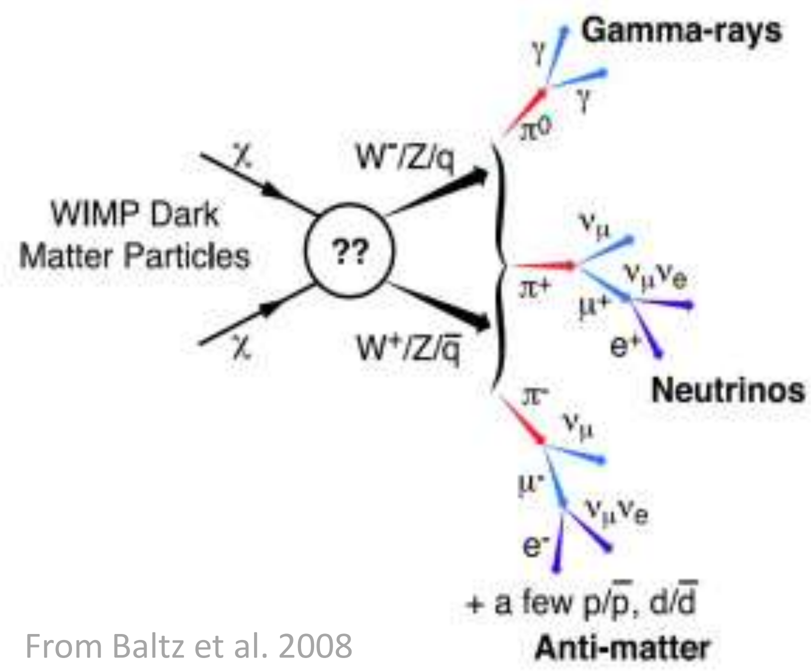
Indirect Search for scotogenic WIMP Dark Matter



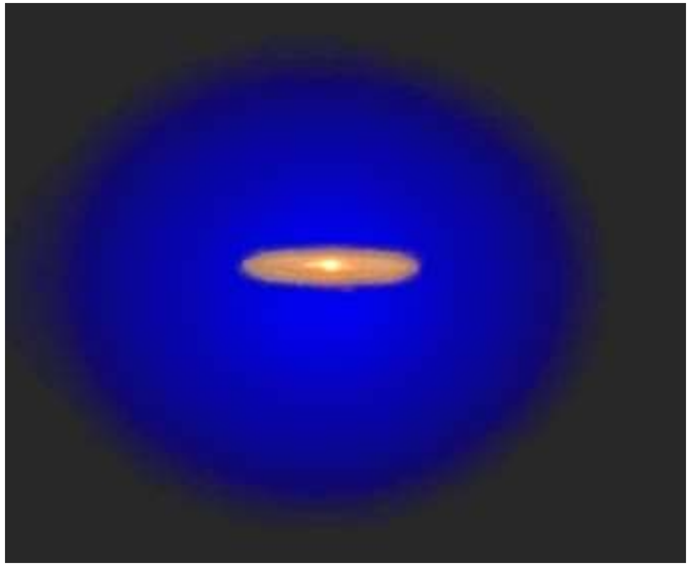
From Baltz et al. 2008

Laura Eisenberger

University of Würzburg

Dark Matter Workshop

Würzburg 2023



From chandra.as.utexas.edu

New Promising Dark Matter Candidate

- **WIMP**: Weakly Interacting Massive Particle
- **Scotogenic** models: additional Z_2 symmetry
(SM particles: even, new particles: odd)
- T1-2-A‘ model: explains neutrino masses, the muon anomalous magnetic moment and consistent with limits for cLFV decays

$\Downarrow$

new WIMP DM type (**m≈1.1 TeV**) consistent with limits from direct DM detection experiments

A. Alvarez et al.: Leptogenesis and muon g-2 in a scotogenic model: arXiv:2301.08485

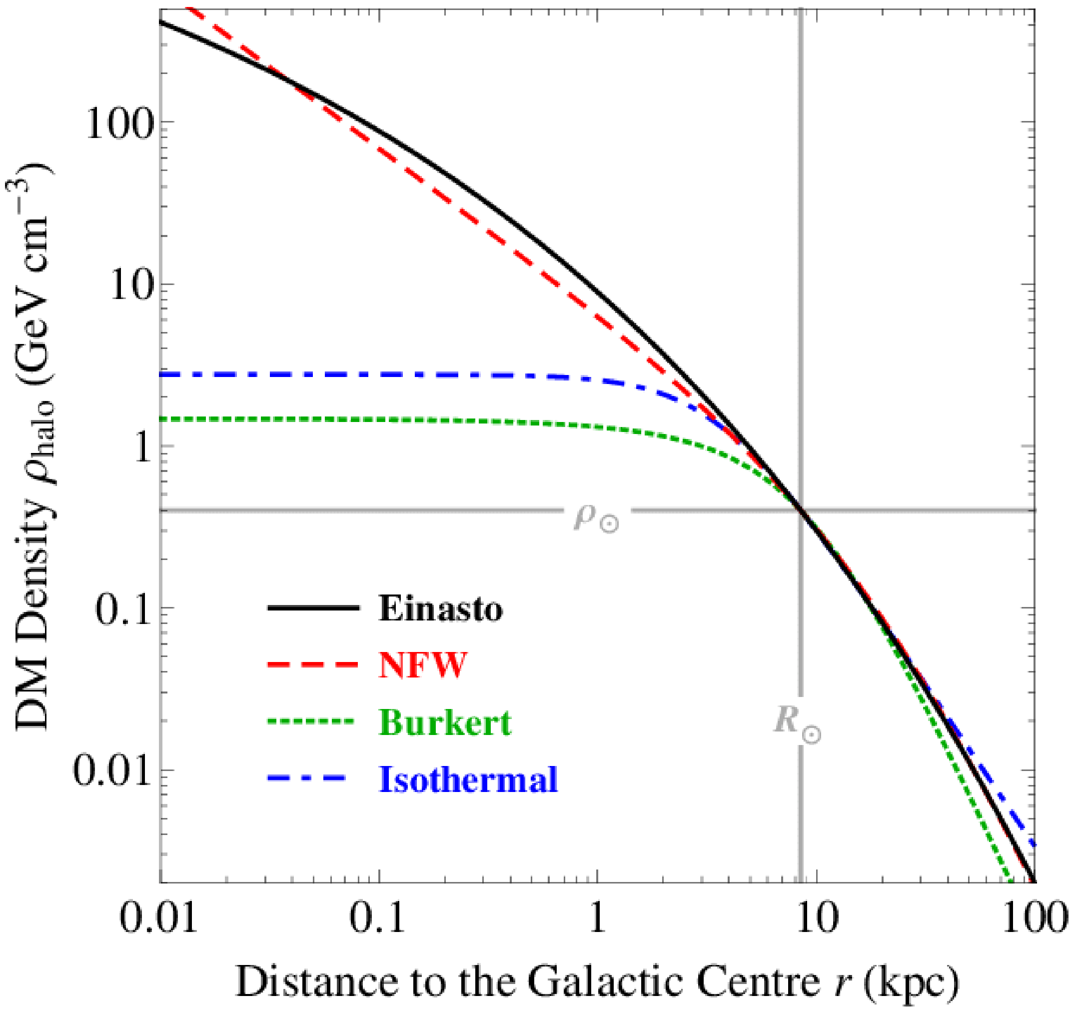
Detection of Annihilation Signals

- Observed emission: $$\frac{dN}{dA\,dt\,dE} = \frac{<\sigma v>}{2m_\chi^2}\frac{dN}{dE}\frac{f}{4\pi} < J >_{\Delta\Omega}$$
- From particle physics side (MicrOMEGAs): cross section (≈$9.5\text{x}10^{-27}$ cm^3/s), mass≈1.1 TeV, annihilation spectra
- From astrophysics side: boost factor f, (angle-averaged) J-factor:

→ los-integral over squared DM density distribution (uncertainties!)

$$< J >_{\Delta\Omega} = \frac{1}{\Delta\Omega}\int_{\Delta\Omega}\int_{los}\rho^2(\psi, s)\,ds\,d\Omega$$

DM Density Profiles



From Albert et al. 2014

- **Cusped** models suggested by numerical simulations of dark halo formation (Navarro et al. 1997, Moore et al. 1998)
- Evidence that MW halo is **cored** (Evans 2000)

→ cuspy halo problem

- **Boost factor** due to sub-halo clumping (~ $10^2 - 10^3$, Springel et al. 2008)

Prediction of Multiwavelength SEDs

- **Very-high-energy photons** from pion decay

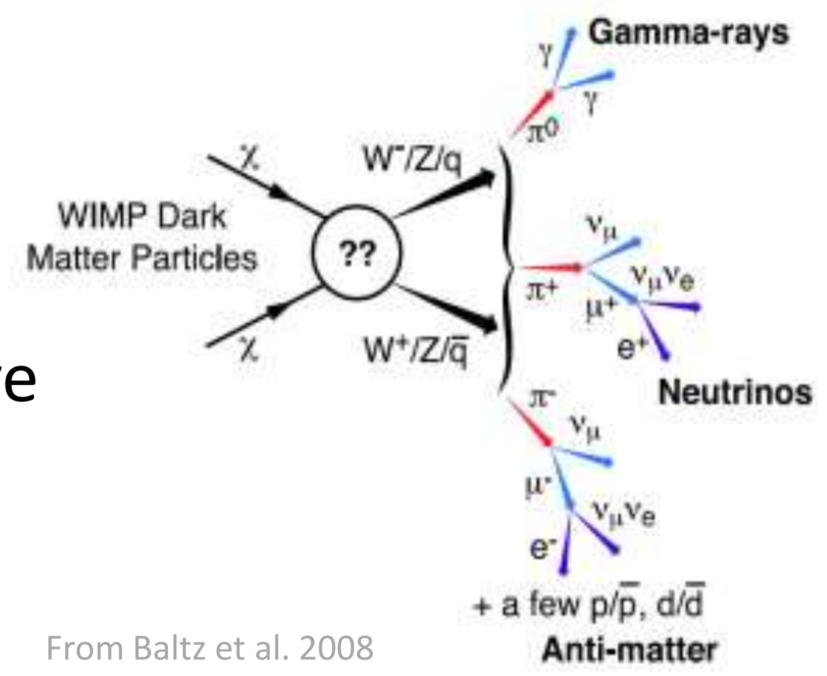
+

- Electron/Positron spectrum
  → **secondary emission** (IC, synchrotron, …)
  → modelling of diffusive transport and radiative losses in the halo plasma

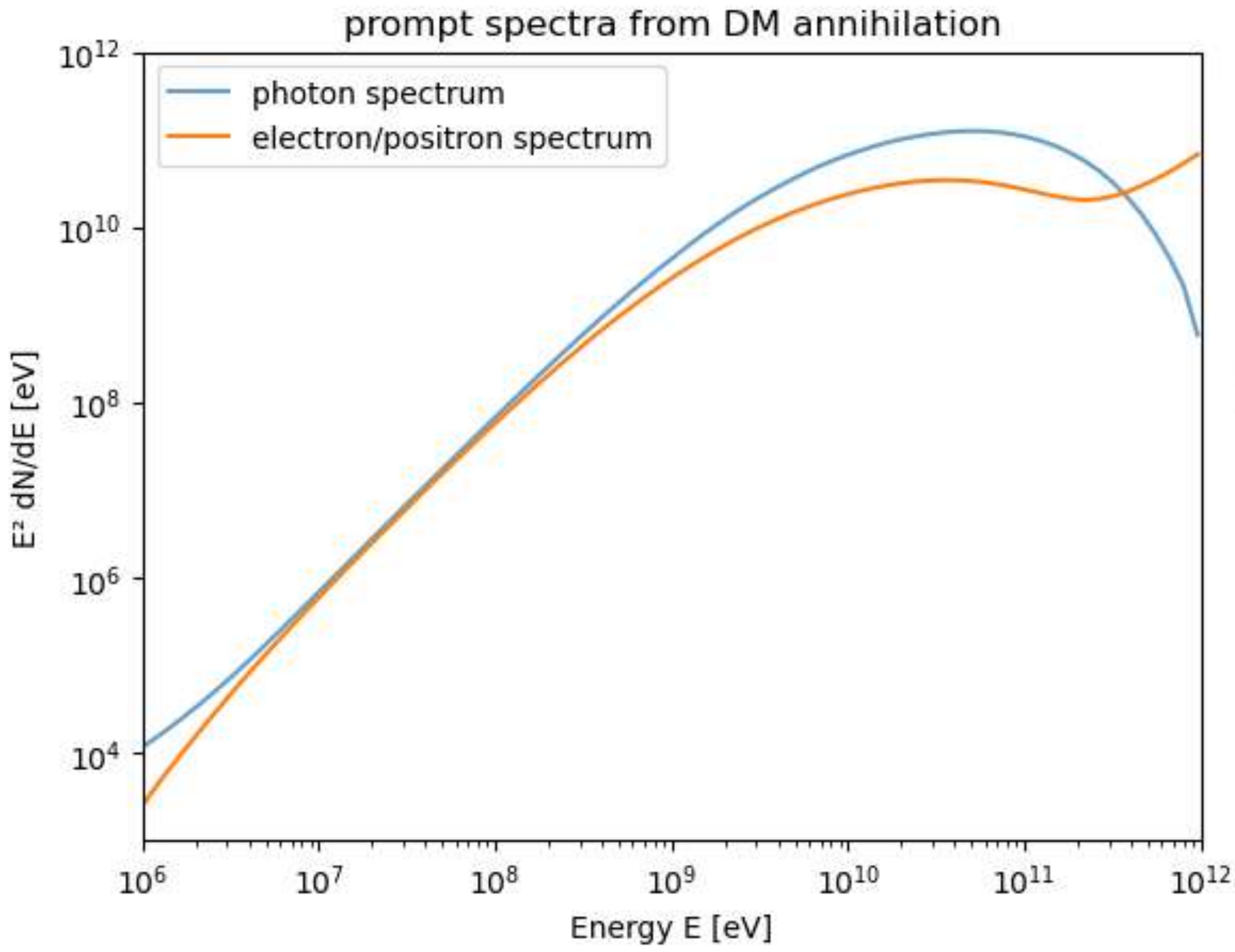
⇨ Comparison with observational limits

⇨ Target selection: M31, dwarf galaxies, GC …

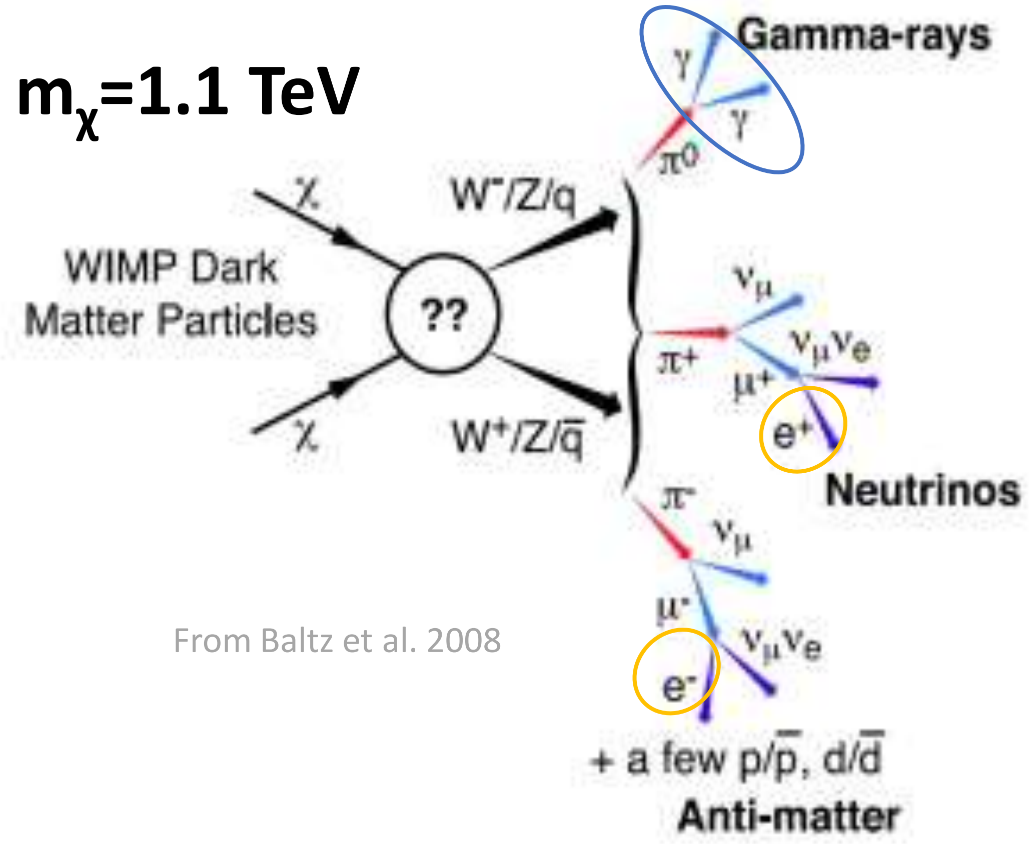
⇨ Discrimination from source/background signals



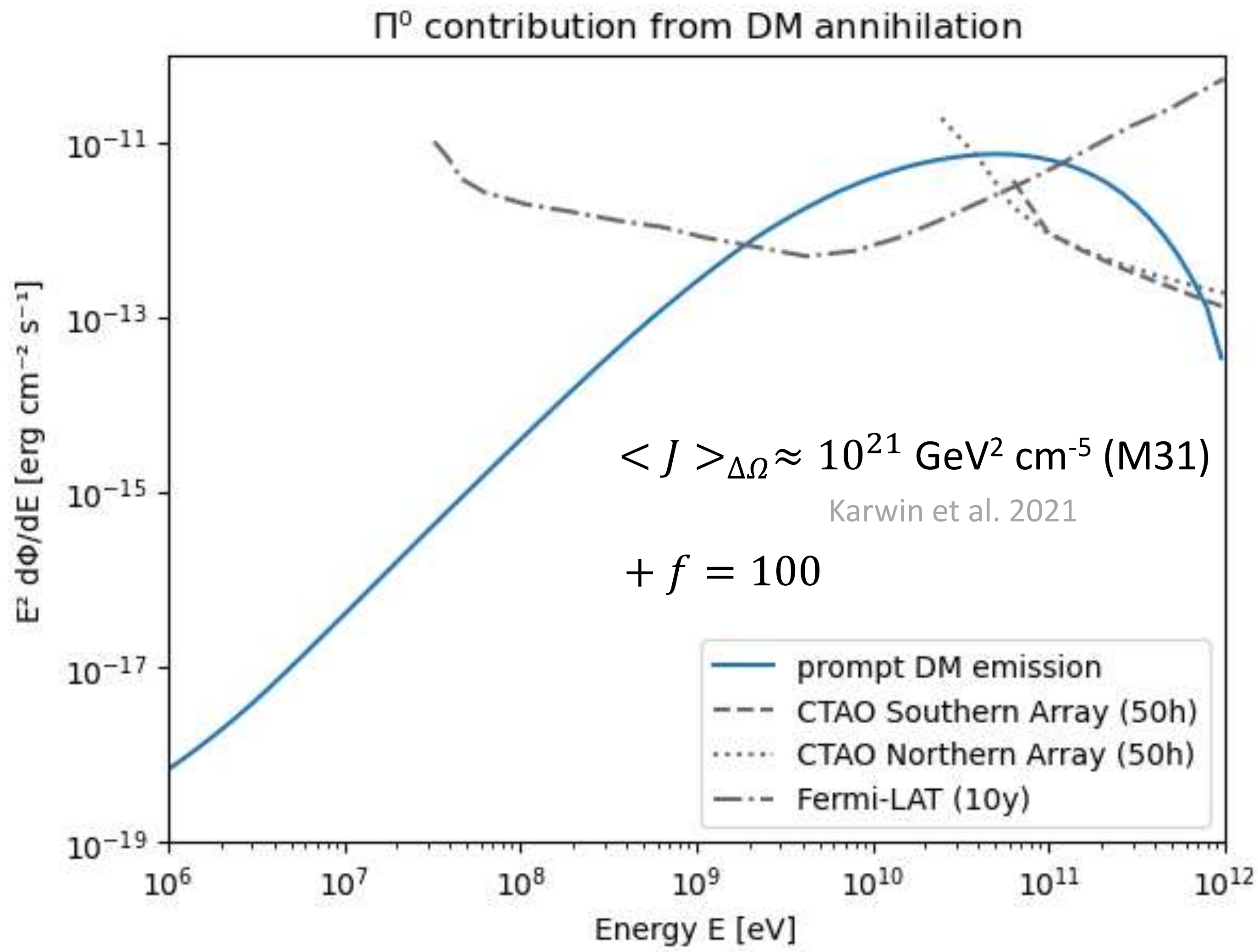
From Baltz et al. 2008



m_χ=1.1 TeV



From Baltz et al. 2008

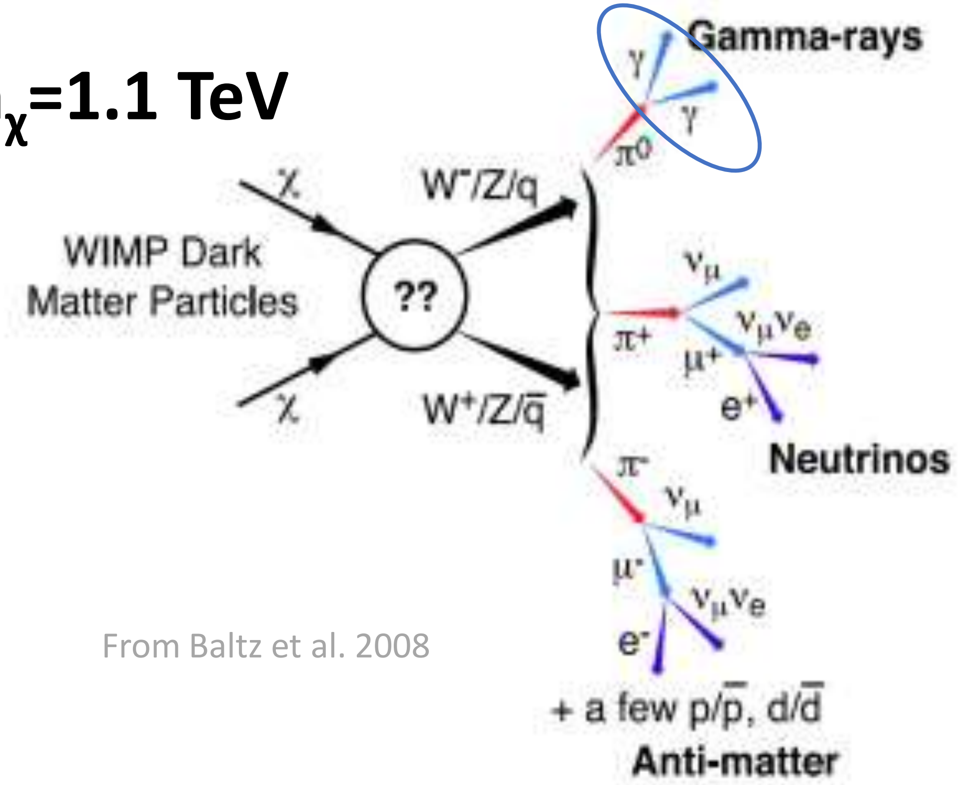


$< J >_{\Delta\Omega} \approx 10^{21}$ GeV^2 cm^{-5} (M31)

Karwin et al. 2021

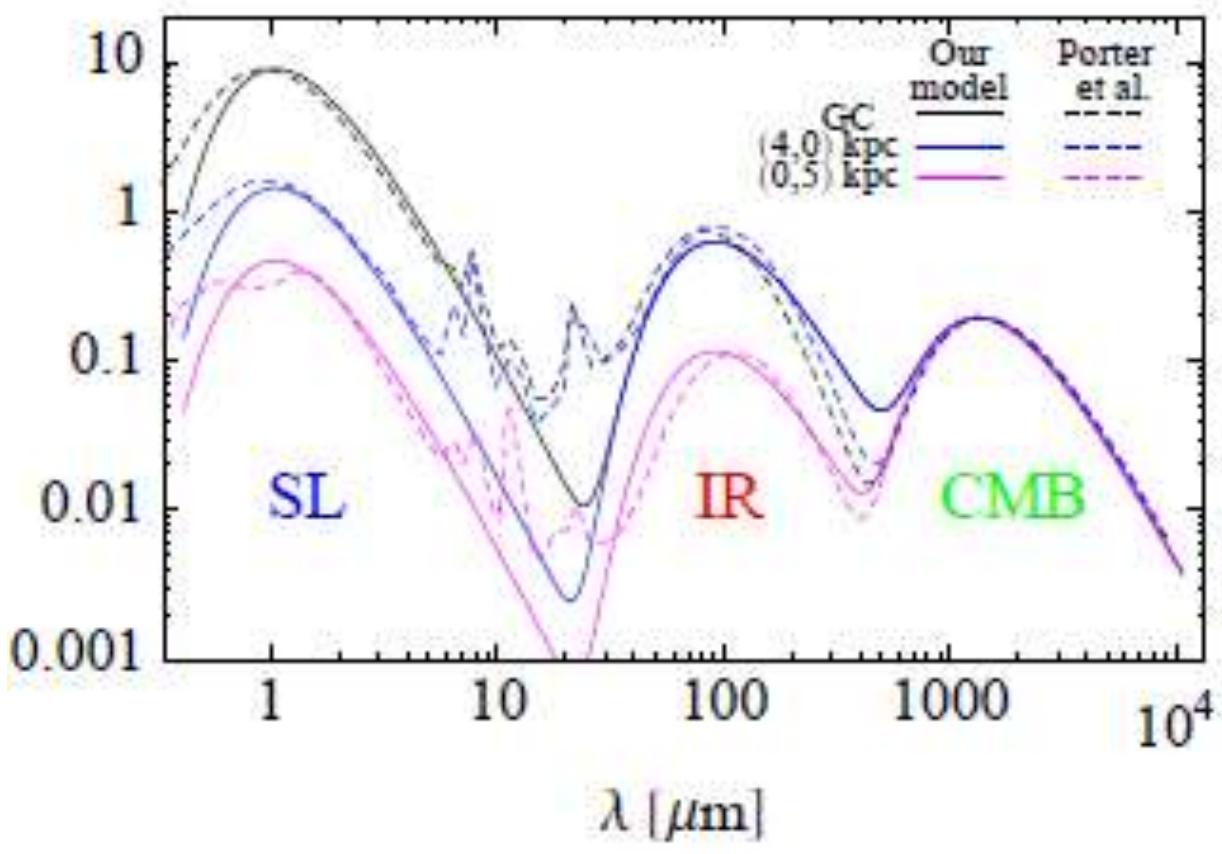
$+ f = 100$

m_χ=1.1 TeV



From Baltz et al. 2008

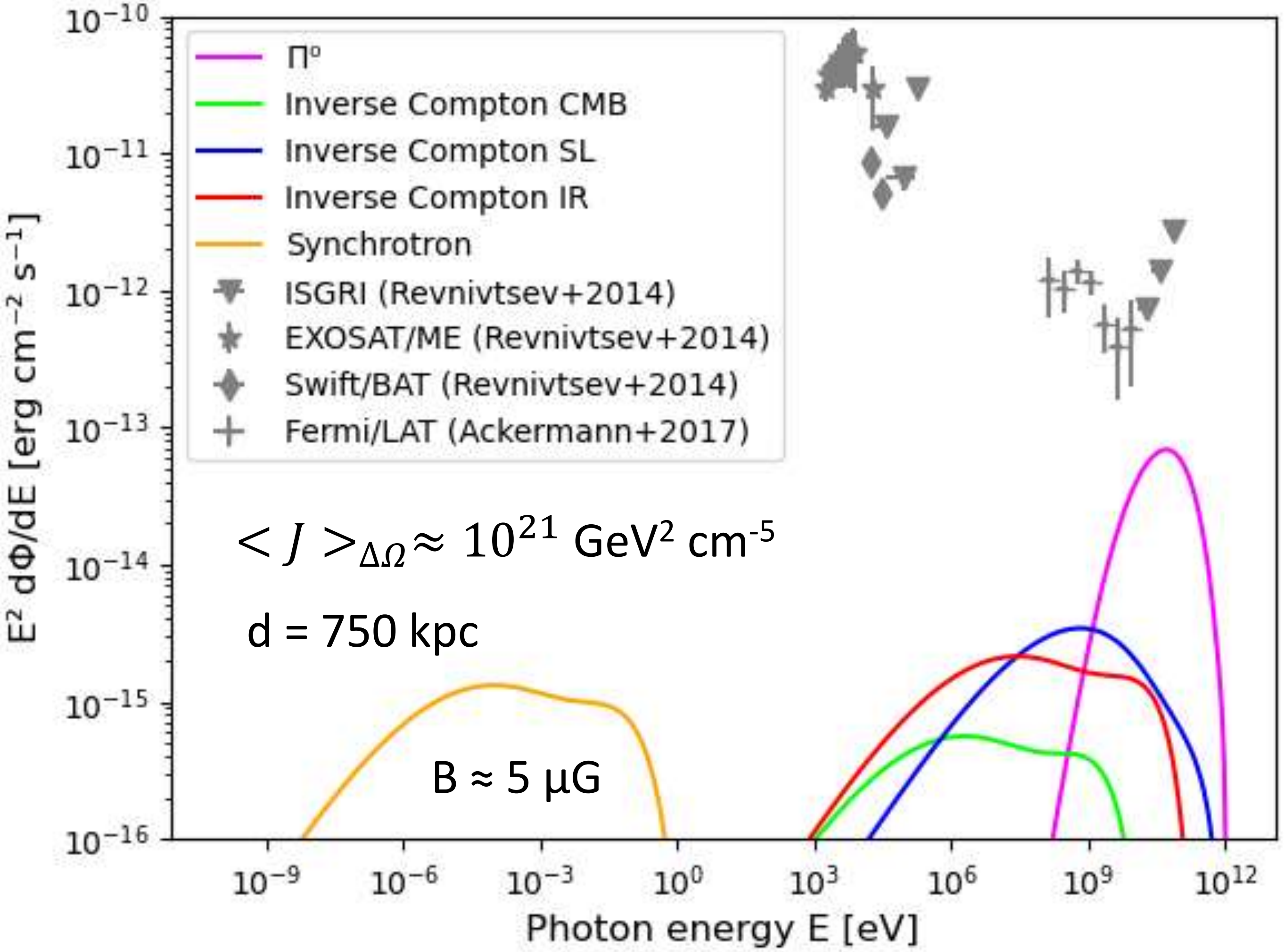
Inverse Compton Scattering

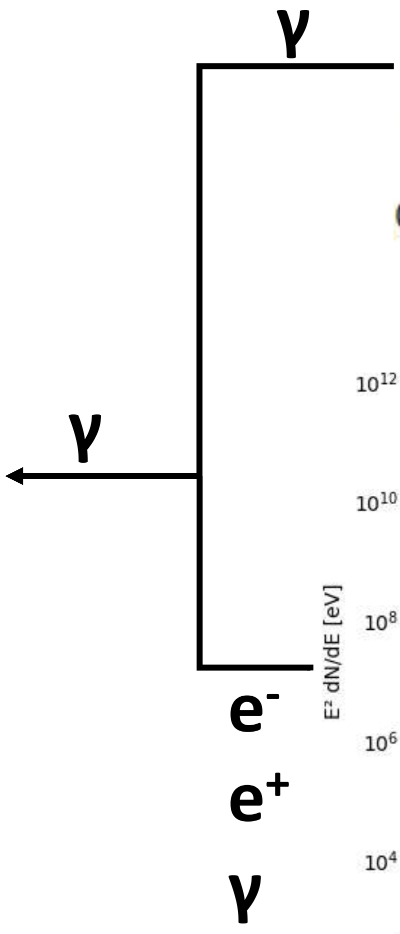


From Cirelli et al. 2009

- Up-scattering of **interstellar photons** by relativistic e^-/e^+
- $\frac{d\Phi}{dE} = \frac{1}{E}\frac{<\sigma v>}{m_\chi^2}\frac{1}{4\pi} < J >_{\Delta\Omega} \times \int_{m_e}^{m_\chi} dE' \frac{P(E,E')}{b(E')} \int_{E'}^{m_\chi} d\tilde{E} \frac{dN_e}{d\tilde{E}}$
- **Naima**: Python package for the computation of non-thermal radiation

Example SED (M31)





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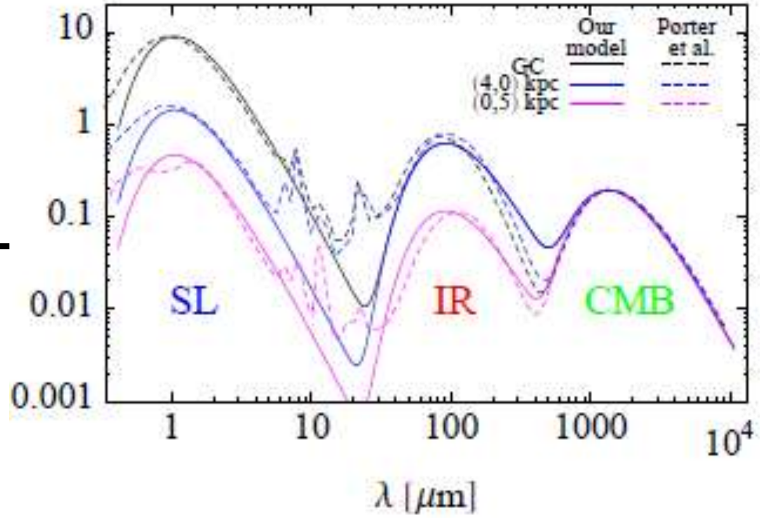
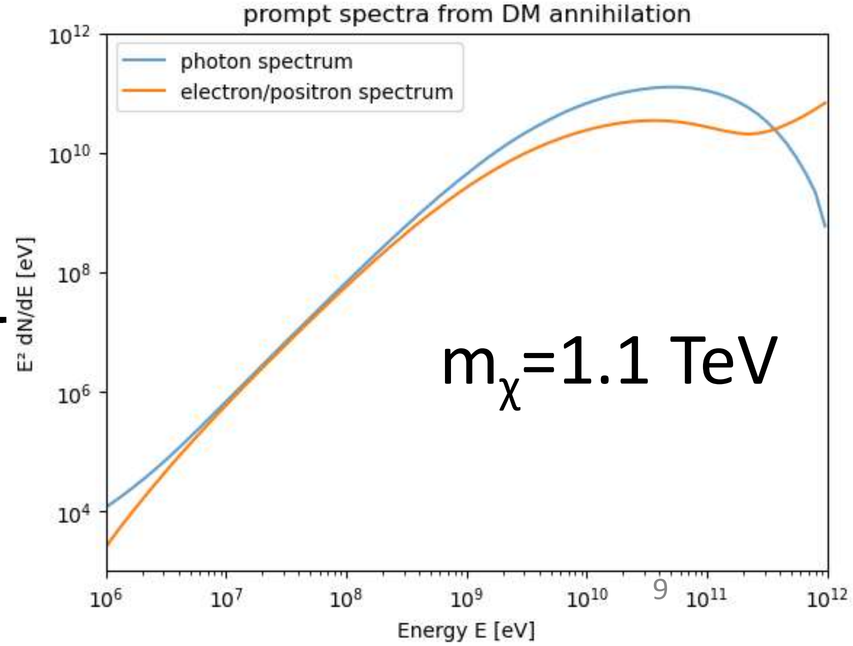
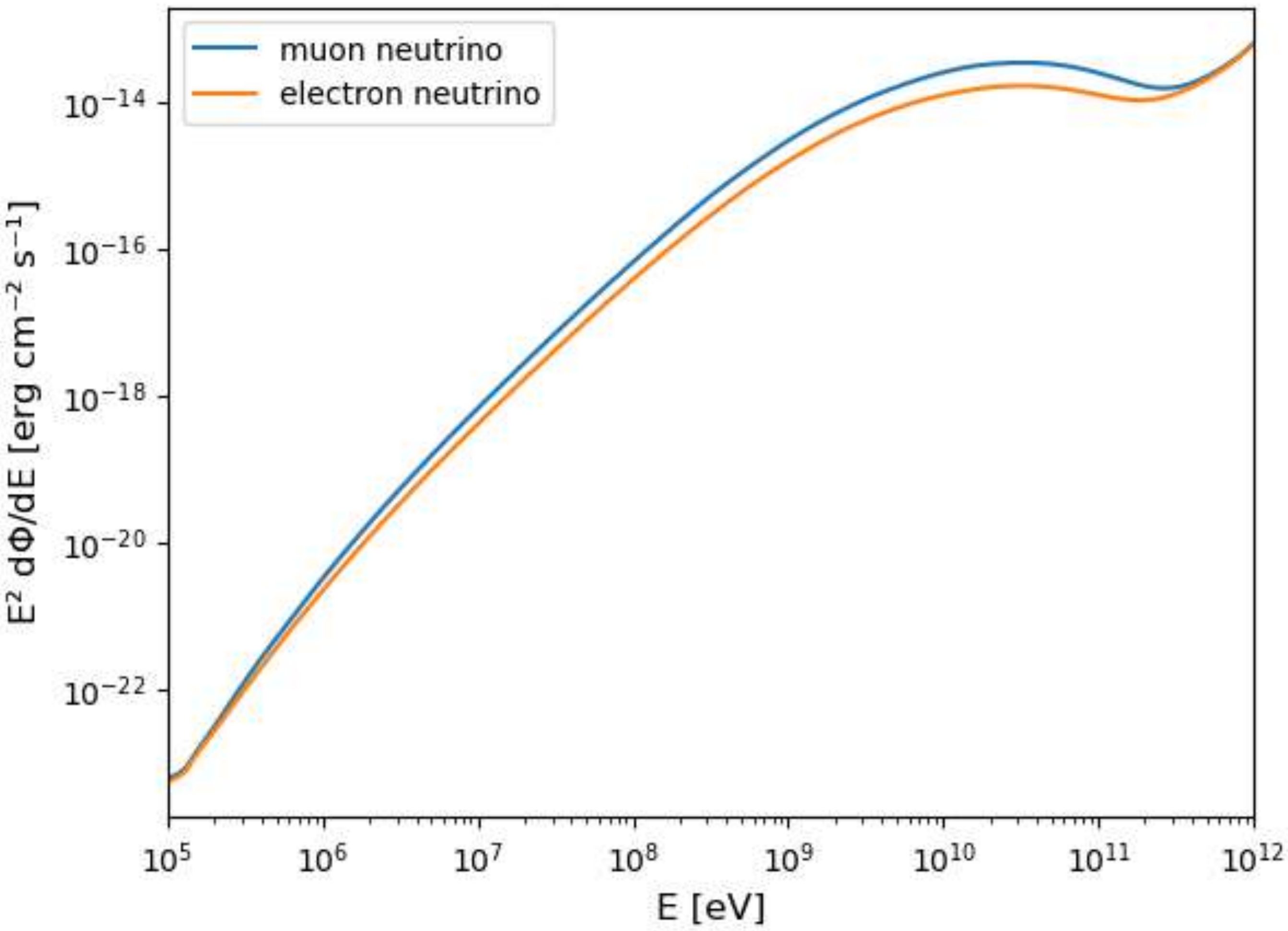
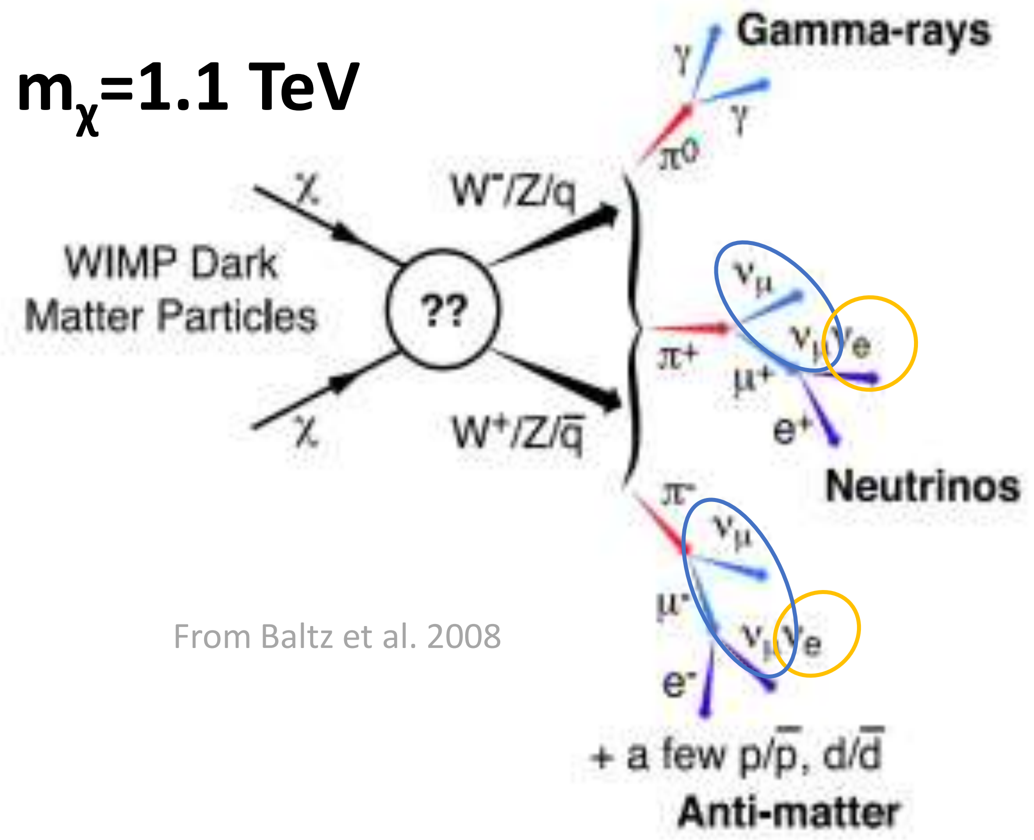




Neutrinos from DM annihilation

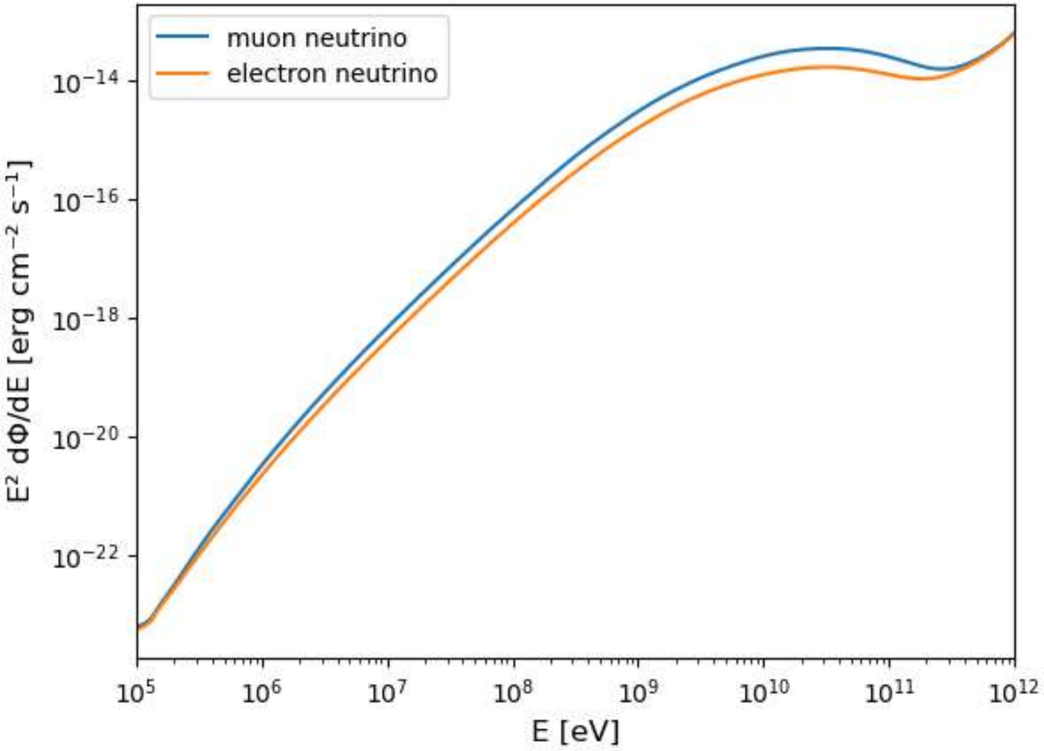


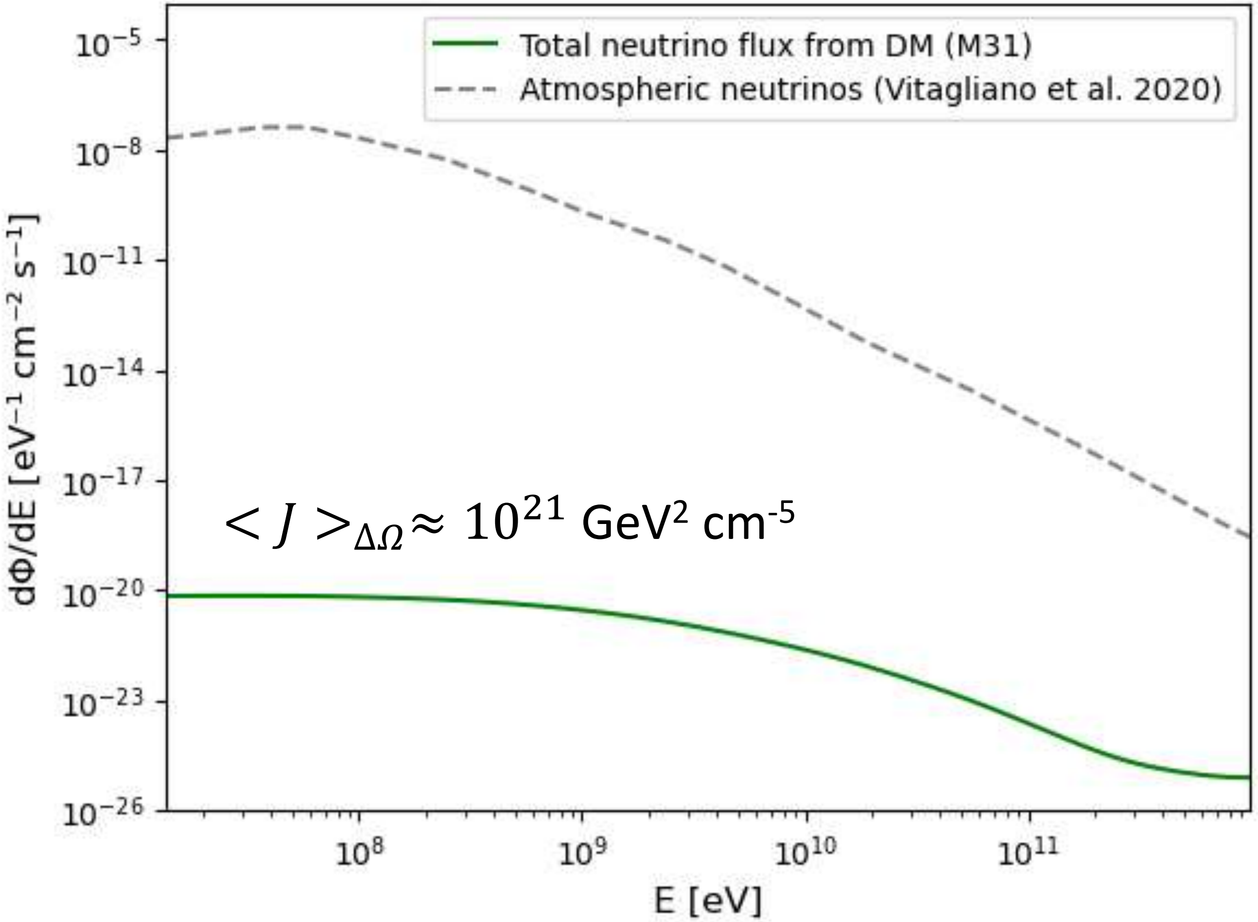
m_χ=1.1 TeV



From Baltz et al. 2008

Neutrinos from DM annihilation



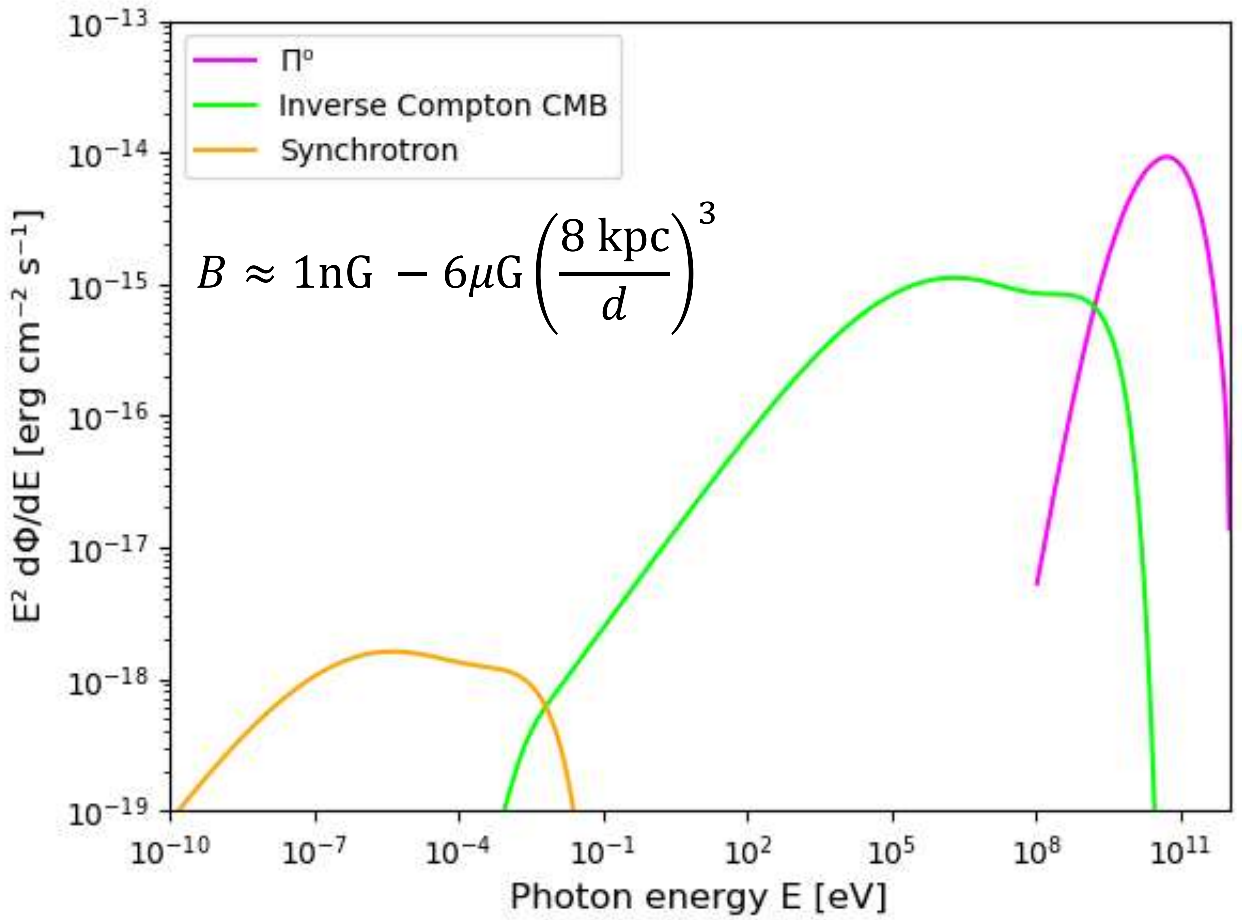


$< J >_{\Delta\Omega} \approx 10^{21}$ GeV^2 cm^{-5}

Stacking of Dwarf Spheroidals

	name	log10J	distance
0	Carina	18.03	105
1	Draco	18.92	76
2	Fornax	18.27	147
3	Leo I	17.80	254
4	Leo II	17.41	233
5	Sculptor	18.73	86
6	Sextans	18.04	86
7	Ursa Minor	19.18	76
8	Boötes I	16.64	66
9	Coma Berenices	18.64	44
10	Canes Venatici I	17.27	218
11	Canes Venatici II	17.63	160
12	Hercules	16.79	133
13	Leo IV	16.56	154
14	Leo V	16.82	178
15	Leo T	17.28	417
16	Segue 1	19.39	23
17	Segue 2	17.06	35
18	Ursa Major I	18.47	97
19	Ursa Major II	19.38	32
20	Willman 1	19.29	38
21	Reticulum II	18.72	30
22	Tucana II	19.10	57
23	Horologium I	18.64	79
24	Hydra II	16.56	134
25	Pisces II	17.90	182
26	Grus I	17.96	120

Evans et al. 2016



- most extreme DM dominated objects $\frac{M}{L} \approx 10 - 100$
- low astrophysical backgrounds
- SL radiation fields to be added

Summary and Outlook

- DM candidate: **scotogenic WIMP** (**m_χ = 1.1 TeV**)
- **Annihilation** into gamma-rays + electron/positrons + neutrinos
- DM Contribution to SED:

  → **Prompt (π^0)** + **Inverse Compton** + **Synchrotron**
- **Template model** for varying parameters:

  J factor, distance, radiation fields, magnetic field
- Comparison with observational limits/data for different galaxies