Dark matter hunting in the CTA era

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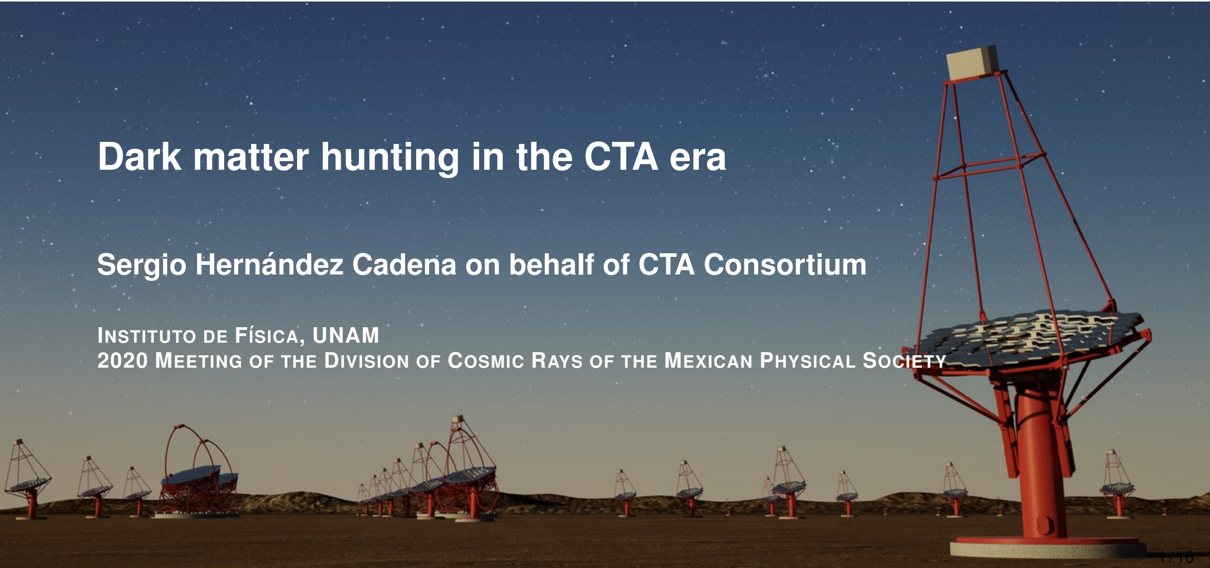
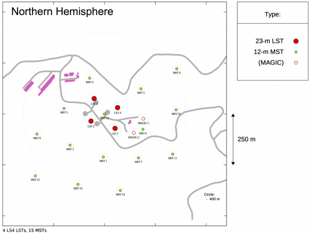
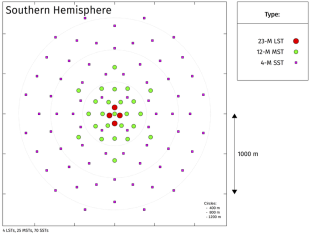


The Cherenkov Telescope Array

CTA is the next generation ground-based gamma-ray observatory

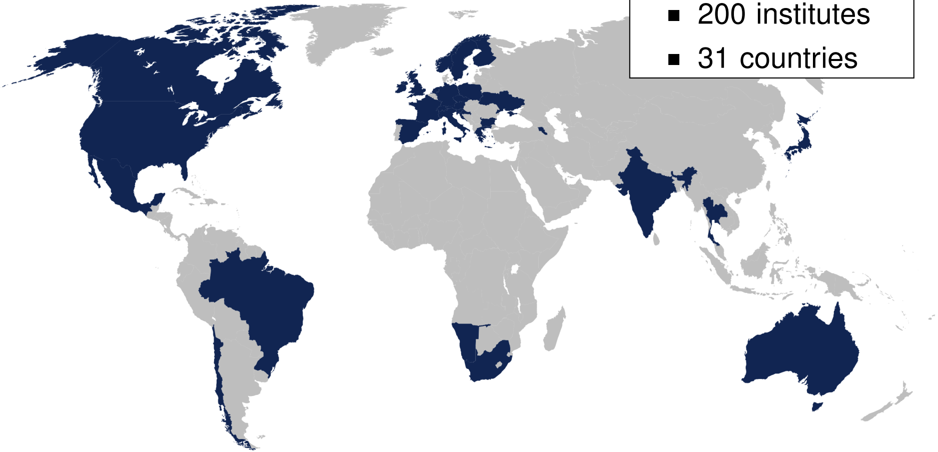
1. Energy range from 20GeV up to 300TeV
2. OPEN OBSERVATORY
3. All-Sky Coverage: Two arrays of Imaging Cherenkov Telescopes (IACTs)
   1) CTA North [La Palma, Canary Islands, Spain]
   2) CTA South [Cerro Paranal, in Chile]



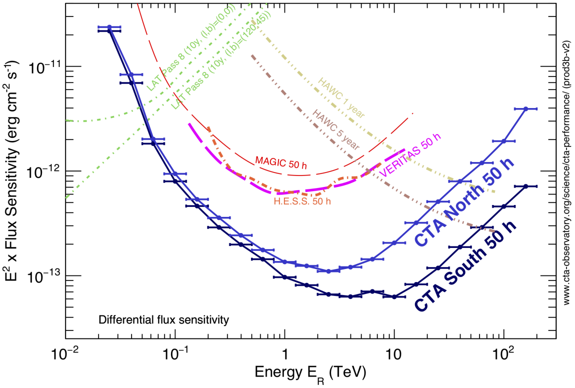


CTA Consortium

- 1500 members
- 200 institutes
- 31 countries

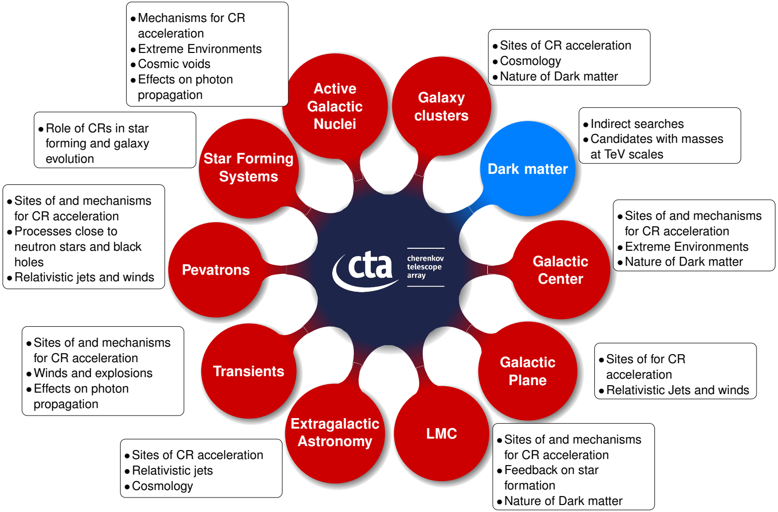


CTA Performance



1. Better energy resolution
2. $10\times$ improvement in Sensitivity
3. Rapid response to follow up of transients
4. Large Field of View
5. Better Angular resolution

CTA Key Science Programs

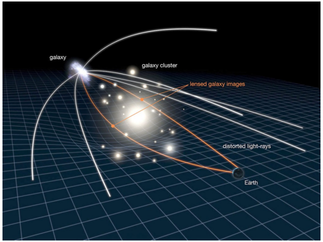


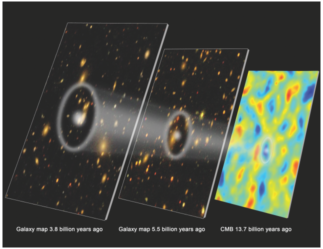
Dark Matter

There is a lot of evidence pointing to the existence of dark matter, but the nature of dark matter is still unknown

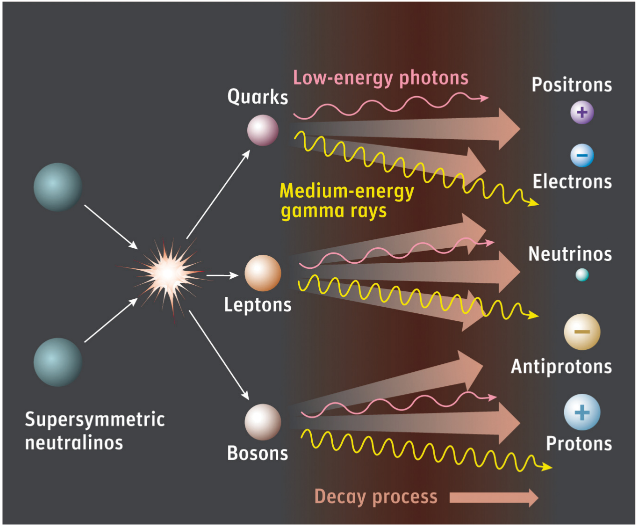
1. Rotation curve of galaxies
2. Gravitational lensing
3. Acoustic oscilations

It is estimated that dark matter represents $\approx 27\,\%$ of the content of the Universe





Indirect Searches

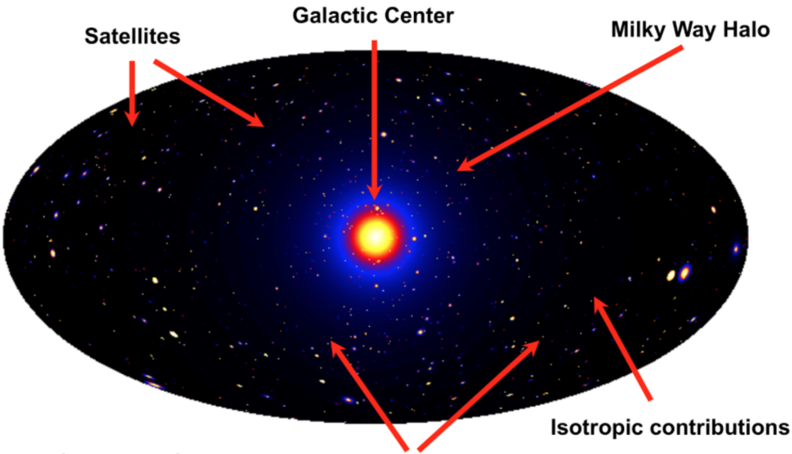


1. Weakly Interactive Massive Particles (WIMPs)
2. Candidates with masses at TeV scales
3. Annhilation and decay of WIMPs
4. Continuum and line-emission spectra

$$\frac{\mathrm{d}\Phi^{\mathrm{ann}}}{\mathrm{d}E} = \underbrace{\frac{\langle\sigma \mathrm{v}\rangle}{8\pi m^2}\frac{\mathrm{d}N}{\mathrm{d}E}}_{\text{P.P. term}} \underbrace{\int\int \rho_{\mathrm{DM}}^2 \,\mathrm{dl}\,\mathrm{d}\Omega}_{\text{J factor}}$$

$$\frac{\mathrm{d}\Phi^{\mathrm{dec}}}{\mathrm{d}E} = \underbrace{\frac{\Gamma}{4\pi m}\frac{\mathrm{d}N}{\mathrm{d}E}}_{\text{P.P. term}} \underbrace{\int\int \rho_{\mathrm{DM}} \,\mathrm{dl}\,\mathrm{d}\Omega}_{\text{D factor}}$$

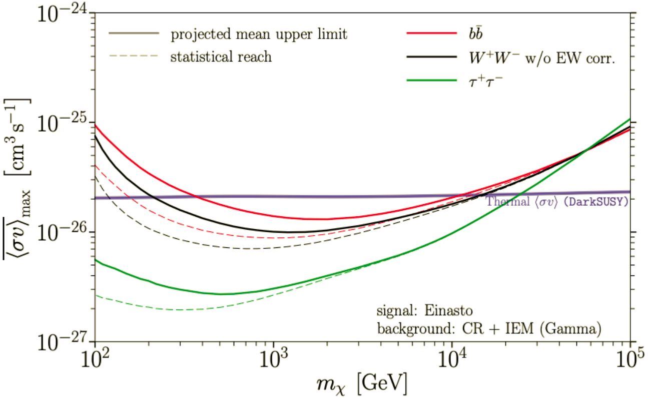
Where to look for dark matter



Features in γ-ray and cosmic-ray spectra

Dark Matter simulation: Pieri+ 2011PhRvD..83b3518P

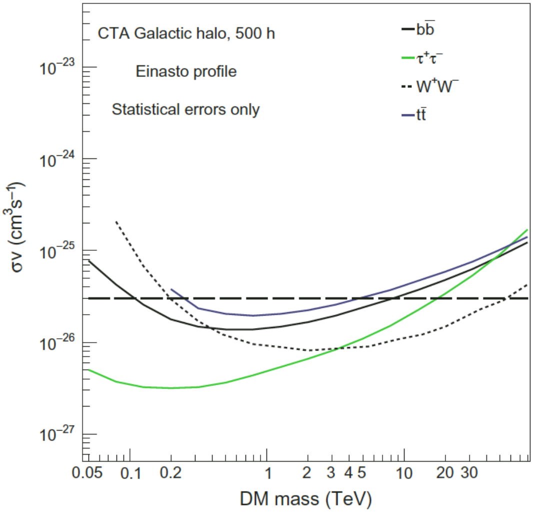
Galactic center



CTA sensitivity to a DM signal from the GC. arXiv:2007.16129

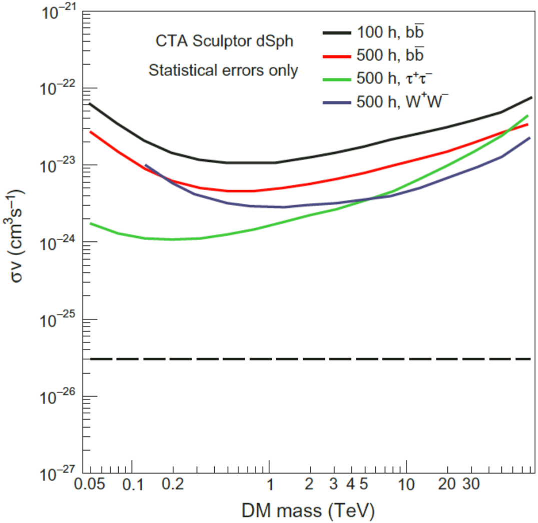
1. Part of the Galactic centre KSP
2. > 500h of observation time
3. Large DM signal
4. Accurate measurements of other astrophysical emission in the region to be able to reduce any contamination

Galactic Halo



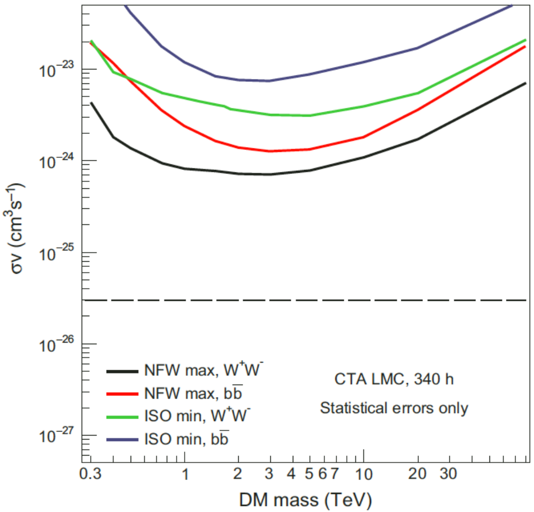
1. Very deep exposure to enable detection and detailed studies
2. Control of systematic effects in the background subtraction and modelling
3. Results from kinematic data will reduce uncertainties in the distribution of dark matter in the inner regions of the galaxy.
   $\rightarrow$ Direct impact in the exclusion limits

Dwarf Spheroidals (dSph) Galaxies



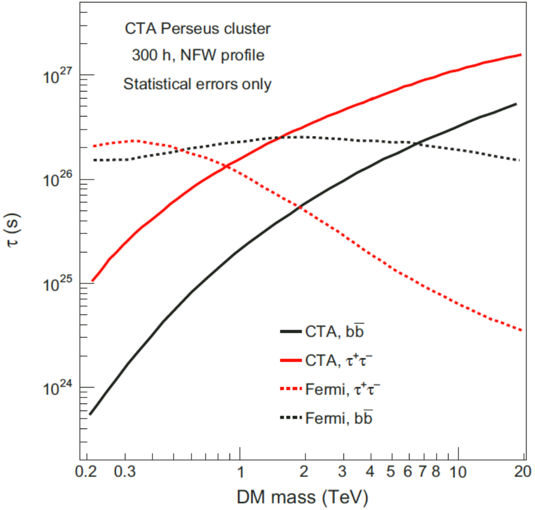
1. Clear and unambiguous detection of dark matter
2. Objects with a favourably low or null astrophysical gamma-ray background
3. Newly discovered dSphs added to the existing sample $\rightarrow$ Choose of the best targets
4. 100h of observations per year of the best dSph candidate

Large Magellanic Cloud



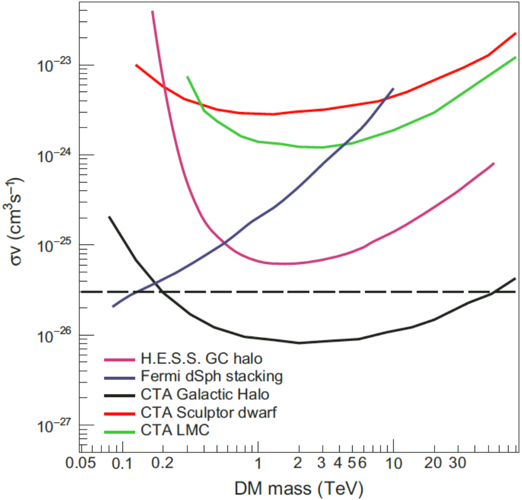
1. Nearby satellite galaxy
2. J factor as high as 1×10^{20}GeV^{2}cm^{-5}
3. Spatial extent and significant astrophysical gamma-ray background
4. Conservative estimates of the dark matter content
5. 340h of observation time

Clusters of galaxies: Perseus



1. Part of the Galaxy clusters KSP
2. 300h of observation time
3. High mass-to-light ratio
4. Very promising targets to constrain lifetime of dark matter particles
5. Studies of the substructure could improve the limits on annihilation cross-section
6. Deep understanding of astrophysical gamma-ray background (NGC 1275 and IC 310 AGNs, and gamma-ray emission induced by CRs)

Comparison with other experiments



1. CTA will complement the results from other experiments, probing thermal WIMPs in a wide range of masses (up to $\sim$ tens of TeV)
2. CTA also will complement results from direct and collider searches

Detection Strategy

Year	1	2	3	4	5	6	7	8	9	10
Galactic halo	175 h	175 h	175 h							
Best dSph	100 h	100 h	100 h							
				In case of detection at GC, large σv						
Best dSph				150 h	150 h	150 h	150 h	150 h	150 h	150 h
Galactic halo				100 h	100 h	100 h	100 h	100 h	100 h	100 h
				In case of detection at GC, small σv						
Galactic halo				100 h	100 h	100 h	100 h	100 h	100 h	100 h
				In case of no detection at GC						
Best Target				100 h	100 h	100 h	100 h	100 h	100 h	100 h

To this program, it must be added the observation time for Perseus (300h) cluster and LMC (340h) $\rightarrow$ More than 1500h of observation time dedicated to dark matter indirect searches

Summary

1. CTA has a unique chance of discovery for DM candidates with masses @TeV scales
2. CTA plans to dedicate more than 1500h to collect data that decisively will improve our knowledge about dark matter in the Universe
3. In addition to the results by Fermi, CTA will probe thermal WIMPs with masses in the range up to tens of TeV
4. Results by CTA, even in the case of null detection, will complement direct and collider searches
5. Understanding of astrophysical contributions to the gamma-ray flux will be important to improve the chances of discovery (Galactic center and LMC KSP)

Thanks!