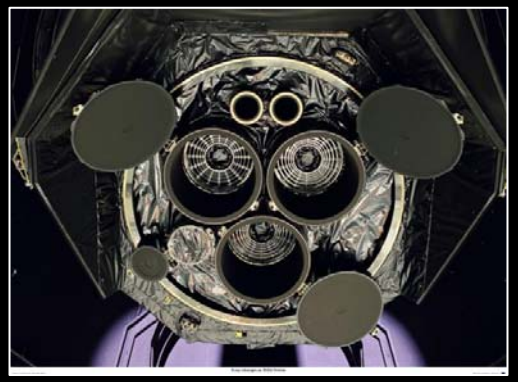
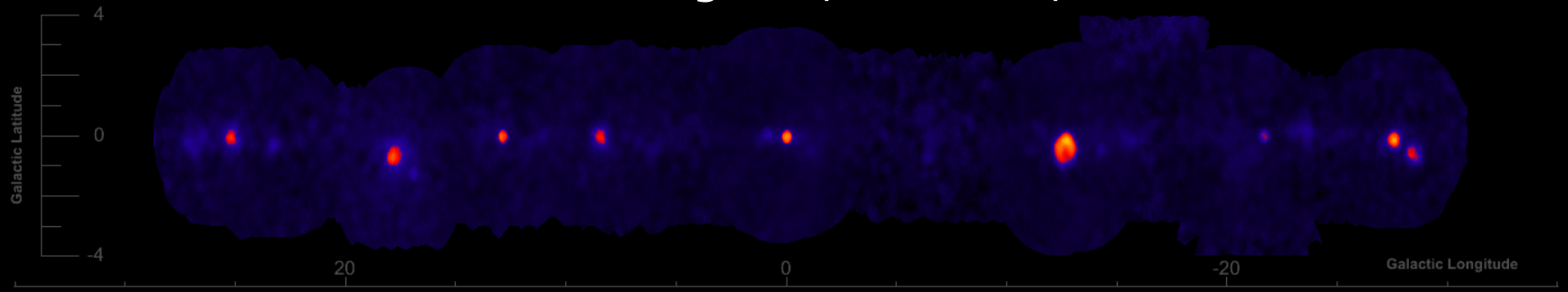




X-ray observations of unidentified H.E.S.S. γ-ray sources

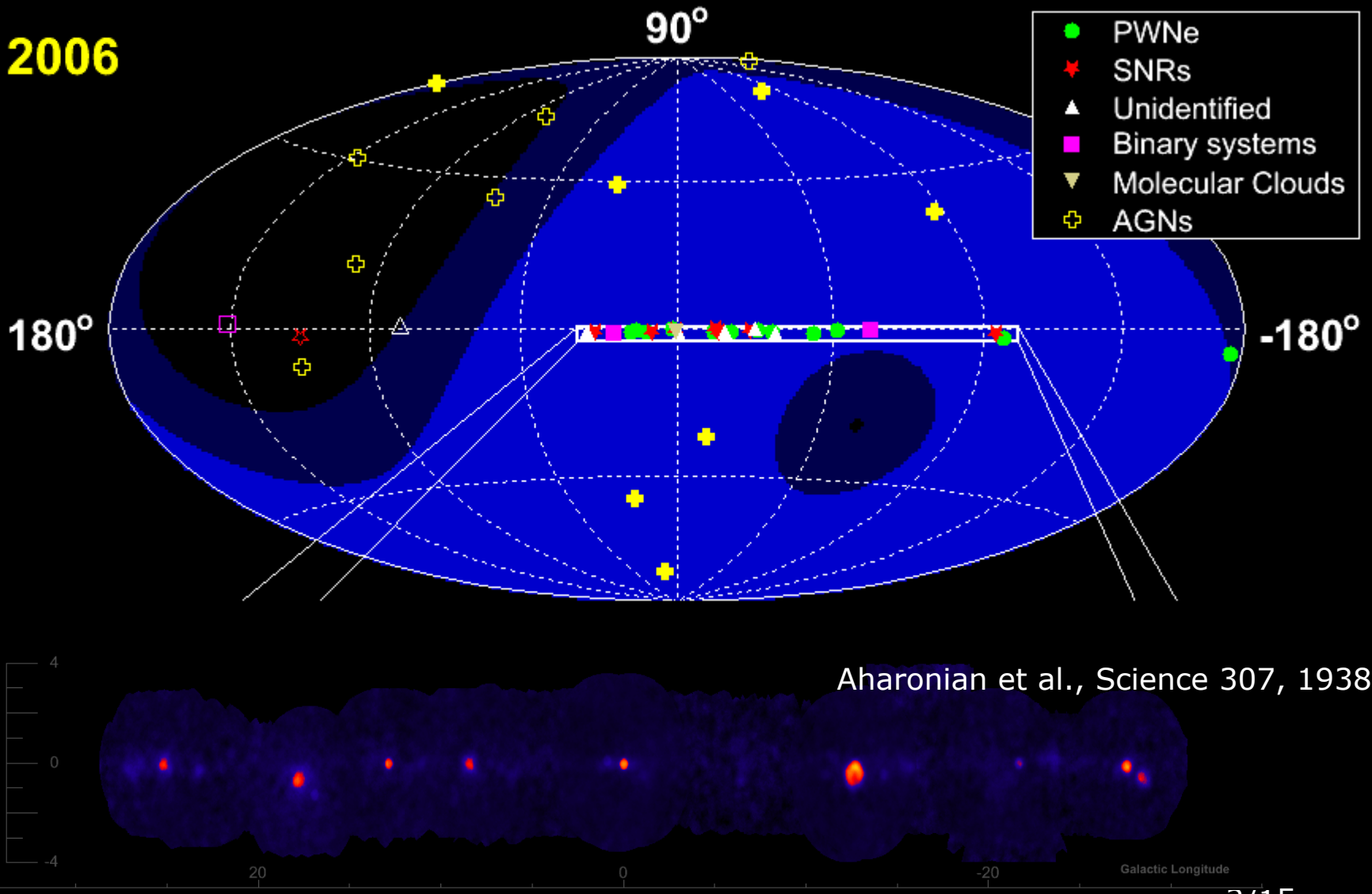
S.Funk

+

J. Hinton, O. Reimer, F. Aharonian,
W. Hofmann, S. Wagner, G. Puehlhofer, J. Vink,
Y. Moriguchi, Y. Fukui, …



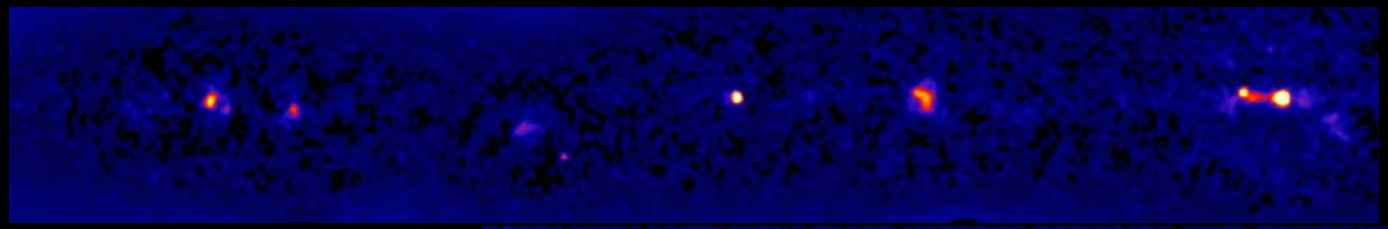
The VHE Gamma-ray Sky

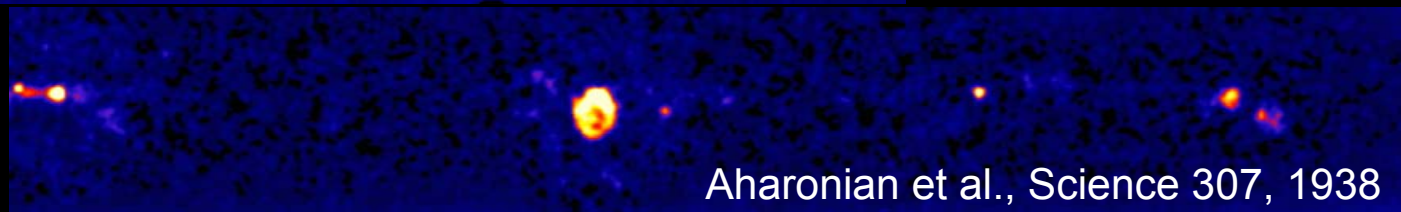


Aharonian et al., Science 307, 1938

H.E.S.S. unidentified sources

- First 2-3 years of H.E.S.S. operations:
  - >15 (initially) unidentified γ-ray sources
  - Mostly found in Galactic plane survey
  - Some serendipitously in targeted observations
  - Common properties of these sources:
    - » Positioned along the plane
    - » Most of the sources (at least) slightly extended
    - » Energy spectra rather hard (Photon index ~ 2.2)



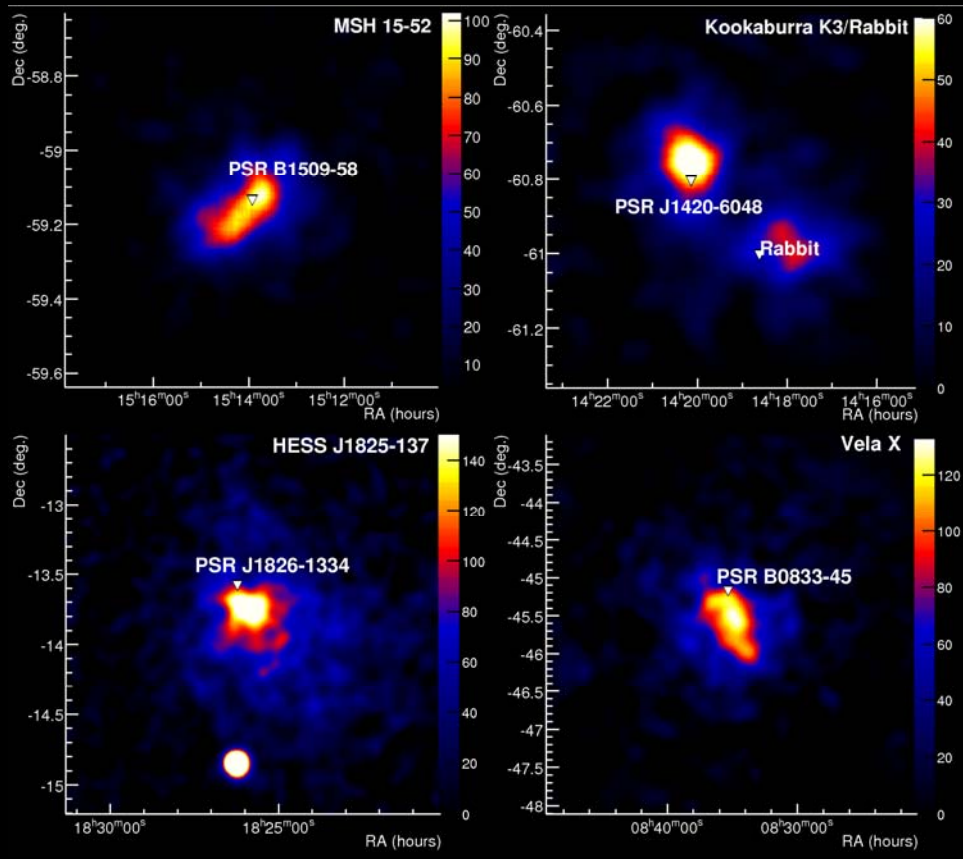


Aharonian et al., Science 307, 1938

What are these?

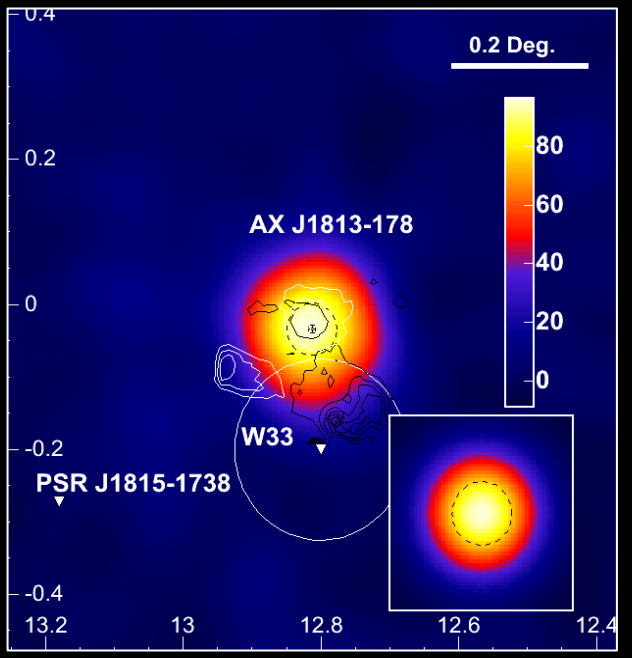
- Detailed program to investigate the X-ray properties of these with *Chandra/XMM/Suzaku*
  - A lot of them connected to energetic Pulsars, $\rightarrow$ PWN
  - Some have no X-ray counterpart even though there have been deep X-ray observations
  - Some are connected to radio shell-type SNRs
    - » HESS J1813-178
    - » HESS J1640-465

Funk, astro-ph/0701471

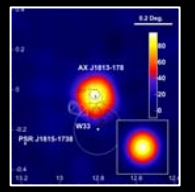


E.g. HESS J1813-178

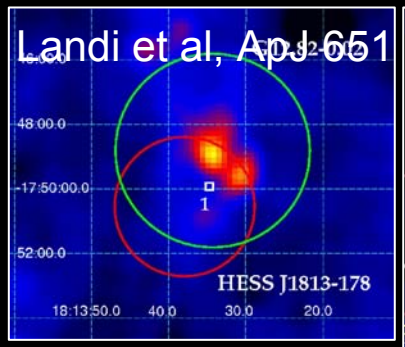
- H.E.S.S. properties:
  - Located in the Galactic plane (l=12.8, b=0)
  - Slightly extended (2.2′)
  - Typical hard γ-ray emission (Γ~2.1)
  - Flux: 6% Crab
  - At first unidentified …

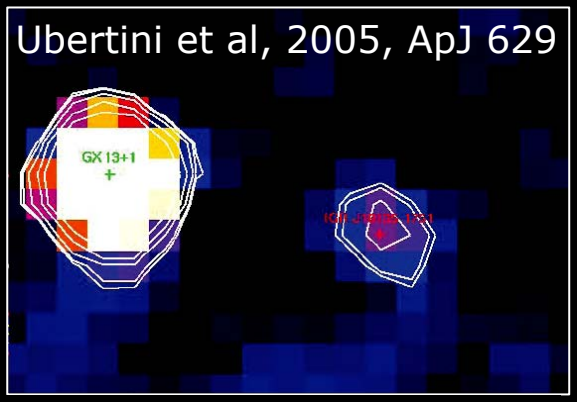


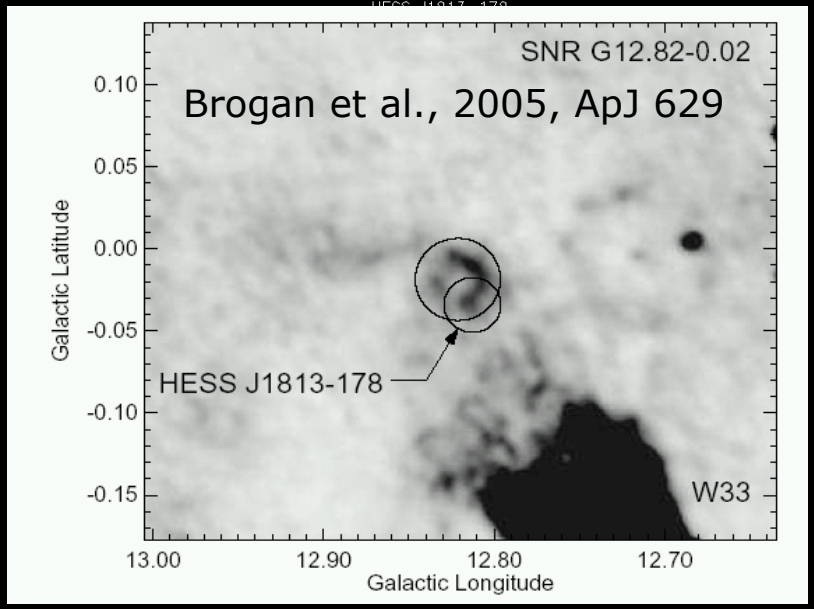
E.g. HESS J1813-178



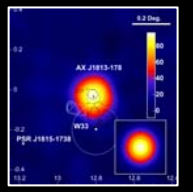
- The MWL picture:
  - X-rays: coincident ASCA, INTEGRAL, Swift (XRT) source
    - » Hard spectrum (Γ~1.7) up to 40 keV
    - » F_{2-10}: $7x10^{-12}$ ergs cm^{-2} s^{-1}
    - » All non-resolved
  - Radio: coincident VLA shell-type SNR
    - » Clearly resolved (3')
    - » Hard spectrum
    - » Distance: >4 kpc from HI absorption data
  - No IR emission (Spitzer)
  - EGRET upper limit





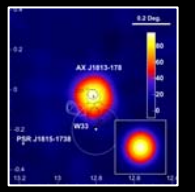


E.g. HESS J1813-178

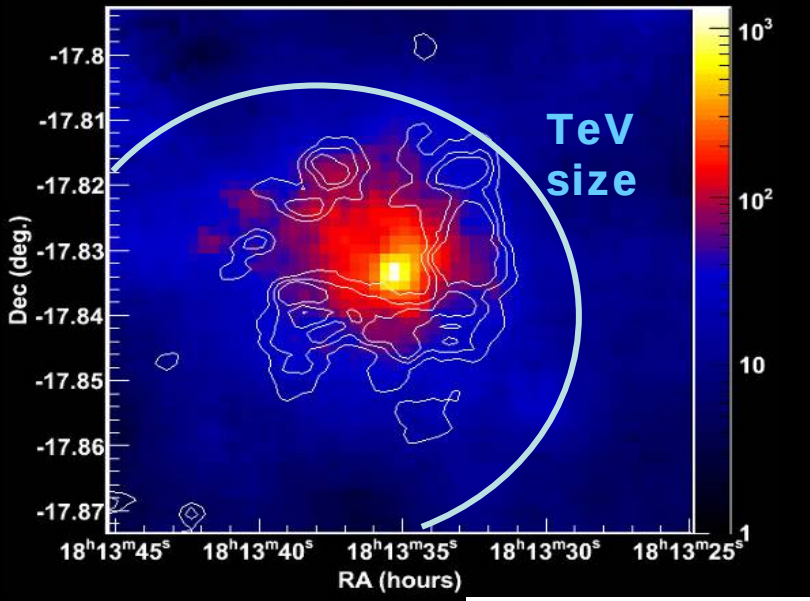


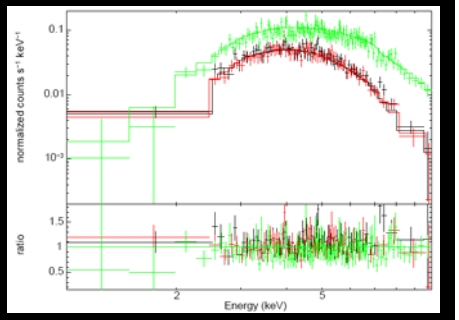
- XMM-Observations:
  - Unresolved X-ray and γ-ray emission from the shell-type SNR or from central source?
    - » γ-ray emission hadronic or leptonic?
  - Try to distinguish by high-angular resolution XMM-Data
    - » 18 ksec
    - » Taken Nov 2005

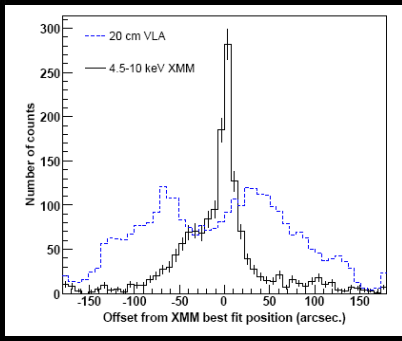
E.g. HESS J1813-178



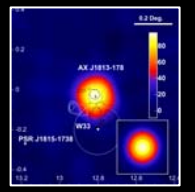
- XMM-Data:
  - Extended (21’’) central source located within the radio shell
  - But much smaller than H.E.S.S. source (2.7’)
  - Upper limit on shell
  - Spectral analysis:
    - » Highly absorbed (10^{23} cm^{-2}) powerlaw
    - » Hard spectrum (Γ~1.5)
    - » Connects to INTEGRAL





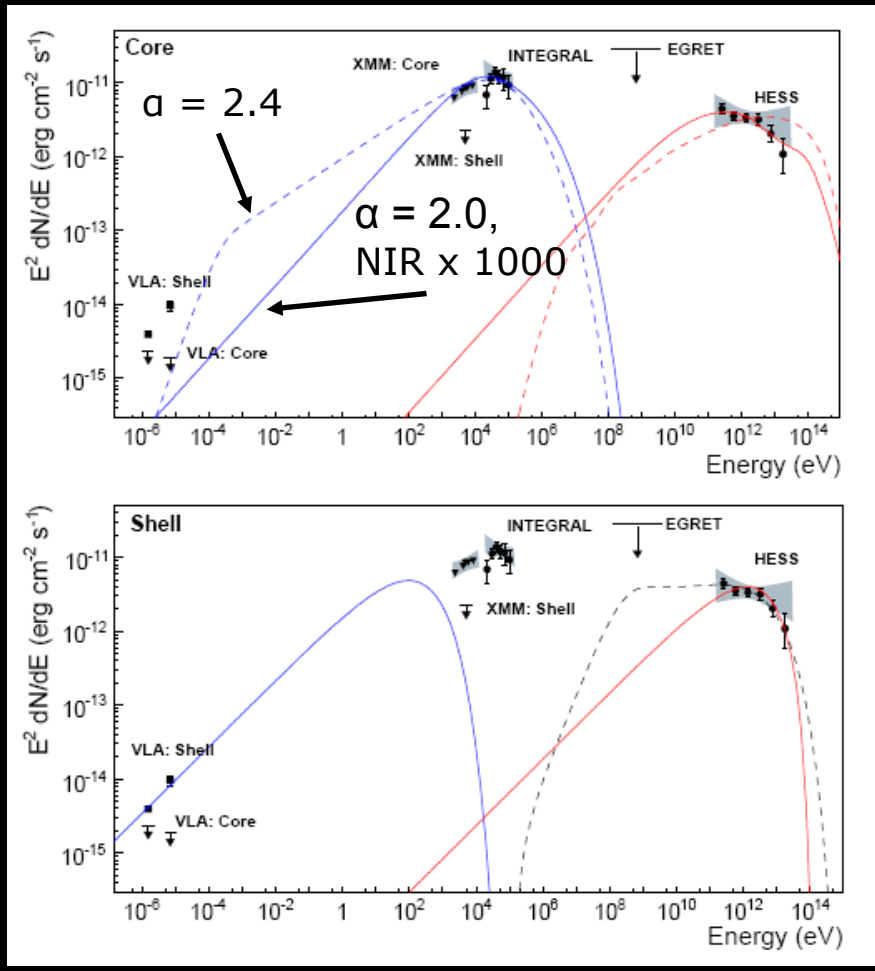


E.g. HESS J1813-178



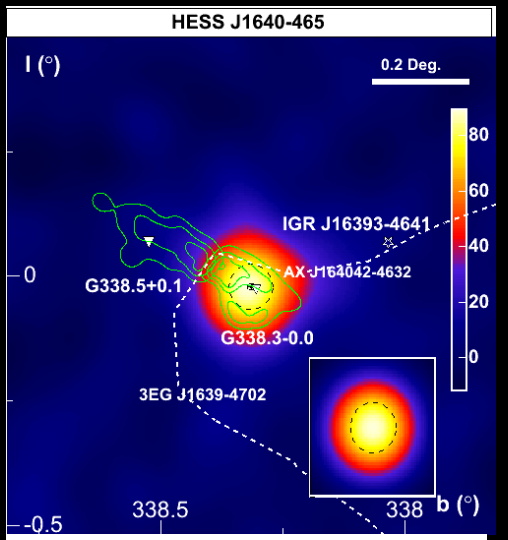
- Origin of the γ–rays?
  - Consider radio shell or central extended object (PWN)
  - Consider both scenarios
    - » γ-rays from core
      - X-ray source associate
      - Radio upper limit
      - Need high e^- energies for INTEGRAL (up to PeV)
      - γ-ray source larger
    - » γ-rays from shell
      - Connect to radio
      - Leptonic or hadronic?
      - No dense molecular cloud
  - Not able to distinguish …
  - Chandra for finding pulsar? (P4.5 E. Gotthelf)
  - GLAST will help !!

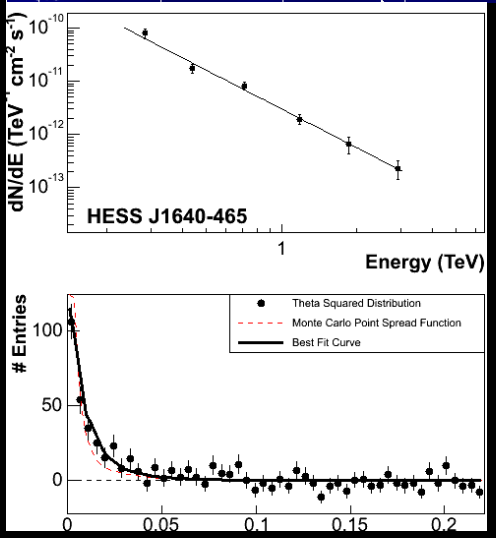
Age: 1000 yr



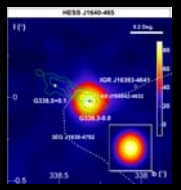
E.g. HESS J1640-465

- H.E.S.S. properties:
  - Located in the Galactic plane (l=338.3°, b=-0.02°)
  - Slightly extended (2.7')
  - Photon index Γ~2.4
  - Flux: 9% Crab
  - γ–ray properties similar to HESS J1813-178 …



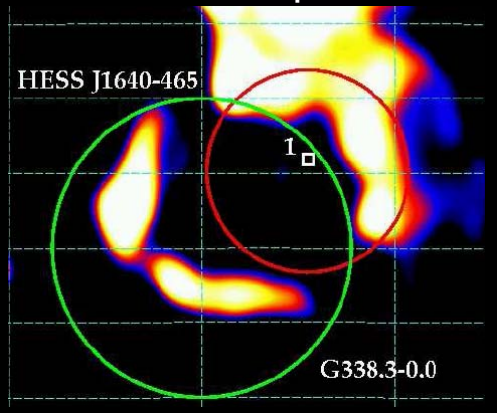


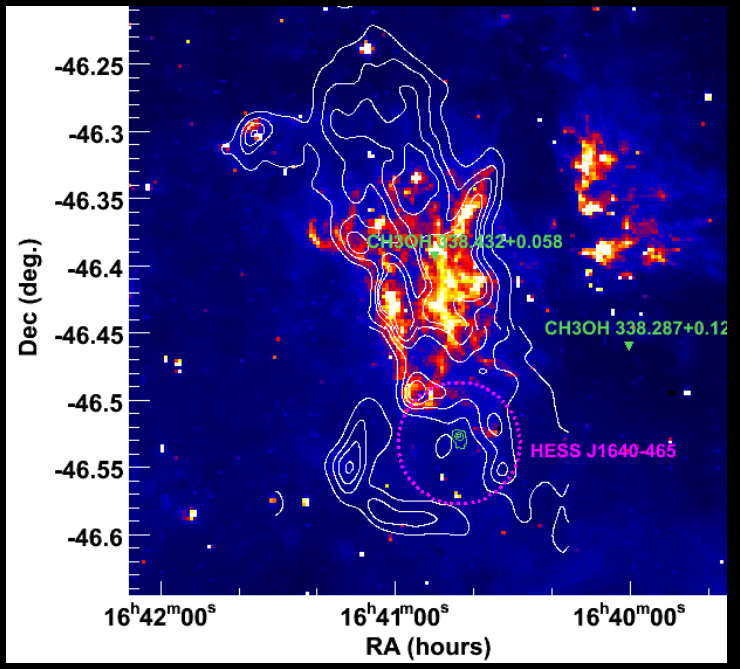
E.g. HESS J1640-465



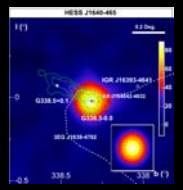
- The MWL picture:
  - X-rays: coincident ASCA, + Swift (XRT) source
    - » No INTEGRAL hard X-rays
    - » Again all non-resolved
    - » Softer spectrum (Γ=2.6)
    - » $F_{2\text{-}10}$: $1\text{x}10^{-12}$ ergs cm^{-2} s^{-1}
  - Radio: coincident Molonglo shell-type SNR
    - » Clearly resolved (4')
    - » Distance: 8.6 kpc ?
      - Sigma-D relation … ☹
  - Close-by bright HII-region at 4 kpc probably unrelated

Landi et al, ApJ 651

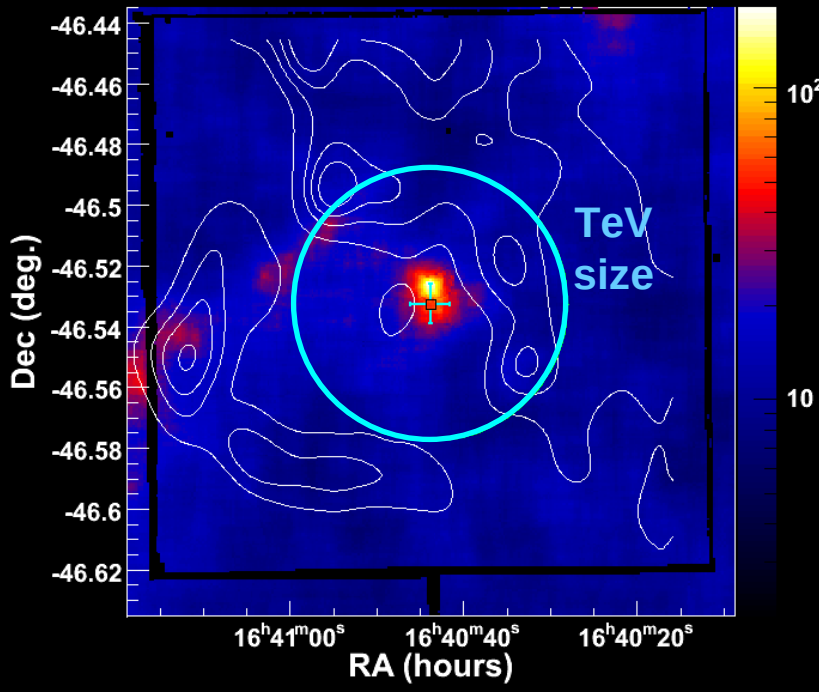


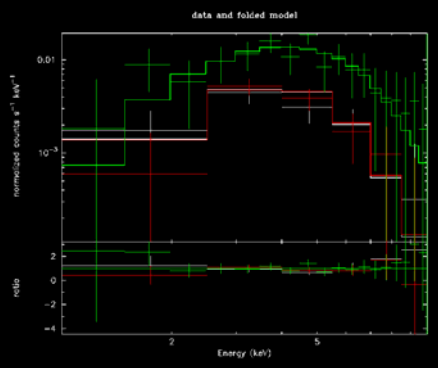


E.g. HESS J1640-465

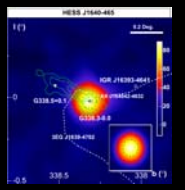


- The XMM Data:
  - Again ~20 ksec observation
  - Extended (30”) faint source at the centre + upper limit from the shell
  - Again much small than H.E.S.S. source
  - Spectral analysis
    - » Again strongly absorbed
    - » Hard powerlaw (Γ=1.7)
    - » $F_{2\text{-}10}$: 7×10^{-13} ergs cm^{-2} s^{-1}
  - Coincident with H.E.S.S. source

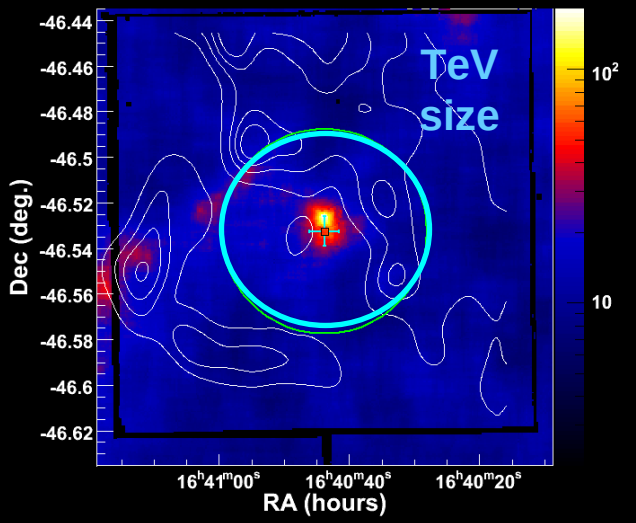


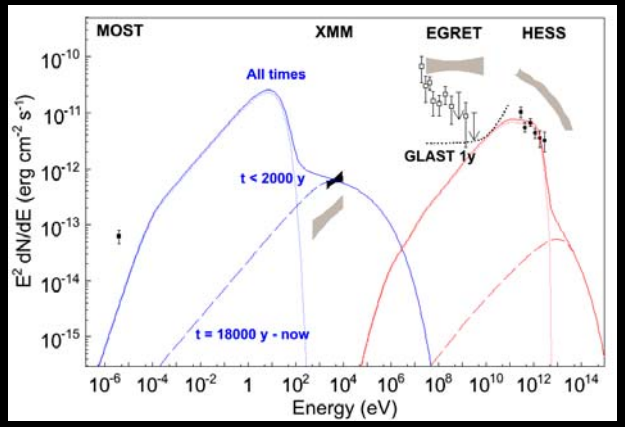


E.g. HESS J1640-465

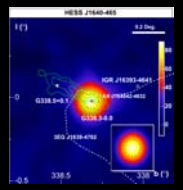


- So what does this all tell us?
  - Can play the same game as for HESS J1813-178
    - » Difference: much weaker in X-rays, no INTEGRAL, but EGRET …
    - » Again cannot distinguish between shell or PWN …
  - … but model should explain:
    - » Different sizes
    - » Low X-ray/γ-ray ratio

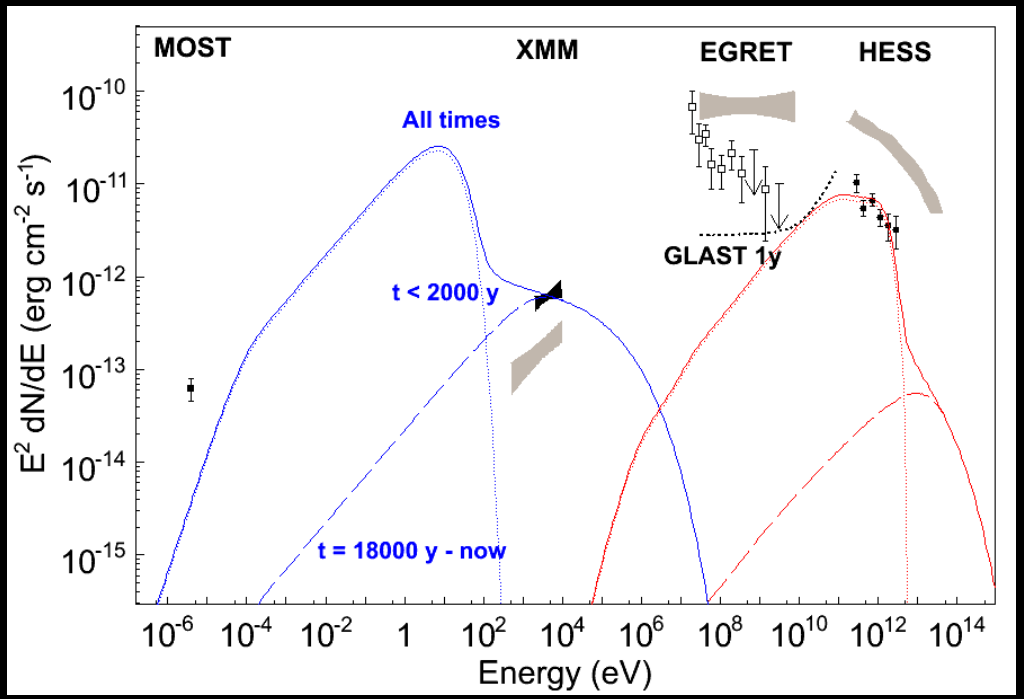




E.g. HESS J1640-465



- Seems not possible to model with simple one-zone leptonic model
  - Can connect X-rays to γ–rays via different electron cooling timescales (a la HESS J1825-137)
  - X-rays from young electrons, VHE γ-rays from old (relic) electrons
  - Explains naturally different sizes
  - Use time evolution for pulsar spin-down
  - EGRET: only through π^0-decay or Brems
  - Again: GLAST will help!



Summary

- X-ray observations of two VHE γ–rays sources connected to shell-type SNRs
  - Shows extended (PWN-like) sources
  - Cannot distinguish between central source vs shell-like scenario
  - Modelling suggests that GLAST will provide important constraints
  - … But these examples also show how hard it is to associate counterparts to γ–ray sources …