# Looking forward to new lattice results

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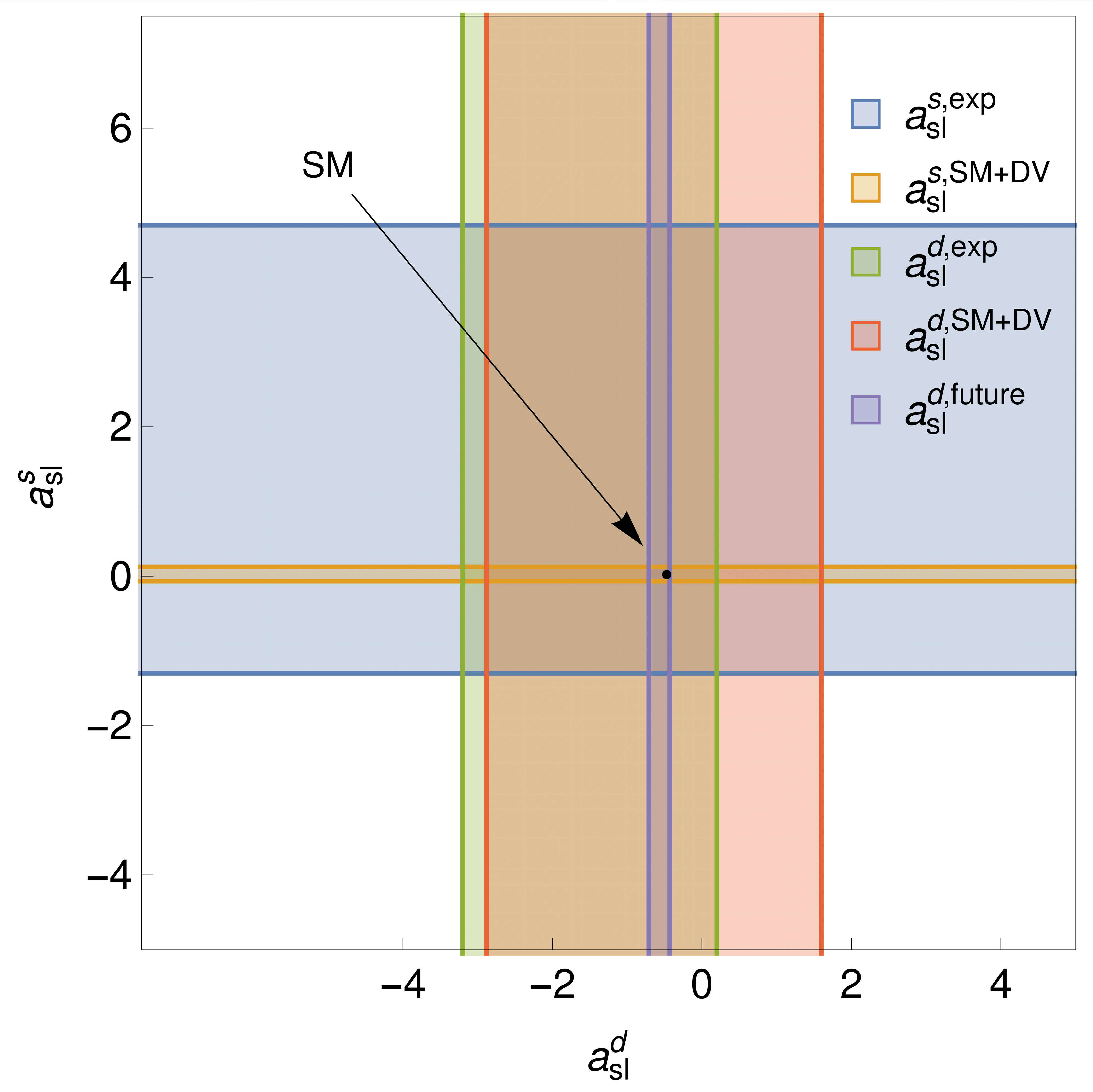
## Duality Violation

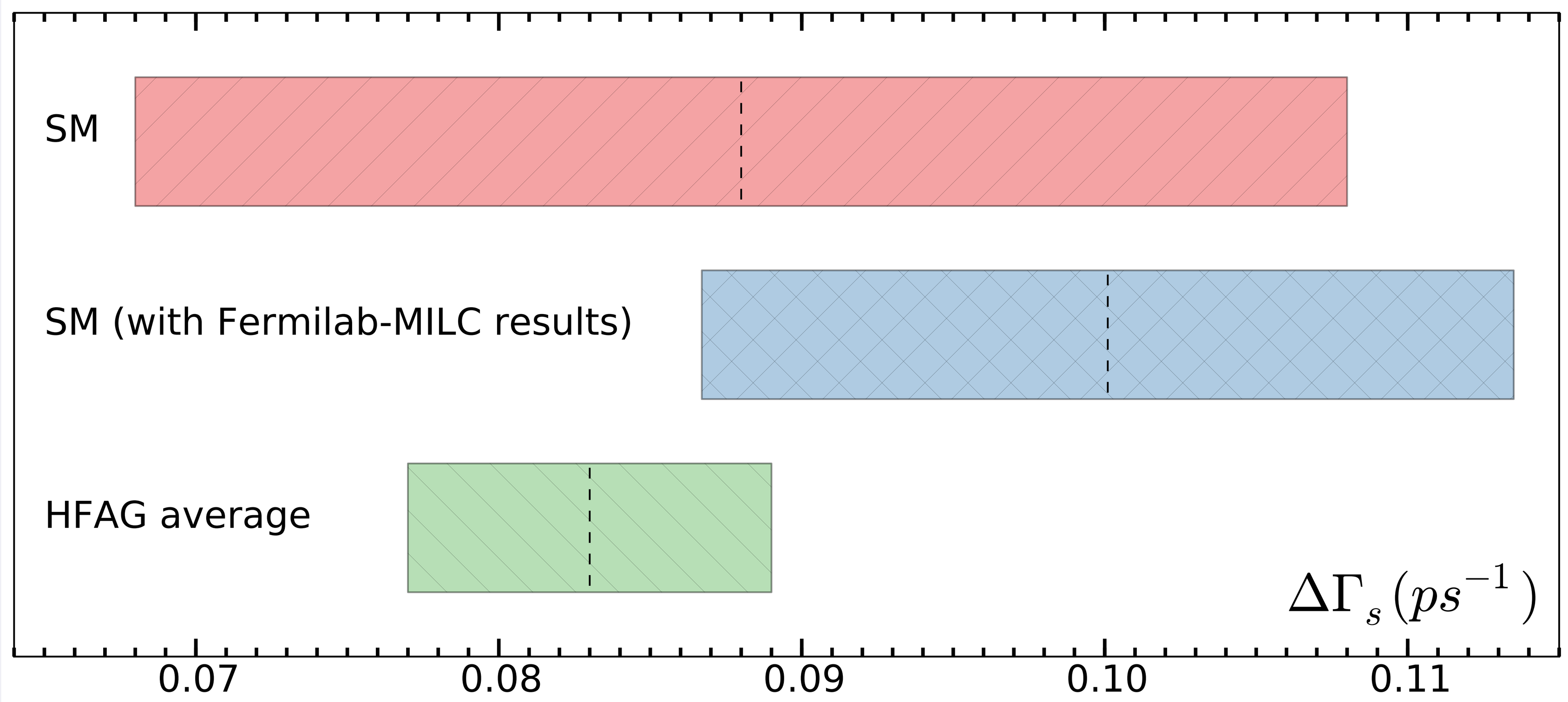
Current results from theory and experiment (ATLAS, CMS, LHCb) on $\Delta\Gamma_s$ constrain quark-hadron duality violation to around 30% [1]. From this result, we can quantify whether deviations of $a_{sl}$ from theory could be explained by duality violation, or whether they would be unambiguous signs of NP.




The future scenarios assume a reduction in the theory error – we need lattice contributions for dimension-6 and dimension-7 operators (some in progress – see talk by M. Wingate at Heavy Flavour 2016, Lattice 2016).

## Improved dimension-6 operators

Most recent lattice calculation from earlier this year [3]. As an example, look at $\Delta\Gamma_s$




Lattice has allowed us to reduce the theory error by around 1/3 – but the central value has shifted away from experiment. Calculations by more lattice groups essential for assessing this.

## B Meson Lifetime Ratio

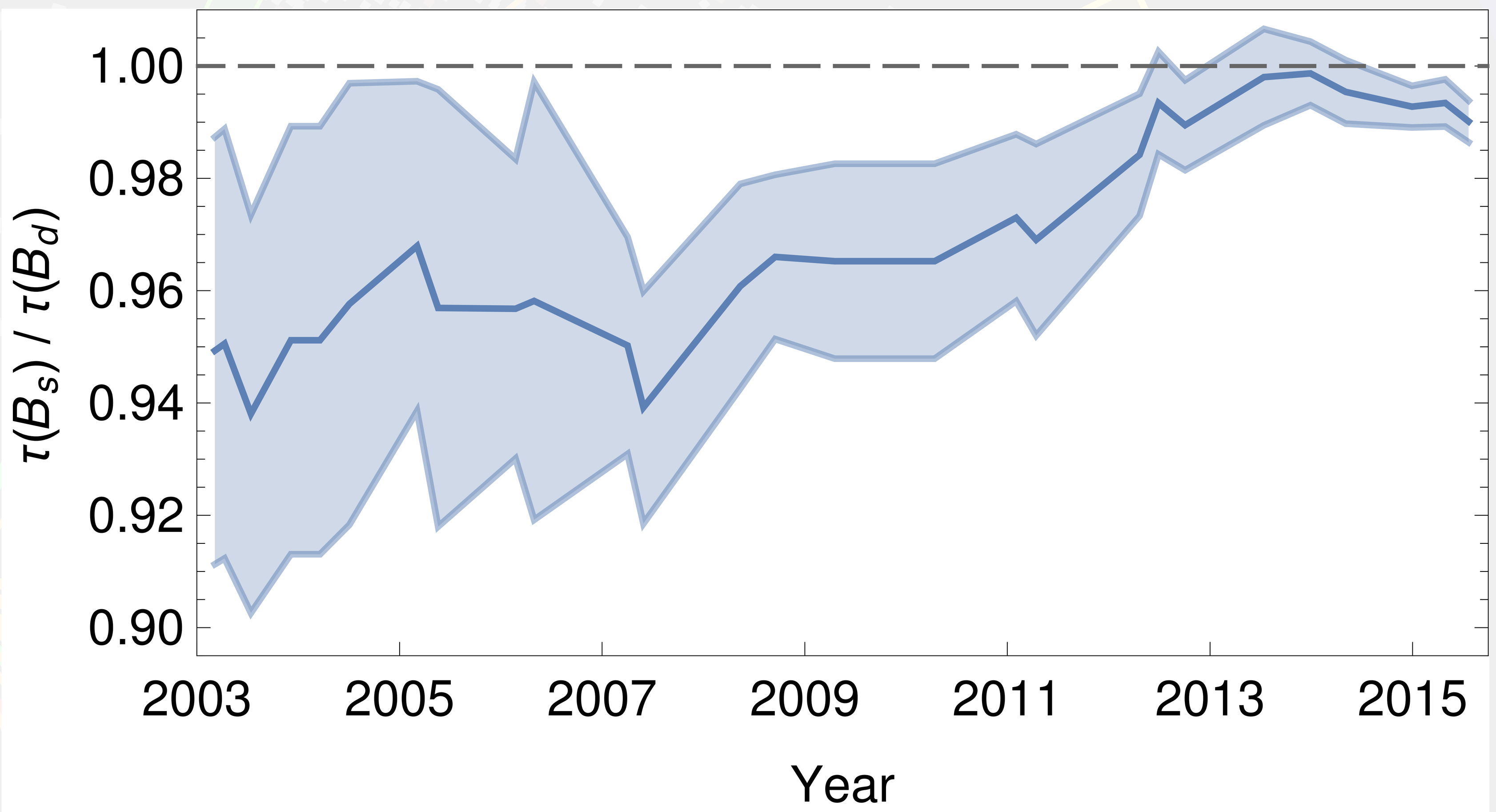
Very strong NP bounds can be obtained using the lifetime ratio $\tau(\mathrm{B_s^0})/\tau(\mathrm{B_d^0})$, as there is strong cancellation in the SM calculation. The most recent theory calculation of $\tau(\mathrm{B_s^0})/\tau(\mathrm{B})$ is $1.00050 \pm 0.00108$. Around 80% of this error comes from lattice calculation of colour-suppressed bag parameters $\epsilon_{1,2}$.

$$\left\langle B \middle| (\bar{\mathrm{b}}\gamma_\mu(1-\gamma^5)T^a q) \otimes (\bar{q}\gamma^\mu(1-\gamma^5)T^a \mathrm{b}) \middle| B \right\rangle = f_{\mathrm{B}}^2 M_{\mathrm{B}}^2 \epsilon_1$$
$$\left\langle B \middle| (\bar{\mathrm{b}}(1-\gamma^5)T^a q) \otimes (\bar{q}(1-\gamma^5)T^a \mathrm{b}) \middle| B \right\rangle = f_{\mathrm{B}}^2 M_{\mathrm{B}}^2 \epsilon_2$$

Last result comes from 2001 proceedings [2]:

$$\epsilon_1 = -0.02 \pm 0.02 \qquad \epsilon_2 = 0.03 \pm 0.01$$

Experimental error has drastically shrunk over the last 15 years, as seen below, and so new results for these parameters are urgently needed.




## Charm Lifetimes

The status of the Heavy Quark Expansion (HQE) in charm sector is almost unknown – an ideal testing ground is charm meson lifetimes. The most recent results are very promising [4]

$$\left.\frac{\tau(\mathrm{D^+})}{\tau(\mathrm{D^0})}\right|_{\text{HQE}} = 2.2 \pm 1.7 \qquad \left.\frac{\tau(\mathrm{D^+})}{\tau(\mathrm{D^0})}\right|_{\text{exp.}} = 2.536 \pm 0.019$$

No lattice calculations of the lifetime matrix elements are available, leading to huge hadronic uncertainties seen above. Some work has been done for charm mixing matrix elements [5] – however calculation of lifetime matrix elements is crucial for precision tests of the HQE.

## References

[1] T. Jubb, M. Kirk, A. Lenz and G. Tetlalmatzi-Xolocotzi, Nucl. Phys. B **915** (2017) 431 [arXiv:1603.07770 [hep-ph]].

[2] D. Becirevic, PoS HEP **2001** (2001) 098 [hep-ph/0110124].

[3] A. Bazavov *et al.* [Fermilab Lattice and MILC Collaborations], Phys. Rev. D **93** (2016) no.11, 113016 [arXiv:1602.03560 [hep-lat]].

[4] A. Lenz and T. Rauh, Phys. Rev. D **88** (2013) 034004 [arXiv:1305.3588 [hep-ph]].

[5] N. Carrasco *et al.*, Phys. Rev. D **90**, no. 1, 014502 (2014) [arXiv:1403.7302 [hep-lat]].

[6] C. C. Chang *et al.* [Fermilab Lattice and MILC Collaborations], PoS LATTICE **2014** (2014) 384 [arXiv:1411.6086 [hep-lat]].