REDUCTION OF TARGET-E LENGTH FROM 60 MM TO 40 MM

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In order to increase the intensity of the proton beam to the SINQ target from 0.85 mA to more than 1.0 mA (with 1.5 mA extracted from the 590 MeV Ring Cyclotron) the length in beam direction of the graphite target at the target station E (see Figure 1) was reduced from 60 mm to 40 mm. With the reduction of the target length several parameters of the proton beam to the SINQ target changed by some amount (see table 1) and therefore the settings of the bending magnets and the quadrupoles had to be adjusted up to about 1 % in order to get the same beam spot size at the SINQ target and about the same proton losses in the beam cellar below the SINQ target. The differences of these parameters extracted from Monte Carlo computations for a location just behind the collimator system after the thick target are shown in table 1.

Table 1: Parameters for the 2 target lengths.

C-target length (mm)	60	40
p-Momentum (MeV/c)	1.17	1.18
Vertical 2σ-angle (mr)	8.3	8.0
Horizontal 2σ-angle (mr)	11.6	10.4
Proton beam losses (%)	43	30

The 2 sets for the bending- and quadrupole-magnets are not shown here. But the computed differences of the 40-mm-optics from the 60-mm-optics could be verified after a short tuning session. Because of the necessity of running with about the same intensity of the beam at the rim of the target window at SINQ, the relative intensity (measured in μA/cm²) in the center is 20 % higher with the 40 mm target compared to the 60 mm target at E. This is due to the relatively longer tails of the beam profiles caused by less beam cut-off at the collimator system behind Target E.

The shorter target reduces the secondary particles from the target interactions and increases the peak proton density at the beam center due to less coulomb scattering of the target. As a consequence the heat load of the shielding collimators after target-E decreases and the heat load of the beam dump collimators increases. Figure 2 shows the change of the heat load of the collimators evaluated from the logging-data using a spreadsheet-based program [1].

All collimators are made from OFHC copper. Fatigue behavior is a central design criterion since the collimator material will be subjected to thermal-mechanical cycling, as a result of the cyclic operation of the accelerator due to interruptions. The collimators have been designed for the operation of a 2 mA beam with a 60 mm target. In order to keep the heat load within the design limits with the 30 mm target the beam intensity has to be kept below 1.6 mA if the beam has to be stopped at the beam dump.

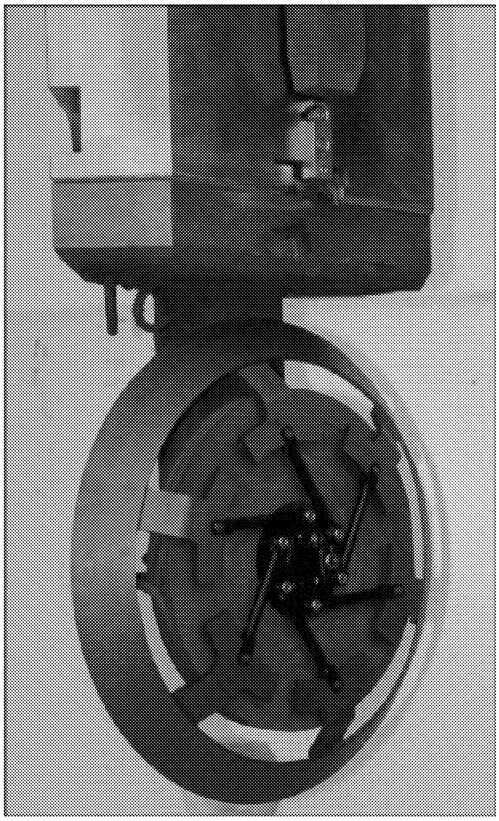

Fig. 1: Picture of the target-E unit. The target consists of a rotating truncated cone of polycrystalline graphite. The length of the target in beam direction was reduced from 60 mm to 40 mm.

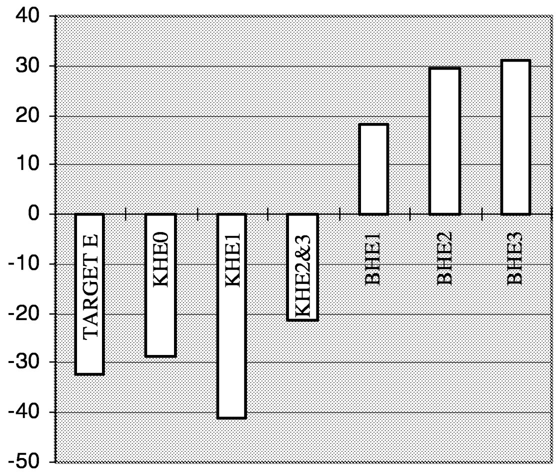

Fig. 2: Measured change [%] of the heat load of the target-E shielding, the shielding collimators KHE0 and KHE1, the shaping collimator system KHE 2&3 and the beam dump collimators BHE1-3 as a result of the reduction of the target length from 60 mm to 40 mm.

A major concern is the mechanical long-time stability of the graphite target wheel design [2]. There is an easy method to check on-line if the target wheel is still behaving well. This is accomplished with the help of the so-called AHPOS scatter plot (see figure 3). While changing slowly and carefully (to avoid an interlock) the horizontal position of the beam on target E by about ±1 mm with the help of the super-knob parameter AHPOS, the beam transmission parameter (MHTR2E) and one of the beam loss parameter (MHI31) are simultaneously observed and plotted with dots (sampling rate = 10 Hz). After about 30 seconds this yields to the 2 curves shown. When the rim of the beam spot reaches the edge either to the left or to the right side of the 6 mm wide target, a small portion of the beam (horizontal width 4σ = 4 mm) will not pass entirely through the target material (width = 6mm) and it causes one or both parameters to rise. As long as the flat region has a width of about 2 mm the target geometry is still OK (wheel running round within an accuracy of about ±0.1 mm). Otherwise the flat region would shrink with time and beam transmission interlocks would be becoming gradually predominant during the operation of the beam.

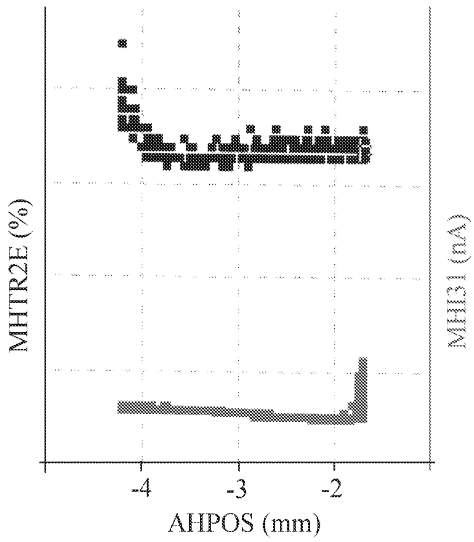

Fig. 3: Scatter plot of the beam transmission through the target E region (MHTR2E, upper curve) and the ionization chamber loss monitor behind target E (MHI31, lower curve) as a function of the horizontal position of the center of the beam spot on target E. With a given target width of 6 mm and a 4σ-width of 4 mm a horizontal flat spread of about 2 mm of the 2 curves is indicating that the geometry of the rotating (1 Hz) target is stable.

The Pion and Muon production is roughly proportional to target length. The reduction from 6cm down to 4cm should decrease the rate by about 30%. πE1 is being used by the Pion-Beta experiment. The expected rate reduction was found. Opening the slits the experiment could recover the DAQ rate. The Sindrum experiment using the πE5 beam line observed a similar rate decrease. Important for Sindrum is the separation of the electrons from the muons. Again opening the slits improved the DAQ conditions, because due to better phase space conditions the electron / muon ratio improved. The Pionic Hydrogen experiment in the πE5 area requires the highest possible pion rate (112 MeV/c). This experiment suffers from the 30% rate reduction.

The µE1 beam is mainly used by the µSR community. They operate with low rates. The muon decay experiment however will suffer from the rate reduction. Opening the slits will reduce the muon polarization which is essential for this experiment.

The influence of the target length reduction onto the µE4 beam line has not been measured. An intensity reduction of 30% would have been expected. The experiments, which take place there, do not require high particle fluxes. There are at the moment no requests for new experiments using a high rate beam for this area.

The πE3 beam line is optimized for the use of surface muons. (Since the extraction in the achromatic mode depends linearly on the target length a muon rate reduction in the order of 30% is assumed.) The beam line originally designed for LEPS is now mostly used by the µSR community including the low energy muon facility (LEM). The operation of the µSR device ALC and LEM need high rate surface muons and can not compensate for the lower intensity adjusting the slit openings.

We conclude: The two large experiments Sindrum and Pion-Beta do not suffer from the target modification. The experiments in µE1 and µE4 generally do not need high particle fluxes. Parts of the µSR facilities and the Pionic Hydrogen experiment ask for higher rates. There is a new experiment (µLAN) proposed to measure the muon lifetime at the πE3 beam line. It will require high rates and a kicker.

To improve the situation in the long run for µSR and LEM a study will be made to modify the πE3 beam line to achieve higher rates there.

The future experiment µeγ will ask for high fluxes of 28 MeV/c surface muons which can be delivered by the πE5 beam line.

One should also consider to have dedicated beam times with a 6 cm target.

REFERENCES

[1] Strinning, A spread-sheet based program for the post-processing of logging-data, This report.

[2] Heidenreich et al., Improvement of the Operational Reliability of Target-E, PSI-Scientific Report 1998, Vol VI, p.16