

# Proposed guidelines for the

---

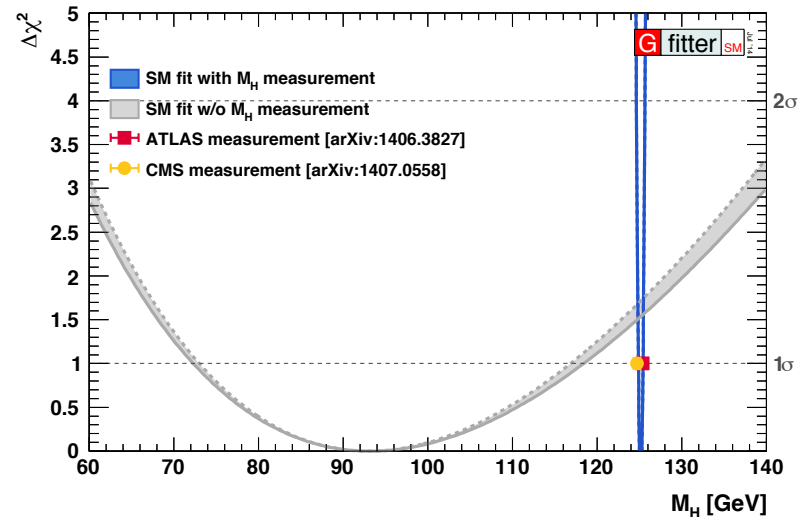
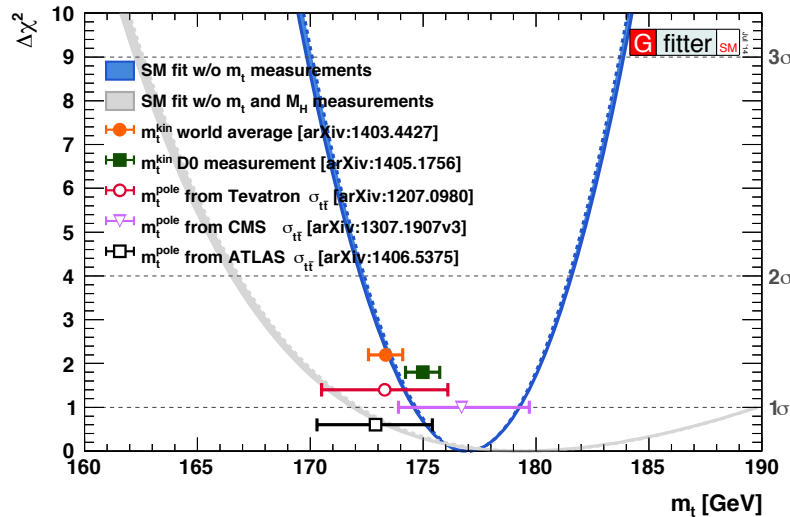
## Discussion on (heavy) Flavour Physics: *CP* violation(s) and rare decays.

Disclaimer: try to suggest here and there provocative statements.

1. The two pillars of the Standard Model (SM).
2. How fragile are they? the  $B \rightarrow \tau \nu$  illustration.
3. On the importance of the  $\gamma$  angle. Also for the loops.
4. What if New Physics is at tree level? the  $B \rightarrow D^{(*)} \tau \nu$  illustration.
5. The experimental programs to come.

# The two pillars of the SM

- Certainly starting by the EWK precision tests

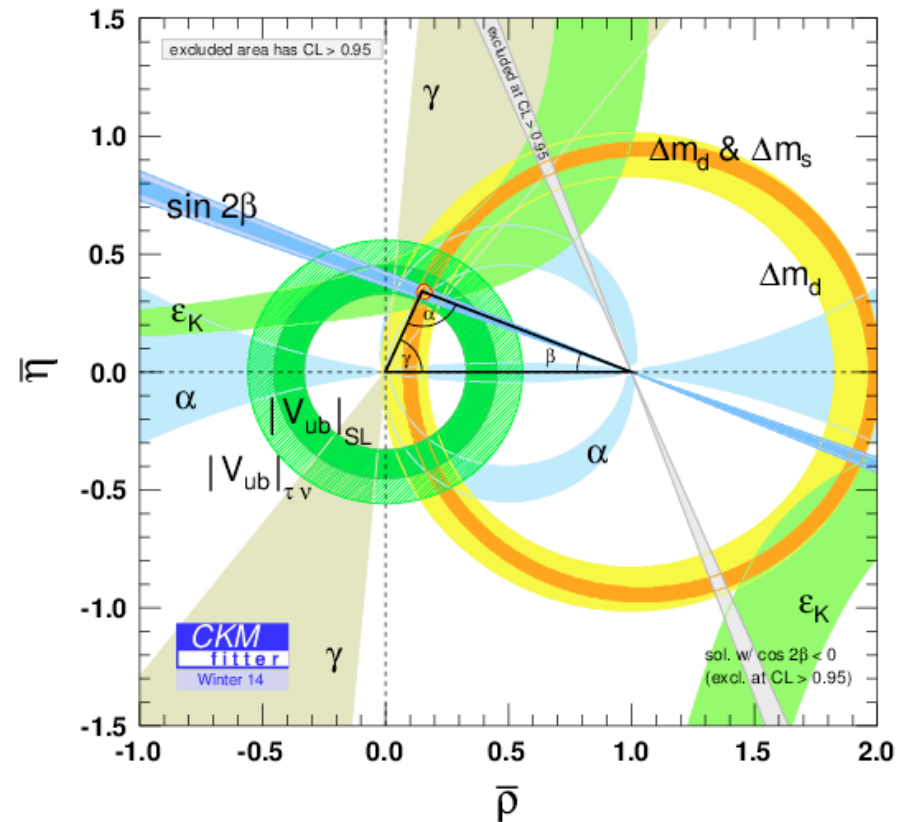


- A tremendous success of SM and a successful continuum of ee/pp machines. Still, the genuine weak radiative corrections are probed at observation level.

$$\rho = 1.0050 \pm 0.0010$$

# The two pillars of the SM - Part II - mass mixing matrix

- Continuing with the CKM profile
- This is a tremendous success of the Standard Model and especially the Kobayashi-Maskawa mechanism. This is simultaneously an outstanding experimental achievement by the B factories.
- CKM is at work in weak charged current.
- The KM phase IS the dominant source of CP violation in K and B system.

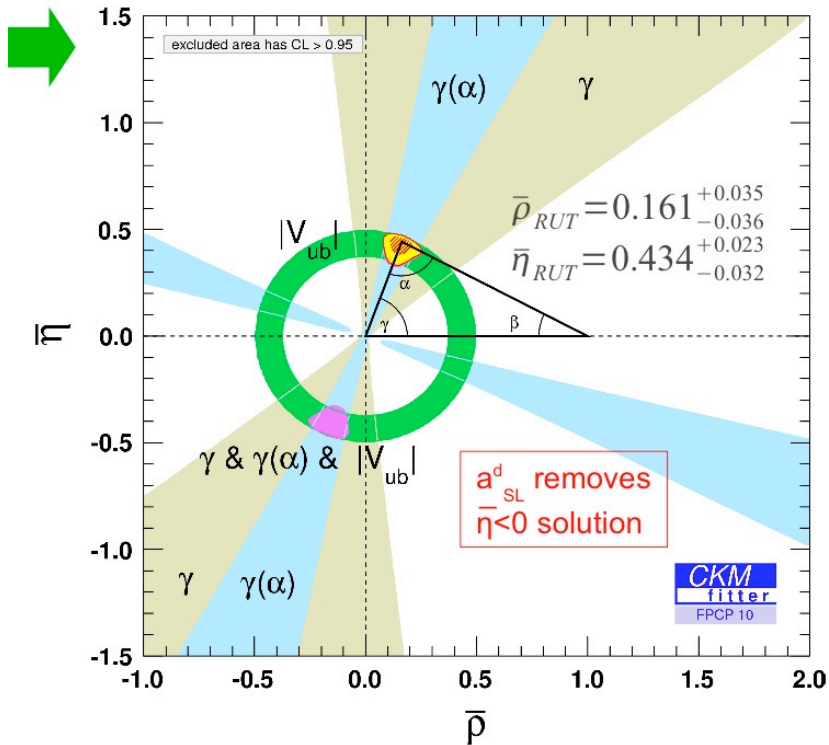


# How fragile is the CKM global consistency check?

## Hypotheses:

- tree-level processes are not affected by NP (so-called SM4FC:  $b \rightarrow q_i q_j q_k$  ( $i \neq j \neq k$ )). As a consequence, the quantities which do not receive NP contributions in that scenario **are**:

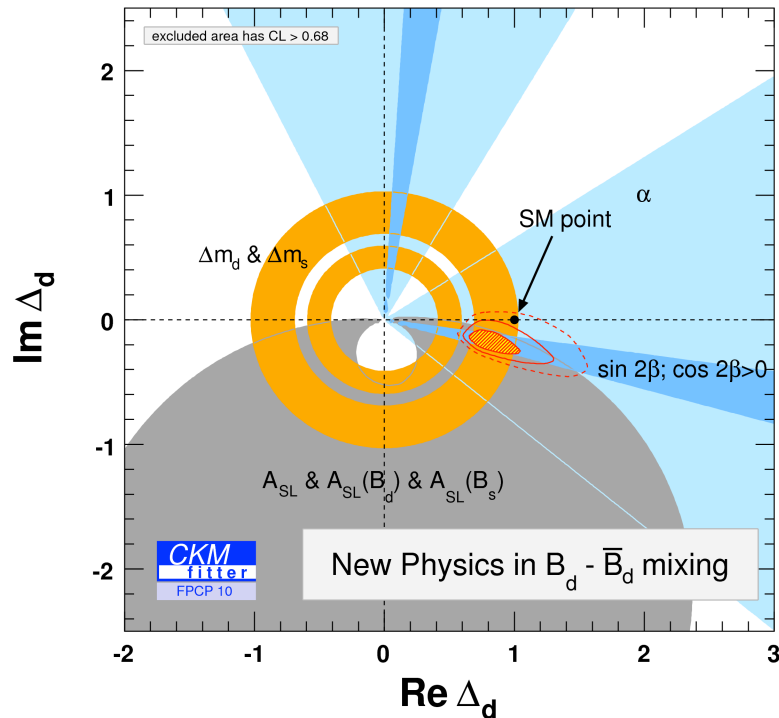
$$|V_{ud}|, |V_{us}|, |V_{ub}|, |V_{cb}|, B^+ \rightarrow \tau^+ \nu_\tau \text{ and } \gamma$$



- They fix the apex of the UT.
- $\alpha$  and  $\beta$  receives the same additional phase with opposite sign and hence can be interpreted as  $\gamma$  tree.
- The second (symmetric) solution is disfavored by the semileptonic charge asymmetry (CP violation in the  $B$  mixing).

# How fragile is the CKM global consistency check?

## NP in $\Delta F=2$ processes: the $Bd$ mixing projection as of 2010

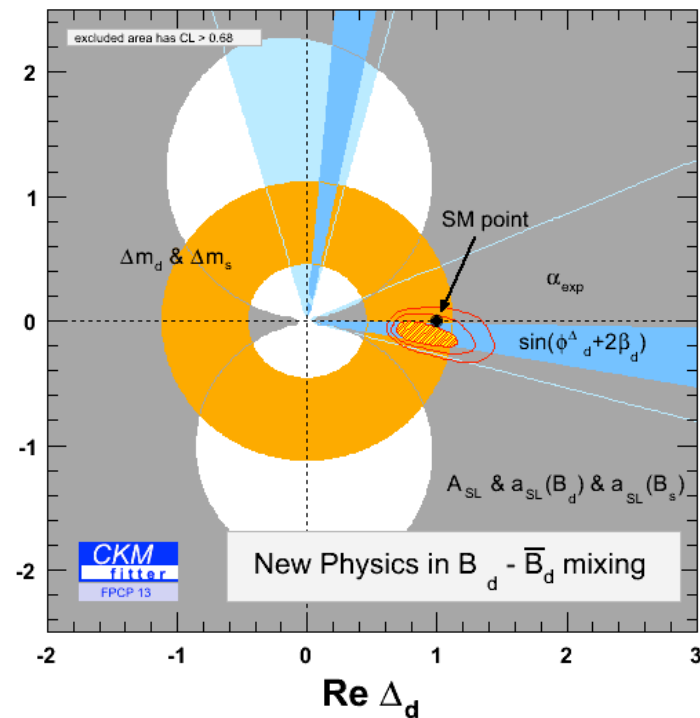
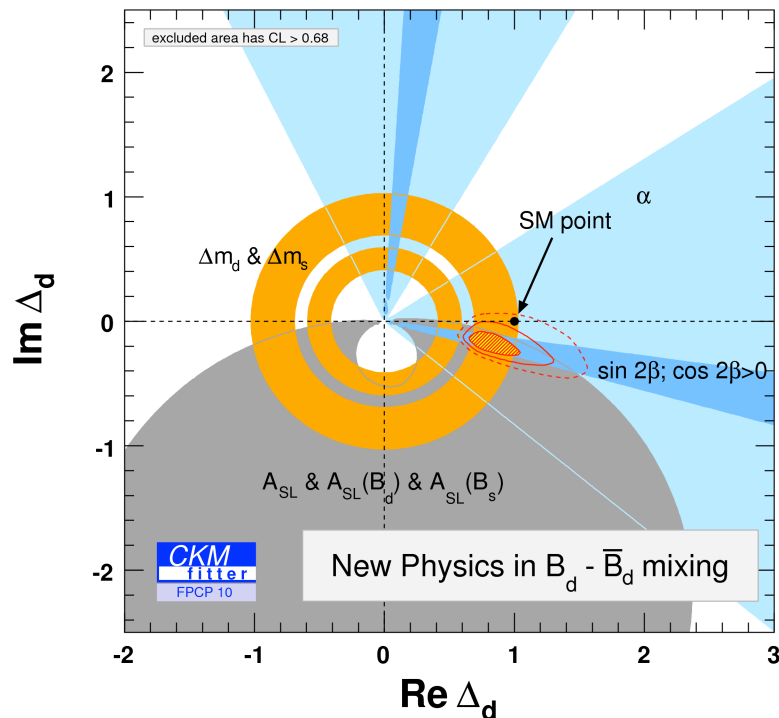


- $\beta$  and  $A_{SL}$  are both favouring the negative imaginary part.
- SM hypothesis (2D):  $2.5\sigma$
- A single (merely observed) process shook the SM.

A new phase in the  $Bd$  mixing accomodates nicely the  $B^+ \rightarrow \tau^+ \nu$  vs  $\sin 2\beta$  discrepancy of the SM global fit.

# How fragile is the CKM global consistency check?

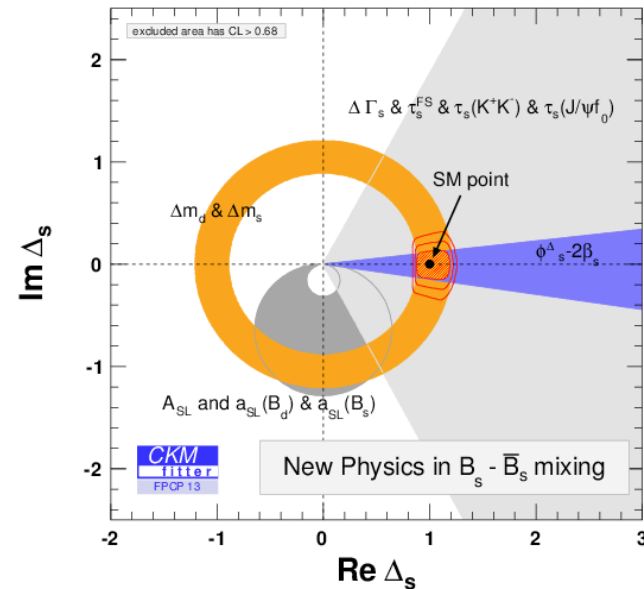
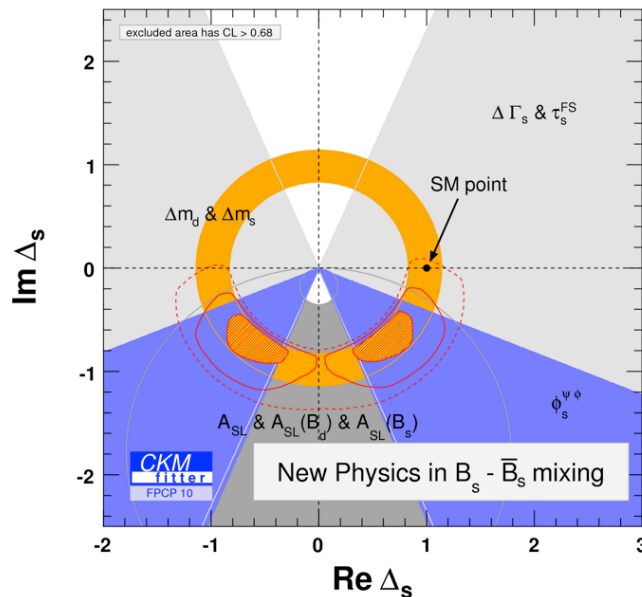
**NP w/ arbitrary flavour structure in  $\Delta F=2$  processes:  
After new Belle Results on  $B \rightarrow \tau \nu$ .**



- Damned, SM strikes back.

# How fragile is the CKM global consistency check?

## NP w/ arbitrary flavour structure in $\Delta F=2$ processes: After LHCb 1/fb.



- The 2D SM hypothesis is:  $0.2 \sigma$  (used to be  $\sim 3 \sigma$ )
- But don't infer a wrong statement: sizeable NP is still allowed by the LHCb and  $B$  factories constraints in both  $Bd$  and  $Bs$  mixing.

# On the importance of the $\gamma$ angle measurement for loops

---

- Defines the model-independent (in MFV *scenarii*) unitarity apex with the  $|V_{ub}|$  matrix element.
- The current global consistency checks (both NP and SM) are limited by the  $\gamma$  angle measurement precision.
- There is an ambitious experimental program on its way to the degree.
- We'll be (quite rapidly) limited by  $|V_{ub}|$  precision. Prospects?

# Loops again: the rare decays.

---

- Look at purely hadronic decays of B mesons. Statistics is the issue there. Prospects:  $B_s \rightarrow \tau\tau$  ?
- In mixed leptonic-hadronic final states, statistics is less and less the issue. Brilliant efforts to reduce the hadronic uncertainties (see Ulrik's talk). Very promising prospects for both LHCb upgrade and Belle II.
- What's next?

# What if NP is present at tree-level?

---

From less difficult to difficult, theory-wise.

- $B \rightarrow \tau \nu$  strikes back: good for 2HDM. Belle II on the way: Prospects?
- The two determinations of  $|V_{ub}|$  are in marginal agreement. A theory question. Comments?
- $B \rightarrow D^{(*)} \tau \nu$  a priori more complicated from hadronic theoretical uncertainties. But there are claims that those are under satisfactory control. BaBar still dominating. Belle (the current one) on the way this time. Models to accommodate the measurements discussed in the session by Andrey. How strong is our belief on the hadronic uncertainties?
- Side comment: departures to the SM predictions less appealing at the places where theory is difficult.

# The experimental programs.

---

- There is a rich flavour and  $CP$ -violation program for next 10-15 years
- LHCb upgrade. 50 /fb
- SuperKEKB and Belle II. 50 /ab.
- Shared master objectives:
  - the degree everywhere:  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\Phi_s$
  - probing  $CP$ -violating phases through loop-dominated decays.
  - rare decays more comprehensively.
  - tree-level observables exploration.
- One should not forget the kaon programs (CERN, JAPAN) as another way to test the universality of CKM paradigm.
- Is Flavour Physics (quarks-wise) completed w/ these programs?