Projecting 8 TeV checkmate limits to 13 TeV.

immediate

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Our 95% CL limits from checkmate with 10 fb^{-1} at 8 TeV is ~ 2 pb.

To project to 13 TeV, and for different luminosities, we need to find how the background changes, $B \to B'$, for new energies/luminosities, and then we can find how the signal must change, $S \to S'$, such that the significance, $\left(\frac{S}{\sqrt{B}}\right)$ is unchanged (at the level giving a 95% CL).

i.e. we need to predict how the background, B, changes, and then we find the new signal, S' that keeps the significance the same (at the 95% level),

$$\frac{S}{\sqrt{B}} = \frac{S'}{\sqrt{B'}} \tag{1}$$

where B is the original background, B' is the background at the new enrgy/luminosity, S is the original signal ruled out at the 95% CL and S' is the new signal ruled out at a 95% CL.

For our signal, we have that

$$\sigma_{8\text{TeV}} = 8 \text{ fb}$$
$$\sigma_{13\text{TeV}} = 50 \text{ fb}$$

Assuming the background scales in a similar manner, we therefore assume that going from 10 fb^{-1} of data at 8 TeV to 10 fb^{-1} of data at 13 TeV, the background scales as $B' = \frac{50}{8}B = 6.25B$, giving

$$\frac{S}{\sqrt{B}} \to \frac{S}{\sqrt{B'}} = \frac{S}{\sqrt{6.25B}} \tag{2}$$

To compare this with the Brasil predictions, we then scale this from 10 fb^{-1} to 5 fb^{-1}, which then halves the predictied background,

$$\frac{S}{\sqrt{6.25B}} \to \frac{S}{\sqrt{\frac{6.25}{2}B}} = 0.57 \times \frac{S}{\sqrt{B}} \tag{3}$$

Therefore, to maintain the same 95% significance,

$$S' = 0.57 \times S = 0.57 \times 2\ pb = 1.14\ pb \tag{4}$$

which we can compare to the limit of around around 1.4 pb from the Brasilians for 13 TeV with 5 fb^{-1} of data.

The procedure can be continued, to take into account larger luminosities, for example to go from 10 fb^{-1} at 13 TeV to 300 fb^{-1} at 13 TeV,

$$\frac{S}{\sqrt{6.25B}} \rightarrow \frac{S}{\sqrt{30 \times 6.25B}} = 0.07 \times \frac{S}{\sqrt{B}} \tag{5}$$

which gives a limit, for 300 fb^{-1} at 13 TeV, of

$$S' = 0.07 \times S = 0.07 \times 2\ pb = 0.14\ pb. \tag{6}$$