Status of the Fast Finder of Tracks

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STAR Note 246

December 1, 1995

1 Introduction

The STAR Time Projection Chamber (TPC) provides tracking information in three dimensions in a large phase space. These data only become available for online event selection at the third level trigger (L3). Space points in the TPC allows track reconstruction. Track information considerably expands the physics selection capabilities compared to the previous trigger levels. However track reconstruction at the trigger level in STAR is a considerable challenge due to the large number of tracks and the space point density. This document presents the status of the fast track finding algorithm.

2 Event sample

A sample of 7 central Landau AuAu events, generated by Ron Longacre, were used to study the performance with heavy ion interactions. In addition a sample of 1000 tracks with a flat distribution in p_t in the range 0-40 GeV was also utilized.

Events were run through the STAR GEANT simulation. The output was treated with the standard STAR analysis shell (TAS). TPC space points were generated with the slow tpc simulator (tss). Subsequently clusters were found using the algorithm to be used in the third level trigger processors (i960). This is performed using the TAS package tdh.

3 Fast Tracking Code

In the last few months the Fast Tracking code (rft) running in the TAS framework has evolved considerably. Even if the philosophy of the algorithms is the same a number of important changes have occurred resulting in a substantial improvement in performance.

Firstly it has been made a stand alone program (fft) to make its testing on L3 cpu's easier. At the moment all tracks are fitted with an algorithm assuming they are produced at the interaction point in the plane transverse to the beam. By default the interaction point is taken to be (x,y)=(0,0). The code has the ability to handle TPC sectors individually or the whole TPC as a whole.

The program has two major sections:

1. *Setup* The polar angle and a variable similar to pseudorapidity are calculated for each space point. In addition several pointers linking space points and other objects (rows,volumes0 are set.

2. Tracking The actual track finding algorithm is executed.

4 Pad-rows configurations

The following scenarios concerning the available TPC pad-rows were considered:

1. Full TPC
2. Pad-rows 21-45
3. Pad-rows 31-45
4. Pad-rows 38-45
5. Even Pad-rows
6. Even Pad-rows in the range 21-45
7. Even Pad-rows in the range 31-45
8. Third Pad-rows (Pad-rows multiple of 3) in the range 21-45.

5 Tracking Performance

Track reconstruction efficiency was estimated using *good quality tracks*, defined as those with at least 5 reconstructed space points in the TPC pad-rows considered for the tracking. The reconstruction efficiency is defined as the fraction of those *good quality tracks* that are found by the pattern recognition program satisfying: $(p_t^g - p_t^r)/p_t^g < C$ $(p_t^g - p_t^r)/p_t^g/p_t^g < C)$ for tracks with $p_t^g < 1$ GeV ($p_t^g > 1$ GeV), where p_t^g and p_t^r correspond to the generated and reconstructed transverse momentum respectively.

Concerning the space points provided by the fast cluster finding running on the i960's, two scenarios are considered. Firstly the second moment of the clusters is taken as a good approximation of the space point. This option will be called *tdh errors*. Secondly a fixed errors for all spaces points are used in the tracking program. This second alternative reduces the calculation load on the i960's and reduces the data flow. It will referred to as *fixed errors*.

The CPU times in this report were all obtained running on an IBM RISC 6000/370. The machine benchmarks are summarized in Table 1.

SPECint92	70.0
SPECfp92	121.0
MFLOPS-DP	25.9
tpm(estimate)	495
MFLOPS-SP	36.7

Table 1: Characteristics of the IBM RISC 6000/370 used to test the time performance of the fast tracking program (fft).

5.1 Sector tracking

The track reconstruction efficiency in TPC sectors as a function of p_t for 3 values of C, was calculated for the varios pad-row configurations. Figures 1, 2 and 3 show the results for tdh errors. The efficiencies obtained with fixed errors can be seen in Figures 4, 5 and 6.

The momentum resolution is obtained by fitting a gaussian to Δp_t, where Δp_t is defined as $(p_t^g - p_t^r)/p_t^g)$ for the longest reconstructed segment of any real track. If the fitted gaussian has a width larger than the RMS of the distribution, the RMS is used instead.

Figure 7 shows the Δp_t versus p_t with tdh errors for the various pad-row configurations in central Lund AuAu events. A similar distribution obtained with fixed errors is depicted in Figure 8.

Δp_t versus p_t in a larger range obtained with tdh errors is shown in Figure 9. The results shown were obtained from a sample of events with tracks generated with a flat distribution in the p_t range 0-40 GeV. Similar results obtained with fixed errors in the tracking code are displayed in Figure 10.

The cpu time needed on an IBM RISC 6000/370 to reconstruct one TPC sector on a central Lund AuAu event was measured. Figure 11 shows the results as a function of the inner most row used in the tracking with tdh errors. Almost identical results are obtained if fixed errors are used instead. The errors of the plot represent the dispersion on the cpu times.

5.2 Full TPC Tracking

As a matter of completeness the fast tracking algorithm is also applied to events with all of the TPC sectors. In this case only tdh errors are considered. The track reconstruction efficiency, for three different values of the parameter C, as a function of transverse momentum, p_t, for the eight configurations considered was calculated. Figures 12, 13 and 14 show the results.

Figure 15 shows the Δp_t versus p_t obtained for the various pad-row configurations in central Lund AuAu events.

Figure 16 shows the time needed to reconstruct a full TPC central Lund AuAu event results as a function of the inner most row used in the tracking.

6 Particle Identification

The track performance as a function of the pad-row configuration has been studied in the past [1], Pablo Yepes, STAR Note 207. In that analysis the particle identification capabilities in L3 with the TOF were presented. Taking into account the improved tracking results presented in this note, we consider the PID results presented a lower limit of what should be achievable.

[1] **Track Finding and TOF Particle Identification with various TPC Pad-rows Patterns**

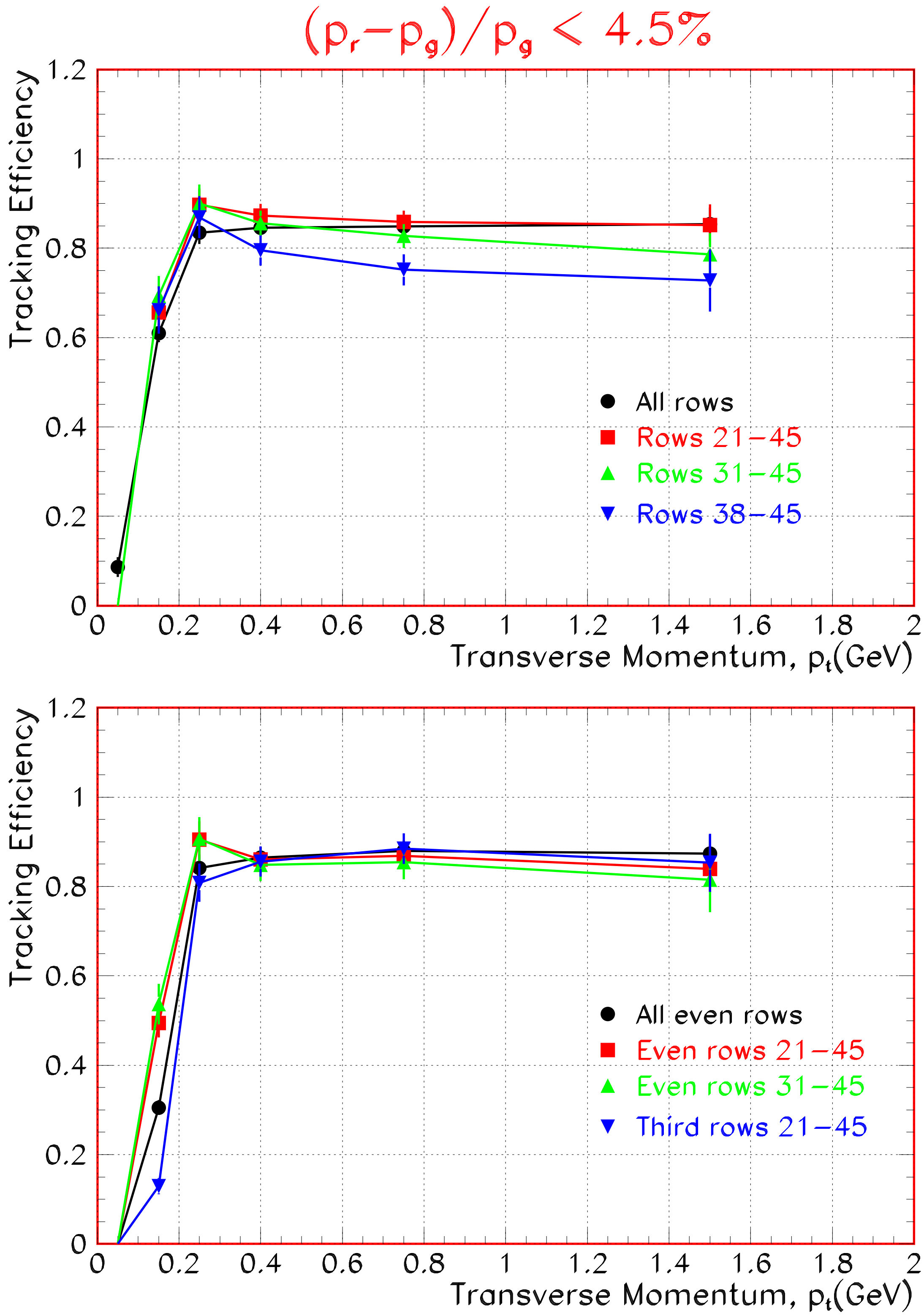

Figure 1: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with minimum acceptable resolution of 4.5% (See text for explanation). Errors used in the tracking are the cluster second moments provided by tdh.

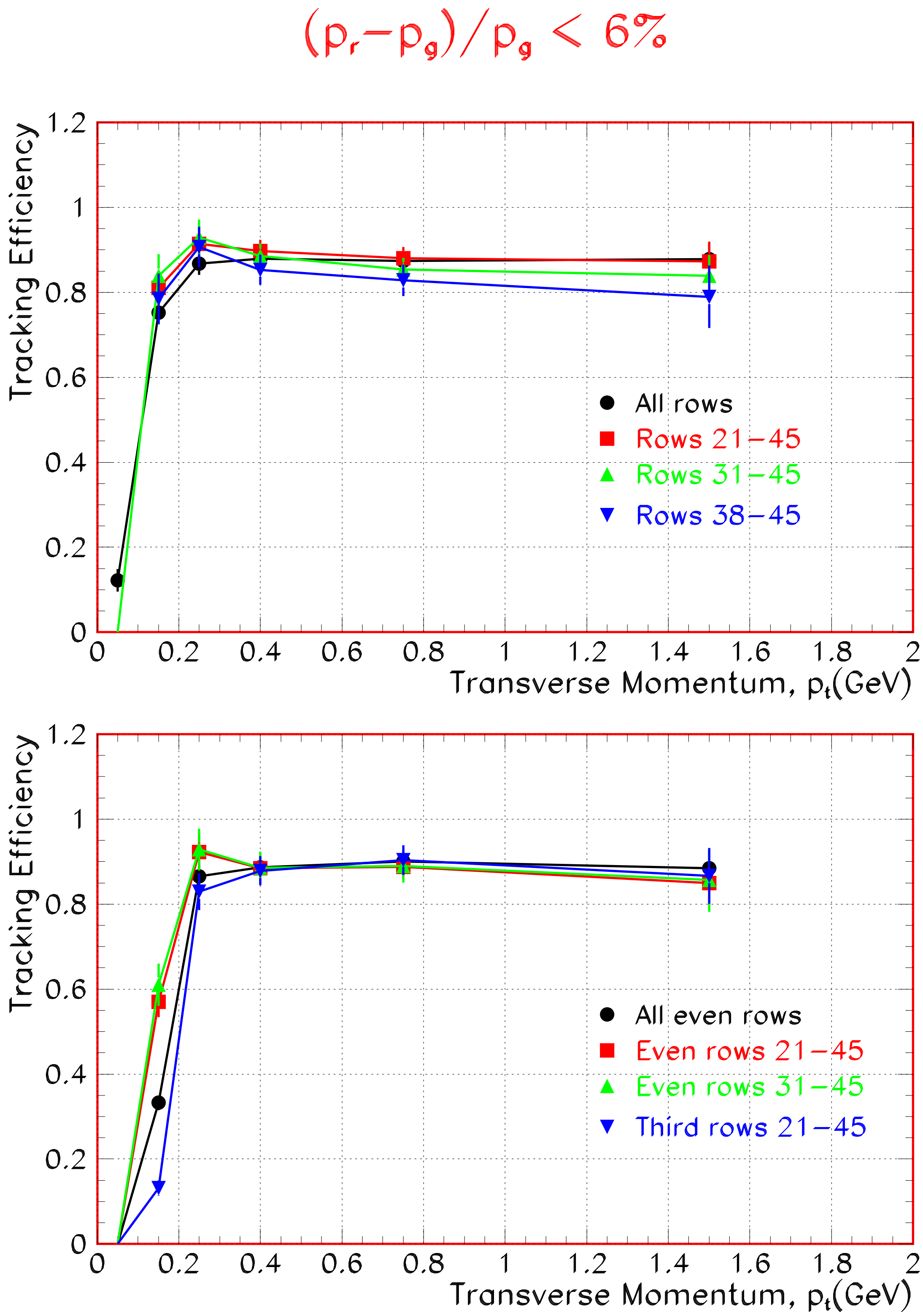

Figure 2: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 6 % (See text for explanation). Errors used in the tracking are the cluster second moments provided by tdh.

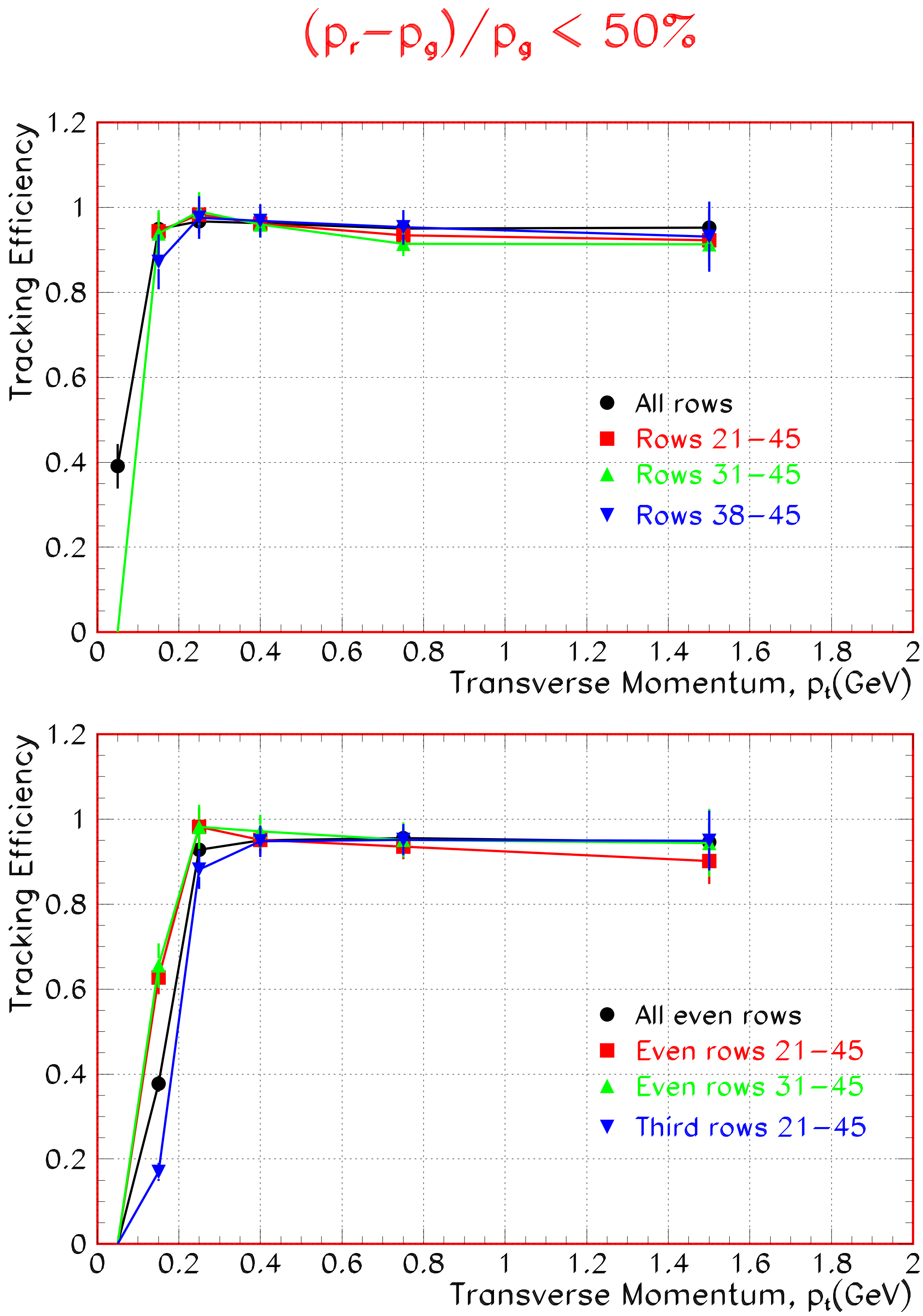

Figure 3: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 50 % (See text for explanation). Errors used in the tracking are the cluster second moments provided by tdh.

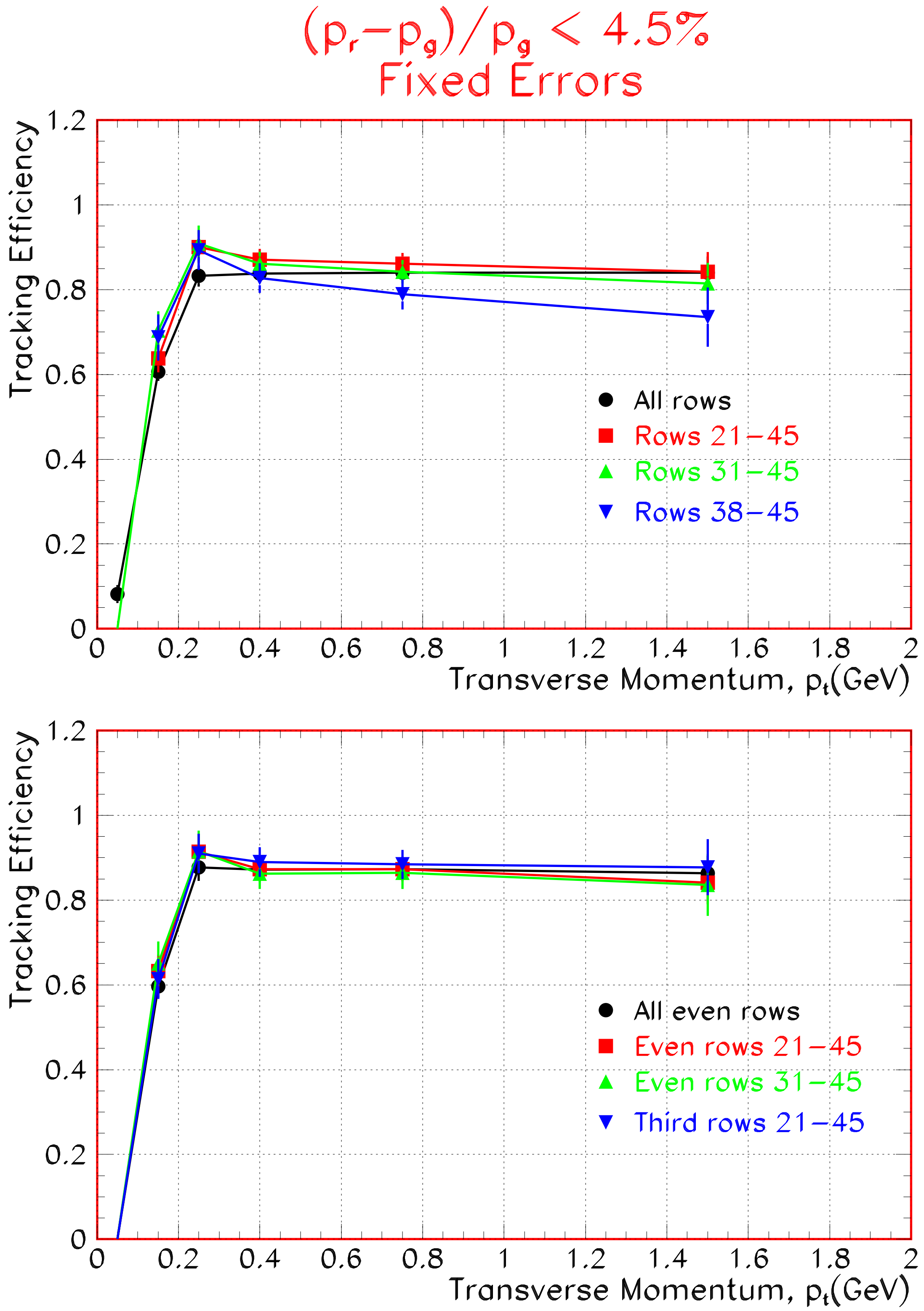

Figure 4: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 4.5% (See text for explanation). Errors used in the tracking are constant for all hits.

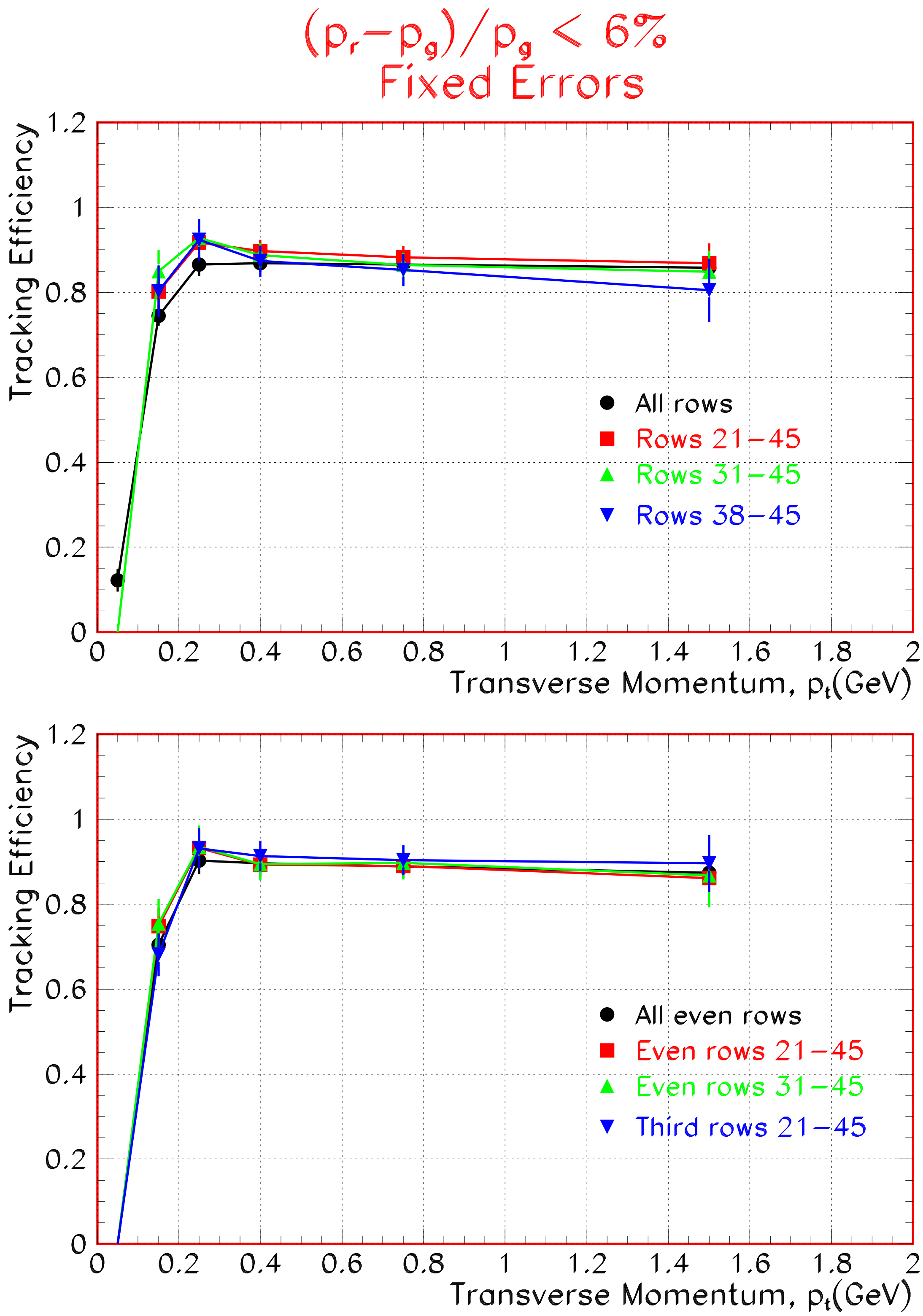

Figure 5: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 6 % (See text for explanation). Error used in the tracking are constant for all hits.

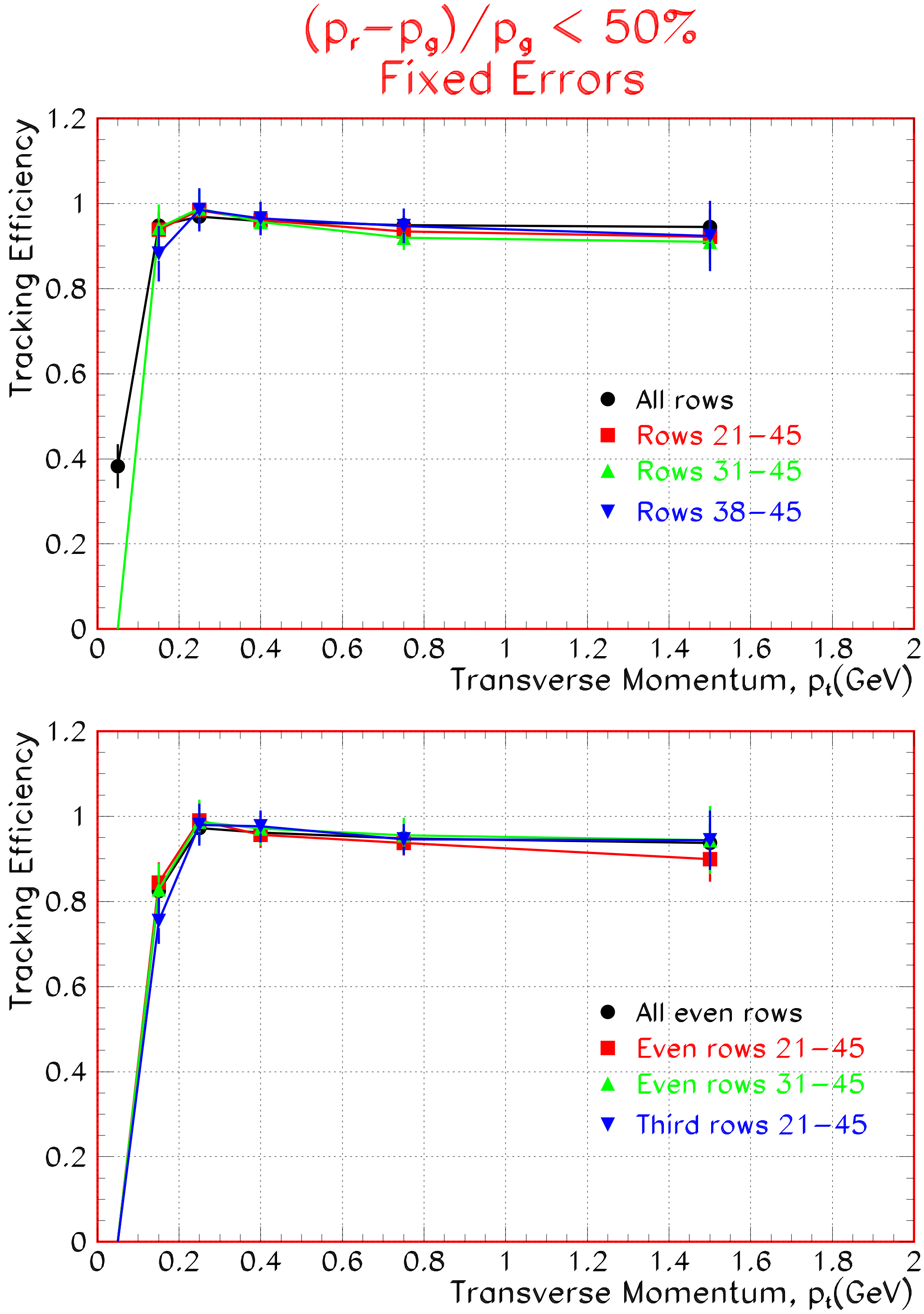

Figure 6: Track finding efficiency in TPC sectors as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 50 % (See text for explanation). Errors used in the tracking are constant for all hits.

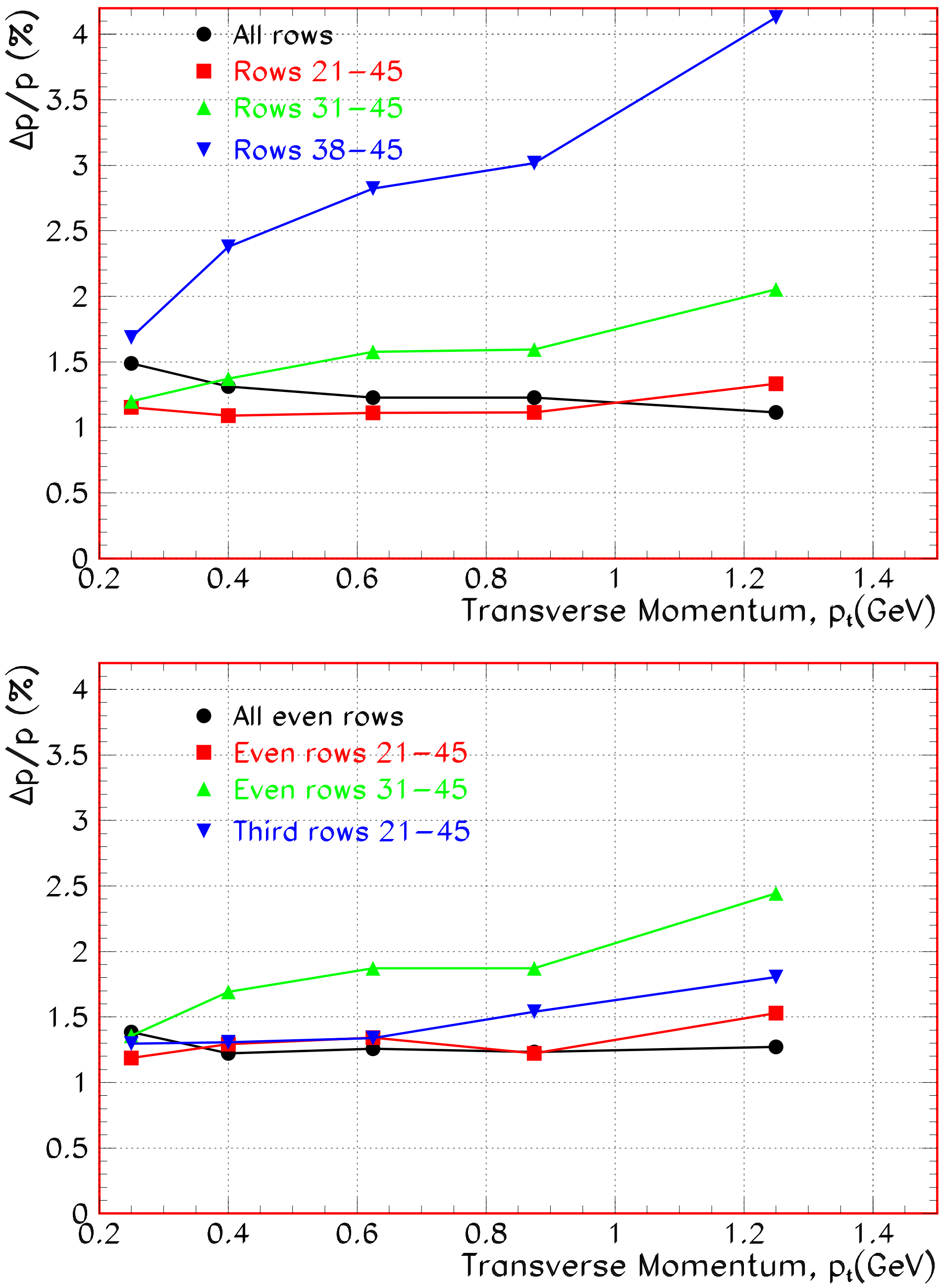

Figure 7: Momentum resolution as a function of p_t for different TPC pad-row configurations obtained using cluster second moments provided by tdh as errors.

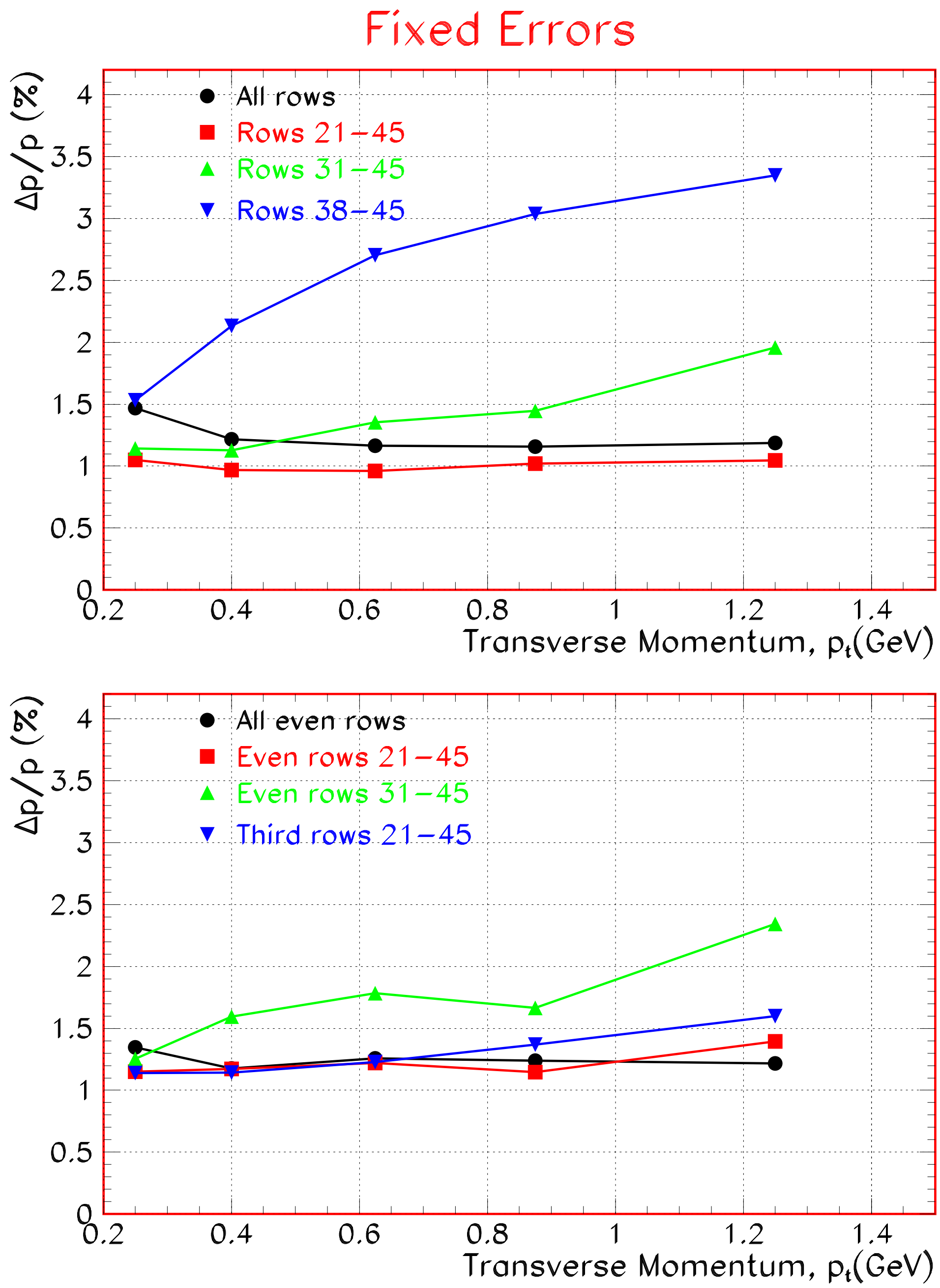

Figure 8: Momentum resolution as a function of p_t for different TPC pad-row configurations obtained using fixed hit errors.

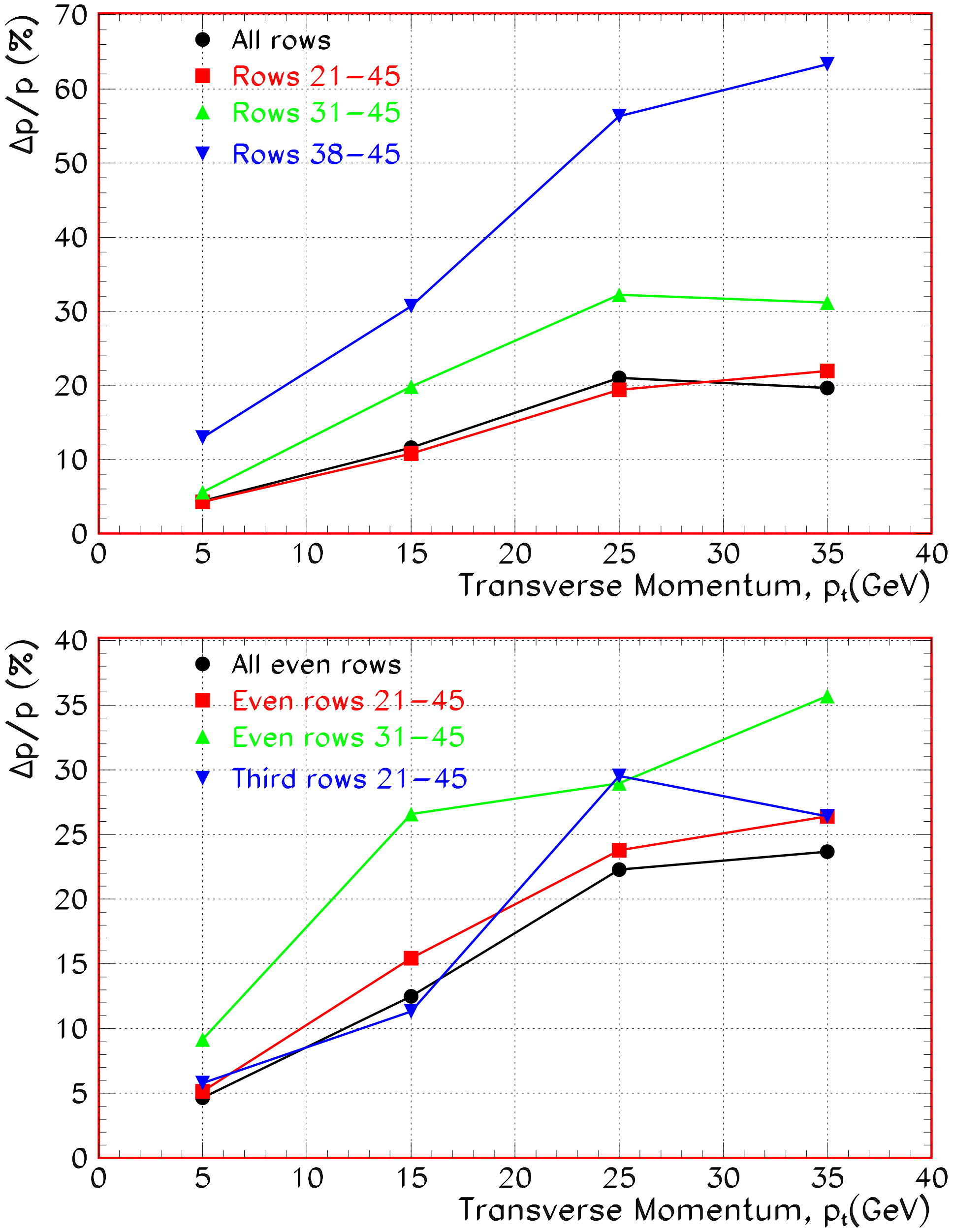

Figure 9: Momentum resolution as a function of p_t in the case of sector tracking for different TPC pad-row configurations obtained using the cluster second moments provided by tdh as errors.

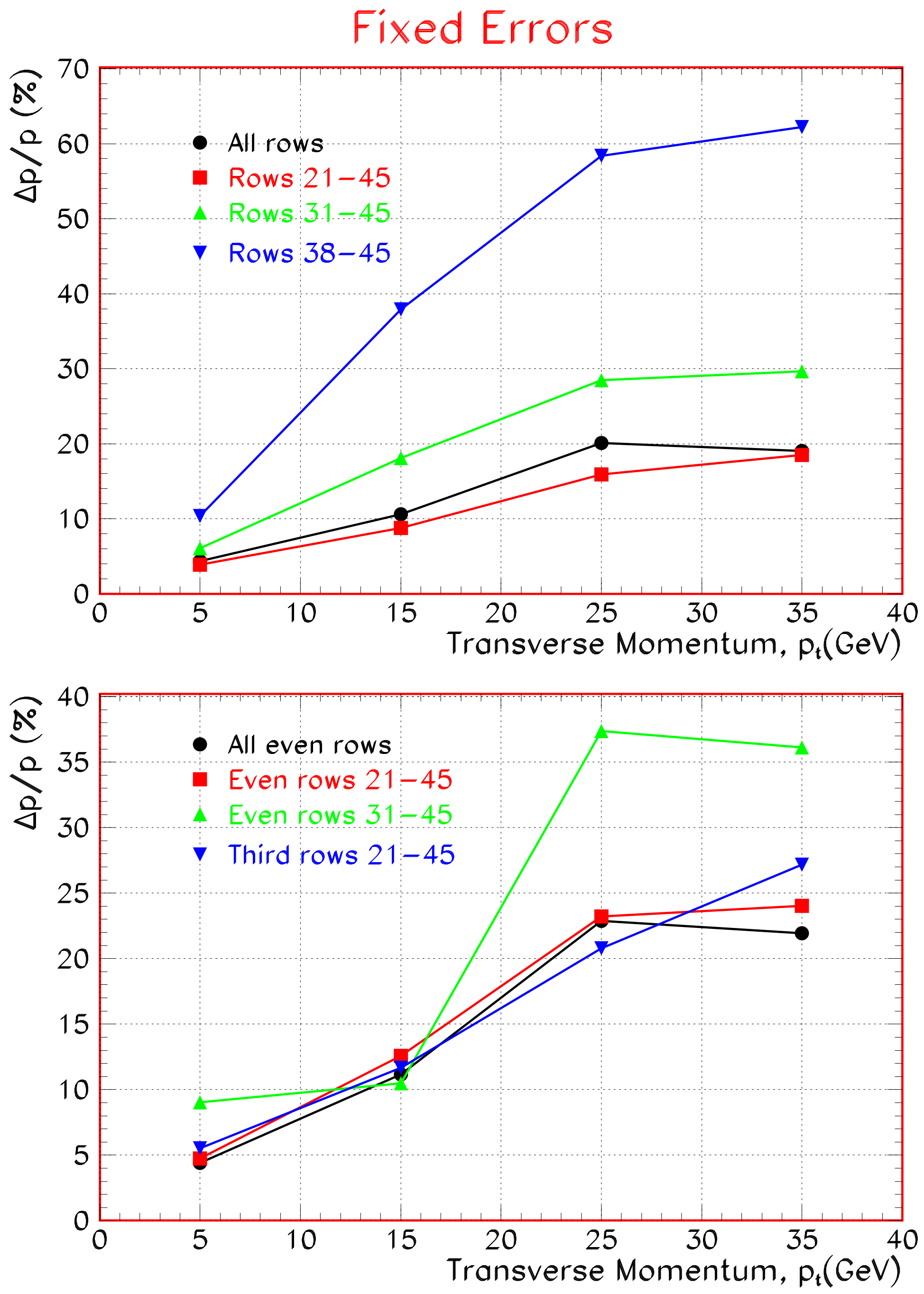

Figure 10: Momentum resolution as a function of p_t in the case of sector tracking for different TPC pad-row configurations obtained using fixed errors.

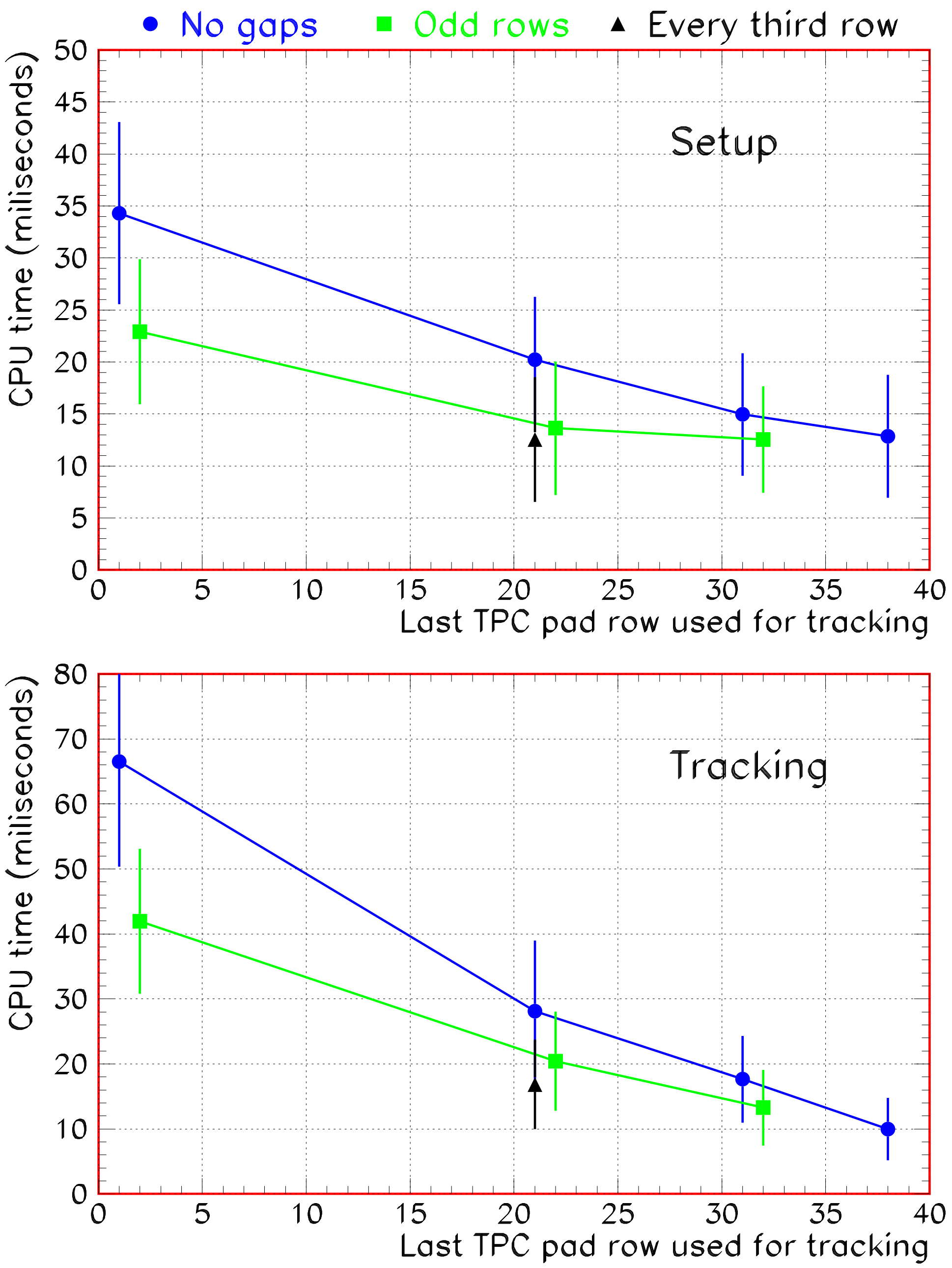

Figure 11: Time needed to reconstruct the tracks in a TPC sector for a central Lund AuAu event as a function of the inner most row used in the tracking. The point errors correspond to the time RMS. The cluster second moments provided by tdh were taken as errors in the tracking code.

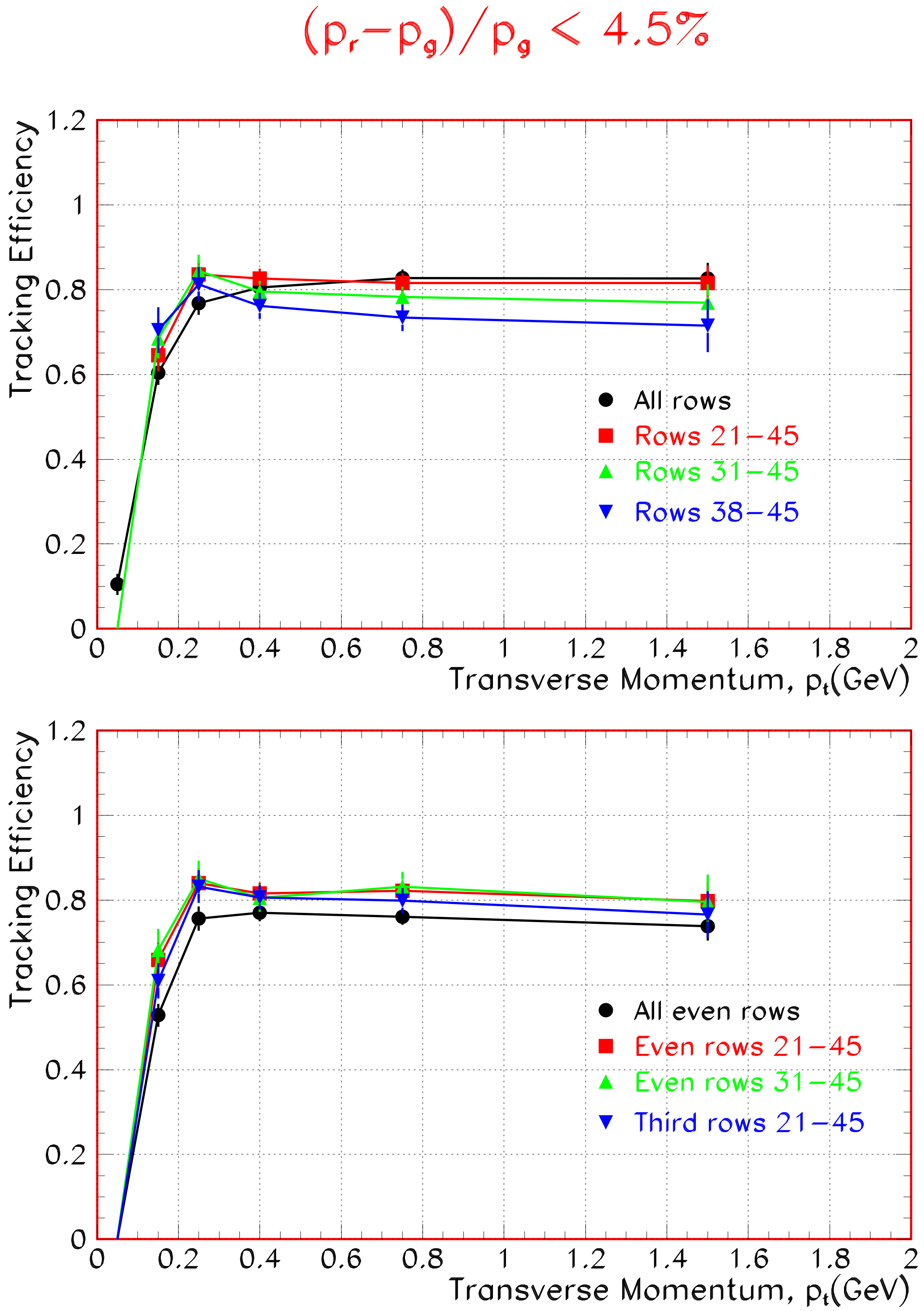

Figure 12: Track finding efficiency for the full TPC as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 4.5% (See text for explanation). Errors used in the tracking are the cluster-second moments provided by tdh.

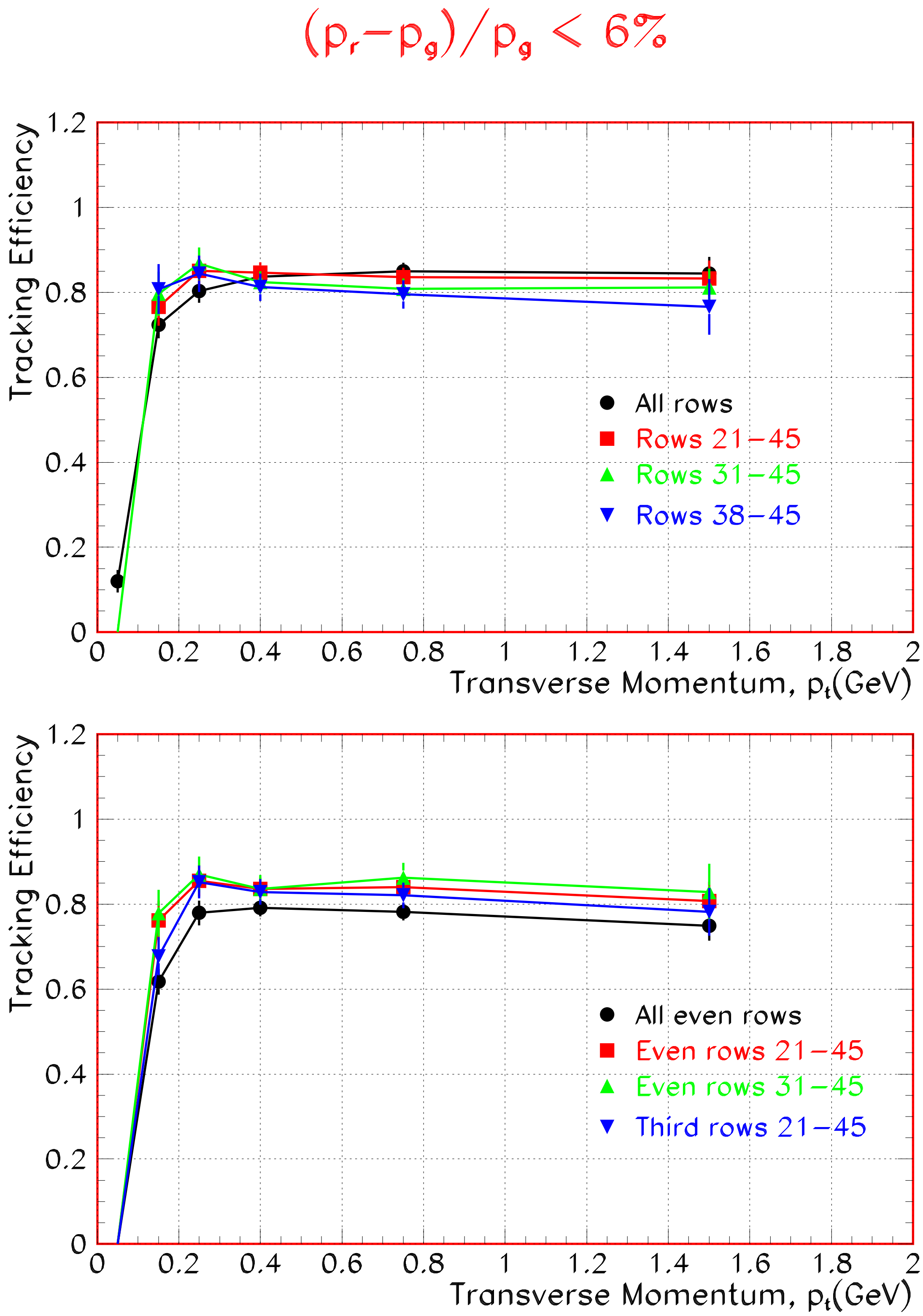

Figure 13: Track finding efficiency for the full TPC as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 6 % (See text for explanation). Errors used in the tracking are the cluster-second moments provided by tdh.

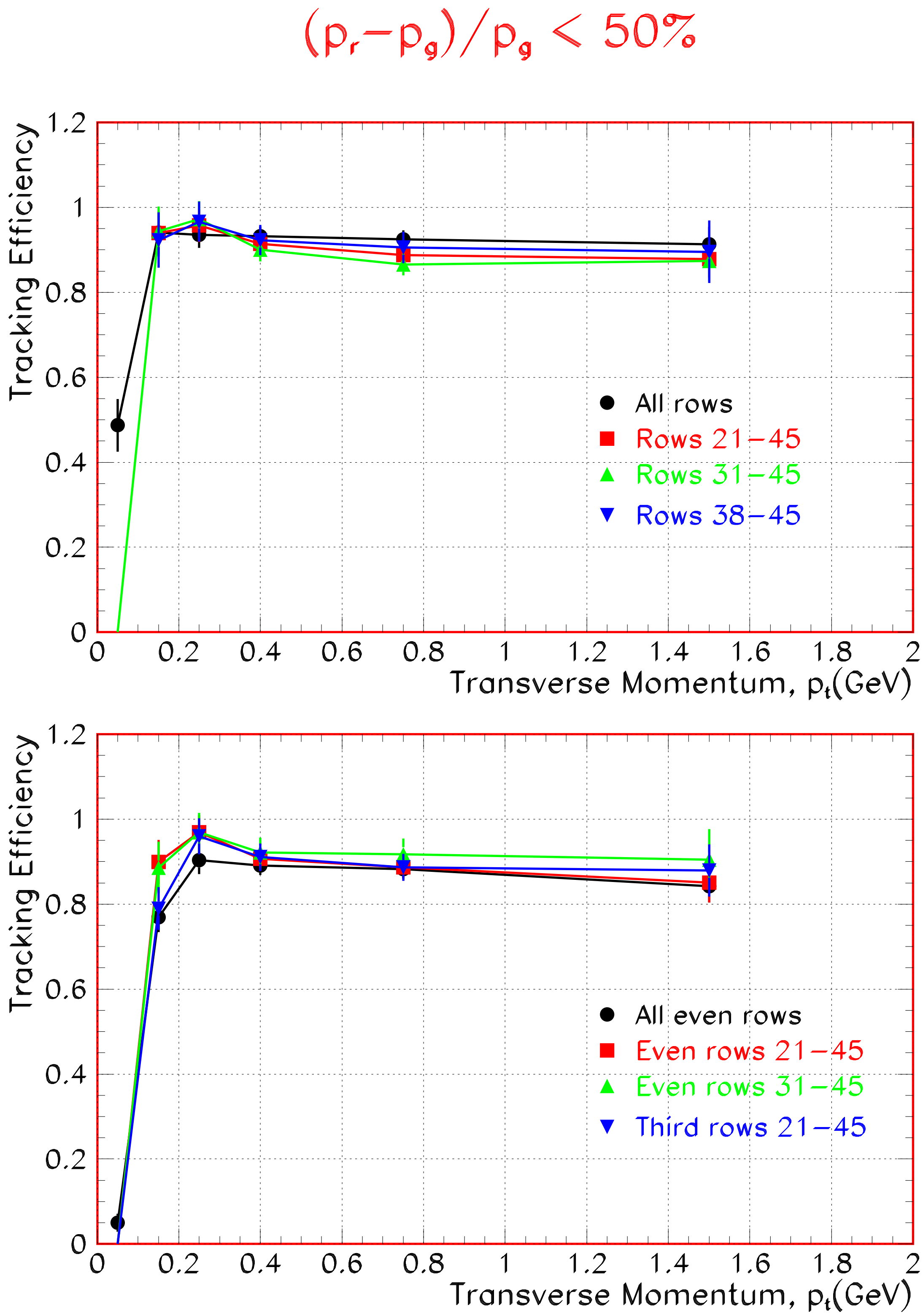

Figure 14: Track finding efficiency for the full TPC as a function of p_t for different pad-row configurations with a minimum acceptable resolution of 50 % (See text for explanation). Errors used in the tracking are the cluster second moments provided by tdh.

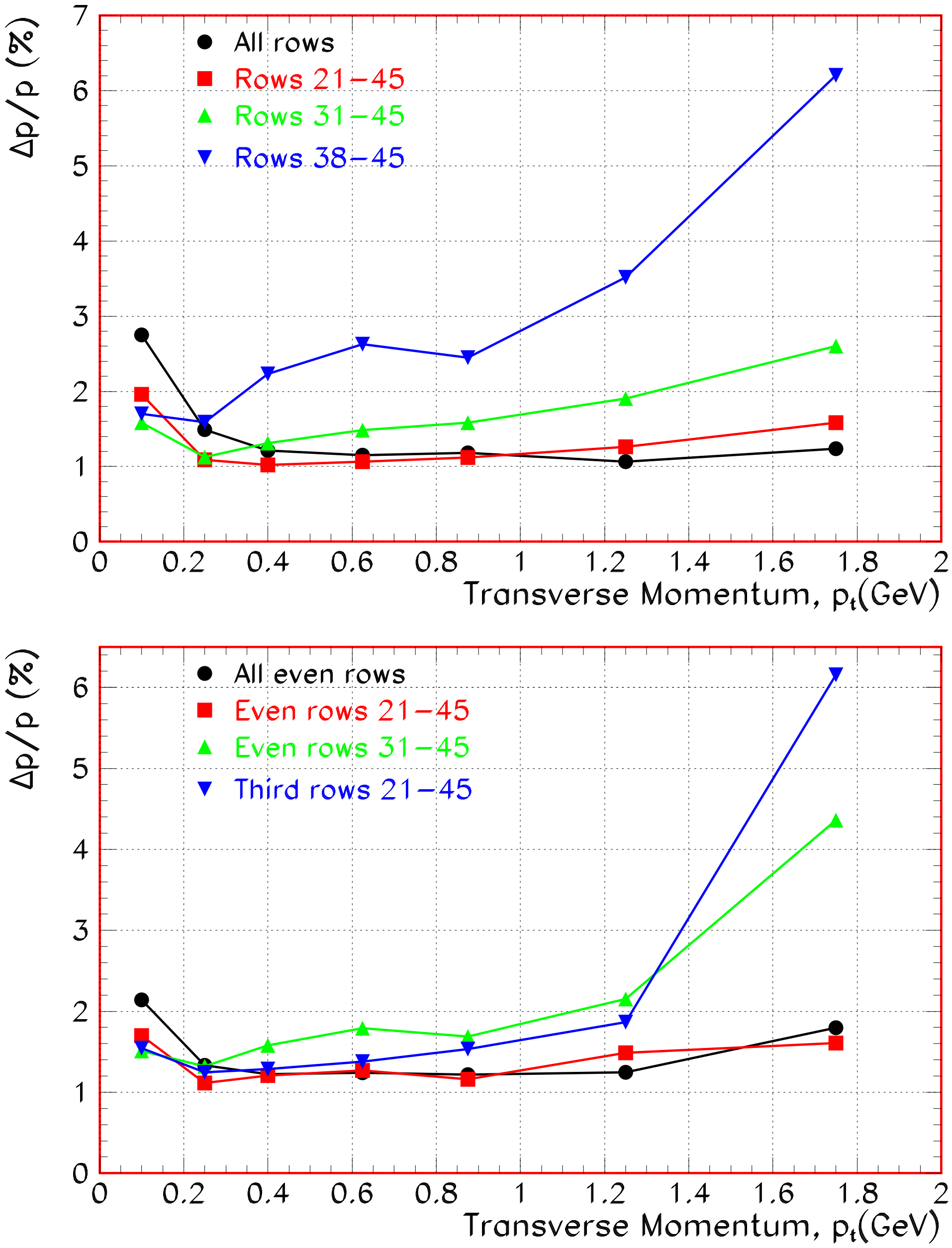

Figure 15: Momentum resolution as a function of p_t for the full TPC for different TPC pad-row configurations obtained using cluster second moments provided by tdh as errors.

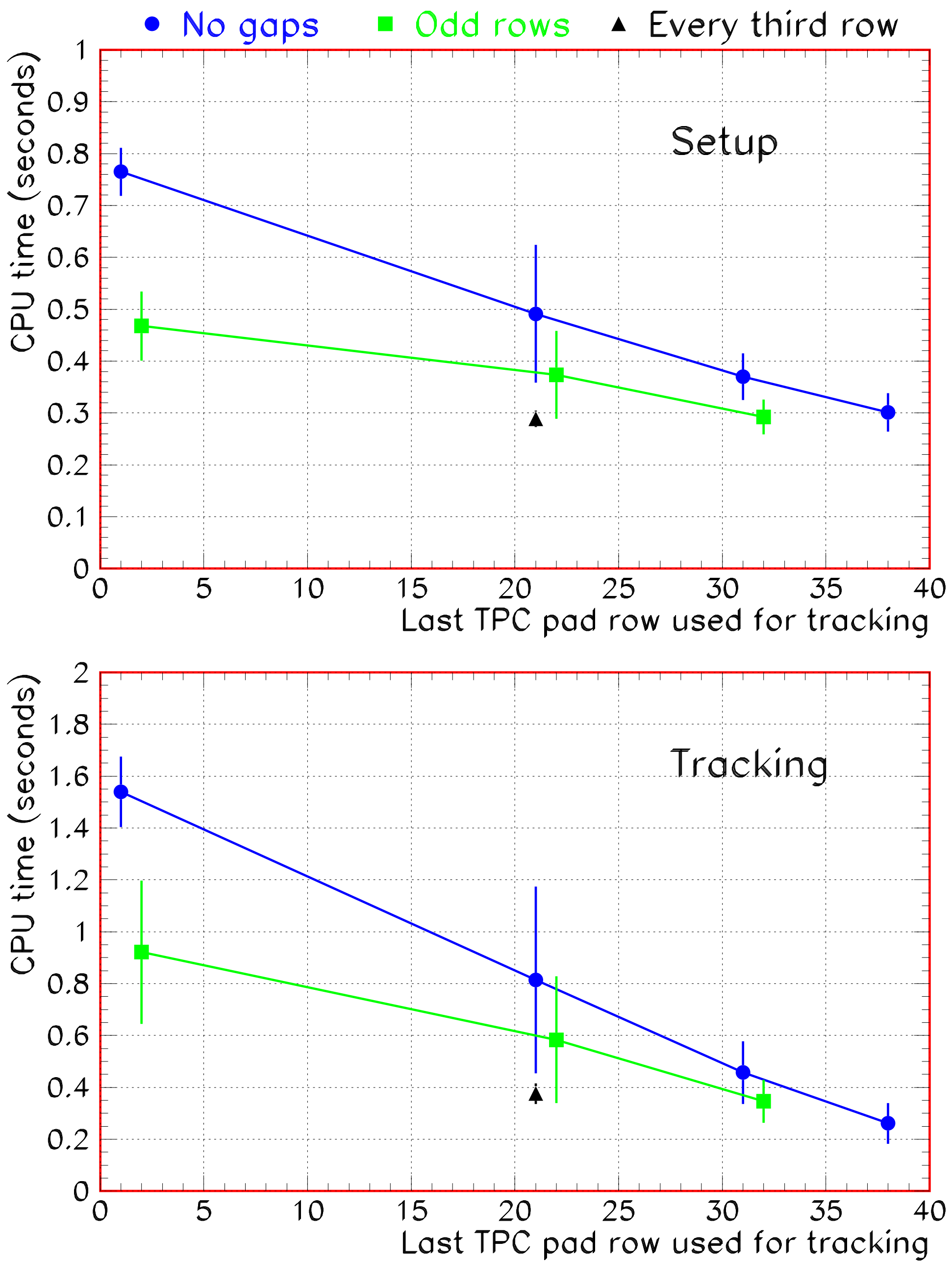

Figure 16: Time needed to reconstruct a full TPC central Lund AuAu event as a function of the inner most row used in the tracking. The point errors correspond to the time RMS. The cluster second moments provided by tdh were taken as errors in the tracking code.