Searching for t-channel mediated dark matter

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1308.0592

The simplified model

- Dark matter is a spin-1/2 particle
- Dark matter couples universally to righthanded quarks
- The dark mediators are degenerate

$$\mathcal{L}_\chi = \lambda \bar{\chi}_L q_R \phi^* + \text{h.c.}$$

This model includes SUSY as a special case

coupling

Dark matter, can be Dirac or Majorana
Important differences in the signal.

quark

Dark mediator, (colored) complex scalar

Two type of signals

- Mono-jet
  - ISR and single mediator production.
  - Harder jet from mediator production.
- Di-jet+MET
  - Similar to SUSY squark pair production.

Mono-jet search

- 8 TeV LHC, 19.5 fb-1 CMS, (Tech. Rep. CMS-PAS-EXO-12-048)
  - At least one central jet with pT > 110 GeV, $|\eta|$ < 2.4
  - At most two jets with pT > 30 GeV, $|\eta|$ < 4.5
  - No isolated electrons with pT > 10 GeV, $|\eta|$ < 1.44 or 1.56<$|\eta|$<2.5
  - No isolated muons with pT > 10 GeV, $|\eta|$ < 2.1
  - MET > 120 GeV
  - For events with a second jet, $\Delta\phi(j1, j2)$< 2.5

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Allowing a second hard jet.
Including both the monojet+MET and the dijet+MET events

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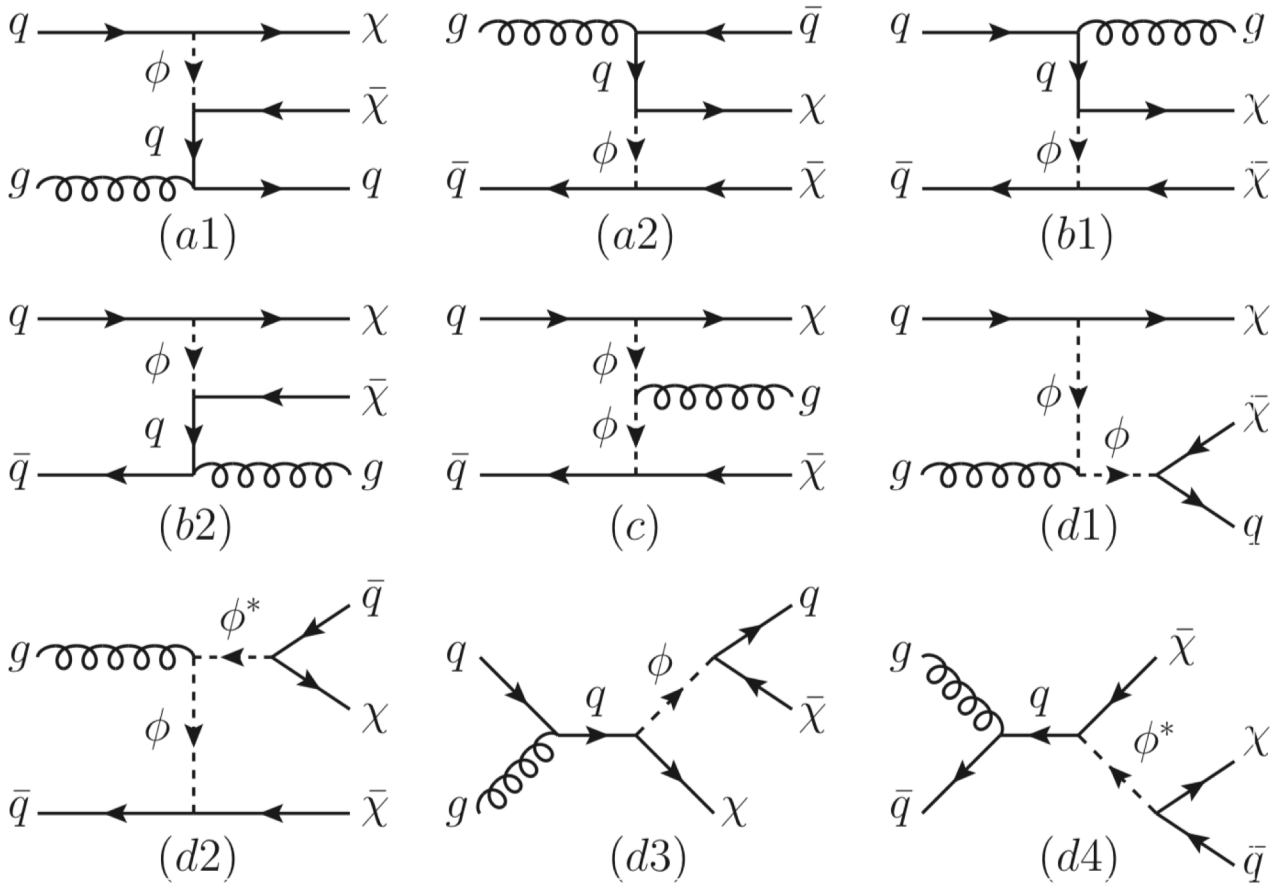
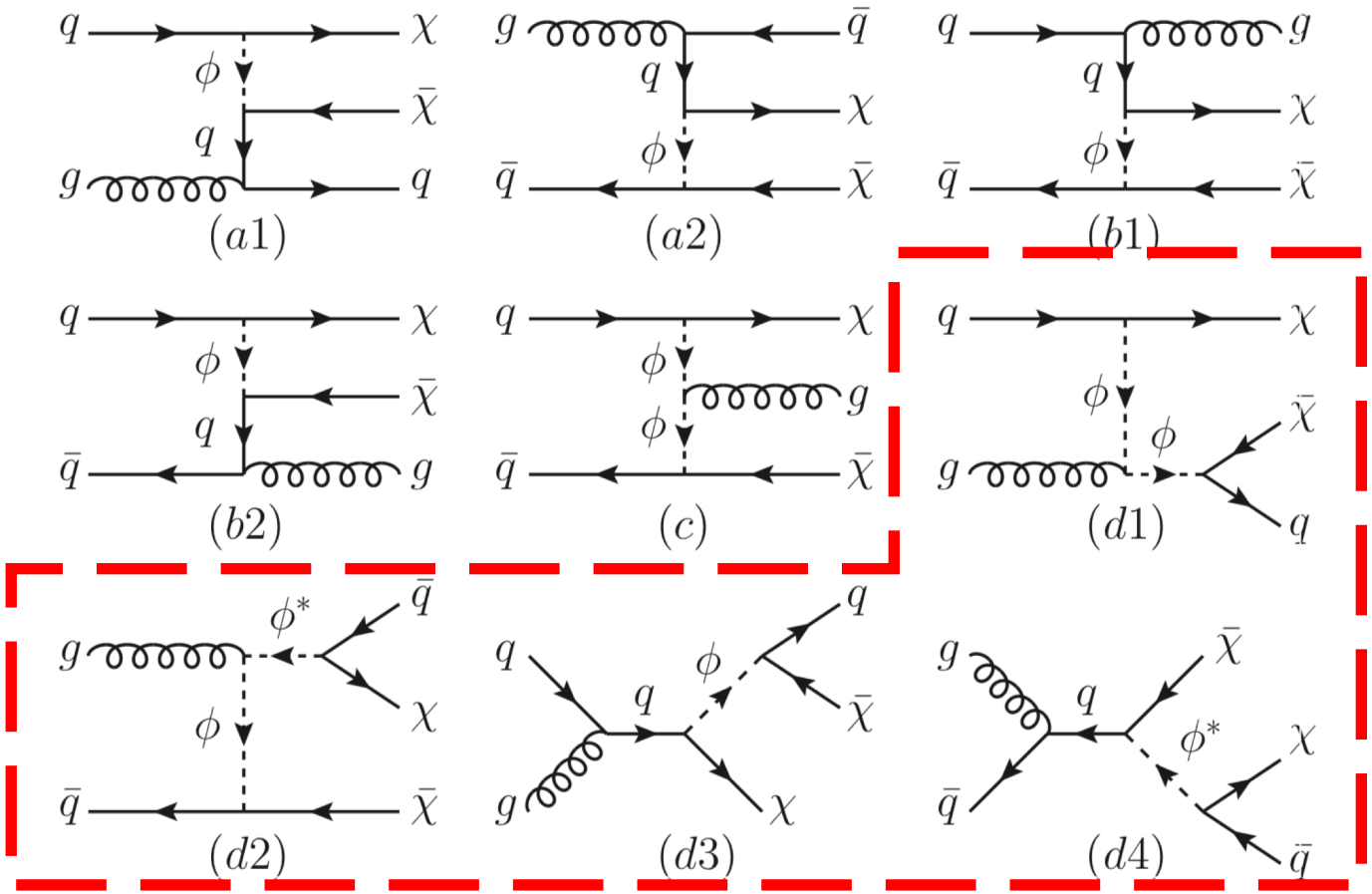
  - No isolated muons with pT > 10 GeV, $|\eta|$ < 2.1
  - MET > 120 GeV
  - For events with a second jet, $\Delta\phi(j1, j2)$< 2.5

Monojet+MET at parton level diagrams



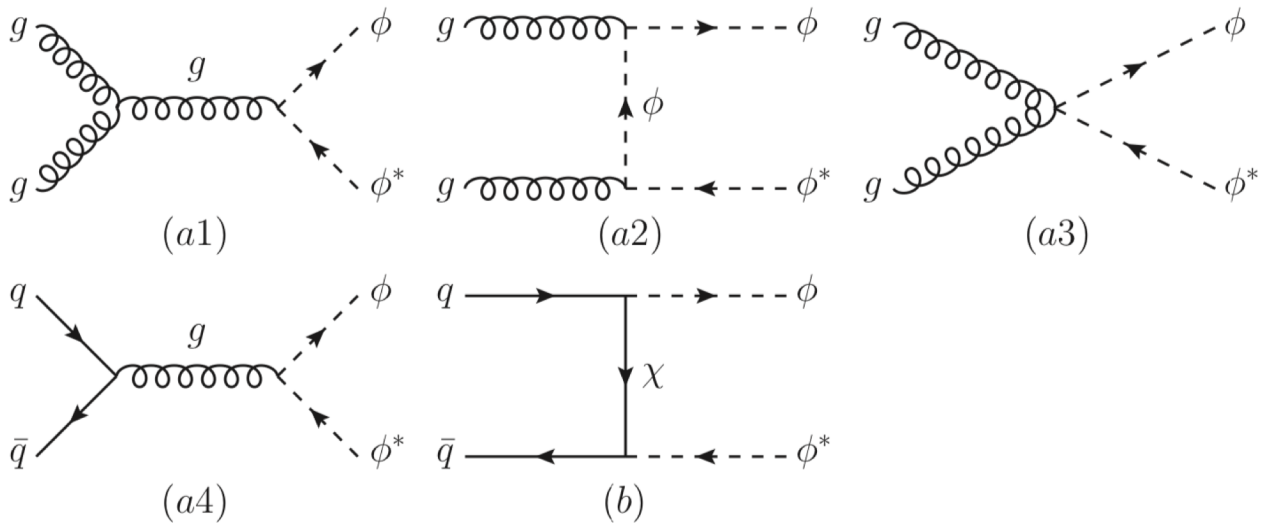
Monojet+MET at parton level diagrams



- ϕ can be produced on shell and then decay into MET and jet.
- 2→3 becomes 2→ 2
- Dominate when ϕ can be produced on-shell

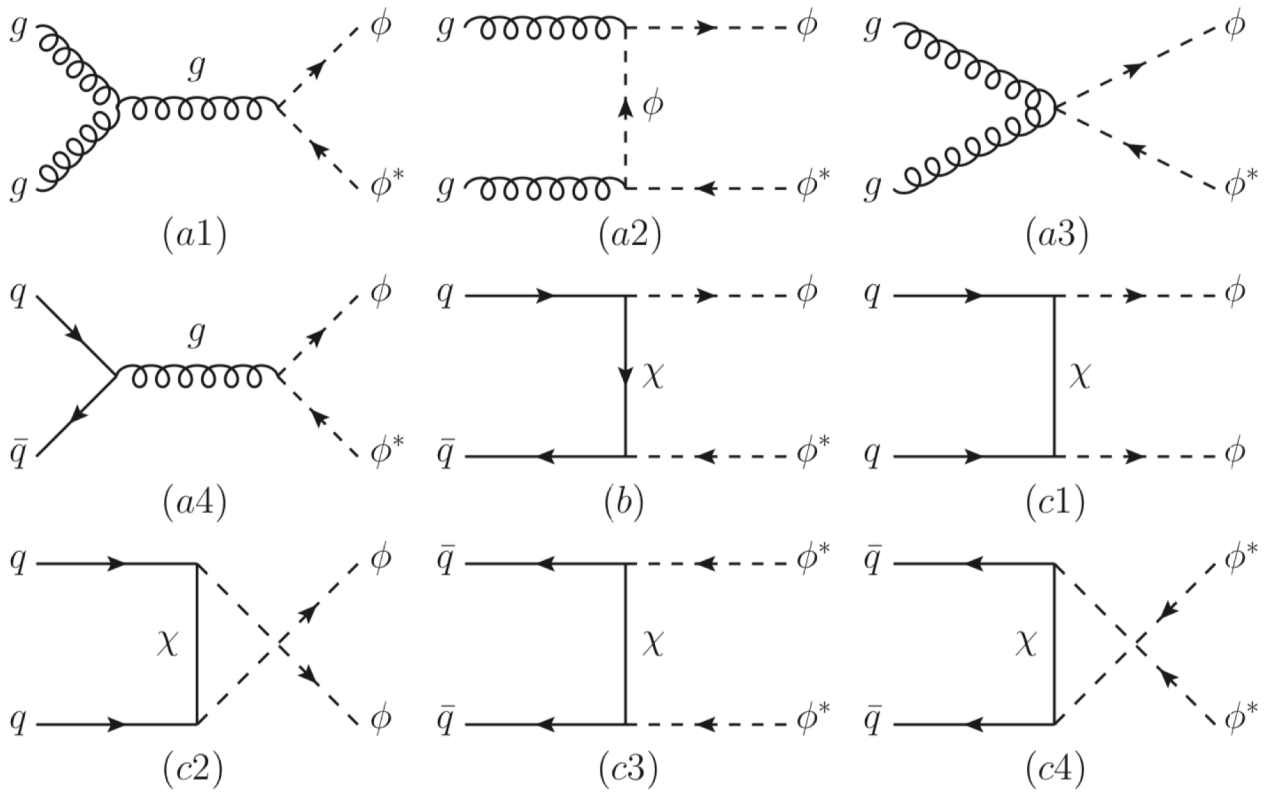
Dijet+MET at parton level

- Dijet+MET is important when a pair of ϕ can be produced on-shell
- If χ is Dirac



Dijet+MET at parton level

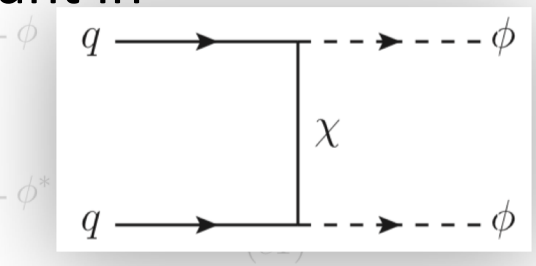
- Dijet+MET is important when a pair of ϕ can be produced on-shell
- If χ is Majorana

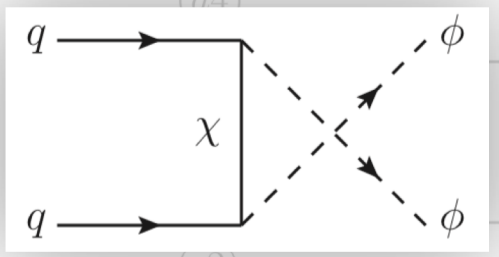


Dijet+MET at parton level

- Dijet+MET is important when a pair of ϕ can be produced on-shell
- If χ is Majorana

1. $\propto M_\chi$, important in the region of heavy DM
2. Valent quark initial states, more important in the large M_χ region.



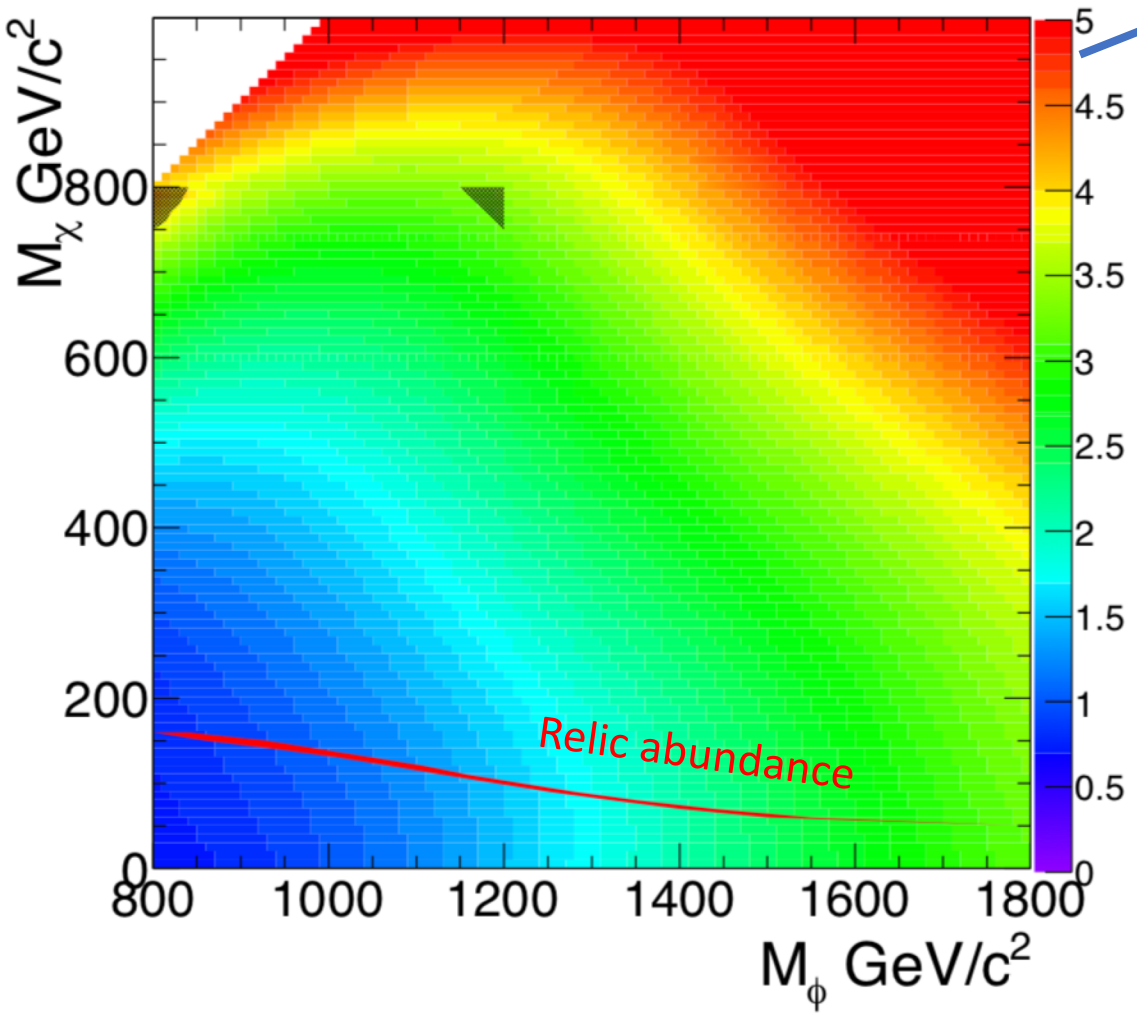


Monojet constraints

- Event generation
  - MG5+ME+Pythia6.4+FASTJET3 for signals
  - MG5+ME+Pythia6.4+PGS4 for background
  - CTEQ6L1
  - anti-KT

Constraints (Dirac case)

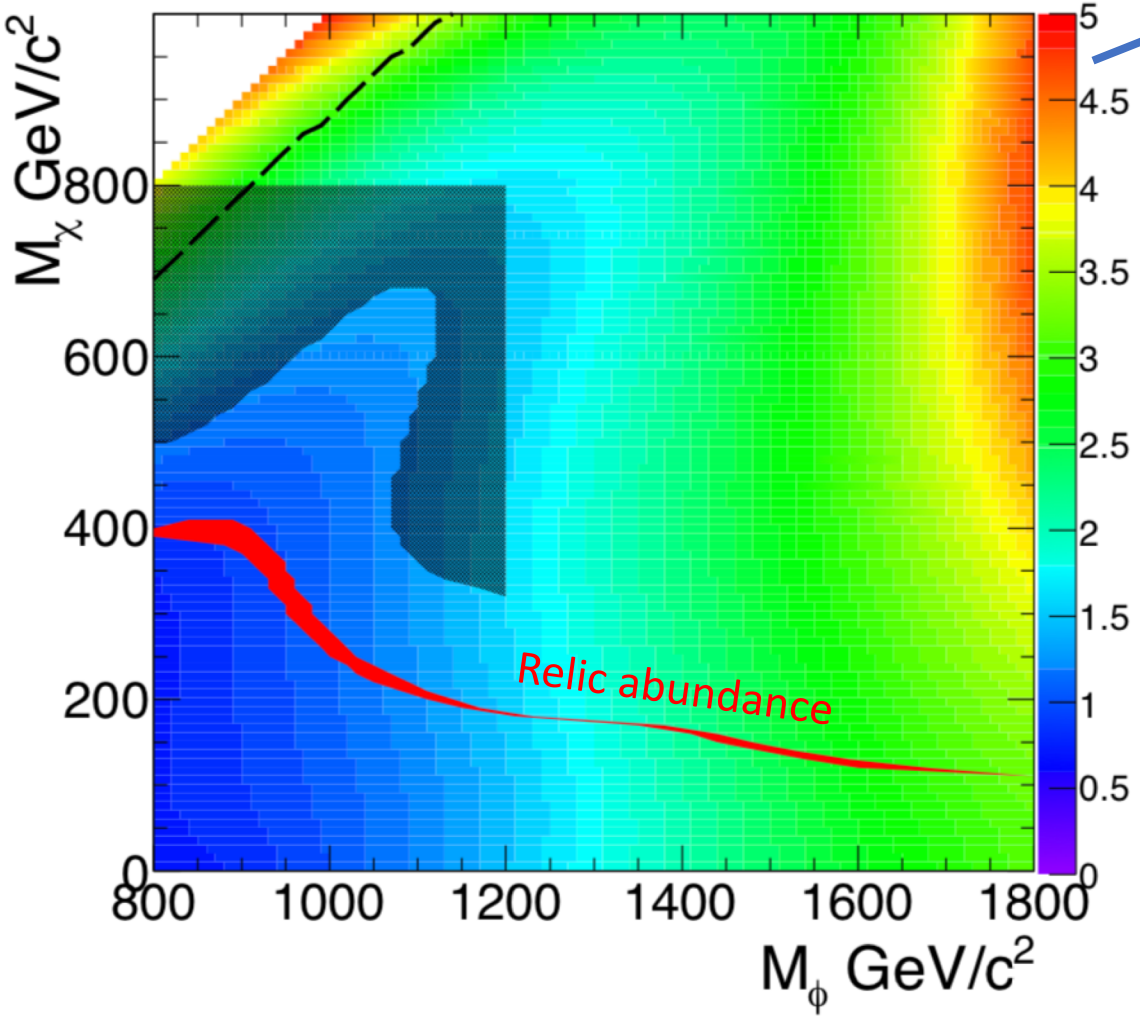
$$\mathcal{L}_\chi = \lambda \bar{\chi}_L q_R \phi^* + \text{h.c.}$$



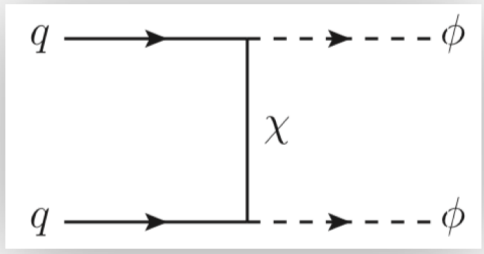
- With fixed M_χ, constraint on coupling becomes weaker with larger M_ϕ, since the production rate of phi becomes smaller.
- With fixed M_ϕ, constraint on coupling becomes weaker with larger M_χ, since the jet becomes softer.

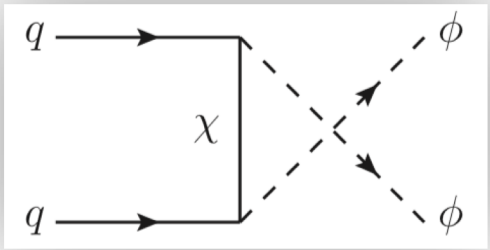
Constraints (Majorana case)

$$\mathcal{L}_\chi = \lambda \bar{\chi}_L q_R \phi^* + \text{h.c.}$$



- With fixed M_χ, constraint on coupling becomes weaker with larger M_ϕ, since the production rate of phi becomes smaller.
- With fixed M_ϕ, the constraint on coupling changes very little with M_χ, event becomes stronger in some region.

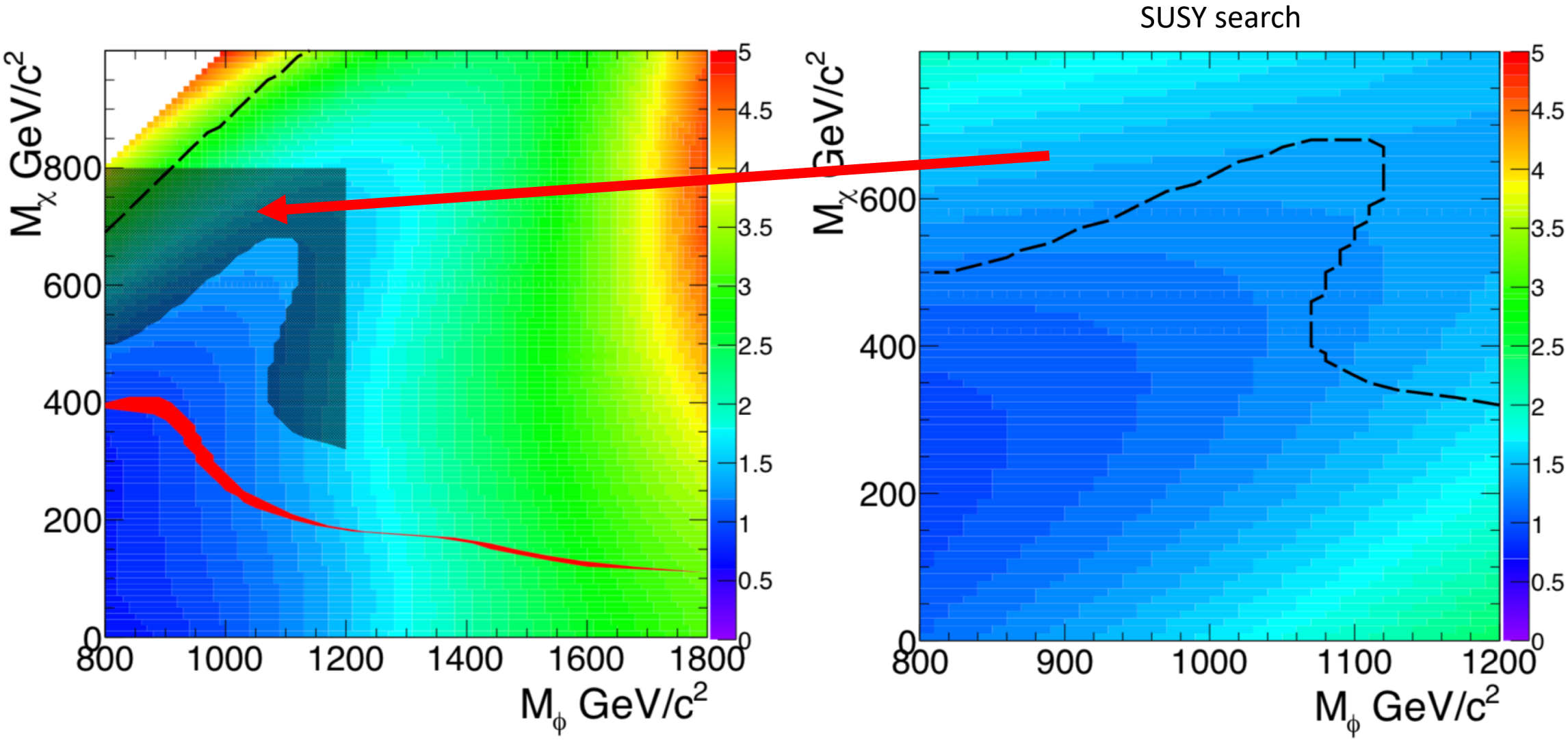




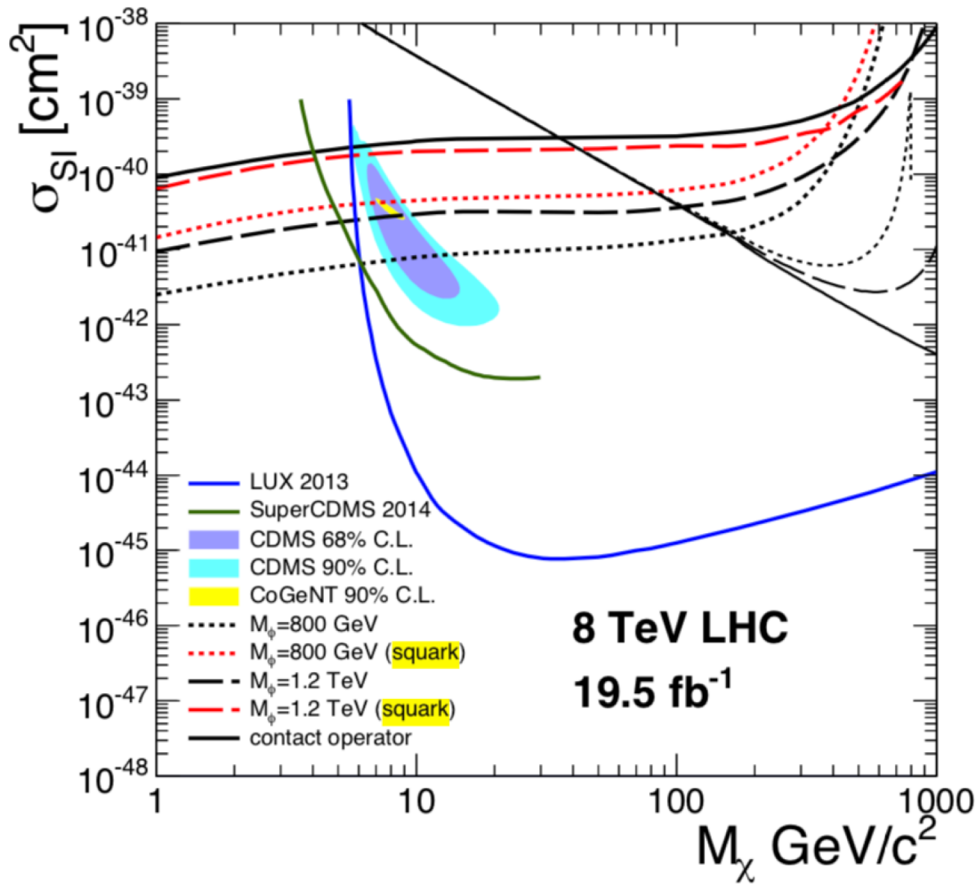
Constraints (Majorana case)

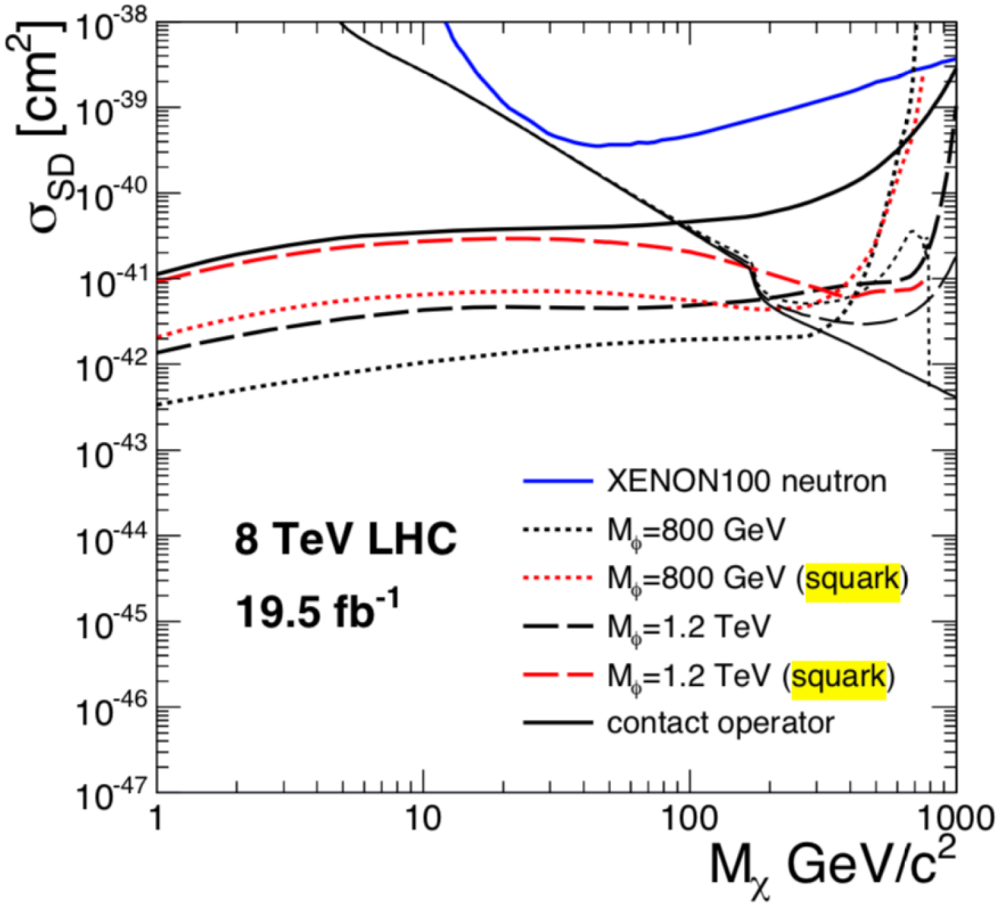
- The dijet+MET contribution is important in the large Mchi region, it may be important to consider “more professional” dijet +MET searches. (The SUSY squark search)
- Tech. Rep. CMS-PAS-SUS-13-012
- CalcHEP is used to calculate the total cross section
- K-factor is small and neglected

Constraints (Majorana case)



Comparison with dark matter direct detection





Overview

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- The model $\mathcal{L}_\chi = \lambda \bar{\chi}_L q_R \phi^* + \text{h.c.}$ χ: fermionic DM, ϕ: mediator
  - DM can be Dirac or Majorana, with important difference in signal
- Parameters
  - Coupling λ, mass of messenger M_ϕ, and mass of DM M_χ. (same for Dirac and Majorana)
- Signals: monojet + MET and dijet + MET
  - In the case that χ is Dirac, monojet + MET search is more important in most of the parameter space.
  - In the case that χ is Majorana, the dijet + MET search is more important in the large M_χ region.