Heavy flavor at the Tevatron

D. Tonelli- Fermilab

HEP2011 Grenoble, July 27, 2011

Probing the next scale

High-transverse momentum processes

Flavor observables

Status

Dedicated experiments, theory and computational advances over the past 10+ years achieved a formidable success.

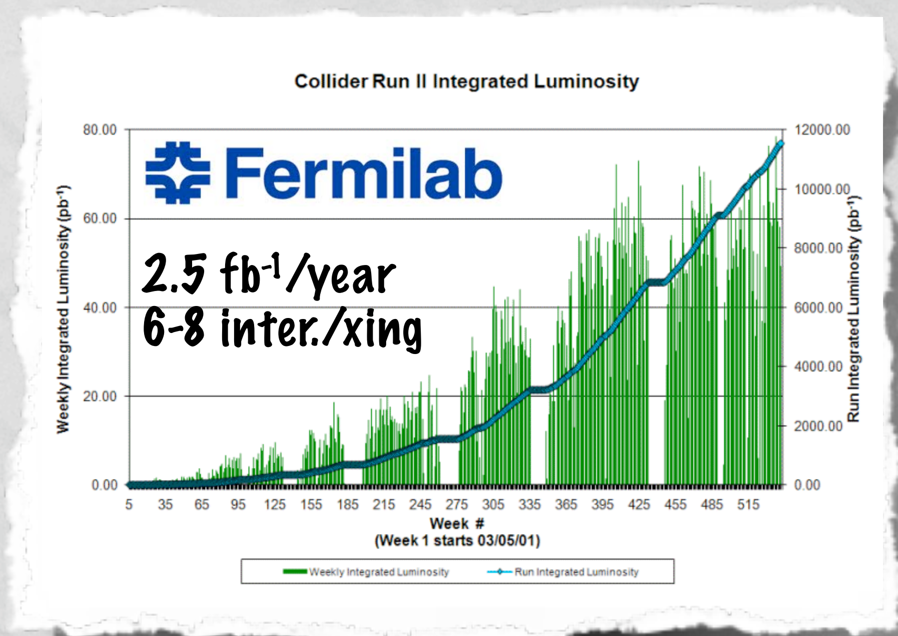
The SM explains satisfactorily data in leading B transitions. 10-15% corrections from non-SM not excluded.

Some of the most promising probes not yet explored. And many of them accessible only in hadron collisions (B_s physics, high-stat FCNC decays, high precision charm physics...)

This is the basic motivation for the CDF and D0 heavy flavor programs.

Tevatron Heavy Flavor

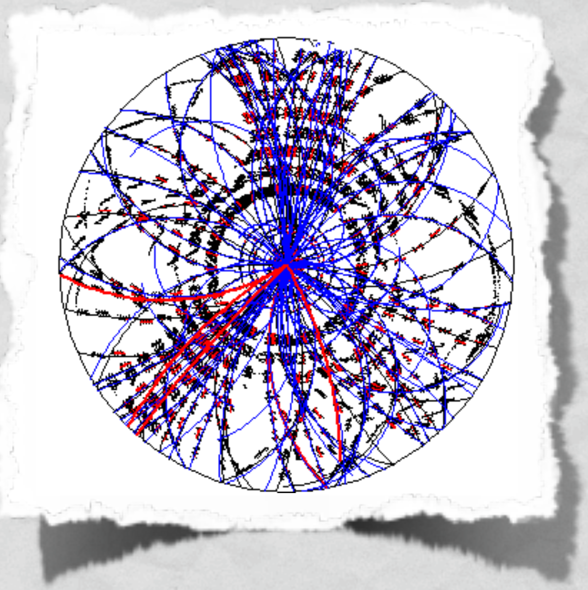
- 2 experiments
- 10^{13} $p\bar{p}$ collisions at 2 TeV in 10 years
- 0.1-1% of them yield B/D
- 0.1-10% of these on tape
- Shut down for good on Sep 30 (12 fb^{-1} for physics)



High-rate of all species of heavy flavors. Higher than B factories (...lower than LHCb).
Symmetric detectors and CP-invariant initial state ensure equal number of particles and antiparticles in acceptance

How do we do it

1 KHz of reconstructable b-pairs (p_T 5-10 GeV)



Trigger: single lepton and dilepton or tracks displaced from $p\bar{p}$ vertex.

Degraded efficiency at high lumi.
Significant bias on kinematics and decay-time.

Tracking: $\sigma(p_T)/p_T^2 = 0.1\%$. Vertex known within 20 μm. Good muons. Some PID (1.5σ)

Usually all-charged final states. Absolute efficiencies are hard - normalize with reference decays. Simulation used only for decay kinematics.

Analysis challenges: determining quark-flavor at production (D*-tag /sophisticated algorithms), sample composition of overlapping signals (joint fits of kinematics+PID)...

A. Duperrin, Mon 11:00 for detectors

The B_s mixing phase

BSM physics in mixing

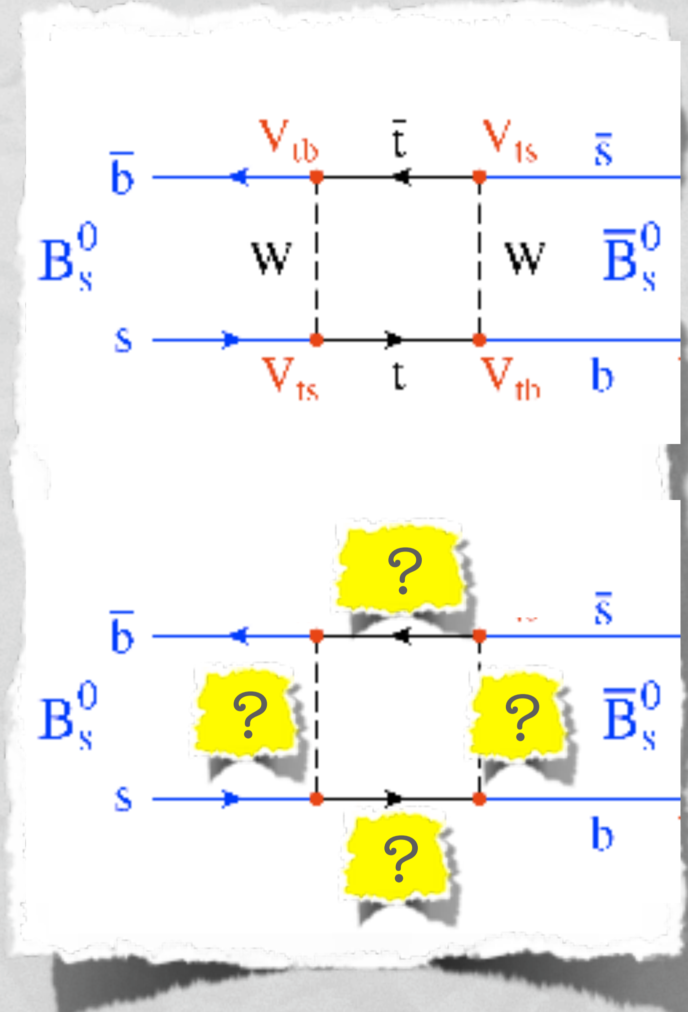
BSM physics can alter mixing phenomenology from SM expectations.

2006: magnitude of mixing consistent with SM (within lattice uncertainties)

Mixing phase unconstrained - large NP effects still possible.

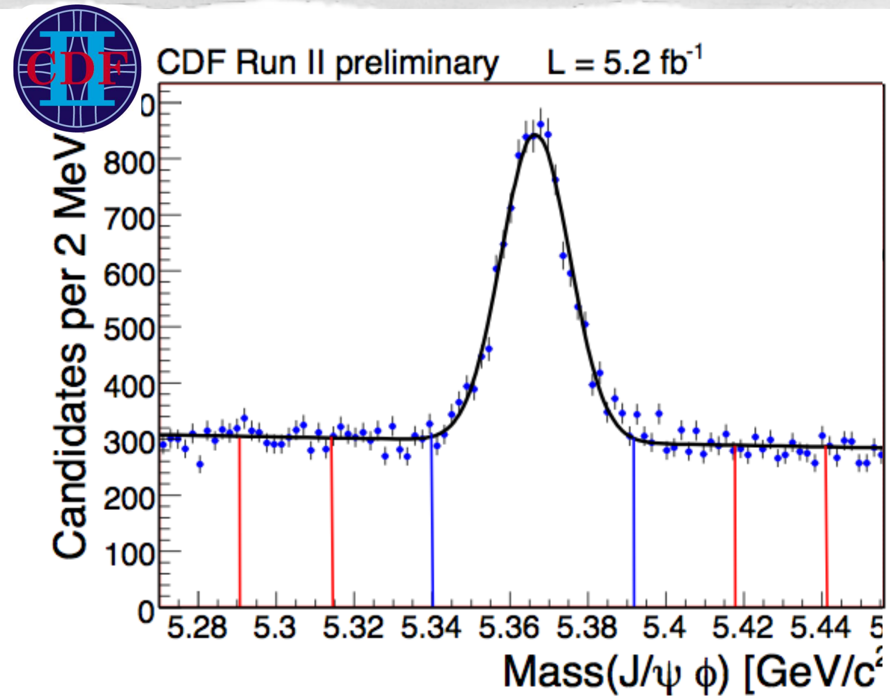
New physics accessible through interference between $B_s \to J/\psi\phi$ decay w/ and w/o flavor oscillations.

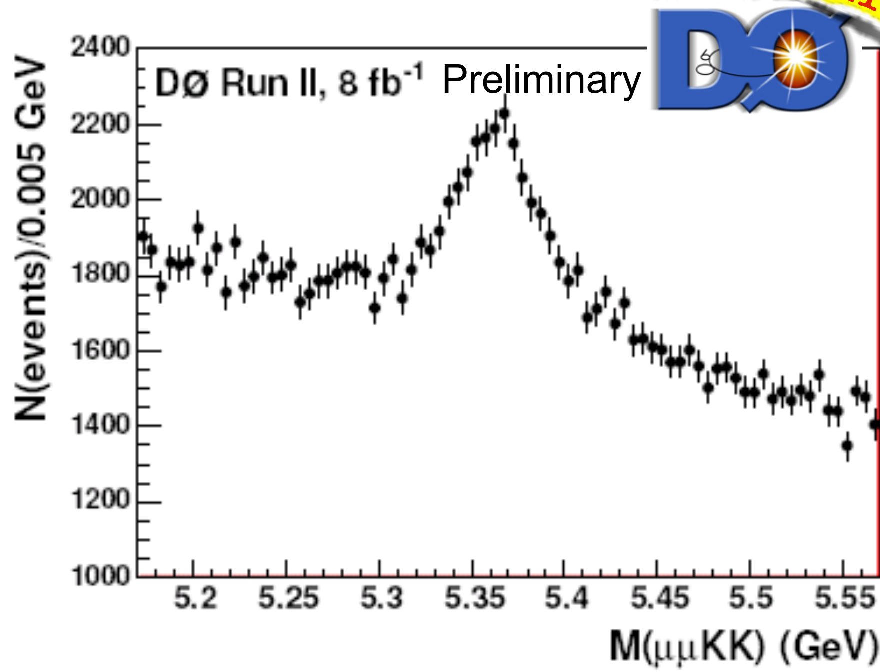
First measurements (2008) showed intriguing 2.2σ discrepancy



$B_s \to J/\psi\phi$ signals

new for EPS





6500 events in 5.2 fb^{-1}

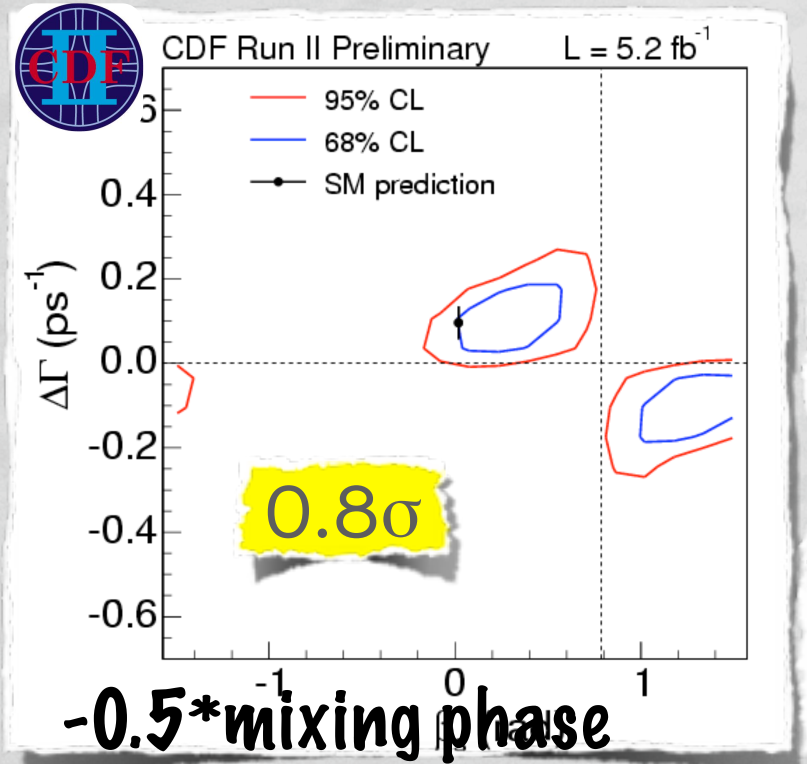
5000 events in 8 fb^{-1}

Identify production flavor using whole event information

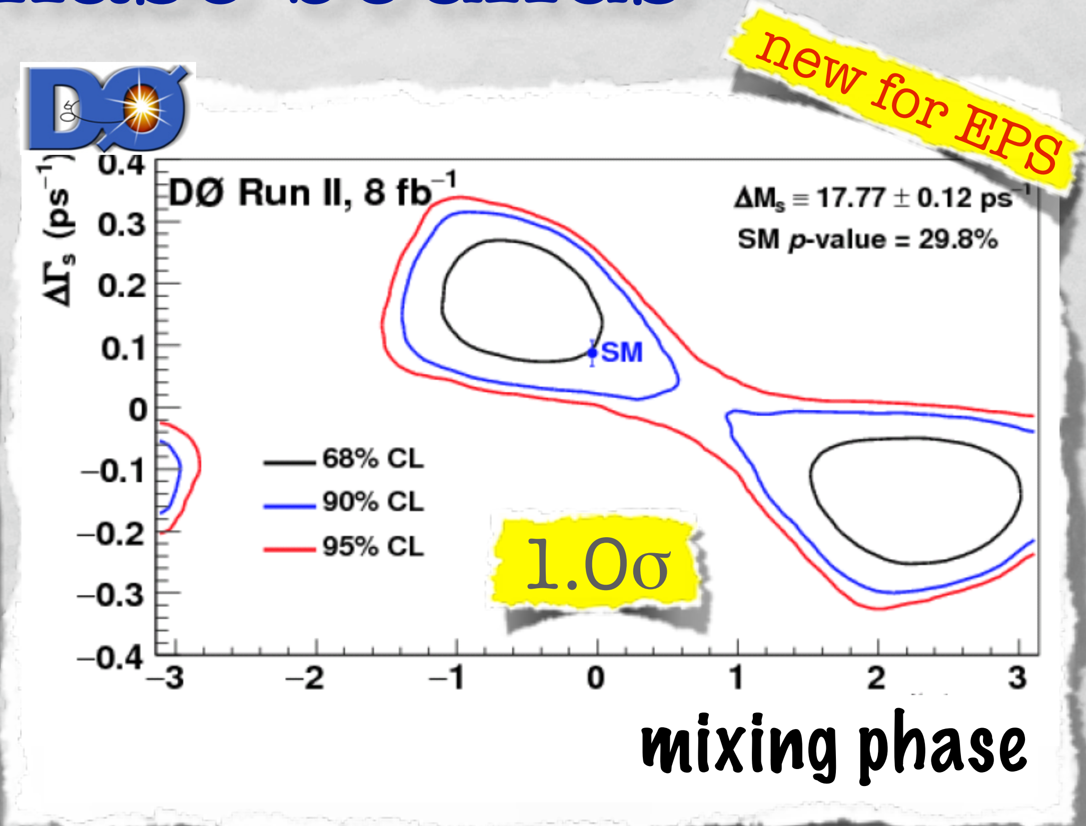
Production flavor using only “other B” in the event

Both include non-ϕ KK component in the angular analysis

Mixing phase bounds



CDF Note 10206



S. Burdin, Thu 15:15

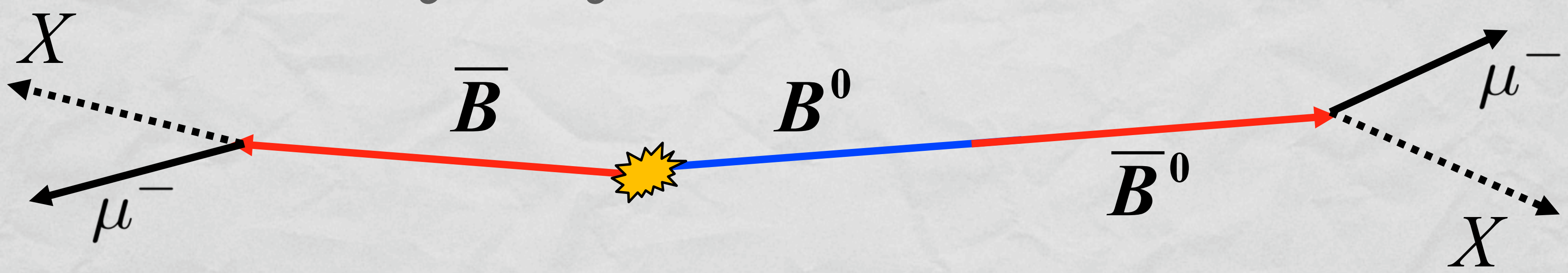
CDF confidence region shrunk. DO region didn't. Both more consistent with SM. Both fluctuate on the same direction.

Tevatron combination in plan. CDF will double statistics.

Another way to look at it

Semileptonic asymmetry

- In flavor-symmetric $\bar{p}p \to \bar{b}b$, like-sign leptons arise from HF decays only if flavor oscillations occur.



- SM predicts small asymmetry between numbers of ++ and -- muons from B. Enhancement implies NP in mixing.

- Derive from dimuon and inclusive muon asymmetries. In 2010 observe 3.2σ.Lots of subtleties. Key points
  - Asymmetric background of kaons faking muons
  - Asymmetry in acceptance/eff between + and - muons

G. Borissov, Thu 15:30

Improved analysis

new for EPS

+50% statistics. Acceptance increased. Fakes reduced with tighter muon matching.

$$A^b_{\rm sl} \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}},$$

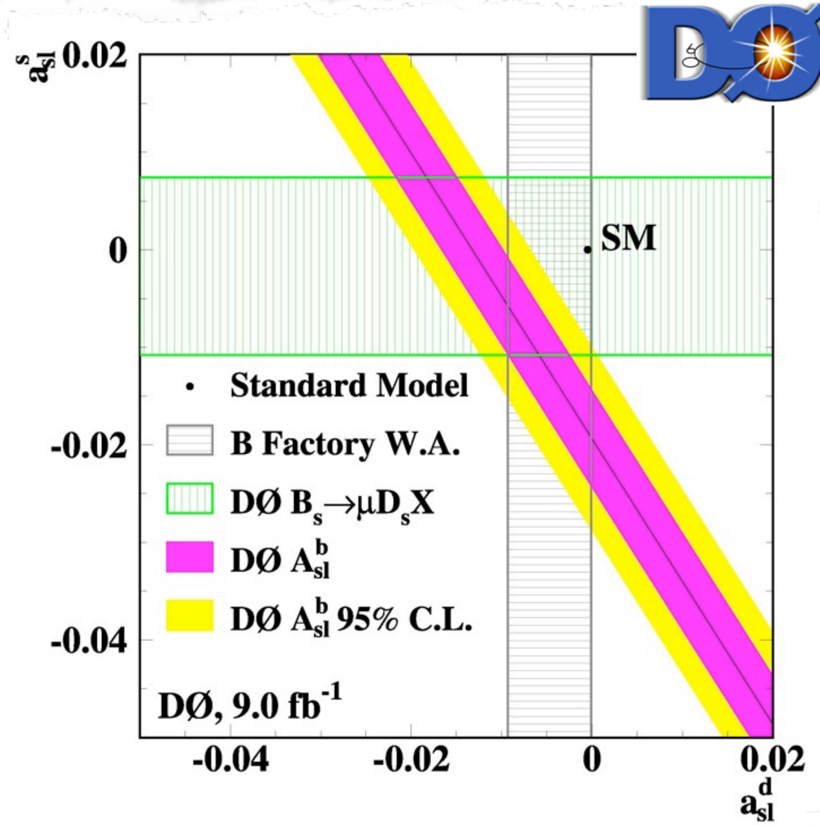
$$A^b_{\rm sl}(\mathrm{SM}) = (-0.028^{+0.005}_{-0.006})\% \approx 0.$$

$A_{sl}^b = (-0.79 \pm 0.17 \pm 0.09)\%$

Assuming "muons" are muons and come from B decays

3.9σ discrepancy

Flight tells B^0 from B_s apart



Extremely interesting. Same direction as J/ψϕ. Independent cross-check measurement is crucial. arXiv:1106.6308

Diversifying the portfolio

A_{SL} from sample composition fit of 2-dim impact parameter of dimuons. 1st step, time integrated mixing, consistent with LEP: $\chi = 0.126 \pm 0.008$ (1.4 fb^{-1}) CDF Note 10335

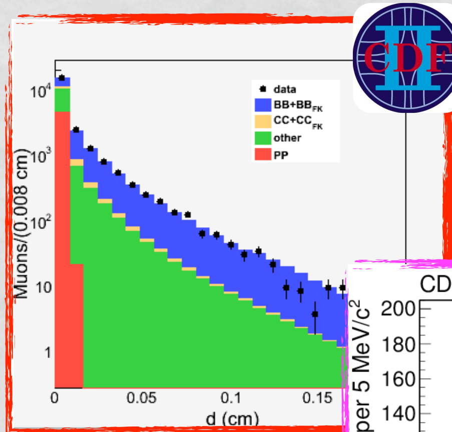
Use CP-pure $B_s \rightarrow J/\psi f_0$. No angular analysis. Lifetime: $\tau = 1.70^{+0.12}_{-0.11} \pm 0.03$ ps (3.8 fb^{-1}) arXiv:1107.3753

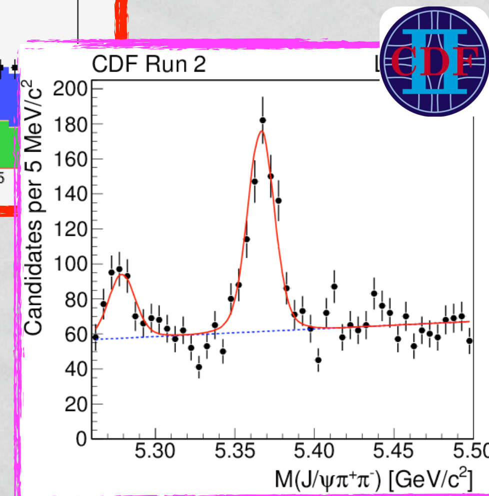
Pioneering penguin-side of B_s mixing with CPV in $B_s \rightarrow \phi\phi$

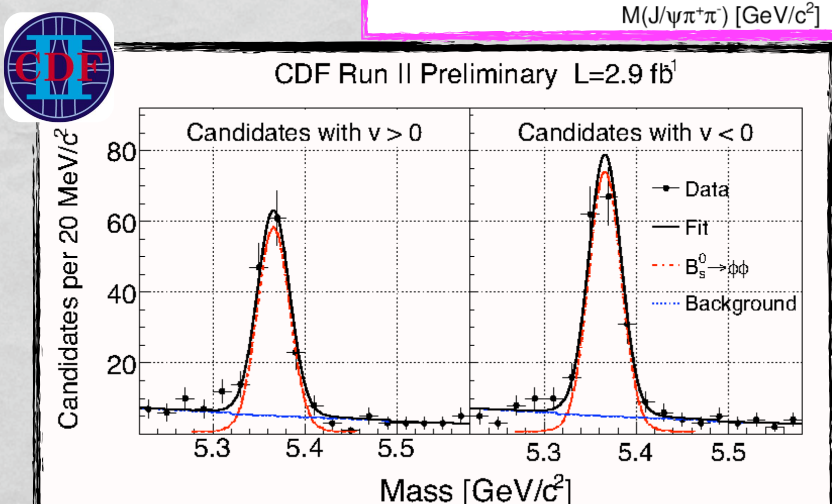
$A_v = (-12 \pm 6.4 \pm 1.6)\%$

$A_u = (-0.7 \pm 6.4 \pm 1.8)\%$ (2.9 fb^{-1})

arXiv:1107.4999

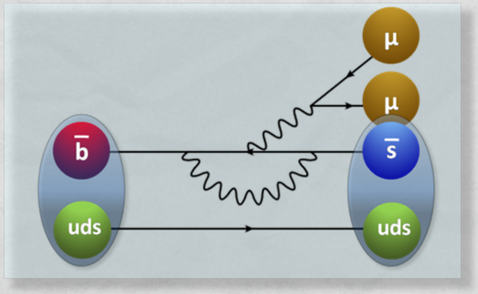






Flavor Changing Neutral Current Decays

$b \to s\mu\mu$ dynamics



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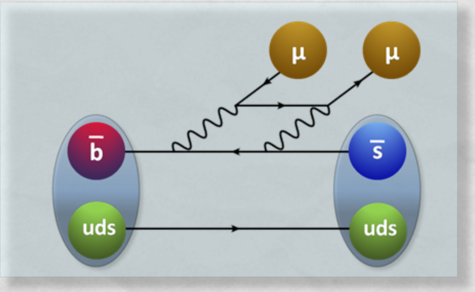

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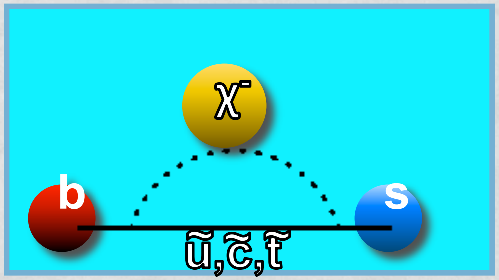


- Multiple channels

  $B^0 \to K^{*0}\mu\mu$, $B^0 \to K_S\mu\mu$, $B^+ \to K^+\mu\mu$, $B^+ \to K^{*+}\mu\mu$, $B_s \to \phi\mu\mu$, $\Lambda_b \to \Lambda\mu\mu$

- Rich dynamics, multiple measurements
  - Total Br -- early access
  - Br vs squared dimuon mass
  - Full angular analysis

Improved 7 fb^{-1} analysis reconstruct 250 B^+, 190 B^0 and 50 B_s decays

H. Miyake - Fri, 12:30

Latest arrival

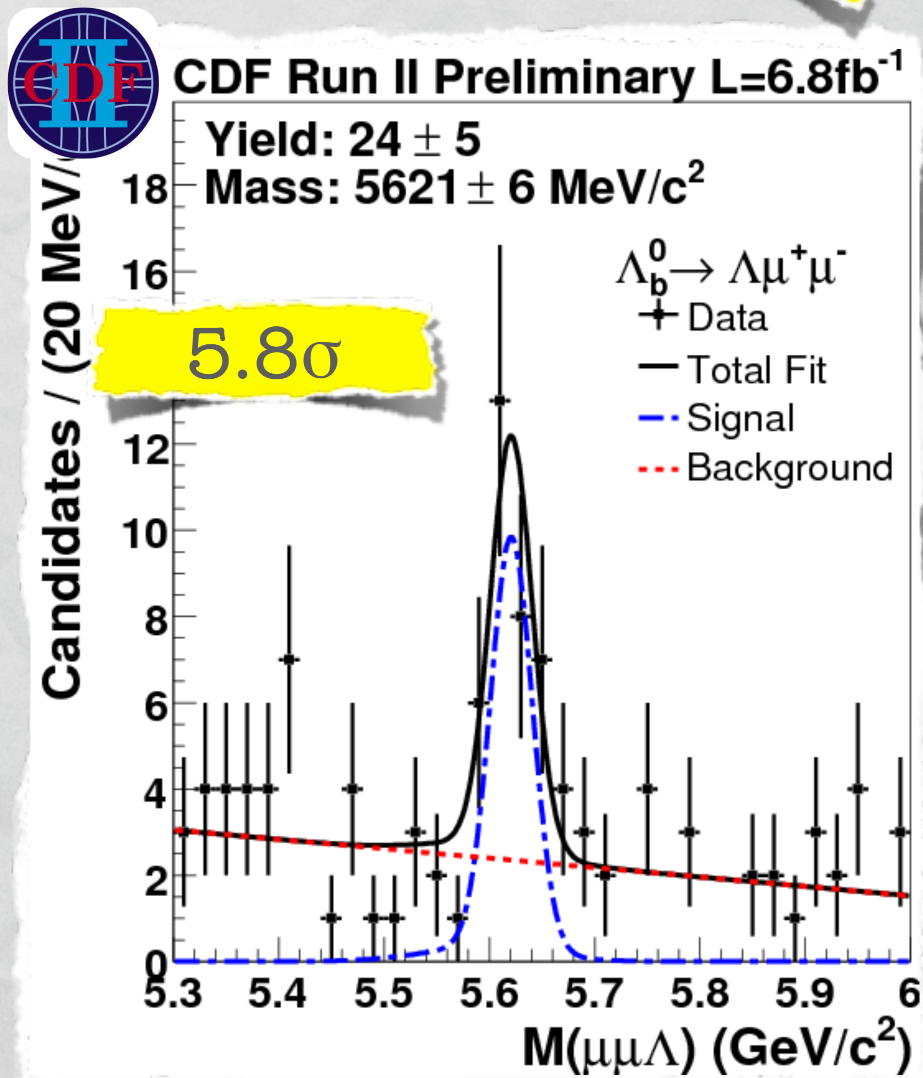
new for EPS

Observation of yet another b->sμμ process.

$Br = (1.73 \pm 0.42 \pm 0.55) * 10^{-6}$

Sensitivity complementary to B processes.

The first Λ_b FCNC decay observed



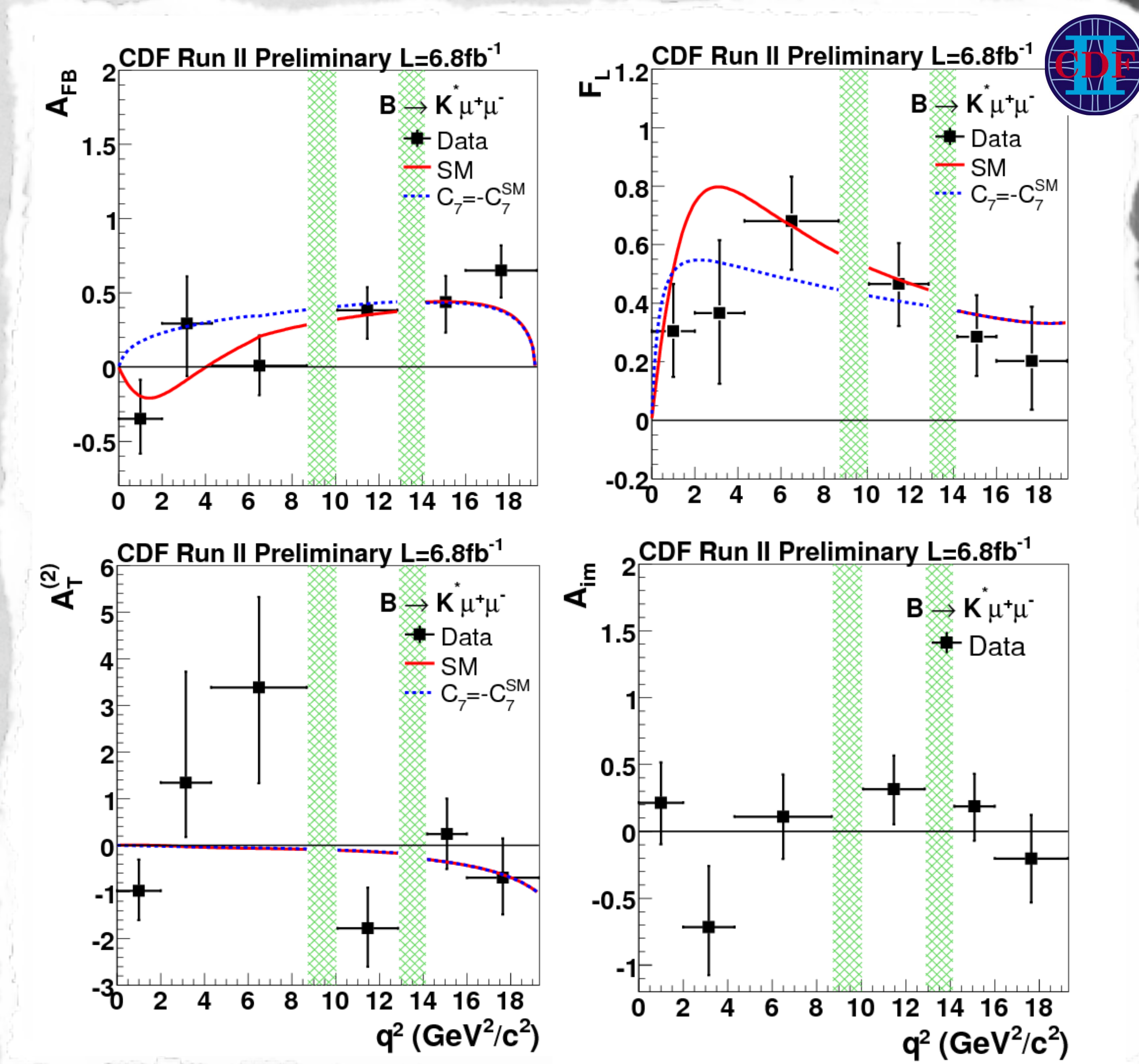
arXiv:1107.3753

Angular fit results

new for EPS

Compatible with SM

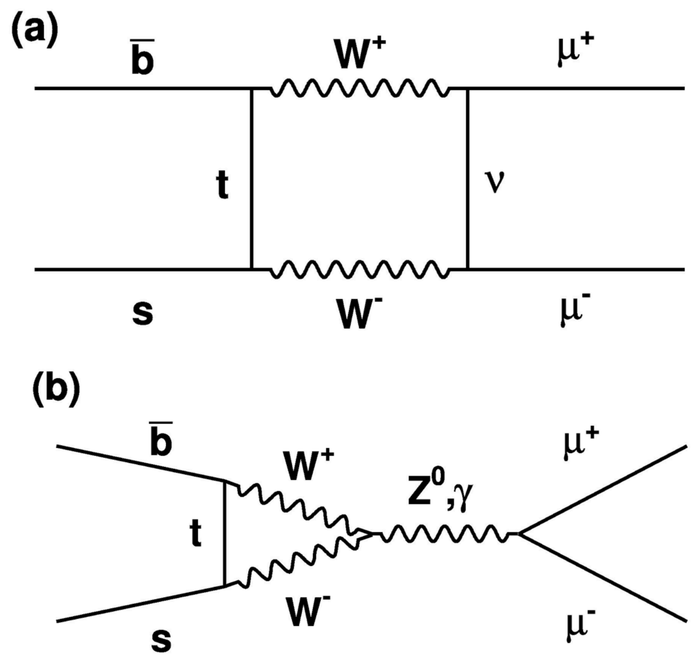
Sensitive to RH-currents. 1st measurement



H. Miyake - Fri 12:30

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

- SM rate is well understood
- SM rate is small, 3.2×10^{-9}
- Broad class of NP models (w/ new scalar operators) enhance it by 10x-1000x
- Signature clean.
- Pre-EPS experimental limits at $Br < 4\text{-}5 * 10^{-8}$ (90% CL)



T. Kuhr, Fri 11:15

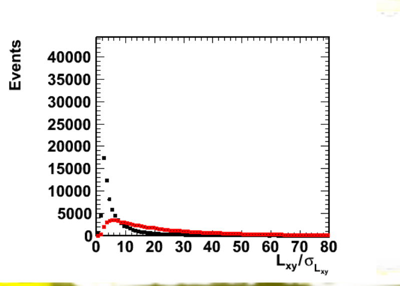
Challenge: reject 10^6 larger bckg. Keep signal efficiency high

The analysis

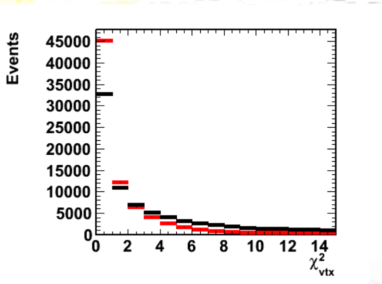
Trigger on two muons with $p_T > 1.5$ - 2 GeV/c

NN classifier separates S from B

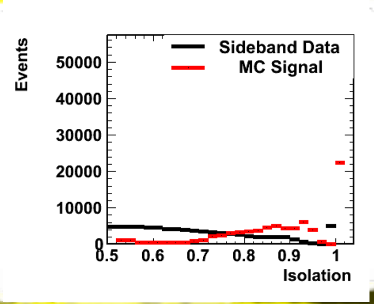
lifetime



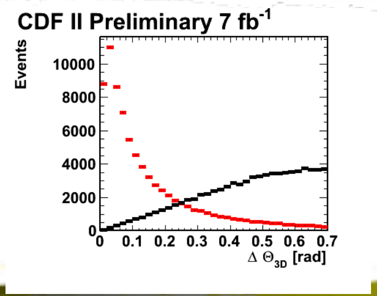
vertex quality



Isolation



Pointing

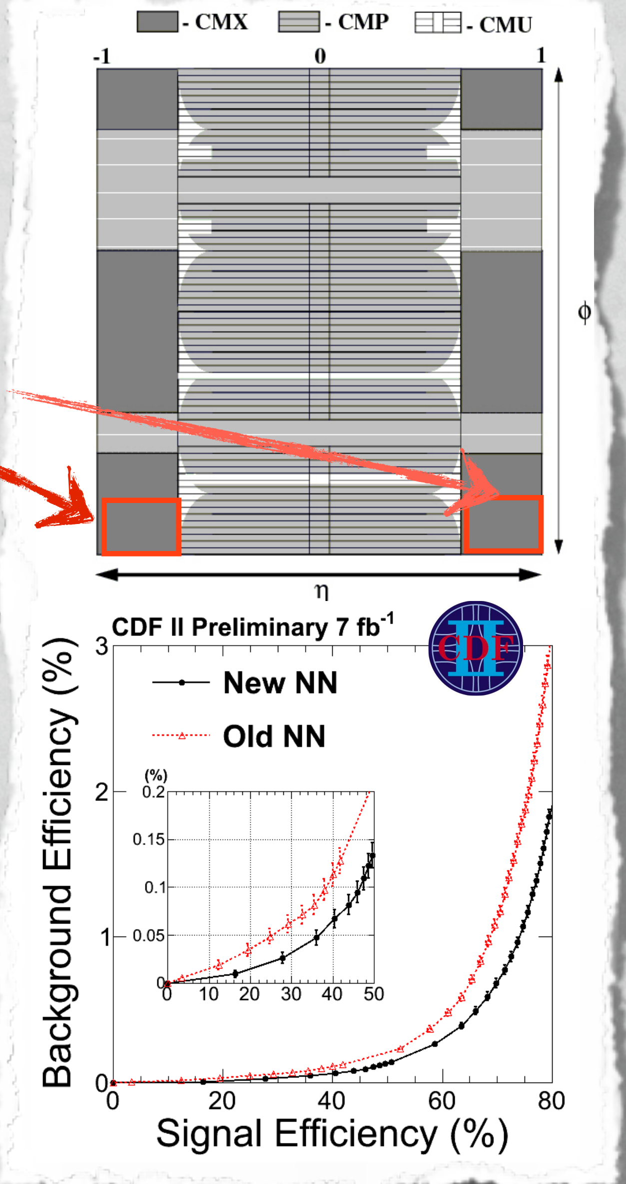


Bckg predicted using mass sidebands (comb.) and fake rates for $B \rightarrow hh$. Checked on many control samples

Look at search region in bins of mass and NN.
Rate determined using $B^+ \rightarrow J/\psi K^+$ as reference

What has changed

- Doubled sample size: 3.7→7 fb^{-1}
- +20% acceptance (partially offset by reduced trigger bandwidth)
  - Added previously unused muons
  - Added tracks that cross drift chamber wire-separator
- Improved NN (more information, different software package)
- B→μμX region excluded from sidebands (m > 5 GeV).



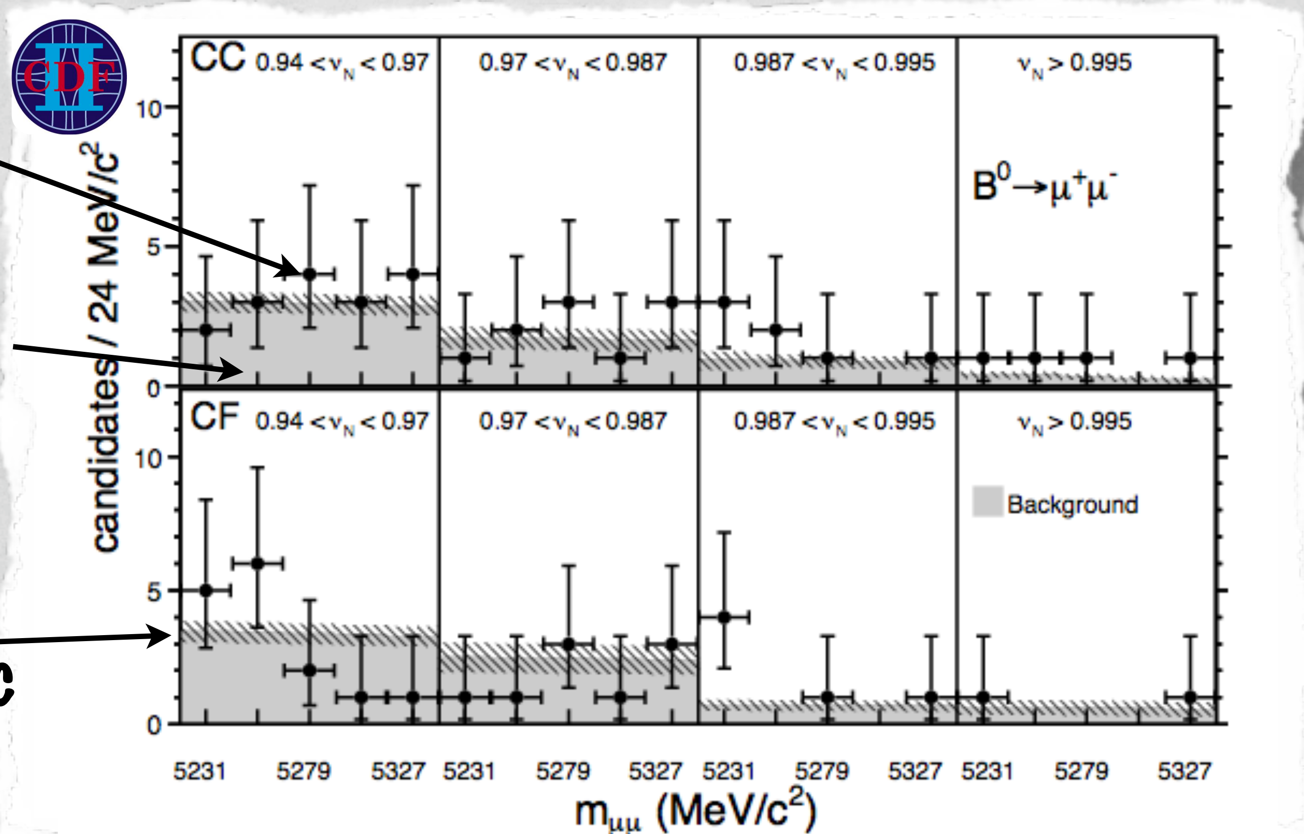
B^0 results

new for EPS

data

expected bckg

bckg systematic



2 central muons

1 central 1 forward

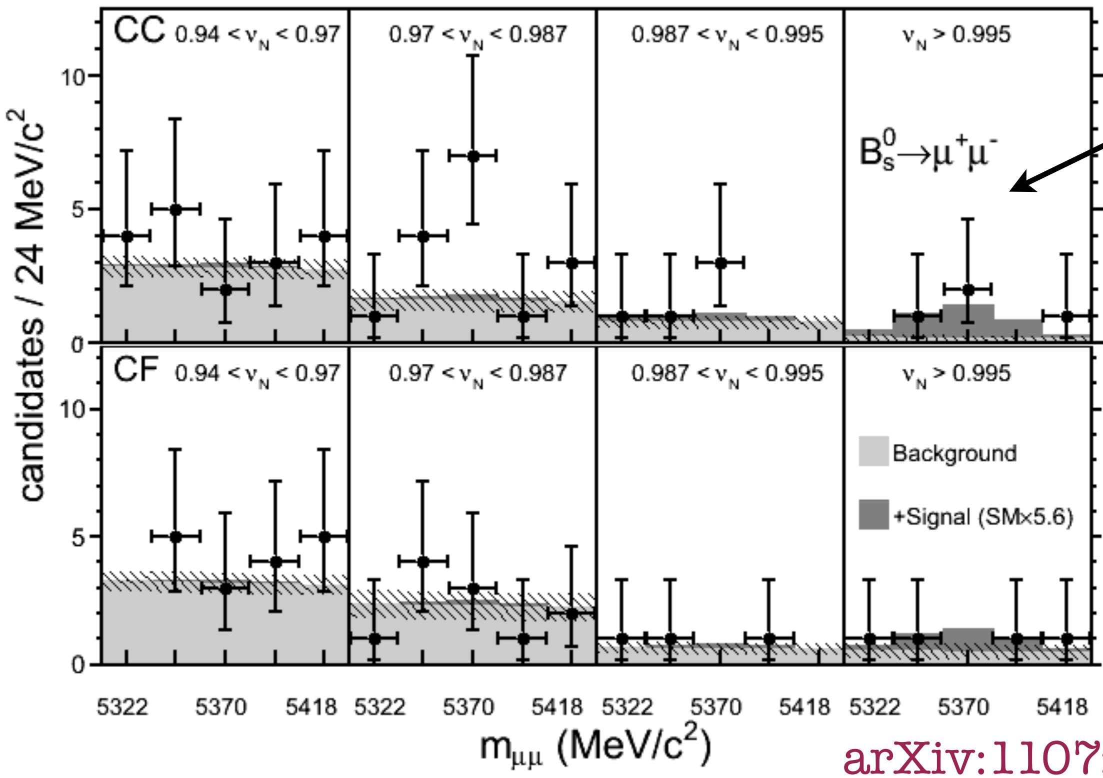
Bckg only fluctuate there or further 23% of times

$Br < 6\times10^{-9}$ at the 95% CL (expected $< 4.6\times10^{-9}$)

arXiv:1107:2304

Indication of $B_s \to \mu^+\mu^-$

new for EPS



Most sensitive bin:
0.9±0.5 exp.
4 observed

arXiv:1107:2304

2.8σ assuming bck-only hypothesis

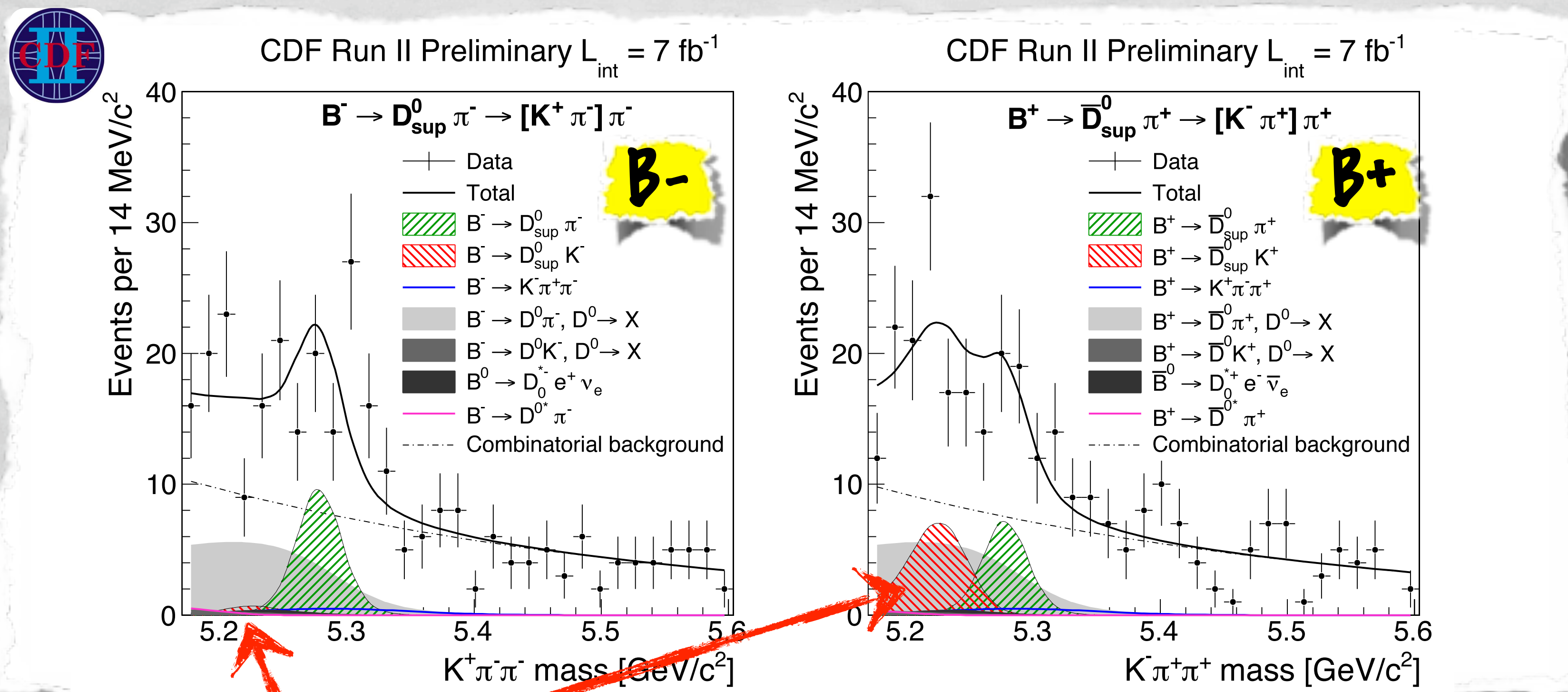
$0.46\times10^{-8} < Br < 3.9\times10^{-8}$ at 90% CL ($Br = 1.8\,^{+1.1}_{-0.9}\times10^{-8}$)

Lower 90% CL bound slightly higher, but compatible with SM (p-value 1.9%). Also compatible with latest LHC upper bounds.

Searches for old physics

Evidence of suppressed B→DK

new for EPS



Asymmetry: (-82 ± 44 ± 9)%

Suppressed/favored rate
(2.20 ± 0.86 ± 0.26)%

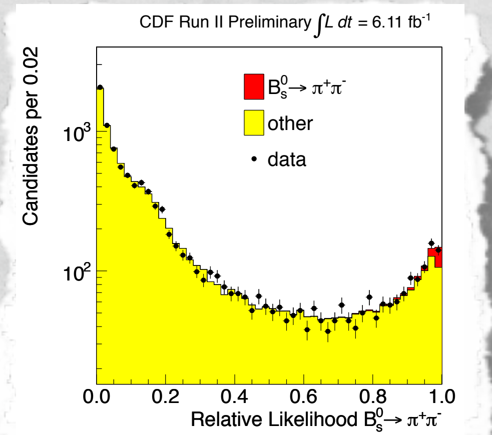
Sensitive to CKM phase γ.
Agrees and competes with B-factories

M.J. Morello, Thu 12:00

new for EPS

Yet another charmless B_s

3.7σ evidence for $B_s \to \pi\pi$.

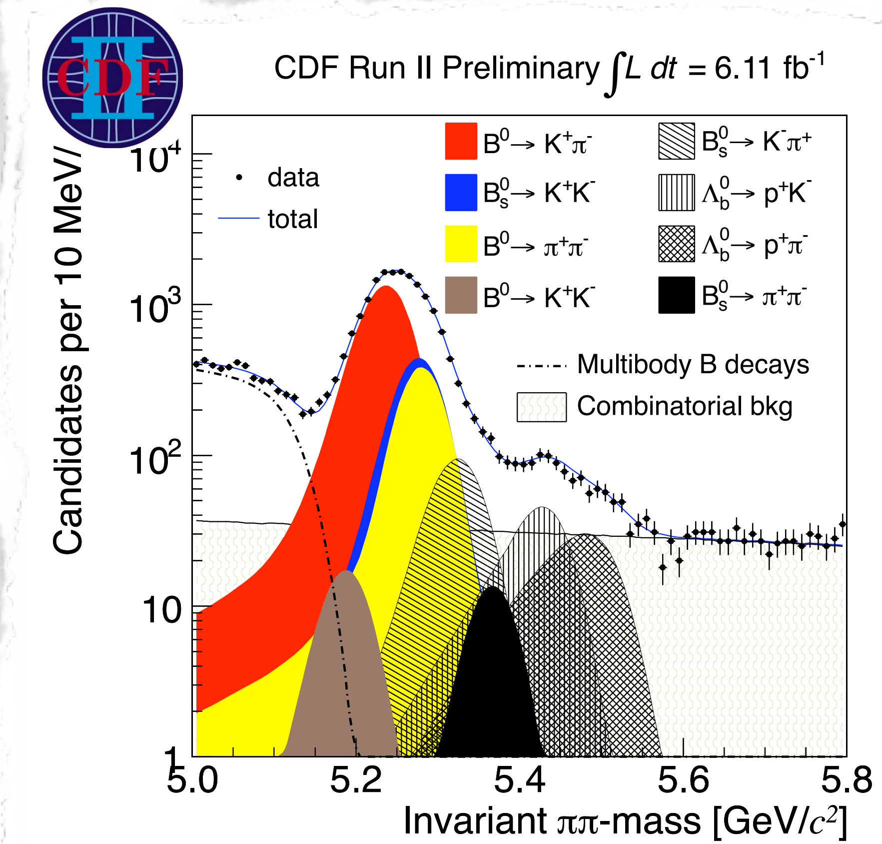


Br = (0.57 ± 0.15 ± 0.10)×10^{-6}

2-sided $B_s \to KK$ bounds.

0.05<Br<0.46 ×10^{-6} at 90%CL

Annihilation decays. Input for modeling B strong dynamics.



M.J. Morello, Thu 12:00
CDF Note 10498

Charm Decay Factory

new for EPS

Trigger on displaced tracks provide huge charm samples. Not in CDF plans.

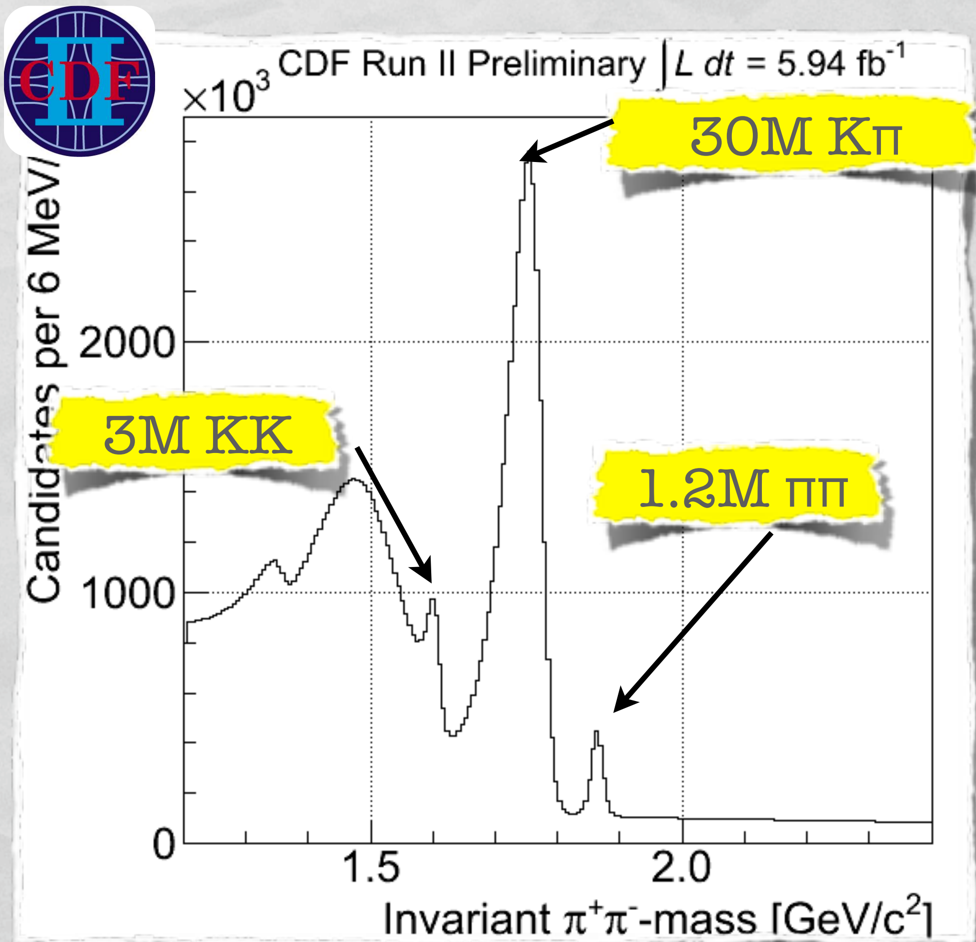
Unprecedented sensitivity to NP in up-quark sector.

$A_{CP}(D^0 \to K^+K^-) = (-0.24 \pm 0.22 \pm 0.10)\%$

$A_{CP}(D^0 \to \pi^+\pi^-) = (+0.22 \pm 0.24 \pm 0.11)\%$

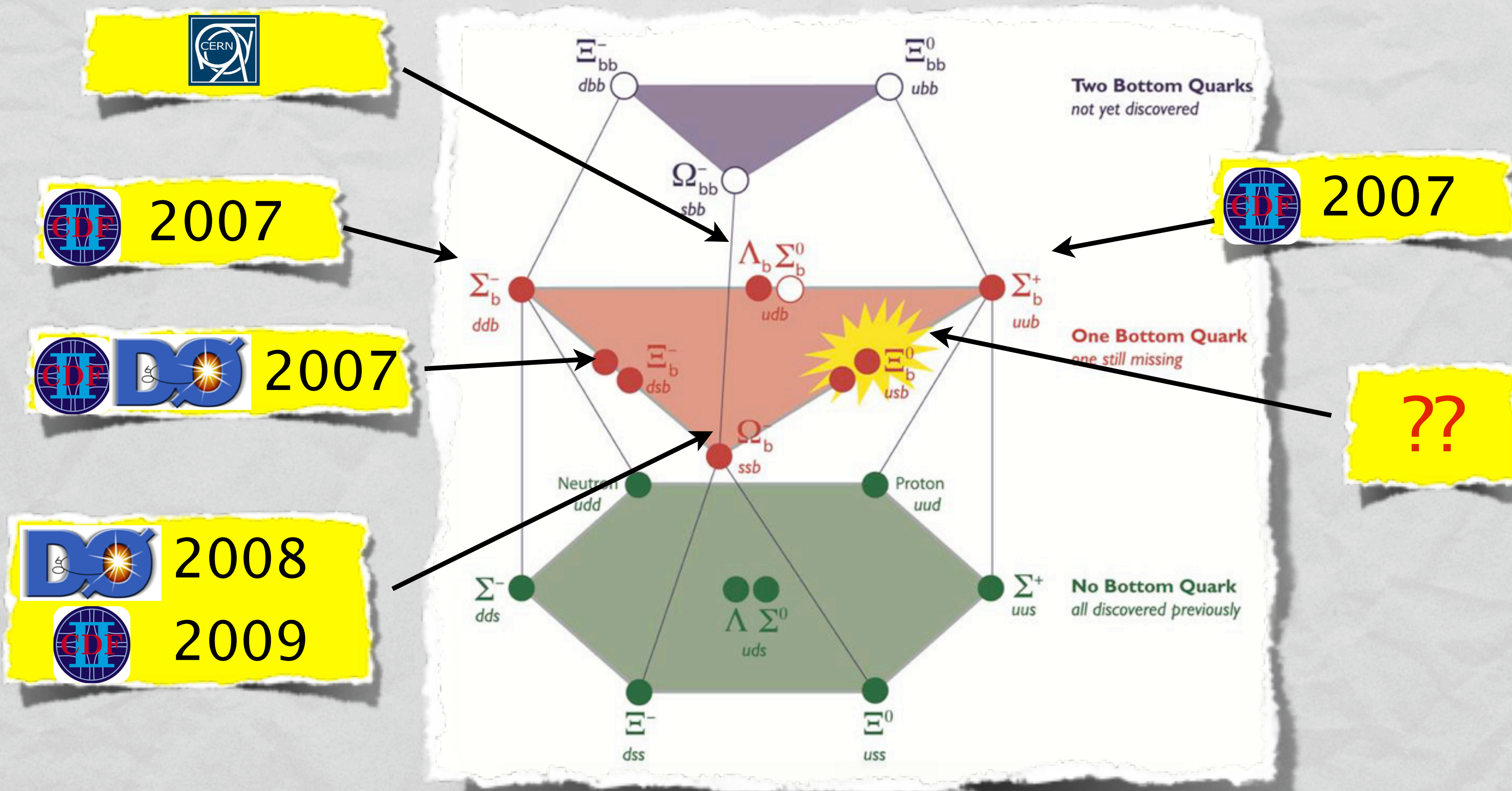
CPV in D^0 mixing < 0.13% at the 90% CL

Will last for long time.



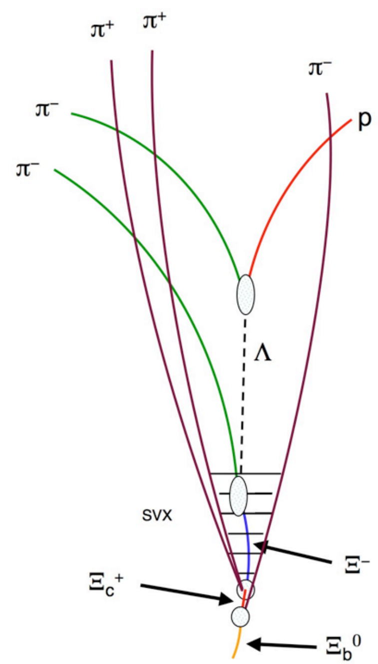
CDF Note 10296

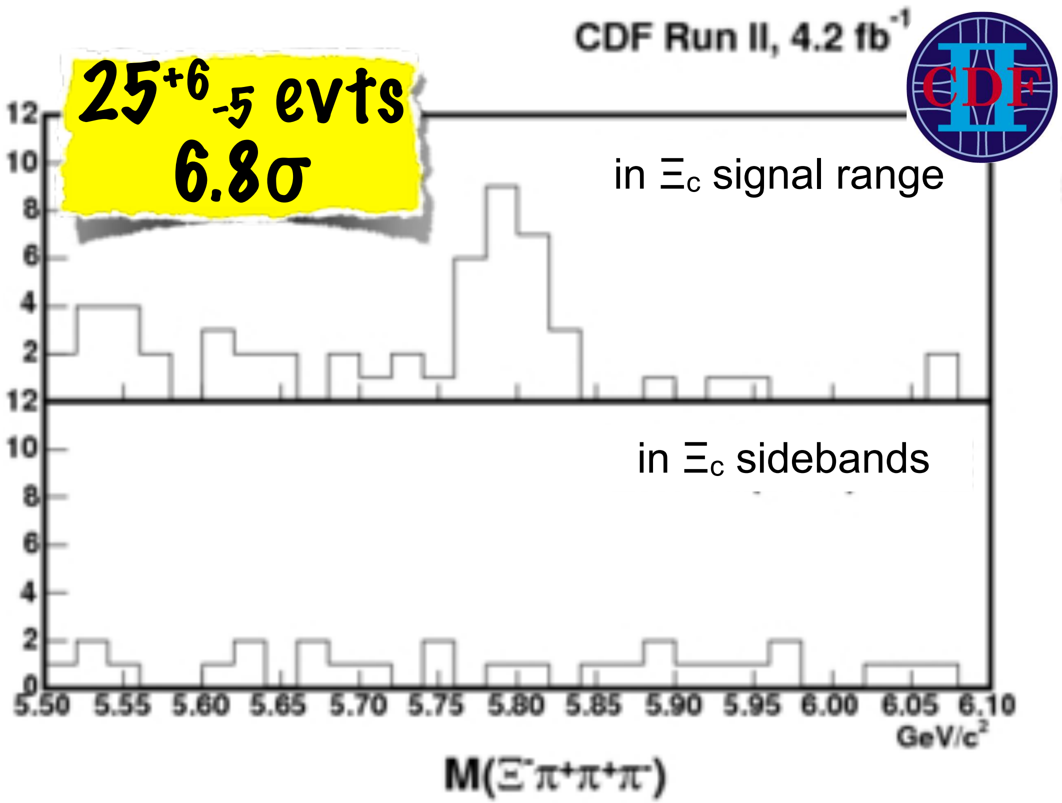
Strangely Beautiful Baryons



Ξ^0_b observation

new for EPS





$M(\Xi^0_b) = 5787.8 \pm 5.0 \pm 1.3$ MeV

$M(\Xi^0_b) - M(\Xi^-_b) = 3.1 \pm 5.6 \pm 1.3$ MeV

P. Bussey, Fri 15:45,
arXiv:1107.4015

Summary

Lean but mean

A program at its peak: samples of unprecedented size,tuned experiments, established analyses, enthusiast and focused people

10 results new for EPS

- Seriously challenging the SM
  - 4σ effect in semi-leptonic decay asymmetry
  - World's best determination of B_s mixing phase
  - Indication of $B_s \to \mu\mu$
- Keep advancing knowledge of CKM physics and QCD
  - Observation of the Ξ^0_b baryon
  - Among world's best BDK and charmless results

Quite a legacy

115 papers (..most cited ones..), 90 PhD theses. And counting...

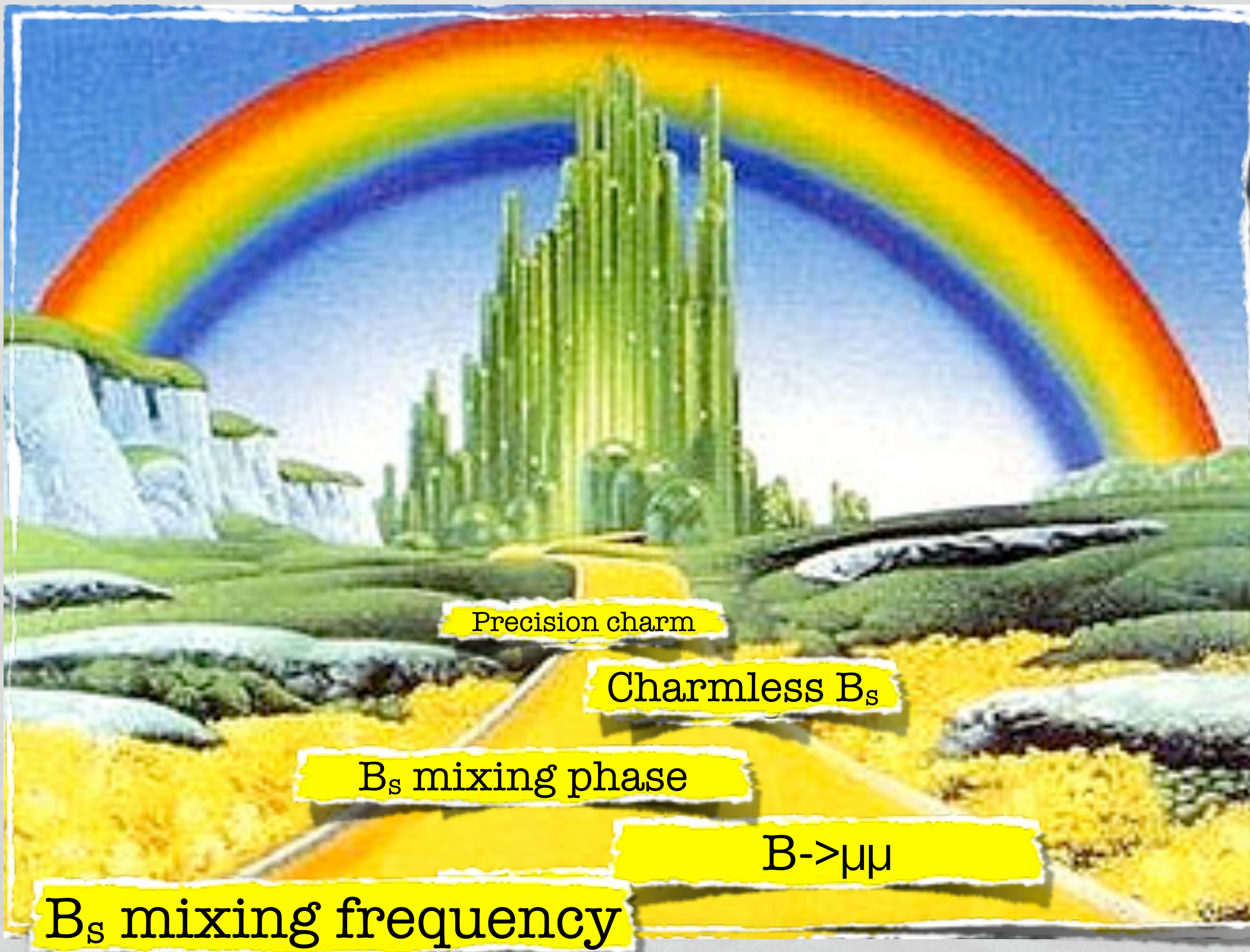
10 resonances discovered

World's best masses

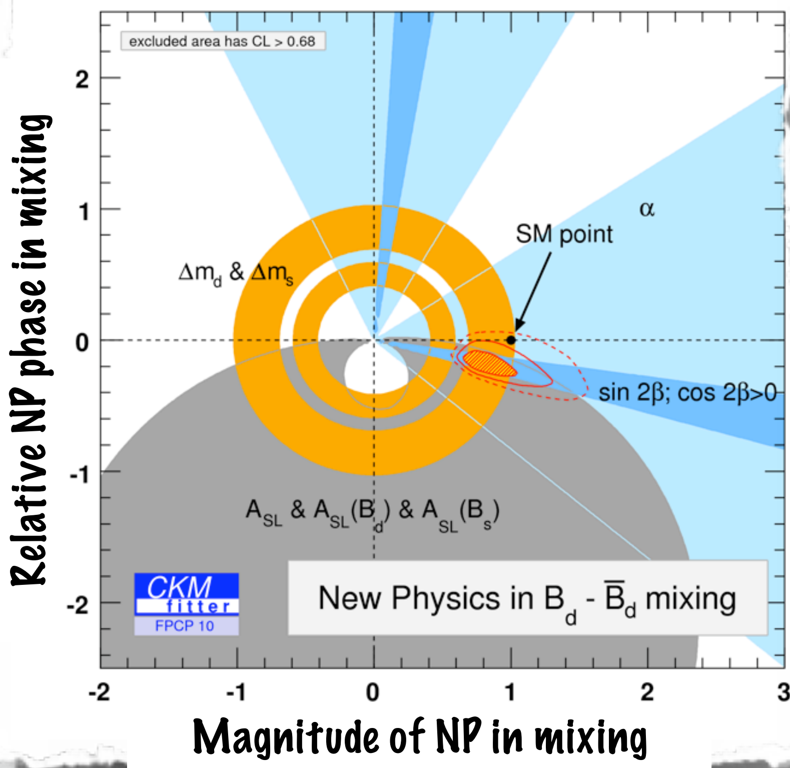
World's best lifetimes

Unique B_c studies

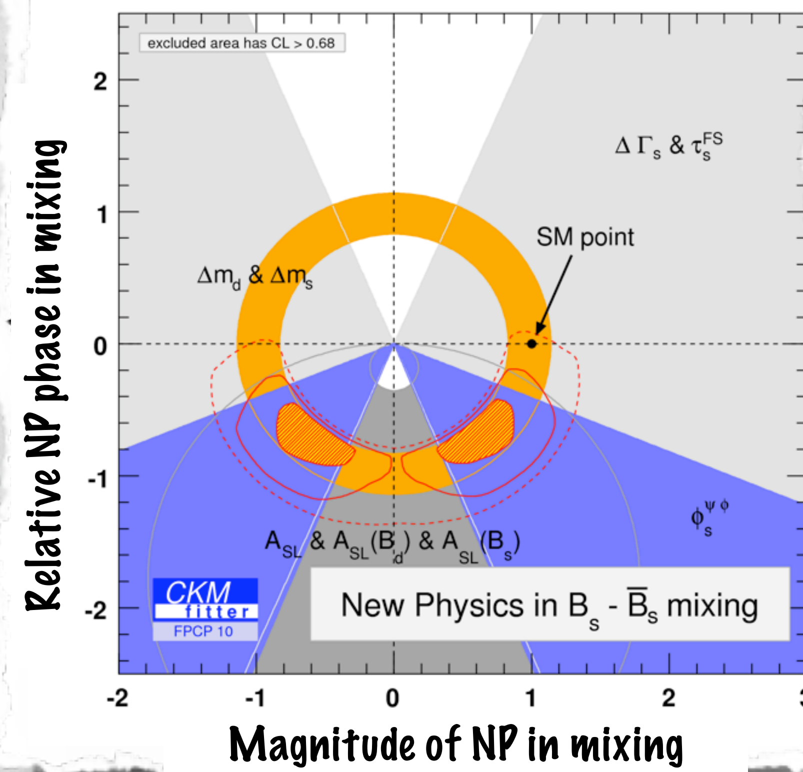
...



One slide show



little Tevatron, if any



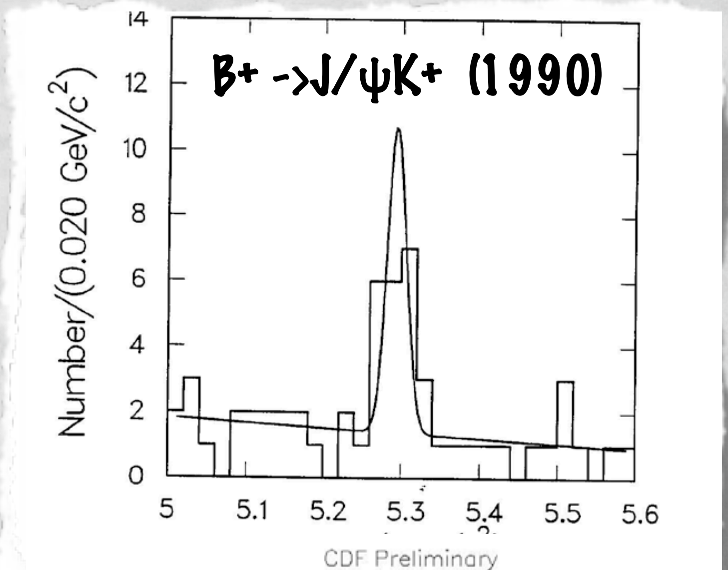
Tevatron only (almost)

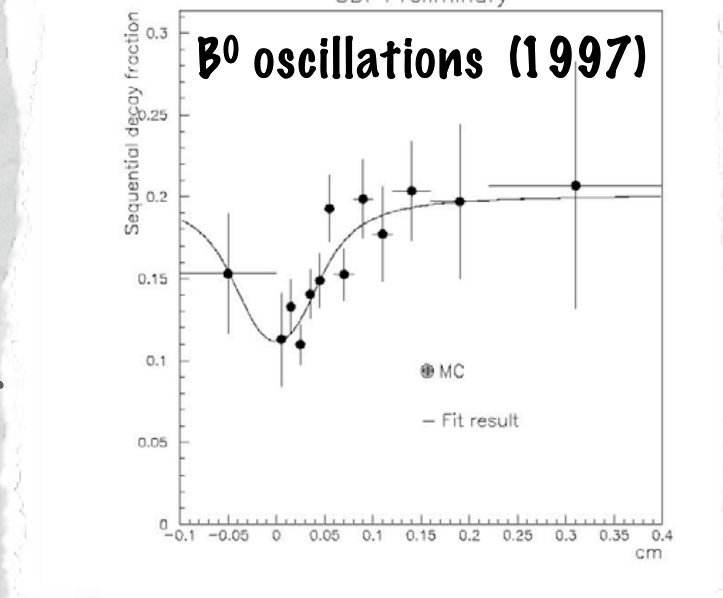
We have come a long way...

Demonstrated that cutting-edge HF physics is possible in addition to high-p_T program.
Two major transitions:

- silicon vertex detector (1991)
- silicon in the trigger (2001)

Tevatron legacy for HF includes ideas, techniques, ecc that we pioneered and have now become standard: flavor-tagging, importance of trigger, importance of doing data-driven

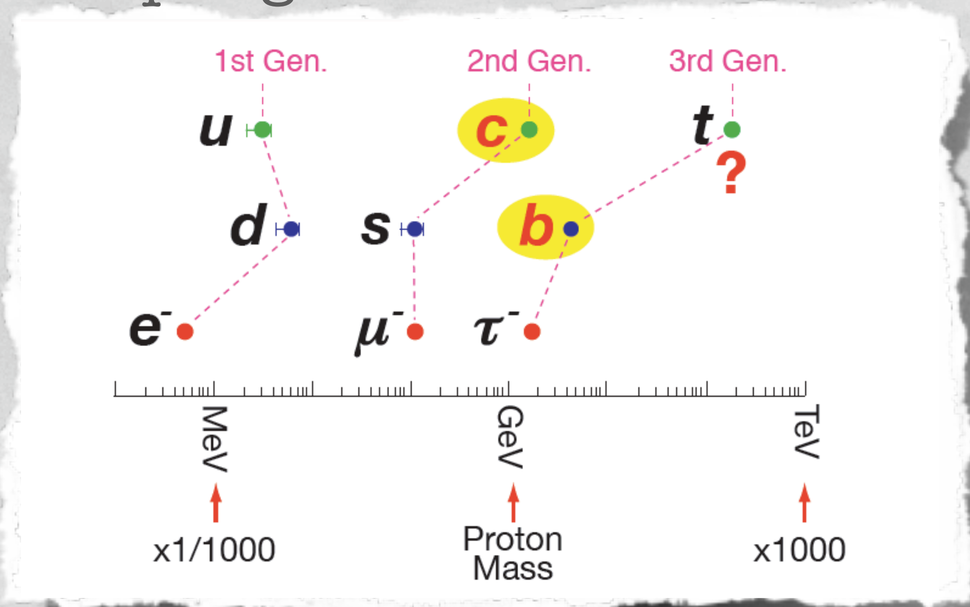




The end

Flavor

Physics of matter at its most fundamental level. Deals with masses/mixings of fermions. Origin of mass? Why are masses so different across families? Why are couplings different?...



$$
\begin{array}{cc}
 & \begin{array}{ccc} d & s & b \end{array} \\
V \approx & \begin{pmatrix} 1 & \lambda & \lambda^3 e^{i\phi} \\ -\lambda & 1 & \lambda^2 \\ -\lambda^3 e^{-i\phi} & -\lambda^2 & 1 \end{pmatrix} \begin{array}{c} u \\ c \\ t \end{array}
\end{array}
$$

$\lambda = 0.22$

Flavor is also where CPV manifests itself. SM has sufficient complexity to accommodate it but says nothing about its origin.

Silicon Vertex Trigger

Dedicated hardware

Combines information from drift chamber and silicon

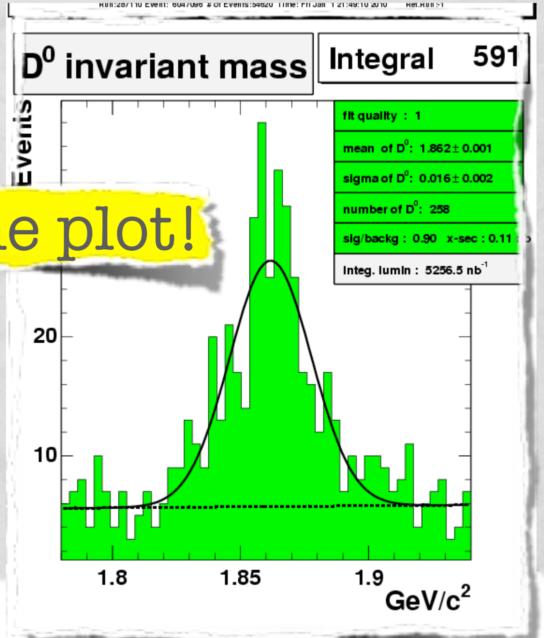
Finds all central tracks with pt>2 GeV/c and determines their impact parameters

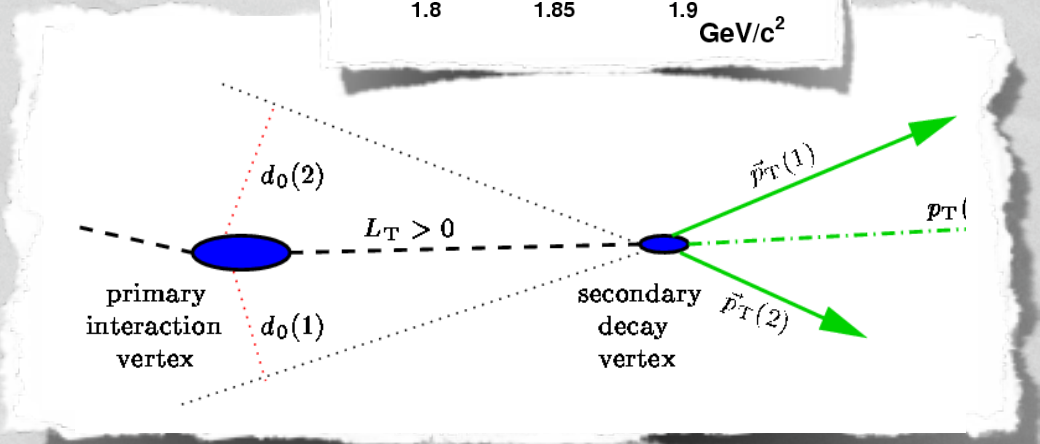
In less than 20μm

Crucial role in this analysis.

Boosts yield by factor 30K

Real-time plot!





J/ψφ at a glance

Trigger on two muons consistent with J/ψ decay

Unbiased optimization of signal selection

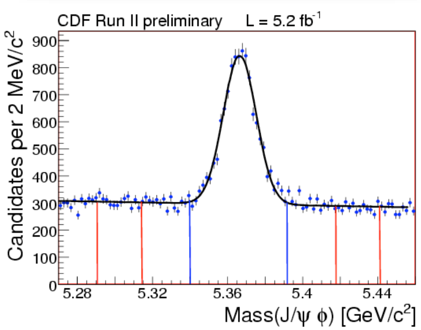
Joint fit to mass, angles, decay time, production flavor

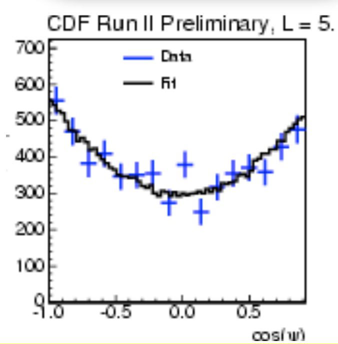
Mass separates signal from background

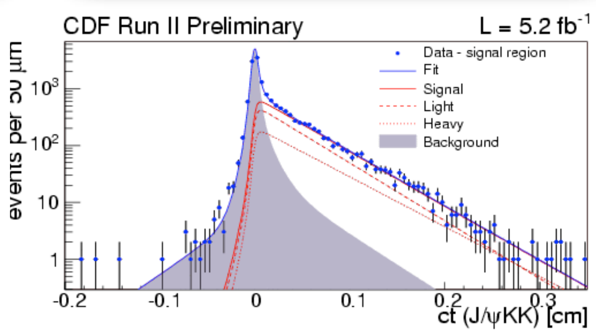
Angles: CP-even from from CP-odd

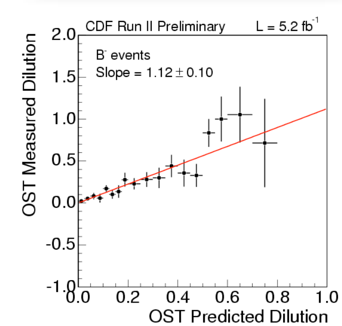
Decay-time to know time evolution

Flavor: B_s from $B_s$bar

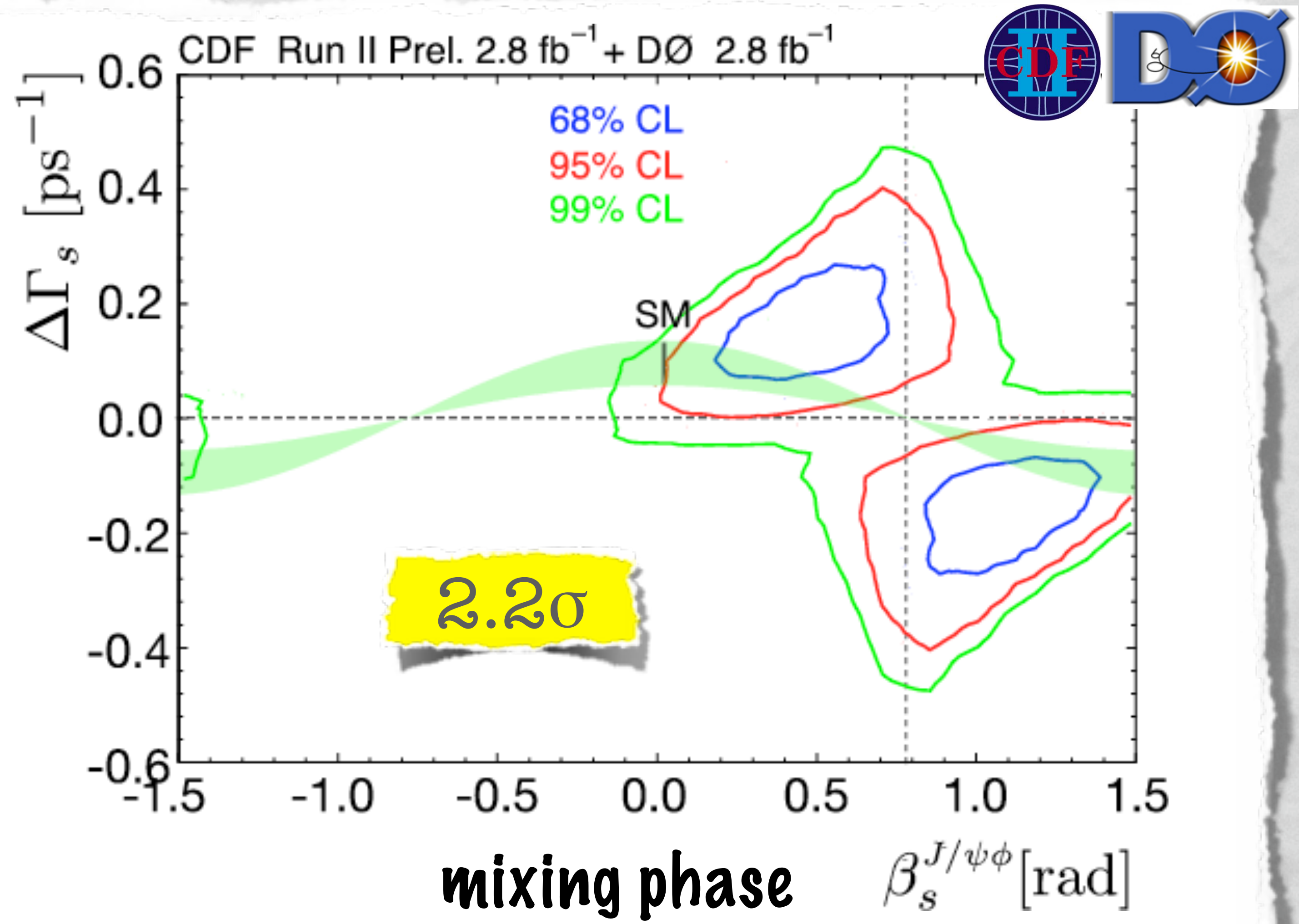








The (mild) excitement



CDF Note 9787/ DO Note 5928

A_{SL} in one slide

two samples: 2 billion single μ and 6 million di-μ in 9 fb^{-1}. $p_T > 1.5$-4.2 GeV/c

Measure +/- asymmetry in both samples

Asymmetry washed by muons from non-oscillating sources (from MC)

Asymmetry biased by background asymmetries from instrumental effects

Kaon contribution measured in data, pions extrapolated from MC.

Combine asymmetries from single-μ and di-μ samples to subtract common backgrounds

G. Borissov, Thu 15:30

The analysis

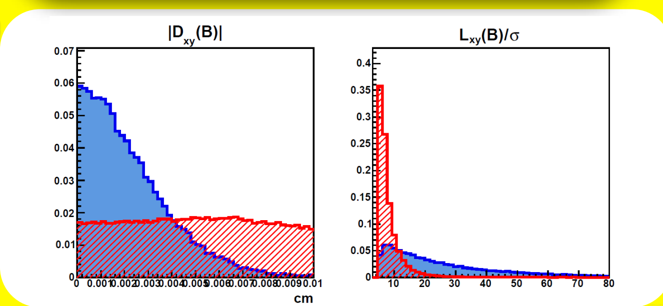
new for EPS

Trigger on two muons with $p_T > 1.5$ - 2 GeV/c

Veto resonant charmonium modes and charm bckg

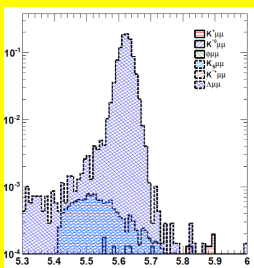
NN separates S from B

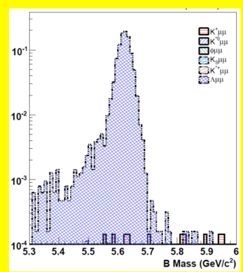
p_T, life, pointing, μ-ID



Reduce cross-feeds

$L\mu\mu$ <-> $K_s\mu\mu$

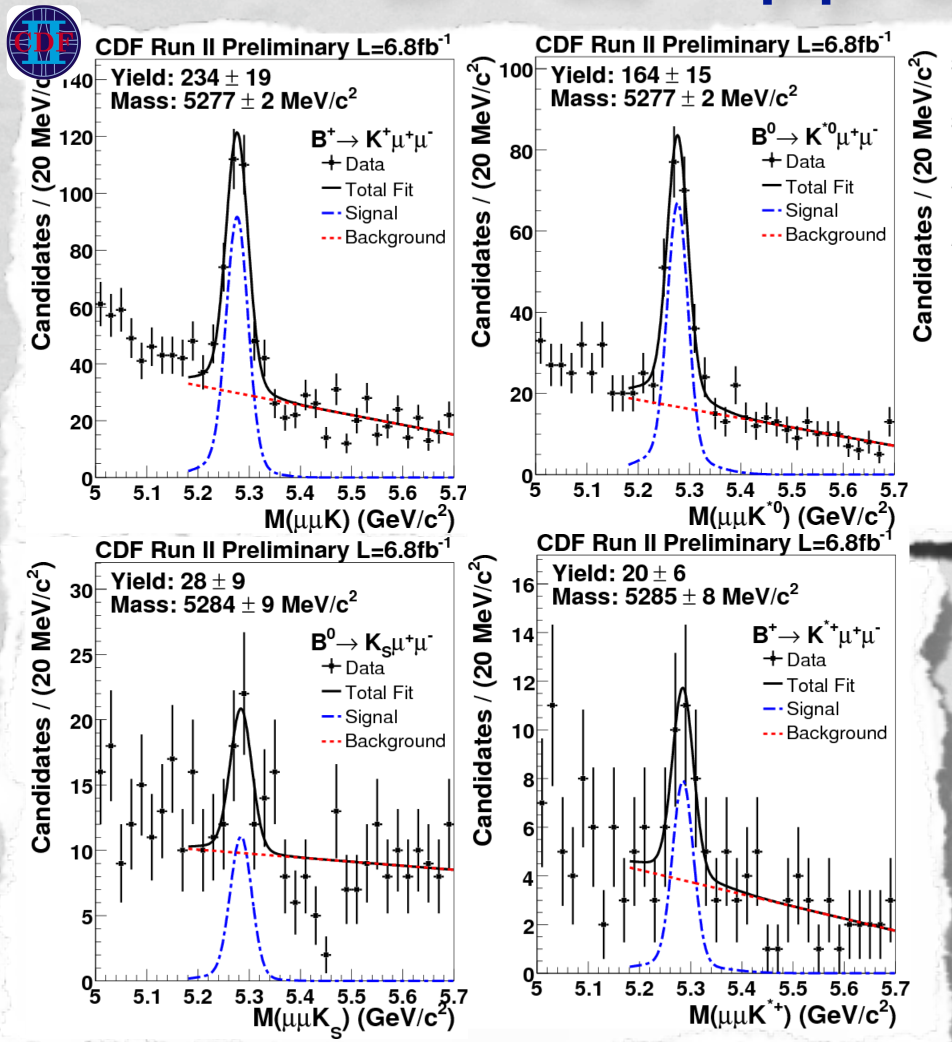




Use resonant $B \rightarrow J/\psi h$ modes as normalization

Extract absolute/differential decay rates and angular asymmetries new for EPS

B->K$^{(*)}\mu\mu$ signals



World's most precise absolute and differential BR measurements

arXiv:1107.3753

Bs->mumu

Signal decays at 95%CL to be measured

Trigger acceptance ratio from MC approx. 0.2-0.3

Rec. efficiency ratio from MC/DATA approx 0.8

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \frac{N_s}{N_+} \cdot \frac{\alpha_+}{\alpha_s} \cdot \frac{\epsilon_+}{\epsilon_s} \cdot \frac{1}{\epsilon_N} \cdot \frac{f_u}{f_s} \cdot \mathcal{B}(B^+),$$

PDG

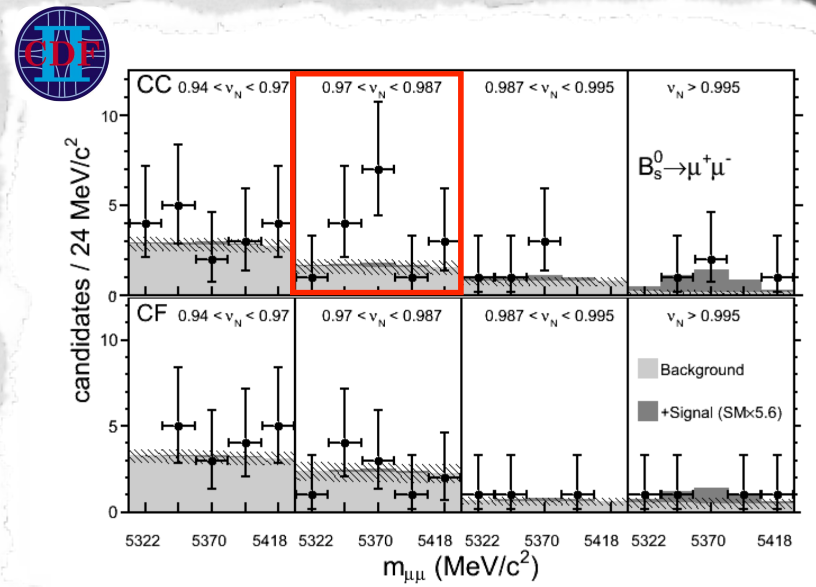
$B^+ \to J/\psi K+$ decays from data approx. 20K

Efficiency of NN requirement from MC, approx 80-20% (cut-dependent)

The 3rd bin

new for EPS

Unlikely to be peaking bckg. Only one is B→hh. Is 10× larger in B^0 window where nothing is seen.



Unlikely to be syst. problem with combinatorial. Same procedure in B^0 where nothing is seen.

Unlikely to be NN-shape issue. Cross-check with B$^+$ looks good within <5%. And several cross-checks show no mass bias vs NN

We conclude this is a fluctuation (2.6σ). Not unlikely in one out of 80 bins.

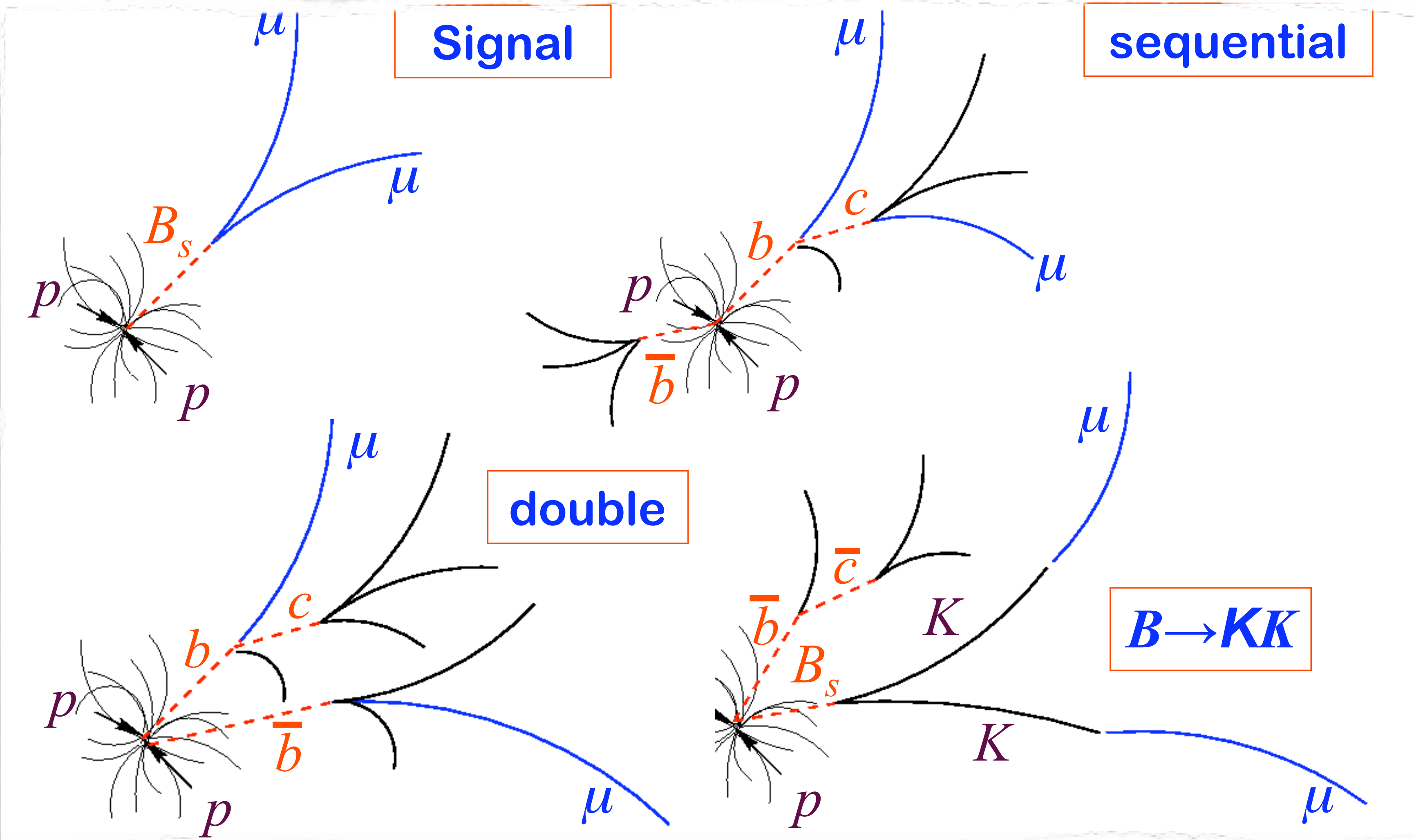
Using last 2 bins only:

$Br = 1.4^{+1.0}_{-0.8} \times 10^{-8}$ $(0.33\times10^{-8} < Br < 3.3\times10^{-8}$ at the 90% CL)

p-value(bckg-only) = 0.66%

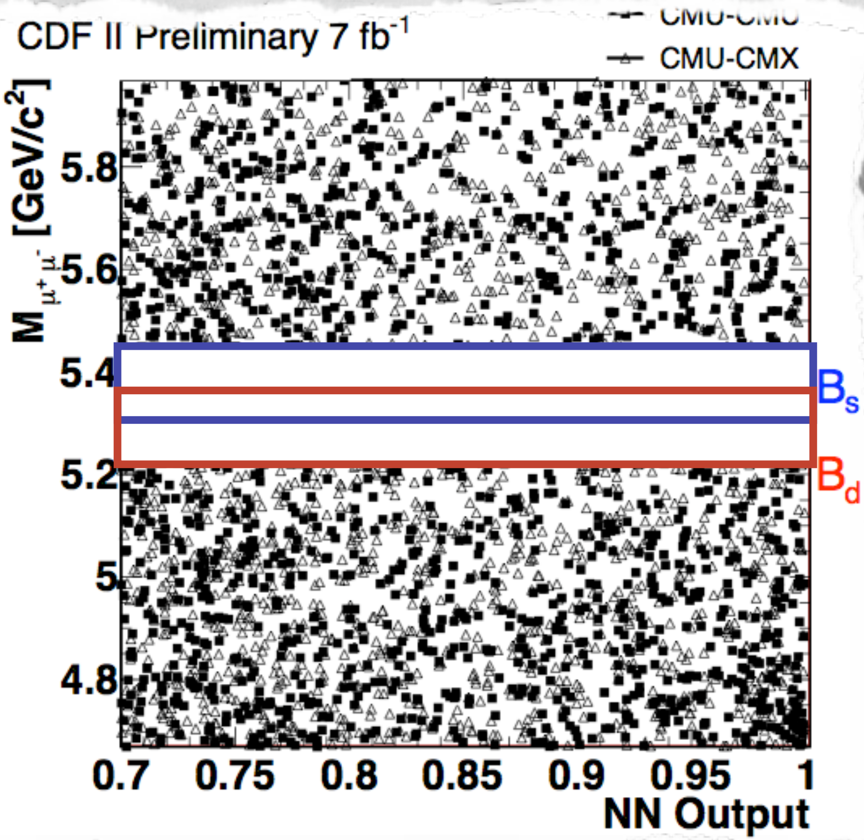
No significant impact on result

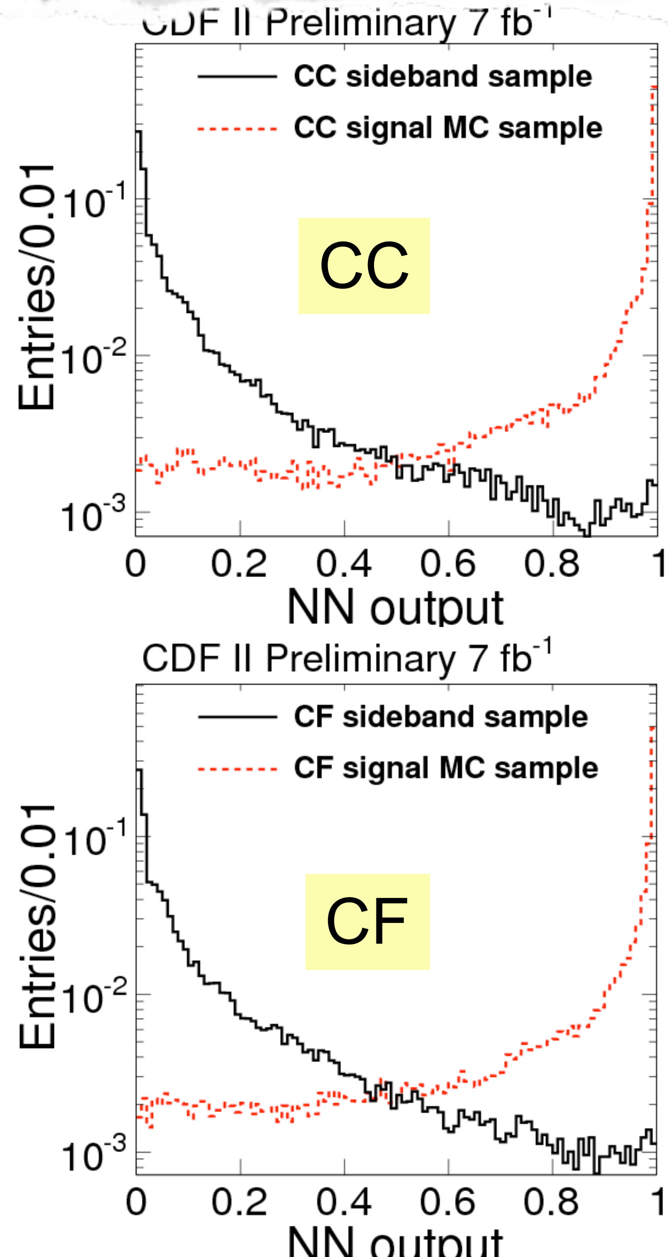
Cartoon



Signal
sequential
double
B→KK
μ
μ
B_s
p
p
μ
c
b
p
$\bar{b}$
p
μ
μ
c
b
p
$\bar{b}$
p
μ
μ
$\bar{c}$
$\bar{b}$
K
B_s
K
p
μ

NN distribution





Combinatorial

All uncertainties are included

B_s signal window:

NN Bin	CC	CF
$0.700 < NN < 0.970$	129.2 ± 6.5	146.3 ± 7.0
$0.970 < NN < 0.987$	7.9 ± 1.9	11.6 ± 1.8
$0.987 < NN < 0.995$	4.0 ± 1.1	3.3 ± 1.0
$0.995 < NN < 1.000$	0.79 ± 0.52	2.6 ± 1.5

B^0 signal window:

NN Bin	CC	CF
$0.700 < NN < 0.970$	134.0 ± 6.6	153.4 ± 7.3
$0.970 < NN < 0.987$	8.2 ± 2.0	12.1 ± 1.9
$0.987 < NN < 0.995$	4.1 ± 1.2	3.4 ± 1.1
$0.995 < NN < 1.000$	0.8 ± 0.5	2.8 ± 1.6

Peaking charmless B

B_s signal window:

NN Bin	CC	CF
$0.700 < NN < 0.970$	0.03 ± 0.01	$0.01 \pm <0.01$
$0.970 < NN < 0.987$	$0.01 \pm <0.01$	$0.01 \pm <0.01$
$0.987 < NN < 0.995$	$0.02 \pm <0.01$	$0.01 \pm <0.01$
$0.995 < NN < 1.000$	0.08 ± 0.02	0.03 ± 0.01

10x smaller than combinatoric bkg

B_d signal window:

NN Bin	CC	CF
$0.700 < NN < 0.970$	0.31 ± 0.08	0.09 ± 0.02
$0.970 < NN < 0.987$	0.13 ± 0.03	0.05 ± 0.01
$0.987 < NN < 0.995$	0.19 ± 0.05	0.04 ± 0.01
$0.995 < NN < 1.000$	0.72 ± 0.20	0.20 ± 0.05

Comparable to combinatoric bkg

Bckg estimate checks

sample	*NN* cut	CC pred	CC obsv	CC prob(%) *
OS-	0.700<NN<0.760	217.4±(12.5)	203	77.7
	0.760<NN<0.850	262.0±(14.1)	213	99.1
	0.850<NN<0.900	117.9±(8.6)	120	44.7
	0.900<NN<0.940	112.1±(8.4)	116	39.4
	0.940<NN<0.970	112.7±(8.4)	108	64.2
	0.970<NN<0.987	80.2±(6.9)	75	68.3
	0.987<NN<0.995	67.6±(6.3)	41	99.8
	0.995<NN<1.000	32.5±(4.2)	35	37.5
SS+	0.700<NN<0.760	3.0±(0.9)	3	55.0
	0.760<NN<0.850	3.3±(1.0)	5	25.4
	0.850<NN<0.900	1.5±(0.7)	2	43.2
	0.900<NN<0.940	0.9±(0.5)	1	56.8
	0.940<NN<0.970	1.2±(0.6)	1	65.9
	0.970<NN<0.987	1.5±(0.7)	2	43.2
	0.987<NN<0.995	0.3±(0.3)	0	74.1
	0.995<NN<1.000	0.3±(0.3)	0	74.1
SS-	0.700<NN<0.760	5.7±(1.3)	8	23.7
	0.760<NN<0.850	8.4±(1.6)	7	69.8
	0.850<NN<0.900	3.3±(1.0)	6	14.3
	0.900<NN<0.940	2.4±(0.8)	4	24.0
	0.940<NN<0.970	2.4±(0.8)	4	24.0
	0.970<NN<0.987	2.1±(0.8)	0	12.2
	0.987<NN<0.995	1.5±(0.7)	0	22.3
	0.995<NN<1.000	0.3±(0.3)	1	30.0
FM+	0.700<NN<0.760	118.3±(8.6)	136	11.1
	0.760<NN<0.850	110.5±(8.3)	121	22.3
	0.850<NN<0.900	52.0±(5.4)	37	96.3
	0.900<NN<0.940	37.3±(4.5)	37	53.0
	0.940<NN<0.970	20.1±(3.3)	20	52.3
	0.970<NN<0.987	8.3±(2.0)	6	77.1
	0.987<NN<0.995	8.7±(2.0)	3	97.5
	0.995<NN<1.000	20.8±(3.5)	24	30.7

Ingredients

	CC		CF	
$(\alpha_{B^+}/\alpha_{B_s})$	0.307 ± 0.018	$(\pm 6\%)$	0.197 ± 0.014	$(\pm 7\%)$
$(\epsilon^{trig}_{B^+}/\epsilon^{trig}_{B_s})$	0.99935 ± 0.00012	$(< 1\%)$	0.97974 ± 0.00016	$(< 1\%)$
$(\epsilon^{reco}_{B^+}/\epsilon^{reco}_{B_s})$	0.85 ± 0.06	$(\pm 8\%)$	0.84 ± 0.06	$(\pm 9\%)$
$\epsilon^{NN}_{B_s}(NN > 0.70)$	0.915 ± 0.042	$(\pm 4\%)$	0.864 ± 0.040	$(\pm 4\%)$
$\epsilon^{NN}_{B_s}(NN > 0.995)$	0.461 ± 0.021	$(\pm 5\%)$	0.468 ± 0.022	$(\pm 5\%)$
N_{B^+}	22388 ± 196	$(\pm 1\%)$	9943 ± 138	$(\pm 1\%)$
f_u/f_s	3.59 ± 0.37	$(\pm 13\%)$	3.59 ± 0.37	$(\pm 13\%)$
$BR(B^+ \to J/\psi K^+ \to \mu^+\mu^- K^+)$	$(6.01 \pm 0.21) \times 10^{-5}$	$(\pm 4\%)$	$(6.01 \pm 0.21) \times 10^{-5}$	$(\pm 4\%)$
SES (All bins)	$(2.9 \pm 0.5) \times 10^{-9}$	$(\pm 18\%)$	$(4.0 \pm 0.7) \times 10^{-9}$	$(\pm 18\%)$

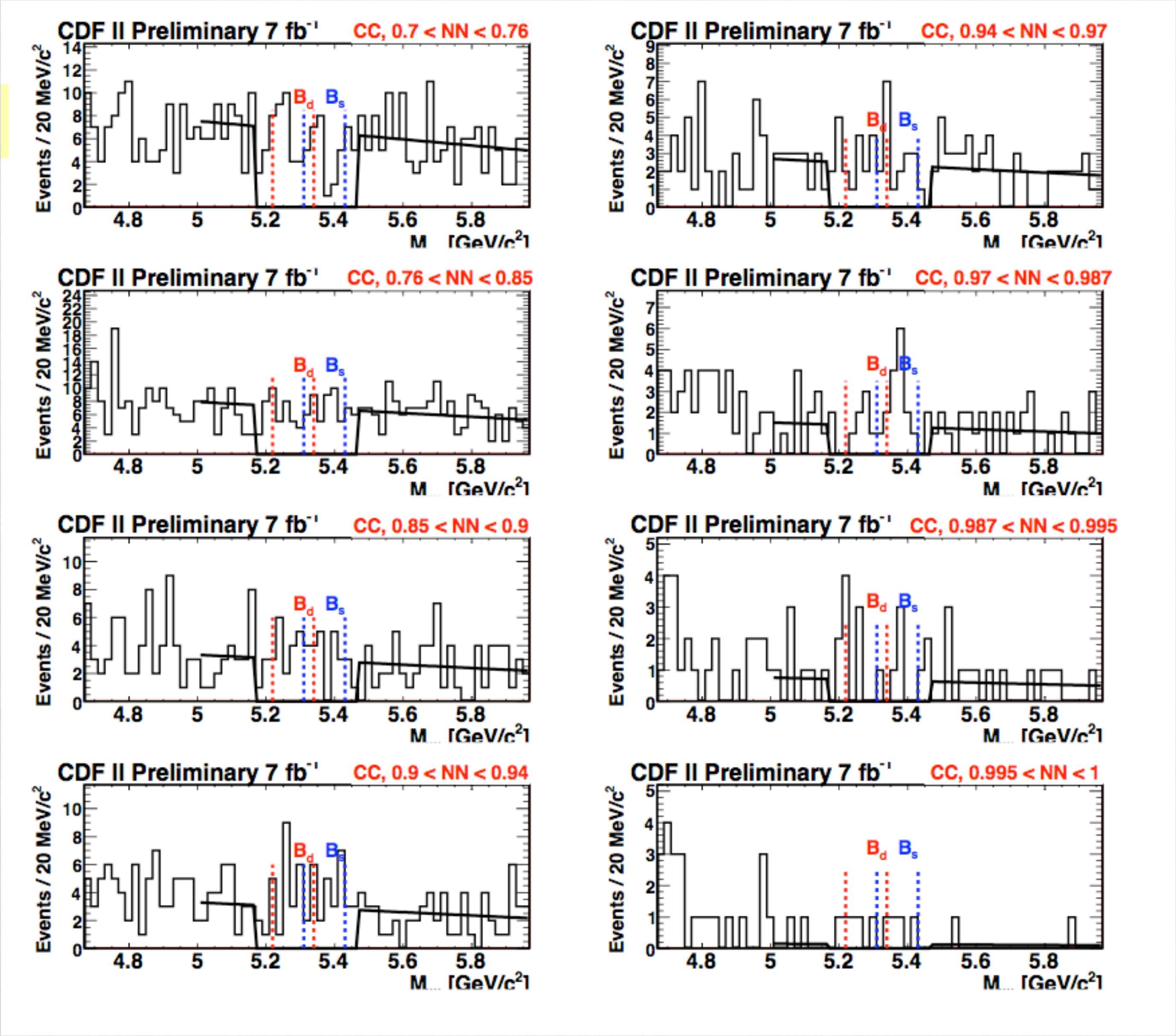
CC only

NN Bin	ϵ_{NN}	B→hh Bkg	Total Bkg	Exp SM Signal
$0.700 < NN < 0.970$	20%	0.03	129.24±6.50	0.26±0.05
$0.970 < NN < 0.987$	8%	< 0.01	7.91±1.27	0.11±0.02
$0.987 < NN < 0.995$	12%	0.02	3.95±0.89	0.16±0.03
$0.995 < NN < 1.000$	46%	0.08	0.79±0.40	0.59±0.11

CF only

NN Bin	ϵ_{NN}	B→hh Bkg	Total Bkg	Exp SM Signal
$0.700 < NN < 0.970$	21%	0.01	146.29±7.00	0.19±0.04
$0.970 < NN < 0.987$	10%	0.01	11.57±1.57	0.09±0.02
$0.987 < NN < 0.995$	8%	0.01	3.25±0.82	0.08±0.01
$0.995 < NN < 1.000$	46%	0.03	2.64±0.74	0.43±0.08

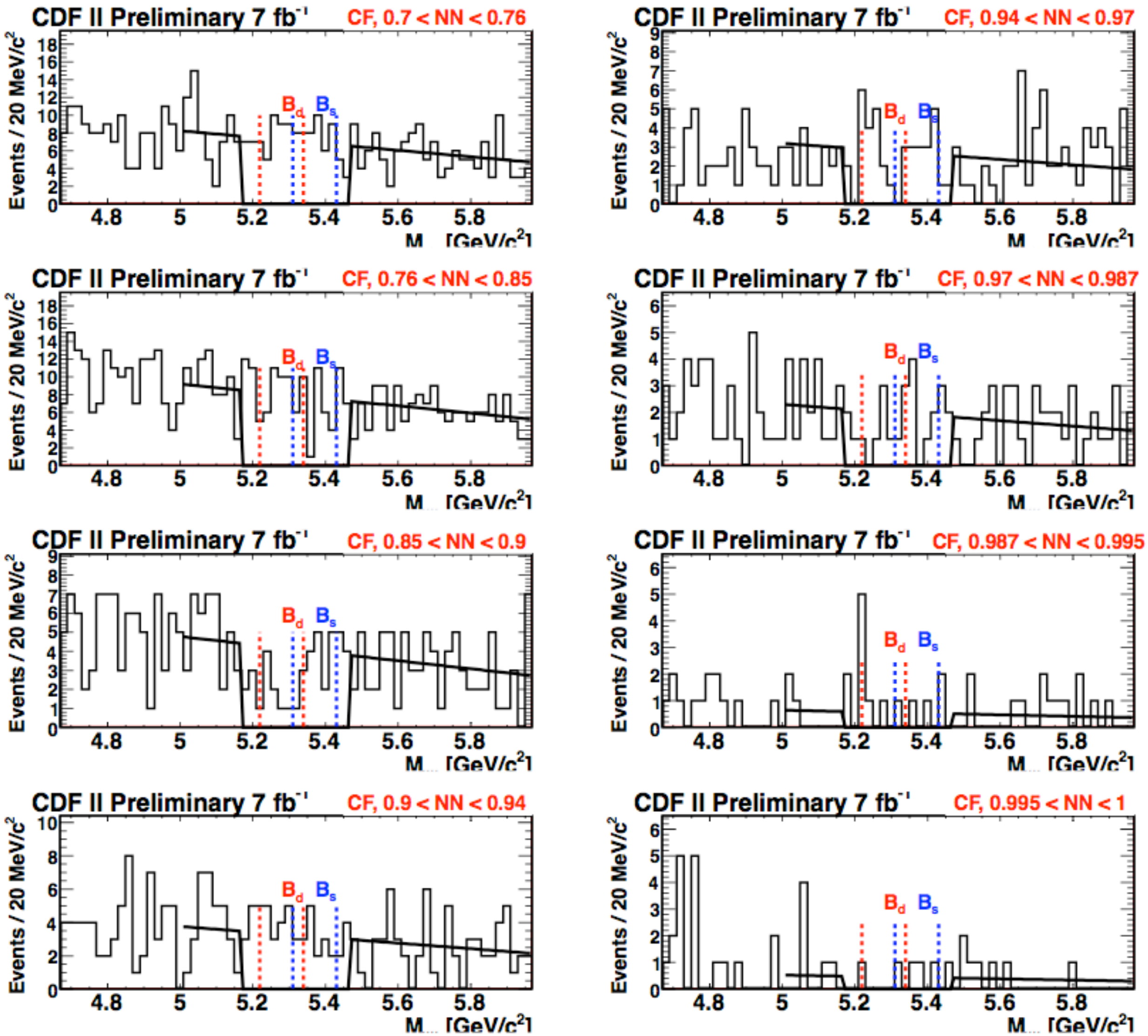
Mass CC



CDF II Preliminary 7 fb^{-1}
CC, 0.7 < NN < 0.76
CC, 0.94 < NN < 0.97
CC, 0.76 < NN < 0.85
CC, 0.97 < NN < 0.987
CC, 0.85 < NN < 0.9
CC, 0.987 < NN < 0.995
CC, 0.9 < NN < 0.94
CC, 0.995 < NN < 1
Events / 20 MeV/c^2
B_d
B_s
M [GeV/c^2]

Mass CF

CF only

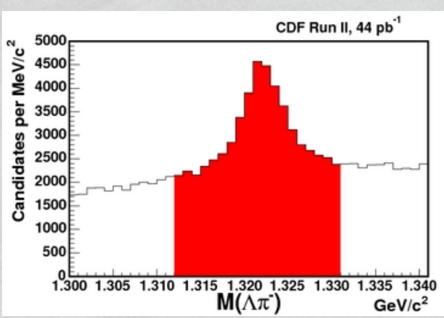


Expected vs Observed Bs

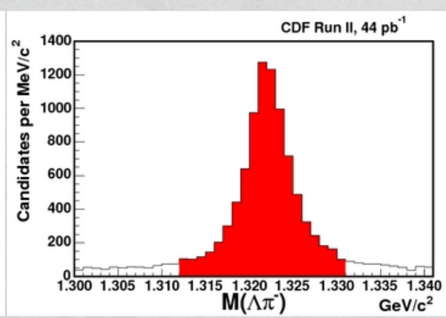
	CC	Mass bins [GeV/c^2]				
NN Bins		5.310-5.334	5.334-5.358	5.358-5.382	5.382-5.406	5.406-5.430
$0.970<NN<0.987$	Exp	1.62 ± 0.49	1.6 ± 0.48	1.58 ± 0.47	1.57 ± 0.47	1.55 ± 0.46
	Obs	1	4	7	1	3
$0.987<NN<0.995$	Exp	0.82 ± 0.27	0.8 ± 0.27	0.79 ± 0.26	0.78 ± 0.26	0.78 ± 0.26
	Obs	1	1	3	0	0
$0.995<NN<1.000$	Exp	0.21 ± 0.14	0.18 ± 0.13	0.16 ± 0.12	0.16 ± 0.12	0.16 ± 0.12
	Obs	0	1	2	0	1
	CF					
$0.970<NN<0.987$	Exp	2.38 ± 0.56	2.34 ± 0.55	2.31 ± 0.54	2.28 ± 0.54	2.25 ± 0.53
	Obs	1	4	3	1	2
$0.987<NN<0.995$	Exp	0.67 ± 0.24	0.66 ± 0.24	0.65 ± 0.24	0.64 ± 0.23	0.63 ± 0.22
	Obs	1	1	0	1	0
$0.995<NN<1.000$	Exp	0.56 ± 0.39	0.54 ± 0.38	0.53 ± 0.38	0.52 ± 0.37	0.51 ± 0.36
	Obs	1	1	0	1	1

All about tracking

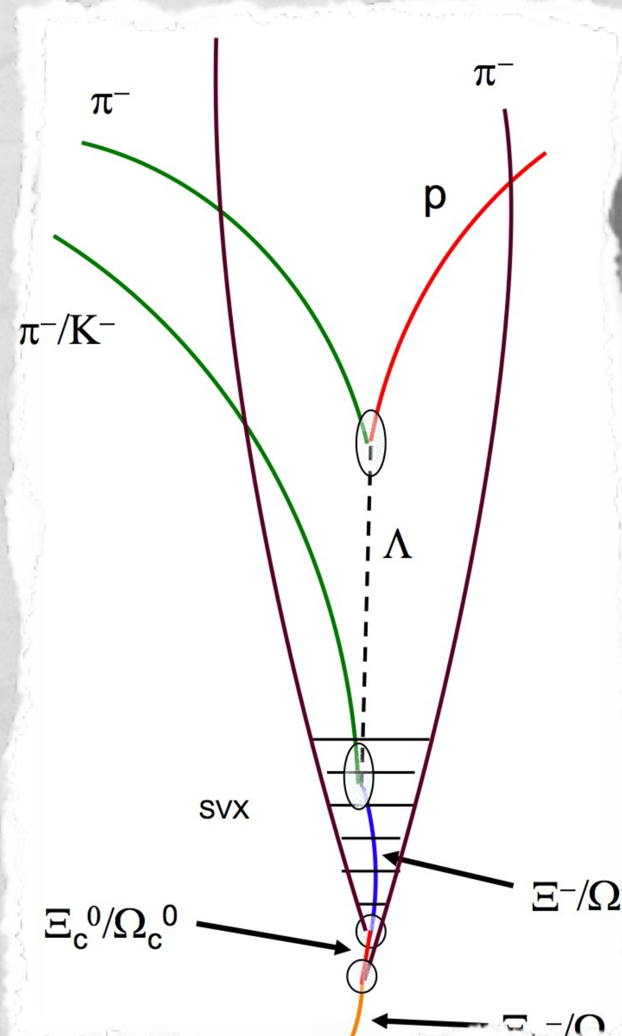
- 4.2 fb^{-1} of displaced-track trigger
- 5 tracks, 4 vertices.
- Use similar decay of known Ξ^-_b as a reference. Use $\Lambda_b \to \Lambda_c \pi$ to optimize charm-baryon lifetime cut.
- Track hyperon in silicon



Ξ^- w/o silicon



with silicon



P. Bussey, Fri 15:45, arXiv:1107.4015