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R. Valicenti
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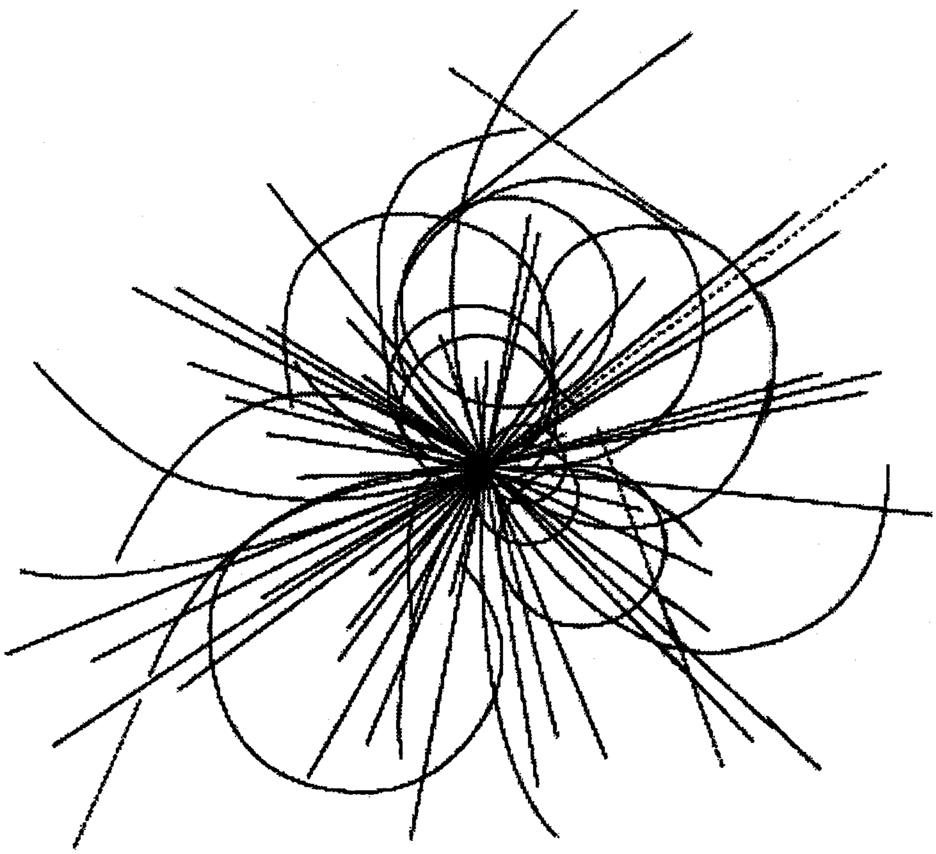

Superconducting Super Collider Laboratory

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R. Valicenti, J. Lenz, N. Okay, L. Plesea, and K. Saadatmand

Superconducting Super Collider Laboratory†
2550 Beckleymeade Ave.
Dallas, TX 75237

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Mechanical Integration of an RF Volume Source and Einzel Lens LEBT to the SSC RFQ*

R.A. Valicenti, J. Lenz, N.C. Okay, L. Plesea, and K. Saadatmand
Superconducting Super Collider Laboratory
2550 Beckleymeade Avenue, MS 4008
Dallas, Tx 75237-3946 USA

Abstract

The Superconducting Super Collider (SSC) LINAC Injector is currently operating with an RF-driven volume ion source coupled with an einzel lens Low Energy Beam Transport (LEBT).The ion source, LEBT and beam diagnostics are integrated into a compact vacuum enclosure which is mounted to the upstream endwall of the Radio Frequency Quadrupole (RFQ). Beam dynamic requirements imposed a minimum longitudinal space of only 23.5 cm, thus creating a very challenging packaging problem. In addition, optimum beam matching to the RFQ specified a maximum gap of 1 cm between the LEBT and the entrance endwall face, thereby excluding the use of a bellows between the LEBT chamber and the RFQ. Vacuum system induced loads and vibrations are isolated from the beamline components by the use of a straddling support frame which is an integral component of the vacuum system/ support cart. This paper will describe some of the unique aspects of the mechanical design resulting from beam requirements, high gas load, availability of the vacuum system and the need for unconstrained attachment to the RFQ. In addition, the mobile installation cart and the fully automated vacuum control system will be discussed.

I. INTRODUCTION

Figure 1 shows the SSC LINAC Injector set up for commissioning at its temporary location at the SSC Central Facility. The first 2.5 MeV output beam was successfully produced on April 8, 1993. With 30 mA at 35 keV out of the source, the Injector output current was 18 mA, 60% of specified transmission. An extensive experimental schedule is planned to fully characterize all injector subsystem components in order to maximize their performance and reliability, thereby insuring the long term availability of the LINAC.

The ion source and LEBT subsystems of the Injector are not configured as fixed, floor mounted devices, but instead are integrated into a mobile vacuum system /support cart which is designed for rapid installation and removal to the RFQ as a unit. This feature permits off-line operation for fine tuning of the ion source and LEBT when necessary, while the RFQ remains under vacuum and RF conditioned. Mobility of the ion source/LEBT installation also allows for improved access to the RFQ downstream endwall when servicing beam instrumentation modules and endwall isolation valves.

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II. ION SOURCE & LEBT SUBSYSTEMS

Parallel R&D programs were used to evaluate the performance and reliability of both a Magnetron and RF Volume H^- sources for near term LINAC Injector commissioning. An RF Volume H^- ion source, based on RF induction discharge, developed for the SSC by LBL[1] was the best performing near term candidate. Beam is extracted at 35 keV and at a current as high as 40 mA of H^-. High electron current which is an inherent characteristic of this type of ion source is deflected out of the beam by a spectrometer assembly. This ion source was chosen not only because of its favorable beam performance[2], but also due to its high reliability, simplicity of its controls and extremely short start up time.

Since the SSC LINAC requires short pulses, electro static LEBT candidates were suitable options. The 30 mA operating current is small enough that several LEBTs using electric field focusing can be used. An einzel lens, HESQ and ESQ have been fabricated and tested, and are currently undergoing further R&D. The einzel lens was the best characterized LEBT[3] of the three at the present time and offered the simplest integration for near term Injector commissioning.

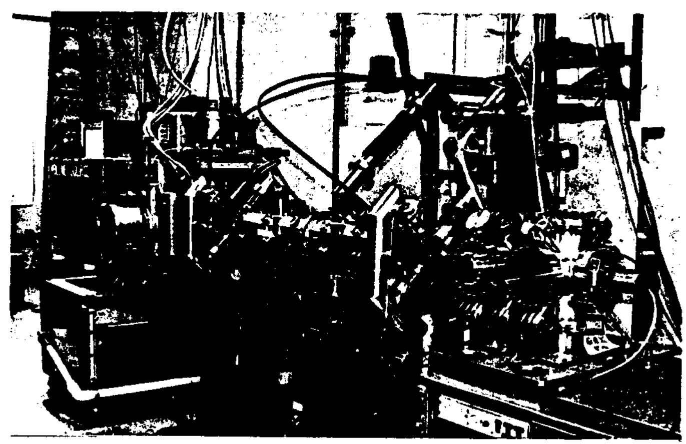

Figure 1. SSC LINAC Injector.

III. MECHANICAL INTEGRATION

A. Design Requirements & Features

The design requirements evolved early on as a combination set of worse case requirements for the two ion source and the three LEBT candidate integration schemes. A universal and upgradable approach was utilized for the final support frame and vacuum system installation concept. Many of the solutions applied to the RF Volume source installation were developed originally for the Magnetron/einzel lens combination.

Three primary requirements drove the design and overall configuration of the system. 1) The vacuum capacity (pumping speed) at the chamber of 2000 l/s was a function of the ion source's gas load and the maximum allowable operating pressure of 7.0 x 10^{-4} Pa in the LEBT. 2) Beam divergence and matching as a function of LEBT type, and the spacial relationship of components - this dictated the minimum length of the vacuum chamber. 3) Existing mounting features on the endwall and minimum induced loads at the RFQ. A cross section of the packaging scheme that is used is shown in figure 2. All other features unique to the integration scheme were determined from beam diagnostics, availability and serviceability of the subsystems, and general LINAC commissioning requirements. Table 1 summarizes the main features incorporated into the design.

Table 1
MECHANICAL INTEGRATION FEATURES

* Compact vacuum enclosure (23.5 cm Lg)
* Vacuum enclosure cantilever mounted to the RFQ
* Vacuum system supported independent from chamber
* (2) Pairs of opposing bellows (no induced vacuum loads)
* (4) 900 l/s (H_2) Turbopumps with ceramic bearings
* (4) Automatic Vacuum Gate Valves with Iso 160 Flanges
* Fully automatic vacuum control system
* (1) Current Toroid & (1) Deployable Faraday Cup
* (8) LEBT externally accessible alignment adjusters
* Cart supports vacuum enclosure for off-line use
* Source alignment adjustment in X, Y & Z axis

B. Vacuum Enclosure

The vacuum enclosure is designed as a minimum envelope, just large enough (35 cm ID) to prevent arcing from the 35 keV reentrant flange of the ion source and to provide sufficient vacuum conductance for differential pumping of the LEBT. The front flange provides a 12 bolt hole pattern and o-ring groove for hard mounting to the RFQ endwall. The rear flange is designed to interface with the ion source assembly. Enclosure length is a function of optimized beam matching requirements - an 8 mm gap between the electron separator and LEBT is available for locating a Faraday cup. Figure 2 depicts the chamber and the internal relationship of all the components.

For ease of fabrication, and to make maximum use of commercially available flanges, the chamber was made from 304 & 316 stainless steel. Four Iso 160 flanges, spaced 90° apart allowed for compact installation of the vacuum pumps, in addition to providing 3000 l/s of conductance at the chamber. The requirement of minimizing distortions of the RFQ specified a 82 kg and 26 kg-m limit for the total cantilevered mounted assembly. Figure 3 shows the integrated chamber installed to the RFQ endwall.

C. Component Alignment & LEBT Support Scheme

The LEBT can be aligned externally to a precision of ±0.1 mm with the use of long piloted set screws acting inboard on the LEBT's casing. These adjusting screw are located con-

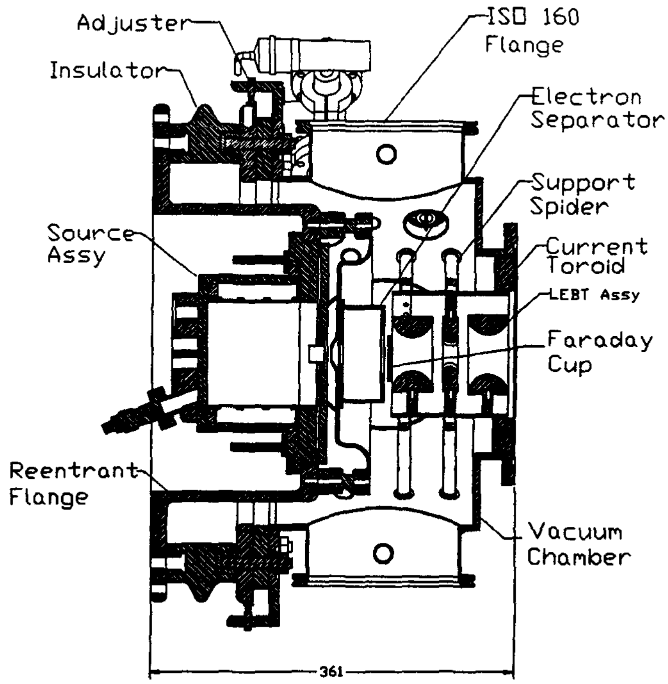

Figure 2. General Arrangement of RF Volume Source & einzel lens LEBT Integration scheme.

centrically within the support tubes spanning from the LEBT's support ring to mini conflat flanges welded to the chamber. Four support tubes are bolted radially to each ring and after their mounting bolts are fully tensioned, the assembly forms a rigid support spider. Since the spiders consist of a mechanical assembly only, they can be replaced to accommodate different size LEBT lens.

The ion source is aligned to the LEBT in the transverse plane within ±0.1 mm with the aid of four bucking screws acting on the source's rear flange. Axial position of the ion source assembly can be adjusted with a machined spacer. Component alignment can be referenced to either a datum on the chamber or directly to an RFQ reference. Prealigned installation to the RFQ is maintained and provided by two brass bushing/inserts.

D. Beam Instrumentation

A single current toroid is located at the exit end of the LEBT to monitor current transmission thru the LEBT. The toroid was sized so it would mount directly on the LEBT casing, allowing it to move with the LEBT during alignment. A graphite Faraday cup was located in the 8 mm gap between the electron separator and LEBT's first element. The cup is mounted on the end of a pivoting arm and is deployed by a 1" travel linear actuator. A rotational deployment scheme created a more compact mechanism, along with limiting the external dimension of the actuator.

E. Support Frame and Vacuum System Cart

An existing general purpose diagnostic cart was utilized for integrating design specific structural elements and all vacuum components. The bare cart is a heavy duty welded aluminum structure that offered many mounting options. The packaging scheme adopted allows the ion source/LEBT subsystem to be fully mobile and functional in both Injector, and off-line modes. Design specific structure consists of aluminum adapting plates and mounting shelves. A welded aluminum frame straddles the vacuum enclosure and carries all vacuum induced loads and the weight of the pumps and gate valves. The gate valves and bellows are mounted on plates with adjustable mounting locations. Provision for aligning the cart and frame are incorporated into the design. The cart is designed for multi mode use - it has provisions for supporting the vacuum chamber while being installed and removed from the RFQ, as well as for off-line testing (operating while removed from the RFQ). Figure 4 represents the as- built hardware.

F. Vacuum System

The vacuum system utilizes four 900 l/s (H_2) ceramic bearing turbopumps. Space limitations required pumps which could be mounted in any orientation. Since the pumps are mounted to the support frame which are connected to the chamber via bellows, frequent separation of the bellows from the chamber, necessitated the use of Iso flanges due to their quick disconnect feature. Automatic gate valves are used at each location to allow removal of a failed pump without bringing the entire system up to air. The use of four pumps provides an additional 1000 l/s of redundancy, allowing the ion source/LEBT to continue operating with one failed pump. Two identical roughing pump strings service each pair of turbopumps. Sentry valves, electro-pneumatic in-line valves, automatic vent valves, seven convectron gauges and a single ion gauge are incorporated into the system, and are hardwired and interlock to a fully automated control system. Figure 4 shows the arrangement of the vacuum system components.

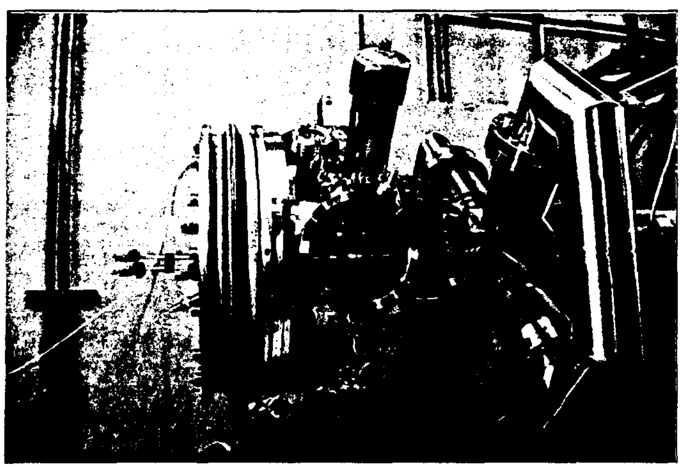

Figure 3. Volume Source/LEBT installed to RFQ.

IV. VACUUM CONTROL SYSTEM

The Ion Source vacuum control system is fully interlocked and automated. A hardwired interlocking scheme was implemented for machine safety. The control system software is TACL (Thaumaturgic Automatic Control Logic, developed at CEBAF). The control system includes one supervisor/database computer and one slave, which in turn controls a CAMAC crate. All the signals required for operation are generated by general purpose CAMAC boards. This control system also controls the RFQ vacuum system. The pumpdown sequence, failure detection, recovery and stop sequence are completely automated. The Controls Group has selected EPICS (developed at LANL) as the control software which will be used at the SSC, and VME as the bus technology. EPICS is ideally suited for controlling large systems and VME will allow increased density, as well as a large base of available products. The ion source vacuum control system will be ported to VME and EPICS in the near future.

V. CONCLUSIONS

The successful mechanical integration of the RF volume ion source and einzel lens LEBT to the RFQ, along with the extensive development of all other subsystems has created a world class Injector at the SSCL. Improved LEBTs are in development which will be installed and operated to increase the beam current transmission of the RFQ.

VI. ACKNOWLEDGMENTS

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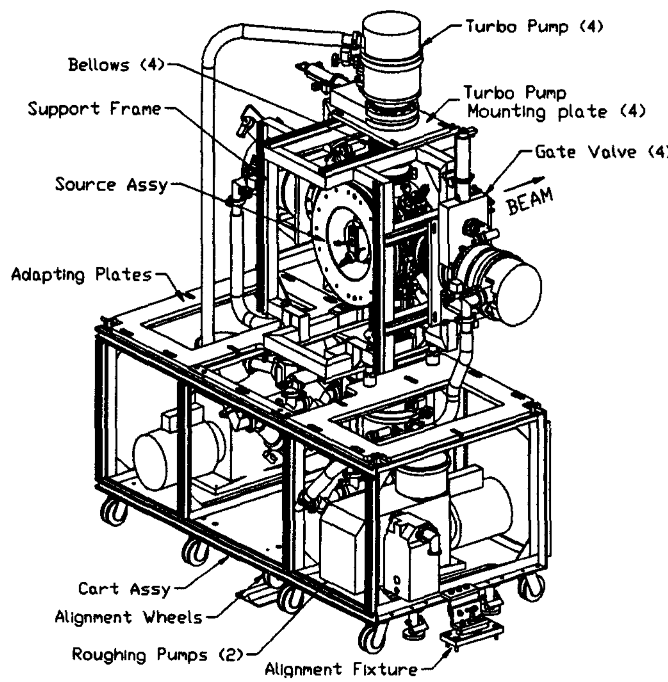

Figure 4. Vacuum cart assembly.

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[1] K.N. Leung, et al., Rev.Sci.Instrum.,62, 100(1991).

[2] K. Saadatmand, et al., these Proceedings.

[3] J. Lenz, et al., "Comparison of Experimental and Simulated Results for the SSC LEBT," these Proceedings.