Constraining box-shaped gamma ray features with CTA

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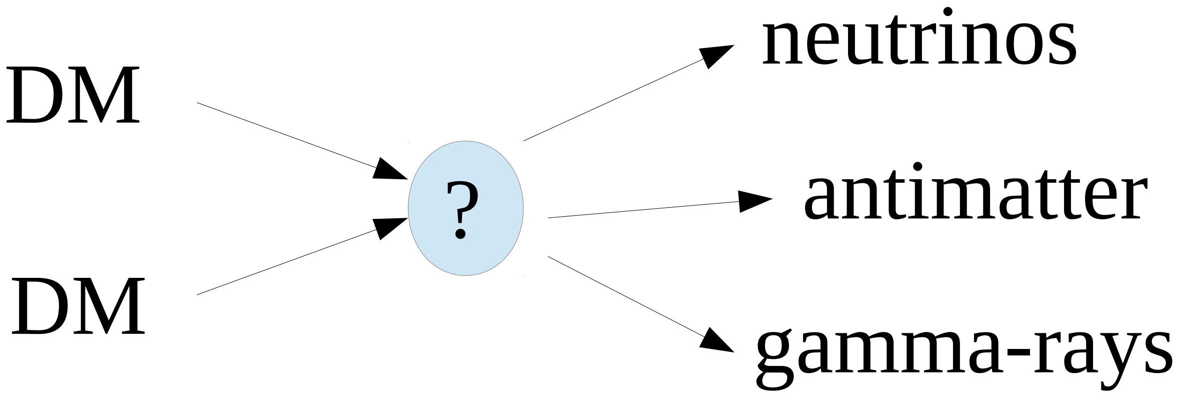
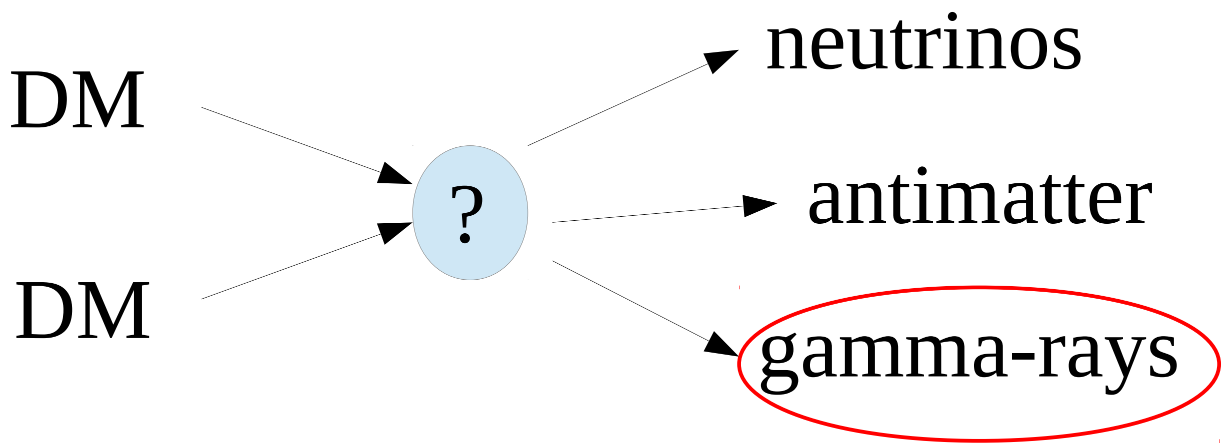
Indirect dark matter searches



Indirect dark matter searches



Indirect dark matter searches

DM

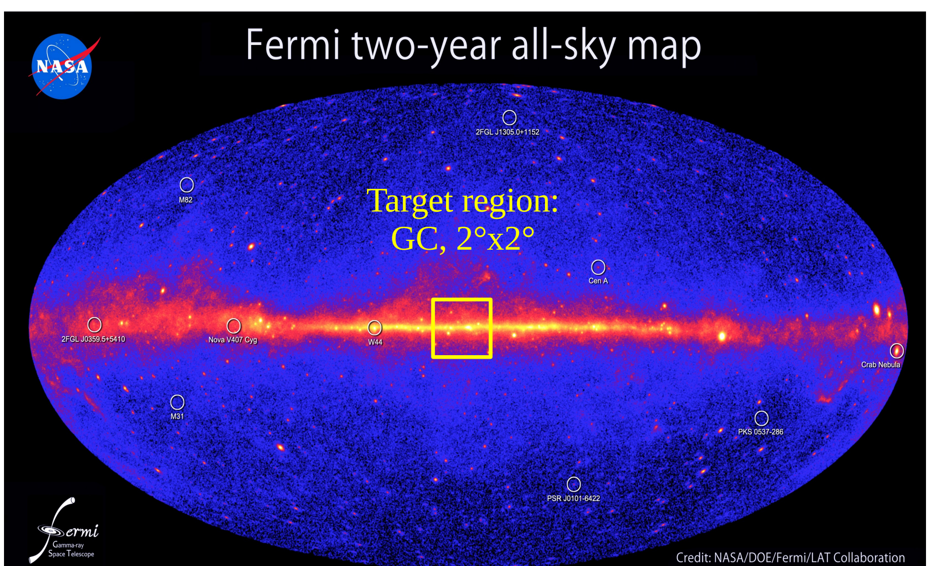
DM

?

neutrinos

antimatter

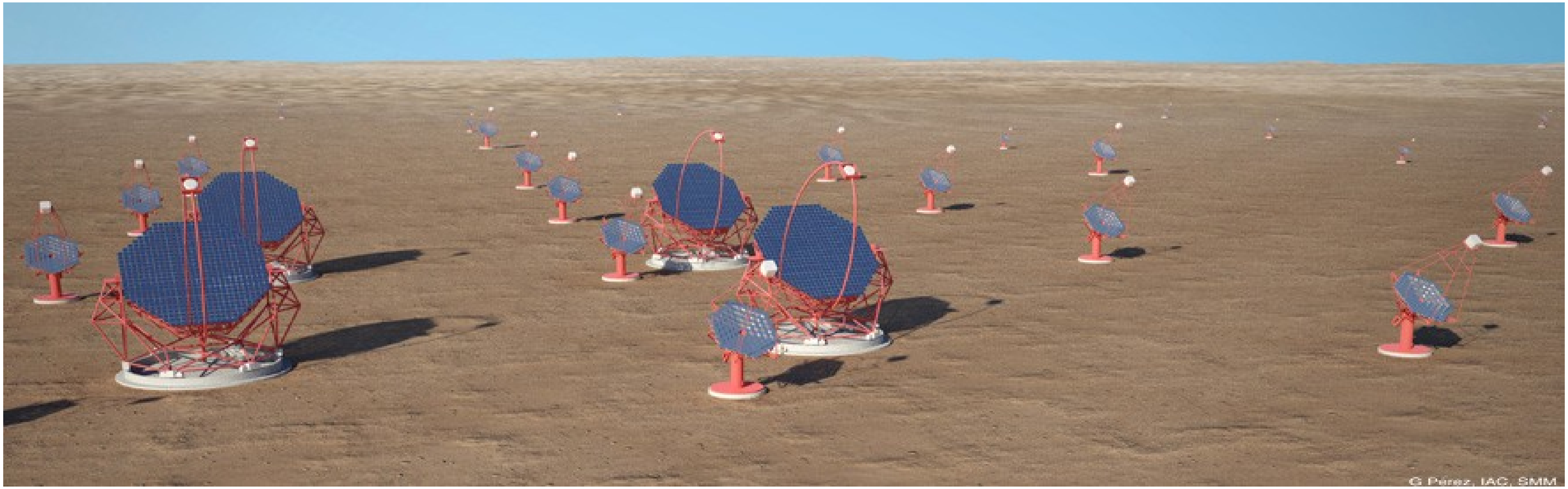
gamma-rays



$$\phi_\gamma(E_\gamma) = \boxed{\frac{\langle \sigma v \rangle}{8\pi m_{DM}^2} \frac{dN_\gamma}{dE_\gamma}} \boxed{\frac{1}{\Delta\Omega} \int_{\Delta\Omega} d\Omega \, J_{ann}}$$

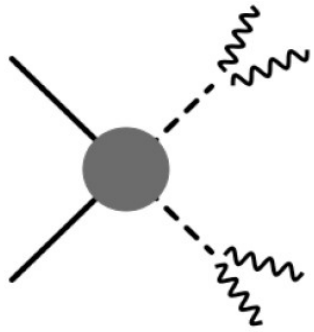
Particle physics Astrophysics

CTA: future Cherenkov Telescope Array



- Use atmosphere as a calorimeter
- Planned: air Cherenkov telescope with northern and southern arrays
- Detection of the cherenkov light produced in the showers created by high energy gammas and cosmic rays that enter the atmosphere

Gamma ray boxes



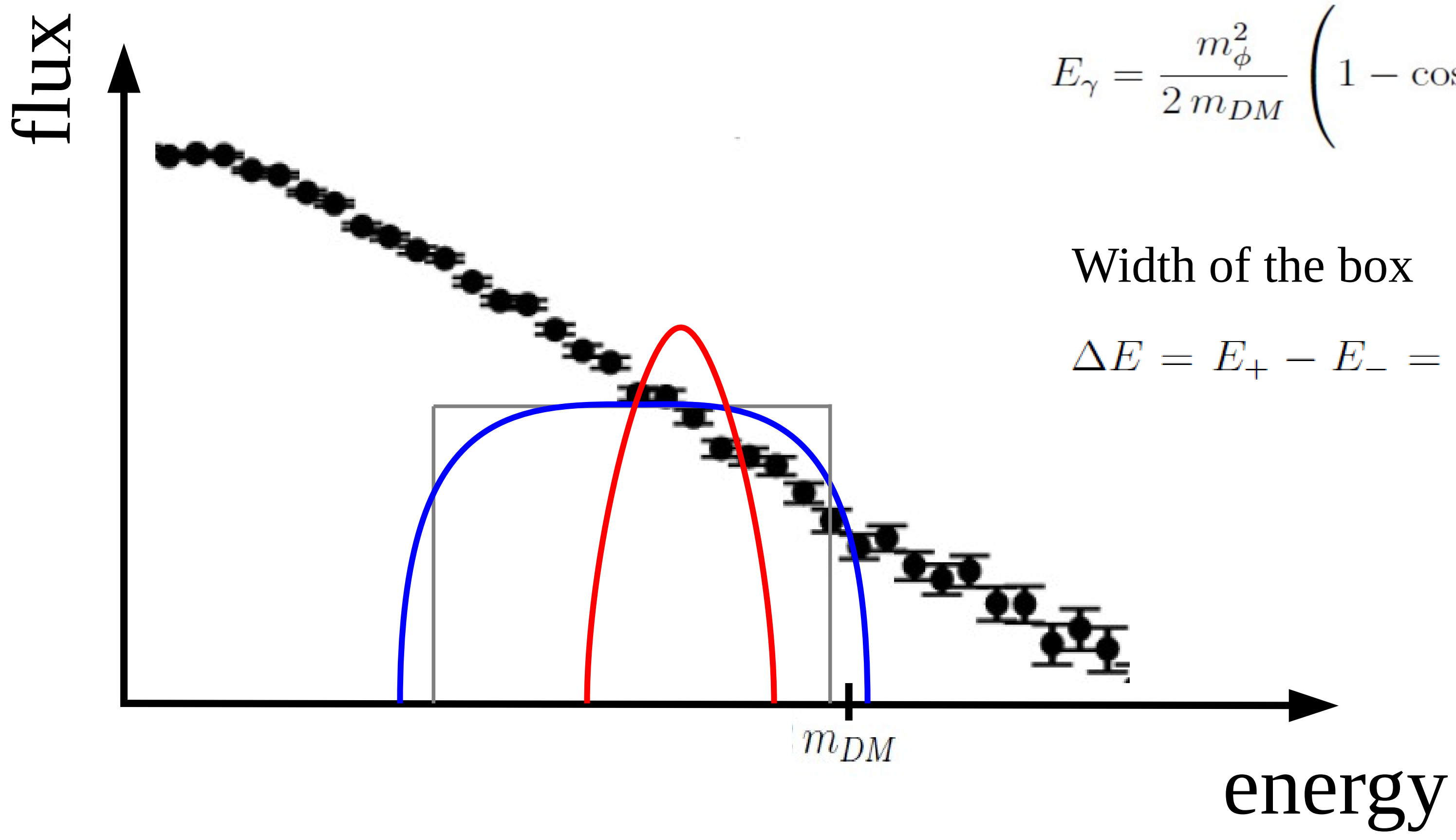
DM annihilation into pair of scalars that decay into photons

Gamma-ray energy:

$$E_\gamma = \frac{m_\phi^2}{2\, m_{DM}} \left(1 - \cos\theta \sqrt{1 - \frac{m_\phi^2}{m_{DM}^2}}\right)^{-1}$$

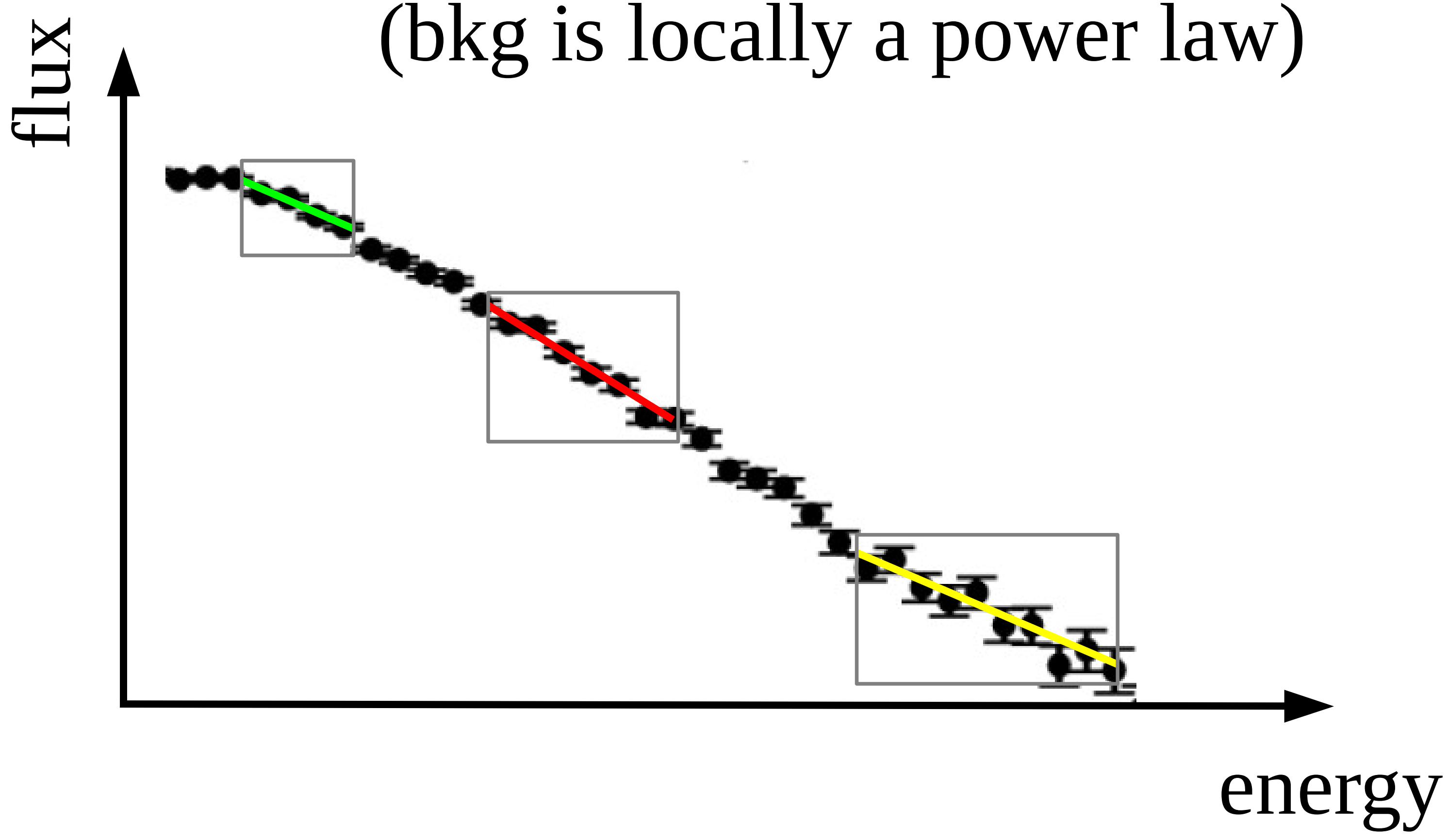
Width of the box

$$\Delta E = E_+ - E_- = \sqrt{m_{DM}^2 - m_\phi^2}$$



Sliding energy window technique

Compare: fit with power law bkg
to fit with power law bkg and signal
in sliding energy window
(bkg is locally a power law)



Procedure

1) Model the background in the target region (Galactic Center)

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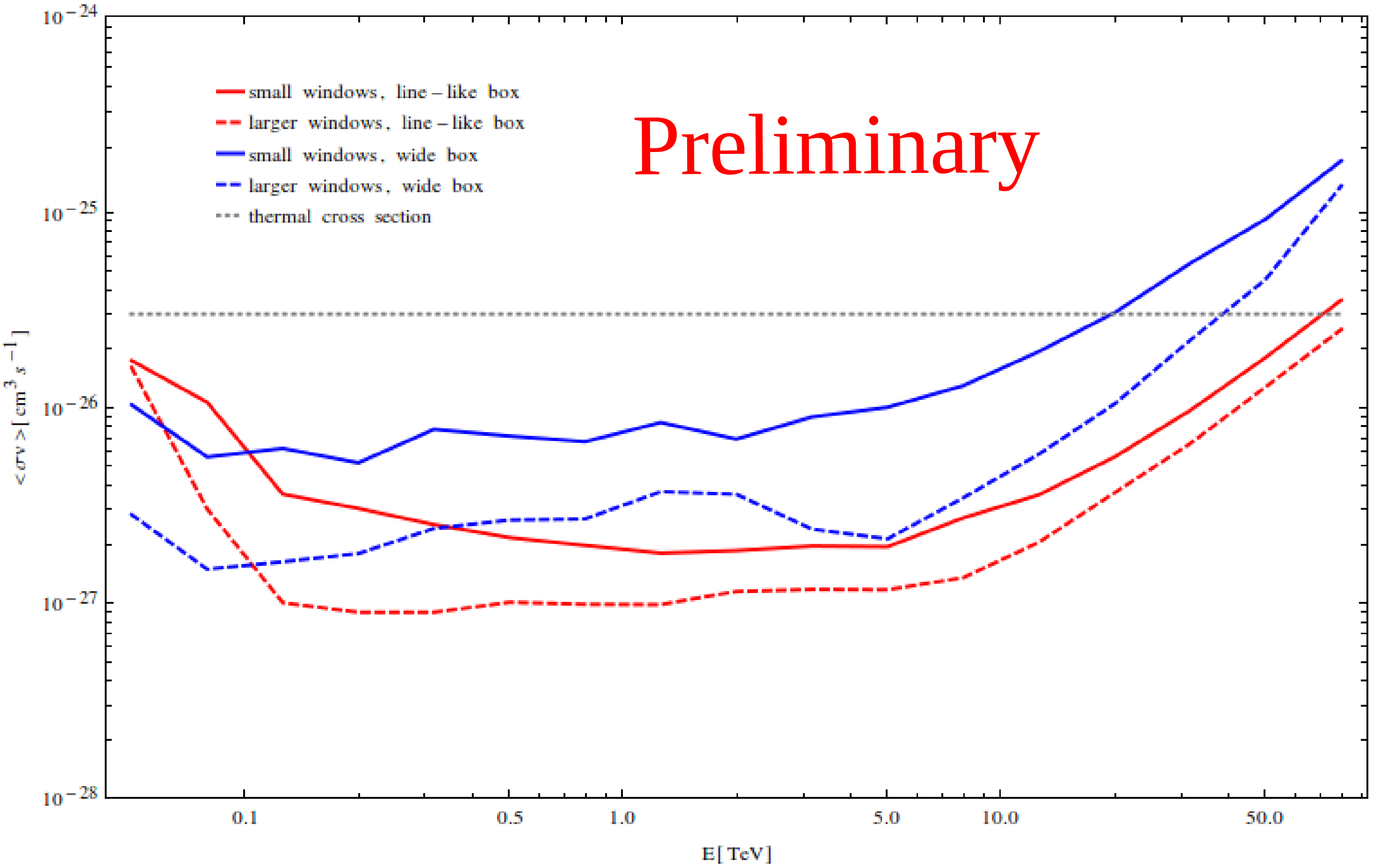
4) Calculate average limit from all mock data sets

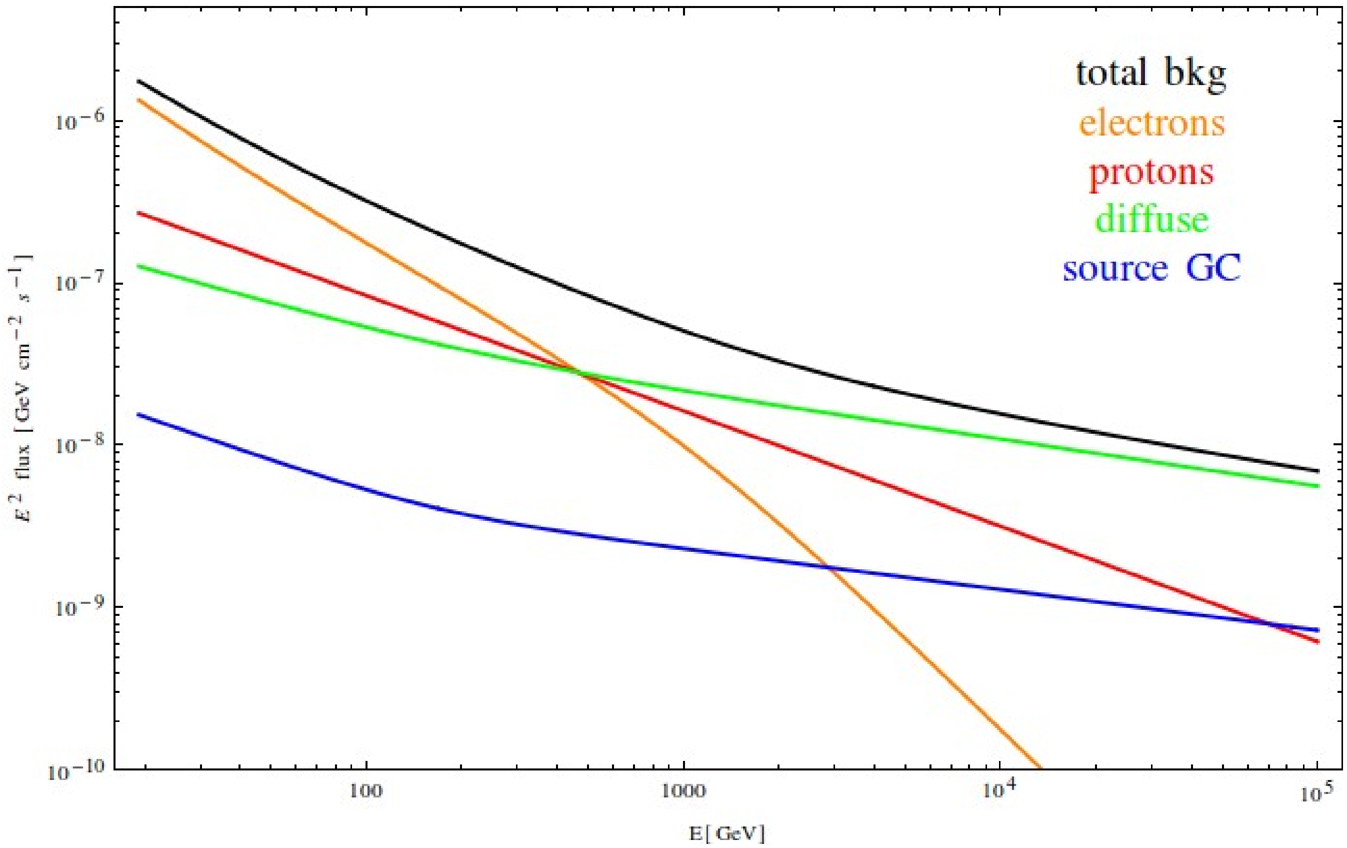
Limits

CTA: a unique opportunity to constrain multiTeV DM candidates with gamma rays



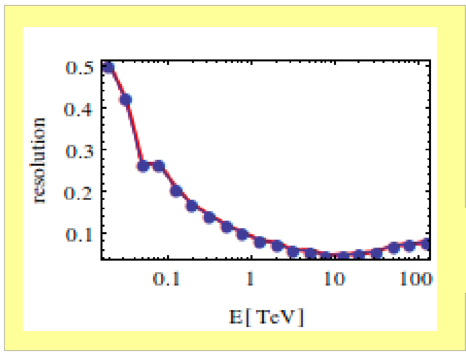
Backup slides

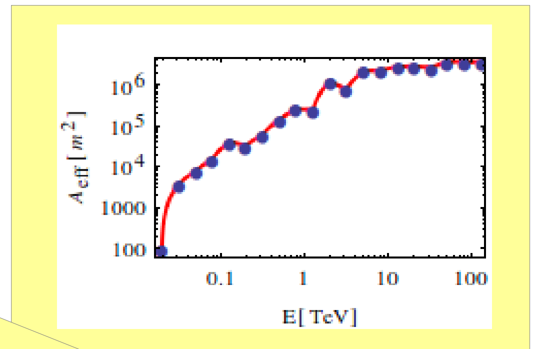
Background Model

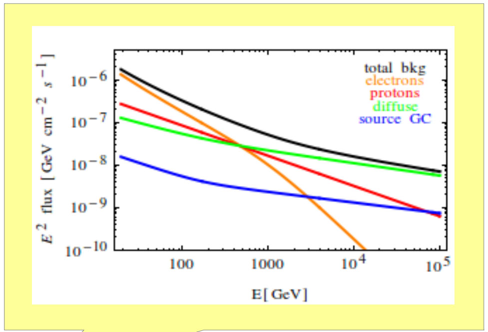


- Gammas from the GC: diffuse gammas and Hess source
- Irreducible background: electrons
- Good rejection: protons, but still sizable background

Mock data: Counts



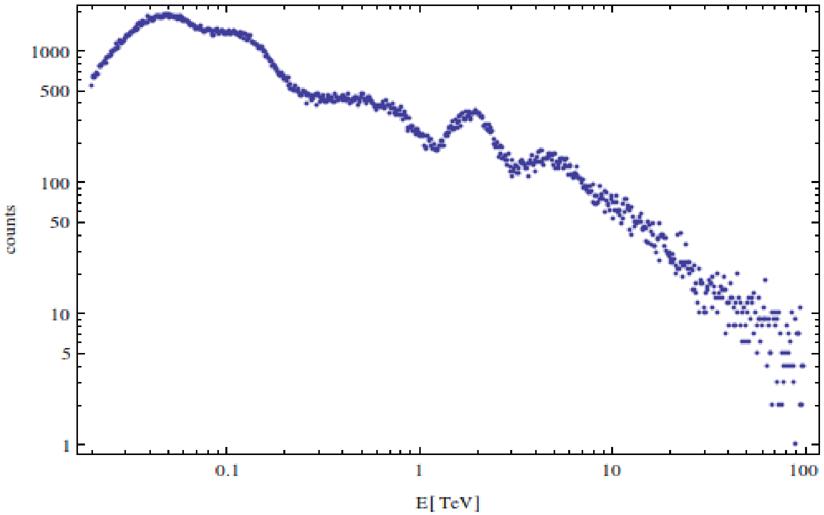




"observed" counts:

$$\frac{c_i}{t_{\rm obs}} = \int_{\Delta E_i} dE \int dE' \mathcal{D}_{E,E'} A_{\rm eff}(E') \left[\frac{dN_{\rm bkg}}{dE'}\right]$$

randomize



Maximum Likelihood analysis

- Likelihood function $L(\boldsymbol{\mu}|\mathbf{c}) = \Pi_{i=i_0,\ldots,i_1} P_{\mu_i}(c_i)$
- Poisson probability $P_\mu(k) = \mu^k e^{-\mu}/k!$

signal

background

- Expected counts $$\frac{\mu_i}{t_{\text{obs}}} = \int_{\Delta E_i} dE \int dE' \boxed{\mathcal{D}_{E,E'} A_{\text{eff}}(E')} \left[\alpha \frac{dN_\chi}{dE'} + \boxed{\beta} E'^{\boxed{-\gamma}} \right]$$

Instrument properties

Signal normalization

fit parameters

- 95.5% C.L. → Increase signal normalization from its best-fit value until -2logL has changed by 2.71