Study of B_s mesons with the CMS detector at LHC

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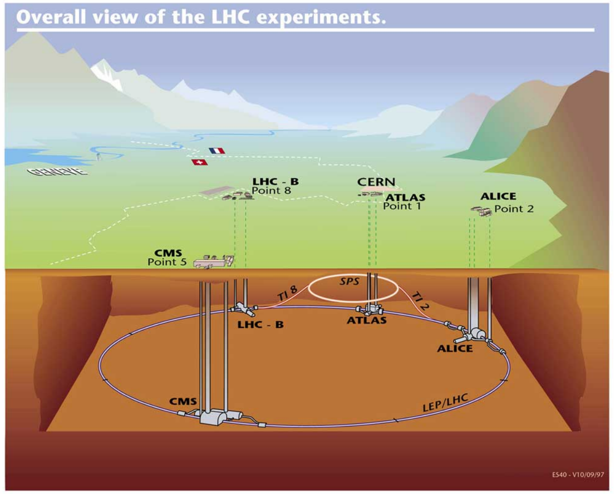
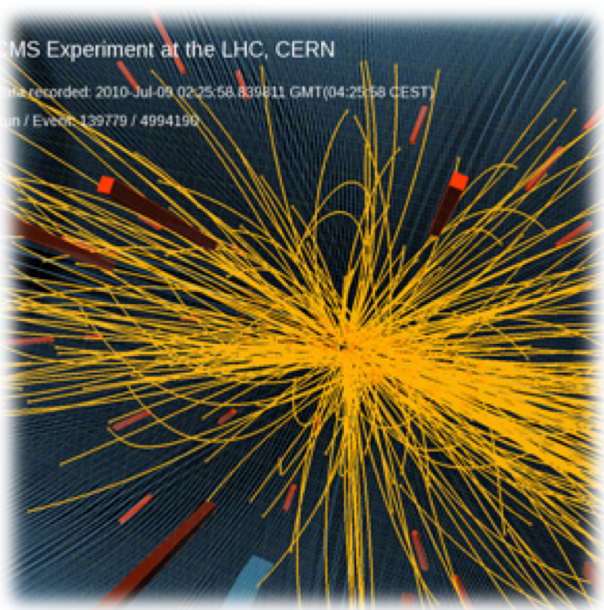
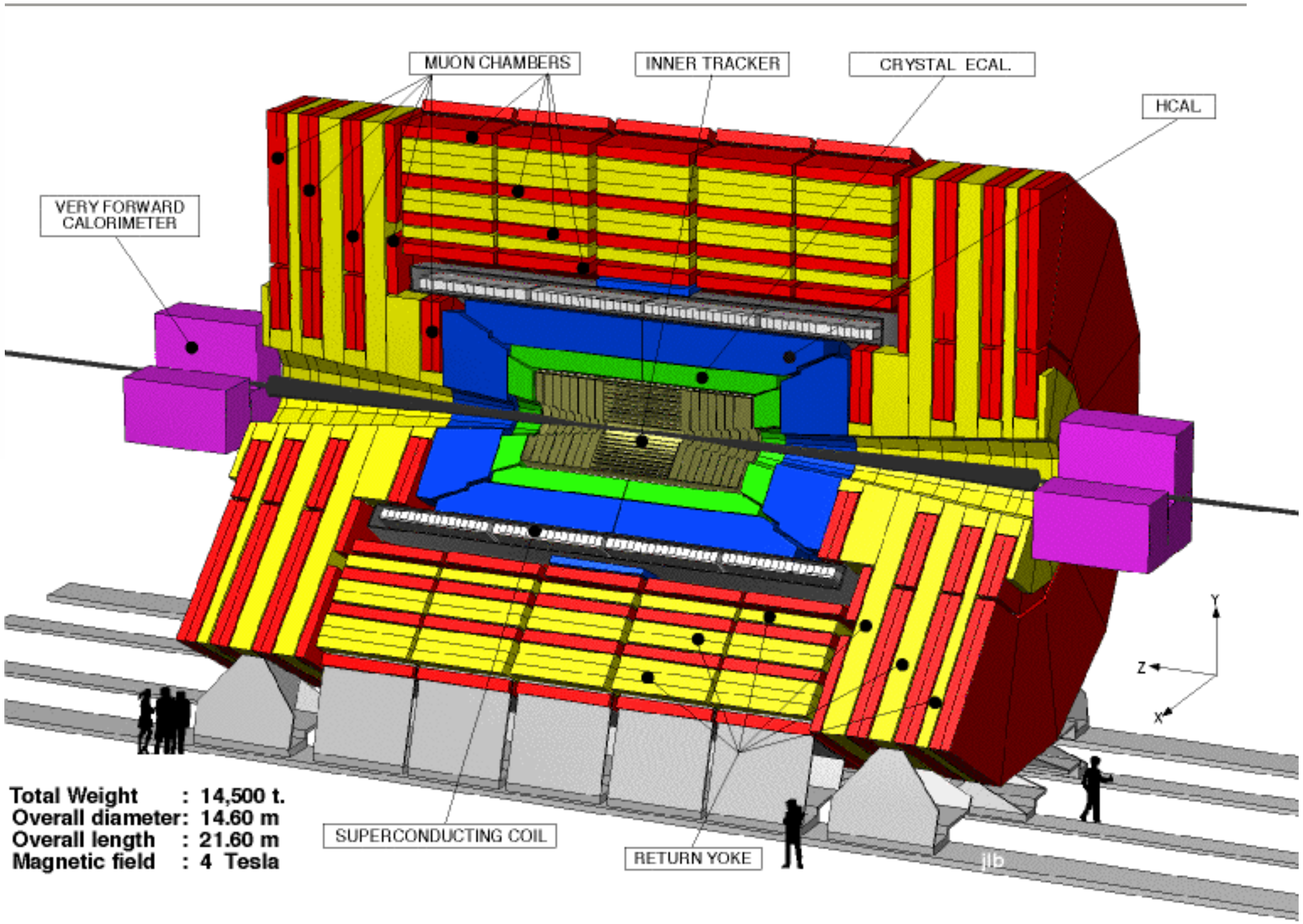
Outline

- CMS experiment at LHC
- B_s meson study
  - Underlying physics
  - Analysis strategy

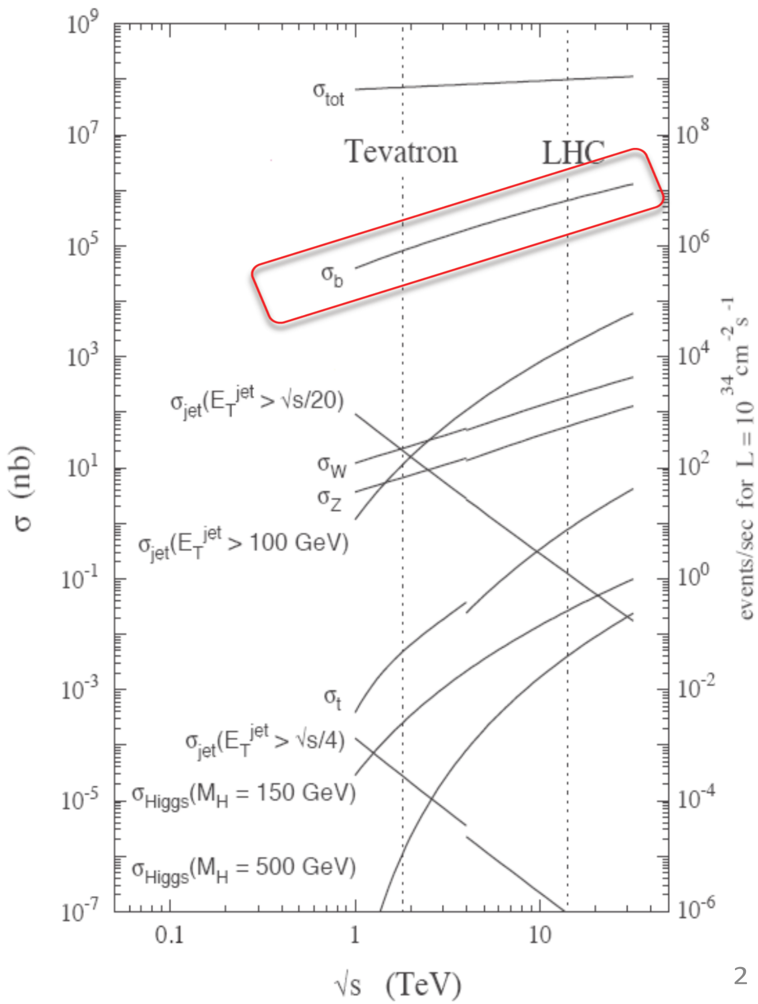
CMS (Compact Muon Solenoid)

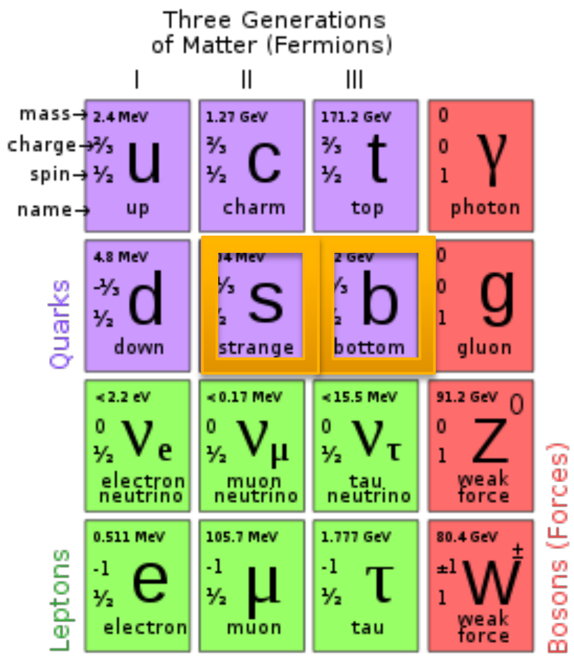






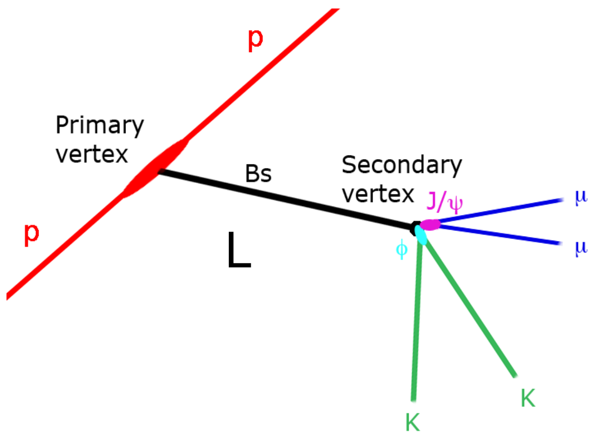
Bs meson





Studied channel:

$B_s \rightarrow J/\psi\varphi \rightarrow \mu^+\mu^-K^+K^-$



τ=1.42 ps

CP violation in the SM

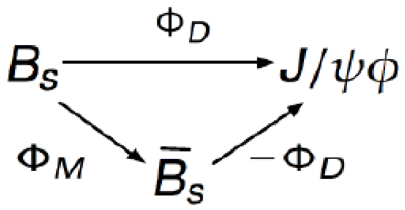
CP violation is taken into account in the Standard Model including a complex phase in the CKM matrix which describes the quark mixing

$$\begin{bmatrix} |d'\rangle \\ |s'\rangle \\ |b'\rangle \end{bmatrix} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} \begin{bmatrix} |d\rangle \\ |s\rangle \\ |b\rangle \end{bmatrix}.$$

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

B_s physics: Overview

- The flavour eigenstates of B_s can oscillate among them
- Interference between B_s decay directly into J/ψφ or via B_s/anti-B_s mixing gives rise to a CP violation phase

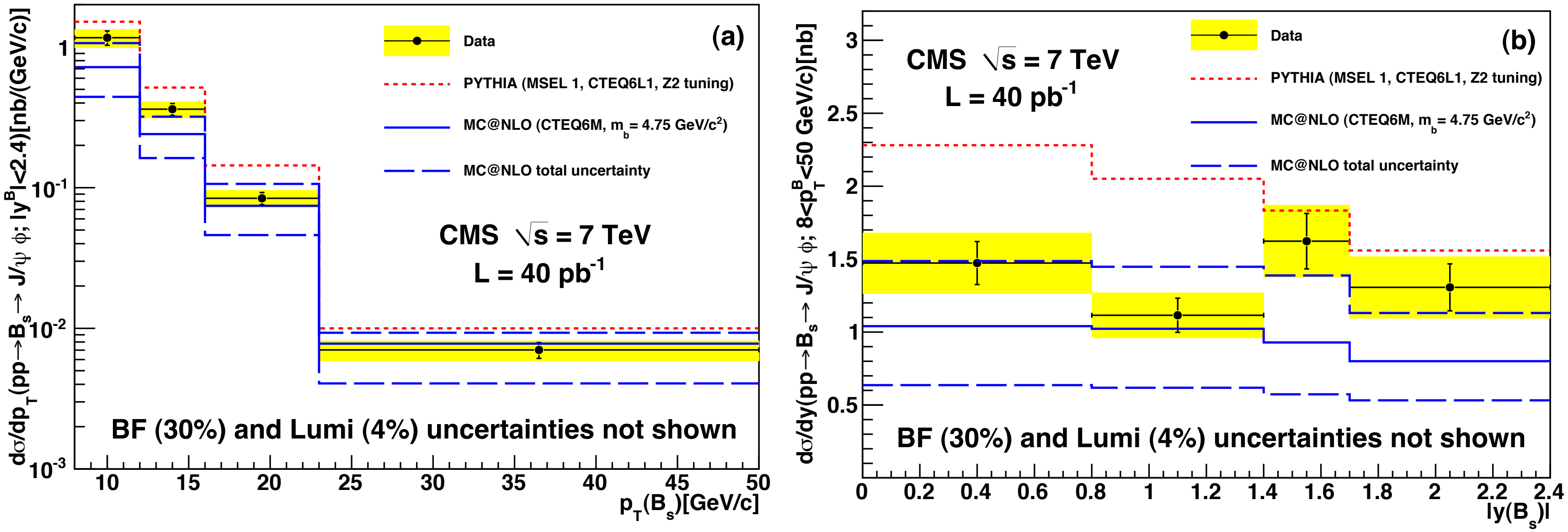


$$\Phi_s = \Phi_M - 2\Phi_D$$

- In the Standard Model $\Phi_s \approx -2\beta_s = -(0.0363 \pm 0.0017)$ rad
- If in the mixing new physics is present, the measured parameter can be larger
- Two CP eigenstates of B_s: B_L and B_H
- A disentangling analysis is needed: $CP = (-1)^L$ and L=0,1,2 since B_s is a pseudo-scalar while J/ψ and φ are vector bosons

Group activity

- Cross section measurement (done) PHYSICAL REVIEW D 84, 052008 (2011)



- Measure of the $\Delta\Gamma_s$ (next step)
- Measure of the ϕ_s (final step)

$\Delta\Gamma_s$ – disentangling time-angular distribution

$$\frac{d^4\Gamma}{dt d\Omega} \propto |A_0(t)|^2 \cdot f_1(\Omega) + |A_\parallel(t)|^2 \cdot f_2(\Omega) + |A_\perp(t)|^2 \cdot f_3(\Omega) + \Im\left(A_\parallel^*(t)A_\perp(t)\right) \cdot f_4(\Omega) + \Re\left(A_0^*(t)A_\parallel(t)\right) \cdot f_5(\Omega) + \Im\left(A_0^*(t)A_\perp(t)\right) \cdot f_6(\Omega).$$

$$|A_0(t)|^2 = |A_0(0)|^2 e^{-\Gamma_q t}\left[\cosh\left(\frac{\Delta\Gamma_q}{2}t\right) - \cos\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

$$|A_\parallel(t)|^2 = |A_\parallel(0)|^2 e^{-\Gamma_q t}\left[\cosh\left(\frac{\Delta\Gamma_q}{2}t\right) - \cos\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

$$|A_\perp(t)|^2 = |A_\perp(0)|^2 e^{-\Gamma_q t}\left[\cosh\left(\frac{\Delta\Gamma_q}{2}t\right) + \cos\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

$$\Im\left(A_\parallel^*(t)A_\perp(t)\right) = |A_\parallel(0)||A_\perp(0)| e^{-\Gamma_q t}\left[-\cos(\delta_\perp - \delta_\parallel)\sin\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

$$\Re\left(A_0^*(t)A_\parallel(t)\right) = |A_0(0)||A_\parallel(0)| e^{-\Gamma_q t}\cos\delta_\parallel\left[\cosh\left(\frac{\Delta\Gamma_q}{2}t\right) - \cos\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

$$\Im\left(A_0^*(t)A_\perp(t)\right) = |A_0(0)||A_\perp(0)| e^{-\Gamma_q t}\left[-\cos\delta_\perp \sin\phi_q \sinh\left(\frac{\Delta\Gamma_q}{2}t\right)\right]$$

- $|A_\perp(0)|^2 + |A_\parallel(0)|^2 + |A_0(0)|^2 = 1.$

$$f_1(\Omega) = \frac{9}{32\pi} 2\cos^2\psi\left(1 - \sin^2\theta\cos^2\varphi\right)$$

$$f_2(\Omega) = \frac{9}{32\pi}\sin^2\psi\left(1 - \sin^2\theta\sin^2\varphi\right)$$

$$f_3(\Omega) = \frac{9}{32\pi}\sin^2\psi\sin^2\theta$$

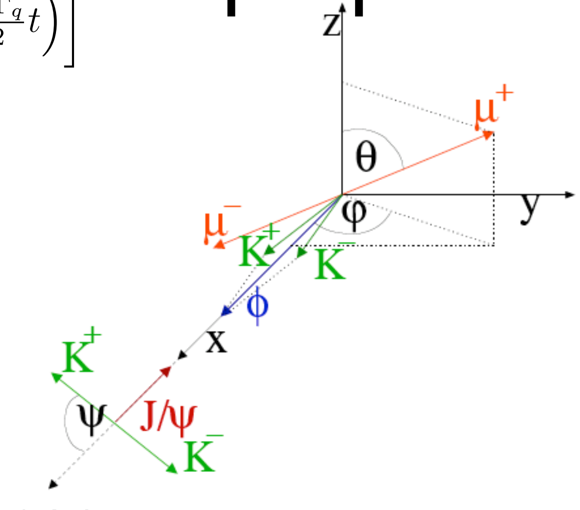
$$f_4(\Omega) = -\frac{9}{32\pi}\sin^2\psi\sin 2\theta\sin\varphi$$

$$f_5(\Omega) = \frac{9}{32\pi\sqrt{2}}\sin 2\psi\sin^2\theta\sin 2\varphi$$

$$f_6(\Omega) = \frac{9}{32\pi\sqrt{2}}\sin 2\psi\sin 2\theta\cos\varphi$$

[Mass, ct_{xy}, cosθ, cosψ, φ]

→ [$\Delta\Gamma_s$, Γ_s, cosδ, A_0, A_{perp}]



: Definition of the three angles used for the describtion of the deacy

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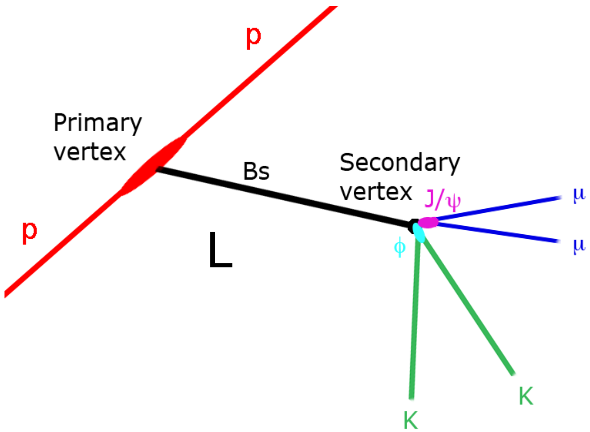
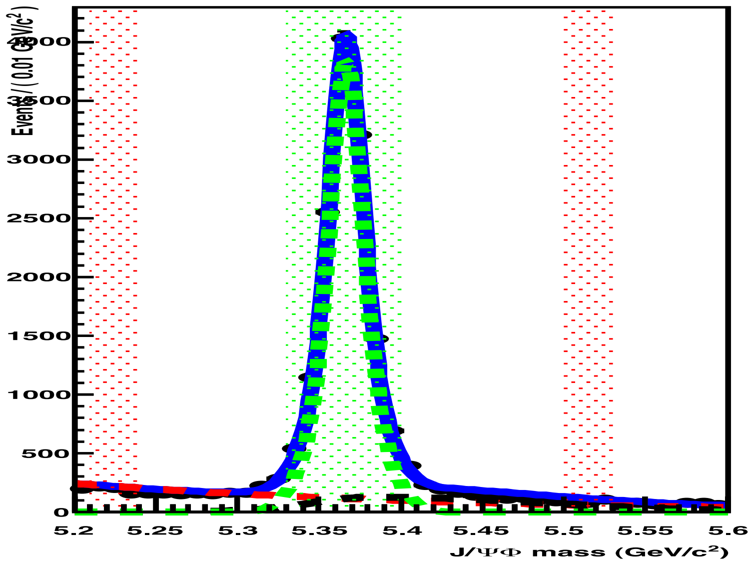
Reconstruction and selections

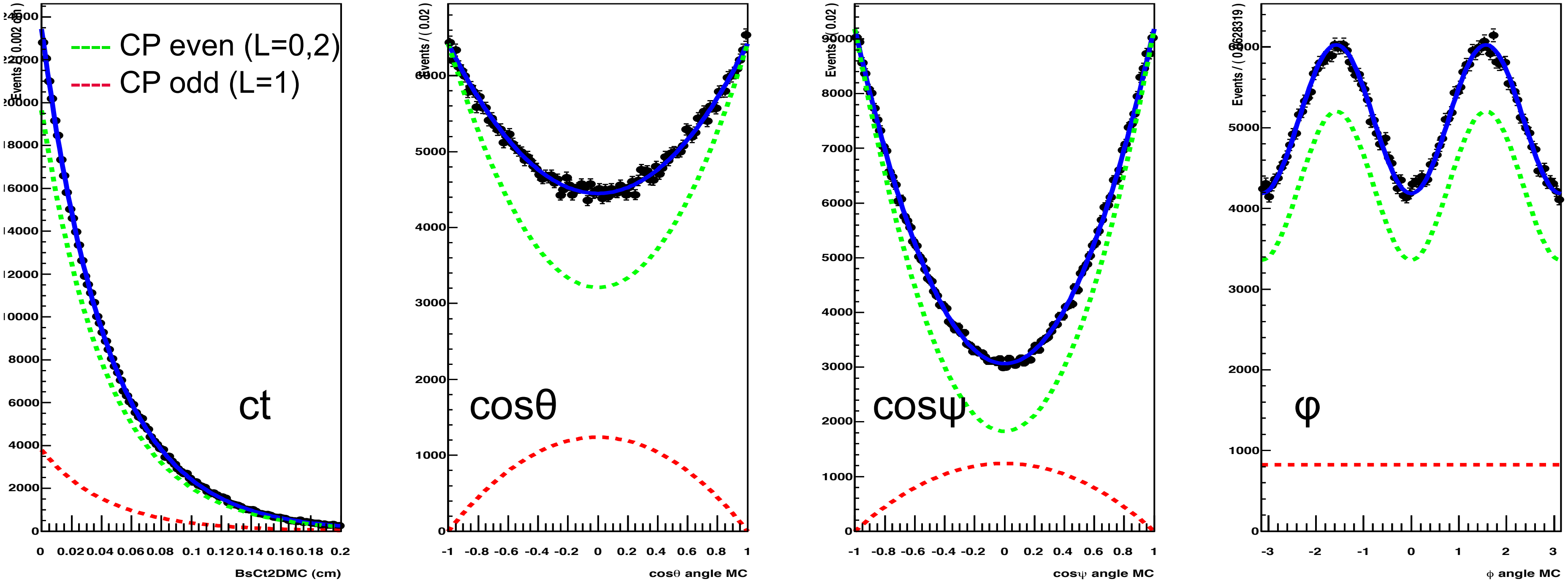
- One pair of opposite sign muons with p_T>4 GeV and |η|<2.2;
- J/ψ candidate with a vertex probability>15%, p_T>7 GeV, mass within 150 MeV the PDG mass, cosα>0.9;
- One pair of opposite sign tracks (suppose to be kaons) p_T>0.7 GeV and >5 tracker hits;
- B_s built from 4 track vertex, constraining the dimuon mass to be the J/psi PDG mass, vertex probability>2%, p_T>8 GeV, 5.2<mass<5.6 GeV, L_{xy}/σ>3.





2011 Data - Preliminary

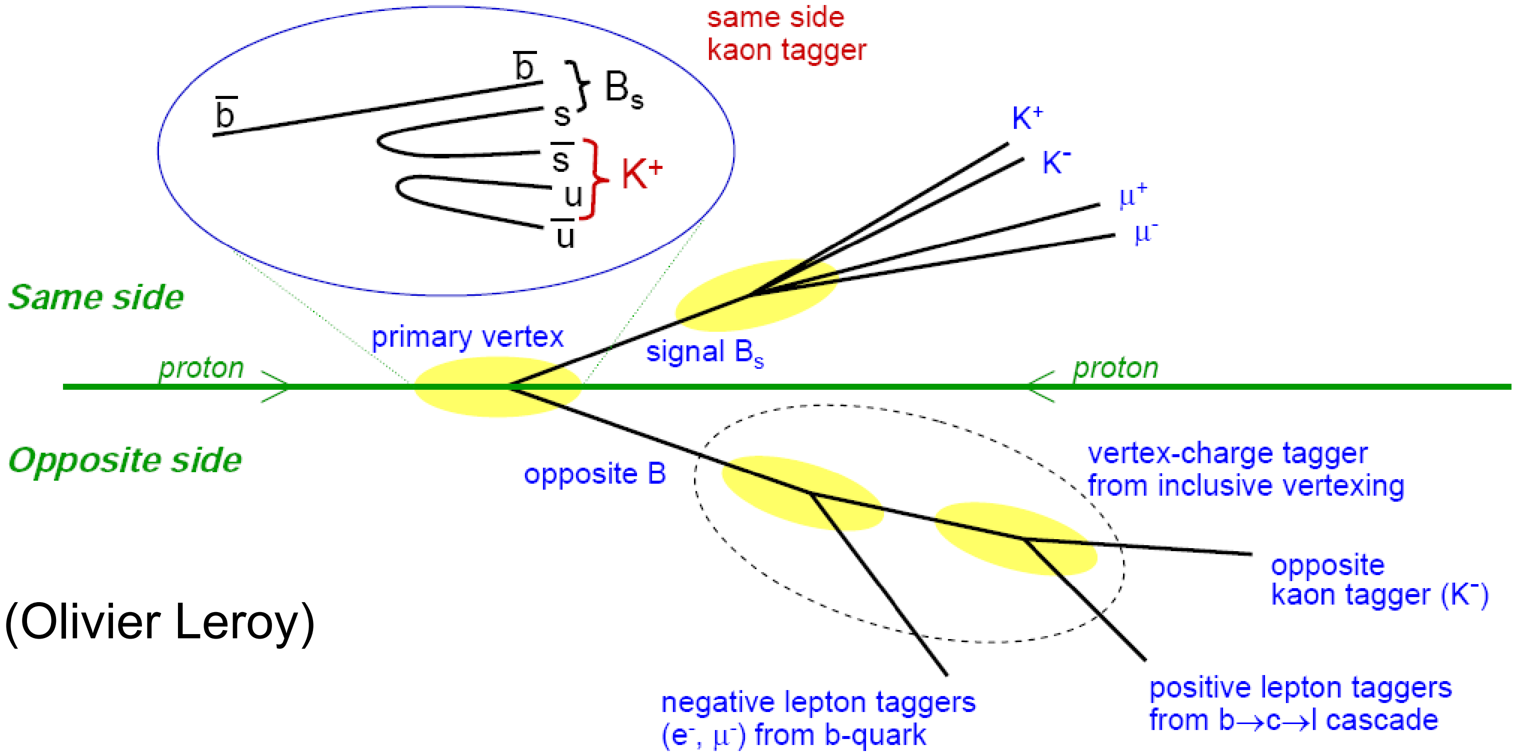
Fit $\Delta\Gamma_s$ model to Monte Carlo simulation



Efficiency corrections (ct - angles) determined through Monte Carlo simulations.

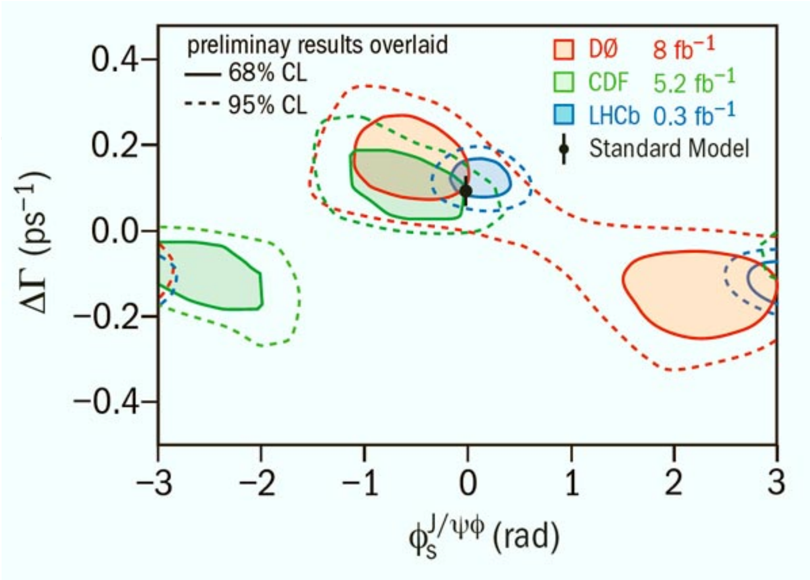
Final goal: Φ_s measurement

Flavour tagging: find the correlation between the initial flavour of the B_s and the other particles in the events.



(Olivier Leroy)

Conclusions



(LHCb – CDF – D0 results)

- Challenges to deal with:
  - High luminosity → high number of interactions per single event
  - Lifetime measurement with decay length cut
  - No π-K discrimination in CMS

- Cross section measurement (done)
- Measure of the $\Delta\Gamma_s$, no flavour tagging needed (soon)
- Measure of the ϕ_s (final step)