IACTS AND DM SEARCHES

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What's next – DM 2014.03.20)

INDIRECT DETECTION PRESENT

- There are currently three large Imaging Cherenkov Telescopes (IACTs): HESS, MAGIC and VERITAS
  - Hess is in the S-hemisphere
  - Veritas, MAGIC are in the N-hemisphere
- 10 years of datataking show no hints of excess for any targets observed for DM searches (GC, dpsh, IMBHs, clusters, lines)

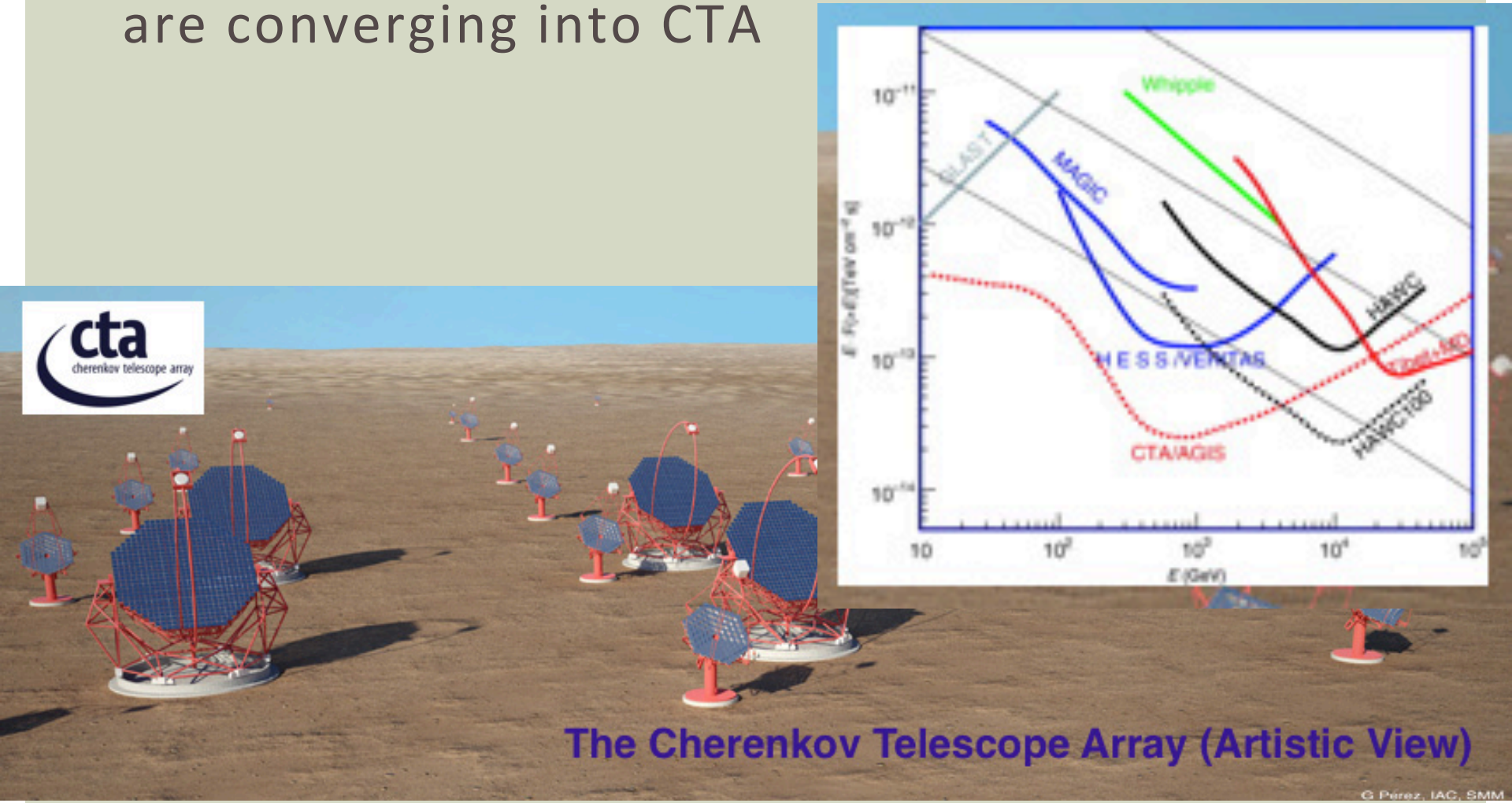
MD, NIM-A, in press

Target	Year	Time	Experiment	Ref.
Globular Clusters				
M15	2002	0.2	Whipple	[5]
	2006 – 2007	15.2	H.E.S.S.	[6]
M33	2002 – 2004	7.9	Whipple	[5]
M32	2004	6.9	Whipple	[5]
NGC 6388	2008 – 2009	27.2	H.E.S.S.	[6]
Dwarf Satellite Galaxies				
Draco	2003	7.4	Whipple	[5]
	2007	7.8	MAGIC	[7]
	2007	18.4	VERITAS	[8]
Ursa Minor	2003	7.9	Vhipple	[5]
	2007	18.9	VERITAS	[8]
Sagittarius	2006	11	H.E.S.S.	[9]
Canis Major	2006	9.6	H.E.S.S.	[10]
Willman 1	2007 – 2008	13.7	VERITAS	[8]
	2008	15.5	MAGIC	[11]
Sculptor	2008	11.8	H.E.S.S.	[12]
Carina	2008 – 2009	14.8	H.E.S.S.	[12]
Segue 1	2008 – 2009	29.4	MAGIC	[13]
	2010 – 2011	48	VERITAS	[14]
	2010 – 2013	158	MAGIC	[15]
Boötes	2009	14.3	VERITAS	[8]
Galaxy Clusters				
Abell 2029	2003 – 2004	6	Whipple	[16]
Perseus	2004 – 2005	13.5	Whipple	[16]
	2008	24.4	MAGIC	[17]
Fornax	2005	14.5	H.E.S.S.	[18]
Coma	2008	18.6	VERITAS	[19]
The Milky Way central region				
MW Center	2004	48.7	H.E.S.S.	[20]
MW Center Halo	2004 – 2008	112	H.E.S.S.	[21]
Other searches				
IMBH	2004 – 2007	400	H.E.S.S.	[22]
	2006 – 2007	25	MAGIC	[23]
Lines	2004 – 2008	112	H.E.S.S.	[24]
	2010 – 2013	158	MAGIC	[15]
UFOs	–	–	MAGIC	[25]
	–	–	VERITAS	[26]
All-electron	2004 – 2007	239	H.E.S.S.	[27, 28]
	2009 – 2010	14	MAGIC	[29]
Moon-shadow	–	–	MAGIC	[30]

Table 2: Compound of observational targets for indirect dark matter searches with gamma rays from the Whipple, H.E.S.S., MAGIC and VERITAS experiments. In the second and third columns, the year and duration of observations (in hours) are given. In the last column, link to papers (or proceedings if papers were not available) are given.

CTA

- The HESS+MAGIC+VERITAS communities+ world are converging into CTA



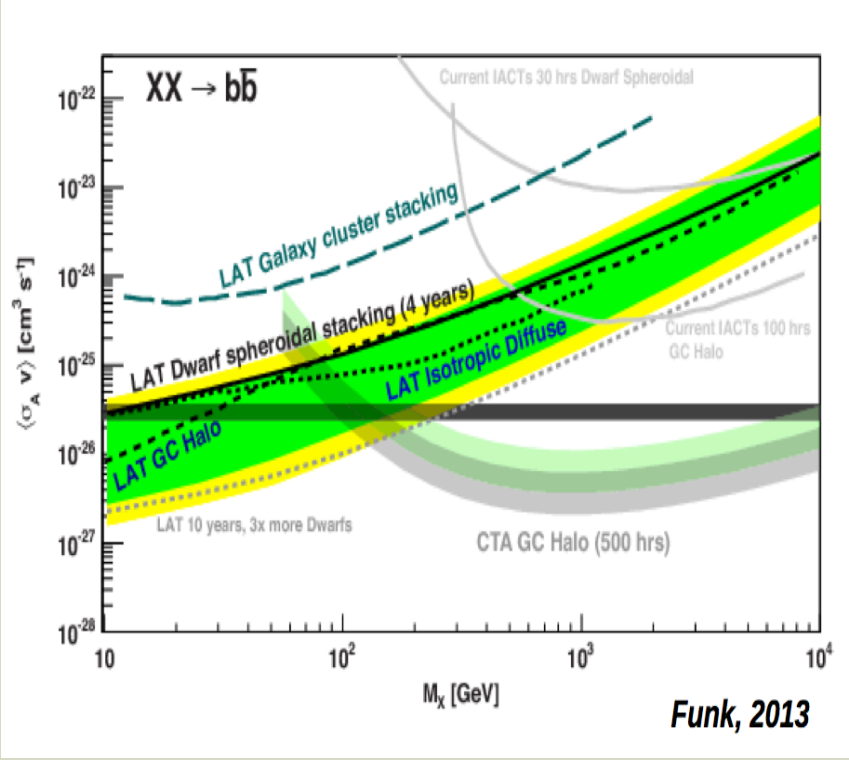
FEW INFO ON CTA

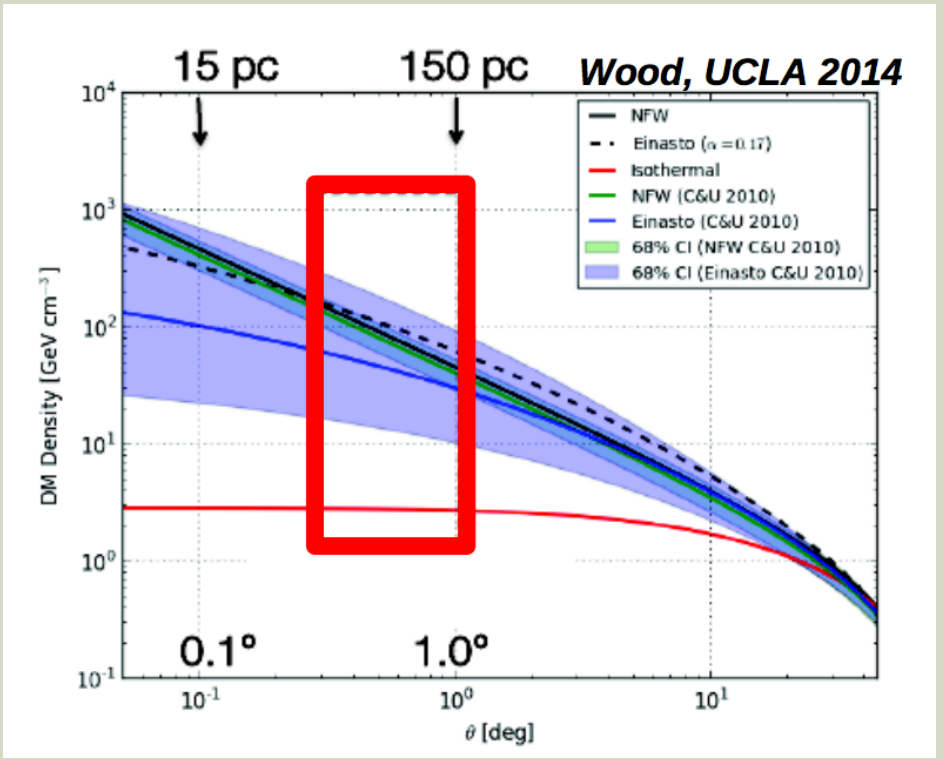
- 2 arrays:
  - South (Namibia, Argentina?),
  - North (Tenerife, USA, Mexico?)
- 1000+ scientists
- Construction 2016-2020?
- Observatory: guest observation time guaranteed and photons publicly available
- INFN is in RD phase now, possibly confirmed soon a project
  - SiPM camera, electronics, atmospheric calibration, ++

ARGUMENTS FOR DM SEARCHES WITH CTA

1. There is at least a part (for now) of the parameter space that can be curbed with CTA (DM at the GC-halo, see later)
2. In case LHC do not discover DM, also with full power, CTA has still chance
3. CTA can be the lonely player if DM is heavy (say few TeV) for 2020-2030.
4. Others can make detection of DM, but in case, CTA can make possibly make **identification:**
    1. Different DM targets should show same spectrum
    2. Universal DM spectrum
    3. Spectral features hints at DM mass and ann/dec channels

GALACTIC CENTER





- GALACTIC CENTER+GALACTIC HALO (300-500h) Very good prospects if:
  - Profile is **cusp,** i.e. baryons do not reduce the DM density
  - Possible problem with background systematics
  - If profile is core, needs to devise new obs. strategy

TARGETS

- DSPH (100 h per year in 5 years on few of the best targets)
  - There can be new dsphs with larger expected flux
  - Cleanest from astrophysical sources and less background systematics
  - There will be news in the future before CTA era
  - Drawback: we could be shooting in the dark, unless we consider
- Dark clumps.
  - There can be the possibility that also dark clumps exist closeby, at the end, they are predicted by N-body simulations

DWARFS AND DARK CLUMPS

- New experiments will surely detect new dsphs (and better constraints known): DES and LSST
- Dark clumps should exist!

H. Zechlin (very very preliminary)

WIMP		Benchmark DM subhalo (M, D, θ_{68})					
		$10^5\,M_\odot$, 1.0 kpc, 0.31°			$10^6\,M_\odot$, 2.0 kpc, 0.37°		
$\chi\chi$ ↓	$m_{\rm dm}$ [TeV]	$\langle\sigma v\rangle/\langle\sigma v\rangle_{\rm th}$	$\phi_{\rm HE}$ [cm^{-2}s^{-1}]	$\phi_{\rm VHE}$ [Crab]	$\langle\sigma v\rangle/\langle\sigma v\rangle_{\rm th}$	$\phi_{\rm HE}$ [cm^{-2}s^{-1}]	$\phi_{\rm VHE}$ [Crab]
$b\bar{b}$	0.5	$19_{97} \leftrightarrow 345_{1723}$	$1.5_{7.7} \times 10^{-10}$	$0.1\%_{0.5\%}$	$12_{59} \leftrightarrow 208_{1042}$	$1.8_{8.8} \times 10^{-10}$	$0.1\%_{0.5\%}$
	1	$14_{58} \leftrightarrow 240_{1028}$	$5.0_{22} \times 10^{-11}$	$0.1\%_{0.5\%}$	$7_{35} \leftrightarrow 128_{622}$	$5.0_{25} \times 10^{-11}$	$0.1\%_{0.5\%}$
	5	$21_{107} \leftrightarrow 377_{1887}$	$9.1_{45} \times 10^{-12}$	$0.1\%_{0.5\%}$	$13_{65} \leftrightarrow 228_{1141}$	$1.0_{5.2} \times 10^{-11}$	$0.1\%_{0.5\%}$
$\tau\bar{\tau}$	0.5	$3_{13} \leftrightarrow 46_{229}$	$6.1_{30} \times 10^{-12}$	$0.1\%_{0.5\%}$	$2_{8} \leftrightarrow 28_{138}$	$6.9_{35} \times 10^{-12}$	$0.1\%_{0.5\%}$
	1	$5_{25} \leftrightarrow 90_{451}$	$3.3_{17} \times 10^{-12}$	$0.1\%_{0.5\%}$	$3_{16} \leftrightarrow 55_{273}$	$3.8_{19} \times 10^{-12}$	$0.1\%_{0.5\%}$
	5	$65_{323} \leftrightarrow 1143_{5715}$	$1.5_{7.5} \times 10^{-12}$	$0.1\%_{0.5\%}$	$39_{197} \leftrightarrow 691_{3455}$	$1.7_{8.5} \times 10^{-12}$	$0.1\%_{0.5\%}$

		$N(\Delta M, \lvert b\rvert \geq 20°)$					
Survey [Crab]	Boost $\langle\sigma v\rangle/\langle\sigma v\rangle_{\rm th}$	$\chi\chi \to b\bar{b}$ 0.5 TeV	$\chi\chi \to b\bar{b}$ 1.0 TeV	$\chi\chi \to b\bar{b}$ 5.0 TeV	$\chi\chi \to \tau\bar{\tau}$ 0.5 TeV	$\chi\chi \to \tau\bar{\tau}$ 1.0 TeV	$\chi\chi \to \tau\bar{\tau}$ 5.0 TeV
0.5%	≤ 10	0.003	0.010	0.003	0.141	0.045	0.0002
	≤ 100	0.220	0.472	0.191	3.45	1.46	0.03

Preliminary
Courtesy of M. Fornasa

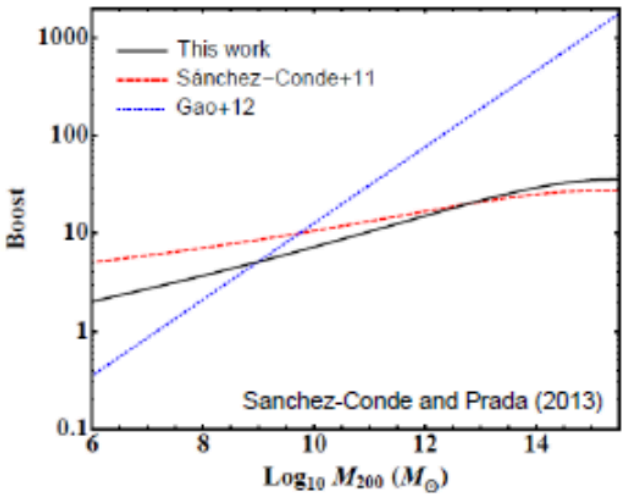
Galaxy clusters

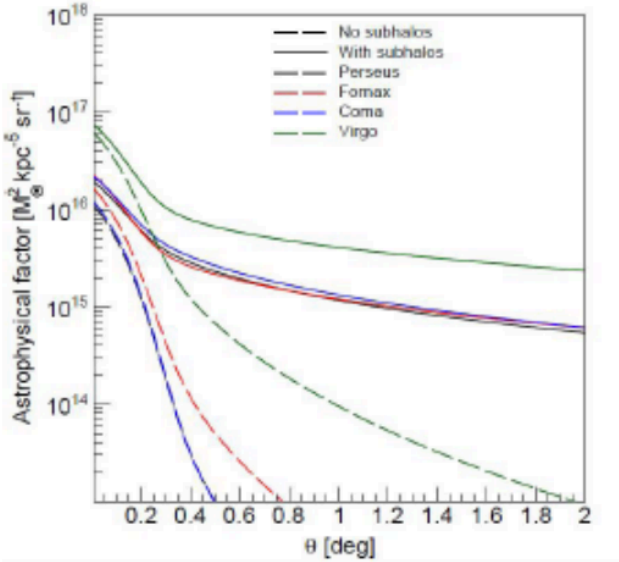
Clusters are good targets for indirect detection of DM

- X-ray and gravitational lensing provide good measurement of their mass
- huge DM content
- subhalo boost can be quite large
- they can be quite extended in the sky

Main challenges from the observation of clusters

- distinguish a DM signal from astrophysical background (CR-induced or individual sources)
- Uncertainties in modeling the subhalos





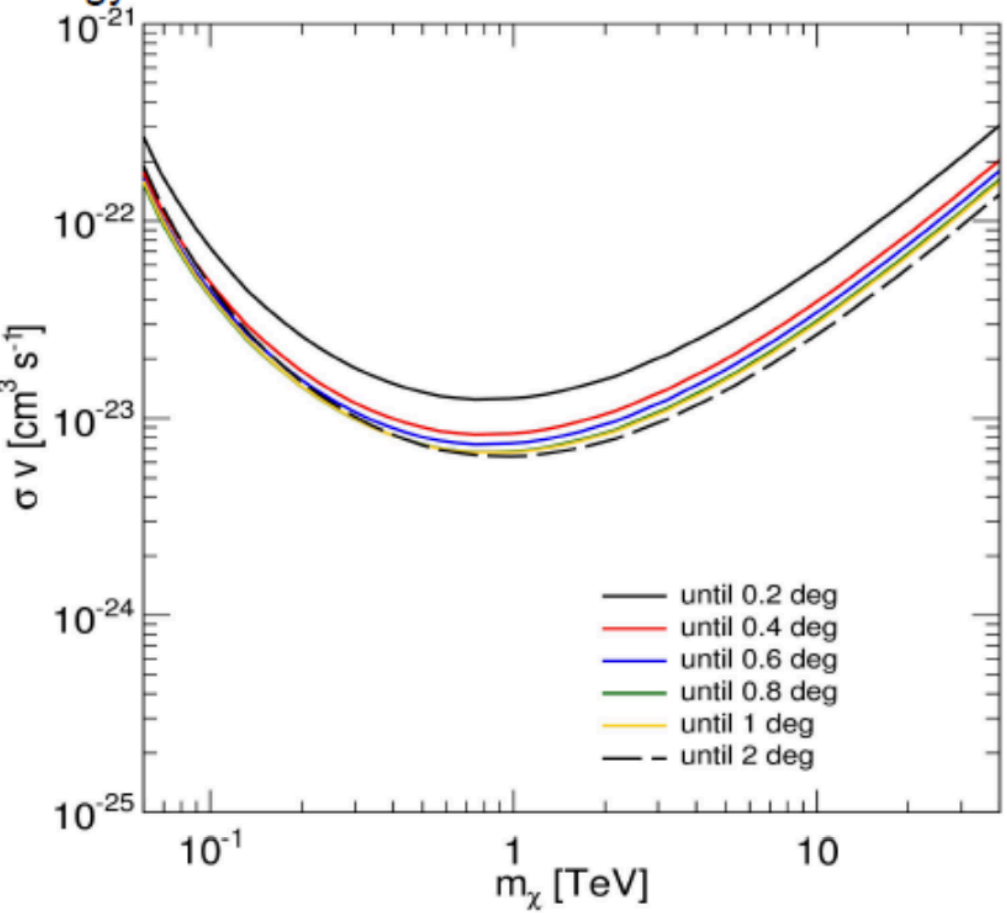
Boost factors:
- Virgo: 33
- Perseus: 32
- Coma: 33
- Fornax: 30

Upper limits for Fornax

Preliminary
Courtesy of M. Fornasa

- SubarrayB_IFAE_50hours_09052011_offaxis.root
- 500 hours
- Taking into account the dependence of the telescope performance on the off-axis angle
- UL computed with Rolke method
- Fixed energy threshold of 50 GeV

Fornax



CONCLUSIONS

- CTA could be a lone player in 2020-2030
- Still chance if DM mass is heavy
- Not possible to say now whether GC is better than dsph but for sure new results will clarify before CTA comes
- Important news before 2020 though (LHC, direct, dpsh-discovery)

THINGS TO BE DONE

1. Investigate dark clumps/dsph
2. Preciser profile at Galactic Center
3. Investigate how populated are parameters spaces for DM at the TeV ← input?
4. Think free: can we envisage to upgrade planned experiments or design new experiments for indirect DM detection at the TeV?
   - High sensitivity
   - Extremely good energy resolution
   - Maybe simplify design to track only few targets?