Hayakawa, S.: The high Rochester abundance of ^3He seems to be inconsistent with the low flourine abundance just reported by Dr. Waddington. In this connection I would like to point out an effect which may be important for low energy heavy nuclei; Since the gyration radius of such low rigidity particles in the geomagnetic field is only of the order of 100 Km, the probability of tipping the earth's atmosphere may be considerable. This could increase the thickness of matter traversed by low rigidity particles and especially by low Z particles which do little suffer from the ionization loss.

Ney, E. P.: It seems to me that the results of the second experiments do not show resolution of the He^3, He^4 peaks and if this had been done first, you might have concluded that there was no He^3 in the cosmic rays.

I also feel that the implication that the non sharp cut-off in galactic cosmic rays is due to the mass mixture of He^3 and He^4 is extreme speculation. The same non sharp cut off occurs with solar protons in the earth's field and almost certainly cannot be explained the same way.

Kaplon: 1. We first did our experiment on the machine accelerated *He* which gave us the courage to go ahead.

2. We are not implying that the non sharp cut-off is due to isotopic mixture. Author, We are pointing out that the influence of isotopic composition on a non-mass sensitive detection is something that should be taken into accounts.

Messel, H.: How large is the neutron stripping correction you must apply to your He^4 result?

Kaplon, H.: We have used the following fragmentation coefficients for atmosphere

$$P^{air}_{He^4-He^3}=0.1 \quad : \quad P^{air}_{M-He^3}=0.5$$

The atmospheric correction is less than 6%.

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III-1-22. Concluding Remarks

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Taken together, the three papers presented in this session give a rather complete summary of our present knowledge of the nature of the galactic component of the Primary Cosmic Radiation.

As the speakers have pointed out, we are only at the beginning of a detailed investigation of the electric charge and energy spectrum of galactic electrons and of the energy spectrum and spatial distribution of galactic γ-rays.

The chemical composition of the nuclear component is now known with reasonable accuracy but only in a narrow energy interval. There is an indication that the details of the composition may be energy dependent in the nonrelativistic range and that even the gross features like the ratio of heavy nuclei to protons may be quite different among the primaries giving rise to air showers, than among those of lower energy which can be observed in emulsion. In principle it seems possible to distinguish whether such changes in composition if present, are due to the fact that sources of different chemical composition predominate in different energy intervals or whether the difference arises from the dependence of the trajectories of primary particles on their magnetic rigidity and resulting changes in the amount of interstellar matter traversed by the particles before arrival.

Even in the energy range corresponding to particles arriving at geomagnetic latitude $\lambda = 41°$, where the chemical composition is known more accurately than in other regions, one is barely able as yet to answer the most fundamental question regarding the origin and propagation of the radiation, (the question which historically gave rise to the Li, Be, B investigations) namely: Does the composition reflect approximately the chemical composition of the source region, or do the protons and α-particles in the primary beam represent mainly fragments from the break-up of heavier nuclei in interstellar space?

The comparatively small flux of Li, Be, B, in particular the scarcity of Be, the abundance minimum at nitrogen, flourine and elements of charge between $Z=16$ and $Z=19$, and the prevalence of even over odd Z-nuclei, speak against the assumption that fragmentation processes play a major role in the observed composition; but this conclusion cannot be accepted as certain until laboratory experiments on the spallation of various elements bombarded by protons and α-particles of different energies have definitely established that the observed features in the primary spectrum are incompatible with a composition consisting predominantly of fragments from heavier nuclei.

In this connection it seems worthwhile to point out that these laboratory experiments should be carried out in such a way that spallation products are identified, not by groups, but as individual nuclear species. This is necessary because the chemical composition of fragmentation products in interstellar space changes considerably after collision, due to radioactive decays. For instance the proportion of boron among the fragmentation products is likely to increase with time by the decay of C^{10}, C^{11}, and Be^{10}, although there will also be some decrease, due to the decay of B^{12}; the increase of Lithium due to the decay of He^{6} and of Be^{7} may or may not be compensated by the loss due to the decay of Li^{8} etc.

The clarification of this question namely importance of fragmentation products among the primaries is now largely a matter to be resolved in the laboratory. Nevertheless new investigations which are in progress such as measurements of the ratio of deuterium to protium in the high energy region of the spectrum, while of great interest in themselves, may also contribute much to the solution of this problem.

When the amount of matter which cosmic ray nuclei have traversed between the time they attained sufficient energy to produce spallation reactions and the time at which they arrived in the solar system has been determined accurately, a new question will arise. It has often been emphasized that the amount of matter traversed by the particles consists of the quite different parts, the gas in the source where acceleration takes place and which contains both light and heavy elements and the interstellar gas which probably contains mainly hydrogen and helium while most of the heavier elements are condensed in dust grains. Dr. Burbidge has drawn attention to the fact, that if spallation reactions could be studied in very great detail and results compared with a primary spectrum in which the intensity of rare elements like Li, Be, B, F were known with very high precision it may be possible eventually to distinguish between these two different media which contribute to spallation reactions. This possibility seems to lie still rather far in the future; but the energy dependence of primary composition *i.e.* detailed studies of a possibly systematic increase of fragmentation products with decreasing primary energy, may even now (at least within the frame work of certain theories of origin and diffusion) permit a separation between fragmentation in transit and fragmentation which occurs during acceleration.

In the future the task of carrying out experiments on the composition of the primary cosmic radiation will shift more and more from balloons and rockets to space ships and from emulsions to electronic detectors. Emulsions can be only of limited use in space ships because they saturate in little more than a day of exposure, on the other hand long exposure times seem essential for studying the less conspicuous features of the primary composition. The charge or mass resolution achieved by electronic detectors is not yet quite adequate for the detailed analysis of the primary charge spectrum which is required. New detectors have to be developed; in particular a combination of gas Čerenkov counter with solid state counter which has been proposed seems promising.

In conclusion it may be worthwhile to point out that present day accelerators and other laboratory facilities, the existing flight techniques and the existing and proposed types of particle detectors, are fairly adequate for the more detailed investigations which are required now. It seems possible to determine the amount of matter traversed by primary nuclei at nonrelativistic, near-relativistic energy and it is therefore possible to obtain a rough picture of the composition of the material leaving the source region in various energy intervals. Discovery of certain isotopic peculiarities of the source, such as the possible high abundances of deuterium, He^3 and C^{13} seem now accessible to direct experimentation. Also in principle at least, it seems possible to determine with available techniques the energy spectrum of electrons and γ-rays, the presence or absence of primary positrons, and the possible existence of discrete sources of nuclear γ-rays. Many of these experiments, are extremely difficult and it may still take several years before the major objectives which have motivated most studies of the primary composition have been achieved.