AN ACCELERATOR FACILITY FOR WDM, HEDP AND HIF INVESTIGATIONS

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Nazarbayev University in Astana, Kazakhstan, is planning to build a new multi- MV, ~10 to several hundred GW/cm^2 ion accelerator facility which will be used in studies of material properties at extreme conditions, and for hydrodynamic experiments relevant to ion-beam-driven inertial fusion energy. This new accelerator, which is named Nazarbayev University Research Accelerator (NURA), is conceived to be one of the two design options described below.

The first and more mature option is a 1.5 MV induction linac with an architecture similar to the Neutralized Drift Compression Experiment (NDCX-II) at LBNL, but with two important differences [1, 2]. The NURA conceptual design is based on accelerating helium ions (NDCX-II was originally designed for lithium ions) and will use electrostatic quadrupole focusing instead of solenoids [3]. Through neutralized drift compression, the 70 nC beam pulse at the target will be less than 1 ns pulse duration, which will be focused a beam spot size about 1 mm to reach power densities of ~10 GW/cm^2.

The second option being considered is a 2-3 MV, ~200 kA, single-gap-diode proton accelerator based on an inductive voltage adder. The high current proton beam is focused to ~1 cm spot size to obtain power densities of several hundred GW/cm^2, in order to heat thick targets to temperatures of tens of eV. In comparison to the linac, the ion beam generated by a high-power ion diode typically has higher current but lower brightness (ion temperature of $\geq$10 eV instead of 0.1-0.5 eV for the linac). The pulse duration is longer (tens of ns), and the spot size is larger (~cm). While the induction linac design (like NDCX-II) is suitable for sub-nanosecond Warm Dense Matter (WDM) studies, the high power diode accelerator is more favorable for studying High Energy Density Physics (HEDP) hydrodynamics at the tens of nanoseconds time scale and tens of eV temperature.

In both cases, a common requirement to achieving high beam intensity on target and pulse length compression is to utilize beam neutralization at the final stage of beam focusing. For example, the required plasma density at NDCX-II to neutralize the beam charge near the target is $n \sim 10^{13}$ cm^{-3}. On the other hand, the single-gap ion diode may require even higher plasma density to neutralize the ion beam.

The experiments on pulsed ion beam neutralization will be carried out on a 0.3 MV, 1.5 GW single gap ion accelerator at Tomsk [4]. The goal is to first create a plasma region in front of a target, at densities exceeding $n \sim 10^{12}$ cm^{-3}, followed by construction of an ion diode capable of delivering hundreds of amperes of proton beam with kinetic energy of a few hundred keV, for studying beam neutralization and compression. Progress of this experiment and the NURA facility design will be reported at the conference.

[1] See paper on NDCX-II experimental recent results in this conference (P. Seidl, et al.)
[2] W. L. Waldron, et al. Nucl. Inst. Methods Phys. Res. A, vol. 733, pp.226 -232, 2014
[3] K. Baigarin, A. Tikhonov, A. Urazbayev, et al., Proc. 20th International Symposium on Heavy-ion Inertial Fusion, HIF-2014, Lanzhou, China, August 11-15, 2014, p.154
[4] E.G. Furman et al. Technical Physics, 2007, Vol. 52, No. 5, pp. 621–630