

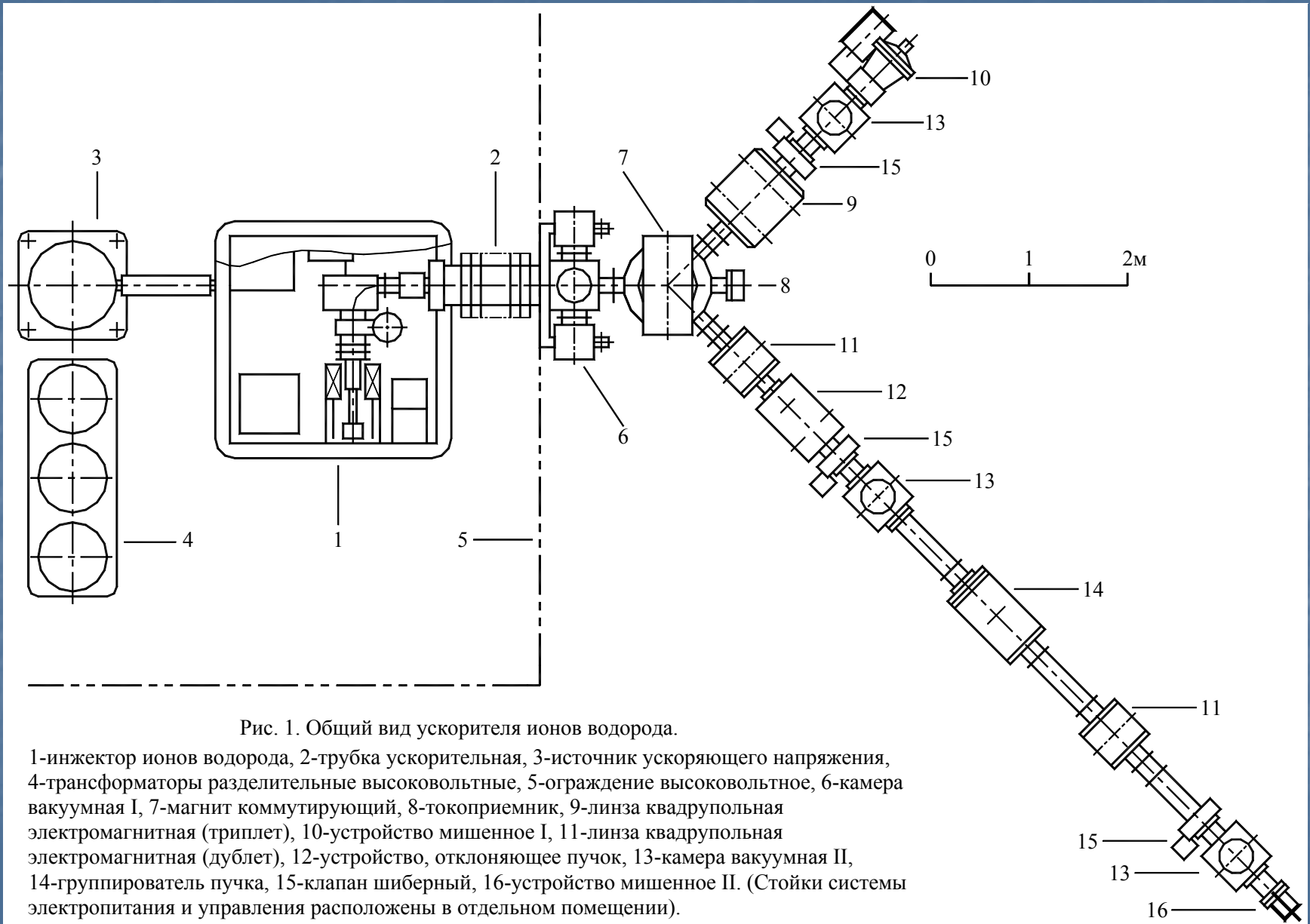
High-voltage Accelerators Intended to Produce Continuous and Pulse Neutron Fluxes

- In the last years the interest towards pulse neutron generators is growing due to continuing research in nuclear physics (using flight time methods) and due to the importance of possible applications. Such generators allow developing highly effective detectors for radioactive materials, but as well for explosives, drugs, and poisons.
- The Efremov Institute has carried out a series of research and development projects in order to create generators capable of producing neutron fluxes of high intensity in continuous mode, but also capable of operating in pulse mode with a wide range of pulse frequency and repetition rate.

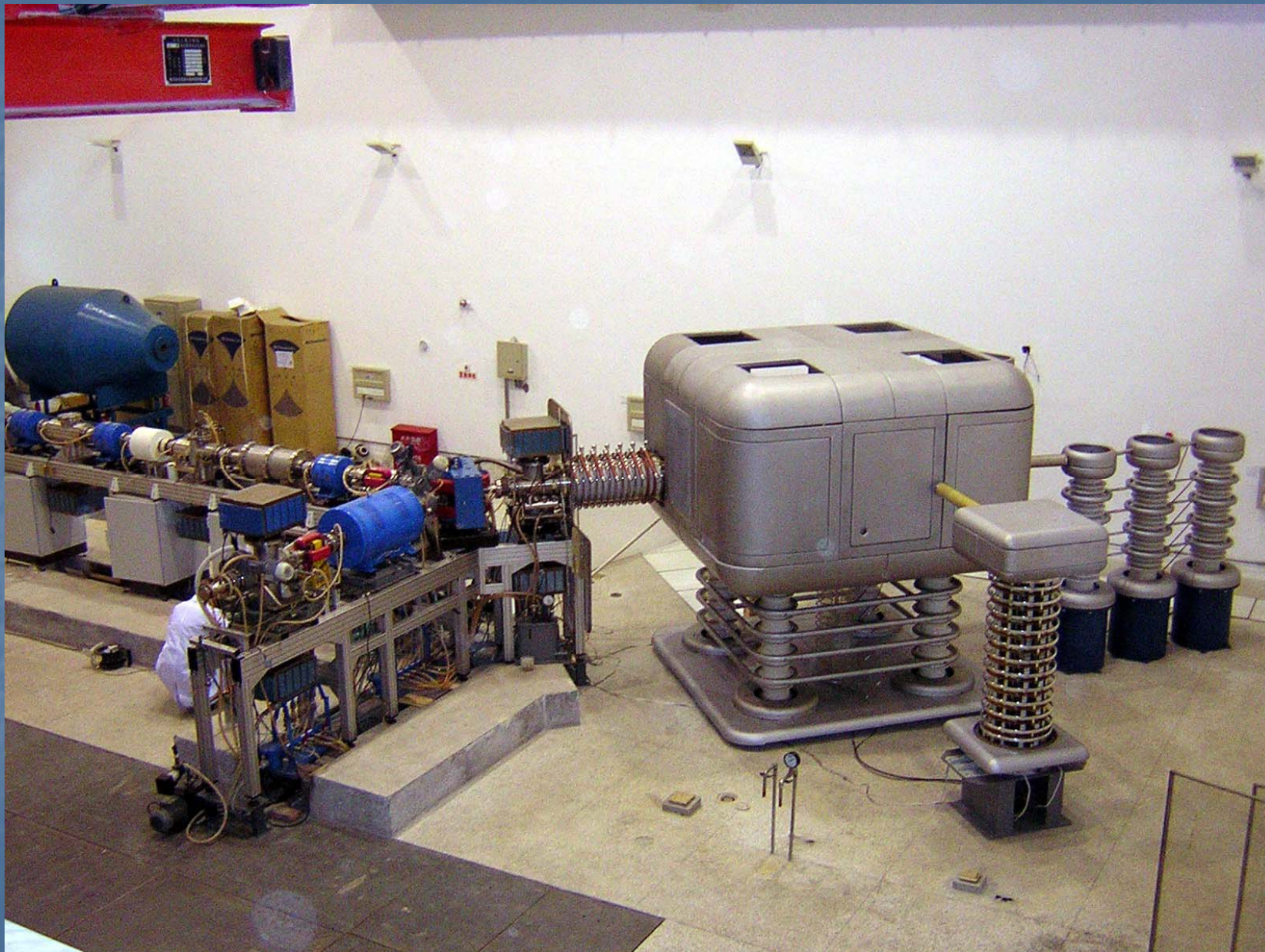
- The neutron generator NG-12-2 is a high-voltage accelerator for deuterium ions with an acceleration voltage 300 kV and a beam current of deuterium atomic ions up to 15 mA.
- The ion injector is installed in the high-voltage terminal of the accelerator. It includes an ion source with initial beam forming system, an analyzing 90-degree electromagnet, an autonomous vacuum system and electric power supply and control system.
- The ion source is an ECR one with a four-electrode ion beam formation system. Spatial and angular characteristics of the beam at the accelerating tube input are controlled with the analyzing electromagnet with double focusing and a solenoid lens.

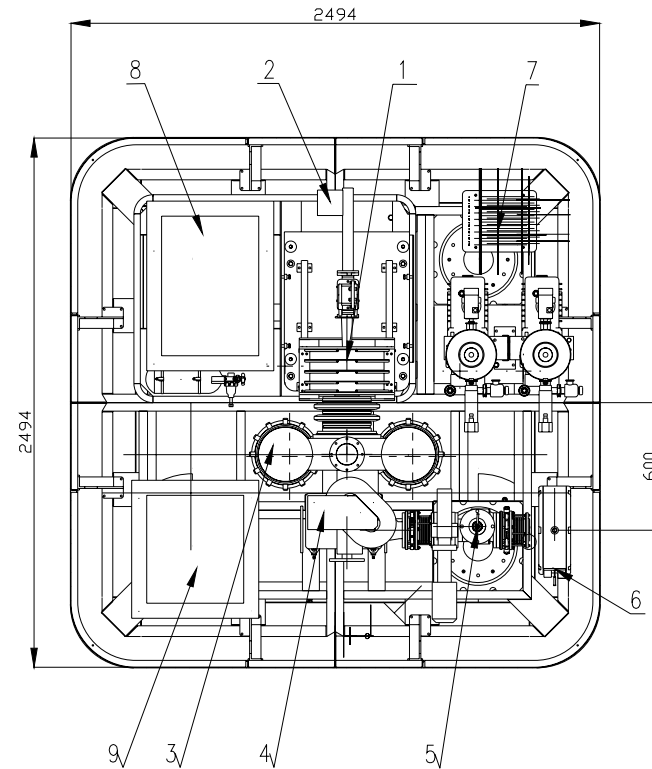
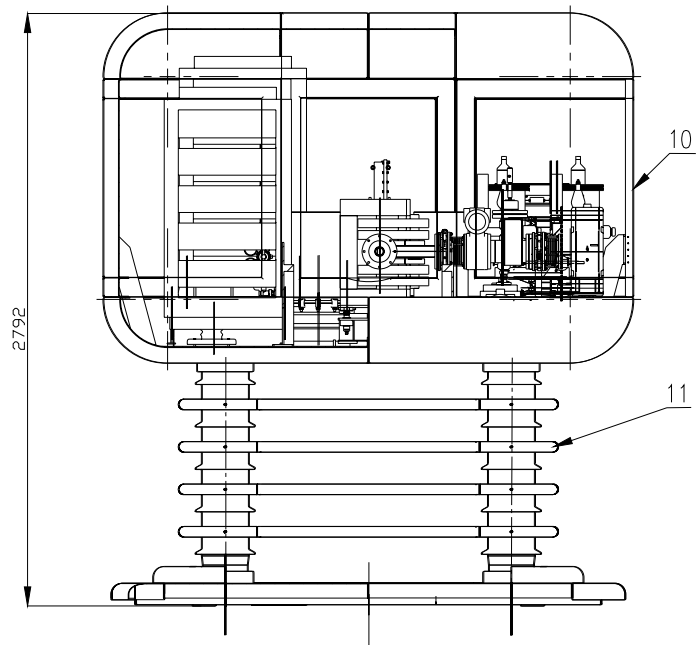
- Technical data on the hydrogen ion accelerator ($E = 300 \text{ keV}$).
- High voltage, kV 300 max
- Hydrogen ion current at the current collector, mA 10 max
- Ion current instability, % ± 5
- Current collector is under zero (ground) potential
- Continuous beam at beam line 1:
- Hydrogen ion current, mA 10
- Beam diameter at the current collector, mm 20 ± 5
- Hydrogen ion current, mA 2
- Beam diameter at the current collector, mm ≤ 10
- Microsecond pulse beam at beam line 1:
- Peak hydrogen ion beam current, mA ≤ 5
- Pulse duration, ms 10-100
- Pulse frequency, Hz 1, 10, 100, 1000
- Beam diameter at the current collector, mm ≤ 15
- Nanosecond pulse beam at beam line 2:
- High voltage, kV 250
- Peak hydrogen ion beam current, mA ≤ 10
- Pulse width (FWHM), ns $\leq 1,5$
- Beam diameter at the current collector, mm ≤ 10
- Total pulse duration, ns ≤ 6
- Pulse frequency, MHz 1, 2, 4
- Pulse frequency, kHz 1-100

NG-12-2



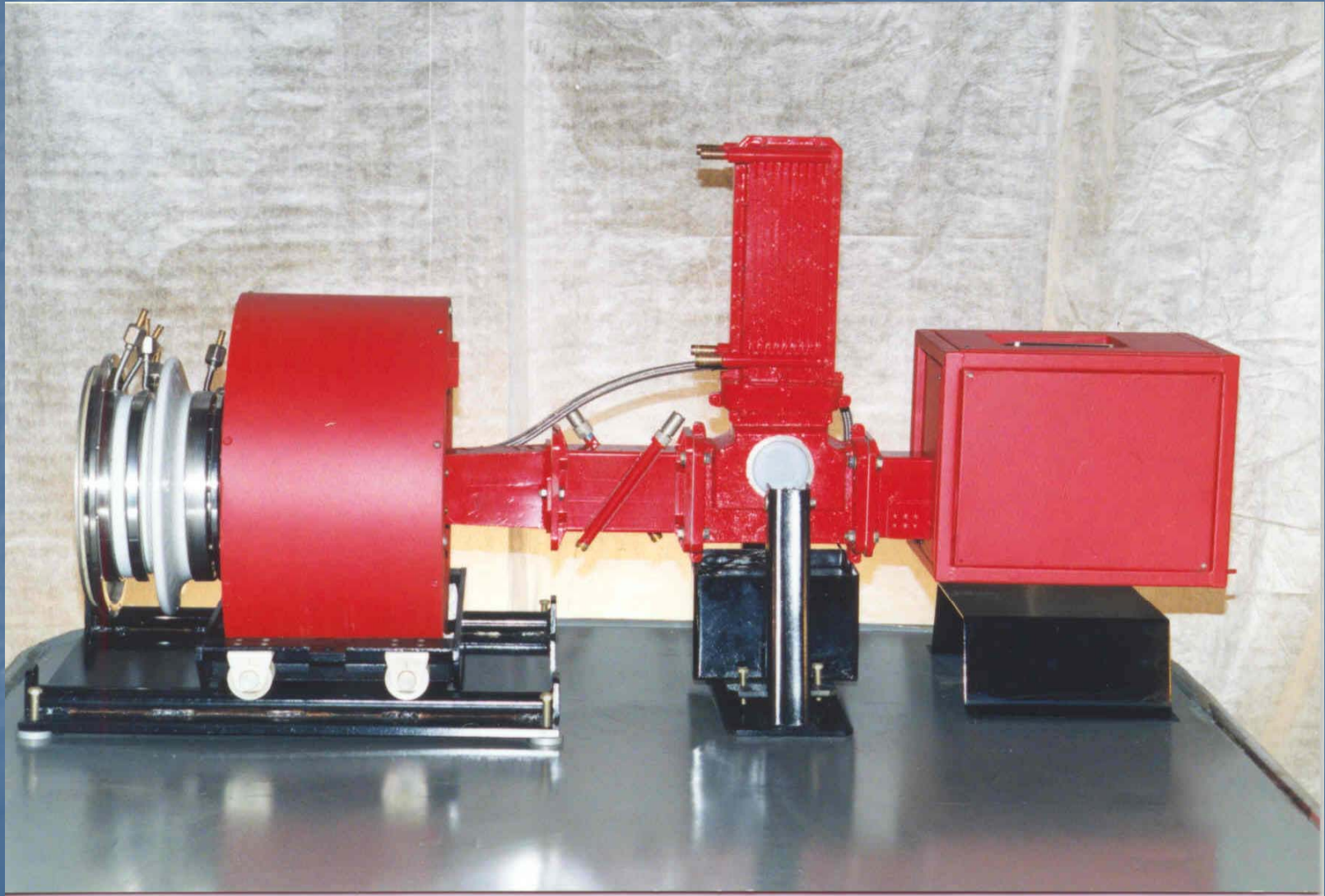
NG-12-2





- 1— Источник ионов водорода
- 2— Магнетрон
- 3— Камера вакуумная
- 4— Электромагнит (90, R=200мм)
- 5— Измеритель тока пучка подвижный
- 6— Линза соленоидальная (d=100мм)
- 7— Источник ускоряющего напряжения
- 8— Система электропитания источника ионов
- 9— Система электропитания инжектора ионов
- 10— Электрод высоковольтный
- 11— Опора изоляционная

ECR-ion source





- The ion optical system of the accelerator has been designed in order to obtain the deuterium ion beam current of up to 20 mA at the accelerator output, in the plane of the distribution magnet.
- This beam has an emittance and regular divergence values required for further transport towards the beam.
- The 45-degrees electromagnet allows switching the beam between the two transport channels.

- The first channel is designed to operate in continuous and microsecond pulse modes. An ion beam with pulse duration of 10-100 ns and repetition rate up to several kHz is obtained by microwave discharge modulation in the ion source.
- The second channel is designed for obtaining ion pulses of 1-2 ns duration at the stationary beam. Such pulses are obtained by means of a beam chopper and a clystron buncher.





Tek Stopped

1 Acqs

01 Apr 06 23:02:25

Buttons

Level

21.2mV

Max(C1) 23.4mV

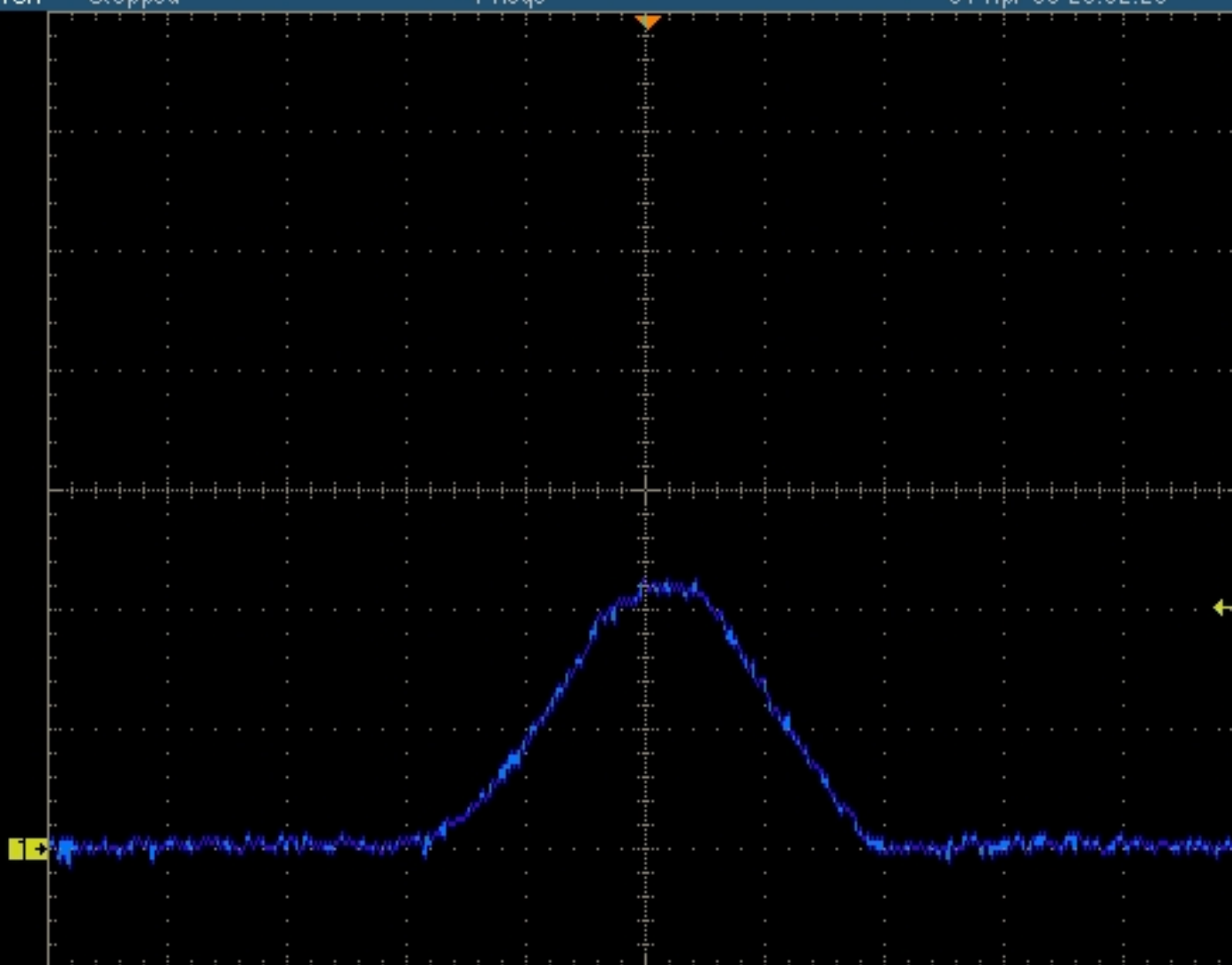
Pos Wid(C1) 17.53ns

Pos Wid(C1) 31.0ns

Pos Wid(C1) 20.8ns

Rise(C1) 13.8ns

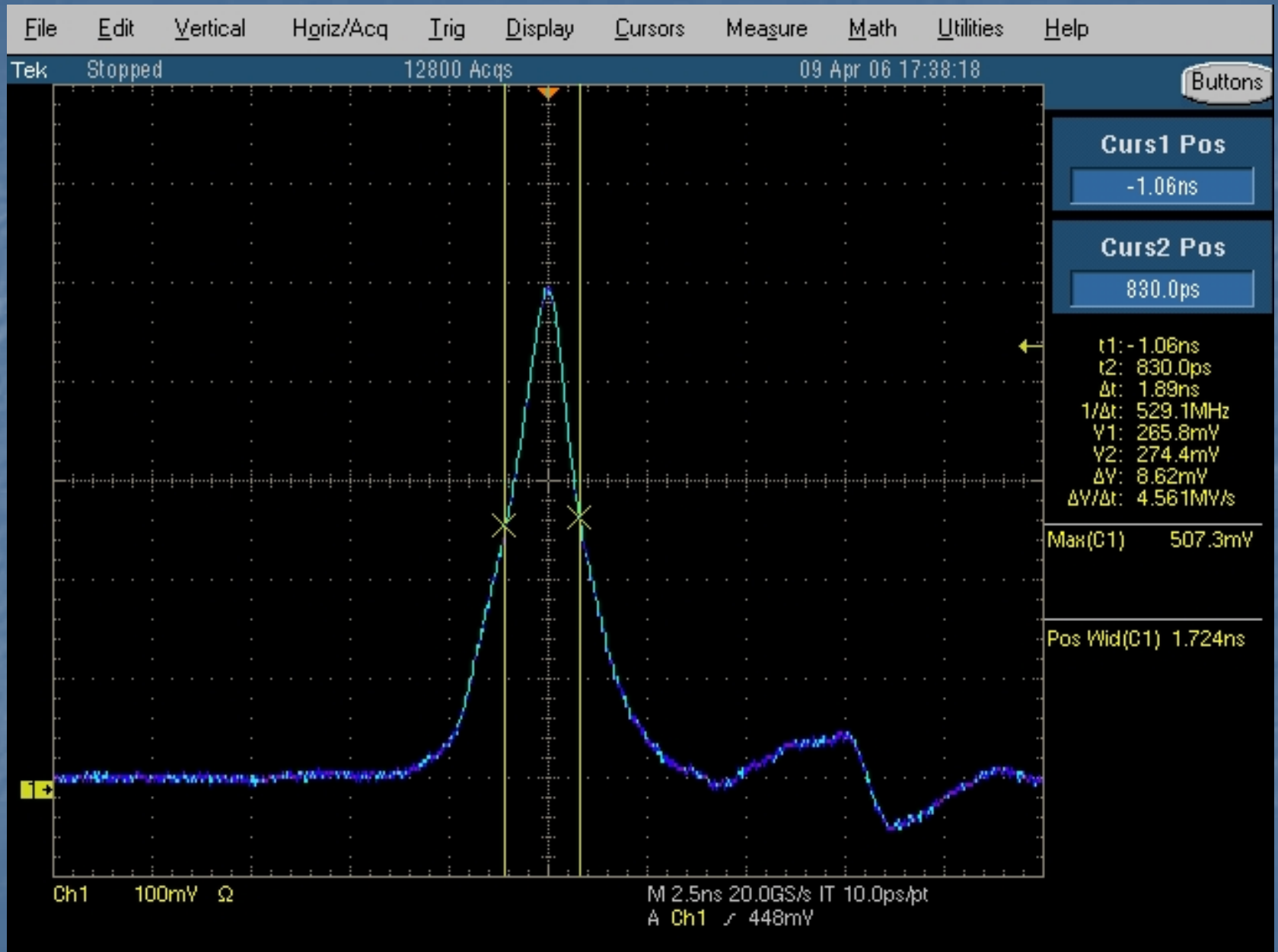
Fall(C1) 12.6ns



Ch1 10.0mV Ω

M 10.0ns 5.0GS/s 200ps/pt

A Ch1 \nearrow 21.2mV

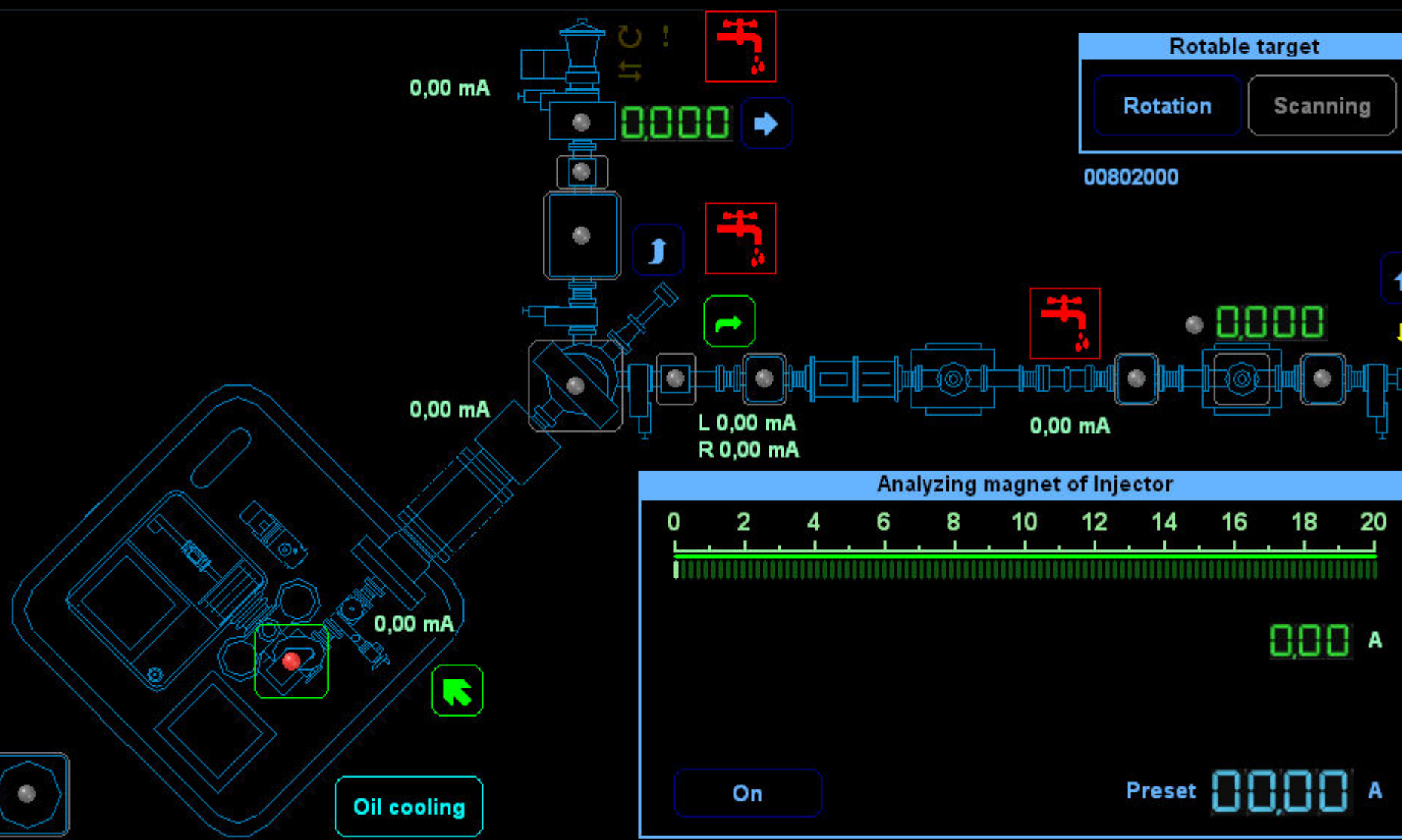


- The neutron generator allows obtaining the beam current of atomic deuterium ions of 20 mA at the rotating target of 230 mm diameter, with the beam diameter of 20 mm. For the pulsed mode with pulse duration 10-100 ms current amplitude can be up to 20 mA.
- The second channel allows obtaining peak current up to 10 mA with pulse duration 1.7 ns. The repetition rate can be set to 1, 2, and 4 MHz, or it can be varied smoothly between 1-100 kHz.
- The generators like NG-12-2 can operate in large research centers, but there is also a demand of less expensive generators with lower neutron yield, but with auxiliary systems broadening the range of possible applications.

Vacuum	Injector:	1.0E+0	#1:	1.0E+0	Beam current	Injector:	0,00 mA	Accelerating voltage	0,00 kV
	#2:	1,0E+0	#3:	1.0E+0		Ion line:	0,00 mA		0,00 mA



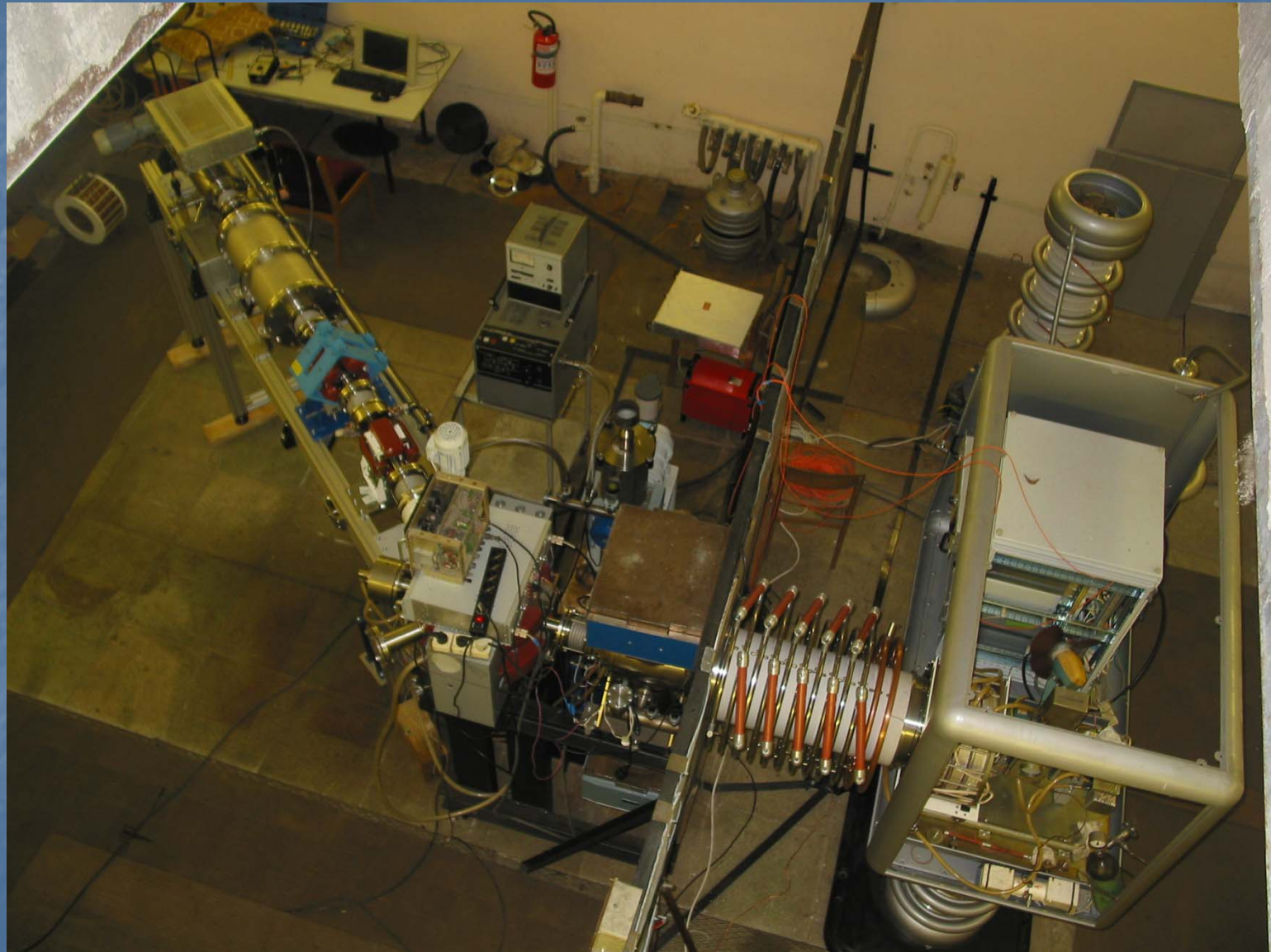
☒ Vacuum
 ☒ Ion line
 ☒ Injector
 ☐ NanoS



NG-11-I

- A neutron generator NG-11I is designed to obtain a neutron yield of 5×10^{11} n/s in continuous mode. It is supplied with a microsecond pulse generation system which operates by modulation of the ion source microwave discharge.
- The generator consists of an accelerator of deuterium ions with acceleration voltage of 180 kV and atomic ion beam current at the target up to 5 mA.

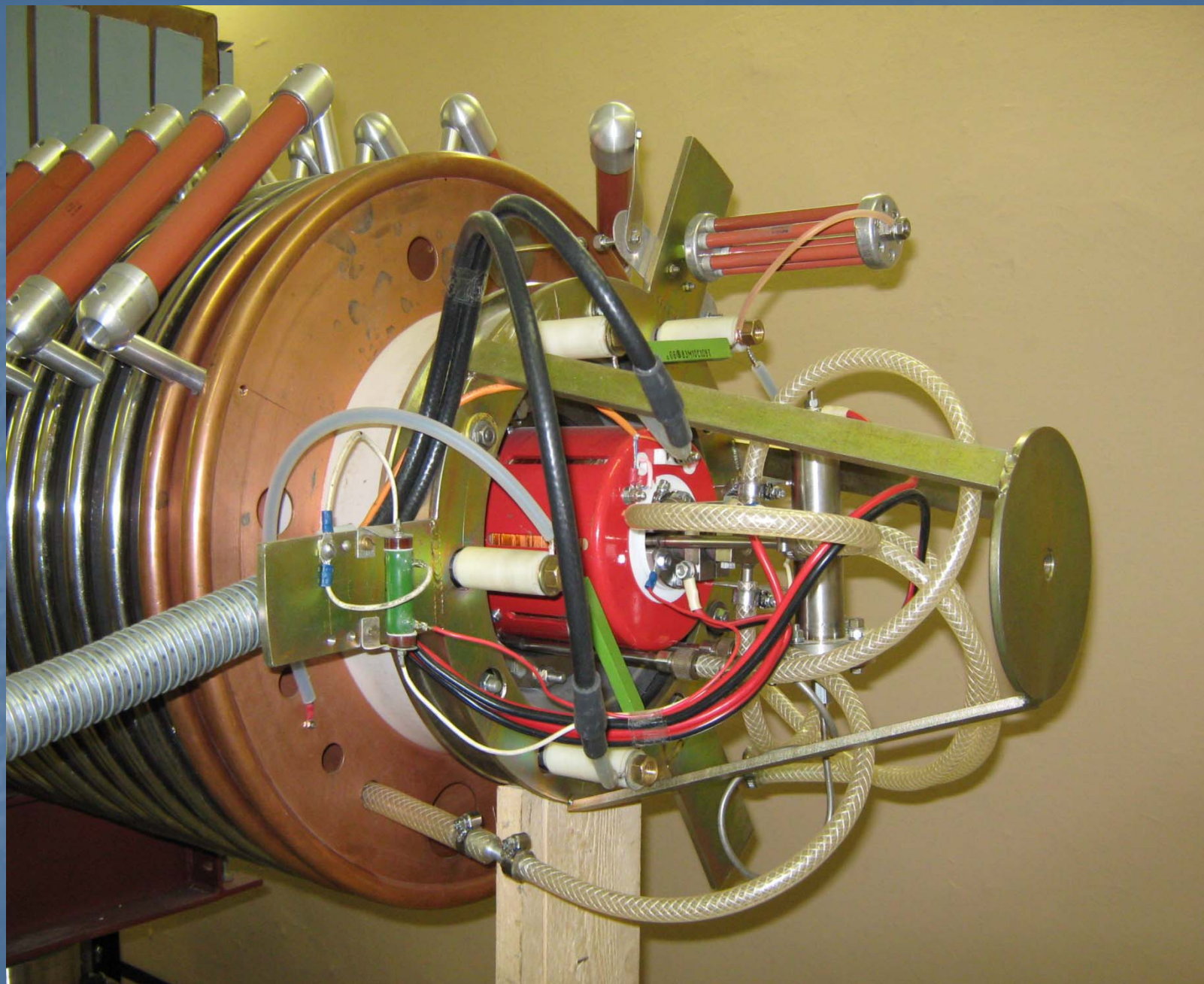
NG-11-I



NG-11I-1







Neutron Generators at D.V. Efremov Research Institute

	Sneg-13	NG-12-2	NG-11-I
High voltage, kV	250-300	250-300	180-200
Ion beam current, mA	100	15	5
Ion beam diameter, mm	40	20	5
Neutron flux, n/s	1×10^{13}	2×10^{12}	5×10^{11}
Pulse, μ s frequency, Hz	10-100 10-100	10-100 1-1000	1-100 10-1000
Pulse, ns frequency, MHz		1-3 1,2,4	2-10 1

NG-11-I