

# ANALYSIS, CHOICE AND DESIGN OF MONITORS FOR BEAM DIAGNOSTICS

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## Abstract.

This paper treats the problem of use of artificial intelligence methods, in particular expert systems, for beam diagnostics because beam diagnostics is a complex process of obtaining, transforming and representing various information about different beam parameters with using theoretical, technical and program tools. Such expert systems help to solve the problems of analysis, choice and design of beam monitors for accelerator's control system according to their purposes, technical demands, working conditions and choice criteria. In this paper there are basic results and the structural scheme of such integrated expert system.

## Introduction.

Beam diagnostics is a complex process of obtaining, transforming and representing various information about beam parameters with using theoretical, technical and program tools. A successful decision of these problems is necessary for effective management of accelerators; not only during the exploitation process, but also during arrangement and tuning; for development of control systems, for increase of exploitation reliability, improvement of metrologic characteristics etc.

## Theory.

It is necessary to note the significance of theoretical tools. They are following:

I. A definition of beam parameters and their common interpretation.

II. A classification of monitors according to different classification signs.

III. A definition and standardization of metrologic, exploitation-reliability and constructive-technological characteristics of beam monitors, change ranges of beam parameters, technical demands, work conditions and choice criteria.

Analysis of modern trends in the development and the realization of monitors for beam diagnostics has revealed some problems. It is necessary to use the methods and ideology of artificial intelligence for arriving at decisions for these problems. For instance, strong integration in the field of development, projection and exploitation of control systems for accelerators displayed evident contradiction with numerous existing commercial and industrial systems. These systems having been created by different organizations and scientific centers are incompatible with each other. The clients

who wish to use and apply concrete expert systems may encounter some difficulties which are just part of the initial problem. Due to a large amount of heterogeneous developments, diversity of characteristics, parameters and demands and as well as a lack of competent independent experts, bring together significant elements of undefined risk, when investment of essential financial means can lead to great economic waste and unpredictable consequences.

The next problem is associated with an exponential growth of information in specialized, technical magazines, books, reports etc. This abundance of information makes it difficult for developers, managers and scientific workers who are specializing in this field, to follow.

## Analysis.

Taking into account all these elements, it is obvious that there is necessity to create an integrated expert system (ES) for analysis and for choosing monitors to analyze charged particles beam according to their purpose; technical demands and abilities; working conditions and the choosing of the setting criteria during projection process of accelerator's control systems.

It is known, that the development of ES is not always well founded, in this case, the principal factors which aided in the development of expert systems are as follows:

1) Problems are extremely specialized. They serve definite purposes and require large amounts of criteria in choice of solutions.

2) Problems require a great deal of experience in field of diagnostics of charged particles beams.

3) Formalization of facts and heuristics of the knowledge field.

The development of such ES is well founded economically because similar systems can satisfy demands on experts and consultant services and save human experience. Lastly, the characteristics of problems under consideration does not allow them to be solved with methods of traditional programming, i.e. the application of non-algorithmic heuristics is essential because it is necessary to manipulate numerical data, as well as symbolic information. There is a great problem complexity, and multitude of problem variants and problem connections.

## Integrated ES.

This report considers a project of integrated ES which examines the use of expert knowledge, as well as, algorithms, procedures and models resulting from previous

investigations regarding the nature of problems, data base monitors and principal elements of measuring schemes [1].

The basic stages of choosing monitors and the parameters definition realized in current ES are:

1) Evaluation of limited abilities of monitors according to their time characteristics and sensibility;

2) Choice of monitors, which satisfy given technical demands and working conditions;

3) Choice of monitors according to their level of influence on beam particles, taking into account required metrologic, exploitation, reliability characteristics and given constraints;

4) Comparison of selected types of monitors according to the information they examine and choice of monitor type with constructive and technological characteristics;

5) Calculation and definition of parameters of selected monitor type with the possibility of technical realization of measuring scheme of charged particles beam parameters.

Integrated ES consist of ES, knowledge base about type and parameters of beam monitors and packet of calculation programs of beam monitor parameters. Integrated system GURU is selected as most convenient and powerful tool of ES design automatization. It unites: ES design means, relational data base, spreadsheets, text editors, business graphics, communications means with other computers.

Integrated ES realization is carried out with IBM-compatible computer of IBM PC/AT type. Knowledge base volume of current integrated ES version is formed by about 200 rules. Integrated ES provides intelligent support of all stages of analysis, choice and design of monitors for beam diagnostics .

At present, integrated expert system's knowledge base holds information about different types of beam parameter monitors (BPM) such as electromagnetic, electrostatic (pick-up electrodes), magnetic monitors, current transformers, Faraday's cups, secondary emission monitors and so on and their main parameters. This information includes basic descriptions and main parameters of known and described BPMs, such as sensitivity, bandwidth, resolution, precision, dimensions, mass and so on. In order to obtain this data as much as 400 papers, reports, lectures describing results of investigations of different BPMs were processed. This knowledge base is being continually appended and extending while receiving new information (conference's proceedings, publications in different journals and so on). Also packet of calculation programs is extending. The possibilities of integrated expert system is continually broadening and this system is used in designing control and measuring systems not only when choosing BPM and calculating its parameters but also to choose the structure and the modules of the systems (analog-to-digital converters, different amplifiers, integrators, the means of processing, registration and displaying the information about beam parameters), concerning their

conditions of work, technical requirements, choice and computation criteria. As an example of rule in the expert system the following one can be presented:

RULE : R1

```
IF : 0.1 <= sm <= 10 &  
    1 <= pl <= 10 &  
    50 <= pf <= 1000 &  
    pc >= 1 &  
    nopcf >= "yes"
```

```
THEN : type = "current transformer"  
      run "ct.exe"
```

There the following variables are used :

sm - sensitivity of monitor (V/A);

pl - pulse length (ms);

pf - pulse frequency (Hz);

pc - pulse current (mA);

nopcf - necessary of obtaining of pulse

current form;

type - type of beam monitors;

"ct.exe" - calculation program of current

transformer".

In conclusion it is necessary to note that demonstration prototype of integrated expert system illustrating basic principles of system work was developed by means of instrumental system GURU for PC 386/486. At present, the elaboration of research real-time prototype is started. This project is based on instrumental system G2 by Gensym for Alpha AXP workstations.

## References.

[1] V.Rybin., G.Rybina., V.Safonenko. "An Expert System for Beam Diagnostics" 15th Intern. Conference on High Energy Accelerators, Hamburg, July 1992, pp. 237-238.