Evidence for TeV gamma-ray emission from the Nearby starburst galaxy NGC253*

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<abstract>

We report the results of TeV γ-ray observation of the nearby normal spiral galaxy NGC253. NGC253 is one of the nearest starburst galaxies. This relative closeness, coupled with the high starformation rate in the galaxy, make it a good candidate TeV γ-ray source. Observations were carried out in 2000 and 2001 with the CANGAROO-II 10-m Imaging atmospheric Cerenkov telescope. TeV γ-ray emission is detected at the 11 σ level with a flux of $(7.8\pm2.5)\times10^{-12}$ cm^{-2}sec^{-1} at energies >0.5 TeV. The data indicate that the emission region is much broader than the point spread function of our telescope. The emission region corresponds to a size greater than 10kpc in radius,which is somewhat larger than the optical image of the galaxy. Our finding of diffuse emission of TeV γ-rays from NGC253 reveals for the first time the existence of TeV cosmic rays in a normal spiral galaxy other than our own.

<NGC253>

(RA,Dec)=(11.89°, -25.29°)
Visual diameter: 0.45°
Distance : 2.5Mpc
Classification : spiral galaxy

Nearest starburst galaxy

- High supernova rate(central region)
- High star formation rate

<Observation data & analyzed data>

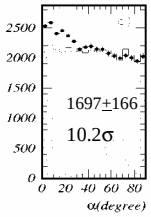
Observation period	Obs.Time(min)		Selected data		T_{on}/T_{off}
	On	Off	On	Off	
03.Oct-18.Nov(2000)	2297	2245	1301	969	1.34
20.Sep-15.Nov(2001)	2567	2401	1658	1448	1.15
Total	4846	4646	2959	2417	1.22

(data selection)

- Elevation >70 degree
- shower rate >2.0Hz :cloud cut
- hit PMTs > 4 adjacent : Reject of night sky background

<standard Square cut analysis>

Image orientation angle "α" distribution .



Dots with error bars are ON source data and the histogram is for the OFF source data.The number in the figure is excess events within 30° of α.

0.05 <Width<0.15

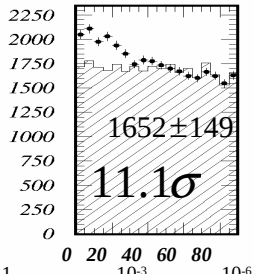
0.05 <Length< 0.3

0.5<Distance<1.2

<Likelihood method analysis>

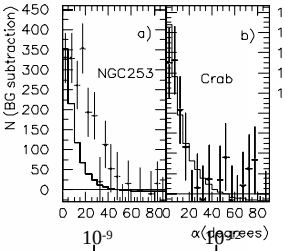
$$L=\frac{P(\gamma)}{P(p)+P(\gamma)}$$

$$P(\gamma)=P(\text{Length})\times P(\text{Width})$$



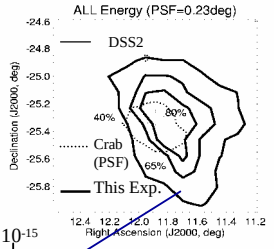
The γ-ray emission is clearly more extended then PSF.

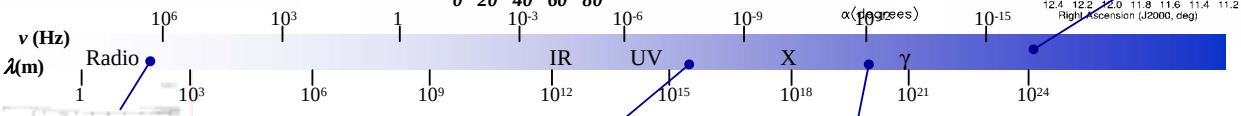
Dots with error bars are obtained by subtracting the off from on-source. The histograms show Monte Carlo simulation of γ-ray from a point source.

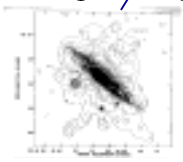


<Significance Map>

The angular resolution was estimated to be 0.23°







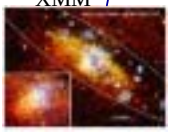
<Large scale synchrotron halo >

The radio continuum emission consists of three main components,a central source inner and outer disk components ,and halo extending ~6kpc.

Carilli et al ApjL 399,L59(1992)

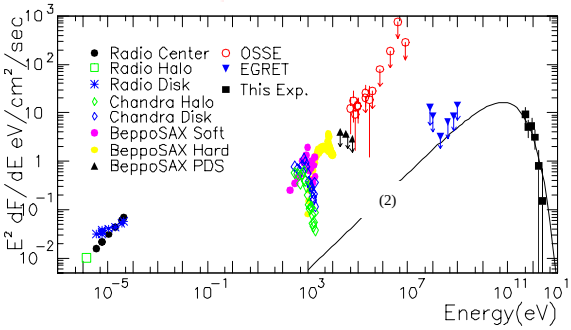
Hubble

XMM



Pietsch et al A&A 365 ,L174(2001)

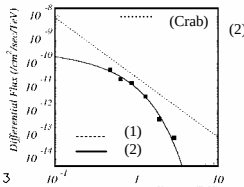
The x-ray structure of NGC253 consists of point source and diffuse emission of hot phase of ISM and galactic wind. (ROSAT,ASCA,BeppoSAX, XMM-Newton,Candra)



TeV region

<Differential flux>

(1) $\frac{dF}{dE}=(2.85\pm0.71)\times10^{-12}\left(\frac{E}{1TeV}\right)^{-3.85\pm0.46}$ $\chi^2/DOF=2.1/4$



(2) $\frac{dF}{dE}=ae^{\sqrt{E_0}/b}\left(\frac{E}{E_0}\right)^{-1.5}e^{\sqrt{E}/b}$ $\chi^2/DOF=1.8/5$

EGRET constraint

$a=6\times10^{-5}$ (*fix*)

$E_0=200$ *MeV* (*fix*)

$b=0.25\pm0.01$

*(submitted for publication)