The $h^0(125)$ decays to $c\,\bar{c}$, $b\,\bar{b}$, $b\,\bar{s}$, $\gamma\,\gamma$, $g\,g$ in the light of the MSSM with quark flavor violation

K. Hidaka
Tokyo Gakugei University

Collaboration with
H. Eberl, E. Ginina

References:

Phys. Rev. D 91 (2015) 015007 [arXiv:1411.2840 [hep-ph]]
JHEP 1606 (2016) 143 [arXiv:1604.02366 [hep-ph]]]
IJMP A34 (2019) 1950120 [arXiv:1812.08010 [hep-ph]]

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$\tilde{u}_{1,2}$

1. Introduction

- ***What is the SM-like Higgs boson discovered at LHC?***
- ***It can be the SM Higgs boson.***
- ***It can be a Higgs boson of New Physics.***
- ***This is one of the most important issues in the present particle physics field!***
- ***Here we study a possibility that it is the lightest Higgs boson*** h^0 ***of the Minimal Supersymmetric Standard Model (MSSM), focusing on the decays*** $h^0(125) \to c\,\bar{c},\ b\,\bar{b},\ b\,\bar{s},\ \gamma\gamma,\ g\,g$.

2. Key parameters of MSSM

Key parameters in this study are:

*** QFV parameters:** M^2_{Q23}, M^2_{U23}, M^2_{D23}, T_{U23}, T_{U32}, T_{D23}, T_{D32}

*** QFC parameter:** T_{U33}, T_{D33}

M^2_{Q23} = ($\tilde{c}_L - \tilde{t}_L$ mixing parameter)

M^2_{U23} = ($\tilde{c}_R - \tilde{t}_R$ mixing parameter)

M^2_{D23} = ($\tilde{s}_R - \tilde{b}_R$ mixing parameter)

T_{U23} = ($\tilde{c}_R - \tilde{t}_L$ mixing parameter)

T_{U32} = ($\tilde{c}_L - \tilde{t}_R$ mixing parameter)

T_{U33} = ($\tilde{t}_L - \tilde{t}_R$ mixing parameter)

T_{D23} = ($\tilde{s}_R - \tilde{b}_L$ mixing parameter)

T_{D32} = ($\tilde{s}_L - \tilde{b}_R$ mixing parameter)

T_{D33} = ($\tilde{b}_L - \tilde{b}_R$ mixing parameter)

3. Constraints on the MSSM

We respect the following experimental and theoretical constraints:

(1) The recent LHC limits on the masses of squarks, sleptons, gluino, charginos and neutralinos.

(2) The constraint on ($m_{A/H+}$, $\tan\beta$) from recent MSSM Higgs boson search at LHC.

(3) The constraints on the QFV parameters from the B meson data.

$B(b \to s\,\gamma)$ ΔM_{Bs} $B(B_s \to \mu^+ \mu^-)$ $B(B_u^+ \to \tau^+ \nu)$ *etc.*

(4) The constraints from the observed Higgs boson mass and couplings at LHC ; e.g.

121.6 GeV < m_h^0 < 128.6 GeV (allowing for theoretical uncertainty) ,

$0.71 < \kappa_b < 1.43$ (ATLAS), $0.56 < \kappa_b < 1.70$ (CMS)

(5) Theoretical constraints from the vacuum stability conditions for the trilinear couplings T_{Uab} and T_{Dab} .

(6) The experimental limit on SUSY contributions to the electroweak ρ parameter

$\Delta\rho$(SUSY) < 0.0012.

4. Parameter scan for $h^0 \to c\bar{c}, b\bar{b}, b\bar{s}$

- We compute the decay widths $\Gamma(h^0 \to c\bar{c})$, $\Gamma(h^0 \to b\bar{b})$, and $\Gamma(h^0 \to b\bar{s})$ at full 1-loop level in the MSSM with QFV.

- We take parameter scan ranges as follows:

1 TeV < M_{SUSY} < 5 TeV

10 < tanβ < 60
2500 < M_3 < 5000 GeV
100 < M_2 < 2500 GeV
100 < M_1 < 2500 GeV
100 < mu < 2500 GeV
800 < m_A(pole) < 6000 GeV
etc. etc.

- In the parameter scan, all of the relevant experimental and theoretical constraints are imposed.

- 101000 parameter points are generated and 2993 points survive the constraints.

5. $h^0 \rightarrow c\,\bar{c}$, $b\,\bar{b}$, $b\,\bar{s}$ in the MSSM

- *We compute the decay widths $\Gamma(h^0 \rightarrow c\,\bar{c})$, $\Gamma(h^0 \rightarrow b\,\bar{b})$, and $\Gamma(h^0 \rightarrow b\,\bar{s})$ at full 1-loop level in the DRbar renormalization scheme in the MSSM with QFV.*

- *Main 1-loop correction to $h^0 \rightarrow c\,\bar{c}$:*

  gluino - su loops [su = ($\tilde{t}$ - $\tilde{c}$ mixture)]
  can be enhanced by large trilinear couplings TU23 TU32 , TU33

- *Main 1-loop corrections to $h^0 \rightarrow b\,\bar{b}$ & $b\,\bar{s}$:*

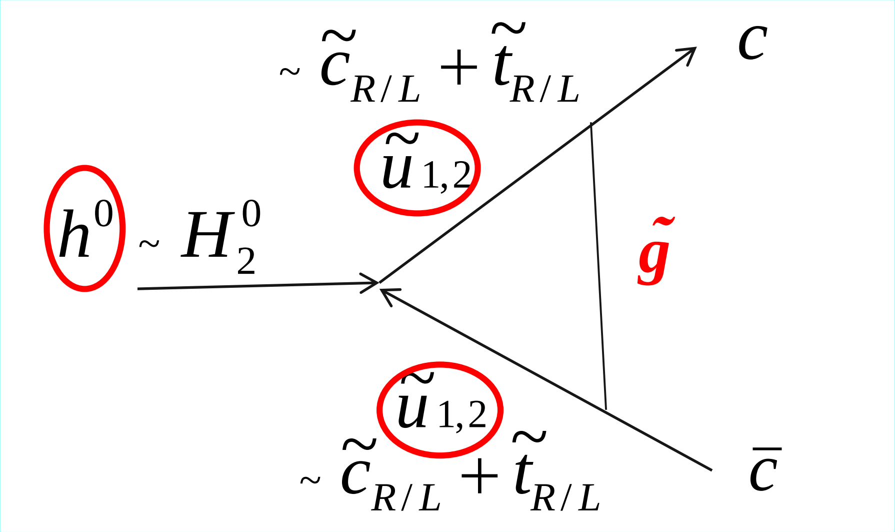
  gluino – sd loops [sd = ($\tilde{b}$ - $\tilde{s}$ mixture)]
  can be enhanced by large trilinear couplings TD23 TD32 , TD33

  chargino - su loops [su = ($\tilde{t}$ - $\tilde{c}$ mixture)]
  can be enhanced by large trilinear couplings TU23 TU32 , TU33

In large $\tilde{c}_{R/L} - \tilde{t}_{R/L}$ & $\tilde{t}_L - \tilde{t}_R$ mixing scenario;

$h^0 \sim H_2^0$

$\tilde{u}_{1,2} \sim \tilde{c}_{R/L} + \tilde{t}_{R/L}$



In our scenario, "trilinear couplings" ($\tilde{c}_R - \tilde{t}_L - H_2^0$, $\tilde{c}_L - \tilde{t}_R - H_2^0$, $\tilde{t}_L - \tilde{t}_R - H_2^0$ couplings) = (T_{U23} T_{U32}, T_{U33}) are large!

$\tilde{u}_{1,2} - \tilde{u}_{1,2} - h^0$ couplings are large!

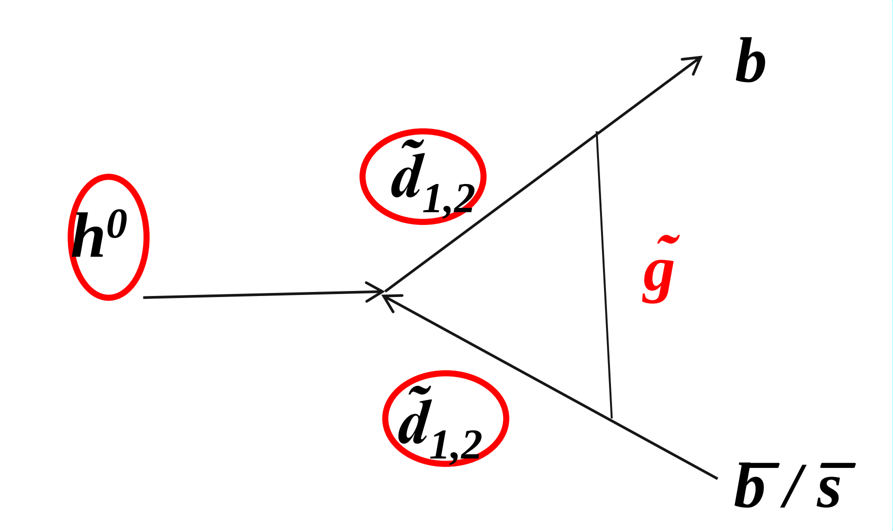
Gluino loop contributions can be large!

Deviation of $\Gamma(h^0 \rightarrow c\,\bar{c})$ from SM width can be large!

In large $\tilde{s}_{R/L}$ - $\tilde{b}_{R/L}$ & $\tilde{b}_L$ - $\tilde{b}_R$ mixing scenario;

$$h^0 \sim -s\alpha H_1^0 + c\alpha H_2^0$$

$$\tilde{d}_{1,2} \sim \tilde{s}_{R/L} + \tilde{b}_{R/L}$$



In our scenario, "trilinear couplings"(T_{D23} T_{D32}, T_{D33}) = ($\tilde{s}_R$ - $\tilde{b}_L$ - H_1^0 , $\tilde{s}_L$ - $\tilde{b}_R$ - H_1^0 , $\tilde{b}_L$ - $\tilde{b}_R$ - H_1^0 couplings) are large!

$\tilde{d}_{1,2}$ - $\tilde{d}_{1,2}$ - h^0 couplings are large!

Gluino loop contributions can be large!

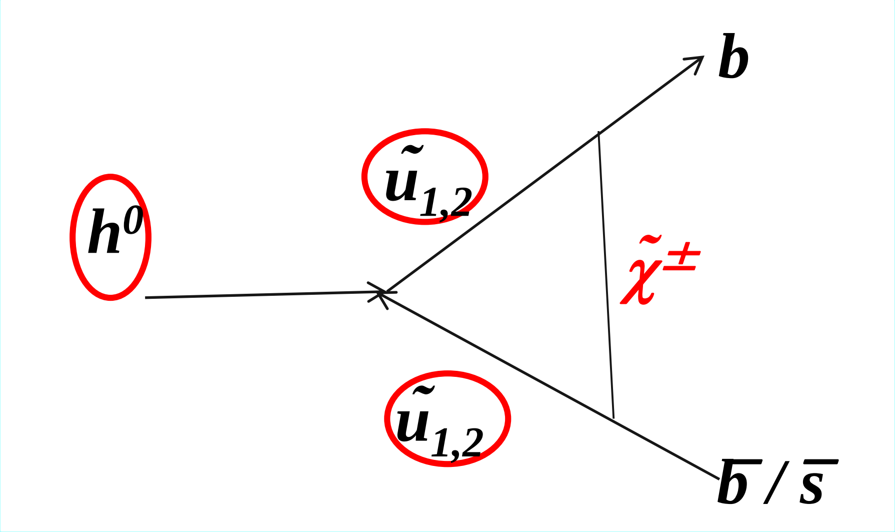
Deviation of $\Gamma(h^0 \to b\,\bar{b}/\bar{s})$ from SM width can be large!

In large $\tilde{c}_{R/L}$ - $\tilde{t}_{R/L}$ & $\tilde{t}_L$ - $\tilde{t}_R$ mixing scenario;

$h^0 \sim H_2^0$

$\tilde{u}_{1,2} \sim \tilde{c}_{R/L} + \tilde{t}_{R/L}$

$\tilde{\chi}^\pm \sim \tilde{W}^\pm + \tilde{H}^\pm$



In our scenario, "trilinear couplings" ($\tilde{c}_R - \tilde{t}_L - H_2^0$, $\tilde{c}_L - \tilde{t}_R - H_2^0$, $\tilde{t}_L - \tilde{t}_R - H_2^0$ couplings) = (T_{U23} T_{U32}, T_{U33}) are large!

$\tilde{u}_{1,2} - \tilde{u}_{1,2} - h^0$ couplings are large!

Chargino loop contributions can be large!

Deviation of $\Gamma(h^0 \rightarrow b\,\bar{b}/\bar{s})$ from SM width can be large!

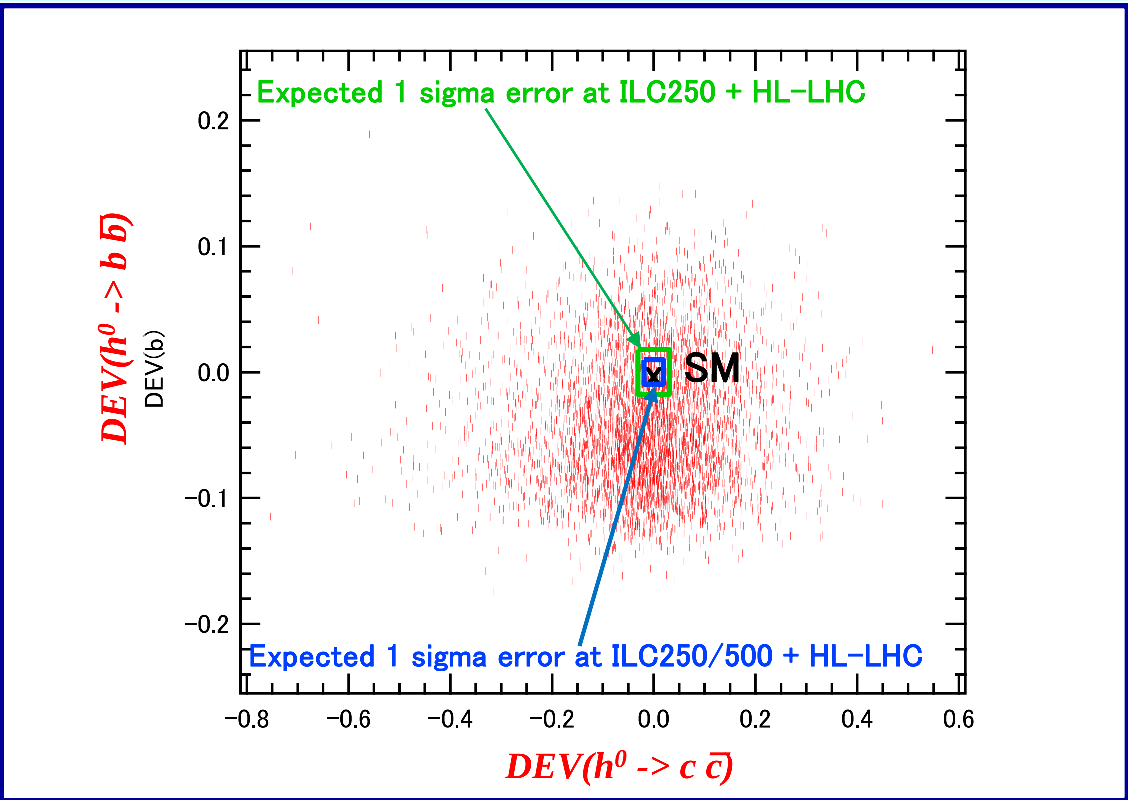
5.1 Deviation of the width from the SM prediction

- The deviation of the width from the SM prediction:

$$DEV(h^0 \to X\bar{X}) = \Gamma(h^0 \to X\bar{X})_{MSSM} / \Gamma(h^0 \to X\bar{X})_{SM} - 1$$

$X = c, b$

Scatter plot in DEV($h^0 \to c\bar{c}$) - DEV($h^0 \to b\bar{b}$) plane



- DEV($h^0 \to c\bar{c}$) and DEV($h^0 \to b\bar{b}$) can be very large simultaneously!:
  DEV($h^0 \to c\bar{c}$) can be as large as ~ ±60%.
  DEV($h^0 \to b\bar{b}$) can be as large as ~ ±20%.

- ILC can observe such large deviations from SM at high significance (arXiv:1908.11299)!:
  Δ DEV($h^0 \to c\bar{c}$) = (3.60%, 2.40%, 1.58%) at (ILC250, ILC500, ILC1000)
  Δ DEV($h^0 \to b\bar{b}$) = (1.98%, 1.16%, 0.94%) at (ILC250, ILC500, ILC1000)

5.2 $BR(h^0 \to b\bar{s} / s\bar{b})$

$BR(h^0 \to b\bar{s} / s\bar{b}) \cong$ **0 (SM)**

$BR(h^0 \to b\bar{s} / s\bar{b})$ can be as large as **~ 0.17% (MSSM with QFV)!**

(See also Gomez-Heinemeyer-Rehman, PR D93 (2016) 095021 [arXiv:1511.04342].)

ILC(250+500+1000) sensitivity could be **~ 0.1% (at 4 σ significance)!**

(Private communication with J. Tian;
see also Barducci et al., JHEP 12 (2017) 105 [arXiv:1710.06657])

6. $h^0 \rightarrow \gamma\gamma, g\,g$ in the MSSM

- *For the h decays to photon photon and gluon gluon we compute the widths at NLO QCD level. We perform a MSSM parameter scan respecting theoretical and experimental constraints.*

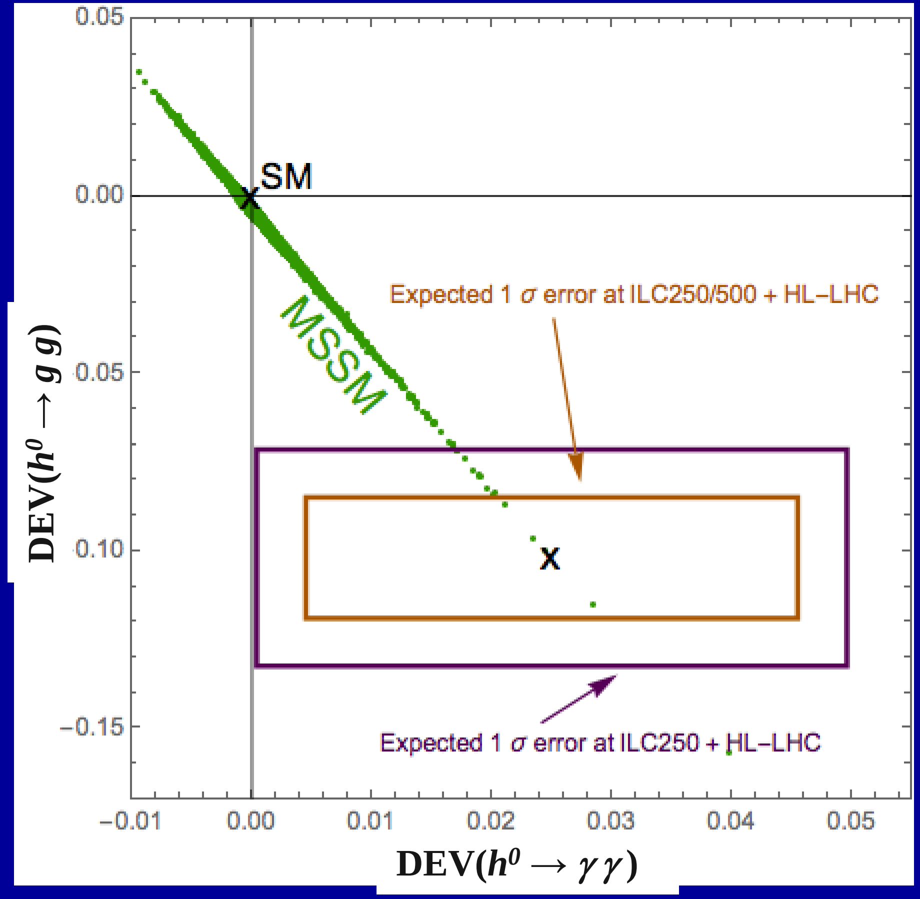
- *From the parameter scan, we find the followings:*

(1) DEV($h^0 \rightarrow \gamma\gamma$) and DEV($h^0 \rightarrow g\,g$) can be sizable simultaneously:
DEV($h^0 \rightarrow \gamma\gamma$) can be as large as ~ + 4%,
DEV($h^0 \rightarrow g\,g$) can be as large as ~ -15%.

(2) There is a very strong correlation between DEV($h^0 \rightarrow \gamma\gamma$) and DEV($h^0 \rightarrow g\,g$). This correlation is due to the fact that the stop-loop (stop-scharm mixture loop) contributions dominate the two DEV's.

(3) The deviation of the width ratio $\Gamma(h^0 \rightarrow \gamma\gamma) / \Gamma(h^0 \rightarrow g\,g)$ in the MSSM from the SM value can be as large as ~ +20%.

Scatter plot in DEV($h^0 \to \gamma\gamma$) - DEV($h^0 \to g\,g$) *plane*



- ***DEV($h^0 \to \gamma\gamma$) and DEV($h^0 \to g\,g$) can be sizable simultaneously!***

- ***There is a strong correlation between DEV($h^0 \to \gamma\gamma$) and DEV($h^0 \to g\,g$)!***

- ***This correlation is due to the fact that the stop-loop (stop-scharm mixture loop) contributions dominate the two DEV's .***

7. Conclusion

- *We have studied the decays*

  h^0 (125GeV) $\rightarrow$ $c\,\bar{c}$, $b\,\bar{b}$, $b\,\bar{s}$, $\gamma\gamma$, $g\,g$ *in the MSSM with QFV*.

- *Performing a parameter scan respecting theoretical and experimental constraints ,*
  we have found the followings:

  * DEV(h^0 -> $c\,\bar{c}$) and DEV(h^0 -> $b\,\bar{b}$) can be very large simultaneously! :
    DEV(h^0 -> $c\,\bar{c}$) can be as large as ~ ± 60%,
    DEV(h^0 -> $b\,\bar{b}$) can be as large as ~ ± 20%.

  * The deviation of the width ratio Γ(h^0 -> $b\,\bar{b}$) / Γ(h^0 -> $c\,\bar{c}$)
    from the SM value can be as large as ~ +200%.

  * BR(h^0 -> $b\,\bar{s}$ / $s\,\bar{b}$) can be as large as ~ 0.17%!
    ILC(250 + 500 + 1000) sensitivity could be ~ 0.1% at 4 sigma signal significance!

* DEV(h^0 -> $\gamma\gamma$) and DEV(h^0 -> g g) can be sizable simultaneously! :

DEV(h^0 -> $\gamma\gamma$) can be as large as ~ +4%,

DEV(h^0 -> g g) can be as large as ~ -15%.

* The deviation of the width ratio Γ(h^0 -> $\gamma\gamma$)/ Γ(h^0 -> g g) from the SM value can be as large as ~ +20%.

* There is a very strong correlation between DEV(h^0 -> $\gamma\gamma$) and DEV(h^0 -> g g). This correlation is due to the fact that the stop-loop (stop-scharm mixture loop) contributions dominate the two DEV's.

- All of these large deviations in the h^0 (125GeV) decays are due to large $\tilde{c}$ - $\tilde{t}$ mixing & large $\tilde{c}$ / $\tilde{t}$ involved trilinear couplings T_{U32}, T_{U23}, T_{U33} and large $\tilde{s}$ - $\tilde{b}$ mixing & large $\tilde{s}$ / $\tilde{b}$ involved trilinear couplings T_{D32}, T_{D23}, T_{D33}.

- ILC can observe such large deviations from SM at high significance!

- In case the deviation pattern shown here is really observed at ILC, then it would strongly suggest the discovery of QFV SUSY (MSSM with QFV)!

- See next slide also.

- *Our analysis suggests the following:*

PETRA/TRISTAN e- e+ collider discovered virtual Z^0 effect for the first time.

Later, CERN p $\bar{p}$ collider discovered the Z^0 boson.

Similarly, ILC could discover virtual Sparticle effects for the first time in h^0(125GeV) decays!

Later, FCC-hh p p colliders could discover the Sparticles!

END

Thank you!

Backup Slides

2. MSSM with QFV

The basic parameters of the MSSM with QFV:

$\{\tan\beta, m_A, M_1, M_2, M_3, \mu, M^2_{Q,\alpha\beta}, M^2_{U,\alpha\beta}, M^2_{D,\alpha\beta}, T_{U\alpha\beta}, T_{D\alpha\beta}\}$

(at $Q = 1$ TeV scale) ($\alpha,\beta = 1,2,3 =$ u, c, t or d, s, b)

$\tan\beta$: ratio of VEV of the two Higgs doublets $\langle H^0{}_2\rangle/\langle H^0{}_1\rangle$

m_A: CP odd Higgs boson mass (pole mass)

M_1, M_2, M_3: U(1), SU(2), SU(3) gaugino masses

μ: higgsino mass parameter

$M^2_{Q,\alpha\beta}$: left squark soft mass matrix

$M^2_{U\alpha\beta}$: right up-type squark soft mass matrix

$M^2_{D\alpha\beta}$: right down-type squark soft mass matrix

$T_{U\alpha\beta}$: trilinear coupling matrix of up-type squark and Higgs boson

$T_{D\alpha\beta}$: trilinear coupling matrix of down-type squark and Higgs boson

Key parameters in this study are:

* *QFV parameters:* M^2_{Q23}, M^2_{U23}, M^2_{D23}, T_{U23}, T_{U32}, T_{D23}, T_{D32}

* *QFC parameter:* T_{U33}, T_{D33}

M^2_{Q23} = ($\tilde{c}_L - \tilde{t}_L$ mixing parameter)

M^2_{U23} = ($\tilde{c}_R - \tilde{t}_R$ mixing parameter)

M^2_{D23} = ($\tilde{s}_R - \tilde{b}_R$ mixing parameter)

T_{U23} = ($\tilde{c}_R - \tilde{t}_L$ mixing parameter)

T_{U32} = ($\tilde{c}_L - \tilde{t}_R$ mixing parameter)

T_{U33} = ($\tilde{t}_L - \tilde{t}_R$ mixing parameter)

T_{D23} = ($\tilde{s}_R - \tilde{b}_L$ mixing parameter)

T_{D32} = ($\tilde{s}_L - \tilde{b}_R$ mixing parameter)

T_{D33} = ($\tilde{b}_L - \tilde{b}_R$ mixing parameter)

4. Parameter scan for $h^0 \to c\bar{c}, b\bar{b}, b\bar{s}$ in the MSSM

- We compute the decay widths $\Gamma(h^0 \to c\bar{c})$, $\Gamma(h^0 \to b\bar{b})$, and $\Gamma(h^0 \to b\bar{s})$ at full 1-loop level in the MSSM with QFV.

- Parameter points are generated by using random numbers in the following ranges (in units of GeV or GeV^2):

$1\ \text{TeV} < M_{SUSY} < 5\ \text{TeV}$

$10 < \tan\beta < 60$

2500 < M_3 < 5000

100 < M_2 < 2500

100 < M_1 < 2500

(without assuming the GUT relation for M_1, M_2, M_3)

100 < mu < 2500

800 < m_A(pole) < 6000;

MQ2_11 = 4500^2 (fixed)

2500^2 < MQ2_22 < 4000^2

2500^2 < MQ2_33 < 4000^2

|MQ2_23| < 1000.^2 <=== QFV param.

MU2_11 = 4500^2 (fixed)

1000.^2 < MU2_22 < 4000.^2

600.^2 < MU2_33 < 3000.^2

|MU2_23| < 1500.^2 <=== QFV param.

MD2_11 = 4500^2 (fixed)

2500.^2 < MD2_22 < 4000.^2

1000.^2 < MD2_33 < 3000.^2

|MD2_23| < 2000.^2

ML2_11 = 1500^2 (fixed)

ML2_22 = 1500^2 (fixed)

ML2_33 = 1500^2 (fixed)

ML2_23 = 0. (fixed)

ME2_11 = 1500^2 (fixed)

ME2_22 = 1500^2 (fixed)

ME2_33 = 1500^2 (fixed)

ME2_23 = 0. (fixed)

|TU_23| < 4000 <=== QFV param

|TU_32| < 4000 <=== QFV param

|TU_33| < 5000 <=== QFC param

|TD_23| < 2000 <=== QFV param

|TD_32| < 2000 <=== QFV param

|TD_33| < 3000 <=== QFC param

TE_23 = 0. (fixed)

TE_32 = 0. (fixed)

|TE_33| < 500

- *In the parameter scan, all of the relevant experimental and theoretical constraints are imposed.*

- *101000 parameter points are generated and 2993 points survive the constraints.*

Main one-loop contributions with SUSY particles

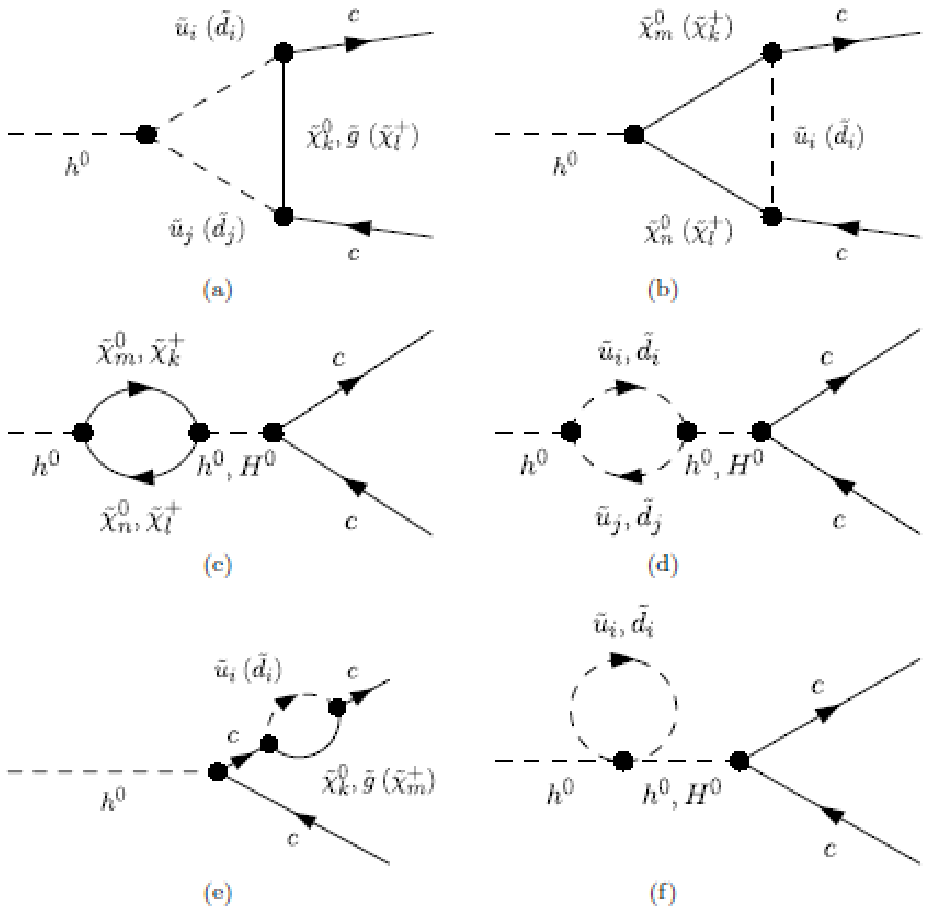
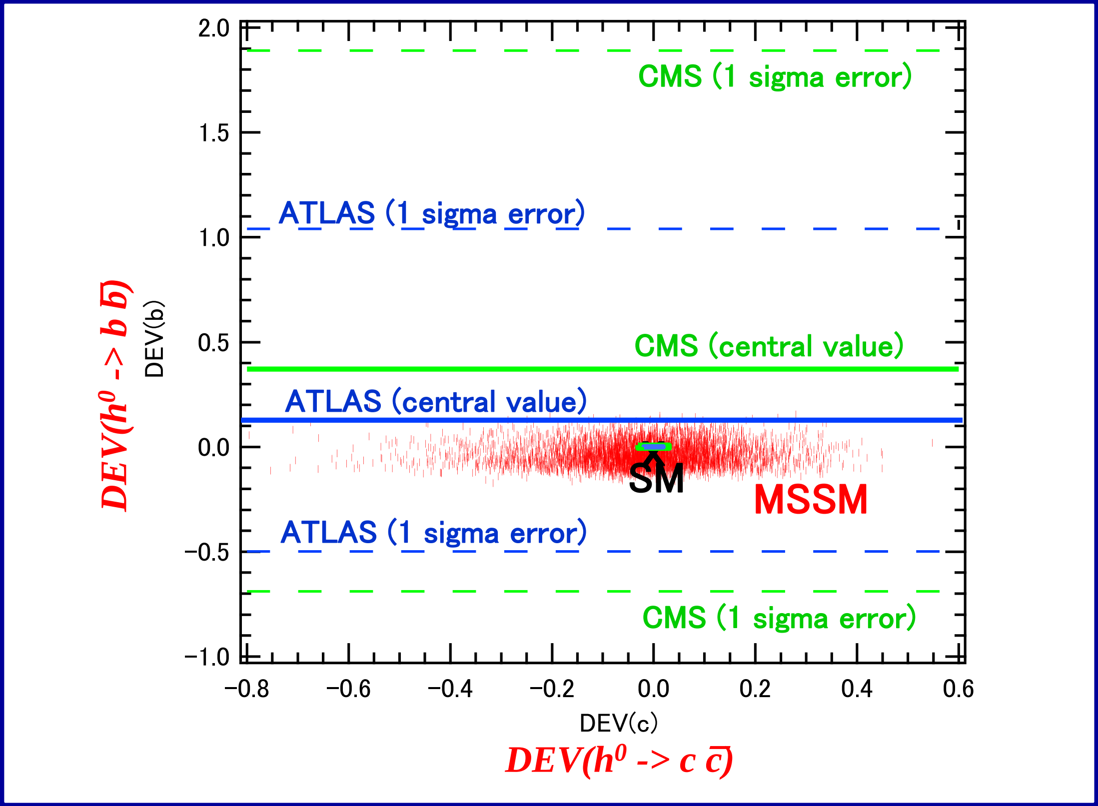


Figure 2: The main one-loop contributions with SUSY particles in $h^0 \to c\bar{c}$. The corresponding diagram to (e) with the self-energy contribution to the other charm quark is not shown explicitly.

Scatter plot in DEV(h^0 -> c $\bar{c}$) - DEV(h^0 -> b $\bar{b}$) plane

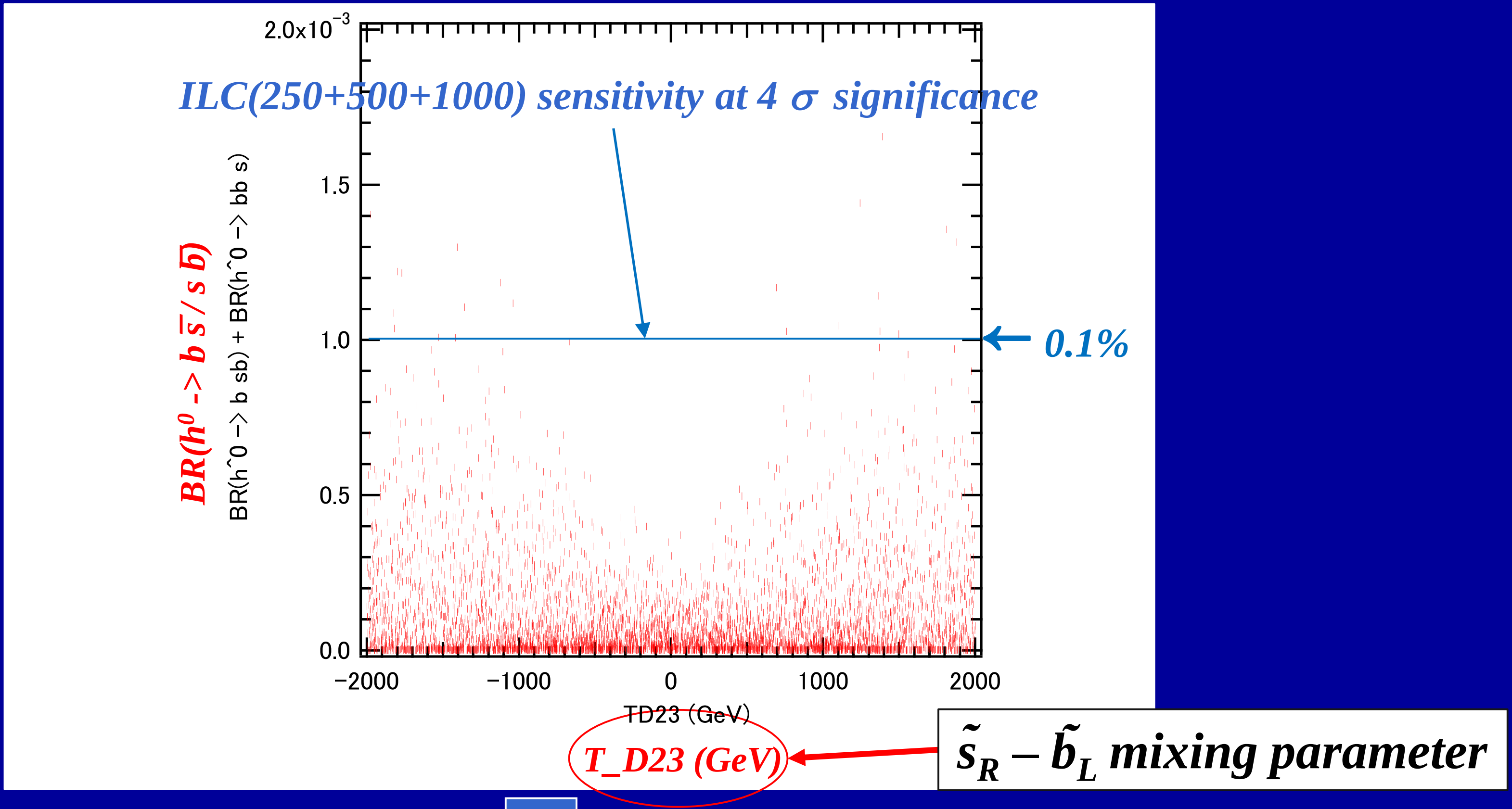


- ***Recent LHC data:***

  DEV(h^0 -> b $\bar{b}$) = 0.12 +0.92/-0.62 = [-0.50, 1.04] (ATLA S) (ATLAS-CONF-2019-005)
  DEV(h^0 -> b $\bar{b}$) = 0.37 +1.52/-1.06 = [-0.69, 1.89] (CMS) (arXiv:1809.10733)

- ***Both SM and MSSM are consistent with the recent ATLAS/CMS data!***
  The errors of the recent ATLAS/CMS data are too large!

Scatter plot in T_{D23} - $BR(h^0 \to b\bar{s} / s\bar{b})$ plane



- There is a strong correlation between T_{D23} - $BR(h^0 \to b\bar{s} / s\bar{b})$!
- $BR(h^0 \to b\bar{s} / s\bar{b})$ can be as large as 0.17% for large T_{D23} !
- ILC(250 + 500 + 1000) sensitivity could be ~ 0.1% at 4 sigma significance!
  (private communication with J. Tian;
  see also Barducci et al., JHEP 12 (2017) 105 [arXiv:1710.06657])
- LHC &HL-LHC sensitivity should not be so good due to huge QCD BG!

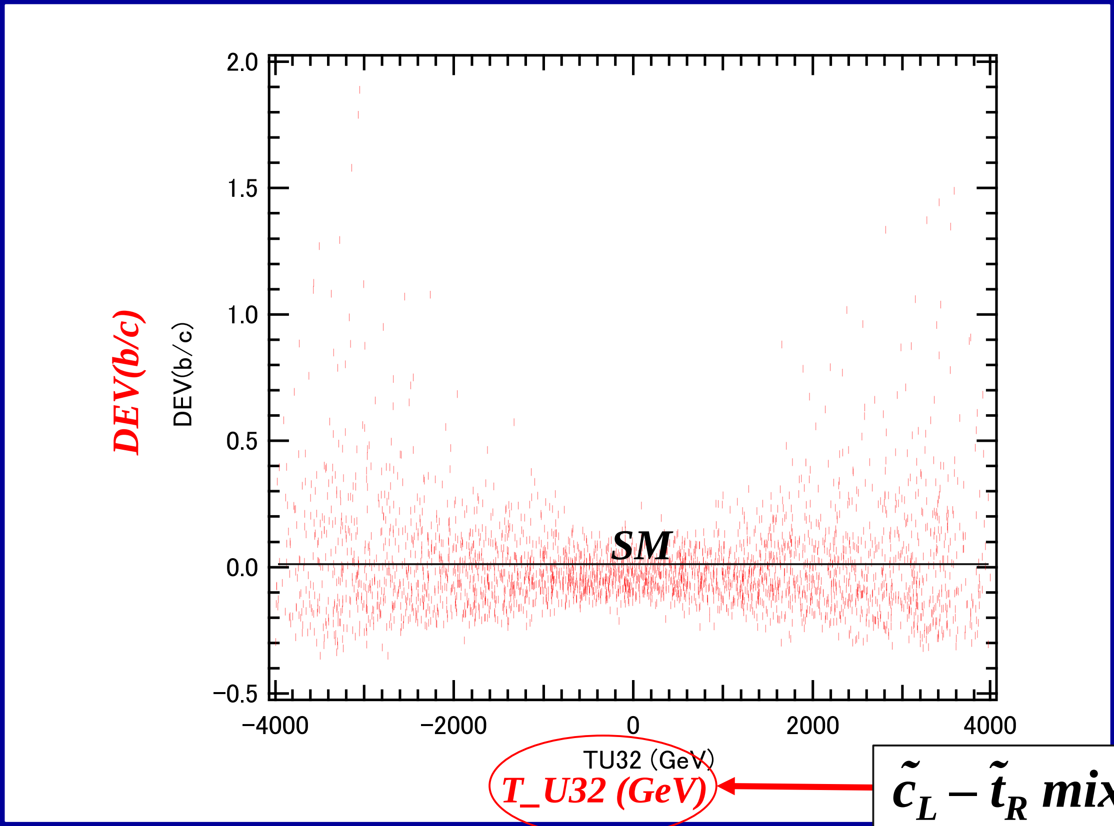
5.2 Deviation of width ratio from the SM prediction

- The deviation of the width ratio from the SM prediction:

$$DEV(b/c) = [\Gamma(b) / \Gamma(c)]_{MSSM} \; / \; [\Gamma(b) / \Gamma(c)]_{SM} \; - \; 1$$

$$\Gamma(X) = \Gamma(h^0 \to X \bar{X})$$

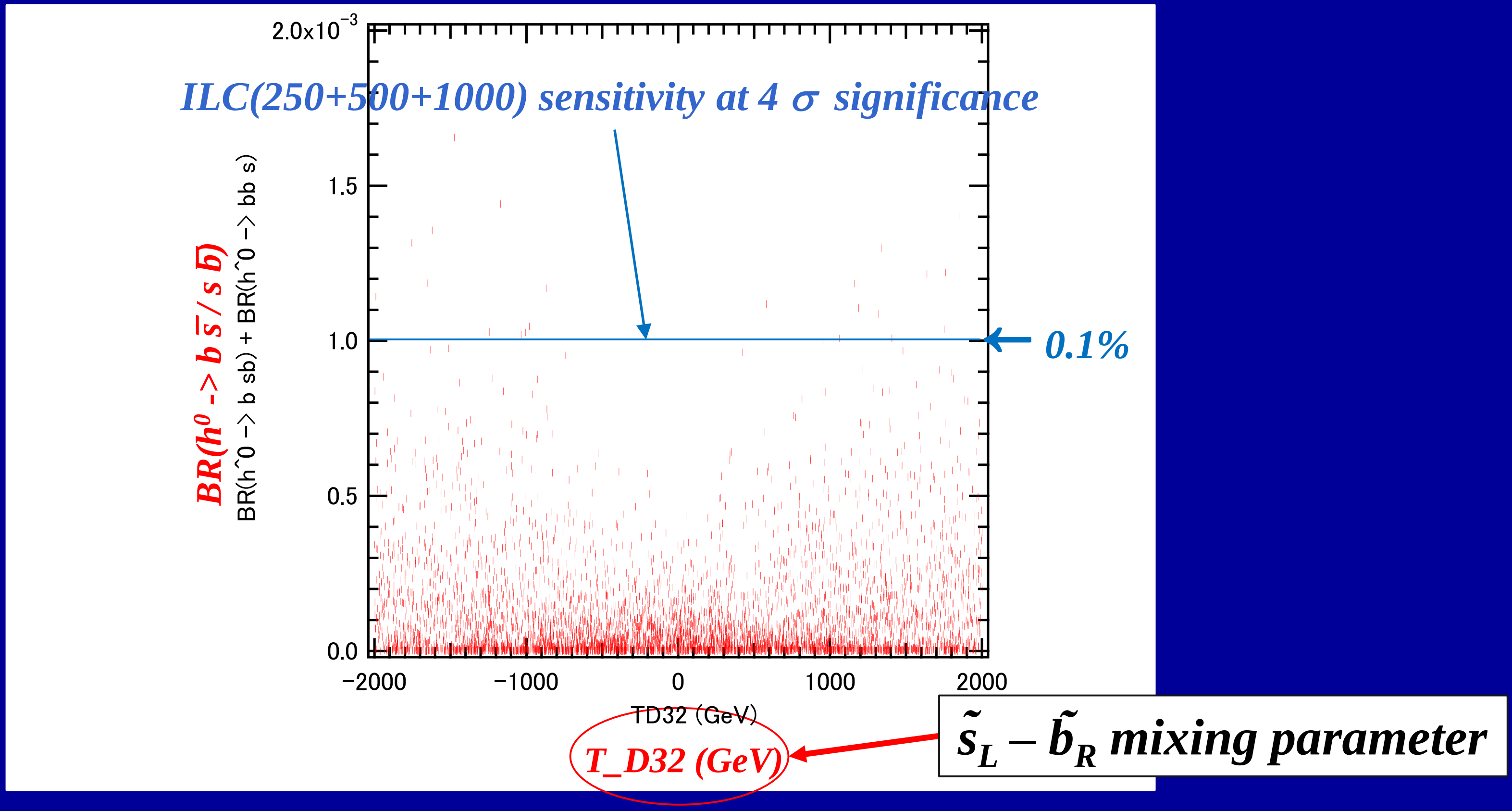
Scatter plot in $T_{U32} - DEV(b/c)$ plane



$\tilde{c}_L - \tilde{t}_R$ *mixing parameter*

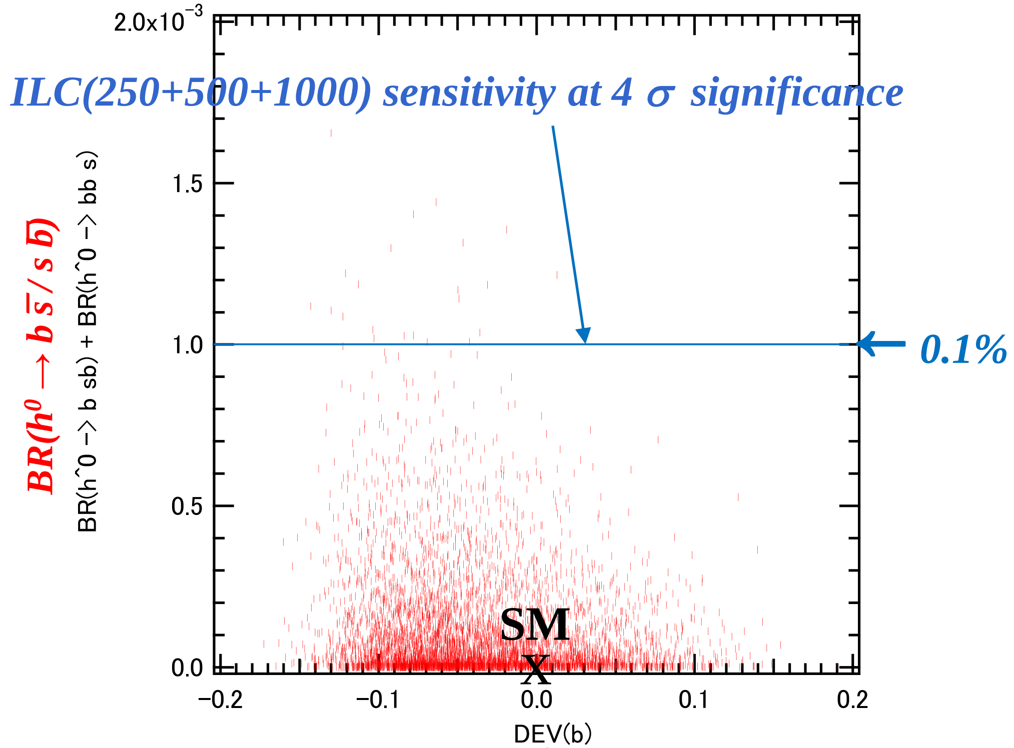
-There is a strong correlation between $T_{U32} - DEV(b/c)$!
- DEV(b/c) can be as large as ~ +200% for large T_{U32} !

Scatter plot in T_{D32} - $BR(h^0 \to b\bar{s}/s\bar{b})$ plane



- There is also a strong correlation between T_{D32} - $BR(h^0 \to b\bar{s}/s\bar{b})$!
- $BR(h^0 \to b\bar{s}/s\bar{b})$ can be as large as 0.17% for large T_{D32} !

Scatter plot in $BR(h^0 \to b\bar{s}/s\bar{b})$ - $DEV(h^0 \to b\bar{b})$ plane



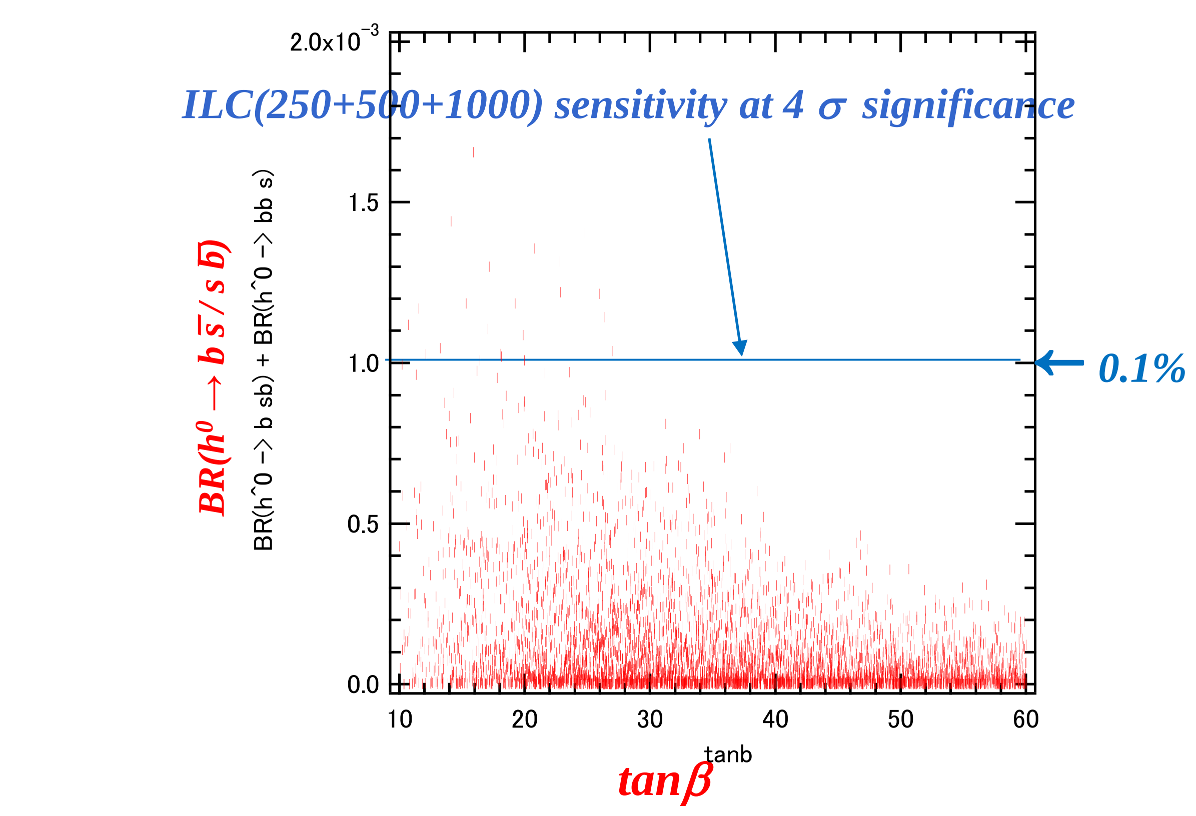
$BR(h^0 \to b\bar{s}/s\bar{b})$

$DEV(h^0 \to b\bar{b})$

- *There is a strong correlation between $DEV(h^0 \to b\bar{b})$ & $BR(h^0 \to b\bar{s}/s\bar{b})$!*

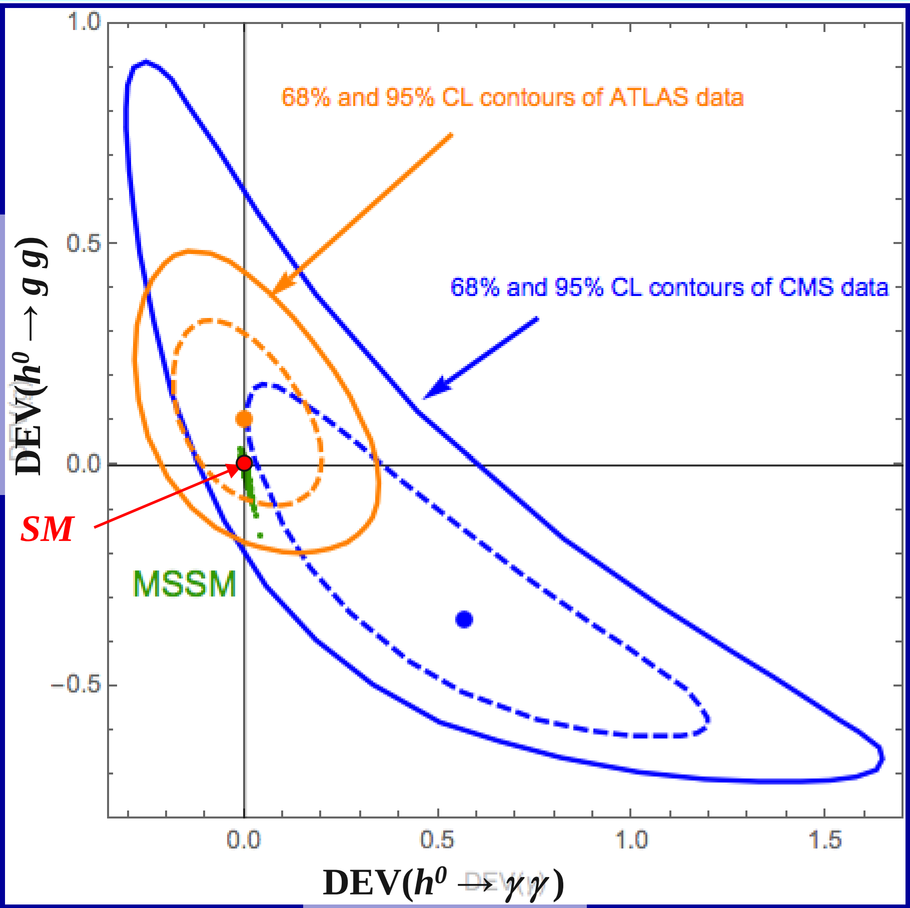
- *This is due to the fact that $DEV(h^0 \to b\bar{b})$ & $BR(h^0 \to b\bar{s}/s\bar{b})$ have a common origin of enhancement effect, i.e. large trilinear couplings $T_{D23,32,33}$ & $T_{U23,32,33}$.*

Scatter plot in $BR(h^0 \to b\bar{s}/s\bar{b})$ - $\tan\beta$ plane



- *There is a strong correlation between $BR(h^0 \to b\bar{s}/s\bar{b})$ & $\tan\beta$!*
- *$BR(h^0 \to b\bar{s}/s\bar{b})$ can be as large as 0.17% for $\tan\beta \sim 20$!*

Scatter plot in DEV($h^0 \to \gamma\gamma$) - DEV($h^0 \to g\,g$) *plane*

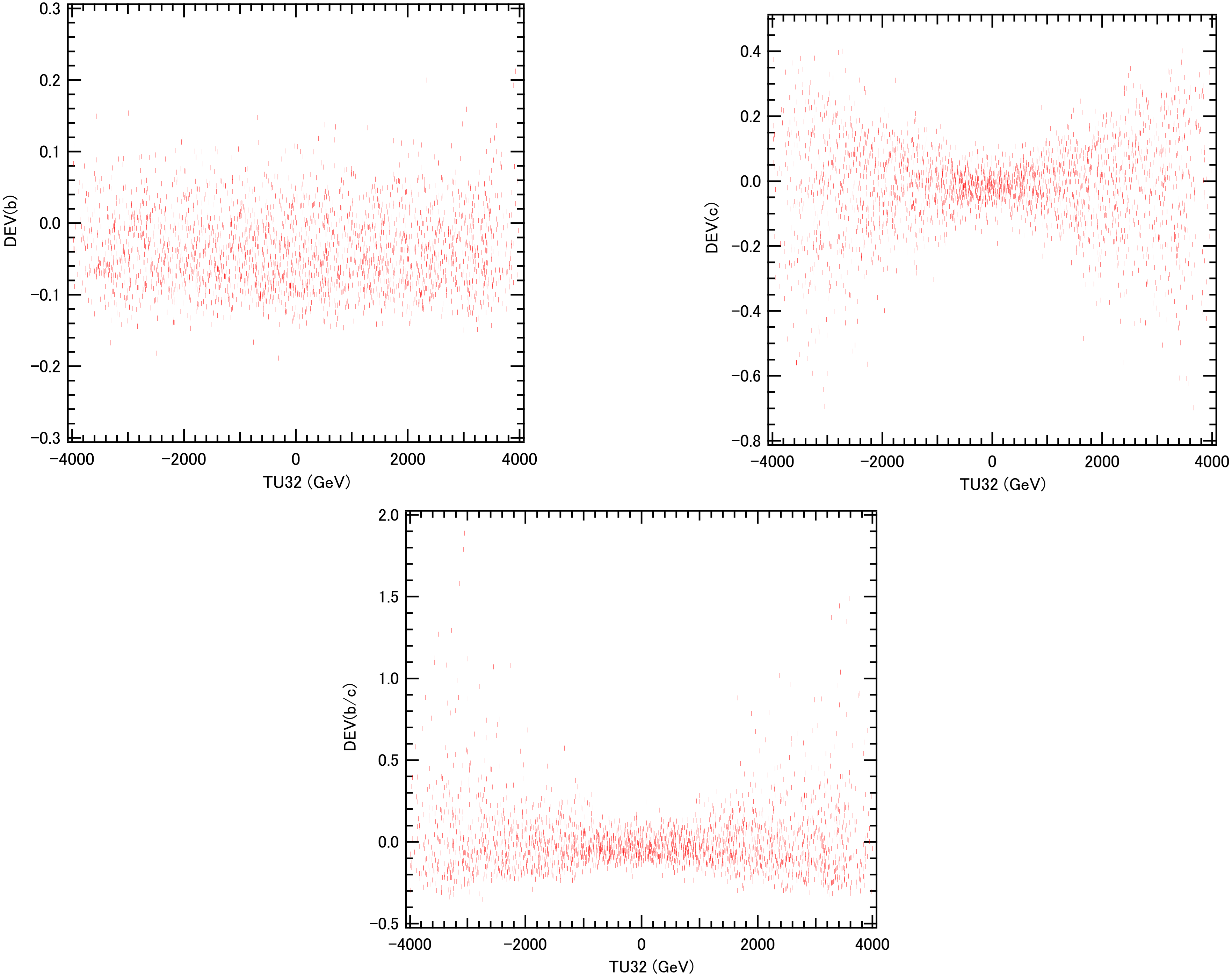


- *Both SM and MSSM are consistent with the recent ATLAS/CMS data!:*

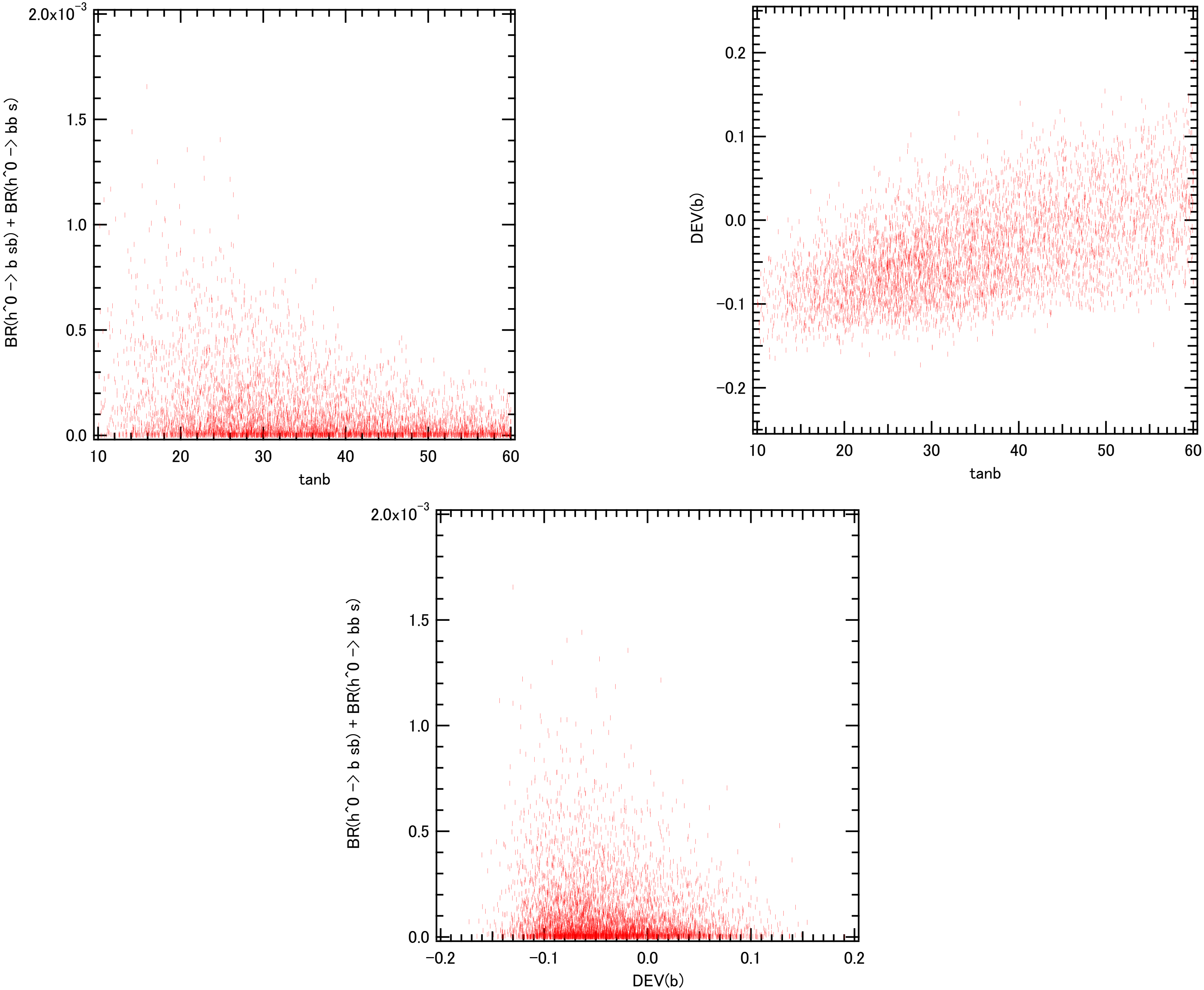
  ATLAS: ATLAS-CONF-2018-031 (ICHEP2018)

  CMS: arXiv:1804.02716 (Submitted to JHEP)

- *The errors of the recent ATLAS/CMS data are too large!*



DEV(b)
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−4000
−2000
0
2000
4000
TU32 (GeV)
DEV(c)
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−4000
−2000
0
2000
4000
TU32 (GeV)
DEV(b/c)
2.0
1.5
1.0
0.5
0.0
−0.5
−4000
−2000
0
2000
4000
TU32 (GeV)



2.0x10^-3
1.5
1.0
0.5
0.0
BR(h^0 -> b sb) + BR(h^0 -> bb s)
10
20
30
40
50
60
tanb
0.2
0.1
0.0
−0.1
−0.2
DEV(b)
10
20
30
40
50
60
tanb
2.0x10^-3
1.5
1.0
0.5
0.0
BR(h^0 -> b sb) + BR(h^0 -> bb s)
−0.2
−0.1
0.0
0.1
0.2
DEV(b)

Constraints on the MSSM parameters from K & B meson and h^0 data:

Table 4: Constraints on the MSSM parameters from the K- and B-meson data relevant mainly for the mixing between the second and the third generations of squarks and from the data on the h^0 mass and coupling κ_b. The fourth column shows constraints at 95% CL obtained by combining the experimental error quadratically with the theoretical uncertainty, except for $B(K_L^0 \to \pi^0 \nu \bar{\nu})$, m_{h^0} and κ_b.

Observable	Exp. data	Theor. uncertainty	Constr. (95%CL)
$10^3 \times \lvert\epsilon_K\rvert$	2.228 ± 0.011 (68% CL) [28]	± 0.28 (68% CL) [29]	2.228 ± 0.549
$10^{15} \times \Delta M_K$ [GeV]	3.484 ± 0.006 (68% CL) [28]	± 1.2 (68% CL) [29]	3.484 ± 2.352
$10^9 \times \mathrm{B}(K_L^0 \to \pi^0 \nu \bar{\nu})$	< 3.0 (90% CL) [28]	± 0.002 (68% CL) [28]	< 3.0 (90% CL)
$10^{10} \times \mathrm{B}(K^+ \to \pi^+ \nu \bar{\nu})$	1.7 ± 1.1 (68% CL) [28]	± 0.04 (68% CL) [28]	$1.7^{+2.16}_{-1.70}$
ΔM_{B_s} [ps^{-1}]	17.757 ± 0.021 (68% CL) [30]	± 2.7 (68% CL) [31]	17.757 ± 5.29
$10^4 \times \mathrm{B}(b \to s \gamma)$	3.49 ± 0.19 (68% CL) [14,30]	± 0.23 (68% CL) [32]	3.49 ± 0.58
$10^6 \times \mathrm{B}(b \to s\, l^+ l^-)$ ($l = e$ or μ)	$1.60\ ^{+0.48}_{-0.45}$ (68% CL) [33]	± 0.11 (68% CL) [34]	$1.60\ ^{+0.97}_{-0.91}$
$10^9 \times \mathrm{B}(B_s \to \mu^+ \mu^-)$	$2.8\ ^{+0.7}_{-0.6}$ (68%CL) [35]	± 0.23 (68% CL) [36]	$2.80\ ^{+1.44}_{-1.26}$
$10^4 \times \mathrm{B}(B^+ \to \tau^+ \nu)$	1.14 ± 0.27 (68%CL) [37,38]	± 0.29 (68% CL) [39]	1.14 ± 0.78
m_{h^0} [GeV]	125.09 ± 0.24 (68% CL) [40]	± 3 [41]	125.09 ± 3.48
κ_b	$1.06^{+0.37}_{-0.35}$ (95% CL) [42] $1.17^{+0.53}_{-0.61}$ (95% CL) [43]		$1.06^{+0.37}_{-0.35}$ (ATLAS) $1.17^{+0.53}_{-0.61}$ (CMS)