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Status of Activity on GOL-NB Multiple-Mirror Experiment

V. V. Postupaev, V. I. Batkin, A. V. Burdakov, V. S. Burmasov, I. A. Ivanov, K. N. Kuklin, N. A. Melnikov,
K. I. Mekler, A. V. Nikishin, S. V. Polosatkin, A. F. Rovenskikh, E. N. Sidorov, and D. I. Skovorodin

Budker Institute of Nuclear Physics, Novosibirsk, Russia
V.V.Postupaev@inp.nsk.su

Introduction

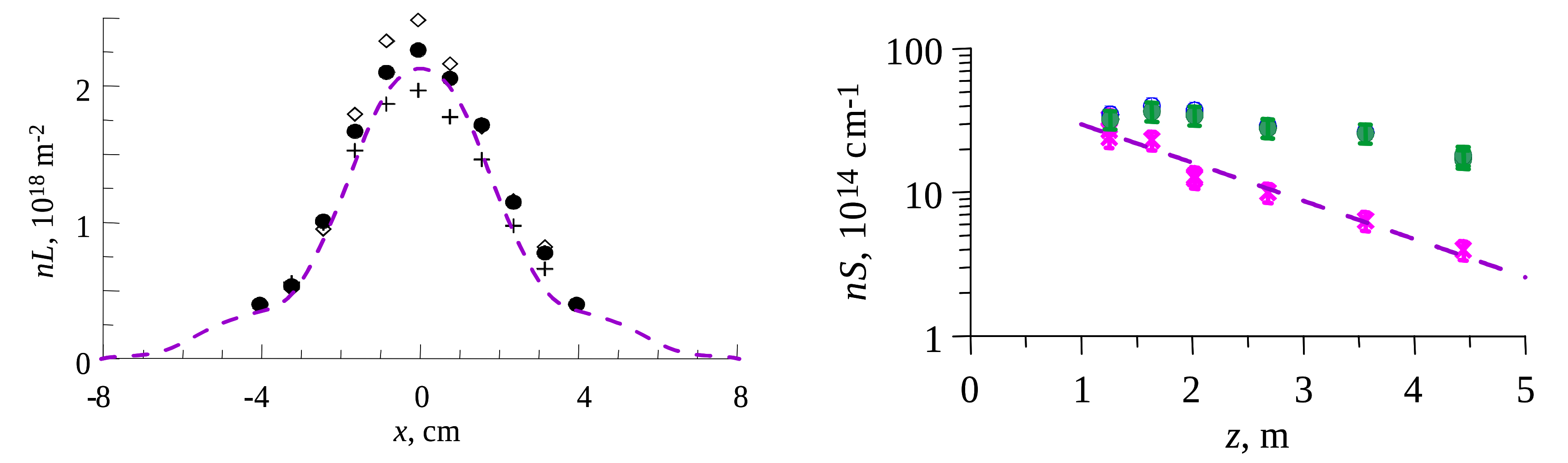
The multiple-mirror confinement idea was introduced as the method of suppression of the longitudinal plasma expansion by a multiple-mirror (periodically varying along the axis) magnetic field. The friction between transiting and locally-trapped particle populations transfers momentum from the plasma flow to the magnetic field and therefore slows down the flow. This technique is effective at moderate collisionality, at an ion free path length comparable with the corrugation period of the magnetic field. A recent review of the multiple-mirror confinement can be found in [1]. The GOL-NB multiple-mirror experiment is under construction in BINP.

The GOL-NB Experiment

- GOL-NB is the first device with the magnetic system that includes the central trap for plasma confinement and two attached multiple-mirror sections for improving the energy and particle confinement [2].
- The magnetic structure can operate as the gasdynamic trap with classical short mirrors, as the trap with long collisional mirrors and as the multiple-mirror system. This makes differences in confinement evident.
- A low-temperature start plasma is generated by an arc gun placed in the end expander tank and then populates the central trap after transport through the high-field section.
- Plasma will be heated by two 25 keV, 0.75 MW neutral beams.
- The trap was intentionally designed with large particle and energy losses along the magnetic field; this makes differences in axial confinement more evident.
- 1-D kinetic simulations by the DOL code predicted $T \sim 40$ eV at 3×10^{19} m^{-3} in the worst-case gasdynamic configuration.
- Direct demonstration of the confinement and plasma parameters improvement at the transition to the multiple-mirror configuration is the main goal of the GOL-NB program.

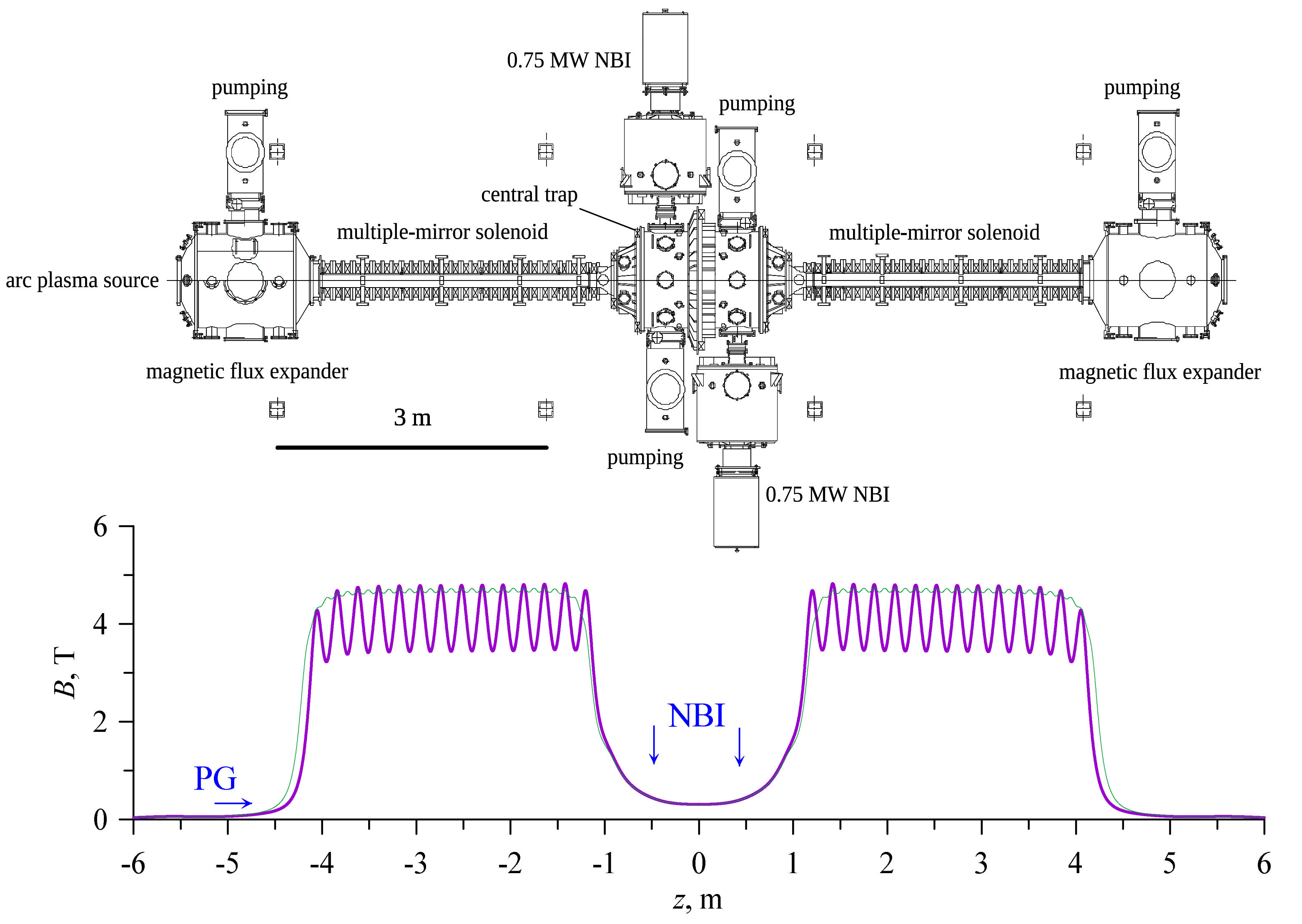
Cold Plasma Transport in Multiple-Mirror Magnetic Field

- In a preliminary experiment [3], the first direct comparison of the flow of the low-temperature collisional plasma through the multiple-mirror system and the solenoidal field was done. No significant differences were found, exactly as was predicted by theory. This assures us that filling the central trap with the start plasma will go as it was planned.
- In experimental campaign of 2020, we optimized the operation regime of the plasma gun thus improved the efficiency of the start plasma transport along the high-field section.
- New diagnostic neutral beam confirmed previous Langmuir probe data.

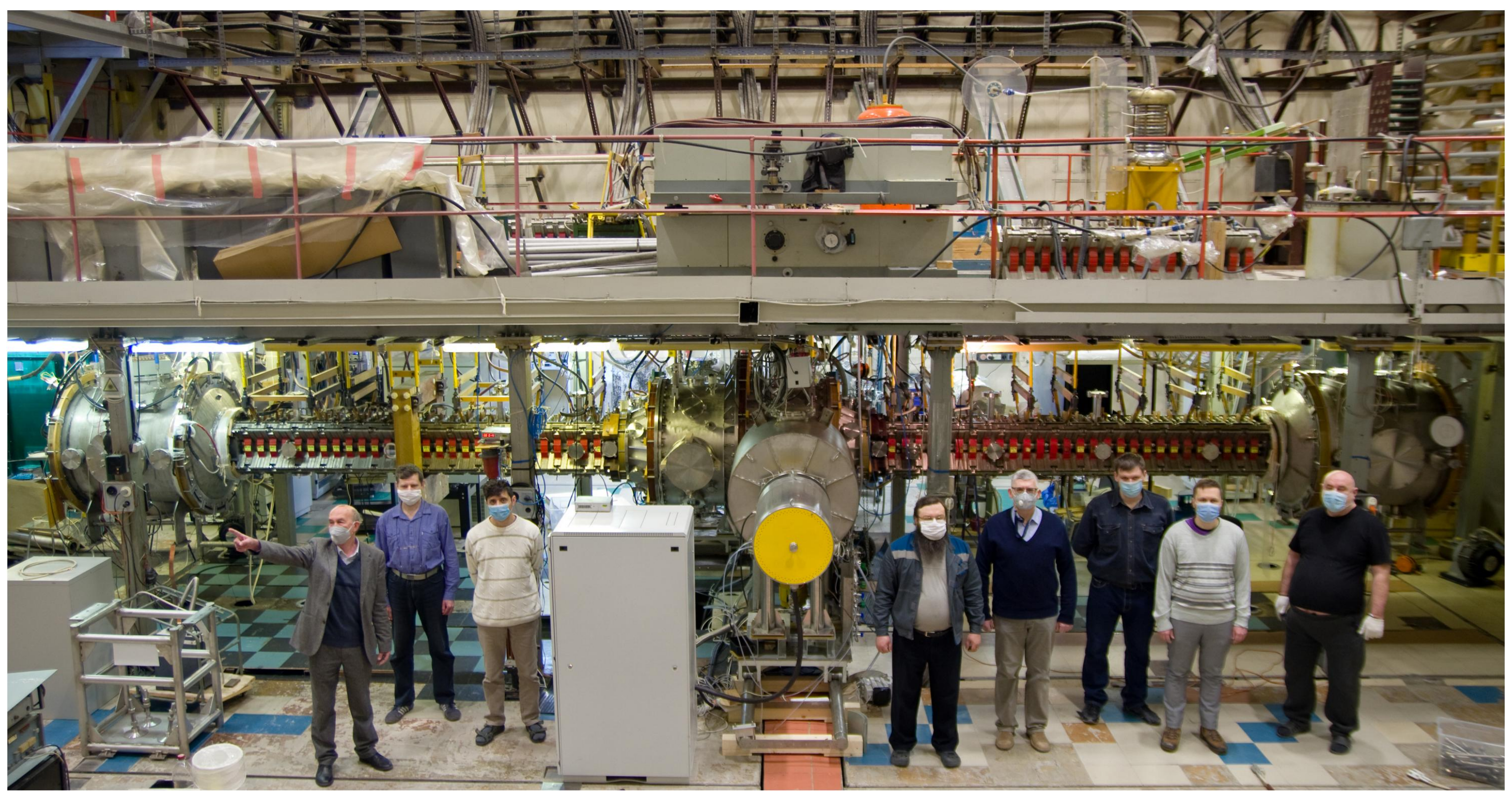


Left: dependence of the line-integrated density on the chord radius from DNBI data (three shots are shown by different symbols) compared with a fit of the Langmuir probe data (dashed line). Right: dependence of number of ions per unit length on the axial coordinate before (crosses and exponential fit [3]) and after (dots) optimization of the plasma gun operation regime

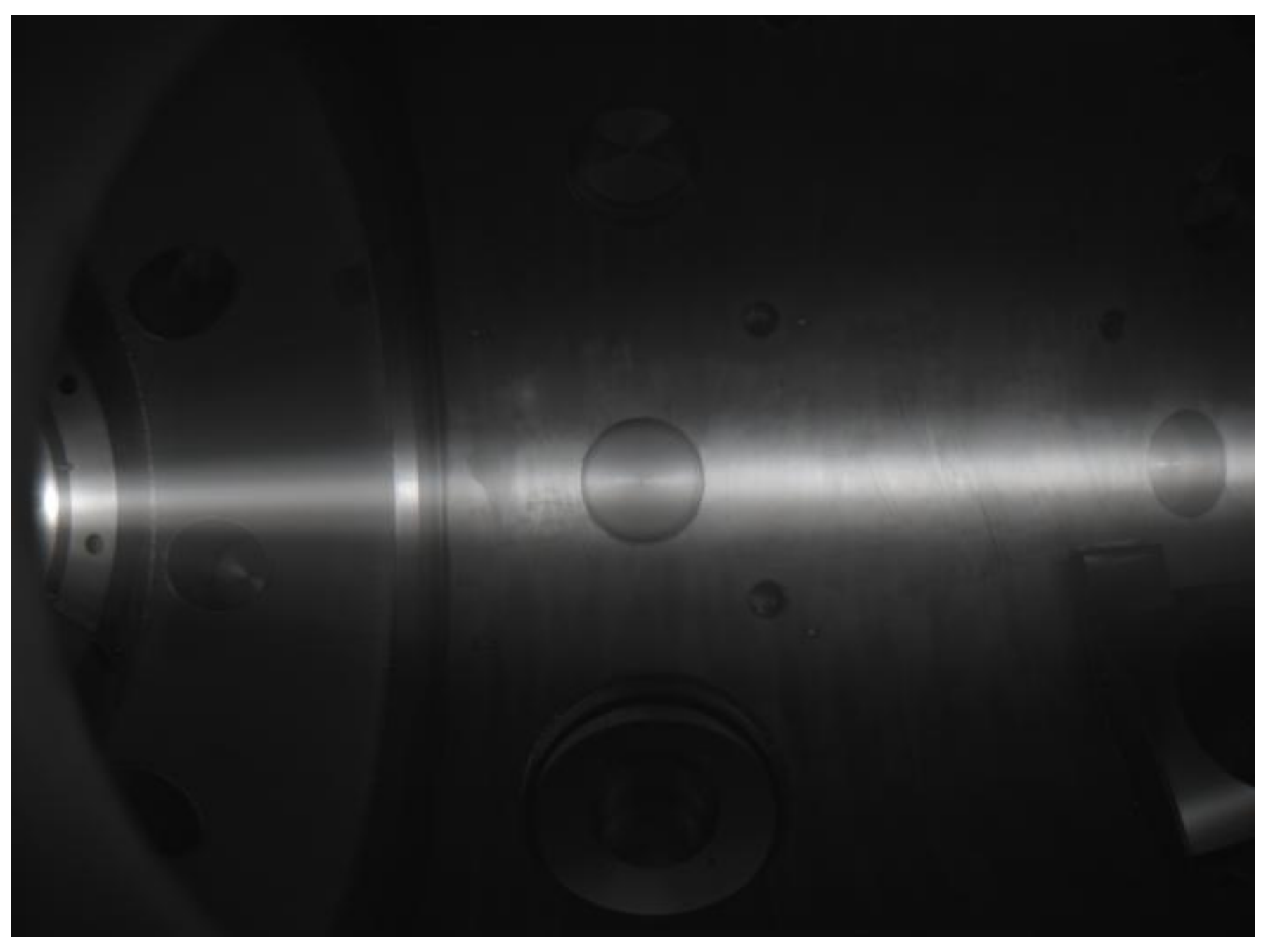
Status of the Device Assembly



Layout of GOL-NB (top view) and magnetic field profile at the axis in the solenoidal and multiple-mirror configurations



GOL-NB during the assembly under COVID-19 restrictions



The start plasma in the central trap

Summary

- GOL-NB is assembled in full design configuration.
- The magnetic and vacuum systems deliver the design parameters.
- A limited start set of diagnostics is operational.
- Both neutral beam injectors are in on-site performance optimization.
- With the start configuration of GOL-NB, we confirmed the old theory prediction on low influence of a multiple-mirror magnetic field on propagation of highly-collisional plasma flow.

References

1. Burdakov, A.V., Postupaev, V.V., Phys. Usp. 61 (2018) 582–600.
2. Postupaev, V.V., et al., Nuclear Fusion 57 (2017) 036012.
3. Postupaev, V.V., et al., Plasma Phys. Control. Fusion 62 (2020) 025008.