Elemental Abundances of Cosmic Rays with Z > 33 as Measured on HEAO-3

B.J. Newport[a], E.C. Stone[a], C.J. Waddington[b], W.R. Binns[c], T.L. Garrard[a], M.H. Israel[c], and J. Klarmann[c].

[a]California Institute of Technology, Pasadena, California 91125, USA
[b]University of Minnesota, Minneapolis, Minnesota 55455, USA
[c]Washington University, St Louis, Missouri 63130, USA

1. Introduction

The Heavy Nuclei Experiment on HEAO-3 (Binns et al., 1981) uses a combination of ion chambers and a Čerenkov counter. During analysis, each particle is assigned two parameters, Z_C and Z_I, proportional to the square roots of the Čerenkov and mean ionization signals respectively. Because the ionization signal is double valued, a unique assignment of particle charge, Z, is not possible in general. Our previous work (Binns et al., 1983, 1985, and Stone et al., 1983) has been limited to particles of either high rigidity or low energy, for which a unique charge assignment was possible, although those subsets contain less than 50% of the total number of particles observed. In this paper we discuss the use of the maximum likelihood technique to determine abundances for the complete data set from ~1.5 to ~80 GeV/amu.

Figure 1 shows the possible values of Z_C and Z_I for elements near iron, and indicates the substantial overlap between adjacent elements, even before smearing by the resolution function. In Figure 2, the curves of Figure 1 have been transformed using the variable Z_C/Z_I instead of Z_I. This transformation simplifies the following data analysis.

2. Analysis

Particles were selected from the full exposure, 580 days, and were required to have a good Čerenkov signal, at least one good ion chamber and a reliable trajectory. These particles were assigned an initial charge estimate, Z_{est}, and 1/40 of those with $Z_{est}>19.5$ were saved, together with all the remaining particles with $Z_{est}>30$. The selected particles were binned in a two dimensional histogram, with one axis being the logarithm of Z_C and the other being Z_C/Z_I. Figure 3 shows a contour plot of the region of this histogram near iron.

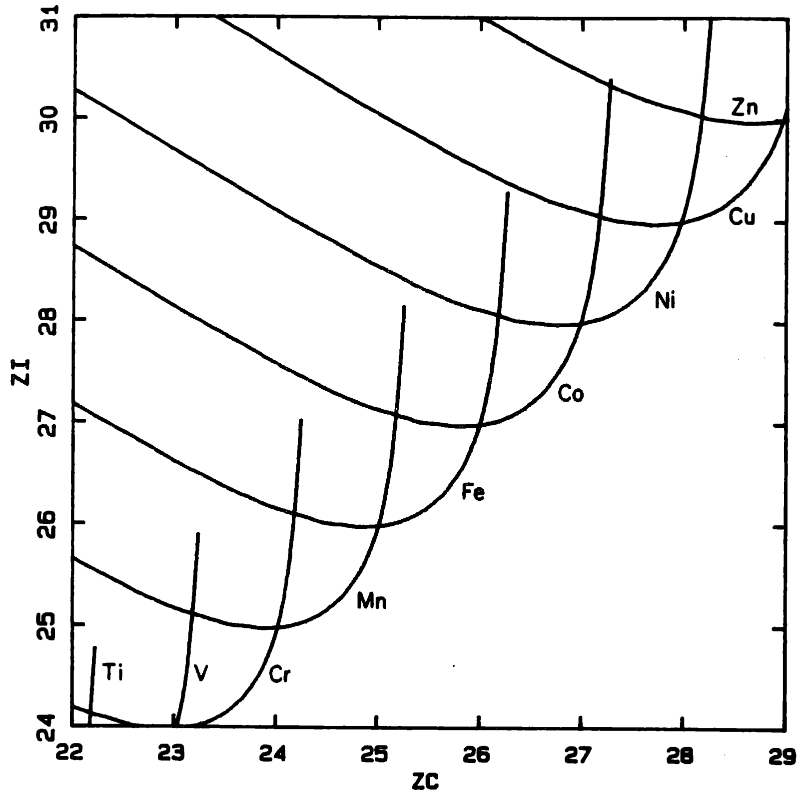

Figure 1. Curves of Z_I *versus* Z_C *for the elements near iron.*

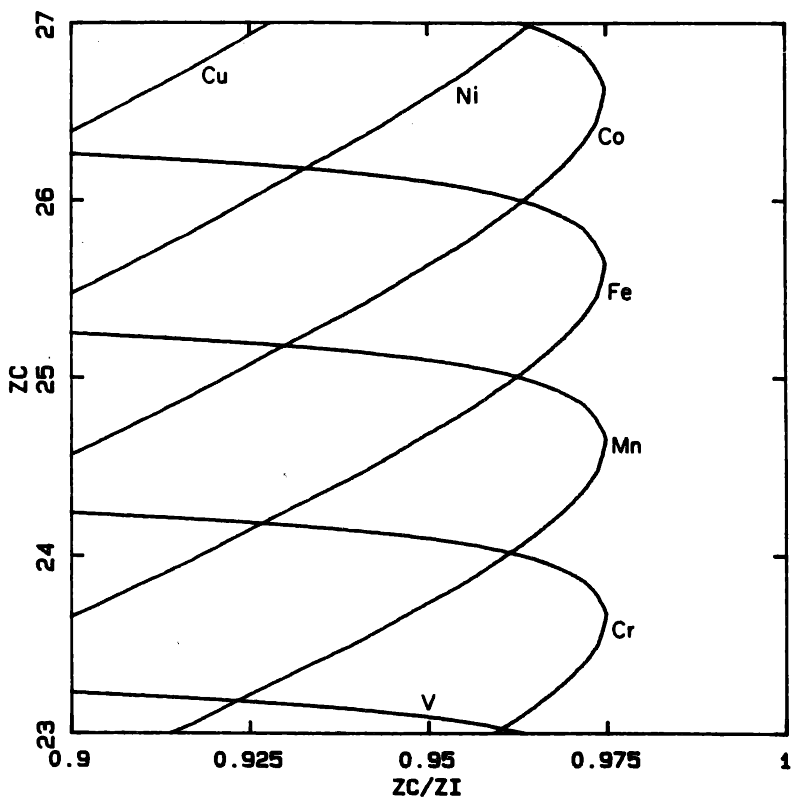

Figure 2. The curves of Figure 1, displayed in $(Z_I/Z_C, Z_C)$ *space.*

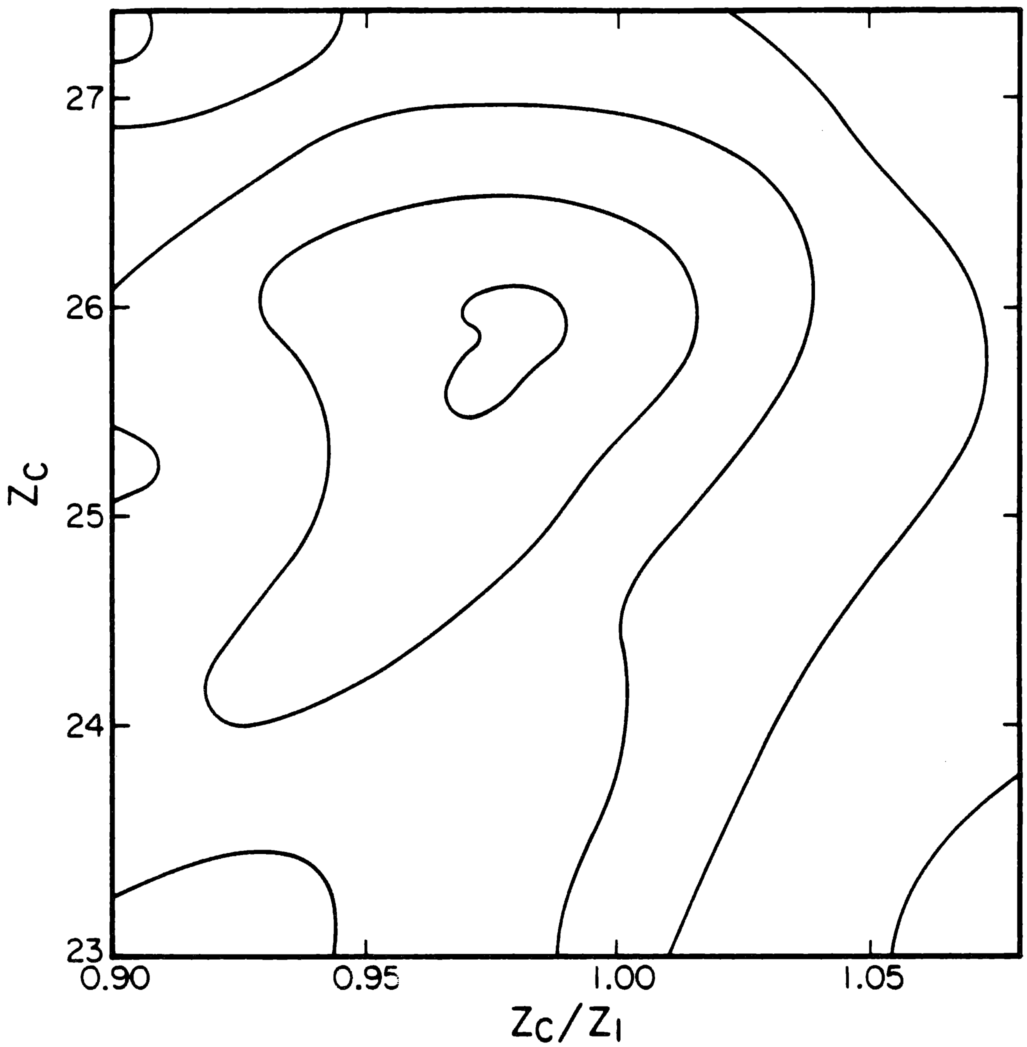

Figure 3. A contour plot of particle density in (Z_I/Z_C, Z_C) *space.*

We have used the iron distribution as a reference distribution for the other elements, by scaling it according to the following criteria:

1) All elements are assumed to have the same energy spectrum, although it is known that the sub-iron secondary elements have steeper spectra (e.g. Jones et al., 1985, OG 4.1-8).
2) Energy independent scaling factors have been used.
3) The resolution of the instrument is a constant fraction of the signal.
4) Non-Z^2 corrections to the scaling laws for Z_C and Z_C/Z_I have been determined directly from the data.

Those elements contaminating the iron distribution have been approximately removed by scaling the contaminated distribution and subtracting according to an assumed set of abundances. The resulting "clean" iron distribution was smoothed and then scaled to the high Z elements, using cubic interpolation techniques.

The likelihood of a given set of abundances may be calculated using Poisson statistics, and maximized by iterating until all the first derivatives are zero, yielding the best fit. Results from the application of this method will be reported.

3. Acknowledgements

We thank B.W. Gauld for assistance in programming for data analysis. This work was supported in part by NASA grants NAG 8-498, 500, 502 and NGR 05-002-160, 24-005-050, 26-008-001.

4. References

Binns, W.R., *et al.,* 1981, *Nucl. Inst. Meth.* **185,** 415
Binns, W.R., *et al.,* 1983, *Proc. 18th I.C.R.C. (Bangalore),* **9,** 106
Binns, W.R., *et al.,* 1985, *Ap. J.* (to be published Oct. 1)
Jones, M.D., *et al.,* 1985, *Proc. 19th I.C.R.C. (San Diego),* OG 4.4-5
Stone, E.C., *et al.,* 1983, *Proc. 18th I.C.R.C. (Bangalore),* **9,** 115