ADVANCES OF NPK LUTS CONTRABAND DETECTION SYSTEM

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Abstract

Principle and project of NPK LUTS contraband detection technological complex (CDTC) was presented by authors at EPAC 2002. This paper reviews researches connected with 433 MHz ion linacs creation for the last four years. Main part is description of designing and testing of RFQ and APF resonators. State of affairs of other CDTC system is described briefly.

INTRODUCTION

Contraband detection system project of Scientific Production Complex of Linear Accelerators and Cyclotrons (NPK LUTS) of D.V. Efremov Institute and first results of investigations on creation 433 MHz accelerating system had been published in proceedings of Linac 2000 and EPAC 2002 [1], [2]. It was supposed to use accelerated protons and deuteron in detection complexes of explosives, fission, vegetable narcotics and may be other applications. It was supposed to use RFQ for acceleration of protons and deuterons up to 1…4 MeV and IH-resonators with alternating phase focusing (APF) for their acceleration from 2 up to 10 MeV. Simultaneously design and manufacture of needed injection and RF systems, feeding system, output devices and processing systems had been realized. These works supported by Russian Federation Agency of Atomic Energy.

INVESTIGATION OF ACCELERATING STRUCTURES

Most difficulties were arised by developing of 433 MHz RFQ. Analytical evaluations and testings of full-scaled 433 MHz resonator prototypes from aluminum alloys had shown tolerances on intervane distances determining quadrupole symmetry of chosen construction mast be ±25 µm for adjacent vanes and ±35 µm for opposed vanes in symmetry plane of each cell. It follows that linear sizes and construction's parameters must have micron tolerances to provide required quadrupole symmetry. Vane modulation and its position relatively plane z = 0 according to beginning of matching cells must be fulfilled with error 3-4 µm. These requirements did not fulfilled completely for the first operating RFQ from chromium copper, intended to accelerate deuterons from 0.06 up to 1 MeV. After alignment and tuning field unevenness along structure was big enough (±7%). Another defect was unperfectness of contact lyings between vanes. Therefore resonator quality was lower than theoretical one. Small current was conditioned by use of old plasma-surface source whose time life was near the end. Calculated data of RFQ parameters from chromium copper and results of testings are given in table 1.

Table 1: Theoretical parameters and tested results of 1 MeV deuteron RFQ

Parameter	deuterons (theory)	protons (theory)	protons (experiment)
Initial energy, MeV	0.06	0.03	0.03
Final energy, MeV	1	0.5	0.5
Spread of energy spectrum, keV	±30	±30	±40
Vane length, m	2.3	-	-
Vane voltage, kV	98; 100 (experiment)	49	50
Quality	6600	6600	4400
Pulsed power, kW	310	77.5	215; 146 (theory)
Input pulsed current, mA	20	25	5
Output pulsed current, mA	15	18	1.3
Gas pressure, Torr			$(7…9)\cdot10^{-7}$

View of 1 MeV deuteron RFQ on laboratory stand is given on fig. 1.

Figure 1: 1 MeV 433 MHz deuteron linac on the laboratory stand.

Tolerance requirements given above were fulfilled under manufacture of experimental structure from aluminium alloy for proton acceleration from 0.06 up to 1 MeV (see fig. 2). Assembling, alignment and operation of resonator confirmed efficiency of the new technology. Achievments were connected with the use for vane machining universal machine tool HS-328 of group PARPAS. Additional equipping of machine, use of special cutting tool, temperature stabilization near machined vane down to ±0.25°C made possible to obtain error of butted surfaces machining 2.5 µm, errors of vane modulation ±5 µm, roughness of surfaces within limits 0.04-0.15 µm. Errors of measurements on machine tool HS-328 were decreased down to 1 µm.

Figure 2: Precise manufactured structure from aluminium alloy.

Because one considered two variants of accelerators for detection system (8 MeV protons and 4 MeV deuterons) it is supposed to use APF resonator for proton acceleration from 2 MeV up to 8 MeV. Such resonator had been manufactured from copper OFE-OK™. Construction and tuning method of APF resonator were described in detail in [3]. Elements of structure: cells with thick holders which are crossed at right angle for neighboring cells, output cell and top with tuning cross are given on fig. 3.

Figure 3: Elements of 433 MHz structure with alternate phase focusing.

OTHER BLOCKS OF DETECTION SYSTEM

RF system of linac with RFQ and APF resonator is composed from independent amplification lines. It is possible to use endotron type devices (american name is coaxitron) KIWI or multibeam tetrods CONGRESS as power amplifiers. Both devices manufactured by SED SPb Ltd and have the same parameters: working frequency 433±5 MHz, pulsed power 500 kW, duty cycle $2 \cdot 10^{-2}$. Principle of making up of RFQ RF system is described in [4]. Four power inputs and hybrid bridges are used to suppress parasite modes. APF-resonator have two power inputs placed on output cell.

At present testing of separate block of detection complex are produced on laboratory stands. A new injector with ion source of duoplasmatron type had been manufactured. System of measuring and processing is described in paper [5]. It consist of 32 independent channels. Each of channels includes detection block based on CsI scintillometer, photomultipliers and charge-sensitive amplifier. Detection console is shown on fig. 4.

Figure 4: View of detection console

Spectroscopical line of each channel forms signal which come to input of analogue to digital converter. Processing time of signal is 1.2 µs. Laboratory testing including measurement of radiation from researched sample, which was irradiated by neutron beam, had been produced in 2001. Neutron beam was obtained from beryllium target by 10 MeV deuteron bombardment from cyclotron MGC-20. Identification of lines of element radiation was observed even under nonoptimized protection.

CONCLUSION

During 2006-2007 one supposes to manufacture two of 433 MHz RFQs. Proton RFQ with acceleration of particles from 0.06 up to 2 MeV and deuteron RFQ with acceleration of particles from 0.06 up to 4 MeV. Existing of last resonator will permit to conduct complete testing of detection complex of explosive and fission.

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