Simplified Models for DM+V

Linda M. Carpenter

Ohio State University

To appear soon on arxiv with Russell Colburn and Jessica Goodman

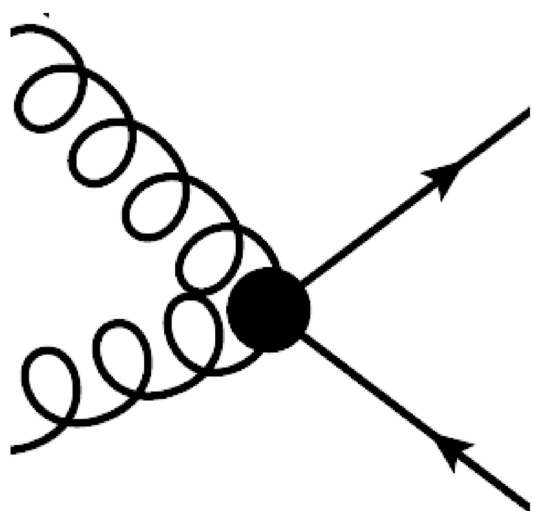
EFT → Simplified Model

D11 $1/M_*^3$ $\bar{\chi}\chi G_{\mu\nu}G^{\mu\nu}$

Fermionic DM

R3 $1/M_*^2$ $\chi^2 G_{\mu\nu}G^{\mu\nu}$

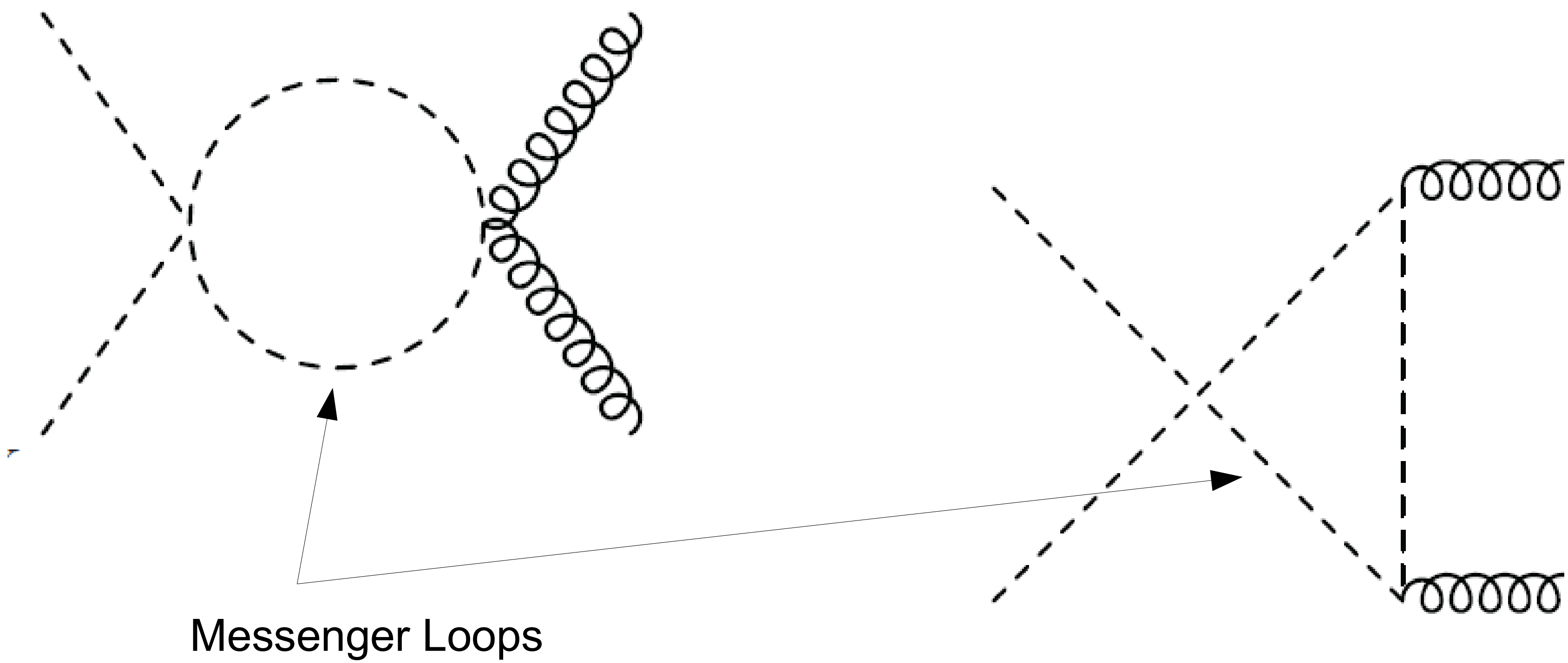
Scalar DM



EFT Operator Coupling DM to Gluons

Messengers with SU(3) Quantum Numbers

$$\lambda|\phi|^2|\chi|^2 + m_\phi^2|\phi|^2 + m_\chi^2|\chi|^2$$

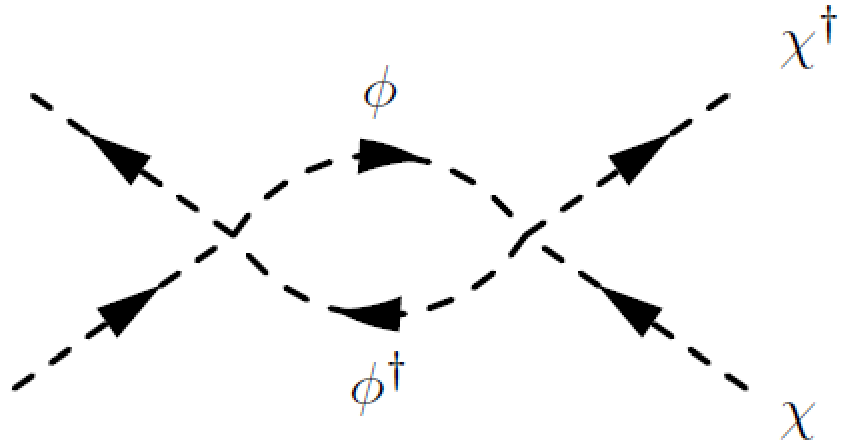


Implement for Event Generation

New FeynRules Tools allow event generation for more complicated models

http://arxiv.org/abs/1406.3030

Check with Analytic Calculation

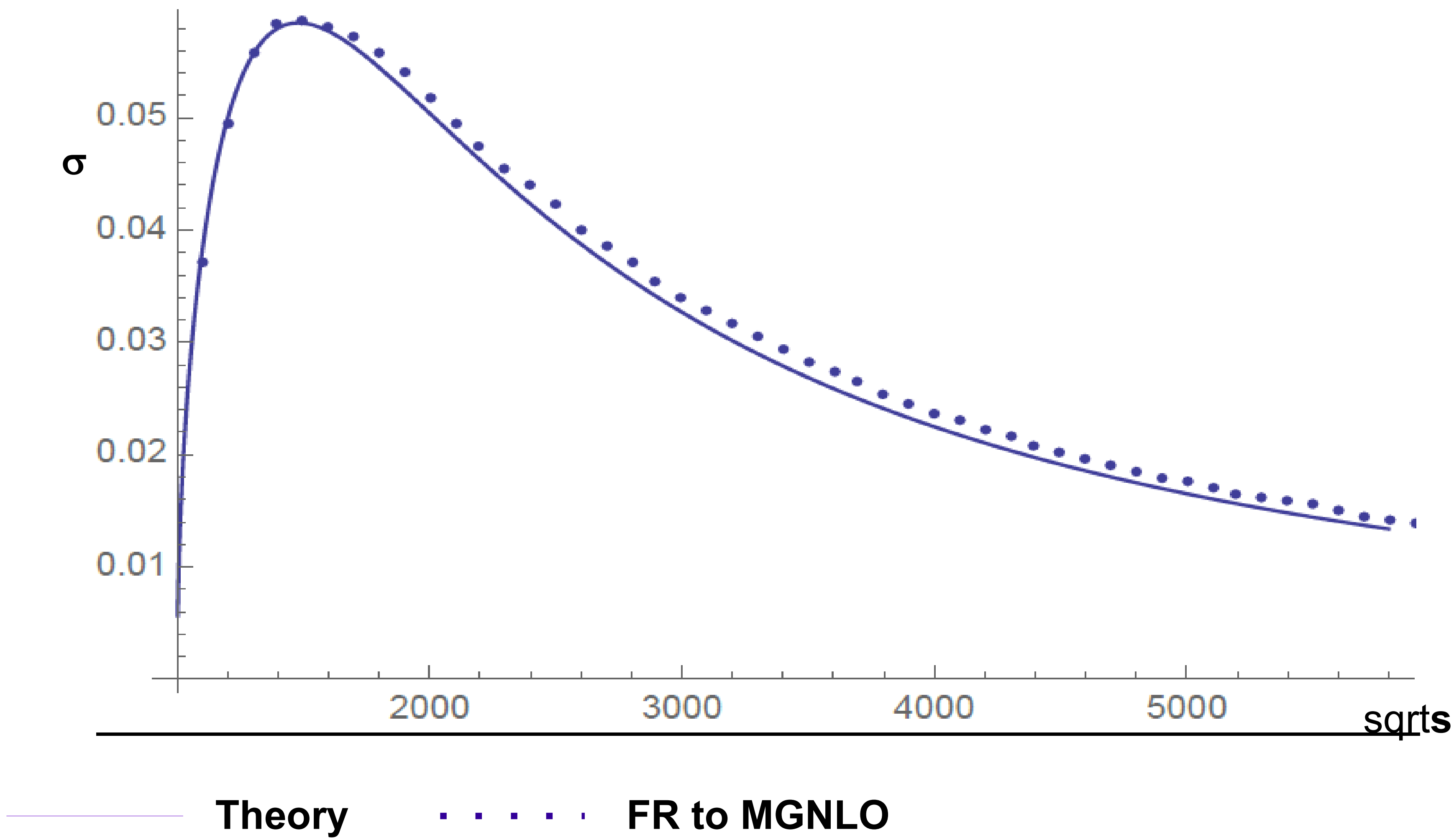


$: (s \gtrsim 4m^2)$

$$\frac{\lambda y}{16\pi^2}\left[\sqrt{1-\frac{4m^2}{s}}\ln\left(\frac{\sqrt{s}+\sqrt{s-4m^2}}{\sqrt{s}-\sqrt{s-4m^2}}\right)+\ln\left(\frac{m^2}{\Lambda^2}\right)-1+i\pi\sqrt{1-\frac{4m^2}{s}}\ \right]$$

Matrix Element

Compare Theory vs Event Implementation



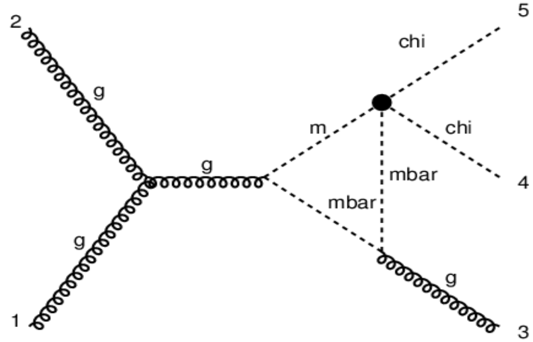


diagram 1 NP=1, QCD=3, QED=0

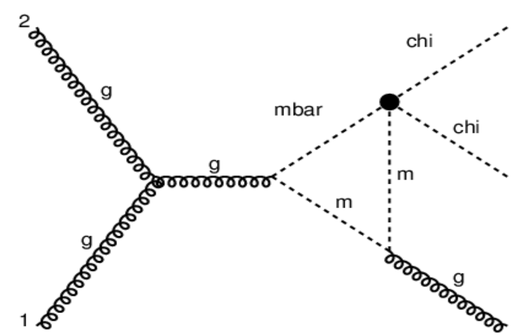


diagram 2 NP=1, QCD=3, QED=0

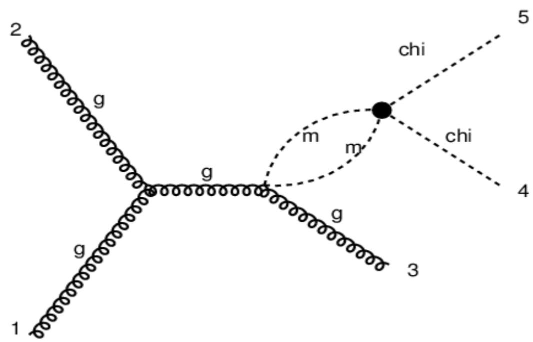


diagram 3 NP=1, QCD=3, QED=0

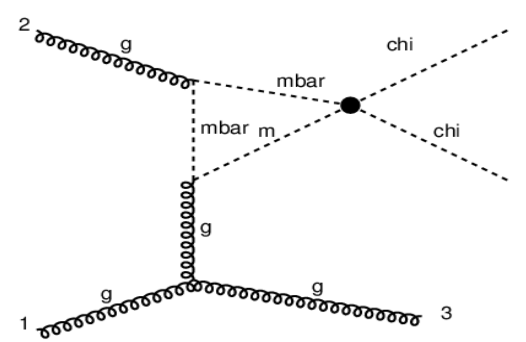


diagram 4 NP=1, QCD=3, QED=0

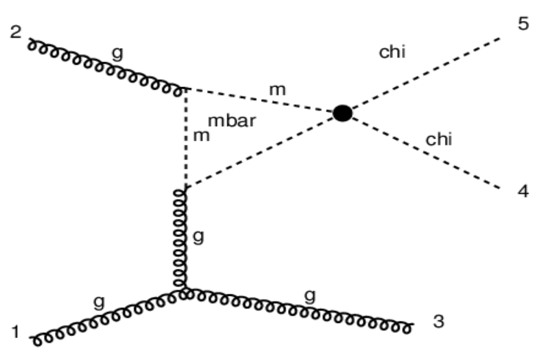


diagram 5 NP=1, QCD=3, QED=0

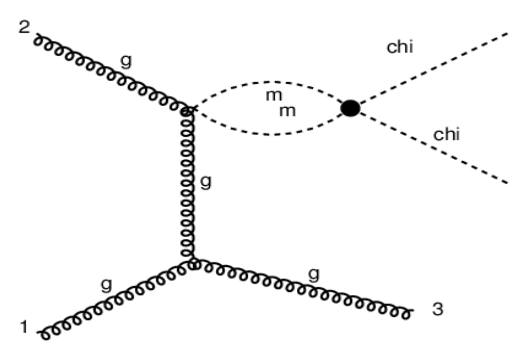
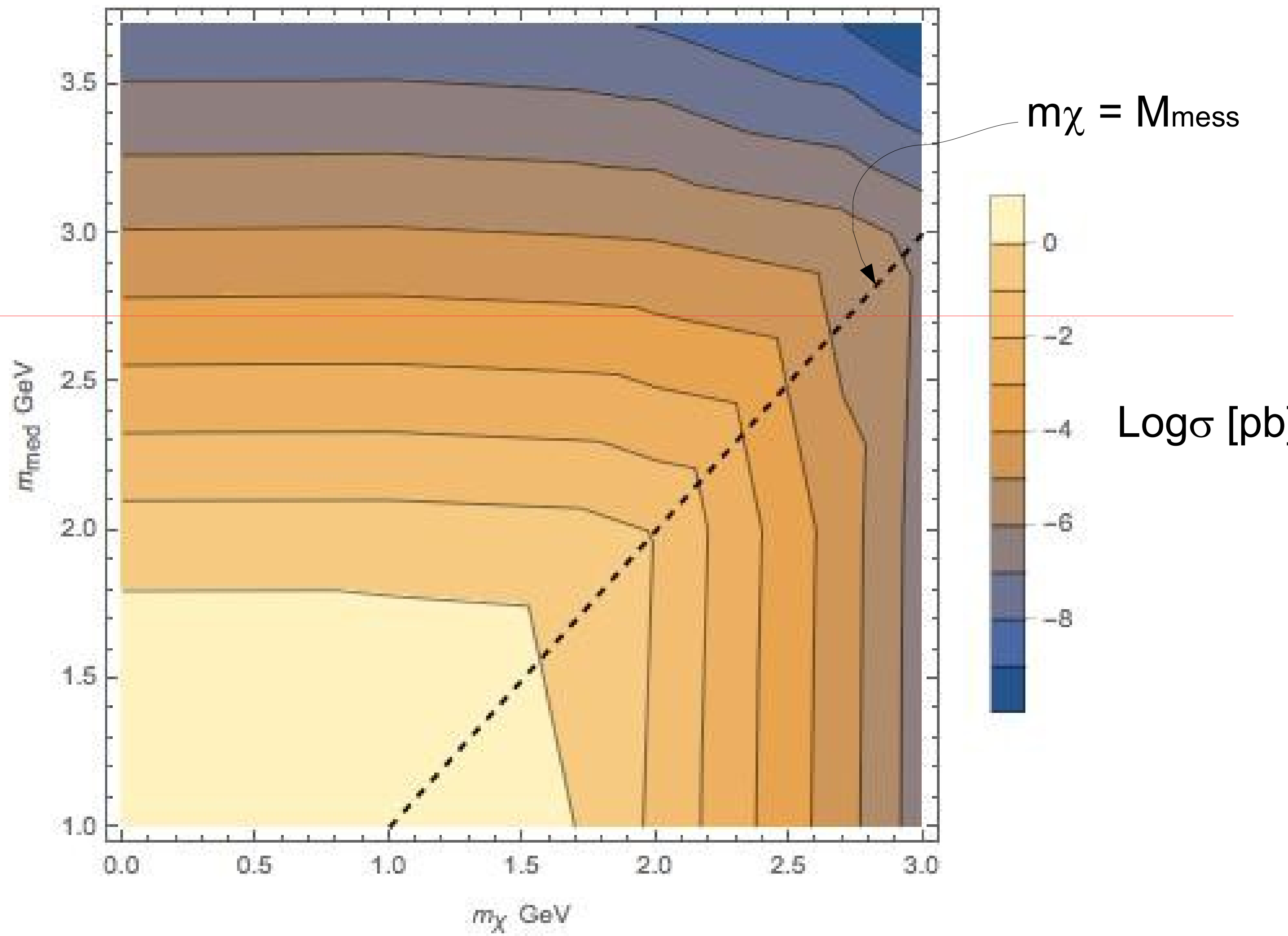


diagram 6 NP=1, QCD=3, QED=0

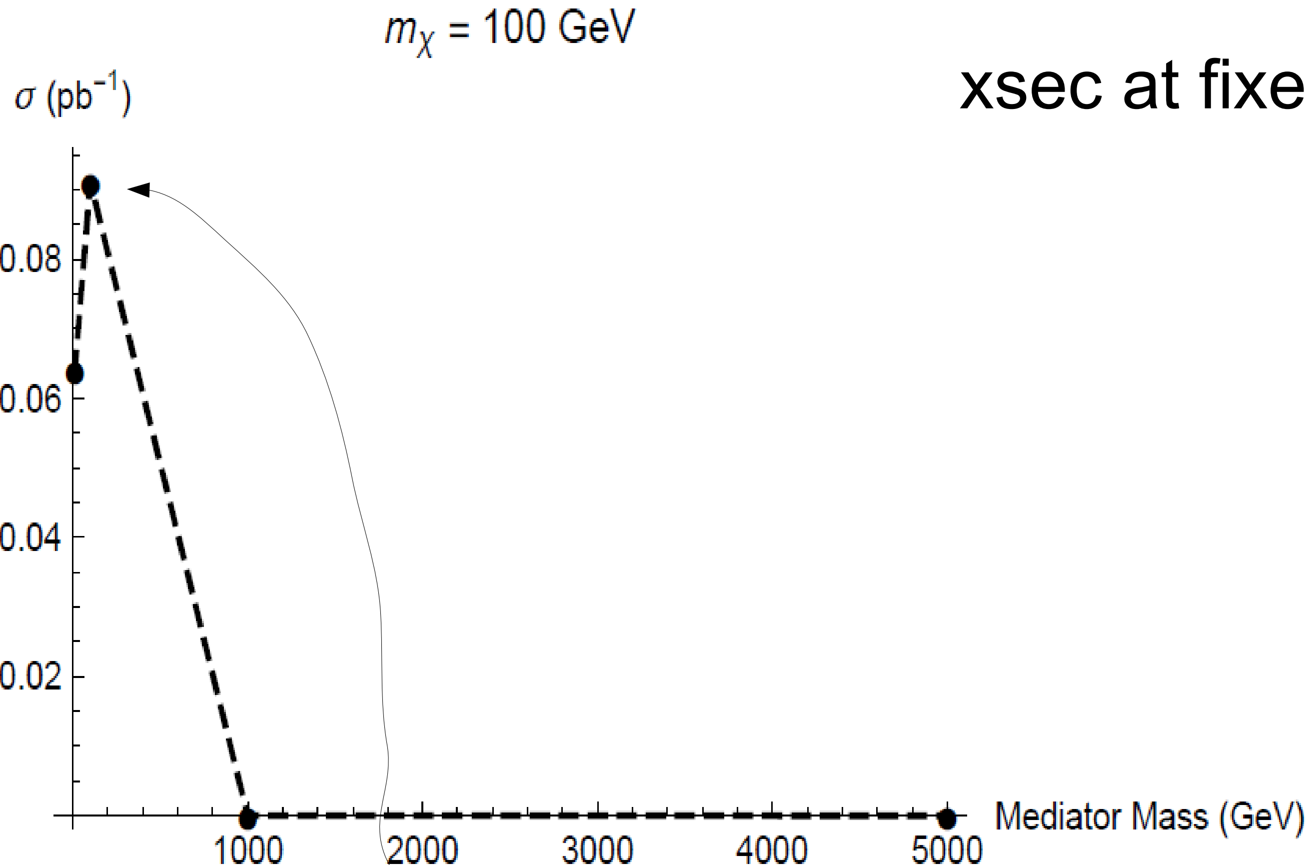
Diagrams made by MadGraph5_aMC@NLO

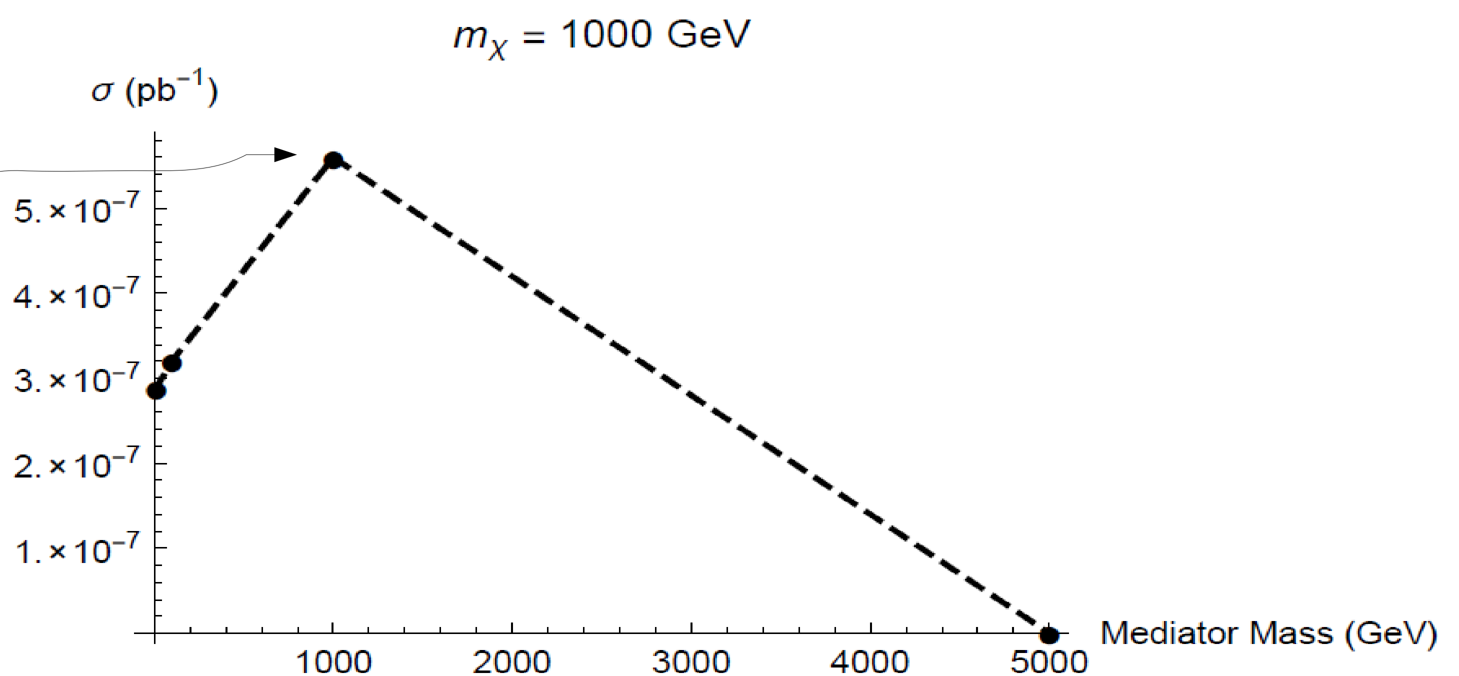
Process p p > j χ

Scan over DM and Messenger Mass with λ =1 for 13 TeV c.o.m Energy



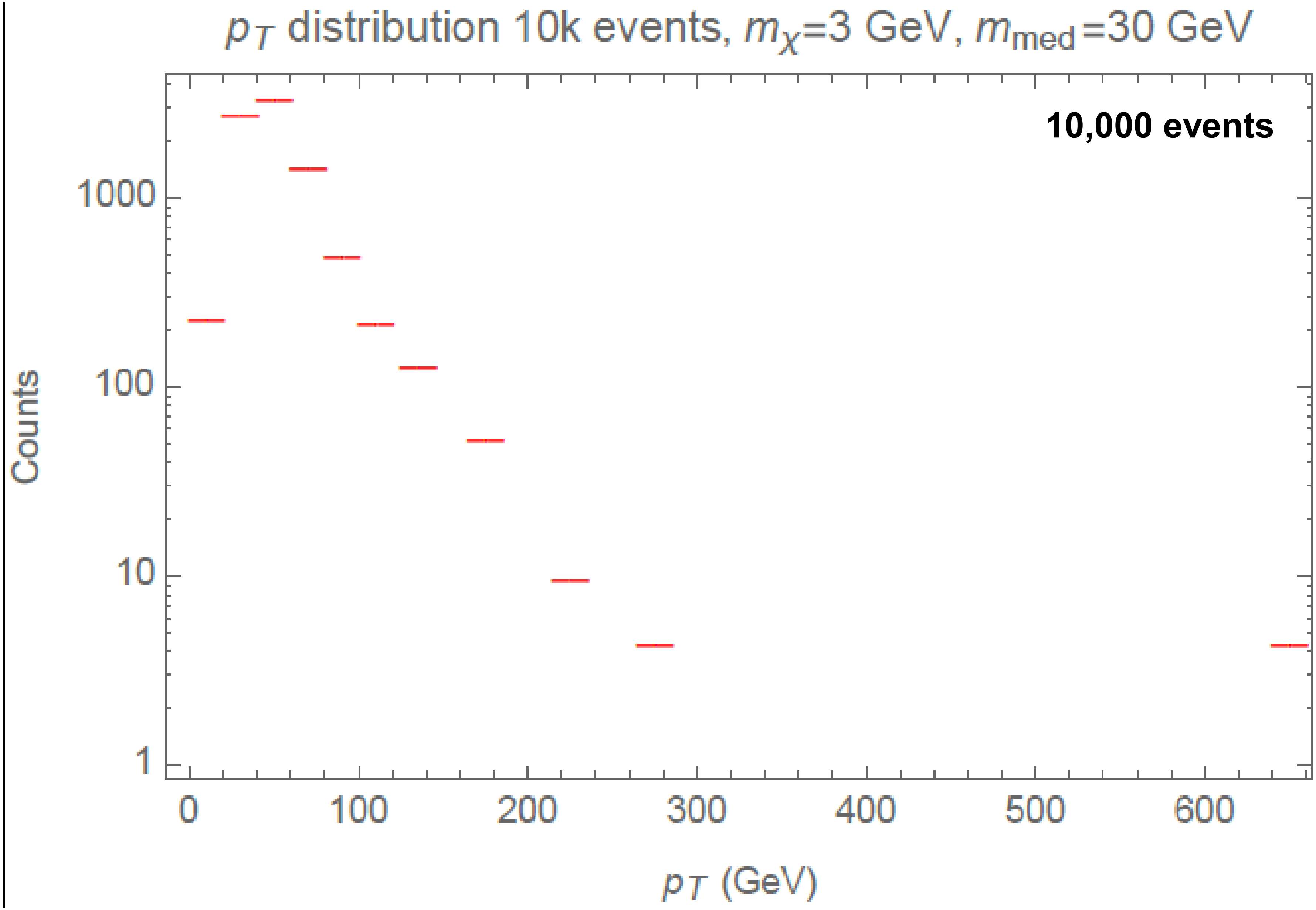
xsec at fixed DM masses





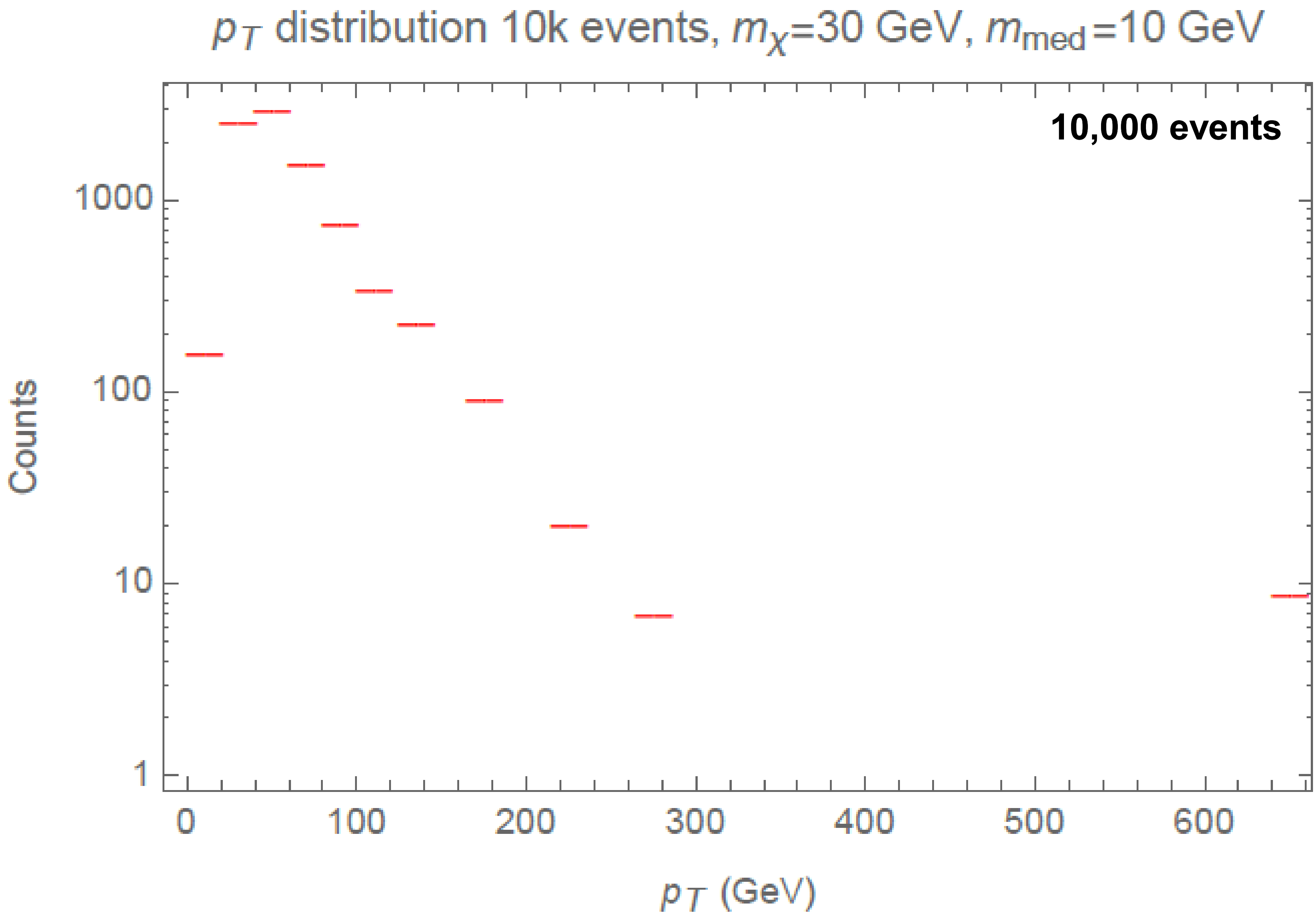
Noticable peak

Leading jet pT



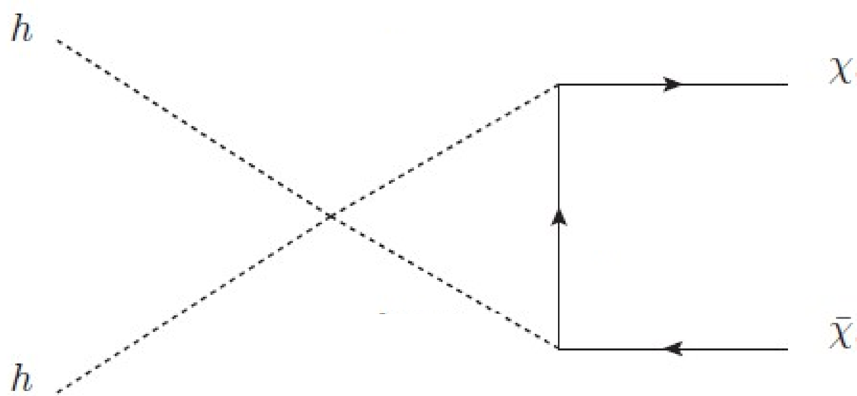
Highest bin contain all events with more than 300 GeV pT

Leading jet pT

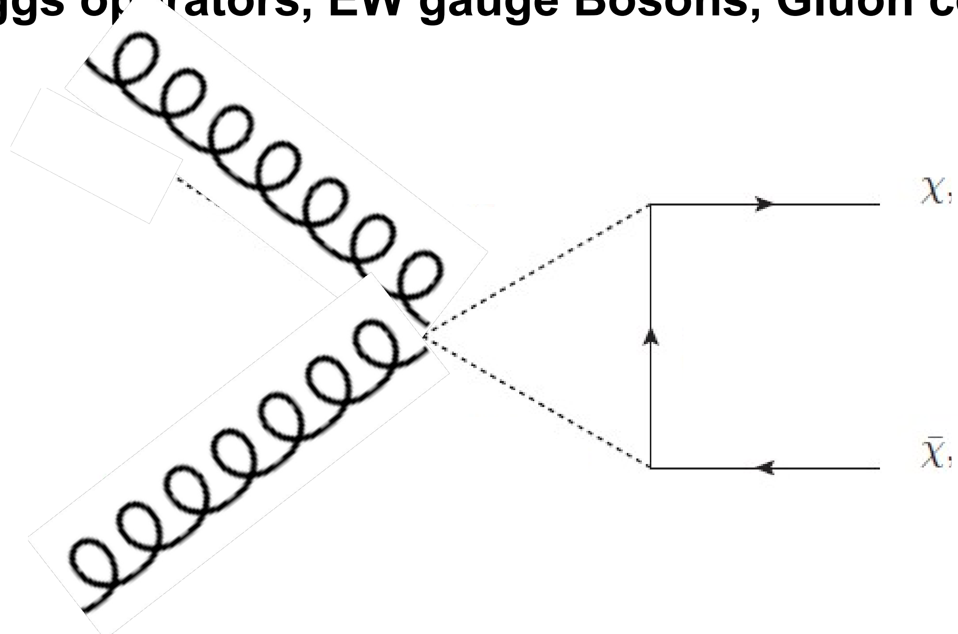


Highest bin contain all events with more than 300 GeV pT

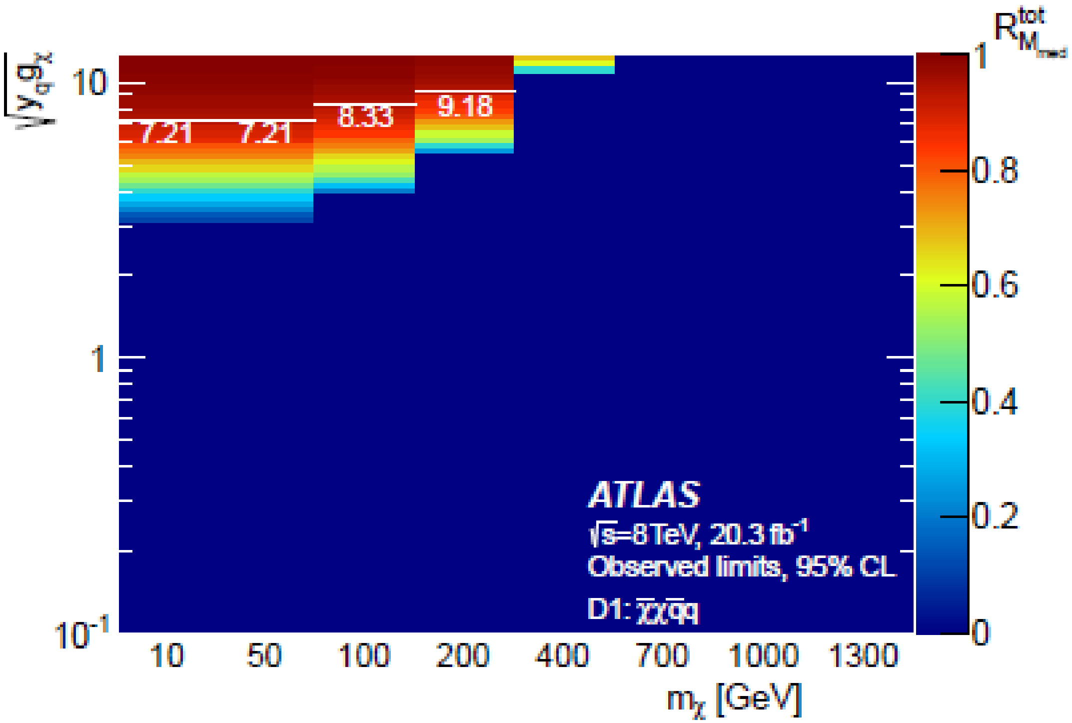
Today Monojets Tomorrow the World



Soon to come, Higgs operators, EW gauge Bosons, Gluon coupling to fermionic DM



Extra Slides ATLAS truncation



D11

$$\frac{\alpha_s}{4M_\star^3} = \frac{\alpha_s g_\chi}{M_{med}^2 \Lambda_s}$$

$$M_{med} = \sqrt[3]{\frac{4g_\chi}{b}}\, M_\star$$

Let $a = 4b^{-1}$

$$M_{med}^{D11} = \sqrt[3]{a g_\chi}\, M_\star$$

$$0 < \sqrt[3]{a g_\chi} < \sqrt[3]{16\pi}$$

1. The starting point is the nominal expected limit on $M_\star$ assuming 100% validity, named $M_\star^{exp}$. $M_\star^{exp}$ is set to $M_\star^{in}$ before executing step 2 for the first time.
2. For each step i, obtain the relative fraction of valid events $R^{i}_{M_{med}}$ satisfying $Q_{tr} < M^{in}_{med}$, where M^{in}_{med} is the mediator mass limit obtained in the previous step (depending on $M_\star^{in}$).
3. Truncate $M_\star$ following Ref. [43]: $M_\star^{out} = \left[R^{i}_{M_{med}}\right]^{1/2(d-4)} M_\star^{in}$, noting that D1 and D11 are dimension $d = 7$ operators, while D5, D8, D9, C1, and C5 are dimension $d = 6$.
4. Go to step 2, using the current $M_\star^{out}$ as the new $M_\star^{in}$, repeating until the fraction of valid events at a given step $R^{i}_{M_{med}}$ reaches 0 or 1.
5. Calculate the total validity fraction $R^{tot}_{M_{med}} = \prod_i R^{i}_{M_{med}}$ and the truncated limit on the suppression scale

$$M_\star^{valid} = \left[R^{tot}_{M_{med}}\right]^{1/2(d-4)} M_\star^{exp}.$$