Other Physics at a Super B Factory

Tim Gershon
University of Warwick

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“Other Physics”

- Key physics priorities of Super B Factory are well established (eg. Bigi, yesterday)
  1) B physics
  2) τ physics
  3) D physics
- When considering the physics case, we should consider as full as picture as possible: 4), 5) …
- We do not know who wins the medals until we run the race!

BABAR 100+ CITATIONS BELLE

1) B. Aubert et al., OBSERVATION OF A NARROW MESON DECAYING TO D+(S) PI0 AT A MASS OF 2.32-GEV/C**2.
Phys.Rev.Lett.90:242001,2003.
[HEP-EX 0304021]

Cited 291 times in the HEP (SPIRES-SLAC) database. [Full entry]

2) B. Aubert et al., MEASUREMENTS OF BRANCHING FRACTIONS AND CP VIOLATING ASYMMETRIES IN B0 --> PI+ PI-, K+ PI-, K+ K- DECAYS.
Phys.Rev.Lett.89:281802,2002.
[HEP-EX 0207055]

Cited 198 times in the HEP (SPIRES-SLAC) database. [Full entry]

3) B. Aubert et al., MEASUREMENT OF THE CP VIOLATING ASYMMETRY AMPLITUDE SIN 2BETA.
Phys.Rev.Lett.89:201802,2002.
[HEP-EX 0207042]

Cited 326 times in the HEP (SPIRES-SLAC) database. [Full entry]

4) B. Aubert et al., A STUDY OF TIME DEPENDENT CP VIOLATING ASYMMETRIES AND FLAVOR OSCILLATIONS IN NEUTRAL B DECAYS AT THE UPSILON(4S).
Phys.Rev.D66:032003,2002.
[HEP-EX 0201020]

Cited 146 times in the HEP (SPIRES-SLAC) database. [Full entry]

5) B. Aubert et al., OBSERVATION OF CP VIOLATION IN THE B0 MESON SYSTEM.
Phys.Rev.Lett.87:091801,2001.
[HEP-EX 0107013]

Cited 335 times in the HEP (SPIRES-SLAC) database. [Full entry]

6) B. Aubert et al., THE BABAR DETECTOR.
Nucl.Instrum.Meth.A479:1-116,2002.
[HEP-EX 0105044]

Cited 595 times in the HEP (SPIRES-SLAC) database. [Full entry]

7) B. Aubert et al., MEASUREMENT OF CP VIOLATING ASYMMETRIES IN B0 DECAYS TO CP EIGENSTATES.
Phys.Rev.Lett.86:2515-2522,2001.
[HEP-EX 0102030]

Cited 138 times in the HEP (SPIRES-SLAC) database. [Full entry]

1) S.K. Choi et al., OBSERVATION OF A NARROW CHARMONIUM-LIKE STATE IN EXCLUSIVE B+- --> K+- PI+ PI- J / PSI DECAYS.
Phys.Rev.Lett.91:262001,2003.
[HEP-EX 0309032]

Cited 189 times in the HEP (SPIRES-SLAC) database. [Full entry]

2) K. Abe et al., MEASUREMENT OF TIME DEPENDENT CP VIOLATING ASYMMETRIES IN B0 --> PHI K0(S), K+ K- K0(S), AND ETA-PRIME K0(S) DECAYS.
Phys.Rev.Lett.91:261602,2003.
[HEP-EX 0308035]

Cited 125 times in the HEP (SPIRES-SLAC) database. [Full entry]

3) P. Krokovny et al., OBSERVATION OF THE D(SJ)(2317) AND D(SJ)(2457) IN B DECAYS.
Phys.Rev.Lett.91:262002,2003.
[HEP-EX 0308019]

Cited 129 times in the HEP (SPIRES-SLAC) database. [Full entry]

4) K. Abe et al., AN IMPROVED MEASUREMENT OF MIXING INDUCED CP VIOLATION IN THE NEUTRAL B MESON SYSTEM.
Phys.Rev.D66:071102,2002.
[HEP-EX 0208025]

Cited 221 times in the HEP (SPIRES-SLAC) database. [Full entry]

5) S.K. Choi et al., OBSERVATION OF THE ETA(C)(2S) IN EXCLUSIVE B --> K K(S) K- PI+ DECAYS.
Phys.Rev.Lett.89:102001,2002., Erratum-ibid.89:129901,2002.
[HEP-EX 0206002]

Cited 100 times in the HEP (SPIRES-SLAC) database. [Full entry]

6) K. Abe et al., OBSERVATION OF DOUBLE C ANTI-C PRODUCTION IN E+ E- ANNIHILATION AT S**(1/2) APPROXIMATELY 10.6-GEV.
Phys.Rev.Lett.89:142001,2002.
[HEP-EX 0205104]

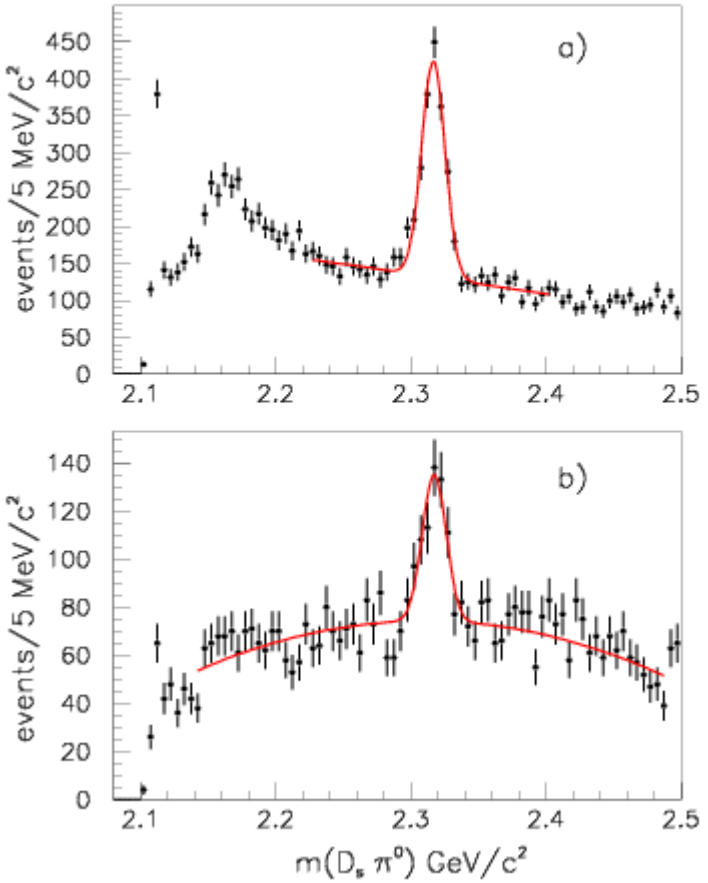
Cited 120 times in the HEP (SPIRES-SLAC) database. [Full entry]

7) K. Abe et al., OBSERVATION OF LARGE CP VIOLATION IN THE NEUTRAL B MESON SYSTEM.
Phys.Rev.Lett.87:091802,2001.
[HEP-EX 0107061]

Cited 349 times in the HEP (SPIRES-SLAC) database. [Full entry]

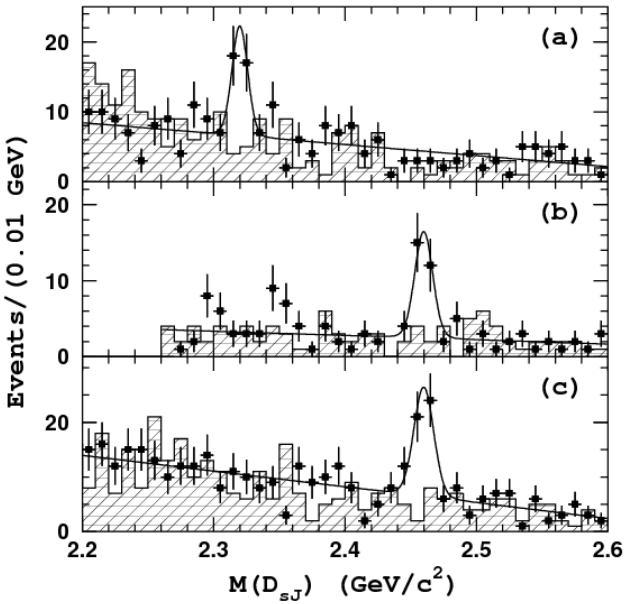
8) K. Abe et al., A MEASUREMENT OF THE BRANCHING FRACTION FOR THE INCLUSIVE B --> X(S) GAMMA DECAYS WITH BELLE.
Phys.Lett.B511:151-158,2001.
[HEP-EX 0103042]

OBSERVATION OF A NARROW MESON DECAYING TO D+(S) PIO



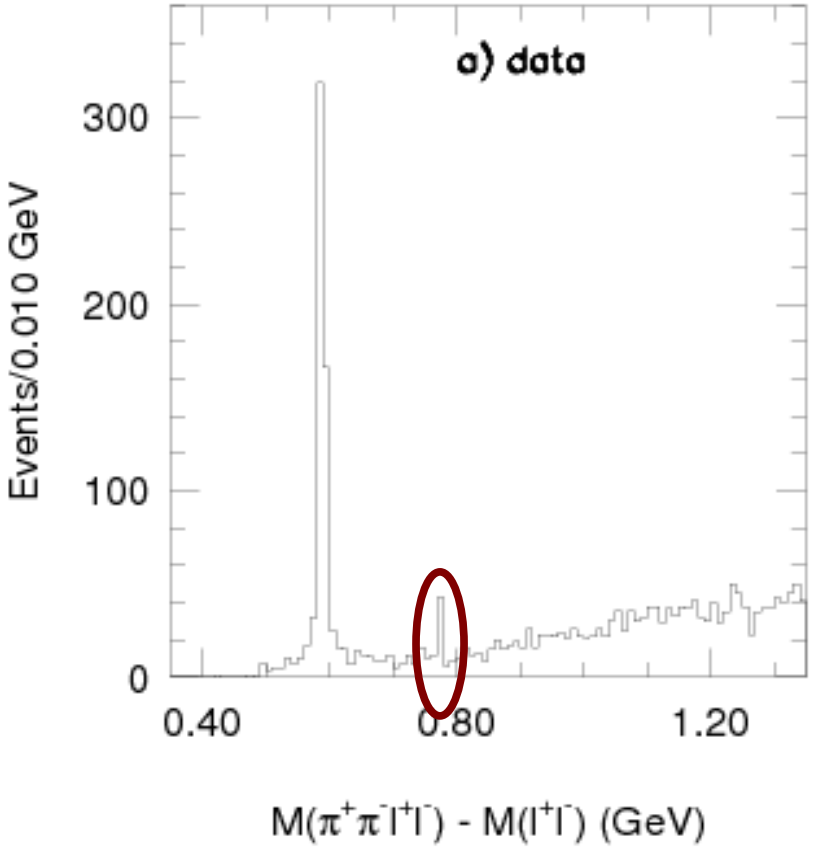
PRL 90 (2003) 242001

Quickly confirmed by Belle (& CLEO):



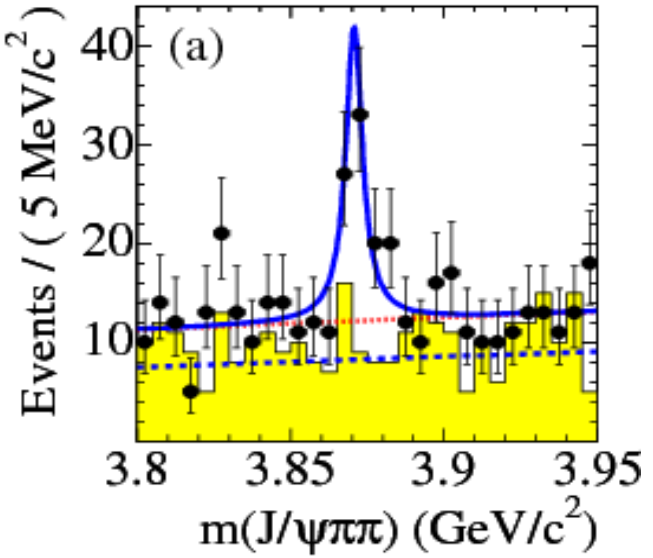
PRL 91 (2003) 262002

OBSERVATION OF A NARROW CHARMONIUM–LIKE STATE



PRL 91 (2003) 262001

Quickly confirmed by Babar (& CDF &D0):



PRD 73 (2006) 011101

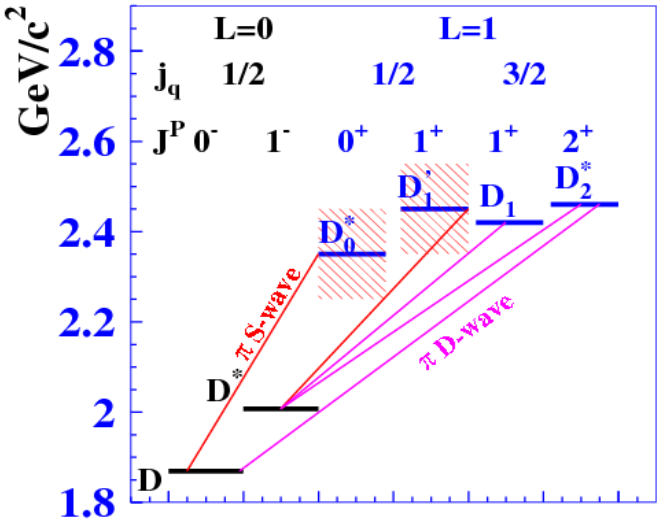
Spectroscopy – possible medallists

- glueballs
  - possible production in B, D, J/ψ, ... decay
- exotic states:
  - 4-quarks, 5-quarks, molecules, hybrids, ...
- low energy spectroscopy
  - eg. ππ S-wave studies via Dalitz plot analyses
- undiscovered states
  - eg. η_b – the lowest energy bb bound state (!)

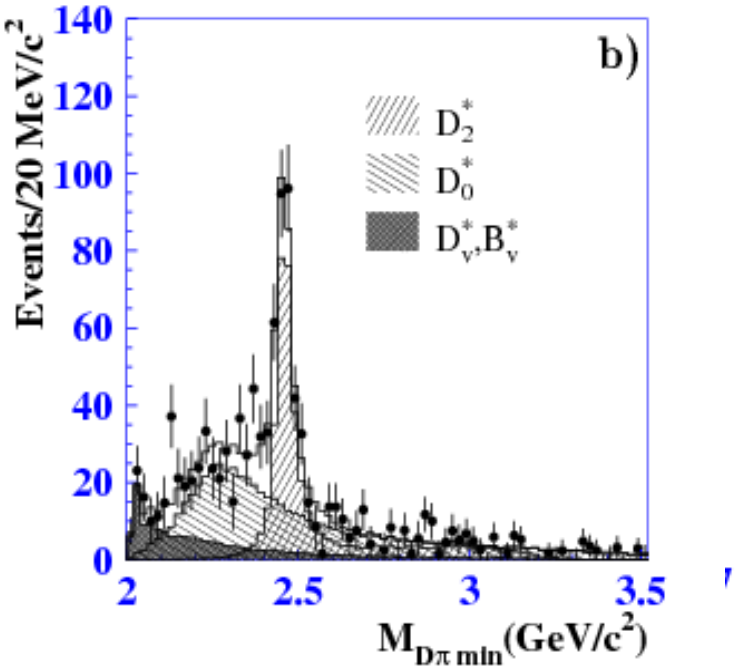
Tools for spectroscopy @ SuperB

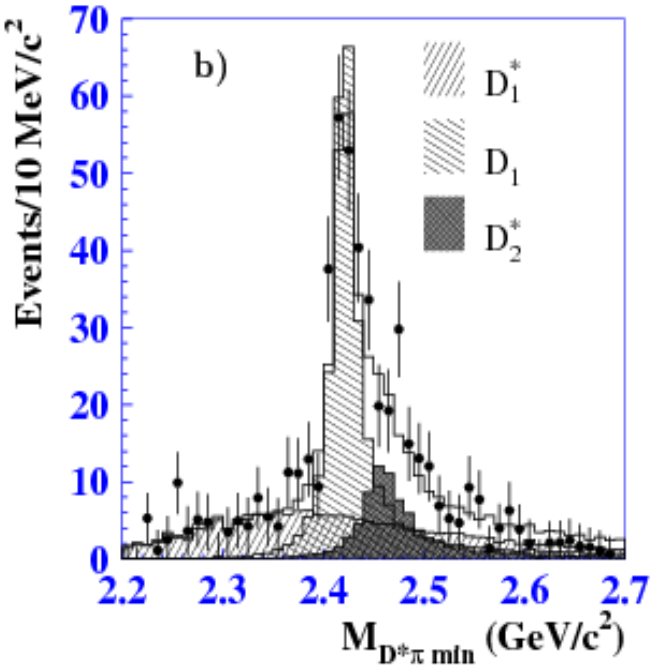
- Production
  - ISR
  - γγ
- Decay
  - B, D, charmonia decays
  - hadronic, semileptonic, radiative decays
  - τ decays
- (Different processes related by Watson's theorem)

Hadronic B decay spectroscopy



- Example from charmed B decays
  - $B^+ \rightarrow D^{(*)-}\pi^+\pi^+$
- Belle, PRD 69 (2004) 112002



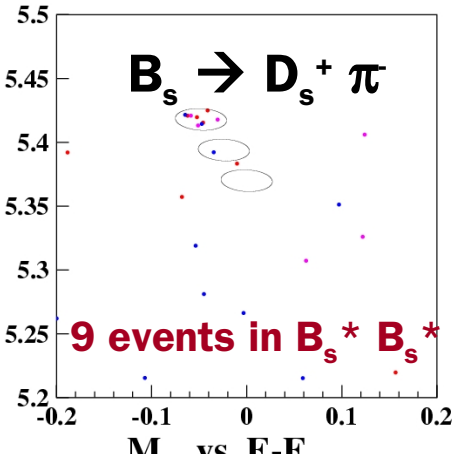


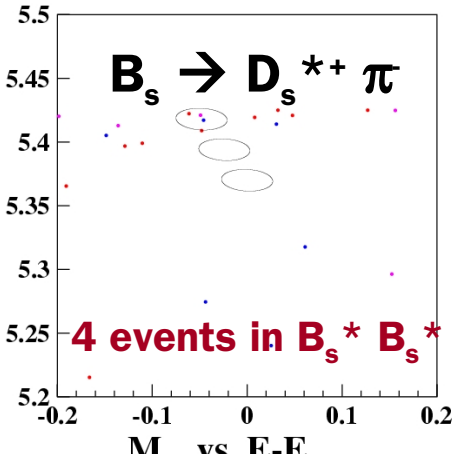
Operation in the Υ region

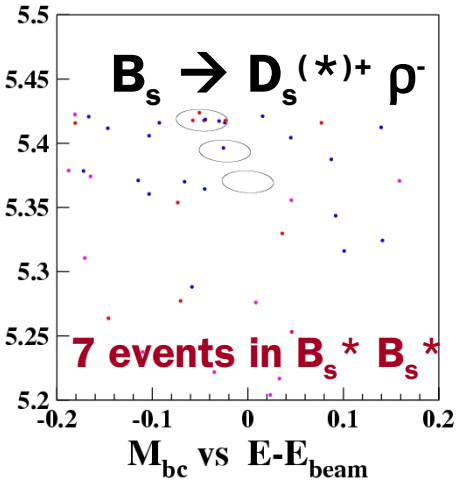
- Primary operation at the Υ(4S)
- Operation also at Υ(5S) (B_s physics) and ψ(3770) also discussed
- Other CM energies
  - Υ(1S) [small energy spread very beneficial]
    - production of η_b via $\Upsilon(1S) \rightarrow \eta_b\gamma$ (?)
  - Υ(2S), Υ(3S) …
  - above Υ(5S)
    - B_c production and decay

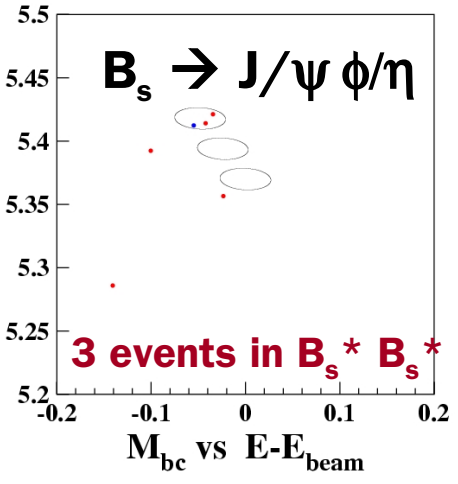
KEK-B Y(5S) Engineering Run

- B_s signals are identified with M_{bc} and ΔE

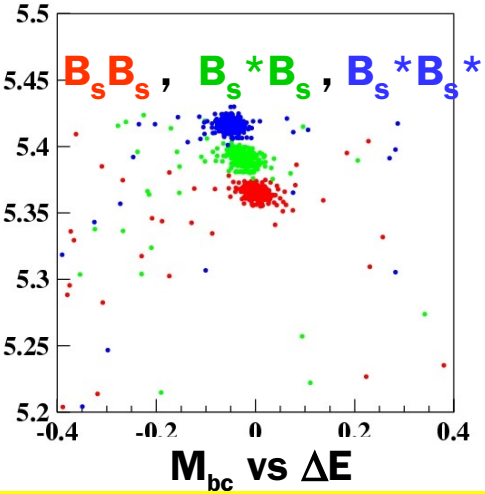




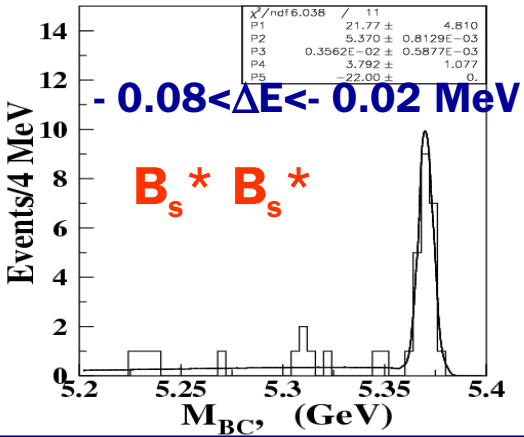




Clear B_s signals seen in $B_s^*B_s^*$ region



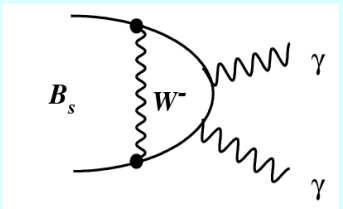
B_sB_s, $B_s^*B_s$, $B_s^*B_s^*$ signals can be separated well

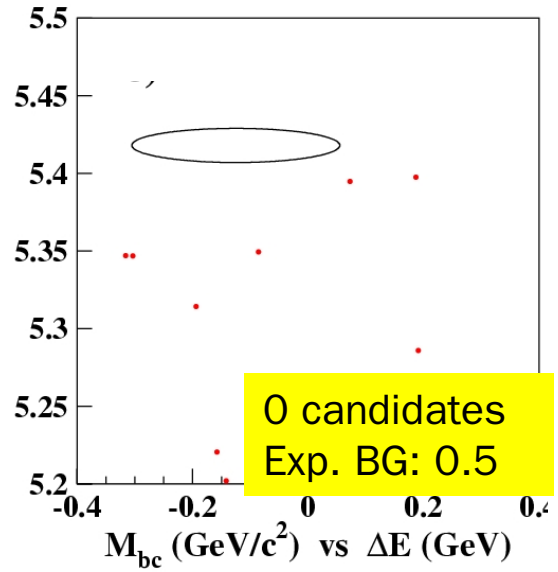


PRELIMINARY

KEK-B Y(5S) Engineering Run

- $B_s \rightarrow \gamma\gamma$

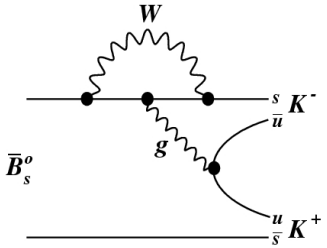


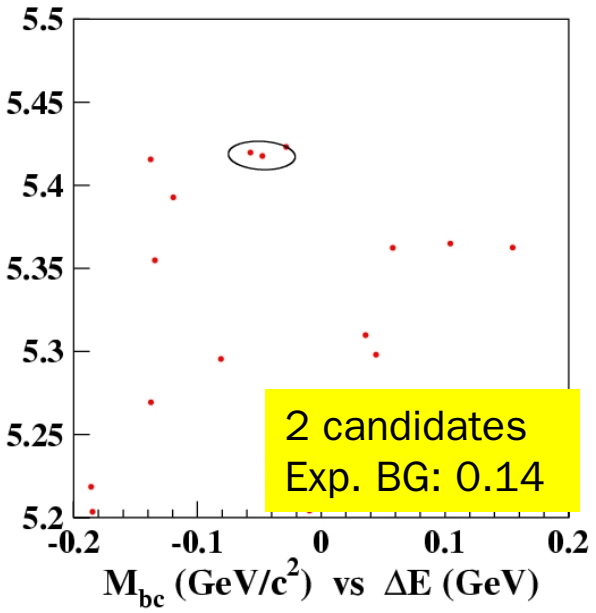


0 candidates
Exp. BG: 0.5

$B(B_s \rightarrow \gamma\gamma) < 0.56 \times 10^{-4}$ (90% CL)
PDG : $< 1.48 \times 10^{-4}$
SM: 0.5-1.0x10^{-}

- $B_s \rightarrow K^+ K^-$

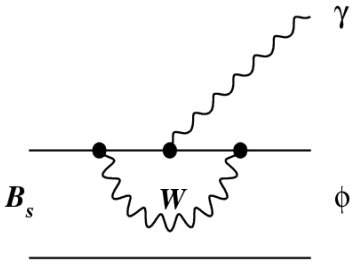


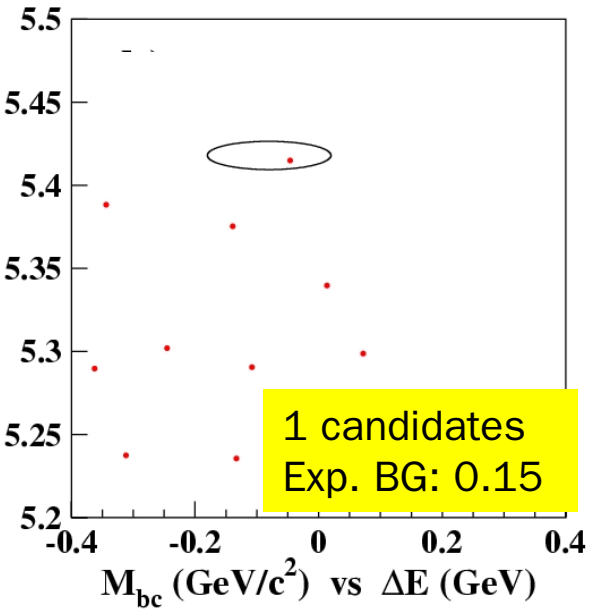


2 candidates
Exp. BG: 0.14

$B(B_s \rightarrow K^+K^-) < 3.4 \times 10^{-4}$ (90% CL)
PDG : $< 0.59 \times 10^{-4}$

- $B_s \rightarrow \phi\gamma$





1 candidates
Exp. BG: 0.15

$B(B_s \rightarrow \phi\gamma) < 4.1 \times 10^{-4}$ (90% CL)
PDG : $< 1.2 \times 10^{-4}$

PRELIMINARY

B_c physics

- Interest in B_c mesons for various reasons
  - QCD : both quarks quite heavy
  - CP violation : several interesting channels
    - $B_c^+ \rightarrow DD_s^+$ is equivalent of $B_u^+ \rightarrow DK^+$ (γ)
    - sensitivity depends on r_B ~10% (B_u) $\Rightarrow$ ~100% (B_c)
- B_c production quite suppressed at LHC
  - what about (near) threshold $e^+e^- \rightarrow B_c^+B_c^-$?
  - clean environment $\rightarrow$ many more available channels

Electroweak physics

- Possibility to measure $\sin^2\theta_W$ in $e^+e^- \rightarrow \mu^+\mu^-$ discussed (by W.Bartel) in SuperKEKB LoI
  - hep-ex/0406071
- For higher luminosity SuperB, $e^+e^- \rightarrow M^+M^-$ (M=π,K,D) also possible
- "Simple" measurement of forward-backward asymmetry, but sensitivity of $O(10^{-3})$ required

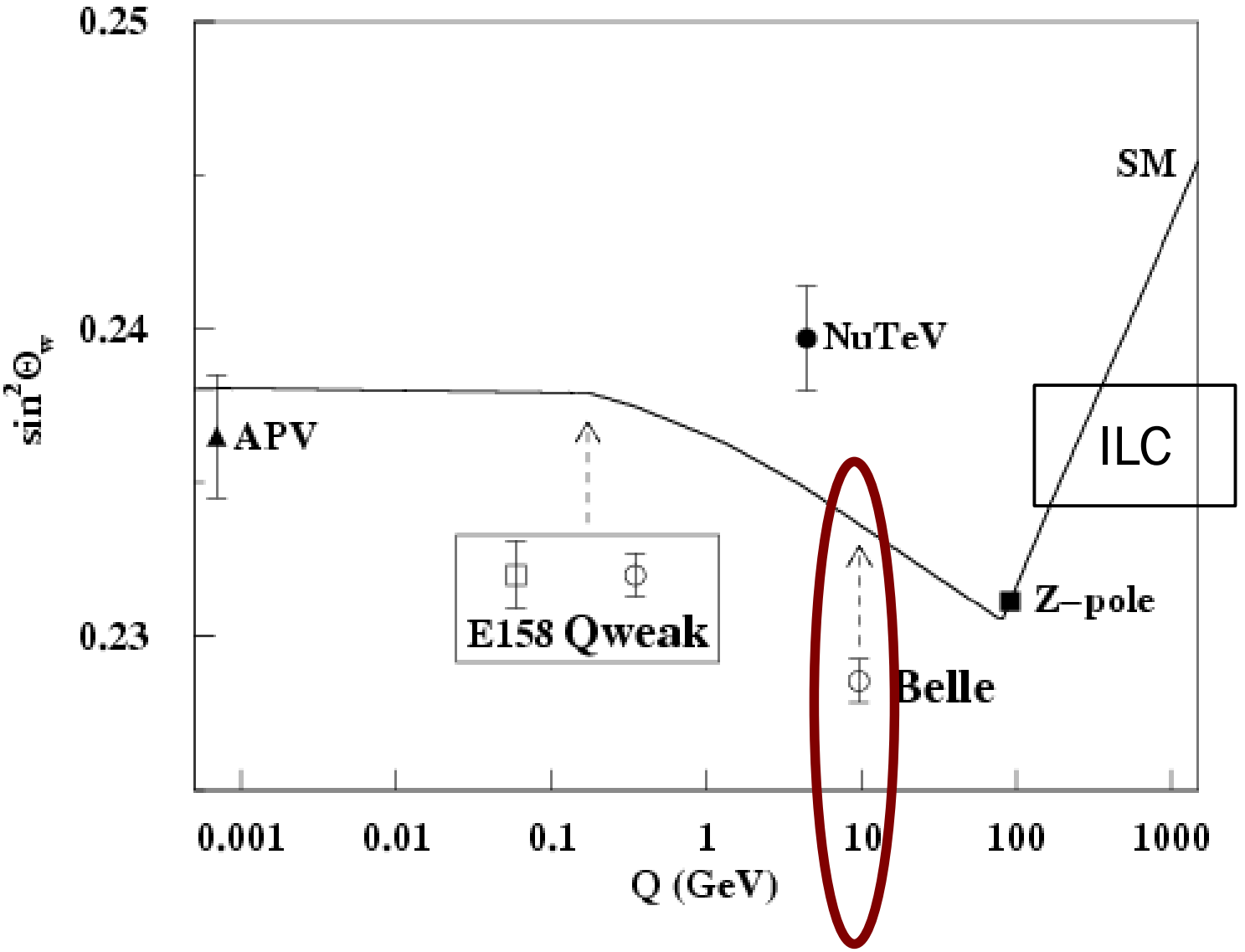


Figure 4.54: Scale dependence of $\sin^2\Theta_W$. The full symbols show the current situation, while the open symbols with error bars for the proposed experiments QWEAK, SLAC E-158 and Belle are placed at the correct cm energy with arbitrarily chosen vertical positions. The previous measurements are determinations from atomic parity violation (AVP) [349], deep inelastic neutrino scattering (NuTeV), and from Z-pole asymmetries (LEP/SLC).

In the electro-weak process $e^+e^- \to \mu^+\mu^-$ the values for $\sin^2\Theta_W$ and ρ are derived from a fit to the angular distribution (Θ^*) of μ pairs with respect to the axis of the incoming positron in the e^+e^- center of mass system [350].

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{4s}(C_1(1+\cos^2\Theta^*) + C_2\cos\Theta^*) \tag{4.96}$$

with the following definitions:

$$C_1 = 1 + 2v_e v_\mu \chi + (v_e^2 + a_e^2)(v_\mu^2 + a_\mu^2)\chi^2, \tag{4.97}$$

$$C_2 = -4a_e a_\mu \chi + 8v_e a_e a_\mu \chi^2, \tag{4.98}$$

$$v_{e,\mu} = -1 + 4\sin^2\Theta_W, \qquad a_{e,\mu} = -1. \tag{4.99}$$

The quantity χ may be written in two different ways, as a function of $\sin^2\Theta_W$ or as a function of ρ

$$\chi = \frac{1}{16\sin^2\Theta_W\cos^2\Theta_W}\frac{s}{(s-M_Z^2)} \tag{4.100}$$

or

$$\chi = \frac{\rho G_F M_Z^2}{8\pi\alpha\sqrt{2}}\frac{s}{(s-M_Z^2)} \tag{4.101}$$

where s is the square of the center of mass energy.

Summary

- The core of the physics program is well established and well motivated
  - addresses “big questions” of particle physics
- However, it is important that SuperB has potential in numerous other areas
- The most interesting results are often surprises!

Super B Factory ⇒ Super Flavour Factory