Coupling scan validation plans

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Introduction

- The coupling scan white paper must have two main purposes:
    1. explain rescaling methods, make code available
    2. demonstrate + quantify the performance of the methods
- This talk is about (2): What do we want to demonstrate?
- Few ideas immediately come to mind:
  - **Inclusive:**
    - In how far does the rescaling reproduce MG-level cross sections as a function of couplings? → next slides
  - **Differential:**
    - In how far are MET shapes in mono-X searches independent of couplings?
    - In how far are angular distributions for visible decay products of mediators indepenendt of couplings?
  - –

Step 1: Inclusive cross section validation

Results as .txt

At the lowest complexity level,
we need to show that we can
reproduce the inclusive XS

Study outline:

- Calculate coupling scan of XS in standalone MG
- Compare to analytical method, e.g. BR-based rescaling

```
$ cat coupling_scan.txt

import DMsimp_s_spin1
generate p p > xd xd~ j


output dmsimp_coupling_scan


launch


set param_card MXd 1.0
set param_card MY1 scan:[100,250,500,1000,1500,2000]
set param_card gVh 0
set param_card gad11 0
set param_card gad22 0
set param_card gad33 0
set param_card gau11 0
set param_card gau22 0
set param_card gau33 0
set param_card gaxc 0
set param_card gaxd 0
set param_card gvd11 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvd22 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvd33 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvu11 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvu22 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvu33 scan1:[0.005,0.01,0.025,0.05,0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.5,0.75,1.0]
set param_card gvxc 0
set param_card gvxd 1
set WY1 AUTO


set run_card ptj 100

$ ./bin/mg coupling_scan.txt
```

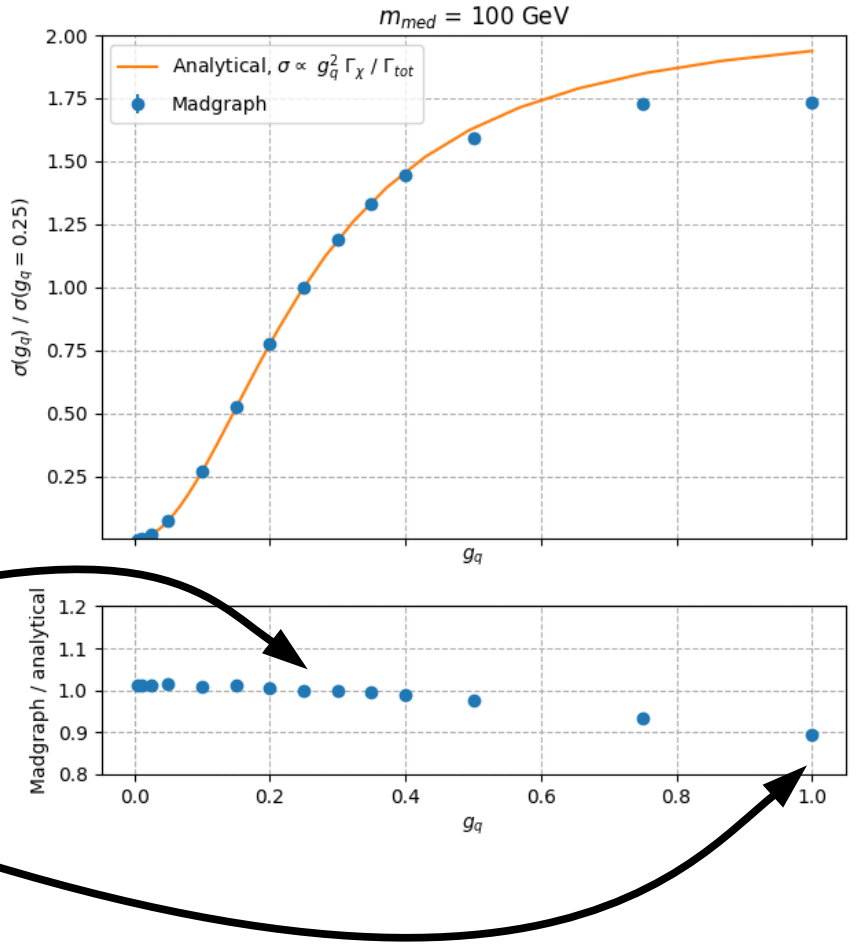
Comparison of analytical and simulated scaling (vector, m_{dm} = 1 GeV)

MG result (blue points) here compared to BR rescaling from mediator width dependence on gq, gchi (orange line)

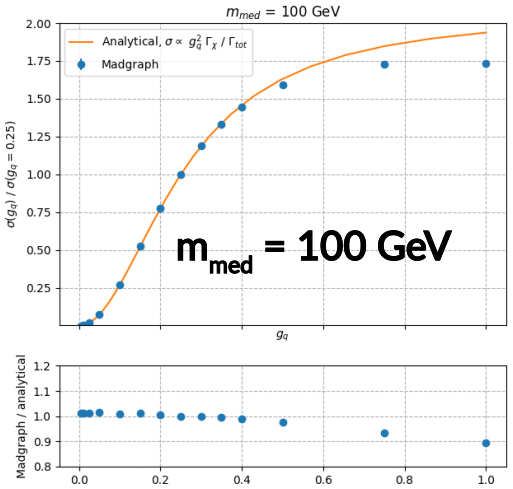
We only care about the ratios
→ y-axis is relative to gq=0.25

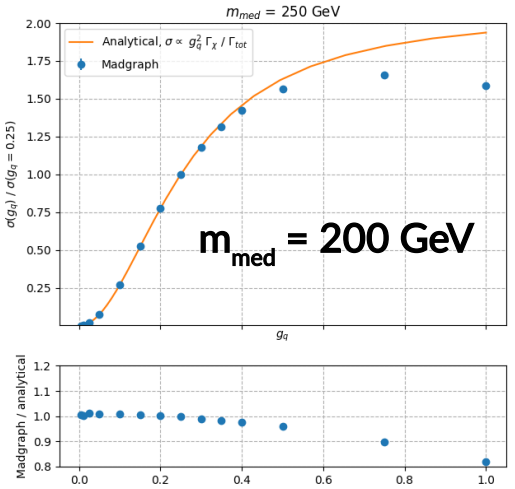
Point here is vector med with
mmed = 100 GeV, mDM = 1 GeV

Quote agreement regions:
few % level for gq∈[0,0.5],
10% level for gq up to 1

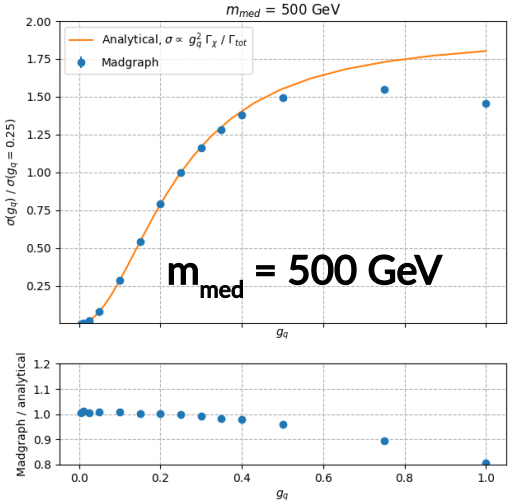


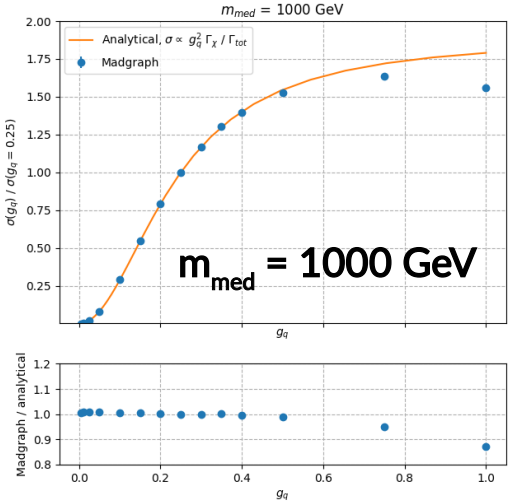
More points, vector m_{DM} = 1 GeV

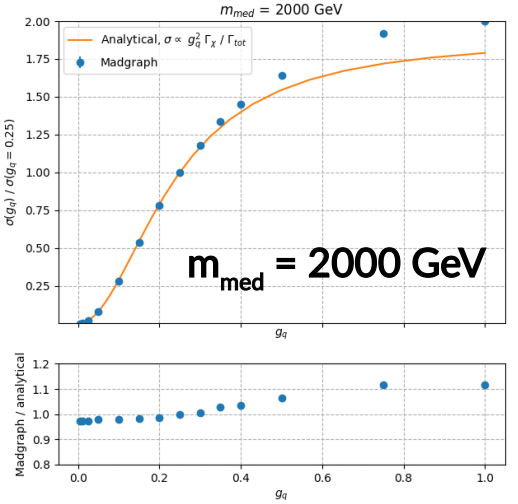




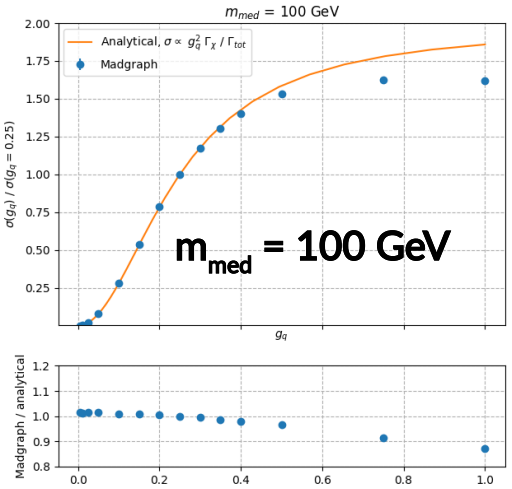
Exact agreement varies with mediator mass, but overall very good until 0.5

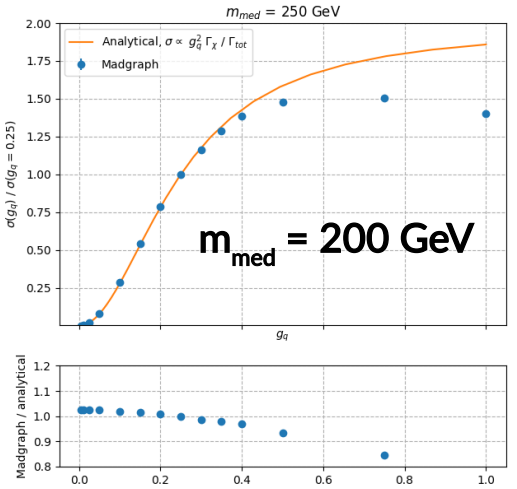






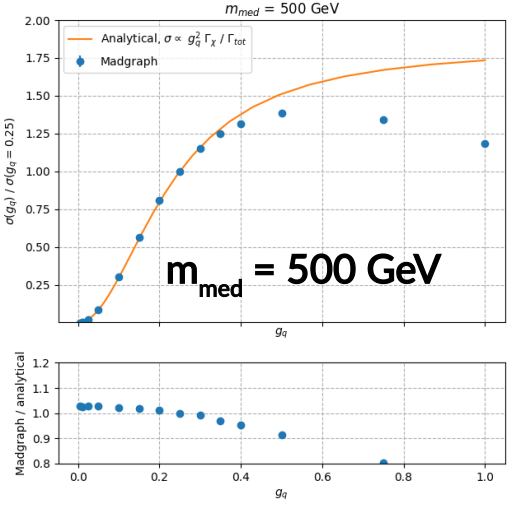
Same as last slide, bt different DM mass: $m_{dm}=m_{med}/3$)

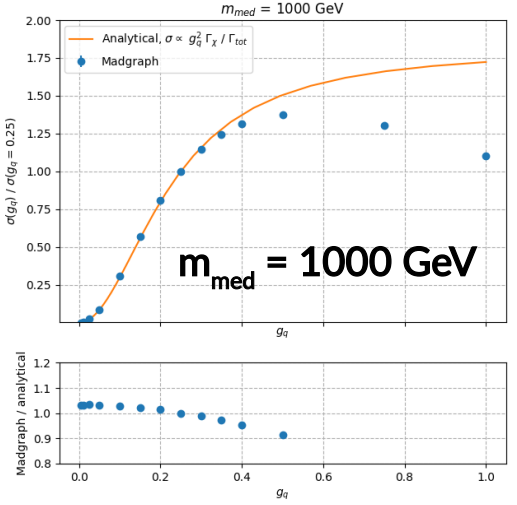


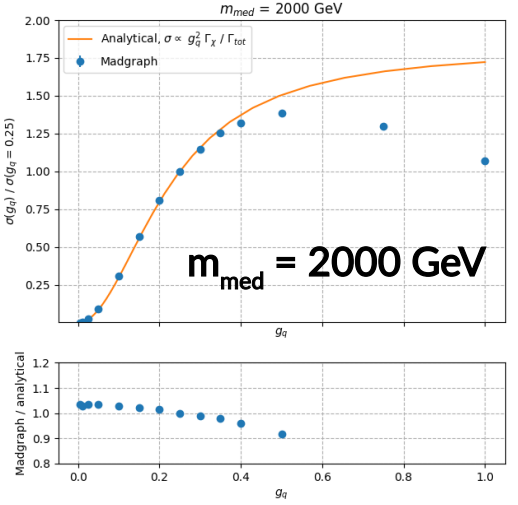


- qualitative similar to m_{dm}=1 GeV
- quantitatively the deviations are bigger

  → **Should trust gq scaling until about 0.5**







Extension?

- **Plots based on simplest level of analytical rescaling**
- **Ideal plot: Overlay different levels of rescaling on same plot.**

  → Demonstrates where exactly additional complexity is useful

  → Allows the user to gauge whether simple method might suffice within needed precision
- Presentation should explore major axes in which agreement develops: mmed, mdm/mmed

Step 2: Differential agreement

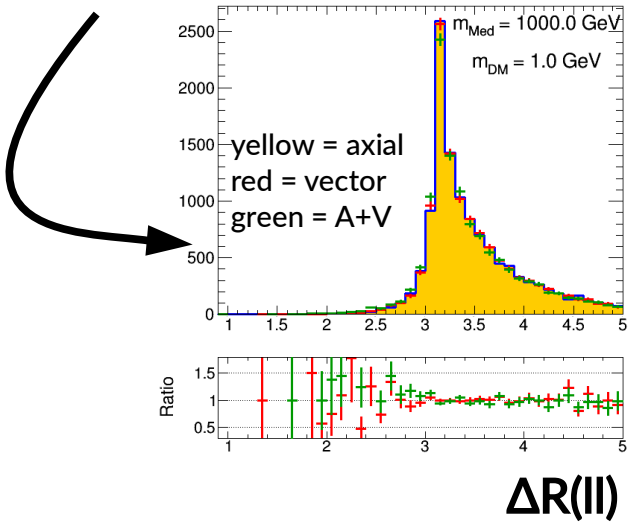
- **Limit rescaling only works if change of differential distributions is understood**
- **For MET+X, this was previously explored in 2015 DMF report (and probably elsewhere, too):**

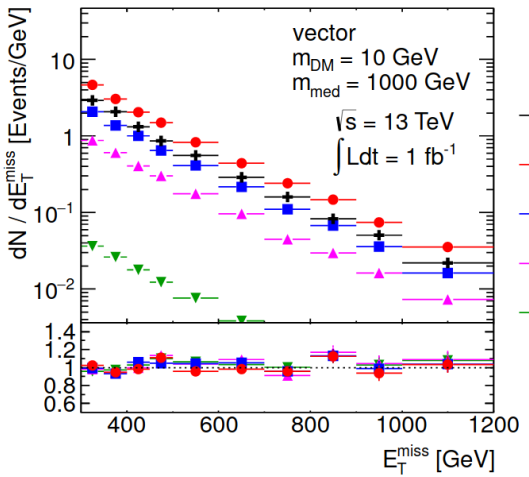
  m_DM dependence not studied here AFAICT

  → Would be good addition
- **For dilepton, differential dists of leptons**

  must agree with DY as function of mass width

  tested explicitly in CMS, easy to replicate standalone





g_{SM}	g_{DM}	Γ/m_{med}	$\sigma \times A_{300}$ [fb]	$\sigma \times A_{500}$ [fb]
1.00	1.00	0.504	4.8e+02	1.2e+02
1.45	1.45	1.059	7.5e+02	1.8e+02
0.25	1.00	0.056	3.5e+02	9.0e+01
0.50	0.50	0.126	1.5e+02	3.8e+01
0.10	0.10	0.005	6.3e+00	1.6e+00

Figure 2.3: Scan over couplings. The E_T distribution is compared for the vector mediator models using the parameters as indicated. Ratios of

Other aspects we should think about?

Summary

- **Validation is integral part of white paper: quantify validity in different parameter ranges**
- **Basis for inclusive validation ready**

  → extend with more complex rescaling methods
- **What do we want to do for differentials?**
  - MET shapes
  - Dilepton angular dists?
  - ?

Backup

Backup