Search prospects for b-associated Z' in the dimuon final state

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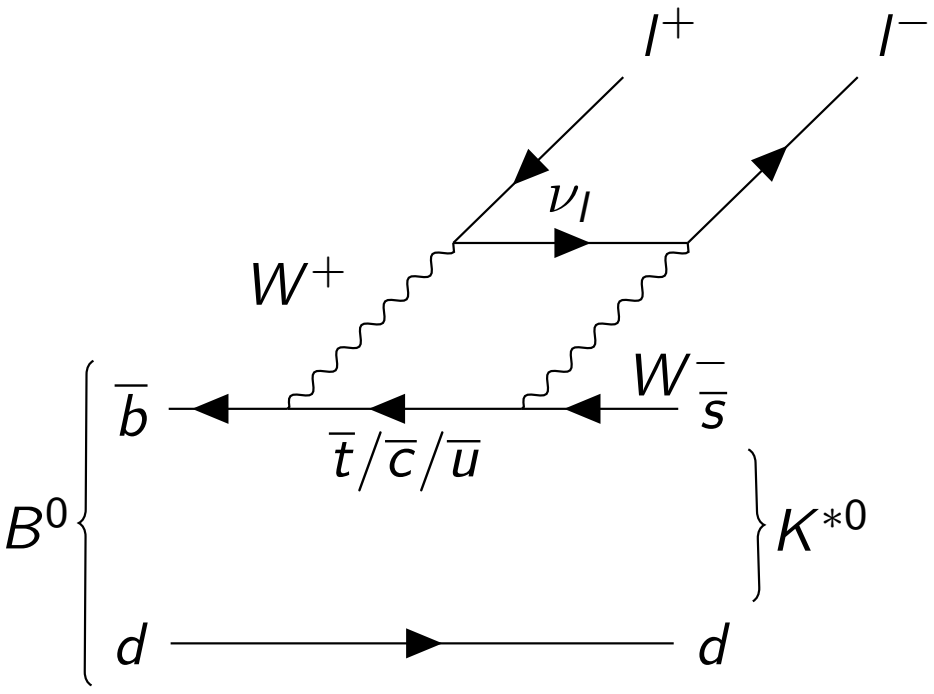
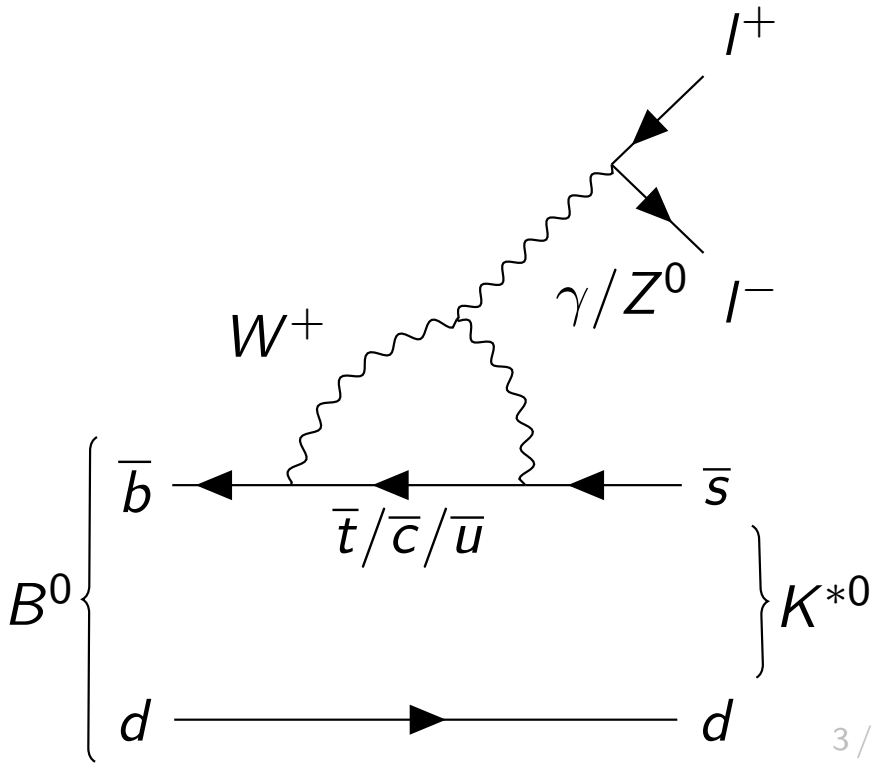
Table of contents

B-flavour anomalies with lepton universality violation

- Hints at new BSM physics are scarce
- LHCb reports an excess in the muon to electron ratio of R_{K^*} ($B^0 \to l^+ l^- K^*$ JHEP 08 (2017) 055) and R_K ($B^+ \to l^+ l^- K^+$ Phys. Rev. Lett. 113, 151601 (2014))
- Combining both measurements, the excess may amount to $\approx 4\sigma$ to date JHEP 1801 (2018) 093

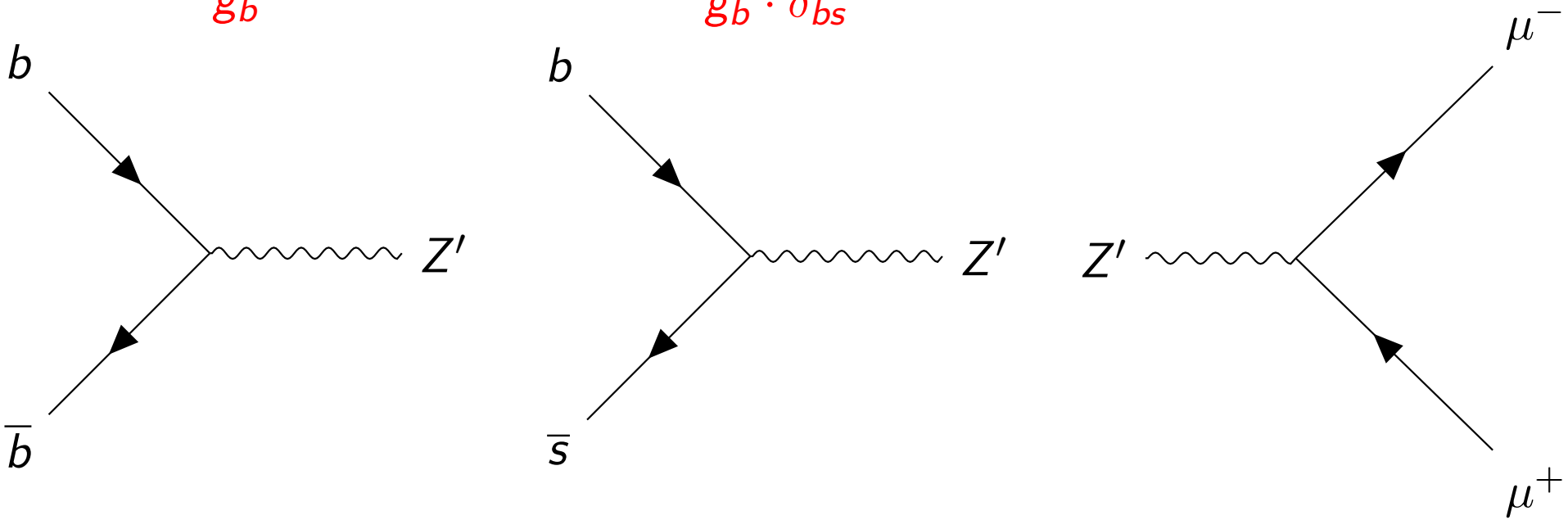




A new heavy gauge boson Z' with flavour violation?

- Model: A new heavy gauge boson Z' with non-universal couplings Phys. Rev. D 97, 075035
- To explain observed anomalies, couplings to 3rd gen. quarks, 2nd gen. leptons + a flavour-violating bs-coupling necessary g_μ

g_b $g_b \cdot \delta_{bs}$



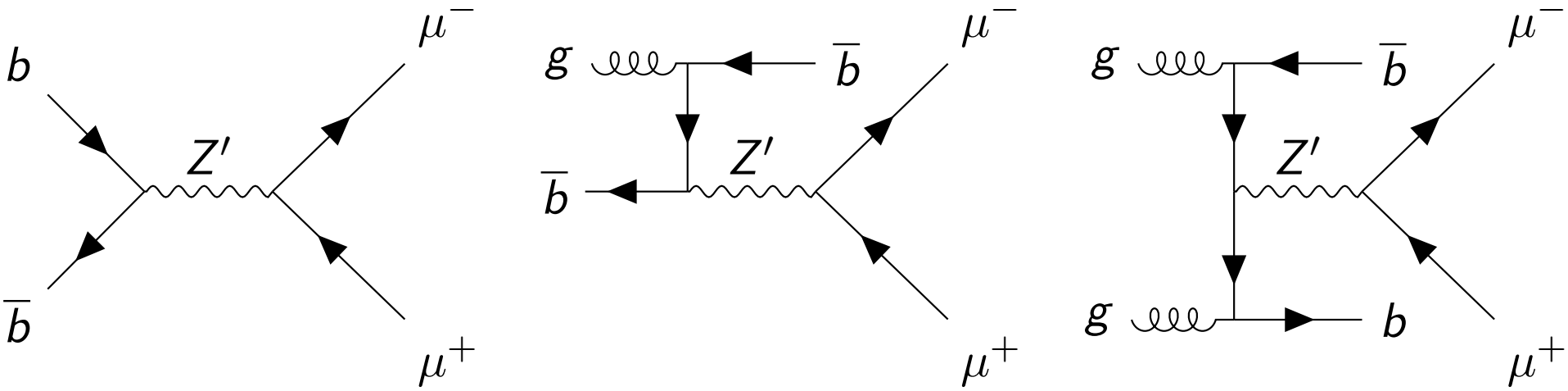
- For this talk, I'll only consider the above three couplings
- Couplings in model inspired and restrained by flavour sector anomalies
- Model proveds a direct connection between general purpose LHC experiments and heavy flavour sector experiments

Table of contents

Associated b-jet multiplicity and kinematics

- As light quarks don't couple directly to this kind of Z', the bottom pdfs and the bottom luminosity from gluon splitting play a major role

0 assoc. jets **1 assoc. jets** **2 assoc. jets**

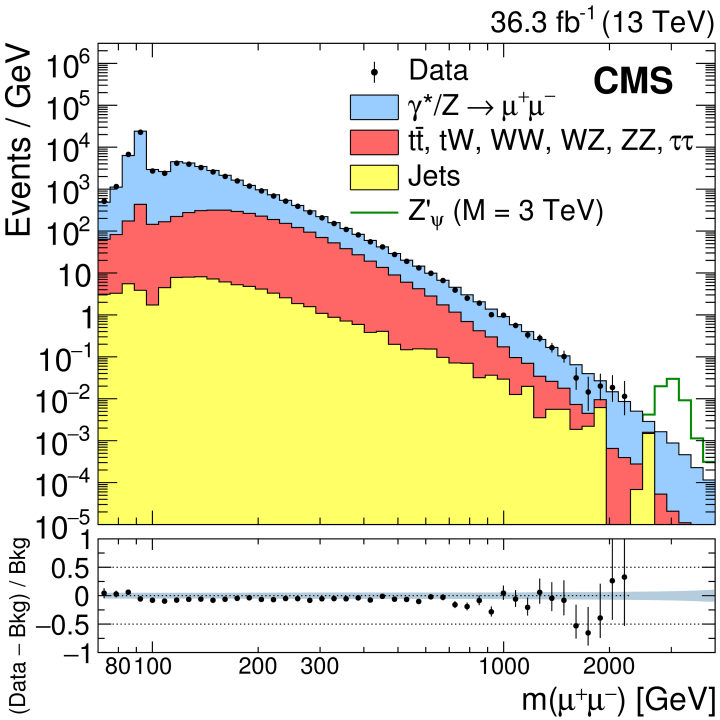


- For a medium b-tag requirement and $p_T(\mathrm{jet}) \geq 30$ GeV, the rate of [0/1/2] associated b-tagged jets is [80.1%/18.5%/1.5%] for a 200 GeV Z' and [71.8%/25.1%/3.0%] for a 500 GeV Z'
- Associated b-tagged jets are central and soft
- For $p_T(b) \geq 20$ GeV: [74.0%/23.8%/2.1%] for a 200 GeV Z'
- The flavour-violating coupling δ_{bs} switches on contributions by s quarks and lowers the relative amount of associated b-tagged jets

Background-suppressing selection requirements - preselection

- An inclusive Z' search from CMS (shown in the left) suffers mostly from Z^0/γ^*, followed by $t\bar{t}$ backgrounds

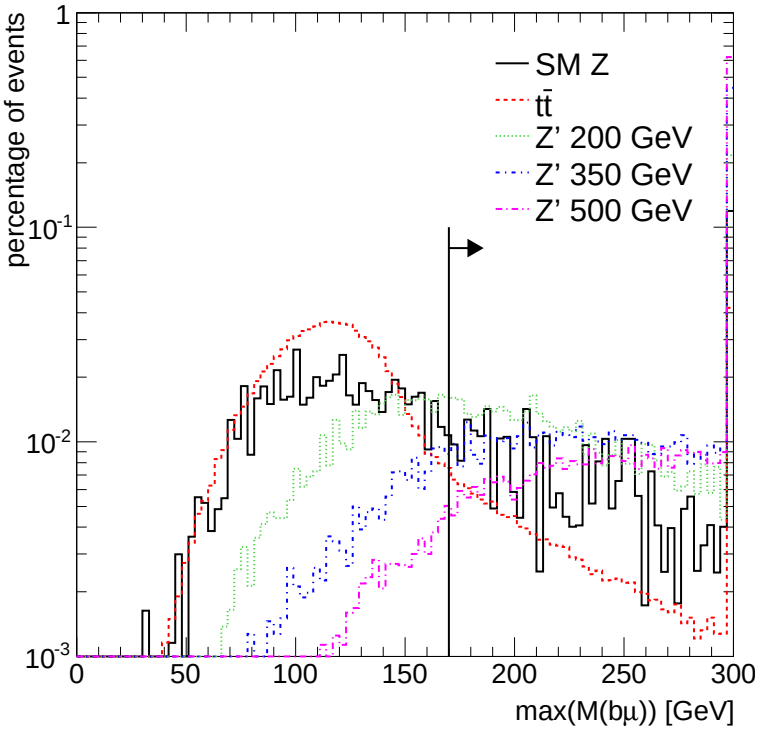
arXiv:1803.06292 [hep-ex]



- For preselection, we require two opposite sign muons as well
- In addition, we require at least two jets ($p_T \geq 30$, $|\eta| \leq 5$) and at least 1 medium bottom tag among them
- The preselection efficiency for (leptonic) $t\bar{t}$ is 8 %
- For (leptonic) DY, it's 0.2 %
- For Z' of [200/350/500] GeV, it is [7 %/10 %/13 %]

Top mass bound

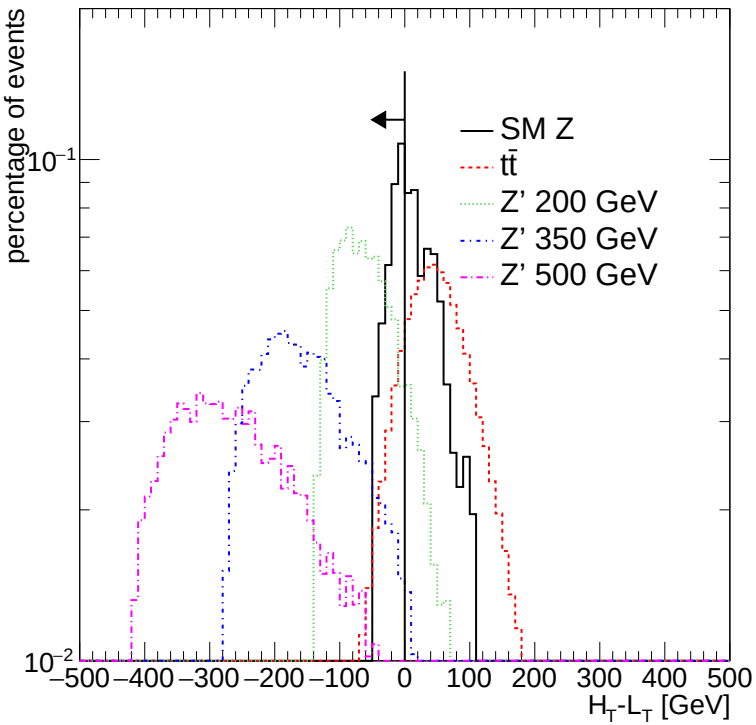
- Plots shown are after preselection



- After preselection, at least two jets and two muons are present
- We take both exclusive permutations of the leading two jet+muon pairs
- For the lowest difference in mass between pairs, we require the largest mass of that pair to be $> 170\,\text{GeV}$
- The efficiencies after preselection are: 17 % for $t\bar{t}$, 41 % for DY, [60 %/82 %/90 %] for a [200/350/500] GeV Z'

Difference in hadronic vs leptonic activity

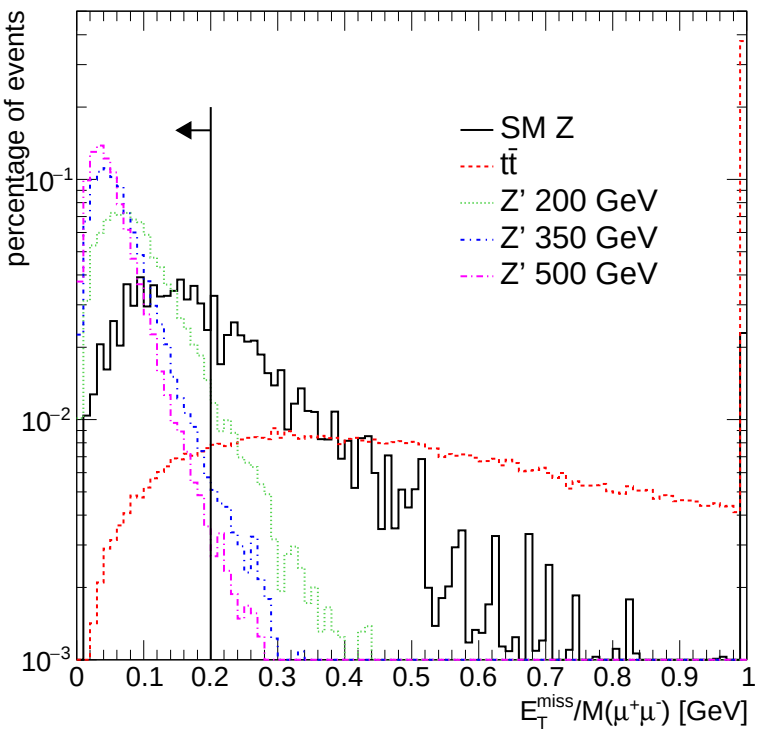
- Plots shown are after preselection



- The associated jet spectrum for the signal is soft compared to the backgrounds
- We require the scalar sum of the leading two muon transverse momenta L_{T} to be greater than the scalar sum of the leading two jet transverse momenta H_{T}
- The efficiencies after preselection and top-mass bound are: 26 % for $t\bar{t}$, 32 % for DY, [74 %/90 %/94 %] for a [200/350/500] GeV Z'

Normalized transverse missing energy

- Plots shown are after preselection



- The Z' signal has no natural source of transverse missing energy, bar reconstructed object mismeasurements
- Therefore, we normalize the $E_{\mathrm{T}}^{\mathrm{miss}}$ to the dimuon mass to account for the most energetic sources of mismeasurement, and require this quantity to be below 0.2
- The efficiencies after preselection, top-mass bound, and $H_{\mathrm{T}} - L_{\mathrm{T}}$ are: 27 % for $t\bar{t}$, 54 % for DY, [89 %/97 %/98 %] for a [200/350/500] GeV Z'

Table of contents

Current reach of CMS inclusive search - and where it may beat dedicated searches

- With this kind of selection, so far only Delphes limits by the presented phenomenology study are available.
- Still, it motivates where a dedicated studies might do better, and where it won't.

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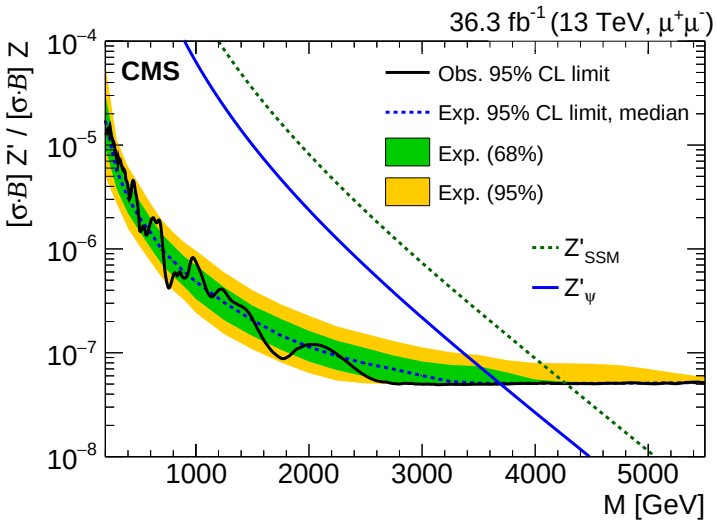
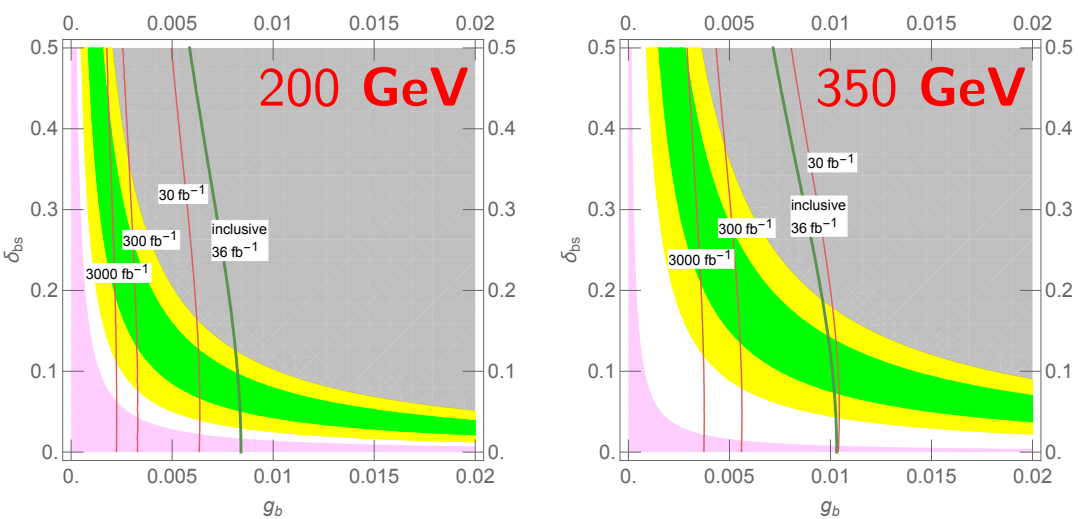


Phys. Rev. D 97, 075035



- For low flavour-violating couplings, a dedicated analysis might be complementary or better for $m(Z') \leq 350$ GeV
- For large δ_{bs} couplings, inclusive analyses will cover more ground, unless going even closer to the Z peak with the Z' mass

Conclusions & Outlook

- The presented phenomenology study suggests that a dedicated search for b-associated Z' is beneficial in searching for an explanation of the R_K and R_K^* anomalies
- Further pheno studies on different final states (like ditau) are work in progress
- As this model does not allow coupling to electrons, a data-driven background estimation from dielectron events should keep systematics to a minimum for experimentalists
- Defining further search regions, especially exactly 1 associated b-tagged jet (e.g. 12% rate for a 200 GeV Z'), may improve sensitivity of actual analyses beyond the shown projection