Constraining Annihilating Dark Matter with e-ASTROGAM

Javier Rico (IFAE-BIST, Barcelona)

On behalf of:
Richard Bartels (GRAPPA, University of Amsterdam)
Daniele Gaggero (GRAPPA, University of Amsterdam)
Christoph Weniger (GRAPPA, University of Amsterdam)
Manel Martinez (IFAE-BIST, Barcelona)

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Motivation

Why MeV Dark Matter?

- Overwhelming evidence for non-baryonic Dark matter
- No WIMP with a mass >1 GeV has been found so far
- sub-GeV DM gaining popularity, e.g.:
  - ★ Self-interacting DM
    Boehm & Fayet (2004)
  - ★ Cannibal DM
    Pappadopulo, Ruderman & Trevisan (2016)
  - ★ Strongly interacting DM (SIMP)
    Hochberg et. al. (2014)

Why gamma-rays?

- MeV DM hard to detect in direct detection (due to threshold on recoil energy).
- Difficult to detect MeV DM through direct measurement of the CR spectrum (due to solar modulation).

  But see Voyager constraints, Boudaud, Lavalle & Salati (2016)
- Gamma-rays can potentially be powerful in setting constraints!

Spectral features

- Annihilation channels for MeV DM are kinematically limited.

- Prompt signals:

  $\chi\chi \to \pi^0\pi^0 \to 4\gamma$

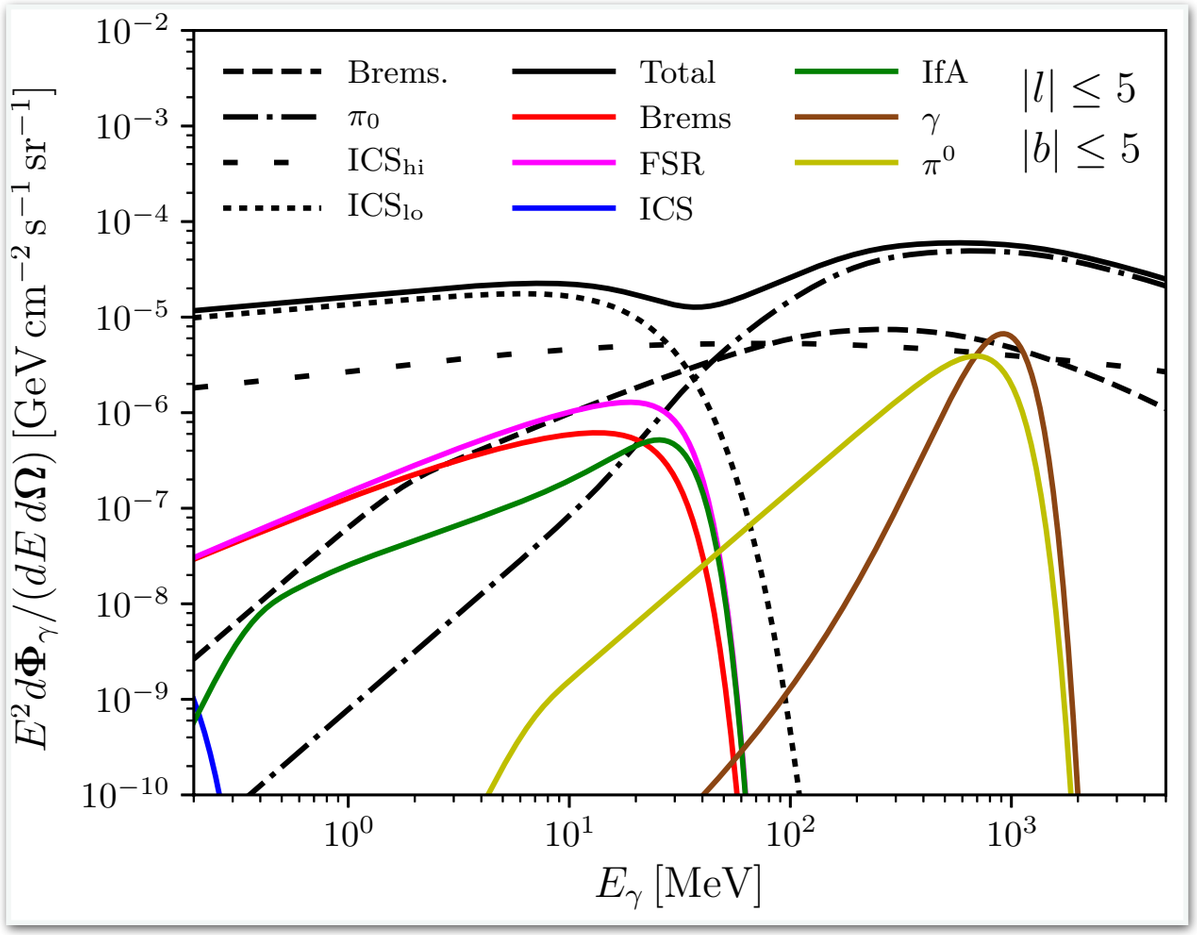
  $\chi\chi \to \pi^0\gamma$

  $\chi\chi \to e^+e^-\gamma\,(\text{final-state radiation, FSR})$

- Secondary emission
  (important for Galactic Center)

  $\chi\chi \to e^+e^-$

  - In-flight annihilation (IfA, positrons)
  - Bremsstrahlung
  - (Inverse-compton, less important)



Colored lines: Various spectral features (convolved with the energy resolution).
Black lines: Background components at the Galactic Centre.

Figure adapted from:
Bartels, Gaggero & Weniger, JCAP 1705 (2017) 001, [arXiv:1703.02546].

Sensitivity of e-ASTROGAM

Galactic Center

- ROI: $|\ell|, |b| \leq 5^\circ$
- Observation time: 5 years (1yr on target)
- Energy dispersion: 30% (pair regime)
- Astrophysical fore- backgrounds included
- Fisher forecast for limit projection:
  see Edwards & Weniger (2017), [1704.05458]
  Bartels, Gaggero & Weniger JCAP 1705 (2017) 001, [1703.02546]
  - Allows for treatment of correlated systematic uncertainties.
    We adopt values inspired by Fermi-LAT:
    - 15% on long-range (0.5 dex in energy) correlated syst. unc.
    - 2% on short range (1% in energy) correlated syst. unc.

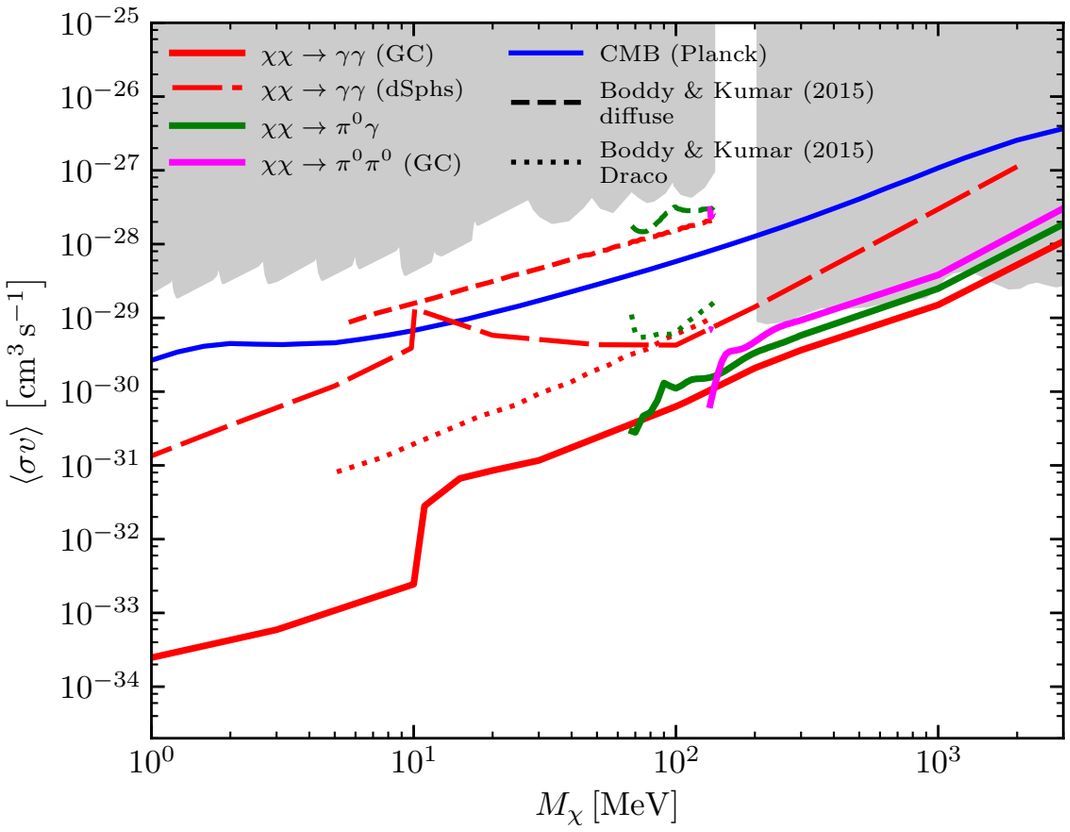
Dwarf Spheroidals

- Stacked sample of 15 dwarfs
  (arXiv:1611.02232)
- Observation time: 5 years (1yr on target)
- Energy dispersion: 25% (pair regime)
- Maximum likelihood analysis
  (as in arXiv:1611.02232)

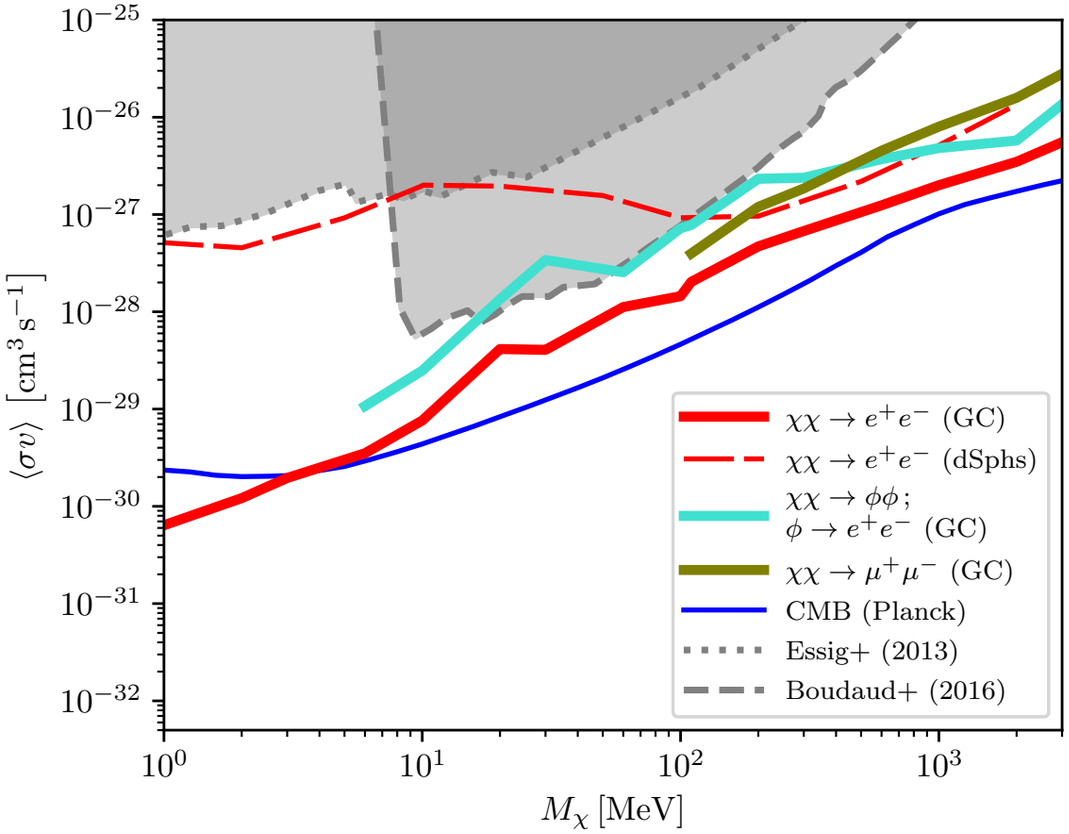
Projected Limits with e-ASTROGAM

e-ASTROGAM can put the strongest indirect-detection constraints on annihilating dark matter.

- Note: CMB constraints weaken for p-wave annihilating dark matter.



Prompt gamma-rays



Final-state radiation + Secondary gamma-rays