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DEPENDENCE OF POSITIVE PION PRODUCTION CROSS SECTIONS ON ATOMIC NUMBER AT LOW ENERGIES

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A preliminary study[1] of positive pion production from proton-nucleus collisions (at $T_\pi = 33$ Mev) revealed that positive pion production cross sections agree more favorably with a $Z^{2/3}$ variation than with a variation proportional to the atomic number. A similar study on negative pion production[2] (both at $T_\pi = 33$ Mev and at $T_\pi = 12.5$ Mev) has shown that negative pion yields from proton-nucleus collisions tend to vary in proportion to the number of neutrons in the nucleus ($N = A-Z$). As a result an experiment was performed to investigate if there is a significant change in positive pion production with changing atomic number at two lower pion energies ($T_\pi = 27$ Mev; $T_\pi = 12.5$ Mev).

For the experiment the 340-Mev deflected proton beam of the synchrocyclotron was used. The collimated (1-inch diameter) proton beam traversed an (argon-filled) ion chamber and then passed down the axis of a 22-inch spiral-orbit spectrometer.[1] Hollow conical targets of Be, C, Al, Cu, Ag and Pb were mounted symmetrically about the median plane along axis of the spectrometer. The apex angle of the conical targets was 25 degrees. The target wall thicknesses were adjusted so that for the low-energy experiment ($T_\pi = 12.5$ Mev), a pion energy loss of 3 Mev was experienced by a pion traversing the target wall.

The stable-orbit energy of the pion was $T_\pi = 9.2$ Mev. Hence for the $T_\pi = 12.5$ Mev experiment a 10-mil tubular degrader was mounted symmetrically about the axis of the spectrometer.[1] A 150-mil copper tubular degrader was used to detect the $T_\pi = 27$ Mev pions.

The pions were detected by Ilford C-2 (200 μ) nuclear emulsions, which were positioned in the stable orbit.[1]

The preliminary results obtained are shown in Fig. 1 and Fig. 2.

A comparison of these two plots with the data reported from the $T_{\pi} = 33$ Mev experiment[1] clearly reveals a definite tendency for variation of positive pion production with atomic number as the pion energy is lowered. The deviation of the experimental data from the $Z^{2/3}$ curve becomes increasingly more important as the pion energy is lowered further. The direction of this deviation is the same as the effect of the nuclear coulomb field on positive pion production. The nuclear coulomb effect may not, however, suffice to explain the deviation observed at higher energies (27 Mev and 33 Mev). It should also be noted that no pronounced opposite effect has been observed for negative pion production.

At this stage of the experiment further discussion would certainly be premature. However the authors are of the opinion that they have gathered some information related not only to the nuclear coulomb field but also to the mean free-path of the incident proton inside the target nucleus, to the mean free-path of the created pions and to the internal nucleon momenta inside the target nucleus. It has been pointed out that if it is assumed that the recently reported nuclear model of high proton concentration at the center of the nucleus[3] is true and also if the concentration of the nuetrons is at most of the same order and most likely less pronounced, then the deviation of our curves on π^+ production from the $Z^{2/3}$ curve and the π^- production variation, which is proportional to N, may be qualitatively explained.

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REFERENCES

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2. W. F. Dudziak, R. Sagane - UCRL-2304
3. Hafstaeder, Schiff - Private Communication
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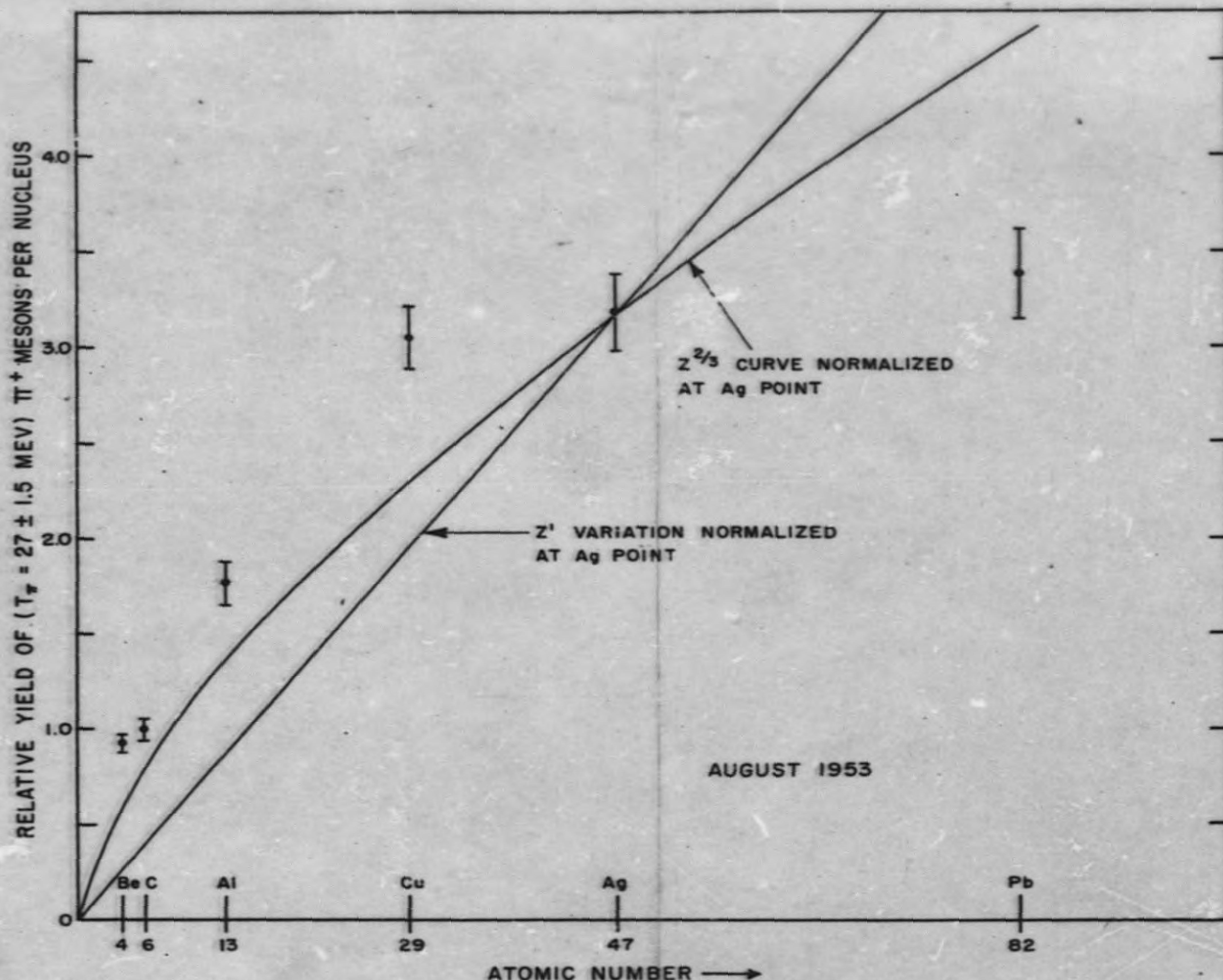
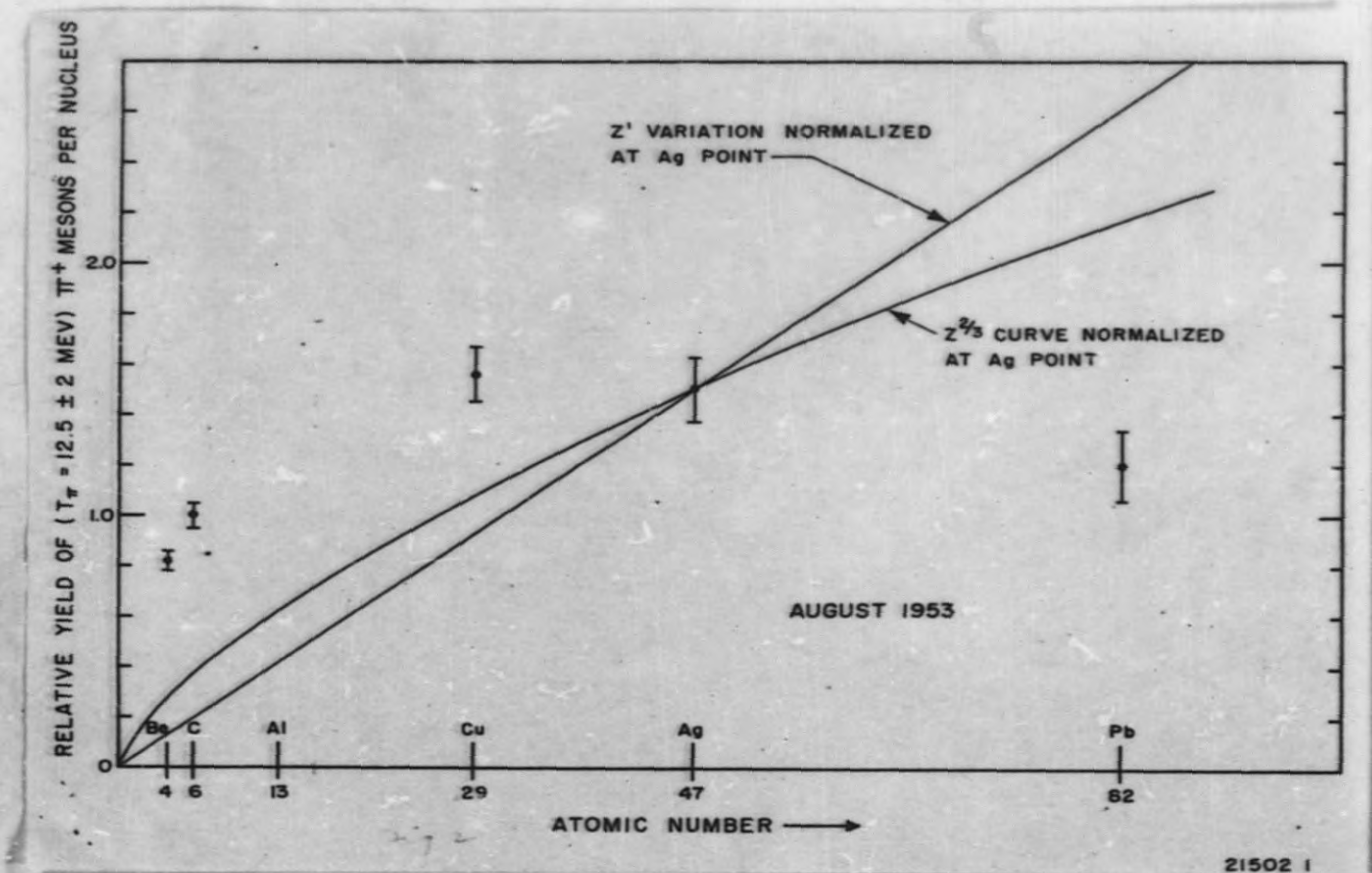
FIGURE CAPTIONS

Figure 1. The variation of positive pion production cross sections with atomic number at a pion energy T_π = 27 Mev. Superimposed on the data are a $Z^{2/3}$ variation and a variation proportional to Z. These variations are normalized at the Ag point.

Figure 2. The variation of positive pion production cross sections with atomic number at a pion energy T_π = 12.5 Mev. A $Z^{2/3}$ variation and a variation proportional to Z, normalized at the Ag point, are also shown.


RELATIVE YIELD OF (T_π = 27 ± 1.5 MEV) π^+ MESONS PER NUCLEUS
4.0
3.0
2.0
1.0
0
Be C Al Cu Ag Pb
4 6 13 29 47 82
ATOMIC NUMBER →
$Z^{2/3}$ CURVE NORMALIZED AT Ag POINT
Z' VARIATION NORMALIZED AT Ag POINT
AUGUST 1953

21503 2



RELATIVE YIELD OF (T_π = 12.5 ± 2 MEV) π^+ MESONS PER NUCLEUS
2.0
1.0
0
Z' VARIATION NORMALIZED
AT Ag POINT
$Z^{2/3}$ CURVE NORMALIZED
AT Ag POINT
AUGUST 1953
Be
C
Al
Cu
Ag
Pb
4
6
13
29
47
82
ATOMIC NUMBER ⟶
21502 I

END