



INTEGRAL X-RAY CONSTRAINTS ON SUB-GEV DARK MATTER

Speaker: Elena Pinetti

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INTEGRAL X-ray constraints on sub-GeV Dark Matter

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

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Outline

- ❑ Motivation for Sub-GeV Dark Matter
- ❑ Inverse Compton Scattering
- ❑ INTEGRAL X-ray data
- ❑ Constraints in the DM parameter space

Beyond WIMPs



**KEEP
CALM**

AND

**DON'T BE A
WIMP**

Direct Detection:

Schumann, J. Phys. G 46 (2019)

Indirect Detection:

Cirelli, PoS ICRC2015 (2016) 014

Gaskins, Contemp. Phys. 57 (216) 496-525

Hooper, PoS TASI2018 (2019) 010

Collider:

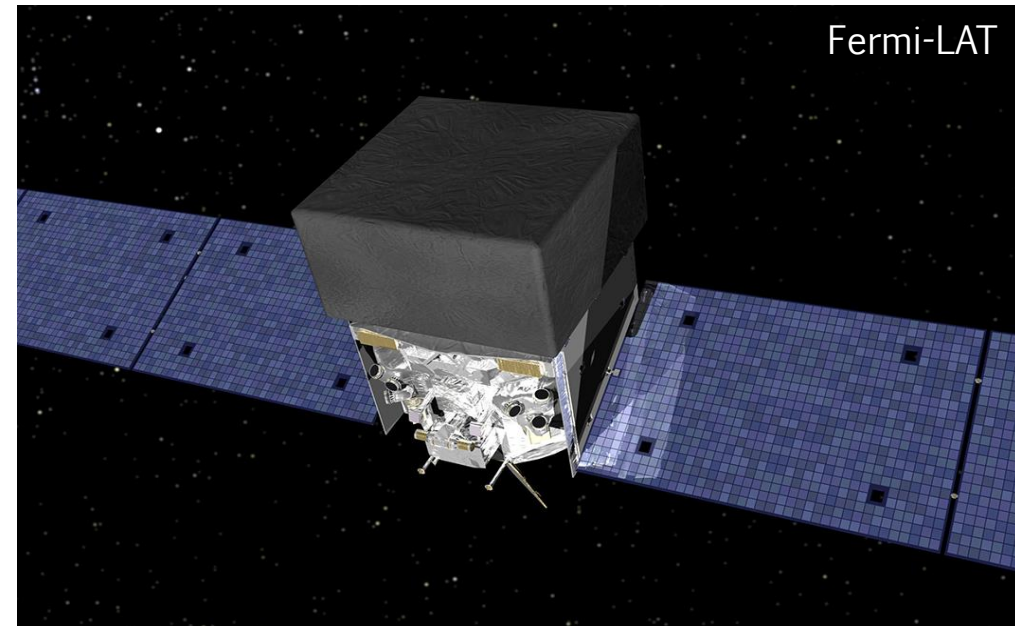
Buchmueller et al, Nature Phys. 13 (2017) 217-223

Kahlhoefer, Int. J. Mod. Phys. A32 (2017) 1730006

Indirect Detection of sub-GeV dark matter

Messengers produced by annihilation or decay of DM particles in the galaxy and beyond:

- Charged CR (e^\pm)
- ν
- Photons (γ rays, X rays)



MeV Gap

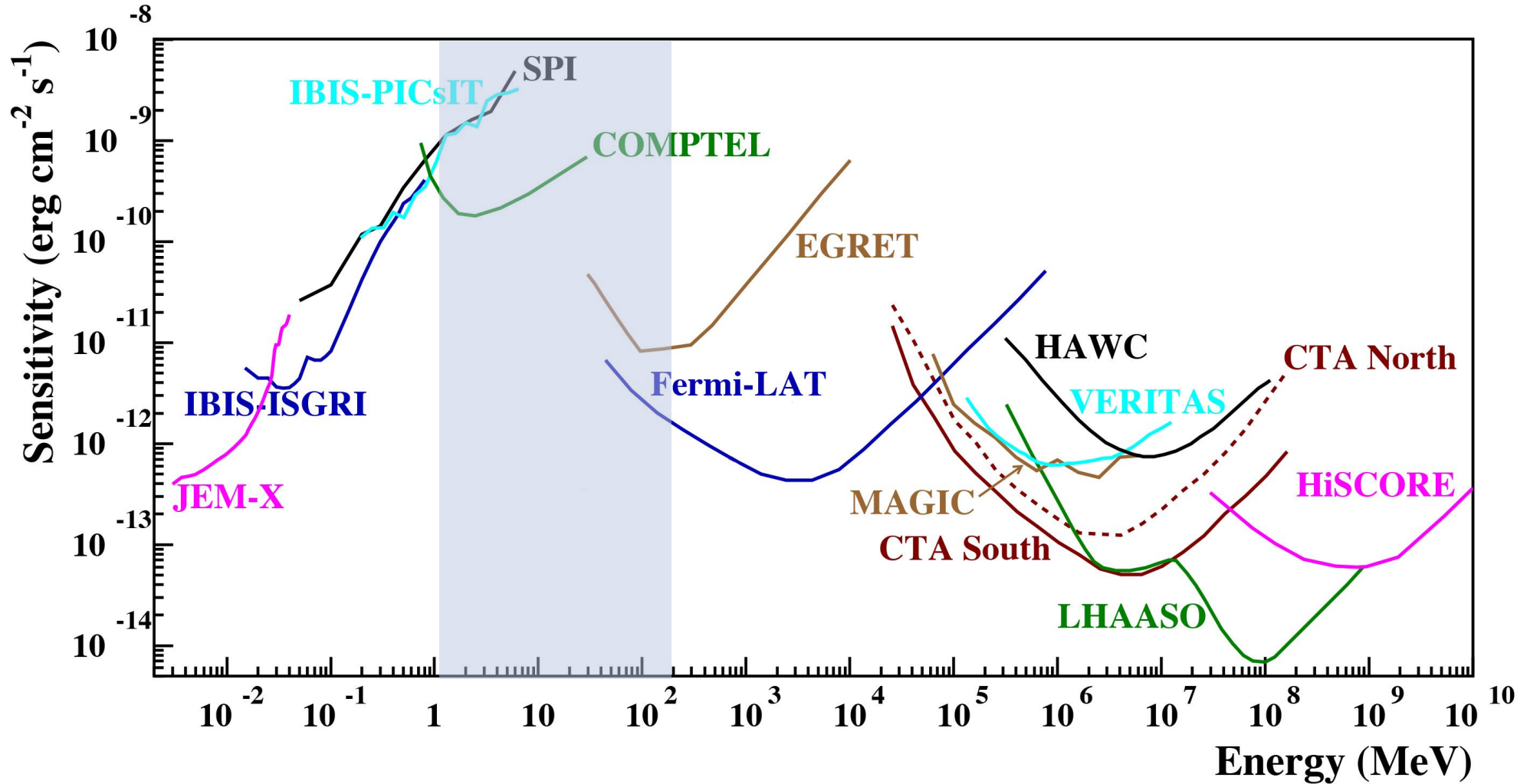


Figure adapted from Tatischeff+, arxiv:1805.06435

MeV Gap

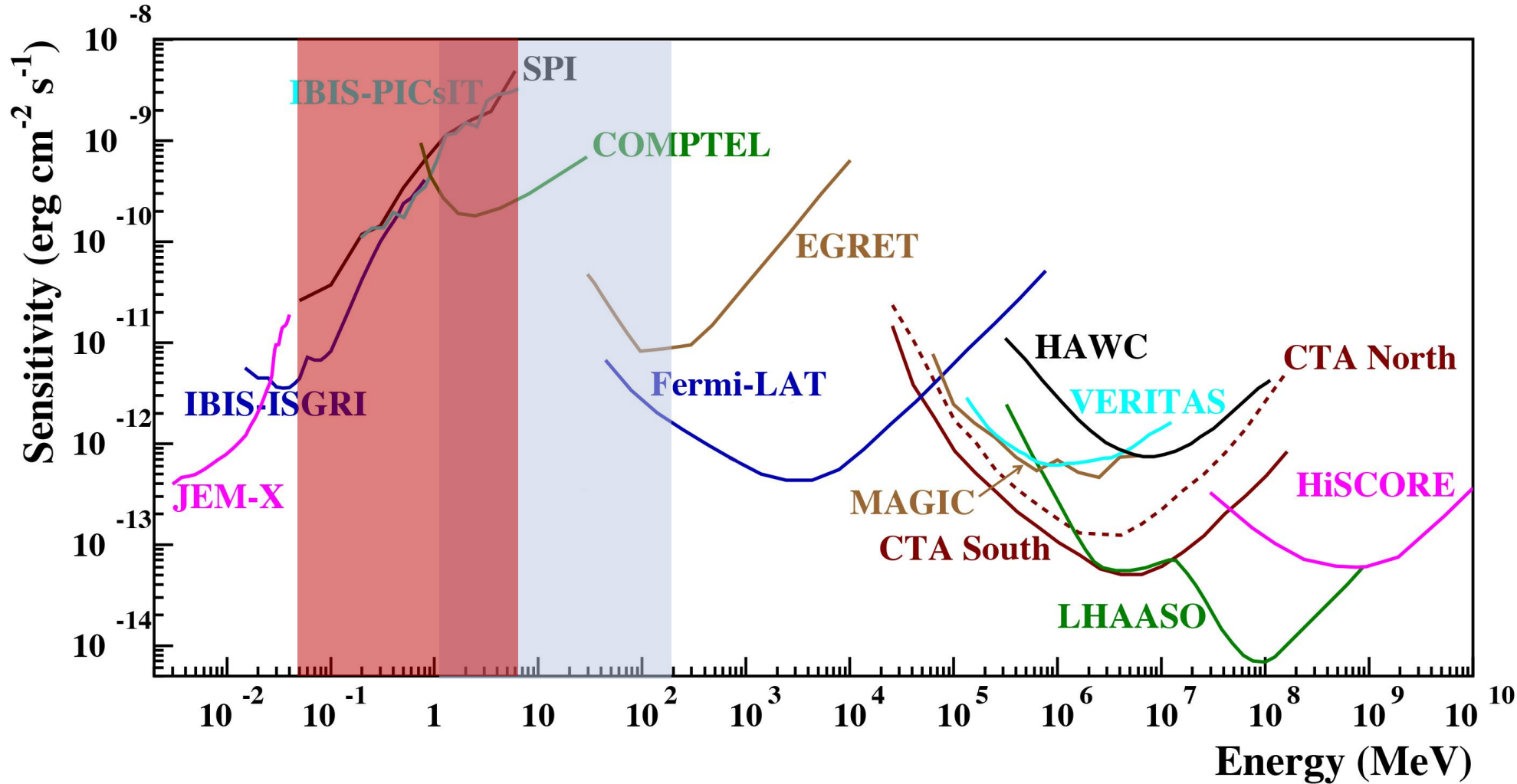


Figure adapted from Tatischeff+, arxiv:1805.06435

Annihilation channels

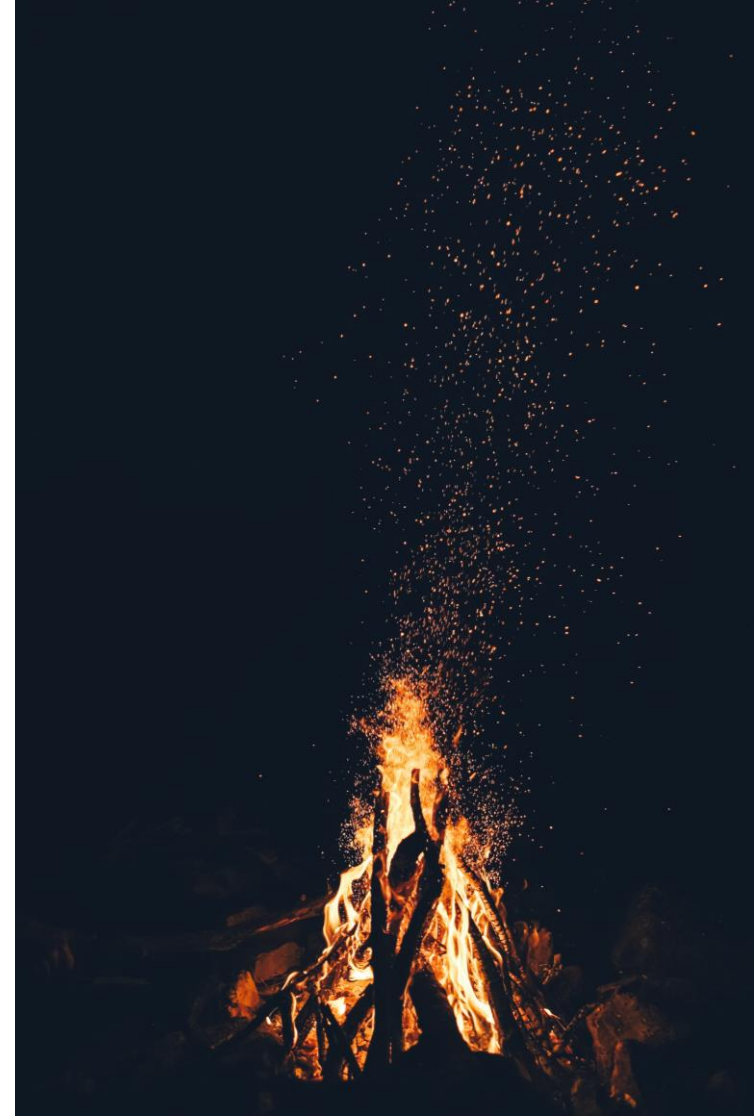
$$1 \text{ MeV} \leq m_\chi \leq 5 \text{ GeV}$$

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

$$\chi\chi \rightarrow \mu^+\mu^-$$

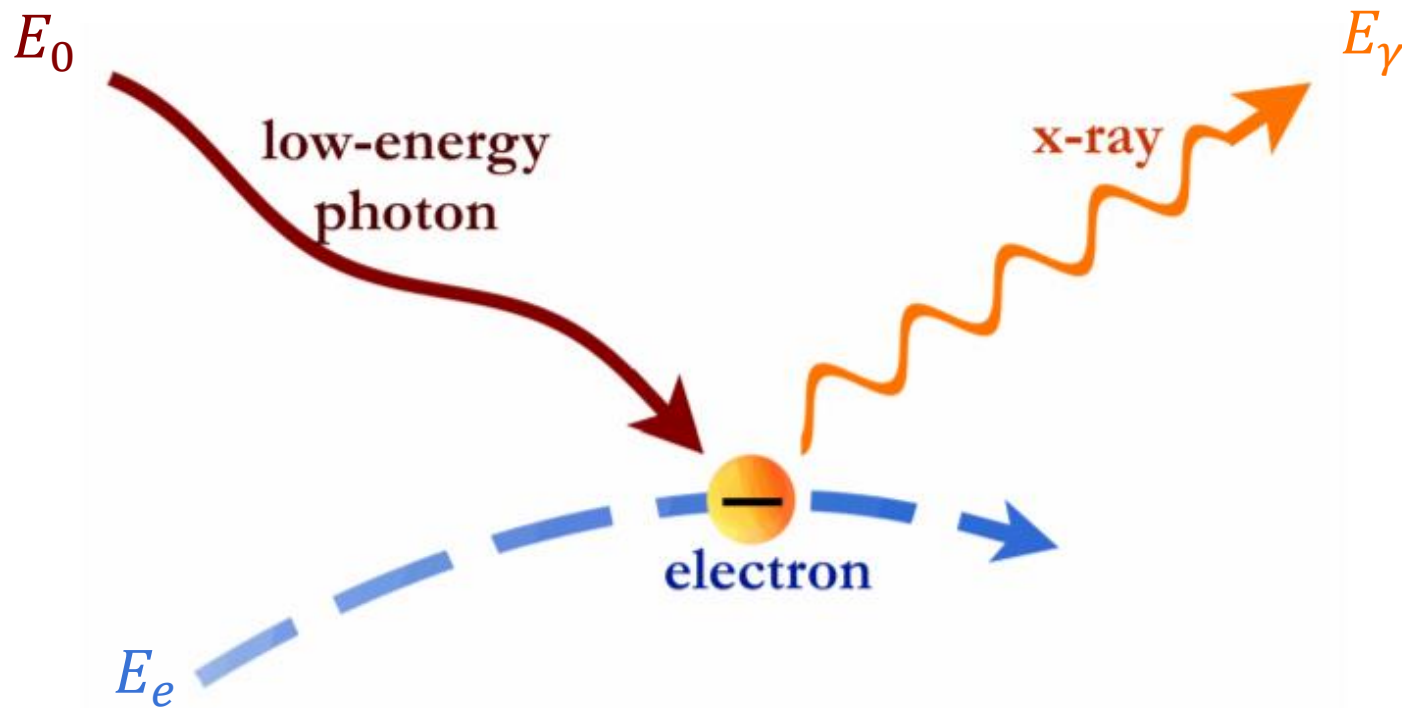
$$\chi\chi \rightarrow \pi^+\pi^-$$

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



Inverse Compton Scattering

$$\chi\chi \rightarrow (\dots) \rightarrow e^+ e^-$$



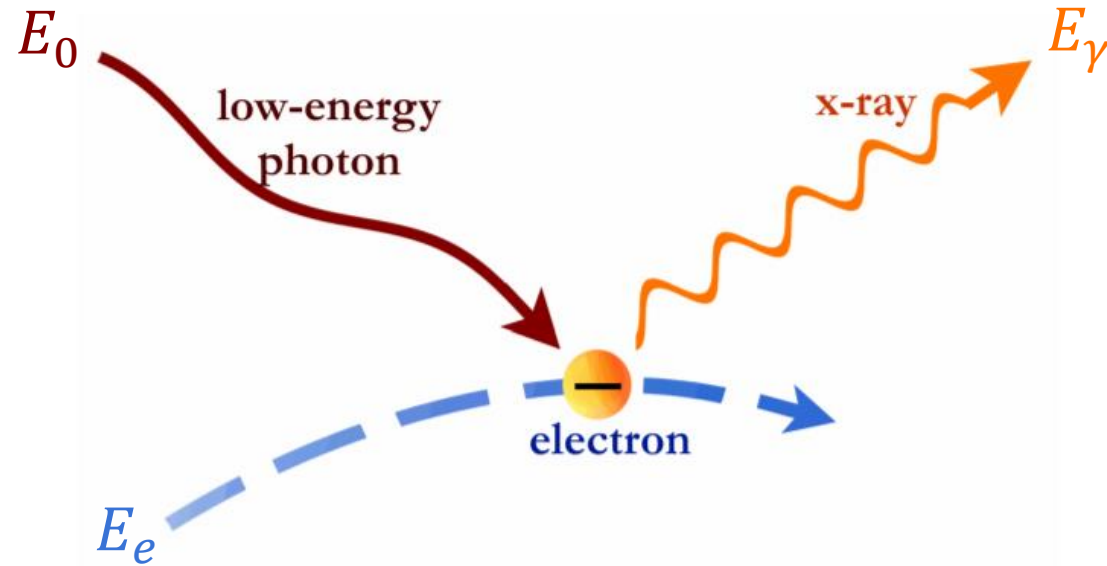
3 kind of photons:

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

X rays

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

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

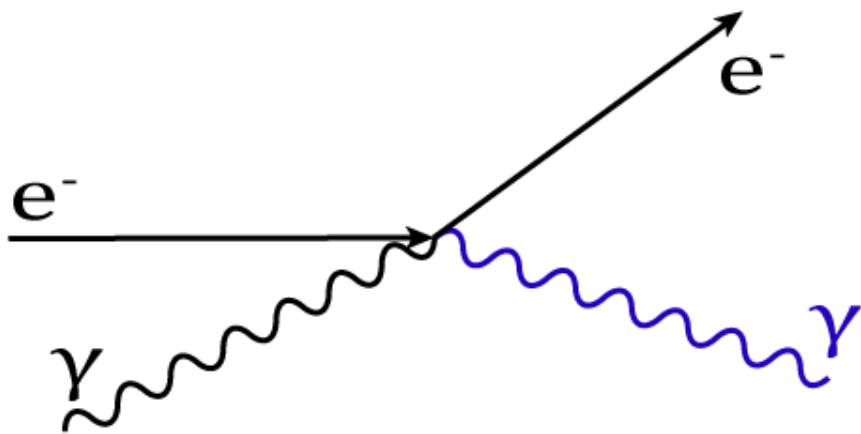


Type	E_0 [eV]	E_e [GeV]	E_γ [keV]
CMB	10^{-4}	5	40
IR	10^{-2}	0.5	40
Opt	10	0.05	400

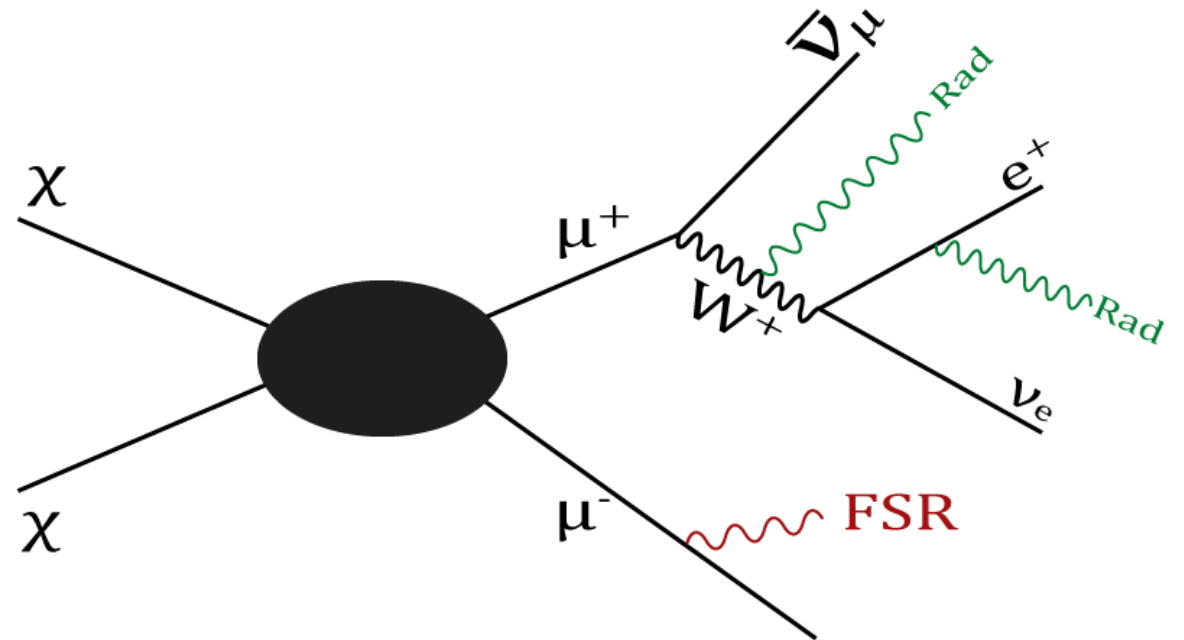
} X rays

Total Flux

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



Inverse Compton Scattering



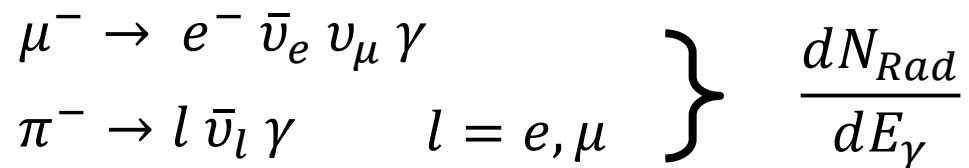
Final State Radiation

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

Particle
Properties

Energy spectrum per
annihilation event

Radiative Decay:

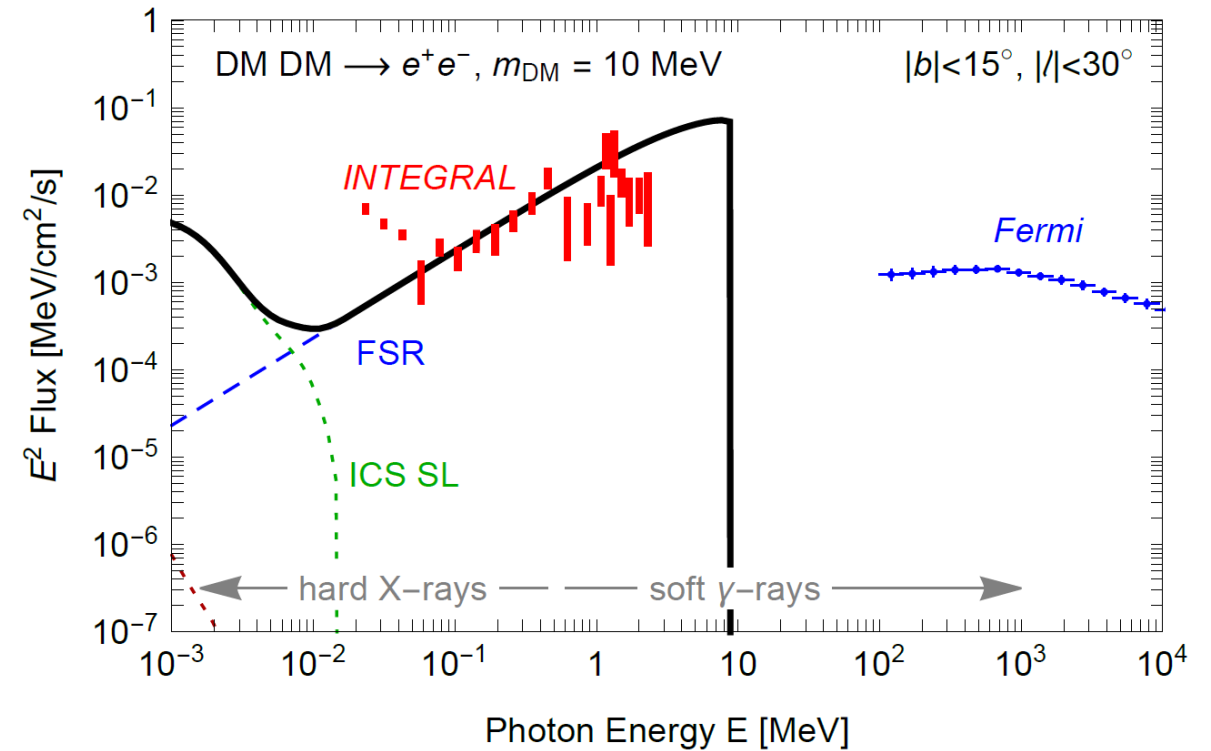
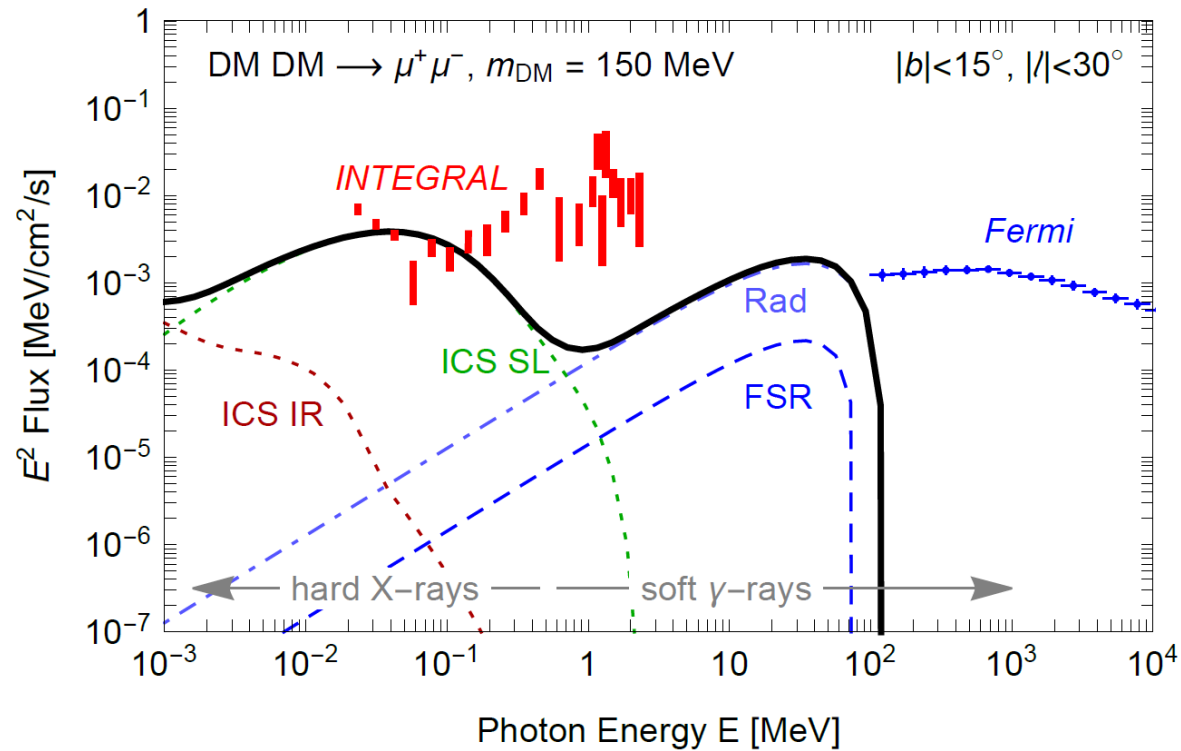


Angle in the sky DM density

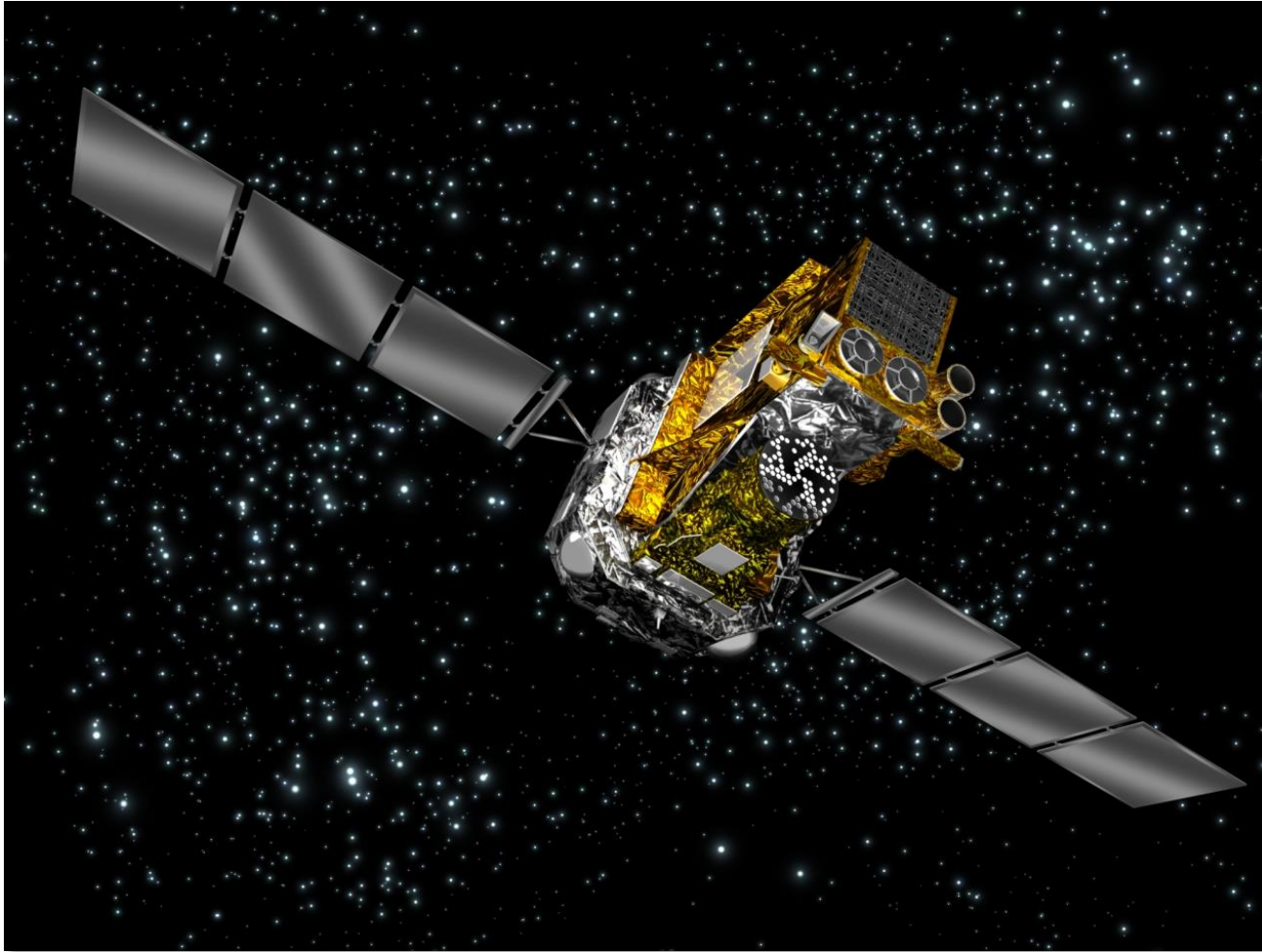
$$J(\theta) = \int_{l.o.s} \rho^2(r(s, \theta)) ds$$

Line of sight

Photon Spectra



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

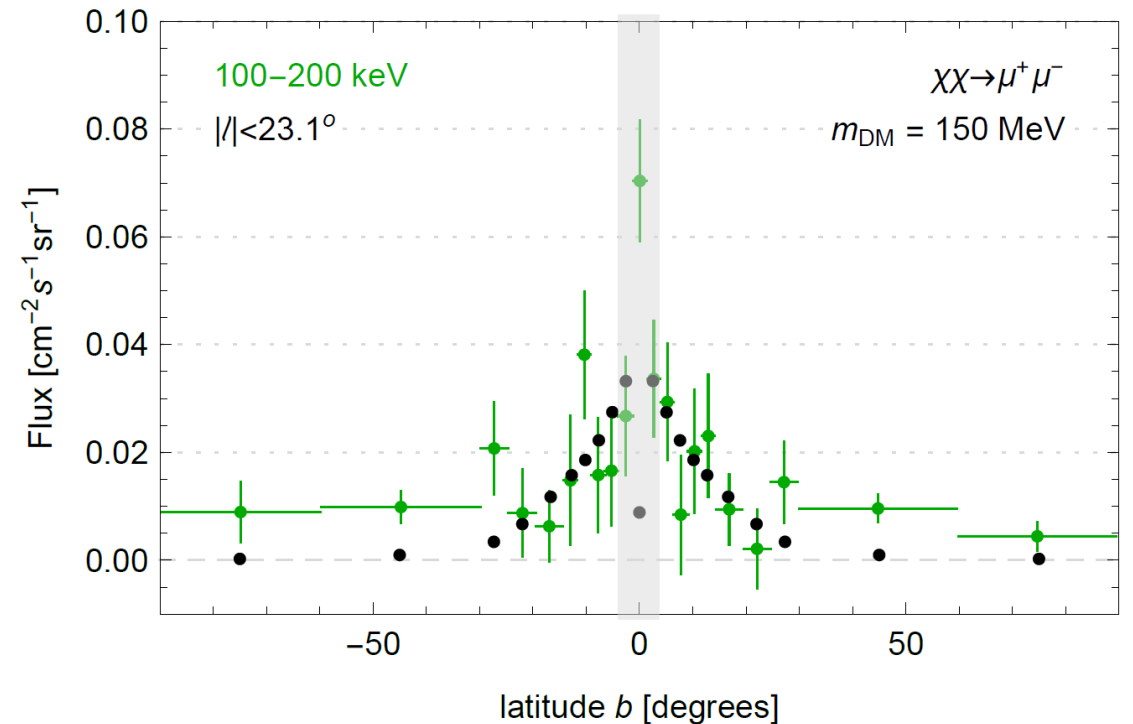
Data sets

5 energy bands:

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

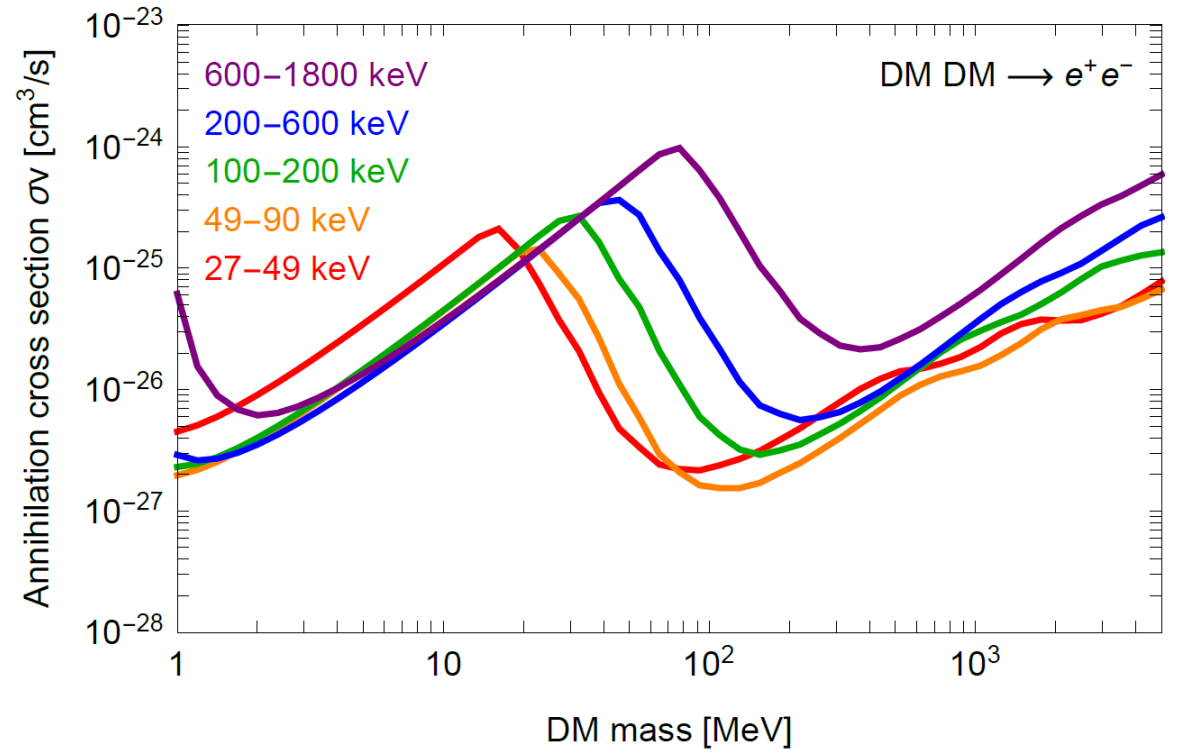
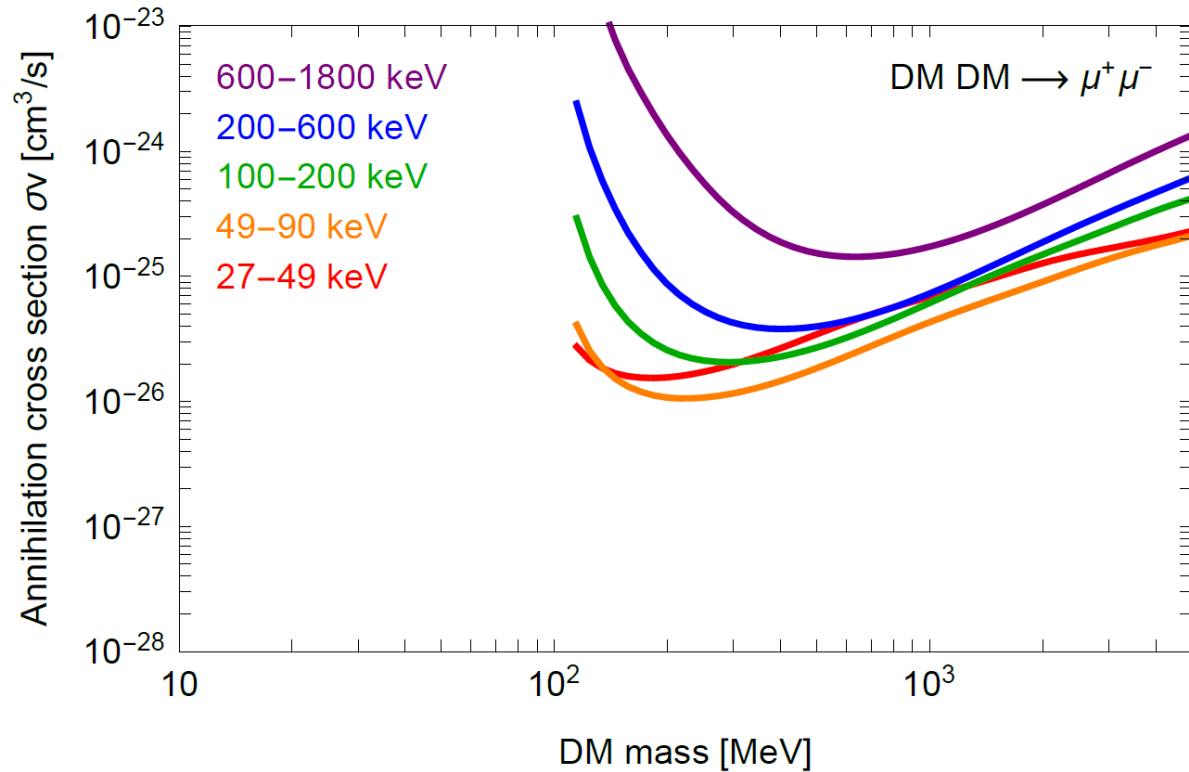
21 bins in latitude (15 for the fifth band)

$-23.1^\circ < l < 23.1^\circ$ ($|l| < 60^\circ$ for the fifth band)

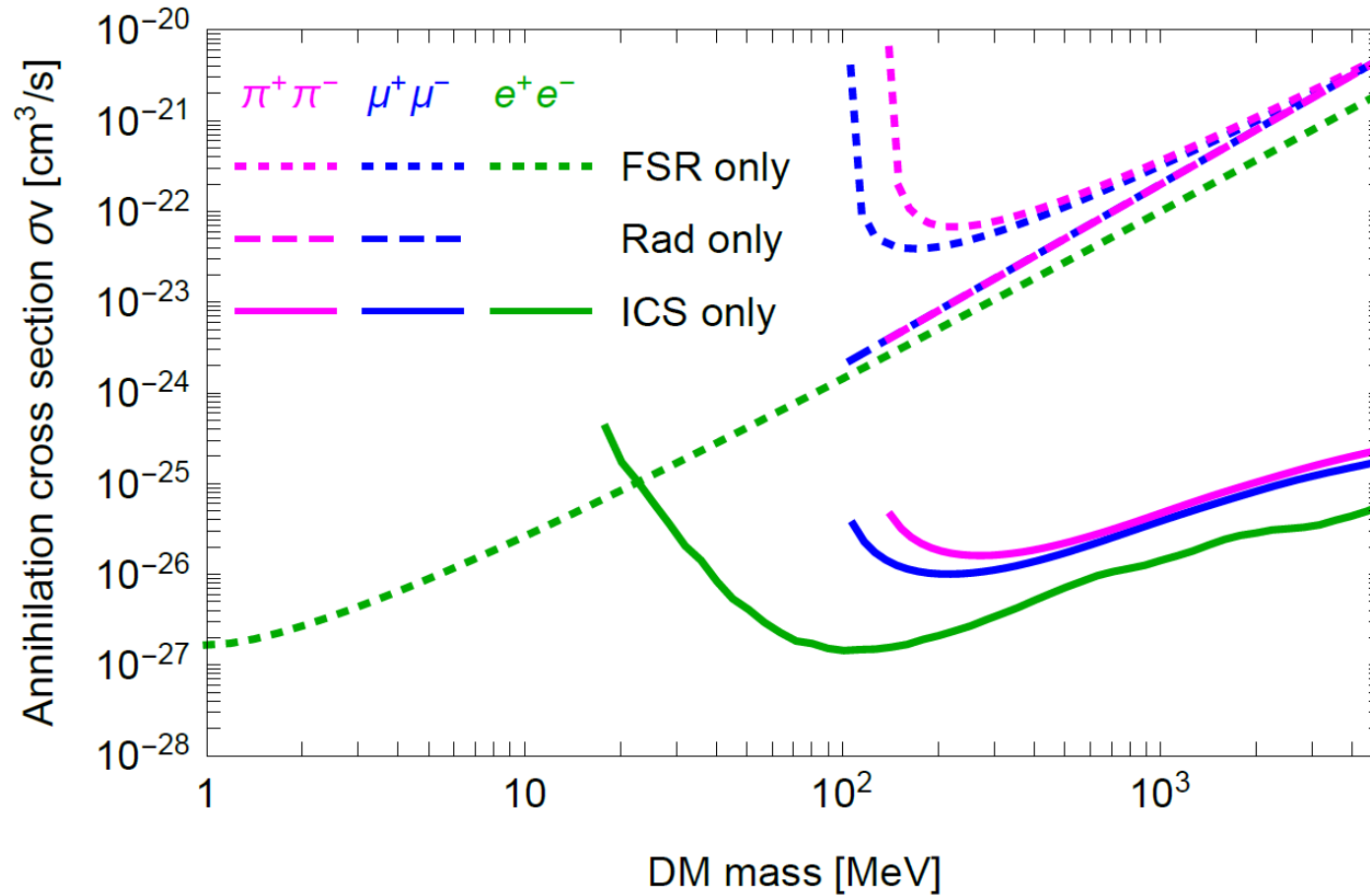


INTEGRAL data (green points)
Bouchet et al. (2011)

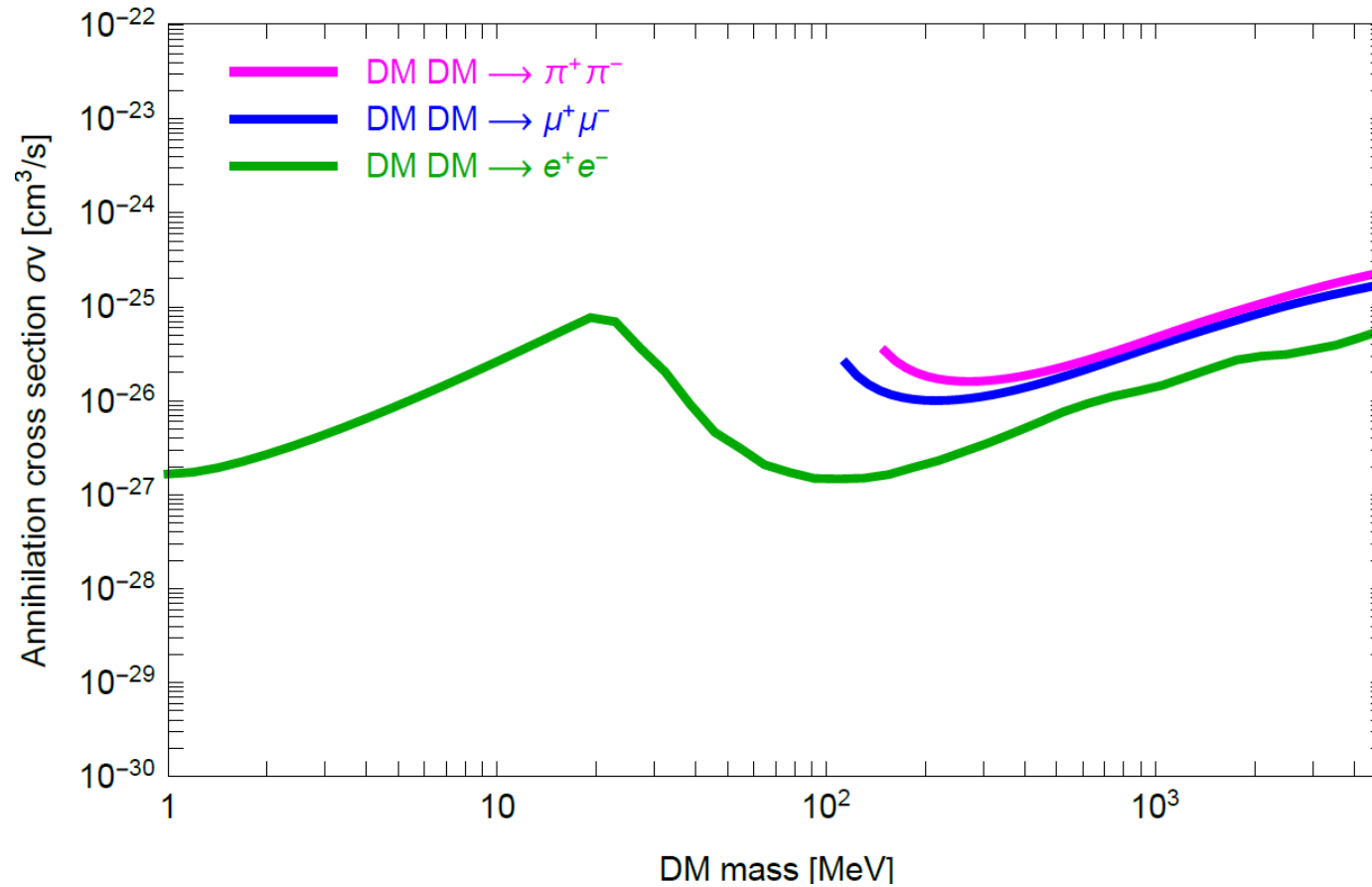
Bounds in the energy bands



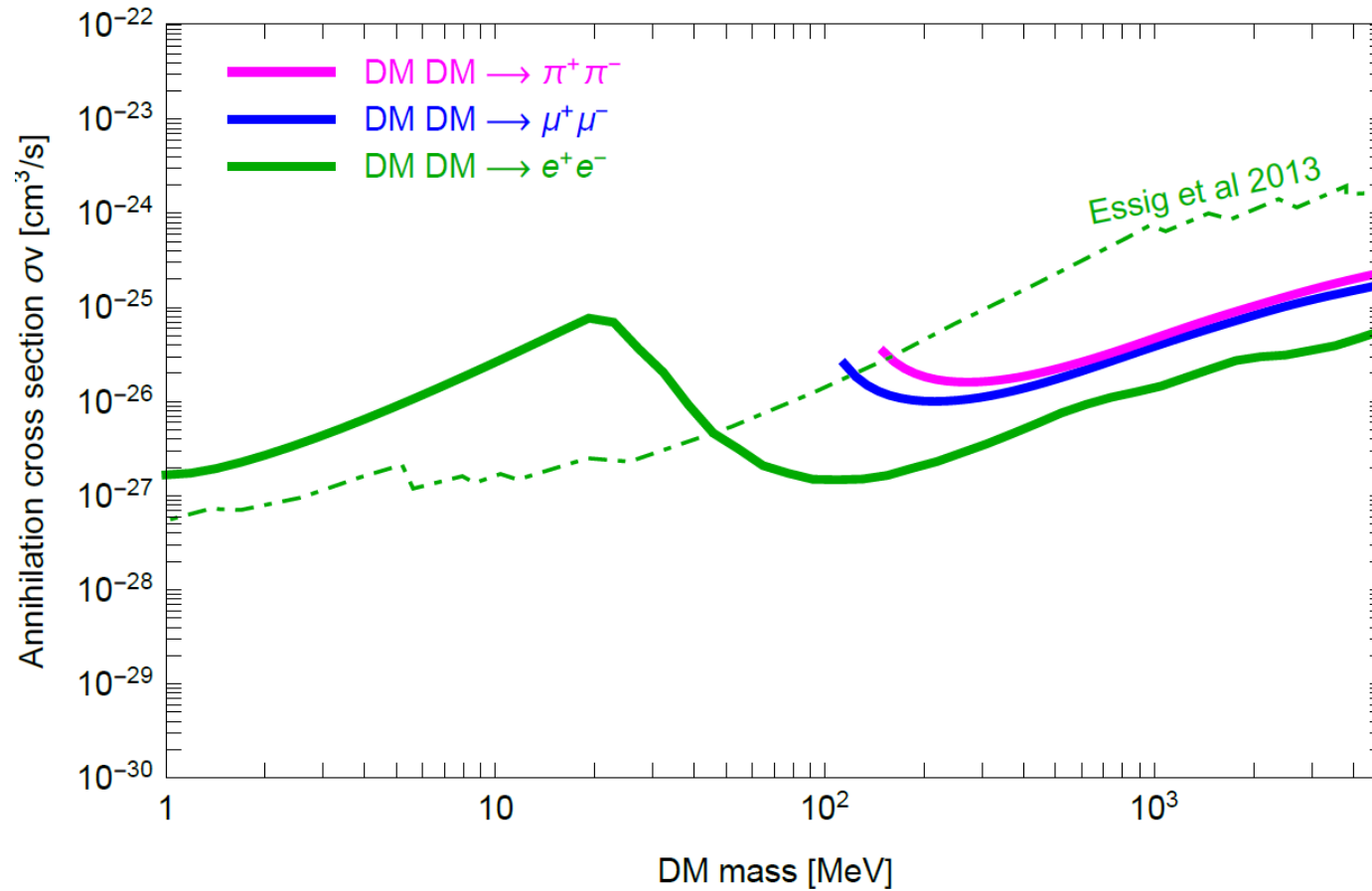
Bounds from FSR, Rad, ICS



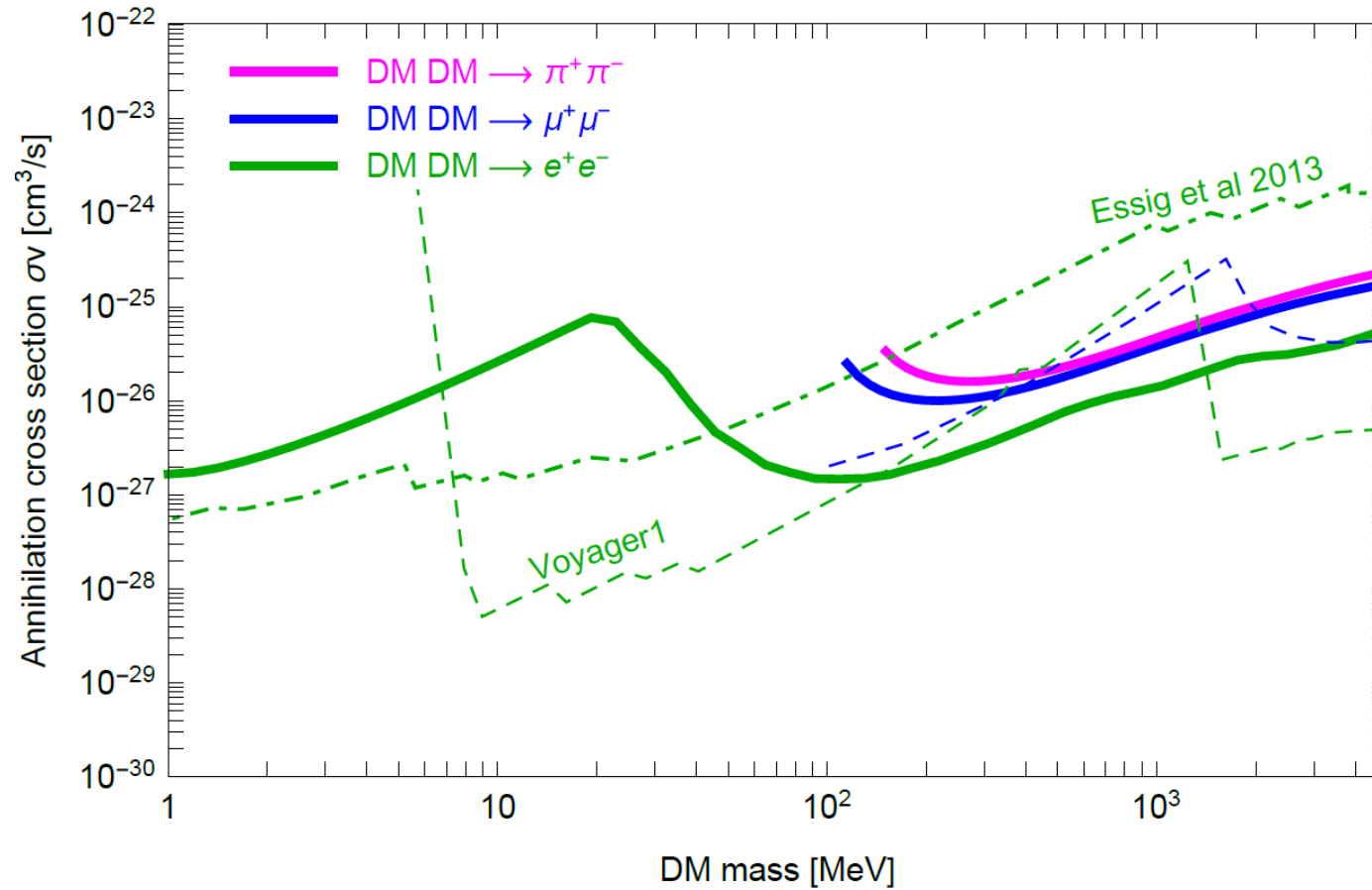
Constraints on sub-GeV Dark Matter



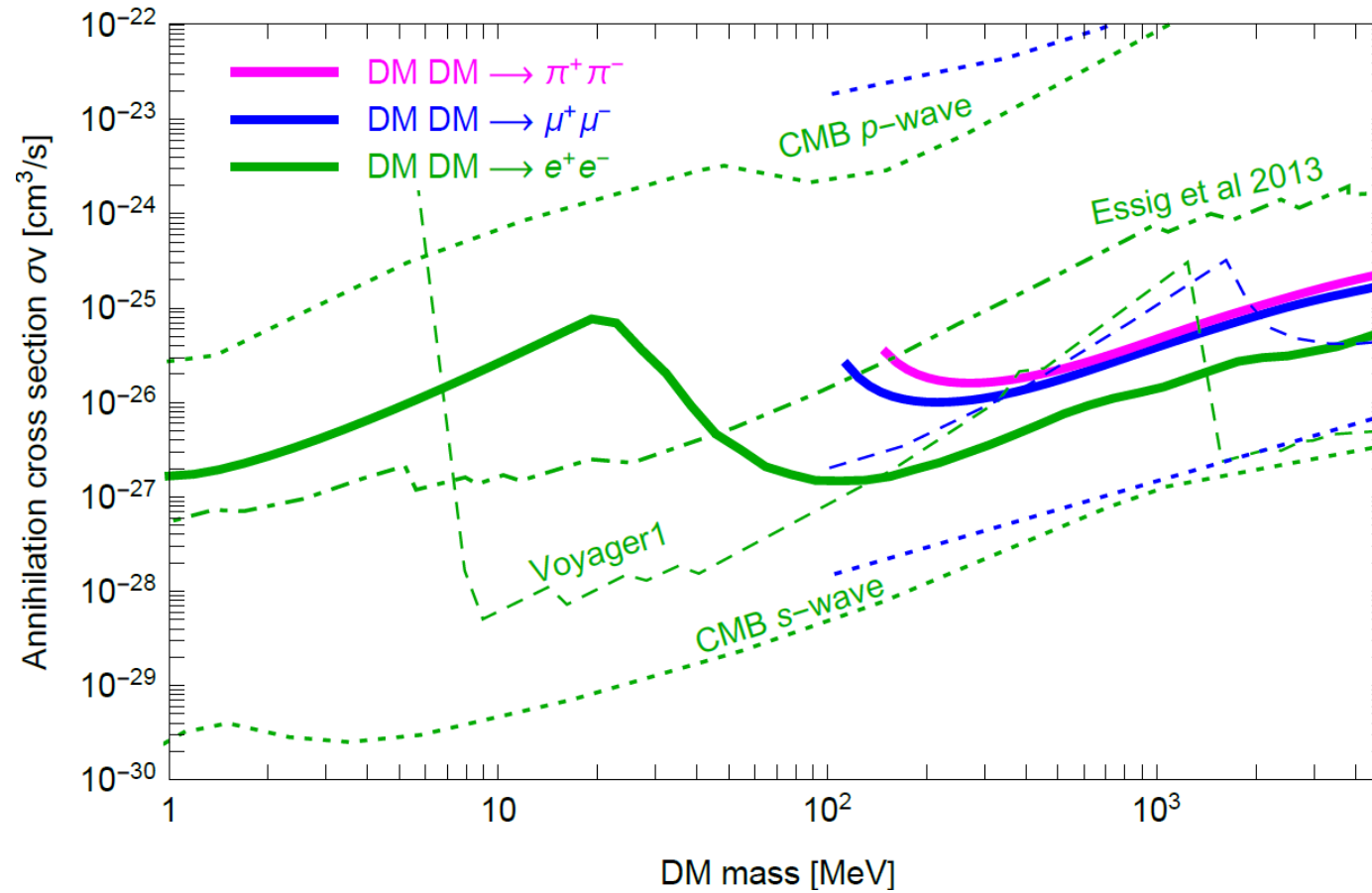
Constraints on sub-GeV Dark Matter



Constraints on sub-GeV Dark Matter



Constraints on sub-GeV Dark Matter

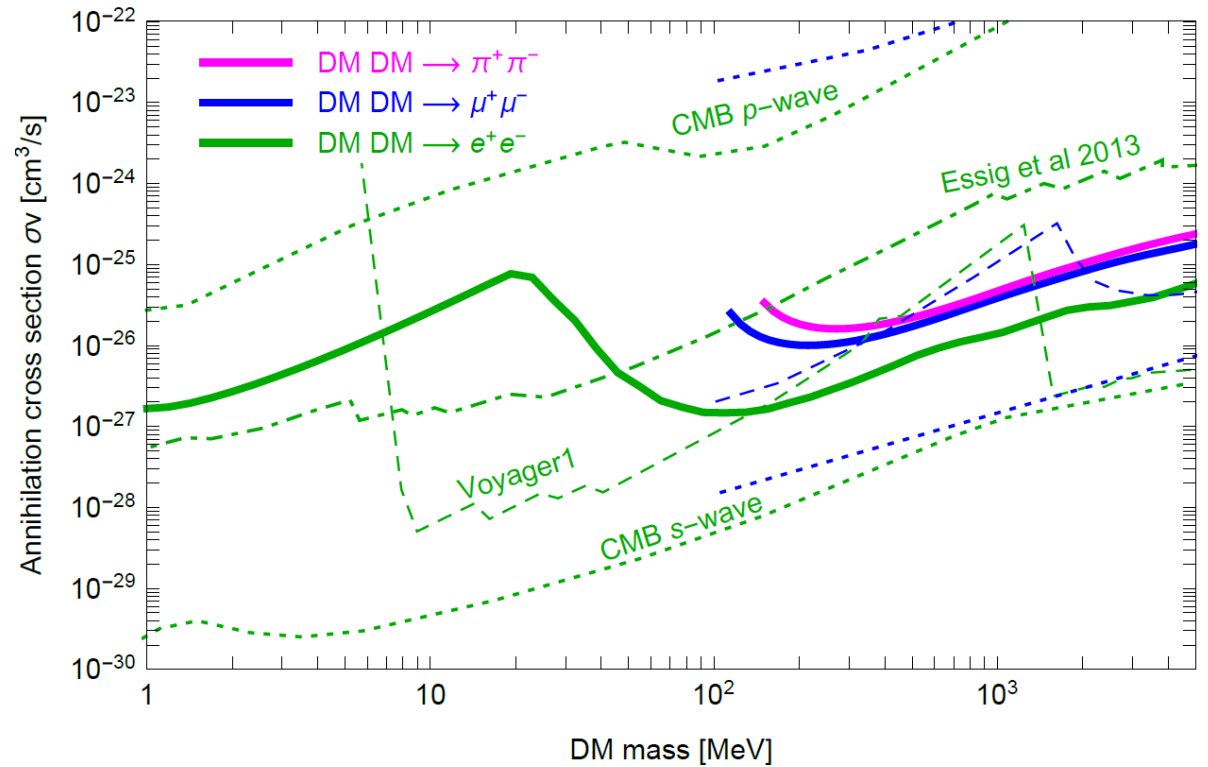


Conclusions

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

Strongest bound (if p-wave):

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

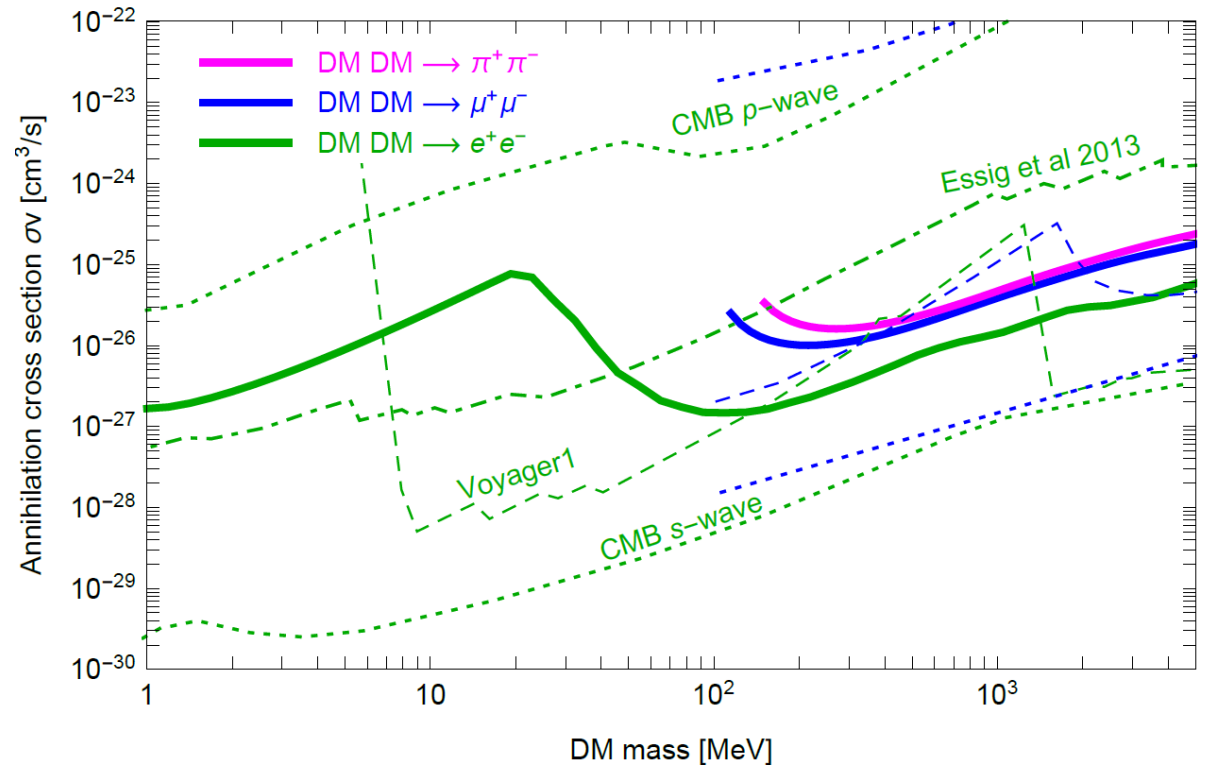


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Thank you for your attention!