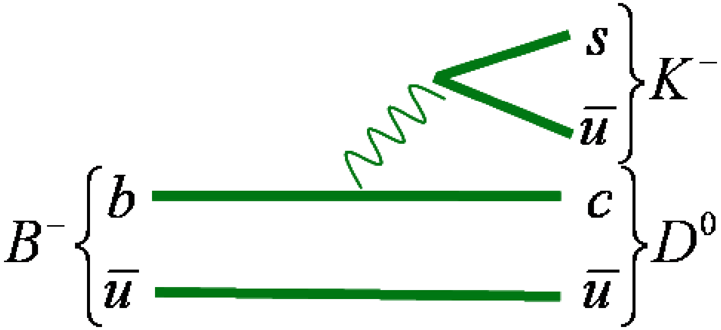
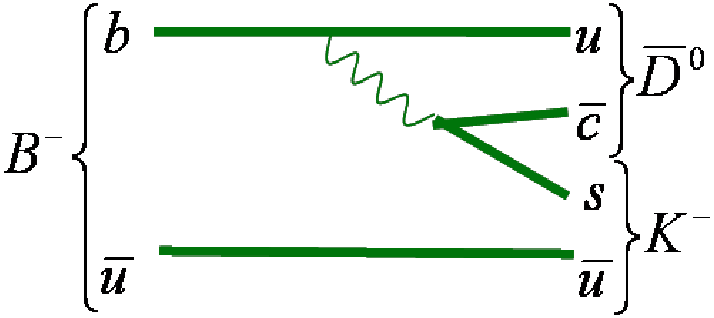
Measuring γ

- γ is the phase of V_{ub}. Can be determined using $B^{\pm}$ decays. These diagrams result in the same final state for $D^0 \to K^+K^-$, $K_S\pi^+\pi^-$….





- $A \propto V_{cb} V_{us} A_T$ $\quad$ $A \propto V_{ub} V_{cs} A_{CT}$
- Phase differs by γ, Amp by A_{CT}/A_T
  - different A's for different final states
  - Can also use doubly Cabbibo suppressed decays

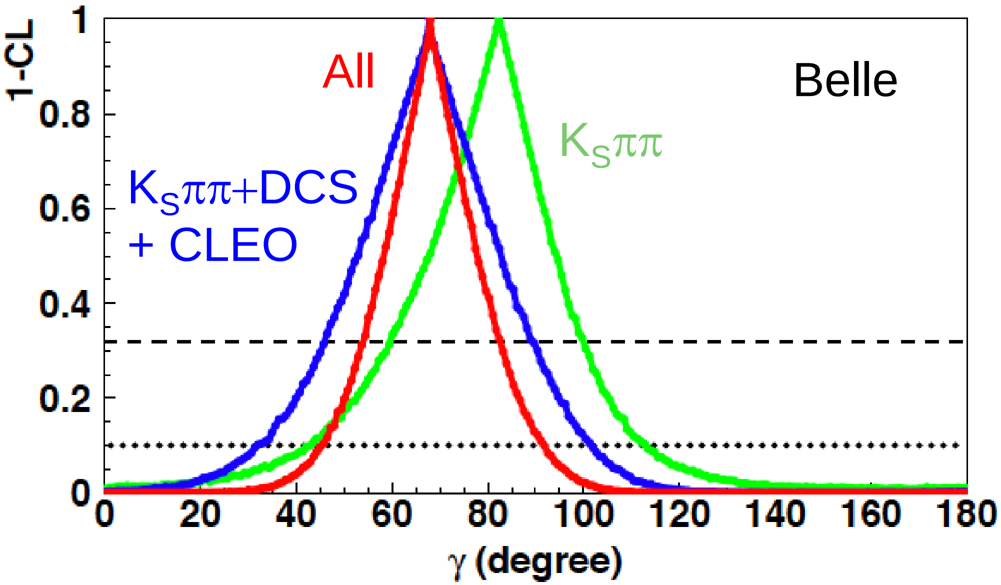
Results

- Analysis is very complicated & sums over many final states (including $D^0\pi^-$)
- Results for γ

BaBar $(69^{+17}_{-16})^{o}$

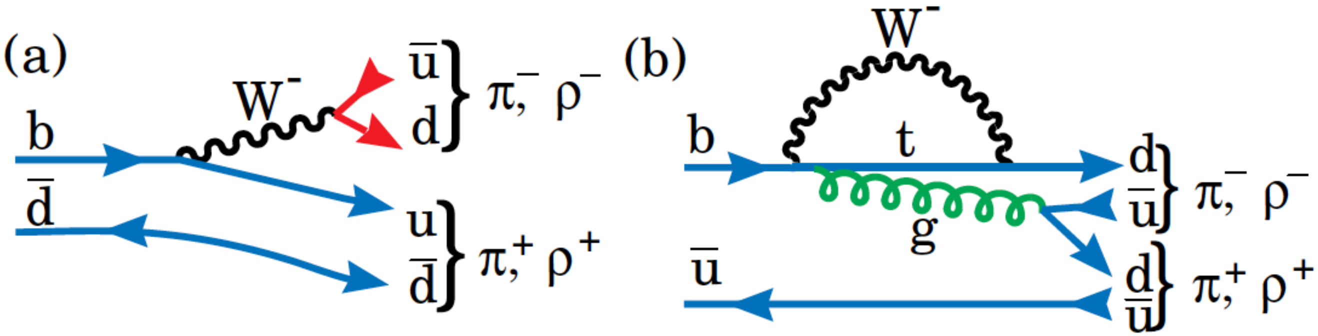
Belle $(68^{+15}_{-14})^{o}$

LHCb $(67\pm12)^{o}$



Measuring α

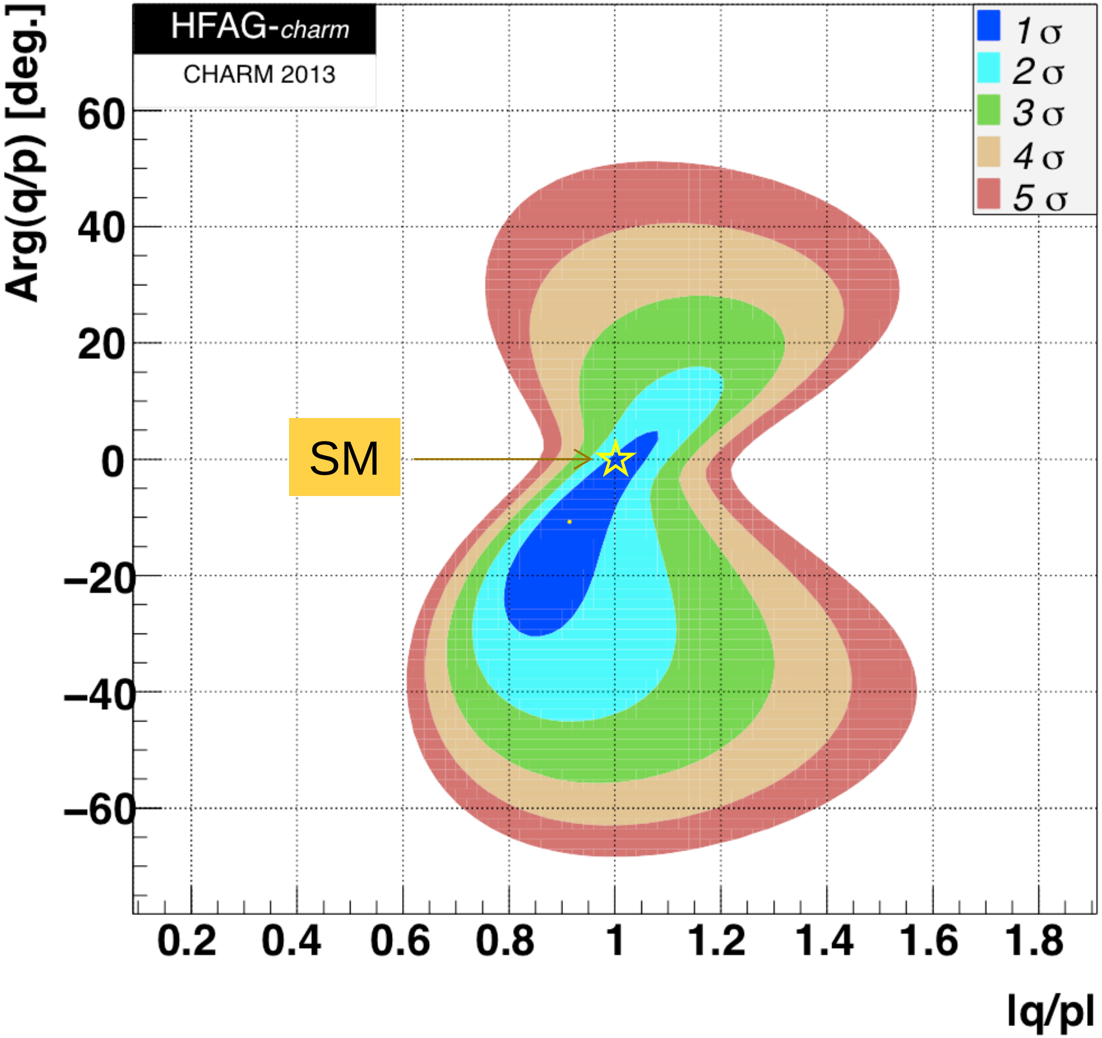
- The $B^0 \rightarrow \pi^+\pi^-$ & $\rho^+\rho^-$ decays can occur via



- If (a) is dominant, then by measuring a_{fcp}, we measure $\sin(2(\beta+\gamma)) = \sin(2(180-\alpha) = -\sin(2\alpha)$
  - Can tell by seeing the size of $\pi^0\pi^0$ & $\rho^0\rho^0$.
  - (a) not dominant for $\pi^+\pi^-$, but OK for $\rho^+\rho^-$. However its not a CP eigenstate, but this can be dealt with
- BaBar: $\alpha = (92.4\ ^{+6.0}_{-6.5})°$, Belle: $(84.9 \pm 12.9)°$

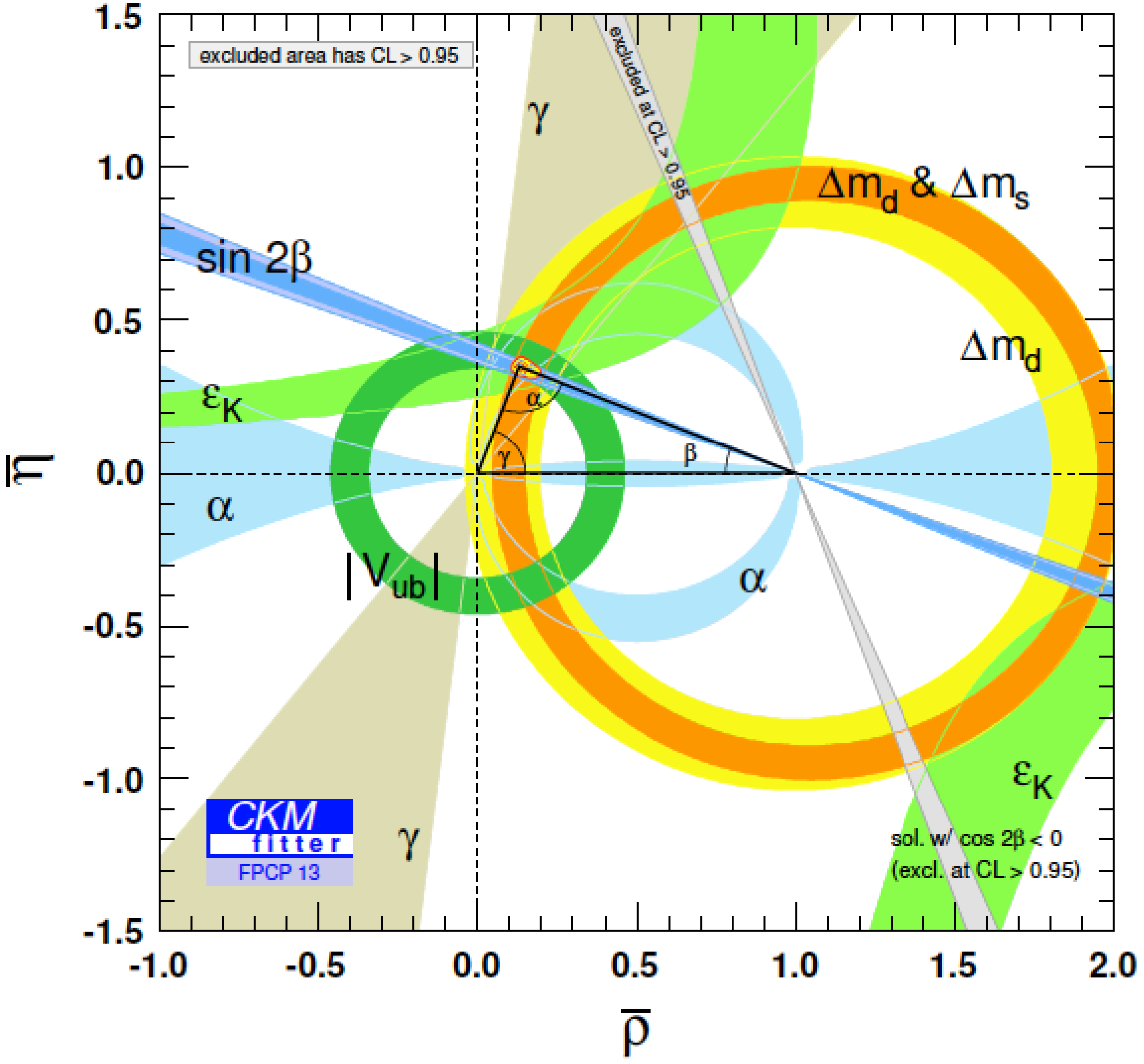
Charm CPV

CP Violation in charm
is not expected at
at a level >~10^{-3},
so is an excellent
place to look for
New Physics



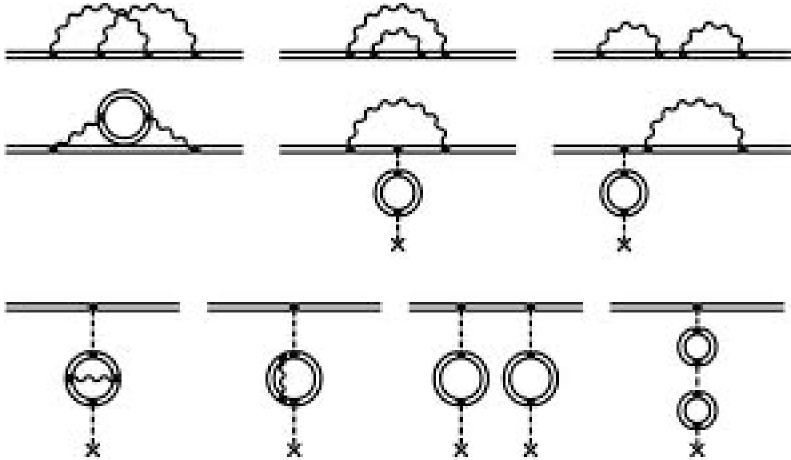
Are these measurements consistent?

- CKM fitter group
- Does a “frequentist” analysis
- Also UT fit group does a “Bayesian analyis



Seeking New Physics

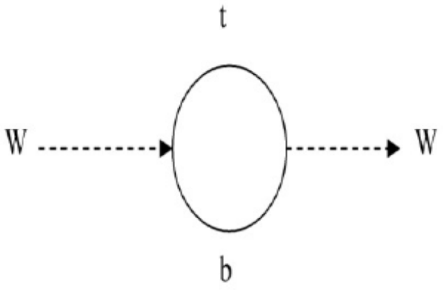
- HFP as a tool for NP discovery
  - While measurements of fundamental constants are fun, the main purpose of HFP is to find and/or define the properties of physics beyond the SM
  - HFP probes large mass scales via virtual quantum loops. An example, of the importance of such loops is the Lamb shift in atomic hydrogen
  - A small difference in energy between $2S_{1/2}$ & $2P_{1\,/2}$ that should be of equal energy at lowest order



Flavor Physics as a NP discovery tool

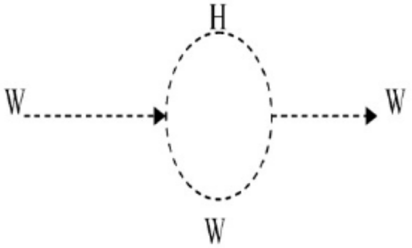
- Another example of the importance of such loops are changes in the W mass
  - M_w changes due to m_t

$$\frac{dM_W}{dm_t} \alpha \frac{m_t}{M_w}$$



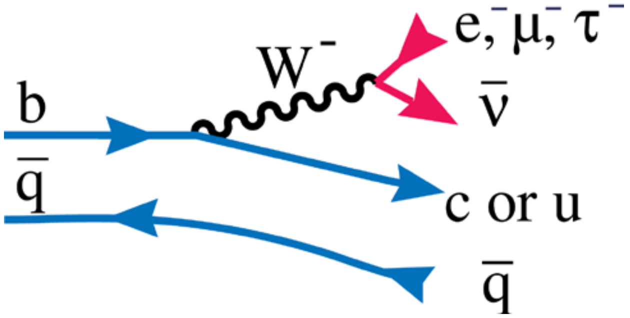
  - M_w changes due to m_H

$$\frac{dM_W}{dm_H} \alpha - \frac{dm_H}{M_H}$$

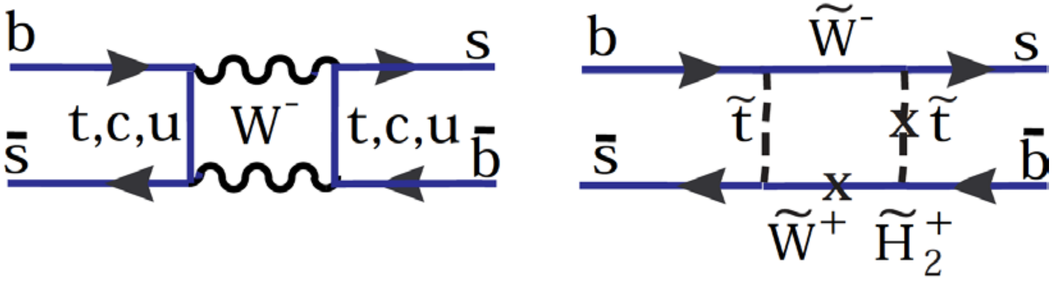


Limits on New Physics

- It is oft said that we have not seen New Physics, yet what we observe is the sum of Standard Model + New Physics. How to set limits on NP?
- One hypothesis: assume that tree level diagrams are dominated by SM and loop diagrams could contain NP



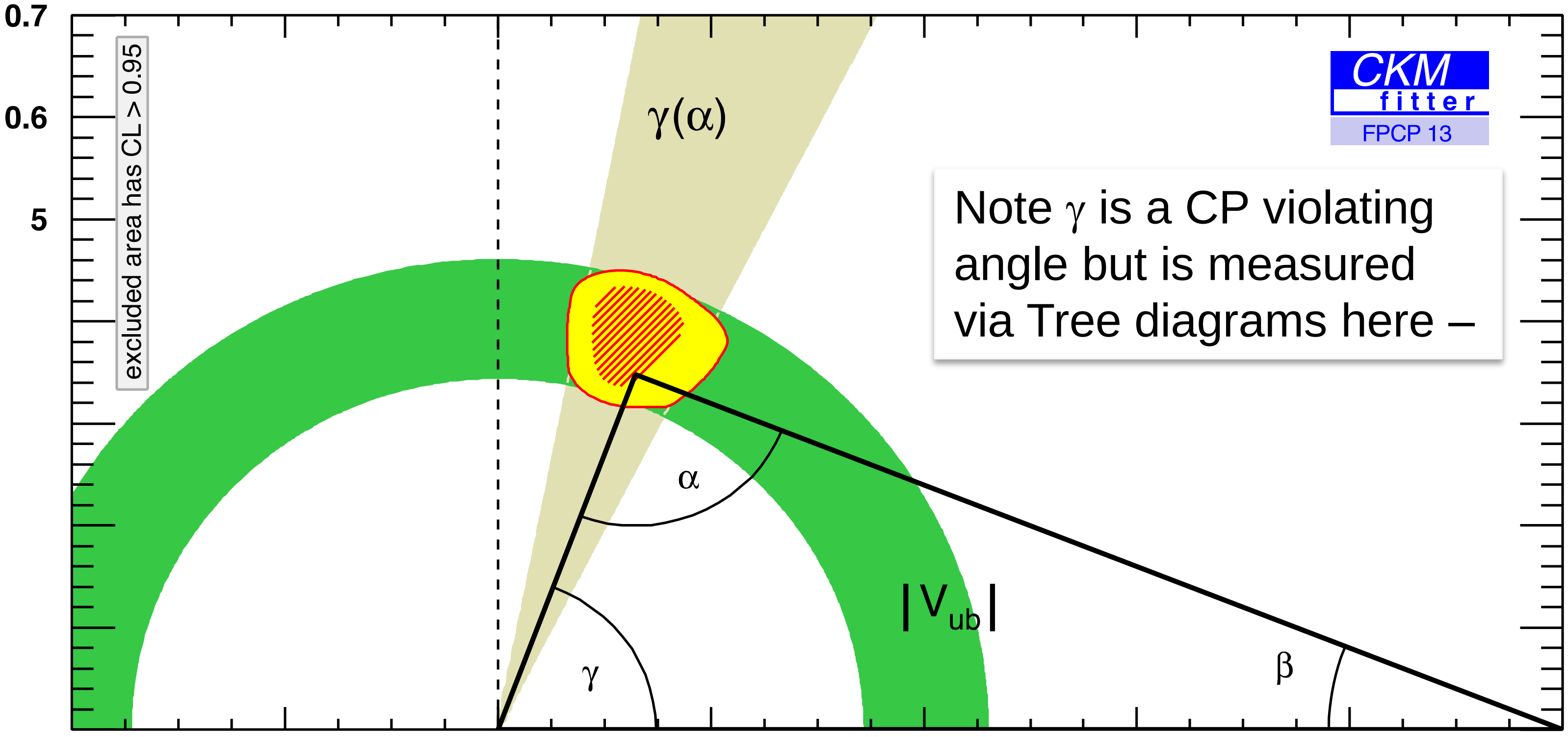
Tree diagram example



Loop diagram example

What are limits on NP from quark decays?

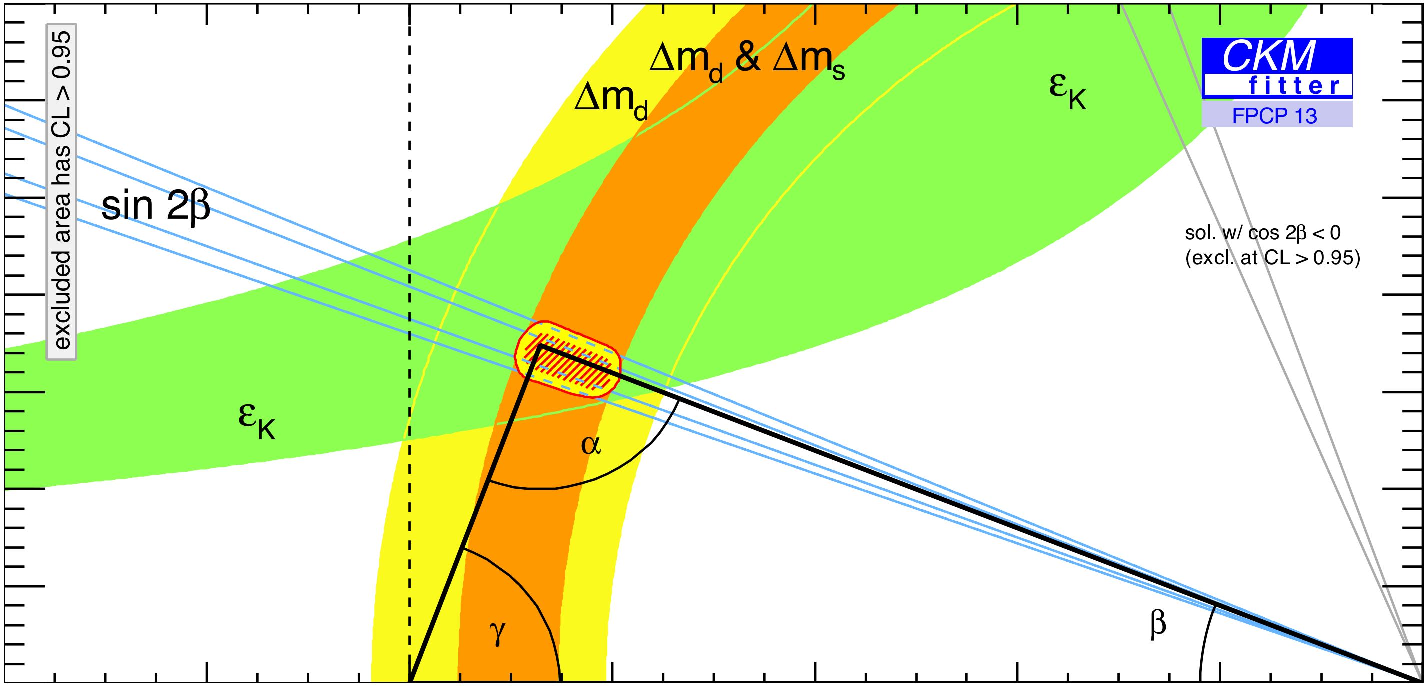
- Tree diagrams are unlikely to be affected by physics beyond the Standard Model



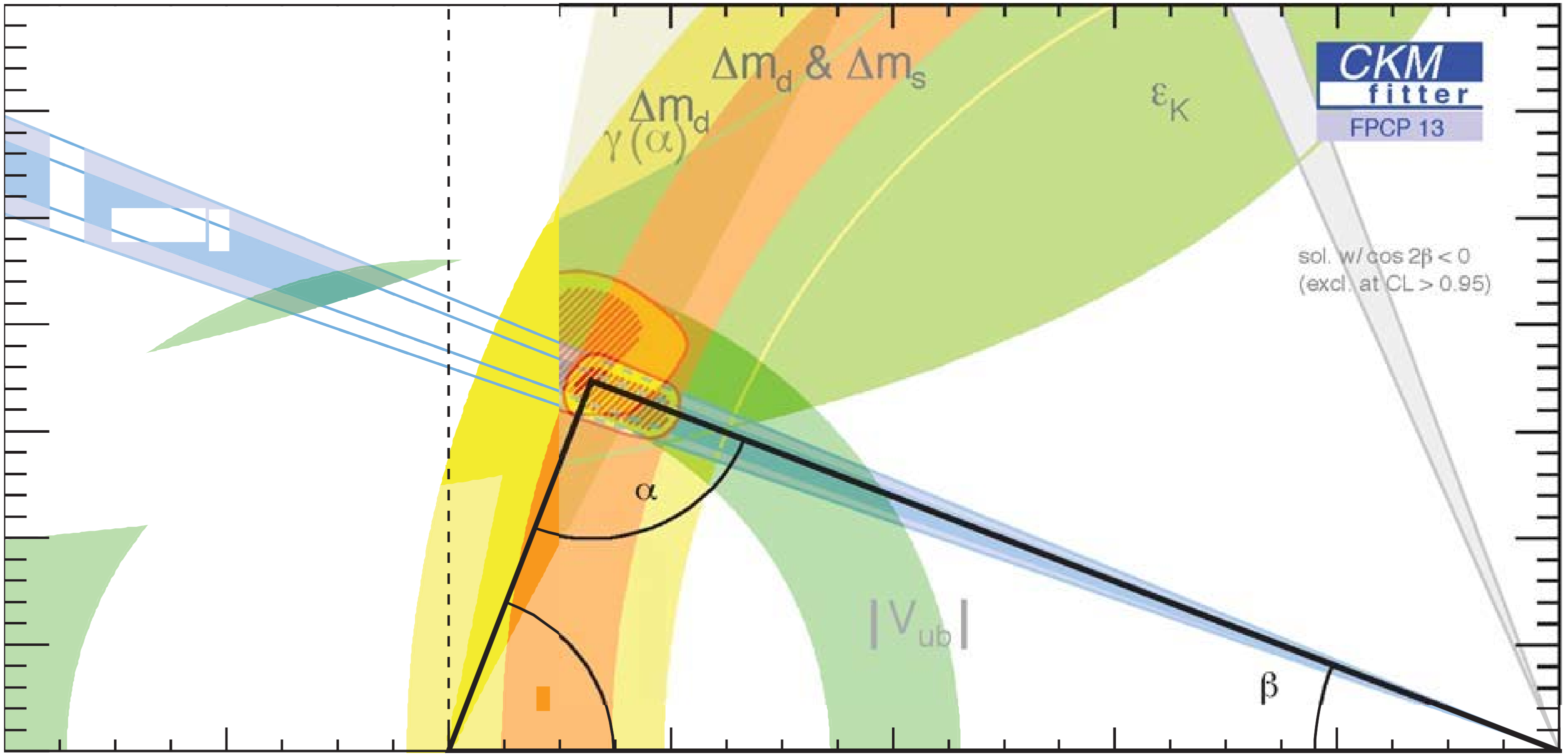
Note γ is a CP violating angle but is measured via Tree diagrams here –

CP Violation in Bº & Kº Only

- Absorptive (Imaginary) part of mixing diagram should be sensitive to New Physics. Lets compare



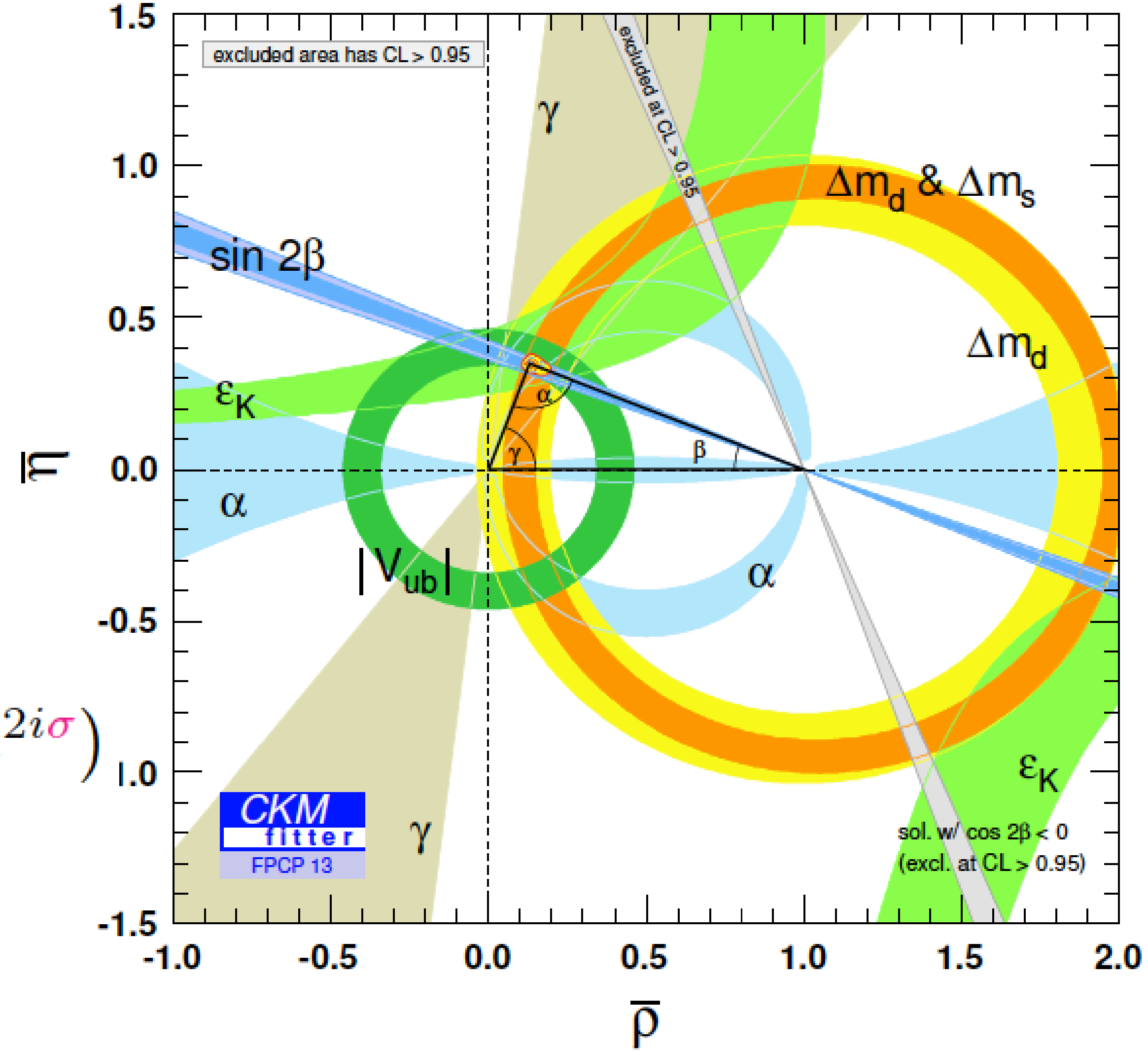
They are Consistent



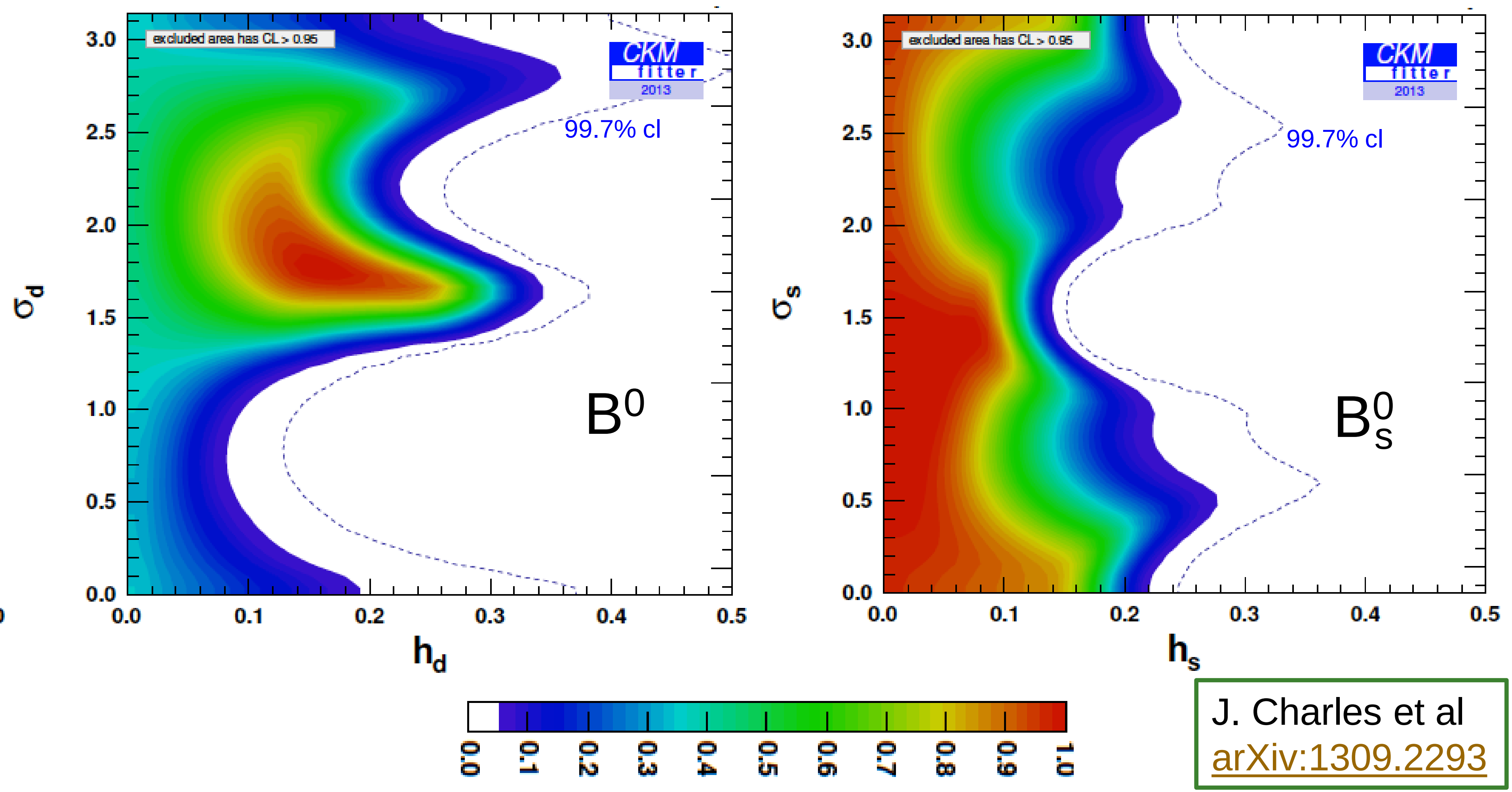
- But consistency is only at the 5% level
- Limits on NP are not so strong

Generic Analyses

- Compare measurements look for discrepancies
- $B^o_{(s)}$ mixing and CP. Parameterize NP as h & σ
- $M_{12} = M_{12}^{\mathrm{SM}} \times \left(1 + h\, e^{2i\sigma}\right)$



Limits on New Physics

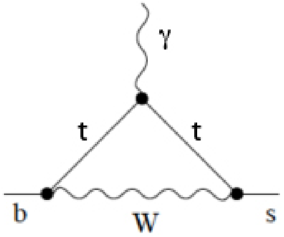


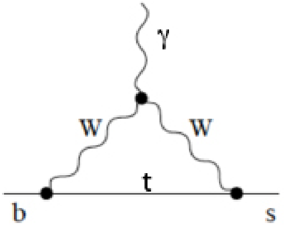
J. Charles et al
arXiv:1309.2293

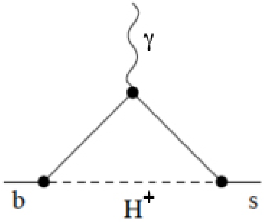
New Physics amplitudes could be ~20% of Standard Model

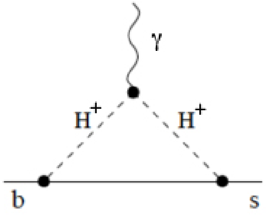
Ex. of Strong Constraints on NP

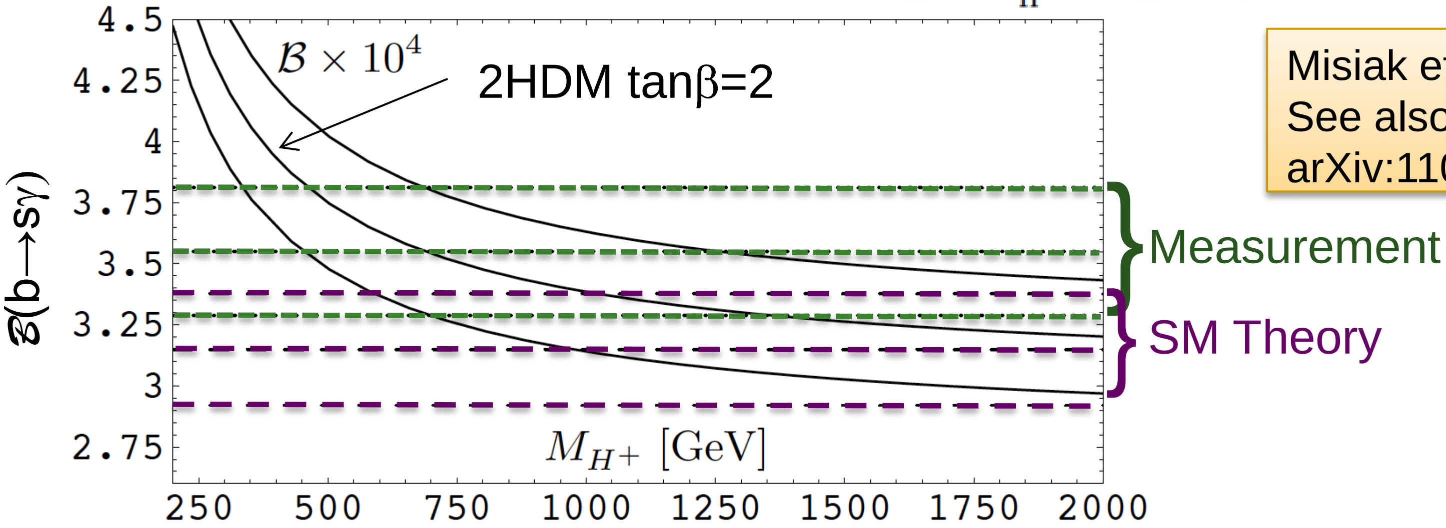
- Inclusive b→sγ, (Eγ > 1.6 GeV)
  - Measured $(3.55\pm0.26)\times10^{-4}$ (HFAG)
  - Theory $(3.15\pm0.23)\times10^{-4}$ (NNLL) Misiak arXiv:1010.4896
  - Ratio = 1.13±0.11, Limits most NP models
  - Example 2HDM
  - $m(H^{+}) < 316$ GeV











Misiak et. al hep-ph/0609232,
See also A. Buras et. al,
arXiv:1105.5146

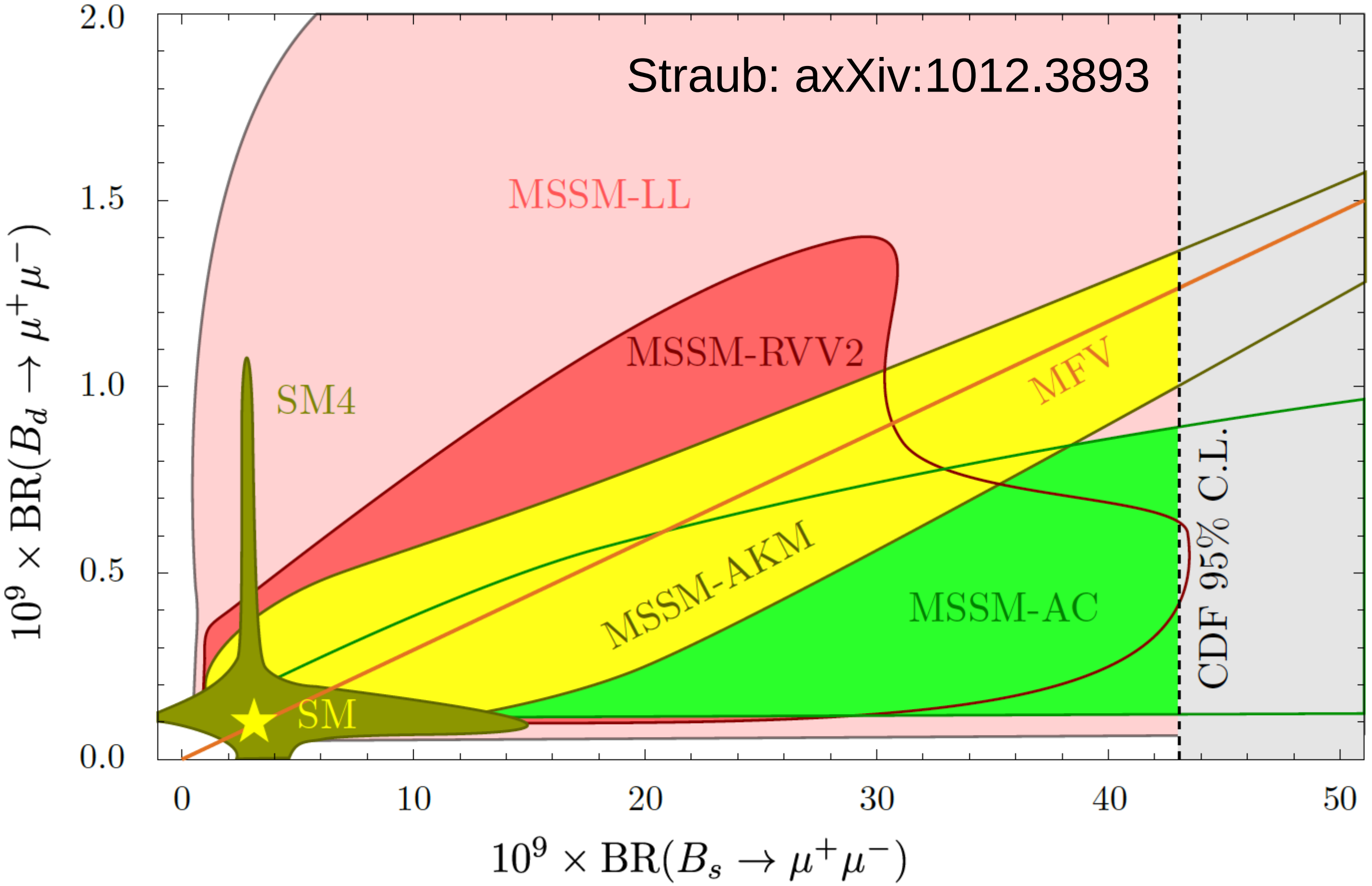
Theorists task

- A given theoretical model must explain all the data

Model must thread through all experimental constraints (12 axe handles). One measurement can, in principle, defeat the theorist, but we seek a consistent pattern.

Top Down Analyses

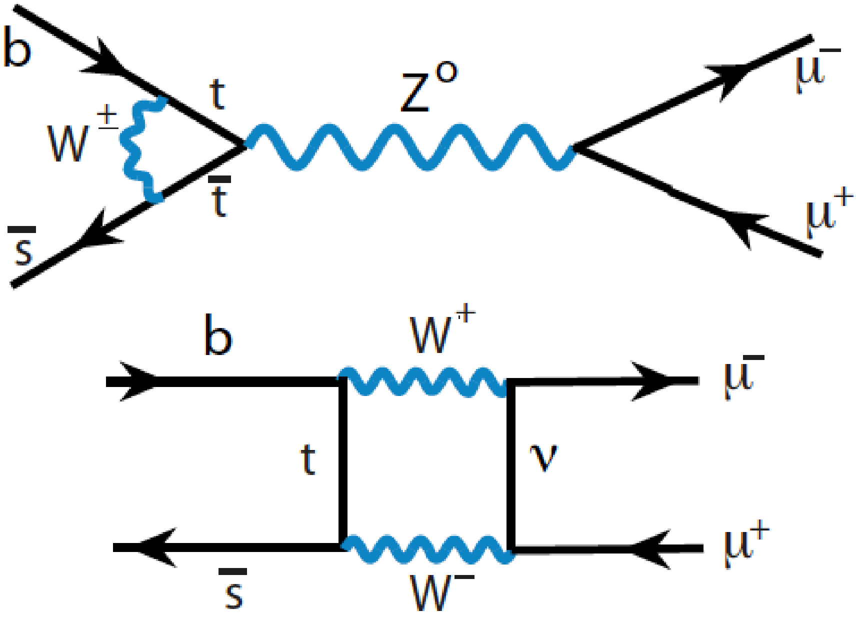
- Here we pick models and work out their consequences in many modes. Ex. (circa 2010):



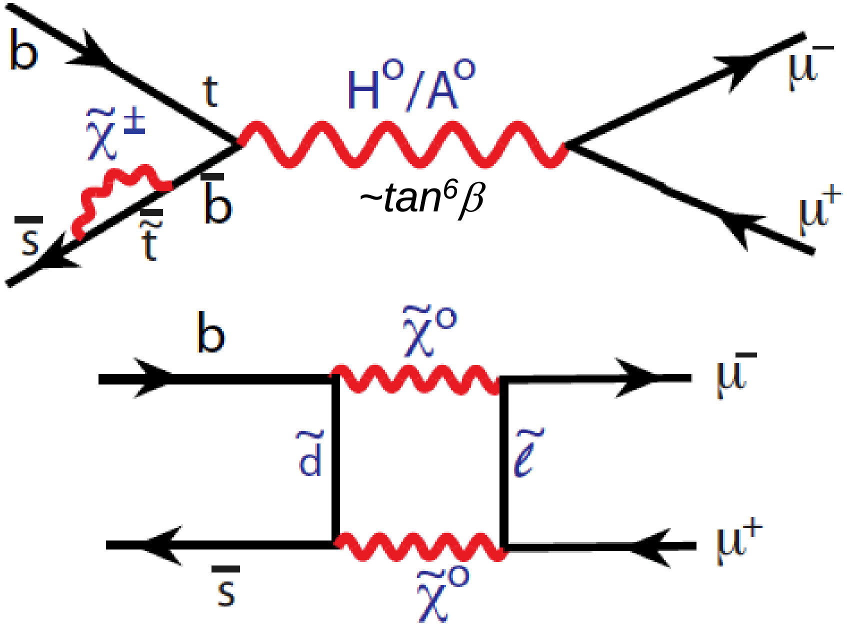
$B_s \rightarrow \mu^+\mu^-$

- SM branching ratio is $(3.5\pm0.2)\times10^{-9}$ [Buras arXiv:1012.1447], NP can make large contributions.

Standard Model



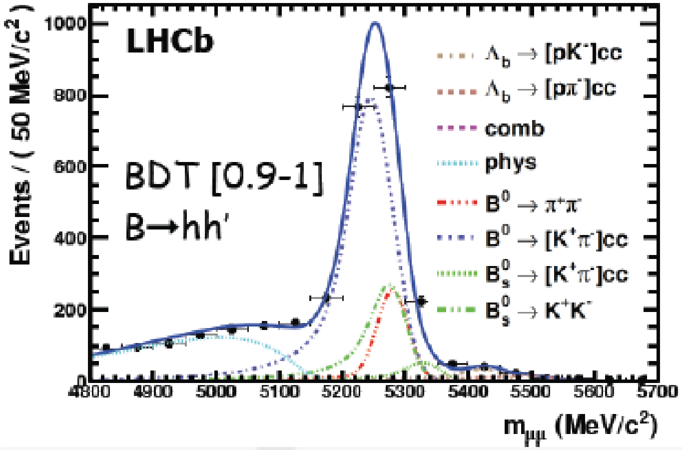
MSSM

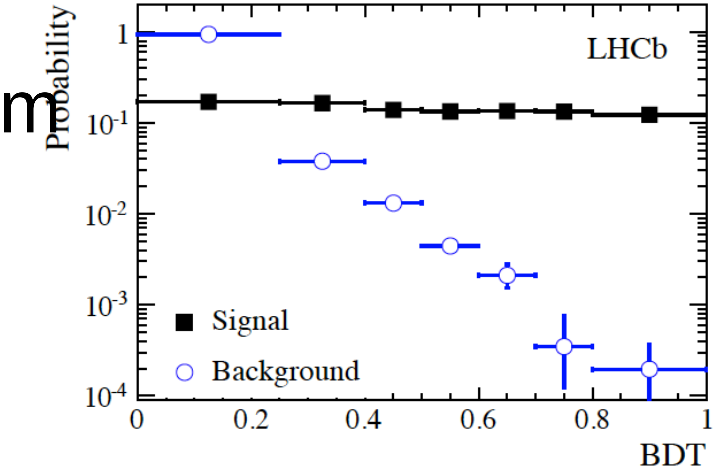


- Many NP models possible, not just Super-Sym

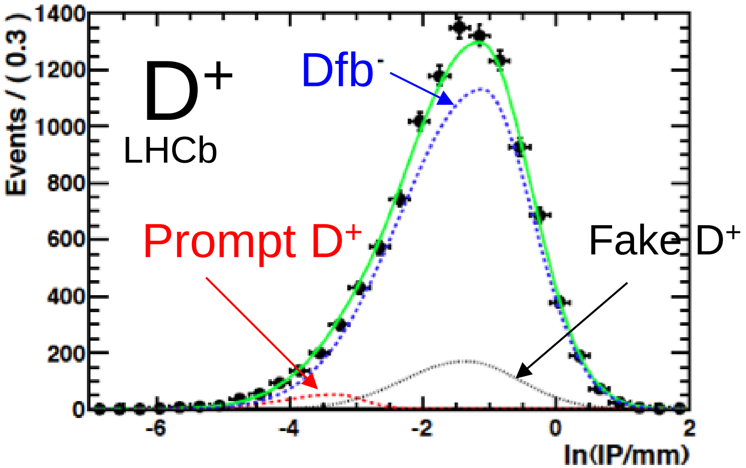
Discrimination

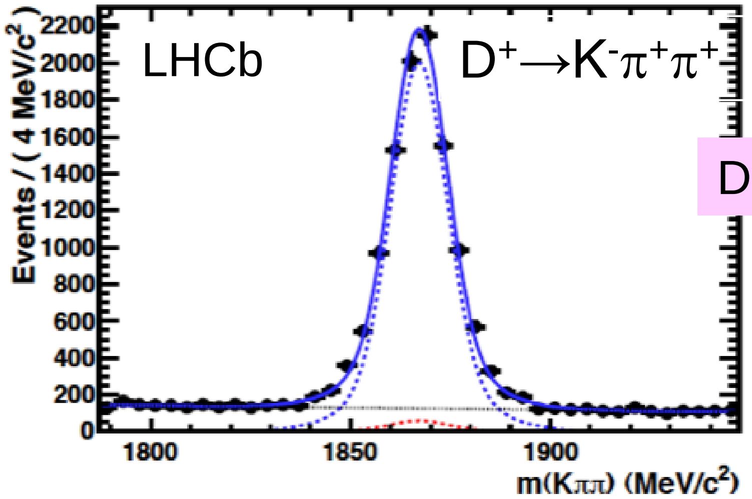
- LHCb uses $B \to h^+h^-$ to tune cuts for a multivariate analysis
- Other variables to discriminate against bkgrd : B impact parameter, B lifetime, B p_t, B isolation, muon isolation, minimum impact parameter of muons, …
- B_s production is measured by using the LHCb measured ratio f_s/f_d. New value of 0.259±0.015



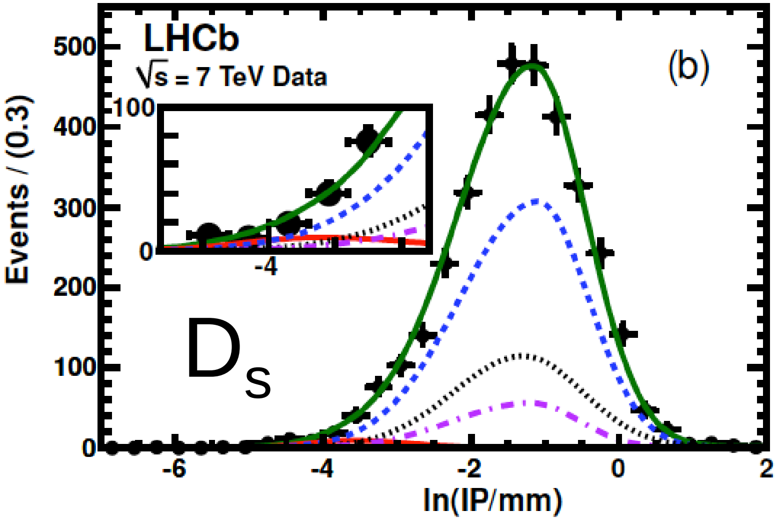


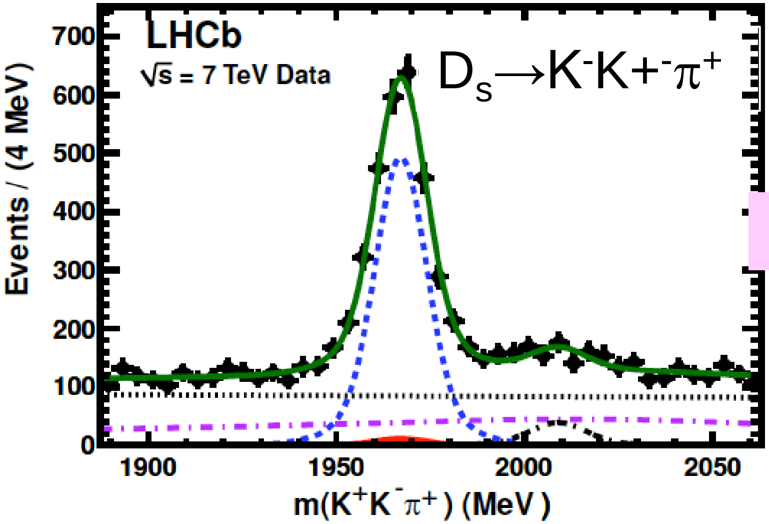
Production fractions: $B \rightarrow DX\mu\nu$ use equality of Γ_{sl} & known τ's





Dfb: 9406±110





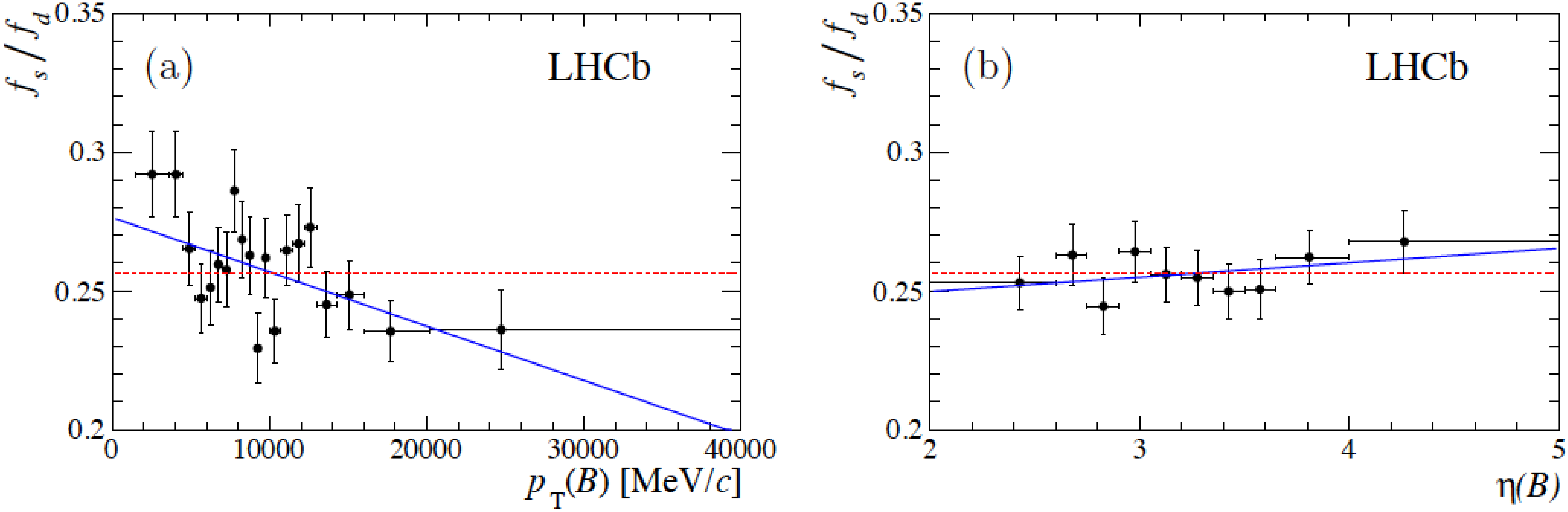
Dfb: 2446±60

Also D^o, Λ_b

P_T & η dependence

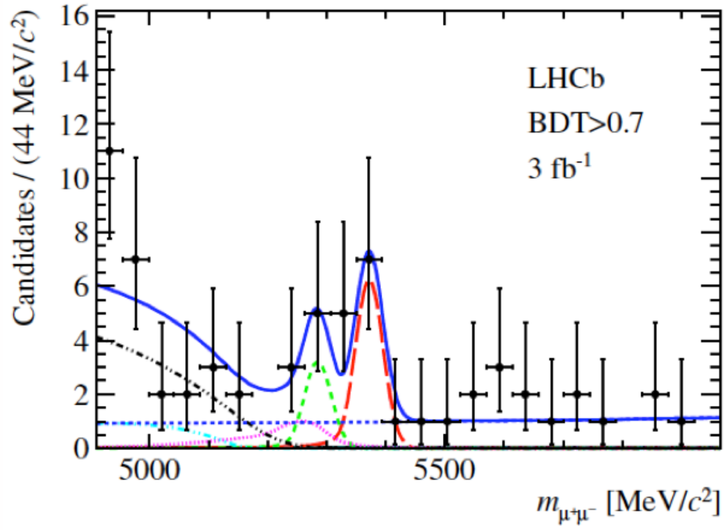
$$\frac{f_s}{f_u+f_d}=\frac{n_{\rm corr}(\bar{B}^0_s\to D\mu)}{n_{\rm corr}(B\to D^0\mu)+n_{\rm corr}(B\to D^+\mu)}\frac{\tau_{B^-}+\tau_{\bar{B}^0}}{2\tau_{\bar{B}^0_s}},$$

- Ncorr(B_s→Dμ) is $D_s\mu$+DKμ
- Also using hadronic B_s & B^0 decays find



Evidence for $B_s \to \mu^+\mu^-$

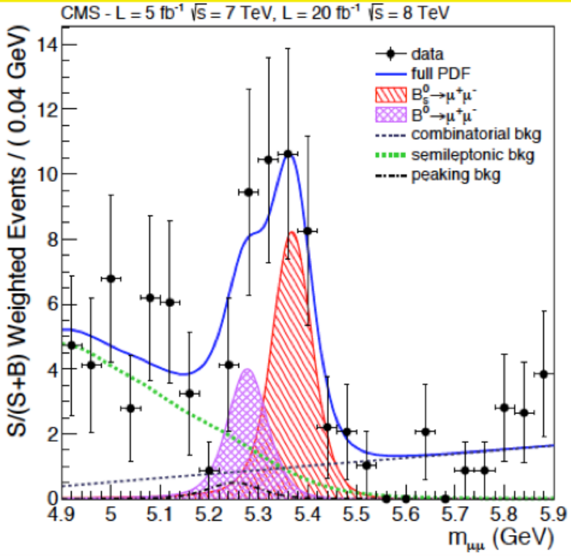
LHCb: arXiv:1307.5024, PRL.111.101805 (2013)



$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (2.9\,^{+1.1}_{-1.0}) \times 10^{-9},$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (3.7\,^{+2.4}_{-2.1}) \times 10^{-10}$$

--> 4.0σ

CMS: arXiv:1307.5025, PRL. 111.101804 (2013)

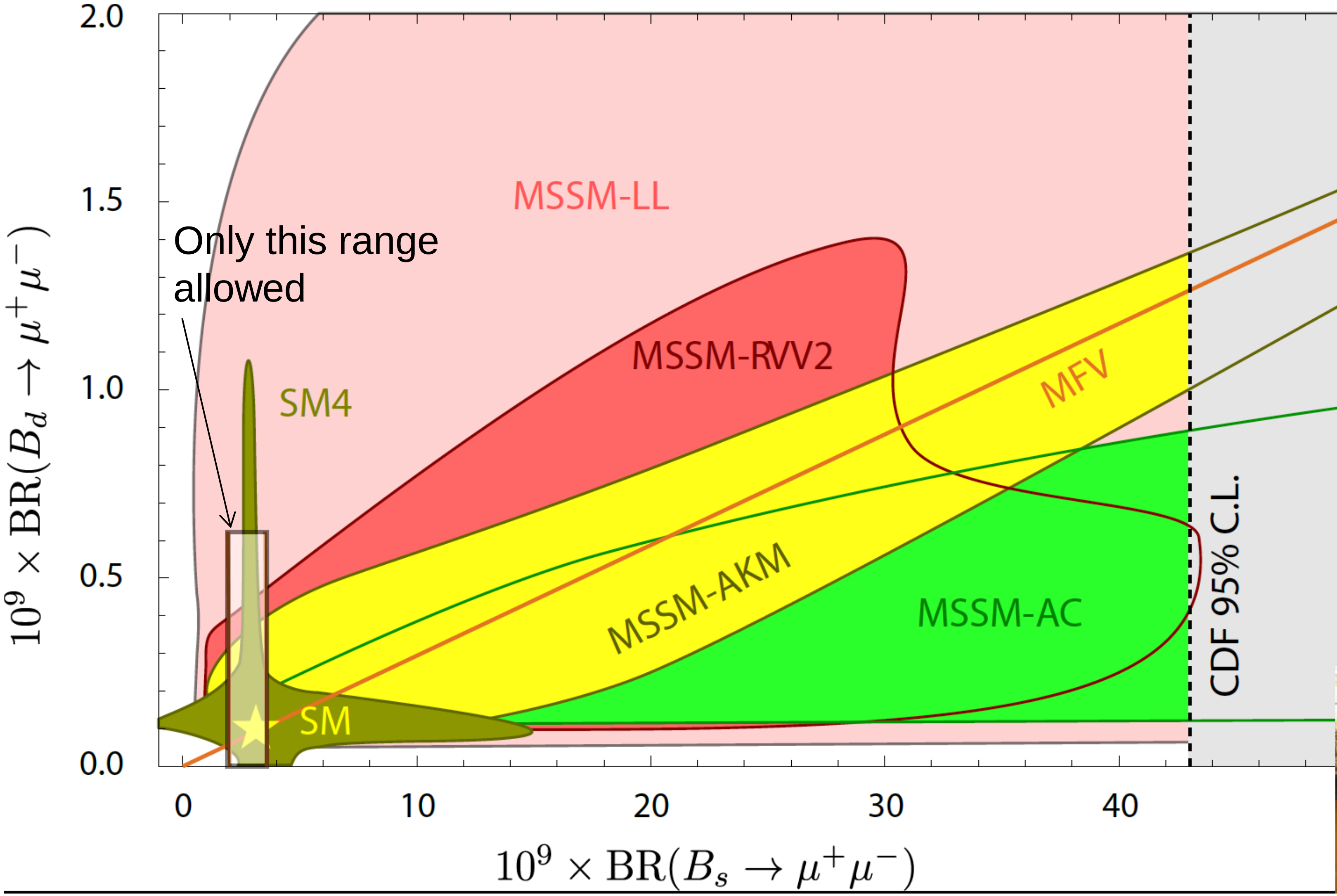


$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.0\,^{+1.0}_{-0.9}) \times 10^{-9},$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (3.5\,^{+2.1}_{-1.8}) \times 10^{-10}$$

--> 4.3σ

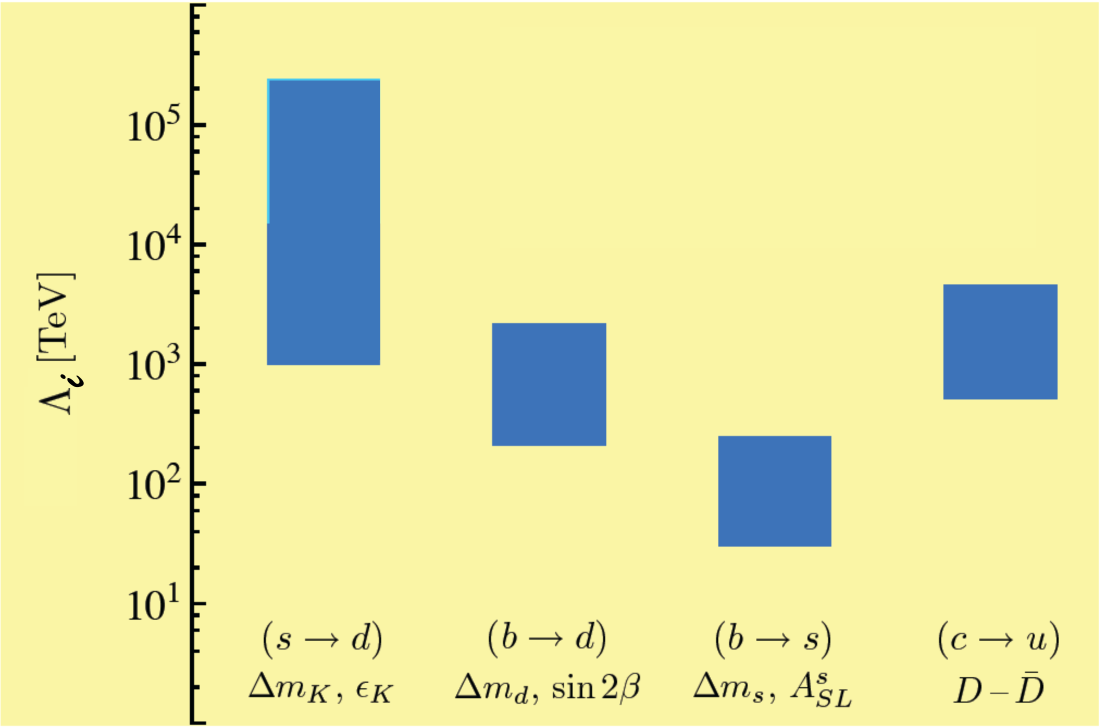
- Avg: $B(B_s \to \mu^+\mu^-) = (2.9 \pm 0.7) \times 10^{-9}$
- Avg: $B(B^0 \to \mu^+\mu^-) = (3.6\,^{+1.6}_{-1.4}) \times 10^{-10}$ (not significant)

Implications


Only this range allowed

Flavor as a High Mass Probe

- Already excluded ranges from box diagrams
  - $\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm SM} + \frac{c_i}{\Lambda_i^2} O_i$, take c_i ~1



Ways out

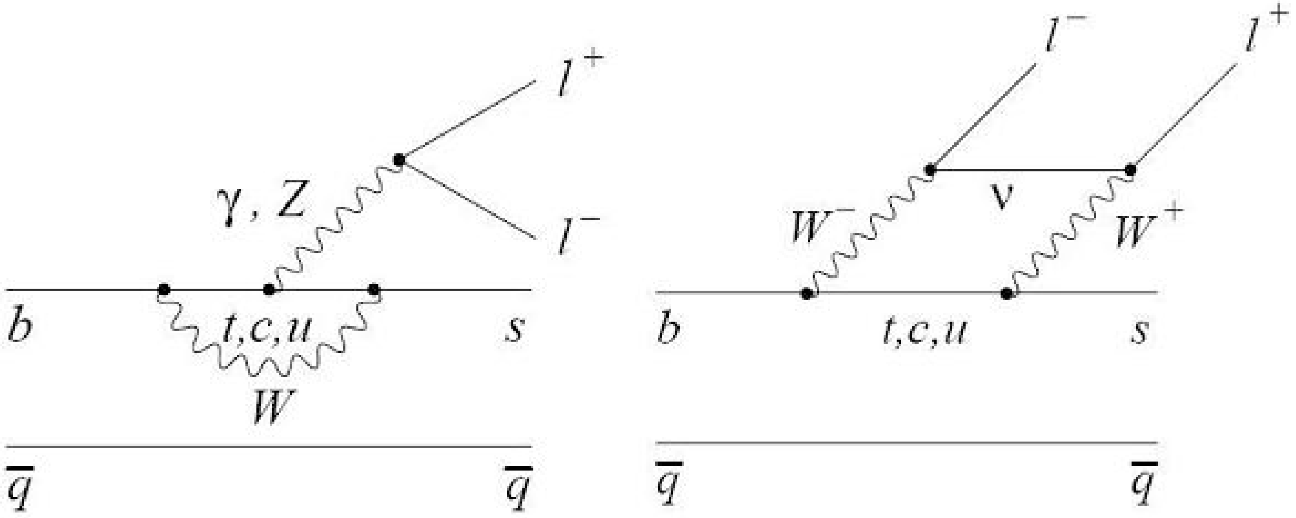
1. New particles have large masses >>1 TeV
2. New particles have degenerate masses
3. Mixing angles in new sector are small, same as in SM (MFV)
4. The above already implies strong constrains on NP

See: Isidori, Nir & Perez arXiv:1002.0900; Neubert EPS 2011 talk

Some hints of discrepancies with SM

$B \to K^{(*)} l^+ l^-$

- Similar to $K^*\gamma$, but more decay paths

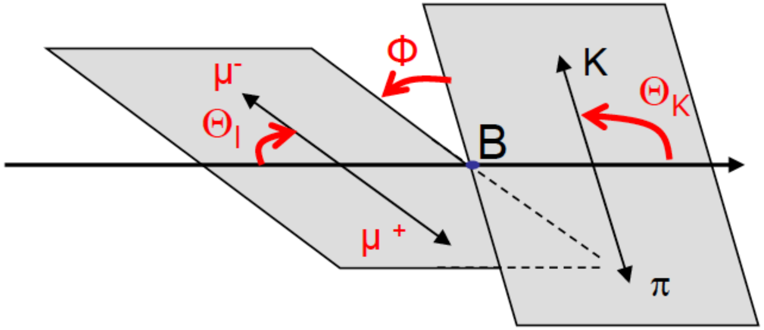


+ new particles in loops

- Several variables can be examined, e.g. muon forward-backward asymmetry, A_{FB} is well predicted in SM

Theory $K^{(*)}l^+l^-$

- Decay described by 3 angles & dimuon invariant mass (q^2)

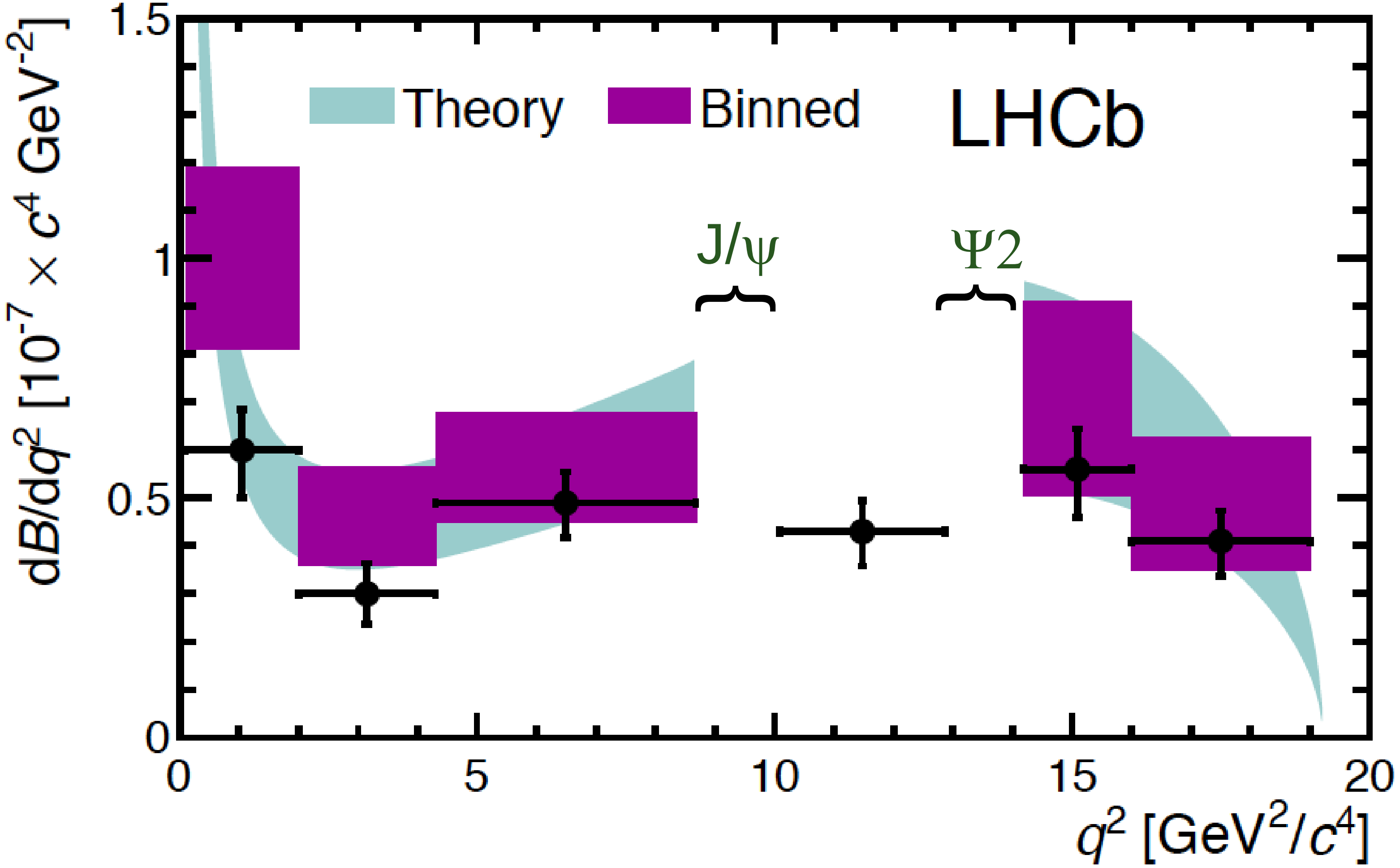


- For each bin in q^2

$$\frac{1}{\Gamma}\frac{d^3(\Gamma+\bar{\Gamma})}{d\cos\theta_\ell\, d\cos\theta_K\, d\phi} = \frac{9}{16\pi}\left[\frac{3}{4}(1-F_L)\sin^2\theta_K + F_L\cos^2\theta_K + \frac{1}{4}(1-F_L)\sin^2\theta_K\cos 2\theta_\ell \right.$$
$$- F_L\cos^2\theta_K\cos 2\theta_\ell + \frac{1}{2}(1-F_L)A_T^{(2)}\sin^2\theta_K\sin^2\theta_\ell\cos 2\phi +$$
$$\left.\frac{1}{2}(1-F_L)A_T^{Re}\sin^2\theta_K\cos\theta_\ell + (S/A)_9\sin^2\theta_K\sin^2\theta_\ell\sin 2\phi\right]$$

- F_L is fraction of longitudinally polarized K^{*0}
- A_{FB}, forward-backward asymmetry $= \frac{3}{4}(1-F_L)A_T^{\mathrm{Re}}$
- SM prediction of q^2 for A_{FB} crossing 0 is $\boxed{q_0^2 = 4.36^{+0.33}_{-0.31}\,GeV^2}$ (Beneke)

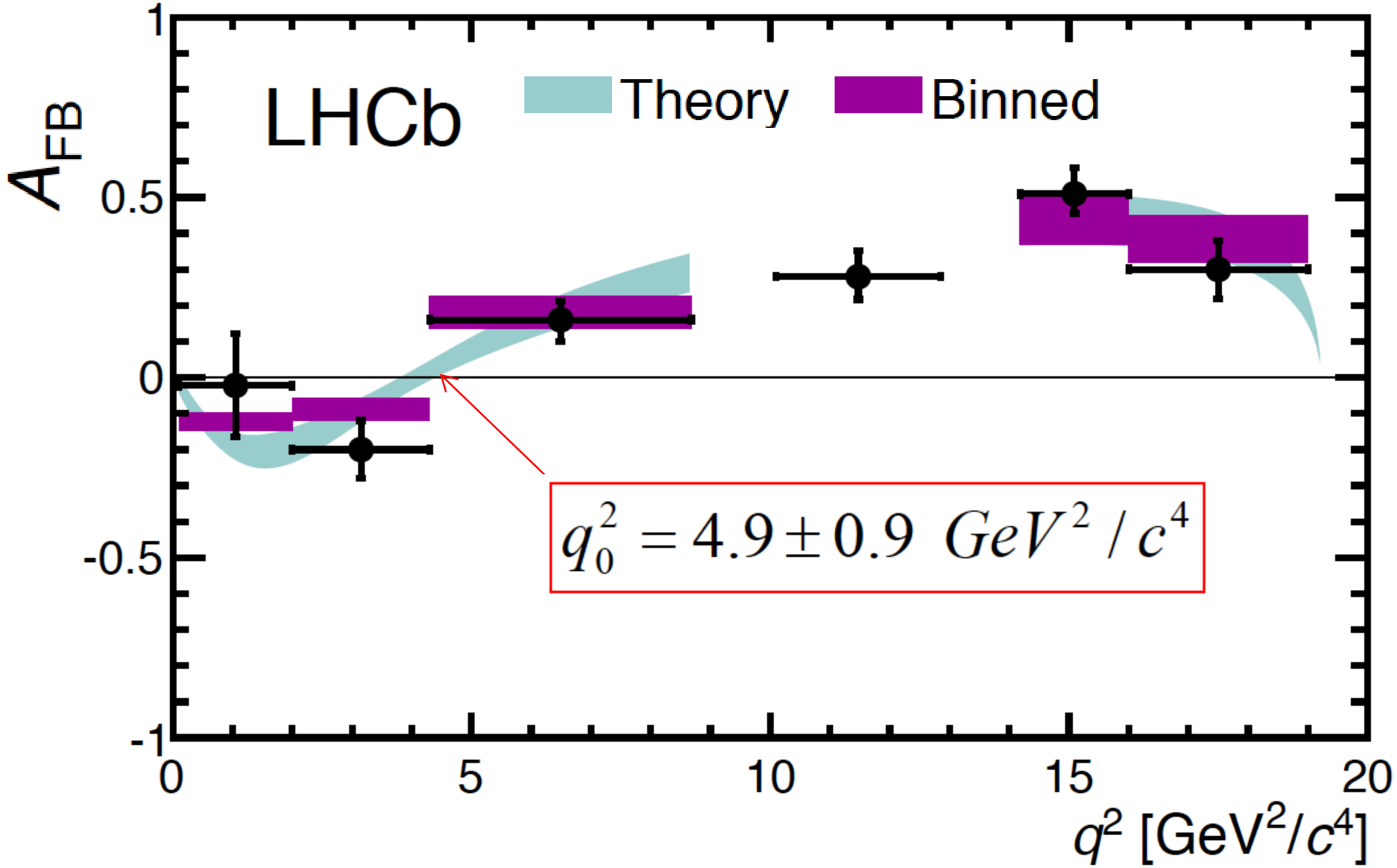
$B^o \rightarrow K^{*o} l^+ l^-$



Other data from CDF, BaBar & Belle

- Conforms to SM predictions by Bobeth et al. & Matias et al

Forward-Backward asymmetry

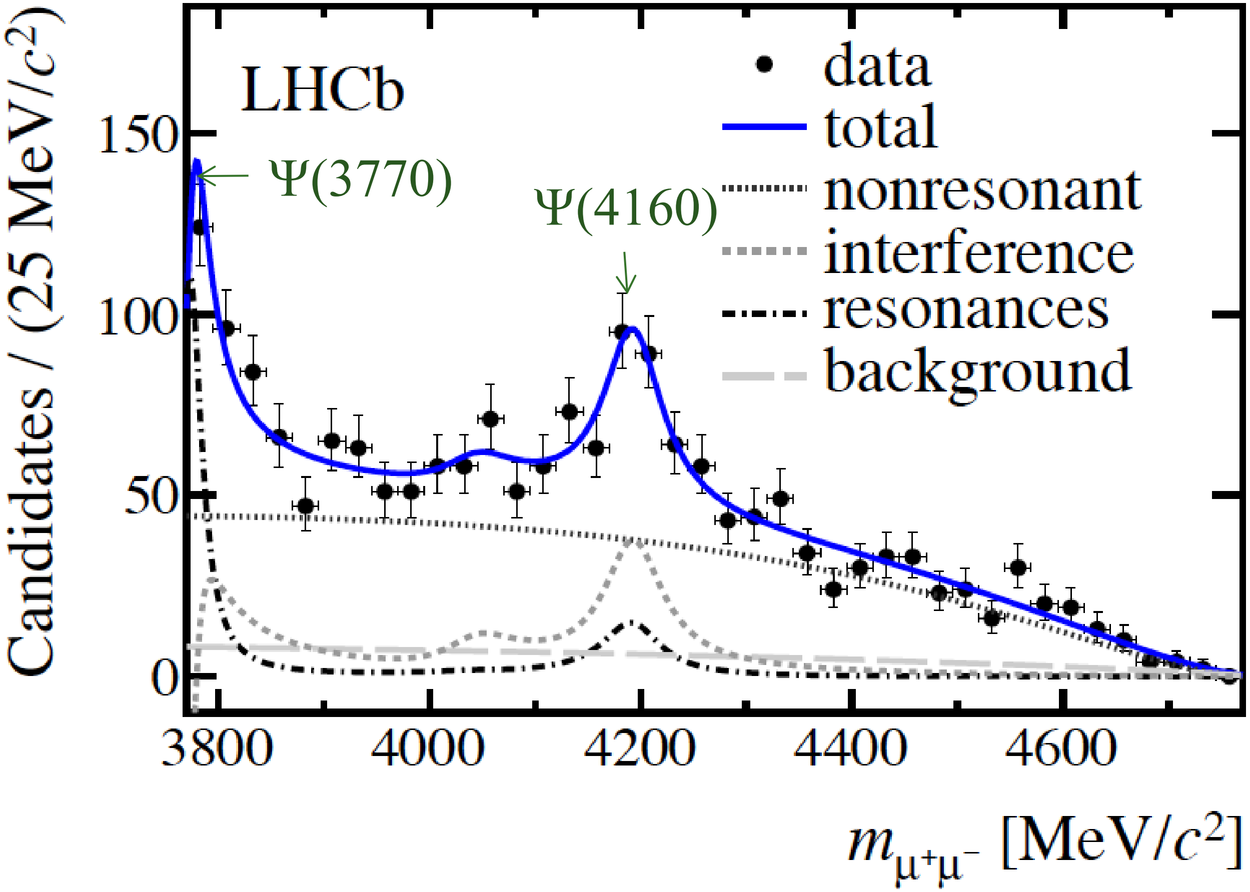


$$q_0^2 = 4.9 \pm 0.9\ GeV^2/c^4$$

No evidence of deviation from SM so far

$B^- \to K^- l^+ l^-$

- Resonances found in high q^2 region
- One would think they would be in $K^{*o} l^+ l^-$ also
- Should affect theory predictions



More ∠variables

- Back to $K^{(*)}l^+l^-$, new observables in formalism designed to less sensitive to hadronic form-factors

Descotes-Genon et al arXiv:1303.5794

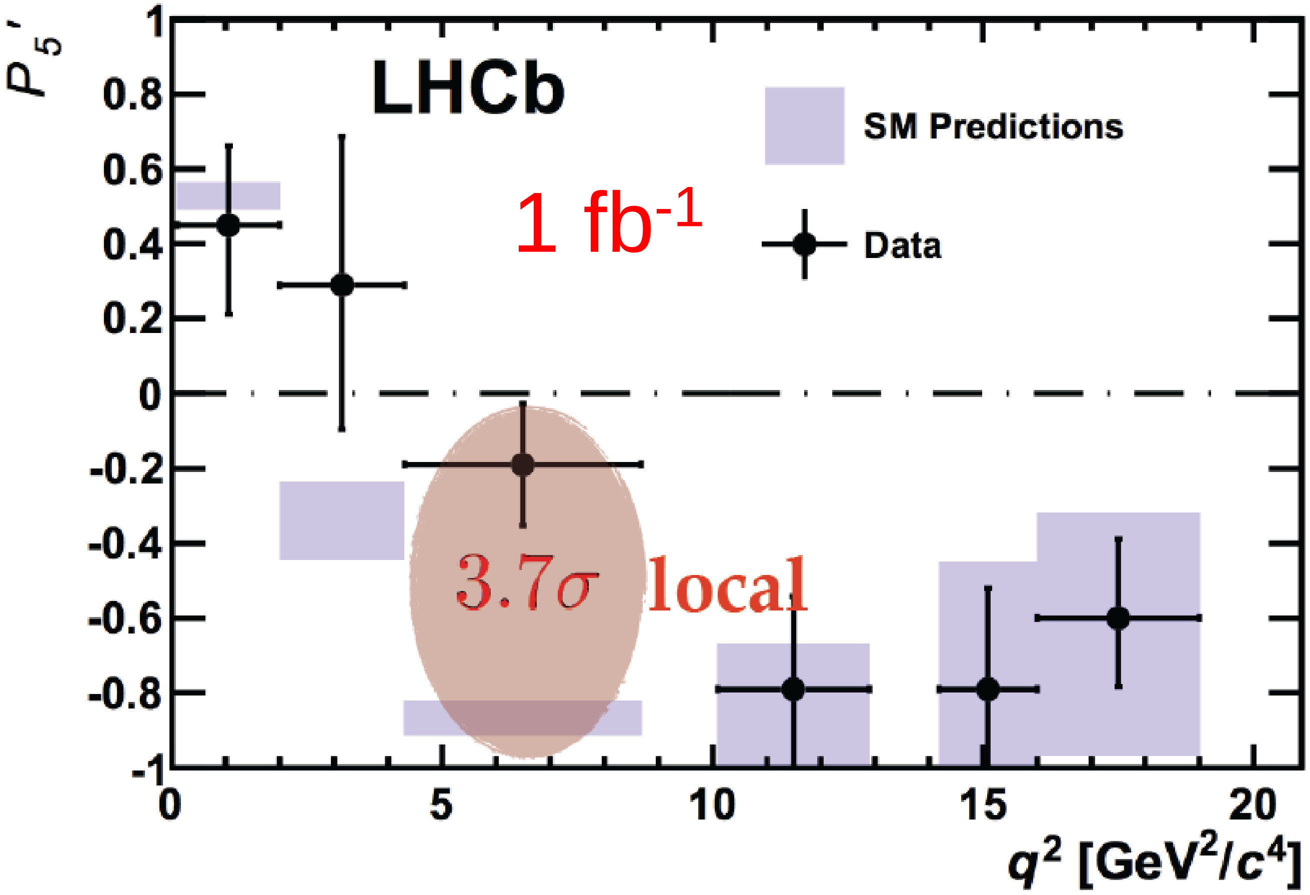
$$\begin{aligned}\frac{1}{\Gamma}\frac{\mathrm{d}^3(\Gamma+\bar{\Gamma})}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\phi} = \frac{9}{32\pi}\Big[&\frac{3}{4}(1-F_{\mathrm{L}})\sin^2\theta_K + F_{\mathrm{L}}\cos^2\theta_K + \frac{1}{4}(1-F_{\mathrm{L}})\sin^2\theta_K\cos 2\theta_\ell \\ &- F_{\mathrm{L}}\cos^2\theta_K\cos 2\theta_\ell + \frac{1}{2}(1-F_{\mathrm{L}})A_{\mathrm{T}}^{(2)}\sin^2\theta_K\sin^2\theta_\ell\cos 2\phi + \\ &\sqrt{F_{\mathrm{L}}(1-F_{\mathrm{L}})}P_4'\sin 2\theta_K\sin 2\theta_\ell\cos\phi + \sqrt{F_{\mathrm{L}}(1-F_{\mathrm{L}})}P_5'\sin 2\theta_K\sin\theta_\ell\cos\phi + \\ &(1-F_{\mathrm{L}})A_{Re}^{\mathrm{T}}\sin^2\theta_K\cos\theta_\ell + \sqrt{F_{\mathrm{L}}(1-F_{\mathrm{L}})}P_6'\sin 2\theta_K\sin\theta_\ell\sin\phi + \\ &\sqrt{F_{\mathrm{L}}(1-F_{\mathrm{L}})}P_8'\sin 2\theta_K\sin 2\theta_\ell\sin\phi + (S/A)_9\sin^2\theta_K\sin^2\theta_\ell\sin 2\phi\ \Big]\end{aligned}$$

Possible deviation

- Could be something,

but significance depends on theoretical model, &

deviation is only in one place



PRL 111, 191801 (2013)

Rare Decays - Generic

- $\mathcal{H}_{\rm eff} = -\frac{4\,G_F}{\sqrt{2}} V_{tb}V_{ts}^* \frac{e^2}{16\pi^2} \sum_i (C_i O_i + C_i' O_i') + \text{h.c.}\ .$
- C_iO_i for SM, $C_i'O_i'$ are for NP. Operators are for $P_{R,L} = (1\pm\gamma_5)/2$

$$O_7 = \frac{m_b}{e}(\bar{s}\sigma_{\mu\nu}P_R b)F^{\mu\nu}\,, \qquad O_8 = \frac{g m_b}{e^2}(\bar{s}\sigma_{\mu\nu}T^a P_R b)G^{\mu\nu\,a}\,,$$

$$O_9 = (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \ell)\,, \qquad O_{10} = (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu\gamma_5 \ell)\,,$$

$$O_S = m_b(\bar{s}P_R b)(\bar{\ell}\ell)\,, \qquad O_P = m_b(\bar{s}P_R b)(\bar{\ell}\gamma_5 \ell)\,,$$

- O'=O with $P_{R,L}\rightarrow P_{L,R}$
- Each process depends on a unique combination

Other Processes

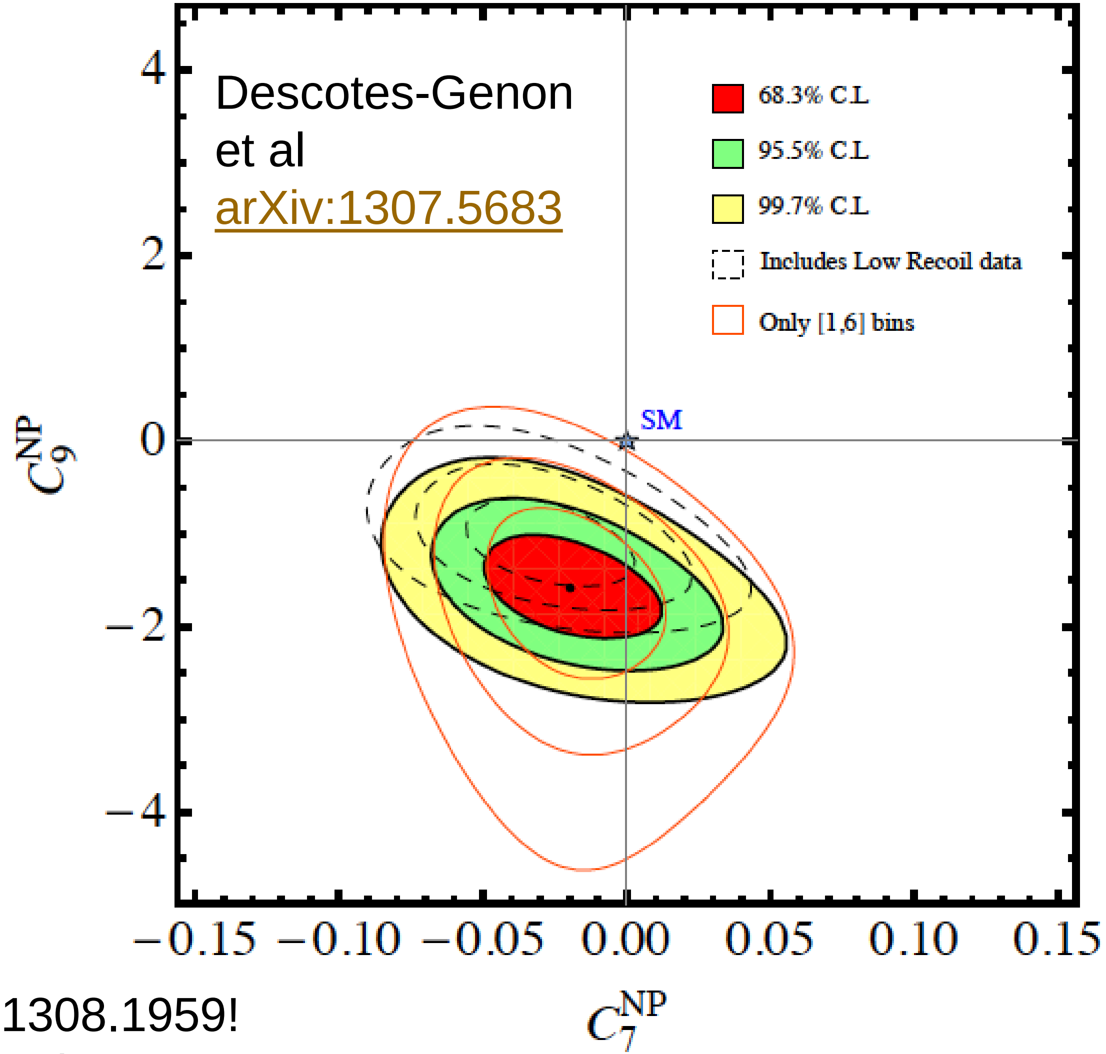
- Other processes probe different operators
- Let δCi=C_i(NP)-C_i(SM)
- Examples:

$$\mathcal{B}(B \to X_s \mu^+ \mu^-) = 10^{-7} \times \left[\sum_{i,j=0,7,7',9,9',10,10'} b_{(i,j)} \delta C_i \delta C_j \pm \delta_b \right]$$

$$\mathcal{B}(\bar{B} \to X_s \gamma)_{E_\gamma > 1.6\,\mathrm{GeV}} = \Big[a_{(0,0)} \pm \delta_a + a_{(7,7)} \left[(\delta C_7)^2 + (\delta C_{7'})^2 \right] + \\ + a_{(0,7)}\, \delta C_7 + a_{(0,7')}\, \delta C_{7'} \Big] \cdot 10^{-4}$$

Maximizing deviations

- Filled bands: $B\rightarrow K^*\mu^+\mu^-$, $K^*\gamma$ & $B_s\rightarrow\mu^+\mu^-$
- Dashed: all q^2 for $K^*\mu^+\mu^-$
- Orange: only $1<q^2<6$ GeV^2 for $K^*\mu^+\mu^-$
- Some suggest a 7 TeV Z′

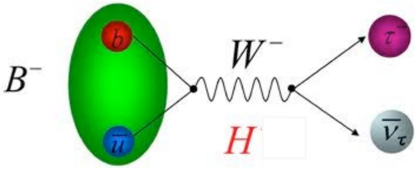


Descotes-Genon et al arXiv:1307.5683

Gauld et al arXiv:1308.1959!
Buras, Girrbach arXiv:1309.2466

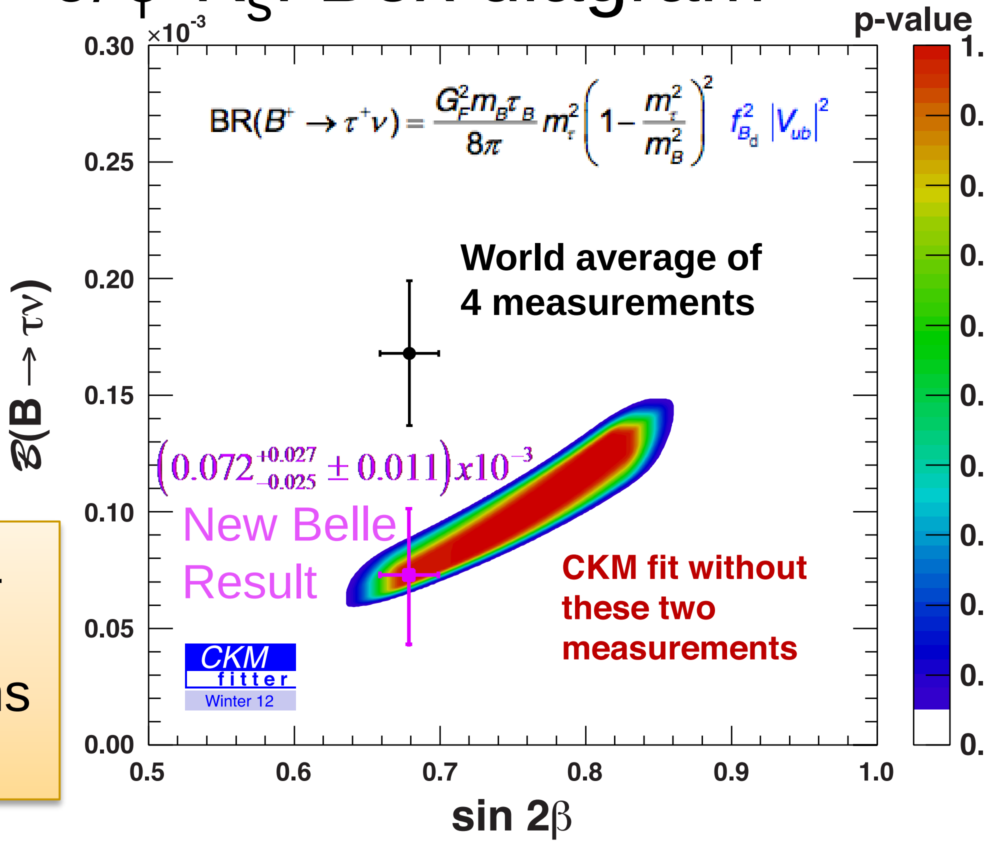
$B^- \to \tau^- \bar{\nu}$ problem?

- $B^- \to \tau^- \nu$, tree process:



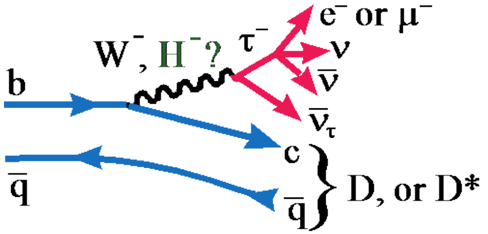
Can be new particles instead of W^- but why not also in $D^+_{(s)} \to \ell^+ \nu$?

- sin2β, CPV in e.g. $B^o \to J/\psi\ K_s$: Box diagram
- Measurement not in good agreement with SM prediction based on CKM fit

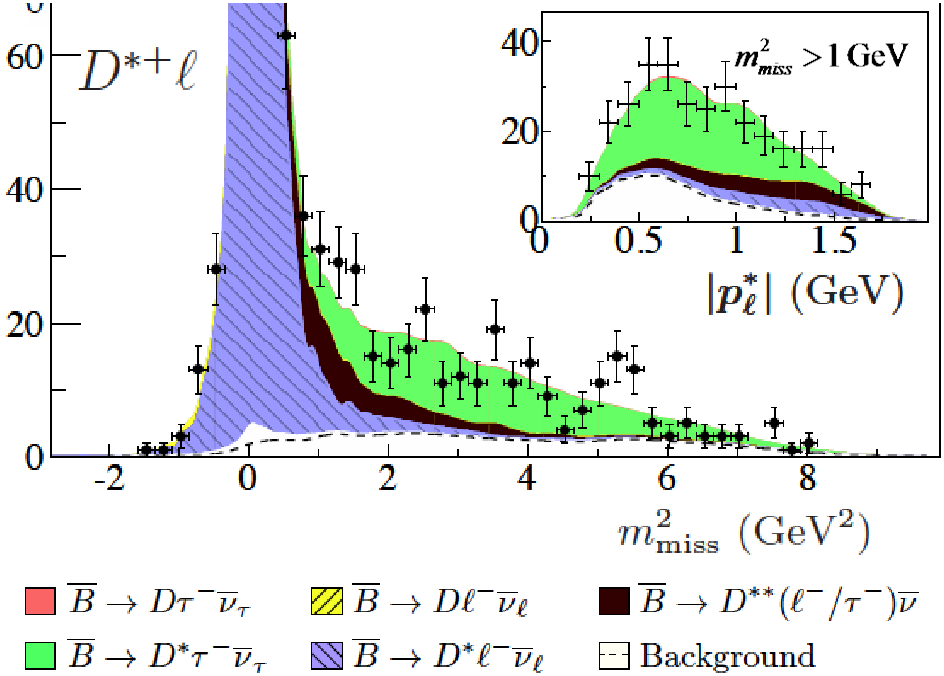


New Belle measurement in using 1 method. Discrepancy may be resolved, but 3 other determinations need to be checked

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



- Also, tree level – BaBar result
- Similar to $B^- \rightarrow \tau^-\nu$ analysis
- Fully reconstruct one B, keep events with an additional $D^{(*)}$ plus an e^- or μ^-.
- Signal is wide, background, especially $D^{**}l\,\nu$, needs careful estimation

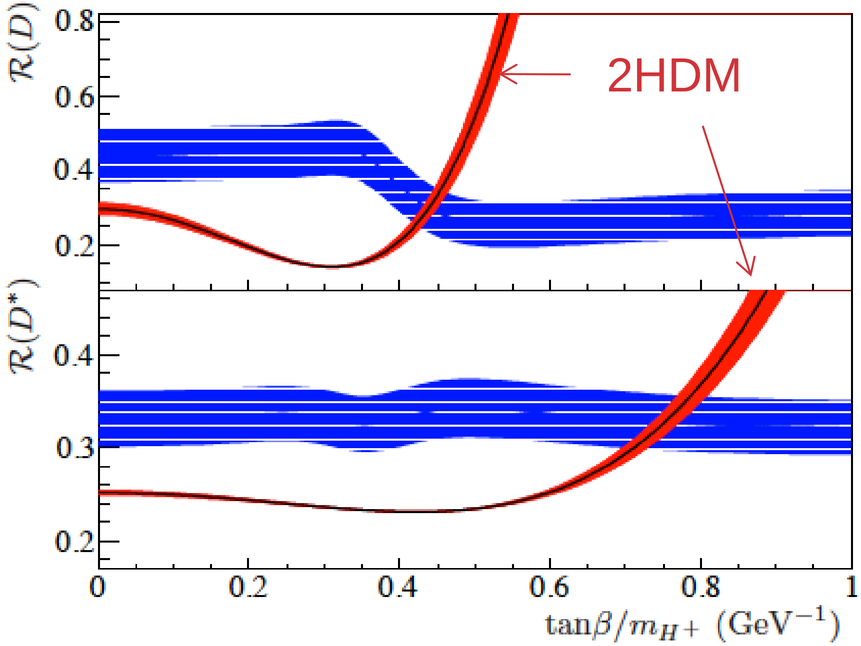


$B\to D^{(*)}\tau\nu$ II

- Results given in terms of ratio to $B\to D^{(*)}l\nu$

	SM Theory	BaBar value	Diff.
R(D)	0.297±0.017	0.440±0.058±0.042	+2.0σ
R(D*)	0.252±0.003	0.332±0.024±0.018	+2.7σ

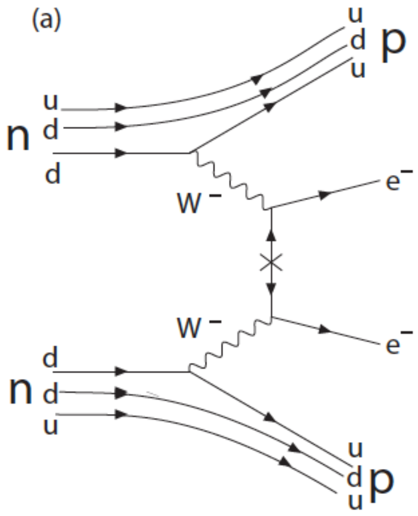
- Sum is 3.4σ above SM
- Also inconsistent with type II 2HDM

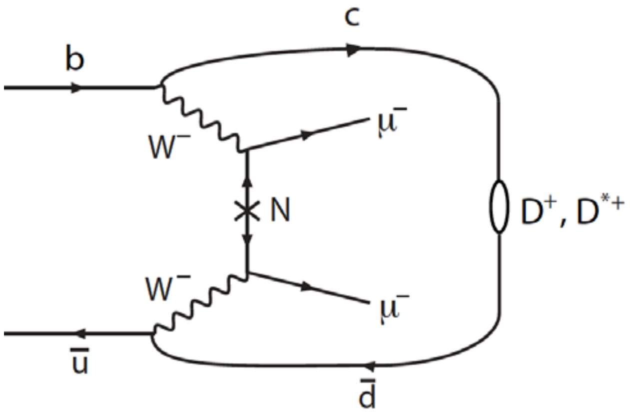


Other searches

Majorana ν’s

- Several ways of looking for presence of heavy ν’s (N) in heavy quark decays if they Majorana (their own anti-particles) and couple to “ordinary” ν’s
- Modes analogous to ν–less nuclear β decay





Simplest Channels: $B^- \to D^+ l^- l'^-$ & $B^- \to D^{*+} l^- l'^-$

l^- & l'^- can be e^-, μ^- or τ^-.

Limits on $D^{(*)+}l^- l'^-$

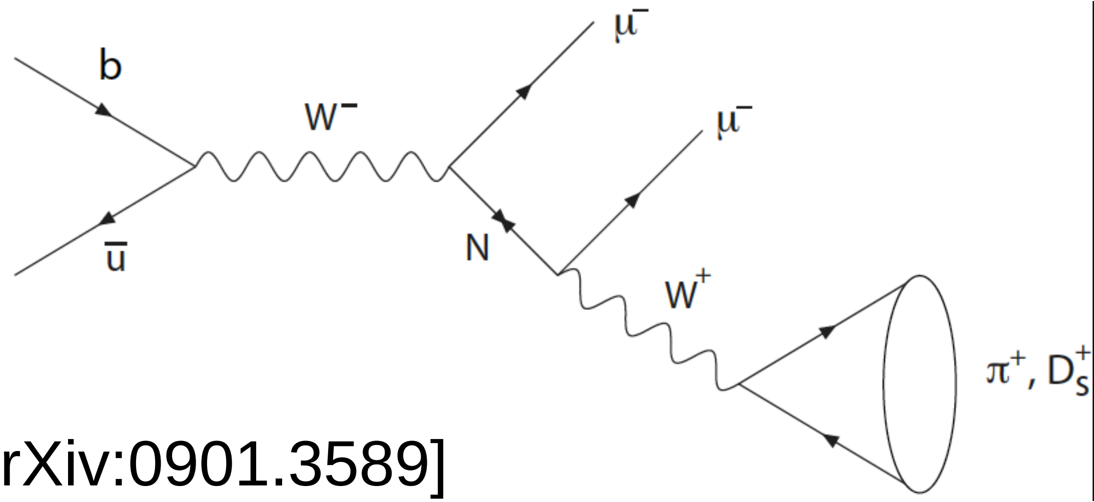
- Upper limits in e^-e^- mode not competitive with nuclear β decay
- Others unique since measure coupling of Majorana ν to μ^-

Mode	Exp.	u. l. x 10^{-6}
$B^-\rightarrow D^+e^-e^-$	Belle	< 2.6
$B^-\rightarrow D^+e^-\mu^-$	Belle	< 1.8
$B^-\rightarrow D^+\mu^-\mu^-$	Belle	< 1.0
$B^-\rightarrow D^+\mu^-\mu^-$	LHCb	< 0.69
$B^-\rightarrow D^{*+}\mu^-\mu^-$	LHCb	< 3.6

Belle [arXiv:1107.064]

On-Shell ν

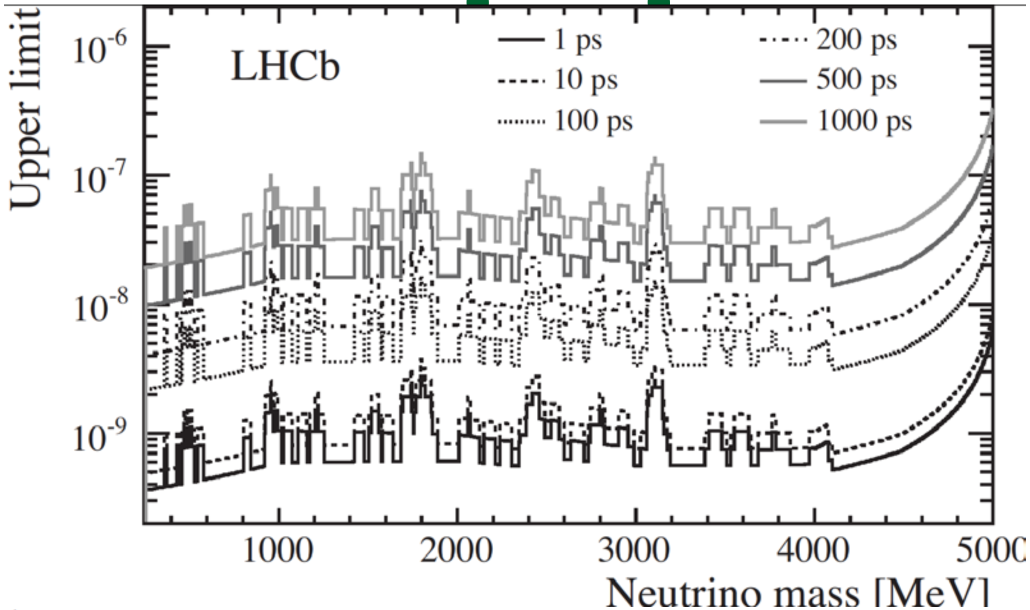
- Can also look for Majorana ν (N), where $N \rightarrow W^+\mu^-$

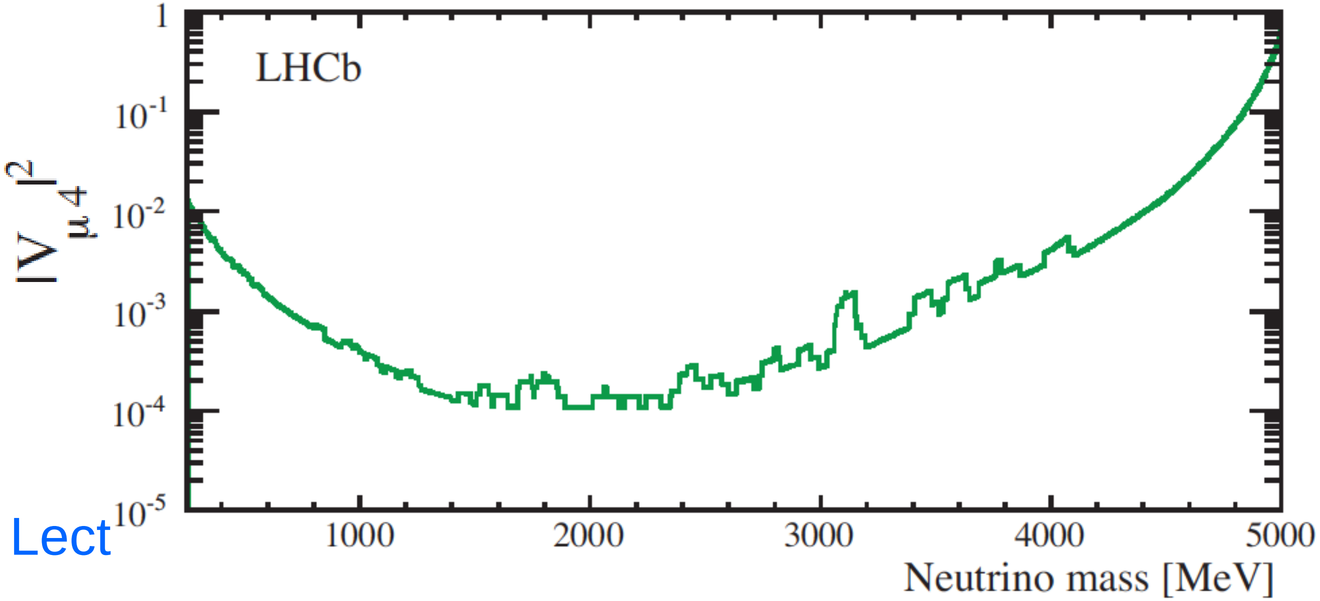


- A. Atre, T. Han, S. Pascoli, & B. Zhang [arXiv:0901.3589]
- Many other ways of searching:
  - K^-□π^-N
  - μ^-□$e^-\gamma$
  - τ^-□$\mu^+\pi^-\pi^-$
  - □..

$B^- \to \pi^+\mu^-\mu^-$

- LHCb search as a function of Majorana neutrino mass and lifetime



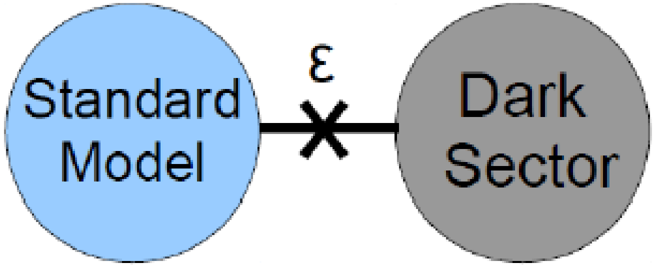


The Dark Sector

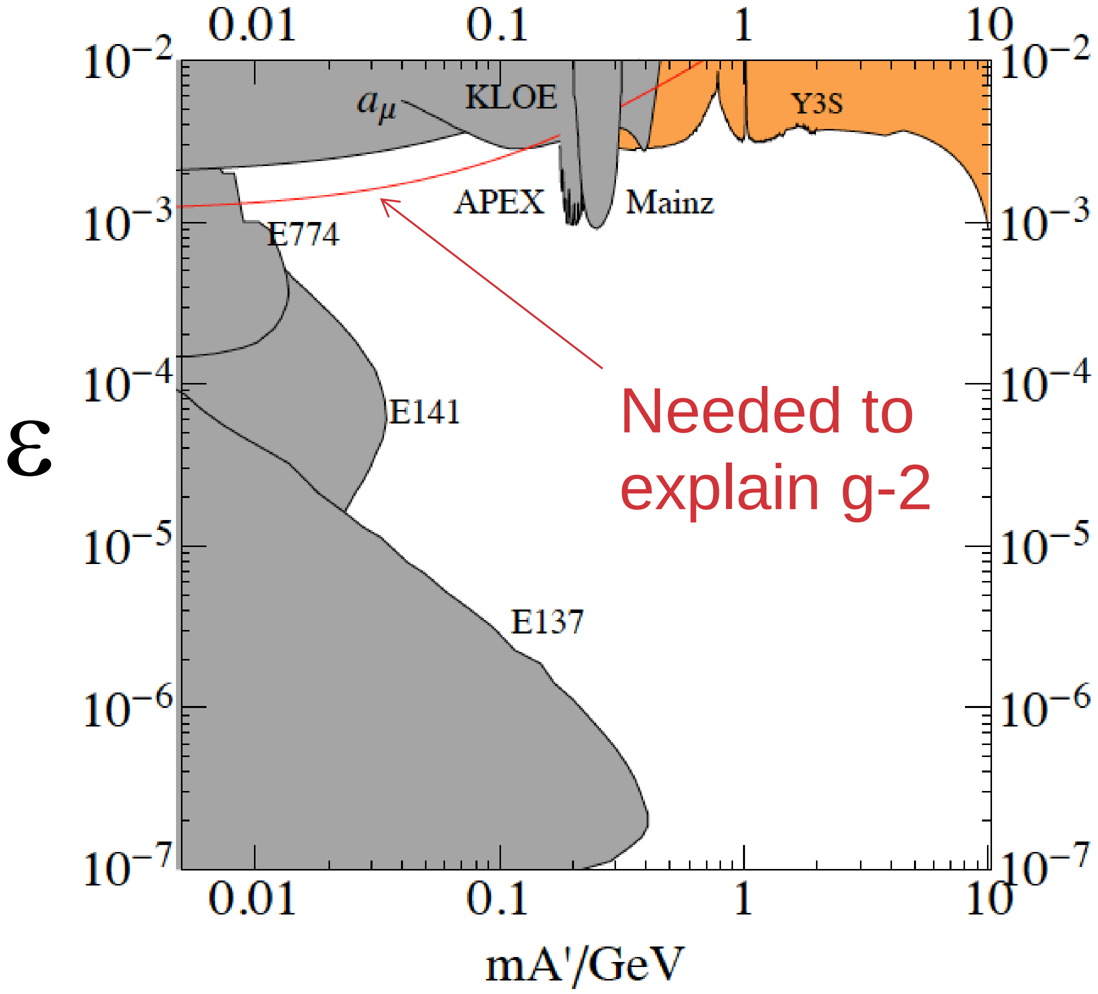
- Could it be that there are 3 classes of matter?
  - SM particles with charges [SU(3)xSU(2)xU(1)]
  - Dark matter particles with “dark” charges
  - Some matter having both (“mediators”)
- Searches for “dark photons”
  - A mediator, couples to b-quarks (see arXiv:056151 hep/ph)
  - BaBar $\mathcal{B}(Y(1S)\to \text{invisible})<3\times10^{-4}$ @ 90% cl
  - Other experiments

Search Summary

- Parameterize by mixing ε



- Dark photon mass mA´



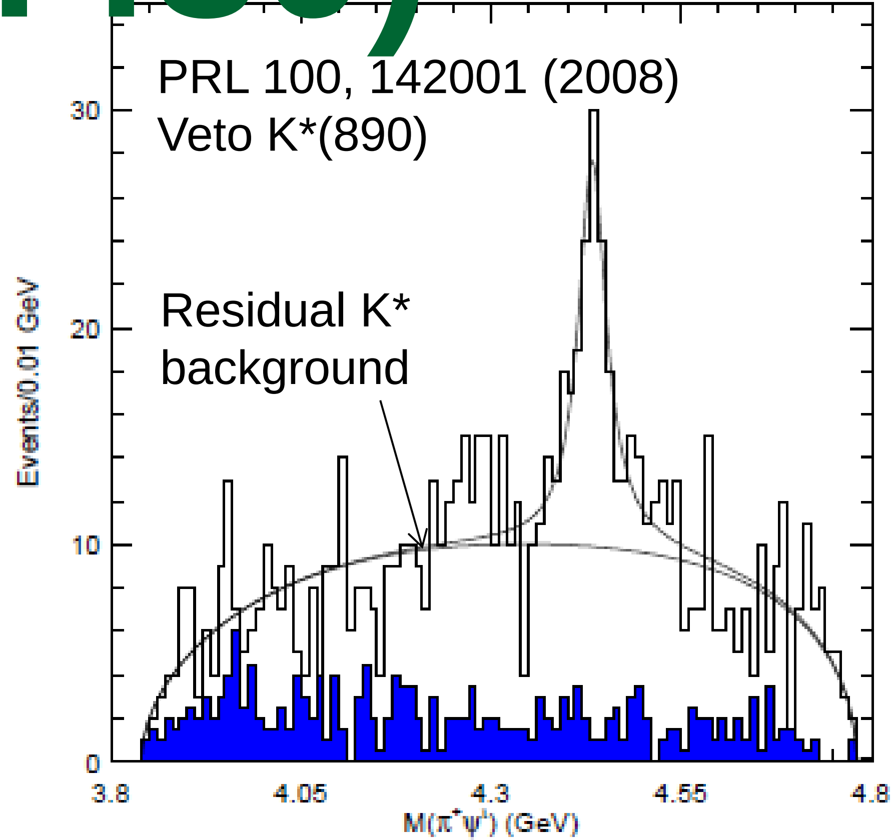
Needed to explain g-2

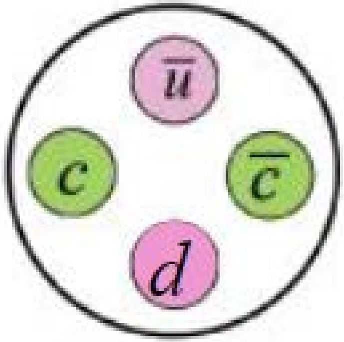
From B. Echenard arXiv:1205.3505

Tetraquarks, both heavy & light

Z (4430)$^-$

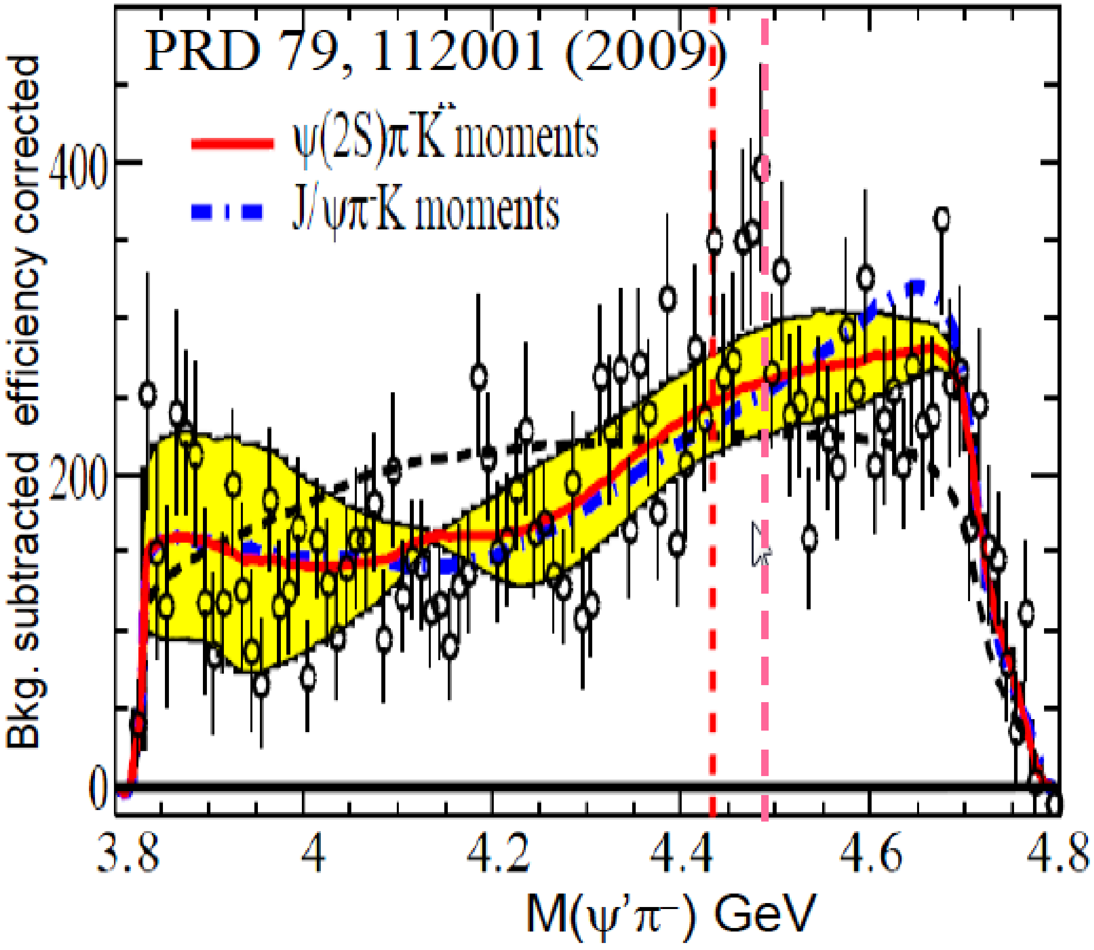
- Belle 2008: $B^0 \rightarrow J/\psi\pi^- K^+$. Claimed resonant signal decaying into $J/\psi\pi^-$ at 4430 MeV ⇒ a charged “charmonium” state, not possible with only $c\bar{c}$
- Tetraquark candidate


PRL 100, 142001 (2008)
Veto K*(890)
Residual K* background



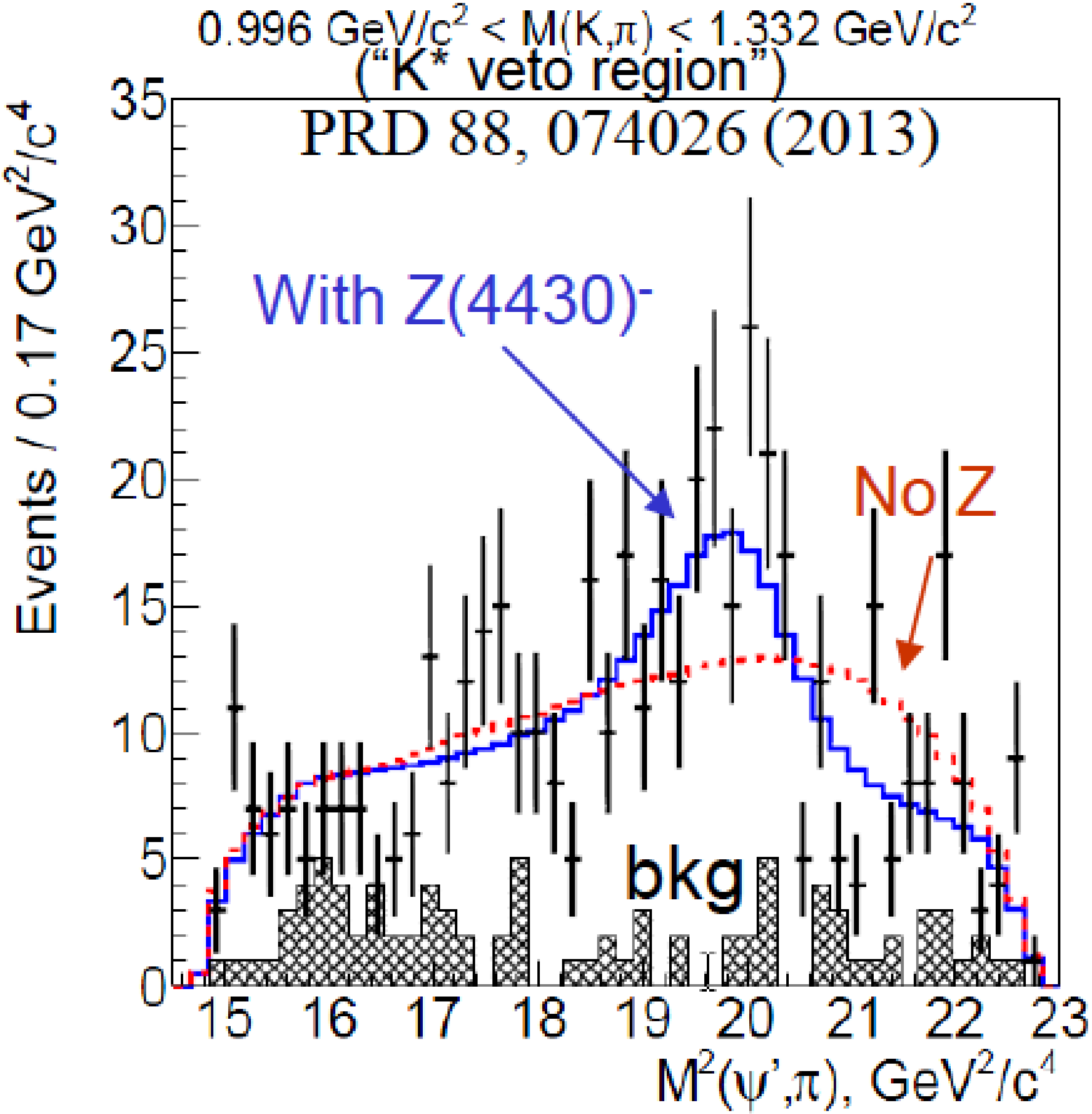
But not BaBar

- BaBar shows that moments of $K^+\pi^-$ resonances can reflect in mass peak
- Data are compatible with Belle
- Difference is in interpretation

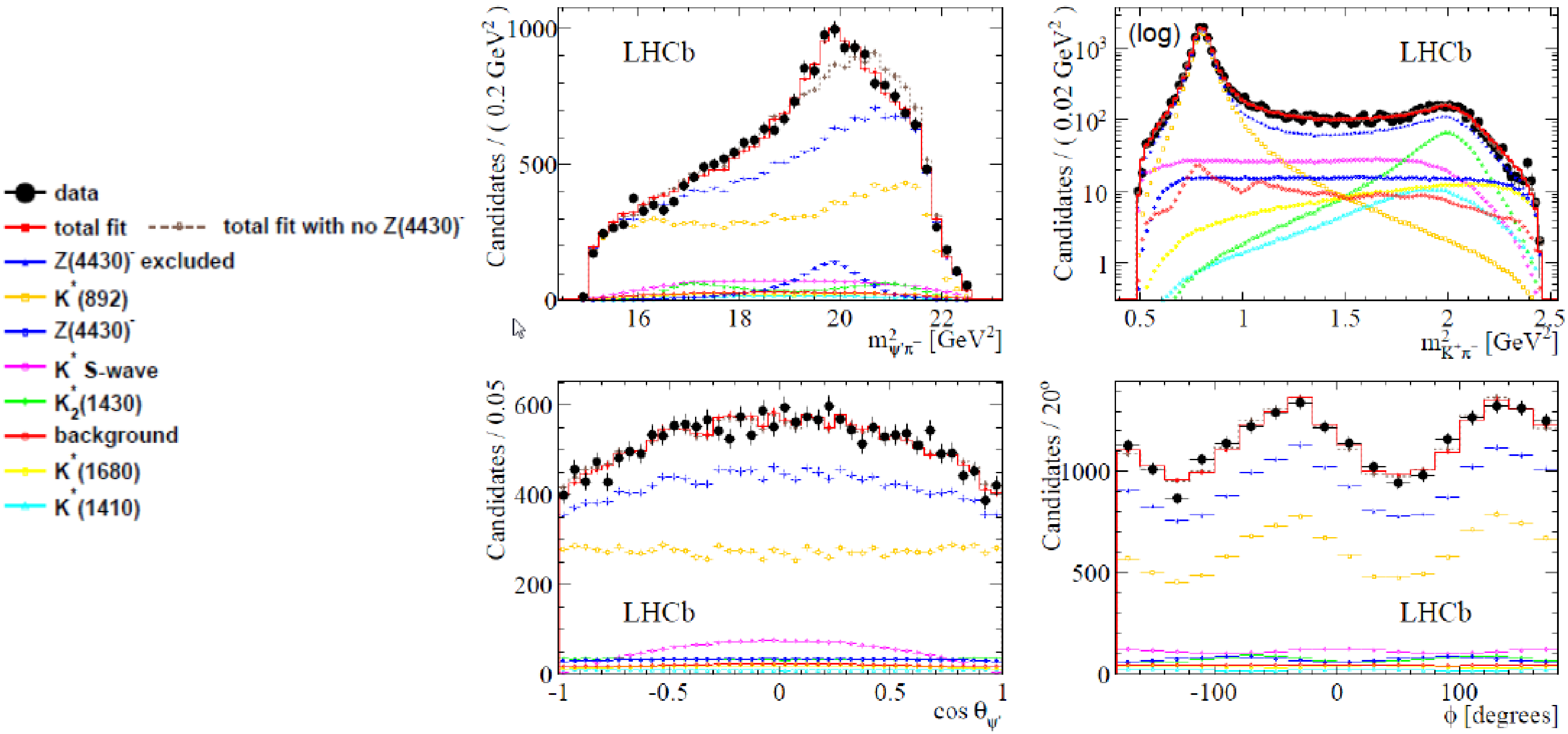


Belle does 4D amplitude fit

- New fit confirms observation, but questions remain



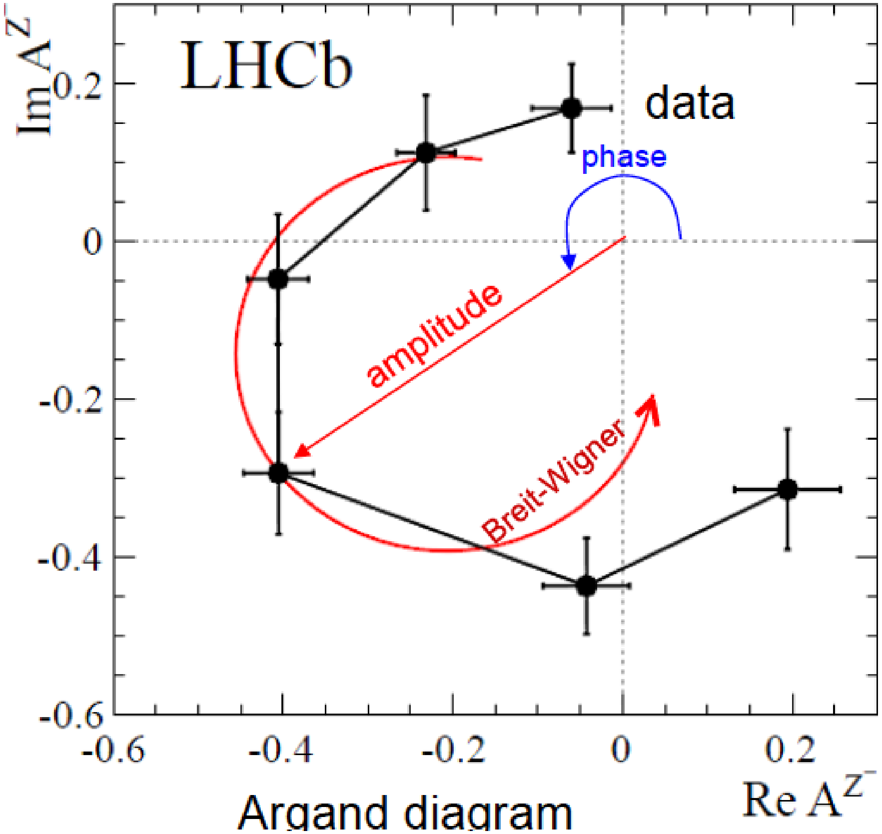
LHCb full fit for 1^+ Z



- p value of 12%   arXiv:1404.1903

Argand diagram

- Replace the Breit-Wigner amplitude for Z(4430)$^-$ by 6 independent amplitudes in $m_{\psi'\pi^-}{}^2$ bins in its peak region



Rapid phase transition at the peak of the amplitude → resonance!

First time ever the resonant character of the four-quark candidate has been demonstrated this way!

arXiv:1404.1903

Scalar octet problem

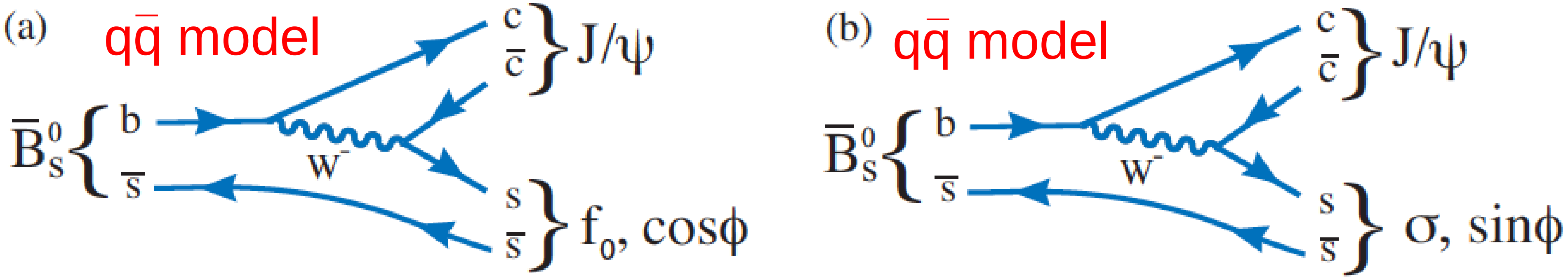
- 0^+ vs 1^- meson masses (charge = 0)

$$\begin{array}{llll}
I=0: m[f_0(600)] \approx 500\text{ MeV} & & I=1: m[\rho(776)] \approx 776\text{ MeV} \\
I=1/2: \quad m[\kappa] \approx 800\text{ MeV} & & I=0: m[\omega(783)] \approx 783\text{ MeV} \\
I=0: m[f_0(980)] \approx 980\text{ MeV} & & I=1/2: m[K^*(892)] \approx 892\text{ MeV} \\
I=1: m[a_0(980)] \approx 980\text{ MeV} & & I=0: m[\phi(1020)] \approx 1020\text{ MeV}
\end{array}$$

- For 1^-, adding an s quark increases meson mass
- Suggestions that 0^+ mesons are tetraquarks
- For $q\bar{q}$, $\sigma \equiv f_0(500)$ & $f_0(980)$ are mixed with $f_0(980)$ mostly $s\bar{s}$
- As tetraquarks $|f_0\rangle = \frac{1}{\sqrt{2}}\left([su][\bar{s}\bar{u}] + [sd][\bar{s}\bar{d}]\right), \quad |\sigma\rangle = [ud][\bar{u}\bar{d}]$

Suggested B_s test

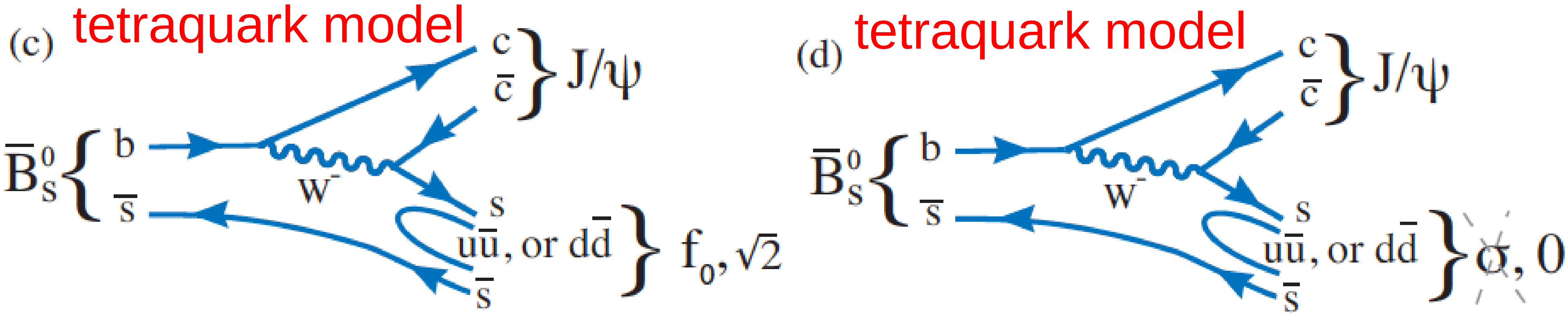
- Here $f_0 \equiv f_0$ (980), $\sigma = f_0$ (500)



$q\bar{q}$ model

$q\bar{q}$ model

Stone & Zhang, Phys.Rev.Lett. 111 (2013) 6, 062001



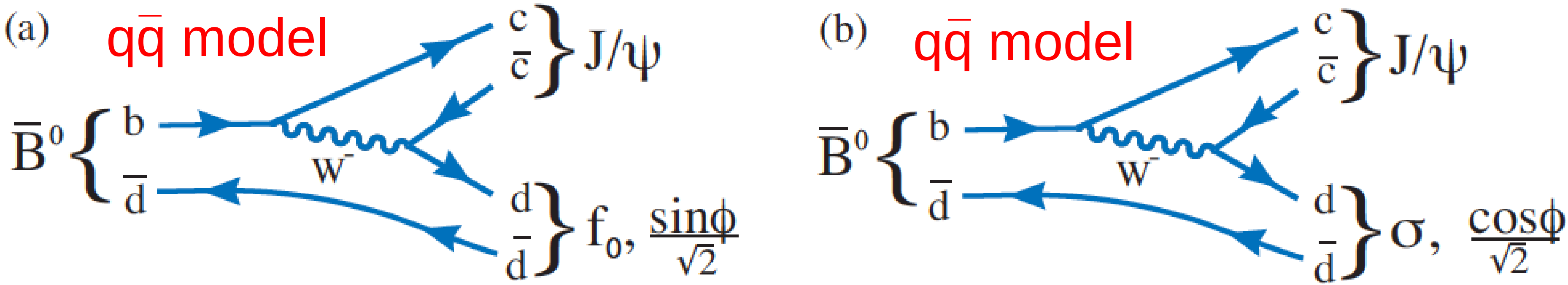
tetraquark model

tetraquark model

- Large f_0 expected in $q\bar{q}$, no σ rate for tetraquark

Suggested B^0 test

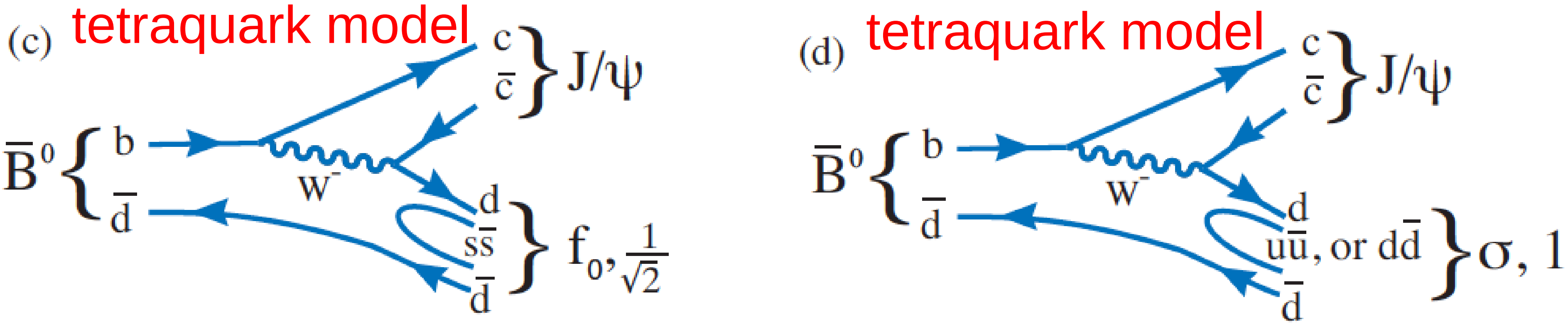
- Here $f_0 \equiv f_0$ (980), $\sigma = f_0$ (500)



(a) $q\bar{q}$ model

(b) $q\bar{q}$ model

Stone & Zhang, Phys.Rev.Lett. 111 (2013) 6, 062001

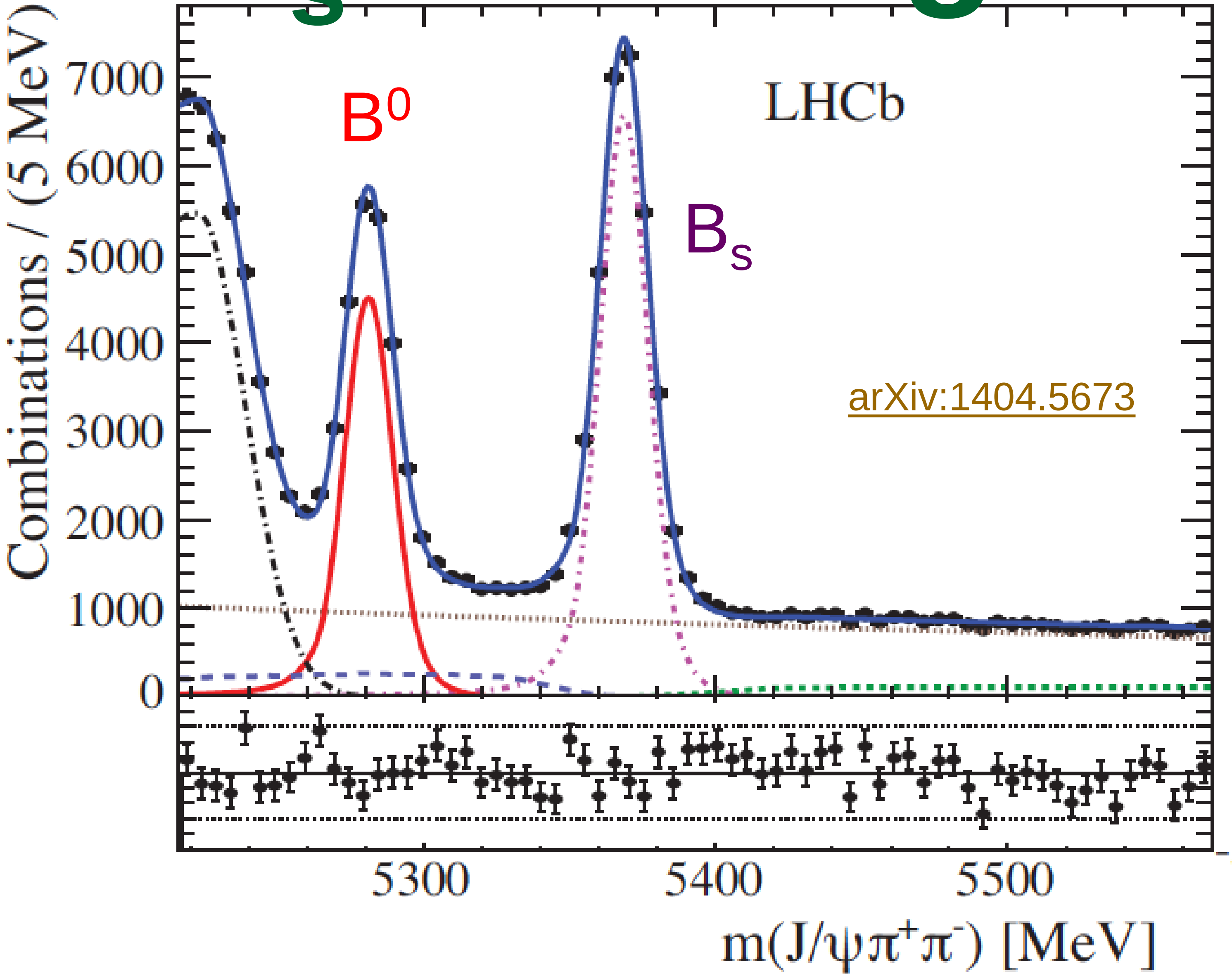


(c) tetraquark model

(d) tetraquark model

- Small f_0 expected in $q\bar{q}$, half of σ rate in tetraquark

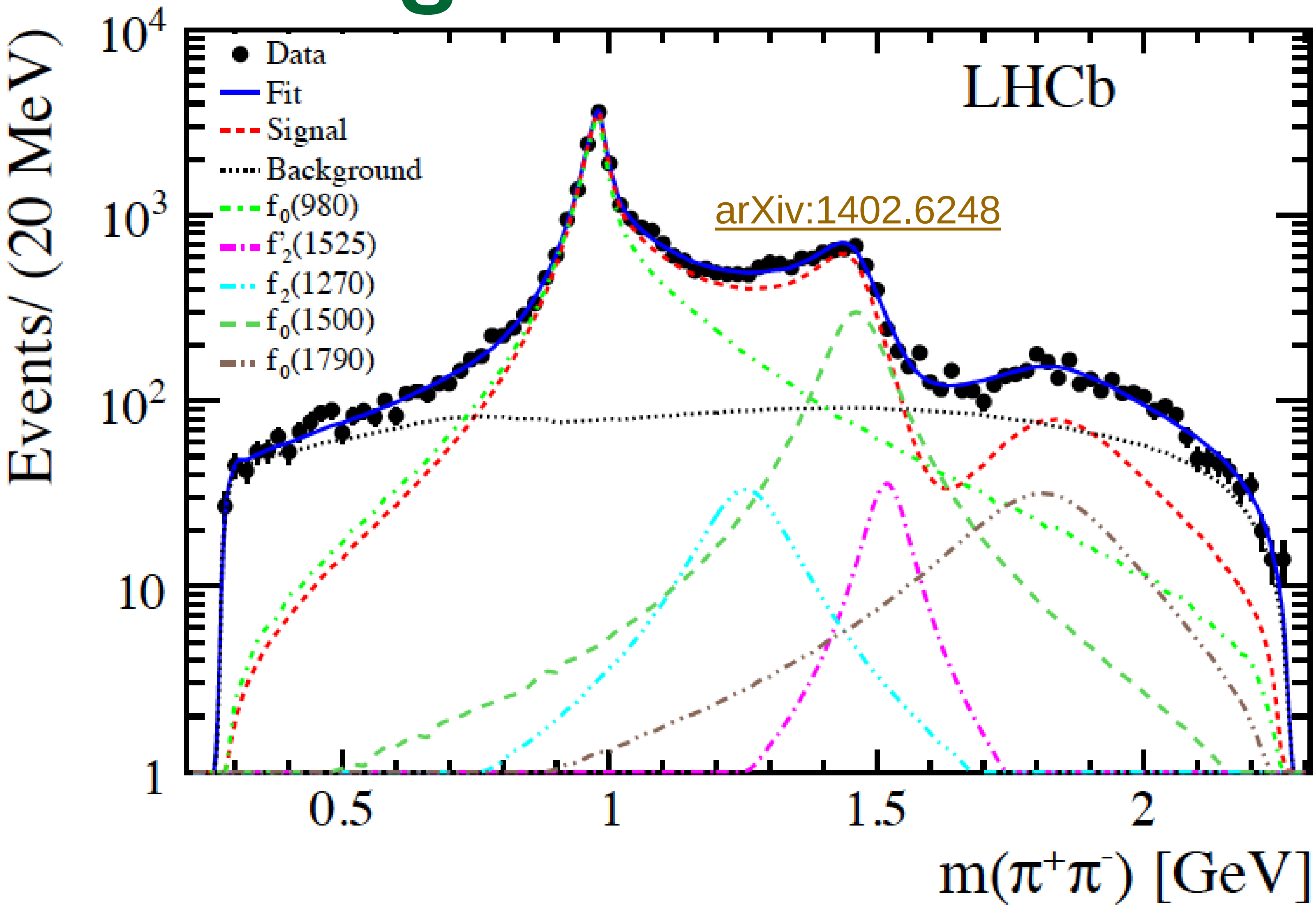
B_s & B^0 signals



arXiv:1404.5673

B_s results

Huge f_0, no σ

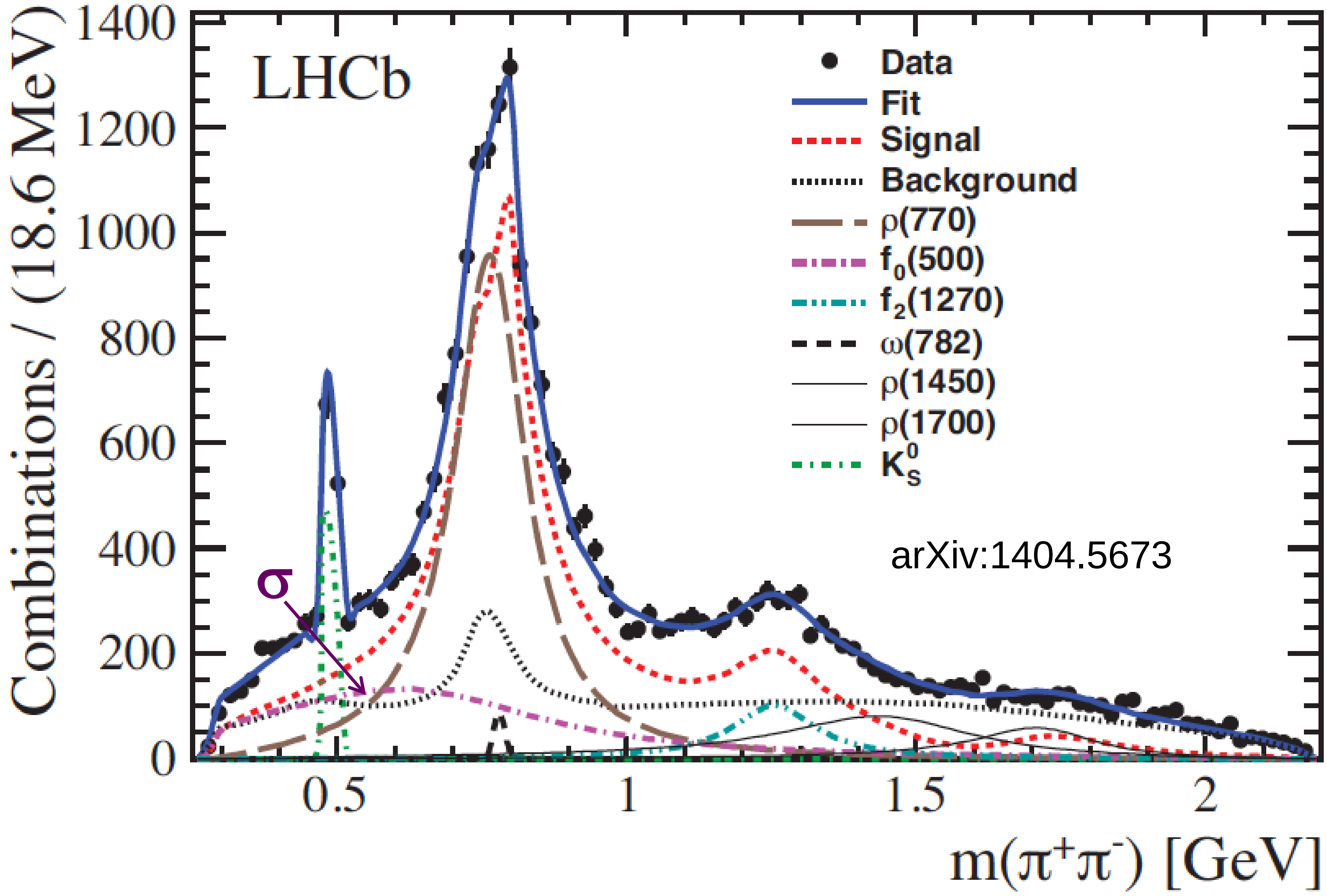


arXiv:1402.6248

B^0 results

Nice σ

no f_0



arXiv:1404.5673

Not tetraquarks

- $$\tan^2\varphi_m \equiv r_\sigma^f = \frac{\mathcal{B}\left(\overline{B}^0 \to J/\psi\, f_0(980)\right)}{\mathcal{B}\left(\overline{B}^0 \to J/\psi\, f_0(500)\right)}\frac{\Phi(500)}{\Phi(980)}$$

$$\frac{\mathcal{B}\left(\overline{B}^0 \to J/\psi\, f_0(980),\ f_0(980) \to \pi^+\pi^-\right)}{\mathcal{B}\left(\overline{B}^0 \to J/\psi\, f_0(500),\ f_0(500) \to \pi^+\pi^-\right)} = (0.6^{+0.7+3.3}_{-0.4-2.6})\%$$

$$\tan^2\varphi_m \equiv r_\sigma^f = (1.1^{+1.2+6.0}_{-0.7-0.7}) \times 10^{-2} < 0.098 \text{ at } 90\% \text{ C.L}$$

- In qq model mixing ∠ $|\varphi_m| < 17^\circ$ at 90% CL
- Tetraquark prediction of 0.5 ruled out at 8σ

arXiv:1404.5673

Future Acts

- LHCb Upgrade: run at 10^{33} cm^{-2}/s (x5), & double trigger efficiency on purely hadronic final states. Much improved sensitivities to New Physics at higher mass
  - Implemented by having a purely software trigger
  - Requires entire detector to be read-out at 40 MHz
- e^+e^- Super Belle
- Time scales are on the order of 5 years

Conclusions

- Heavy Flavor physics is very sensitive to potential New Physics effects at high mass scales
- LHCb has started to make world class measurements of flavor physics.
- We hope to find physics beyond the Standard Model or derive limits that strongly constrains theories of New Physics.
- The LHCb upgrade is necessary to improve sensitivities.
- Many other interesting results have not been mentioned

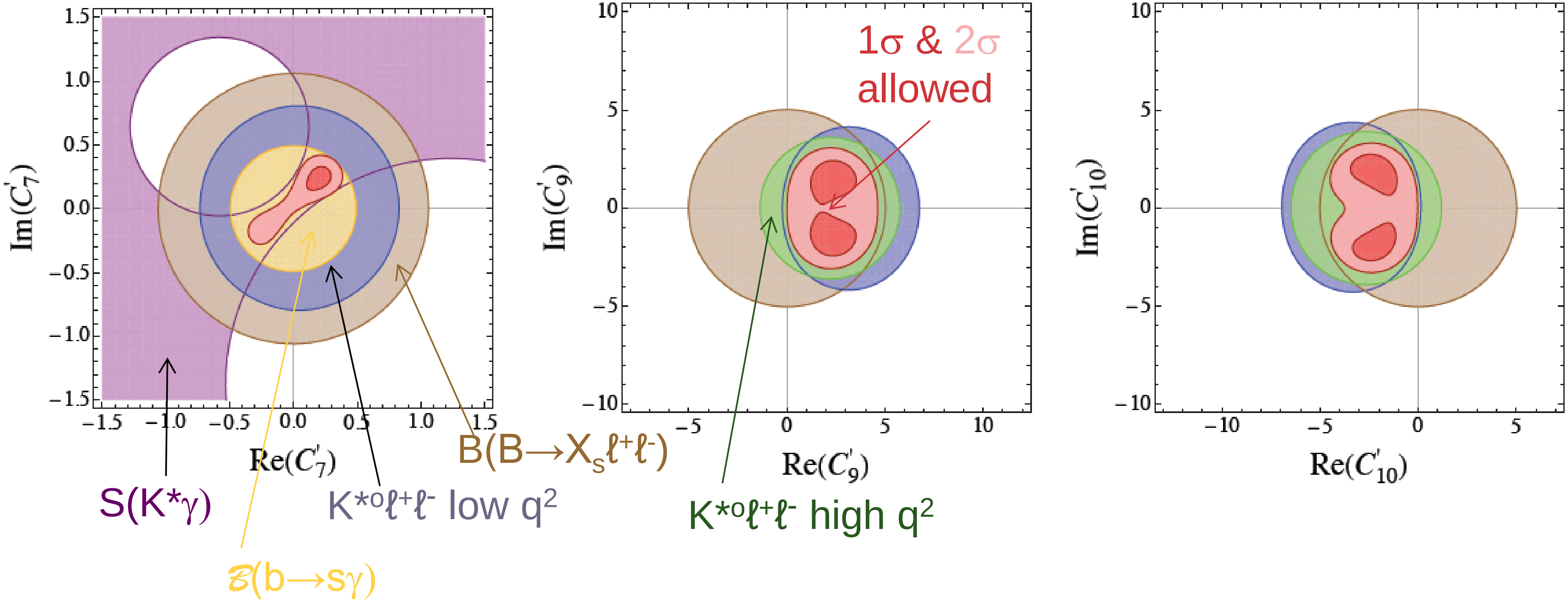
Theory conquers

The

End

Common Analysis

- APS ≡ W. Altmannshofer, P. Paradisi & D. M. Straub arXiv:1111.1257v2



1σ & 2σ allowed

$B(B\to X_s\ell^+\ell^-)$

$S(K^*\gamma)$

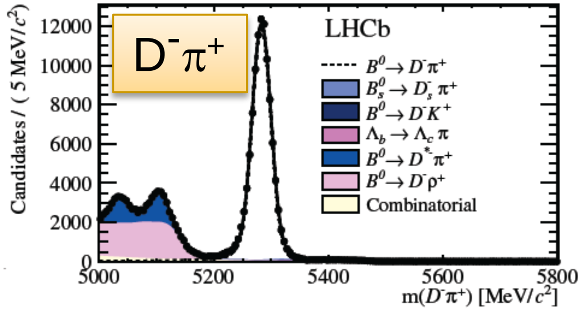
$K^{*o}\ell^+\ell^-$ low q^2

$K^{*o}\ell^+\ell^-$ high q^2

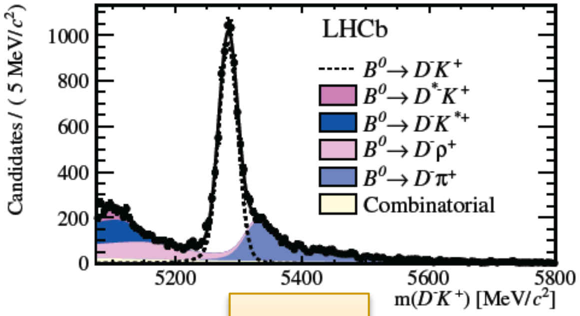
$\mathcal{B}(b\to s\gamma)$

- Many more such generic constraints

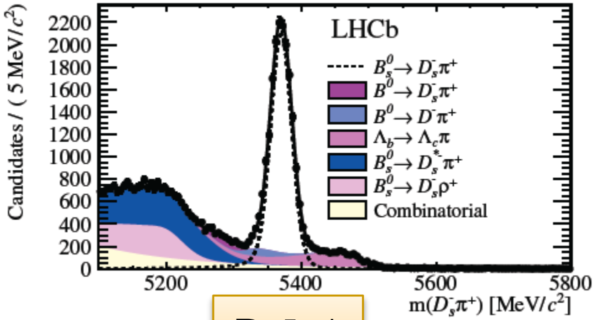
Also B→Dh$^-$



D$^-\pi^+$

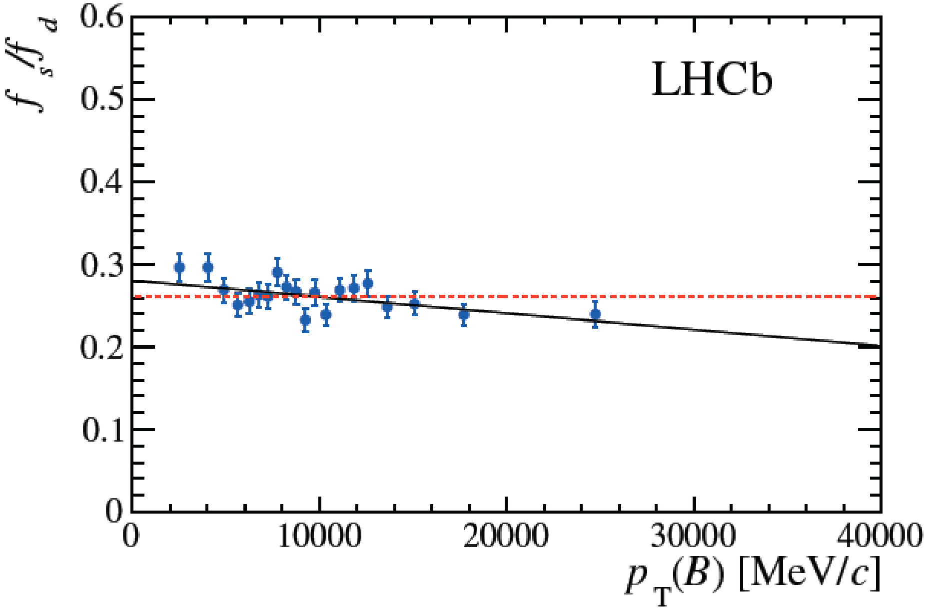


D$^-$K$^+$



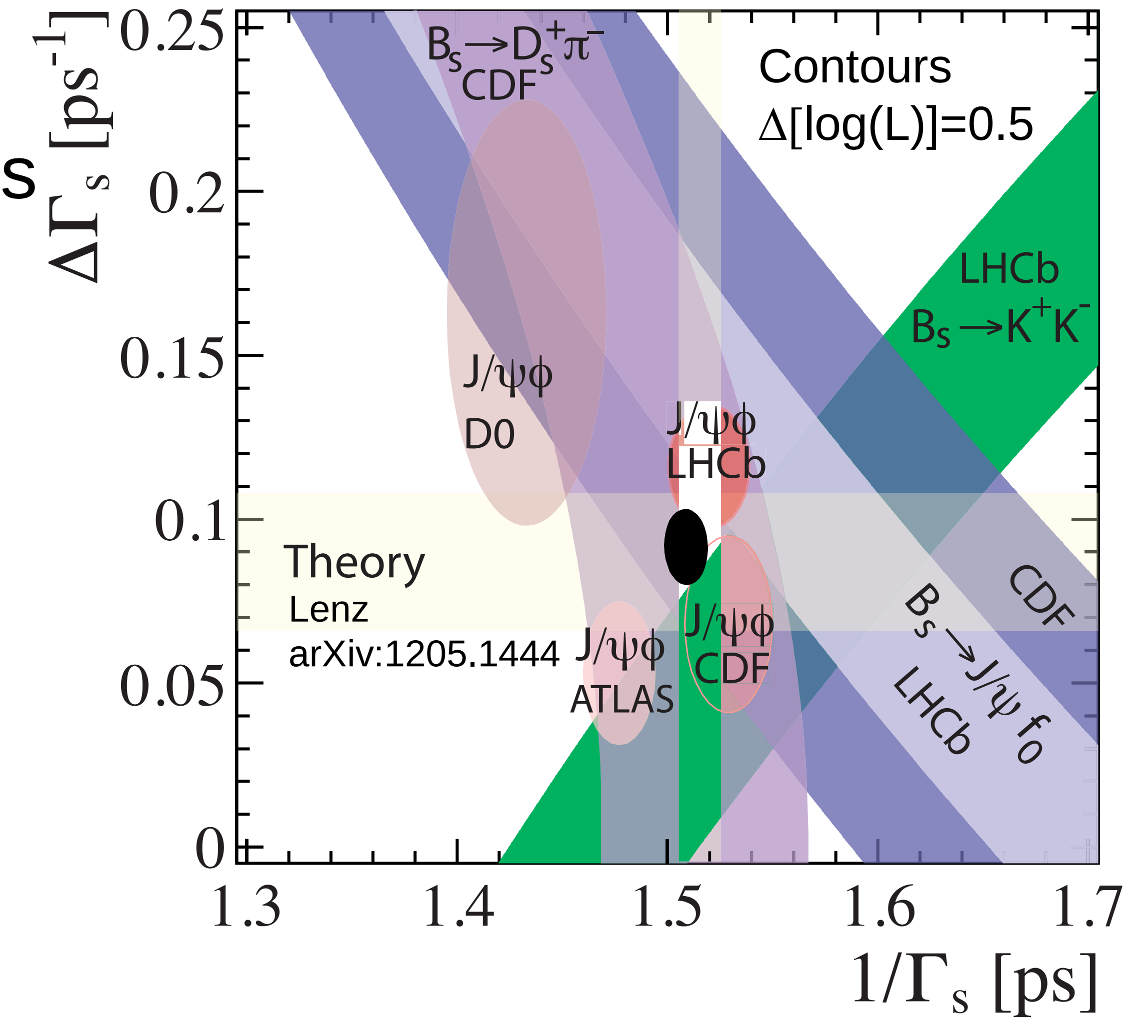
D$_s^-\pi^+$

- Take ratios, use theory
- P$_t$ dependence now evident, implications for ATLAS, CMS analyses



Γ_s & $\Delta\Gamma_s$

- B_s lifetime results here use only fully reconstructed decays
- K^+K^- is taken as CP even ($A_{\Delta\Gamma}$=-1)
- Ovals show 39% cl, while bands 68% cl
- τ_s=1.509±0.010 ps, $\Delta\Gamma_s$ = 0.092±0.011 ps^{-1}, $y_s=\Delta\Gamma_s/2\Gamma_s$= 0.07±0.01 (from Anna Phan)



only full reconstructed B_s decays used

a_{sl}

- By definition

$$a_{sl}=\frac{\Gamma\left(\bar{M}\rightarrow f\right)-\Gamma\left(M\rightarrow \bar{f}\right)}{\Gamma\left(\bar{M}\rightarrow f\right)+\Gamma\left(M\rightarrow \bar{f}\right)}$$

at t=0 $\bar{M}\rightarrow f$ is zero as is $M\rightarrow\bar{f}$

- Here *f* is by construction flavor specific, $f \neq \bar{f}$
- Can measure eg. $\bar{B}_s\rightarrow D_s^+\mu^-\nu$, versus $B_s\rightarrow D_s^-\mu^+\nu$,
- Or can consider that muons from two B decays can be like-sign when one mixes and the other decays, so look at $\mu^+\mu^+$ vs $\mu^-\mu^-$
- a_{sl} is expected to be very small in the SM, $a_{sl}=(\Delta\Gamma/\Delta M)\tan\phi_{12}$, where $\tan\phi_{12}=\mathrm{Arg}(-\Gamma_{12}/M_{12})$
- In SM (B^o) $a^d_{sl}=-4.1\text{x}10^{-4}$, ($B_s$) $a^s_{sl}=+1.9\text{x}10^{-5}$

arXiv:1205.1444 [hep-ph]

$D^{o}\ a_{sl}$

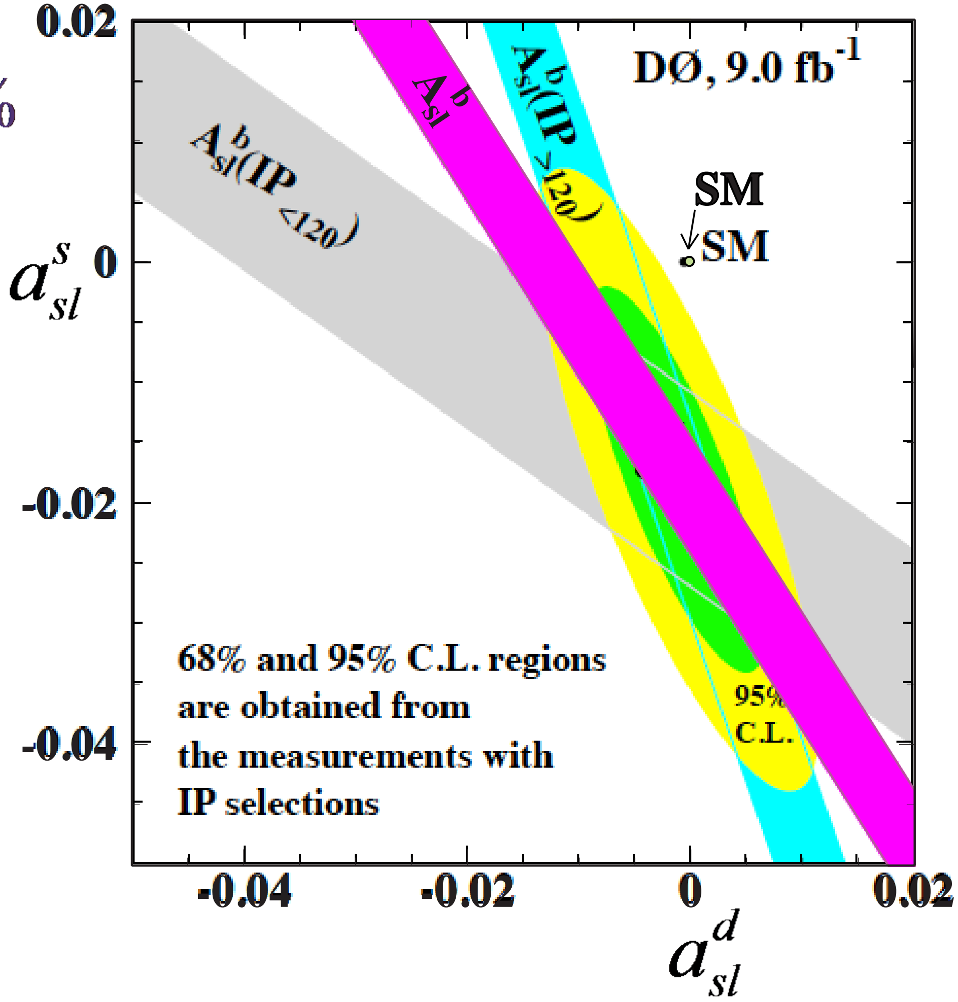
- Using dimuons (3.9σ)

$$A_{sl}^{b} = (-0.787 \pm 0.172 \pm 0.093)\%$$

- Indication from D0 that its B_s
- Separate dimuons into B_d and B_s samples using muon impact parameter
- Find

$$a_{sl}^{d} = (-0.12 \pm 0.52)\%$$

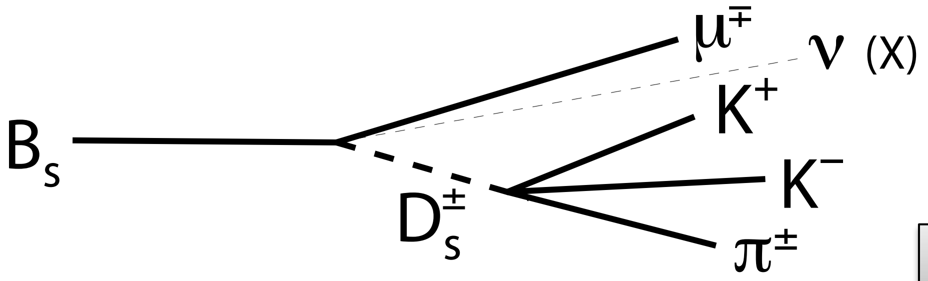
$$a_{sl}^{s} = (-1.81 \pm 1.06)\%$$

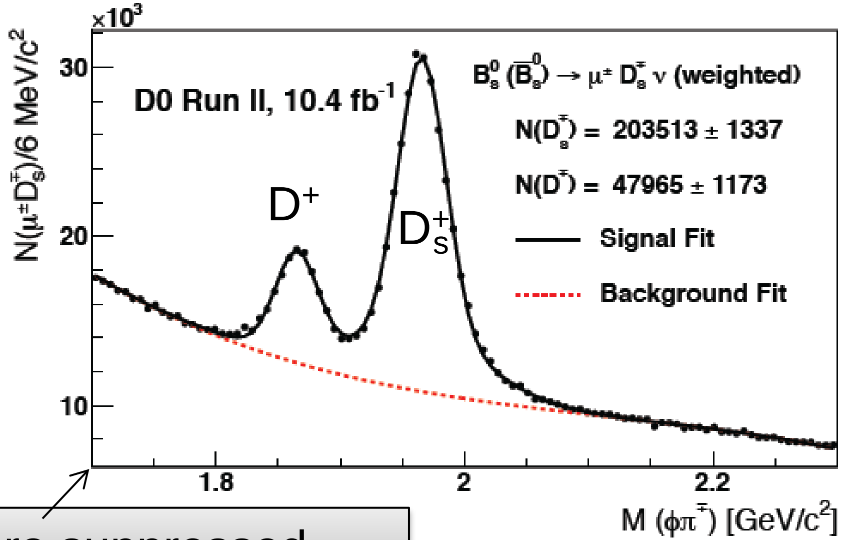


68% and 95% C.L. regions are obtained from the measurements with IP selections

New D0 Analysis

- Measure a_{sl}^{s} using $D_s\mu^-\nu$ events, $D_s\rightarrow\phi\pi^\pm$
- Detect a μ associated with a D_s decay



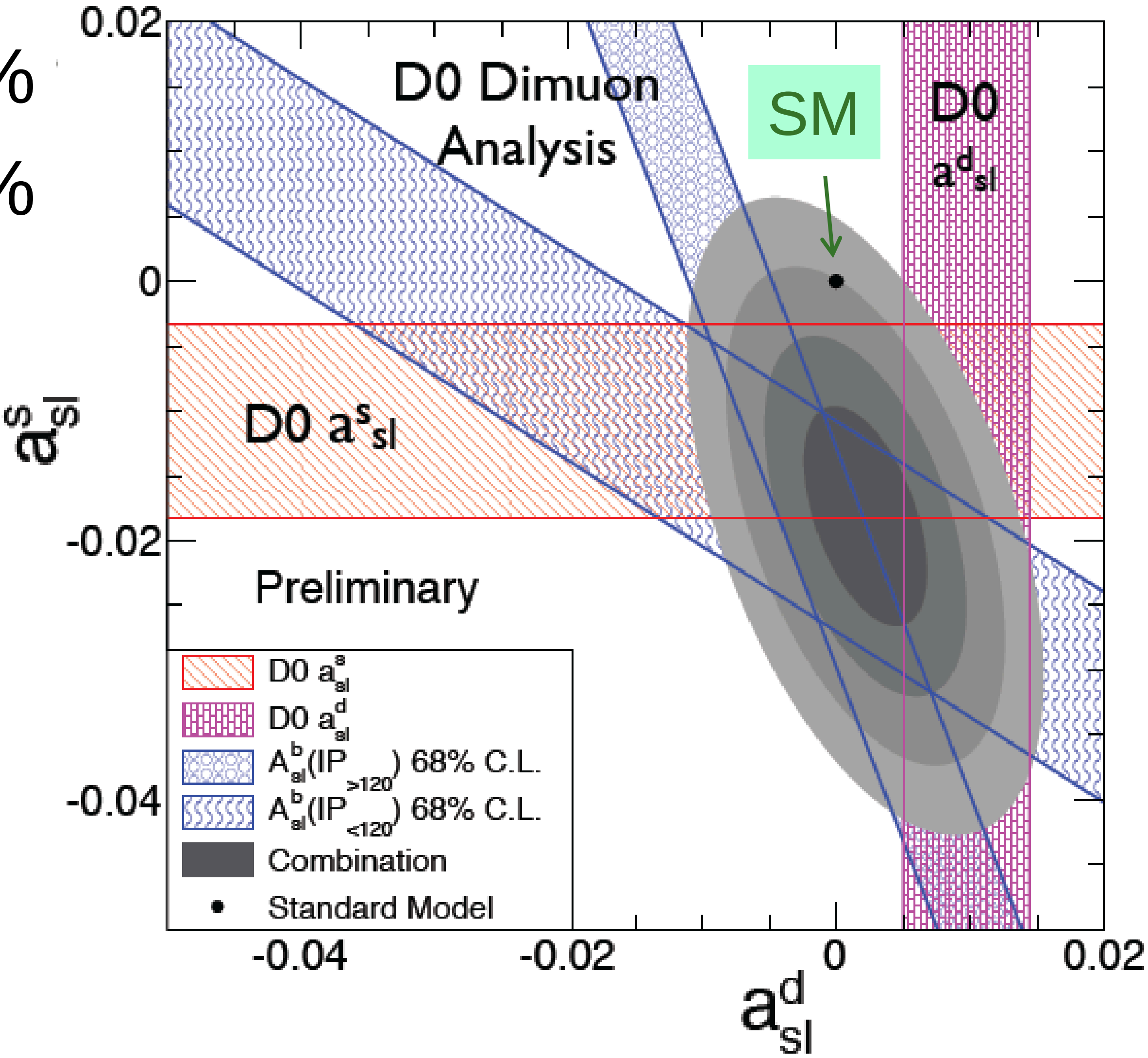


zero suppressed

- Find $a_{sl}^{s}=(-1.08\pm0.72\pm0.17)\%$
- Also measure a_{sl}^{d} using $D^+\mu^-\nu$, $D^+\rightarrow K\pi^+\pi^+$
- $a_{sl}^{d}=(0.93\pm0.45\pm0.14)\%$

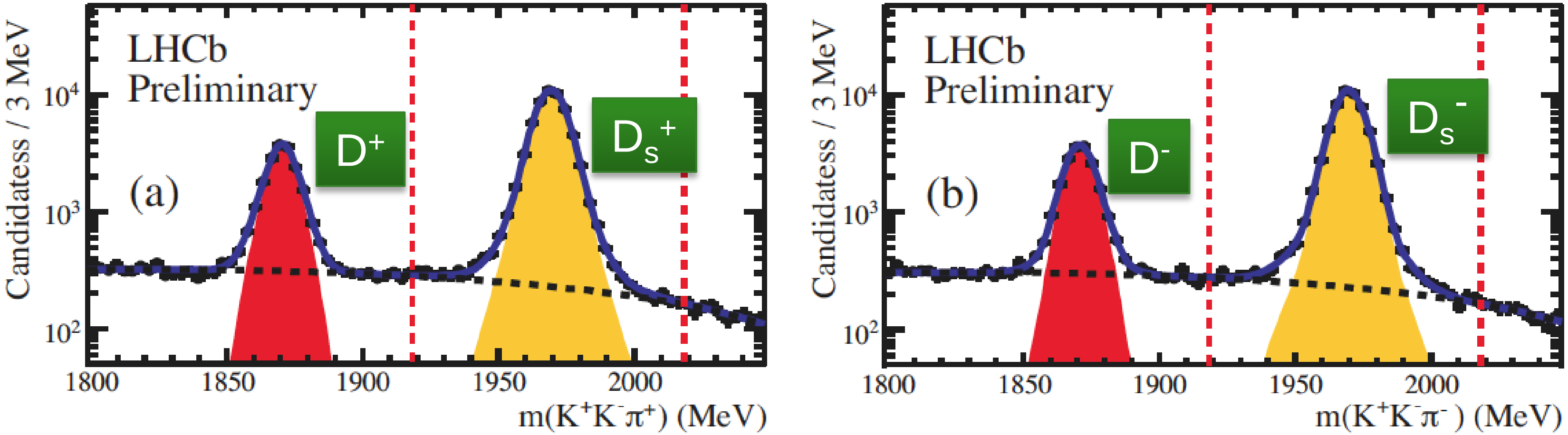
a_{sl} according to D0

- a^s_{sl}=(-1.81±0.56)%
- a^d_{sl}=(-0.22±0.30)%
- 3σ from SM
- arXiv:1208.5813



LHCb measurement

- Use $D_s\mu^-\nu$, $D_s\rightarrow\phi\pi^\pm$, magnet is periodicaly reversed. For magnet down:



- Effect of B_s production asymmetry is reduced to a negligible level by rapid mixing oscillations
- Calibration samples (J/ψ, D^{*+}) used to measure detector trigger, track & muon ID biases

a_{sl} not D0

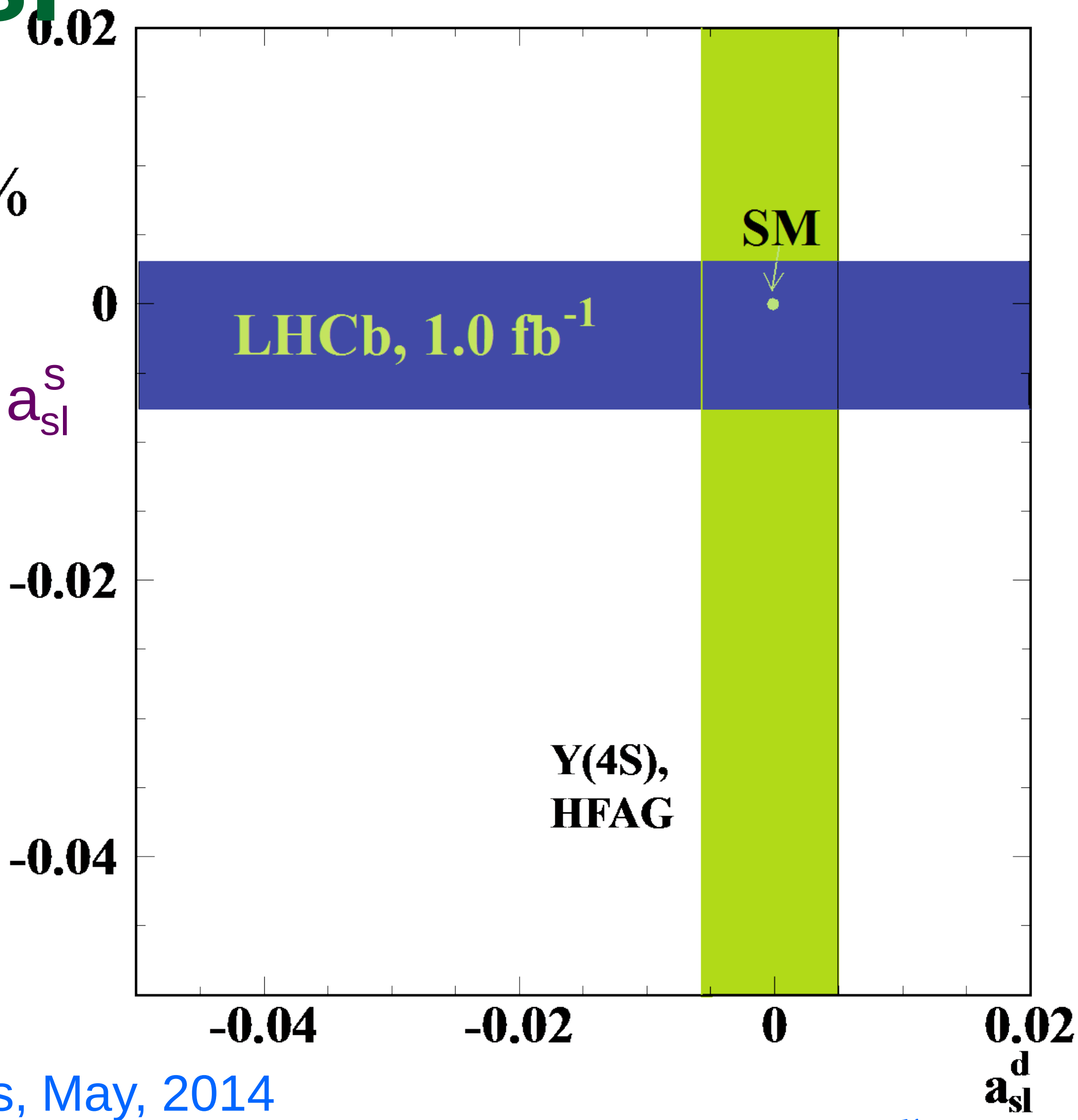
- LHCb finds

$$a_{sl}^{s}=\left(-0.24\pm0.54\pm0.33\right)\%$$

- B-factory

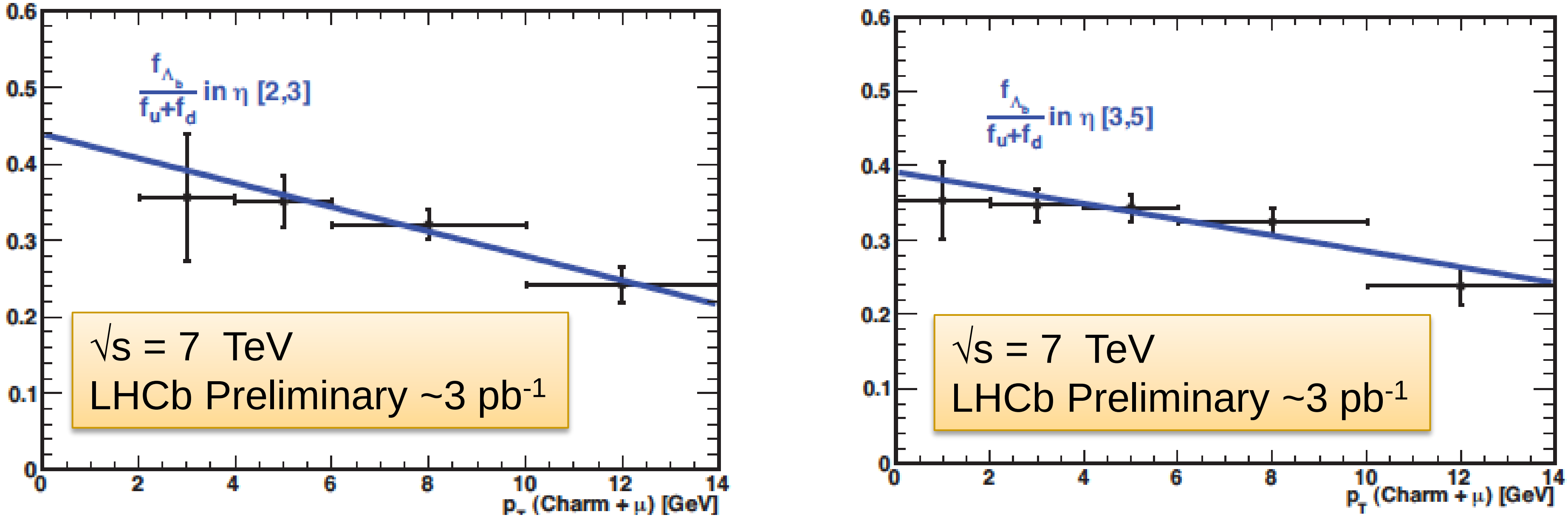
$$a_{sl}^{d}=\left(-0.05\pm0.56\right)\%$$

- Results consistent with SM
- Expect ϕ_s to grow as $\sin\overset{s}{[}2|\beta_s|+\arg(M_{12})]$ for finite a_{sl}.



Λ_b Fraction

- Significant p_t dependence



√s = 7 TeV
LHCb Preliminary ~3 pb^{-1}

√s = 7 TeV
LHCb Preliminary ~3 pb^{-1}

$$[f_{\Lambda_b}/(f_u + f_d)] = 0.401 \pm 0.019 \pm 0.106 - (0.012 \pm 0.0025 \pm 0.0012) \times p_t(\mathrm{GeV})$$

- In general agreement with CDF measured at $<p_t>$~10 GeV/c $f_{\Lambda_b}/(f_u + f_d) = 0.281 \pm 0.012^{+0.011+0.128}_{-0.056-0.086}$