Evaluation of the STAR TPC Performance for Detecting $p + p$ Collisions at RHIC

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During the $p + p$ data taking period at RHIC a high luminosity is foreseen. It will result in a high interaction rate and consequently many events may be registered during the time when the TPC gate is opened. These events will show up in addition to the triggered event and will look like secondary tracks. The goal of this study is to show that such compound events can be analyzed and that separate events can be distinguished.

In order to answer the questions raised above the following procedure was adopted:

- o Time when the chamber is sensitive was evaluated.
- o Number of events that occur within this time was calculated assuming *pp* cross section and the design luminosity.
- o Appropriate number of minimum bias FRITIOF $p + p$ events was generated.
- o Events were processed by GEANT.
- o Fast TPC simulator was used to assign each point a spatial resolution and diffusion that corresponds to its true position in the chamber.
- o Z coordinates of the hits from the different events were modified according to the drift time.
- o Events were combined to make 1 full event.
- o Overlapping hits were merged.
- o Pattern recognition was run and results were evaluated.

1 Sensitive Time

Due to the 50μs drift time in the TPC[1], the detector is sensitive to events in a 100μs window around the triggered event. At the beginning of the triggered event, mid-rapidity tracks from an event 50μs earlier will just be arriving at the endplate. The last event that has any chance to be recorded is one that occurred just before the gate was closed, 50μs after the triggered event. In this case ionization that is very close to the endplate will be registered and will appear in the triggered event as short tracks about the mid-plane. Additionally all the events that occurred between these two extremes will contribute to the signal. The total time when chamber is sensitive is therefore 100μs.

2 Multiplicity

Number of events that occur within the time when chamber is sensitive can be derived from the pp inelastic cross-section and the design luminosity.

$$N_{ev} = \sigma_{inel} * L \tag{1}$$

N_{ev} – number of events per second
σ_{inel} – inelastic cross-section
L – luminosity

If we take the design luminosity of 1.4×10^{31} cm^{-2}s^{-1}[2] and an inelastic pp cross-section (45 mb for $\sqrt{s}$ 500 GeV[3]) then we get 6.3×10^5 events per second. This combined with the 100μs sensitive time gives us the number of events seen by the TPC.

$$N_{reg} = N_{ev} * dt \tag{2}$$

N_{reg} – number of events "seen" by the TPC
dt – time interval when TPC is sensitive

So finally we end up with 63 events on average registered together with the triggered event.

3 Simulation

Since the spacing between two consecutive bunch crossings is 220ns[2], during the 100μs "sensitive time" 455 of them will occur. This shows that we should expect 0.14 minimum bias events per crossing and this was taken into account when the z coordinates were modified. On average events are separated by 10cm along the drift direction. A detailed description of the event merging procedure is given in the TPC Fast Simulator User's Guide[4].

4 Evaluation

The combined pp event was then reconstructed and the results evaluated. Evaluation shows that such multi-pp events are reconstructed well. Comparison of Fig. 1a and 1b shows that most of the available hits were assigned to tracks. The level of the confusion (hits from different MC tracks assigned to the same reconstructed tracks) is low (Fig. 3) and momentum resolution was not affected (Fig. 2).

Another crucial question is whether the different events can be distinguished. In order to investigate this problem the position of the vertex for each reconstructed track of $p_t > 150$ MeV/c was calculated. Figure 4 shows a histogram of the reconstructed z coordinates of the vertices for these tracks. We observe that they cluster in groups spaced by approximately 10 cm. This corresponds to the average spacing between consecutive events. Thus we conclude that we can properly assign high p_t tracks to different events. Further study of lower momenta tracks needs to be completed. Further on, the SVT and TOF systems could enhance the ability of the spectrometer to deal with such events.

References

[1] Update to the RHIC Letter of Intent for an Experiment on Particle and Jet Production at Mid-rapidity, The STAR Collaboration, LBL-31040 (July 1991).

[2] Conceptual Design of the Relativistic Heavy Ion Collider RHIC, BNL 52195.

[3] Review of Particle Properties, Particle Data Group, Phys. Letters B 239.

[4] The STAR FaSt TPC Simulation, STAR Note #56 (1992).

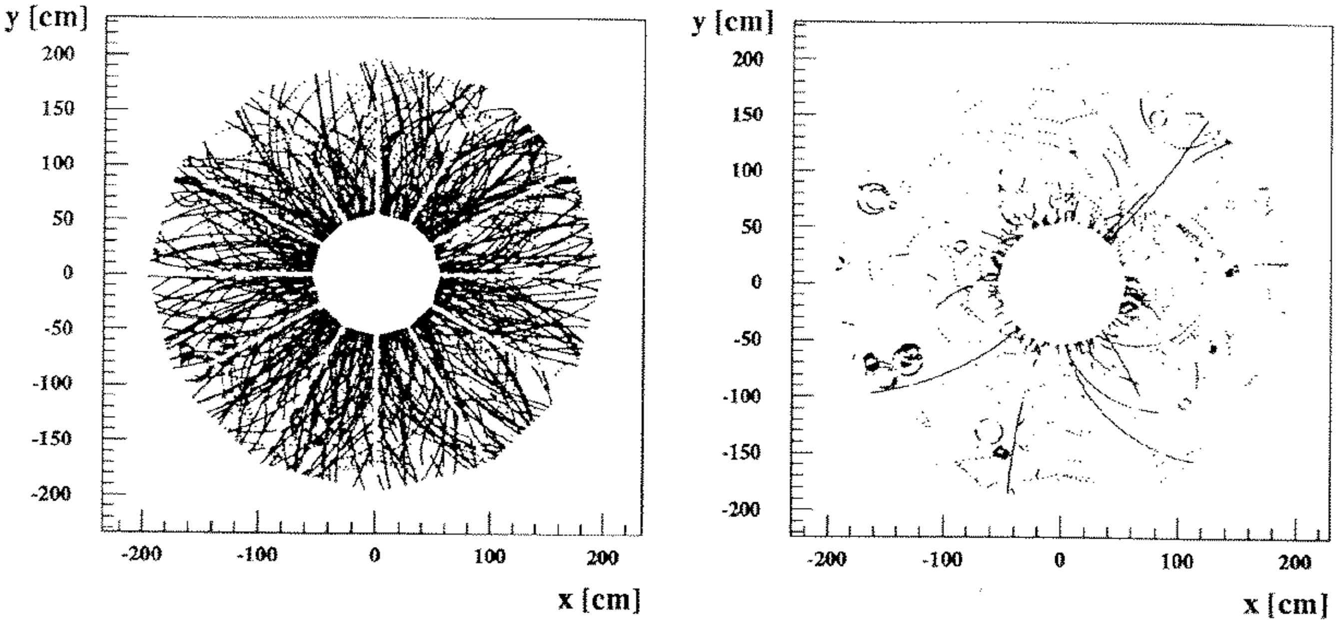

Figure 1: TPC hits from a multi-proton projected to the endplate: (a) all the hits. (b) hits that were not assigned to any tracks.

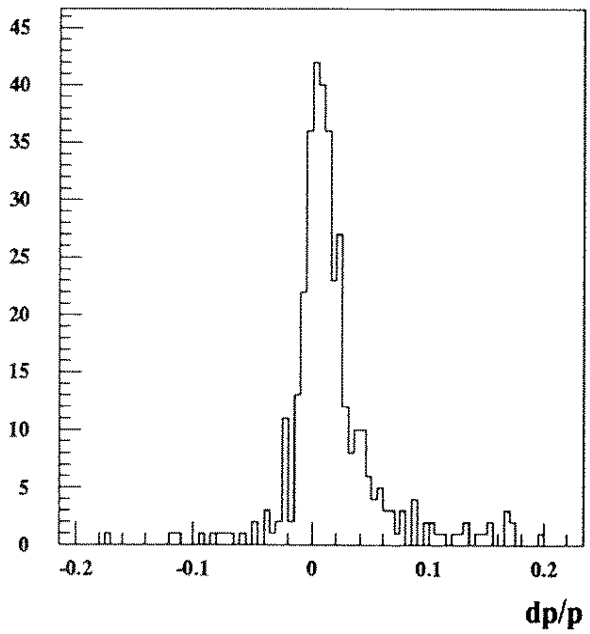

Figure 2: Momentum resolution for the pp events.

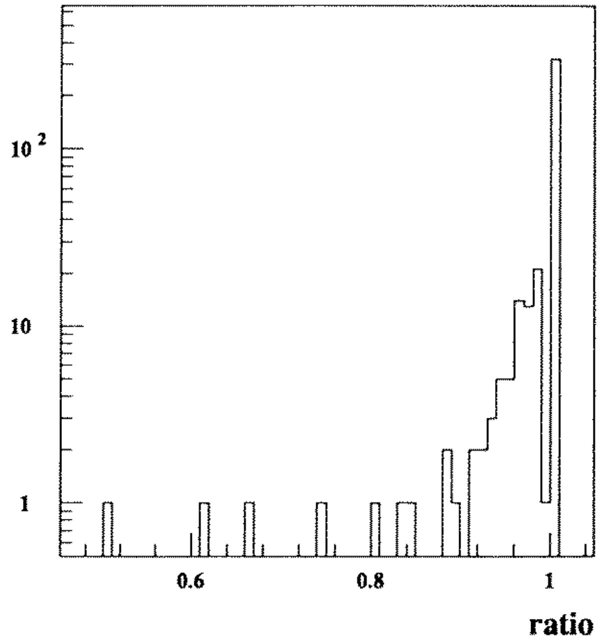

Figure 3: Ratio of good hits to the total number of hits on a track.

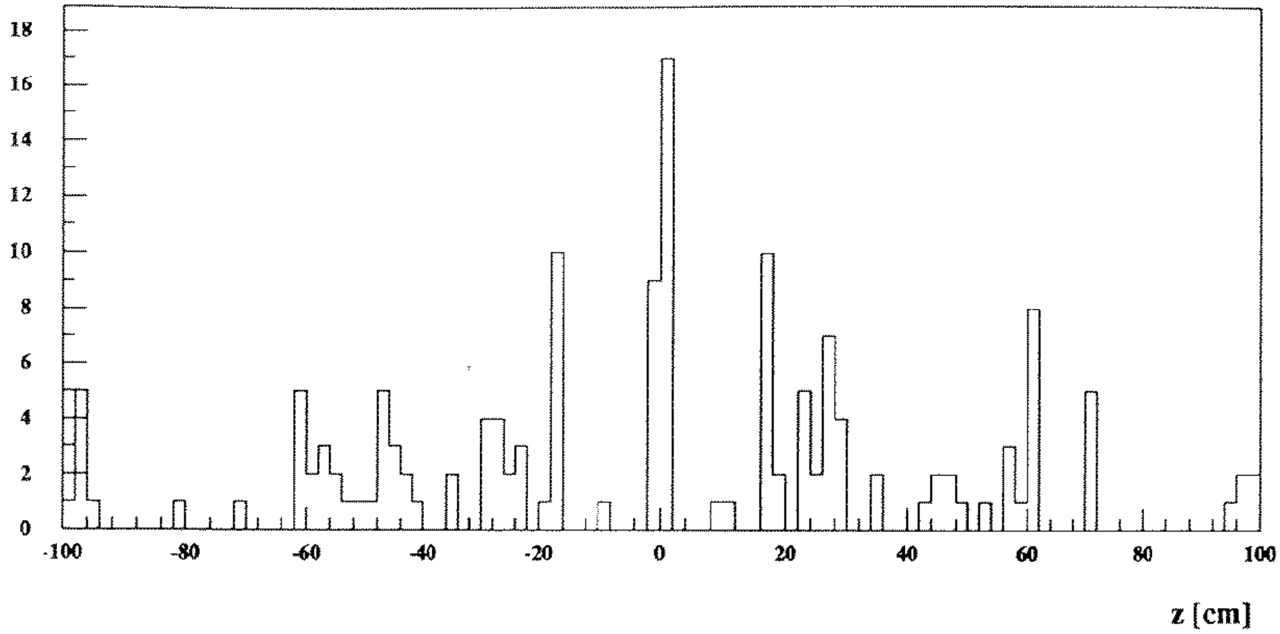

Figure 4: Reconstructed z coordinate of the vertex for tracks with momentum greater than 150 MeV/c. Separate clusters corresponds to different events.