

Dark matter annihilation in the Galaxy: Gamma-rays from dwarf spheroidal galaxies

C. Combet, University of Leicester

A. Charbonnier (LPNHE)

J. Hinton (Leicester, UK)

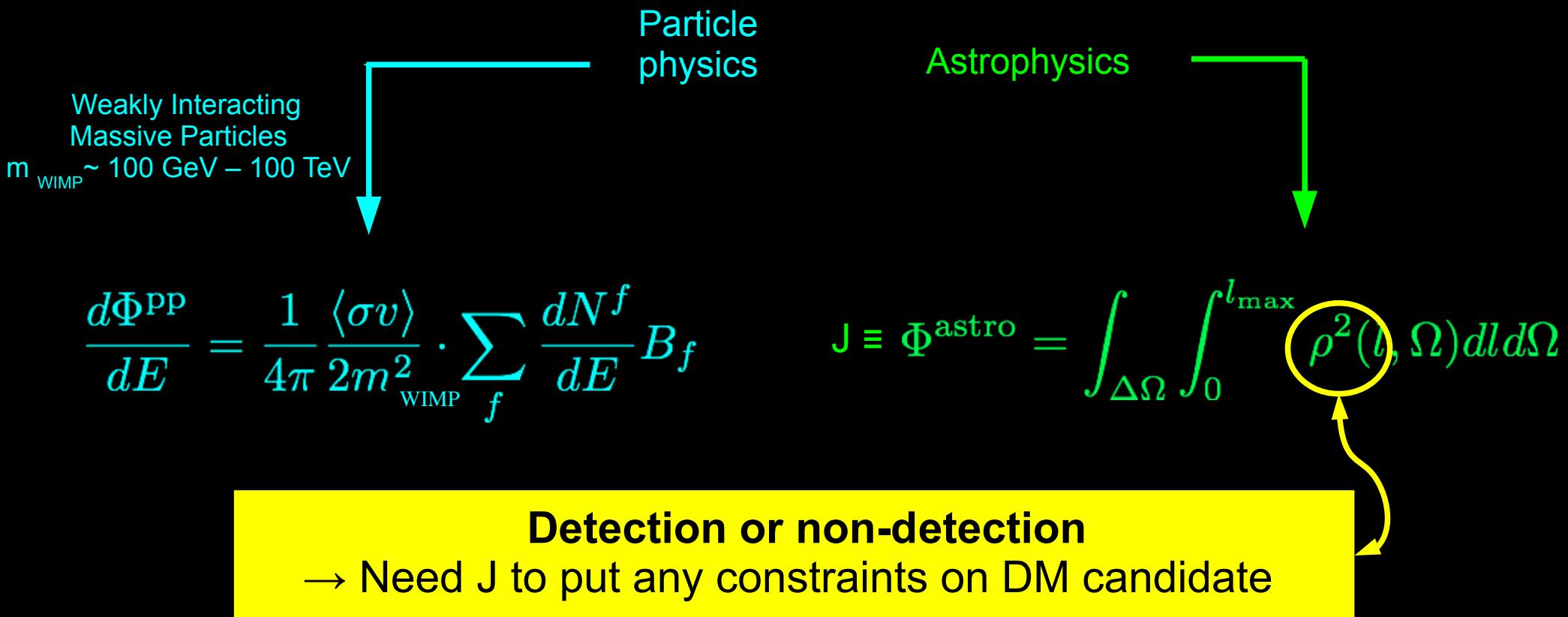
D. Maurin (LPSC)

Matt Walker (CfA, Cambridge, USA)
+ others...

Gamma-ray flux from DM annihilation

The γ -ray flux is given by

$$\frac{d\Phi}{dE}(E, \phi, \theta, \Delta\Omega) = \frac{d\Phi^{\text{pp}}}{dE}(E) \times \Phi^{\text{astro}}(\phi, \theta, \Delta\Omega)$$

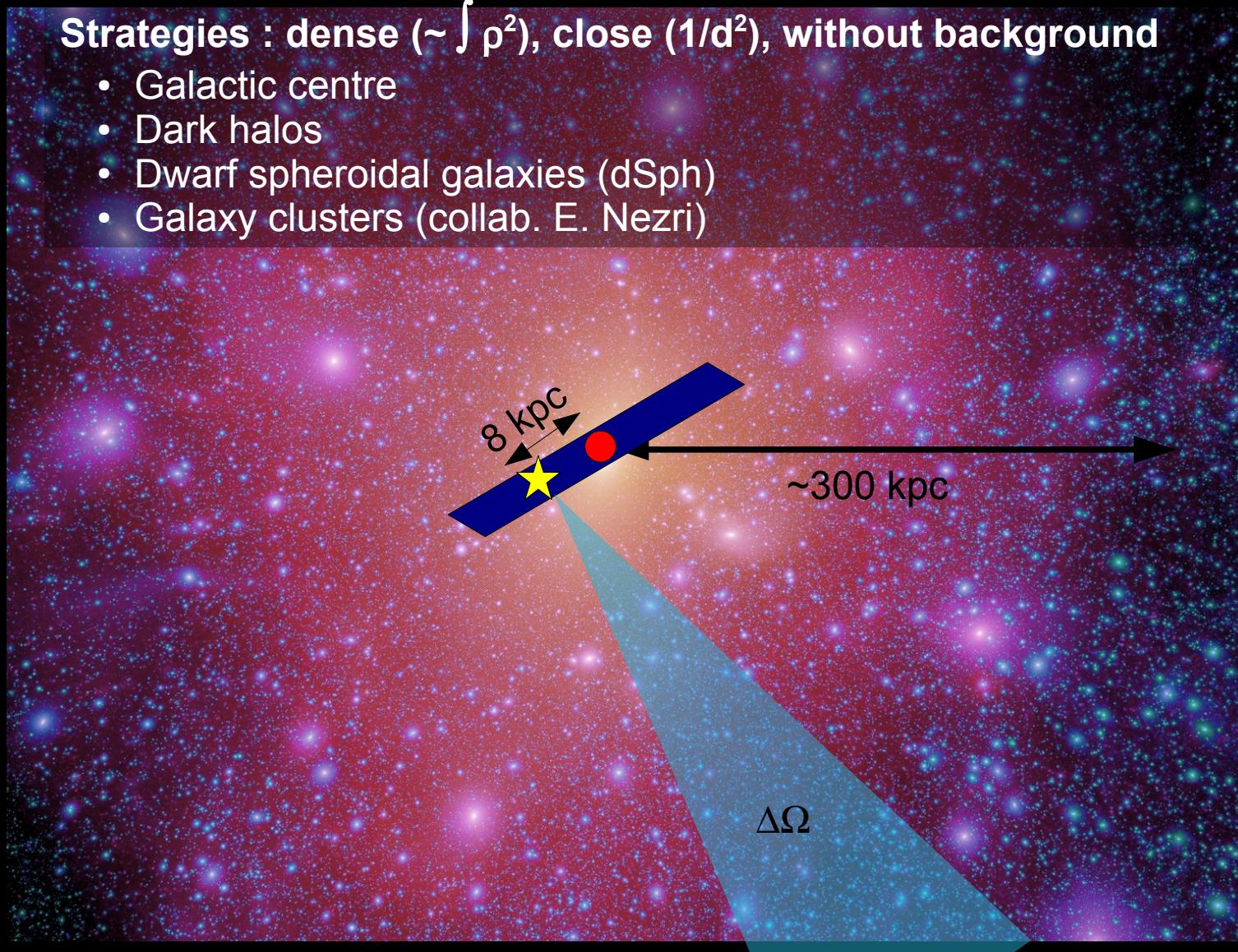


MW's dark matter halo

Aquarius – Springel et al (2008) – MW-like halo - Λ CDM

Strategies : dense ($\sim \int \rho^2$), close ($1/d^2$), without background

- Galactic centre
- Dark halos
- Dwarf spheroidal galaxies (dSph)
- Galaxy clusters (collab. E. Nezri)



Dwarf spheroidal galaxies

DM dominated + no astro. sources → good alternative to the galactic centre

- 8 "classical" dSphs (before SDSS, 2005)
- Brightest satellites → more kinematical data

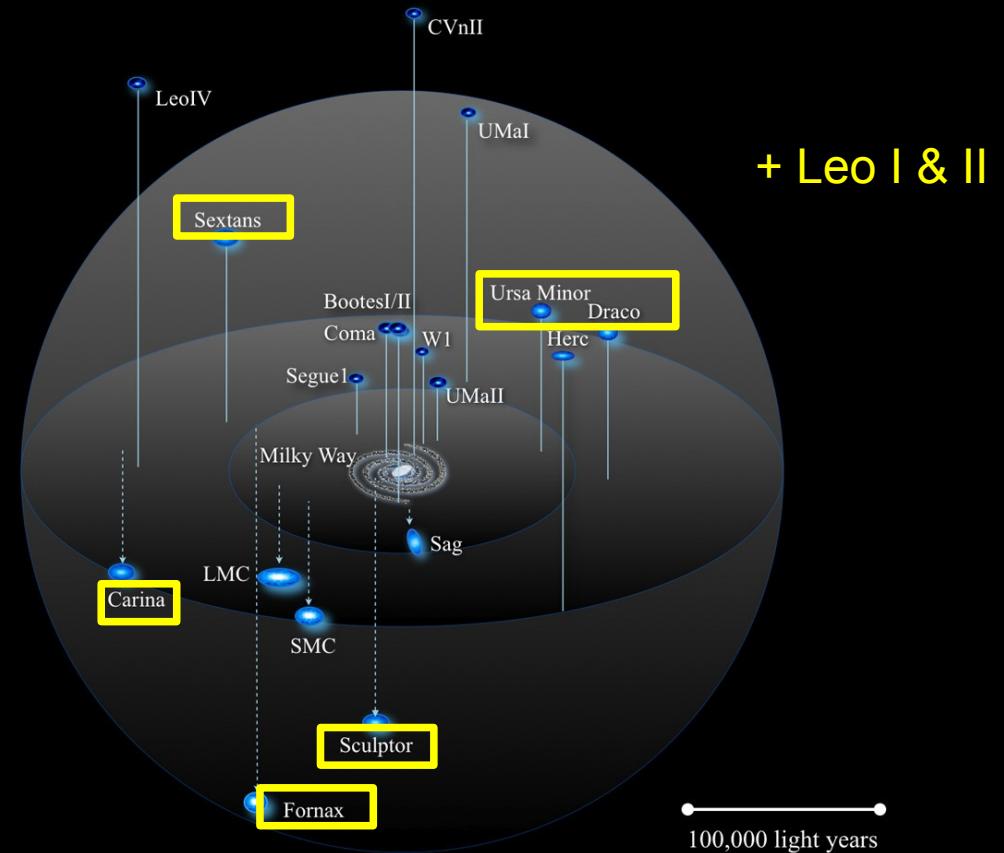
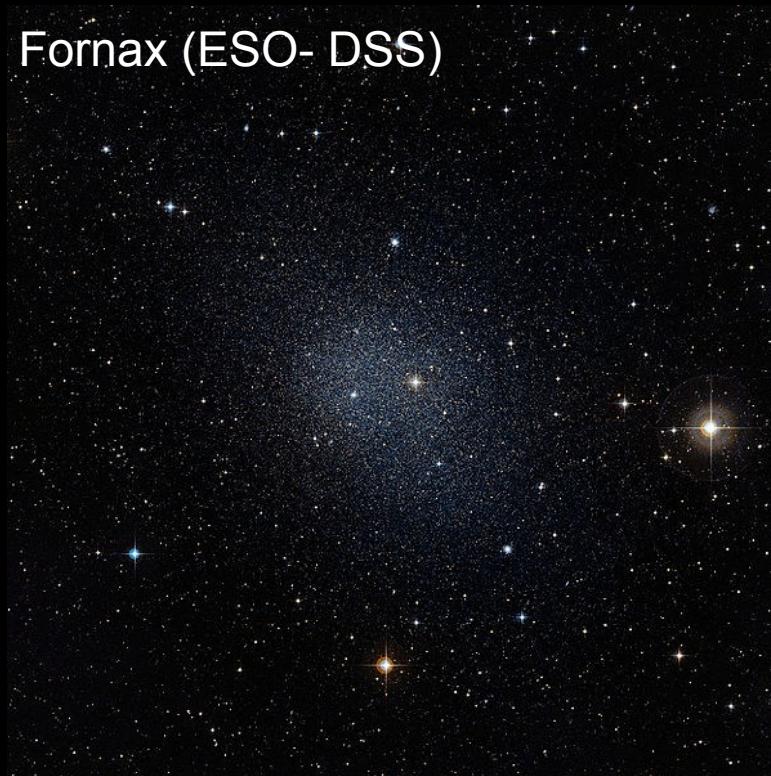


Image Credit: Bullock, Geha, Powell

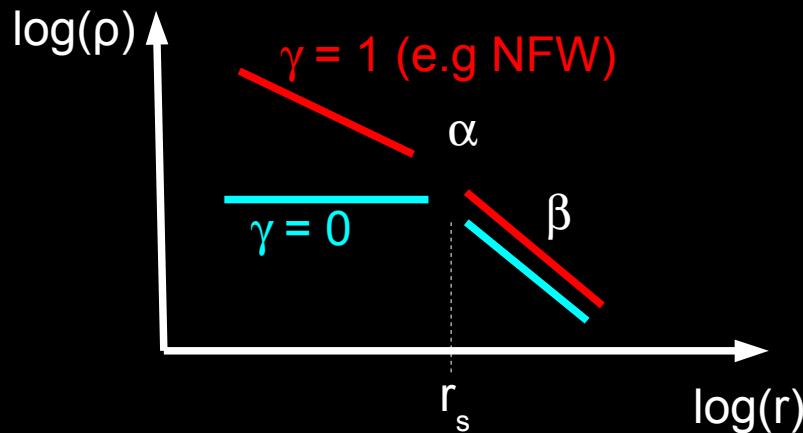
Dwarf spheroidal galaxies

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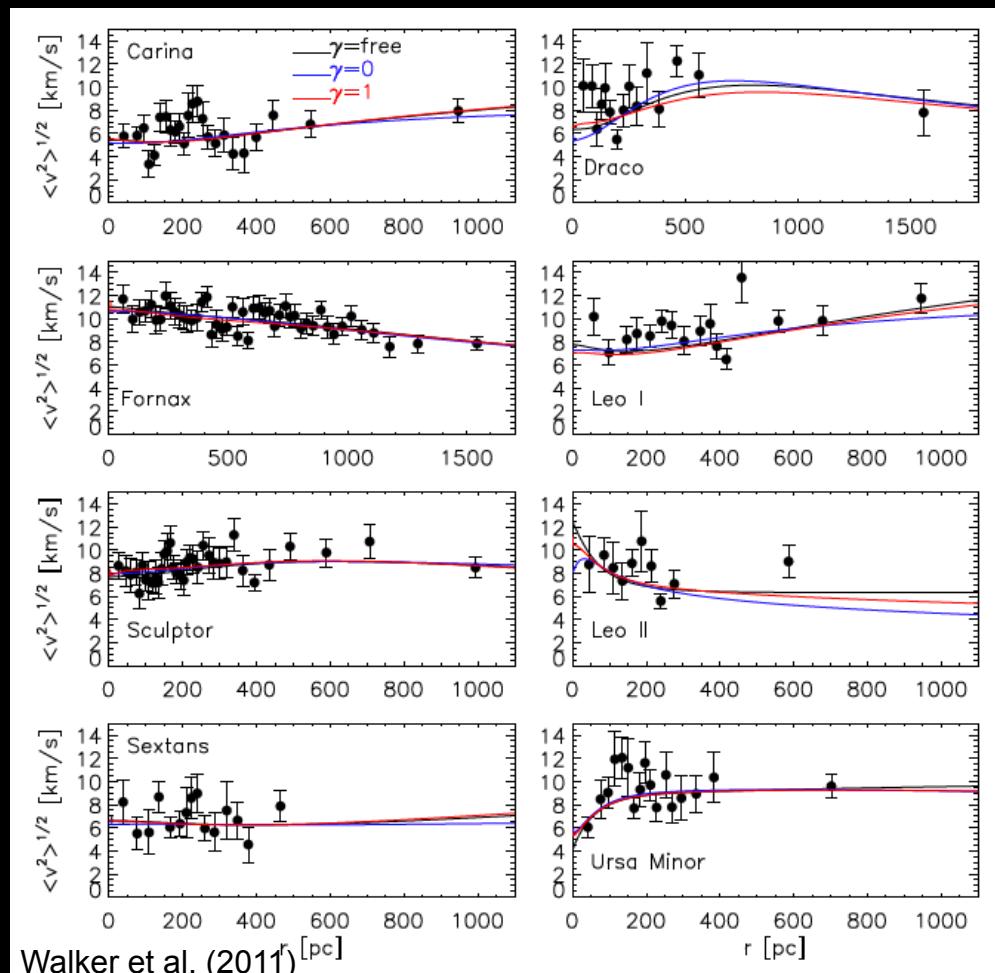
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Jeans' method : $\langle v_*^2 \rangle^{1/2} \rightarrow \rho_{\text{DM}}(r)$

$$\rho(r) = \frac{\rho_s}{(r/r_s)^\gamma \cdot [1 + (r/r_s)^\alpha]^{(\beta-\gamma)/\alpha}}$$



$$\rho_{\text{DM}}(r) \rightarrow J(\gamma, d, \alpha_{\text{int}})$$

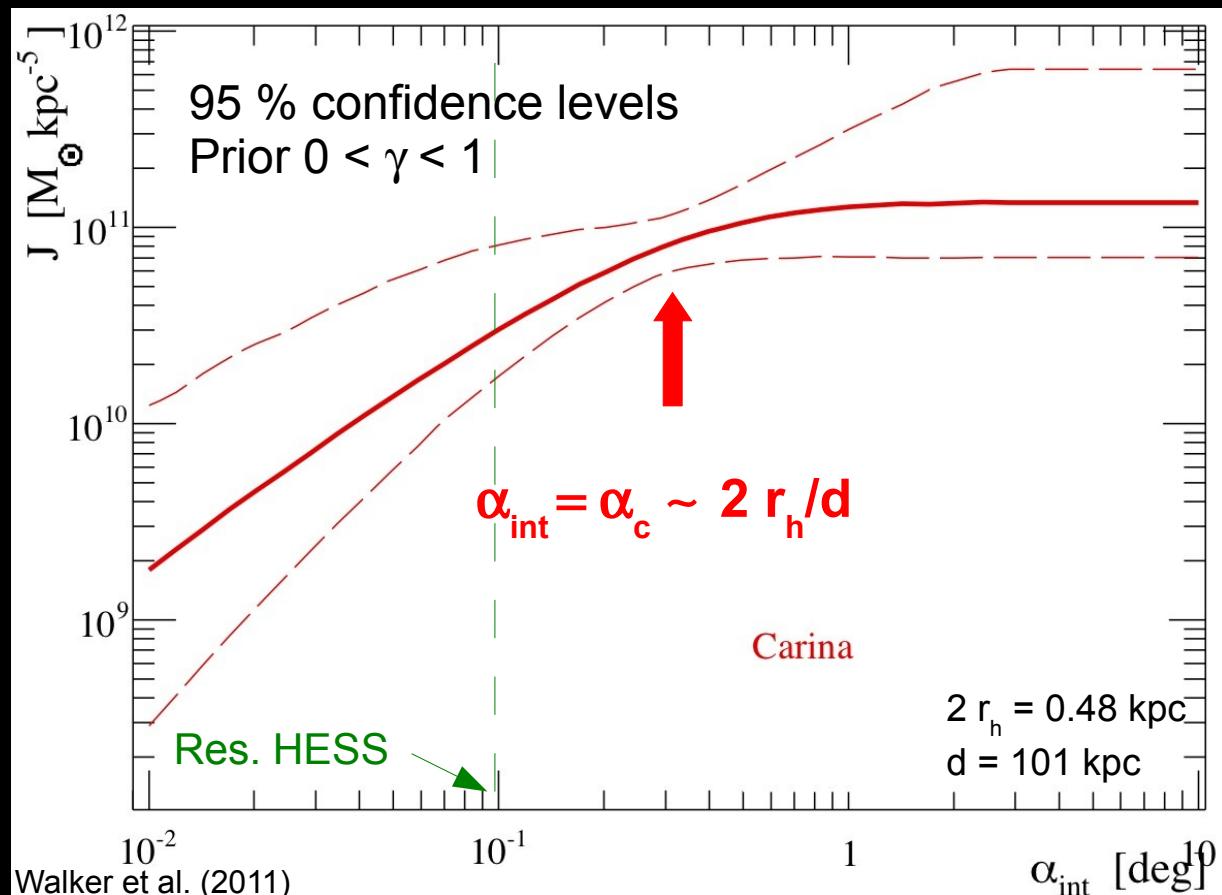


Constraining J in dSph galaxies

MCMC → PDF of all parameters + correlations

$$J = \int_0^{2\pi} d\beta \int_0^{\alpha_{\text{int}}} \sin \alpha d\alpha \int_0^{l_{\text{max}}} \rho^2 dl d\alpha d\beta$$

→ Median value + confidence levels of J



Thousands of models to run CLUMPY + Alice cluster (+validated using fake data)



- Optimal angle for the integration
- $\alpha_c >$ angular resolution
→ Implication on instrumental sensitivity for Cherenkov instr.

Define the best strategy for (non-)detection in dSphs

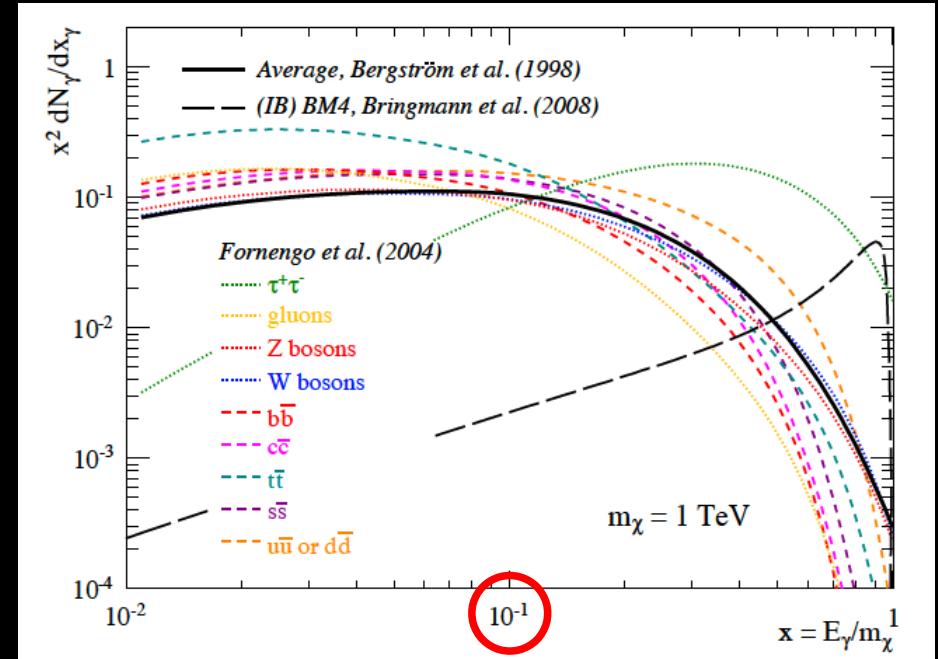
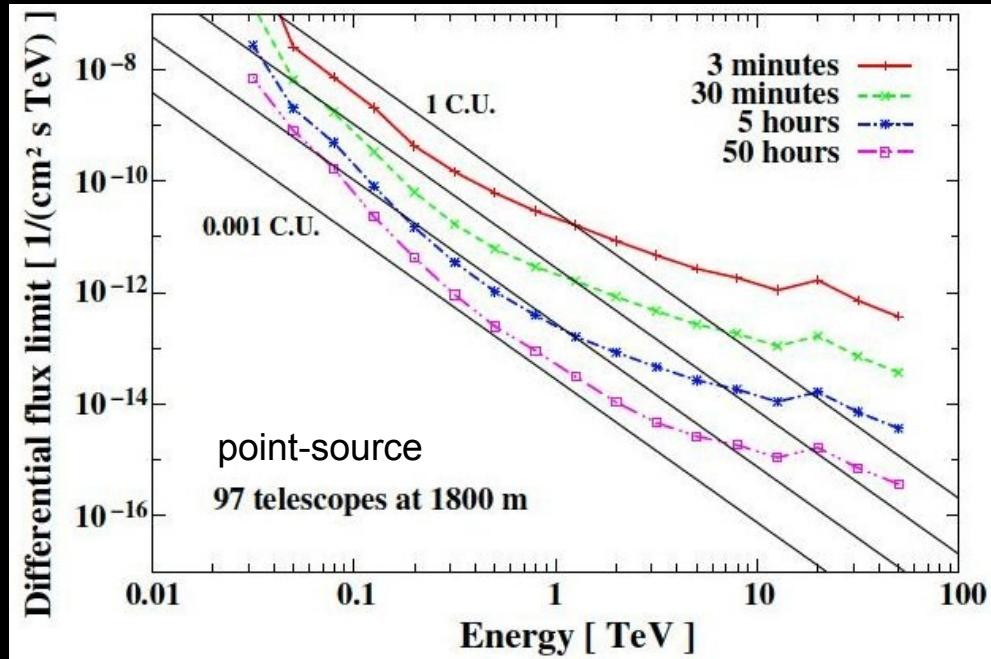
Detectability with CTA

$$\frac{d\Phi}{dE}(E, \alpha_{\text{int}}) = J(\alpha_{\text{int}}) \times \frac{d\Phi^{pp}}{dE}(E)$$

sensitivity
constrained

$$\frac{d\Phi^{pp}}{dE}(E) = \frac{1}{4\pi} \frac{\langle \sigma v \rangle}{2m_\chi^2} \sum_f \frac{dN^f}{dE} B_f$$

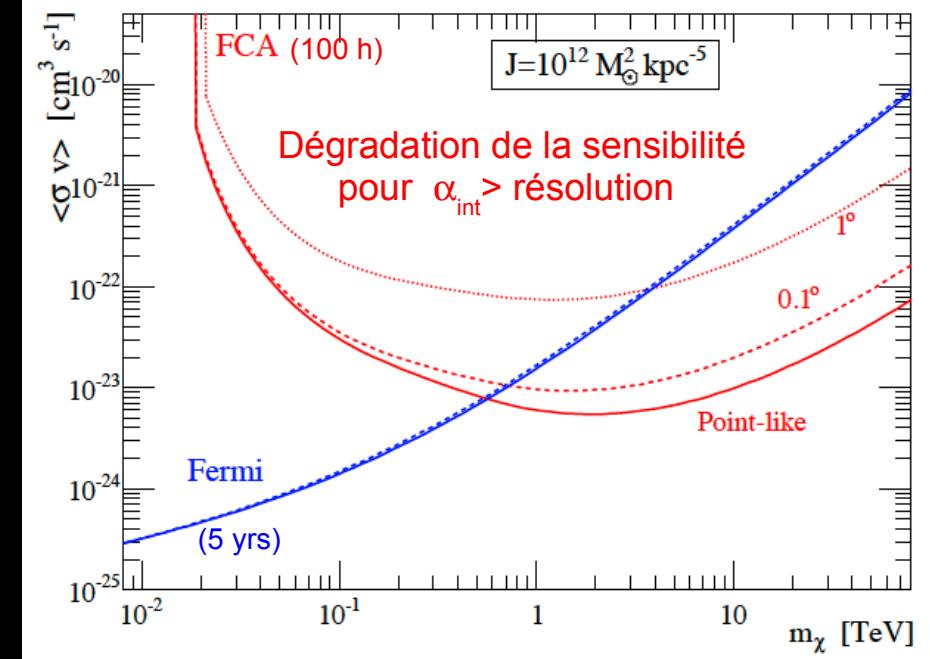
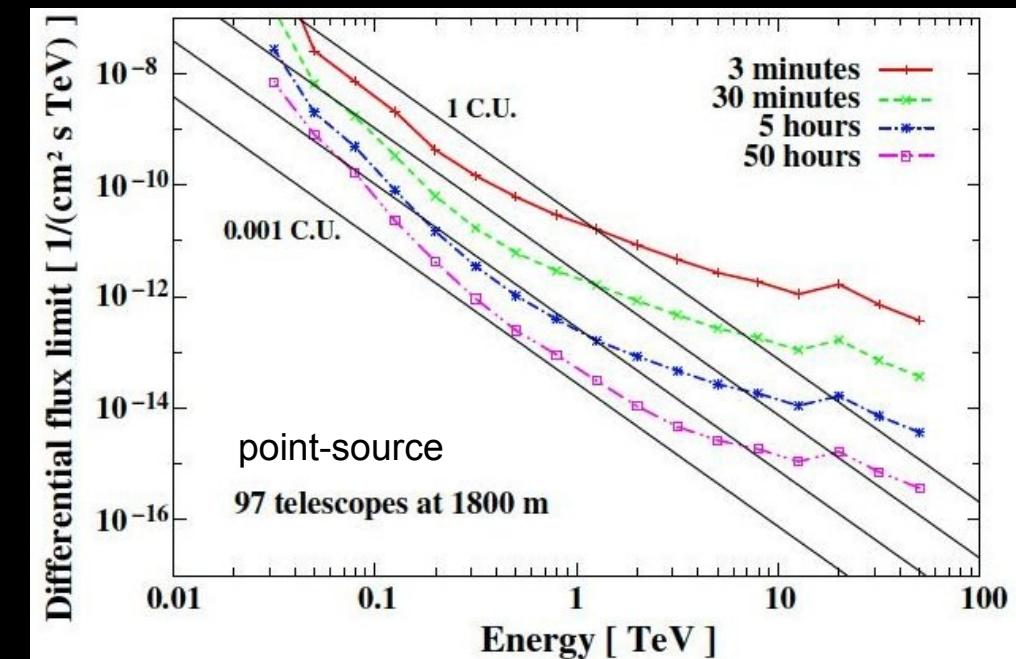
SUSY - LSP
Neutralino : “good” WIMP candidate



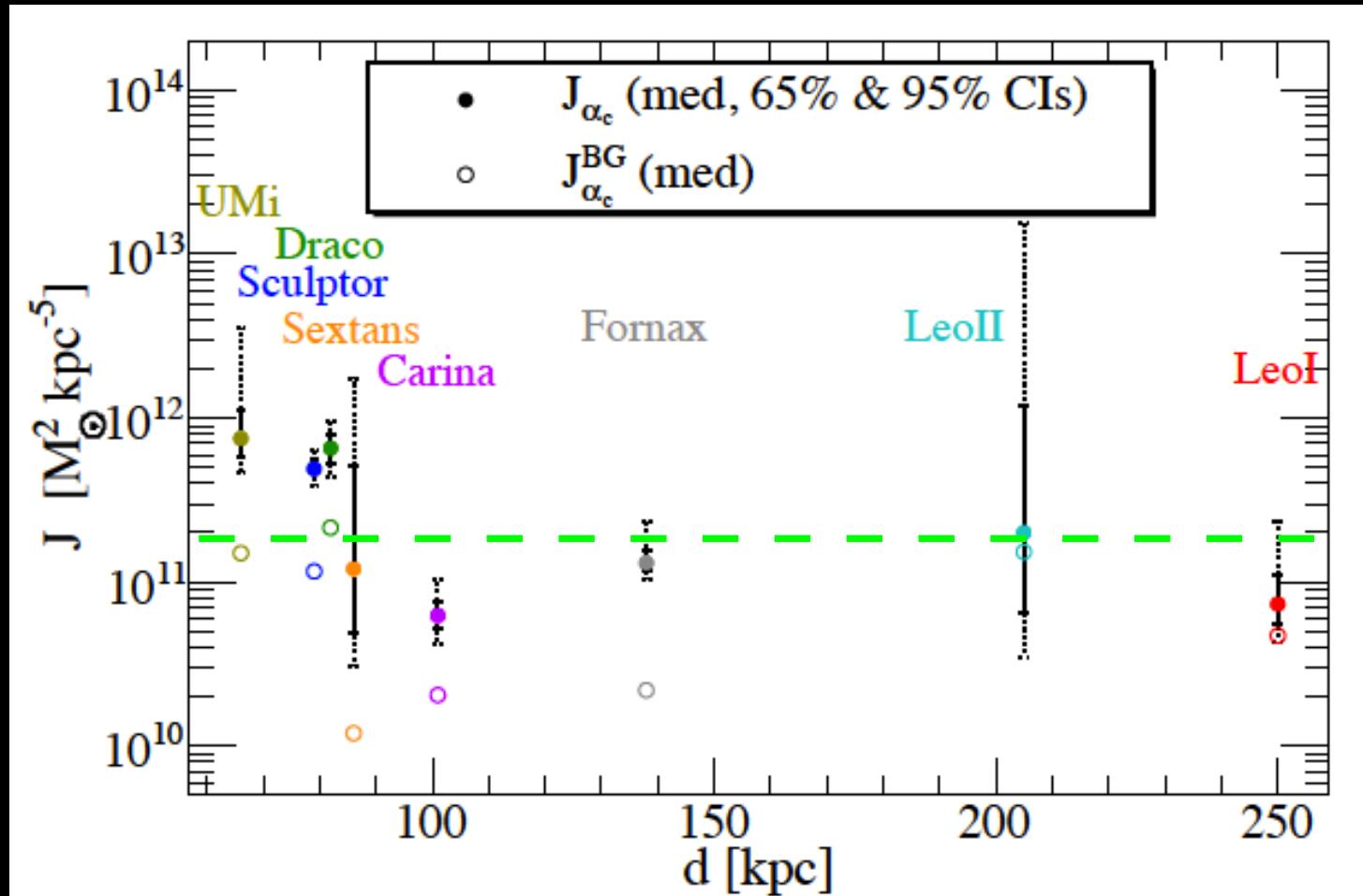
Detectability with CTA

$$\langle \sigma v \rangle \propto m_\chi^2 \cdot J(\alpha_{\text{int}}) \cdot \frac{\text{Sensib}(E, \alpha_{\text{int}})}{\text{constrained}} \cdot \frac{dN^{pp}}{dE} \cdot \frac{\text{Bergström}}{\text{Bernlöhr}}$$

Finite size effects are important

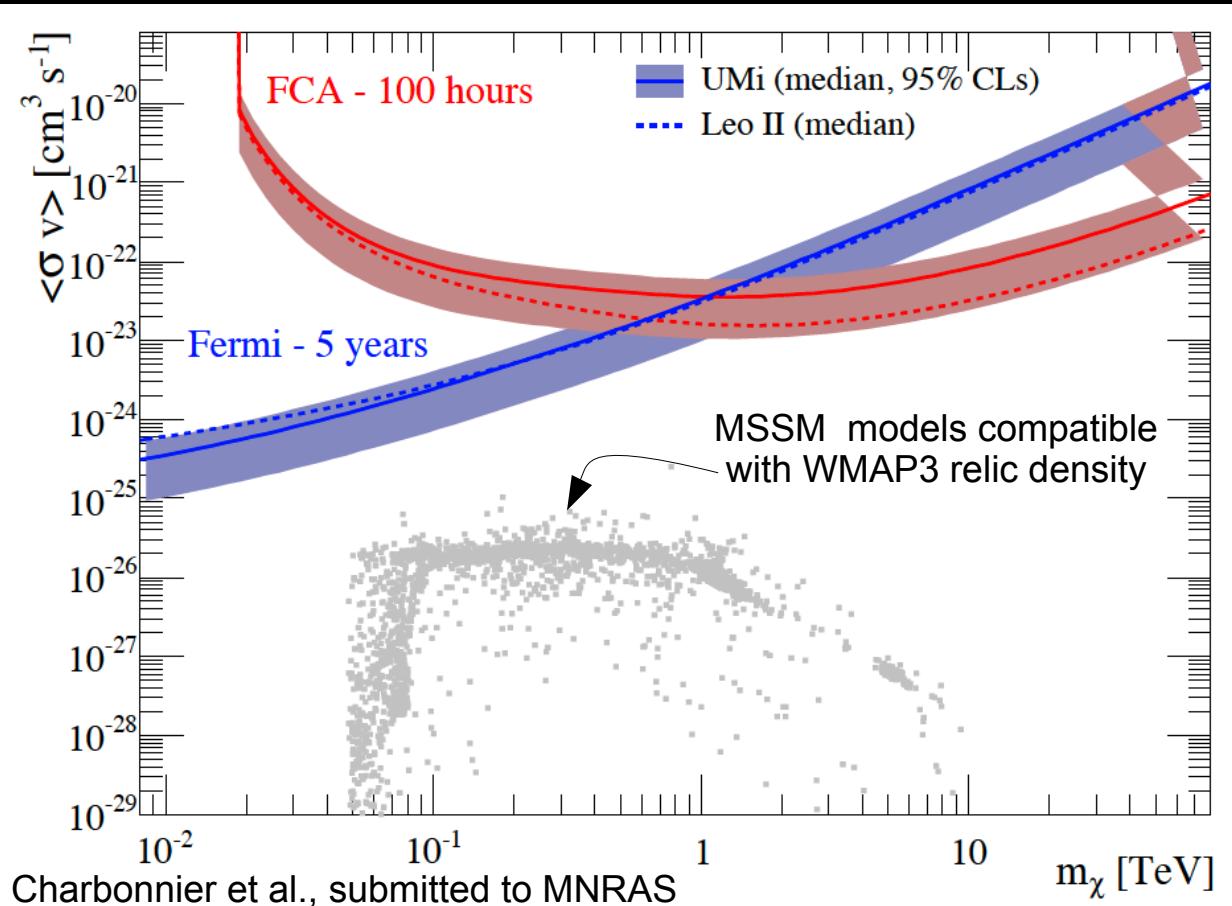


Ranking



UMi, Sculptor, Draco
+ Leo II (very uncertain)

Conclusions



- Got robust exclusion plots
- Still far from SUSY space
- Classical dSph may not be the best targets
- Pipeline ready for ultra-faint dSph (in progress)
- Galaxy clusters (in progress)

Note:

- Very conservative spectrum
- Does not mean we shouldn't look

CLUMPY

<http://www.astro.le.ac.uk/~cc234/clumpy/>

CLUMPY: Main Page

http://www.astro.le.ac.uk/~cc234/clumpy/html/

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CLUMPY Documentation

Aldée Charbonnier¹, Céline Combet², David Maurin³

¹(LPNHE/IN2P3/CNRS/Universités Paris VI et VII)
²(Dept. of Physics and Astronomy, University of Leicester, UK)
³(LPSC/CNRS/IN2P3, Université Joseph Fourier Grenoble 1, INPG)

aldee@lpnhe.in2p3.fr
cc234@astro.le.ac.uk
dmaurin@lpsc.in2p3.fr

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Hi guys!

We hope you will enjoy using CLUMPY whether you are

- an experimentalist looking for realistic γ -ray skymaps to calculate your new instrument sensitivity, or simply to use them in model/template analyses;
- an astrophysicist working on the DM content of dSphs who wishes to calculate the J factor;
- a theoretician who wants to plug his/her preferred particle physics model and see what is the corresponding γ -ray flux in the Galaxy/dSph, etc.

If you want to install the code, or to have a quick overview before getting started, please visit the following pages:

- [Introduction](#) – J-factor calculation and conventions
- [Downloads](#) – tar.gz archive of the code
- [README](#) – Follow the instructions to install CLUMPY

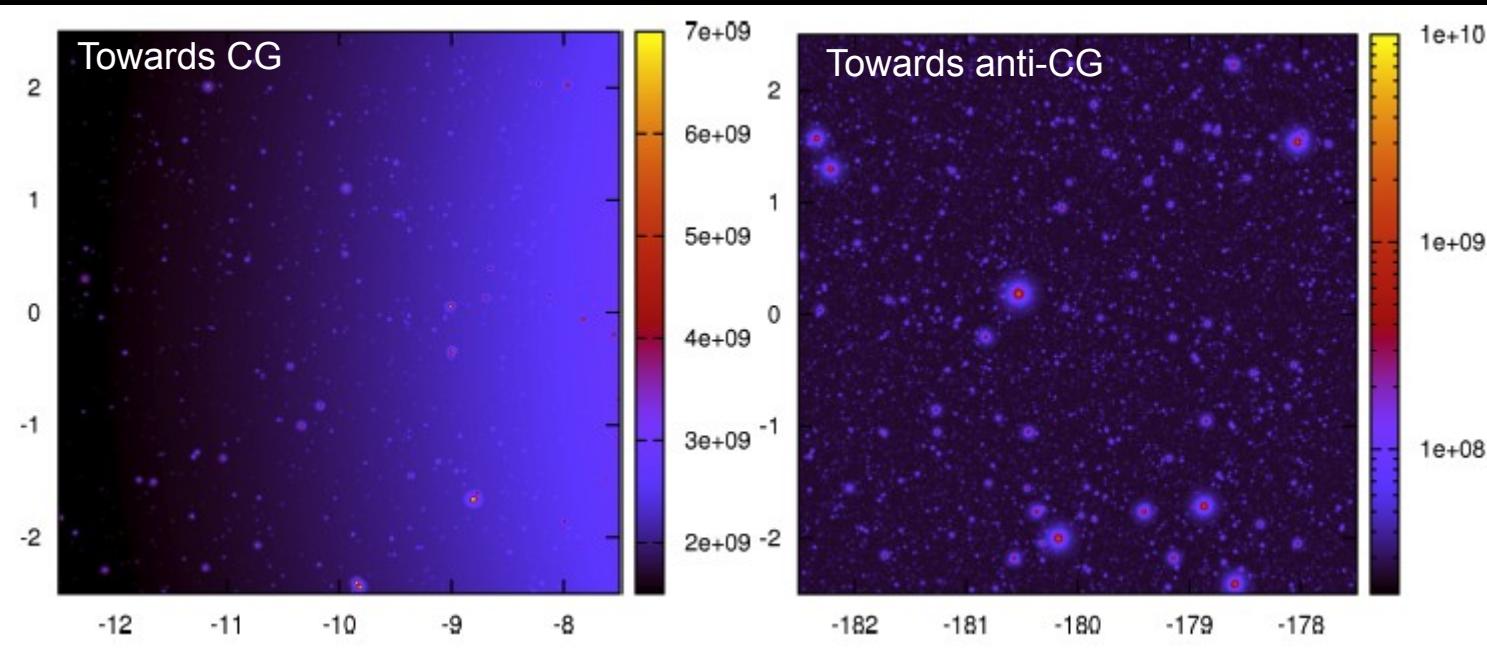
Generated on Tue Apr 26 2011 10:40:48 for CLUMPY by doxygen 1.7.4

- Public
- C/C++
- Interfaced with ROOT
- Fully documented

Calculates J in several configurations:

- dSph + statistics
- Skymaps:
smooth + sub-structures

CLUMPY's skymaps



- Fast
- “Scan” parameter space
 - Dark clumps
 - prospect for CTA

dSphs maps

