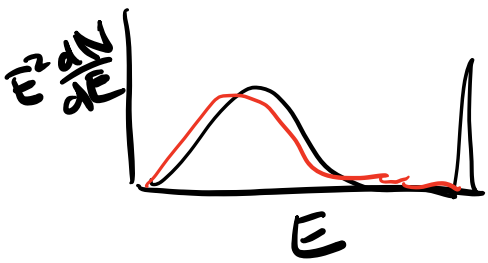
Goals

- Wrap up J-factor discussion
- Briefly outline some key backgrounds/uncertainties
- Discuss real searches & results

Beyond J-factors

- Can include $e^{-\tau(z)}$ (optical depth) term inside integral to capture absorption
- More generally, interactions can produce secondary particles - need to track these particles & their propagation



Typical J-factors & density

- In simulations with DM only (no baryons), density profiles are modeled by NFW (Navarro-Frenk-White) or Einasto density profiles

NFW: $\rho(r) = \frac{\rho_0 (r/r_s)^{-1}}{(1+r/r_s)^2}$

r_s = scale radius

For MW, $r_s \approx 20$ kpc

Einasto: $\rho(r) = \rho_{-2} \exp\left[\frac{-2}{\alpha}\left(\left(\frac{r}{r_{-2}}\right)^{\alpha} - 1\right)\right]$

For MW, $\alpha \approx 0.17$

r_{-2}: $\frac{d\ln\rho}{d\ln r} = -2$ analogous to r_s

Also consider cored profiles, e.g Burkert profile,

$$\rho(r) = \frac{\rho_0}{(1+r/r_s)(1+r^2/r_s^2)}$$

→ estimate possible effect of baryons

- Large uncertainties associated with small r (from center of system) due to effect of baryons
- For dwarf galaxies, $\rho(r)$ profiles based on observations, can be large uncertainties if # of stars in galaxies
- These are smooth densities – every halo has substructure – enhances annihilation as $\langle \rho^2 \rangle > \langle \rho \rangle^2$ (ratio = "boost factor")
  Substructure often leads to large uncertainties (esp. true for galaxy clusters)

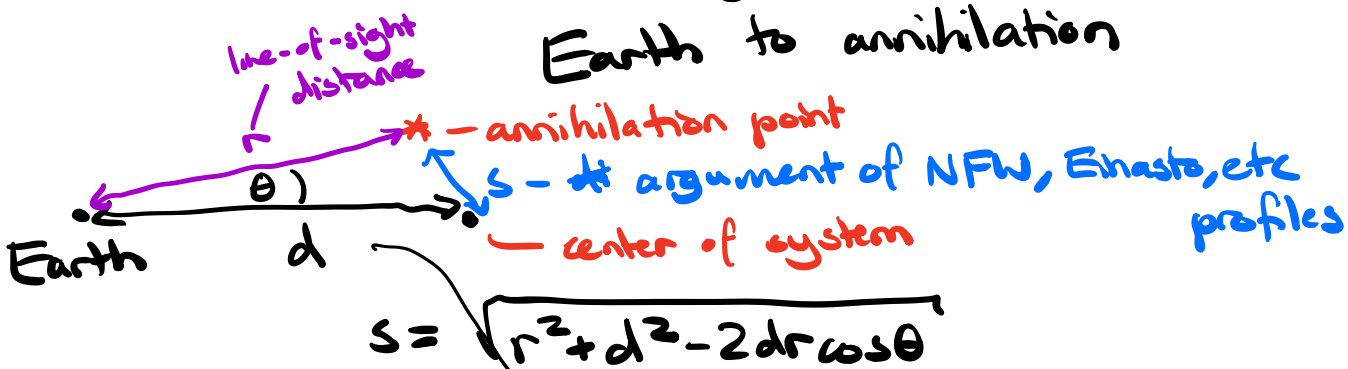
Typical J-factors:

GC region, 1° radius, NFW profile: $J \sim 10^{22}\ \text{GeV}^2\ \text{cm}^{-5}$

Dwarf galaxies: $J \sim 10^{17\text{-}20}\ \text{GeV}^2\ \text{cm}^{-5}$

$$J = \int \rho(\vec{r})^2\, dr \quad \left(\text{or } D = \int \rho(\vec{r})\, dr\right)$$

↳ line-of-sight distance from Earth to annihilation



For MW studies, often use "Galactic coordinates"

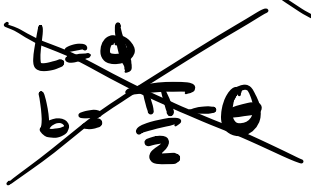
l = Galactic longitude

b = " latitude

Equator = plane of MW

$b = 0$

Define the GC to be at $l = 0$



Letting θ be as defined above,

$\cos\theta = \cos l \cos b$

Backgrounds

- Background-free:
  - gamma-ray lines / sharply peaked spectra
  - antideuterons
  - heavier antinuclei

(Note: X-ray lines have backgrounds from atomic/nuclear processes)

- Continuum photons & charged particles
  - protons hitting the gas → shower of particles
  - ICS from CR e^- interacting w/ radiation field

- At low energies:
  - synchrotron radiation (radio → microwave)
  - stars, thermal emission

also ↓ high-energy signals from pulsars, supernovae, active Galactic nuclei

- All backgrounds are worse in Galactic plane