ASTR-518 HW-4 Spectral Analysis on RCW-86 With Fermi-LAT

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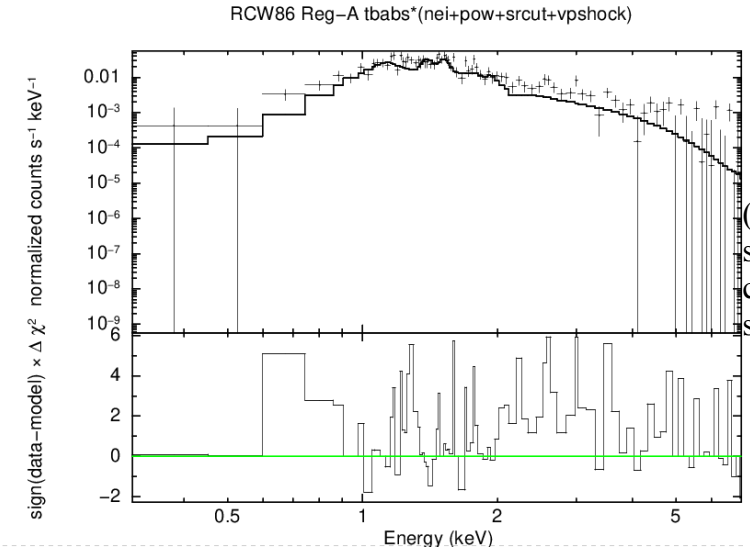
Introduction

SN 185 was observed in year 185 by Chinese astronomers. In the Book of Later Han, it claims that this event was remained for 8 months. With the observations by the telescopes XMM – Newton and Chandra it is suggested that RCW 86 is strongly linked with this event when the age estimations are done when counting the shock waves. [1] Diffusive shock acceleration (DSA) is responsible from magnetic field amplification in outer parts. Since this SNR's outer rims aren't confined in a narrow regions. Densities are low. Synchrotron emissions are key for in order to find velocities of post-shocks. Due to synchrotron radiation both x-ray and gamma radiation ranges (depending the particle type) there are cut-offs are visible on the spectrum. Where they loose their energies from synchrotron loss. [2,3,4] In order to see the bigger picture we need to look at the previous analysis which is x-ray analysis from Chandra ACIS-I (OBSID: 15608).



(Fig. 1 one of the regions's X-Ray spectrum analysis of RCW 86, cut-off can be seen from 2 keV due to synchrotron loss)

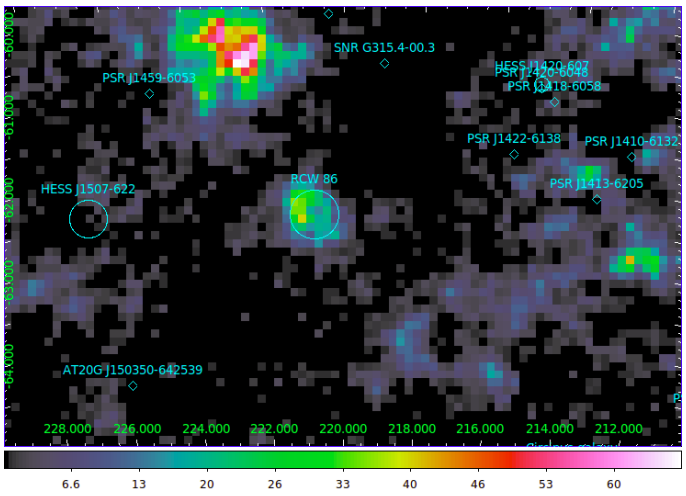
Data Analysis

I did this analysis by using several tools. These are Fermitools, CFITSIO (v3.43), Python (2.7.14), Fermi-4FGL catalog, fermipy, make4FGLxml.py (python 2.7 version), plot_sed.py, P8R2_SOURCE_V6 (IRF), iso_P8R2_SOURCE_V6_v06.txt (Isotropic difusse background), gll_iem_v06.fits (Galactic diffuse background), gtselect, gtmktime, SAOImage DS9(v 7.5)

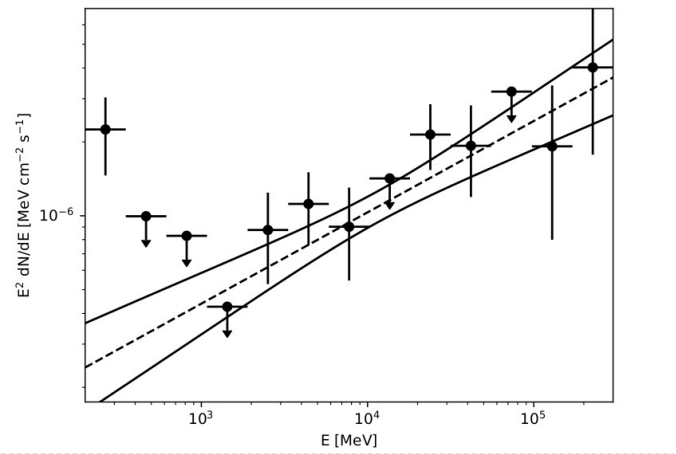
I used the data (L20062213164362D4444F86) from Fermi-LAT. Then, the data are selected with gtselect evclass=128 evtype=3 script with recommended configurations except the energy range 200-300000 MeV and max. zenith angle was set to 90 degrees. The data are filtered by gtmktime script with (DATA_QUAL>0)&&(LAT_CONFIG==1) configuration. Then XML file edited and whole point-like sources foldings and last two diffuse source foldings were erased. After configuring the YAML file python analysis was started.

On 4FGL, RCW 86 named with its name with offset 0.354 and near to 9 sigma for this analysis.

name	SpatialModel	SpectrumType	offset	ts	npred
RCW 86	SpatialMap	PowerLaw	0.354	79.62	543.0



(Pic. 1, RCW 86 is removed from the background gamma-ray model fk5, deg.)



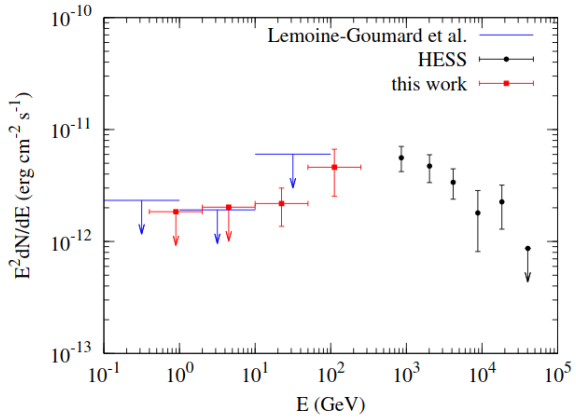
(Fig.2 Spectral SED graph of RCW 86)

energy	energy_edge_lo	energy_edge_hi	flux	flux_error_lo	flux_error_hi	ul
float	float	float	float	float	float	long
MeV	MeV	MeV	1 / (cm2 MeV s)	1 / (cm2 MeV s)	1 / (cm2 MeV s)	
264.96286	200.0	351.02658	2.2479305e-06	7.8774053e-07	7.8774053e-07	0
465.05038	351.02658	616.1125	9.956625e-07	0.0	0.0	1
816.2346	616.1125	1081.3593	8.284957e-07	0.0	0.0	1
1432.6167	1081.3593	1897.9729	4.261444e-07	0.0	0.0	1
2514.4617	1897.9729	3331.1946	8.753654e-07	3.4860696e-07	3.6771922e-07	0
4413.265	3331.1946	5846.8237	1.1178053e-06	3.590108e-07	3.866429e-07	0
7745.9556	5846.8237	10261.952	9.0257544e-07	3.5790373e-07	3.9961267e-07	0
13595.338	10261.952	18011.504	1.4199709e-06	0.0	0.0	1
23861.898	18011.504	31612.584	2.142871e-06	6.069277e-07	7.0455746e-07	0
41881.285	31612.584	55485.562	1.9288675e-06	7.360482e-07	8.879875e-07	0
73508.07	55485.562	97384.54	3.2067749e-06	0.0	0.0	1
129017.91	97384.54	170926.73	1.9187141e-06	1.1196098e-06	1.4792515e-06	0
226446.19	170926.73	299999.12	4.0230143e-06	2.2473894e-06	2.9691769e-06	0

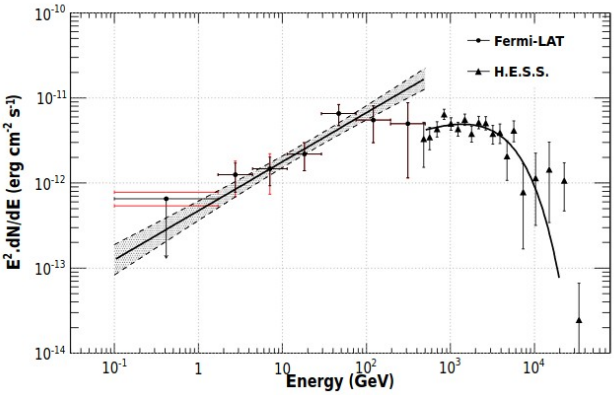
(Table 1. table of SED)

Discussion

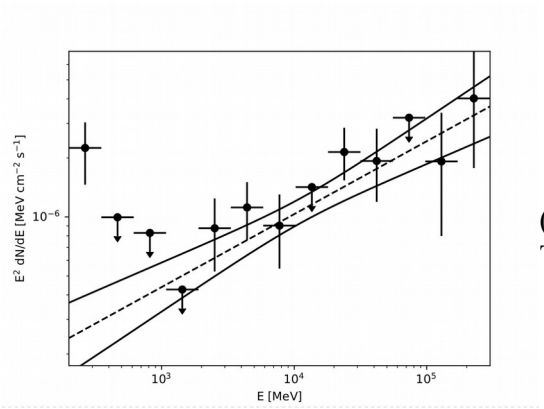
When we compare the graphs with (Yuan et al. 2018) and (Ajello et al. 2016) with this analysis they are close to each other.



(Fig. 3 , 2018, Yuan et al. RCW 86 gamma spectrum TS=30)



(Fig. 4 , 2016, Ajello et al. RCW 86 gamma spectrum TS=68)



(Fig.1 Spectral SED graph of RCW 86 current analysis TS=79.62)

SED shows leptonic behaviors which can be seen by two peaks on SED graph. Moreover, if we take x-ray image into account it is easy to say this object's multi-wavelength graph's two major peak behavior shows synchrotron radiation and inverse compton. Due to synchrotron loss 2 keV and 20 TeV (Yuan et al. 2018) but the energy range of this analysis couldn't reveal that. But upcoming peak from10^3 MeV shows inverse compton effect. Left peak looks similar to bremsstrahlung. According to Yuan et al. In low densities like RCW 86's post-shock density requires 50 TeV with index 1.7 since in low densities accelerating protons requires higher energies. RCW 86's has low ambient medium density. It varies in some range which makes it difficult to point it out. [4]

References:
[1]https://www.esa.int/Science_Exploration/Space_Science/
New_evidence_links_stellar_remains_to_oldest_recorded_supernova

[2] THE X-RAY SYNCHROTRON EMISSION OF RCW 86 AND THE IMPLICATIONS FOR ITS AGE, Vink et al. ,2018

https://arxiv.org/pdf/astro-ph/0607307.pdf

[3] A CHANDRA VIEW OF NONTHERMAL EMISSION IN THE NORTHWESTERN REGION OF SUPERNOVA REMNANTRCW 86: PARTICLE ACCELERATION AND MAGNETIC FIELDS, Castro et al. ,2011

https://arxiv.org/pdf/1309.2936.pdf

[4] FERMI LARGE AREA TELESCOPE DETECTION OF SUPERNOVA REMNANT RCW 86, Yuan et al. , 2018
https://arxiv.org/pdf/1403.4915.pdf

[5]DEEP MORPHOLOGICAL AND SPECTRAL STUDY OF THE SNR RCW 86 WITHFERMI-LAT, Ajello et al. 2016
https://arxiv.org/pdf/1601.06534.pdf