# $B_s \to J/\psi\ \phi$

| | $(x_s = 20)$ $\phi_s$ Sensitivity | $(x_s = 40)$ |
|---|---|---|
| ATLAS (3yrs) | 0.03 | 0.05 |
| CMS (3yrs) | 0.014 | 0.03 |
| LHCb (5yrs) | 0.02 | 0.03 |
| BTeV (1yr) | 0.025 | 0.035 |

ATLAS, CMS, LHCb: B Decays at the LHC (hep-ph/003238)

BTeV: R. Kutschke, talk presented at the "Workshop on B Physics at the Tevatron: Run II and Beyond", Fermilab, Feb. 24 2000. (http://www-pat.fnal.gov/personal/kutschke/BTeV/talks/000224_wg1.ps)

# Experimental limitations

| | ATLAS | CMS | LHCb |
|---|---|---|---|
| Event yields | 300k | 600k | 370k |
| Proper time resolution | 0.063ps | 0.063 ps | 0.031ps |
| Background dominated by | ~15% dominated by $B_d^0 \to J/\psi\, K^*, J/\psi\, K^+\pi^-$ | ~ 10% combinatorial $B_d^0 \to J/\psi\, K^*, J/\psi\, K^+\pi^-$ | ~3% |
| Tagging | jet charge tag ε ~ 63% wrong 38% | jet charge tag ε ~ 32% wrong 33% lepton tag ε ~ 6.1% wrong 28% | lepton tag + charged K tag ε ~ 40% wrong 30% |

- CMS: dimuon trigger ($J/\Psi \to \mu^+\mu^-$) ⇒ higher event yields
  stronger solenoidal field ⇒ better $B_s$ invariant mass resolution and lower background than in ATLAS
- LHCb: RICHes to separate charged K/ π mesons ⇒ reduction in background
  superior proper time resolution

# Prospects for improvement

Inclusion of low threshold dimuon triggers that may boost the final event yields in ATLAS and LHCb

(limited) possibility of charged hadron identification in ATLAS and CMS
(dE/dx info from the ATLAS straw tracker, dE/dx using pulse height info from CMS's Si tracker)

Improvements in flavor tagging
(CMS extending their study to include other tags)

Prerequisites:
Untagged analyses require large $\Delta\Gamma_s$
Tagged analyses require the fast $\Delta m_s$ oscillations to be resolved!

# Theoretical limitations

$$B_s \to J/\psi \; \phi$$

$J/\psi \to l^+l^-$, $\phi \to K^+K^-$

Clean experimental signature

BUT final state is an admixture of different CP eigenstates

$\Rightarrow$ angular analysis needs to be performed

4 final state particles $\Rightarrow$ angular distributions will be in terms of 3 angles

large number of angular terms $\Rightarrow$ formidable task of disentangling of coeffs

Method of angular moments helps (sort of!) Dighe, Dunietz, Fleischer (hep-ph/9804253)

But

- as many as 6 angular terms in the complete 3 angle distribution
- involves a fit to as many as 8 independent parameters, some of which have strong correlations

$\Rightarrow$ large errors in the determination of coefficients

(The LHC report uses a max. likelihood fit for its results. The method of moments gave results that were in broad agreement but with certain differences that are yet to be resolved.)

# Prospects for improvement

*Transversity angle* analysis: Dighe, Dunietz, Lipkin & Rosner (hep-ph/9511363)

The angles are chosen such that the angular distribution that separates the CP odd and even terms can be written in terms of a single angle.

Reduces the problem to disentangling only 2 angular terms and only 5 independent parameters!

In the φ rest frame, the decay $B \rightarrow J/\Psi\ K^+K^-$ is planar (x-y plane).

*Transversity axis* is defined as ⊥ to this decay plane ⇒ z axis

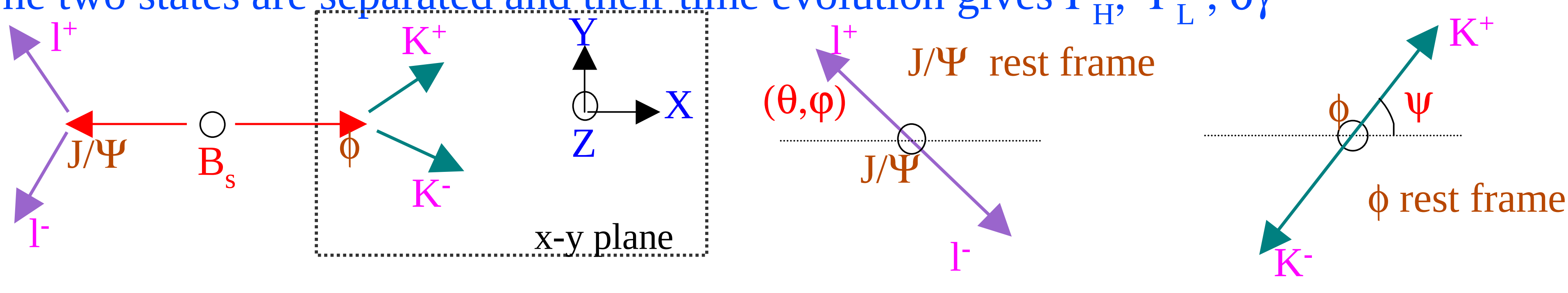
*Transversity angle* is the angle made by the spin of the J/Ψ with this axis.

Define transversity of J/Ψ (the projection of its spin along the transversity axis)

Final states with even CP parity have transversity equal to 0

Final states with odd CP parity have transversity equal to ±1

The two states are separated and their time evolution gives $\Gamma_H$, $\Gamma_L$ , δγ



# Searching beyond the SM

Tiny CP violating asymmetry in the SM O(0.03)

$\Rightarrow$new physics contribution is a correction to essentially zero!

The left-right symmetrical model with spontaneous CP violation(NP-LR)

Ref: P. Ball and R. Fleischer, Phys. Lett. **B475**, 111 (2000).

$$A_{CP}(B_s(t) \to J/\psi\,\phi) \equiv \frac{\Gamma(t)-\overline{\Gamma}(t)}{\Gamma(t)+\overline{\Gamma}(t)} = \left[\frac{1-D}{F_+(t)+DF_-(t)}\right] \sin(\Delta m_s t)\sin(\phi_s)$$

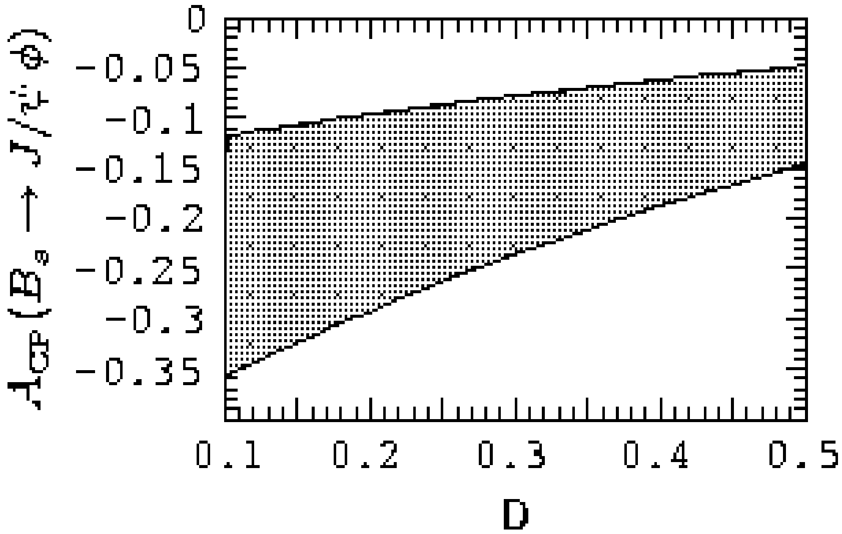
$$D \equiv \frac{|A_\perp(0)|^2}{|A_0(0)|^2+|A_\parallel(0)|^2} \text{ and } F_\pm(t) \equiv \frac{1}{2}\left[(1\pm\cos\phi_s)e^{+\Delta\Gamma_s t/2} + (1\mp\cos\phi_s)e^{-\Delta\Gamma_s t/2}\right]$$

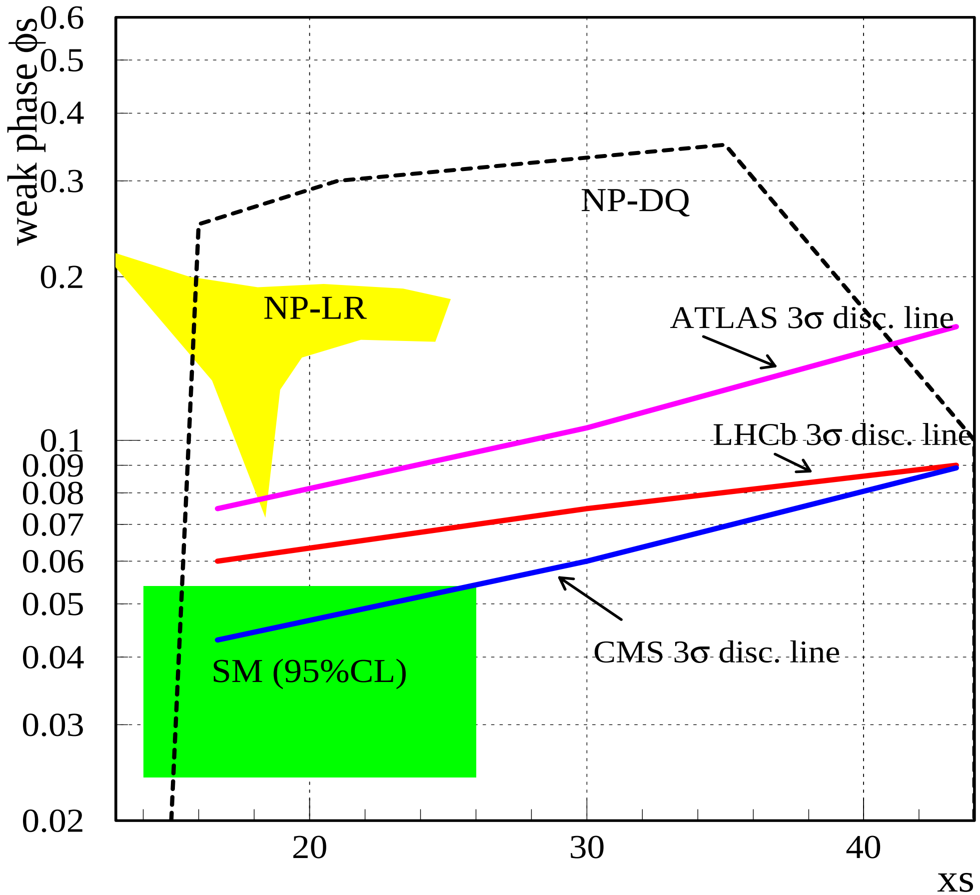
The first extremal value of the time-dependent CP asymmetry, corresponding to $\Delta m_s t=\pi/2$ is ~

$$A_{CP}(B_s \to J/\psi\,\phi) = \left(\frac{1-D}{1+D}\right)\sin\phi_s$$

where D= 0.1 . . .0.5 (Dighe, Dunietz, Fleischer (hep-ph/9804253), CDF (F.Abe et al., Phys. Rev.Lett. 75 (1995) 3068) )

For a value of D=0.3, the CP asymmetry can be as large as -25%




The isosinglet down quark (NP-DQ)

Ref: D. Silverman, Phys. Rev.**D 58**, 095006(1998).