Status of GOL-NB Project

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I. INTRODUCTION

New GOL-NB open trap is currently under development in the Budker Institute of Nuclear Physics [1]. The trap is a scaled-down physical model of a future fusion-grade reactor system. It combines physics and technology from two different branches of open traps with a central section for gas-dynamic plasma confinement and two adjacent multiple-mirror solenoids that will decrease particle and energy losses along the magnetic field.

Plasma parameters in axisymmetric open confinement systems are usually defined by the power balance between an external heating and losses along the magnetic field. Any improvement in axial confinement will lead to an improvement of the fusion performance of such system. Linear topology of open traps enables modular designs of their magnetic systems. The conceptual project of the GDMT next-generation open trap [2] considers multiple-mirror sections as an important element that significantly improves confinement properties of a central gasdynamic trap.

The main physical task of GOL-NB is the direct performance demonstration of the multiple-mirror sections that will change the escaping plasma flow and equilibrium plasma

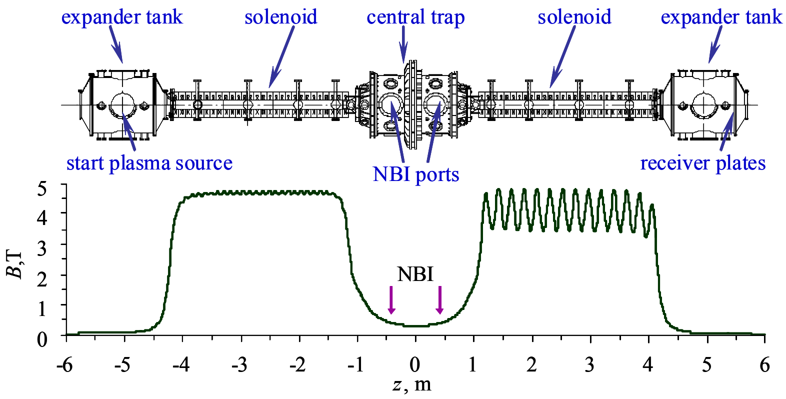
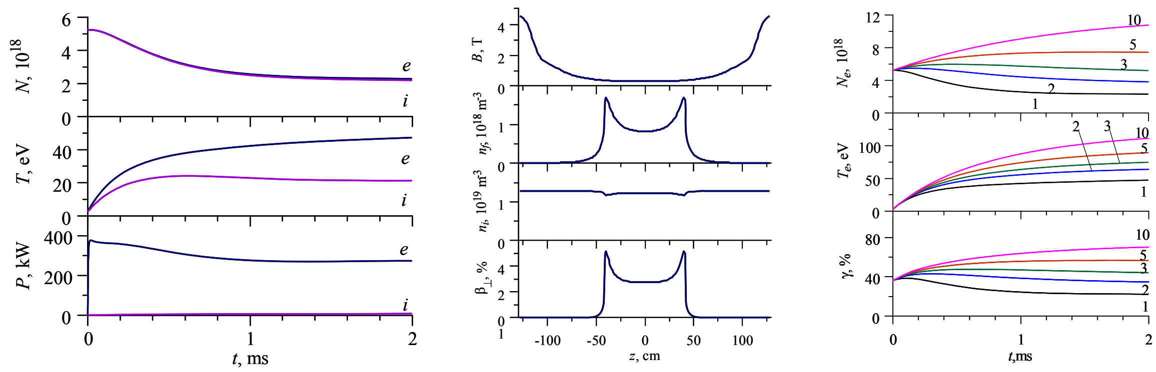


Figure 1. Top: layout of GOL-NB. Bottom: the magnetic field profile at the axis.

parameters in the central trap depending on the magnetic configuration in solenoids. The general layout of GOL-NB is shown in the Fig. 1. It consists of the central trap with two 0.75 MW NBIs, two solenoids, two expander tanks and a plasma gun that creates start plasma. Detailed discussion of physics and hardware of GOL-NB can be found in [3]. Simulations [4] predict that plasma temperature in the central trap will reach 70-100 eV in the multiple-mirror configuration comparing with 30 eV in the standard gas-dynamic regime (at mirror ratio R = 15, density $n = 3\times10^{19}$ m^{-3} and 1.5 MW NBI). In this paper, we discuss the progress made since the previous EPS conference. The assembly of an initial configuration for the commissioning of GOL-NB subsystems has been started.

II. GOL-NB PHYSICS

The GOL-NB device is a support experiment that should explore multiple-mirror confinement (initially proposed in [5]) and provide the required knowledge base and scalings for larger GDMT project. For the central trap, we suppose that all known physics from the GDT experiment [6] will work and all technical solutions found by GDT team can be reproduced for the new device. Each solenoid can be configured for a uniform magnetic field (like the left one shown in Fig. 1) or as a multiple-mirror system (like the right one). This will enable us to separate effect of the corrugated field on plasma parameters from other experimental factors. The mirror ratio R = 15 for $B_{z=0}$= 0.3 T is low enough; this makes the axial power and particle losses dominant in GOL-NB that simplifies the related physics.



(a) (b) (c)

Figure 2. (a) Basic parameters without the multiple-mirrors: total number of particles in the trap N, temperature T, and power from fast ions to warm plasma P. (b) Axial profiles without the multiple-mirrors at $t = 2$ ms: magnetic field at the axis B, fast ions density n_f, warm ions density n_i, and relative transverse pressure of fast ions $\beta_{\perp}$. (c) Plasma parameters at different suppression of plasma flow by multiple-mirror field (shown as numbers near curves): total number of electrons in the trap N_e, electron temperature T_e, and beam capture efficiency γ.

The central trap will confine two-component plasma that will consist of thermalized warm plasma and fast beam ions. Captured beam ions will decelerate mainly in collisions with electrons down to thermalization. The warm plasma will be confined in gasdynamic regime. The requirement of warm plasma collisionality there will be satisfied automatically because of the condition $l \leq \lambda_i << L$ that is required for the multiple-mirror confinement. In GOL-NB, the central trap is simply a plasma source that provides a flux of moderately-hot plasma through mirrors. Figure 2 shows some simulation results for the baseline regime from the DOL code (adapted from [4]).

III. GOL-NB HARDWARE

The project was optimized under the existing funding constraints that led to some important compromises in its technical and physical parameters. The device will reuse some infrastructure and hardware from our previous GOL-3 beam-plasma experiment [7]. It will occupy a part of current GOL-3 experimental area that houses several independent experiments now. Currently, an initial configuration of GOL-NB is assembled in the available space. It will be used for commissioning of NBIs and some other systems. The device currently includes the full-size right solenoid, a short section of the left one, expander tanks with pumping systems and temporary vacuum section with ports for NBIs – see Fig. 3.

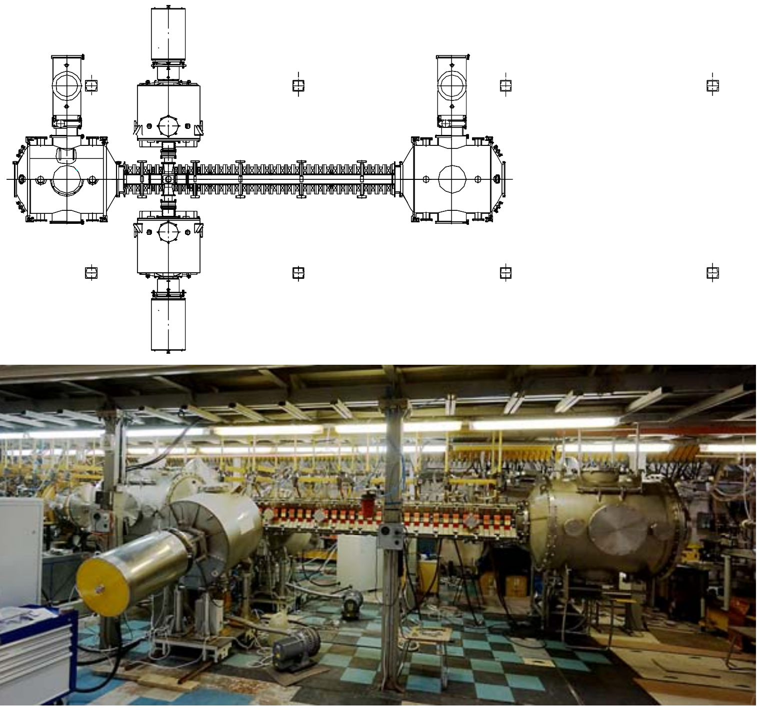


Fig. 3. Layout and photo of the initial configuration that will be temporarily used for the commissioning of main subsystems. Spacing between the structural columns is 3 m.

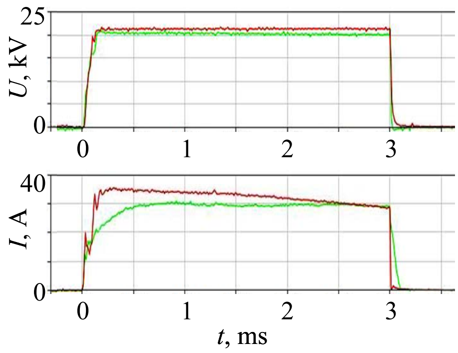


Fig. 4. Current parameters of beams from ion sources (red lines for NBI1, green lines for NBI2).

Both neutral beam injectors [8] are now in operation with the regular power supplies and control systems; parameters of the beams are gradually improving due to grids training and regime optimization – see Fig. 4. Several major components of GOL-NB including the central trap with its magnetic system are in the manufacturing now.

IV. SUMMARY

New linear trap GOL-NB will be created in Budker Institute of Nuclear Physics in a timeframe of several years. This device will combine physics of two existing linear magnetic configurations, namely gas-dynamic in the central trap and multiple-mirror in attached high-field solenoids. Depending on the magnetic configuration of the adjacent multiple-mirror solenoids, the baseline plasma losses through mirrors will change thus changing the confinement. GOL-NB project is designed as a low-cost supporting experiment that should improve the knowledge base required for the fusion-grade next step GDMT project. The construction schedule actively uses one of the engineering advantages of open systems over toroidal devices; currently GOL-NB operates in the start configuration with the available hardware. In addition to the multiple-mirror configuration that provides a passive method of improving the confinement, a novel active plasma flow control system with a helical mirrors will be studied in BINP in the SMOLA device (see P1.139 and [9]).

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