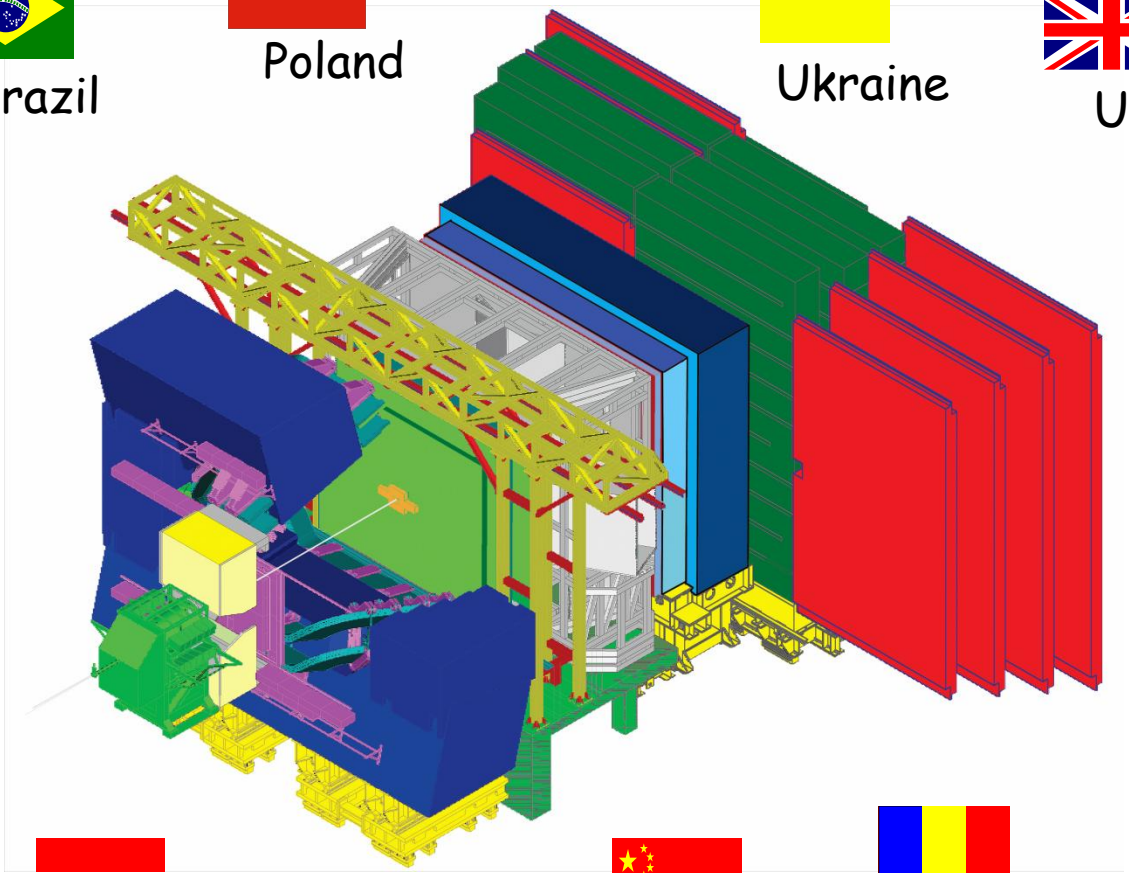
Overview of LHCb



Brazil
Poland
Ukraine
UK
France
Switzerland
Germany
Spain
Italy
Russia
Netherlands
PRC
Romania

Hervé Terrier

XXXXth Rencontres de Moriond
QCD AND HIGH ENERGY HADRONIC INTERACTIONS
Spectroscopy

On behalf of the LHCb Experiment

Overview of LHCb

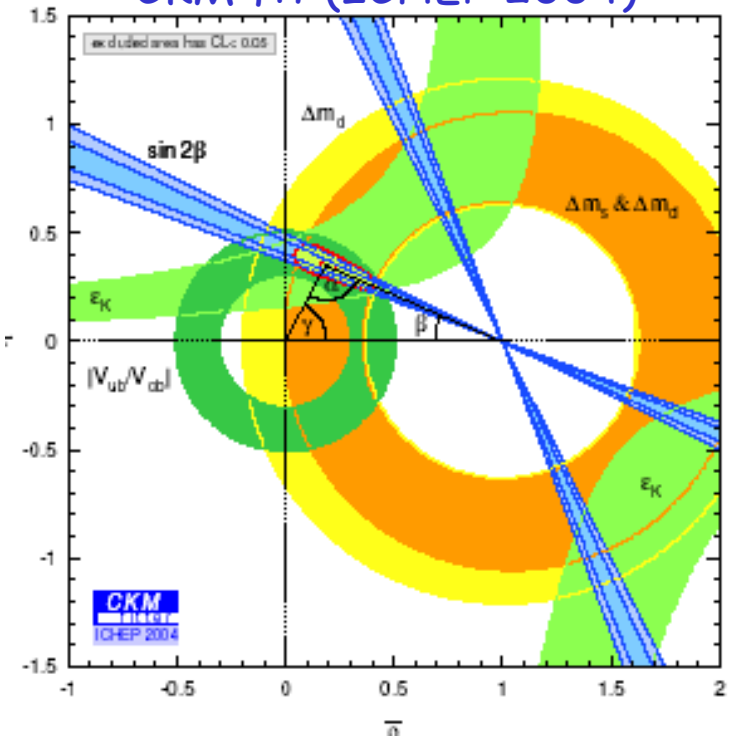
Contents :

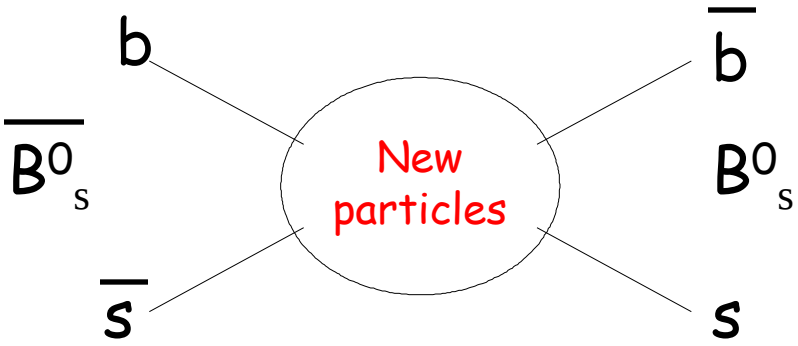
- Physics Motivations
- LHC environment
- LHCb expected performance

Physics Motivations

- BABAR, BELLE, Tevatron and kaon experiments have tested and will test CKM picture of CP violation
(no clear hint of NP for the moment)

CKM fit (ICHEP 2004)



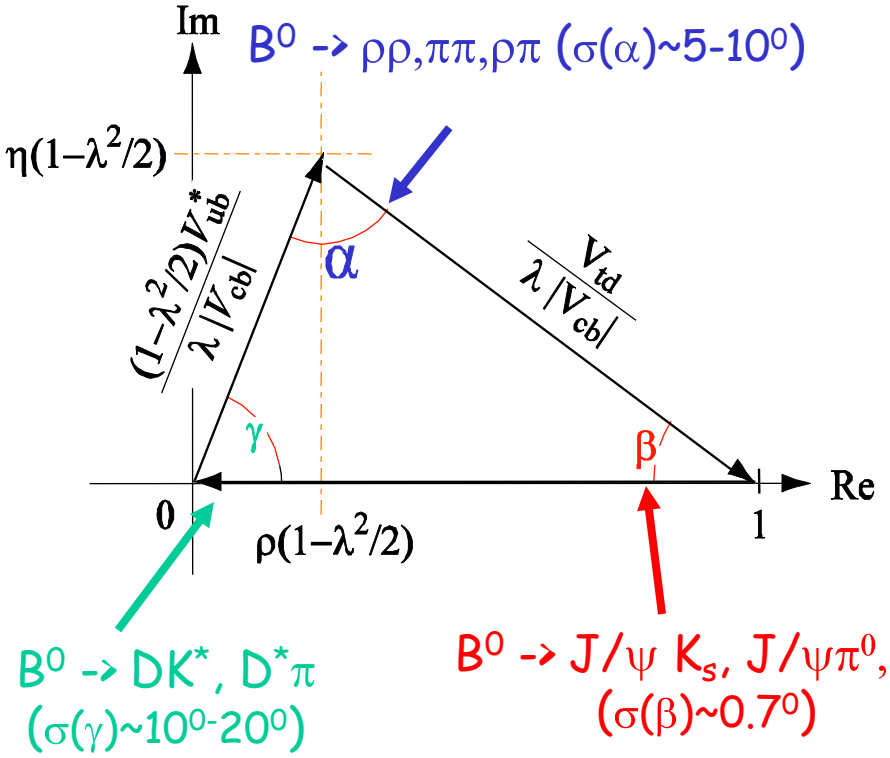


- NP could still be hidden in box and loop diagrams

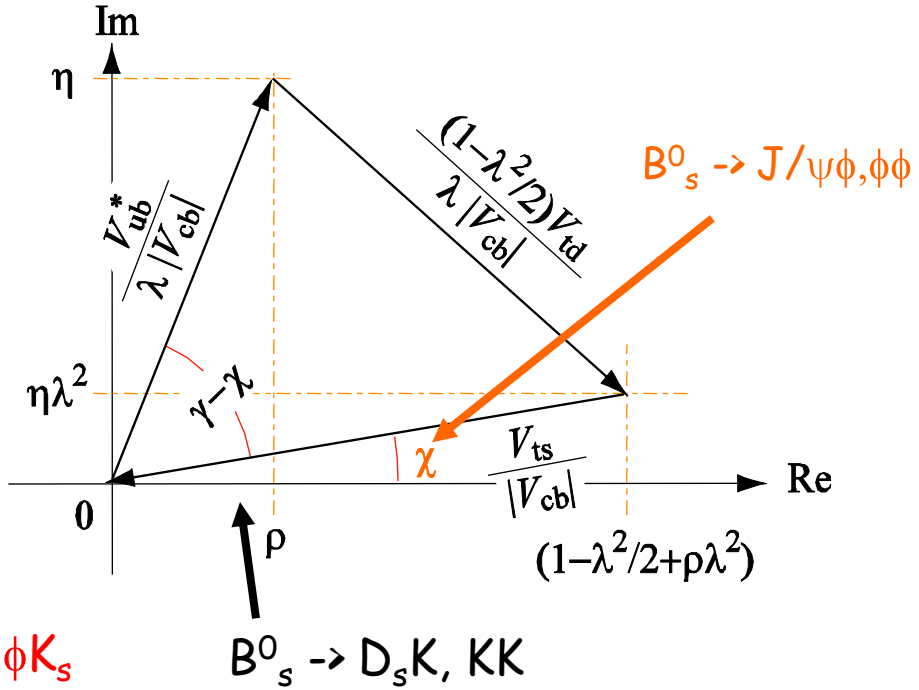
Physics Motivations

LHCb will study all types of B mesons !

B^0_d system



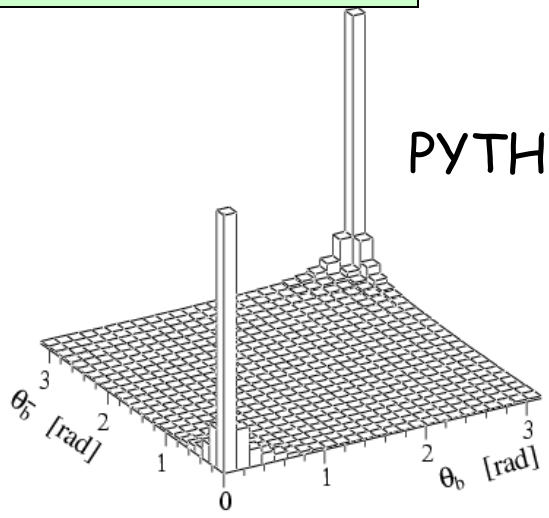
B^0_s system



(Expected sensitivities of B factories in 2007)

LHC environment

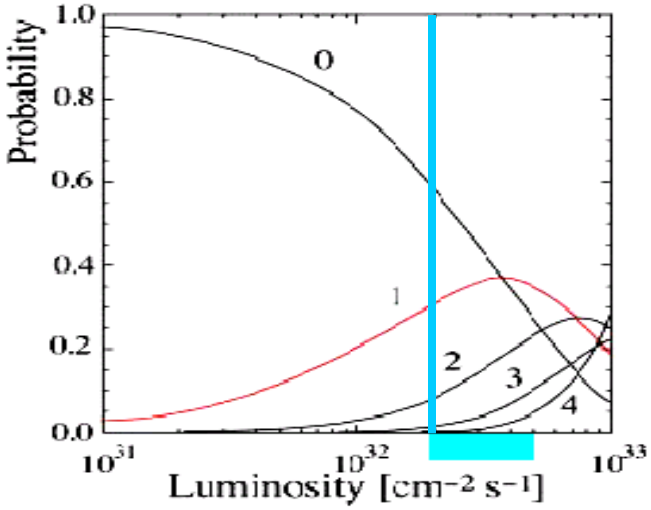
- LHC : pp collisions at $\sqrt{s}$ = 14 TeV (40 MHz)
- bb pairs are mostly produced at small angles wrt beam pipe
  --> forward spectrometer



- $\mathcal{L} = 2.10^{33} - 10^{34}\ cm^{-2}s^{-1}$

  to avoid high number of interaction / bunch crossings : $\mathcal{L} = 2 .10^{32}\ cm^{-2}s^{-1}$ for LHCb

  --> simpler events and less radiation damage for the detectors



- $\sigma_{inelastic} \approx 80$ mb and $\sigma_{bb} \approx 0.5$ mb

  --> need an efficient trigger

  but N_{bb} (1 year in 4π) = 10^{12}

  with B^+ / B^0_d / B^0_s / b-baryon

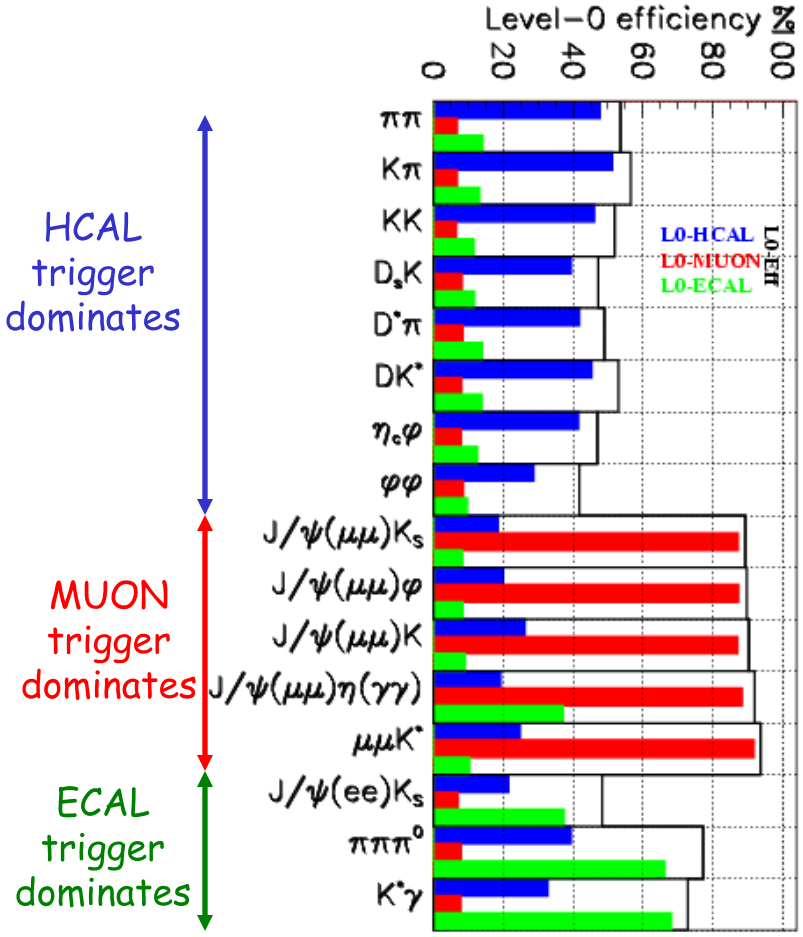
  (4 : 4 : 1 : 1)

Trigger

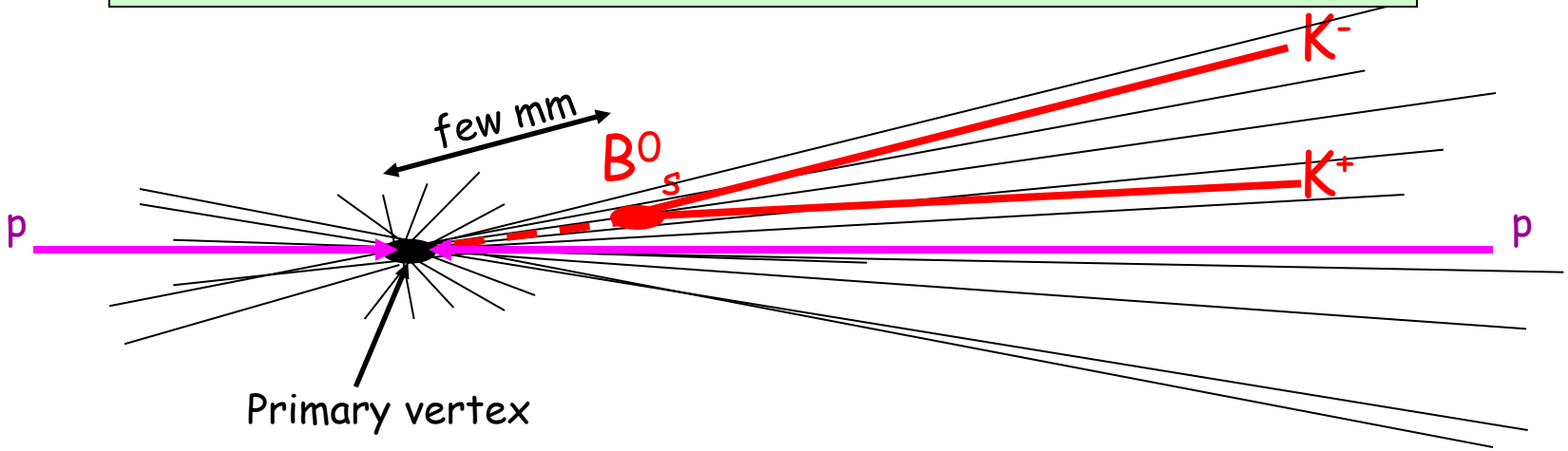
- multi-level trigger :

  - Level 0 (40 MHz --> 1 MHz):
    reject complicated events
    high p_T e, γ, π^0, μ, or hadrons
  - Level 1 (1 MHz --> 40 KHz):
    large IP and p_T tracks
  - HLT (40 KHz --> 200 Hz):
    access to complete events
    ~ offline selection

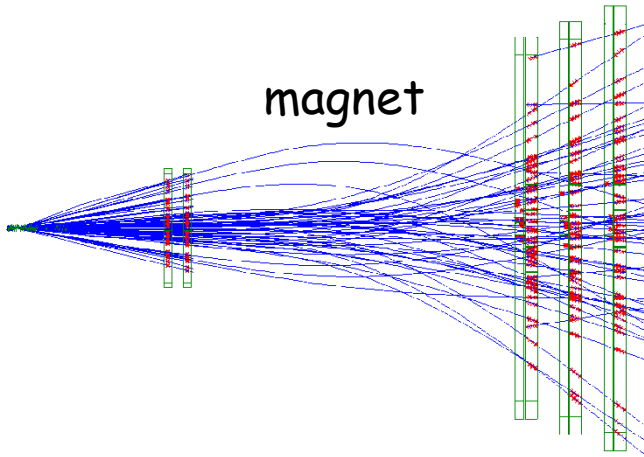
  + 1.8 KHz to get systematics from data
    high dimuon mass --> tracking
    inclusive b (b→μ) --> trigger + data mining
    D* --> PID



LHCb detector requirements

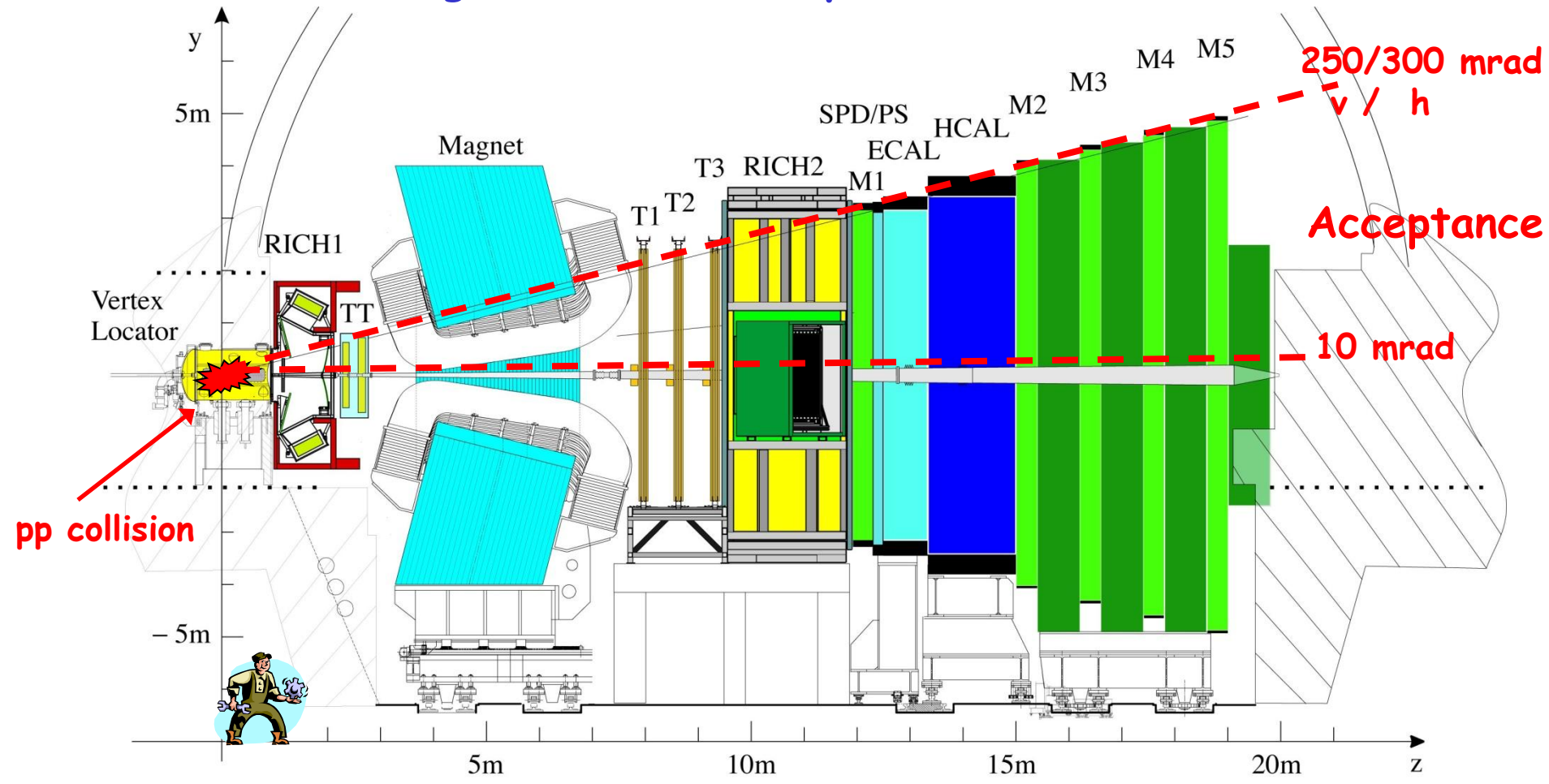


- **Efficient particle identification :**
  - π/K separation (1-->100 GeV) --> RICH (for $B^0_{(s)}$ --> hh, flavour tagging, …)
  - electron and muon ID --> CALO + MUON (for $B^0_{(s)}$ --> J/ψ X, flavour tagging, …)
- **Good decay time resolution (~ 40 fs):**
  - vertex detector (for B^0_s --> $D_s\pi$, B^0_s --> J/ψ ϕ, …)
- **The best mass resolution and efficient tracking :**
  - tracker and magnet



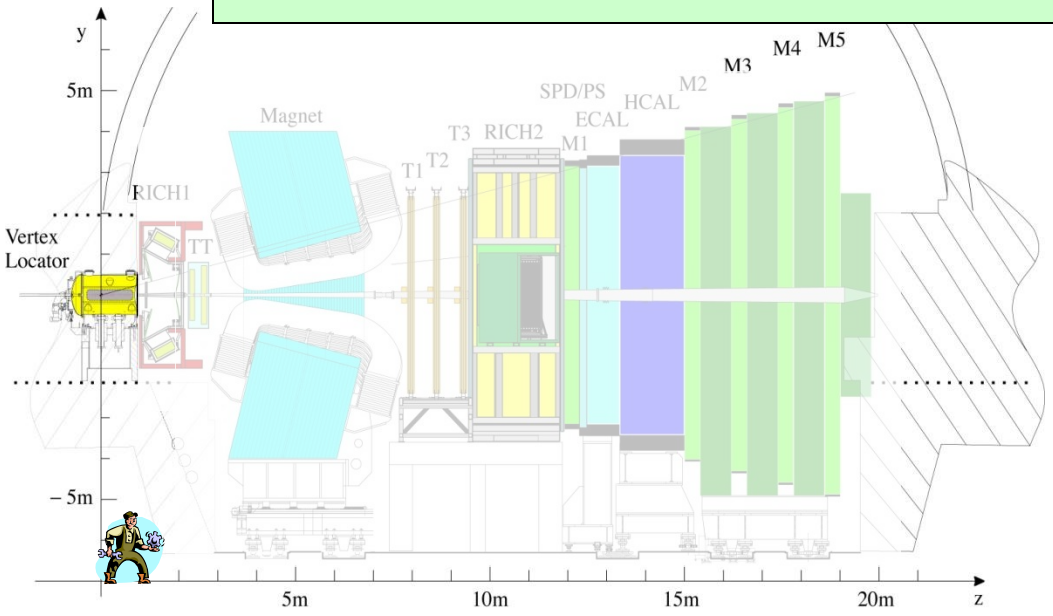
LHCb experiment

Single arm forward spectrometer



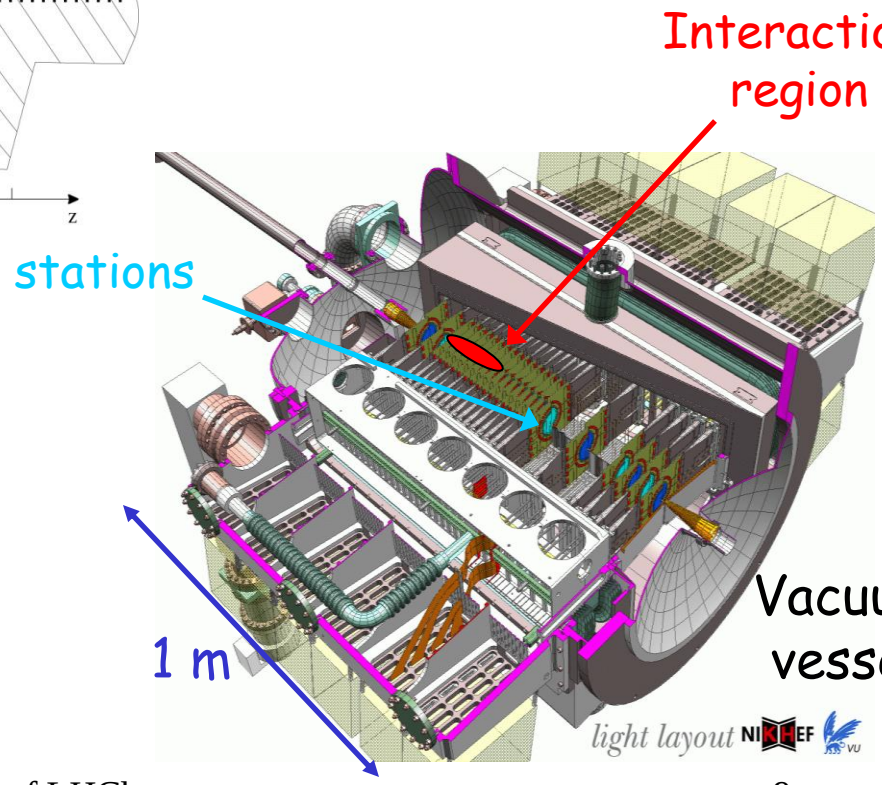
side view

Vertex Locator



Vertex and tracking detector :

- silicon discs
- 8 mm from beam axis
- 21 stations (retractable)



PV position resolution :

~ 8 μm (x,y) and ~ 44 μm (z)

IP precision :

~ 40 μm

B_s oscillation frequency Δm_s

LEP + SLD -> $\Delta m_s > 14.4\ ps^{-1}$

Important physics subject of CDF+D0

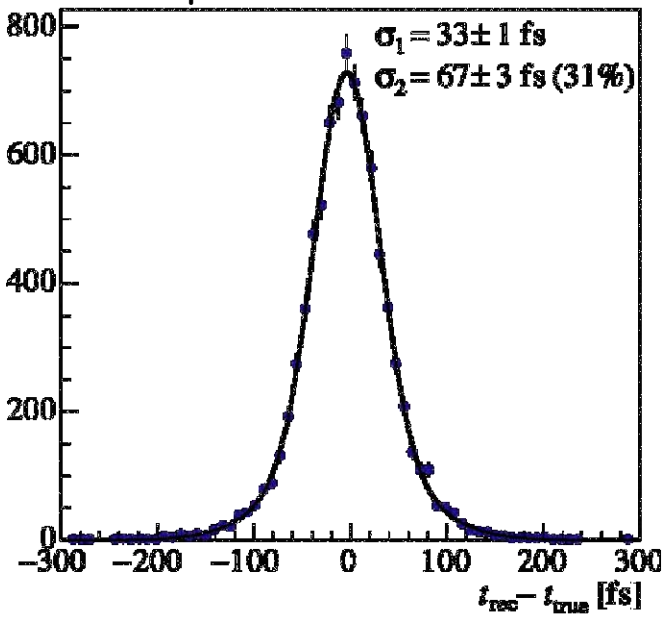
Needed for the observation of CP asymmetries with B_s decays

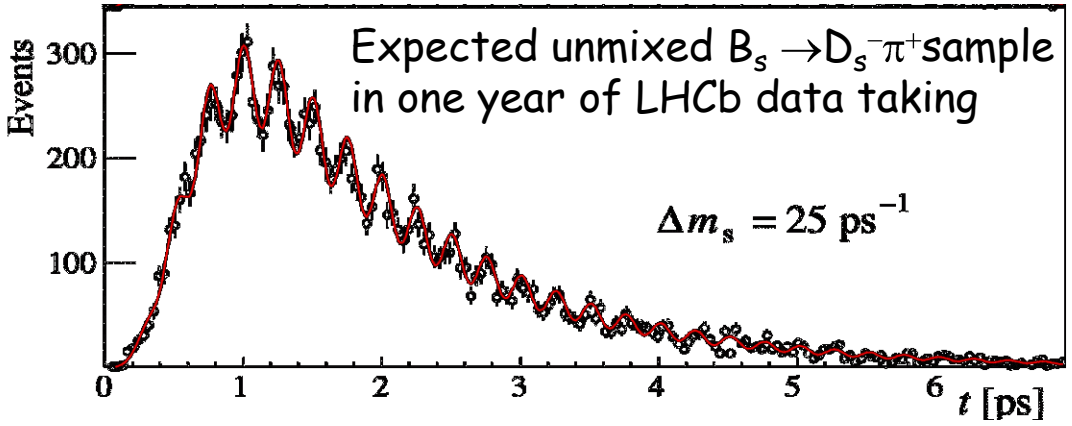
Use $B_s \to D_s^- \pi^+$ (~80k evts/year expected)

If $\Delta m_s = 20\ ps^{-1}$ $\sigma(\Delta m_s) = 0.011\ ps^{-1}$

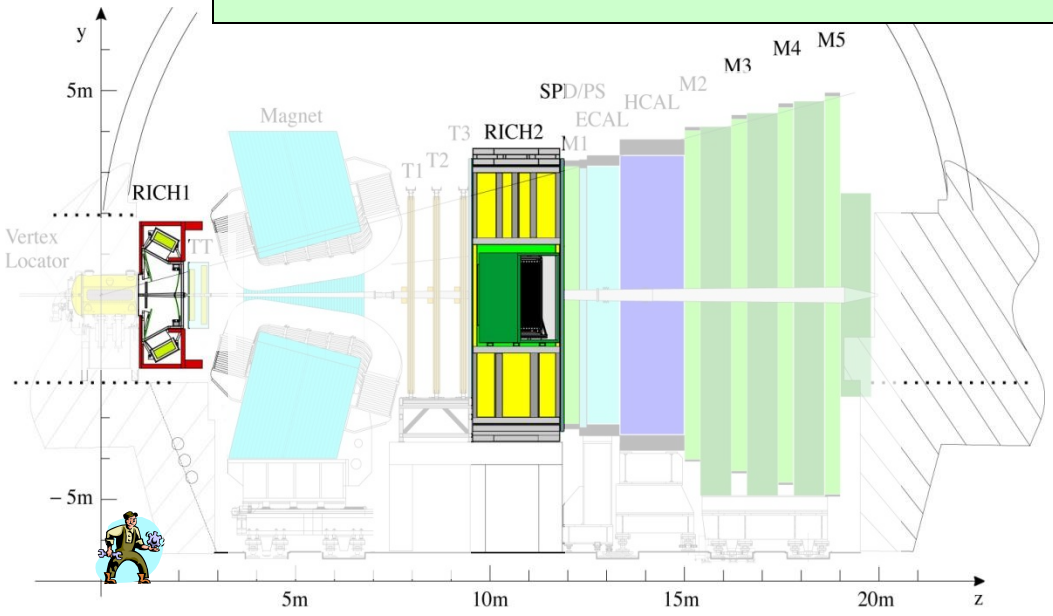
Can observe 5σ oscillation signal if $\Delta m_s < 68\ ps^{-1}$ (well beyond SM prediction)

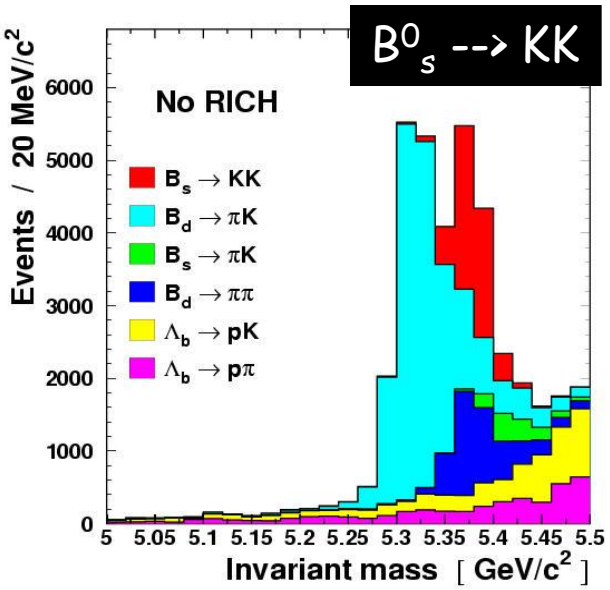
Propertime resolution :

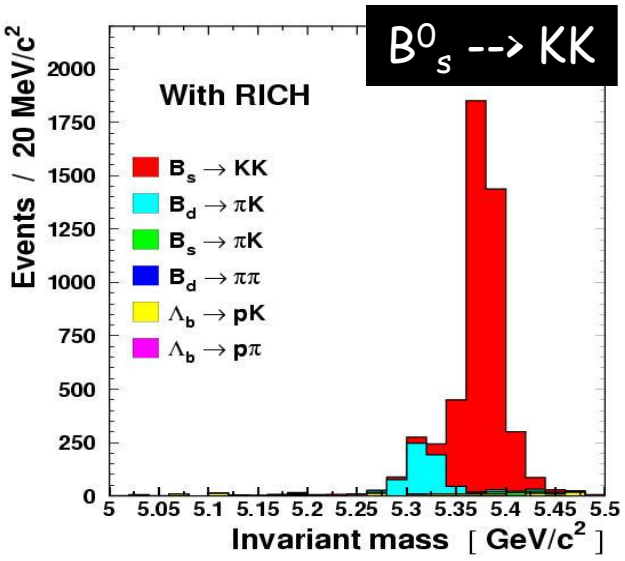




RICH



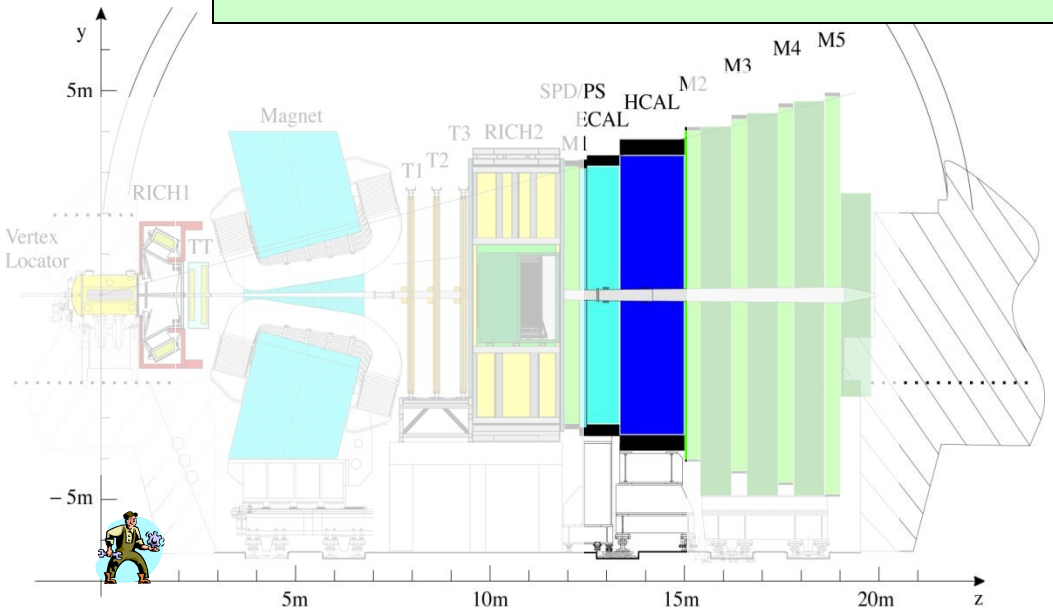


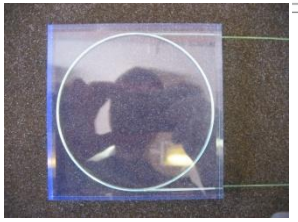


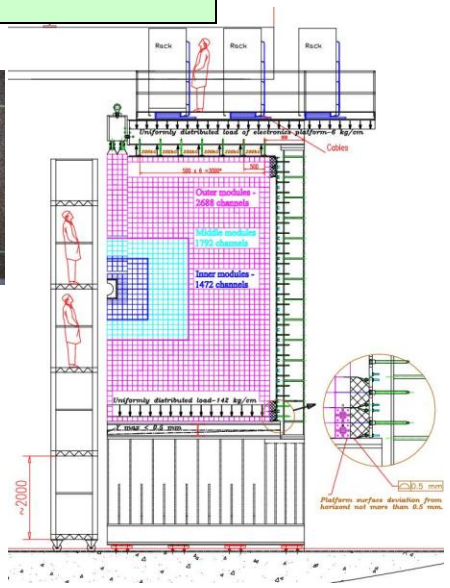
2 RICHs and 3 Cherenkov radiators to cover the full momentum range

good π/K separation for 2<p<100 GeV

Calorimeter System





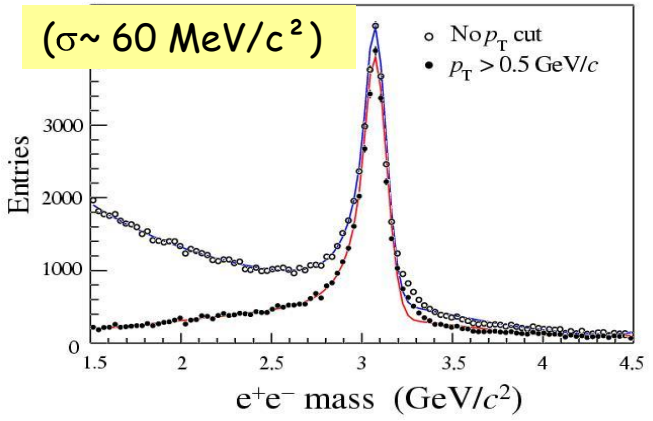


With Bremsstrahlung recovery

SPD/PS ($2X_0$) ECAL ($25X_0$) : lead/scintillator
HCAL (5.7λ) : iron/scintillator

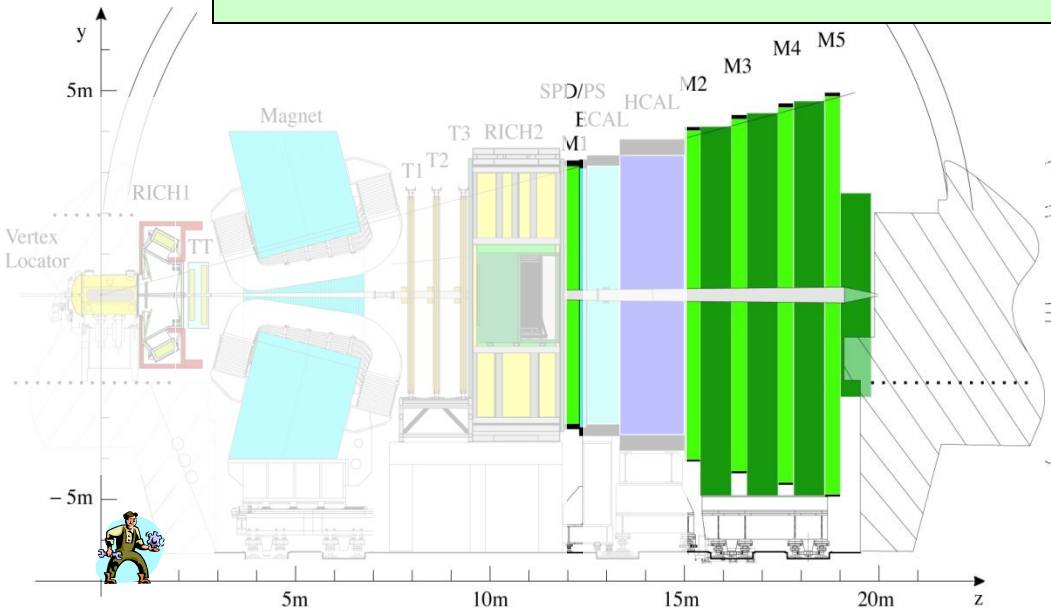
Readout every 25 ns (L0 trigger)
Identification : electrons, hadrons and π^0

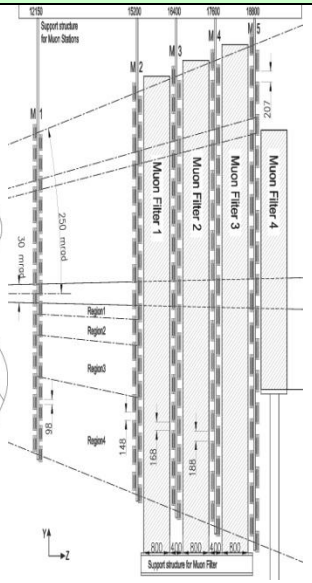
ECAL : $\sigma_E/E \sim 10\% / \sqrt{E} \oplus 1\%$
HCAL : $\sigma_E/E \sim 80\% / \sqrt{E} \oplus 10\%$

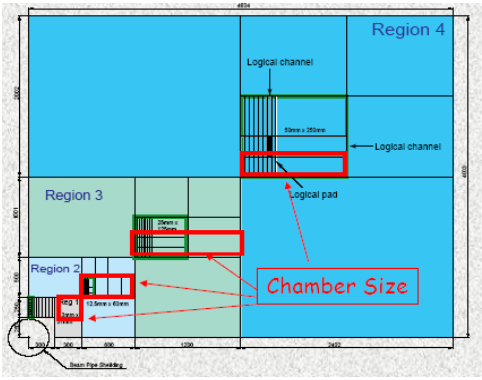


$\langle \varepsilon_{e \to e} \rangle \sim 94\%$ and $\langle \varepsilon_{\pi \to e} \rangle \sim 0.7\%$ for tracks in ECAL acceptance

Muon System







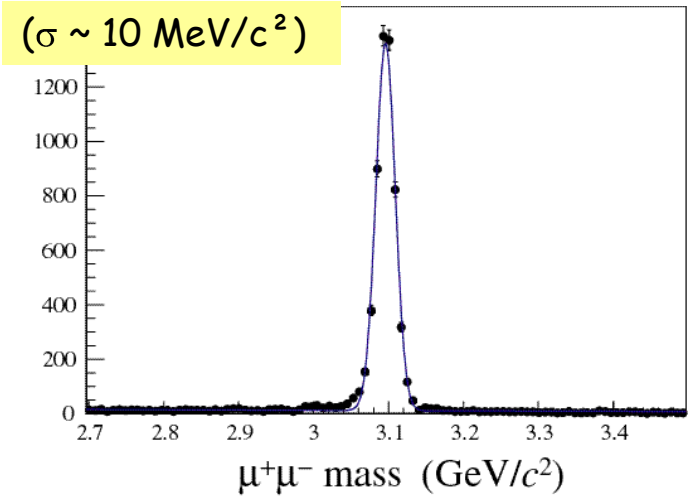
5 stations with 1380 MWPCs

Projective geometry

Each station subdivided into four regions

$\langle \varepsilon_{\mu \to \mu} \rangle$ ~ 93 % $\langle \varepsilon_{\pi \to \mu} \rangle$ ~ 1.0 % for tracks in Muon detector acceptance

(σ ~ 10 MeV/c^2)



Many Physics Topics at LHCb

- Measurement of α angle

  B -> $\rho\pi$ (12k evts/year) $\sigma(\alpha) < 10^0$ (1 year)

- Measurement of β angle

  B -> $J/\psi K_s$ (240k evts/year) $\sigma(\beta) \sim 0.7^0$ (1 year)

I will give more details hereafter

- Measurement of γ angle

  with B_s->D_sK, B->$\pi\pi$ and B_s->KK, B->DK* decay

- Measurement of B_s mixing angle χ

  with B_s->$J/\psi\phi$ decay

- New physics in b -> s penguin process

  B -> $K^*\gamma$, B -> ϕK_s , B_s -> $\phi\phi$, $\phi\gamma$

-D physics

  Mixing, CPV

- Rare decays

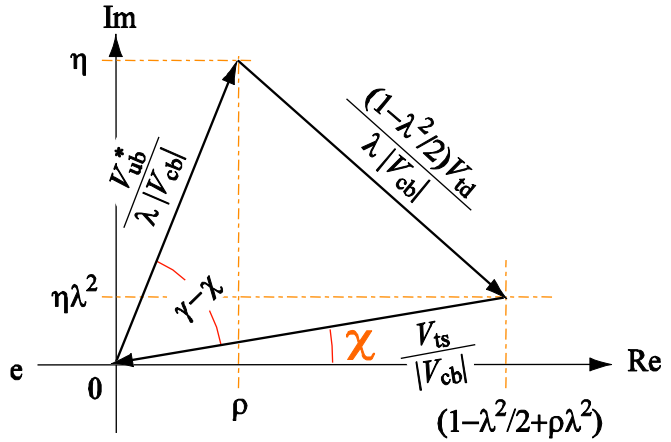
  B_s -> $\mu\mu$, B -> $K^*\mu\mu$

- B_c physics, b baryons

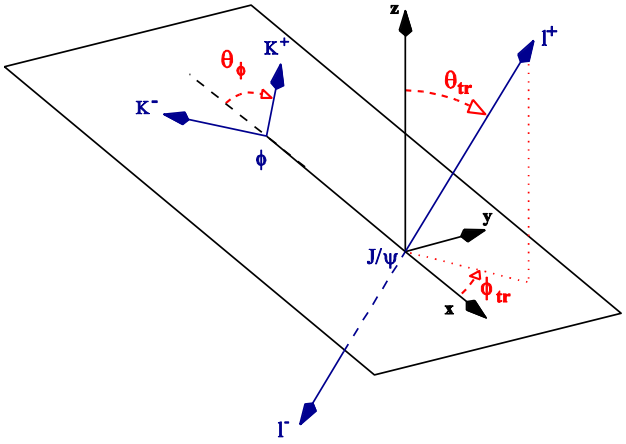
  lifetimes, masses, branching ratios

B^0_s Mixing Phase (χ)

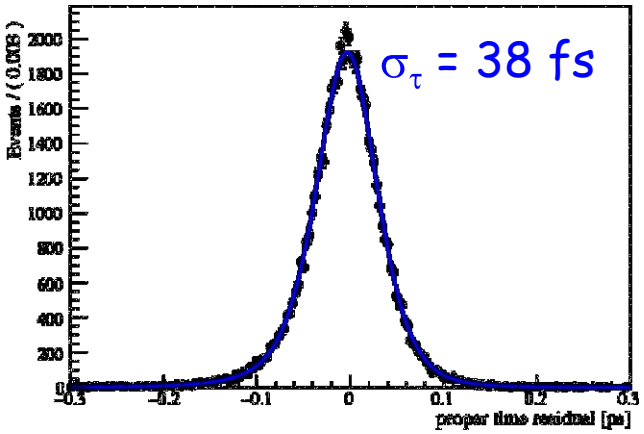
- needed for some γ measurements
- use $B_s \to J/\psi\phi$ (~120k evts/year expected)



Angular analysis to separate CP even and CP odd



Propertime resolution



$\sigma(\sin 2\chi)$~0.06 and $\sigma(\Delta\Gamma_s/\Gamma_s)$~0.02 (with Δm_s = 20 ps^{-1})

Measurements of angle γ : possible scenario

1. $B_s \to D_s K$ ($\sigma(\gamma) \sim 14\text{-}15^0$)

2. $B \to \pi\pi$, $B_s \to KK$ ($\sigma(\gamma) \sim 4\text{-}6^0$)

3. $B \to DK^*$ ($\sigma(\gamma) \sim 7\text{-}8^0$)

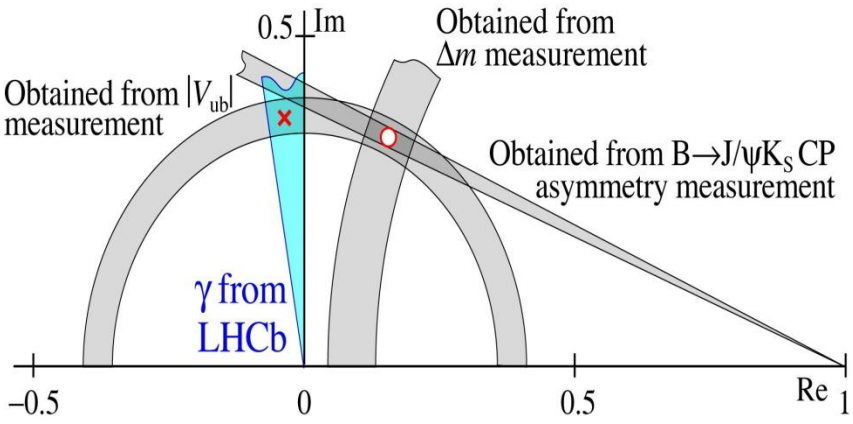
γ not affected by new physics in loop diagrams

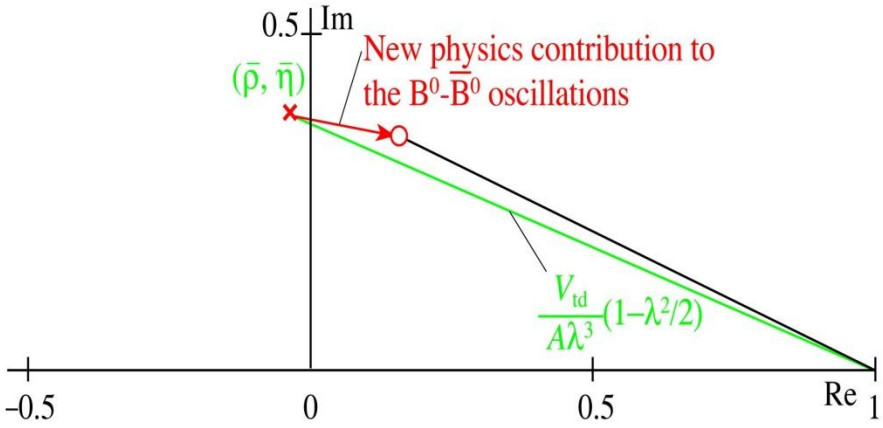
γ affected by possible new physics in penguin

γ affected by possible new physics in D-$\bar{D}$ mixing

Determine the CKM parameters A, ρ, η independent of new physics

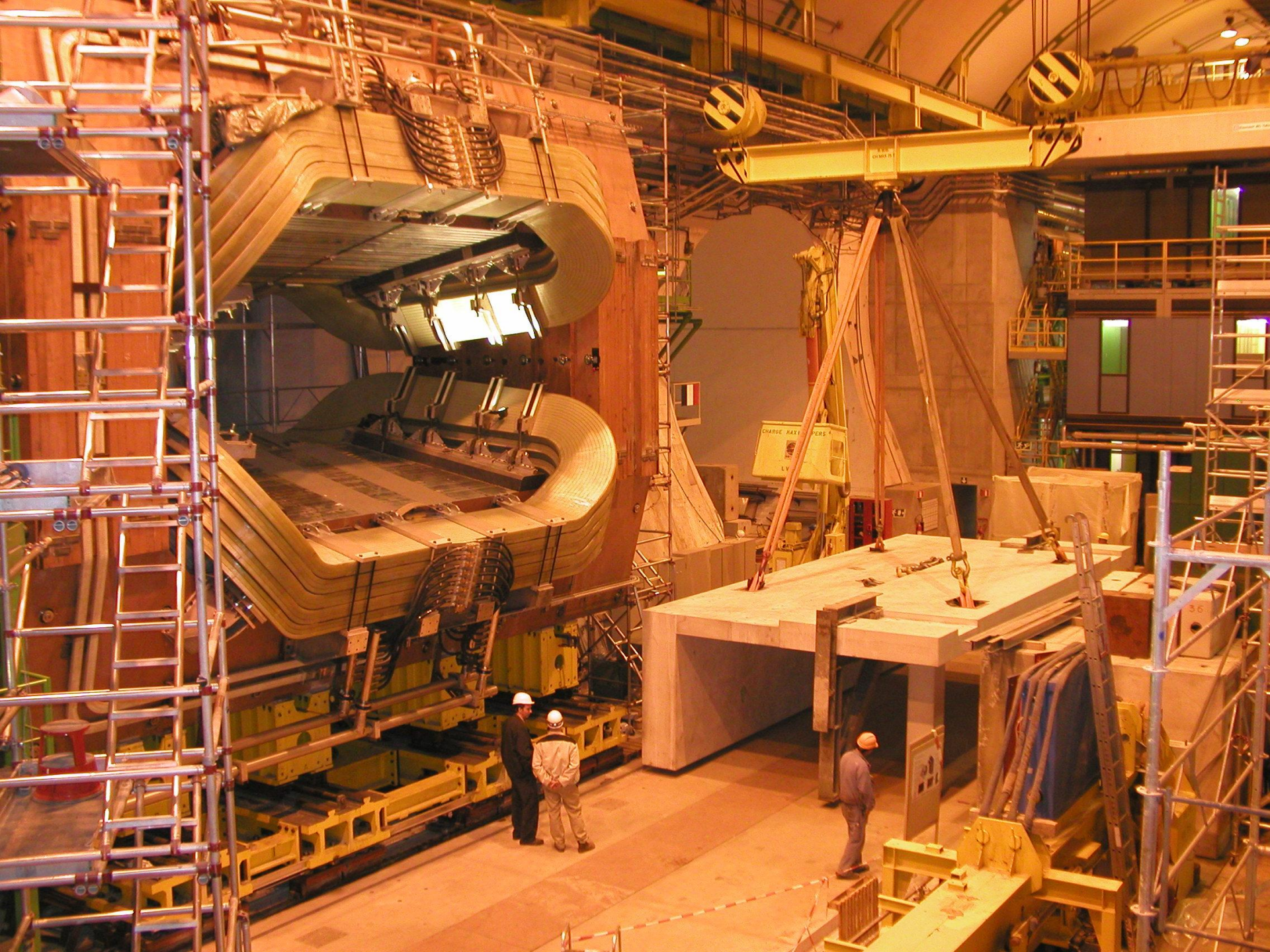
Extract the contribution of new physics to the oscillations and penguins





Conclusion

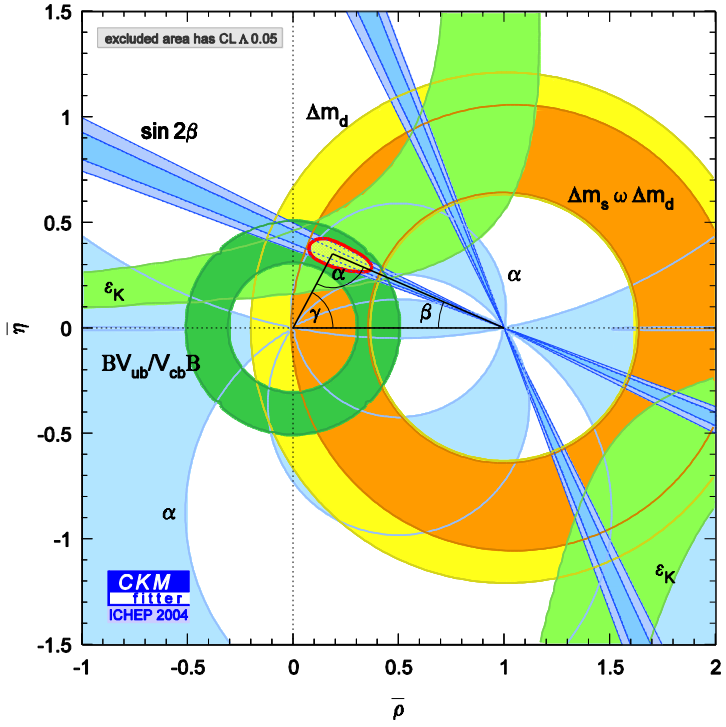
- **LHC offers great opportunity for B physics**
- **LHCb is dedicated to b Physics with**
  - Efficient trigger for b physics
  - Excellent vertex and momentum resolution
  - Excellent particle identification
  - Access to all b-hadron species
- **Promising potential for studying New Physics**
- **Construction of the experiment is on the way…**



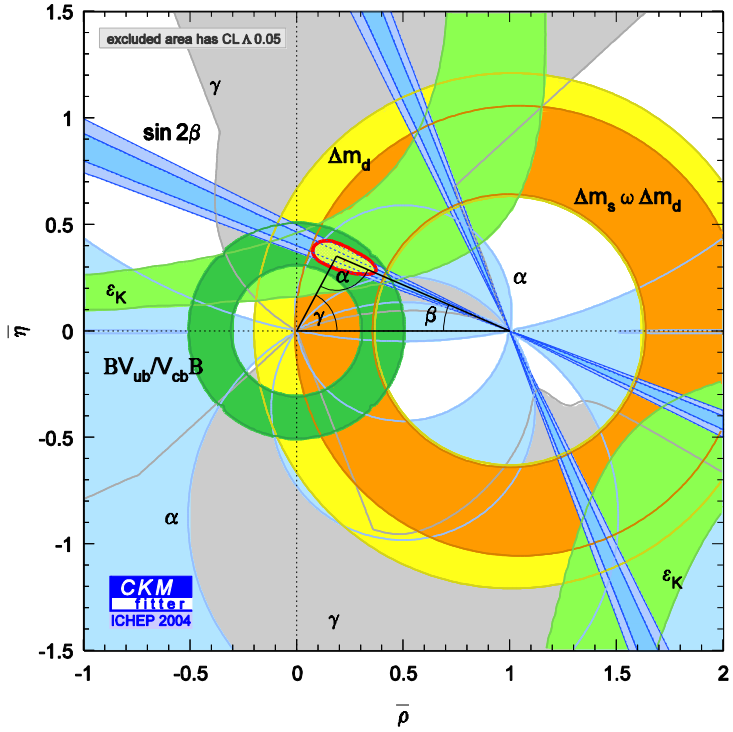
Back Up Slides

CKM fit (ICHEP 2004)

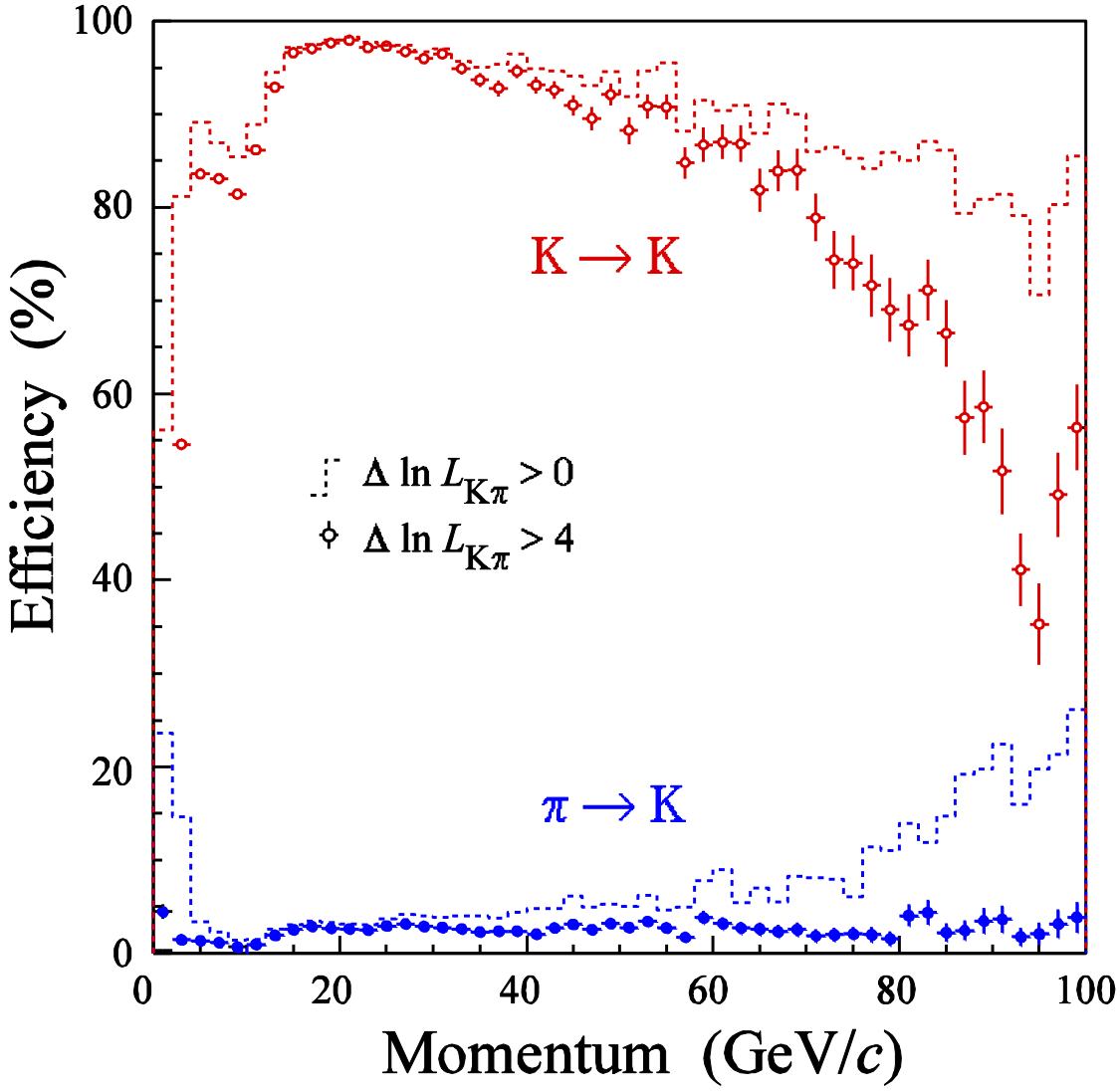
Adding α measurements



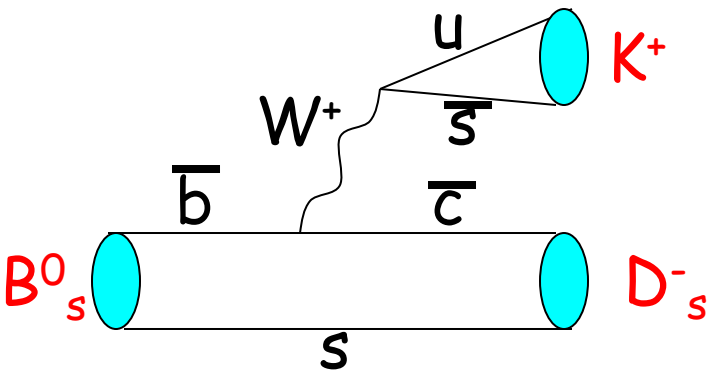
Adding α and γ measurements

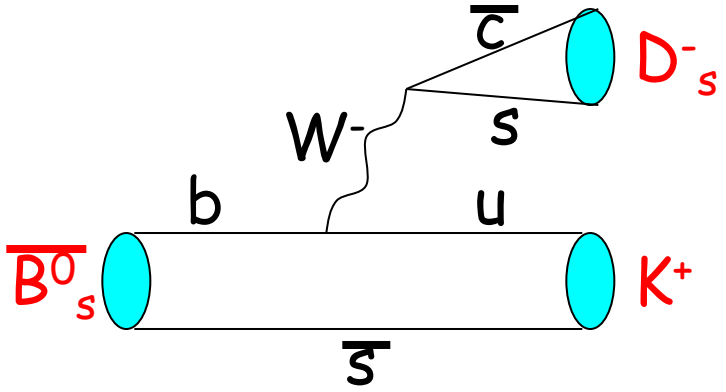


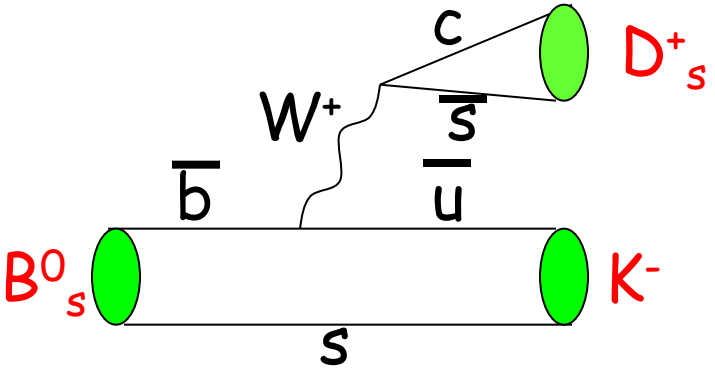
RICH PID performance

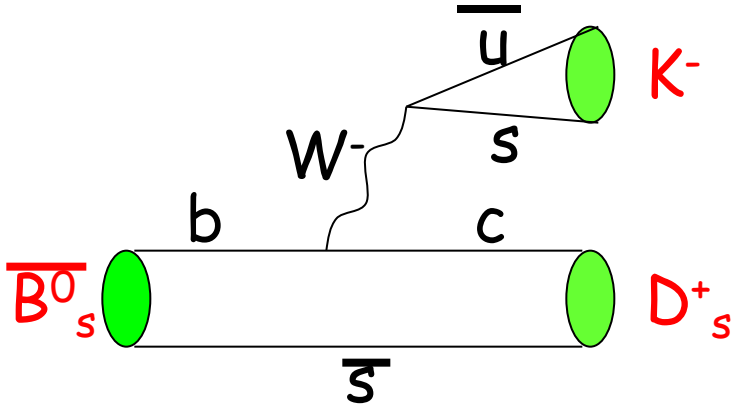


B_s -> D_sK diagrams

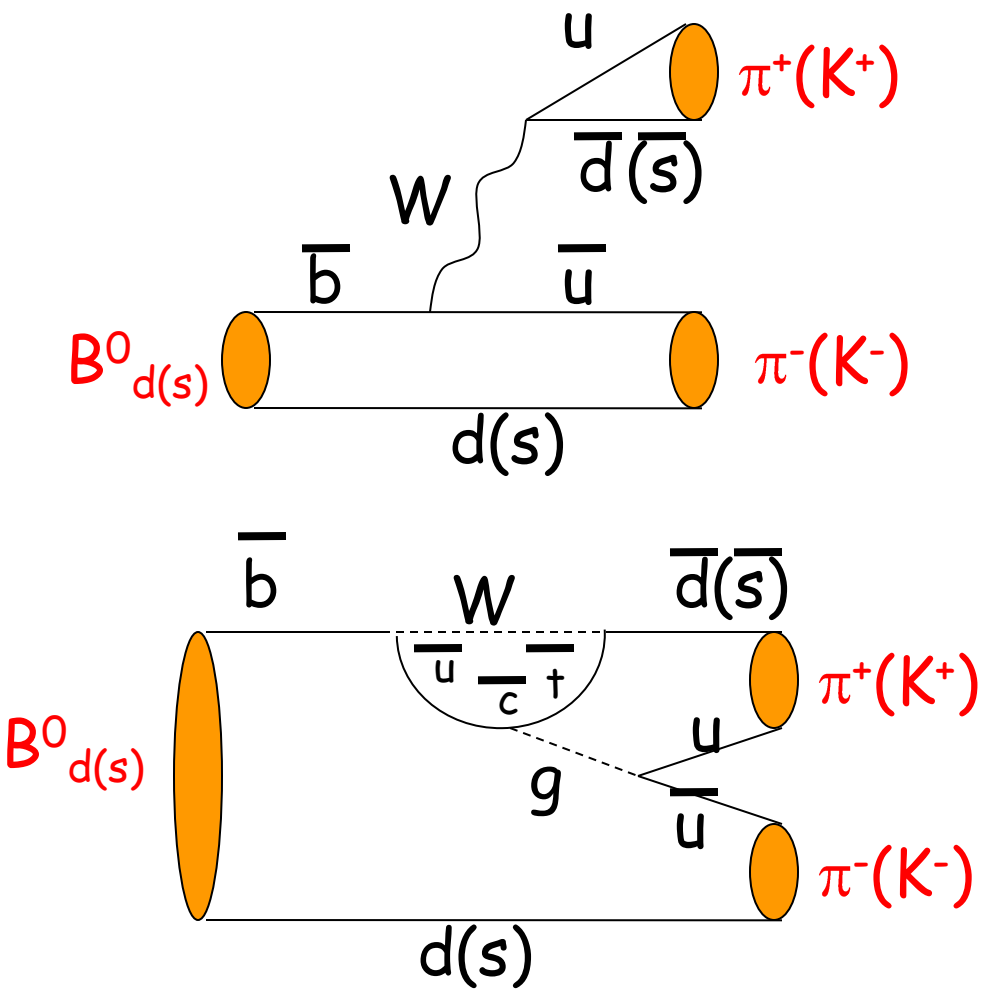








$B^0_{d(s)}$ -> hh diagrams



B^0_d-> DK* diagrams