Constraints on resonant and non-resonant production modes of SVJs

Dark Showers Workshop

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CONTUR

Constraints On New Theories Using RIVET

- Toolkit designed to probe BSM theories using measurements at particle colliders
- We have a vault of information from SM measurements and BSM searches that have been performed at the LHC
- How can we use this information to search for BSM physics?
- CONTUR produces combined-sensitivity limits derived from comparisons between theoretical BSM simulations and data at particle-level

UFO describing BSM model

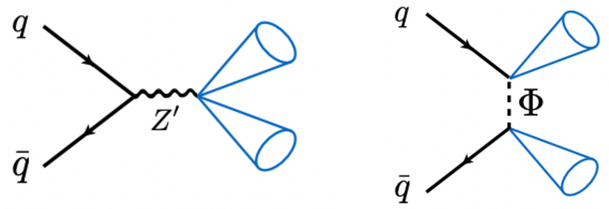
MadGraph5 for the event generation, Pythia8 for showering

Using RIVET and HEP data: effect of the BSM model on existing measurements

CLs method for exclusions

Repeat for each point in the parameter space!

SVJ Generation



Followed <u>this</u> approach using s-channel or t-channel UFOs producing dark matter particles via a heavy Z′ mediator, or via a scalar bi-fundamental mediator.

s-Channel:

- Pythia8 Hidden Valley (HV) module
- Proof-of-principle exercise

t-Channel:

- MadGraph5, then changing the PIDs of the DM particles to match with Pythia8 HV dark quark PIDs

dark hadronisation

↓

flavour-diagonal and off-diagonal π_D (spin-0) and ρ_D (spin-1) mesons

↓

decay into off-diagonal stable dark π_D and ρ_D pairs, and to SM quarks controlled by R_{inv}

final state obtained was insensitive to the detailed choices made for the dark sector parameters

CONTUR Scan Parameters

branching fraction of unstable dark mesons decaying to stable dark mesons

number of dark flavours

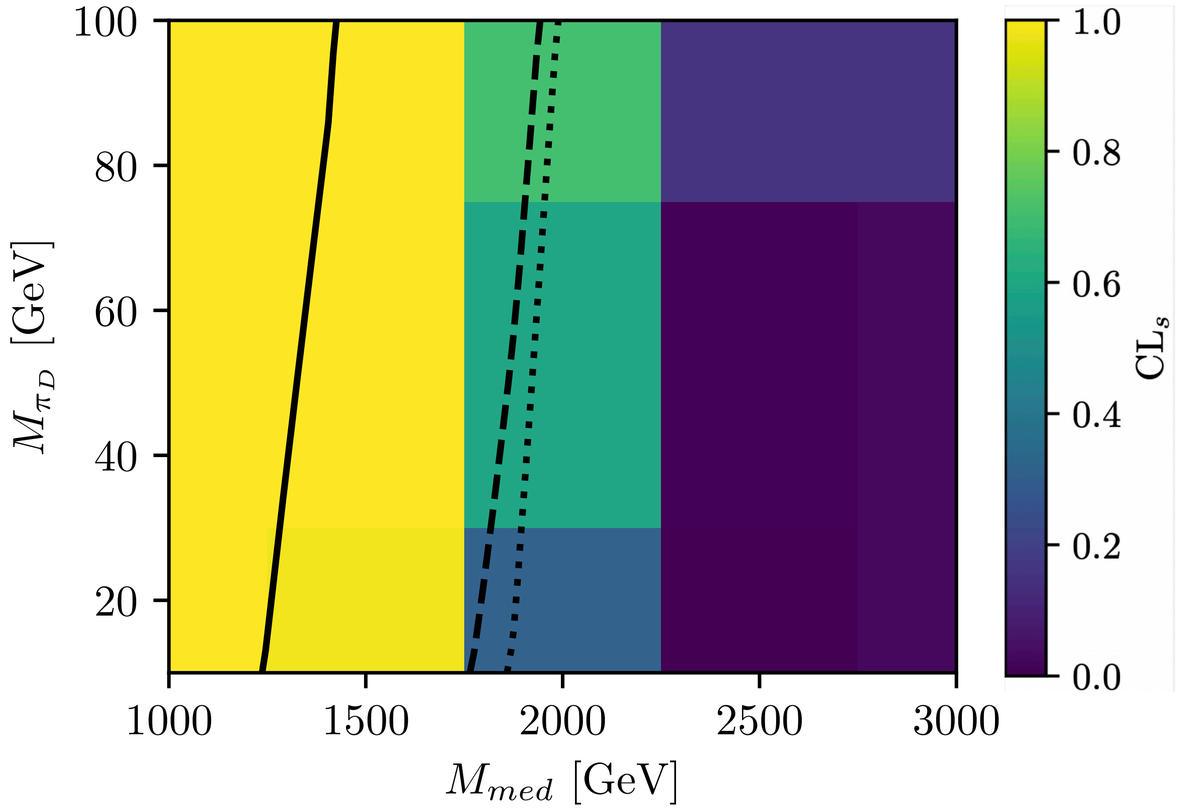
Coupling strength between SM and DM sectors

dark QCD confinement scale

lowest allowed pT of the HV FSR emission

Parameter	Range	Comments
$M_{Z'}$ or M_{med}	1,3,5 TeV	Both channels
M_{π_d}	10, 50, 100 GeV	Both channels
R_{inv}	0.0, 0.25, 0.5, 0.75, 1.0	Both channels
N_F	1, 2, 3	Only s-channel
λ	0.1 - 1	Only t-channel
M_{ρ_d}	16, 80, 160 GeV	Function of M_{π_d}
Λ_D	5, 25, 50	Function of M_{π_d} and M_{ρ_d}
pTMinFSR	5.5, 27.5, 55	Function of Λ_D

Reading CONTUR Scans

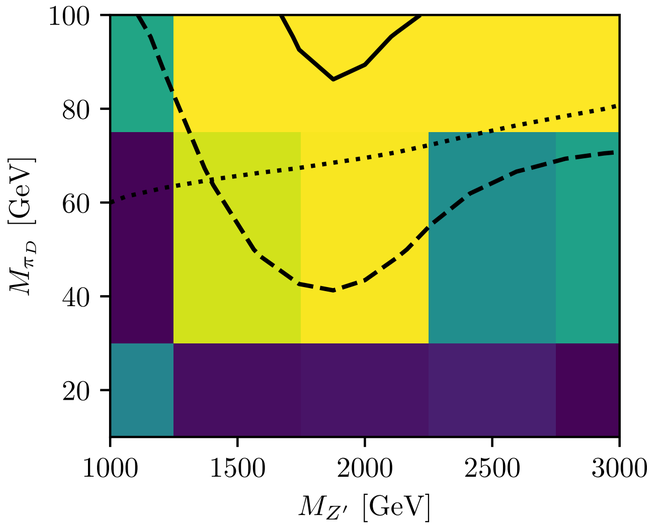


Yellow = excluded

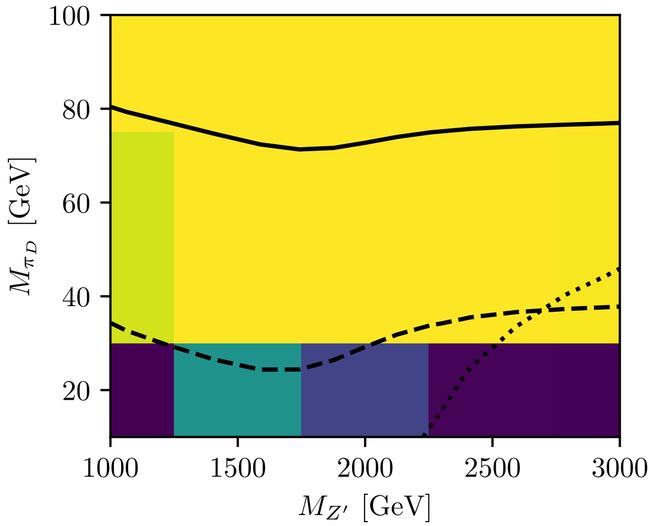
- Solid line = 95% confidence exclusion
- Dashed line = 68% confidence exclusion
- Dotted line = 95% expected exclusion

s-Channel

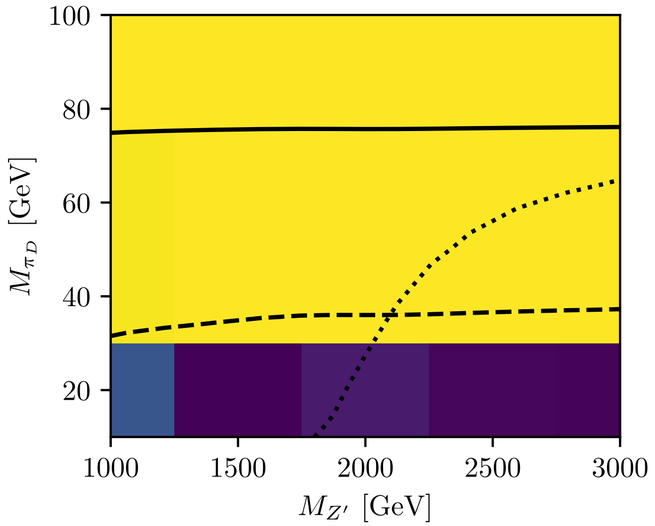
Scans of $M_{Z'}$ versus M_{π_D} for different values of R_{inv} , fixed $N_F = 2$



$R_{inv} = 0.2$



$R_{inv} = 0.5$

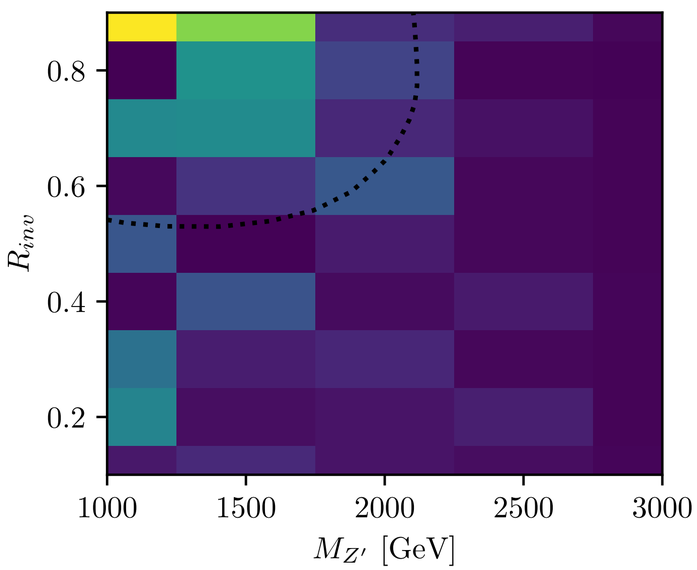


$R_{inv} = 0.8$

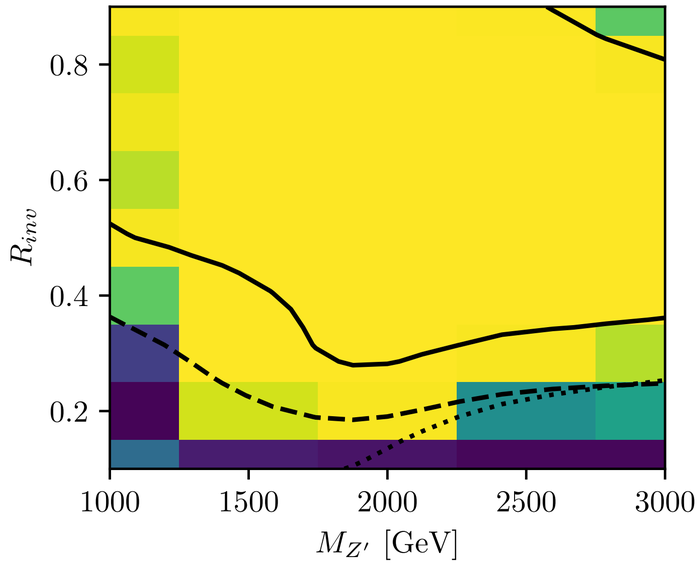
Higher values of π_D mass are mostly excluded, except at low R_{inv} and low Z' mass

s-Channel

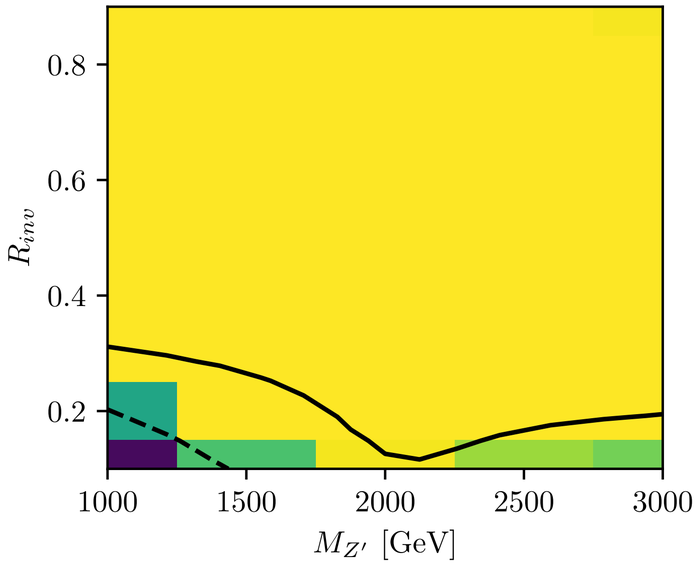
Scans of $M_{Z'}$ versus R_{inv} for different values of M_{π_D}, fixed $N_F = 2$



$M_{\pi_D} = 10$ GeV



$M_{\pi_D} = 50$ GeV

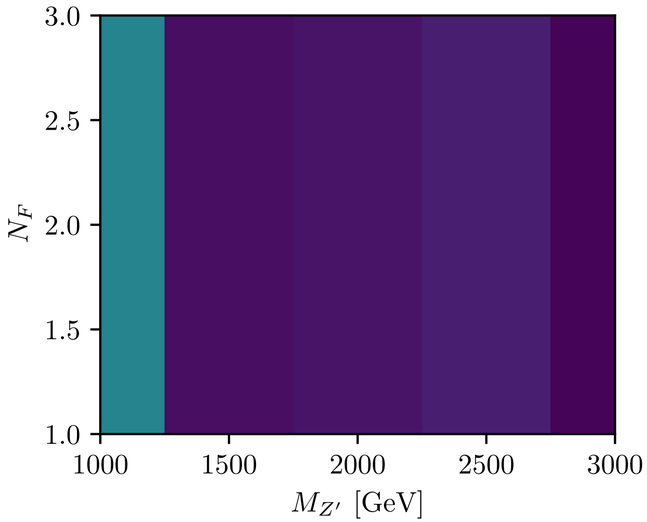


$M_{\pi_D} = 100$ GeV

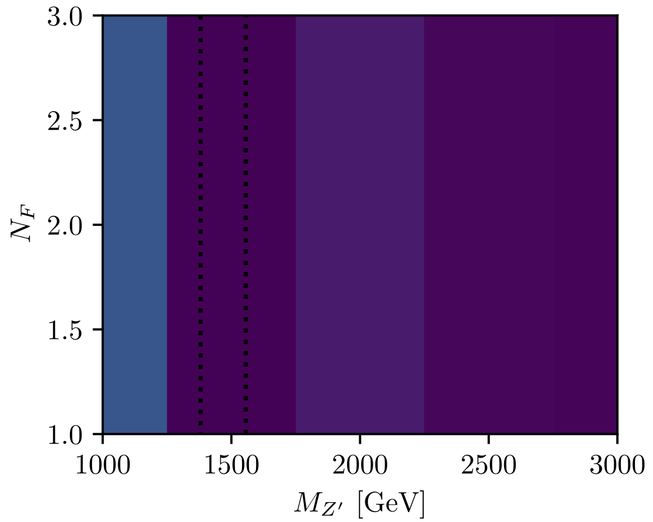
Exclusion driven by M_{π_D}

s-Channel

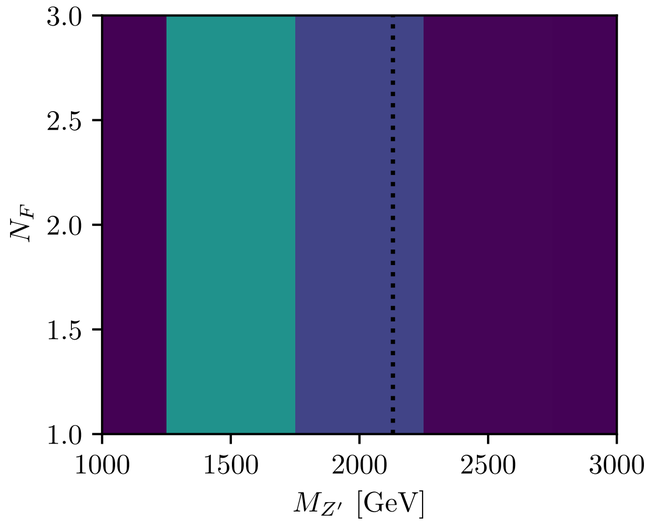
Scans of $M_{Z'}$ versus N_F for different values of R_{inv} , fixed $M_{\pi_D} = 10$ GeV



$R_{inv} = 0.2$



$R_{inv} = 0.5$

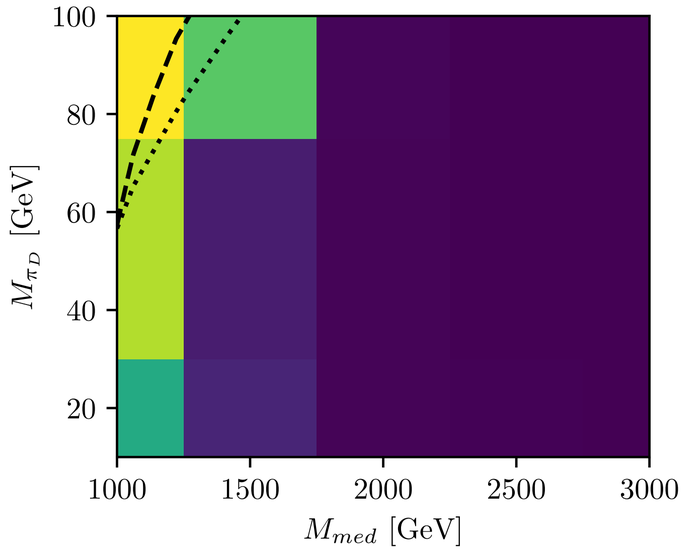


$R_{inv} = 0.8$

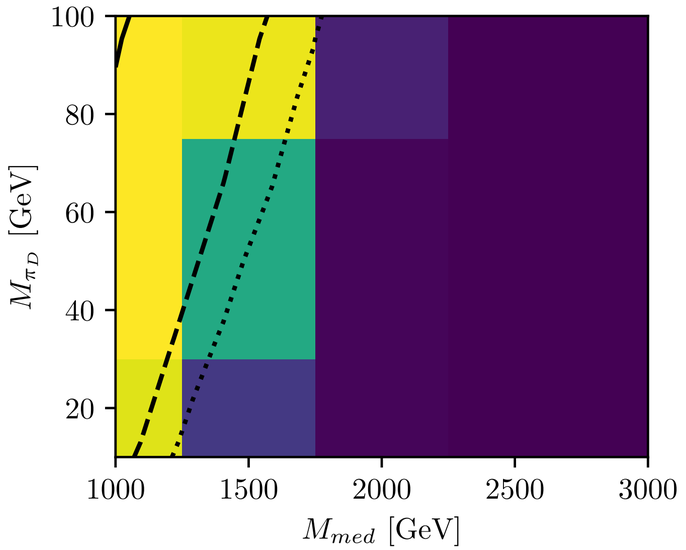
N_F does not affect the exclusion, low π_D masses are not excluded

t-Channel

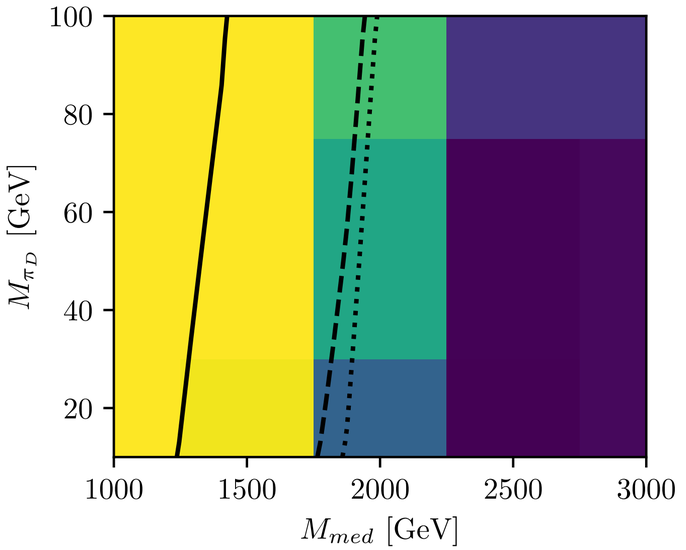
Scans of M_{med} versus M_{π_D} for different values of R_{inv} , fixed $\lambda = 1$



$R_{inv} = 0.2$



$R_{inv} = 0.5$

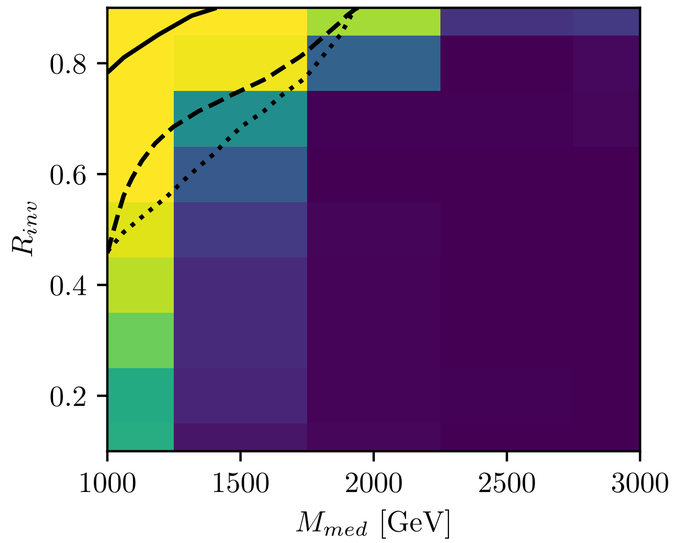


$R_{inv} = 0.8$

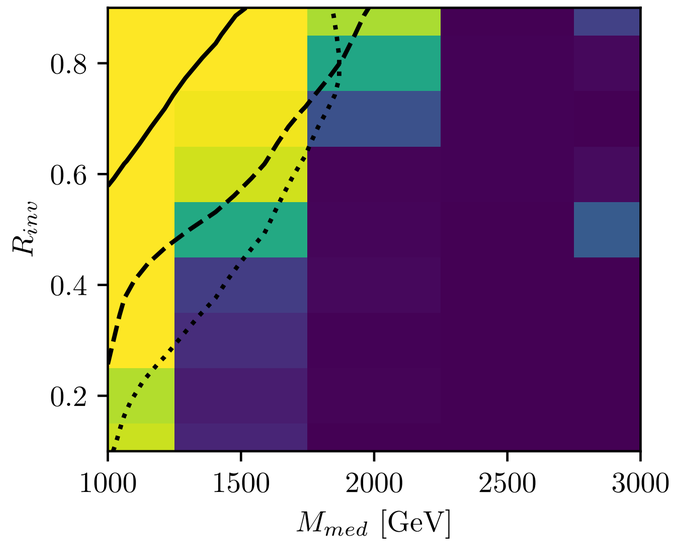
Some dependence on R_{inv} for excluded mediator masses,
almost up to 1.75 TeV is excluded for high R_{inv} value

t-Channel

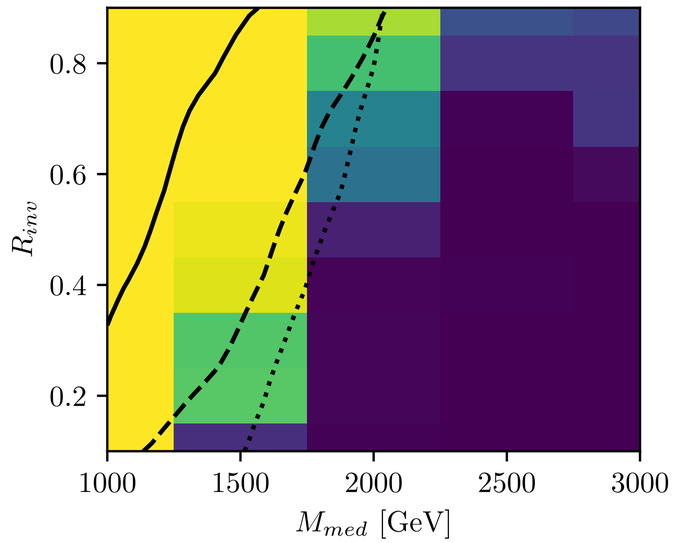
Scans of M_{med} versus R_{inv} for different values of M_{π_D}, fixed $\lambda = 1$



$M_{\pi_D} = 10$ GeV



$M_{\pi_D} = 50$ GeV

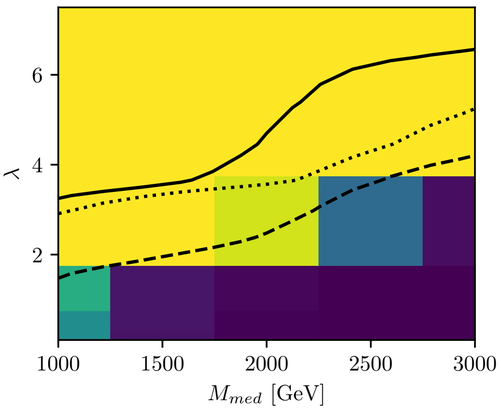


$M_{\pi_D} = 100$ GeV

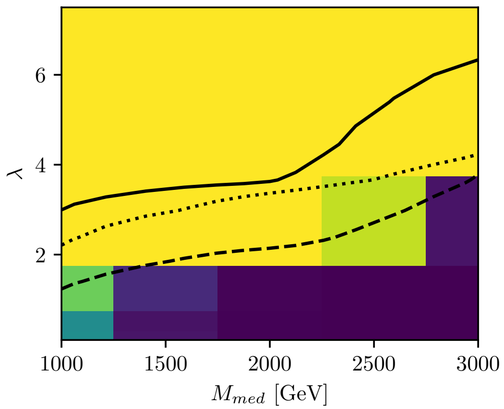
Higher values of π_D mass are mostly excluded, except at high M_{med}

t-Channel

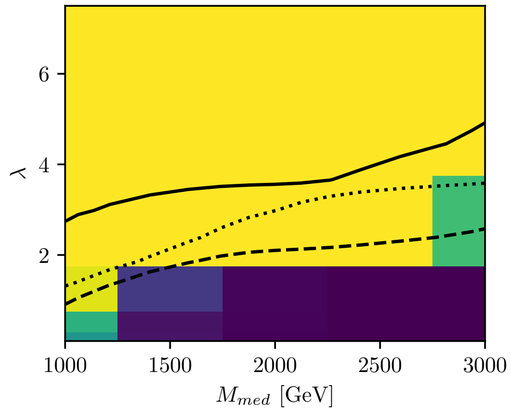
Scans of M_{med} versus λ for different values of R_{inv}, fixed $M_{\pi_D} = 10$ GeV



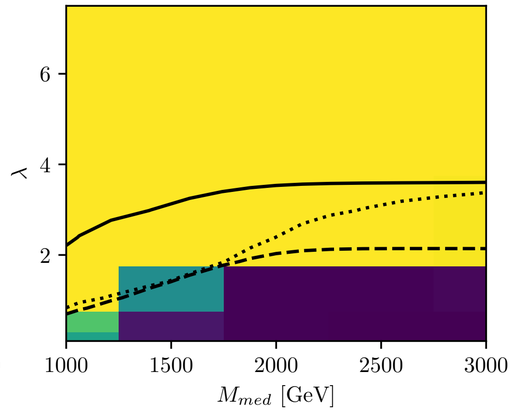
$R_{inv} = 0.1$



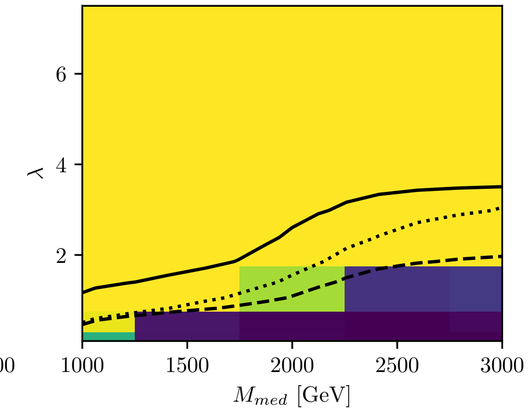
$R_{inv} = 0.3$



$R_{inv} = 0.5$



$R_{inv} = 0.7$



$R_{inv} = 0.9$

Higher values of λ are excluded

Summary

- Higher M_{π_D} are excluded for all combinations
- N_F has no effect
- λ has a cut-off around 4
- t-channel can be excluded almost up to 1.75 TeV for high R_{inv}
- CONTUR is a great tool to use for ReInt :)

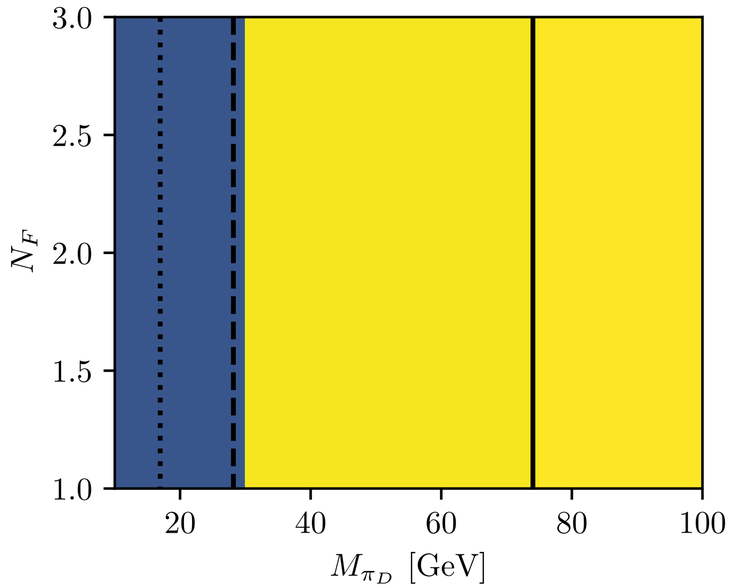
EXTRA

s-Channel

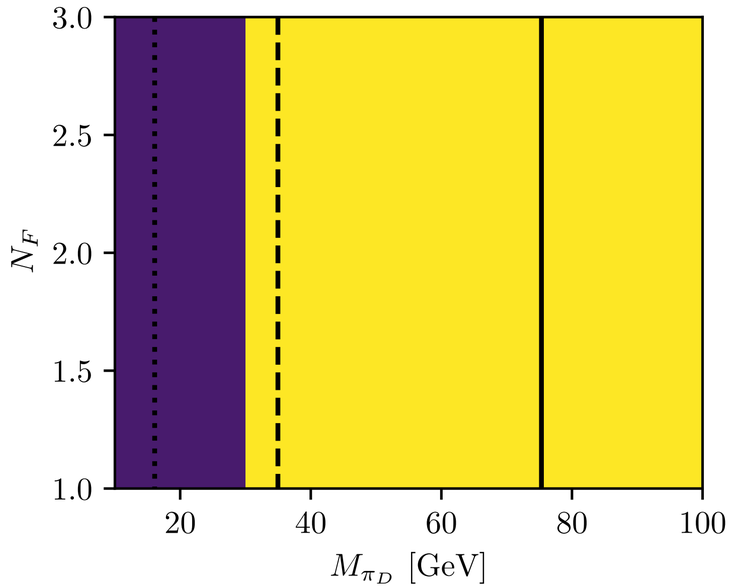
```
4900111:m0 = 10    !!! M_pi SCAN 10, 50, 100
4900113:m0 = 16.0    !!! M_rho = M_pi*1.6

4900211:m0 = 4.99    !!! M_pi/2 -  0.01
4900213:m0 = 7.99     !!! M_rho/2 -  0.01


HiddenValley:setLambda=on
HiddenValley:Lambda = 5   !!! CALCULATE from FORMAULA, OR CREATE A LIST: 5, 25, 50


#Simplified non conserving setup
4900111:onechannel = 1 0.1 0 4900211 -4900211     !!! RINV SCAN
4900111:addchannel = 1 0.9 91 -3 3                !!! RINV SCAN
```

s-Channel

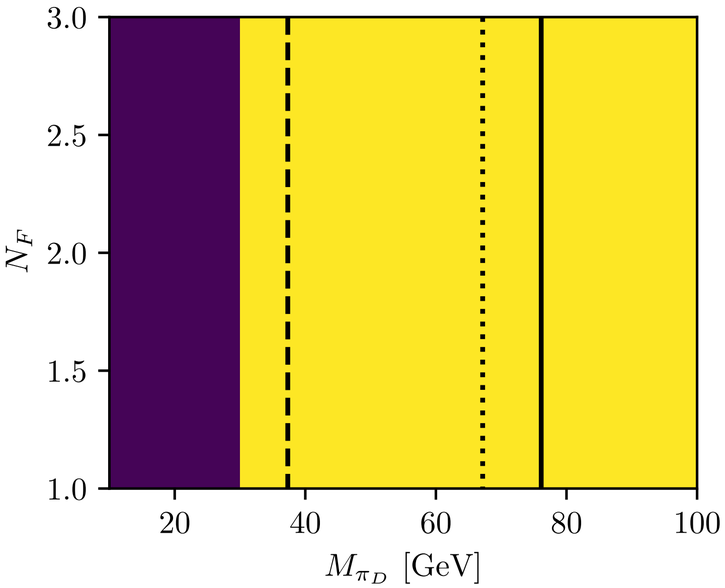
Scans of M_{π_D} versus N_F for different values of $M_{Z'}$, fixed $R_{inv} = 0.5$



$M_{Z'} = 1000$ GeV



$M_{Z'} = 2000$ GeV



$M_{Z'} = 3000$ GeV