PROCEEDINGS
2nd ISPRA
NUCLEAR ELECTRONICS
SYMPOSIUM

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Foreword

This Ispra Nuclear Electronics Symposium succeeded in attracting for the second time many high level scientists whose work is contributing to a remarkable advance in the techniques of nuclear electronics and related fields. What exactly constitutes these "related fields" is still rather hazy but some idea can be gained by reading the report on the two round tables, annexed to the symposium, which will be published in report EUR 5371.e.

The organization of this second symposium was undertaken, as before, by the Euratom Joint Research Center of Ispra with the sponsorship of American and Italian institutions (see list in the opposite page). The technical program committee met at Ispra on February 25-26, 1975 and made the selection of the papers based on 50-word summaries. We probably accepted a few conventional or unoriginal papers and, on the other hand, we must have rejected some papers that deserved a better chance. I would like to apologize for this and to explain that this entire task was done in two days and therefore lack of time did not allow more thorough perusal. But I am convinced that in general the technical program committee did an excellent job! This book therefore has a sound scientific content.

It is a pleasure for me to thank the program committee most sincerely for the appreciation they gave to this symposium and for the suggestion to hold it every four years. I wish to thank above all the authors, who came here with their high quality contributions and the attendees who stimulated the discussions. I was particularly touched by the spontaneous words of congratulation and proofs of solidarity given by many delegates.

L. Stanchi

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Foreword

Many valuable scientists met twice around a table on the occasion of the 2nd Ispra Nuclear Electronics Symposium. All the participants to the symposium were given the opportunity to intervene.

The aim of these two panel discussions was to stimulate these first-class brains to see into the future of nuclear electronics and electronics for physical science in general, both in the sense of entering new interesting fields – contributing to their advancement as happened with nuclear physics – and in the sense of employing new technologies and new philosophies in the architecture of experiments.

The two round tables were introduced by some papers which gave some food for thought. Therefater people sitting around the table or those in the audience gave their contributions. I have purposely not reported the complete interventions because this would be tremendously tedious and not always very clear. I have tried to summarize and synthetize both tables, each one with a co-author the better to catch, by means of critical discussion, the content and the feeling behind each intervention. Inevitably there are some personal comments or thoughts in our papers and we may have distorted some concepts. But our aim was to include all the interesting topics we heard. So we should more properly write as "authors' names" the names of all the participants to be found in the Proceedings of the Symposium.

L. Stanchi

PAPERS PRESENTED AT THE
SECOND ISPRA NUCLEAR ELECTRONICS SYMPOSIUM

SESSION 1 : SIGNAL PROCESSING I

Chairman : G. Pietri

SESSION 2 : SIGNAL PROCESSING 2

Chairman : E. Gatti

SESSION 3 : ENVIRONMENTAL AND BIOMEDICAL ELECTRONICS

Chairman : G.L. Miller

SESSION 4 : ROUND TABLE

Microprocessors and Minicomputer Balance for Nuclear, Biomedical and Environmental Measurements

Chairman : R.L. Heath

Papers and discussion are collected in report EUR 5371.e

SESSION 5 : DIGITAL PROCESSING

Chairman : K. Zander

SESSION 6 : CAMAC

Chairman : F. Iselin

SESSION 7 : FAST ELECTRONICS AND TIMING

Chairman : V. Radeka

SESSION 8 : ROUND TABLE

Extension of Nuclear Techniques to Other Fields

Chairman : K. Kandiah

Papers and discussion are collected in report EUR 5371.e

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ROUND TABLE DISCUSSION ON MICROPROCESSORS AND MINICOMPUTER BALANCE FOR NUCLEAR, BIOMEDICAL AND ENVIRONMENTAL MEASUREMENTS

Chairman : R.L. Heath

ROUND TABLE DISCUSSION ON EXTENSION OF NUCLEAR TECHNIQUES TO OTHER FIELDS

Chairman : K. Kandiah

PARTICLE IDENTIFICATION BY PROCESSING OF SIGNALS FROM MULTIPLE DETECTORS

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Some interesting instrumentation problems concerning particle recognition have arisen in connection with the development of new detectors especially transition radiation detectors.
The use of likelihood estimation has been suggested by Ellsworth et al. [1]. The majority logic technique has been proposed by Atac and Wang[2]. Analog computation of the geometric mean of the signal amplitudes from several detectors has been used by Uto et al.[3].
This paper attaks the problem quite generally in order to compare different methods and to provide suggestions for more convenient instrumentation for different cases. Treatment is not confined to transition radiation problems but can be applied to identification problems for which not only the amplitude of a radiation detector pulse but also its pulse shape is observed.
Some of the ideas discussed in this paper have been published recently[4].
Let us suppose that a set of radiation detectors gives an output described by a vector $\bar{v}$ when a particle is detected. The vector $\bar{v}$ might have scalar components v_k, where v_k is the pulse amplitude of the kth detector, or it can be more generally formed by several vectors $\bar{v}_k$ each representing a waveform at the output of the kth detector.
Our aim is to find the best operator $\bar{A}$ for processing the output $\bar{v}$ in order to obtain a discrimination parameter S suitable for estimating according its amplitude which of two different kinds of particles F and G might have produced the signal $\bar{v}$.
Let us process $\bar{v}$ linearly so that S will be given by

$$S = \bar{A} \cdot \bar{v} \tag{1}$$

as shown in fig. 1 a.
The average signal S given by particle F will be

$$\langle S_F \rangle = \int (\bar{A} \cdot \bar{v})\, D(\bar{v}|F)\, d\bar{v} \tag{2}$$

where $D(v|F)$ is the conditional probability density of an output $\bar{v}$ when the set of counters detects a particle F. The integral spans over the whole space in which $\bar{v}$ is defined. For $D(\bar{v}|F)$ holds:

$$\int D(\bar{v}|F)\, d\bar{v} = 1. \tag{3}$$

Similarly

$$\langle S_G \rangle = \int (\bar{A} \cdot \bar{v})\, D(v|G)\, d\bar{v} \tag{4}$$

beeing $D(v|G)$ the normalized conditional probability density referred to particle G.

+ On leave from Politecnico of Milano and CISE Milano.

We look for an operator $\bar{A}$ which produces the largest separation of the average discrimination signals S_F and S_G with respect to the sum of variances of the signals $S - S_F$ and $S - S_G$ due respectively to F and G only. $\bar{A}$ should therefore maximize the following expression:

$$R_S^2 = \frac{\left[\langle S_F \rangle - \langle S_G \rangle \right]^2}{\int \left[(\bar{A} \cdot \bar{v}) - \langle S_F \rangle \right]^2 D(\bar{v}|F)\, d\bar{v} + \int \left[(\bar{A} \cdot \bar{v}) - \langle S_G \rangle \right]^2 D(\bar{v}|G)\, d\bar{v}} \tag{5}$$

By standard variational analysis it is easily shown that R_S^2 is maximized by A chosen so that

$$S = \bar{A} \cdot \bar{v} = \frac{D(\bar{v}|F) - D(\bar{v}|G)}{D(\bar{v}|F) + D(\bar{v}|G)} \tag{6}$$

this expression does not give an explicit value for A but the result of its operation on $\bar{v}$ (fig. 1 b).
By the choice of $\bar{A}$ suggested by (6), the figure of merit R_S^2 given by (5) becomes:

$$R_S^2 = \frac{2 \int \frac{\left[D(\bar{v}|F) - D(\bar{v}|G) \right]^2}{D(\bar{v}|F) + D(\bar{v}|G)}\, d\bar{v}}{2 \int \frac{\left[D(\bar{v}|F) - D(\bar{v}|G) \right]^2}{D(\bar{v}|F) + D(\bar{v}|G)}\, d\bar{v}} \tag{7}$$

The instrument should code the output $\bar{v}$ of the detectors in order to produce a signal S given by (6).
Recalling the Bayes relationships:

$$\begin{aligned} D(\bar{v}|F)\, d\bar{v}\, P(F) &= P(F|\bar{v})\, D(\bar{v})\, d\bar{v} \\ D(\bar{v}|G)\, d\bar{v}\, P(G) &= P(G|\bar{v})\, D(\bar{v})\, d\bar{v} \end{aligned} \tag{8}$$

(where P(F) and P(G) are the a priori probabilities for a particle to be respectively F or G, $P(F|\bar{v})$ and $P(G|\bar{v})$ are the conditional probabilities for a particle to be respectively F or G, when $\bar{v}$ is produced by the detectors and $D(\bar{v})$ is the probability density for an output $\bar{v}$) remembering also the fact that a particle must be either F or G, so that

$$P(F)+P(G) = 1 \qquad P(F|\bar{v})+P(G|\bar{v}) = 1, \tag{9}$$

we can write S, as given by (6), as:

$$S = \frac{P(F|\bar{v}) - P(F)}{P(F|\bar{v})\,(1-2P(F)) + P(F)} \tag{10}$$

and solving for $P(F|\bar{v})$:

$$P(F|\bar{v}) = P(F)\, \frac{1+S}{1-S(1-2P(F))}. \tag{11}$$