

Future Prospects

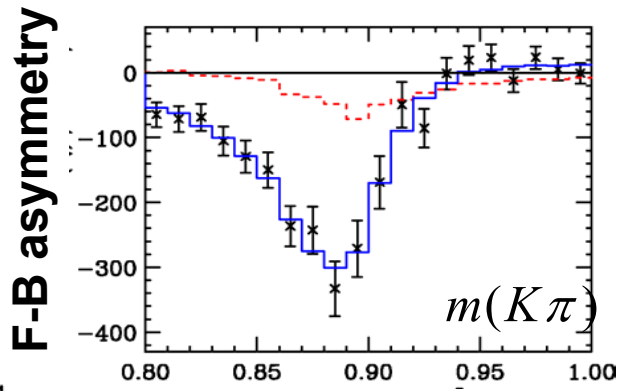
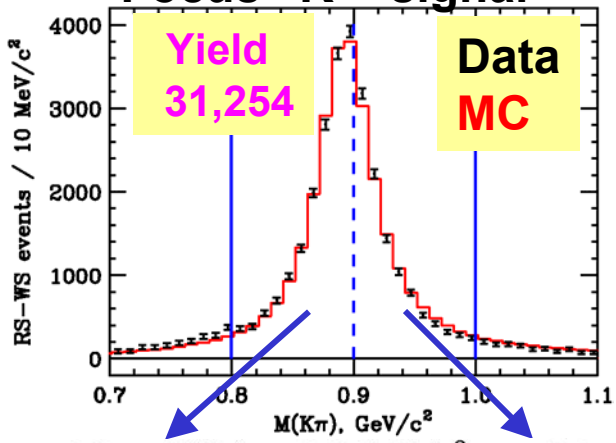
BTeV at Fermilab:

-Physics Expectations

Will Johns – Vanderbilt University

- Abject lesson in high statistics – Suppose there is an indication of a new coupling in a well understood decay...
- Case in point (means the one I know...) $D^+ \rightarrow \bar{K}^{*0} \mu^+ \nu$

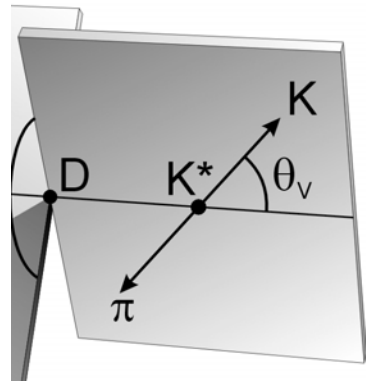
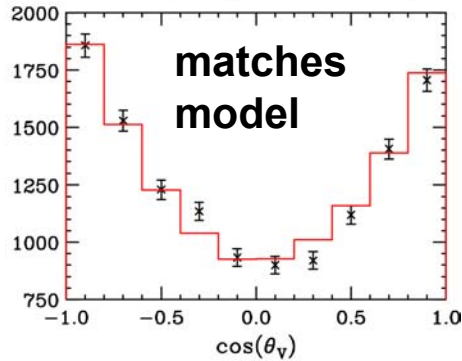
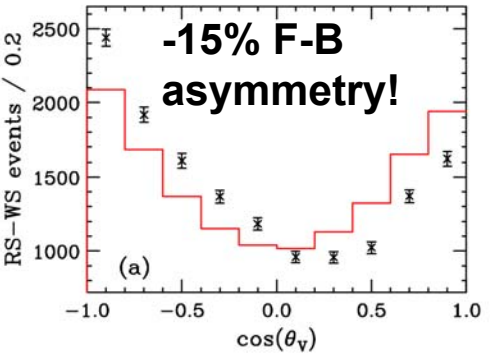
Focus “K*” signal



K* μν interferes with S-wave Kπ and creates a forward-backward asymmetry in the K* decay angle with a mass variation due to the varying BW phase

$0.8 < M(K\pi) < 0.9 \text{ GeV}/c^2$

$0.9 < M(K\pi) < 1.0 \text{ GeV}/c^2$

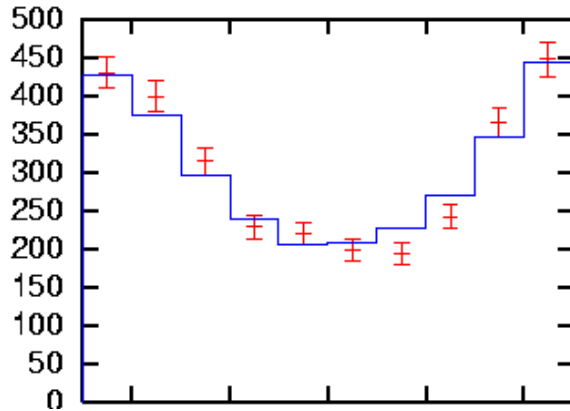


The S-wave amplitude is about 7% of the K* BW with a 45° relative phase

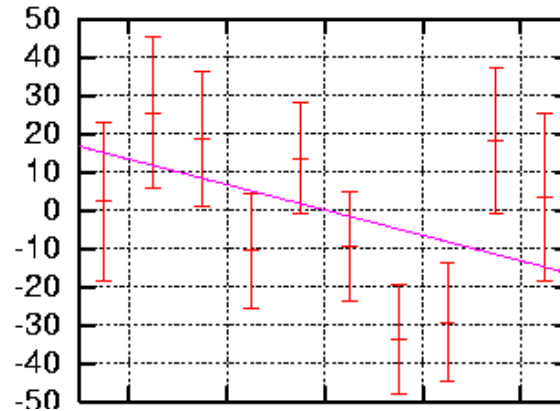
'Small' effects are tough to see

- Shouldn't a 7% effect been seen before?

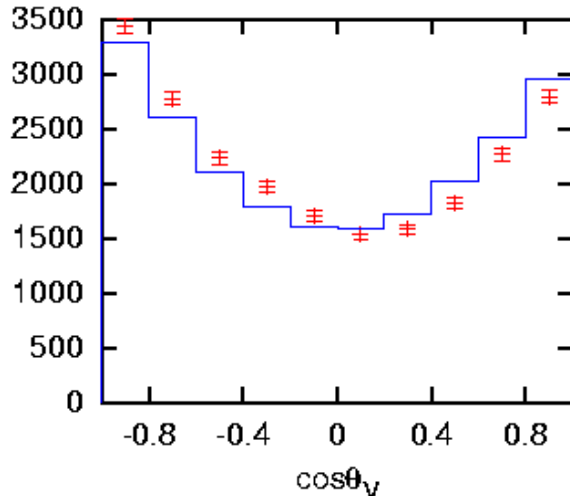
All data



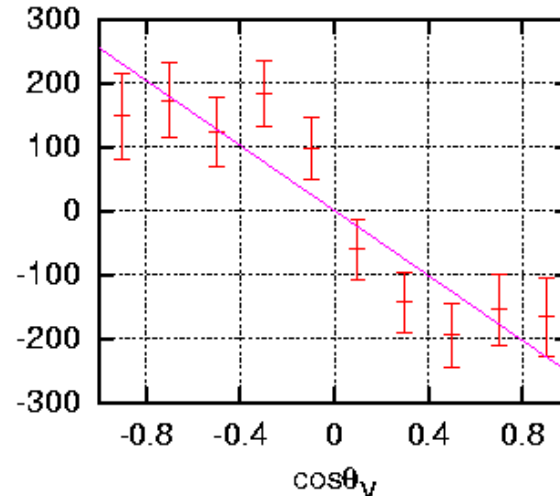
all data - MC



All data



all data - MC



- New Physics, Standard Model subtleties etc. can be locked in DISTRIBUTIONS rather than PEAKS

-Look for new Physics!-

(Away from poles!)

**MSSM R-Parity
Violating Terms Boost
Rates**

**(Burdman, Golowich,
Hewett, Pakvasa)**

[hep-ph/0112235 v2]

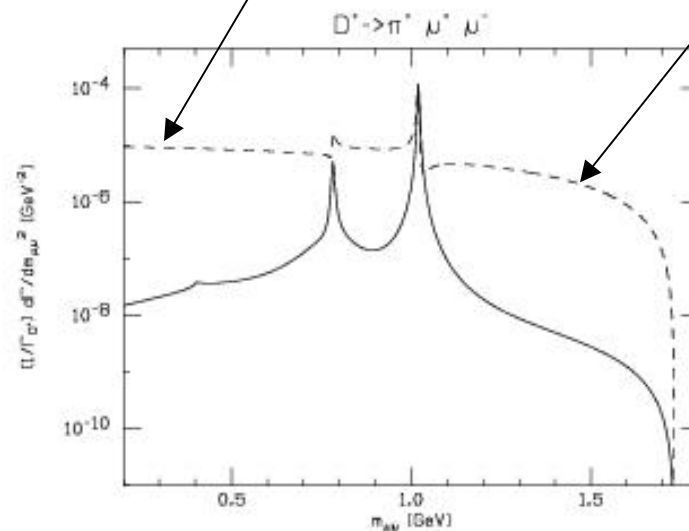


Figure 12: The dilepton mass distribution for $D^+ \rightarrow \pi^+ \mu^+ \mu^-$ normalized to Γ_{D^+} . The solid line shows the sum of the short and the long distance SM contributions. The dashed line includes the allowed R-parity violating contribution from Supersymmetry (see text for details).

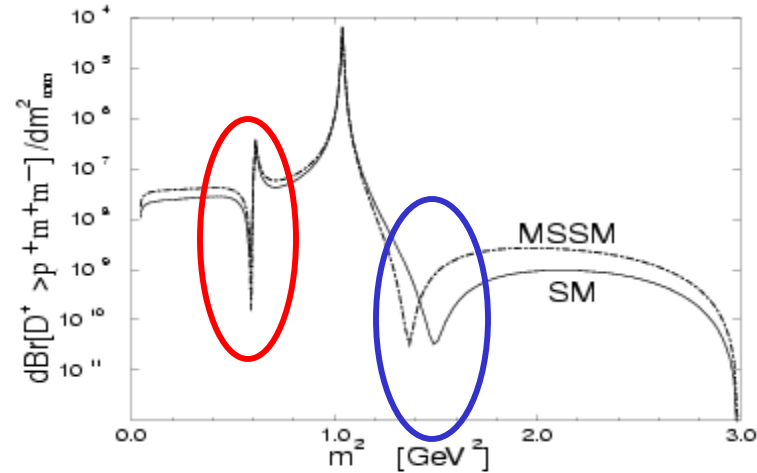
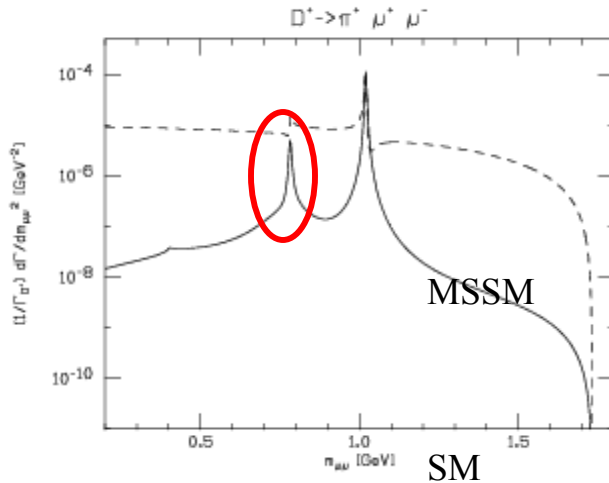
R-Parity Violating Enhancement is Clear

yet...



SM Predictions Differ

(integrated rates differ x2)



Use Large Samples to measure SM effects too.

(Burdman, Golowich, Hewett, Pakvasa)

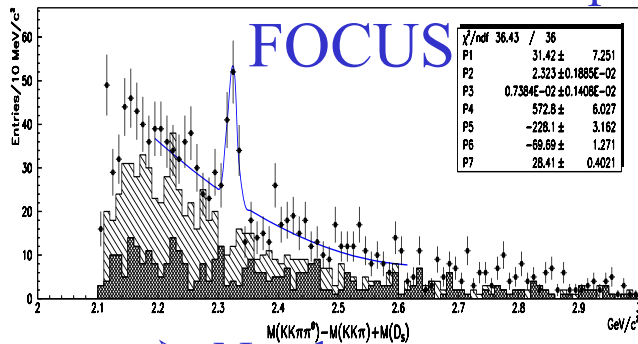
[hep-ph/0112235 v2]

S. Fajfer, S. Prelovsek and P. Singer

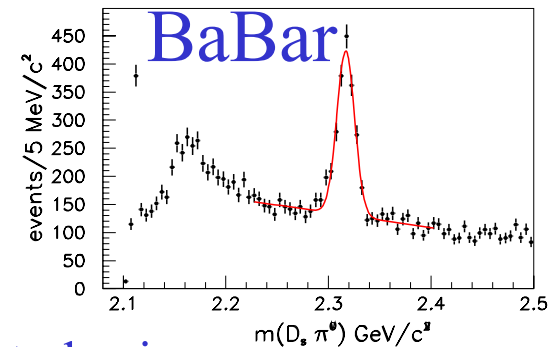
Phys. Rev. D Volume 64, 114009 (2001)

Why the Mom and Apple Pie story?

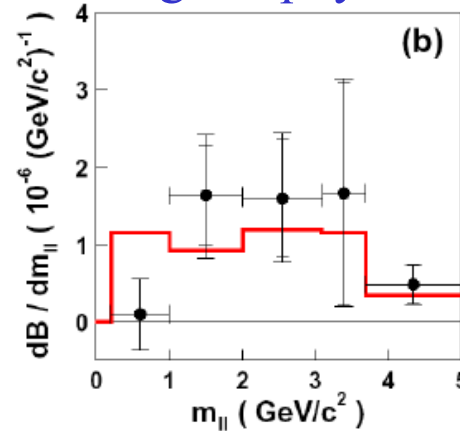
- Our lessons with high statistics are important
 - Coupling effects can be SUBTLE
 - A factor of even 10 can be important
 - More than one experiment needs to look at the data



Ds(2317)



- Need even more statistics to bring out physics



lepton-lepton
Mass spectra

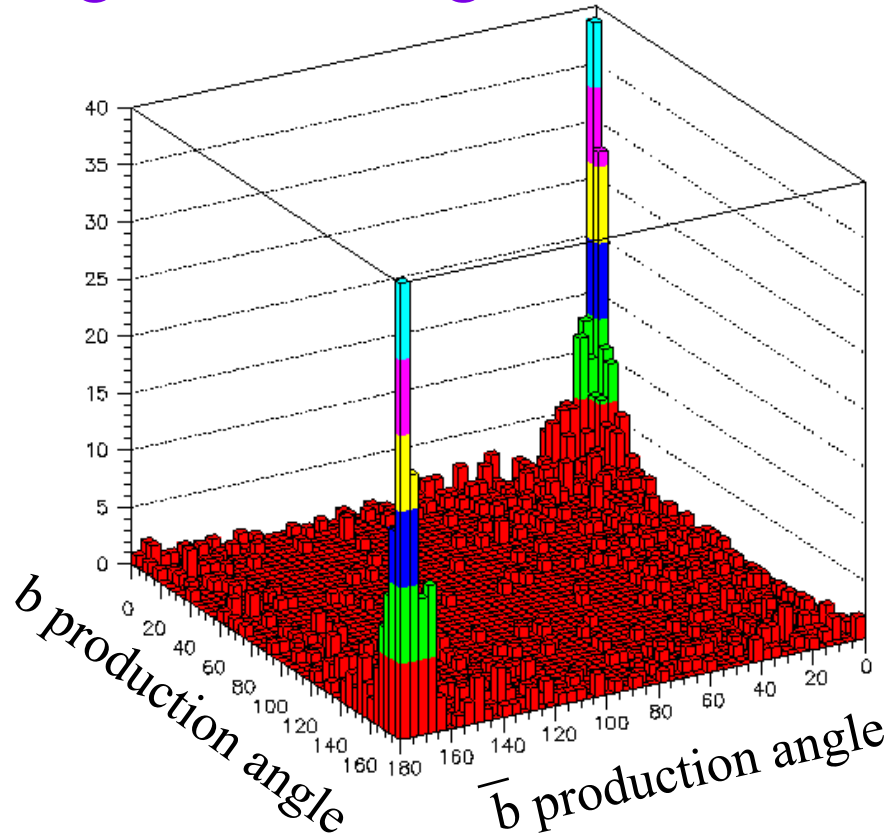
$\sqrt{s} = 1.8 \text{ TeV}$
 C_0

Where will giga-heavy hadron statistics come from?

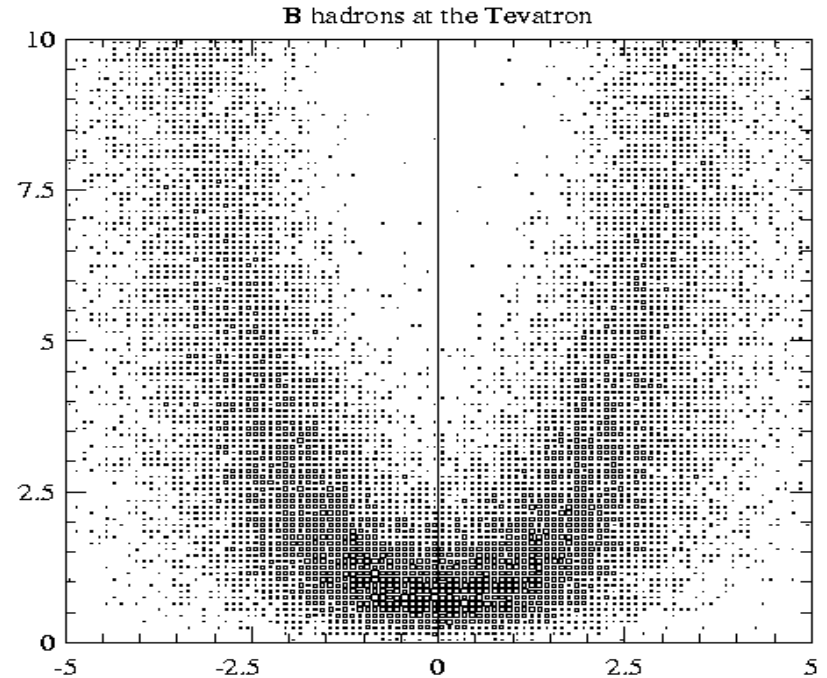
$$p\bar{p} \rightarrow b\bar{b} + X$$

b production peaks at large angles with large $\bar{b}b$ correlation

The higher momentum b 's are at larger η 's



$\beta\gamma$



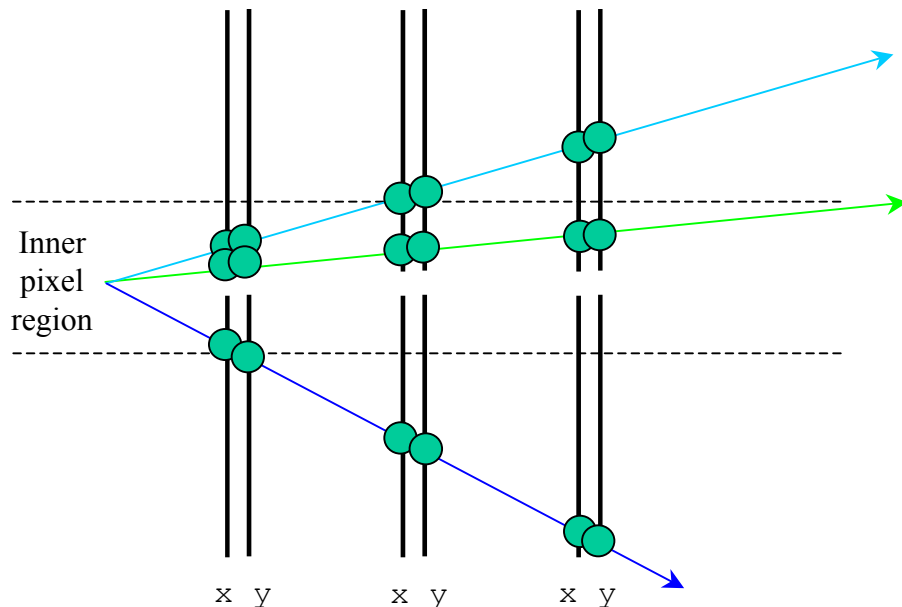
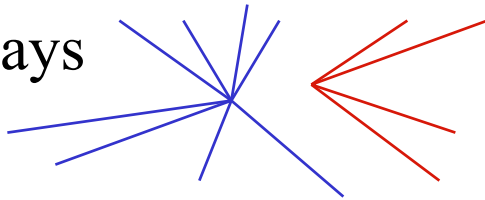
$$\eta = -\ln\left(\tan\frac{\theta}{2}\right)$$

How do we measure 10's x giga-statistics?

- An Internet that never slows down due to traffic, hardware failures, different tasks etc. (within limits of course) **DAQ**

◆ Idea: find primary vertices & detached tracks from b or c decays

TRIGGER

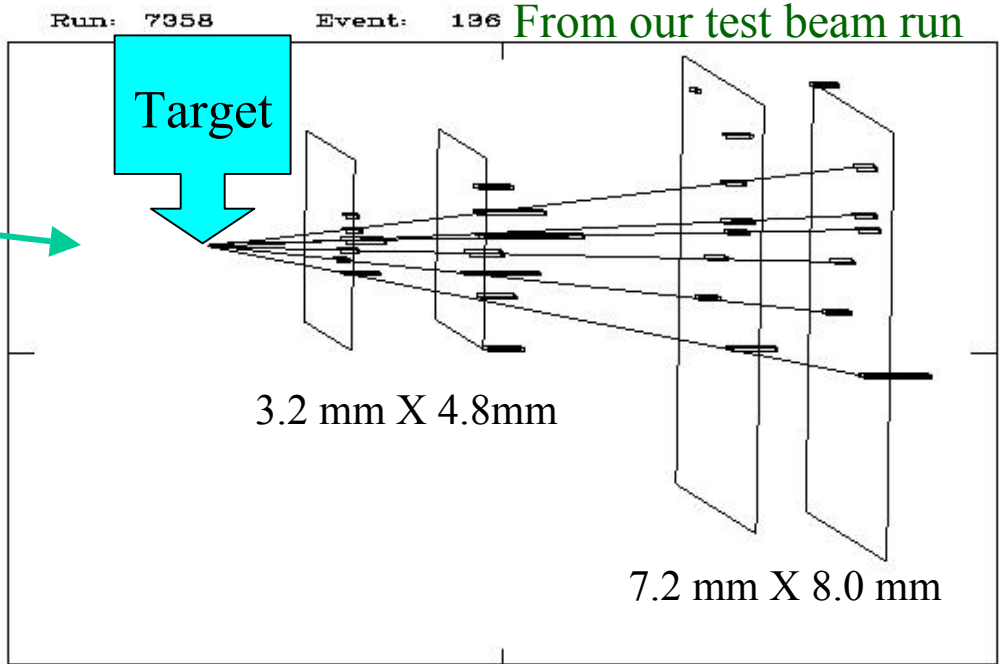


- Pixel hits from 3 stations are sent to an FPGA tracker that matches “interior” and “exterior track hits
- Interior and exterior triplets are sent to a farm of DSPs to complete the pattern recognition:
 - interior/exterior triplet matcher
 - fake-track removal

- Full GEANT has multiple scattering, bremsstrahlung, pair conversions, hadronic interactions and decays in flight; smears hits and refits the tracks using “Kalman Filter.” No pattern recognition (except for trigger). However, we do not expect large pattern recognition problems

- This track density is 3x higher than what is expected in BTeV!

- ◆ Detailed studies of efficiency and rejection for up to an average of six interactions/crossing



- For a requirement of at least 2 tracks detached by more than 4σ from a primary (interaction) vertex

State	efficiency(%)	state	efficiency(%)
$B \rightarrow \pi^+\pi^-$	55	$B^0 \rightarrow K^+\pi^-$	54
$B_s \rightarrow D_s K$	70	$B^0 \rightarrow J/\psi K_s$	50
$B^- \rightarrow D^0 K^-$	60	$B_s \rightarrow J/\psi K^*$	69
$B^- \rightarrow K_s \pi^-$	40	$B^0 \rightarrow K^* \gamma$	40

@ 2 int/crossing

- Need good pion/kaon separation (RICH)
- Need good EM calorimetry
- Need good muon ID
- Need tracking over a large volume of detector

Why would you want a loose trigger?

Precision Standard Model tests require many different modes

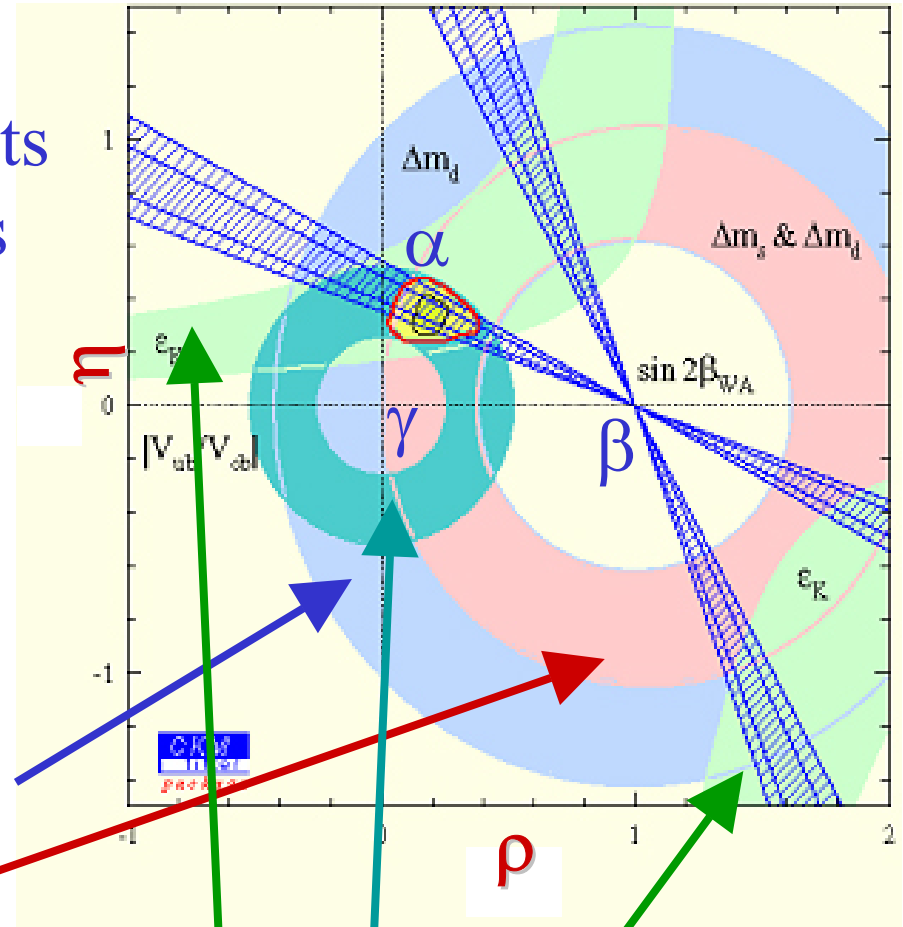
Over-constraining the CKM matrix with precision will be challenging

B_d^0 mixing

B_s^0 mixing

CPV in K^0 mixing

Cabibbo suppressed B semileptonic decay



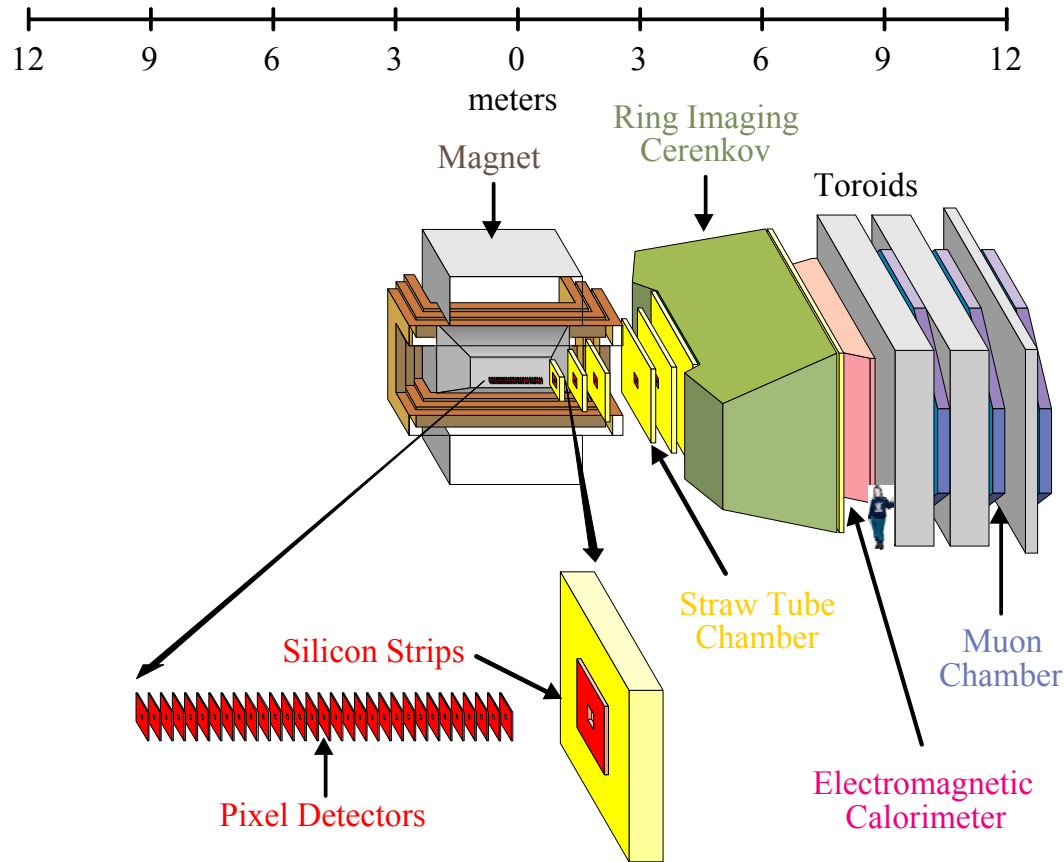
Why would you want to take advantage?

- Detector requirements in order to map out the CKM triangles.

Physics Quantity	Decay Mode	Vertex Trig	K/ π Sep	γ Det	Decay Time σ
$\sin(2\alpha)$	$B^0 \rightarrow \rho\pi \rightarrow \pi^+\pi^-\pi^0$	✓	✓	✓	
$\cos(2\alpha)$	$B^0 \rightarrow \rho\pi \rightarrow \pi^+\pi^-\pi^0$	✓	✓	✓	
$\sin(\gamma)$	$B_s \rightarrow D_s K^-$	✓	✓		✓
$\sin(\gamma)$	$B^0 \rightarrow D^0 K^-$	✓	✓		
$\sin(2\chi)$	$B_s \rightarrow J/\psi\eta, J/\psi\eta'$		✓	✓	✓
$\sin(2\beta)$	$B^0 \rightarrow J/\psi K_s$				
$\cos(2\beta)$	$B^0 \rightarrow J/\psi K^0, K^0 \rightarrow \pi l \nu$		✓		
x_s	$B_s \rightarrow D_s \pi^-$	✓	✓		✓
$\Delta\Gamma$ for B_s	$B_s \rightarrow J/\psi\eta^{(\prime)}, K^+K^-, D_s\pi$	✓	✓	✓	✓

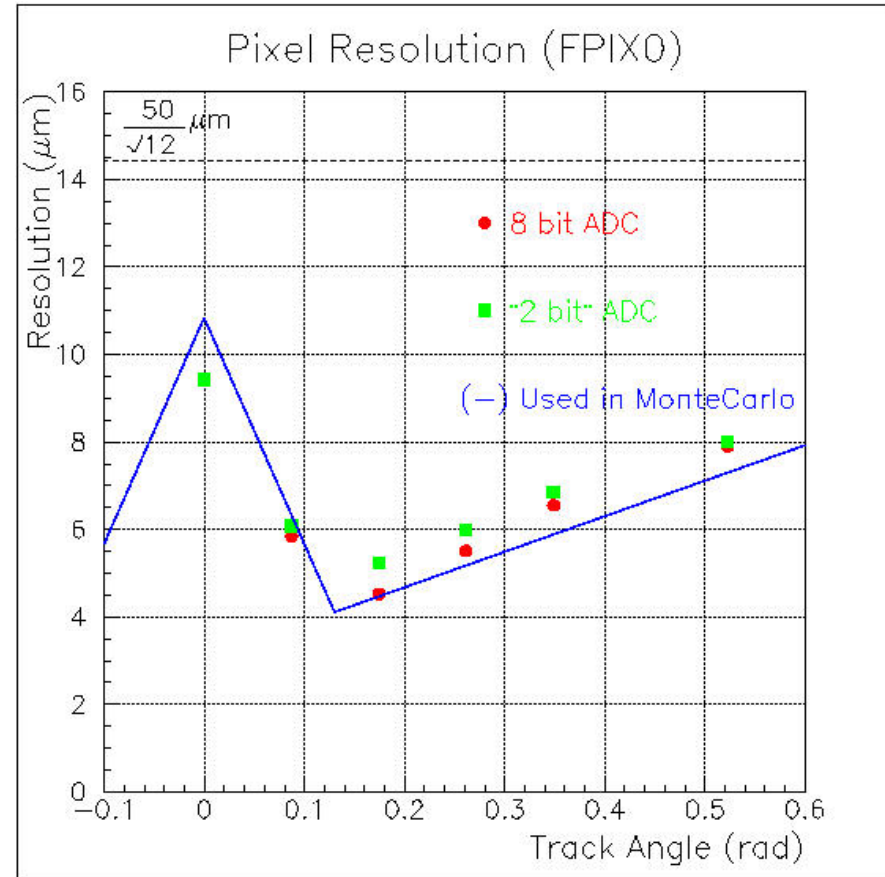
The BTeV Detector

BTeV Detector Layout



...and more info on Pixel, RICH, EMCAL

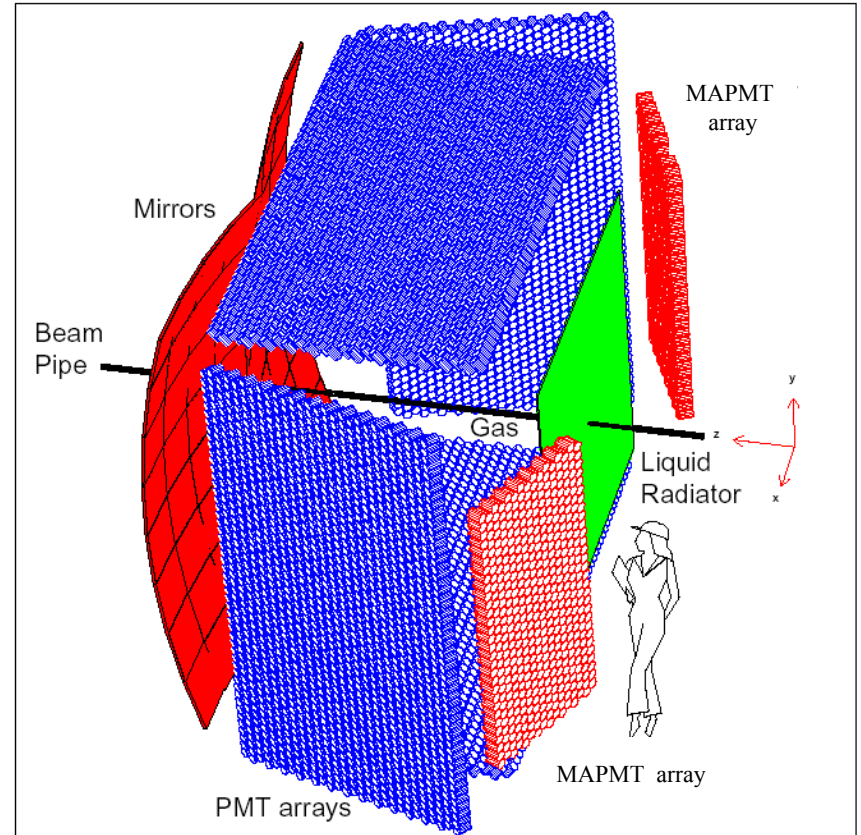
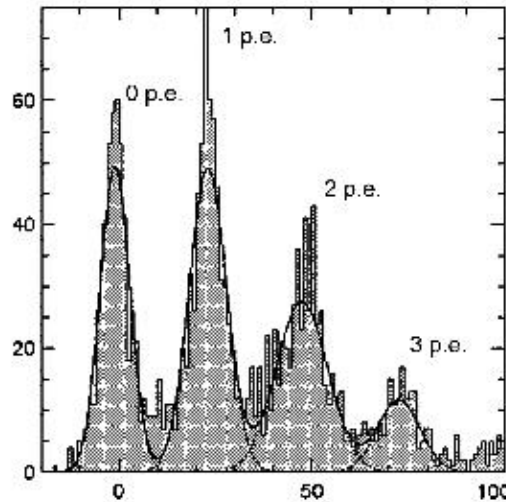
- Pixel – working systems studied in beams, including “almost” final electronics
- Full mechanical design done and being tested



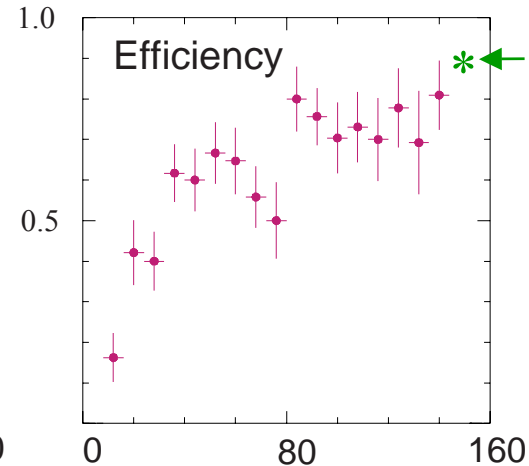
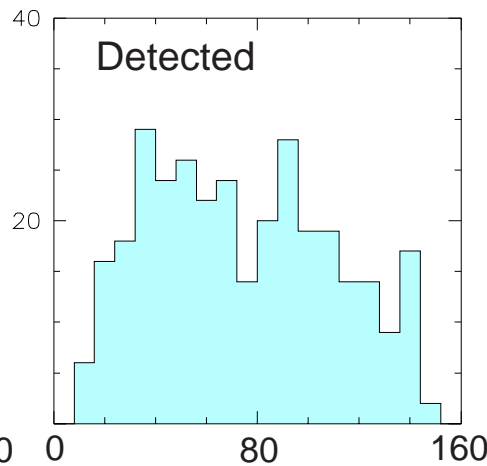
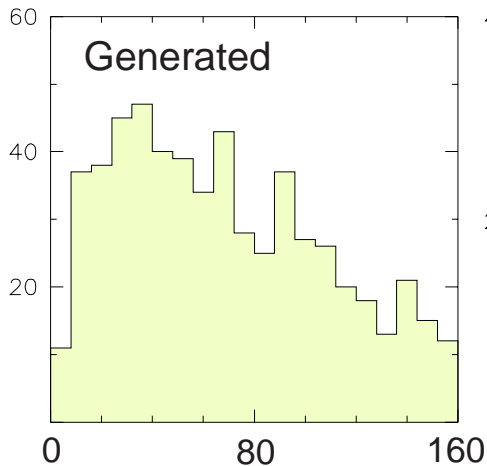
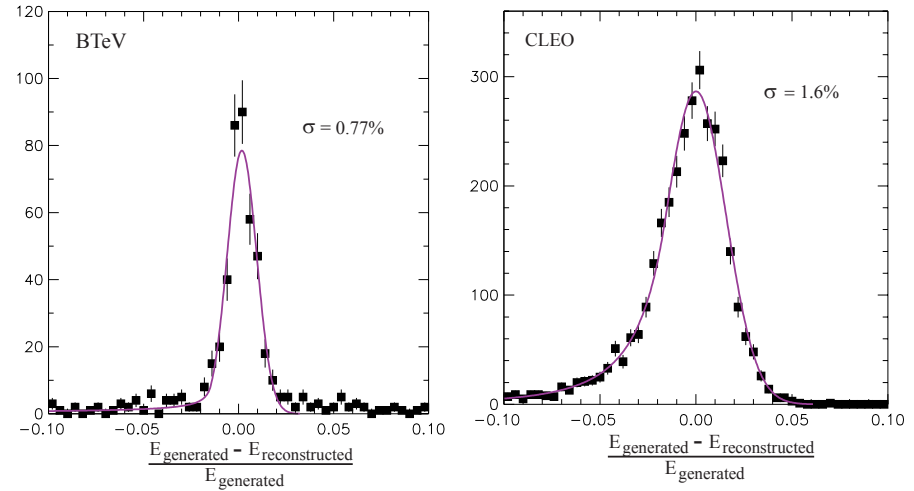
RICH (liquid and gas)

- Gas + Mirror + MAPMT to identify b decay products
- Liquid + PMT's to help with flavor tagging of b's (p/K separation for $p < 9 \text{ GeV}/c$)
- Excellent particle id. distinguishes BTeV from "Central pp Detectors"

● Bench test at Syracuse showing pulse height distribution from prototype

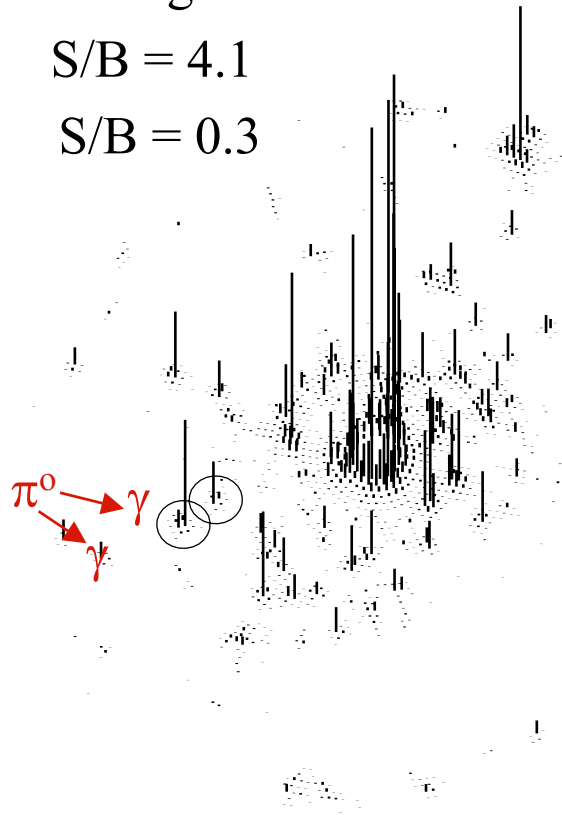


- GEANT simulation of $B_0 \rightarrow K^* g$, for BTeV & CLEO
- Isolation & shower shape cuts on both

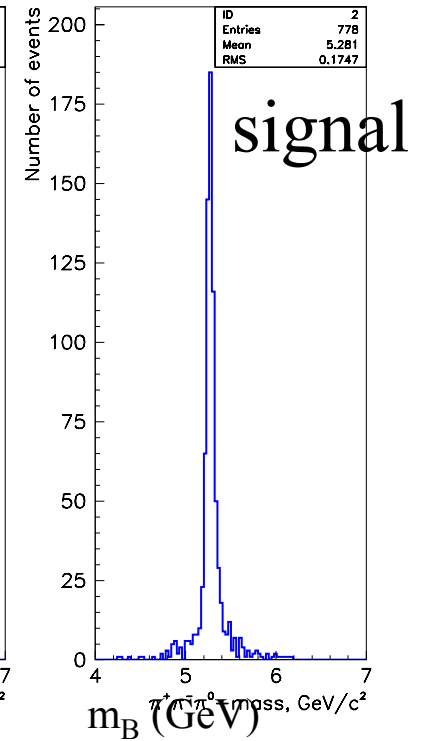
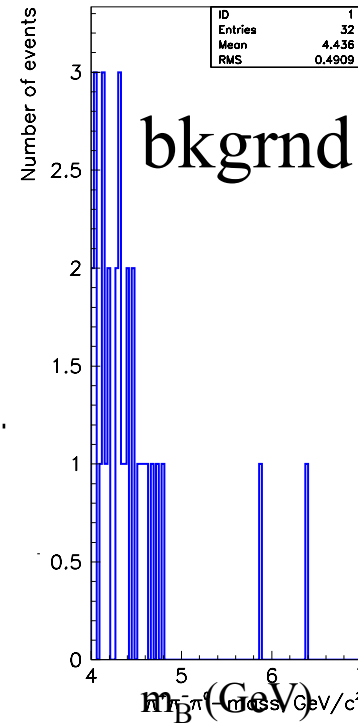


CLEO
barrel
 $\epsilon = 89\%$

- Based 9.9×10^6 bkgrnd events
- $B^0 \rightarrow \rho^+ \rho^-$ S/B = 4.1
- $B^0 \rightarrow \rho^0 \pi^0$ S/B = 0.3



$B^0 \rightarrow \rho \pi$



Dalitz Analysis required for this

Decay	$\mathcal{B}(B)$ ($\times 10^{-6}$)	# Events	S/B	Parameter	Error or (Value)
$B_s \rightarrow D_s K^-$	300	7500	7	$\gamma - 2\chi$	8°
$B_s \rightarrow D_s \pi^-$	3000	59,000	3	x_s	(75)
$B^0 \rightarrow J/\psi K_S \quad J/\psi \rightarrow \ell^+ \ell^-$	445	168,000	10	$\sin(2\beta)$	0.017
$B^0 \rightarrow J/\psi K^0, K^0 \rightarrow \pi \ell \nu$	7	250	2.3	$\cos(2\beta)$	~ 0.5
$B^- \rightarrow D^0 (K^+ \pi^-) K^-$	0.17	170	1	γ	13°
$B^- \rightarrow D^0 (K^+ K^-) K^-$	1.1	1,000	> 10		
$B_s \rightarrow J/\psi \eta$	330	2,800	15	$\sin(2\chi)$	0.024
$B_s \rightarrow J/\psi \eta'$	670	9,800	30		
$B^0 \rightarrow \rho^+ \pi^-$	28	5,400	4.1	α	$\sim 4^\circ$
$B^0 \rightarrow \rho^0 \pi^0$	5	780	0.3		

	BTeV	LHCb[10]
$B^0 \rightarrow K^* \mu^+ \mu^-$	Yield (2 fb ⁻¹)	2277
	S/B	>0.5
	QF	0.71
	Yield in 1 calendar year	1700
	QF /year steady state	0.63
$B^0 \rightarrow \rho \pi$	Yield (2 fb ⁻¹)	11,340
	S/B	20
	$\epsilon \cdot D^2$	13%
	Tagged yield (2 fb ⁻¹)	1474
	Error in χ for 2 fb ⁻¹	0.7°
$B_s \rightarrow D_s K^-$	Error in χ /year (steady state)	0.9°
	Yield (2 fb ⁻¹)	6,750
	S/B	7
	$\epsilon \cdot D^2$	13%
	Tagged yield (2 fb ⁻¹)	878
$B_s \rightarrow D_s K^-$	Error in γ for 2 fb ⁻¹	8.4°
	Error in γ /year (steady state)	10.9°
		26.5°

EM CAL

Mode	BTeV (10 ⁷ s)			B-Factory (500 fb ⁻¹)		
	Yield	Tagged	S/B	Yield	Tagged	S/B
$B_s \rightarrow J/\Psi \eta^{(\prime)}$	12650	1645	>15	-	-	-
$B^- \rightarrow \phi K^-$	11000	n/a	>10	700	700	4
$B^0 \rightarrow \phi K_s$	2000	200	5.2	250	75	4
$B^0 \rightarrow K^* \mu^+ \mu^-$	2530	n/a	11	~50	~50	3
$B_s \rightarrow \mu^+ \mu^-$	6	0.7	>15	-	-	-
$B^0 \rightarrow \mu^+ \mu^-$	1	0.1	>10	0	-	-
$D^{*+} \rightarrow D^0 \pi^+, D^0 \rightarrow K \pi^+$	~10 ⁸	~10 ⁸	large	8×10 ⁵	8×10 ⁵	large

Multiple year running to see subtle effects in rare decays even with BTeV AND LHCb

BTeV Open Trigger and Detector Choices are suited to a variety of analysis

We can argue about startup scenarios but:

- In the steady state LHCb gets $\sim 0.8 \text{ fb}^{-1}$
- In the steady state BTeV gets $\sim 1.6 \text{ fb}^{-1}$

BTeV has an advantage in the steady state (more...

- Awaiting CD-1 official approval (reviews done)
- Base-lining this summer CD-2, CD-3x Winter

LHC running time

In steady state mode, after a few years, they are scheduled to run 160 days a year for physics MINUS running for Heavy Ions - estimate 139 days on pp (see Collier, BTeV-Doc (We can discuss offline))

LHCb will start running at 2.8×10^{32} ; this gives using formula in Collier 0.8 fb⁻¹ per calendar year

First year will see limited running at 75 ns bunch spacing; LHCb needs special setup, will also serve to limit luminosity

Second year will switch from 75 ns to 25 ns “when possible”

LHC schedule (LHCb-1)

Nominal: start April 1, 2007 (we know already that this is now August, but we have not factored that in)

We predict LHCb 2007 integrated luminosity to be 0.1 fb⁻¹

Since the first quarter of 2008 is still in the first year of tuning we give them 0.6 fb⁻¹

They get the full 0.8 fb⁻¹ in 2009

- Stage I starts August 1, 2009
- Then we run until July 1, 2010
 - Expect about 1 month to commission IR
 - Then its up to us to produce physics
- Summary of Stage 1
 - Estimate 6 months running time
 - Lab says that we will run 10 months a year and get 1.6 fb-1
 - Thus this is a 1 fb-1 run
 - We have 75% of our “normal” rate on all charged flavor tagged modes
 - We have $75\% \times 60\% = 45\%$ of our “normal” rate on flavor tagged modes with neutrals