The CKM Review

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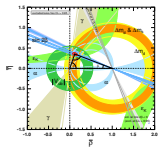
- 2014 is 5th edition for us: biannual updates (some major) / iterations / referees
- Outline:
  1. Introduction
  2. Some recent changes and issues
  3. Future

Huge progress in this Millenium

- Before 2004 we did not know that the CKM picture was (essentially) correct
  $\mathcal{O}(1)$ deviations in CP violation were possible
- Nobel Prize in 2008 recognized that the KM phase has been esablished as the dominant source of CP violation in flavor changing transitions of quarks



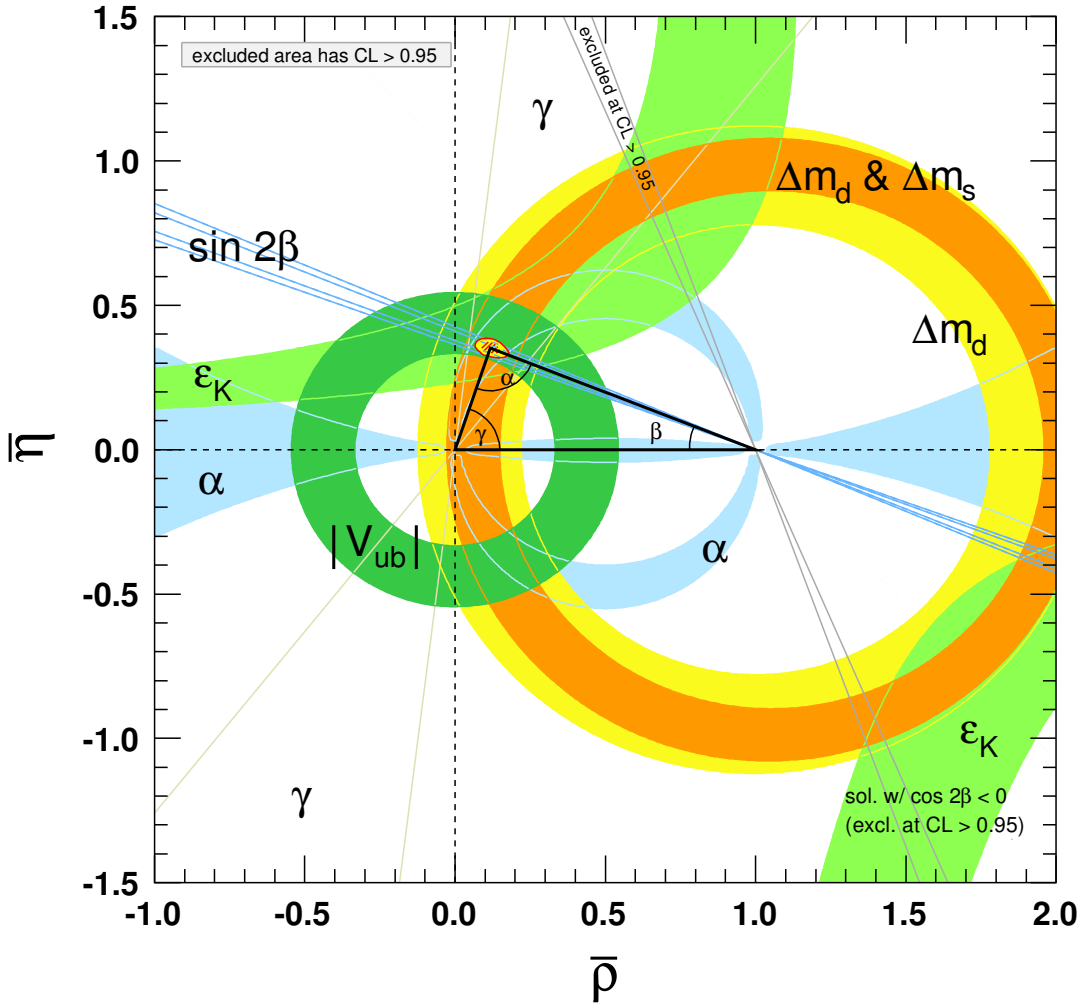
- Present: no significant deviations from SM, several hints of possible NP signals



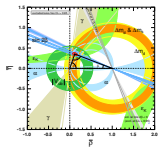
Current status of the SM CKM fit

- CKMfitter and UTfit do dedicated fits for us, with our inputs

  LHCb results have started to impact several of these measurements



- However, $\mathcal{O}(20\%)$ deviations from SM are still allowed in most FCNC processes



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Some input issues

- Still no HFAG average for α (ϕ_2) and γ (ϕ_3)

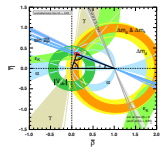
  Here 2006: *"results this April make constraints on α and γ weaker (hopefully HFAG will provide ... averages by 2008)"*

- CKMfitter (frequentist) vs. UTfit (bayesian) have both been doing fits for us with our inputs, we mainly quote frequentist results, comment on consistency

  Differences due to method & dependence on priors (far from infinite statistics limit)

- α : conceptual differences CKMfitter / UTfit [hep-ph/0703073, hep-ph/0607246 / hep-ph/0701204]

- Fit results in the SM are very similar, but the impact on NP fits is larger
  (Comparing loop-mediated and tree-dominated processes)



Inputs from minireviews and lattice QCD

- Most important minireviews for us: (i) V_{cb} and V_{ub} ; and (ii) V_{ud} and V_{us}
- Persistent tension in determination of V_{cb} and V_{ub} from inclusive and exclusive semileptonic decays — and then the interesting tension between V_{ub} and $\sin 2\beta$

  Since 2008, minireview inflates uncertainty, and we accept it

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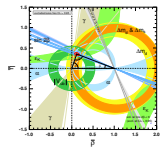
- FLAG (flavor lattice av. group) now provides "official" lattice QCD averages (Broad involvement of lattice QCD community — long awaited)

  Issues when one lattice calculation dominates a quantity (sometimes by a lot)
- E.g., V_{us} and V_{ud} minireview does not use the FLAG average for $f_+(0)$ in $K \to \pi e \nu$

  Had detailed discussions with authors and we agreed — criticised by a referee
- How each case is treated should not depend on whether result agrees with SM fit



Some of the largest changes for 2014

- $|V_{tb}| = 1.021 \pm 0.032$

  top decays: $\mathcal{B}(t \to Wb)/\mathcal{B}(t \to Wq) = |V_{tb}|^2/(\sum_q |V_{tq}|^2) = |V_{tb}|^2 \quad (q = b, s, d)$

  Single top quark production cross section, does not rely on unitarity:

  Tevatron: $(3.51^{+0.40}_{-0.37})$ pb $\Rightarrow |V_{tb}| = 1.03 \pm 0.06$

  LHC t-channel single-top cross section: 7 TeV, (68.5 ± 5.8) pb $\Rightarrow |V_{tb}| = 1.03 \pm 0.05$

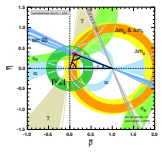
  8 TeV, (85 ± 12) pb $\Rightarrow |V_{tb}| = 0.99 \pm 0.07$

- $|V_{cs}| = 0.986 \pm 0.016$

  $D_s^+ \to \mu^+\nu$ and $D_s^+ \to \tau^+\nu$ with $f_{D_s} = (248.6 \pm 2.7)$ MeV $\Rightarrow |V_{cs}| = 1.008 \pm 0.021$

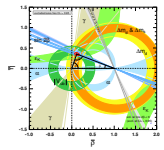
  $D \to K\ell\nu$ and lattice QCD calculation of the form factor $|V_{cs}| = 0.953 \pm 0.025$

  We quote average with ν scattering determination — becoming less important



Refereeing and other feedback

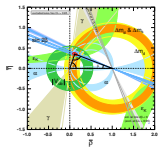
- Included many useful comments — and have disagreed with some
- Comments I recall that made us think:
  - Some of the lattice inputs may be viewed as too optimistic
  - Amount of beyond SM discussion / interpretation / implications
    [Not a single typical BSM model for flavor; too many new parameters in general]
  - Quantify uncertainty from $\sin 2\beta$ "penguin" modes
    [A major issue both at LHCb and Belle II workshops]
  - Balance between best determinations of a certain quantity and reflecting on the state of the field (the best channel now may not be it the next time around)
  - More introduction & explanation of details $\Rightarrow$ length? [more citations...?]
- Despite pressures, we have kept the length of the review roughly constant



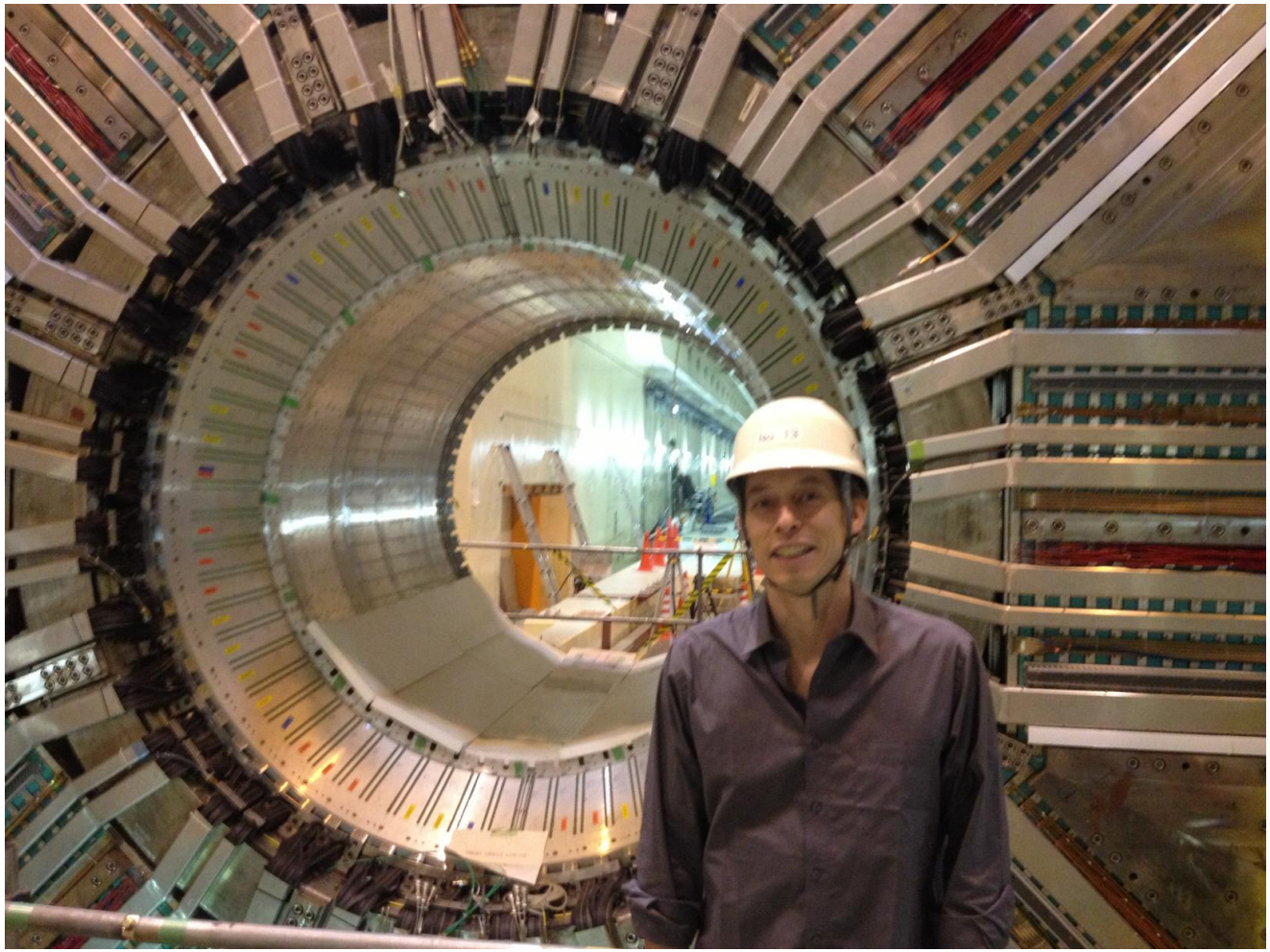
Future: NA62

- NA62: Physics in 2015

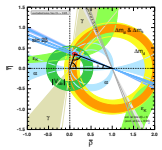
Mary K.: "Been waiting 40 years—longer than for Higgs!"



Future: Belle II



- Belle II: Physics by 2017



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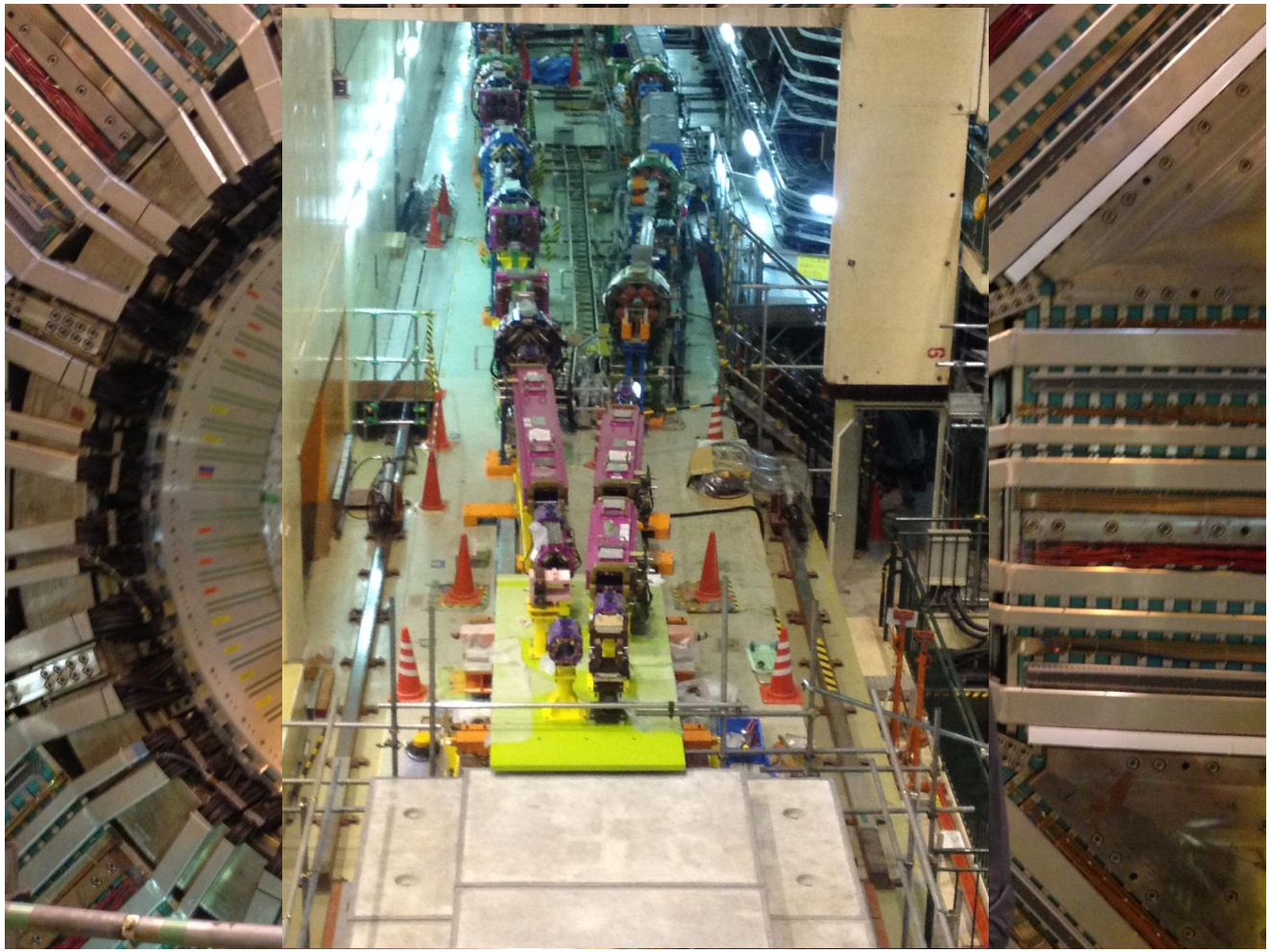

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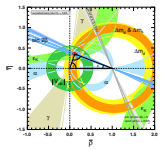
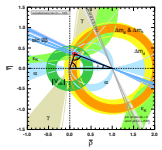


Future: LHCb upgrade

- LHCb upgrade: collect $50\,\mathrm{fb}^{-1}$ in the 2020-s



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Summary

- Flavor physics remains vibrant: new experiments w/ exciting discovey potentials:

  NA62: $K \to \pi\nu\bar{\nu}$, the long-awaited complementarity with B decays

  LHCb: Sensitivity to NP in B_s FCNCs at similar level to B_d, will improve similarly

  Belle II: Near order of magnitude improvement in many measurements

- Looking for corrections to the SM picture of flavor and CP violation

- Large impacts in any case, in ways dependent on what experiments do (not) see

- If the LHC sees new physics, it will tell us the scale of the new operators, which will make the interpretation of flavor physics data even more interesting

  (And pose new challenges to the PDG — how to present information on flavor structure of NP?)