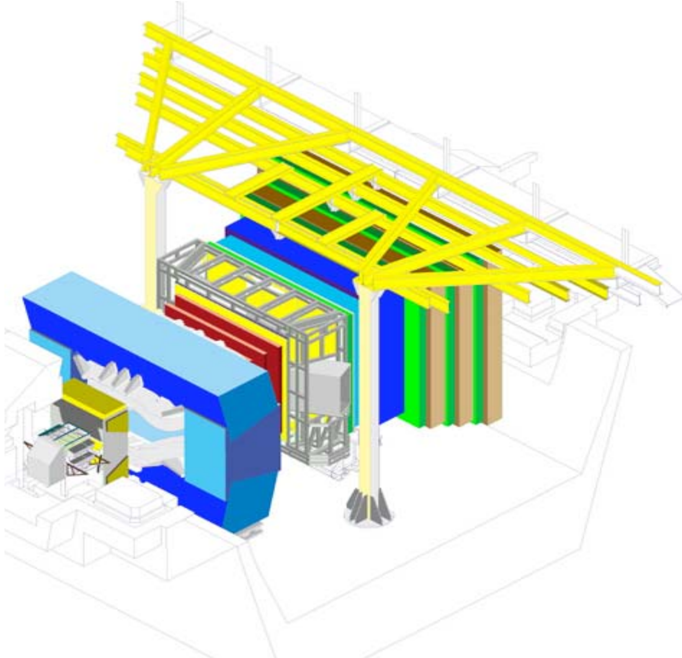
Status and expectations for first physics with LHCb



M. Needham

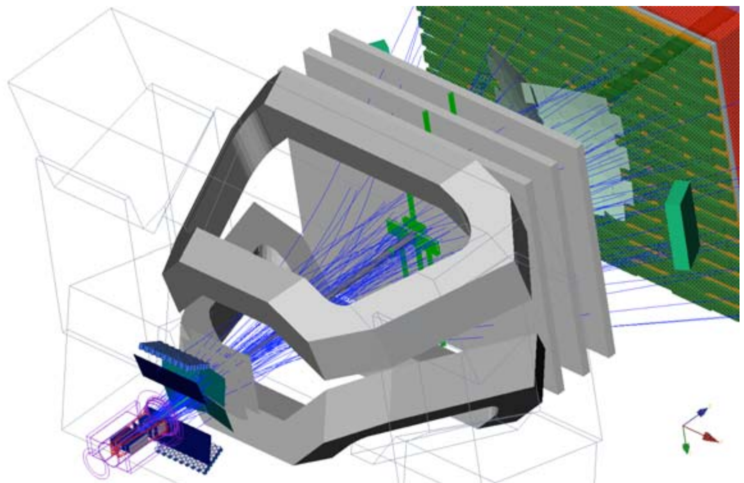
On behalf of the LHCb collaboration

Symmetries and Spin

July 20th - 26th Prague

Outline

- Introduction to LHCb
- Tour of the detector
- First Physics in 2008
- B_s mixing phase: β_s (Key 2009 measurement)
- Rare B decays
  - $B_s \rightarrow \mu^+\mu^-$ (Key 2009 measurement)
- Angle γ
- Summary

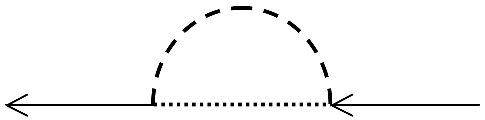


Searching for New Physics

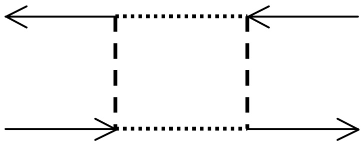
Expect New Physics at the TeV scale

Two complementary approaches to discovering it:

- Direct searches (ATLAS + CMS)
- Indirect searches (LHCb)
- Look for effect of virtual particles in loop processes
- Indirect searches very important in development of Standard Model
  - Suppression of $K_L \to \mu^+\mu^-$ (GIM mechanism) charm



New particles ?

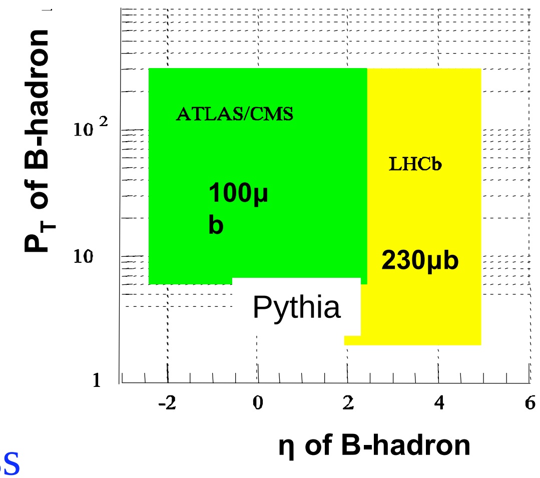


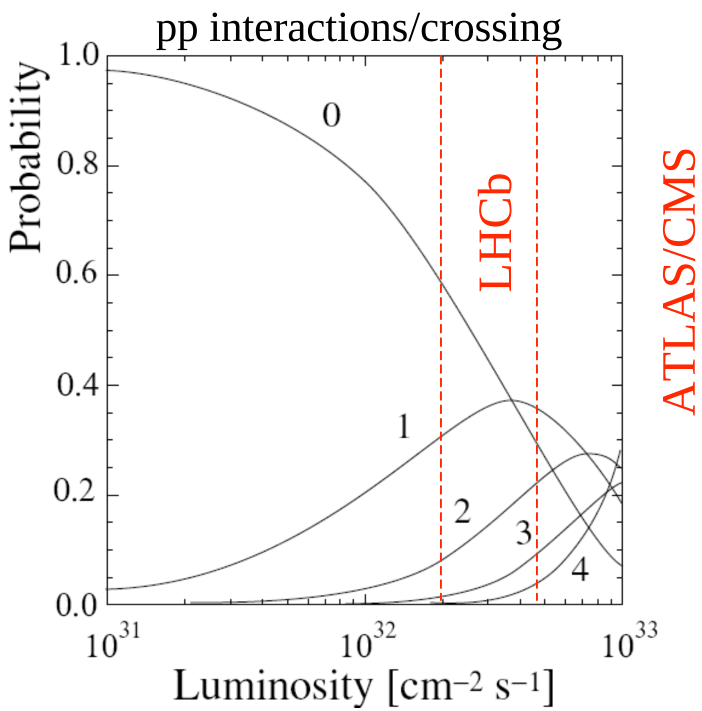
New particles ?

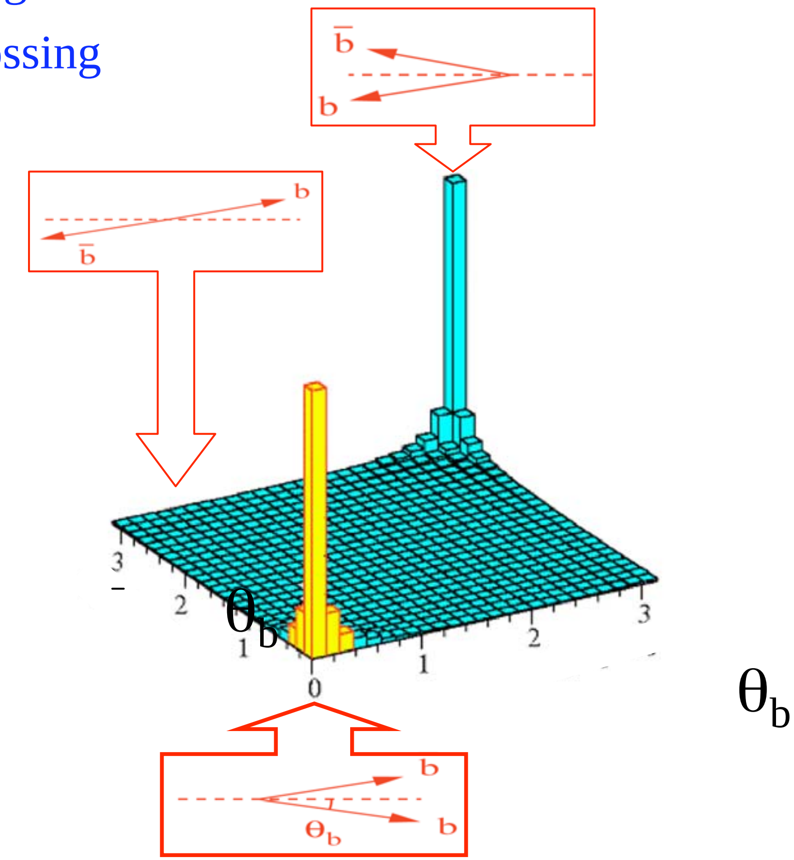
LHCb

Dedicated B physics experiment at the LHC:

- 10^{12} bb pairs produced in the acceptance per year
- All B species produced: B_d, B_s, B_u, B_c , Λ_b
- B production correlated and peaked in the forward direction
- LHCb luminosity of 2×10^{32} $cm^{-2}s^{-1}$ by focussing the beam less
- Maximizes probability of one interaction per crossing



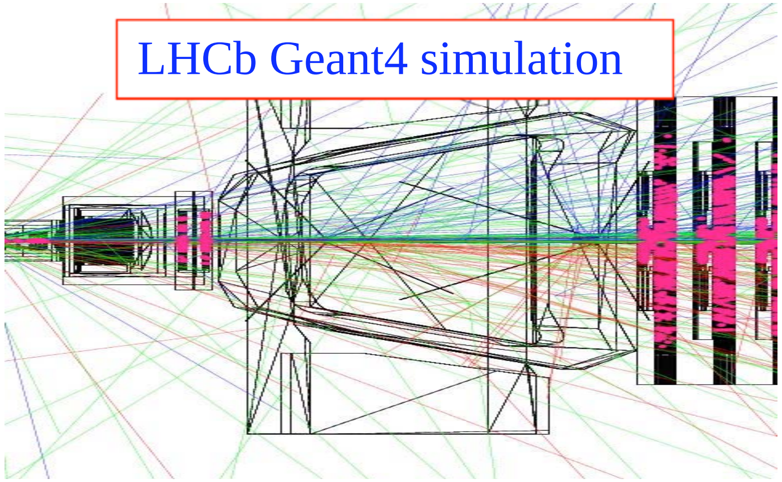




Key Ingredients

- Perform time dependent measurements
- Harsh enviroment of the LHC
- ~ 50 tracks per event from primary vertex
- B events 1 % of the visible cross-section
- Selective trigger needed

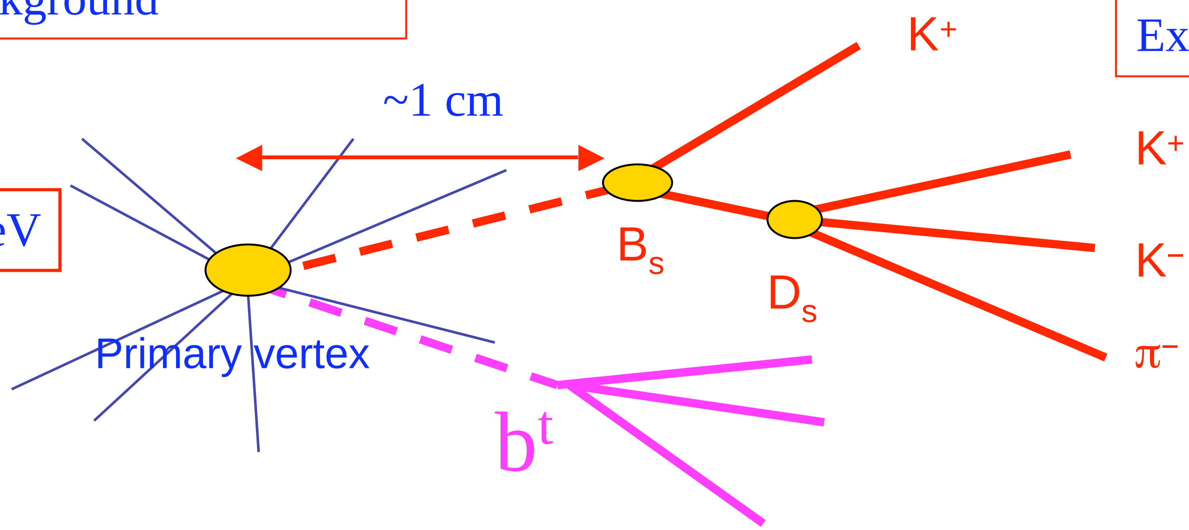
LHCb Geant4 simulation



Mass + pointing constraints to reduce background

Example: $B_s \rightarrow D_s K$

p_B ~ 80 GeV

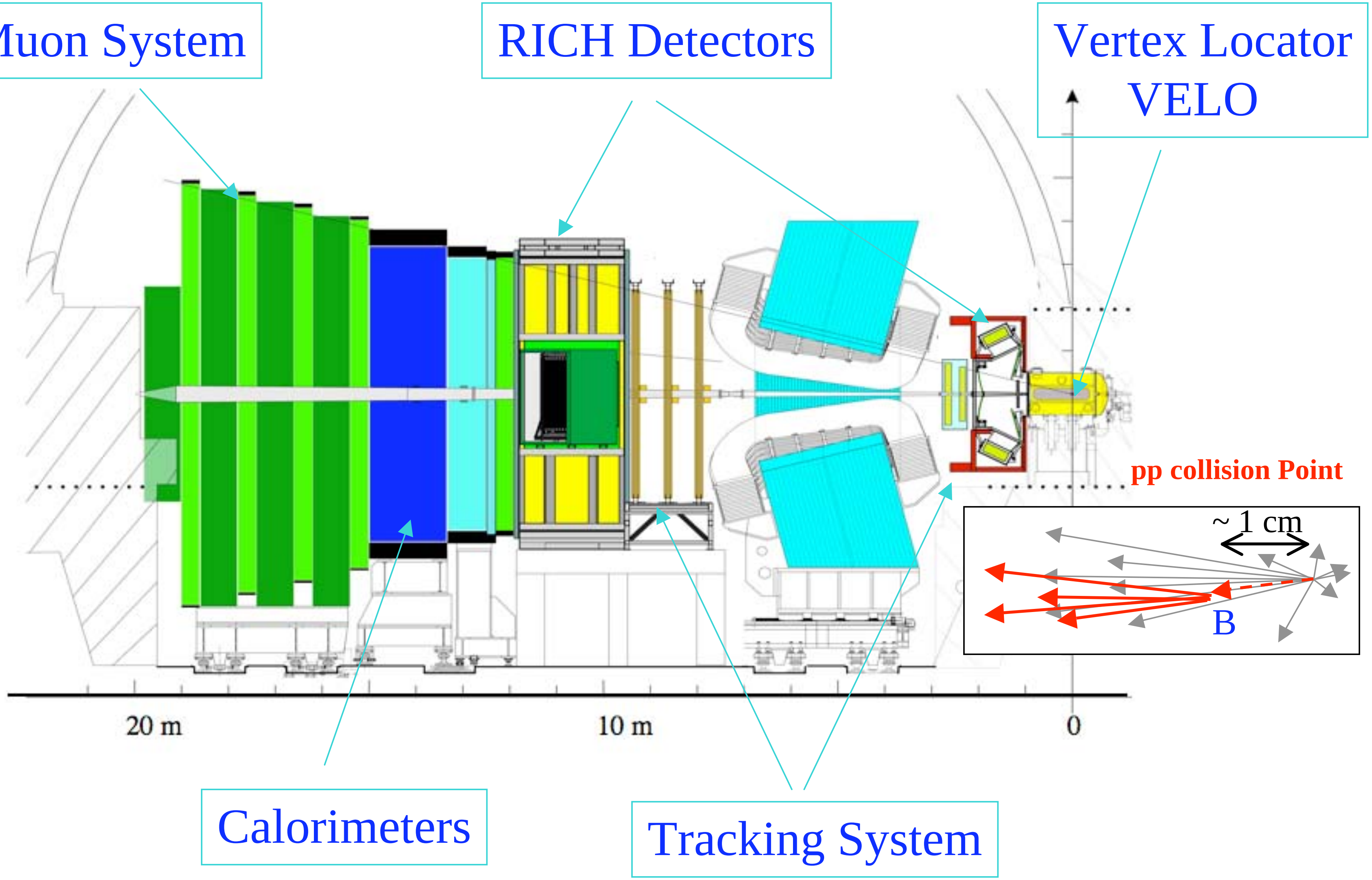


Good K/π separation

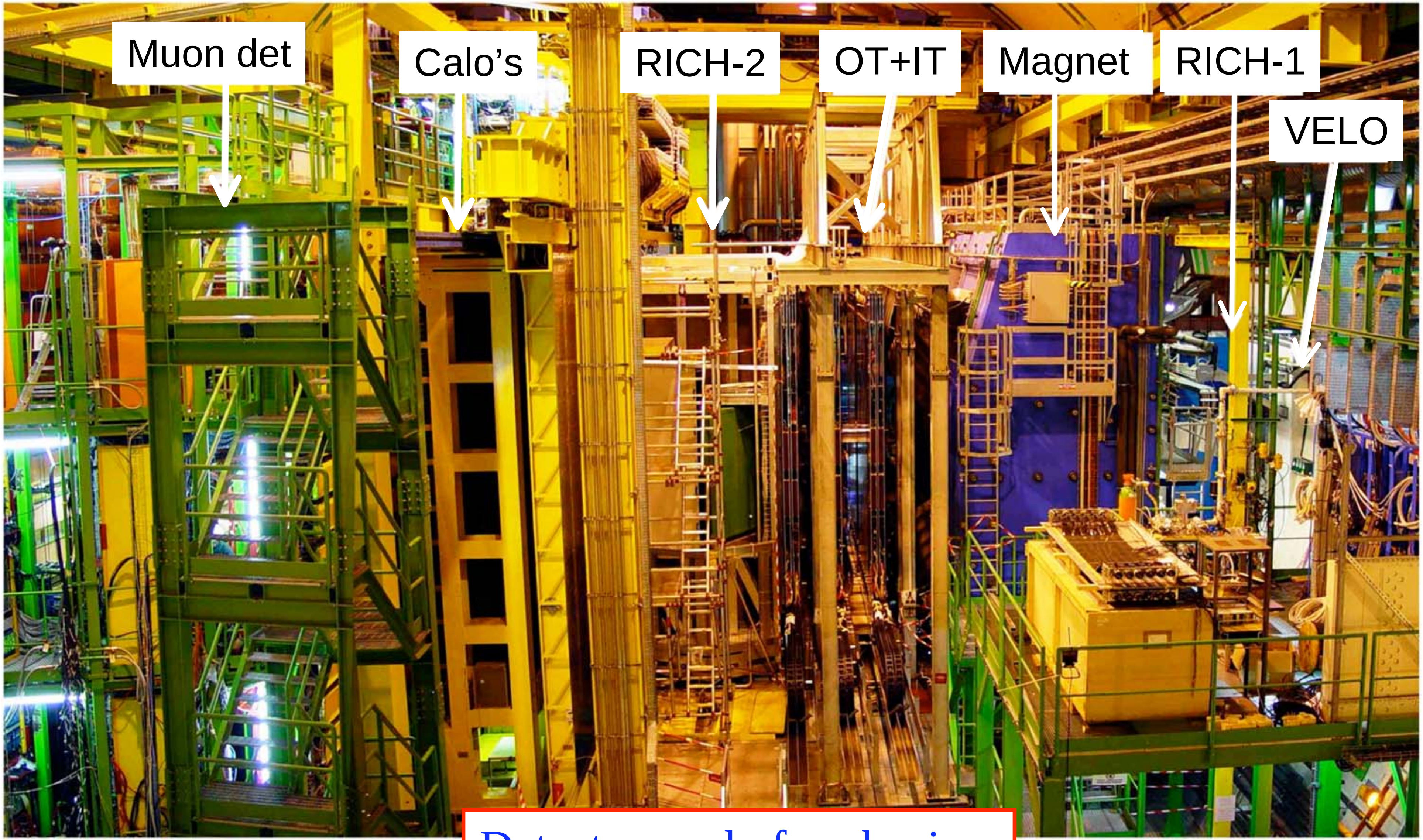
Good primary + secondary vertexing to measure proper time

Flavour Tagging

The Detector



The Detector

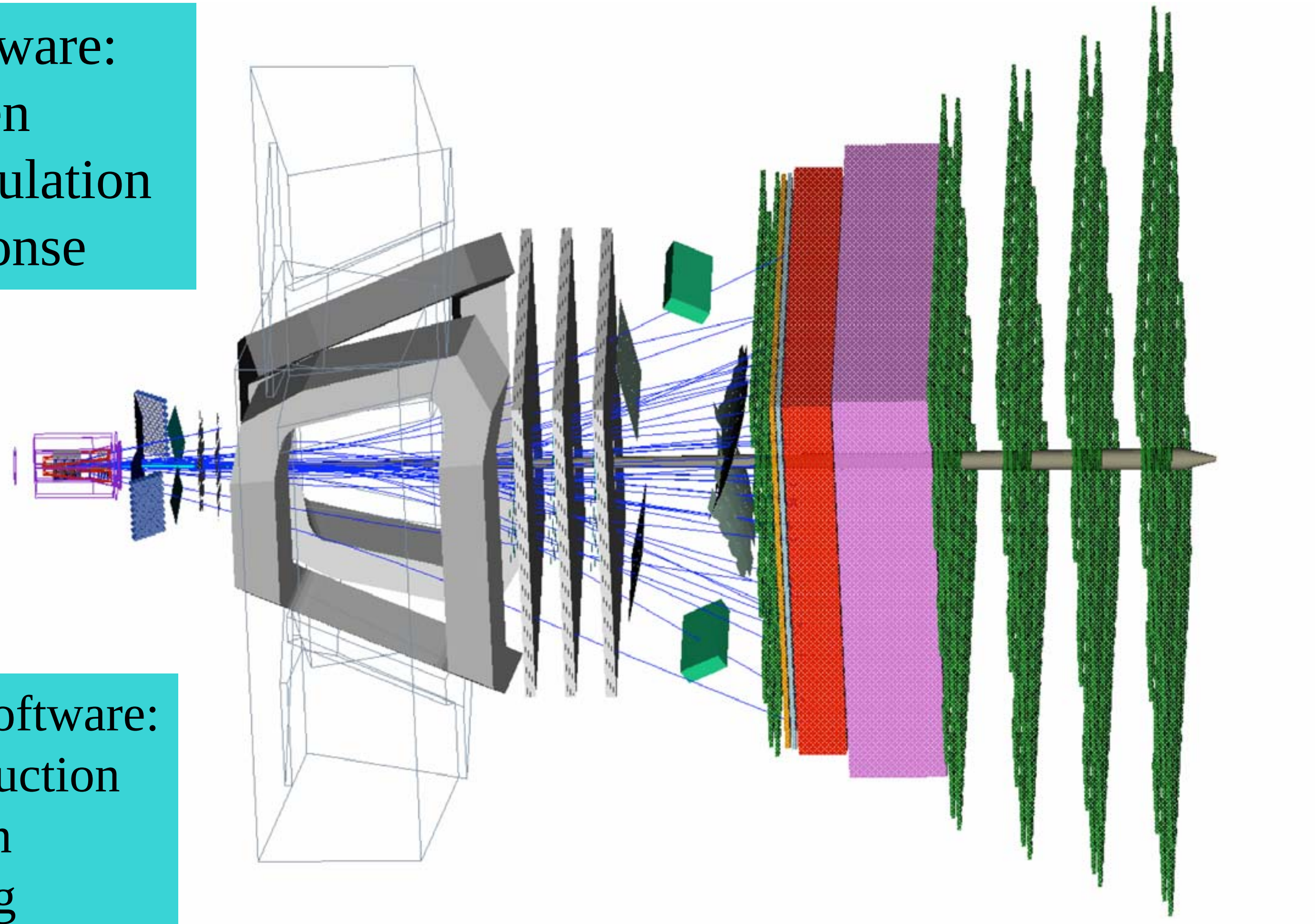


Detector ready for physics

Tour of the Detector

MC Simulation

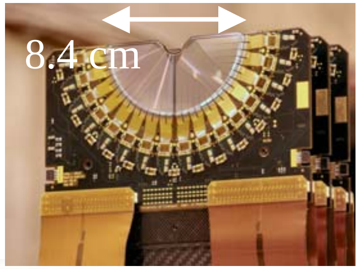
Simulation software:
- Pythia+EvtGen
- GEANT4 simulation
- Detector response



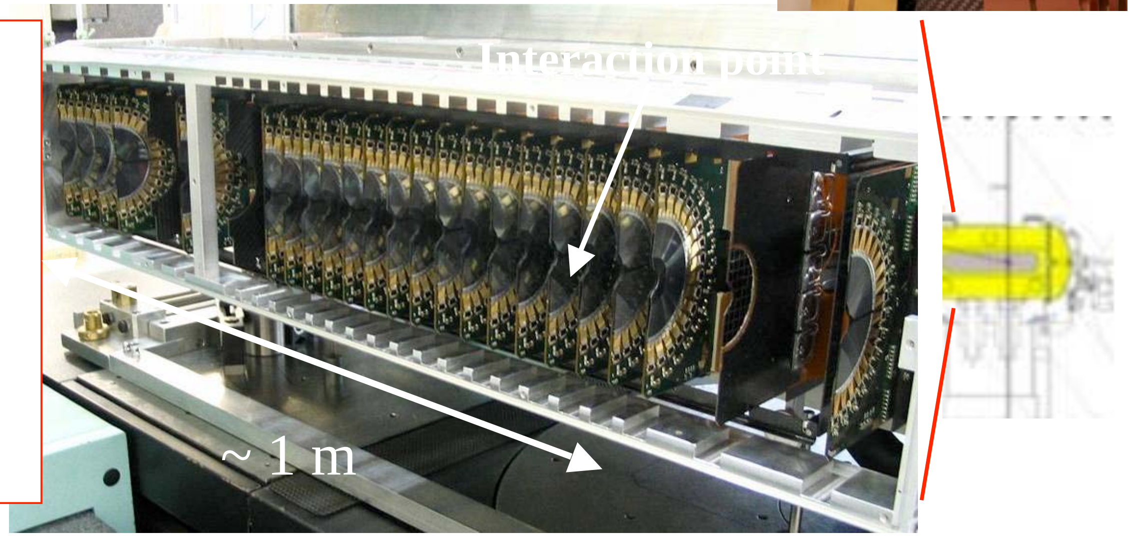
Reconstruction software:
- Event Reconstruction
- Decay Selection
- Trigger/Tagging
- Physics parameter fits

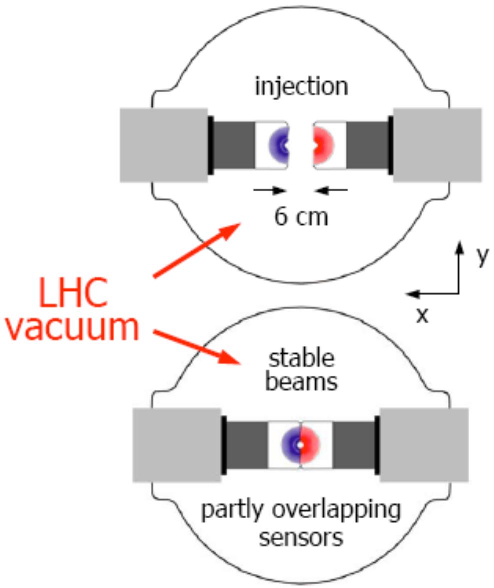
Optimise the experiment+ test physics sensitivities

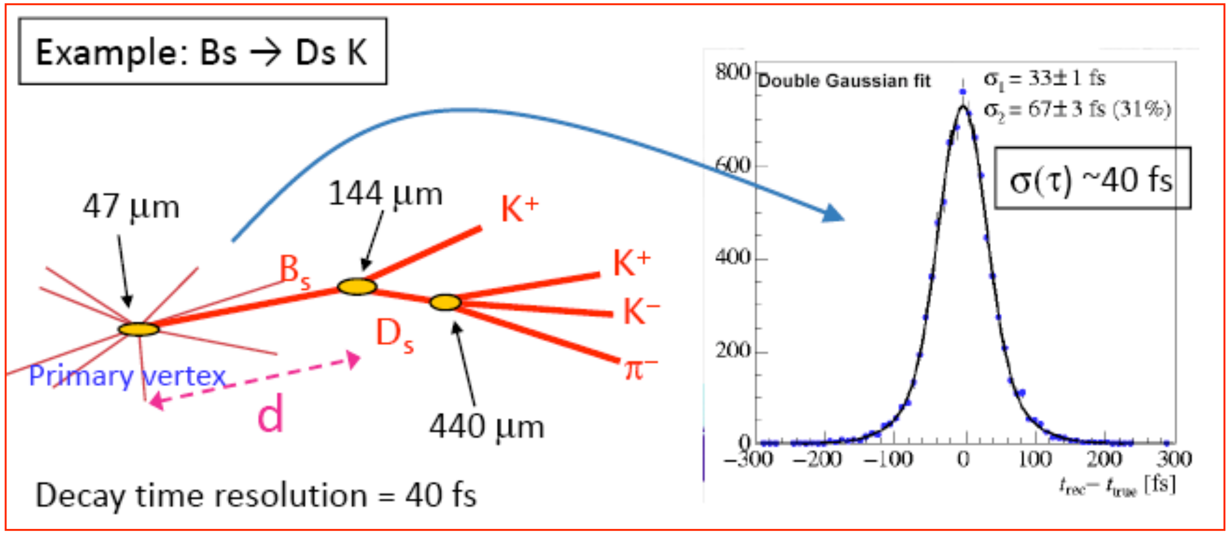
Vertex Locator



- 21 stations
- Silicon Strip detectors
- Strips measuring r and ϕ
- Sensitive area ~ 8 mm from beam
- 5 μm hit resolution
- 30 μm impact parameter resolution
- Detector halves retracted/inserted each fill

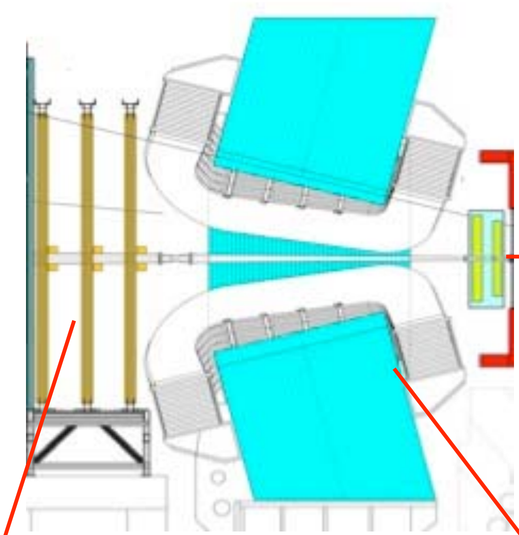


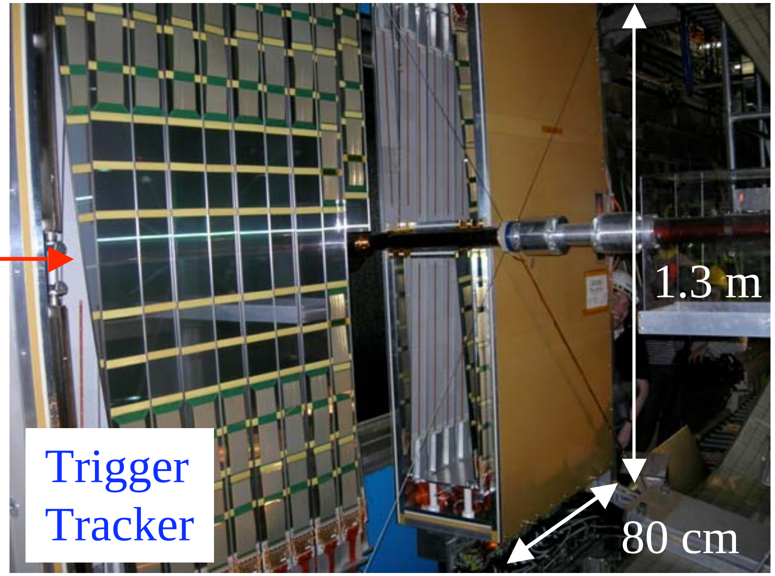


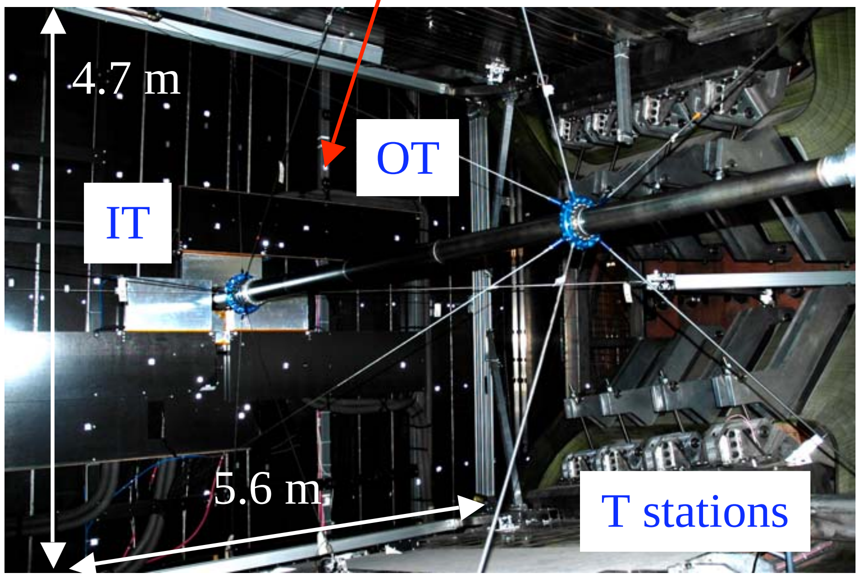


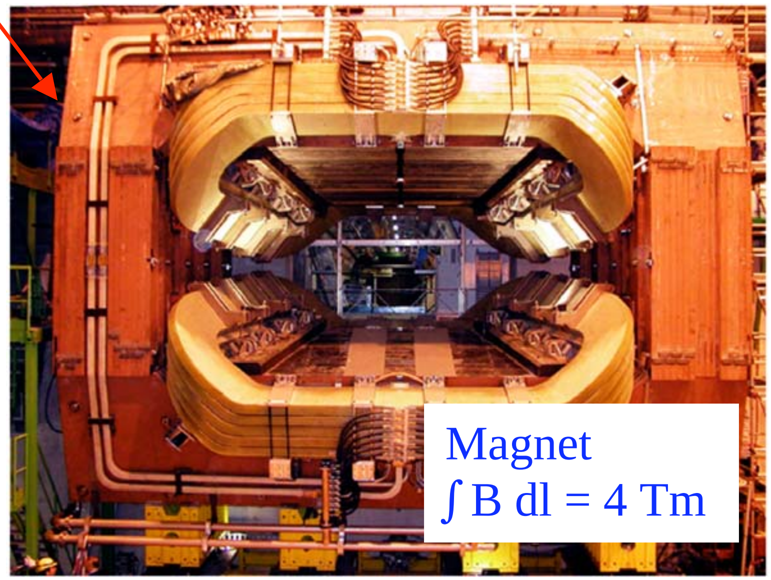
Tracking System

Large Silicon Detector before Magnet +
3 stations [straws + Silicon] after magnet

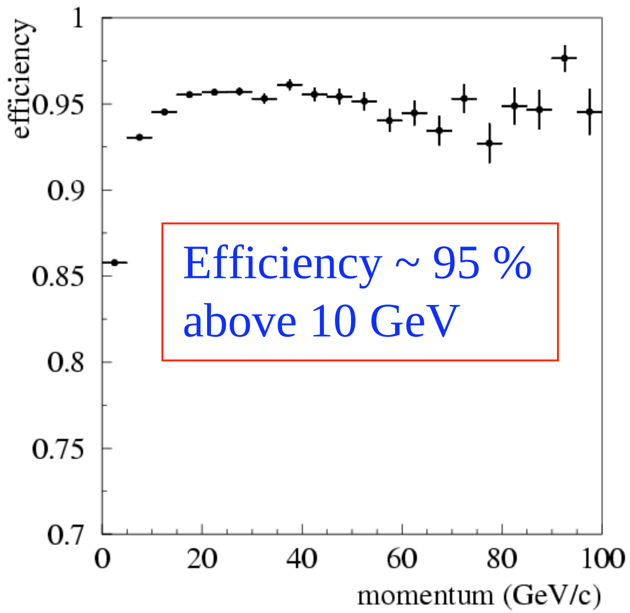








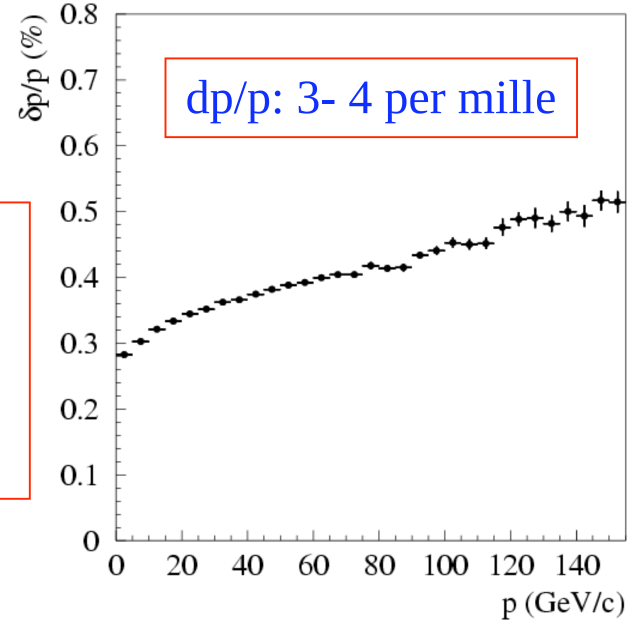
Tracking System



Efficiency ~ 95 %
above 10 GeV

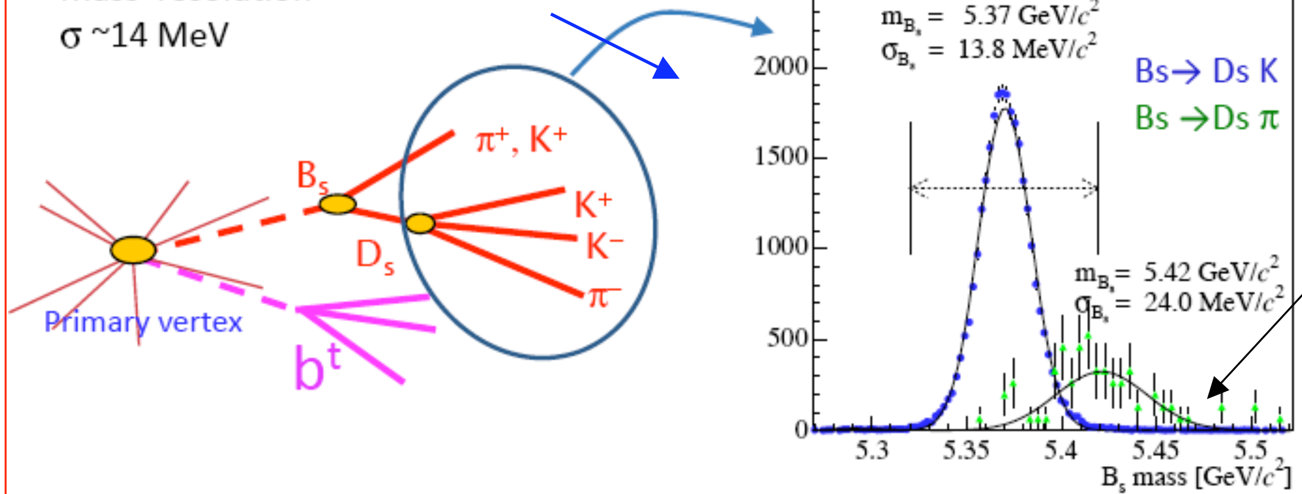
- ~4-5 particles in final state
- High tracking efficiency

- Good dp/p resolution
- Mass constraints



dp/p: 3- 4 per mille

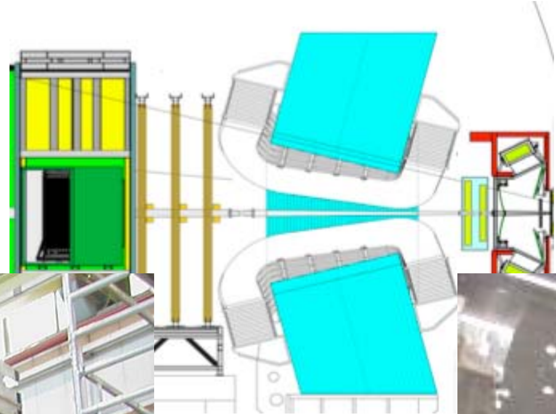
Mass resolution
σ ~14 MeV



Remaining background from $B_s \rightarrow D_s\,\pi$ after PID suppressed by good mass resolution

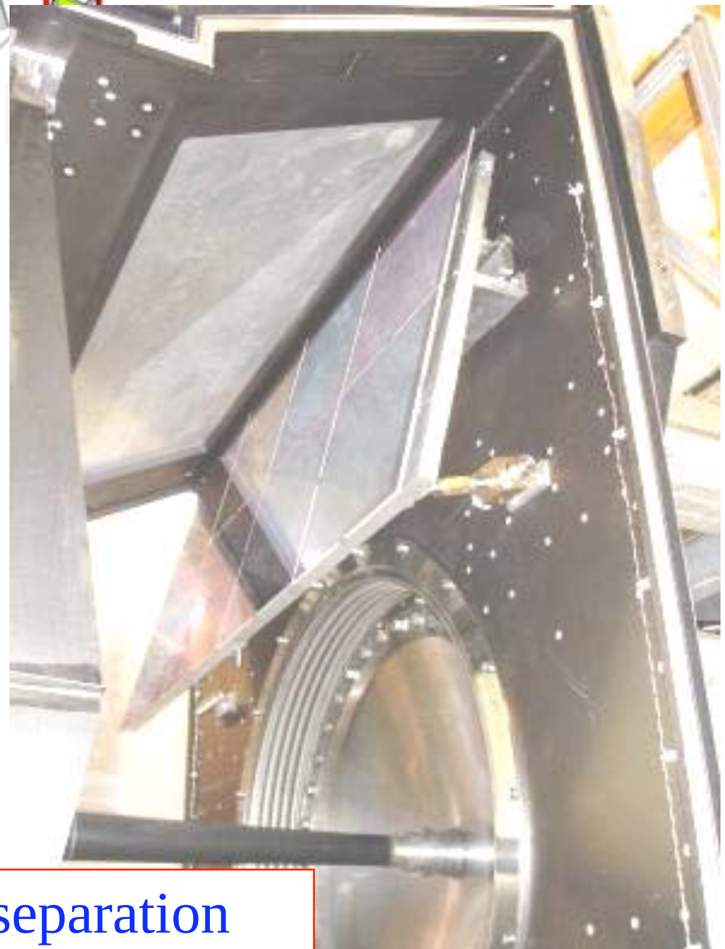
Particle Identification

RICH2: 100 m3 CF4



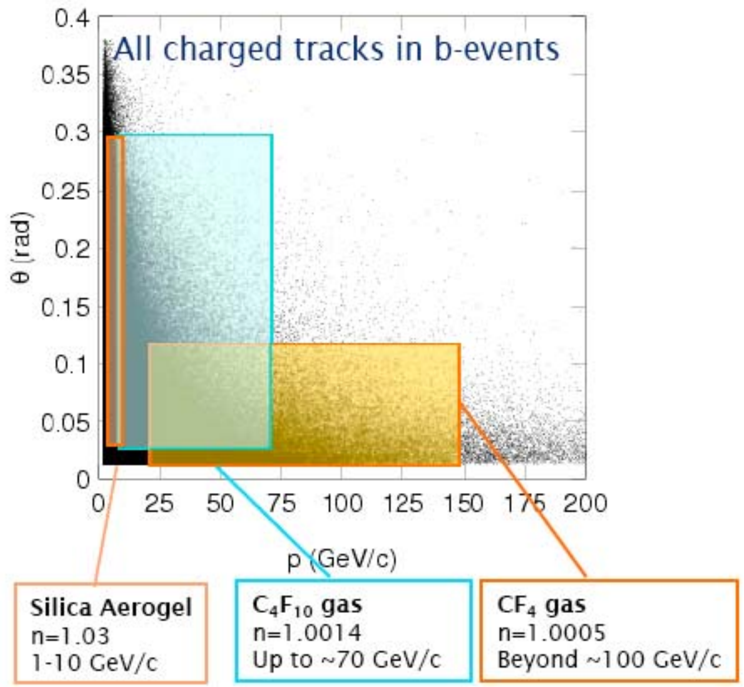
RICH1: 5 cm aerogel

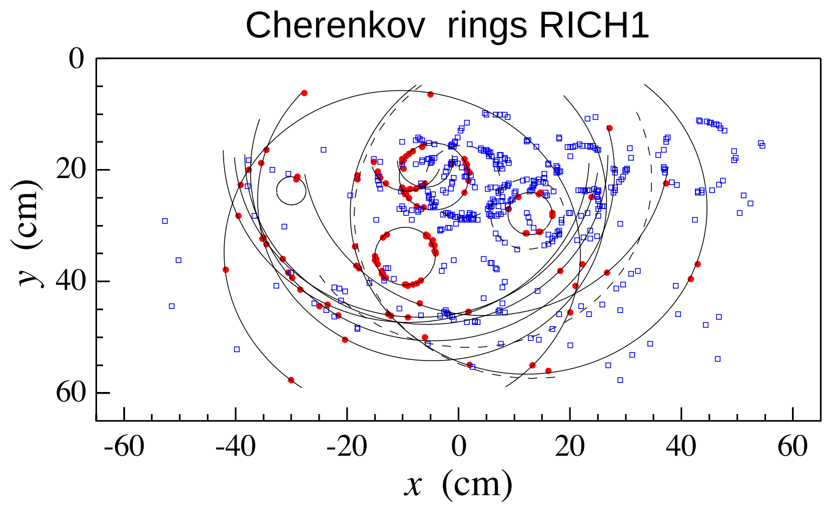
$4\ m^3\ C_4F_{10}$

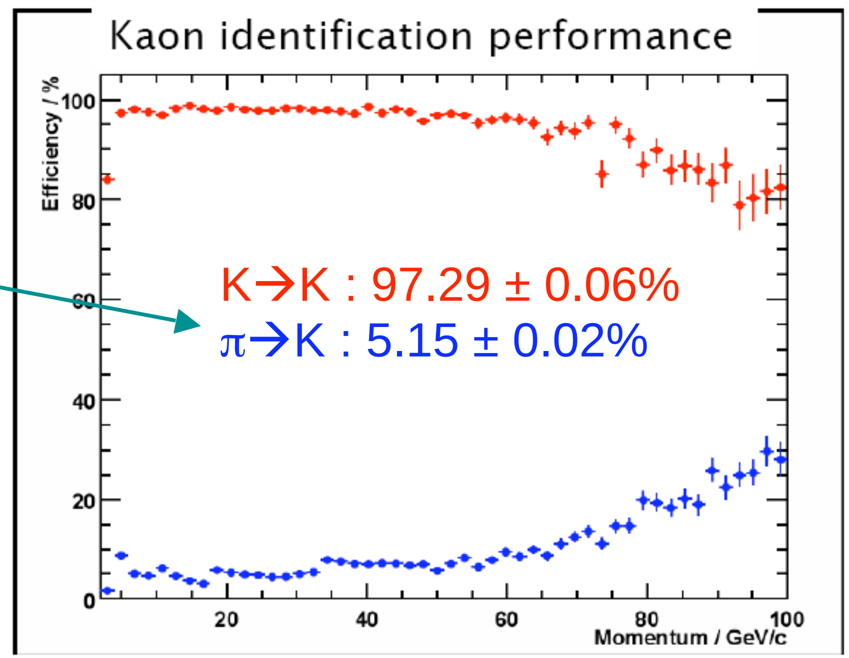


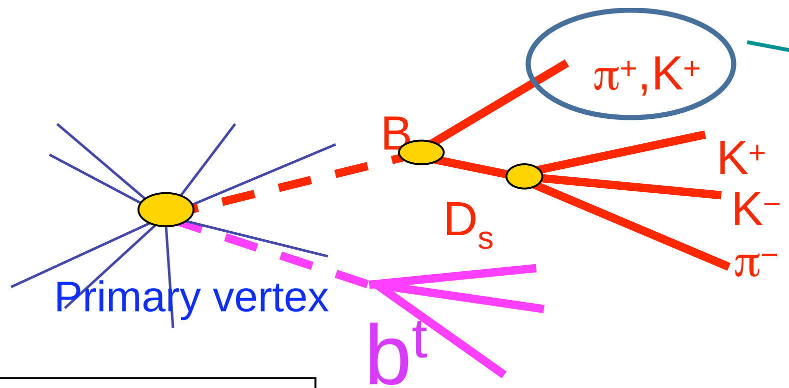
2 RICH detectors for K/π separation

Particle Identification





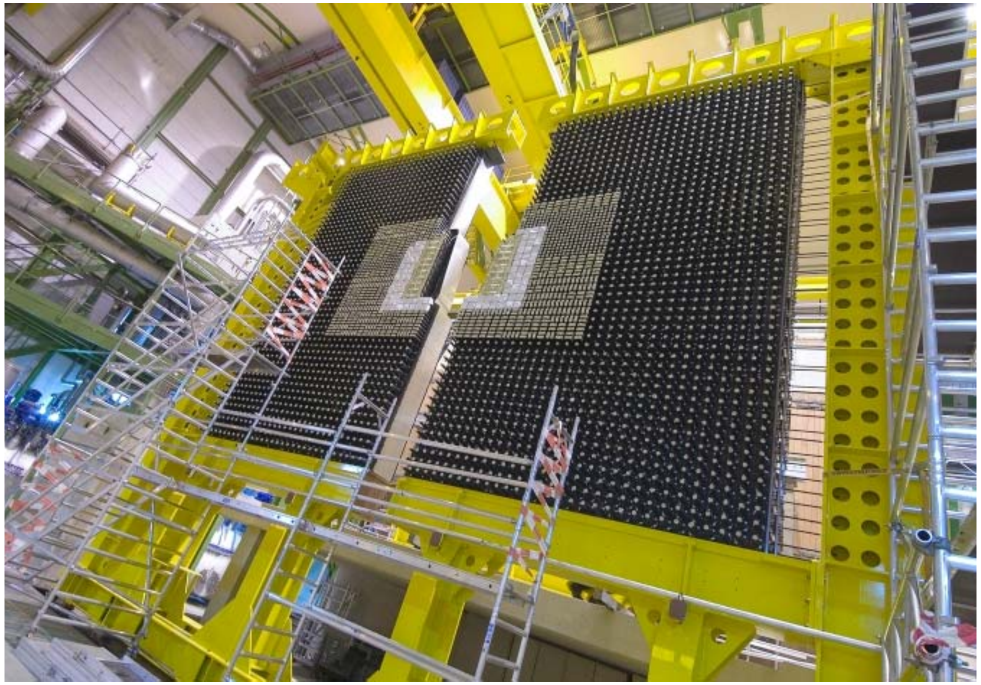




$B_s \to D_s K$

Calorimeters

Calorimeter system : Preshower, ECAL, HCAL
- Detection of electrons, π^0, γ
- Level 0 trigger: high E_T electron and hadron, photon



PreShower/SPD:
- 12k scintillator pads

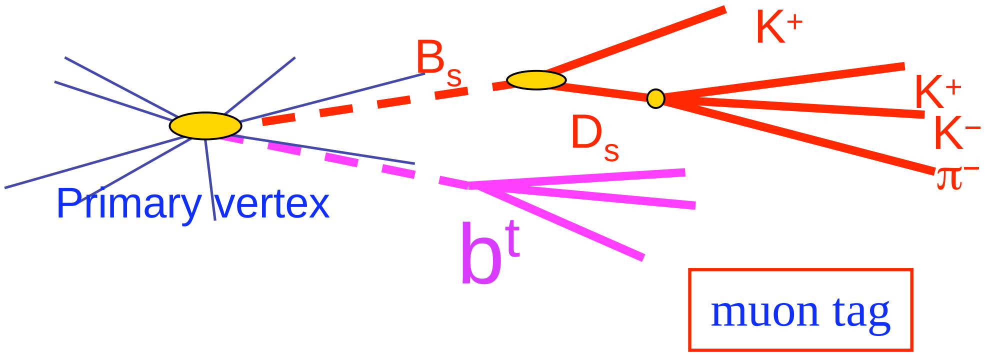
Shaslik ECAL:
- Pb/Scintillator, 25 X_0
- 6k cells
- $\sigma/E \sim 10\%/\sqrt{E} \oplus 1\%$

Tile HCAL (only for trigger)
- Fe/Scintillator, 5.6 λ_0
- 1.5k channels
- $\sigma/E \sim 80\%/\sqrt{E} \oplus 10\%$

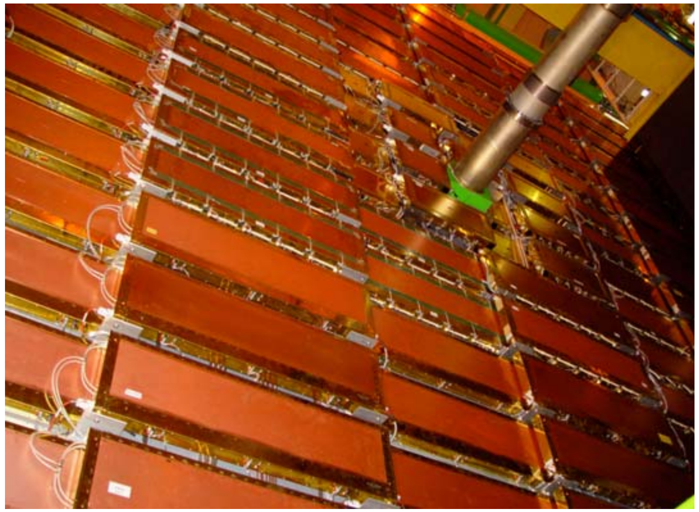
Muon System

Muon system:

- Level 0 trigger: High Pt muons
- Flavour tagging



- Arranged in 5 stations;
- Inner part M1: 24 triple GEM chambers;
- Outer part M1, M2-M5: 1100 MWPCs



Trigger

pt ~ 1 GeV μ
pt ~ 3 GeV e,h

1000 box

CPU farm

Detector

40 MHz

L0: high p_T (μ, e, γ, h) [hardware]

1 MHz

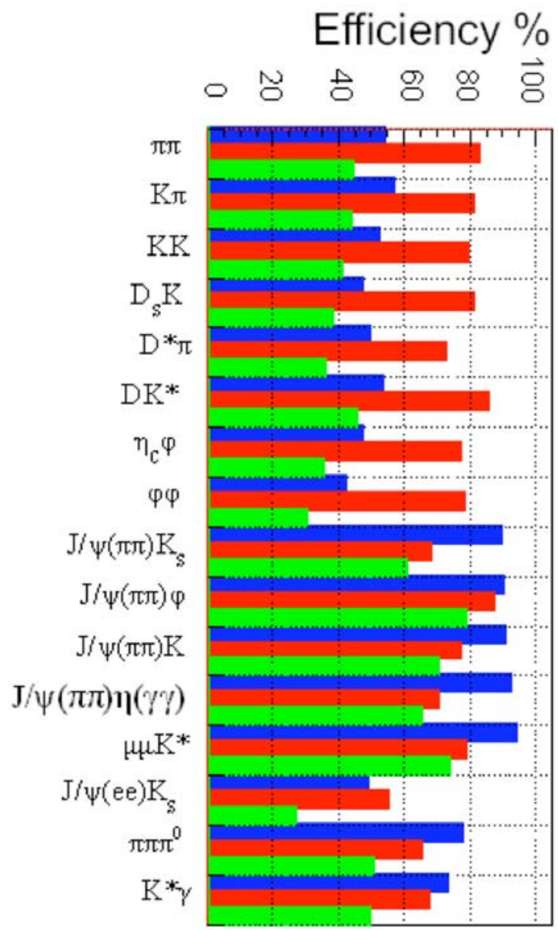
HLT: L0 confirmation + high IP[software]
then full reconstruction of event

2 kHz

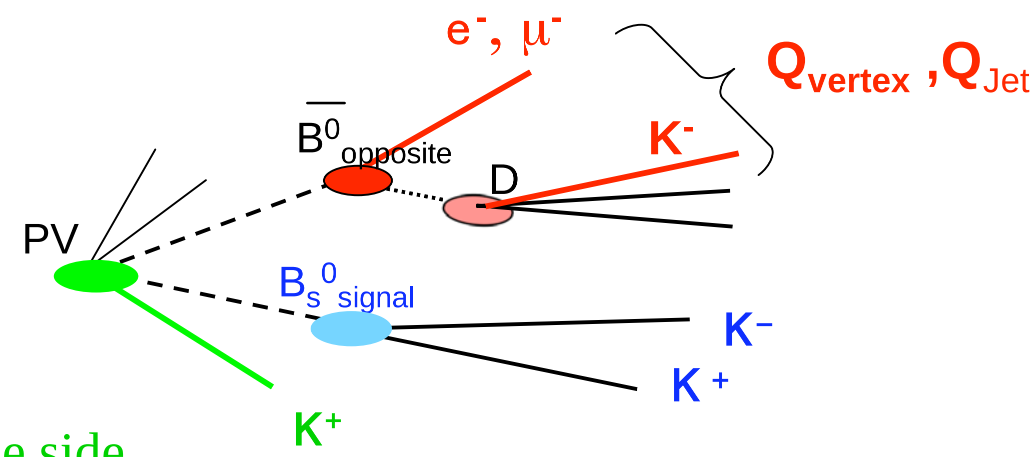
Storage (event size ~ 35 kB)

HLT rate	**Event type**	**Physics**
200 Hz	Exclusive B candidates	B (core program)
600 Hz	High mass di-muons	J/ψ, b→J/ψX (unbiased)
300 Hz	D* candidates	Charm (mixing & CPV)
900 Hz	Inclusive b (e.g. b→μ)	B (unbiased sample)

L0, **HLT** and **L0×HLT** efficiency (normalized to offline selected)



Flavour Tagging



Same side

- Fragmentation $K^{\pm}$ accompanying B_s
- $\pi^{\pm}$ from $B^{**} \rightarrow B^{(*)}\pi^{\pm}$

Opposite side

- High Pt leptons
- $K^{\pm}$ from $b \rightarrow c \rightarrow s$
- Vertex charge
- Jet charge

Figure of merit:

$\varepsilon D^2 = \varepsilon(1-2\omega)^2$: tagging power

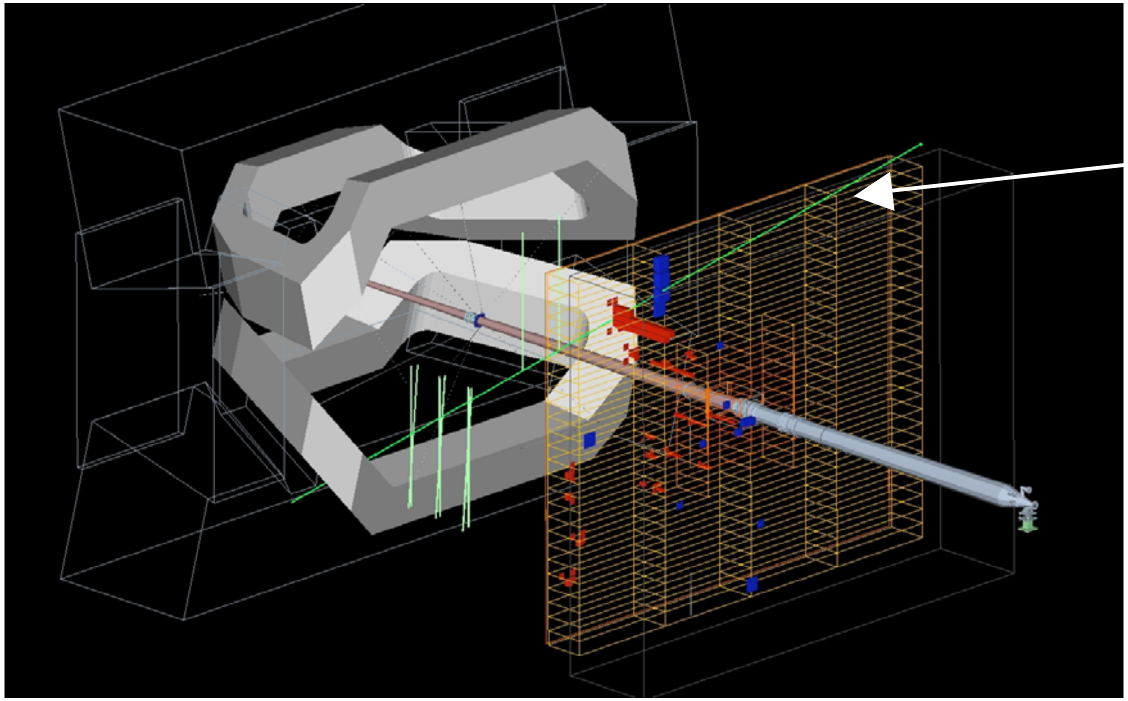
ε: tagging efficiency

ω: wrong tagging fraction

Tag	B_d	B_s
Muon	1.1	1.5
Electron	0.4	0.7
Kaon opp.side	2.1	2.3
Jet/ Vertex Charge	1.0	1.0
Same side pπ / K	0.7 (πp)	3.5(K)
Combined (Neural Net)	~ 5.1	~9.5

Detector Commissioning

- Detector commissioning progressing with cosmics
- Time alignment of calorimeters, muons, Outer Tracker
- Regular readout of major components
- Ramp up to data taking with beam gas in August
    - This data will allow first alignment + calibration



Cosmic track
Triggered by calorimeters
Seen in the tracker

Physics Program

Physics Program

2008: Low luminosity $\sim 10^{31}$ cm^{-2}s^{-1} 50 days, 10 TeV

Minimum bias +proto-HLT trigger, collect ~ 5 pb^{-1}

Calibration + Alignment
Minimum bias physics
Charmonium production

2009: Luminosity 2×10^{32} cm^{-2}s^{-1} 140 days, 14 TeV

L0 + HLT , collect ~ 0.5 fb^{-1}

B Physics Run
Calibration CP ($\sin 2\beta$, Δm_s,..)
CP + rare decays
Key measurements: βs, $Bs \rightarrow \mu\mu$

2010+: Luminosity 2 -5 $\times 10^{32}$ cm^{-2}s^{-1} 140 days

collect total of ~10 fb^{-1}

Full Physics program

2013+: Upgrade ? to run at luminosity 2×10^{33} cm^{-2}s

Collect 100 fb^{-1}

Physics Program

γ with loops and trees
B_s mixing phase ϕ_s
$B \rightarrow \mu\mu$, $B \rightarrow K^* \mu\mu$
Radiative penguins: $B \rightarrow K^*\gamma$, $B_s \rightarrow \phi\gamma$

Key Measurements

β with $B \rightarrow J/\psi\ K_s$
α with $B \rightarrow \rho\pi$
B_c and Λ_b physics
Other rare B decays
….

Other B Physics

Minimum bias physics

Charm Physics

W, Z, production [constrain PDF]

Higgs search

Exotics: Neutralino, Hidden valley particles

More than B Physics

First Physics

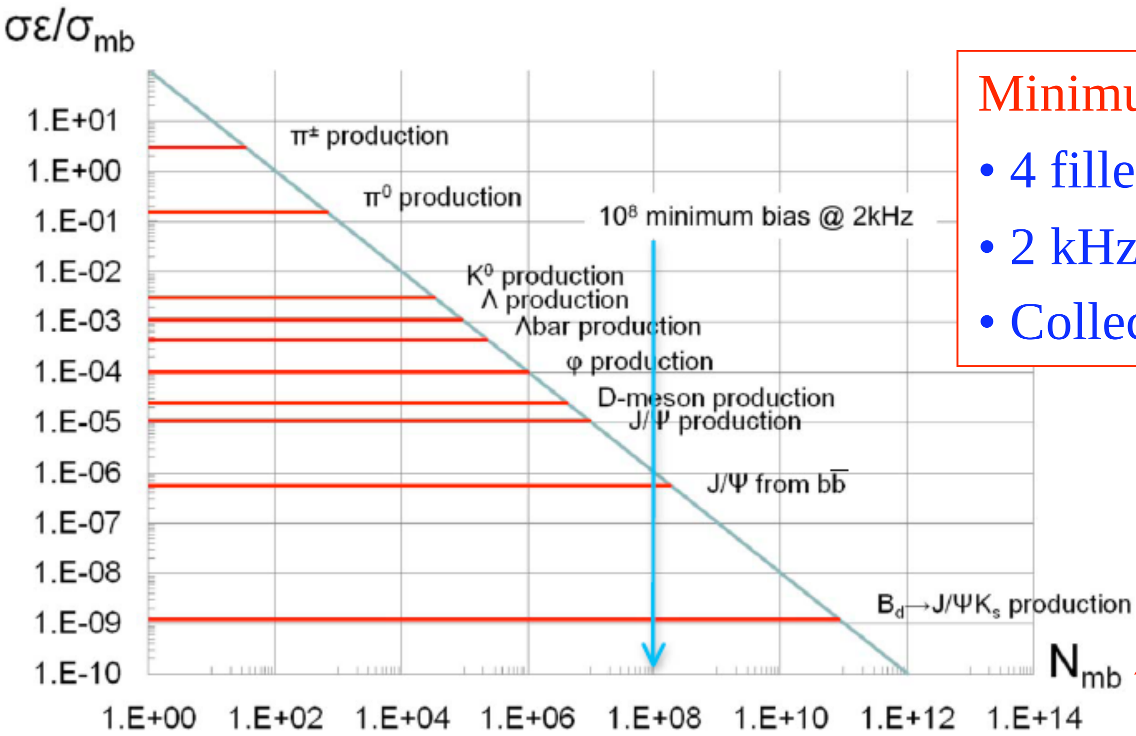
First Physics

- Start "Physics" with first 10 TeV collisions
  - 2 bunches on 2 bunches
- Increase luminosity gradually (zero external crossing angle)
- Target luminosities (for 9×10^{10} protons per bunch, $\beta^* = 6$m)

Scheme	*coll. pairs*	*non-coll. bunches*	*Lumi at IP8*
2x2	*1*	*1*	*1.7 ´1029 cm-2 s-1*
43x43	*19*	*24*	*3.3 ´1030*
156x156	*68*	*88*	*1.2 ´1031*

- Expected integrated luminosity in 2008: ~5 pb^{-1}

First Physics



Minimum bias running

- 4 filled bunches L = 1.1 x $10^{29}cm^{-2}s^{-1}$
- 2 kHz minimum bias to disk
- Collect 2 $\times 10^8$ events in 100 hours

min bias events needed to perform 10 % measurement

Sample will contain ~500, 000 reconstructed K_s and 2000 J/ψ

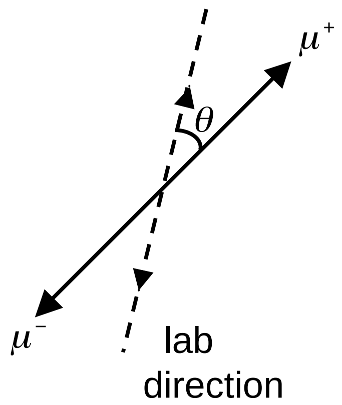
- Alignment, calibration of tracking/PID
- Studies of single particle production, generator tuning
- K_s , Λ production + polarization + hyperon production $\Xi^- \to \Lambda\pi^-$, $\Omega^- \to \Lambda K^-$
- Vector meson production (K*, ϕ)

J/ψ Production

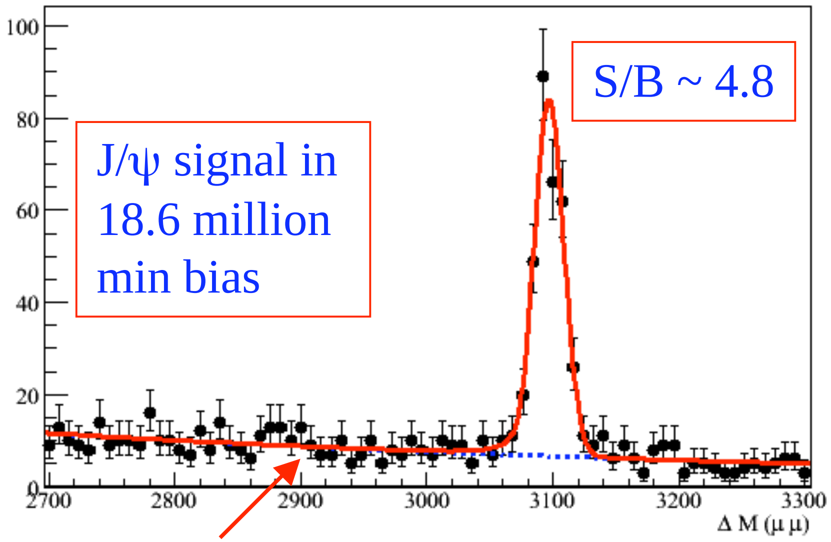
5 pb-1 will have ~ 5 millon J/ψ. Potential physics:

- Fraction of prompt J/ψ and from B [+ hence the B lifetime]
- Prompt J/ physics:
  - pt spectra
  - polarization (spin alignment)
- χ_c production
- Extend to ψ(2S), Upsilon

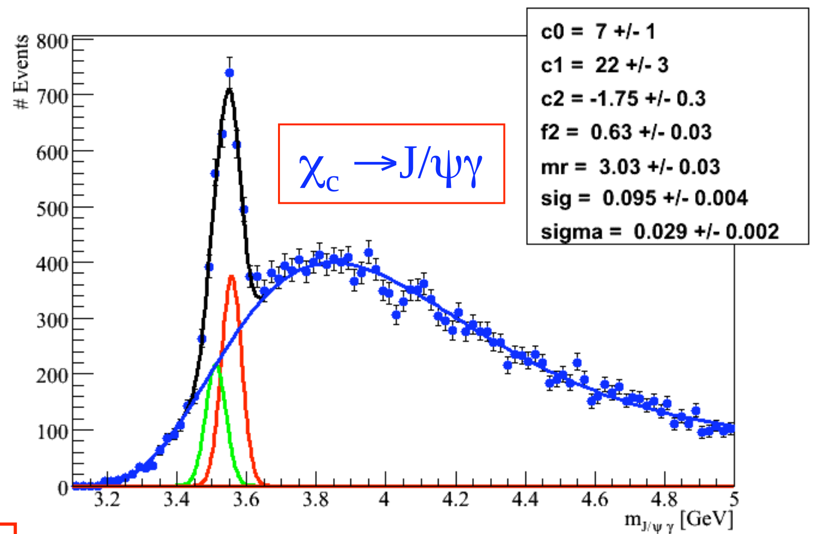
Tests of the Color Octet Model



$$\frac{dN}{d\cos\theta^*} \propto 1 + \alpha \cos^2\theta^*$$



Combinatoric background from decays in flights



B Physics: First steps

Significant samples should be available when high pt muon/hadron trigger are commissioned

Channel	Yield / 5 pb^{-1}
$B \to D(K\pi)X$	31k
$B^+ \to D(K\pi)\pi^+$	1700
$B \to D^*\mu\nu$	23k
$B \to J/\psi K^*$	2.3k
$B_s \to J/\psi\phi$	330
$B \to K^*\gamma$	150

Angle γ

- Study background with $B \to D(K\pi)\pi$
- Vertex, mass resolutions + lifetimes with $B(D) \to hh$

For $Bs \to \mu\mu$

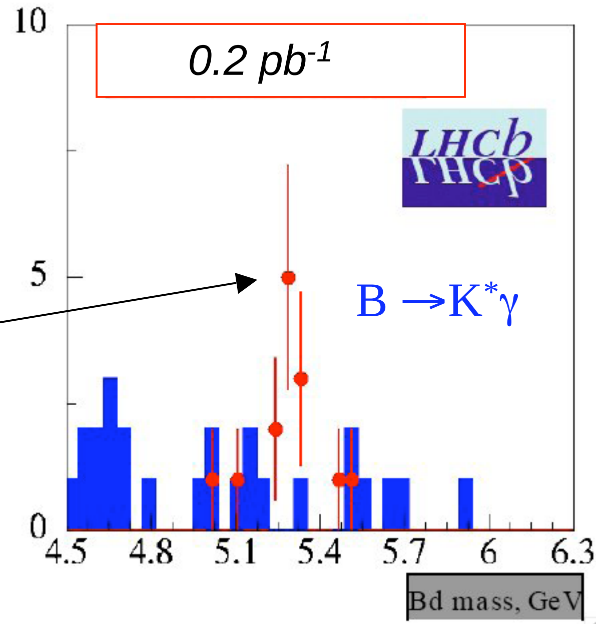
- Methods for calibrating mass, PID demonstrated

For $B \to K^*\mu\mu$

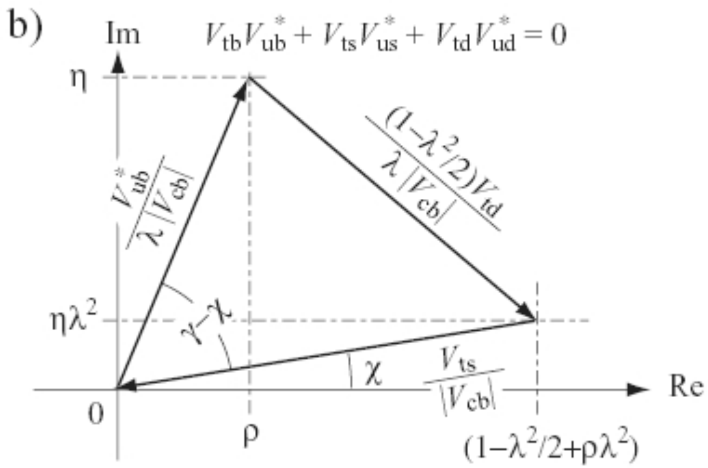
- Muon efficiency at low momentum understood
- Experience with angular fits of $\psi(2S) \to J/\psi\ \pi\pi$

Radiative Penguin decays

- Calibrate calorimeter
- First $b \to s\ \gamma$ decays seen

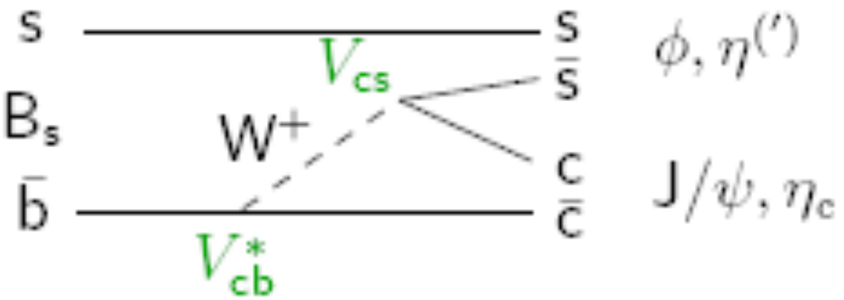


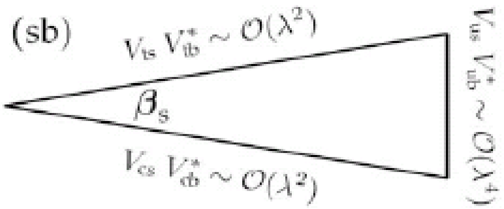
B_s Mixing Phase: β_s



β_s with b→ ccs

- Key measurement for 2009
- β_s , Bs oscillation mixing phase (analogue of sin $2\beta_d$)
- β_s is small in the SM: $\phi_s = -\arg(V_{ts}{}^2) = -2\ \beta_s = -2\lambda^2\eta \sim -0.04$ radian
- Sensitive probe for new physics: $\phi_s = \phi_s{}^{SM} + \phi_s{}^{NP}$
- Measure from time dependent asymmetry in b →ccs transitions
- For measurement need Δm_s as input



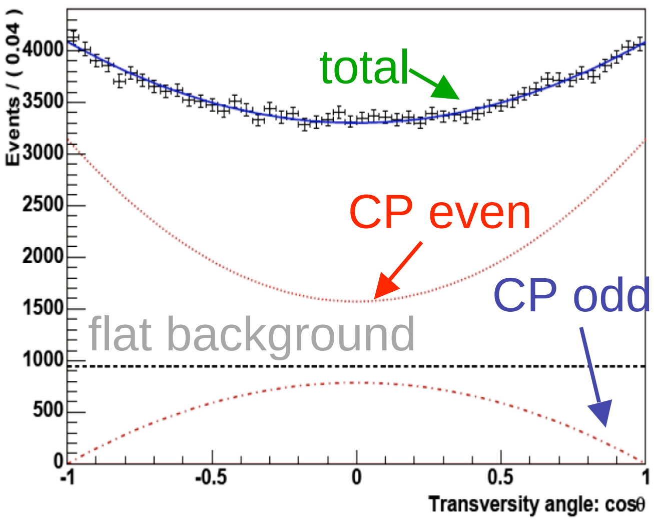


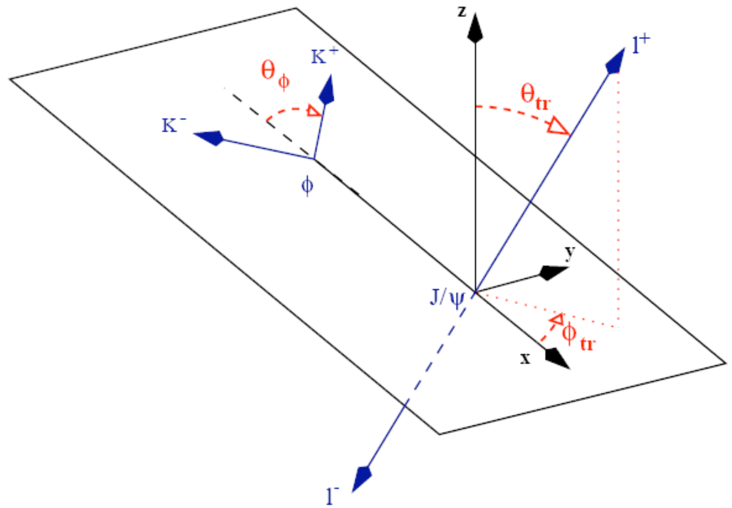
$$\beta_s = \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right)$$

Tevatron results:
D0 $2\beta_s = -0.57^{+0.24}_{-0.30}$ with with 2.8 fb^{-1}
CDF $-2\beta_s = [0.32, 2.82]$ @ 68%CL with 1.35 fb^{-1}

β_s: Measurement

- $B_S \rightarrow J/\psi\ \phi$ counter part of the golden mode $B_d \rightarrow J/\psi\ K_s$
- High yield: 125 k signal events per $2fb^{-1}$ (before tagging)
- Vector-Vector final state: Admixture of CP eigenstates
  - Angular analysis needed





- Pure CP eigenstates (e.g. $B_S \rightarrow J/\psi\ \eta$) can also be added
  - No angular analysis needed but total statistics lower (27k $2fb^{-1}$)

β_s: Physics Reach

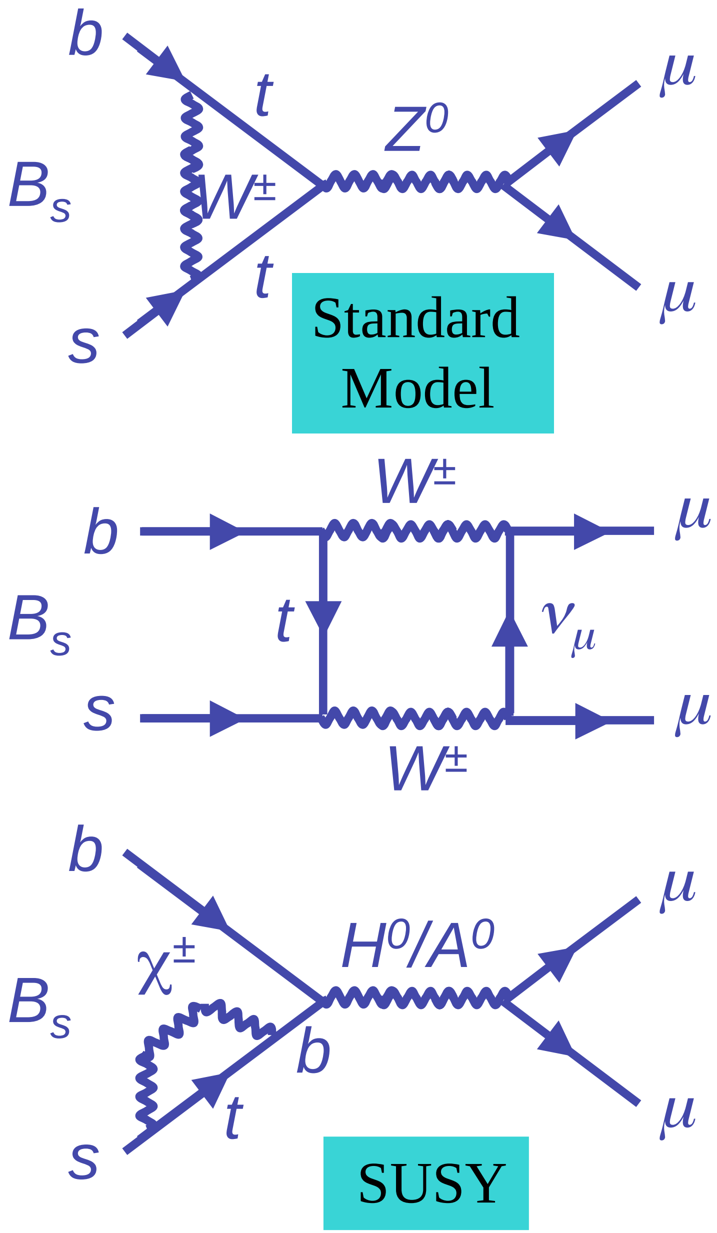
2009: 0.5 fb^{-1}: sensitivity ~0.042 using $B_S \rightarrow J/\psi\ \phi$
(cf SM value 2 β_s~ - 0.04)

Decay Mode	Yield (2 fb^{-1})	σ ($2\beta_s$)
$J/\psi\ \eta(\gamma\gamma)$	8.5 k	0.109
$J/\psi\eta(\pi\pi\pi)$	3 k	0.142
$J/\psi\ \eta'(\pi\pi\pi)$	2.2 k	0.154
$J/\psi\ \eta'(\rho\gamma)$	4.2 k	0.08
$\eta_c\ \phi$	3 k	0.108
$D_s^+ D_s^-$	4k	0.133
All CP eigenstates	-	0.046
$J/\psi\ \phi$	130 k	0.023
All	-	0.021

Sensitivity with 2 fb^{-1} and Δm_s = 17 ps^{-1}, $2\beta_s$= -0.04, $\Delta\Gamma/\Gamma$= 0.15

Rare Decay Program

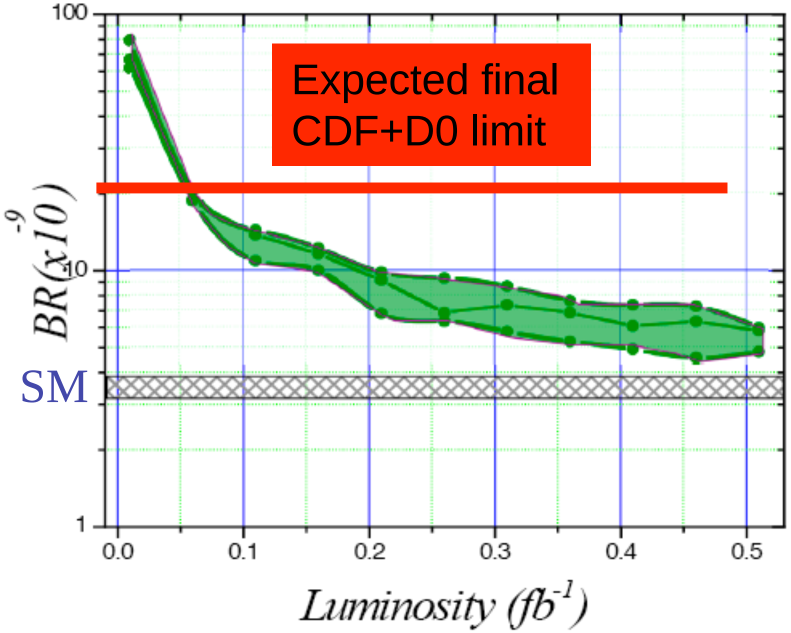
$B_s \to \mu^+ \mu^-$



- Key measurement for 2009
- Flavour Changing neutral current
- Highly suppressed in SM:
  - $BR(B_s \to \mu\mu) = (3.35 \pm 0.32) \times 10^{-9}$
- Can be enhanced in SUSY
  - $BR(B_s \to \mu\mu) \propto \tan^6\beta / M_H^2$
- Currents limits from Tevatron ~2 fb^{-1}:
  - CDF BR < 4.7 10^{-8} 90 % CL
  - D0 BR < 7.5 10^{-8} 90 % CL

$B_s \rightarrow \mu^+\mu^-$

90% CL limit on BR
(only bkgrd is observed)



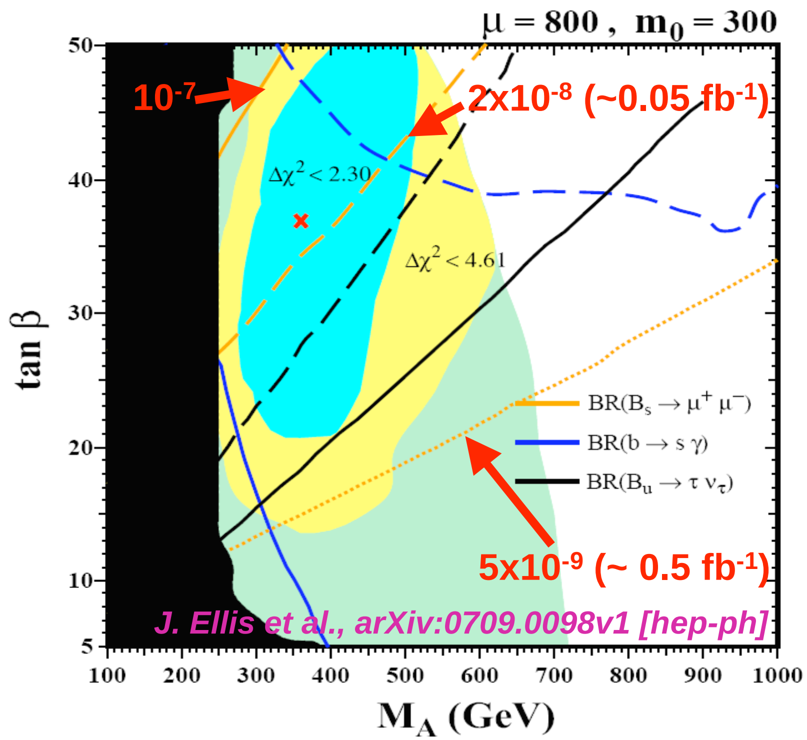
- High statistics + trigger efficiency
- Main issue is background rejection
- Largest background is b →μ, b →μ.
- Exploit good mass resolution ~ 20 MeV

Exclusion

- 0.1 fb^{-1} BR < 10^{-8}
- 0.5 fb^{-1} < SM (2008)

SM Branching ratio

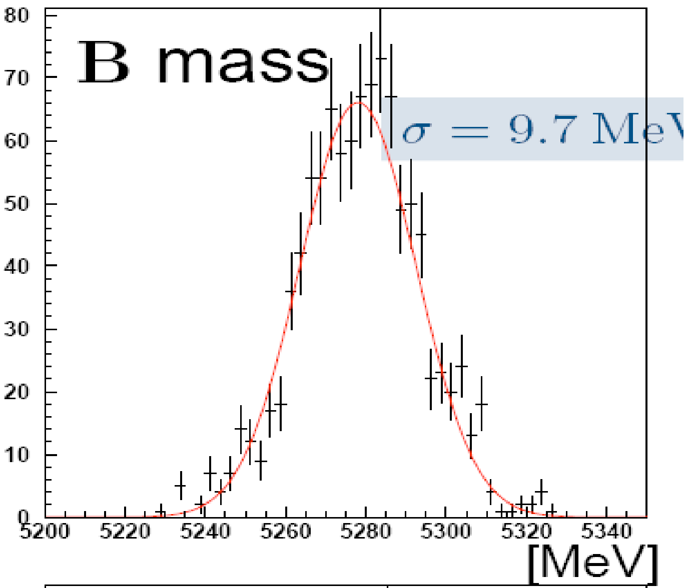
- 2 fb^{-1}: 3σ evidence
- 2 fb^{-1}: 6σ evidence

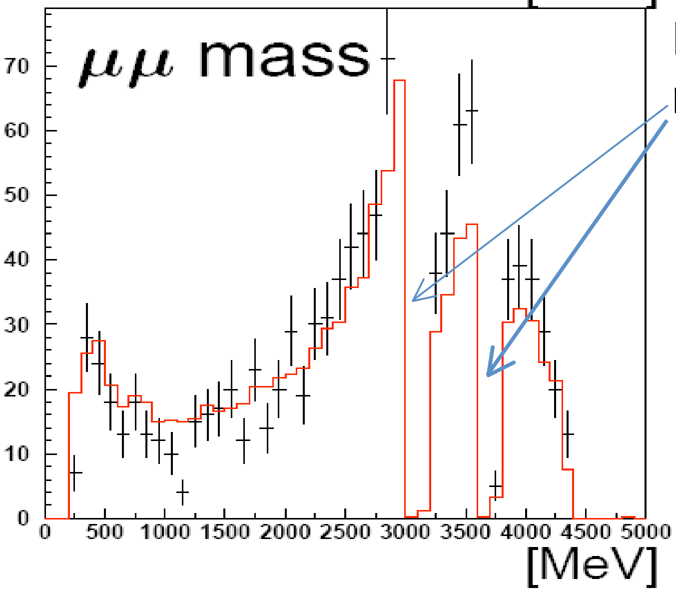


$B_d \rightarrow K^* \mu^+\mu^-$

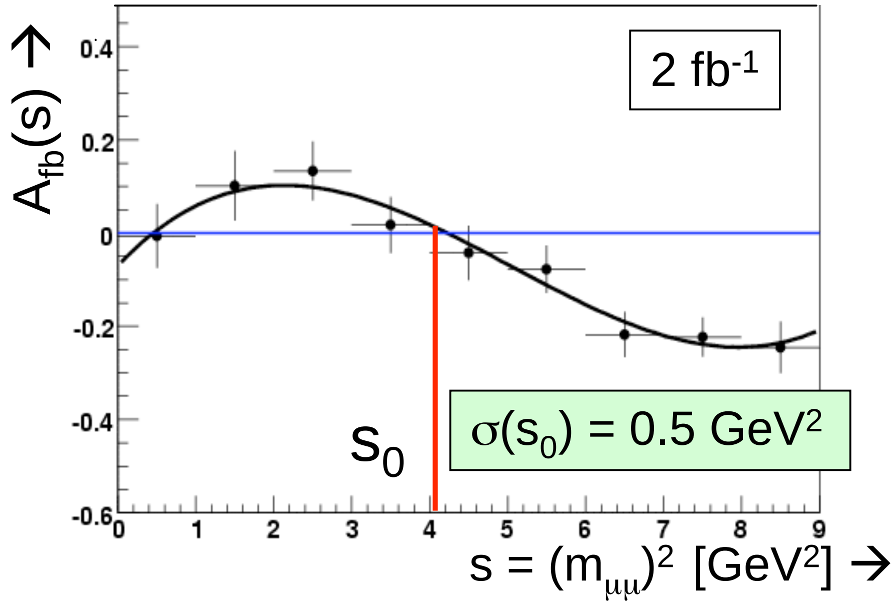
- 2009: 0.5 fb-1 expect 2000 events
- B factories total ~ 1000 events by then

Channel	Yield (2 fb^{-1})	BG (2 fb^{-1})
$Bs \rightarrow K^*\mu^+ \mu^-$	7200+-2200 (BR)	1770+-310





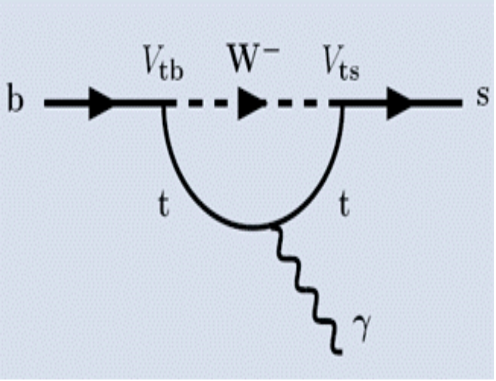
Remove resonances



- Zero crossing point of forward-backward asymmetry A_{FB} in θ_l angle, as a function of $m_{\mu\mu}$ precisely computed in SM: $s_0^{SM}(C_7,C_9)=4.39^{+0.38}_{-0.35}$ GeV^2

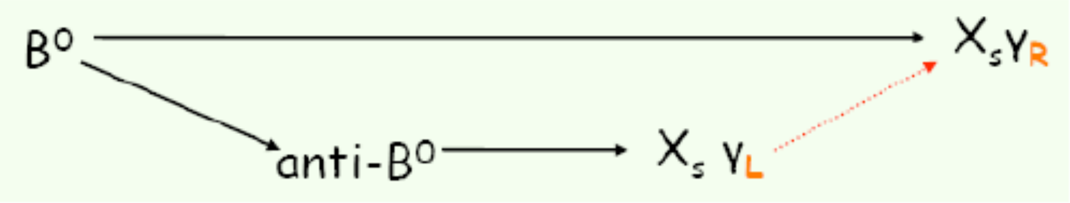
$B_s \to \phi\gamma$

- Probes the exclusive b →sγ radiative penguin
  Measure time dependent CP asymmetry:



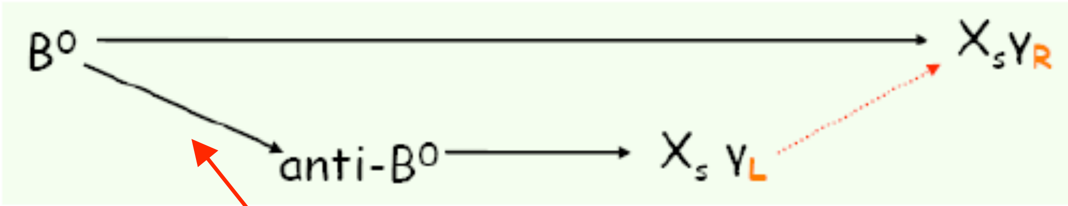
$$A_{CP}(t) = \frac{\Gamma(\bar{B}_s \to \phi\gamma) - \Gamma(B_s \to \phi\gamma)}{\Gamma(\bar{B}_s \to \phi\gamma) + \Gamma(B_s \to \phi\gamma)} = \frac{A_{dir}\cos\Delta mt + A_{mix}\sin\Delta mt}{\cosh\left(\frac{\Delta\Gamma t}{2}\right) + A_\Delta \sinh\left(\frac{\Delta\Gamma t}{2}\right)}$$

Interference can only occur for final states with same photon polarization



In SM b→s γ is predominantly $(O(m_s/m_b))$ left handed
Interference +hence mixing induced CP violation suppressed

$B_s \to \phi\gamma$



SM:

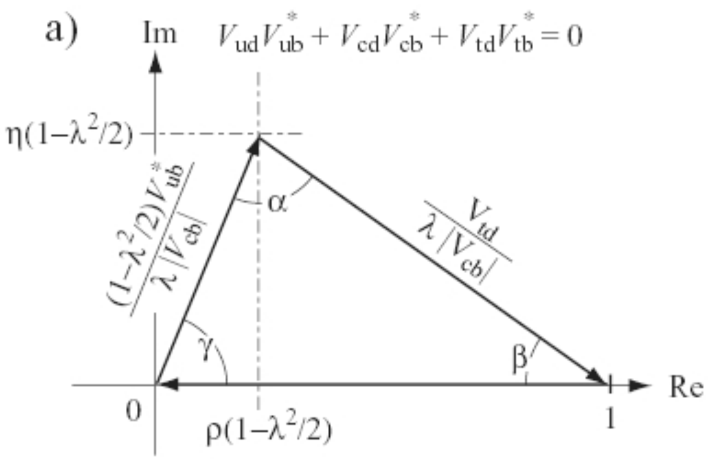
$A_{dir} \approx 0$, $A_{mix} \approx \sin 2\psi \sin 2\beta$
$A_\Delta \approx \sin 2\psi \cos 2\beta$
$\tan \psi = |b \to s\gamma_R| / |b \to s\gamma_L|$,
$\cos 2\beta \approx 1$

Channel	Yield (2 fb^{-1})	B/S
$Bs \to \phi\gamma$	11k	<0.55

Statistical precision after 1 year (2 fb^{-1})
$\sigma(A_{dir}) = 0.11$, $\sigma(A_{mix}) = 0.11$ (requires tagging)
$\sigma(A_\Delta) = 0.22$ (no tagging required)

Measures fraction "wrong" γ polarization
Suppressed in SM

Angle γ

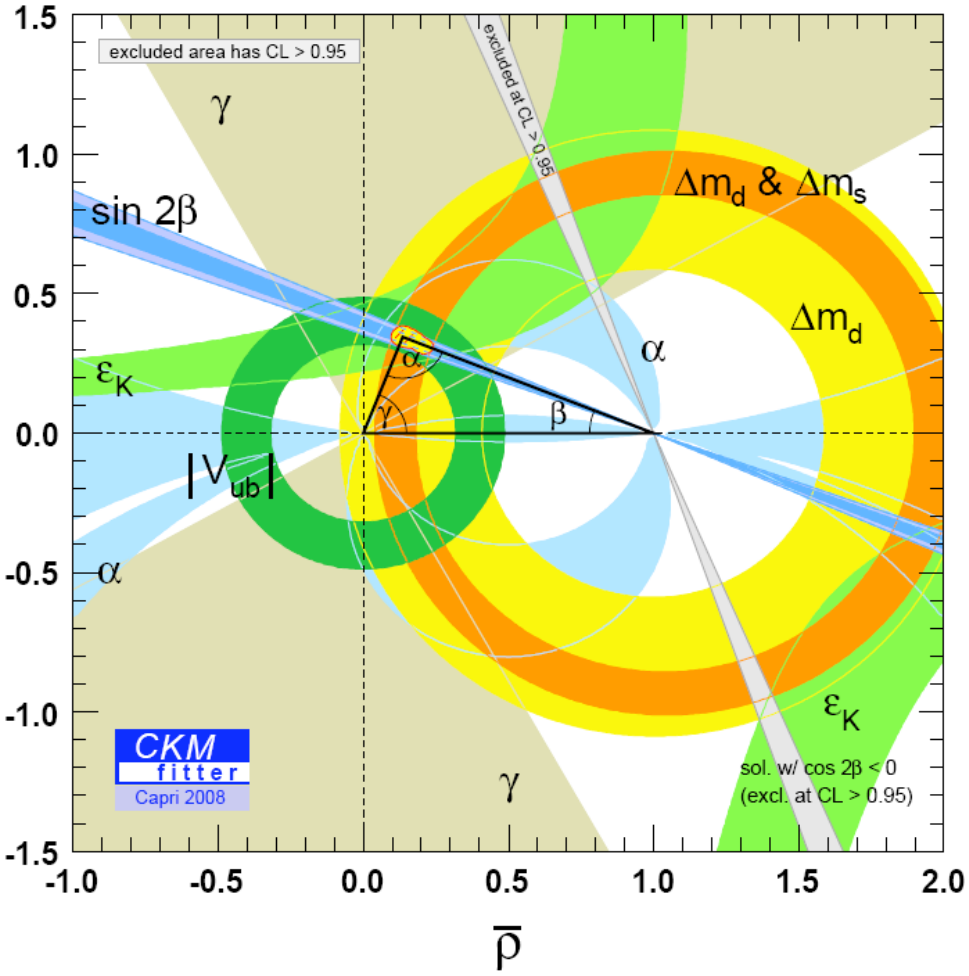


a)
Im
$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$
$\eta(1-\lambda^2/2)$
$\frac{(1-\lambda^2/2)V_{ub}^*}{\lambda|V_{cb}|}$
α
$\frac{V_{td}}{\lambda|V_{cb}|}$
γ
β
0
$\rho(1-\lambda^2/2)$
1
Re

Angle γ

	Measured values 90% CL	Fit results 90% CL
α	87.5 + 31.1 - 10.2	90.7 + 16.8 - 5.4
β	21.5 + 2.0 - 1.9	21.7 + 2.0 - 1.8
γ	76.8 + 52.7 - 50.4	67.6 + 5.3 - 15.9

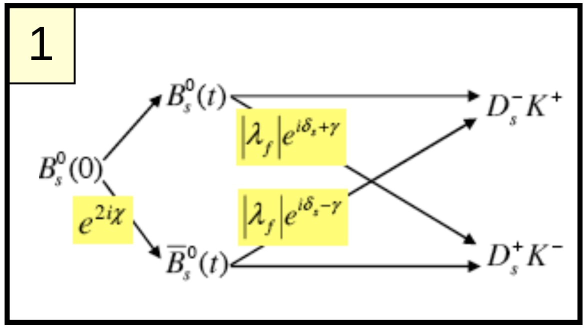
γ angle is least constrained
Key measurement of LHCb



Several independent strategies to extract γ

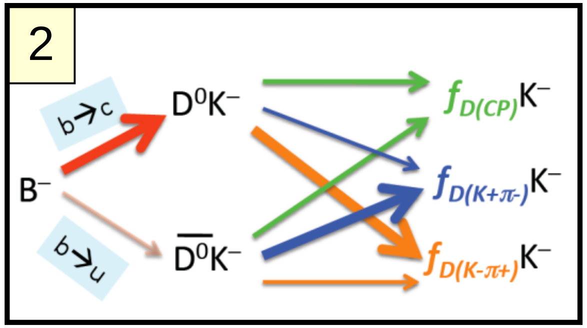
Angle γ

From tree amplitudes : $B_s \rightarrow D_sK$



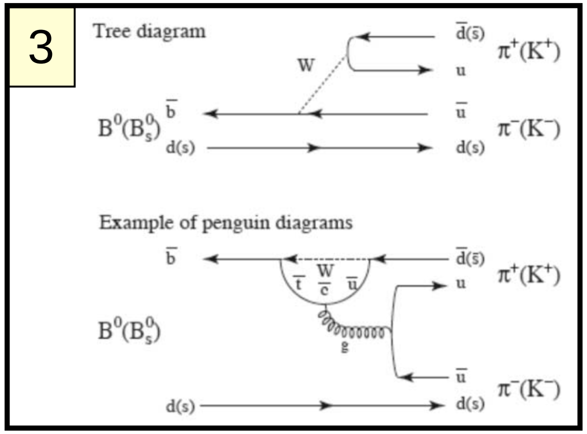
From tree amplitudes : $B \rightarrow DK$

(ADS /GLW methods)

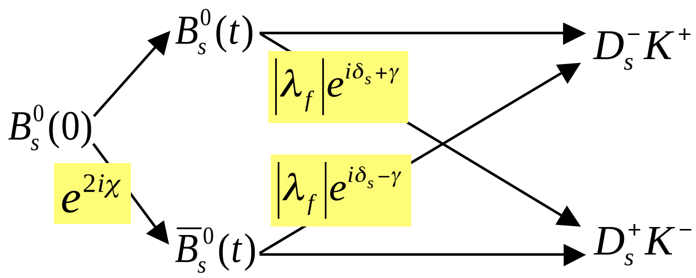


From penguins : $B \rightarrow h\ h$

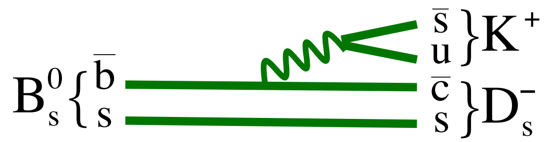
Sensitive to New Physics

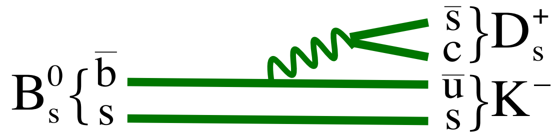


γ from $B_s \rightarrow D_sK$

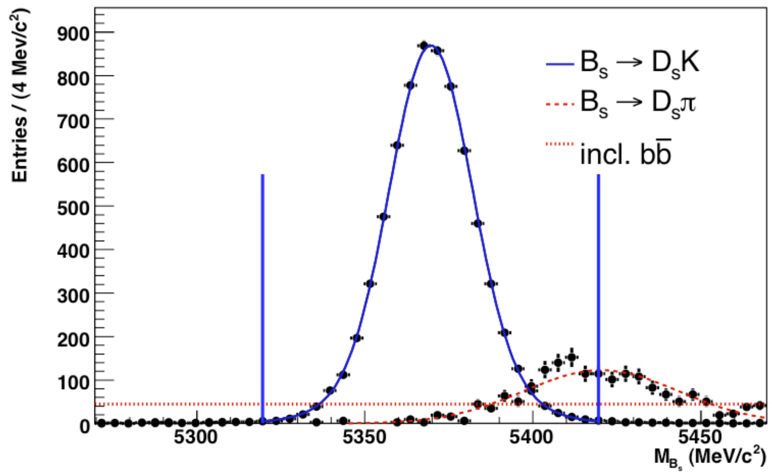


- Interference between tree level decays via mixing
- Insensitive to New Physics
- Determines γ in a clean way
- Measures $\gamma + 2\beta_s$
- β_s from $B_s \rightarrow J/\psi\phi$
- Main background $B_s \rightarrow D_s\,\pi$
  - 10 times higher branching ratio
- Suppressed using Kaon identification by RICH



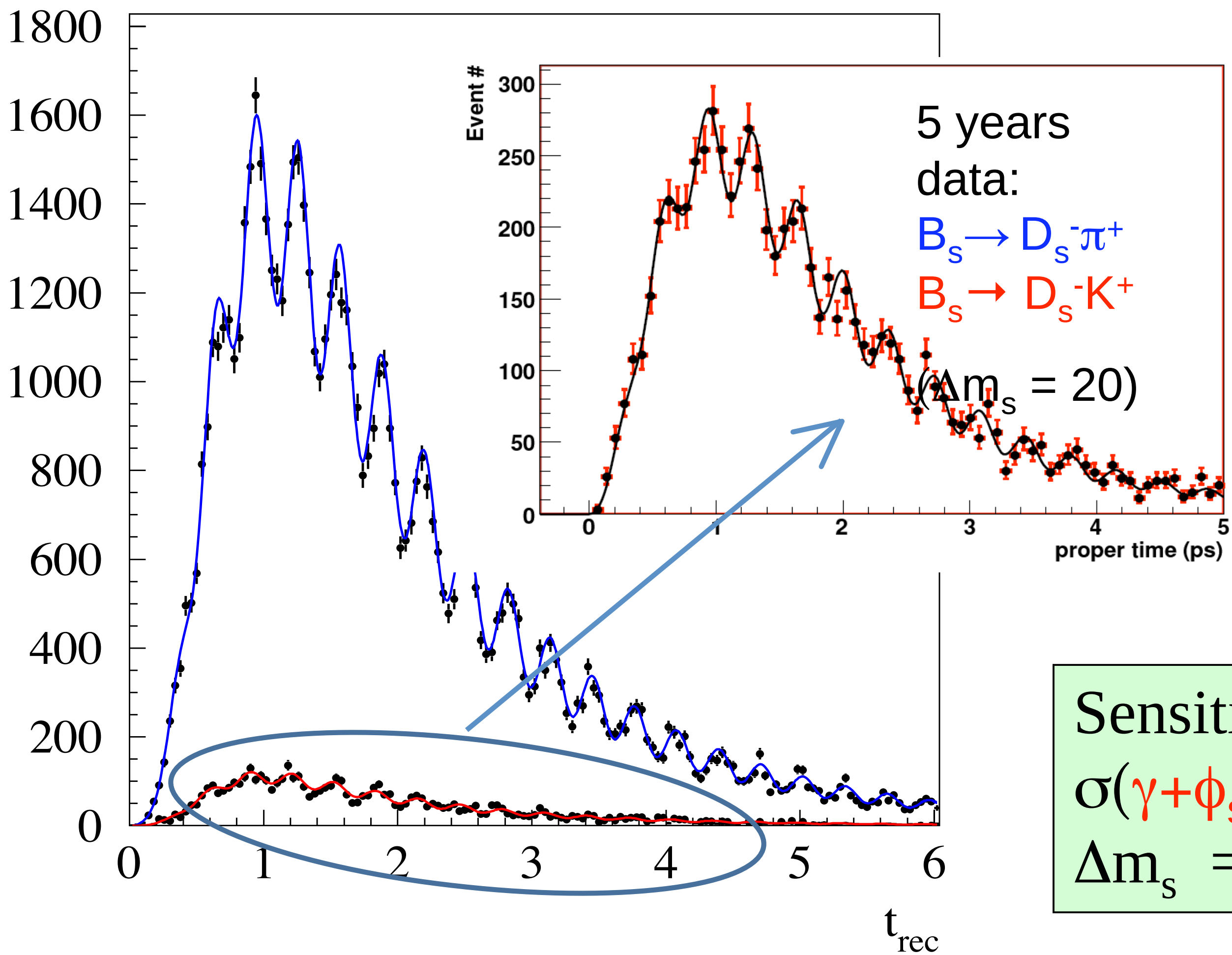


Channel	Yield (2 fb-1)	B/S (90% C.L.)
Bs→DsK	6.2 k	[0.08-0.4]
Bs→Dsπ	140 k	[0.08-0.3]



γ from $B_s \rightarrow D_sK$

$B_s \rightarrow D_sK$, $B_s \rightarrow D_s\pi$ have same topology combine samples to fit Δm_s, $\Delta\Gamma_s$ and mistag rate together with CP phase $\gamma+\phi_s$.



Sensitivity: 2 fb^{-1}

$\sigma(\gamma+\phi_s) = 9^o–12^o$

$\Delta m_s = 0.007\ ps^{-1}$

γ from $B^{\pm} \rightarrow DK^{\pm}$ (ADS)

Measure relative rates of $B^{-} \rightarrow D(K\pi) K^{-}$ and $B^{+} \rightarrow D(K\pi) K^{+}$

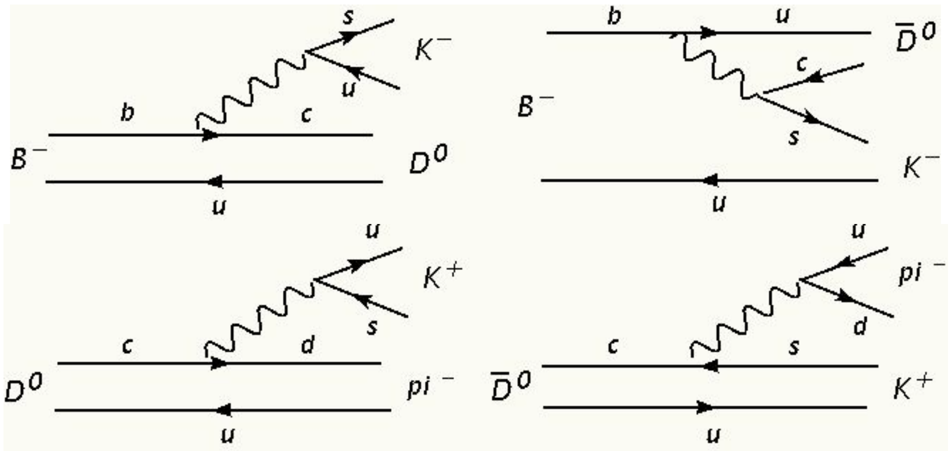
- Two interfering tree B-diagrams, one colour-suppressed (r_B ~0.077)
- D^0, anti-D^0 reconstructed in same final state (interference term accessing γ)
- Two interfering tree D-diagrams, one Double Cabibbo-suppressed ($r_D^{K\pi}$ ~0.06)

Colour allowed

Colour suppressed

Double Cabbibo suppressed

Cabbibo favoured



- Reversed suppression of the D decays relative to the B decays results in more equal amplitudes
- Large interference effects
- Simple counting experiment (no tagging, no proper time) measure:

γ from $B^{\pm} \rightarrow DK^{\pm}$ (ADS)

$$\Gamma(B^- \to (K^-\pi^+)_D K^-) \;\propto\; 1 + (r_B r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B - \delta_D^{K\pi} - \gamma\right), \quad (1)$$

$$\Gamma(B^- \to (K^+\pi^-)_D K^-) \;\propto\; r_B^2 + (r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B + \delta_D^{K\pi} - \gamma\right), \quad (2)$$

$$\Gamma(B^+ \to (K^+\pi^-)_D K^+) \;\propto\; 1 + (r_B r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B - \delta_D^{K\pi} + \gamma\right), \quad (3)$$

$$\Gamma(B^+ \to (K^-\pi^+)_D K^+) \;\propto\; r_B^2 + (r_D^{K\pi})^2 + 2 r_B r_D^{K\pi} \cos\left(\delta_B + \delta_D^{K\pi} + \gamma\right), \quad (4)$$

favoured (1), (3)

colour suppressed (2), (4)

Channel	Yield (2 fb^{-1})	B/S
$B \rightarrow D(hh)\ K$	7.8 k	1.8
$B \rightarrow D(K\pi)\ K$, Favoured	56 k	0.6
$B \rightarrow D(K\pi)\ K$, Suppressed	0.71k	2
$B \rightarrow D(K3\pi)\ K$, Favoured	62k	0.7
$B \rightarrow D(K3\pi)\ K$, Suppressed	0.8k	2

$\sigma(\gamma)$ = 5^o to 13^o depending on strong phases.

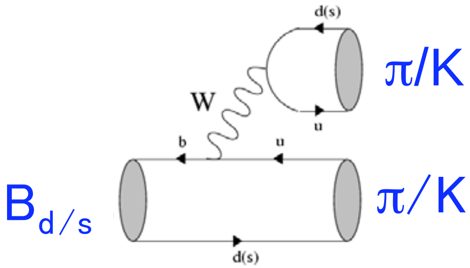
<u>Also under study:</u>

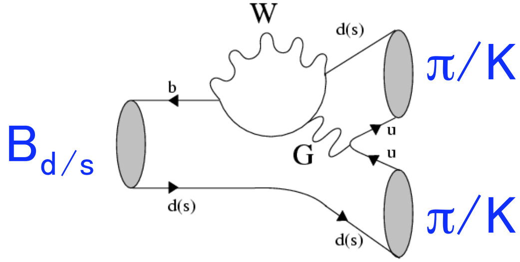
	$\sigma(\gamma)$	
$B^{\pm} \rightarrow DK^{\pm}$ with $D \rightarrow K_s\ \pi\pi$	8^0–12^o	Dalitz analyses
$B^{\pm} \rightarrow DK^{\pm}$ with $D \rightarrow KK\ \pi\pi$	18^o	Dalitz analyses
$B^0 \rightarrow DK^{*0}$ with $D \rightarrow KK, K\pi, \pi\pi$	6^o –12^o	
$B^{\pm} \rightarrow D^*K^{\pm}$ with $D \rightarrow KK, K\pi, \pi\pi$	(high background)	

<u>Overall</u>: expect precision of $\sigma(\gamma)$ = 5^o with 2 fb^{-1} of data

γ from $B \to hh$

- $B^0 \to \pi^+\pi^-$ originally proposed for measurement of angle $\alpha = \pi - \beta - \gamma$
- But extraction of α compromised by influence of penguin diagrams





- Measure time-dependent CP asymmetries for $B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$

$$A_{CP}(t) = A_{dir} \cos(\Delta m\, t) + A_{mix} \sin(\Delta m\, t)$$

- Extract four asymmetries:

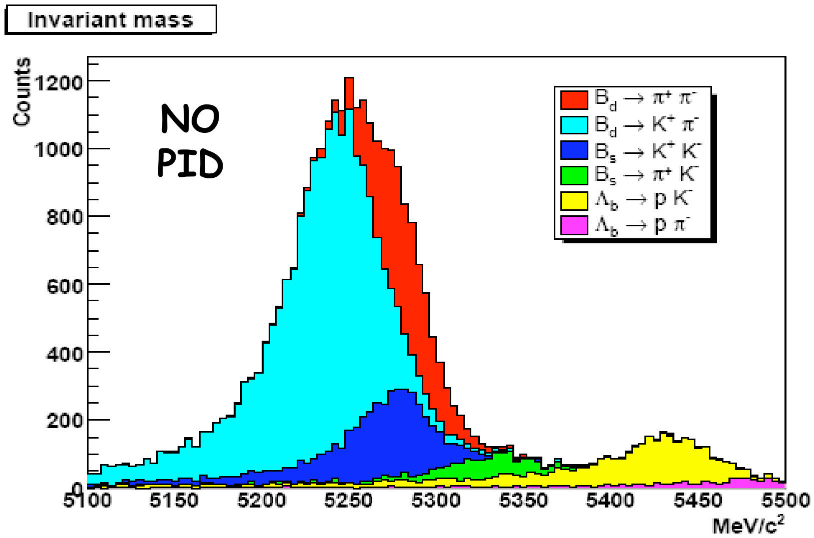
$$A_{dir}(B^0 \to \pi^+\pi^-) = f_1(d, \theta, \gamma)$$
$$A_{mix}(B^0 \to \pi^+\pi^-) = f_2(d, \theta, \gamma, \beta)$$
$$A_{dir}(B_s \to K^+K^-) = f_3(d', \theta', \gamma)$$
$$A_{mix}(B_s \to K^+K^-) = f_4(d', \theta', \gamma, \beta_s)$$

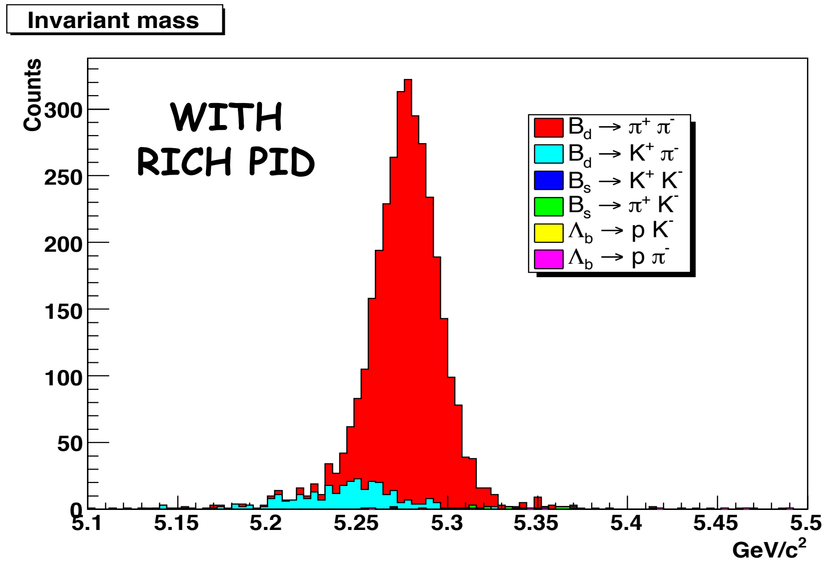
$de^{i\theta}$ = ratio of penguin and tree amplitudes in $B^0 \to \pi^+\pi^-$

$d'e^{i\theta'}$ = ratio of penguin and tree amplitudes in $B_s \to K^+K^-$

- Assume U-spin flavour symmetry ($d \Leftrightarrow s$) $d = d'$ and $\theta = \theta'$
- Take ϕ_d from $B_d \to J/\psi\, K_S$ and ϕ_s from $B_S \to J/\psi\, \phi$ solve for γ
- 4 observables , 3 unknowns (can relax U-spin assumptions)

γ from B → hh





Channel	Yield (2 fb^{-1})	B/S
$B \rightarrow \pi\pi$	36k	0.5
$B_s \rightarrow KK$	36k	0.15

$\sigma(\gamma) \sim 10^o$ with 2 fb^{-1}

$\sigma(\gamma) \sim 5^o$ with 10 fb^{-1}

θ, θ' free in the fit

Assume d = d' (at 20 % level)

Summary

- LHCb will collect high statistics samples of B hadrons
  - Including B_s and b baryons
- Detector installed and being commissioned for physics this summer
- First physics in 2008 with 5 pb^{-1}
  - Alignment and detector calibration
  - Particle multiplicities
  - Ks and Λ production
  - Charmomium physics
  - Preparation for B physics measurements in 2009

Summary

- Key measurements with 0.5 fb^{-1} in 2009:
  - β_s [precision ~0.04]
  - Bs →mm [exclusion down to SM model expectation]
- Full physics program in 2010+: aim to collect 10 fb^{-1} by ~ 2013+
  - Angle γ precision ~ 5^o with 2 fb^{-1}
  - Search for new physics in photon polarization in radiative penguin decays
  - Precision measurement of forward-backward asymmetry in B →K*μμ
  - Δm_s precision of 0.01 ps^{-1}
  - sin2β precision of 0.01 with 10 fb^{-1}
  - α with B → ρπ precision of 10^o
  - Charm physics: D^0 mixing, direction CP violation in D^0→ KK, D^0→μμ
  - Z, W production at high rapidity
  - And much more

LHCb offers an excellent opportunity to spot New Physics signals beyond the Standard Model

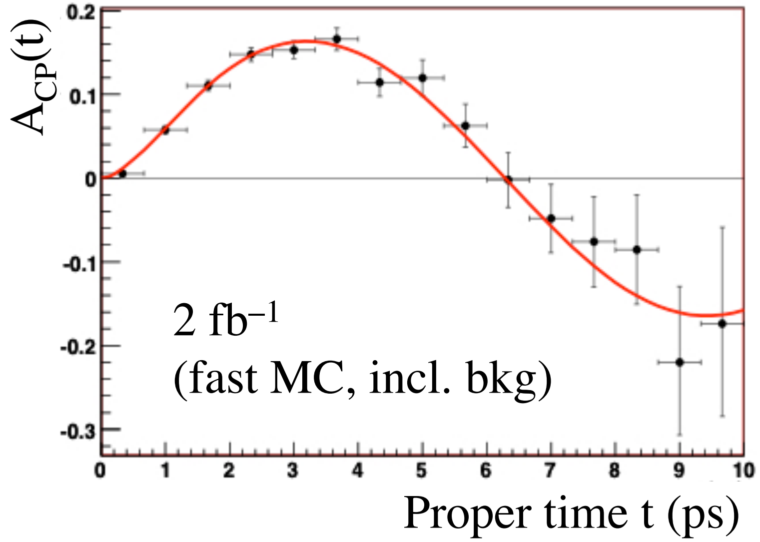
Backup

$\sin 2\beta$ with $B^0 \to J/\psi K_s$

Time dependent CP asymmetry in will one of the first CP measurements at LHCb.

- 236k signal events / 2 fb^{-1}
- B/S= 0.6 (bb)
- $\sigma_{stat}(\sin(2\beta)) = 0.020$ in 2 fb^{-1}
- cf ~0.019 expected from B-Factories with 2ab^{-1}

$$A_{CP}(t) = \frac{N\left(\overline{B}^0 \to J/\psi K_S\right) - N\left(B^0 \to J/\psi K_S\right)}{N\left(\overline{B}^0 \to J/\psi K_S\right) + N\left(B^0 \to J/\psi K_S\right)}$$



With 10 fb^{-1}: σ (sin(2β)) ~ 0.010

Can also push further the search for direct CP violating term $\cos(\Delta m_d t)$

Charm Physics

LHCb will collect large tagged $D^* \to D^0 \pi$ sample

- Used for PID calibration
- Dedicated D* trigger for this purpose.
- Tag flavour with pion from $D^{*\pm} \to D0\ \pi^{\pm}$

D*-tagged signal yield in 2 fb^{-1} (from b hadrons only)	
$D^0 \to K^-\pi^+$ right sign	12.4 M
$D^0 \to K^+\pi^-$ wrong sign	46.5 k
$D^0 \to K^+K^-$	1.6 M

Interesting measurements:

- Time-dependent D^0 mixing with wrong-sign $D^0 \to K^+\pi^-$ decays
  - $\sigma_{stat}(x'2)$ ~0.14 $\times 10^{-3}$, $\sigma_{stat}(y')$ ~2 $\times 10^{-3}$ with 2 fb^{-1}
- Direct CP violation in $D0 \to K^+K^-$
  - $A_{CP} < 10^{-3}$ in SM, up to 1% with New Physics
  - Expect $\sigma_{stat}(A_{CP})$ ~ 0.001 with 2 fb^{-1}
- $D^0 \to \mu^+\mu^-$
  - $BR < 10^{-12}$ in SM, up to 10^{-6} with New Physics
  - Expect to reach ~5×10^{-8} with 2 fb^{-1}