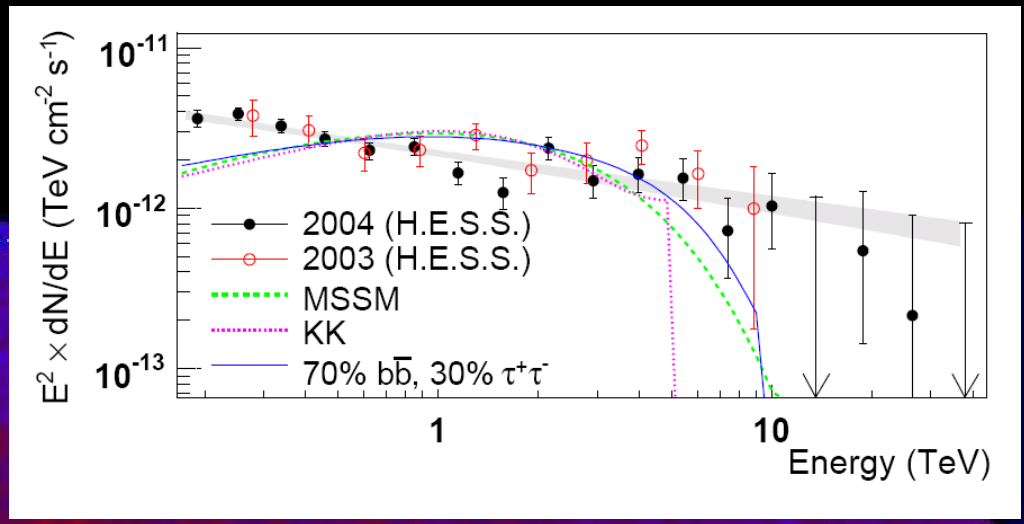
Prospects for Dark Matter Detection from the Galactic Halo with Current IACTs

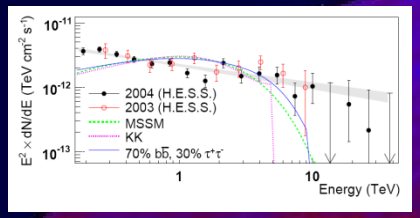
Ullrich Schwanke
Humboldt University Berlin

Galactic Centre



Galactic Centre

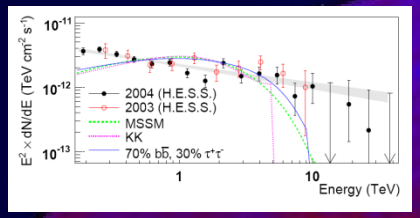
Unidentified sources from the H.E.S.S. scan



Galactic Centre

Unidentified sources from the H.E.S.S. scan

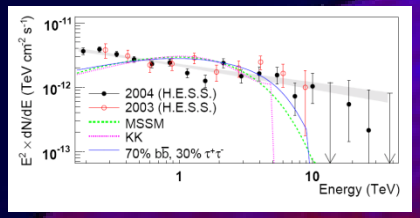
Neighbouring Galaxies, Globular Clusters

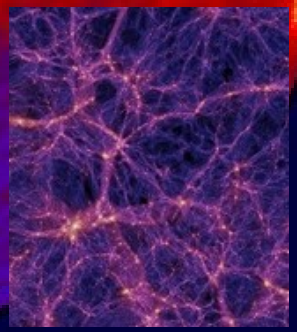


Galactic Centre

Unidentified sources from the H.E.S.S. scan

Neighbouring Galaxies, Globular Clusters



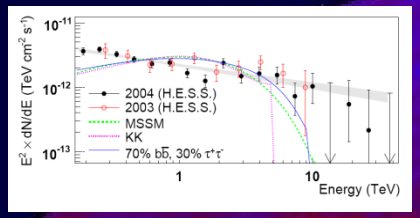


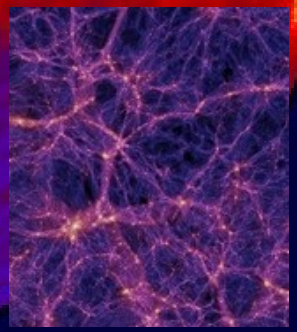
Anisotropies of Extragalactic γ-rays

Galactic Centre

Unidentified sources from the H.E.S.S. scan

Neighbouring Galaxies, Globular Clusters





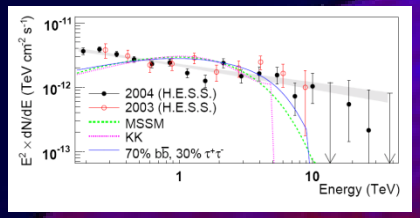
Dwarf Galaxies orbiting the MW

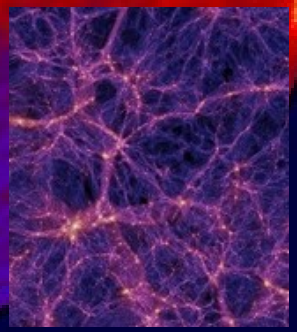
Anisotropies of Extragalactic γ-rays

Galactic Centre

Unidentified sources from the H.E.S.S. scan

Neighbouring Galaxies, Globular Clusters





This Talk!

Dwarf Galaxies orbiting the MW

Milky Way Halo

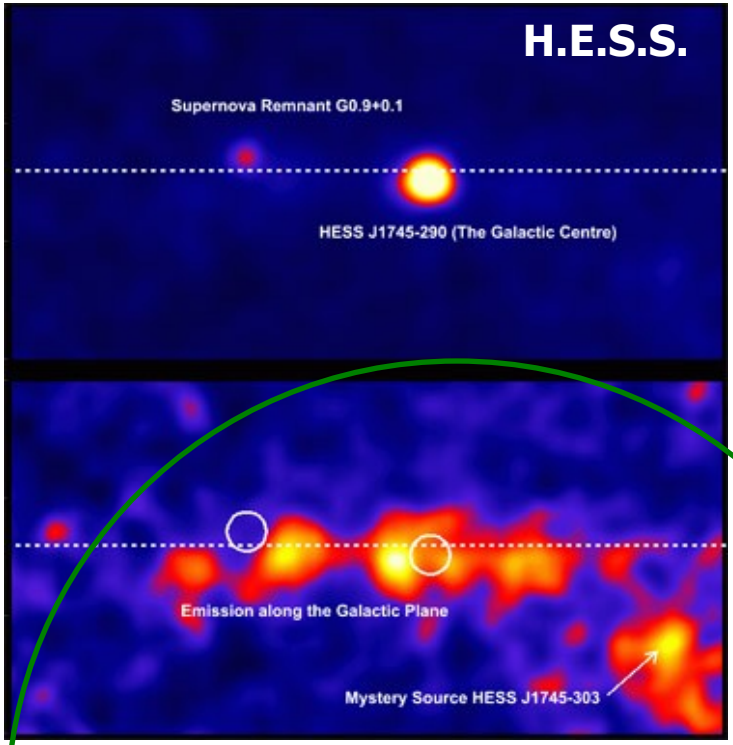
Anisotropies of Extragalactic γ-rays

Contents

- **Why is the Milky Way Halo a good target ?**
- **Expected fluxes and H.E.S.S. sensitivity**
- **Possible observation techniques and their challenges**
- **Summary**

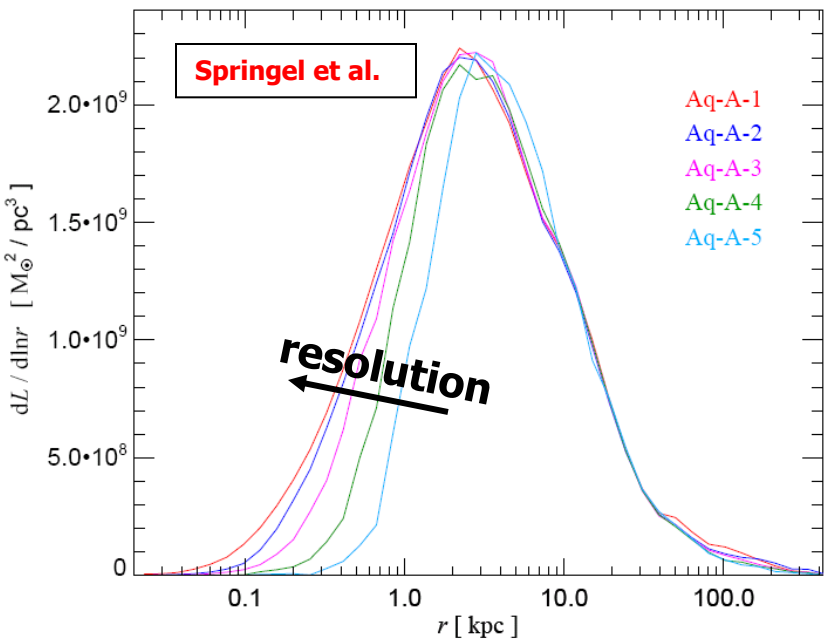
Why the Milky Way Halo ?

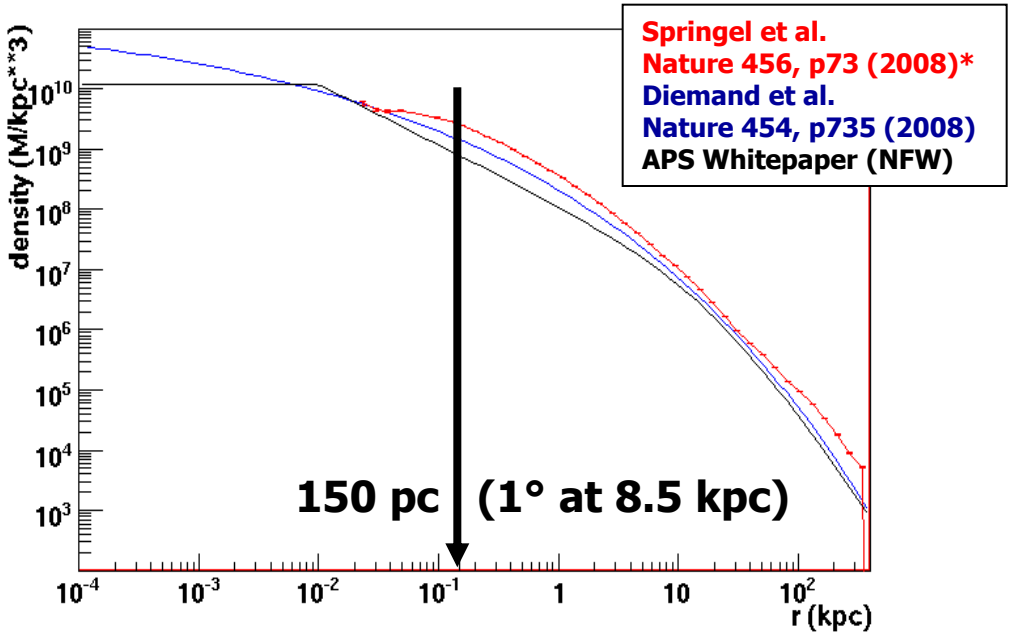
- It's relatively close.
- Avoids astrophysical souces close to the GC (HESS J1745-290, diffuse emission etc.) and in the Galatic plane.
- Avoids uncertainties related to the poor knowledge of the exact shape of the DM density close to the Galactic Centre.
- Recent N-body simulations (Springel et al. (2008)) predict that the smooth halo component is the largest contribution seen by an observer placed within the MW.



H.E.S.S. Field of View (5° diameter)

Predictions (1/3)



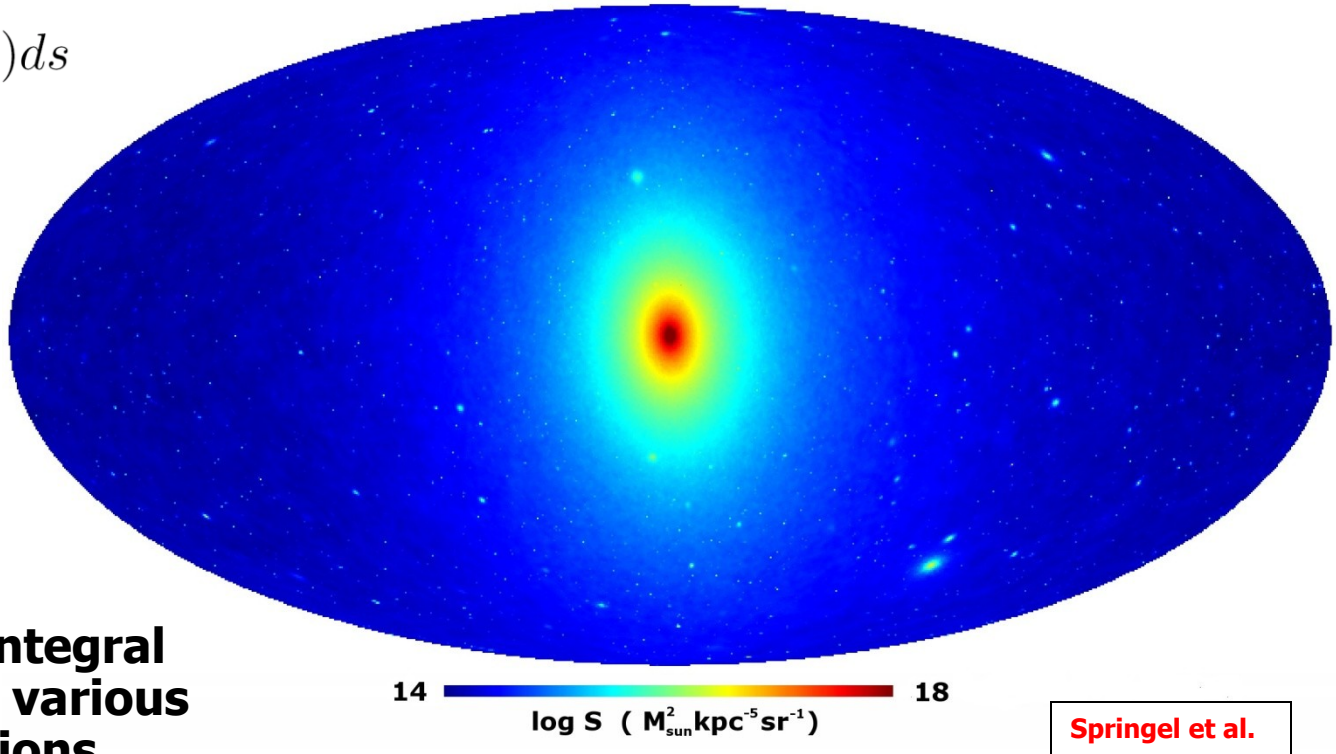


- **The highest-resolution N-body simulation (Springel et al.) used particle masses of ~1700 M_{sun} and attained converged length scales of 120 pc**
- **Claim that all substructures are taken into account → no additional boost factores are expected**

***Only the density of the smooth halo component is shown.**

Predictions (2/3)

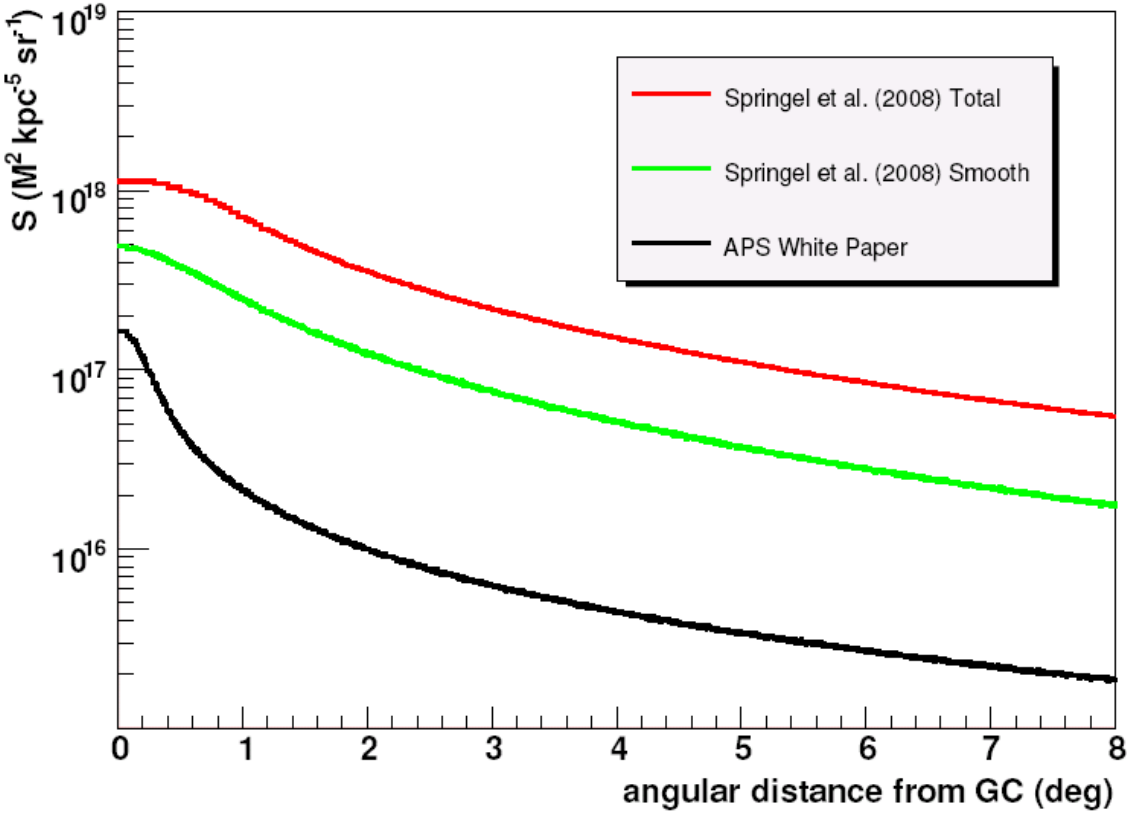
$$S = \frac{1}{4\pi} \int_{\mathrm{los}} \rho^2(r(s))ds$$



Springel et al.

- **Line-of-sight integral averaged over various observer positions**
- **Smoothed with a PSF of 10‘**

Predictions (3/3)

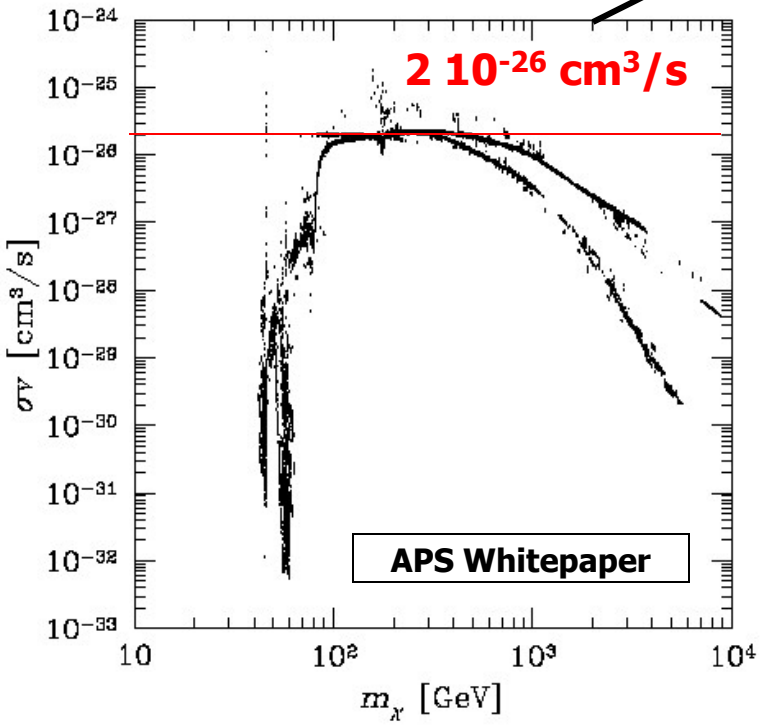


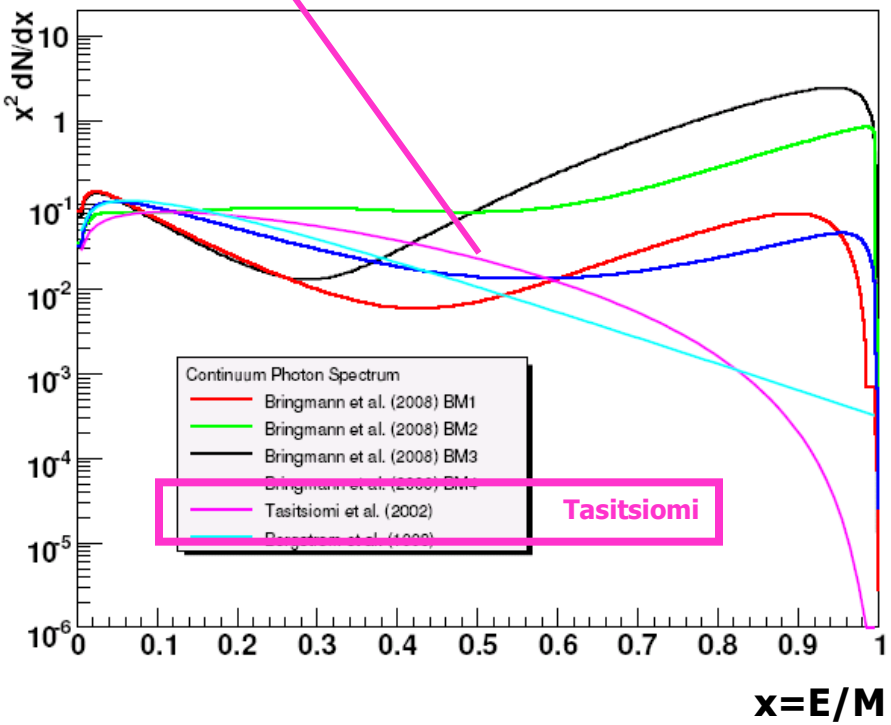
- **Einasto profile provides better description of DM density than NFW**
- **Boost due to substructure is only ~3 close to the Galactic centre**
- **Impact of baryons?**
- **Matching between simulated galaxy and Milky Way ?**

Concise Assumptions…

$$\frac{d\Phi}{dE} = \langle \sigma v \rangle \cdot \frac{1}{M^2} \frac{dN_\gamma}{dE} \cdot S$$

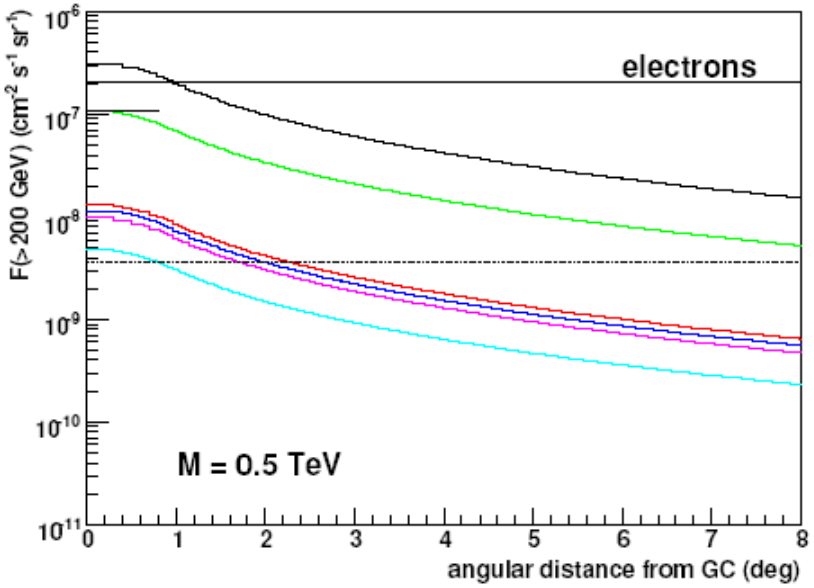
Springel et al.

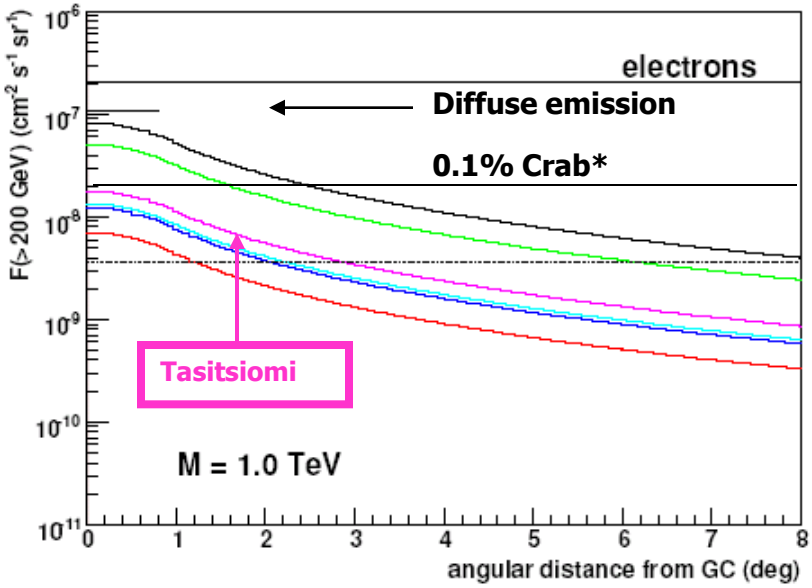




- **WIMP Mass M = 0.5 – 1 TeV**

...Diffuse Fluxes



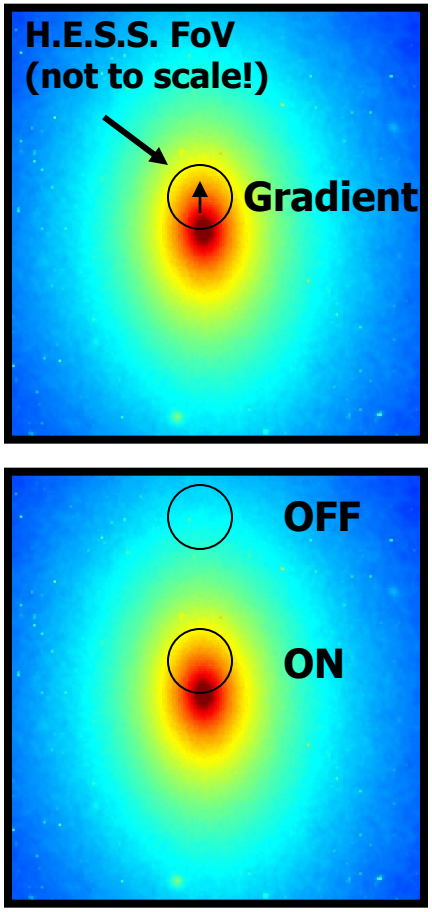


- **Plotted fluxes above 200 GeV**
- **At 1° from the Galactic Centre, the predicted DM photon flux is a factor ~10 (~20) below the diffuse emission from the Galactic plane (the electron flux)**
- **Flux falls by one order of magnitude when going from 1° to 8°**

*** Solid angle of $\Delta\Omega=2\pi(1-\cos(0.\ 1°))$**

DM Annihilation Flux

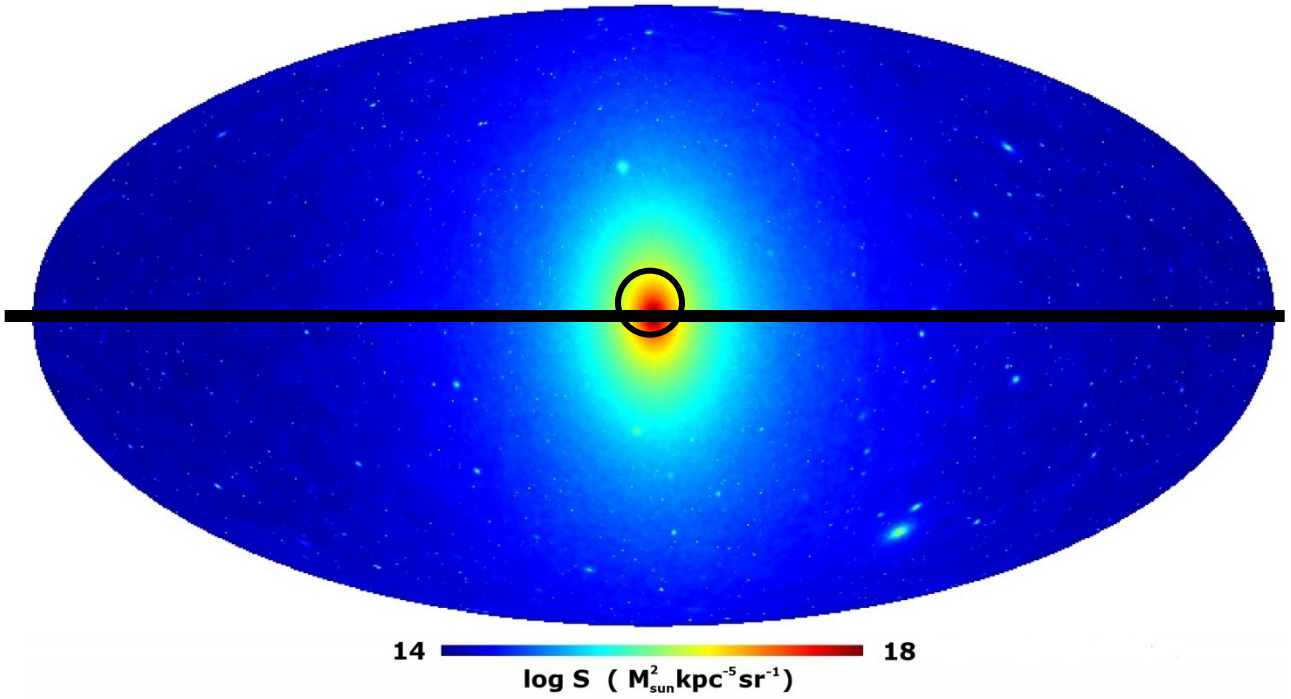
- The estimated flux is too low to measure a gradient within one field of view
- Alternatively: Sum flux over areas covering a good fraction of the FoV (or the entire FoV)
- Use areas further away from the GC for normalization
- Exploit spectral features (maybe on top of an astrophysical background)



H.E.S.S.

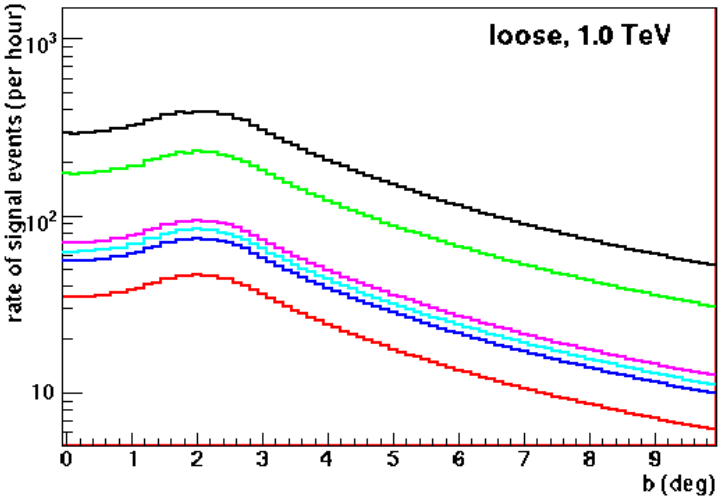
- 4 telescopes (12m diameter) located in Namibia
- Trigger threshold 100 GeV, angular resolution ~0.1°, energy resolution ~15%
- Sensitivity: 1% Crab in 25h (for 5σ, 20° zenith angle)
- A fifth telescope (27m, H.E.S.S. II) with lower threshold is being added

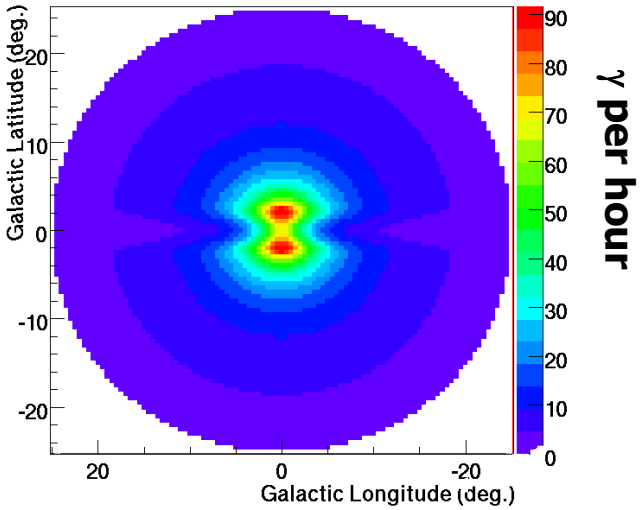
Sensitivity (1/3)



- **Blanked out Galactic plane (i.e. considered only |b|>0.8°)**
- **Events within 2° radius of observation position**

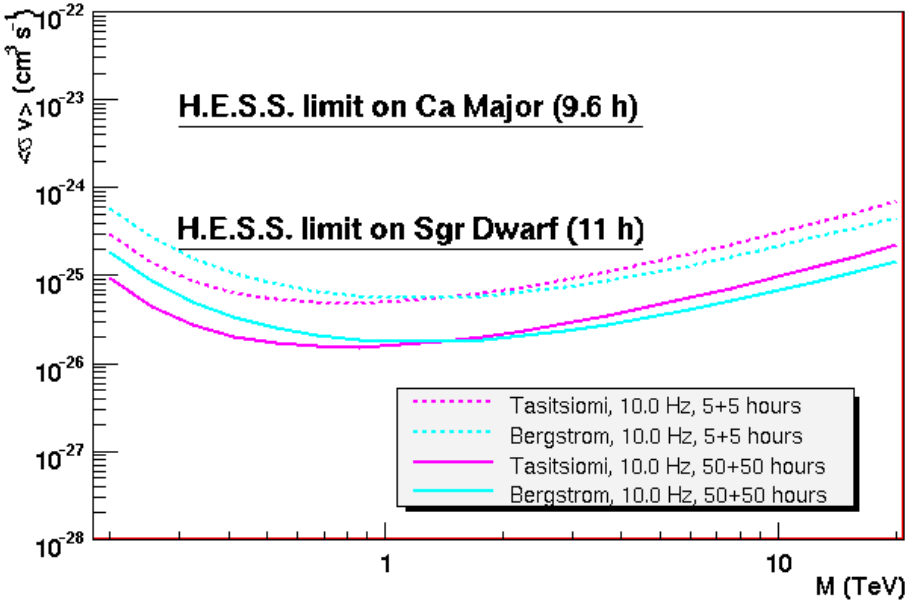
Sensitivity (2/3)





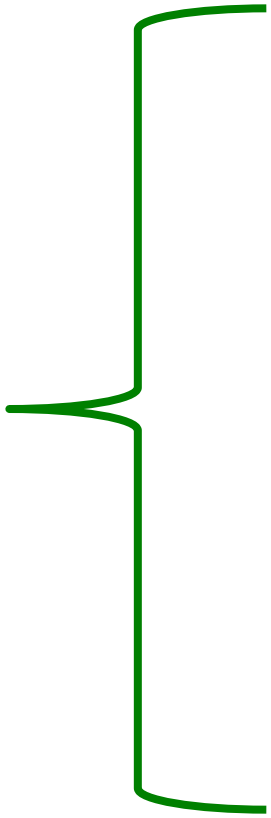
- **Hillas-type analysis and (loose) selection cuts**
- **H.E.S.S. effective areas evaluated at 20° zenith**
- **~100 events per hour**
- **Backgrounds:**
  - **Hadrons+Electrons (1.5 Hz): ~15 Hz (from data)**
- **A better analysis should reduce the background rate by a factor 2-3**

Sensitivity (3/3)

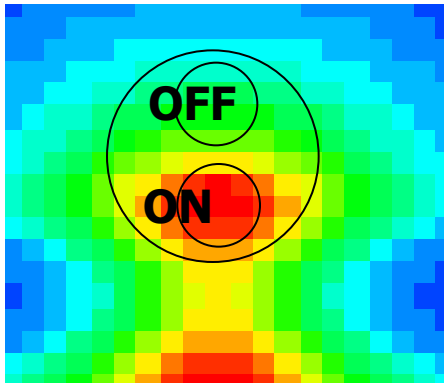


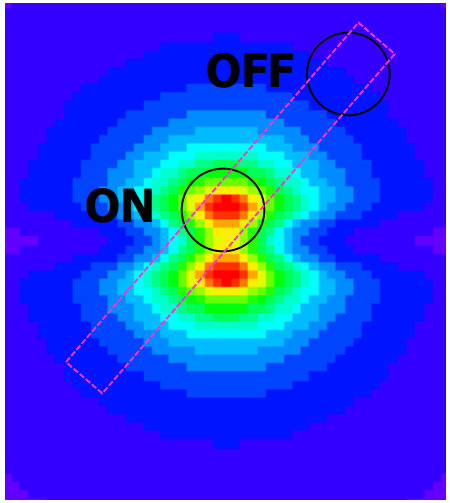
- **After 5h ON + 5h OFF, the limit is more constraining than limits obtained from the dwarf galaxies… assuming the astrophysical factor from the Aquarius simulations**
- **Caveat: perfect background subtraction**
- **Sensitivity for the DM halo at a boost factor of O(1)**

For Experimentalists



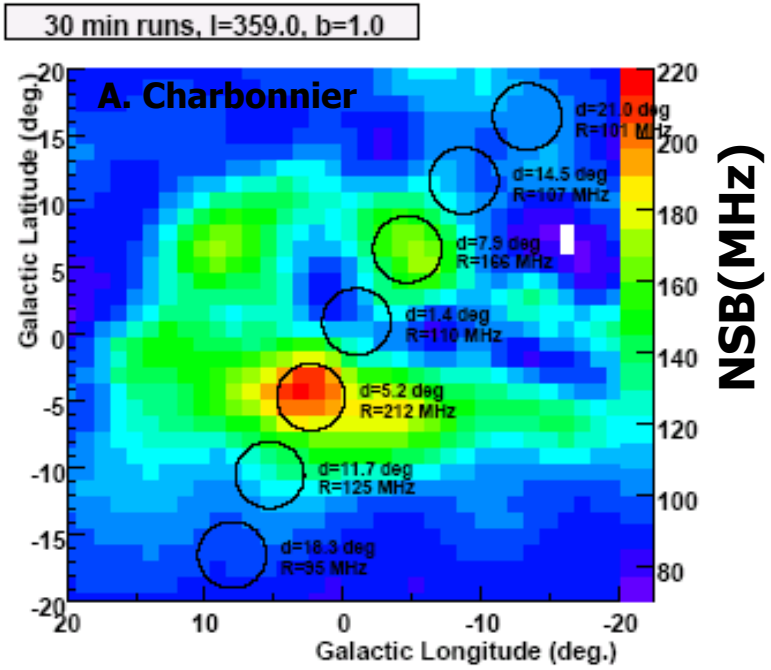
Flux Measurement

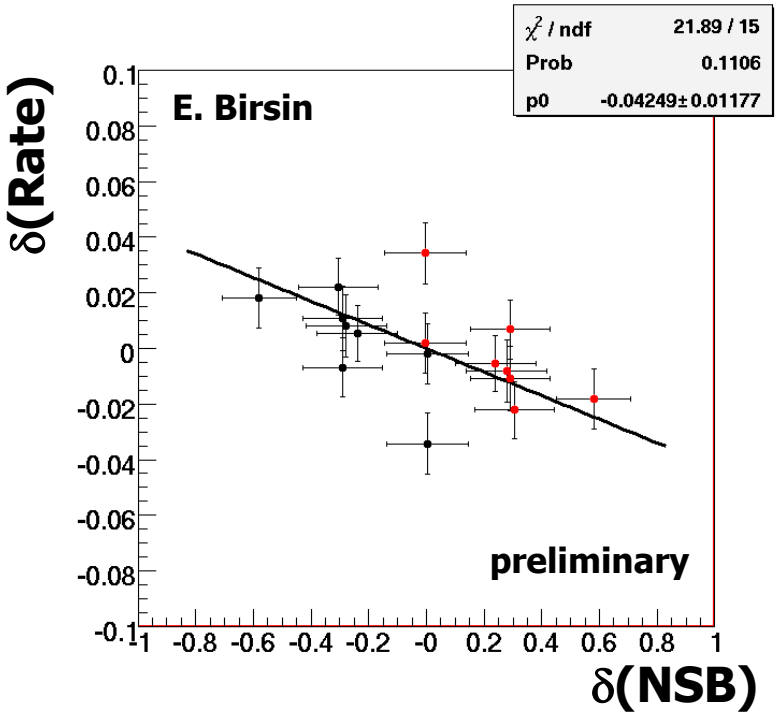




- Compare sky regions within one FoV that have identical acceptance but different distance from the GC
- Compare FoVs that differ *only* by their distance to the Galactic centre
  - Varying zenith and azimuth angles → ON-OFF data with offset in RA or drift-scan data
  - Varying weather conditions and detector state → take ON and OFF in same night; monitoring
  - Varying NSB/stars in FoVs → careful selection of FoVs; corrections
- Take data with constant acceptance (drift-scan)

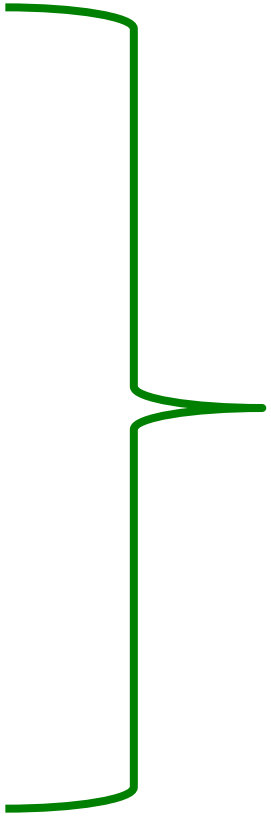
Experimental Challenges





- **The ON-OFF technique requires careful consideration of systematic effects, like**
  - **Varying night sky background, stars in FoV**
  - **Varying weather conditions, varying camera state**

For Experimentalist



Summary

- **A search for diffuse DM photons from the Halo at distances ≥0.5° from the GC with IACTs has potential**
  - **Reduced uncertainties on astrophysical factor (DM profiles)**
  - **Possibly better limits on $<\sigma v>$ than from dwarf galaxies**
- **The measurement of diffuse photon fluxes is challenging for IACTs, and requires dedicated techniques and careful control of systematic effects**
- **Current IACTs (like H.E.S.S. (II)) are an ideal testing ground and first results will be published soon**
- **Prospects for CTA should be good – we are working out the details**

Thank you.