Projecting 8 TeV checkmate limits to 13 TeV.

immediate

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Our 95% CL limits from checkmate with 20.3 fb^{-1} at 8 TeV is $\sim$ xxx pb.

This means that with 10 fb^{-1} at 8 TeV, $\frac{S}{\sqrt{B}} = 0.95$, where S is the signal and B is the background at this energy and lumniosity.

At our new energy and luminosity, the new signal and background will be B' and S' respectively, and we will have

$$\frac{S'}{\sqrt{B'}} = \frac{S}{\sqrt{B}} = 0.95 \tag{1}$$

therefore,

$$\frac{\sigma'_{95\%}\epsilon'\mathcal{L}'}{\sqrt{\sigma'_b\epsilon'_b\mathcal{L}'}} = \frac{\sigma_{95\%}\epsilon\mathcal{L}}{\sqrt{\sigma_b\epsilon_b\mathcal{L}}} \tag{2}$$

Where $\sigma_{95\%}$ is the cross section limit, ϵ is the signal efficiency, $\mathcal{L}$ is the luminosity, σ_b is the background cross section, and ϵ_b is the background efficiency, with prime or no prime indicating the original or new variables after changing the energy and luminosity.

Rearranging, we get,

$$\sigma'_{95\%} = \sqrt{\frac{\mathcal{L}}{\mathcal{L}'}}\sqrt{\frac{\sigma'_b\epsilon'_b}{\sigma_b\epsilon_b}}\frac{\epsilon}{\epsilon'}\sigma_{95\%} \tag{3}$$

If we define $\sigma'_{b,\mathrm{cut}} = \sigma'_b\epsilon'_b$ and $\sigma_{b,\mathrm{cut}} = \sigma_b\epsilon_b$, and also define σ_s and $\sigma_{s,\mathrm{cut}}$ to be the signal cross section before and after selection cuts for the old luminosity and collision energy, and define σ'_s and $\sigma'_{s,\mathrm{cut}}$ to be the signal cross section before and after selection cuts at the new luminosity and energy, so that $\epsilon = \frac{\sigma_{s,\mathrm{cut}}}{\sigma_s}$ and $\epsilon' = \frac{\sigma'_{s,\mathrm{cut}}}{\sigma'_s}$, we have,

$$\sigma'_{95\%} = \sqrt{\frac{\mathcal{L}}{\mathcal{L}'}}\sqrt{\frac{\sigma'_{b,\mathrm{cut}}}{\sigma_{b,\mathrm{cut}}}}\frac{\frac{\sigma_{s,\mathrm{cut}}}{\sigma_s}}{\frac{\sigma'_{s,\mathrm{cut}}}{\sigma'_s}}\sigma_{95\%} \tag{4}$$

$$\sigma'_{95\%} = \sqrt{\frac{\mathcal{L}}{\mathcal{L}'}} \sqrt{\frac{\sigma'_{b,\text{cut}}}{\sigma_{b,\text{cut}}}} \frac{\sigma'_s}{\sigma_s} \frac{\sigma_{s,\text{cut}}}{\sigma'_{s,\text{cut}}} \sigma_{95\%} \tag{5}$$

we now have $\sigma'_{95\%}$ in terms of values which we can compute.

In order to in incorporate a minimum background error of $0.6\% \times B$, this can be rearranged as,

$$\sigma'_{95\%} = \frac{\mathcal{L}}{\mathcal{L}'} \frac{\max\left(\sqrt{\mathcal{L}'\sigma'_{b,\text{cut}}}\ ,\ 0.006\mathcal{L}'\sigma'_{b,\text{cut}}\right)}{\sqrt{\mathcal{L}\sigma_{b,\text{cut}}}} \frac{\sigma'_s}{\sigma_s} \frac{\sigma_{s,\text{cut}}}{\sigma'_{s,\text{cut}}} \sigma_{95\%}. \tag{6}$$

in order to use variables already defined in our code, this can be re-written as,

$$\sigma'_{95\%} = \frac{\mathcal{L}}{\mathcal{L}'} \max\left(\frac{\sqrt{\mathcal{L}'\sigma'_{b,\text{cut}}}}{\sqrt{\mathcal{L}\sigma_{b,\text{cut}}}}\ ,\ \frac{0.006\mathcal{L}'\sigma'_{b,\text{cut}}}{\sqrt{\mathcal{L}\sigma_{b,\text{cut}}}}\right) \frac{\sigma'_s}{\sigma_s} \frac{\sigma_{s,\text{cut}}}{\sigma'_{s,\text{cut}}} \sigma_{95\%}. \tag{7}$$