Laser calibration system for the CERES TPC

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In order to improve the mass resolution the CERES experiment at the CERN SPS was upgraded in 1998 by adding a Time Projection Chamber (TPC). For the purpose of calibrating the TPC a laser system was developed and built at GSI. The concept was described in [1]. Here we report on its realization.

The mirrors, which send the light into the TPC, are mounted on the 10 cm thick aluminum backplate (see Fig. 1 in [1]). The 45 holes in the backplate, through which the laser rays get into the TPC, provide a position reference. In March 1998, when the backplate was already delivered but the TPC not yet mounted to it, we used the opportunity to check the geometry and to measure the positions of the laser rays on the TPC side. It turned out that the positions of the holes were not as precise as specified. (We noticed differences as large as 0.5 mm while the specified precision was 0.05 mm.) We therefore first measured the relative distances between the holes as well as their distances to the backplate center, and fitted the 150 measured distances with 89 parameters. This way we obtained the actual hole positions with the precision of about 120 microns in r and 100-250 microns in $r\phi$. We then installed the laser, sent the light through the backplate, and measured the position (relative to the hole) and the angle of outcoming rays on the TPC side.

In May 1998 the TPC was mounted on the backplate and ready for a test. We sent the laser beam into the special sector of the TPC. This sector has seven holes with semi-transparent mirrors arranged such that every laser pulse produces seven parallel tracks at the same ϕ and at different r's. The response of two pads in the TPC readout chamber is shown in Fig. 1. The reconstructed laser tracks were not straight – the drift velocity was changing along z, i.e. along the beam direction. This observation triggered a new calculation of the electric field which previously had been done in only two dimensions.

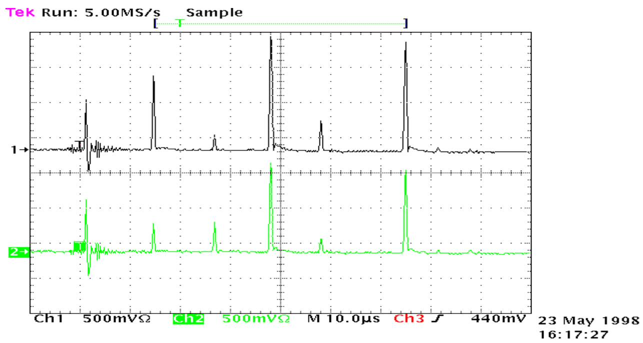

Figure 1: Charge on two readout-pads versus drift time - scope snapshot. The bipolar pulse is noise; its source was later found and removed. The tiny peak at 83% of the x-scale is produced by the electrons knocked-out from the inner cylinder wall of the TPC by the scattered laser light.

In June the TPC and the laser system were installed in the CERES experimental area. The laser and the PC attached to it were placed in a far corner to protect them from the magnetic field. The finite pointing stability of the laser, multiplied by the 16 m distance between the laser and the TPC, results in a standard deviation of about 60 microns. The diode resolution is 40 microns and the beam diameter is 2 mm. A typical event with the laser tracks in the special sector, visualized by the HEP-Explorer, is shown in Fig. 2. The signal from the inner

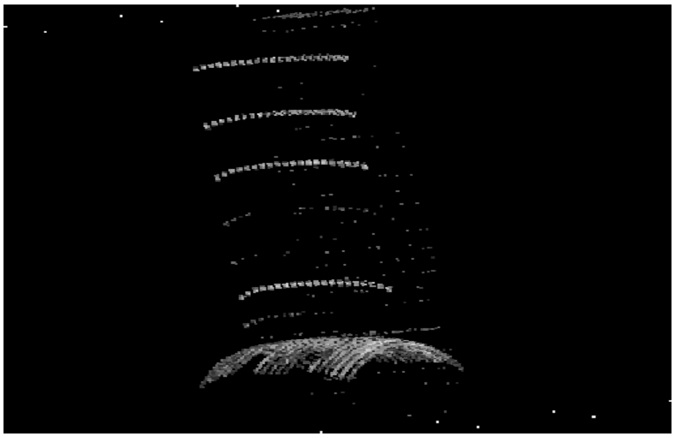

Figure 2: Laser tracks in the special sector of the TPC.

cylinder and the track curvature close to the end caps, not entirely removed by the new electric field calculation, are clearly visible. Further calculations are in progress.

As described in [1], the design requires that two mirrors, one diode, and one quarter-wave plate stay in the particle beam axis. Monte Carlo simulations predicted a non-negligible load on the TPC resulting from the nuclear reactions in these elements. Motivated by this result we designed and built a mechanism for moving the mirrors in and out of the beam. The mechanism was built of non-magnetic materials, with pneumatic actuators and remotely controlled valves used to move the mirrors. The full monitoring cycle consists in moving the mirrors in at the beginning of the spill pause, fast rotation of the central mirror toward the next TPC sector, slow rotation during which the laser is running with 10 Hz so the diode of the next sector can be found, centering on this diode, decreasing the laser frequency to 1 Hz and sending one laser puls with simultaneous generation of the TPC trigger, and finally moving out the mirrors in time before the next spill. The 14 s duration of the spill pause was not always enough to accomodate the described cycle. The software used for the coupling between the position information and the mirror motion still needs to be optimized.

References

[1] P. Braun-Munzinger, D. Miśkowiec, P. Stiller, GSI Scientific Report 1997 p. 186.