ABUNDANCE OF LOW ENERGY (50-150 MeV) ANTIPROTONS IN COSMIC RAYS

Apparao, K.M.V., Biswas, S., Durgaprasad, N.
and Stephens, S.A.
Tata Institute of Fundamental Research
Homi Bhabha Road, Bombay 400005, India

ABSTRACT

We present the progress of our nuclear emulsion experiment to determine on abundance of low energy antiprotons in cosmic rays. We have not detected any so far and obtain an upper limit of $\bar{p}/p \lesssim 4\times10^{-4}$ in the energy range 50-150 MeV.

During the last International Conference on Cosmic Rays at Bangalore, we[1] reported preliminary results of an experiment to determine the abundance of low energy antiprotons in cosmic rays. We are using a nuclear emulsion stack of 200 Ilford G5 emulsion pellicles exposed on July 3, 1972 at Fort Churchill, Canada for 13h 45m at a depth of 1.7 $g.cm^{-2}$ of residual atmosphere. We scanned at a depth of mostly 2 cms from the top edge, for nuclear interactions containing one high energy track and then followed all tracks in the upper hemisphere towards the edge of the entry. This will pick out interactions produced by a particle coming from outside the stack. The signature of a low energy anti-proton is a track corresponding to a slow particle (<200 MeV) of protonic mass and producing an interaction with a visible energy release more than the kinetic energy of the incoming proton[2].

In the previous ICRC we had reported five candidates. These were obtained by making grain density measurements along the track, which indicated the direction of motion of the particle producing the track, i.e. whether the particle is coming into the interaction or produced in the interaction and going away from the interaction. None of the candidates stopped in the emulsion at the point of interaction. We have now scanned a total volume of 7.8 cm^{-3} of emulsion. A total of about 19,590 interactions were looked at and 10,169 tracks were followed towards the top of the stack. Out of these 288 tracks left the stack at the top and grain density measurements were carried out on them. Those that showed that they are proceeding towards the interaction are called candidates for $\bar{p}$ and were subjected to blob-gap measurements in all pellicles through which they pass. We have made extensive grain density and blob-gap measurements on relativistic alpha tracks in various regions of the stack to determine variations of the sensitivity of the emulsion in a single pellicle as well as from pellicle to pellicle. We used stopping protons and electron pairs to obtain the calibration curves for ionization versus range.

With the above effort, we found that the previous candidates are not anti-protons. We also found another 15 candidates, which also did not turn out to be antiprotons. We have calculated the gathering power of our volume to be 2.38×10^{3} m^{2}.sr.s.MeV yielding as an upper limit to $\bar{p}$ flux of $\sim 4 \times 10^{-4}$ $m^{-2}.s^{-1}.sr^{-1}.MeV^{-1}$ in the energy range 50-150 MeV. This flux limit is to be compared to the flux of $(1.7 \pm 0.5) \times 10^{-4}$ $m^{-2}.\ sr^{-1}.\ s^{-1}.\ MeV^{-1}$ obtained by Buffington et al.[3]; however the flux obtained by Buffington et al. is in the energy range 130-320 MeV. The upper limit to the $\bar{p}/p$ ratio in the energy range 50-150 MeV is obtained using the proton flux in this energy range of 0.96 ± 0.07 $m^{-2}.\ s^{-1}.\ sr^{-1}\ MeV^{-1}$ obtained* from IMP-6 satellite on this date, and is 4.3×10^{-4} (1σ).

---

* We are thankful to Dr. T. von Rosenvinge for this information.

In the last ICRC we reported an event which we interpreted as an anti-triton event on the basis of grain density measurements. Since then we have made blob gap measurements and multiple scattering measurements on the track in all the pellicles through which it passes. After taking into account the plate to plate variations, we found that the ionization measurements made the identification of the incoming track between t and He^3 ambiguous; perhaps more consistent with He^3 nucleus (Fig. 1). In Fig. 2 we show the plot of normalised ionization parameter obtained from blob-gap measurements, versus the multiple scattering parameter for 100μ cell length. (The parameter for 100μ is obtained from values obtained from higher cell lengths and the usual third difference method to remove distortion effects). The curves for H^3 and He^3 are shown. Here again we do not find convincing evidence that the incoming track is a triton, eventhough the measurements do not fit well with a He^3 curve. Therefore, we do not believe the track to be due to an anti-triton.

Acknowledgements: Our thanks are due to Dr. R. Silberberg and the authorities of the Naval Research Laboratory, USA for loaning the emulsion stack. We appreciate the patient scanning and measuring work of Ms. S. Savitri, Mrs. S.P. Prabhudesai, Mrs. R. Chandrasekhar, Mr. D.M. Pawar and Mr. D. Mane.

<u>References</u>

1. Apparao, K.M.V., Durgaprasad, N., Stephens, S.A. and Biswas, S., 1983, Proc. 18th ICRC, Vol.2, pps.75 and 79.
2. Apparao, K.M.V., 1967, Nature Phys. Sci., 24, 98.
3. Buffington, A., et al. 1981, Ap.J. Lett., 247, L105.

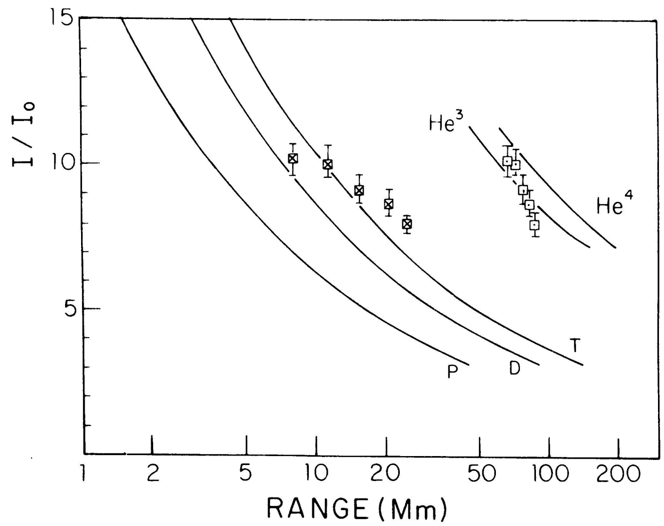

Fig. 1. Normalised ionisation parameter I/I_o obtained from blob-gap measurements versus residual range. The curves for protons (P) and He^4 are obtained from calibration tracks. The measurements of the candidate track are plotted once on the triton curve and once on He^3 curve to examine the fits.

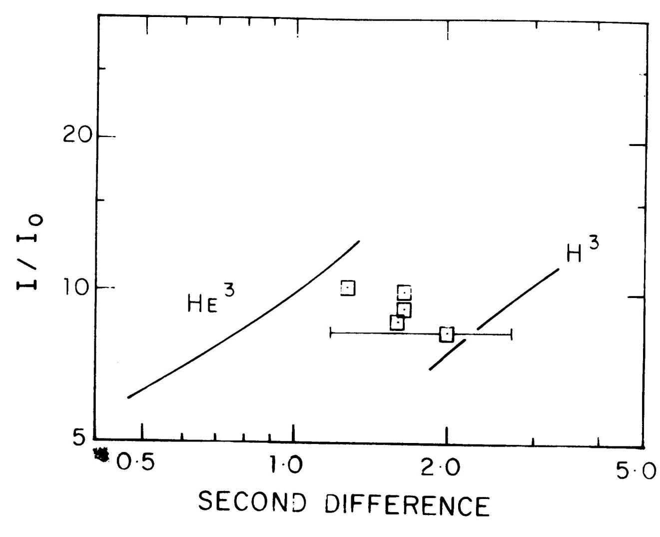

Fig. 2. Normalised ionisation parameter I/I_o obtained from blob-gap measurements versus scattering parameter. The measured values for the candidate track are plotted; typical error is shown.