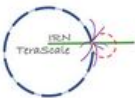


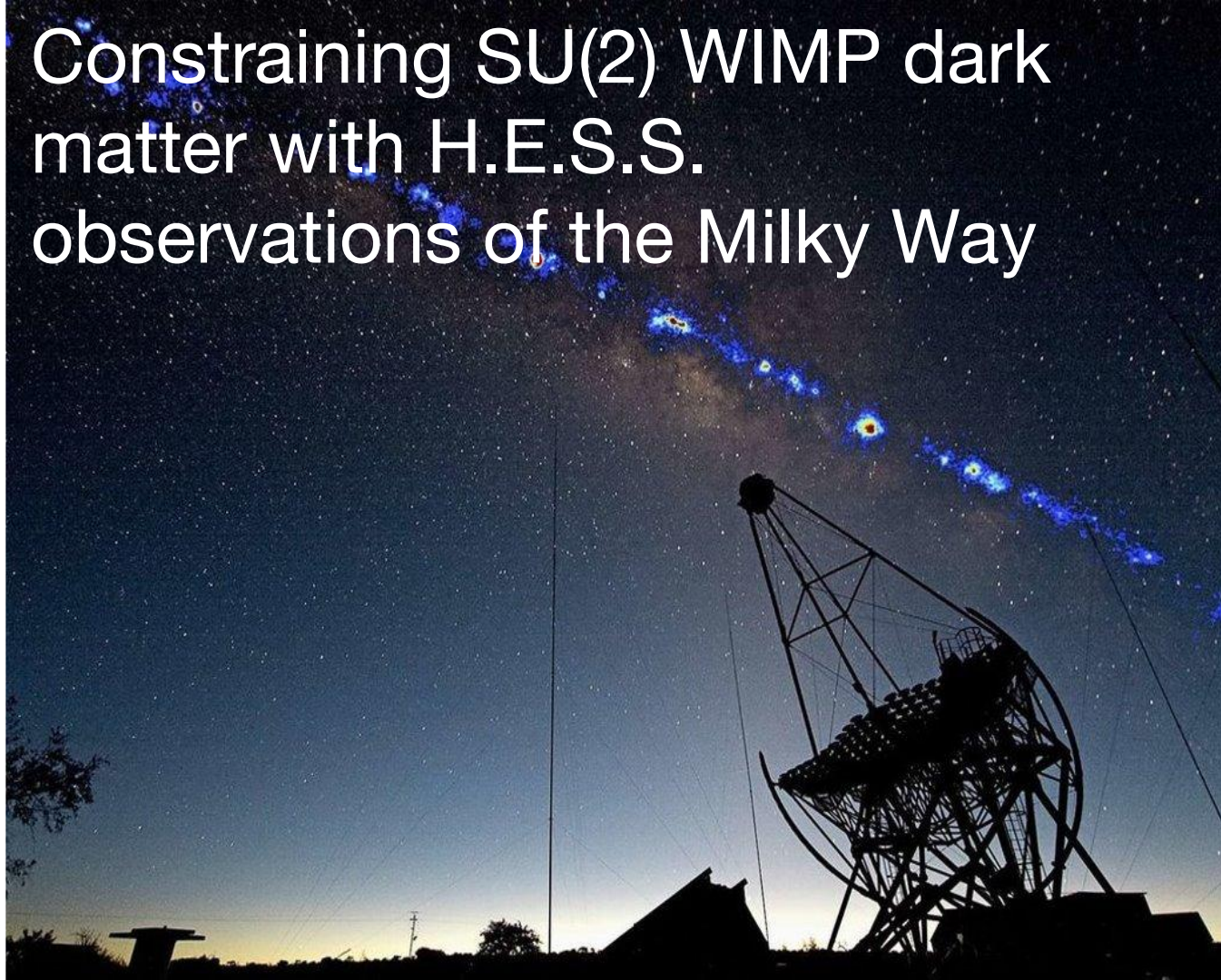
Alessandro Montanari
montanari@llr.in2p3.fr

Laboratoire Leprince-Ringuet,
École polytechnique

IRN Terascale,
Dark Universe session
22 April 2026



Constraining SU(2) WIMP dark matter with H.E.S.S. observations of the Milky Way



IMAGING ATMOSPHERIC CHERENKOV TELESCOPES

Inside the light pool to detect the Cherenkov flashes of light:

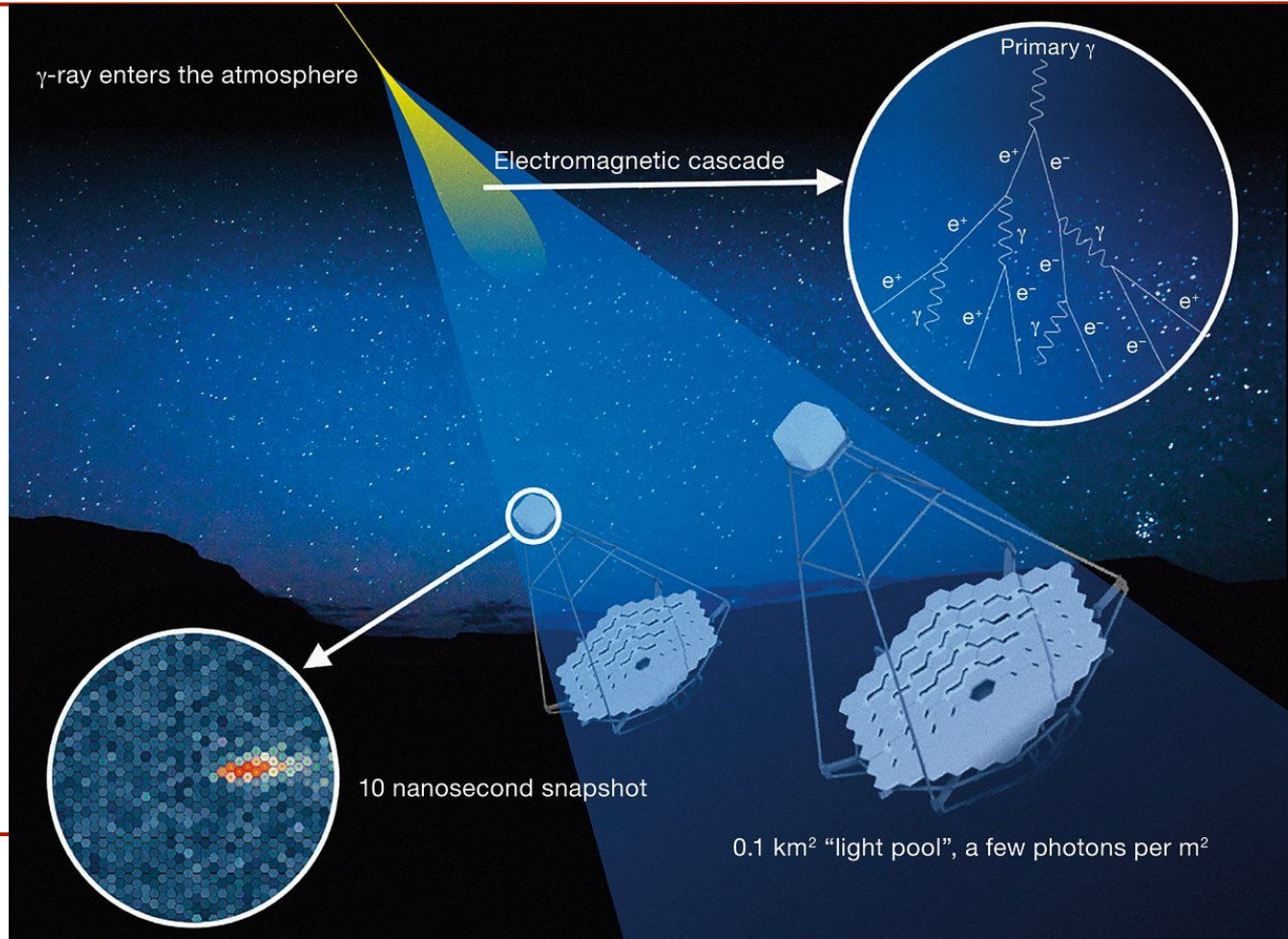
- peak in the blue/ultraviolet ($\lambda \sim 300 - 600 \text{ nm}$)

Now:

H.E.S.S., MAGIC, VERITAS

Future:

Cherenkov Telescope Array Observatory

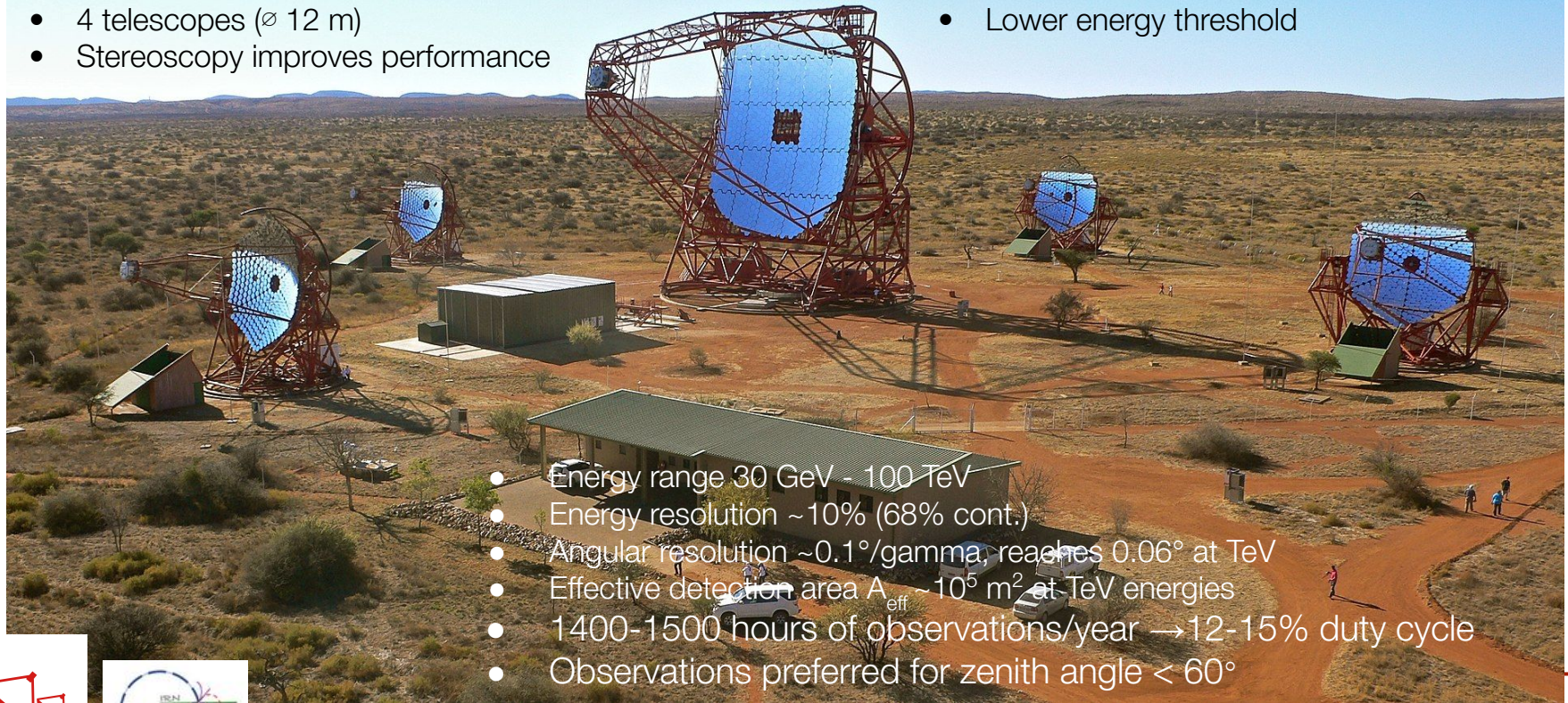


HESS I (since 2003):

- 1800 m a.s.l.
- 4 telescopes (\varnothing 12 m)
- Stereoscopy improves performance

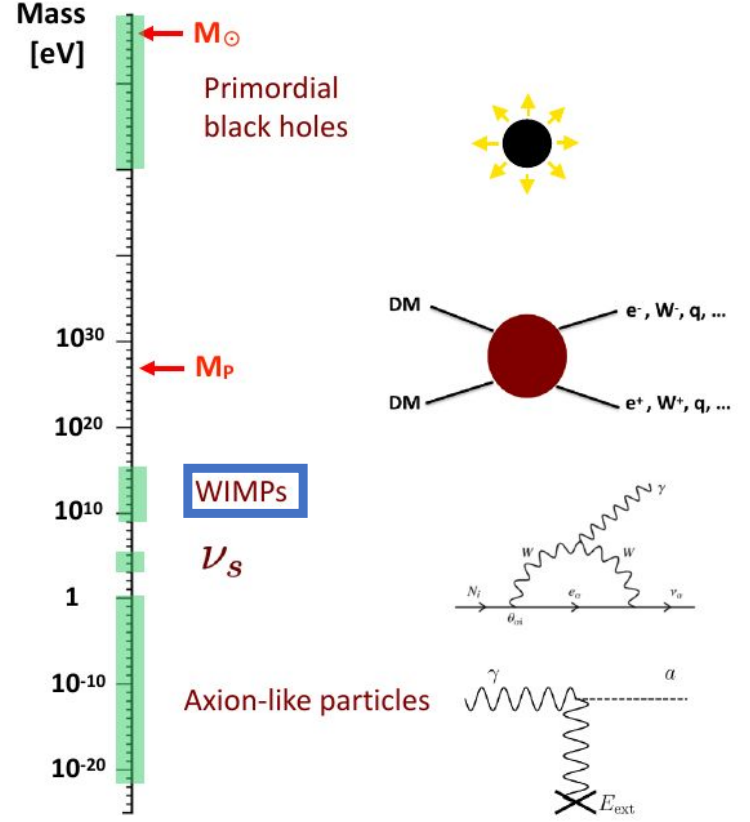
HESS II (since 2012):

- 5th larger telescope (\varnothing 28 m)
- Lower energy threshold



DARK MATTER CANDIDATES

- Cold Dark Matter paradigm
- Considering Weakly Interacting Massive Particles (WIMPs)



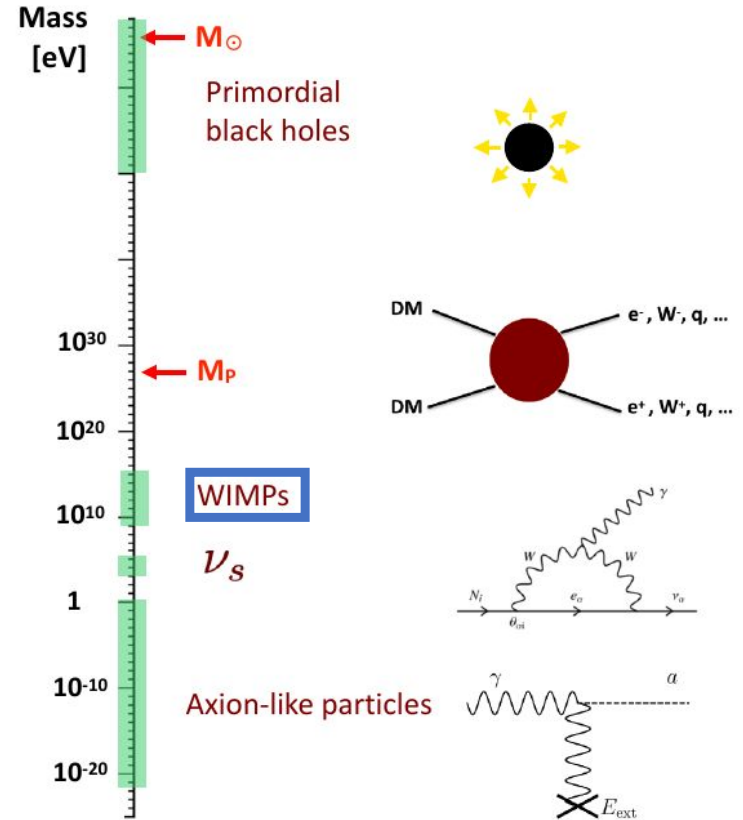
DARK MATTER CANDIDATES

- Cold Dark Matter paradigm
- Considering Weakly Interacting Massive Particles (WIMPs)
- Weak interaction mass scale and ordinary gauge couplings → right relic DM density with no fine-tuning

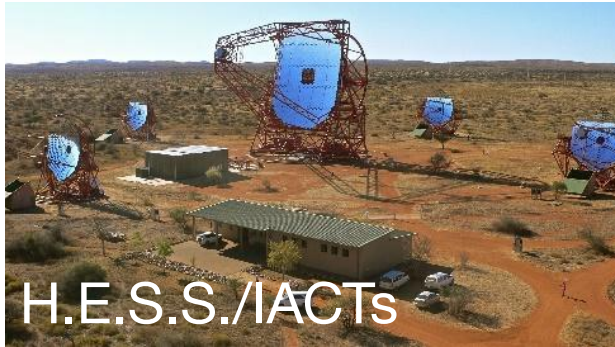
$$\Omega_{\text{DM}} h^2 = \frac{3 \times 10^{-27} \text{cm}^3 \text{s}^{-1}}{\langle \sigma v \rangle}$$

$$\langle \sigma v \rangle_W \sim \frac{\alpha^2}{m_{\text{WIMP}}^2} \sim 3 \times 10^{-26} \text{cm}^3 \text{s}^{-1}$$

- Mass scale at GeV-TeV
- **Benchmark for DM (indirect) detection: thermally produced WIMPs**



DARK MATTER DETECTION TECHNIQUES

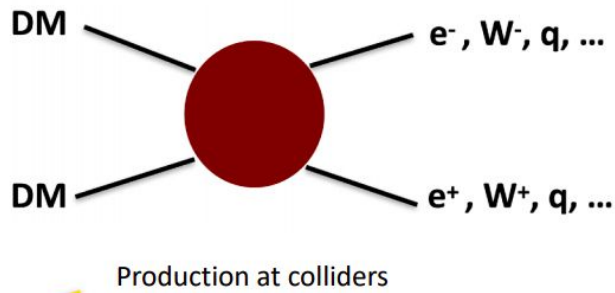


H.E.S.S./IACTs

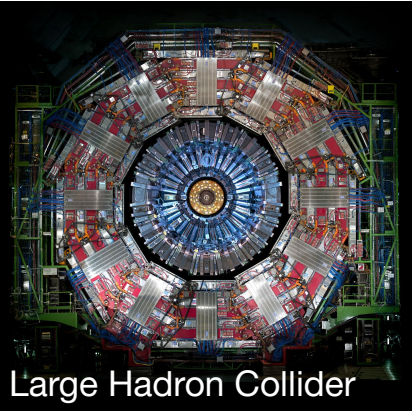


Fermi-LAT

Indirect detection



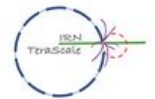
Direct detection



Large Hadron Collider



Xenon



A. Montanari, for the H.E.S.S. Collaboration

Flux for annihilation...

$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{\langle\sigma v\rangle}{2m_{\text{DM}}^2} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2(r[s]) ds$$

$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{\langle\sigma v\rangle}{2m_{\text{DM}}^2} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2(r[s]) ds$$



Particle physics factor:

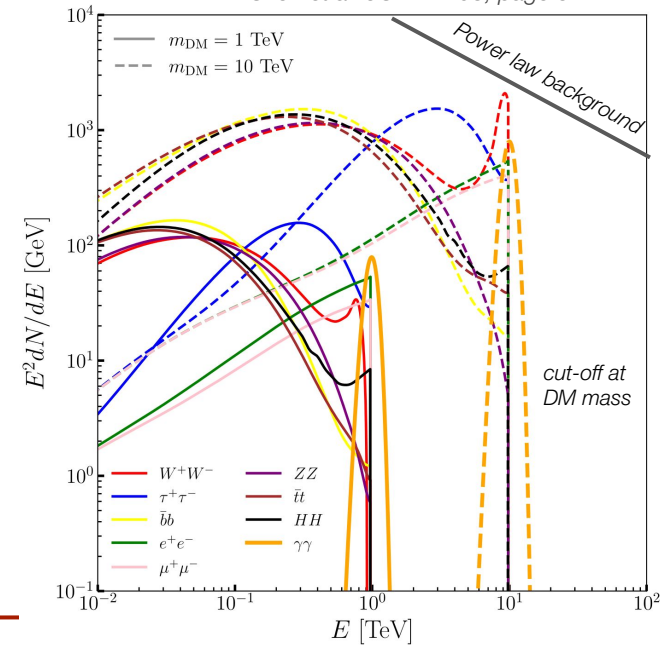
- Differential photon yield
- Dark Matter (DM) particle mass
- Cross section

→ No target dependence

→ Uncertainties on the particle physics model

Flux for annihilation...

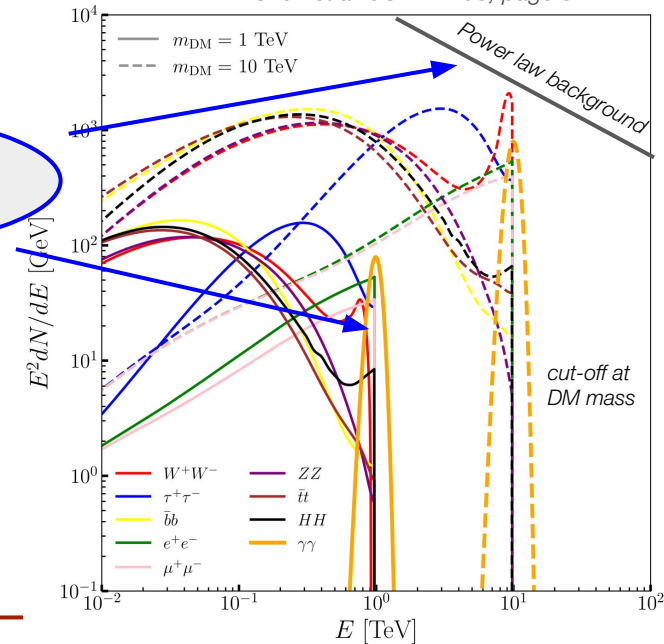
Spectra computed from
Cirelli et al. JCAP 1103, page 51



$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{\langle\sigma v\rangle}{2m_{\text{DM}}^2} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2(r[s]) ds$$

Flux for annihilation...

Spectra computed from
Cirelli et al. JCAP 1103, page 51



Particle physics

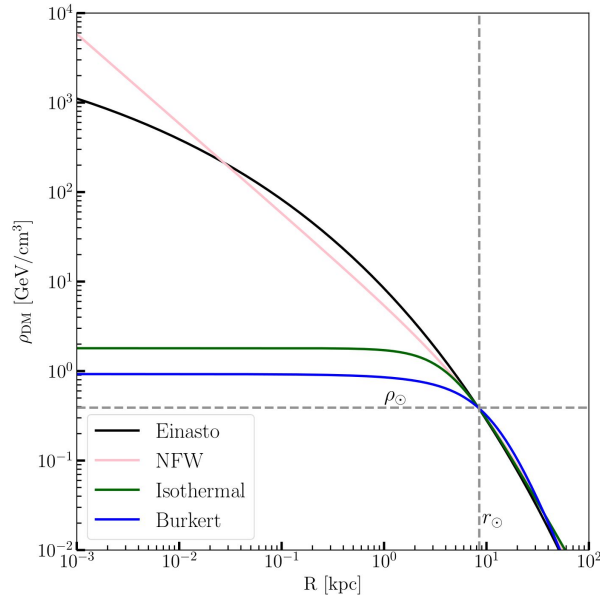
Discrimination from background

-
- Dark mass
- Cross section

- No target dependence
- Uncertainties on the particle physics model

Flux for annihilation...

$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{\langle\sigma v\rangle}{2m_{\text{DM}}^2} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2(r[s]) ds$$



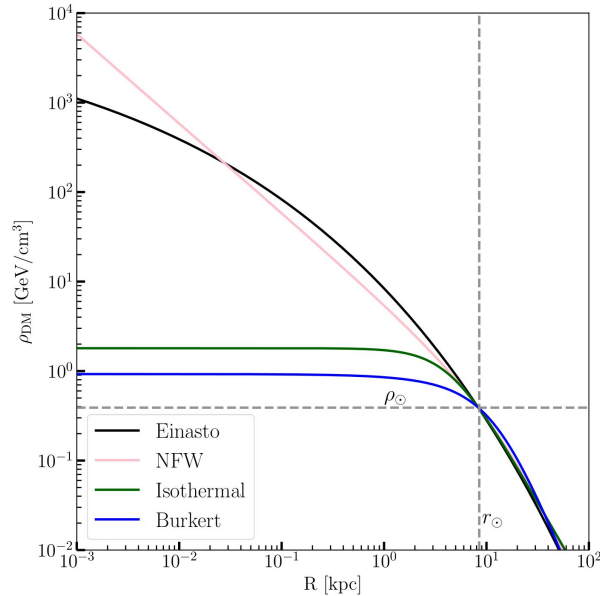
Astrophysics factor: J -factor

- DM distribution in the target
- Large uncertainties...
 - Baryon feedback
 - Tidal Stripping
 - Clustering

→ Looking for the target with the largest J -factor

Flux for annihilation...

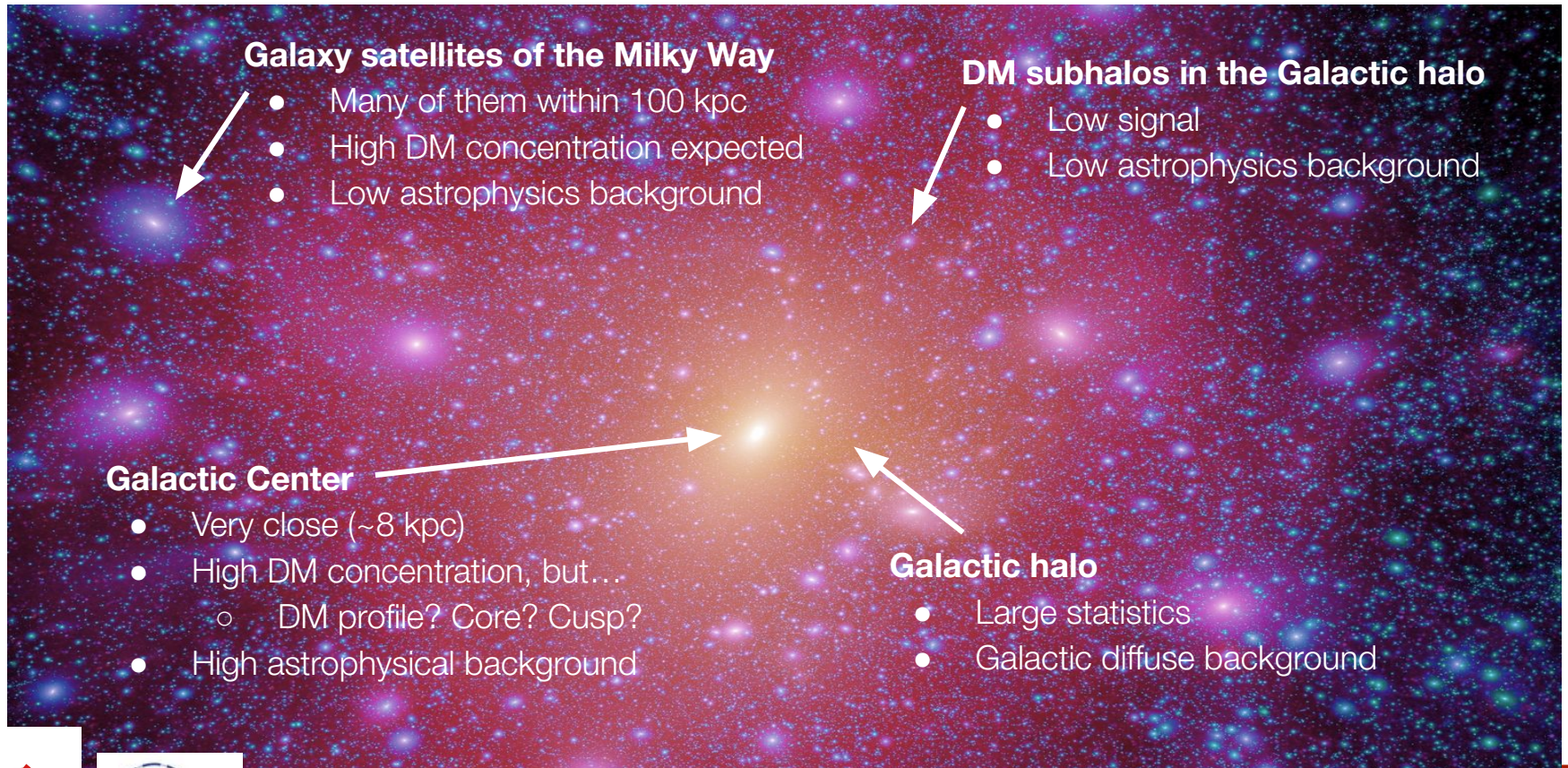
$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{\langle\sigma v\rangle}{2m_{\text{DM}}^2} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho^2(r[s]) ds$$



Astrophysical J -factor

Gamma-rays pointing
back to the source:
**Reveal DM abundance
and distribution**

→ Looking for the target with
the largest J -factor



Galaxy satellites of the Milky Way

- Many of them within 100 kpc
- High DM concentration expected
- Low astrophysics background

DM subhalos in the Galactic halo

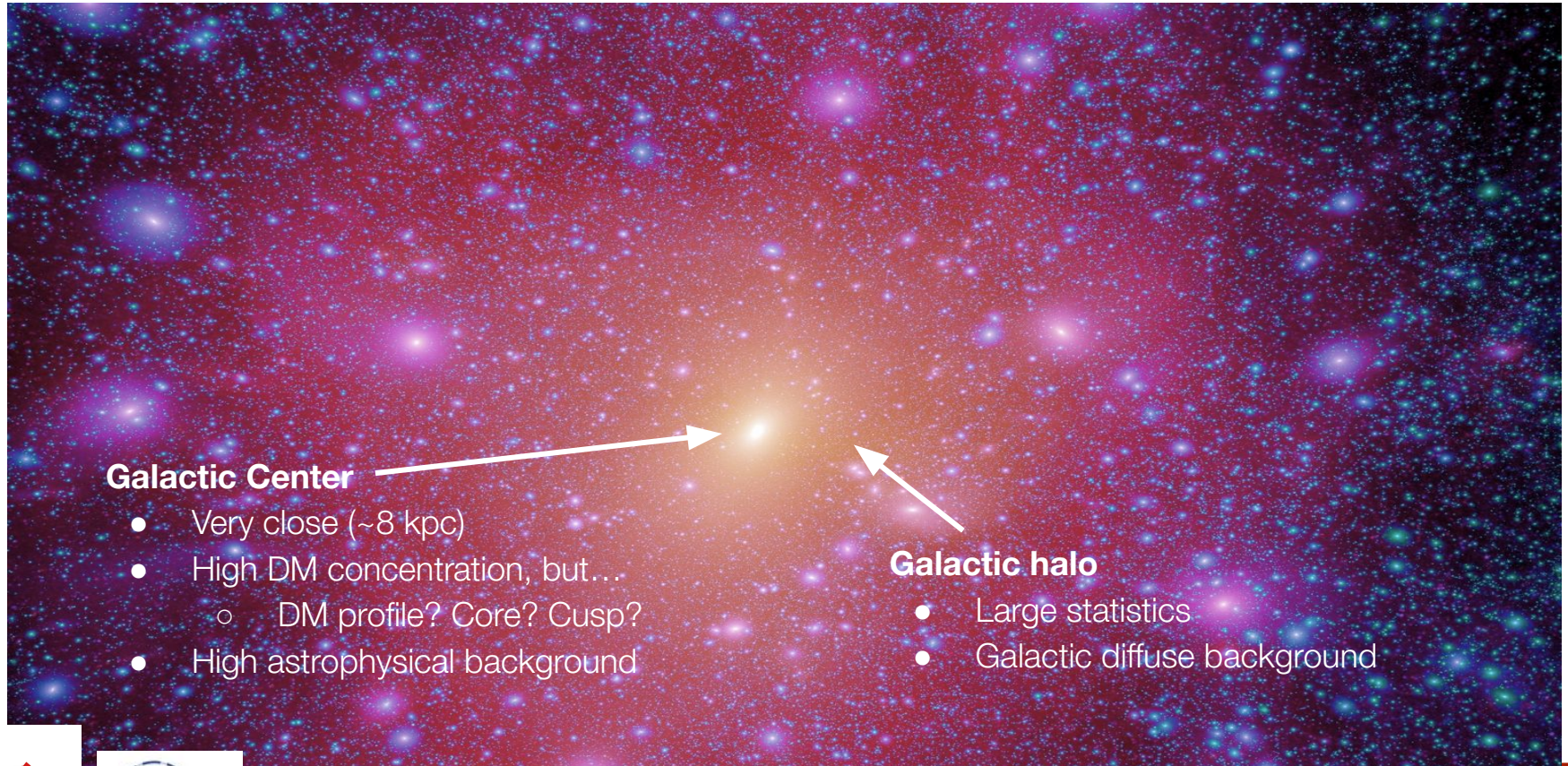
- Low signal
- Low astrophysics background

Galactic Center

- Very close (~ 8 kpc)
- High DM concentration, but...
 - DM profile? Core? Cusp?
- High astrophysical background

Galactic halo

- Large statistics
- Galactic diffuse background



Galactic Center

- Very close (~ 8 kpc)
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 - DM profile? Core? Cusp?
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- Galactic diffuse background

Galaxy satellites of the Milky Way

- Many of them within 100 kpc
- High DM concentration expected
- Low astrophysics background

DM subhalos in the Galactic halo

- Low signal
- Low astrophysics background

IACT observational strategies for DM search:

- Deep observations of the Galactic Center region
- Observations of the most **promising dwarf galaxies**
- Observations of promising **DM subhalo candidates**

Galactic Center region

- Very close (~8 kpc)
- High DM concentration, but...
 - DM profile? Core? Cusp?
- High astrophysical background

Galactic halo

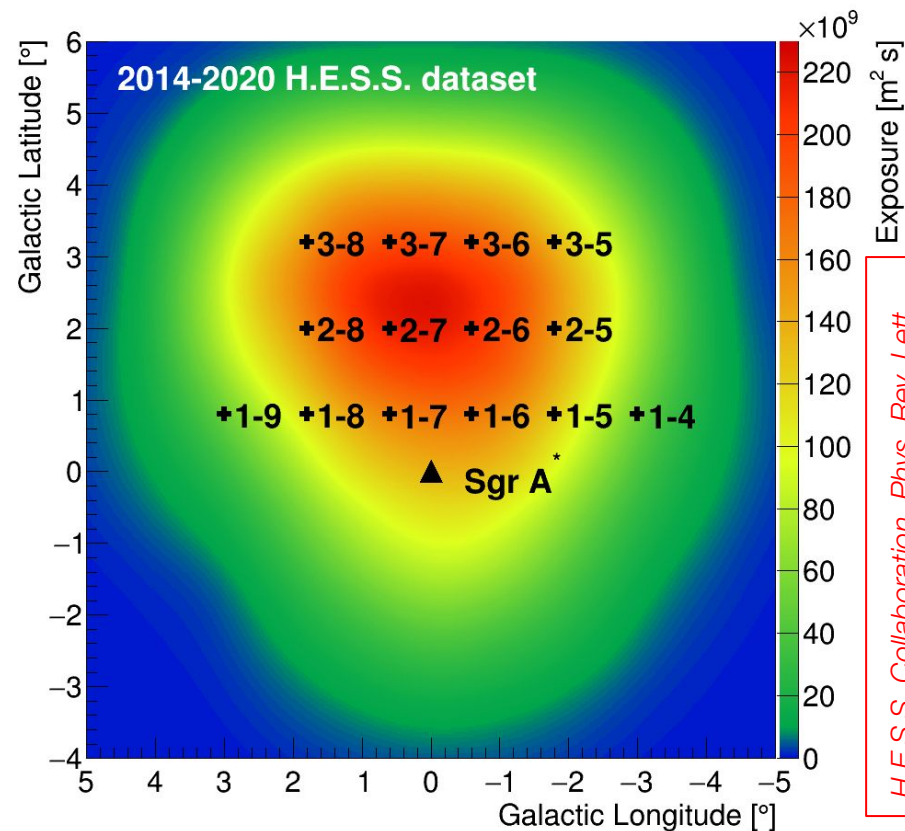
- Large statistics
- Galactic diffuse background

LOOKING AT THE GALACTIC CENTER

~ surveyed region by H.E.S.S.



- **The Inner Galaxy Survey (IGS, 2014-2020)**
→ **546 hours of high quality data**
- H.E.S.S. multi-year observational program of the inner few degrees around the Galactic Center, conducted with the full five-telescopes array
- **One of the motivations: to reach the best sensitivity possible to DM annihilation signals**



H.E.S.S. Collaboration, Phys. Rev. Lett.
129, 111101 (2022)

$$L(N_S, N_B | N_{ON}, N_{OFF}, \alpha) = \frac{(N_S + N_B)^{N_{ON}}}{N_{ON}!} e^{-(N_S + N_B)} \frac{(N'_S + \alpha N_B)^{N_{OFF}}}{N_{OFF}!} e^{-(N'_S + \alpha N_B)}$$

- Counting experiment, measured events
- Expected events in the ON and OFF regions
- Ratio between the angular size of the ON and OFF regions
- **Comparison of hypotheses through Log-Likelihood Ratio Test Statistics (TS)**
 - Null hypothesis H0, “background”
 - Alternative hypothesis H1, “signal”
- No significant excess in the dataset

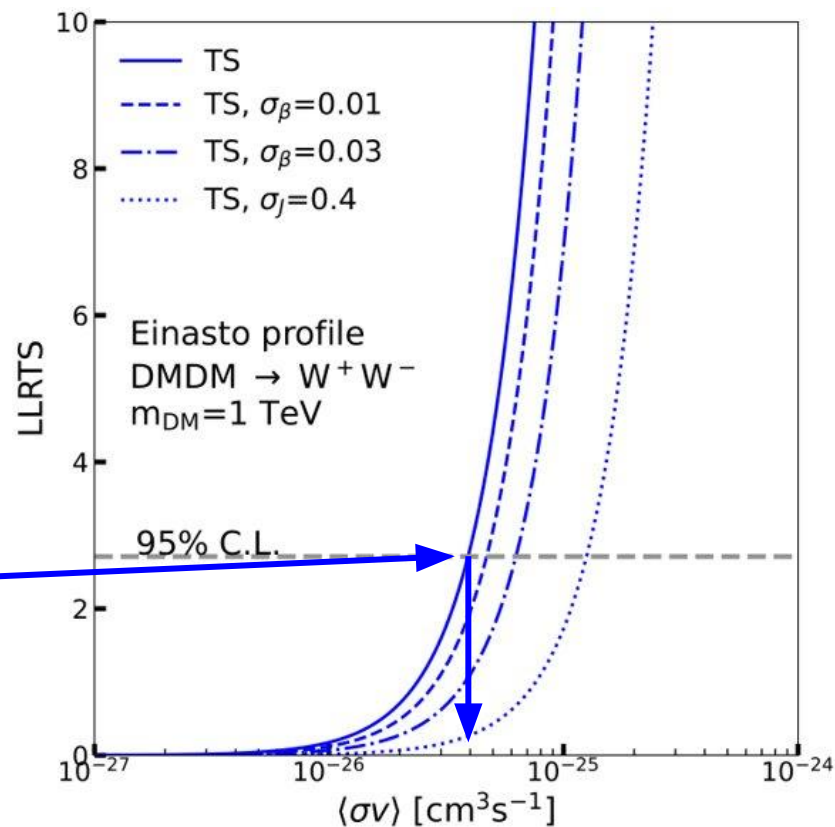
$$LLRTS = -2 \ln \left(\frac{L_1}{L_0} \right)$$

→ **Upper limits (U.L.) on the free parameter that we want to test**

- Comparison of hypotheses through Log-Likelihood Ratio Test Statistics (TS)
- No significant excess in the dataset
→ **Upper limits (U.L.) on the free parameter that we want to test**

LLRTS (1dof) = 2.71 for 95% C.L. UL

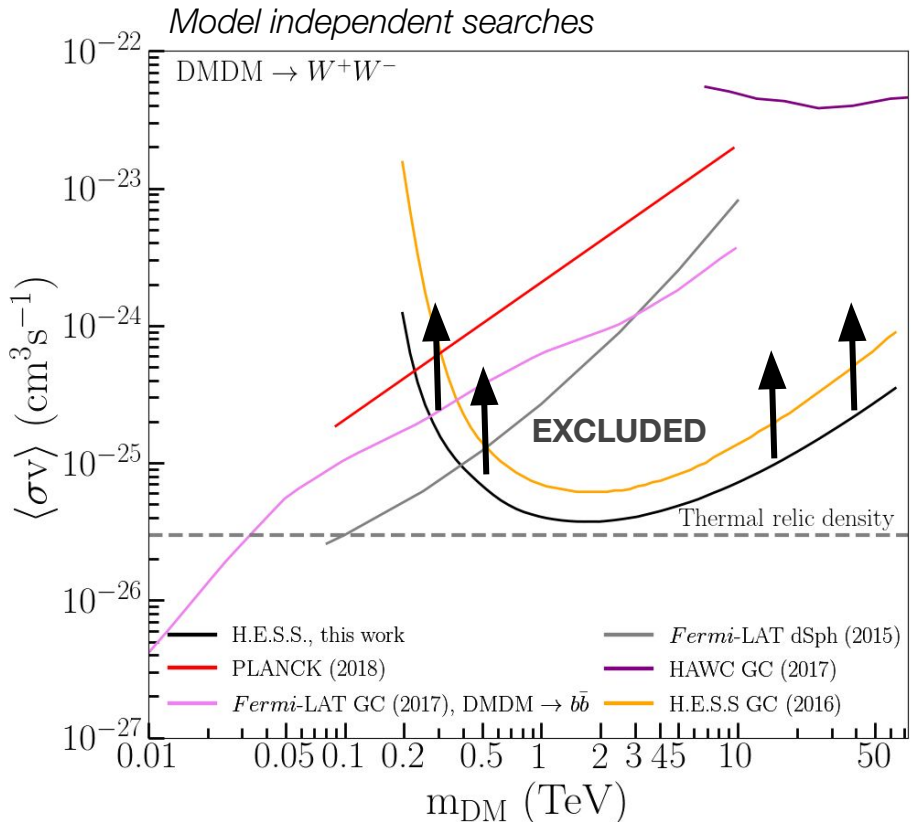
Ref. Cowan, G., Cranmer, K., Gross, E. et al. *Eur. Phys. J. C* 71, 1554 (2011)



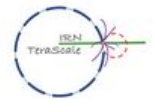
CONSTRAINTS ON THE CONTINUUM



- No excess compatible with DM signal
→ **Computation of upper limits on the annihilation cross section**
- **Most constraining limits for TeV mass range for the channels tested:**
 - Annihilation into the W^+W^- channel $\langle\sigma v\rangle = 3.7 \times 10^{-26} \text{ cm}^3/\text{s}$ at 1.5 TeV
- Comparing w/ other experiments

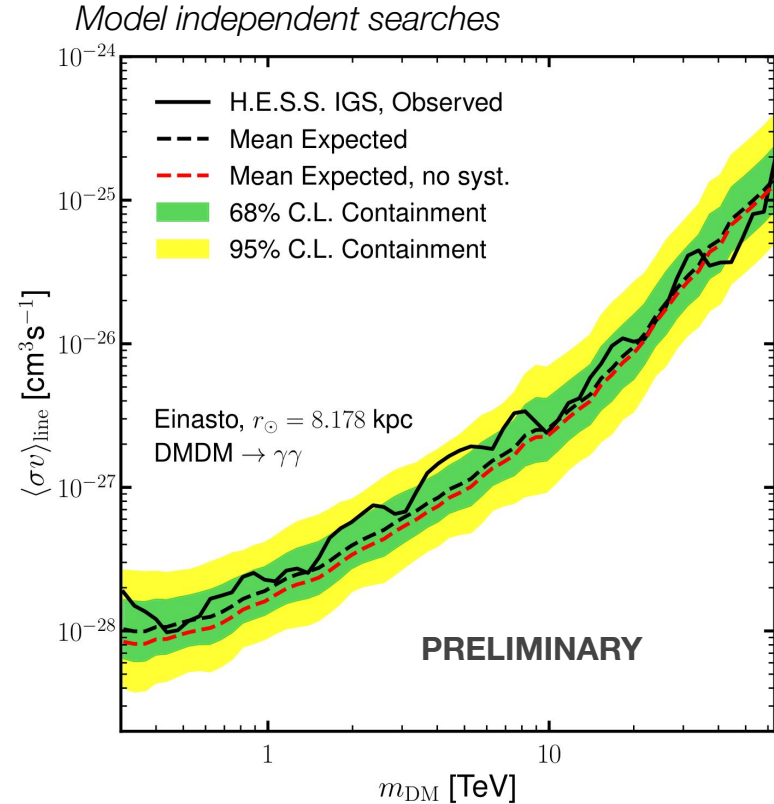


H.E.S.S. Collaboration, Phys. Rev. Lett. 129, 111101 (2022)



CONSTRAINTS ON THE LINE

- No excess compatible with DM signal
→ **Computation of upper limits on the annihilation cross section**
- **Most constraining limits for TeV mass range for the channels tested:**
 - DM promptly annihilating to photons
 - Annihilation into the $\gamma\gamma$ channel
 $\langle\sigma v\rangle = 2.4 \times 10^{-28} \text{ cm}^3/\text{s}$ at 1 TeV



H.E.S.S. Collaboration, resubmitted to Phys. Rev. Lett. (April 2026)

SPECIFIC WINP SCENARIOS SPECTRA

- Full models from UV scenarios realizing supersymmetry: **Wino, Higgsino, Quintuplet**
 - Actively searched at LHC
- **Line contribution** dominating the spectra of gamma-rays, compute limits in terms of the line cross section, which is dominating the total cross section

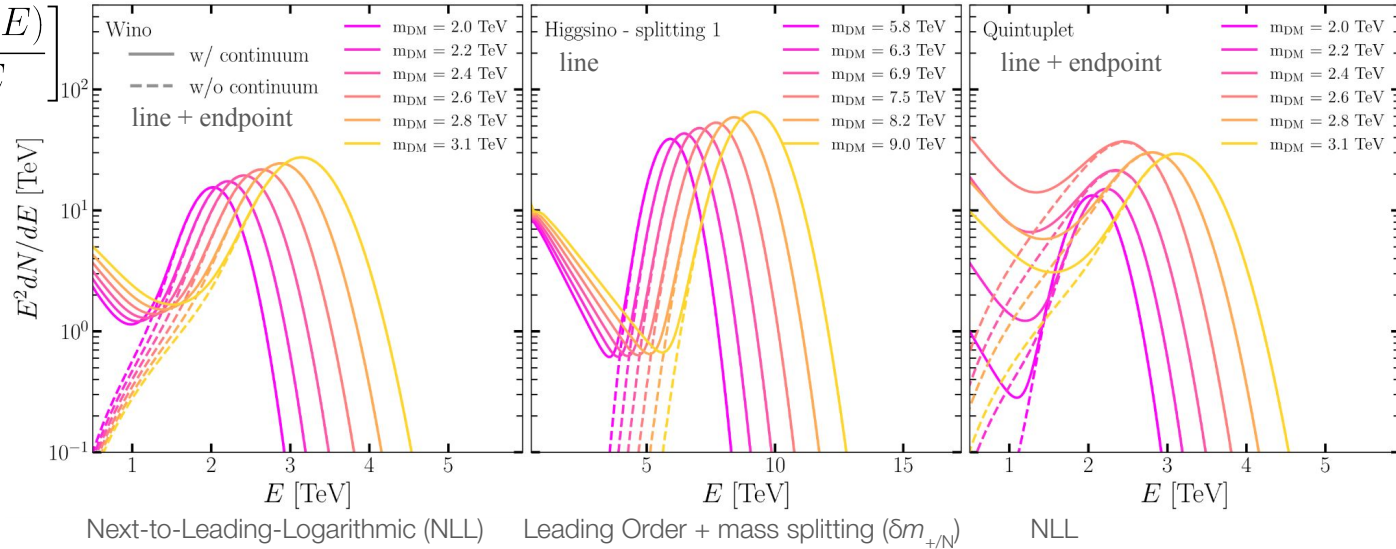
AM, Moulin and Rodd, *Phys. Rev. D* 107, 043028 (2023)

$$\frac{d\Phi_{\gamma}^{\text{DM}}}{dE} = \frac{\langle\sigma v\rangle_{\text{line}} J(\Delta\Omega)}{8\pi m_{\text{DM}}^2} \left[\frac{dN_{\gamma}(E)}{dE} \right]$$

$$\left[\frac{dN_{\gamma}(E)}{dE} \right] = 2\delta(E - m_{\text{DM}})$$

$$+ \left(\frac{dN_{\gamma}(E)}{dE} \right)_{\text{endpoint}}$$

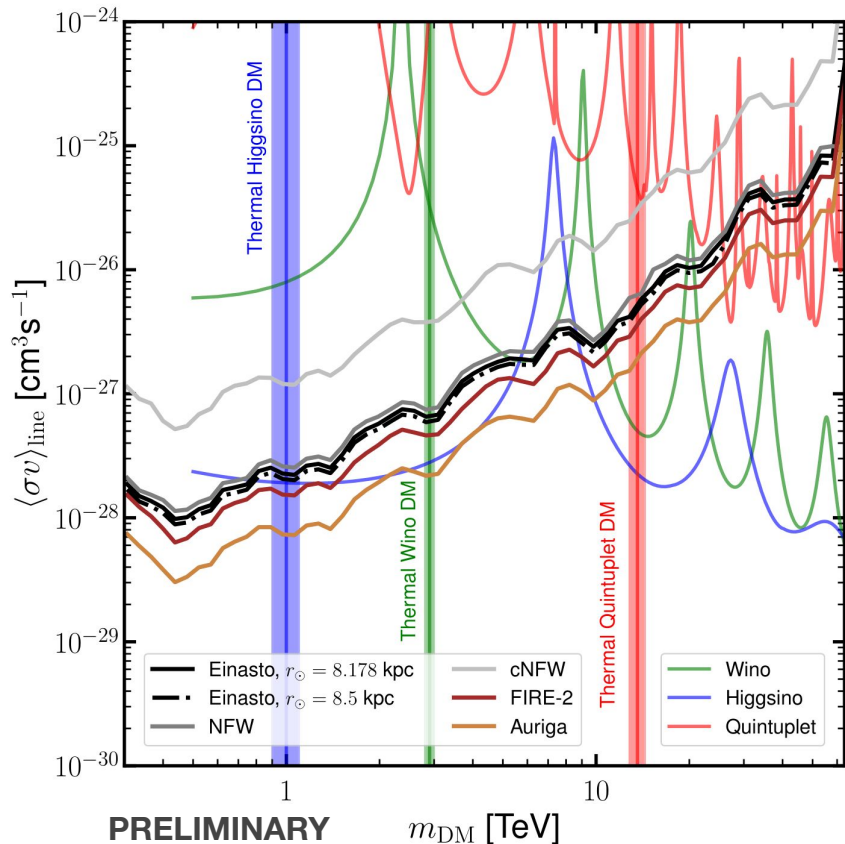
$$+ \left(\frac{dN_{\gamma}(E)}{dE} \right)_{\text{continuum}}$$



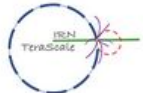
CONSTRAINTS ON SPECIFIC WIMP SCENARIOS



- Several DM distribution profiles (cusps, cores) tested for the Milky Way halo
- Masses for thermal DM:
 - Wino, $m_{DM} = 1.0 \pm 0.1$ TeV
 - Higgsino, $m_{DM} = 2.9 \pm 0.1$ TeV
 - Quintuplet, $m_{DM} = 13.6 \pm 0.1$ TeV
- Wino and Quintuplet excluded even with cored distributions
- **Challenging thermal Higgsino for the first time...**



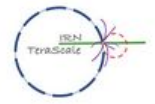
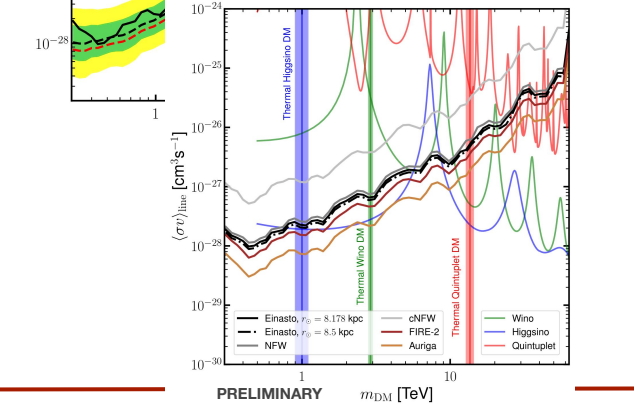
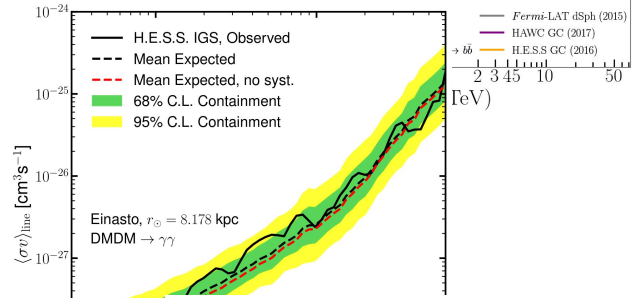
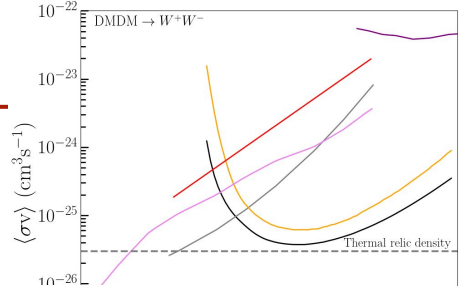
H.E.S.S. Collaboration, resubmitted to Phys. Rev. Lett. (April 2026)



SUMMARY AND OUTLOOK

After more than 20 years of observations with H.E.S.S.

- **Most constraining limits at the TeV** mass range with the H.E.S.S. IGS, for the continuum and the line
- **Already excluded Wino and Quintuplet**
- **Challenging thermal Higgsino for the first time...**
- **DM distribution in the GC region is still uncertain**
- **Statistical uncertainty is still dominating**
 - Limits can still be improved with more data
- Waiting for the Cherenkov Telescope Array Observatory



Thank you for your attention!

Backup slides

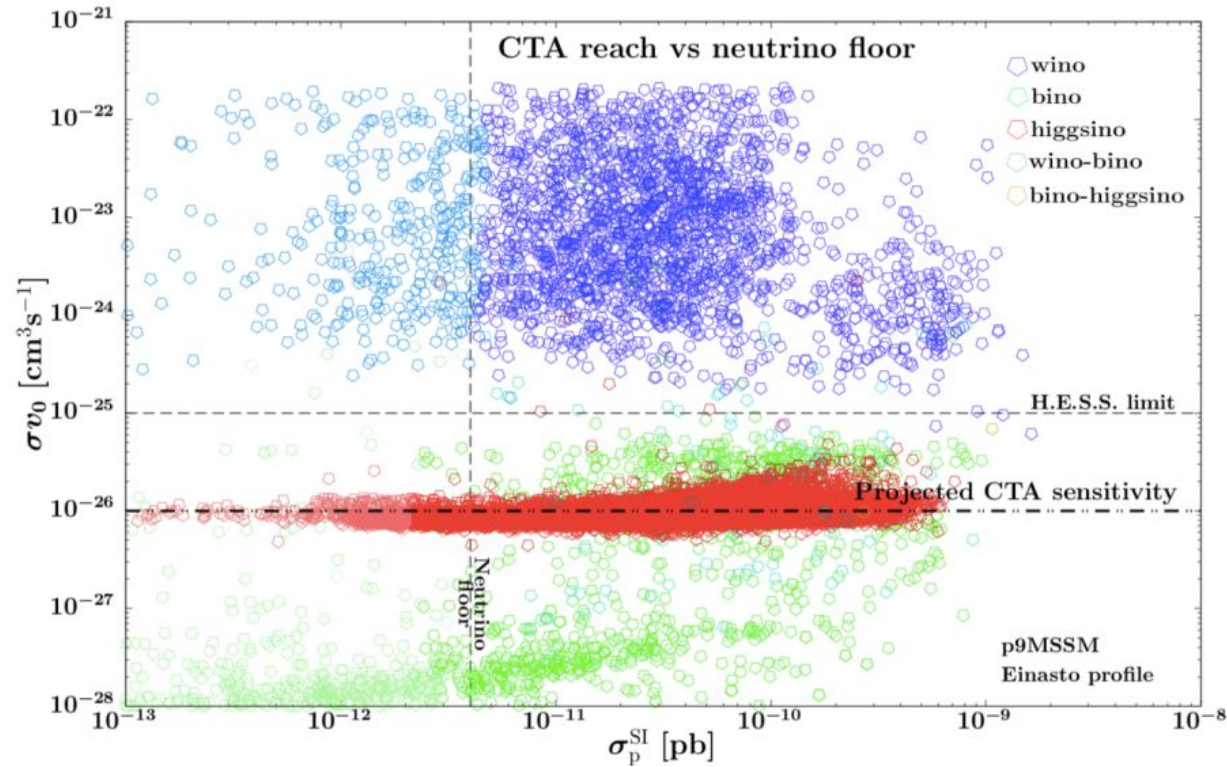
POINTS OF THE p9MSSM IN THE $(\sigma^{\text{SI}}, \sigma_{\nu_0})$ SPACE



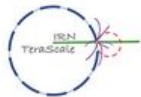
9-parameter MSSM framework

- Reference irreducible neutrino floor ($m_{\text{DM}} = 2 \text{ TeV}$)
- H.E.S.S. limits at $m_{\text{DM}} = 2.5 \text{ TeV}$
- CTA projected limits at $m_{\text{DM}} = 1 \text{ TeV}$

Points are upper limits on σ^{SI} sensitivity from XENON1T



Hryczuk A., Jodlowski K., Moulin E. et al., JHEP, 43, 1910 (2019)

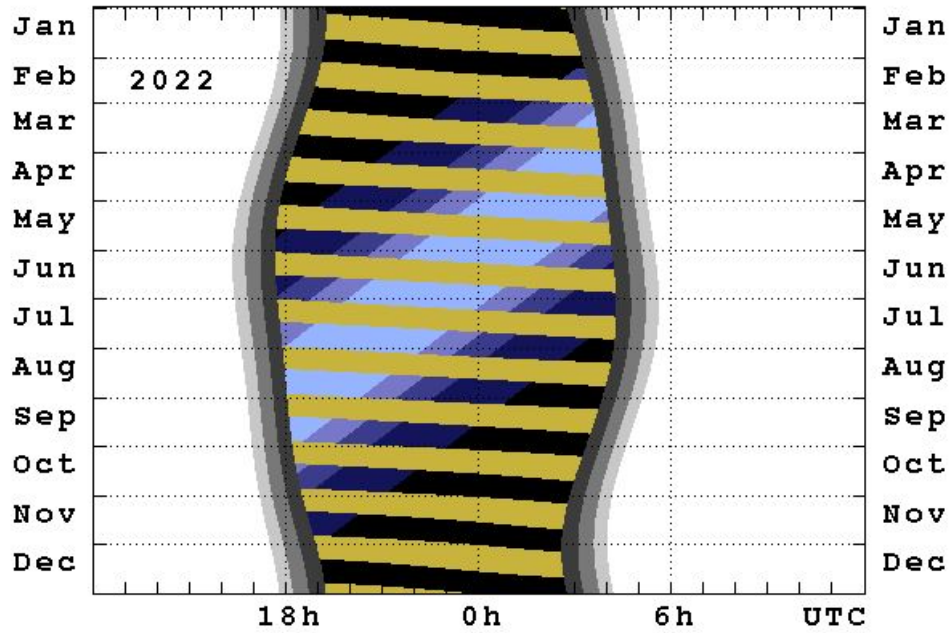


GALACTIC CENTER VISIBILITY WITH H.E.S.S.

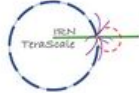


- Visibility plot from the H.E.S.S. site, for Sgr A* → the GC region
 - From March to September
 - ($\theta_z \leq 30^\circ$)
 - Dark time conditions
- ~ **320 hours of observations per year!**

Selected object at R.A. 17:45:40, Dec. -29:00:28 (J2000)



RA: 17:47:08 Dec: -29:00:57 (Sgr A*)
Gal.long.: 359:57 Gal.lat.: -0:03
Altitude: ■ 0 ■ 30 ■ 45 ■ 60
Geo.long.: 16:30.0 lat.: -23:16.3



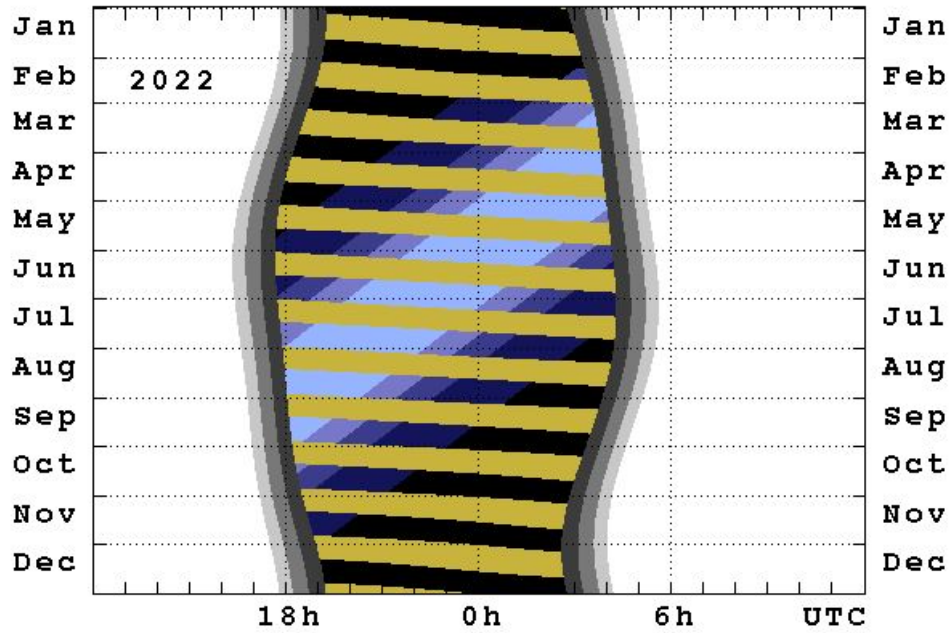
GALACTIC CENTER VISIBILITY WITH H.E.S.S.



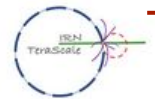
- Visibility plot from the H.E.S.S. site, for Sgr A* → the GC region
 - From March to September
 - ($\theta_z \leq 30^\circ$)
 - Dark time conditions
- ~ **320 hours of observations per year!**
- No, not so easy...
 - 17-hour RA band crowded with other interesting sources
 - Bad weather
 - Technical problems

→ **A realistic and significant achievement is 100-150 hours of observations per year**

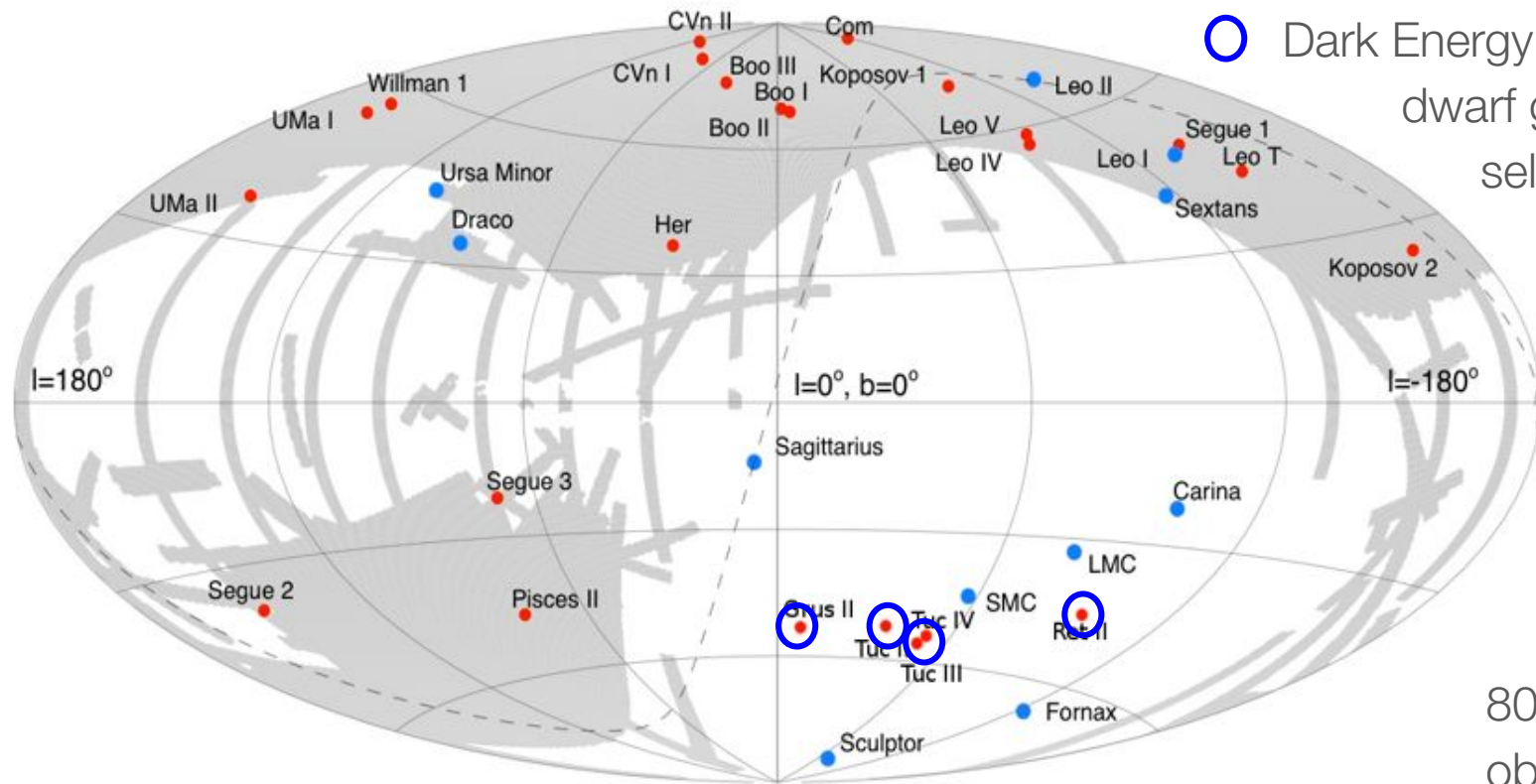
Selected object at R.A. 17:45:40, Dec. -29:00:28 (J2000)



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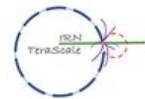
OBSERVING DES DWARF GALAXIES



○ Dark Energy Survey (DES) dwarf galaxy satellites selected and observed by H.E.S.S.

H.E.S.S. Collaboration, Phys. Rev. D 102, 062001 (2020)

80 hours of observations

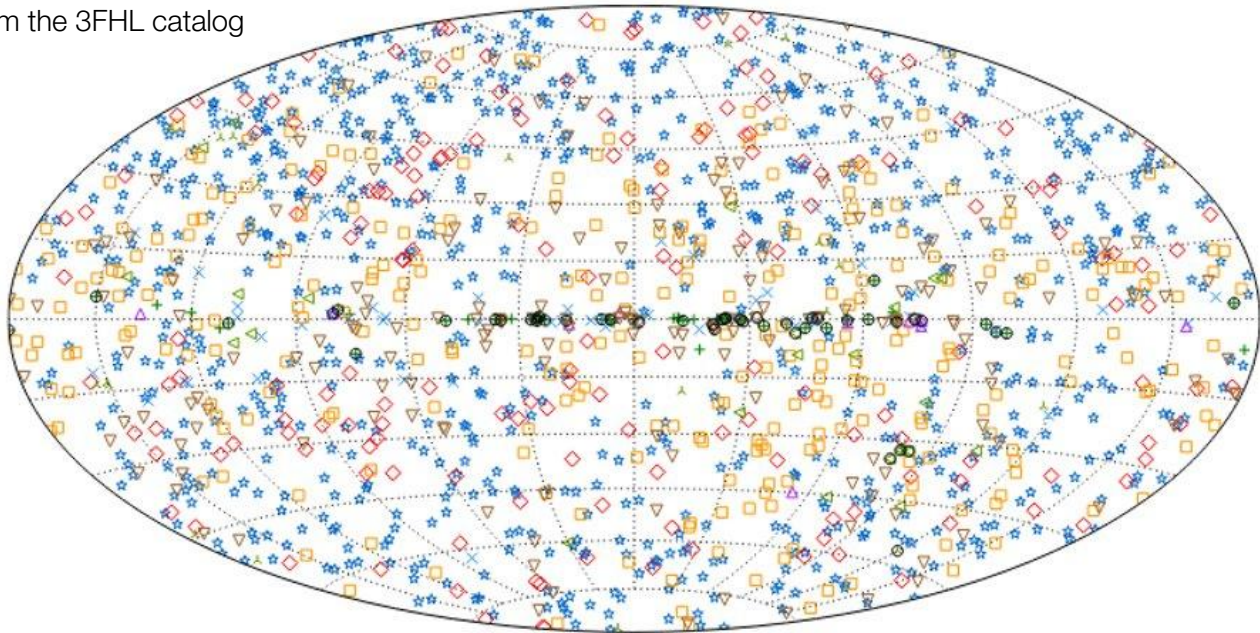


LOOKING AT DARK MATTER SUBHALOS



Ref. Ajello et al., *Astrophys. J. Suppl.* 2017, 232, 18

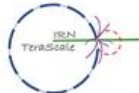
From the 3FHL catalog



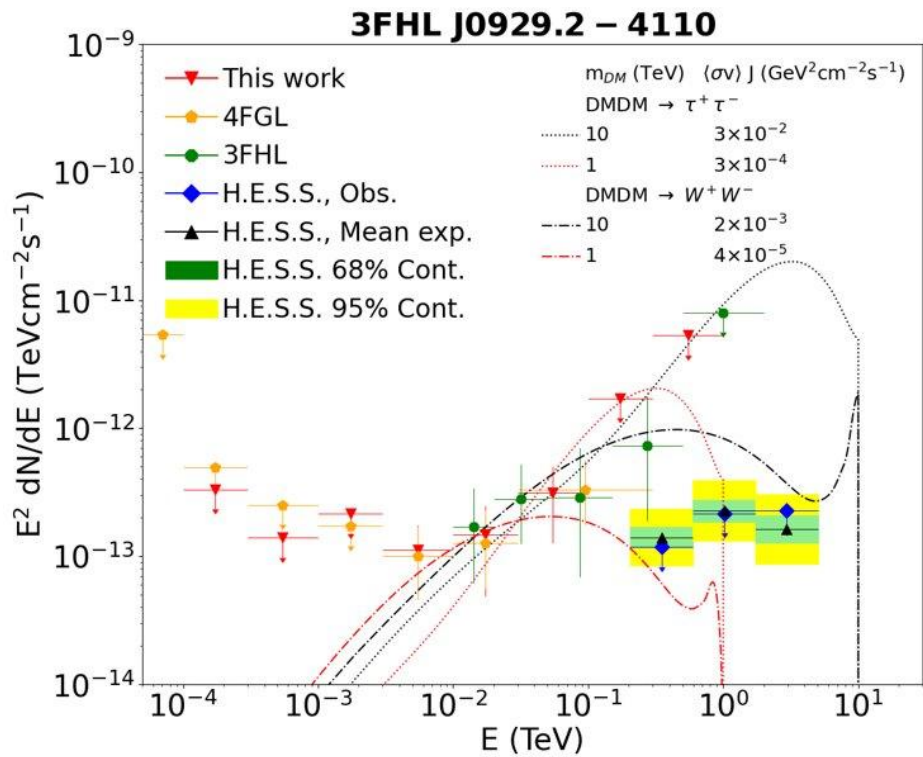
+	SNRs and PWNe	*	BL Lacs	□	Unc. Blazars	△	Other GAL	▽	Unassociated
×	Pulsars	◇	FSRQs	▲	Other EGAL	◀	Unknown	○	Extended

Thorough selection of **the most promising unassociated sources** in the *Fermi*-LAT catalog as DM subhalos – the unidentified Fermi objects (UFOs)

4 observed by H.E.S.S.



- *Fermi*-LAT flux points and upper limits
- **DM-induced emission models are viable according to *Fermi*-LAT measurements**
- Need massive DM because no energy cut-off is seen from the *Fermi*-LAT data analysis



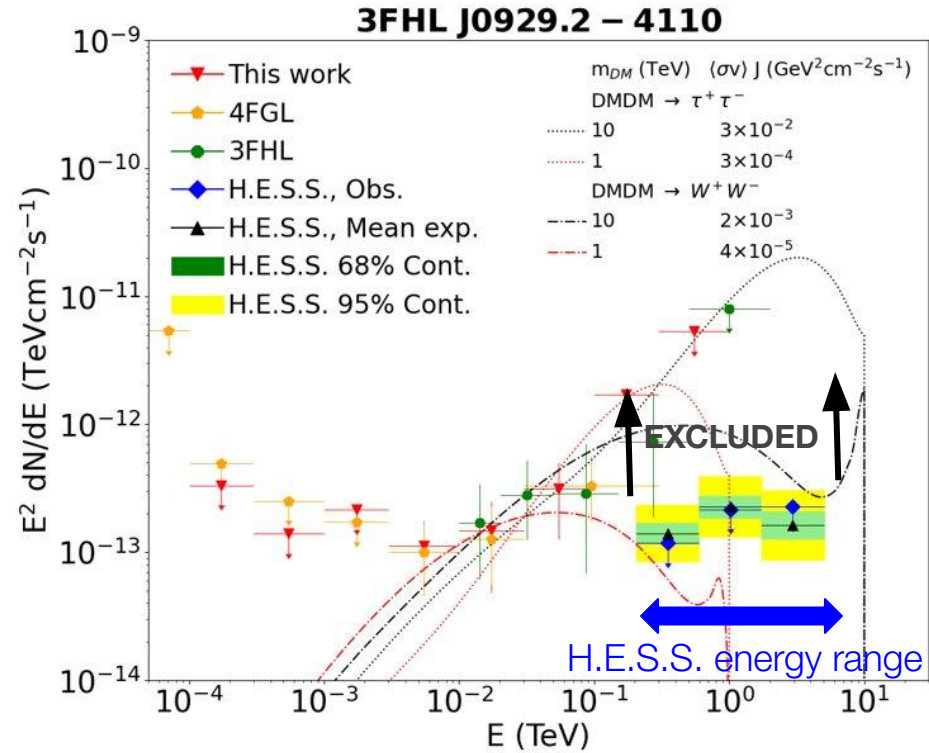
H.E.S.S. Collaboration, Astrophys. J. 918, 17 (2021)



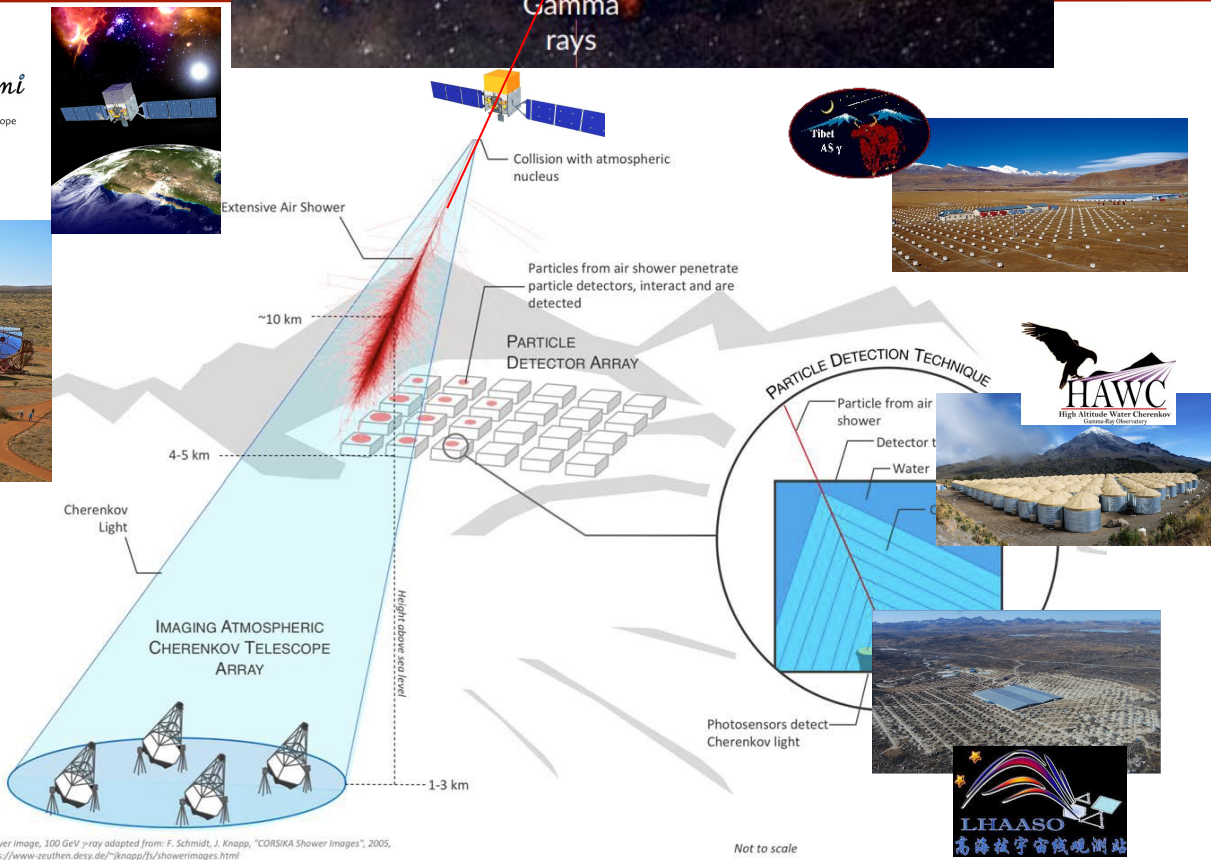
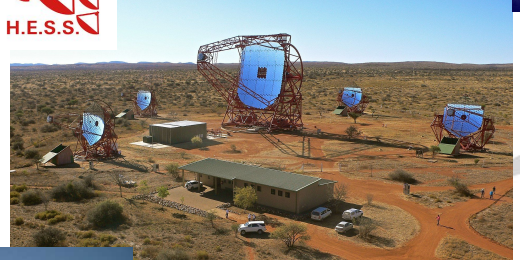
H.E.S.S. UPPER LIMITS

- *Fermi*-LAT flux points and upper limits
- DM-induced emission models are viable according to *Fermi*-LAT measurements
- Need massive DM because no energy cut-off is seen from the *Fermi*-LAT data analysis

→ **H.E.S.S. upper limits (no excess found) constrain some viable DM-induced emission models for *Fermi*-LAT**



DETECTION TECHNIQUES



Shower image, 100 GeV γ -ray adapted from: F. Schmidt, J. Knapp, "CORSIKA Shower Images", 2005, <https://www.seuthen.desy.de/~jknapp/fv/showerimages.html>

Not to scale



DETECTION TECHNIQUES

space based experiments

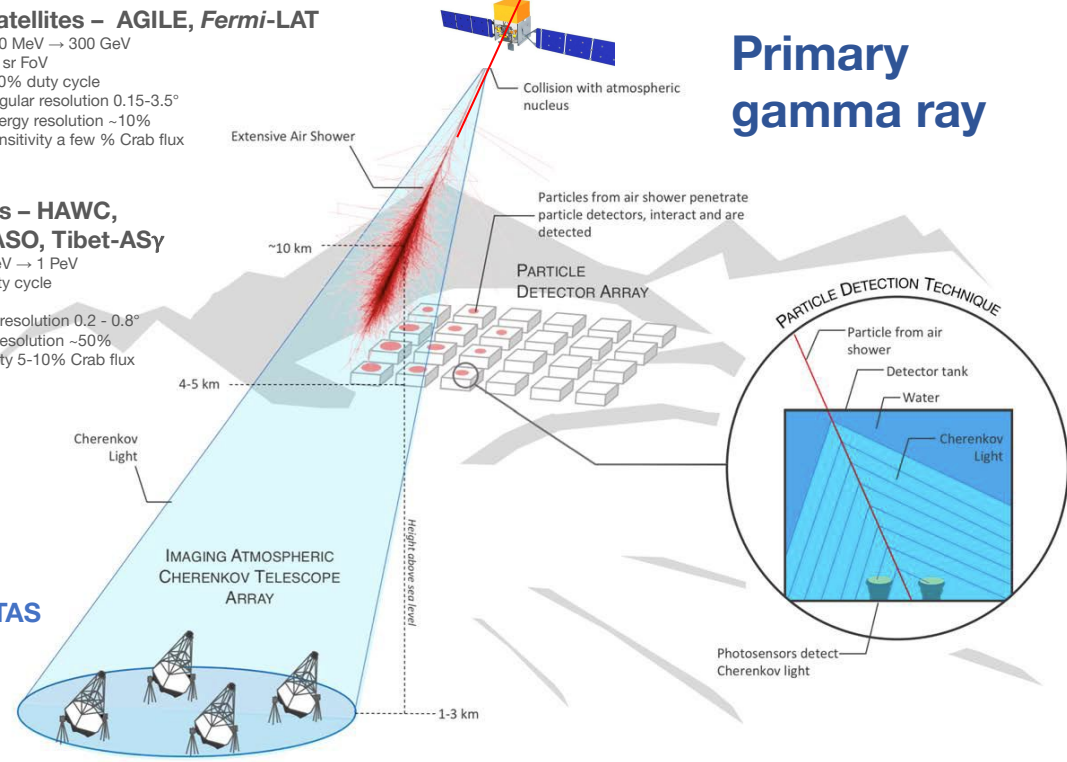
ground based experiments:
Water Cherenkov Detectors

ground based experiments:
Imaging Atmospheric
Cherenkov Telescopes (IACTs)
H.E.S.S., MAGIC, VERITAS

IACTs – H.E.S.S., MAGIC, VERITAS
~30 GeV → ~100 TeV
Small FoV : ~5°
Duty-cycle: 10-15%
Angular resolution <0.1°
Energy resolution ~10%
Sensitivity 1% Crab flux

Satellites – AGILE, Fermi-LAT
~20 MeV → 300 GeV
>2 sr FoV
100% duty cycle
Angular resolution 0.15-3.5°
Energy resolution ~10%
Sensitivity a few % Crab flux

WCDs – HAWC, LHAASO, Tibet-ASy
~100 GeV → 1 PeV
90% duty cycle
~sr FoV
Angular resolution 0.2 - 0.8°
Energy resolution ~50%
Sensitivity 5-10% Crab flux



Shower image, 100 GeV γ -ray adapted from: F. Schmidt, J. Knapp, "CORSIKA Shower Images", 2005, <https://www.seuthen.desy.de/~knapp/jv/showerimages.html>

Not to scale

PARTICLE SHOWERS

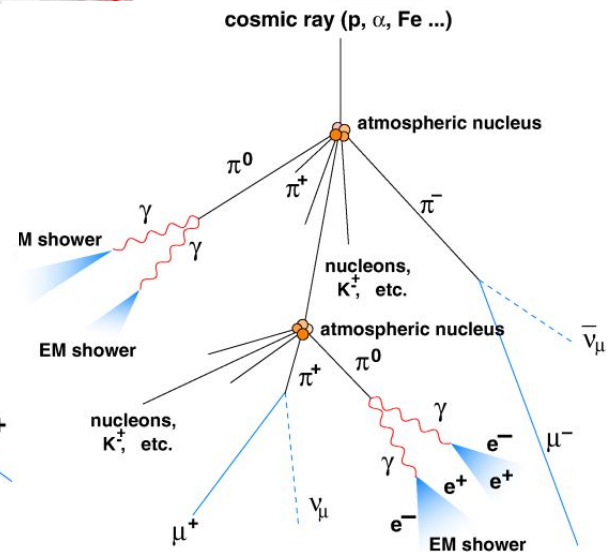
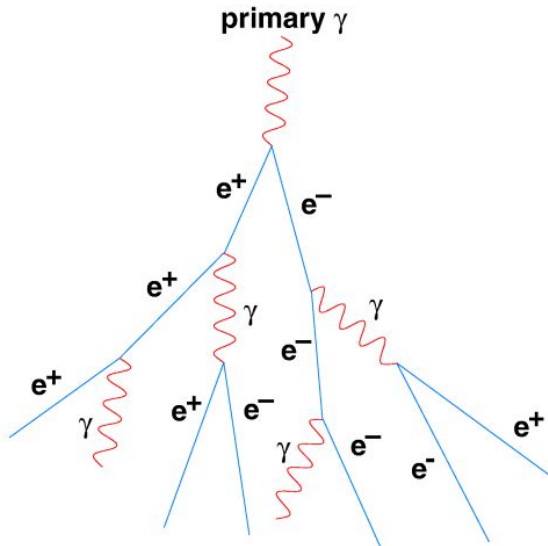


LMU

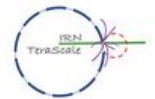
- Incident VHE charged/neutral particles interacting with Earth's atmosphere (opaque)

→ Shower of secondary particles can be produced

- Electromagnetic showers
- Hadronic showers



R.M. Wagner, Ph.D. thesis, Technical University of Munich, MPP-2006-245, (2006)



PARTICLE SHOWERS

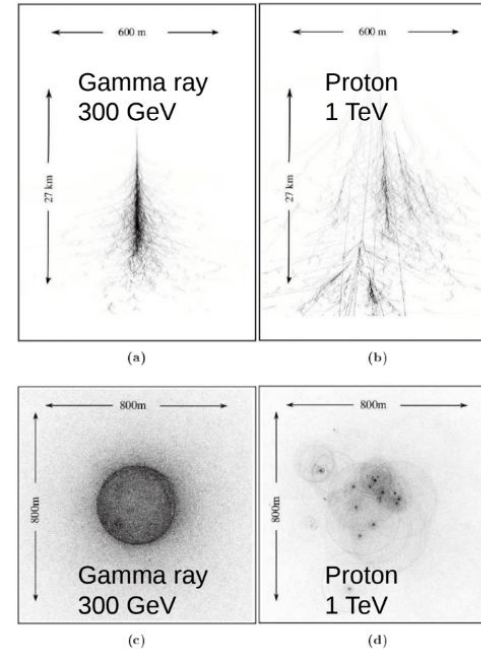


- Incident VHE charged/neutral particles interacting with Earth's atmosphere (opaque)

→ **Shower of secondary particles can be produced**

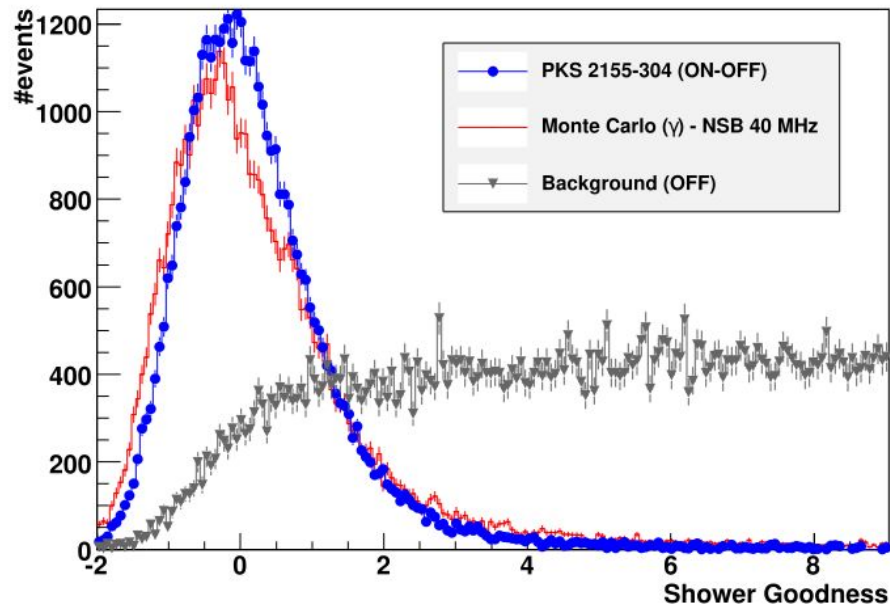
- Electromagnetic showers
- Hadronic showers

Primary gamma ray



Images of the showers at the ground

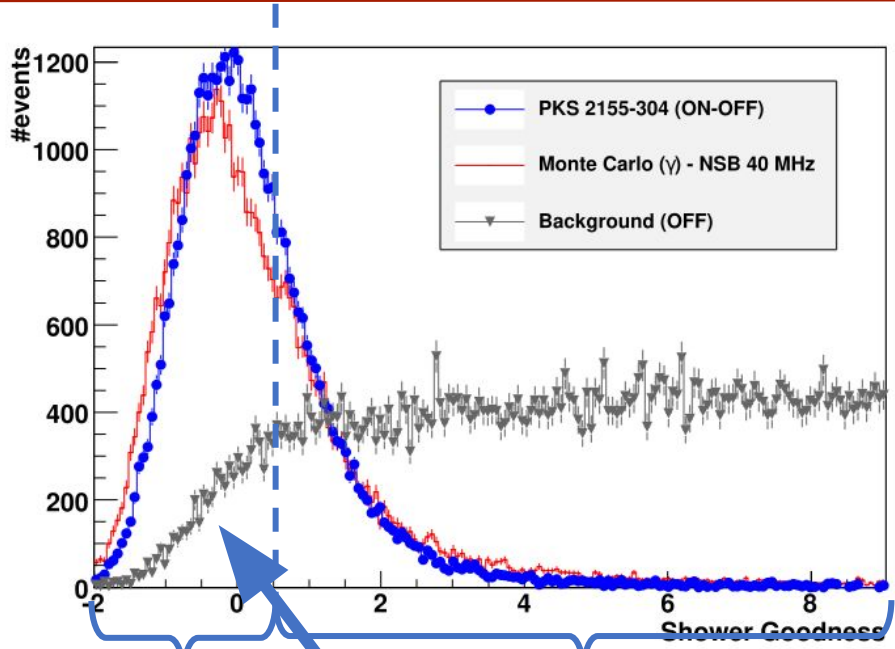
- Images on the camera
 - **gamma-like and hadron-like events are discriminated based on the template fitting technique between the measured and the simulated showers – «shower goodness»**



EVENT SELECTION



- Images on the camera
 - **gamma-like and hadron-like events are discriminated based on the template fitting technique between the measured and the simulated showers – «shower goodness»**



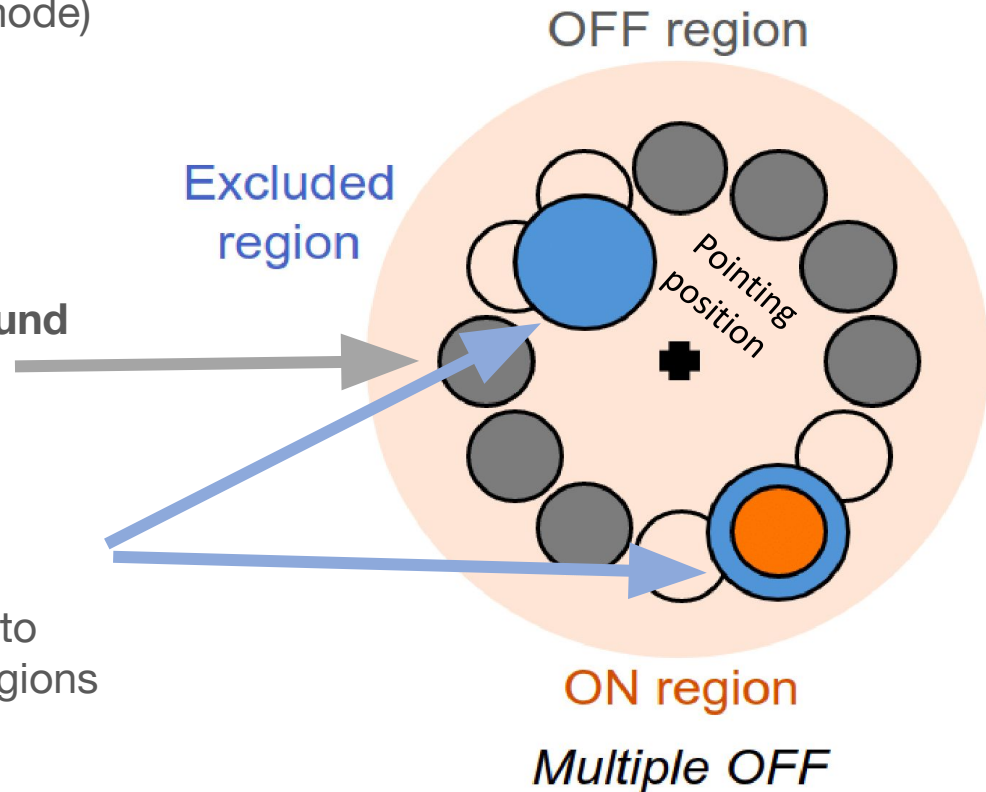
- recover event's energy and position in the sky

gamma-like hadron-like

Misidentified hadrons identified as gamma-like events: residual background



- Observations in wobble mode (or survey mode)
- Pointing position offset from the target, which is in the **ON region**
 - Collect photons from the target
- Measure the isotropic **residual background** in the **OFF regions**
- VHE sources in the FoV are excluded: **exclusion regions**
- A ring is excluded around the ON region to avoid leakage of ON signal in the OFF regions
 - For background determination



$$L(N_S, N_B | N_{\text{ON}}, N_{\text{OFF}}, \alpha) = \frac{(N_S + N_B)^{N_{\text{ON}}}}{N_{\text{ON}}!} e^{-(N_S + N_B)} \frac{(N'_S + \alpha N_B)^{N_{\text{OFF}}}}{N_{\text{OFF}}!} e^{-(N'_S + \alpha N_B)}$$

- Counting experiment, measured events
- Expected events in the ON and OFF regions
- Ratio between the angular size of the ON and OFF regions
- **Comparison of hypotheses through Log-Likelihood Ratio Test Statistics (TS)**
 - Signal against background-only

$$LLRTS = -2 \ln \left(\frac{L_1}{L_0} \right)$$

- No significant excess in the dataset
 - **Upper limits (U.L.) on the free parameter that we want to test**

- Comparison of hypotheses through Log-Likelihood Ratio Test Statistics (TS)

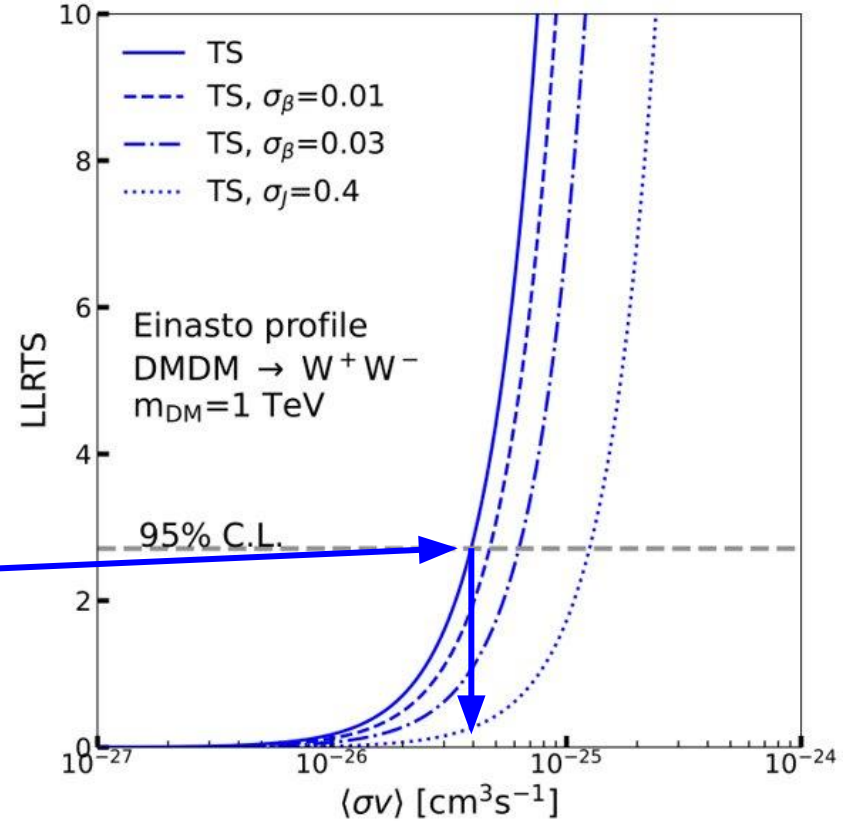
$$LLRTS = -2 \ln\left(\frac{L_1}{L_0}\right)$$

- No significant excess in the dataset
→ **Upper limits (U.L.) on the free parameter that we want to test**

LLRTS (1dof) = 2.71 for 95% C.L. UL

Ref. Cowan, G., Cranmer, K., Gross, E. et al. *Eur. Phys. J. C* 71, 1554 (2011)

Example for Dark Matter search

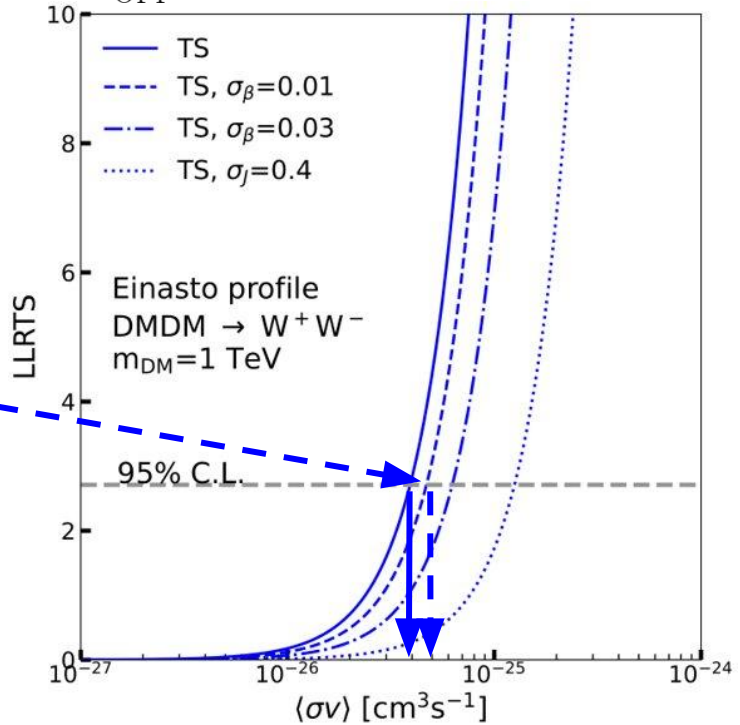


$$L(N_S, N_B | N_{ON}, N_{OFF}, \alpha, \beta) = \frac{[\beta(N_S + N_B)]^{N_{ON}}}{N_{ON}!} e^{-\beta(N_S + N_B)} \frac{[\beta(N'_S + \alpha N_B)]^{N_{OFF}}}{N_{OFF}!} e^{-\beta(N'_S + \alpha N_B)} e^{(1-\beta)^2/2\sigma_B}$$

- No significant excess in the dataset
 → Upper limits (U.L.) on the free parameter that we want to test

Upper limits for 1% systematic uncertainty: 20% less constraining

Using a nuisance parameter in the Likelihood



Refs. H., Silverwood, et al., JCAP 03, 055 (2015)
 E. Moulin, et al., CTA Dark Matter Programme (2019)
 V. Lefranc, et al., Phys. Rev. D 91, 12203 (2015)

Flux for decay...

$$\frac{d\Phi(\Delta\Omega, E_\gamma)}{dE_\gamma} = \frac{1}{4\pi} \frac{1}{m_{\text{DM}}\tau} \frac{dN_\gamma}{dE_\gamma} \times \int_{\Delta\Omega} d\Omega \int_{l.o.s.} \rho(r[s]) ds$$

If the source is distant:

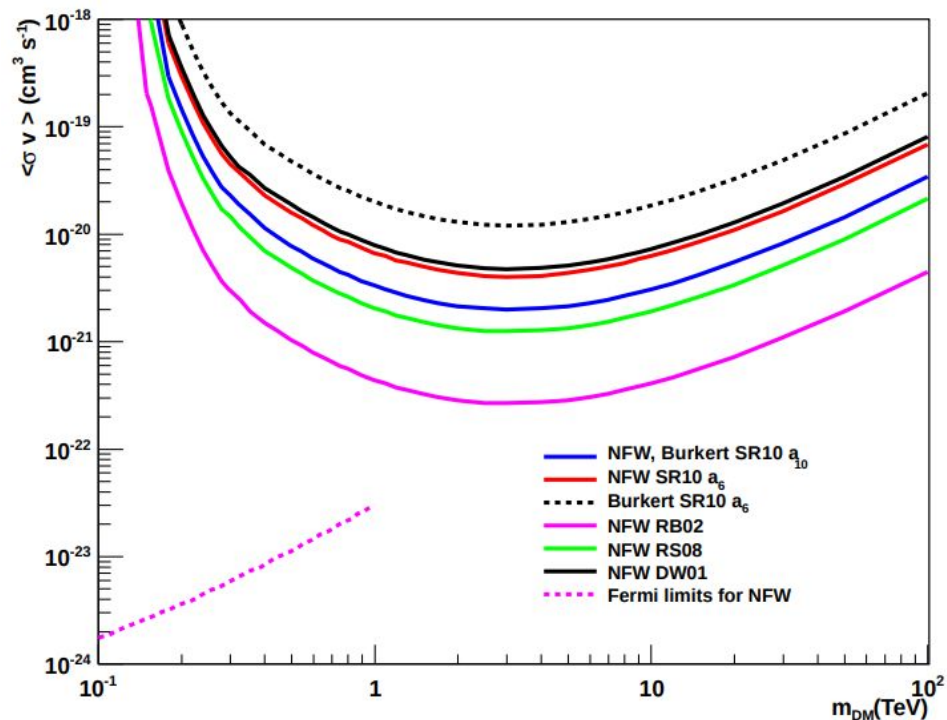
- every point in the source is distant $\rightarrow r \sim R$
- the flux depends approximately $\sim M/R^2$ (M total mass of the source)
- strongest signal from targets with the largest DM mass and also quite close
 \rightarrow **strongest constraints from galaxy clusters observations**

LIMITS FROM GALAXY CLUSTERS

LIR

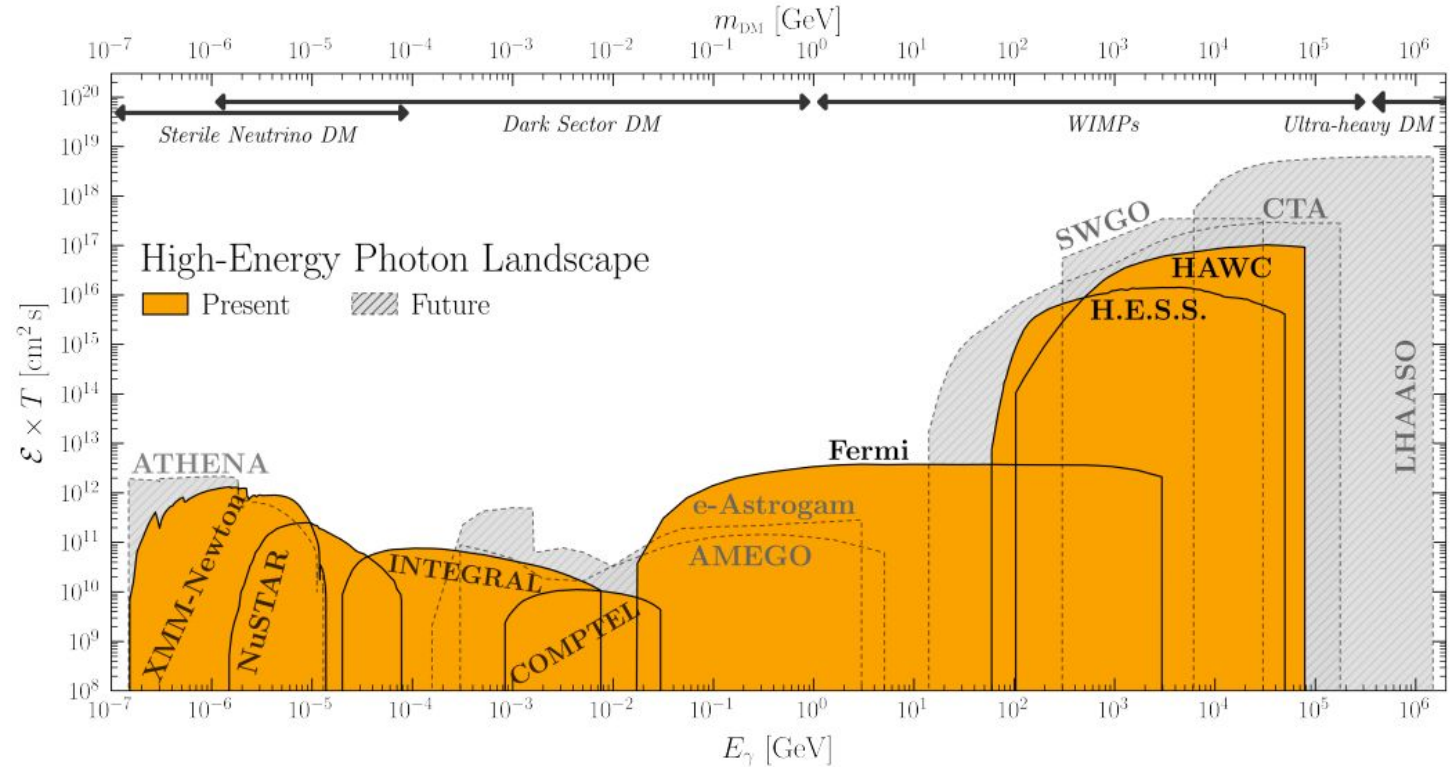
- Observations of the Fornax galaxy cluster
- 14.5 hours of total live time
- Possible enhancements to the gamma-ray flux are considered:
 - DM substructures
 - Sommerfeld effect
- Limits for different particle models and annihilation channels

→ reaching $\langle\sigma v\rangle \sim 10^{-21-22} \text{ cm}^3/\text{s}$
at 1 TeV

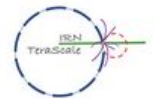


H.E.S.S. Collaboration, *Astrophys. J.*, 750, 123 (2012)

SENSITIVITY TO PHOTON DETECTION

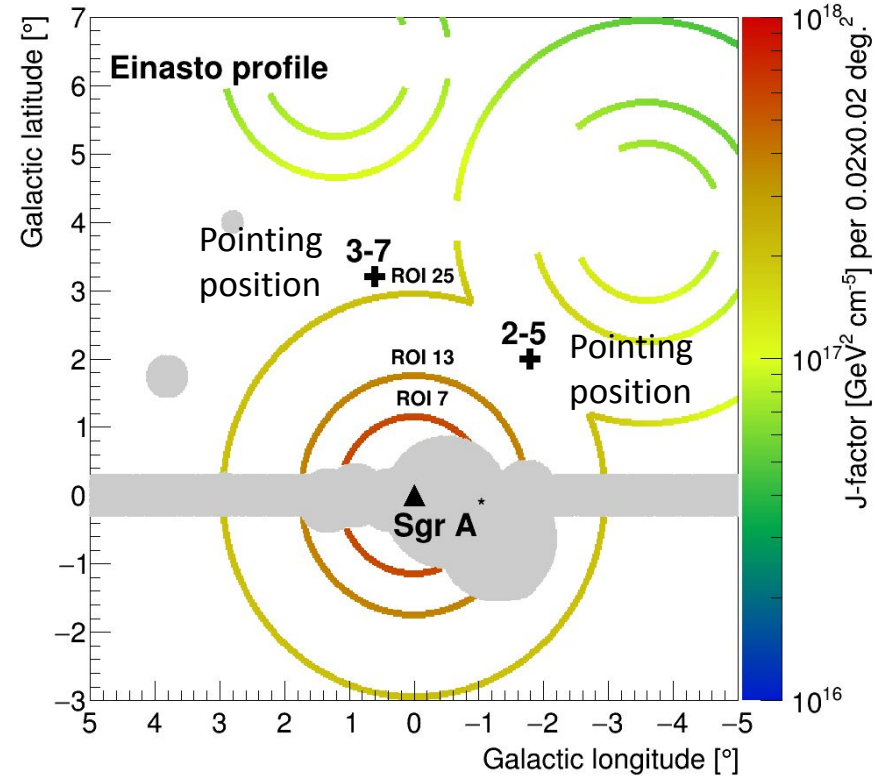


Boddy, Lisanti, McDermott, Rodd, Weniger et al., arXiv: 2203.06380

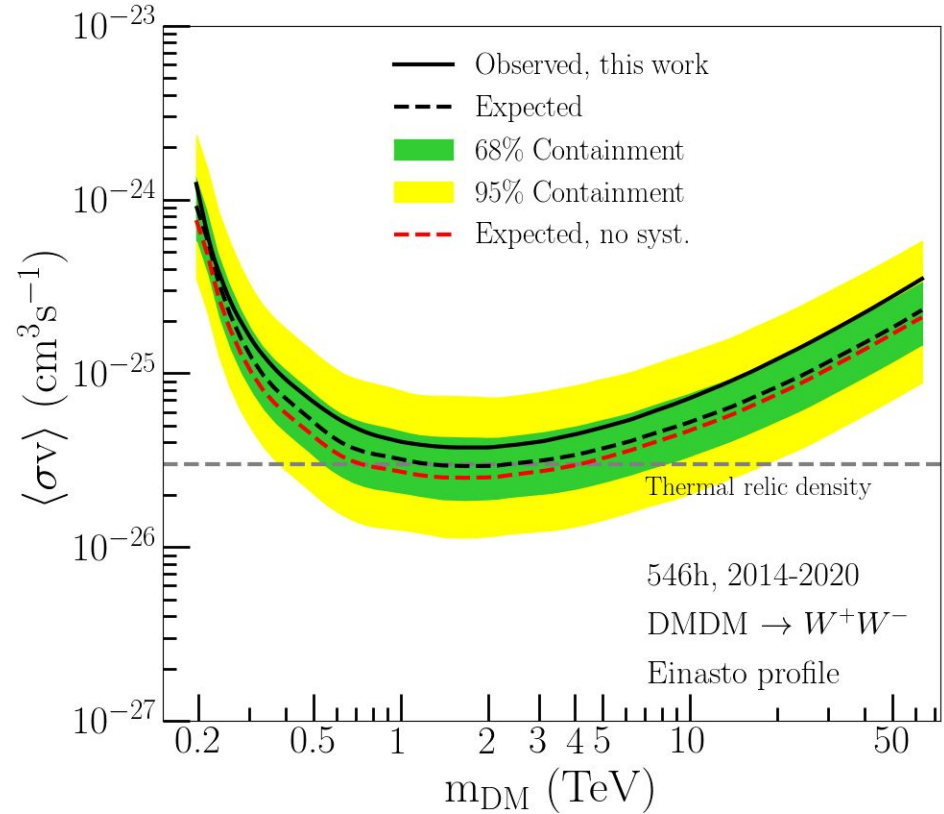


- **Reflected Background method:**

- OFF region:
 - Symmetric to the ON region
 - Same FoV and acceptance
 - Exclusion regions cut symmetrically
 - Same solid angle size
 - Cut overlapping areas and areas where OFF is closer to the GC than ON:
 - The DM signal in the ON region is always higher than in the OFF region
- Repeated for all the 25 ROI and over the ~1300 runs



- No excess compatible with DM signal
→ Computation of upper limits on the annihilation cross section
- **Most constraining limits for TeV mass range** for the channels tested:
 - annihilation into the W^+W^- channel $\langle\sigma v\rangle = 3.7 \times 10^{-26} \text{ cm}^3/\text{s}$ at 1.5 TeV

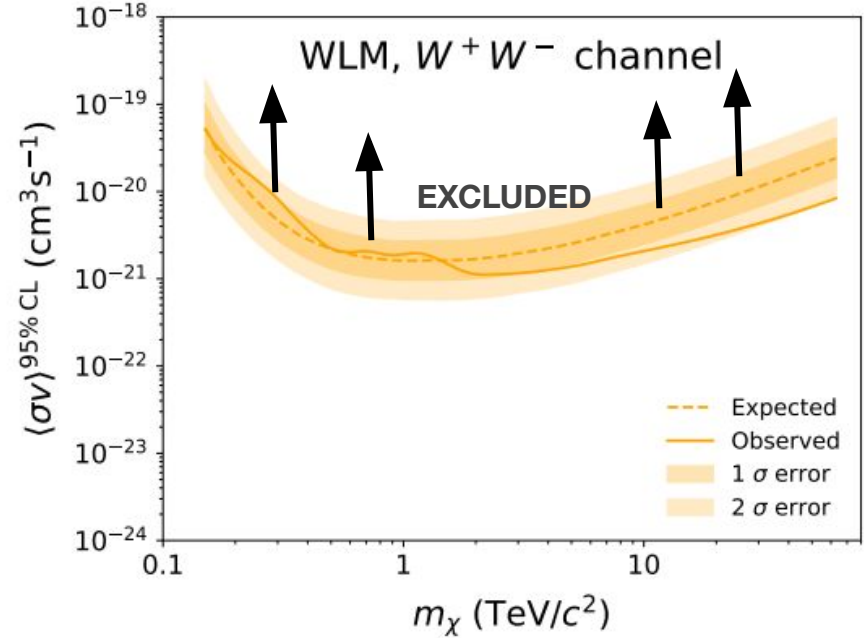


H.E.S.S. Collaboration, Phys. Rev. Lett.
129, 111101 (2022)

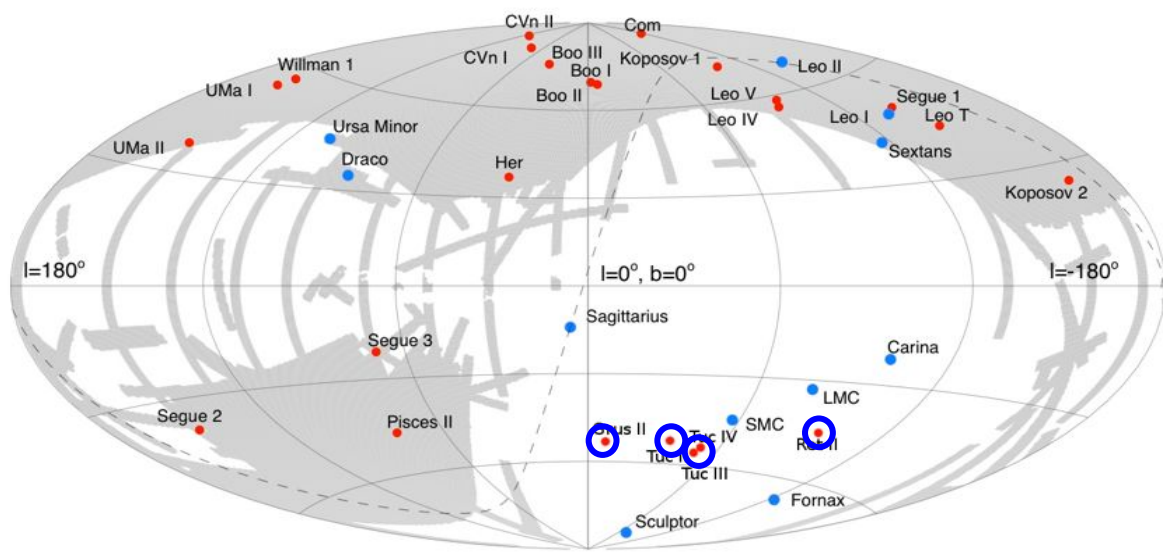
H.E.S.S. Collaboration, Phys. Rev. D 103, 102002 (2021)

- Complementary targets are dwarf irregular galaxies
- 18 hours of observations with H.E.S.S. of the Wolf-Lundmark-Melotte galaxy
- DM distribution well parametrized by a *coreNFW*

→ **Improvement of a factor at least 10 w.r.t. previous limits from other experiments**



SEARCHES TOWARDS DWARF GALAXIES



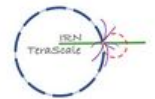
Modeling the DM distribution:

- Pressure-supported systems
- Use kinematic tracers of the gravitational potential
- Works very well in DM-dominated environments, e.g. dwarf galaxies, via the Jeans equation modeling

Determination for Reticulum II

- Stellar velocity dispersion \rightarrow J-factor

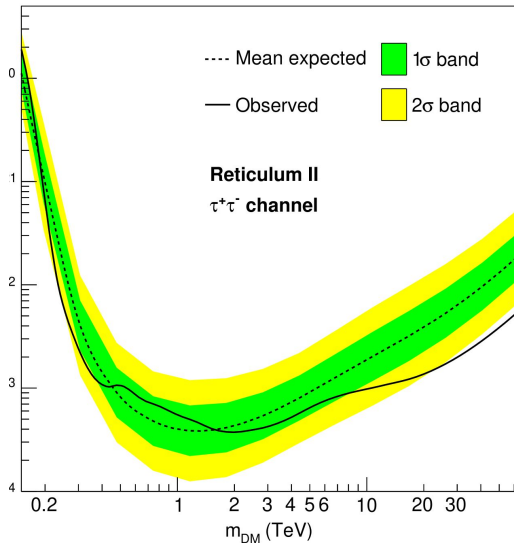
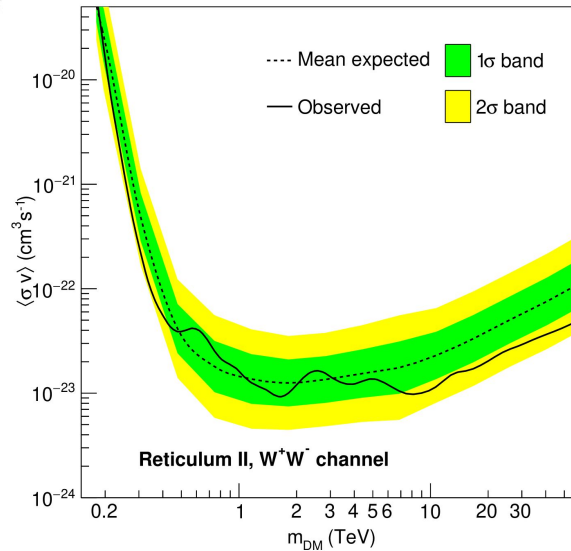
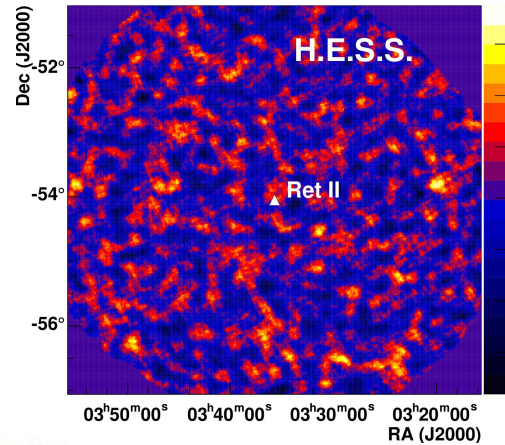
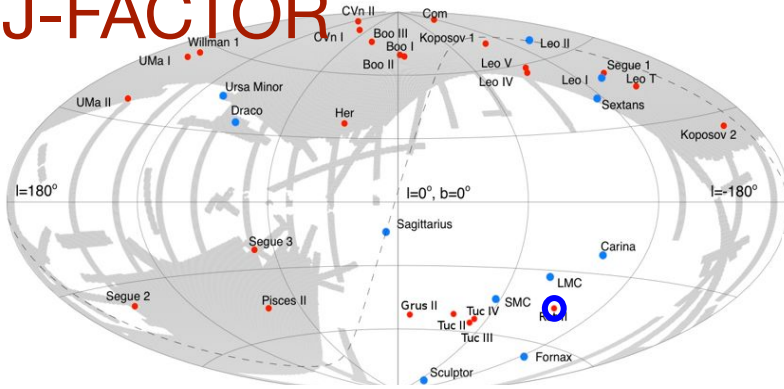
H.E.S.S. Collaboration, Phys. Rev. D 102, 062001 (2020)



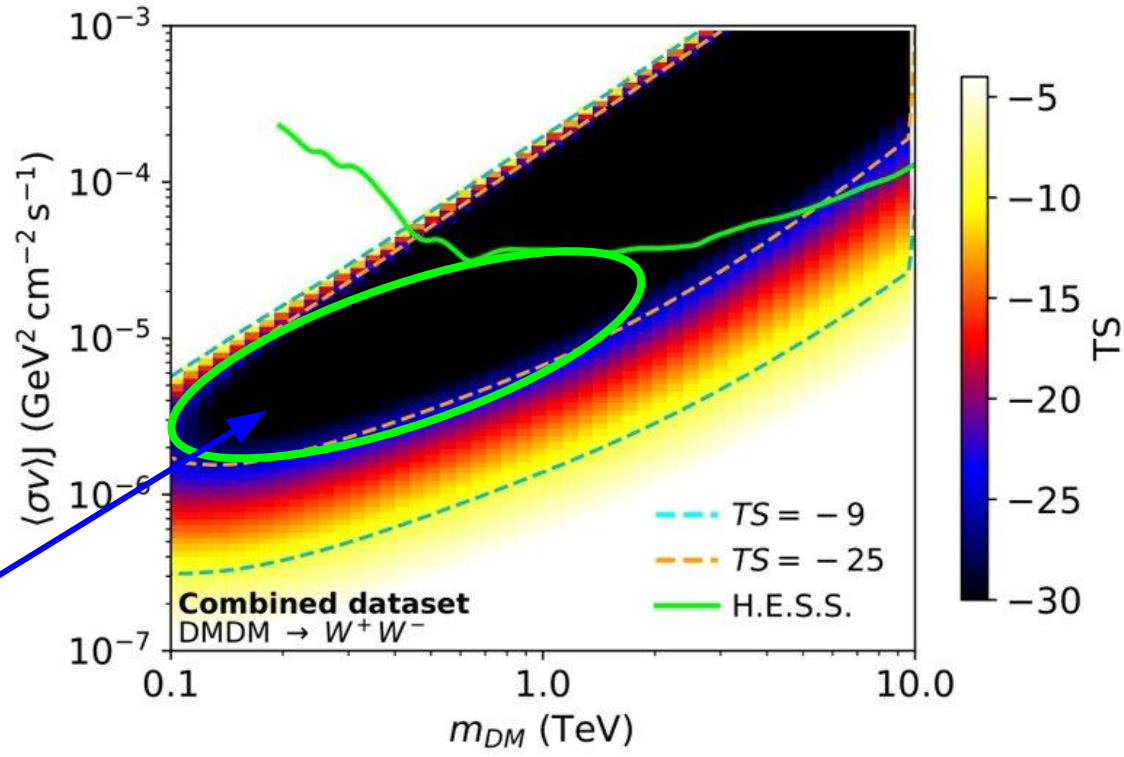
LIMITS AND UNCERTAINTY ON THE J-FACTOR

H.E.S.S. Collaboration, Phys. Rev. D 102, 062001 (2020)

Results for various annihilation channels and including the uncertainty on the J-factor



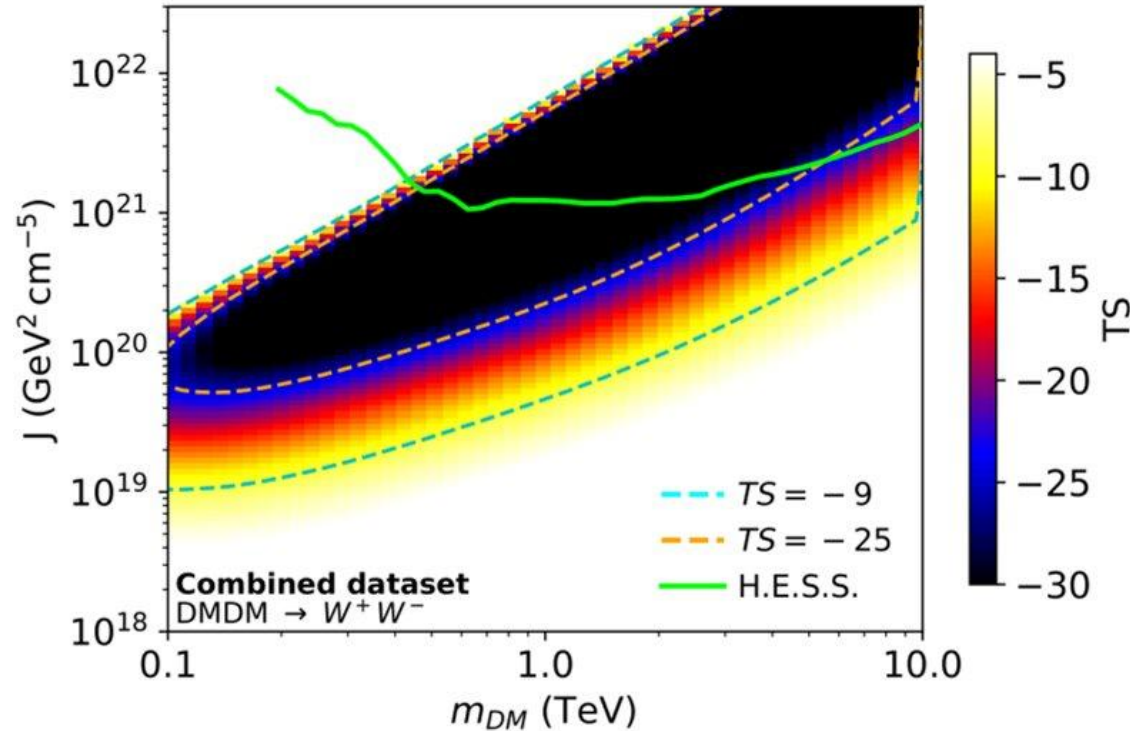
- Combination of Fermi-LAT and H.E.S.S. datasets
- 95% C.L. combined U.L. on the product between the annihilation cross section and the J-factor
- Some viable models to explain the stacked Fermi-LAT datasets and considering the H.E.S.S. U.L.



H.E.S.S. Collaboration, Astrophys. J. 918, 17 (2021)

- Assuming thermally produced WIMPs, we fix the annihilation cross section
- J-factors allowed given combined H.E.S.S.
- But, high J-factors for the UFOS from cosmological simulations

→ **DM induced emission for the UFOS very unlikely, according to the H.E.S.S. constraints**



H.E.S.S. Collaboration, Astrophys. J. 918, 17 (2021)

- Mock dataset of H.E.S.S. IGS observations
→ **simulating 500h and 1000h of flat exposure**

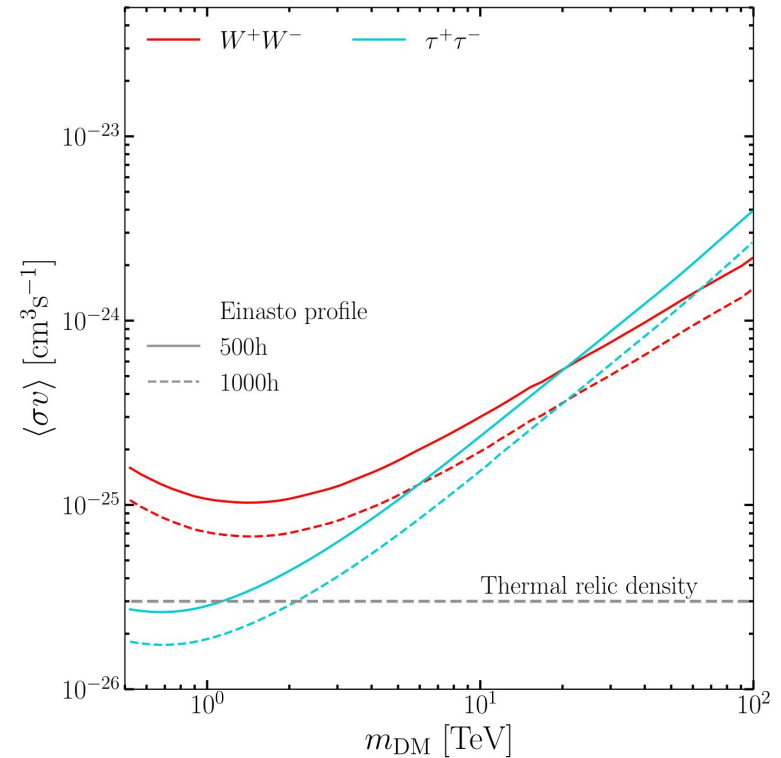
flat exposure

- Most up-to-date and advanced calculations for theoretical gamma-ray DM annihilation yields
- Recent DM profiles determination from measurements of the MW rotation curve

Cautun et al., MNRAS, 494.3, (2020)

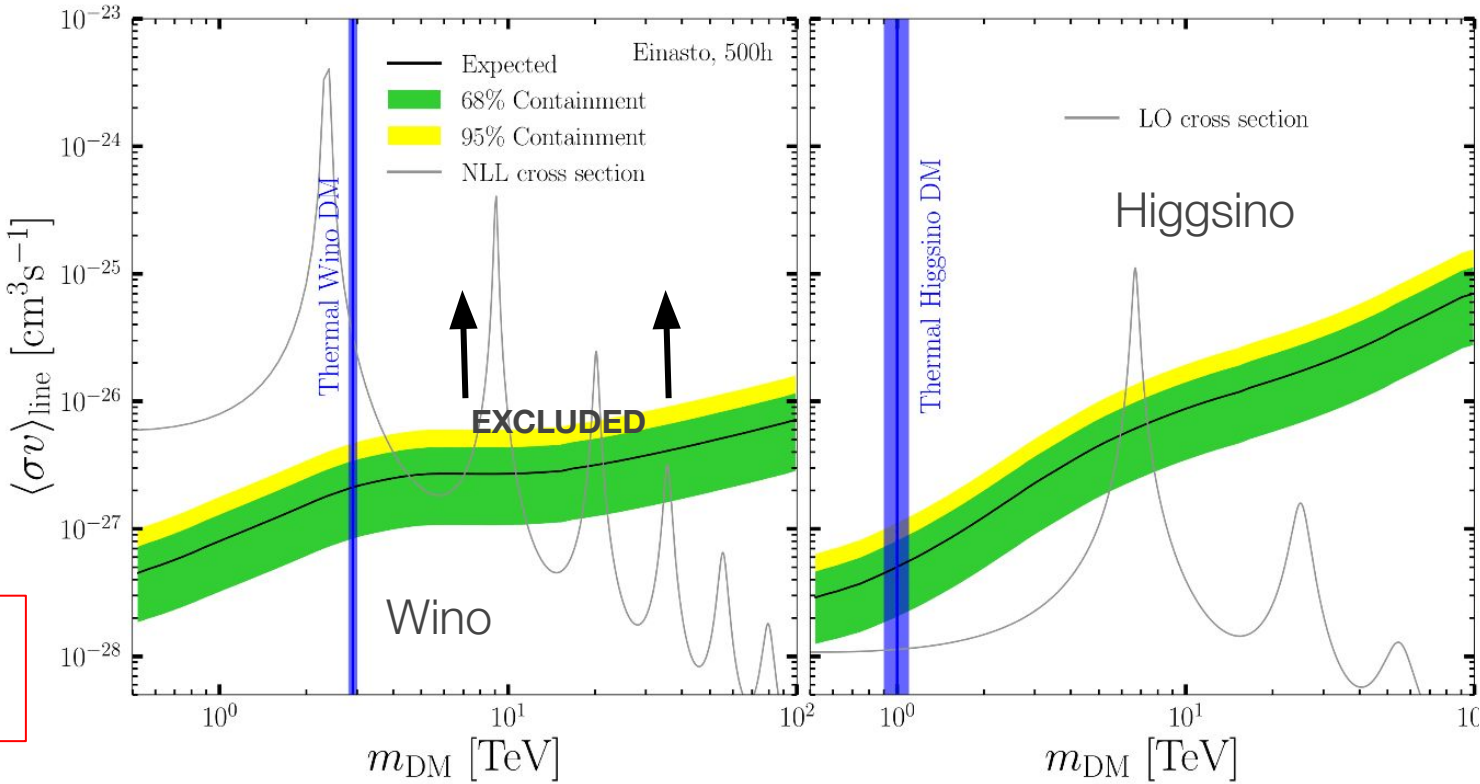
- Background modeling considering residual and conventional TeV astrophysical background

→ **Assessing the ~ final sensitivity reach of the current generation of IACTs**



AM, Emmanuel Moulin and Nicholas L. Rodd, Phys. Rev. D 107, 043028 (2023)

- Thermal Winos excluded
- Higgsino DM masses excluded at around 6.5 TeV



AM, Emmanuel Moulin and Nicholas L. Rodd, *Phys. Rev. D* 107, 043028 (2023)

- The Quintuplet, TeV scale state charged under representation 5 of SU(2)

Ref. for the spectra Bauer, C. W., Rodd N. L., and Webber B. R., JHEP 06, 121 (2021)

- **Thermal Quintuplet excluded within the present sensitivity**
- **A few non-thermally produced Quintuplet models are still available above several ten TeV masses**

AM, Emmanuel Moulin and Nicholas L. Rodd, Phys. Rev. D 107, 043028 (2023)

