Status of the LHCb Experiment

Mitesh Patel (CERN)

29th March 2006

Introduction

- LHCb is the dedicated B physics experiment at the LHC designed for the precision study of CP violation and rare decays

- Following cancellation of BTeV + foreseen closure of BaBar LHCb may become the *only* running B physics experiment after the B-factories (unless Super-Belle is approved)

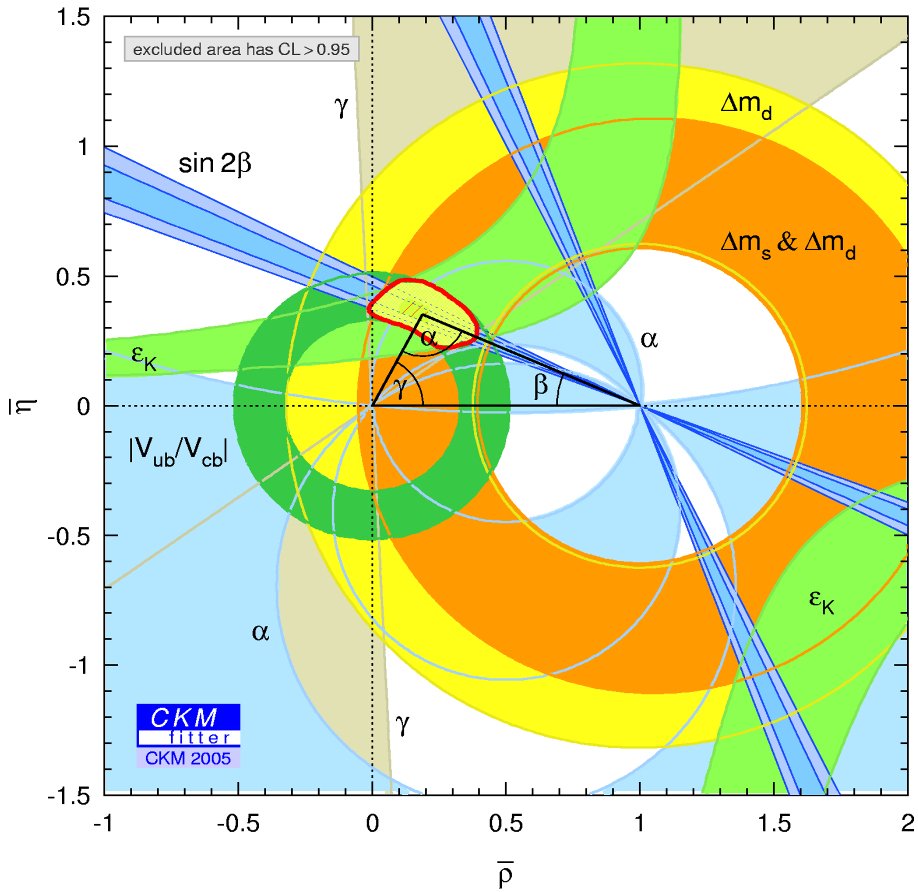
- Syracuse University group from BTeV recently joined LHCb
  $\rightarrow$ now 47 institutes in 16 countries
  > 600 authors

- Why are we preparing a B physics experiment, after the B-factories?

- Spectacular progress from the B-factories :

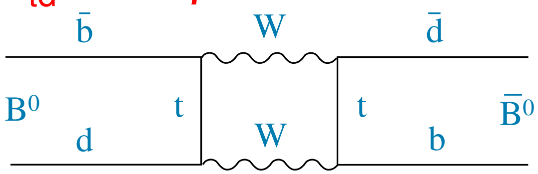
  Precision result of their baseline measurement A_{CP} ($J/\psi K_S$) in striking agreement with the Standard Model CKM picture

- Also performed an impressive range of additional measurements

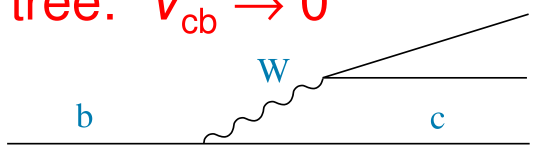


- However… $\sin 2\beta_{b\to s} = \sin 2\beta_{b\to c}$ in the Standard Model

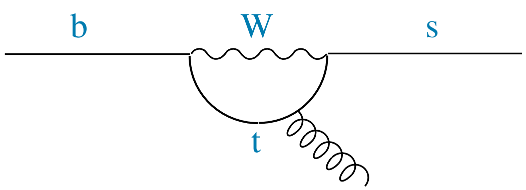
Box: $V_{td}^2 \to 2\beta$

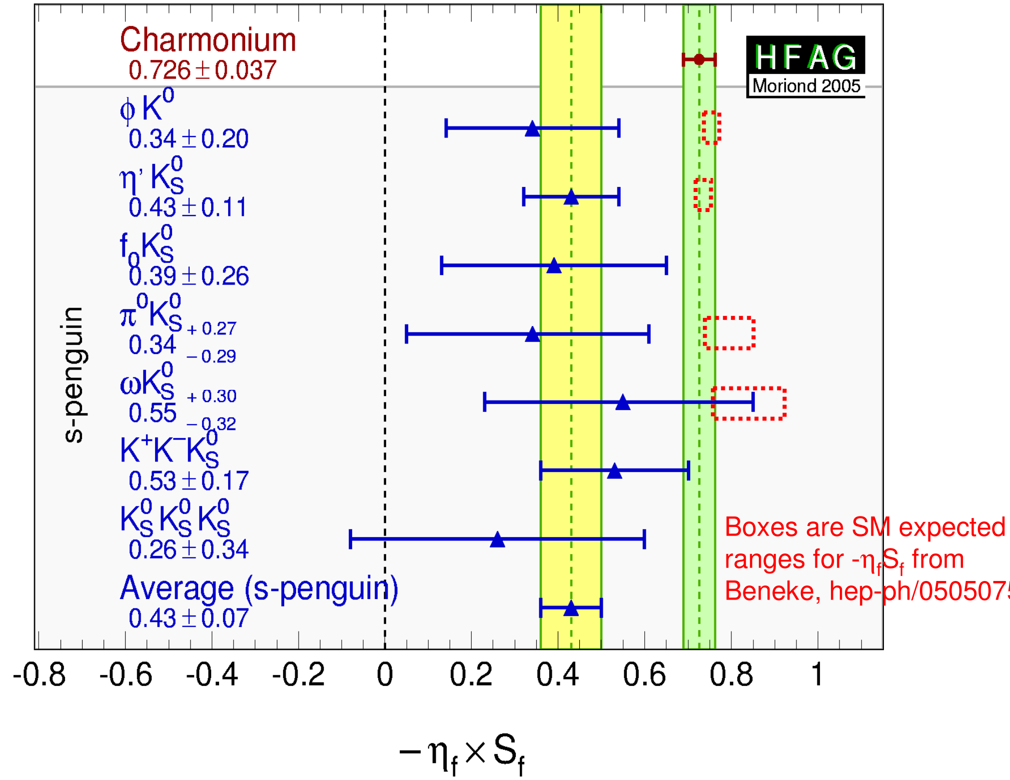


$b \to c$ tree: $V_{cb} \to 0$



$b \to s$ penguin: $V_{ts} \to \sim 0$

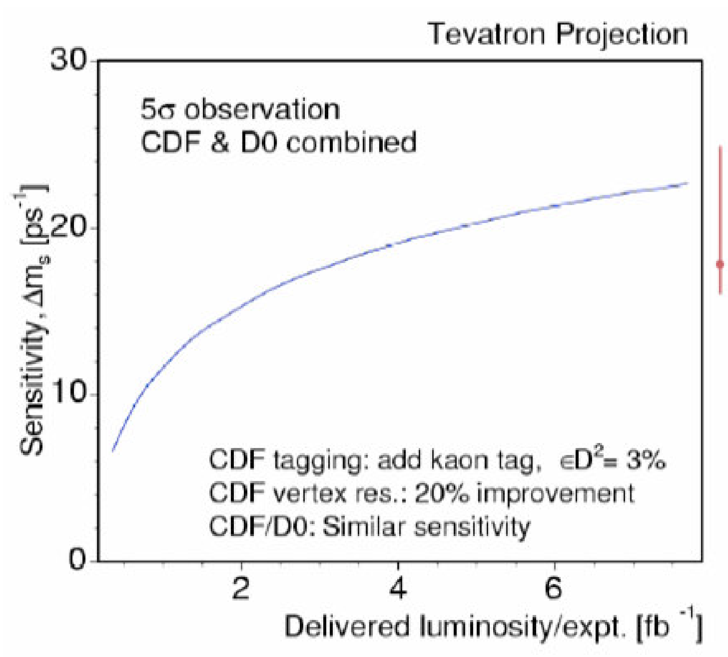


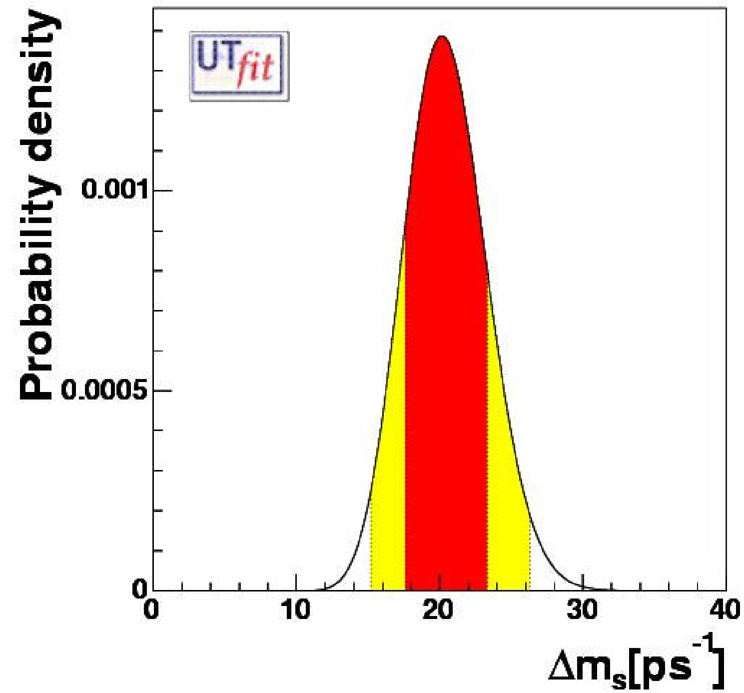


- If $b \to s$ transition has a contribution from new physics
  - should see effect in other modes, such as $B_s \to \phi\phi$
  - may give increased branching ratio for $B_s \to \mu^+\mu^-$
  - B_s oscillation may be affected $\to$ higher frequency Δm_s
  - or larger CP violation in $B_s \to J/\psi\phi$

B_s–$\overline{B}_s$ oscillation

- Expected value of $\Delta m_s < 30\ ps^{-1}$ from Standard Model CKM fits
- If Δm_s as expected in Standard Model CDF or D0 might measure it …

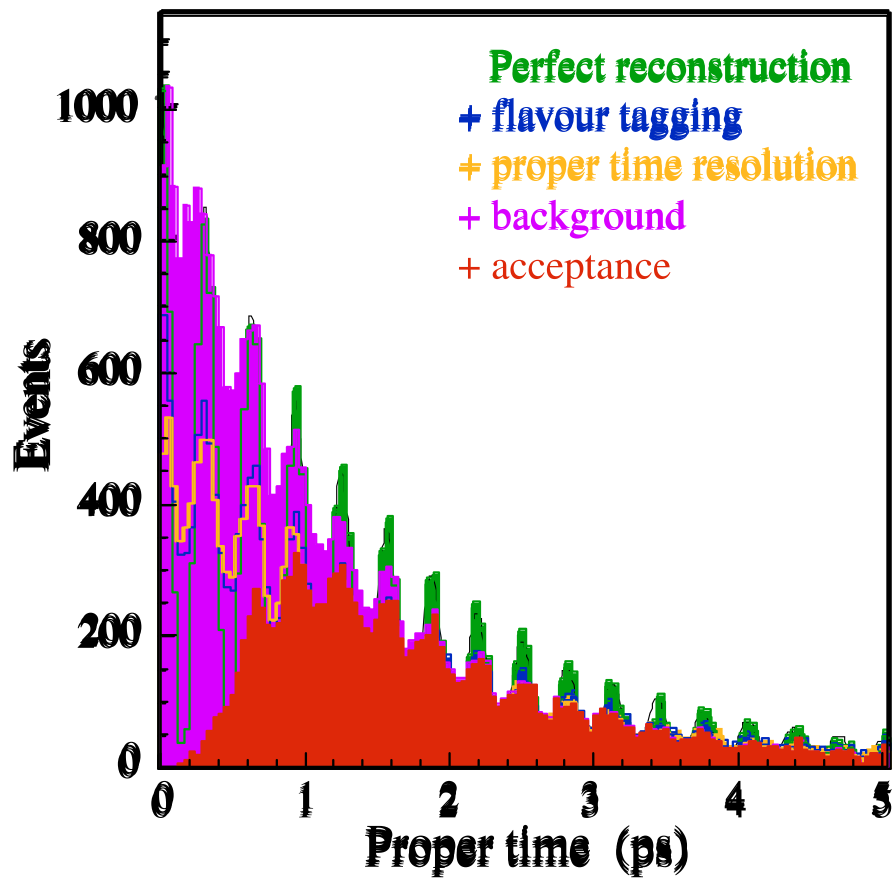




But if the value is *beyond* the Standard Model expectation, LHCb should be the first to see it (or rule out the entire SM range)

B physics sensitivity

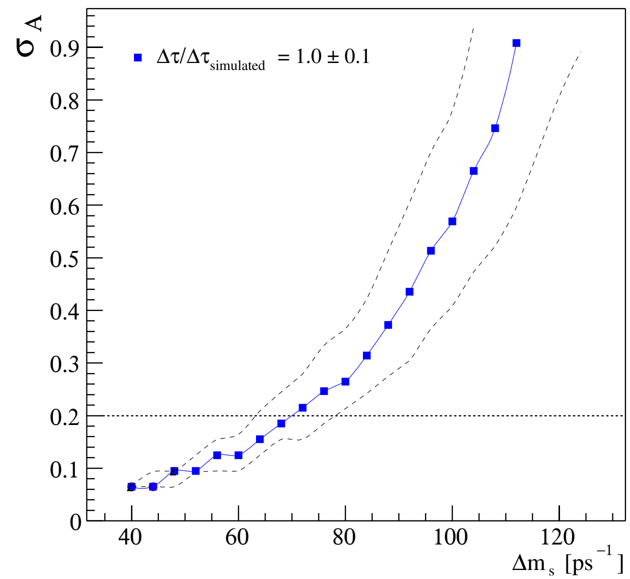
- Illustrate analysis steps for measurement of B_s–$\overline{B}_s$ oscillations
- Use mode: $B_s \rightarrow D_s^- \pi^+$
  Plot made for 1 year of data (80k selected events) for Δm_s = 20 ps^{-1} (SM preferred)



- Diluted by flavour tagging:
  εD^2 ~ 6% for B_s decays
- Proper time resolution ~ 40 fs
- Signal/Background ~ 3
  (from 10^7 inclusive bb events)
- Include effect of acceptance:
  Oscillations still clearly seen

B_s–$\overline{B}_s$ oscillation sensitivity

- Plot uncertainty on amplitude of fitted oscillation *vs* Δm_s:



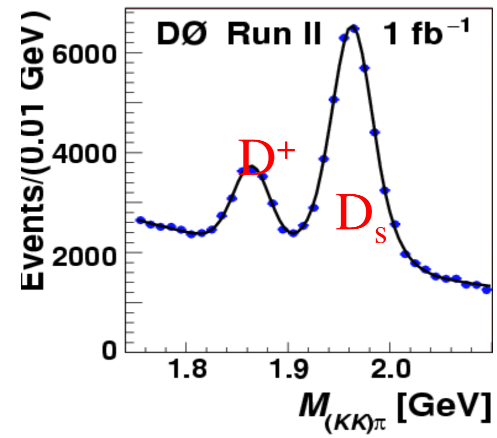
- 5σ observation of B_s oscillation for $\Delta m_s < 68$ ps^{-1} (in one year) $\rightarrow$ LHCb could exclude *full* SM range
  Once observed, precise value is obtained: $\sigma_{stat}(\Delta m_s) \sim 0.01$ ps^{-1}

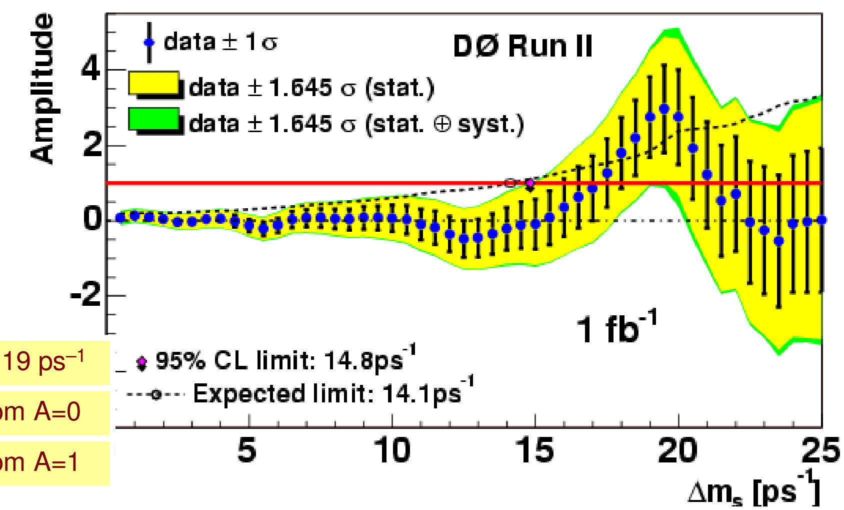
- Use mode $B_s \rightarrow J/\psi\phi$ to measure the phase of B_s oscillation
  In Standard Model expected asymmetry $\propto \sin 2\chi$
  = very small (~ 0.04) $\rightarrow$ sensitive probe for new physics

- 120,000 events should be reconstructed per year
  $\rightarrow \sigma(\sin 2\chi) \sim 0.06$, $\sigma(\Delta\Gamma_s/\Gamma_s) \sim 0.02$ in one year

New D0 result on Δm_s

- V.M. Abazov et al. (D0 collaboration),
  "First Direct Two-Sided Bound on the B_s Oscillation Frequency"
  hep-ex/0603029, March 15, 2006, submitted to PRL :
  - 1 fb^{-1} of data (April 2002–October 2005)
  - $B_s \to D_s^-(^*)\mu^+\nu X$, $D_s^- \to \phi(K^+K^-)\pi$
  - 26.7 k signal events
  - proper decay length measured in transverse plane
    use MC "K factor" to correct $p_T(D_s\mu)$ to $p_T(B_s)$
  - opposite-side tagging, $\varepsilon D^2 = (2.48 \pm 0.21 \pm 0.07)\%$

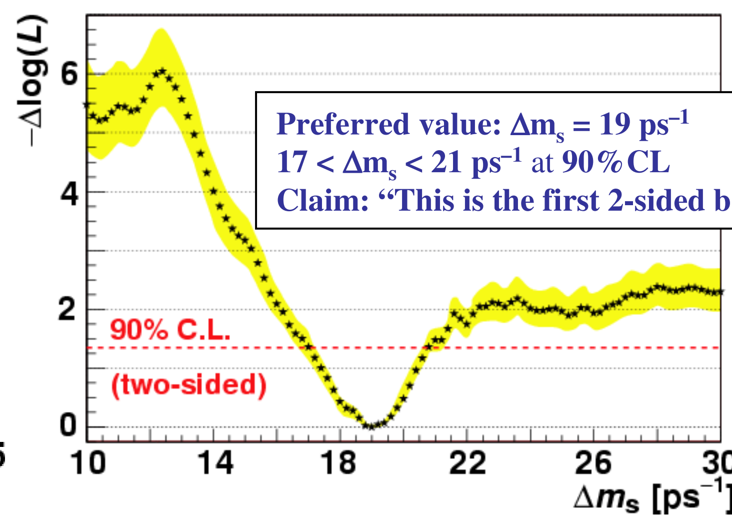




A=2.75 ± 1.12 at 19 ps^{-1}

2.5σ deviation from A=0

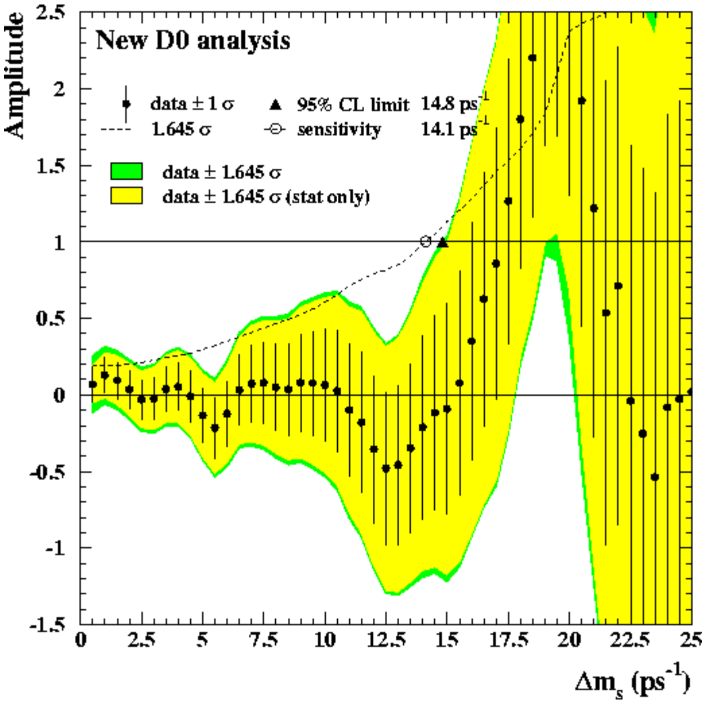
1.6σ deviation from A=1



Preferred value: $\Delta m_s = 19\ ps^{-1}$
$17 < \Delta m_s < 21\ ps^{-1}$ at 90% CL
Claim: "This is the first 2-sided bound"

- D0 do not claim a measurement

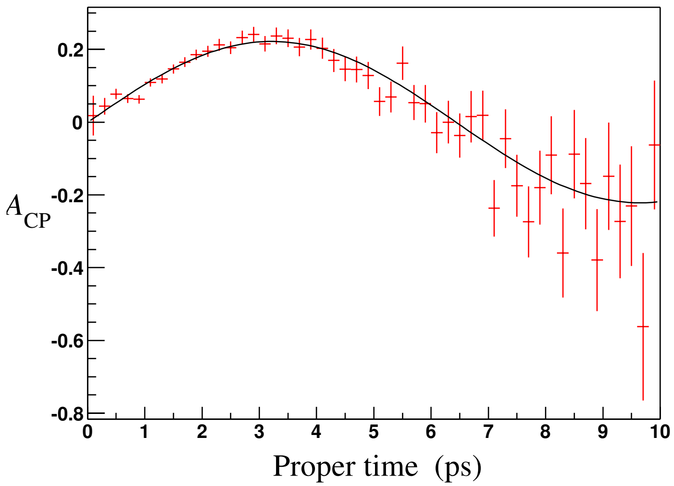
D0 sensitivity	Now at 1 fb^{-1}	Extrapolated to 10 fb–1
5σ observation of Δm_s up to	5.6 ps^{-1}	14.4 ps^{-1}
3σ observation of Δm_s up to	9.3 ps^{-1}	18.6 ps^{-1}
95% CL exclusion up to	14.1 ps^{-1}	24.1 ps^{-1}



- No sensitivity yet to observe a signal above 10 ps^{-1}
- Need 10 times more data (or equivalent analysis improvements) for a 3σ observation at 19 ps^{-1}

Other topics

- Sin 2β not a central physics goal (as so well measured by B-factories) but an important check :
  Expect 240,000 reconstructed
  $B^0 \to J/\psi K_S$ events/year
  $\sigma_{stat}(\sin 2\beta) \sim 0.02$ in one year



- Measure γ in various channels, differing sensitivity to new physics:
  - Time-dependent CP asymmetry of $B_s \to D_s^- K^+$ and $D_s^+ K^-$ $\to \sigma_\gamma \sim 14^o$
  - Asymmetries of $B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$ (U(1) sym, loop eff.) $\to \sigma_\gamma \sim 5^o$
  - Decay rates in the $B^0 \to D^0 K^{*0}$ system $\to \sigma_\gamma \sim 8^o$
  - Asymmetries of decays $B^\pm \to D^0 K^\pm$ – potentially LHCb's most precise measurement of γ – will come back to…

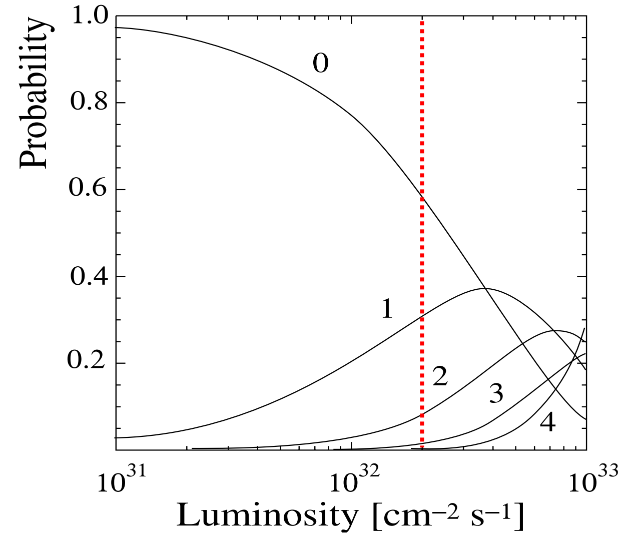
- Study rare decays such as $B_s \to \mu^+\mu^-$ and $B^0 \to K^{*0} \mu^+\mu^-$ etc…

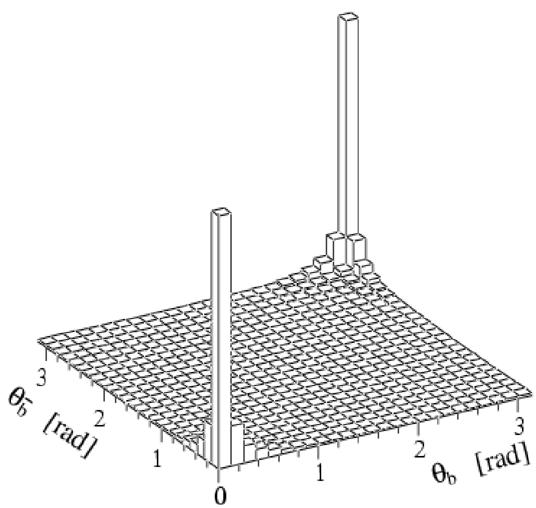
B production at LHC

- Large b cross section σ_{bb} ~ 500 μb
  But only ~ 0.5% of total cross section

- Pile-up at high luminosity:
  Choose luminosity ~ 2 $\times 10^{32}$ $cm^{-2}s^{-1}$
  Tuneable by defocusing beams
  $\rightarrow$ most events have single interactions
  + reduced radiation dose

pp interactions/crossing

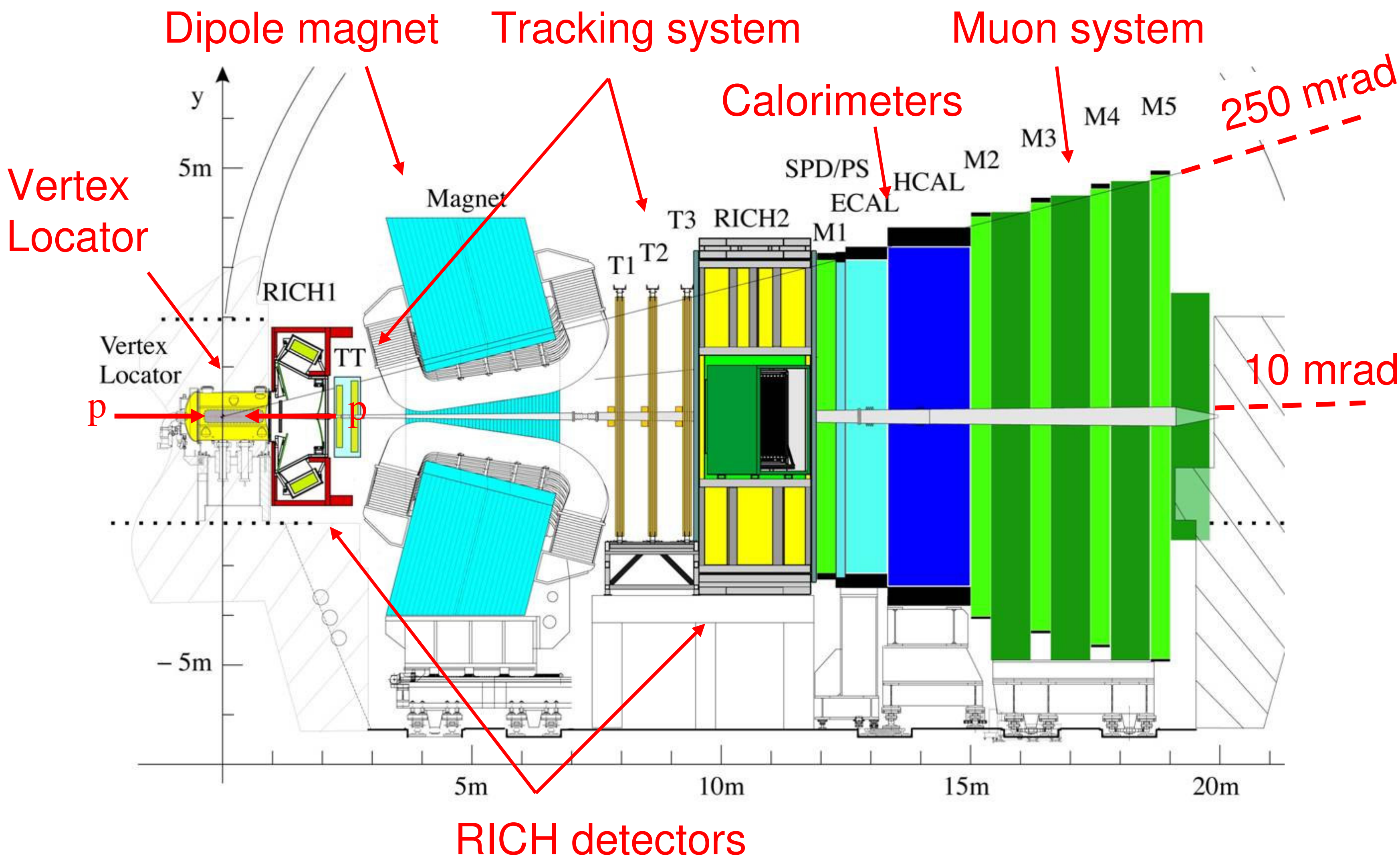




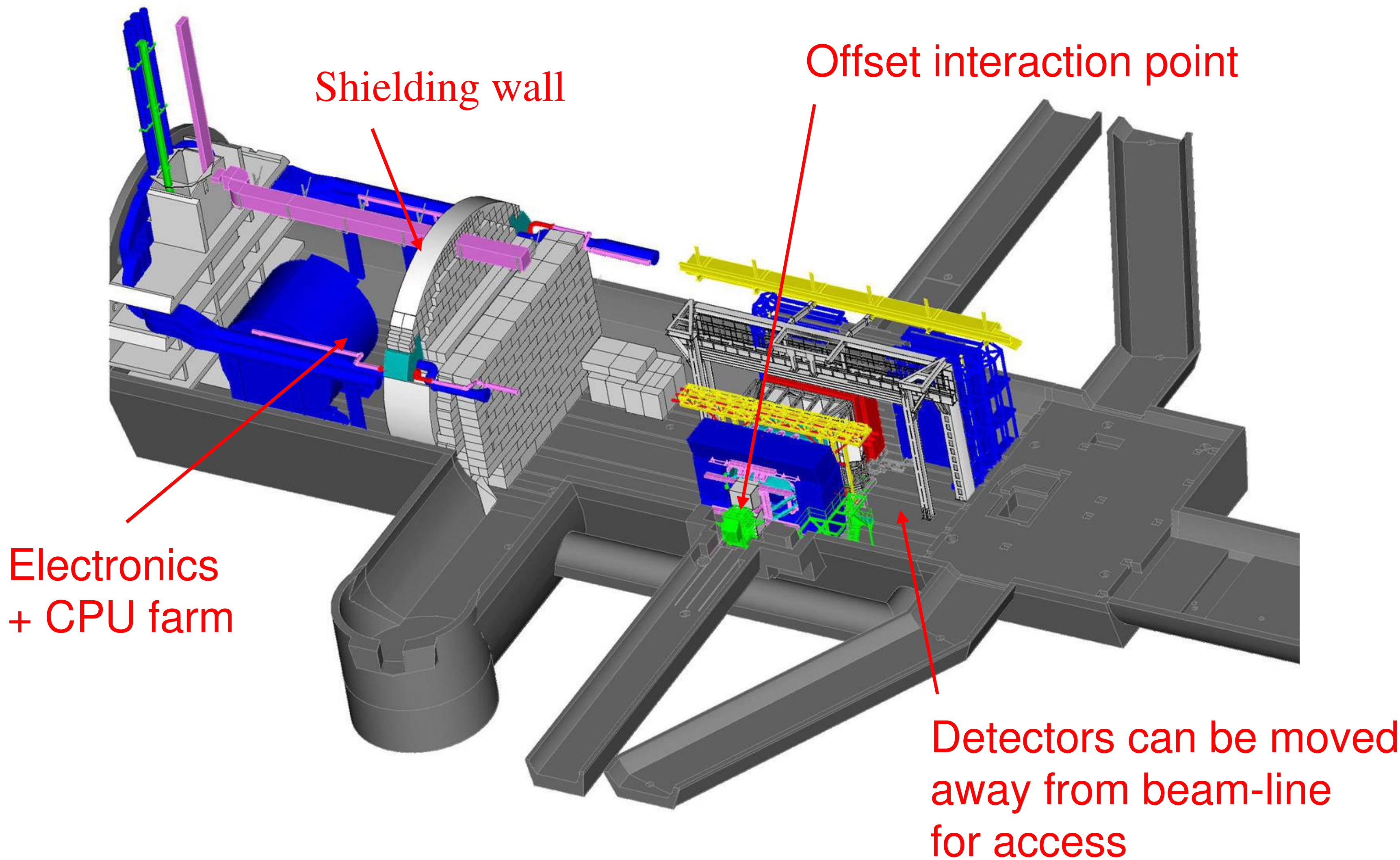
- 10^7 s taken as nominal "year" = 2 fb^{-1}
  $\rightarrow$ 10^{12} bb produced/year

- Forward peaked b production at the LHC
  $\rightarrow$ LHCb is a forward spectrometer

Spectrometer



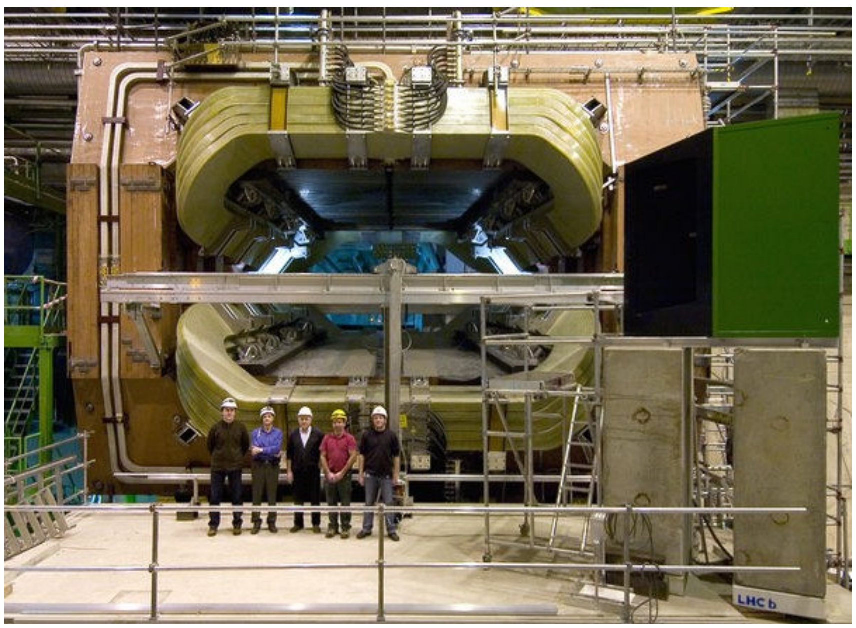
LHCb at Point 8



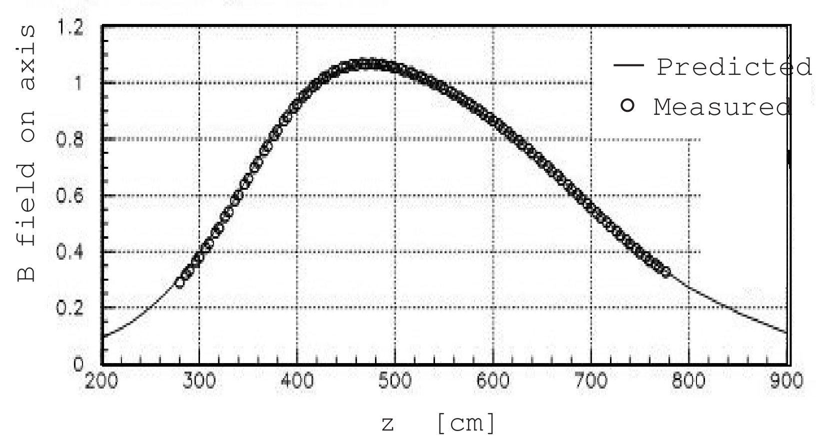
Detector status

- Conical Be beam-pipe: completed

- Warm dipole magnet: $\int B\, dL = 4$ Tm
  Regular field reversal planned
  for systematic control of CP

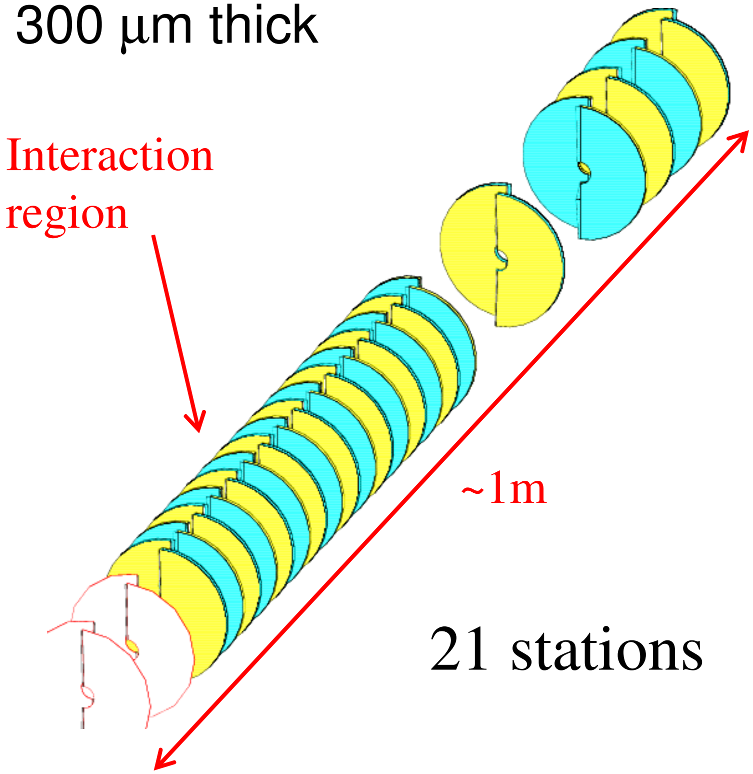


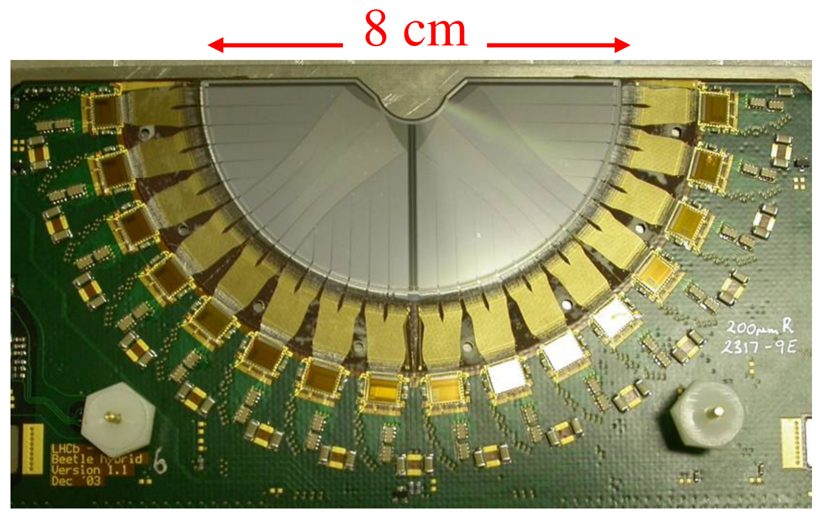
Field mapping completed

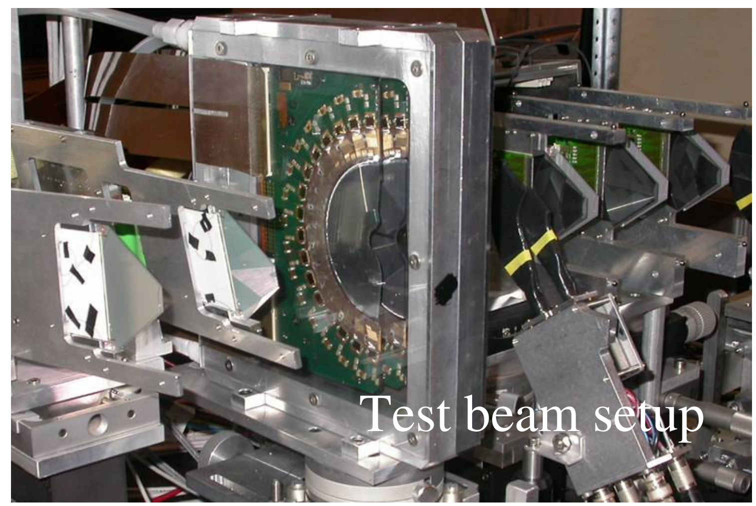


Vertex locator

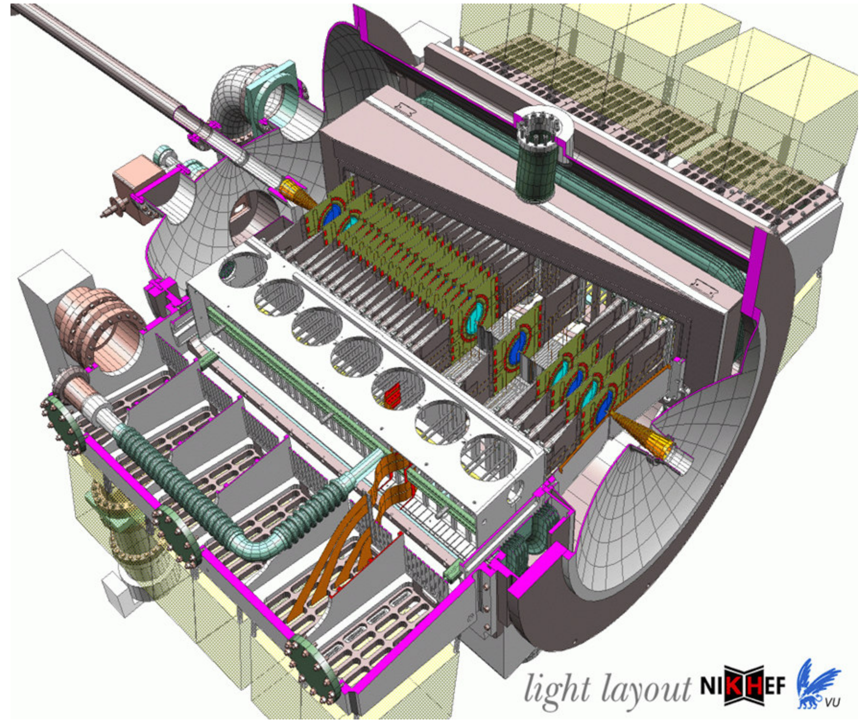
- Silicon microstrip detector with *r*-ϕ geometry
- Variable pitch 40–100 μm 300 μm thick







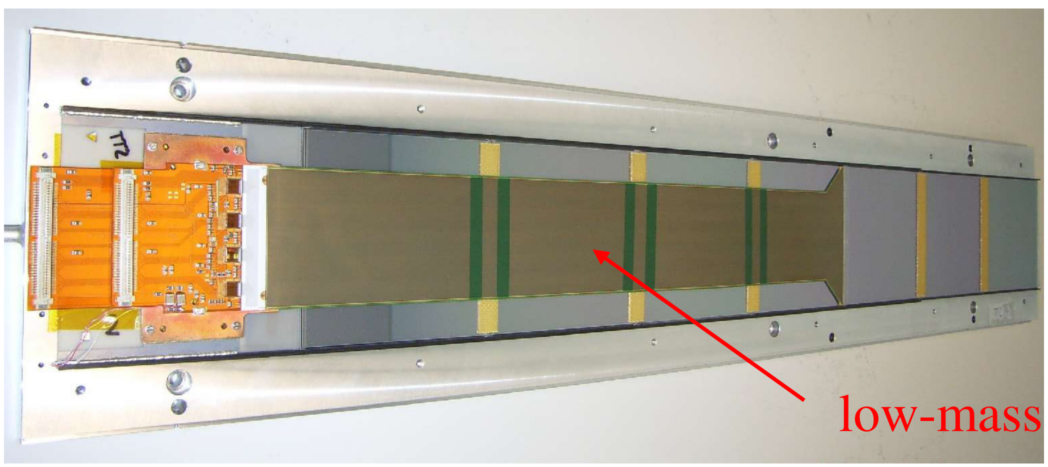
- To give precise reconstruction, silicon approaches to 8 mm from beam
- Uses secondary vacuum system like a Roman Pot

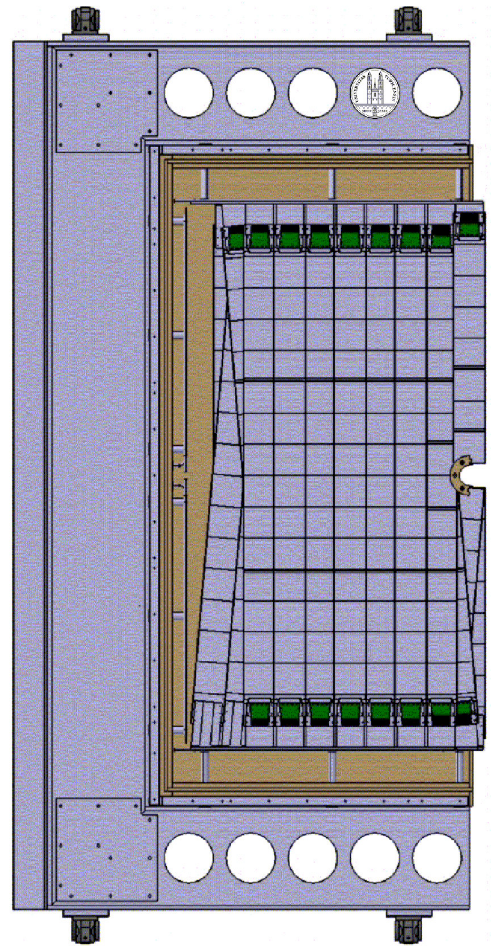


- Complex mechanics to allow retraction during injection: close to completion
- Module production in progress

Trigger Tracker

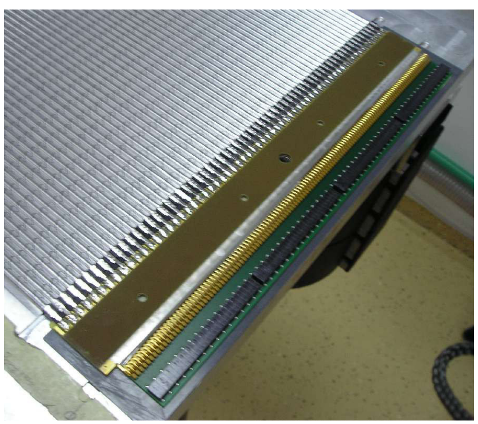
- Silicon strip detectors covering full acceptance upstream of magnet: ~ 8 m^2
  Together with Vertex Locator measures p_T of tracks for use in the trigger
- 500 μm silicon, CMS OB2-type sensors
- Now in production

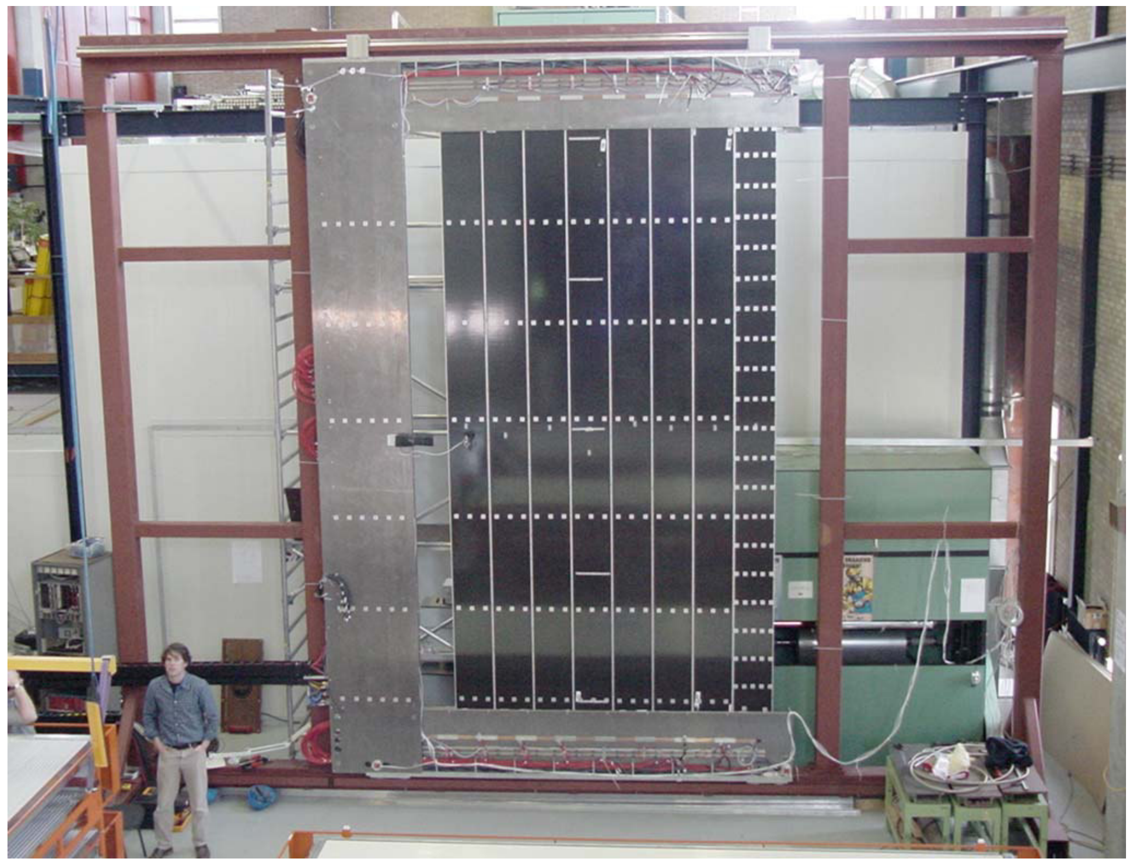




Outer Tracker

- 3 stations each made up of 4 double-layers of Kapton/Al straws glued together to form modules: module production now complete

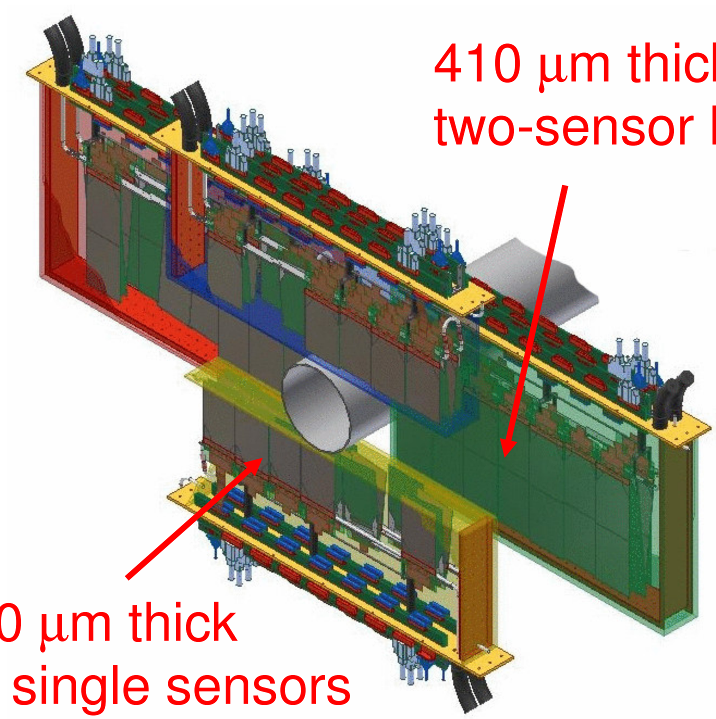


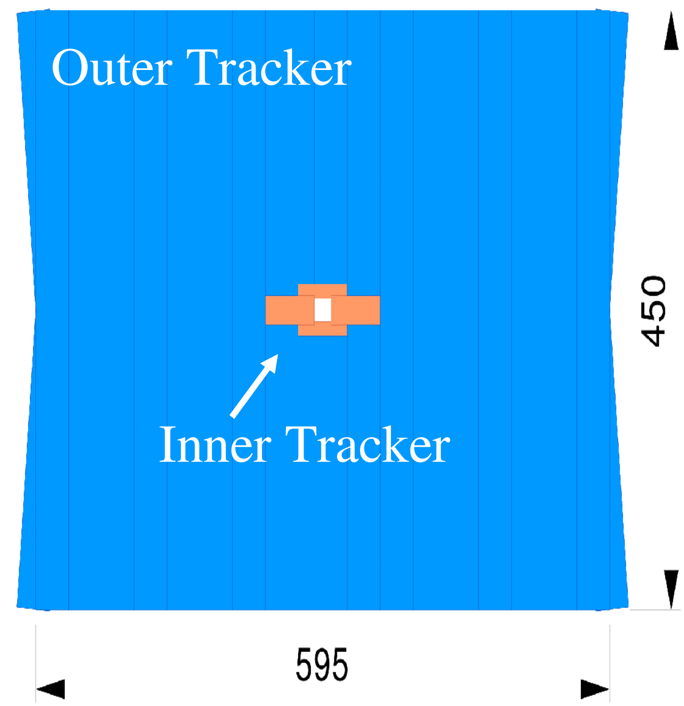


Inner Tracker

- Silicon strip detectors close to beam pipe, in region of high occupancy: only 2% of area, but 20% of tracks

- 11 cm strips, 198 µm pitch
  arranged in boxes around beam pipe



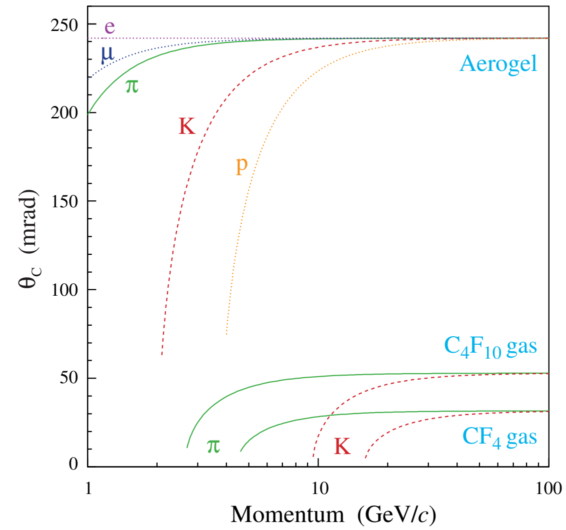


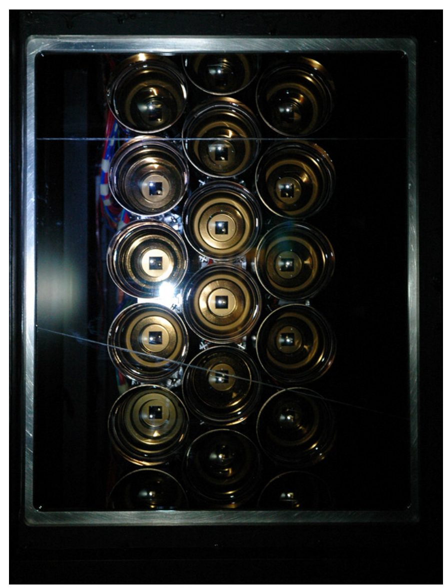
Production of ladders under way

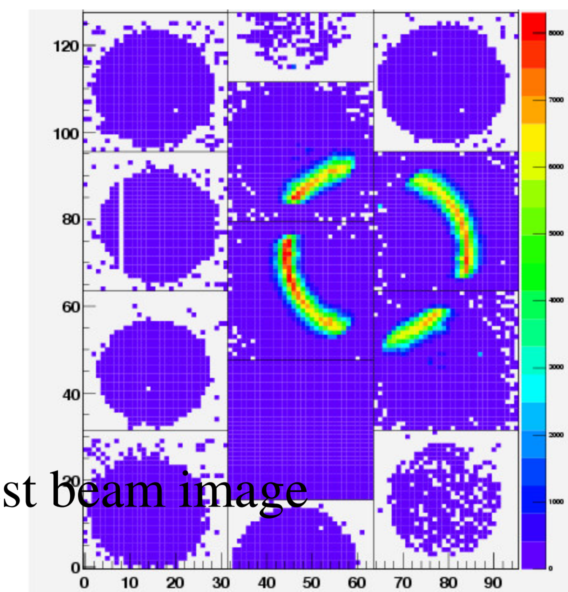
RICH system

- Three radiators used to give
  π-K separation from 2–100 GeV

- Novel photon detectors:
  Hybrid Photon Detectors
  ~ 500 tubes, each with ~1000 pixels
  Production underway

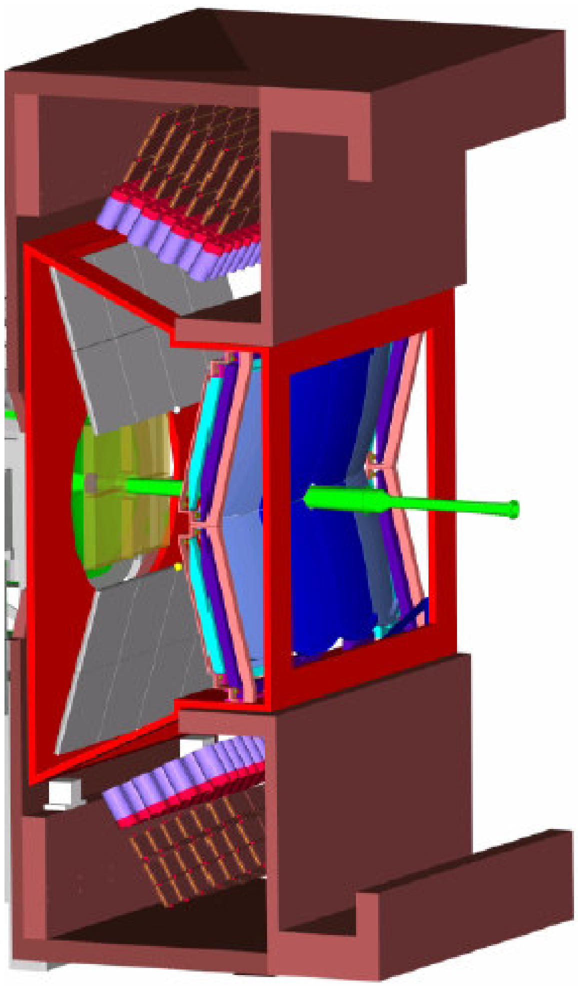






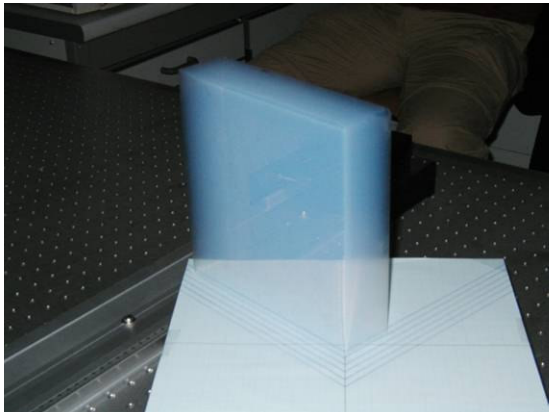
Test beam image

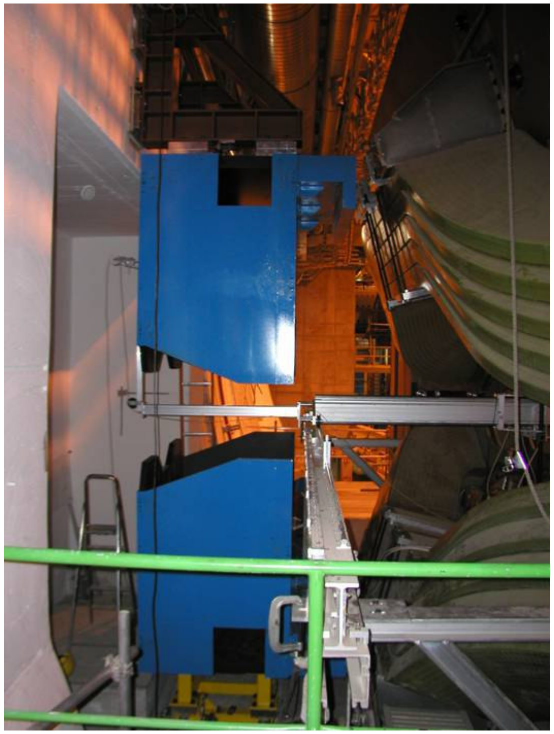
- RICH-1 (before magnet) combines the use of aerogel and C_4F_{10} gas radiators for low momentum tracks



- Vessel under construction, magnetic shielding box for HPDs installed

- High clarity aerogel developed, production nearing completion

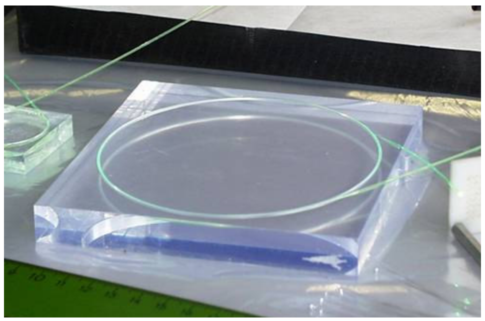


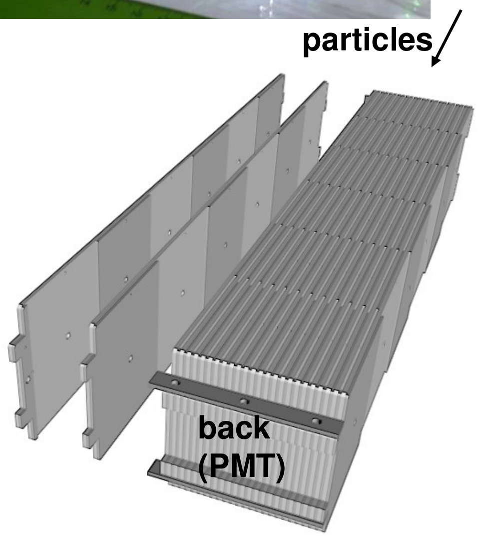


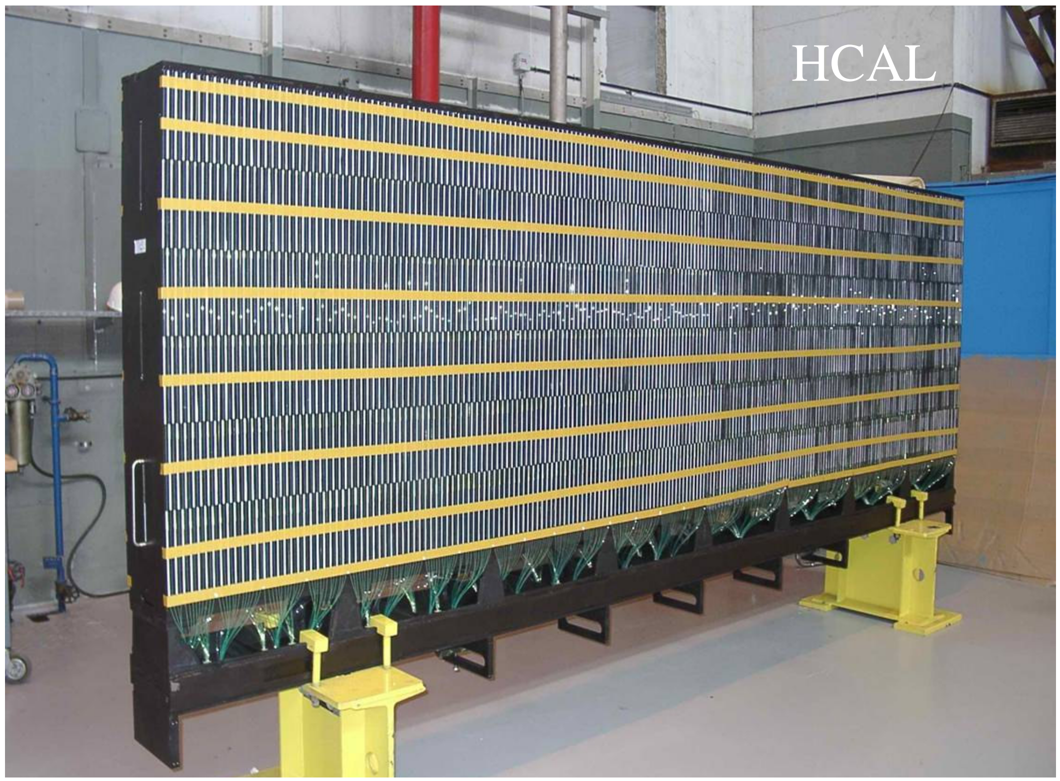
- RICH-2 (after magnet) uses CF_4 gas radiator for high *p* tracks
- Vessel completed and in position, mirrors installed and aligned

Calorimeter system

- *Pre-shower:* scintillating pads + WLS fibres + 2 X_0 Pb
- *Electromagnetic:* Pb-scintillator Shashlik calorimeter, 25 X_0
- *Hadronic:* Fe-scintillator tile calorimeter, 5.6 λ_I

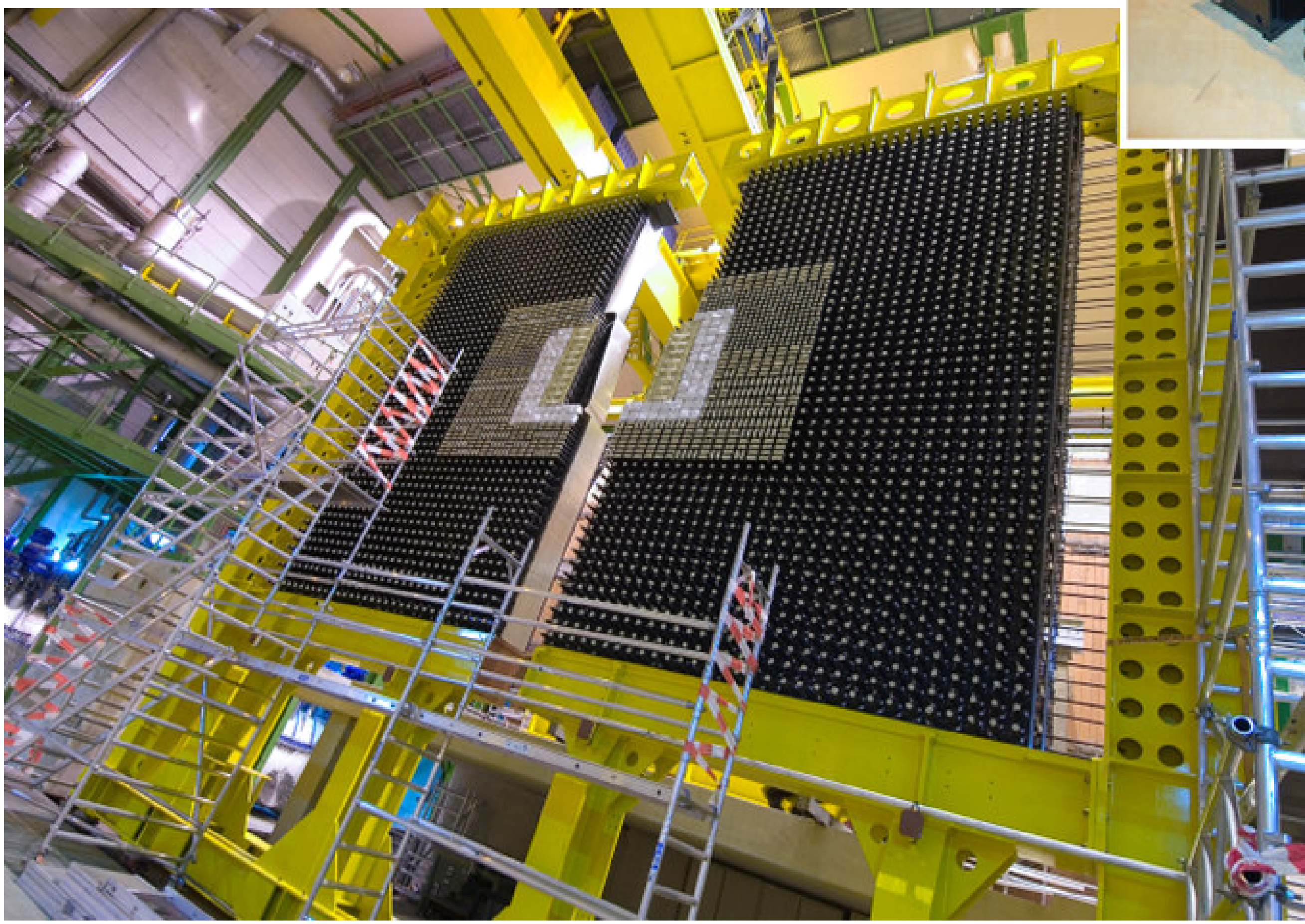






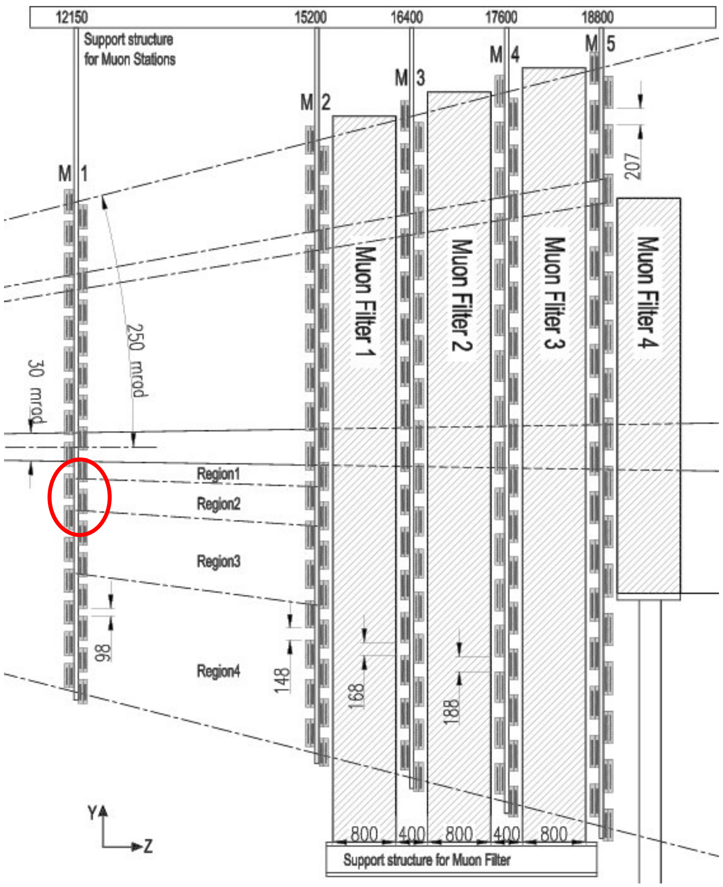
- ECAL modules: $\sigma_E/E = 10\% /\sqrt{E} \oplus 1\%$

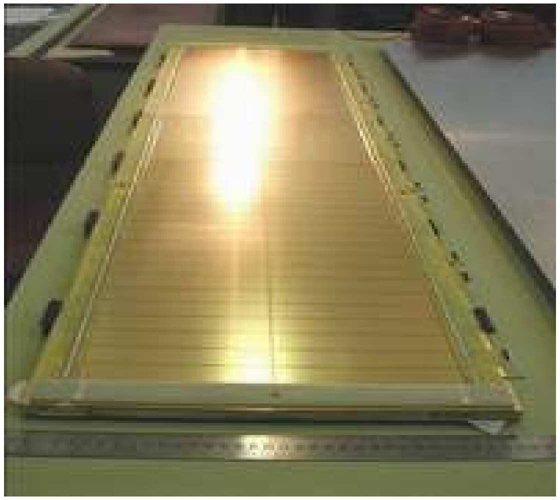
- 3300 modules stacked: ~ 6 m high
  dimensions agree to specification < 1 mm

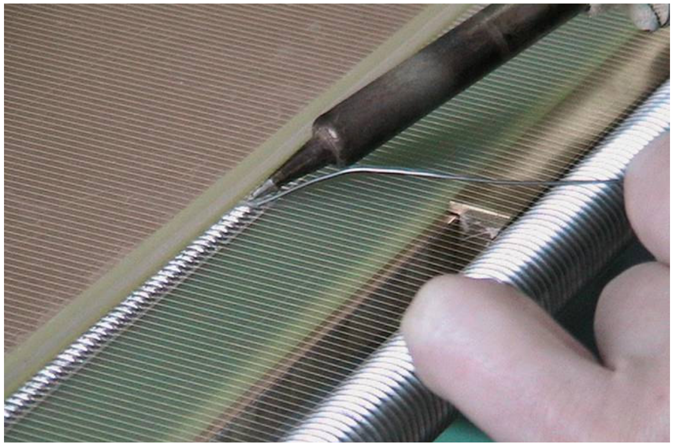


Muon system

- MWPCs used for all except highest rate region (inner part of M1, > 100 kHz/cm^2) where triple-GEMs are used instead

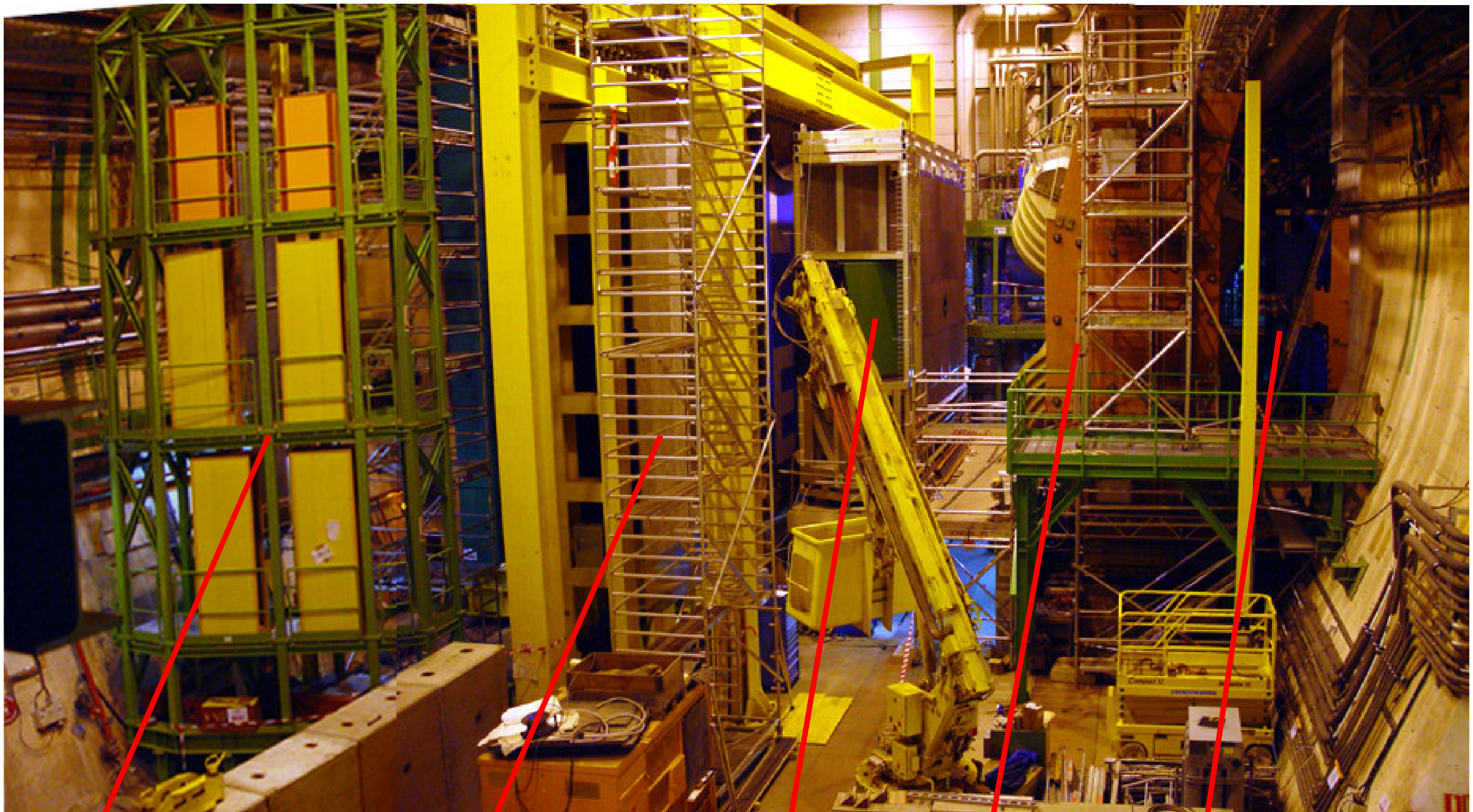






~50% of chambers complete

Installation status



Muon system
-iron shielding
-electronics tower

Calorimeter
-E-cal, H-cal modules

RICH2

Magnet

RICH1
- shielding box

Trigger

detector

40 MHz

L0: high p_T (μ,e,γ,h) [hardware, 4 μs latency]

1 MHz

L1: high IP, high p_T tracks [software, 1 ms]

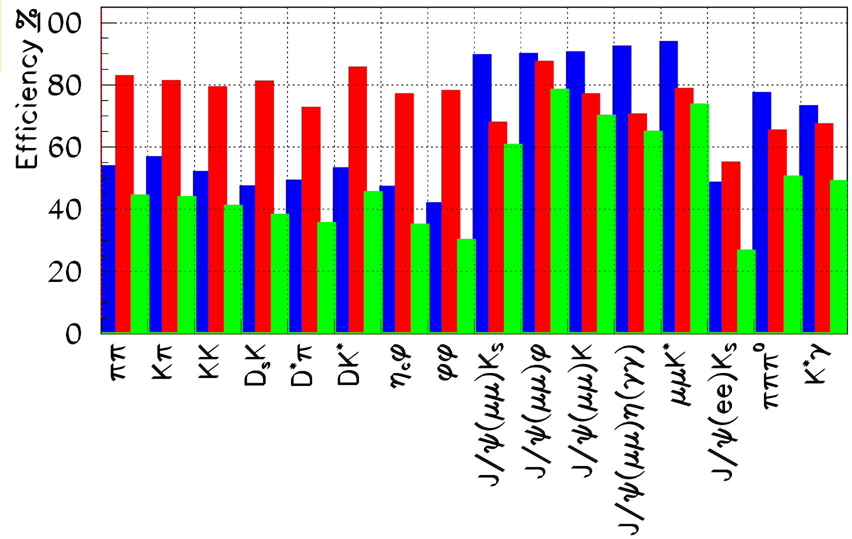
40 kHz

HLT: software using complete event [10 ms]

2 kHz

storage

L0, L1 and L0×L1 efficiency



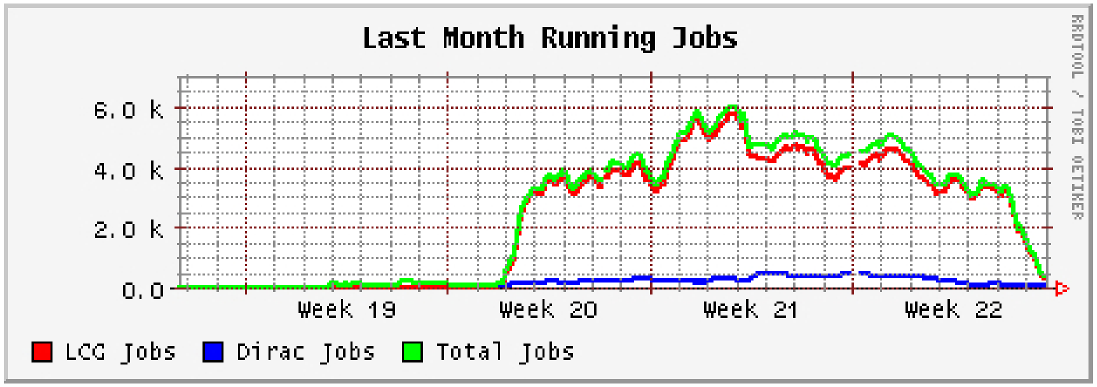
HLT rate	Event type	Calibration	Physics
200 Hz	Exclusive B candidates	Tagging	B (core program)
600 Hz	High mass di-muons	Tracking	J/ψ, $b\rightarrow J/\psi X$ (unbiased)
300 Hz	D* candidates	PID	Charm (mixing & CPV)
900 Hz	Inclusive b (e.g. $b\rightarrow\mu$)	Trigger	B (data mining)

Computing

- Final system: filter farm of ~ 2000 CPU nodes at pit + extensive use of the Grid for offline computing

- Test-bed of a CPU sub-farm set up with 44 CPU nodes

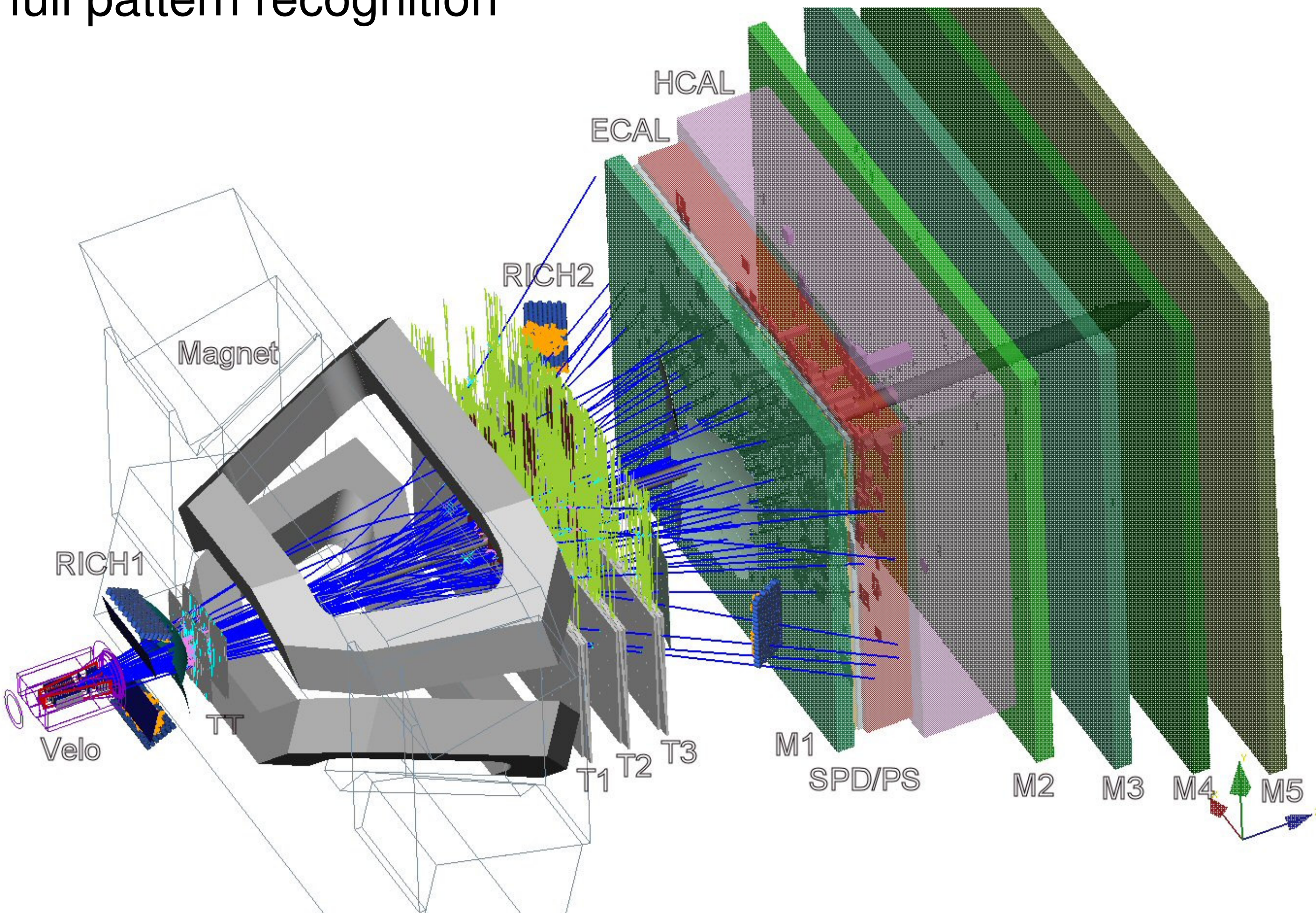
  Test the transfer of data through the system, running the trigger code



Populated with 150M events generated using the Grid in 3 weeks

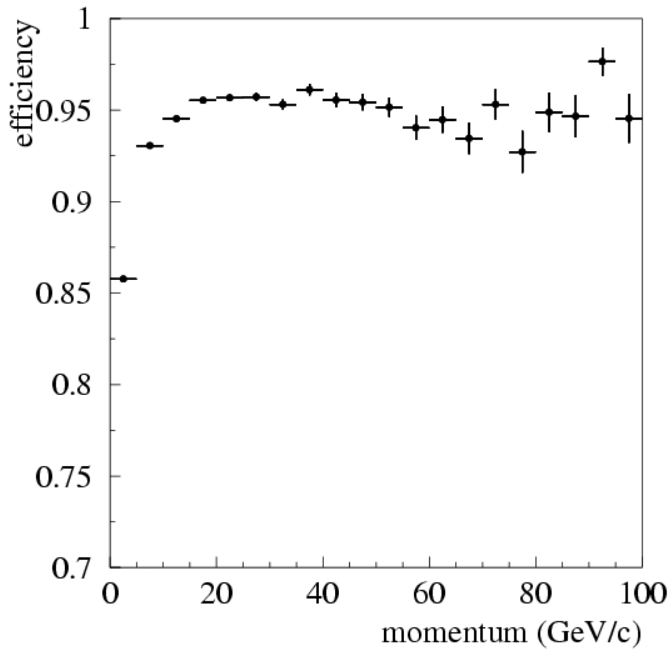
Expected performance

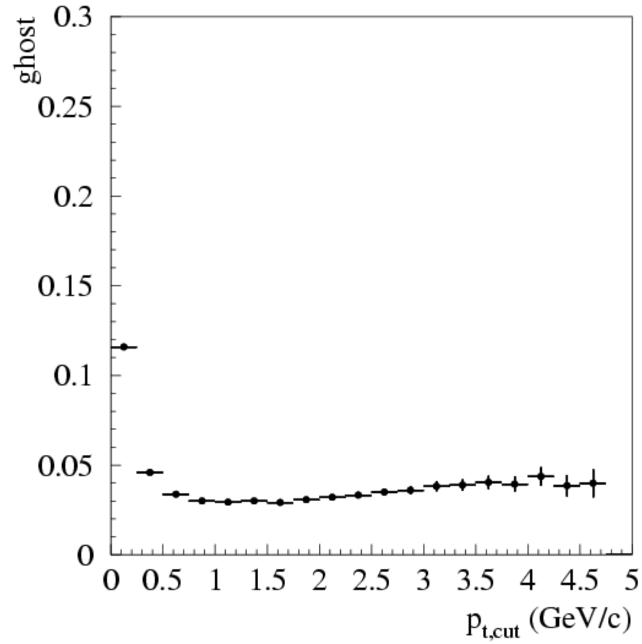
- Study performance using fully-simulated events (GEANT4) and full pattern recognition



Tracking

- Reconstruction of tracks passing through full spectrometer: efficiency ~ 95%, with a few percent of ghost tracks

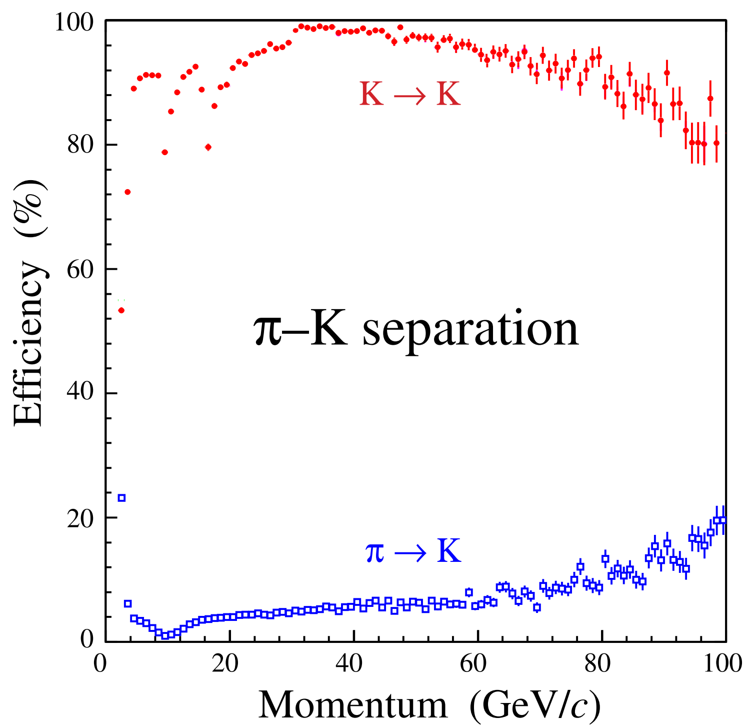


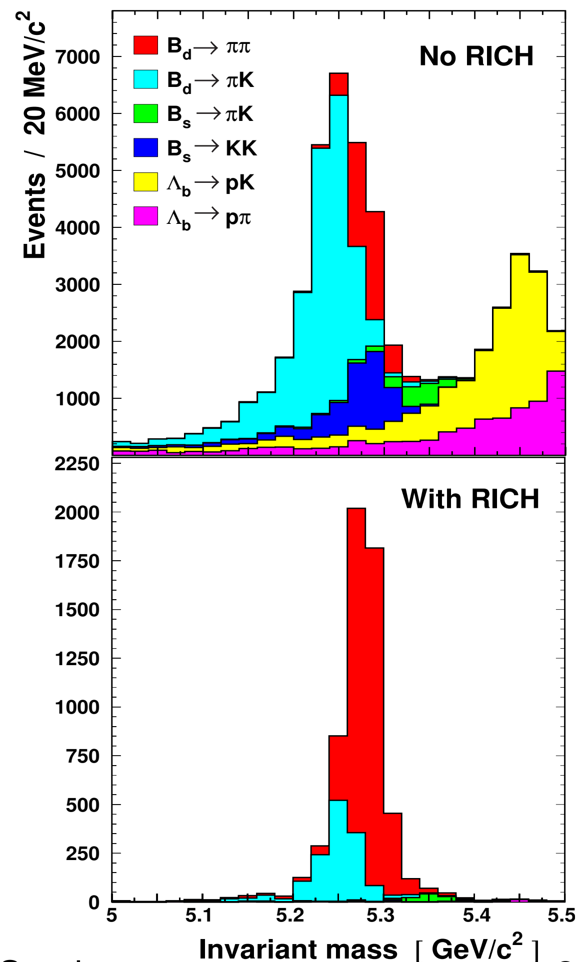


- Momentum resolution $\Delta p/p$ ~ 0.4%
  Impact parameter resolution σ_{IP} ~ 20 μm for high-p_T tracks

Particle ID

- RICH system provides excellent hadron identification 2–100 GeV
$\rightarrow$ K tagging + clean separation of two-body B decays





- Lepton ID: for e (μ) in ECAL (Muon)
efficiency ~ 90% for π misid rate of < 1%

A physics study …

The ADS Method - Introduction

- Decays B and $\overline{B}$ to $D^0(\overline{D^0})K$ involve $b \to c$ and $b \to u$ transitions
  $\to$ sensitive to γ if a common final state is studied for both D^0 and $\overline{D^0}$

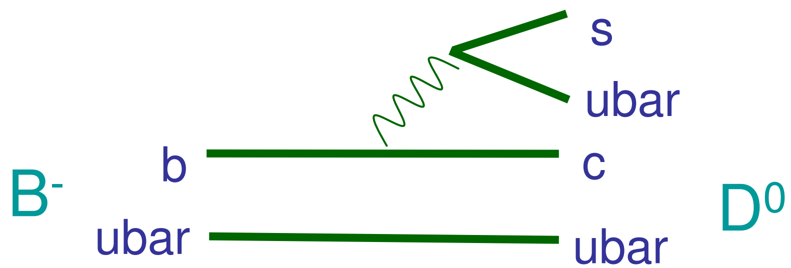
- LHCb will exploit a number of strategies to study such decays :
  - Atwood-Dunietz-Soni ('ADS') — $B^{\pm}$ decays
  - Dalitz — B^0 and $\overline{B^0}$ decays
  - Gronau-London-Wyler-(Dunietz) ('GLW')

- The ADS method is a candidate for LHCb's most precise measurement of γ

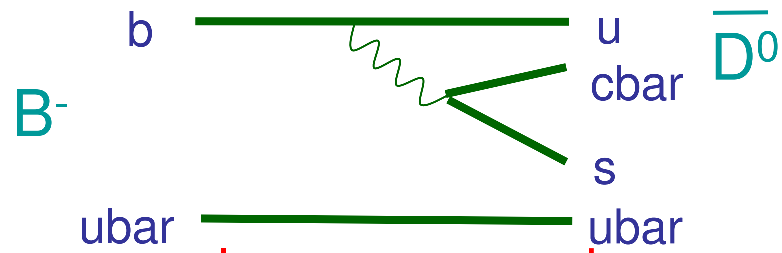
- Dalitz plot analysis sensitive to some of the same parameters – two methods complementary

ADS method – $B^{\pm} \rightarrow DK^{\pm}$ diagrams

- B^- can decay into both D^0 and $\overline{D^0}$, diagrams have very different amplitudes



colour favoured



colour suppressed

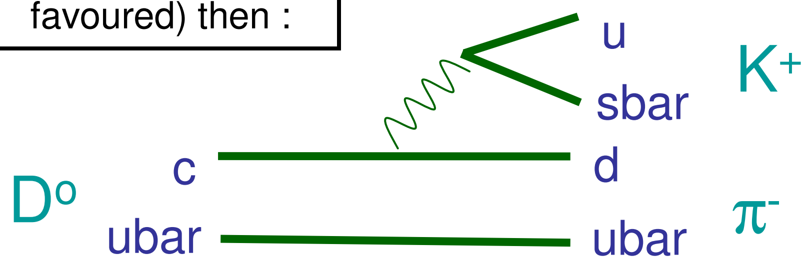
- Decays of D^0, $\overline{D^0}$ to same final state allows these two *tree diagrams* (theoretically clean!) to interfere

eg. consider decays $D^0 \rightarrow K\pi$ $(K\pi\pi\pi)$ …

ADS method – $D \rightarrow K^+\pi^-$ diagrams

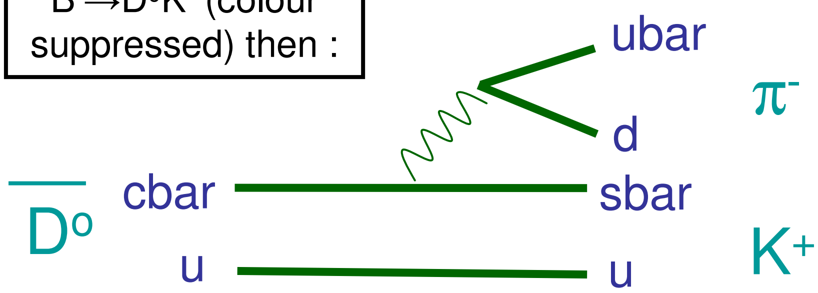
- Both D^0 and $\overline{D^0} \rightarrow K^+\pi^-$:

$B^- \rightarrow D^0 K^-$ (colour favoured) then :



(doubly) cabibbo suppressed

$B^- \rightarrow \overline{D^0} K^-$ (colour suppressed) then :



cabibbo favoured

- For these decays the reversed suppression of the D decays relative to the B decays results in much more equal amplitudes
  $\rightarrow$ big interference effects

- Counting experiment – no need for flavour tagging or proper time determination

Interference parameters

- Interference depends on a number of parameters :
  - From the B decays : γ – because have $b \to u$, $b \to c$ interference
    r_B – the ratio in magnitude of two diagrams (0.1 – 0.3)
    δ_B – a CP conserving strong phase difference
  - The D decays introduce : $r_D^{K\pi}$ – the ratio in magnitude of two diagrams (0.060)
    $\delta_D^{K\pi}$ – a CP conserving strong phase difference

- BELLE measure :
  - $r_B = 0.25 \pm 0.22$
  - $\delta_B = 157 \pm 30$

  [hep-ph/0411049, 0504013 – Dalitz analysis]
  - BR(suppressed) = $(3.9 \pm 2.1) \times 10^{-7}$

  [hep-ph/0412025 – ADS anal, 275M BB]
  - $r_B < 0.18$ (90% CL)

  [hep-ex/0508048 – ADS anal, 386M BB]

- BABAR measure :
  - $r_B = 0.12 \pm 0.09$
  - $\delta_B = 104 \pm 53$

  [hep-ph/0504039, 0507101 – Dalitz analysis]
  - $r_B < 0.23$ (90% CL)

  [hep-ph/0504047 – ADS anal, 232M BB]

- We have assumed : $r_B = 0.15$, $\delta_B = 130^o$, $\delta_D^{K\pi} = 180^o$ (arb.) $\to$ BR(sup.) ~ 4.5×10^{-7}

- Allowing for all possibilities, have 4 $B^{\pm} \rightarrow D(K\pi)K^{\pm}$ rates we can measure :

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

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

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

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

- Two rates are favoured (1) and (3)
- Two rates are suppressed (2) and (4)

– but these *suppressed rates have order 1 interference effects* as $r_B \sim r_D$

- Although $r_D^{K\pi}$ known, taking the relative rates have more unknowns than equations – need information from other decays

eg. $D \rightarrow K\pi\pi\pi$, or the CP eigenstates KK, $\pi\pi$ ($r_D^{KK}=1$, $\delta_D^{KK}=0$)

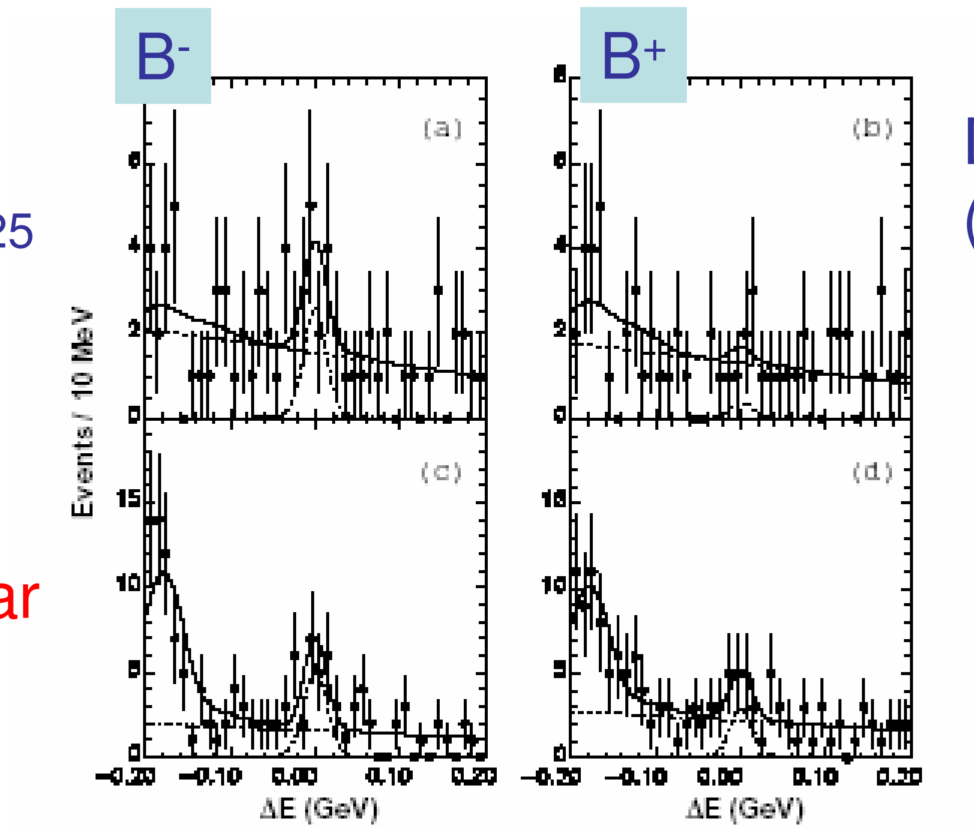
CLEO-C also expected to measure δ_D

Present Experimental Status

B factories are looking for these suppressed decays (2) & (4)

eg. Belle,
hep-ex/0412025

275M BBbar

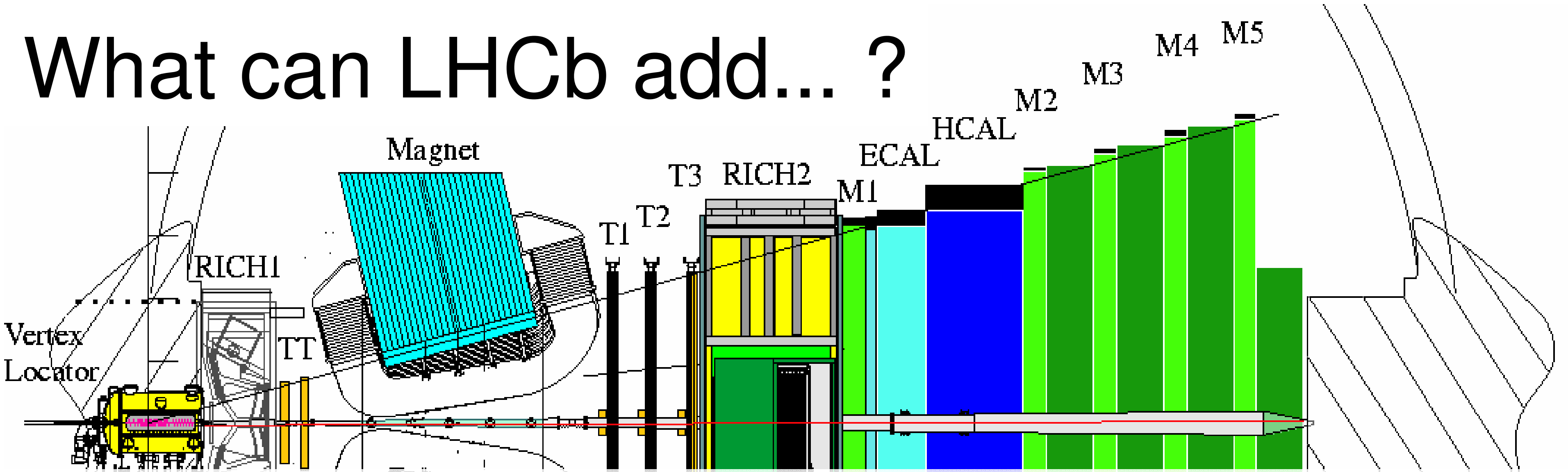


DK decays
(~ 15 events;
hint of asymmetry)

Dπ decays
(control channel;
order 30 events)

Analysis is statistically limited … what can LHCb add … ?

What can LHCb add... ?



- LHCb intends to take 2fb^{-1} per year – 10^{12} bb, 0.4 of which expected to be $B^{\pm}$

  In both sign combinations signal yields then :

  10^{12} bb / year × 0.4 × 2 × ε_{TOT} × BR

  Favoured: BR = 1.4×10^{-5}
  Suppressed: BR = 4.5×10^{-7}

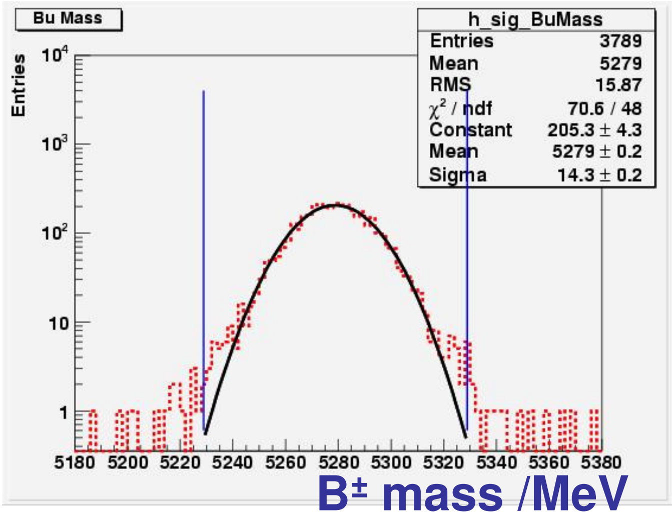
- Our total efficiency, ε_{TOT}, and resulting sensitivity depend entirely on our ability to control the background – in very different environment to the B factories

- Full simulation indicates that acceptance × trigger efficiency × selection efficiency gives ε_{TOT} = 0.5% (more in a moment) :
  - Favoured → ~60,000 events/year
  - Suppressed→ ~2,000 events/year

  cf. the ~15 events in the suppressed modes currently seen by BELLE

Full MC performance

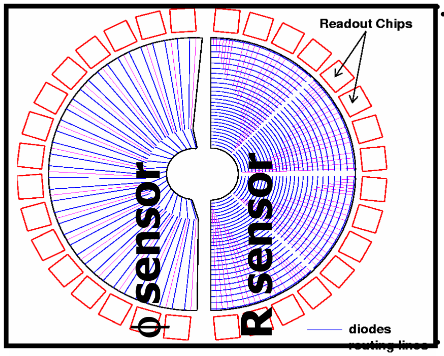
- LHCb uses full MC simulation to estimate the signal selection efficiency and the background :
  - PYTHIA - generation of p-p collisions at √s = 14TeV
  - GEANT - full detector response/spill-over and tracking through material
  - on/offline pattern recognition, full trigger chain, selections

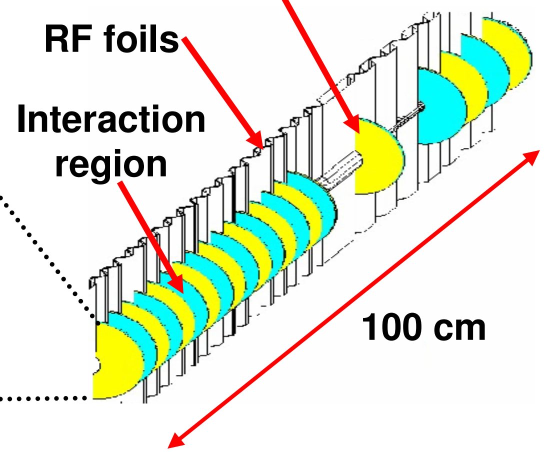


- Signal selection efficiency ε_{TOT}=0.5% :

  8.2% (geom.) × 87.8% (rec.) × 28.4% (seln.) × 25.0% (trig.)

- Mass resolutions
  - $B^{\pm}$ ~15 MeV
  - D^0 ~6.5 MeV
- Vertex resolutions
  - Primary vertex σ_z ~ 50 μm
  - B decay vertex σ_z ~ 200 μm





Estimating the background

- From a large sample of minimum bias events find no events are selected by selection cuts
- To study background in more detail focus on bb events where one b decays in 400 mrad – after the application of the trigger most likely source of background
- Background sample 20 million bb events generated with above condition

  (→ factor 0.434, sample equivalent to ~46M bb events)
- Still equivalent to only a few minutes of LHCb running !

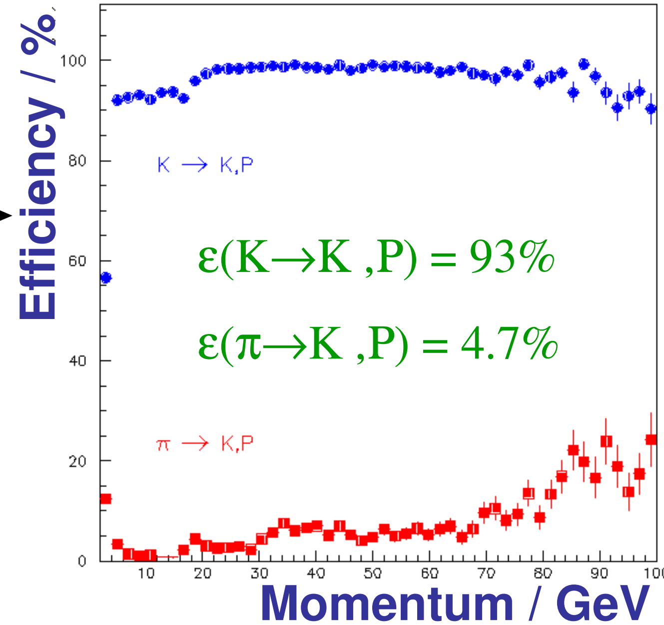
Background studies

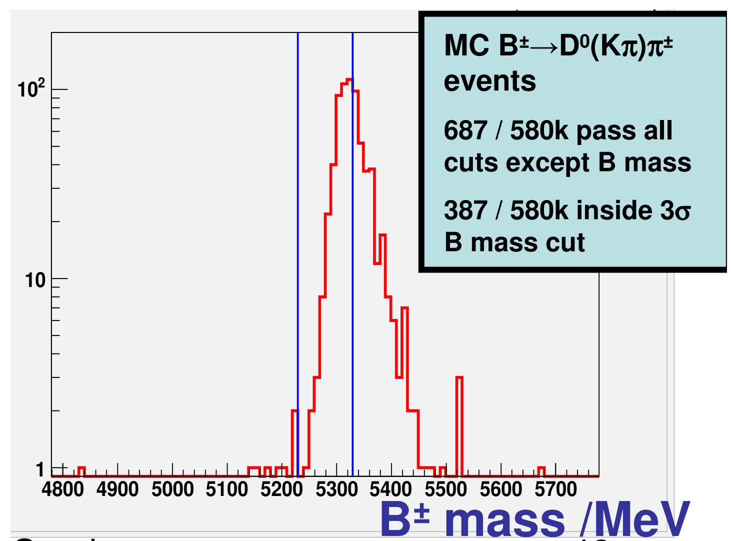
- Favoured modes - expect ~60k signal events/year
  - Background from $D^0\pi$ decays dominates (BR ~13 × D^0K)
    - Use RICH information to separate D^0K and $D^0\pi$
    - Find 3 $D^0\pi$ events survive analysis from bb sample
    - Generate a larger sample of $D^0\pi$ decays to get better idea of B/S – find 387/580k $D^0\pi$ events accepted

    → Expect ~25k bkgrd events/year from $D^0\pi$
  - Find no other events from bb sample survive all cuts
  - To improve background estimate – in particular from 'combinatoric' events – widen B mass window to 10×the standard one :
    - Then find 3 events survive analysis from bb sample
    - Linearly extrapolate into normal mass window

    → Expect ~1k bkgrd events/year from combinatoric

    (making conservative assumption trigger efficiency same for combinatoric background as for signal)
  - B/S ~ 0.5 [dominated by $D^0\pi$]





Background studies

- Suppressed modes – expect 2k signal events /year
  - $D^0\pi$ suppressed by subsequent DCS D^0 decay → contribution with B/S ~ 0.5
  - In addition, bb sample indicates that there is significant combinatoric contribution :
    - No events in normal mass window
    - Find 3 events in the 10× standard mass window
    - Linearly extrapolate into normal mass window

    → Expect ~1k background events/year from combinatoric events
  - B/S ~ 1 [both D0π and combinatoric events]
  - Other sources of background have been considered :
    - Favoured sign events when Kπ mis-identified as πK
      - Factor ≥0.05 for π mis-id as K, factor for K mis-id as π ≤0.10 → 300 events, B/S ~0.15 (BELLE veto on D^0 mass with particle hypotheses reversed)
    - B→KπK mode – BELLE estimate from D^0 mass sidebands → contribution with B/S ~ 0.20
    - $B\to D^0(KK)\pi$ mode – BR ~40 × sup. modes - BELLE use veto on m(KK) – little impact on E_{TOT}
- The other modes that are required to solve for all unknowns are under study eg. $B \to D^0(KK,\pi\pi,K\pi\pi\pi)$

Estimating LHCb's sensitivity

- Preliminary studies performed using toy MC to generate event yields
  - Fix : [CERN-LHCb-2005-066]
    - $\gamma = 60^o$
    - $\delta_B = 130^o$
    - $r_B = 0.15$
    - $r_D^{K\pi}$, $r_D^{K3\pi} = 0.060$
  - Try full range of values for $\delta_D^{K\pi}$, $\delta_D^{K3\pi}$
- Using particular set of parameters generate event yields
- Assume cos (δ_D) known to ±0.20 (conservative estimate CLEO-C precision)
- Fit parameters (r_B, δ_B, $\delta_D^{K\pi}$, $\delta_D^{K3\pi}$ and γ)
- Establish errors from spread of results over 1000 experiments

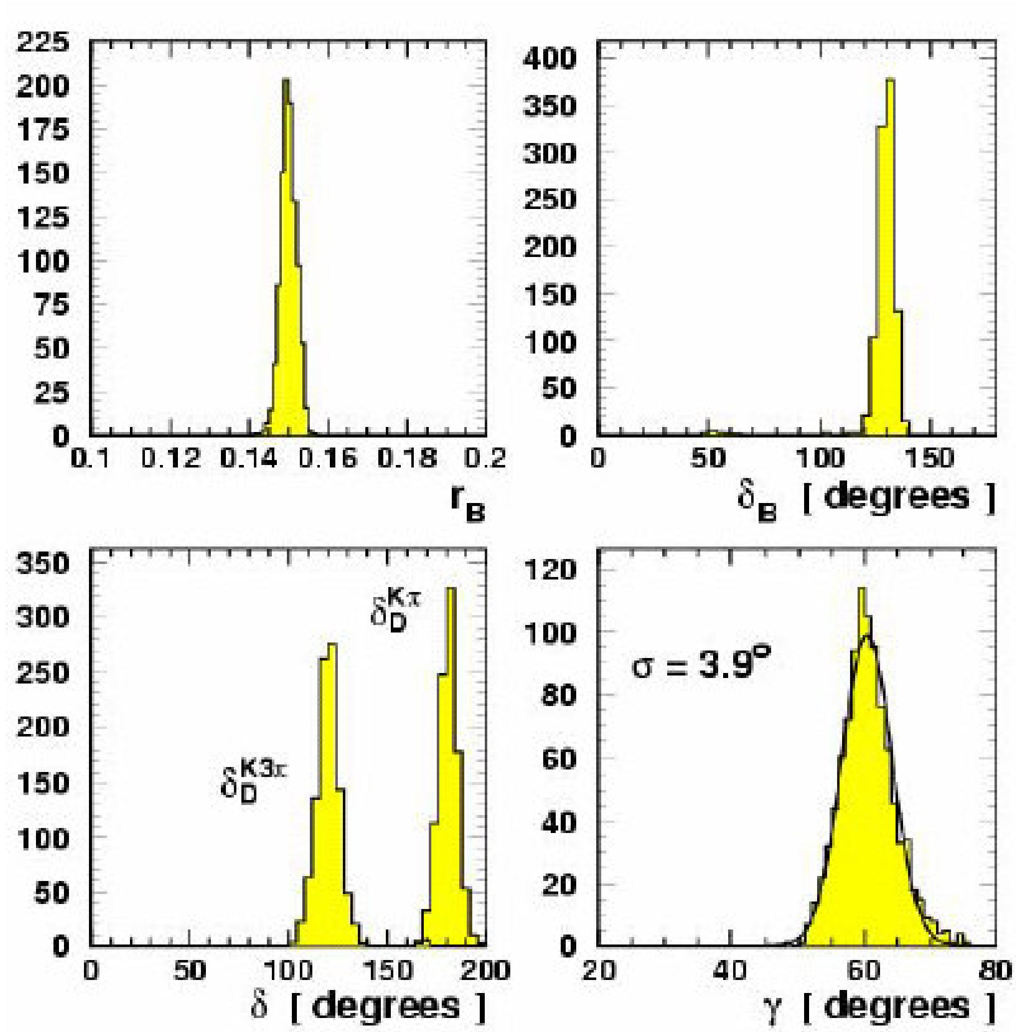
Typical fit results: $\delta_D^{K\pi}=180^o$, $\delta_D^{K3\pi}=120^o$

2 fb^{-1}

Without background included

Fit results return input values

Error on $\gamma = 3.9^o$



Adding the background …

- Precision on γ after adding the background :

		B/S πK, KK, ππ			
		0	1	2	5
B/S Kπππ	0	3.9°	4.0°	4.0°	4.1°
	1	4.6°	4.8°	4.8°	5.0°
	2	5.0°	5.1°	5.3°	5.5°
	5	5.6°	5.9°	6.0°	6.3°

taking same example position in parameter space ($\delta_D^{K\pi}$=180°, $\delta_D^{K3\pi}$=120°)

Recall background estimate for B→D(Kπ)K : B/S ~ 1

B→D(Kπππ)K under study

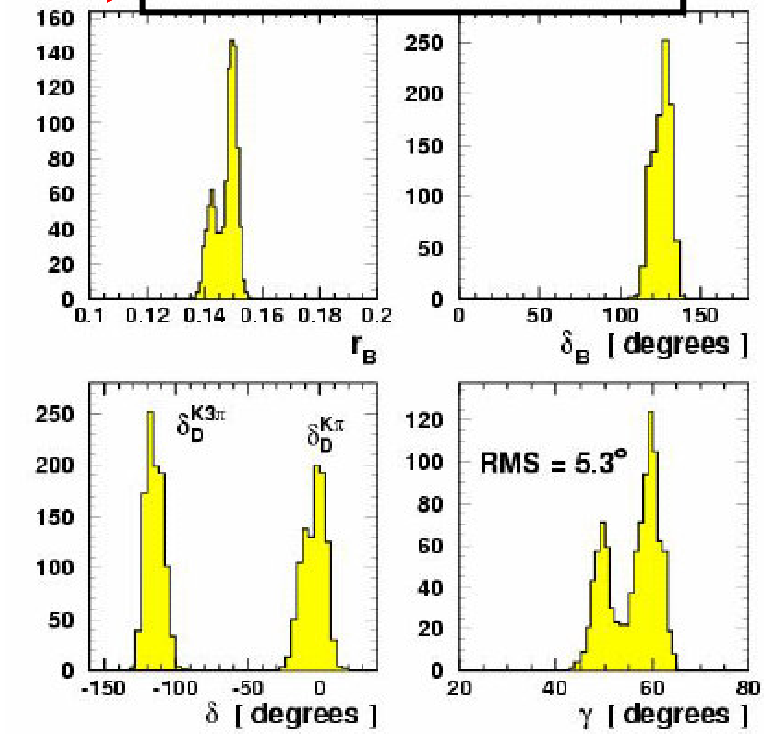
Robustness

- Scan over range of D strong phases, $\delta_D^{K\pi}$, $\delta_D^{K3\pi}$

  While there are some values where close lying ambiguities cause problems, in general fit robust to range of values :

$\delta_D^{K\pi}$ vs $\delta_D^{K3\pi}$	$-180°$	$-120°$	$-60°$	$0°$	$60°$	$120°$	$180°$
$-180°$	* 23.3°	4.6°	4.3°	3.9°	2.8°	4.0°	* 23.9°
$-120°$		4.6°	3.2°	* 5.3°	1.9°	3.1°	4.6°
$-60°$			4.1°	4.4°	3.1°	3.7°	4.4°
$0°$				* 17.2°	4.8°	4.1°	3.9°
$60°$					* 8.5°	3.0°	2.6°
$120°$						3.3°	3.9°
$180°$							* 20.4°

An unlucky position in parameter space



- A global fit including Dalitz information (or more D decays) may get rid of these ambiguities

- Precision also found to be only weakly dependent on r_B and cos δ_D knowledge

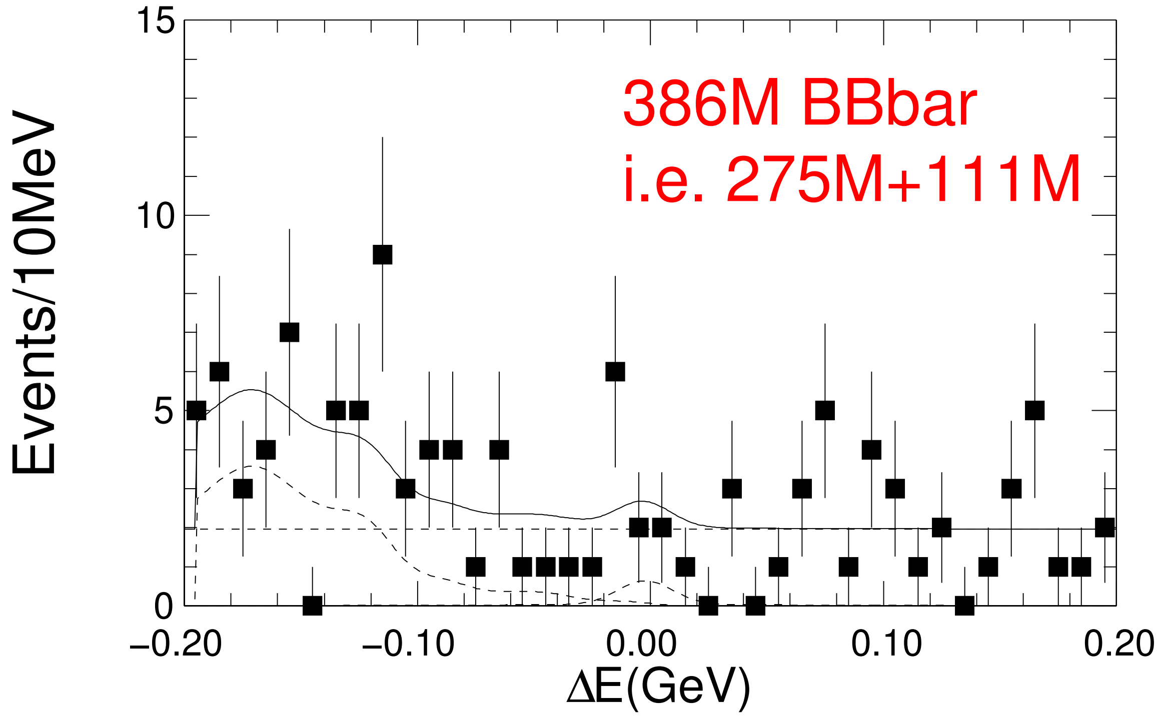
Conclusions

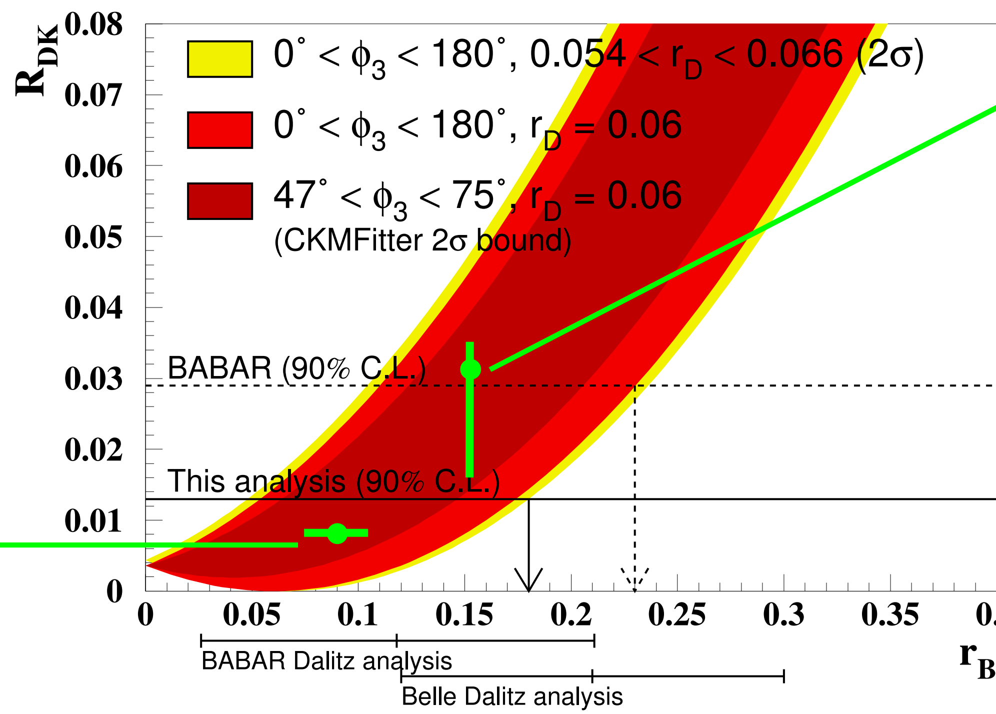
- Construction of the LHCb experiment proceeding well

- Hope to address wide range of B physics topics :
  - B_s oscillations, 5σ observation of B_s osc. for $\Delta m_s < 68\ ps^{-1}$ (in one year)
  - Rare decays eg. $B_s \rightarrow \mu^+\mu^-$ and $B^0 \rightarrow K^{*0}\mu^+\mu^-$, sensitive to NP
  - CKM angles α, β (cross-check)
  - CKM angle γ
    - ADS method - candidate for LHCb's most precise measurement
    - Other $B \rightarrow DK$ decay modes will provide complementary information on γ :
      - GLW method
      - Dalitz plot analysis

- Eagerly awaiting the first collisions at the LHC !

Belle,
hep-ex/0508048

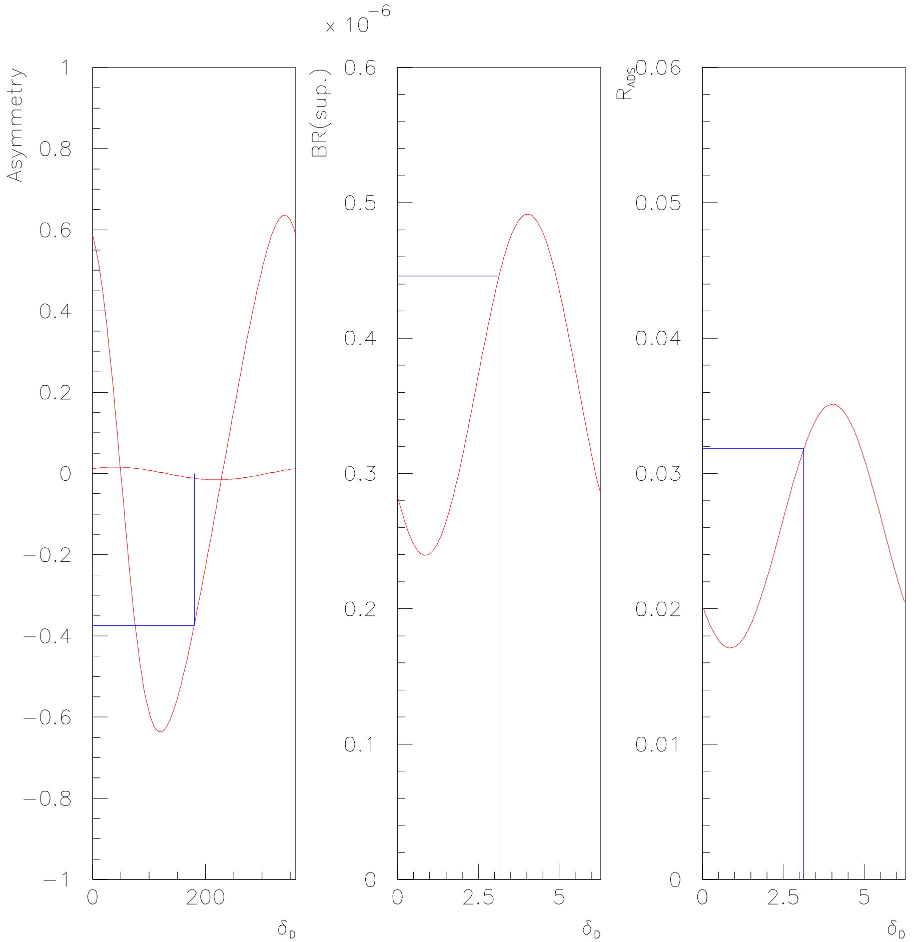




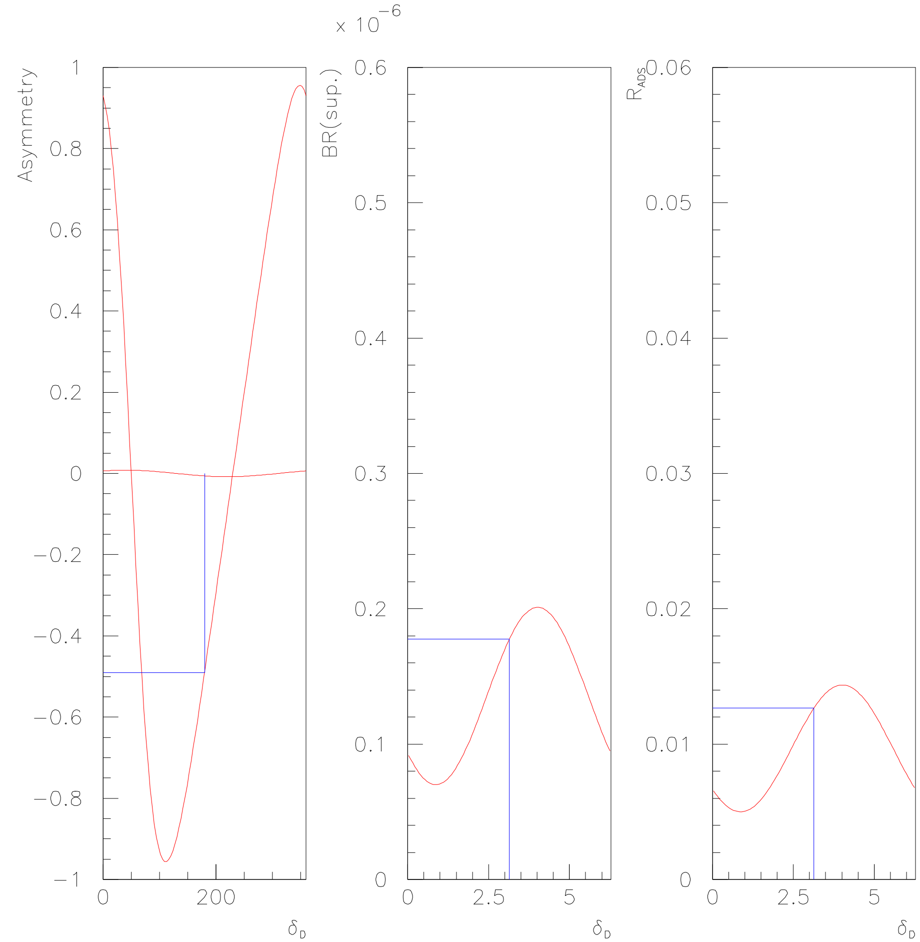
Point taken by LHCb –
Would expect 18 evts from 275M BB (cf. 15 reported) and 28 evts above!

UT fit :
r_B = 0.078 ± 0.028

r_B=0.15



r_B=0.078



Extending to B→D*K

- D*K has an extremely attractive feature :
  - $D^* \to D^0\pi^0$ – here the D* and D^0 have the same CP
  - $D^* \to D^0\gamma$ – here the D* and D^0 have opposite CP

  → relative 180^o offset to δ_B in the expression for the rates

- If can distinguish the two decays → powerful additional constraint ! [Bondar and Gershon: hep-ph/0409281]

- LHCb's ability to separate the π^0 and γ contributions is under investigation