Chapter 3

# Beam Transfer to Targets

## Authors and Contributors

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## Beam Transfer to Targets

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# 3 BEAM TRANSFER TO TARGETS

## 3.1 OVERVIEW

The main design is basically unaltered from the ESS 2002 technical report [ESS, 2002], and we have consequently only included an executive summary and an outline of remaining work. The technical details for the beam transport lines to the LP and SP target stations are given in a separate ESS report [Bechstedt, 2003]. The overall layout and component specification is clearly sufficient to give high confidence in the feasibility and the cost estimate.

## 3.2 INTRODUCTION

The ESS facility has a Long Pulse (LP) target station, which accepts the 2 ms beam pulse from the linac and a Short Pulse (SP) target station, which accepts the 1.4 µs beam pulse from the two ESS compressor rings [ESS, 2002]. While the beam transport lines to both target stations differ in some respects they must both transmit the beam with very low beam loss to avoid component activation and produce elliptic beam spots of 6 cm height by 20 cm width. From the linac we have a small emittance $H^-$ beam which is converted to a proton beam before transmission to the LP target. This prevents unwanted beam loss through stripping of the $H^-$ beam in high magnetic fields. The proton beams from the two compressor rings have large, and slightly different, emittances as the lower ring retains its full intensity beam for about 0.5 ms longer than the top ring. The proton beams from the two rings are extracted sequentially and are combined with fast kicker magnets in the SP beam transport line.

In both lines the beams are raised by 4 m just upstream of the target stations allowing 500kW beam dumps to be placed in the undeflected position under the beam line, as shown in Figures 3.3.1 and 3.4.1. Standard multipole magnets control the particle distributions on the targets and additional non-linear magnets are considered for the SP beam line. Horizontal and vertical beam scrapers, capable of dissipating up to 200 kW each, are proposed upstream of each target station.

A detailed report containing more technical information is available [Bechstedt, 2003]. Part of the results can be found in [Tang, 2003].

## 3.3 BEAM TRANSFER TO THE LONG PULSE (LP) TARGET STATION

Figure 3.3.1 shows the arrangement of the 100 m LP target beam line, starting in front of the achromat and ending at the LP target beam window. Good separation between the linac beam dump and the beam for the LP target station is provided by the high strength dipoles that raise the beam up to final target level. This also provides a compact design.

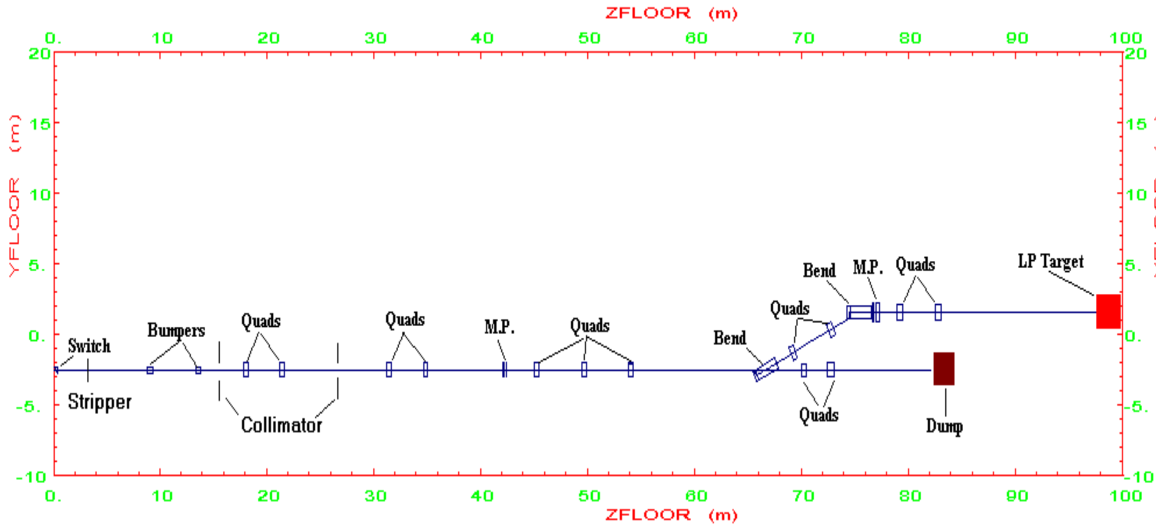


**Figure 3.3.1: LP target beam line from the achromat to the target beam window equiped with standard multipole magnets (M.P.)**

The $H^-$ beam from the linac is deflected onto a stripping foil by a switched magnet upstream of the achromat. The switched magnet requires rise and fall times of less than 5 ms each and a flat top of 3 ms. As the full 5 MW LP $H^-$ beam must pass through a similar stripping foil to that used for the ESS rings, peak temperatures are expected to be higher. Temperature reduction may be achieved by the use of transverse painting as in the rings, see chapter 2, or by the use of multiple or angled foils. The resultant proton beam passes through two permanent dipole magnets that restore the beam direction to be parallel to, but horizontally displaced from, its original direction. The stripped electrons with about 5 kW power are caught on a cooled collector. Downstream scrapers are proposed for the removal of halo particles.

An almost uniform, sharply truncated beam profile is produced at the target window. Further scrapers just upstream of the target remove any halo particles and protect the last focusing elements from backstreaming neutrons, see chapter 4.

Further error studies and estimates of the radiation levels in the proposed scraping systems are still to be carried out. The exact position of the scrapers is dependent on details of the biological target shielding.

## 3.4 BEAM TRANSFER TO THE SHORT PULSE (SP) TARGET STATION

Figure 3.4.1 shows the arrangement of the SP target beam line, starting from ring extraction and ending at the SP target beam window. The two proton beam lines from the two rings are separated by 2m and then combine at 40 m. Standard magnet elements allow full transmission of the beam from both rings to the SP target. The beams are combined using fast pulsed kicker magnets, of similar design to the ring extraction kickers, as the beam bunches from the two rings are separated by about 200 ns. The 200 ns gap can be adjusted via the ring synchronisation scheme.

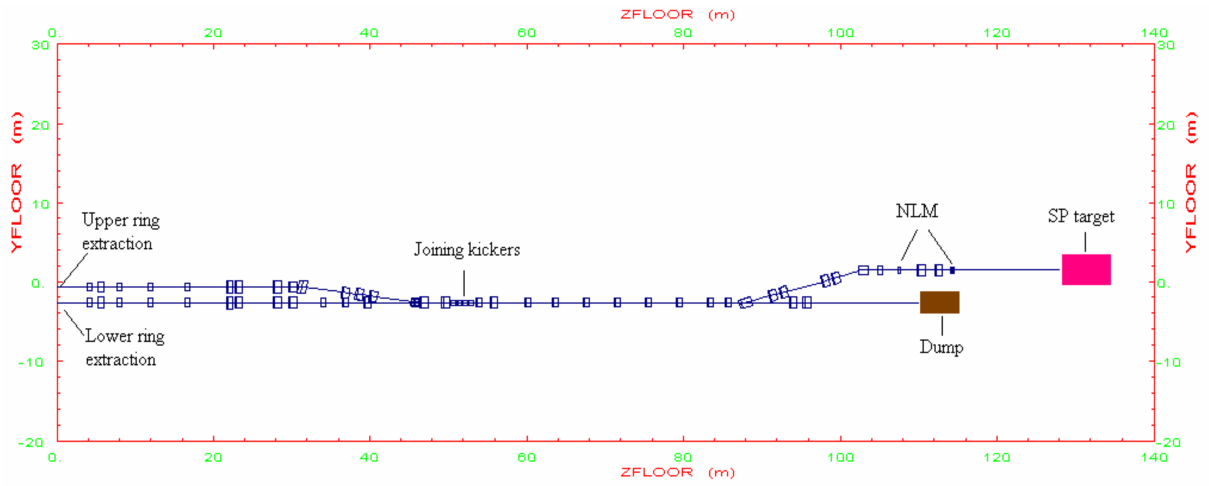


**Figure 3.4.1: SP target beam line from the ring to the target beam window equipped with non-linear magnets (NLM)**

An almost uniform, sharply truncated beam profile is produced at the target window and for some beam distributions non-linear magnets are being considered. Scrapers placed close to the target shield will remove halo particles and help to protect the last focusing elements from backstreaming neutrons, see chapter 4.

The exact position of the scrapers is not yet fixed and is also dependent on details of the target biological shield.

## 3.5 DISCUSSION AND REMAINING WORK

For both beam transport lines errors and radiation levels at scrapers remain to be studied. For the LP beam line, foil temperature estimates and stripping efficiencies need to be considered along with the possible use of transverse painting or use of multiple or angled foils. For the SP beam line the effect of missed kicker magnet pulses and the stability of the beam spot on the target need further study as do the beam distributions from variations to the ring painting parameters. Specifications for the non-linear magnets are pending.

None the less, the overall layout and component specification is clearly sufficient to give high confidence in the feasibility and the cost estimate.

## REFERENCES


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