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NEUTRAL BEAM DEVELOPMENT AT THE LAWRENCE BERKELEY AND LAWRENCE LIVERMORE LABORATORIES

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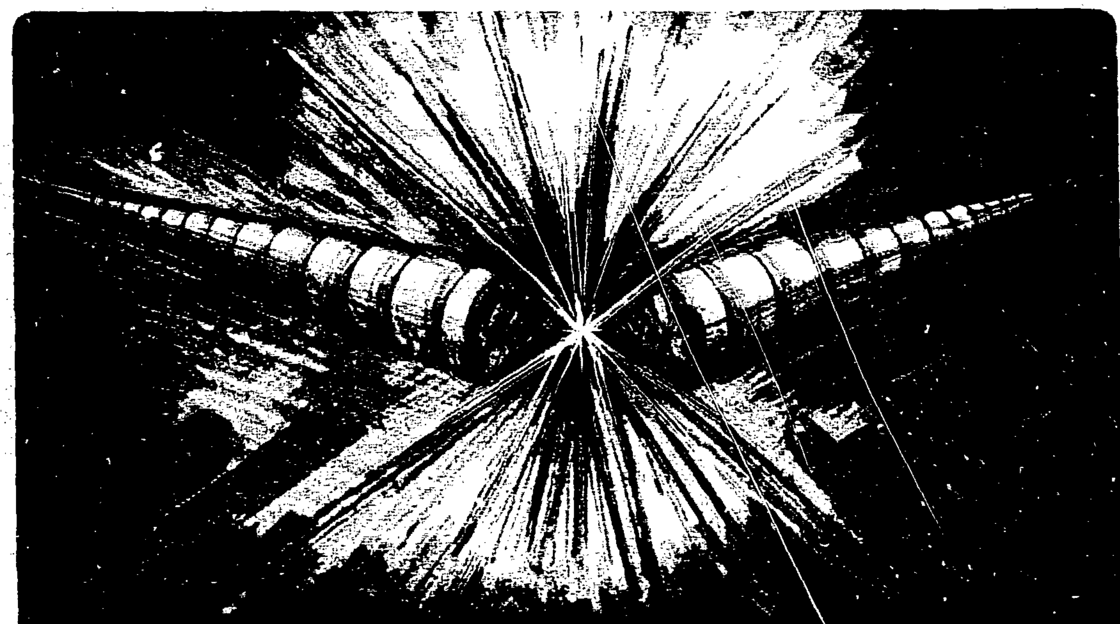

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Summary for
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The Lawrence Berkeley and Livermore Laboratories Neutral Beam Development Group's work proceeds along two lines: The first is required for the near-term applications (e.g., MFTF, TFTR, and DIII), which require injection at energies up to 120 keV, ion currents per module up to 80 A, and pulse lengths ≥ 0.5 s. These systems are based on the acceleration and neutralization of positive ions. The second part of our program is devoted to development for longer-term applications: positive-ion-based systems with 150-200-keV/65-100-A/10-30-s modules and, somewhat later, negative-ion-based systems for injection at 200 keV and higher energies.

Development programs are based on research, in our case primarily devoted to atomic-collision and plasma physics topics associated with neutral beam systems. These studies involve graduate students and professional experimental and theoretical staff. The main emphasis at present is on negative ion production and neutralization, the ionic species distribution in an intense discharge, and plasma effects in neutralizers. This work is supported by the Office of Fusion Energy Division of Applied Plasma Physics.

Application to hardware R&D is managed by the OFE Division of Development and Technology. We start by building fractional-area modules that can be extrapolated to full-size modules when the understanding of the design problems is far enough along. To date, several full-scale 80-120-keV/

65-80-A/0.5-s positive ion (MFTF, TFTR, DIII) sources have been built and tested with a short-pulse (25 ms), high-voltage power supply after one-fifth to one-fourth area modules had been tested for the full pulse length (0.5-1.5 s). Two full-size TFTR-type sources have been operated at 120 kV/60 A/0.5 s with deuterium at the LBL/TFTR Neutral Beam Engineering Test Facility (NBSTF), and the MFTF source has operated at 80 kV for 125 ms on the LLNL High Voltage Test Stand (HVTS).

The accelerator electrodes of these modules are cooled only at the edges, so the heat transfer is inadequate for pulse lengths more than about 1.5 seconds. To permit long-pulse operation a water-cooled 120-150 keV/15-A dc module has been built and testing is in progress; the construction of a full-scale 50-A module is well along.

Direct recovery of the energy of unneutralized ions is an important long-range objective. Experiments with 100-keV helium and hydrogen beams showed over 50 percent power recovery efficiency; however, we do not have an active program on energy recovery at present.

Until last year the negative ion program has concentrated on production of negative deuterium ion beams by double charge exchange in cesium and sodium vapors. D^- currents of about 2 A have been obtained. Recently a surface-formation negative ion source has been built; it produces about 0.5 A of negative ions in long (30-s) pulses. A 1A model is under construction. This type of source offers apparent advantages over the double-charge-exchange negative ion approach and will be used to produce 40 keV long-pulse beams during the next year. Our first goal for a system of interest to potential users is to produce a dc, ~ 1 MW beam at 200 keV. Achievement of this goal appears to be at least five years away.

A large part of our effort in recent years has been the development of suitable test facilities. In the process of designing and constructing them, it has been necessary to develop new concepts and components for the high-power electronic circuits, and new diagnostic technology. Two neutral beam facilities, the 80-100-kV/65-100-A/1-s HVTS at LLNL and the 120-kV/65-A/0.5-s NBSTF at LBL, have sufficient neutron shielding to permit extensive operation with deuterium. A 150-kV/15-A/5-s facility (TSIIIA at LBL) has recently been completed for testing fractional-area advanced positive ion sources. The NBSTF will be upgraded this year for 1.5 s operation, and in about 2 years for 170 kV, 65 A, 30 s operation. The HVTS will be upgraded to operate at 80 kV, 88 A, 30 s. A test facility for high-power-negative-ion-beam development does not exist at present.

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