INTEGRAL X-RAY CONSTRAINTS ON SUB-GEV DARK MATTER

Speaker: Elena Pinetti

PONT, 10th December 2020

University of Turin & Sorbonne University

arxiv:2007.11493

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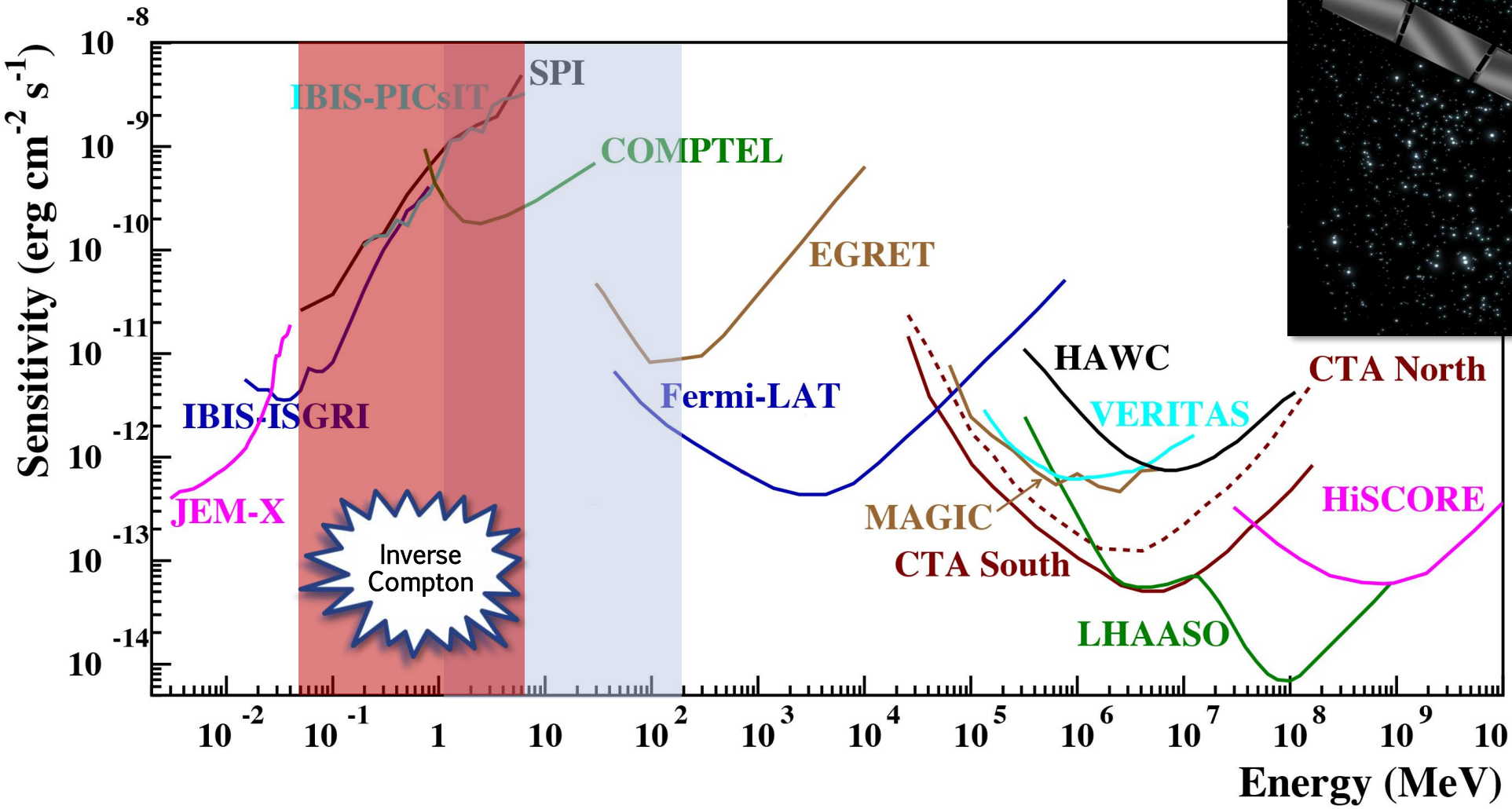
$1\ \mathrm{MeV} \leq m_\chi \leq 5\ \mathrm{GeV}$

Photon searches



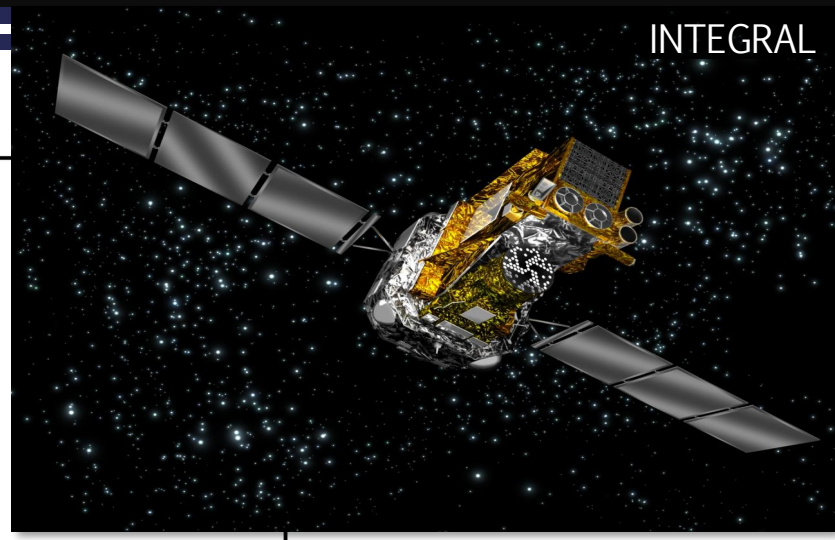


Figure adapted from Tatischeff+ arxiv:1805.06435

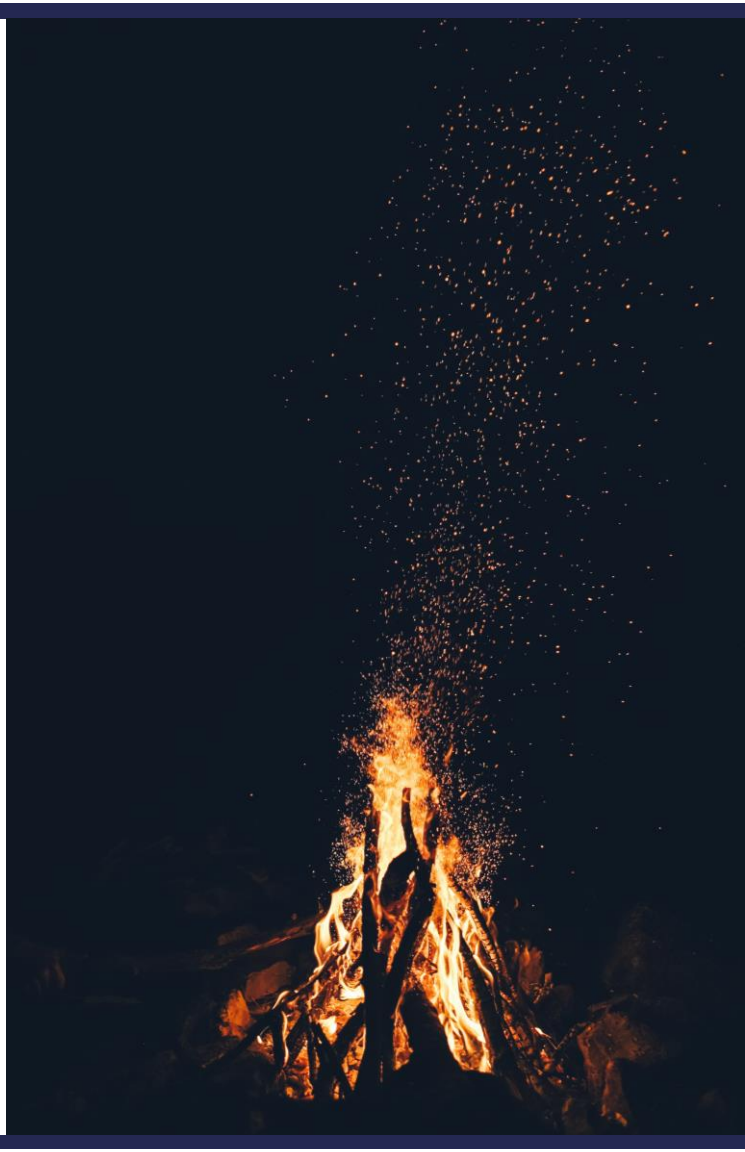
Annihilation channels

3 annihilation channels: $\chi\chi \longrightarrow e^+e^-$

$\chi\chi \longrightarrow \mu^+\mu^-$

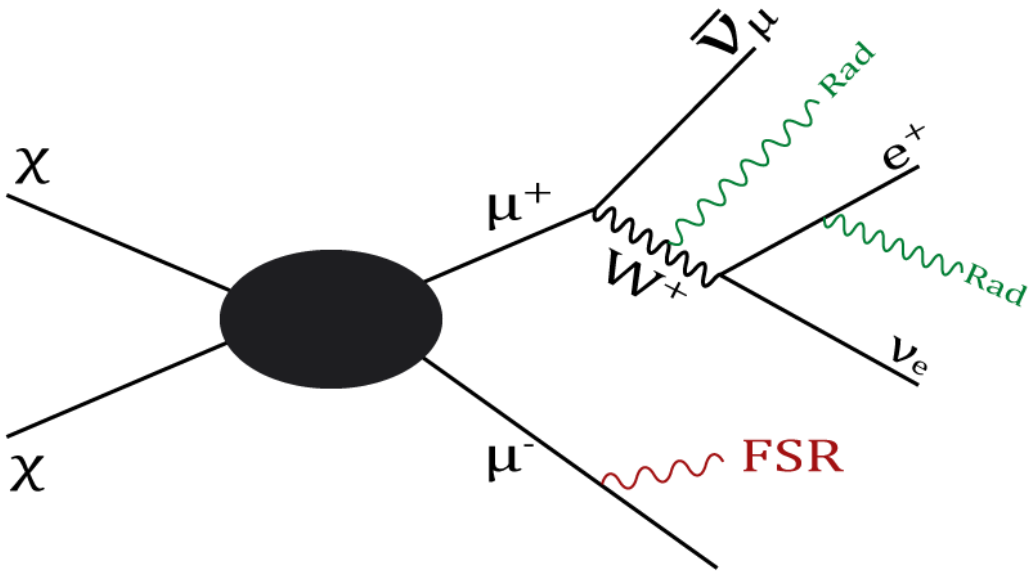
$\chi\chi \longrightarrow \pi^+\pi^-$

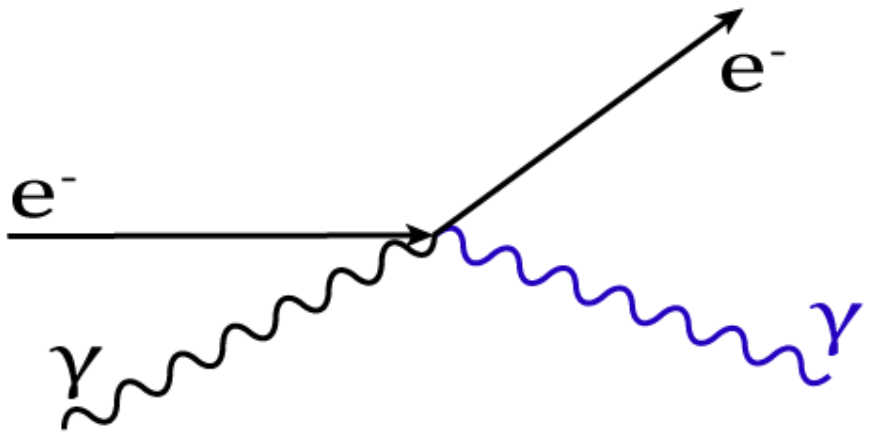
Kinematically open: $m_\chi > m_i \qquad i = e, \mu, \pi$



Total Flux

$$\phi_{TOT} = \phi_{FSR} + \phi_{Rad} + \phi_{ICS}$$





Inverse Compton Scattering

$\chi\chi \longrightarrow \mu^+\mu^-\gamma$ FSR

$\chi\chi \longrightarrow \mu^+\mu^-$ Rad

$\hookrightarrow e^+\nu_e\bar{\nu}_\mu\,\gamma$

$\chi\chi \longrightarrow (\ldots) \rightarrow e^+\,e^-$

$e^- + \gamma \rightarrow\ e^- + \gamma$

Final State Radiation

$$\frac{d\phi_{FSR}}{dE_\gamma\, d\Omega}(E_\gamma,\theta) = \frac{1}{4\pi}\frac{\langle\sigma_{ann}v\rangle}{2m_{DM}^2}\frac{dN_{FSR}}{dE_\gamma}\, J(\theta)$$

Particle Properties

Energy spectrum per annihilation event

Angle in the sky

DM density

$$J(\theta) = \int_{l.o.s} \rho^2\big(r(s,\theta)\big)ds$$

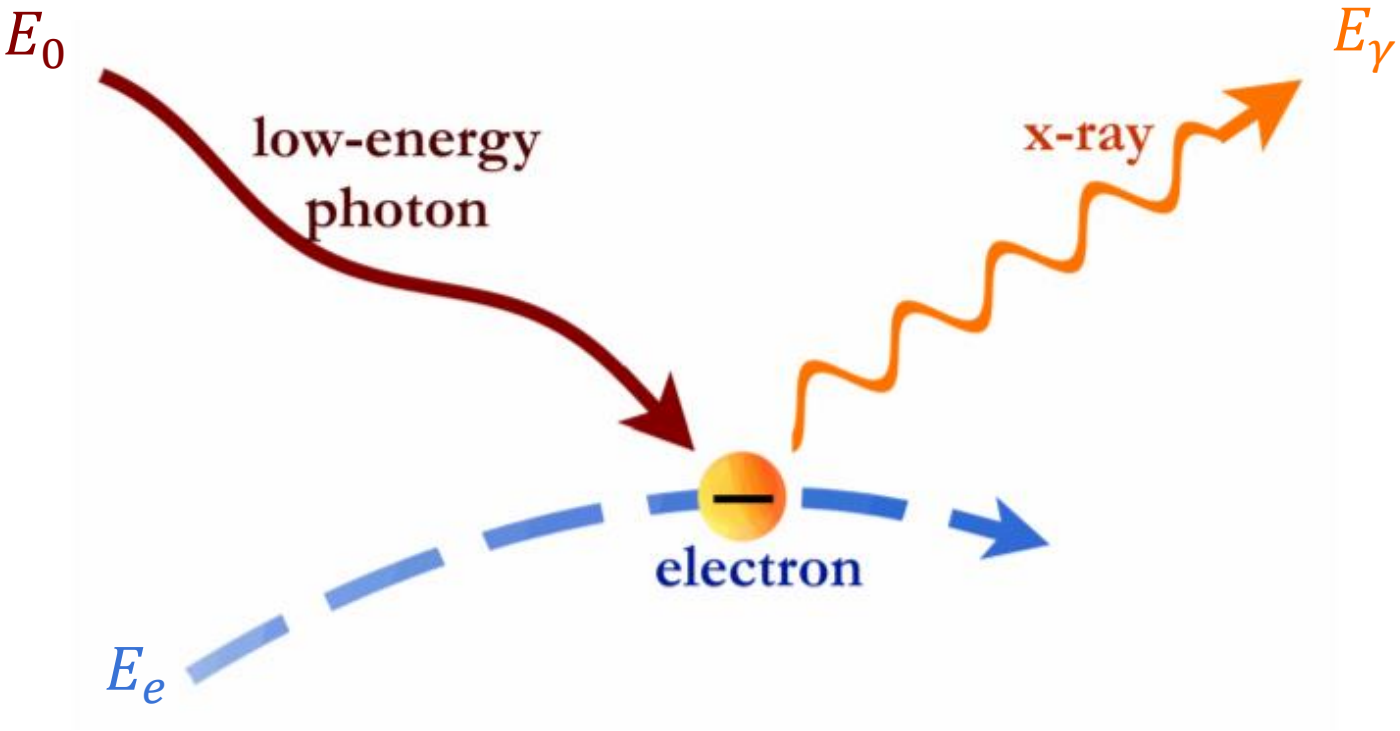
Line of sight

Radiative Decay:

$$\left.\begin{array}{ll} \mu^- \to e^-\,\bar{\upsilon}_e\,\upsilon_\mu\,\gamma & \\ \pi^- \to l\,\bar{\upsilon}_l\,\gamma & l = e,\mu \end{array}\right\} \frac{dN_{Rad}}{dE_\gamma}$$

Inverse Compton Scattering

$$\chi\chi \longrightarrow (\ldots) \rightarrow e^+ \, e^-$$



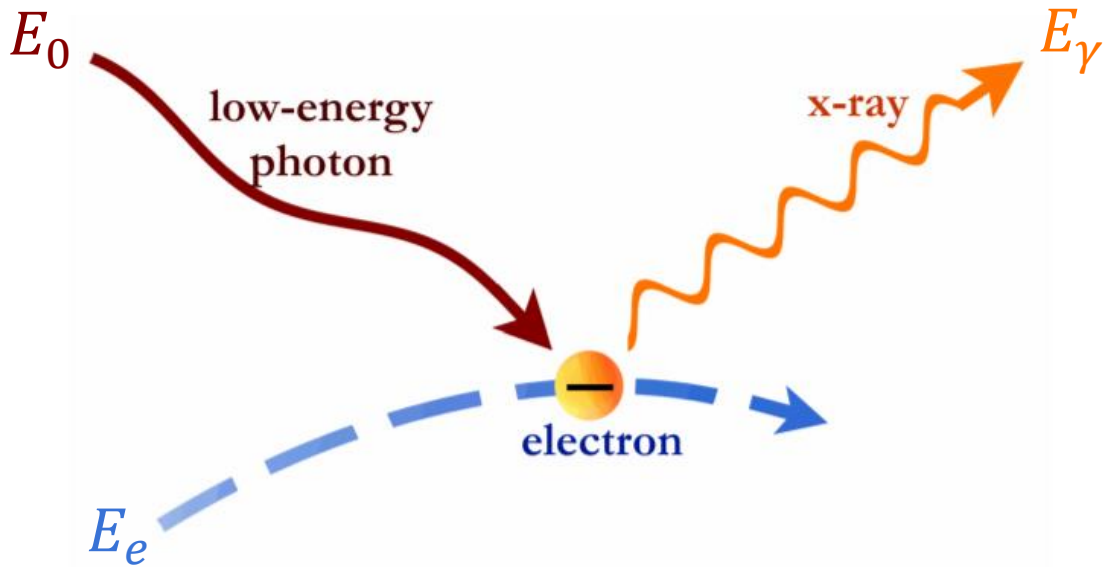
3 kind of photons:

- CMB
- IR (dust)
- Optical (starlight)

X rays

$$\gamma = \frac{E_e}{m_e}$$

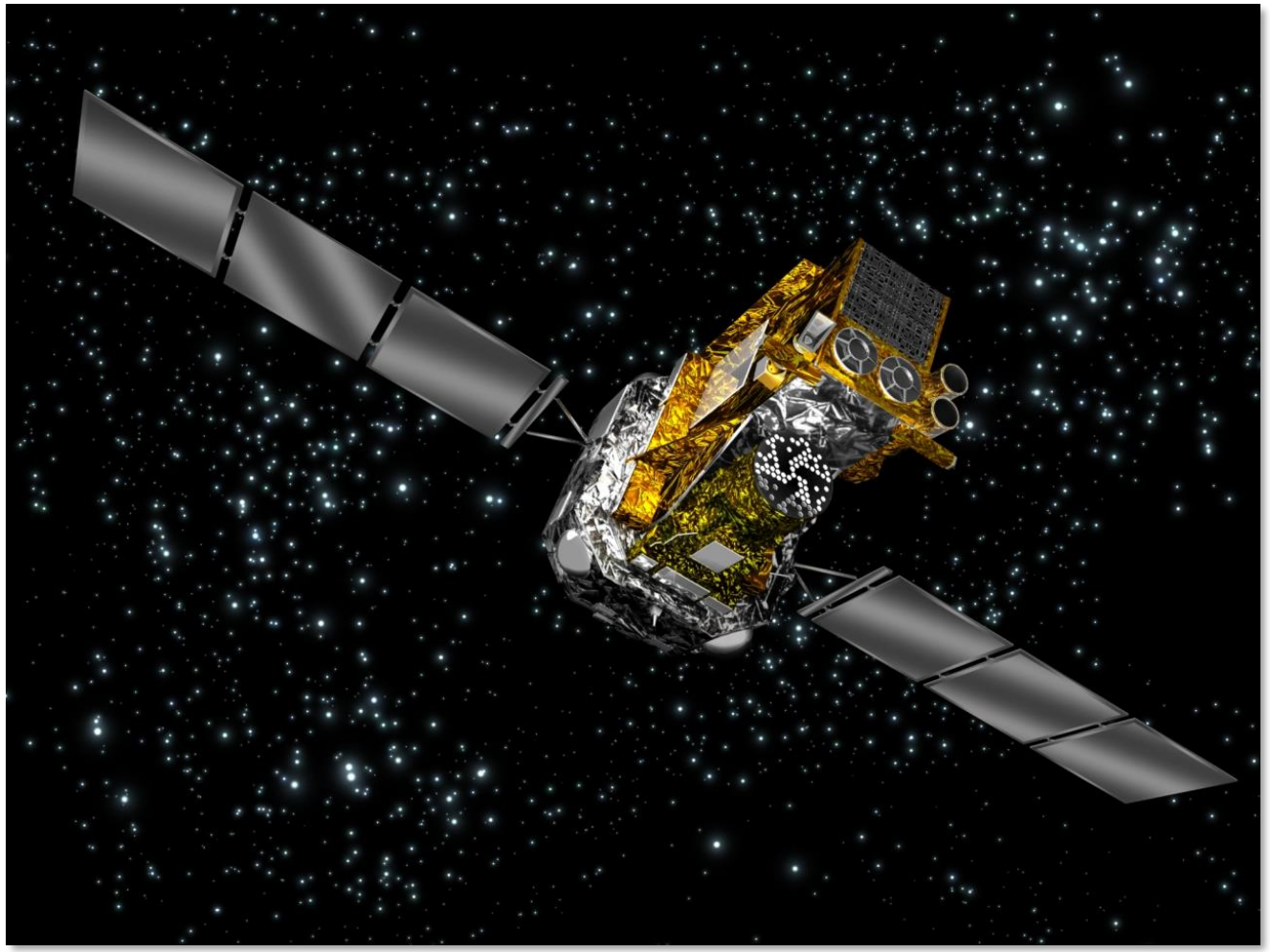
$$E_\gamma \approx 4\gamma^2 E_0$$



Type	E_0 [eV]	E_e [GeV]	E_γ [keV]
CMB	10^{-4}	5	40
IR	10^{-2}	0.5	40
Opt	10	0.05	400

X rays

INTEGRAL Space Telescope



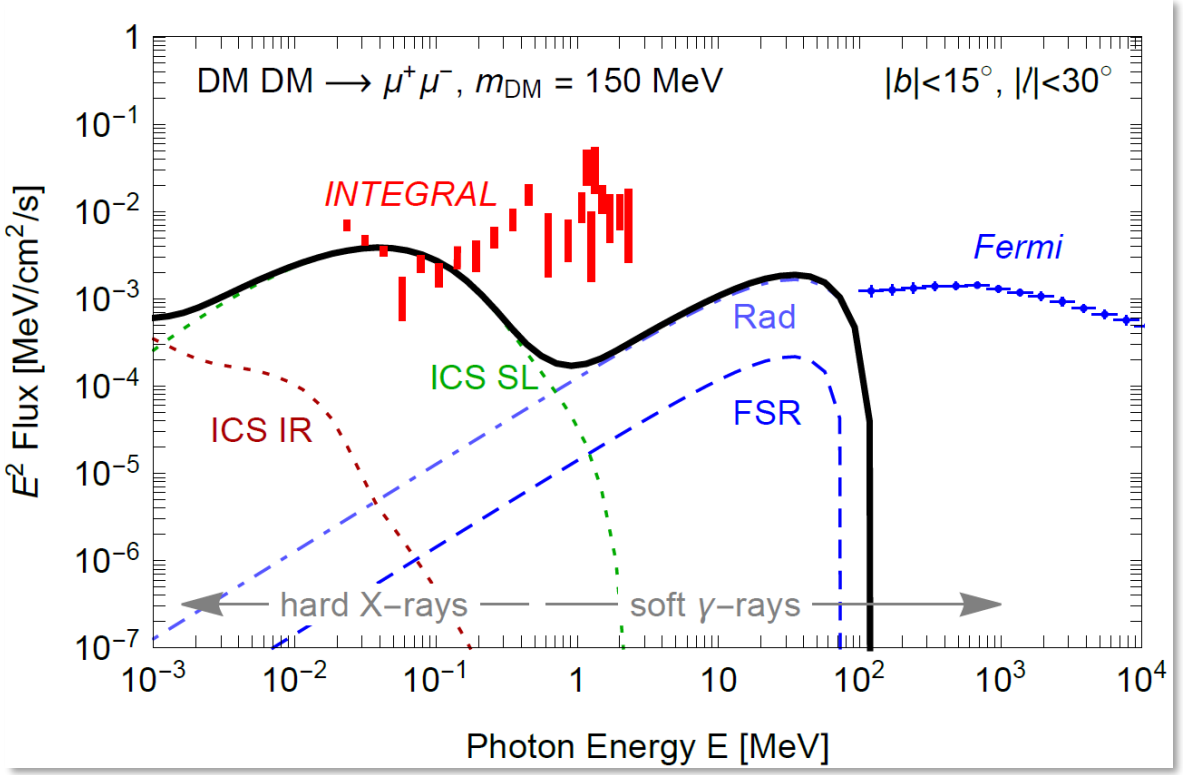
Data taking: 2003-2009

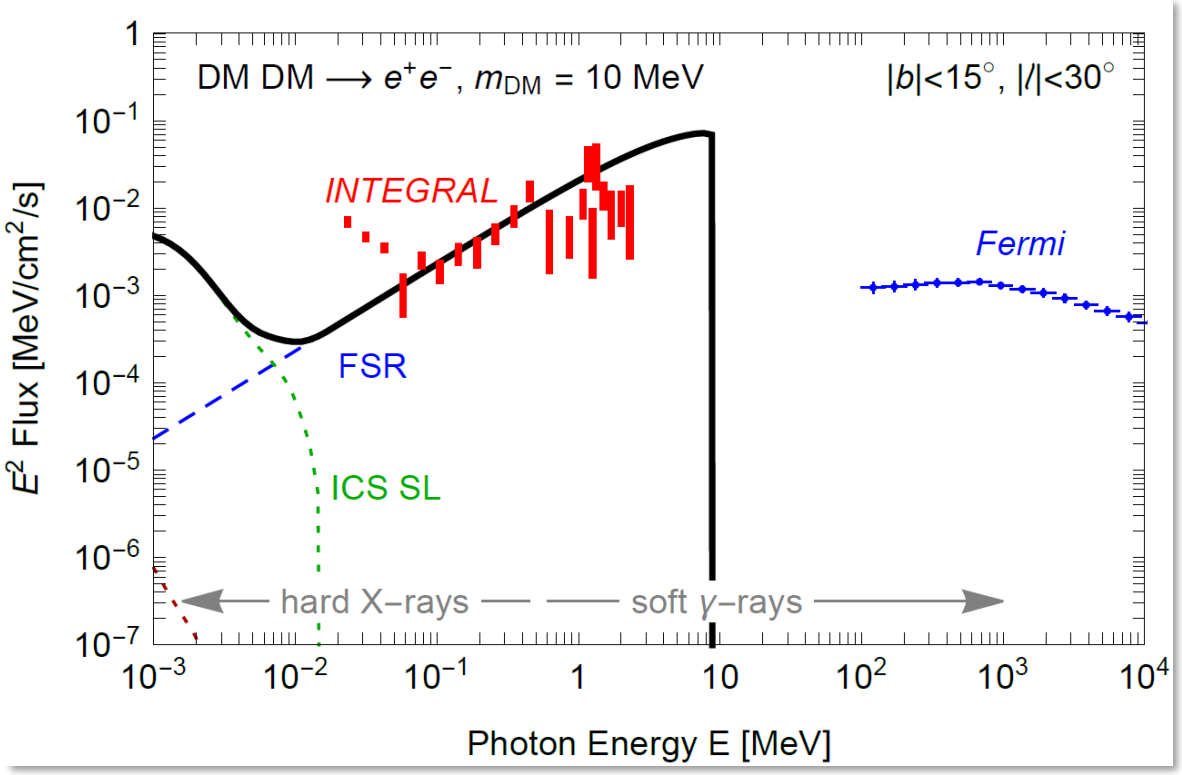
Photons in the energy range:
20 keV ~ 8 MeV

- Hard X rays
- Soft gamma rays

INTEGRAL:
INTErnational Gamma-Ray Astrophysics Laboratory

Photon Spectra





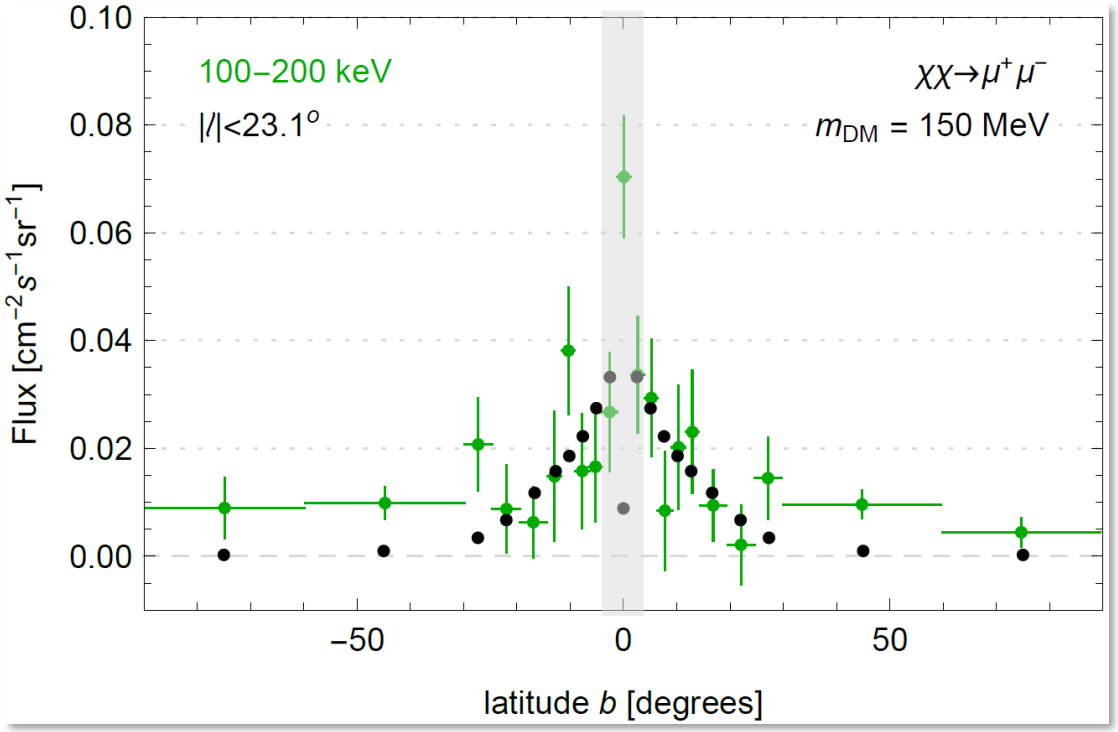
Data sets

5 energy bands:

- 27-49 keV
- 49-90 keV
- 100-200 keV
- 200-600 keV
- 600-1800 keV

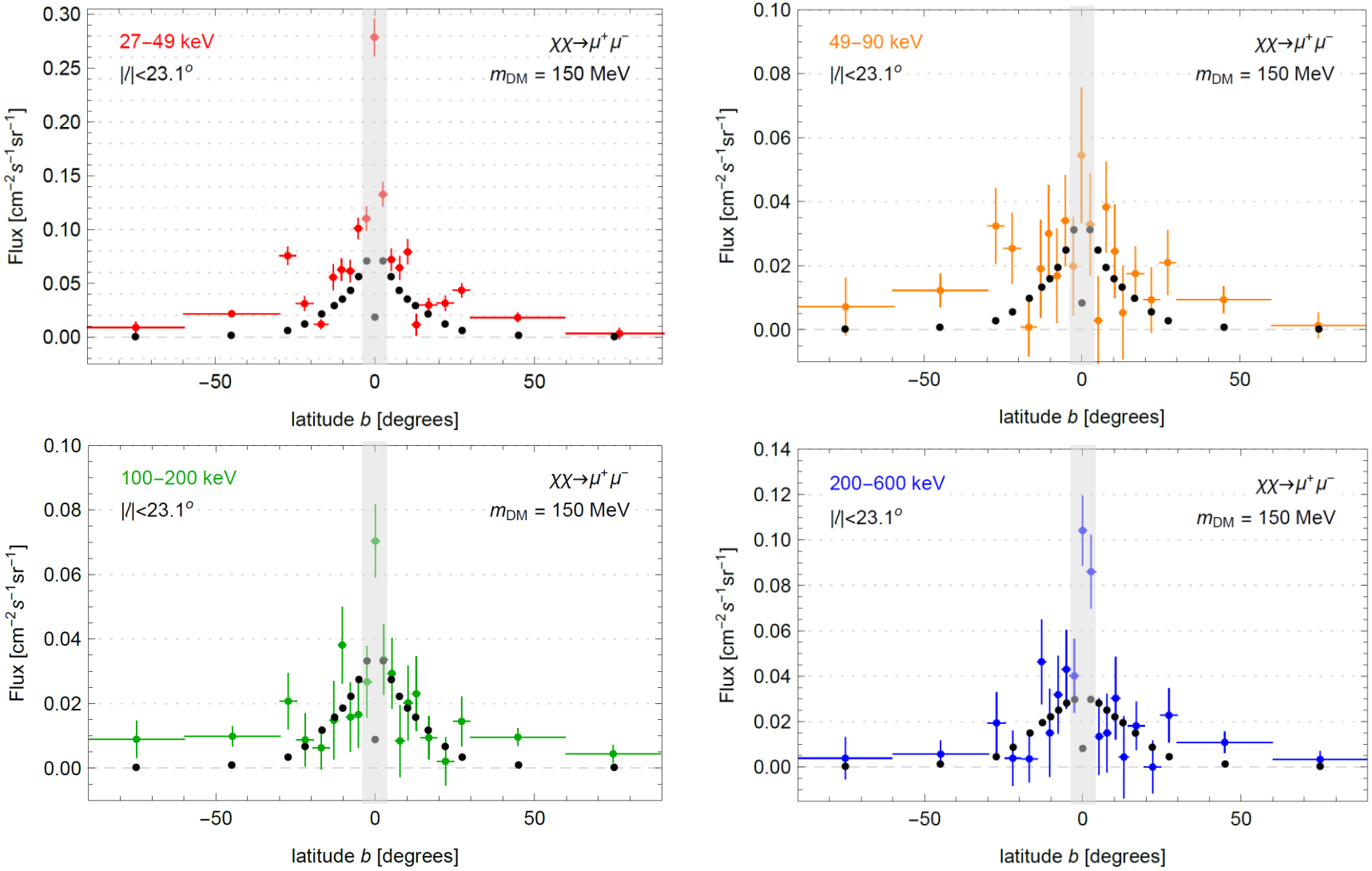
21 bins in latitude (15 for the fifth band)

-23.1° < l < 23.1° (|l|<60° for the fifth band)

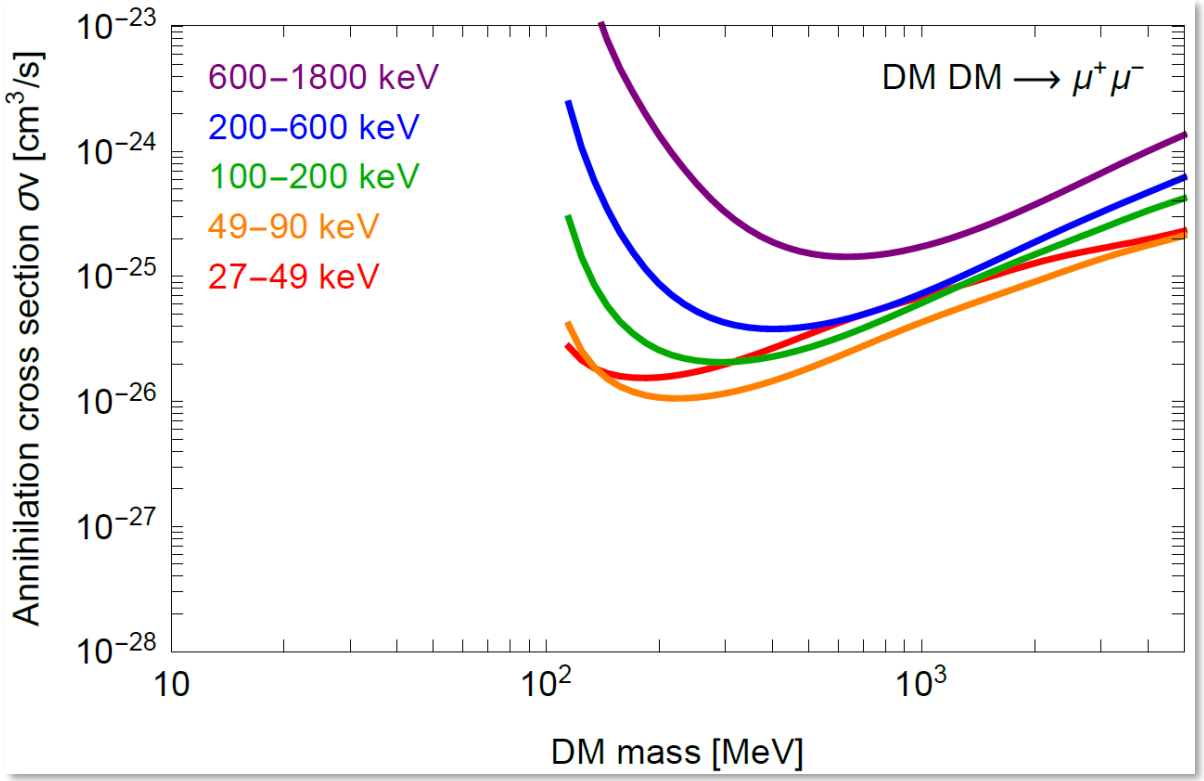


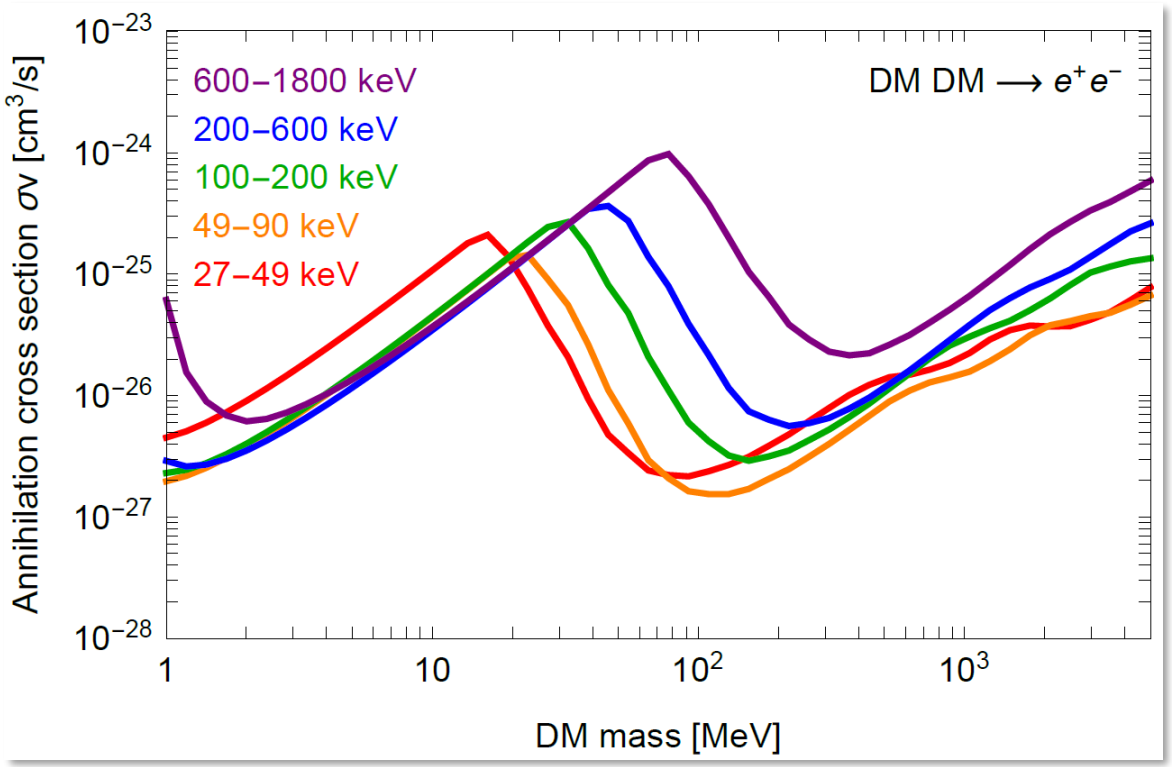
INTEGRAL data (green points)
Bouchet et al. (2011)

Angular profile

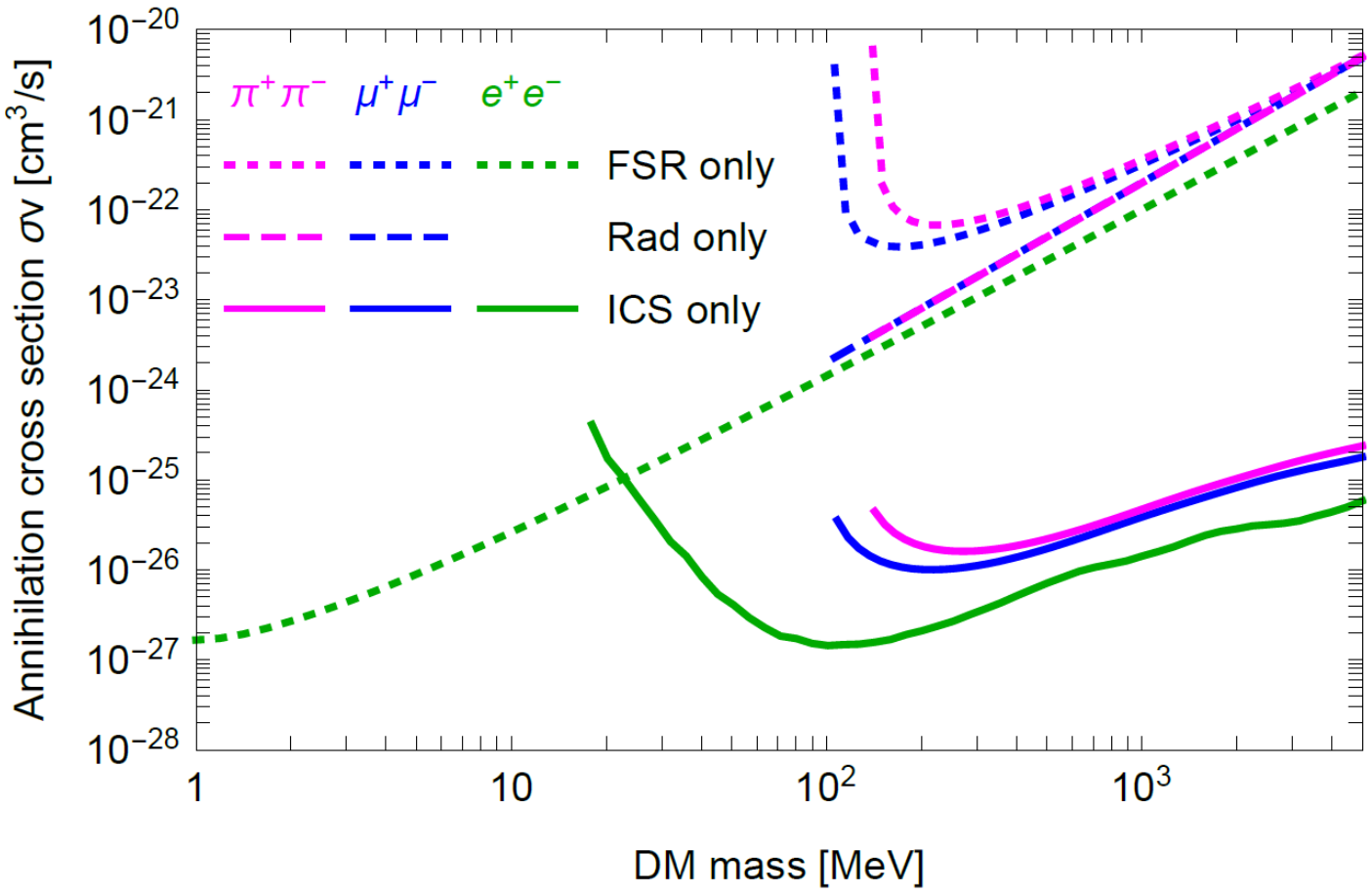


Bounds in the energy bands

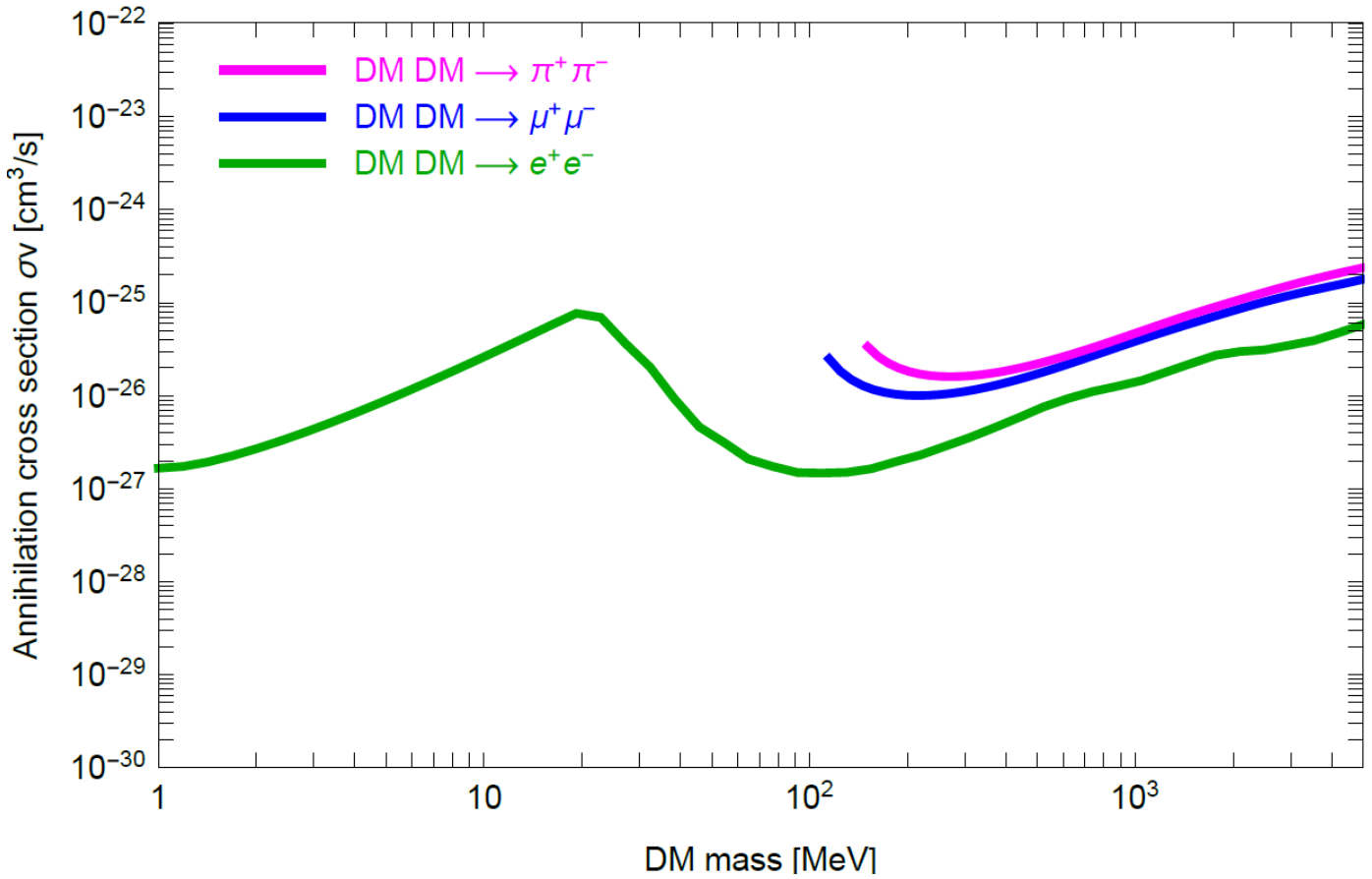




Bounds from FSR, Rad, ICS



Constraints on sub-GeV Dark Matter



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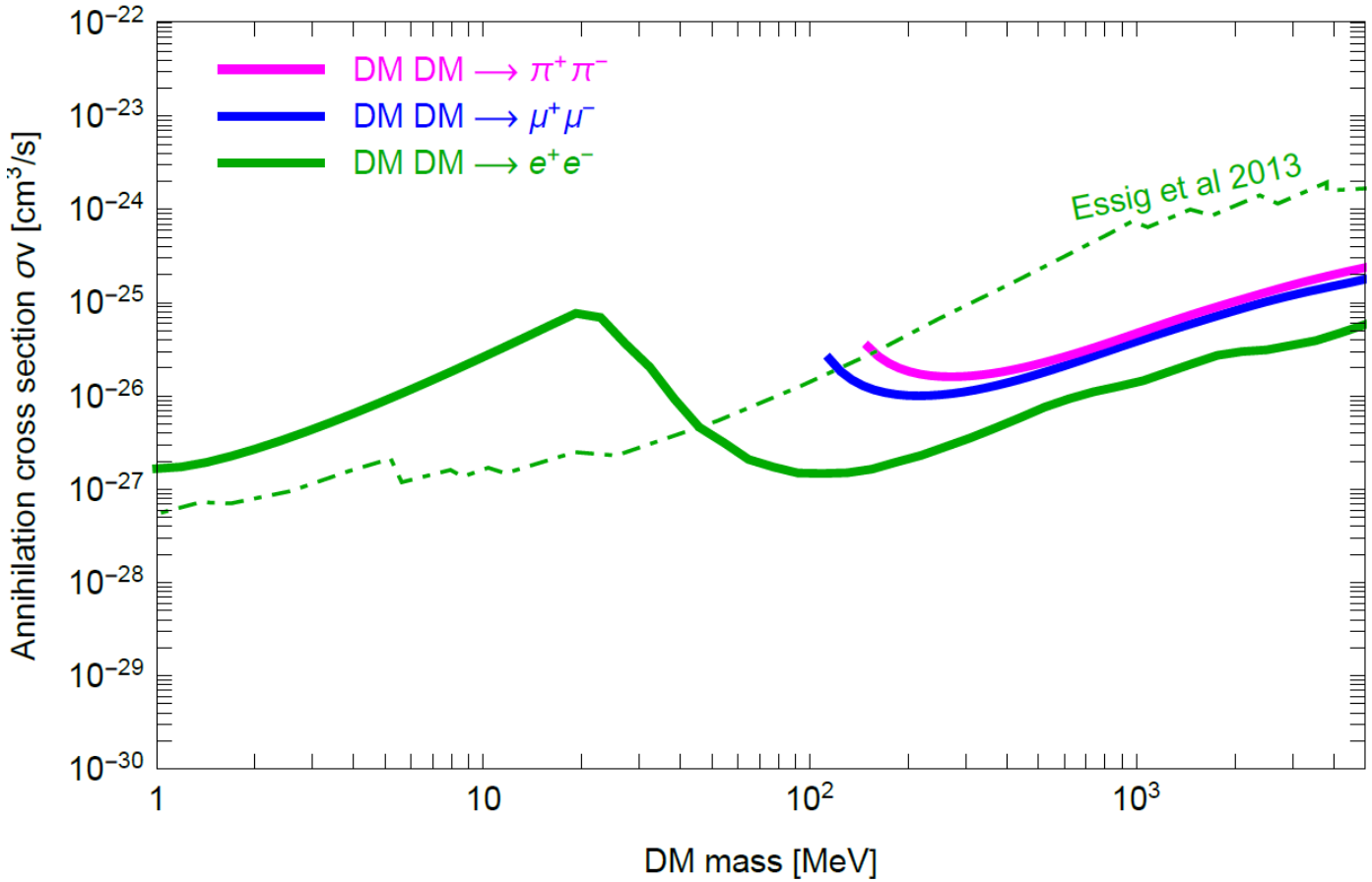
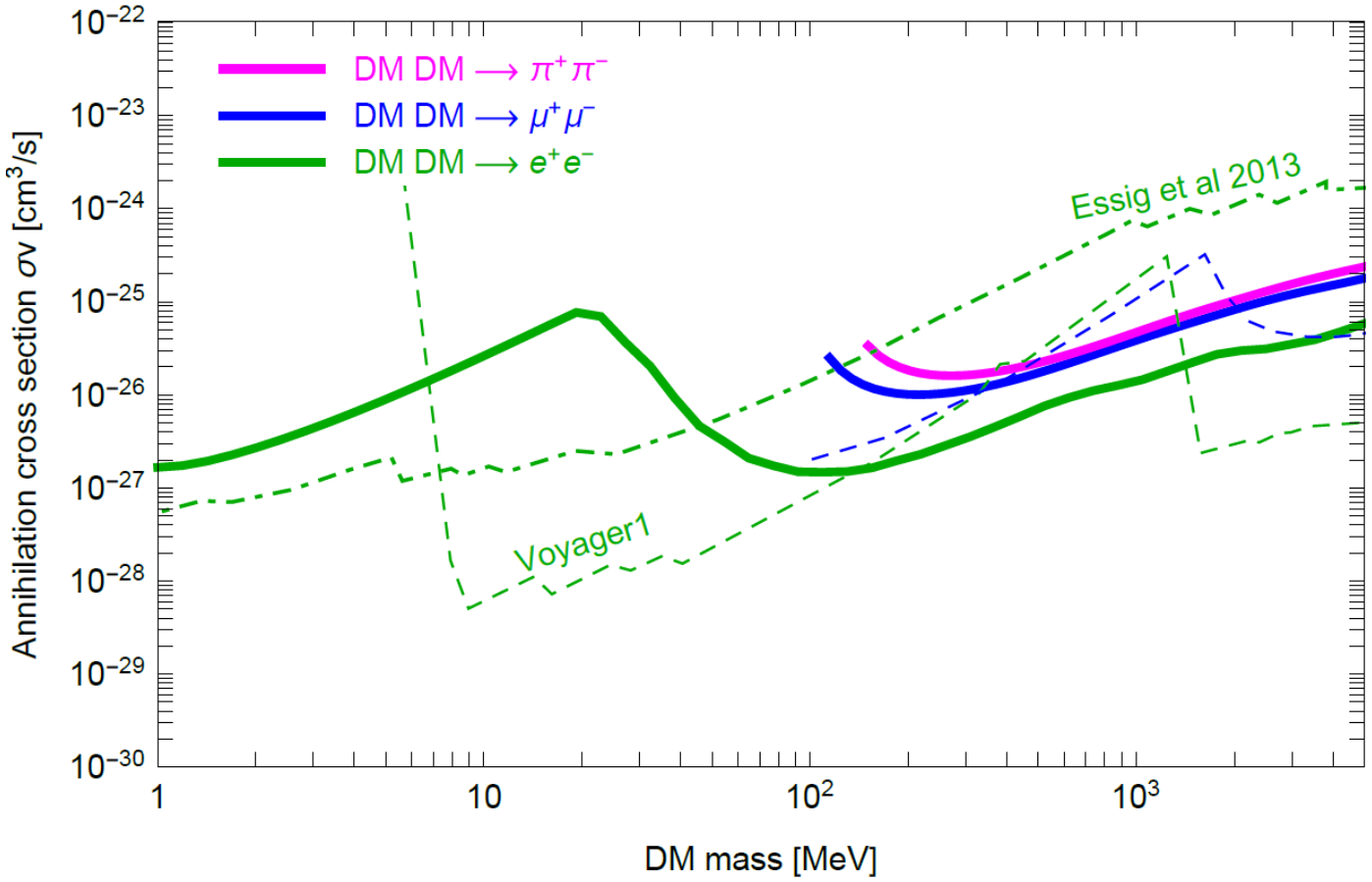


Essig et al., JHEP 11 (2013) 193

Constraints on sub-GeV Dark Matter



Boudaud et al., Phys. Rev. Lett. 119 (2017) 021103

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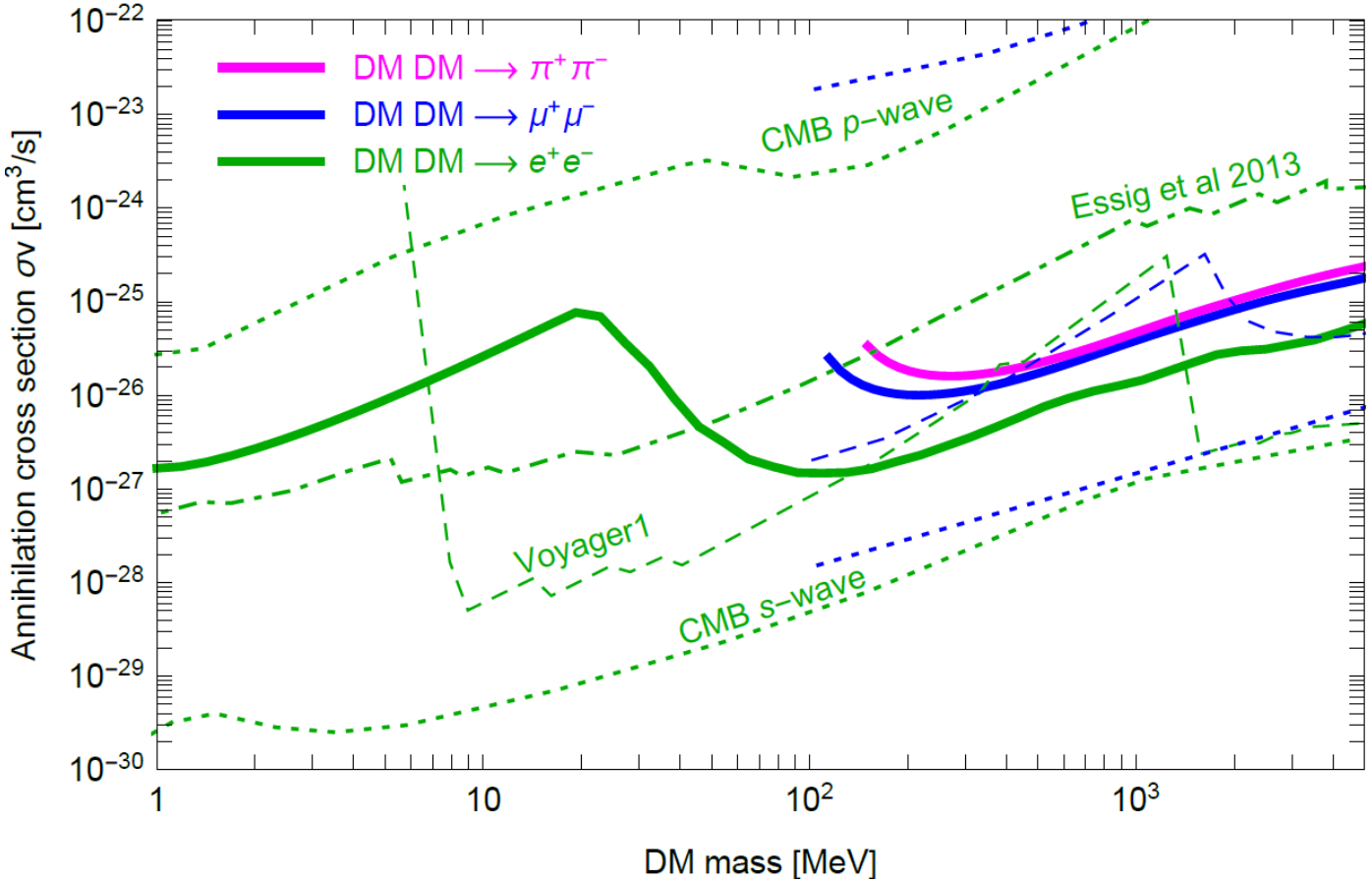


Slatyer, Phys. Rev. D 93 (2016) 023527

Lopez-Honorez et al., JCAP 07 (2013) 046

Diamanti et al., JCAP 02 (2014) 017

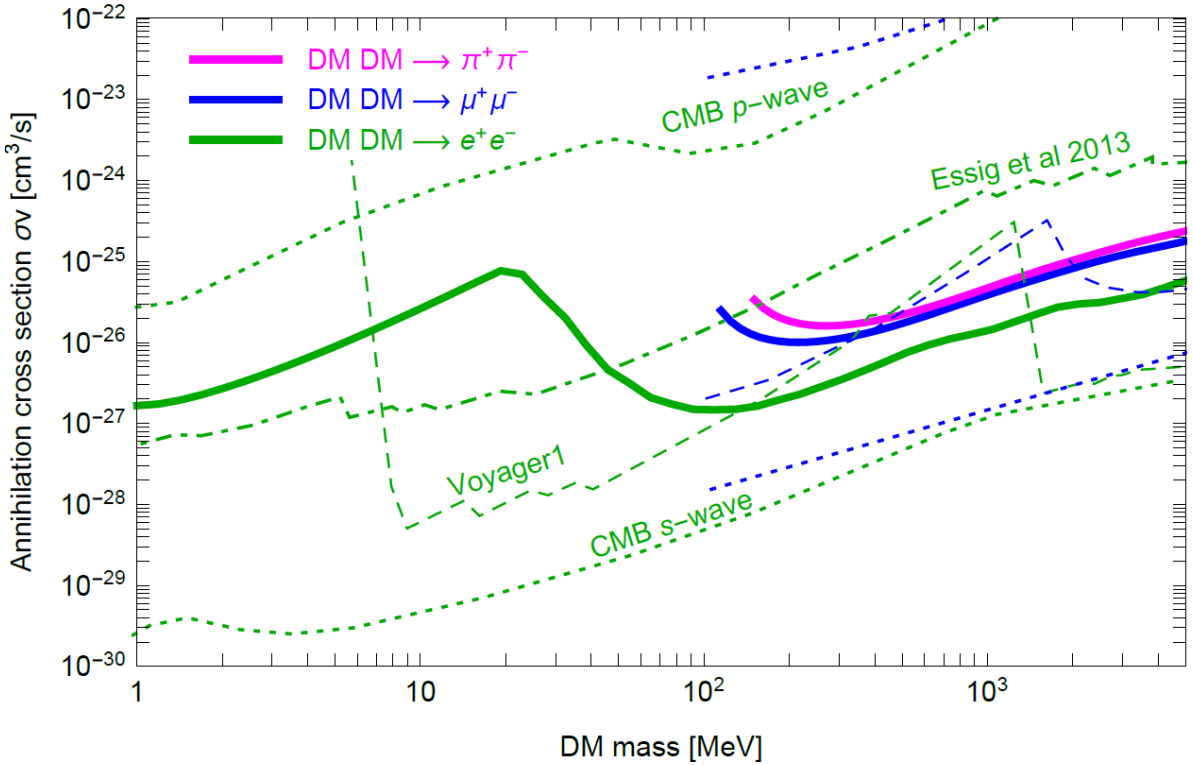
Liu et al., arXiv:2008.01084

Conclusions

- $1\ \text{MeV} \leq m_\chi \leq 5\ \text{GeV}$
- Include Inverse Compton Scattering
- X-ray data from INTEGRAL telescope

Strongest bound (if p-wave):

$150\ \text{MeV} \leq m_\chi \leq 1.5\ \text{GeV}$



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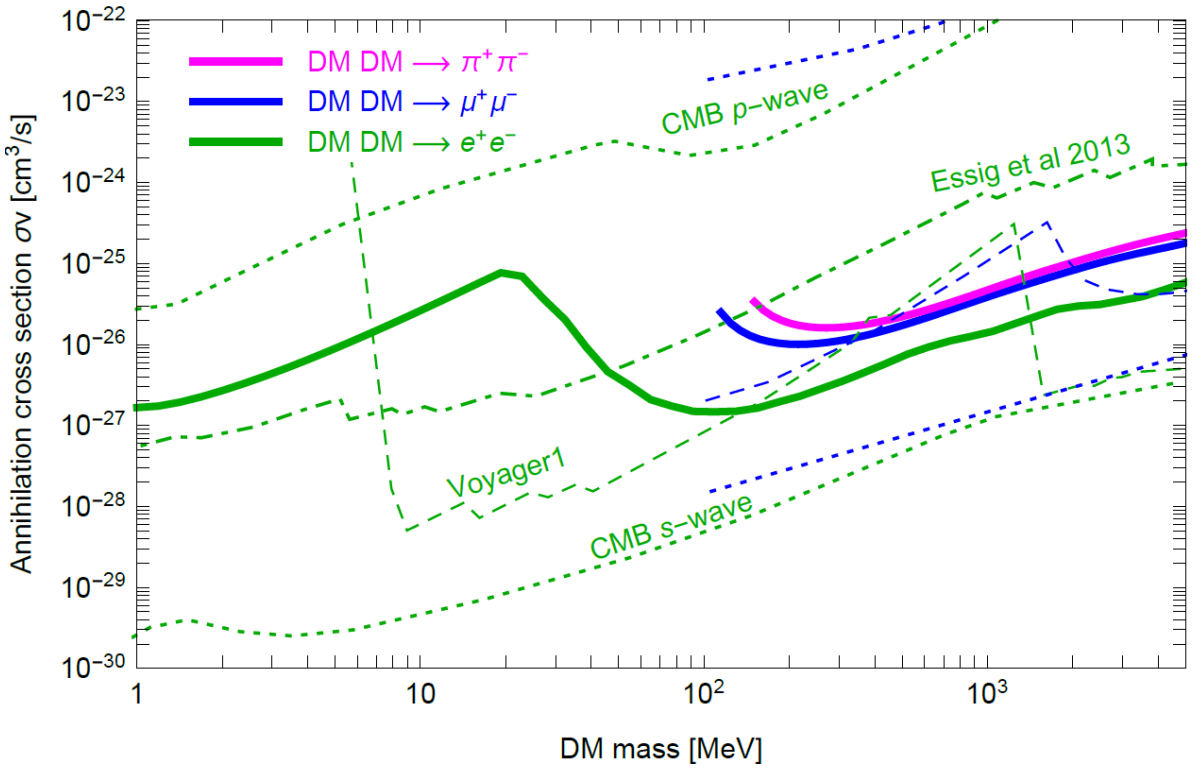

Thank you for your attention!