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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF MARCH 8, 1951

Bonnie E. Cushman

June 27, 1951

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Berkeley, California

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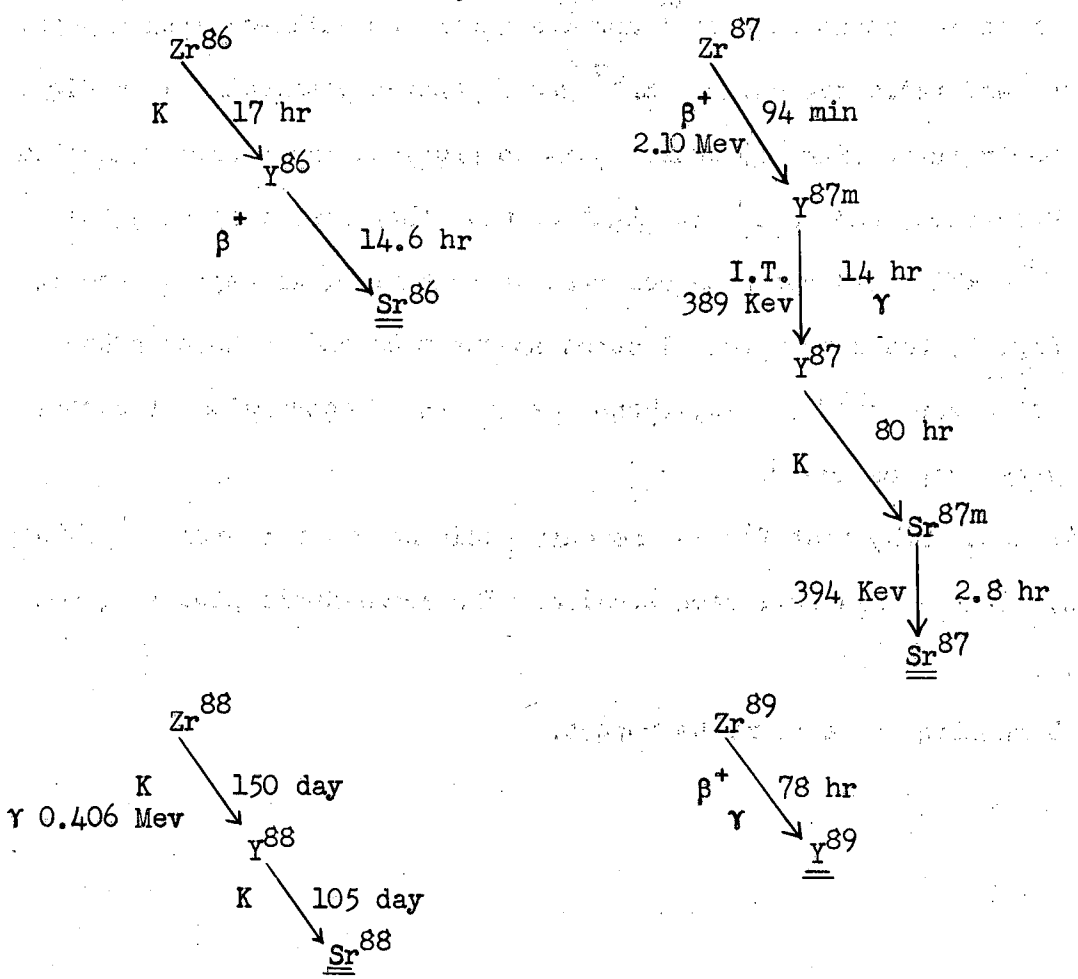
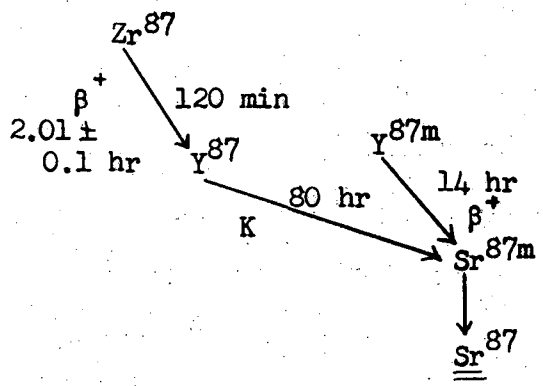
I. Radiochemical Studies on Isotopes of Zirconium. Earl Hyde.

A number of zirconium isotopes are known and have been studied, but until a year ago the only neutron deficient one was Zr^{89}. These isotopes were obtained as fission products of uranium or by cyclotron bombardment. Recently, after bombarding $_{41}Nb^{93}$ with protons, a number of neutron deficient isotopes have been obtained through spallation reactions. Their decay schemes, determined by several investigators, are given below.

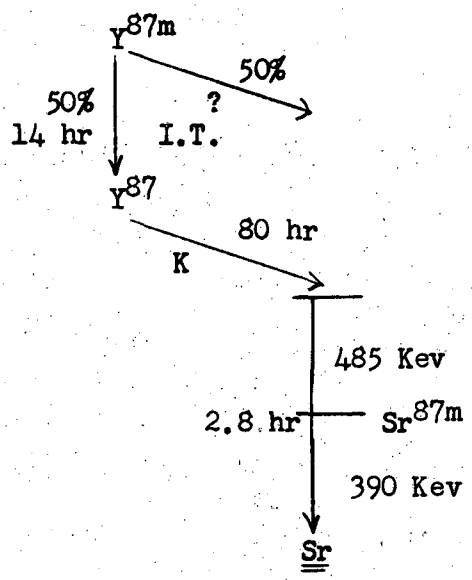
Hyde and O'Kelley



Scott, Robertson, and Pool



Mann and Axel



Attention was focused on Zr^{87} and its decay was followed with a β-ray spectrometer and radiochemically. Sr^{87} was separated chemically at various times and the results (Fig. 1) would seem to prohibit the scheme suggested by Scott, Robertson, and Pool. It might be that they were measuring the 14.6 hour Y^{86}, which had not been reported at that time, as well as the 14 hour Y^{87}. Fig. 2, the conversion electron spectrum 28 and 46 hours after preparation of a pure Y^{87m} sample, shows the growth of conversion electrons of 0.394 Mev gamma ray of Sr^{87m}.

It is noteworthy that Y^{86} is the only positron emitter with a forbidden shape known, although few have been studied. The Fermi-Kurie plot is given in Fig. 3.

See UCRL-1064 for a complete report.

II. Photomesons from Deuterium. R. S. White.

The cross section of meson production by photons from the synchrotron has been studied by A. Schulz, M. Jakobson, and R. S. White. The reaction is

$$k + {}_1D^2 \rightarrow \begin{cases} 2n + \pi^+ \\ \text{or} \\ 2n + \pi^- \end{cases}$$

The report was concerned with π^+ mesons and their differential cross section was calculated by

$$d\sigma/d\Omega = \frac{d^2 N_{[1]}(\theta, k)}{dE d\Omega} \frac{1}{\frac{dN_{[2]}}{dk} \left(\frac{dk}{dE}\right)_\theta nt}$$

or in terms of equivalent quanta, Q,

$$d\sigma/d\Omega = \frac{d^2N}{dEd\Omega} \frac{1}{Q\ nt}$$

where n refers to the number of target atoms per cm^3 (the number of protons were actually used here), t the target length, $N_{[1]}$ the number of counts, and $N_{[2]}$ the number of photons. The factors measured, therefore, were the number of photons or equivalent quanta, the density of the particles in the beam, the counting rates from crystals and plates, and the geometrical factors.

The apparatus (Figs. 4 and 5) used liquid nitrogen for cooling the target and five channels. Four energies and three different angles could be observed in each run. Uranium slits were employed in order to get the detectors as close to the target as possible.

The mesons were detected in three ways: $\pi \rightarrow \mu$, $\pi \rightarrow \beta$, and $\pi \rightarrow \mu \rightarrow \beta$. Details of the results and the various detection methods will be found in UCRL-1319. The area under the curves for the $\pi \rightarrow \mu$ data was integrated to

give $d\sigma(\theta)/d\Omega$ as follows in units of 10^{-30} $cm^2(ster)^{-1}(eq)^{-1}(proton)^{-1}$:

θ	H_2	D_2
90°	9.3	6.9
135°	6.1	5.8

The total cross section was calculated roughly (i.e., without the benefit of data for 45°) to be 9×10^{-29} and 7×10^{-29} for H_2 and D_2 respectively. On a basis of 60 π^- and 88 π^+ particles the ratio π^-/π^+ at 90° was found to be $1.37\ \sigma/(\pi - \mu) = 0.9 \pm 0.2$ for deuterium. The theory of Lewis and Chew does not hold well at this angle, but it was in qualitative agreement.

Corrections to be made for these calculations include the following: 1. Time of flight (5 -10 percent over the entire energy spectrum). 2. Slit penetration (making σ too high - 5 percent). 3. Nuclear absorption (0 - 30 percent, where the largest correction is applied to the highest energies). 4. Poor geometry for the plates, though it is not so pronounced for the crystals (10 percent for crystals, due to the fact that some mesons are scattered out of instead of into the crystals).

Work is being continued on the problem, the next phase being concerned with obtaining data at 45°.

III. <u>Photomesons from Helium</u>. M. Jakobson.

This experiment uses the same target and detection equipment, and personnel as in the previous report (photomesons from deuterium). The reaction in this case is

$$k + {}_2He^4 \longrightarrow \pi^+ + (3\ \pi,\ p,\ \text{or various combinations})$$

but the model is so complicated that the results cannot be predicted.

Fig. 6 graphs the electronics involved, and Fig. 7 shows the distributed circuits. In taking data, absorbers were added and removed consecutively in order to cut down the effects of beam drift. The gas was interchanged three or four times daily and a blank run on the target indicated that all mesons came from the gas in the target. The number of mesons leaving the target was difficult to determine; photographic plates were used and it was then estimated that only 1/3 of the mesons actually opened gates. n for helium (the number of target atoms per cm^3) has not been measured in the region used in this series of experiments, although it has been calculated by S.W. Akin (see Transactions of the American Society of Mechanical Engineers 72, 751 (Aug., 1950).

Complete experimental results and comparisons are given in UCRL-1317; they are summarized below.

$d\sigma/d\Omega$ (in units of 10^{-30} $cm^2 ster^{-1} eq^{-1} proton^{-1}$

θ	He	C
90°	5.4	4.3
135°	4.3	2.0

Ratios of the differential cross sections are

D/H = 0.75 He/H = 0.5 C/H = 0.3 per proton.

Using the $A^{1/3}$ rule these are 0.6 for He/H and 0.4 for C/H. See UCRL-703 for further data re carbon.

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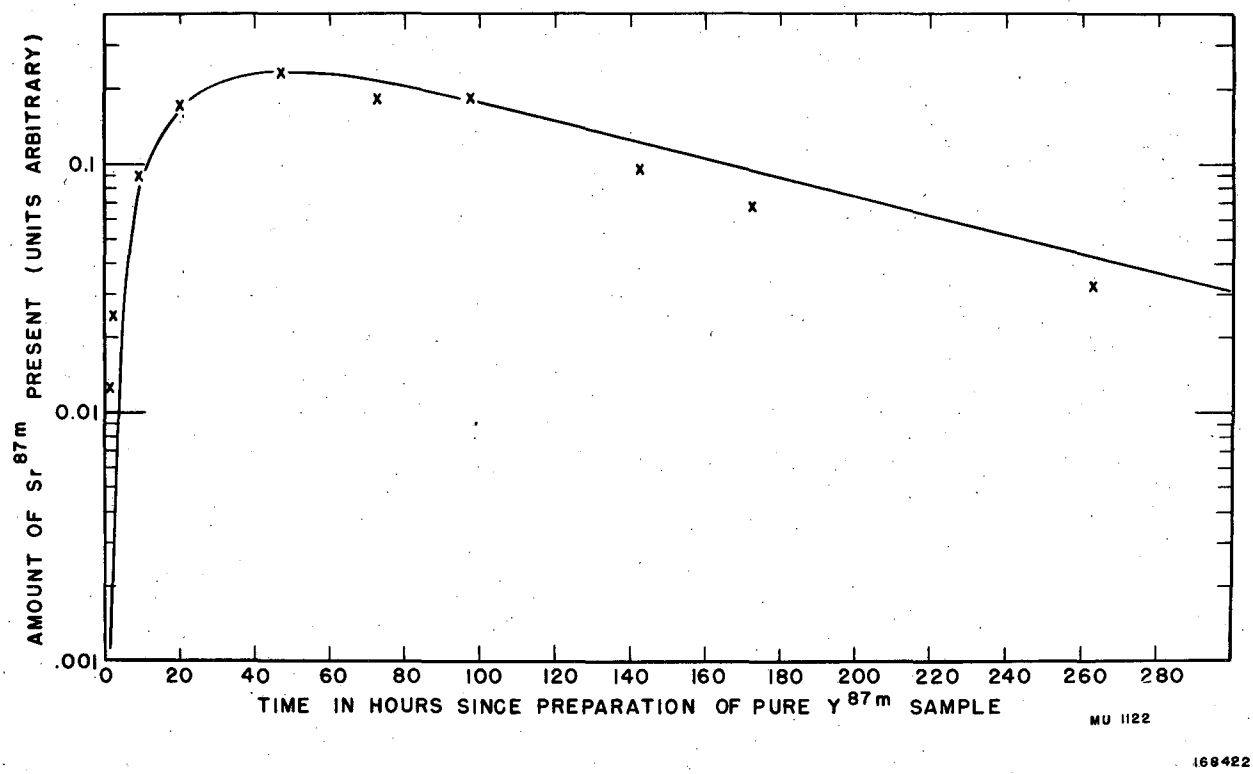

AMOUNT OF Sr 87m PRESENT (UNITS ARBITRARY)
0.1
0.01
.001
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
TIME IN HOURS SINCE PREPARATION OF PURE Y 87m SAMPLE
MU 1122
168422

Fig. 1

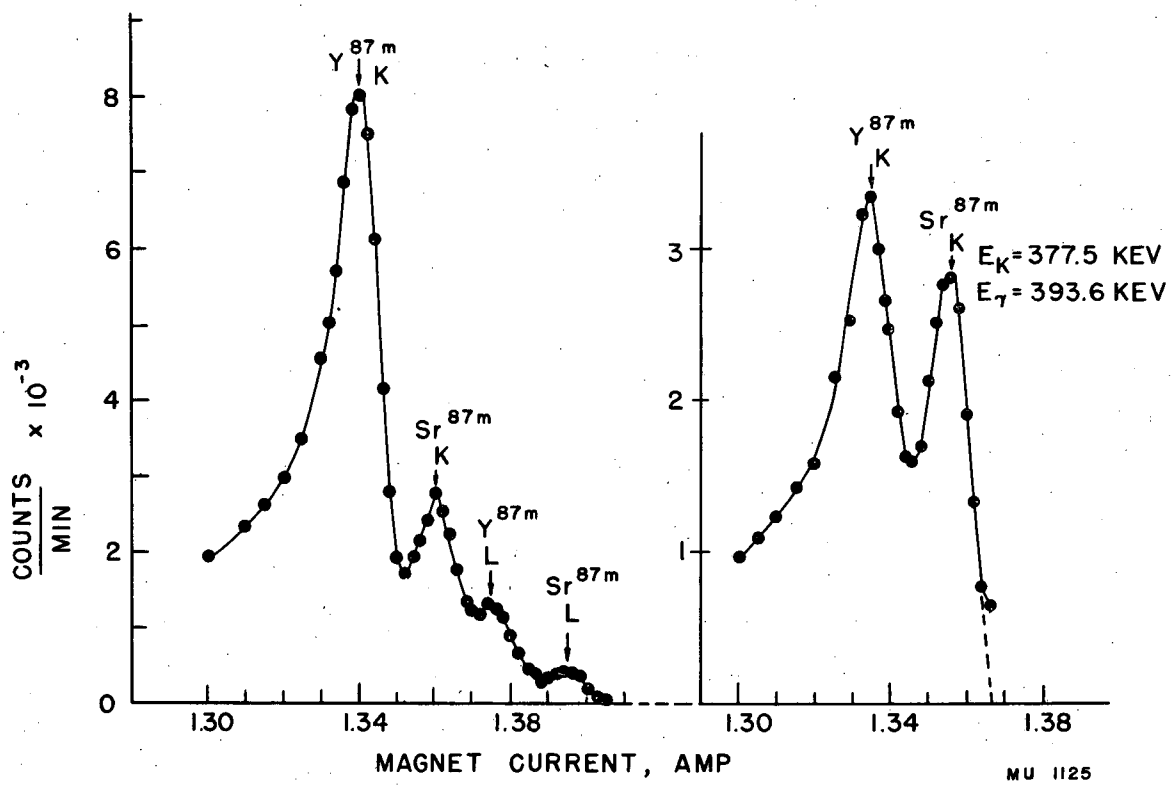

Y 87m K
Sr 87m K
Y 87m L
Sr 87m L
COUNTS / MIN x 10^-3
0
2
4
6
8
1.30
1.34
1.38
MAGNET CURRENT, AMP
Y 87m K
Sr 87m K
E_K = 377.5 KEV
E_γ = 393.6 KEV
1
2
3
1.30
1.34
1.38
MU 1125

Fig. 2

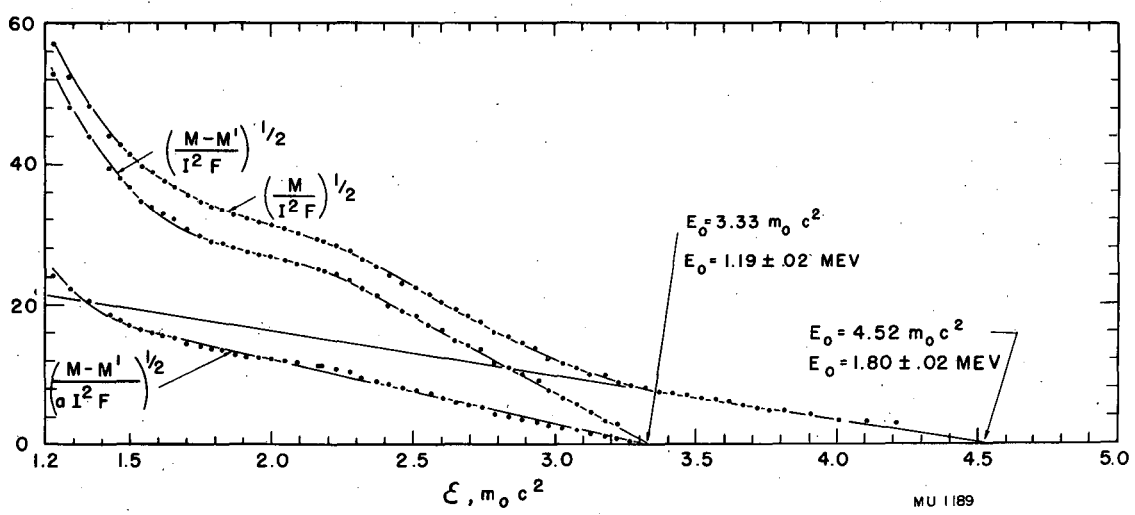
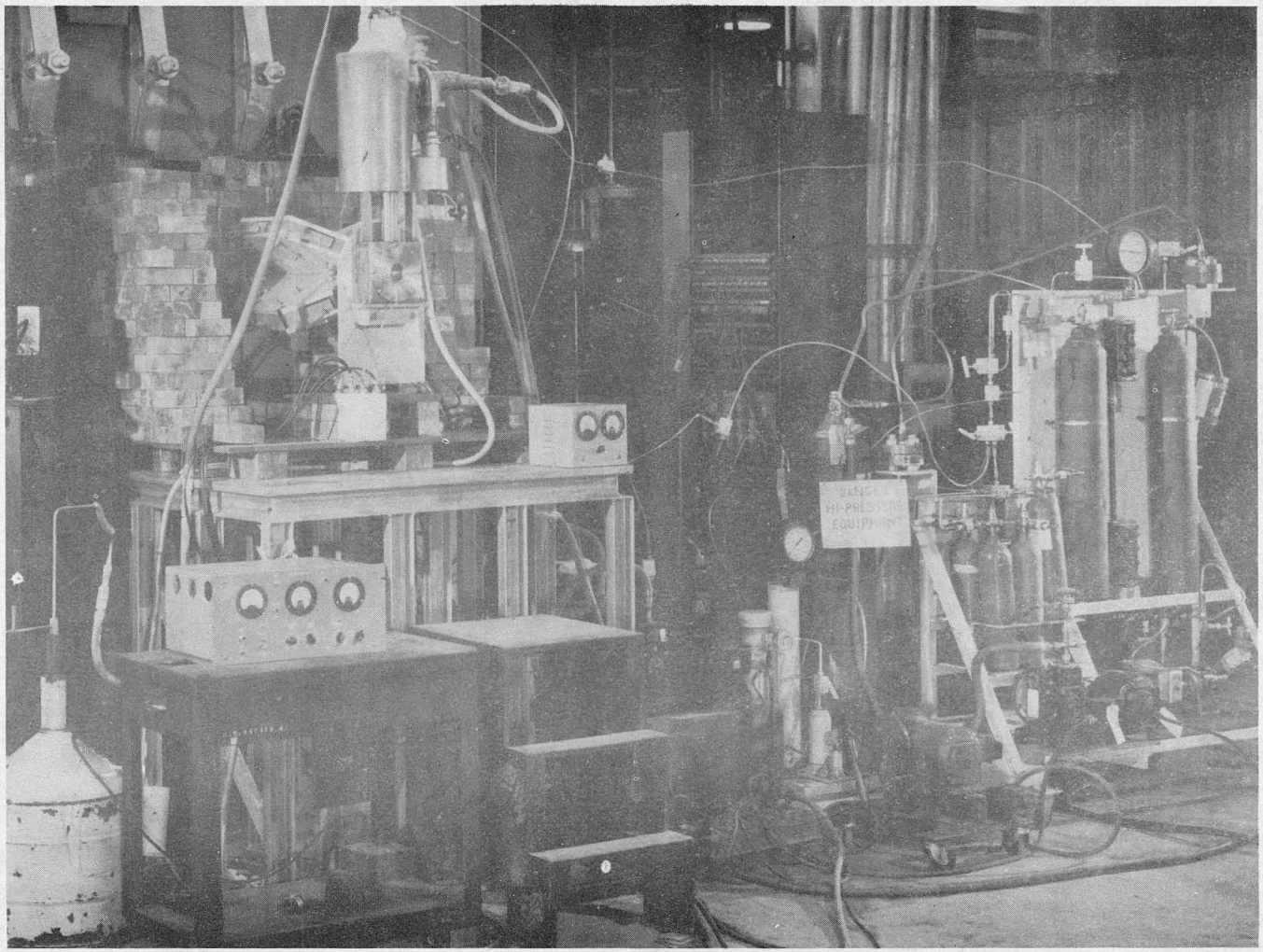

60
40
20
0
1.2
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
$\mathcal{E}$, $m_0 c^2$
$\left(\frac{M-M'}{I^2 F}\right)^{1/2}$
$\left(\frac{M}{I^2 F}\right)^{1/2}$
$\left(\frac{M-M'}{a I^2 F}\right)^{1/2}$
$E_0 = 3.33\ m_0 c^2$
$E_0 = 1.19 \pm .02$ MEV
$E_0 = 4.52\ m_0 c^2$
$E_0 = 1.80 \pm .02$ MEV
MU 1189

Fig. 3



ZN 56

Fig. 4

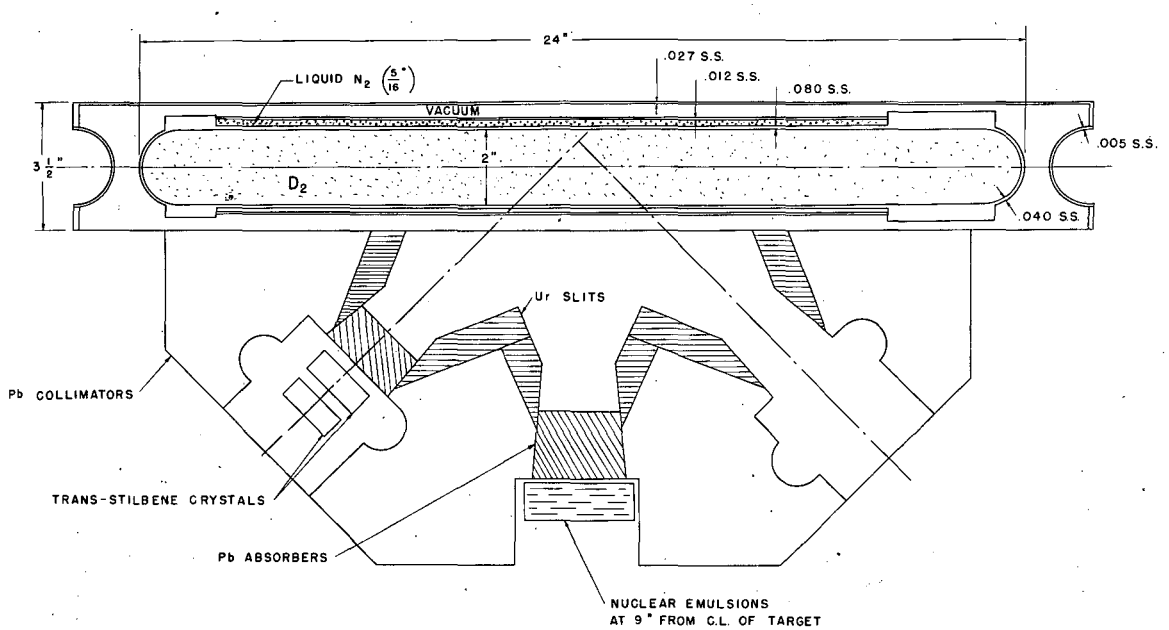
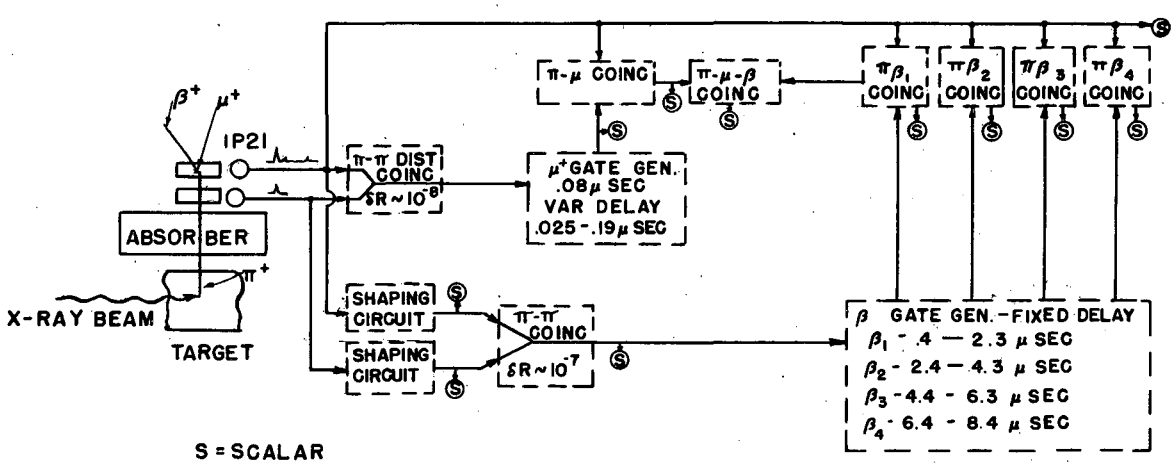

24"
.027 S.S.
.012 S.S.
.080 S.S.
LIQUID N_2 $\left(\frac{5}{16}"\right)$
VACUUM
.005 S.S.
$3\frac{1}{2}$"
2"
D_2
.040 S.S.
Ur SLITS
Pb COLLIMATORS
TRANS-STILBENE CRYSTALS
Pb ABSORBERS
NUCLEAR EMULSIONS
AT 9° FROM C.L. OF TARGET
MU 1499

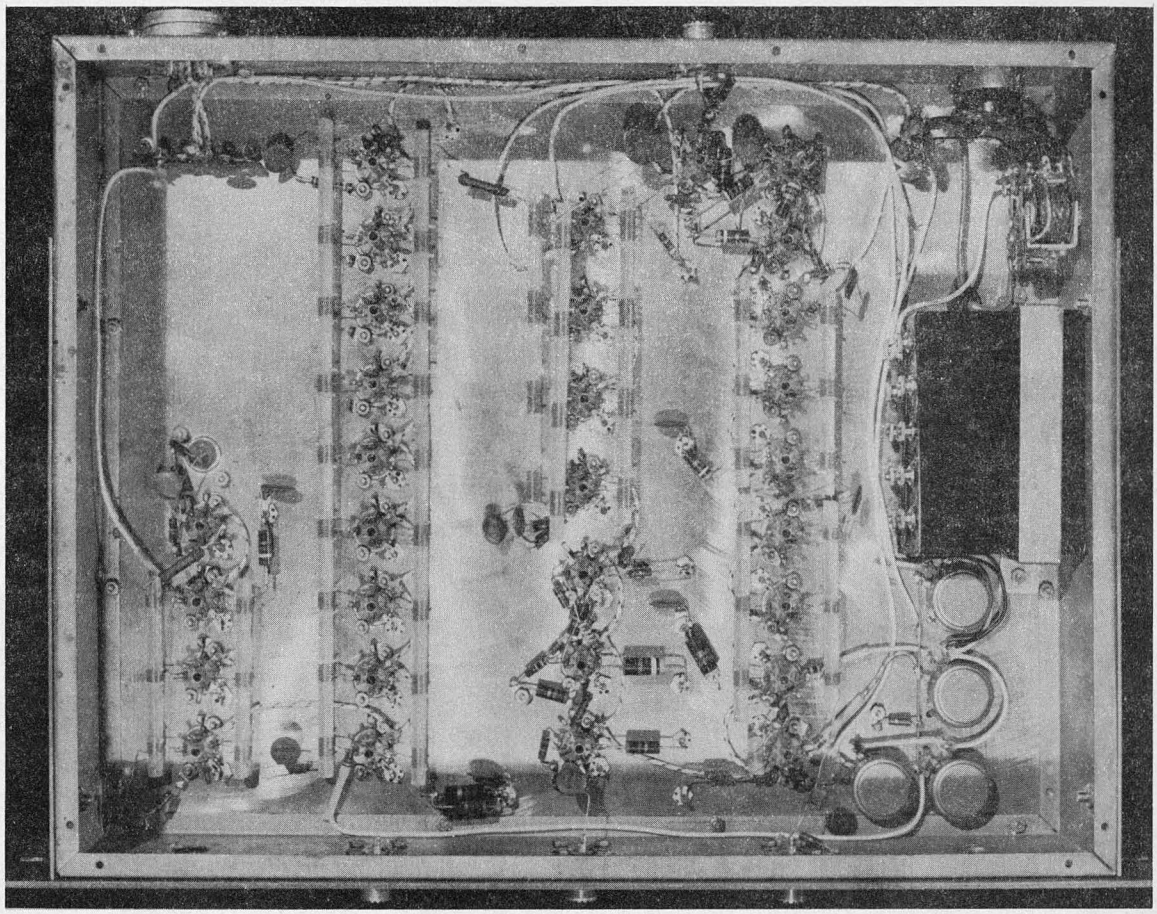
Fig. 5

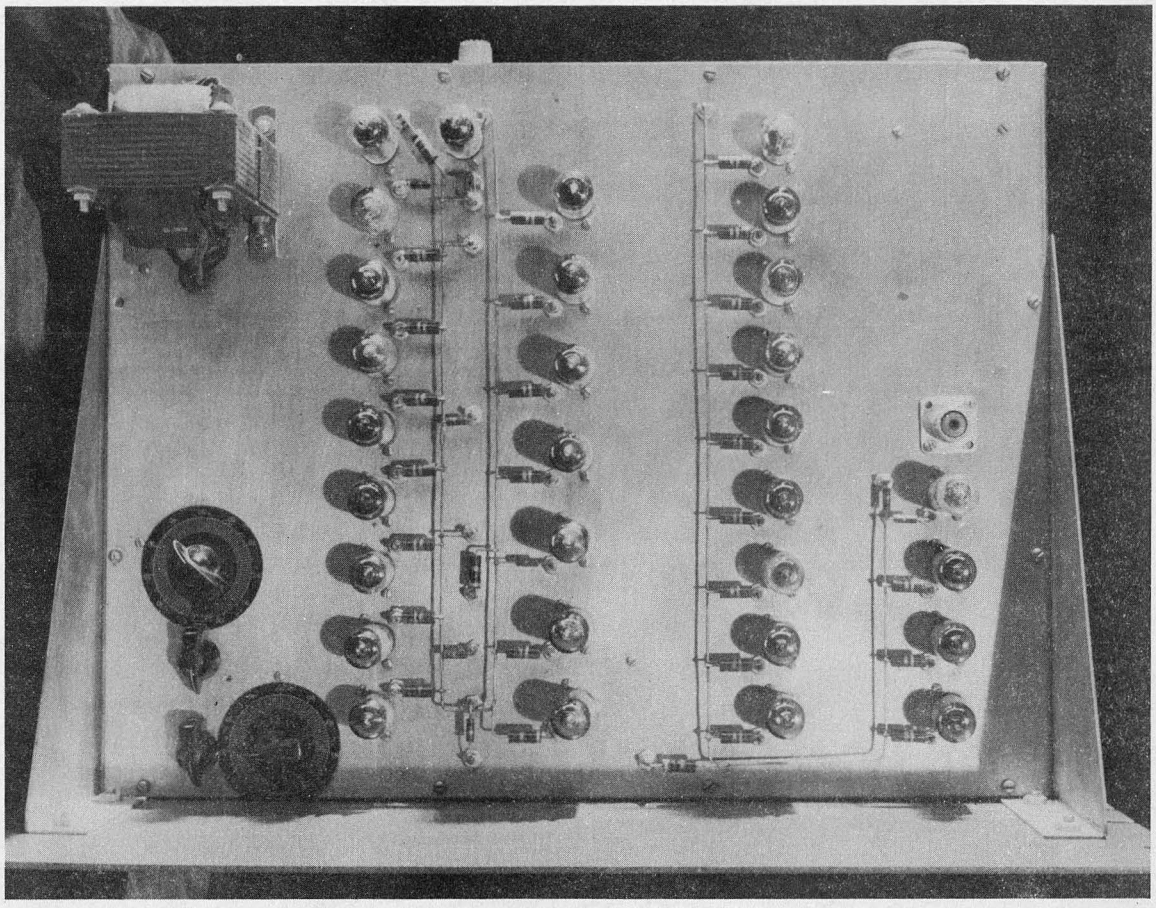


BLOCK DIAGRAM – ELECTRONICS

MU 1498

Fig. 6





ZN 58

Fig. 7