Peripheral Collisions in MDC2

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This note will summarize the reconstruction and analysis of Peripheral Collisions events in MDC2.

1 Event Samples

The samples generated and analyzed are presented in Table 1. 6 event samples were generated, 3 samples of signal events and 3 samples of background events. As can be seen in the Table, essentially only the signal samples were reconstructed during MDC2. Of these, roughly 30% were reconstructed with the fast simulator. 10,000 of the $\gamma\gamma$ events have been re-reconstructed about 2 weeks after the end of MDC2.

Event Sample	Generated Events	gstar	reconstructed (tfs)	reconstructed (tss)
Signal Events				
$\gamma\gamma \to \mu\mu, f_2$	25,000	25,000	6,684	0
$\rho \to \pi\pi$	15,000	15,000	5,781	237
$\phi \to KK$	10,000	10,000	676	0
Backgrounds				
Photonuclear	50,000	0	0	0
Beam-gas	50,000	13,518	18	0
Cosmic Rays	100,000	100,000	0	124

Table 1: Peripheral collisions event samples in MDC2.

2 Main Problems in the reconstruction

The majority of the problems encountered when trying to run peripheral events through the reconstruction chain were caused by the low multiplicity and the inability of several modules/makers to handle events with empty input tables. This was the case for the MWC, EMC, and global modules. These routines were all fixed during MDC2, however, so at least several thousand events could be processed.

The problem of empty input tables is a general one, and is of concern not only to peripheral collisions but also to pp and (perhaps) very peripheral, hadronic nucleus-nucleus collisions. It is also a very unnecessary problem that should be easy to avoid in the future. It should be an official STAR programming policy to include in the beginning of every maker a statement which checks if the input is emtpy, and, if so, prints a message and returns. This simple measure would prevent many crashes and save a lot of time now wasted debugging the standard chain.

It was found that the standard primary vertex reconstruction fails when there are fewer than 10-15 primary tracks in the event. This could also affect pp events.

3 Reconstruction Timing

The CPU times for reconstruction of 1000 two–photon events for the different bfc modules are shown in Table 2. The total mean time for reconstructing one event is 0.68 sec. I have the following times for central events from MDC2:
Venus (8,600 tracks, fast sim.): 420 sec/event,
Hijing (5,800 tracks, fast sim.): 460 sec/event.
The reconstruction time per track is 0.342 sec for peripheral events which can be compared with 0.049 sec and 0.079 sec for central events, Venus and Hijing, respectively. Most of the time for peripheral collisions is spent in tpc-hits, which includes the fast simulator. The simulation and reconstruction time per track is a factor 4-7 larger for peripheral events. It is not known what causes this overhead.

Module	Real Time	CPU Time
params :	16.77 seconds	8.41 seconds
geom :	11.33 seconds	4.49 seconds
geant :	81.67 seconds	64.31 seconds
calib :	28.23 seconds	11.75 seconds
emc-raw :	48.02 seconds	31.34 seconds
tpc-hits :	419.94 seconds	361.27 seconds
svt-hits :	29.88 seconds	16.83 seconds
tpc-tracks:	92.00 seconds	71.23 seconds
svt-tracks:	14.69 seconds	3.79 seconds
global :	68.78 seconds	49.42 seconds
ctf :	16.86 seconds	4.94 seconds
mwc :	27.70 seconds	14.73 seconds
trg :	14.59 seconds	3.68 seconds
run-summary:	15.59 seconds	4.02 seconds
dst :	18.52 seconds	6.12 seconds
QA :	18.40 seconds	6.37 seconds
Output :	35.34 seconds	20.67 seconds
bfc :	958.31 seconds	683.37 seconds

Table 2: Reconstruction times for 1000 two-photon events (2 tracks/event).

4 Analysis and QA Histogram

The output of the reconstructed events in MDC2 have been stored in DST format on disk and in HPSS. The DSTs have then been analyzed by using StEvent. First, a set of QA histograms have been produced. Some of these are shown and discussed below.

Figure 1 a) (upper left) shows the distribution of the number of TPC tracks for $\rho \rightarrow \pi^+\pi^-$ events. The number of tracks can reach 10-15 in a single event.

Figure 1 b) shows the distribution of the number of tracks coming from a vertex on or close to the Z-axis (the primary vertex). The minimum number of tracks to form a vertex is obviously 2. Fewer than 5% of the events with a reconstructed vertex have an additional

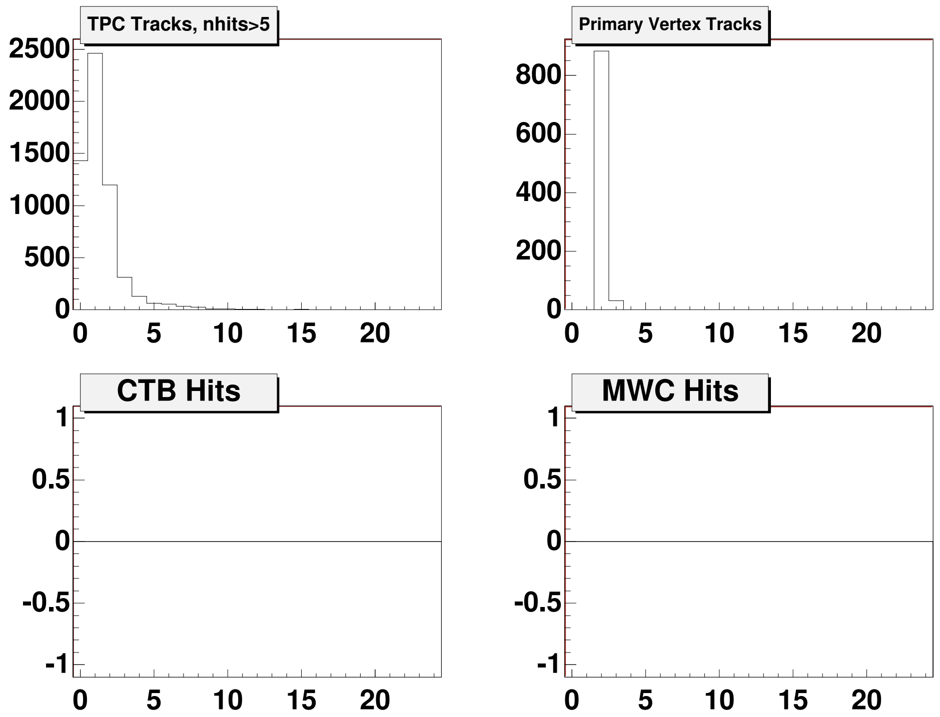

Figure 1: Distribution of the number of TPC and TPC Vertex tracks for $\rho \rightarrow \pi\pi$.

(background) track. This background could be due to split tracks or to a secondary track that happens to point close to the primary vertex.

It was planned to study also the information of the CTB and MWC, but due to a a bug in the code that loads CTB, MWC info into the DST table this could not be done. The bug renders the MWC info unusable and zeros out the first 96 CTB bins. The bug is now fixed.

A special vertex finder for peripheral collisions has been developed, which can handle low multiplicity events. A track belongs to the vertex if it has a minimum perpendicular distance from the beam axis of less than 2 cm, and a Z-position less than 2 cm from the Z of the vertex. Two tracks are enough to form one vertex. The number 2 cm has been determined from simulations which are illustrated in Figure 2. This figure shows the distribution of the distance of tracks from the vertex along the beam axis (Z) and perpendicular to it. Figure 2 was obtained with relaxed distance cuts, so that tracks could be up to 4 cm from the vertex and still be included. In rest of the analysis, cuts of 2 cm were always used.

The deviation from the beam axis in the perpendicular direction for a primary vertex track is determined mainly by the spatial tracking resolution. The beam size of $\sim 500\ \mu$m is much smaller than the single track position resolution when the track is extrapolated to the primary vertex. The simulations include the effects of multiple scattering and energy loss, which give the main contribution to the uncertainty in position. The effect of the intrinsic spatial resolution of the TPC should be small. For the future, one might study the position resolution as a function of particle momentum and develop momentum dependent vertex cuts.

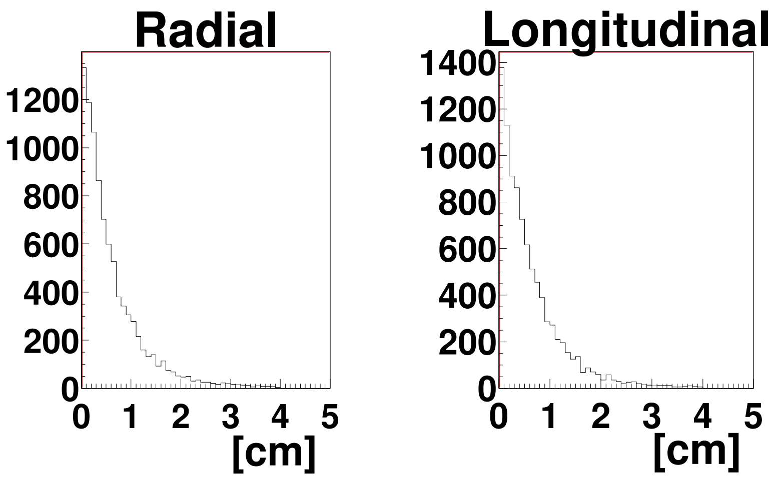

Figure 2: Extrapolated distance (along and perp. to beam axis) of tracks from the primary vertex.

Figure 3 shows some QA histogram obtained from events that have a well determined vertex with 2 tracks for interactions of the type $\gamma\gamma \to \mu^+\mu^-$ or $\gamma\gamma \to f_2(1270) \to \pi^+\pi^-$.

Figure 3 a) shows the Z-distribution of the primary vertex. It looks OK. The problem that was reported during MDC2 about a spike at about Z=-30 cm has been identified. It was due to a problem with the random number generator in gstar on files produced at the PSC, and thus only affects central events.

Figure 3 b) shows the distribution of $\sum Q_i$. This sum should be 0 for a two-photon interaction, as is the case.

The bottom two histograms c) and d) show the distributions of two important variables in the peripheral collisions analysis, $\sum p_T$ and m_{inv}. The invariant mass is calculated assuming the tracks are pions (in reality most of them are muons). The peak corresponding to the $f_2(1270)$ is clearly seen. The simulation does not include the natural width.

5 Acceptance and Efficiency

The acceptance studies done earlier for peripheral collisions (Star Note 347) were all based on a simplified, geometrical acceptance. It was chosen so that tracks tracks should be detected in the TPC and reach the CTB and cause a trigger. The cuts used were $|\eta| \leq 1.5$ and $p_T \geq 150$ MeV/c. This is obviously a too crude approximation and as we get near to taking real data, better estimates have to be made.

The result of a straight-forward rate calculation is shown in Table 3. For the ρ sample the acceptance obtained through gstar and the reconstruction is in very good agreement with what is obtained by the geometric cuts above. In reality the limits of acceptance are of course not so sharp and some tracks outside this region will be reconstructed and some inside will be missed.

For the $\gamma\gamma$ sample the agreement is not so good. This discrepancy is understood and is due to the hard cut on $p_T \geq 150$ MeV/c in the geometrical model. In reality, the acceptance of the TPC is good also at lower transverse momenta. This affects the

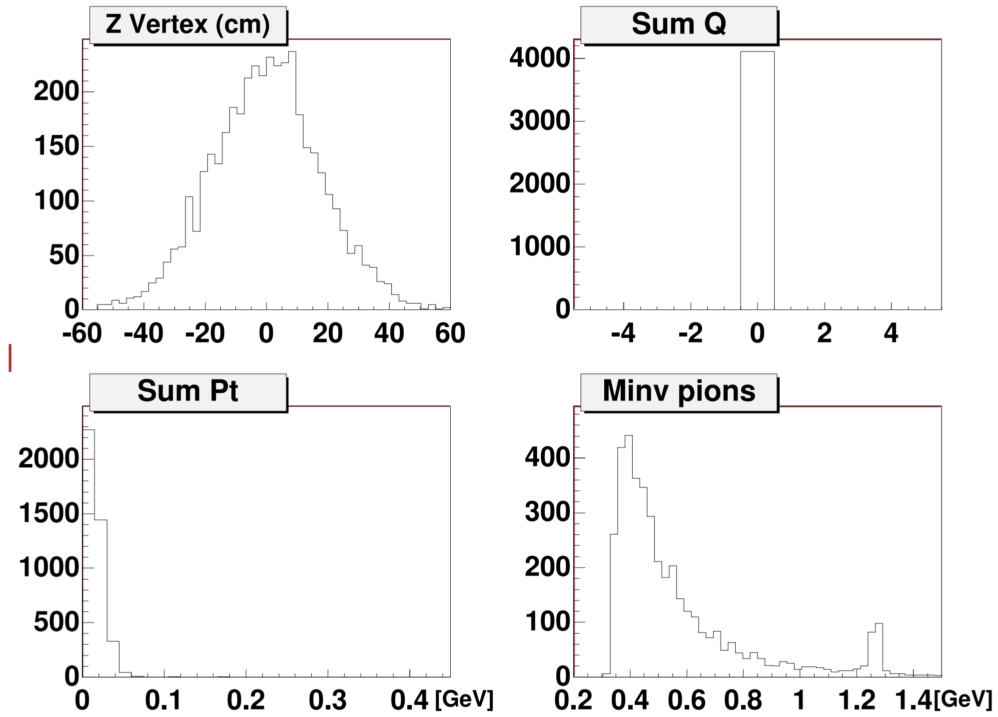

Figure 3: QA histograms for two-photon events.

muon sample because the muons primarily are produced at low invariant masses, and are hence limited to having also a low transverse momentum. The geometrical cut of $p_T \geq 150$ MeV/c is thus unrealistic in this case, but seems to give a good description for states with higher invariant masses, such as the $\rho \to \pi^+\pi^-$. Unfortunately, without the CTB and MWC output, we cannot determine the trigger rate.

The single particle efficiency has also been investigated. In the region $|\eta| \leq 1.5$ and $p_T \geq 150$ MeV/c, it was found to be 96% for the $\gamma\gamma$ sample and 87% for the ρ sample. The reason for the difference is not clear. The samples were reconstructed at different times (the $\gamma\gamma$ sample after the end of MDC2) and it is possible that some bug, which was later fixed, reduced the efficiency for the ρ sample. Due to the distribution of the vertex Z position, the acceptance might be less than 100% in the selected region, but this effect should be the same for both samples.

	$\rho \to \pi\pi$	$\gamma\gamma \to \mu^+\mu^-$
Production Rate	120 Hz	27 Hz
Geometric Acceptance	16 Hz	1.3 Hz
gstar+rec Acceptance	16 Hz	2.4 Hz

Table 3: Production rates and rates for accepted events.

6 Conclusions

One of the main reasons for including peripheral events in MDC2 was to make sure that the reconstruction chain is flexible enough to handle them. Several problems were found during MDC2 and many of them were solved. About 30% of the signal samples were also reconstructed.

The goal has not been reached, however. For instance, neither beam-gas nor cosmic rays can be reconstructed at this time, and this is a serious limitation. Furthermore, all simulations so far have been done with the fast simulator. The slow simulator, tss, crashes after some 10 peripheral events for still unknown reasons and can thus not be used.

7 Future Work

The list below summarizes what should be done in the near future for peripheral collisions computing.

- A first version of a peripheral collisions maker, StPeCMaker, exists. At this time it can read and analyze DST data and produces a set of QA histograms, some of which are shown above. Future improvements should include the possibility of writing out micro DSTs.
- The acceptance studies and rate calculations presented here for two of the final states with highest cross section should be repeated for a wider range of final states. Similar studies should also be performed for the background samples.
- Acceptance maps in invariant mass, rapidity and transverse momentum should be produced. This should be done for all final states we want to study during the first years (2 pions, 4 pions, 2 kaons, 4 kaons, proton-antiproton etc.).

8 Summary

1. 30% of the generated signal samples were reconstructed during MDC 2. Essentially none of the background samples were.
2. Most problems in the reconstruction were due to some modules/makers not being able to handle events where the input is empty. All makers should be able to handle this. It should be an official STAR computing policy.
3. The average time to reconstruct 1 two–photon event (2 tracks) with the fast simulator is 0.68 sec. This is a factor $\sim$650 faster than a typical central Au+Au event.
4. The analyzed data look reasonable.
5. The lack of trigger detector information hampers the usefulness of the samples.
6. The acceptance studies of two peripheral event samples is in acceptable agreement with results from a simplified, geometrical acceptance model.
7. We eagerly await the re-reconstruction of the signal samples (with correct trigger information) and reconstruction of the background samples.

Acknowledgments

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