in the analog memory, and also the analog summing for the trigger.

5.4.5 Bias Supplies

Each detector wafer has an independently controlled bias supply. The individual detector source, or bias, voltage is computer-controlled and has adjustable overcurrent protection. It must ramp up to the desired operating voltage slowly. This voltage is distributed to each detector wafer via a shielded cable. As the detectors are FOXFETs, they require a gate, source and drain voltage. The drain voltage is at ground potential, and the gate voltage is supplied to all the detectors by four common supplies. These are IEEE 488 triple voltage power supplies and they also provide power to the hybrid circuits.

5.5 Silicon System Performance

5.5.1 Multiplicity Trigger

The first level trigger will select central collisions by means of a threshold on the analog sum of charge deposited in the silicon pad and strip detectors. This is essentially a threshold on $dN/d\eta$, and is approximately independent of the vertex position. This is so because the signal per particle in the central barrel varies as $1/\sin(\theta)$, but dη versus z varies as $\sin(\theta)$.

Specifically, the signal is $\mathrm{S0}/\sin(\theta)$, where S0 is the signal for a particle at normal incidence. For a fixed number of strips (all strips on one wafer, for example), which corresponds to a fixed dz, the η range covered by those strips is

$$d\eta = dz \times \frac{\sin(\theta)}{\mathrm{R}},$$

where R is the radius of the cylinder, and the analog sum is

$$ADC = \frac{dN}{d\eta} \times d\eta \times \frac{\text{signal}}{\text{particle}} = \frac{dN}{d\eta} \times dz \times \frac{\mathrm{S0}}{\mathrm{R}}.$$

For the end caps, a similar argument holds: the signal is $\mathrm{S0}/\cos(\theta)$,

$$d\eta = -d\mathrm{R} \times \frac{\cos(\theta)}{\mathrm{R}},$$

and

$$ADC = \frac{dN}{d\eta} \times d\eta \times \frac{\text{signal}}{\text{particle}} = \frac{dN}{d\eta} \times d\mathrm{R} \times \frac{\mathrm{S0}}{\mathrm{R}}.$$

Therefore, the analog signal from any group of pixels (again, this could be one wafer) depends on the signal for one particle at normal incidence and several geometric constants.

From this it follows that we can measure dN/dη at any z value on an event-by-event basis. This does not even require knowing where the vertex is. If we assume that dN/dη is flat in the central region, then a simple trigger using only an analog sum can be used. If the vertex position along the beams is also known, then η for any z value is known, and dN/dη versus η and the total multiplicity can be determined.

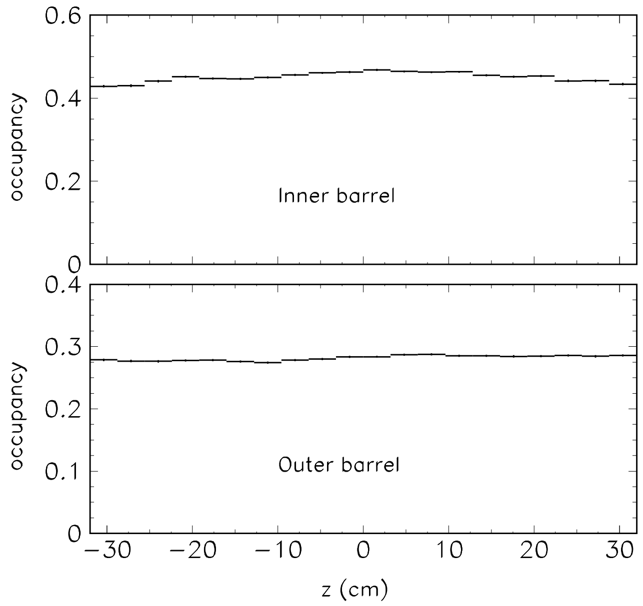

Figure 5.9: Occupancy of strips in the two layers of the silicon barrel, as a function of the position of the vertex along the beams (z direction). Calculated for central Au + Au collisions.

5.5.2 Vertex Position Measurement

The performance of the detector system was simulated to determine the precision and efficiency of the vertex measurement. Vertex finding is accomplished using data from the silicon strip detectors. The simulations were done using the PISA/PISORP programs. The particle distributions were simulated with HIJET, varying the longitudinal position of the vertex according to a Gaussian with $\sigma_z = 22$ cm for Au + Au and p + Au, and 15 cm for p + p [4]. Effects of particles entering the silicon strips at a small angle of incidence, along with charge sharing between adjacent strips, multiple scattering, noise, and inefficiencies have been incorporated in a model of the detector performance.

Figure 5.9 shows the mean occupancy of strips in the two layers of the barrel detector for central Au + Au collisions, as a function of the vertex position along the beams. The large pitch of the strips results in a high occupancy, particularly in the inner barrel. However, recording of the pulse height from each strip allows a determination of the number of charged particles entering the strip.

All pairs of hits in the two central barrel layers are treated as potential tracks and projected to the vertex position; the actual vertex appears as the most probably value of the vertex position. The pairs are constrained by the approximate vertex from the beam-beam counters. Figure 5.10 shows an example of such a distribution in a Au + Au collision. The vertex resolution for such events is approximately 165 μm, as seen in Figure 5.11. The figure

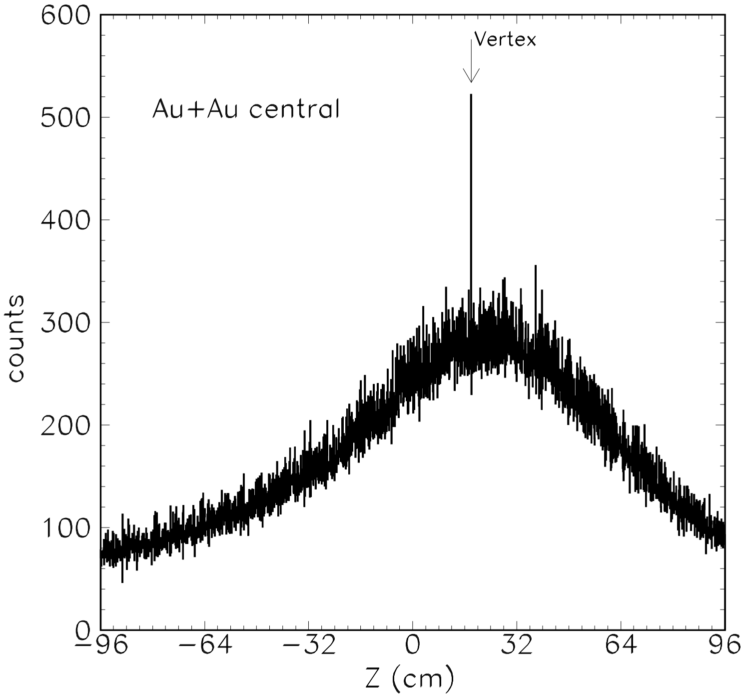

Figure 5.10: Z position of vertices from combinations of hits on the inner and outer layer of the silicon barrel in one Au + Au event. The most probable distribution agrees with the actual vertex at which this event was generated, indicated by the arrow.

also shows the vertex resolutions for p + Au and p + p collisions, which have somewhat poorer resolutions due to the smaller number of charged particles entering the silicon barrel. The figure also states the percentage of events which have vertices found to an accuracy of 0.2 cm for central Au + Au, and 0.5 cm for the other systems. The vertex resolution is adequate for the needs of PHENIX.

The most important parameter in finding the vertex is the number of charged particles which hit the vertex detector. To be useful, particles must hit both layers of the detector. The simulations show that the vertex finding efficiency approaches 100% when the number of charged particles hitting the detector is above 10. This is clearly visible in Fig. 5.12, which shows the multiplicity of particles entering the silicon barrels on the left, and the efficiency of finding the vertex as a function of the charged particle hits on the right. The integrated efficiencies for p + p and p + Au collisions are 95% and 98%, respectively; the difference arises from the different multiplicity distributions. The vertex finding efficiency is approximately 100% for central Au + Au collisions. It is clear that the vertex detector cannot be 100% efficient for the lowest multiplicity events; however, the requirement that particles are also detected in other parts of PHENIX will tend to reduce the number of

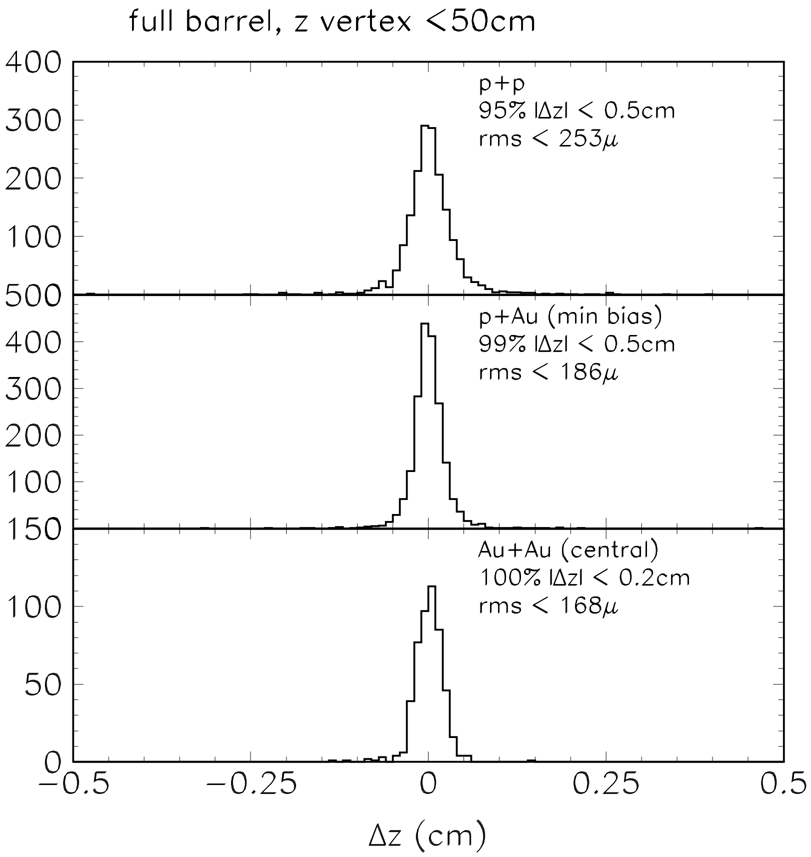

Figure 5.11: Resolution of vertex finding in p + p, p + Au and central Au + Au collisions. The distribution of differences between the true and reconstructed vertices is plotted for all three cases.

accepted very low multiplicity events.

For low multiplicity events, the highest vertex finding efficiency is reached for full azimuthal coverage, as shown in Fig. 5.13. Consequently we have rearranged the silicon area, compared to that in the PHENIX pCDR, to provide full azimuthal coverage for high vertex finding efficiency in p + p and p + Au collisions. In the high multiplicity central Au + Au collisions, high vertex finding efficiency and resolution can be achieved with partial azimuthal coverage. This allows us to remove silicon from the electron arm acceptance to reduce the combinatorial background, but preserve the capability of the silicon system to determine the vertex.

For interactions near the center of the detector, particles entering the barrel near its ends have shallow incident angles and pass through multiple strips. For accurate measurements of the multiplicity and $dN/d\eta$ it is necessary to correct for this effect by using the pulse heights

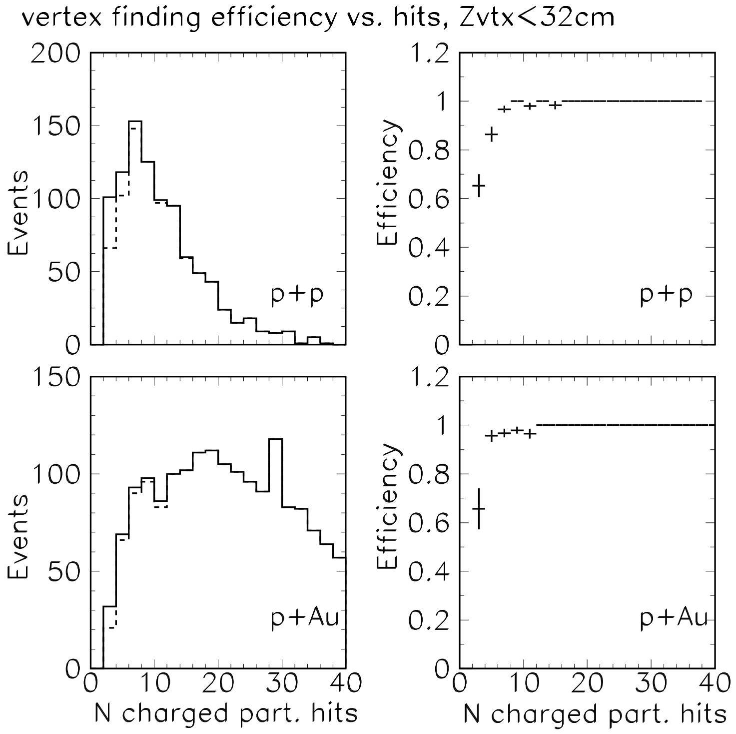

Figure 5.12: Multiplicity of hits in the silicon barrel (left), and the vertex finding efficiency as a function of the number of hits (right). p + p collisions are shown on top, and p + Au below.

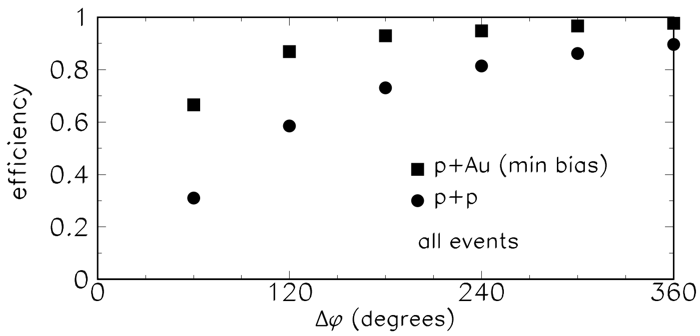

Figure 5.13: Vertex finding efficiency as a function of the azimuthal coverage of the silicon barrel for p + p and p + Au collisions.