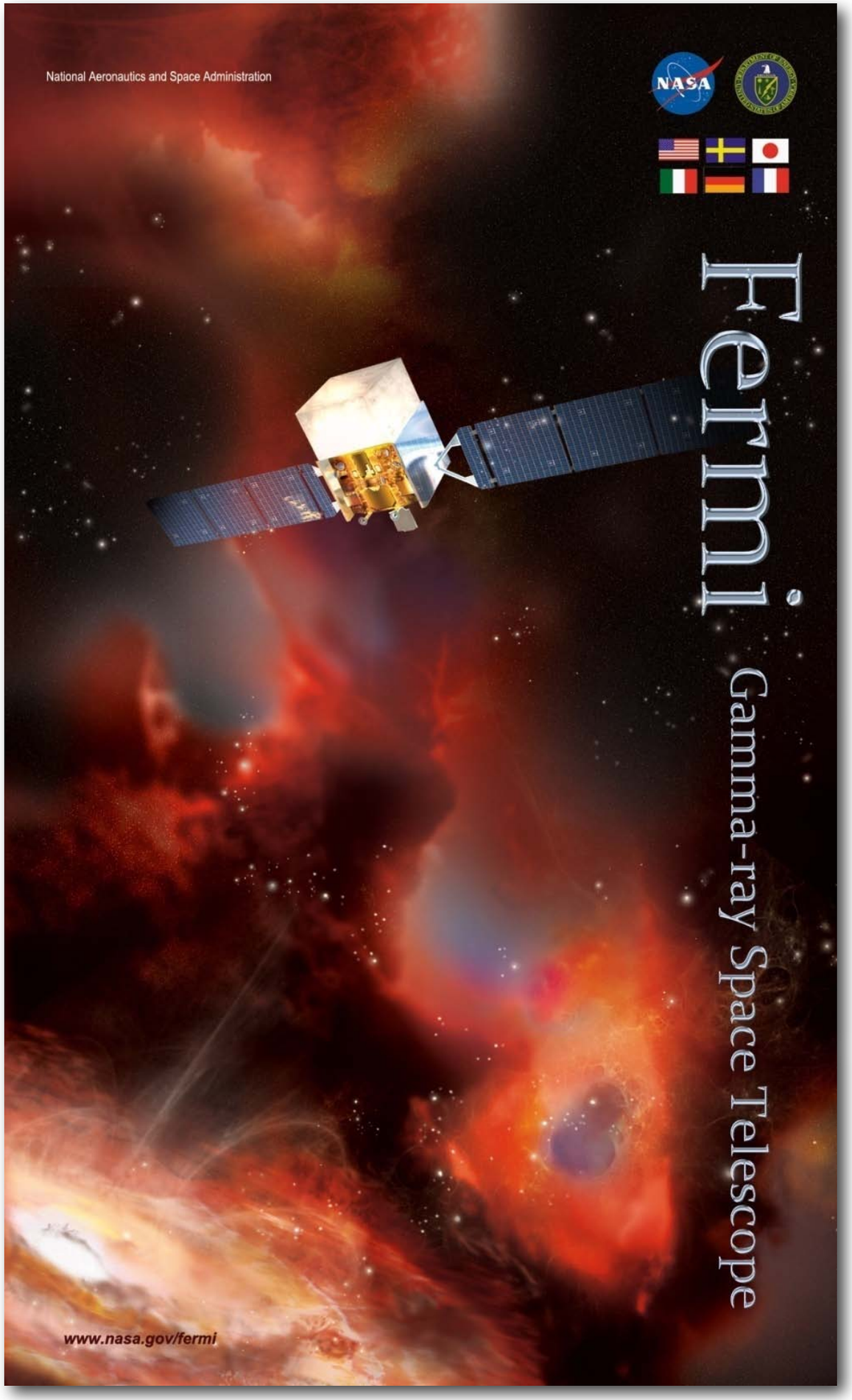


Gamma-Ray Observations of the Supernova Remnant RX J0852.0–4622 with the Fermi LAT

Takaaki Tanaka (KIPAC, Stanford)

on behalf of the Fermi LAT collaboration

Fermi Symposium 2011
@ Rome, Italy (May 11th, 2011)

TeV emitting SNRs

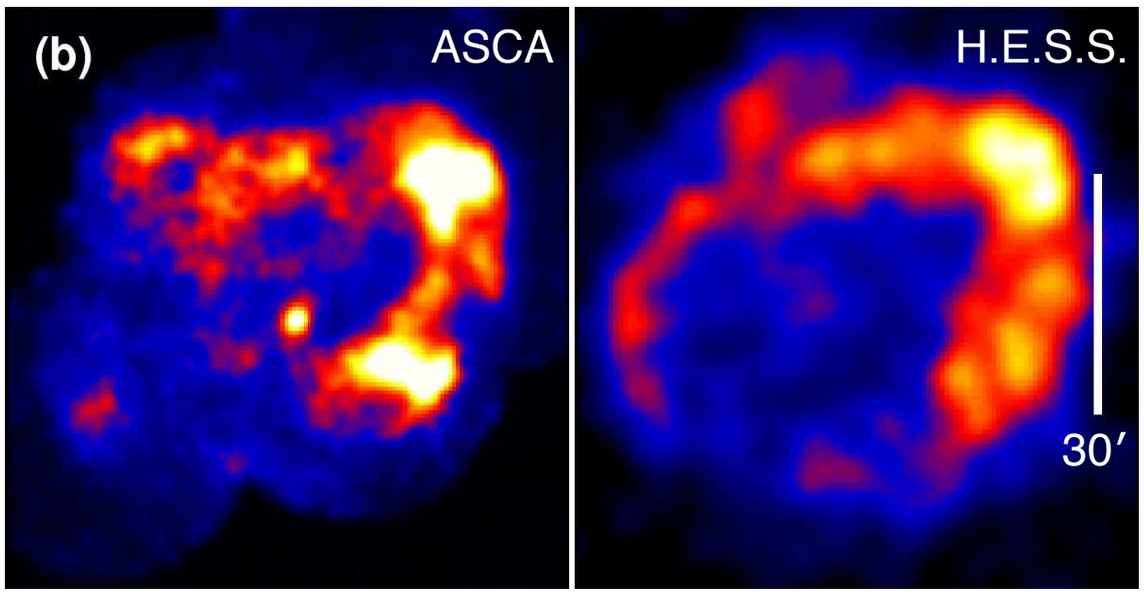
Detection & imaging of young supernova remnants (SNRs) by air Cherenkov telescopes

Evidence of acceleration of either electrons or protons up to TeV energies

Multi-wavelength study with high-quality spectra

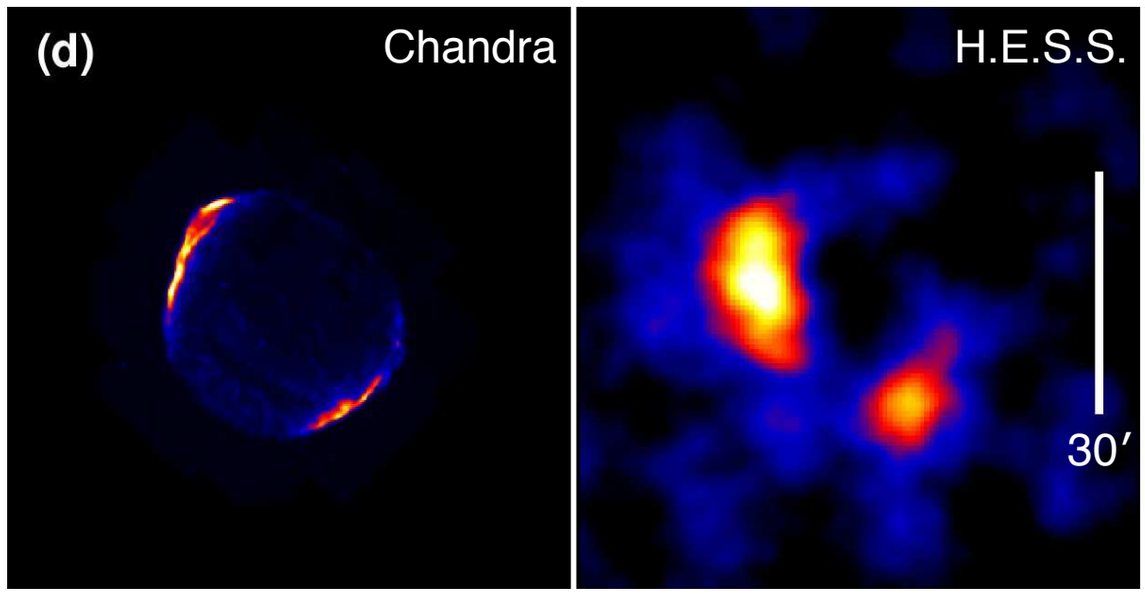
Direct comparison of gamma-ray morphologies with non-thermal X-rays
(X-rays = synchrotron radiation from TeV electrons)

RX J1713.7–3946



X-rays TeV gamma rays

SN 1006



X-rays TeV gamma rays

Images taken from Hinton & Hofmann (2009)

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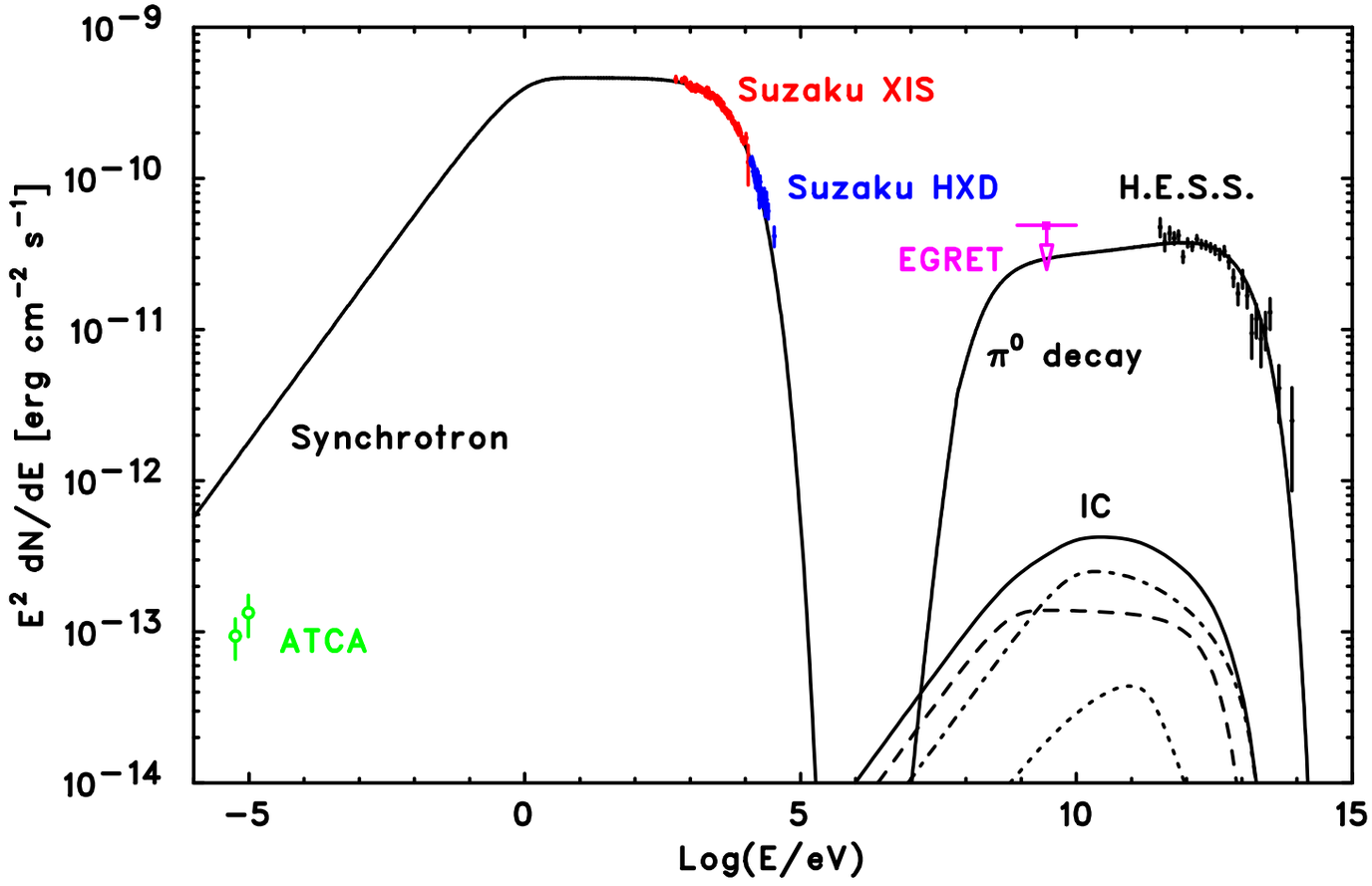

Tanaka+ 2008

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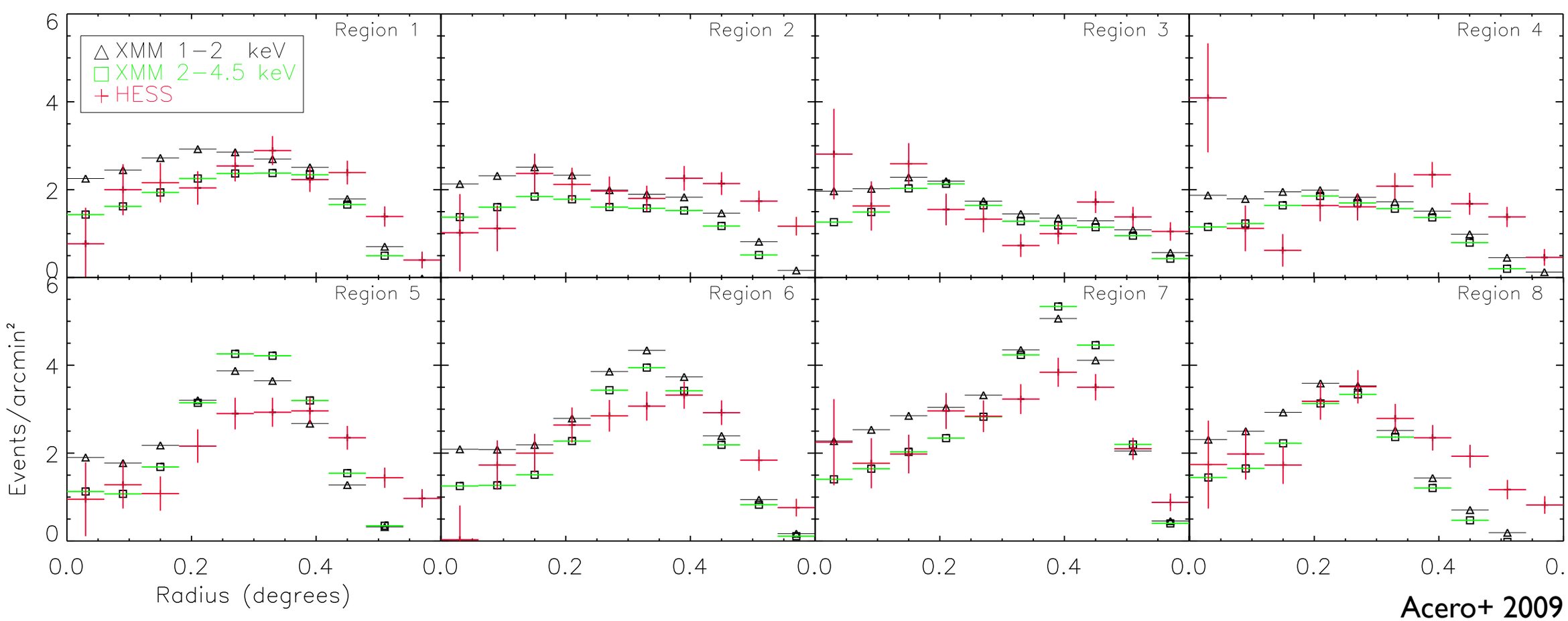

Acero+ 2009

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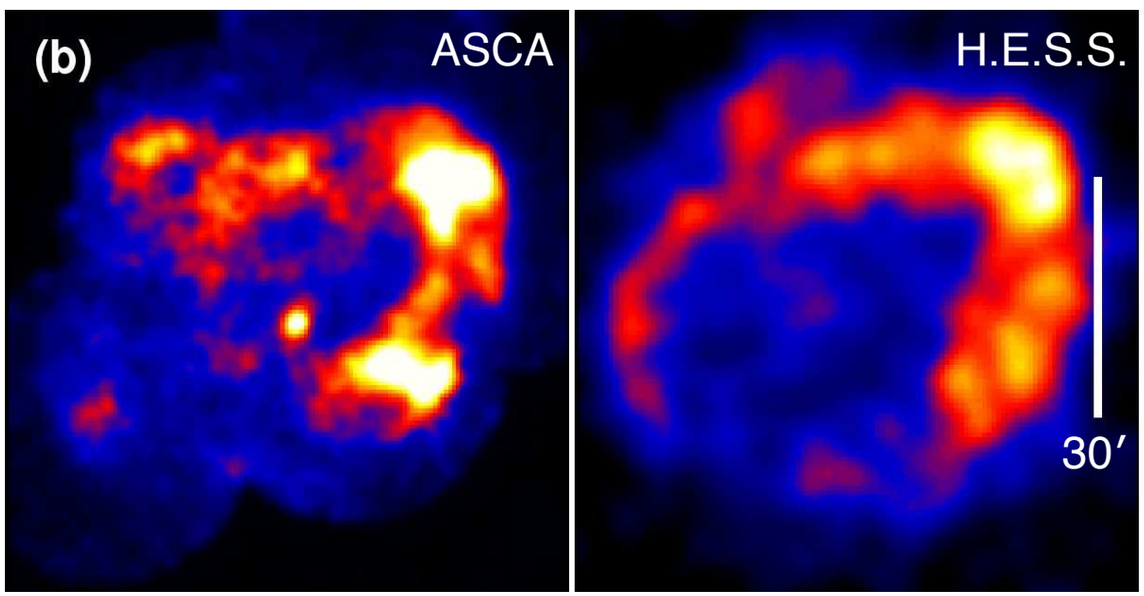

X-rays TeV gamma rays

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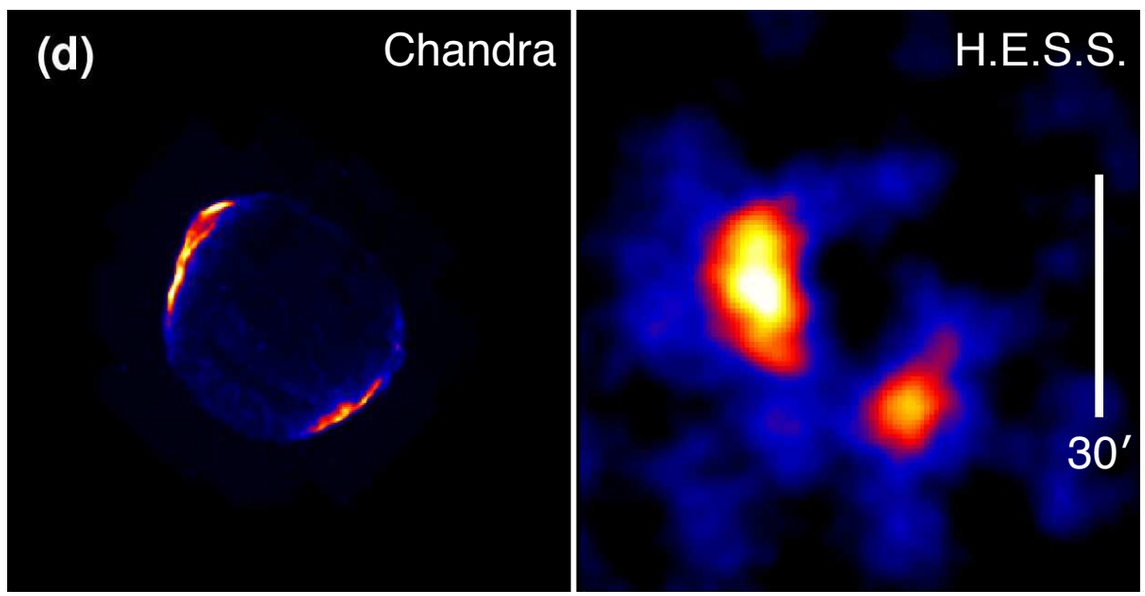


X-rays TeV gamma rays

Images taken from Hinton & Hofmann (2009)

Role of the Fermi LAT

Key Issue

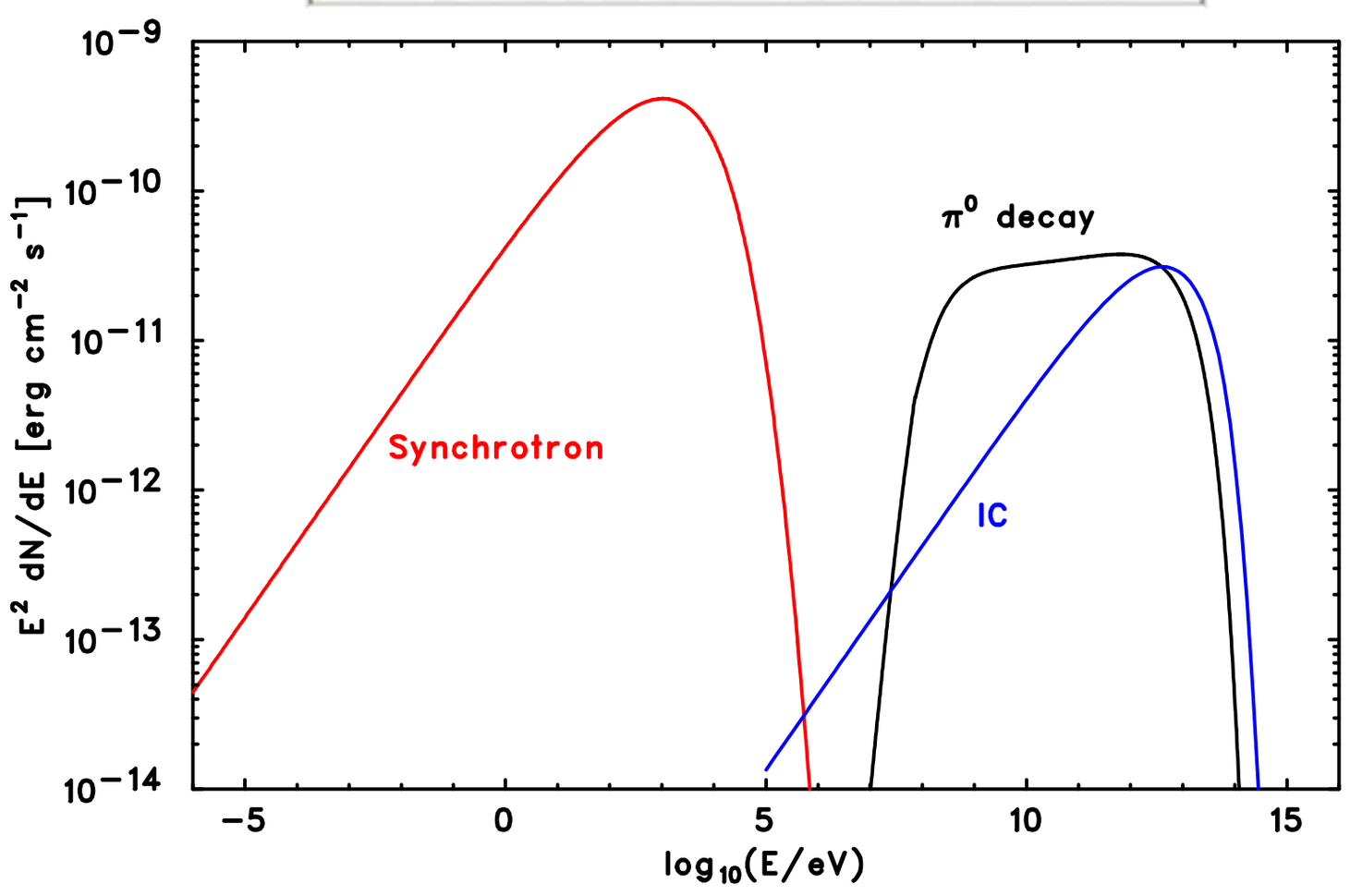
Origin of the gamma-ray emission

Hadronic (π^0 decays)

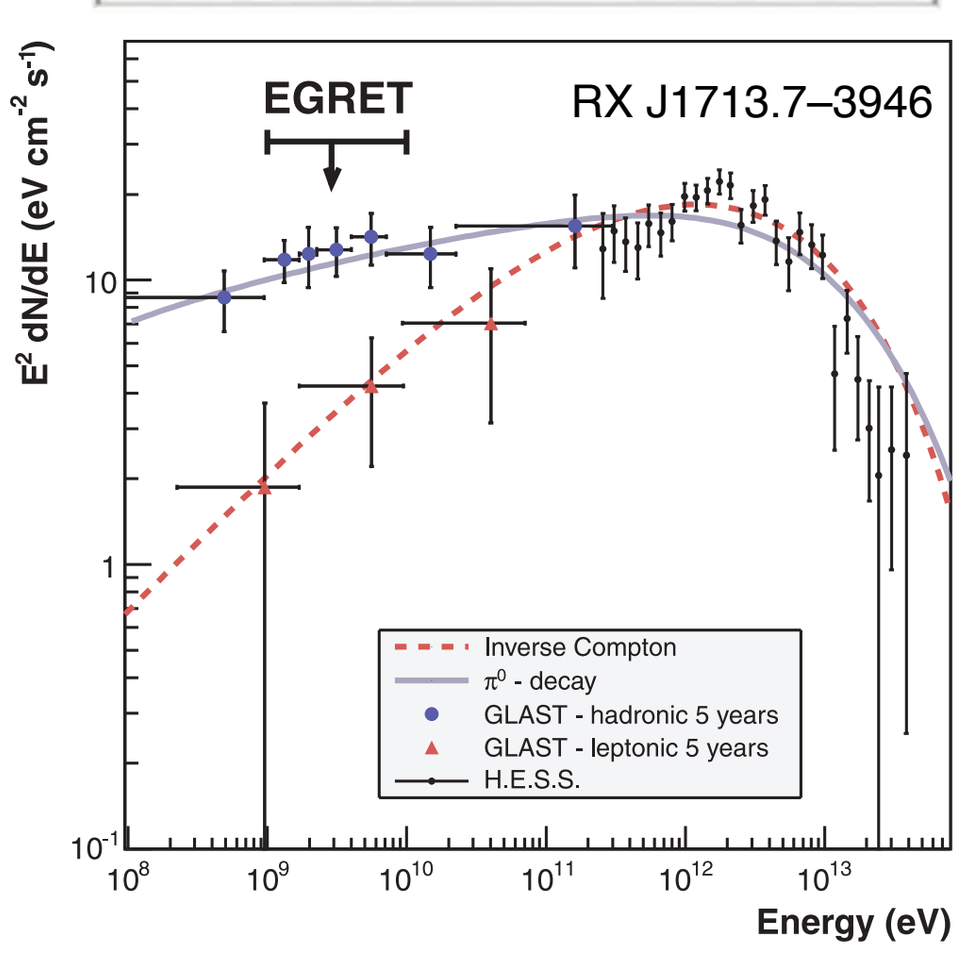
or

Leptonic (inverse Compton scattering of electrons)

Non-thermal Radiation from an SNR

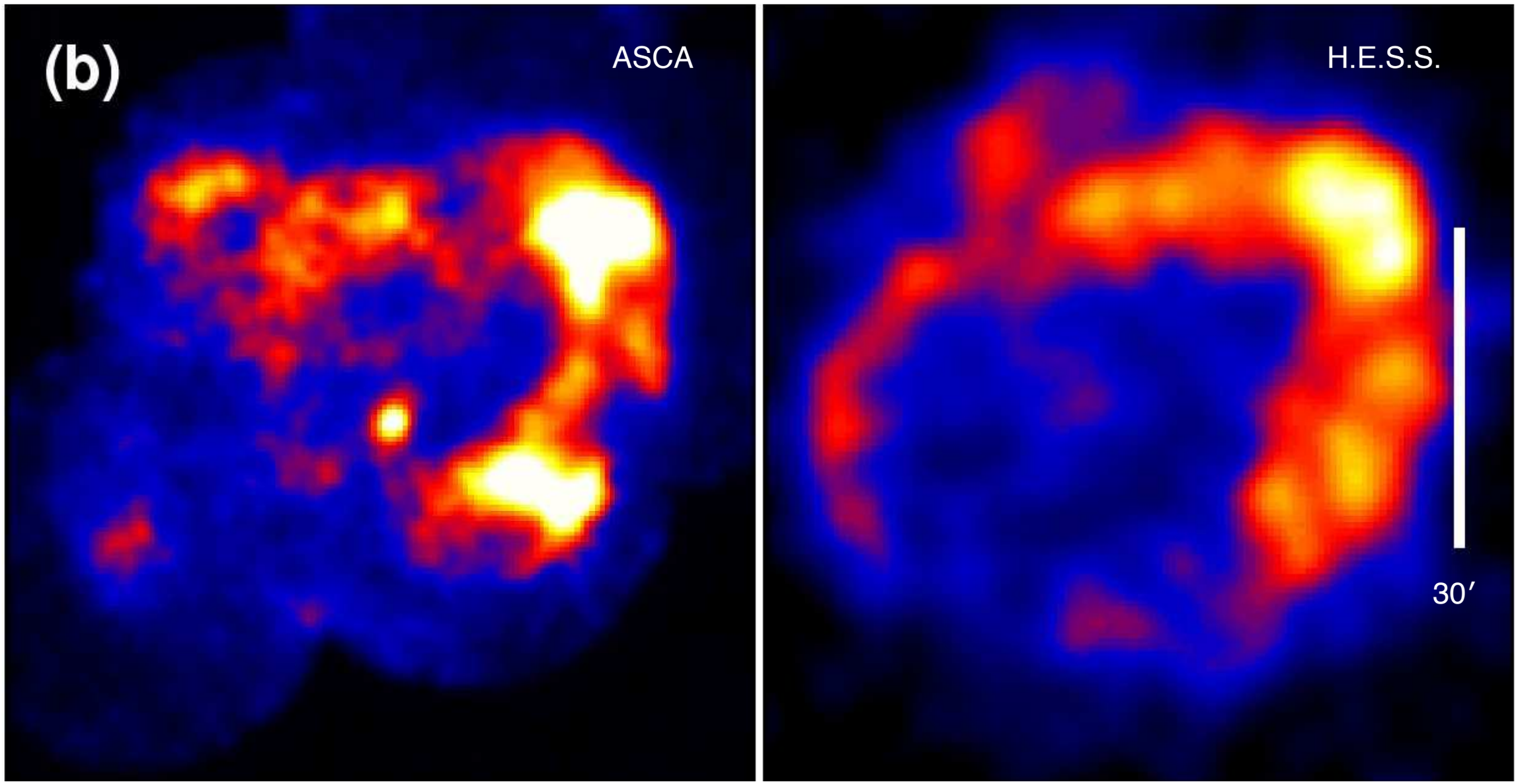


Prelaunch Simulation (Funk+ 2008)



RX J1713.7–3946

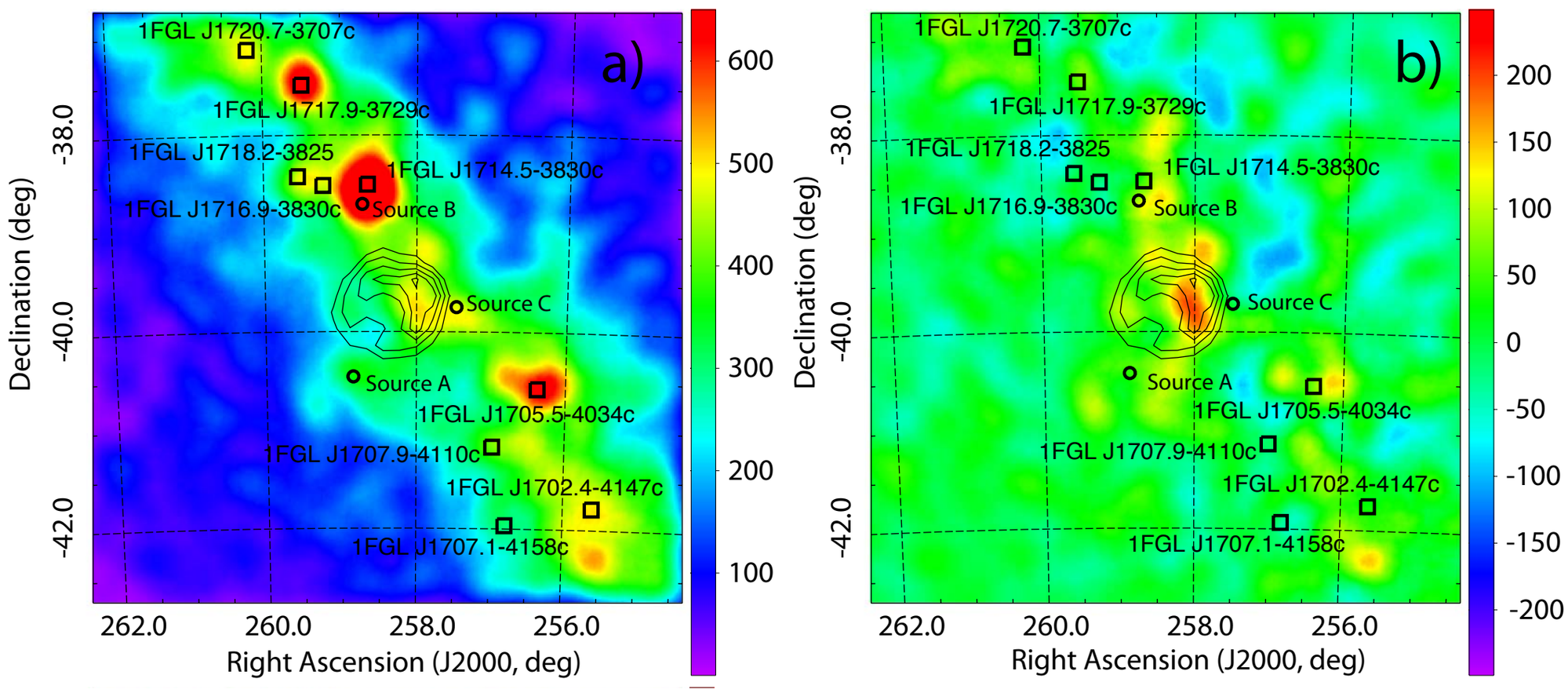
One of the well-studied TeV-bright SNRs



RX J1713.7–3946

The Fermi LAT collaboration recently published the results (Abdo+ 2011; arXiv 1103.5727)
Spatially extended source at the location of the SNR
The extent determined by a maximum likelihood fit is consistent with that of the SNR observed in other wavelengths

Fermi LAT count maps (> 3 GeV)



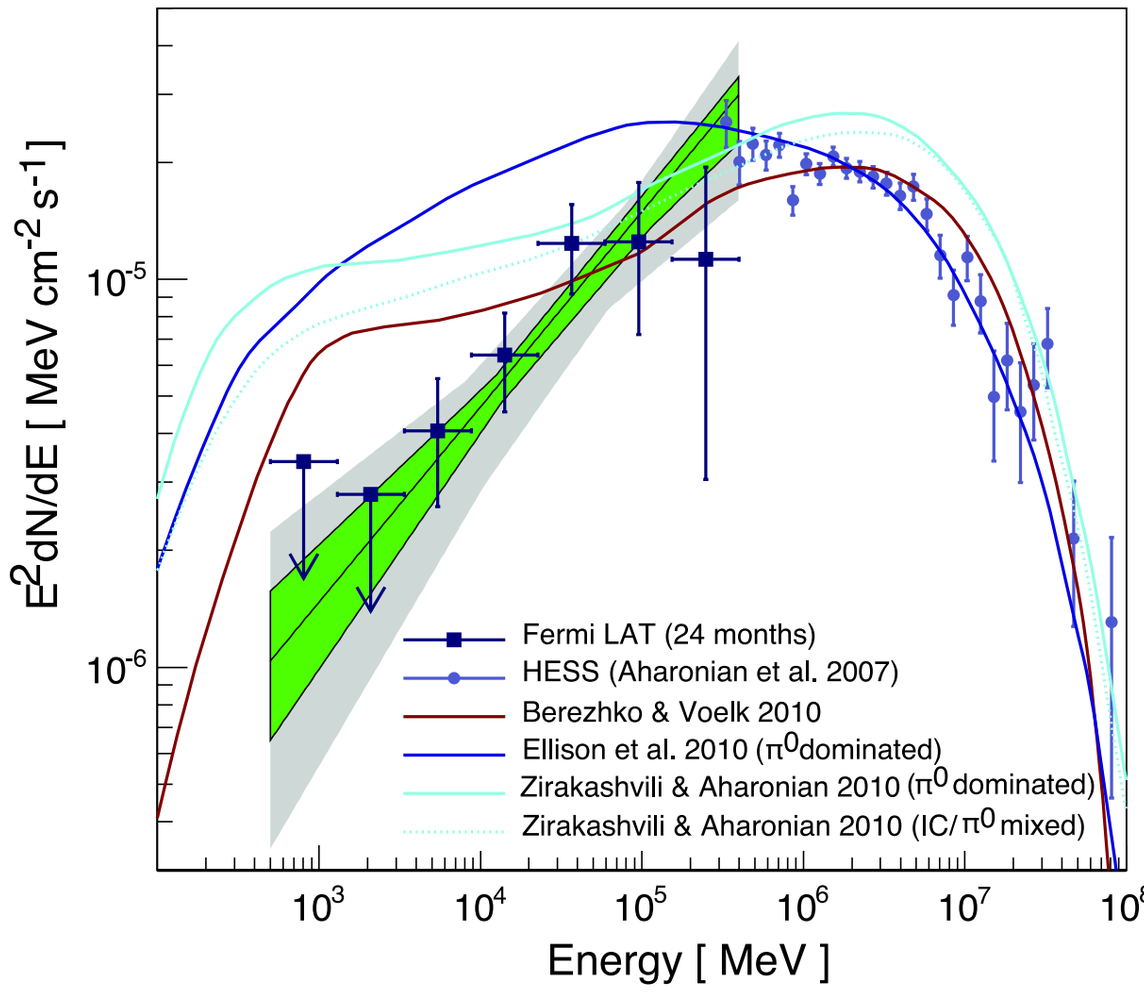
Before background subtraction

After background (contributions from diffuse backgrounds + other sources) subtraction

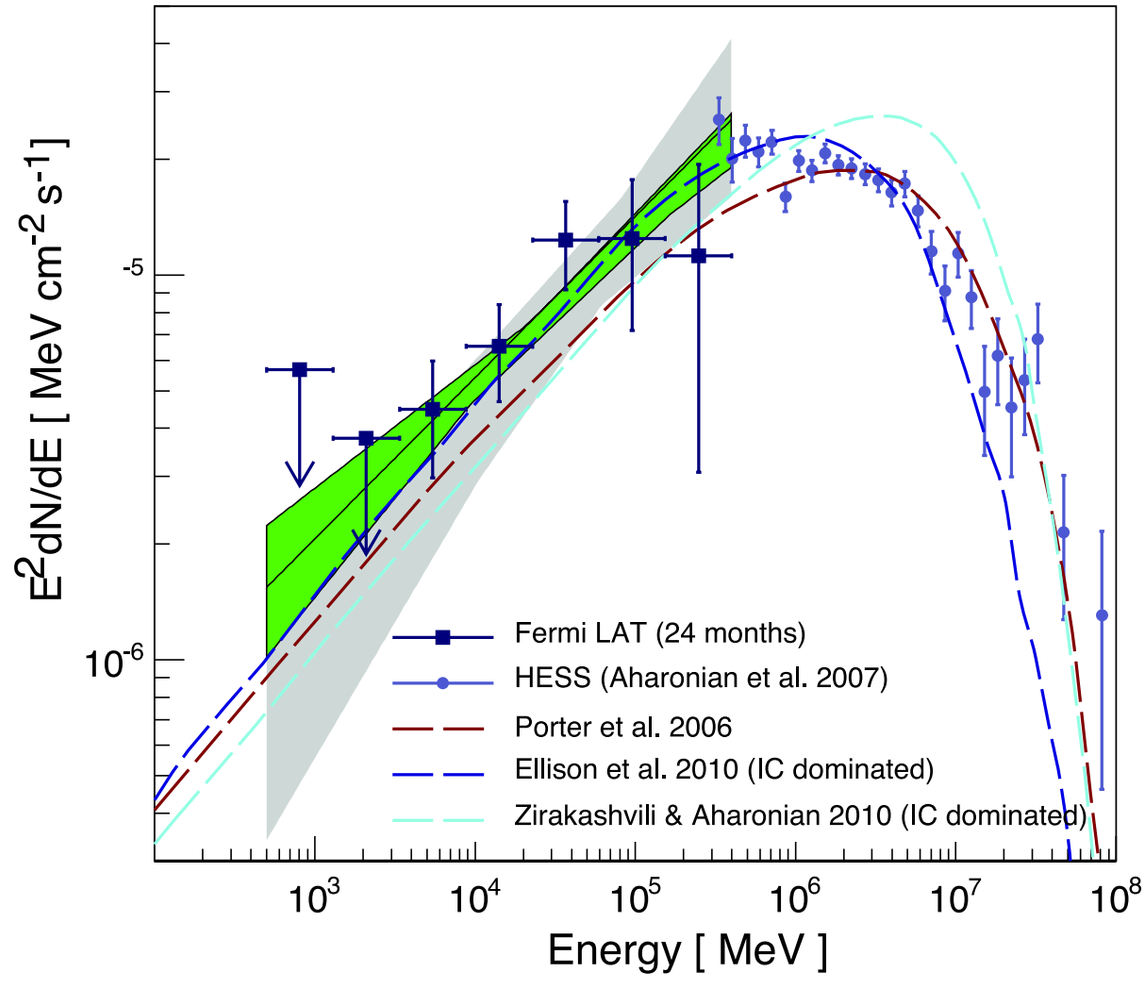
RX J1713.7–3946

Fermi LAT spectrum: Very hard with $\Gamma = 1.5 \pm 0.1$ (stat) ± 0.1 (sys)

Hadronic Models



Leptonic Models



The Fermi LAT + H.E.S.S. spectrum can be fit well with leptonic models

If interpreted with hadronic models, extremely efficient particle acceleration is required to fit the data (proton index must be $s_p \sim 1.5$ to fit the Fermi LAT spectrum)

RX J0852.0–4622 (Vela Jr)

Another TeV-bright young SNR

Discovered by ROSAT (Aschenbach 1998)

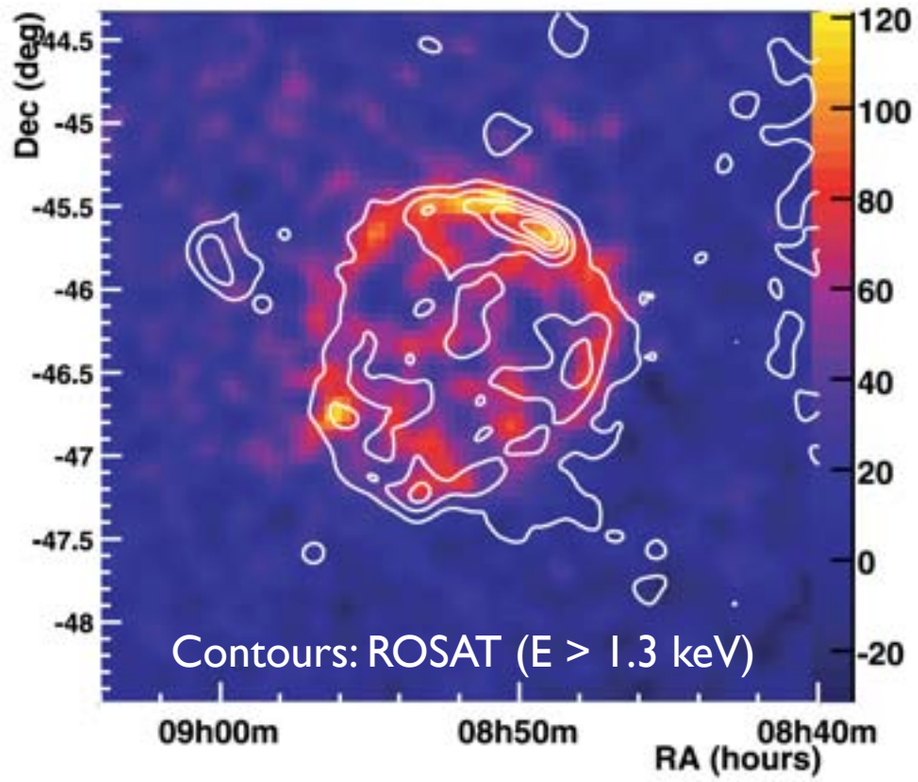
Non-thermal X-rays (Slane+ 2001)

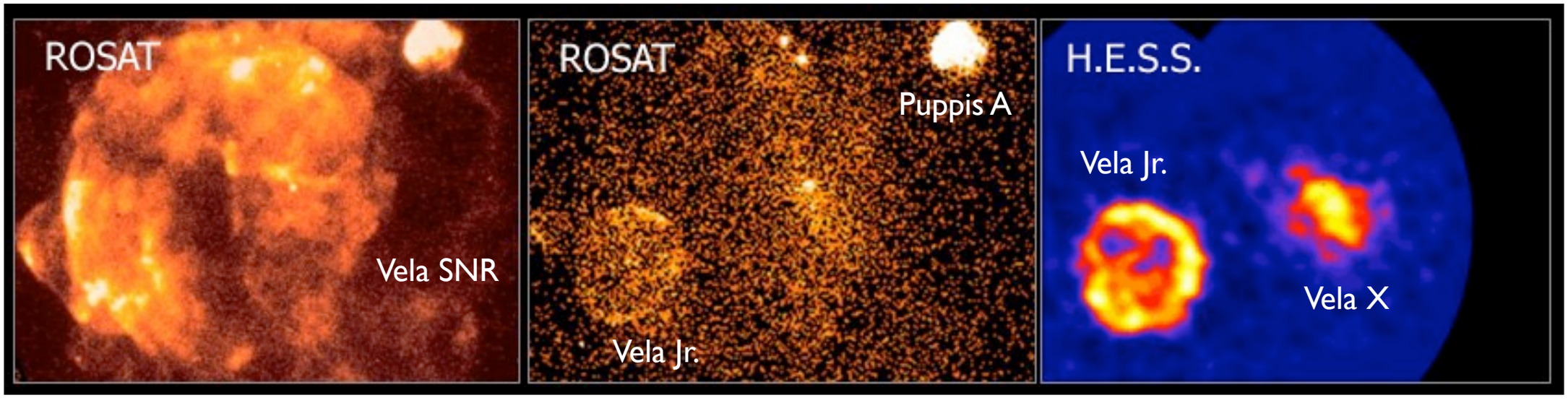
Detected in TeV
CANGAROO: Katagiri+ (2005)

Spatially resolved image by H.E.S.S.
(Aharonian+ 2005, 2007)

Latest estimate of age & distance (Katsuda+ 2008):
τ = 1700–4300 yr, D ~ 750 pc
(Further away than Vela SNR)

TeV Gamma-ray Image by H.E.S.S.
(Aharonian+ 2007)





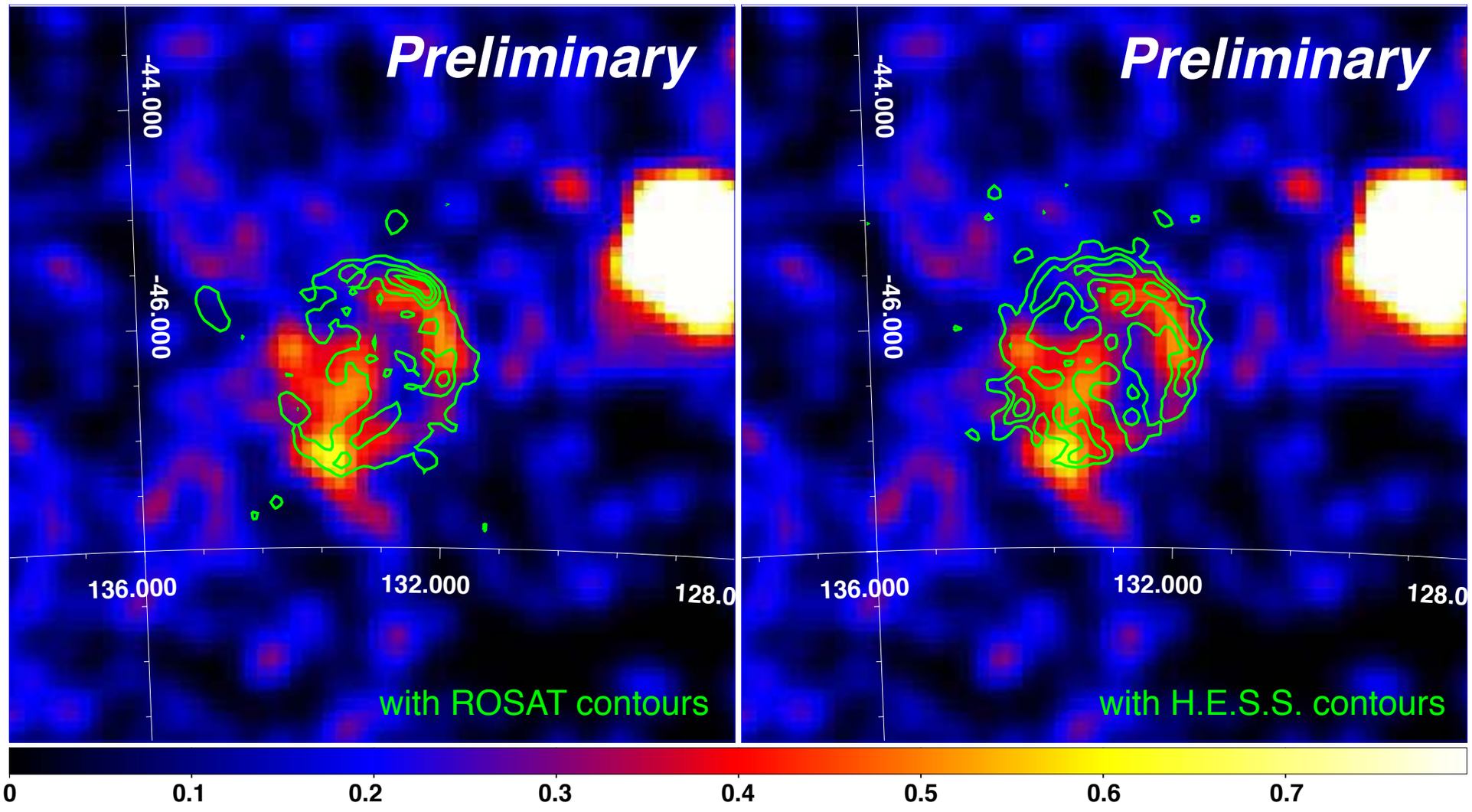
0.1 keV < E < 2.4 keV

E > 1.3 keV

TeV

Fermi LAT image

Fermi LAT count maps (> 10 GeV)



Spatially extended source at the location of the SNR RX J0852.0–4622

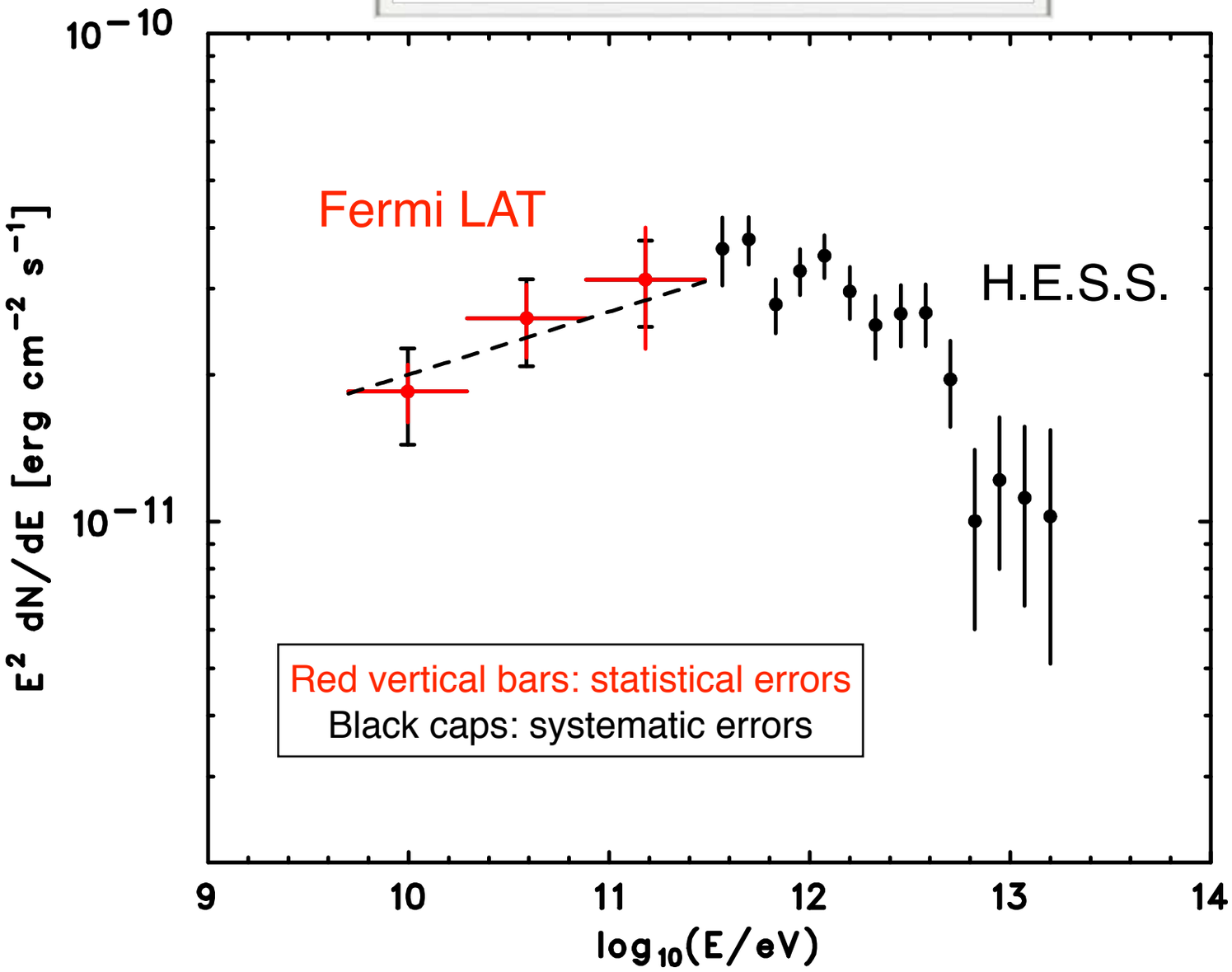
The emission clearly detected in the high energy region (Hereafter we show results with events > 5 GeV)

TS = 221 with the H.E.S.S. image used as a spatial template

Using a uniform disk as a spatial template, we obtain a radius of 1.12 (+0.07, –0.06) deg, which is consistent with the extent observed in radio, X-rays, and TeV gamma rays

Fermi LAT Spectrum

Fermi LAT + H.E.S.S. spectrum



Fermi LAT spectrum connects smoothly to the H.E.S.S. spectrum

Power-law fit to the Fermi LAT spectrum yields $\Gamma = 1.87 \pm 0.08_{(stat)} \pm 0.17_{(sys)}$

Hard GeV spectrum but softer than RX J1713.7–3946 ($\Gamma = 1.5$)

Systematic errors: mainly from imperfect modeling of the Galactic diffuse emission and uncertainties in effective area calibration

Hadronic or Leptonic

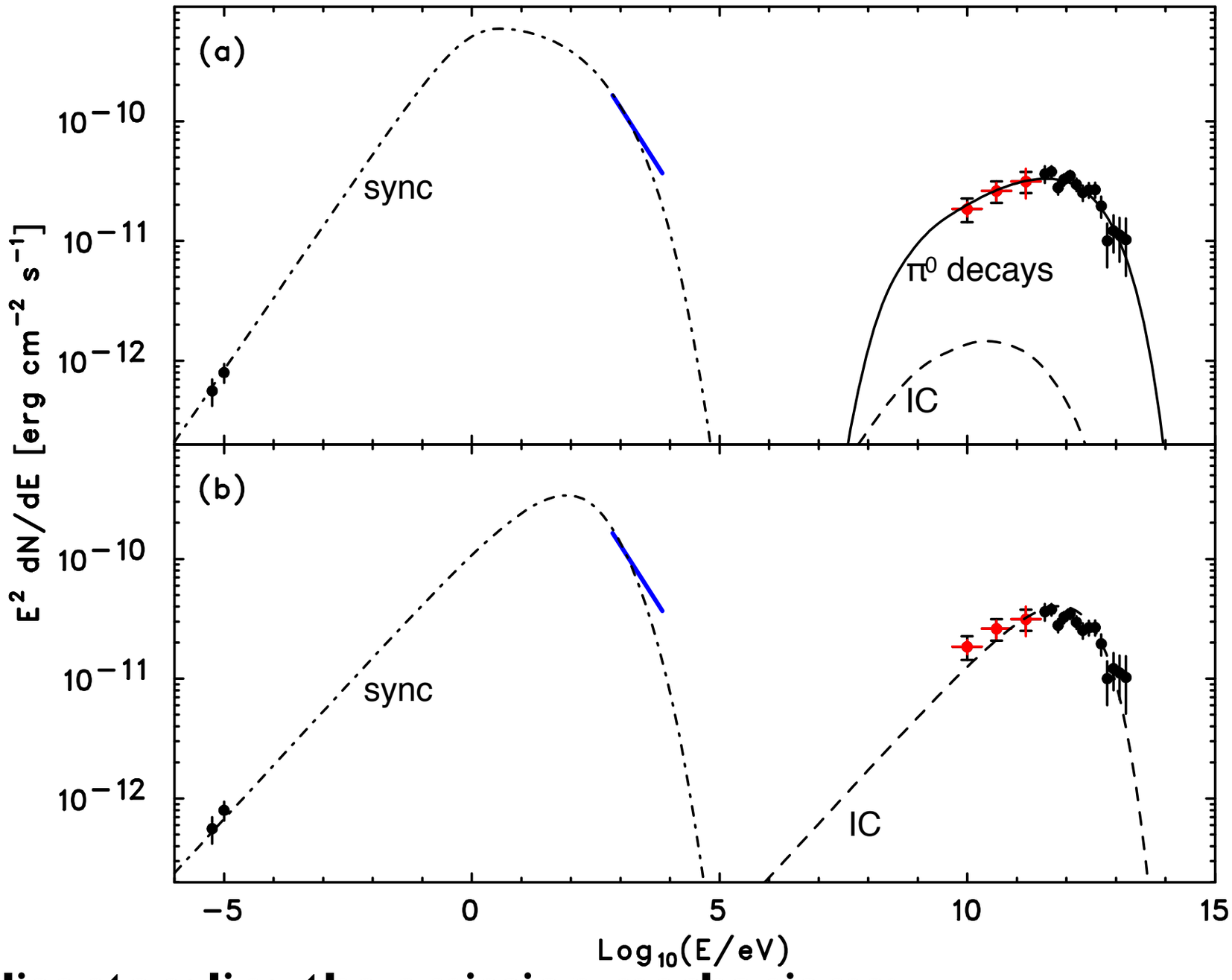
Calculated assuming
D = 750 pc
constant injection over 3000 yr

(a) Hadronic scenario

s_p = 1.8, s_e = 1.8
B = 100 μG
$W_p = 5.2 \times 10^{50}\ (n/0.1\ \mathrm{cm}^{-3})^{-1}$ erg
$W_e = 3.9 \times 10^{46}$ erg

(b) Leptonic scenario

s_e = 2.1
B = 12 μG
$W_e = 6.9 \times 10^{47}$ erg



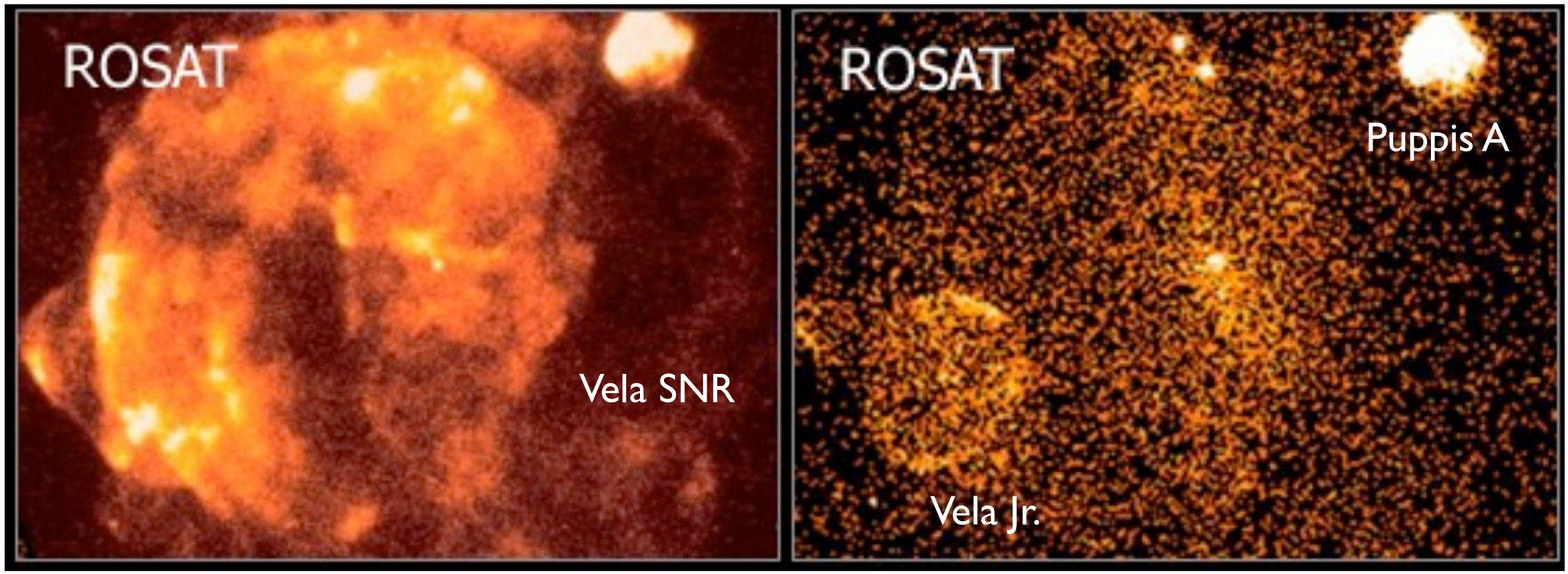
The keys to disentangling the emission mechanisms:

Low energy data from Fermi LAT

Estimate of the gas density (n) from thermal X-rays (not yet detected)

How to reconcile the weak magnetic field with X-ray filaments in the case of the leptonic model

Vela SNR & Vela Jr.



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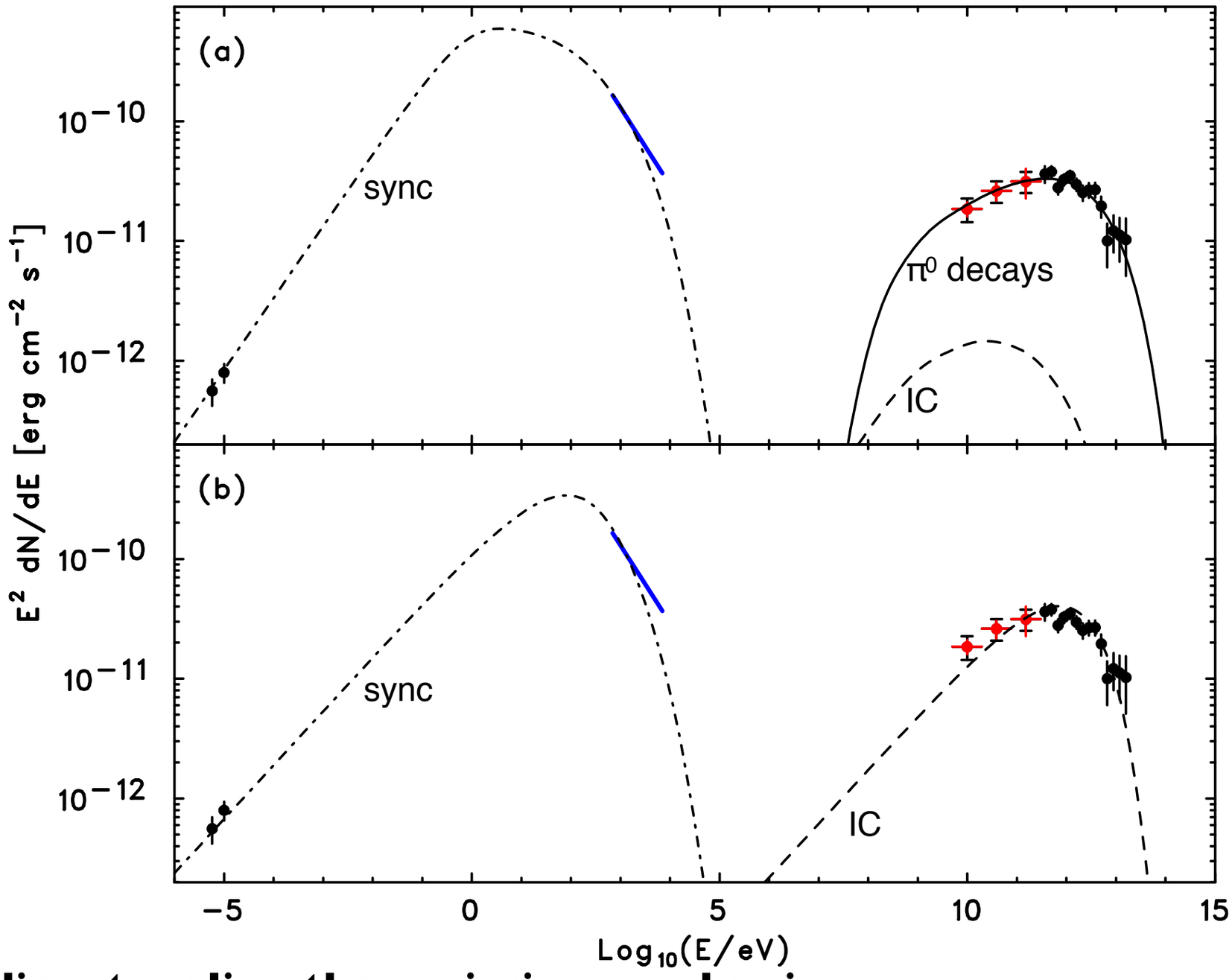

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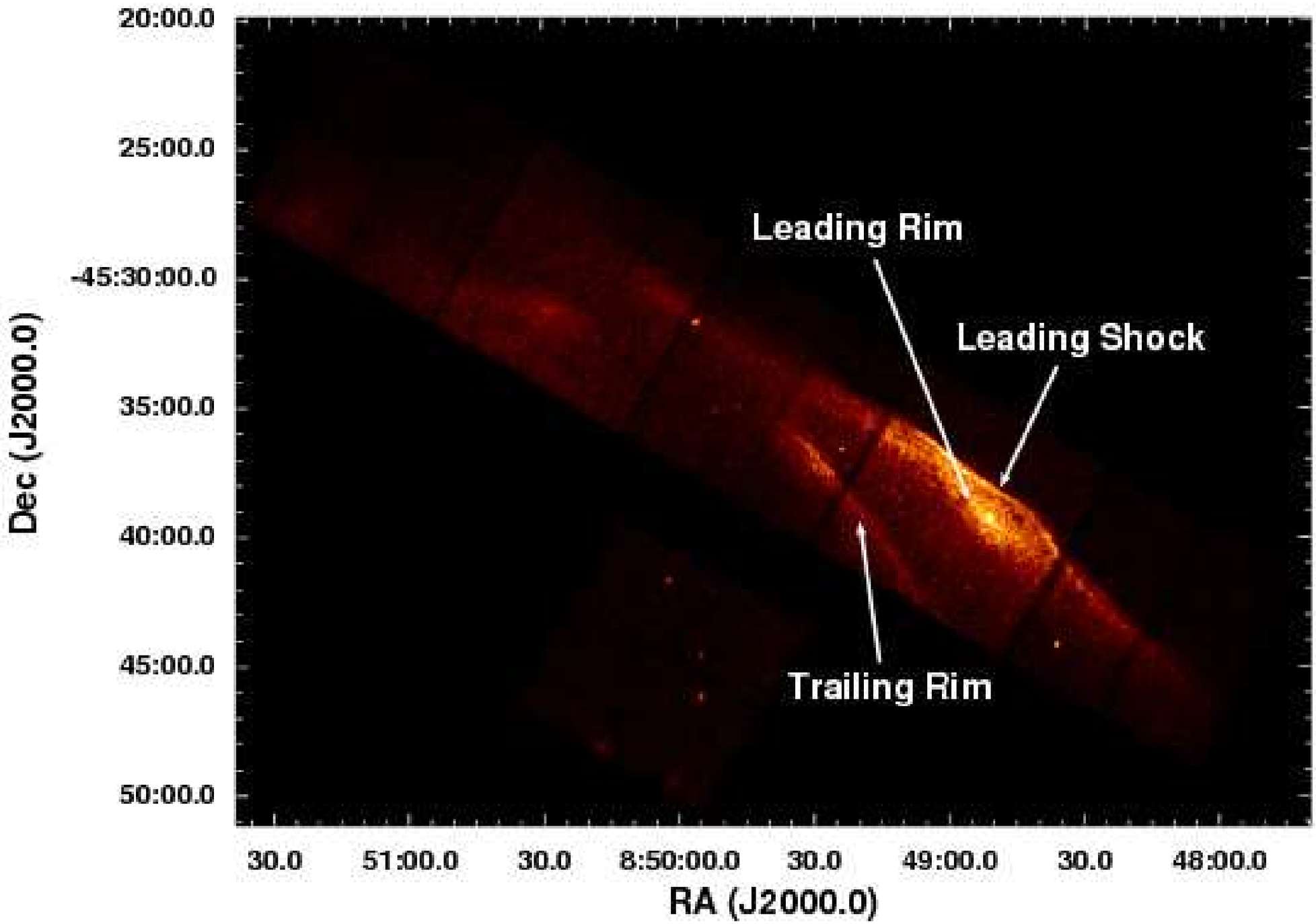
X-ray Filaments in NW



Chandra image (1–5 keV) of the NW rim Pannuti+ (2010)

Summary

- Gamma-ray observation in the GeV band is important to disentangle emission mechanisms of non-thermal radiation from supernova remnants
- Fermi LAT detected gamma rays from young SNRs such as RX J1713.7–3946 and RX J0852.0–4622 (a.k.a. Vela Jr.), which are know as bright TeV gamma-ray emitters
- The Fermi LAT spectrum of RX J0852 is well described by a hard power law with $\Gamma = 1.87$, but softer than RX J1713 ($\Gamma = 1.5$)
- The multi-wavelength spectrum of RX J0852 can be fit either by hadronic or by leptonic models, taking into account the statistical and systematic errors in the current Fermi-LAT spectrum