The role of the diffusive protons in the gamma-ray emission of SNR RX J1713.7-3946

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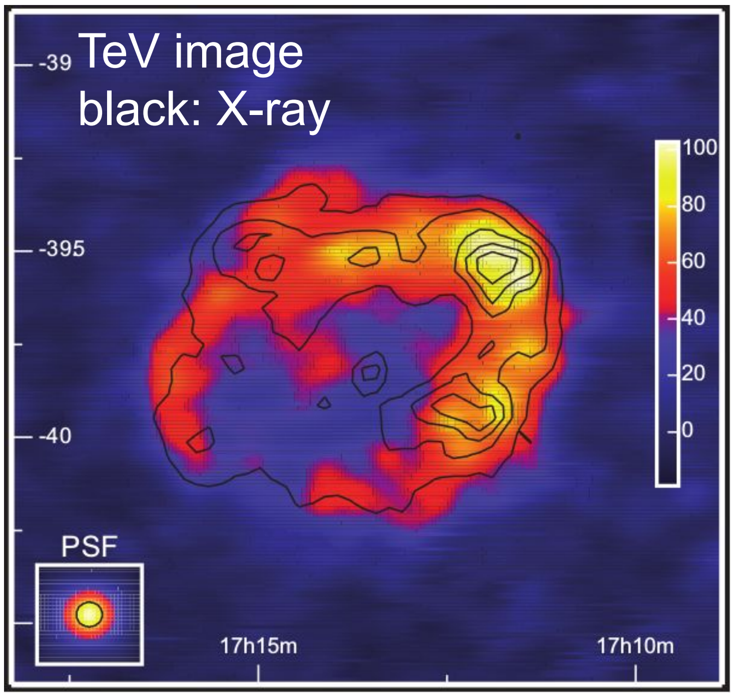
RX J1713.7－3946 at HE

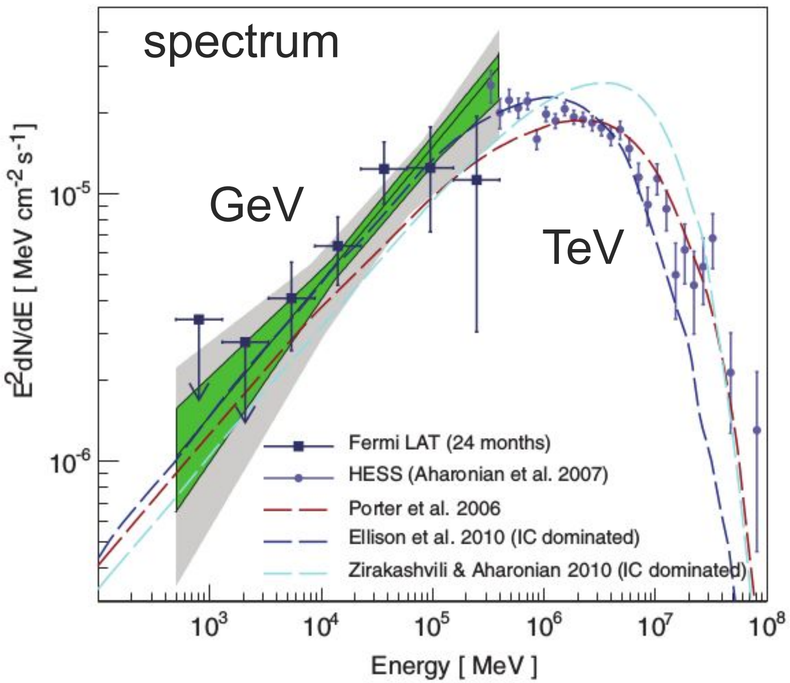
GeV－TeV observations

- TeV image matches X-ray shell
- hard photon index Γ ~ 1.5

→ purely leptonic origin！



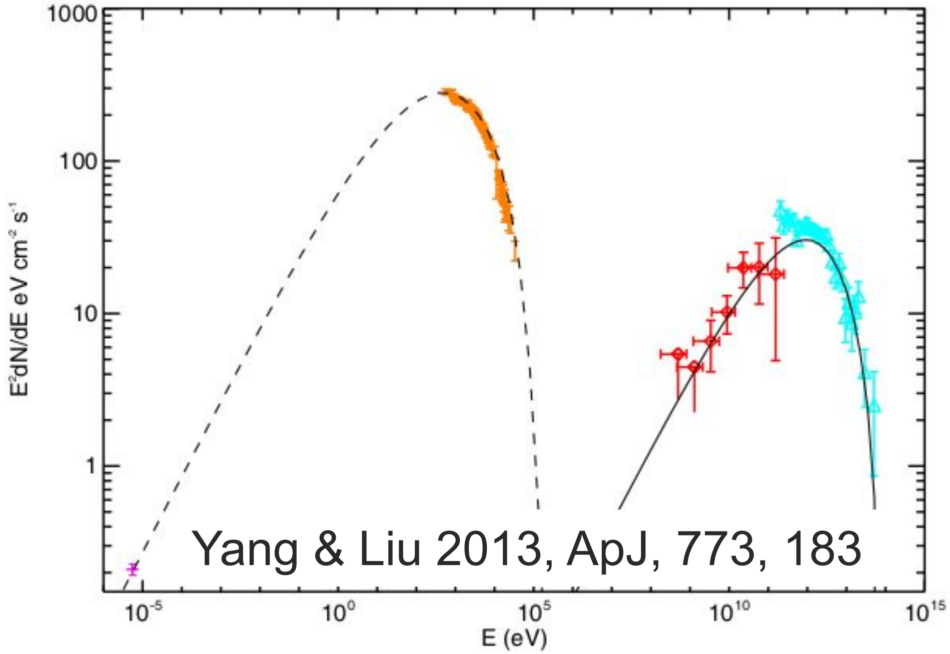
Aharonian et al. 2007



Abodo et al. 2011

Leptonic model and its difficulty

$$\frac{dN}{dE} \propto E^{-\alpha}\exp[-(E/E_{cut})^{\delta}]$$



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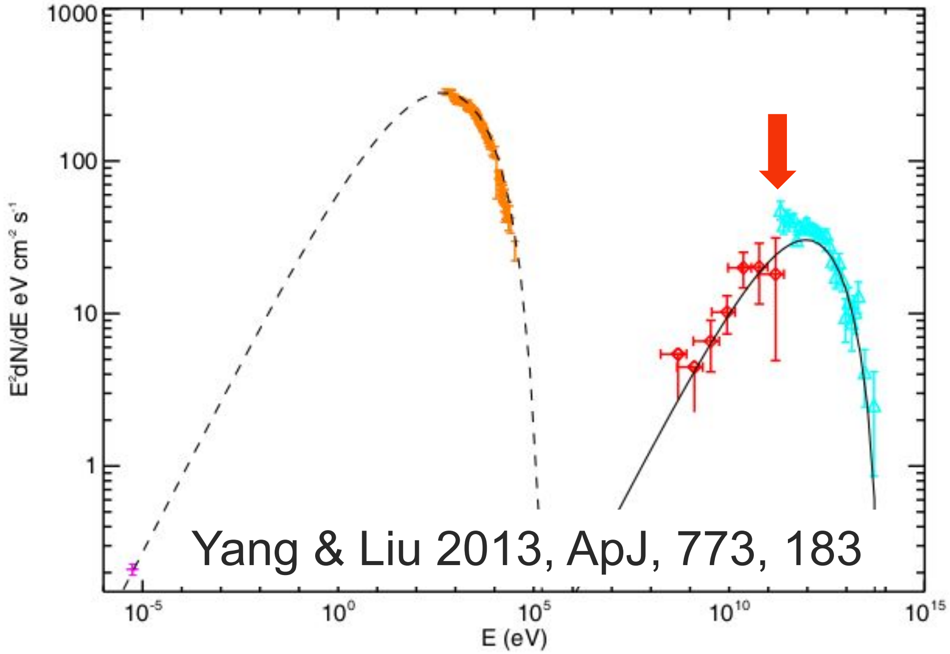
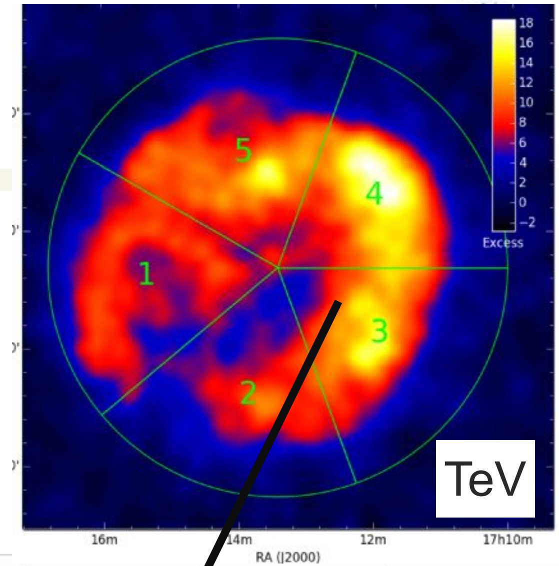


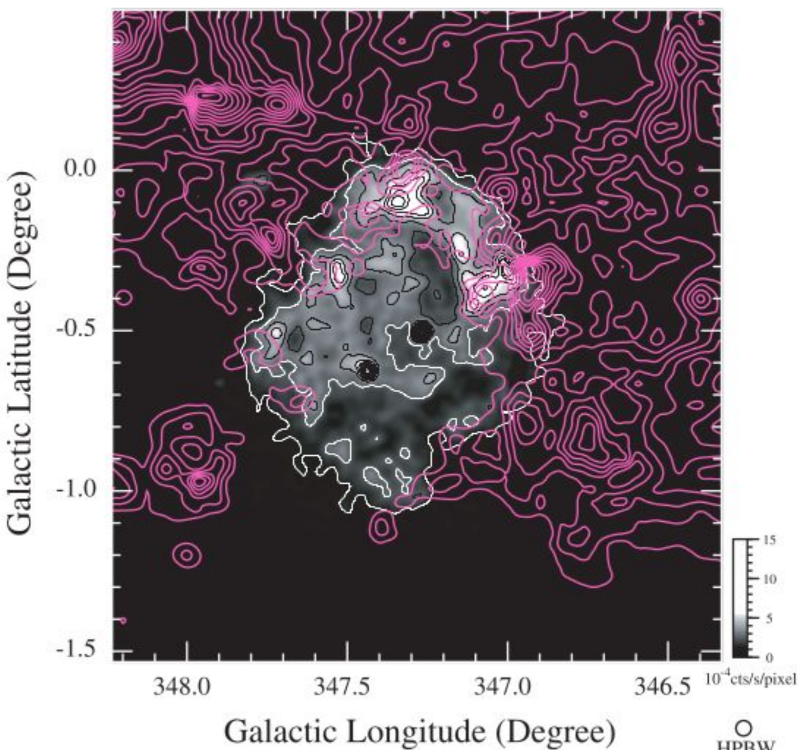
Radio + Xray → Super exponential: δ > 1.0

GeV + TeV → Sub exponential: δ ~ 0.5

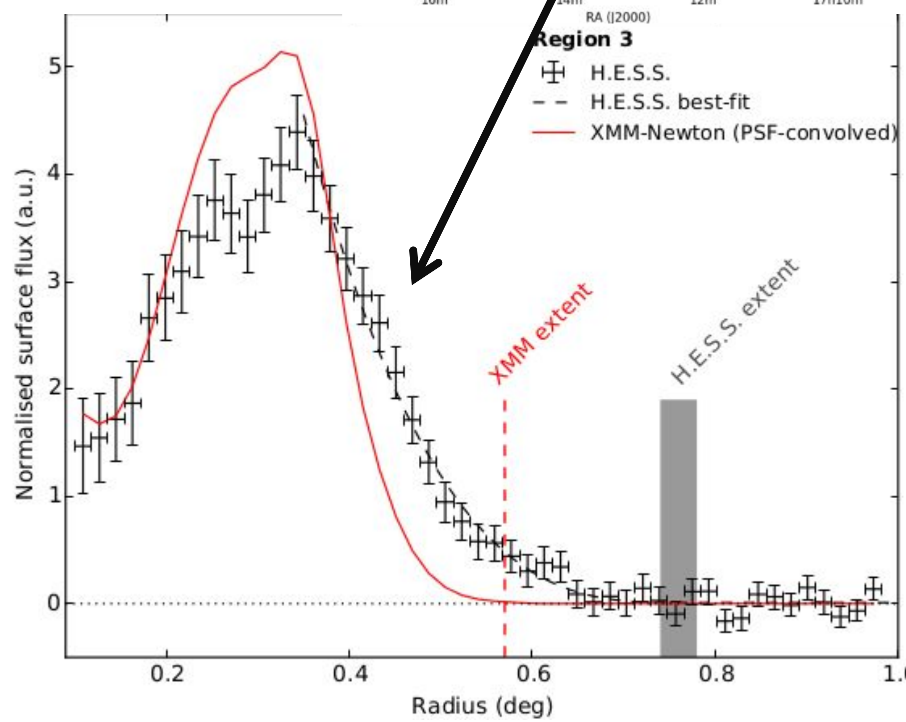
Hadronic component ?

- CO： located in a MC cavity
- TeV radial profile beyonds X-ray's



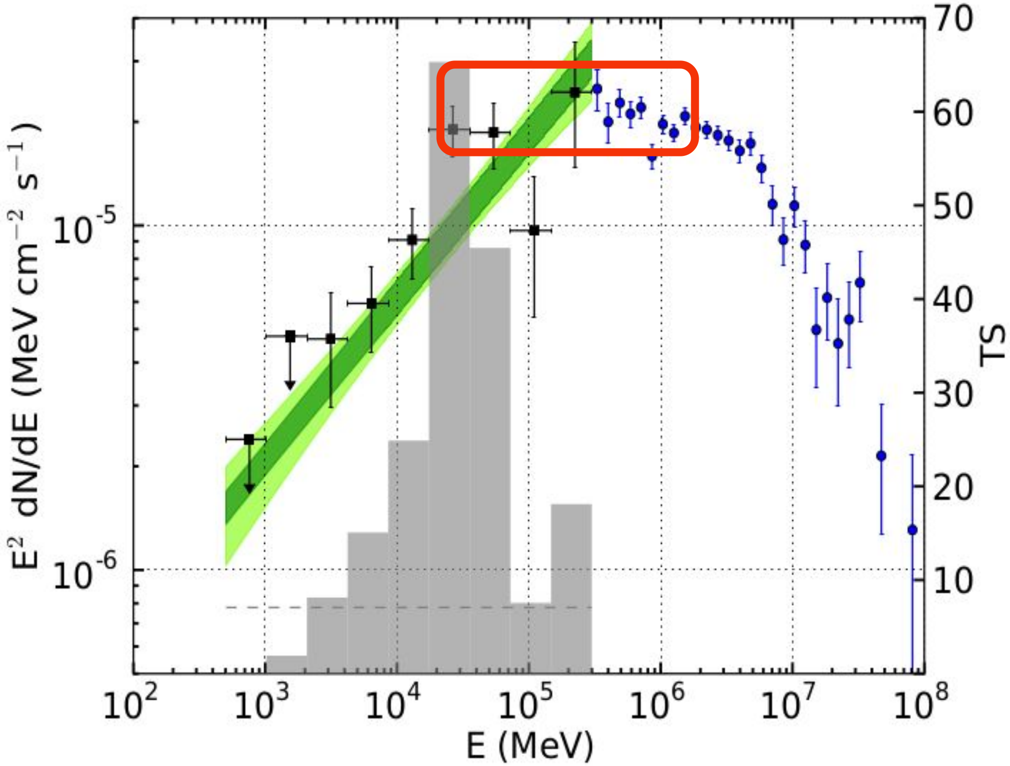


Fukui et al. 2003



de Naurois 2015

The spectral break/platform?

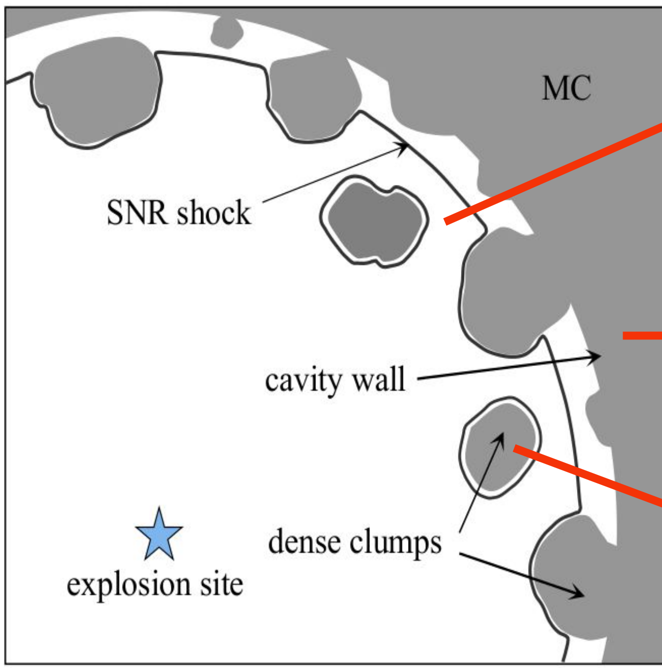


Federic et al. 2015 A&A

not a simple power law plus cutoff ？

Two-zone model

- Due to V_{sh} ~ 4000 km/s and n ~ 0.01 cm^{-3}, we assume that the shock doesn't extensively hit upon the MC but may sweep up some dense clumps.



INNER ZONE (I)
IC (Model Ib)

OUTER ZONE

INNER ZONE (II)
pp (Model IIb)

Model Ia

Model IIa

Particle distributions

- INNER ZONE (I) pow law + cutoff
- OUTER ZONE

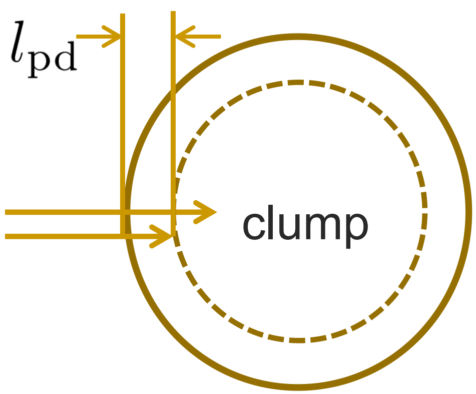
$$\frac{\partial}{\partial t} f(E_{\rm p}, R, t) = \frac{D(E_{\rm p})}{R^2} \frac{\partial}{\partial R} R^2 \frac{\partial}{\partial R} f(E_{\rm p}, R, t) + Q(E_{\rm p}, R, t).$$

$$Q(E, R, t) = Q_0 E^{-\alpha} \delta(R - R_{\rm esc}(t))/4\pi R^2$$

- INNER ZONE (II)

The penetration depth (Inoue et al. 2012) :

$$l_{\rm pd} \approx (\kappa_{\rm d} t)^{1/2} \propto E^{1/2}$$



$$N_\gamma(E)dE \propto M(E)E^{-p}dE$$

$$\propto l_{\rm pd}(E)E^{-p}dE$$

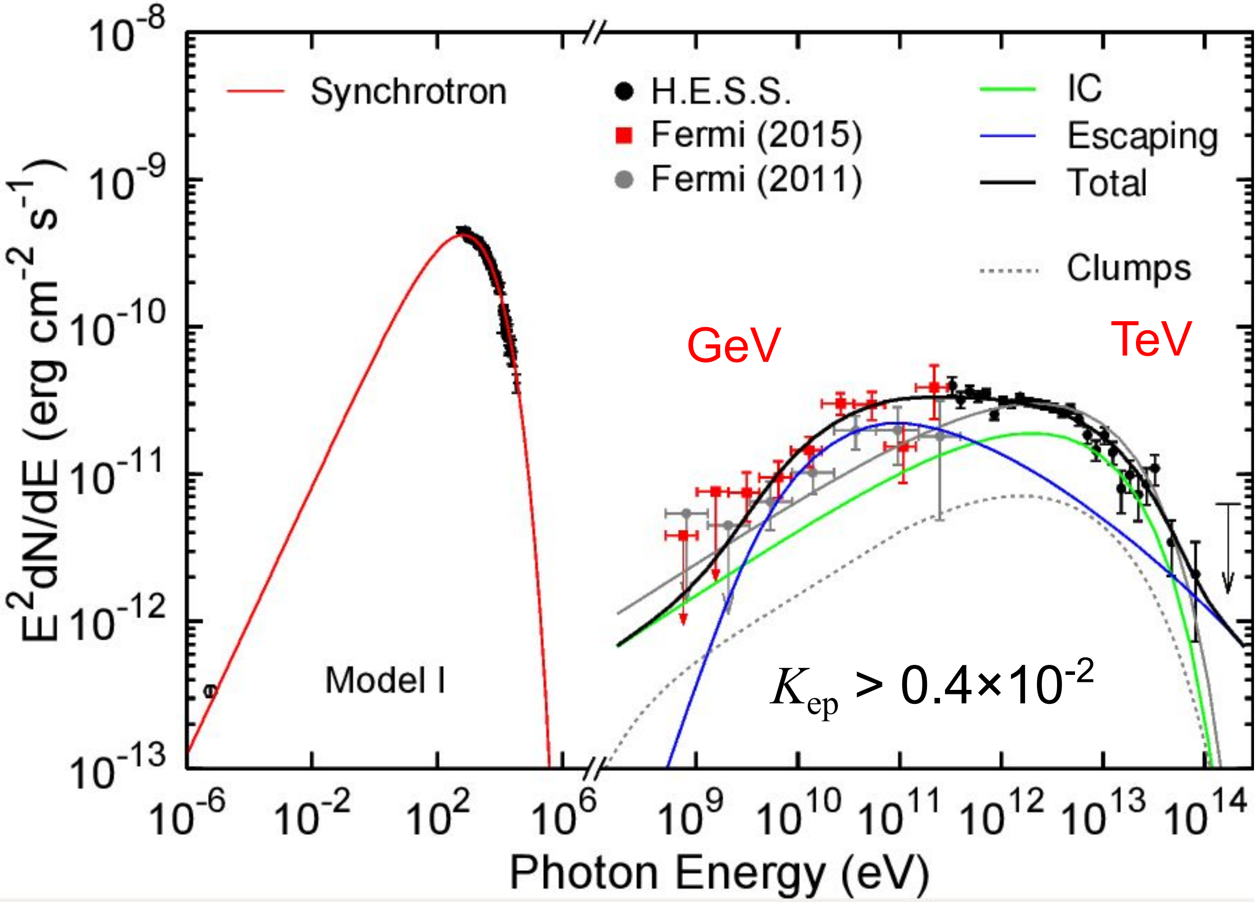
$$\propto E^{-p+1/2}dE$$

$$N_\gamma(E) \propto E^{-1.5} \text{ for } p = 2$$

The mass of the shock clumps can be found in Sano et al. 2013

Model I

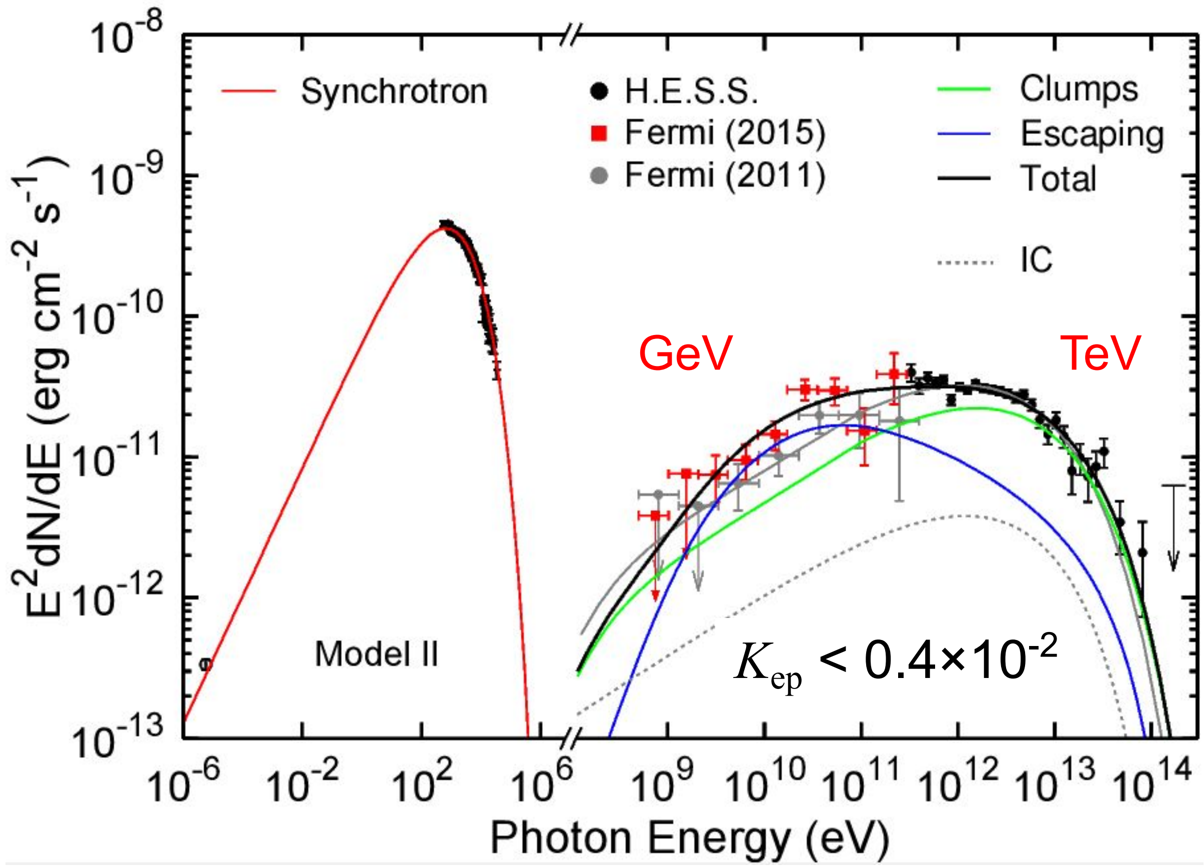
- The MCMC method is employed to constrain the parameters.
- The electron to proton number ratio: $K_{ep} = 0.01$



Zhang & Chen 2016

Model II

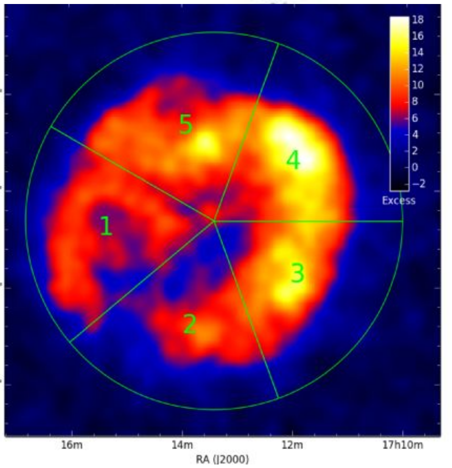
- The electron to proton number ratio: K_{ep} = 0.001

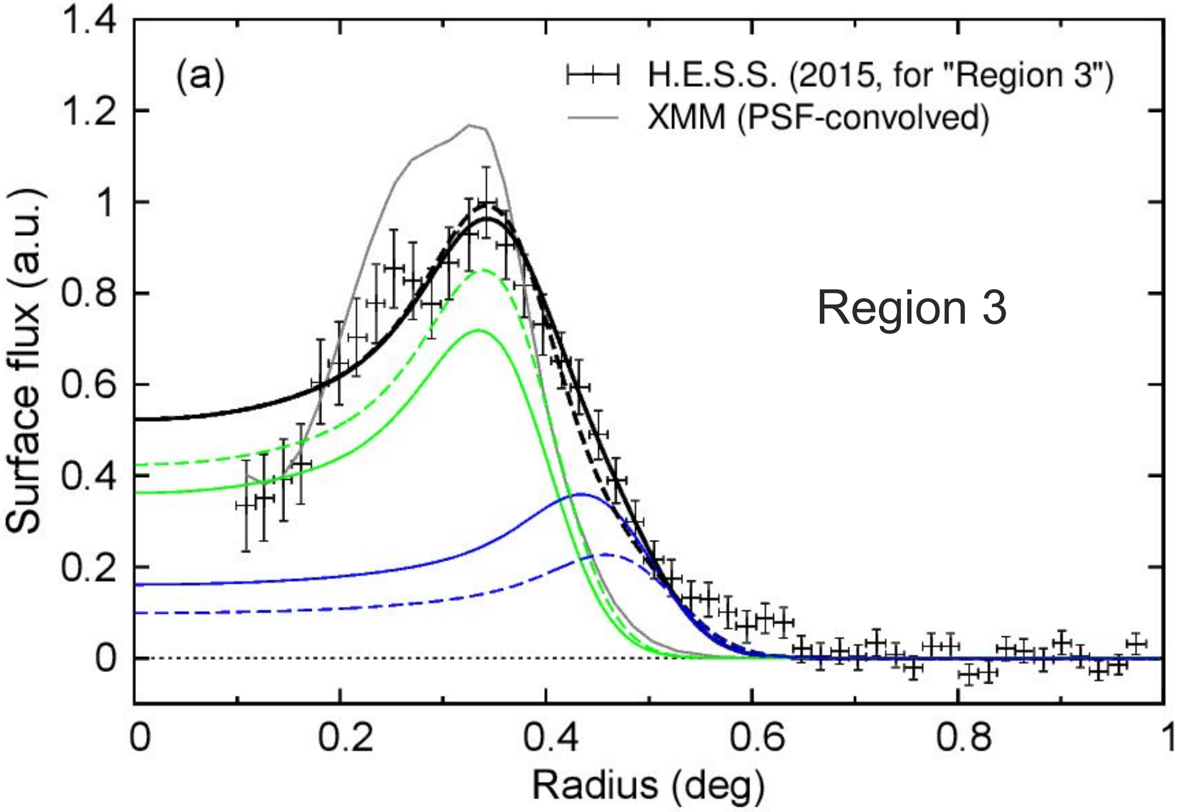


Zhang & Chen 2016

The radial profile at the TeV band

$$J(R) = 2\int_{r_{1,\min}}^{r_{1,\max}} \frac{\sigma_1 r\mathrm{d}r}{\sqrt{r^2 - R^2}} + 2\int_{r_{2,\min}}^{r_{2,\max}} \frac{\sigma_2 r\mathrm{d}r}{\sqrt{r^2 - R^2}}$$

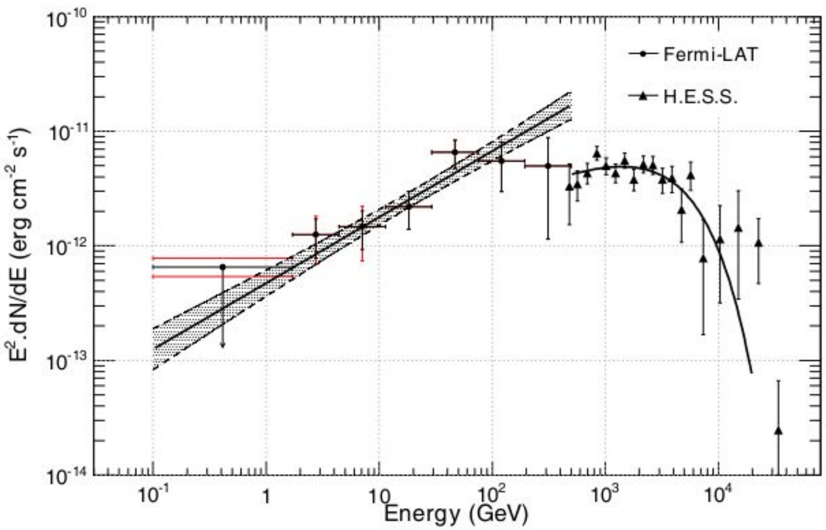




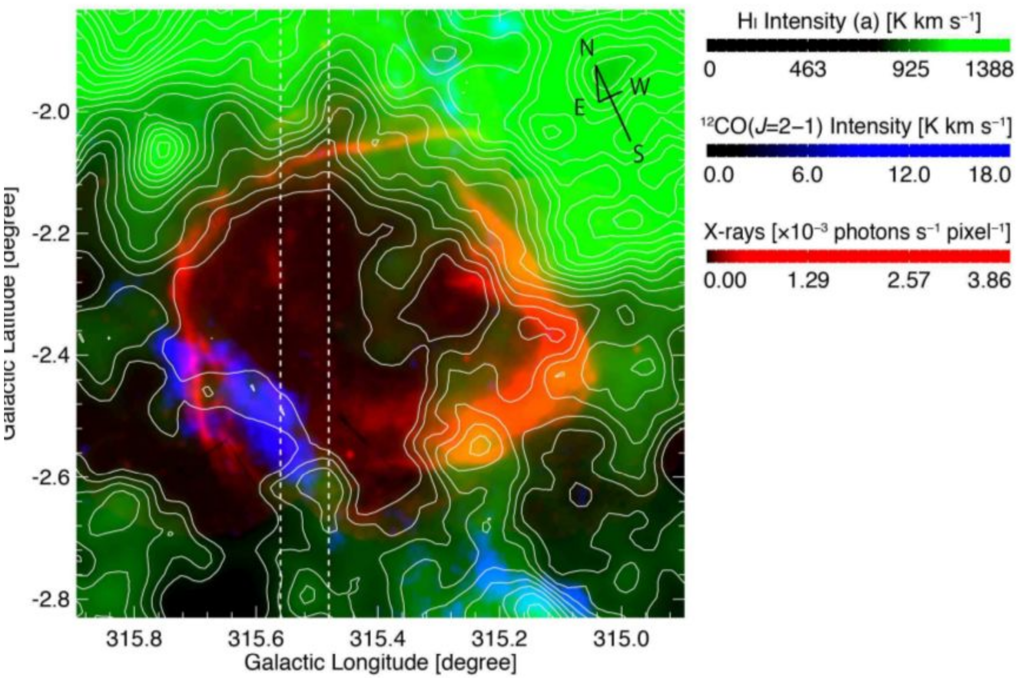
solid: Model Ia
dashed: Model IIa

green: inner
blue: outer

RCW 86: another case ?



Ajello et al. 2016



Sano et al. 2016

Summary

- ✓ The broadband fluxes can be well explained by the two-zone model, in which the gamma-ray emission from inside governs the TeV band, while the outer emission component substantially contributes to the GeV gamma-rays.
- ✓ The two-zone model can simultaneously reproduce the TeV gamma-ray radial brightness profile that significantly extends outside the nonthermal X-ray-emitting region.
- ✓ For the inner region, dominated by the IC process for $K_{ep} > 4\times10^{-3}$ and by pp in the shocked clumps for $K_{ep} < 4\times10^{-3}$.

Thanks!