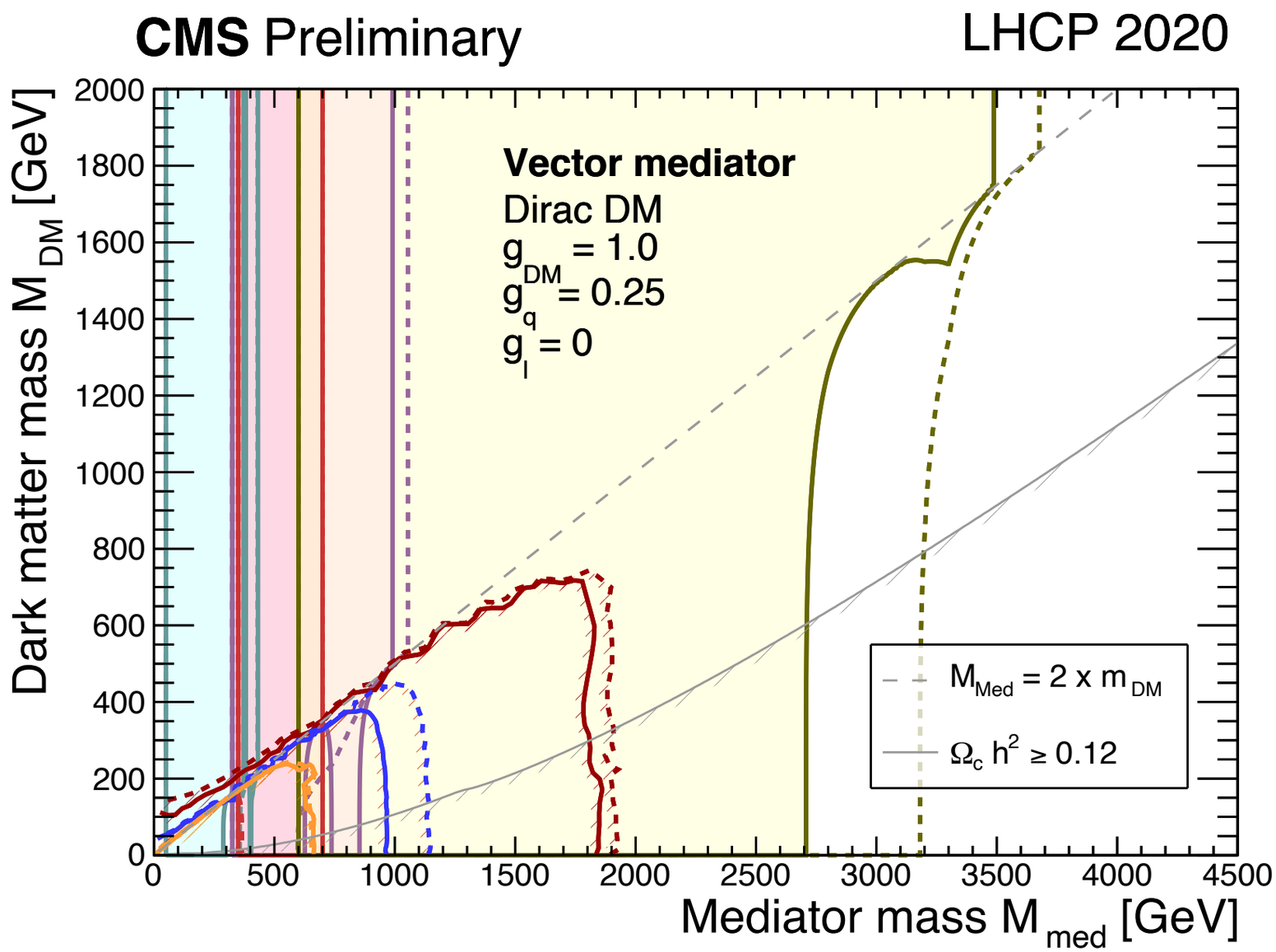
Analytical rescaling for DM simplified models

Andreas Albert, Kate Pachal
for the team

Goal: produce the same kinds of plots with less labour!

The problem to solve

- Making these plots has been very **time consuming** historically
- How they're done: generate a lot of MC with fixed couplings in the mass-mass plane, then scale existing analysis limits to the cross sections of the new samples
- Problems: this is very slow and so **limits the number of couplings** etc which we can display



Given a signal strength limit μ for one set of model parameters, can we easily and accurately find mu for another set of parameters?

What we can use

- These plots (and others) are based around s-channel simplified model described here

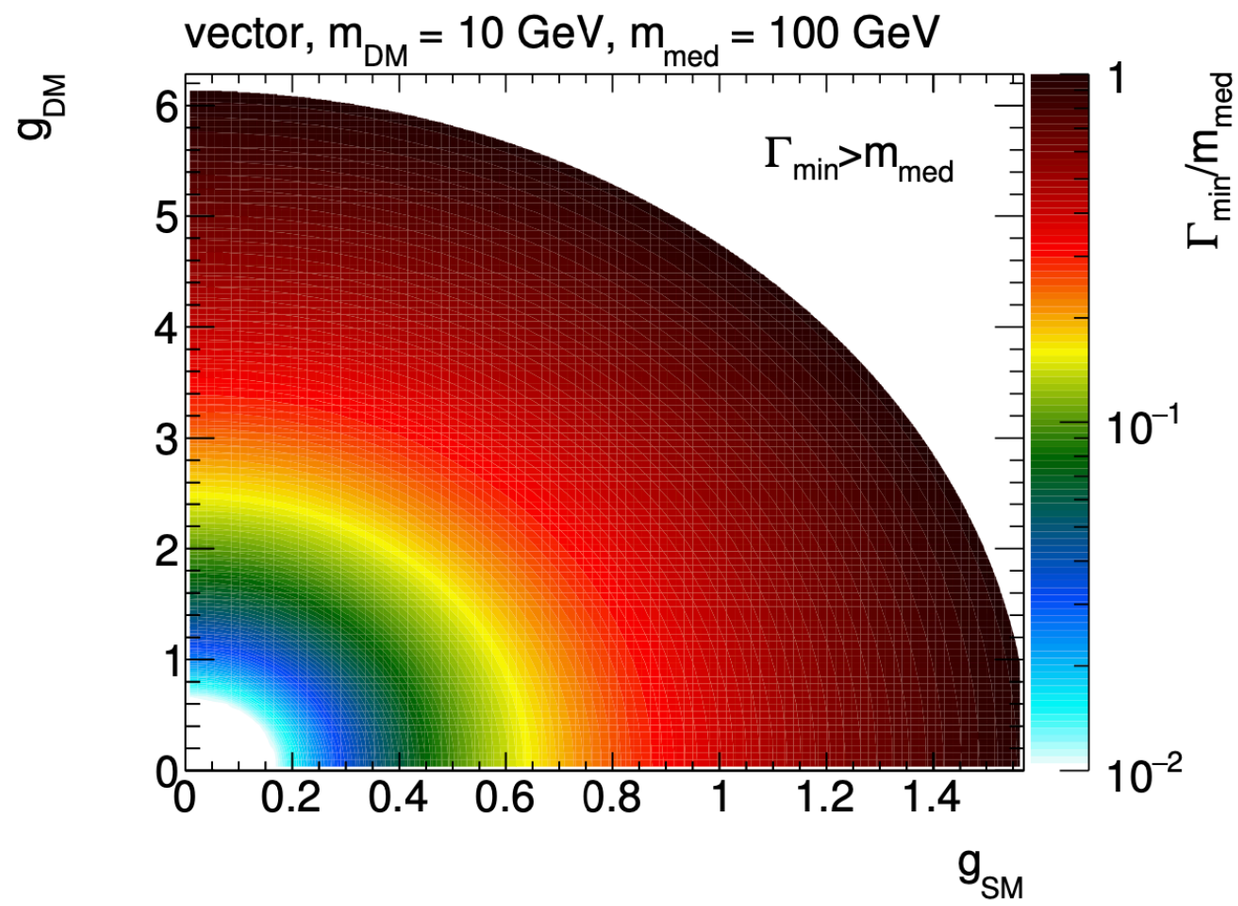
- We have known analytical relationships between the mediator branching ratio/width and cross section and the couplings and masses:

$$\Gamma^{\chi\bar{\chi}}_{\text{vector}} = \frac{g^2_{\text{DM}} M_{\text{med}}}{12\pi} \left(1 - 4z_{\text{DM}}\right)^{1/2} \left(1 + 2z_{\text{DM}}\right) ,$$

$$\Gamma^{q\bar{q}}_{\text{vector}} = \frac{g^2_{q} M_{\text{med}}}{4\pi} \left(1 - 4z_{q}\right)^{1/2} \left(1 + 2z_{q}\right) , \qquad \text{etc.}$$

- We can use this information to rescale limits from one set of couplings to another*

arXiv:1507.00966



Relationship between mediator width and couplings for an example point in m_{DM}, m_{med} space

* many caveats apply

The challenges

Type 1: cross section

- Effect of masses and couplings on cross sections is analytically computable (with some edge cases)

- Same for ~all analyses

Type 2: kinematics etc.

- Effects of coupling changes on acceptance, kinematics, etc via (for example) changing a resonance width

- Very analysis dependent

- In this project, we focus on solving the type 1 challenges. Requires providing clear recipes for users, benchmarking performance, understanding edge cases

- On type 2 challenges, we will define regions of validity for rescaling methods so analyses know what they need to check before using them

Ongoing work and next steps

- Studies continuing to finalise rescaling methods to recommend
- Document being written via the LHC Dark Matter Working Group specifying how to analytically rescale limits within s-channel simplified models
  - Cover visible (resonant) and mono-X final states
  - Aiming for a fairly short paper
- Along with the paper we intend to release our code that actually performs the rescaling, allowing ATLAS & CMS to share labour and coordinate interpretations
- In Snowmass context, we hope making these tools available will be useful for e.g. extending any HL-LHC projections in this simplified model, etc