Laser calibration system for the CERES TPC

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The CERES experiment at the CERN SPS is currently being upgraded by a TPC detector in order to improve the mass resolution. For the purpose of calibrating the TPC a laser system is being developed and built at GSI. The laser will generate narrow light beams at known positions (resolution 200 μm) and times (resolution 10 ns) in the sensitive volume of the TPC. These beams will be used to simulate charged particle tracks in the TPC. The response of the TPC to tracks at different position and at different values of the magnetic field will be used to verify the knowledge of the electric and the magnetic fields, and to test the tracking routines. During data taking, the laser system will generate low-rate events which will go on tape in parallel with the physics events. This will enable us to monitor changes of the TPC behavior during experiment.

An ionization similar to the one caused by fast charged particles can be achieved using low divergence ($<$ 0.5 mrad), low diameter (2 mm) laser beams with 266 nm wavelength, pulse duration of several nanoseconds, and beam energy of 10-20 μ J per pulse. We use a Nd:YAG laser SL 401T Nd:YAG from Spectron Laser Systems (1064 nm) with two frequency doublers, running in the TEM_{00} mode. After some optics (intensity control, circular polarization and telescope), the laser beam will be transported to the accelerator beam axis and then upstream up to 4 cm before the downstream surface of the aluminum backplate of the TPC (Central Distribution Point) using two partially (90%) reflecting remotely controlled mirrors MIR 1 and MIR 2 (see Fig. 1). The beam position will be monitored using two x-y position sensitive diodes placed directly behind the mirrors. At the Central Distribution Point the beam will be either reflected or split (Fig. 2), resulting in one or several beams perpendicular to the accelerator beam axis and parallel to the TPC backplate. These beams will pass through two or more partially reflecting mirrors which will send part of the light into the TPC through two quartz windows. The remaining light will hit an x-y position sensitive diode. The position information from this diode, combined with the informations from the main beam diodes and the reflection angle of the last mirror, will be used to calculate the laser beam position in the TPC for every pulse. No additional measurement of the beam position at the other end of the TPC is necessary.

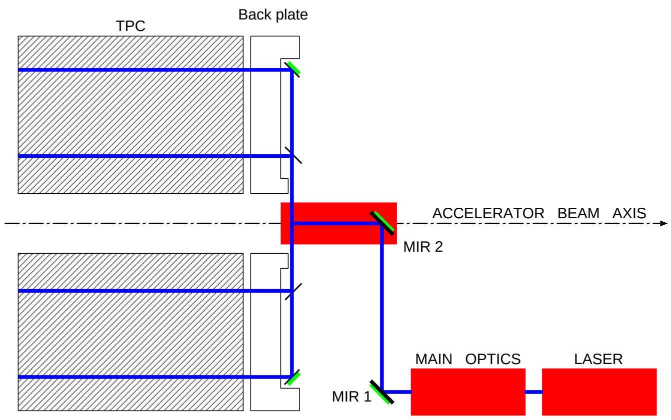

Fig. 1. Laser calibration system concept. The laser, the two bending mirrors and the splitter mirror are remotely controlled. Position sensitive diodes are behind all mirrors.

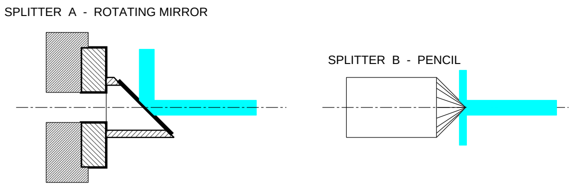

Fig. 2. Two methods of splitting the beam at the Central Distribution Point. Left: a rotating mirror sends the beam towards one TPC segment at a time. Rigth: a prism splits the light into 16 beams, one for each TPC segment.

The concept assumes that two mirrors will stay in the accelerator beam axis. A mechanism will be provided to move the mirrors out of the beam during spills. The laser will pulse only between spills.

The diodes, used to monitor the laser beam position, are Silicon Sensor diodes DL-100-7Ker. Their active area is 10×10 mm^2 and the position resolution is better than 1 μm. Hit by a laser beam, each diode produces two cathode and two anode signals. The sum of amplitudes is proportional to the light intensity, and the difference between the two cathode (anode) signals is related to the position in x (y). The signals are amplified, streched and digitized by the electronics which is located on two boards of 10×10 cm^2 each. The diode itself is mounted at the center of the first board. The digitized data are transported via a daisy chain to the PC. The electronics is developed by the Data Acquisition and Electronics Department of GSI (H-P. Liebold, J. Hoffmann).

A personal computer (Pentium processor 133 MHz, 32 MB memory, 2 GB hard disk, Ethernet card, 4 independent serial ports, 1 parallel port), running optionally under Linux or WIN95, is used to control the laser and the positions of the optomechanical elements. The same PC is used to collect the diode data. Via an I/O card the PC will have access to the spill signal. In addition, during the laboratory tests the PC is used to read out the beam profile data obtained from a CCD camera, and to control two Ealing linear translation stages used to calibrate the diodes. The software to control the laser and the Picomotor Driver under Linux was written. The low level communication routines were written in C, and the user interfaces are in TCL/Tk.

The first TPC calibration using the complete laser system is planned for May 1998.