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Nuclear Physics A638 (1998) 559c–563c

NUCLEAR PHYSICS A

Recent Developments on the Star Detector System at RHIC

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PII S0375-9474(98)00385-6

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A progress report is given for the various components of the STAR detector system. We report on the recent developments in the detector proto-typing and construction, with an emphasis on the main TPC, recent TPC cosmic ray testing and shipping to Brookhaven National Laboratory

1. INTRODUCTION

The STAR detector system [1,2] is designed to provide tracking, momentum analysis and particle identification for many of the mid-rapidity charged particles produced in collisions at the RHIC collider. A silicon vertex detector (SVT) provides three layers of tracking near the interaction point. This is followed by the main time projection chamber (TPC), which continues tracking out to 200 cm radial distance from the interaction region. The detector design also includes an electromagnetic calorimeter, various trigger detectors, and radial TPCs in the forward region. The entire system is enclosed in a 0.5 T solenoid magnet.

The SVT will be constructed using silicon drift chamber technology to handle the high particle density near the interaction point while avoiding an excessive channel count[4]. Proto-type elements of the SVT have recently been tested successfully with interactions.

The TPC design [3] has been optimized to provide tracking and dE/dx values for the high density of particles in the pseudo-rapidity range $|\eta| = 0$ - 1.8. The active volume of the TPC is a cylinder 4.2 meters long by 4 meters in diameter. Electrons left by the ionizing particles drift to either end of the TPC cylinder where they are detected with multi-wire proportional chambers equipped with continuous array pad-readout. There are a total of 140,000 pads, each equipped with low noise electronics [5,6] which take 512 time sample measurements, thereby providing a full 3D, 70 million pixel representation of the tracks through the gas volume. Both tracking and dE/dx are obtained from the pad signals. The basic hardware of the STAR TPC, including gas system, laser system, field cage and readout sectors is complete. With partial implementation of the readout electronics, detailed testing with cosmic rays was undertaken at LBL prior to shipping to Brookhaven.

Development work is also progressing on the forward TPCs, which will extend the tracking coverage to $\eta = 4.5$. These TPCs use a radial field design to magnify the high density track images near the beam pipe, making them accessible to normal wire chamber density readout. The radial design requires curved wire chamber geometry.

2. STAR TPC

The main mechanical parts of the TPC described in more detail in Reference [3], were constructed and assembled for testing at LBNL in the summer of 97. The TPC was tested for one month with cosmic rays and laser beams to verify tracking precision and to test for the first time the entire system. The main goal of this exercise was to look for drift distortions caused by errors in the field cage structure that would require rework at LBNL. This was the last required check before shipping the TPC to BNL to be assembled into the STAR detector system at RHIC.

2.1. Testing Setup

The TPC was operated in the test much as it will be run in the final installation. The gas system provided a drift gas mixture of (Ar 90% + CH_4 10%). Nitrogen gas was used in the gas insulator surrounding the outer field cage. The main differences from the final configuration were having no magnetic field and having only one of the 24 sectors instrumented with pad readout electronics. The laser system was operated with 2 lasers and 2 primary beams out of 12. One beam provided a 42 beam track array from beams in the gas and the other illuminated the aluminum fiducial pattern on the central membrane. The beams were selected to provide patterns visible with the one instrumented sector. A trigger for recording cosmic ray tracks was generated by coincidences between scintillators above and below the TPC. These scintillators were the central trigger barrel scintillators which will be used in the normal TPC installation. Two inch thick lead bricks covered the bottom set of scintillators to limit triggers to high energy cosmic rays which would have little multiple scattering distortion. This trigger setup provided a tracking window that covered much of the active sector for the full drift length from the sector to the central membrane. Triggers for the laser tracks were taken from the laser Q switch driver circuit. The gating grid was operated in DC mode, always open, and set at the potential calculated to match the field cage termination potential as required to minimize the drift field distortions. A special data acquisition system developed to read out and test a single sector was used for these cosmic ray tests. The data acquisition system provided a data channel to Exabyte tape and two channels for monitoring and online analysis. The online analysis consisted of hit finding (point reconstruction) code and track fitting code with histogramming of track residuals to study deviations of measured tracks from straight lines. In addition to this measurement of tracking precision and distortion, a pad monitor program provided point and click access to all of the raw pad signals (amplitude versus time) and a means to visually scan for unusually noisy channels.

2.2. Measurement of Position Resolution

The position resolution was measured by accumulating statistics on the point by point fluctuations from a straight line track fit where hit points were generated for each pad row using either a three point gaussian fit determination of the track crossing position or a weighted mean determination. A representation of the raw data for a cosmic ray track is shown with the pad monitor in Figure 1. The signal amplitude for one selected pad is shown as a function of time in the lower insert of Figure 1 and the upper insert shows a straight line fit through the reconstructed points. The position resolution was measured as a function of track crossing angle and as a function of drift distance. Although further tuning of algorithms is required the position resolution is close to predicted values[7].

Similar measurements were made with laser tracks. Figure 2 shows the hit centroids and the track fit for tracks radiating from a single mirror bundle. The measured position resolution as expected is better for the laser tracks because of greater signal to noise and the absence of Landau fluctuations.

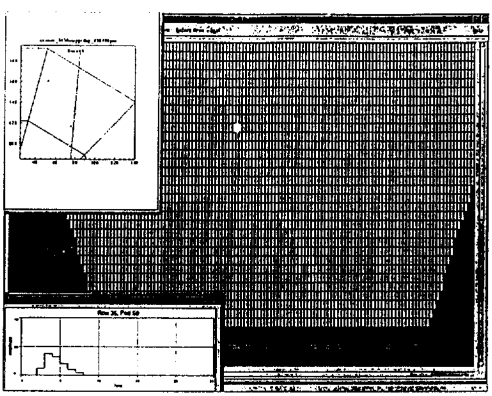

Figure 1. Pad monitor display showing pads above threshold for a cosmic ray event plus the amplitude signal for a selected pad. The upper insert shows the reconstructed crossing points plus the straight line fit through the points.

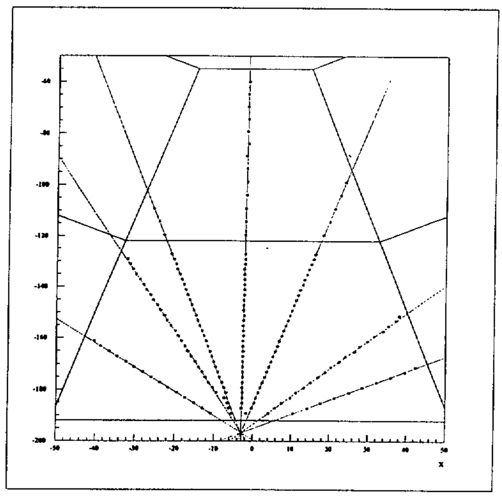

Figure 2. Reconstructed points and straight line fits for laser beams radiating from one mirror bundle in the TPC.

2.3. Measurement Drift Distortion

Drift distortions were measured with the cosmic ray tracks by looking for deviations from a straight line. The cosmic ray angles were chosen at about 25 degrees off radial to enhance sensitivity to possible distortions. Calculation of distortions for a variety of possible mechanical errors in the construction of the field cage show that errors tend to show up as radial components in the field close to the field cage, so angled tracks were chosen that will curve off the line near the field cage if radial field components are present. A local distortion near some of the field defining mirror covers was discovered which is due to a small construction flaw in some of these structures. This will require some minor rework to correct. The field cage structure as a whole, however, appears quite good and it was decided to ship the TPC to RHIC.

3. Conclusion

The TPC was flown aboard an airforce C5C cargo plane from the Travis Air Force Base near Sacramento, California, to Long Island and it was then trucked to RHIC where it is currently being installed. The main effort will be installing the remainder of the electronics. The analysis codes will be refined and tuned using both the data already taken during the test period and future cosmic ray data taken at BNL before beams are available from RHIC. First operation of the TPC in the beam is planned for June 1999.

4. Acknowledgments

This work was supported in part by the Director, Office of Energy research, Division of Nuclear Physics of the Office of High Energy and Nuclear Physics of the U.S. Department of Energy under contract DE-AC03-76SF00098.

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