IMPROVEMENTS OF THE SAFETY ENVIRONMENT FOR THE UCN-KICKER MAGNET

U. Rohrer, R. Dölling

After a successful test of the UCN-kicker at the end of 2002, its ceramic tube did not survive the HE-beam period 2003, because the metallic joint at its entrance got overheated by some temporarily misguided proton beam, and started to leak. A new ceramic tube has now been inserted with three protective diagnostic elements added in its environment, which should avoid any further damage of this piece of vacuum tube. An additional benefit of this upgrade is the improved awareness for minimizing the beam spill in the region of the kicker magnet.

INTRODUCTION

In December 2002 it was successfully demonstrated in situ with beam, that a newly designed fast kicker magnet fulfils the requirements for switching the beam normally going to the targets M, E and SINQ into the beam line leading to the future UCN target forth and back in less than 1 ms (see [1], [2]). But during the HE-period of 2003 some overheating caused by a temporarily misguided beam produced a vacuum leak at the soldering joint of the ceramic tube at its entrance. The kicker magnet and its ceramic tube had to be removed until a solution with some diagnostics to detect false beam conditions at this location was found and successfully tested.

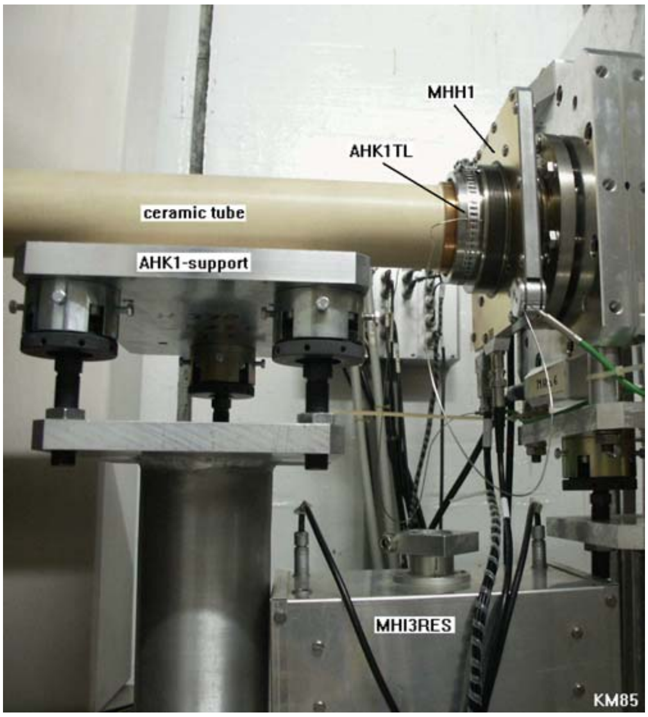

Fig. 1: Photo of the ceramic tube with the 4-segment (l/r/o/u) halo monitor (MHH1), the thermo couples (AHK1TL/R) on each side of the entrance flange and the ionisation chamber (MHI3RES) below the support for the kicker magnet (AHK1, not in place).

ADDITION OF DIAGNOSTICS

During 2004 three different types of diagnostic elements were mounted near the newly installed ceramic tube of the kicker magnet (Fig. 1):

1) Two thermo-couples at the entrance of the tube, one at the left and one at the right side of it. The interlock levels are set to 40 °C. The normal operational temperature is not significantly higher than the ambient temperature of 30 °C.
2) An additional dedicated ionisation chamber is placed underneath the kicker magnet as close to it as possible. About the usefulness of ionisation chambers for protecting the 590 MeV proton channel see [3] and [4]. At normal operating conditions, the signal from this chamber is in the range of 5 to 30 nA at 1.8 mA proton beam intensity. The interlock level is set at 100 nA.
3) Application of a newly developed halo monitor (see [5], [6]) for the first time with the 590 MeV proton beam. Unlike ionisation chambers, this device monitors only the losses due to the halo of the proton beam at the location where the beam traverses its 4 active volumes (Fig. 2). Therefore it is very sensitive to miss-steering of the beam. The interlock levels of all 4 segments are set to 100 nA. Measured currents are usually not exceeding 5 nA (Fig. 3). There is always a higher signal on the left than on the right side (low energy tail of the halo).

Fig. 2: Halo-monitor MHH1 (to be clamped over an indentation of the beam tube, e.g. bellows) initially designed for the new PROSCAN Facility at PSI (see [5], [6]). Well visible are the high voltage electrodes of the 4 segments (the inner diameter of the device is 82 mm), which are hit directly by protons traversing the beam tube at large radii up to about 50 mm (halo).

A special synoptic display for the operator's console shows continuously all the measured signals of these 3 diagnostic devices (Fig. 3). Therefore via some tuning it is possible to minimize the beam losses in this region of the proton beam line. In case of a misguided beam, the interlock system will turn off the beam before any damage to the ceramic tube will happen.

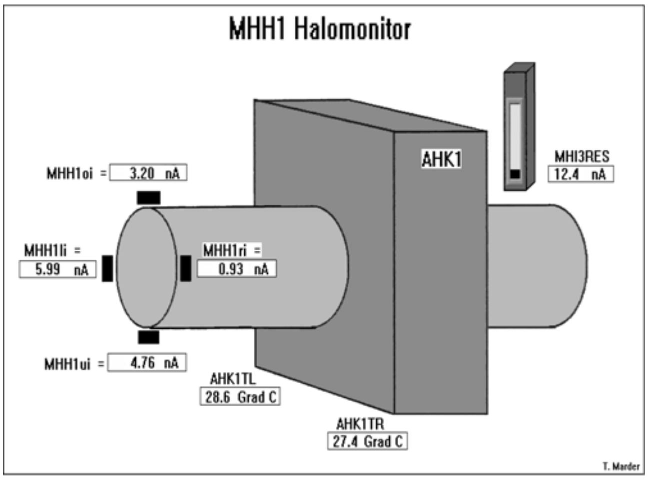

Fig. 3: Operator's synoptic screen display with the measured currents at the 4 segments of the halo monitor (MHH1l/r/o/ui), the 2 temperatures (AHK1TL/R) at the entrance of the ceramic tube and the current signal from the ionisation chamber (MHI3RES) positioned underneath the kicker magnet (AHK1).

ADJUSTMENT OF THE BEAM OPTICS

After reinstalling the ceramic beam tube with the new diagnostic elements in mid 2004, the monitored losses at this location exceeded the tolerable values by far. The reason is the constraint caused by the ceramic tube aperture with only 58.5 mm inner diameter compared to 100 mm with a standard vacuum tube. Even after a considerable tuning effort the losses could not be reduced to a satisfying level. Therefore it was decided to change the optics by lessening the width in x from around 4σ = 25 mm to less than 20 mm without modifying the envelope near the target M (Transport envelope fit, see Fig. 4 and [7]). This modification has the consequence that the losses during DC-splitter operation for biomedical applications are typically 20 % higher. But this trade-off is tolerable because of the low duty-factor of this beam production mode. With the new optics the x-width (4σ) of the beam at the kicker position varies between 15 and 20 mm depending on the accelerator setup.

CONCLUSIONS

Weeks of smooth HE-production at 1.85 mA showed, that the newly installed diagnostic elements to protect the kicker tube work reliably. Additionally, with the help of the 'MHH1 halo monitor synoptic display' (see Fig. 3) the operation crew can reduce the losses in the vicinity of the kicker magnet to minimal values. This is mainly accomplished with proper adjustments of the 590 MeV accelerator phase. Experience over the last months has shown, that this procedure is also beneficial for the whole 590 MeV beam line section between the accelerator exit and target M. We are very enthusiastic about the usefulness of this new type of halo monitor and are hoping to use it also at other locations in the near future. One condition for this is that it proves to be enough radiation resistant (it contains parts made out of epoxy) to survive at least one HE production period.

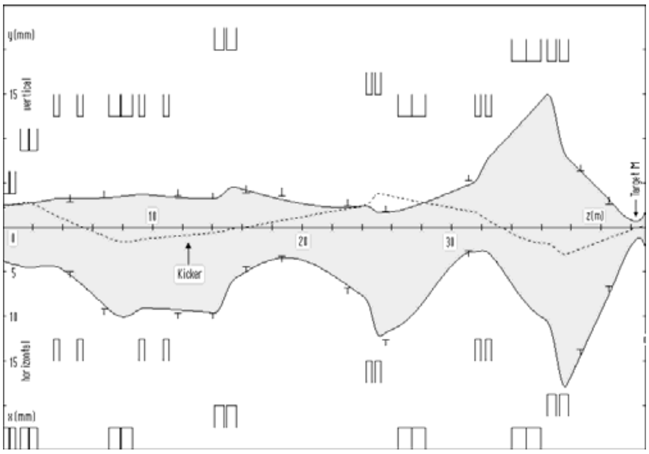

Fig. 4: The 2σ beam envelope of the newly adapted optics for the proton beam between the extraction of the 590 MeV Ring Cyclotron and Target M. The 2σ half-width in x at the location of the kicker is around 10 mm. The measured 2σ beam profile half-widths are indicated as T-symbols. The fit of the beam envelope to these data was done with the program Transport [7]. All drawn magnet aperture dimensions are scaled by a factor of 0.25. The dotted line represents the 0.1 % dispersion trajectory.

REFERENCES

[1] U. Rohrer et al., *First Beam Tests with the Fast Kicker Magnet for the Ultra Cold Neutron Facility*, PSI Scientific and Technical Report 2002, Volume VI, p.22-25.

[2] http://people.web.psi.ch/rohrer_u/pdfs/ucn.pdf

[3] U. Rohrer*, The Multilevel Protection System for the Vacuum Chambers of the High-Intensity 590 MeV Proton Beam Lines*, PSI Scientific and Technical Report 2003, Volume VI, p.45-48.

[4] http://people.web.psi.ch/rohrer_u /protect.htm

[5] R. Dölling*, Profile-, Current- and Halo-Monitors of the PROSCAN Beam Lines.* PSI Scientific and Technical Report 2003, Volume VI, p.99-100.

[6] R. Dölling*, Profile, Current and Halo Monitors of the PROSCAN Beam Lines*, 11th Beam Instrumentation Workshop (BIW04), Knoxville, Tennessee, USA, May 3-6, 2004, AIP Conf. Proc. 732, p. 244-252.

[7] http://people.web.psi.ch/rohrer_u /trans.htm