Physics
OSAKA UNIVERSITY

$\bar{B} \rightarrow D^{(*)} \tau \bar{\nu}$

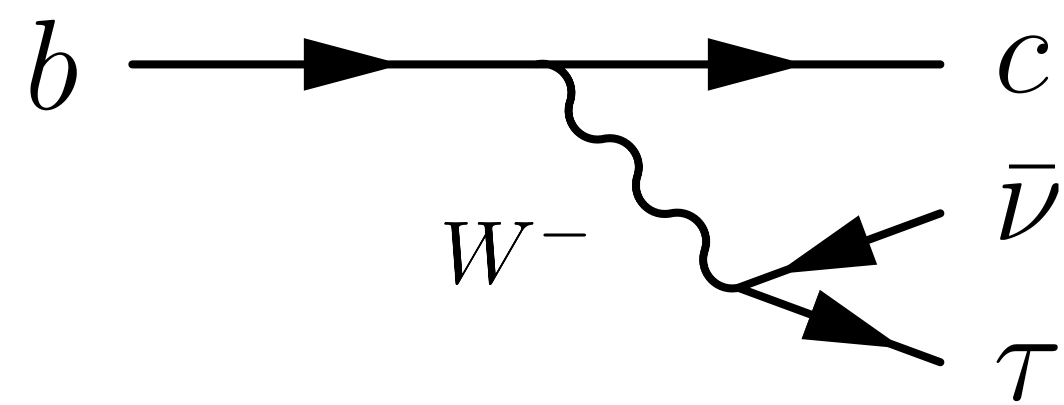
M. Tanaka (Osaka U)

B2TIP meeting, June 17, 2014

Introduction

Semitauonic B decays

$\bar{B} \to D^{(*)}\tau\bar{\nu}$



Experiments

BABAR 2012 arXiv: 1205.5442, PRL.109.101802(2012)

$$R(D) \equiv \frac{\mathcal{B}(\bar{B} \to D\tau\bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to D\ell\bar{\nu}_\ell)} = 0.440 \pm 0.058 \pm 0.042$$

$$R(D^*) \equiv \frac{\mathcal{B}(\bar{B} \to D^*\tau\bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to D^*\ell\bar{\nu}_\ell)} = 0.332 \pm 0.024 \pm 0.018$$

Belle 2007, 2009, 2010

Combined: $R(D) = 0.42 \pm 0.06$

$R(D^*) = 0.34 \pm 0.03$

Theory (SM)

$R(D) = 0.297 \pm 0.017$ (BABAR, Fajfer et al.)

0.302 ± 0.015 (MT, Watanabe)

$0.316 \pm 0.012 \pm 0.007$ (Bailey et al., lattice)

0.31 ± 0.02 (Becirevic et al.)

$R(D^*) = 0.252 \pm 0.003$ (BABAR, Fajfer et al.)

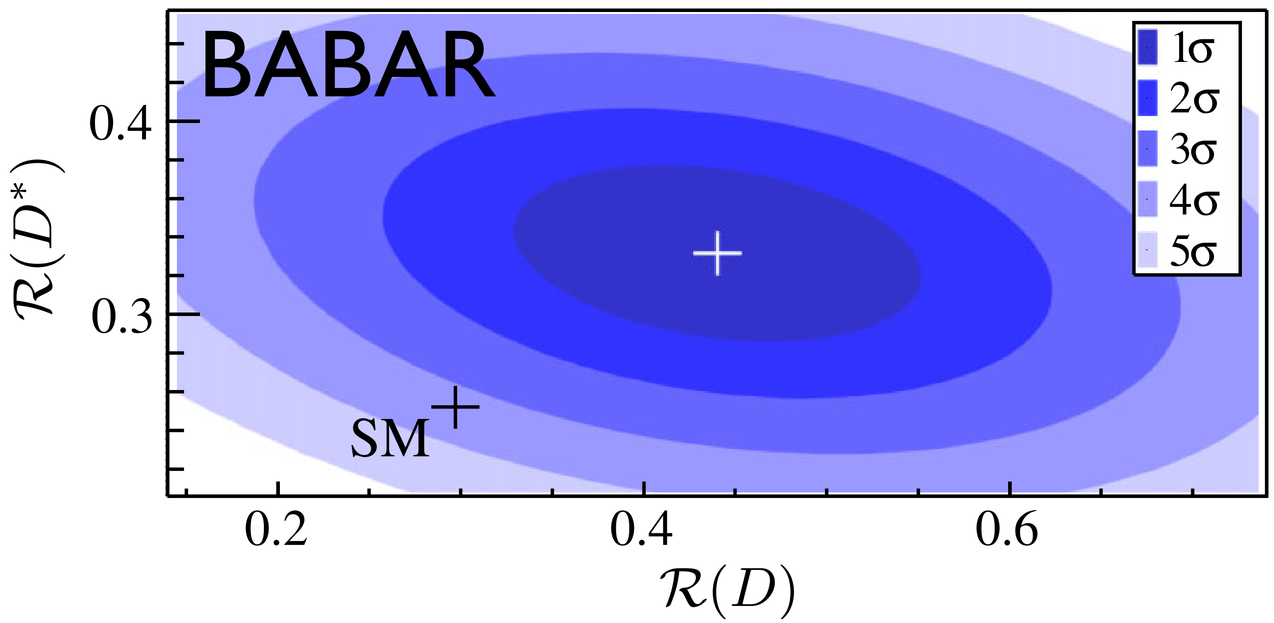
0.251 ± 0.004 (MT, Watanabe)

$R(D)$ 1.9σ

$R(D^*)$ 2.9σ

→ 3.5σ

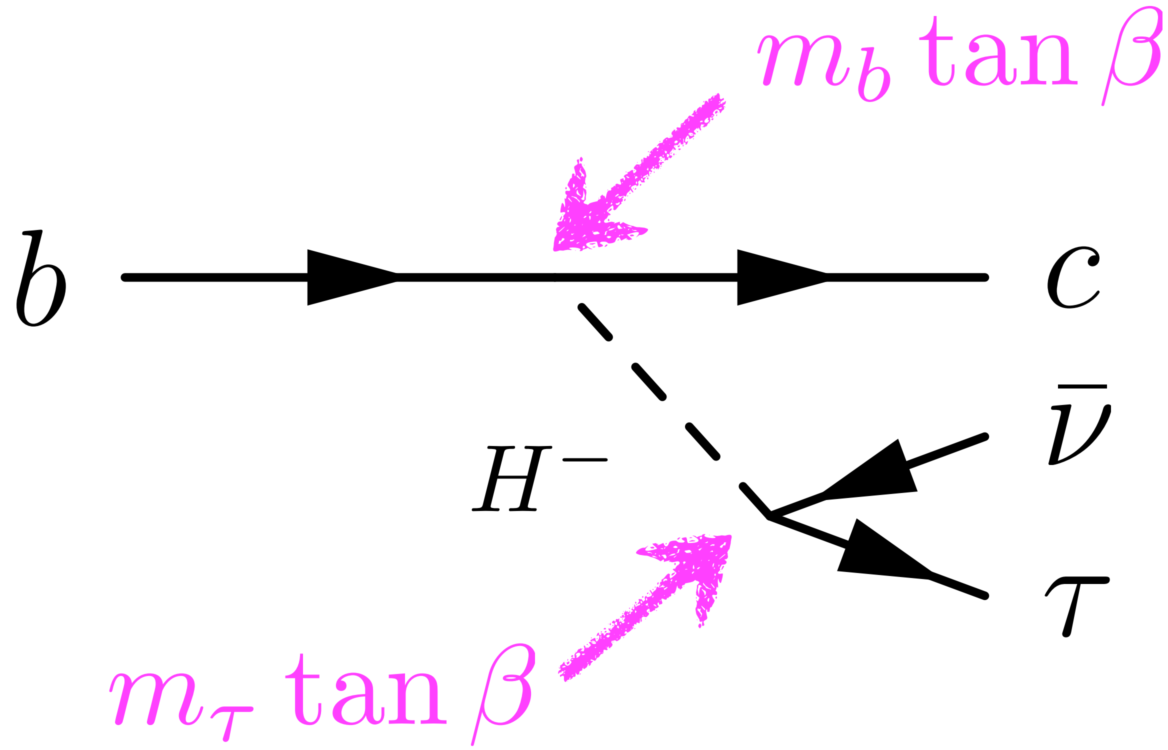
arXiv:1303.0571, PRD88.072012(2013)



Charged Higgs

W.S. Hou and B. Grzadkowski (1992), M.T. (1995), ...

Type-II 2HDM (SUSY)



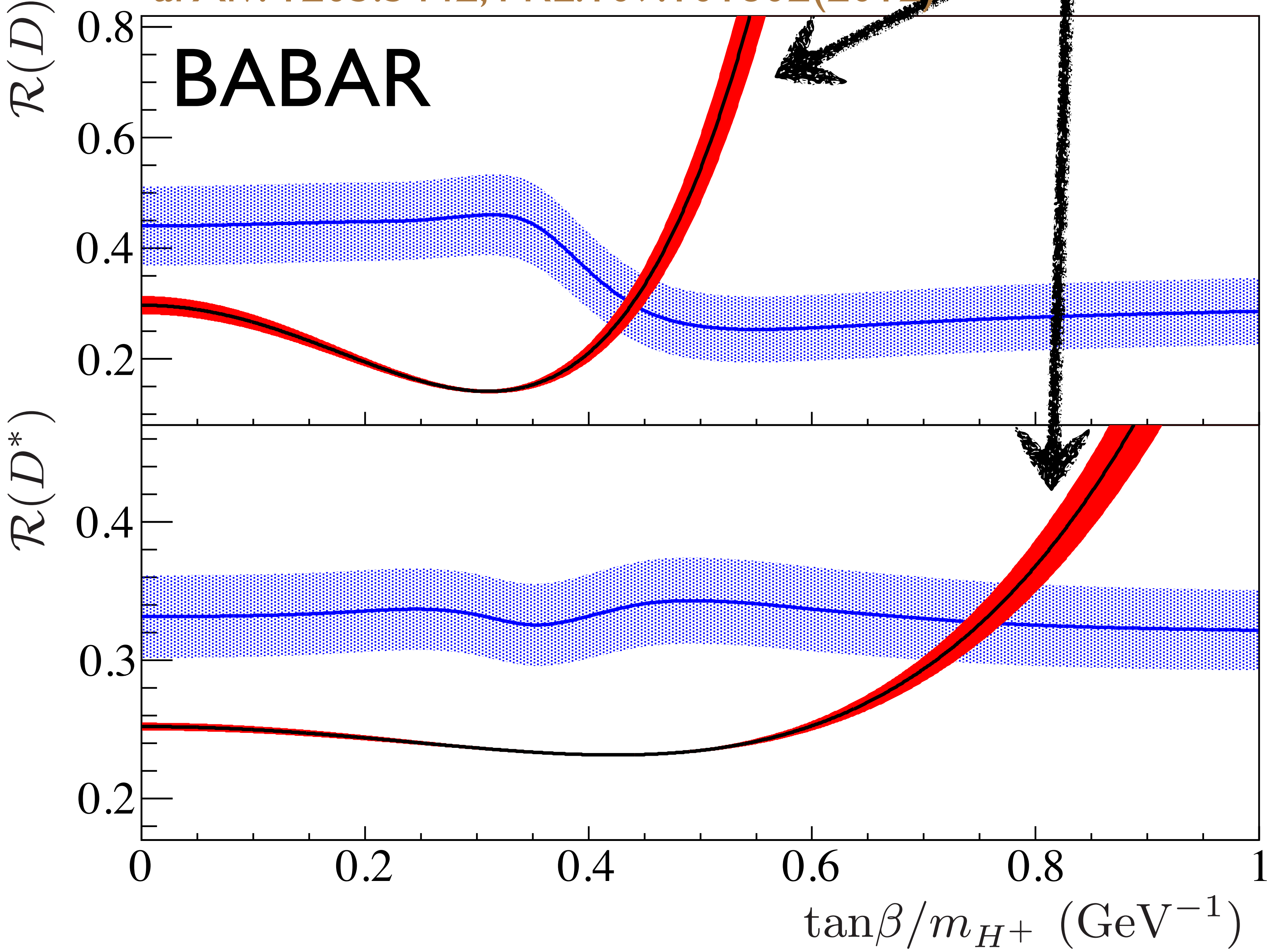
$\propto m_b m_\tau \tan^2\beta$

Sensitive to the charged Higgs if tanβ is large.

But, negative interference.

predictions of 2HDM II

arXiv: 1205.5442, PRL.109.101802(2012)



charged Higgs *excluded* at 99.8% CL

Model-independent approach

MT, R.Watanabe, arXiv:12121878,
PRD87.034028(2013).

Effective Lagrangian for $b \longrightarrow c\tau\bar{\nu}$

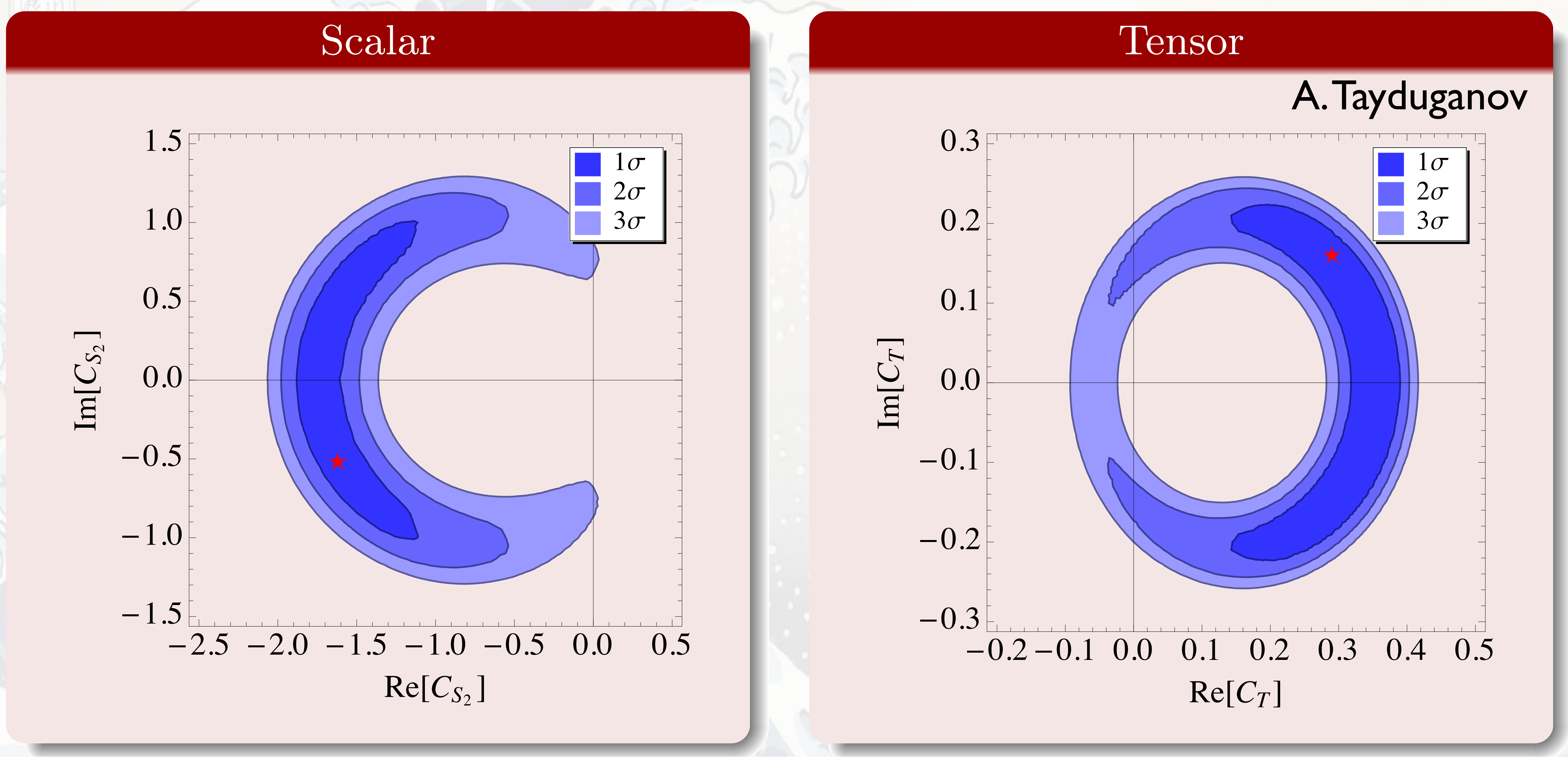
all possible 4f operators with LH neutrinos

$$-\mathcal{L}_{\rm eff} = 2\sqrt{2}G_F V_{cb} \sum_{l=e,\mu,\tau} \left[(\delta_{l\tau} + C^l_{V_1})\mathcal{O}^l_{V_1} + C^l_{V_2}\mathcal{O}^l_{V_2} + C^l_{S_1}\mathcal{O}^l_{S_1} + C^l_{S_2}\mathcal{O}^l_{S_2} + C^l_T\mathcal{O}^l_T \right]$$

SM

$\mathcal{O}^l_{V_1} = \bar{c}_L\gamma^\mu b_L\,\bar{\tau}_L\gamma_\mu\nu_{Ll}\,,$	V−A	SM-like
$\mathcal{O}^l_{V_2} = \bar{c}_R\gamma^\mu b_R\,\bar{\tau}_L\gamma_\mu\nu_{Ll}\,,$	V+A	RH current
$\mathcal{O}^l_{S_1} = \bar{c}_L b_R\,\bar{\tau}_R\nu_{Ll}\,,$	S+P	charged Higgs (II)
$\mathcal{O}^l_{S_2} = \bar{c}_R b_L\,\bar{\tau}_R\nu_{Ll}\,,$	S−P	charged Higgs
$\mathcal{O}^l_T = \bar{c}_R\sigma^{\mu\nu} b_L\,\bar{\tau}_R\sigma_{\mu\nu}\nu_{Ll}$	Tensor	GUT, LQ

Operators favored



$$\bar{c}_R b_L \bar{\tau}_R \nu_L$$

$$\bar{c}_R \sigma^{\mu\nu} b_L \bar{\tau}_R \sigma_{\mu\nu} \nu_L$$

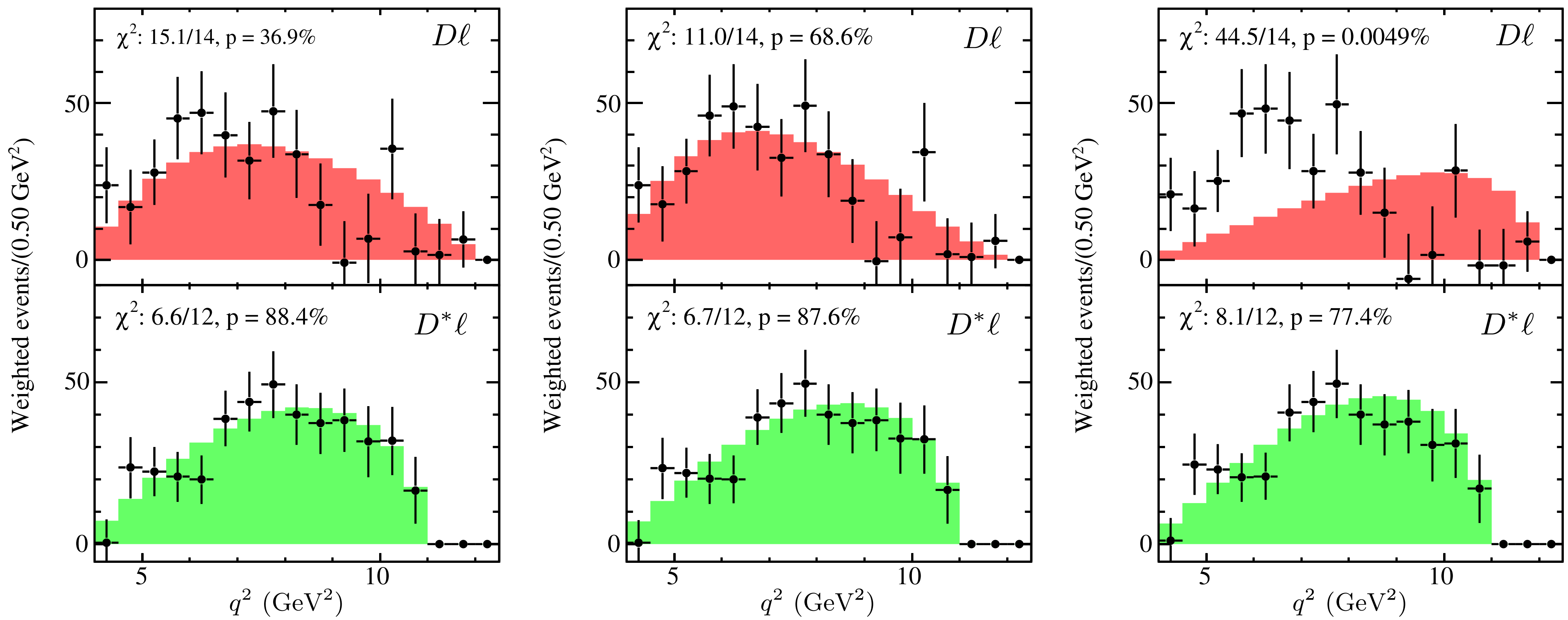
type III 2HDM, LQ

LQ

Y. Sakaki, MT, A. Tayduganov, R. Watanabe
arXiv:1309.0301, PRD88.094012(2013)

Lepton invariant mass (q2) distribution

arXiv:1303.0571, PRD88.072012(2013)



SM

$\bar{c}_L b_R \bar{\tau}_R \nu_L$

$\tan\beta/m_{H^\pm} = 0.30\ \mathrm{GeV}^{-1}$

$\bar{c}_L b_R \bar{\tau}_R \nu_L$

$0.45\ \mathrm{GeV}^{-1}$

What about other operators?

work in progress

Y. Sakaki, MT, A. Tayduganov, R. Watanabe

Talks at Moriond EW 2014 by A. Tayduganov, FPCP 2014 by R. Watanabe

Summary

Observables

$R(D^{(*)}),\ P_\tau(D^{(*)}),\ P_{D^*}$

q^2 dist., etc.

input →

← output

Effective Lagrangian

C_X^ℓ

constraint ↓ ↑ prediction

Models

2HDM's, MSSM,
RPV, LQ, etc.

Further study

- More data

  Belle update, LHCb

- Better use of distributions

  q2 dist.

- Expected accuracy at Belle II

- Hadronic form factors

  FFs of NP operators

- Combination with other processes

  $$B^- \to \tau\bar{\nu},\ B \to X\tau\bar{\tau},\ B \to X\nu\bar{\nu}$$