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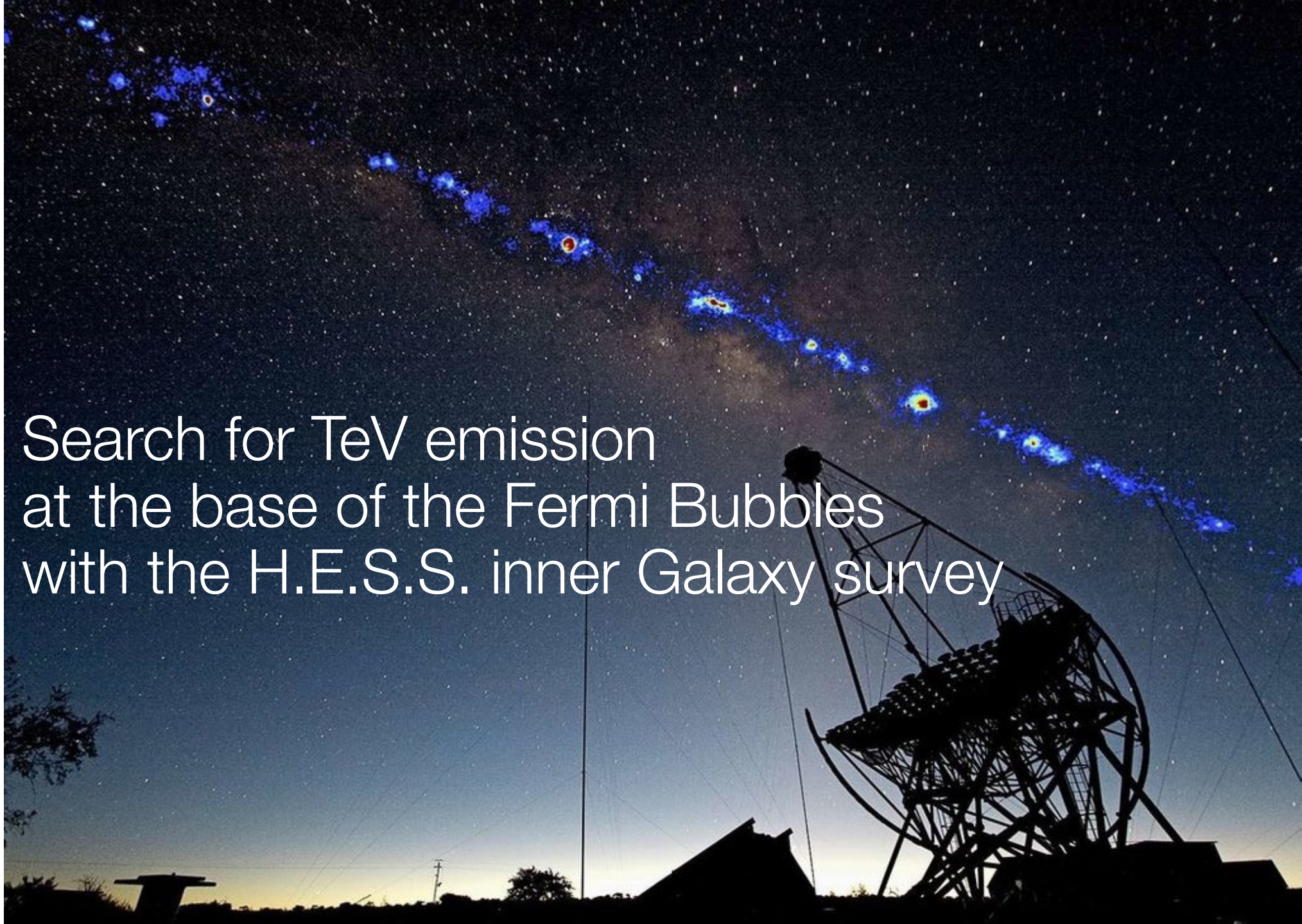
ICRC – 19th July 2021

Search for TeV emission at the base of the Fermi Bubbles with the H.E.S.S. inner Galaxy survey



Outline

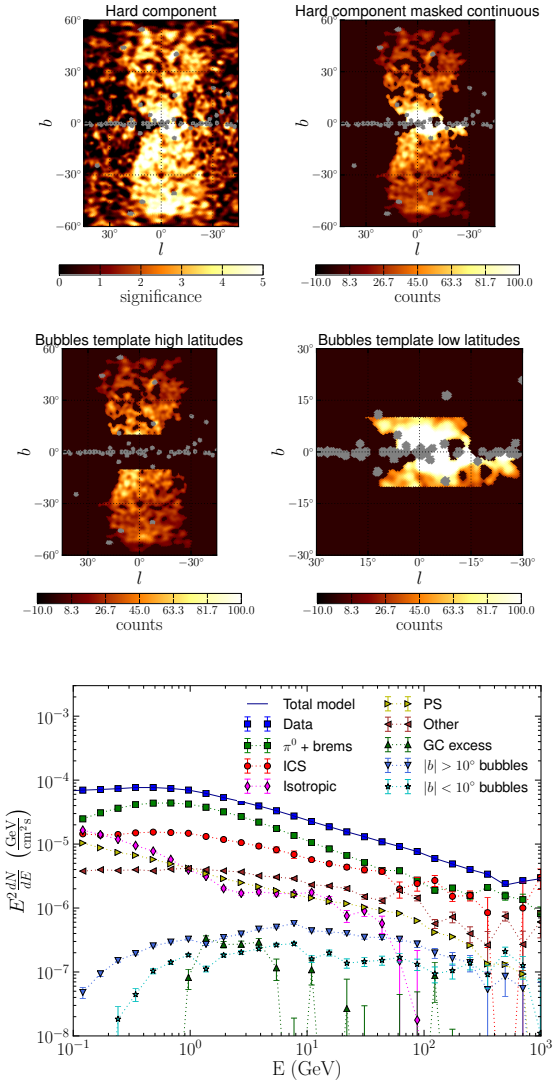
- Aim: search for the low-latitude Fermi Bubbles TeV emission
- Fermi-LAT template of the Fermi Bubbles
- H.E.S.S. data analysis
- Differential flux upper limits
- Discussion

Search for low-latitude Fermi Bubbles emission

- Fermi Bubbles discovered about a decade ago : a double-lobe structure extending up to 55° in Galactic latitudes above and below the Galactic Centre
- Possible counterparts at other wavelengths, e.g., the microwave haze and X-ray features near GC

- At Galactic latitudes >10°, their morphology is consistent with an almost uniform distribution and their energy spectrum a E^{-2} with a significant softening above ~100 GeV

- The Fermi Bubbles emission is brighter at low-latitudes, i.e. <10°, an energy spectrum that remains hard a E^{-2} up to ~1 TeV



Ackermann et al. (Fermi-LAT Coll.), 2017, ApJ 840, 43

Search for low-latitude Fermi Bubbles emission

- Deep observations of the FBs near the GC in VHE gamma- rays can provide crucial insights into their origin:
  - AGN-like burst: past activity of the SMBH Sagittarius A*
  - a star-formation activity near the GC
  - multiple core-collapse supernovae

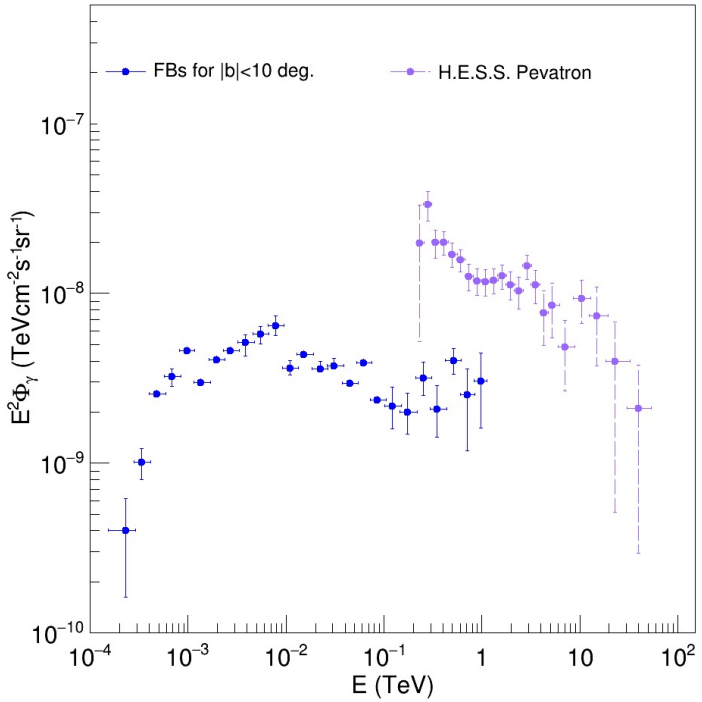
  …

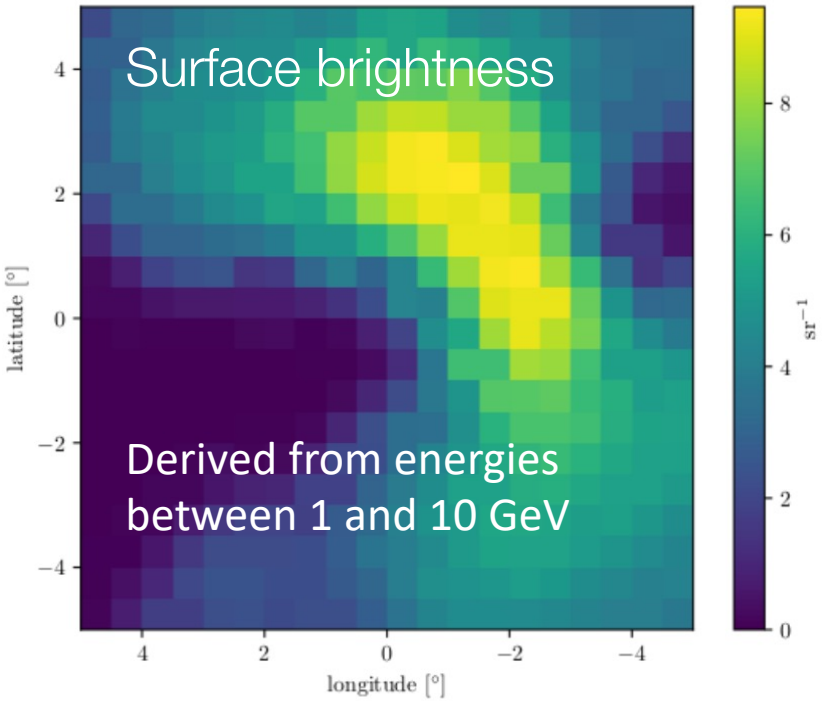
- H.E.S.S. TeV measurements can be used to study the base of the FBs and help to distinguish between different scenarii of the Bubbles formation

Low-latitude Fermi Bubbles template

- Spatial template from Fermi-LAT

  M. Ackermann et al 2017 ApJ 840 43 (Fermi-LAT Collaboration)
- Best-fitted: power law with spectral index Γ=1.9
- Maximum surface brightness at Galactic longitude $l \approx$ -1◦ and latitude $b \approx 2$◦.

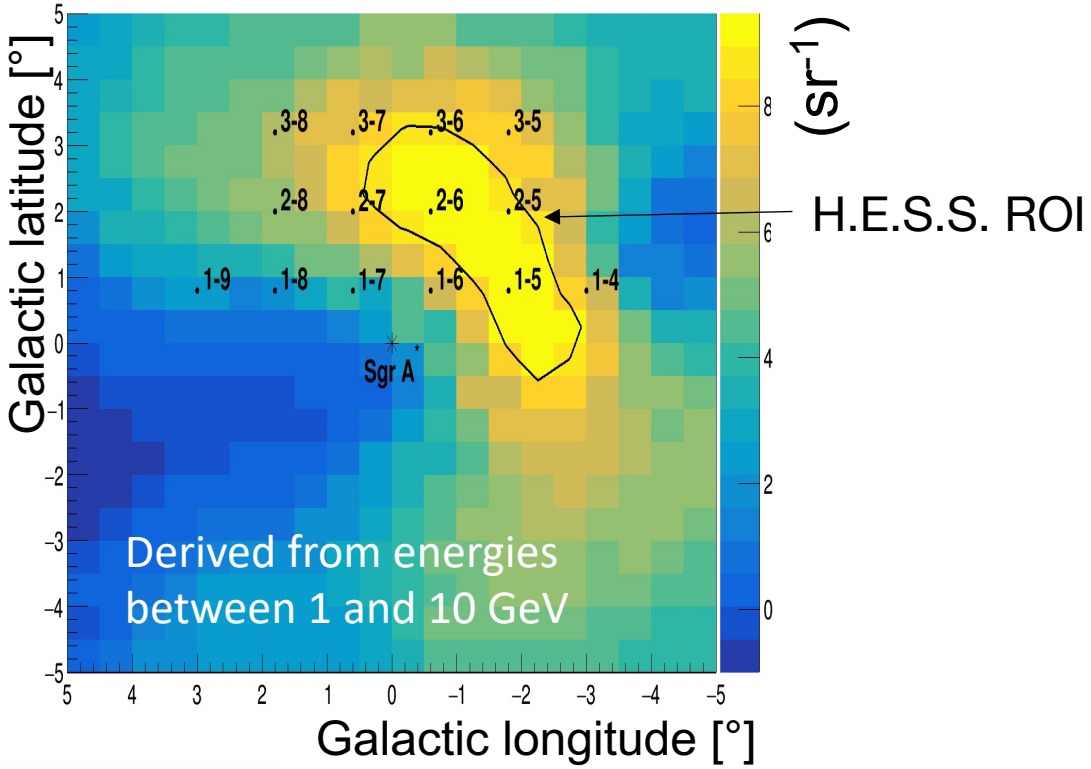




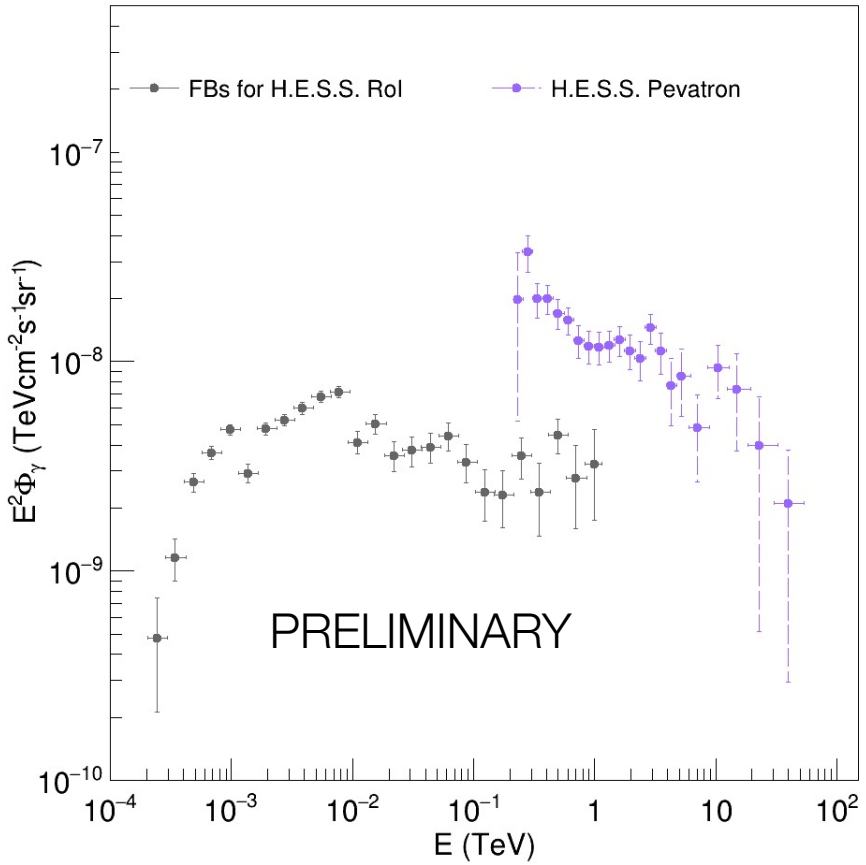
Fermi Bubbles spectrum in the H.E.S.S. ROI

From the Fermi Bubbles spatial template given in a region of 10°x10° around GC:

- The energy spectrum of the FBs is re-computed in the H.E.S.S. ROI



H.E.S.S. ROI

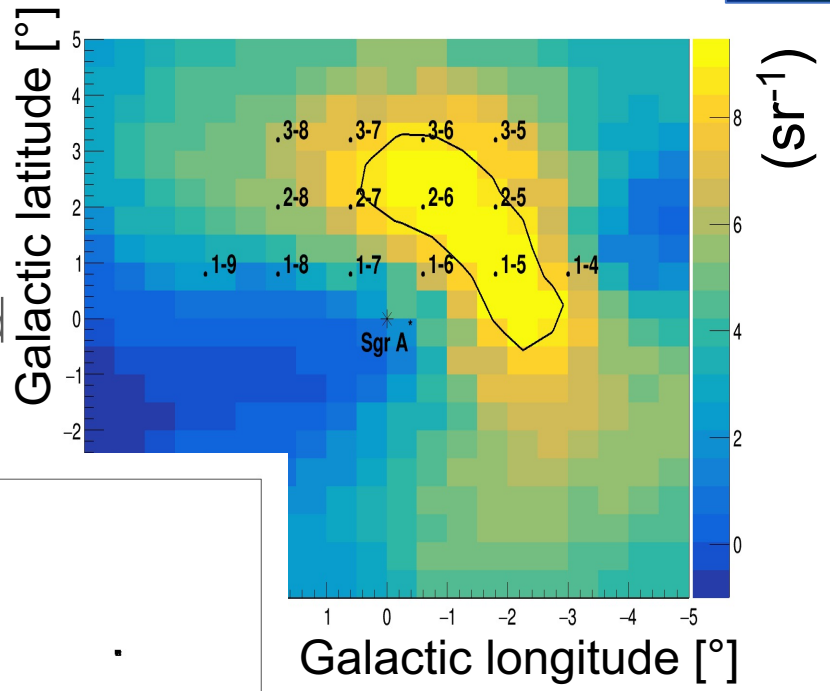


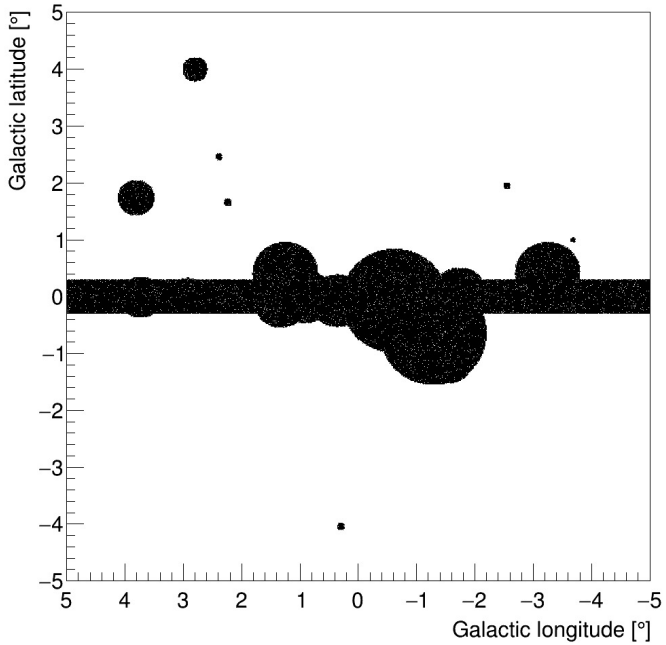
Exclusion regions and background measurement

- The GC region is a very crowded region in VHE gamma rays

- Conservative set of exclusion regions used to avoid contamination of the nearby VHE sources/emissions
  - Sources and Diffuse emission from Galactic Plane
  - Additional masks on 13 Fermi-LAT sources within the 10° around the GC

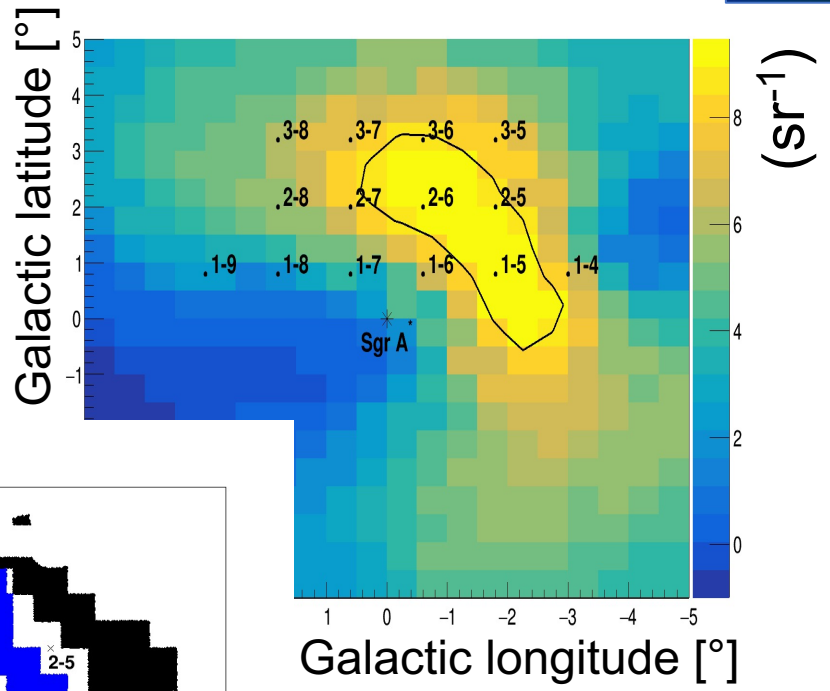
Ajello et al. (Fermil-Lat coll.), Astrophys.J.Suppl. 232, 2 (2017)

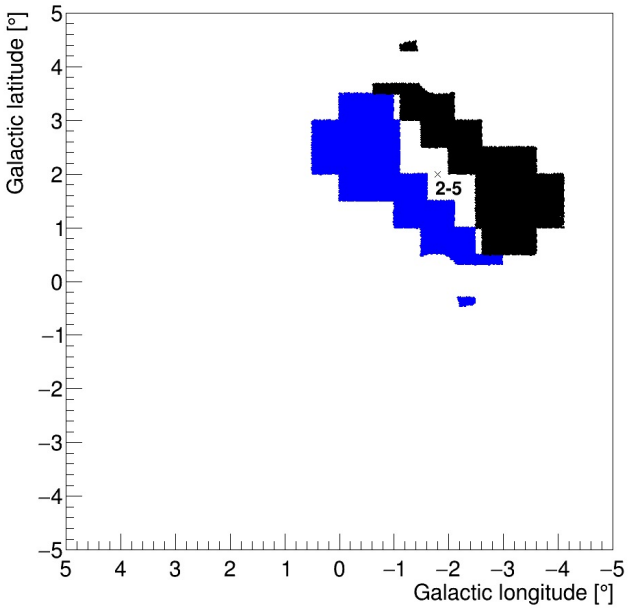




Exclusion regions and background measurement

- Reflected background method on a run-by-run basis:
  - Symmetric OFF (black) wrt the ON (blue)
    → same $\Delta\Omega$ and acceptance
  - The signal gradient is maintained between the ON and the OFF
  - Excluded regions and overlapping areas removed both in the ON and OFF





Data analysis

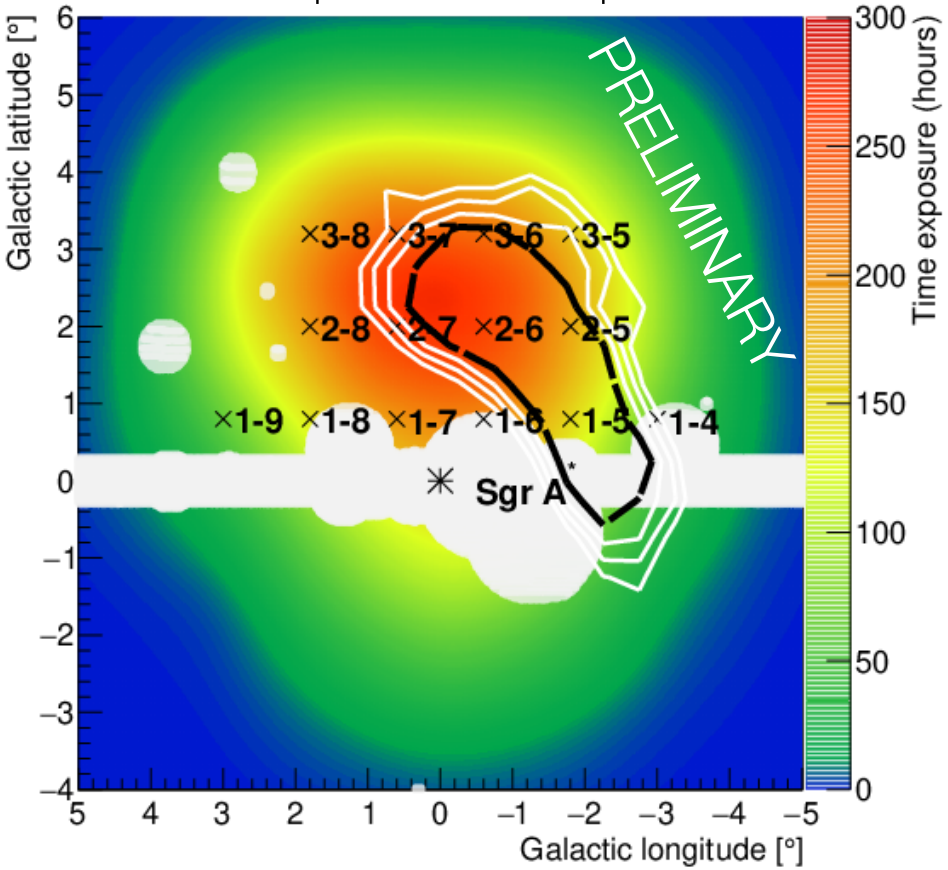
- 2014-2020 observations with the five-telescope array of H.E.S.S.
  - 546 hours of high-quality data
  - mean observational zenith angle 18°

- 14 IGS pointing positions
  - Fermi-LAT contours in white
  - H.E.S.S. ROI in black

- No significant excess between the ON and OFF energy count distributions

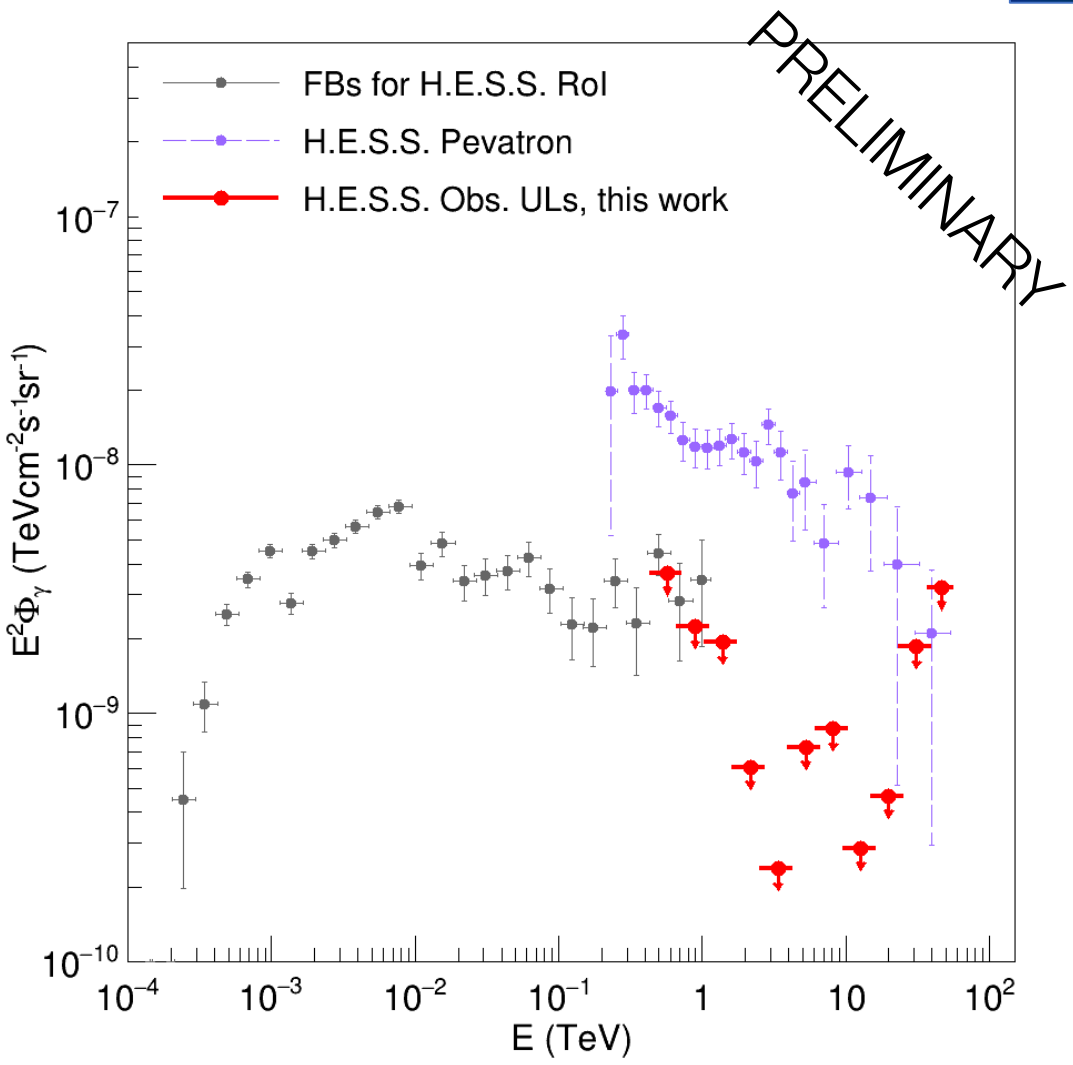
→ derivation of flux upper limits

Exposure map



Differential flux upper limits

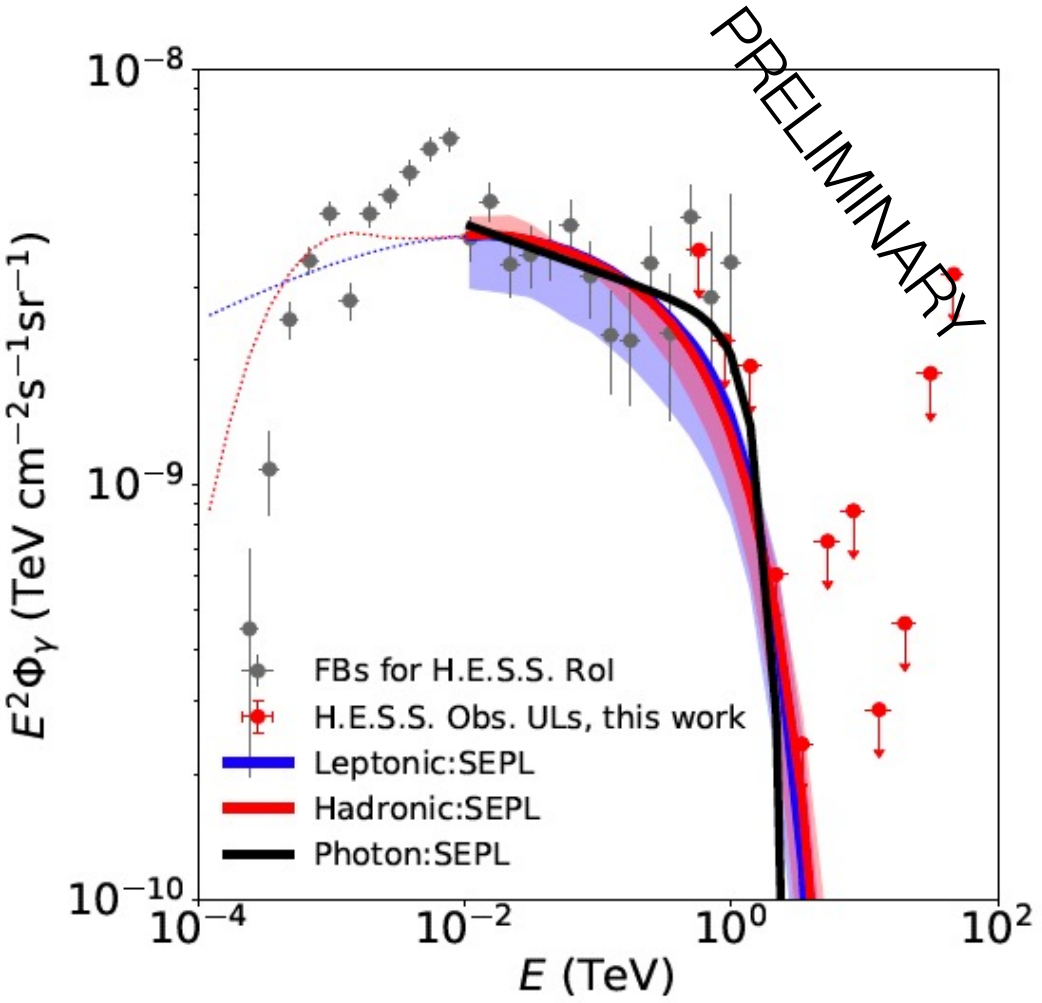
- 546 hours of high-quality data
- No significant excess between the ON and OFF energy count distributions according to the background method determination
- Differential flux upper limits
  - 0.2 dex energy bins
  - 95% C.L. UL
  - 20% systematic uncertainty included



Results and discussion

- Constraints on model parameters of the injected particle spectrum in leptonic and hadronic scenarios

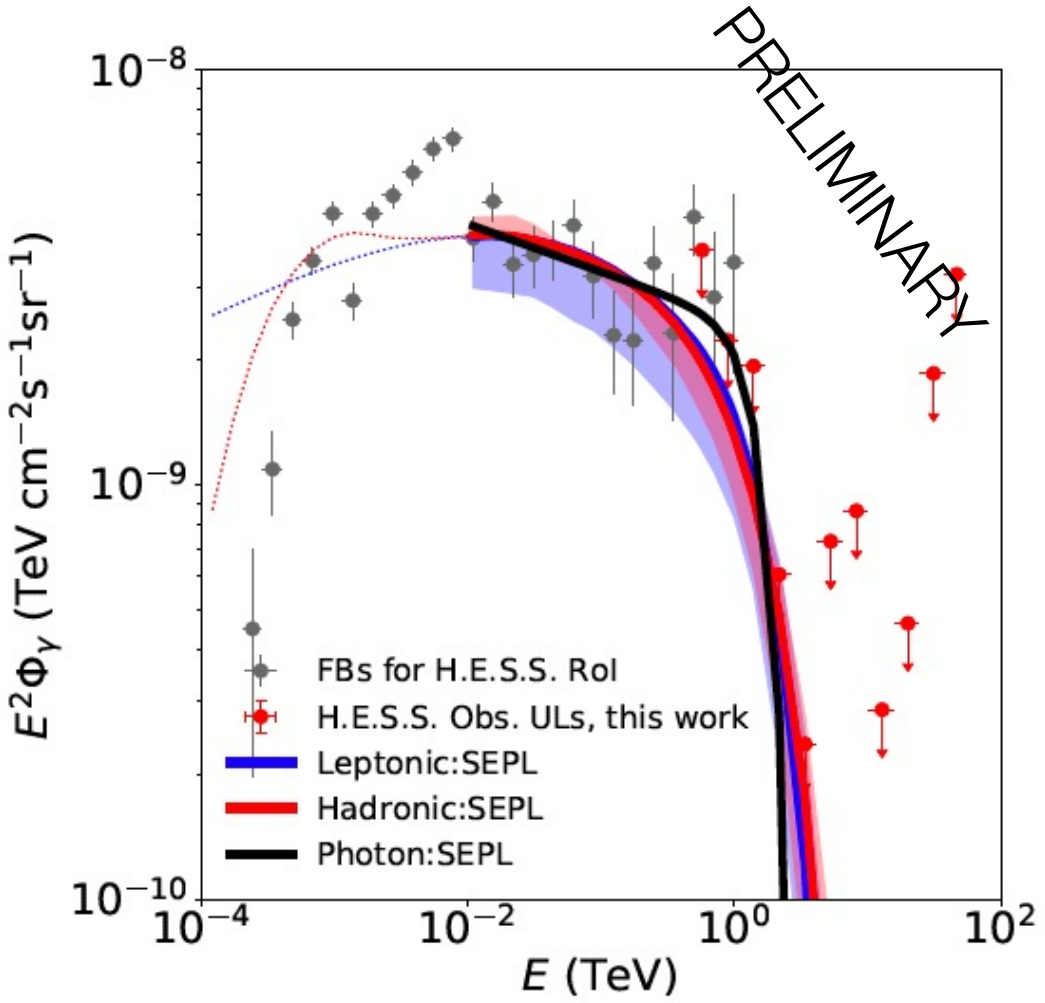
- Joint analysis of Fermi-LAT and H.E.S.S. datasets, the energy cutoff in the photon spectrum is $E_{\gamma,cut} = 1.1^{+0.6}_{-0.4}$ TeV
  - 95% C.L. UL is 2.2 TeV



Results and discussion

- Constraints on model parameters of the injected particle spectrum in leptonic and hadronic scenarios

- Assuming one-zone leptonic and hadronic models:
  - 95% C.L. upper limit on the energy cutoff are:
    $E_{\mathrm{e,cut}} = 9.7$ TeV and $E_{\mathrm{p,cut}} = 22.9$ TeV



Summary

- IGS campaign with pointing positions up to 3.2° is very fruitful:
  - 546 hours of high-quality data from 2014 to 2020.

- Computation of 95% C.L. observed upper limits including systematic uncertainty: ~ 2×10^{-9} TeVcm^{-2}s^{-1}sr^{-1} at 1 TeV

- Assuming an energy-independent spatial template of the Fermi Bubbles in the TeV energy range:
  → the H.E.S.S. upper limits constraint power-law extrapolation in the TeV energy range of the best-fit Fermi-LAT spectrum with a hard index

- Constraints in leptonic and hadronic scenarii on model parameters of the injected particle spectrum