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STAR-TPC TESTS at LBNL

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Philosophy

The primary aim is to work toward the goal of having STAR ready to do physics at the turn on of RHIC. STAR at RHIC startup primarily consists of TPC, trigger and DAQ. The testing that we do at LBNL, first and foremost, must determine that the status of the TPC is such that *no work that requires the fixtures and apparatus unique to LBNL and the assembly process will be required after shipment to BNL.* Other testing, while important to the primary aim, will be included if time is available.

Schedule

The TPC is scheduled to be shipped to BNL on September 15, 1997. To ship on this date requires that testing end on July 30, 1997 to allow for disassembly and packaging. TPC construction and assembly is currently 35 days behind schedule. If no more time is lost, in mid May 1997 testing can begin. At that date the TPC will be gas tight, high potted and laser and electronics will be in place and ready for data taking. There are currently 50 working days for testing (or 75 physicist working days).

Testing Equipment

One sector of FEE cards and 6 readout boards will be available along with the 6 ROSIE and 3 CYCLONE boards needed to read them out through MINI-DAQ. Roy Bossingham estimates that readout speed for pedestal subtracted compressed data is about 2 sec./event. Ten CTB trays will be available and trigger electronics to accompany them plus one sector of anode wires have been requested. Laser illumination of one raft at a time will be possible. There will be no attempt to use external tracking chambers to project tracks into the TPC because simulations have shown that the multiple scattering in the CTB trays, their supports, the gas vessel and the outer field cage makes the prediction too unreliable. Hence the testing will have to be done based on the knowledge that lasers make straight tracks and that cosmic rays are straight in the average.

Specific Tests

These tests are ordered with respect to the effort involved to correct the fault. In practice we will attempt to identify all faults before opening the TPC for repairs.

1. Shorted Stripes: Shorted stripes in the inner or outer field cage cause large unacceptable radial and phi distortions. Such defects can be fixed by either repairing the short or by properly biasing the two stripe combination. Most likely the later repair is easier to accomplish however if it is used a hard short should be introduced to be sure the condition doesn't repair itself. Methods of detecting shorted stripes depend on the magnitude and extent of the distortions. The STAR note SN0253 addresses distortions caused by shorted stripes in Section 6. Reproduced below is Figure 16 from that section.
For B=0 operation the distortion integral is equal to the radial distortion. From the plot we see that tracks through out the TPC will be distorted and, in particular, they will have distortions of more than 5 mm for tracks drifting from within a volume 30 cm in z and ρ of the shorted stripes. Since we have 6 bundles of 7 mirrors on each laser raft we have laser beams roughly every 40 cm along the drift direction. These beams have various angles in phi making them more or less useful for detecting radial distortions by analysis of straightness. Calculations done by Mike Lisa indicate the beams at about 30 degrees and near the outer field cage are the most useful. Illumination of one laser raft on each end of the TPC and analysis of the corresponding tracks for straightness will show the existence of any shorted stripes. To locate shorted stripes accurately one can use cosmic rays tracks which enter the chamber through the CTB trigger slats located on top of the TPC and exiting through the outer edge of the endcaps located at 90° to the top sector which is instrumented. This setup gives tracks slanting through the instrumented sector at about 30° and covering the full range of z. This test can be done on both endcaps at once if the FEE cards are first placed on the outer rows to test the outer field cage and then on the inner rows to test the inner field cage. The peak of the distortion in z will identify the shorted stripes.

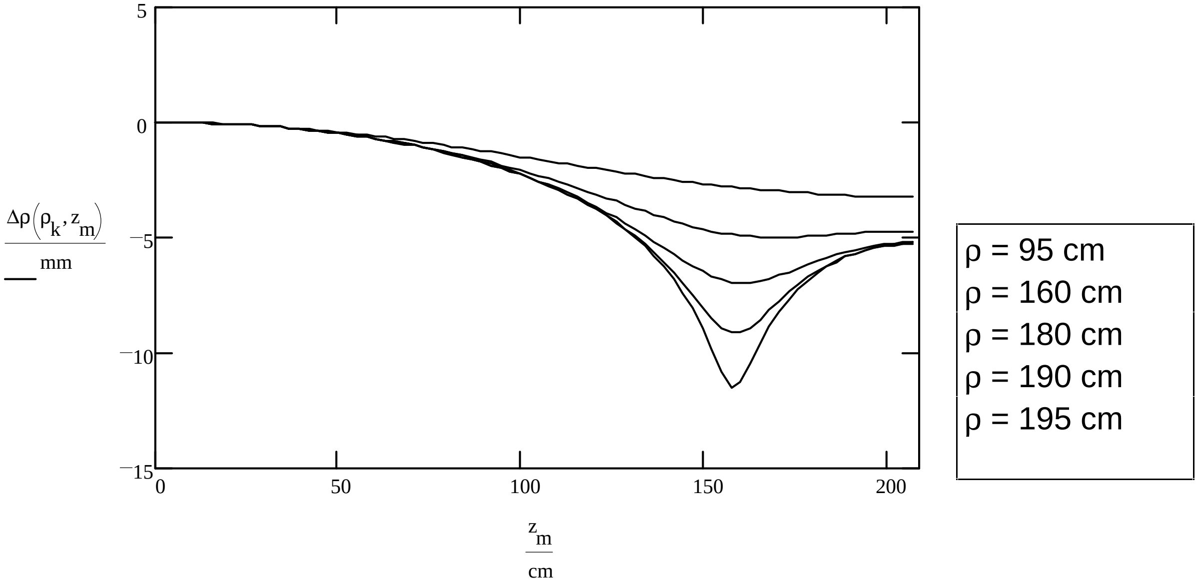

Figure 16. A plot of the radial distortion integral as a function of z for selected radii. The distortion is calculated for a pair of shorted stripes on the out field cage cylinder at z = 158 cm.

The number of events required for the laser test is minimal as the beam movement over short times is less than 60μ. A laser data set of 1800 events can be taken in an hour. The number of events needed for determination of precise shorted stripe positions is dependent on the resolution of the TPC, multiple scattering effects and the location of the defects. The necessary Geant simulations are being carried out by the group at Birmingham (they will also be developing and testing analysis techniques). However, simulations of trigger rates done at LBNL indicate that available trigger rates will considerably exceed the rate at which data can be taken. Until the Birmingham calculations are complete we will assume for time estimating purposes that 100,000 events (about 56 hours of data taking) are sufficient for these tests. This data will also be used for the determination of phi distortions to be discussed later.

To summarize, finding shorted stripes on each field cage requires electronics placed near the radius of the field cage and a short run with laser followed by a 2.3 day run with a cosmic trigger. It is clear that data collection time will be minor compared to the time required to do the analysis. Unlike an experiment, *the tests are not complete till all the data analysis is done*. This means we need to have a strong, skilled and dedicated data analysis team ready to work hard during the test time. We should take use of the fact that the analysis effort at Birmingham can proceed while it is night in California, effectively giving us two shifts of analysis capability.

Experience dictates that the time for taking one set of laser and cosmic data for the outer field cage will be one week. Analysis can begin right after laser data is taken and run concurrently with data taking for the inner field cage. Hence, testing for shorted stripes is determined by the analysis time which may be 4 weeks if sufficient staff is available and well trained.

Data taking - 2 weeks Analysis - 4 weeks

2. Potential Mismatch with Central Membrane: The central membrane may not be biased or placed properly relative to the field cages. This defect introduces distortions of the same sort as those discussed in SN0253 section 7. Assuming that the distortions are of the same magnitude as shown in Figure 17 of SN0253, determining if such distortions are present can be done with the laser tracks in the regions close to the inner and outer field cages and near the membrane. To determine if the distortions are due to the membrane being not flat or not perpendicular to the field cages requires analysis of data taken at different phi regions to see the symmetry properties. Best choice is to take laser data with at several (at least 4) different sectors on each end of the TPC instrumented. Estimate it would take one week to do 8

different rafts.

Data taking - 1 week   Analysis - 2 weeks

3. Central Membrane Pattern Tests: If the calibration lines on the central membrane are for some reason not emissive enough, or our illumination method is not correct repairs would best be done at LBNL. These defects we can determine by flashing the membrane and analyzing the resultant data. Such data would need to be taken at several sector positions for a valid test. This data taking will be combined with the potential mismatch testing discussed in 2 above. Analysis time is estimated to be one week, running concurrently with the rest of the analysis.

Data taking - 1/2 week   Analysis - 1 week

4. Strip discontinuities, phi distortions: If a strip is not continuous then the distortion will not be not cylindrically symmetric. This possibility requires testing at several phi values. Best coverage of the entire TPC volume can be done in several cosmic runs with the instruction on different (at least 4 sectors). This data can be combined with the tests in 2 above eliminating the need to move electronics repeatedly. This data also should be carefully analyzed for distortions in the phi direction. Such distortions whatever their cause directly affect the momentum accuracy of the TPC and must be kept below 200 microns. We will try to simulate the effects of the RHIC beam charging up parts of the TPC by using radioactive sources. Another test method involving introducing a laser parallel to the field cage and reading the signal induced on the anode wires is under discussion and looks feasible at this point. Again data taking is short, analysis time is the major element and will run concurrently with the effort on the other questions.

Data taking - 1 week   Analysis - 2 weeks

5. Potential Mismatch with TPC Endcap: This effect is discussed in SN0253 section 7. It can be detected by the data taken to deal with 2 and 4 above. The effect can be corrected by proper trimming with the gated grid, this is a matter of learning to run the TPC and doesn't require modifications at LBNL, however, some analysis time will be needed to separate the effect from 2 above.

Data taking - 0 weeks Analysis - 1 week

Strategy

Total time for data taking is 4.5 weeks, analysis is 10 weeks, that is all the time available. Best strategy is to have at least 10 physicists doing analysis on the various subjects as we take data. Analysis can begin as soon as the first data is available. The analysis programs need to be developed well in advance and tested on simulated data to demonstrate the ability to isolate the various TPC defects. Full advantage needs to be taken of groups not located at LBNL to carry the analysis load during the tests. The data must be understood quickly to prompt taking special diagnostic data sets. Instant feedback is needed to guide the data taking. The effort will be managed the same as an experimental physics run with daily progress meetings of all people involved and a network available log of results and open tasks. It will be a challenge to understand this new detector in such a short time with so little equipment.

Outcome

If no defects are found we will ship on the September 15, 1997 date. **If any defects requiring entering the TPC to correct them are found there will not be time to make the corrections and complete the testing before the shipping date.** The tests described here are the beginning of what we need to be ready do physics. In particular, no effort has been directed toward understanding efficiency corrections. When the TPC arrives at BNL some tests should be repeated to check for damage in transit. Testing should then continue, addressing areas which were neglected earlier.