Forbidden Dark Matter Combusted Around Supermassive Black Hole

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2012-2016 Scholarship, East China University of Science and Technology (ECUST).
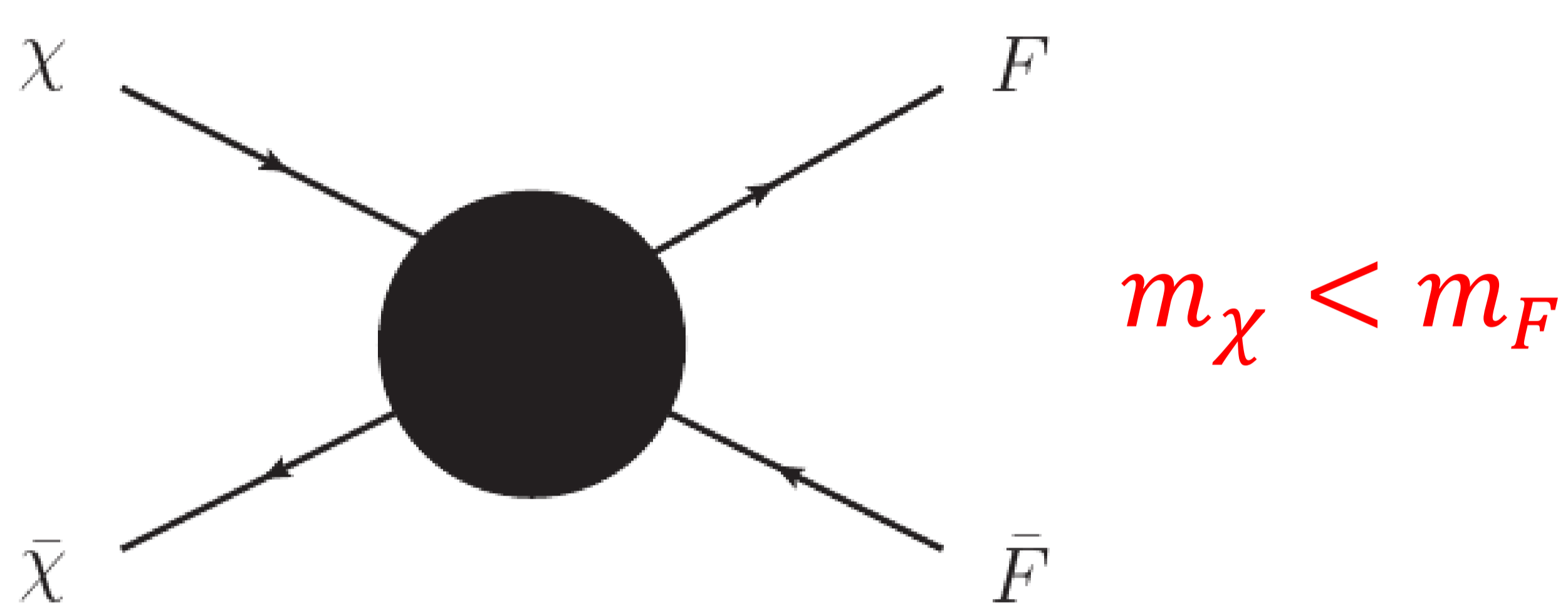2017-2020 Master, ECUST.
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Research Interests:
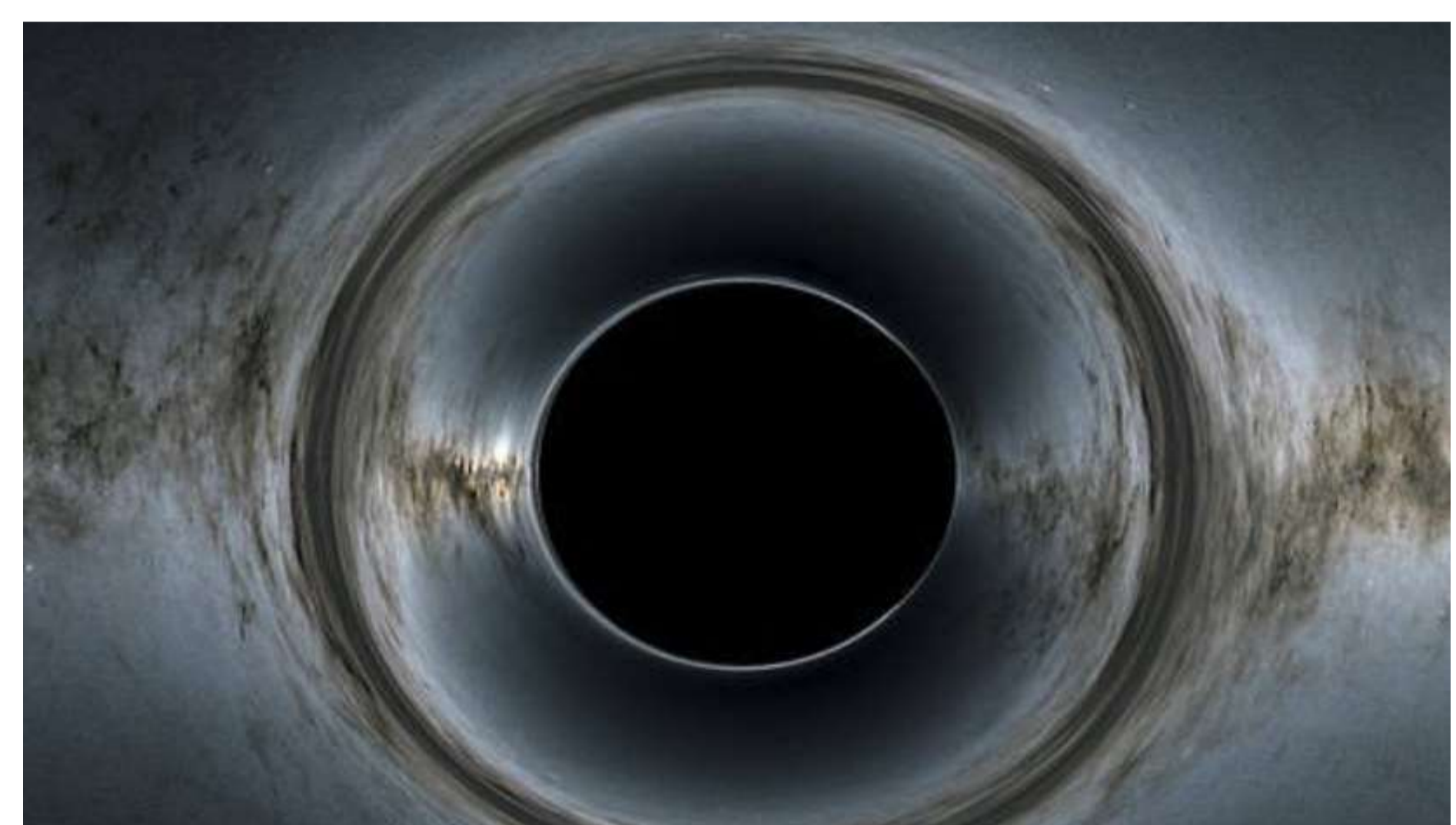High Energy Physics, Dark Matter Phenomenology

1. Forbidden annihilation :

$$m_\chi < m_F$$

$$\langle \sigma_{\chi\bar\chi} v \rangle = \frac{(n_F^{eq})^2}{(n_\chi^{eq})^2} \langle \sigma_{FF} v \rangle$$

$$\langle \sigma_{FF} v \rangle \sim \frac{\alpha_d^2}{m_F^2}$$

$$n_{eq} \propto \exp\left(-\frac{m}{T}\right)$$

$$\langle \sigma_{\chi\bar\chi} v \rangle \approx 8\pi f_\Delta \frac{\alpha_d^2}{m_\chi^2} e^{-2\Delta x}$$

$$\Delta \equiv \frac{m_F - m_\chi}{m_\chi}$$

2. Black hole acceleration

$$v^2 \sim \frac{GM}{r} \quad\longrightarrow\quad v(r) \sim \frac{1}{\sqrt{r}}$$

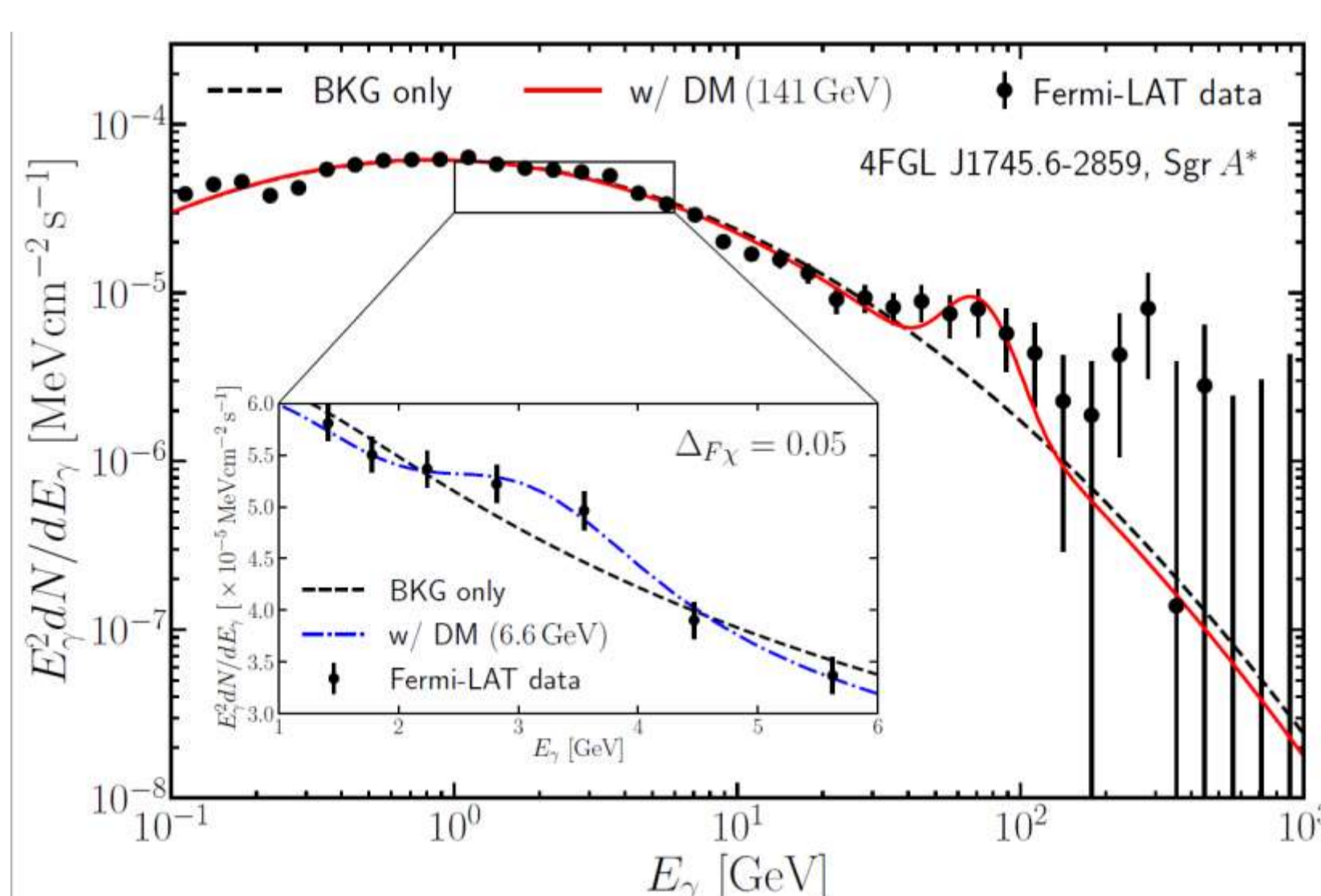$$\rho \propto \begin{cases} r^{-7/3} \ (\text{CDM}) \\ r^{-7/4} \ (\text{SIDM}) \end{cases}$$

3. Gamma ray flux and constrains:

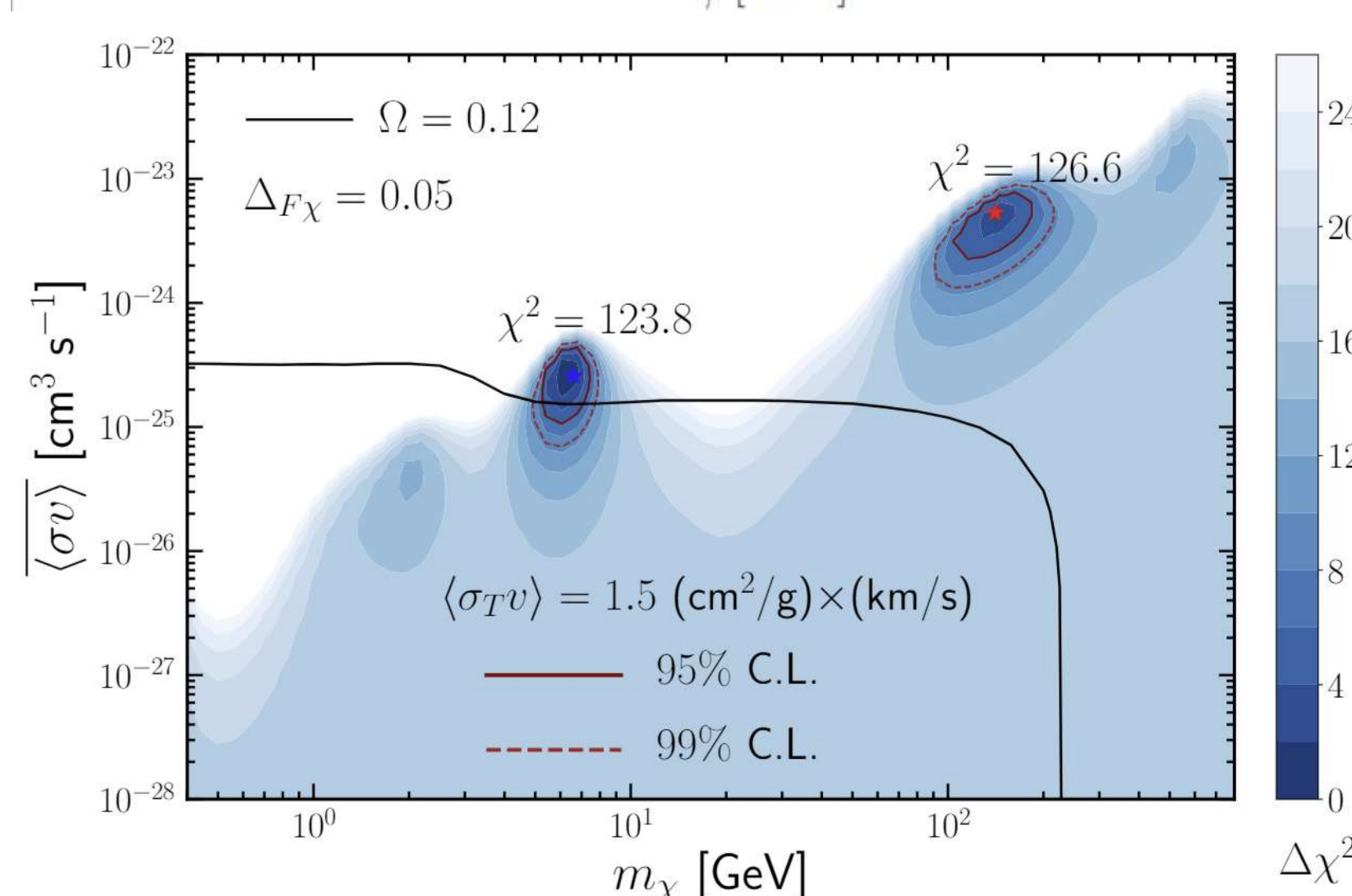$$\mathcal{L}_{DM} = g_\chi \bar\chi \gamma^\mu \chi \phi_\mu + g_{F\chi} \bar F \gamma^\mu F \phi_\mu$$

- **Forbidden channel**
  $$\chi\bar\chi \to F\bar F$$
- **Decay signal**
  $$F \to \nu\gamma$$

The Fermi-LAT data (black points with error bar), background-only fit (black dashed line), and the signal fit with forbidden DM annihilation for $m_\chi = 141$ GeV (red solid) and $m_\chi = 6.6$ GeV (blue dash-dotted).


The sensitivity contours of forbidden DM annihilation cross section obtained by fitting the Fermi-LAT data. The red solid and dashed lines are the sensitivity contours at 95% and 99% C.L.[1]

4. Right-Handed Neutrino DM model with Forbidden Annihilation:

- **Seesaw mechanism**
  - N_3 — Neutrino oscillation
  - N_2 — Baryon asymmetry
  - N_1 — DM O(100) GeV

$$\mathcal{L}_{int} = (y\phi N_1 \chi + \text{h.c.}) + \lambda m_\phi \phi H^\dagger H$$

- **Z_2 Symmetry**
  - N_1 odd — Stable, DM
  - χ odd
  - ϕ even — Decay, Signal
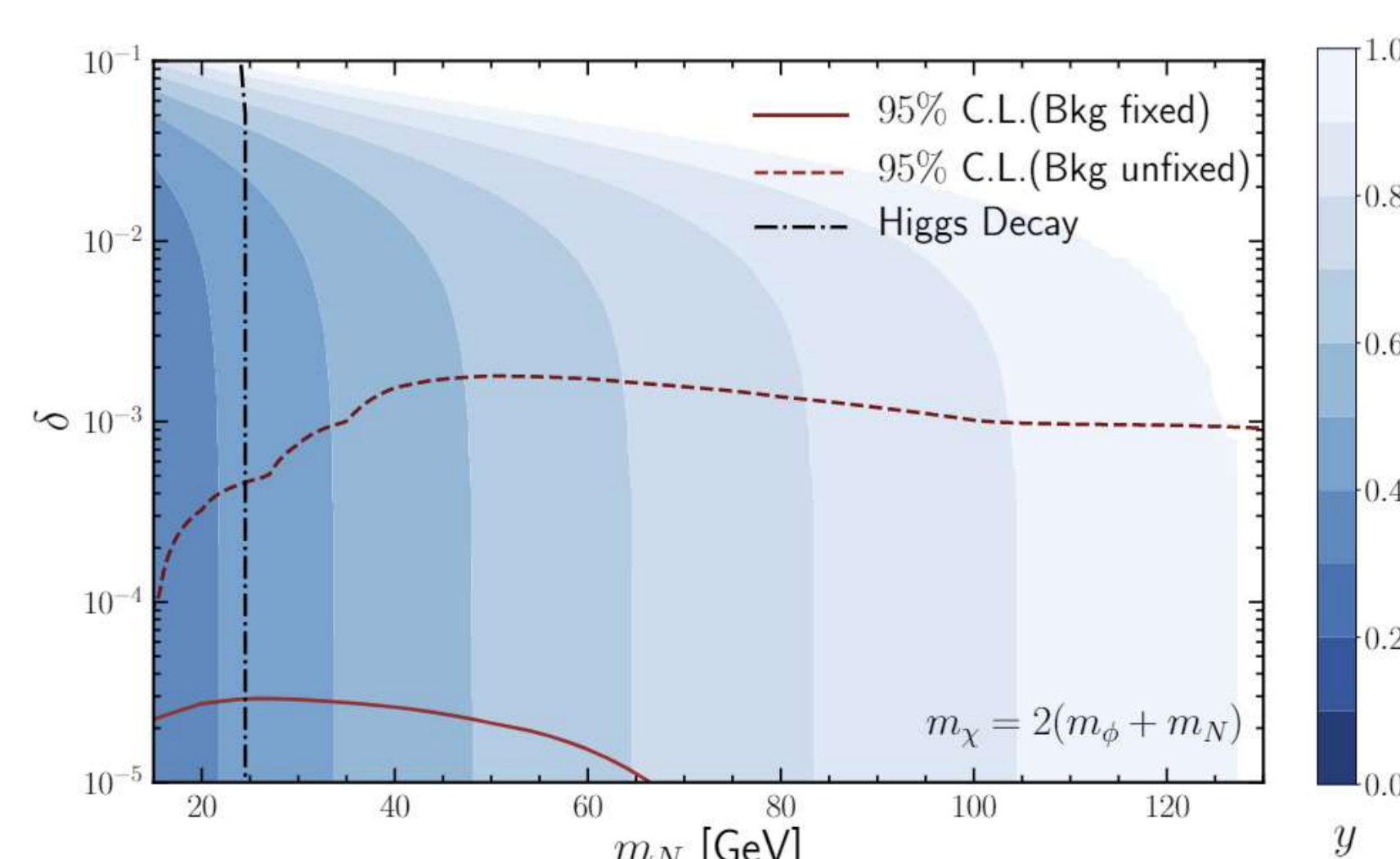
The allowed parameter space contour to obtain the DM relic density through freeze out. Red lines show the 95% limit. Both cases with fixed (solid red) and unfixed (dashed red) background are shown for comparison.[2]

[1] **Y.C**, Shao-Feng Ge, Xiao-Gang He and Jie Sheng, [arXiv:2211.05643 [hep-ph]].
[2] **Y.C**, Shao-Feng Ge, Jie Sheng and Tsutomu T. Yanagida, [arXiv:2304.02997 [hep-ph]].