A Laser Calibration System for the STAR TPC

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The STAR Time Projection Chamber (TPC), designed to determine momenta and identity for particles produced in 100 GeV/nucleon Au-Au collisions at the RHIC collider, requires a reliable, high-precision calibration system. Laser beams can be used to excite organic gas impurities, producing ionization similar to that along charged-particle tracks and providing very accurate space and time calibration. They can also be used to monitor drift velocity, measure Lorentz angle, study two-particle resolution and provide crucial alignment information. An overview of such calibrations is presented in [1].

The laser system designed for the STAR TPC [2] is based on two Nd:YAG lasers. This laser type was chosen because the energy density it delivers (2–10 μJ/mm^2) is sufficient to produce ionization equivalent to minimum-ionizing particle tracks—without special organic gas additives that would accelerate aging of the TPC read-out wires. The lasers operate in Q-switched mode to obtain high-power pulses 3–4 ns long. Doubling crystals and harmonic separators are used to extract the 266-nm component from the 1064-nm primary beam. A rotating Glan polarizer and a half-wave plate are used to obtain a wide range of laser beam intensities.

The two original beams are expanded to a 30-mm diameter and directed to the outer radii of the TPC cylinder's endcaps, on which systems of dielectric splitters and mirrors are installed. These split each primary beam into six secondary beams of equal intensity, and direct them just inside the outer field cage cylinder, parallel to its axis, where each one illuminates six bundles of seven 1-mm mirrors installed in rafts at intervals along the field cage. One such raft is visible at the bottom of Fig. 1. This system generates 504 laser beams that uniformly cover the TPC volume. Scattered laser light illuminates a pattern of 3-mm wide aluminum stripes attached to the central membrane (Fig. 1), generating additional "tracks" of photo-emitted electrons.

Figure 1: TPC central membrane showing the radial-strip pattern used in laser calibrations. A laser raft is visible at the bottom of the picture.

To stabilize and steer the laser beam position, a procedure based on referencing the Poisson line of a wide laser beam, was chosen[3]. A miniature CCD camera that can work in magnetic fields up to 1.0 Tesla was installed to pick up the beam image. A laser pattern-recognition system finds the coordinates of the Poisson spot, and maintains the laser beam position within 50 μ. The system was installed and tested during the summer, 1997 TPC cosmic-ray test at LBNL.

References

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