Gamma Rays from Dark Matter Annihilations

Michael Gustafsson

22 September 2008

Stockholm University

The second network school and meeting
Oxford, UK, 22 to 26 September 2008

Padova

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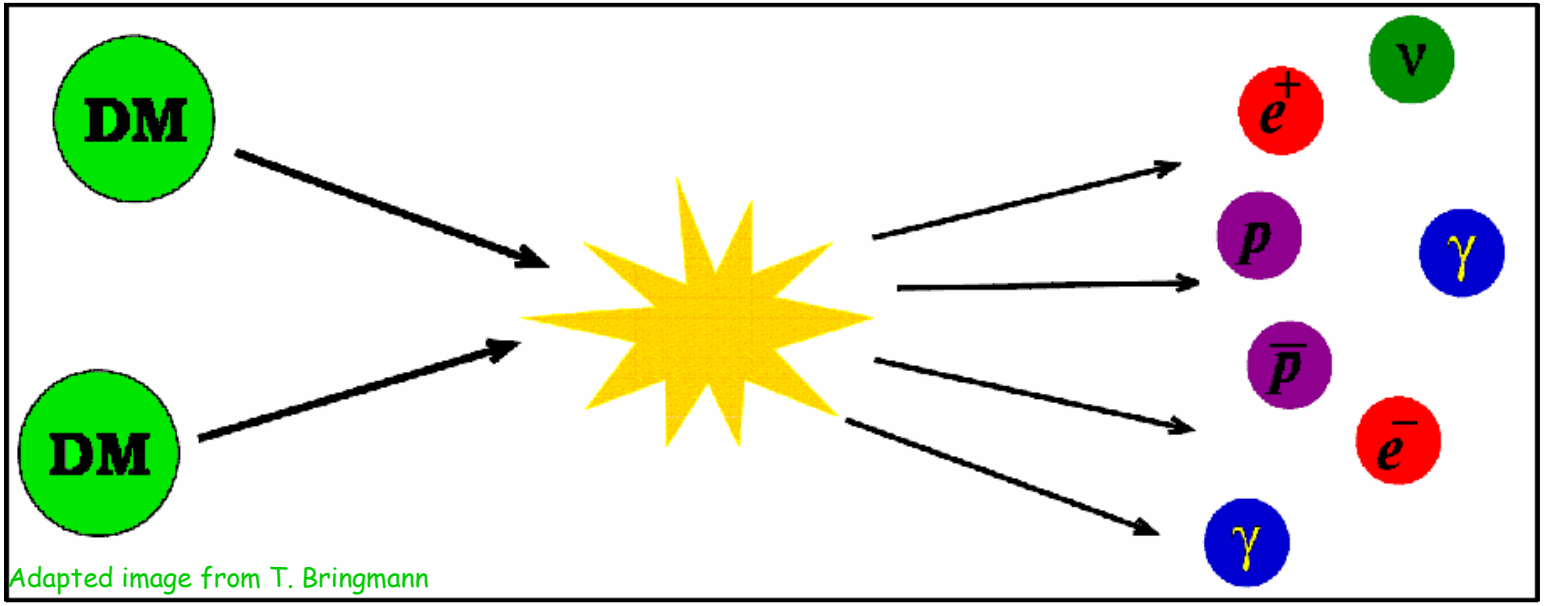
Basic idea

– indirect detection of particle dark matter

Two dark matter particles annihilate ...



... and the products can then be detected

Basic idea

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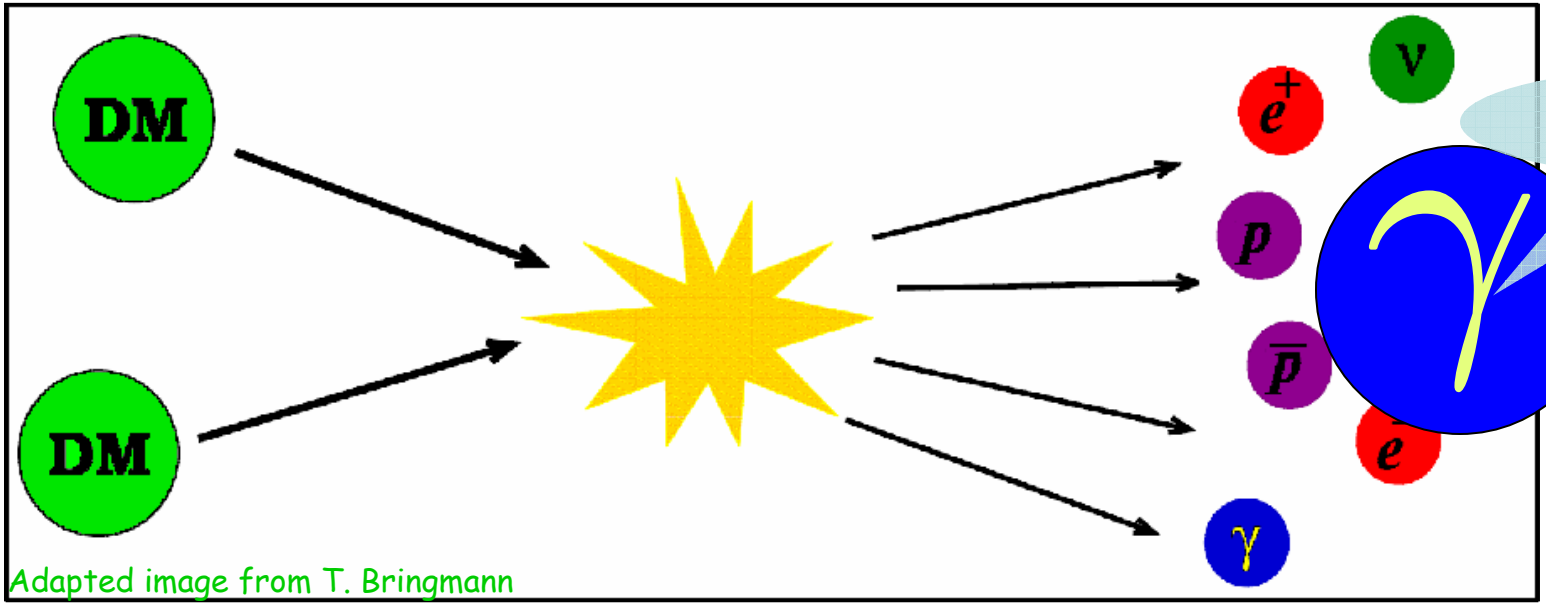

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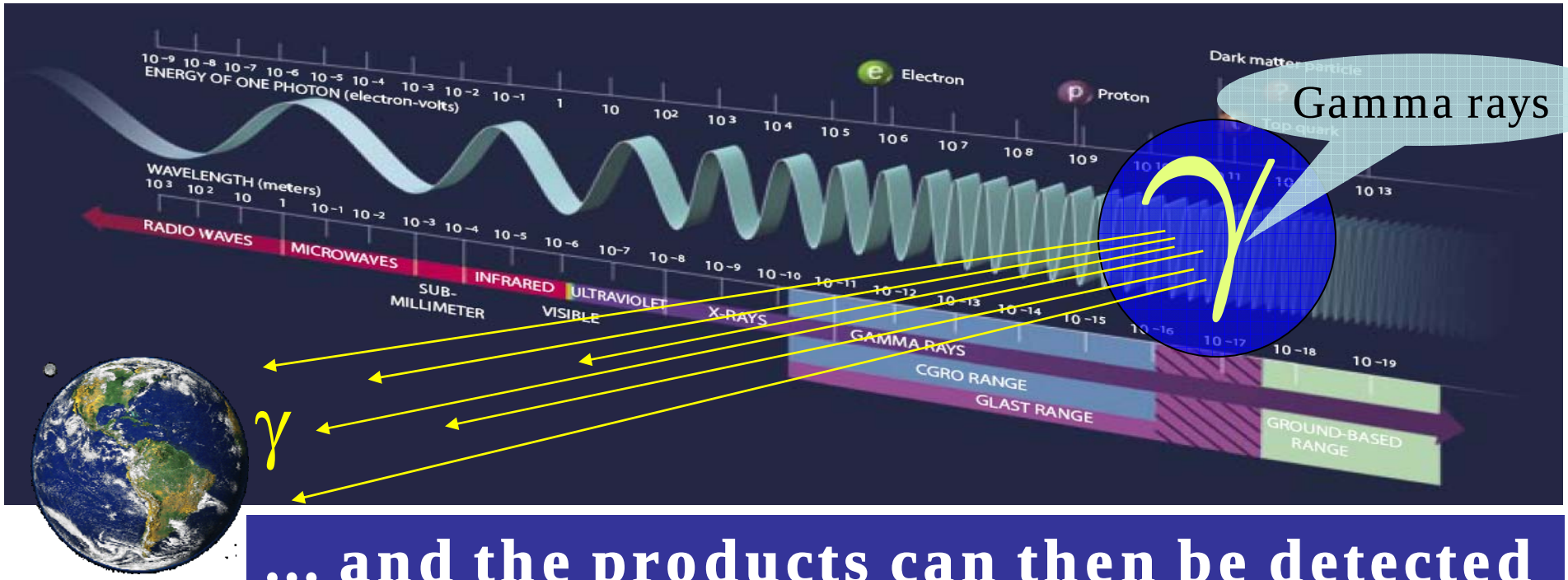
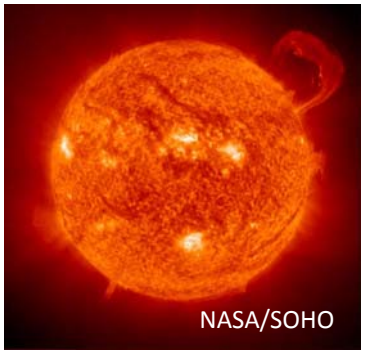
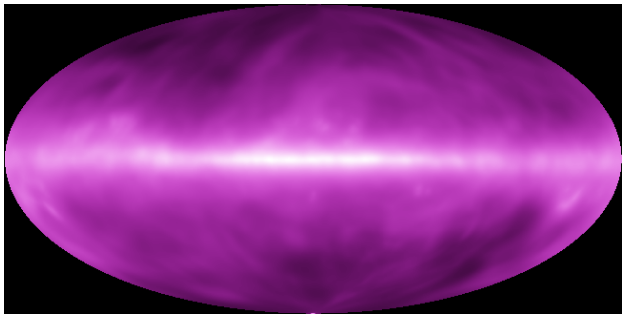


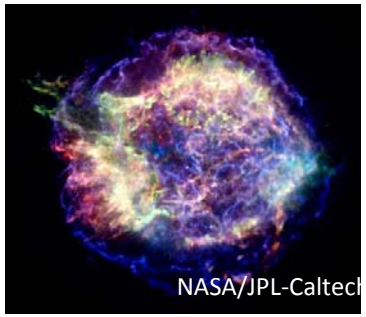
... and the products can then be detected

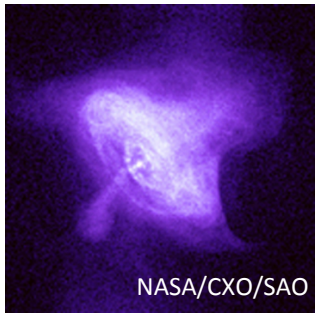
Can gamma rays provide a clear signature of DM?

- Gamma-ray Backgrounds:
  - Solar system
  - Galactic
  - Extragalactic



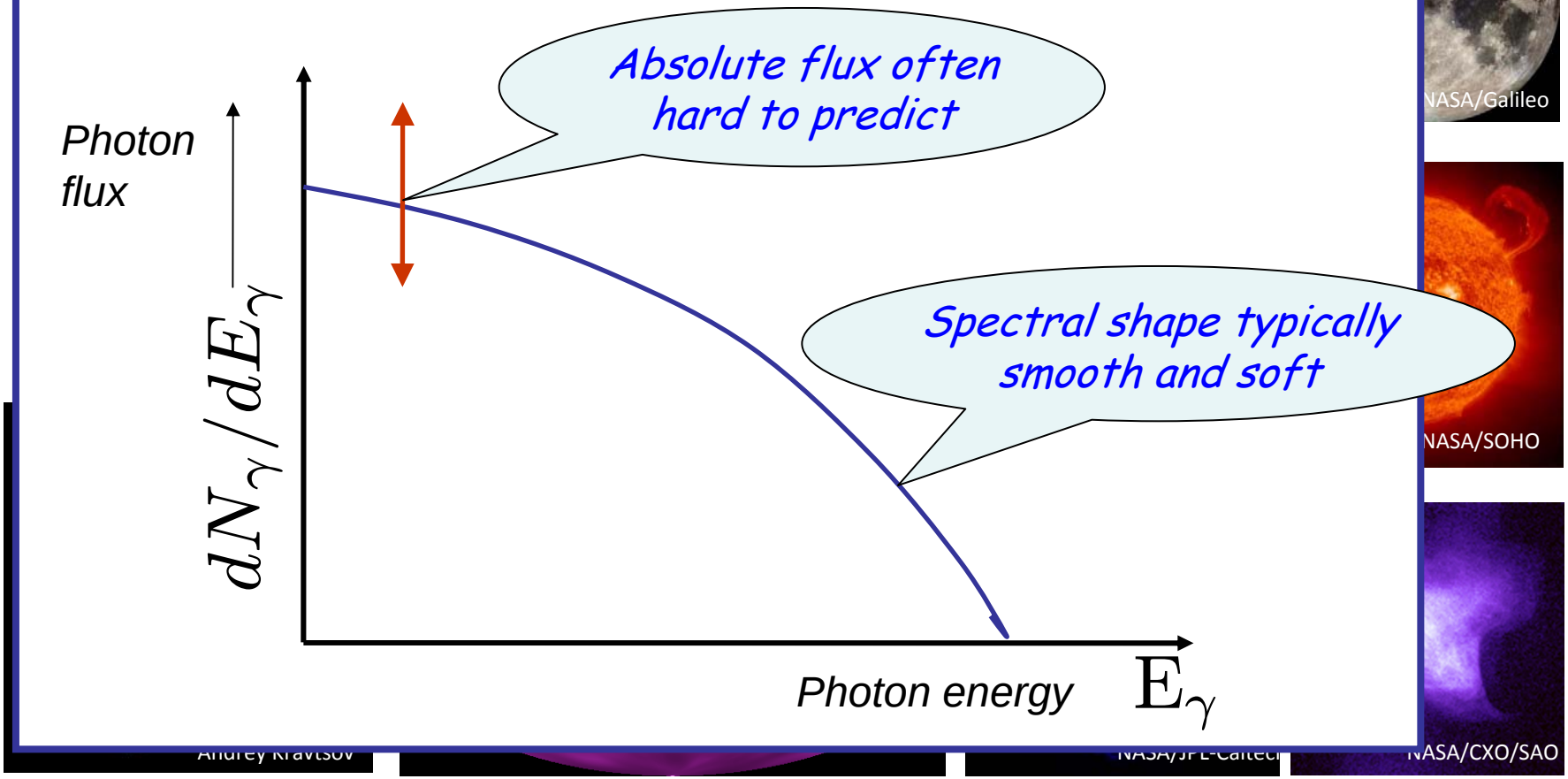






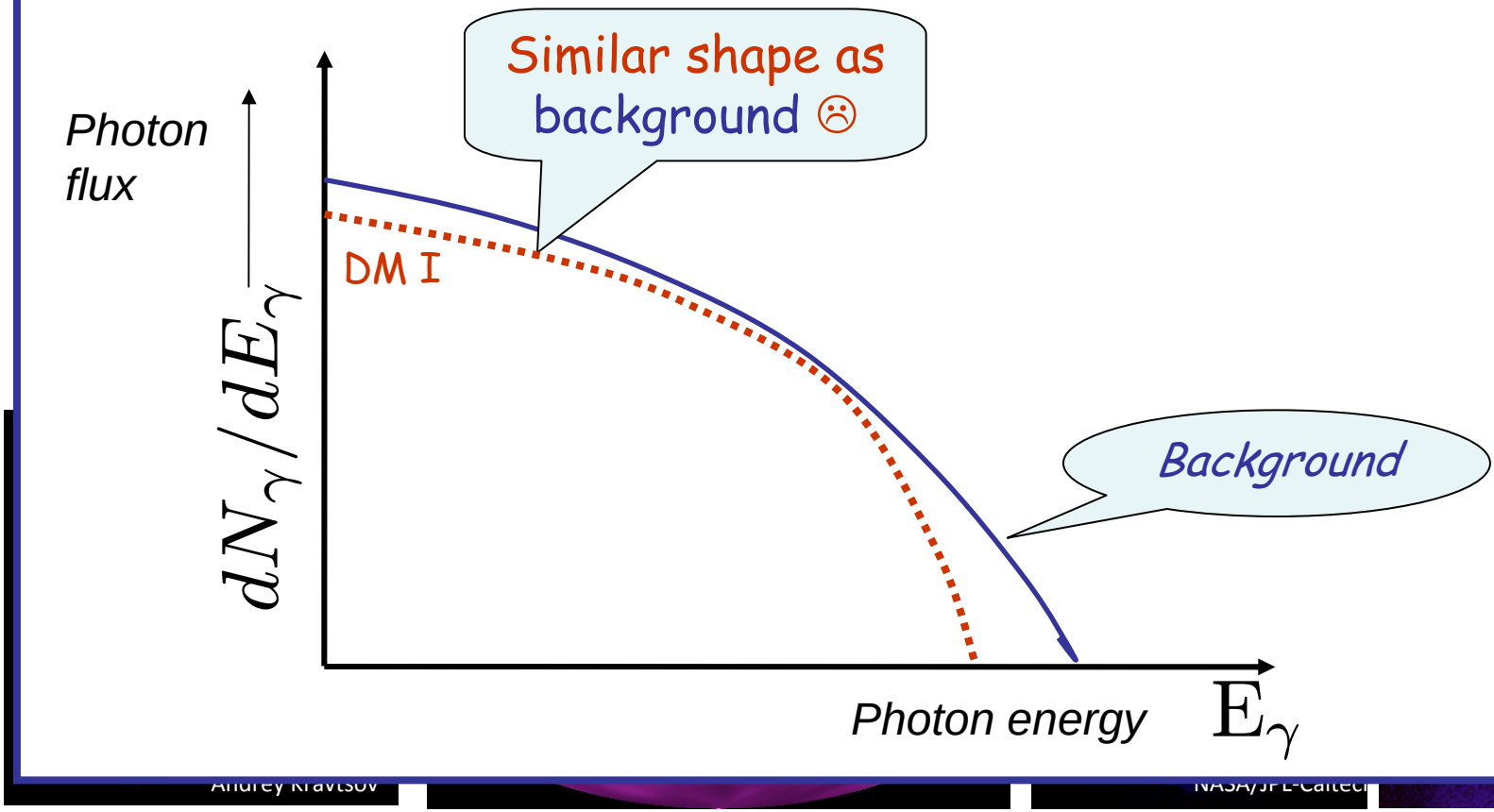
Can gamma rays provide a clear signature of DM?

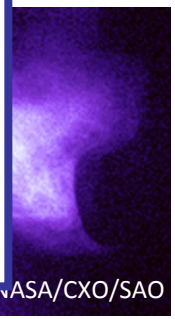
- Gamma-ray Backgrounds:



Can gamma rays provide a clear signature of DM?

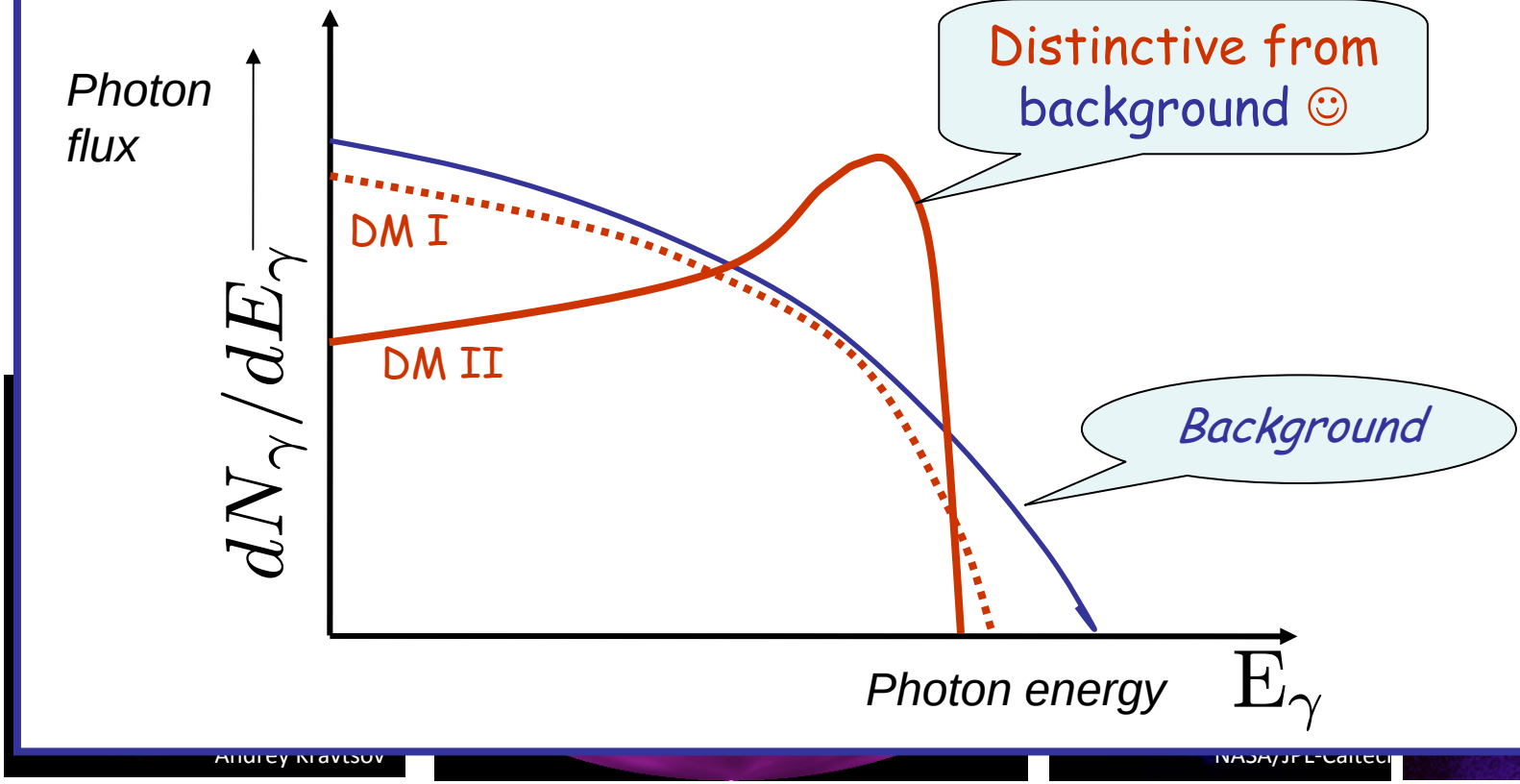
- Dark matter I – signal not clear

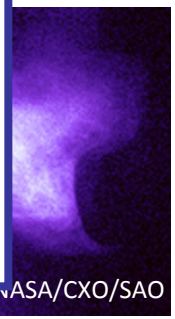




Can gamma rays provide a clear signature of DM?

- Dark matter II – clear signal!

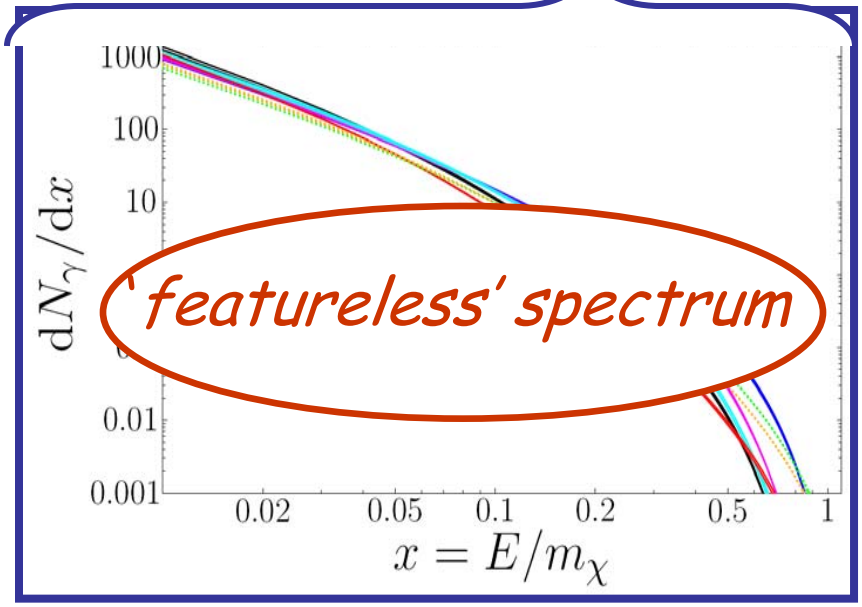




DM gamma-ray spectrum

Note: Details determined by the microphysics of DM candidate

$$\frac{dN_\gamma}{dE_\gamma} = \frac{dN^{sec}}{dE_\gamma} + \frac{dN^{IB}}{dE_\gamma} + \frac{dN^{line}}{dE_\gamma}$$



E.g. Bertone et al., astro-ph/0612387

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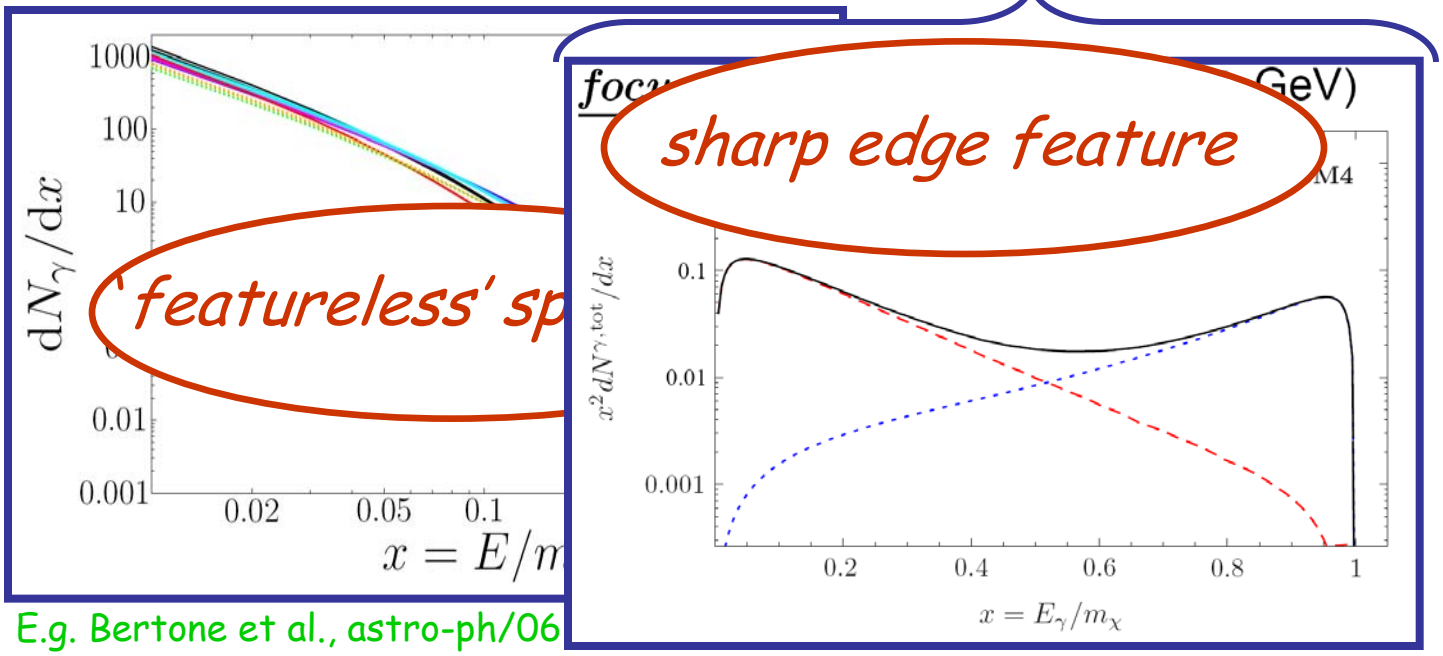

E.g. Bertone et al., astro-ph/06

Bringmann, Bergström & Edsjö '08
Bergström, Bringmann, MG & Eriksson '04

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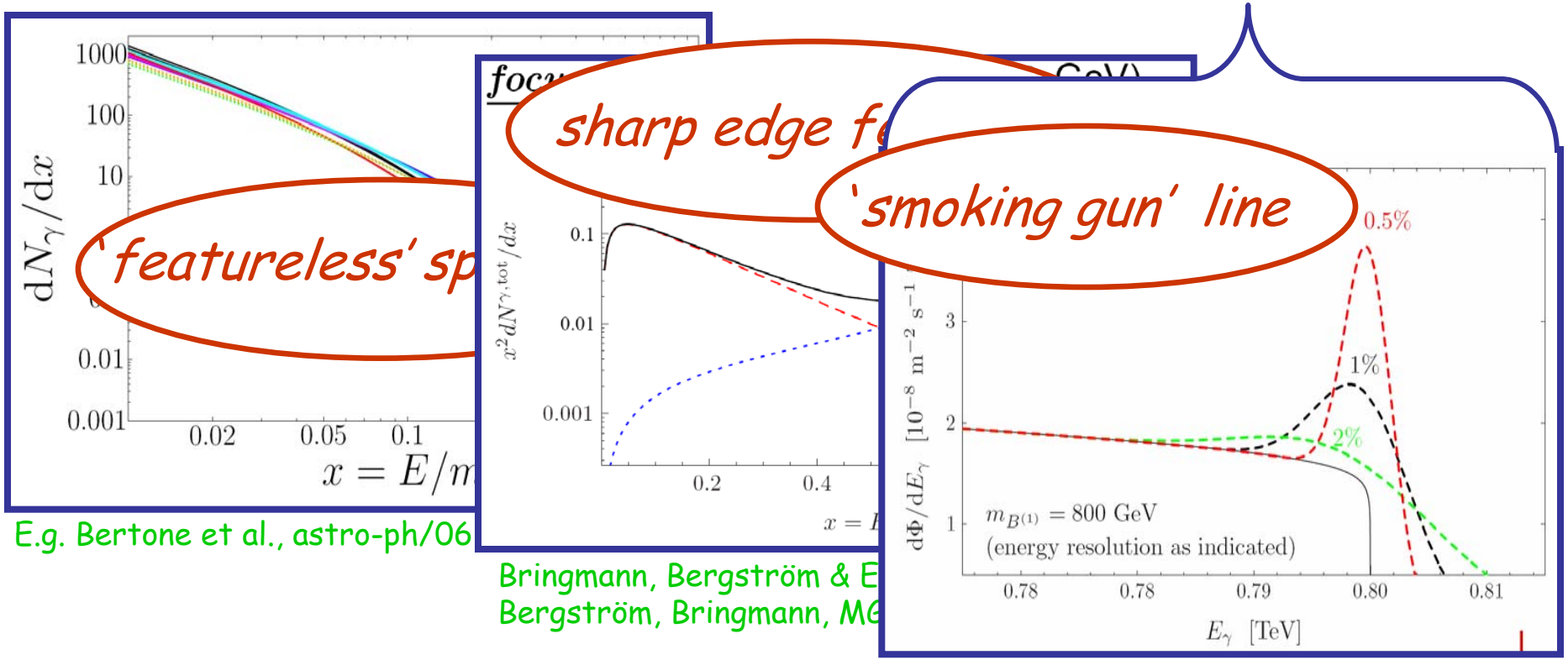

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Bringmann, Bergström & E
Bergström, Bringmann, MG

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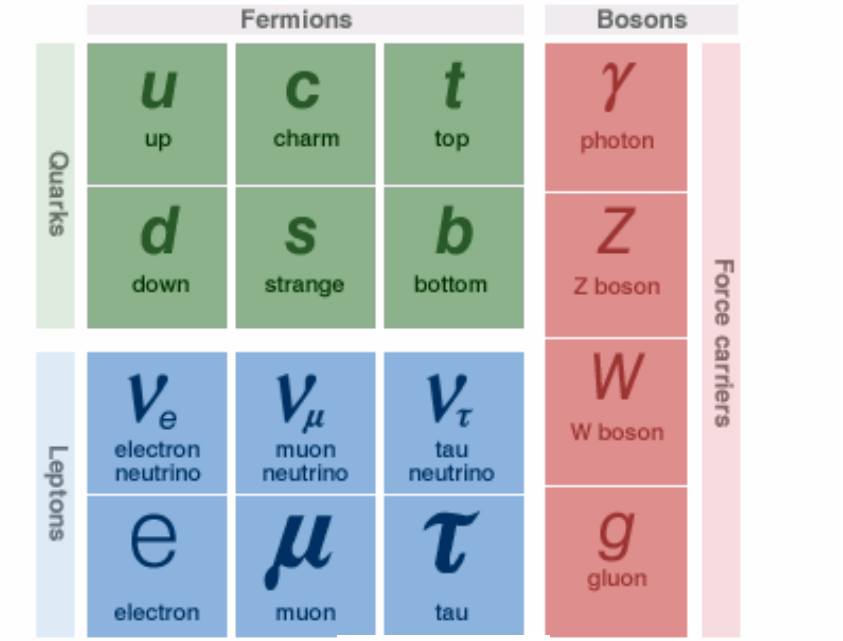
Standard model

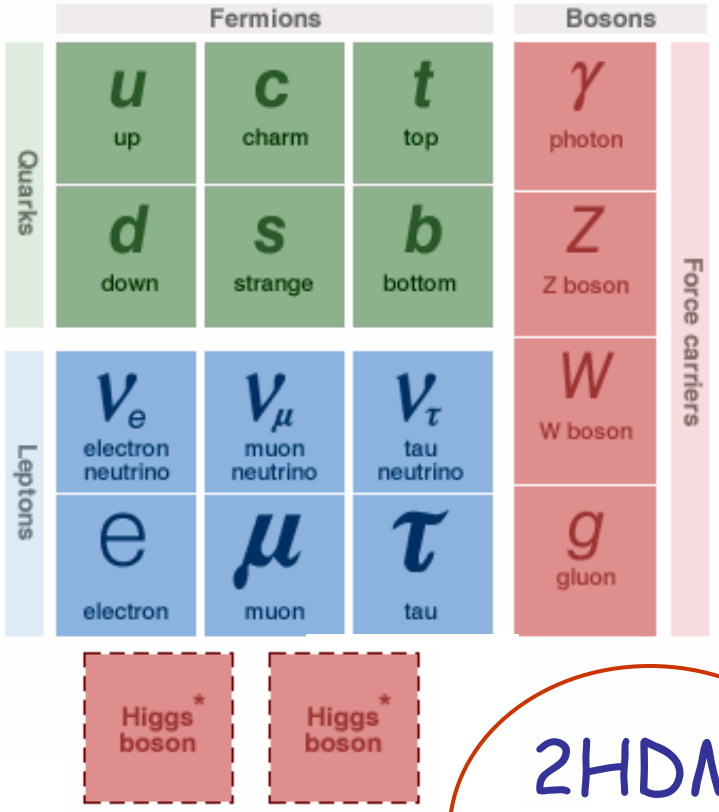


ϕ_1 ϕ_2

Scalar doublets

2HDM
= Two Higgs doublet model

Standard model



ϕ_1 ϕ_2

Scalar doublets

2HDM
= Two Higgs doublet model

Inert Doublet model (IDM)

Deshpande & Ma 1978 , Barbieri *et al.* 2006, Honorez *et al.* 2007

- 2HDM with an imposed

  Z_2-symmetry: $\phi_2 \rightarrow -\phi_2$

  and even Z_2-parity for all SM fields.

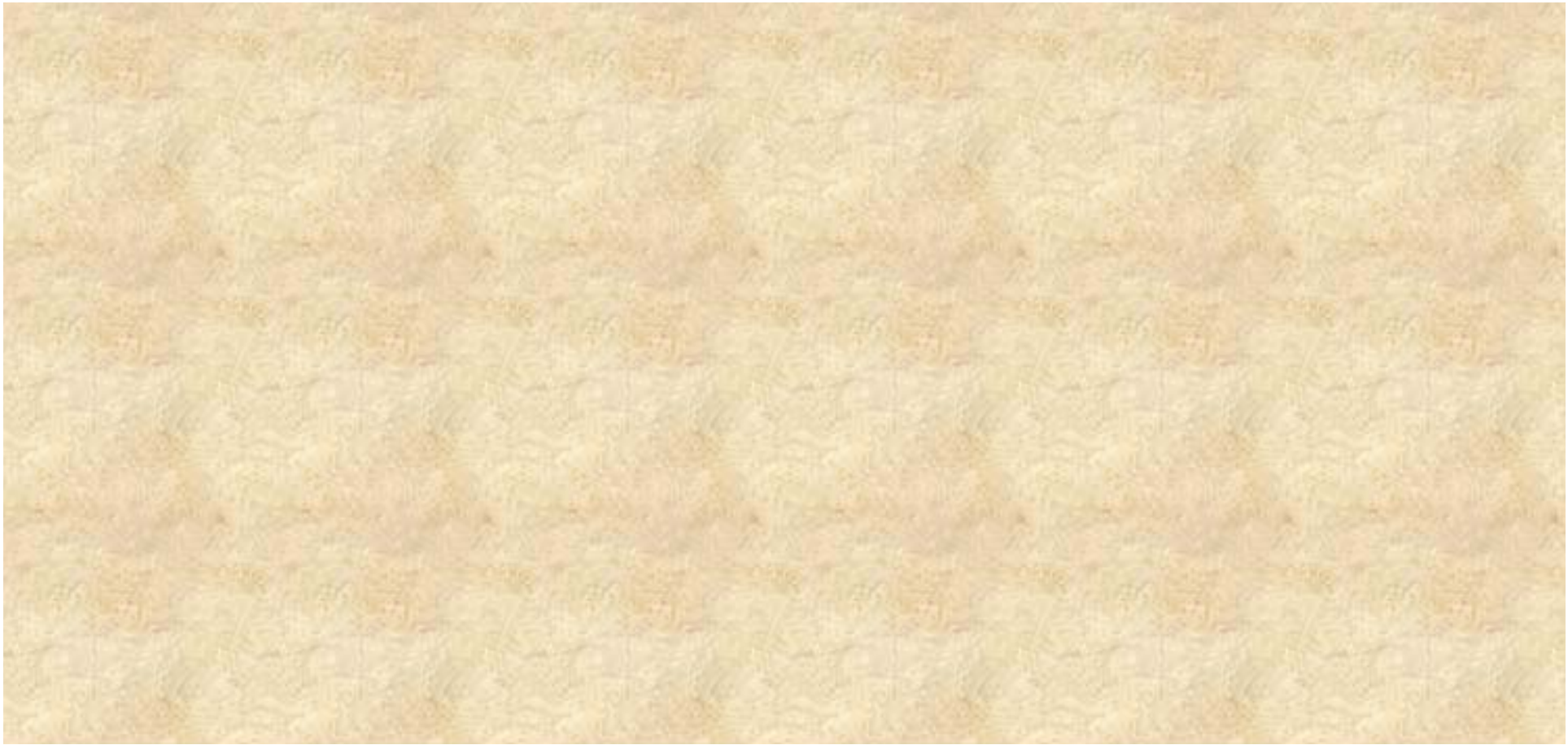
- Implications for ϕ_2 :

  - No direct couplings to fermions, i.e. **inert**
  - Allows for a **heavy SM Higgs**, up to about 500 GeV
  - Provide a **dark matter** candidate H^0 with a mass ~ 50 – 80 GeV (without fine tuning)

IDM gamma-ray spectrum

Inert Doublet Model

$$\frac{dN_\gamma}{dE_\gamma} = \frac{dN^{sec}}{dE_\gamma} + \frac{dN^{IB}}{dE_\gamma} + \frac{dN^{line}}{dE_\gamma}$$



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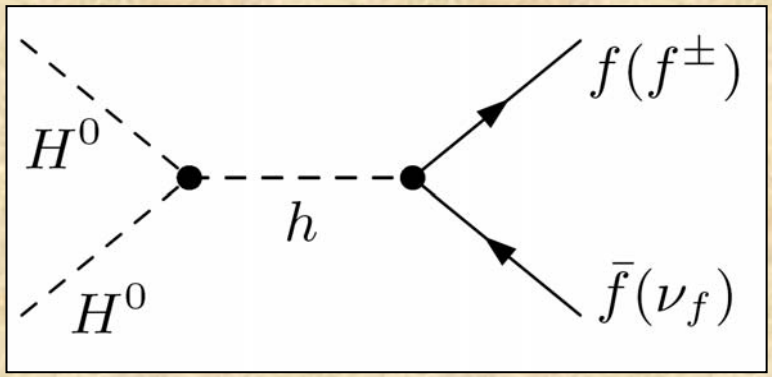

$$\sigma v \propto \frac{\lambda_L \alpha^2 m_f^2}{(4m_{H^0}^2 - m_h^2)^2}$$

Three-level annihilation are typically very weak for this dark matter candidate in the halo.

⇨ **Low continuum spectra**

(especially for heavy SM Higgs)

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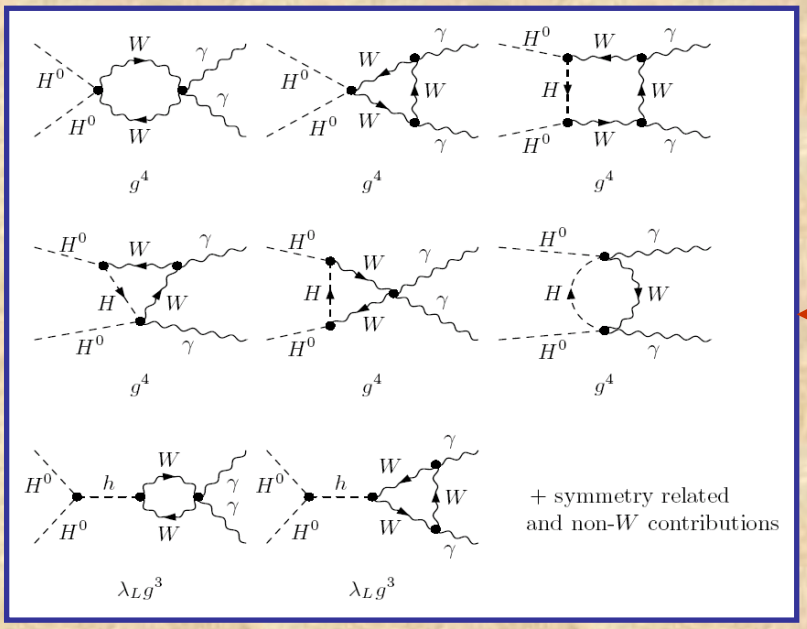

M.G., Lundström, Bergström, Edjö '07

IDM gamma-ray spectrum

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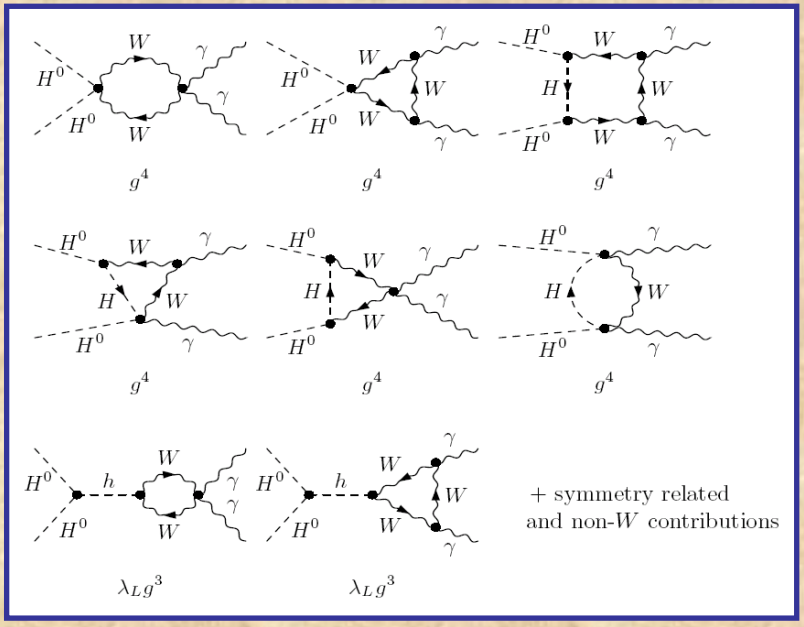

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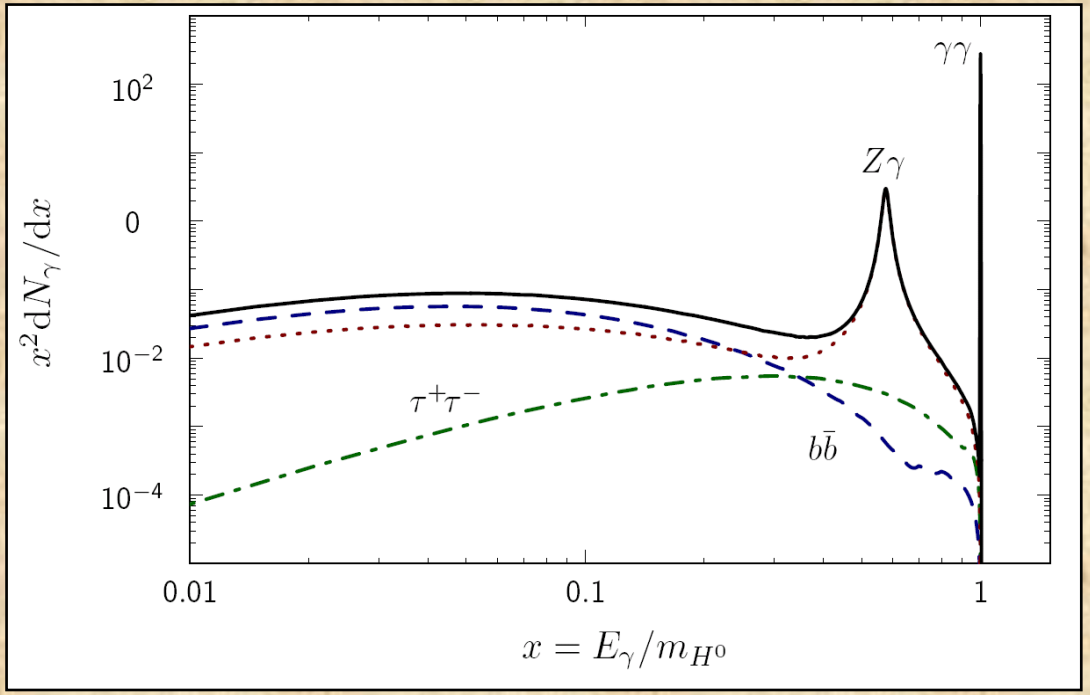

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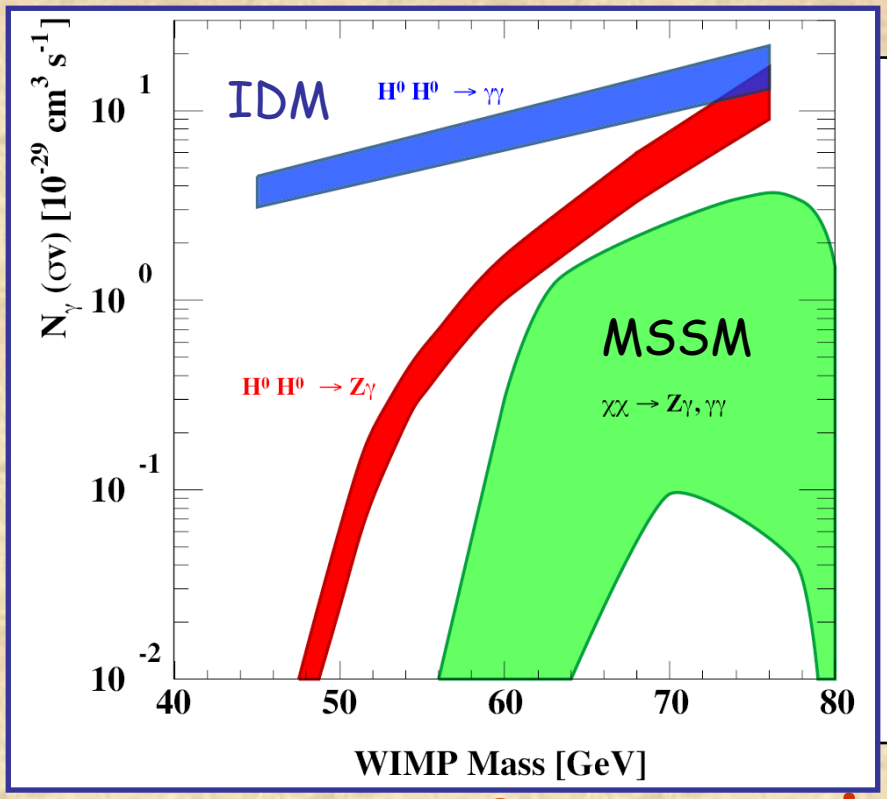
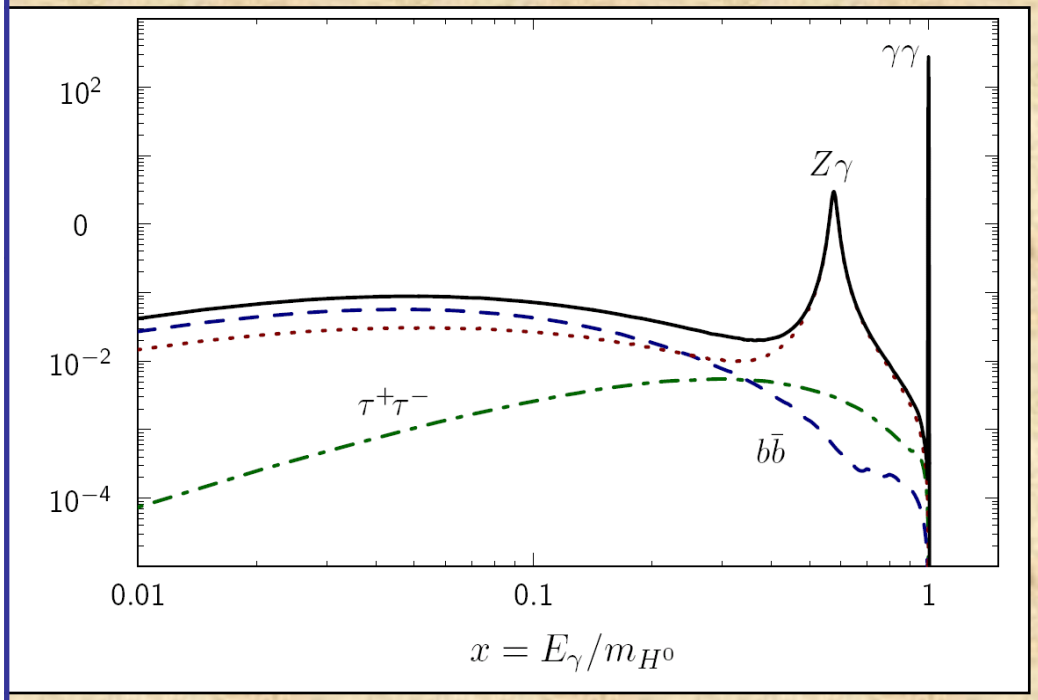
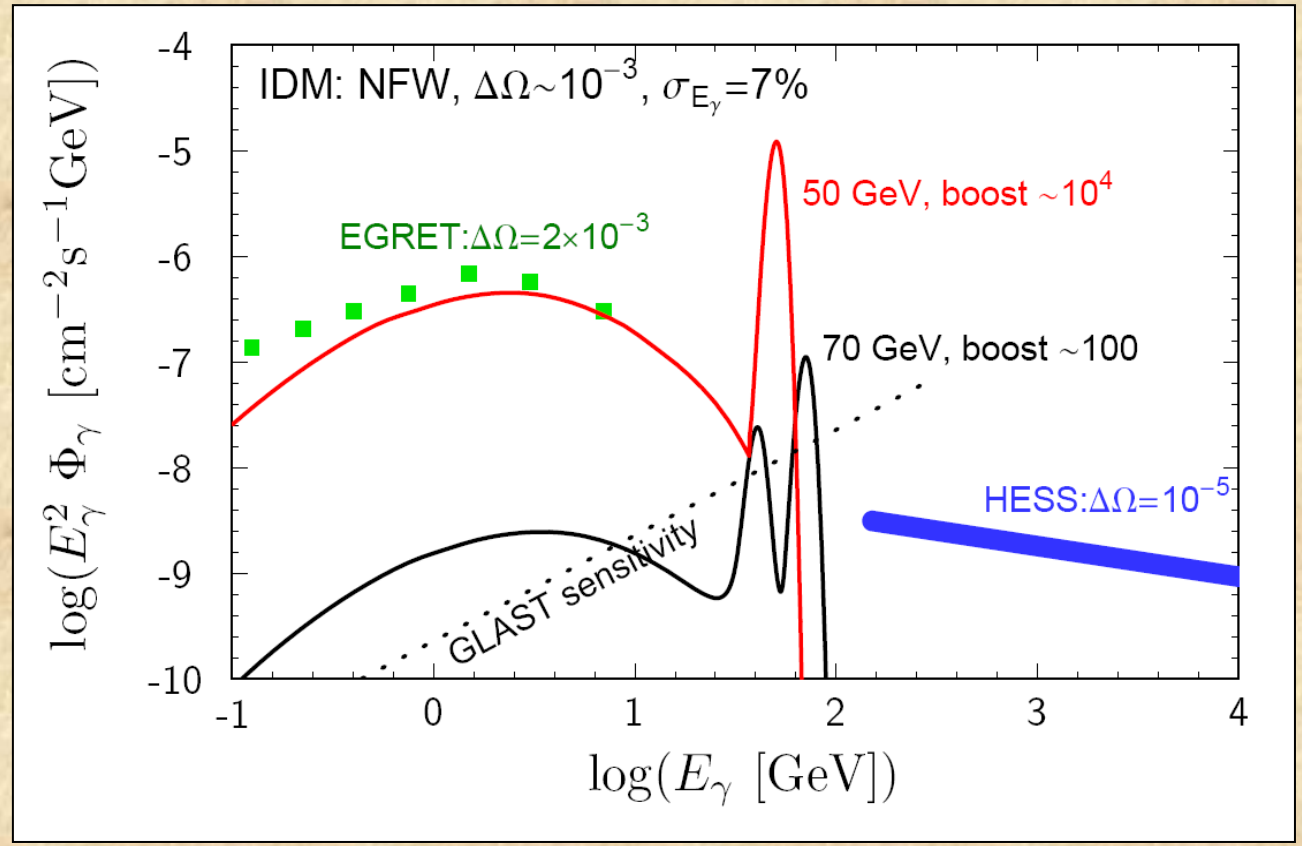




⇨ Spectacularly strong line(s)!

Inert Doublet Model



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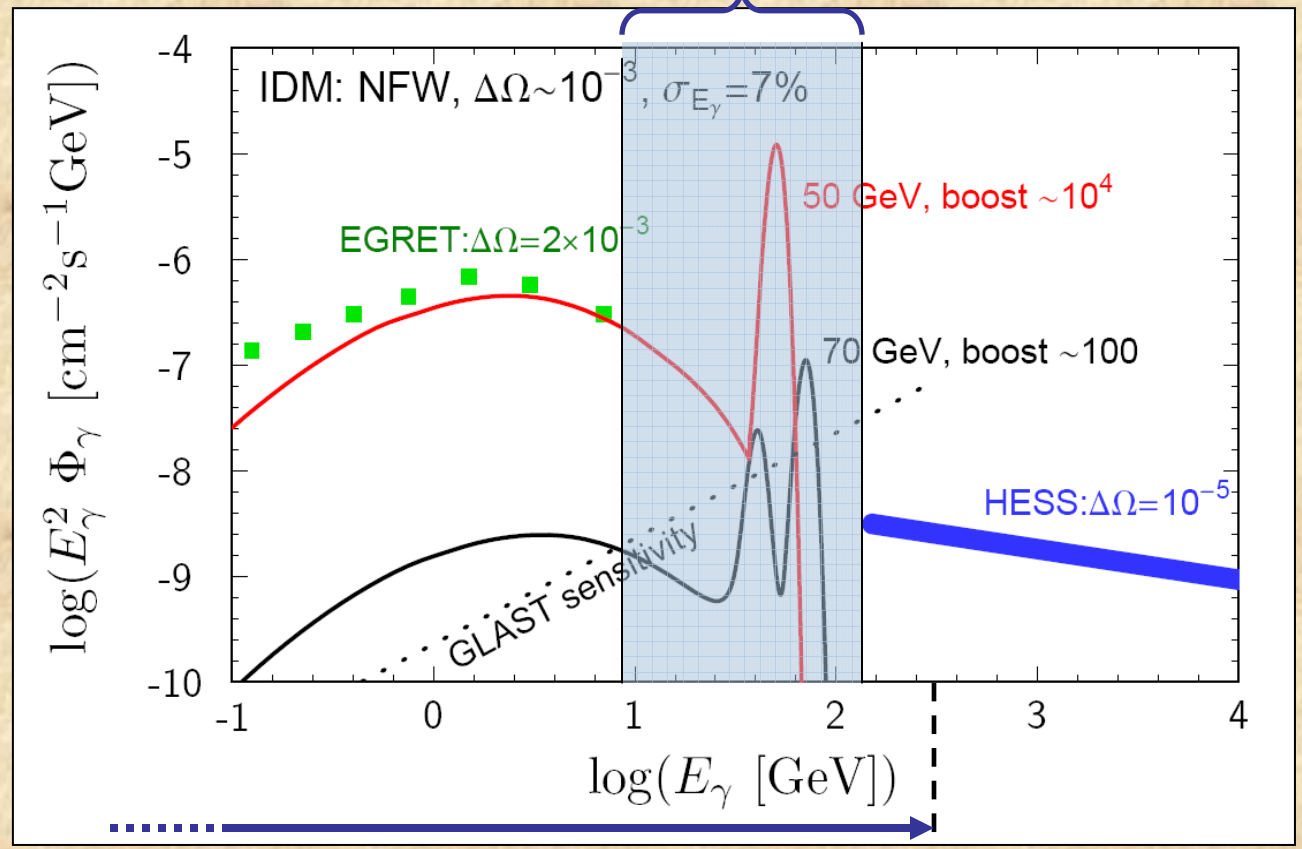
Inert Doublet Model

Unexplored energy window



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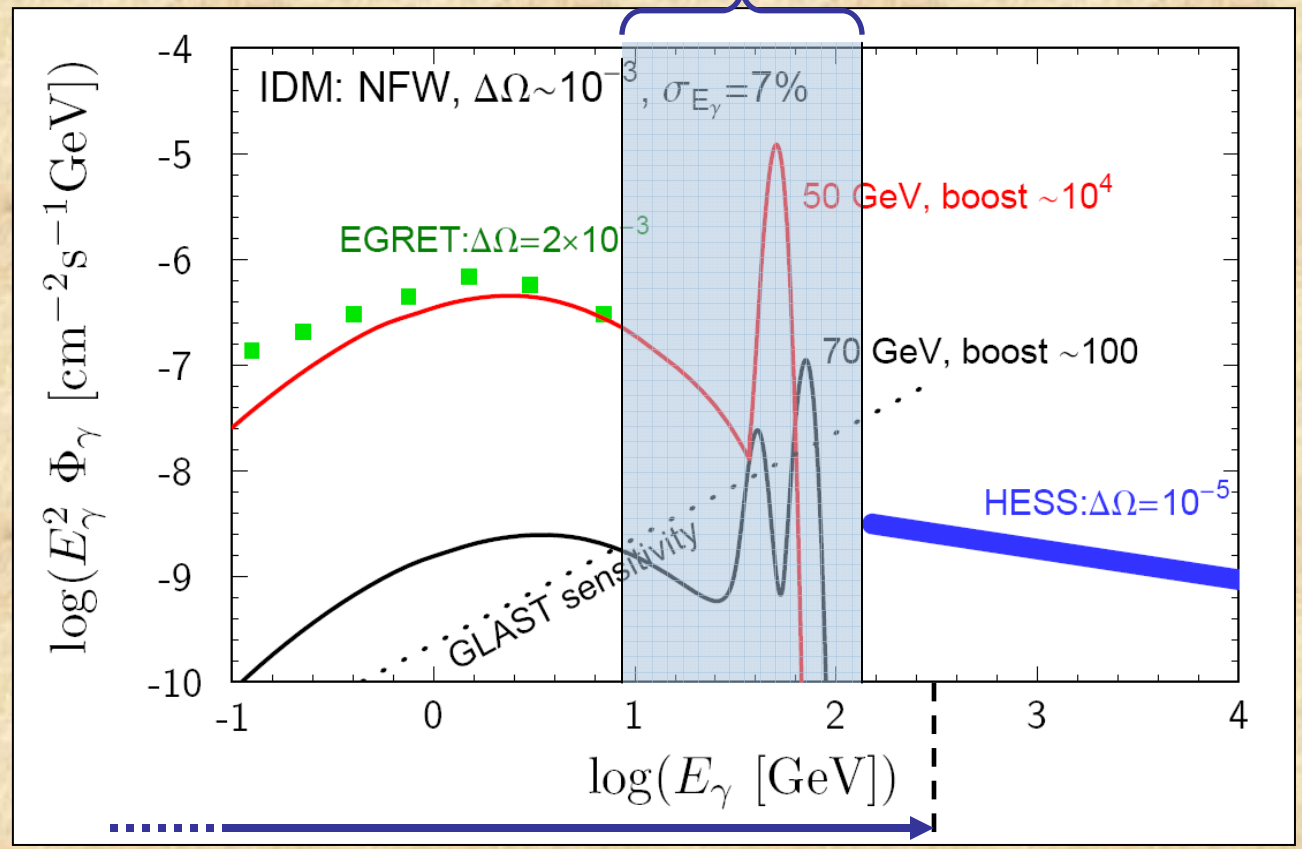
Energy range for the Fermi satellite

Inert Doublet Model



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Perfect DM candidate for detection with Fermi!

(GLAST/Fermi launched June 2008)