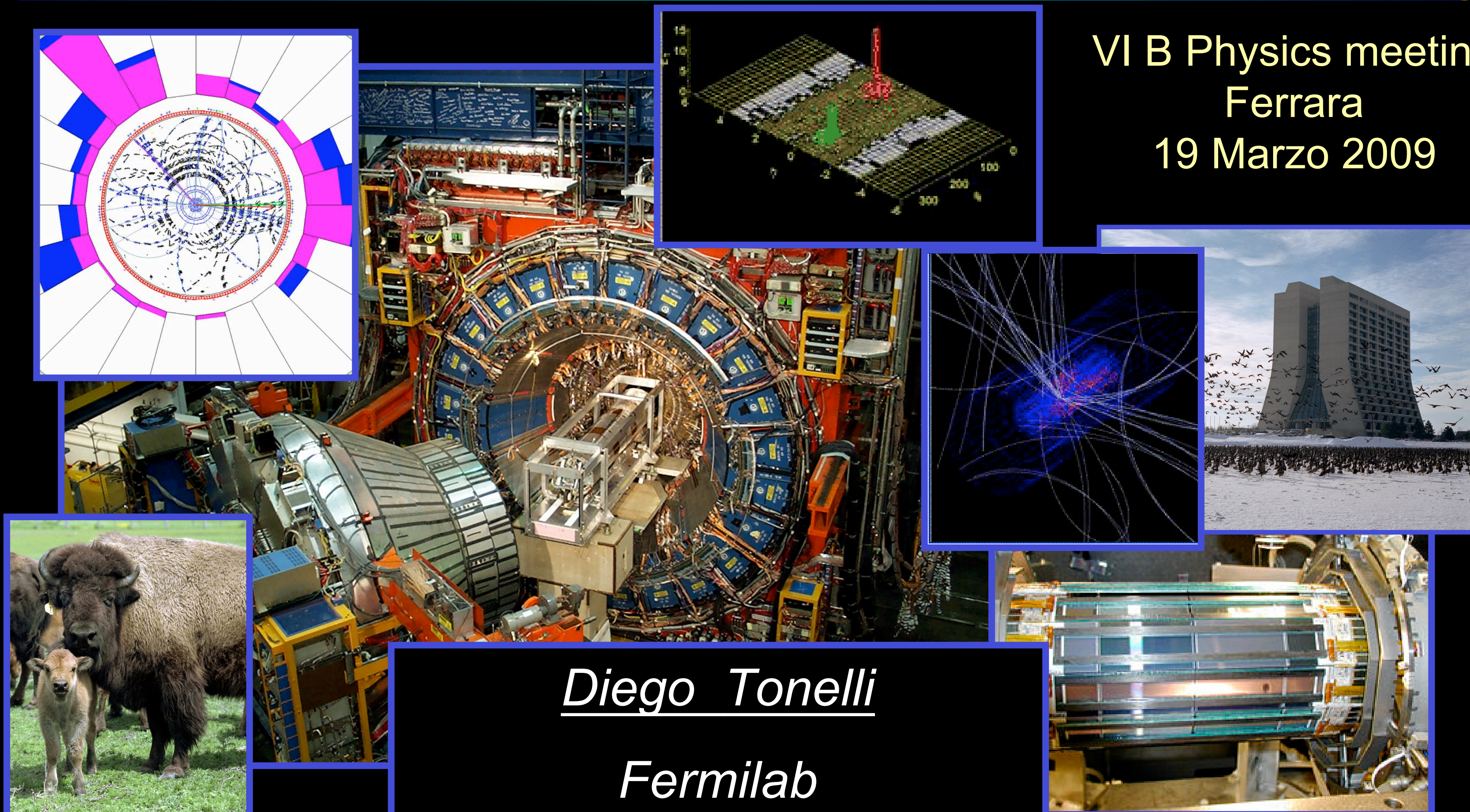
B^0_s physics - a Tevatron's goldmine

VI B Physics meeting
Ferrara
19 Marzo 2009



Diego Tonelli

Fermilab

for the CDF and DØ collaborations

Introduction

Kaon physics and *B* factories: satisfactory SM picture of CP violation - at least at tree level in B^0 and B^+ decays.

[I. Bigi, CERN Theory Institute, 5/26/08]

V On the Autonomy of B_s Dynamics

original paradigm: need B_d & B_s to determine all 3 angles

ϕ_2/α, ϕ_1/β from B_d vs. ϕ_3/γ from B_s

new paradigm: can get all angles from B_d

Furthermore NP in general will not obey SM relations between B and B_s decays

➡ B_s decays a priori independent chapter in nature's book on fundamental dynamics

$B_s(t) \to \psi\phi, \psi\eta, \phi\phi$ not a repetition of lessons from B_d & B_u decays!

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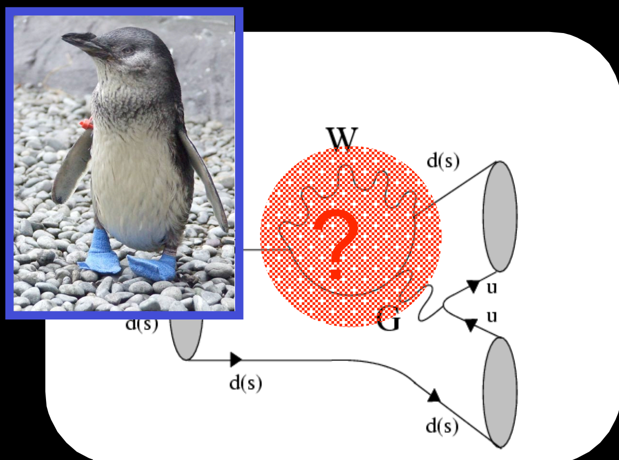
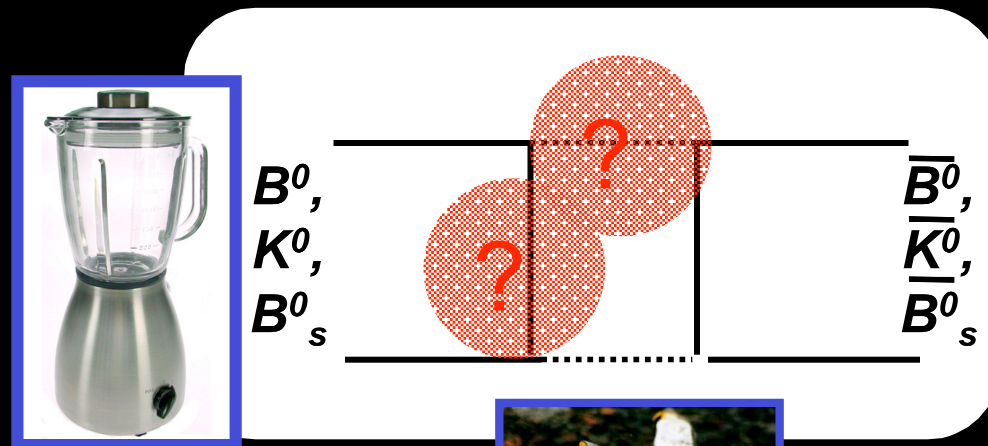
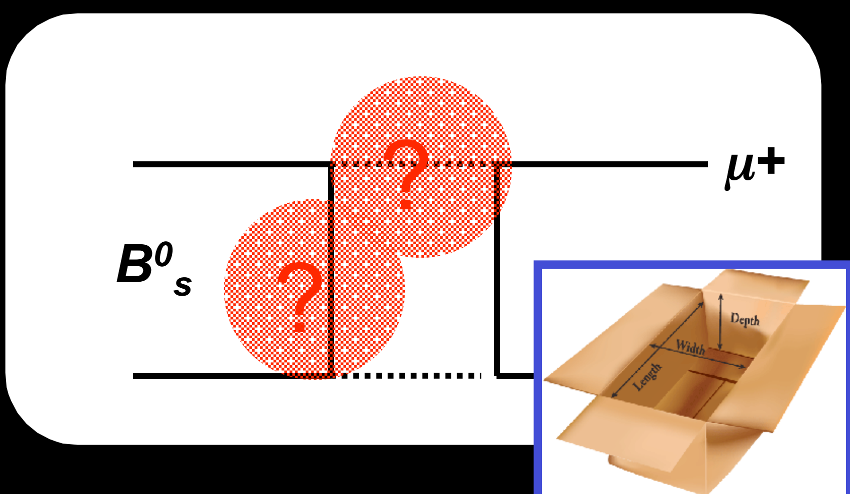
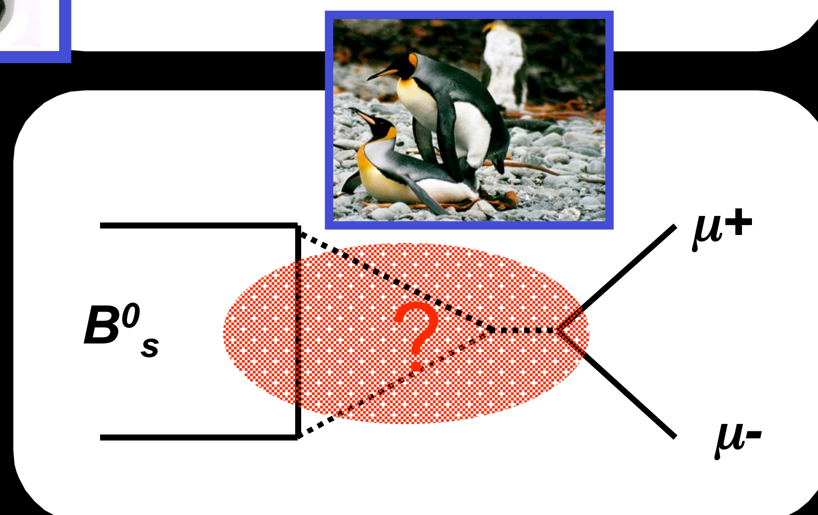
What's left for New Physics?

New physics, if any, in suppressed processes.









$B^0_s \to \mu^+ \mu^-$

$B^0_s \to \mu^+\mu^-$ trivia

Robust SM expectation BR=(3.42 ± 0.54)×10^{-9}. NP can enhance up to 100×

MSSM: BR∝$\tan^6(\beta)$. RPV SUSY enhances also at low tan(β). Complementary to many TeV/LEP searches.

Either observation or null result provides crucial information.

Already 3(CDF) + 2(DØ) Run II publications - copious source of citations.

The measurement (CDF 2/fb)

$$BR(B_s \to \mu^+\mu^-) = \frac{N_{Bs}}{N_{B+}} \cdot \frac{\alpha_{B+}}{\alpha_{Bs}} \cdot \frac{\varepsilon^{total}_{B+}}{\varepsilon^{total}_{Bs}} \cdot \frac{f_{b\to B+}}{f_{b\to Bs}} BR(B^+ \to J/\psi K^+) BR(J/\psi \to \mu^+\mu^-)$$

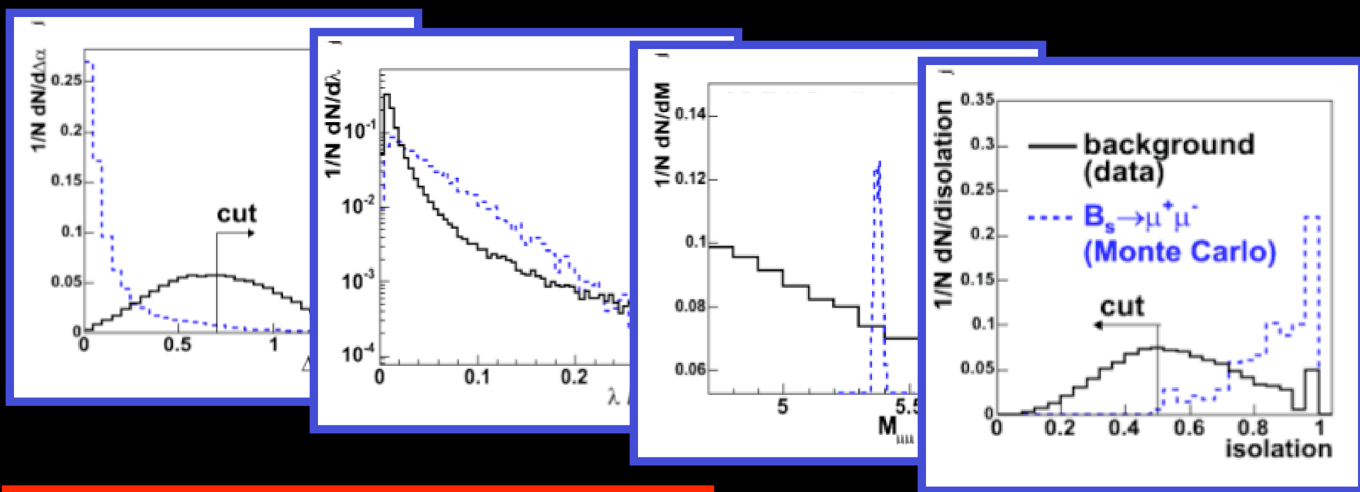
N_{B+}: 11K; α_{B+}/α_{Bs}: 0.2-0.3; $\varepsilon^{total}_{B+}/\varepsilon^{total}_{Bs}$: 0.9

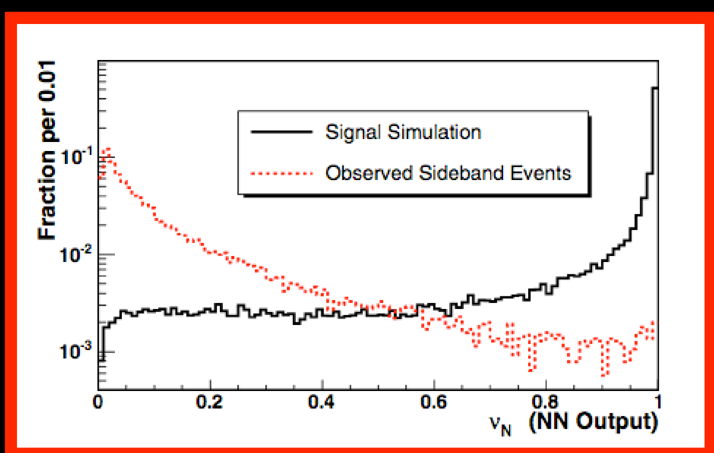
The challenge

Reject 10^6 bckg while keeping signal efficiency high.

$B^0_s \rightarrow \mu^+\mu^-$ - selection

Use trigger muons with $|\eta|<1$, $p_T>2$ GeV/c, $p_T(B)>4$ GeV/c





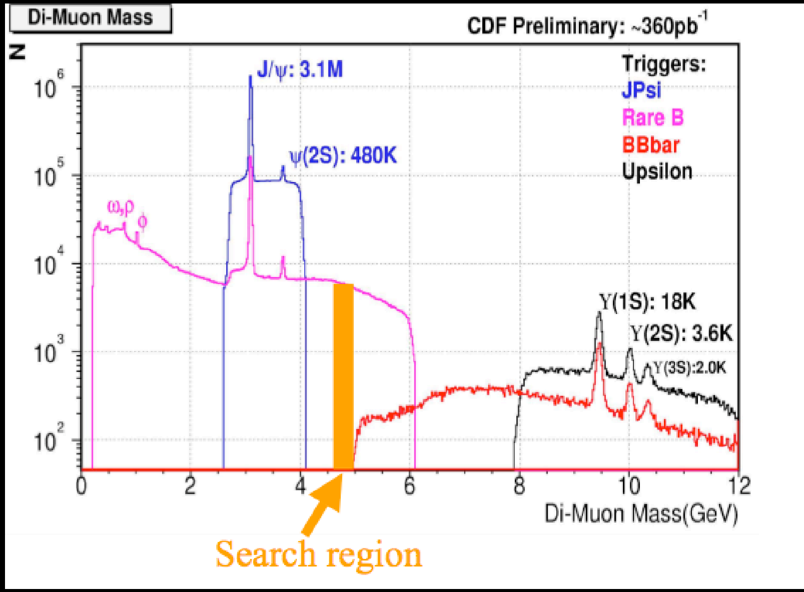
Combine discriminating quantities in ANN

+25% rejection at same efficiency wrt to LR

$B^0_s \rightarrow \mu^+\mu^-$ - backgrounds

Possible offenders:

- ✓ Continuum μμ from Drell-Yan
- ✓ Sequential b→c→s semileptonic
- ✓ Double semileptonic $b\bar{b} \rightarrow \mu\mu$+X
- ✓ b/c → μ + fake
- ✓ Fake + fake (dominated by B → hh)



Suppress fakes: calorimeter, dE/dx, muon-track matching. All calibrated on $J/\psi \rightarrow \mu\mu$, $D^0 \rightarrow K\pi$, $\Lambda \rightarrow ph$ decays in data.

Combinatorial: extrapolate from sidebands into signal region

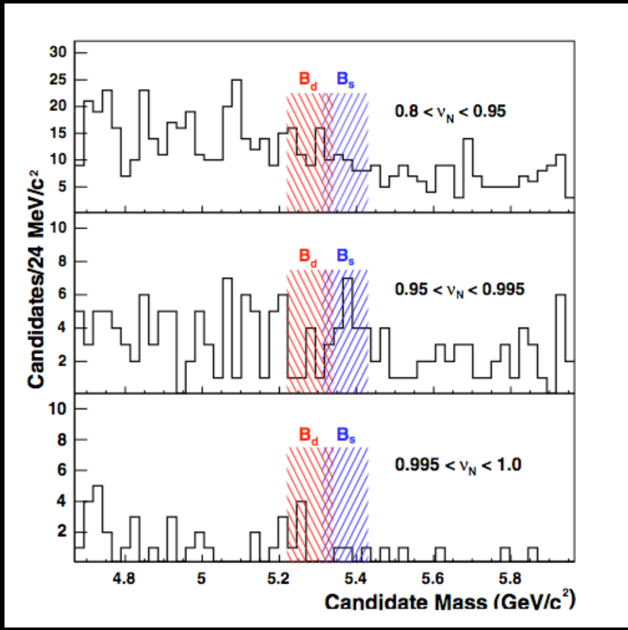
Extensive checks with BCKG-enriched control samples: same-sign dimuons, dimuons with <0 decay-length, dimuons failing fake veto

$B^0_s \rightarrow \mu^+\mu^-$ - results

Limit 90% (95%) × 10^8	$B^0_s \rightarrow \mu\mu$	$B^0_d \rightarrow \mu\mu$
BaBar [PRD 77, 032007 (2008)]	n/a	5.2
DØ	7.5 (9.3)	n/a
CDF [PRL 100, 101802 (2008)]	4.7 (5.8)	1.5 (1.8)

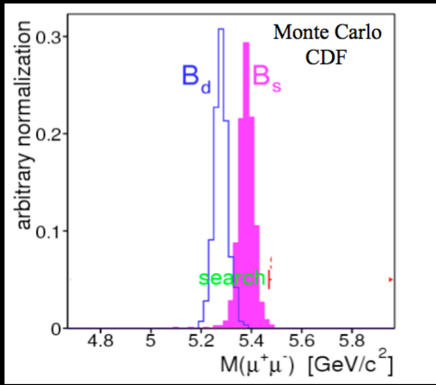
DØ 5/fb update. $|\eta|<2$ pT(B)>5 GeV/c. BDT rather than NN

Expected limit 5.3×10^{-8} [note 5906]



CDF mass resolution allow independent search for B^0 mode. Probes non-MVF models where $BR(B^0_s)/BR(B^0) \neq (V_{td}/V_{ts})^2$

σ_m ~ 23 MeV ~1/4 of mass difference



$B^0_s \to \mu^+\mu^-$ - what next?

CDF extrapolation. No improvements assumed

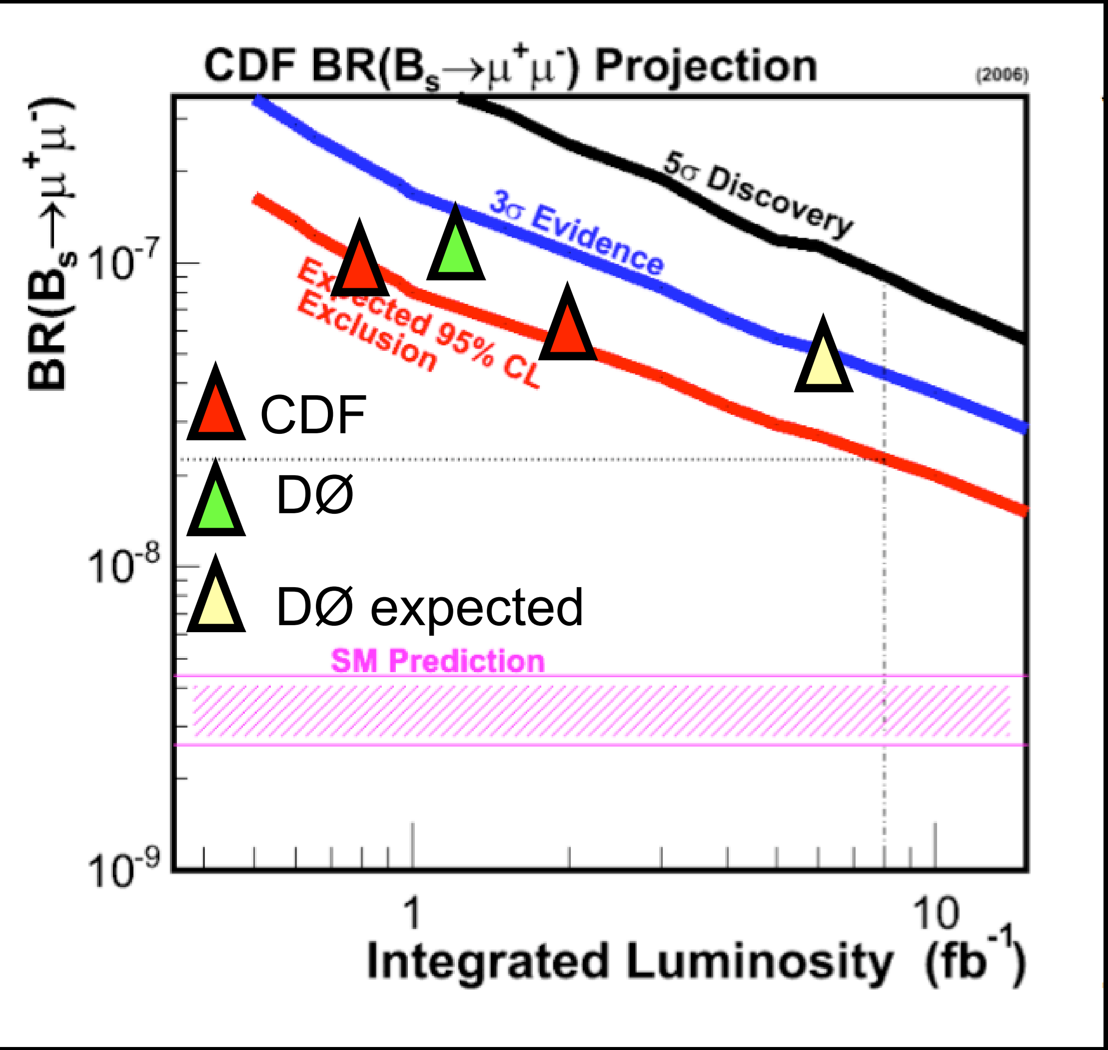
2×10^{-8} ($6\times$SM) at 8/fb per experiment (~year 2010)

Combined may reach $4\times$SM

Improvements in progress

CDF: +20% acceptance by recovering tracks that cross the COT spacers

DØ working on adding single-muon trigger



Aside: $B^0_s \rightarrow e^+\mu^-$ / e^+e^-

$B^0_s \rightarrow e^+\mu^-$ (almost) forbidden in SM. Enhanced by some models (RPV SUSY, Pati-Salam Leptoquarks (don't ask…)

Limit 90% (95%) × 10^8	$B^0_s \rightarrow e\mu$	$B^0_d \rightarrow e\mu$
Previous best	610	9.2
BaBar [PRD 77, 032007 (2008)]	n/a	9.2
CDF	20 (26)	6.4 (7.9)

Limit 90% (95%) × 10^8	$B^0_s \rightarrow ee$	$B^0_d \rightarrow ee$
Previous best	5400	11.3
BaBar	n/a	11.3
CDF B.F. limit	28 (37)	8.3 (10.6)

Leptoquark mass greatly constrained by CDF limits

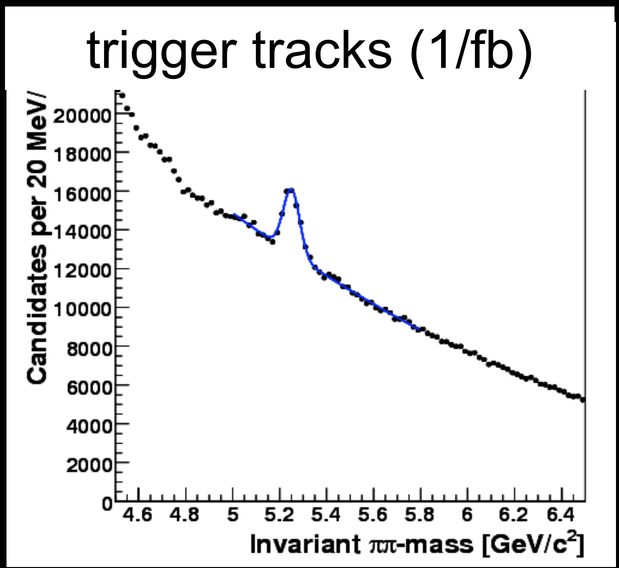
New Penguins in charmless *B* decays

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

Charmless B decays: the original motivation for the CDF trigger on displaced tracks (back in the 90's, nobody cared about B^0_s mixing).

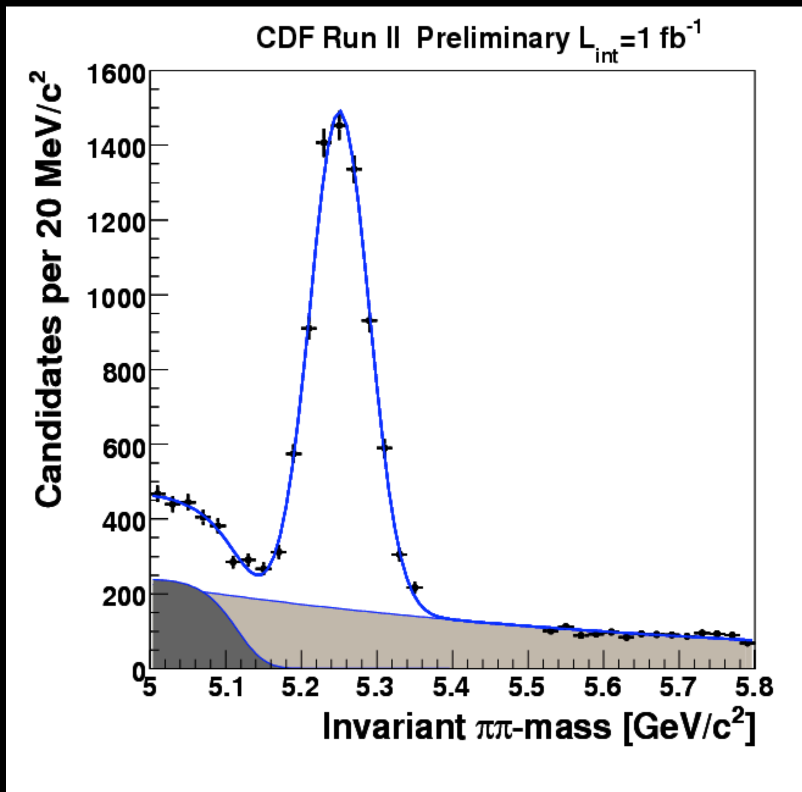
Still in 2000 a few believed that a *signal would have ever been seen*.

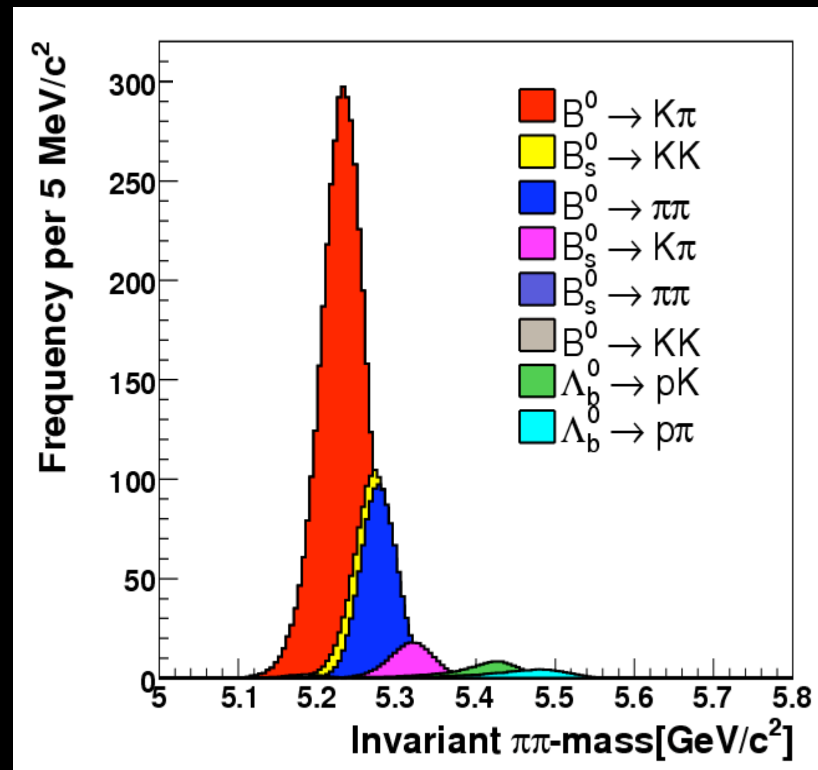
The first challenge: see a signal



CDF has today the world's largest samples of charm-less B decays.

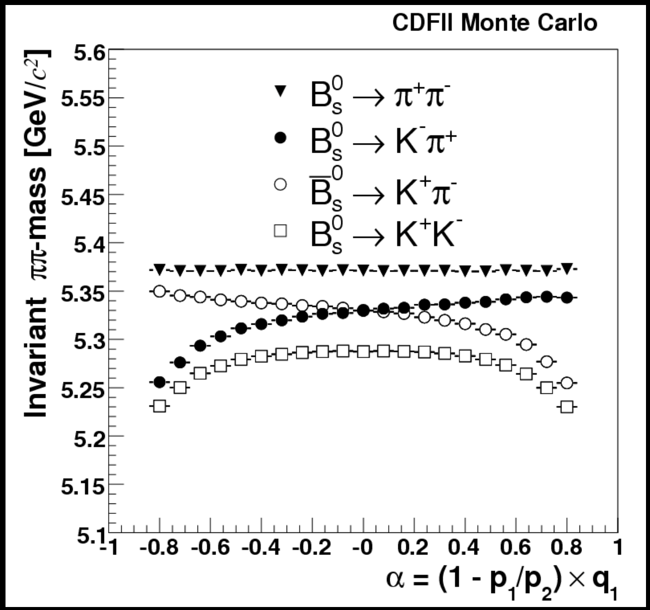
$B^0_{(s)} \rightarrow h^+h'^-$ the second challenge



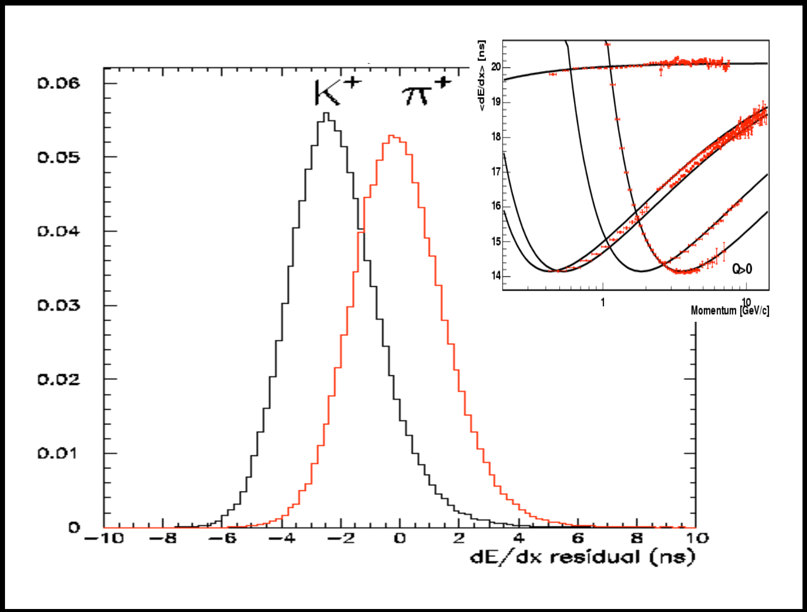


Insufficient mass and PID resolution to discriminate decay modes on a per-event basis

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



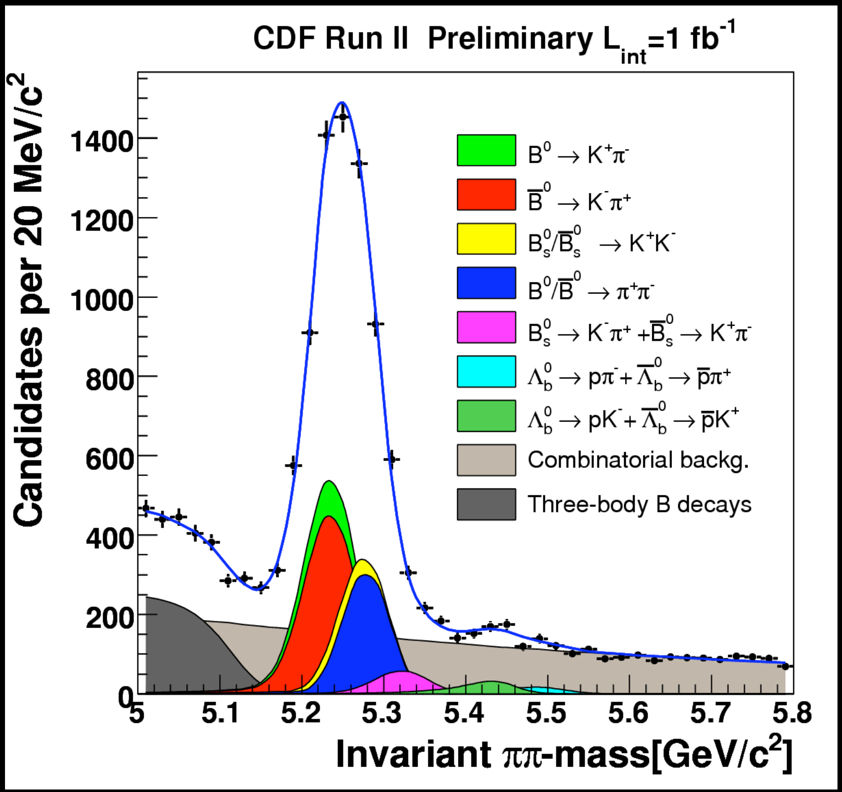
Any (arbitrary) mass assignment correlated with and momentum imbalance



Output pulse-width of 96 COT samplings ∝ log(Q). 1.5σ K/π separation at p>2 GeV/c

Statistical separation using kinematics and PID folded in a 5-dimensional ML fit.

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



Four new decay modes observed (2 B^0s and 2 Λb). Access to DCPV asymmetries in B^0s decays and competitive DCPV asymmetries in B^0 decays.

$$\frac{f_s}{f_d} \times \frac{BR(B_s^0 \rightarrow K^+K^-)}{BR(B^0 \rightarrow K^+\pi^-)} = 0.347 \pm 0.020(stat.) \pm 0.021(syst.)$$

$$BR(B_s^0 \rightarrow K^-\pi^+) = (5.0 \pm 0.7(stat.) \pm 0.8(syst.)) \times 10^{-6}$$

$$A_{CP}(B^0 \rightarrow K^+\pi^-) = -0.086 \pm 0.023(stat.) \pm 0.09(syst.)$$

4000 $B^0 \rightarrow K^+\pi^-$ and 1300 $B^0_s \rightarrow K^+K^-$ per 1/fb.

A plethora of measurements, see PRL97,211802(2006) and arXiv:0812.4271

Model-independent test for NP in $B^0_{(s)} \to h^+ h'^-$ decays

$$\Gamma(\overline{B}^0 \to K^- \pi^+) - \Gamma(B^0 \to K^+ \pi^-) = \Gamma(B^0_s \to K^- \pi^+) - \Gamma(\overline{B}^0_s \to K^+ \pi^-)$$

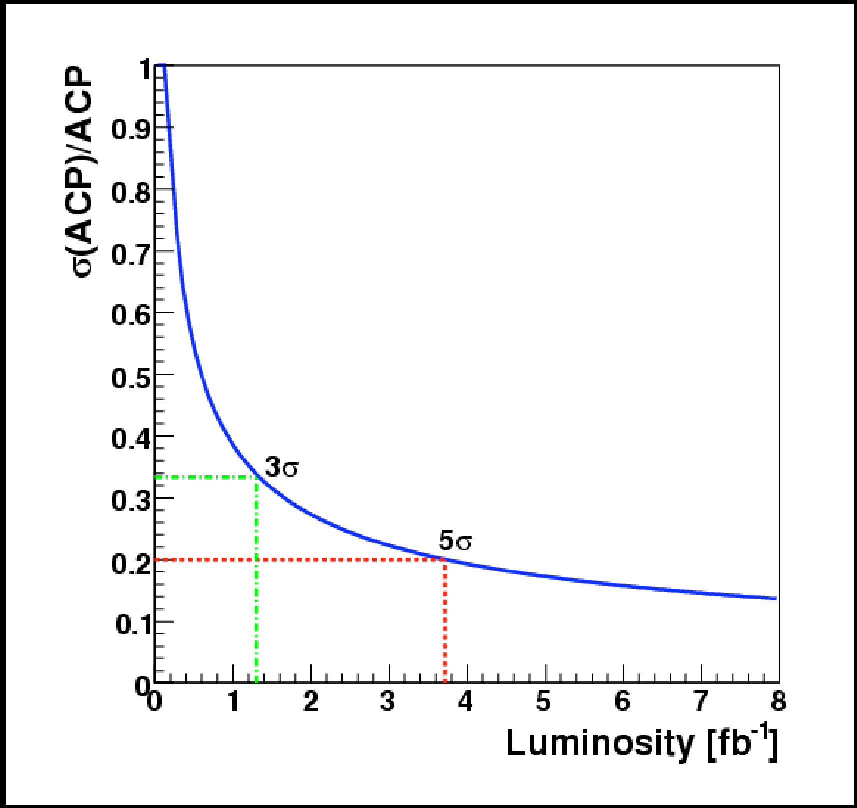
The above relation does not rely on any model-dependent assumptions. No flavor symmetries nor neglecting second order amlitudes. Just the result of a lucky coincidence in relative CKM-hierarchies between P and T amplitudes in these two modes. (**Gronau, Phys.Lett. B492, 297 (2000), Lipkin, Phys. Lett. B621,126, (2005)]**

Unambiguous check if DCPV in these decays is induced by NP amplitudes or SM amplitudes. CDF result (1/fb).

$$\frac{\Gamma(\overline{B}^0 \to K^- \pi^+) - \Gamma(B^0 \to K^+ \pi^-)}{\Gamma(\overline{B}^0_s \to K^+ \pi^-) - \Gamma(B^0_s \to K^- \pi^+)} = -0.83 \pm 0.41(stat.) \pm 0.12(syst.)$$ (1 in the SM)

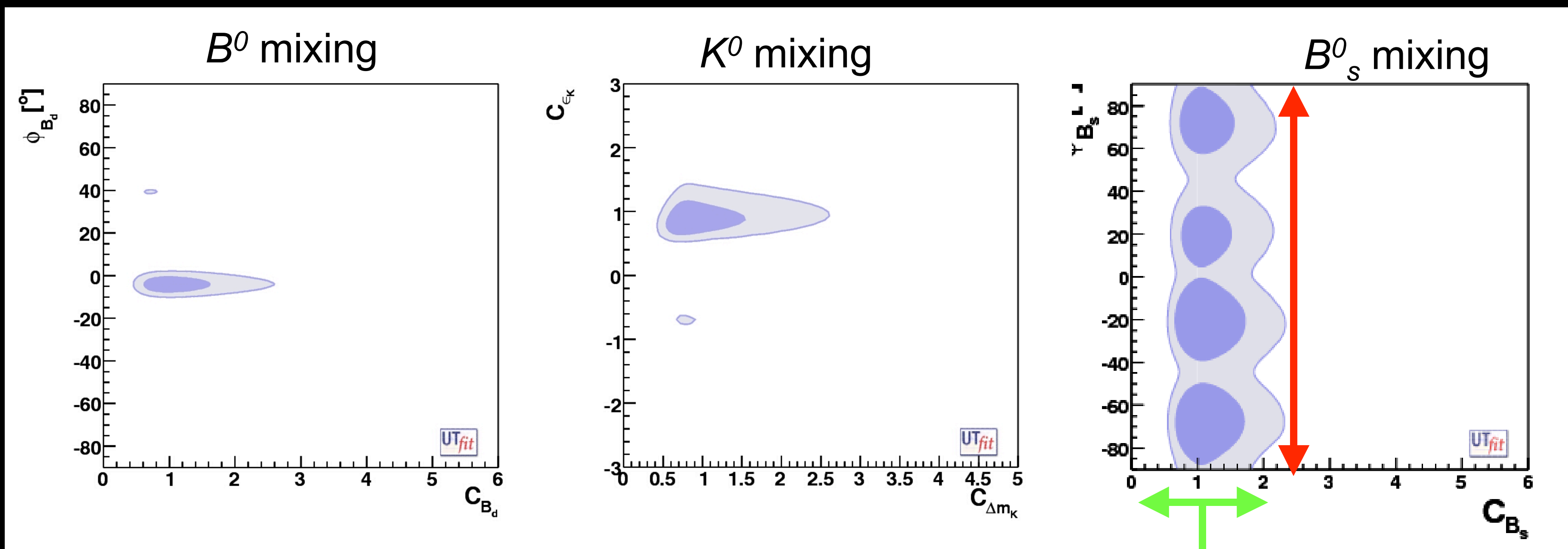
Model-independent test for NP in $B^0_{(s)} \to h^+ h'^-$ decays

Assuming SM true, I.e. ratio=1 we can predict the DCPV asymmetry in $B^0_s \to K^- \pi^+$ decays and by scaling the currently measured uncertainty obtain a promising chance of observing 5σ significant DCPV in B^0_s *decays*



NP in B^0_s mixing

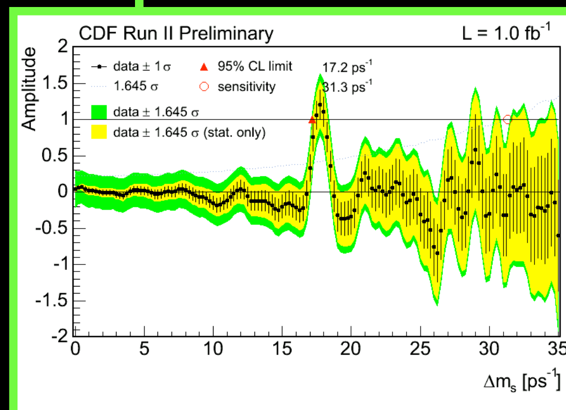
Current experimental picture



Lattice-QCD dominated uncertainty

$$\frac{\langle M|H_{\mathrm{eff}}^{\mathrm{full}}|\bar{M}\rangle}{\langle M|H_{\mathrm{eff}}^{\mathrm{SM}}|\bar{M}\rangle} = C_M e^{2i\phi_M}$$

Experimentally-dominated uncertainty. This measurement is today's topic



Probing the phase at the Tevatron

$$\phi_s = \arg[-M_{12}/\Gamma_{12}]$$

If $M_{12} >> \Gamma_{12}$, asymmetry in semileptonic B^0_s decays is

$$A^s_{SL} = \frac{\Delta\Gamma_s}{\Delta M_s} \tan\phi_s$$

$$\Delta\Gamma = \Gamma_L - \Gamma_H \approx 2|\Gamma_{12}|\cos(\phi_s)$$

BR($B^0_s \to D_s^{(*)} D_s^{(*)}$ provides information on Γ_{12}

$$\beta_s^{SM} = \arg(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*) \qquad \Delta\Gamma = \Gamma_L - \Gamma_H \approx 2|\Gamma_{12}|\cos(\phi_s)$$

Time-evolution of $b \to c\bar{c}s$: $B^0_s \to J/\psi\eta$, $B^0_s \to J/\psi\phi$ sensitive to width-difference and βs which is affected by same NP as ϕ

$\Delta\Gamma_{CP}$ from $B^0_s \rightarrow D_s^{(*)} D_s^{(*)-}$ approach

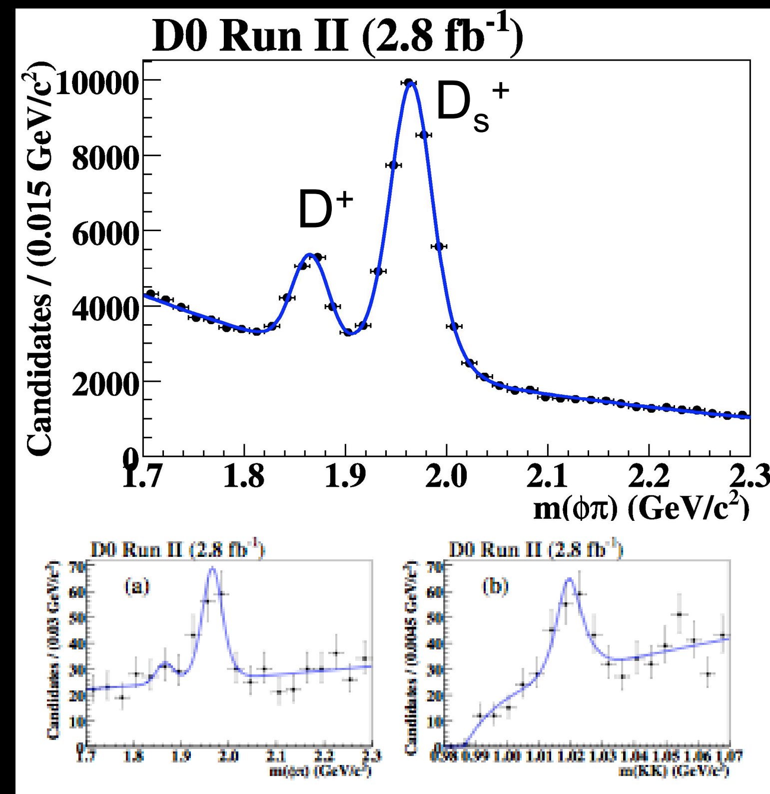
Color-allowed tree $b \rightarrow \bar{c}cs$ transition, contributes ~99% of light-vs-heavy width-difference.

Assuming $m_b \sim 2m_c$ and infinite colors extract width-difference from BR

DØ measures rate of $D_s^{(*)}(\rightarrow\phi\pi)\ D_s^{(*)}(\rightarrow\phi\mu\nu)$ relative to known $B^0_s \rightarrow D_s\mu\nu$ decay.

2-D fit in the m(ϕ)-m(KK) space to identify correlations.

Signal yield: 31±4 evts

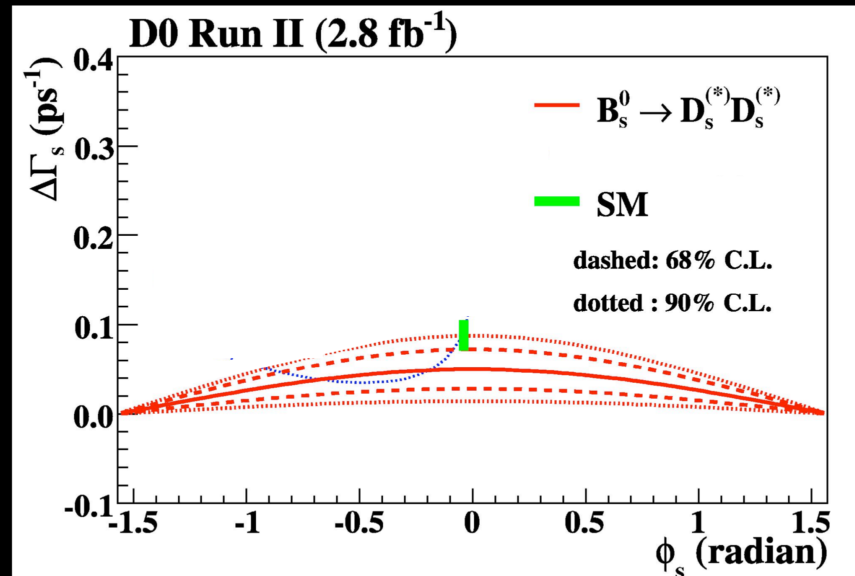


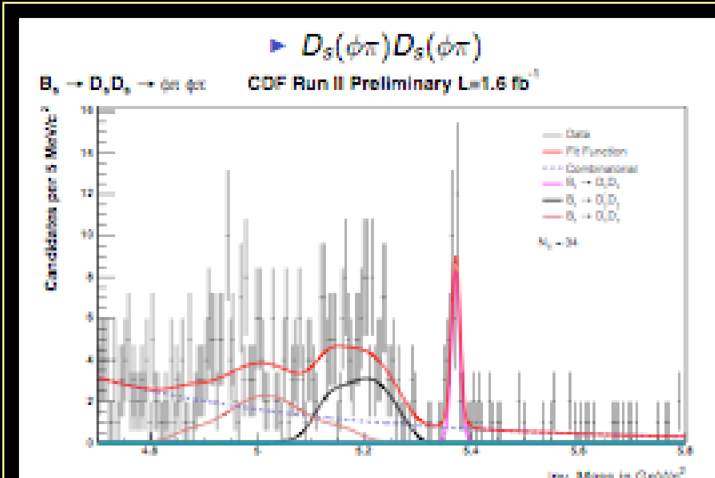
$$\mathcal{B}(B^0_s \rightarrow D_s^{(*)} D_s^{(*)}) = 0.035 \pm 0.010(\text{stat}) \pm 0.008(\text{exp syst}) \pm 0.007(\text{ext}),$$

$\Delta\Gamma_{CP}$ from $B^0_s \to D_s^{(*)} D_s^{(*)}$ - results

$$\frac{\Delta\Gamma_s^{CP}}{\Gamma_s} \simeq \frac{2\mathcal{B}(B_s^0 \to D_s^{(*)} D_s^{(*)})}{1 - \mathcal{B}(B_s^0 \to D_s^{(*)} D_s^{(*)})}$$
$$= 0.072 \pm 0.021(\text{stat}) \pm 0.022(\text{syst}).$$

First evidence of non-zero width difference PRL **102,** 091801 (2009)





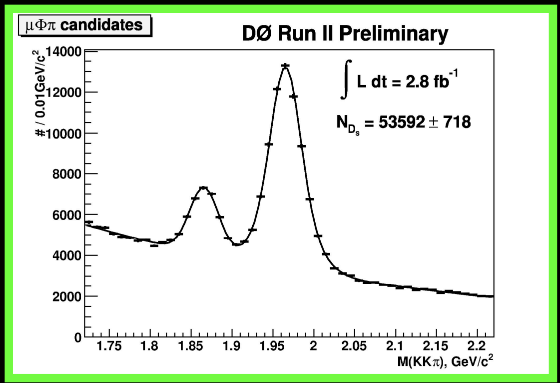
CDF also look at this mode, thanks to the displaced-tracks trigger, First result with 0.3/fb PRL **100,** 021803 (2008)

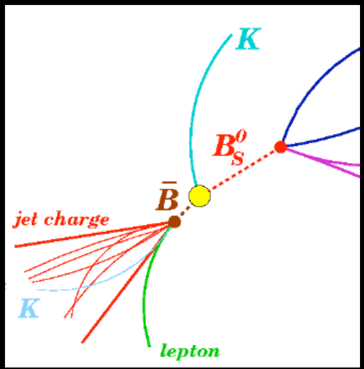
Now ~100 candidates in 1.6/fb exploting three different combinations of Ds decays.

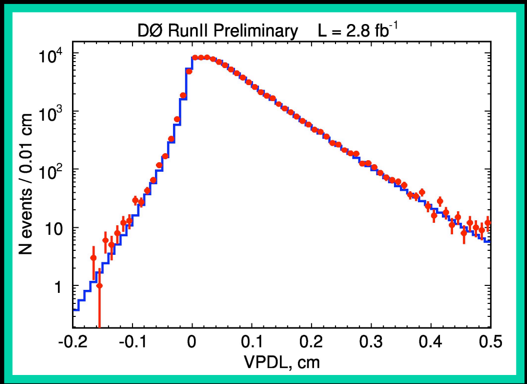
ϕ_s from SL asymmetries - *approach*

Any difference in mixing rate between meson and antimeson?

$A \propto N[B^0_s \rightarrow \overline{B^0_s} \rightarrow D_s^+\mu^-\nu X] - N[\overline{B^0_s} \rightarrow B^0_s \rightarrow D_s^-\mu^+\nu X]$







Decay flavor: count + vs - leptons

Production fl. tagging

Sample-composition visible decay-length

All combined into an unbinned ML fit

ϕ_s from SL asymmetries - *results*

✓ undetected ν: MC correction of decay length

✓ Handle bckg from $D_s^{(*)}$ + prompt HF decay (ccbar most harmful)

✓Efficiency curves for signals from MC

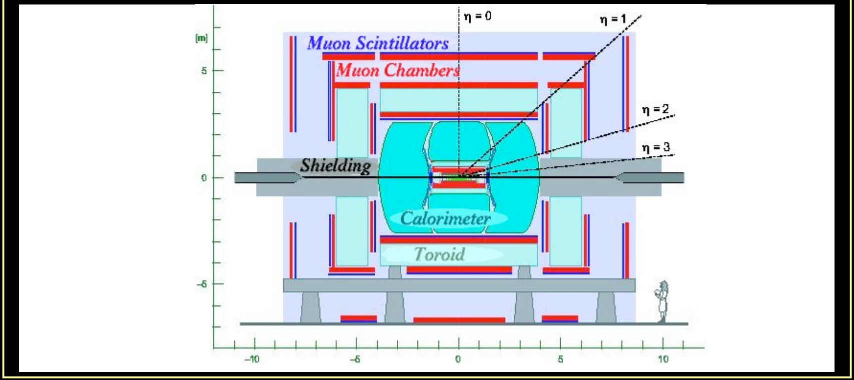
✓B^+ and B^0_s lifetimes and $\Delta\Gamma$ as inputs

$$a^s_{sl} = -0.0024 \pm 0.0117(stat)^{+0.0015}_{-0.0024}(syst)$$

Note 5730

Control detector asymmetries

Charge-symmetric geometry of DØ detector and weekly magnet polarity reversal



World best - limited by statistical uncertainty. Can be combined with a_SL from inclusive same-sign dimuons (minimal overlap):

$$= -0.0023 \pm 0.0011(\text{stat}) \pm 0.0008(\text{syst}),$$

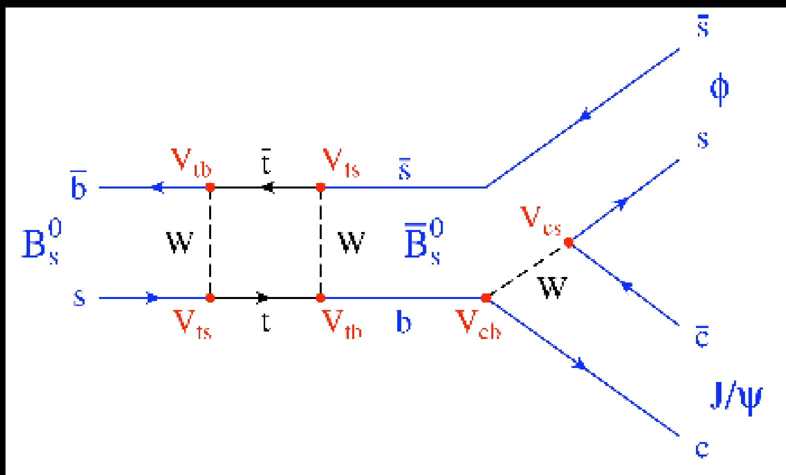
PHYSICAL REVIEW D **74**, 092001 (2006)

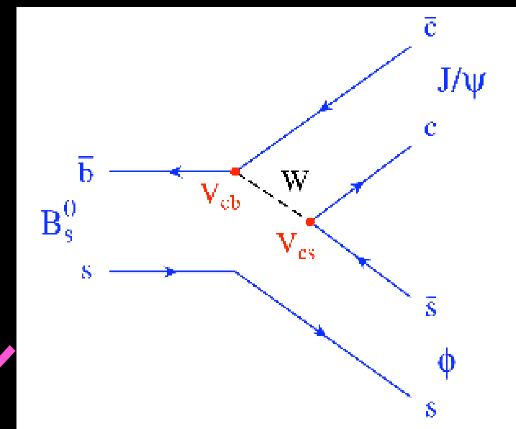
$$_L = 0.020 \pm 0.028.$$

CDF public note 9015

Time-evolution of flavor-tagged $B^0_s \to J/\psi\phi$ decays

Role of $b \to c\bar{c}s$ transitions





Mixing phase – sensitive to NP

Tree b→ccs phase ≈ 0

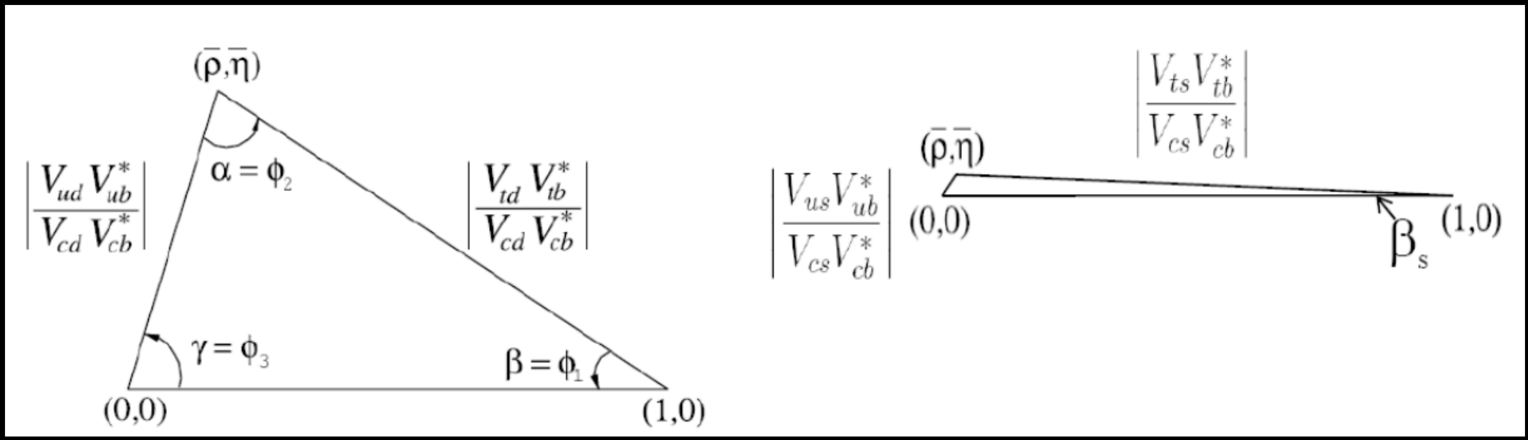
Time-evolution:

$$2\beta_s = -\arg[(V_{tb}V_{ts}^*)^2/(V_{cb}V_{cs}^*)^2]$$

$$\begin{pmatrix} 1-\frac{1}{2}\lambda^2-\frac{1}{8}\lambda^4 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda+\frac{1}{2}A^2\lambda^5[1-2(\rho+i\eta)] & 1-\frac{1}{2}\lambda^2-\frac{1}{8}\lambda^4(1+4A^2) & A\lambda^2 \\ A\lambda^3[1-(1-\frac{1}{2}\lambda^2)(1-\rho-i\eta)] & -A\lambda^2+\frac{1}{2}A\lambda^4[1-2(\rho+i\eta)] & 1-\frac{1}{2}A^2\lambda^4 \end{pmatrix}$$

Analogy

$B^0_s \to J/\psi\phi$ golden mode for sin(2βs) , analogous of $B^0 \to J/\psi K^0_S$



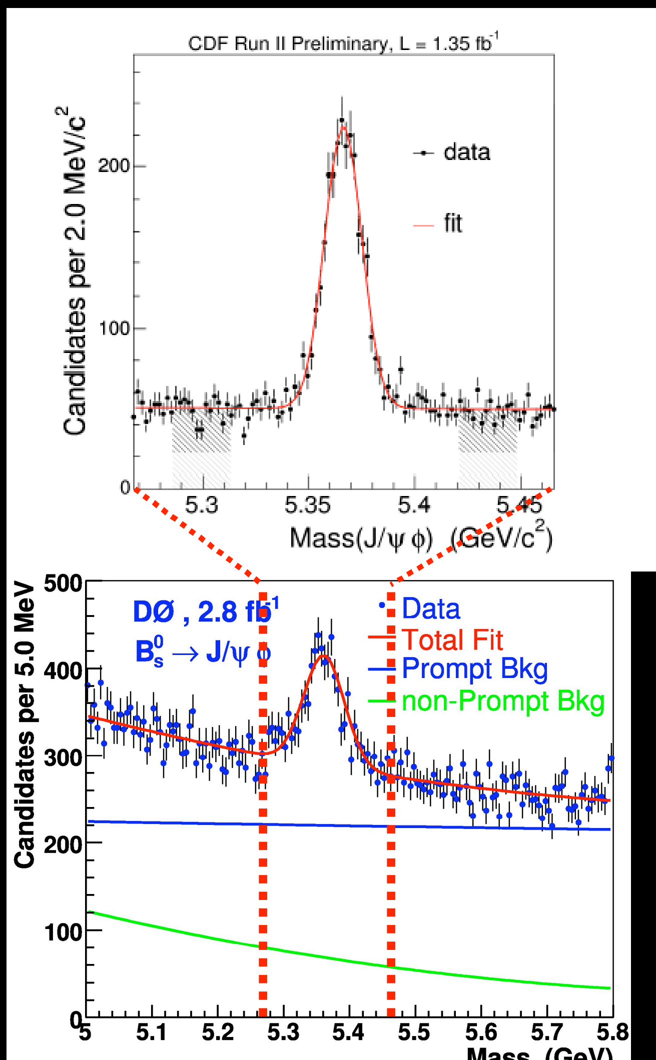
Additional experimental complications:

✓ $J/\psi\phi$: a mix of CP-even and CP-odd eigenstates, treat them separately

✓ B^0_s oscillates ~35 times faster than B^0

✓ sin(2β)~ 0.7, sin(2βs) expected x20 smaller

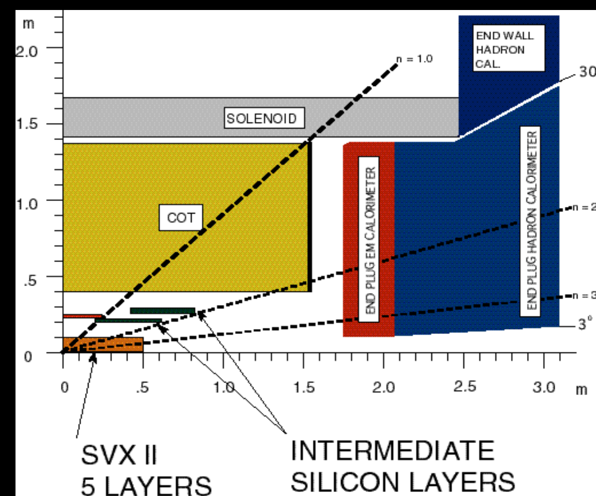
Signal extraction



CDF - NN selection, 1.4 fb^{-1}, ~2000 decays S/B~2

D0 - cuts, 2.8 fb$^{-1,}$ ~2000 decays S/B~0.3

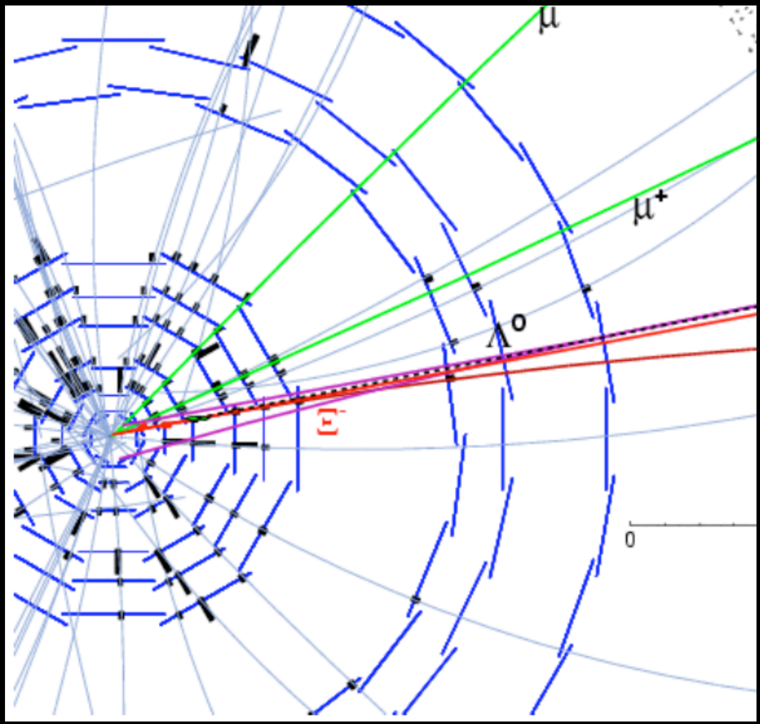
CDF superb tracker: 1.4T by 132 cm lever-arm with 96 drift chamber + 6 Silicon samplings

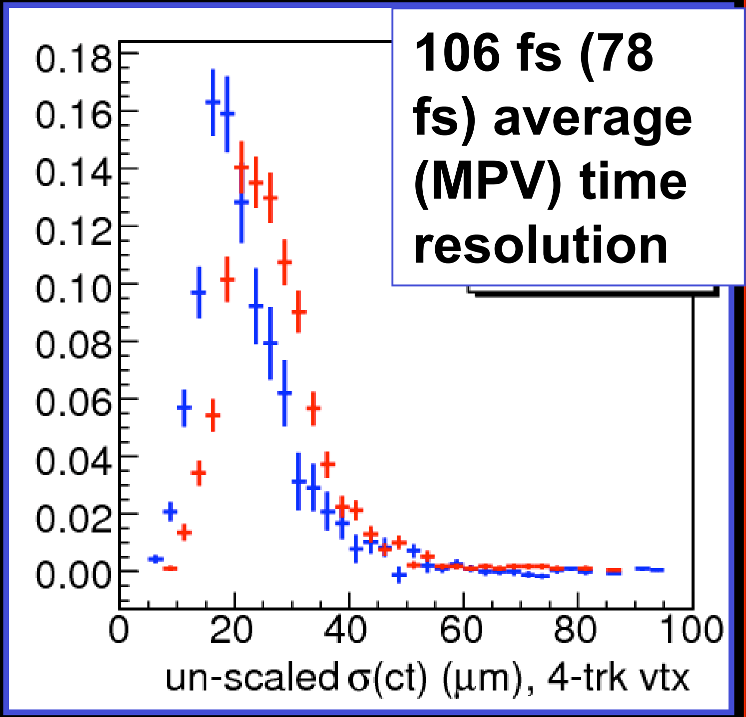


DØ has superior muon acceptance extending down to |η|~3

Diego Tonelli, CDF

Vertex resolution

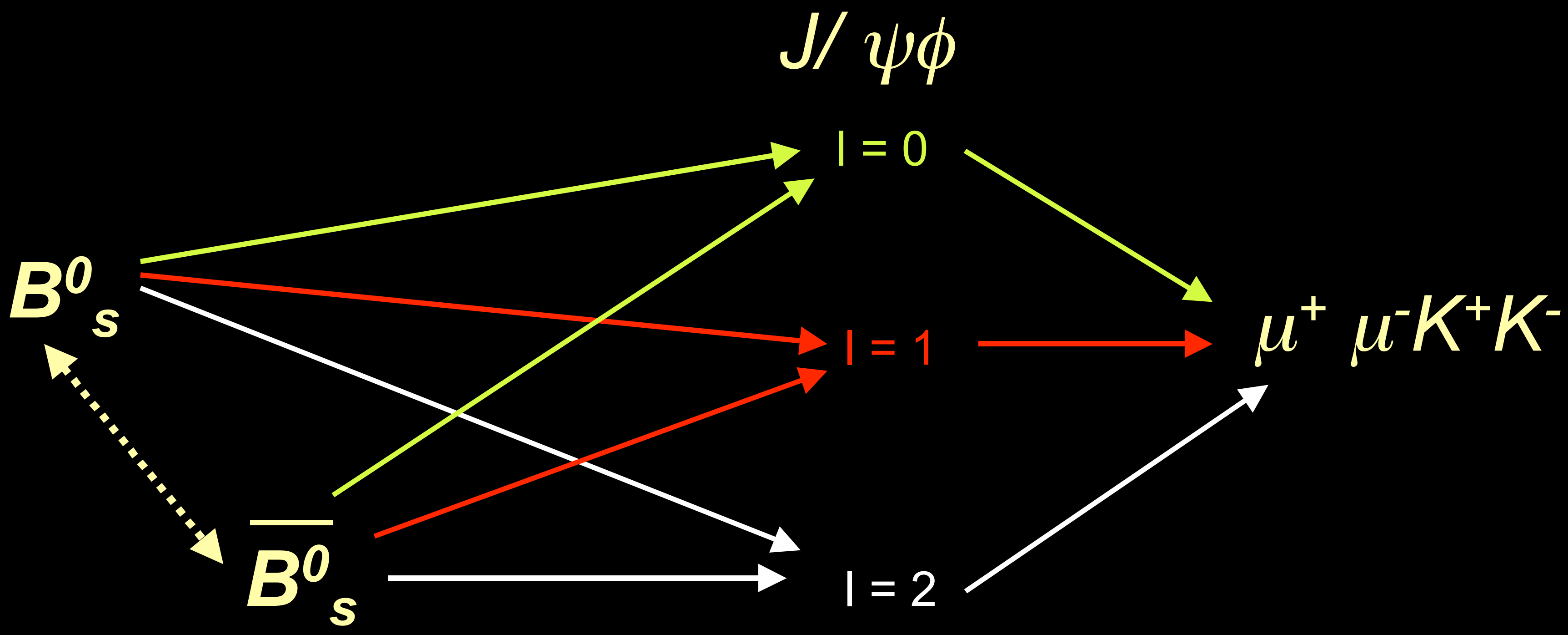




CDF superb tracker - 5 double-sided silicon sensors between 2.5-10 cm + one at 1.5 cm from the beam. Typical Lorentz boost of B is $\beta\gamma$~1-2

CP-eigenstates separation

B^0_s (pseudoscalar) $\rightarrow J/\psi$(vector) ϕ (vector). Final states CP-even (S- or D-wave, short-lived and light) and CP-odd (P-wave, long-lived, heavy).

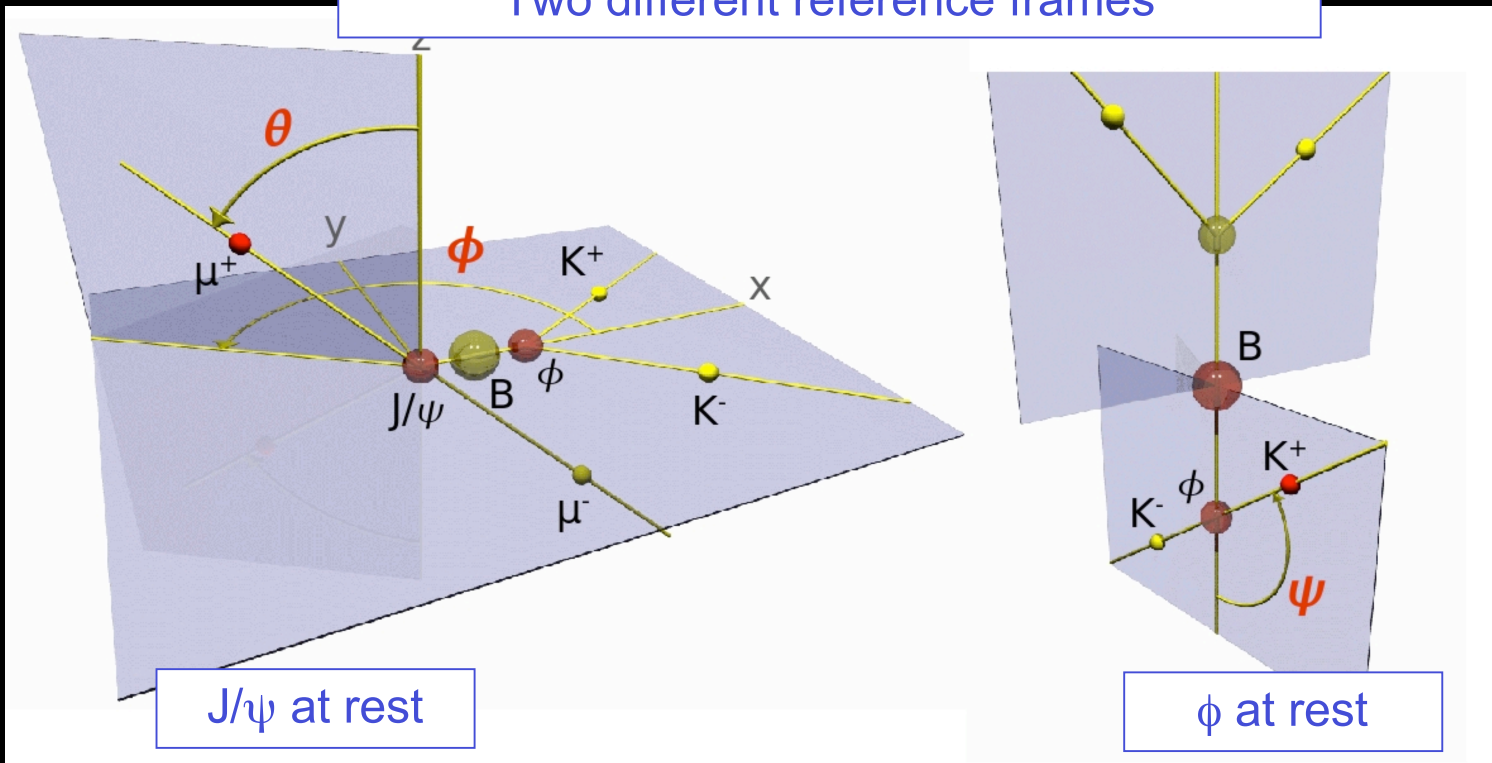


Exploit different dependence on phase between *CP*-even *and CP*-odd

Angular correlations in decay products ➔ separation of CP-components.

"Transversity" basis

Two different reference frames



J/ψ at rest

ϕ at rest

State at time *t* decomposed in: polarizations longitudinal to direction of motion (CP-even), polarizations transverse and ⊥ each other (CP-even), polarizations transverse and // each other (CP-odd). PLB 369, 144 (1996)

Production-flavor determination

Flavor-tagging inherited from mixing-frequency measurement

b-quarks mainly produced in *b/bbar*-pairs at the Tevatron

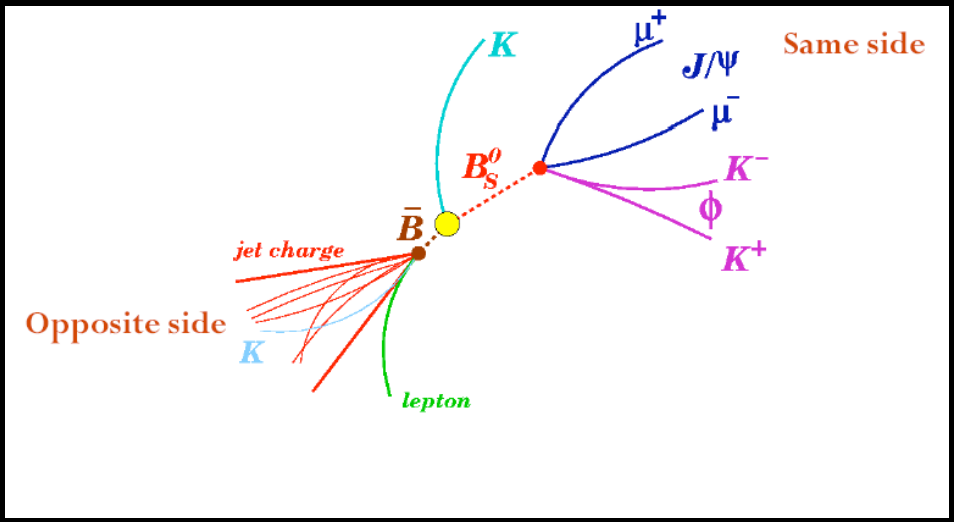
Opposite Side: looks at decay of the ‘other’ *b*-hadron in the event

Same Side: exploits the charge/species correlations with associated particles produced in hadronization of reconstructed B^0_s meson

OST efficiency	96 ± 1%
OST dilution:	11 ± 2%
SST efficiency	50 ± 1%
SST dilution	27 ± 4%

Total $\varepsilon D^2 \sim 4\%$

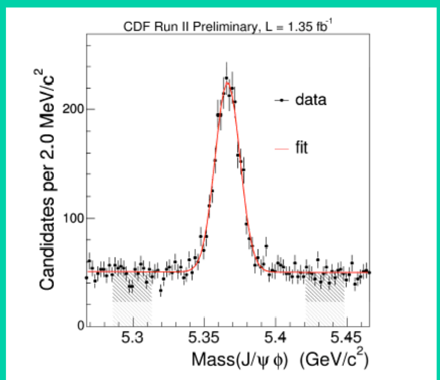
Similar performance at DØ



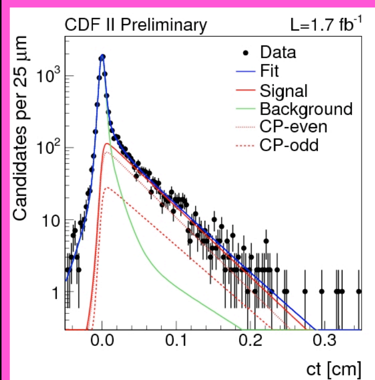
Output: decision (*b*-quark or $\bar{b}$-quark) and probability of being correct

Overview of fit

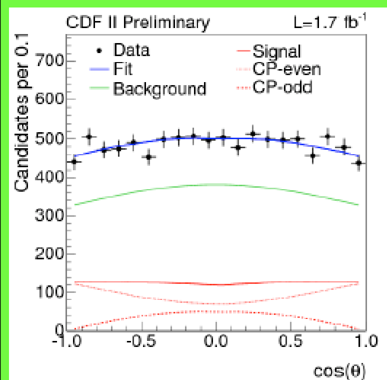
$$f_s P_s(m|\sigma_m) P_s(t,\vec{\rho},\xi|\mathcal{D},\sigma_t) P_s(\sigma_t) P_s(\mathcal{D})$$



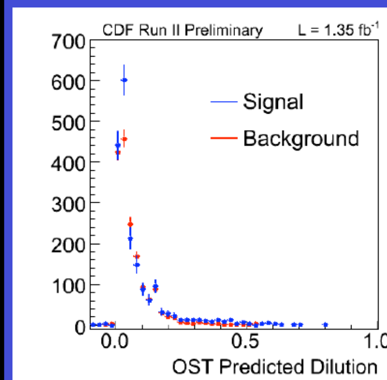
Mass
discriminate signal against background



Decay-time
Determine lifetime of each CP and flavor state



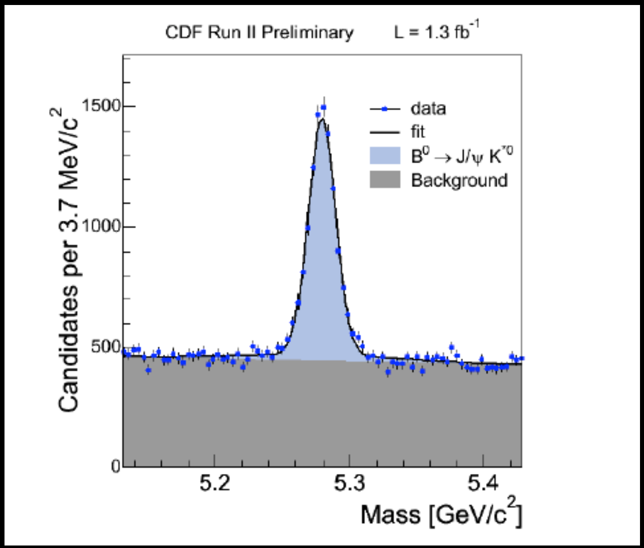
Angles
Separate CP-even from CP-odd final states



Tagging
Determines flavor of initial state

Data-driven checks

Angles

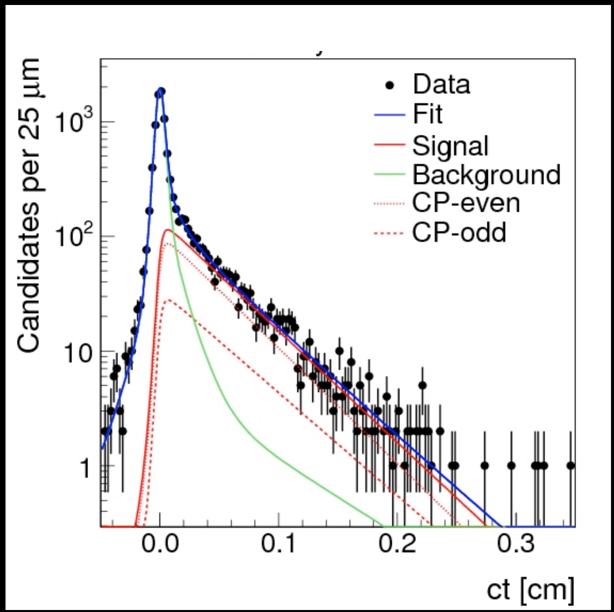


Polarization of $B^0 \to J/\psi K^*$: consistent w/ B-factories

CDF: www cdf.fnal.gov/physics/new/bottom/070830.blessed-BdPsiKS/

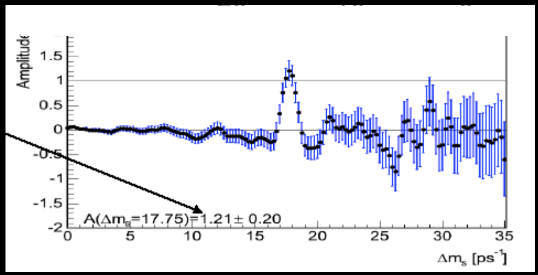
DØ: arXiv:0810.0037

Mass-lifetime



Measurement w/o flavor tagging of lifetime and width-difference

Flavor tagging

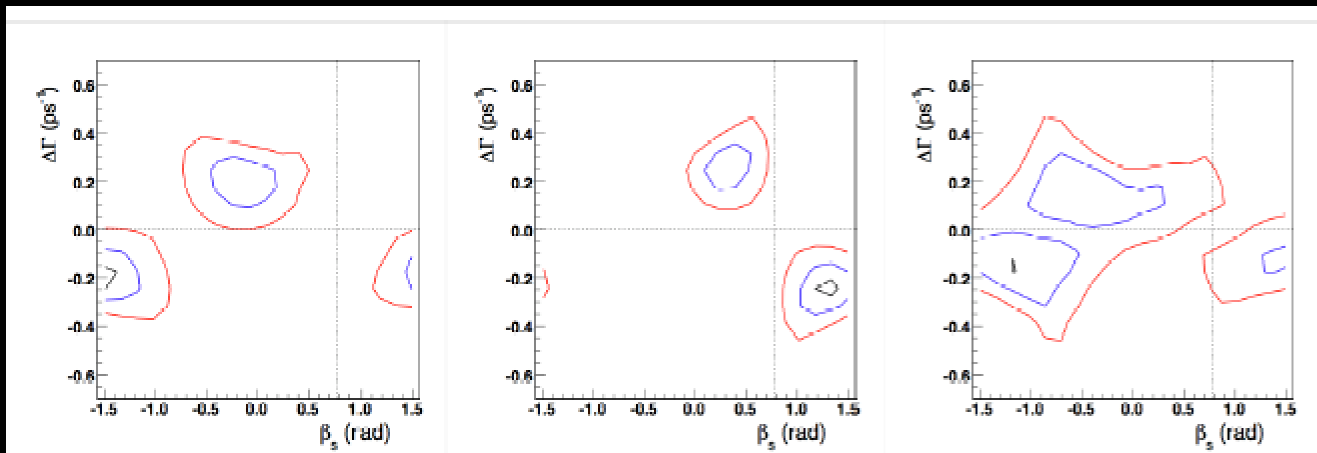


OST tuned on B^+

SST tuned on MC, checked on mixing measurement *a posteriori*

Likelihood features

1σ and 2σ Likelihood sections in the $(\Delta\Gamma, \beta s)$ plane.
All samples below generated with same 'true' values of parameters!



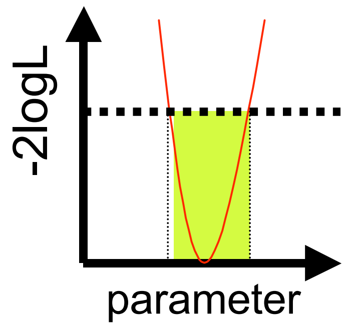
$$2\beta_s \to \pi - 2\beta_s$$
$$\Delta\Gamma \to -\Delta\Gamma$$
$$\delta_\parallel \to 2\pi - \delta_\parallel$$
$$\delta_\perp \to \pi - \delta_\perp$$

Non-Gaussian Likelihood: (a) symmetries: multiple minima dependent on choice of strong phases (undetermined from data) (b) degenerate: sensitivity to some parameters vanishes for specific values of others.

Not quote central values and their uncertainties. Use interval estimation (confidence regions) instead

Ensuring coverage

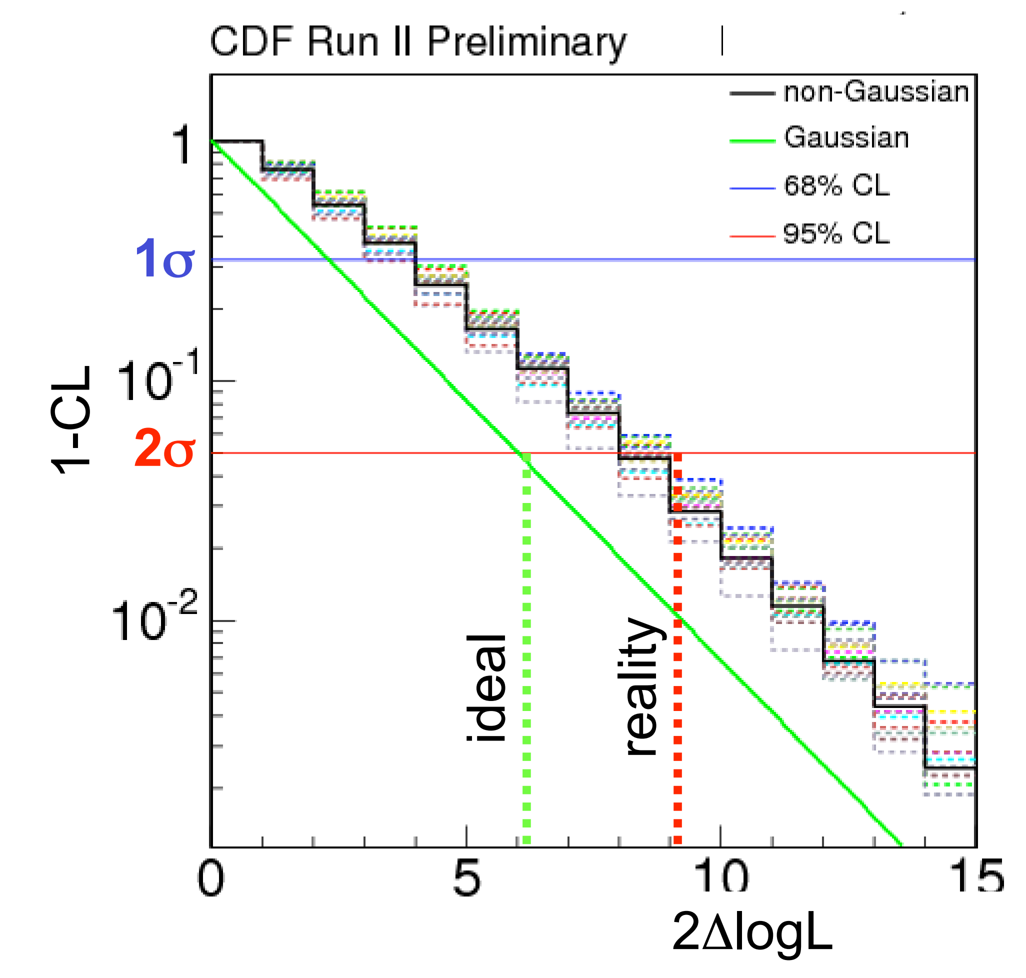
Standard likelihood ratio method fails



Remap observed 2ΔlogL distribution to obtain coverage: accounts for non-Gaussian/non-asymptotic Likel.

E.g. to get the 68% CL, climb -2logL by 3.4 units (as opposed to 2.3 of the asymptotic case)

Include systematics: vary nuisance parameters (flat) within 5σ of their estimates on data. Worst case defines the final region.



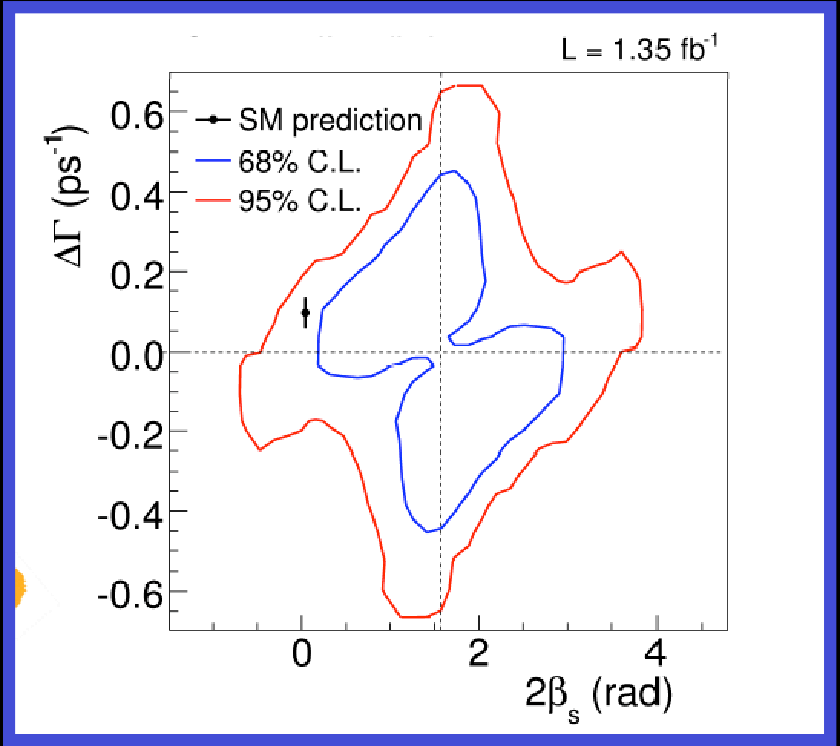
arXiv:0810.3229

1.4 fb^{-1} results - CDF

2D projection of the multidimensional region in the space of all (27) fit parameters: a specific value of $\Delta\Gamma$ and βs is excluded only if it can be excluded for any assumed values of the nuisance parameters (within 5σ from their nominal values).

<u>No assumptions on strong phases: just data</u>!

PRL100, 161802(2008)



Assuming the SM, the probability of observing a fluctuation as large or larger than observed in data is 15% (1.5σ)

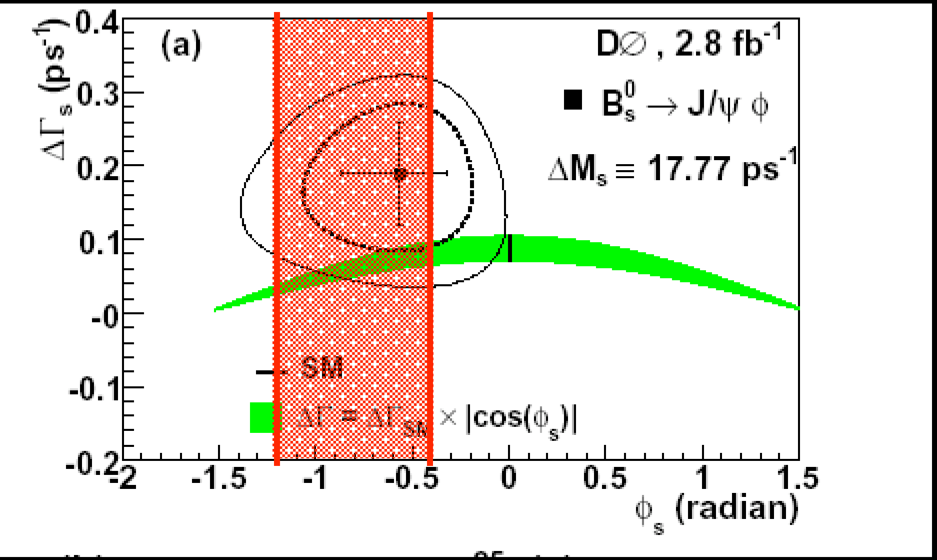
One dimensional: $0.16 < \beta s < 1.41$ at 68% CL

2.8 fb^{-1} results - DØ

2D confidence region. Remember $\phi s \sim -2\beta s$.).

Assumption on strong phases: mildly constrained to be as in $B^0 \to J/\psi K^*$

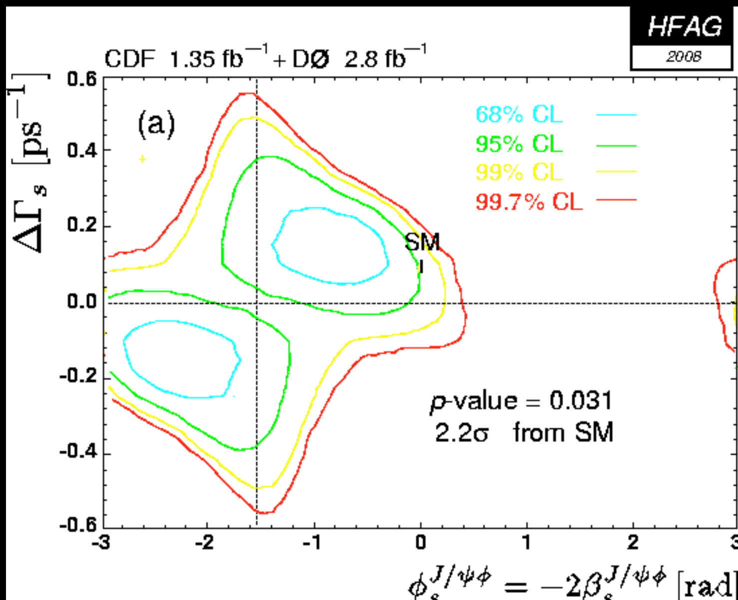
PRL101, 241801(2008)

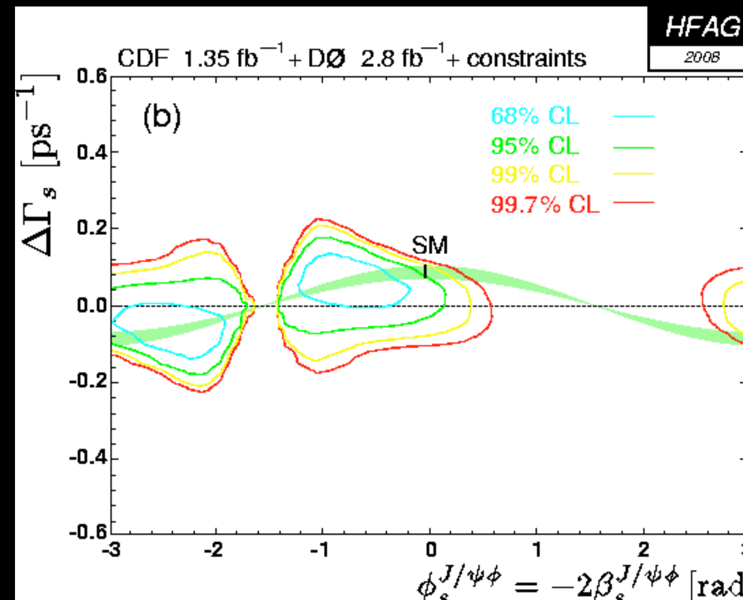


Assuming the SM, the probability of observing a fluctuation as large or larger than observed in data is 6.6% (1.8σ)

One dimensional: 0.35 < βs < 0.58 at 68% CL

Tevatron combination





2.2σ consistency with SM.

One-dimensional:

0.24 < βs < 0.57 OR

1.0 < βs < 1.33 at 68% CL

Includes additional constraints from B^0_s lifetime, a_SL.

Marginal effect on phase.

www.slac.stanford.edu/xorg/hfag/osc/end_2007/#DMS and **arXiv:0808.1297[hep-ex]**

Impact

If large phase confirmed - not only unambiguous signal of physics beyond SM, but also beyond MFV. Several speculations: non-abelian flavor symmetries, SUSY GUT, CKM non-unitarity….

Take fourth family a'la George Hou as an example: presence of a t' quark with mass in the 300-1000 GeV/c^2 range

PRL **95,** 141601 (2005) PHYSICAL REVIEW LETTERS week ending 30 SEPTEMBER 2005

Difference in B^+ and B^0 Direct CP Asymmetry as an Effect of a Fourth Generation

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(Received 8 March 2005; revised manuscript received 20 June 2005; published 30 September 2005)

Direct CP violation in $B^0 \to K^+\pi^-$ decay has emerged at the -10% level, but the asymmetry in $B^+ \to K^+\pi^0$ mode is consistent with zero. This difference points towards possible new physics in the electroweak penguin operator. We point out that a sequential fourth generation, with sizable $V^*_{t's}V_{t'b}$ and near maximal phase, could be a natural cause. We use the perturbative QCD factorization approach for $B \to K\pi$ amplitudes. While the $B^0 \to K^+\pi^-$ mode is insensitive to t', we critically compare t' effects on direct CP violation in $B^+ \to K^+\pi^0$ with $b \to s\ell^+\ell^-$ and B_s mixing. If the $K^+\pi^0 - K^+\pi^-$ asymmetry difference persists, we predict $\sin 2\Phi_{B_s}$ to be negative.

Hou's 4th generation

t' quark with 0.3 < m < 1 TeV

✓Accommodates Kπ puzzle

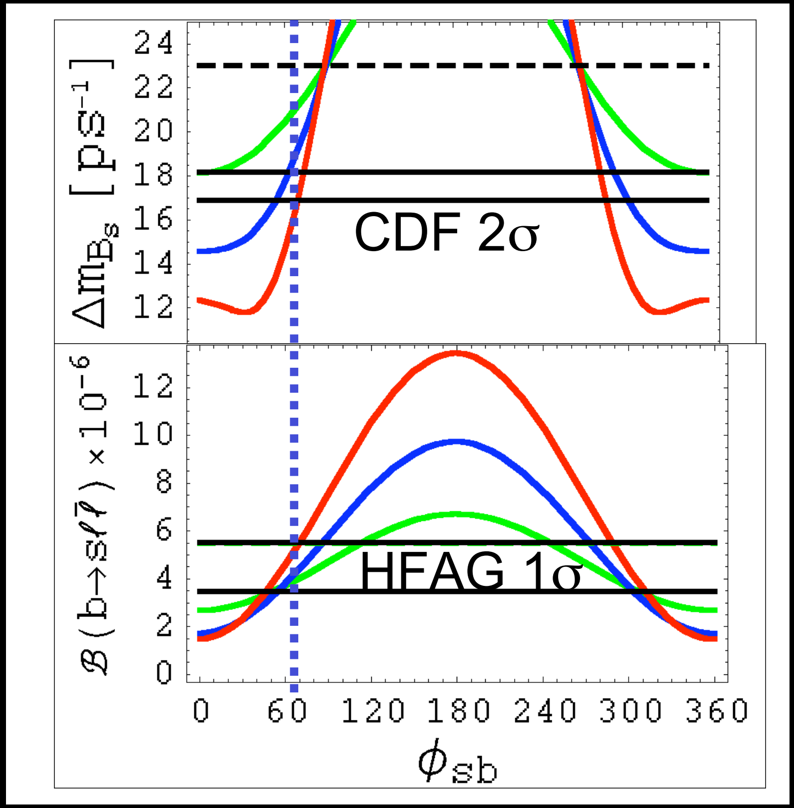
✓Consistent with precision EWK tests

✓Consistent with BR(*$B^0 \to K^* l^+ l^-$*)

✓Consistent with *K^0/B^0_s* mixing freq.

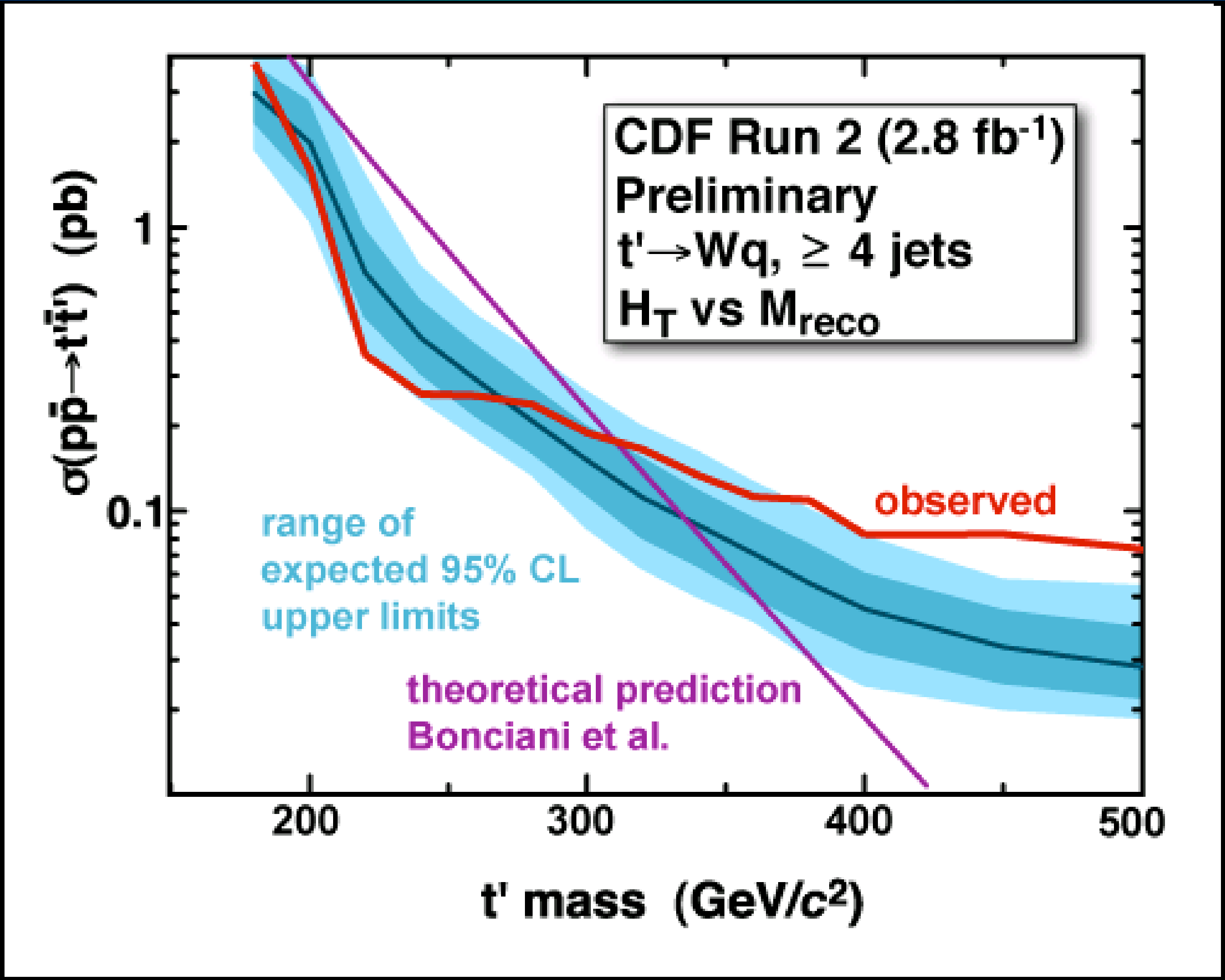
Predicts LARGE *B^0_s* mixing phase

As prediction, we find $\sin 2\Phi_{B_s} < 0$ for CPV in B_s mixing, which is plotted versus ϕ_s in Fig. 3(d). We find $\sin 2\Phi_{B_s}$ in the range of -0.2 to -0.7 and correlating with $\mathcal{A}_{K\pi^0} - \mathcal{A}_{K\pi}$. Three generation SM predicts zero.

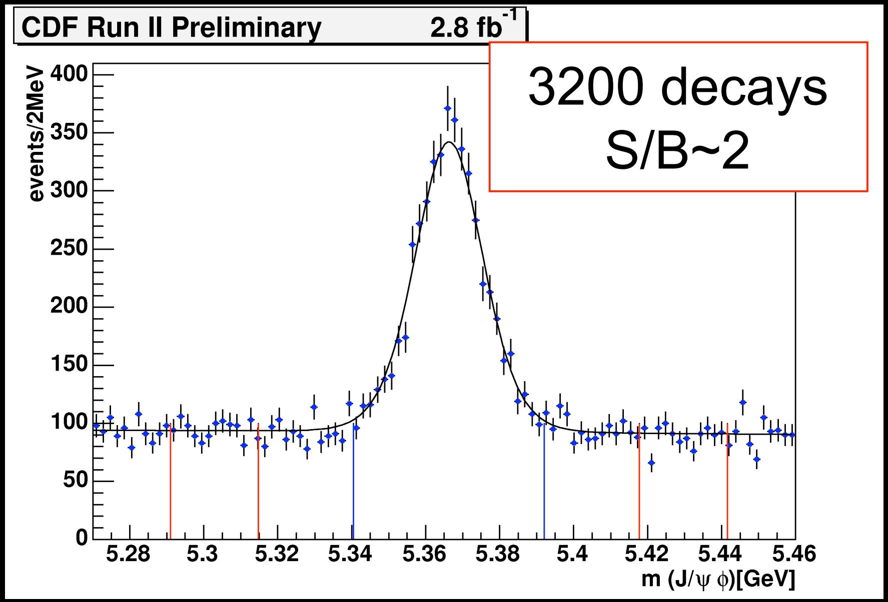


Surprisingly enough - experimental we find one minimum at -0.7

Complementary to direct search



2.8 fb^{-1} partial update - CDF



Same-side tagger NOT yet used in 2nd half of sample. PID calibrations still being finalized.

Equivalent to reduced sample size: 2.8/fb → 2/fb

arXiv:0810.3229, www-cdf.fnal.gov/physics/new/bottom/080724.blessed-tagged_BsJPsiPhi_update_prelim/

Once the same-side tagger will be calibrated, will have:

+20% signal events – by using PID info in selection

x3 tagging power in second-half of the sample

CDF partial update (2.8 fb^{-1})

Increased dataset still hints at larger than SM values!

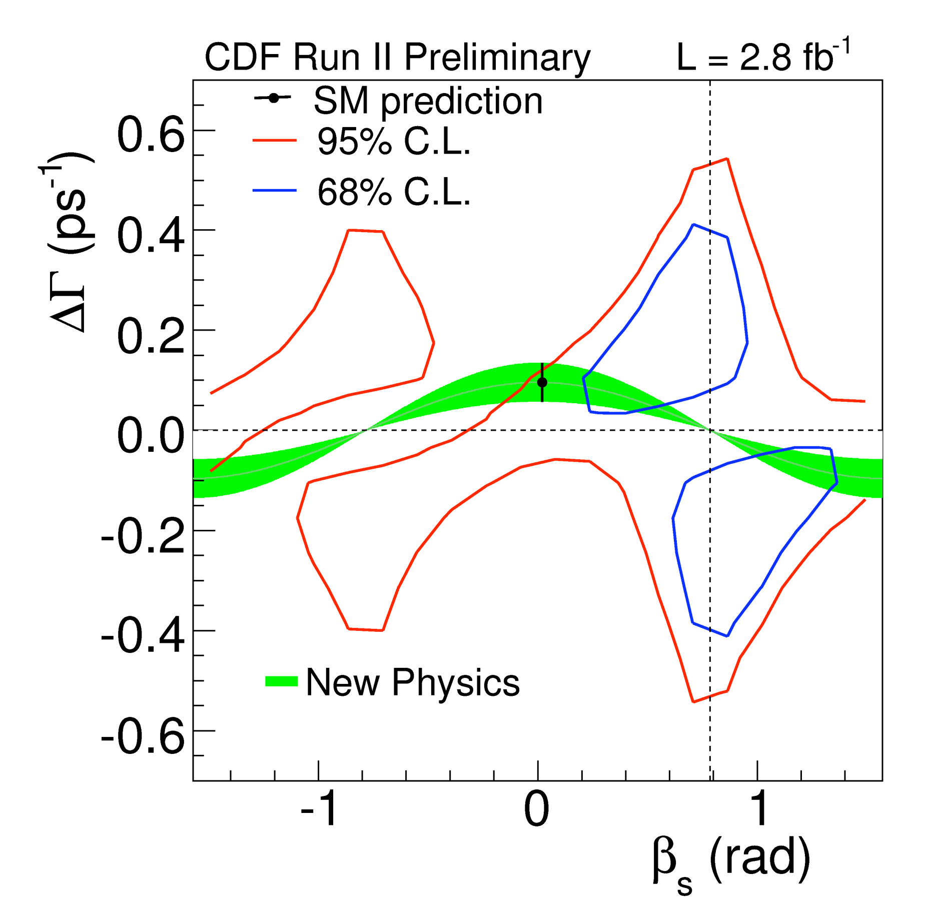
Consistency with SM keeps decreasing 15% → 7% (~1.8σ)

0.28 < βs < 1.29 at 68% CL

-π/2 < βs < -1.45 OR

-1.01 < βs < -0.57 OR

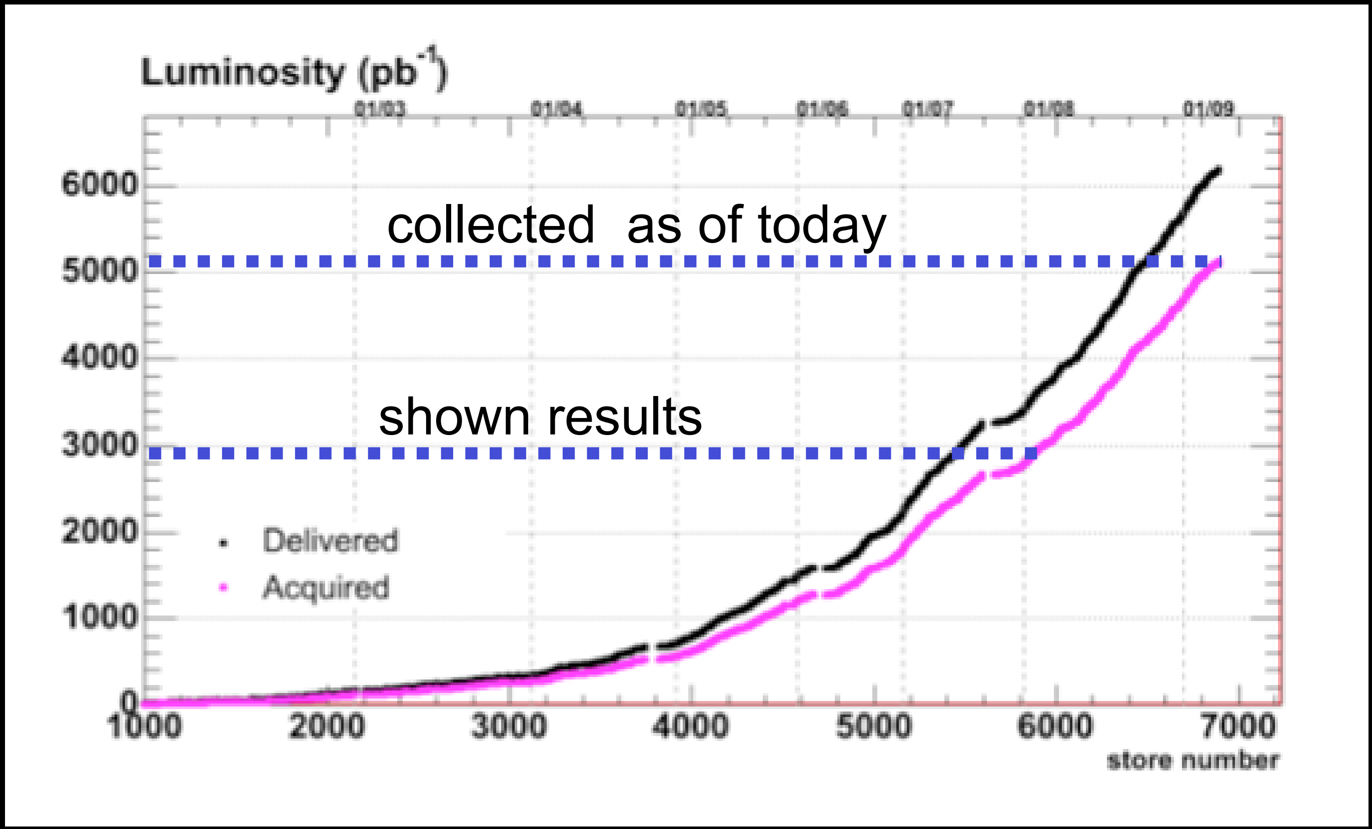
-0.13 < βs < π/2 at 95% CL



arXiv:0810.3229 and www-cdf.fnal.gov/physics/new/bottom/080724.blessed-tagged_BsJPsiPhi_update_prelim/

Will shrink further with PID in the whole dataset

What next?



More than 6/fb (8/fb) of physics-quality data on tape expected by the end of 2009 (2010, if Run II extended). Double (triple) current samples.

A conservative outlook

% of CDF+DØ 'clones' that would observe a 5σ-effect, as a function of β_s

<u>Assumptions</u>

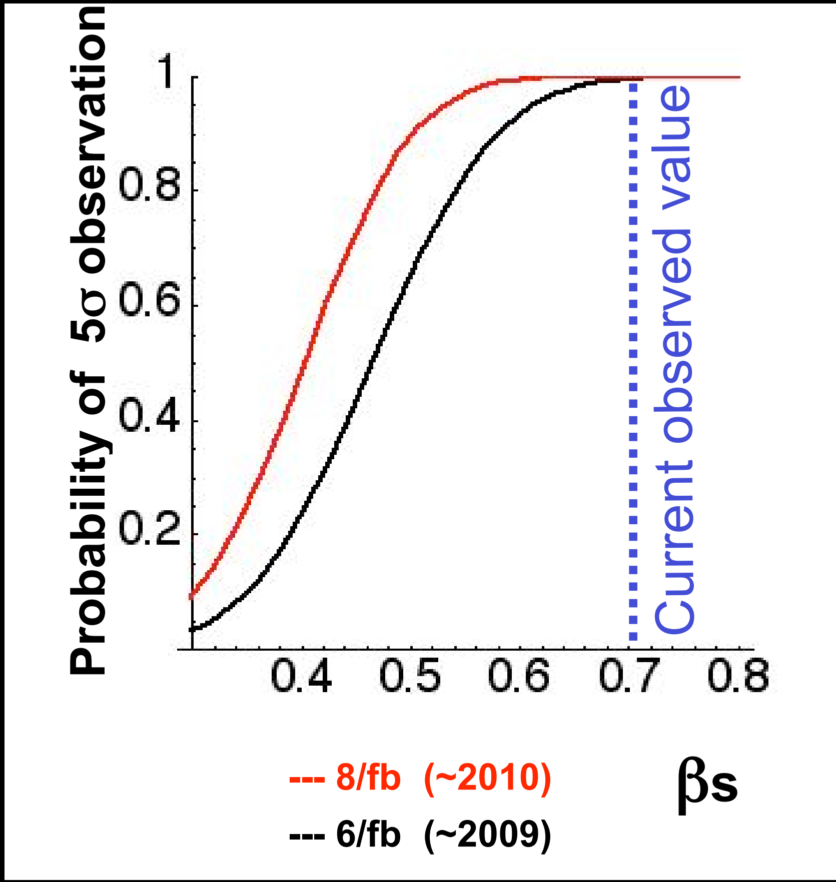
✓ $\Delta\Gamma_s = 0.1\ ps^{-1}$

✓ Constant data-taking efficiency

✓ No analysis improvements.

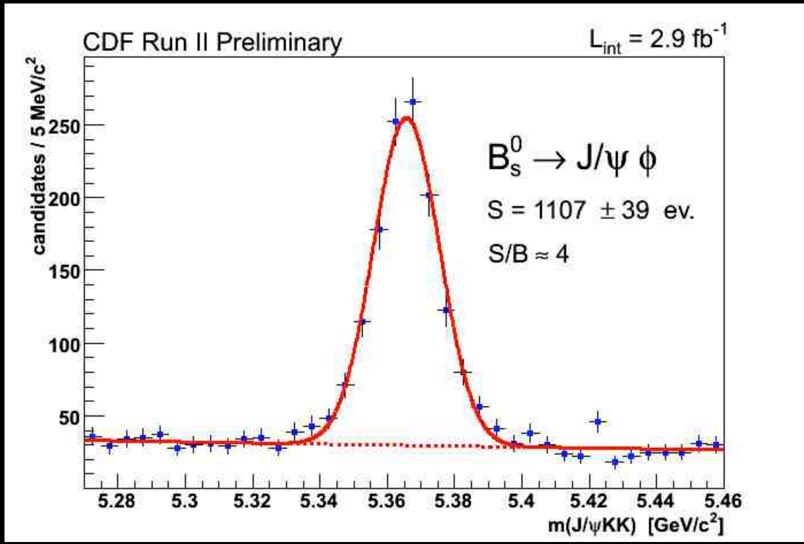
✓ No external constraints (A_{SL}, lifetimes) used.

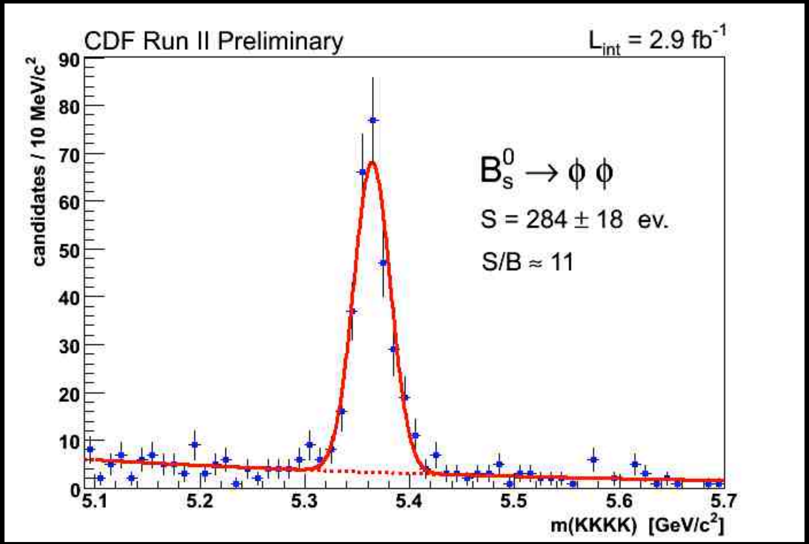
Our next future will probably be better than that.



A more realistic outlook

Analysis is being improved: e.g. significant advancement in tagging performance ongoing. Also, other trigger/samples will be added:





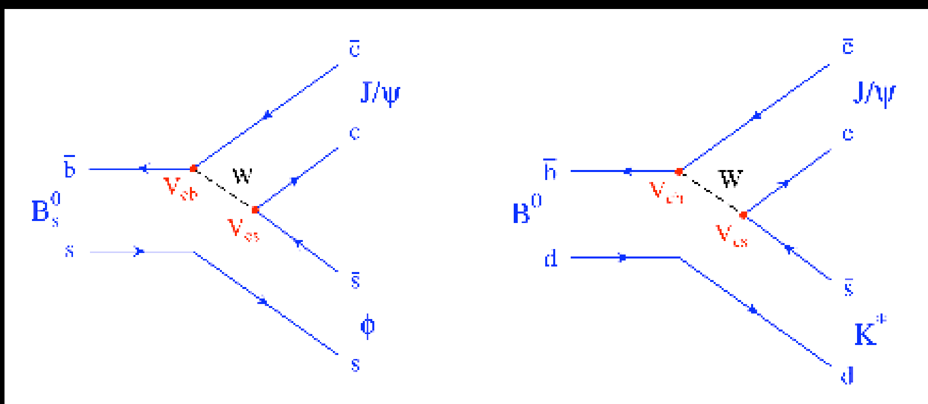
At least +25% signal found in displaced-track trigger (w/ better S/B). Sample independent of the one used for current results.

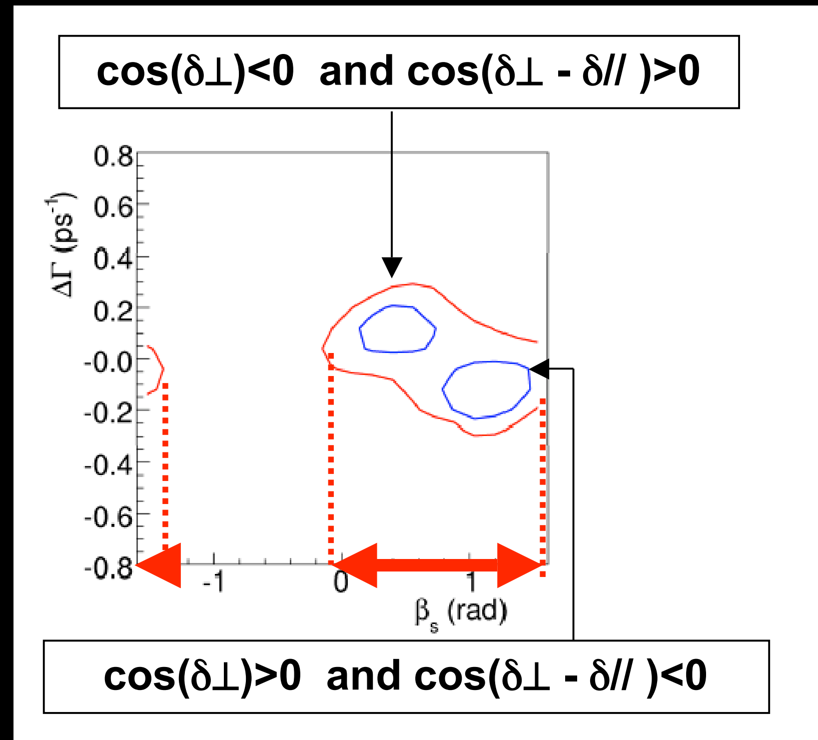
Possible extensions to the only $B^0_s \to \phi\phi$ sample currently available…

Main limitation: strong-phases ambiguity

Worst offender on phase-resolution

Exploit the U(3) relation between B^0 and B^0_s is tempting…already assuming same quadrant would help…

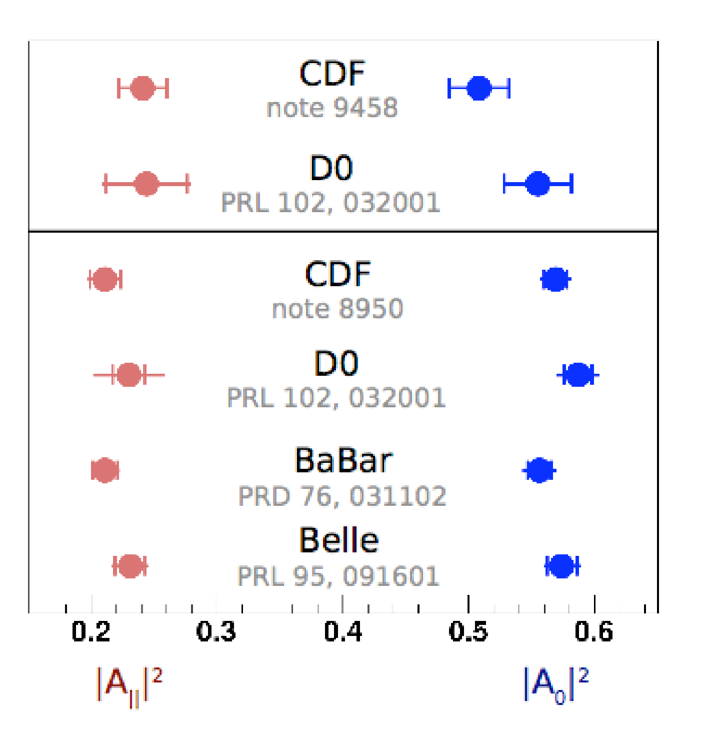




Not that easy. Even if SU(3) would be exact, ϕ differs from K* because it contains a singlet component while K* is pure octet. So the assumption here would be more restrictive: SU(3) and negligible singlet amplitude

Main limitation: strong-phases ambiguity

However - experimental data seem to favor the “similarity” between strong-phases in these two decays.



Gronau-Rosner: reinforce claim of U(3) arXiv:0808.3761[hep-ph]

M. Suzuki: long-range FSI flips quark helicity. Global comparison of strong phases and amplitudes in $B \rightarrow VV$ to check for flip PRD64,117503 (2001)

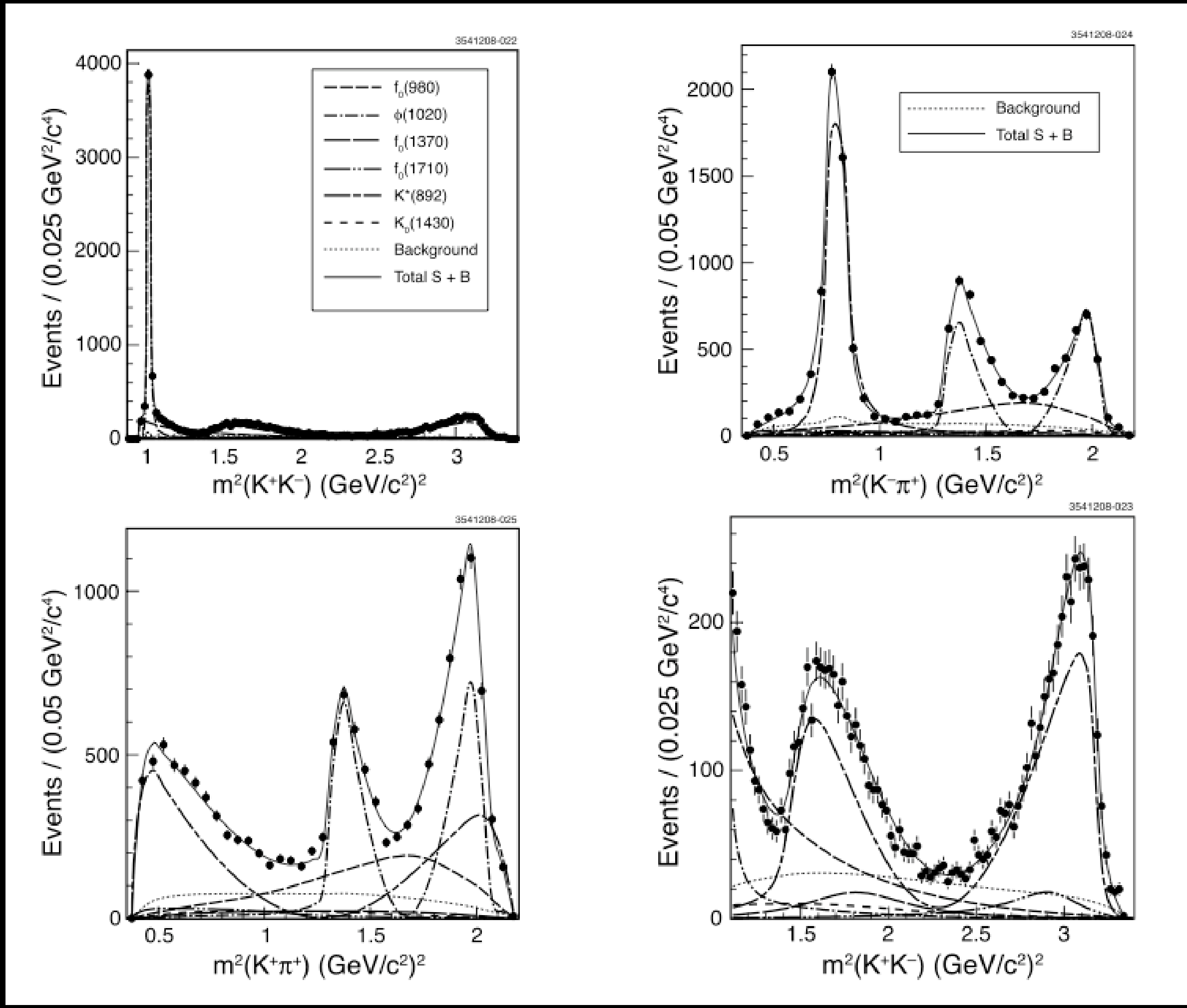
Nandi-Nierste: (tagged) $B^0_s \rightarrow D_s K$. Precise γ a necessary input. Large samples needed, perhaps feasible at CDF. PRD77, 054010,(2008).

A’ la *Babar*: search data for S- and P-waves interference patterns in *KK* mass spectrumPRD71,032005,(2005).

Other resonances below the $\phi(1020)$?

KK resonances other than phi (e.g. f0) may have an impact on the measured phase (http://arXiv.org/pdf/0812.2832), If included in the fit can resolve strong-phases ambiguity. If neglected may bias resolution on betas.

See CLEO plots on $D_s^+ \to KK\pi$ Dalitz study



Conclusions

Tevatron at full steam with third-generation flavor-physics analyses. Ultimate impact in B^0_s sector. CDF/DØ somehow complementary in exclusive/inclusive measurements.

World best result on FCNC $B^0_s \rightarrow \mu\mu$ - will probably be very close to exclude all NP-space by the end of Run II especially if extended.

Charmless B^0_s decays - a CDF heritage that provides a model-independent test for non-SM physics.

First direct, tagged determination of NP phase in B^0_s mixing. Already halved the allowed space of parameters. Tantalizing fluctuation towards a large, non-SM phase. Still quantitatively modest (~2.2σ) but remains there. A_SL will provide further info soon.

Shown only 1/2 (1/3) of the data expected by the end of 2009 (2010). And, still large room for improvement in analyses. Psycologically advantaged: lots of data, complex analyses already set up, all pressure on CERN.