Dark matter constraints from observations of dwarf spheroidal galaxies with the Fermi-LAT

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Outline

- Dark matter searches through γ-ray and targets
- Analysis & fluxes upper-limits
- Constraints on several DM framework

DM signal in High Energy γ-rays

DM composed ¼ of the total energy budget of the Universe but its nature is still unknown

Self annihilation of **WIMPs** led to High Energy γ-rays in final state

$$\Phi_{WIMP}(E,\Psi) = J(\Psi) \times \Phi^{PP}(E)$$

Astrophysical factor

Particle physics factor

$$J(\Psi) = \int_{l.o.s} dl(\Psi)\,\rho^2(l)$$

Nb of annihilations

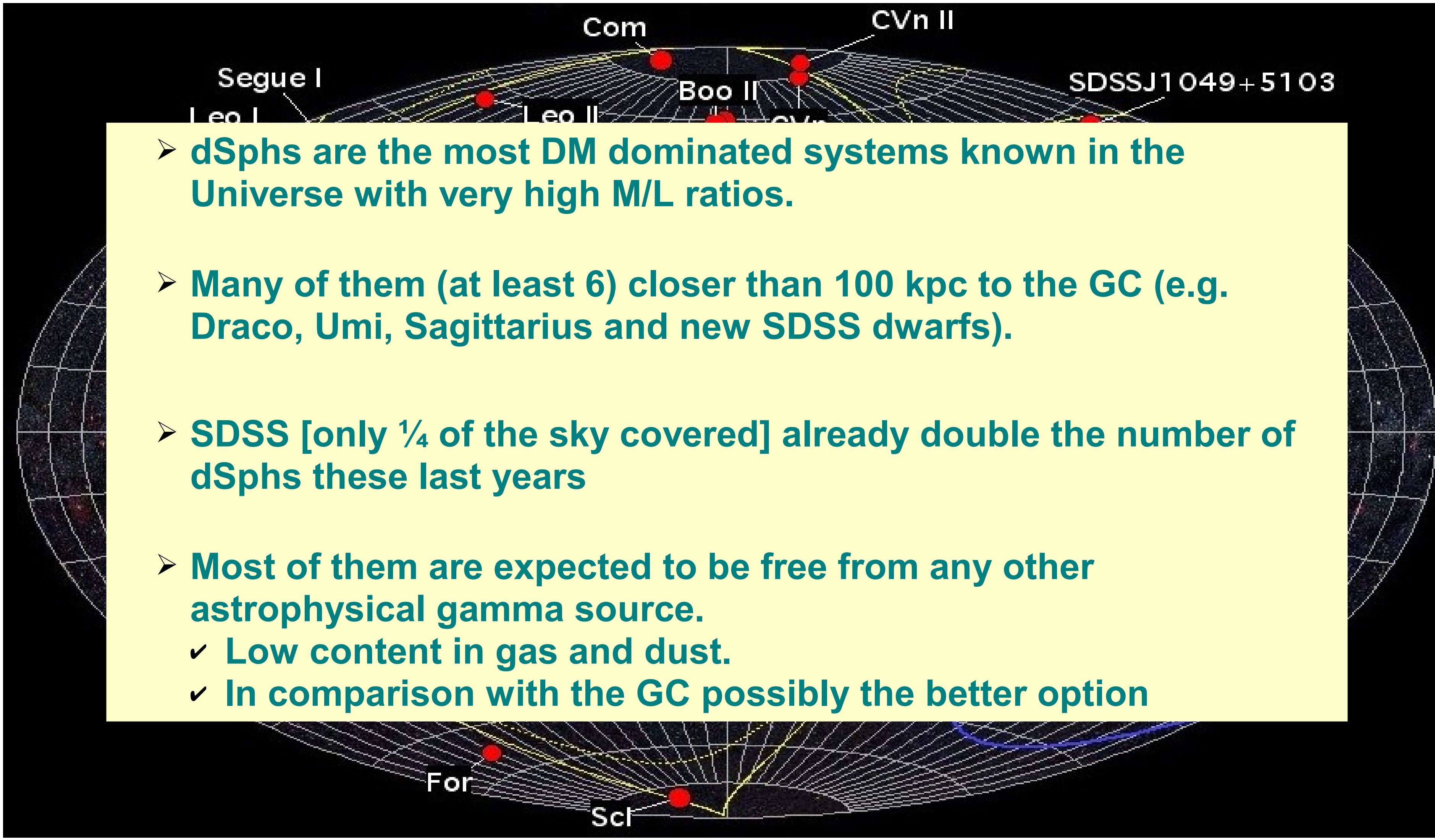
$$\Phi^{PP}(E) = \frac{1}{2}\frac{\langle\sigma v\rangle}{m^2_{WIMP}}\sum_f \frac{dN_f}{dE}B_f$$

Nb of γ per annihilation

Particle physics factor spectrum features:

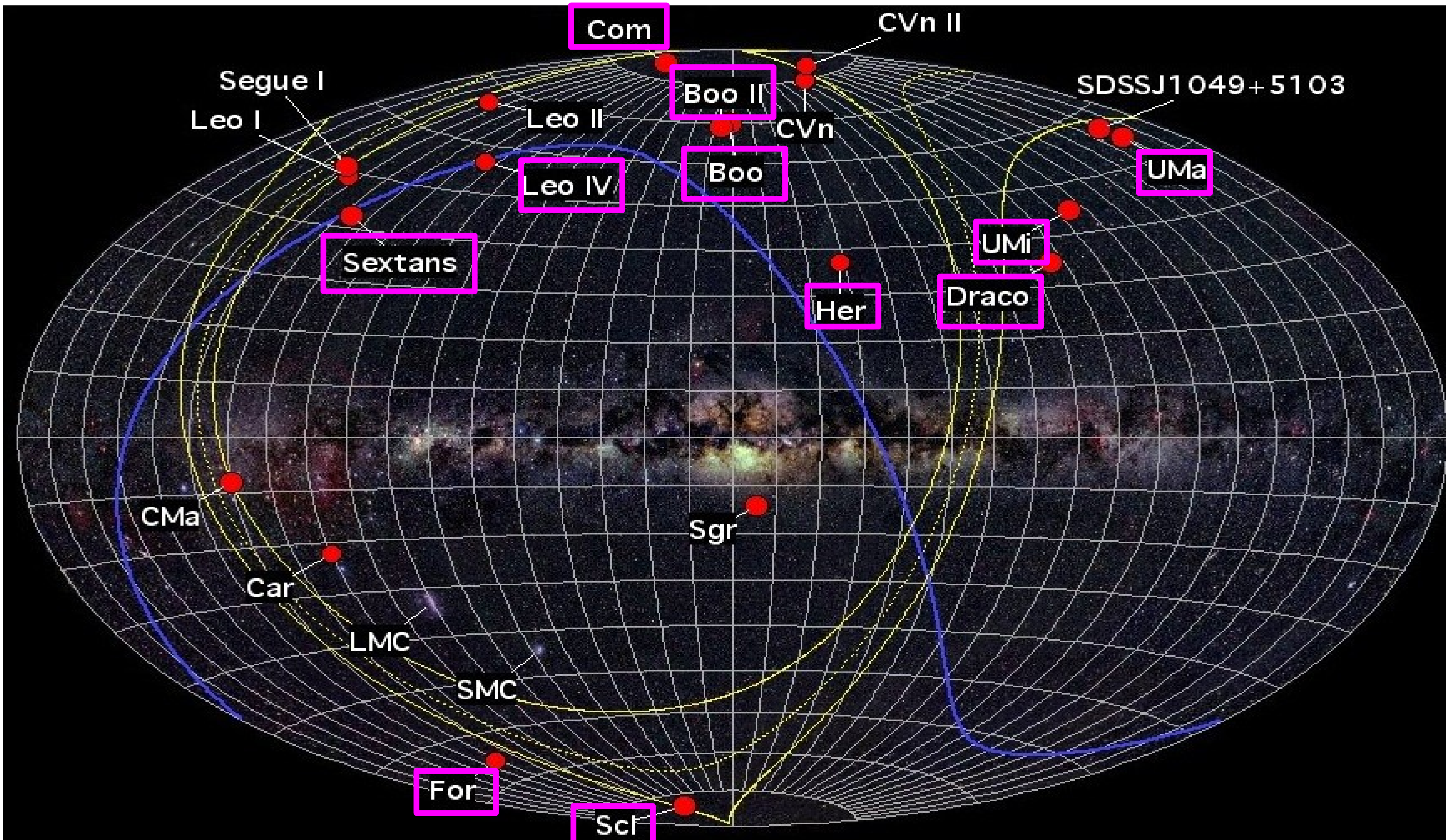
- line: « smoking gun » for DM search but loop suppressed (Poster 134 – Y. Edmonds)
- continuum: differs from power-law with a cut-off at the mass, m_{WIMP}

Dwarf spheroidal galaxies (dSph): promising targets for DM detection



- **dSphs are the most DM dominated systems known in the Universe with very high M/L ratios.**
- **Many of them (at least 6) closer than 100 kpc to the GC (e.g. Draco, Umi, Sagittarius and new SDSS dwarfs).**
- **SDSS [only ¼ of the sky covered] already double the number of dSphs these last years**
- **Most of them are expected to be free from any other astrophysical gamma source.**
  - ✔ **Low content in gas and dust.**
  - ✔ **In comparison with the GC possibly the better option**

Dwarf spheroidal galaxies (dSph): promising targets for DM detection



Analysis of LAT dSph targets

Submitted to ApJL

- 14 dSphs considered:
  - Selection criteria:
    - Proximity (< 180 kpc)
    - Far from the Galactic Plane (|b|>30°)
- 11 months data analyzed
- Event selection:
  - Diffuse class events
  - Zenith Angle < 105°
  - Field of view (fov) radius: 10°
- dSph fov modelisation:
  - Diffuse components: galactic diffuse & isotropic
  - Point sources (as determined in the Fermi-LAT catalog)
- Energy ranges: 100, 500 & 1000 MeV – up to 50GeV

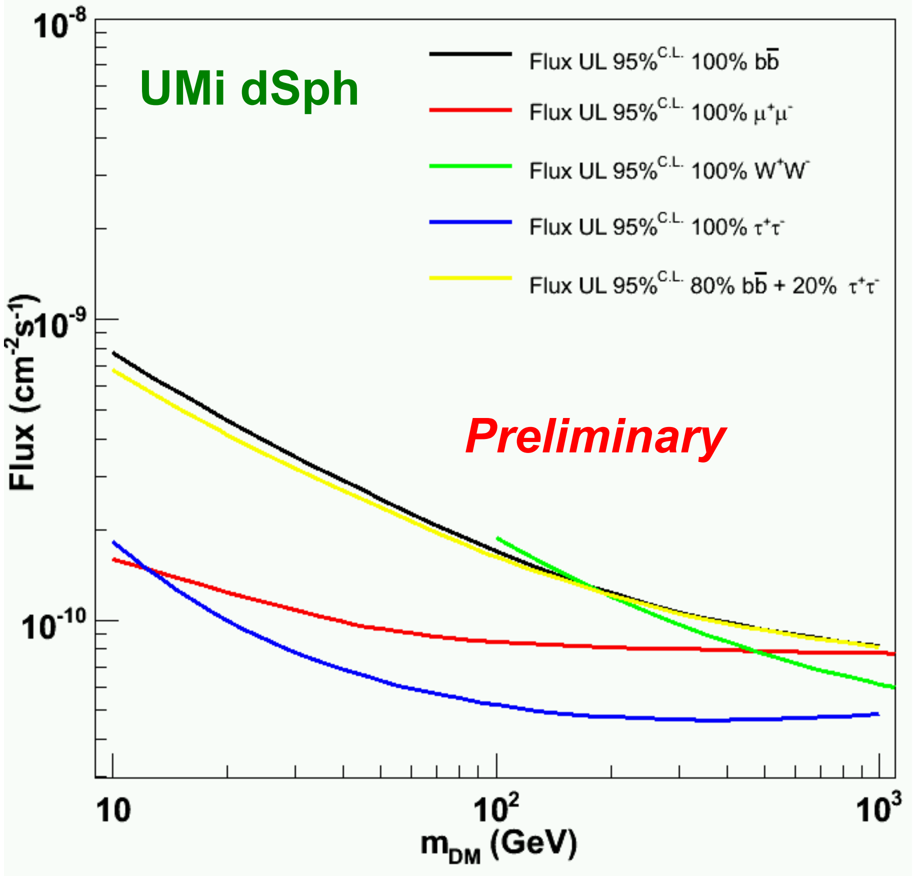
Results:

No significant signal detected at any of the dSphs selected

Flux upper-limits

Flux 95% upper-limits derived from profile likelihood and calculated for several spectra:

- Power-law spectrum with spectral index of -1, -1.8, -2, -2.2, -2.4
- Dark matter annihilation γ-ray spectrum shape using DMFit module (Profumo & Jeltema, 2008):
  - Several exclusive annihilation channels: bbbar, $\tau^+\tau^-$, AMSB (100% W^+W^-), $\mu^+\mu$
  - As well as mixed finale state: 80%bbbar+20% $\tau^+\tau^-$
  - And Kaluza-Klein $B^{(1)}$ branching ratio



Independant of the DM distribution

$O(10^{-9}$ ph/cm^2/s)

Density profile modelisation

- **Astrophysical factor J** derive from kinematic individual stellar data for 8 dSphs
- **Profile assume:** NFW
- **Procedure:** maximum likelihood Markov-chain iteration

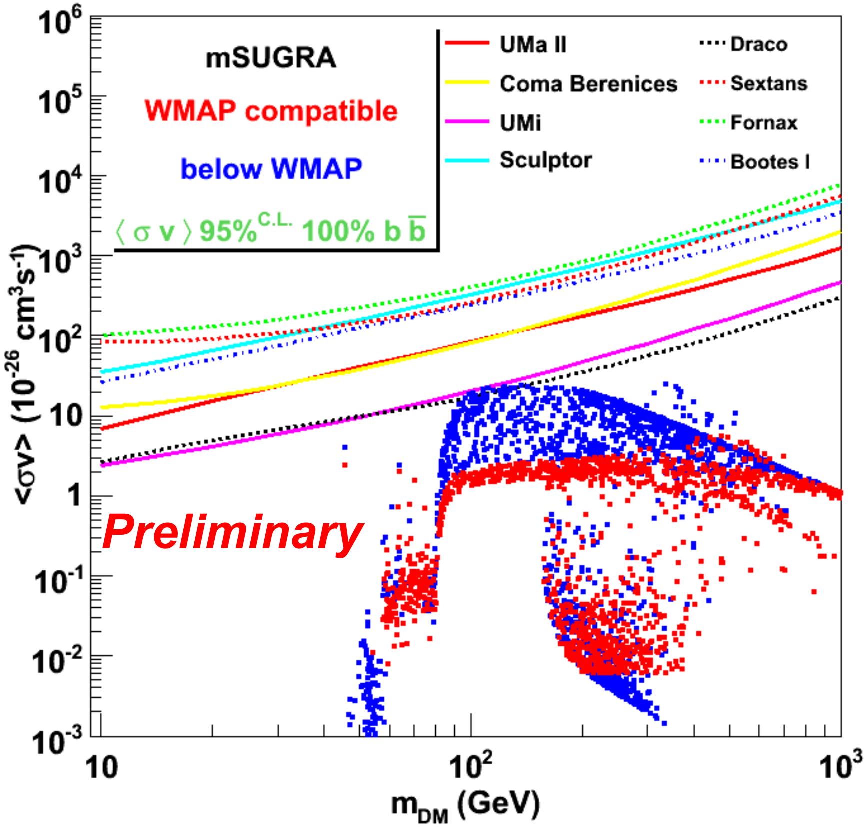
Name	ρ_s ($10^8\ M_\odot\ kpc^{-3}$)	r_s (kpc)	J^{NFW} ($10^{19}\ GeV^2\ cm^{-5}$)
Ursa Major II	$1.43^{+3.37}_{-0.52}$	$0.13^{+0.10}_{-0.05}$	$0.58^{+0.91}_{-0.35}$
Coma Berenices	$0.84^{+2.98}_{-0.42}$	$0.11^{+0.11}_{-0.05}$	$0.16^{+0.22}_{-0.08}$
Bootes I	$0.89^{+2.34}_{-0.69}$	$0.18^{+0.19}_{-0.09}$	$0.16^{+0.35}_{-0.13}$
Ursa Minor	$0.44^{+1.04}_{-0.27}$	$0.48^{+0.38}_{-0.2}$	$0.64^{+0.25}_{-0.18}$
Sculptor	$0.21^{+0.32}_{-0.12}$	$0.70^{+0.57}_{-0.27}$	$0.24^{+0.06}_{-0.06}$
Draco	$0.19^{+0.14}_{-0.07}$	$1.84^{+1.0}_{-0.66}$	$1.20^{+0.31}_{-0.25}$
Sextans	$0.47^{+0.81}_{-0.30}$	$0.30^{+0.19}_{-0.11}$	$0.06^{+0.03}_{-0.02}$
Fornax	$0.36^{+0.69}_{-0.26}$	$0.43^{+0.36}_{-0.19}$	$0.06^{+0.03}_{-0.03}$

Preliminary

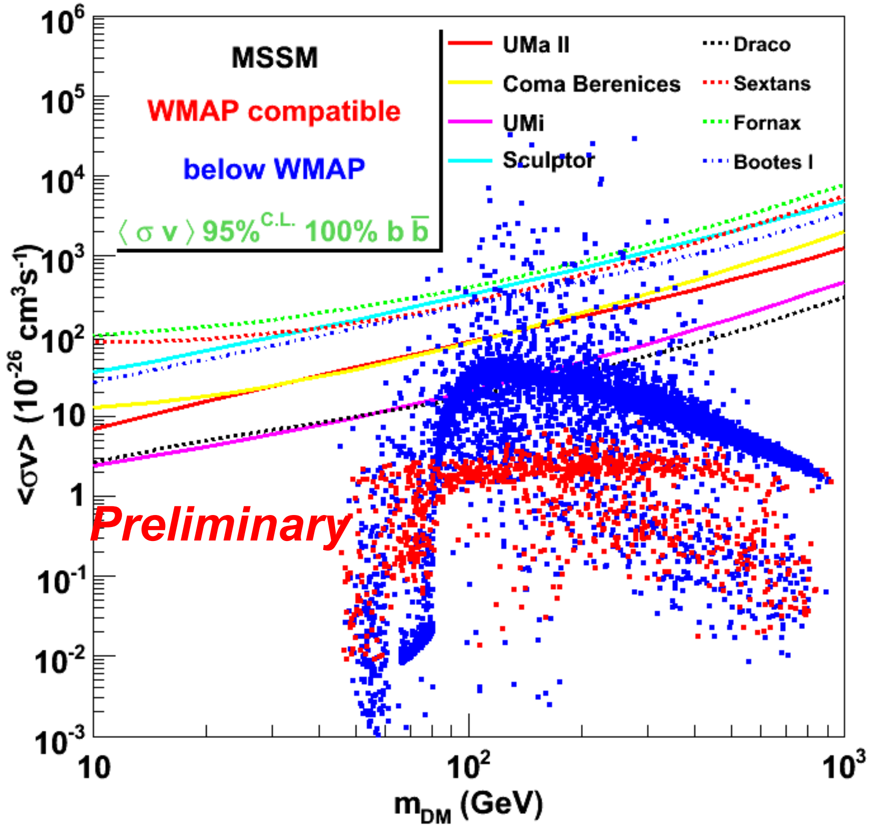
Annihilation cross section constraints

$95^{\%CL}$ upper-limits on $\langle\sigma v\rangle$ inferred from flux upper-limits

mSUGRA - 100% b-bbar



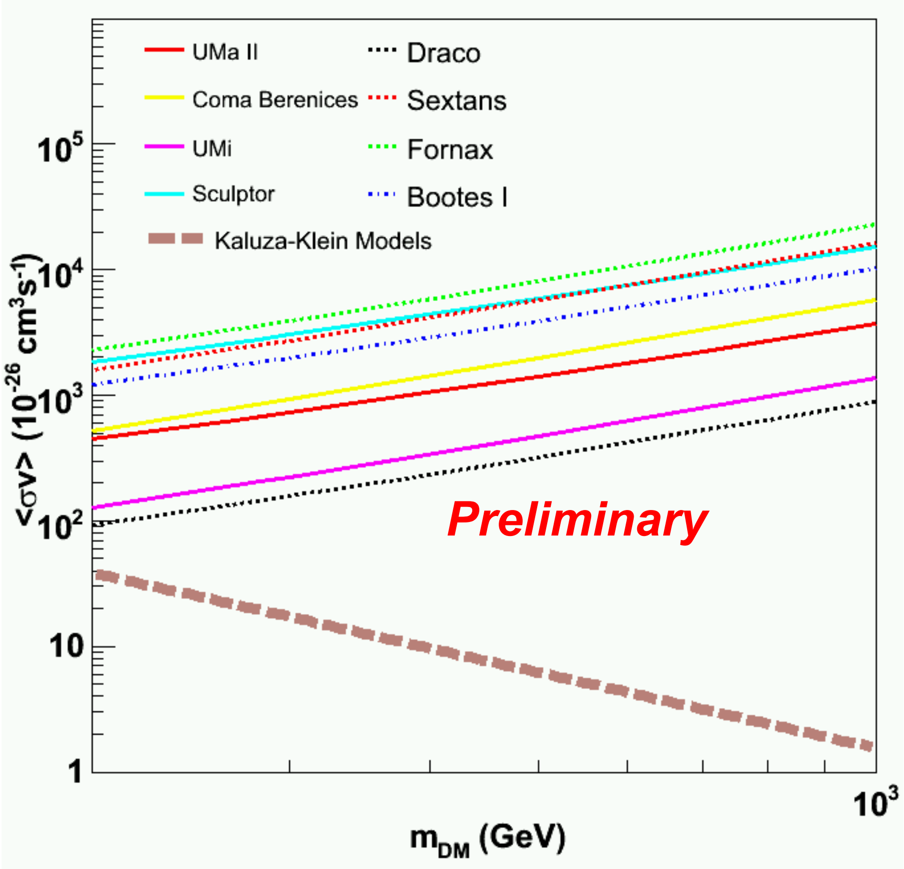
MSSM – 100% b-bbar



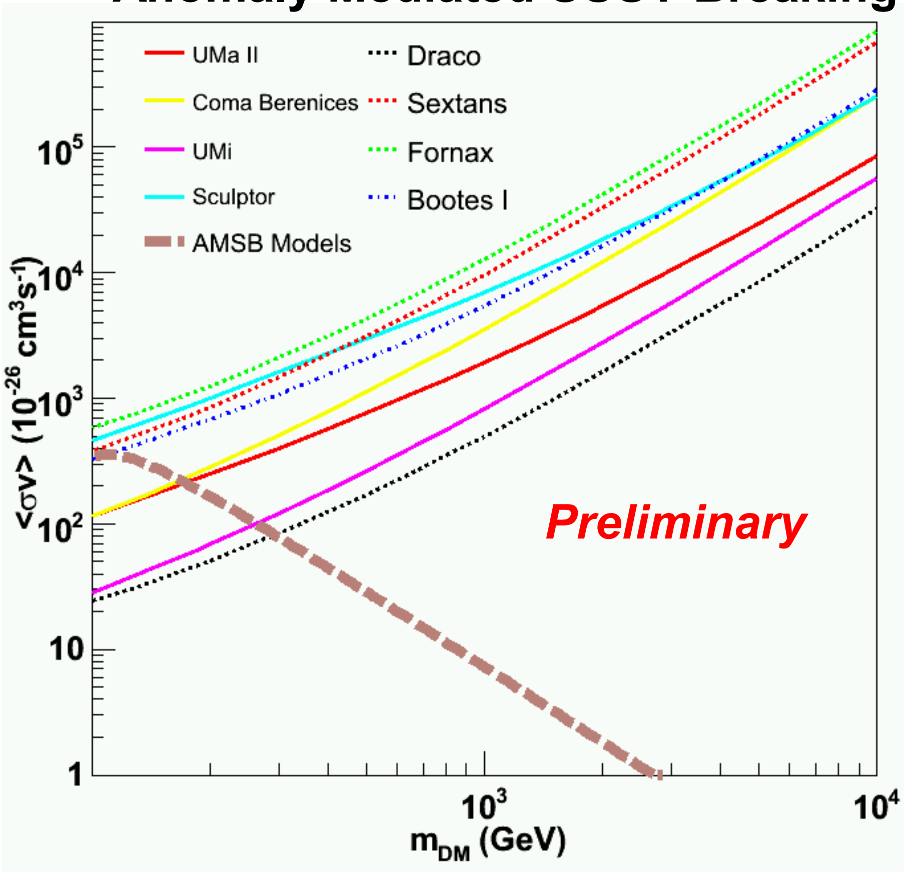
Stronger upper-limits obtained for Umi & Draco dSphs
After only 11 months, the LAT constraints are at the level of SUSY models

Annihilation cross section constraints

Universal Extra-Dimension



Anomaly Mediated SUSY Breaking

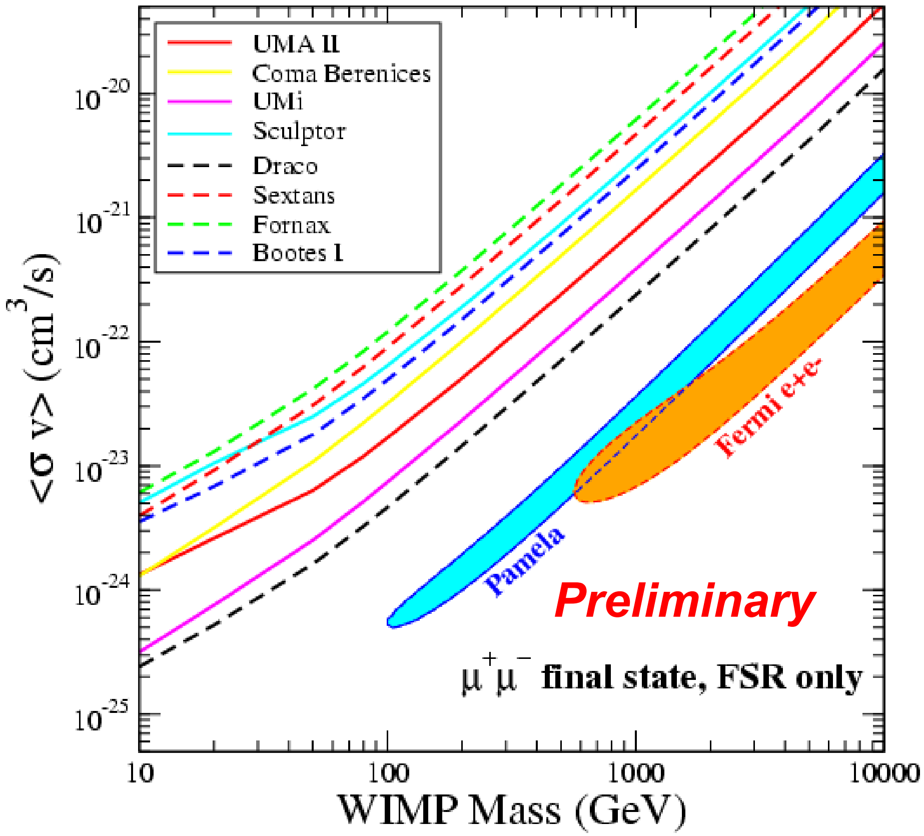


No constraints derived on UED models

AMSB models with masses < 300GeV are already disfavoured by our limits

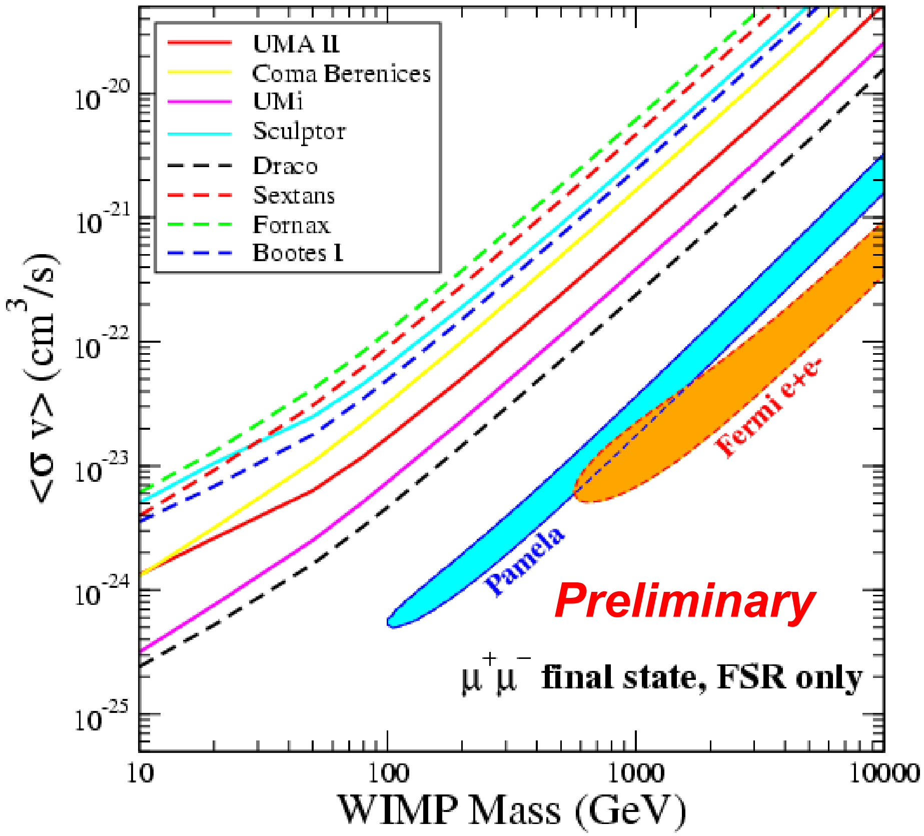
Annihilation cross section constraints

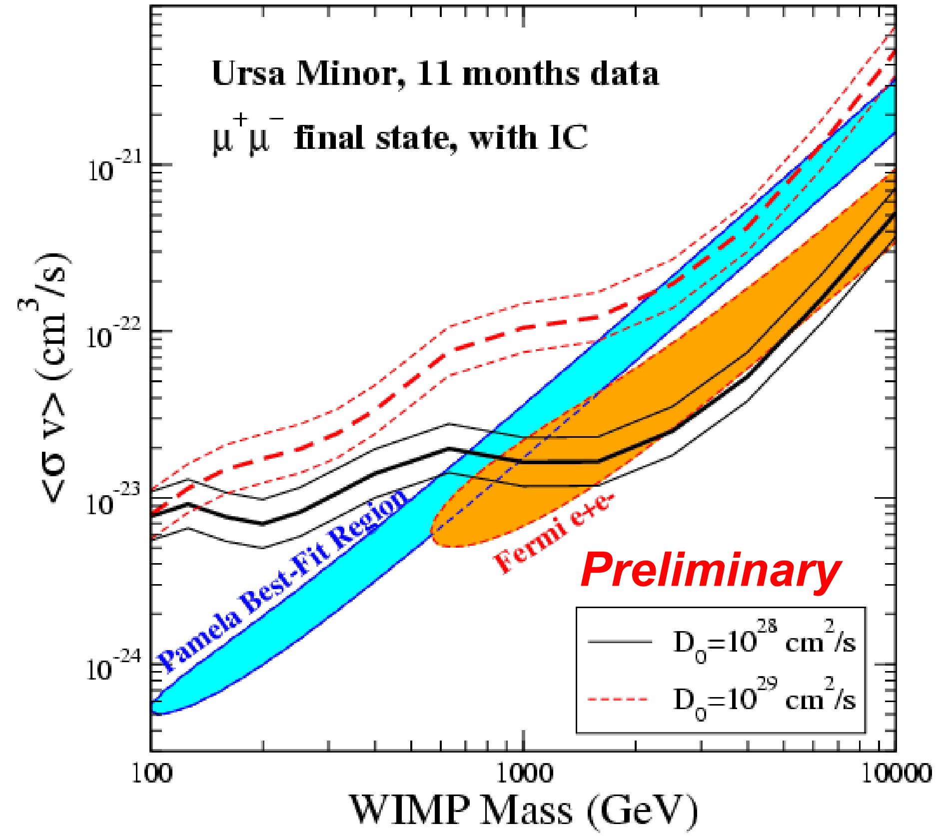
Pamela and Fermi measurements on positrons & positrons+electrons can be explained by leptonic DM models



Annihilation cross section constraints

Pamela and Fermi measurements on positrons & positrons+electrons can be explained by leptonic DM models





Constraints derived on dSphs including IC scattering of secondary e+e- can already restrain favoured region

Conclusion

- **No significant signal** detected for any of our catalog of dwarfs
- **Flux upper-limits derived** for several spectra

  $\Rightarrow \langle\sigma v\rangle$ upper-limits (0(5×10^{-26} cm^3/s @ 30GeV- 10^{-25} cm^3/s @ 100GeV) for NFW profiles) starting to constraint low relic density models

- **Important restriction** of the PAMELA & Fermi-LAT favoured leptophillic models
- **Limits improvements expected** in the future with the enlargement of the energy range and the improvements on the diffuse emission modeling