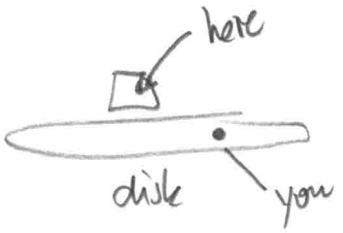
Indirect detection ...

where to look? near center of galaxy



halo

expect rate of photons $\propto n^2 \cdot$ Volume looked at

$$\#\gamma's = \int \frac{\rho_{DM}^2}{m_{DM}^2} d\vec{V} \langle \sigma v \rangle \cdot \left[\begin{array}{l}\text{photon} \\ \text{production} \\ \text{rate per} \\ \text{annihilation}\end{array}\right]$$

gamma ray excess: 2009 L. Goodenough
in Fermi data D. Hooper

endless debate: pulsars vs. DM

↑ point sources

↑ smooth distribution

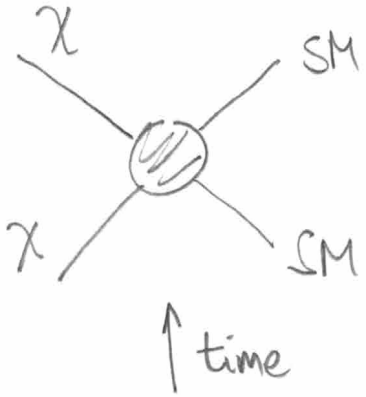
DM decay? 

decay rate per volume? $\sim \frac{N}{V}\Gamma = n\Gamma = \frac{\rho}{m}\Gamma$

$\Rightarrow \#\gamma's = \int dV \frac{\rho}{m}\Gamma$ (photon efficiency)

distribution of photons less peaked compared with annihilation.

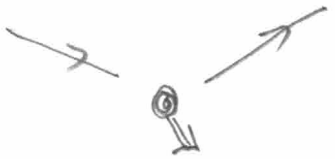
Direct detection



SM could be nucleus or e^-

→ sudden recoil of SM particle

event rate per SM particle:

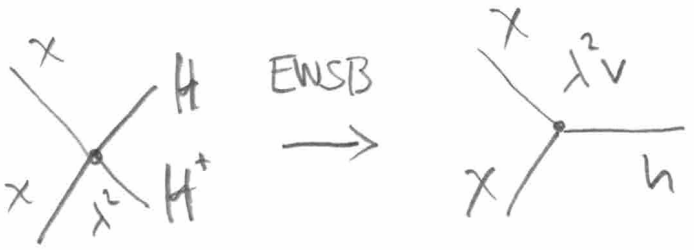


$$n_\chi \langle \sigma v \rangle_{\chi p^+ \to \chi p^+}$$

event rate per detector

$$N_{\text{targets}}\, n_\chi \langle \sigma v \rangle$$

example: Higgs portal



$$\sigma v \sim \frac{\lambda^4 v^2}{m_h^4} \frac{\alpha_s^2}{(4\pi v)^2} E^2$$

$$\sim \frac{\alpha_s}{4\pi} \frac{\lambda_t}{m_t} \sim \frac{\alpha_s}{4\pi v}$$

recoil energy? non-relativistic

$$q_{DM} \sim m_\chi v \quad \leftarrow 220\,\text{km/s}$$

$$E_\chi^{kin} \sim \frac{1}{2} m_\chi v^2$$

$$E_{recoil} = \frac{\mu^2 v^2}{M}(1-\cos\theta)$$

$$\mu = \frac{m_\chi M}{m_\chi + M}$$

$$E_{max} = 2\frac{m_\chi^2}{(m_\chi+M)^2} M v^2$$

↑ in direction of incoming χ

optimal target $M \sim m_\chi$

$$E_{opt} \approx 50\,\text{keV}\left[\frac{M}{100\,\text{GeV}}\right]$$

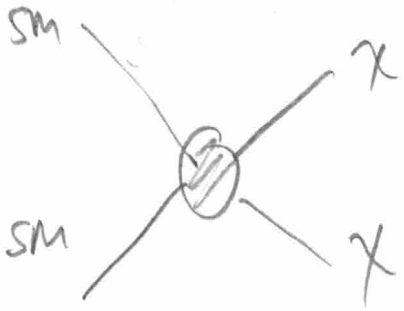
light DM

$$E \sim 50\,\text{keV}\left[\frac{m_\chi}{100\,\text{GeV}}\right]^2\left[\frac{100\,\text{GeV}}{M}\right]$$

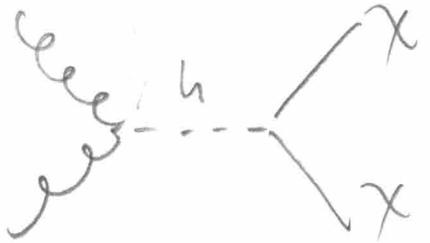
Xenon 1T plot.

lighter DM, · electron recoil
· Atomic physics

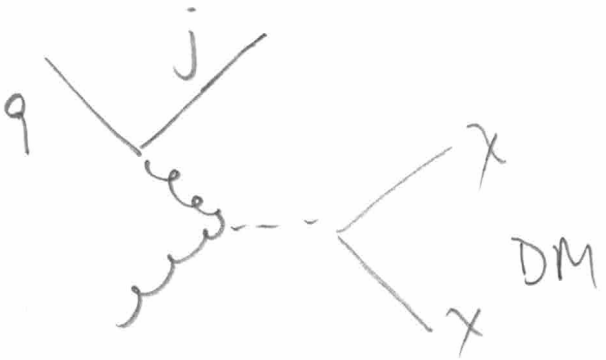
Colliders



example:

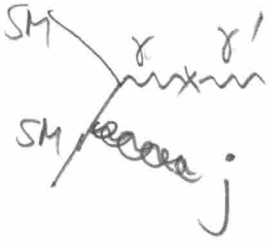


nothing to observe ...



$\Rightarrow \quad j + \not{E}_t$

Mediators: e.g. γ'
dark photon



γ' couples to DM but that's not important here.