

Title: Astroparticle Physics & Theory: Indirect detection

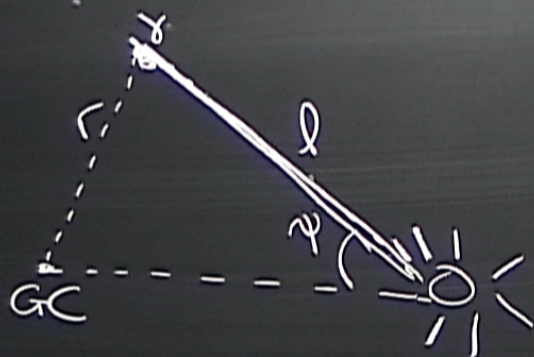
Date: Jul 07, 2015 03:45 PM

URL: <http://pirsa.org/15070020>

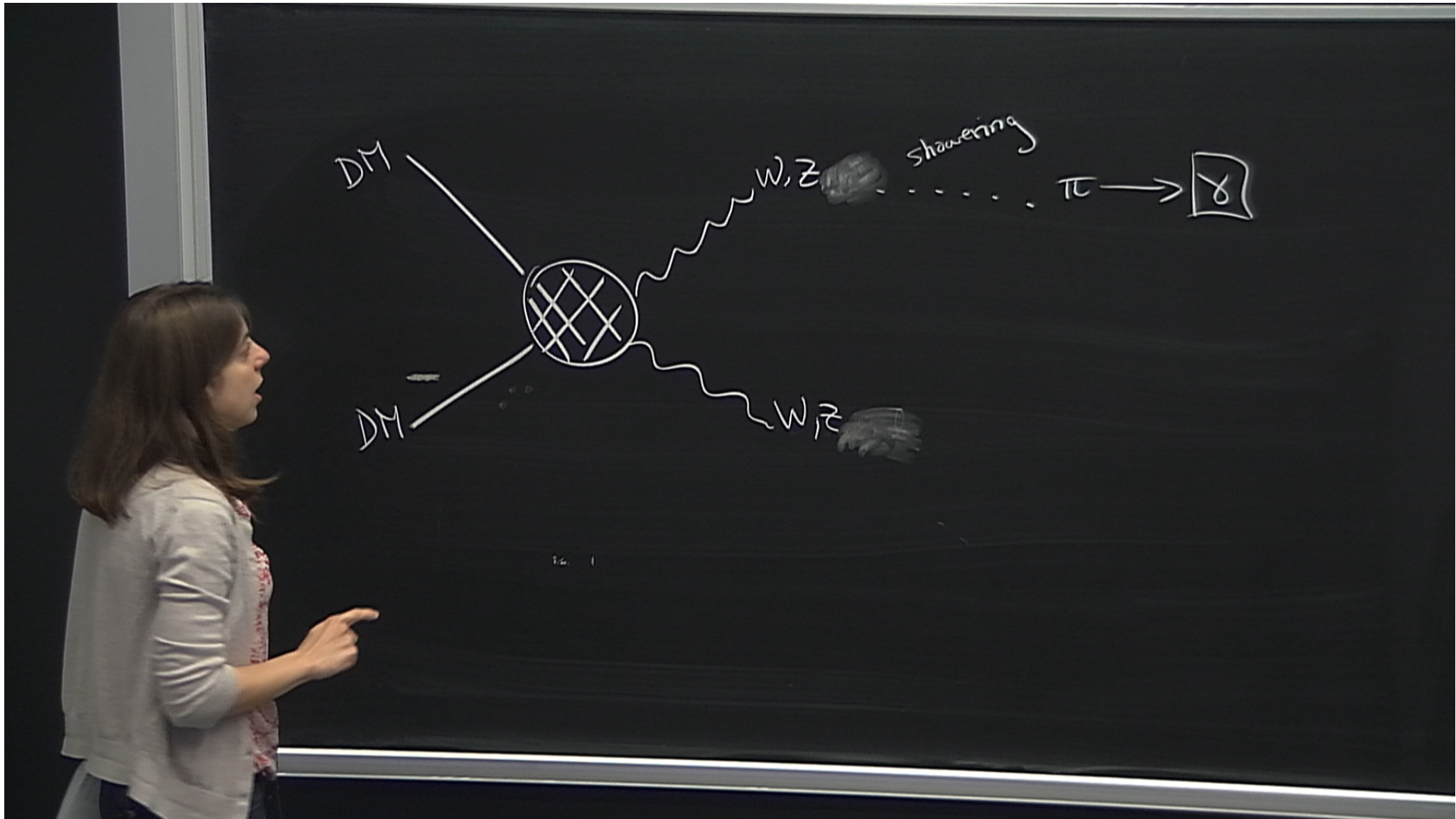
Abstract:

intensity profile for annihilation

$$\Phi(E, \psi) = \frac{\langle \sigma v \rangle}{8\pi m^2 c^3} \frac{dN}{dE} \int_{l.o.s.} dl \rho[r]^2$$

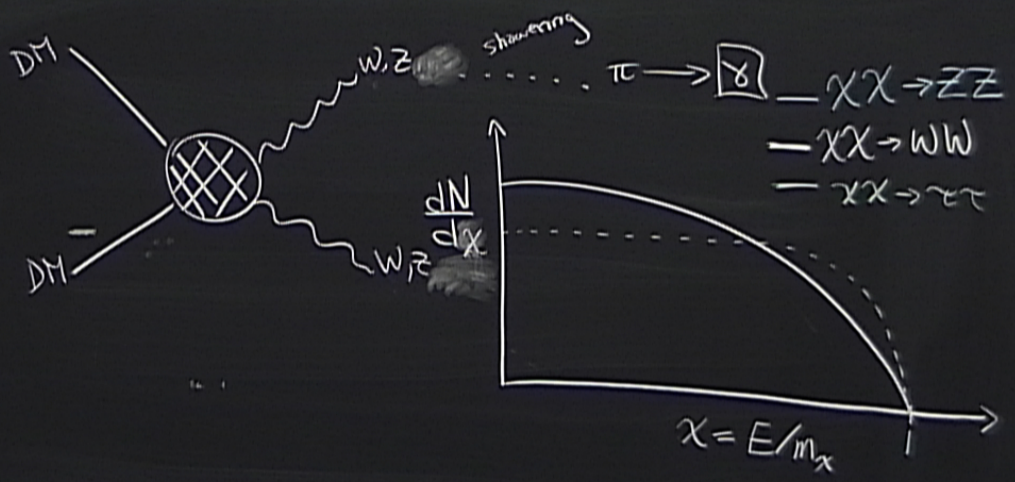


photon energy spectrum

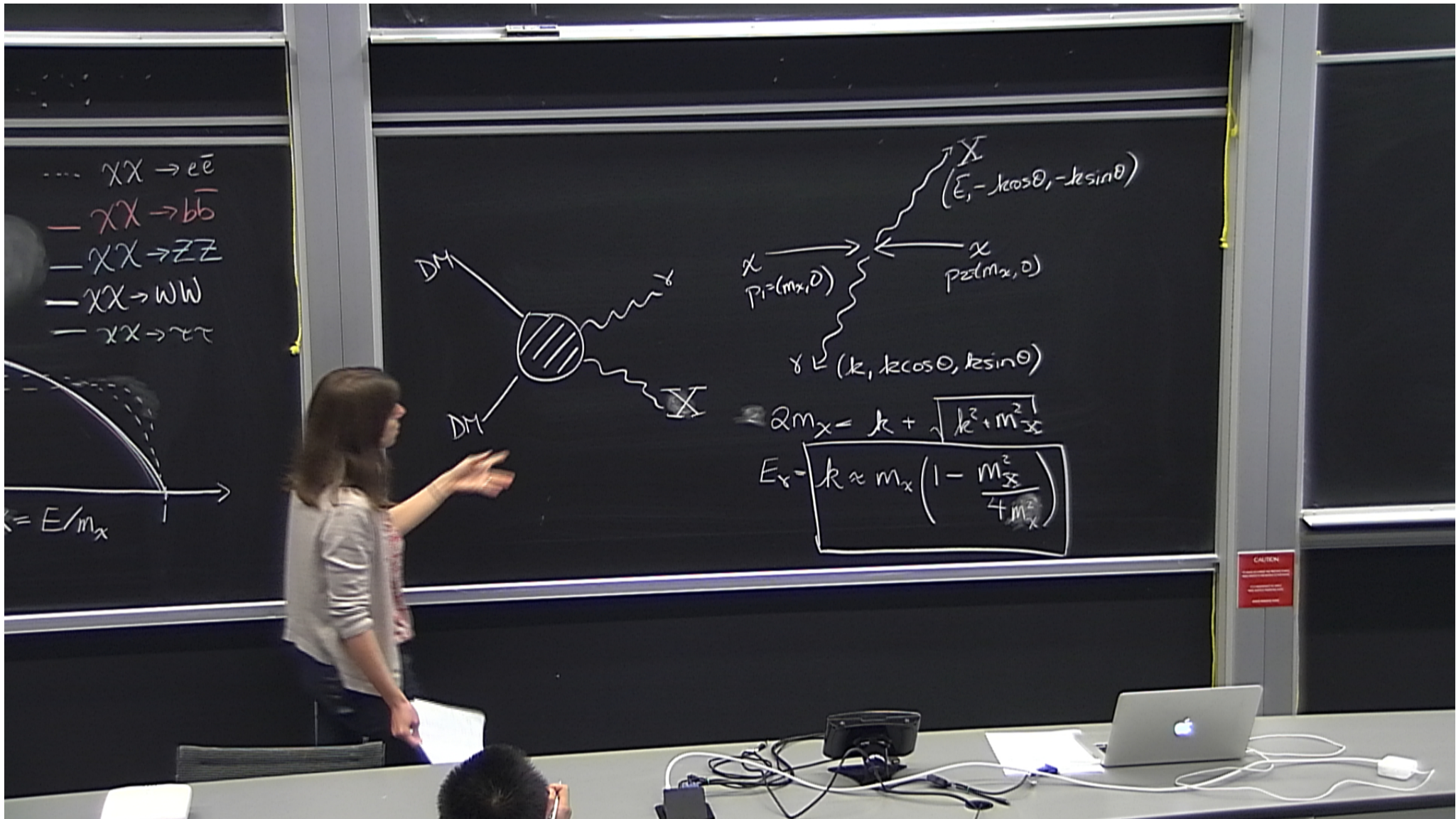




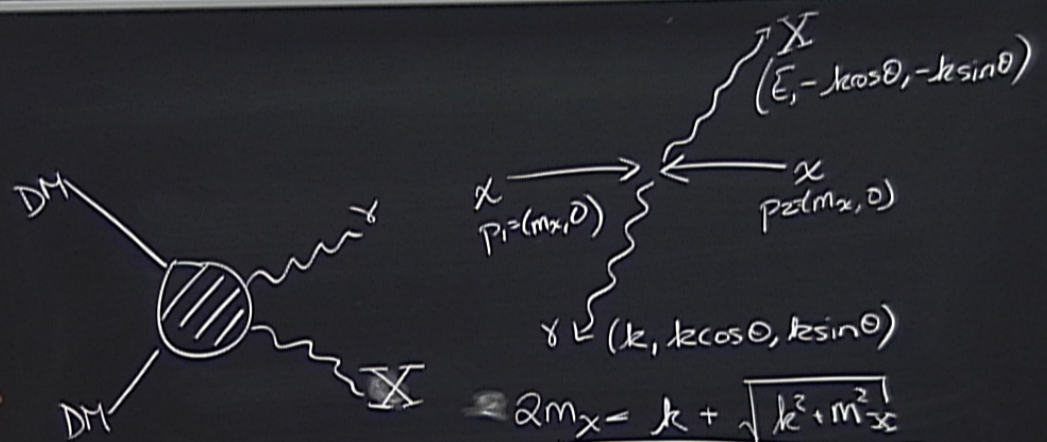
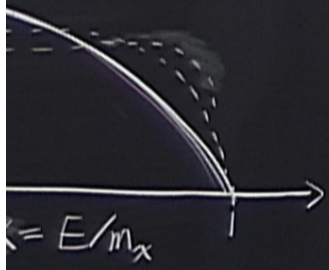
photon energy spectrum



CAUTION

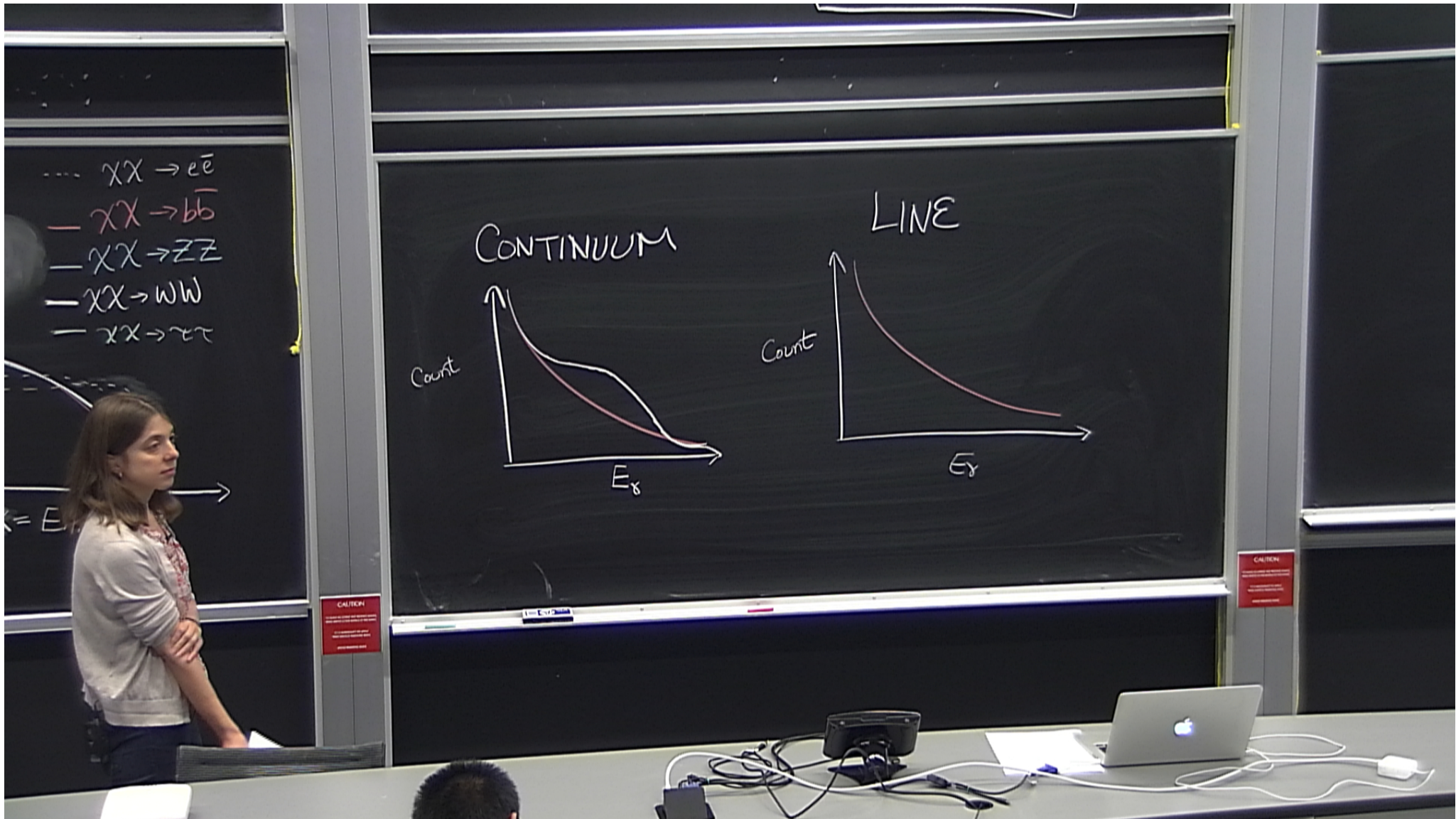


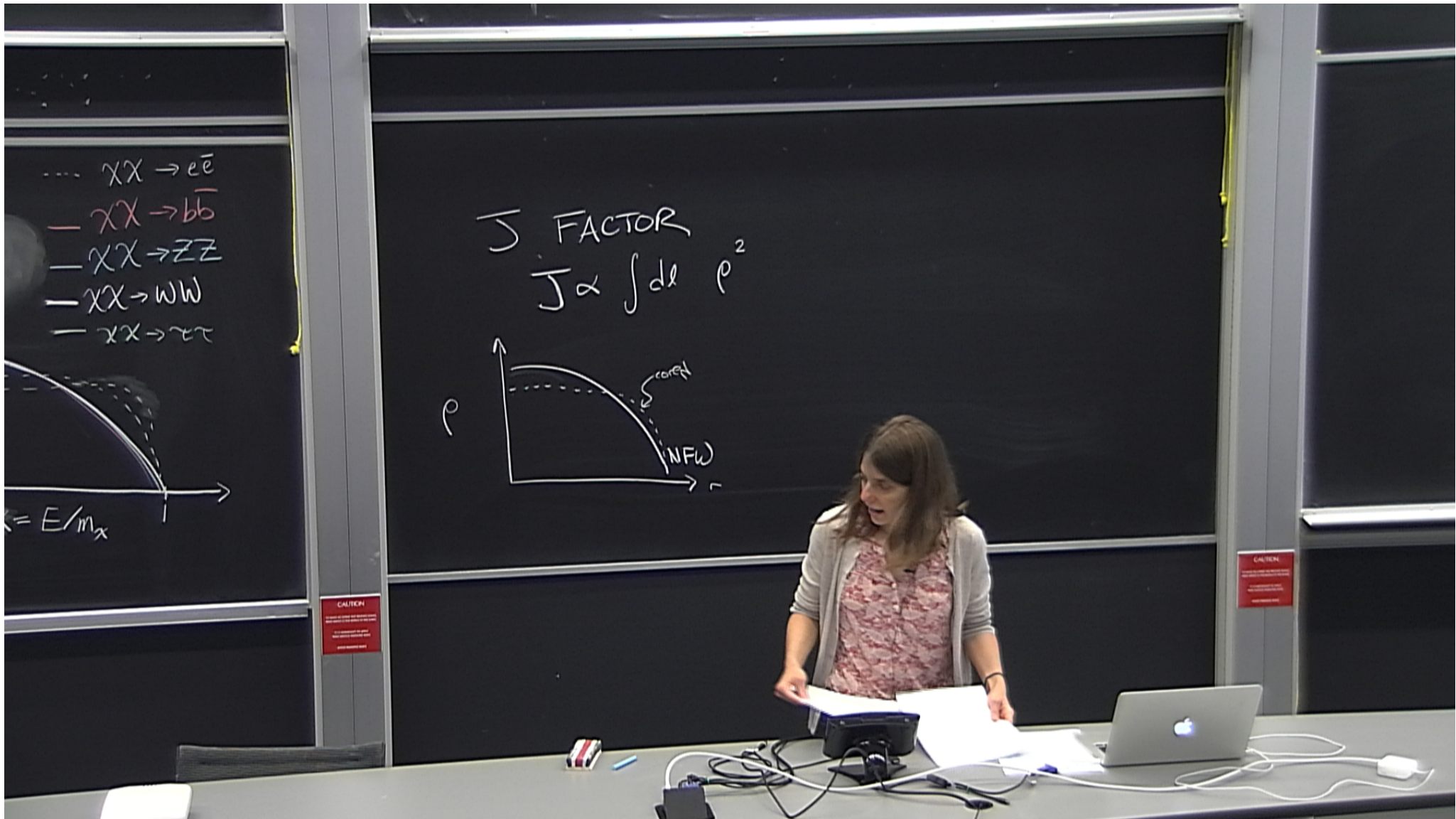
- $\chi\chi \rightarrow e\bar{e}$
- $\chi\chi \rightarrow b\bar{b}$
- $\chi\chi \rightarrow Z\bar{Z}$
- $\chi\chi \rightarrow W\bar{W}$
- $\chi\chi \rightarrow \tau\bar{\tau}$



$$2m_\chi = k + \sqrt{k^2 + m_\chi^2}$$

$$E_\chi = k \approx m_\chi \left( 1 - \frac{m_\chi^2}{4m_\chi^2} \right)$$





# *Fermi* LAT



Launched June 11, 2008

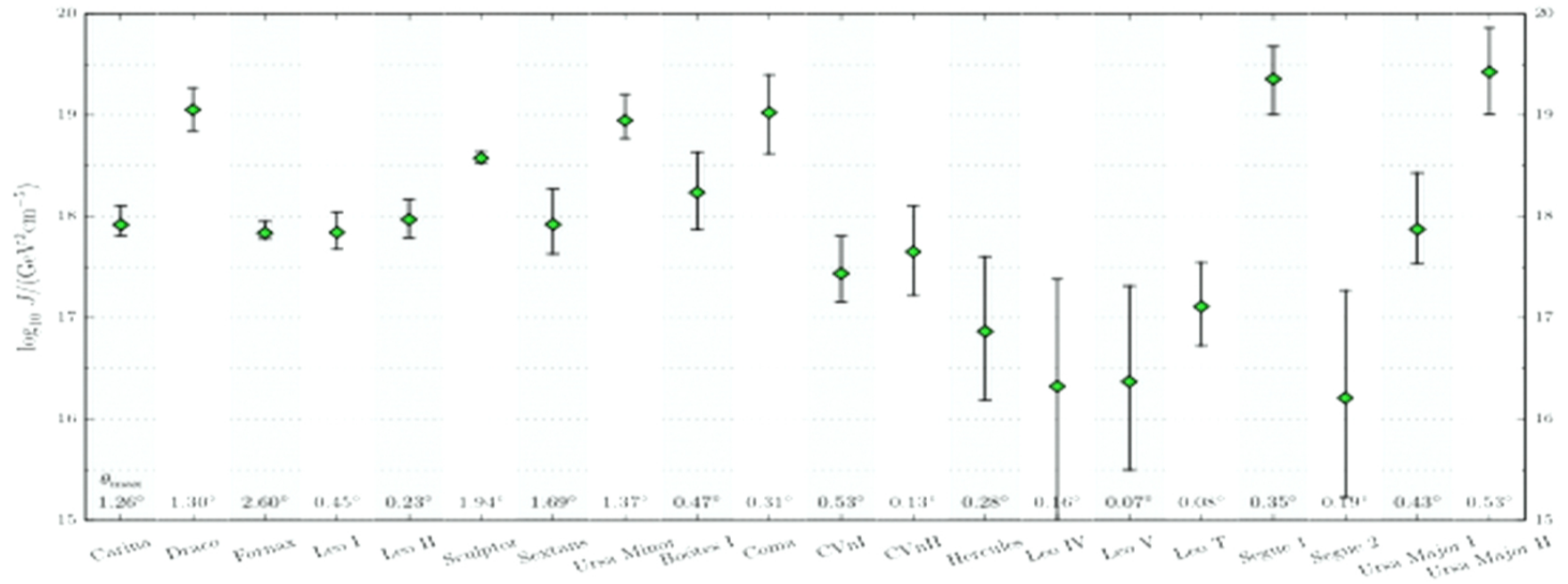
Sensitive to energies from  
20 MeV to  $> 300$  GeV

Scans over the whole sky every  
three hours



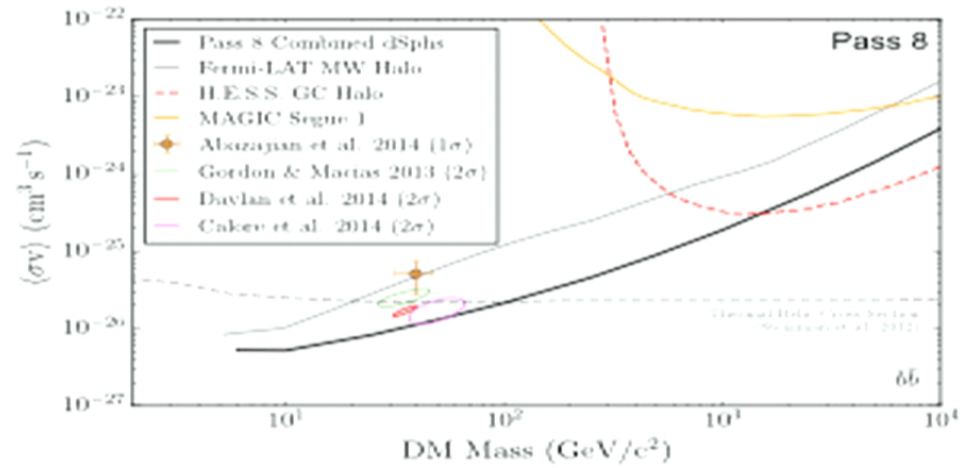
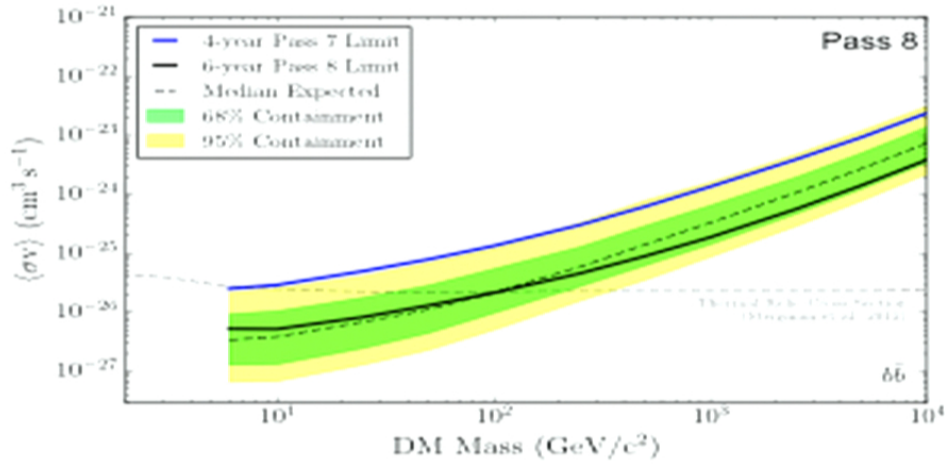
# Dwarf Galaxies

Fit stellar velocity dispersions for each dwarf to determine J factor



Geringer-Sameth, Koushiappas, and Walker [1408.0002]

# Dwarf Galaxies

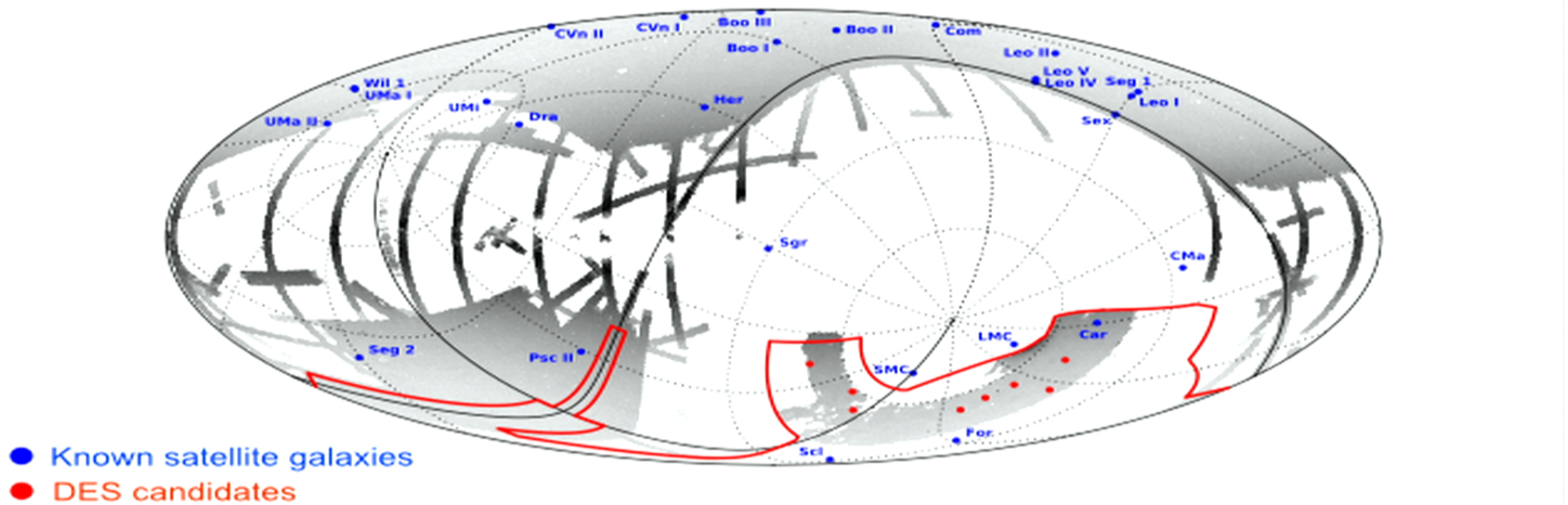


Ackermann et al. [1503.02641]

# New Dwarf Candidates

Evidence for 8 new dwarf candidates from Dark Energy Survey

These stellar overdensities range in heliocentric distance from 30-300 kpc



Bechtol *et al.* [1503.02584]; Koposov *et al.* [1503.02079].

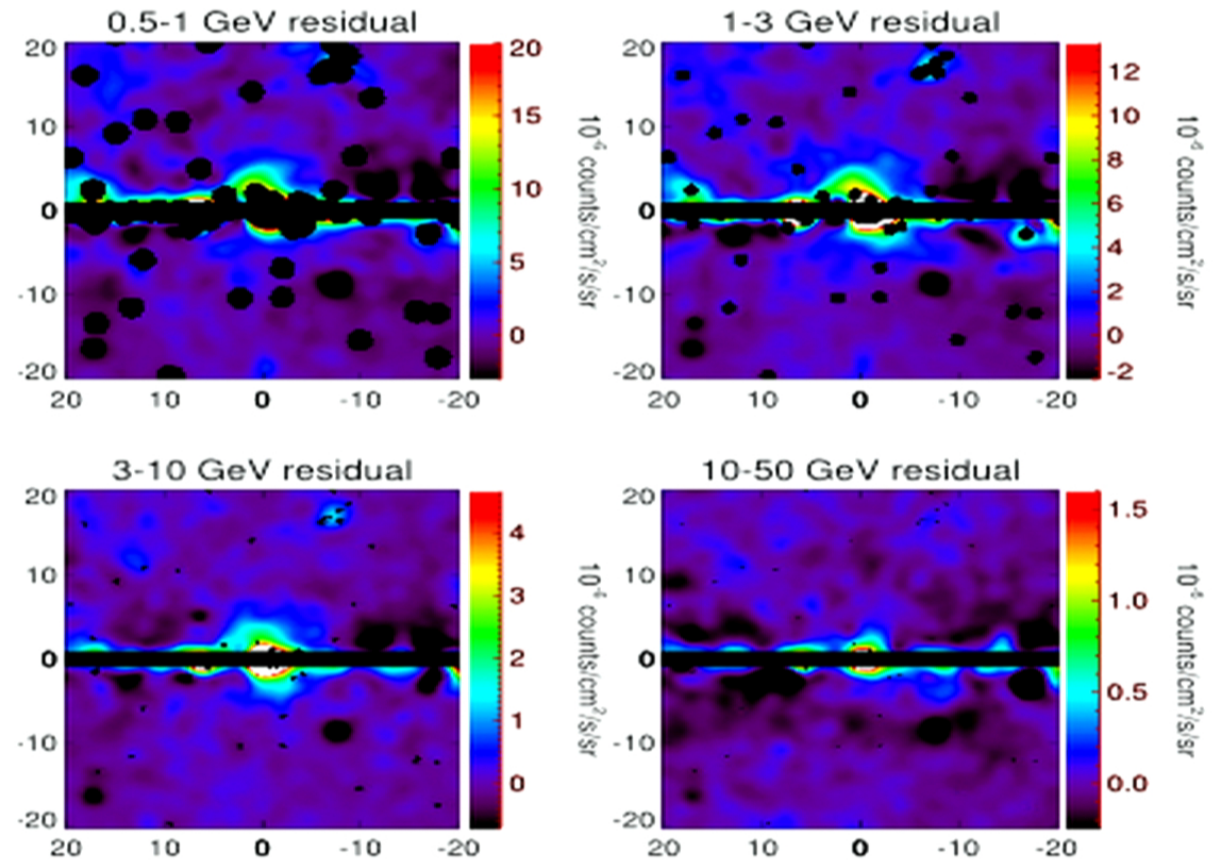
# GeV Photon Excess

Observed at the Galactic Center and Inner Galaxy ( $\approx 10^\circ$ )

Constitutes  $\sim 10\%$  total flux

High statistical significance

Goodenough and Hooper [0910.2998]  
Hooper and Goodenough [1010.2752]  
Boyardsky, Malyshev, Ruchayskiy [1012.5839]  
Hooper and Linden [1110.0006]  
Abazajian and Kaplinghat [1207.6047]  
Gordon and Macias [1306.5725]  
Abazajian *et al.* [1402.4090]  
Daylan *et al.* [1402.6703]  
Calore, Cholis, and Weniger [1409.0042]



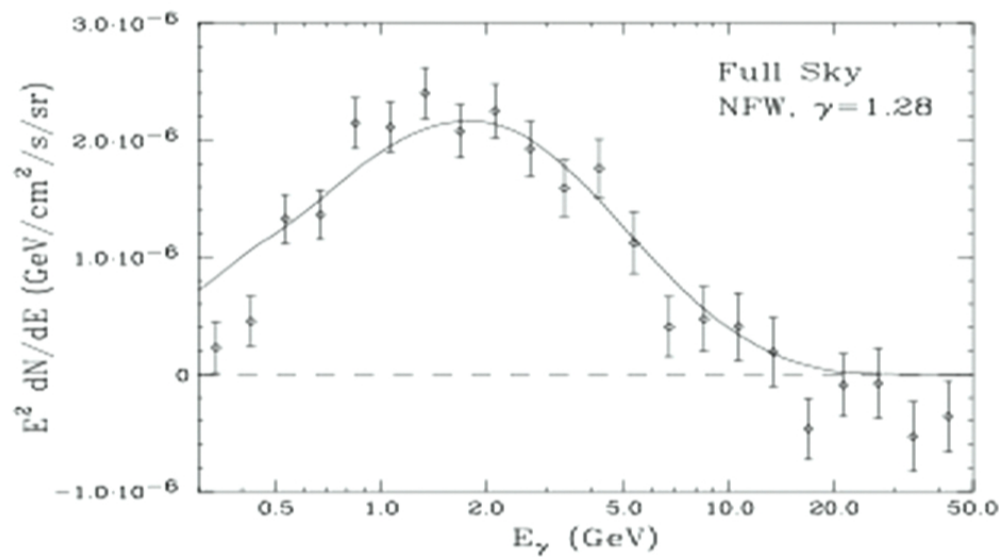
Daylan *et al.* [1402.6703]

# The Signal

Approximately spherically symmetric, centered on Sgr A\*

Flux falls off radially as  $\sim r^{-(2.2-2.6)}$

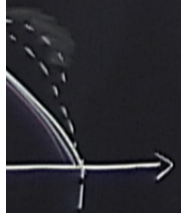
Extends up to  $10^\circ$  off the plane



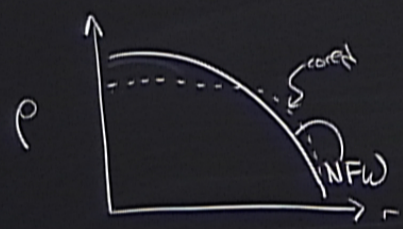
Daylan *et al.* [1402.6703]

$$[r]^2$$

$X \rightarrow bb$   
 $X \rightarrow ZZ$   
 $X \rightarrow WW$   
 $X \rightarrow \tau\tau$

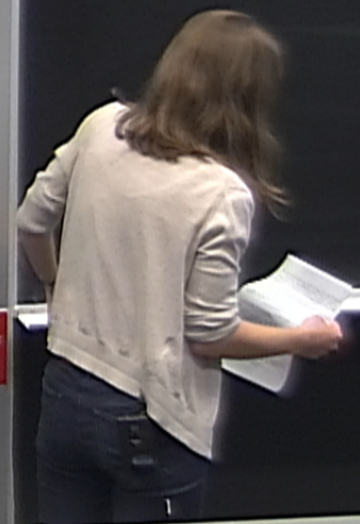


J FACTOR  
 $J \propto \int d^3p \rho^2$



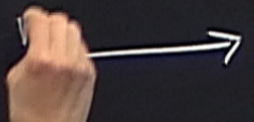
FERMI  
\* DWARF GALAXIES  
 $\log_{10} J$   
\* Galactic Center

SOMMERFELD ENH  
non-relativistic  
enhancements in



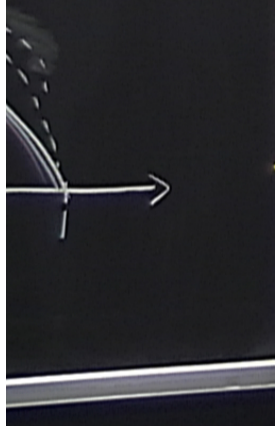
ES

SOMMERFELD ENHANCEMENT  
non-relativistic  
enhancements in  $\langle \sigma \sigma \rangle$



$$r^2$$

- $x \rightarrow bb$
- $x \rightarrow ZZ$
- $x \rightarrow WW$
- $x \rightarrow \tau\tau$



CAUTION

$\rightarrow xz$

$$E_x = k^2 m_x \left( 1 - \frac{m_x^2}{4m_x^2} \right)$$

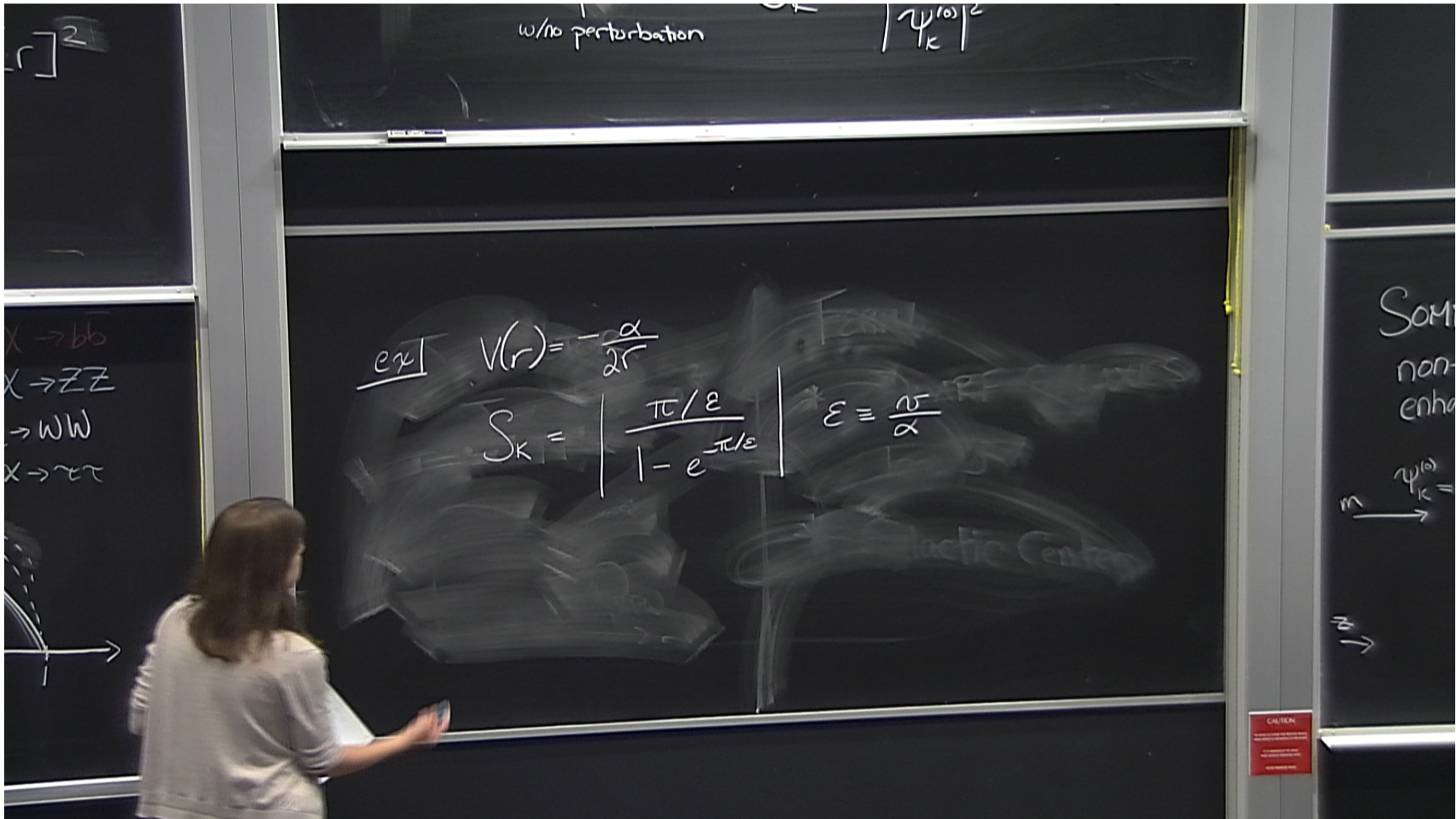
Final-state wavefunction

$$-\frac{1}{2M} \nabla^2 \psi_k + V(r) \psi_k = \frac{k^2}{2M} \psi_k$$

B.C.  $\psi \rightarrow e^{ikz} + f(\theta) \frac{e^{ikr}}{r} \text{ as } r \rightarrow \infty$

Some non-enhanced  $\psi_k^{(0)}$





w/no perturbation

$$|\psi_k^{(0)}|^2$$

ex |  $V(r) = -\frac{\alpha}{2r}$

$$S_k = \left| \frac{\pi/\epsilon}{1 - e^{-\pi/\epsilon}} \right| \quad \epsilon \equiv \frac{\beta}{\alpha}$$

Som  
non-  
enha

$$\psi_k^{(0)} = m$$

CAUTION

ex  $V(r) = -\frac{\alpha}{2r}$

$$S_k = \left| \frac{\pi/\varepsilon}{1 - e^{-\pi/\varepsilon}} \right| \quad \varepsilon \equiv \frac{2r}{\alpha}$$

EXERCISE  $\varepsilon \rightarrow \infty$ ,  $\varepsilon \rightarrow 0$

$\varepsilon \rightarrow \infty$ , high  $v$ ,  $S_k \rightarrow 1$

$\varepsilon \rightarrow \infty$ ,  $S_k \rightarrow \pi\alpha/v$  ( $\alpha=1$ )

$$S_k \rightarrow e^{-\pi\alpha/v} \quad \alpha=1$$

CAUTION

CAUTION

SOME  
non  
enh  
 $\psi_{1c}^{(0)}$   
 $m$   
 $z$

ex  $V(r) = -\frac{\alpha}{2r}$

$$S_k = \left| \frac{\pi/\varepsilon}{1 - e^{-\pi/\varepsilon}} \right| \quad \varepsilon \equiv \frac{2\sigma}{\alpha}$$

EXERCISE  $\varepsilon \rightarrow \infty$ ,  $\varepsilon \rightarrow 0$

$\varepsilon \rightarrow \infty$ , high  $\sigma$ ,  $S_k \rightarrow 1$

$\varepsilon \rightarrow 0$ ,  $S_k \rightarrow \pi\alpha/v$  ( $\alpha=1$ )

$S_k \rightarrow e^{-\pi|\alpha|/v}$   $\alpha=1$

CAUTION

CAUTION

SOME  
non  
enh  
 $\psi_{lc}^{(0)}$   
 $m \rightarrow$   
 $z \rightarrow$

# Non-Thermal Wino

