Upgrade of the Forward Range Hodoscope of the WASA-at-COSY facility

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In the CELSIUS/WASA experimental facility at TSL, the energy reconstruction of the forward scattered particles was based on the measurement of the energy losses in the Forward Range Hodoscope (FRH) which consisted of four layers of plastic scintillators each with a thickness of 11 cm [1]. The thickness was optimized for measurements of protons originating from the $pp \rightarrow pp\eta$ reaction (T_p = 100-550 MeV) at the beam energies in the range of the CELSIUS accelerator.

The transfer of the WASA detector from CELSIUS to COSY opened possibilities to study the production and decays of mesons heavier than the η meson, in particular the η' meson [2]. The resolution of the FRH appeared, however, to be insufficient for such investigations, in particular due to much higher background-to-signal ratio and due to higher energies of the outgoing protons than in the case of $pp \rightarrow pp\eta$ reaction. For the beam momentum of P_{beam} = 3.35 GeV/c, anticipated as an optimum value for the studies of the η' mesons [3], the kinetic energy of protons ranges from 300 MeV to 800 MeV. The resolution with the setup used at the CELSIUS facility was about 1.5% ($\sigma(T)/T$) for protons with kinetic energy lower than T = 300 MeV i.e. for protons stopped in the detector material. However, it worsens significantly for larger energies relevant for the studies of the η' meson. Therefore, in order to improve the accuracy of the FRH for the reconstruction of protons with energies higher than 300 MeV the effective thickness of the sensitive material of the detector was increased by 19 cm. This was achieved by adding two new layers each with a thickness of 15 cm at the downstream end. The first of the old layers had to be taken away due to a necessary extension of the Forward Proportional Chamber (FPC) for improving the reconstruction of the scattering angles of the particles. The configuration of the upgraded Forward Detector (FD) is shown in Fig. 1. A total thickness of the scintillation material in this detector amounts now to 68 cm and stops protons with kinetic energies up to the 360 MeV. We expect that the upgrade of FRH will improve the accuracy of the determination of protons energy by about 25% (at the highest energies). By analogy to the design used at CELSIUS the new layers consist of 24 independent detection units, each built out of a cake-piece shaped plastic scintillator (see Fig. 2) with a photomultiplier tube attached at the outer edge. The scintillators material is of type EJ-200 produced by the ELJEN company and the PMTs are of type XP3540B with voltage dividers of type VD202K/T1 from the PHOTONIS company. No lightguides were used and the PMs were connected directly to the scintillator material using Bicron BC-630 optical grease.

The outer edge of the cake piece scintillator has a rectangular shape with dimension 23.7 cm x 15 cm which is much larger than the active area of the photomultiplier tube (diameter = 13 cm). Therefore, in order not to suffer from the inhmogeneities in the collection of light in the region close to the PMT, the length of the scintillator unit (radius of the sensitive area of the detection layer) is more than 5 cm bigger than necessary for full geometrical acceptance.

For light tightness the scintillators were wrapped with thin ($26\mu m$) aluminized mylar foil. In addition there are black paper covering the front and rear surface of each detector layer. The light tightness was checked before the final assembly and installation.

The scintillator units in a detector layer are mecanically supported and kept together in between two 8 mm thick plexiglass sheets with aluminium structures at the outer edge and at the central hole (for the beam pipe).

The first of the new layers was installed in the summer 2006 and its functionallity was proven during the commissioning runs in the autumn. The second layer was installed in December.

The funding for the upgrade was provided by The Knut and Alice Wallenberg Foundation. The conceptual design was made at INS Warsaw and the final design and fabrication of the mechanical support details and PM housing were done at JU Cracow. The plexi sheets were water-beam cut by the Malarlaser company. Tests with accelerator beam for selecting PM readout system were done at TSL Uppsala.

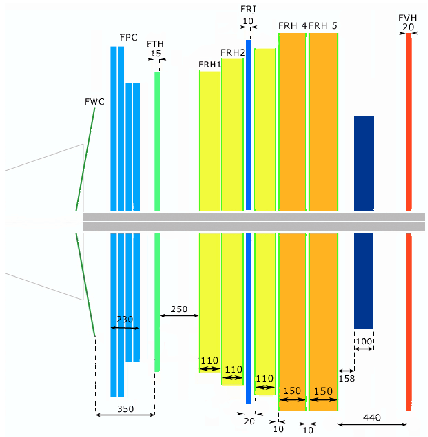

Fig. 1: Layout of the Forward Detector of WASA-at-COSY.

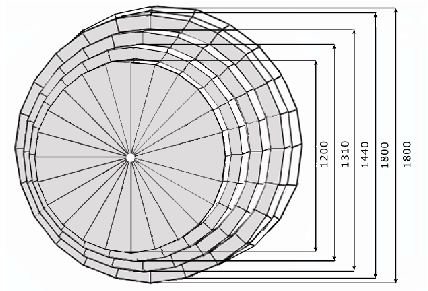

Fig. 2: Schemantic view of the upgraded FRH.

References:

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