EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
CERN — A&B DEPARTMENT

AB-Note-2004-034-OP

POSSIBLE CONFIGURATION FOR A HIGH-CHARGE-STATE HIGH-VOLTAGE PLATFORM

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(from November 2003 until January 2004)

Abstract

For many interesting applications, particularly in solid state physics or nuclear astrophysics, the beams available directly from the ISOLDE separators are too low in energy and the beams from REX-ISOLDE too high.

Therefore a project has been started to produce beams of radioactive ions in the intermediate energy range. One obvious possibility for this purpose is to use the high charge state ions produced in the TRAP/EBIS charge breeder of the REX facility and feed them into a high voltage platform. The present layout study was done to investigate the feasibility of this approach at the existing facility. In addition a possible second way of breeding high charge state ions by injecting the 1+ low energy ion beam from the ISOLDE separators into an ECR ion source is being studied at present. The incorporation of this option into the general layout had also to be investigated here.

Geneva, Switzerland
March 2004

Motivation

The beam energies available at the ISOLDE facility at present are in two widely different ranges:

1) The ion beam extracted directly from the separators is limited to the range of 20 keV to 60 keV for 1+ ions. In principle in favorable cases ions of charge state 2+ or even 3+ are produced in some of the ion sources in operation at ISOLDE also, but generally with an intensity reduced by orders of magnitude. A high-voltage platform installed at one of the beamlines allows an energy increase for experiments mounted there at a negative potential. At present this potential is limited to 220 kV, but the design of the facility should allow at least -400 kV. This then will result in a beam energy of 0.46 MeV for 1+ ions in principle, or correspondingly higher values for higher charge states.

2) The REX-ISOLDE facility at present delivers beam energies if typically 1-2 MeV per amu after acceleration of highly charged ions in a system of linacs. An increase to about 3 MeV per amu is being installed.

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Boundary conditions

The presently installed experiments and facilities in the ISOLDE experimental hall are already making intensive use of most of the space available, as may be seen in the overview in Figure 1. These facilities are of varying complexity and delicacy, so not all may be moved to other locations without undue complication. In particular the following restrictions have been assumed:

The REX linac is not moved from the present position.

The TRAP/EBIS cage is not relocated.

The ISOLDE central beamline is not changed from its present location.

The WITCH experiment is not moved.

Other than these conditions the necessary move of existing cabling, pumping equipment, support structures, or shielding material has been considered possible and is not studied explicitly. Of particular importance for the present study is the fact that the height of the ISOLDE low energy beamlines is approximately 1.28 m above the floor, while the REX beamline is at 1.75m.

As shown in Figure 1 the WITCH experiment has support structures very close to the possible points of extraction and injection of high charge beam into and out of the REX facility. This actually presents the most serious problem for the proposed beamline design.

High Voltage Platform

Before considering a use in the present state, a relocation, or a replacement of the existing HV platform some comments on the possibilities and operational limitations are called for.

The present platform was designed and constructed for a specific experiment, but with the use as a general facility at ISOLDE in mind. Due to budget restrictions most of the components of the existing installation have been taken from equipment available at CERN. Only the driving motor for the power generator had to be obtained commercially. The mechanical construction was adapted to the location and the needs of experiment IS303. Figure 1 shows a sketch of the location of the facility at beamline LC0. The most important aspects of the present performance limitation are:

High Voltage:

Design aim:	400 kV
Tube limitation:	500 kV
HV Generator:	300 kV
Resistor chain:	260 kV
Practical limit:	220 kV

3-Phase Power Generator: 7 kW

Optical links used:

- GPIB
- ETHERNET
- TTL pulses

Obviously some of these limitations can rather easily be overcome in a technical upgrade, but others will need new equipment or location.

In constructing a new HV platform it would certainly be possible to use a few of the present components, notably the acceleration tube, but basically a complete redesign should be made, taking also into account some of the experience gained during the operation of the present facility.

The most serious problem with the present design is the incorporation of all components in a single HV cage. This severely hampers testing and trouble shooting. At a newly designed HV platform any effort should be made to enclose the HV and power generator in a cage separate from the experiment platform, though this will require considerably more floor space. In principle the connection between the two cages can even be through properly dimensioned HV cables, as is done at CRYRING, Stockholm. This rather costly alternative can be a solution if space does not allow otherwise.

The three possible locations of a HV platform in the ISOLDE hall considered here are included in Figure 1.

Beam Transport

Preliminary beam transport calculations have been done with the program GIOS to test the feasibility of the layout options considered here. Up to now only the transport in the horizontal plane has been calculated, ignoring the height difference between ISOLDE and REX beamlines. In a final version the benders suggested to change the beam height would have to be included in an optimized layout, where also the exact position of the electrostatic transport elements would have to be optimized.

The use of standard ISOLDE electrostatic quadrupoles has been assumed, though a somewhat cheaper solution might be possible in a final layout.

High Voltage platform at present the ECR

A rather uncomplicated option for the use of high charge state radioactive beams at a HV platform would be the move of the existing platform (or the construction of a similar one) to a position close to the ECR source presently under investigation as a charge breeding device at ISOLDE. This option presents very little complications, as space at the necessary position is available with little relocation effort. As Figure 1 shows the only structural obstacle is a support pillar for the "toilet platform" in the ISOLDE hall. Beam transport from the ECR analyzing magnet to such a platform should be absolutely straightforward.

Obviously such a solution would require a dedicated experiment that could make efficient use of the ECR source at the present temporary position in a rather short time period. It is not a long term solution.

REX to Present HV

The simplest and most economical solution for the purpose of moderate energy boosting would certainly be the use of the present HV platform coupled to the REX EBIS as high charge state breeding device. Unfortunately the construction of a beamline coupling these two facilities is complicated by the installed equipment and small space available at the natural extraction point following the EBIS analyzing magnet. Also the support structures of the WITCH experiment are difficult to avoid. In addition the relative position of the two facilities in the ISOLDE hall and the different beamline heights make the use of several bending elements necessary. Nevertheless a solution has been found that seems to accomplish the wanted purpose with 4 electrostatic bending elements and 5 additional quadrupole lenses.

The suggested layout is superposed on an updated drawing of the equipment installed in the region of the ISOLDE hall in Figure 2. It consists of a 90° bender inserted in the REX beamline, an electrostatic triplet lens, a 17° horizontal bender, another electrostatic doublet, a low angle vertical bender and finally a tilted 40° insertion bender before the focusing doublet into the HV cage. Mechanical design of all elements will be rather complicated, however. The support structures have to take into account existing devices, partly suspended from the WITCH construction. Space being very tight, some chambers will have to be specially designed for their exact location.

The most serious problem is, however, the construction of the extraction and injection benders. They must be, at least in part, moveable in order to let the EBIS beam pass to the REX accelerator or the standard ISOLDE beam enter the HV platform. Obviously these engineering issues will require careful study, but a suitable solution can undoubtedly be found.

The results of the preliminary beam transport calculations, shown in Figure 3, demonstrate that for a beam energy of 60 keV per charge state 100% of the ion beam can be transported to the HV platform in the suggested way.

New HV Platform

In case a new HV platform with more experimental space is opted for, a position more adapted to the REX layout would naturally have to be chosen. A logical space for the position of such a new platform would be to the left of the REX linac. The high charge state beam extraction could be done in a similar way as described above. Included in Figure 2 is a possible layout with the necessary electrostatic optical elements. Bending the extracted beam back is quite straightforward with one additional bender and a focusing triplet. This is demonstrated by the calculated preliminary ion beam profile in Figure 4.

A serious drawback of such a solution would unfortunately be the blocking of the experimental stations at RB2 (presently occupied by ASPIC) and RC0 (presently serving TaGS). The opportunity to build a HV platform from scratch with ample space available would of course permit the construction of a much more professional facility. The increased beamline height will allow a higher voltage to be reached, in principle even above the 500 kV level.

With little additional modification of the RB (UHV) beamline it would also be possible to use the regular ISOLDE beam in such a facility.

Obviously the same position would also be well suited for the implementation of the variable frequency linac proposed as an alternative solution for medium energy experiments with the high charge state radioactive beams from ISOLDE.

The ECR source at the LA5 beam-line

Since the present study of the performance of the ECR source as a charge breeder for radioactive ions is being performed also in order to use such a facility possibly as a source for REX, one obviously has to find a layout for injection into the present or slightly modified REX linac. Again space restrictions in the ISOLDE hall are rather severe.

An elegant way to locate the ECR source within the present beamline layout would be by using the port LA5, at the moment unoccupied. Actually the extension of this beamline points quite closely to a possible position between beamlines CC0 and RB0, considering the increased beamline height that must be chosen for injection into REX. Transport of the ISOLDE beam to this new ECR location, as shown in Figure 2, can be achieved with a standard doublet, 2 low angle vertical benders, and an additional triplet. The beam transport calculations in Figure 5 demonstrate this possibility.

Unfortunately the space available at the suggested location for installation of the ECR source is quite limited. In case this crowded situation is considered unpractical, installation at another beamline, LA4 or RB0, would appear conceivable. In addition to the loss of existing experimental stations for experiments with the low energy ISOLDE beams also the beam transport would be more complicated in this case.

Actually the injection of the ECR beam into the REX linac is even more problematic than the extraction. A possible solution, with all the technical difficulties mentioned above, has been found. The suggested layout is included in Figure 2. After the focal point of the ECR analyzing magnet it consists in a doublet, a small angle horizontal bender, a triplet, a 45° bender, a singlet and another 45° bender. Beam transport through this system is relatively easy at 60 kV, and still possible at 30 kV, as demonstrated in Figure 6.

Summary

In this study the feasibility of extracting and injecting the high charge low energy beam of the REX facility has been demonstrated. The restrictions by the existing boundary conditions, though severe, nevertheless will not forbid to build the necessary beamlines. The choice between the different alternatives will naturally have to take into account the physics requirements and resource availability.

Further work

The present preliminary layout study would have to be complemented with much more detailed investigations once a specific solution is favored:

1) Ion optics calculations with better accuracy to specify exact locations and characteristics of optical elements. Apparently the program SIMION in its 3-dimensional version can be used for this purpose.

2) Approximate costing of the solution considered.

3) Design of specific beamline elements and support structures.

Figure 1: Positions of the three locations for a high-voltage platform in the ISOLDE hall considered in this study

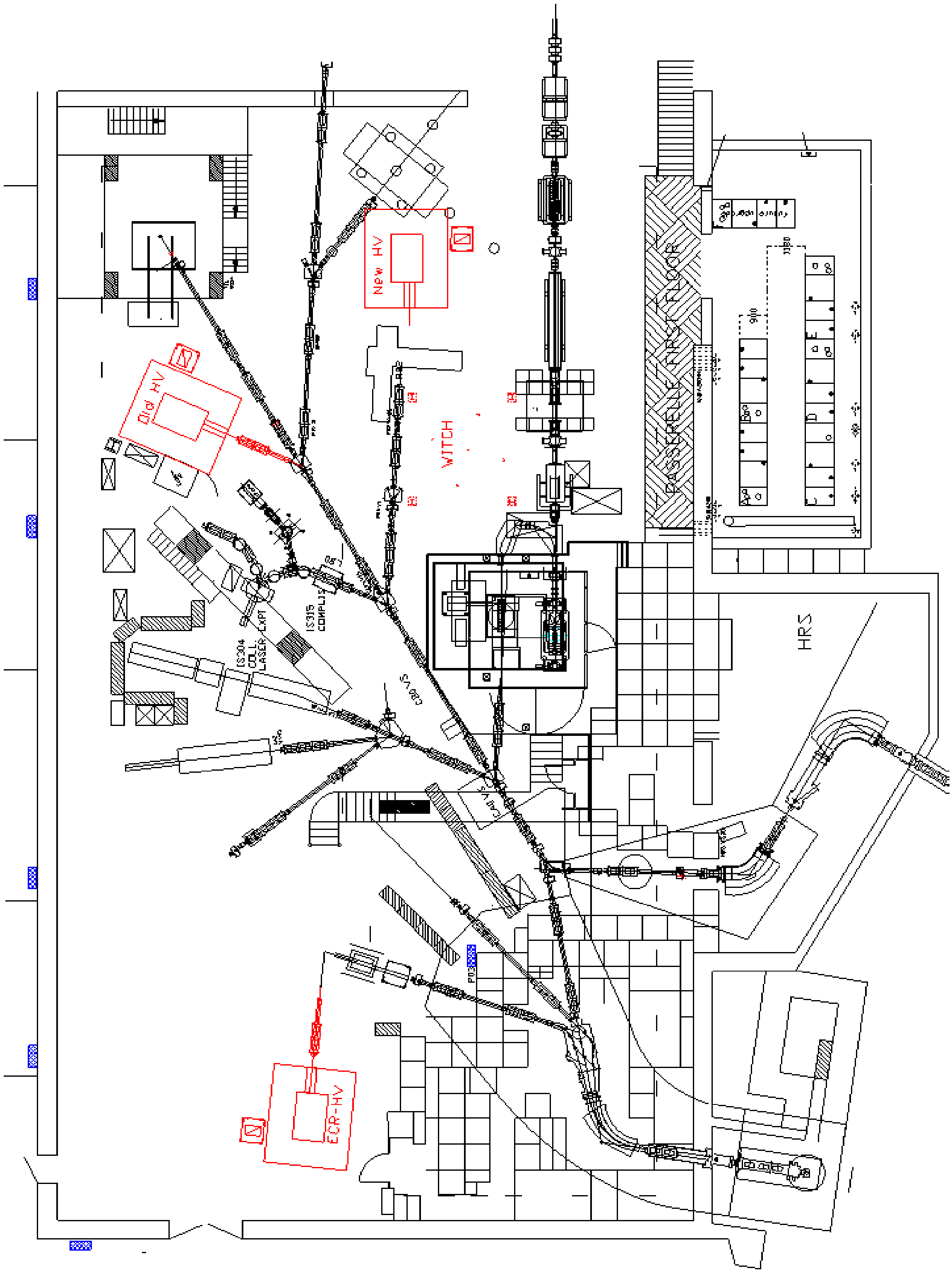


Figure 2:Beamlines for extraction and injection of the low energy high charge state ion beam of the REX facility suggested in this study

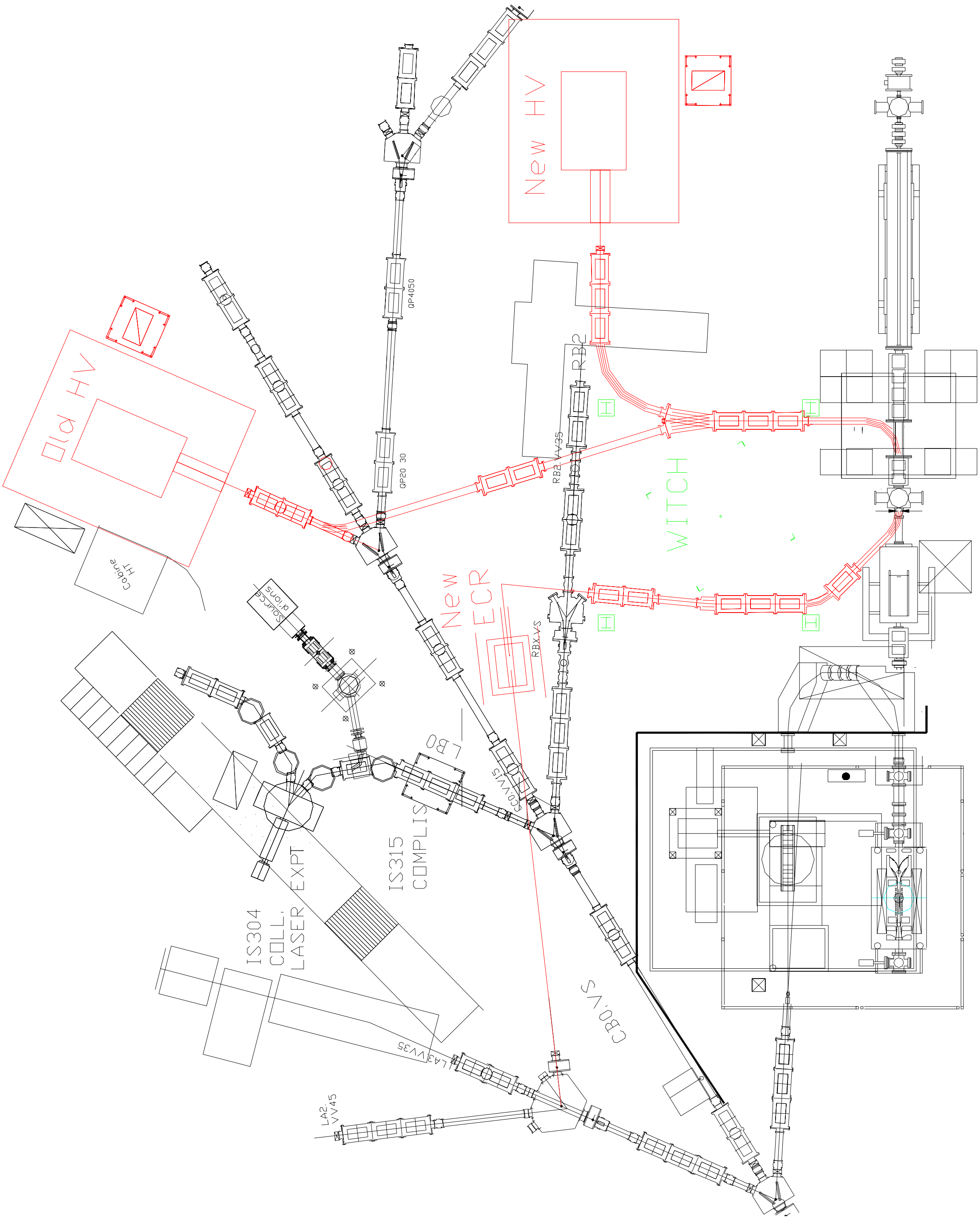


Figure 3:

Beam Transport from REX to old HV

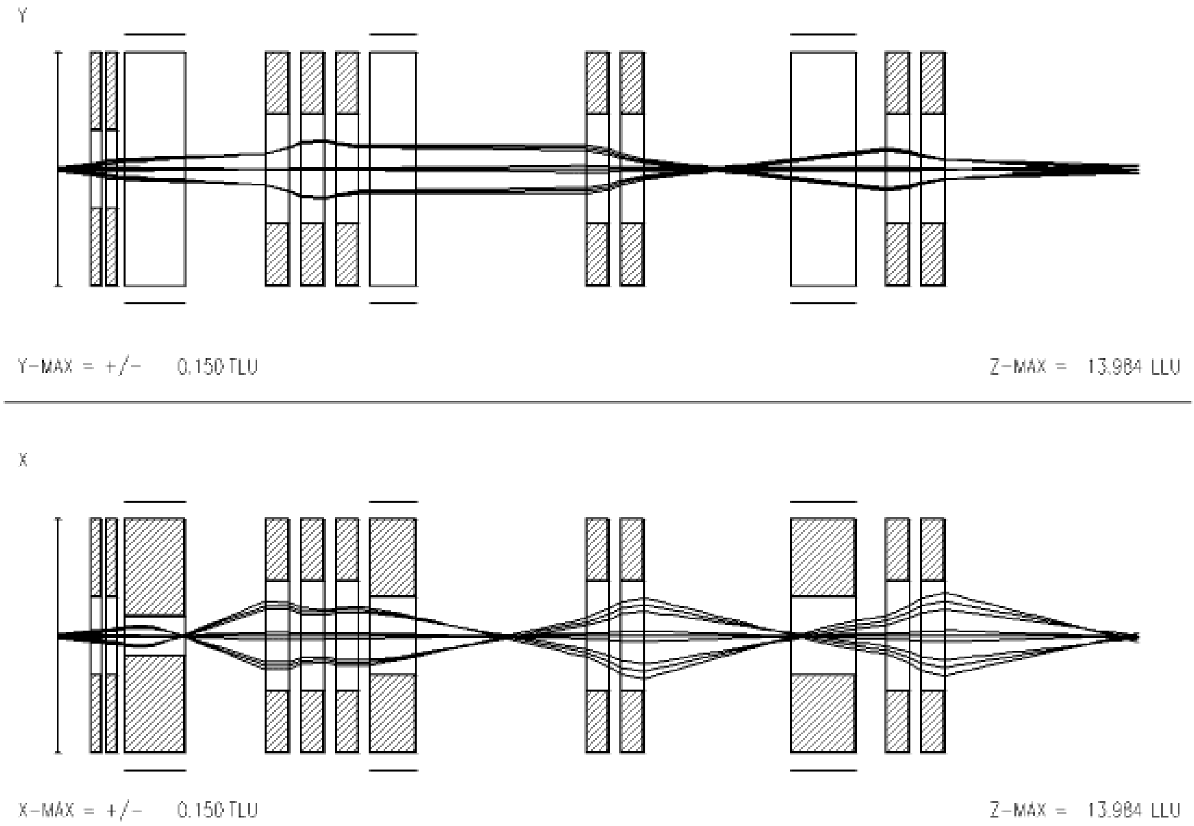


Figure 4:

Beam Transport from REX to new HV

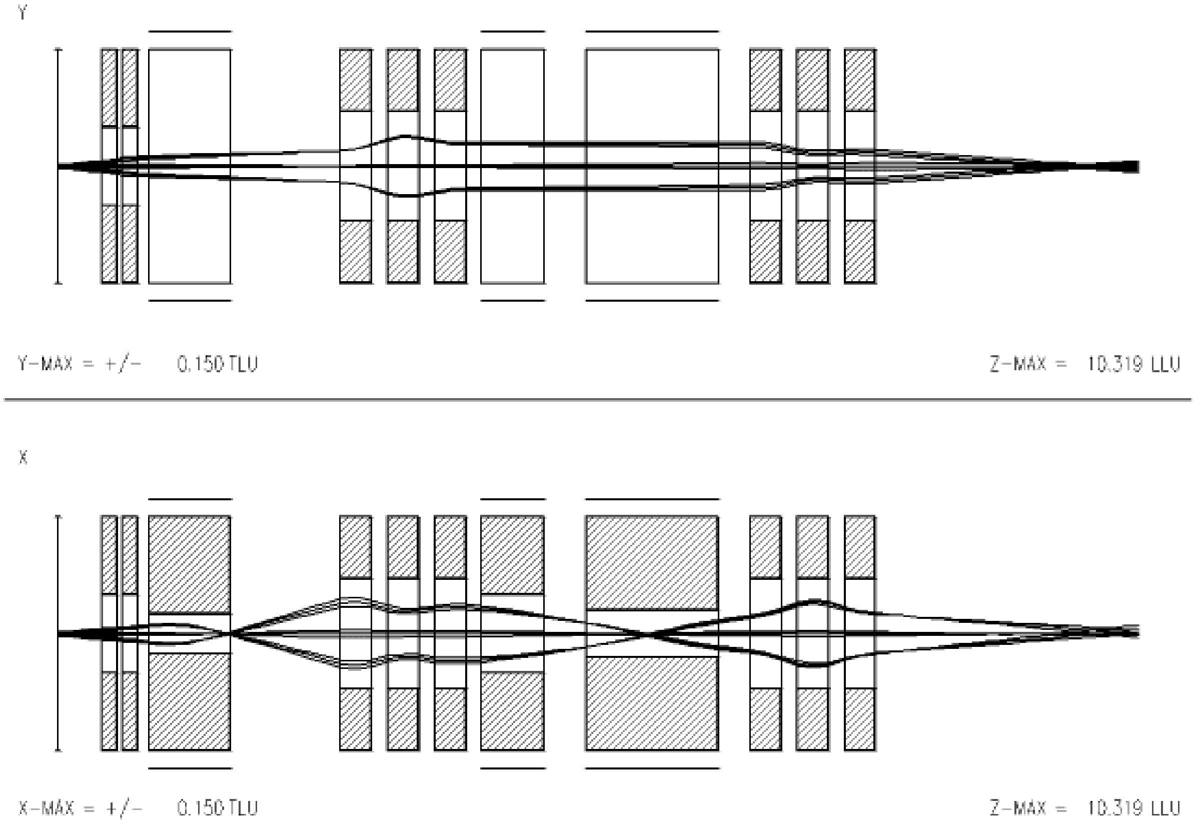


Figure 5:

Beam Transport to ECR Breeder at LA5

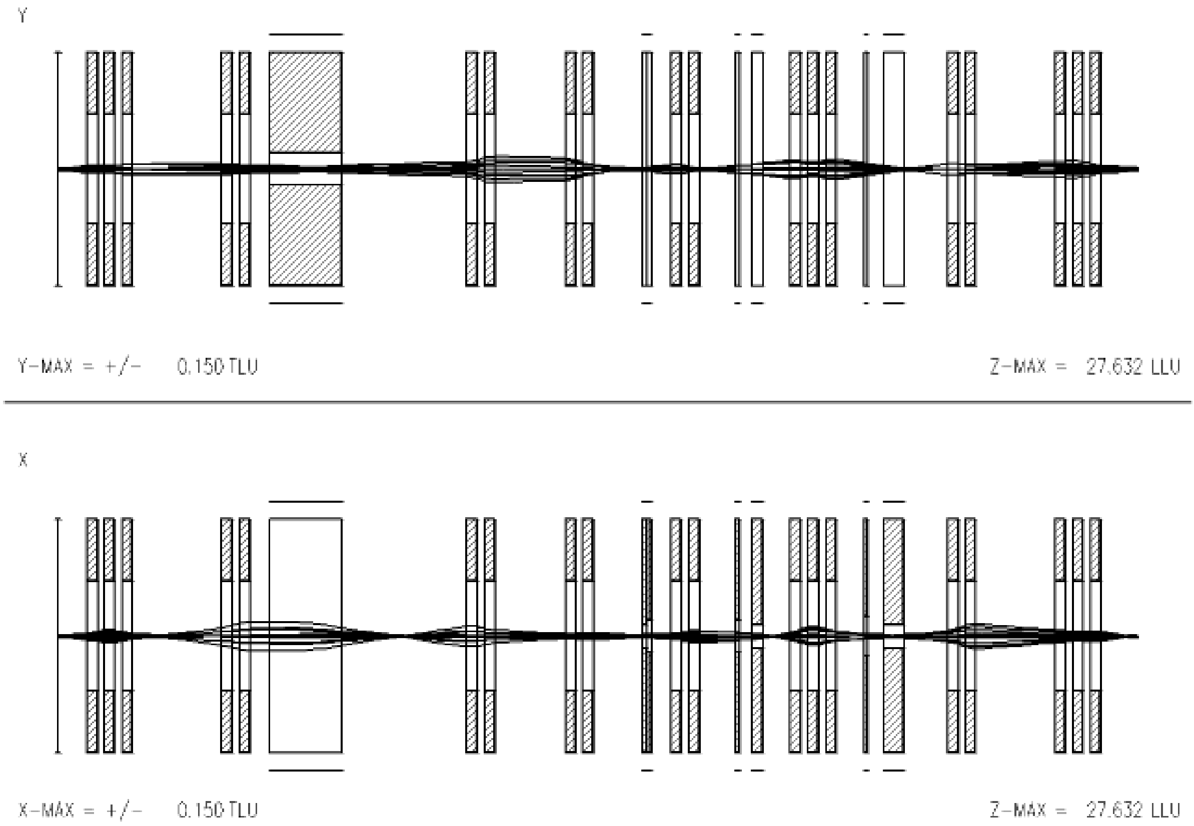
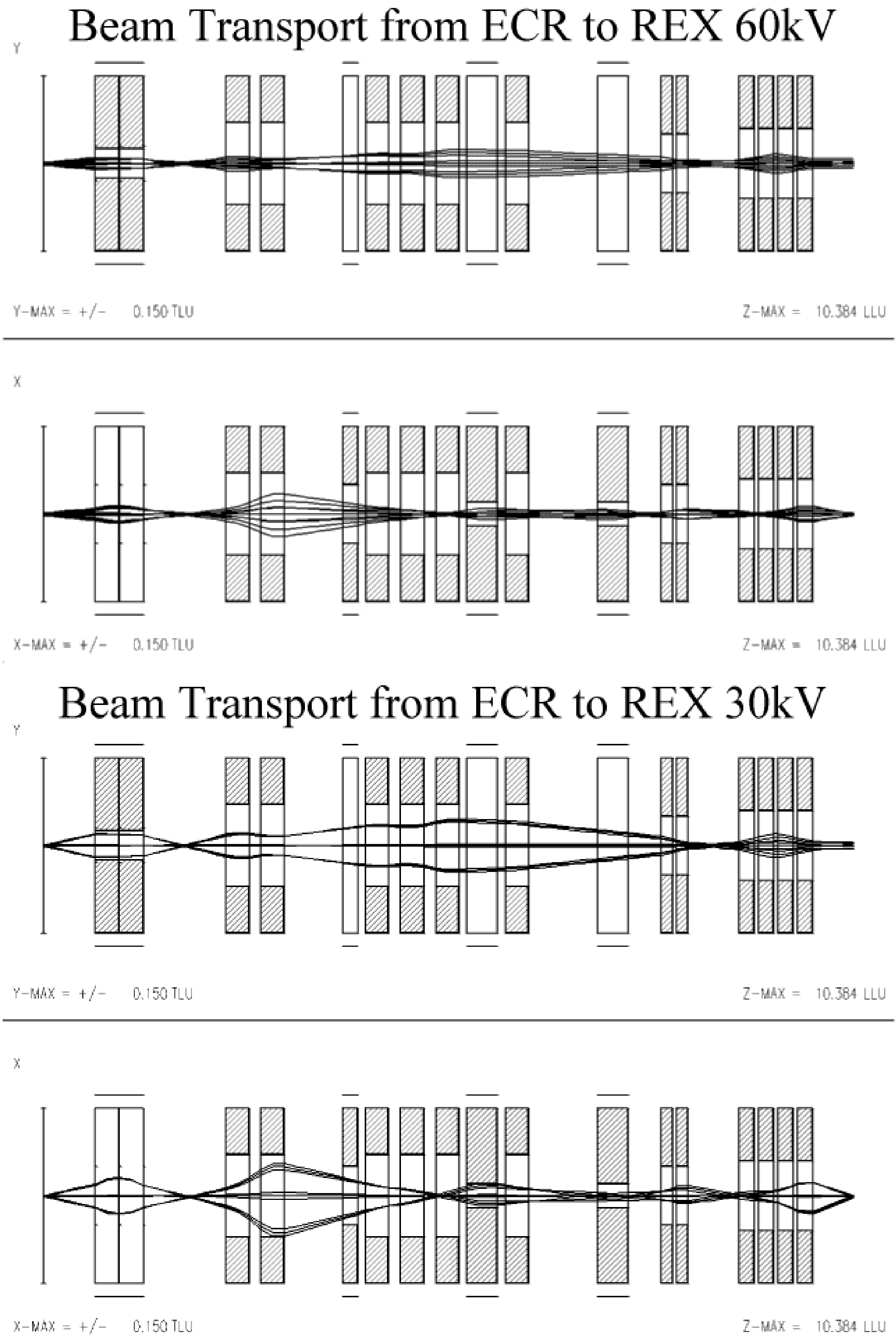


Figure 6:



Beam Transport from ECR to REX 60kV
Y
Y-MAX = +/- 0.150 TLU
Z-MAX = 10.384 LLU
X
X-MAX = +/- 0.150 TLU
Z-MAX = 10.384 LLU
Beam Transport from ECR to REX 30kV
Y
Y-MAX = +/- 0.150 TLU
Z-MAX = 10.384 LLU
X
X-MAX = +/- 0.150 TLU
Z-MAX = 10.384 LLU