

Charming Penguins  
strike back again ?



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# Motivations for our Study

## Basic Fact:

FCNCs arise @ loop level in the Standard Model (SM)

(TeV) Beyond SM Physics (challenging) opportunity in FCNCs

0. Discrepancies between measurements & theory predictions showed up in the *last years* ... EXP *recently* confirmed!

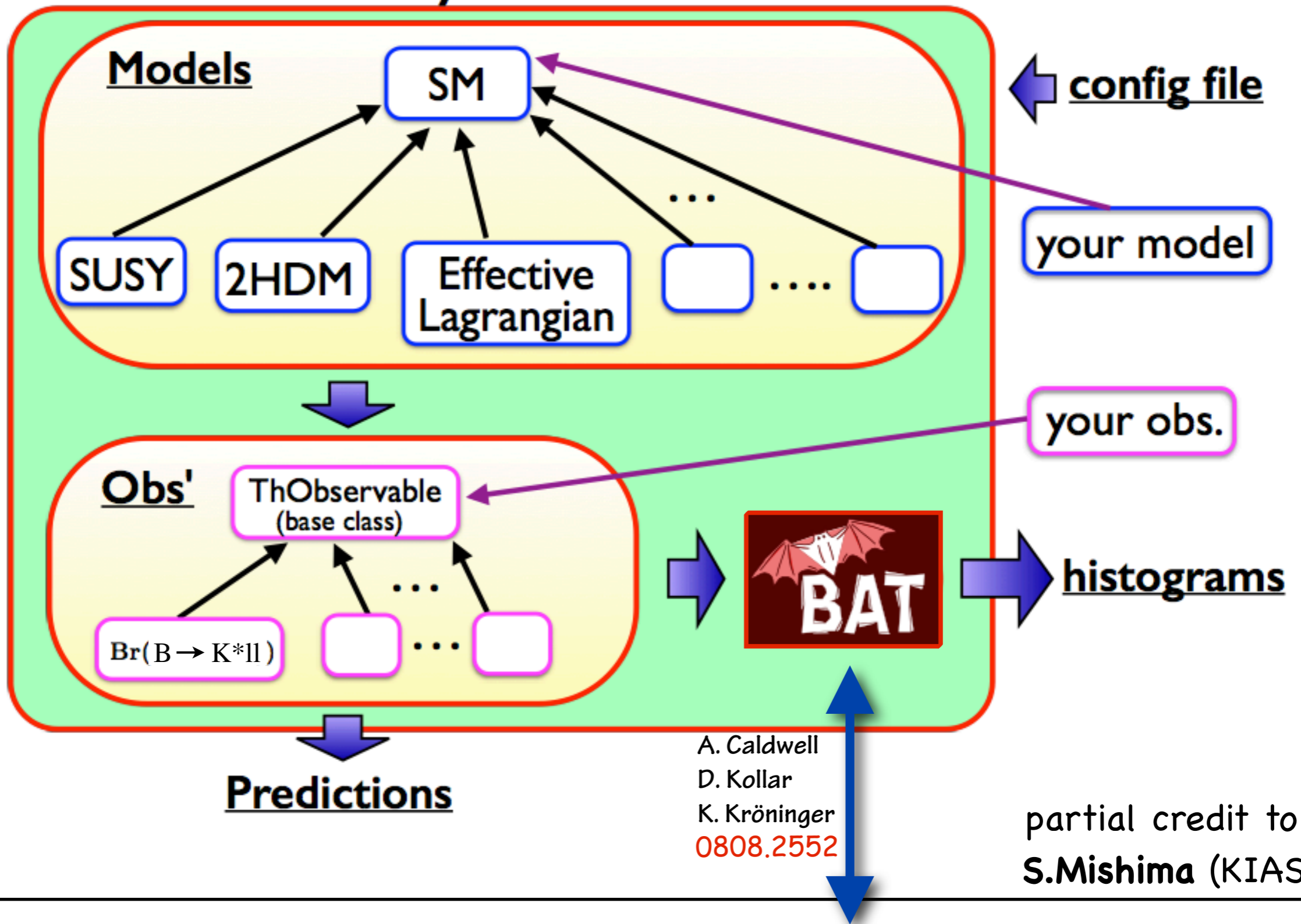
see e.g. 1503.03328, CERN-LHCb-CONF-2015-002  
1307.5683

→ no statistical fluke in  $P'_5$  ... is this New Physics (NP)?  
We need to have control of the SM prediction, first!

1. Departure from  $\infty$  mass limit vs "cleanness" of observables 2. Size of non-factorizable contribution to fit data

( 3. A very good reason to test the predictive power of **SusyFit!** a tool to combine indirect & direct searches for NP )

# SusyFit (more info @ <http://susyfitroma1.infn.it/doc/v0.2/>)



Full-fledged statistical data analysis **in this work** carried out by means of **Bayes Theorem**

$$P(\lambda|D) \propto P(D|\lambda) P_0(\lambda)$$

$\lambda$  posterior      likelihood       $\lambda$  prior

# Choices of Setup

1212.2263

- Work in the **Helicity Basis** as in **Jaeger & Camalich** hierarchies between amplitudes

experimental observables in the fit

Low  $q^2$  region

$F_L, A_{FB}, S_{3,\dots,9}, \text{B.R.}^{K^*\mu\mu}, \text{B.R.}^{K^*\gamma}$

- Form factors from **Ball & Zwicky** LCSR computation 0412079

in good agreement within errors

$$F \sim \frac{r}{1 - q^2/m^2}$$

- implemented correlation to respect exact relations from HQ/LE @  $q^2=0$
- Gaussian prior with  $\sigma = 10\%$  mean value for  $r$  parameters only

experimental observables in the fit

High  $q^2$  region

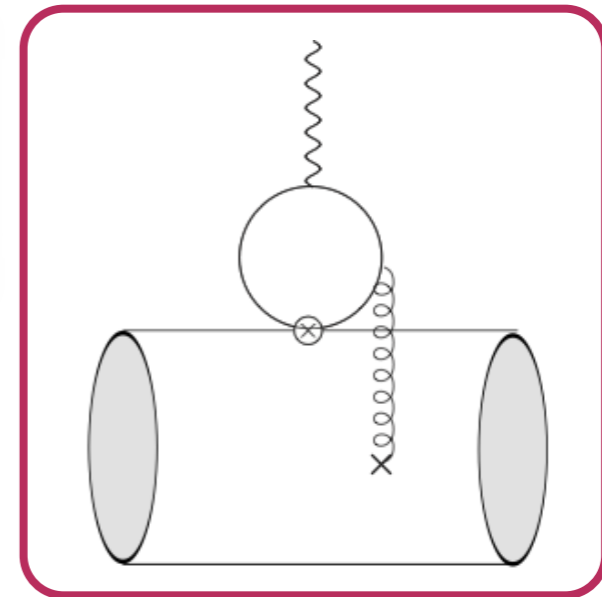
$F_L, A_{FB}, S_{3,\dots,9}, \text{B.R.}^{K^*\mu\mu}$

- Form factors from **updated lattice** in **Horgan et al.**  
 $T_{1,2,3}$  now correlated! 1501.00267

# The Charm-Loop Unknown

From the correlator of  $O_{1,2}^c$  with the E.M. current one can get the main responsible for the long-distance effect in B to  $K^*ll$ .

Great effort in 1006.4945 to compute this contribution, but only single soft-gluon emission included so far ...



Here, we remark that the result in 1006.4945 needs to be taken with a grain of salt for pheno-applications:

1. Light-cone expansion by definition requires “low  $q^2$ ”

Higher order gluon exchange is subleading as far as  $1/(4m_c^2 - q^2)$  suppression is efficiently @ work 2.

3. The closer one gets to the charmonium region, the more challenging becomes the estimate to do

➔ no definite clue about the phenomenological impact!



Ok ... then,  
What to do?

We can try to read  
the contribution directly  
from the fit of the data!

In order to do so, we provide a parametrization of the charm-loop along the same line of e.g. 1412.3183:

$$h_\lambda = h_\lambda^{(0)} + h_\lambda^{(1)} q^2 + h_\lambda^{(2)} q^4, \quad (\lambda = 0, \pm)$$

TO PROVIDE A MORE RELIABLE DESCRIPTION ABOVE FEW  $\text{GeV}^2$

$q^2$  IN NEW DATA BINNING UP TO  $8 \text{ GeV}^2$

@  $q^2 \sim 4m_c^2$ , higher power corrections reasonably important!

We give an educated guess according to what just said:

$O(1) \times \Delta C_9$   
of 1006.4945



6 real parameters for each  $\lambda$ ,  
flatly distributed btw  $\pm 2 \times 10^{-4}$

Low  $q^2$  only

# Fit Results

Part I

WHAT HAPPENS IF WE  
COMPLETELY DISCARD  $h_\lambda$ ?

PULL of the  
FIT

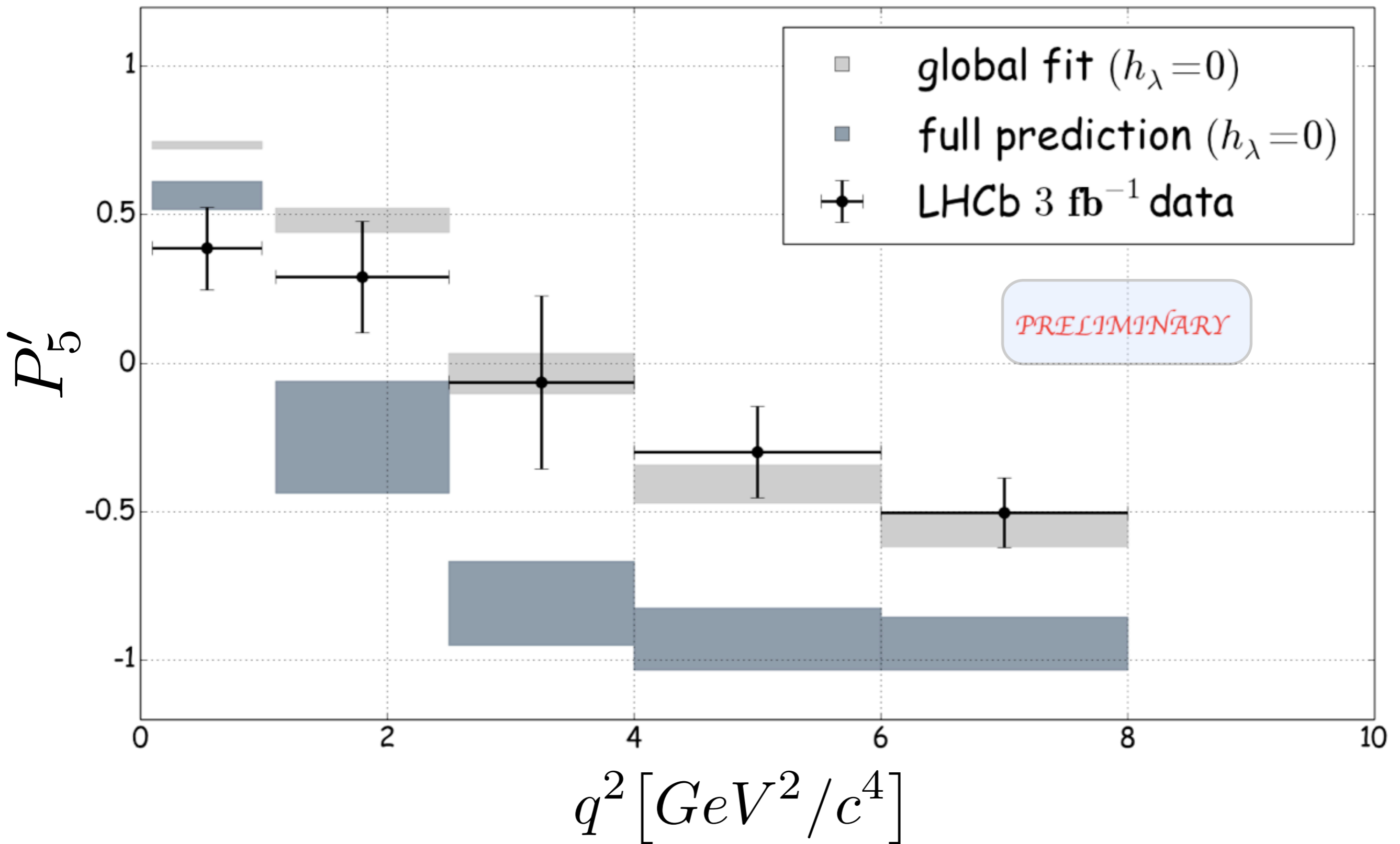
$$\frac{\mathcal{O}_{th} - \mathcal{O}_{exp}}{\sqrt{\sigma_{th}^2 + \sigma_{exp}^2}}$$

Bin $q^2$ [ $GeV^2/c^4$ ]	$A_{FB}$	$F_L$	$S_3$	$S_4$	$S_5$	$S_7$	$S_8$	$S_9$
[0.1, 0.98]	1.6	0.2	-0.9	0.6	-1.2	0.3	1.0	-1.4
[1.1, 2.5]	0.1	-0.6	-0.9	-0.6	-0.8	-2.2	-0.8	-1.3
[2.5, 4]	-0.6	0.7	0.8	-1.1	-0.1	0.6	0.2	-0.8
[4, 6]	-1.3	-2.4	1.8	-1.0	0.3	-0.2	1.8	-0.4
[6, 8]	-1.4	-1.6	1.4	-2.3	0.2	-0.7	-1.2	-0.4
[1.1, 6]	-1.2	-1.5	1.6	-1.2	-0.1	-1.5	0.6	-0.6

10 deviations @ the level of  $1.5 \sigma$  or more.

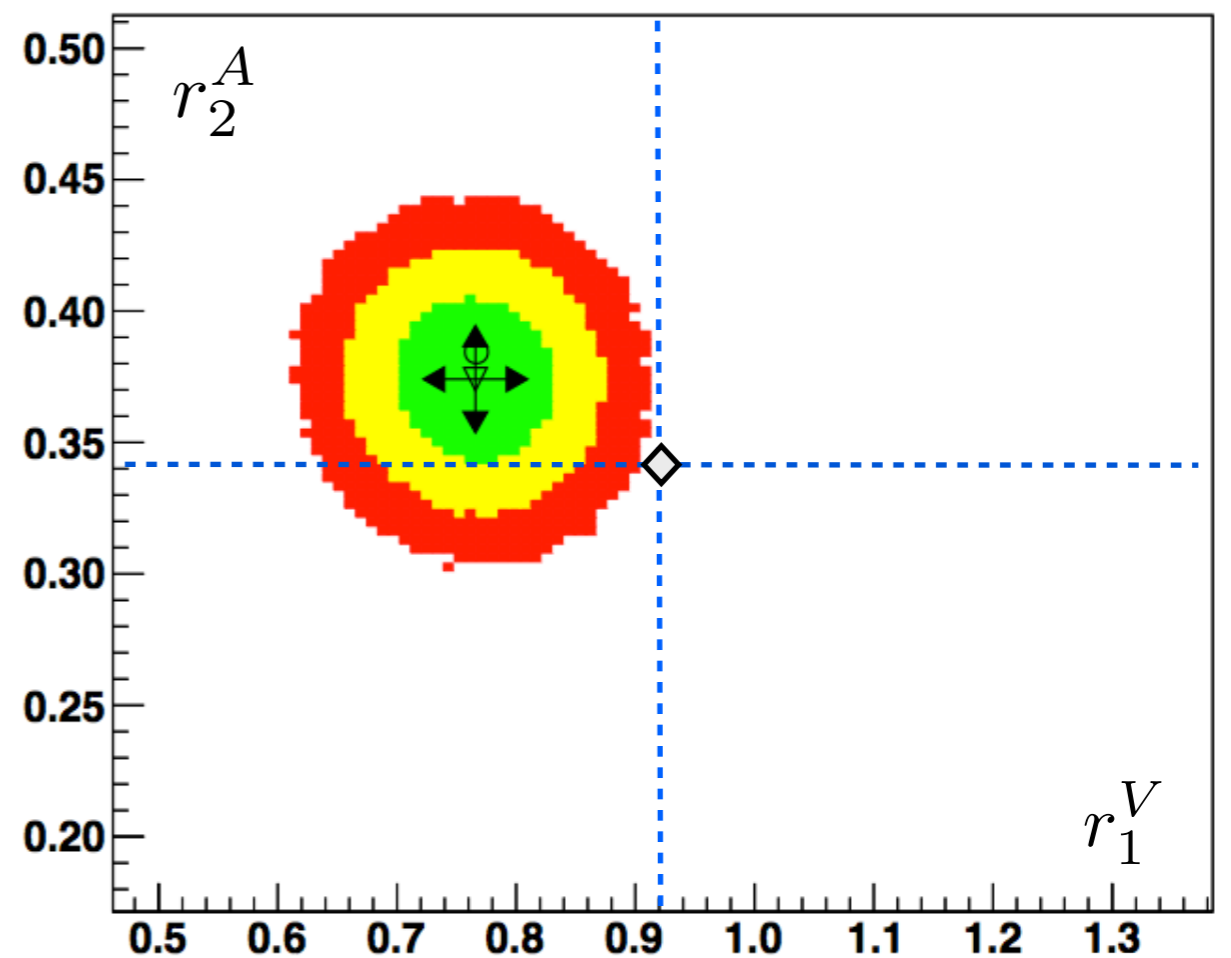
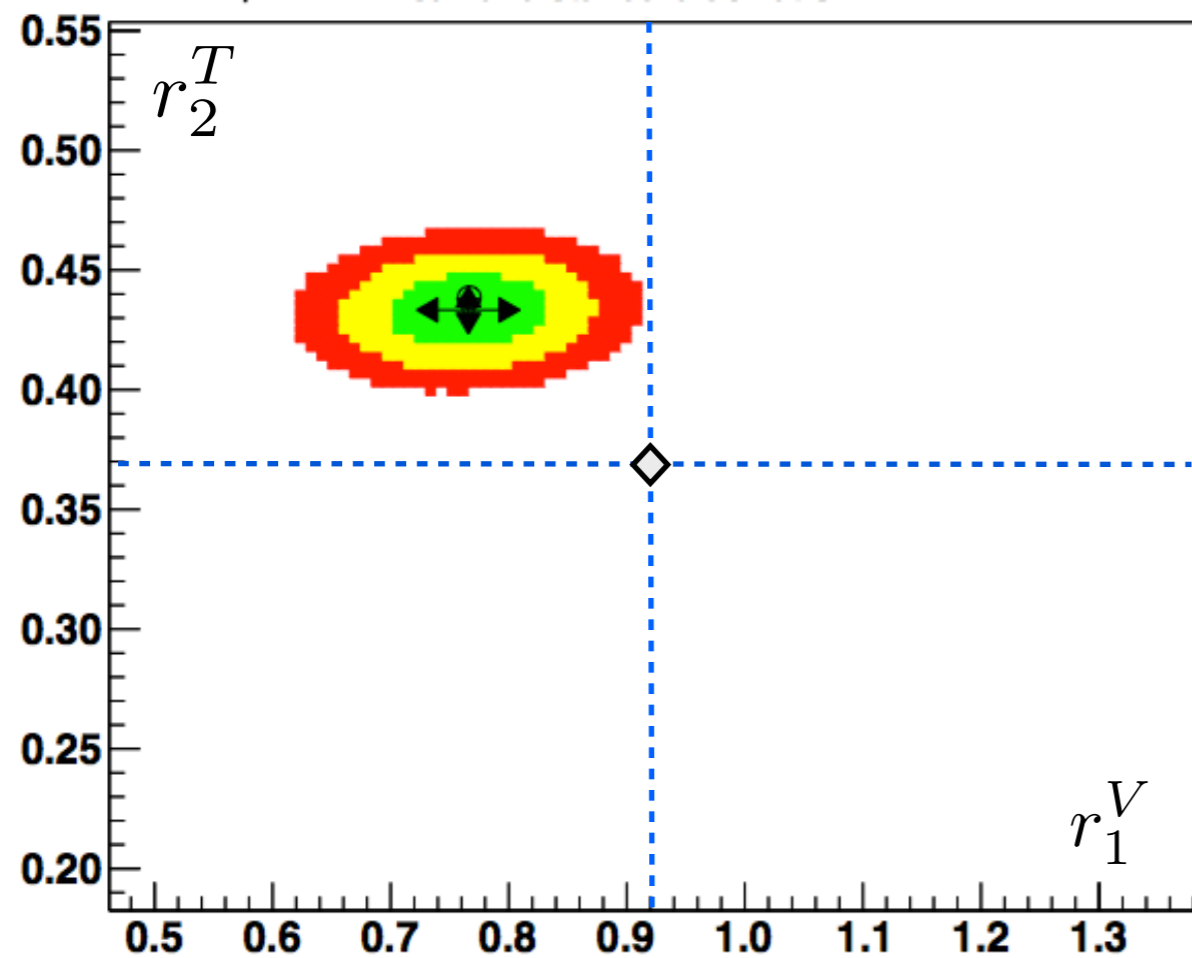
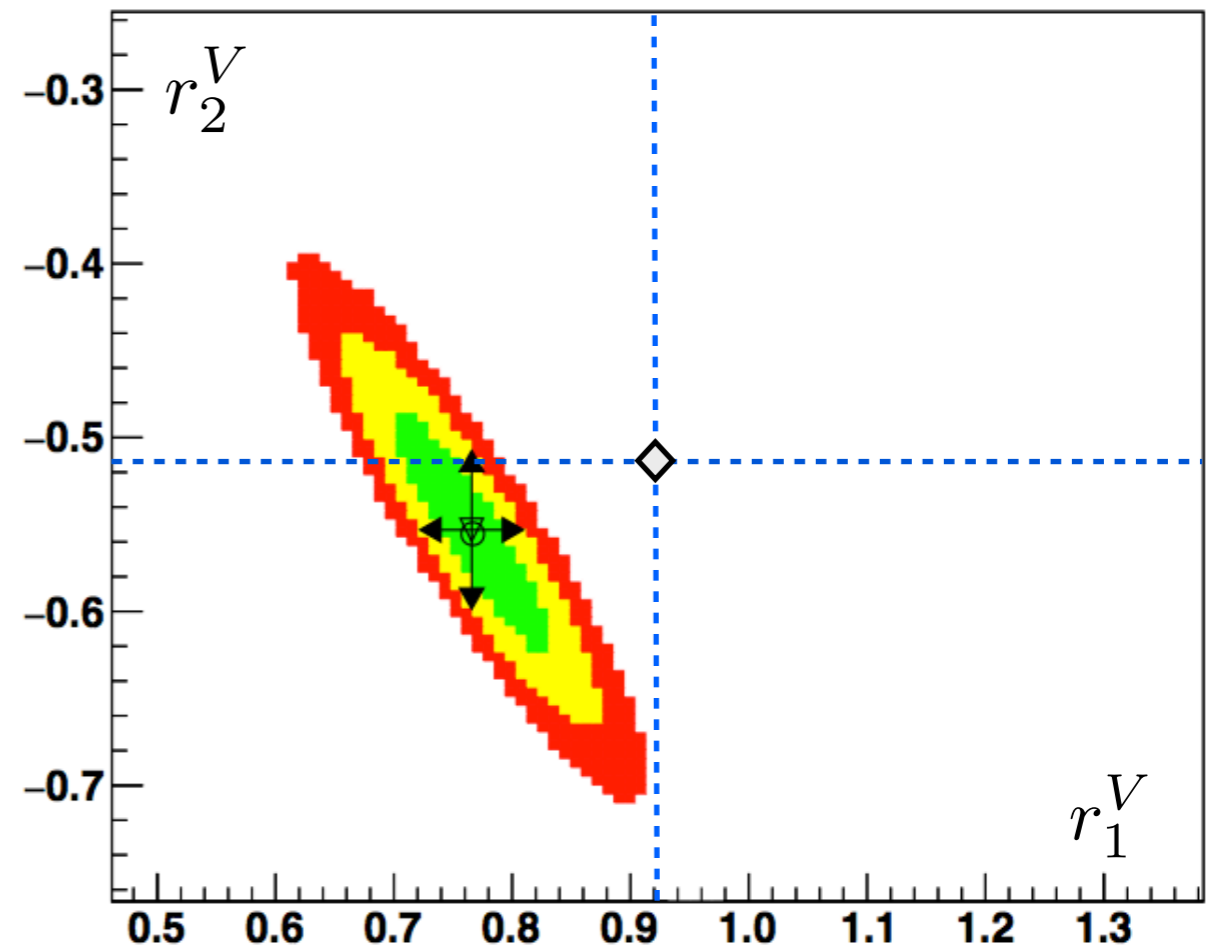
No strong tension ( $>3\sigma$ ) btw TH & EXP here ...





If we are EXP blind, we hit undoubtedly a  $P'_5$  anomaly.  
 Anyway, even using EXP info, we get a **2.5  $\sigma$  deviation** ...

... on top of that, some  
FF parameters look  
a bit overconstrained!



Low  $q^2$  only

# Fit Results

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Part II

BACK INTO  
THE  
BUSINESS!

BUSINESS



PULL of the  
FIT

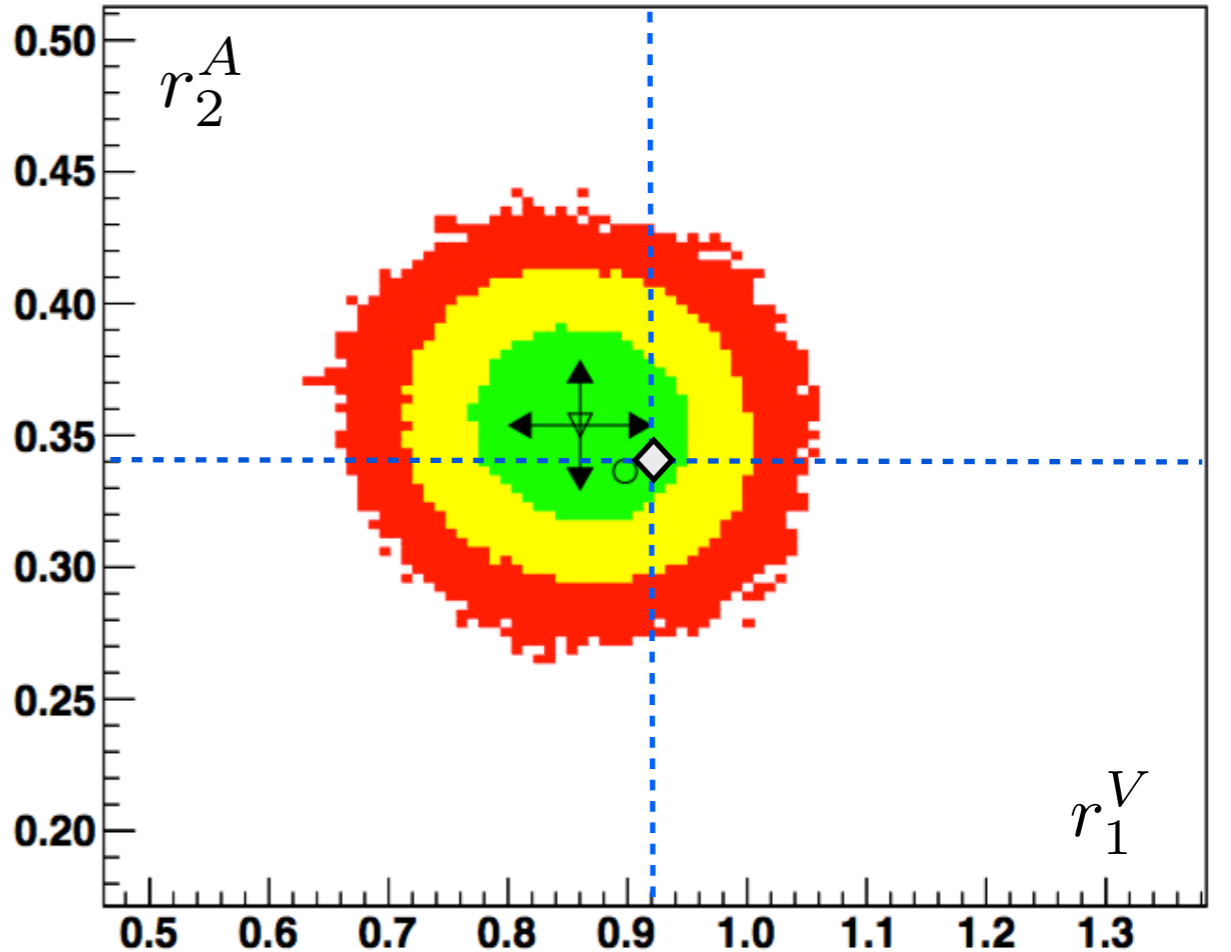
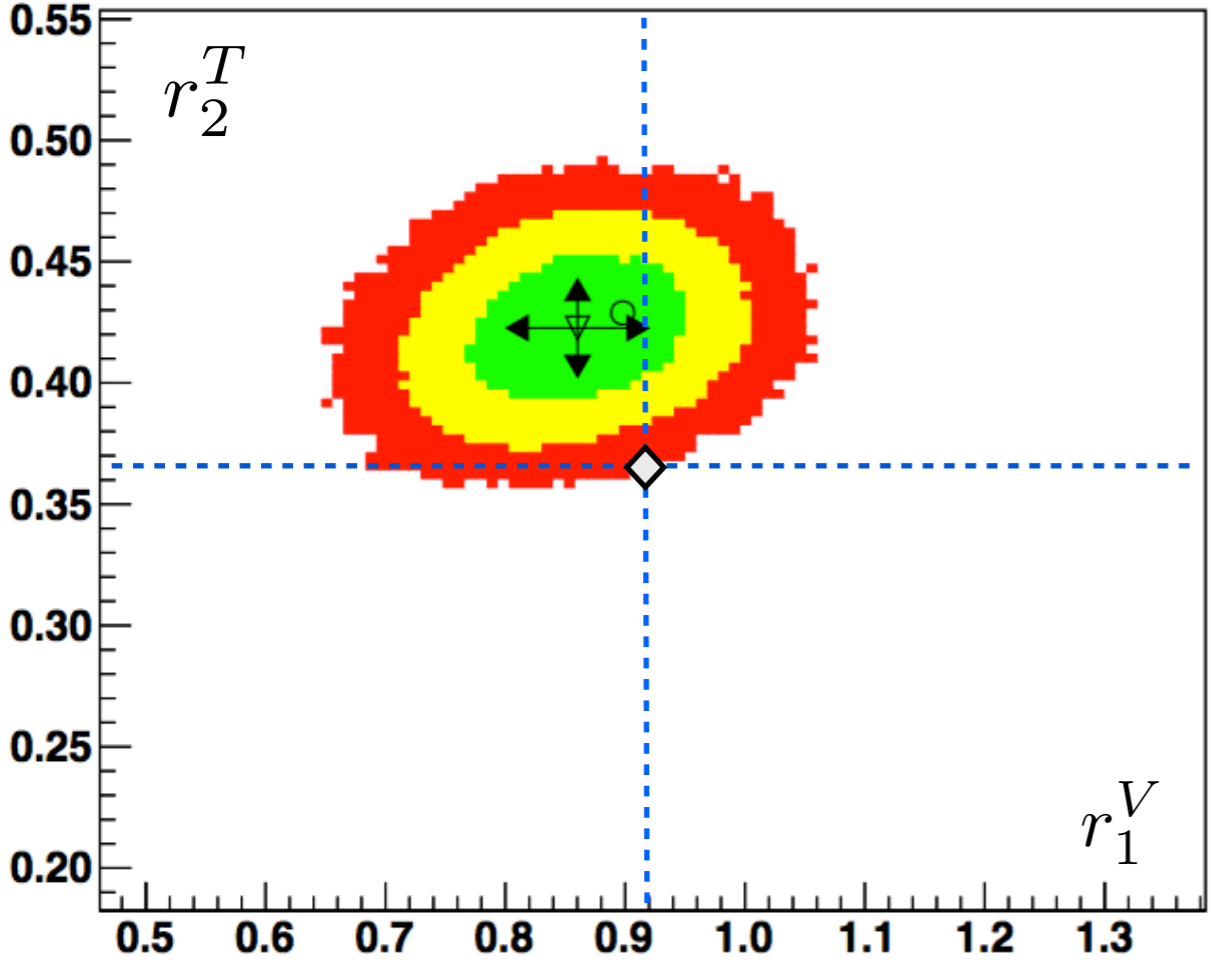
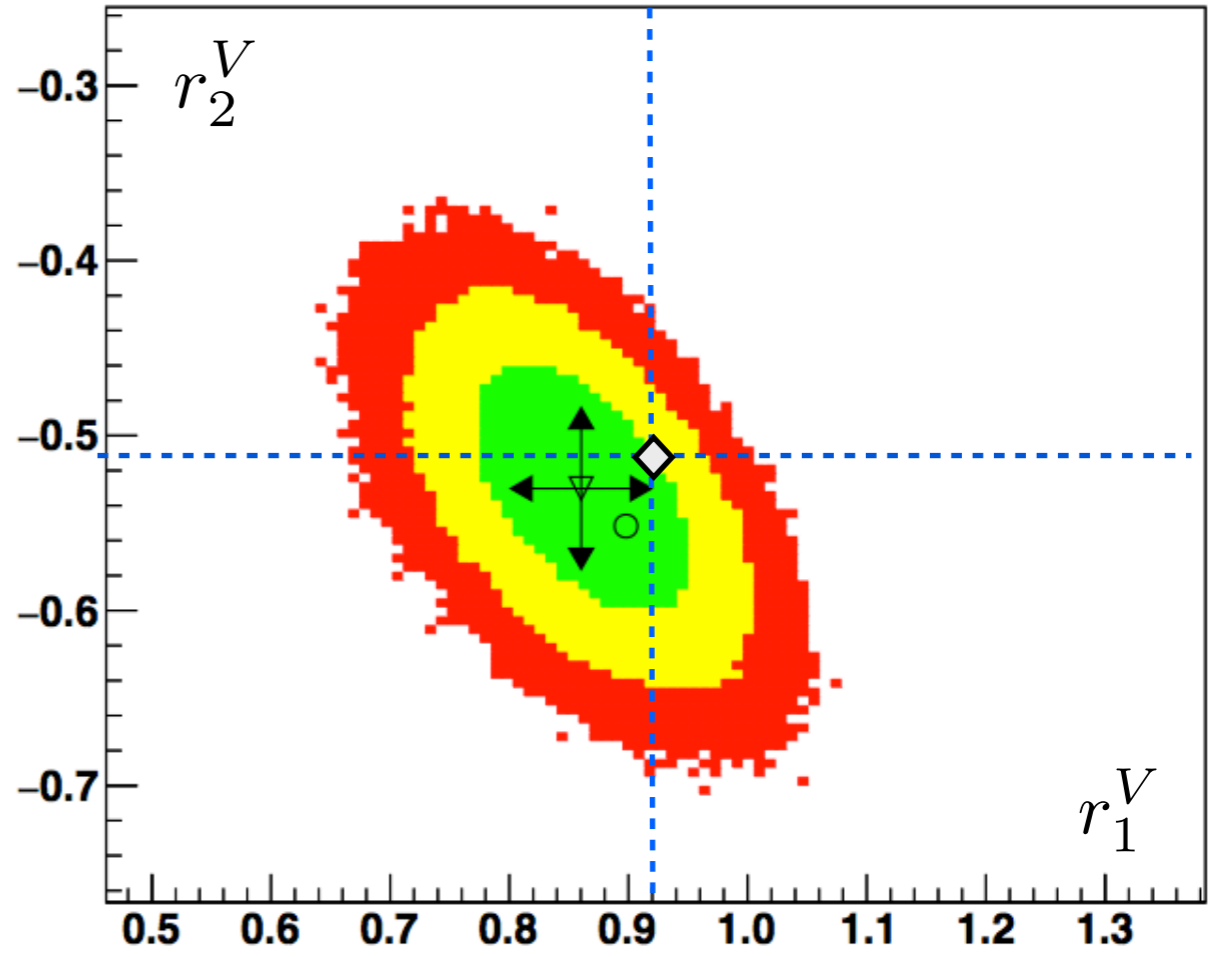
$$\frac{\mathcal{O}_{th} - \mathcal{O}_{exp}}{\sqrt{\sigma_{th}^2 + \sigma_{exp}^2}}$$

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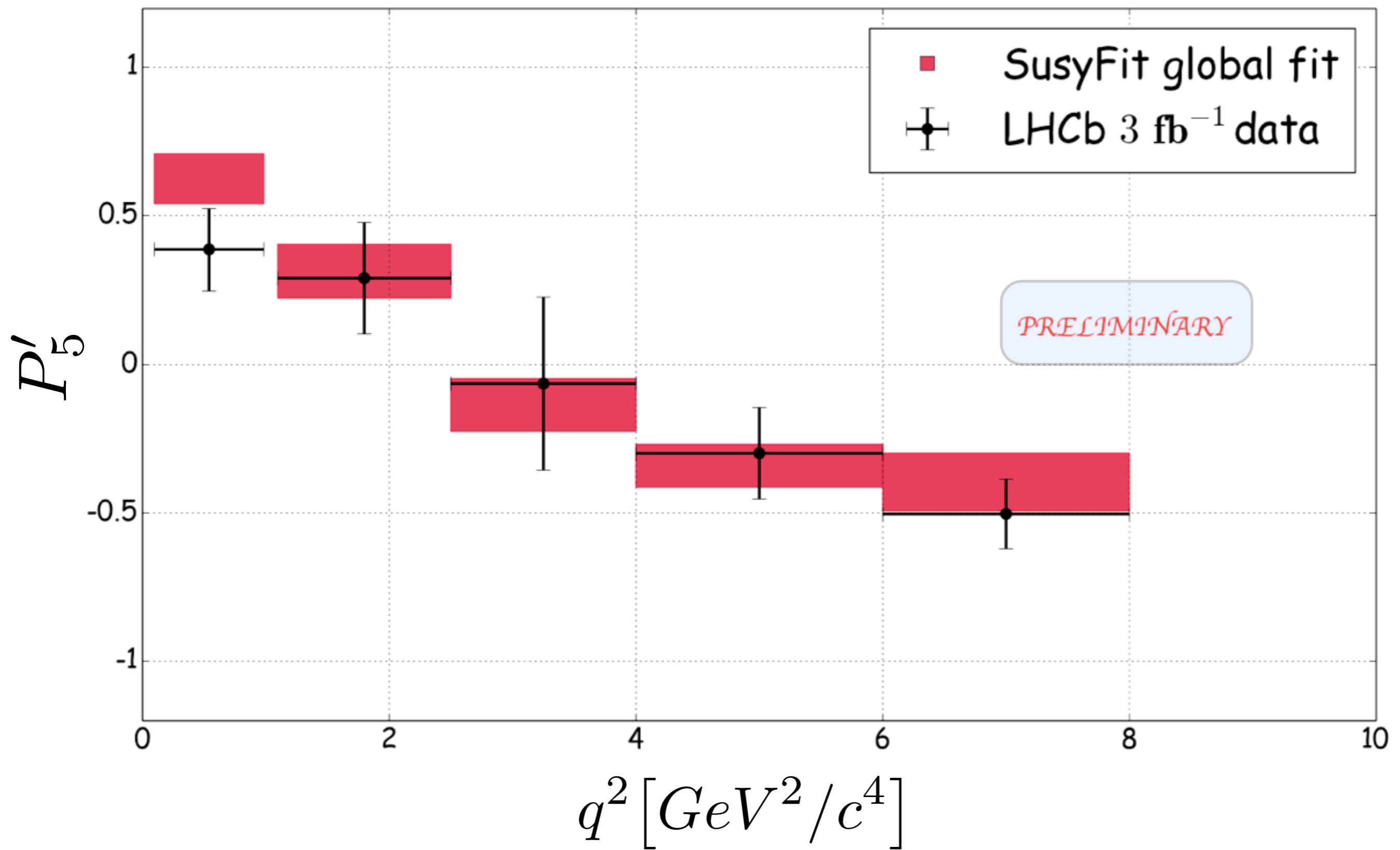
Only 4 deviations @ the  $1.5 \sigma$  level or more.

No strong tension ( $>3\sigma$ ) btw TH & EXP observed.

Correlations btw FF parameters get relaxed

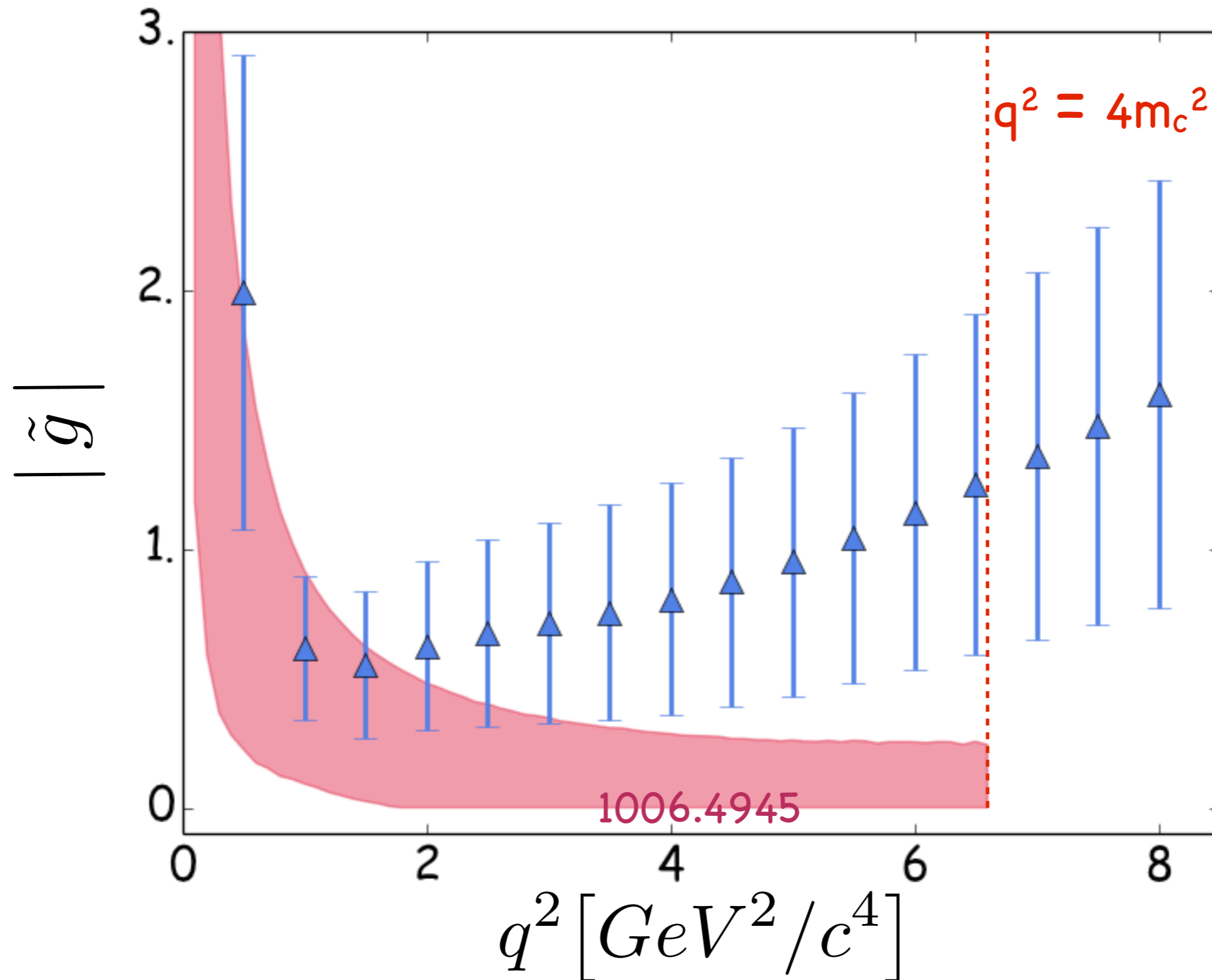






No tension (pulls  $< 1.5 \sigma$ ) in  $P'_5$  with current data!

# Are we overestimating the charm-loop?



Current data turn out to be constraining!  
The outcome of the fit agrees with our initial expectations.

# Final Remarks

Current experimental data in  $B$  to  $K^*\mu\mu$  possibly point to a non-zero sizeable long-distance contribution coming from the "hadronic part" of the  $|\Delta B|=1$  weak effective Hamiltonian.

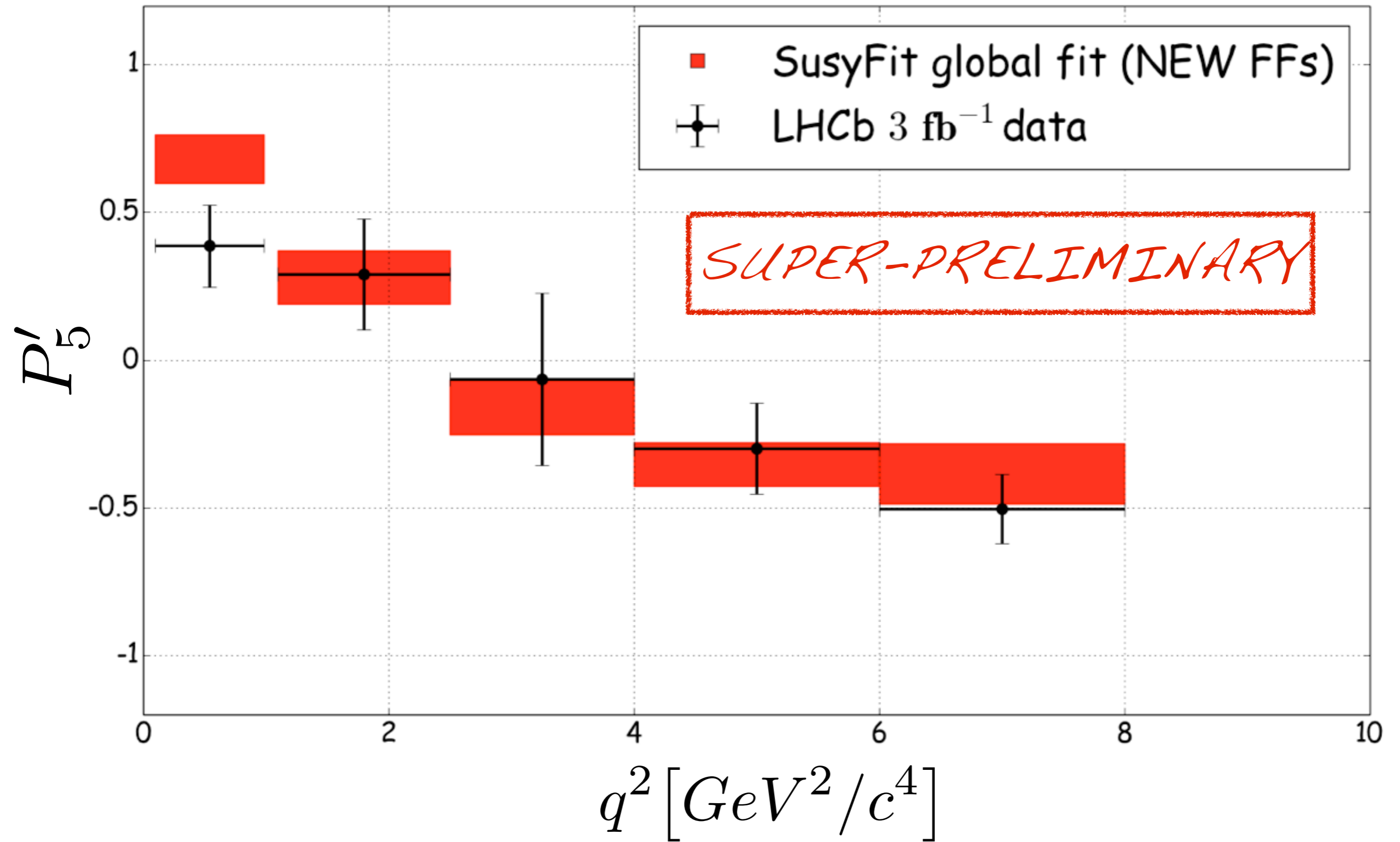
@ present the SM looks in good shape, i.e. it is in remarkable agreement with EXP. The effect of the charming penguin read from our fit suits well in this picture.

**SIGNPOST.** Pushing down theory uncertainties (FFs &  $h_\lambda$ ) + collecting more data is of vital importance if we want to talk about NP unambiguously in this channel ...

STAY TUNED!

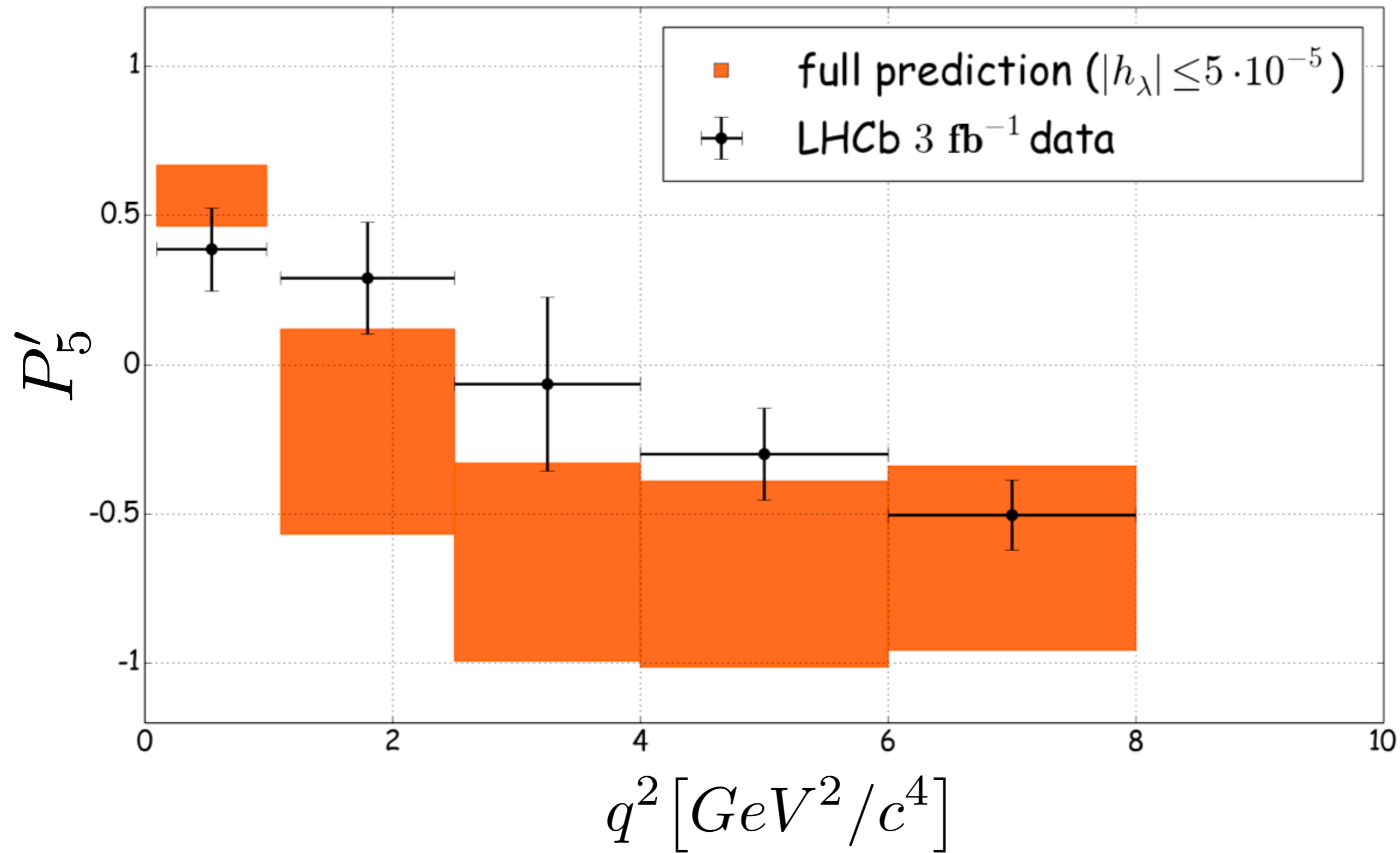


# Back-up On $P'_5$

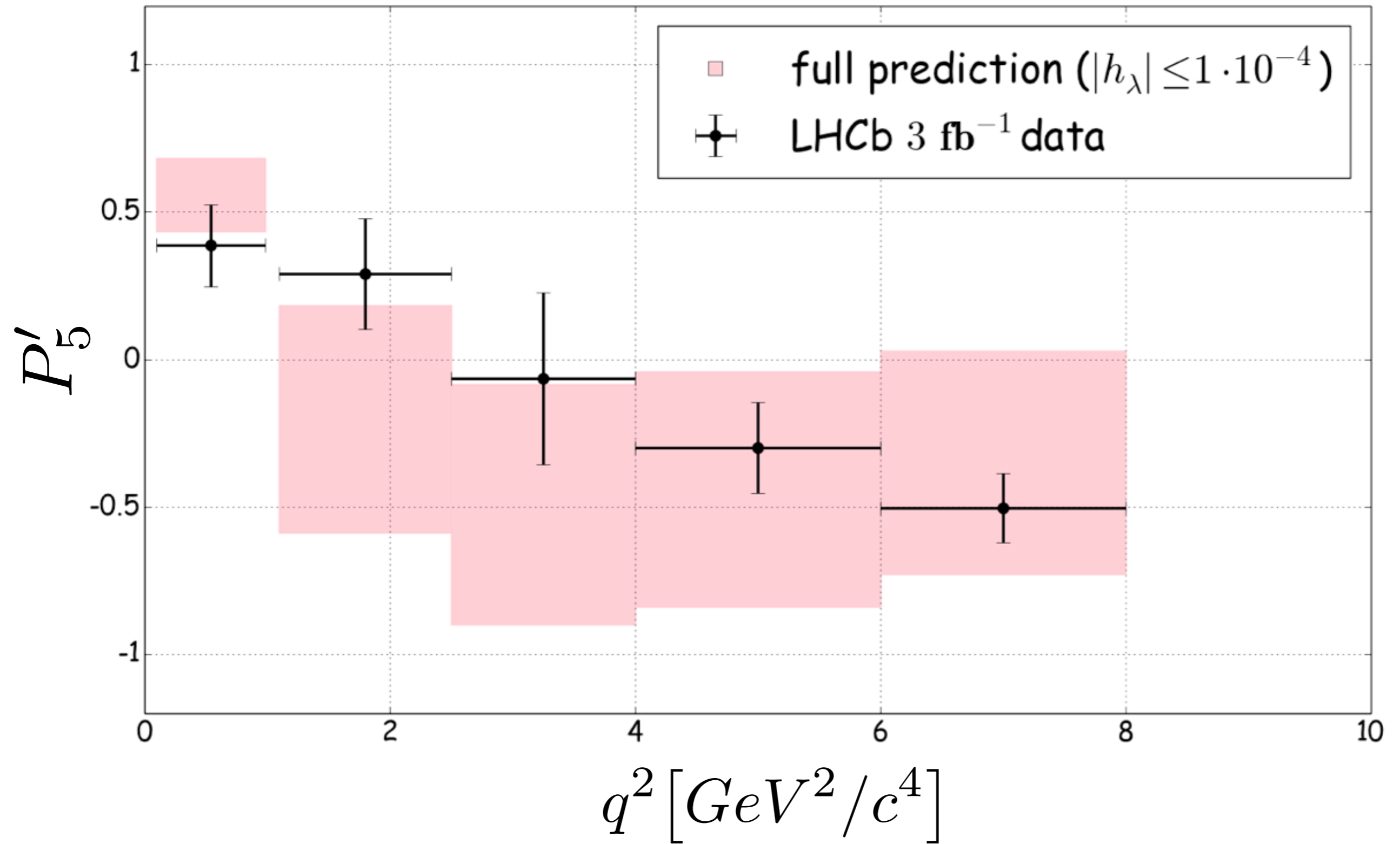




# Back-up On $P'_5$



# Back-up On $P'_5$



# Back-up On $P'_5$

