CONCEPT OF DECISION SUPPORT SYSTEM FOR INR RAS LINAC BEAM TUNING

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Abstract

During the last decade instruments of machine learning are gaining popularity in accelerator control systems. One of these instruments is decision support system (DSS) that is already successfully used in other fields of science. In this article a motivation for implementation of such system for INR RAS linac tuning is discussed. Concept of developed DSS is presented. Changes in INR RAS linac data acquisition system essential for future DSS operation are proposed.

Introduction

Machine learning (ML) techniques are widespread in modern science, industry and everyday life. Majority of these tasks can be applicated to accelerator physics. One of the ML instruments is a decision support system (DSS). In case of INR linac DSS, which can help beam operator to analyze the current situation and make decisions to solve problems that arise during accelerator run, is a suitable system that would be helpful for routine operation.

INR linac DSS concept

INR linac DSS is designed as a Bayesian network. Its advantage is ability to insert knowledge in it by designing its structure and to determine probabilistic transition values based on the knowledge base. Input to the DSS will be problems that arise during accelerator operation and output will be ranged list of the most probable solutions for the problems. System has 6 layers. Connection between layers is shown in figure 1. Concept scheme of the DSS is shown in figure 2.

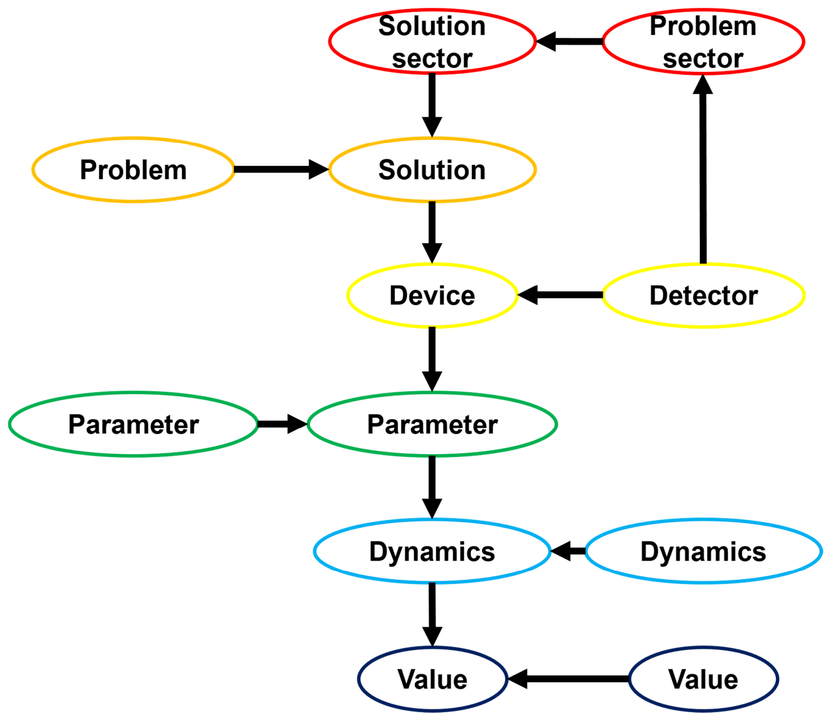

Fig. 1. INR linac DSS connections scheme.

INPUT PARAMETRES – INPUT LAYERS						→	OUTPUT LAYERS – OUTPUT PARAMETERS					
Layer 6 (discrete function of input values ranges)						→	Layer 6 (discrete function of output values ranges)					
	Layer 5 (4 nodes)					→	Layer 5 (4 nodes)					
		Layer 4 (6 nodes)				→	Layer 4 (10 nodes)					
			Layer 3 (~500 nodes)			→	Layer 3 (~500 nodes)					
				Layer 2 (10 nodes)		→	Layer 2 (8 nodes)		→	→	→	
					Layer 1	→	Layer 1	→				
Value	Dynamics	Parameter	Detector №	Problem	Sector		Sector	Solution	Device №	Parameter	Dynamics	Value
	+	Signal amplitude	IC, ND; MPS, MPS MRC; BCT	Beam loss; Current	1		1	Injector	Acc. tube; Duoplasmatron	RF phase; RF amplitude	+	
		Signal form	Wall detector; Pickup; BPM	Pulse length	2		2	RF	chopper, C1, C2; RFQ, DTL, DAW	Voltage; Current		
	CONST	Duration	WS; SEM-grid; BCSM	Pulse form	3		3	LLRF	LLRF devices	Temperature	CONST	
	VAR	Time delay	Luminophore; Camera; MGC	Time delay; Frequency; Energy	4		4	Focusing system	Current sources; Thermometry	Pressure	VAR	
	–	Setpoint	Synchronization; ΔF_{beam} fault	Position	5		5	Vacuum	Vacuum gauge; Vacuum pump; Vacuum valve	Duration	–	
		Detector status	ΔBCT_{IF} fault; ΔBCT_{RADEX} fault; $\Delta ИДТ_{IN-06}$ fault; датчики ИК	Profile; Emittance	6 (MRC)		6 (MRC)	DAQ	Crate, plate server, *.vi	Time delay; Setpoint; Device status		
								Beam instrumentation	Beam instrumentation devices; IC, ND; MPS, MPS MRC			
								Dosimetry				
Value	Dynamics	Parameter	Detector №	Parameter	Sector		Sector	System	Device №	Parameter	Dynamics	Value
					Layer 1	→	Layer 1	→	→	→	→	
				Layer 2		→	Layer 2					
			Layer 3			→	Layer 3					
		Layer 4				→	Layer 4					
	Layer 5					→	Layer 5					
Layer 6						→	Layer 6					
INPUT PARAMETRES – INPUT LAYERS						→	OUTPUT LAYERS – OUTPUT PARAMETERS					

Fig. 2. INR linac DSS concept scheme.

INR linac DAQ system

The INR linac data acquisition (DAQ) system is a software package based on the LabVIEW. It consists of DAQ sources running on servers, DAQ receivers running on client computers and DAQ storage server (figure 3). Currently, DAQ system consists of 17 source servers,13 servers that transfer data via DAQ storage server and 18 servers, which are not implemented into the system.

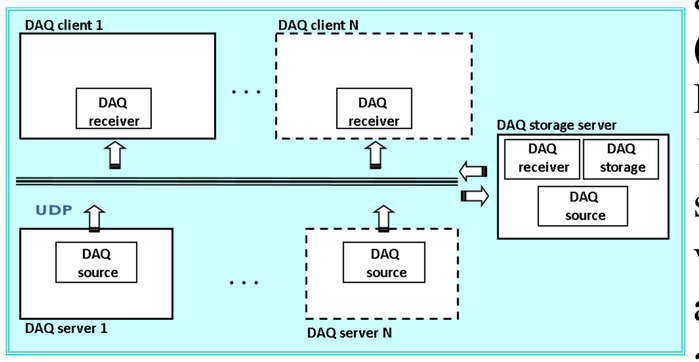

Fig. 3. INR linac DAQ scheme.

DAQ upgrade

Currently, INR linac DAQ system stores not all acquired data. System stores information about accelerator systems. Beam parameters are not stored automatically. For DSS data analysis software all beam parameters should be stored. Also new signals, which are constantly added for accelerator control, should be added to DAQ system. Examples of DAQ upgrade during last year are presented on figures 4-6.

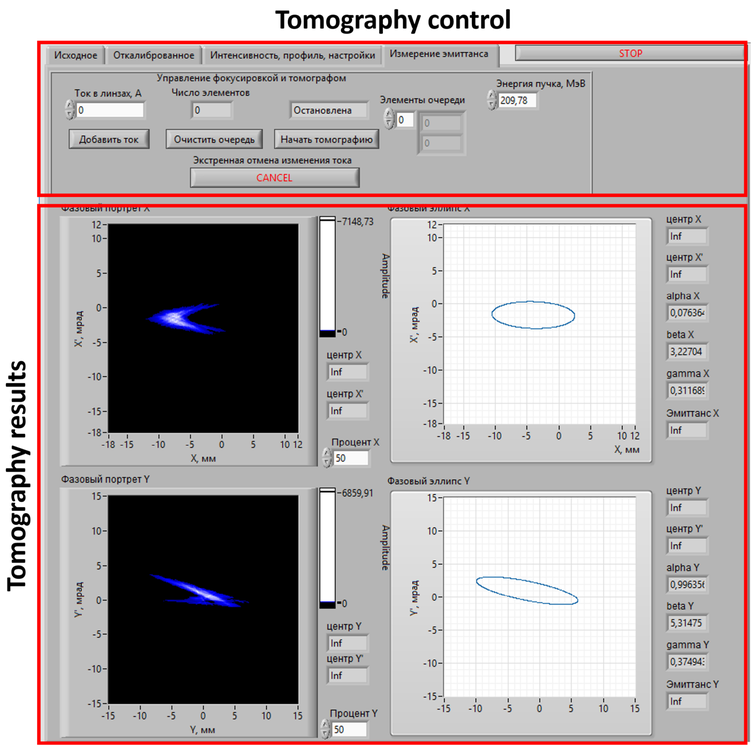

Fig. 4. Online tomography software.

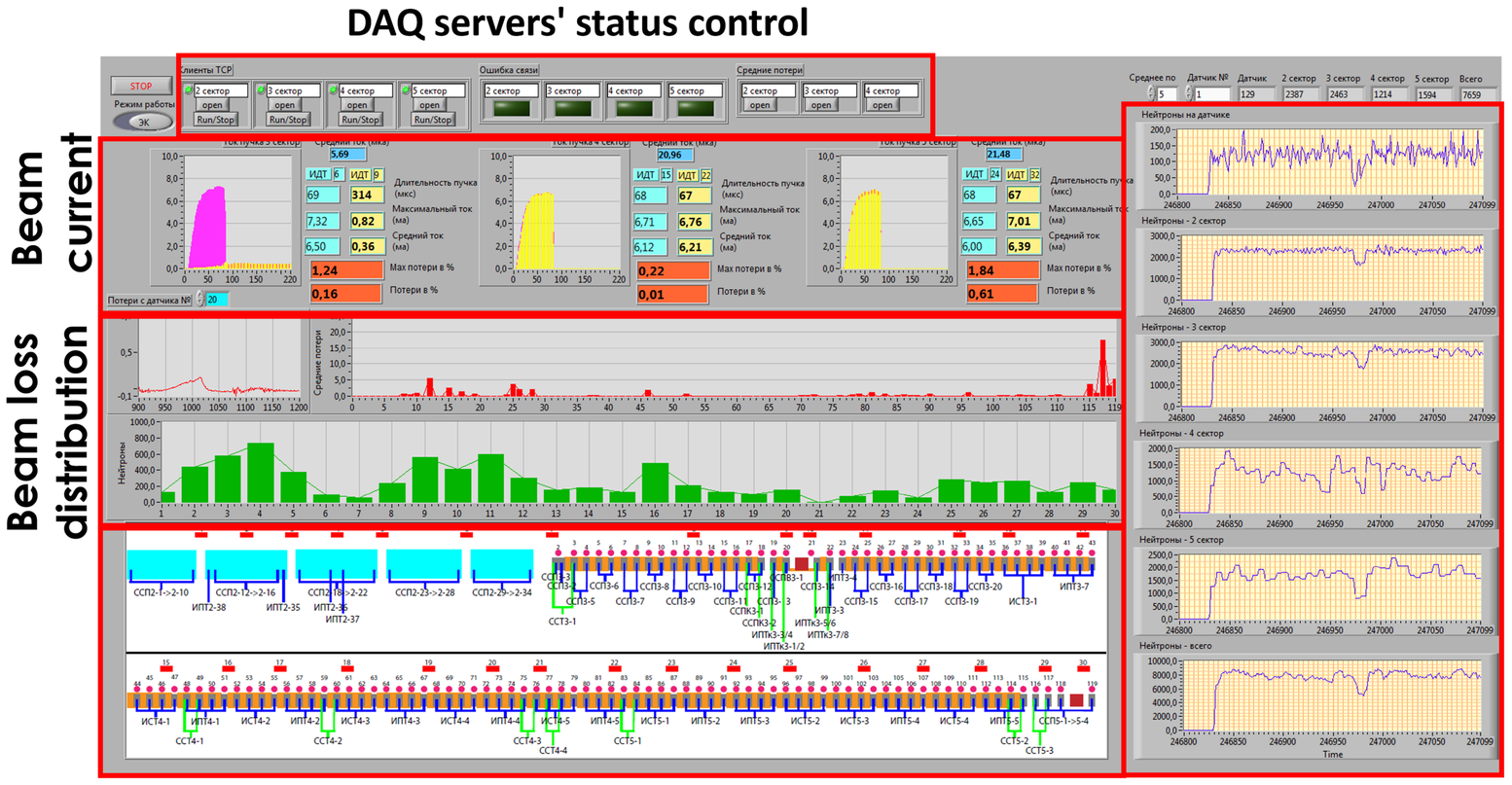

Fig. 5. Upgraded beam current and loss software.

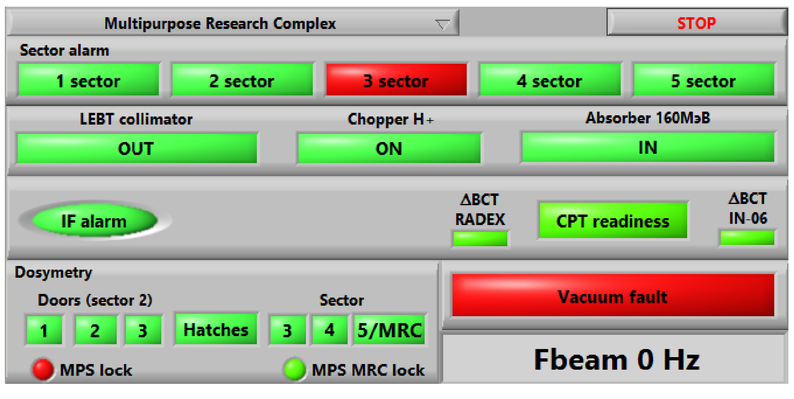

Fig. 6. Upgraded linac alarm software.