MODIFICATION OF THE EHT-SPLITTER REGION

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The 590 MeV proton channel region between the bending magnet AHC and the magnetic septum ABS has been modified in the shut-down 1997/98 [January-June 1998]. This was mainly done in order to radiation harden the components after the EHT splitter and to reduce the proton losses along the beam line leading to the pirex target station. The drawing in Fig 1 shows the new mechanical design. An important constraint for the new layout was the need to stick as close as possible to the former optical conditions. This means that the new quadrupoles, steering magnets and profile monitors remained as close as possible at the locations of the former elements which had to be replaced. Two additional new components are the 2 movable pairs of slits (KHNX1 and KHNY2 at the location of the former BH1) which offer the possibility to trim the beam halo produced by the splitter (and therefore the activation further downstream) as much as possible. Near the 2 exit flanges of the ABS there are 2 additional fixed aperture slits consisting of copper which help further to downgrade the halo produced by the splitter. Fig.3 shows a photographic top view of the new EHT region taken just after completion of the installation work. What you see are mainly the white top surfaces of the shielding blocks (concrete, steel or marble) a vacuum pump, the 2x2 slit-motors, some covers, the electrical cabling, water and vacuum hoses, compressed air and

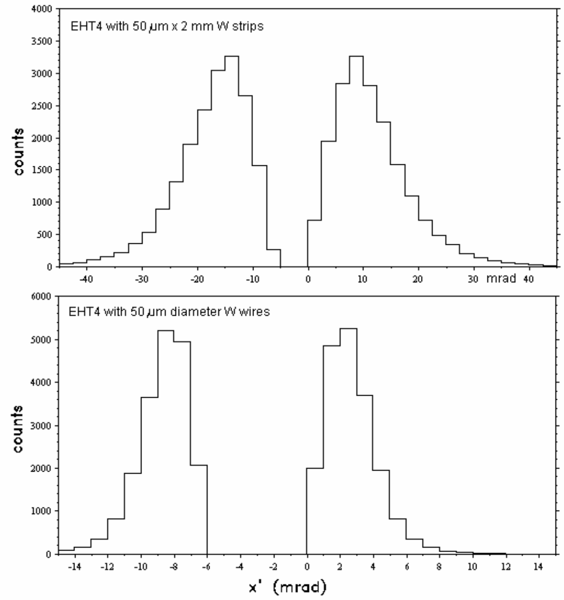

Fig 2: Histograms of the 2 angular distributions of the scattered protons hitting the splitter consisting either of tungsten strips (top) or tungsten wires (bottom). The RMS-angles differ by about a factor of 4 to 5. The estimated width of the septum for head-on collision is in both cases about 70 µm. The beam width at the septum is usually around 20 mm (4-sigma).

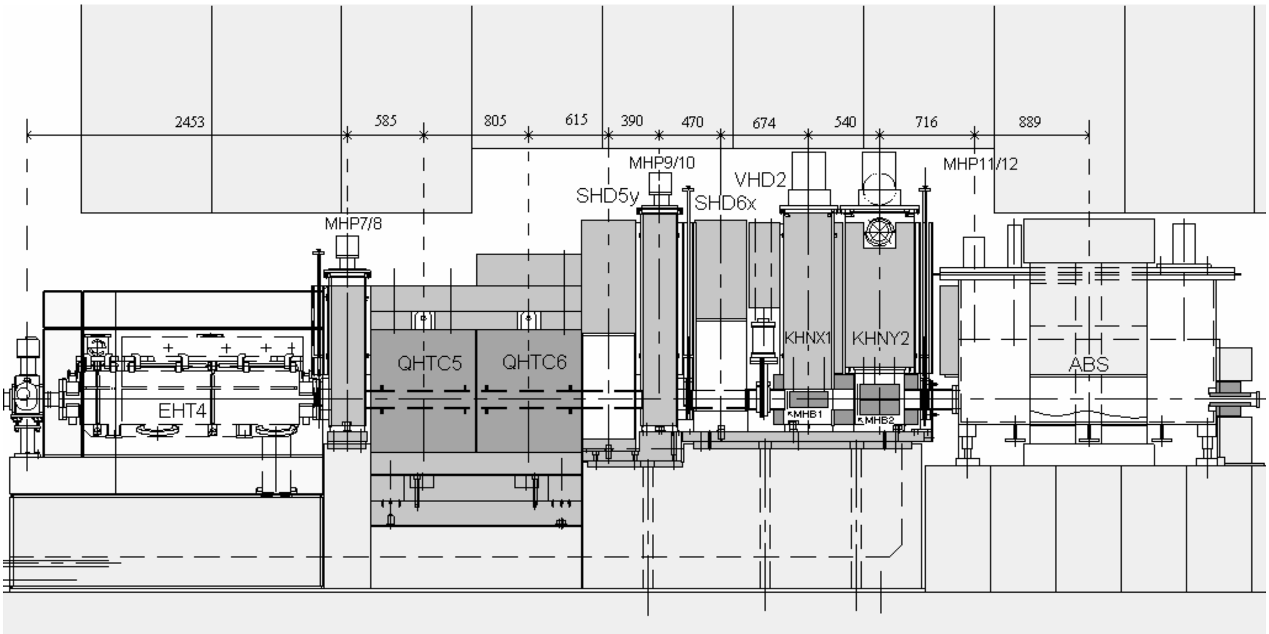

Fig 1: Drawing (H. Kalt) of the mechanical layout of the new beam line section between the splitter (EHT4) and the magnetic septum (ABS). The components in between are (from left to right) profile monitor (MHP7/8), 2 quadrupoles (QHTC5, QHTC6), vertical steering magnet (SHD5y), profile monitor (MHP 9/10), horizontal steering magnet (SHD6y), vacuum valve (VHD2), horizontal (KHNX1) and vertical (KHNY2) slits and profile monitor (MHP11/12). All new components are supported by precisely positioned concrete blocks and top-shielded by iron blocks.

water pipes leading to or sitting on top of the different devices integrated into the shielding blocks. Tags with the names of the devices have been drawn into the photograph on top of each unit in order to make it easier for getting some orientation. Like all of the other proton beam lines the shown new beam line section is normally also covered by some more local shielding consisting of several layers of concrete blocks.

The dominating problem of this section of beam line is the activation generated by the relatively high splitter (EHT) losses. When cutting off 20 µA from the 1.5 mA main beam as much as 2 µA of the protons are making head-on collisions with the septum (wires or strips) as has been estimated by computer simulations and also verified through measurements by M. Olivo [1,2]. All protons making head-on collisions with the EHT foil undergo some angular straggling and therefore are lost somewhere along the beam line, as can be shown with the Monte Carlo program Turtle [3]. The angular straggling distribution of these protons is depending on the septum material (tungsten or molybdenum) and its distribution along the beam axis (wires or strips of different dimensions). If the angular distribution of the scattered protons is narrow (wires), many of these protons may hit the vacuum tube constraints as far away as in the vicinity of the bending magnet ABK1 (some 30 m distant from the EHT). If the angular distribution is broad (W strips), then most lost protons hit the vacuum chambers before the ABS magnetic septum. Therefore an EHT splitter equipped with strips is the better choice, because it is easier and cheaper to radiation-harden the region between EHT and the magnetic septum ABS instead of the whole rest further down stream. For the 2 computed angular distributions of the scattered protons at the splitter exit see Fig.2. Half of the spilled protons make their way along the main beam line to the target M, the other half goes towards the pirex target. Therefore both beam lines are messed up about equally.

Observations of the beam losses during the HE-production period of 1998 have shown that the spill levels behind the non-radiation hardened region are now reasonably low. Also the EHT-splitter has proven to be stable (no aging effects of the W strips) during the whole production period of 1998, and there has been no accident with this new beam line section during this time span. But in case a component in this region would fail one day, then it can be repaired with a minimum of radioactive dose applied to the service personnel mainly because for all needed work a sufficient distance between the activated material and the human bodies involved into the repair work is maintainable. For this reason all components can be moved in or out vertically with no direct human contact near the beam axis by the usage of remote handling techniques.

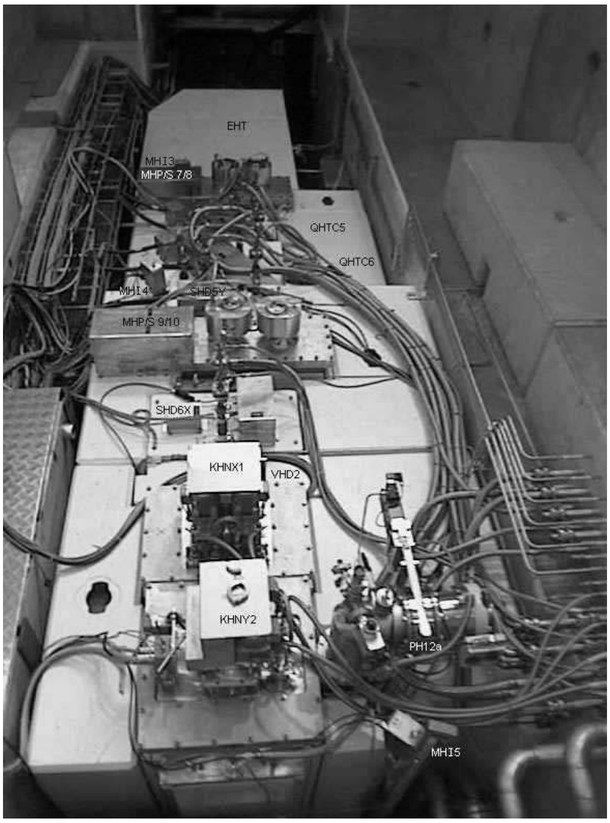

Fig 3: Photograph (by H.R. Vetterli) of the newly built EHT spitter region. To the left and to the right are the fixed concrete walls of the proton channel. At the lower right corner one can see the feed-through block for the water, compressed air and vacuum pipes. On top there is the cover of the white marble (extra low heavy metal contamination) local shielding of the EHT splitter. Further downwards one can see the white painted surfaces of the concrete and iron shielding blocks with the top ends of the different components (Labels are drawn into the photograph). For replacing the EHT splitter or the slits (KHNX1 and KHNY2) special shielded transportation boxes are available.

[1] M. Olivo, E. Mariani, D. Rosetti: Electrostatic Beam Splitter for the 590 MeV-1 MW Proton Beam Line, PSI Annual Report 1996 Annex I, page 6.
[2] E. Mariani, M. Olivo, D. Rosetti: An Electrostatic Beam Splitter for the PSI 590 MeV-1 MW Proton Beam Line, 6th European Particle Accelerator Conference, Stockholm 1998 (EPAC-98) pages 2129-2131.
[3] The program is available electronically, please see the Web site:
http://people.web.psi.ch/rohrer_u/turtle.htm