CTA sensitivity to branon dark matter models

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Alejandra Aguirre-Santaella
Instituto de Física Teórica, Universidad Autónoma de Madrid
with
Viviana Gammaldi (IFT UAM-CSIC)
Miguel A. Sánchez-Conde (IFT UAM-CSIC)
Daniel Nieto (UCM)

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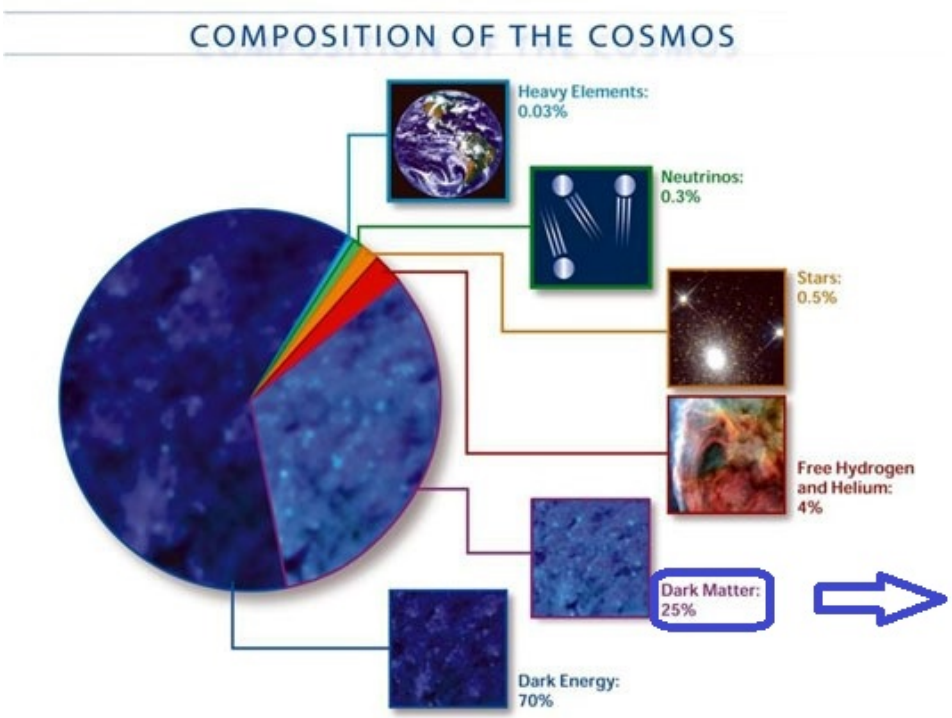
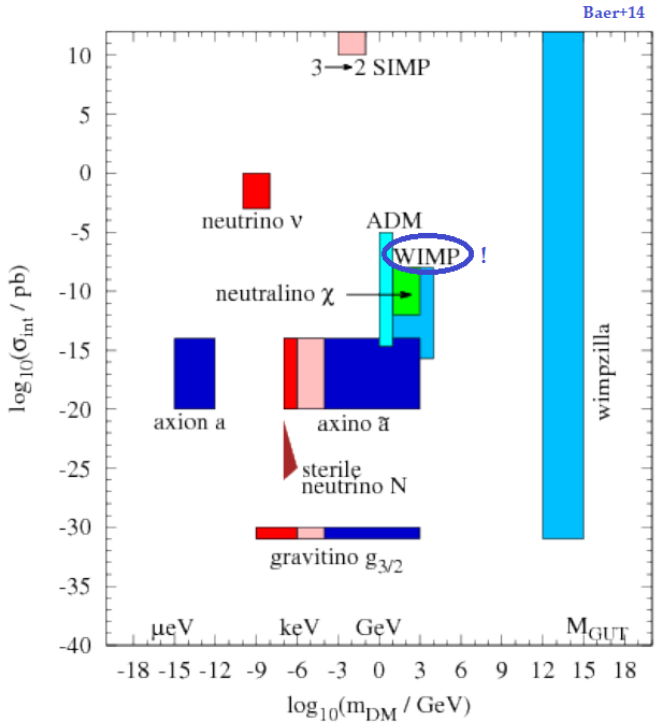
Motivation



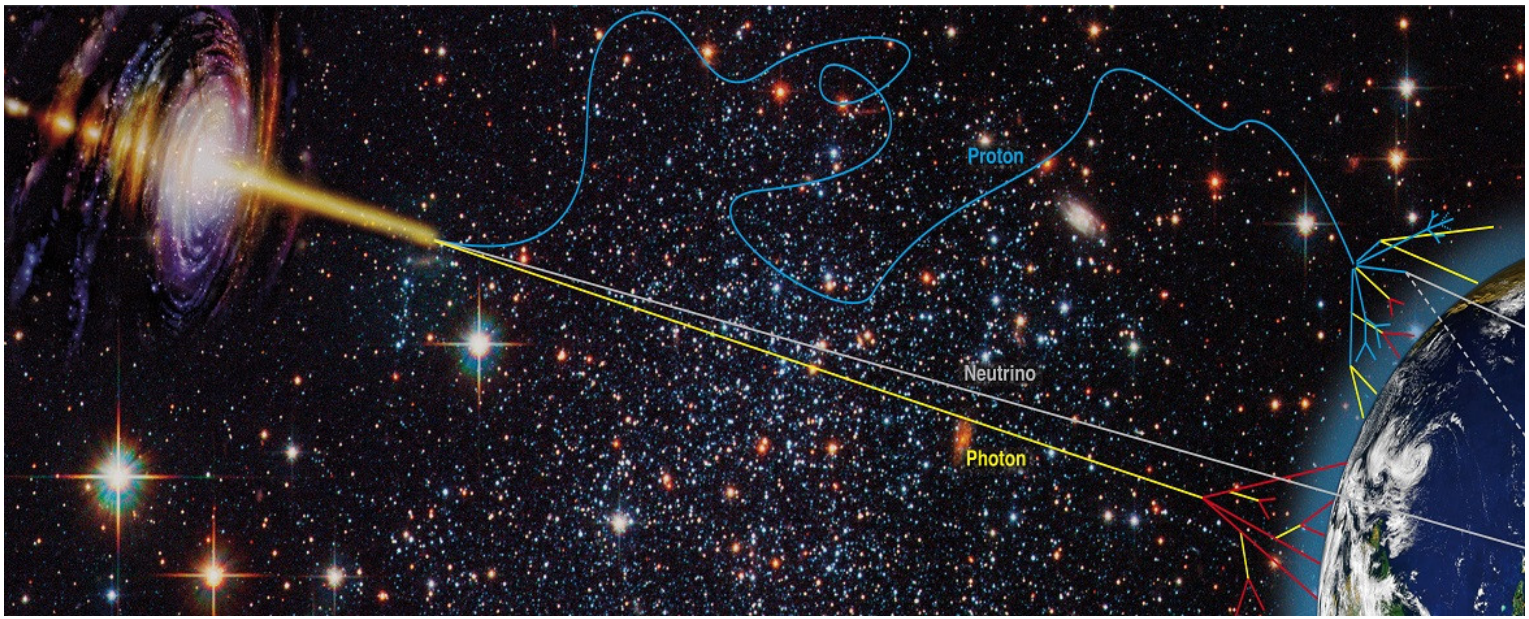


Indirect detection: annihilation of dark matter (DM) particles ⇒ gamma rays

WIMP = Weakly Interacting Massive Particle

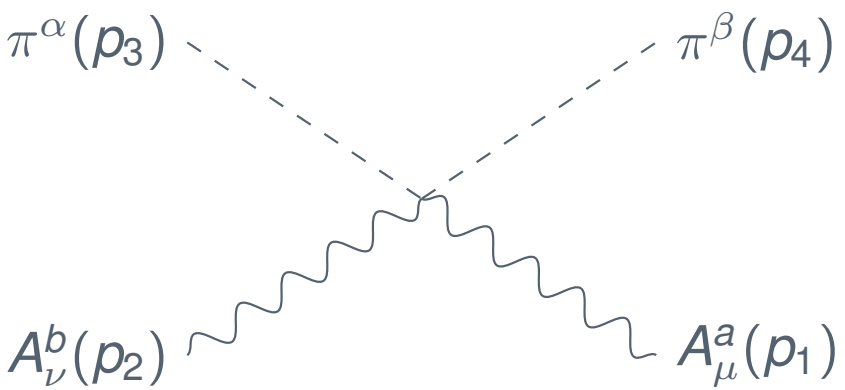
Why branons?

- WIMPs: plausible DM candidates
- up to now, no univocal evidence of GeV WIMPs (e.g. Fermi, CERN)
- what to look for next? $\rightarrow$ TeV DM
- branons are an interesting example of TeV WIMP candidates that could account for the right amount of DM
  [Cembranos, Gammaldi+12, Cembranos, Gammaldi+13]



Branons

- theory: brane-world extension of the Standard Model (SM) [Cembranos+03]
- the existence of large extra dimensions has been proposed as a new setting for a possible solution to the hierarchy problem
- branons are brane vibrations



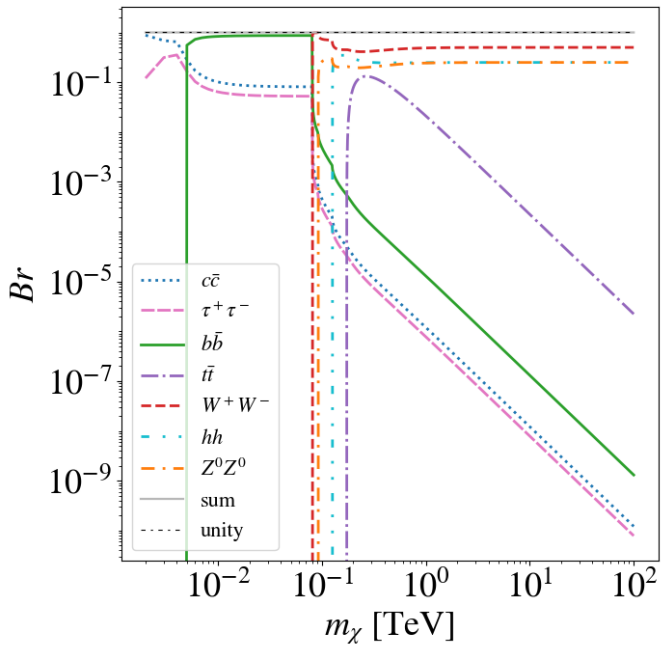
Branons

- WIMPs that annihilate producing SM particles [Cembranos+11]
- Branching ratios depend on branon mass: $B_r^i = B_r^i(m_\chi)$

$$\frac{dN}{dE} = \int_{los} \rho_A^2(r)\, dr \qquad \frac{\langle \sigma v \rangle_{th}}{8\pi m_\chi^2} \sum B_r^i \frac{dN_i}{dE}$$

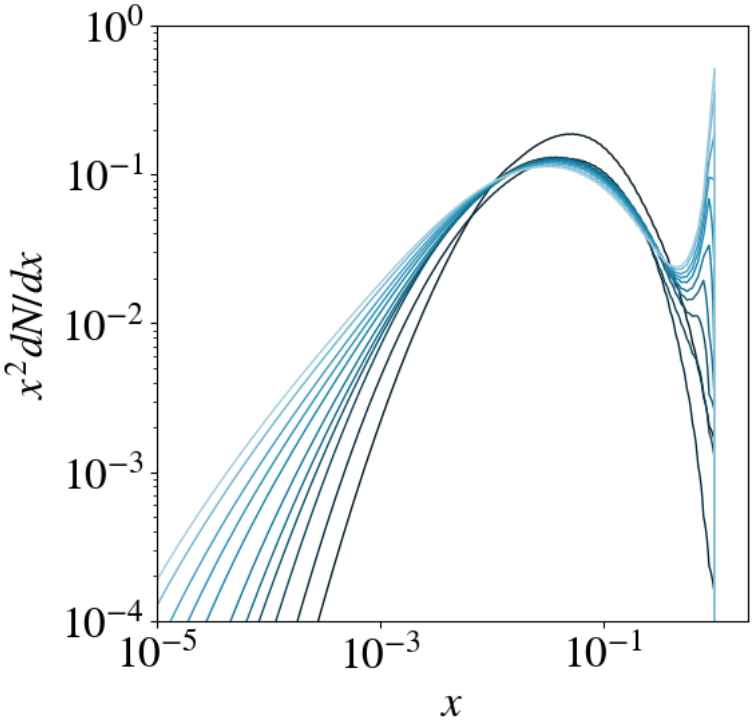
J-factor

particle physics factor

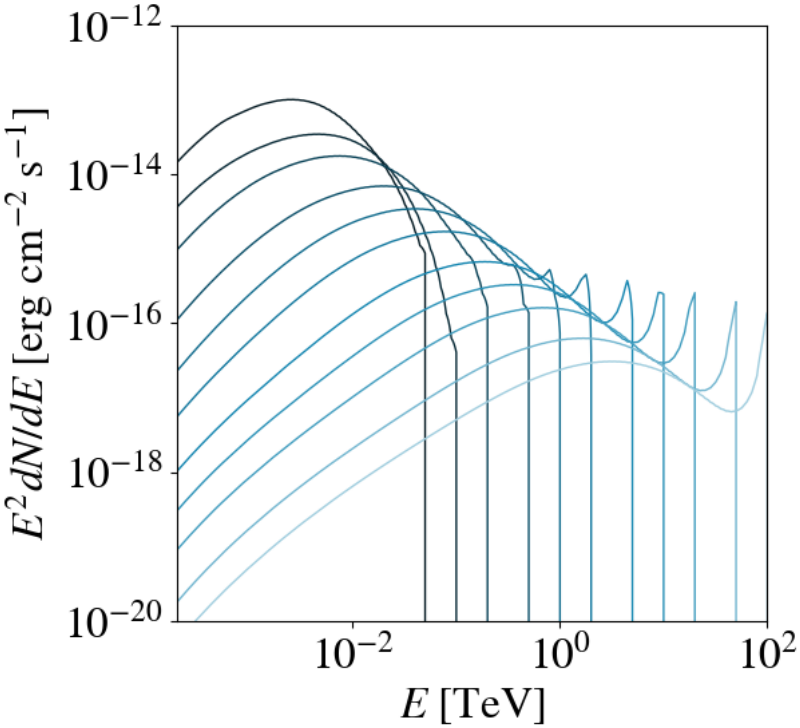


Right panel of Fig. 1 from AAS+20

Branons spectra



photon yield, $x = E_\gamma / m_\chi$



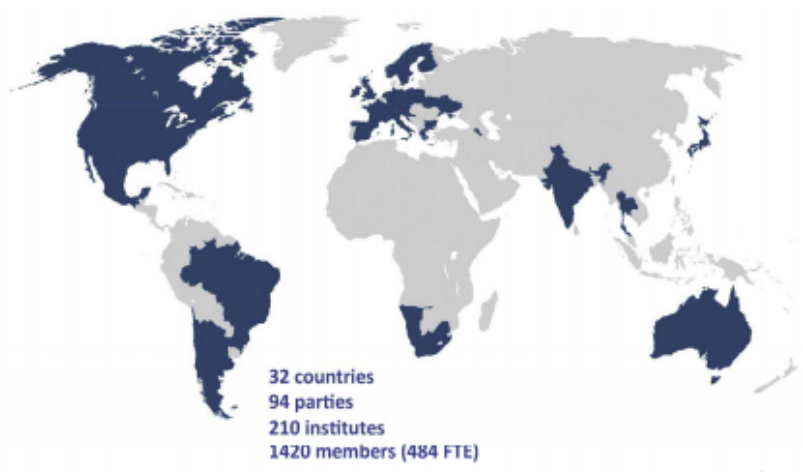
annihilation flux

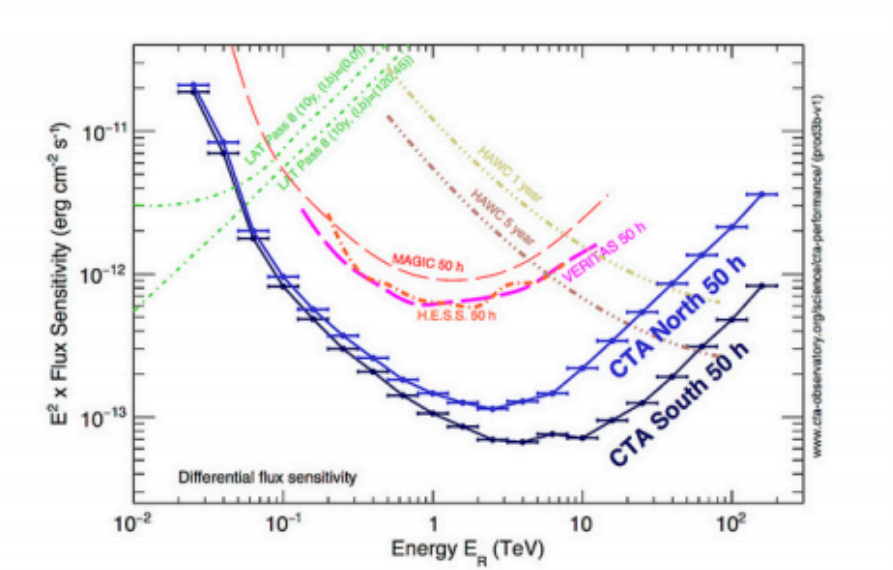
masses ranging from 50 GeV (dark blue) to 100 TeV (light blue)

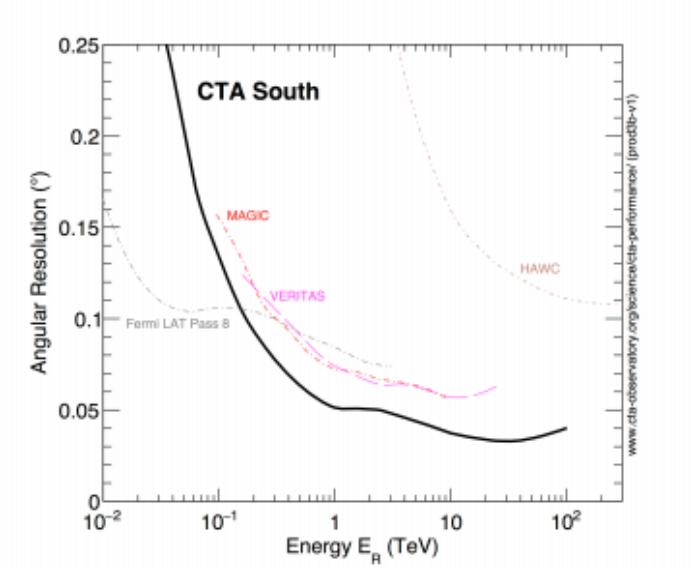
plots computed using PPPC4DMID [Cirelli+11] and applying electroweak corrections

Cherenkov Telescope Array (CTA)

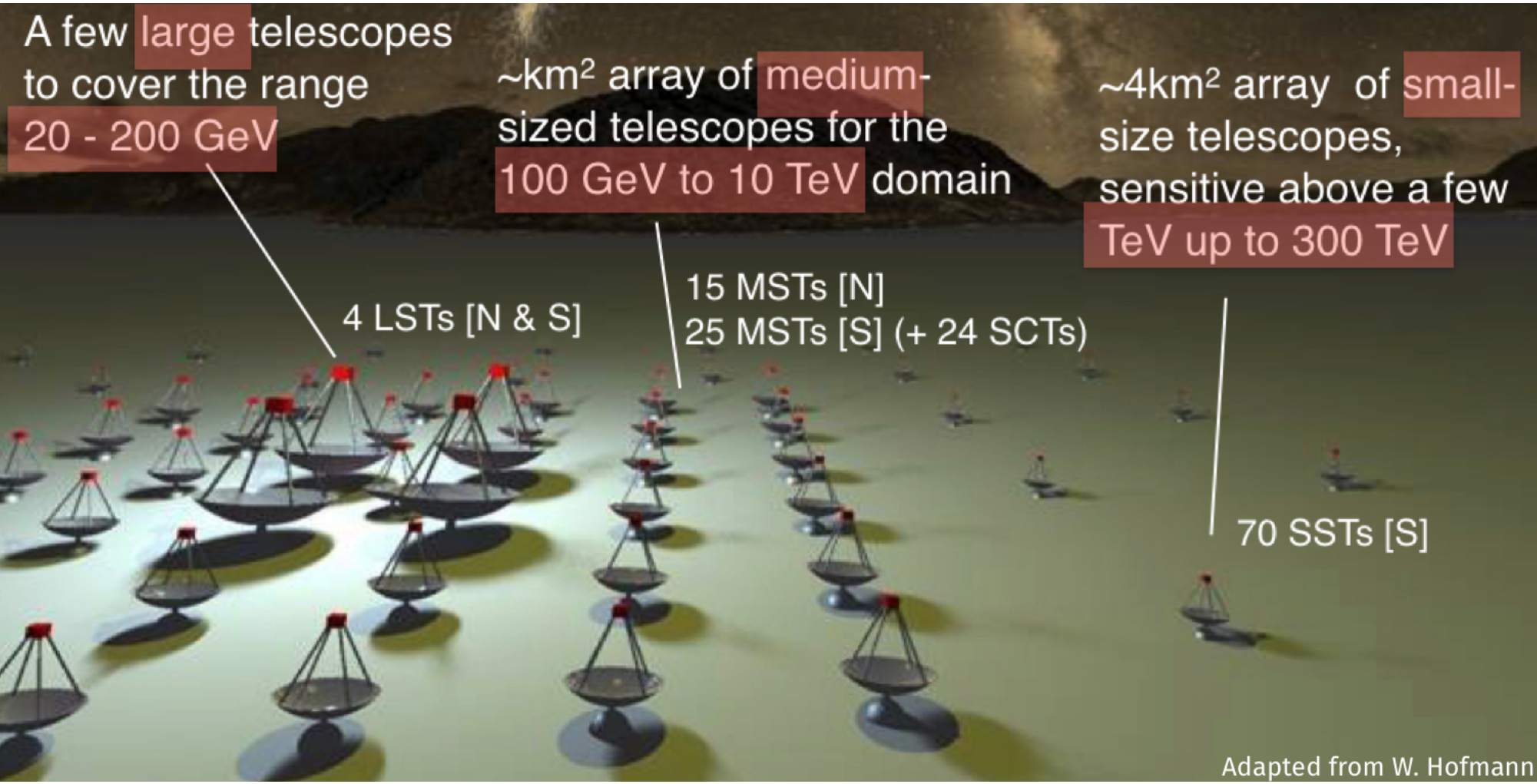
Big international effort: more than 30 countries and 200 institutions







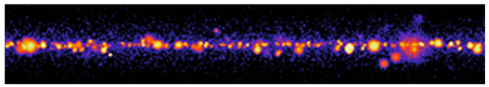
CTA layout (under discussion)

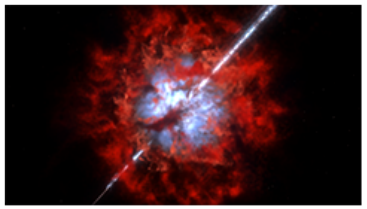


CTA targets

Galactic Center

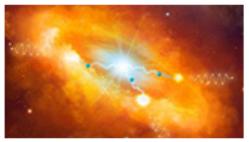
Galactic Plane





Transients

Active Galactic Nuclei

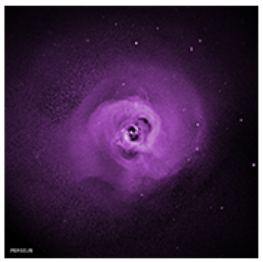


Cosmic Ray PeVatrons

Dwarf Spheroidal Galaxies

Large Magellanic Cloud

Star Forming Systems



Galaxy Clusters

Key Science Projects

- major scientific cases
- surveys and deep observations of key objects

We are focusing on dwarf spheroidal galaxies (dSphs)

Analysis pipeline

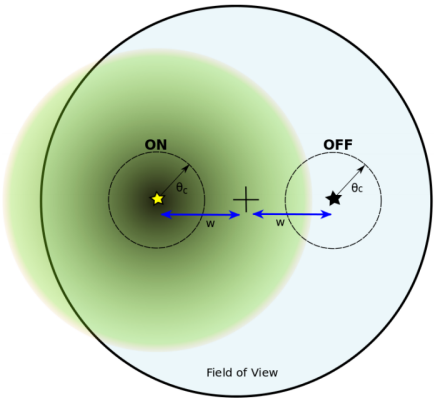
1. Use CTA standard tools for analysis: `ctools`
2. Simulate branon spectra as would be measured by CTA

i) we compute $\langle \sigma v \rangle$ values needed for a 5σ detection

ii) we compute 95 % c.l. upper limits in absence of a signal

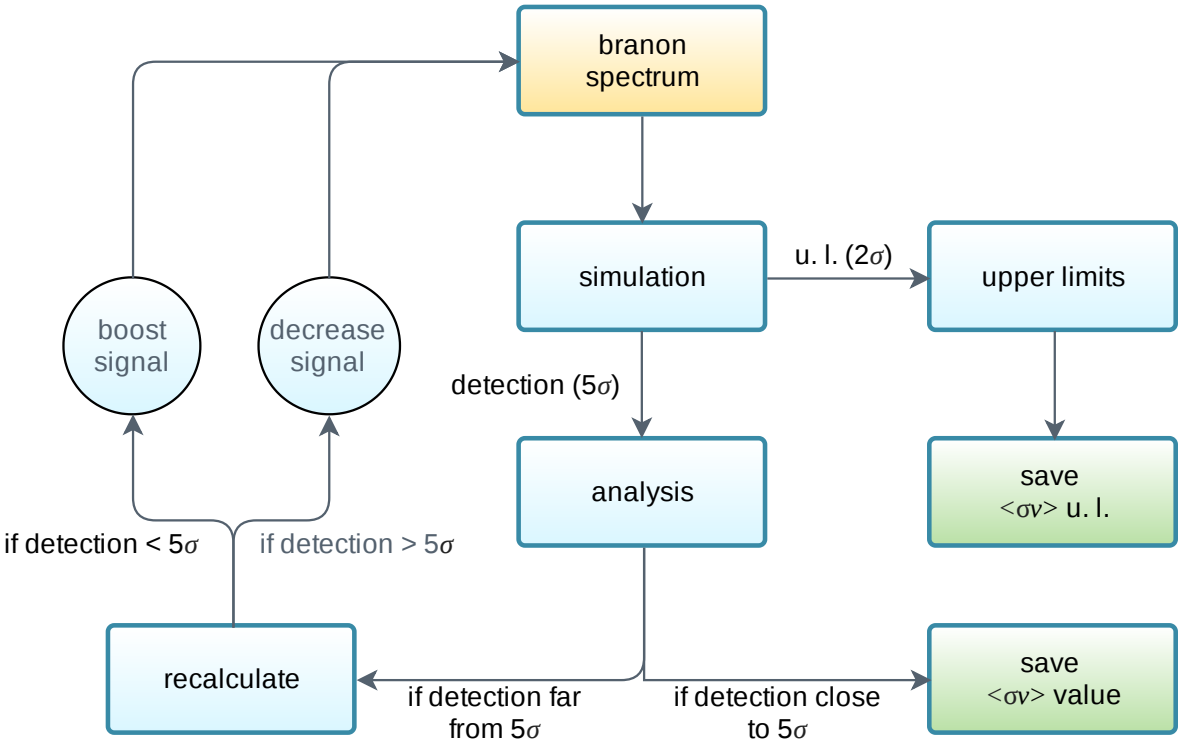
Considerations and targets:

- J-factor (assuming puntual sources) from two dSphs: Draco (North) and Sculptor (South)
- latest instrumental response functions, w/ zenith angle of 20 deg
- 300 h of observation using the whole CTA energy range (expected observation time for a dSph in the first years of CTA operation)
- wobble analysis, simulating instrumental background once
- 100 MonteCarlo seeds for each dwarf and DM mass



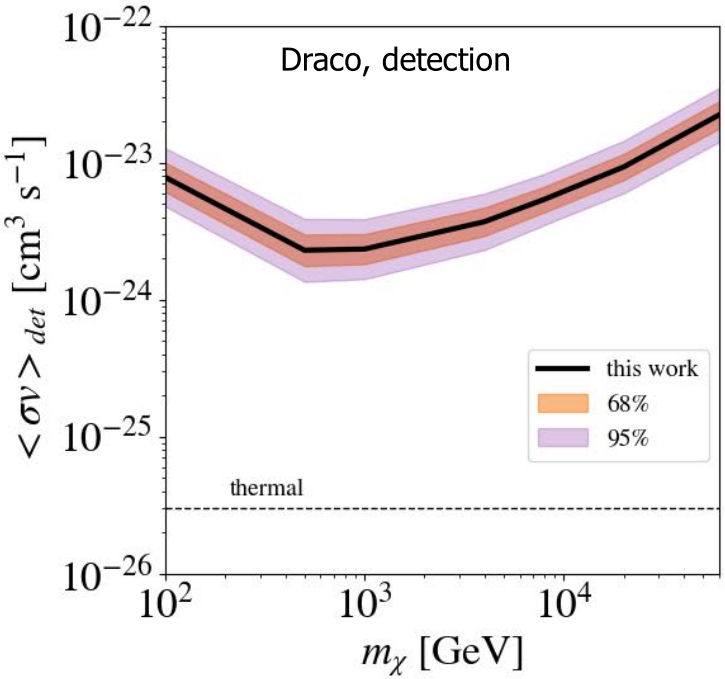
Analysis flowchart

Target	m_χ [TeV]	T_{obs} [h]	(RA, DEC) [deg]	$J\left[\frac{\mathrm{GeV}^2}{\mathrm{cm}^5}\right]$	(E_{min}, E_{max}) [TeV]
Draco	[0,1, 60]	300	(260.05, 57.915)	$1{,}42 \cdot 10^{19}$	(0.03, m_χ)
Sculptor	[0,1, 60]	300	(15.0375, -33.7092)	$3{,}56 \cdot 10^{18}$	(0.03, m_χ)

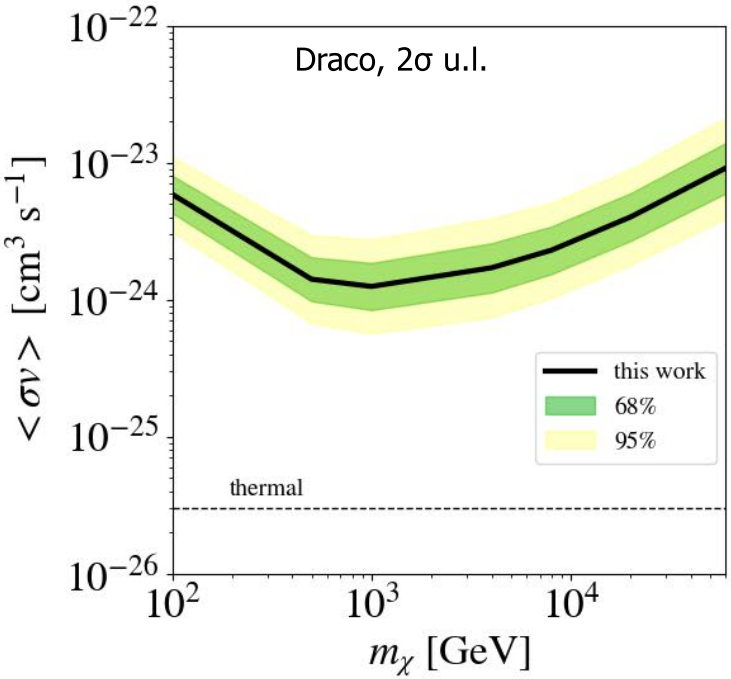


Results

Cross section as a function of the branon mass



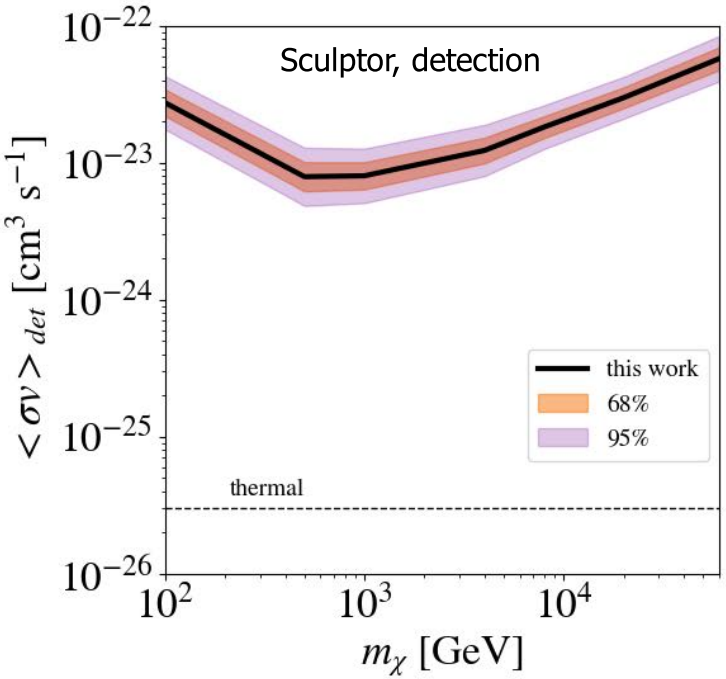
$\langle \sigma v \rangle$ values for detection

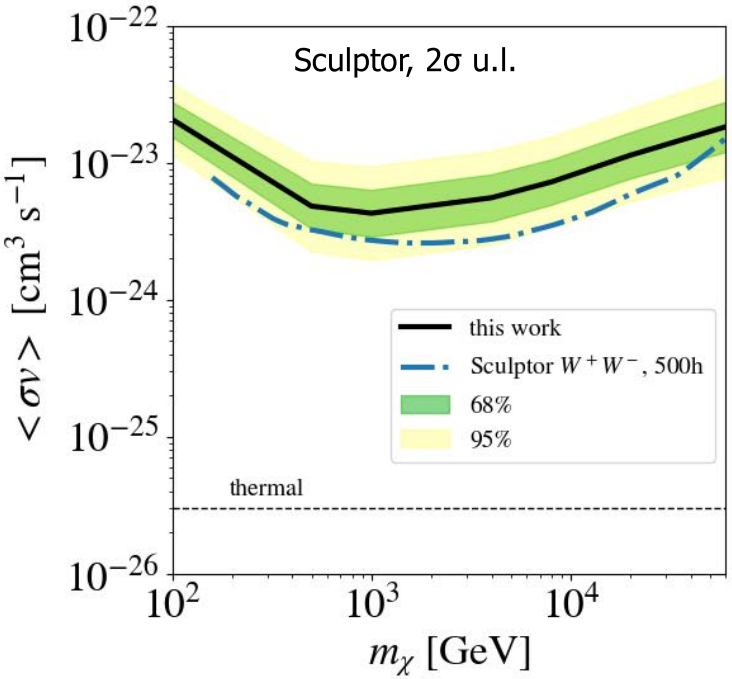


upper limits for $\langle \sigma v \rangle$

nearly two orders of magnitude far from the thermal, at best

Results
Cross section as a function of the branon mass





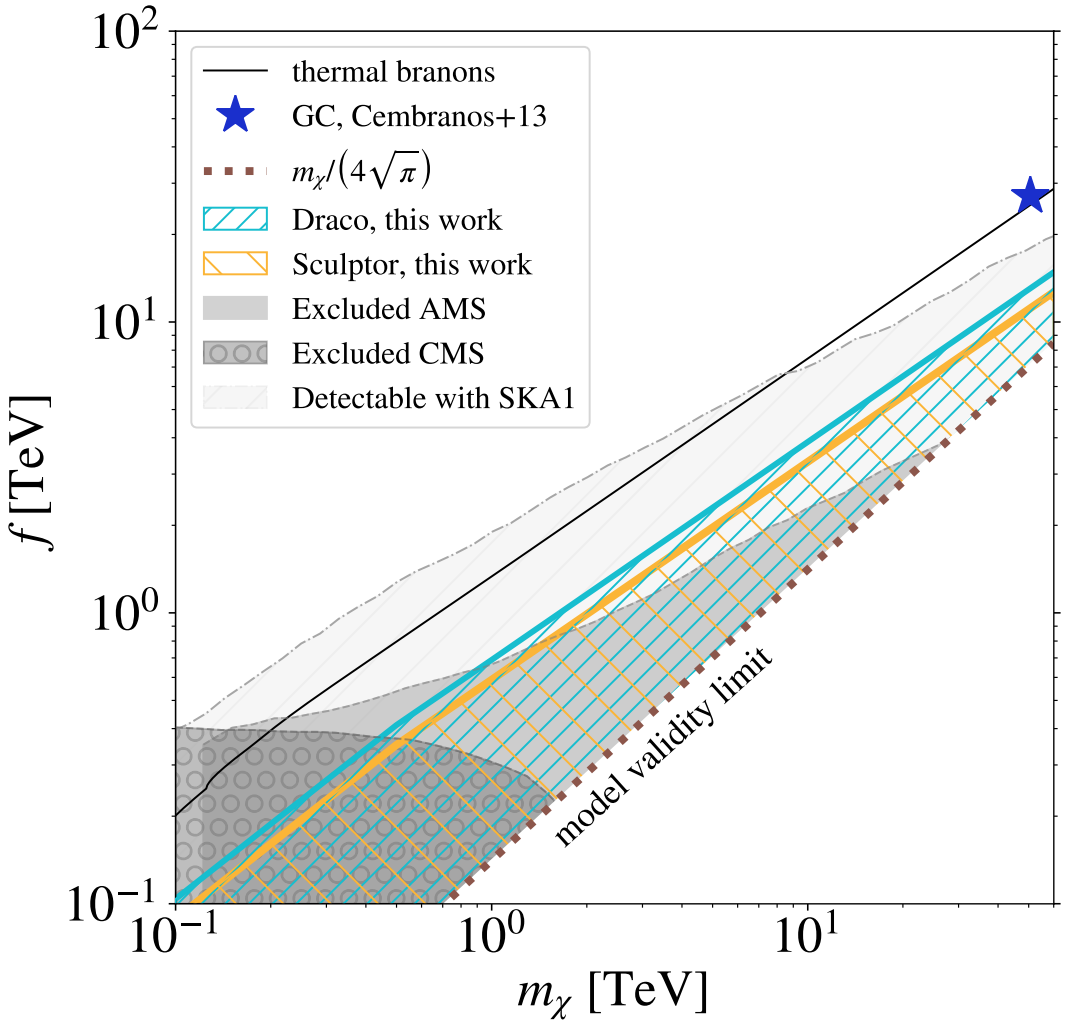
$\langle \sigma v \rangle$ values for detection

upper limits for $\langle \sigma v \rangle$

blue dash-dotted: W^+W^-, 500h, older IRFs [Carr+15]

Results

Brane tension as a function of the branon mass



large region of the mass-tension parameter space excluded, expanding previous results from other experiments and messengers

Conclusions

- Branons are good TeV DM candidates
- CTA has superb capabilities to probe these models
- Dwarfs are one of the best targets to test branons
- Competitive results, compatible with current predictions for generic WIMPs
- Significant portion of the mass-tension parameter space will be excluded

Thank you!