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TIMING IN FISSION FRAGMENT DETECTION AT HIGH ALPHA-BACKGROUND

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Объединенный ин[illegible]тут
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БИБЛИОТЕКА

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Детектирование осколков деления при высоком фоне альфа-частиц

Описывается плоскопараллельная ионизационная камера для исследования деления ядер на пучке μ^--мезонов. Рассмотрена необходимая электроника, в частности, малошумящий предусилитель. Приводятся результаты экспериментальных измерений временного распределения деления, индуцированного μ^--мезонами в ^{237}Np и ^{239}Pu.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

Препринт Объединенного института ядерных исследований
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Timing in Fission Fragment Detection at High Alpha-Background

The ionisation multi-plate fission chamber working together with the fast, low-noise level preamplifier, is described. Fission fragments were registered with the efficiency of about 50% at the background of $10^8 \alpha sec^{-1}$ The timing characteristics are illustrated by the time distributions of fission events measured at the μ^--beam of 680 MeV synchrocyclotron, JINR, Dubna.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

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Dubna 1975

1. Introduction

The investigation of fission phenomena in the transuranium elements requires often good timing characteristics along with sufficiently high efficiency of the fission fragment detection in the high alpha-background conditions.

Recent progress in the current preamplifier design makes it possible to use simple multi-plate ionization chambers having timing characteristics comparable with those of gaseous scintillation chambers and being superior in other aspects, such like the possibility to operate simultaneously with many different targets (isotopes), remarkable simplicity and compactness.

The fast multi-plate methane filled ionization chambers were used in the programme of investigation of fission induced by μ^--developed in the last years at the Laboratory of Nuclear Problems, JINR, Dubna.

In the present paper this type of chamber is shortly described together with the electronics used with it.

A special attention is paid to the preamplifier. The performance of the whole system is illustrated by the typical results obtained in measurements with the μ^-beam.

2. Description of the Ionization Chamber

In a cylindric chamber (150 *mm* long and 90 *mm* in diameter) the isolated aluminium plates each 0.05 *mm* thick and 60 *mm* in diameter, are supported by three grounded steel rods between two steel rings. The teflon rings maintain a gap of 2 *mm* between the plates. Every second plate is connected to a common output providing a positive voltage to them.

The signal plates can be connected in various combinations. Typically 4, 8 and 16 paralleled signal plates were used giving 250, 450 and 800 *pF*, at the preamplifier input respectively.

The assembled chamber is filled with methane of 98% purity at a pressure $p = 2$ *atm* (absolute).

With 450 *V* of voltage supply it gives an optimum value for E/p ratio (E being the electric field) important for timing characteristics. At the same time using the 2 *mm* gap between the plates we have a minimum ratio between the amplitudes of signals due to alpha-particles and fragments [1]).

3. *The Preamplifier*

In order to detect effectively the fission fragments in the conditions of the high alpha-activity background, the preamplifier should fulfill two conditions: to provide a signal as short as possible and to have a sufficiently low noise level.

To obtain a short pulse using the current amplifier with the feedback loop in the input stage we are forced to employ a feedback resistor having a resistance smaller than 10 $k\Omega$. But it deteriorates the noise characteristic considerable.

Another design of the current preamplifier is proposed in refs.[2,3]. The preamplifier described in ref. [3] has been adopted for working with the fission chamber and is shown in *fig. 1*.

The charge sensitive section provides the pulses with the rise time of 2 *nsec*. They are converted to the current pulses by differentiation and fed then to the current amplifier with the low input impedance through the capacity defining the bandwidth of the amplifier.

In such a way the pulses are shortened to 8 *nsec*. In this design the possibility to obtain fast current pulse is aligned with the low noise characteristics of the preamplifier.

After the preamplifier the fast linear amplifier with the rise time of 3.5 *nsec* was employed [3].

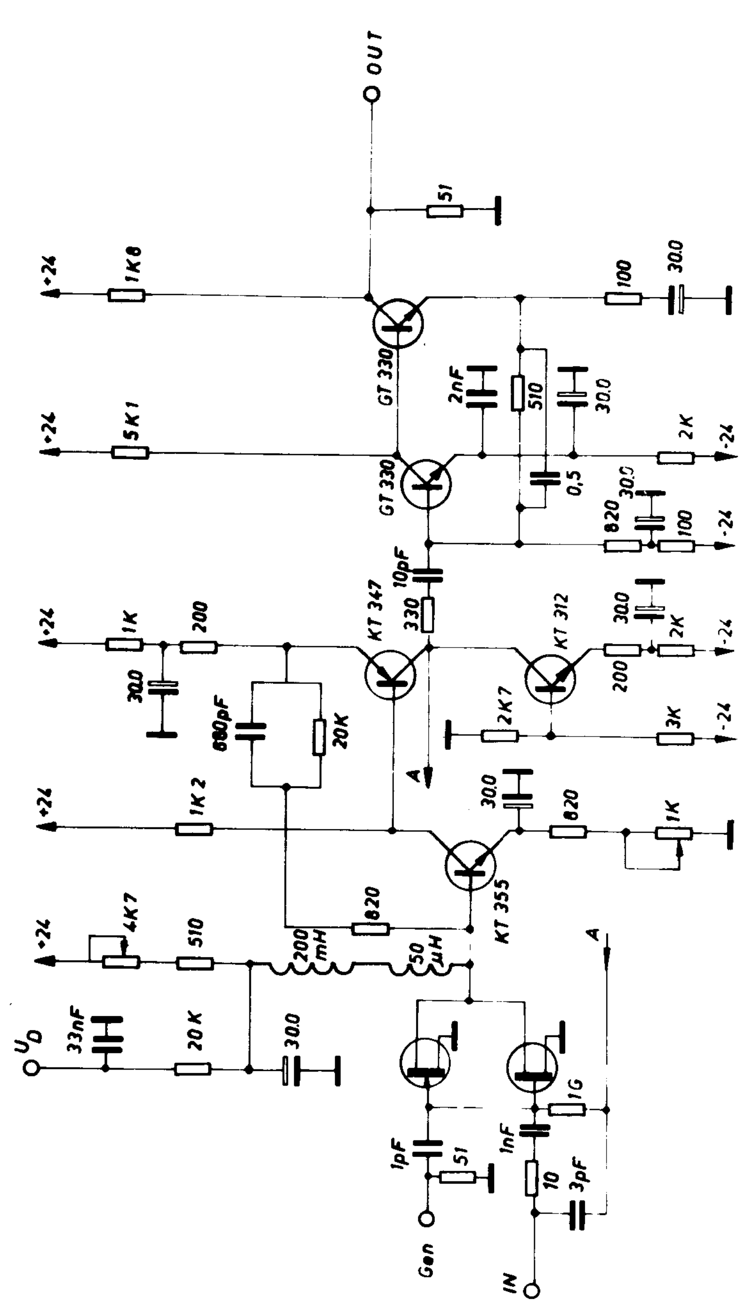

Fig. 1. Circuit diagram of the preamplifier.

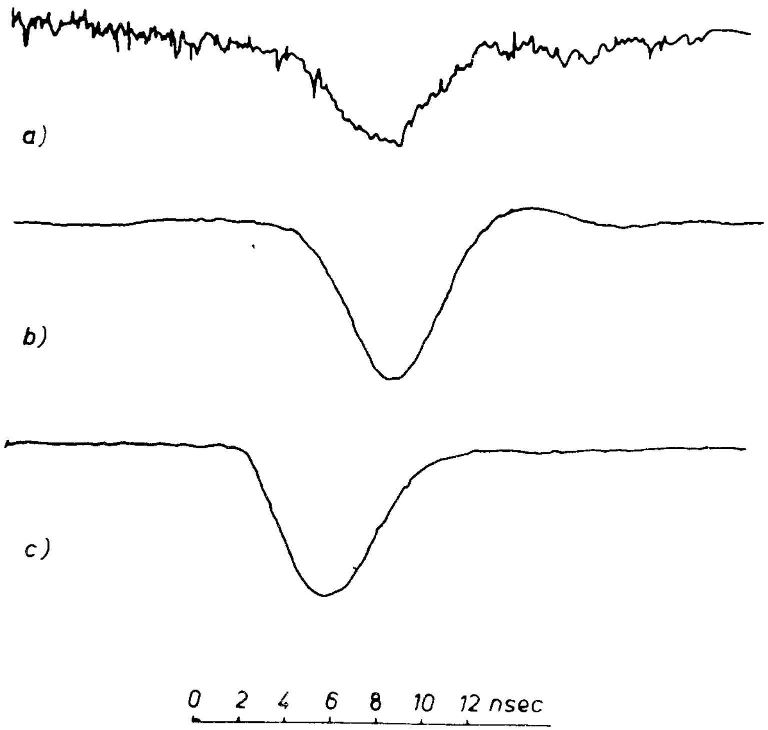

Fig. 2. Oscillograms of the following signals a) alpha-particle pulse corresponding to the energy loss of 200 keV from the fast amplifier output, b) a generator pulse from the fast amplifier output, c) a generator pulse from the preamplifier output.

The alpha-particles and generator pulses at the outputs of the preamplifier and the amplifier are shown in *fig. 2*. The timing signal was provided by the constant fraction unit operating together with the duration time discriminator, as described in ref. /3/.

4. Results

The integral characteristics of the chamber working in conjunction with the described electronic circuit are shown in *fig. 3*.

There is an evident difference in the performance of the system for moderate and high alpha-activity background. It should be pointed out that the used duration discriminator could not operate effectively at a very high counting rate. Therefore, it should be possible to improve considerably the operation of the system by using a non-overloading duration discriminator.

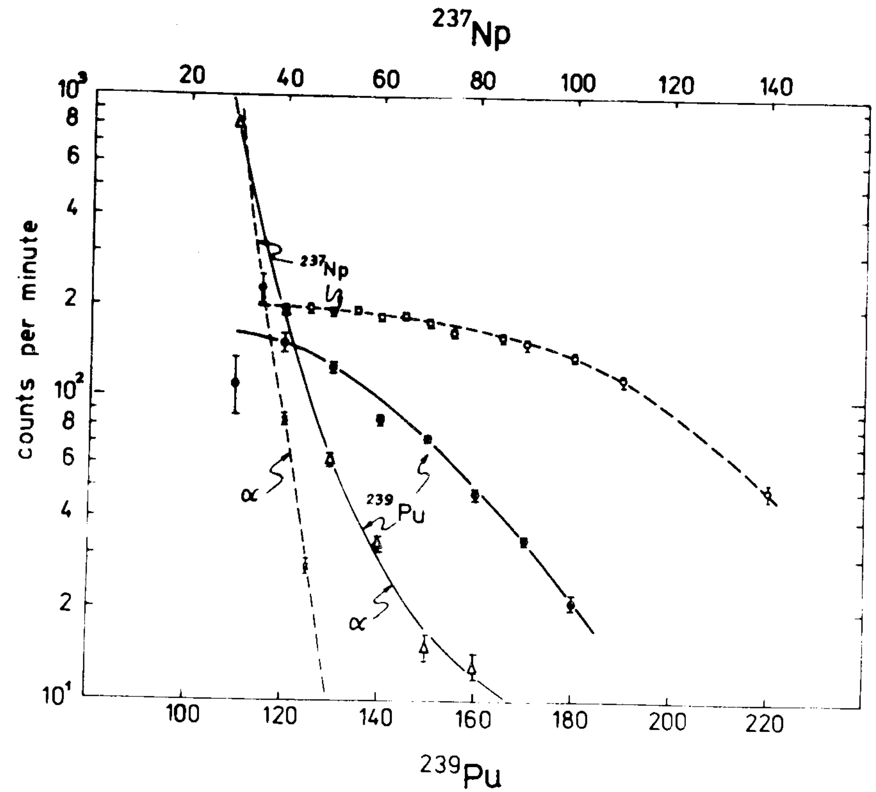

Fig. 3. The integral characteristics of the chamber as measured with the fission events induced by fast neutrons (^{237}Np) and thermalized neutrons (^{239}Pu) from a Po–Be source. Scale of abscissa (discriminator level) is different for both isotopes. The chamber contained about 111 mg of ^{237}Np and 125 mg of ^{239}Pu. The total flux of the neutrons from the Po–Be source was about $5x10^6$ nsec $^{-1}$.

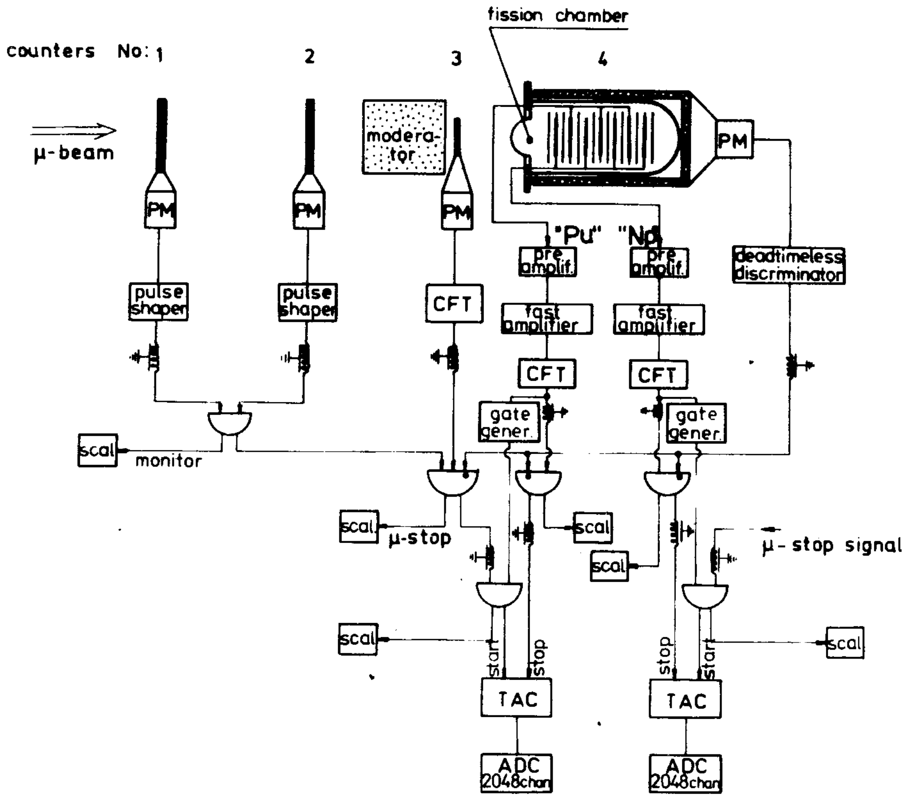

Fig. 4. A block-diagram of the experimental set-up used in measurements with the μ^- beam.

The control measurement in the conventional set-up of the prompt gamma-fission coincidences in the case of ^{235}U thermal neutron fission has given the width of the time distribution: FWHM = (2.2. ± 0.3) *nsec*. In this measurement the plastic scintillator 40 *mm* in diameter x 40 *mm* high was used to detect gamma-rays. Replacing the fission chamber by the second identical gamma-detector we obtained the time resolution of about 0.7 *nsec* for gamma-gamma coincidences from ^{60}Co in the dynamic range of 20 : 1.

The performance of the chamber and the described electronics was tested in the μ^- beam of the Dubna

670 *MeV* synchrocyclotron in the measurements of the time distributions of fission events induced by μ^- in ^{237}Np and ^{239}Pu .

The time distributions were measured respectively to μ -stop events detected by the counter telescope of four plastic scintillators operating in the usual $123\bar{4}$ coincidence mode (see *fig. 4*). The targets were 48 *mm* in

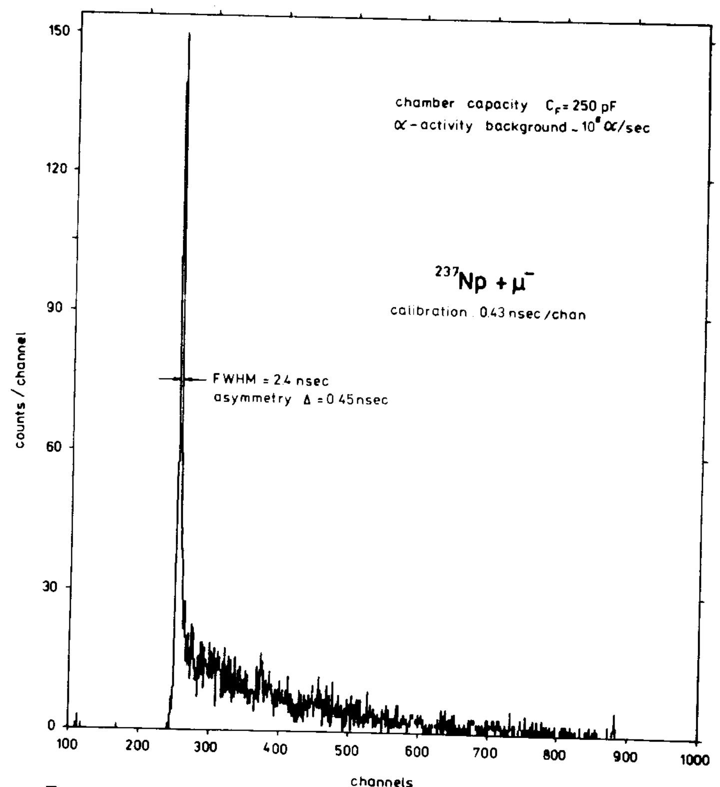

Fig. 5. Time distribution of fission events in ^{237}Np induced by μ^- . Two components of the spectrum, prompt and exponentially decaying one are connected with various physical processes: the radiationless transition fission (prompt) and delayed fission following the nuclear μ^- capture.

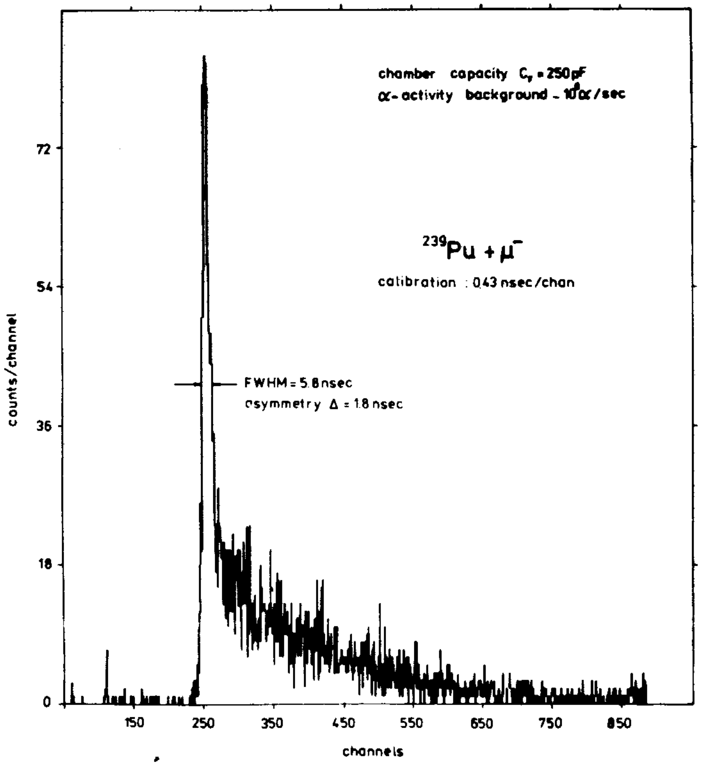

Fig. 6. Time distribution of the fission events in ^{239}Pu *induced by* μ^- *(see fig. 5).*

diameter and the dispersion of the beam was about 50 x 70 *mm*. The measured typical spectra are shown in *figs. 5* and *6*. The deterioration of the time resolution for the very high alpha-background is clearly visible. But even for such high alpha-activity it is possible to make the timing sufficiently good for many problems encountered in the fission investigations.

The timing results presented in ref. /4/ for low alpha-activity are about two times better but they can hardly be compared with ours as the capacity at the preamplifier input was three times lower and, what is even more

important, the measurements were made in ideal conditions with a small source of ^{252}Cf. Unfortunately, the results obtained in the beam for real dimensions of the target are not presented there.

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