Reconstruction efficiency in the BRAHMS forward arm detectors.

Paweł Staszel, NBI

1 Introduction

The note is dedicated to describe a reconstruction efficiency module (BrEfficiencyFinderModule) that can be used to find the track reconstruction efficiency in each of the forward BRAHMS spectrometer arm (FS) tracking detector e.g. in TPCs: T1, T2, and in DCs: T3, T4 and T5. In this note, I will attempt to explain how the package works and how to use it to be sure that the result is correct. All figures showed in this note can be found among the package diagnostic plots.

2 Track Reconstruction Efficiency

The idea of determining the track reconstruction efficiency applied in the BrEfficiencyFinderModule base on the determination of a reference track, which can be used as a reference for the local tracks in the studied detector. Knowing the way, how to construct a reference tracks, we can define the reconstruction efficiency as:

$$E_{rec} = \frac{N_{local}}{N_{ref}}, \tag{1}$$

where, N_{ref} is a total number of reference tracks and N_{local} is a number of reference tracks that match, in a given event, to any of the local detector track. By definition $N_{local} \leq N_{ref}$, so $E_{rec} \leq 1$. Of course, the investigated detector, in terms of the tracking efficiency, can not contribute to the reference track determination.

The FS arm consists of 5 independent tracking detectors, which makes it very simple to construct a reference tracks, i.e. for each detector under study there is a 4 tracking detectors left that possibly can be used to define a reference track. The important issue is a background and ghost tracks contribution to the reference tracks. This problem will be discussed individually for each detector.

Note, that the presented approach to the determination of the detector tracking efficiency can not be used for MRS (however, one can try to do it for D5 magnet zero field runs).

2.1 T3

In case of T3 the reference track is just a bfs track, i.e. track defined by T2, T4 and T5 detectors. T3 is placed between T2 and T4, and such a reference track should also be seen in T3. Figures 1 and 2 show a correlation between momenta of the front (T2-D3-T4) and back (T4-D4-T5) section each bfs track reconstructed in run 5685 (12 deg.) and 5931 (4 deg.), respectively. It is seen from the plots that the background contribution to the bfs tracks (if any) is very small and no other requirement on the reference tracks are necessary. The correlation of the bfs and T3 tracks for FS settings at 12 deg. is shown in the figure 3. The plots are constructed in such a way that the bfs track is transformed into the local T3 detector frame and then the deviation between bfs and T3 local tracks are plotted. Black and red line histograms on the top panel

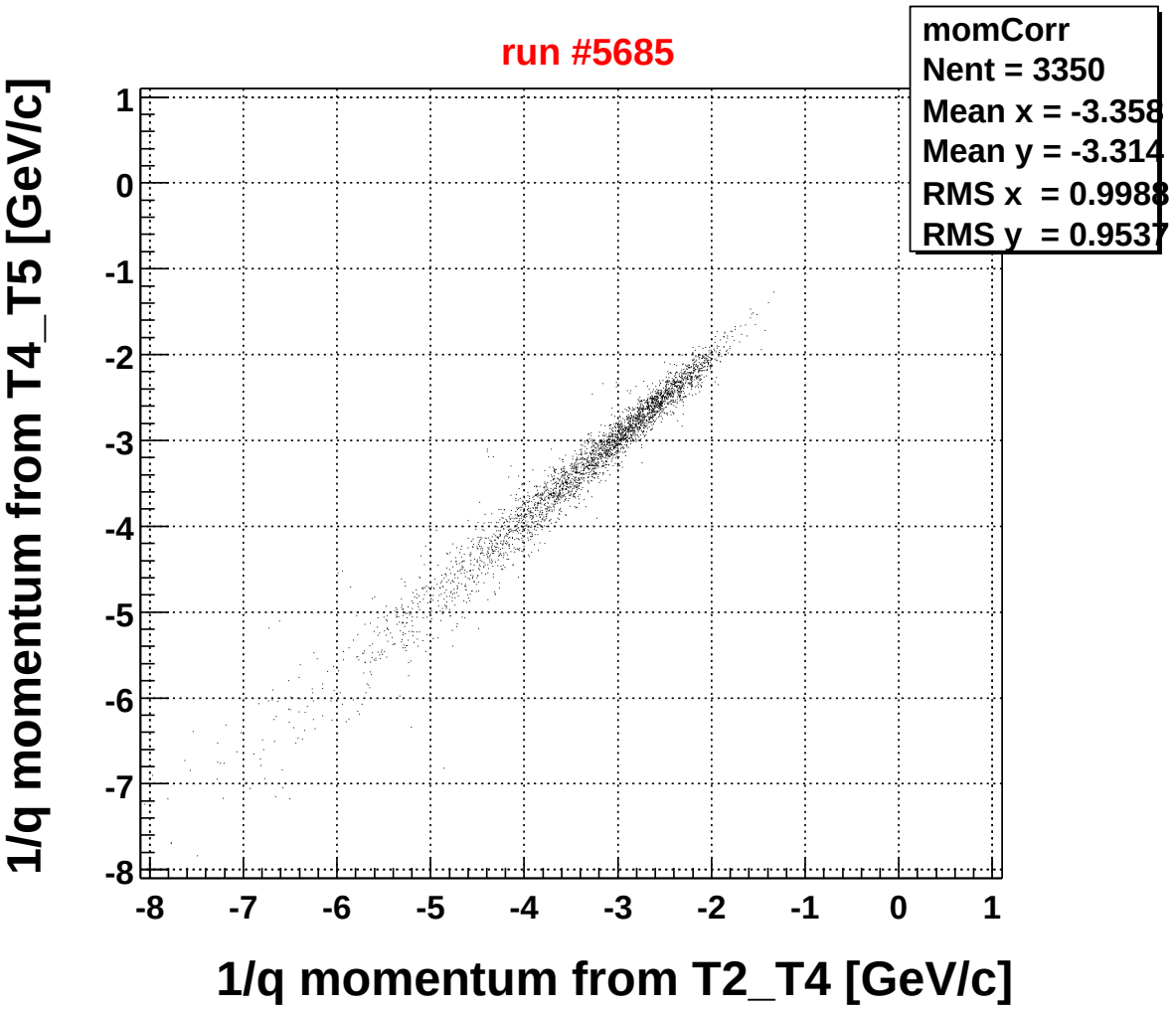

Figure 1: correlation between momenta of the front (T2-D3-T4) and back (T4-D4-T5) section of each bfs track reconstructed in run 5685 (12 deg.)

refer to deviation in x (dx), and y (dy) position, respectively. On the bottom panel, the histograms refer to the deviation in x-slope (dax, black line) and y-slope (day, red line). We define that a local track match to the bfs reference track, when dx, dy, dax and day lie within the distance of $\pm 4\sigma$ from the mean peak value (see figures 3, 4, 6 and 7).

2.2 T4

The reference tracks for the T4 detector are constructed in the following way: we start with a ffs track (defined by matching T1 and T2), then we swim forward the track through D3 and D4 magnets. To check whether the ffs track represent a particle that really reached a back end of the spectrometer we impose additional requirement: **a)** the track was properly transported both through D3 and D4 magnets (SwimStatus==kTRUE), **b)** transported track match to any of the T5 local tracks (confirmation by T5), and **c)** transported track match to any of the H2 hits (confirmation by H2). The matching with T5 local tracks is done as described in sec. 2.1 applying $\pm 3\sigma$ cuts, and the correlation between ffs transported tracks and T5 local tracks is shown in fig. 4. The matching between transported ffs tracks and H2 hits is done in x and y coordinates

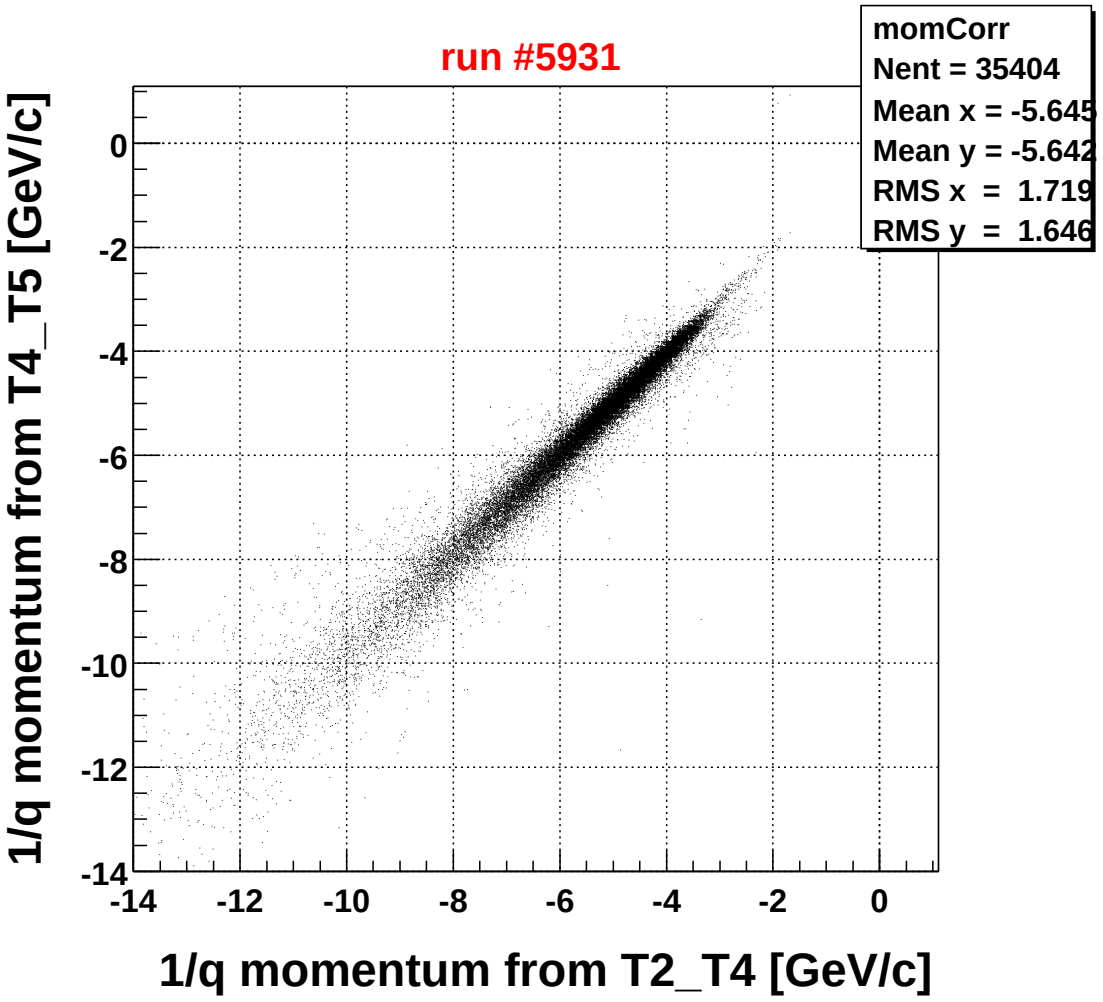

Figure 2: correlation between momenta of the front (T2-D3-T4) and back (T4-D4-T5) section of each of the bfs track reconstructed in run 5931 (4 deg.)

by applying $\pm 2\sigma$ cuts (see sec. 2.3 and fig. 5 for more details).

2.3 T5

In the case of T5 detector we start with a front bfs track (T2-T4). We take only these tracks that match to any of the ffs track (ffs and bfs track ID in T2 detector is the same), so our initial reference track candidate is defined by T1, T2 and T4 detectors (there is an option to replace T2 by T3 (see also sec. 3), but in this case a matching condition with the ffs tracks has not yet been implemented). Then, we swim the front bfs track forward through the D4 magnet. To verified wether the track represents a particle that passed through D4 and reached T5 detector we require, that a track's swim status is "true" and that the transported track match to any of a valid H2 hits. The correlation between the bfs front tracks, transported through D4 magnet and projected into the H2 local frame, and the H2 detector hits, is presented in figure 5. Black and red line histograms on the top panel correspond to correlation in x and y coordinate, respectively. Bottom panel shows the same correlation but in two dimensions (black color markers), and correlation

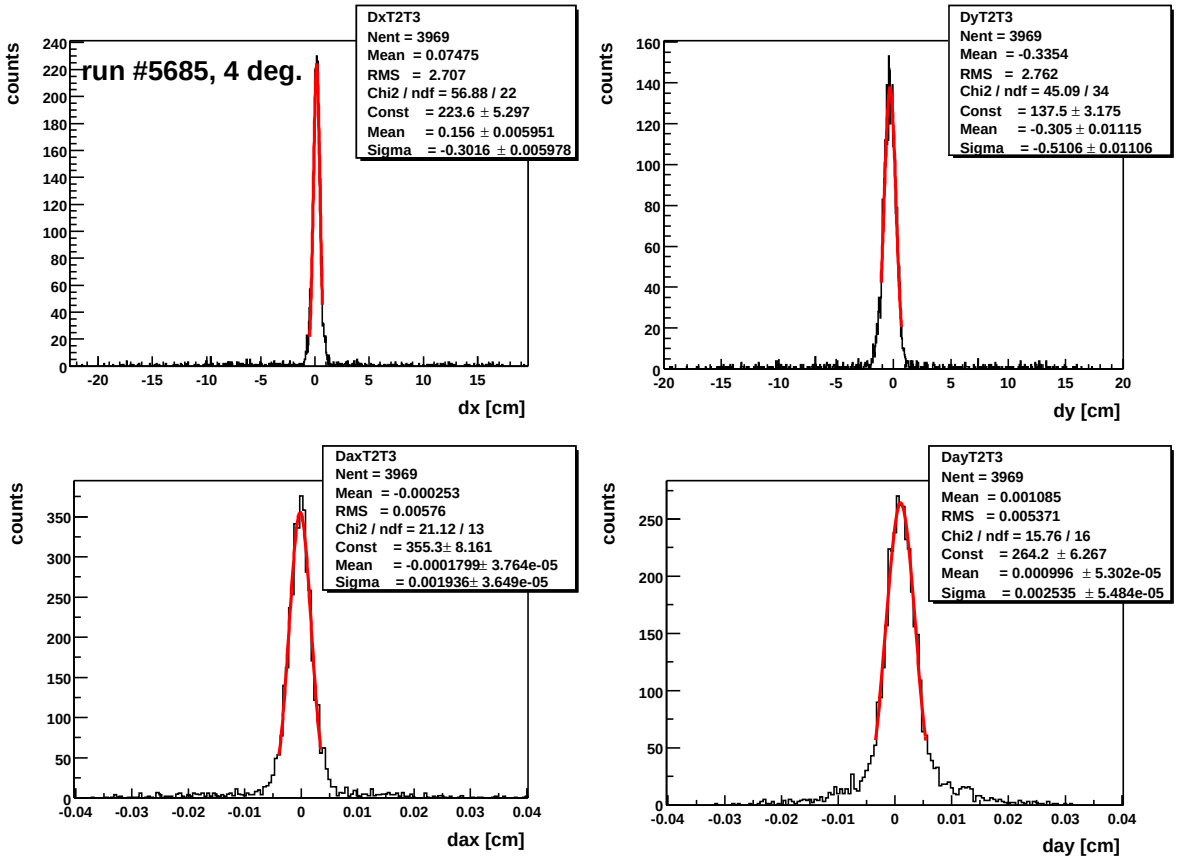

Figure 3: The correlation of the bfs (T2) and T3 tracks for FS settings at 12 deg.

for tracks that survive a $\pm 2\sigma$ cuts both, on dx and dy (red color markers). The latest tracks are chosen as a reference tracks for the T5 detector. Note, that the T5 detector case is the only one, where we can not use other tracking detector placed at the front and at the back side of T5 to construct a reference track. On the back site of this detector we can use only H2 detector that provide much worse position resolution (in x and y) compare to any other tracking detectors as well as a contribution of the background hits to the "real hits" is larger that contribution of the background and ghost tracks to the "real tracks". Fortunately the background contribution to the reference tracks, which will underestimate the derived efficiency, can be estimated from the background around the correlation peak from the bottom panel in fig. 6.

2.4 T1 and T2

As a reference tracks for T1 and T2 detectors we use bfs tracks defined by T3, T4 and T5. Here we make on assumption that each particles represented by bfs track passed through T1 and T2 detectors. The correlation peaks between bfs reference tracks projected to T2 local frame and T2 local tracks are very close to those shown in figure 3. To get a reference track for T1 we take a T2 track that match to bfs reference track, swim it backward through D2 magnet and then project into a T1 local frame. The bfs_{T2} - T1 correlation is shown in fig. 6 and fig. 7 for 4 deg. and 12 deg. of the FS setting angle, respectively. From the figure 6 it is seen that for FS settings at 4 deg. the correlation peaks are accompanied by a significant amount of the uncorrelated background. To

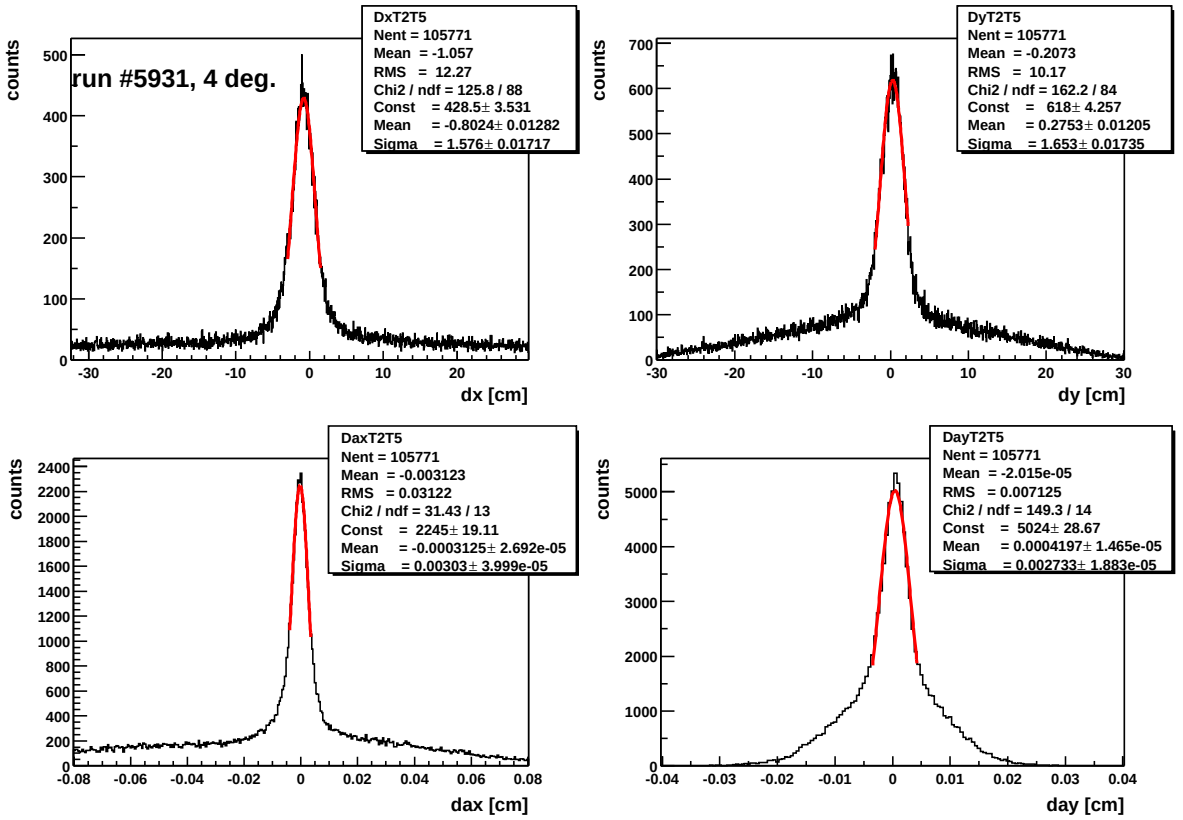

Figure 4: The correlation of the ffs (T2) and T5 tracks for FS settings at 4 deg.

see how the matching procedure can select only a correlated tracks we construct bfs_{T2}-T1 deviation distribution in ay, under condition that bfs_{T2} and T1 track is already correlated in x, y and ax (within $\pm 4\sigma$ cuts). The result is plotted on the forth panel of fig.6 as a blue line histogram. One can clearly seen that the matching procedure applied only to 3 (out of four) matching variables, remains only a really correlated bfs_{T2} and T1 track pairs, therefore a contribution of the background or ghost tracks to the derived efficiency, event in this most critical case (T1 detector at 4 deg.) is very small (probably negligible).

3 How to get and use BrEfficiencyFinderModule

BrEfficiencyFinderModule can be found in `brahms_app/ps_app/fs/receff`. The script is called `fsRecEff.C`. To get a description of the command line options just write `>bratmain fsRecEff.C -h`.
A few specific options require some explanation:

- option `-p` (platform name), has two possible arguments: `bfs` or `ffs`. By selecting `bfs` we chose a searching for the reconstruction efficiencies in T3, T4 and T5, and by selecting `ffs`, a searching for reconstruction efficiencies in T1 and T2.

- option `-t` (data type) and `-L` (data level). If you want to use raw data as an input select `raw` for `-t` option, and `hits` for `-L` option. To read reduce data one should select `root` for `-t` and `tracks` for `-L`.

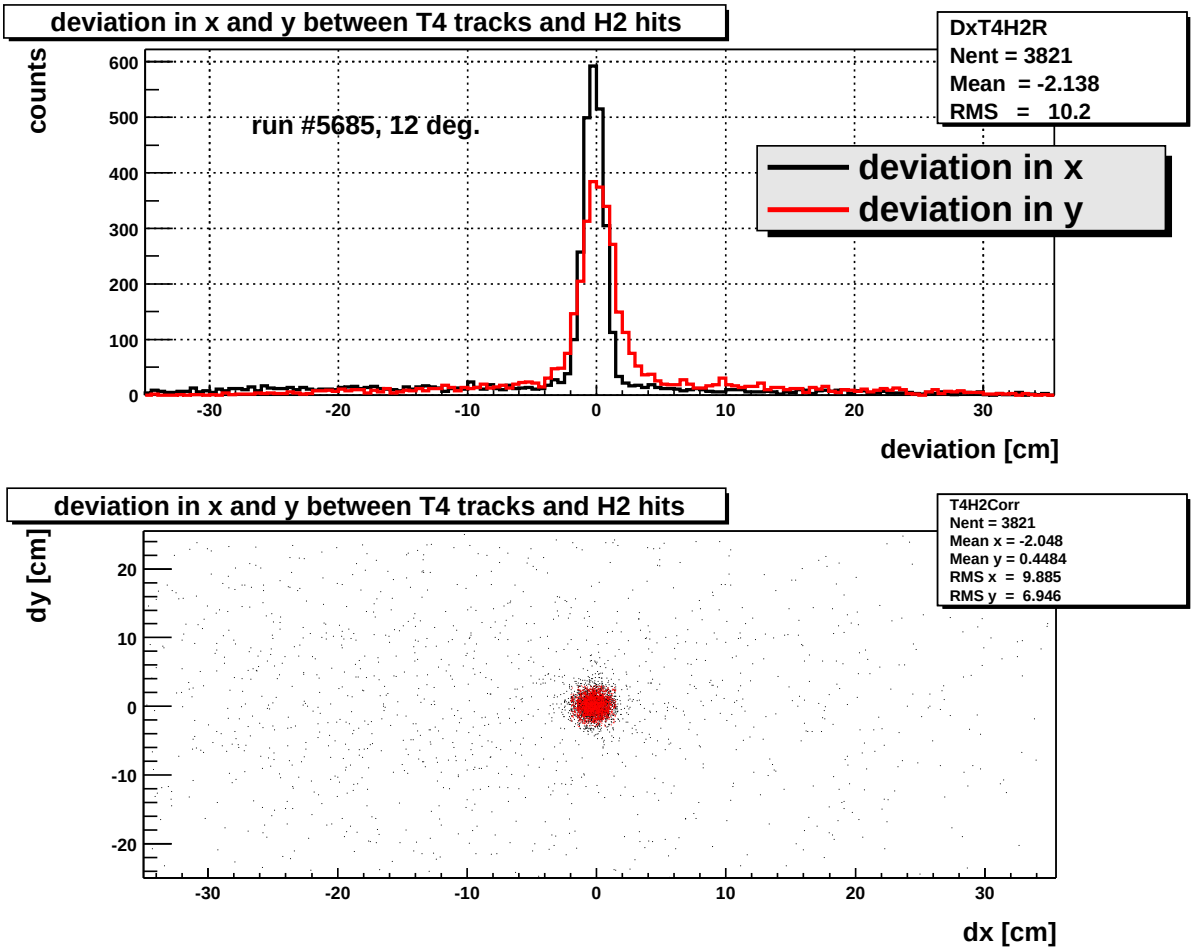

Figure 5: Black and red line histograms on the top panel correspond to correlation in x and y coordinate, respectively. Bottom panel shows the same correlation but in two dimensions, black color markers, and correlation for tracks that survive a $\pm 2\sigma$ cuts both, for x and y coordinate, red color markers.

- option `-F` (front detector name), has to possibilities `T2` or `T3`. Use always `T2` with `-p bfs` and `T3` with `-p ffs`. (It is not hard-coded to handle some exceptions).

Other options are rather commonly used.

Very important:

Note that the module uses a hard-coded offset and sigma values for the correlation peaks. If you use wrong values it could significantly affect the derived efficiencies. The diagnostic root file, in the directory `Tracking_BFS`, contains histograms showing the correlation peaks, e.g. correlation between T2 and T3 in the x coordinate is stored in DxT2T3 histogram. To be sure the efficiencies are calculated in the proper way one should check whether the hard-coded (specially) offsets and sigmas definitions are consistent (lets say $\pm 20\%$) with those from the related diagnostic histograms. However, the hard-coded values should be appropriate for all runs reduced on, or after the 19^{th} of November 2001. Be sure that you use a correct geometry files.

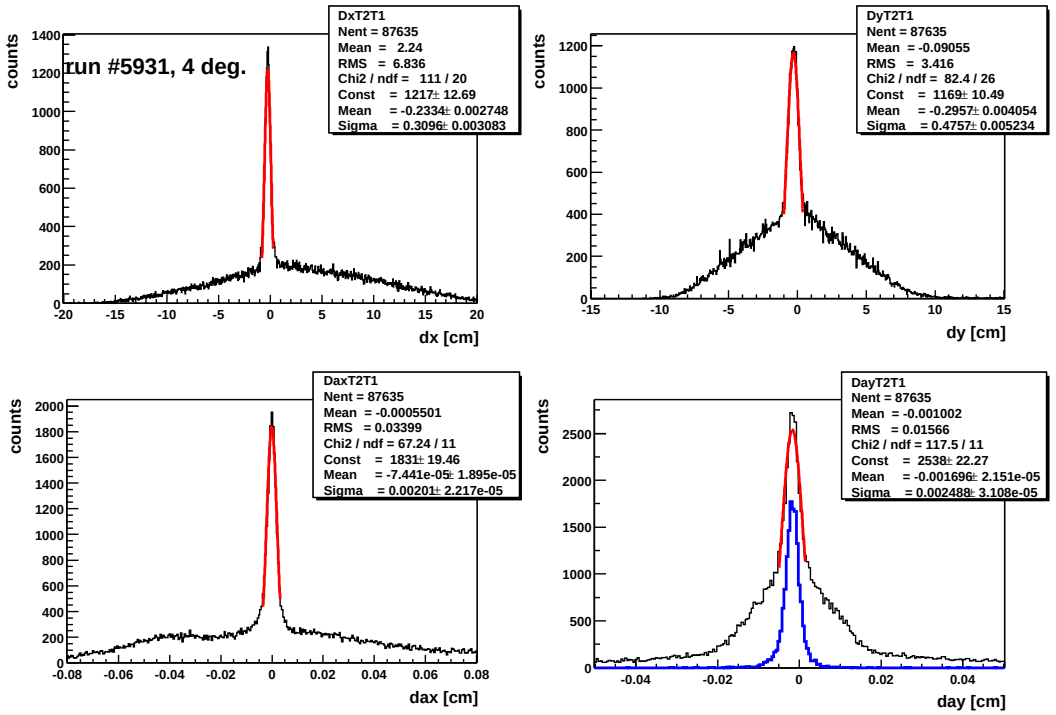

Figure 6: The correlation of the bfs (T2) and T1 tracks for the FS settings at 4 deg. Blue line histograms shows y-slope deviation distribution only for those tracks that match in in x, y and x-slope (see also text).

4 Summary

Lets enjoy the code and bring me your remarks and suggestions.

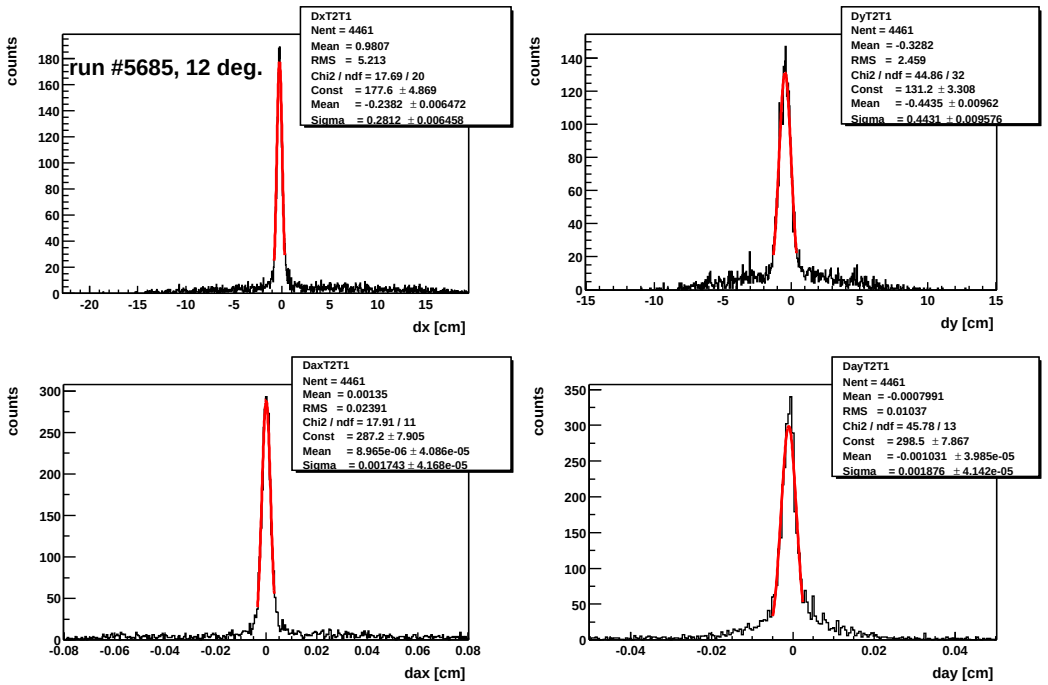

Figure 7: The correlation of the bfs (T2) and T1 tracks for FS settings at 12 deg.