A NOVEL METHOD TO IMPROVE THE SAFETY OF THE PLANNED MEGAPIE TARGET AT SINQ.

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Currently the SINQ spallation targets are only protected through the target-E beam transmission interlock from being hit by some unscattered and therefore more intense beam caused by protons missing the target-E. In order to improve this situation, an additional method to detect already small portions of unscattered beam is proposed. The idea is to block the unwanted beam with a newly to add slit at the dispersive focus of the proton beam line and to trigger an interlock via an ionisation chamber when the wrong beam hits the lower jaw of the slit.

INTRODUCTION.

Because of the possibility of the contamination of the proton beam line underneath SINQ with liquid metal pouring out of a broken liquid metal target for the MEGAPIE project, it is desirable to add at least one additional safety-element to the already existing beam transmission interlock. The main reason for a possible breaking of the 2 windows of the liquid metal target is overheating caused by the unscattered proton beam, which has a much smaller spot size at the SINQ target (caused by ion-optical reasons) than the beam passing through the graphite material of target E.

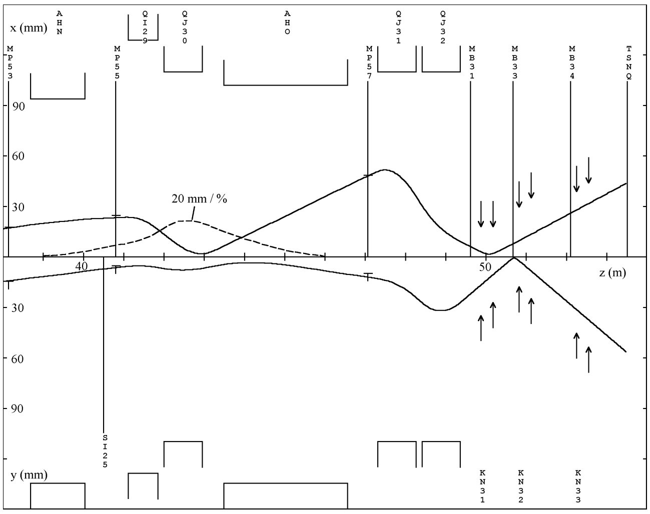

Figure 1: Portion of the graphic output of the TRANSPORT envelope fit (with target E length = 4 cm) of the proton beam between bending magnet AHN and SINQ-target together with the computed 1%-dispersion trajectory (dotted line), which reaches a maximum inside the quadrupole lens QHJ30 near the dispersive focus (best separation of the 2 beams).

THE NEW IDEA.

As may be seen from Figure 1, the momentum dispersion at the dispersive focus between the 2 bending magnets AHN and AHO is quite large (20 mm / %). This means, that the 2 beams (momenta p=1181 and 1205 MeV/c) at this location are separated by an amount of about 40 mm with a beam spot size in y of only about 12 mm FWHM (see Figure 2). In order to verify the Monte-Carlo TURTLE) computations, the observable profile widths (measured with profile monitors MHP41-MHP58) have been compared with the simulated profile widths and found in good agreement. Also the behavior of a proton beam, which is shifted sideward by 2 mm at the target E location has been investigated with the same Monte-Carlo computations and experimentally by performing a so-called AHPOS-plot [1] and at the same time observing MHP56 when the proton beam is positioned near one or the other edge of the target E, so that around 50

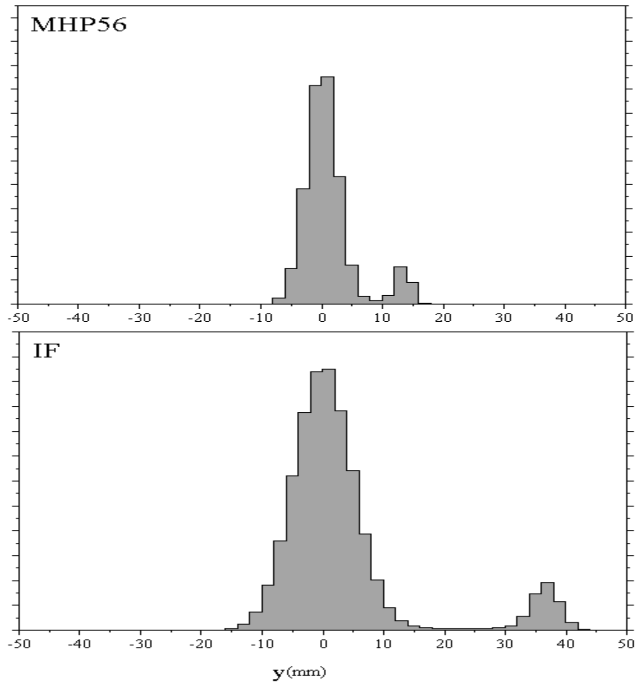

Figure 2: Monte-Carlo simulation with TURTLE of the beam profiles at MHP56 and at the dispersive focus (IF) inside the quadrupole QHJ30. The beam centre in front of target E (4 cm graphite) has been shifted by 2 mm off centre, so that about 10 % of the protons are missing the target ($\Delta p/p=+2\%$).

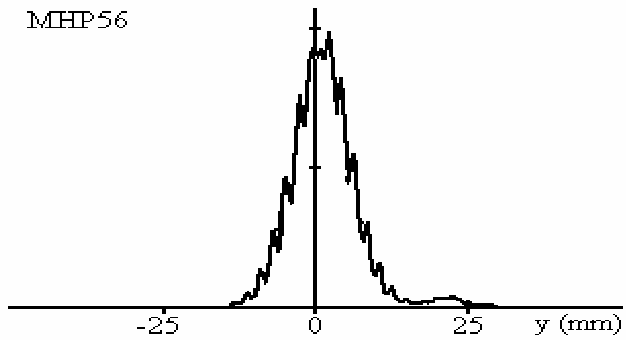

Figure 3: Measured beam profile (MHP56) with some beam (1-2%) steered besides the target E (6 cm graphite). The little peak at +20 mm is well visible. For a 4 cm target the separation would be less (14 mm).

μA are missing it (which will not yet trigger a beam transmission interlock). The graphical output of one of the typically recorded profile monitor scans is shown in Figure 3. This had to be taken with a target E of 6 cm graphite length, because at the moment a high muon rate in the experimental hall has priority over a high neutron yield at SINQ. The separation with a target of 4 cm length would be less. The computed separation at the location of the profile-monitor MHP56 and inside the quadrupole lens QHJ30 are shown in figure 2. Figures 4 and 5 are demonstrating with

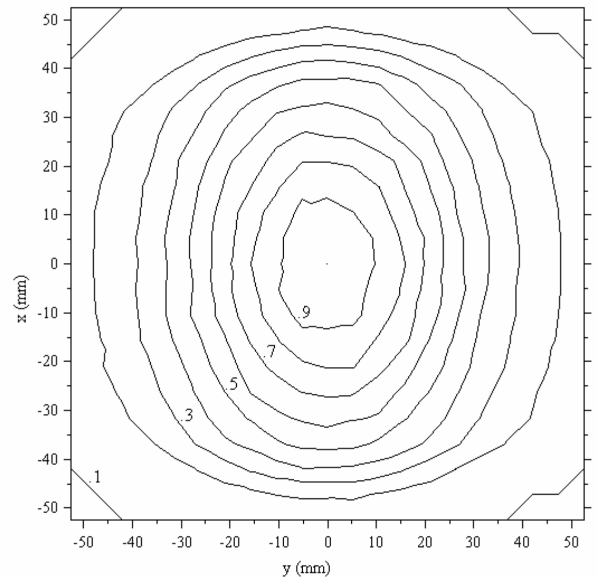

Figure 4: Contour plot of the computed (Monte-Carlo extrapolation with TURTLE) proton beam spot at the SINQ target for the optics used with the target E of 4 cm graphite length (all beam is passing through the target material). The peak current density is 20.7 $\mu A/cm^2$ for 1 mA on target E.

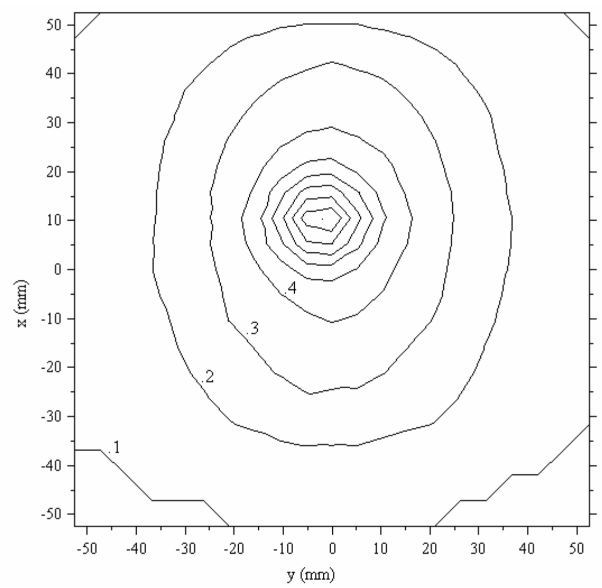

Figure 5: Contour plot of the computed (extrapolated) proton beam spot at the SINQ target for the optics with the target E of 4 cm graphite length (about 10 % of the beam are missing the target E). Obviously, a shifted (10 mm in x, -3 mm in y) hot spot on the SINQ target is showing up. The peak current density is 45.8 $\mu A/cm^2$ for 1 mA on target E (more than a factor of 2 higher than in Figure 4).

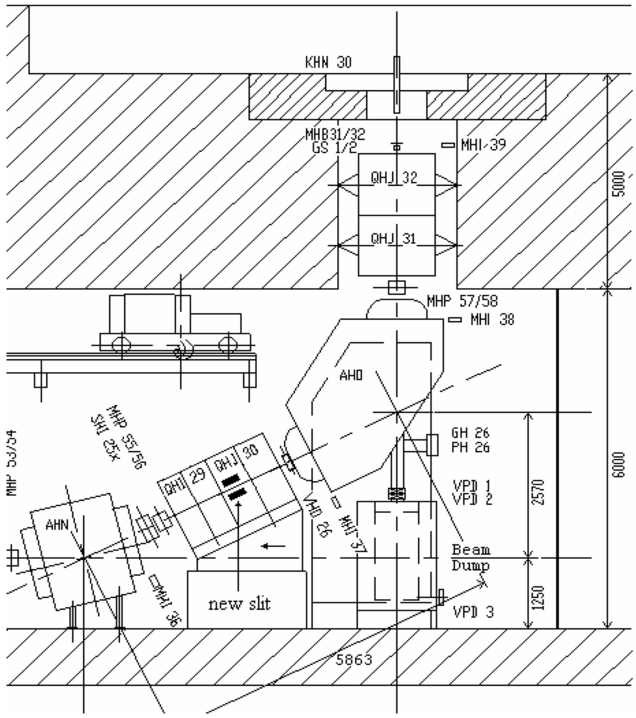

Figure 6: Side view of the situation of the proton beam line below the SINQ target. The new, vertically acting slit should be paced inside the quadrupole lens QHJ30. The nearby ionisation chamber MHI37 would detect the beam spill produced by the wrong beam not traversing target E and therefore hitting the lower jaw of the slit inside QHI30.

the help of the same Monte-Carlo computations what happens with the proton beam spot at the position of the SINQ target, if 10 % of the protons are not hitting the target E material (4 cm graphite): A dangerous hot spot of about $\sigma_x \cong \sigma_y = 5.7$ mm instead of the normal size of $\sigma_x \cong \sigma_y = 21$ mm is created, which may lead to damages caused by overheating (breaking windows), if the amount of beam not hitting the target E would be approaching 100 %. With a target E length of 6 instead of 4 cm graphite this narrowing effect of the beam spot would be much less dramatic (by a factor of 4 in surface). Therefore, using 6 cm graphite instead of 4 cm for target E would increase the safety of the MEGAPIE project, but at the expense of 20 % in beam intensity.

CONCLUSION.

Adding a vertically adjustable slit inside the quadrupole lens QHJ30 (see figure 6) would add a considerable amount of safety for the MEGAPIE project, because the dangerous proton beam component would be safely detectable and blocked from reaching the SINQ target. There is some experimental evidence, that with a well-centered beam on target E most of the beam halo will be lost before it could hit the adjustable slits. The realization of this modification is not an easy task, because space in this region is scarce.

REFERENCES

[1] K. Deiters, F. Foroughi, G. Heidenreich, U. Rohrer, Reduction of Target-E Length from 60 mm to 40 mm, PSI Scientific and Technical Report 1999, Volume VI, page 26.