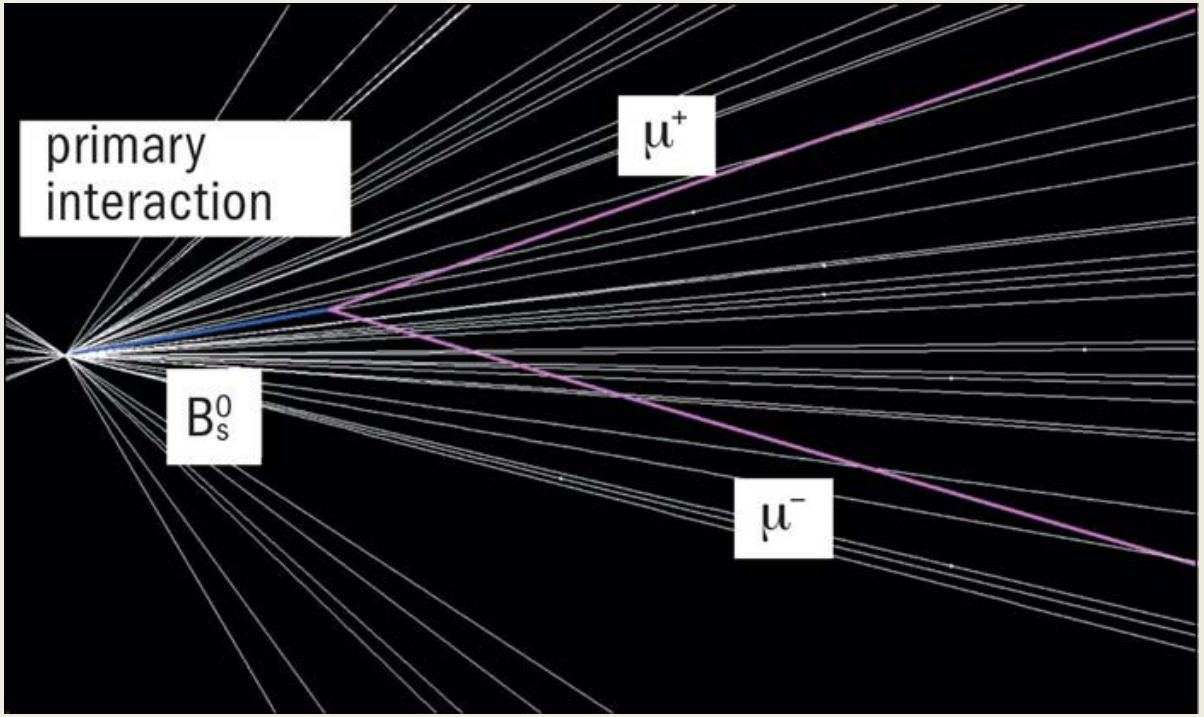
Third Workshop on Flavour Physics in the LHC Era:
THEORETICAL AND EXPERIMENTAL VIEWS

Some provocative ideas

$B_s \rightarrow \mu\,\mu$ AT LAST SEEN … AND WHAT?

(1), (2), …, (7)

The Magnificent Seven, with Stars



- ElectroWeak Penguins with NON-DECOUPLING
- Displaced Vertex

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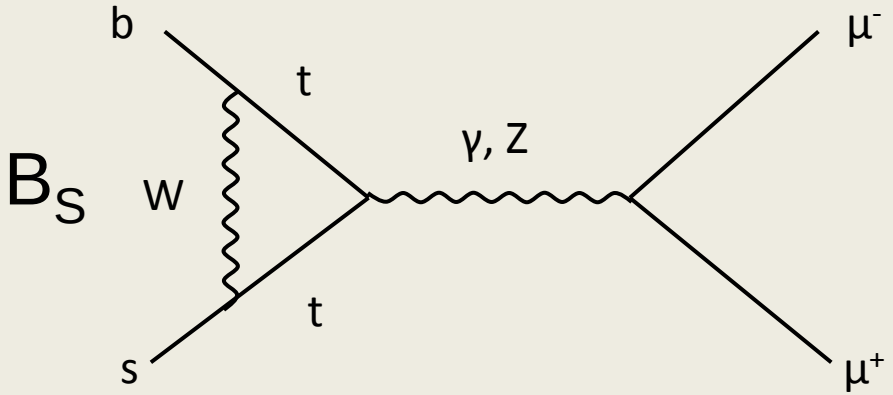
- (1) RARE DECAY $B_s \rightarrow \mu\,\mu$
- (2) $B_s \rightarrow \tau\,\tau$
- (3) Invisible Decay $B_d \rightarrow \nu\,\nu$
- (4) $B_d \rightarrow \nu\,\nu\,\gamma$
- (5) FCNC & CPV at Z peak $Z \rightarrow b\,s$ ★★★
- (6) $b \rightarrow s\,\nu\,\nu$
- (7) $s \leftrightarrow d$

(1) RARE DECAY $B_s \rightarrow \mu\,\mu$

LHCb Collaboration, PRL (2013)



Penguin projected to a pseudoscalar

➡ Helicity suppression

➡ Proportionality with the mass of the lepton

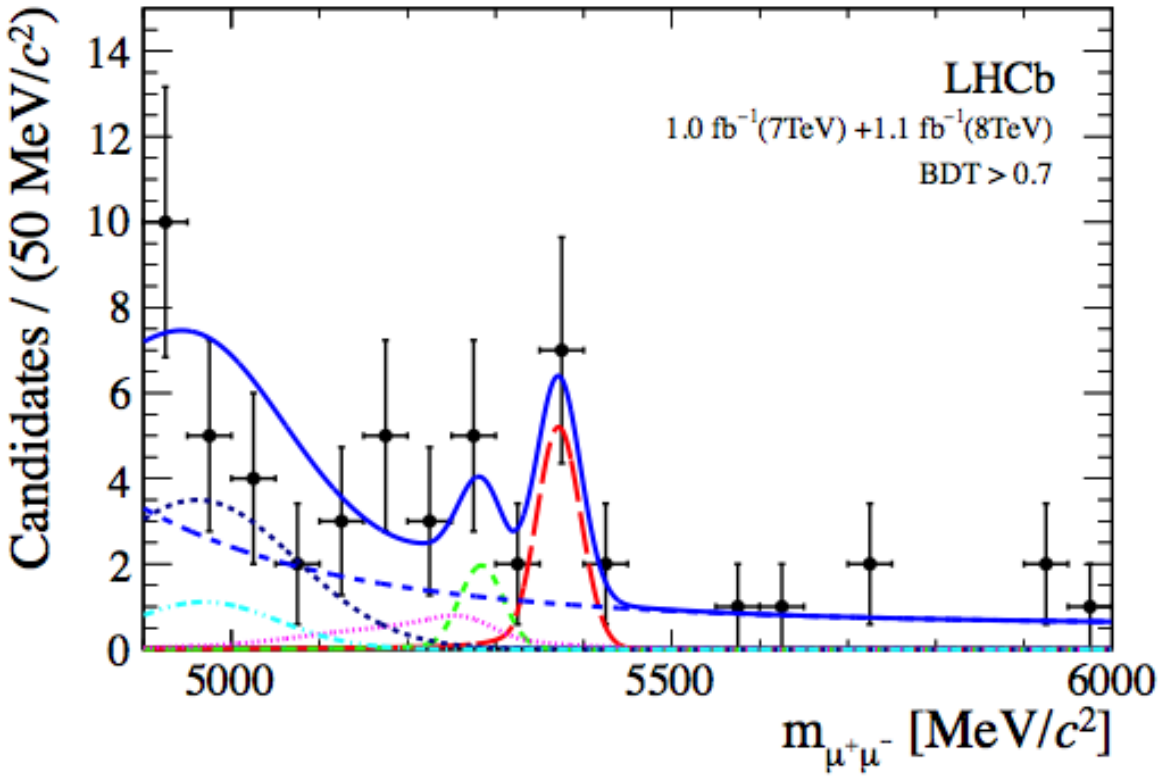
FCNC, CPV

- Prospects for new physics, thinking on: - Origin of Baryogenesis
  - Essence of Dark Matter
- In addition**, Z-penguin can induce NON DECOUPLING effects**, providing information on EWSB mechanism.

(1) RARE DECAY $B_s \rightarrow \mu\,\mu$

Latest disappointment (12 November 2012):

first evidence for very rare decay $B_s \rightarrow \mu^+\mu^-$

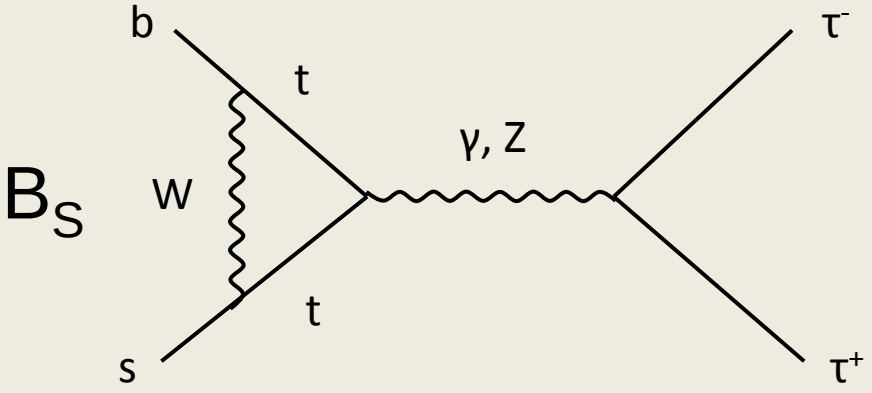


$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.2\,^{+1.4}_{-1.2}(\text{stat})\,^{+0.5}_{-0.3}(\text{syst})) \times 10^{-9}$$

SM: $(3.23 \pm 0.27) \times 10^{-9}$

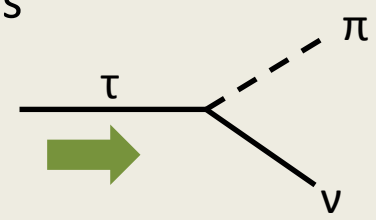
(2) $B_s \rightarrow \tau\,\tau$

- A discrepancy in Bs → μ μ could have been orders of magnitude away
- Anything to gain by going to τ's ? Besides the magnitude of the Branching Ratio



Longitudinal polarization of τ's is accessible

Boosted τ's



- Energy distribution of π's measures the τ polarization
- Normally this polarization is a consequence of PARITY violation. But…
- **if the parent B_S is projected on particle-antiparticle eigenstates, a non-vanishing value needs CP violation ! …**

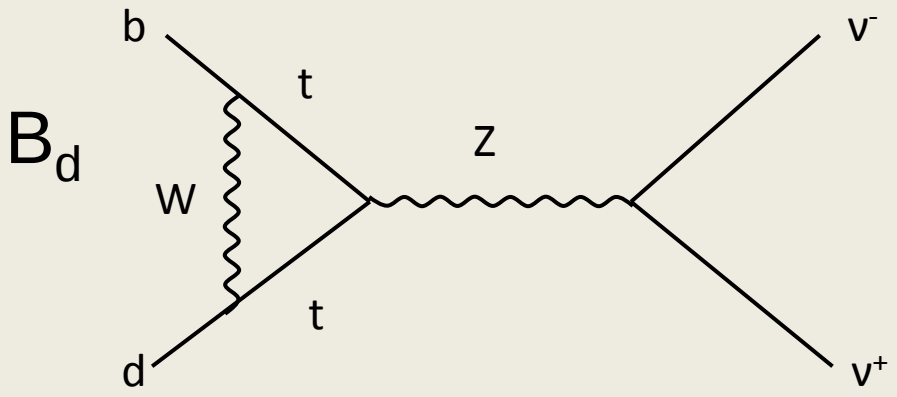
Similar to the famous muon longitudinal polarization for $K_L \rightarrow \mu\,\mu$.

- Experimental question: Is it possible to project on "CP-eigenstates" ?

Time-Dependence? Non-vanishing ΔΓ ?

(3) Invisible Decay $B_d \rightarrow \nu\,\nu$

- Advantage: Z-penguin only. The longitudinal components give non-decoupling effects, proportional to new physics scale.
- Proportional to ν mass. Is new physics so enhanced to compensate ?

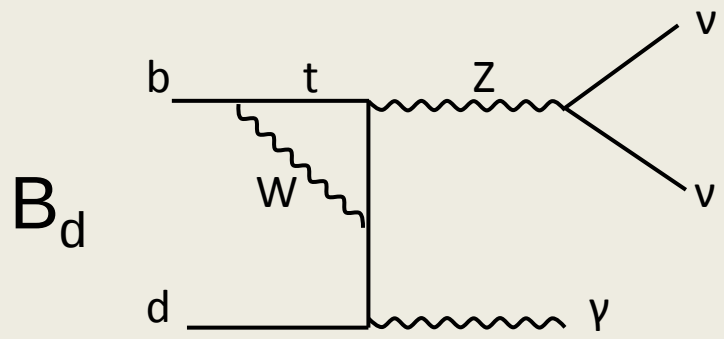


BABAR, PRD (2012)

$Br < 22 \times 10^{-5}$, 90% CL

(4) $B_d \rightarrow \nu\,\nu\,\gamma$

- Box with the Penguin Vertex: Similar arguments for non-decoupling,
- But… no proportionality to ν mass.
- The point is that the penguin is **NOT projected to a pseudo-scalar**



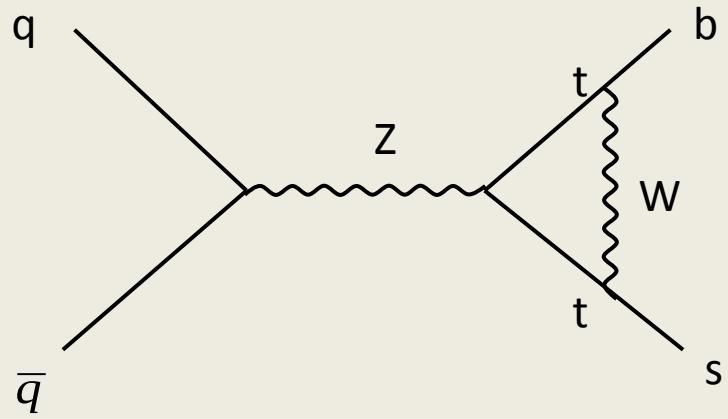
BABAR, PRD (2012)

$Br < 4.7 \times 10^{-5}$, 90% CL

- **For LHC detectors: Is Displaced Vertex enough ?**

★★★ (5) FCNC & CPV at Z peak Z → b s ★★★

- What novelty to perform with plenty of on-shell Z's at LHC ? ATLAS, CMS, LHCb
- Proposal: J.B., A. Santamaria, M.B. Gavela, PRL (1986)
- **Liberate the helicity suppression** due to the projection to a pseudoscalar

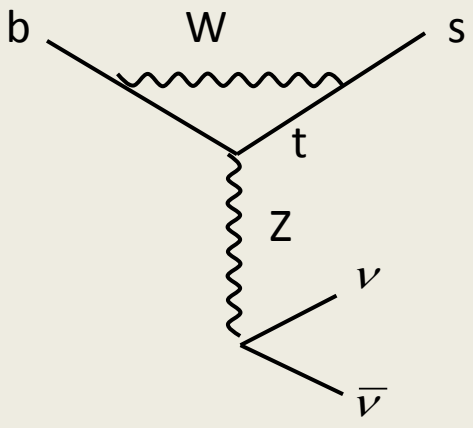


Longitudinal component effects of a massive Z automatically generated when sitting at the Z peak: NON DECOUPLING

	R		$\lvert\alpha\rvert$	
	$R^{(3)}$	$R^{(4)}$	$\lvert\alpha^{(3)}\rvert$	$\lvert\alpha^{(4)}\rvert$
$Z^0 \to d\bar{s}$	10^{-11}	10^{-8}	$10^{-1} s_\delta$	s_ϕ
$Z^0 \to d\bar{b}$	10^{-9}	10^{-8}	$10^{-3} s_\delta$	s_ϕ
$Z^0 \to s\bar{b}$	10^{-7}	10^{-6}	$10^{-5} s_\delta$	s_ϕ

(6) b → s ν ν

- Move the penguin away from the s-channel
- Returning to B physics



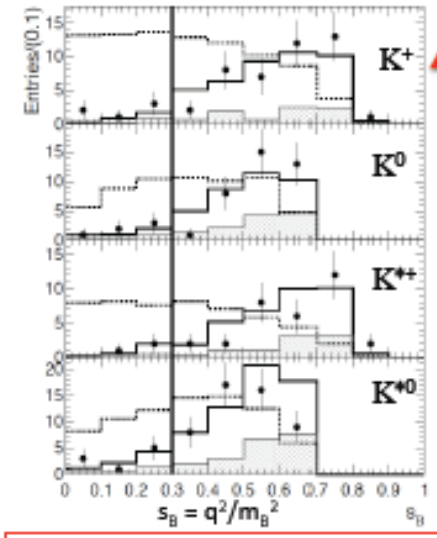
In the process of being measured by BABAR

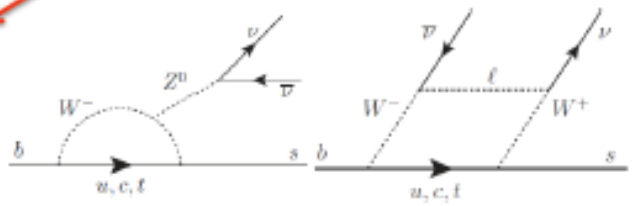
$B \rightarrow K^{(*)} \nu \nu$

Not proportional to ν mass

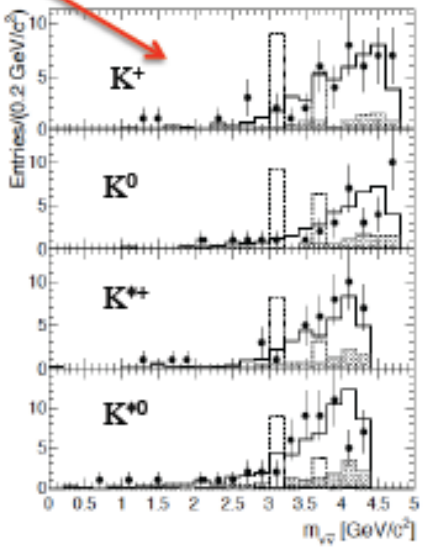
$B \to K^{(*)}\nu\nu$ and ccbar $\to$ invisible CWT: May&October CM

Dana Lindemann, Steve Robertson, Racha Cheaib, BAD # 2513





- Processes strongly suppressd in the SM
- NP can enhance them and modify the s_B spectrum for b ➔ svv
- **Both full and partial BF are measured**
- Most stringent limit using hadronic tags



$B \to K\nu\nu$
- SM: (4.5± 0.7) 10^{-6}
- This analysis < 32 10^{-6} @90%C.L.
- Comb. with SL < 17 10^{-6} @90%C.L.

$B \to K^*\nu\nu$
- SM: (6.8± 1.1) 10^{-6}
- This analysis < 79 10^{-6} @90%C.L.
- Comb. with SL < 76 10^{-6} @90%C.L.

$$\frac{\mathcal{B}(J/\psi \to \nu\bar{\nu})}{\mathcal{B}(J/\psi \to e^+e^-)} < 6.6 \times 10^{-2}$$

$$\frac{\mathcal{B}(\psi(2S) \to \nu\bar{\nu})}{\mathcal{B}(\psi(2S) \to e^+e^-)} < 2.0$$

- BES (from $\psi(2S) \to J/\psi\,\pi\pi$) : <1.2 10^{-2}
- first search ever of $\psi(2S) \to \nu\nu$

(7) s ↔ d

- The program on penguins, penguins, penguins can be completed by exchanging the “s” and “d” legs

- As a general rule, perhaps not valid beyond the Standard Model with 3 families, the b-d transitions are suppressed in the Branching Ratio but enhanced for CP violating effects

CONCLUSION

An interesting program for the search of New Physics beyond the Standard Model may be performed with LHC detectors and B factories by looking for

- Flavour Changing Neutral Currents
- CP violation

using transitions induced by electroweak penguins.

THANK YOU VERY MUCH FOR YOUR ATTENTION

TWO VISIONS OF NEAR FUTURE