Fermi-LAT Observations of the Core of Centaurus A

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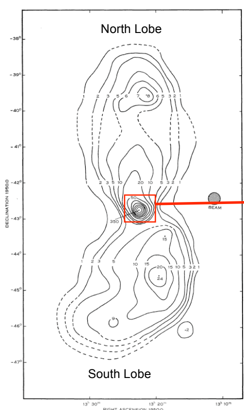
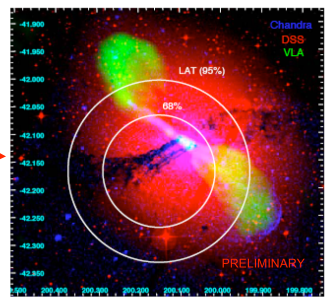
We report on the Fermi-LAT detection of the core of the nearby radio galaxy Centaurus A integrated over 10 months. The spectral energy distribution of this object, including a variety of contemporaneous and archival data is fit with a synchrotron self-Compton model, which is not able to account for the non-simultaneous HESS observation in 2004-2008.

OBSERVATIONS

Cen A is the nearest radio galaxy to Earth, at a distance of 3.7 Mpc. Its giant radio lobes occupy ~ 10 degrees on the sky. It is a Fanaroff-Riley (FR) type I radio galaxy. It's core has been detected by EGRET (Hartman et al. 1999), HESS (Aharonian et al. 2009), and a variety of X-ray telescopes.



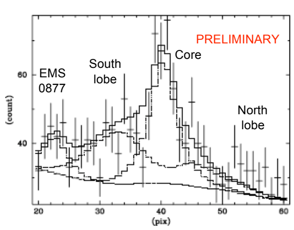
Above: Parkes telescope radio image (960 MHz) of Cen A (Cooper et al. 1965).



Above: Composite radio, optical and X-ray image of Cen A with LAT error circles superimposed.

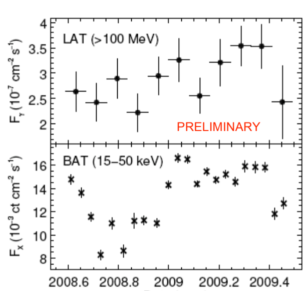
The *Fermi*-LAT detection of Cen A was reported in *the LAT Bright AGN Source List* (Abdo et al. 2009a) 3 month data set. Here we report on the 10 month data set of the core of Cen A. The giant radio lobes have also been detected in gamma-rays (see talk by Teddy Cheung).

Separating the flux from the core and lobes was quite a challenge, due to the LAT's large and energy-dependent point spread function. To aid in this, the *WMAP* 20 GHz image of the source (Hinshaw et al. 2009) was used as a template.



Above: The *Fermi*-LAT projected count profile (0.3-1 GeV) along the North-South axis of Cen A. The core, North and South lobes, and the nearby source EMS 0877 (from the LAT eleven month source list; see Abdo et al. 2009, ApJ. In preparation) can be seen. 1 pix = 0.25 deg.

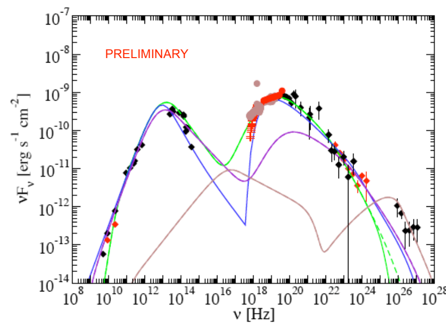
PRELIMINARY	TS	Flux [10^{-7} ph cm^{-2} s^{-1}]	Γ
Core	318	1.75 +/- 0.25	2.71 +/- 0.09
North Lobe	44	0.87 +/- 0.24	2.66 +/- 0.20
South Lobe	94	1.23 +/- 0.25	2.66 +/- 0.14



Right: The *Fermi*-LAT and *Swift*-BAT light curves of Cen A. There are hints of a correlation, but it is not definitive.

During the first 10 months of LAT science operation, Cen A was also observed from time to time by the *Swift* BAT and XRT, *Suzaku*, and the Southern Hemisphere Long Baseline Array. From the BAT data it was possible to create a light curve (above). From the other data (including LAT data) it was possible to create a *spectral energy distribution*.

SPECTRAL ENERGY DISTRIBUTION



Left: The spectral energy distribution (SED) was formed from archival (black) and contemporaneous data (red/brown). This was fit with the *synchrotron self-Compton* (SSC) emission model (e.g., Finke et al. 2008) for a relativistic jet. Since it is unclear whether the X-rays originate from the jet or near the disk, we fit the SED with two SSC models, one which fit the X-rays (green) and one which under fit them (violet). None of these models seem able to fit the entire SED, including the (non-simultaneous) HESS data. Another blob, however, which was fit to explain this emission (brown) without over-producing radiation at other wavelengths. The decelerating jet model of Georganopoulos & Kazanas (2003a,b; see below) is also not able to explain the HESS emission (blue).

Model Parameters. PRELIMINARY

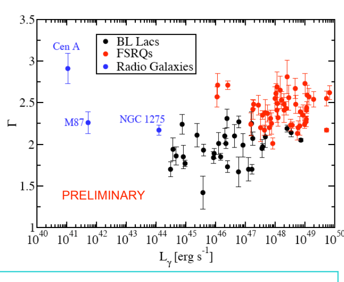
Parameter	Symbol	Green[1]	Blue[2]	Violet[3]	Brown[4]
Bulk Lorentz Factor	Γ	1.0/7.0	$5 \rightarrow 2$	3.7	2.0
Doppler Factor	δ_D	1.0	$1.79 \rightarrow 1.08$	3.9	3.1
Jet Angle	θ	30°	25°	15°	15°
Magnetic Field [G]	B	6.2	0.45	0.2	0.02
Variability Timescale [sec]	t_v	1.0×10^5		1×10^5	1×10^5
Comoving blob size scale [cm]	R_b	3.0×10^{15}	3×10^{15}	1.1×10^{16}	9.2×10^{15}
Low-Energy Electron Spectral Index	p_1	1.8	3.2	1.8	1.8
High-Energy Electron Spectral Index	p_2	4.3		4.0	3.5
Minimum Electron Lorentz Factor	γ_{min}	3×10^2	1.3×10^3	8×10^2	8×10^2
Maximum Electron Lorentz Factor	γ_{max}	1×10^8	1×10^7	1×10^8	1×10^8
Break Electron Lorentz Factor	γ_{brk}	8×10^2		2×10^3	4×10^5
Jet Power in Magnetic Field [erg s^{-1}]	$P_{j,B}$	$0/6.5 \times 10^{43}$	1.7×10^{41}	2.7×10^{43}	4.3×10^{38}
Jet Power in Electrons [erg s^{-1}]	$P_{j,e}$	$0/3.1 \times 10^{43}$	3.1×10^{42}	2.3×10^{42}	7.0×10^{40}
Jet Power in protons (1 cold p^+ per e^-) [erg s^{-1}]	$P_{j,p}$	$0/4.7 \times 10^{43}$	6.2×10^{42}	1.3×10^{42}	4.0×10^{40}
Jet Power in protons ($10 \times P_{j,e}$) [erg s^{-1}]	$P_{j,p}$	$0/3.1 \times 10^{44}$	3.1×10^{43}	2.3×10^{43}	7.0×10^{41}

[1]SSC Model
[2]Decelerating Jet Model (Georganopoulos & Kazanas 2003a,b)
[3]SSC Model excluding X-rays
[4]SSC Fit to HESS data only

BLAZAR-RADIO GALAXY UNIFICATION

FRII galaxies seem to be flat spectrum quasars pointed away from our line of sight, and FRIs seem to be BL Lacs pointed away from our line of sight (Urry & Padovani 1995). However, the cores of FRIs seem to be too bright in the optical to be de-beamed BL Lacs (Chiaberge et al. 2000). This could be explained if jets have velocity gradients, so that off axis emission is dominated by an outer, slower-moving "sheath", and on-axis emission is dominated by a faster-moving "spine". Alternatively, a decelerating jet model may also explain this discrepancy (Georganopoulos & Kazanas 2003a,b).

Right: The LAT gamma-ray spectral index versus gamma-ray luminosity from the 3-month LAT Bright AGN Sample (Abdo et al. 2009a) of BL Lacs and FSRQs. These two classes are separated fairly well in this plane. We have added to this the 3 radio galaxies seen so far with the LAT: NGC 1275 (Per A; Abdo et al. 2009b) and M87 (Vir A; Abdo et al. 2009c). They seem to occupy a different region of phase space than the BL Lacs and FSRQs, possibly indicating a different emission source.



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