A method to reanalize Dark Matter experimental results in different theoretical scenarios

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An old joke: are we physicists or mathematicians?

- How to cook pasta: fill the pan with water, fire up the stove, add pasta when boiling starts, …
- What if the water is already boiling?

- Physicist: add pasta.
- Mathematician: throw water away and turn stove off, so you're back to the known case.

How to calculate twists to experimental limits?

- Experiments usually publish limits or positive results for standard interpretations (e.g., $f_p = f_n$).
- Common method: redo calculation from scratch, with simplifying assumptions like constant efficiency. Vary assumed parameters until published result is well approximated, then calculate from scratch new scenario with simplified efficiency, etc.
- But the original results include important information like detector efficiencies
- So, common method throws away much hard experimental work … like the mathematician! Can we do better?

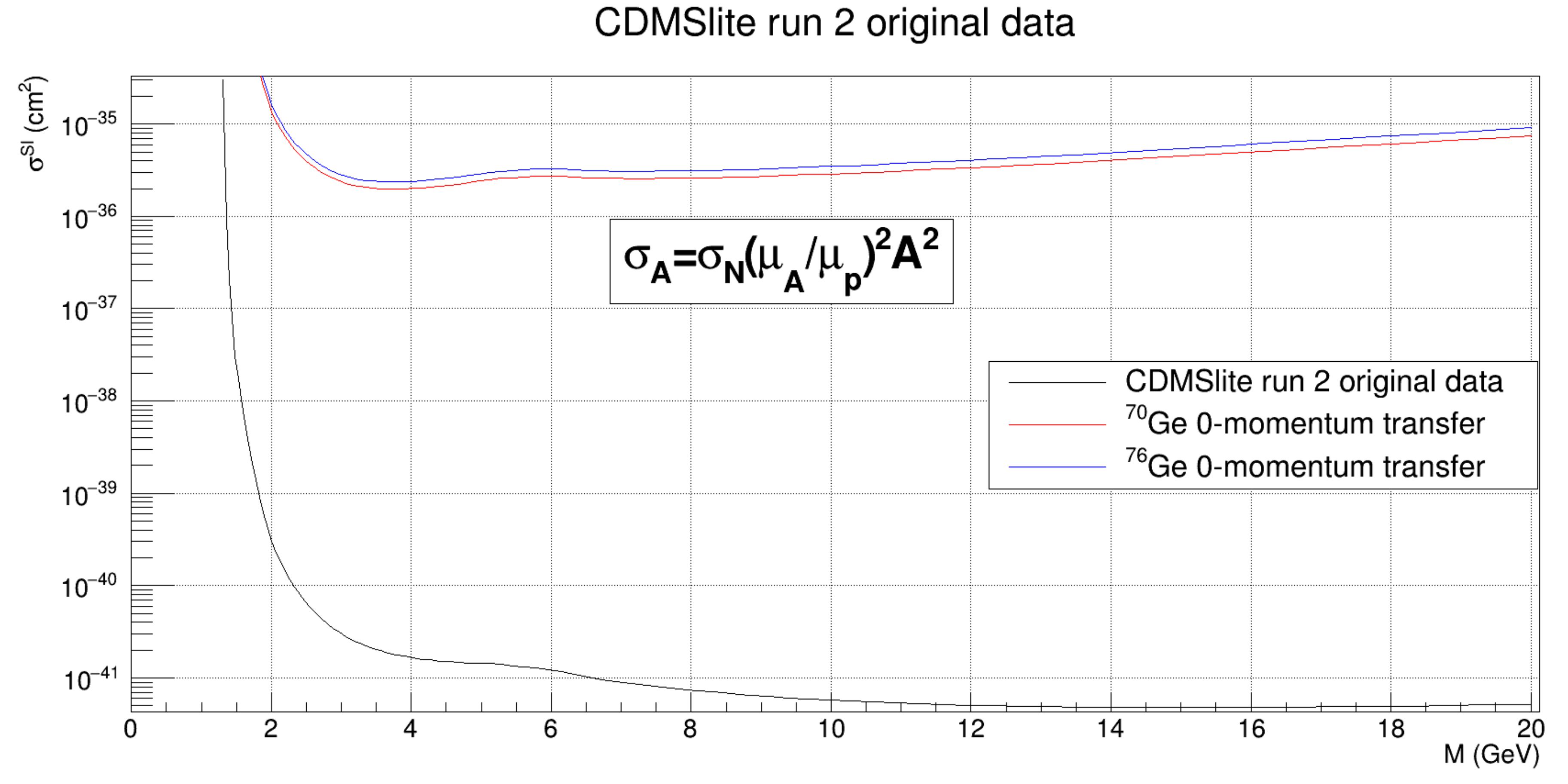
“Physicist’s” alternative

- Just undo the last step(s) of the derivation of the published result
- Typically, calculate **nucleus** zero mom. transfer σs from the ***nucleon***’s
- This nucleus σ(s) still contains all the detector info as included by the experiment!
- If nuclear form factor doesn’t need change (high A and low E_{nr}), this is sufficient
- Then, calculate constraints to “twisted” model from zero mom. transfer σ of the isotopes in the detector
  - This retains all the knowledge of the detector response that only the original experiment has, without you actually knowing it.

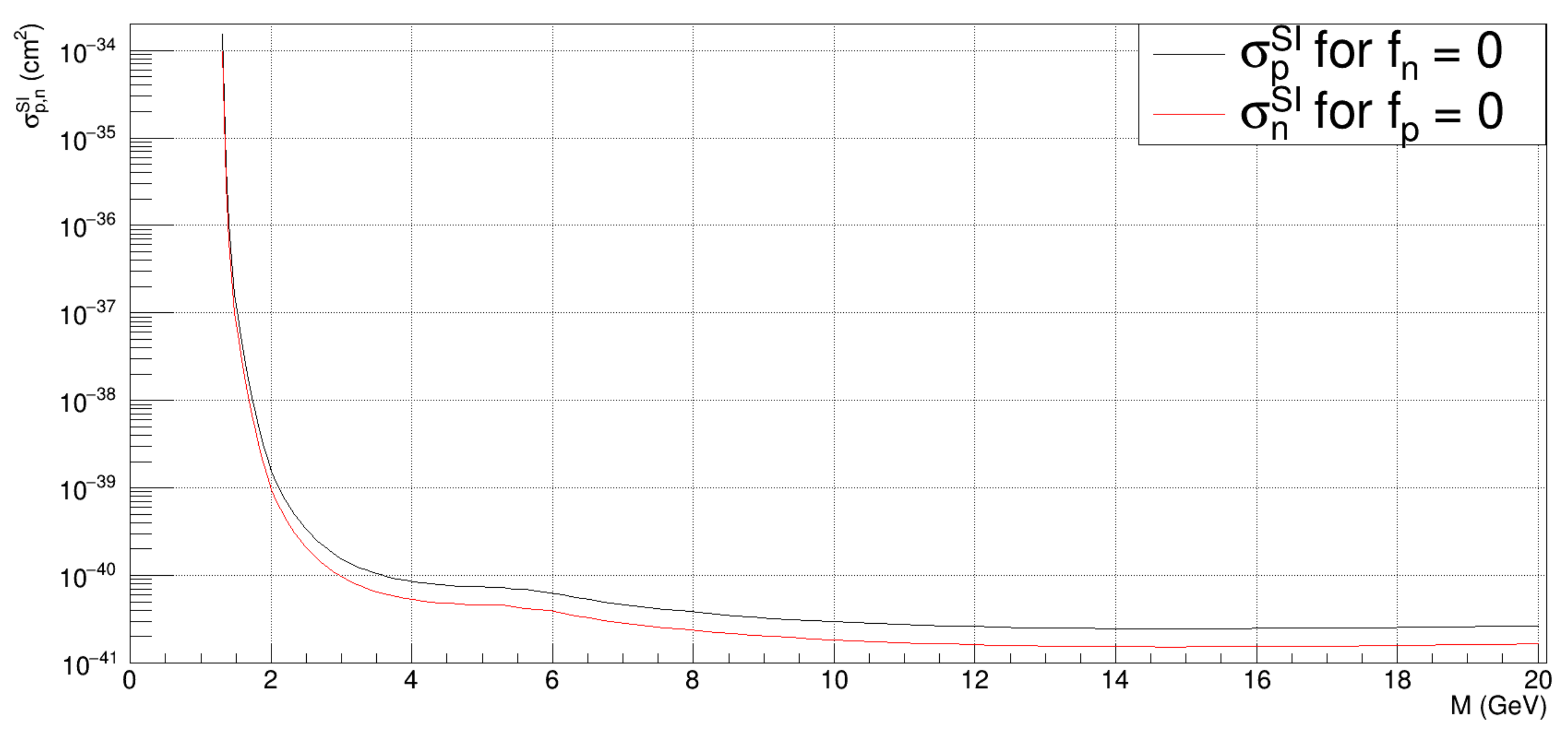
An example: SI limits with $f_p \neq f_n$

- Follow PRL **95** (2005) 101301
- Data from http://dmtools.brown.edu
- Case of CDMSlite (Phys. Rev. Lett. 116 (2016) 071301)
- These data were acquired at low recoil energy, so form factors ≈ 1

0-mom transfer σ_A's from published σ_N



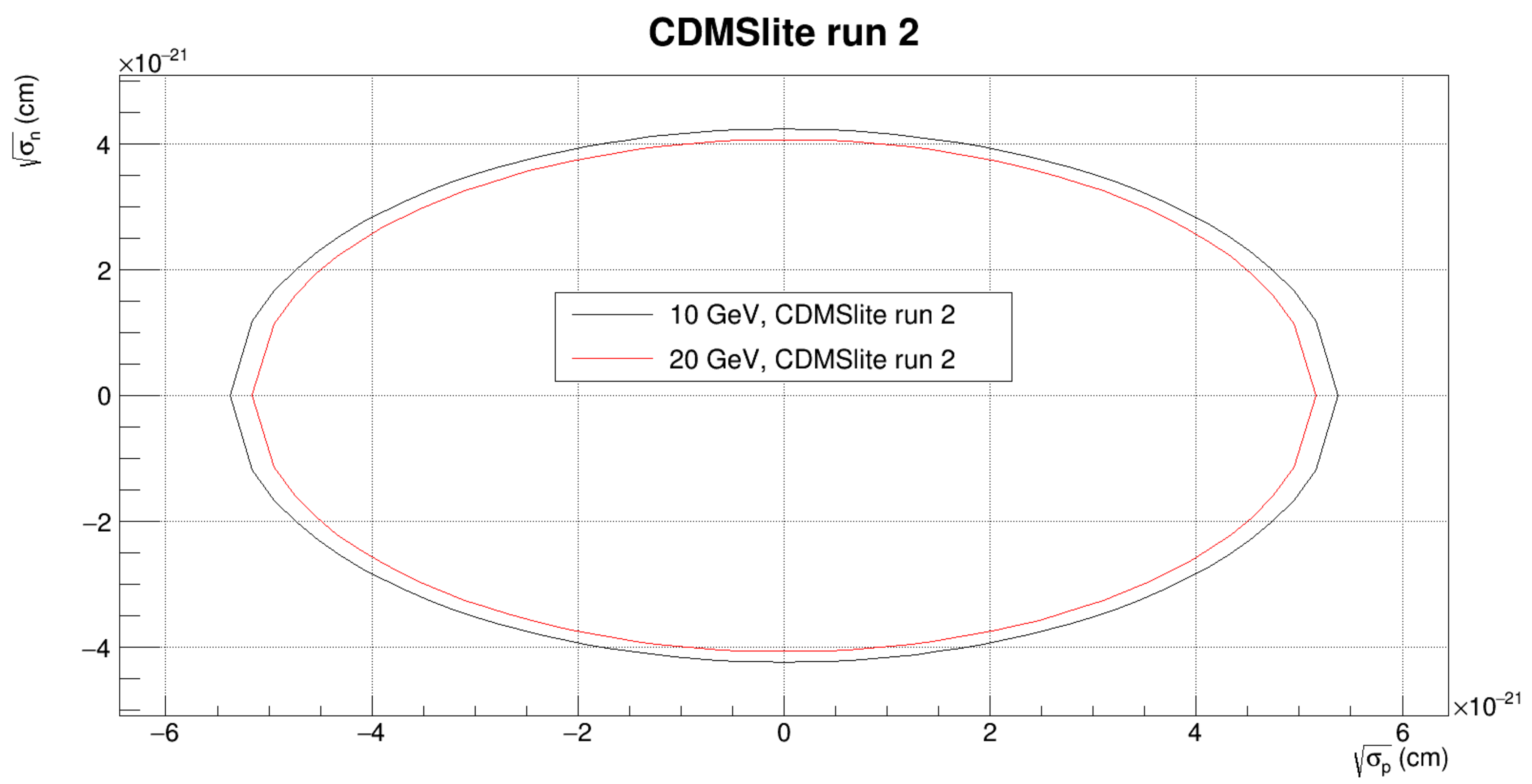
If the DMP coupled to only one type of nucleon…



Elliptical inequalities

$$\begin{cases} \sum_A \left(\sqrt{\frac{\sigma_p}{\sigma_p^{\mathrm{SI}(A)}}} \pm \sqrt{\frac{\sigma_n}{\sigma_n^{\mathrm{SI}(A)}}} \right)^2 & \leq & 1 \\ \sum_A \left(\frac{g_p}{\sqrt{\sigma_p^{\mathrm{SI}(A)}}} + \frac{g_n}{\sqrt{\sigma_n^{\mathrm{SI}(A)}}} \right)^2 & \leq & \frac{\pi}{4G_F^2 \mu_p^2} \end{cases}$$

Synopsis of the allowed SI $\sigma_{p,n}$ for 2 DMP masses



Conclusion

- Sometimes it is desirable to use experimental limits or positive results to constrain a scenario not fitting the standard framework the experiments usually employ to deliver their results (e.g., SI interactions with $f_p \neq f_n$).
- In these cases, it is possible to convert the published cross sections to a modified framework, retaining all the detector and run information the original experiments used to produce their results
- Such an approach does not require any deep knowledge of the experimental details, but simply to avoid throwing away the information originally included in the standard plots by those who best know it.

Original CDMSlite plot