LUE200 - DRIVER LINAC FOR INTENSE RESONANT NEUTRON SPECTROMETER (IREN)*

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Abstract

The *200 MeV* electron linac as a driver of the Intense REsonant Neutron source (IREN) is being created at Frank Lab of Neutron Physics (JINR). IREN being a new neutron pulse source for time-of-flight spectrometers, should combine a high average intensity with a short pulse. The operating neutron source, the IBR-30 facility, consists of the LUE-40 linac (with an energy of *40 MeV*, a pulse current *of 0.3 A*, a pulse duration of *1.8 msec*, and a repetition rate of *100 Hz*) and a neutron multiplication target (with a gain of *200*). The resulting intensity of the neutron flow is about 4.5×10^{14} sec^{-1} and the pulse duration is *4 msec*. In the IREN project, a decreasing the neutron pulse duration by at least in one order is proposed. It follows that the target multiplication should also be reduced by the same order, and the average power of the new linac beam should be significantly greater than that of LUE-40. The main parameters of the new LUE-200 linac are described and the current status of the facility will be addressed for this conference.

Loss of the electron beam cannot be permitted during beam's acceleration and transportation due to the high average power. The energy spread should be limited, mainly, by optimal conditions for transporting the beam and focusing it on the phototarget. This condition limits the emittance of the beam as well, because of the high heat generation in the target body. The spot of the focused beam cannot be smaller than *20 mm*.

Introduction

The scheme of the IREN facility is the following [1]. The accelerated electron beam is directed to the tungsten target-converter. The converter is the source of photoneutrons produced by the *(g, n)* reactions. The W-converter is surrounded by a fuel plutonium (Pu_{239}) core elements combined in groups (fuel assemblies).

For high-efficiency neutron production in the phototarget, the energy of the accelerated electrons must be greater than *60 MeV*. The upper limit for the electron energy is determined by necessity to locate the accelerator in an existing building and hence, by the maxim achievable acceleration gradient.

The basic project of the accelerator was performed by A.Novokhatsky team (Novosibirsk) [2]. The use of 5045 SLAC klystrons [3] should provide the continuous operation regime of the facility. Finally, the main parameters of the IREN facility is shown in Table 1, in comparison with those of IBR-30 [1].

As the neutron pulse duration is, mainly, determined by the multiplication time, the electron pulse duration is chosen to be < *0.3 msec*.

Table 1

Facilities	**IREN**	**IBR-30**
Neutron integral yield, *n/s*	1×10^{15}	5×10^{14}
Fast neutrons pulse duration, *ns*	*400*	*4500*
Neutron multiplication gain	*28*	*200*
Electron Linacs	**LUE-200**	**LUE-40**
Electron beam energy, *MeV*	*200*	*40*
Beam average power, *kW*	*10*	*2.5*
Electron pulse duration, *ns*	*250*	*1600*
Beam pulse current, *A*	*1.5*	*0.3*
Repetition rate, *Hz*	*150*	*100*

The repetition rate of the pulses should be limited by the existing experimental conditions and must be less than *200 Hz*.

The IREN project, including LUE-200, is realized by the efforts of a number of research and science centers, both from Russia and abroad. The accelerator sections, the buncher, SLED cavities, and some elements of the RF gun will be provided by the Budker Institute of Nuclear Physics (BINP), Nobosibirsk. The RF feeder has been designed and its manufactured is almost by the Moscow Engineering Physics Institute and ISTOK company (Moscow). The 5045 klystrons, with accessories and RF loads, will be provided by SLAC. The klystron modulators supplied by Yerevan Physics Institute are upgraded to the required parameters with the help of the Russian Institute of Powerful Radioconstruction. The vacuum equipment designer and manufacturer would be VACUUM PRAHA company. The target-converter have been designed by Science Research & Design Institute for Energy & Technology [4]. The focusing system and other elements of the transport channel will be provided by JINR.

Layout of the IREN Facility

The IREN project assumes the new facility will be positioned of in the building of the now-operating LUE-40 & IBR-30 JINR neutron source (see Fig. 1). The main elements of the LUE-200 accelerator and multiplying target will be placed in the three levels of the building [5]. The area of each level's is approximately *100* m^2.

The electron gun, buncher, first accelerating section, and 5045 klystron with its modulator, will be placed on the second level. In the same area all DC power supplies for the focusing

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system should be mounted. The second accelerating section is under the first one. The *700 mm* long diagnostics units will be located after the electron gun, between the accelerating sections and before the target. The second klystron with a modulator will placed on the first level.

The electron beam will be transported from the second accelerator section to the target throught a *12 m* long drift channel.

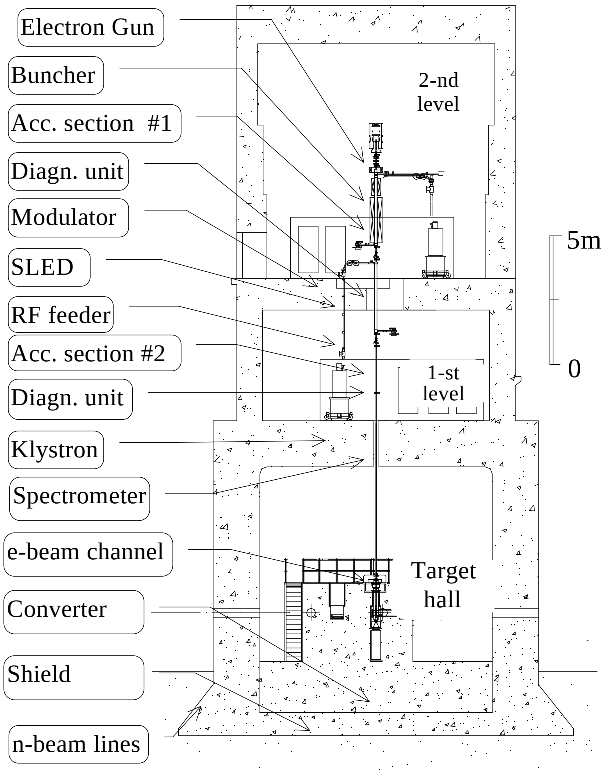

Fig. 1. IREN linac layout

Electron Gun

A pulsed electron beam is emitted by the grid-controlled electron gun having *12 mm* diameter oxide thermocathode. The electron gun developed by BINP for theΦ-factory injector [2] was used as a prototype of the electron source for IREN linacThe design of the gun advanced for the vertical arrangement is shown in Fig. 2; the main beam parameters are presented in Table 2.

Table 2

Electron energy	*200 keV*
Peak current	*5 A*
Pulse duration	*250 ns*
Repetition rate	*150 Hz*
Emittance	*£ 0.01 p ×cm ×rad*
Time jitter	*£ 1 ns*
Energy spread	*£ 2 keV*

The cathode heater and control unit of the gun are placed into a high presure tank under a high voltage cathode potential and fed by a coaxial ferrite HV transformer (*100W x 200kV*). The control block is triggered with an optical channel. The basic elements of the electron gun are being made by BINP and JINR.

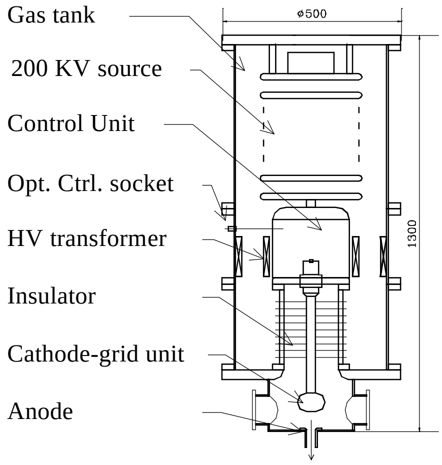

Fig. 2. The electron gun layout.

RF System

The accelerating structure of the LUE-200 consists of the buncher and two accelerating sections. It was initially designed for the Φ-factory injector at BINP. Each section is powered by a 5045 SLAC klystron with a SLED system. The length of the accelerating section is *3030 mm*, so the acceleration gradient is greater than *35 MeV/m.* The accelerating section and buncher is now being manufactured by BINP (Novosibirsk).

All RF components and vacuum equipment will be put together and certified at the IREN Full-Scale Test Facility (FSTF) [6]. At the present time the power supply for FSTF has been put into operation, the M-350 klystron modulator [7] is being tuned, and the SLAC 5045 klystron is being prepared for installation. FSTF program includes also RF and vacuum processing, the dark current measurement and development the RF diagnostic equipment for IREN. A numerical simulation of the IREN dark current is performed at this conference [8].

Focusing System

The focusing system should provide electron beam transport from *200 keV* to *200 MeV*. This system consists of two parts. In the first, where the beam energy is relatively low, a solenoidal focusing is used. In the second one, the beam is focused by quadrupole lenses.

The solenoidal focusing system is optimized to completely accept the beam from the gun and to compensate for the space charge influence at the bunching step and at initial stage of acceleration.

Transportation of the beam after the first acceleration section (where the beam has an energy above *100 MeV*) to the target is performed by nine quadrupole lenses.

The design of the focusing system elements has already been completed. The power supplies of the are under construction.

Target

The main elements of the target are shown in Fig. 3

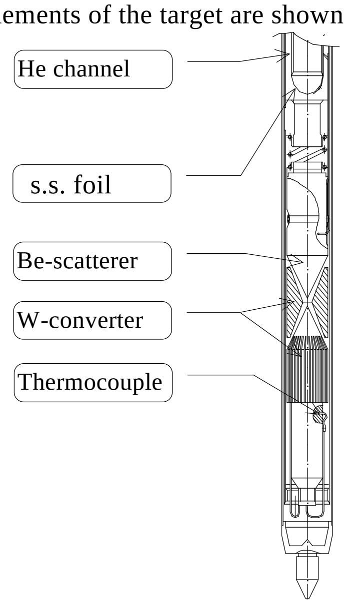

Fig. 3. Basic target-converter elements.

The Be-scatterer is placed before the tungsten target to increase the size of beam spot. The W-converter is cooled by gaseous He. The vacuum space is separated from the helium one with thin stainless steel foil. The temperature of this foil, as well as rhe temperature of the W-target, is controlled by a set of thermocouples. Recently, this scheme was investigated experimentally on the base operating facility, IBR-30. The thermal regime of this Be-W target as well as its neutron-production ability were measured [9].

Control System and Diagnostics

Three beam control and diagnostics units will be mounted at the linac. Each unit contains beam current and position monitors, a beam scraper and a profile monitor.

The accelerated beam energy and energy spread should be monitored with a spectrometer. The use of a magnetic spectrometer does not appear to be optimal because of the high average intensity of the electron beam. We are we studying now an opportunity to use non-destructive methods for advanced on-line beam diagnostics. Since the undulator output wavelength is a strong function of the beam energy the wavelength shift will be caused by energy shift. Observation of the optical transition radiation could provide information about beam size, emittance, etc.

The combination of high average power and high accelerating gradient cause us to pay additional attention to the thermostat system. The just-performed modernization of the existing thermostat scheme of the LUE-40 could be considered as a preliminary experiment. The accelerator section temperature vs. time dependence is shown in Fig. 4. To test the stability of the system, the temperature mode was changed from *40.0°C* to *39.0°C* at the moment t_1. At the moment t_2 the temperature regime was returned to its steady state *40°C*. Finally the thermostat system should be verified at the IREN Full-Scale Test Facility (FSTF) [6].

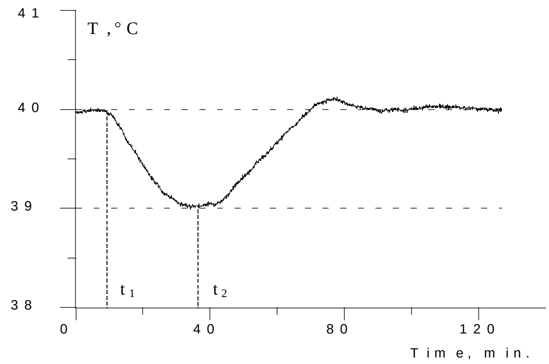

Fig. 4. The temperature of the accelerating section. At the moment *t1* the thermal mode was changed from *40°C to 39°C*, and at the moment *t2*, it was returned to *40°C*

Conclusion

The IREN's team nearest plans are the equipment manufacture and adjustment of the IREN RF full-scale test facility.

Acknowlegments

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