LEM - LOW ENERGY MUONS
THE REPLACEMENT OF THE μE4 SECONDARY BEAM LINE

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PSI has constructed a new beam line for the LEM facility, which replaces the former μE4 beam line. Design and production of all new components were fully controlled by PSI. During the 2004 winter shutdown period of the proton accelerator, the beam line section inside the primary shielding was replaced. The external beam line was completed during the rest of the year. During October, more than 200 million muons could be counted.

INTRODUCTION

During the first half of 2004, the μE4 secondary beam line has been replaced with a new beam line, with the goal to deliver as many muons as possible. The 28 MeV/c muons will be used to characterise solid state surfaces. To achieve a high muon flux, a solenoid magnet is mounted close to the production Target E. This technique is unprecedented at PSI and makes it possible to explore new research areas. The solenoid coils were manufactured in Novosibirsk, Russia, and can withstand the high radiation. The beam line is more than 20 meters long and the diameter of the vacuum chamber is 500 mm.

During 2002 and 2003, all components were produced and tested except for the radiation hard coils for the solenoid. Towards the end of 2003, the new μE4 area was prepared to accommodate the new installation. Only the existing insertion wagon, carrying beam line elements and serving as a part of the primary shielding, had to stay in place. Provisions were made for its removal during the shutdown period.

THE NEW INSERTION WAGON

At the beginning of 2004, after dismounting Target E, the roll out of the insertion wagon could begin. The wagon with its weight of more than 200 tons was slowly moved out using an electric motor and gear box.

Fig. 1: The old insertion wagon with its rusty shielding after extraction in January 2004.

To avoid dents in the rails caused by the heavy wagon resting for years in the same position, the rails were fitted with hardened steel inserts. This certainly helped to make the removal of the wagon easier.

The magnets, dismantled from the wagon, are stored in PSI's depository for activated components, together with the slit systems and the beam shutter. We are planning to give the muon channel, a superconducting solenoid, to Rutherford Appleton Laboratory in England to be re-used. The channel is still valuable but had to be sacrificed for the new beam line. We had to dispose of the old wagon shielding, composed of concrete blocks and iron bricks, together with cables, pipes and plastic parts.

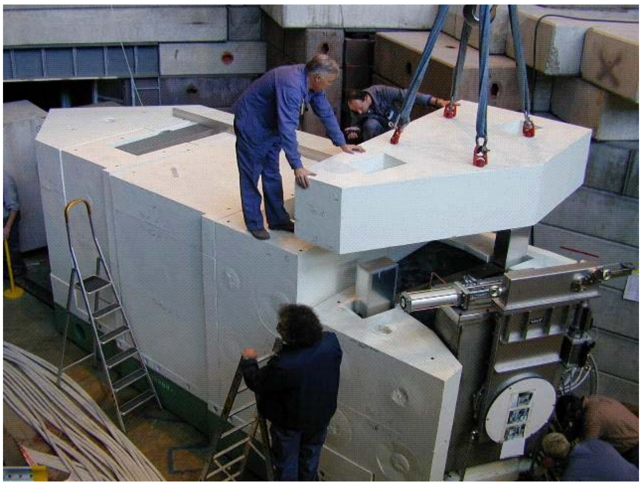

Fig. 2: The insertion wagon with its new beam line components packed in 100 tons of white painted cast iron shielding. The vacuum system can be partitioned with a slide valve, visible in the bottom right hand corner.

The new components were carefully mounted onto the platform of the old wagon. There were two main technical constraints. The position of the vacuum chamber of the bending magnet, the first element of the wagon, had to match the vacuum chamber of the solenoid and the wagon had to fit into the existing tunnel. At first, we mounted only the components and a part of the shielding. The wagon was then carefully moved into its final position to check its size and the chamber position. Since the dimensions of the tunnel were only roughly known, the construction of the new components anticipated a clearance of about 30 mm. This was unfortunately not sufficient. Luckily, this problem could be solved by reducing the height of the beam shutters by several millimetres.

Chain clamps hold the bellows assemblies which interconnect the vacuum chambers of the components. The bellows compensate geometrical errors and, when removed, provide space needed for the replacement of components. Only radiation hard metallic seals were used on the wagon.

THE SOLENOIDS

To achieve a high flux of muons, a solenoid lens pair was mounted next to the production Target E. The coils are mineral insulated to stand the high radiation dose level. The 24 coils arrived at PSI in March 2004. Only the big effort of all involved groups made it possible to prepare the magnet for its installation on time.

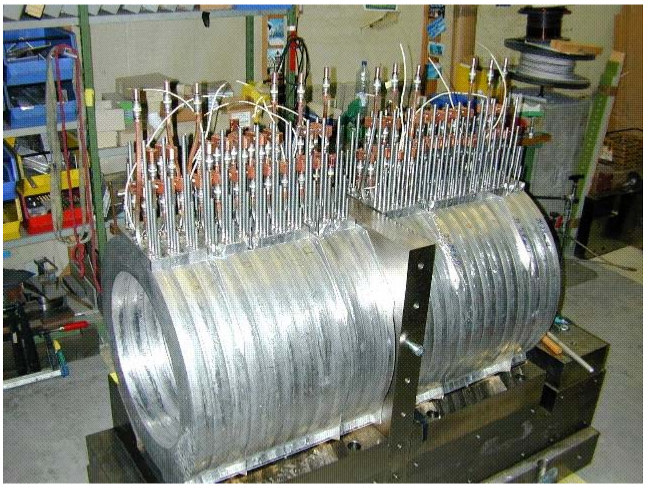

Fig. 3: The WSX solenoid with its coils from Novosibirsk during assembly. Each coil pancake consists of electrical windings on both sides and cooling plates in the centre. To keep the conductors and cooling components in position and to guarantee a good heat flow, they are cast in soft solder under vacuum.

Fig. 4: The solenoid was installed at the end of April 2004. It was attached to the revolvable crane hook using special remote-controlled equipment. The radiation level around the production target prohibited direct access.

RADIATION

The relatively low radiation level allowed direct access to the old wagon. However, special attention was taken for work on the beam entrance side. The radiation caused by the bending magnet reached a level of 70 mSv/h at a distance of 30 mm (10 mSv/h at a distance of 1 m). This source of radiation had to be removed first. The remaining parts had only irradiation levels below 3 mSv/h at a distance of 30 mm.

The old triplet QTD, which was replaced by the WSX solenoid, was highly activated. On the beam entrance side, up to 2000 mSv/h at a distance of 30 mm (outlet side: 70 mSv/h) were recorded. Using the special remote-controlled equipment, the triplet could be lifted out and directly placed in a concrete container for transport and storage. During the replacement work, the total dose collected by all the involved people was 11.5 mSv.

COMPLETING THE BEAM LINE

The installation of the wagon and solenoid had to be completed during the shutdown period. During summer 2004, the remaining components for transporting the beam from the end of the wagon to the experiment were installed. The installation of electrical power supplies, electronics and cables as well as the pipe work for the cooling system was extensive. In particular, the testing of various subsystems was very time consuming.

Fig. 5: The beam line components following the insertion wagon are also packed in concrete blocks. The blocks in the background are part of the primary shielding.

During the last years, the muon experimental facility was used on another beam line at PSI and has to be modified for the new beam line. The new experimental facility will be finished soon.

The final element to be installed is the electrostatic separator, which is needed to clean the beam from positrons. Nearly all parts for the separator have already been produced in our workshops. The device will be assembled from January 2005.

Initial tests with the beam line demonstrated that more than 200 million muons per second are achievable. Next April, the research using the revised experiment facility will start.

REFERENCES

[1] PSI FUN newsletter 2002

[2] PSI Scientific and Technical Report 2002

[3] PSI Scientific and Technical Report 2003