

# Studies for Real Vector DM & Characterization analysis

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# Cross Sections at LO

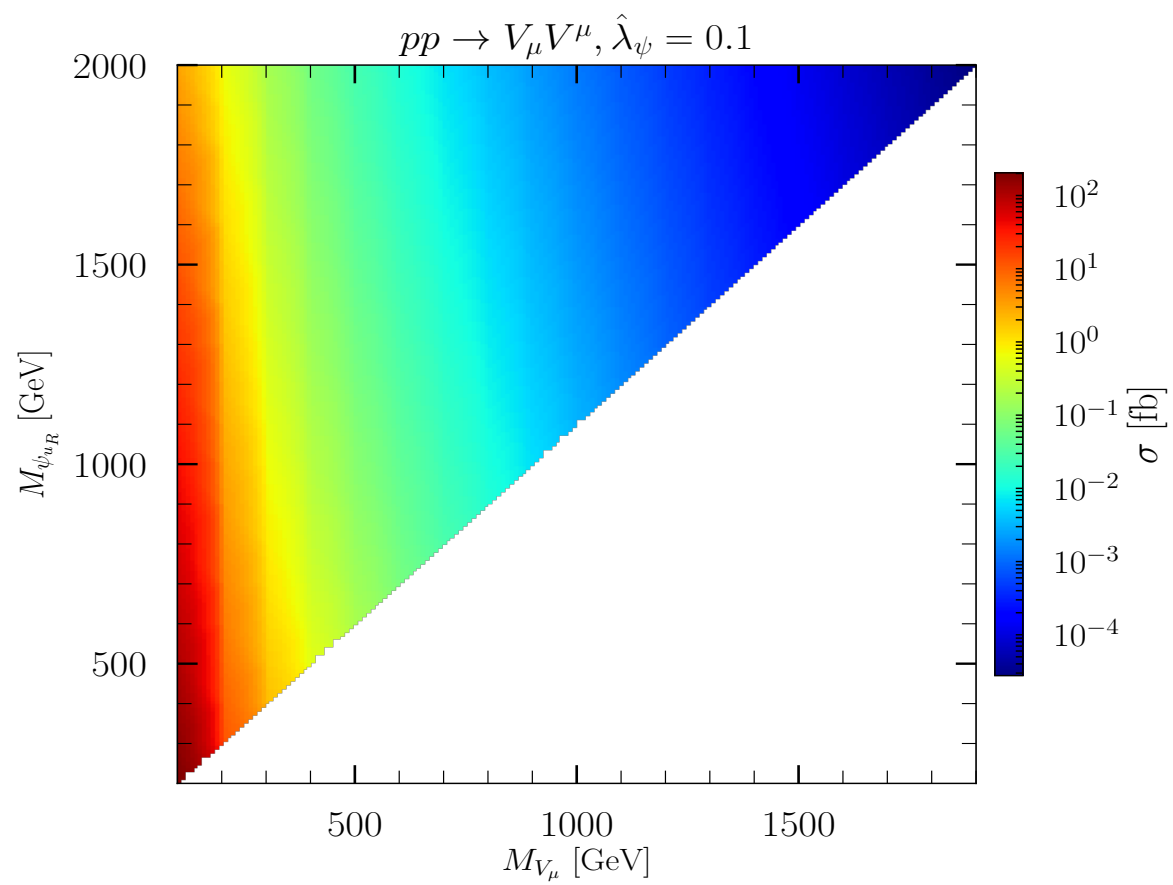
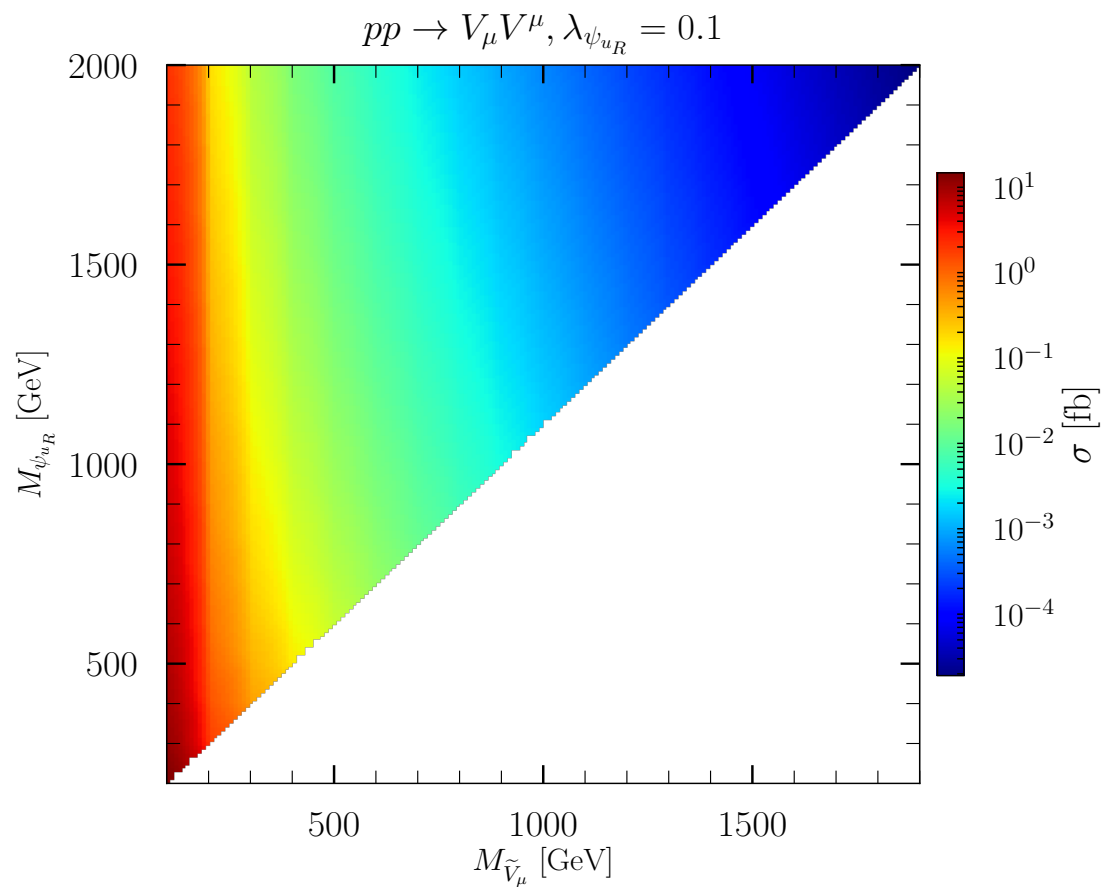
- I started with the computation of LO cross sections for various processes; DM pair production, DM+mediator production, and mediator pair production (t-channel & QCD only) for both the real vector DM and the complex vector DM.
- I used the standard setup:

NNPDF31@LO with  $\alpha_s(M_Z^2) = 0.118$ .

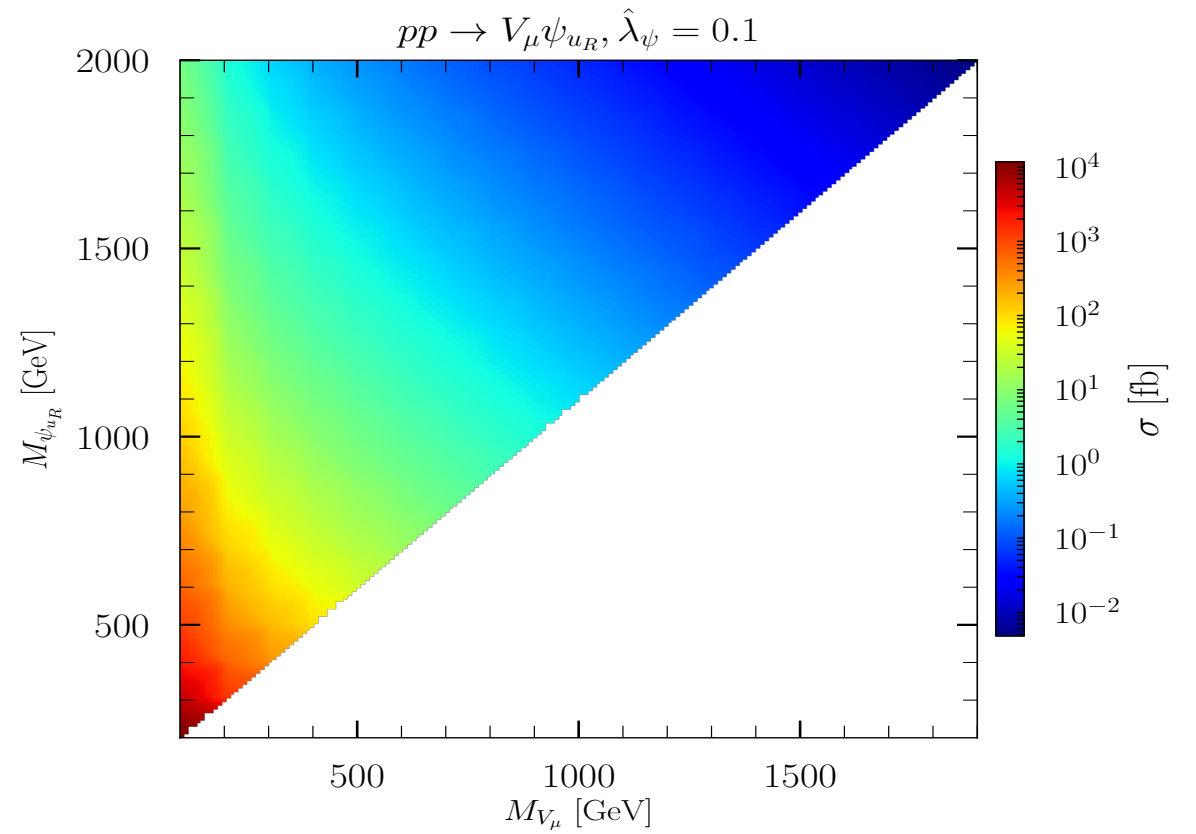
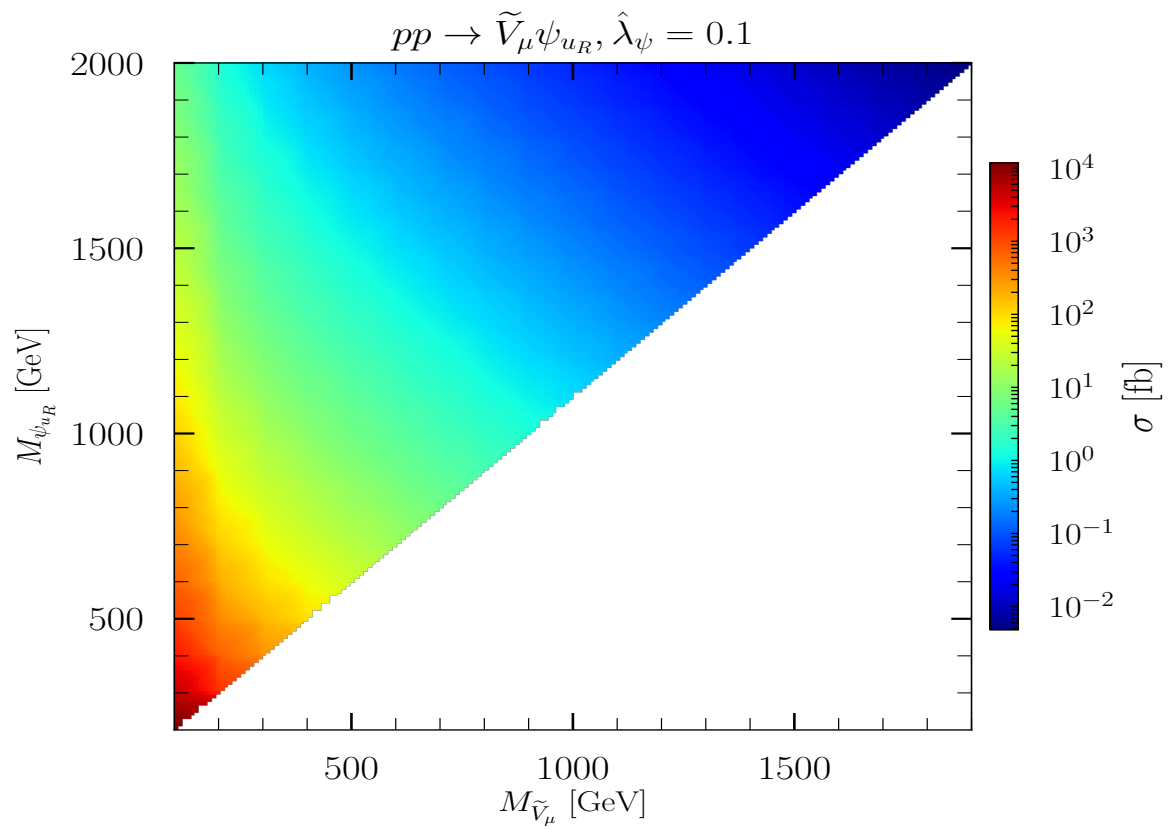
Renormalization & Factorization scales equal to the sum of the transverse masses of the final state particles.

I fix  $\hat{\lambda}_\psi = 0.1$ .

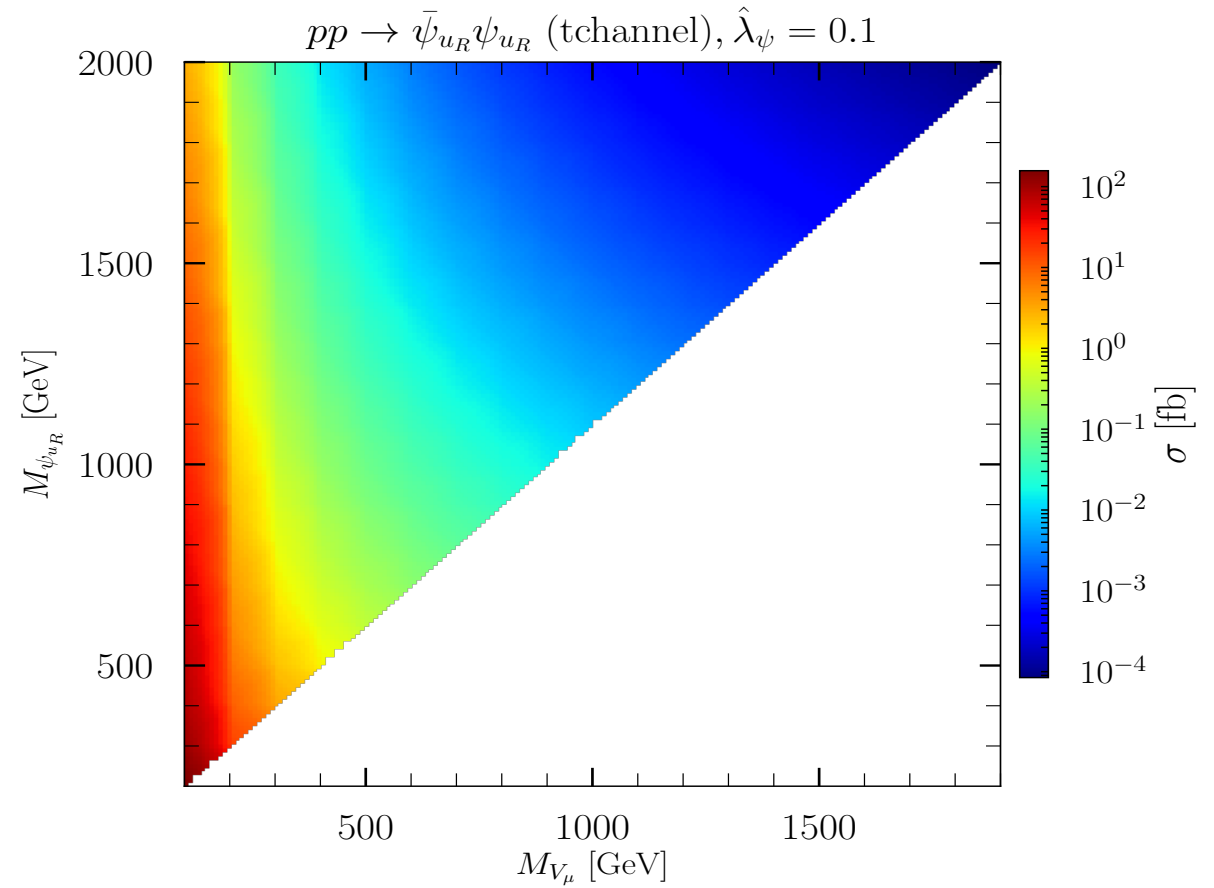
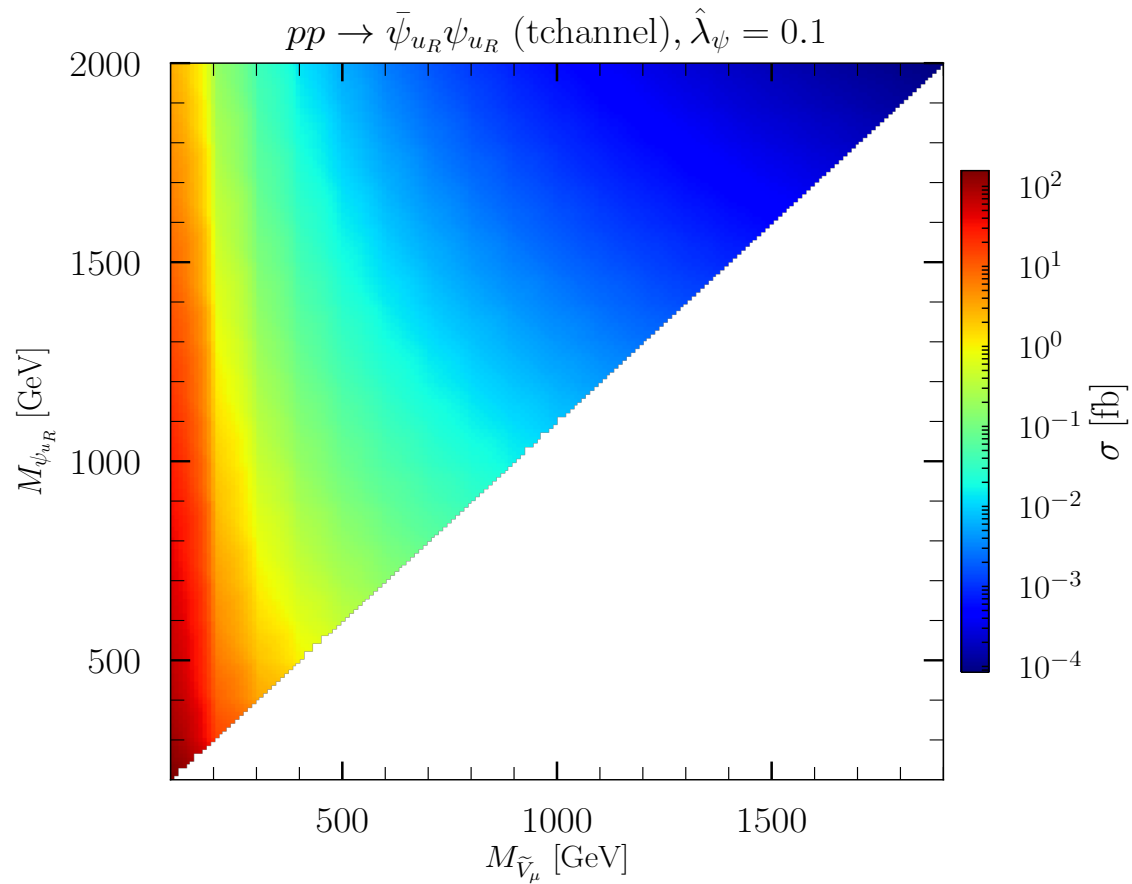
$pp \rightarrow V_\mu V^\mu @ LO$



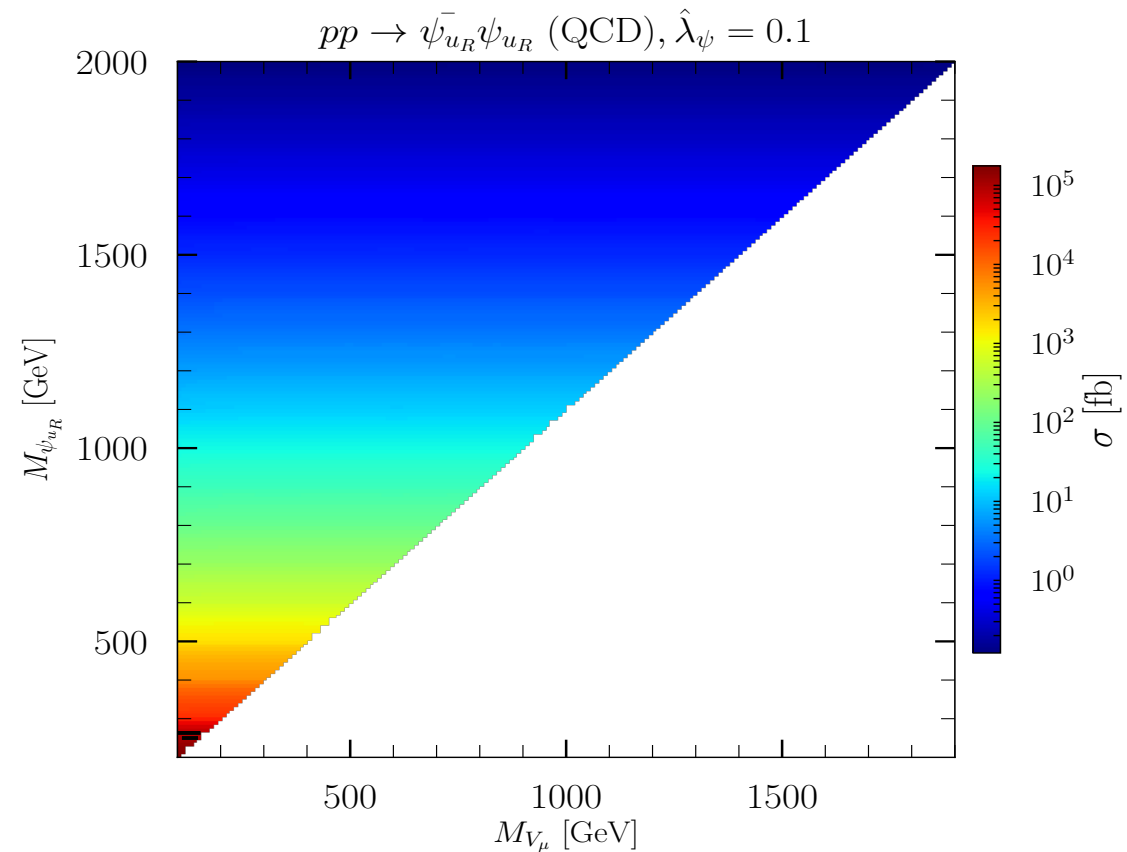
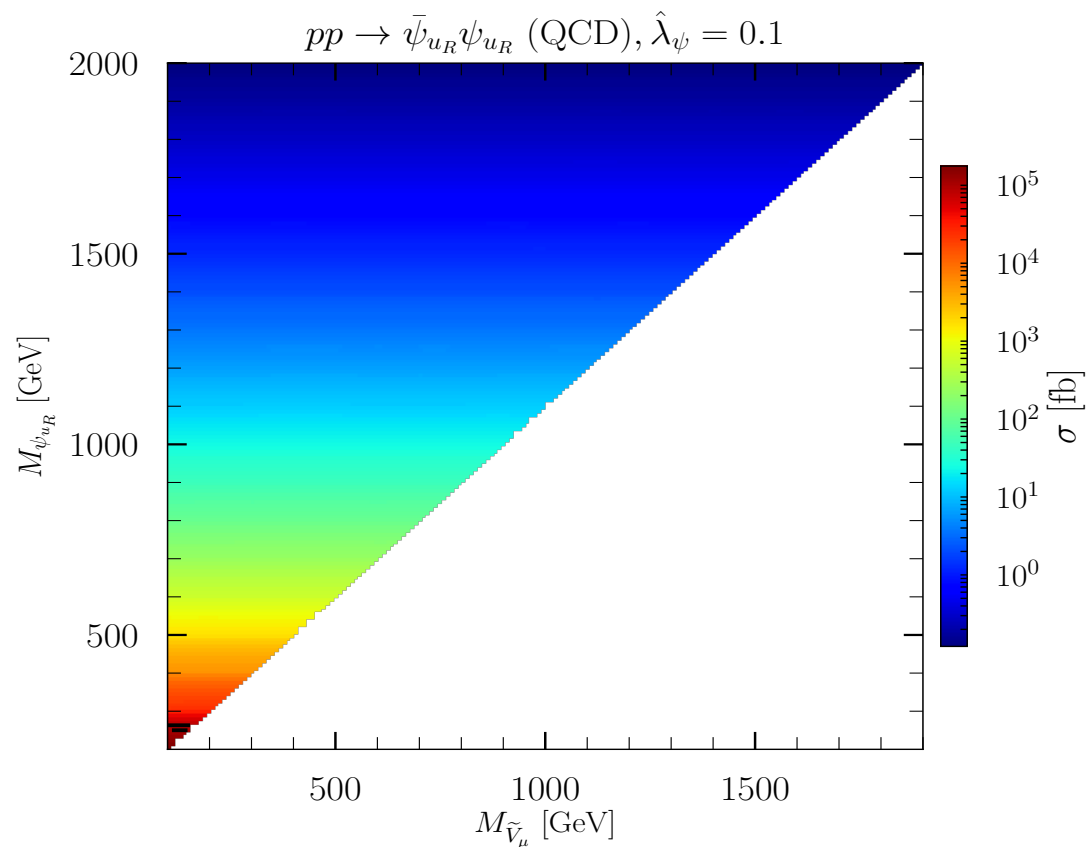
$$pp \rightarrow V_\mu \psi_{uR} + \text{H.c.} @ \text{LO}$$



$pp \rightarrow \bar{\Psi}_{u_R} \Psi_{u_R}$  @ LO (t-channel only)



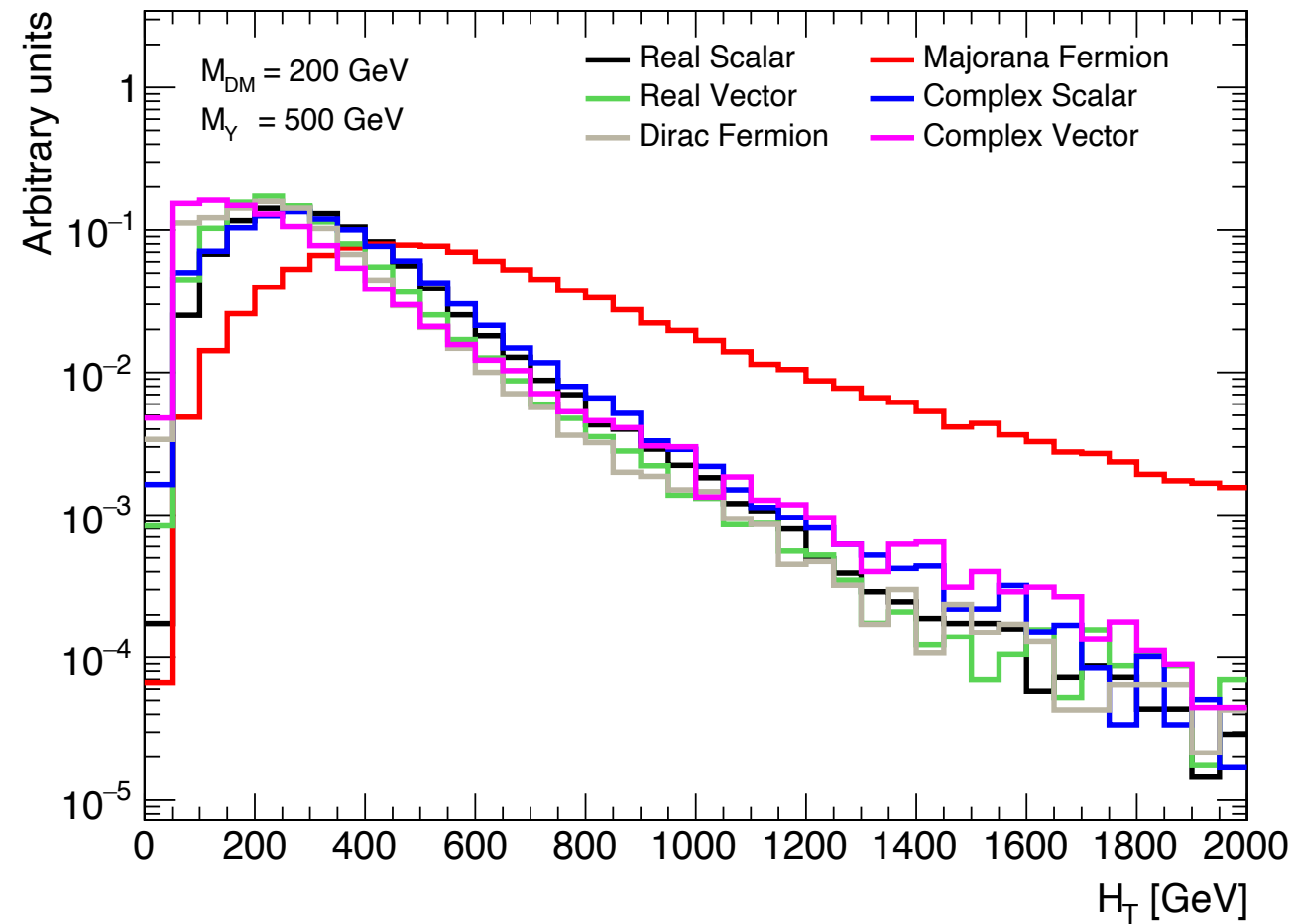
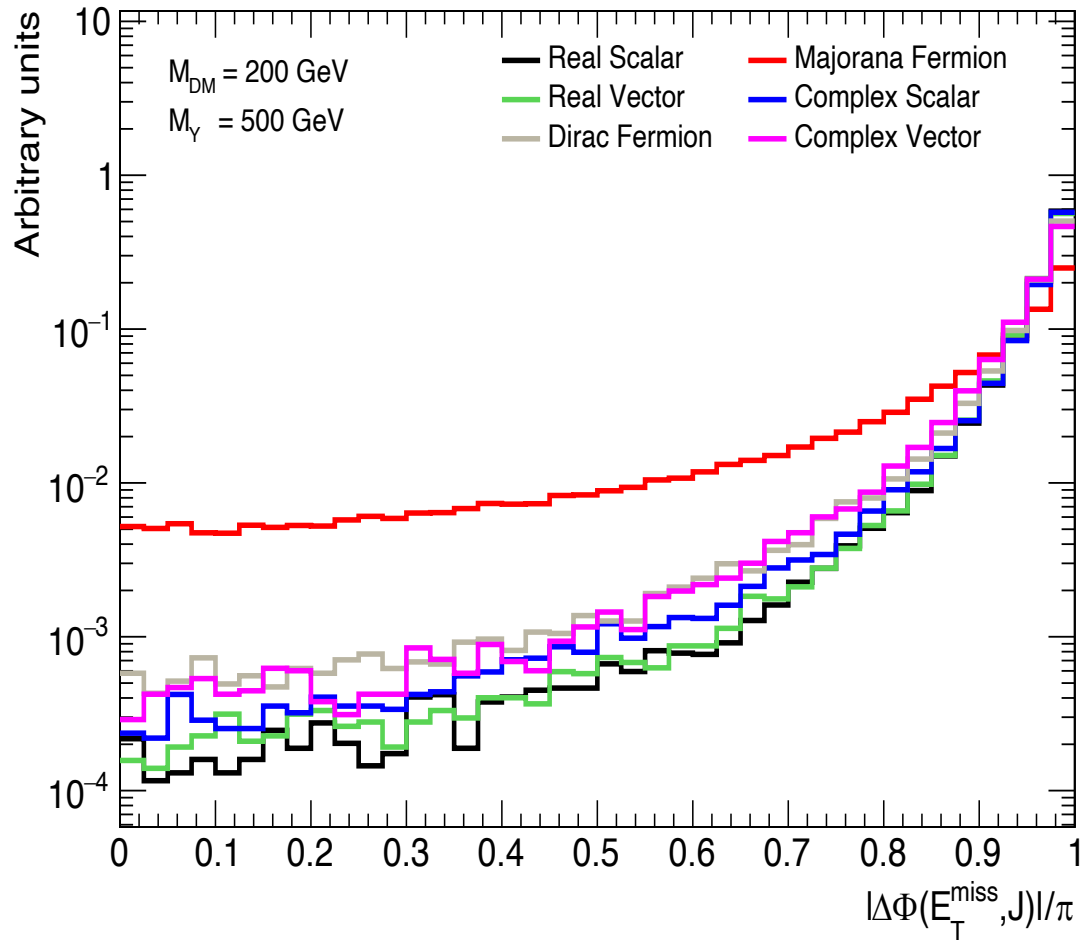
$pp \rightarrow \bar{\psi}_{uR} \psi_{uR}$  @ LO (QCD only)



# Characterization study

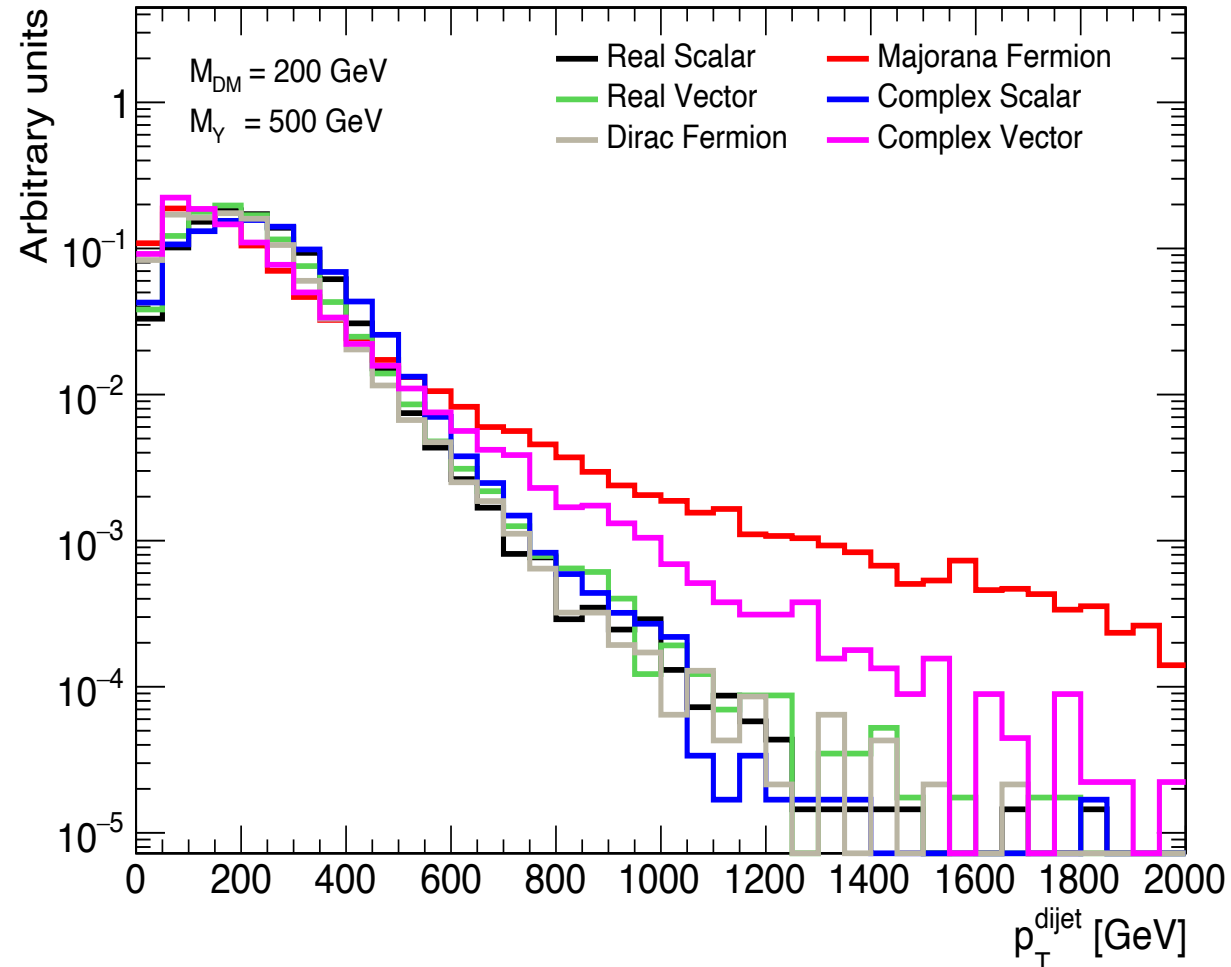
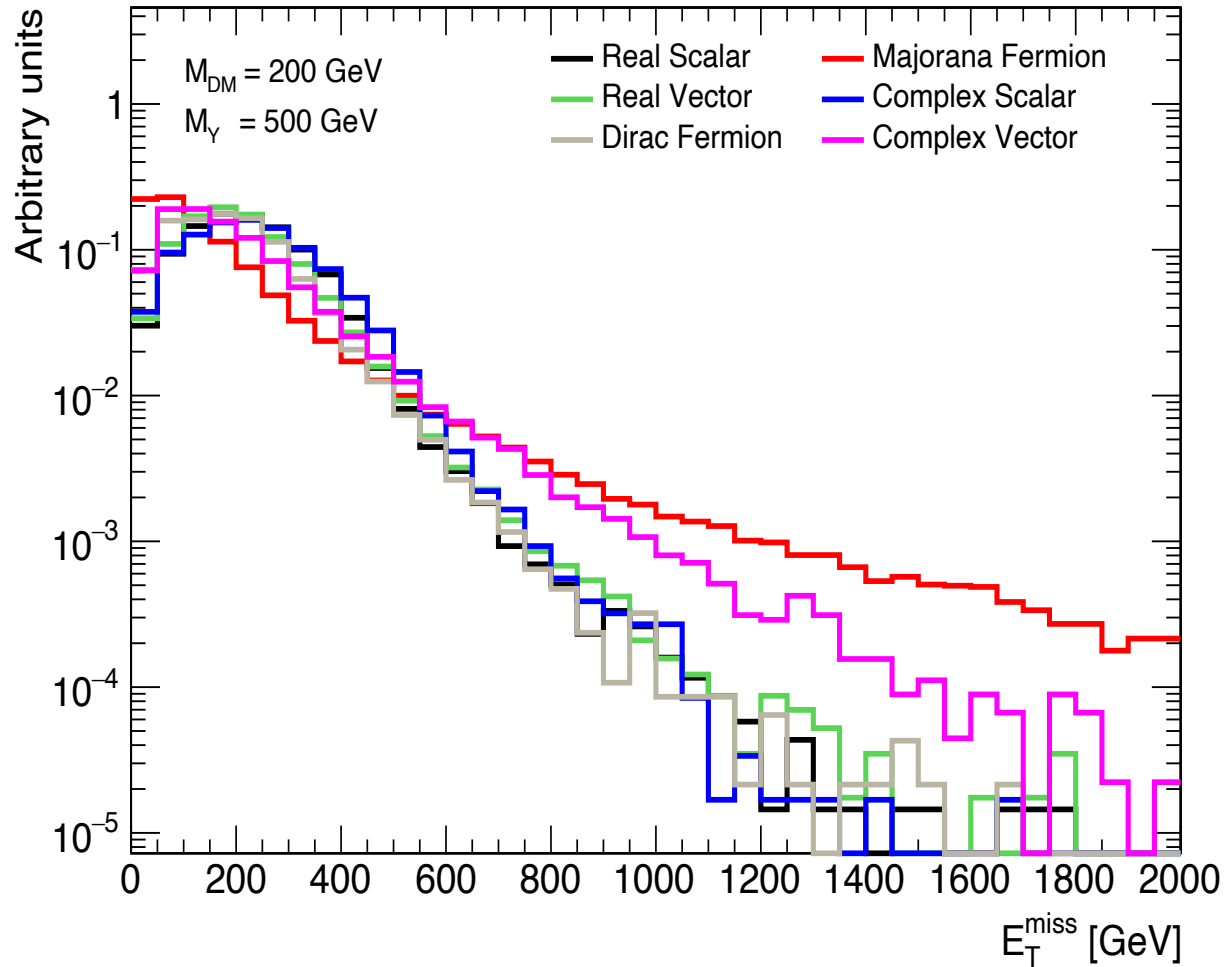
- For the characterization part, I simulated DM+jet production with jet multiplicity up to 2 jets. I used the MLM merging scheme with  $x_{\text{qcut}} = 20$ . The other setup is similar to the LO calculation of the cross section.
- I considered all the six cases for DM: Real Scalar, Majorana Fermion, Real Vector, Complex Scalar, Dirac Fermion, and Complex Vector.
- The new couplings are fixed to unity for all the models.
- For the analysis: I used a simple selection (which will be refined later): at least two jets with  $p_T > 20$  GeV and  $|\eta| < 2.8$ .
- In a time-scale of one week or so, I will adopt a more standard mono-jet analysis like the one published by U. Haisch and G. Polesello (arXiv:1812.08129).

$$M_{DM} = 200 \text{ GeV} \quad \text{and} \quad M_Y = 500 \text{ GeV}$$

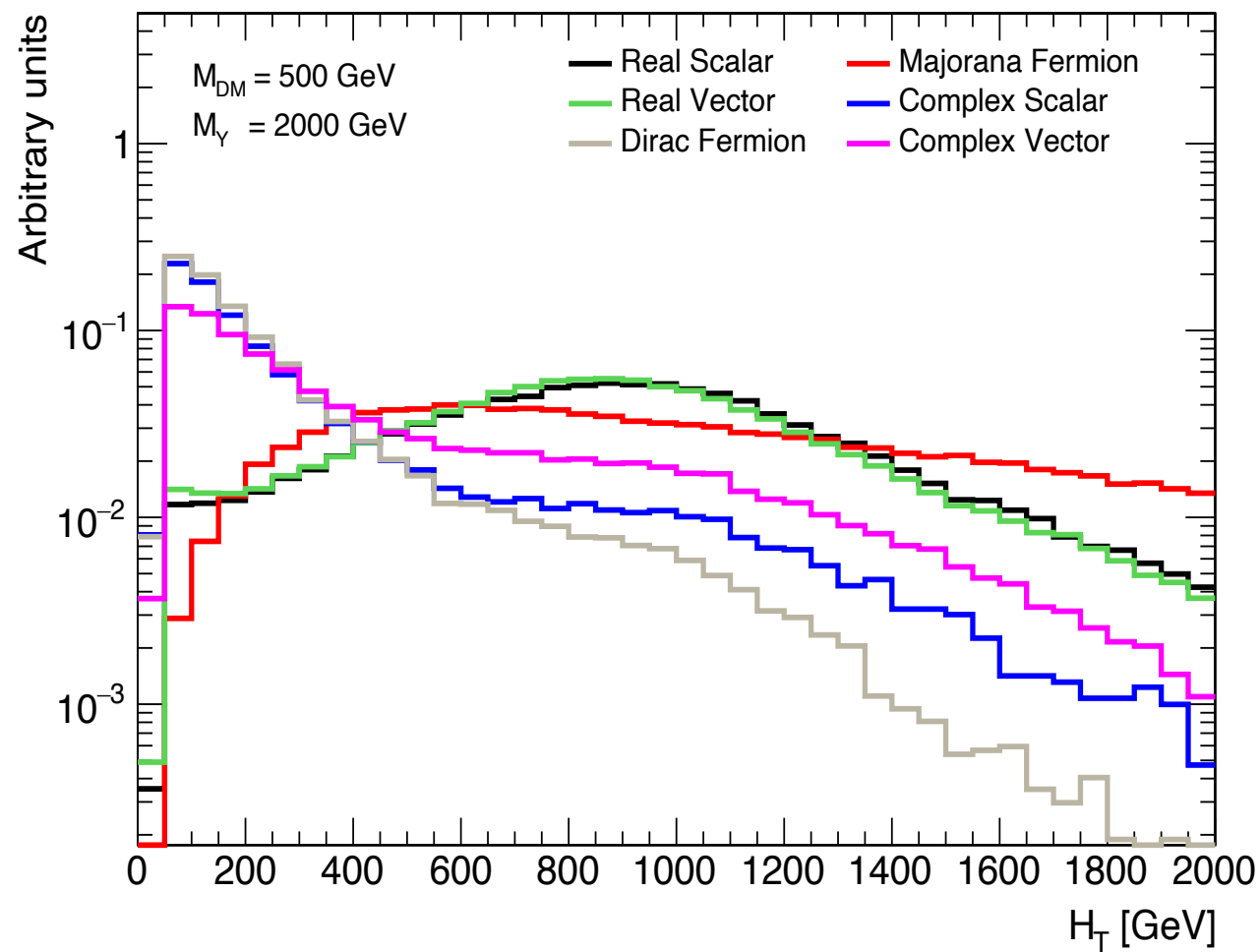
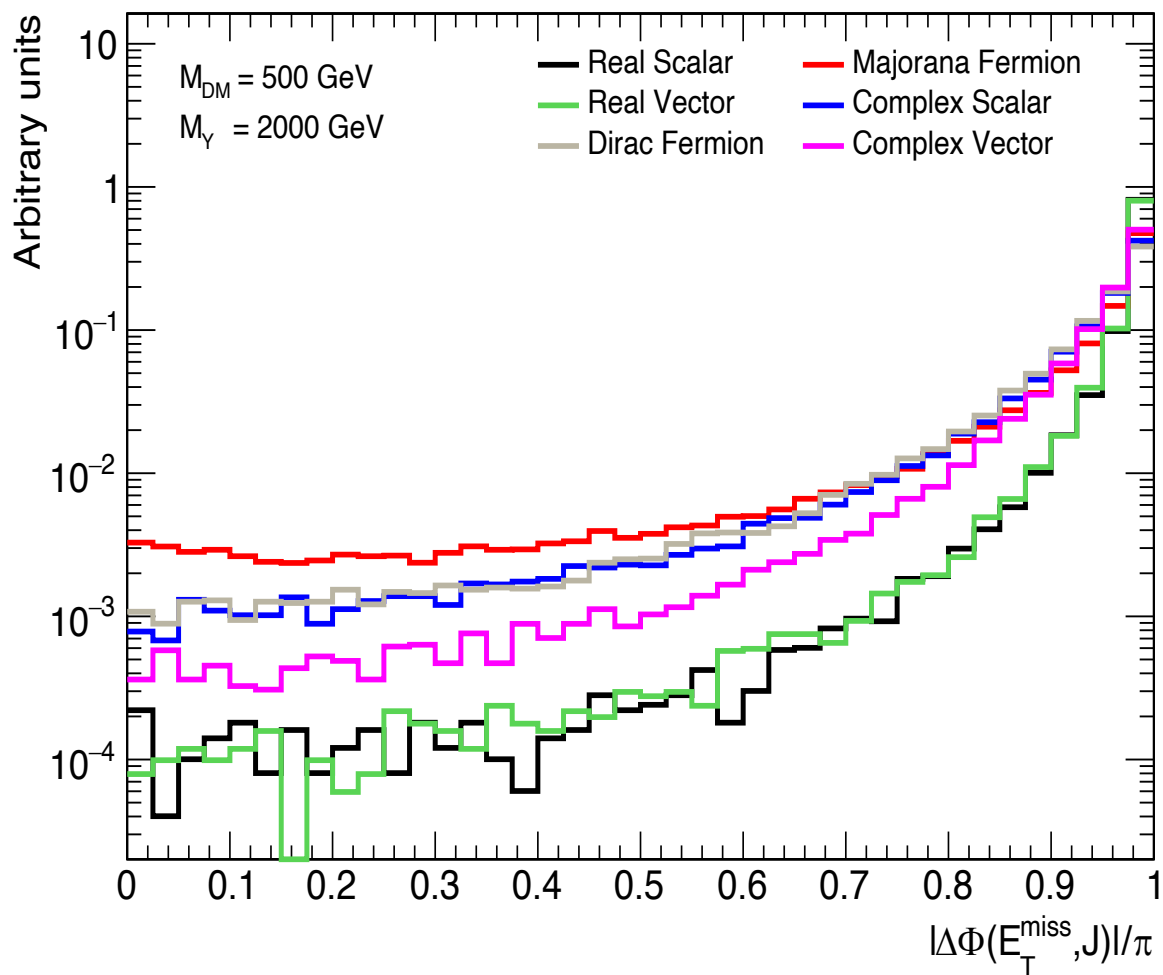




$M_{DM} = 200 \text{ GeV}$  and  $M_Y = 500 \text{ GeV}$

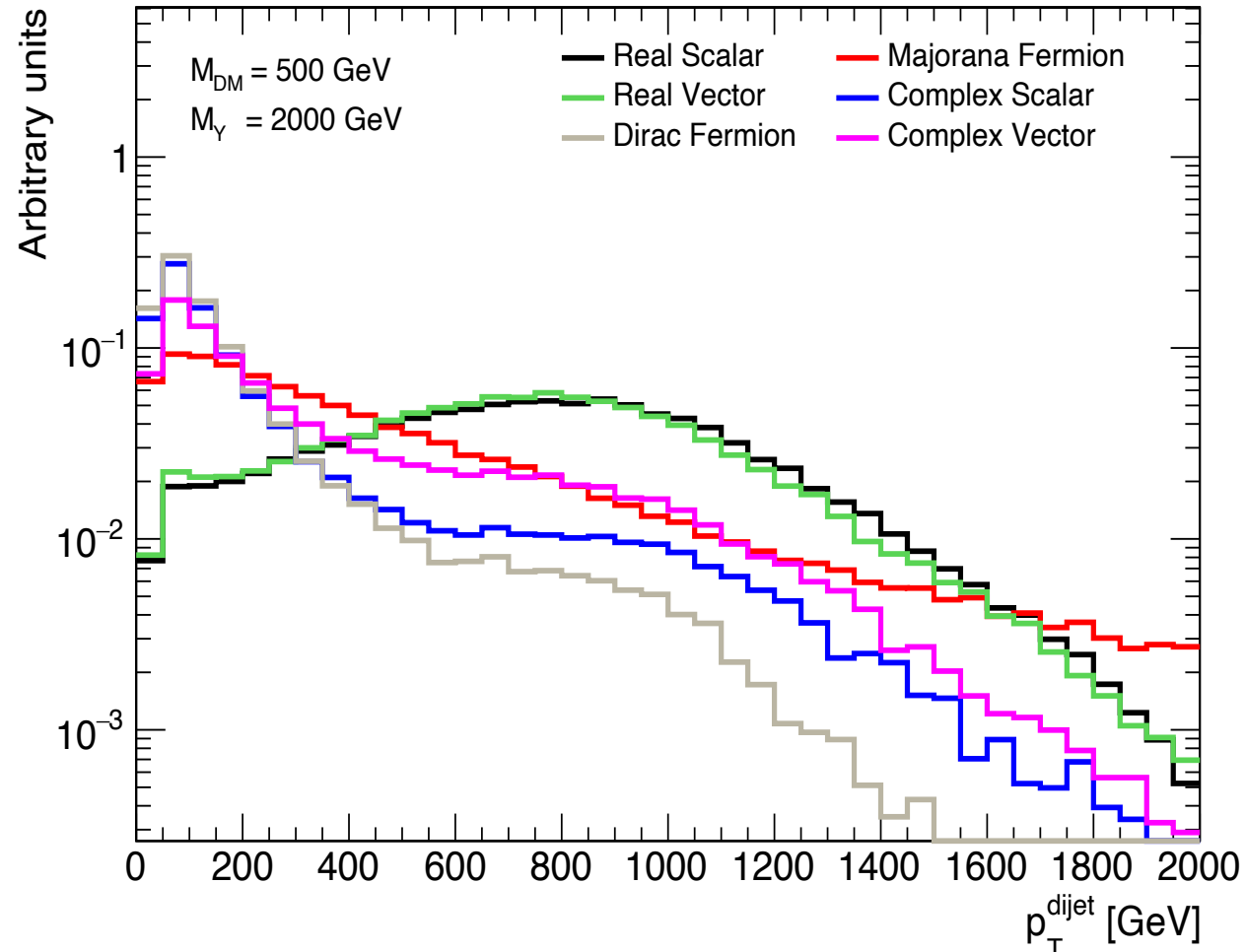
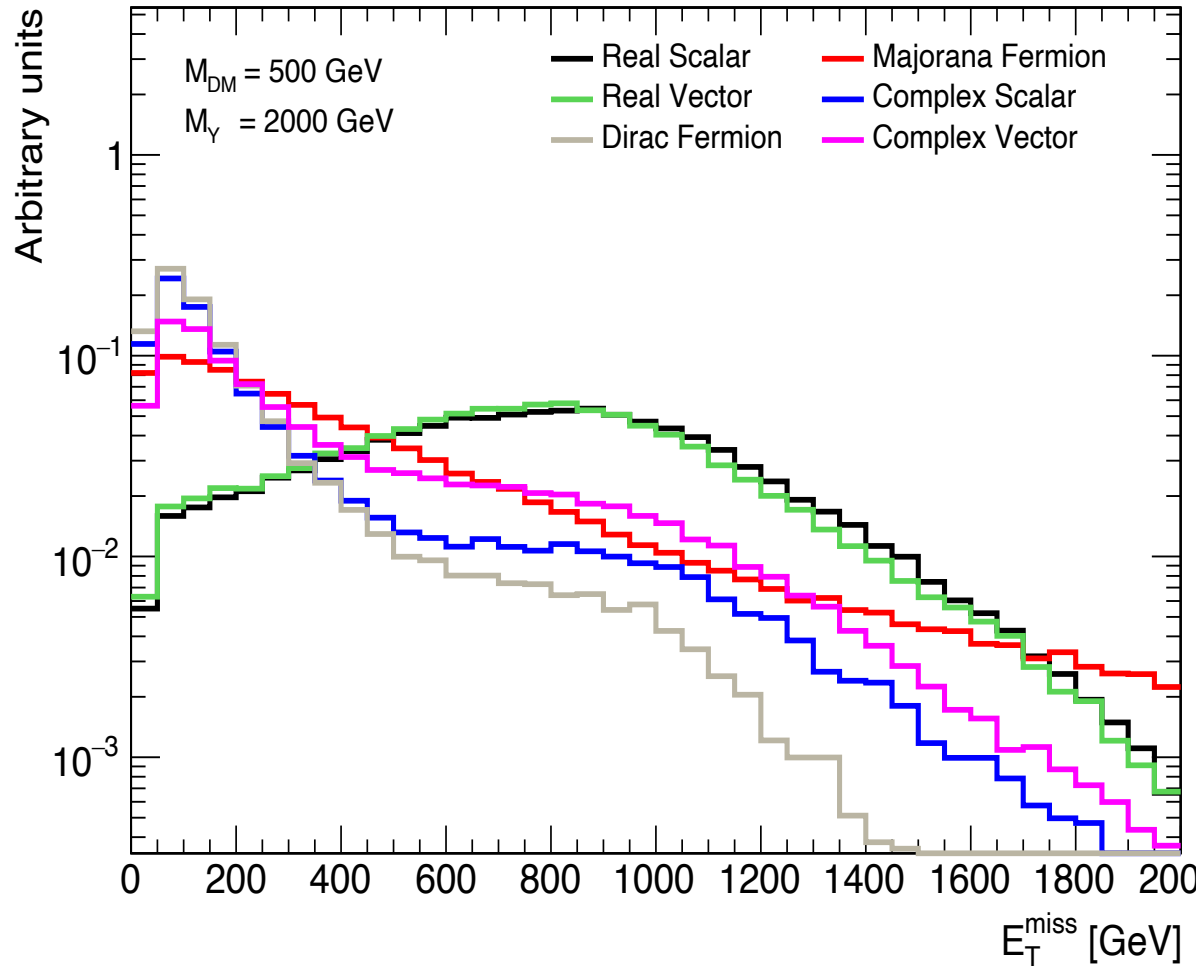


$M_{DM} = 500 \text{ GeV}$  and  $M_{\gamma} = 2000 \text{ GeV}$



$M_{DM} = 500 \text{ GeV}$

and  $M_{\gamma} = 2000 \text{ GeV}$



# LO vs NLO: case of real vector DM

- I studied the difference between LO and NLO predictions in various distributions for mono-jet production in the real-vector DM case with  $\hat{\lambda}_\psi = 0.1$ .

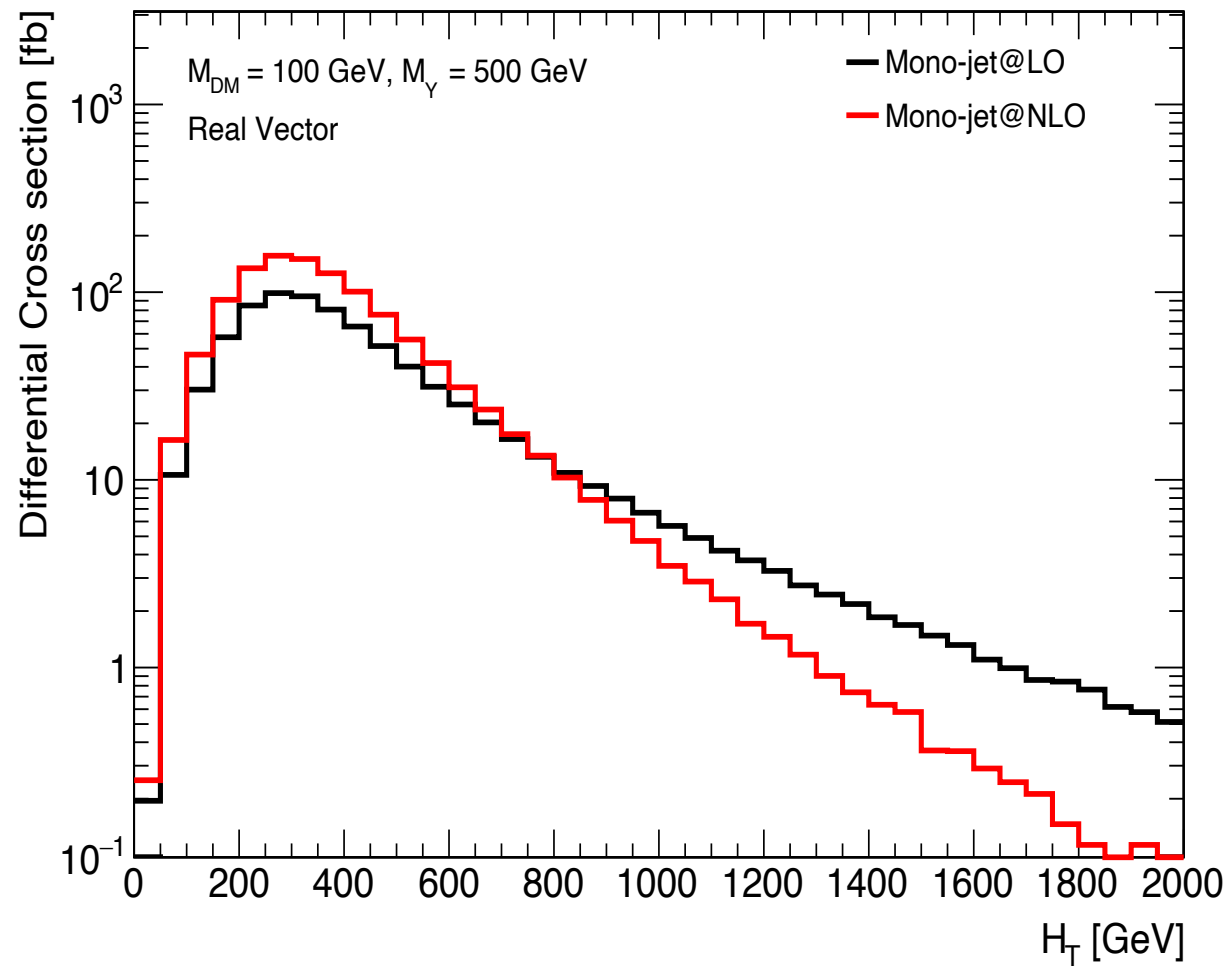
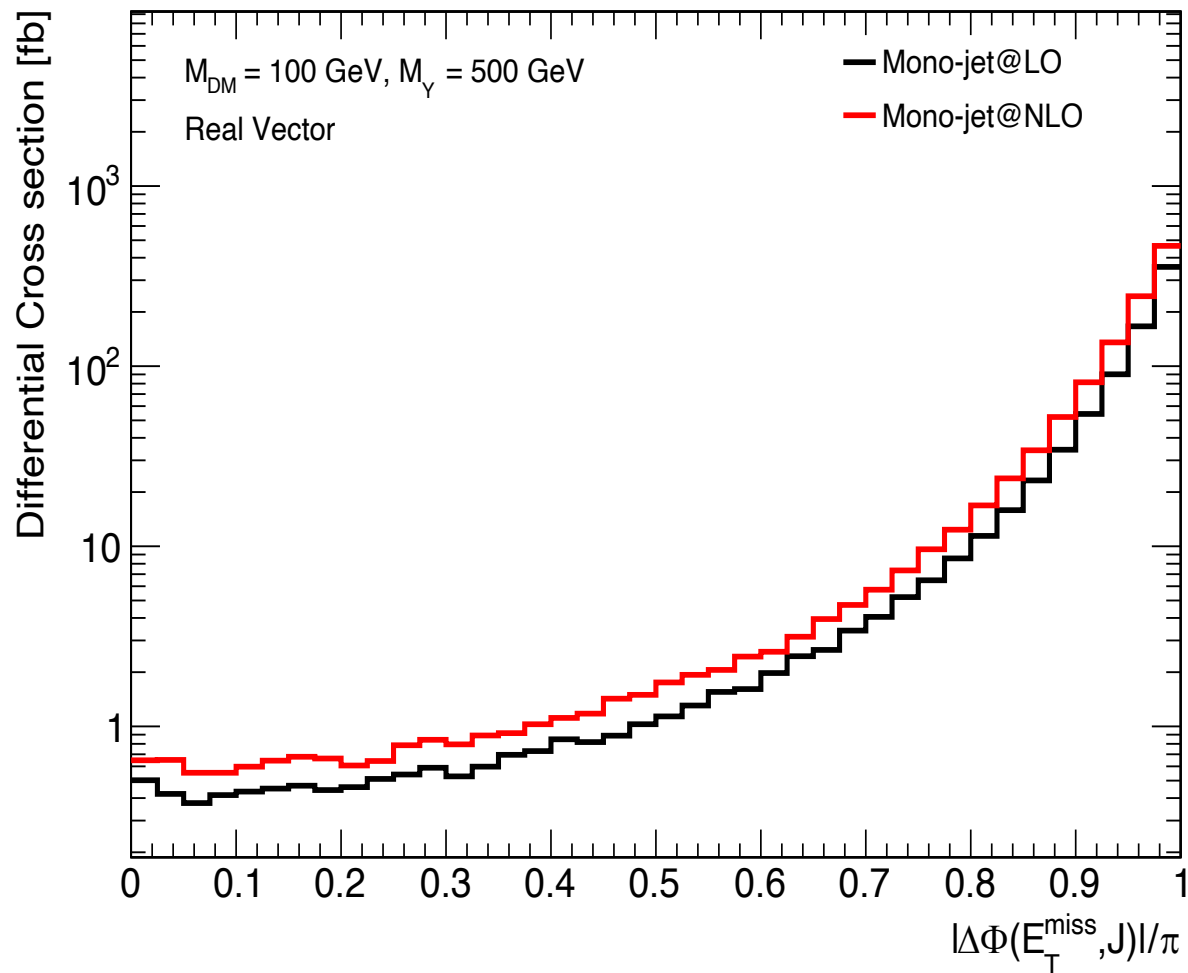
	$M_{\text{DM}}$ [GeV]	$M_Y$ [GeV]
BP1	100	500
BP2	500	1000

- Cross sections:

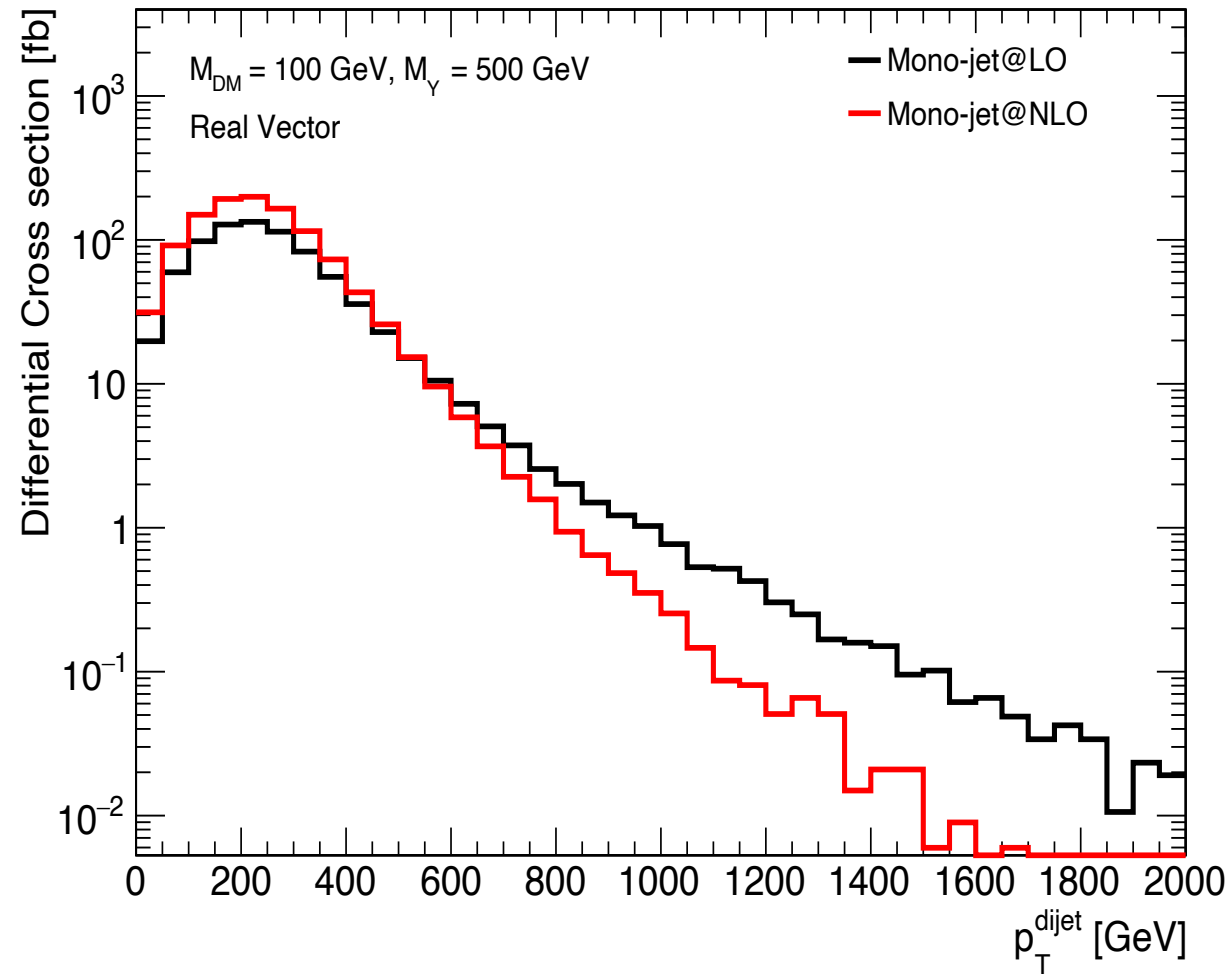
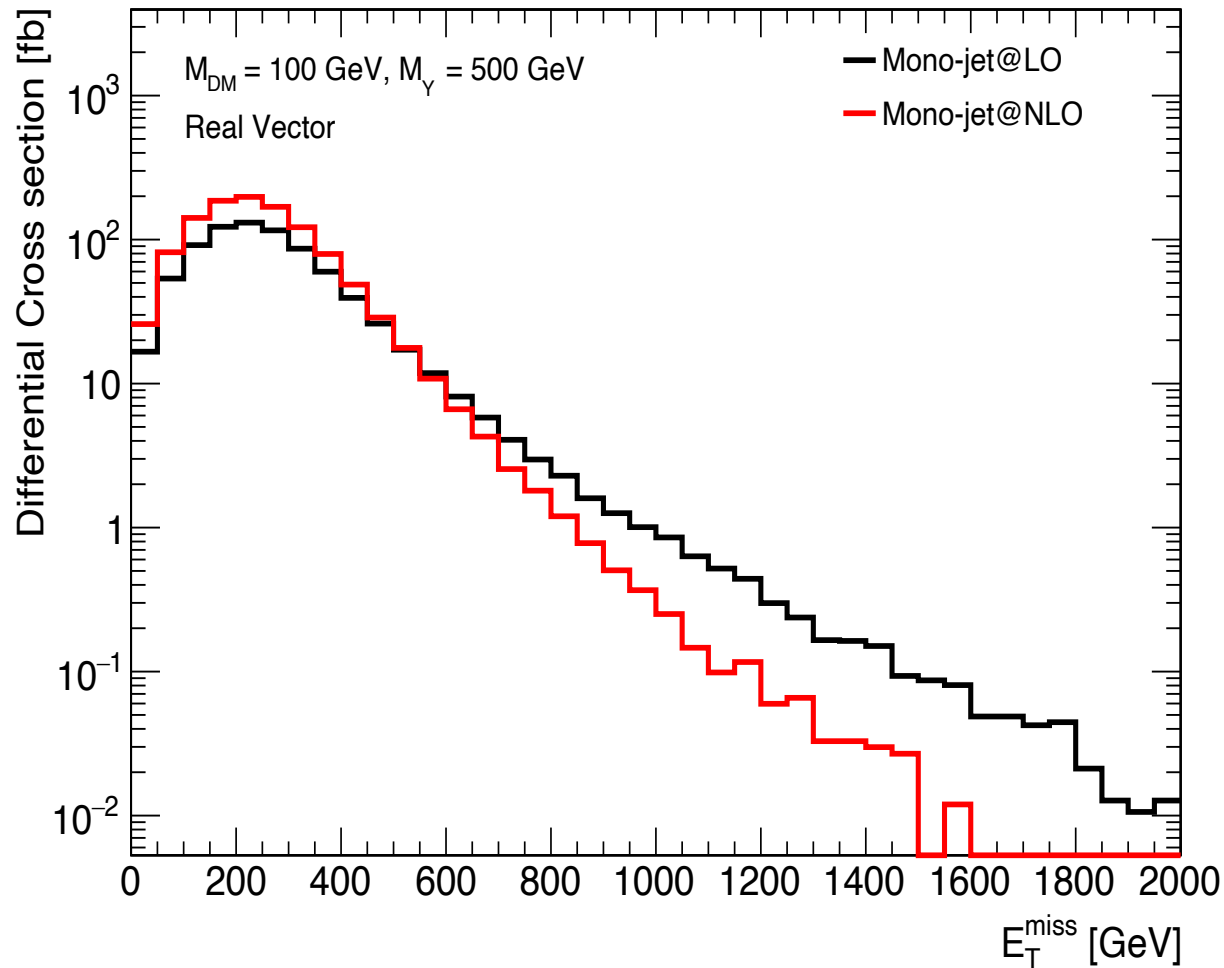
	$\sigma_{\text{LO}}$ [pb]	$\sigma_{\text{NLO}}$ [pb]	$K$ -factor
BP1	1.06	1.49	1.4
BP2	0.006	0.009113	1.5

$M_{DM} = 100 \text{ GeV}$

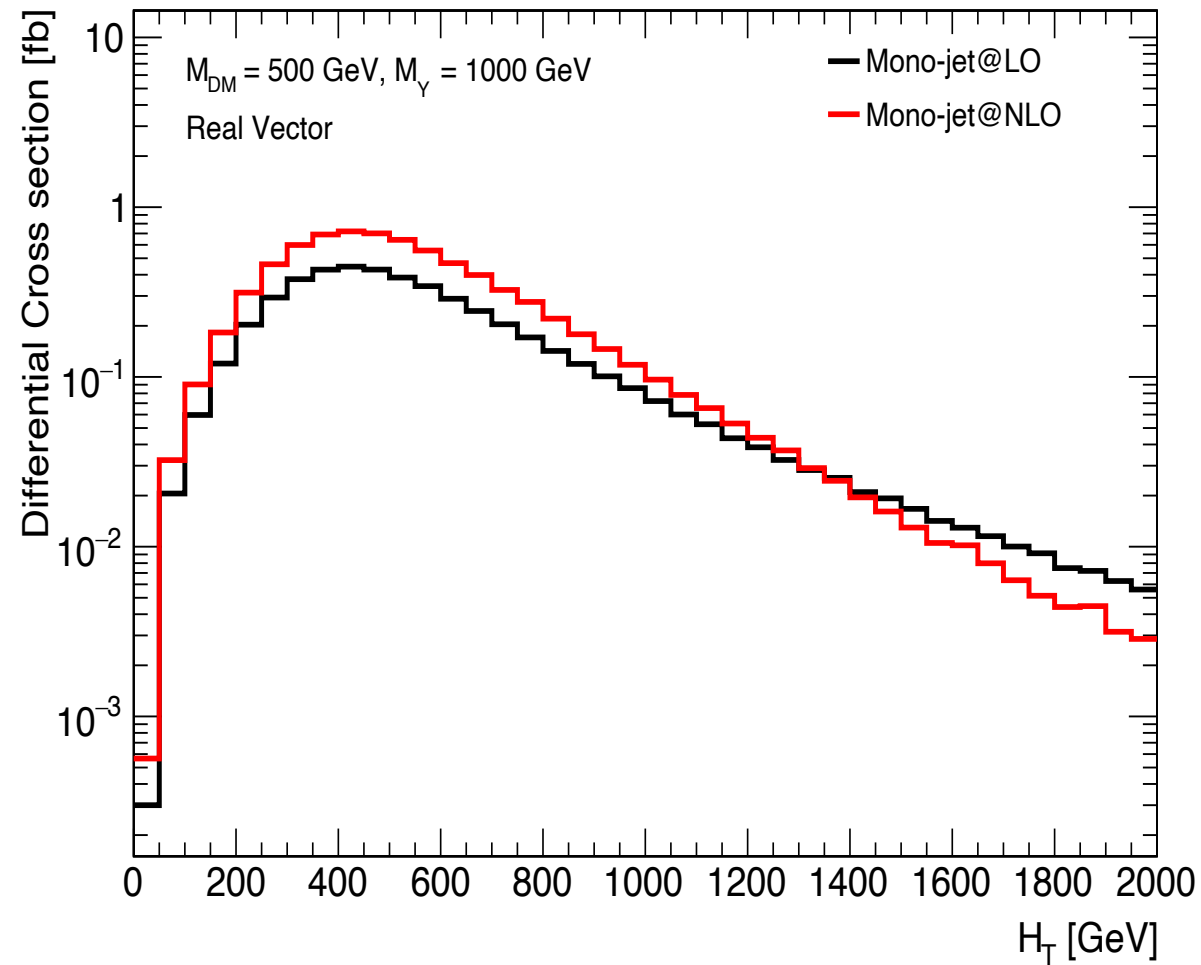
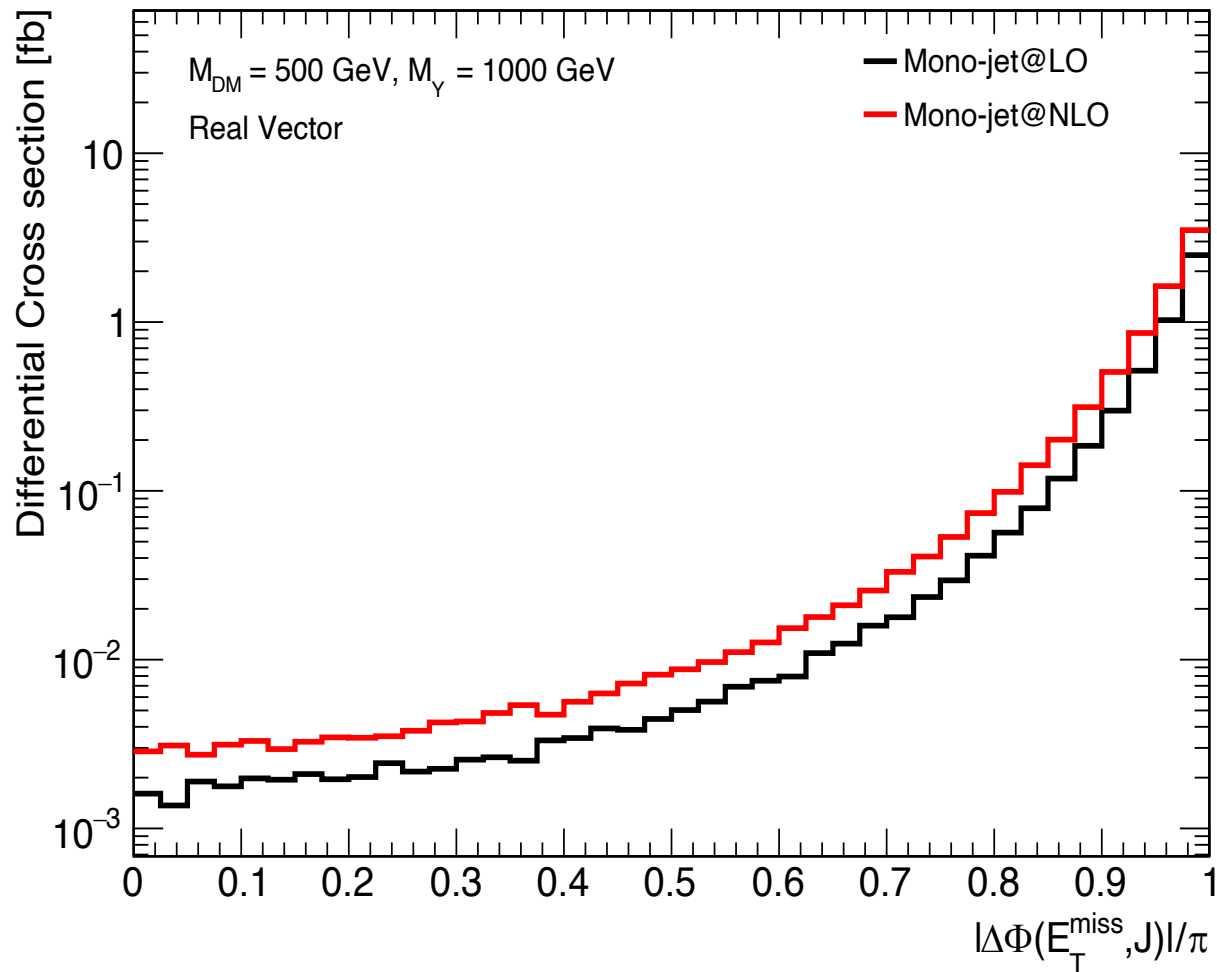
and  $M_Y = 500 \text{ GeV}$



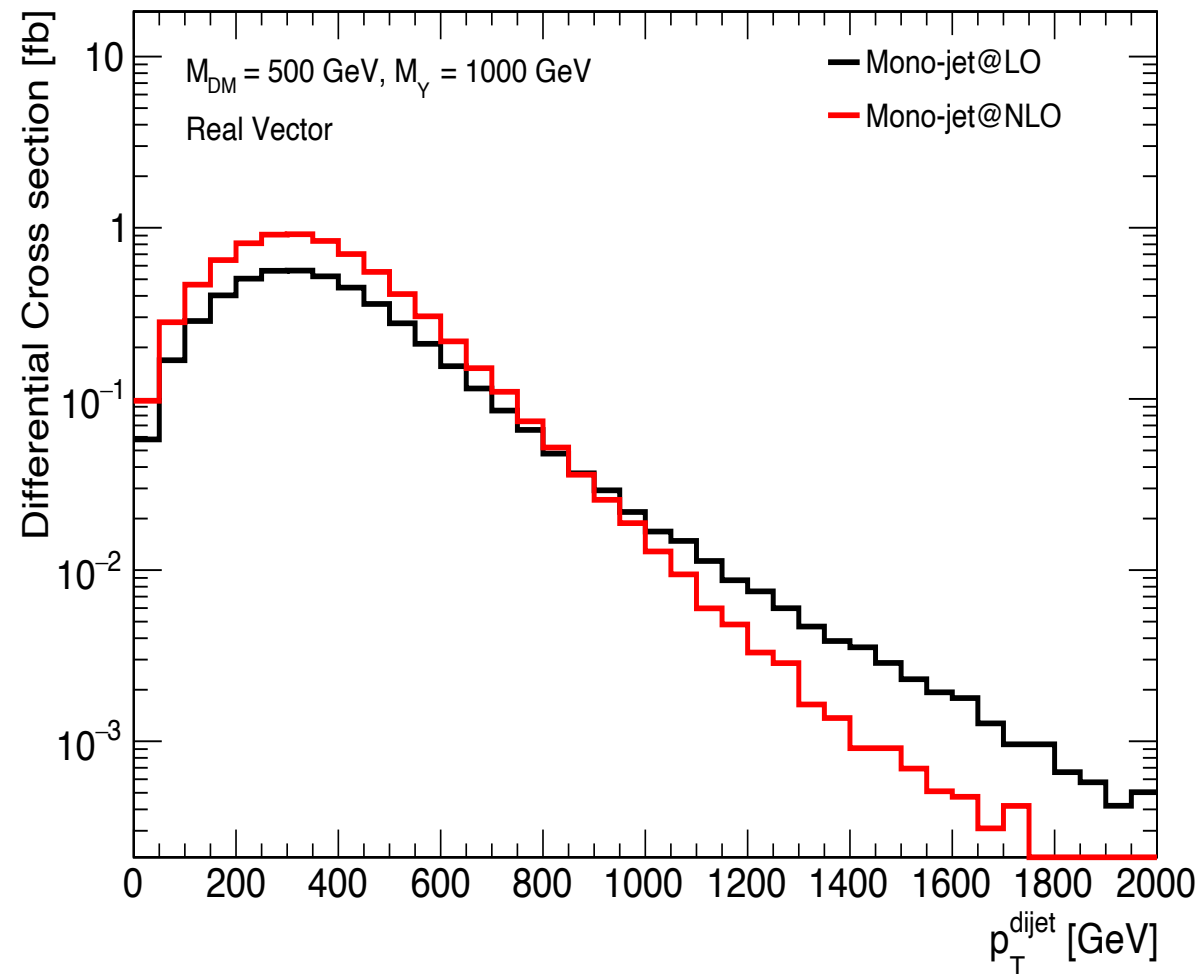
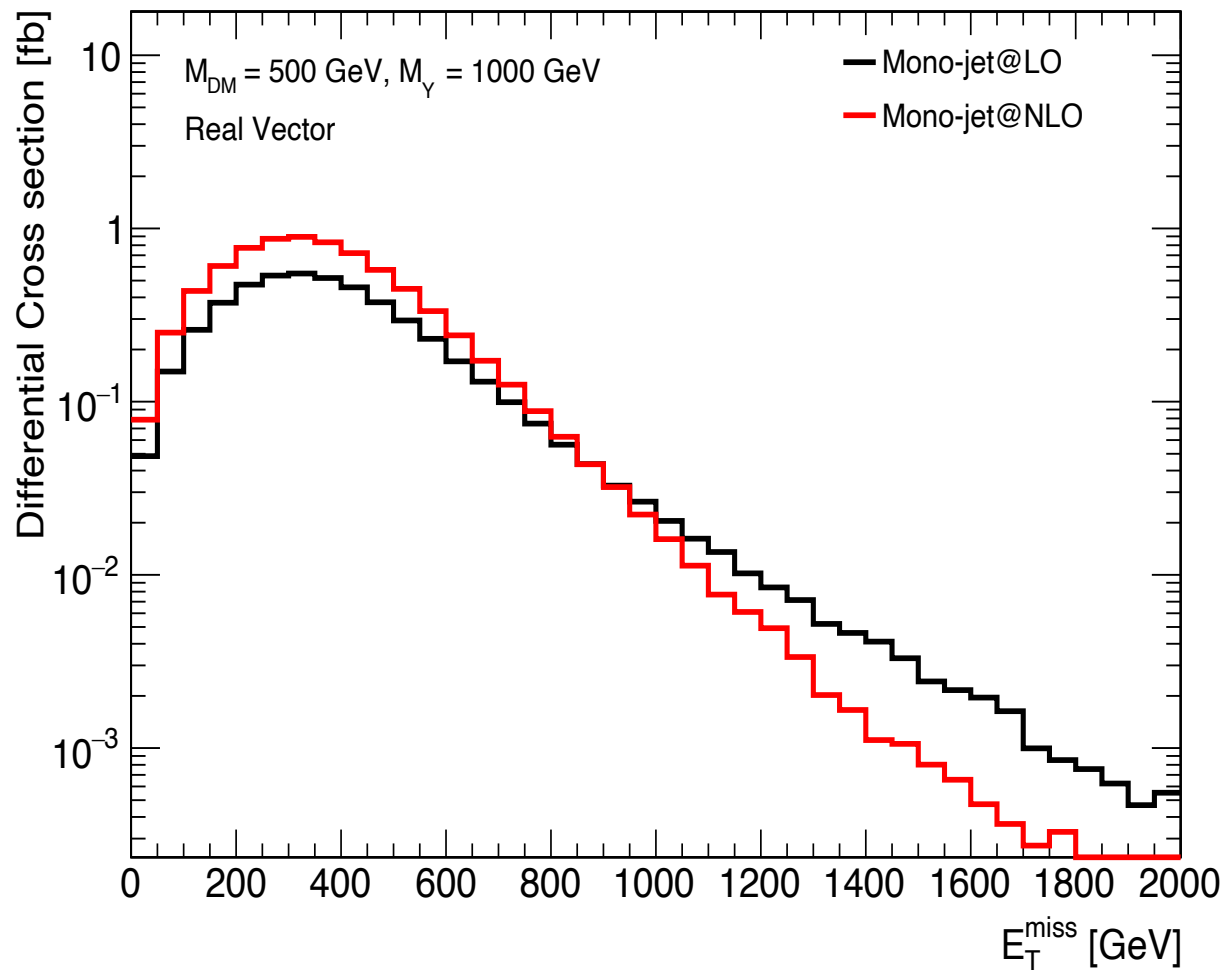
$M_{DM} = 100 \text{ GeV}$  and  $M_\gamma = 500 \text{ GeV}$



$M_{DM} = 500 \text{ GeV}$  and  $M_{\gamma} = 1000 \text{ GeV}$



$M_{DM} = 500$  GeV and  $M_{\gamma} = 1000$  GeV





- Still some work need to be done.
- Make these xcomparisons for standard mono-jet searches at the LHC with relatively large number of events.
- Compare the efficiencies of the selections (or even do a standard CheckMate/MadAnalysis exclusions).
- Need to fix the couplings, masses for benchmarking.
- Anything else?