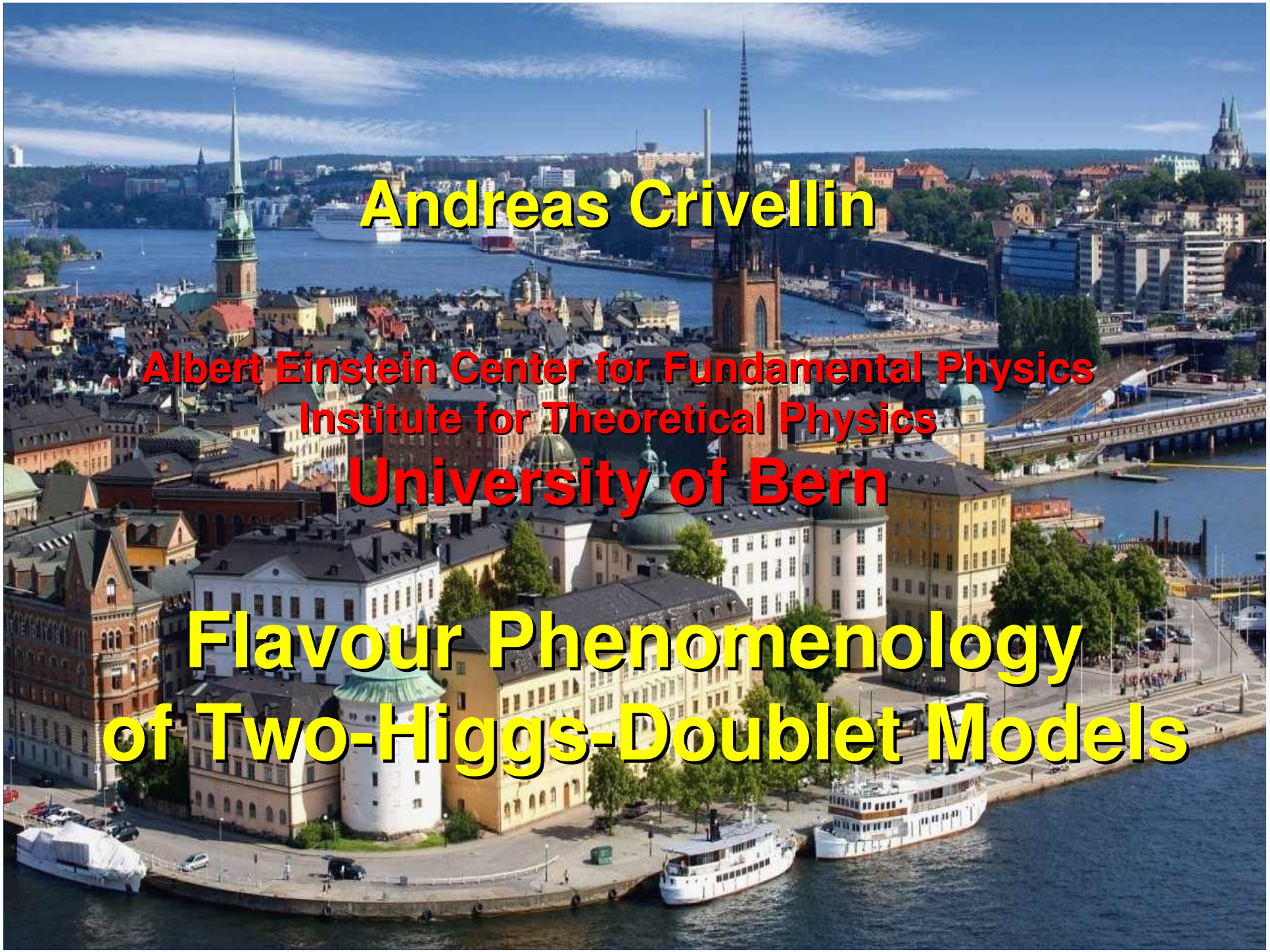

Andreas Crivellin
Albert Einstein Center for Fundamental Physics
Institute for Theoretical Physics
University of Bern
Flavour Phenomenology
of Two-Higgs-Doublet Models

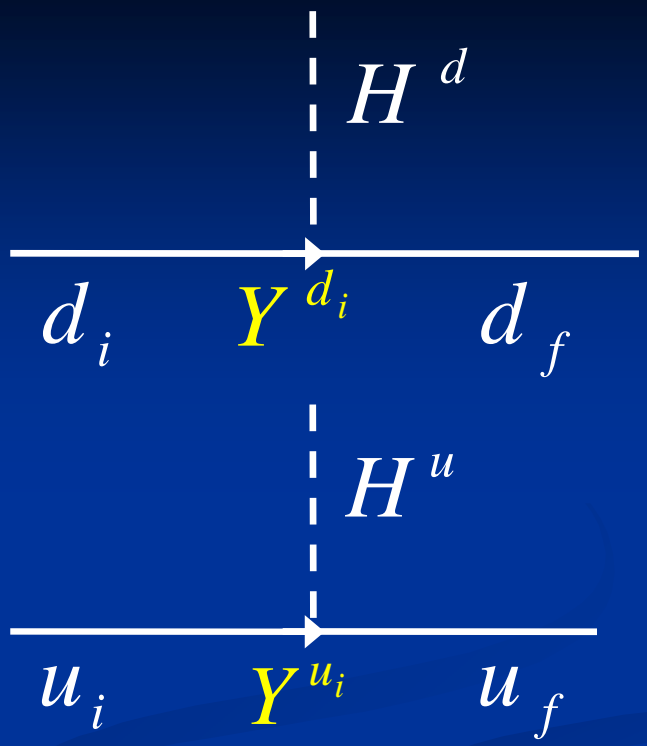
Outline:

- Introductions:
  Yukawa interactions in 2HDMs
- Phenomenology
  - Constraints from FCNC processes
  - Tauonic B decays
  - LFV processes
- Conclusions

Introduction

Yukawa interactions

2HDM of type II
(MSSM at tree-level)



- One Higgs doublet couples only to down-quarks (and charged leptons), the other Higgs doublet couples only to up-quarks.
- 2 additional free parameters: $\tan(\beta)=v_u/v_d$ and the heavy Higgs mass

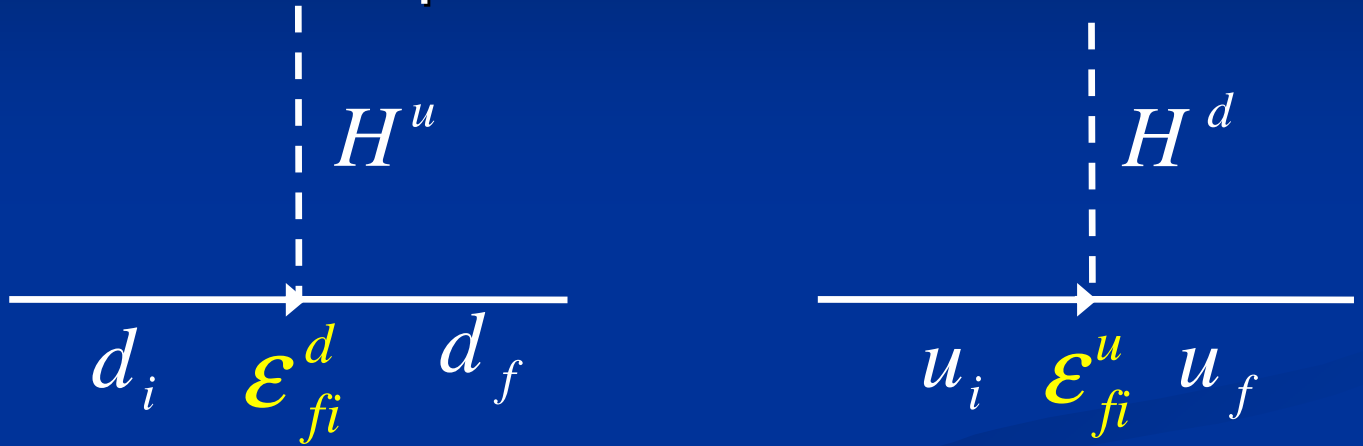
  $m_H \approx m_{A^0} \approx m_{H^\pm} \approx m_{H^0}$

$$m_{q_i} = v_q Y^{q_i}$$

- All flavor-violations is due to the CKM matrix: neutral Higgs-quark couplings are flavor-conserving.

2HDM of type III

- Both Higgs doublets couple simultaneously to up and down quarks.



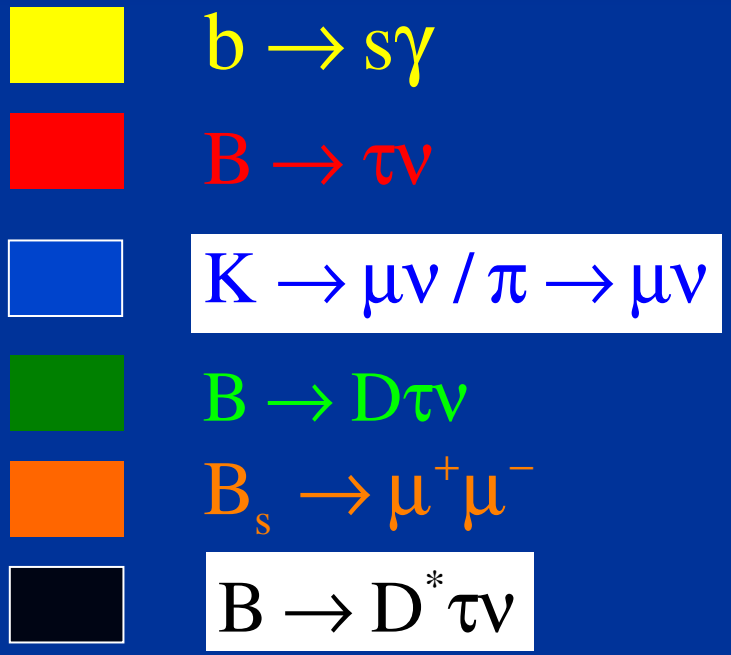
$$m^d_{ij} = v_d Y^d_{ij} + v_u \varepsilon^d_{ij} \qquad m^u_{ij} = v_u Y^u_{ij} + v_d \varepsilon^u_{ij}$$

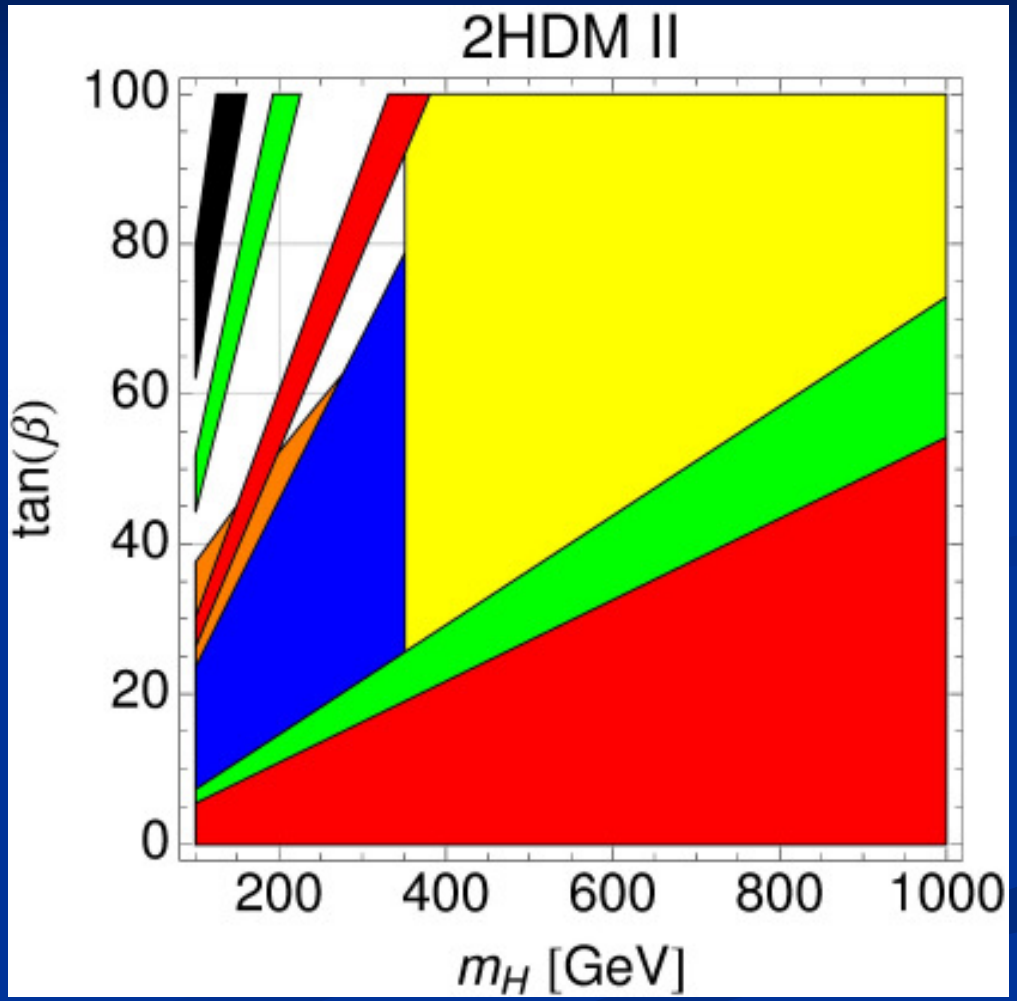
- The parameters $\varepsilon^{u,d}_{ij}$ describe flavor-changing neutral Higgs interactions
- In the MSSM, $\varepsilon^{u,d}_{ij}$ are induced via loops

Phenomenology

Type-II 2HDM

- Allowed
  2σ regions from:
  (superimposed)





➡ Tension from $B \to D^*\tau\nu$

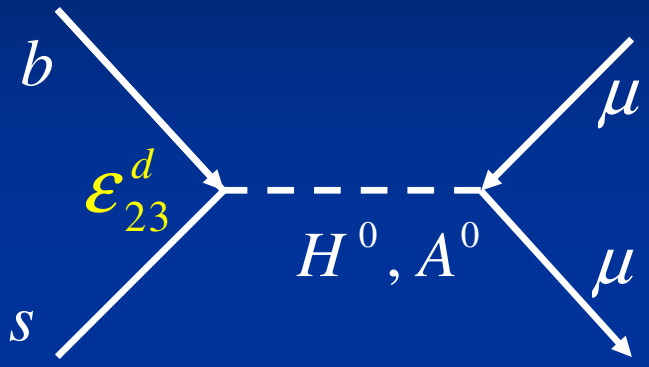
Type-III: constraints from M→μ⁺μ⁻

$\tan(\beta) = 50$

$m_H = 700$ GeV

$m_H = 500$ GeV

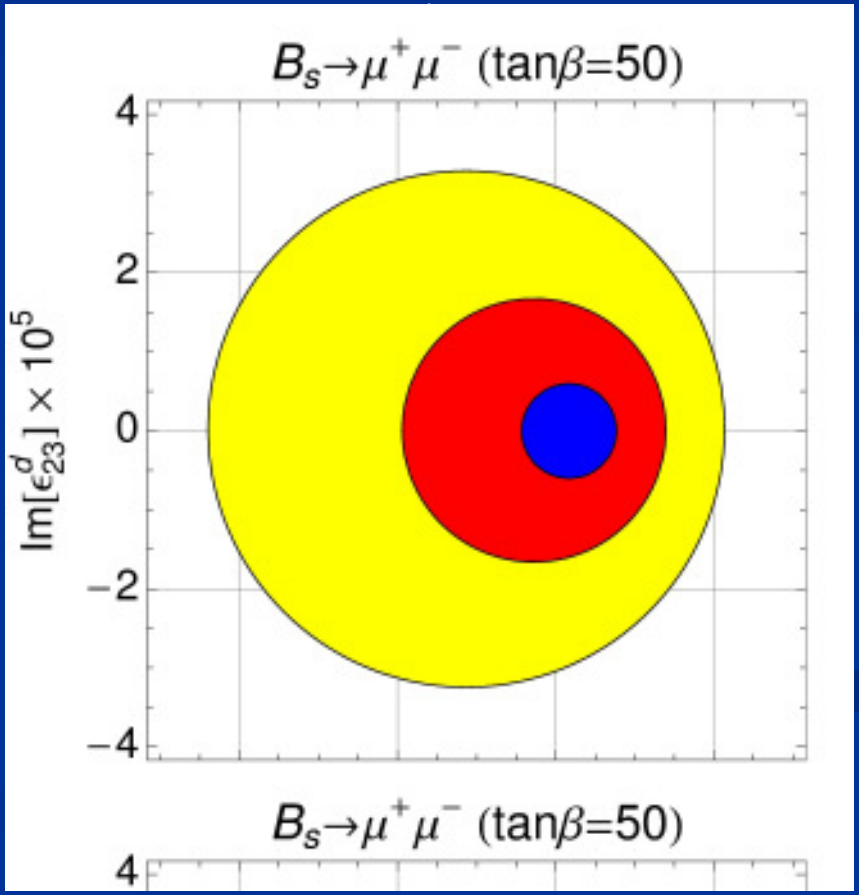
$m_H = 300$ GeV



- B → μ⁺μ⁻ constrains $\varepsilon^d_{13,31}$
- B_s → μ⁺μ⁻ constrains $\varepsilon^d_{23,32}$
- K_L → μ⁺μ⁻ constrains $\varepsilon^d_{12,21}$
- D → μ⁺μ⁻ constrains $\varepsilon^u_{12,21}$

$\varepsilon^u_{32,23}$ and $\varepsilon^u_{13,31}$ unconstrained

→ from tree-level FCNCs



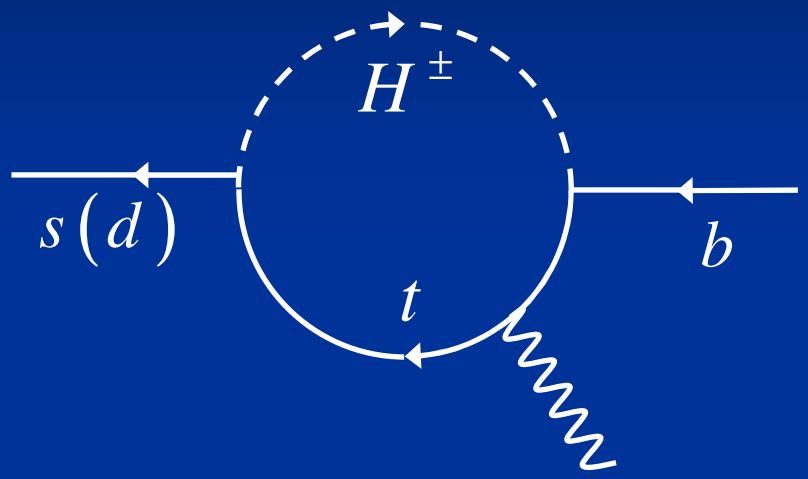
Type-III: Constraints from b→s(d)γ

$\tan(\beta) = 50$

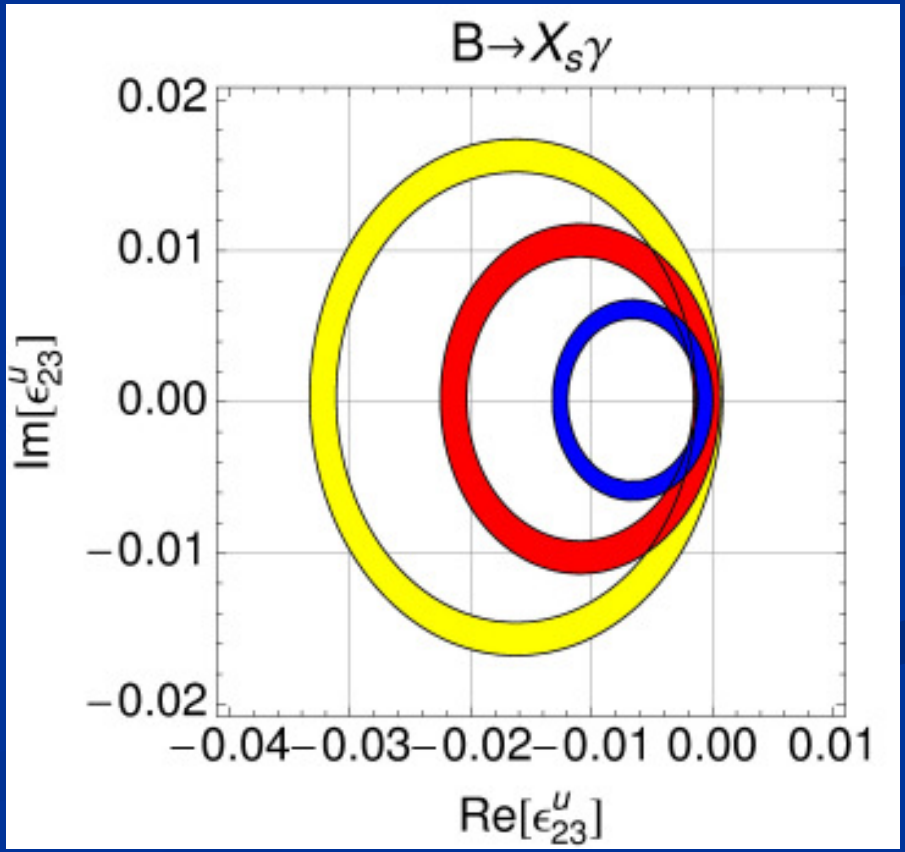
$m_H = 700$ GeV

$m_H = 500$ GeV

$m_H = 300$ GeV



- $b \to s\gamma$ constrains ε^u_{23}
- $b \to d\gamma$ constrains ε^u_{13}
- $\varepsilon^u_{31,32}$ still unconstrained



Tauonic B decays

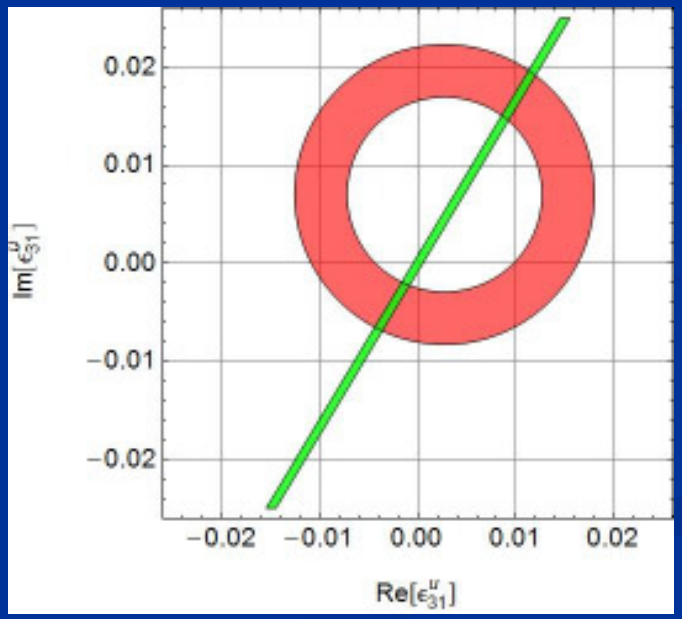
- Constructive contribution to B→τν using ε_{31}^{u} is possible.
- B→D$^{(*)}$τν and B→Dτν can be explained simultaneously using ε_{32}^{u} . ➡ Check model via $H^0, A^0 \to \bar{t}c$

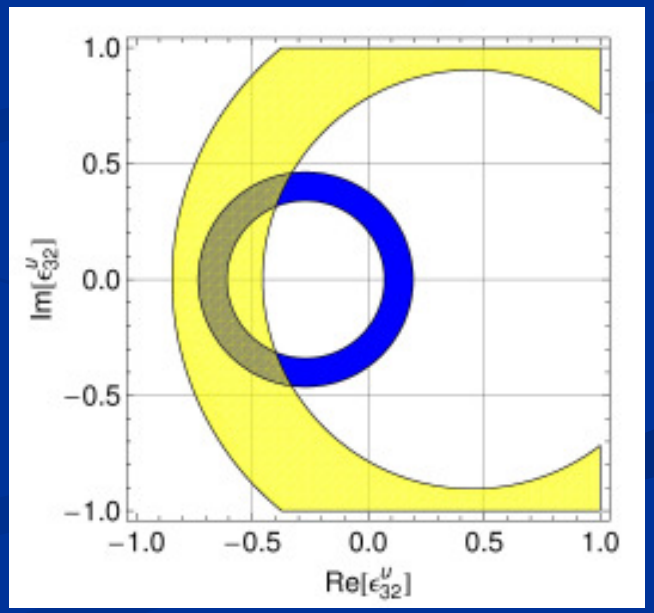
Allowed regions from:

$B \to D\tau\nu$

$B \to D^{*}\tau\nu$

$B \to \tau\nu$





Lepton Flavor violation

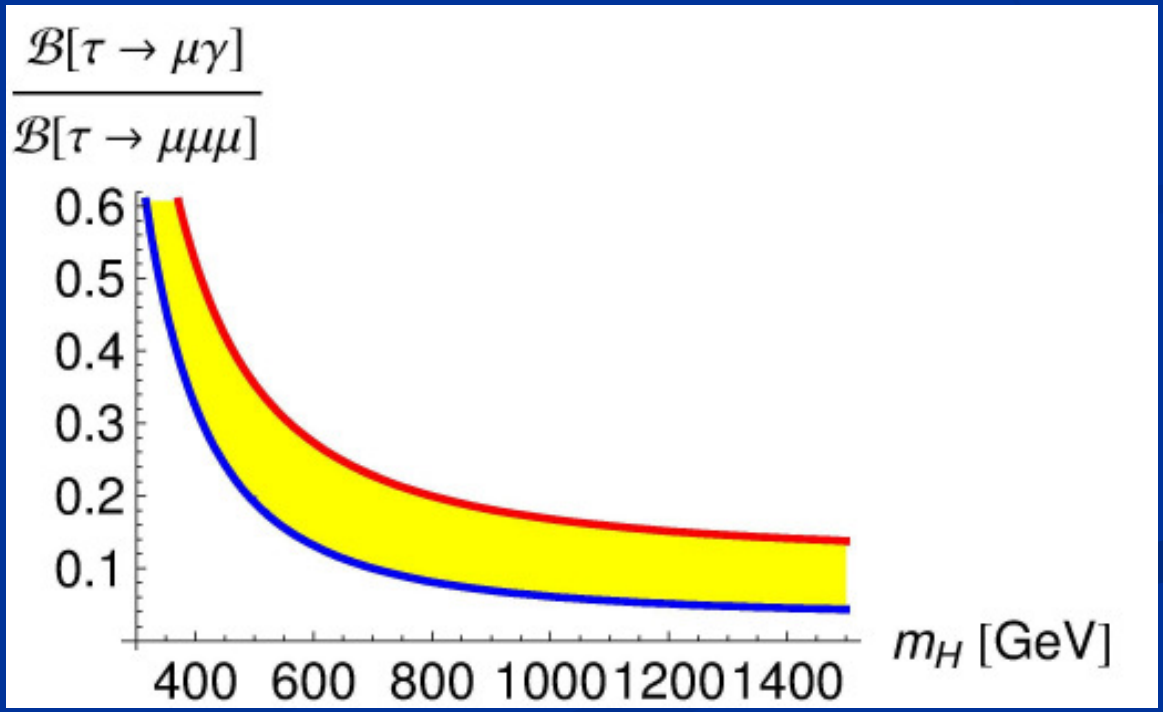
- Correlations between $\tau \to \mu\mu\mu$ and $\tau \to \mu\gamma$

Predicted ratio in the 2HDM of type III

$\varepsilon_{23}^{\ell} \neq 0, \varepsilon_{32}^{\ell} \neq 0$

$\varepsilon_{32}^{\ell} = 0, \varepsilon_{23}^{\ell} \neq 0$

$\varepsilon_{32}^{\ell} \neq 0, \varepsilon_{23}^{\ell} = 0$



Upper limits on lepton flavour violating B decays

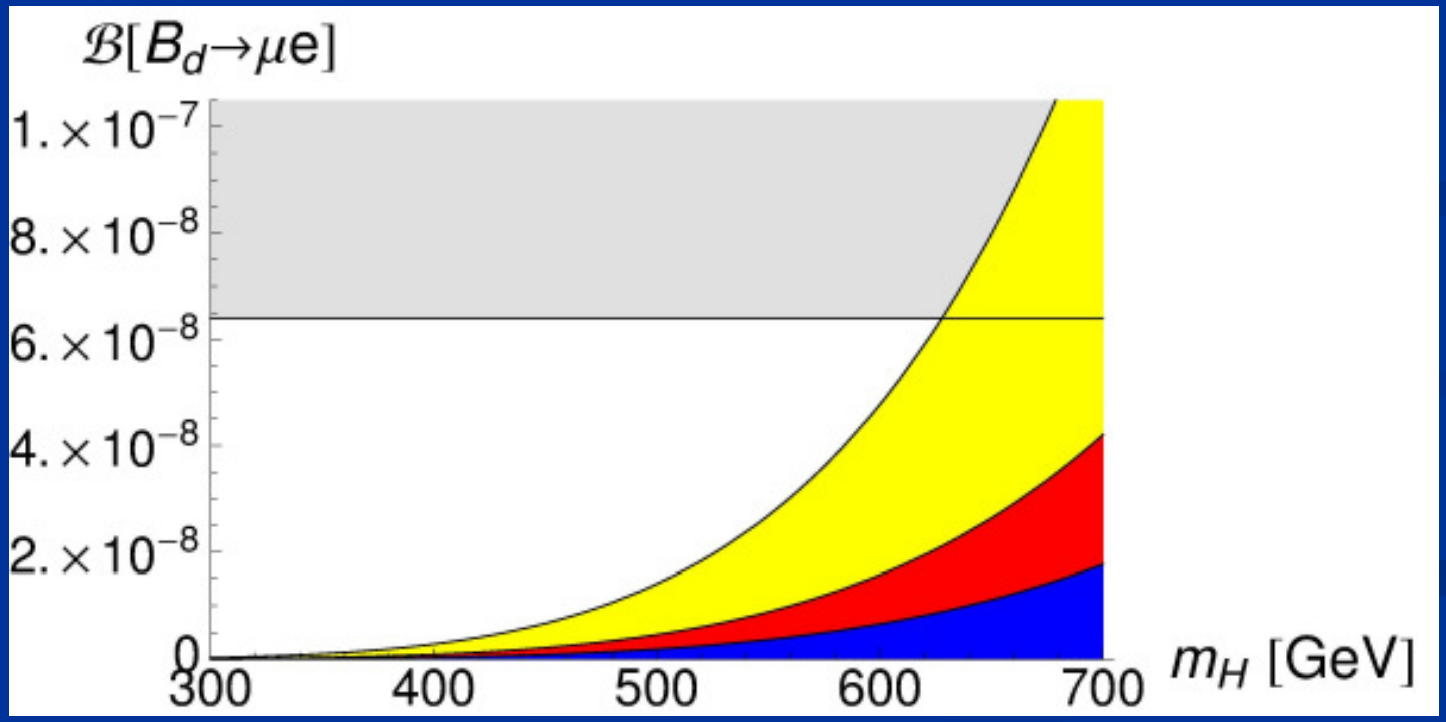
Excluded by experiment

$\tan(\beta) = 30$

$\tan(\beta) = 40$

$\tan(\beta) = 50$

Allowed regions respecting the constraints from $\mu \to e\gamma$ **and** $B_d \to \mu^+\mu^-$



Conclusions

- The 2HDM of type II is disfavored by current data on tauonic B decays
- In the 2HDM with generic Yukawa structure all off-diagonal elements ε^q_{ij} except $\varepsilon^u_{31,32}$ must be small.
- A 2HDM of type III with flavour violation in the up-sector can explain $B \to \tau\nu$, $B \to D\tau\nu$ and $B \to D^*\tau\nu$ simultaneously using $\varepsilon^u_{31,32}$.

  ➡ enhancement of $A^0 \to tc$
- Interesting correlations between among lepton flavor violating observables.