DM @ LHC

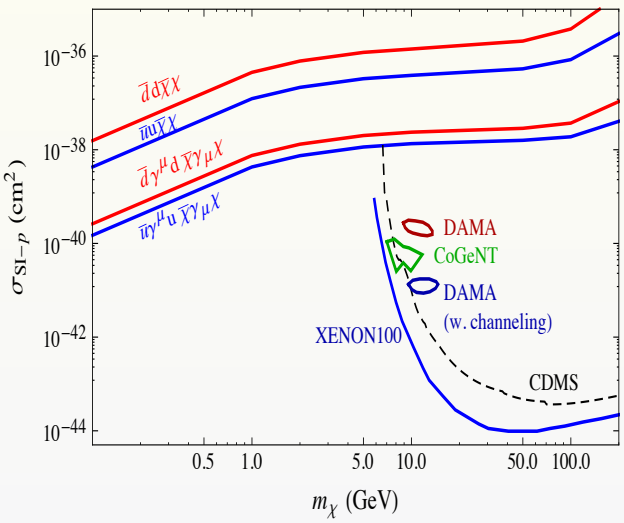
Yuhsin Tsai

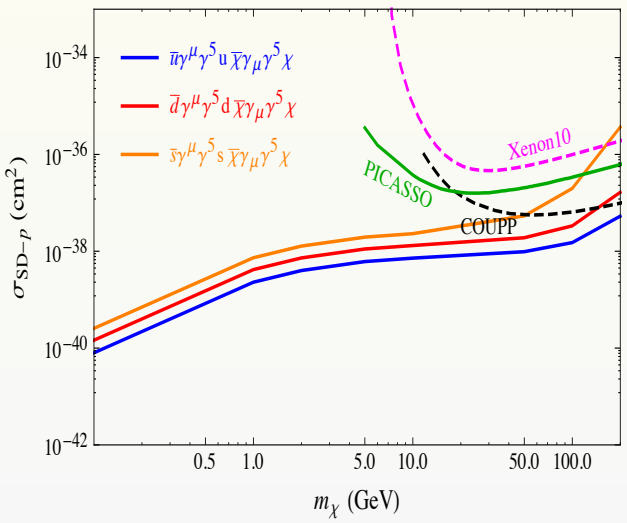
In collaboration with Patrick Fox, Roni Harnik, and Joachim Kopp

Fermilab/SUSY11, 28 Aug 2011

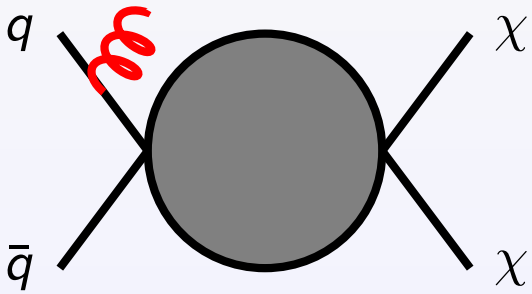
Earlier result: Bounds from Tevatron

Y. Bai et al. (10), J. Goodman et al. (10), J. Goodman et al. (11)

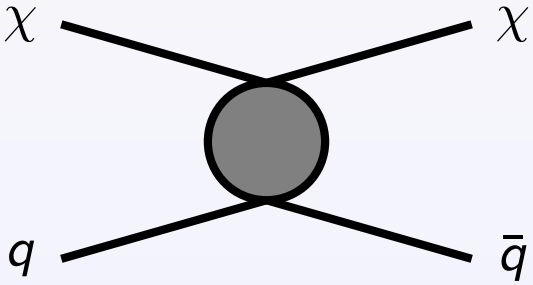




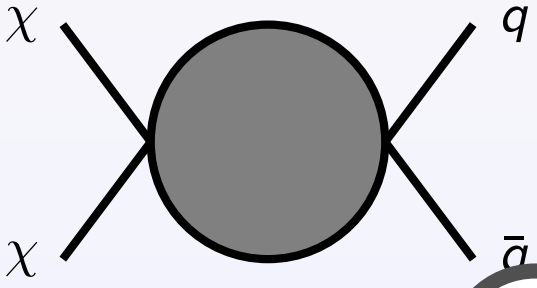
Collider



Direct



Indirect



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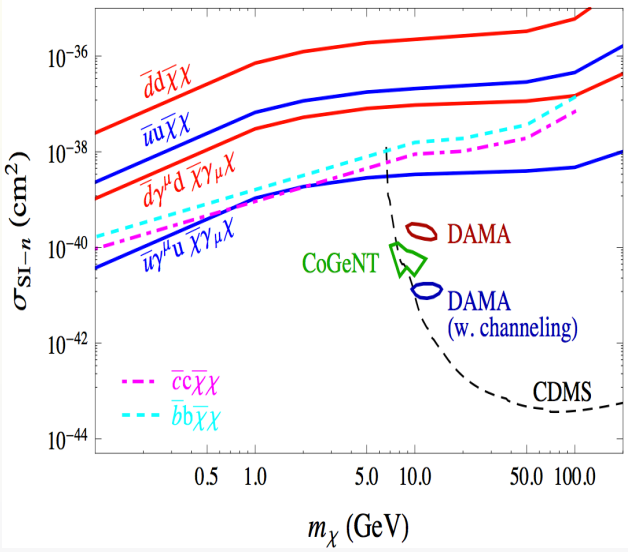

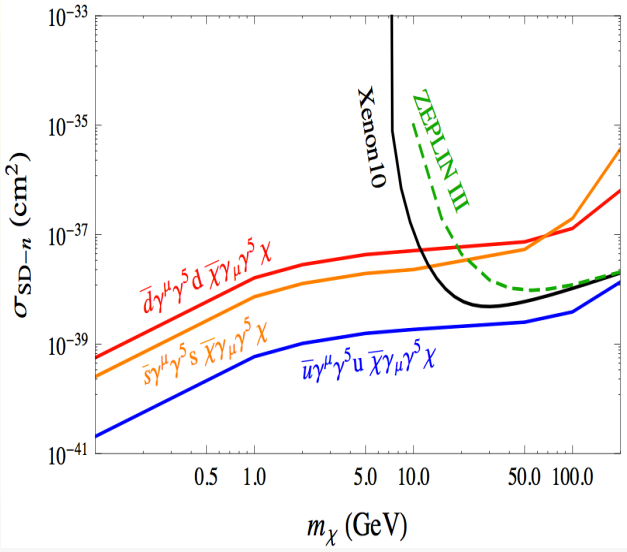

- independent of astrophysical and experimental assumptions.
- good bounds on light DM.
- good bounds on spin dependent case.

How to improve the bounds?

There are two ways we can go

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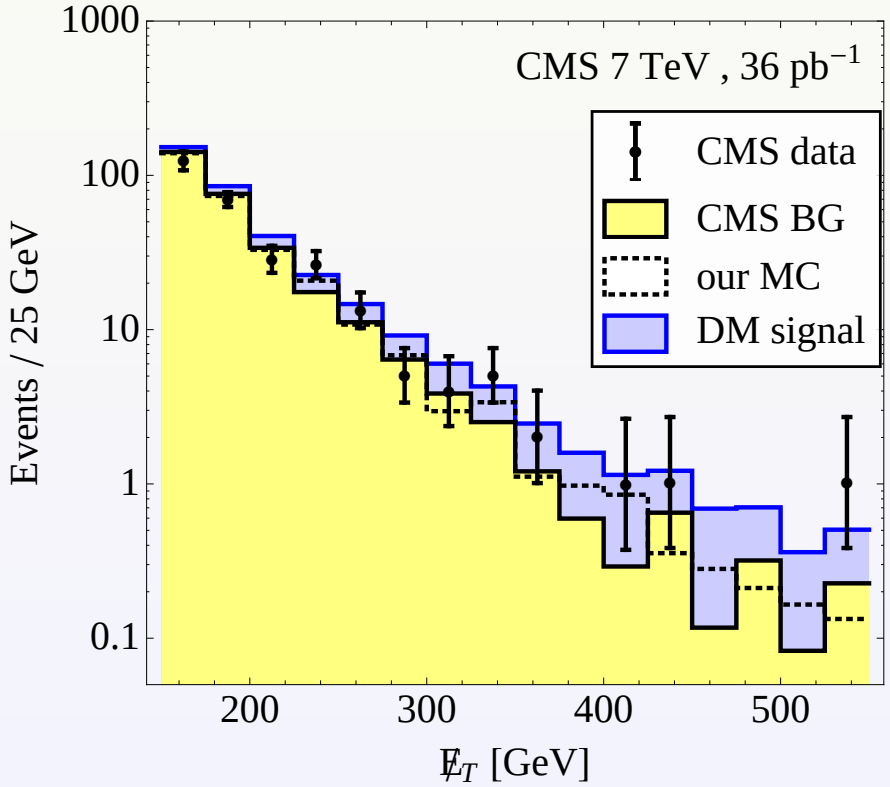
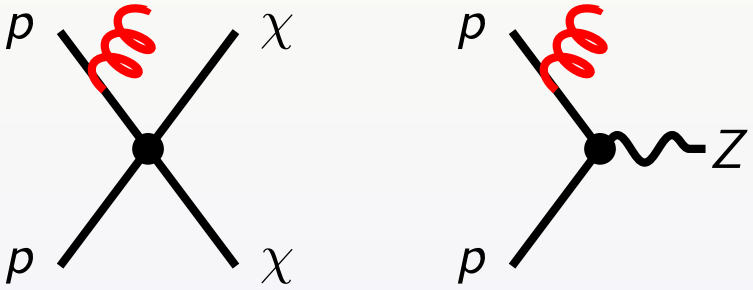


$2 \to 3$ VS. $2 \to 2$



The shapes are different!

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Question

Which of them helps more at this stage?

We can get some idea from the following Mono-Jet searches:

- CMS $36\,\mathrm{pb}^{-1}$
- ATLAS $1\,\mathrm{fb}^{-1}$: LowPt, HighPt and veryHighPt.

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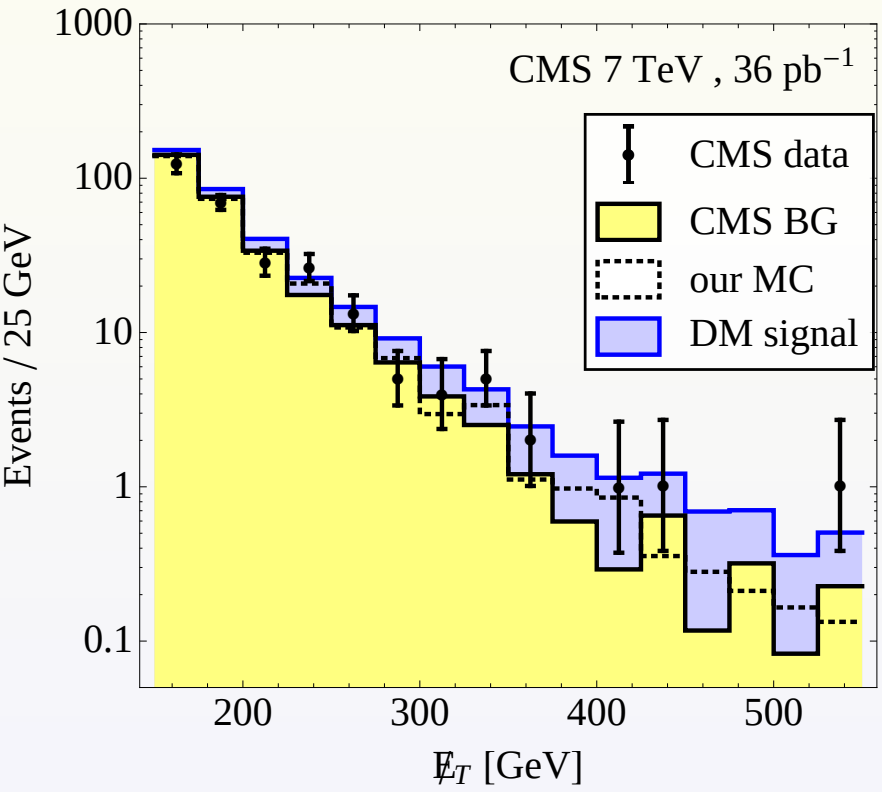
Mono-Jet search at CMS

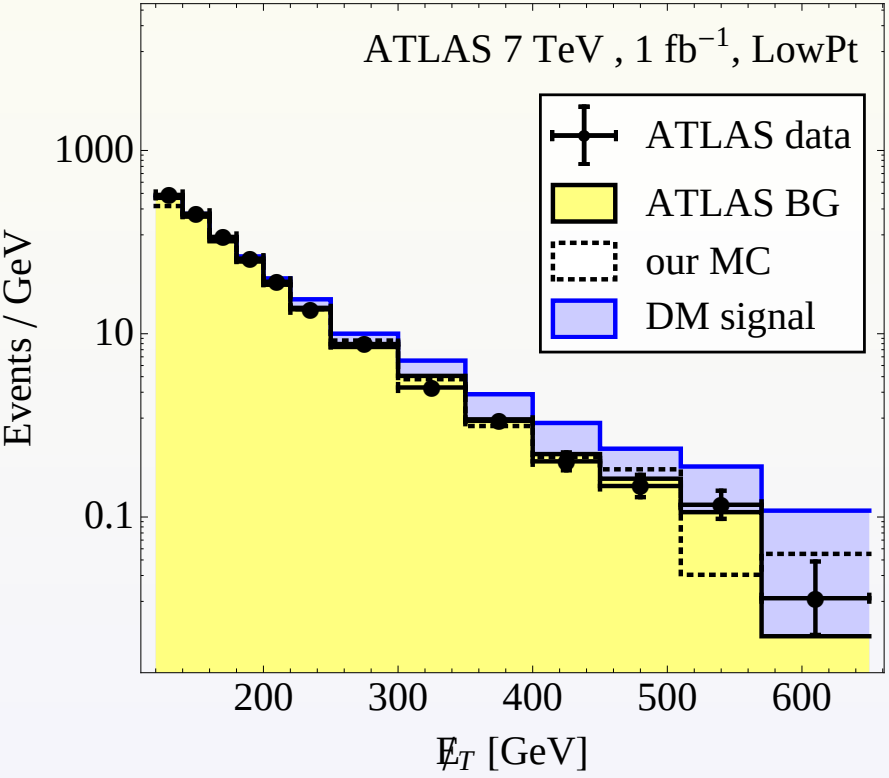
arXiv:1106.4775



- 7 TeV, 36 pb^{-1}
- Search: Mono-Jet + $\not{E}_T$.
- Background:
  Jet + ($Z \to \nu\nu$, $W \to \nu\ell$).
- Main cuts:
  $\not{E}_T > 150\,\mathrm{GeV}$, $p_{T,j_1} > 110\,\mathrm{GeV}$.
- Result: 275 (297 $\pm$ 45 for the BG).

Mono-Jet search at ATLAS (LowPt)

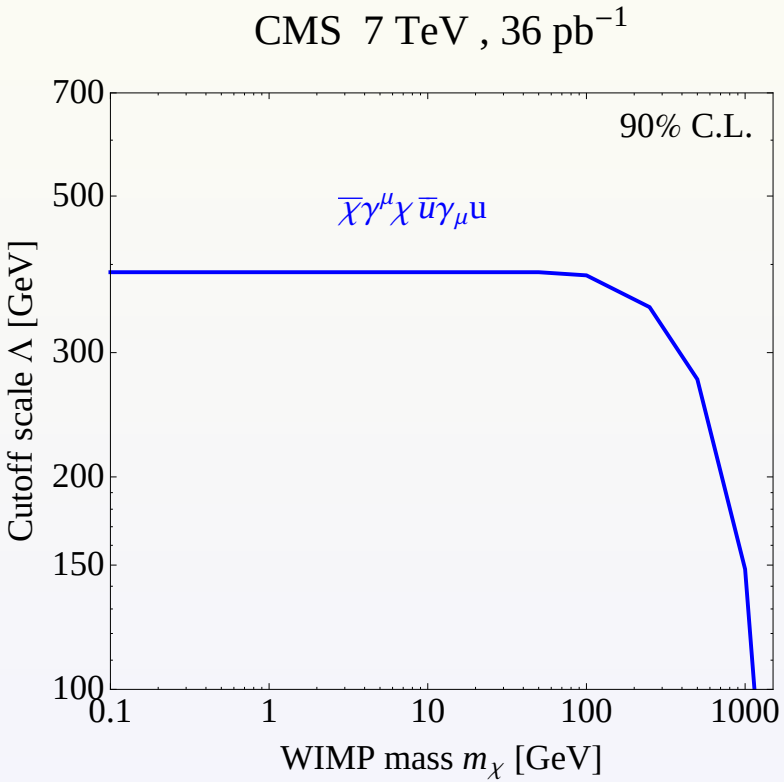
ATLAS-CONF-2011-096

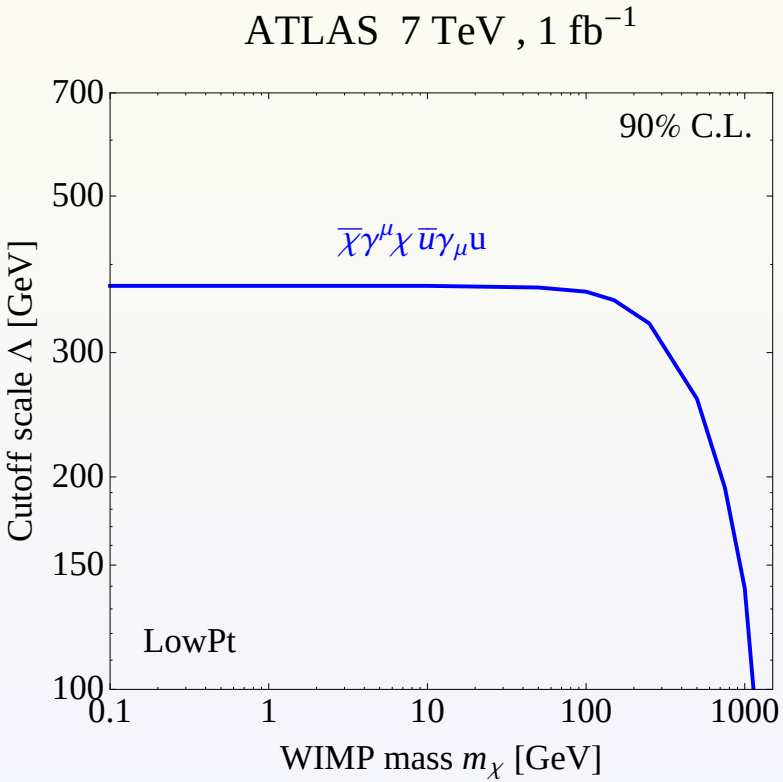


- $7\,\mathrm{TeV},\ 1\,\mathrm{fb}^{-1}$
- Search: Mono-Jet $+\ \not{E}_T$.
- Background:
  Jet $+\ (Z \to \nu\nu,\ W \to \nu\ell)$.
- Main cuts:
  $\not{E}_T > 120\,\mathrm{GeV},\ p_{T,j_1} > 120\,\mathrm{GeV}$.
- Result: 15740 $(15100 \pm 170 \pm 680)$.

Lower bound on the cutoffs

- Bound for vector operator $\frac{(\bar{\chi}\gamma^\mu\chi)(\bar{u}\gamma_\mu u)}{\Lambda^2}$ from counting.





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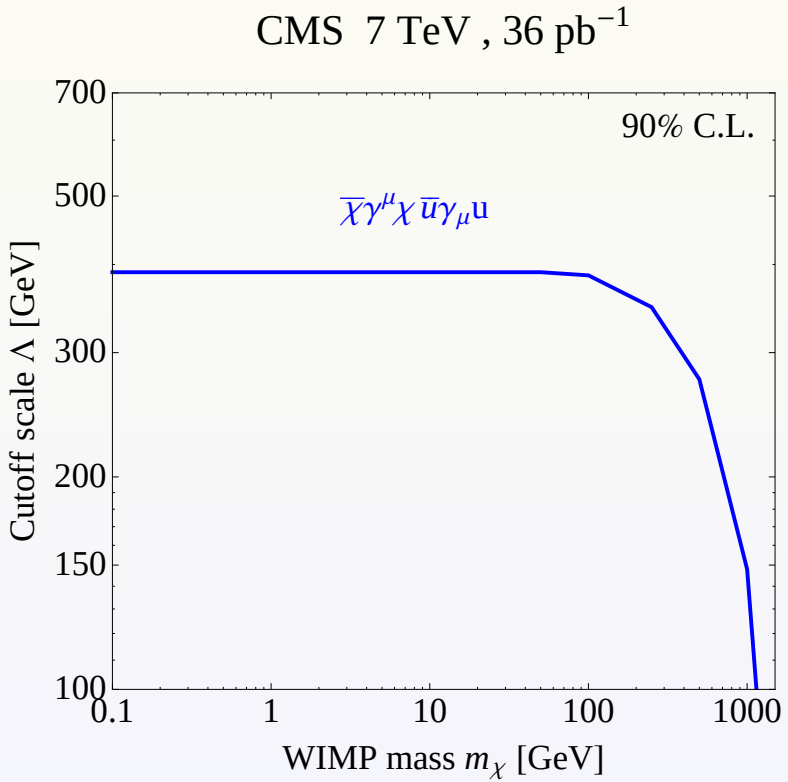
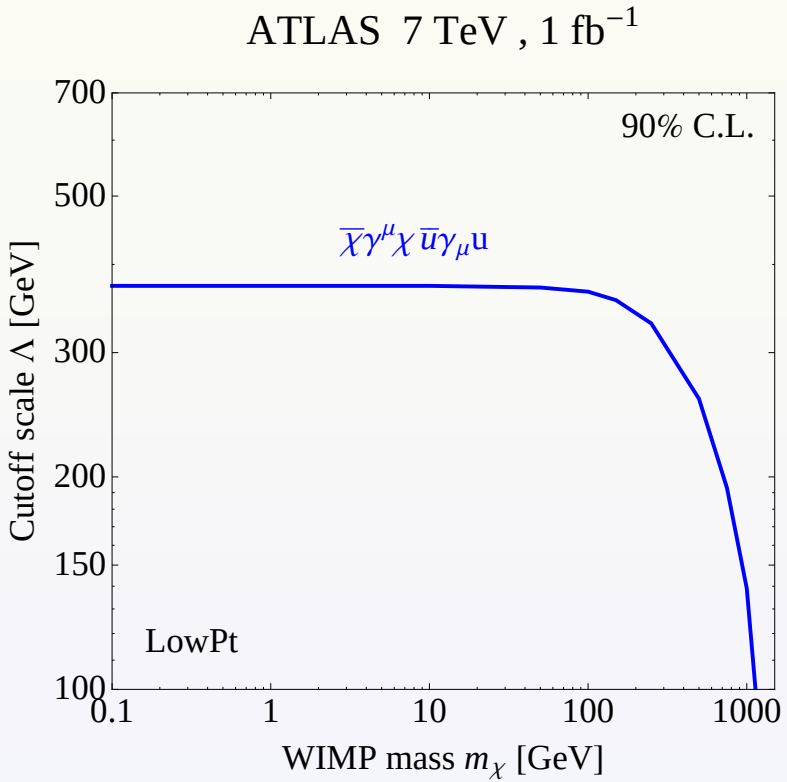
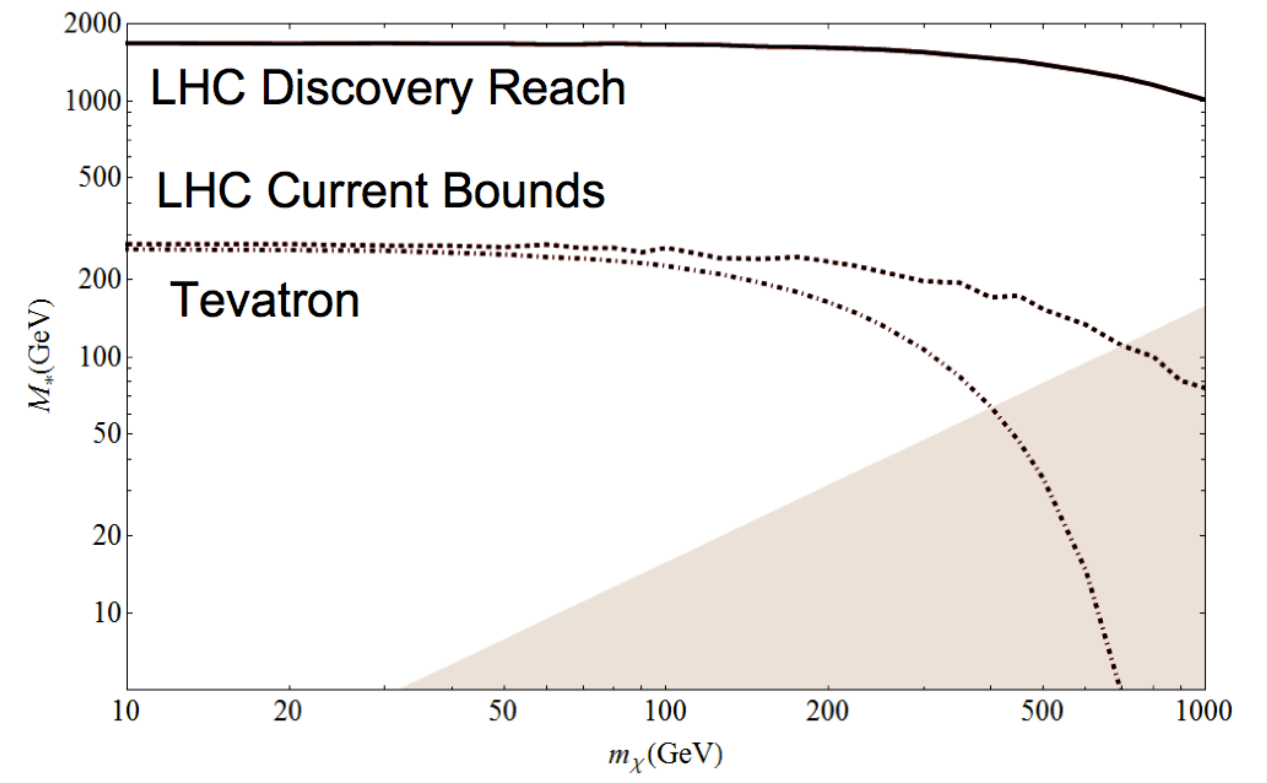




$36\,\mathrm{pb}^{-1} \to 1\,\mathrm{fb}^{-1}$ doesn't buy us much!

ATLAS LowPt VS. CDF $1\,\mathrm{fb}^{-1}$

A. Rajaraman, W. Shepherd, T. Tait, A. Wijangcoar (1106.4775)

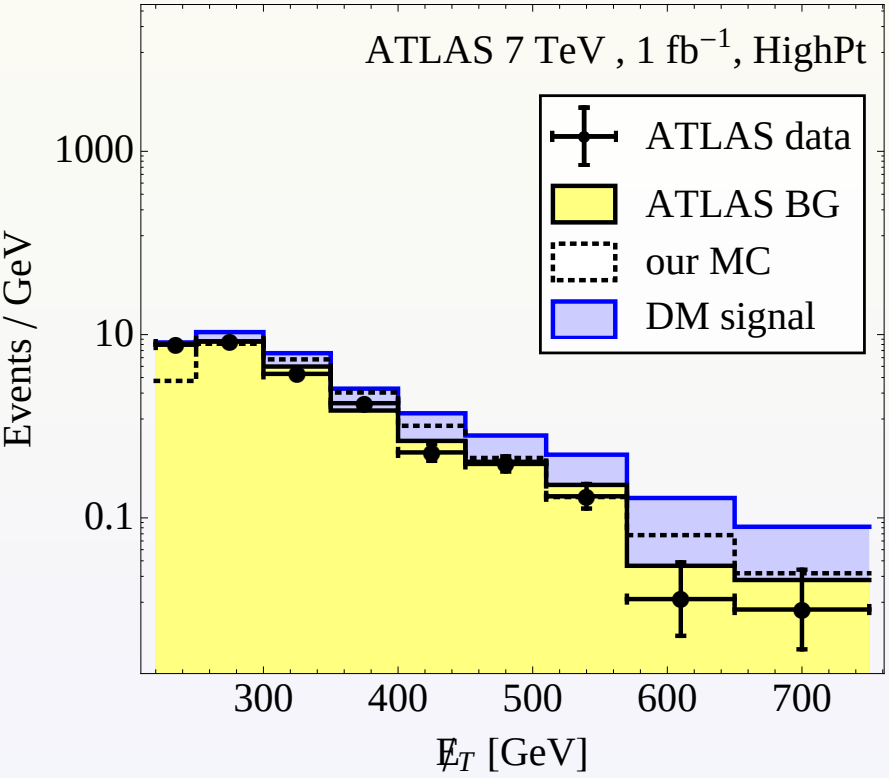


- $\frac{(\bar{\chi}\gamma^5\gamma^\mu\chi)(\bar{u}\gamma_\mu u)}{2M_*^2}$
- Majorana DM
- 2σ for Current Bounds.
- 5σ assuming $100\,\mathrm{fb}^{-1}$ for Discovery Reach.

Mono-Jet search at ATLAS (HighPt)

Go to the higher p_T region!

ATLAS-CONF-2011-096

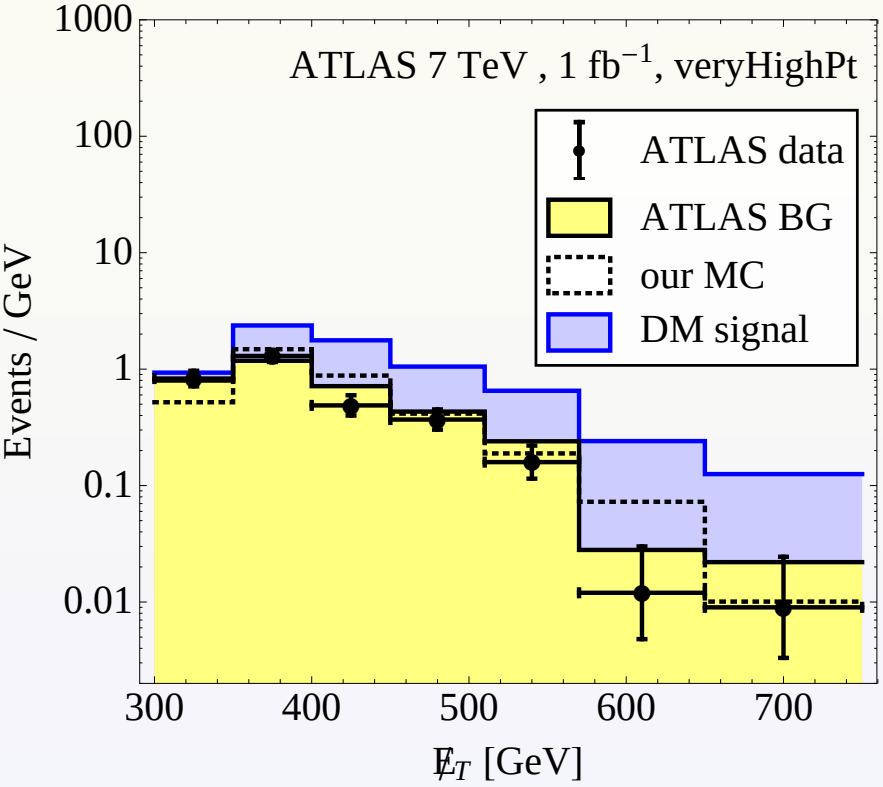


- $7\,\mathrm{TeV},\ 1\,\mathrm{fb}^{-1}$
- Search: Mono-Jet $+\ \not{E}_T$.
- Background:
  Jet $+\ (Z \to \nu\nu,\ W \to \nu\ell)$.
- Main cuts:
  $\not{E}_T > 220\,\mathrm{GeV},\ p_{T,j_1} > 250\,\mathrm{GeV}$.
- Result: 965 $(1010 \pm 37 \pm 65)$.

Mono-Jet search at ATLAS (veryHighPt)

Go to the higher p_T region!

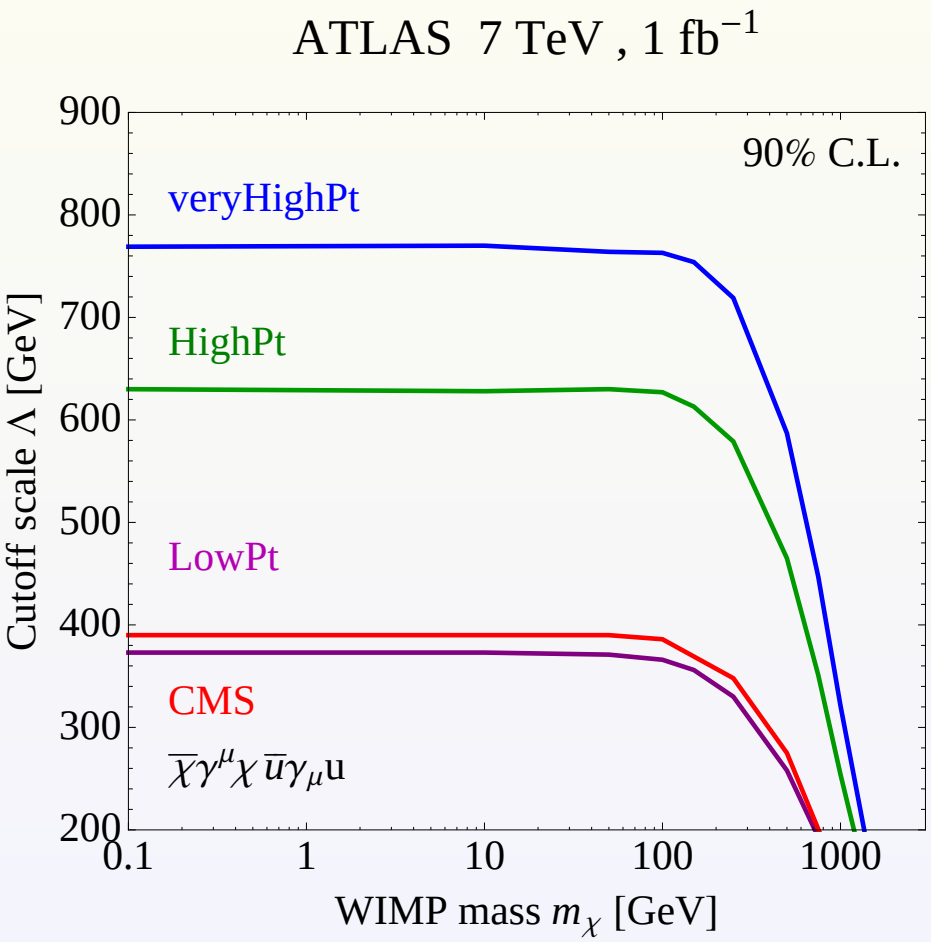
ATLAS-CONF-2011-096



- $7\,\mathrm{TeV}$, $1\,\mathrm{fb}^{-1}$
- Search: Mono-Jet + $\not{E}_T$.
- Background:
  Jet + ($Z \to \nu\nu$, $W \to \nu\ell$).
- Main cuts:
  $\not{E}_T > 350\,\mathrm{GeV}$, $p_{T,j_1} > 300\,\mathrm{GeV}$.
- Result: 167 ($193 \pm 15 \pm 20$).

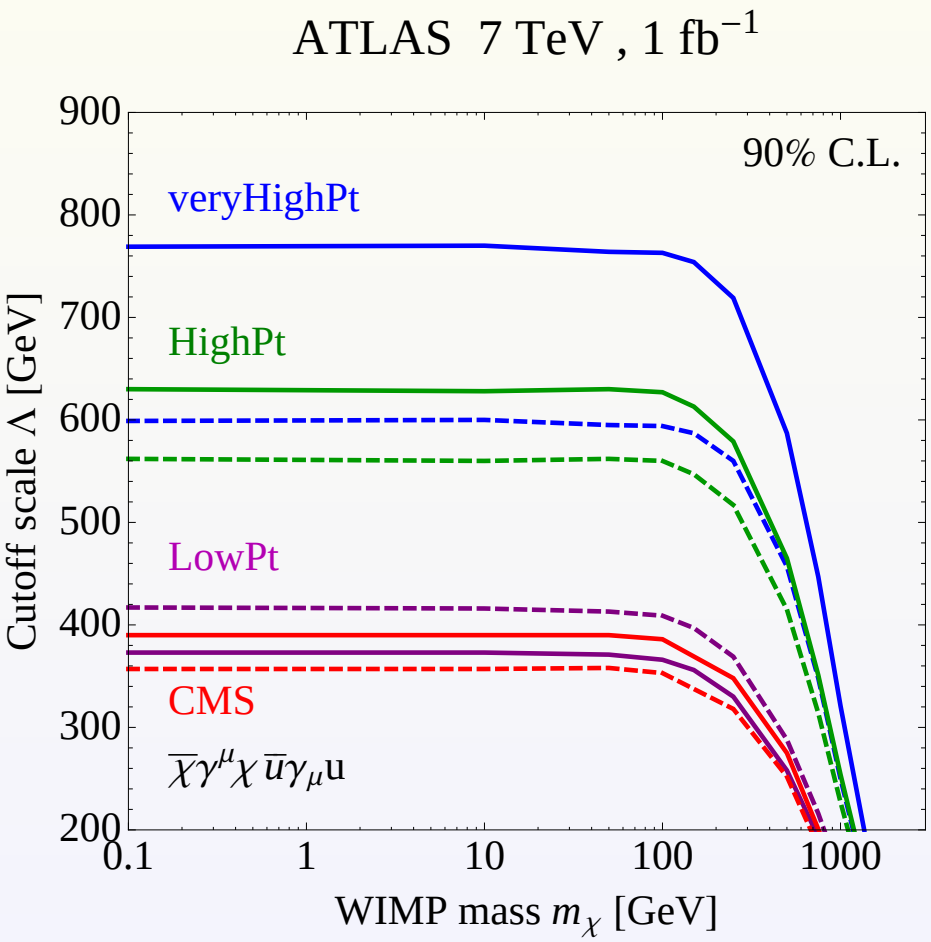
Higher p_T rocks!

- Current bounds: vector operator $\frac{(\bar{\chi}\gamma^\mu\chi)(\bar{u}\gamma_\mu u)}{\Lambda^2}$ from counting.



Higher p_T rocks!

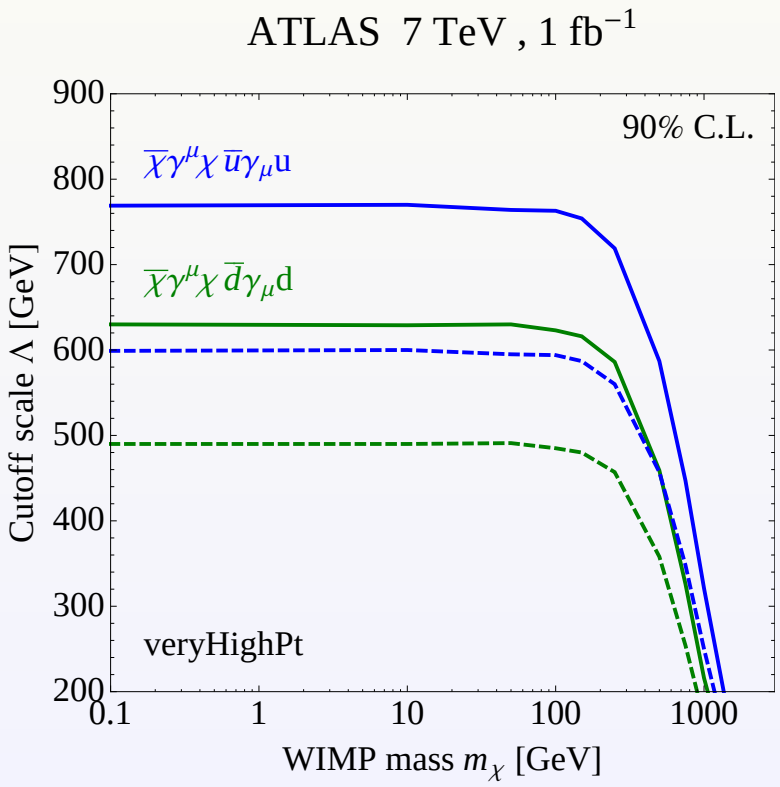
- Expected bounds: vector operator $\frac{(\bar{\chi}\gamma^\mu\chi)(\bar{u}\gamma_\mu u)}{\Lambda^2}$ from counting.

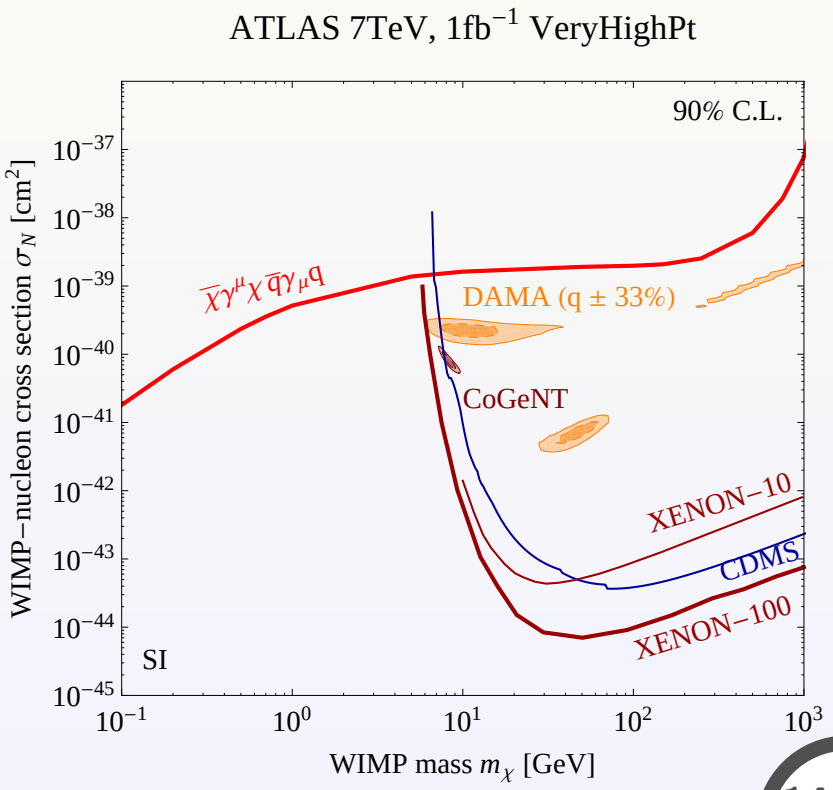


Bounds from higher p_T searches

Spin-independent case

- Using ATLAS $1\,\mathrm{fb}^{-1}$ veryHighPt.
- Direct detection bound for universal coupling $q \in (u, d)$.





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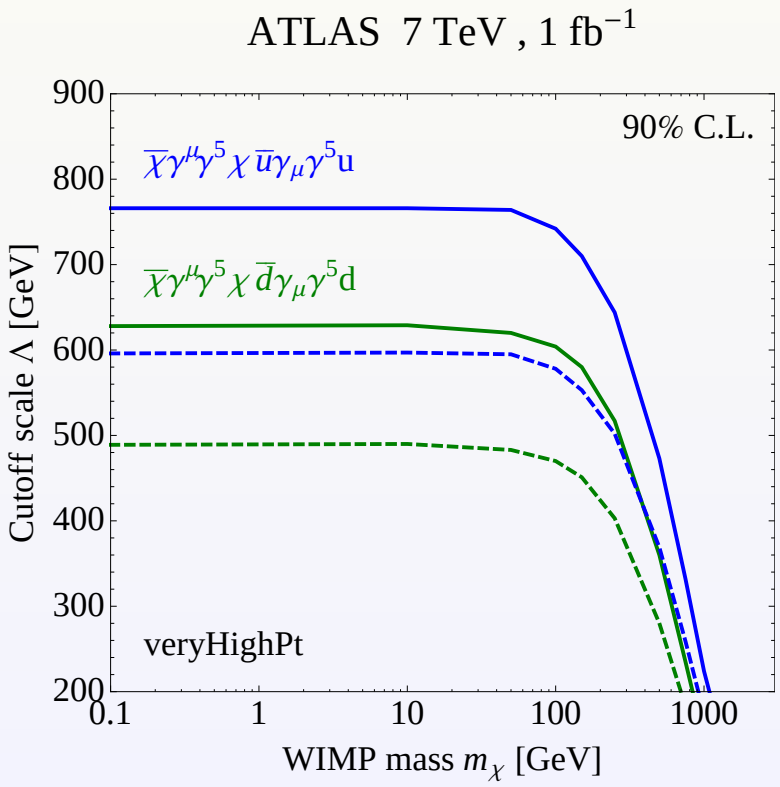
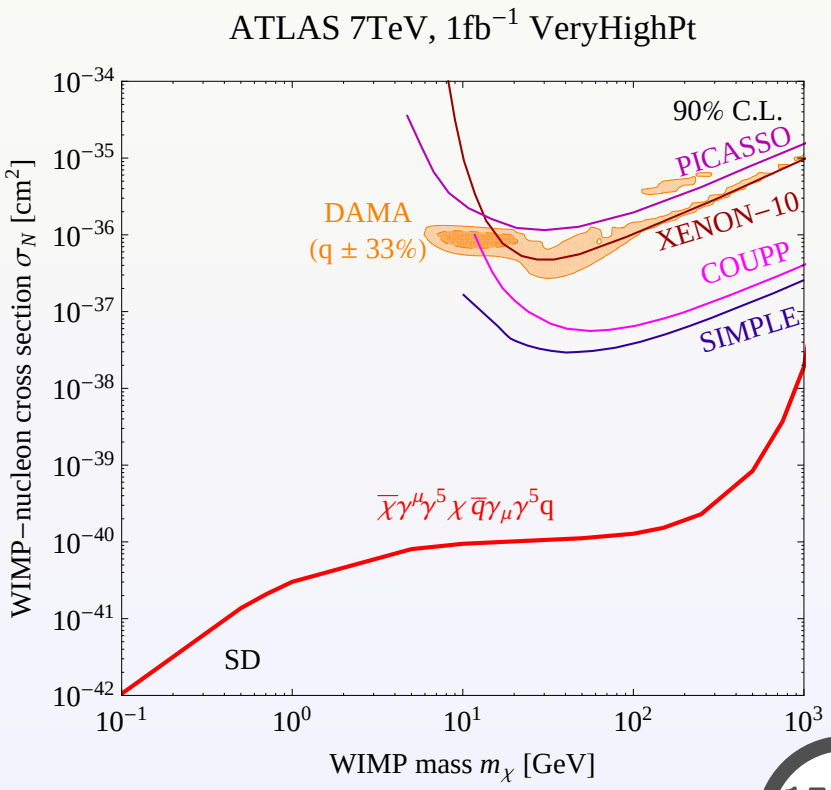


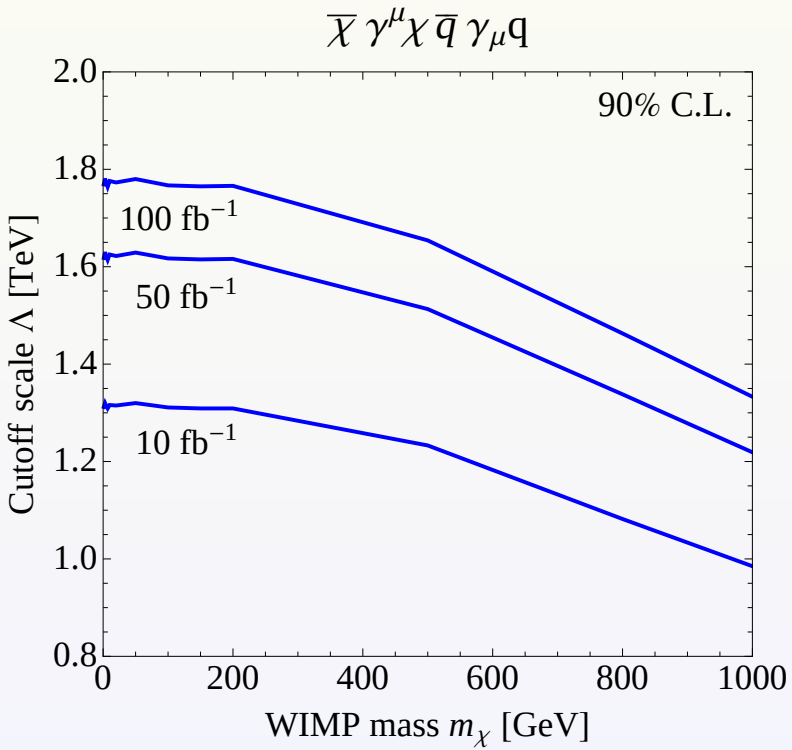


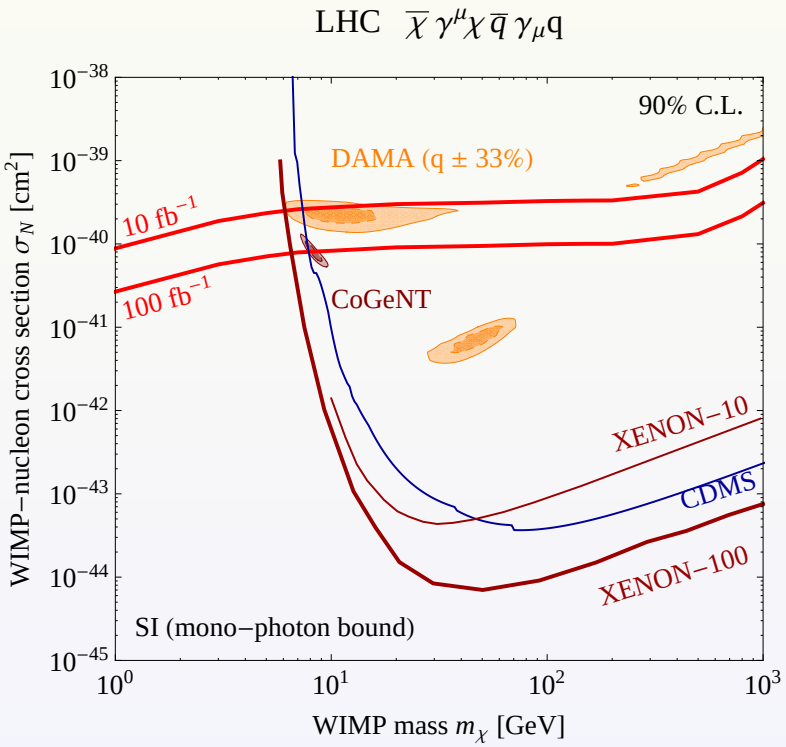
Some Future Bounds

Mono-Photon search at LHC

May have a smaller systematic uncertainty...

Follow the analysis in arXiv:0809.2849[1], with 14 TeV CM energy.

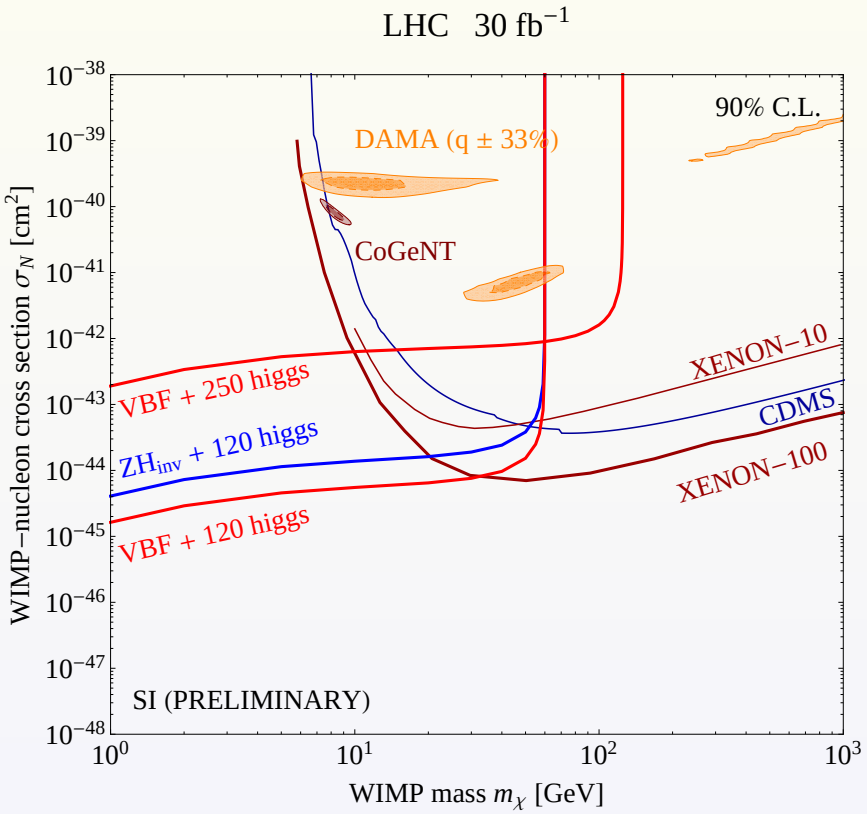




[1] Y. Gershtein, F. Petriello, S. Quackenbush and K. Zurek

Invisible-higgs search at LHC

When DM couples through higgs portal



Conclusion

- Go to a higher p_T region to constraint the DM interaction.
- ATLAS mono-jet search at veryHighPt region sets the best current bounds on DM (from colliders).
- Many other interesting channels at LHC can be used to constraint DM (mono-photon, invisible-higgs search...).