The search for Dark Matter with the Cherenkov Telescope Array

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Imaging Cherenkov telescopes

- optical telescopes located in the light pool of a Cherenkov shower
- background discrimination (1 gamma-ray candidate every 1000 recorded events)

http://spie.org/x48508.xml

The Cherenkov Telescope Array (CTA)

- up to 100 hundreds telescope of 3 sizes to cover energy range from 20 GeV to 300 TeV

- an open observatory with 2 sites for whole sky coverage

- negotiation has started with candidate host countries: Aar (Namibia) or Cerro Armazones (Chile) for Southern site and La Palma (Spain) or San Pedro Martir (Mexico) for Northern site

http://www.isgtw.org/feature/grand-vision-cherenkov-telescope-array


\[ \frac{d\Phi_\gamma}{dE}(E_\gamma, \Psi) = \frac{(\sigma_{\text{ann}} \nu)}{8 \pi m_\chi^2} \int d\lambda \sum_i B_i \frac{dN^i_\gamma}{dE} (E_\gamma (1 + z)) \rho_\chi^2 (\lambda(z), \Psi) \]

maximum energy of the produced gamma rays (cut-off)
Searching for Dark Matter (DM) with CTA

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thermal cross-section \((3 \times 10^{-26} \text{ cm}^2\text{s}^{-1})\) to reproduce Planck DM relic density

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that the model is correct. The 68% and 95% credibility model, given the experimental data, under the hypothesis function (PDF) shows relative probabilities within a space that reproduce all experimental observables within 2σ. In fact, wave functions, it is more efficient to self-annihilate, therefore, a specific mass relation with other regions, with dark matter between 1 TeV and 3 TeV, can be needed to discriminate amongst them in the (typical) situation.

maximum energy of the produced gamma rays (cut-off)

thermal cross-section (3×10⁻²⁶ cm²s⁻¹) to reproduce Planck DM relic density

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curved continuum with the possibility of features (bumps and lines)

Bringing and Weniger, Phys. Dark Univ. (2012)

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thermal cross-section (3×10^{-26} cm^2 s^{-1}) to reproduce Planck DM relic density

\[ x^2 \frac{dN}{dx} \]

- need to be constrained with other observations
- N-body simulations can also help

Bringmann and Weniger, Phys. Dark Univ. (2012)
The advantage of CTA

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energy range from few tens to GeV to few hundreds of TeV
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energy range from few tens to GeV to several tens of TeV

better sensitivity over the whole energy range (complementarity with Fermi-LAT)
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Bernlohr et al., Astropart. Phys. 43 (2013)
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The inner halo of the Milky Way

- \( N_{ON}, N_{OFF} \): “experimental” data
- \( N_{\gamma}^S, N_{\gamma}^B, \beta \): model and systematic uncertainty
- Poissonian statistics

\[
\mathcal{L}_{ij}(N_{\gamma}^S, N_{\gamma}^B, \beta | N_{ON}, N_{OFF}) = e^{-\frac{(1-\beta_{ij})^2}{2\sigma_{ij}^2}} \beta_{ij}^{N_{ON},ij} \left( N_{\gamma}^S_{ij} + N_{\gamma}^B_{ij} \right)^{N_{ON},ij} e^{-\beta_{ij} \left( N_{\gamma}^S_{ij} + N_{\gamma}^B_{ij} \right)} e^{N_{OFF,ij}} e^{-N_{\gamma}^B_{ij}/\alpha_i}
\]
Sensitivity from the MW inner halo

- improvement in the “morphological” analysis compared to the “Ring” method
- effect of systematic uncertainties

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- mixing of ALPs with photons in the presence of magnetic fields
- excess of photons in the “optical thick” regime due to reconversion of from ALPs to gamma rays
Conclusions

• CTA will have the best sensitivity to search for DM in the near future (especially for heavy candidates)

• sensitivity reaches thermal cross-section for WIMPs

• complementarity with other detection strategies (collider and direct detection)

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