70

COMPTTEL

COMPTTEL PREPRINT No. 16

COMPTTEL Papers
presented at the

COSPAR Gamma-Ray Astronomy Symposium

HAMBURG

July 1994

THE COMPTTEL COLLABORATION

Max-Planck-Institut für Extraterrestrische Physik, Garching, FRG
Laboratory for Space Research Leiden, The Netherlands
Space Science Center, University of New Hampshire, Durham NH, USA
Space Science Department of ESA, Noordwijk, The Netherlands

See 9505

SCAN-9501327

CERN LIBRARIES, GENEVA

CGRO-COMPTEL OBSERVATIONS OF THE CENTAURUS A REGION

H. Steinle*, K. Bennett†, H. Bloemen**, W. Collmar*,
R. Diehl*, W. Hermsen**, G. Lichti*, M. McConnell***,
D. Morris***, R. Much†, J. Ryan***, V. Schönfelder*,
A.W. Strong*, M. Varendorff*, and C. Winkler†

* *Max-Planck-Institut für extraterrestrische Physik, Postfach 1603,
85740 Garching, Germany*

** *SRON-Utrecht, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands*

*** *Space Science Center, University of New Hampshire,
Durham, NH 03824, U.S.A.*

† *Astrophysics Division, ESTEC, 2200 AG Noordwijk, The Netherlands*

ABSTRACT

The sky region containing the active radio-galaxy Centaurus A has repeatedly been observed with the COMPTEL instrument onboard the Compton Gamma Ray Observatory (CGRO). The nine observation periods during the CGRO phases I and II in which Cen A was in the field of view of COMPTEL are spread over 18 months in the years 1991 to 1993. The energy range 0.75 to 30 MeV is covered.

Clear evidence for a source with emission up to several MeV is seen from a region coinciding with the position of Cen A. The spectra change significantly over ~ 6 months between the two observation phases. A possible source confusion with the nearby gamma-ray source MS1312.1-4221 is discussed.

INTRODUCTION

The active radio galaxy Centaurus A was one of the few known MeV gamma-ray sources when the Compton Gamma Ray Observatory was launched /1/. Since then, it is among the objects which have been observed repeatedly by all CGRO instruments /2,3,4/. In nine pointings during the CGRO observation phases I and II, spanning the years 1991 to 1993, the Centaurus A region was in the wide field of view of the Compton telescope COMPTEL onboard CGRO. In view of the results presented below, it has to be pointed out, that all previous "detections" of Centaurus A in the MeV energy range (1 - 50 MeV), have been made by instruments which had a rather poor angular resolution of several degrees (for references see /5/). Also COMPTEL has an angular resolution for weak sources of only a few degrees. Thus the identification of the MeV gamma-ray source in the Cen A region with this AGN is only based on the coarse directional agreement and the compatibility with the low-energy gamma-ray spectrum of Cen A. More recently /9/, EGRET reported the possible detection >50 MeV of MS1312.1-4221, a source in only 2° distance from Centaurus A. MS1312.1-4221 belongs to the class of BL Lac type objects many of which have been detected by EGRET and which show large spectra variations on time scales of days. Thus, variations in the emission from the Centaurus A region may not be attributed to Cen A alone.

OBSERVATIONS

Phase I Observations

During Phase I (the Sky Survey) of the CGRO observations, the Centaurus A region was in the field of view of COMPTEL in viewing periods 12, 14, 23, 27, and 32. They cover the time interval October 1991 till July 1992 spending in total 58 days on this region. However, the total effective on-axis observing time for phase I is only about 7 days. This value takes into account several factors, including earth occultation periods, SAA passages and CGRO tape recorder problems (which were especially acute during observation 23). It also incorporates the angular dependence of the COMPTEL efficiency. To enhance statistics, all five observations were combined in the present analysis.

Phase II Observations

During Phase II of the CGRO observations, the Centaurus A region was in the field of view of COMPTEL in viewing periods 207, 208, 215, and 217. They cover the time interval January 1993 till April 1993 spending in total 41 days on this region. Again, the effective observing time is only ~ 7 days. Similar to Phase I, all 4 observations have been combined for analysis.

SPECTRA FROM THE CENTAURUS A REGION

During Phase I, COMPTEL detects emission from this region only in its low energy bands (i.e. 0.75 - 1 MeV and 1 - 3 MeV). No emission at higher energies is detected. Under the assumption that this emission is from Cen A, these data are in agreement with the OSSE observations reported by Kinzer et al. /2/. Table 1 gives for the combined observations of Phase I the measured fluxes in all COMPTEL energy bands. If the derived fluxes are below 2σ , upper limits are quoted which are derived by adding the 2σ error to the measured flux value. The statistical errors are 1σ , an estimated systematic error of about 30 % is not included. The spectrum of the emission from the Centaurus A region during Phase I, is shown in Figure 1.

Table 1 Measured flux values from the emission of the Centaurus A region during Phase I and Phase II

CGRO Phase	Energy (MeV)	Counts	Flux ($10^{-5} \text{cm}^{-2} \text{s}^{-1}$)	significance (sigma)
I	0.75 - 1	1179 ± 298	(11.3 ± 2.9)	4.0
	1 - 3	2218 ± 633	(14.2 ± 4.1)	3.5
	3 - 10	< 985	< 5.5	2σ u.l.
	10 - 30	< 130	< 1.4	2σ u.l.
II	0.75 - 1	< 382	< 4.4	2σ u.l.
	1 - 3	< 1639	< 13.9	2σ u.l.
	3 - 10	1003 ± 239	(7.0 ± 1.7)	4.2
	10 - 30	< 200	< 2.7	2σ u.l.

Fig.1. (left) Spectrum from the Centaurus A region as measured by COMPTEL during Phase I. It is shown together with the OSSE results of observation period 12. The fits are to the OSSE data only (adapted from /6/).

Fig.2. (right) Spectrum from the Centaurus A region as measured by COMPTEL during Phase II. Again it is shown together with the OSSE results of observation period 12 (adapted from /6/).

In Phase II of the CGRO observations, the emission from the Centaurus A region in the two low energy bands of COMPTEL has fallen below the detection limit, so that only upper limits can be derived. Again in

agreement with the COMPTEL findings (if Cen A is the source of the emission), OSSE reports a very low intensity level for the Cen A emission during Phase II /2/. However, emission in the energy band 3 - 10 MeV with a significance of > 4 sigma is detected by COMPTEL. Table 1 gives for the combined observations of Phase II the measured fluxes in all COMPTEL energy bands. As for Phase I, the flux values or 2σ upper limits are given. The spectrum of the emission from the Centaurus A region during Phase II, is shown in Figure 2.

LOCATION OF THE EMISSION FROM THE CENTAURUS A REGION

The imaging instrument COMPTEL can locate the direction of the sky from which γ -rays in the MeV range are emitted. Depending on the strength of the source, the location accuracy varies between $\sim 1^\circ$ for strong sources and few degrees for weaker sources. As described in /7/, only strong sources with a separation $\geq 4^\circ$ can be resolved. Figures 3 and 4 show the 1σ , 2σ , and 3σ location error contours as derived for the low energy detection during Phase I and the 3-10 MeV detection from Phase II respectively. The location contours in the COMPTEL skymaps for the observations of the Centaurus A region are always compatible with an origin of the emission from Cen A. However, the BL Lac type object MS1312.1-41221 /8/ which is only $\sim 2^\circ$ separated from Cen A, has always about the same probability for being the source of emission as Cen A.

Fig.3. (left) COMPTEL location contours for 0.75 - 1 MeV emission, obtained from a combination of all Phase I observations of the Centaurus A region. The positions of Cen A and MS1312.1-4221 are marked by a square and a triangle respectively. The 1σ , 2σ , and 3σ location error contours are plotted. The coordinate grid is in galactic coordinates.

Fig.4. (right) COMPTEL location contours for 3 - 10 MeV emission, obtained from a combination of all Phase II observations of the Centaurus A region. The positions of Cen A and MS1312.1-4221 are marked by a square and a triangle respectively. The 1σ , 2σ , and 3σ location error contours are plotted. The coordinate grid is in galactic coordinates.

DISCUSSION

Clear evidence for a source with emission up to several MeV is seen from a region coinciding with the position of Cen A. The spectra change significantly over ~ 6 months between the two observation phases. Because of co-adding the single observations of each phase, this time scale is only an upper limit to the variability. Besides the possibility that the active galaxy Centaurus A shows such large variations in its spectral shape, the COMPTEL data may hint at the presence of another active and variable object in the vicinity of Cen A. The changes in the MeV spectrum of Cen A would indicate an extreme hardening of

the source when it decreases in intensity in the low energy part so that only emission in the 3-10 MeV energy band is detected. The marginal detection by EGRET of a source > 50 MeV in only 2° distance from Centaurus A, tentatively identified with MS1312.1-4221 /9/, suggests that the emission seen by COMPTEL in Phase II originates from this BL Lac type object rather than from Cen A.

The presently available data are not sufficient to solve this problem. Therefore, to verify the supposition, multi-wavelength observations of both objects have been proposed. Proposals for CGRO, ROSAT, and optical (IR) observations have been accepted for July 1995. Proposals for ASCA and radio observations are submitted.

ACKNOWLEDGEMENTS

This research was supported by the Bundesministerium für Forschung und Technologie under the grant 50 QV 9096, by NASA contract NAS5-26645 and by The Netherlands Organization for Scientific Research (NWO). It also has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, CALTECH, under contract with the National Aeronautics and Space Administration. R. Much acknowledges receipt of a research fellowship from the European Space Agency.

REFERENCES

1. Gehrels N., Cheung C., High Energy Continuum Measurements of Active Galactic Nuclei, in: Testing the AGN Paradigm, eds. Holt S.S., Neff S.G. and Urry C.M., *AIP Conference Proceedings* 254, 348 (1992).
2. Kinzer R.L., Johnson W.N., Kurfess J.D., Strickman M.S., Grove J.E., Kroeger R.A., Grabelsky D.A., Purcell W.R., Ulmer M.P., Jung G.V., OSSE Observations of Centaurus A Over 18 Months, in: Proc. of 2nd Compton Symposium, University of Maryland, Washington 1993, ed. Fichtel C.E., Gehrels N. and Norris J.P., *AIP Conference Proceedings* 304, 531 (1994).
3. Paciesas W.S., Harmon B.A., Pendleton G.N., Finger M.H., Fishman G.J., Meegan C.A., Rubin B.C. and Wilson R.B., Studies of hard X-ray source variability using BATSE, *A&AS* 97, 253 (1993).
4. Steinle H., Bloemen H., Collmar W., Diehl R., Hermesen W., Lichti G., McConnell M., Ryan J., Schönfelder V., Stacy G., Strong A.W., Swanenburg B.N., Varendorff M., Williams O.R., COMPTEL Observations of AGNs, *Adv. Space Res.* Vol. 13, No.12, p. 731 (1993).
5. von Ballmoos P., Diehl R., Schönfelder V., Centaurus A Observation At MeV-Gamma-Ray Energies, *ApJ* 312, 134 (1987).
6. Johnson W.N., Kurfess J.D., Purcell W.R., Matz S.M., Ulmer M.P., Strickman M.S., Murphy R.J., Grabelsky D.A., Kinzer R.L., Share G.H., Cameron R.A., Kroeger R.A., Maisack M., Jung G.V., Jensen C.M., Clayton D.D., Leising M.D., Grove J.E. and Dyer C.S., Initial Results from OSSE on the Compton Observatory, *A&AS* 97, 21 (1993).
7. Schönfelder V., Aarts H., Bennett K., de Boer H., Clear J., Collmar W., Connors A., Deerenberg A.J.M., Diehl R., van Dordrecht A., den Herder J.W., Hermesen W., Kippen M., Kuiper L., Lichti G.G., Lockwood J.A., Macri J., McConnell M., Morris D., Much R., Ryan J., Simpson G., Snelling M., Stacy G., Steinle H., Strong A.W., Swanenburg B.N., Taylor B., de Vries C. and Winkler C., Instrument Description and Performances of the Imaging Gamma-Ray Telescope COMPTEL Aboard NASA's Compton Gamma-Ray Observatory, *ApJS* 86, 657 (1993).
8. Stocke J.T., Morris S.L., Gioia I., Maccacaro T., Schild R.E. and Wolter A., No Evidence For Radio-Quiet BL Lacertae Objects, *ApJ* 348, 141 (1990).
9. Fichtel C.E., Bertsch D.L., Chiang J., Dingus B.L., Esposito J.A., Fierro J.M., Hartman R.C., Hunter S.D., Kanbach G., Kniffen D.A., Kwok P.W., Lin Y.C., Mattox J.R., Mayer-Hasselwander H.A., McDonald L., Michelson P.F., von Montigny C., Nolan P.L., Pinkau K., Roethermel H., Sreekumar P., Sommer M., Schneid E.J., Thompson D.J. and Willis T., The First Energetic Gamma-Ray Experiment Telescope (EGRET) Source Catalog. *ApJS*, in press (1994).