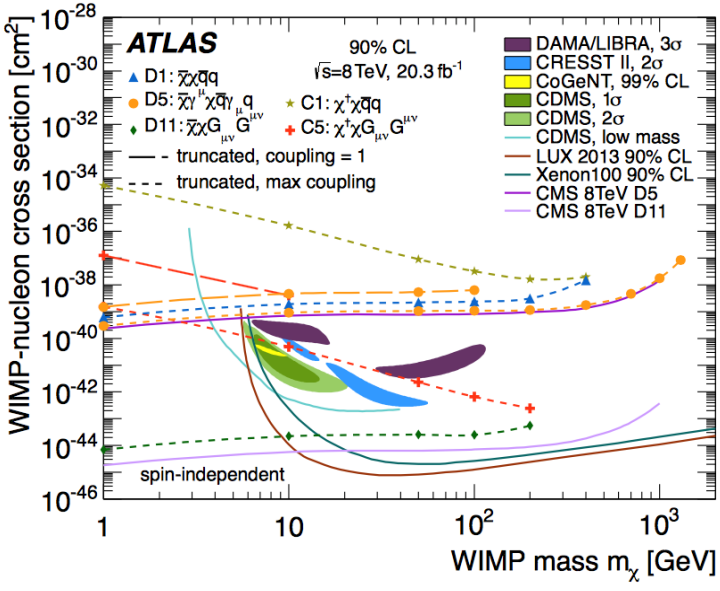
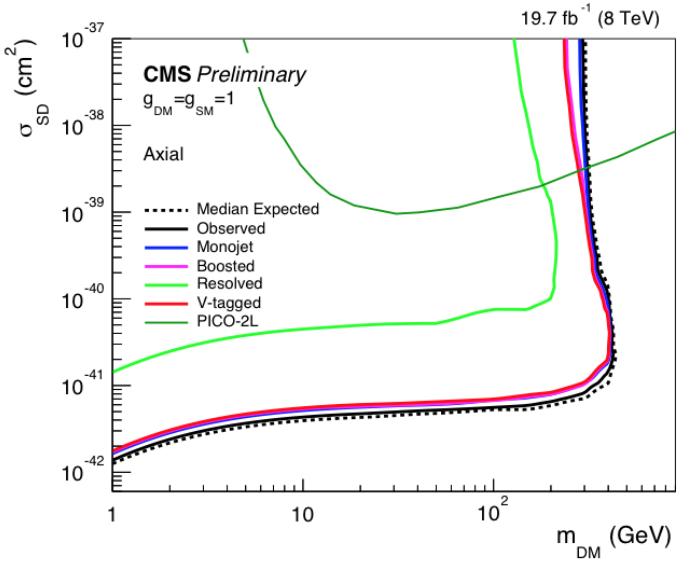
LHC DM WG conveners

COMPARING COLLIDER DM SEARCHES WITH DIRECT AND INDIRECT DETECTION EXPERIMENTS USING SIMPLIFIED MODELS

FIRST MEETING OF THE NEW LHC DARK MATTER WORKING GROUP.

DECEMBER 10-11





New LHC Dark Matter Working Group

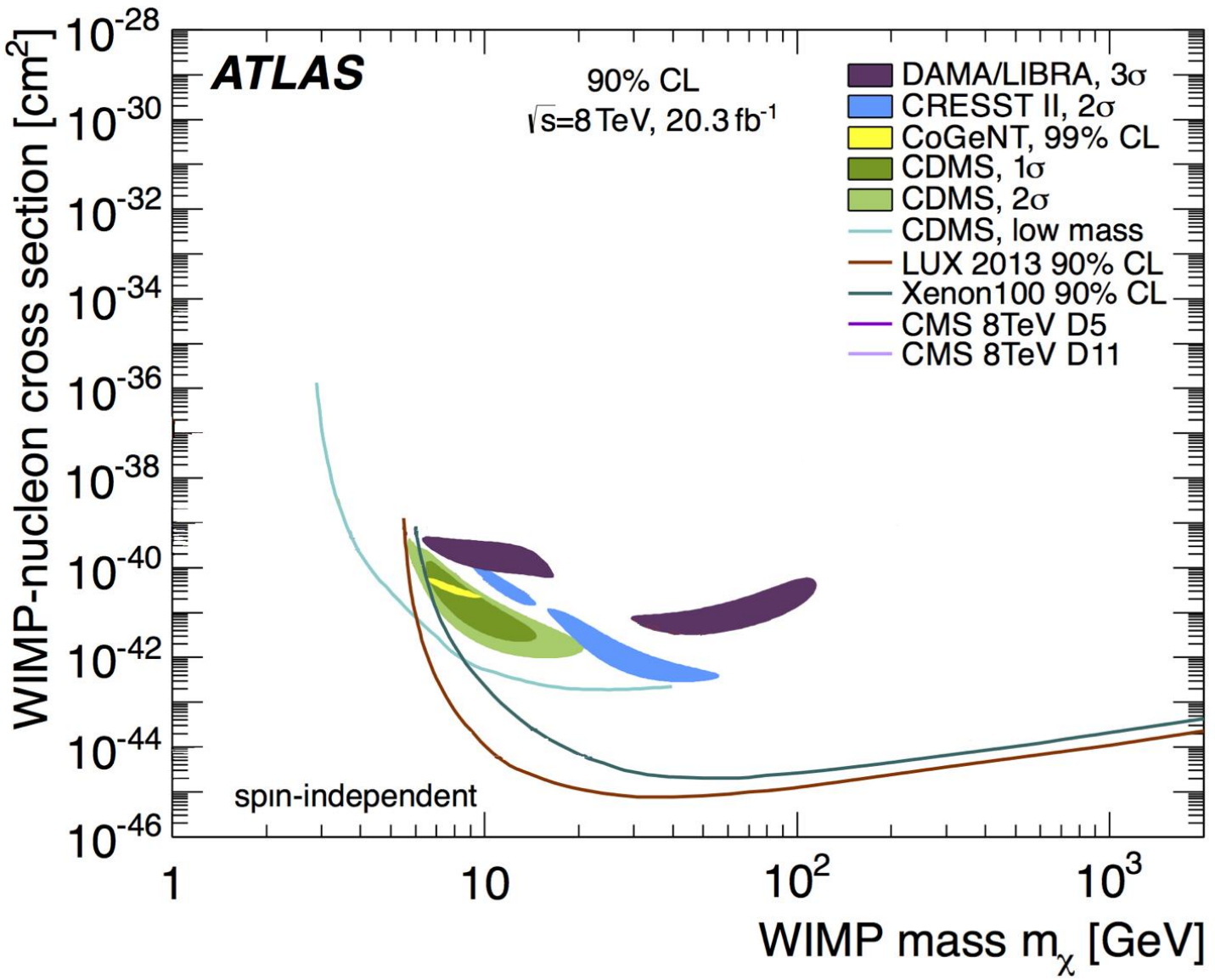
This Working Group brings together theorists and experimentalists to define guidelines and recommendations for the benchmark models, interpretation, and characterisation necessary for broad and systematic searches for dark matter at the LHC. More details can be found at this page:

http://lpcc.web.cern.ch/LPCC/index.php?page=dm_wg

and the mailing list (which now also includes the lhc-dmf@cern.ch mailing list recipients) is lhc-dmwg@cern.ch.

Our first goal is to discuss and agree upon the presentation of collider searches for DM between ATLAS and CMS. Both LHC experiment and theory community will collaborate, in order to decide upon the best format for comparison between collider and non-collider results and on the usability of the material that is made public for the Winter conferences 2016.

Comparison with Direct Detection: EFT



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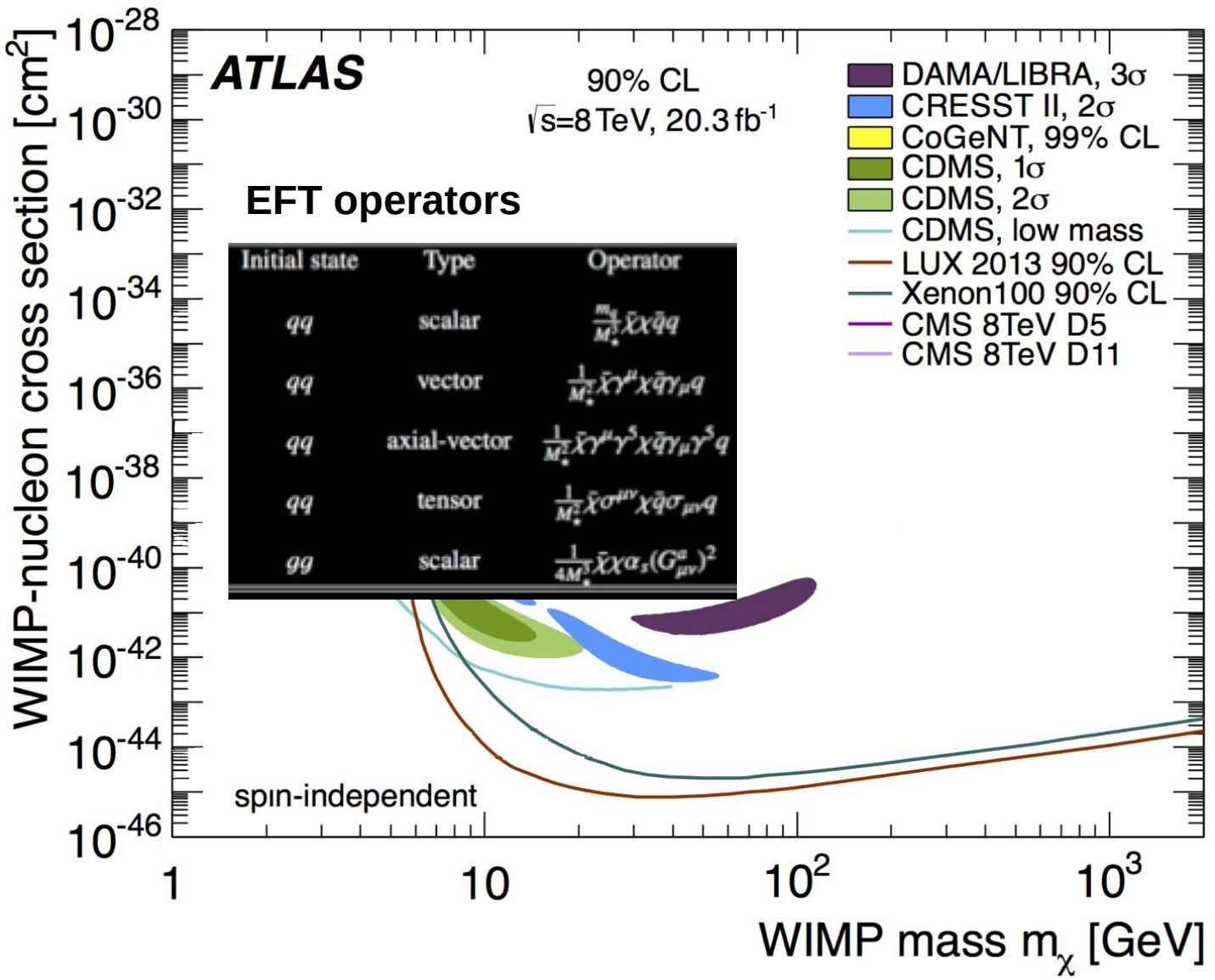

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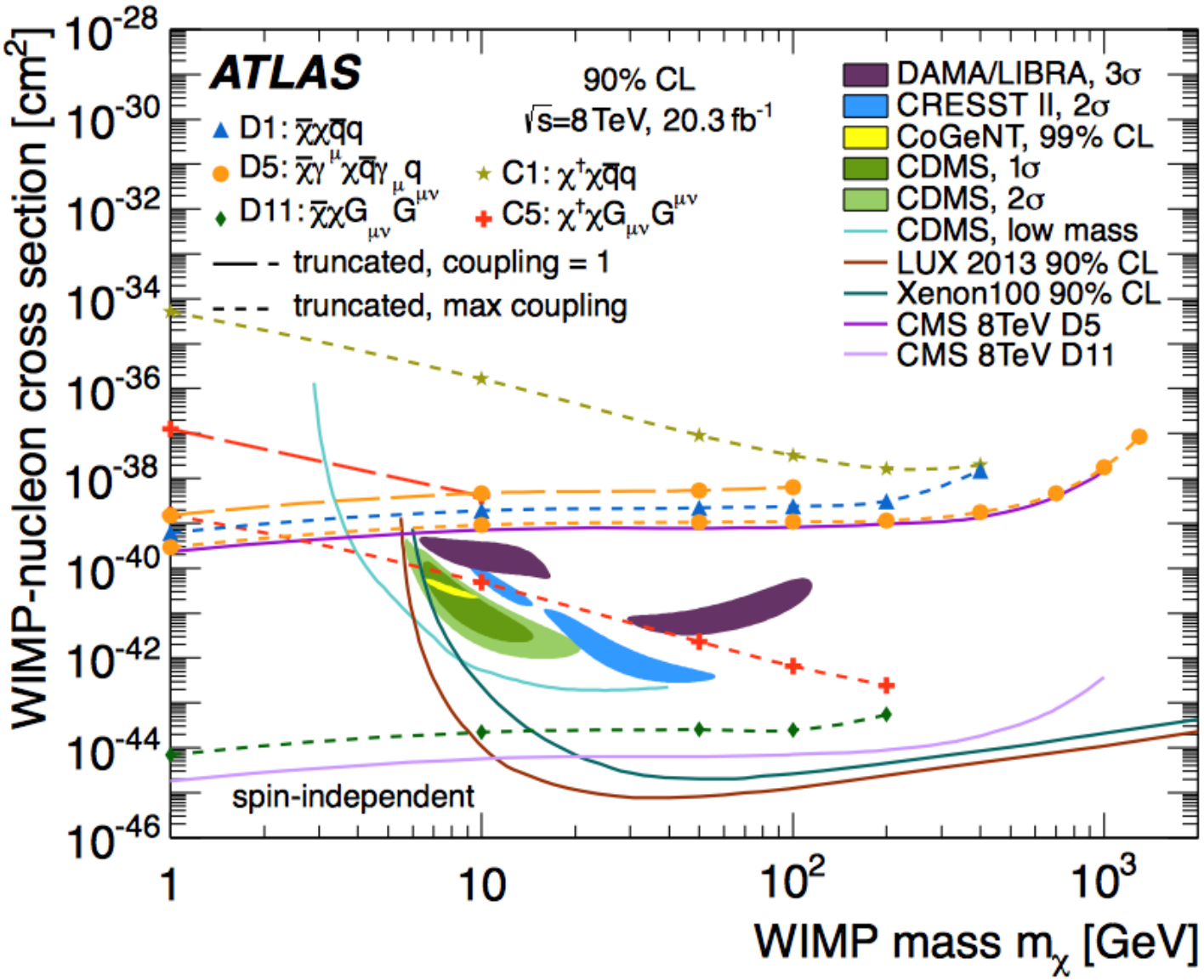

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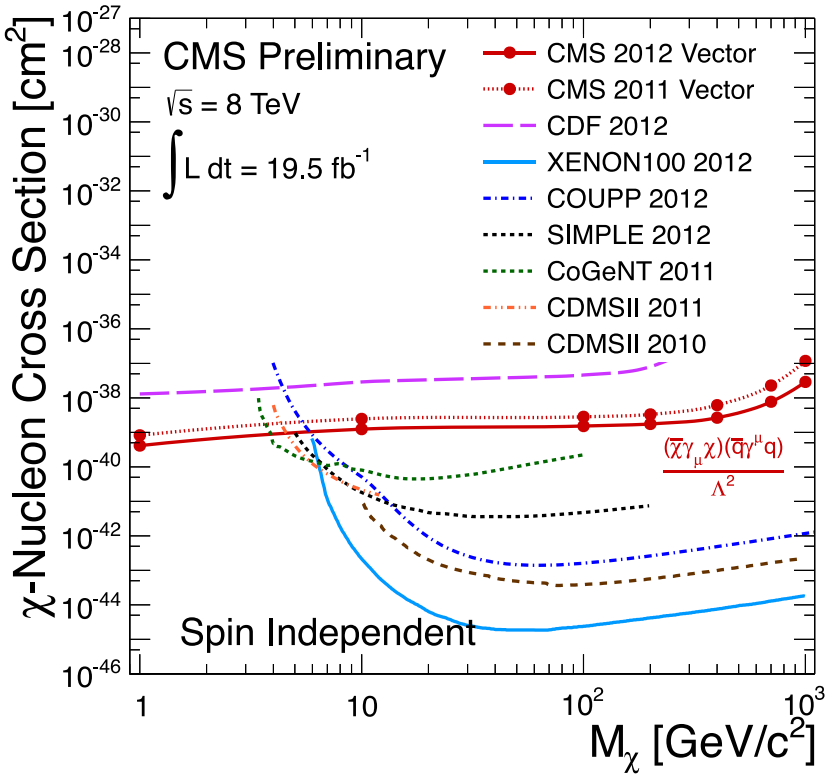
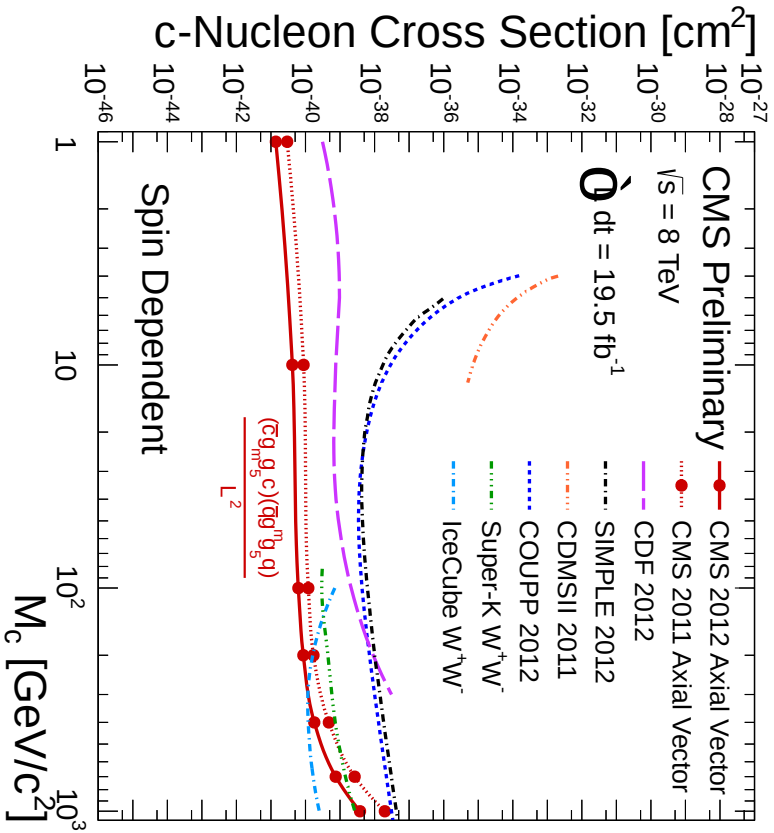




Beyond the Effective Field Theory

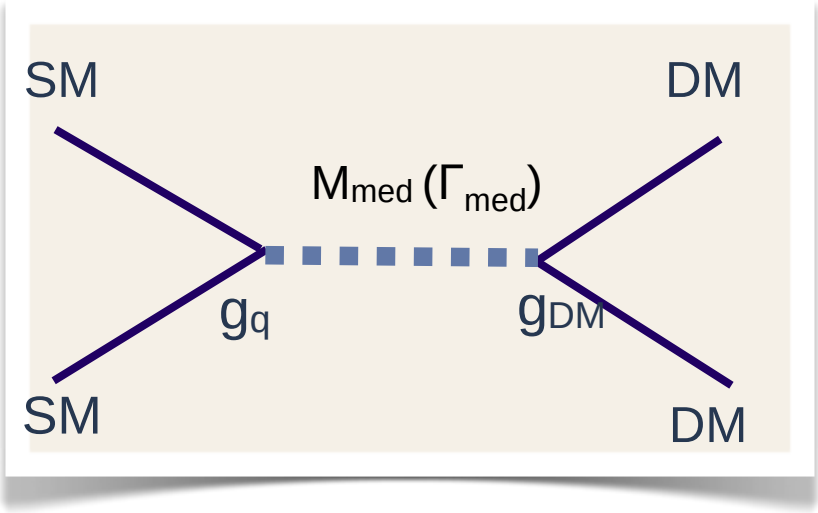
- The interpretation of collider DM searches in the EFT framework and the corresponding comparison with other experiments such as DD and ID has become in question. [see e.g.]

- Y. Bai, P. J. Fox, and R. Harnik, The Tevatron at the Frontier of Dark Matter Direct Detection, JHEP 1012 (2010) 048, [arXiv:1005.3797].
- P. J. Fox, R. Harnik, J. Kopp, and Y. Tsai, Missing Energy Signatures of Dark Matter at the LHC, Phys.Rev. D85 (2012) 056011, [arXiv:1109.4398].
- J. Goodman and W. Shepherd, LHC Bounds on UV-Complete Models of Dark Matter, arXiv:1111.2359.
- I. M. Shoemaker and L. Vecchi, Unitarity and Monojet Bounds on Models for DAMA, CoGeNT, and CRESST-II, Phys.Rev. D86 (2012) 015023, [arXiv:1112.5457].
- O. Buchmueller, M. J. Dolan, and C. McCabe, Beyond Effective Field Theory for Dark Matter Searches at the LHC, JHEP 1401 (2014) 025, [arXiv:1308.6799].
- G. Busoni, A. De Simone, E. Morgante, and A. Riotto, On the Validity of the Effective Field Theory for Dark Matter Searches at the LHC, Phys.Lett. B728 (2014) 412–421, [arXiv:1307.2253].
- G. Busoni, A. De Simone, J. Gramling, E. Morgante, and A. Riotto, On the Validity of the Effective Field Theory for Dark Matter Searches at the LHC, Part II: Complete Analysis for the s-channel, JCAP 1406 (2014) 060, [arXiv:1402.1275].
- G. Busoni, A. De Simone, T. Jacques, E. Morgante, and A. Riotto, On the Validity of the Effective Field Theory for Dark Matter Searches at the LHC Part III: Analysis for the t-channel, JCAP 1409 (2014) 022, [arXiv:1405.3101].

- The collider community has decided to complement the EFT framework with simplified models to overcome these issues and to facilitate a more comprehensive interpretation (and comparison) of collider DM searches.

Simplified Dark Matter Models

See also DM forum report which brought together experimentalist from ATLAS and CMS as well as theorists. See: arXiv:1507.00966



s-channel

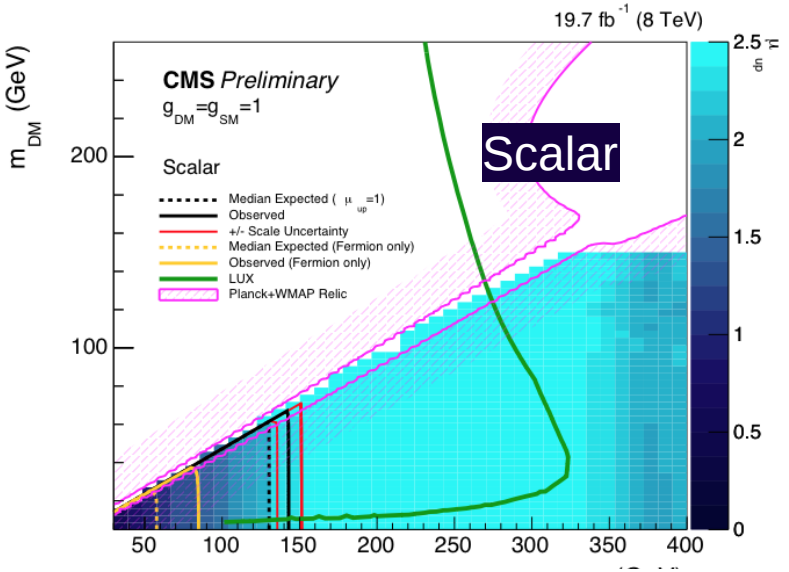
Define simplified model with (minimum) 4 parameters	
Mediator mass (M_{med})	DM mass (M_{DM})
g_q	g_{DM}

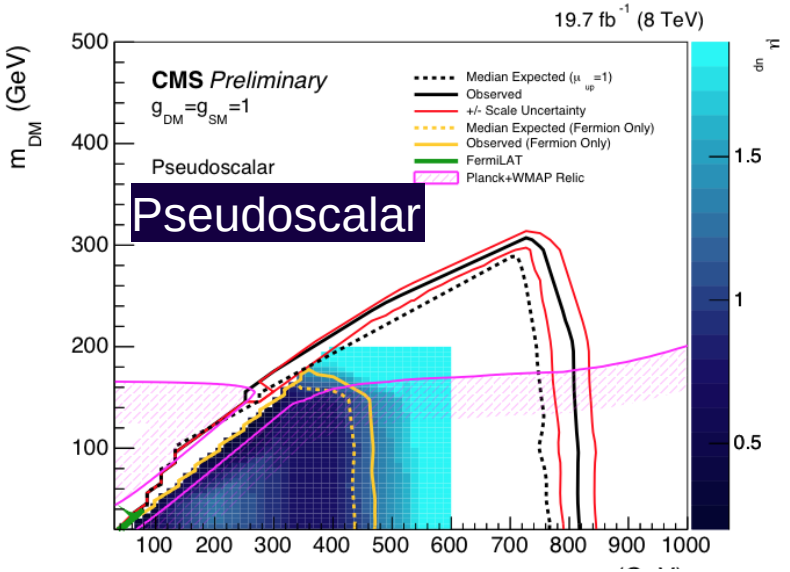
(Γ_{med} can also be free as long As $\Gamma_{med}<M_{med}$)

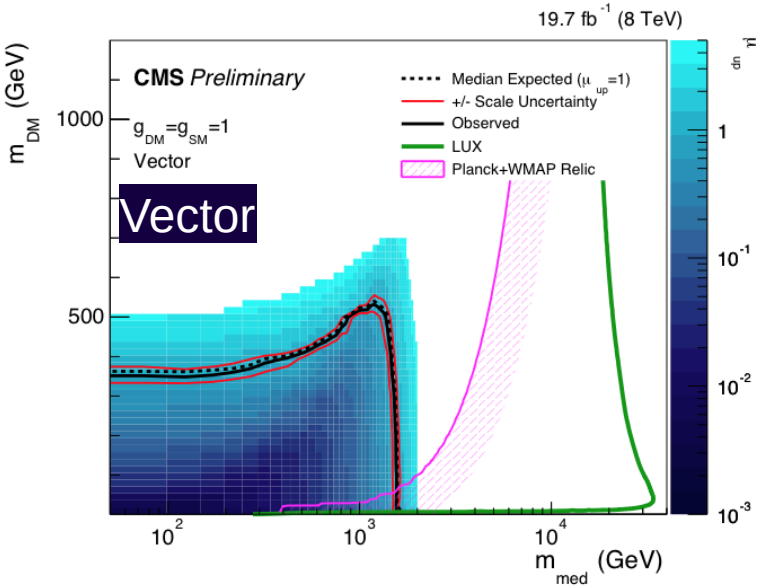
DM	
Dirac fermion	Scalar - real
Majorana fermion	Scalar - complex

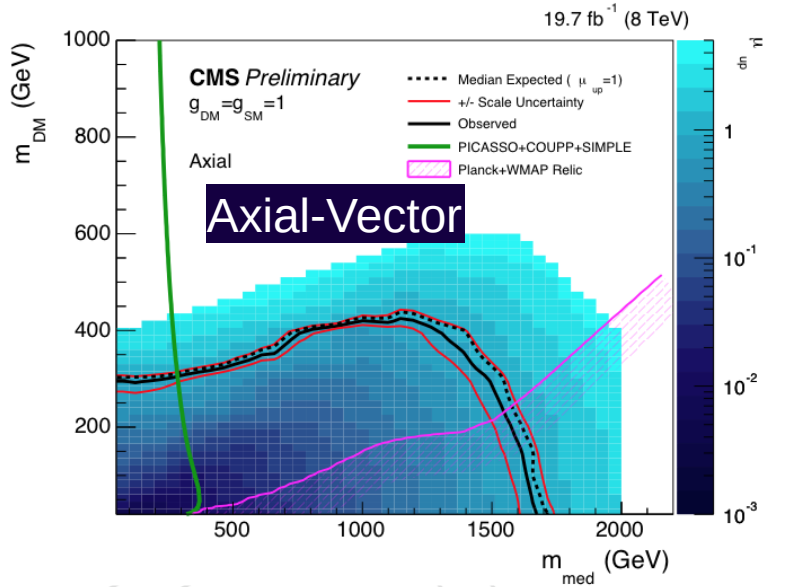
Consider comprehensive set of diagrams for mediator	
Vector	Axial-vector
Scalar	Pseudoscalar

Recent released CMS "mono-jet" result 8 TeV



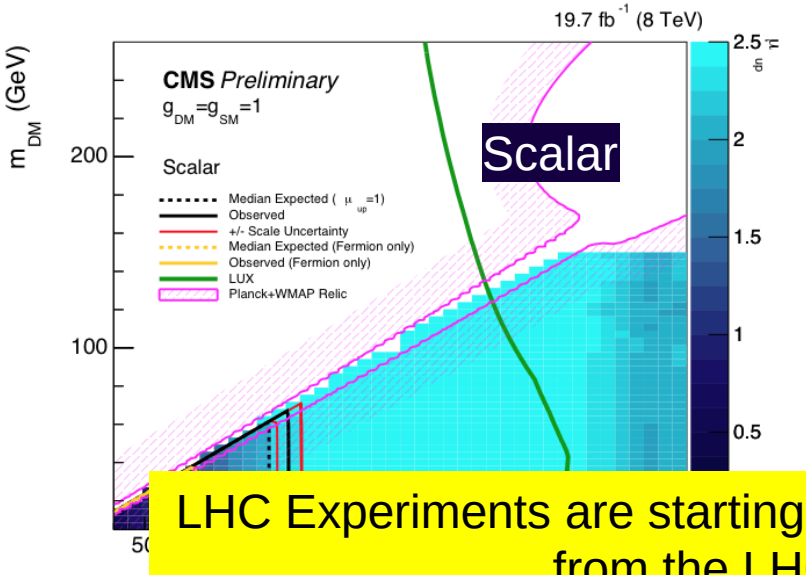




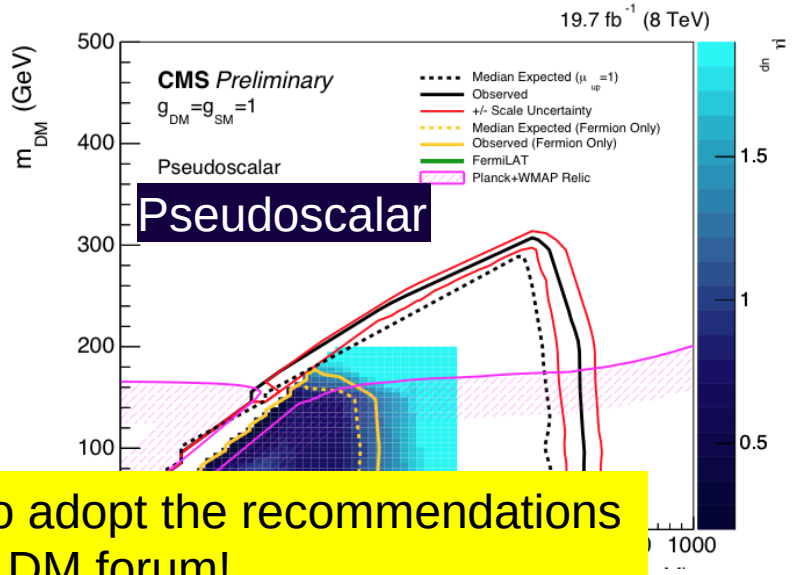


CMS PAS-EXO-12-055

Recent released CMS "mono-jet" result 8 TeV

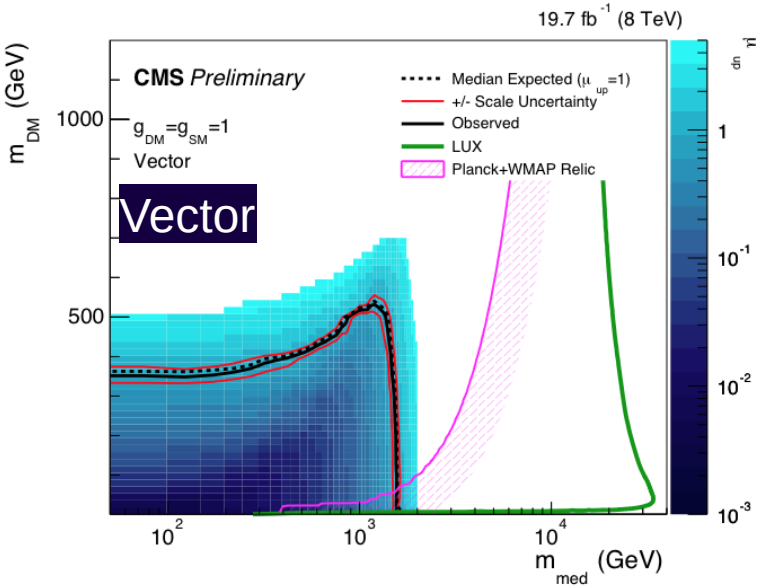


Scalar

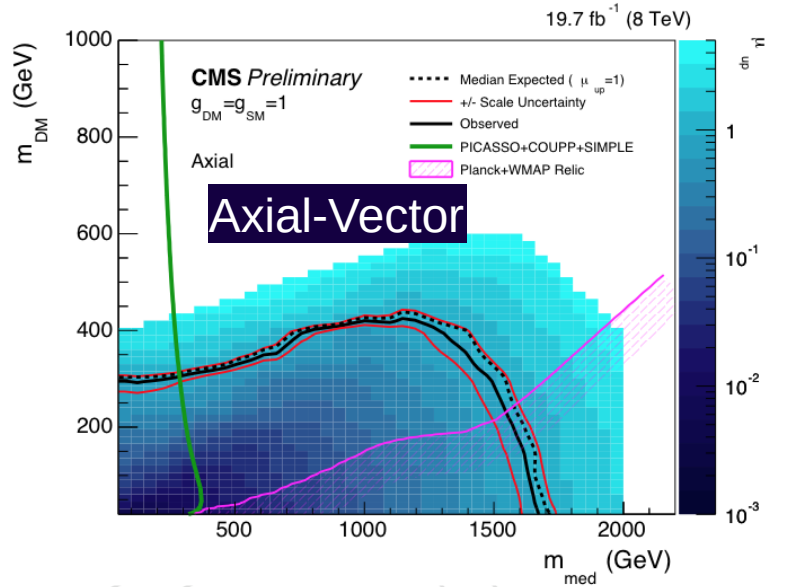


Pseudoscalar

LHC Experiments are starting to adopt the recommendations from the LHC DM forum!



Vector



Axial-Vector

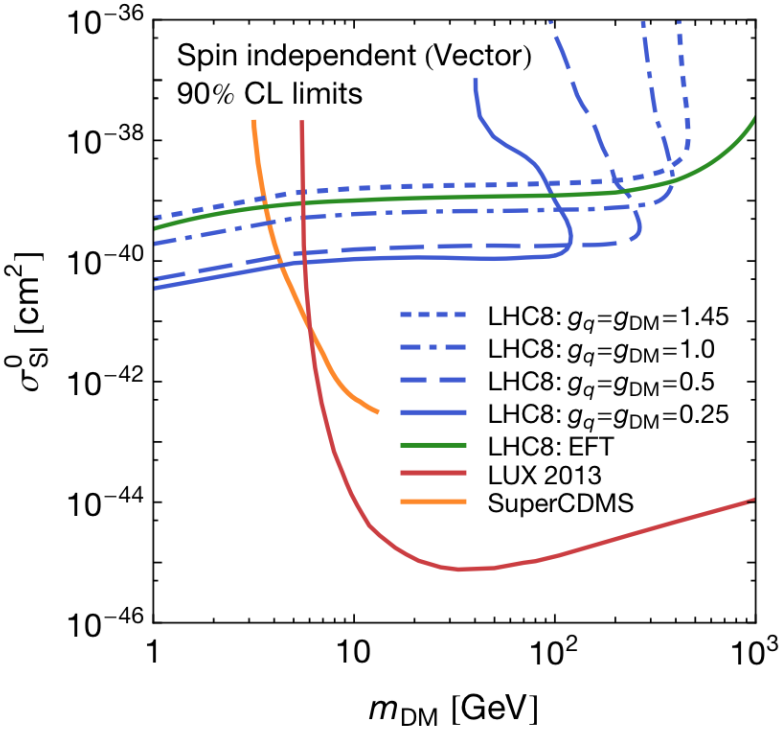
CMS PAS-EXO-12-055

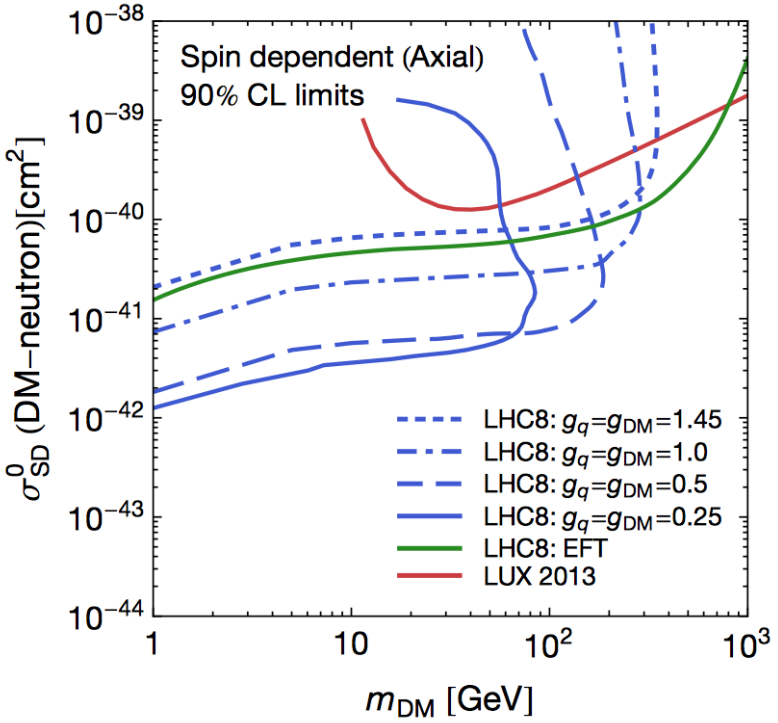
Comparison of collider with DD and ID

"Direct translation of M_{med}-M_{DM} collider limits into $\sigma_{SI/SD}$ planes

arXiv:1407.8257

arXiv:1409.4075





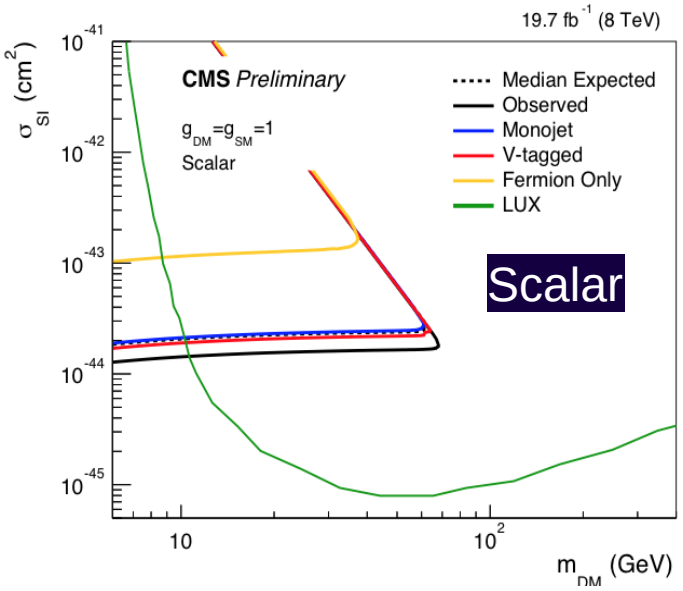
$$\sigma^0_{\rm SI} = \frac{9\, g^2_{\rm DM}\, g^2_q\, \mu^2_{n\chi}}{\pi M^4_{\rm med}}$$

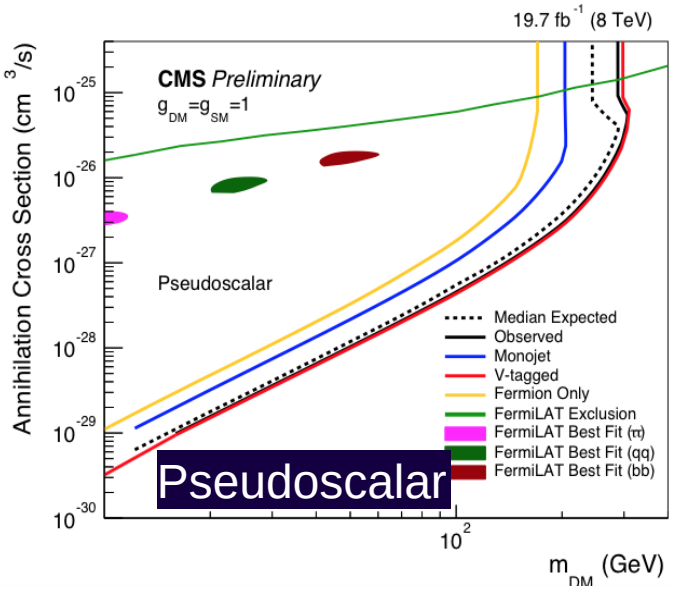
$$\approx 1.1\times 10^{-39}\ {\rm cm}^2 \cdot \left(\frac{g_{\rm DM}\, g_q}{1}\right)^2 \left(\frac{1\ {\rm TeV}}{M_{\rm med}}\right)^4 \left(\frac{\mu_{n\chi}}{1\ {\rm GeV}}\right)^2$$

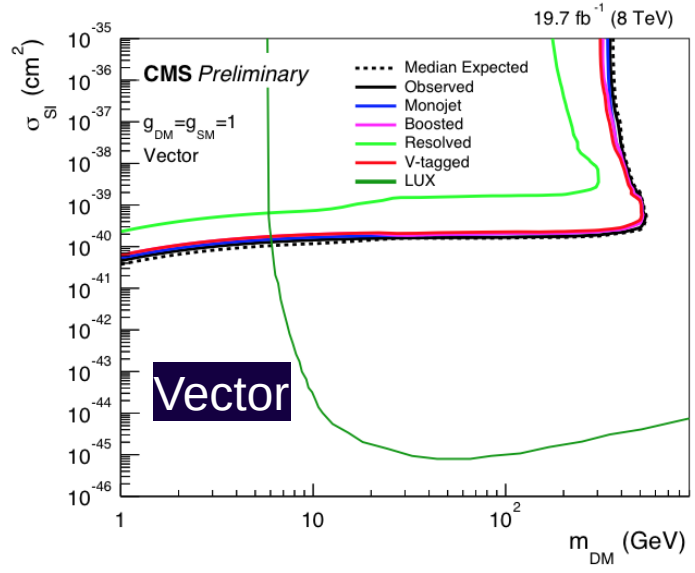
$$\sigma^0_{\rm SD} = \frac{3\, g^2_{\rm DM}\, g^2_q (\Delta_u + \Delta_d + \Delta_s)^2\, \mu^2_{n\chi}}{\pi M^4_{\rm med}}$$

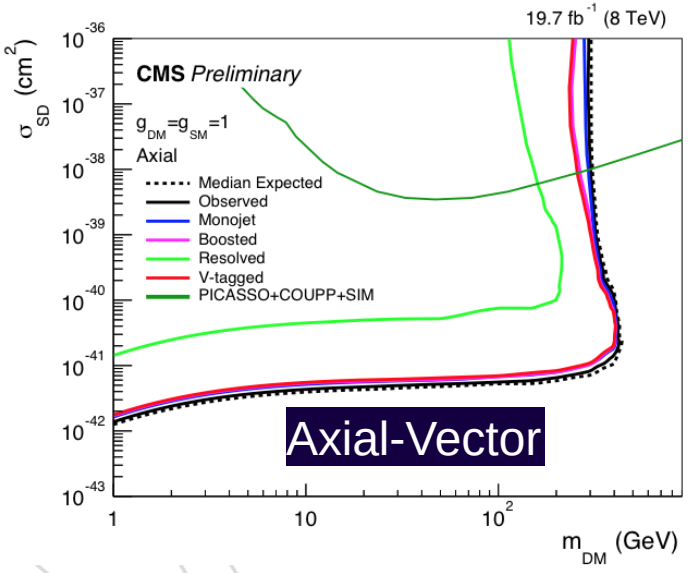
$$\approx 4.6\times 10^{-41}\ {\rm cm}^2 \cdot \left(\frac{g_{\rm DM}\, g_q}{1}\right)^2 \left(\frac{1\ {\rm TeV}}{M_{\rm med}}\right)^4 \left(\frac{\mu_{n\chi}}{1\ {\rm GeV}}\right)^2$$

Comparison of collider with DD and ID (II)









CMS PAS-EXO-12-055

Further Details

- The next two talks by Chris McCabe and Felix Kahlhoefer will provide further details on the use of the limit mass plans and how these can be translated into the language of the DD and ID experiments (or vise versa).

- These talks will be followed by a 30 min discussion