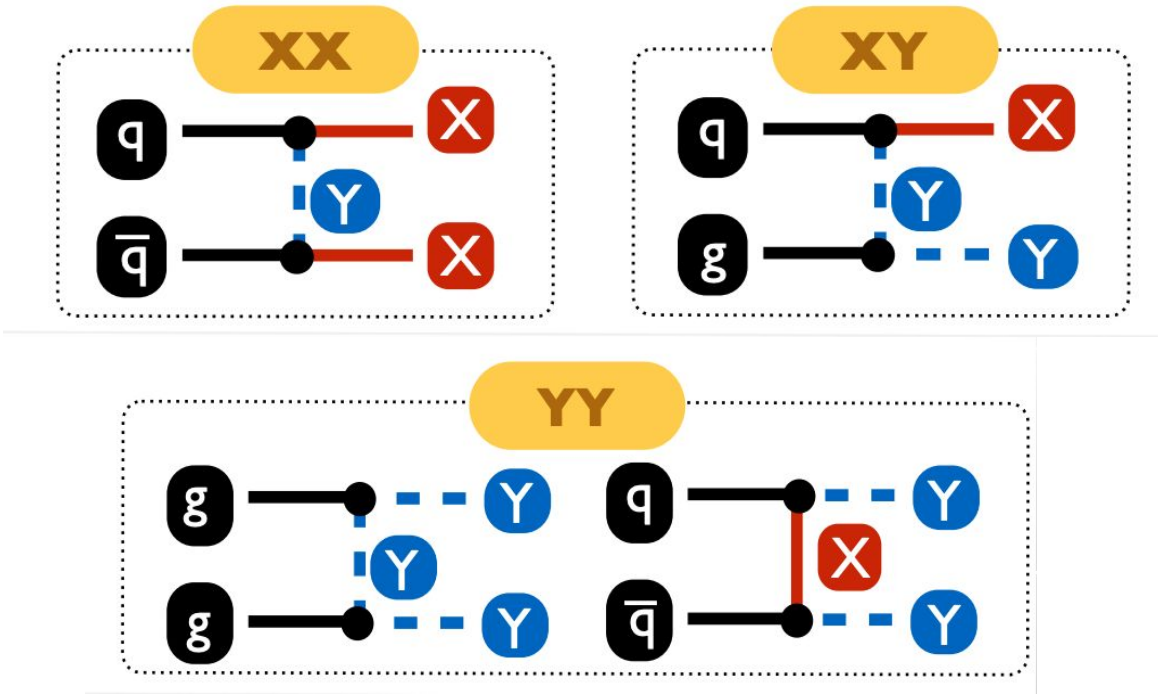
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

LHC-DMWG White paper: t-channel studies

Sukanya Sinha

CDM Meeting: 28th May 2020

Generic implementation of t-channel DM



Diagrams from Benjamin's talk

3 Main processes:

- **DM pair production**
- **DM/mediator associated production (+ mediator decays into DM+jet)**
- **Mediator pair production (+ mediator decays into DM+jet)**

Mediator pair-production has 3 separate contributions @NLO: t-channel and QCD contributions, LO interferences

Present focus: S3D_uR model restrictions

Name	DM	Mediators	Parameters
S3M_uni	$\tilde{\chi}$	$\varphi_{Q_f}, \varphi_{u_f}, \varphi_{d_f}$	
S3D_uni	χ		
S3M_3rd	$\tilde{\chi}$	$\varphi_{Q_3}, \varphi_{u_3}, \varphi_{d_3}$	$M_\varphi, M_\chi, \lambda_\varphi$
S3D_3rd	χ		
S3M_uR	$\tilde{\chi}$	φ_{u_1}	
S3D_uR	χ		

uR models :

- 1 dark matter particle
- 1 mediator
- Coupling to the right-handed up-quark

$$\mathcal{L}_{\text{X_uR}}(X) = \left[\lambda_\varphi \bar{X} u_1 \varphi^\dagger_{u_1} + \text{h.c.}\right]$$

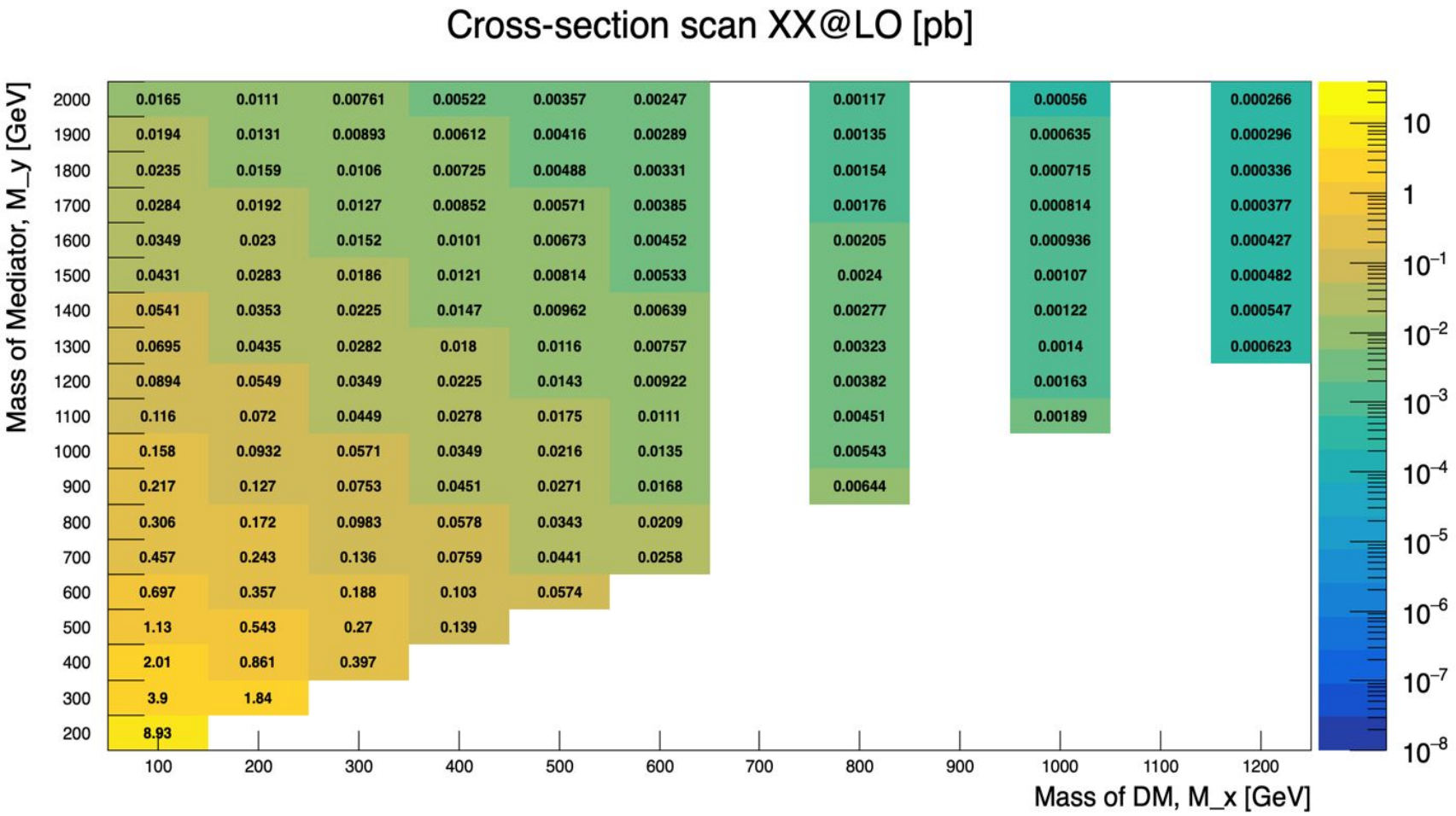
LO Studies for S3D_uR

As a preliminary study, focussed on cross-section scans with the conditions:

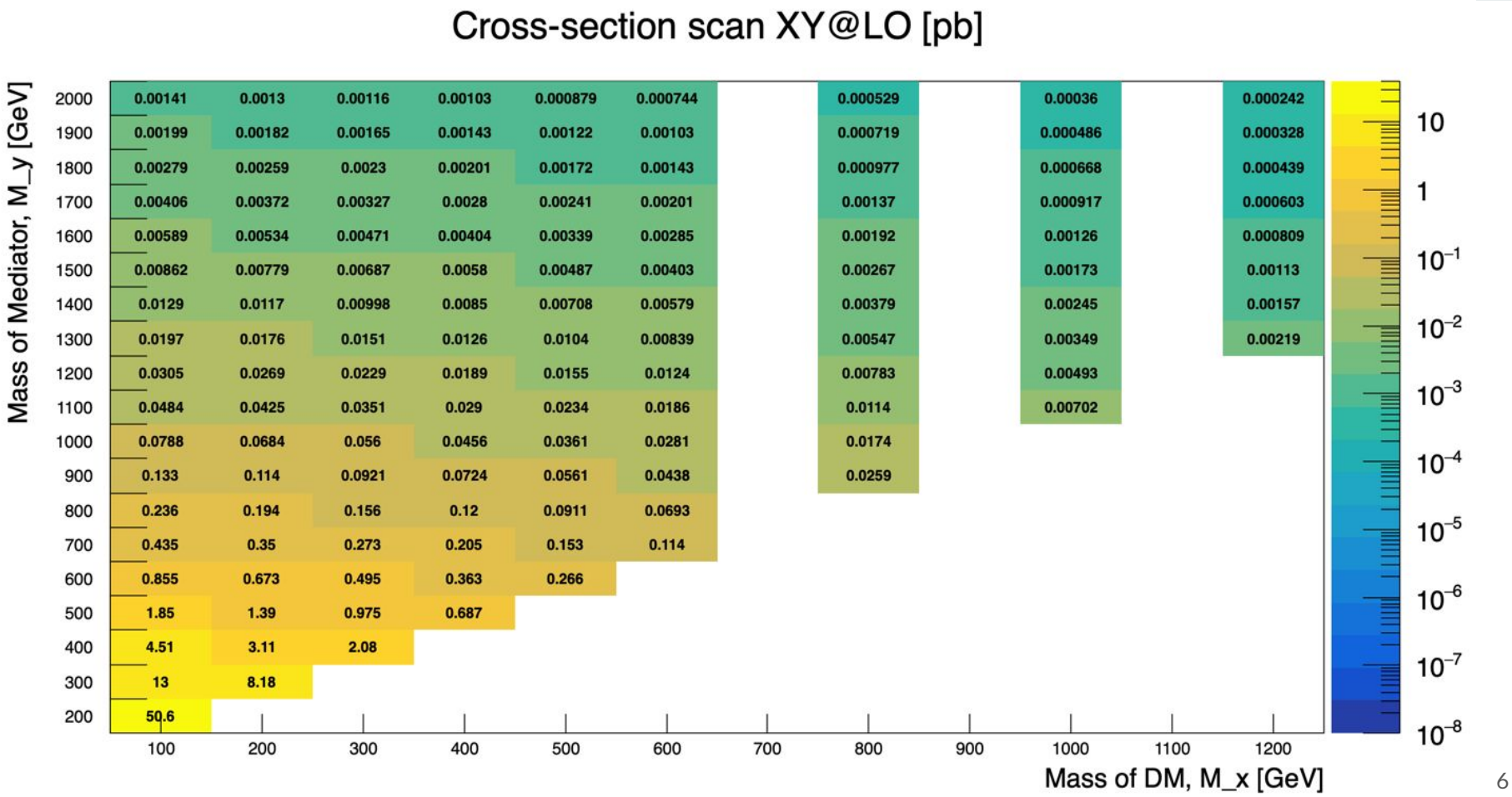
- **Lambda = 1, $M_X < M_Y$: Grid scan with**
  - **M_X = 200-600, 800, 1000, 1200 GeV**
  - **M_Y = 300 - 2000 GeV**

- **Processes considered:**
  - **XX**
  - **XY**
  - **YY**
    - **t - channel contribution**
    - **QCD contribution**

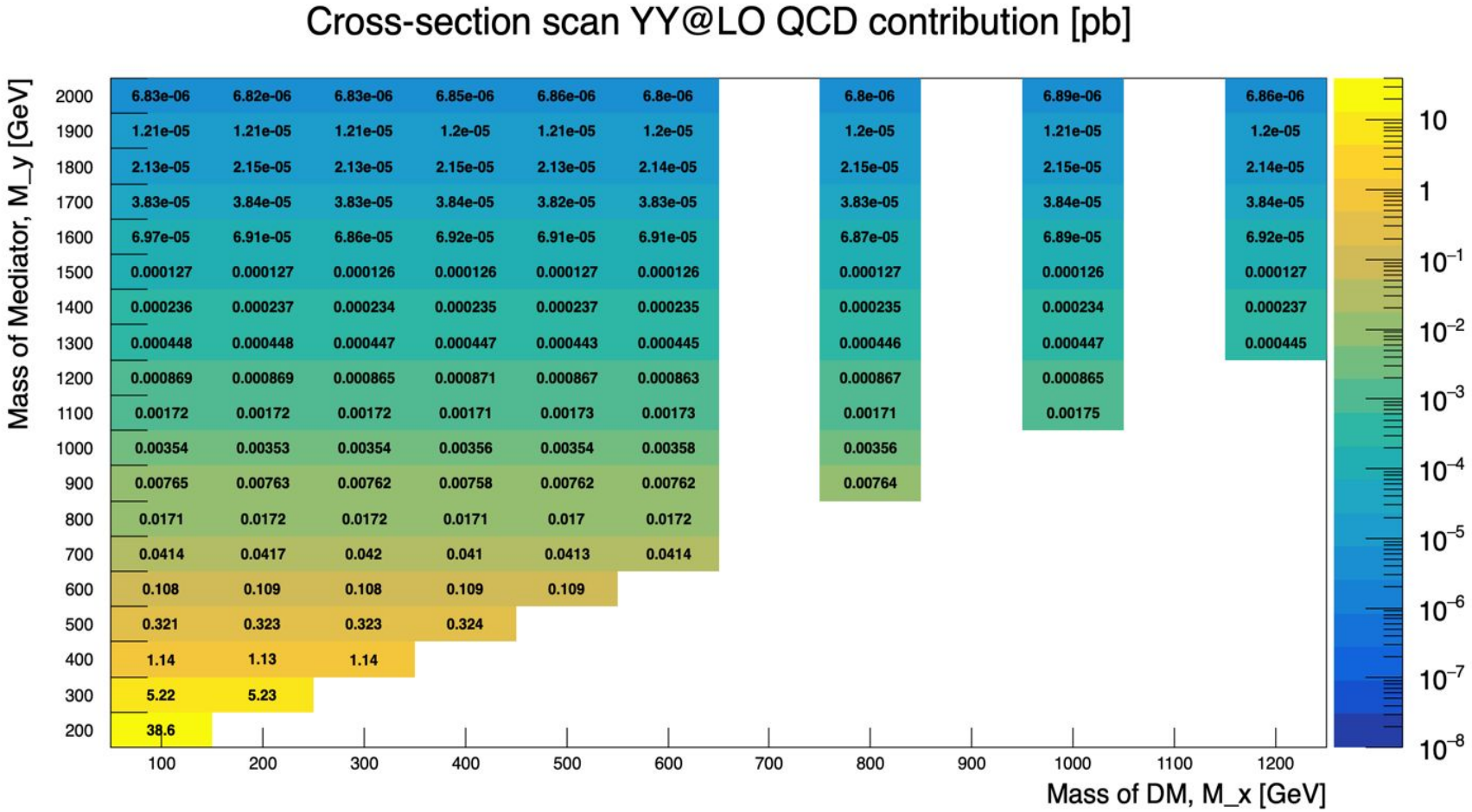
XX@LO Cross-section scan



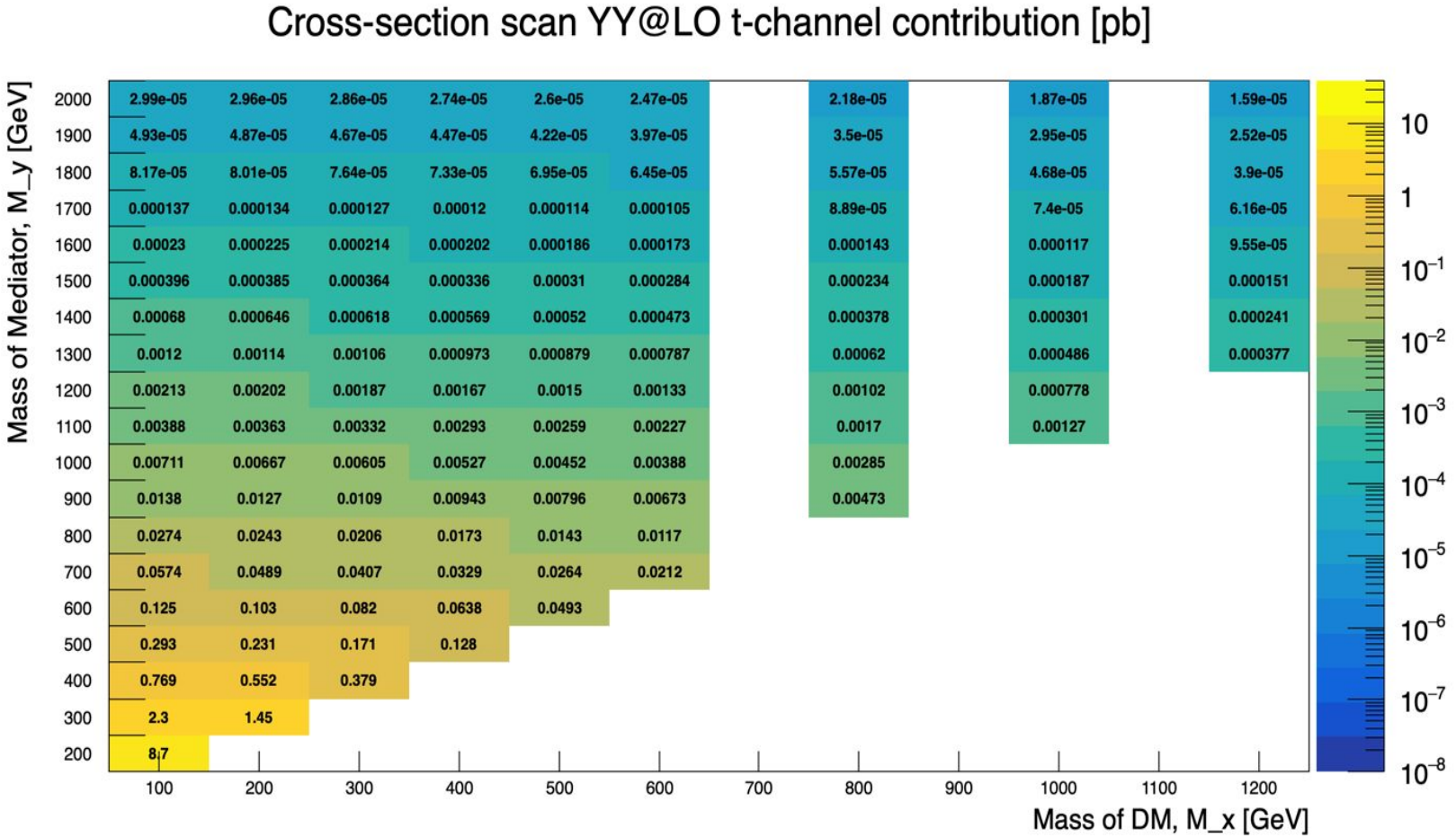
XY@LO Cross-section scan



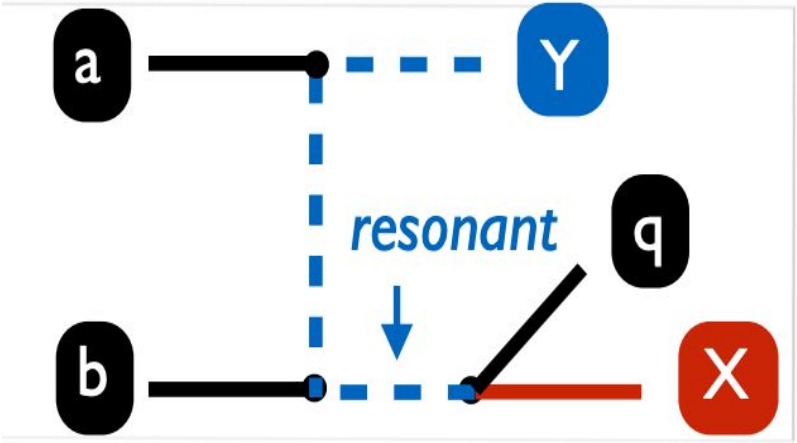
YY@LO Cross-section scan



YY@LO Cross-section scan



NLO Studies of S3D_uR



Overlap with

- YY @ LO with resonant Y → Xq decay
- XY @ NLO (real emission)

Resonances must be carefully subtracted

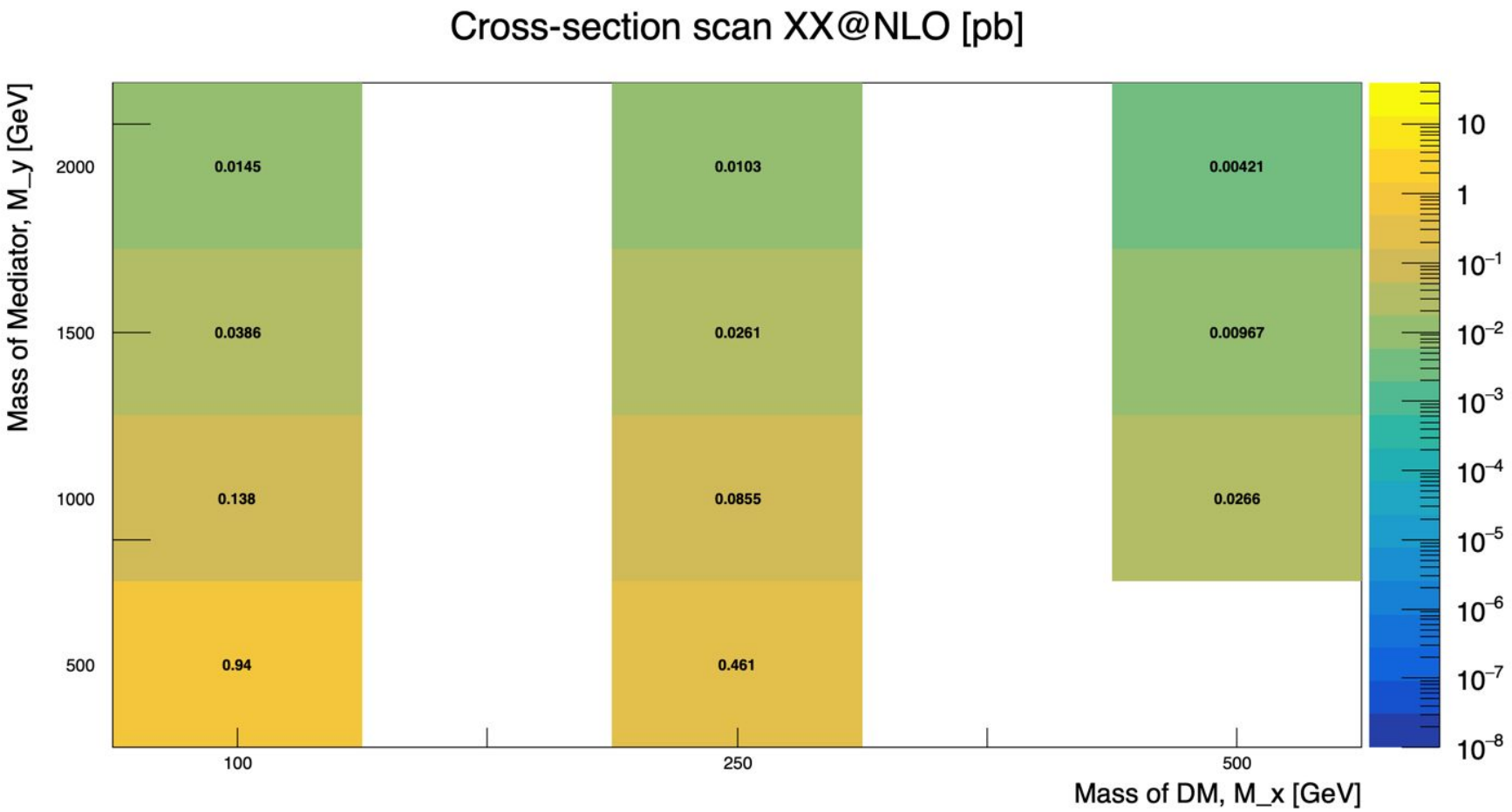
LO interferences needed to be considered to scale the amplitudes

Cross-section scans with the conditions:

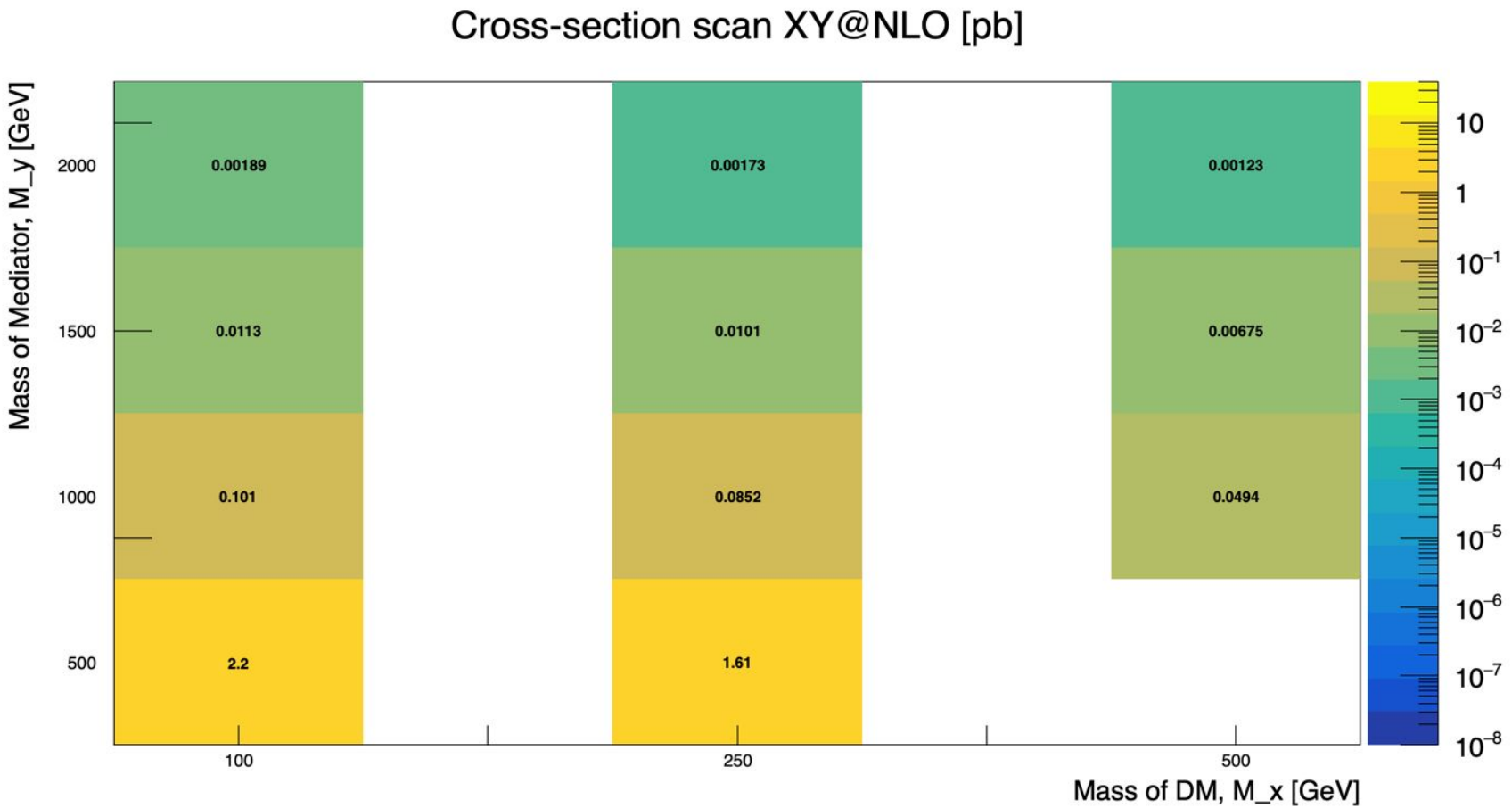
- Lambda = 1, $M_X < M_Y$: Grid scan with
  - M_X = 100, 250, 500 GeV
  - M_Y = 500 - 2000 GeV (in steps of 500 GeV)

- Processes considered:
  - XX
  - XY
  - YY
    - t - channel contribution
    - QCD contribution
    - LO interferences

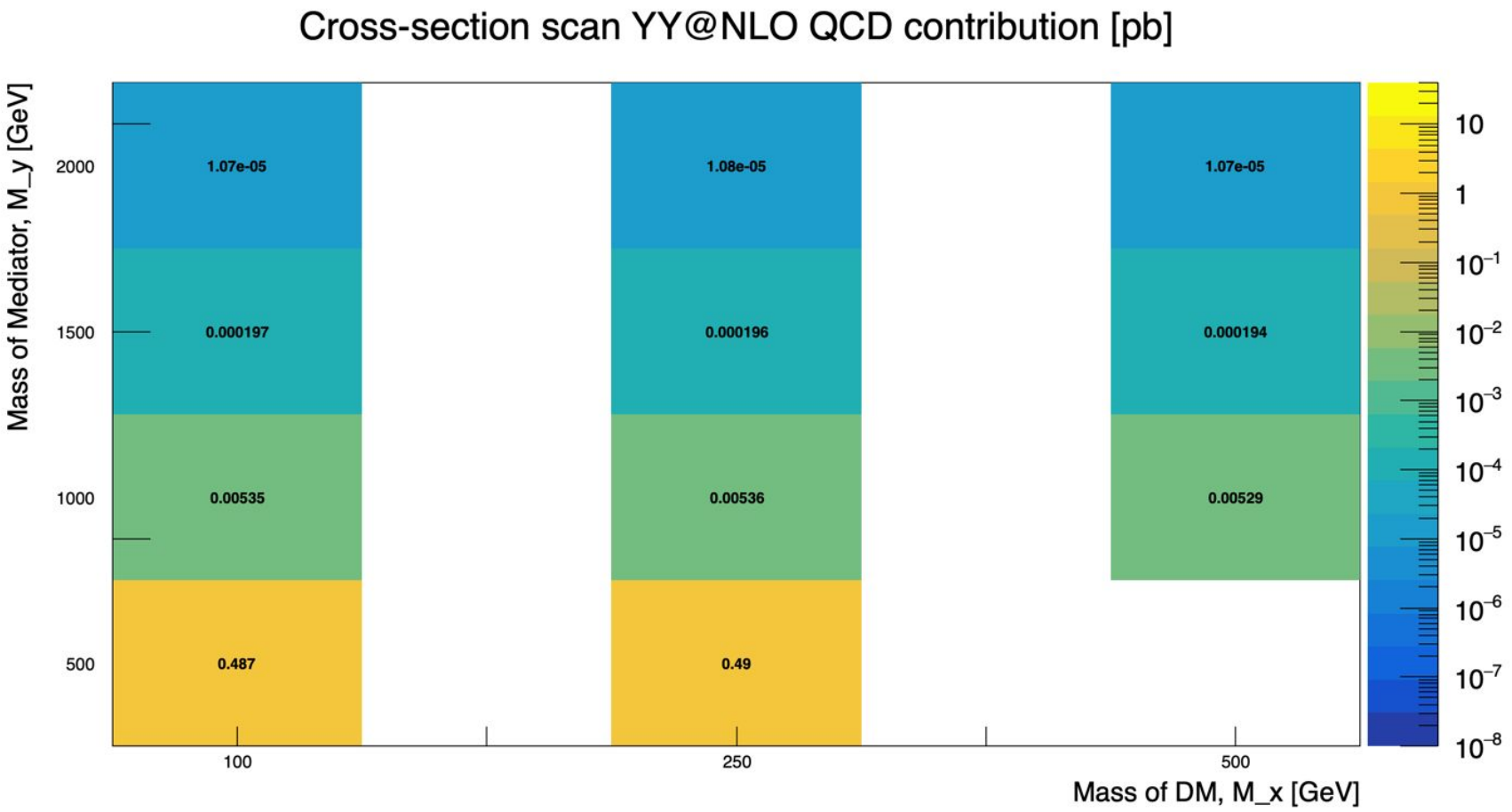
XX@NLO Cross-section scan



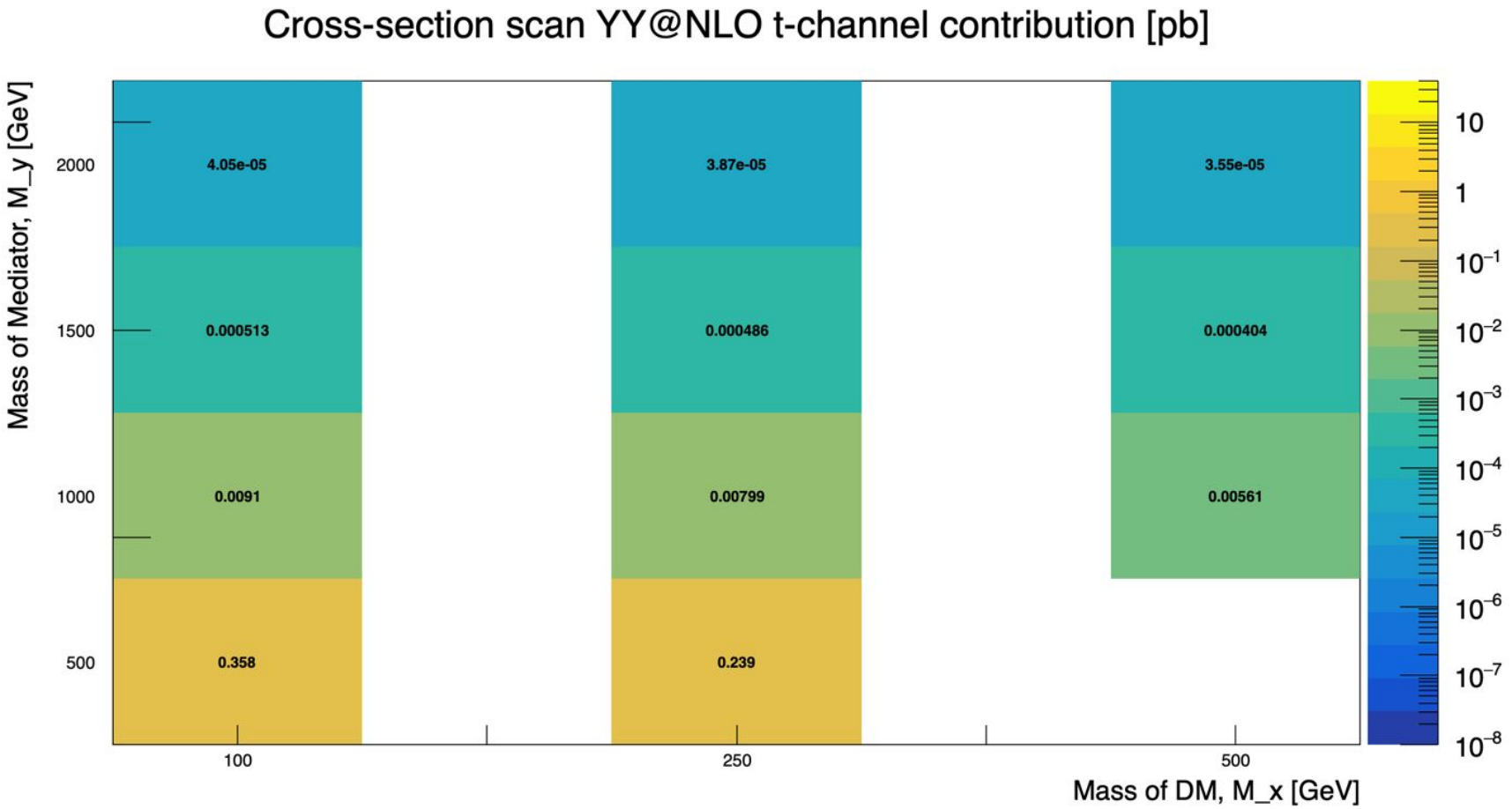
XY@NLO Cross-section scan



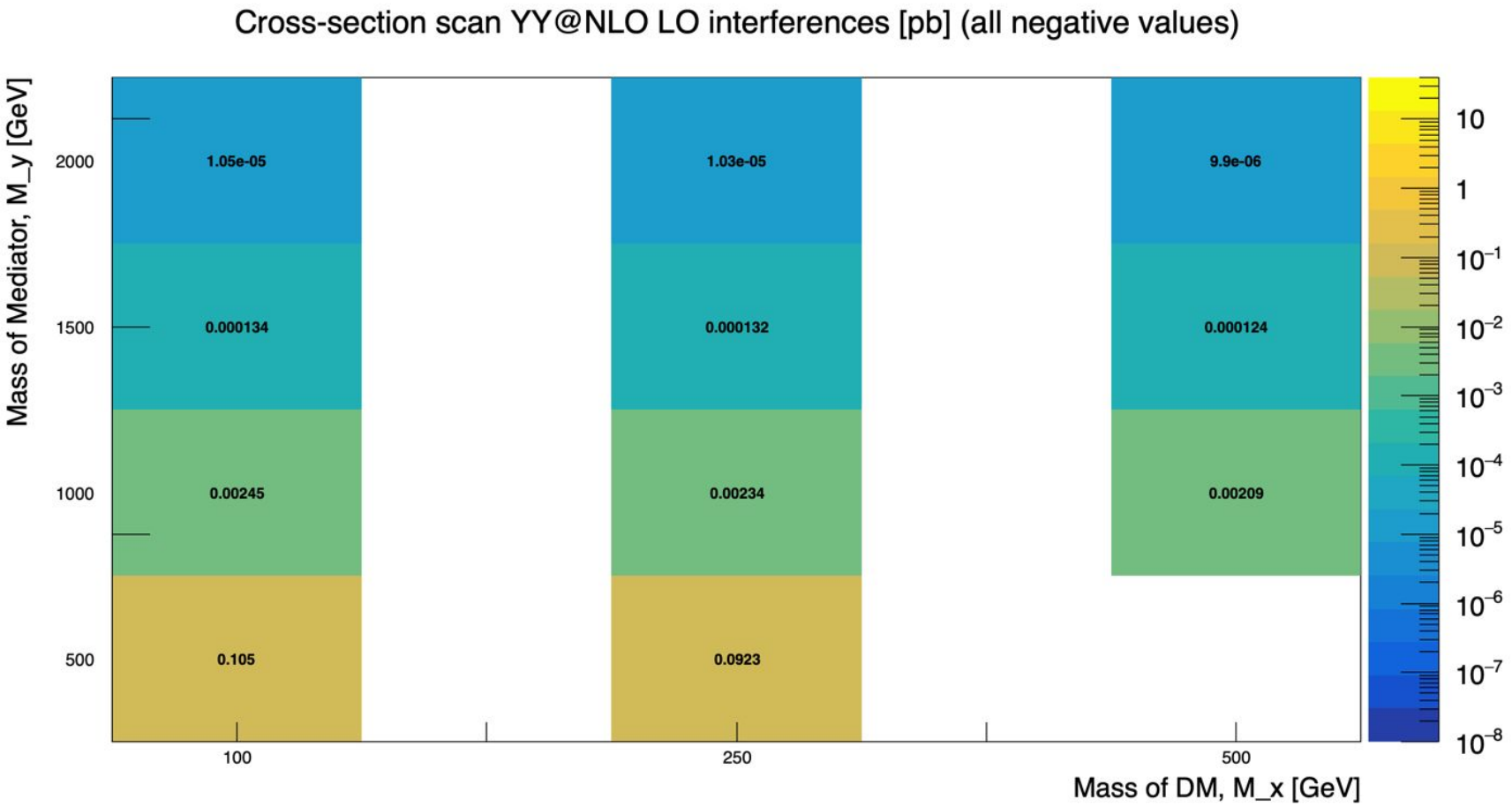
YY@NLO Cross-section scan



YY@NLO Cross-section scan



YY@NLO Cross-section scan



- Increasing the value of M_X decreases the cross section
- Tested over a vast range of masses

Next Steps?