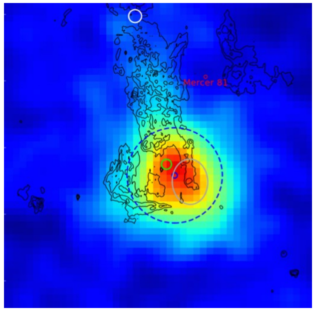
HESS J1640–465, an exceptionally luminous TeV gamma-ray SNR



Peter Eger & Stefan Ohm

on behalf of the H.E.S.S. Collaboration

May 21st, 2014

26th Rencontre de Blois

The quest of Galactic TeV gamma-ray science

- Astrophysics of the most extreme non-thermal objects

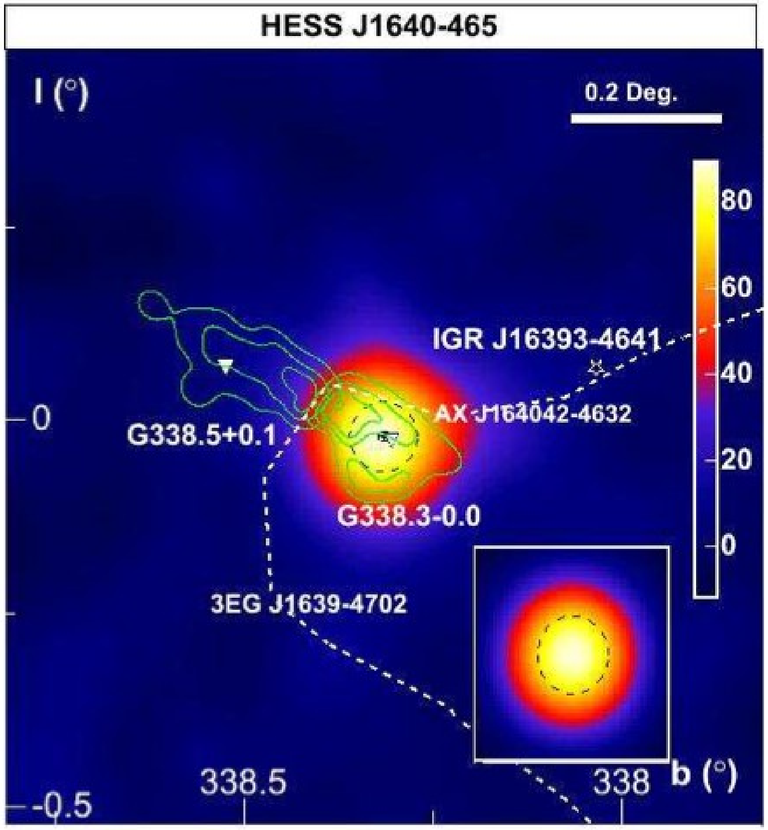
  (pulsars, pulsar wind nebulae, gamma-ray binaries, young supernova remnants, starforming regions, molecular clouds, ...)

- Explore the origin of Galactic cosmic rays

The H.E.S.S. II array in Namibia

- Energy range: 100 GeV (~30 GeV) – 100 TeV
- Angular resolution: ~4'
- Field of view: 5.0° (3.5°)
- Effective area: 5×10^5 m^2

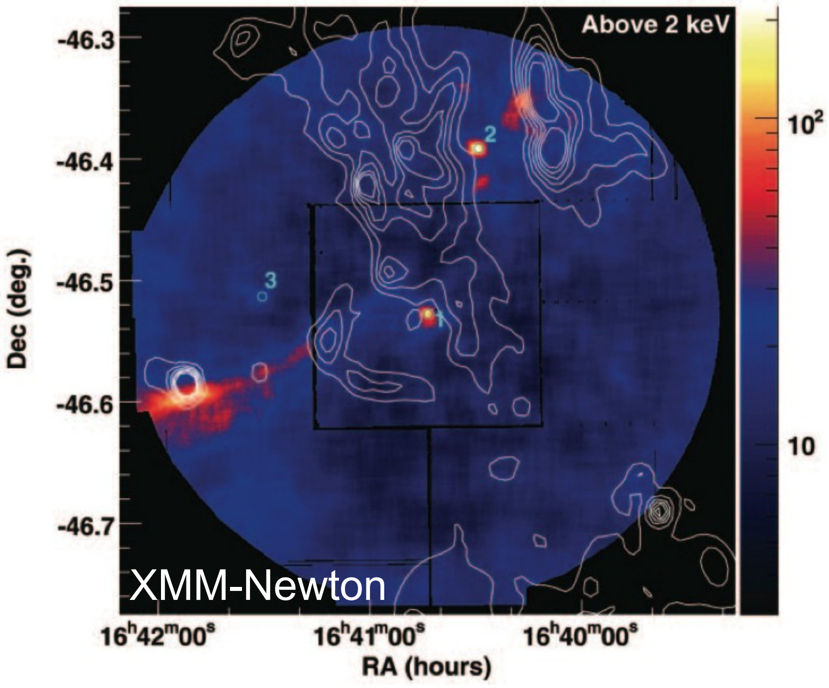
Original discovery by H.E.S.S. in the Galactic plane scan



Flux: ~10% Crab

HESS collaboration (2006)

Follow-up observations in X-rays & Radio



Funk et al. (2007), XMM-Newton
Lemiere et al. (2009), Chandra

- X-rays (XMM-Newton & Chandra):
  - Detection of compact source + extended nebula
  - Highly absorbed → large distance
  - Pulsar wind nebula interpretation of TeV signal

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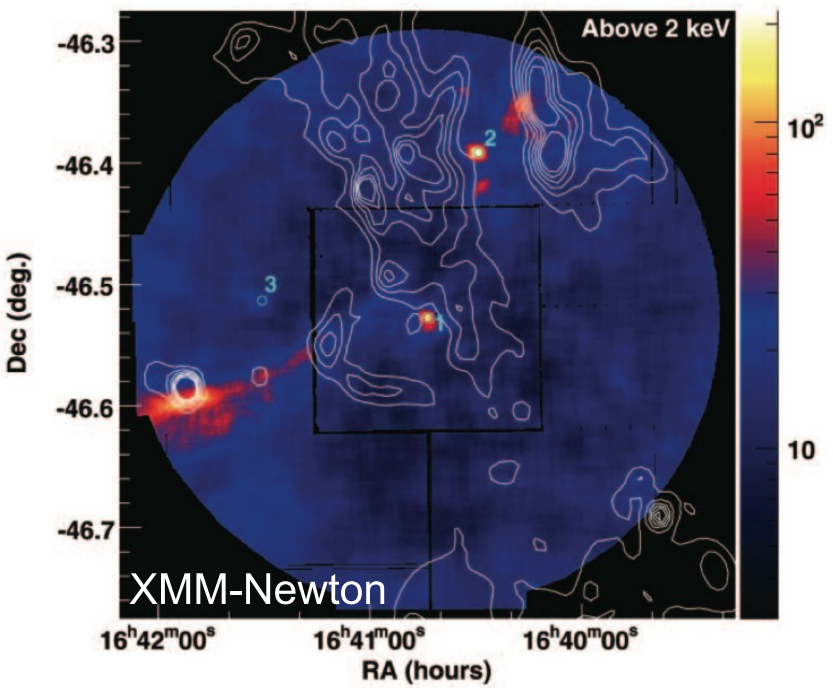

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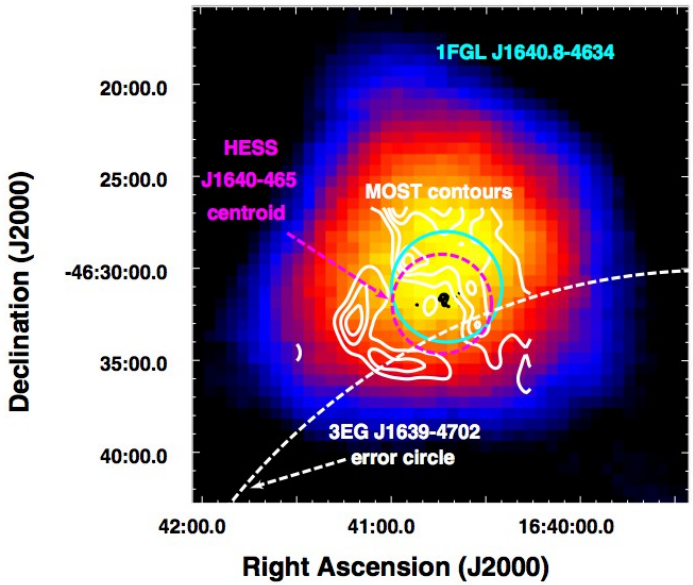
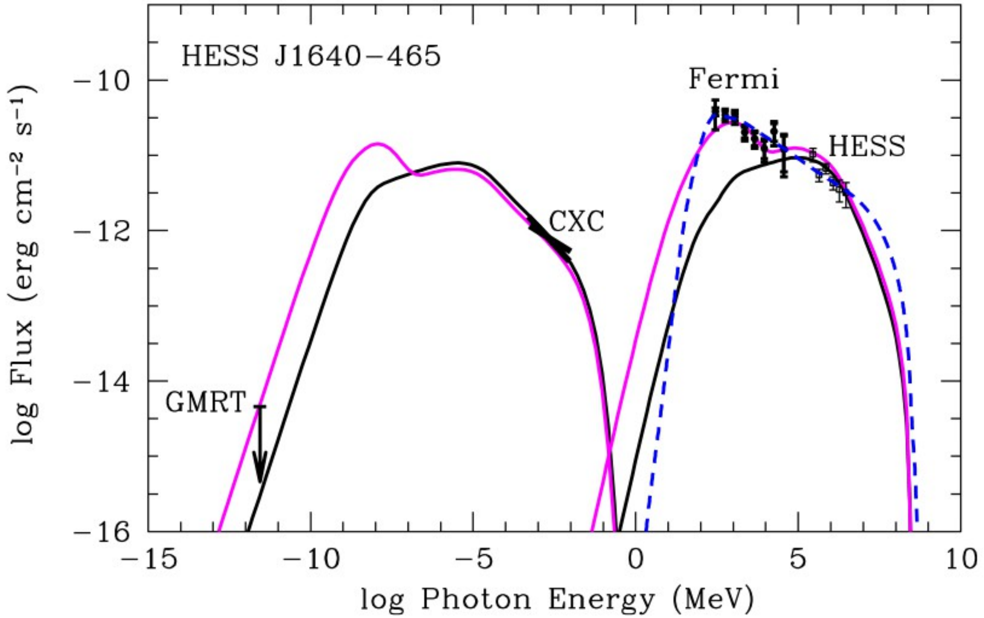
  - Detection of compact source + extended nebula
  - Highly absorbed → large distance
  - Pulsar wind nebula interpretation of TeV signal
- HI absorption measurements (SGPS)
  - >10 kpc distance
  - Most luminous Galactic TeV gamma-ray source

Fermi observations

Fermi skymap



SED + PWN models

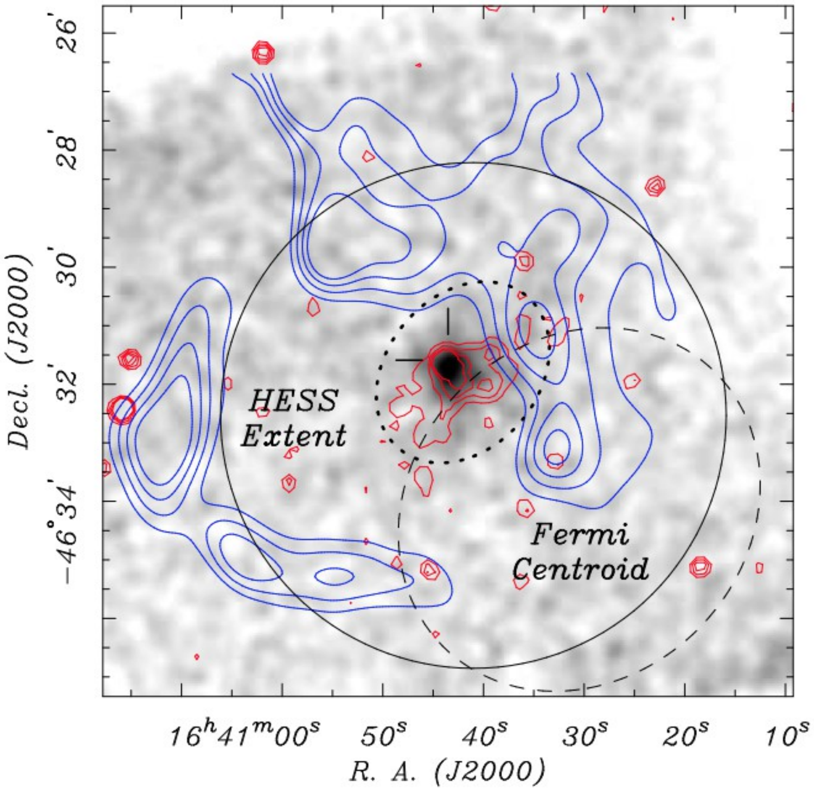


- Detection of luminous GeV source
- GeV-TeV spectrum interpreted as IC emission from a PWN
- Additional low-energy relativistic Maxwellian component needed to fit the data

Slane et al. (2010)

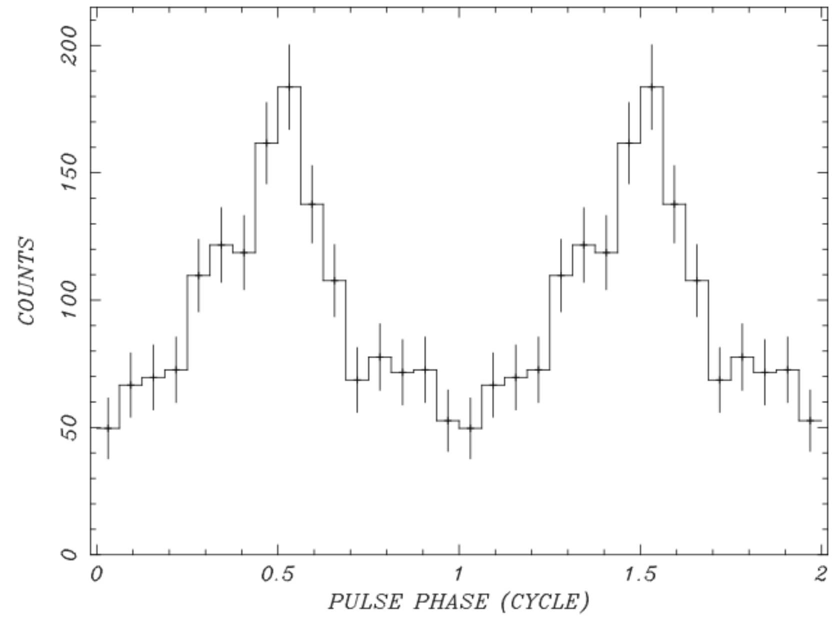
Recent NuStar pulsar detection

Hard X-ray skymap



Gotthelf et al. (2014)

Pulsar phasogramm



Pulsar period: 206 ms

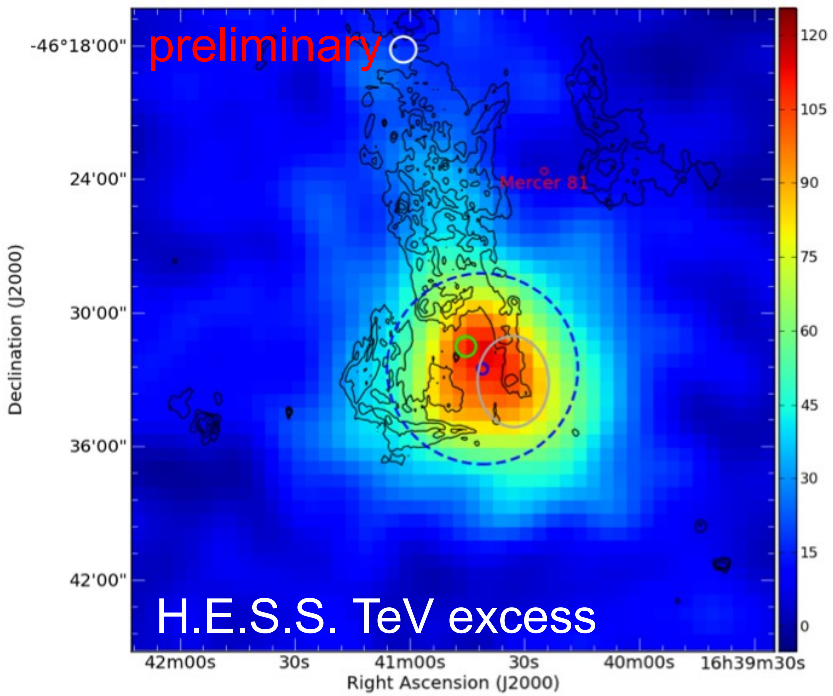
Pulsar spin- down: 4.4×10^{36} erg s^{-1}

Age τ_c : 3350 yr

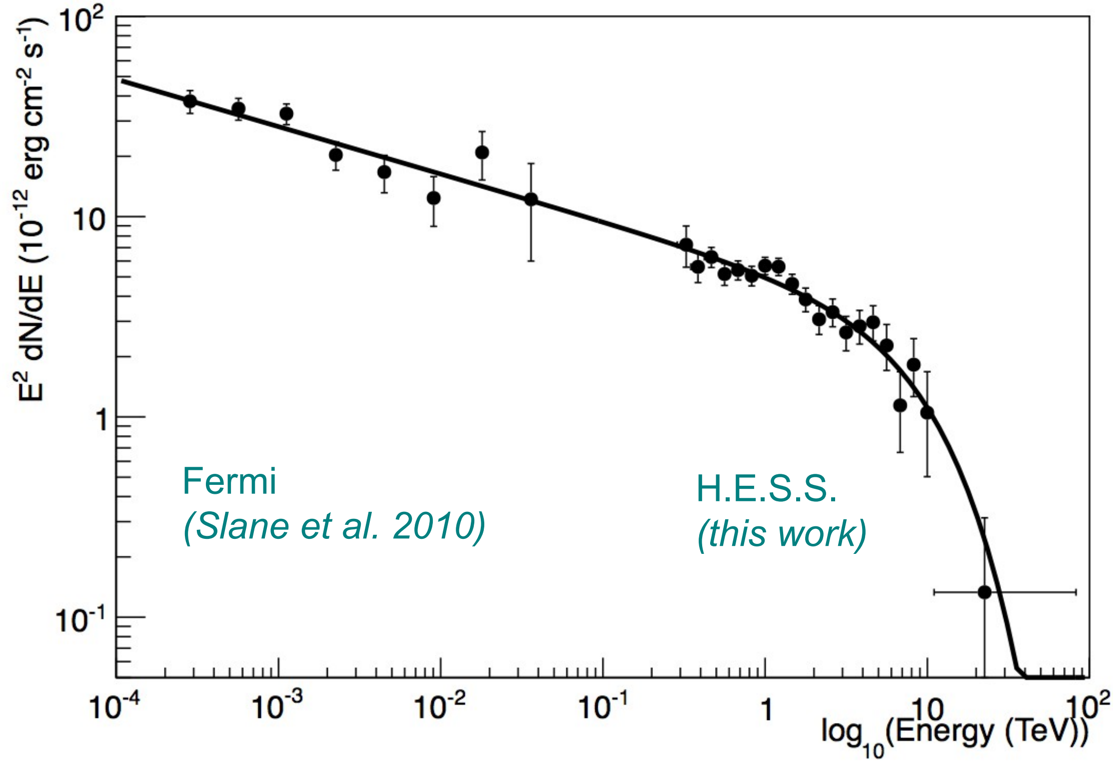
P_0 : 15 ms

Updated analysis of the HESS TeV data

- Total livetime: 63.4 h (previously 14.3 h)
- ~1800 excess events
- Morphology:
  - Significantly extended: $\sigma = (4.3 \pm 0.3)'$
  - Asymmetric extension towards HII region slightly preferred by 2σ
  - Significant overlap with north-western SNR shell



HESS J1640-465: GeV-TeV spectrum



Data	$E_{\min}$	$E_{\max}$	Γ	Φ_0 $10^{-12}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$	$1/E_c$ 1 / TeV
H.E.S.S.	260 GeV	80 TeV	2.15 ± 0.10	3.13 ± 0.12	0.14 ± 0.05
H.E.S.S. + *Fermi*-LAT	200 MeV	80 TeV	2.24 ± 0.01	3.43 ± 0.16	0.11 ± 0.02

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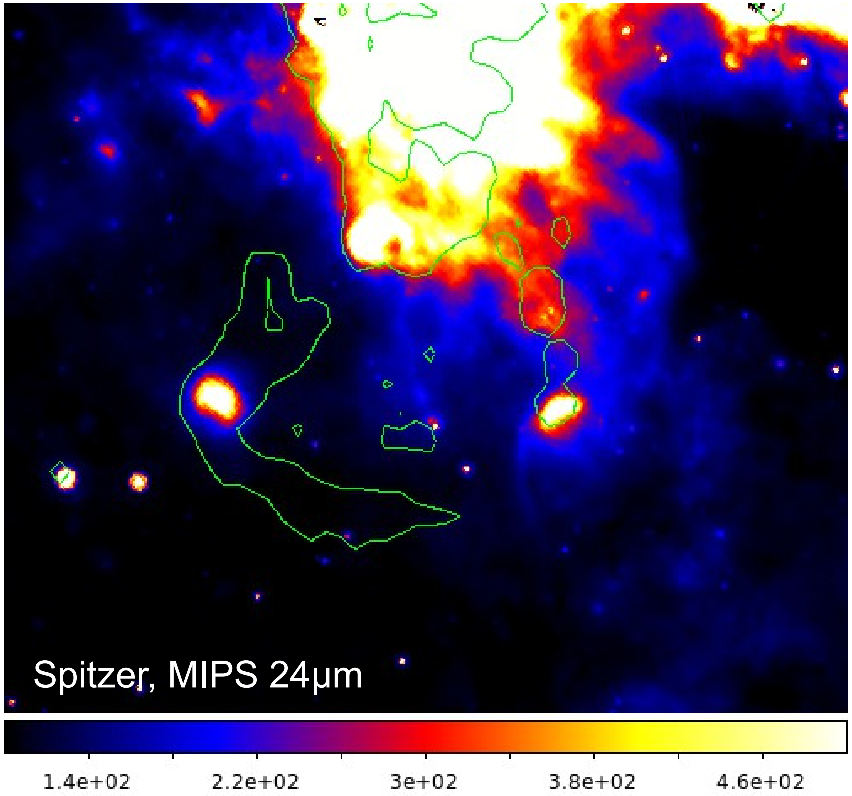
- Overlap of PWN IC emission with SNR shell
  a) Not observed for any other composite SNR so far
  b) Requires relic PWN and old system?

Alternative interpretation:
Hadronic emission from northern SNR shell



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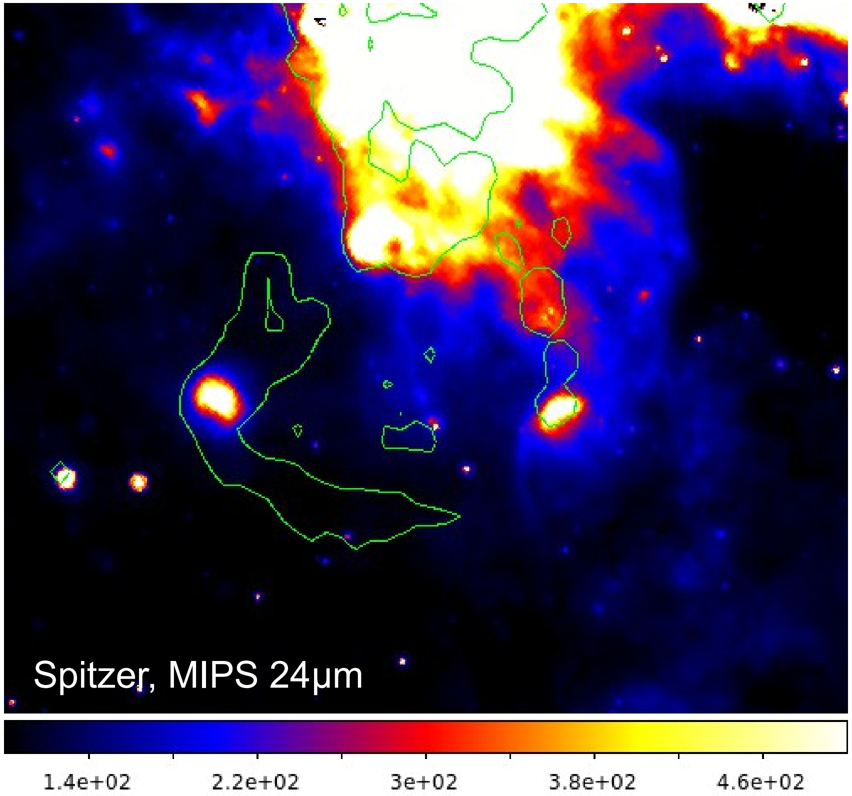
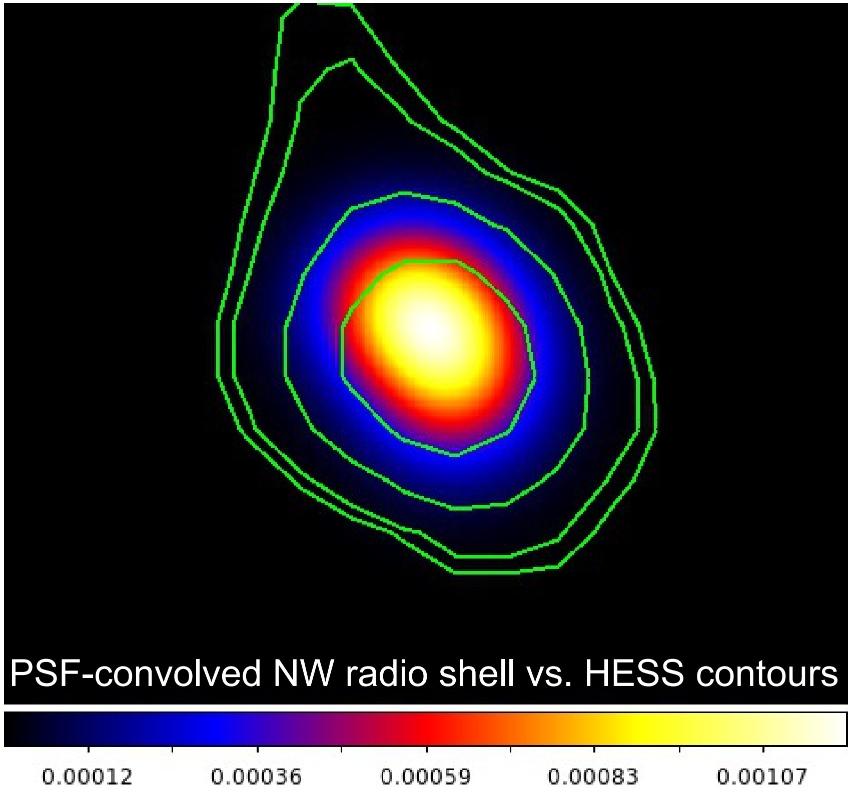
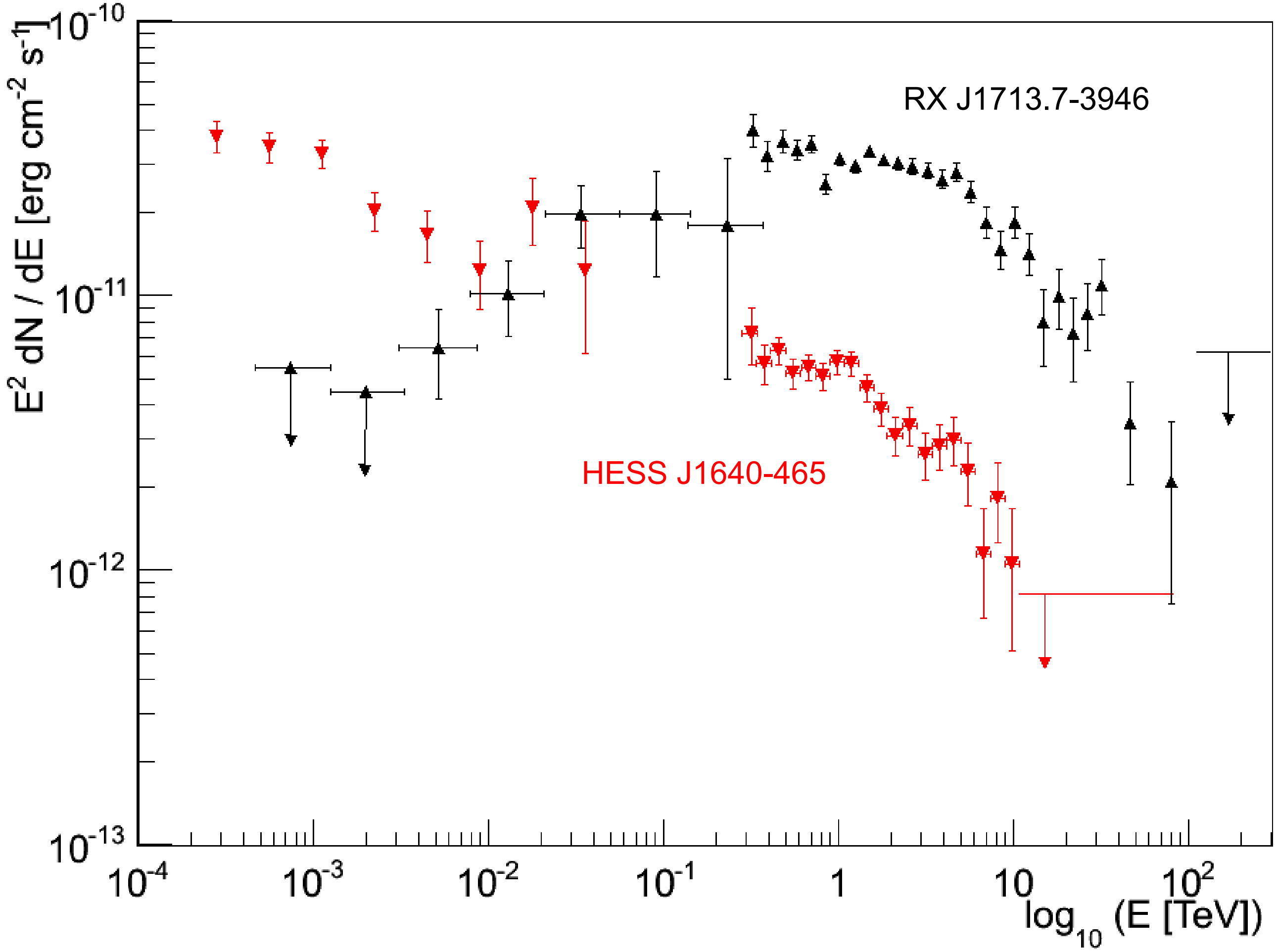




Comparison to RX J1713.7-3946



P. Eger, on behalf of H.E.S.S., May 21st, 2014, R.d. Blois

Summary & Conclusions

- Most luminous Galactic TeV gamma-ray source
- TeV morphology:
  - Significantly extended, preferably asymmetric
  - Overlap with northern SNR shell in projection
- GeV – TeV spectrum compatible with one featureless powerlaw over 6 orders of magnitude
- Currently interpreted as leptonic emission from PWN inside the SNR
- Alternative interpretation: Hadronic emission from SNR shell
  - Morphology & Spectrum well reproduced
  - High ambient density and energy in protons required

Backup slides

Evolution of the SNR inside wind-blown bubble

- Bubble size of ~10 pc typical for 20 solar mass O-type star: (Chevalier, 1999)
  - Lifetime: 7 Myr
  - Wind speed: 700 km/s
  - Mass-loss rate: 10^{-7} solar mass / yr
  - Total mass-loss: ~1 solar mass

- Lower limit on age, assuming total mass inside bubble only from wind:

  ~1 kyr for free expansion of SNR until edge of wind-bubble