Positron Production and Focusing Section for the SPring-8 Linac

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As the SPring-8 is a commercial operating machine, We are planning to use positrons to avoid ion-trapping in the SPring-8 Storage Ring. The positrons will be generated in the SPring-8 Linac at 250MeV section, and accelerated up to 900MeV at the end of the Linac. For redusing an injection time to the Storage Ring, we have to achieve high electron/positon conversion efficiency as possible.

In order to design an electron/positron convertor (target and focusing system) for the Linac, we constructed a test apparatus mounted with the JAERI Linac at Tokai Establishment, JAERI in 1991, and obtained energy spectrums of the generated positrons with various parameters of focusing system. Also, we developed a simulation code of tracking particles in the positron focusing section.

The test apparatus is shown in FIG.1. It consists of a removable tungsten target (insert or pull out), a focusing section (a pulse solenoidal coil, a DC1 solenoidal coil, a DC2 solenoidal coil, an accelerator structure, and a quadrupole magnet), and a measurement section (an energy analyzing magnet and a Faraday-cup). Electrons bombard the target with an energy of about 90MeV. Generated positrons are focused and accelerated up to ~35MeV in the focusing section.

The simulation consists of two codes. One is EGS4 and another is our original tracking code. EGS4 is Montecalro code. It calculates positron production at the surface of the tungsten target and provides initial data to the tracking code for tracking through the focusing section. In the test apparatus, variable parameters are magnetic field of focusing section and rf power to the accelerator structure which are important information as design parameters. And these are also variable in the tracking codes. More informations of the codes are in ref. [1],[2],[3].

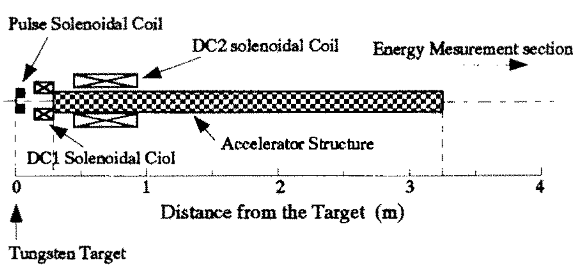

FIG.1 Outline of the test apparatus

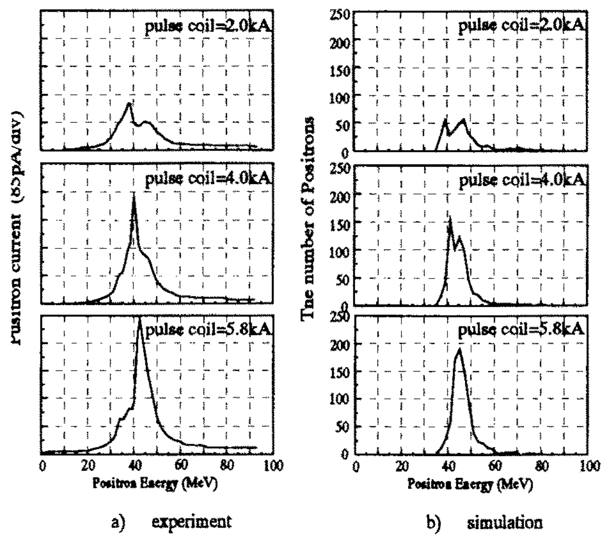

FIG.2 Energy distributions of produced positron

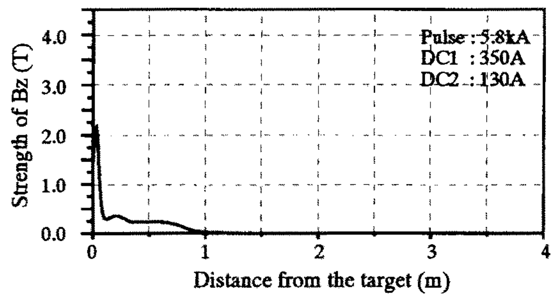

FIG.3 Magnetic field distribution of the test apparatus

TABLE.1 experiment parameters

Target	Tungsten
Target radius	10.0mm
Target thickness	6.0mm
Ingected electron current	150nA(average)
Injected electron energy	90MeV
Repetition rate	5pps
Pulse width of electron current	1 μ sec
Energy gain of positrons	33.1MeV

FIG.2 shows representative data of simulation and experiment. These are energy distributions of positrons at the final point of focusing section. In FIG.2, variable parameter is current of pulse solenoidal coil. Parameters of the DC1 and DC2 coils and rf power for the accelerator structure are fixed. Magnetic field distribution is shown in FIG.3, which corresponds to the case of bottom graph in FIG.2. TABLE.1 shows experiment parameters of FIG.2.

From the FIG.2, figure of distribution in simulation data qualitatively accords with that in experiment data. Further more, when the other parameters are varied, DC1 or DC2 coils, they are also in agreement qualitatively. Other data can be referred in ref.[4] in Japanese and in ref.[5] in English respectively.

In the FIG.2, a lower side peak in the energy distribution shifts to right hand side as the pulse solenoidal current increases. From this, the pulse solenoidal coil has selectivity of positron energy. Other coils don't have such contribution[4]. This is important issue for designing the focusing section.

A conversion efficiency of generated positrons at the end of the focusing section against injected electrons is obtained of 0.077% in FIG.2 simulation data, where generated positrons energy is 0~50MeV on the surface of the target. Within the limited energy, the peak ± 1MeV, the efficiency is 0.018%.

In the experiment data, energy resolution at the peak is about ± 1MeV, and an efficiency of positron current at the peak against injected electron current is 0.01%, which is comparable with simulation data of 0.018%. So experiment efficiency is 55% of simulation data. Reason of this difference is not cleared to us enough, but all other data show around this rate.[4]

Now, the positron focusing section is under construction by Mitsubishi Corporation. Its outline is shown in FIG.4. Capable magnetic field will be update in FIG.5. For designing this section, some studies are referred. From simulation data of tilting pulse solenoidal coil , the efficiency was appeared to decrease a lot.[2] So the pulse solenoidal coil has adjustable mechanism for tilting. The efficiency increase were observed in the simulation when magnetic field distribution of DC2 solenoidal coils is not uniform, so 3 power supplies will be prepared independently to drive 6 DC2 solenoidal coils.[2] The actual conversion efficiency will be predicted of around 0.3% from above rate and ref.[2].

Further studies of superconducting magnets are

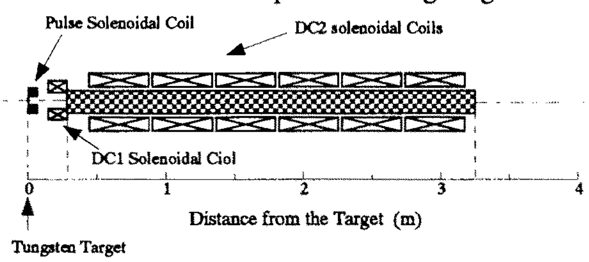

FIG.4 Outline of the focusing section for the Linac

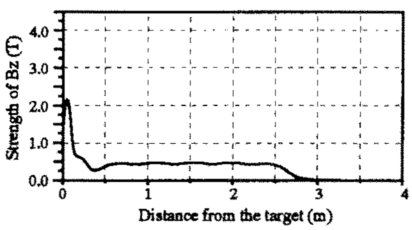

FIG.5 Magnetic field distribution of the SPring-8 Linac

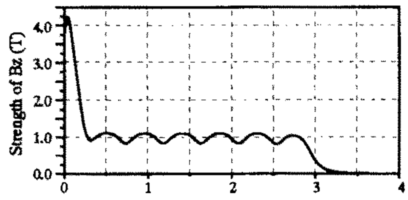

FIG.6 Magnetic field distribution for future plan

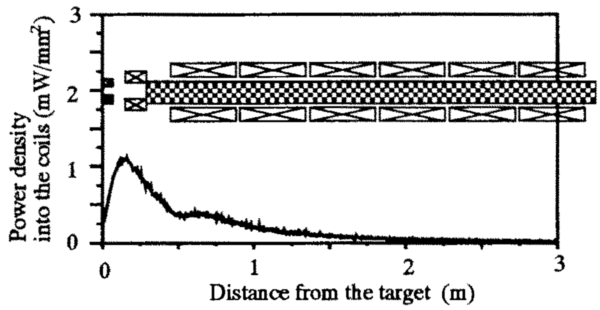

FIG.7 Incident heat power to the coils

mentioned below. In this system, maintenance-free refrigerated super-conducting magnet is used instead of liquid helium type.[6] FIG.6 shows capable magnetic field distribution with new type superconducting magnet system. In this system, a DC coil is used instead of the pulse solenoidal coil. But keeping superconductivity against incident radiation power to the coils, which are provided by neutrons, electrons, positrons or photons, is severe problem. FIG.7 shows EGS4 simulation data of distribution of the incident power to the wall of the coils with full power injection to the target. (except for contribution of neutrons) In this case, an inside diameter of the DC coil will be made larger, and a lead will be inserted between the target and the coil. But the incident power to the DC coil of 16W is about one order lager than the level of keeping superconductivity. So this system can not to be acceptable this time, it is one of a theme in the future.

The positron generation and focusing section will be accomplished by the end of this year.

References

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