Effective Approach to Dark Matter Decay into γ-Ray Line

and constraints from cosmic rays

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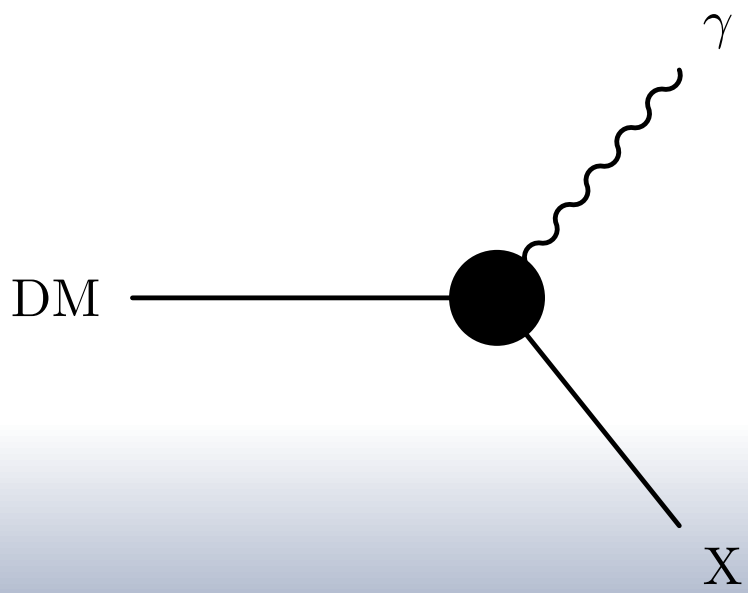
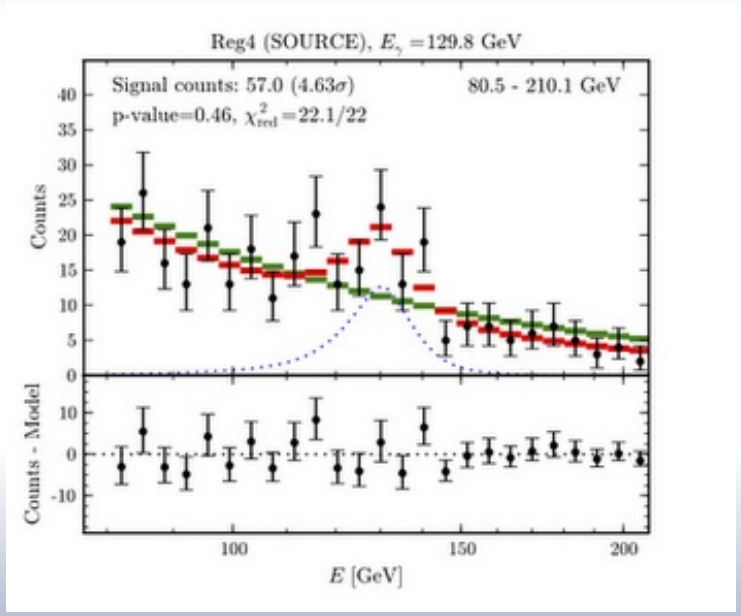
based on M. Gustafsson, T. Hambye, T.S. Phys.Lett. B724 (2013) 288-295
C. El Asaiti, T.Hambye, T.S. arXiv:1403.1280 [hep-ph]

Interest of γ-Ray Lines

- A γ-ray line (monochromatic photon) is a ”smoking-gun” signature of DM





C. Weniger arXiv:1205.1520[hep-ph]

DM Decay into γ-Ray Lines

- Dark Matter is (almost) neutral: coupling to the photon?
  - neutral DM: coupling to the photon through a loop
  - millicharged DM: very small tree-level DM-γ coupling

- DM is really long lived: why study a decay?
  - An *accidental* symmetry might provide a long but finite lifetime to the DM
  - Allows for indirect detection signal with distinct features with respect to annihilation

Effective Approach to Dark Matter Decay

- Model-independent approach
- Justified in the case of a decay

$$\tau_{DM} \geq 10^{26}\text{sec} \qquad \frac{\mathcal{O}_6}{\Lambda^2}$$

$$m_{DM} \simeq 100\text{GeV} \qquad \Lambda \simeq 10^{15}\text{GeV}$$

Full list of operators of dimension five and six
$SU(2)_L \times U(1)_Y \times G_{\text{hidden}}$ invariant, giving
$\psi^0_{DM}/\psi^{milliQ}_{DM} \to X + \gamma$

Lists of Operators

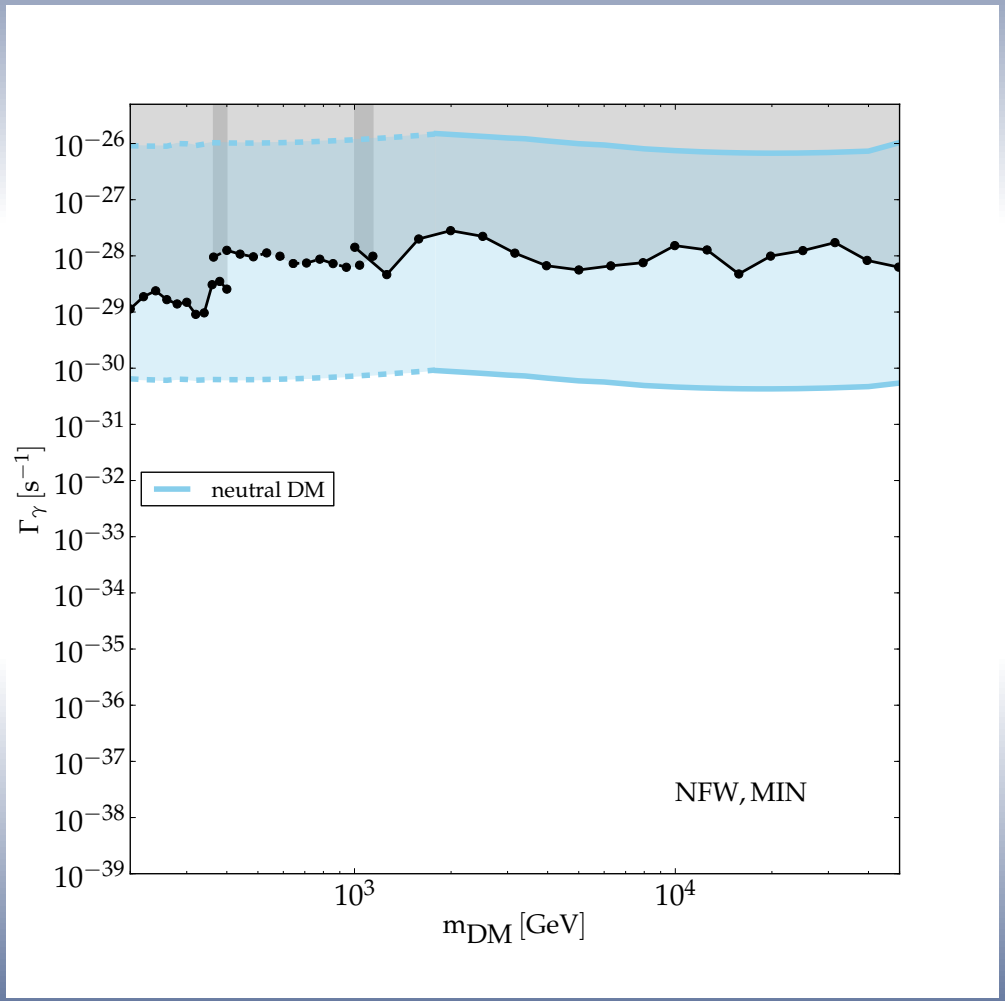
Neutral DM

Fermion DM	Scalar DM	Vector DM
$\bar{\psi}\sigma_{\mu\nu}\psi_{DM}F^{\mu\nu}(\phi)$	$\phi_{DM}F_{\mu\nu}F^{\mu\nu}(\phi)$	$F^{DM}_{\mu\nu}F^{Y\nu\rho}F^{\prime\prime}_{\mu}{}^{\rho}$
$D_\mu\bar{\psi}\gamma_\nu\psi_{DM}F^{\mu\nu}$	$D_\mu\phi_{DM}D_\nu\phi F^{\mu\nu}$	$F^{DM}_{\mu\nu}F^{\mu\nu}\phi(\phi')$
$\bar{\psi}\gamma_\mu D_\nu\psi_{DM}F^{\mu\nu}$		$D^{DM}_{\mu}\phi D^{DM}_{\nu}\phi' F^{\mu\nu}$

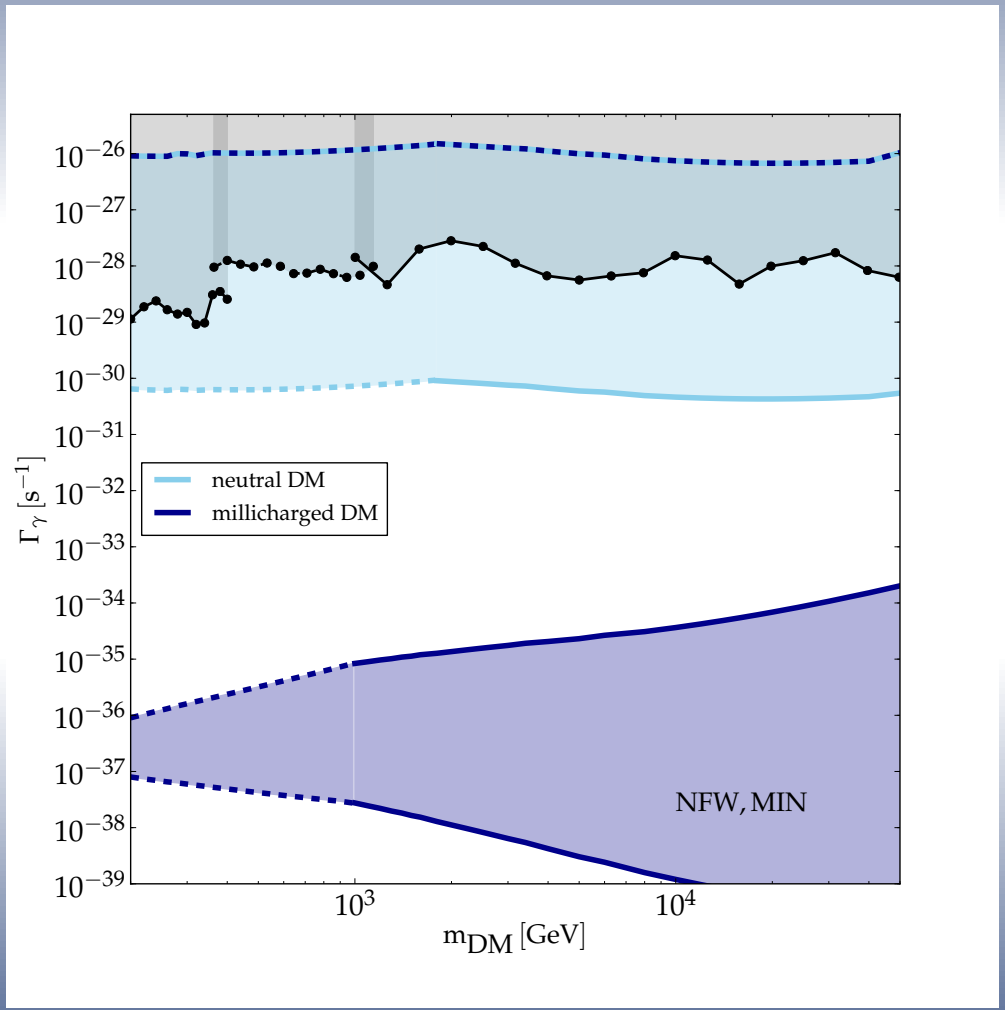
Millicharged DM

Fermion DM	Scalar DM	Vector DM
$D_\mu D_\nu\bar{\psi}\sigma_{\mu\nu}\psi_{DM}(\phi)$	$\phi_{DM}F^{A}_{\mu\nu}F^{A\mu\nu}(\phi)$	$\phi F^{A}_{\mu\nu}F^{A\mu\nu}(\phi')$
$\bar{\psi}\sigma_{\mu\nu}D_\mu D_\nu\psi_{DM}(\phi)$	$F^{A\mu\nu}D_\mu\phi_{DM}D_\nu\phi'$	$F^{A\mu\nu}D_\mu\phi D_\nu\phi'$
$D_\mu\bar{\psi}\sigma_{\mu\nu}D_\nu\psi_{DM}(\phi)$		$F^{A\mu\nu}F^{A}_{\nu\rho}F^{A\rho}_{\mu}$

Cosmic Rays Constraints



Cosmic Rays Constraints



Conclusions

- The complete list of operators up to dimension six that could account for neutral or millicharged DM decay into γ-ray lines has been written down.
- Due to gauge invariance, to each operator producing a γ-ray signal, there is an associated operator producing a continuum of cosmic rays, which puts constraints on the maximum intensity of the γ-ray line.
- In the case of neutral DM, various operators could account for a γ-ray line if it were detected at the present experimental sensitivities, and there is a potential to discriminate among them.
- Instead a millicharged DM decay is bounded to produce very weak γ-ray lines except if it is a singlet of the SM gauge group.