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PROPOSAL FOR A STUDY OF HIGH-ENERGY NUCLEAR FISSION
IN THE SLOW EJECTED PROTON BEAM AT THE PS

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I. INTRODUCTION

In a recent survey given by G. Friedlander at the Symposium in Salzburg, 1965 [1], and in some earlier reviews [2], [3] the phenomenology of high-energy fission-like processes and the physical aspects of the results obtained were discussed. The most important problems concerning the fission-like break-up of nuclei can be summarized as follows:

1. The fissility $f = \sigma_f / \sigma_{inel}$ for heavy and medium nuclei and its dependence on the primary energy.
2. Charge and mass-distribution for fission-like products.
3. Neutron-rich and neutron-deficient products obtained in high-energy collisions (>100 MeV). The dependence on the deposition energy. Thermal-like and fragmentation-like fission.
4. Kinetic-energy spectra and angular distributions of fission fragments.
5. Comparison studies of fission of heavy and medium nuclei.
6. Detailed information on high-energy fission needed for tests of theoretical models.

A great deal of radiochemical work on this subject has been done. The experiments with nuclear emulsions of low sensitivity and, recently, with mica detectors efficiently enriched the accumulated results. Coincidence measurements with energy-sensitive detectors, dE/dx discriminating counters and time-of-flight measurements are needed to sort out the complex processes indicated by the data available at present [1].

In the last few years the important technique of semiconductor detectors has been developed rapidly and is now being used in the majority of fission studies at low energy. The small dimension of semiconductor counters and the precision of energy determination allow exact measurements of angular and energy distributions. The measurements of both fission fragments in coincidence give more complete information and can be performed in slow ejected beams. The time-of-flight technique is also feasible in these experiments giving additional information on fragment velocity, useful for a more complete description of the process.

The interest in the study of nuclear fragments at CERN using the semiconductor-counter technique in the slow ejected proton beam of the PS has been already expressed in our letter of intention of January, 1965 [4].

We should like to study fission of several elements starting with coincidence measurements of angles and energies, applying also the time-of-flight technique. This experiment could be performed in parallel with the experiment concerning $3 < Z < 10$ fragments proposed by the Orsay group [5].

The first technical test concerning the application of semiconductor counters in the conditions of the e_2 beam was done in June of this year. The results are the following:

The test was performed parasitically in the e_2 beam. It showed that semiconductor detectors may be used in coincidence measurements of the energy distribution of the fission fragments in the conditions of the e_2 beam. The background may be reduced appreciably by a shortening of the resolving time of the coincidence unit (from 2 μ sec to 100 nsec), changing of the sensitive layer of the detectors from 50 μ m to 20 μ m and by improvement of the geometrical conditions. Some changes of the properties of the semiconductor counters have been noticed during the run. Most probably it is a result of a destructive influence of the recoiling nuclei and other fragments coming from the walls of the chamber. It should be possible to reduce it by screening of the counters and improvement of the geometry of the chamber.

2. THE AIM OF THE PROPOSED TEST IN SEPTEMBER

Apart from the continuation of the technical study of the operation of counters in high-energy-beam conditions, we should like to do some measurements of the angular and energy distributions of fission fragments from uranium nuclei using two counters in coincidence.

The detection system will consist of two semiconductor detectors D1 and D2 at equal angles $\theta_1 = \theta_2$ with respect to the beam direction (Fig. 1).

We have in mind the following measurements which, in principle, can be performed parasitically during the run in September:

- i) The energy distribution of fission fragments at several values of the angle θ .
- ii) The distribution of the angle θ .

- iii) The distribution of the angle between two fission fragments in the plane perpendicular to the beam ($\theta = 90^\circ$).
- iv) Two-parameter energy distribution of both fission fragments emitted at the angle $\theta = 90^\circ$.

We expect to accomplish only a part of these measurements in the time available.

3. MANPOWER, REQUEST FOR THE BEAM, EQUIPMENT REQUIRED

Three persons from Warsaw will come to CERN to take part in the study. The help of Mr W. Bell of CERN would be of great value for one week's time.

The e_2 beam would be used parasitically during the run in September. The thickness of the target is $200 \mu\text{g}/\text{cm}^2$ of uranium and $200 \mu\text{g}/\text{cm}^2$ of supporting aluminium foil.

The thickness of aluminium windows which will be put into the beam is equal to about $40 \text{mg}/\text{cm}^2$ (Fig. 2).

The following equipment will be provided by Heidelberg and Warsaw:

- i) vacuum chamber
- ii) semiconductor detectors
- iii) basic electronic equipment for semiconductor counters, e.g. charge preamplifiers.

The equipment required from CERN is given in Appendix 1.

For Heidelberg: R. Brandt

For Warsaw : P. Zielinski

4. REFERENCES

- 1 G. Friedlander, Proc. Salzburg Conf., II, p. 265
- 2 E.K. Hyde, The Nuclear Properties of the Heavy Elements III, Fission Phenomena, Prentice Hall Inc., Englewood Cliffs, N.J. (1964)
- 3 N.A. Perfilov, O.V. Lozhkin, V.I. Ostroumov, Nuclear Reactions Induced by High-Energy Particles, Moscow (1962) English transl.: Unpublished Report UCRL-Trans. 949 (1964)
- 4 Study of High-Energy Proton-Induced Reactions in Complex Nuclei with Semiconductor Detectors, letter of intention by CERN-Heidelberg- Warsaw Collaboration, CERN-NCS-65/2 (7 January 1965).
- 5 M. Lefort, X. Tarrago, H. Dubort, B. Gatty, Proposition d'expérience sur la fragmentation au PS du CERN (Faisceau éjecté 28 GeV), Orsay, (1965).

APPENDIX 1

5. EQUIPMENT NEEDED FROM CERN

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|-----|---------------------------|---------------------------|
| 1) | One multichannel analyser | SCIPP-1600 ^(x) |
| 2) | Four delayed triggers | (SEN 122) |
| 3) | Four pulse amplifiers | (Type 3-41-04 A) |
| 4) | Four inverter amplifiers | (Type 41-10 A) |
| 5) | Three power supplies | (Type 10-10 C ser. 149) |
| 6) | Two gate-pulse generators | (Type 3-2207 A ser. 9) |
| 7) | One pulse generator | |
| 8) | One scope "Tektronix") | |
| 9) | One vacuum pump | |
| 10) | One vacuum gauge | |
| 11) | 300 metres of cable (75Ω) | |

(x) The analyser is needed for full-time only during the run (two weeks from 15 September to 30 September). It would be useful to use it for several short tests of the electronics before the run (5 to 6 hours each time).

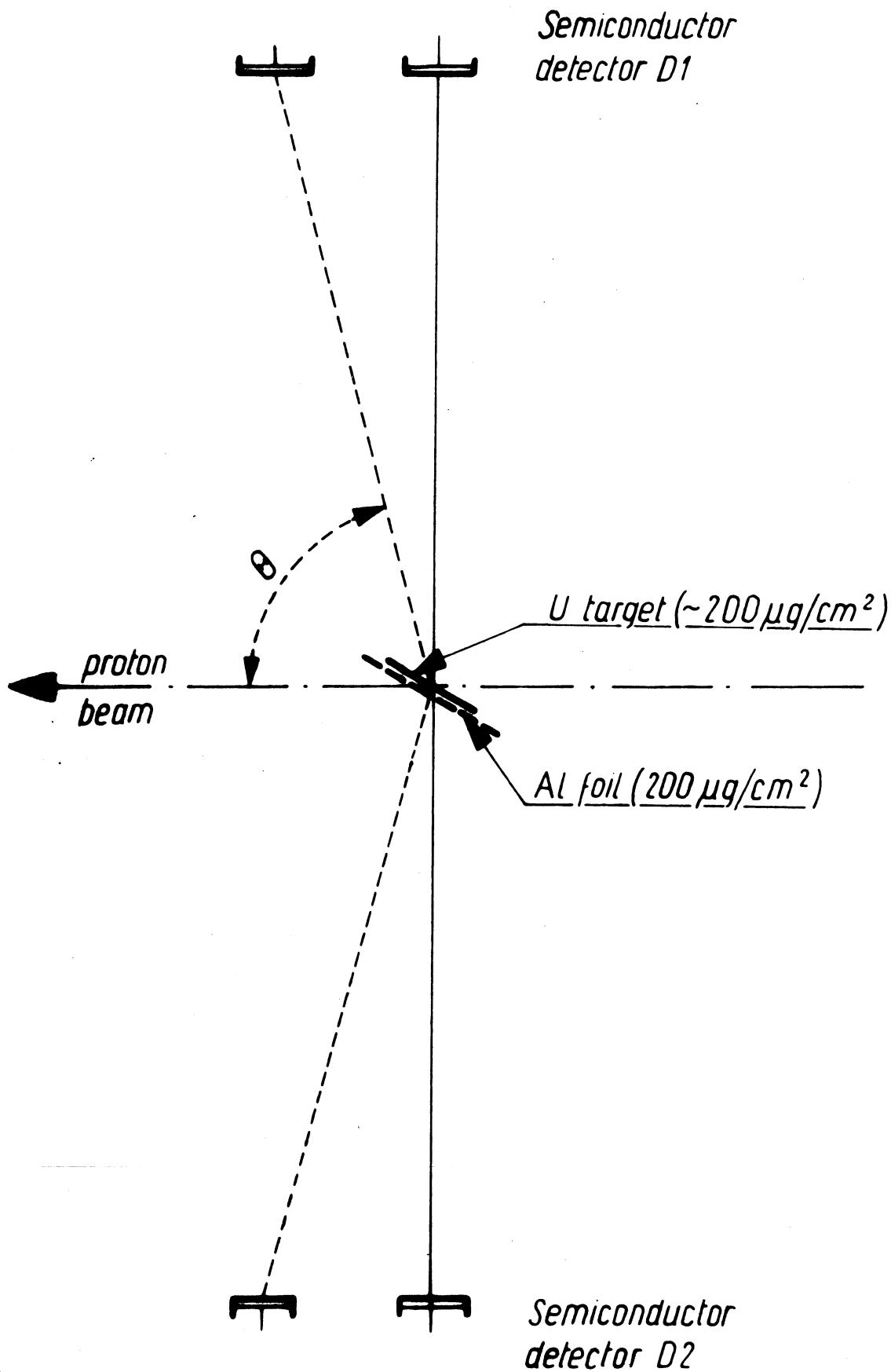
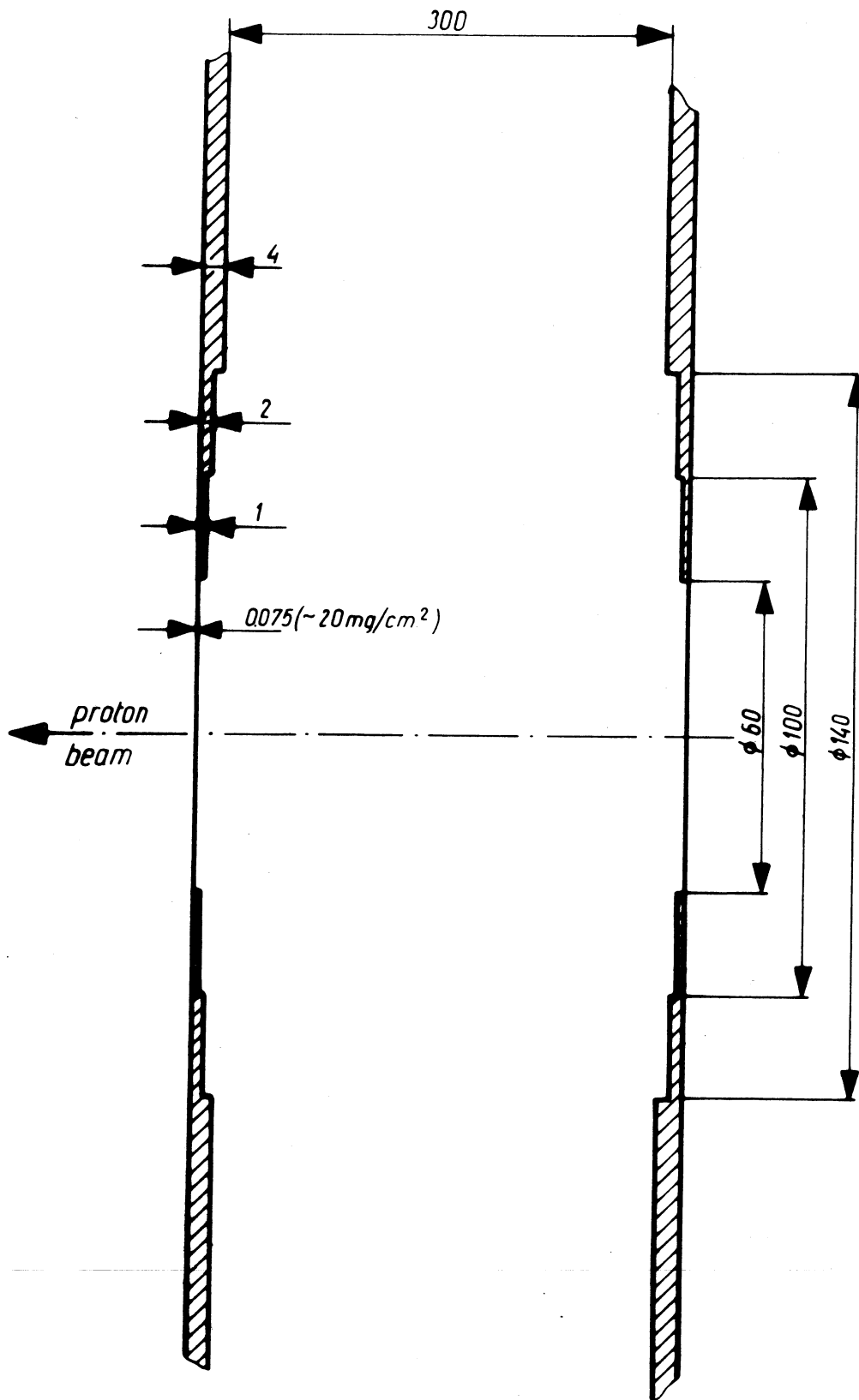


FIG. 1



The walls of the vacuum chamber

FIG. 2