

Gamma rays from dark matter annihilations

Stefan Vogl

T. Bringmann, X. Huang, A. Ibarra, SV and C. Weniger **JCAP 1207 (2012) 054**
M. Garny, A. Ibarra, M. Pato and SV **in preparation**



Technische Universität München

Outline

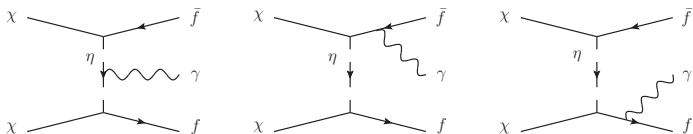
- 1 Introduction
- 2 Internal Bremsstrahlung
- 3 Searching for a gamma ray feature
- 4 Further constraints
 - Quarks
 - Leptons
- 5 Conclusion

gamma-ray features

- gamma-ray features as smoking gun for dark matter detection
- numerous possibilities:
 - ▶ line
 - ▶ box
 - ▶ virtual internal bremsstrahlung
 - ▶ ...
- generically small cross section
- hint of a excess at 130 GeV

↪ focus on internal bremsstrahlung

What is Internal Bremsstrahlung?



- hard gamma from a three-body process

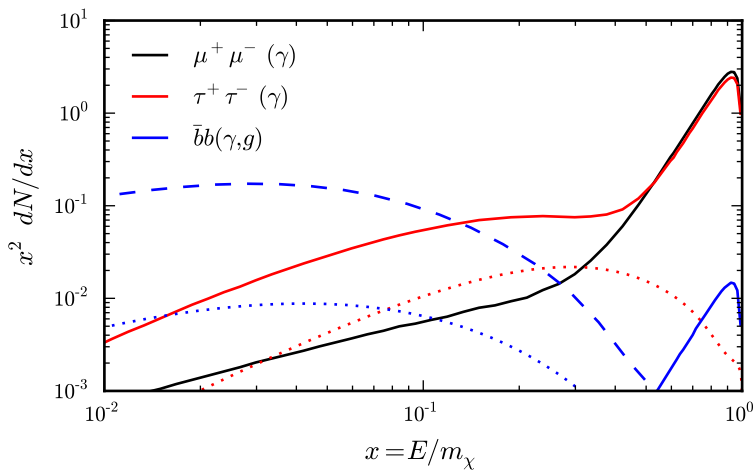
When does it happen?

- dark matter χ is a Majorana fermion
- scalar η couples to Standard Model
- $\mathcal{L}_{\text{int}} = -y\bar{\chi}\Psi_R\eta + \text{h.c.}$

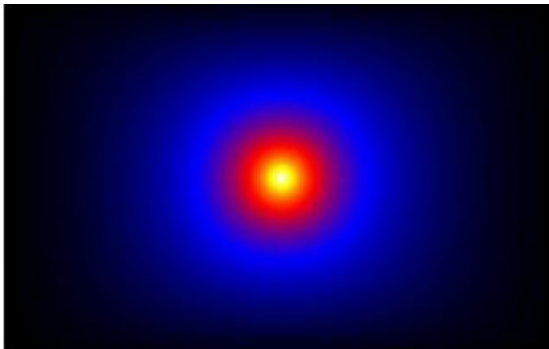
\Rightarrow chirality suppression

- suppression is lifted by emission of hard gamma
- strong enhancement for $\Delta m = m_\eta - m_\chi$ small
- Examples:
 - ▶ slepton or squark coannihilation in MSSM
 - ▶ right handed neutrino DM [\[Bergstrom 2012\]](#)

Spectrum

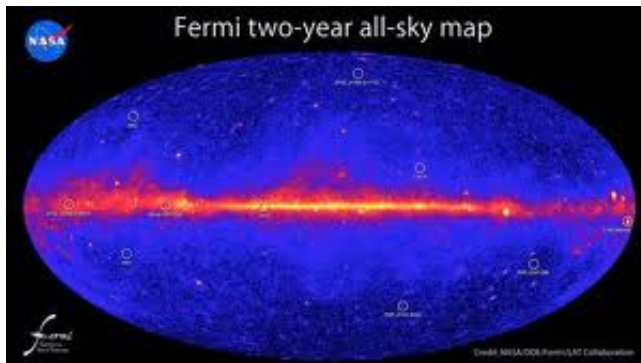


Where to look for DM?



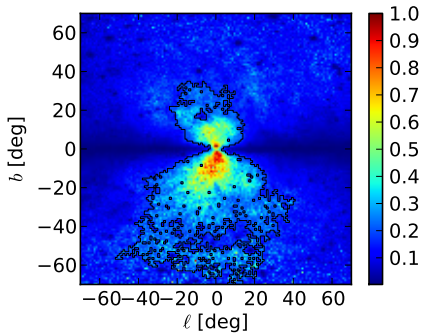
$$\text{Flux} \sim J = \int_l \int_{\Delta\Omega} \rho_{DM}^2(l, \Omega) dl d\Omega$$

Look at the Galactic Center?

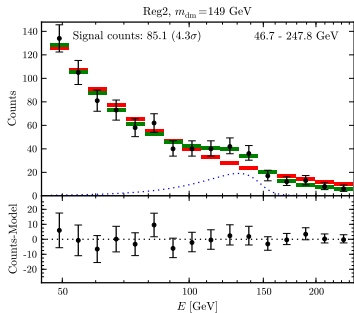


- pro: highest J -factor
- con: huge background in the Galactic Center
- but: characteristic signature

⇒ look at the center

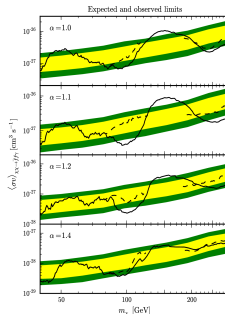
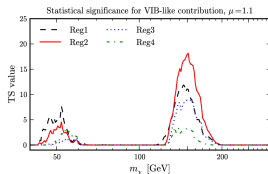
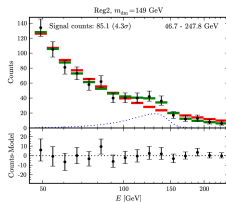


select region of interest



analyse spectrum

Fermi 130 GeV excess



- internal bremsstrahlung is a good fit for the 130 GeV excess
- global (local) significance 3.1 (4.3) sigma

The Fermi Collaboration

- official line paper this week [arXiv:1305.5597](https://arxiv.org/abs/1305.5597)
- three different analyses
 - ▶ unprocessed data and 1D energy dispersion $\rightarrow 4.5\sigma$
 - ▶ reprocessed and 1D energy dispersion $\rightarrow 4.1\sigma$
 - ▶ reprocessed and 2D energy dispersion $\rightarrow 3.3\sigma$
- same number of events, but excess too narrow for good fit with line energy resolution
- "More data and study are needed to clarify the origin of this feature "

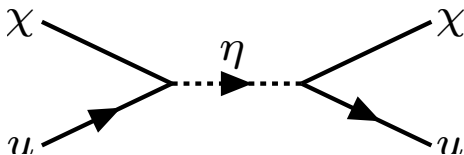
Going beyond the 130 GeV excess

- What else can be said about these models?
- Can we extend the range of gamma ray searches?
- Are there other observables predicted?

other gamma ray searches

- Fermi dwarf observations (continuum photons)
- line search by HESS, 500 GeV - 20 TeV [A. Abramowski et al. '13]
- principles similar to those described above, different background

Direct Detection



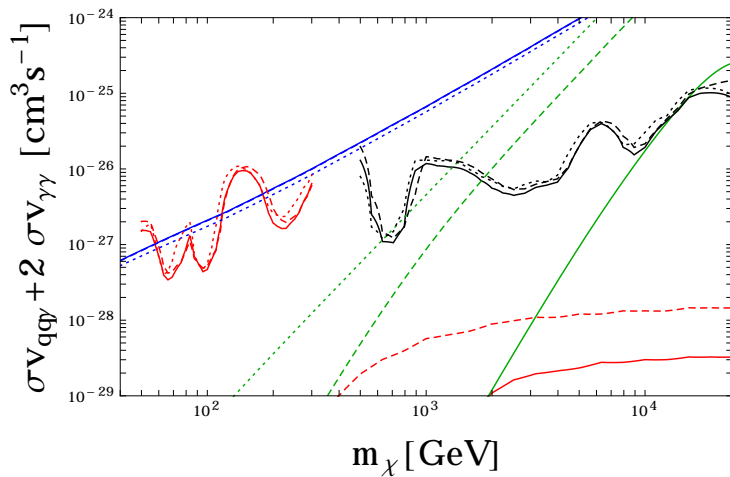
- scattering of quarks and gluon in the nucleus
- heavy quarks flavour suppressed compared to valence quarks
- enhancement for small Δm

Collider



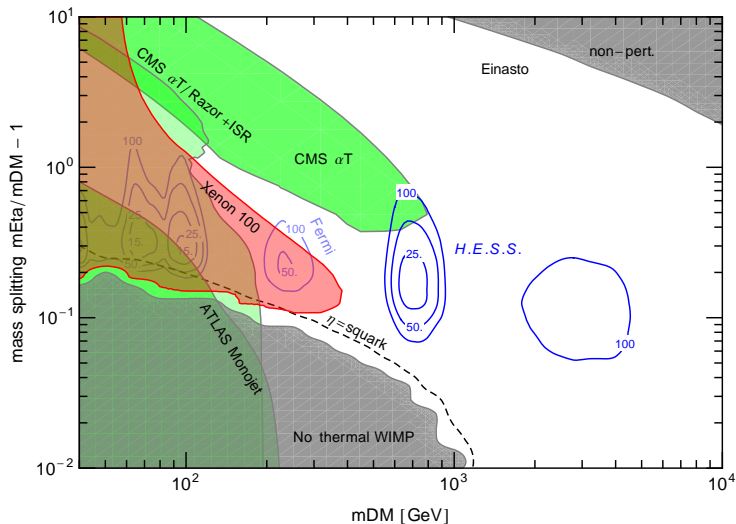
- production of coloured η due to strong interaction
- signature at collider: 1,2 jets plus missing E_T
- efficiency depends on $m_\eta - m_\chi$
- for $m_\eta - m_\chi \lesssim 100$ GeV rely on ISR [Dreiner, Kramer, Tattersall '12]
- $m_\eta \gtrsim 200$ GeV

Collecting the constraints



How about thermal dark matter?

DM coupling to RH up-quark (thermal production)



Leptons

- LEP: $m_\eta \gtrsim 90$ GeV
- only electroweak production \Rightarrow so far no LHC bound
- no direct detection
- reduced branching ratio to continuum photons

Conclusion

- spectral features provide save information from Galactic Center
- IB can account for line like gamma ray feature
- more data necessary
- coupling to light quarks constrained
- coupling to heavy quarks or leptons rather free