# Searching for Top-philic Dark Matter
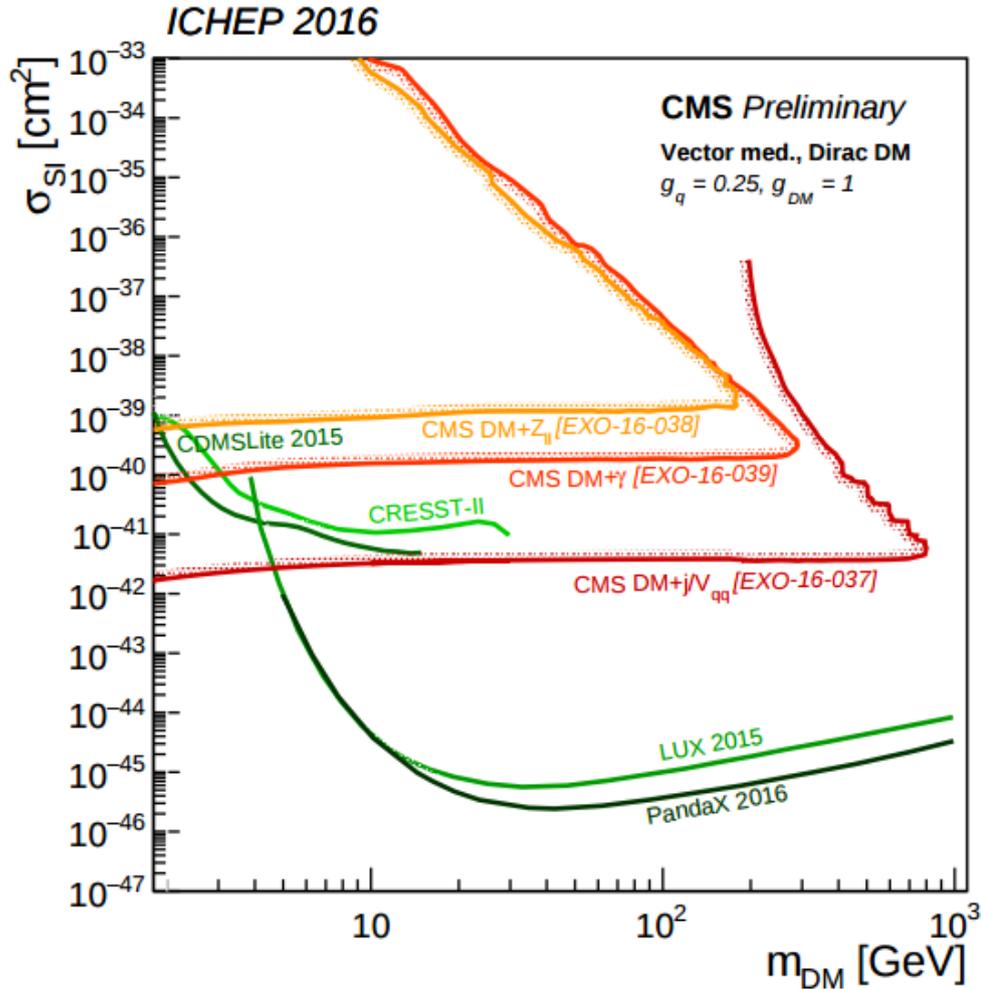
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In collaboration with:
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Angelo Monteux, David Shih

Pheno 2017

# DD vs Colliders

$\sigma_{SI}$ [cm$^2$]

**CMS** *Preliminary*

**Vector med., Dirac DM**
$g_q = 0.25$, $g_{DM} = 1$

CDMSLite 2015

CMS DM+Z$_{\parallel}$ [EXO-16-038]

CMS DM+$\gamma$ [EXO-16-039]

CRESST-II

CMS DM+j/V$_{qq}$ [EXO-16-037]

LUX 2015

PandaX 2016

$m_{DM}$ [GeV]

| Operator | | SI / SD | Suppression |
|---|---|---|---|
| $\mathcal{O}_1^f =$ | $\bar{\chi}\chi\,\bar{q}q$ | SI | — |
| $\mathcal{O}_2^f =$ | $\bar{\chi}i\gamma^5\chi\,\bar{q}q$ | SI | $q^2$ |
| $\mathcal{O}_3^f =$ | $\bar{\chi}\chi\,\bar{q}i\gamma^5 q$ | SD | $q^2$ |
| $\mathcal{O}_4^f =$ | $\bar{\chi}\gamma^5\chi\,\bar{q}\gamma^5 q$ | SD | $q^4$ |
| $\mathcal{O}_5^f =$ | $\bar{\chi}\gamma^\mu\chi\,\bar{q}\gamma_\mu q$ | SI | — |
| $\mathcal{O}_6^f =$ | $\bar{\chi}\gamma^\mu\gamma^5\chi\,\bar{q}\gamma_\mu q$ | SI | $v^2$ |
| | | SD | $q^2$ |
| $\mathcal{O}_7^f =$ | $\bar{\chi}\gamma^\mu\chi\,\bar{q}\gamma_\mu\gamma^5 q$ | SD | $v^2$ or $q^2$ |
| $\mathcal{O}_8^f =$ | $\bar{\chi}\gamma^\mu\gamma^5\chi\,\bar{q}\gamma_\mu\gamma^5 q$ | SD | — |
| $\mathcal{O}_9^f =$ | $\bar{\chi}\sigma^{\mu\nu}\chi\,\bar{q}\sigma_{\mu\nu}q$ | SD | — |
| $\mathcal{O}_{10}^f =$ | $\bar{\chi}i\sigma^{\mu\nu}\gamma^5\chi\,\bar{q}\sigma_{\mu\nu}q$ | SI | $q^2$ |

CMS – ICHEP: DP-2016/057
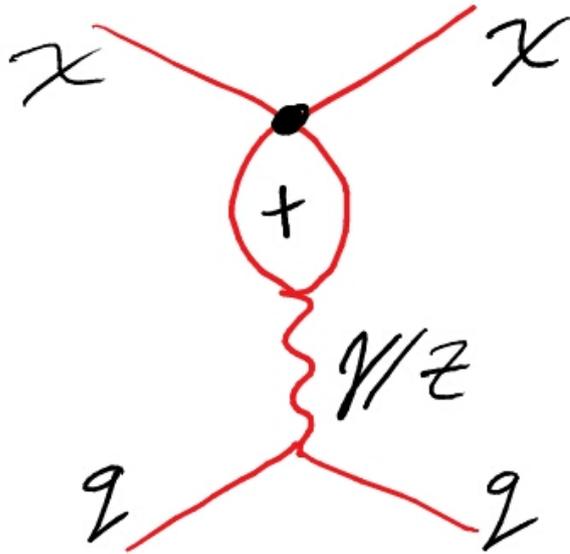
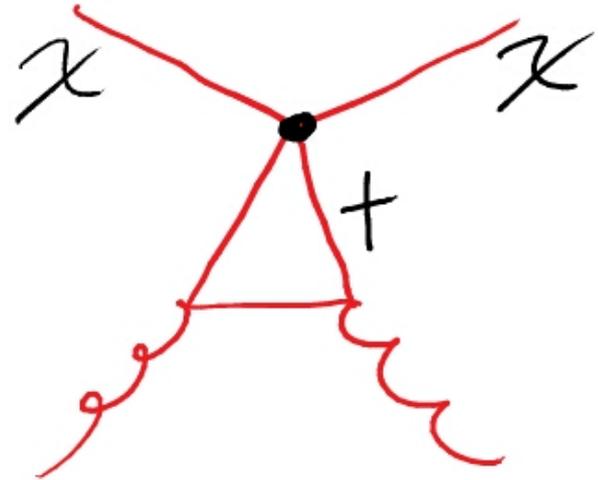Freytsis&Ligeti, arXiv:1012.5317

# Top-philic DM: Colliders
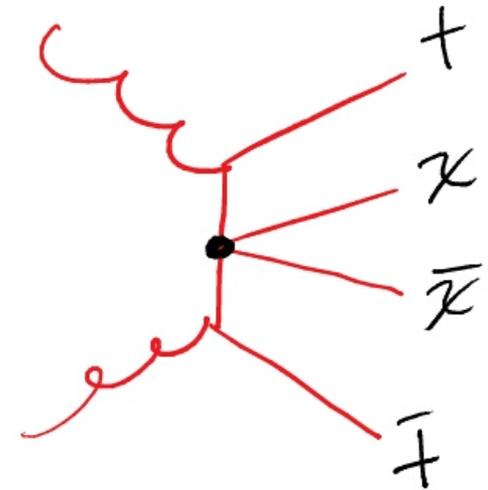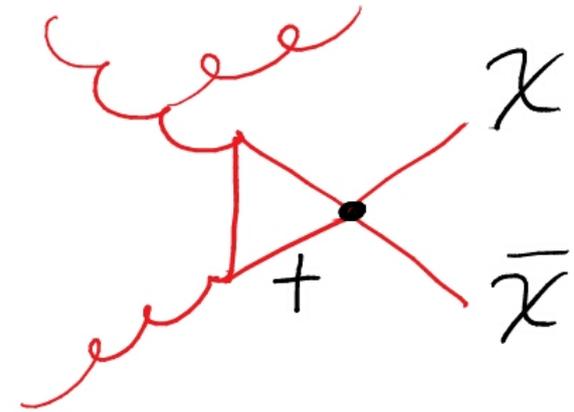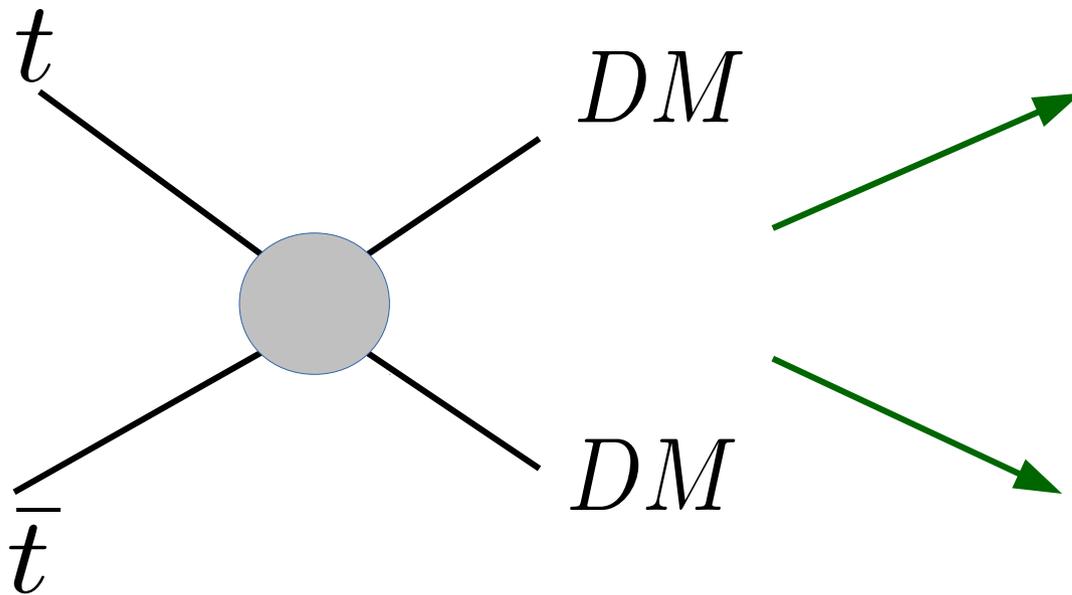
# Top-philic DM: DD



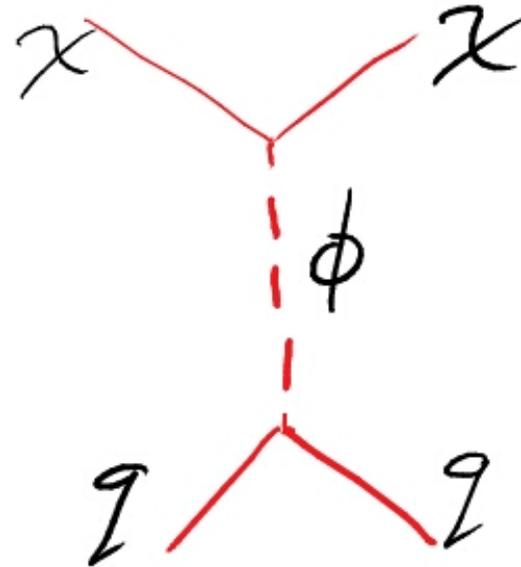$$\mathcal{M} \sim \frac{1}{\Lambda^2} \bar{\chi} \gamma^\mu \chi \bar{N} \gamma_\mu N$$
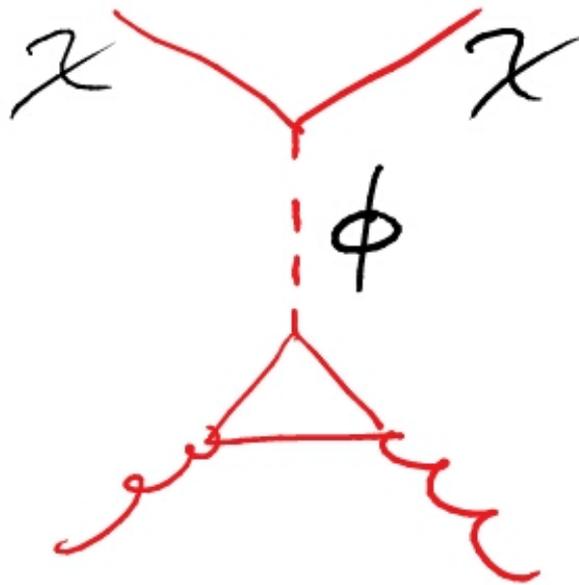
$$\mathcal{M} \sim \frac{1}{\Lambda^2} \bar{\chi} \chi \bar{N} N$$

# Models - Scalar

$$\mathcal{L}_\phi \supset g\phi\bar{\chi}\chi + \sum_q \frac{g_q y_q}{\sqrt{2}}\phi\bar{q}q$$

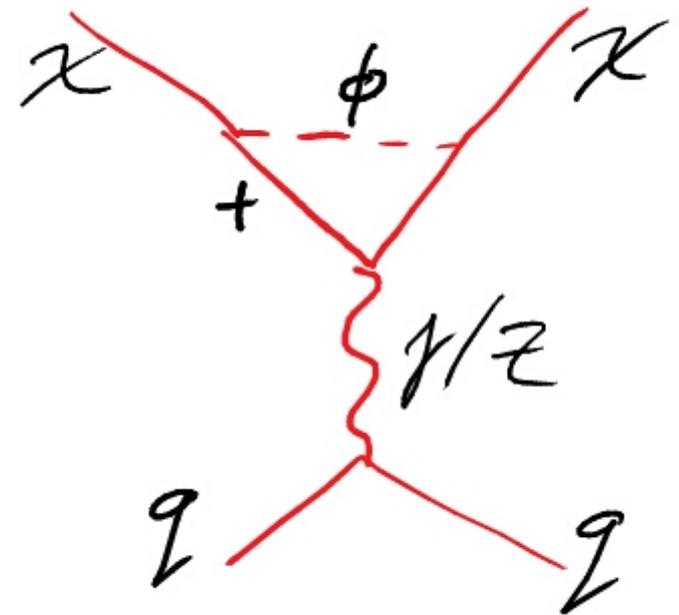Couple like quark yukawas, top naturally dominant portal
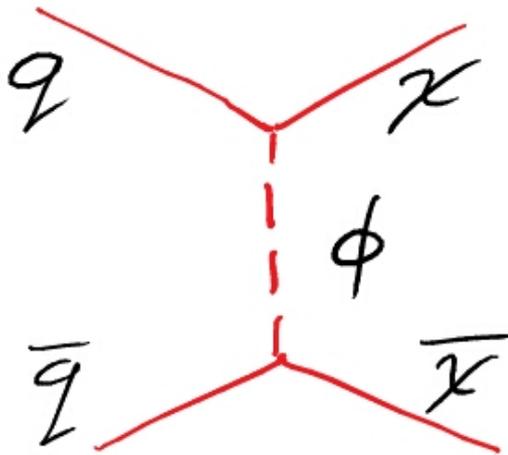
# Models - Pseudoscalar

$$\mathcal{L}_A \supset i g A \bar{\chi} \gamma_5 \chi + \sum_q \frac{i g_q y_q}{\sqrt{2}} A \bar{q} \gamma_5 q$$

- Couplings also proportional to yukawas

- Colliders physics is quite similar to scalar, however DD and ID are starkly different:

- Scalar:
  - DD: Spin-Independent
  - ID: p-wave

- Pseudo-Scalar:
  - DD: Spin-Dependent, $q^4$
  - ID: s-wave

# Models – "t-channel"

$$\mathcal{L}_t \supset \sum_i g_i \phi_i \bar{u}_i P_L \chi + h.c.$$

$$\phi : (3,1)_{2/3}$$

# Models

### Scalar

$$\mathcal{L}_\phi \supset g\phi\bar{\chi}\chi + \sum_u \frac{gy_u}{\sqrt{2}}\phi\bar{u}u$$
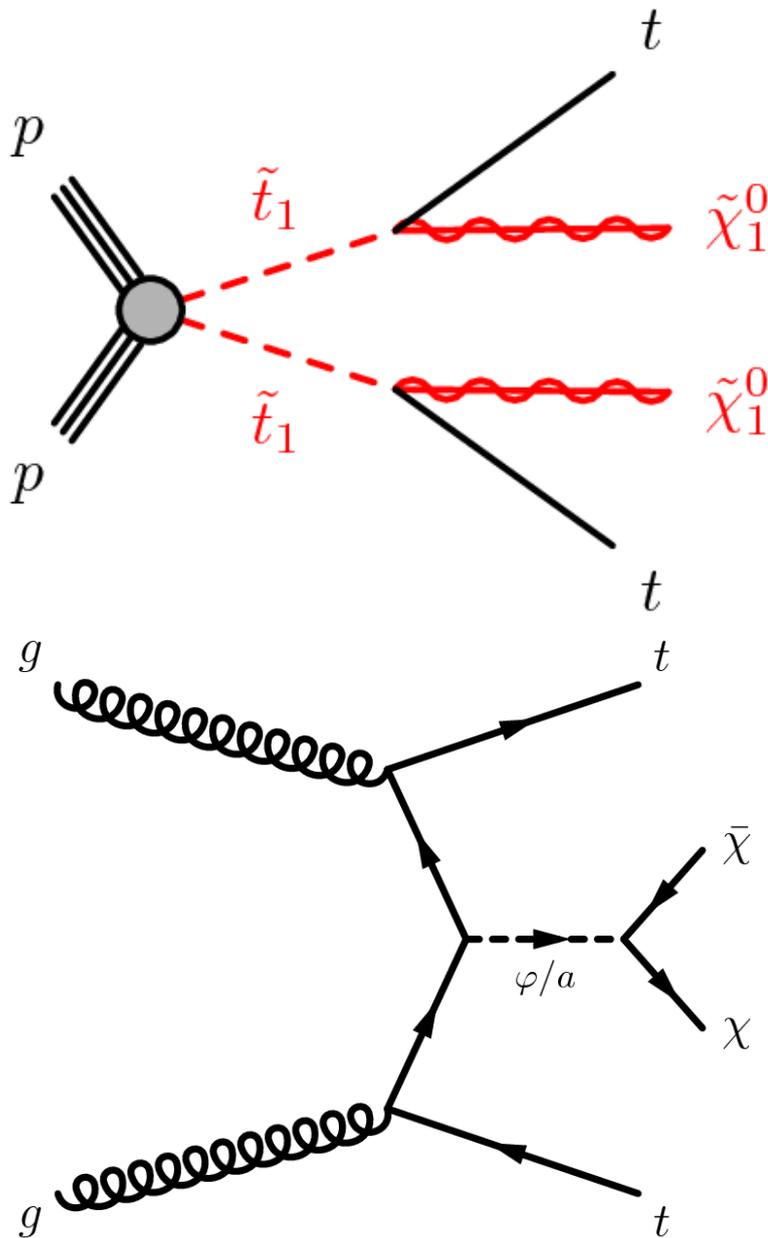
### Pseudo-Scalar

$$\mathcal{L}_A \supset igA\bar{\chi}\gamma_5\chi + \sum_u \frac{igy_u}{\sqrt{2}}A\bar{u}\gamma_5 u$$

### Colored Scalar

$$\mathcal{L}_t \supset g\phi\bar{t}P_L\chi + h.c.$$

# ttbar+MET searches
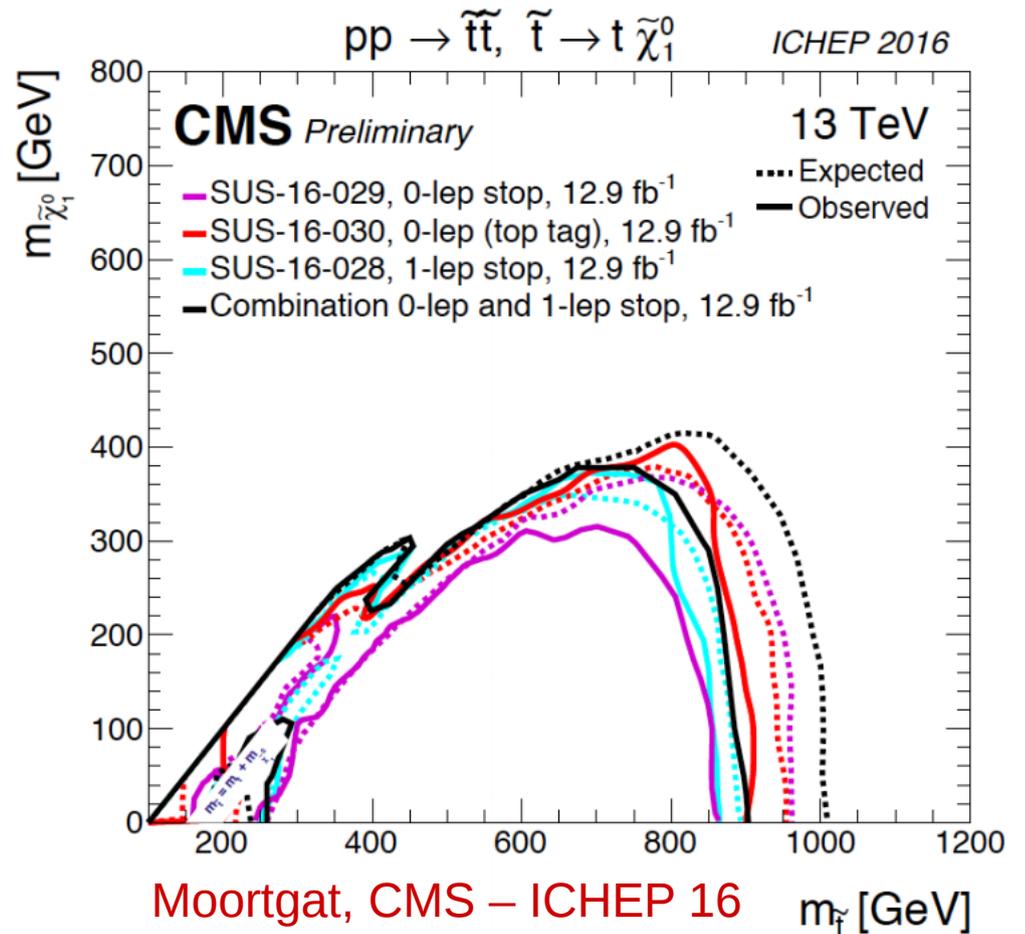


CMS:

0L: SUS-16-030

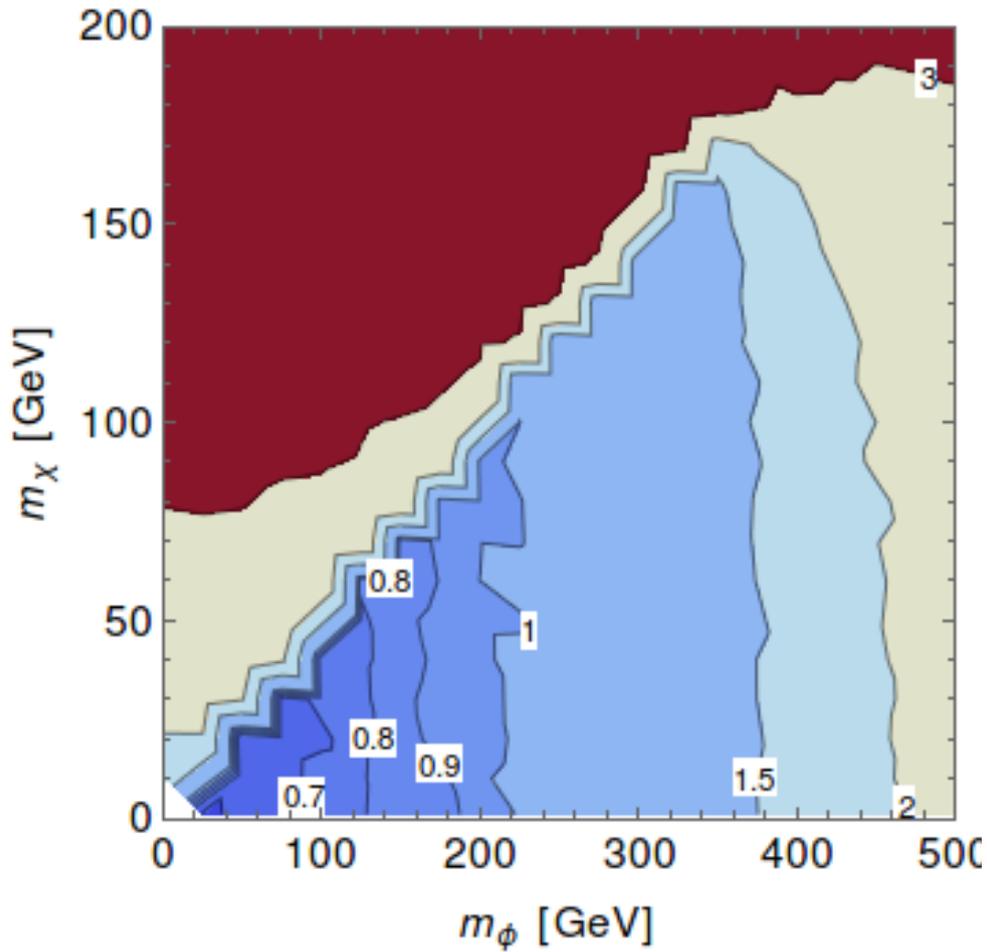1L: SUS-16-028

2L: SUS-16-027

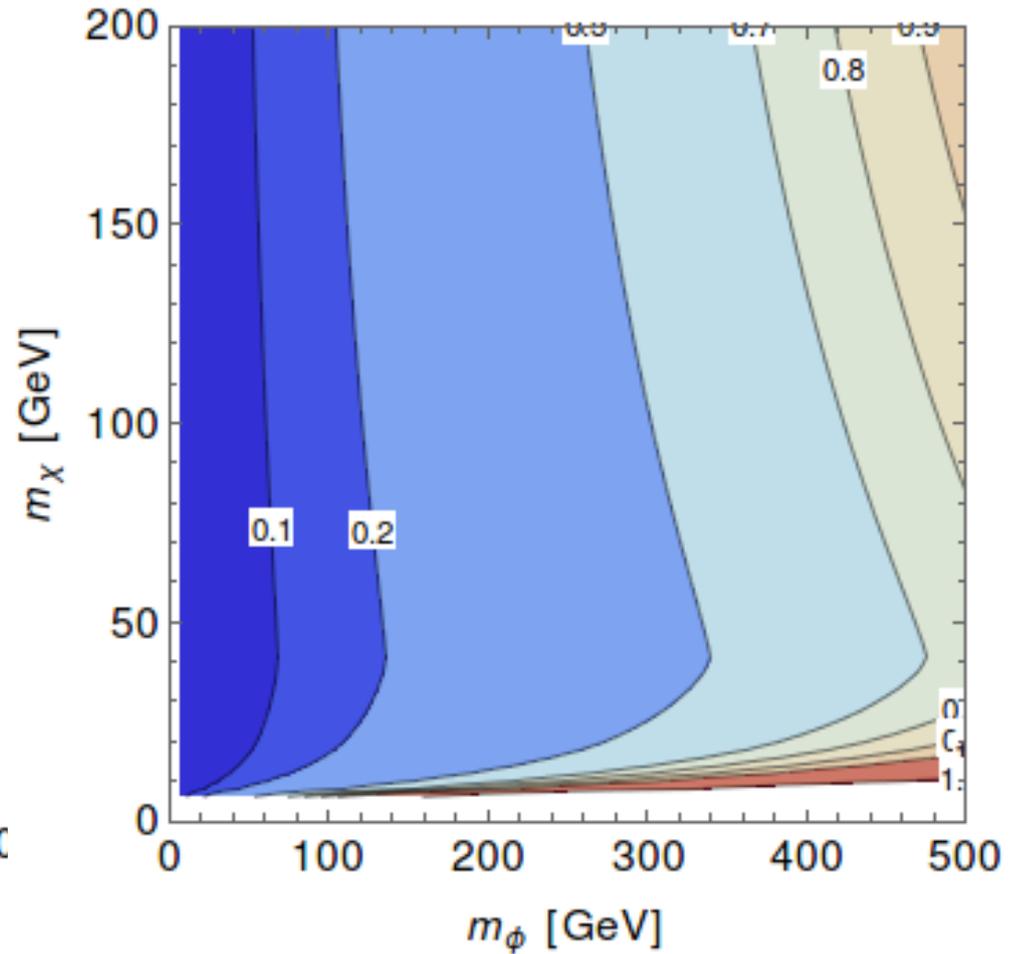ATLAS:

0L: CONF-2016-077

1L: CONF-2016-050

2L: CONF-2016-076



$pp \to \tilde{t}\tilde{t}$, $\tilde{t} \to t \tilde{\chi}_1^0$   ICHEP 2016

**CMS** Preliminary    13 TeV

---- Expected
— Observed

— SUS-16-029, 0-lep stop, 12.9 fb$^{-1}$
— SUS-16-030, 0-lep (top tag), 12.9 fb$^{-1}$
— SUS-16-028, 1-lep stop, 12.9 fb$^{-1}$
— Combination 0-lep and 1-lep stop, 12.9 fb$^{-1}$

$m_{\tilde{\chi}_1^0}$ [GeV]

$m_{\tilde{t}}$ [GeV]

Moortgat, CMS – ICHEP 16
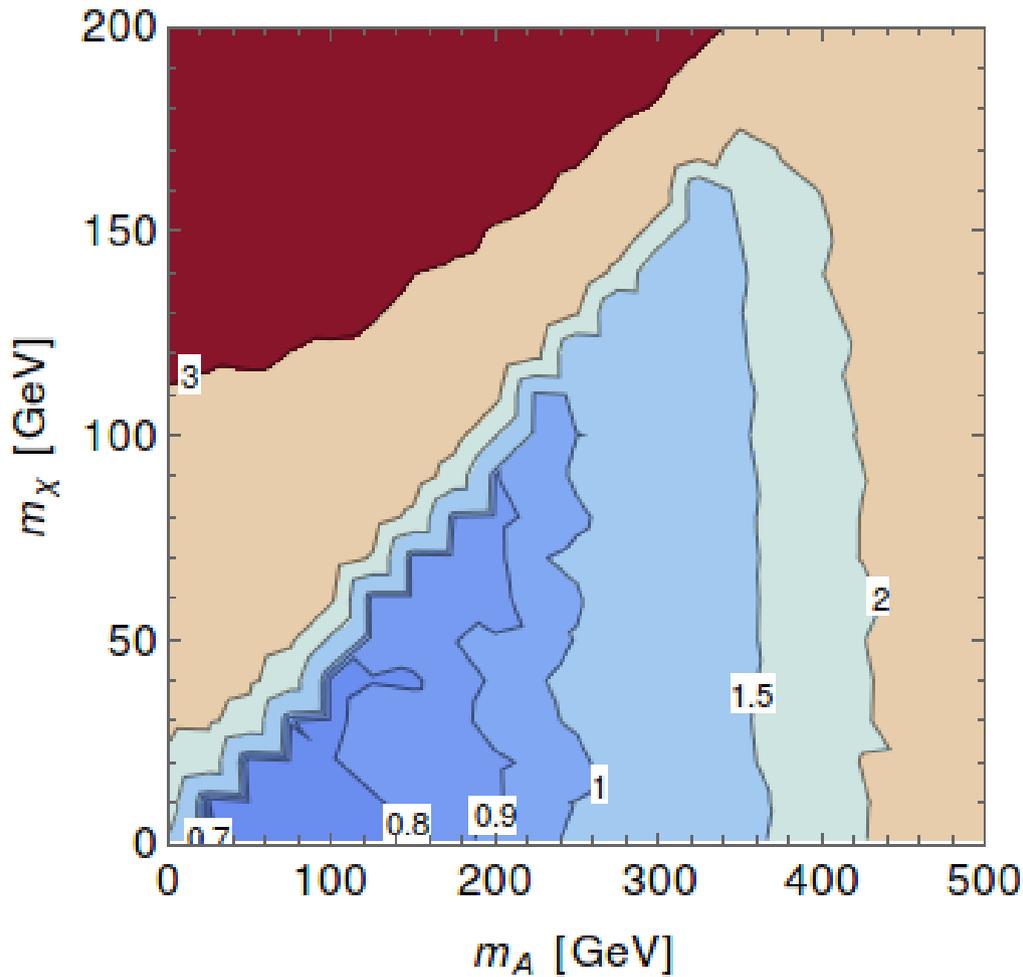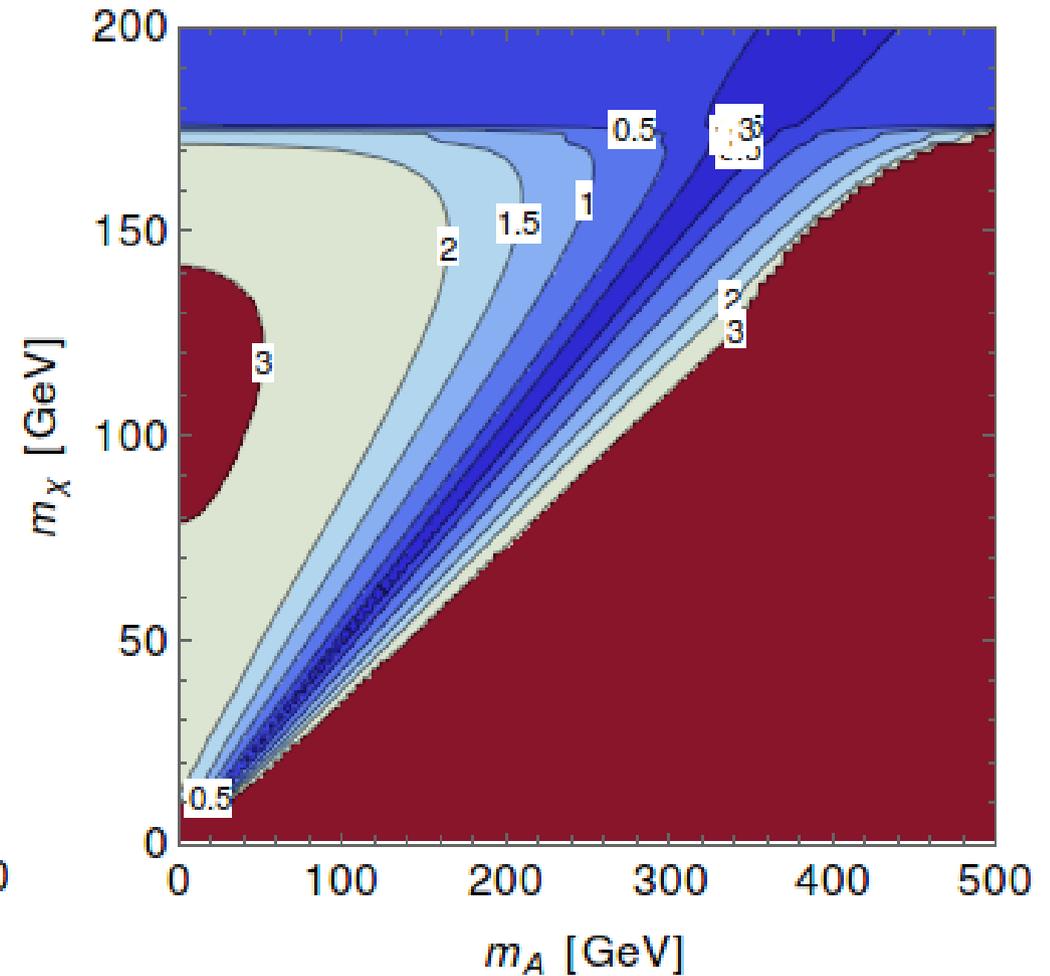
# Results - Scalar



Scalar: ttbar+MET

Scalar: DD

DD limits from LUX, arXiv:1608.07648

# Results – Pseudoscalar



PseudoScalar: ttbar+MET

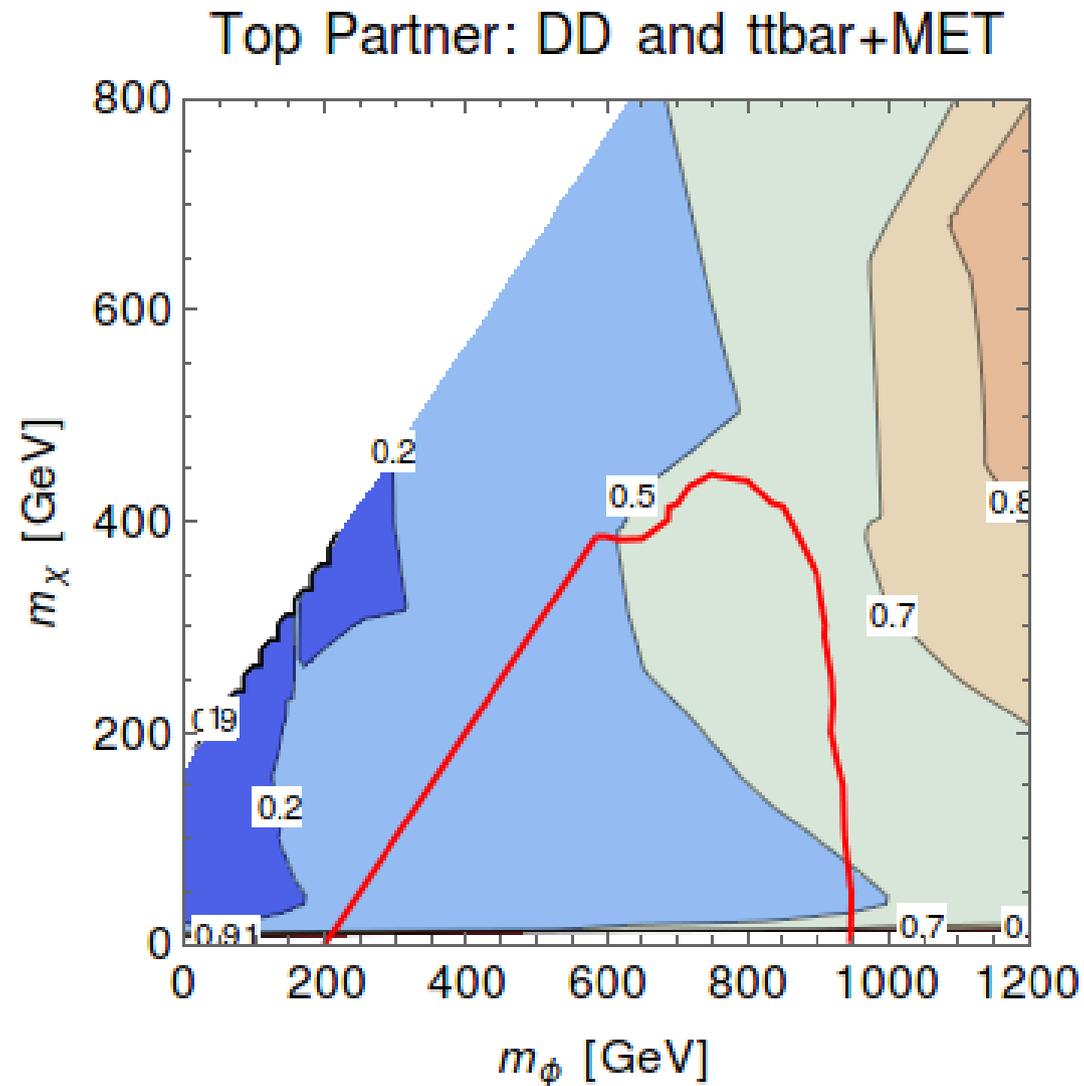PseudoScalar: ID

Fermi+MAGIC arXiv:1601.06590

# Results – Colored Scalar



Top Partner: DD and ttbar+MET

# Conclusions

- <span style="color:green">Don't despair!</span> There's still rich pheno to explore where colliders play a crucial role

- Top-philic models are well motivated and evade some of the strongest DM constraints

- Keep an eye out for our paper which will include Moriond updates and broader recasting efforts

# Thank you! Questions?