Status and startup for physics with LHCb

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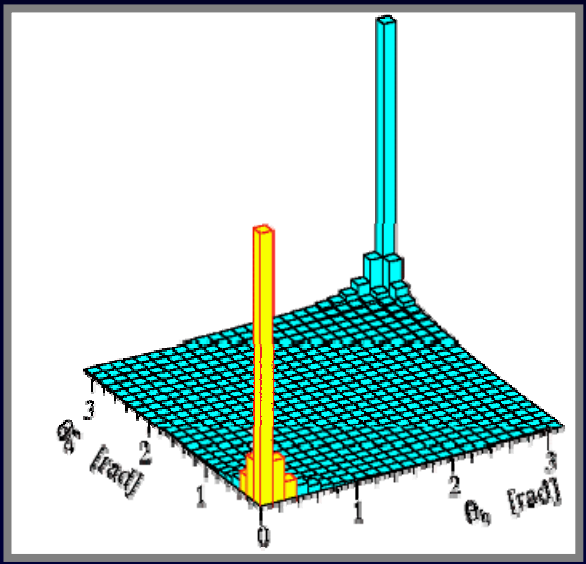
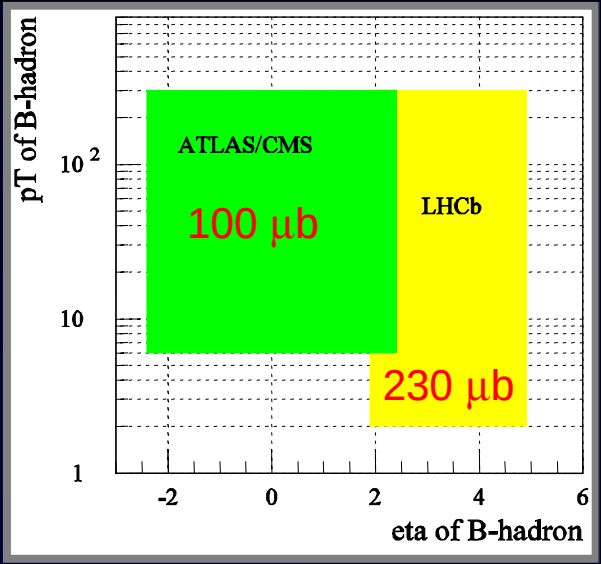
On behalf of the LHCb collaboration

Outline

- The LHCb experiment
  - Detectors
  - Trigger
  - Expected performance
  - Detector status
- LHC startup scenario
- Commissioning plans
- First physics measurements
- Conclusions

LHCb environment

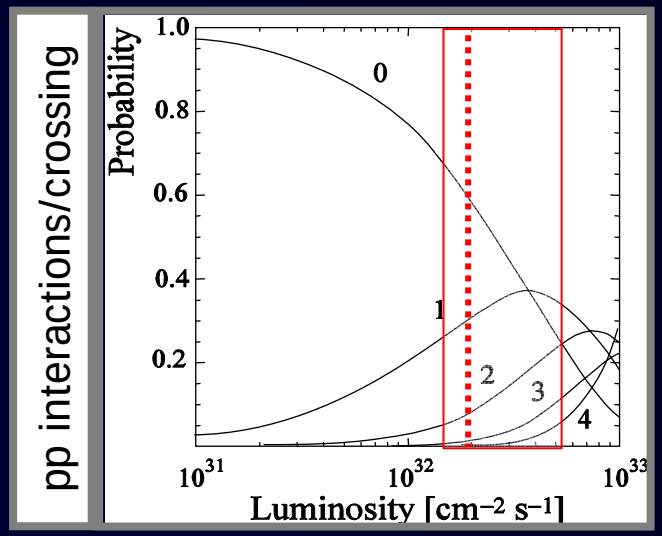




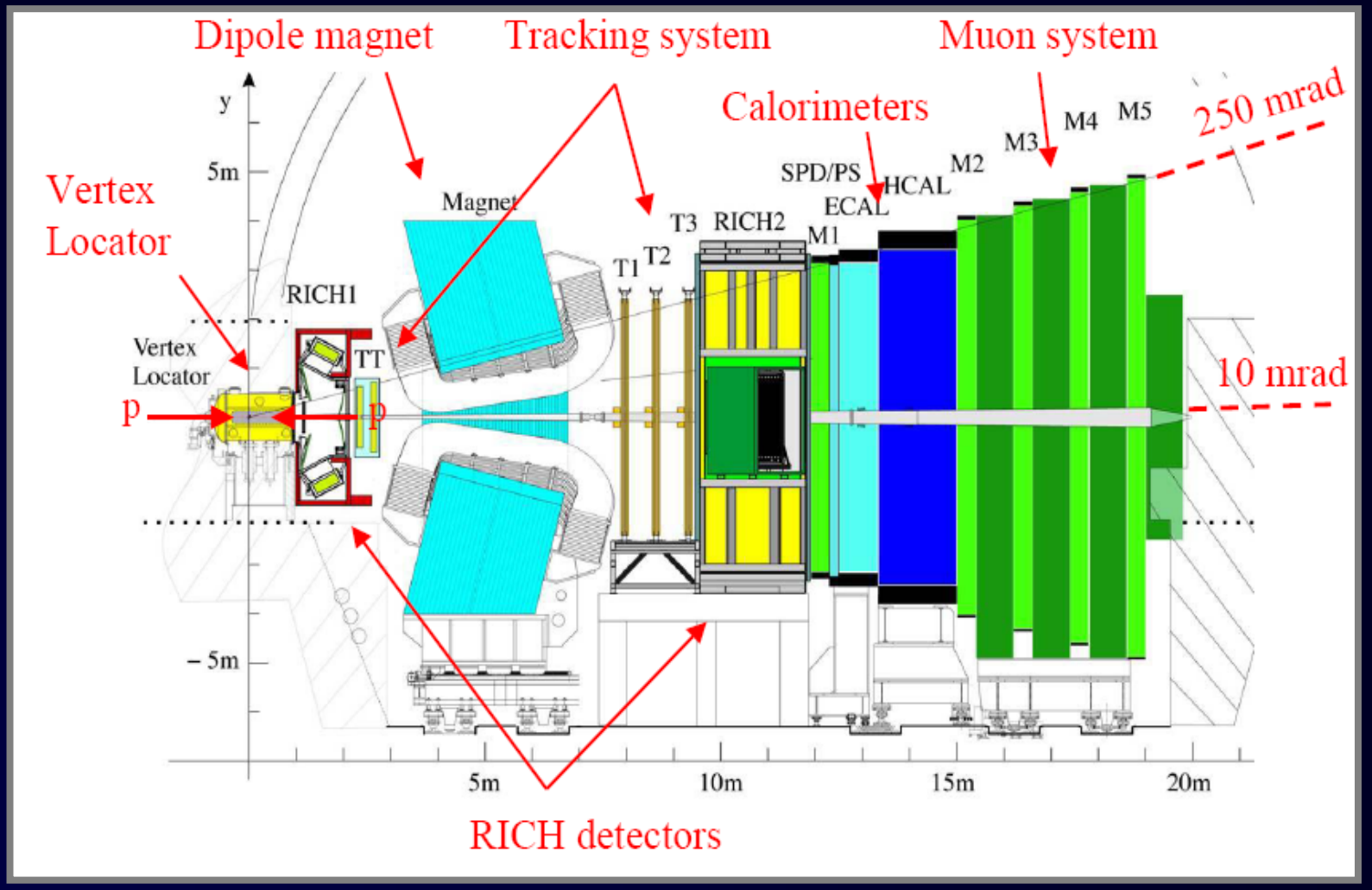
Forward peaked, correlated bb pair production ⇒
LHCb is a forward spectrometer
$2.0 < |\eta| < 5.3$

<u>L tuneable by defocusing the beams</u>

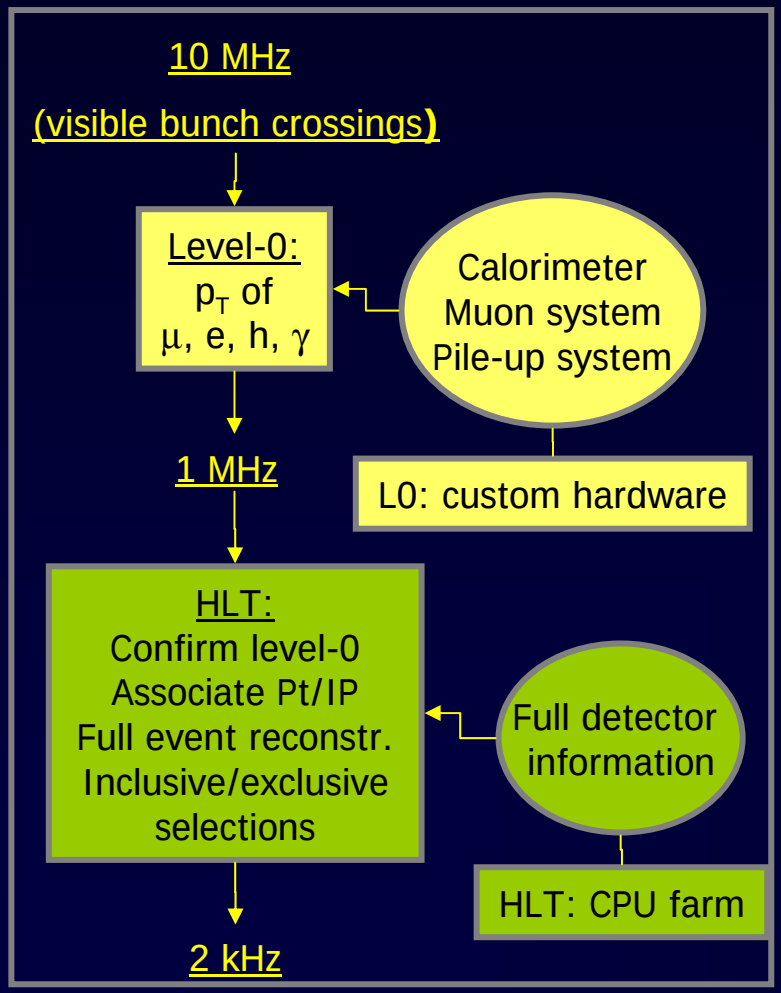
- Choose to run at <L> ~ 2×10^{32} $cm^{-2}s^{-1}$ (max. 5×10^{32} $cm^{-2}s^{-1}$)
  - Will be available from 1st physics run
  - Clean environment (n = 0.5)
- $2\ fb^{-1}$ / year

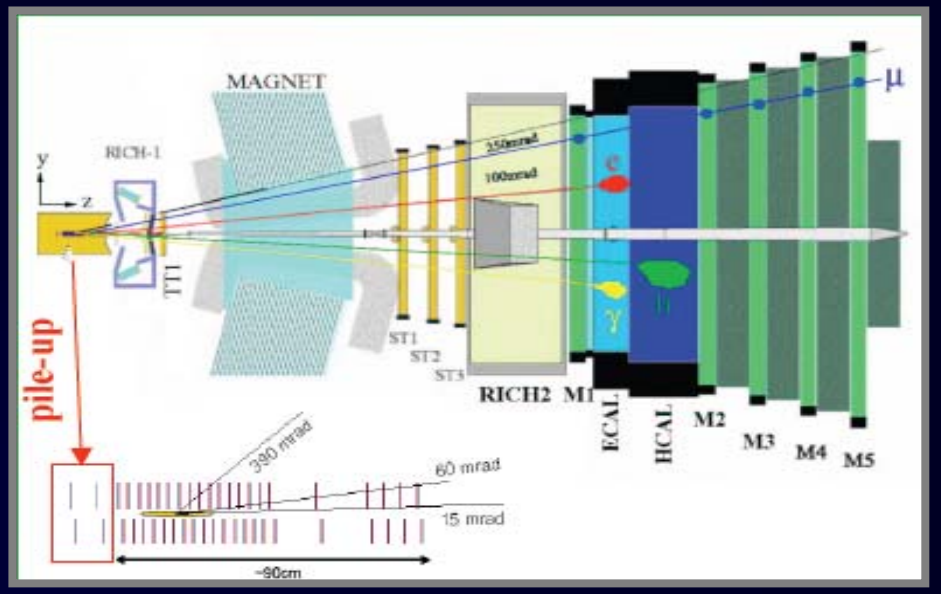


The LHCb spectrometer



Trigger





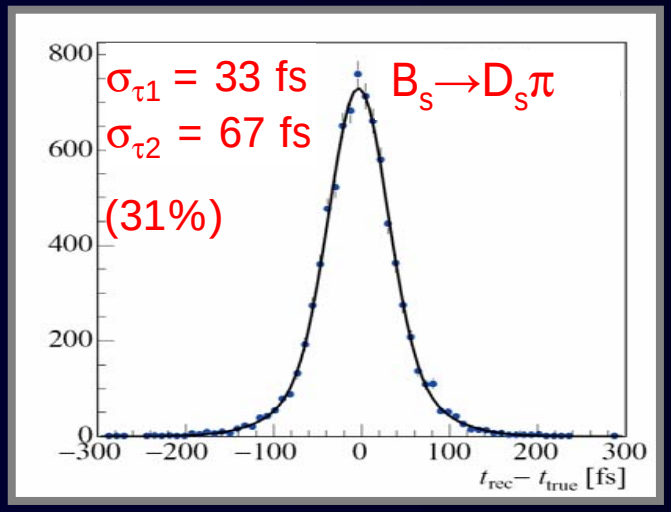
Output rate	Event type	Physics
200 Hz	Exclusive B candidates	B (core program)
600 Hz	High mass di-muons	J/ψ, b→J/ψX (unbiased)
300 Hz	D* candidates	Charm
900 Hz	Inclusive b (e.g. b→μ)	B (data mining)

Expected performance

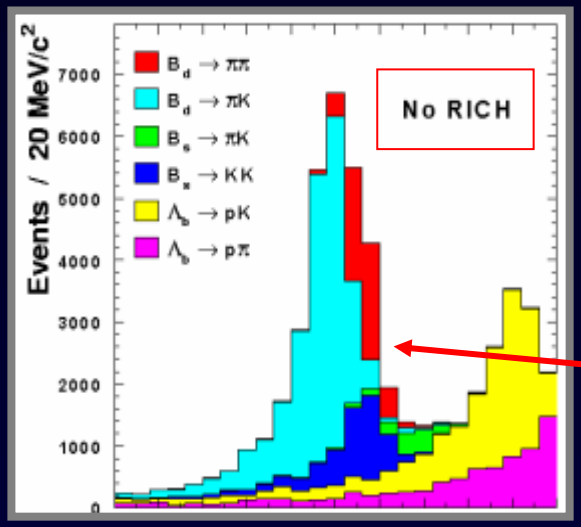
- Full detector simulation based on Pythia and GEANT4
- Full pattern recognition implemented:
- Track finding efficiency: ~ 95% for long tracks p > 10 GeV/c
- Momentum resolution: 0.4%
- Mass resolution: ~ 14 MeV/c^2 for B mesons
- Secondary vertex resolution (in z): ~ 170 μm
- Proper time resolution for B decays: ~ 40 fs

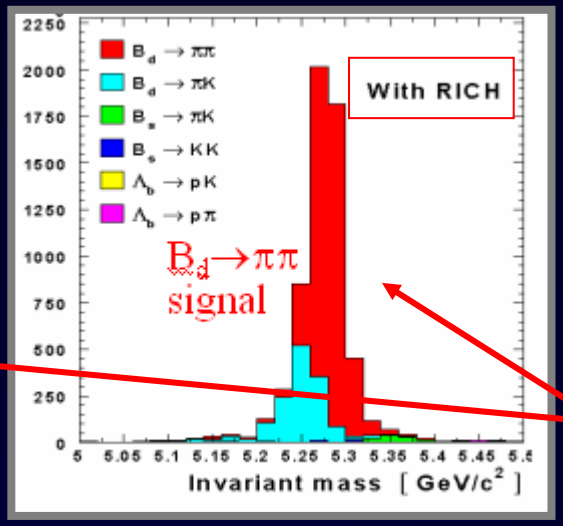
Flavour tagging efficiency

	B_d	B_s
Comb. εD^2	4-5%	7-9%



Particle ID





<u>π/K separation</u> provided by RICH for 2<p<100 GeV:

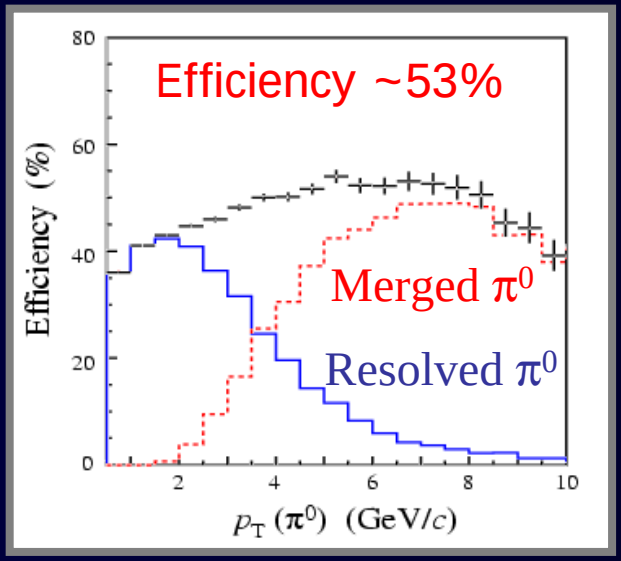
- $<\varepsilon(K\to K,p)>$ = 83%
- $<\varepsilon(\pi\to K,p)>$ = 6%

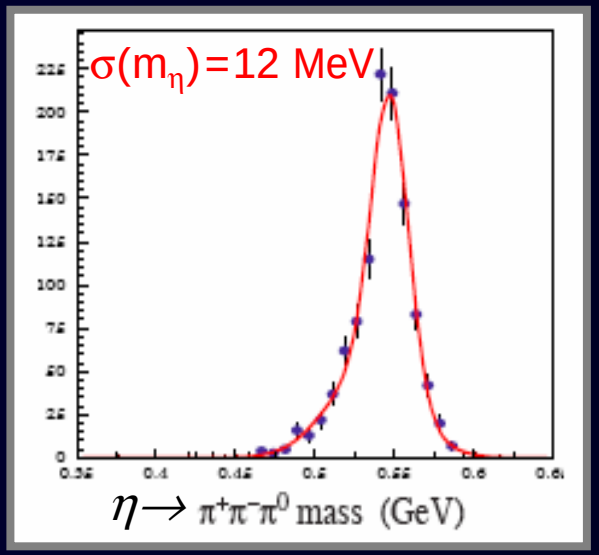
Clean separation of two-body B decays, e. g. $B\to \pi\pi$

<u>Neutral reconstruction</u>

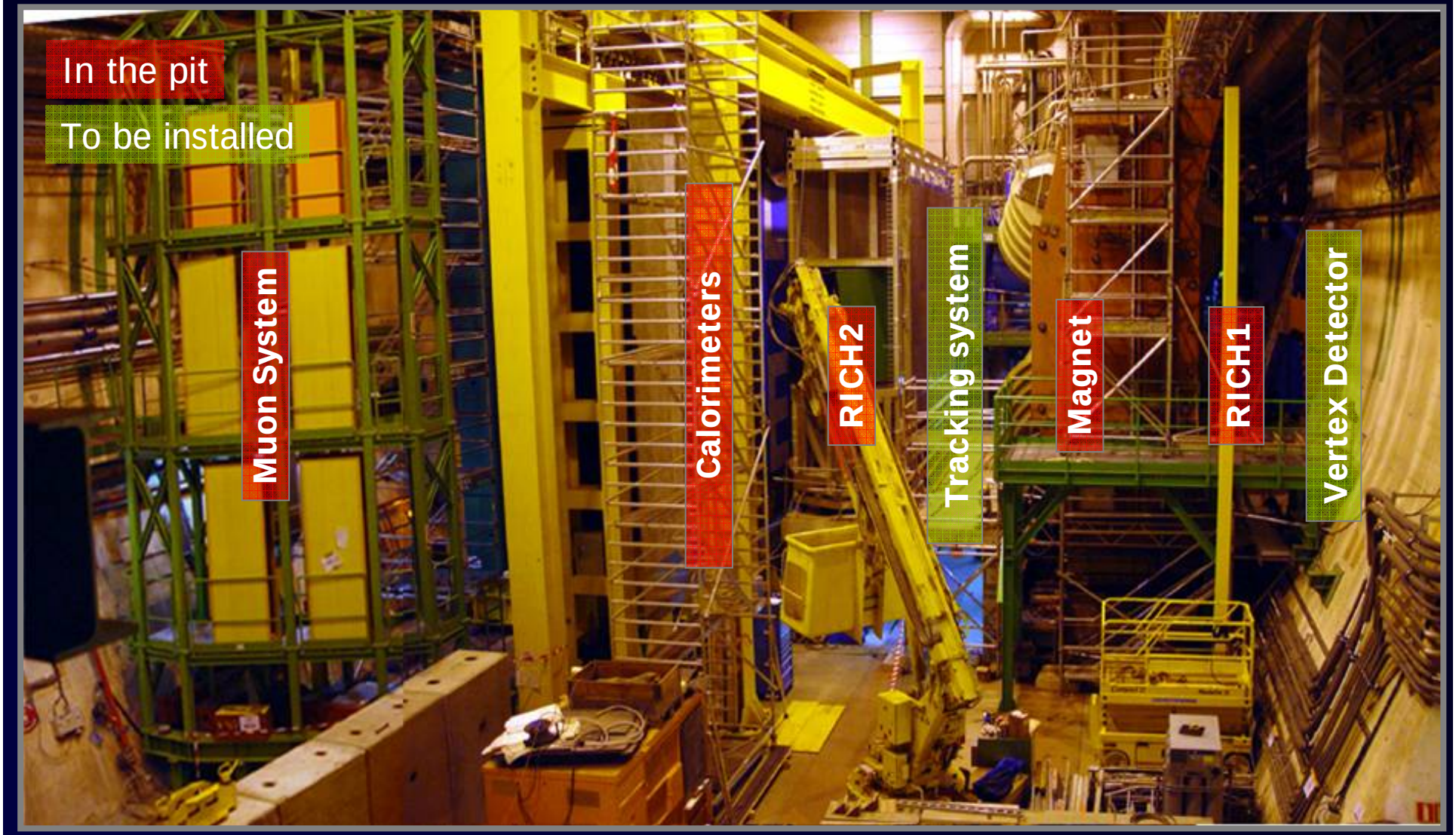
Good efficiency for π^0 in $B^0\to \pi^+ \pi^- \pi^0$, using both resolved and merged clusters in the ECAL

Modes with multiple neutrals ($\pi 0$, η, KS,...) will be challenging at LHCb

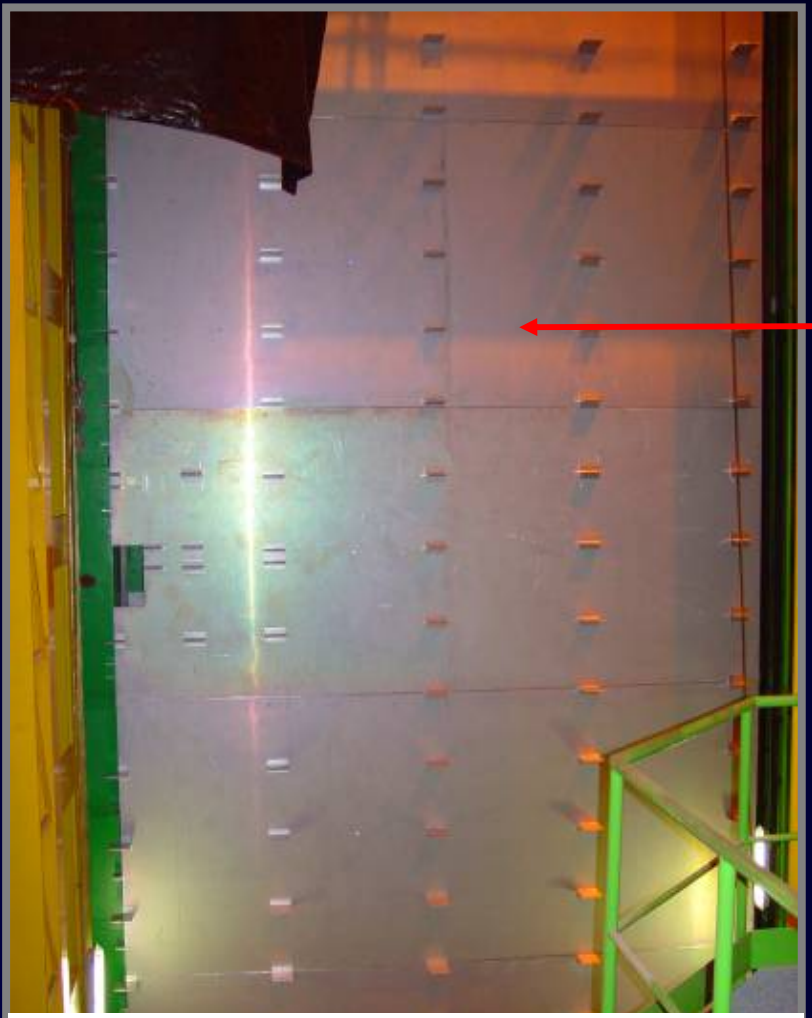




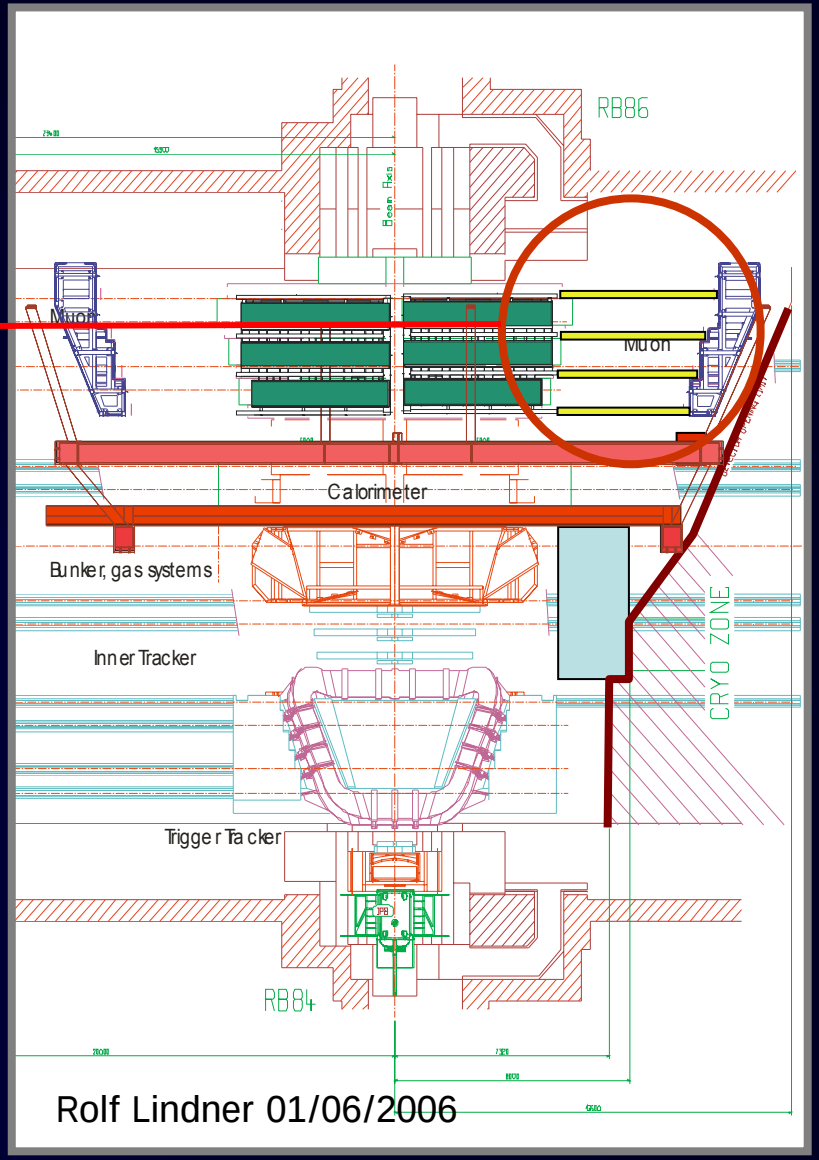
Detector status: a snapshot from the pit



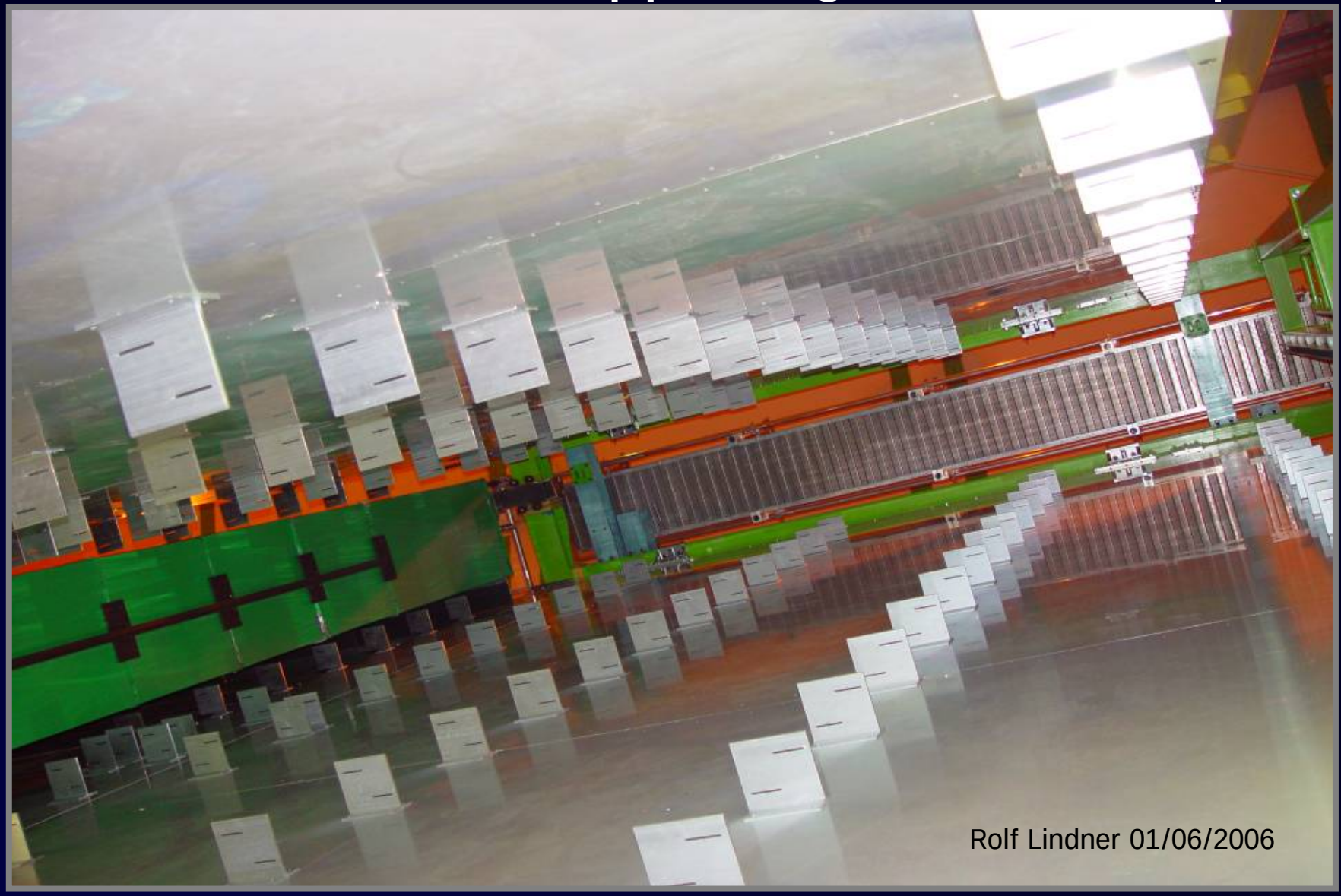
Muon system support walls



All four panels M2-M4 installed.
87% of muon chambers built



Muon chamber supporting wall from top



Outer Tracker installation

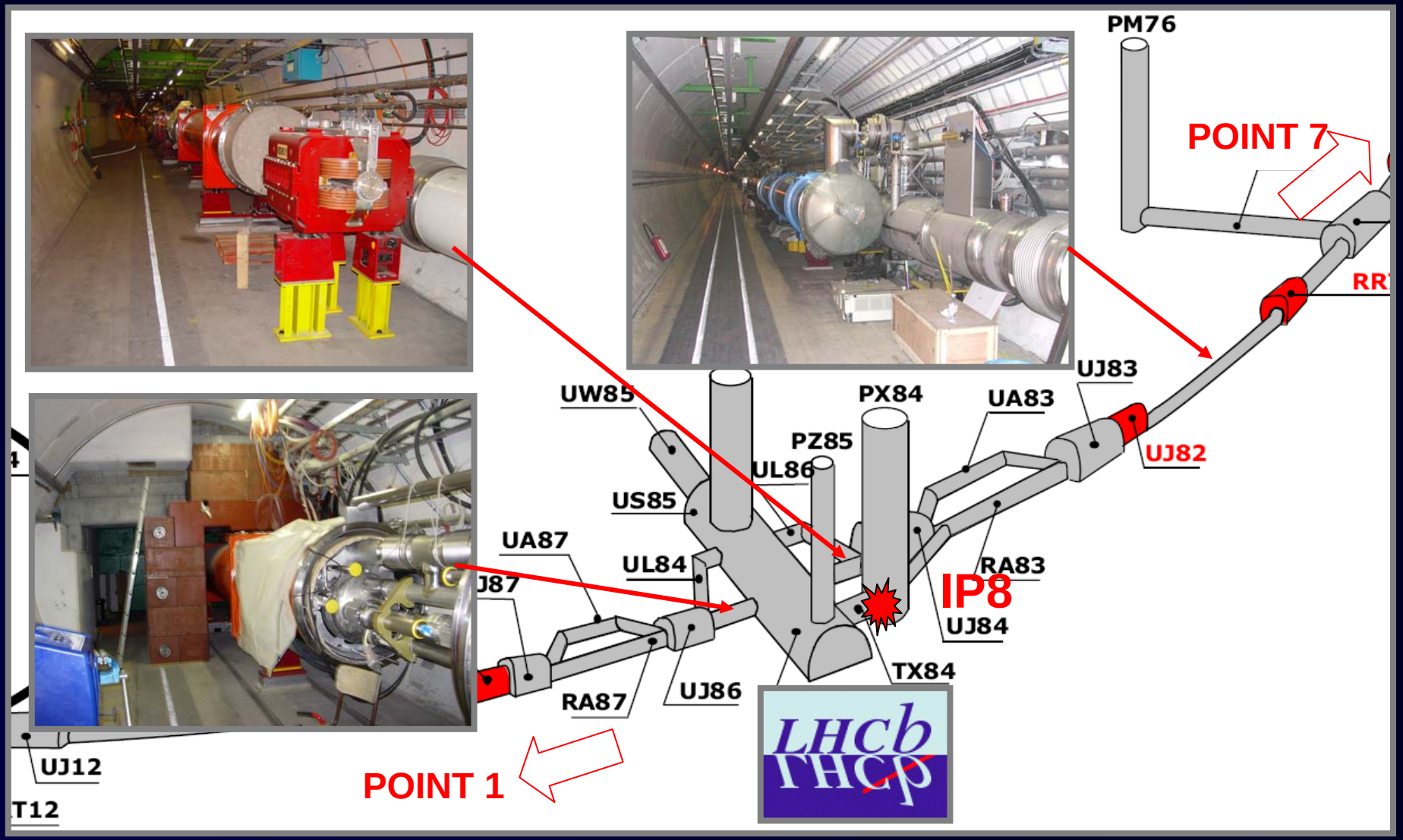
Arrival of Outer Tracker support structure April '06

Vertex detector installation

The vacuum tank of the vertex detector is lowered into the pit...

...and installed in front of the RICH I magnetic shield (in blue)

LHC both sides of the IP8



Detector status: details

- Magnet: installed & mapped
- Vertex detector: Vacuum tank being installed; silicon modules in production; installation at beginning of 2007
- Tracking system: Production almost complete; installation in the pit will end in fall 2006
- Calorimeters: installation finished, commissioning ongoing
- RICH System: RICH I shielding installed, installation completed by fall 2006; RICH II in the pit, installation ongoing
- Muon system: 85% of chambers produced; installation in progress

- ON/OFF-line software: is progressing well

Detector status

- Plan to have everything installed by the end of 2006/beginning of 2007
- Aiming to have the complete experiment ready for data taking in 2007

LHC startup scenario
(from the LHCb point of view)

From the LHCb point of view this would be a desirable scenario:

2007: detector alignment and calibration, possibly already with J/ψ signals from pp collisions

2008: 0.5 fb^{-1}

2009: 1.0 fb^{-1}

2010: 1.5 fb^{-1}

i.e. ~3 fb^{-1} by the end of 2010 at the required average luminosity of ~$2x10^{32}$ $cm^{-2}s^{-1}$

Commissioning plans

Global commissioning without beam in 2006 - 2007

- Commission the subdetectors (starting now !)
- Test the DAQ
- Test the electronics calibration procedures
- Check the scalability of the system, improve when needed
- Use of circulating beam in summer 2007: LHCb is a forward detector, cosmics can not help: beam-gas gives useful tracks for time and position alignment. Study of beam gas events ongoing: useful also for measuring and monitorng the luminosity (cross section measurements! See M. Ferro-Luzzi contribution to this workshop)

Pilot Run (low luminosity)

- Without magnetic field: (time and space) alignments
- With magnetic field: Trigger setup and start collecting data

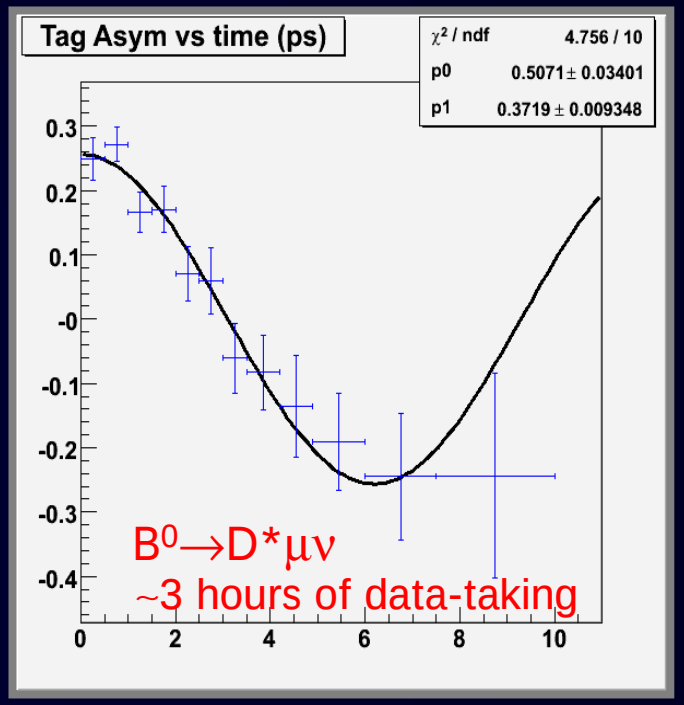
Preparing for physics...with 0.1 fb^{-1} of data

1. Use special samples (mainly from inclusive HLT) for recontsruction and PID calibration and tuning:
   $J/\Psi \rightarrow \mu\mu$ for μ ID
   $D^* \rightarrow D^0(K\pi)\pi$ for K/π ID and μ mis-ID

2. Use B^+/B^0 control channels for tagging tuning

events after triggerxSelection (0.1 fb^{-1}):	
$B^+ \rightarrow J/\Psi(\mu\mu)K^+$	~ 80 k
$B^+ \rightarrow D0^{(*)}\mu\nu$	~ 100 k
$B^0 \rightarrow D^{*+}\mu\nu$	~ 350 k
$B_s \rightarrow D_s^{(*)}\mu\nu$	~ 50 k

σ_ω/ω ~1-2 % per tagger



3. Use B^0 control channels for oscillation measurement, as a first check of tagging performance.

First physics measurements

LHCb physics program with the very first data:

- J/ψ production studies (e.g. prompt vs $B\rightarrow J/\psi X$, bb cross section)
- $\sin(2\beta)$ (as a proof of principle of CPV measurements)
- Δm_s and ϕ_s (after CDF Δm_s, measurement, recent theoretical papers indicate ϕ_s measurement as very interesting for NP)
- $B_s\rightarrow\mu\mu$

J/ψ production studies

LHCb will record a very large sample of J/ψ

σ(J/ψ prompt) = 0.313 mb

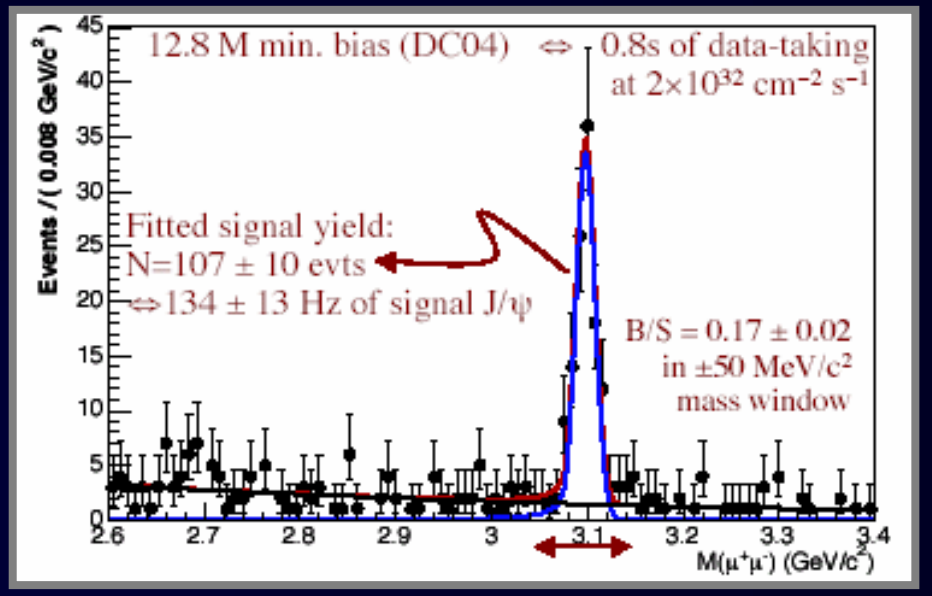
σ(J/ψ from B) = 11 μb

Inclusive HLT rate ~ 600 Hz

True J/ψ rate ~ 130 Hz

$\Rightarrow 10^9$ J/ψ per year

First preliminary studies on bb production cross section using B → J/ψ decays are ongoing



- ATLAS/CMS will measure $|\eta| < 2.5$
- ALICE will measure $|\eta| < 0.9$ and $2.5 < |\eta| < 4$
- LHCb will measure $2.0 < |\eta| < 5.3$

$\Rightarrow$LHCb measurement of σ_{bb} will allow a test of QCD in new region of phase space.

- Not really for the very first data ! A rough measurement would be iteresting anyway

J/ψ production studies

Generator studies

- Detailed generator studies on quarkonia production are ongoing.
- First preliminary results give large inconsistency between our standard PYTHIA settings (v 6.3) and version 6.4 where NRQCD model has been introduced for heavy quarkonia production:

  $\sigma(J/\psi \text{ prompt}) \sim 3$ times lower

  (See M. Bargiotti talk at this workshop for details)

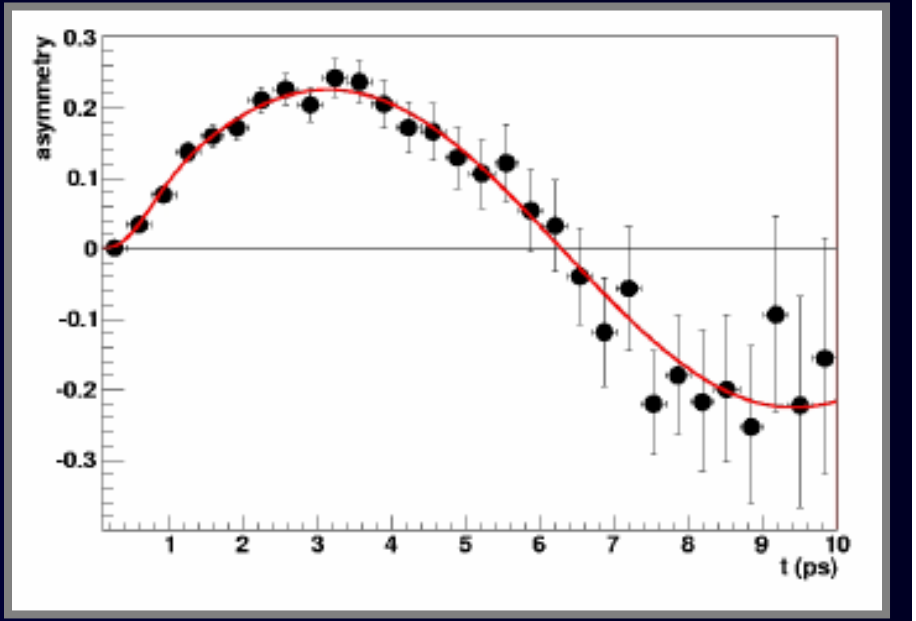
- $\Rightarrow$ even a rough measurement of the ratio of prompt J/ψ vs J/ψ from B will be very interesting at the very beginning

sin(2β) with $B^0 \to J/\psi\, K_S$

Expected to be one of the first CP measurements:

- Demonstrate tagging performance and ability for CP physics
- Sensitivity:
  - LHCb expects ~60k signal events for 0.5 fb^{-1}
    $\Rightarrow \sigma_{stat}(\sin(2\beta)) \sim 0.04$

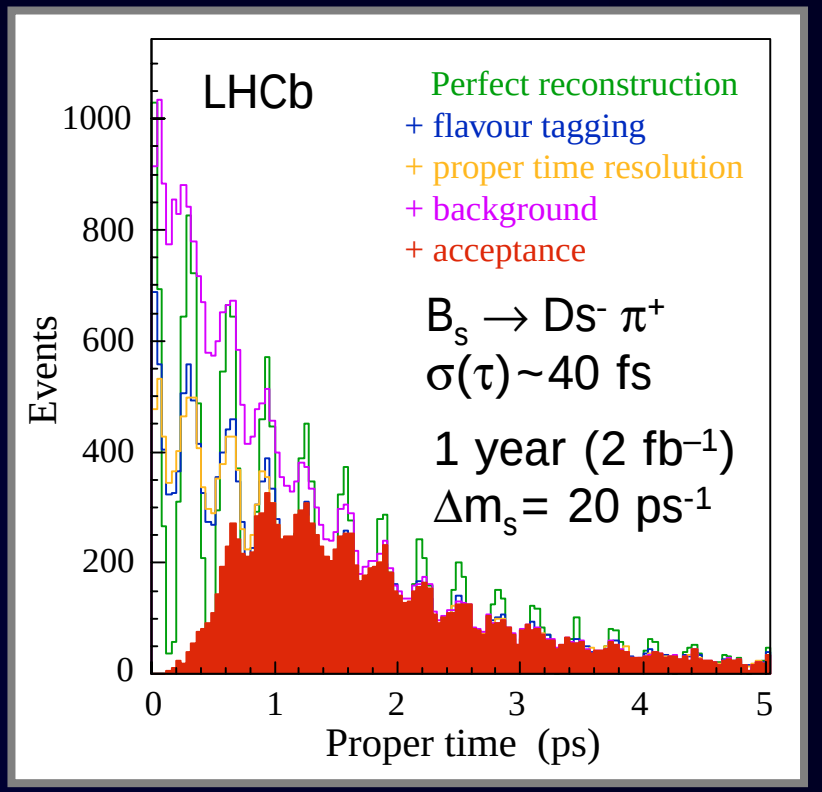
$A_{CP}(t)$ (background subtracted)



B_s mixing: Δm_s

$$CDF: \Delta m_s = 17.33^{+0.42}_{-0.21} \pm 0.07 \quad ps^{-1}$$
$$D0: 17 < \Delta m_s < 21\, ps^{-1} @\ 90\%\, c.l.$$

- CDF results with 1 fb^{-1}:
  3.7k fully reconstructed $B_s \rightarrow D_s^- \pi^+$, $D_s^- 3\pi$
  σ_τ~85 fs, εD^2 = 5 %
  ~3σ significance at Δm_s~17 ps^{-1}
- CDF measurement is already statistically very precise (~2%)
- LHCb expects:
  120k $B_s \rightarrow D_s^- \pi^+$ evts/year (2 fb^{-1})
  B/S = 0.4, σ_τ ~ 40 fs, εD^2 = 9 %



LHCb can reach Tevatron (statistical...) precision in the first months of data taking.
Note also that as Δm_s~17 ps^{-1}, the ultimate σ_τ of LHCb is not essential.
Δm_s is in any case needed for ϕ_s measurement

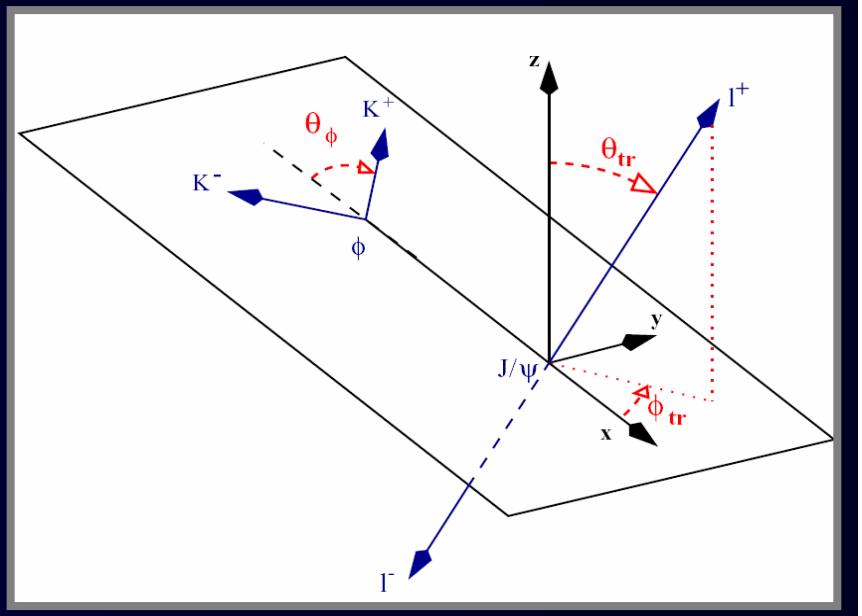
ϕ_s and $\Delta\Gamma_s$ from $B_s \to J/\psi\phi$

$B_s \to J/\psi\phi$ is the B_s counterpart of $B^0 \to J/\psi\, K_S$:

- B_s mixing phase ϕ_s is very small in SM:
  $\phi_s = -\arg(V_{ts}^2) = -2\lambda\eta^2 \sim -0.04$
  $\Rightarrow$ sensitive probe for new physics

Sensitivity (at $\Delta m_s = 17.5\ ps^{-1}$):

- 131k $B_s \to J/\psi\phi$ signal events/year B/S=0.12
- $\sigma_{stat}(\sin\phi_s) = 0.023$
- $\sigma_{stat}(\Delta\Gamma_s/\Gamma_s) \sim 0.011$ (1 year, 2 fb^{-1})



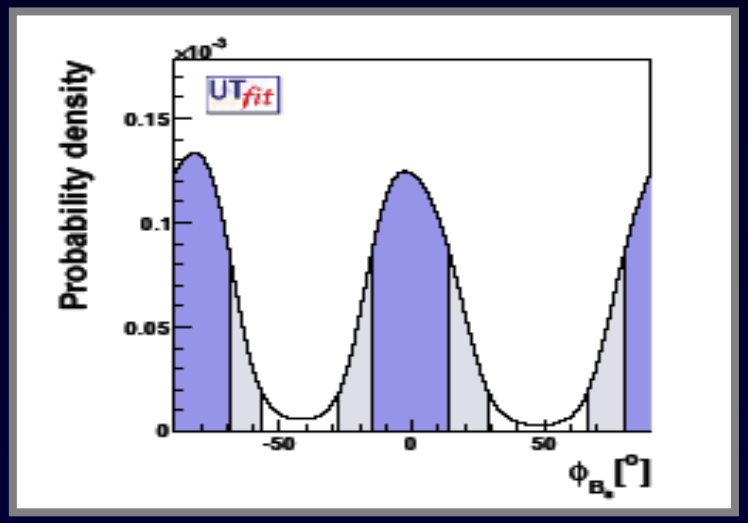
Recent theoretical works indicate that large values of ϕ_s are not excluded:

$\Rightarrow$ already with 0.2 fb^{-1} set an interesting limit or measure it if large,

$J/\psi\phi$ final state contains two vectors: angular analysis needed to separate CP-even and CP-odd
Fit for $\sin\phi_s$, $\Delta\Gamma_s$ and CP-odd fraction (needs external Δm_s)

Constraints on NP from ϕ_s measurement

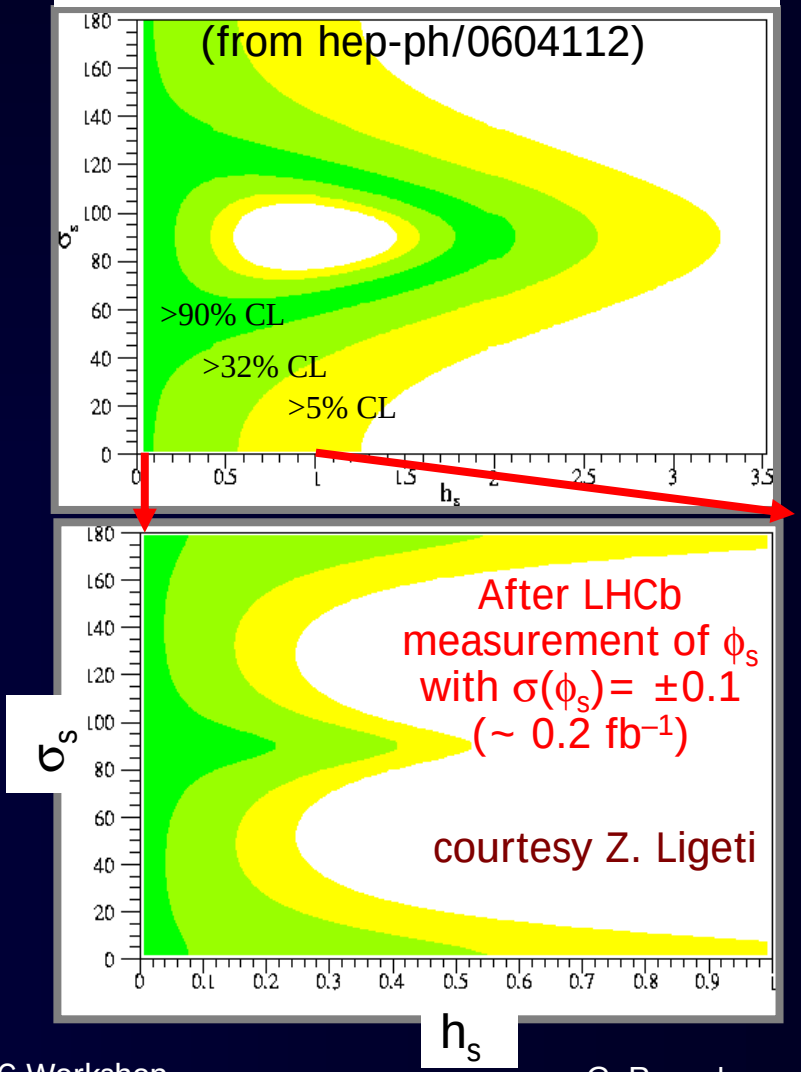
Constraints on NP contribution to ϕ_s



UT fit collaboration estimate for ϕ_s (hep-ph/0605213)

$S_{J\psi\phi} = \sin(2\chi - 2\theta_s) = 0.07 \pm 0.49$

$$S_{\psi\phi} = \sin\left[2\beta_s + \arg\left(1 + h_s e^{2i\sigma_s}\right)\right],$$



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

Very rare decay, sensitive to new physics

BR ~ 3.5×10^{-9} in SM, can be strongly enhanced in SUSY

Current limit from Tevatron:

D0: 2.3×10^{-7} at 95% CL

CDF: 1.0×10^{-7} at 95% CL

LHCb has prospect for significant measurement but difficult to get reliable estimate of expected background:
Full simulation: 10M incl. bb events + 10M $b\to\mu$, $b\to\mu$ events (all rejected)

	1 year	$B_s \to \mu+ \mu^-$ signal (SM)	$b\to\mu$, $b\to\mu$ background	Inclusive bb background	All backgrounds
LHCb	2 fb^{-1}	17	< 100	< 7500	

In principle a (lucky !) measurement is possible already with 0.5 fb^{-1}

Conclusions

- Construction of LHCb is well advanced: we plan to complete the installation by the end of 2006 aiming to have the full detector ready for data in 2007.
- Commisioning strategy is being prepared in detail
- Strategy for calibrations, alignments, trigger and analysis tuning being devised
- Already with the very first data very interesting measurement can be performed: I invite you to follow the startup of our experiment !