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STATUS REPORT ON THE HOLIFIELD RADIOACTIVE ION BEAM PROJECT*

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1. Introduction

In July 1992, a project was started to reconfigure the Holifield Heavy Ion Research Facility (HHIRF) to form the Holifield Radioactive Ion Beam Facility (HRIBF). This ORNL project[1,2] to produce medium-intensity, proton-rich, radioactive ion beams (RIBs) for astrophysics, nuclear physics, and applied research was first described to the SNEAP community at Chalk River in 1992.[3] To briefly review, radioactive ions will be produced by light ion beams from the Oak Ridge Isochronous Cyclotron (ORIC) striking a target in an Isotope Separator On-Line (ISOL)-type target-ion source assembly. The radioactive ions will be converted to negative ions either directly in the ion source or by charge exchange following positive ionization. After acceleration to approximately 300 keV, these ions will be injected into the tandem accelerator for acceleration to higher energies.[4] Successful production and acceleration of RIBs requires changes in the existing accelerators, development of the target-ion source, and construction of a new high-voltage injector and new injection beam line for the tandem accelerator. Figure 1 shows a floor plan of the facility as it should be when the project is finished. Progress has been made in all areas and will be detailed starting with the cyclotron.

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2. ORIC

The ORIC is a k = 100 ($k = mE/q^2$) variable frequency, isochronous cyclotron built in the early 1960's as a light-ion accelerator with heavy-ion capabilities.[5] An internal ion source was used for operation until ORIC became an energy booster for tandem beams. At that time the internal ion source was removed, a foil stripper was added and extensive revisions were made to allow traversal of the injected beam. Routine operation in the coupled mode lasted from June 1982 to June 1990 when coupled operation was halted due to budgetary constraints.

To provide light-ion beams to the RIB injector, ORIC operation had to return to the use of an internal ion source. It is fortunate that the old internal ion source was not scrapped during the years of coupled operation and that staff are still available with ion source operating experience. The ion source has been reinstalled as have various carbon scrapers to minimize activation. Controls for the ion source, a beam diagnostics probe, and extraction system position readouts have been implemented on the new Vista control system, which is a commercial product from Vista Control Systems, Inc. A $^4He^{2+}$ beam has been produced using the internal ion source and has been extracted with a 33% efficiency. Current work on ORIC includes modifications to improve extraction efficiency and an optimized central region design. The beam line leading from the cyclotron to the RIB injector has been completed.

3. Target-Ion Source

The electron-beam-plasma (EBP) target-ion source, which has been designed and fabricated, is similar to the ISOLDE FEBIAD target-ion source assembly. It is shown in Figs. 2 and 3, with Fig. 2 showing the details of the target and ionization chambers. Characterization studies were first performed in the new ion source test facility, then the source was mounted on the RIB injector platform. The UNISOR facility has been reconfigured to mount a duplicate of the EBP source for further characterization and possible target implantation studies using beam from the tandem accelerator. The UNISOR facility also has a FEBIAD ion source and mass separator which have already been used to study thermal diffusion, desorption, and ionization for particular beam/target combinations. The EBP source has provided beam for the initial testing of the RIB injector.

4. RIB Injector

An informal report was given at SNEAP 1993 concerning the RIB injector high-voltage platform system design, fabrication, and acceptance tests. The injector is now fully operational with a maximum voltage of negative 300 kV. A schematic drawing of the equipment located on the high-voltage equipment platform is shown in Fig. 4 while Fig. 5 shows a floor plan of the entire platform system. Controls for all equipment on the injector have been implemented on the Vista control system with communication via a fiber optic ethernet link.

Transport of a positive mass-28, 20-keV beam off the platform to a diagnostics station in the next room was accomplished November 1,1994.

5. Second-Stage Mass Separator

The mass resolution of the magnet situated on the injector platform is expected to be approximately 1/1000. Therefore a second stage of mass separation is necessary to separate the radioactive ion of interest from possible isobaric contaminants. This second stage will be part of the negative-ion injection line from the high-voltage injector to the tandem accelerator. The two magnets for this separator have been specified to have a mass resolution of 1/20,000. Expected delivery of the magnets is early 1995.

Other components for the negative-ion injection line are either on order or in the last stages of design. The 90° bend for the vertical line will be made by a magnet which has been specified and is being fabricated at this time. This magnet will be suspended from the ceiling and will not interfere with the rotating, tandem accelerator, energy-analyzing magnet. Figure 6 shows the horizontal portion of the beam line while Figure 7 shows the vertical portion.

6. Tandem Accelerator

Stability of the beam from the tandem accelerator has been enhanced by the resistor-based, voltage-grading system which has been described in detail in another paper at this meeting. The terminal potential stabilizer, which was installed in early 1992, allows fairly stable operation with very low currents but may be improved by a few small changes. These changes will probably not be done until we find they are necessary.

Logarithmic amplifiers for the Faraday cups will be upgraded to read as low as one pA throughout the tandem accelerator and its associated beam lines. New low intensity diagnostics, consisting of a plate to interrupt the beam and a continuous dynode electron multiplier to count either secondary electrons or Rutherford back-scattered ions, will be added at the two waists in the accelerator. Others will be added if they are found necessary. The current thoughts on tuning the accelerator are to tune with a stable isotope that is close to the RIB of interest and change the magnets when ready to accelerate the proper radioactive ion. Low intensity diagnostics will be added at the object and image slits of the tandem energy-analyzing magnet as well as other necessary locations along experimental beam lines.

7. Discussion

As work continues on construction of the negative-ion injection beam line, development will continue on the RIB injector and with the target-ion source. Safety documentation has been completed to allow low-intensity commissioning of the project. In this phase, the ORIC beam intensity and target materials will be restricted so that special handling equipment is not required for work on activated components. Radioactive beams produced by the RIB injector will be transported to a diagnostic station where characteristic gamma rays of each radioactive species will be detected. This diagnostic station will aid the development of RIBs since it will give an absolute measure of the intensity of the species of interest. Acceleration of the first RIB (species unknown at this time) through the tandem accelerator is expected by August 15, 1995.

8. References

1. "A Proposal for Physics with Exotic Beams at the Holifield Heavy Ion Research Facility," eds. J. D. Garrett and D. K. Olsen (ORNL, February 1991).

2. "The ORNL Radioactive Ion Beam Project," D. K. Olsen, et al., Proc. of the Workshop on the Production and Use of Intense Radioactive Beams at the Isospin Laboratory, Oak Ridge, TN (Oct. 1992) p. 375.

3. "Radioactive Ion Beam Production Challenges at the Holifield Heavy Ion Research Facility," M. J. Meigs, et al., Proc. of the Symposium of North Eastern Accelerator Personnel, Chalk River, Ontario, Sept. 22-25, 1992, to be published.

4. "Use of the Holifield Facility 25-MV Tandem Accelerator in the Oak Ridge Radioactive Ion Beam Project," C. M. Jones, et al., Proc. of the Particle Accelerator Conference, Washington, DC (May 1993) p. 1660.

5. R. S. Livingston and F. T. Howard, Nucl. Instr. and Meth. 6 (1960) 1.

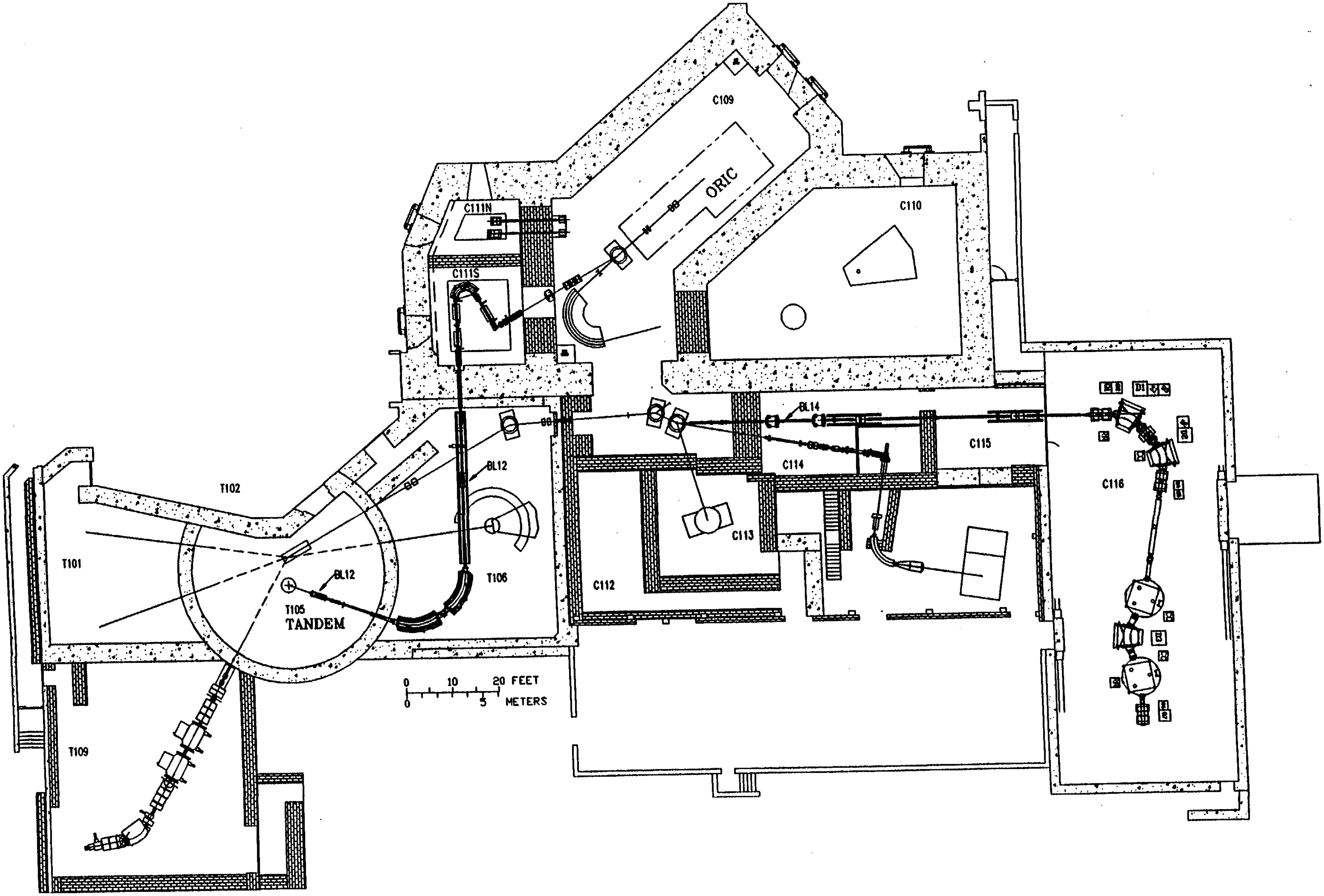

Fig. 1. First floor layout of the ORNL RIB facility.

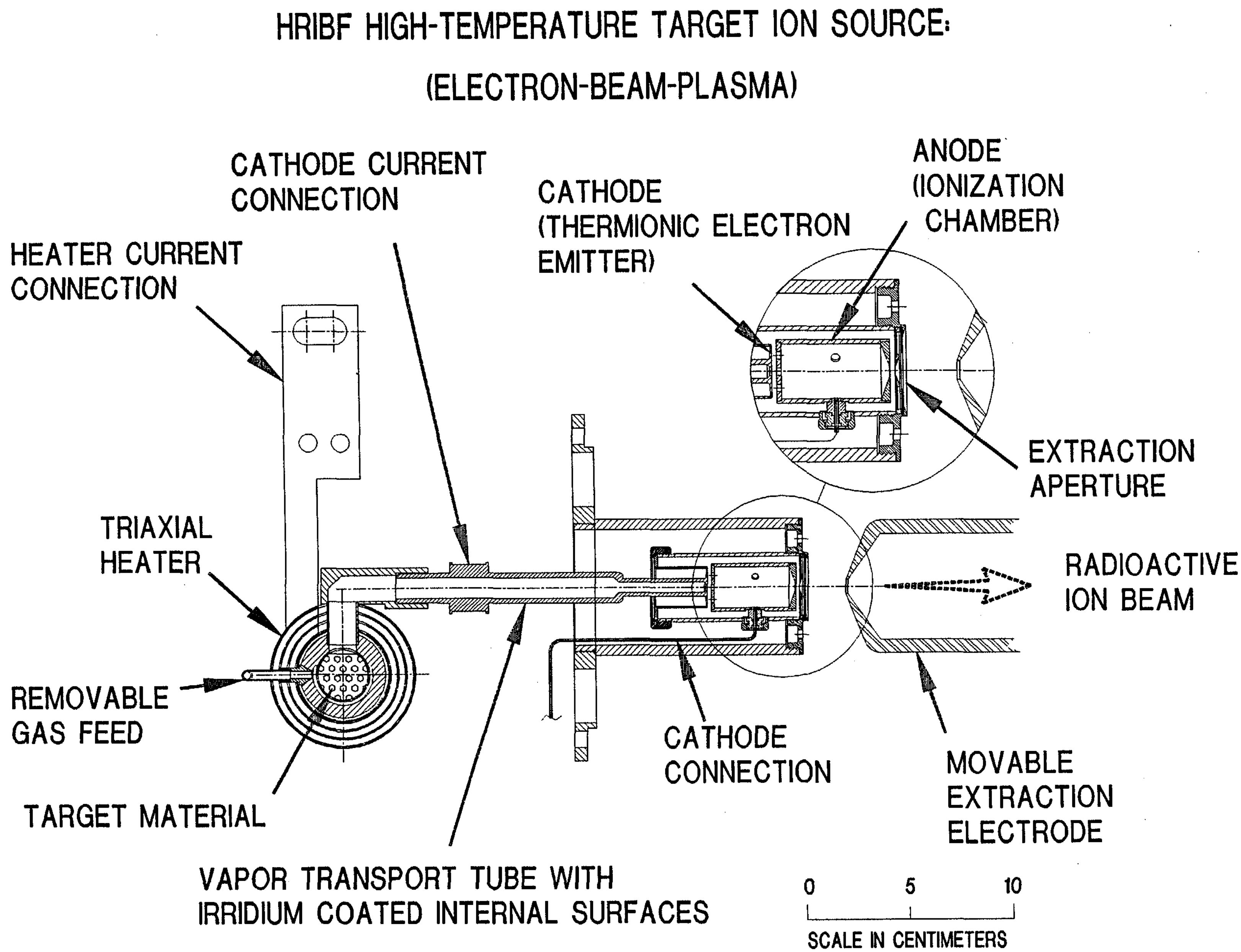

Fig. 2. ORNL EBP target-ion source based on the ISOLDE FEBIAD target-ion source design.

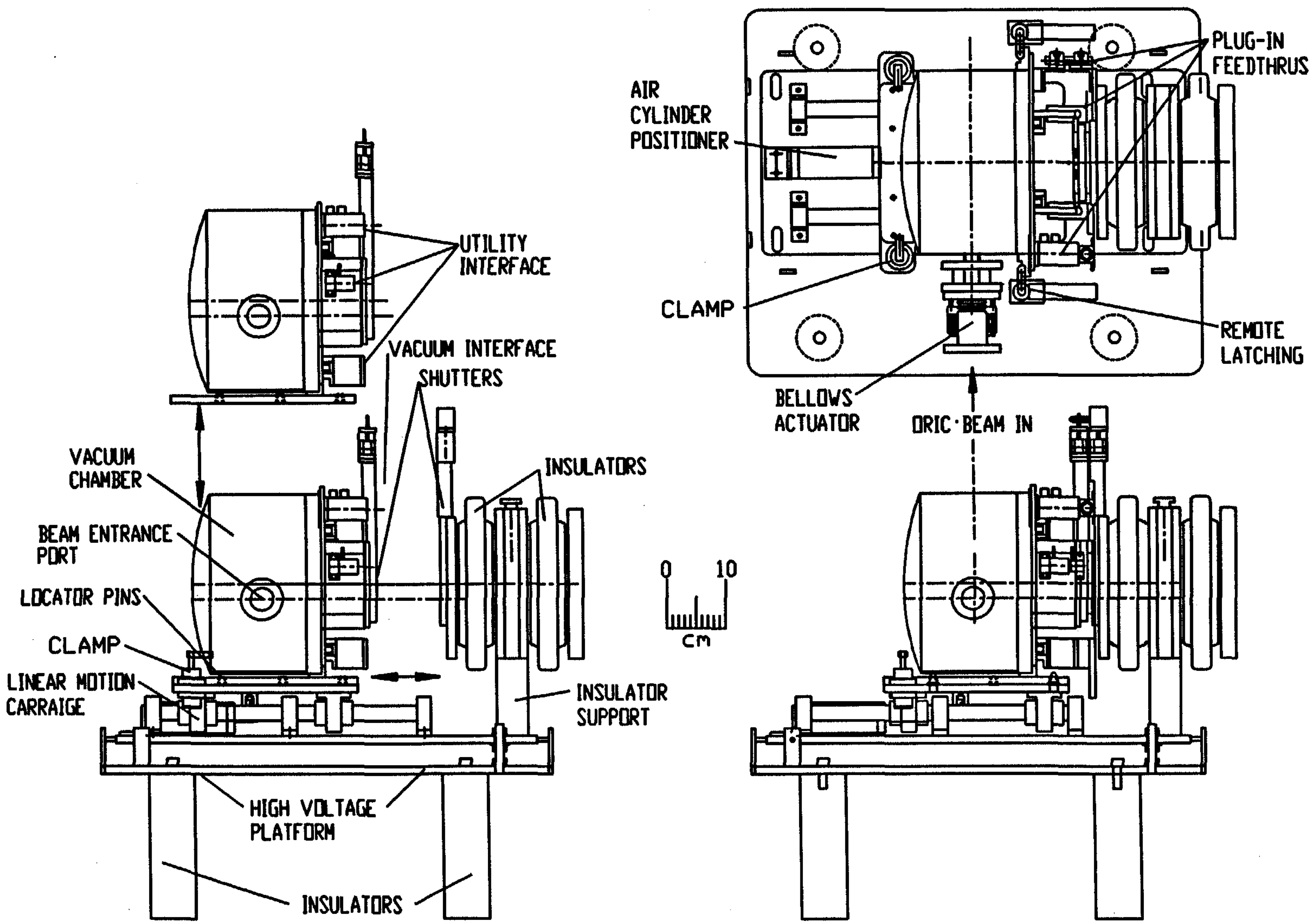

Fig. 3. ORNL RIB EBP target-ion source assembly which has been designed for remote installation and removal.

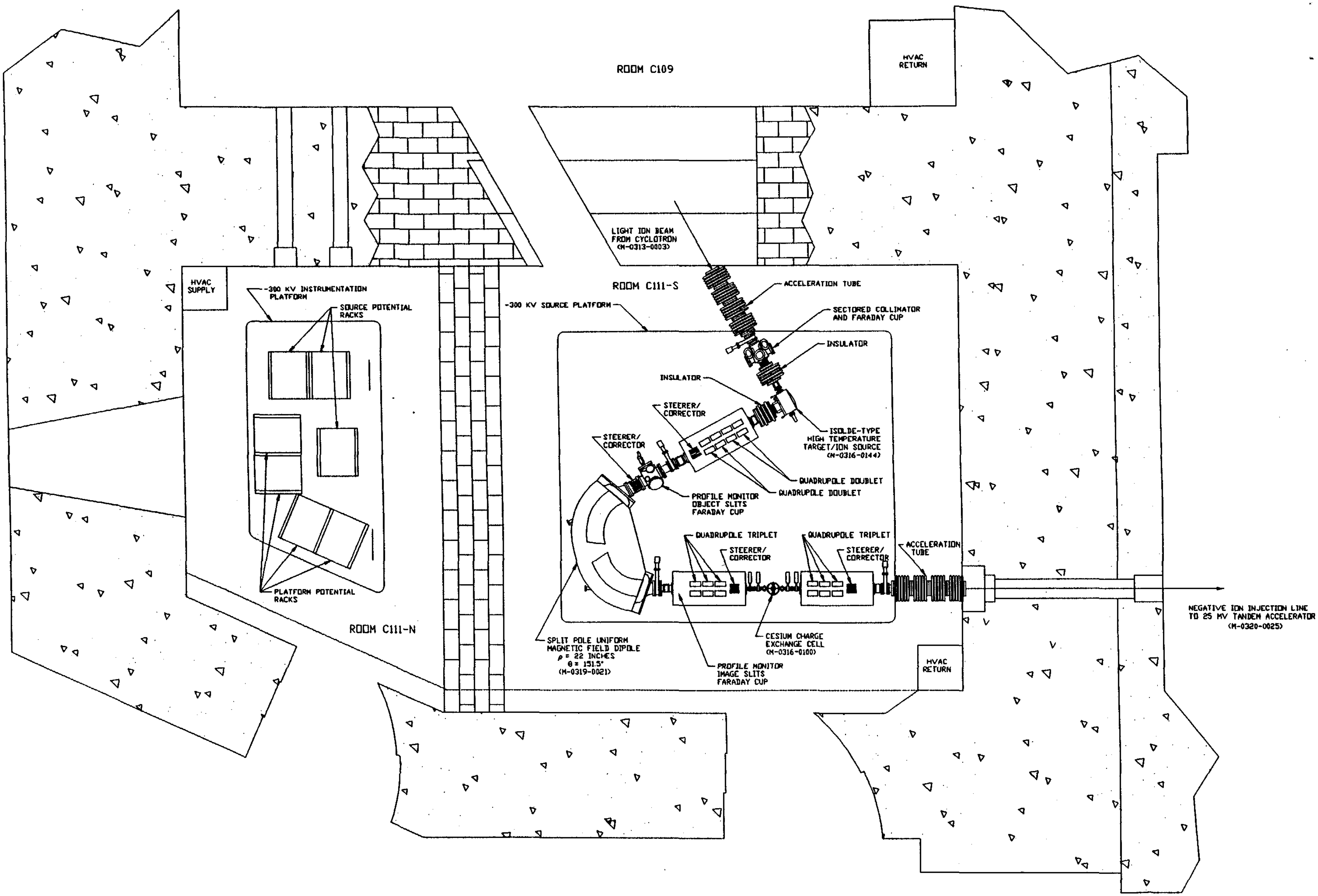

Fig. 5. High-voltage platform system floor plan showing the source platform, instrumentation platform, shielding wall, high-voltage conduits, and instrumentation racks.

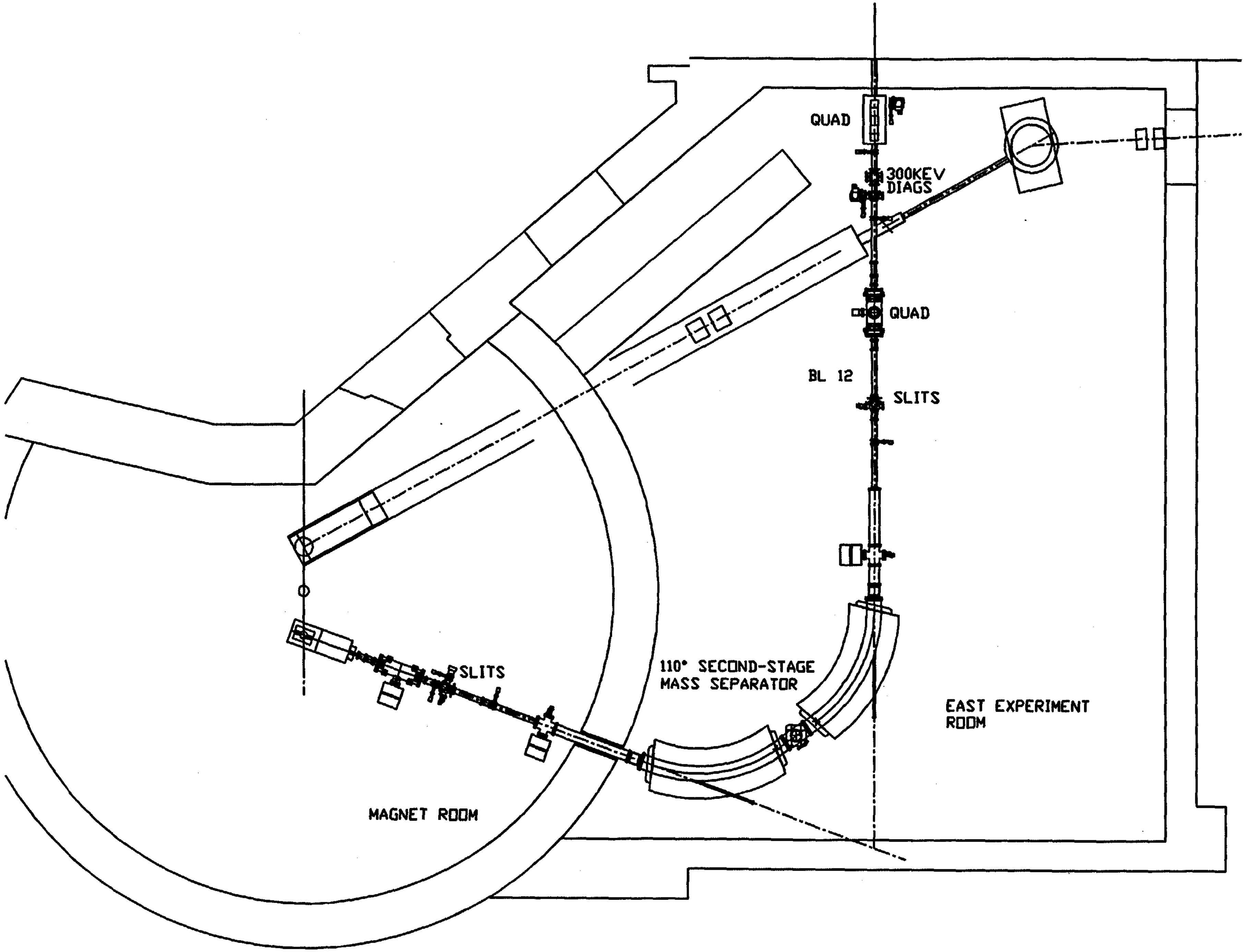

Fig. 6. Horizontal negative-ion injection beam line layout.

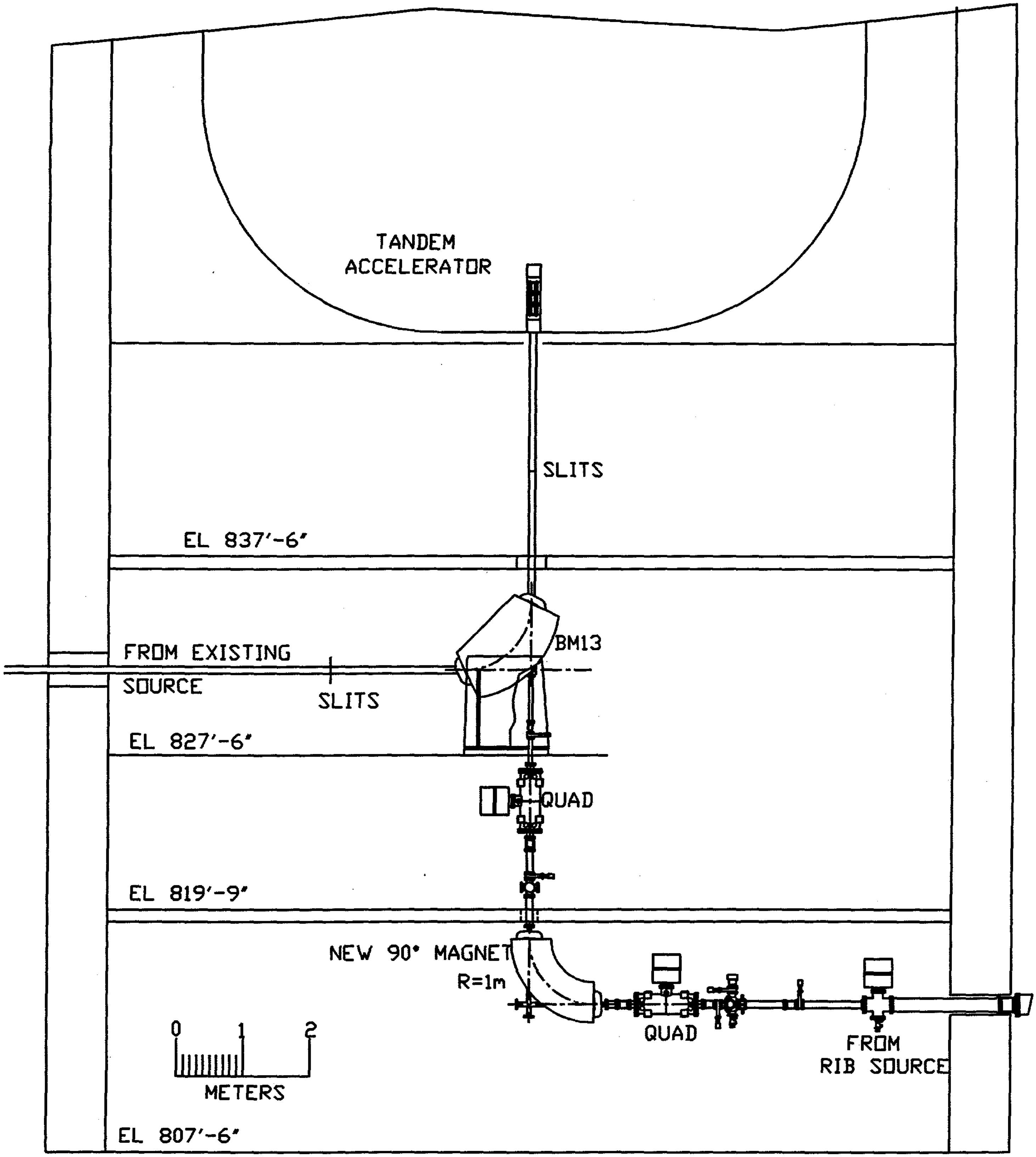

Fig. 7. Vertical negative-ion injection beam line layout.