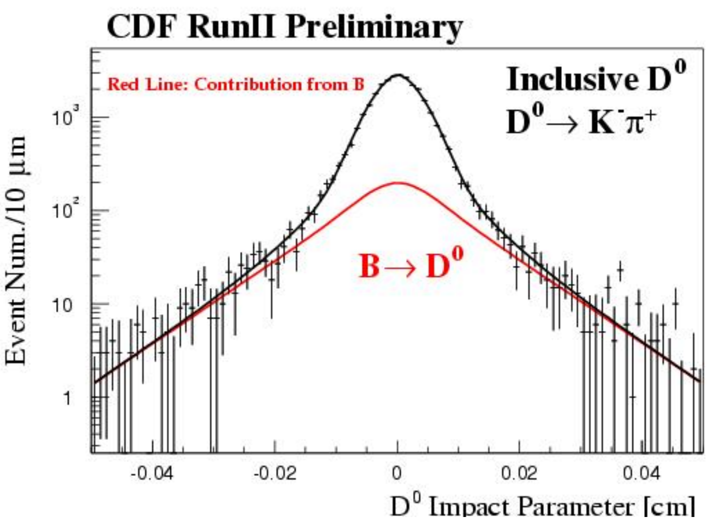
⇒Huge sample (x3 yield/lum of runI) for **lifetimes** measurements and CKM triangle elements (Vcb, Vub) as well as B/C-barions study.

Hadronic sample

bb/cc fraction in the hadronic trigger sample:

Understanding the SVT trigger sample **i.e.** Displaced vertices events

D mesons I.p.(d0) distribution



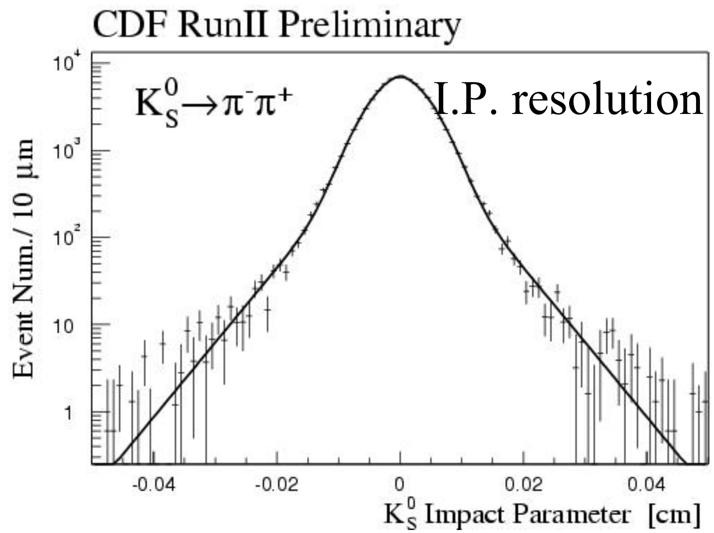
From reconstructed D mesons in hadronic final states D+-→Kππ , D0→Kπ , D*→πD0 , Ds→φπ ; produced at ppbar interaction, the relative fraction between **prompt** D's and **secondary** D's from B.

Given the high impact parameter resolution, the Distance of closest approach (**d0**) from Primary vertex Was used to discriminate the two components.

D's from p.v. have d0≈0

Ks→ ππ are primary → I.P. resolution

…just to have a feeling:

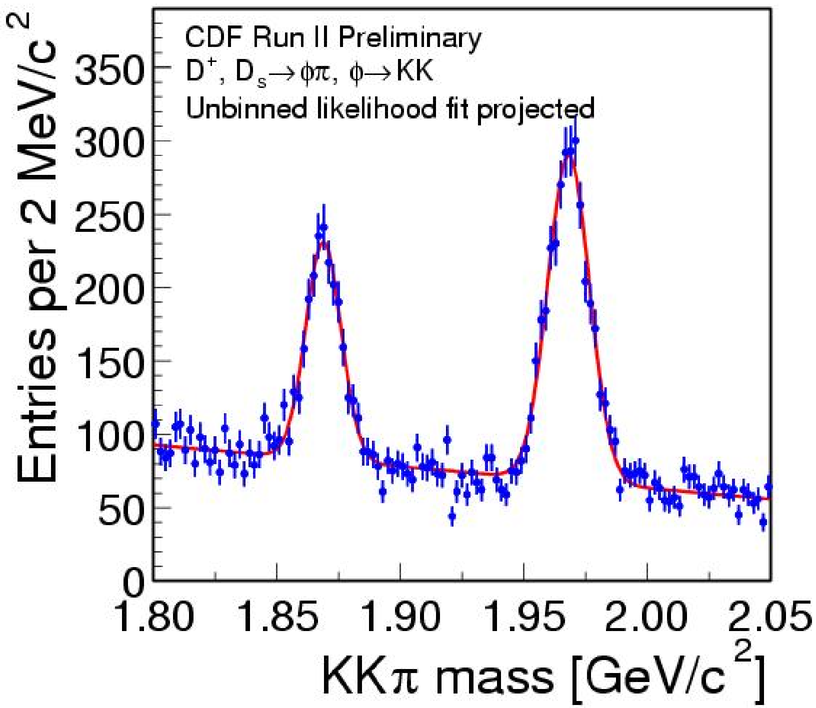


B fraction:

D0 sample : 16.4 ± 0.7 %

Ds – D+ mass difference

•Based on ~ 11 pb-1 of luminosity collected with the new **SVT** two track trigger.
•Ds and D+ are reconstructed in the $\varphi\pi$ channel where $\varphi \rightarrow KK$.
•Almost the same statistics of Ds and D+ even if D+$\rightarrow$ $\varphi\pi$ is Cabibbo suppressed, this is due to the higher efficiency of **SVT** trigger to long lifetimes: τ(D+) ~ 2 τ(Ds).



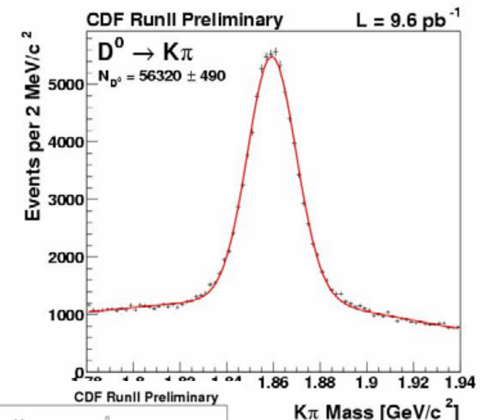
About 2400 Ds and 1400 D+ after selection:

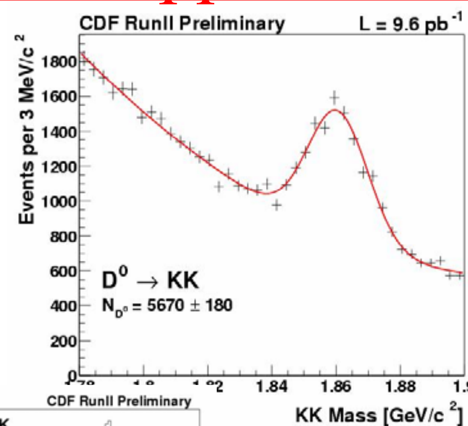
•Offline confirmation of SVT tracks requirements.
•1010<M(φ)<1035 MeV/c2.
•Projected flight distance Lxy(D) > 500 μm.
• + other cinematic cuts.

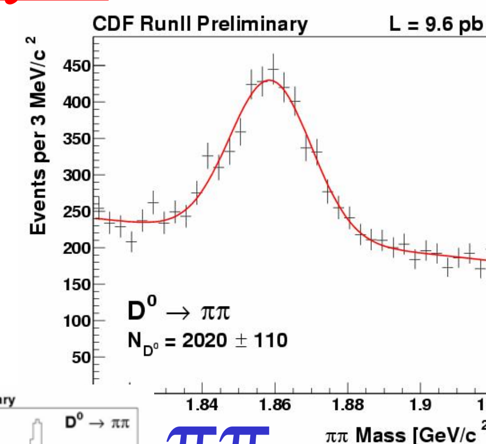
{ *Result is already competitive →*
PDG average: (99.2 ± 0.5 MeV/c2) }

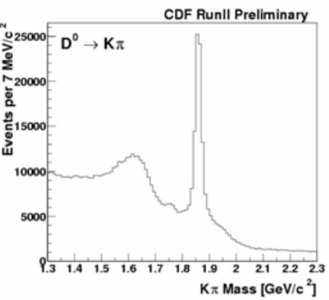
M(Ds)–M(D+) = 99.28 ± 0.43(stat) ± 0.27(syst) MeV/c2

Cabibbo suppressed D decays :



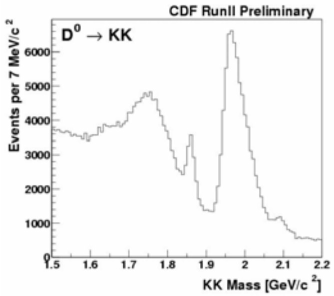






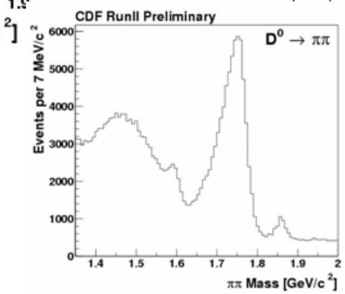
Kπ mass

56320±490



KK mass

5670±180



ππ mass

2020±110

After correction for relative acceptance of SVT trigger & reconstruction for the 3 decays

⇓

9.6 pb-1 only

$\Gamma(D \rightarrow KK)/\Gamma(D \rightarrow K\pi)$ = 11.17 ± 0.48(stat) ± 0.98 (syst) %

$\Gamma(D \rightarrow \pi\pi)/\Gamma(D \rightarrow K\pi)$ = 3.37 ± 0.20(stat) ± 0.16(syst) %

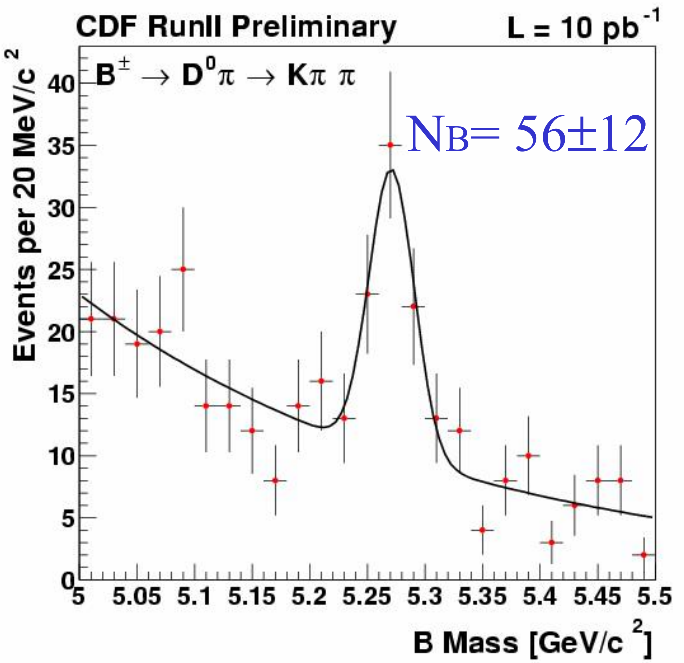
Already competitive measurements in Charm with
The first statistic collected with the new SVT trigger.

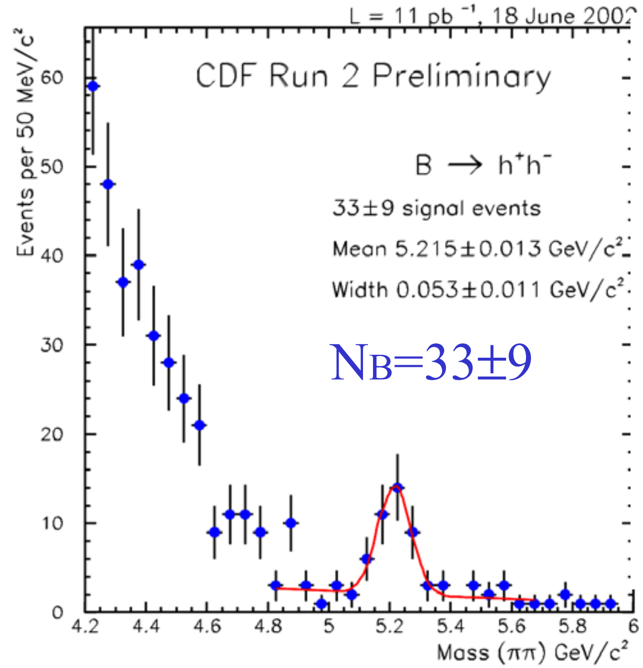
WORLD BEST MEASURES: CLEO2 (PDG 2002)

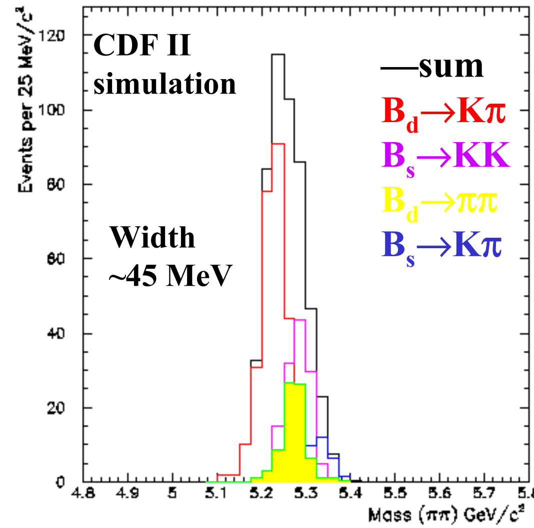
- $\Gamma(D \rightarrow KK)/\Gamma(D \rightarrow K\pi)$ = 10.40 ± 0.33 ± 0.27 %
- $\Gamma(D \rightarrow \pi\pi)/\Gamma(D \rightarrow K\pi)$ = 3.51 ± 0.16 ± 0.17 %

Huge sample of D→had's expected → **D0 mixing** & **CPV** in D decays

Firsts fully hadronic B signals in the SVT trigger:







$B^{\pm} \rightarrow D_0 \pi^{\pm}$ $(D_0 \rightarrow K\pi)$ **$B_0 \rightarrow h^{+}h^{-}$** ($\pi\pi$ inv.mass)

Reconstructed from 10 pb-1 out of **SVT** trigger data. (@ ICHEP 2002)

•Very good (better than expected) Signal/Noise (lowers the stat. needings)

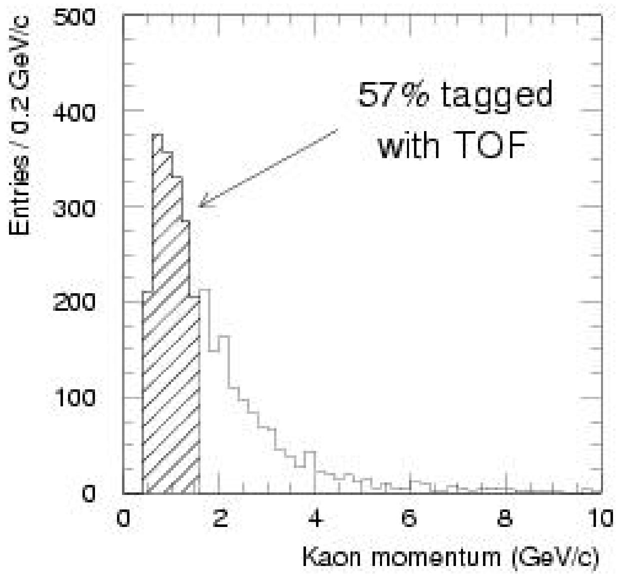
⇒Recent improvement : 50 % increase of **SVT** efficiency to hadronic decays of heavy mesons due to enlarged SVX coverage & optimization of SVT patterns.

CDF B-tagging capabilities

• SLT Soft Lepton Tagging based on lepton charge correlation with B flavour in semileptonic B decays.
• JQT Jet charge of opposite B tagging.
• SST Same Side Tagging, in hadronization of **B$_{d/s}$** meson a **d$\bar{d}$/s$\bar{s}$** pair is produced giving a π/K associated to the B meson at production vertex.
• OSK Opposite Side Kaon tagging, due to **b→c→s** it is more likely that a b quark will contain in final state a K- than a K+, this Kaon is associated to the opposite B decay vertex.

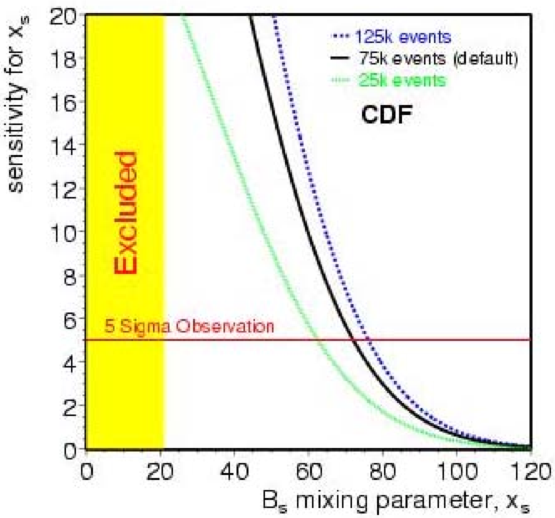
SST(kaon) & OSK are possible with PID from TOF

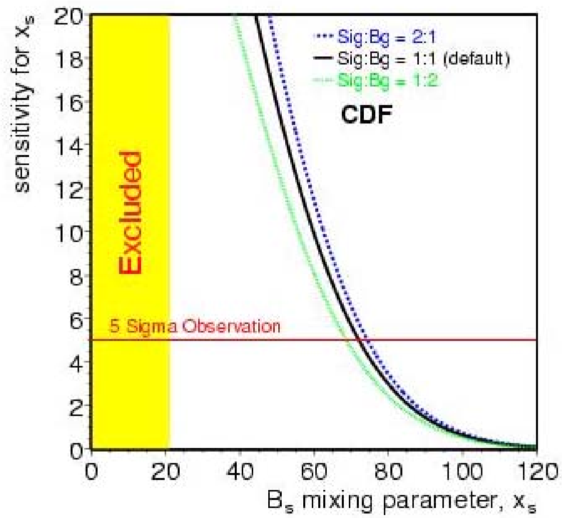
Method	**runI εD2**	**runII εD2**
SLT	1.7%	1.7%
JQT	3.0%	3.0%
SST	1.0%	4.2%
OSK	---	2.4%
Total	5.7%	11.3%



Projections for Δm_s

…CDF toward new constraint of CKM triangle:





In $\int L = 2$ fb-1 (run IIa)
Expected from SVT trigger, in fully reconstructed hadronic modes:

75k $B_s \to D_s\pi$; $D_s\pi\pi\pi$;
with $D_s \to \varphi\pi$; K^*K; K_sK;

Assuming: BR($D_s\pi$)=0.3% and BR($D_s3\pi$)=0.8%

- **S/B** from 2/1 to 1/2
- **σ_t** = 60 fs (45 fs with L00)
- **εD^{2}** = 11.3% (with TOF)

⇓

CDF sensitivity at 5σ for :
$x_s < 70$ ($\Delta m_s < 45$ ps^{-1})

$A_{mix} = (N_{nomix} - N_{mix}) / (N_{nomix} + N_{mix}) \propto D \cos\Delta m_s$

where:

$D = 2P_{tag} - 1$; $\Delta m_s = m(B_H) - m(B_L)$

and $x_s = \Delta m_s / \Gamma_s$

Significance(Δm_s) $\propto$ sqrt[N εD^2] Exp[$\Delta m_s \sigma_t$]^2

Latest LEP limit: $\Delta m_s < 14.4$ ps^{-1} at 95% CL

Standard Model expectation : $\Delta m_s < 24.6$ ps^{-1} at 95% CL ⇒

CDF will be able to cover SM allowed range in a fraction of runIIa Luminosity.

CDF B physics program:

(only some hints)

•sin(2β) from $B_d \rightarrow J/\psi\ K_s$, improve the runI measure, benchmark for CDF B tagging capabilities.

•A_{CP}($B_d \rightarrow \pi\pi$; $B_d \rightarrow K\pi$; $B_s \rightarrow KK$; $B_s \rightarrow K\pi$); special SVT trigger path optimized for $B \rightarrow \pi\pi$.

•CP asymmetries in other relevant B_d, B_u, B_s and Λ_b decays.

•Lifetimes of B_s and Λ_b.

•sin(γ) measurement in $B_s \rightarrow D_s K$ (after Δm_s measure) and in $B_u \rightarrow D_0(D_*)K$.

•Study of B_c and rare B decays as $B \rightarrow \mu\mu$; $B \rightarrow K(K^*)\mu\mu$ ...

… and much more to come …

Perspectives for Charm physics:

- At present (8/2002) working conditions we will collect ≅ **750K $D0 \to K\pi$** and ≅ **250K $D^* \to \pi D0$ ($D0 \to K\pi$) / 100 pb-1.** [Babar & Belle ~600K D*/exp. in 200fb-1]
- This a sector in which **CDF** is already an **HIGH STATISTICS experiment**: in few hundreds of pb-1 we will be competitive on relevant measurements like **CP asymmetries** in D0 → KK, ππ (with D*tag) as well as **D0 mixing**(via $\Delta\Gamma$).
- The CDF experiment has started a program to look for **rare** and forbidden **Charm decays,** start to be competitive with 100 pb-1.
- **Charm production cross section** measurement based on the huge amount of charmed mesons in the SVT trigger, will be for the first time measured at proton-antiproton by CDF.
- These Charm measurements are also excellent to test with a high statistic sample most of the ingredients in B-physics analysis like lifetime resolution, vertexing capabilities, trigger efficiency and PID methods for tagging.

Ex.: $D_0 \to hh$ from SVT has almost the same cinematic as $B \to hh$ and will be the control sample for dE/dx separation power between B_d and B_u.

Backup slides

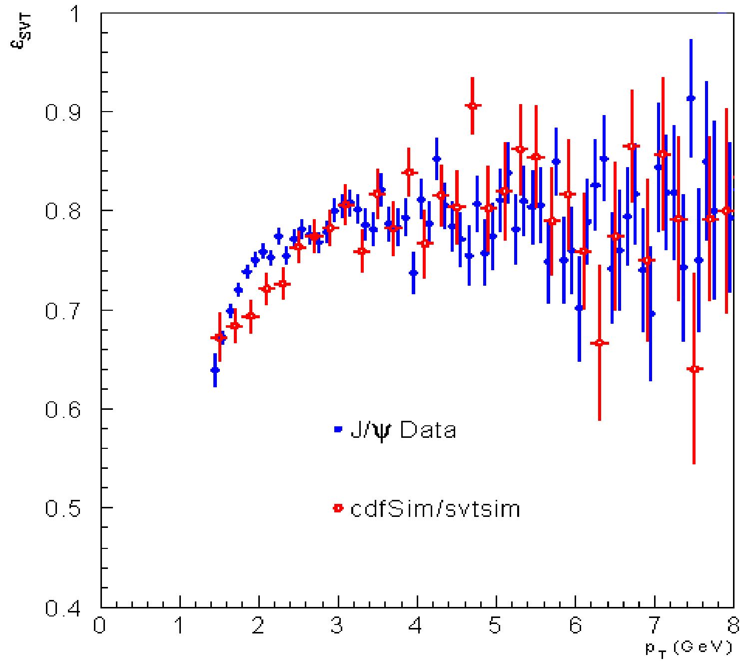
Realistic Simulation of SVT

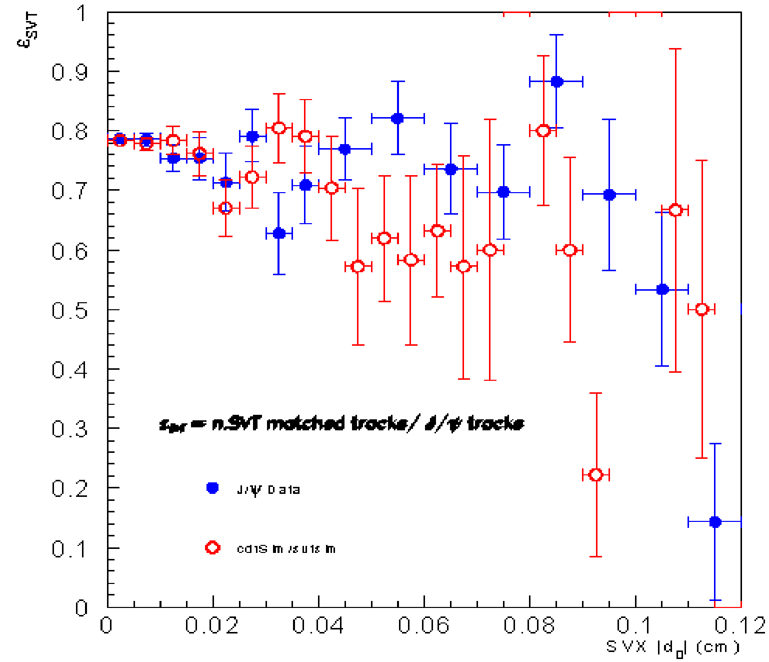
Effects simulated:

- Geometry in Geant shifted from nominal using actual alignement tables (impact on efficiency)
- Beam offset similar to what we have in data (impact on efficiency)
- Emulation of real XFT and SVT algorithm using constants from database (patterns and fit constants)
- Dead channel list from database

- Tested with a sample composed of:
  - 80% prompt J/ψ from FakeEvent with a realistic spectrum
  - 20% of $B^{\pm} \rightarrow J/\psi K^{\pm}$ from BGEN
  - no muon trigger simulation yet

Simulation of SVT tracking efficiency





- SVT tracking efficiency is defined as the probability to match in φ and curvature an SVT track to an offline track that has ≥ 4 silicon hits in the layer required by SVT in each wedge
- Pt dependence of efficiency comes from pattern acceptance
- Impact parameter efficiency curve from svtsim matches within statistics

Recent SVT efficiency improvement