H.E.S.S. precision measurements of the SNR RX J1713.7-3946

Peter Eger

for the H.E.S.S. Collaboration

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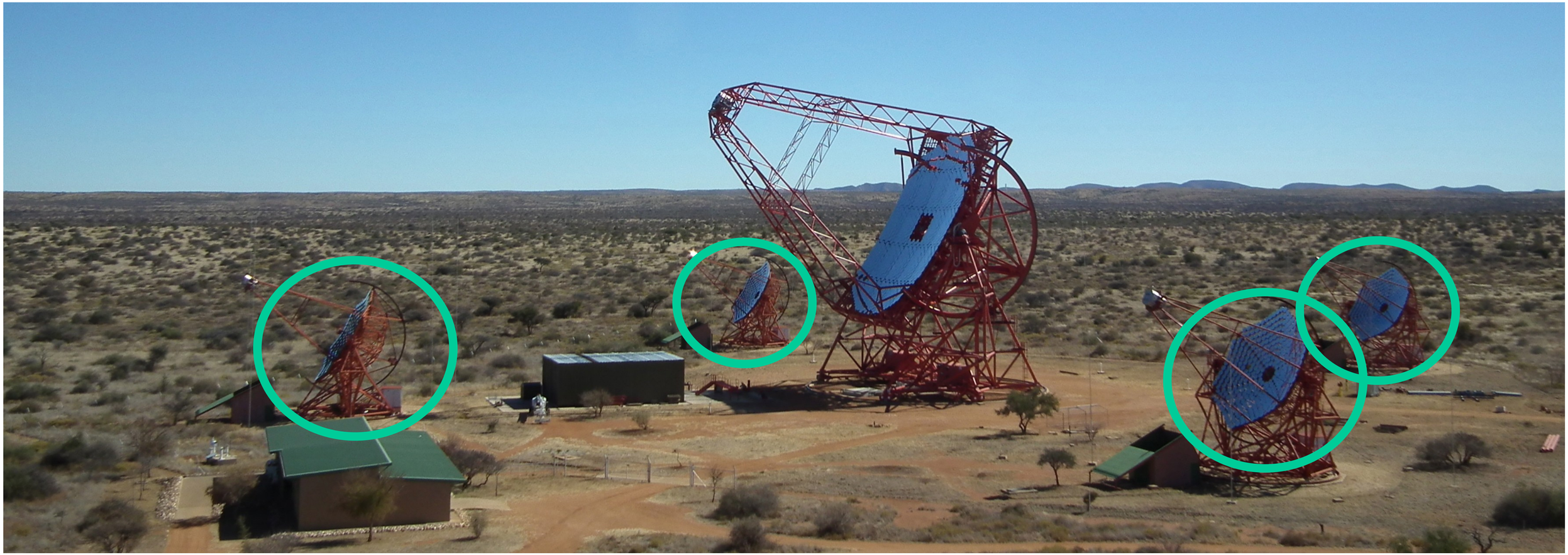
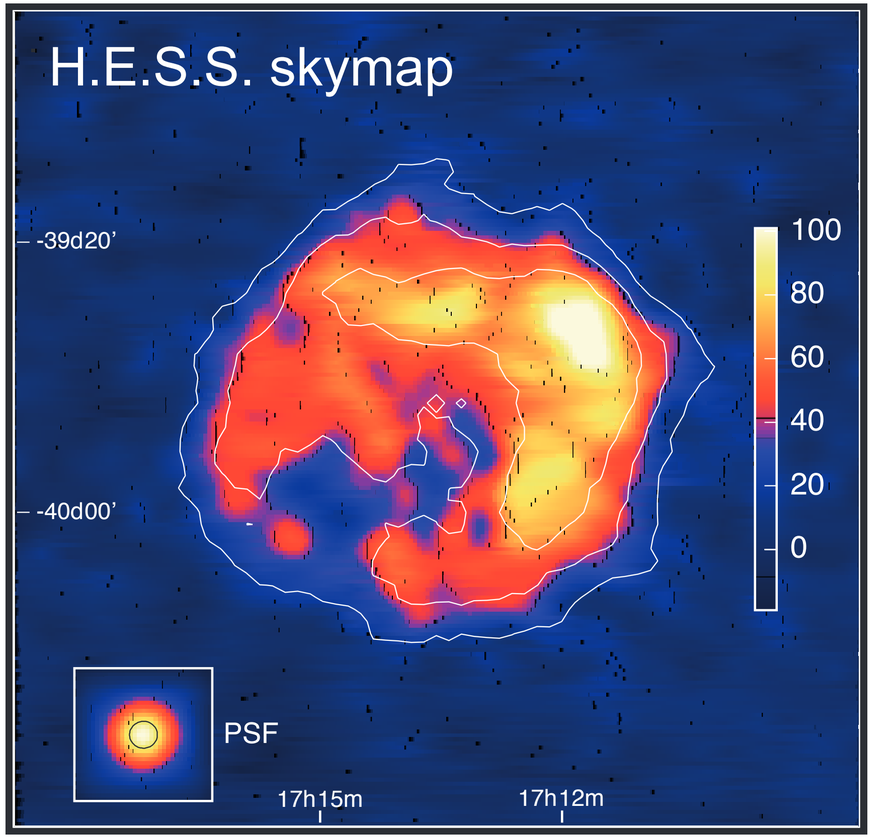
FÜR KERNPHYSIK

H.E.S.S.

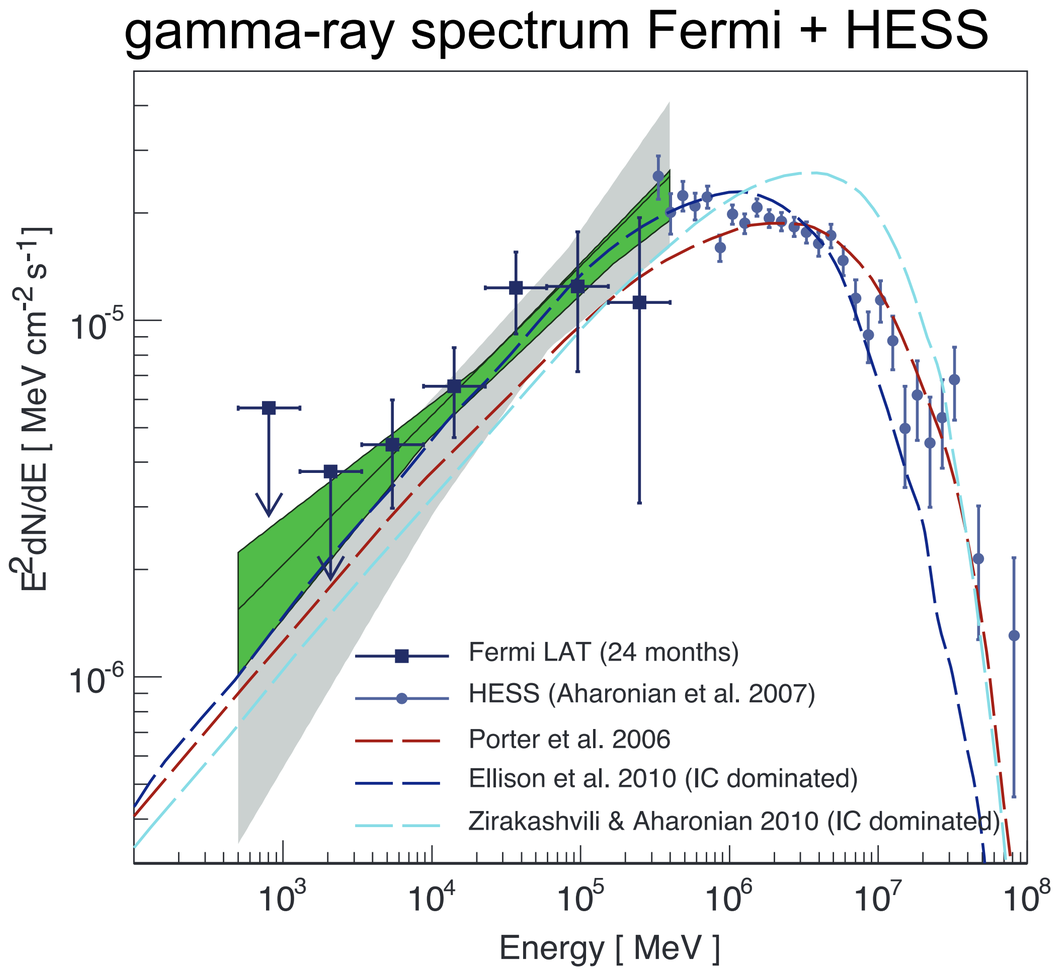


- Energy range: 100 (~30) GeV - 100 TeV
- Field of view: 5º (3.5º)
- Angular resolution: 0.1º - 0.05º
- Effective area: 5 x 10^5 m^2

First shell-type SNR ever detected in TeV gamma-rays



HESS Collaboration (2006)



Fermi/LAT collaboration (2011)

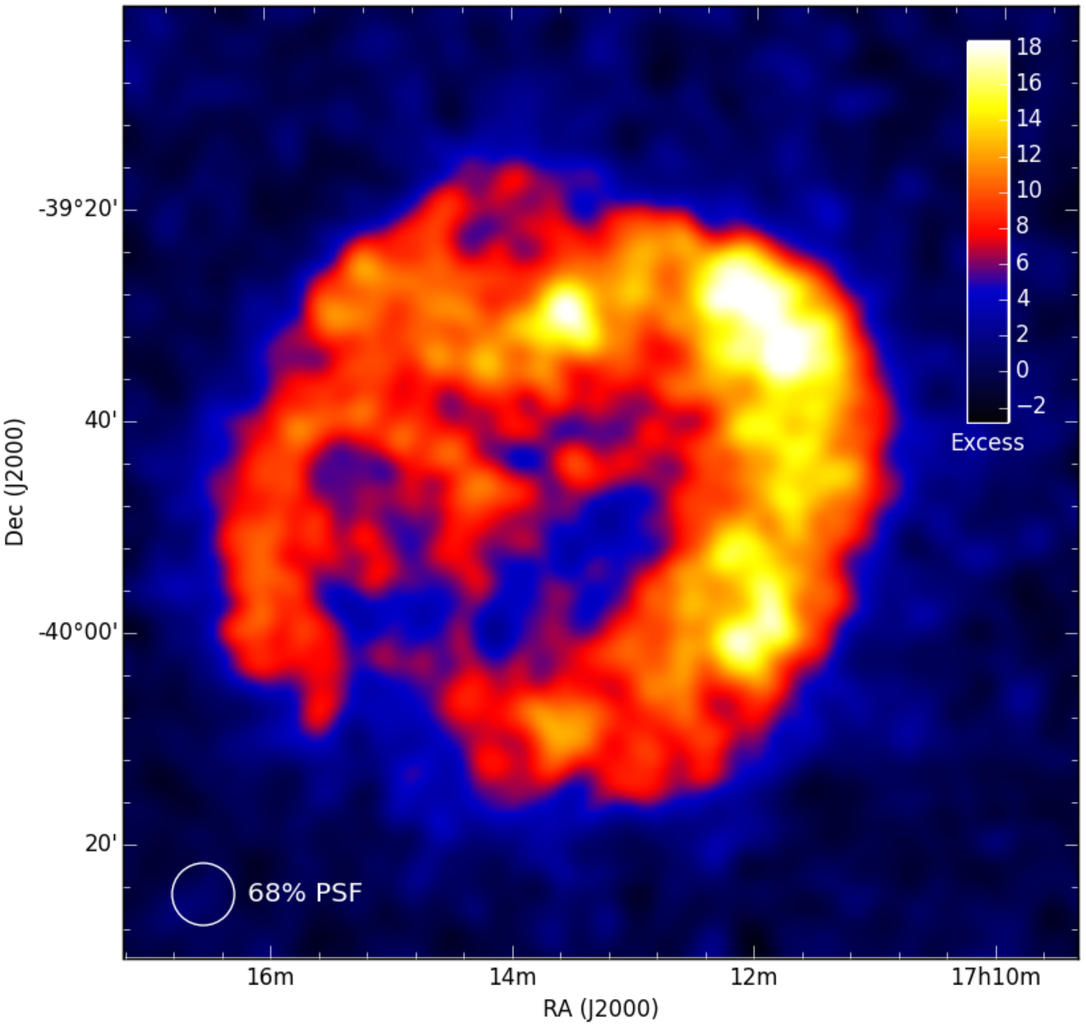
3 HESS publications so far — why do we want to revisit this source again?

- Ongoing debate in the literature about the origin of the emission
- Dataset increased by factor of ~2 since last publication *(HESS Coll. 2004, 2006, 2007)*
- New high-resolution / high-throughput analysis techniques available

re?

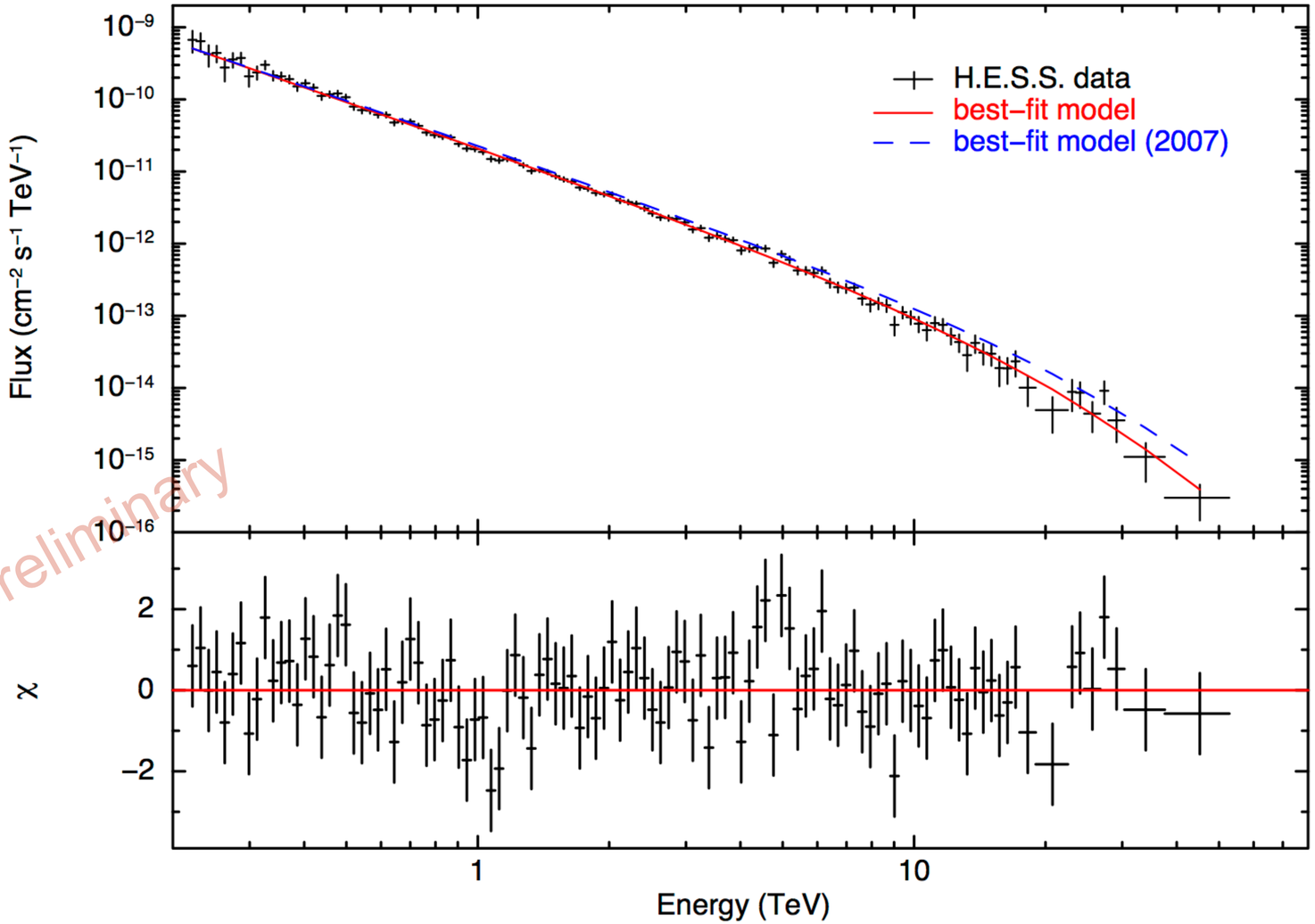
- Spectral cut-off shape —> electrons vs. protons
- Spatially-resolved spectra w/ unprecedented resolution —> maps of physical quantities
- Morphology & radial profiles, comparison to X-rays —> particle diffusion + escape

The new high-resolution H.E.S.S. map



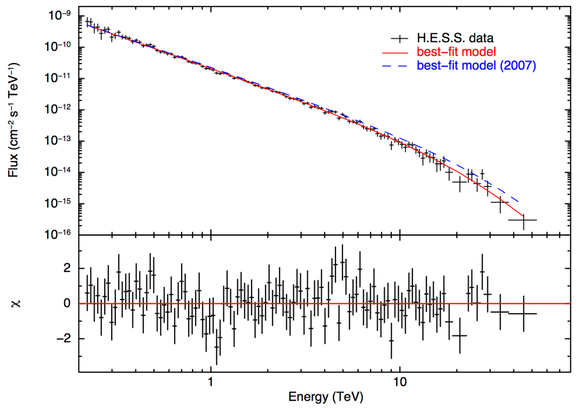
- exposure: 170 h
- angular resolution: 0.05º
- energy threshold: 250 GeV
- Analysis: Model w/ HiRes cuts
  (de Naurois & Rolland, 2007)

Full-remnant photon flux spectrum



- exposure: 150 h
- threshold: 200 GeV
- excess: >27000 counts

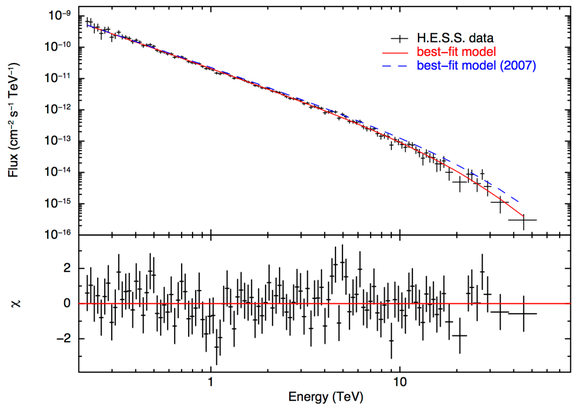
Full-remnant photon flux spectrum: cutoff behaviour



preliminary

Spectral Model	Γ	E_{cut} (TeV)	$F(>1\ \mathrm{TeV})$ $(10^{-11}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1})$	χ^2 / ndf
$F_0 E^{-\Gamma}$	2.32±0.02	-	1.52±0.02	304.2/118
$F_0 E^{-\Gamma} \exp\left(-\frac{E}{E_{cut}}\right)$	2.06±0.02	12.9±1.1	1.64±0.02	120/117
$F_0 E^{-\Gamma} \exp\left(-\frac{E}{E_{cut}}\right)^2$	2.17±0.02	16.5±1.1	1.63±0.02	113.8/117
$F_0 E^{-\Gamma} \exp\left(-\frac{E}{E_{cut}}\right)^{0.5}$	1.82±0.04	2.7±0.4	1.63±0.02	142.1/117

Full-remnant photon flux spectrum: cutoff behaviour



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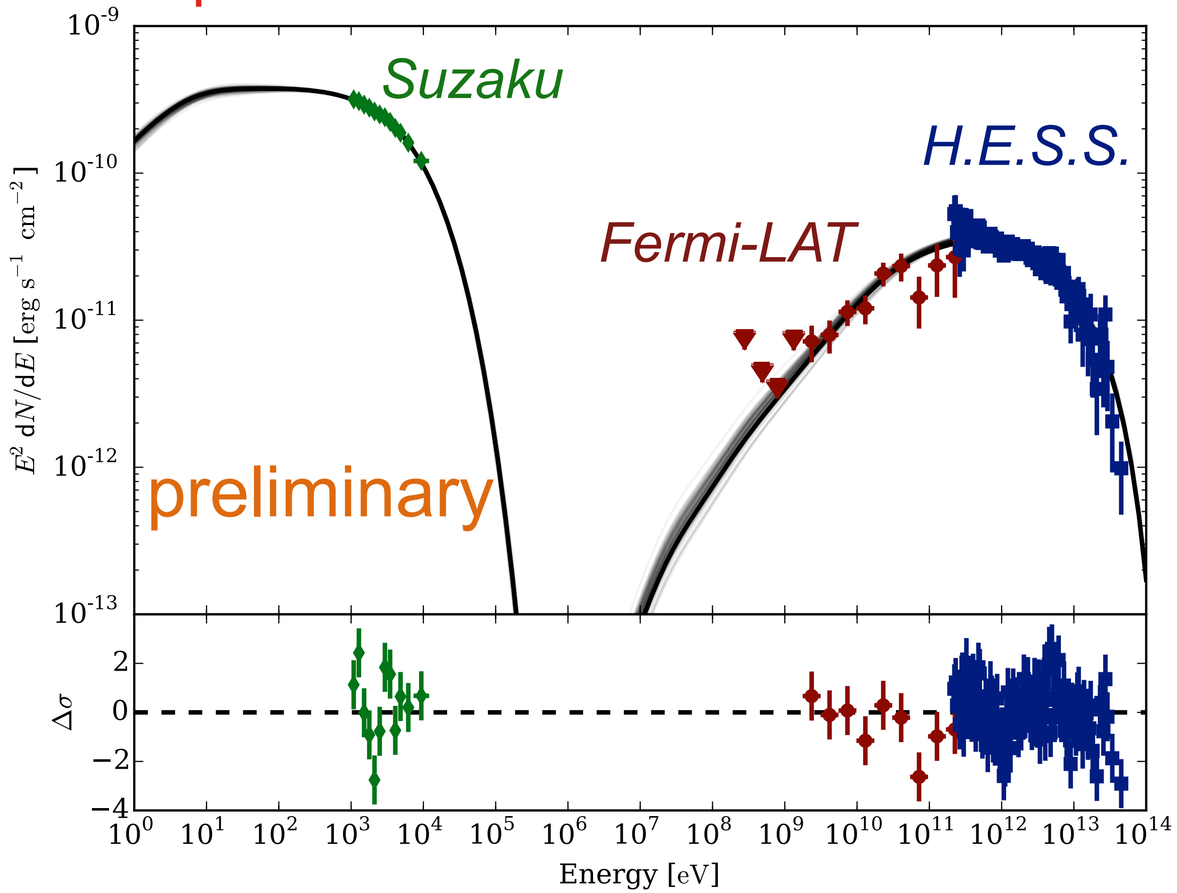
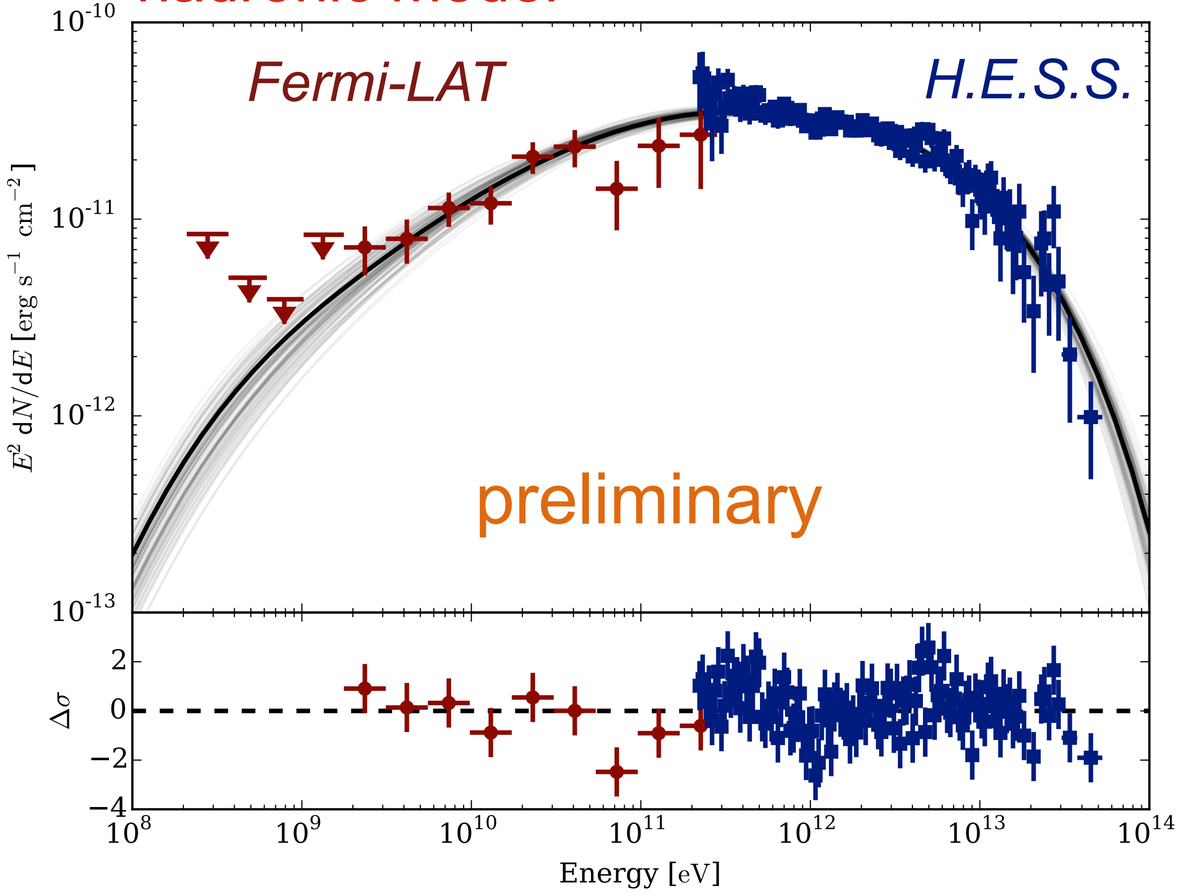
Modelling the spectral energy distribution

leptonic model

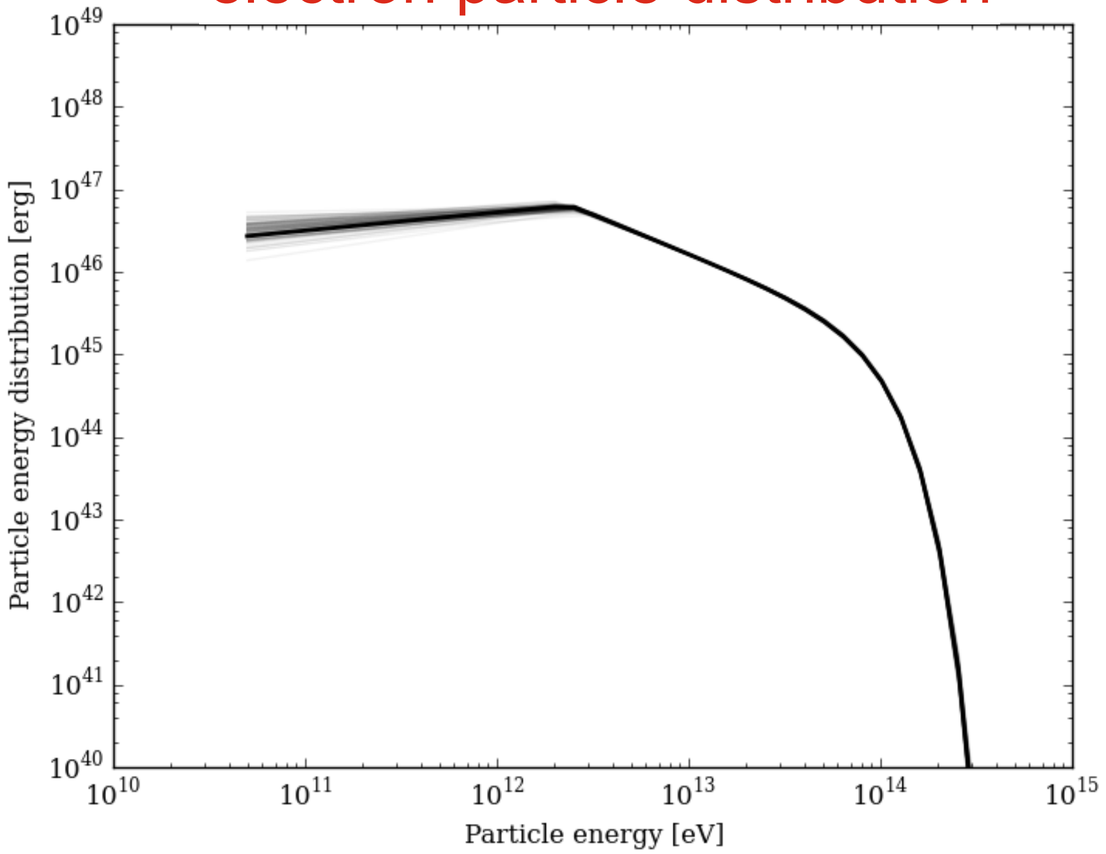


hadronic model



spectral fits performed with *naima*, see poster by *V. Zabalza*

electron particle distribution

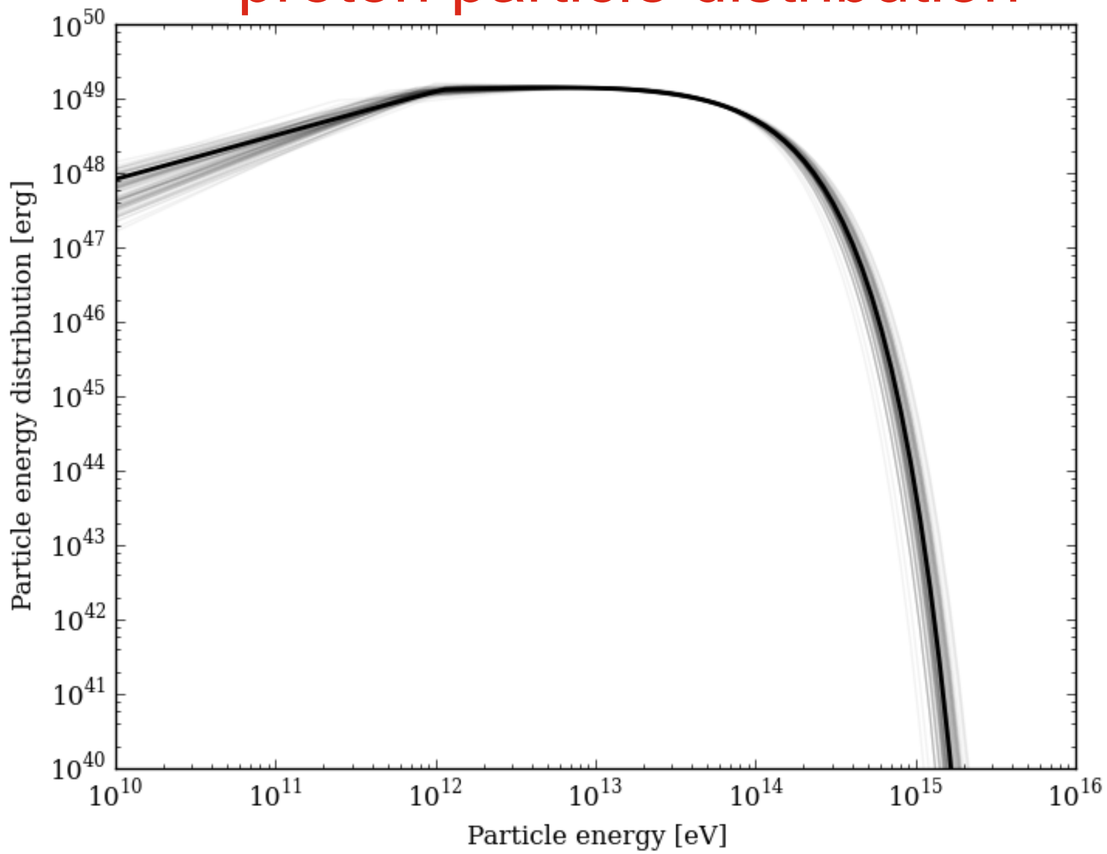


- Break in electron spectrum @2.5 TeV
- Synchrotron cooling?
  - required B-field: ~140 µG
  - at odds with X-ray measurement
    B = 14.8 ± 0.2 µG
- Additional target photon field?
  - required energy density: 140 eV cm^{-3}
  - 10^2 times larger than in all previous estimates

- Break in proton spectrum @0.8 TeV
- potential explanation through energy-dependent diffusion into dense molecular clumps?
- Detailed studies of the ISM and photon fields:

  Porter+ (2006), Inoue+ (2012), Fukui+ (2012), Sano+ (2013,2015) Maxted+ (2013)

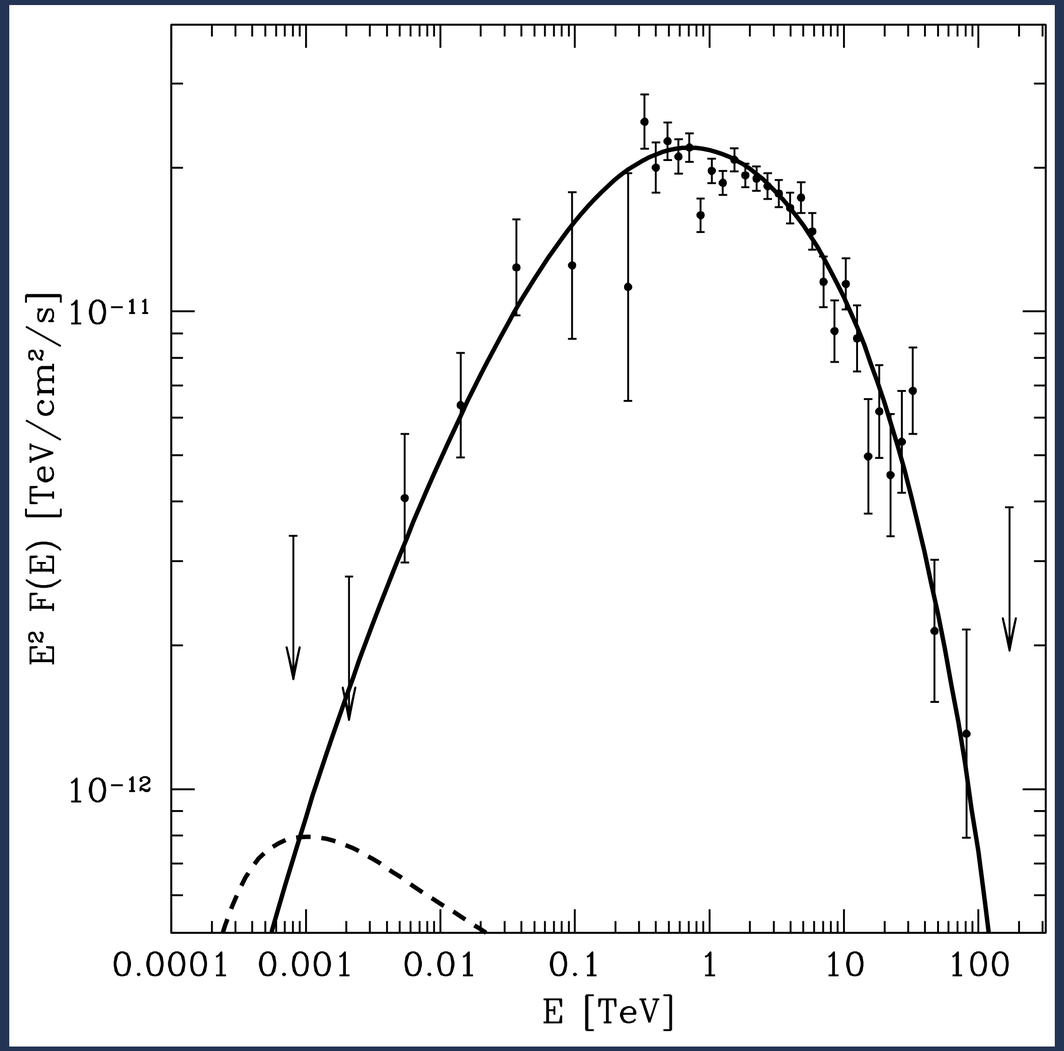
proton particle distribution



Spectral hardening at lower energies

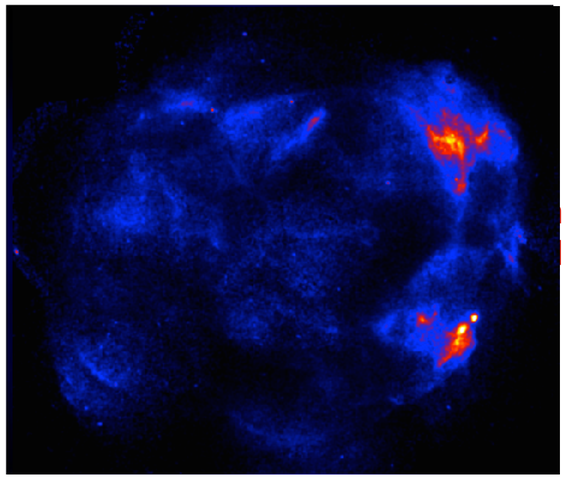
- Break in proton spectrum @0.8 TeV
- potential explanation through energy-dependent diffusion into dense molecular clumps?
- Detailed studies of the ISM and photon fields:

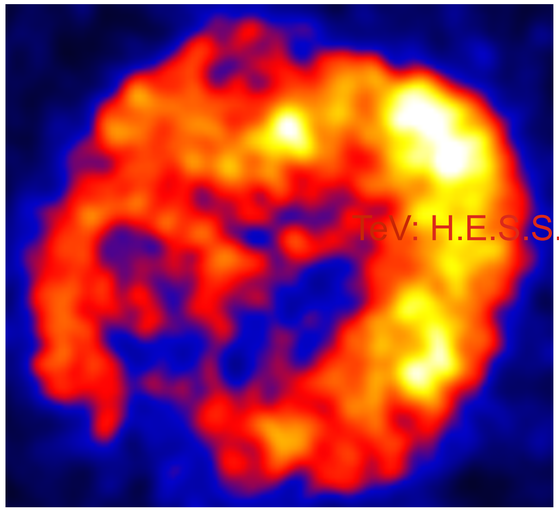
  Porter+ (2006), Inoue+ (2012), Fukui+ (2012), Sano+ (2013,2015) Maxted+ (2013)



Gabici & Aharonian (2014)

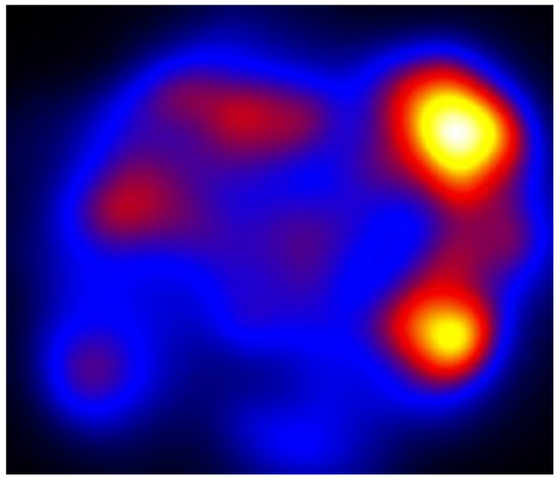
Mapping the magnetic field



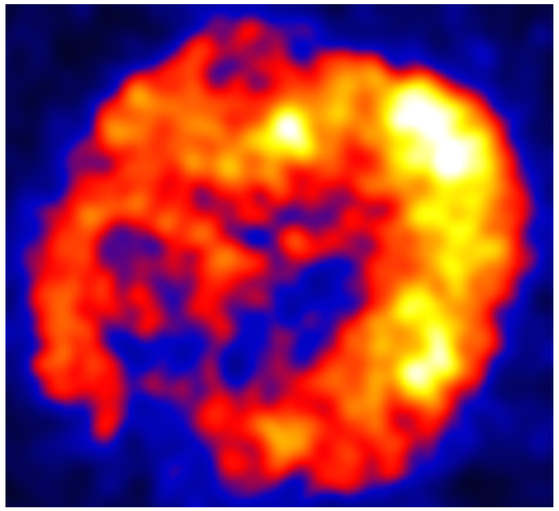


TeV: H.E.S.S.

Mapping the magnetic field



X-rays: XMM-Newton
H.E.S.S.-PSF-convolved



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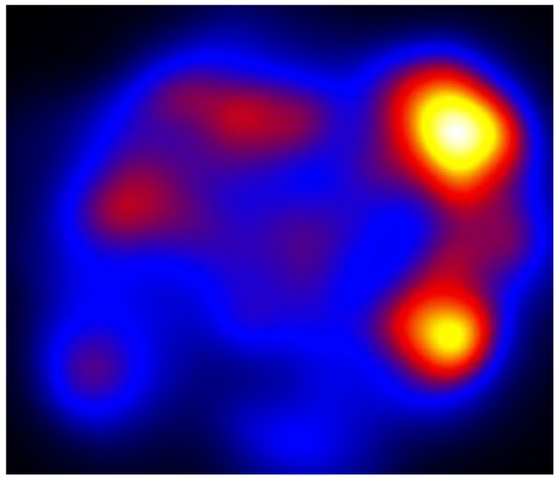

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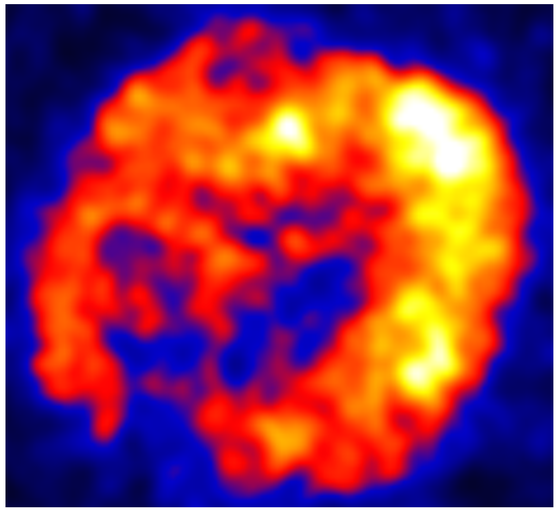

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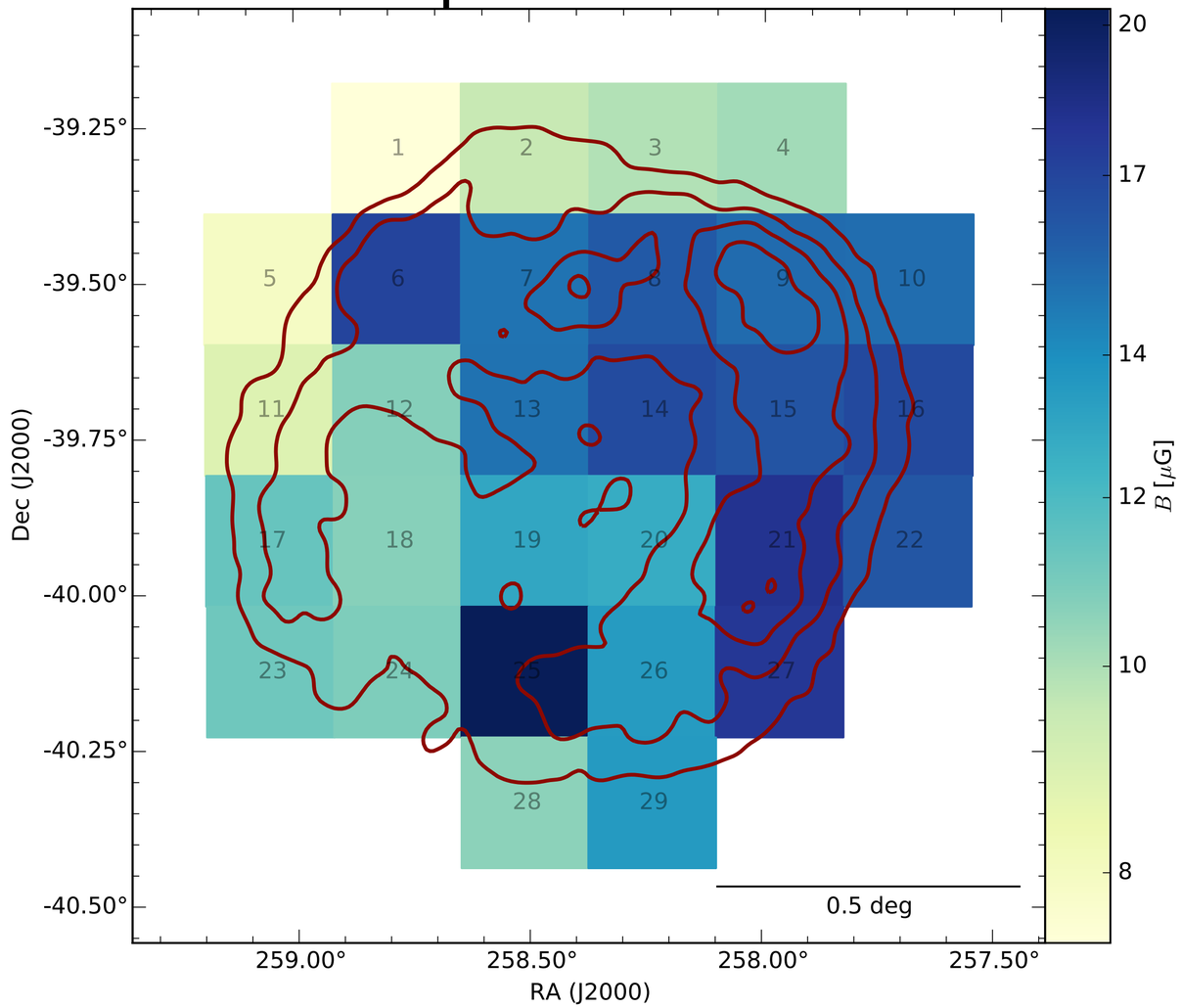
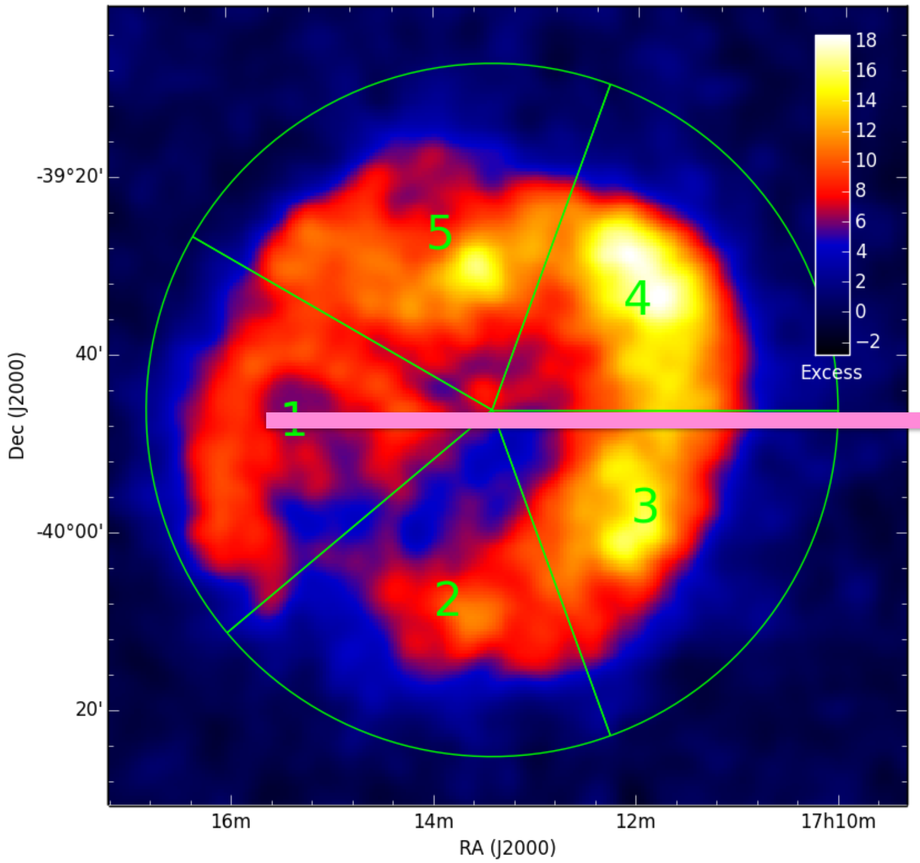
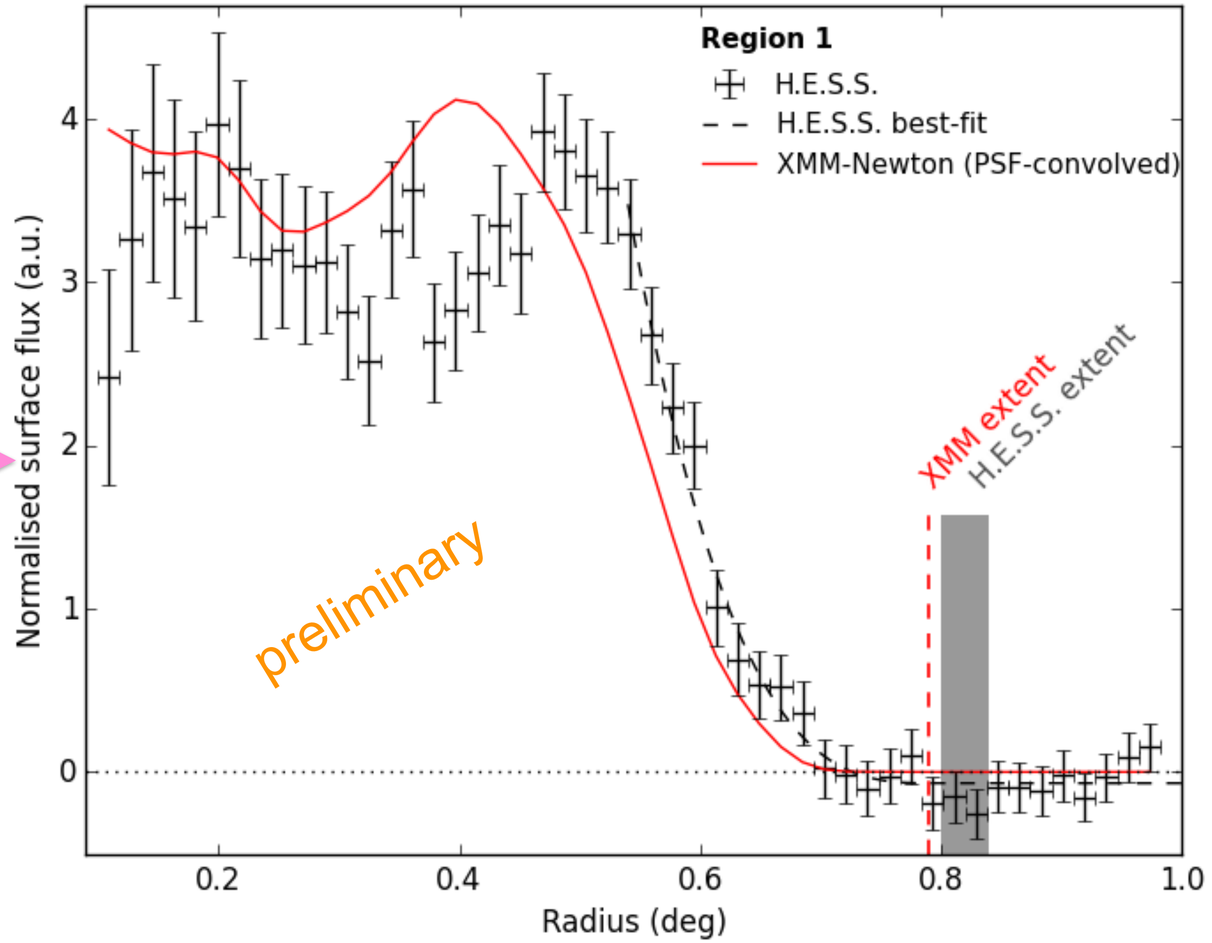
B-field map



Radial profiles: X-ray vs TeV





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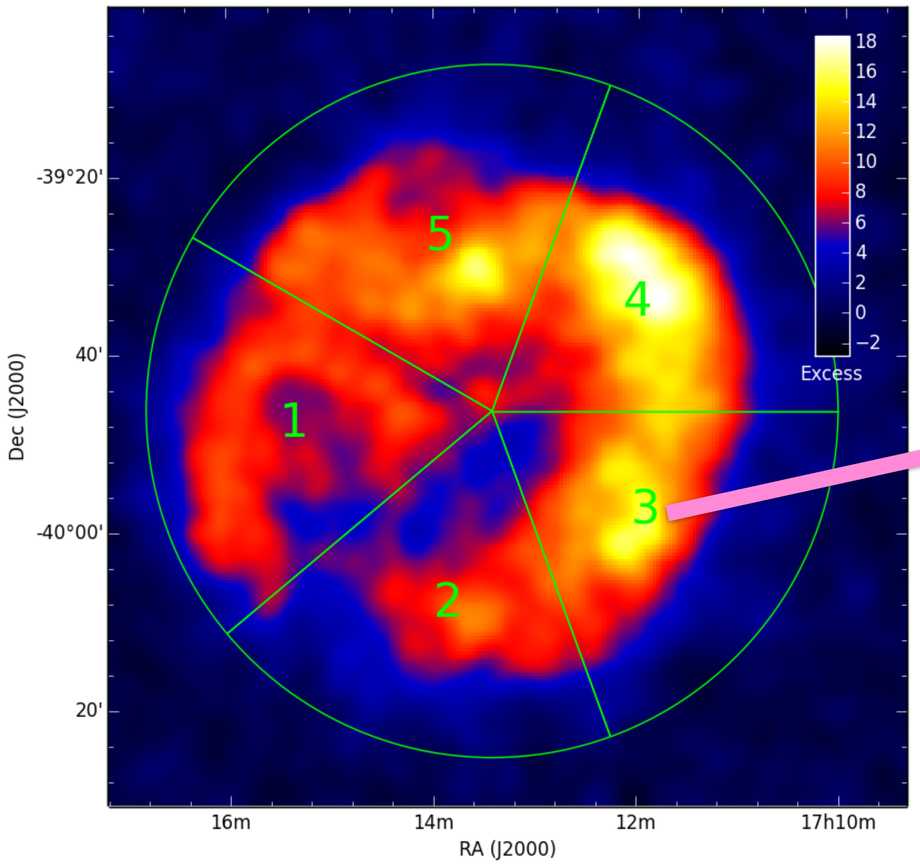

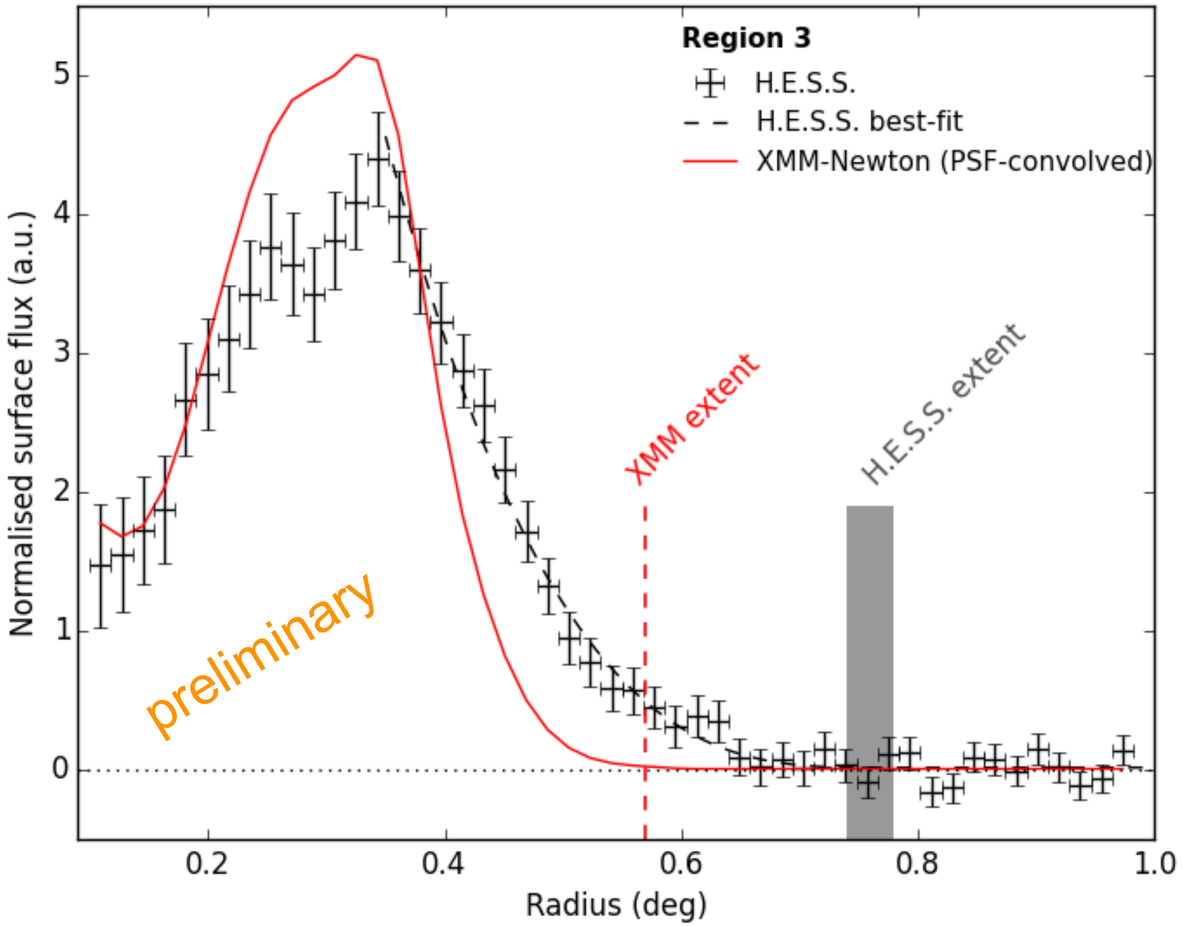

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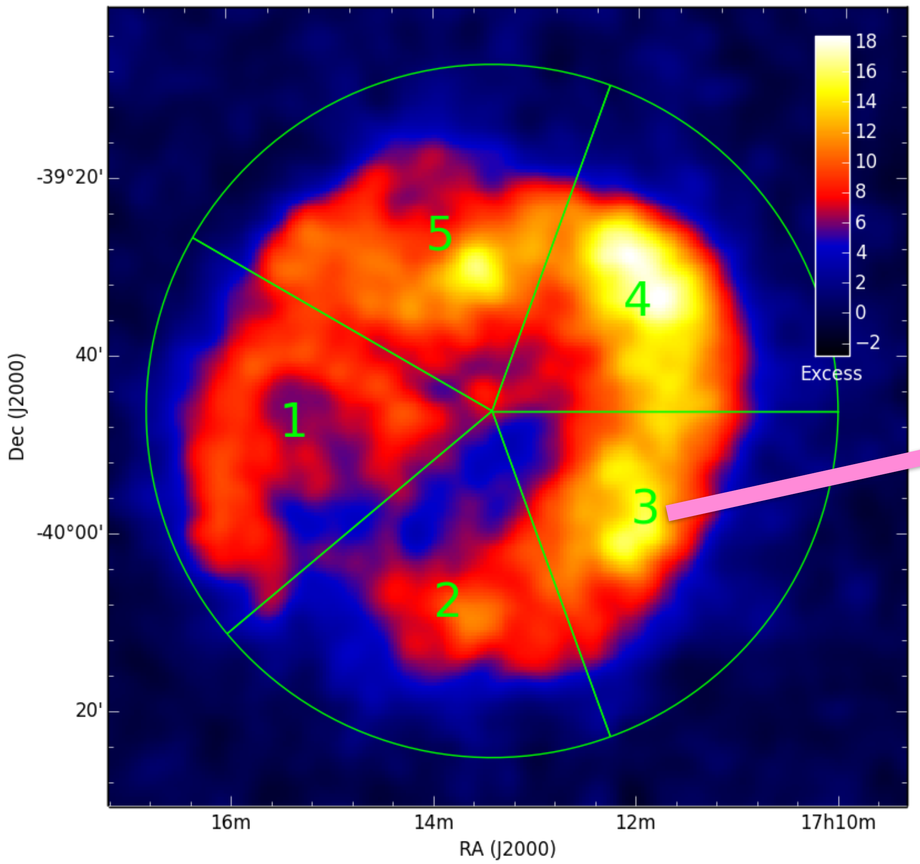

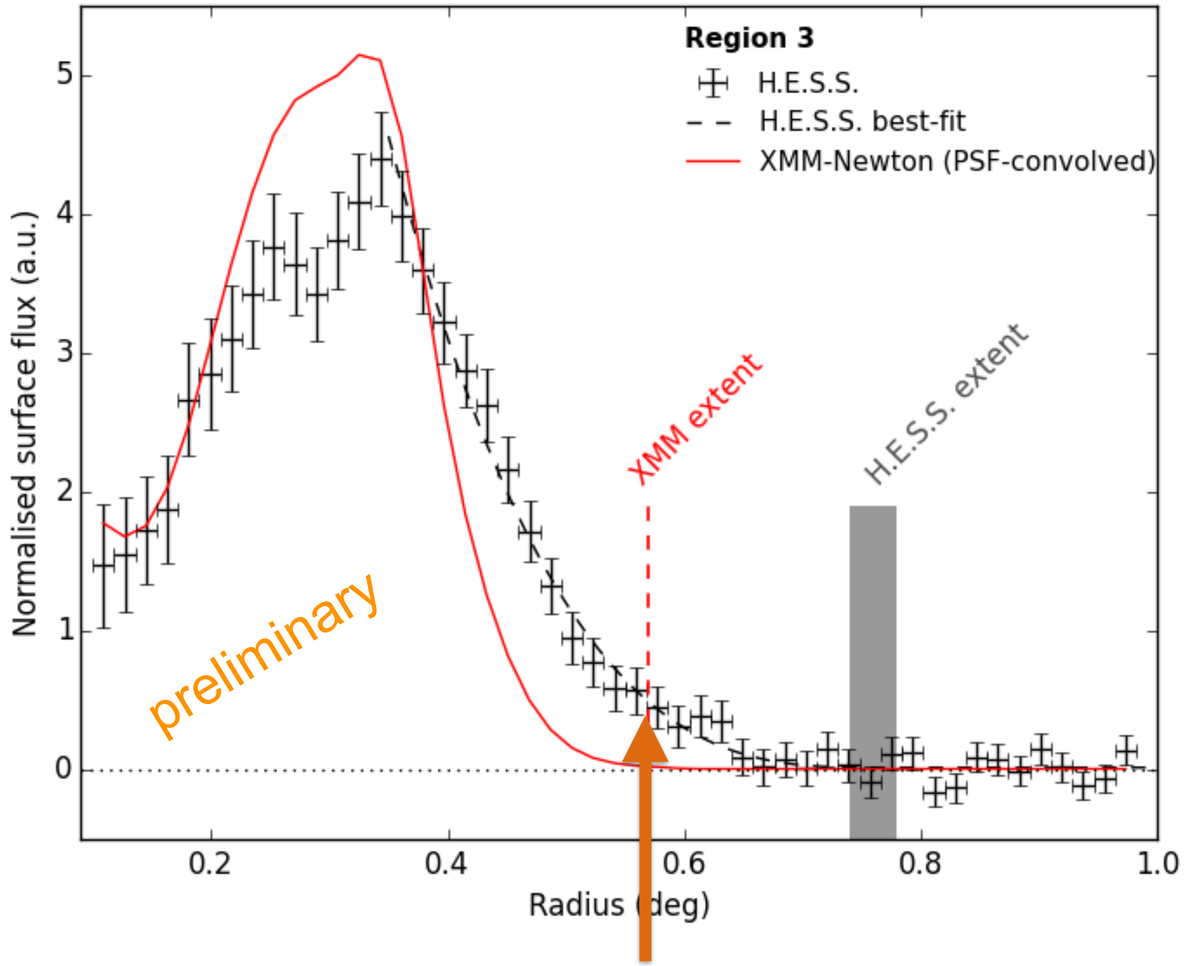

particle escape?

Summary

- Break in electron and proton spectrum required to describe the data
  —> challenges for leptonic scenario
  —> energy-dependent diffusion into dense molecular clumps in hadronic scenario?

- Large fluctuation of the magnetic field throughout the remnant

- TeV shell extended beyond X-ray shell
  —> detection of particle escape? (protons)
  —> B-field evolution? (electrons)