

STATUS OF THE ULTRA-COLD POLARIZED JET FOR NEPTUN AND NEPTUN-A AT UNK

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ABSTRACT

After tests of the prototype ultra-cold polarized jet, the jet assembly for use in the experiment NEPTUN-A at UNK is being designed, built, and tested at the University of Michigan. Planned improvements include a more powerful refrigerator, a 12 T high-gradient solenoid, and a superconducting focusing sextupole. In this talk the design and present status are described.

The experiments NEPTUN¹ and NEPTUN-A² at UNK, IHEP require a polarized hydrogen gas target. Expected beam size and limits on background gas density set by the experiments preclude the use of the storage cell technique to increase target thickness. We therefore decided to concentrate efforts on an ultra cold free jet.

In this type of atomic beam source atoms are cooled from about 25 K to about 0.3 K in a strong magnetic field gradient. For the present tests, for example, cooling took place at about 6 T in the gradient at one end of a solenoid with a maximum central field of 8 T. Once cooled, the thermal energy of the atoms, kT , is much lower than their magnetic energy, $\mu_e B$, so the field gradient separates the atoms according to electron spin direction. Atoms in the two upper hyperfine states are accelerated out of the field to form a beam, with an energy corresponding to a temperature of several kelvins.

For tests of this concept we used a prototype device³. The refrigerator in this device had a cooling power of 25 mW at 350 mK at the mixing chamber, inside of the solenoid. The beam transport and analysis systems consisted of a concave mirror, a focusing sextupole magnet and a compression tube. Drift lengths were similar to those required for the working target. The highest measured flow into the 0.5 cm² aperture of the compression tube was 3.7×10^{15} /s, corresponding to a density of atoms of 3×10^{11} /cm³.

We know that the flow achievable in the present system is limited by, among other things, the refrigerator cooling power, the efficiency of cooling of the atoms, and transport efficiency of the beam. In order to increase focused beam density, cryogenic efficiency, and reliability of operation a new jet, shown in the Figure and intended for use at UNK, is being designed and built. Among the features of the new device are the following:

- a fully vertical design to match required experimental access.
- full shielding of liquid helium-temperature components by liquid nitrogen-cooled shields.

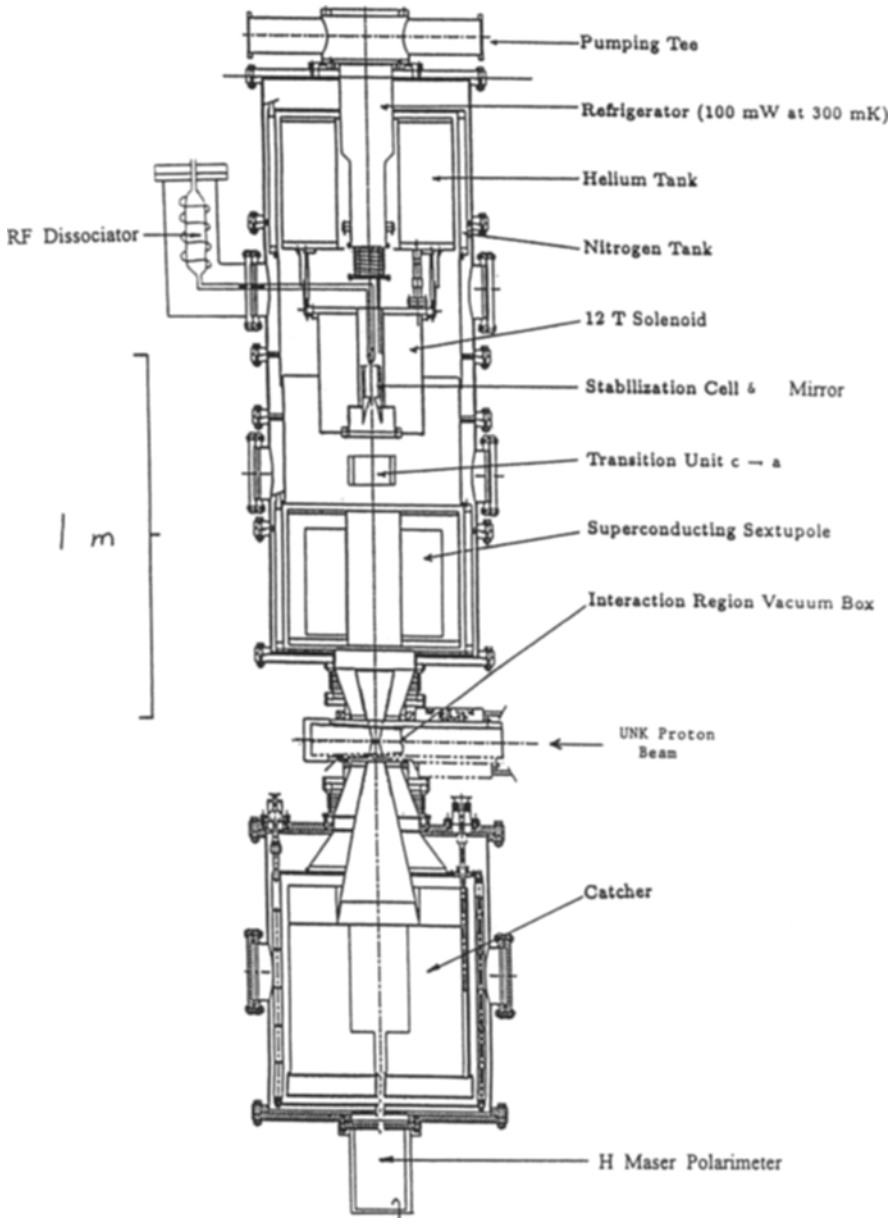


Figure 1. The layout of the polarized hydrogen jet for the experiments NEPTUN and NEPTUN-A at UNK, Protvino, Russia. Scale is approximate.

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- a dilution refrigerator with a cooling power of 100 mW at 300 mK, circulating 30 millimole/s of ^3He .
- a refrigerator mixing chamber designed to provide the maximum possible cooling of the exit aperture and mirror. The mirror shape itself is being designed using more complete calculations than were used for the test mirror.
- a separation solenoid with a maximum central field of 12 T, compared to 8 T used in the tests. This solenoid also has a bucking coil at the beam-output end, resulting in a fast fall off of the axial field. This allows the possibility of installing a 2 to 4 rf transition unit. The design of this unit is being studied.
- a focusing sextupole magnet, 20 cm long and having an 11 cm diameter bore, with superconducting coils on iron pole pieces. The maximum pole-tip field will be about 0.8 T. Use of a cold magnet allows cryopumping along most of the atomic beam path.
- a catcher, consisting of a large cryocondensation pump operating at 3 K. There will also be baffles and cryopanel above and below the UNK proton beam. With this arrangement we expect to achieve a background gas pressure in the interaction region of 3×10^{-9} torr.
- a maser polarimeter below the catcher to monitor atomic state populations and thus electron and proton polarizations. Proton polarization will also be measured by measuring the elastic scattering asymmetry in the Coulomb-nuclear interference region.

With these improvements we expect to reach atomic densities of over $5 \times 10^{12}/\text{cm}^3$ in the area where the high energy beam crosses the atomic beam. We expect to have the atomic beam 2cm wide along the high energy beam direction, giving a target thickness of over $10^{13}/\text{cm}^2$.

Most of the vacuum chambers and the upper jet helium and nitrogen reservoirs have been built and tested. These were mounted and used last fall for a successful test of the 12 T solenoid. Parts of the refrigerator are being designed and manufactured now, with assembly to begin this summer and cryogenic testing expected to begin late this fall. The conceptual design of the sextupole is complete. Discussions with one possible vendor of the coils are continuing. The catcher design is complete and parts are being machined. The maser polarimeter is now undergoing final tests at MIT. Depending on how quickly tests of refrigerator can be completed, we hope to begin atomic beam tests early in 1994.

ACKNOWLEDGEMENTS

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