BRATISLAVA MULTIPURPOSE NEUTRON SOURCE

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A 14 MeV neutron source based on the T(d,n)α reaction is under development in our laboratory. The source is designed for a variety of experiments in low energy nuclear physics involving the in-beam γ-ray, neutron and charged particle spectrometry, neutron activation measurements as well as neutron irradiation studies. So far, we have completed a low intensity dc beam line with a neutron yield of up to 10^{10} n/s.

Introduction

In recent years, a multipurpose 14 MeV neutron source has been designed in our laboratory. It will be used in low energy nuclear physics involving the in-beam γ-ray, neutron and charged particle spectrometry, neutron activation measurements as well as neutron irradiation studies. For the production of neutrons the reaction T(d,n)α is used. A TiT target is bombarded with deuterons accelerated up to 300 keV in an electrostatic air insulated accelerator.

The neutron source has two beam lines: a dc/pulsed beam line and an intense beam line.

The low intensity dc beam line has been completed. It is capable of producing a 0.4 mA deuteron beam on a target spot. The beam is generated in a high frequency ion source. It is accelerated by an accelerating tube and further transported to a target chamber. With such a beam and a fresh target a neutron yield of 10^{10} n/s for a beam spot of 1 cm^2 is obtained.

The fast pulsed beam line will be capable to generate a compressible D^+ ion beam of up to 1 ns on a target spot.

The intense beam line should be capable of producing 10 mA of a separated D^+ ion beam. With such a beam and a fresh target a neutron yield of 10^{12} n/s for a beam spot of 1 cm^2 can be expected.

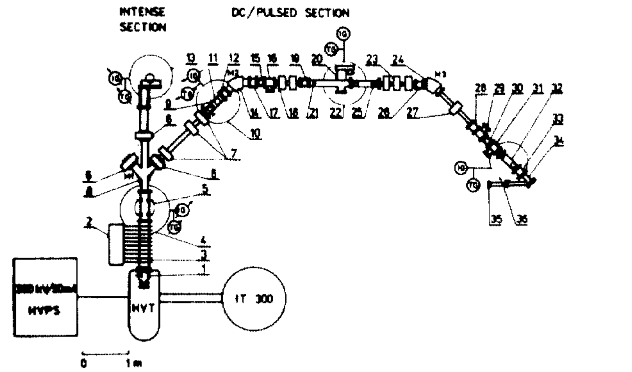
The paper gives a short survey of the present status in the development of the accelerator. We also briefly outline the new design concept.

Description of the neutron source

The layout of the source is shown in Fig. 1. It is based on two beam lines: the dc/pulsed beam line and the intense beam line.

The main parts of the source are a high voltage power supply, a high voltage terminal with an ion source, a vacuum system, a homogeneous field accelerating tube, a target chamber as well as a beam profile monitor. It is constructed in order to obtain a neutron yield of 10^{10} n/s.

A klystron bunching system is incorporated in the dc beam line. It includes moreover a switching magnet, bending magnets, quadru-



LEGEND:

1 ION SOURCE	11,16,19,31 BEAM MONITORS
2 COLUMN RESISTOR	12,33 STATIC BEAM MONITORS
3 ACCELERATING TUBE	13 ROTATING TARGET
4 MAIN VACUUM SYSTEM	14,24 BENDIG MAGNETS
5 BEAM STEERER	15,30 WATER COOLED SLITS
6,20 GATE VALVES	17,26,28,29 DIAPHRAGMS
7,18,23,27 QUADRUPOLE LENSES	21 CHOPPER
8 SWITCHING MAGNET	25 BUNCHING
9,32 DYNAMIC BEAM MONITORS	34 TARGET CHAMBER
10,22,36 AUXILIARY VACUUM SYSTEMS	35 DETECTOR
TG THERMOCOUPLE GAUGE	HVT HIGH VOLTAGE TERMINAL
IG IONIZATION GAUGE	M1,M2,M3 MAGNETS
IT 300 ISOLATION TRANSFORMER	
HVPS HIGH VOLTAGE POWER SUPPLY	

Fig. 1. Layout of the neutron source.

pole lenses, diagnostic elements of the beam auxiliary vacuum systems, a chopper as well as diaphragms and water cooled slits. The beam line will be capable to generate a beam pulse of up to 1 ns wide on a target spot. An approximately 10^3 n/pulse for a 1 mA primary beam current will be generated.

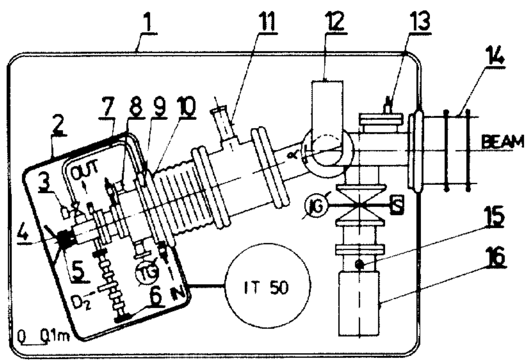
The intense beam line should be capable of producing a 10 mA separated D^+ ion beam. The high voltage terminal, in this case, will involve a duoplasmatron ion source. The scheme of this configuration is shown in Fig. 2. The beam should pass through a double focusing dipole magnet. It is accelerated up to an energy of 300 keV by the same accelerating tube and further transported to a rotating target chamber. With such a beam and a fresh target a neutron yield of 10^{12} n/s, for a beam spot of 1 cm^2 and a useful target lifetime of about 10 h can be expected.

Recent developments and status

Recent developments have been centred on the assembly and tests of the dc beam line.

High voltage power supply

The high voltage power supply is mounted in a 6 m x 6 m cell (Fig. 3). Next to it, another cell is used for the source. They are interconnected through a water resistor by a



LEGEND:

1 300 kV HIGH VOLTAGE TERMINAL DOME
2 50 kV DUOPLASMATRON DOME
3 SOLENOID VAVLE
4 CATHODE FEEDHROUGH
5 COOLER
6 Pd VAVLE
7 VACUUM BEAM LINE
8 HOLDER
9 ANODE
10 Al_2O_3 CERAMIC
11 50 kV FEEDTHROUGH
12 ANALYSING-FOCUSING MAGNET
13 BEAM MONITOR
14 ACCELERATING TUBE
15 ION PUMP FEED-THROUGH
16 ION PUMP

Fig. 2. Scheme of the high voltage terminal of the intense section of the accelerator.

high voltage cable.

The major components of the supply (the regulating transformer, the high voltage transformer, the Se-rectifiers, the multiplier capacitors, the protective resistor and the electro-hydraulic discharger) were supplied by TUR Dresden. The supply is constructed with respect to a long operation at 40 mA/20 °C or 30 mA/35 °C. The ripple factor of the supply is 3 % at the operation current of 10 mA.

In order to decrease the ripple factor of the supply to about 0.5 % we added a capacitor battery with a capacity of 0.125 µF. A safety system which can quickly discharge the battery through a 100 kΩ water resistor by a pneumatic discharger is also developed. It shorts the battery to the ground potential either at switching off the supply or at the breakdown in the high voltage terminal of the accelerator.

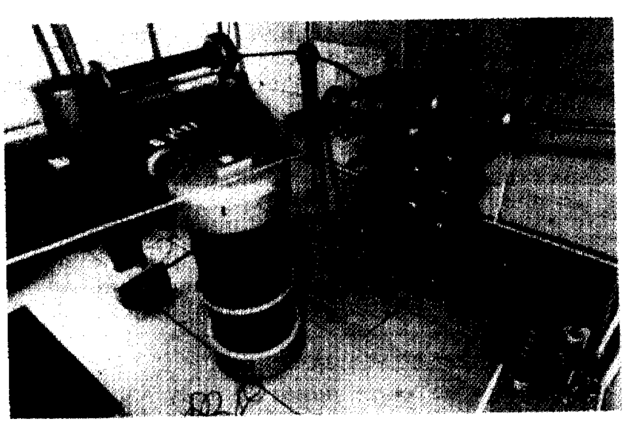


Fig. 3. General view of the high voltage power supply.

Fig. 4. General view of the high voltage terminal and the low intensity dc section.

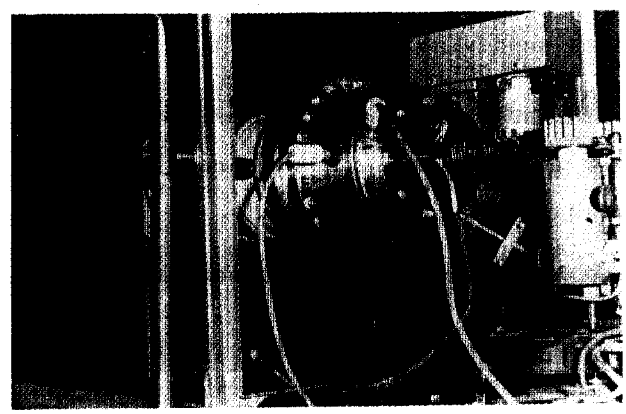


Fig. 5. General view of the high frequency ion source, column resistor and Pd valve.

High voltage terminal and ion source

The general view of the high voltage terminal and the dc beam line are shown in Fig. 4. This part of the accelerator is also mounted in a 6 m x 6 m cell. The high voltage terminal of a 3.4 m^2 surface and 0.9 m height contains the high frequency ion source and the other associated equipment. The power for the terminal is supplied by the isolation transformer IT 300 [1-3].

The general view of the ion source is shown in Fig. 5. The high frequency ion source was used for the operation in the dc beam line. It was shown that one can achieve the 0.4 mA deuteron beam on the target at an approximately 6 kV extraction voltage. The high frequency power of 150 W at 42 MHz is coupled to a D_2 gas with a pressure of 1 Pa contained in a quartz cylinder. To increase the plasma density in the ion source a solenoid is mounted on the upper source plate. The D_2 gas container and the Pd valve were also built into and fitted to the ion source.

Vacuum system

A detailed description of the vacuum system is given elsewhere [4]. The general view of the vacuum system of the dc beam line is also shown in Fig. 4. It is constructed mainly of stainless steel with ConFlat flanges and copper gasket seals. The pumping unit was completed and successfully tested together with the dc beam line. It consists of a 2000 l/s diffusion pump, a baffle, a liquid nitrogen trap, two sorption zeolite pumps, a foreline trap as well as a rotation pump. The diffision pump usually pumps either with the sorption pump depending on the pumping efficiency of the molecular sieves used at liquid nitrogen temperature. As soon as a vacuum of 10 Pa is reached, the sorption pump is automatically connected to the diffusion pump while the rotary pump is connected to it when the fore-vacuum increases up to 20 Pa. Two sorption pumps are provided. The pumpdown time of this vacuum system (main vacuum system) operating with a 100 l volume from 0.1 MPa to 10^{-3} Pa is about 1.5 h.

The pressure inside the vacuum system is measured by a thermocouple and a Bayard-Alpert ionization gauge. Also, a quadrupole type gas analyser is installed in order to permit a quick diagnosis and a residual gas analysis even with the beam on.

Accelerating tube

The ion beams are accelerated to the final energy of 300 keV in the homogeneous field of the accelerating tube. It consists of 11 Al electrodes with a 86 diameter beam aperture. The electrodes are separated by ceramic insulating rings which have a 148 mm inside diameter and 63 mm length. The whole system is glued together with polyvinyl acetate. A lead seal is fitted between the glue layer and the inner part of the tube to prevent any glue outgassing. The insulators are shielded from the beam by conically shaped metal electrodes.

The potential is equally distributed along the accelerating tube by means of multiple series of resistor blocks 30 MΩ/30 kV built into an oil-filled insulating box.

The electrostatic beam steerer for the correction of the ion beam position is located inside the beam line behind the accelerating tube.

Target chamber

The dc target chamber fixes the TiT target. Water is used as a coolant and is driven to a channel placed near the target periphery. We use a 45 mm diameter target manufactured in the USSR [5].

It was shown that the beam generated in the high frequency ion source can be accelerated to an energy of 200 keV by the accelerating tube and further transported to the target chamber. With a beam of 0.2 mA and a fresh target a neutron yield of 10^{10} n/s, for a beam spot of < 1 cm^2 is produced.

Beam profile monitor

The KBr luminiscent beam profile monitor was used for the dc beam line. The luminiscent screen is scanned by a CCD TV camera [6].

Concluding remarks

The dc/pulsed beam line of the source will be the next step in the construction of the accelerator. In the next few years the beam line will be the main tool for the γ-γ and the n-γ coincident in-beam experiments as well as for the exclusive neutron spectra measurements. For this reason nine quadrupole lenses, three dipole magnets and dynamic beam monitors have been designed. The switching magnet and all quadrupole lenses have been completed.

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