Questions and Comments (this is not a Summary!!!!)

Joaquim Matias
Universitat Autònoma de Barcelona

February 6, 2013

The bad news

- New Physics signals (if any) will be very subtle, so Precision Flavour Physics is now the only way.
- Several promising signals/tensions have evaporated
  - "Old" discovery channels like $B_s \to \mu^+\mu^-$ turns out to be new strongly constraining channels for CMSSM but less for pMSSM, but not yet at the level of ruling out those models.
  - $B \to \tau\nu$ versus $\sin 2\beta$ tension, after last Belle measurement are now in very good agreement
  - Isospin asymmetry of charged and neutral $B \to K^*\mu^+\mu^-$ channel is now consistent with SM prediction for all q^2.
  - Semileptonic decay asymmetry using dimuons: while the combined semileptonic asymmetries a_{sl}^s and a_{sl}^d from D0 exhibits clearly a tension with SM, the combination of B-factories result for a_{sl}^d and a_{sl}^s from LHCb is perfectly consistent with SM
  - and so on and so forth...

The good news

- New puzzles have poped up or have kept unresolved
  - Ratios $B \to D^{(*)}\tau\nu$ to $B \to D^{(*)}\ell\nu$ are at 2 sigmas. Form Factor issue? New Physics models difficult to accommodate (2HDM)
  - $\Delta A_{CP}(B \to \pi K)$ channels is with us since long time ago...
  - Isospin asymmetry of $B \to K\mu^+\mu^-$ that globally deviates by 4.4 σ, even if each bin does not deviate by more than 2 sigmas except for the last one. Very difficult to accommodate naturally NP models.
  - Evidence (more than 4σ) for direct CP asymmetry in singly Cabibbo suppressed D decays $\Delta A_{CP} = A_{CP}(K^+K^-) - A_{CP}(\pi^+\pi^-)$. Naive expectations in SM (and MFV) is one order of magnitude smaller.
  - Very low longitudinal Polarization fractions in non-leptonic B decays.

The ugly news

- Economy, politics,....

Future possibilities

- CP Violation: A more and more accurate determination of CKM-γ from $B \to DK$ will provide another handle on the UT. But also available from 3-body B decays ($B \to KKK, K\pi\pi$). A more precise determination of ϕ_s can signal some tension?
- Non-leptonic B decays still offer many possibilities to search for NP: triple products, angular analysis ($B_s \to \phi\phi$), CP violating observables.
- Important step forward for hadronic decays will be done in the 2018 LHCb upgrade with the increase of the trigger efficiency.
- New constraints are coming into play like $K_s \to \mu^+\mu^-$ sensitive to a different set of models (...)
- Rare decays: The corresponding counterpart of the UT correlation plot in the search for NP are the Wilson coefficients correlation planes. Plethora of model independent full analysis of rare decays can restrict severely the allowed regions for electromagnetic and semileptonic operators.

- Photon polarization at LHCb (CP asymmetry $B_s \to \phi\gamma$, Angular analysis and Dalitz plot in $B \to K_1\gamma$). Acceptance function crucial to be at 2-3 % level for a 0.2 uncertainty. Required theory input for $K_1 \to K\pi\pi$.
- Can SCET help in getting a better handle on endpoint divergences and power corrections?
- Can we see non-decoupling effects from electroweak Z penguins? Can we measure $Z \to bs$?

Promising new horses come into play for $\mathbf{B} \to \mathbf{K}^* \mu^+ \mu^-$

- First, focus on observables with less QCD pollution, like the proposed P_i with a higher sensitivity to NP. We can miss NP signals if we focus on polluted or less NP sensitivity observables (F_L, S_i,...). New Physics will be subtle.
- Second, compute those observables using as many different approaches as possible, QCDF, LCSR approach to FF, lattice, different parametrizations of FF (transversity, helicity), charm pollution, etc. All of them give compatible results and enhance our confidence that if a signal is seen is not QCD pollution. Be conservative with FF error estimates.
- Try to find an optimal binning, and treat each region differently, ultra-low q^2 including light resonances, 1-6 with QCDF and other approaches, high-q^2 region: HQET, lattice.
- The smart idea of folding angles gives access to specific sets of P_i, not requiring the full angular distribution. More and more systematics (lepton masses, S-wave, ...) are being included and refined. Future q^2 parametrization, access to $A_T^{3,4,5}$.

Taus and LFV

- What happens with taus??? There is a systematic problem with them? It is important to learn the experimental lessons ($B \to \tau\nu$).
- New opportunities to test models with a challenging $B_s \to \tau^+\tau^-$ mode...
- Can LHCb measure the τ lifetime?
- Construct observables based on polarization of τ's.
- New challenges: τ decays at hadron collider: LFV using $\tau \to \mu\mu\mu$ and BNV using $\tau \to p\mu\mu$.
- Suggestions for measuring different *tau* decays, to get a handle on
  - isospin breaking NP ($\tau^- \to \eta\pi^-\nu_\tau$) (SuperBelle)
  - CP violation in $\tau^- \to (K\pi)^-\nu_\tau$
  - Lepton universality studies.

- What about LFV mode $B \to K\tau\mu$? Is it possible for LHCb?
- LHCb establishes best limits (mass dependent) on the coupling $|V_{\mu 4}|$ of a 4th generation N to $W\mu$ using $B \to \pi\mu\mu$
- Susy models can enhance LFV tau decays by several orders of magnitude.

Lattice

- Be careful with lattice.... V_{us}, f_{Bs}, direct determination of FF ($T_{1,2}$),... Lattice is a central player.

Finally...

Our twofold goals:

- We should keep testing and constraining models to guide direct searches. And keep proposing NP sensitive observables.
- But at the same time we should focus also (when possible) in establishing the tensions by finding correlations among them.