CTA Dark Matter Group Update

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Papers in preparation:

- Dark matter limits from the Inner galaxy (KSP)
- Dwarf spheroidal galaxies (KSP)
- Dark Matter in the Large Magellanic Cloud
- Dark Matter in Clusters of Galaxies
- EBL / ALP / LIV / IGMF publication (inter-groups)

CTA DM 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

First 3 years

- The principal target is the Galactic Center Halo (most intense diffuse emission regions removed)
- Best dSph as “cleaner” environment for cross-checks and verification (if hint of strong signal)

Next 7 years

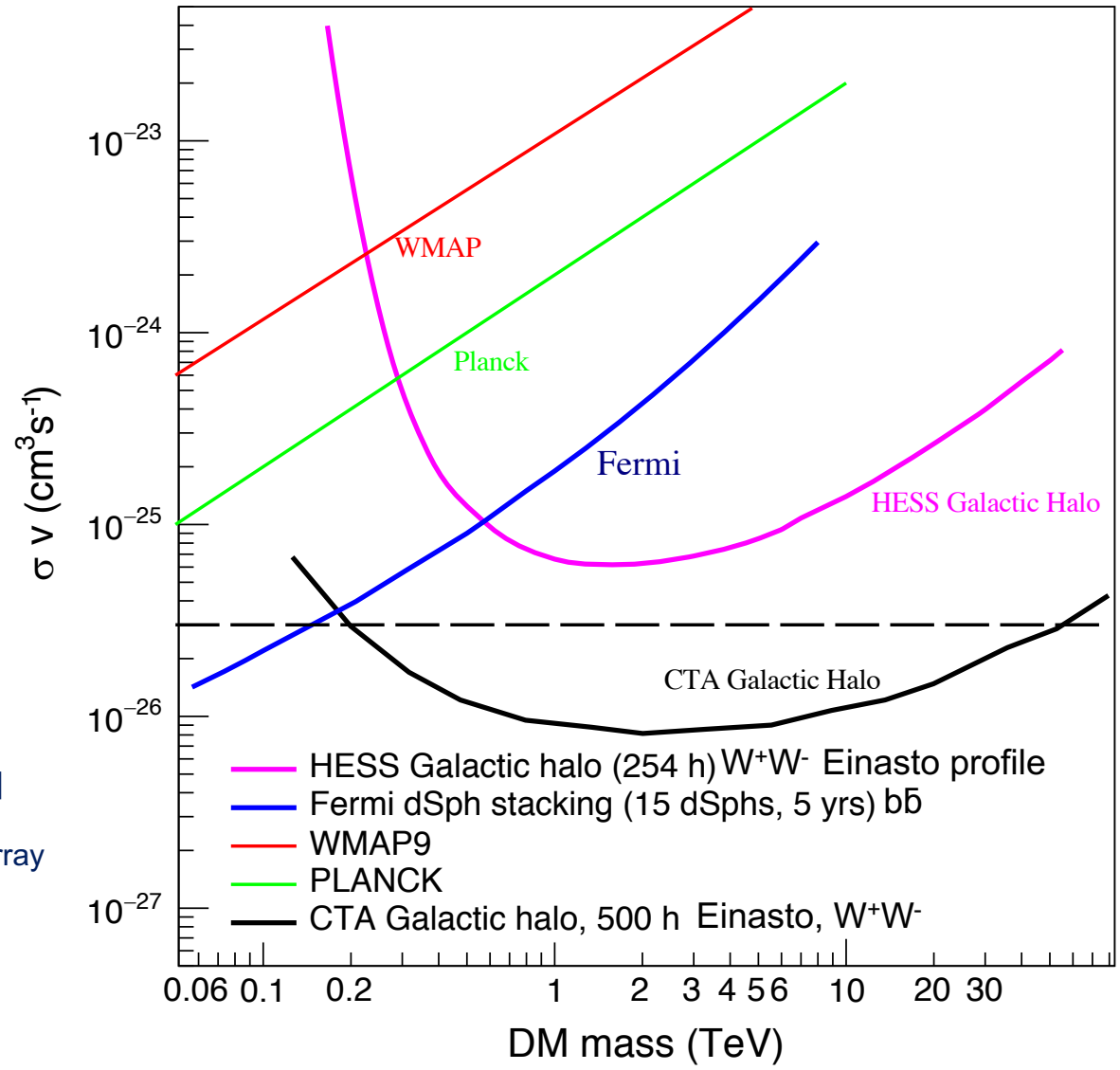
- If there is detection in GC halo data set (525h)
  - Strong signal: continue with GC halo in parallel with best dSph to provide robust detection
  - Weak signal: focus on GC focus to increase data set until systematic errors can be kept under control
- If no detection in GC halo data set
  - Focus observation on the best target at that time to produce legacy limits.

CTA, HESS, FERMI, PLANK DM upper-limits

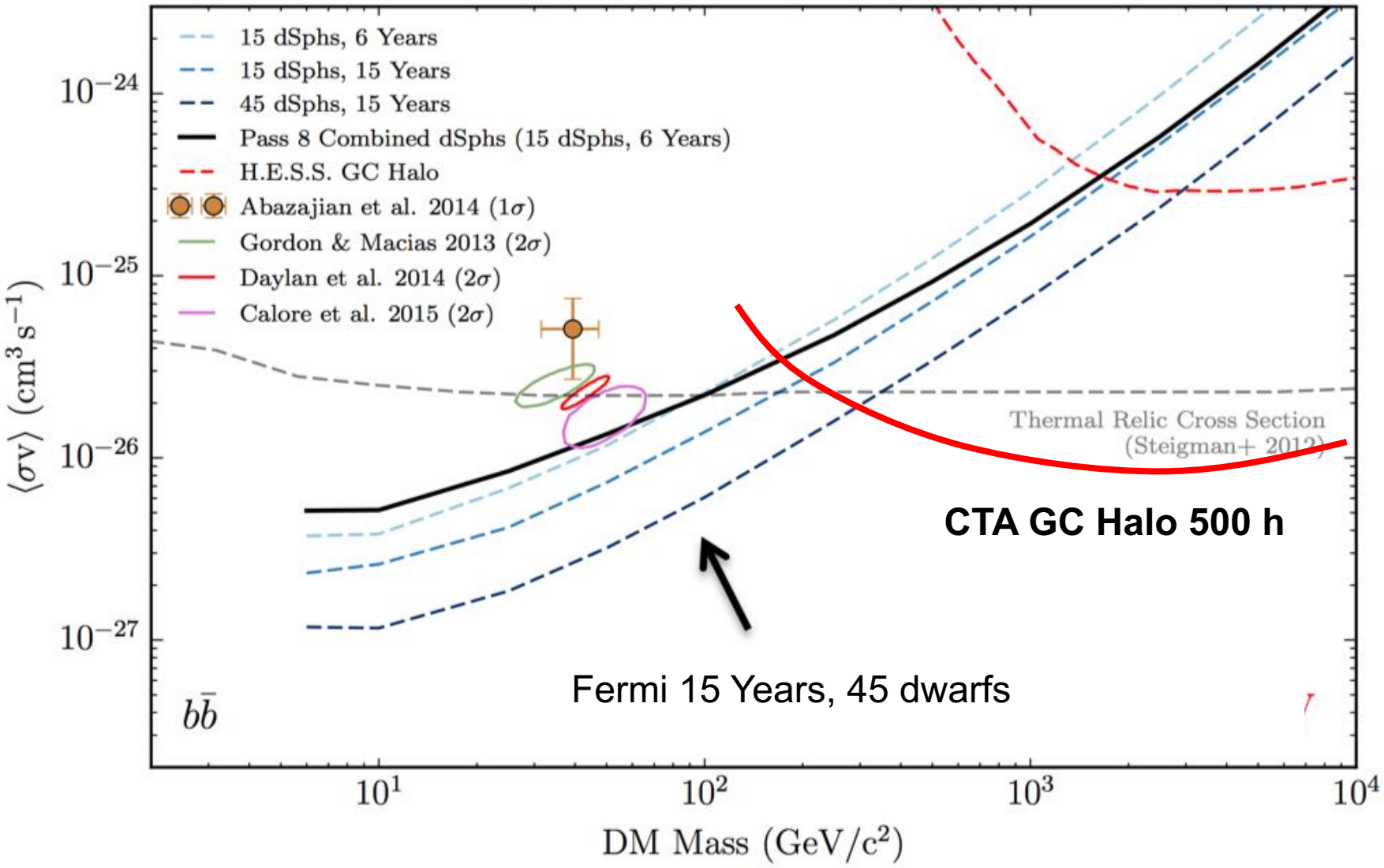
Together Fermi and CTA will probe most of the space of WIMP models with thermal relic annihilation cross section
The expectation for CTA is for the Einasto profile and is optimistic as includes only statistical errors.
The effect of the Galactic diffuse emission can affect the results by ~ 50%

The Dark Matter Programme of the Cherenkov Telescope Array
PoS(ICRC2017)921 [arXiv:1709.01483]

Science with the Cherenkov Telescope Array
arXiv:1709.07997v2

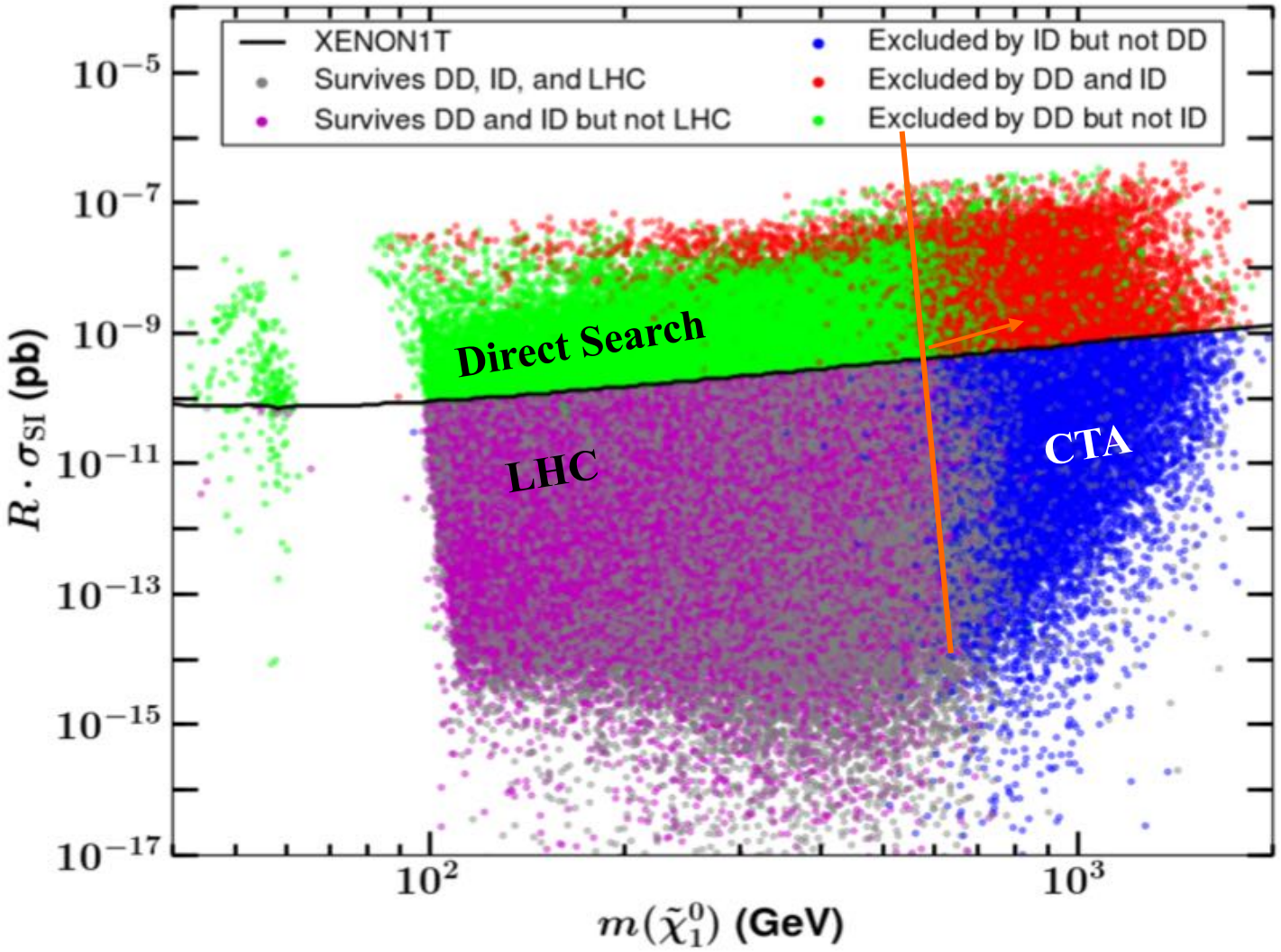


DM limit improvement estimate in 15 years (2008- 2023)



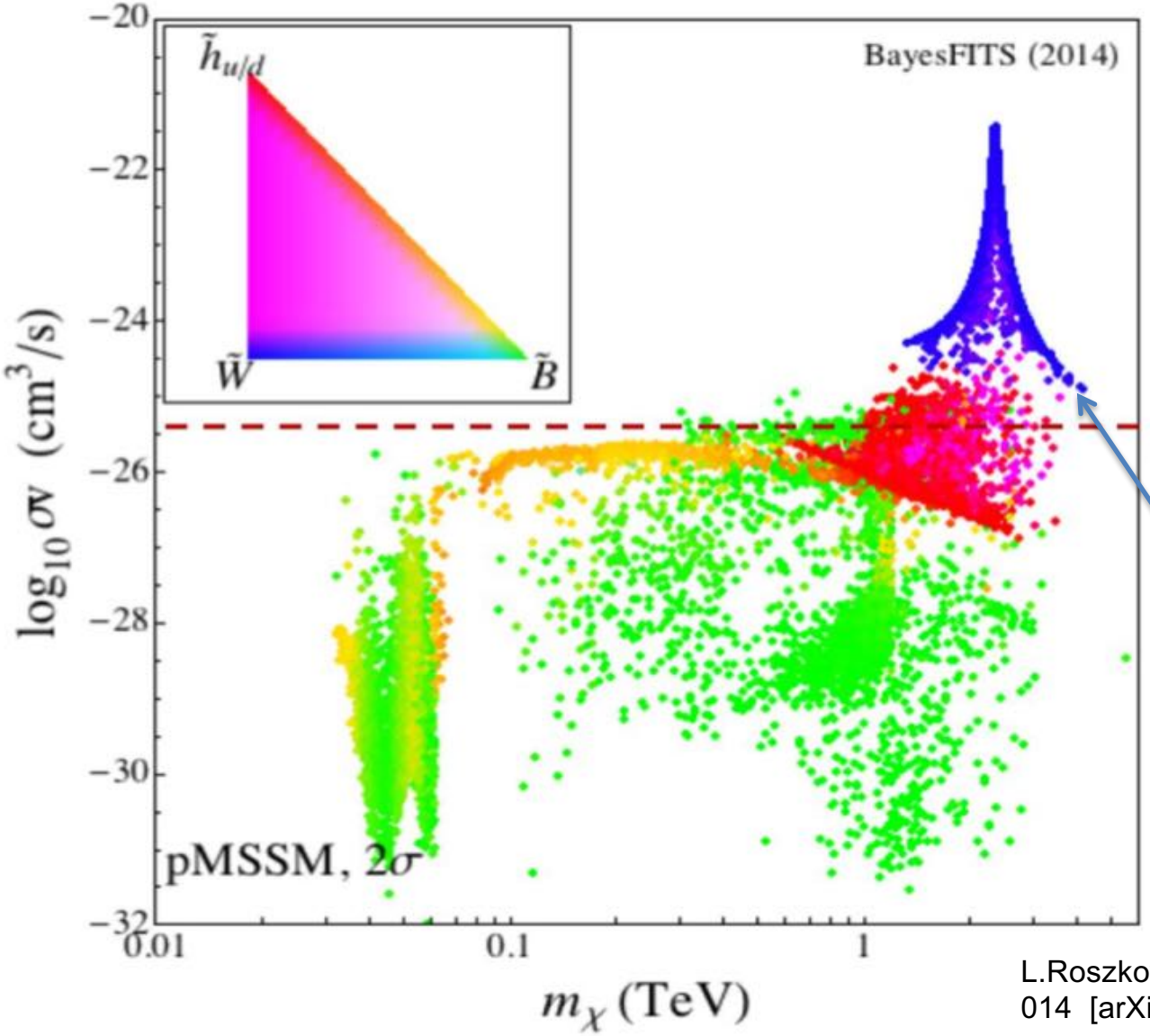
Together Fermi and CTA will probe most of the space of WIMP models with thermal relic annihilation cross section

Complementarity and Searches for Dark Matter in the pMSSM



Cahill-Rowley et al. arXiv:1305.6921

note:the "thermal" cross section is only a reference value. The real cross section can be higher or lower



Example: Annihilation cross-section points from a 19 dimensional pMSSM fit

Note that a strong enhancement of the annihilation cross section occurs for winos around 2-3 TeV due to Sommerfeld enhancement.

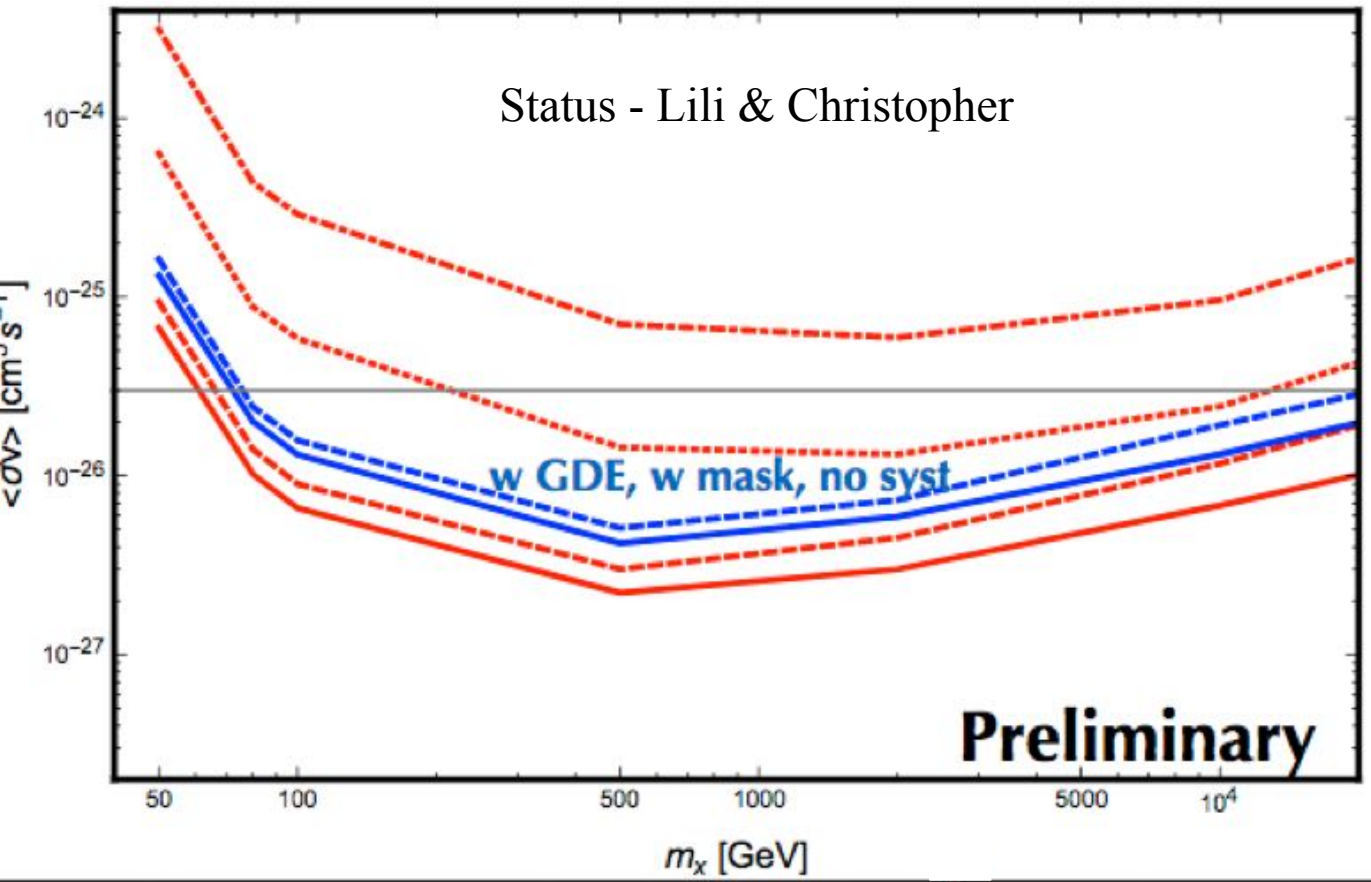
L.Roszkowski et al., JHEP 1502 (2015) 014 [arXiv:1411.5214]

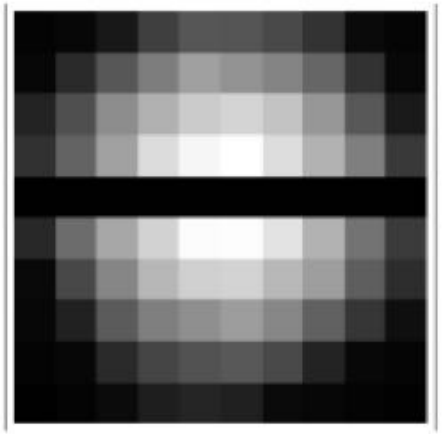
Dark matter limits: Inner galaxy

Einasto profile, WW channel, 500h

5deg ROI, 0.5 deg bins, no MASK, Single pointing

Status - Lili & Christopher





Without GDE

With GDE

With GDE, 1% systematic

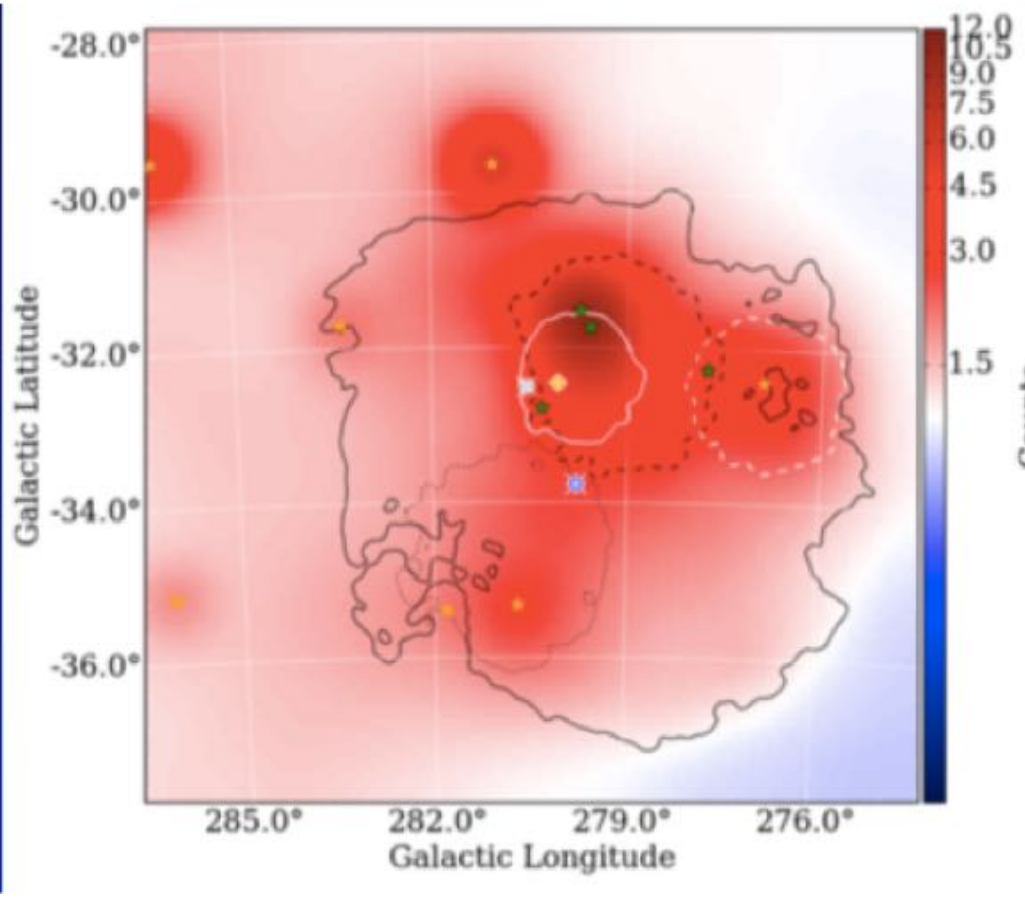
With GDE, 5% systematic

Without GDE, masking

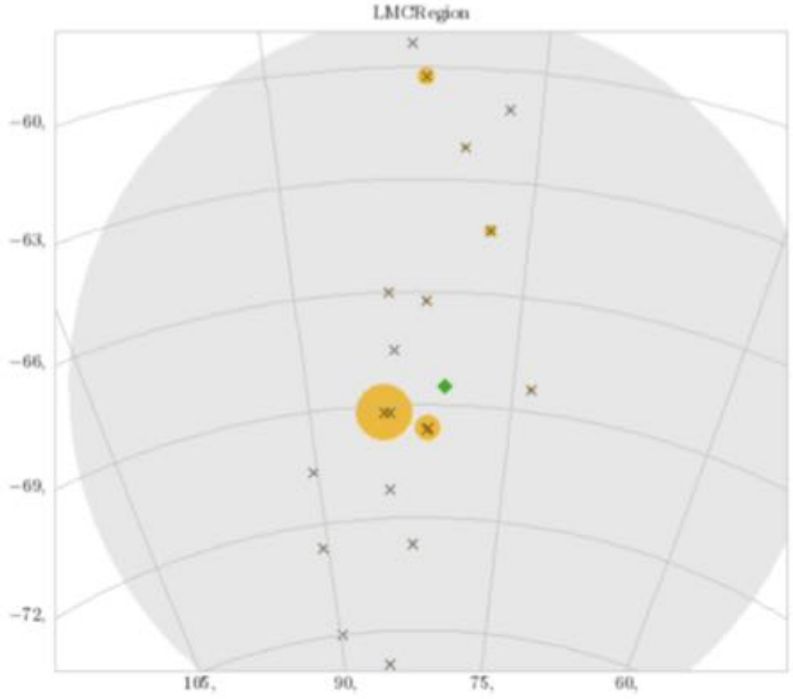
With GDE, masking

Dark matter limits: LMC

Astrophysical sources

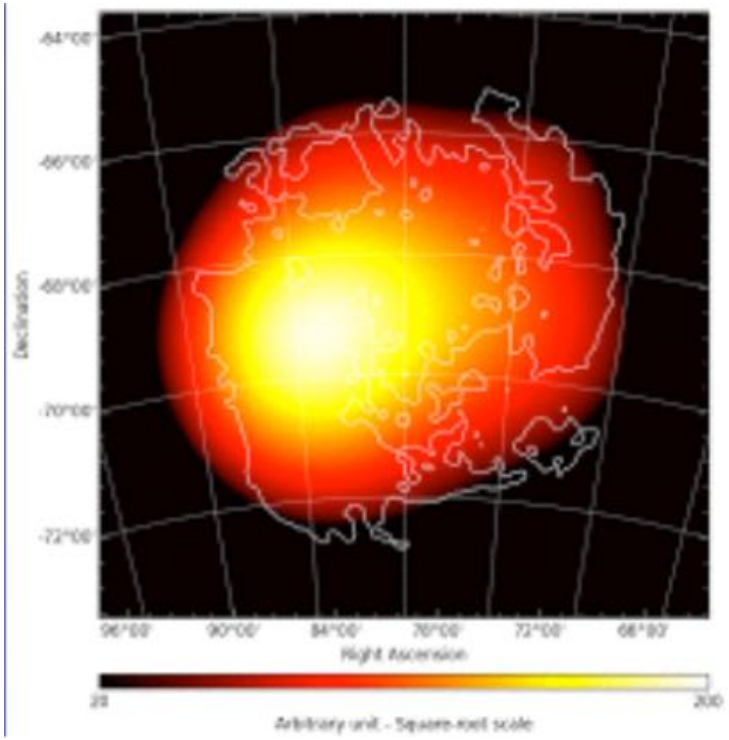


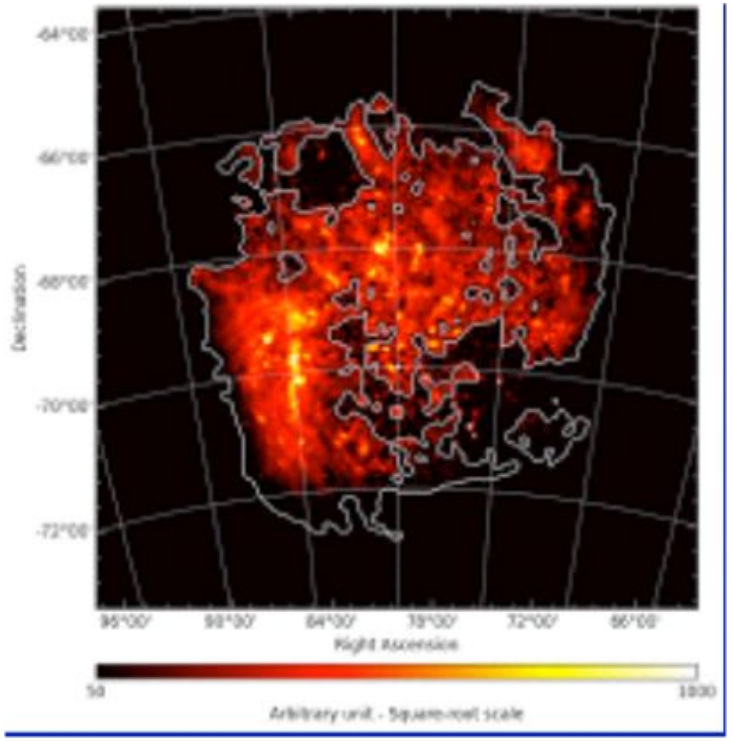
Right now:
16 point sources + 3 Extended



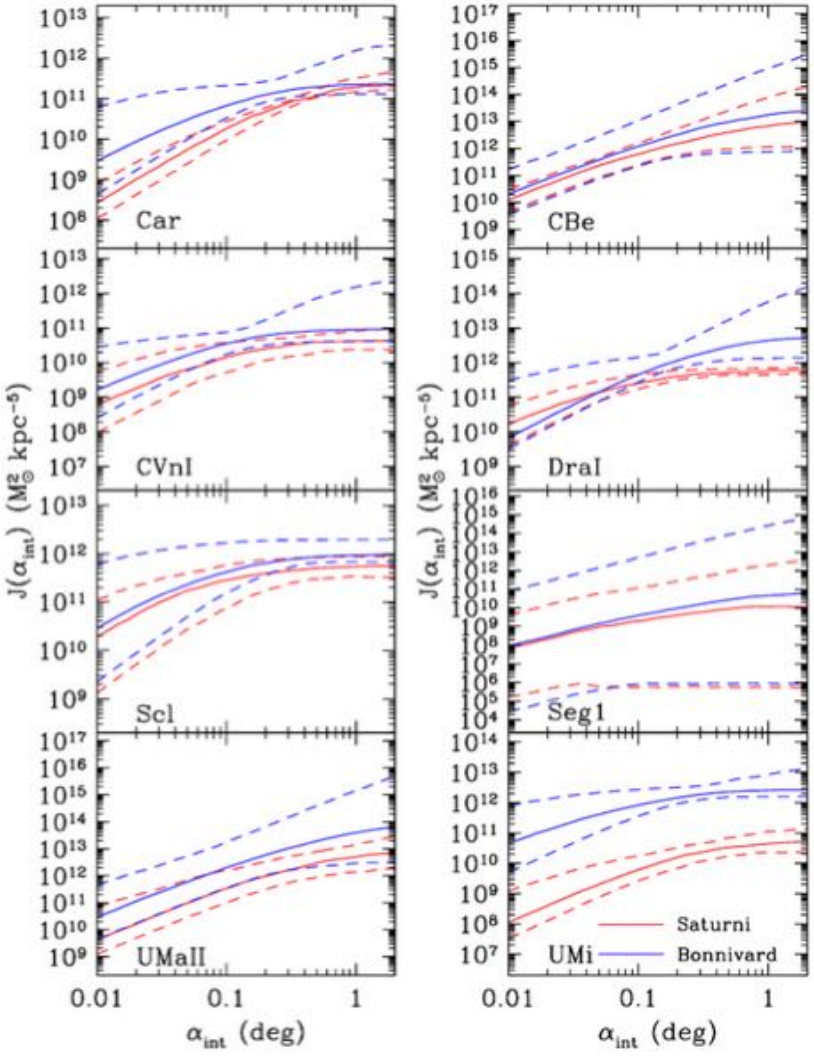
Dark matter limits: LMC

Leptonis and Hadronic Diffuse
(from Pierrick Martin)





Dark matter limits: Dwarf Sph Galaxies



(F.G. Saturni)
Use of Clumpy code to generate j-factor & D-factor

J/D-factor profiles for dSph are converging towards the results by Bonnivard+ 2015.

Cooperation with CLUMPY experts.

Dark matter limits: Dwarf Sph Galaxies

IRF: Prod3b:

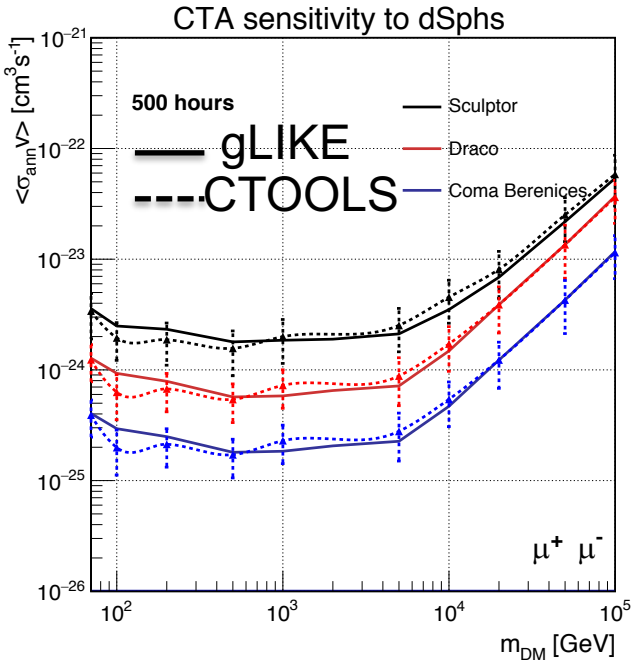
- South_z20_average_50h
- North_z20_average_50h

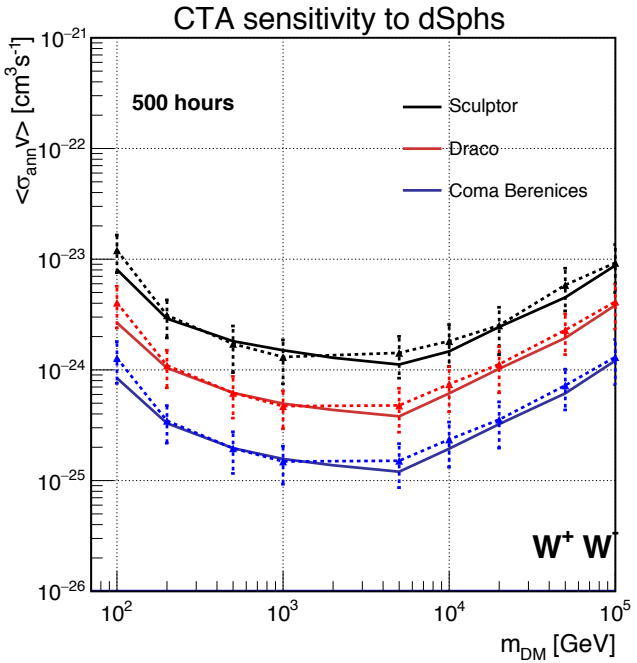
- Binned Poisson distribution

- DM spectra from Cirelli+

(http://www.marcocirelli.net/PPPC4DMID.html)

Cross check code:





Gonzalo

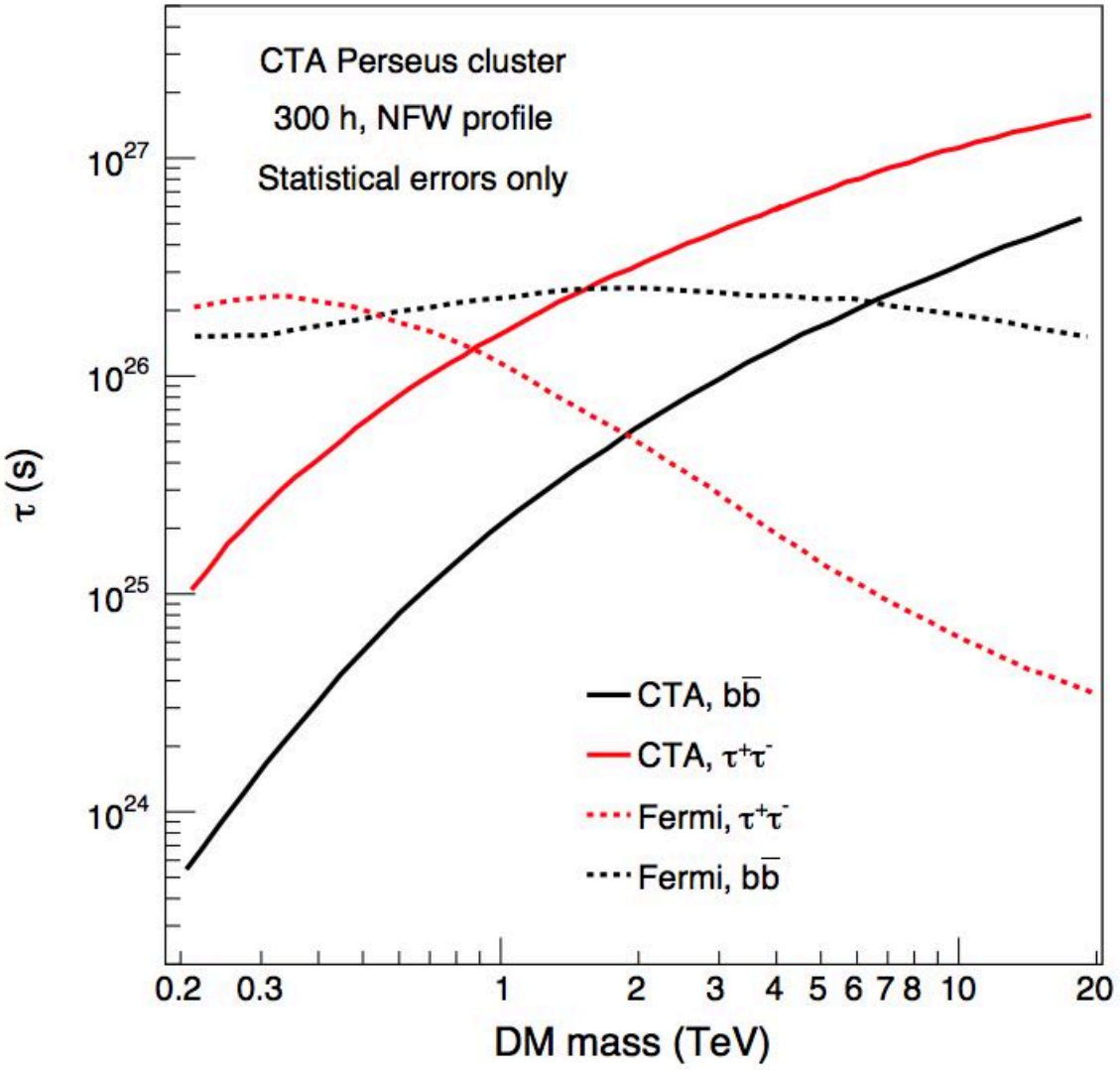
DM Programme Metrics

Dark matter and exotic physics	Reach in DM cross section (DM masse 0.5 TeV, bbar annihilation channel) with of 500 hr of observation of the Galacitc Center
	Reach in DM cross section (DM masse 0.5 TeV, bbar annihilation channel) with of 100 hr of observation of the Sculptor dwarf spheroidal galaxy

Threshold	Baseline	Threshold/Baseline
1.1E-25 (100 GeV), 2.2E-26 (500 GeV), 3.2E-26 (10 TeV)	1.6E-26 (100 GeV), 1.4E-26 (500 GeV), 2.6E-26 (10 TeV)	6.9 (100 GeV), 1.6 (500 GeV), 1.2 (10 TeV)
1.7E-22 (100 GeV), 2.0E-23 (500 GeV), 1.3E-23 (10 TeV)	3.8E-23 (100 GeV), 6.9E-24 (500 GeV), 8.1E-24 (10 TeV)	4.5 (100 GeV), 2.9 (500 GeV), 1.6 (10 TeV)

Perseus cluster

Expected CTA sensitivity to the dark matter decay lifetime for 300 h of observation of the Perseus cluster compared with the results from the Galactic Halo by Fermi



Contributo INFN :

Al momento Gonzalo, Michele e io sull'articolo delle Dwarfs
Gabi sull'inner galaxy

volunteers are welcome !!

backup

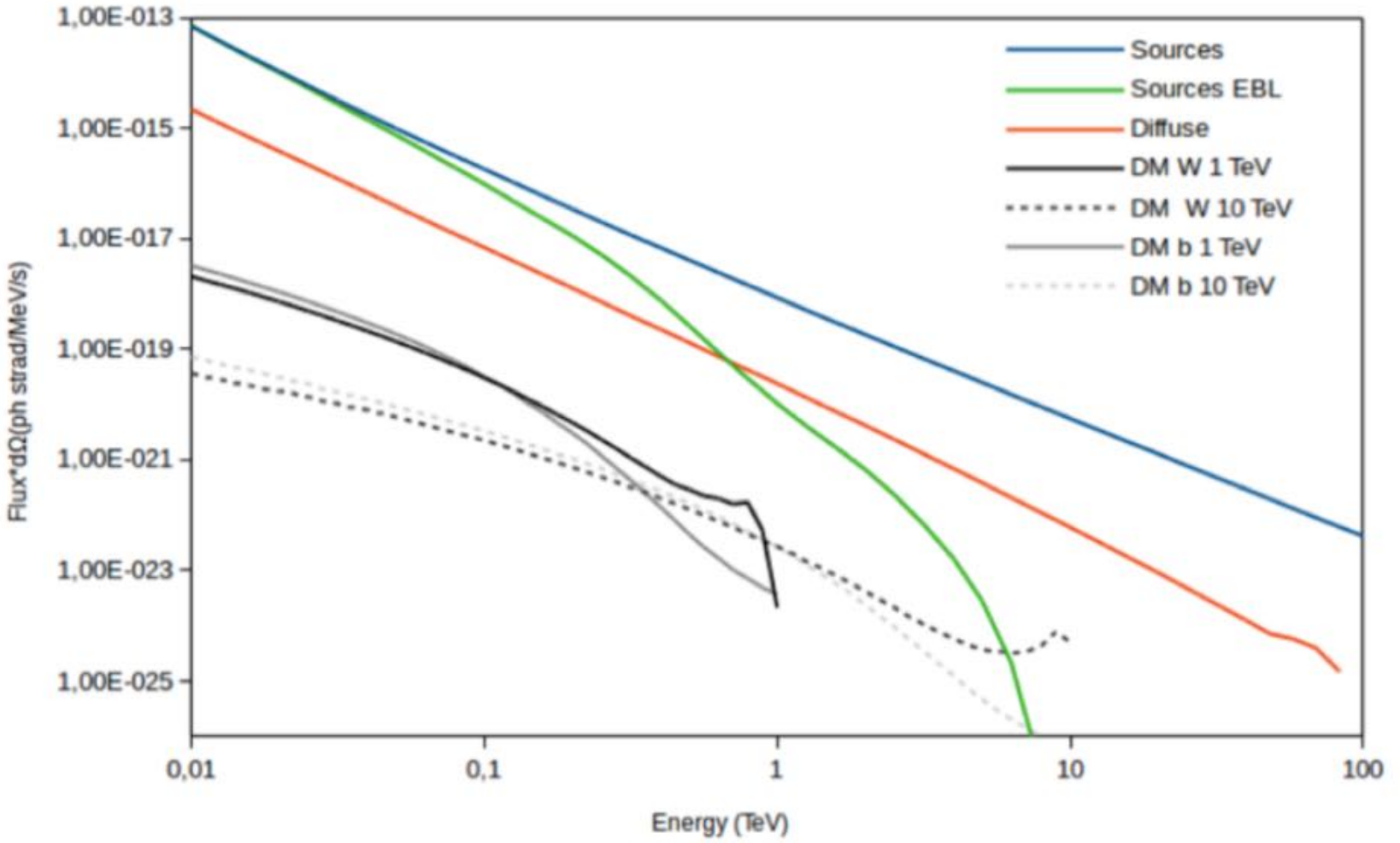
CTA CONTRIBUTION TO DM RESEARCH (SUMMARY)

- CTA has good prospects to probe for the first time WIMP models with thermal relic cross-section and masses above 200 GeV;
- Together with Fermi CTA will be able to exclude thermal WIMPs within the mass range from a few GeV up to a few tens of TeV.
- For heavy WIMPs (>TeV) CTA will provide unique observational data to probe parameter space not reachable by the other experiments.
- CTA is complementary instrument to LHC and direct DM searches probing some non-overlapping regions of DM particle parameter space.
- If DM is detected by CTA, it will also be possible to explore some properties of DM particle through the study of annihilation channels, etc.
- Control of systematics in deep observations of GC halo and dSph(s) is critical for the success of these studies and will require full knowledge of the instrumentation (hence CTA KSP)
- Better understanding of J factors is essential for interpretation of observational data and derivation of limits.

Dark matter limits: Inner galaxy

- Lili & Christopher (&Gabi): ctools for mock data and model bin counts predictions + 'off-line' likelihood fitting
- Anastasia (& Torsten): ctools binned counts + likelihood fitting
- Idea is to compare results, pro's and con's

Dark matter limits: LMC



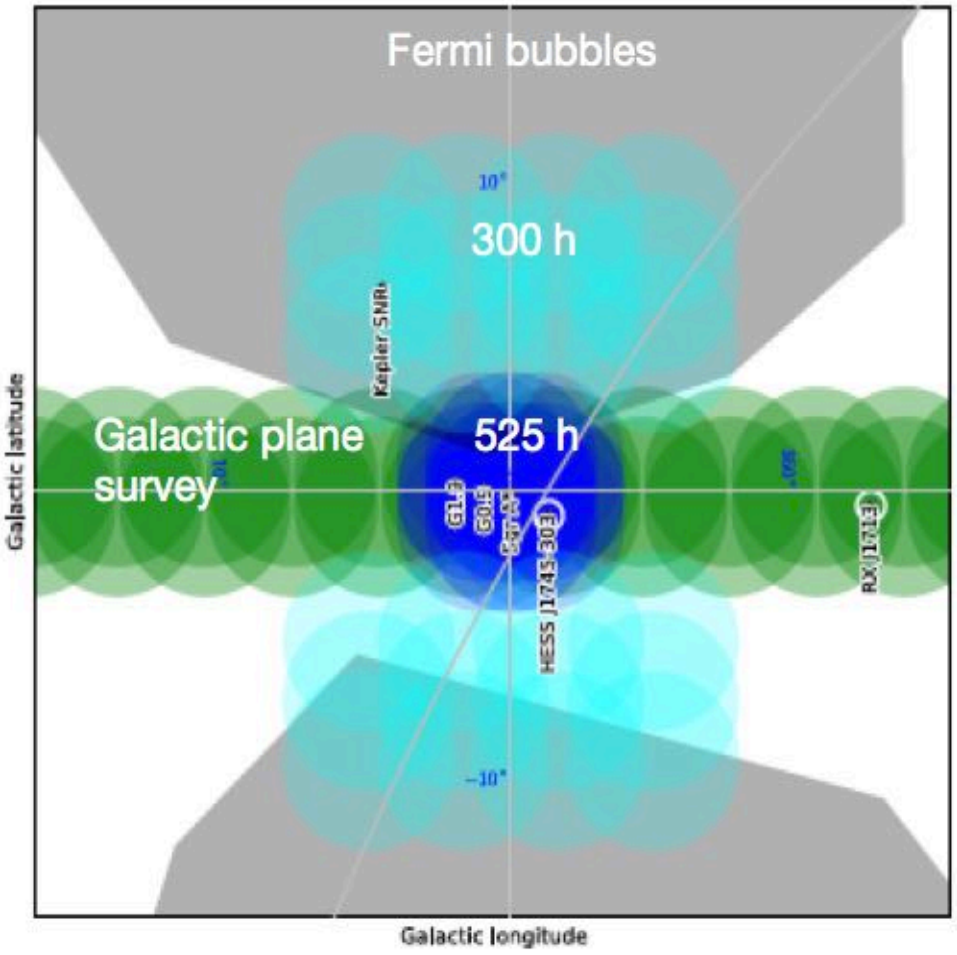
DEEP OBSERVATIONS OF GC REGION

Deep 525 h exposure in the inner 5° around Sgr A*;

Extended 300 h survey of 10°x10° region;

Produce CTA legacy data set for large range of scientific topics, which include

- GC and GC DM halo
- Understand "backgrounds" pin down VHE sources and map diffuse emission
- Astrophysics of SNRs (multiple sources, e.g. G1.9, …)
- Astrophysics of PWNe and Pulsars
- Extended objects such as Central Radio lobes (central ±1°) and arc features.



CTA legacy data set