LEM - LOW ENERGY MUONS
PREPARATION WORK FOR THE NEW BEAM LINE DURING 2003

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PSI is constructing a new beam line for the LEM facility which will replace the present μE4 beam line. Design and production of new components is fully controlled by PSI. The year 2003 was mainly used to prepare the replacement of the whole beam line in winter 2004.

THE NEW BEAM LINE

The new beam line at area μE4 is designed to achieve charged particle fluxes of about $5 \times 10^8\,\mu^+$/s which will be ten times larger than the old design was able to deliver. The first part of the beam line will be a solenoid lens system, directly connected to the main pion production target E. The following elements are conventional large acceptance quadrupoles and dipoles. Design and construction of the beam line had to fulfil different constraints. The new beam line has to fit into the existing tunnel in the primary concrete shielding around the production target. The exchange work can only be done during a shut-down period. We estimate that the first magnet of the old beam line is activated and has a dose rate up to 5 Sv/h in 50 cm distance. The coils for the new magnets placed near the target have to be insulated using radiation hard material.

INITIAL SITUATION

At the end of the year 2002 several components were still under production in our workshop. The radiation hard coils for the solenoid were not yet delivered, and we had not made a pre-assembly to check that the components fit together properly. In the past we experienced that a pre-assembly usually uncovers several errors which can be corrected in advance of a time-limited shut-down period. Therefore the assembly had to be postponed to the next shut-down.

PRE-ASSEMBLY AND COMPONENTS

The first part of the existing beam line which leads the beam through the primary shielding is assembled onto an insertion wagon. The new beam line elements will replace this assembly, but will use the same wagon. During 2003 most elements became available. Only the radiation hard coils were missing. A pre-assembly was performed to minimise last-minute corrections. Compared to the old design we could implement several improvements, especially concerning shielding and easy handling. For example, hundreds of old rusty iron bricks will be replaced with painted blocks of cast iron. This will reduce the time people repairing components on the wagon have to be exposed to activated material. The first bending magnet was shielded by extra copper plates, the second by polyethylene plates. Another improvement is the vacuum flange compression chain developed by the PSI vacuum section. The new chain connection optimally applies the pressure to the metallic seal and is easy and fast to dismantle.

Fig. 1: The pre-assembly of the insertion wagon shows from left to right the first dipole, a slit, a quadrupole triplet and the second dipole magnet in between two beam blockers. Inside the second dipole there is a slit. The wagon sticks into the primary shielding.

Fig. 2: The shielding of the insertion wagon which is made out of 22 cast iron blocks, with a total weight of 97 tons. The blocks are painted to allow decontamination and will replace more than 600 rusty iron bricks from the old superstructure.

Fig. 3: A new vacuum chain connection system has been developed by the PSI vacuum section. It optimally applies the pressure to the seal and can be dismantled in a short time. The bellows can compensate geometrical errors and can provide space needed for replacement of components.

Fig. 4: This picture shows the drive unit of a slit system. We could redesign parts from existing slit systems. The drives are provided with excess-current switches and slipping clutches installed to prevent collisions. Unfortunately, it was not possible to relocate the drives of the horizontal jaws to more accessible positions.

Fig. 5: The former μE4 area has been rearranged for the new beam line. In the background are the new platforms for the electrical cabinets. At the end of the rails the insertion wagon with the cryostat of the muon channel can be seen.

REARRANGING THE AREA

In October 2003, the operation of the secondary beam line was terminated and the rearrangement of the μE4 area could be started. New platforms to carry the beam line infrastructure were installed. In view of the inaccuracy between drawing and actual position of bounding concrete blocks, the installation could be made with amazingly few minor changes. A new shielding wall to the neighbouring experimental πM1 area was built. The beam line to that area had to be switched off only for a few days. The same beam line was then covered with concrete blocks available from PSI depots. Those will be replaced later with beams designed for heavier loads. The careful planning and preparation of these operations enabled us to finish all these tasks successfully and on time.

Fig. 6: This picture shows the mounting frame for the solenoid. For the first of three sections the lateral plates are removed, therefore one can see the vacuum tube. The inside of the vacuum tube is not visible because the end flanges of the beam pipe are covered as usual during mechanical work.

Fig. 7: This detail of the solenoid mounting frame shows the adjustment system for the vacuum chamber. A plate connected with the vacuum tube can be moved in the axial direction and fixed at the correct position with a large bolt. The adjustment must be done very carefully to avoid damage to the sealing surfaces.

THE RADIATION HARD COILS

The beam line elements next to the target are the solenoid followed by a bending magnet. Both magnets are exposed to high radiation and need to withstand that radiation for many years. This requires the coils to be mineral insulated. An additional condition in high radiation areas is that the cooling water should not get in contact with copper. The technique that has been adopted at PSI with good results is to make a coil out of pyrotenax cable interspersed with stainless steel tubes and to fill the spaces with soft soldering metal.

It was not easy to find a manufacturer who could master this technique. Finally, the Budker Institute in Novosibirsk/Russia succeeded in delivering this type of coils for the dipoles of the LEM beam line. We had to provide them with pyrotenax cable we could order in Canada. Now, the Budker Institute is in process of manufacturing the radiation hard solenoid coils which we expect to receive in the middle of March 2004. That would be the latest possible date to allow installation of the solenoid lens during shut-down 2004. We are now in a position to complete the reconstruction of the wagon but the beam line cannot be brought into operation without the solenoid.

THE MUON CHANNEL

At the Rutherford Laboratory in Chilton/England a new project called MICE will study prototypes of accelerator elements for muon cooling. They can make use of the μE4 muon channel magnet which is no longer required at PSI. This would be the Swiss contribution to that project. We will measure the activation level to ensure that it is low enough to allow transport to England. In advance, we checked the costs and effort needed to prepare for a possible transport. PSI could provide a transportation rack and a haulage contractor would organise the shipping.

OUTLOOK

At the beginning of the shut-down period in 2004 we will take out the insertion wagon and dispose of some old components while others like magnets and slits will be stored. The dismantling of the old components and shielding parts and the assembly of the new components will take about seven weeks. The wagon with its new superstructure should be pushed back into the tunnel at the end of February 2004. The remaining couple of weeks we can use to begin the installation of the rest of the beam line. If the missing radiation hard coils for the solenoid arrive on time on 15^{th} of March 2004 we should be able to install the solenoid during the planned shut-down. Otherwise, we will have to postpone the solenoid installation and foresee a shut-down during summer 2004.

REFERENCES

[1] PSI FUN newsletter 2002.

[2] PSI Scientific and Technical Report 2002, Volume II.