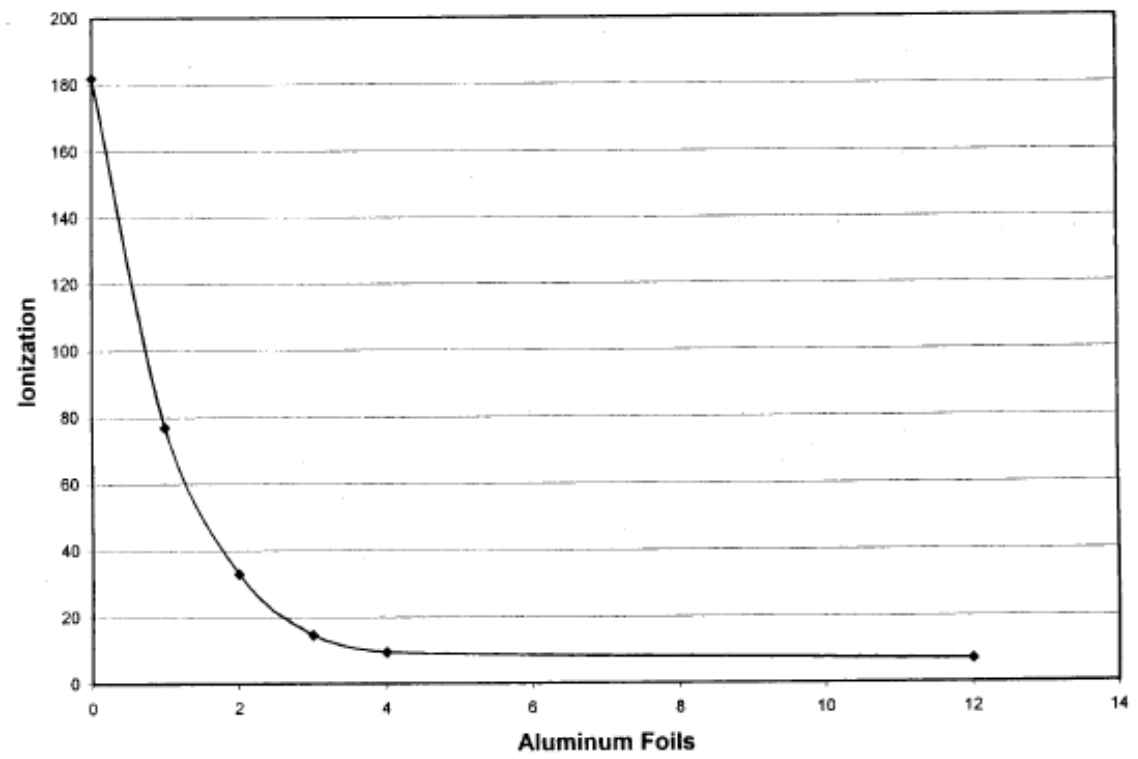


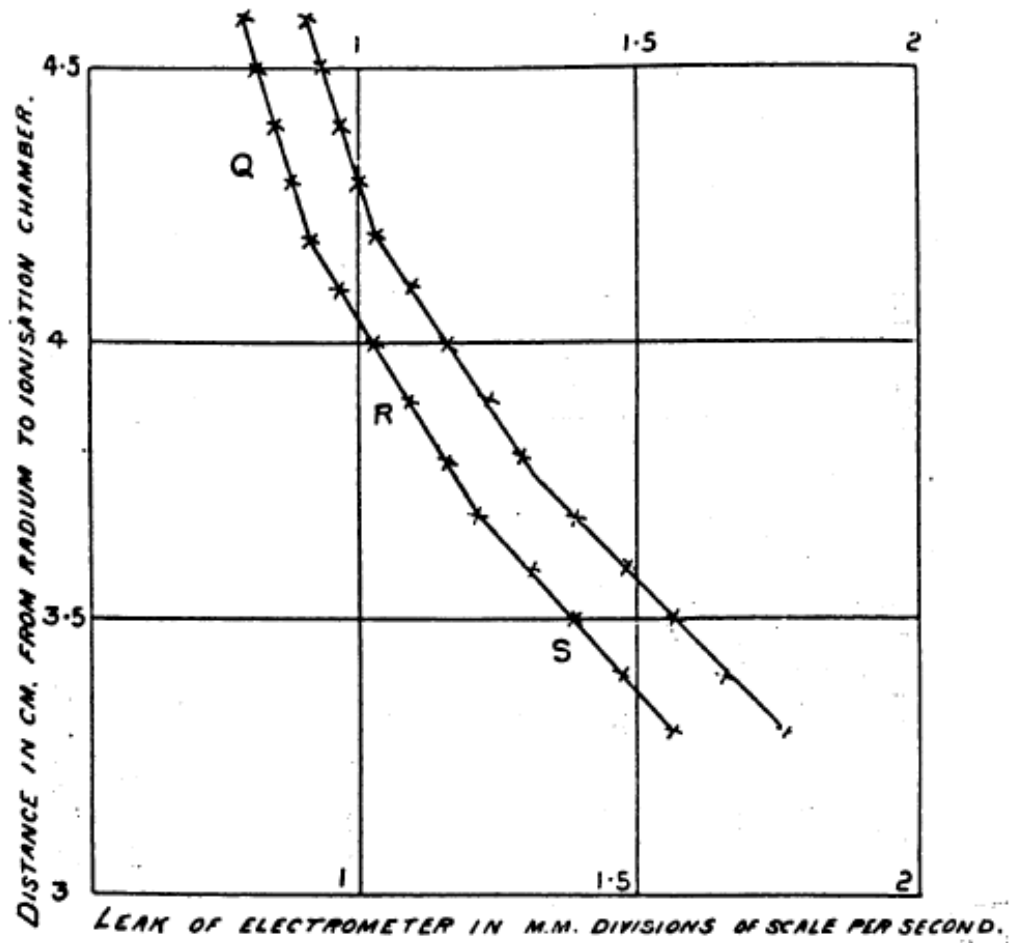
The Prehistory of the Neutrino
Allan Franklin
Department of Physics
University of Colorado

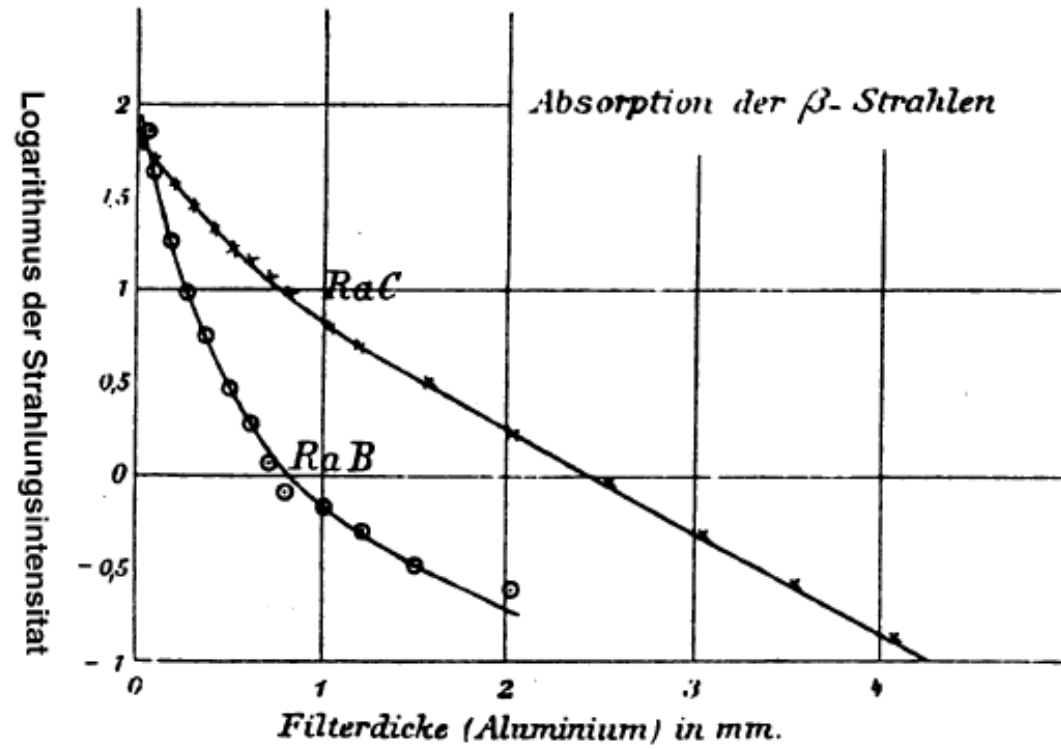
History of the Neutrino Conference
Paris, September 5, 2018

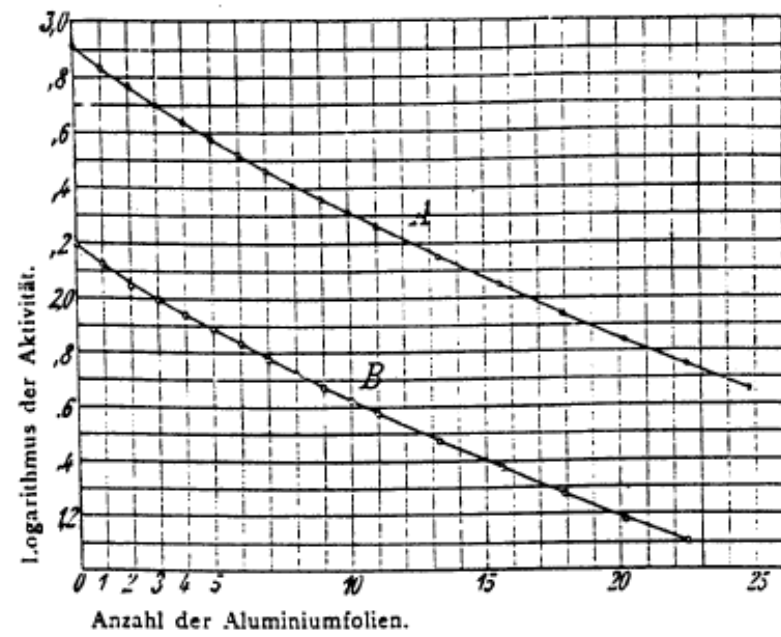


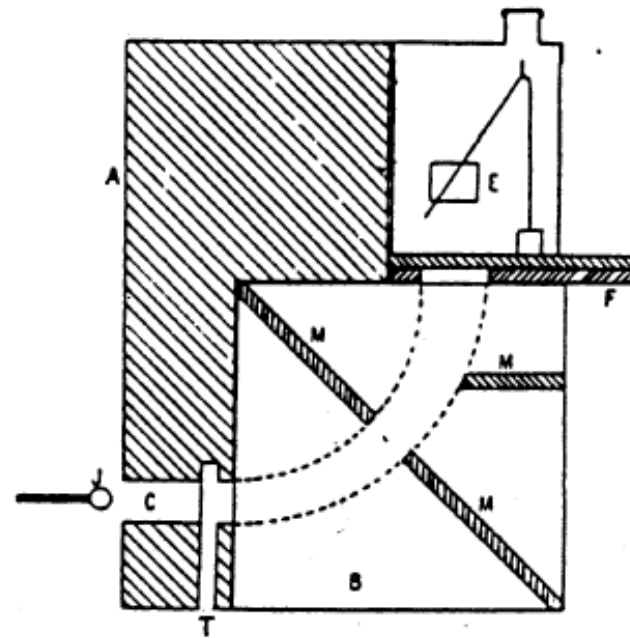
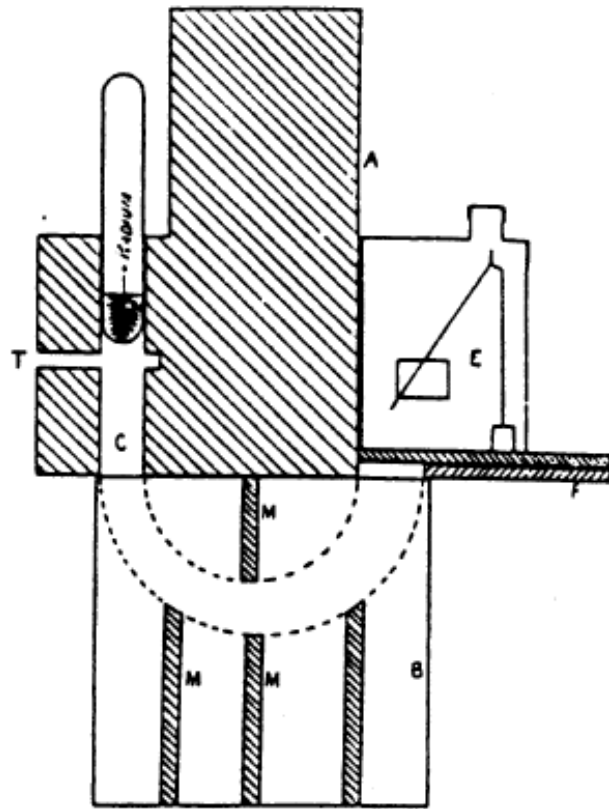
10 - 17 - 96. Sulfide Double Through of Dr. Pollock
Papier noir. Copy of Carion's notes.
Exposé au sujet de 27. et de la même affaire. Le 27.
Vendredi 17. 1896.











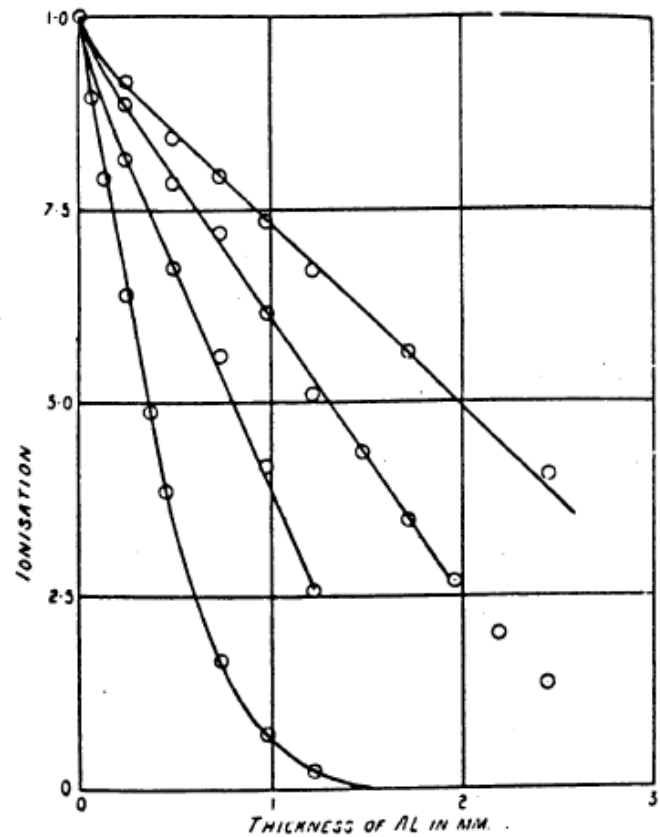
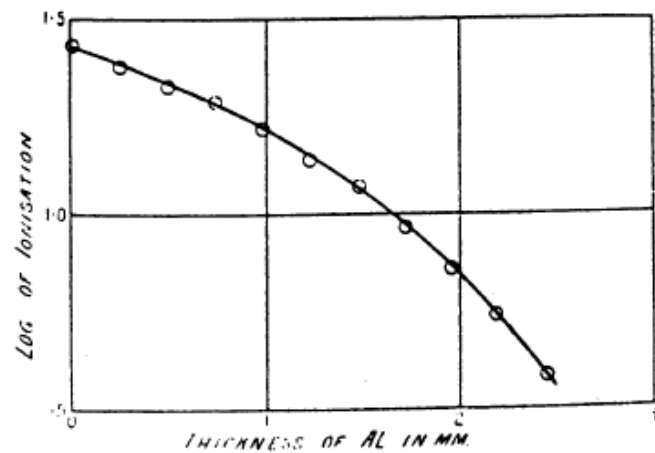
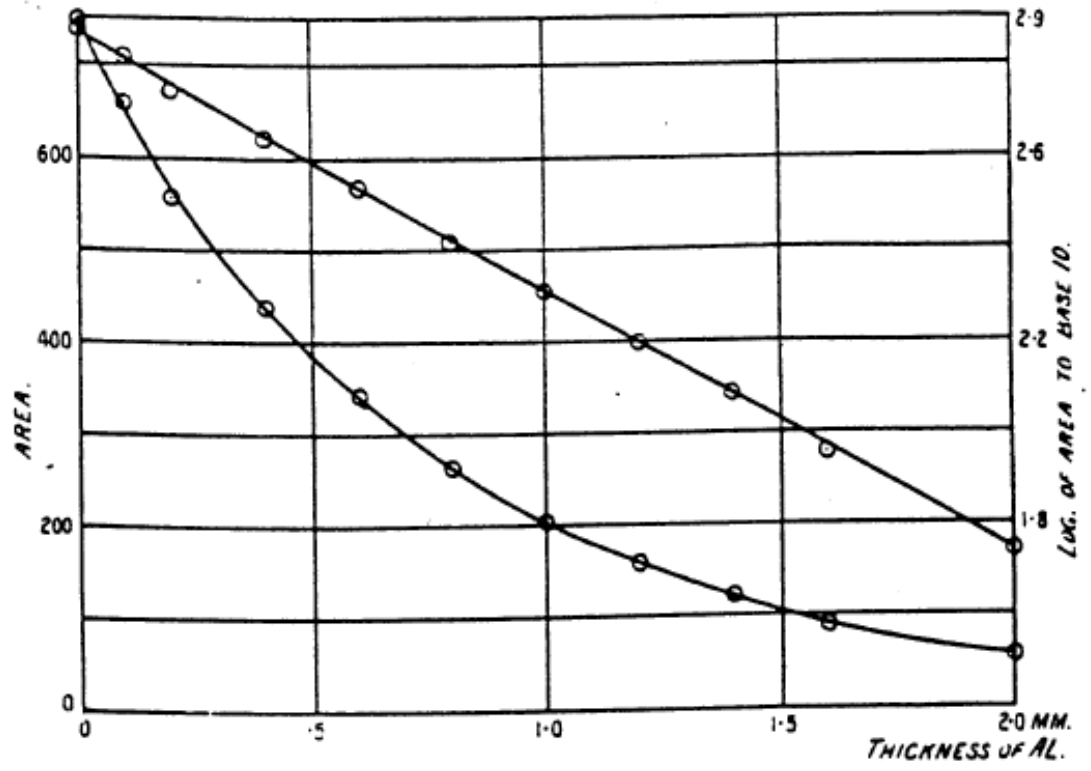
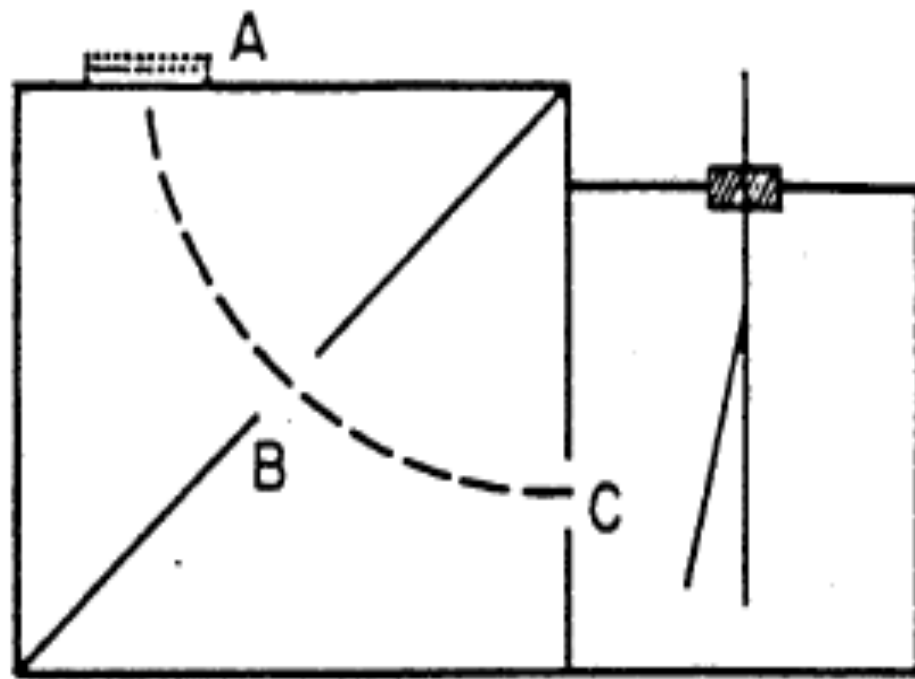
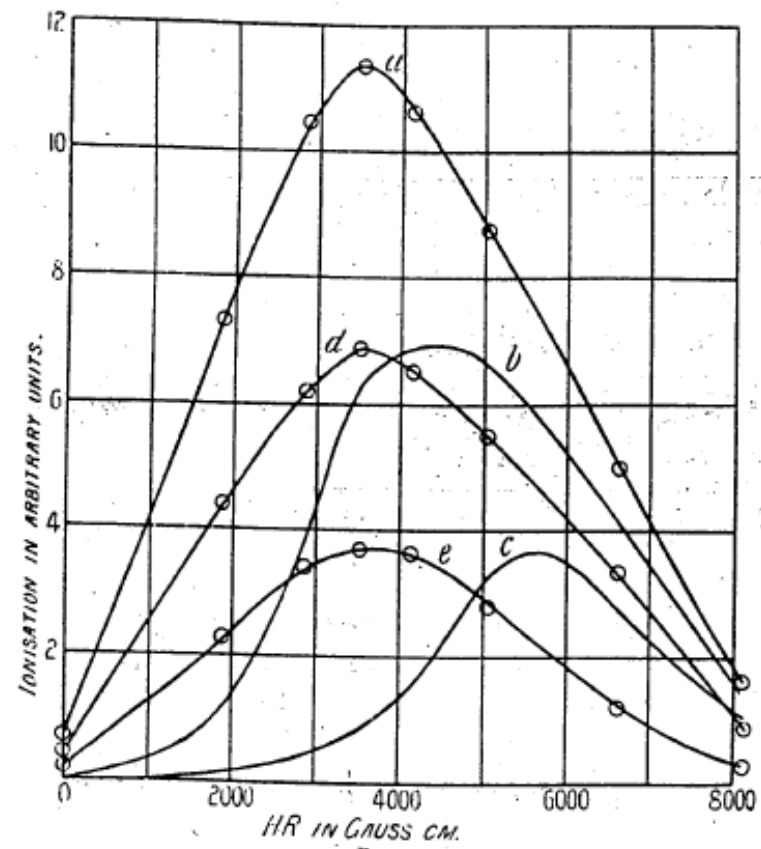


FIG. 3.









“This experiment also explains why the experiments of Schmidt apparently show no change in the velocity of the rays. According to the views expressed in this paper he was dealing with heterogeneous rays and the position of the maximum should therefore move to the higher fields if the velocity of the rays does not change. The actual decrease in velocity, however, brings the maximum point back to practically the same position as before. “

Wilson (1909)

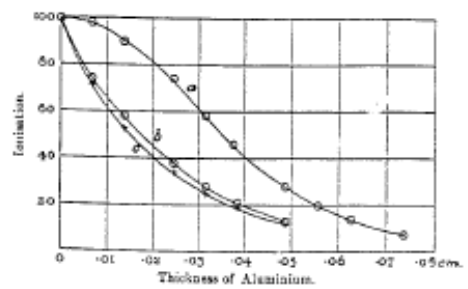
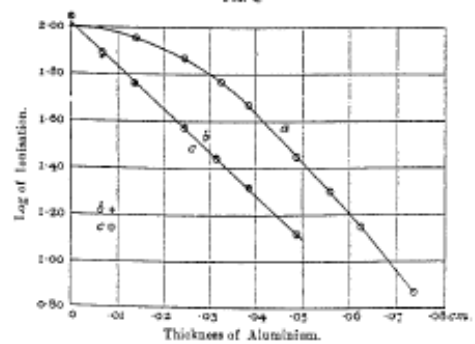
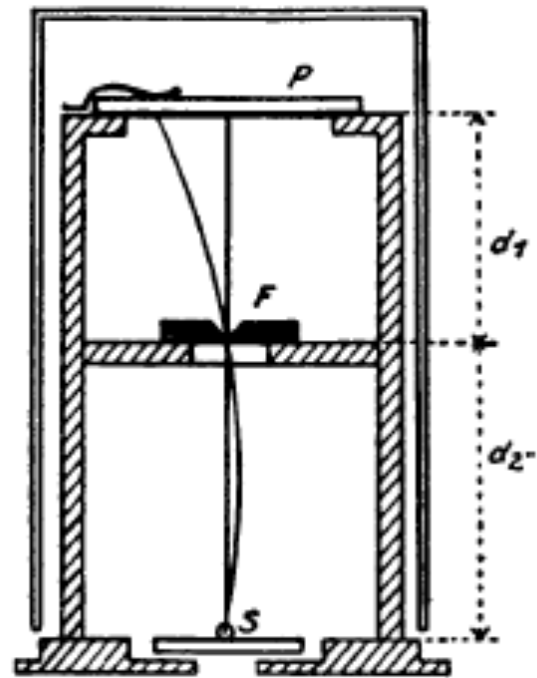
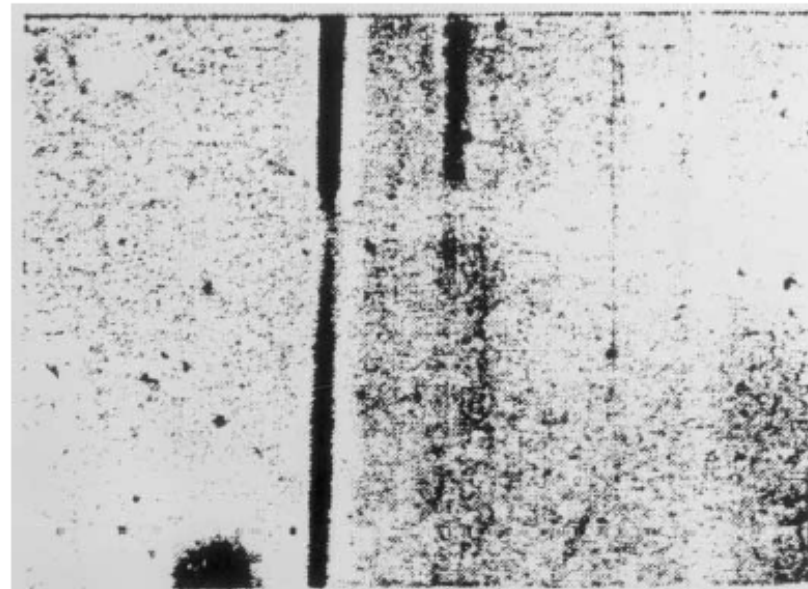


FIG. 4.







· first line spectrum for β decay published by Meitner, Hahn, and von Baeyer



Blattler 2 frisch hergestellt.

Fig. 4.



Dasselbe Blattler 2 20^{te} alt (zeigt bereits einen T3,1-Streifen).

Fig. 2.



Dasselbe Blattler 2; 5 Tage alt (zeigt keine Blauschwarzstreifen mehr, dafür die T3,1- und T3,2-Streifen).

Fig. 5.



T3,2 + B + C + D.

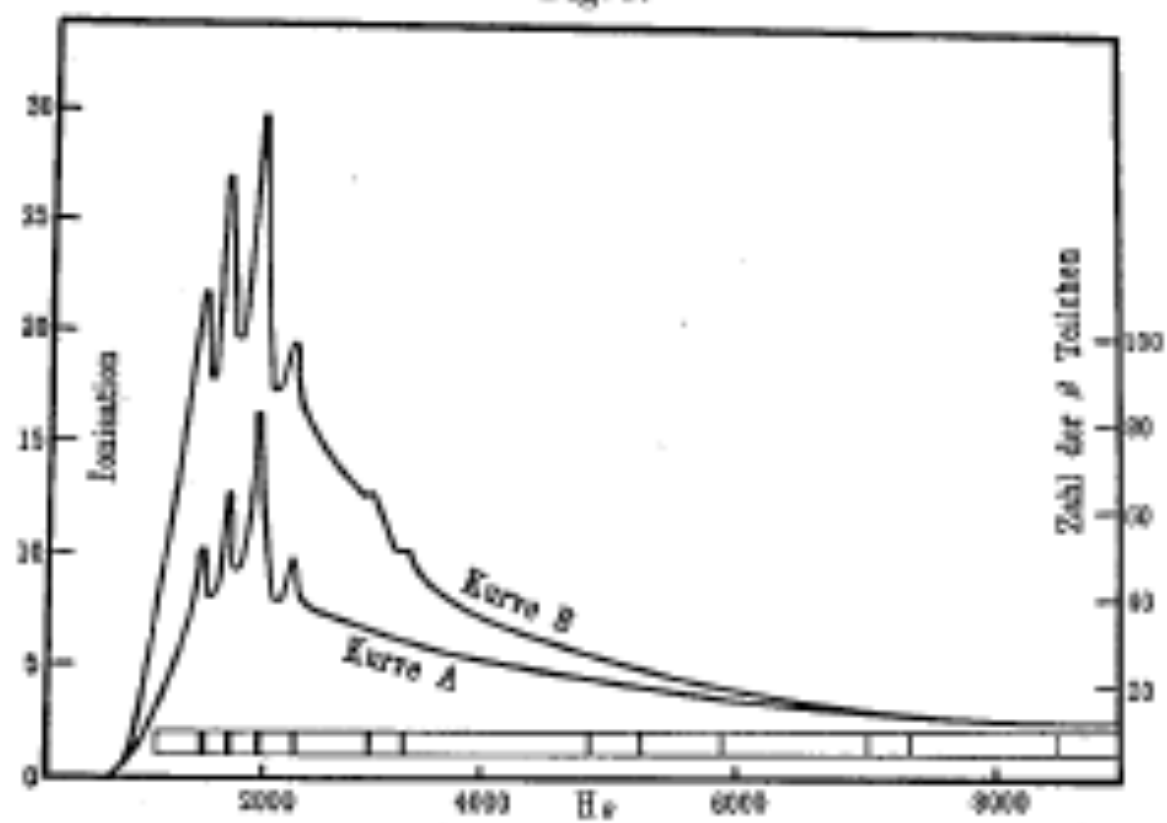
Fig. 4.



T3,2 + C + D.

Fig. 5.

Fig. 3.



“We [Geiger and Chadwick] wanted to count the β -particles in the various spectrum lines of RaB + C and then to do the scattering of the strongest swift groups. I get photographs very quickly easily, but with the counter I can’t even find the ghost of a line. There is probably a silly mistake somewhere.

**J. Chadwick, letter to
Rutherford, 14 June 1914,**

“We are left with the conclusion that the disintegration electron is actually emitted from the nucleus with a varying velocity. We are not able to advance any hypothesis to account for this but we think it important to examine what this fact implies.”

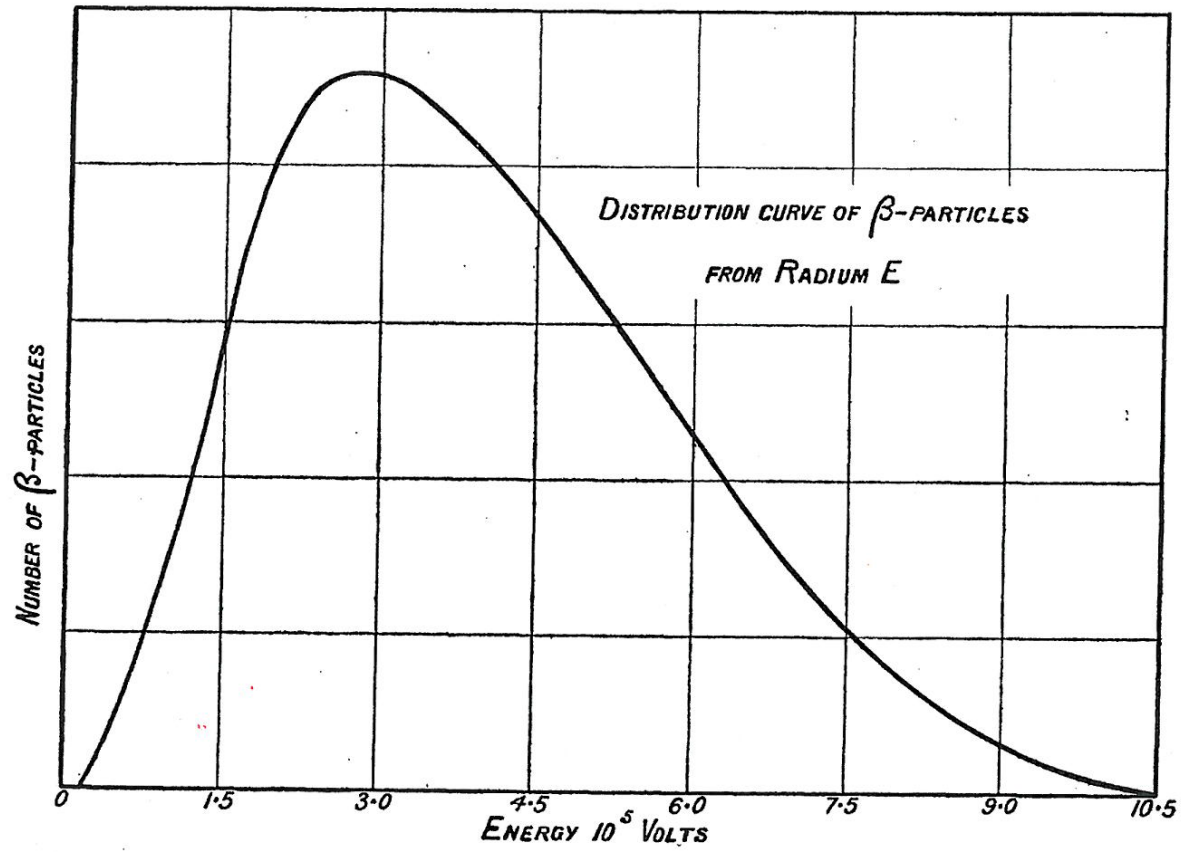
Ellis and Wooster 1925

“The next point is to consider how this inhomogeneity of velocity has been introduced. We assume that energy is conserved exactly in each disintegration, since if we were to consider the energy to be conserved only statistically there would no longer be any difficulty in the continuous spectrum. *But an explanation of this type would only be justified when everything else had failed, and although it may be kept in mind as an ultimate possibility, we think it best to disregard it entirely at present.*”

Ellis and Wooster, 1925

“This is to find the heating effect of the β -rays from radium E. If the energy of every disintegration is the same then the heating effect should be between 0.8 and 1.0×10^6 volts per atom and the problem of the continuous spectrum becomes the problem of finding the missing energy. It is at least equally likely that the heating effect will be nearer 0.3×10^6 volts per atom, that is, will be just the mean kinetic energy of the disintegration electrons .”

Ellis and Wooster 1925



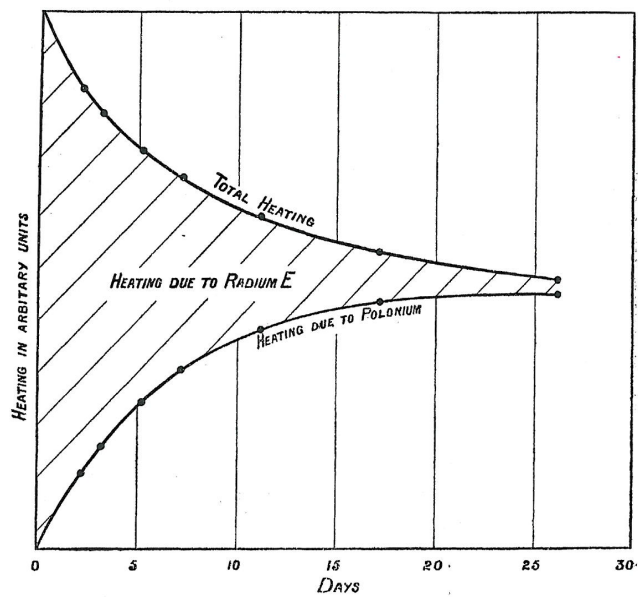


FIG. 3A.

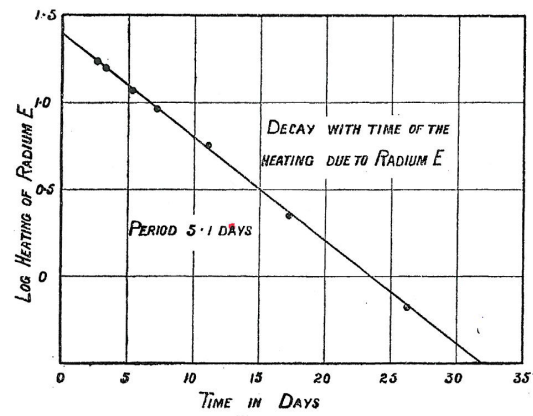


FIG. 3B.

Ratio of the heating effect of Radium E/Heating effect of Polonium at time t is given by

$$\exp(-\lambda_E t) (\lambda_E - \lambda_P) / [X \lambda_P [\exp(-\lambda_P t) - \exp(-\lambda_E t)]]$$

where X is the ratio of the energy of a polonium decay to the average energy of a Radium E decay

Table I.—Heating Effect of Radium E deduced from Curves of fig. 3.

True age.	Total heating.	Portion due to Po.	Portion due to Radium E.	x .	Disintegration energy of Radium E in volts.
days.	mm.				
2·25	22·0	3·68	18·3	15·4	339000
3·20	20·8	4·91	15·9	15·5	337000
5·20	19·0	6·99	12·0	15·5	337000
7·20	17·8	8·64	9·2	15·6	335000
11·20	16·1	10·53	5·6	14·5	360000
17·20	14·2	11·83	2·4	14·7	355000
26·20	12·85	12·18	0·67	15·1	346000

Table II.—Mean Energy of Disintegration of Radium E.

Source.	I	II.	III.	IV.
	Amount of Radium E	Age of source	Ratio of Radium E heating to Po heating	Mean disintegration energy of Radium E.
	at time of first heating measurement.			
	mg.	days.		
1	0.13	11.3	0.50	320000
2	0.17	3.3	3.15	420000
3	0.22	12	0.43	320000
4	1.02	2.25	5.1	344000

“The above considerations clearly indicate that the electrical methods show that the average energy per disintegration is 400,000 volts to within 15 per cent., and this is in good agreement with the average total energy of disintegration found by the heating method of 350,000 volts \pm 40,000 volts.” They added that they believed that this conclusion concerning radium E could be generalized to all β decays and that “the long controversy about the origin of the continuous spectrum of β -rays appears to be settled. We must conclude that in a β -ray disintegration the nucleus can break up with an amount of energy that varies within wide limits.”

Ellis and Wooster, 1927

“We have verified your results completely. It seems to me now that there can be absolutely no doubt that you were completely correct in assuming that beta radiations are primarily inhomogeneous. But I do not understand this result at all.”

Lise Meitner, letter to Ellis (1930)

“At present I have high hopes for solving the radiation problem, and that without light-quanta . . . One must renounce the energy principle in its present form.”

**A. Einstein, letter to Laub, 14
November 1910**

“It is impossible to believe that if the science of the present time had not been saturated with the idea of conservation of energy, these complications would have been avoided by saying that there is no *exact* conservation in such cases.”

C.G. Darwin, 1919, unpublished manuscript,

“As regards the occurrence of transitions, which is the essential feature of the quantum theory, **we abandon** on the other hand any attempt at a causal connexion between the transitions in distant atoms, and *especially a direct application of the principles of conservation of energy and momentum* so characteristic for the classical theories.”

Bohr, Kramers, and Slater 1924

“Some of these questions I should like very briefly to discuss, but we now leave the sure foothold of experiment for the dangerous but fascinating paths traced by the mathematicians among **the quicksands of metaphysics .”**

G.P. Thomson 1928

“At the present stage of atomic theory, however, we may say that we have no argument, either empirical or theoretical, for upholding the energy principle in the case of β -decay disintegrations, and are even led to complications and difficulties in trying to do so. Of course, a radical departure from this principle would imply strange consequences if such a process could be reversed.”

Bohr 1932

**Dear Radioactive ladies and gentleman,
I have come upon a desperate way out
regarding the wrong statistics of the β - and Li-6
nuclei, as well as to the continuous β -
spectrum, in order to save the “alternation
law” of statistics and the energy law. To wit,
the possibility that there could exist in the
nucleus electrically neutral particles, which I
shall call neutrons, which have spin $\frac{1}{2}$ and
satisfy the exclusion principle and which are
further distinct from light-quanta in that they
do not move with light velocity.**

Pauli, 1931