Details of the 62 GeV pp spectrum analysis Analysis Note 58 version 2

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Abstract

Details of the analysis of the spectra for the pp 62 GeV data are presented. The main emphasis is on data selection, methods, and quality control. The physics analysis will primarily be given in the longer paper draft.

1   Introduction

In this note I describe the details of analysis of the 62 GeV pp data. The note describes the data preparation, the run selection, particle indentification, various quality controls that were carried out, the cuts and ranges used in the playback of the DST, the spectrum generation, normalization issues, and final spectra.

2   Data preparation

The analysis uses the **DST** (Data Summary Tape) production version 2. These DSTs are produced from the **GTR** (Global Tracking) files version 2. This is all done in the normal production mode with the scripts used available in the bramreco/Dataproduction/run06/pp/62 subdirectories and saved in the CVS repository. The time-of-flight calibrations were done for several subsets of the data. The focus was to have good relative timing between slats and slewing corrections. Final adjustments were made run by run as described in the PID section.

3 Run Selection

Most runs recorded in the RHIC run-6 62 GeV pp run are usable for analysis. Only some short or aborted runs are skipped. The ones included in the analysis are given in the list below. The analysis session actually picks these up through root macros in the main analysis directory. The file **Files_pp.C** contains the list of runs for each angle and field setting. Consult this file for the latest runlists considered good.

The settings that we use from the 62 GeV run includes for the two spectrometer arms the following angle and fields in the Mid Rapidity Spectrometer (MRS) and the Forward Spectrometer (FS).

- **FS:** 2A1723, 2B1723, 3A1723, 3B1723, 4A608, 4B608, 6A861 and 6B861. In addition there are two runs for 4B1723 that might be used.

- **MRS:** 90A350, 90A700, 90B700, 90B1050, 45A700, 45B700 and 45B1050. The 90B1050 is marginal is statistics and does not add much to the overall quality of the 90 degree data set.

For completeness I give the list of runs assigned to each setting.

- **2A1723 :** 16213, 16214, 16215, 16216, 16217, 16218, 16219, 16220, 16221, 16222, 16229, 16231, 16232, 16233, 16234, 16235, 16236, 16237, 16238, 16239, 16240, 16241, 16242, 16243, 16244, 16245, 16246, 16248, 16261, 16262, 16263, 16264, 16265, 16266, 16267, 16268, 16261, 16271, 16272, 16273, 16274, 16277, 16278, 16279, 16280, 16281, 16282, 16283, 16284, 16385, 16288, 16289, 16292, 16293

- **2B1723 :** 16249, 16250, 16251, 16252, 16255, 16256, 16257, 16258, 16259, 16260

- **3A1723 :** 16048, 16050, 16051, 16052, 16053, 16054, 16055, 16056, 16057, 16062, 16064, 16065, 16066, 16067, 16068, 16070, 16071, 16072, 16073, 16074, 16075, 16076, 16077, 16078, 16079, 16080, 16081, 16082, 16083, 16084, 16085, 16086, 16087, 16090, 16091, 16092, 16093, 16094, 16097, 16098, 16100, 16101

- **3B1723 :** 16109, 16111, 16112, 16113, 16114, 16115, 16116, 16118, 16119, 16124, 16125, 16126, 16127, 16128, 16129, 16130, 16131, 16132, 16133, 16134, 16135, 16138, 16139, 16140, 16141, 16142, 16143, 16145, 16146, 16147, 16148, 16149, 16150, 16151, 16152

- **4A608 :** 16030, 16031, 16034, 16035, 16036, 16037, 16040, 16041, 16042, 16043

- **4B608 :** 15988, 15989, 15990, 15991, 16006, 16007, 16008, 16009, 16017, 16018, 16019, 16020, 16021, 16022, 16025, 16026, 16027

- **6A861 :** 16185, 16186, 16187, 16192, 16193, 16195, 16196, 16197, 16198, 16199, 16200, 16201, 16202, 16203, 16204, 16205, 16206, 16207, 16208, 16209, 16210, 16211, 16212

- **6B861 :** 16158, 16166, 16167, 16168, 16169, 16170, 16171, 16175, 16176, 16177, 16178, 16179, 16180, 16181, 16182

- **90A350** 16261, 16262, 16263, 16264, 16265, 16266, 16267, 16268, 16269, 16271, 16272, 16273, 16274, 16277, 16278, 16279, 16280, 16281, 16282, 16283, 16284, 16285, 16288, 16289

- **90A700** 16185, 16186, 16187, 16192, 16193, 16195, 16196, 16197, 16198, 16199, 16200, 16201, 16202, 16203, 16204, 16205, 16207, 16208, 16209, 16210, 16211, 16212,

16213, 16214, 16215, 16216, 16217, 16218, 16219, 16220, 16221, 16222, 16229, 16231, 16232, 16233, 16234, 16235, 16236, 16237, 16238, 16239, 16240, 16241, 16242, 16243, 16244, 16245, 16246, 16247, 16248, 16292, 16293

- **90B700** 16171, 16175, 16176, 16177, 16178, 16179, 16180, 16181, 16182, 16249, 16250, 16251, 16252, 16255, 16256, 16257, 16258, 16259, 16260

- **90B1050** 16166, 16167, 16168, 16169, 16170

- **45B700** 15988, 15989, 15990, 15991, 16006, 16007, 16008, 16009, 16017, 16018, 16019, 16020, 16021, 16022, 16025, 16026, 16027, 16030, 16031, 16034, 16035, 16036, 16037, 16040, 16041, 16042, 16043, 16048, 16050, 16051, 16052, 16053, 16054, 16055, 16056, 16057, 16058, 16062, 16064, 16065, 16066

- **45B1050** 16067, 16068, 16069, 16071, 16072, 16073, 16074, 16075, 16076, 16077, 16078, 16079, 16080, 16081, 16082, 16083, 16084, 16085, 16086, 16087, 16090, 16091, 16092, 16094, 16097, 16098, 16100, 16101, 16109, 16111, 16112, 16113, 16114, 16115, 16118, 16119, 16124, 16125, 16126, 16127, 16128, 16129, 16130, 16131, 16132, 16133, 16134, 16135, 16138, 16139, 16140, 16141, 16142, 16143, 16144, 16145, 16146, 16147, 16148, 16149, 16150, 16151, 16152, 16158

The runs use in the final analysis can be found in the scripts loading the dst files, these are named **Load_**< Angle >< Polarity >< Field >**.C** e.g. **Load_2A1723.C**.

4   Analysis Method

The DSTs are analyzed using **root** selector classes reading chains of DST. This can be done using **PROOF** or single processor CPUs. The output of these analysis are root files for each setting and particle type (π, K or proton) that contains maps in $y - p_T$ of counts in each bin, counts divided by effeciencies and acceptance for several vertex bins. These root files are then later used for generating spectra as described in detail later. Multiple cuts are applied in in the Selector class, including PID selection. The Selector is different for FS and MRS, but common for different particles type. The files are **mrsSelector.C** and **fsSelector.C** for MRS and FS, respectively. They are derived from a base Selector Class **baseSelector.C** generator within a root session using the chain->MakeSelector(¨ baseSelector¨) method after a chain of the DSTs have been loaded.

Typically the MRS data set can be analyzed for all 6 settings and 3 species with TOFW or TFW2 fiducial detector in about 30 minutes. The FS takes slightly longer but less than 1 hour.

I like to acknowledge that this present implementation of the selector class ans associated utility macros utilizes several ideas from Steve Sanders analysis scripts.

5   Selection and Cuts

The selector code applies a large number of cuts before accepting a track for inclusion in the 2D-map of accepted tracks. These are different for MRS and FS and described below. For some cuts additional information is presented. The cuts are all applied inside the Selector class used to analyse the DSTs.

5.1 MRS

The selector class is **mrsSelector.C**. The cuts and corrections applied for the MRS analysis are as follows. There are really two different kinds of cuts, those applied at the global level and those at the track level.

- **CC vertex.** The presence of a CC vertex is checked. If we have a trigger 5, the normalization vertex distribution is updated. Since PID in MRS uses the time-of-flight a CC vertex is always required.

- **Trigger conditon.** For each track it is required that an exclusive trigger 3 is set. This trigger is build from the RHIC clock, a signal in TRMRS and a signal in TOFW.

- **Magnets.** The **swimStatus** through D5 has to be good (i.e. 1) as well as the fiducial cuts in X and y for D5 has to be > 0.

- **Fiducial volume cuts.** It is required that the TPM1 tracks pass the front of TPMW within $-18.72 < X_{projected} < 18.72$. This is 18.3 cm from the midplane.

- χ^2 **cuts** from the track has to fullfill the standard cuts estimated from the single-track simulations. This is estimated from $\chi^2 < cutFactor * (A + B(Mass^2 + p)/p^4)$. Recall the cuts and conditions was evaluate from the geant simulation of the mid rapidity spectrometer response. The cut factor is 10. This is not an important cut, only a very small number of tracks are removed by this cut ($\leq 2\%$).

- **Vertex cuts** on the distributions of projection of the MRS tracks to the vertex. An elliptic cut on (Ty,Tz) is made where Tz is the difference between the track projection on the beamplane and the CC-vertex. The offsets and variance of the distribution in z and y are estimated run-by-run with the values stored in a text file. (pp06_mrs_vtz_dat.txt and pp06_mrs_vty_data.txt).

- **Vertexrange.** This is taken very wide at the data playback step i.e it is required the tracks points to a CC vertex is within the range $[-30, 30]$ cm. Additional cuts can be made in the spectrum projections.

- **Time-of-flight Cuts**. Two cuts are applied. One to ensure that the geometry of TFW2 matches the trigger TOFW, and another requiring that the pointing of track to the time-of-flight wall is ok. At $90°$ the geometric acceptance of the trigger TOFW slats is smaller than for TFW2. A fiducial cut of TFW2 is applied to ensure there is no trigger bias. At $45°$ there is no such problem since the TFW2 is further back. This is demonstrated in Fig.1. At $90\,\mathrm{deg}$ one can see from the plot below that the TFW2 is not hit at full coverage when the TOFW hits are required. Thus the fiducial cuts are not set by the full TFW2 wall. By selecting 3-37 complete overlap is ensured. Later analysis revealed that the lower channels in most cases are dead, so to get stable result cuts are made requiring $9 \leq Slat \leq 37$ (as of March 15). This will be used in the final analysis.

5.2 FS

The selector class is **fsSelector.C**. The cuts and corrections applied for the FS analysis goes as follows. These are really two different sets of cuts, those applied at the global level and those at the track level.

4
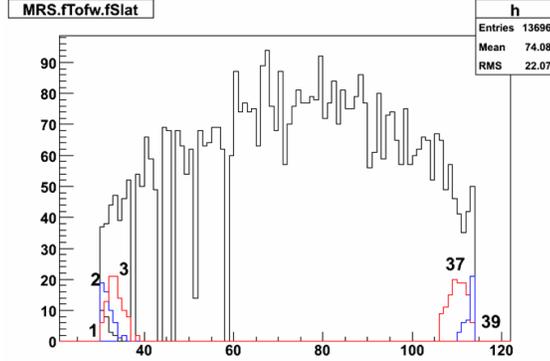
Figure 1: TOFW distribution for trigger 3 events with MRS spectrometer at 90°.Imposed on plot are distribution of hits where additionally specific TFW2 slats are hit.

- **CC vertex.** The presence of a CC vertex is checked. When an exclusive trigger 5 is present , the normalization vertex distribution is updated. In the case of vertexMethod 0 the CC vertex is required for further analysis. For vertexMethod 1 it is assumed that the minimum bias CC trigger is only sensitive to 12 mb out of the 36 mb cross section and the normalization histogram is incremented by a factor of 3 (36/12) per trigger 5. The vertex position used in the acceptance maps are then the track projection vertex. Depending on the vertex methods cuts are made on the trackprojection relative to CC vertex (Y , and Z for method 0). The values for the offsets are determined run by run and stored in ascii text files.

- **Trigger conditon.** For each track it is required that an exclusive trigger 2 is set. This trigger is build from the RHIC clock, a hit in TRFS, a hit in H1 and a hit in H2. A hit in any of these detectors requires that both the top and bottom PMT fires.

- **RICH fiducial cuts.**. It is required the track hits the rich with a projected range of $|y| < 15$ cm and $|x| < 20$ cm. Outside this range the number of hits in the rings falls rapidly and the efficiency becomes bad. Too, the tracks passes through additional material. This cut is applied even whem H2 is used for PID, to be able to use the veto fearures of the RICH.

- **Magnet cuts.** The swimStatus through D1 has to be ok (i.e. 1) and the fiducial cuts in X for D1 has to be > 0. There are no conditions on the **y** fidiciual cuts. The final fiducial vertical cut is done in RICH or T5 for the y-cuts, as per design of spectrometer.

- χ^2 **cuts** from the track has to fullfill the standard cuts estimated from the single-track simulations. This is estimated from $\chi^2 < cutFactor * (A + B/p)$. Recall the cuts and conditions was evaluate from the geant simulation of the forward spectrometer response.

- **Vertex cuts** on the distributions of projection of the MRS tracks to the vertex. In case of vertexMethod 0 an elliptic cut on (Ty,Tz) is made where Tz is the difference between the track projection on the beamplane and the CC-vertex. In case of vertex-Mode the cut is on Ty only. The offsets and variance of the distribution in z and y are estimated run-by-run with the values stored in a text file. (pp06_vtz_dat.txt and

pp06_vty_data.txt). The offsets are generated from the histograms generated by the selector scripts with the condition VertexCut=0 using the **VertexTools.C** script. A given track is associated with the CC vertex in the case of method 0, and with the trackprojection on the beamplane in case of method 1.

- **Vertexrange.** This is taken very wide at the data playback step i.e it is required the tracks,CC vertex is within the range $[-60, 40]$ cm. Additional cuts can be made in the spectrum projections. With the spectrometer trigger at a forward angle the peak of track vertex position is between -30 to -20, whereas the minimum bias distribution peaks close to 0.

6 PID

The particle identification for MRS and FS are described in the following two subsections. As will be evident from the following sections cuts are made in the natural variables, that are close to Gaussian distributed, namely $R - R_{calculated}$ for the RICH and

$$1.0/\beta_{measured} - 1.0/\beta_{calculated}$$

for Time-of-flight detectors (TOFW, TFW2 or H2) and **not** in $Mass^2$ where the widths are momentum dependent. [1] Mathematically the two methods are equivalent, but cutting in the natural parameter gives results less sensitive to small errors in determination of means and widths. In the rest of this document the $\beta_{Calculkated}$ is denoted β_C.

6.1 Mid Rapidity Spectrometer PID
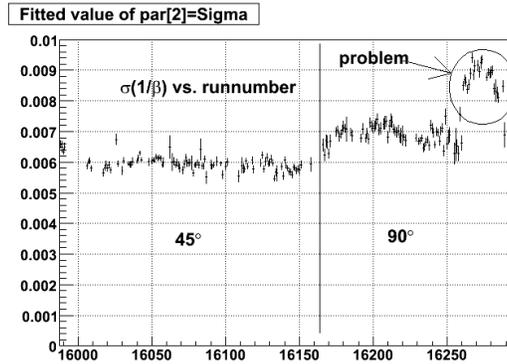
Figure 2: Width of $1/\beta - 1/\beta_{calculated}$ in TFW2 vs. runnumber. The width is estimated from a Gaussian fit to the difference. The two groups corresponds to 40° and 90° settings, respectively.

In MRS the particle identification is done using the time-of-flight with the CC time as start and the TFW2 (or TOFW) time as the stop. The TOFW time-of-flight was used for checking result from TFW2. Due to the longer flight path the result from TFW2 are in general better. The average resolution in β for TFW2 vs. run number is displayed in

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[1]In the first version of the note I used $\beta - \beta_C$. The current is formally better since it is proportional to t not 1/t. But the widths are still momentum and mass dependent, albeit only very little at large momenta

Fig. 2 with average values of 0.0055 at 45° and 0.007 at 90°. The larger width for the last set of runs comes form the 90A350 setting. The $1/\beta$ resolution does in fact go up as the momentum decreases. This is demonstrated in Fig.3 which shows the resolution of pions vs. p/q for this field setting. This is a consequence of making the cut in $1.0/\beta$. The cut is made in $1/\beta - 1/\beta_C$. The width of this distribution should be evaluted as
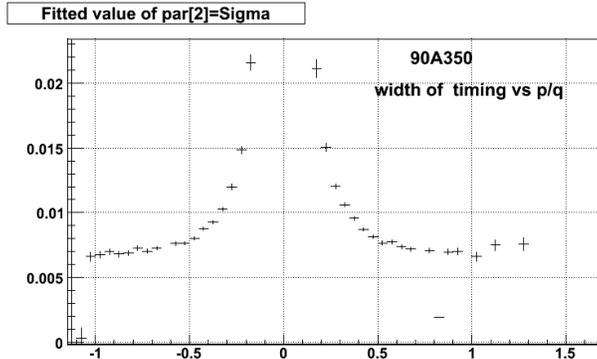
Figure 3: Width of $1/\beta - 1/\beta_C$ vs. p/q for the 90°A350 setting. The with is found by Gaussian fitting of slices of the 2D histograms (like in the next figure).

$\sigma^2(1/\beta) + \sigma^2(1/\beta_C)$. The first term is simply $\sigma(t)c/L$ squared while the second term is $\sigma(E/p) = (\beta - 1.0/\beta_C)\delta p/p$. These terms are similar to those showing up for the momentum resolution in the spectrometer and has contributions from multiple scattering (MS) and tracking resolution (tr). For the PID widths only the timing and MS term are important. The final result is that

$$\sigma(1/\beta)^2 = \sigma(t)^2(c/L)^2 + (\beta - 1.0/\beta_C)^2(\sigma_{MS}^2/\beta^2 + \sigma_{Tr}^2 p^2)$$

.

Using parameters similar to those from the PRC paper[2] quite good agreement with measured widths like those in Fig.3 are obtained. This functional form has been coded into the script for running the MRS PID analysis. At large momenta the main contributing factor is the timing resolution.

Even after the basic TOF calibration applied to the gtr output small residual timing shifts are observed. In general these are overall shifts, not slat to slat corrections. Therefore we calculated for each run $1/\beta - 1/\beta_{calc}$ assuming the pion mass, and fitted the resulting spectum with a Gaussion using the **FitSlicesY** method in **TH2F** class. The resulting means and siwere thus pre calculated. gma are stored in text files for lookup by the analysis session selector classes. The measured $1/\beta$ is corrected by this run dependent offset. A typical PID spectrum for 45° is shown in Fig. 4 demonstrating the overall good PID in the MRS. It is important to note that in order to make the PID a CC vertex is required. This has important consequences for the normalization.

The PID selection for a given particle kind (pion, kaon, or proton) is done by making a 3σ cut in $1/\beta - 1/\beta_C$ where the σ is calculated as described above.

A demonstration of the PID method is shown in Fig. 5. The seperation in TOFW and TFW2 is slightly different. Kaons are well seperated from pions up to 1.8 GeV/c, while protons are seperated from kaons up to 3 GeV/c. The pion spectra can be extended to

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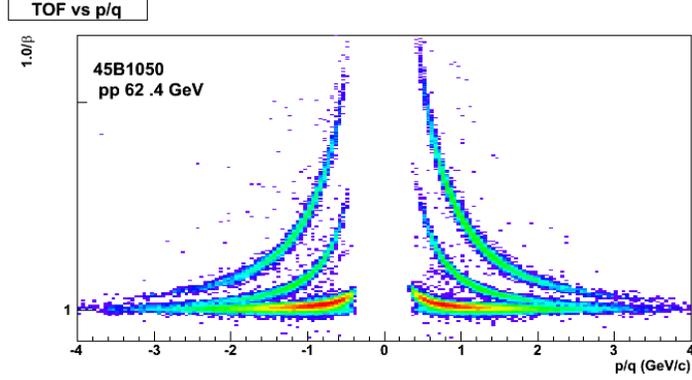
Figure 4: β vs. p/q for the 45 B1050 setting.
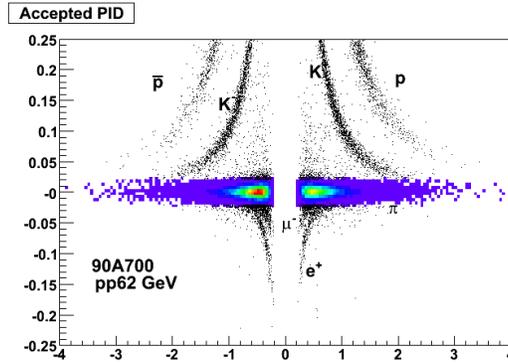
Figure 5: $1/\beta - 1/\beta_C$ vs. p/q assuming the pion mass for the track. The colored area shows the accepted pions (3σ cut), and the black regions the rejected particles. The bands of electrons and muons are visible at low momenta.

somewhat higher momenta since the K/π ratio is below 1 ($\approx 0.2 - 0.35$). An analysis which made slices in the $1/\beta - 1/\beta_C$ distributions was used to extract the ratio of K/π vs. momentum at 90° and 45°. At the same time an estimate of the contamination from kaons in the 3σ cut made for the pions can be evaluate. Below 2 GeV/c it is negligible, but grows to 30% for π^+ at 2.6 GeV/c and to 25% for π^- at 3 GeV/c. Two figures are shown with typical quality of extraction of these numbers at 90° and 45 ° in Fig.6).

The purity of the pion sample vs. momentum is given in the following table.

| P | 90 Deg | 90 deg | 45 Deg | 45 deg |
GeV/c	π^+	π^-	π^+	π^-
2.0	0.94	0.98	0.97	0.97
2.2	0.87	0.86	0.90	0.93
2.4	0.79	-	0.83	0.87
2.6	-	-	0.76	0.84
2.8	-	-	0.70	0.82
3.0	-	-	0.66	0.77

8
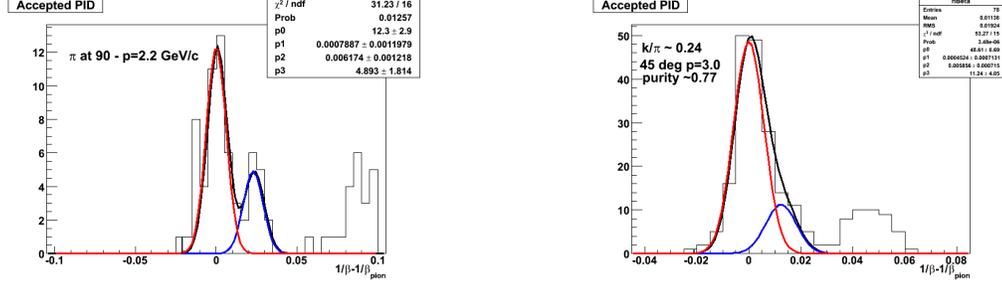
Figure 6: Left hand side: A slice in $1/\beta - 1/\beta_C$ around p=2.2 GeV/c at 90°. Right hand: A slice in $1/\beta - 1/\beta_C$ around p=3.0 GeV/c at 45°. The curves show the fit to the pion and kaon yields.

6.2 Forward Spectrometer PID

In the forward spectrometer the primary PID method comes from utilizing the RICH. For pions it is used exclusively. In the case of protons the low momentum range can be extended using H2. As we know from several other analysis the RICH analysis is quite clean and easy, and can be applied without using the requirement of having a CC vertex. This later observation gives us capabilities to reduce systematic biases. In case of using H2, this does require a CC vertex, and thus have to correct for the bias from the CC trigger, albeit this is reduced in the low momentum range.

The criteria for accepting a particle where the ring radius (FS.fRich.fRadius) is considered are:

- Momentum must be sufficient above the threshold i.e.

$$p > 1.1 * mass * \gamma_{Threshold}$$

. This ensure we only deal with radia ≥ 4 cm and with reasonable efficiency ($\geq 60\%$) for observing a ring. The efficiencies has bee parameterized but close to threshold the corrections becomes large. For protons in the run-6 this is at 18 GeV/c, kaons at 9.5 GeV/c, and pions at 2.6 GeV/c

- The radius of the rings in the RICH (R) must fulfill $|R - R_{Calculated}| < 3\sigma_R$. Here σ is momentum, or rather radius dependent. I have used the equation

$$\sigma_R = 0.14 R_{max}/R_{Calc}.$$

- For pions it is required that the $R > R^K_{calculated} + 2\sigma_R$. I do not consider pions above the momentum where the kaons and pions cut curves cross. For the 62 GeV data this is a very small fraction of the data. For kaons it is required that $R < R^\pi_{calculated} - 3\sigma_R$, due to the higher pion yield.

- For protons in the veto range i.e. $10 < p < 18$ GeV/c all tracks with a ring radius 0 or less than 3 cm are considered as protons candidates. The veto maps are incremented for momenta in this same range when the radius is greater than 3 cm. Recall the vetomaps are also done per y-p_T and vertex bin.

To obtain the final spectra for protons and $\bar{p}$ one has to subtract the contribution from the pions that do not have a ring associated (in efficiency). This is in general determined

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to be ≈ 3%. For the protons which dominate at high rapidity over pions and kaons this is a negligible corrections. On the other hand for p̄ it is significant. This is illustrated in Fig.7 The resulting uncertanty is significant both on overall yield but also the spectrum shape.
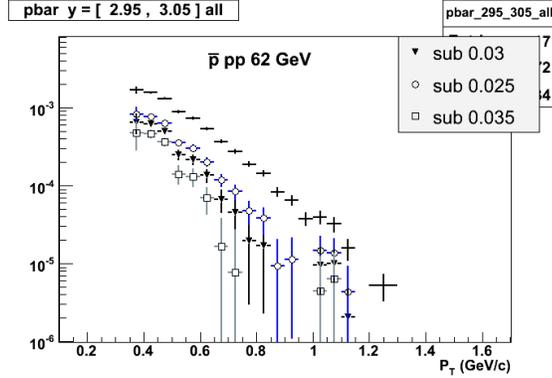
Figure 7: Generation of p̄- spectrum at y=2.95 using the subtraction of contamination pi and K. the Top curve are the p̄ candidates. The 3 other spectra represents subtracting by 2.5%, 3%, and 3.5%.
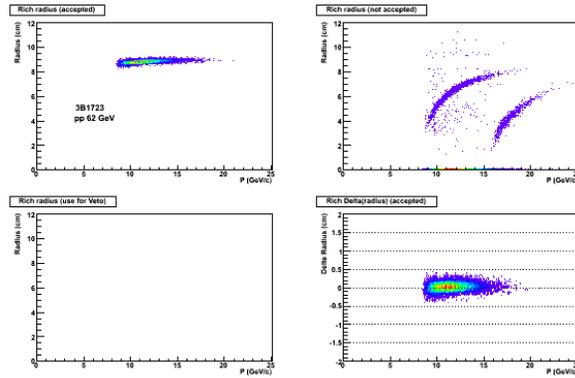
Figure 8: Miscelaneous summary plots for RICH PID. The panels show the accepted tracks, the tracks not accepted, the veto tracks (only relevant for analysis of protons), and the RICH $R_{measured} - R_{calculated}$ vs. momentum.

It is not sufficient to use the RICH for proton PID for all settings. This can be seen be considering the yield-acceptance map for identified protons in the FS. Figure.9 shows the acceptance range where the RICH can be used. Substantial yields are not included at $y \approx 2.5$ i.e. the 4°608 and 6°861 settings. To get the protons at the lower p_T at 4° and 6° it is necessary to use time-of-flight information from H2. The protons (p̄s) can then be extracted up to about momenta of $\approx 10 GeV/c$. The PID is not completely clean, but is improved much by requiring that the tracks do not produce a ring in the RICH. Only Kaon and protons are expected to fullfill this condition. Since there is leakage of $\approx 3\%$ from track that produce a ring (pions) into the sample of tracks of having no ring, a fraction has to be subtracted just like in region for protons for $p > 10$ GeV/c. To ensure good efficiency of

10
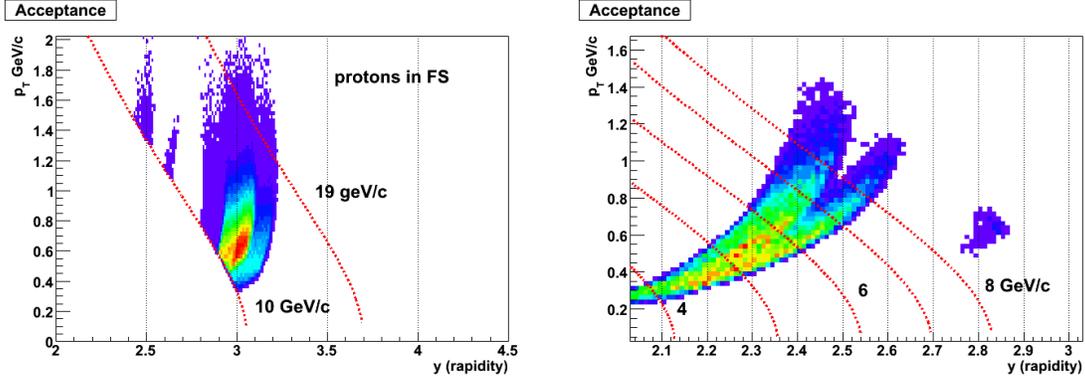
Figure 9: Acceptance plots for protons. At the left hand plot is shown using RICH. For $p > 19$ GeV/c the ring radius is > 4 cm, while the veto mode are used between 10 and 19 GeV/c. The right hand plot shows acceptance for proton candidates when using H2. lines for constant momenta are superimoosed.

this cut it is required that the tracks points to slat $5 - 30$. This range was found based on analysis (see Fig.10) that shows the population of H2 slats with and without the fidicual rich condition cut.
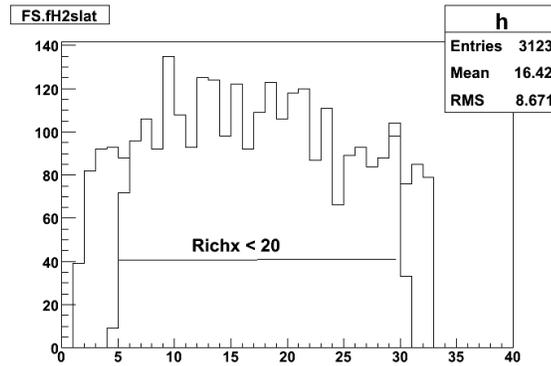
Figure 10: H2 slat distributions.

The data for the 4B608 setting that fullfills this condition are shown in Fig.11. The particle contributing are protons and kaons, albeit a small contamination from pions can be seen. The distribution of track which have a non-zero ring radius is shown in 12 It can clearly be seen that applying the RICH cut improves the PID quality, but at the cost of loss of statistics due to the slat cut in H2. The PID is done as for MRS using a cut in $1/\beta - 1/\beta_C$. The purity in the range of overlapping band is done using the same method as for MRS. The results are summarized in the table below. Due to the much lower yield of $\bar{p}$ even relative to K^- it can only be extracted well up to 7.0 GeV/c. The systematic uncertainty on the purity grows from 0 to about 10% at the highest p in each of the cases. This was estimated from looking at the variation in purity vs. assigned width of the distributions. The purity of the p and $\bar{p}$ sample vs. momentum is given in the following table.

11
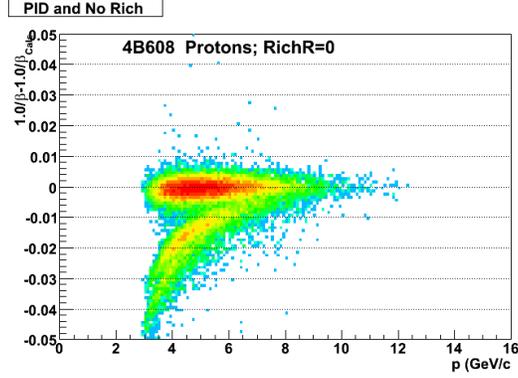
Figure 11: $1/\beta - 1/\beta_C$ vs. momentum for protons. The weak band below the protons are K^+ and a small fraction of leakage π^+(no RICH ring).
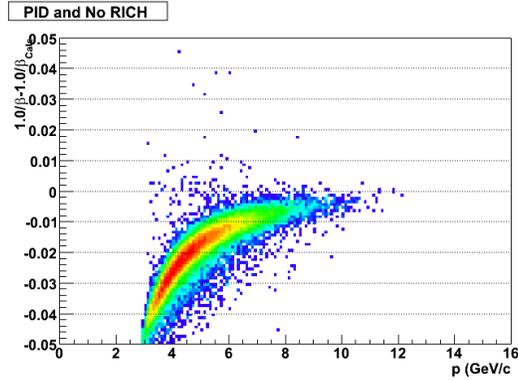
Figure 12: $1/\beta - 1/\beta_{Calculated}$ vs. momentum for protons when a RICH ring is required. These are exclusively π^+.

| P | 4 Deg | 6 deg | 4 Deg | 6 deg |
GeV/c	p	$\bar{p}$	p	$\bar{p}$
4.0	1.00	1.00	1.00	1.00
5.0	1.00	0.99	0.99	0.97
5.5	0.98	0.96	0.89	0.88
6.0	0.94	0.92	0.74	0.73
6.5	0.90	0.88	0.61	0.84
7.0	0.87	0.83	0.50	0.55
7.5	0.84	0.81	-	-
8.0	0.82	0.80	-	-

The corrections from the purity is applied at the stage of the final analysis not at the level of playback into the 2D histograms.
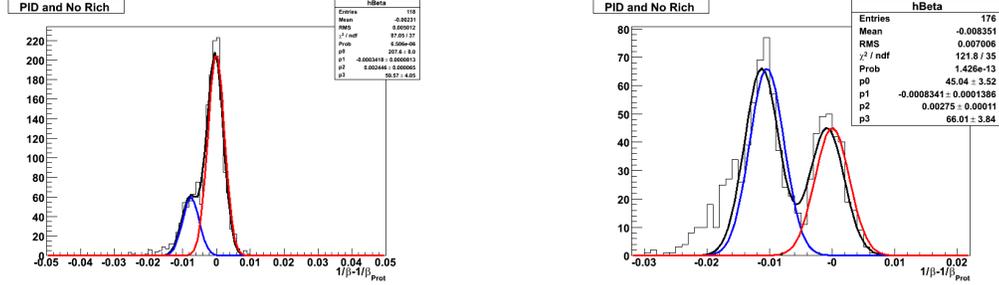
Figure 13: Left hand side: A slice in$1/\beta - 1/\beta_C$around p=6.5 GeV/c at 6° for the positive settings. The seperation between p and K^+ is demonstrated. Right hand side: A slice in$1/\beta - 1/\beta_C$around p=5.5 GeV/c at 4° for the negative settings. The seperation between $\bar{p}$ and K^- is demonstrated. The purity of p and $\bar{p}$ are estimated from such fits.

7 Efficiencies and Corrrection

A number of corrections are made on a track by track basis. These are the typical one used, namely tracking effeciencies, geant corrections i.e. decay, multiple scattering and decay corrections, particle identification efficiencies, and trigger efficiencies.

For the MRS efficiencies for track by track are

- The tracking efficiencies are taken from the recent efficiency study made by my-self and discussed at the analysis meetings The values are taken from a root file MrsEfficiency.root. This was generated with the programs and scripts available in /brahms_app/kh_app/pp/200 and described in analysis meetings. Typical values are around 95% with a drop at the edges. The numbers extracted using this reference track method is probably an lower limit estimate of the tracking efficiency due to the issue of defining good reference tracks with only two tracking detectors. This is particular the case for TPM2. Thus I believe that the systematic uncertainty on the efficiencies values used are $-2\% - +6\%$.

- Geant corrections i.e. decay, interaction and multiple scattering are take from the official repository /brahms/data08/corrections/geantSim with the default values. The corrections have been evaluated down to 0.2 GeV/c for pions and kaons.

For the FS efficiencies for track by track are

- The tracking efficiencies are taken from the recent efficiency file made by Pawel and Nathalia with the suffix **nvk2**, found in the default correction directory /brahms/data08/corrections/tra The corrections are taken from the XA settings.

- Geant corrections i.e. decay, interaction and multiple scattering are take from the official repository /brahms/data08/corrections/geantSim with the default values. The corrections have been evaluated down to 1 GeV/c.

8 Histogram generated by DST analysis

The histograms being filled in the DST analysis after a track has been accepted, or at the final stage are

- Acceptance Maps. These maps are not directly used in the analysis excpet for picking up the vertex range, vertex bin size, and the bin sizes in p_T, rapidity. The have been generated by the standard accpectancemap package in banapp with an accuracy of 2%. There is one map per vertex setting for the particle kind in question.

- Count Maps. There is one map per vertex bin with the same binning as accptancemaps. The bins are updated by 1 (one) per accepted track.

- Efficiency Counted Maps. There is one map per vertex bin with the same binning as acceptancemaps. The bins are updated by 1/effeciency per accepted track where the effeciency is the product of the tracking efficiency and the PID efficiency. In case of FS where in some cases the presence of rich rings are used as veto (e.g. protons in $10 < p < 18$ GeV/c) an efficiency counted map is also filled.

- Normalization histogram. This contains the properly scaled minimum bias counts for the vertex bins.

In addition several diagnostics histograms are generated.

9   Trigger Biases and Corrections

Even though TOFW is not used directly in the analysis I looked at the efficiency for have a tofw hit when one has a full reference track (identified by have a pointed tfw2 slats and a found tofw slat. This efficiency is very good   2%, and part of the remaining has to do with multiple scattering out of slat+-1. This particular effect of slat range is Included in the Geant corrections. For the full PID efficiency one further have to consider the sigma cut applied in the PID ($2\ \sigma = 5\%$, $3\sigma = 1\%$). I suspect that the PID efficiency for TFW2 is similar, but cannot evaluate this from data.

The corrections for the CC minimum bias is disccused in greater detail in the note on CC response [1].

10   Data Yields

This section is essential a set of summary plots showing the yields in y-$p_\mathrm{T}$that are present in the datasets. These figures have been used to evaualte what spectra can be reasonably be produced in terms of particle kind and rapidity bins.

tracks, the tracks not accepted, the veto tracks (only relevant for proton analysis), and the $R_{measured} - R_{calculated}$ all vs. momentum.

11   Spectrum Generation

The generation of spectra is done using the **SpecProject.C** script. It is completely self-contained and requires only the histogram files generated in the DST step. It is run by root. The spectra can be projected from a single setting summing in the style of SpectraObject over vertexbins, rapidity and pt bins creating appropriate sums of counts, counts divided by efficiencies and acceptances. The summing is not carried out over different settings, but settings are combined by standard averaging within root. Since p_T-bins with a low number of counts are usually rejected before then, the averaging in this last step should work well.
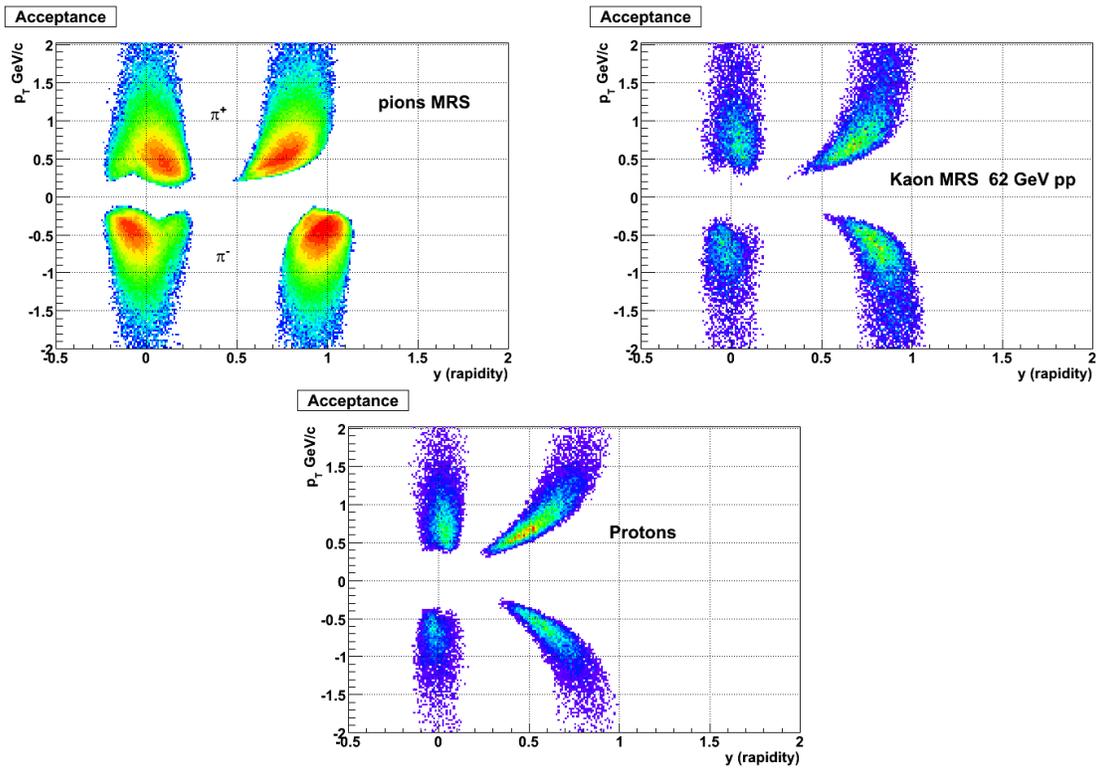
Figure 14: Acceptances and yields for 62 GeV pp with MRS. All data are included.
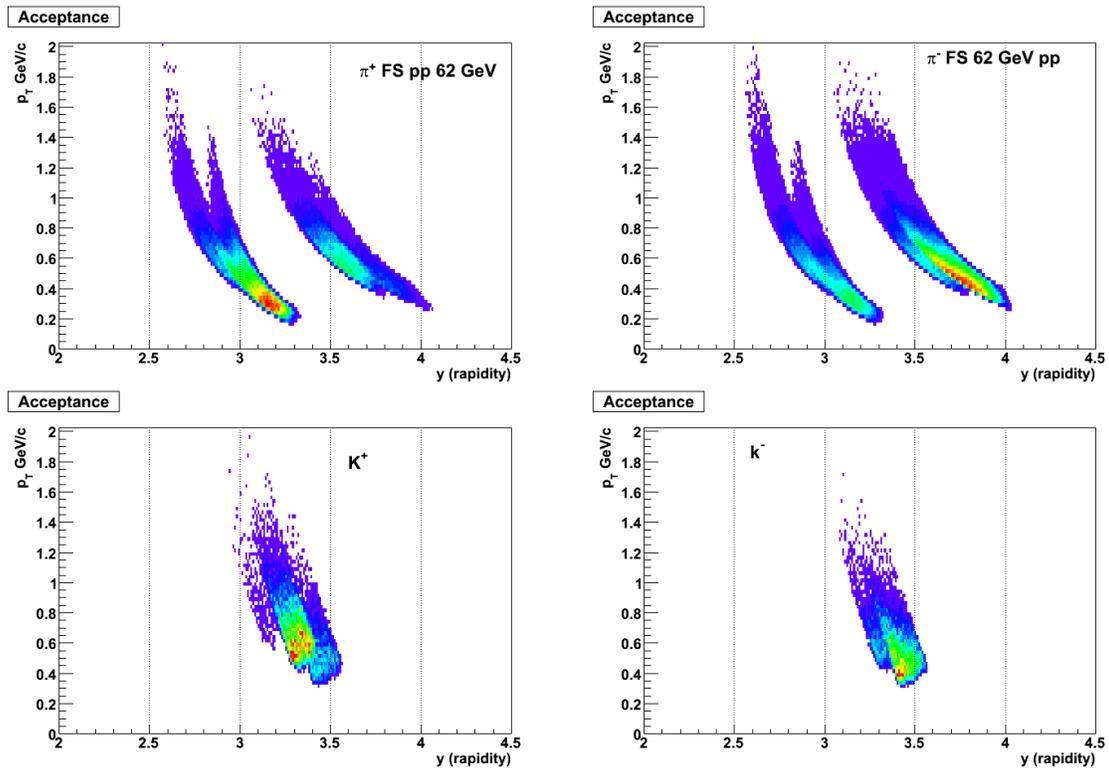
Figure 15: Acceptances and yields for 62 GeV pp with FS. Pions two top panels, Kaons the next two.

Special care was taken to make sure that the corners or edges of acceptance maps were not considered.

The general rules applied were:

- Overall value. If the value of the acceptance in a bin (y-p_T) was less than a factor of the average acceptances for a given eta or rapidity bin it was rejected. The factor is **binLimit** with a default of 0.6;

- it is required that the acceptance in a given neigbourhood bin (ie. 9 other bins) is larger than the given acceptance times **neighbourLimit** (0.7). This particular cut has some problem in the case of many dead slats. This is subject of evaluation what is the best method (March 15).

Examples of generated spectra generation are shown. In Fig.16 are shown data for π^+ at 90° from the 3 different settings contributing. This summing used the TFW2 cuts of $9 \leq slat \leq 37$ both in analyis and in acceptance map. Another average for π^+ is displayed
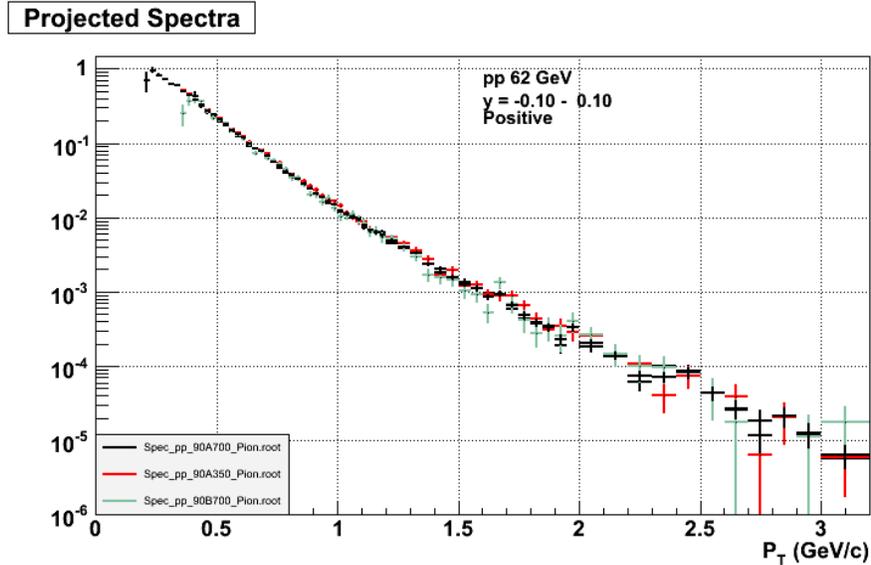
Figure 16: The spectra of π^+ at y=-0.10 to 0.10 from 90° data.

in Fig.20 where it is compared to ISR data (Alper et al.)

12 Quality control

12.1 Run dependences

Part of the quality control consisted in monitoring several key variables like the vertex differences in z and y, the calculated vs. measured radius, β for pions in MRS. Since run dependent corrections were made these should all be centered around 0, and they are. The summary plots are all present in the final spectrum files, and are not show here. An example is given in the appendix. Files can be found in /public_thml/analysis/summary.

12.2 TOFW vs. TFW2 comparison

For the MRS data PID can be done with either TOFW or with TFW2. As argued earlier the TFW2 was used for the final analysis due to the better time resolution.As a check on procedure for the analysis I compared spectra generated from tofw with those from tfw2. This essentailly checks the consistency in analysis method, in acceptance maps, and of the corrections due to decay, absorption. The track data will have a large overlap, but will not be identical since the statistics in TFW2 is smaller than TOFW. In Fig.17 are shown the spectra of π^+ at y=0.8 at 45° using TOFW (black) and TFW2 (red).
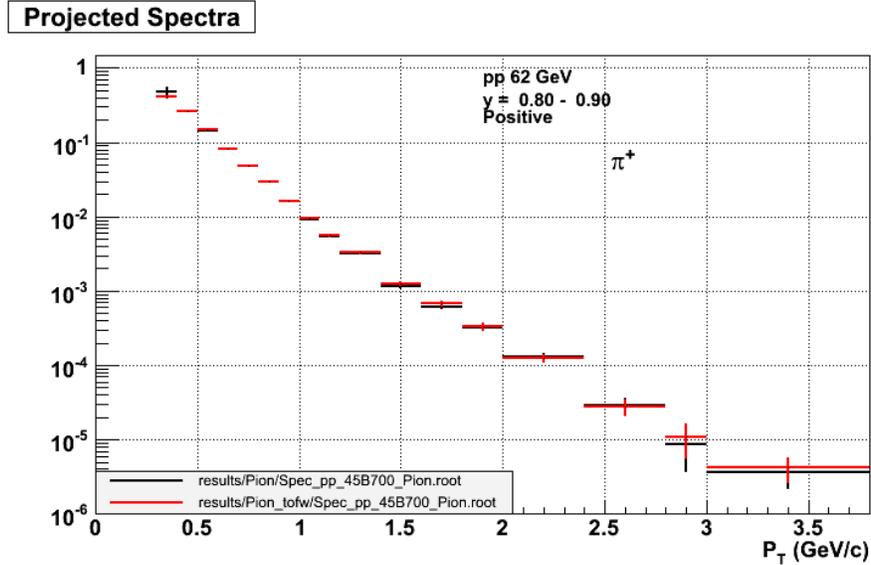
Figure 17: The spectra of π^+ at y=0.8 at 45° using TOFW and TFW2.

Figure 18 shows the ratio of each spectrum to the average (not the ratio). The agreement is satisfactory, better than a few % in most of the range with good statistics. Note the errors shown are not correct, but are roughly $\sqrt{2}$ too large due the correlated data (average vs. individual in the division of histigram).

12.3 Acceptance Effects

The effect of changing the binwidth of the acceptance vertex bins were also studied. A set of fine maps with 2.5 cm binwidth were generated. Comparison of spectra generated with these maps and the standard maps were done. The main conclusion is that it make little difference. In most of the cases studied the effect were $\leq 1\%$, but deviations up to 4% was found in a single case. A typical example is show below for π^+ at y=0 using PID from TOF.
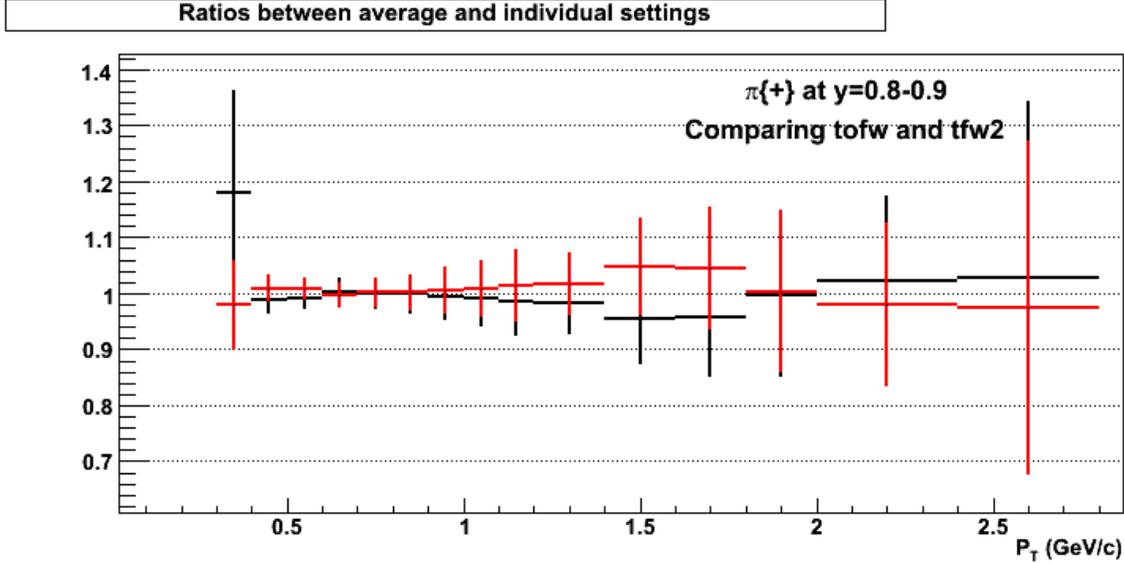
Figure 18: The ratio of spectra relative to the average of π^+ at y=0.8 at 45° using TOFW and TFW2.

13   Open Issues

14   Comparison to ISR data

Several experiment explored hadron production at ISR. The present data at y=0 are compared to those for π^+ production in Fig.20. A systematic difference is seen at the lower p_T. There is a difference how the data are normalized. The ISR data are normalized to the total luminosity determined by Vernier scans, and has no requirements of a vertex (i.e. NSD like events) , as we do have for the mid-rapidity data. Our correction is though quite solid in term of p_T-dependence, being fairly flat between 0.4 and 2.0 GeV/c. The yield at low p_T is sensitive to how the corrections are applied i.e. are muons and electrons excluded, are momentum dependent cuts applied are not. I know what we did in this analysis, but it is difficult to extarct from the publications.

15   Appendices

15.1   Macros

A large number of macros and programs are used to make the analysis fairly easy and reproducible.

- **DstUtil.C** The master macro. It should be loaded in a **bratroot** session first, followed by a call to the **InitSetup()**. The InitSetup load multiple files includes the 3 files next described in this list.

- **Files_pp.C** This macro contains one function per setting. Executing this function from your bratroot session will setup the runlist for the setting, and will find the
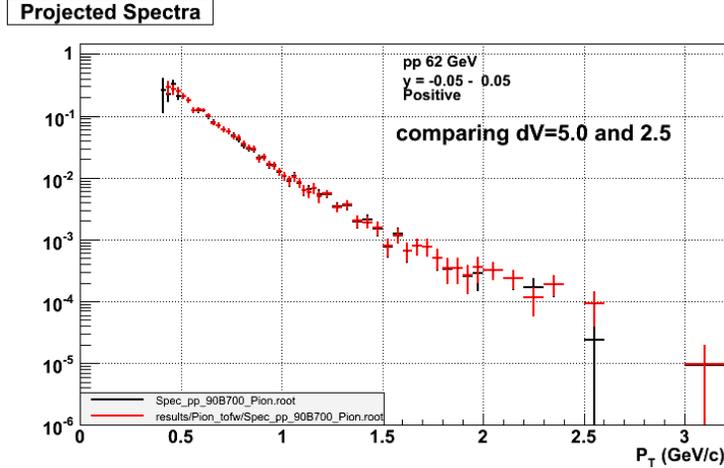
Figure 19: Comparison of π^+ spectra with two different vertex binning factors.

location using the filecatalog, and append the physiccal file to a TTree chain.

- **LoadFilesBase_pp.C** A general macro file used used by the load settings macros in Files_pp.C.

- **Setup_Settings.C** Macro file with function for setting parameters for the dst-analysis, and loading specific sets of dst files.

- **RichSummary.C** One macro to create the RICH ring summary, tof as demonstrated in 8.

- **TofSummary.C** One macro to create the TFW2 $1/\beta - 1/\beta_C$ summary as demonstrated in 21.

- **runAllMrs.C** Macro to replay all the MRS data. Load the macro and execute. With PROOF this takes about 1/2 hour. It has a flag to run for either TFW2 or TOFW.

- **RunSummary.C** Produces a single plot with all the rundependent parameters with offsets read from a text file, and the number of track with and without PID per run. The integration is performed over 500 trigger (3 or 2), a litttle tricky since this is also done using parallel processing with proof.

15.2   Run 6 triggers

The triggers in RUN-6 were not changed over run-5. The following table summarizes the trigger numbering for completeness.
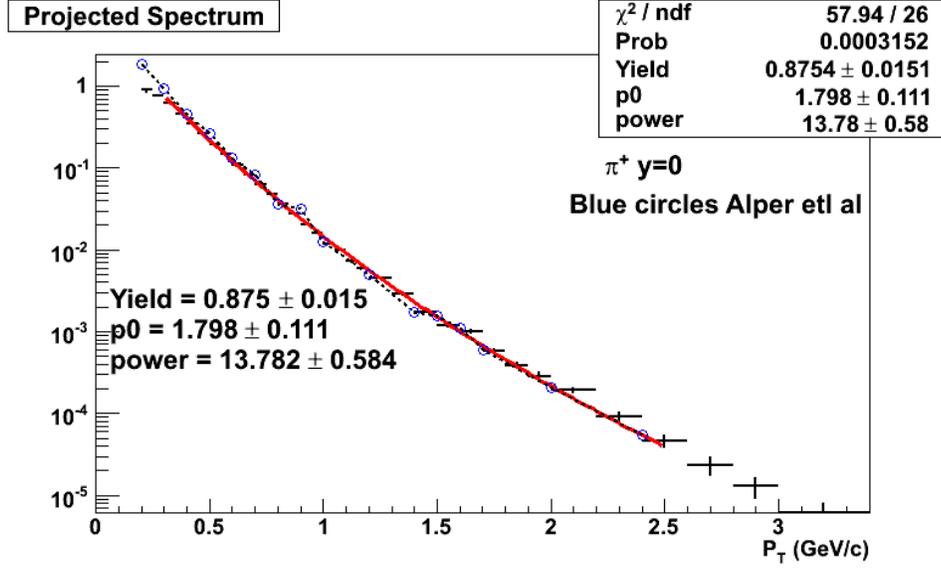
Figure 20: Comparison of π^+ spectra at y=0 with the data Alper et.al.

Trigger	Run-6 pp 62.4 GeV
1	BB($n >= 1$)
2	FS (TRFS.H1.H2.RC)
3	MRS (TRMRS.TOFW.RC
4	ZDC
5	CC
6	FFS (TRFS.H1.RC)
7	Pulser
8	sync

References

[1] D.Beavis and F.Videbaek.*Corrections to pp cross sections due to trigger counter acceptance* Brahms Analysis Note.XX.

[2] I.Arsene et al. PHYSICAL REVIEW C 72, 014908 (2005)
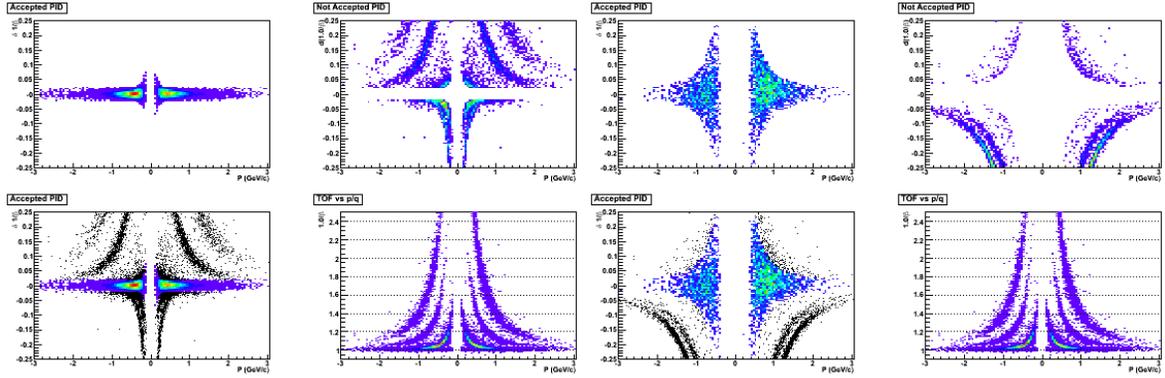
Figure 21: Misc summary plots for TFW2 PID. The panels show the accepted tracks, the tracks not accepted, and the $1/\beta - 1/\beta_C$, all vs. p/q (momentum). This is for the 90A350 setting.
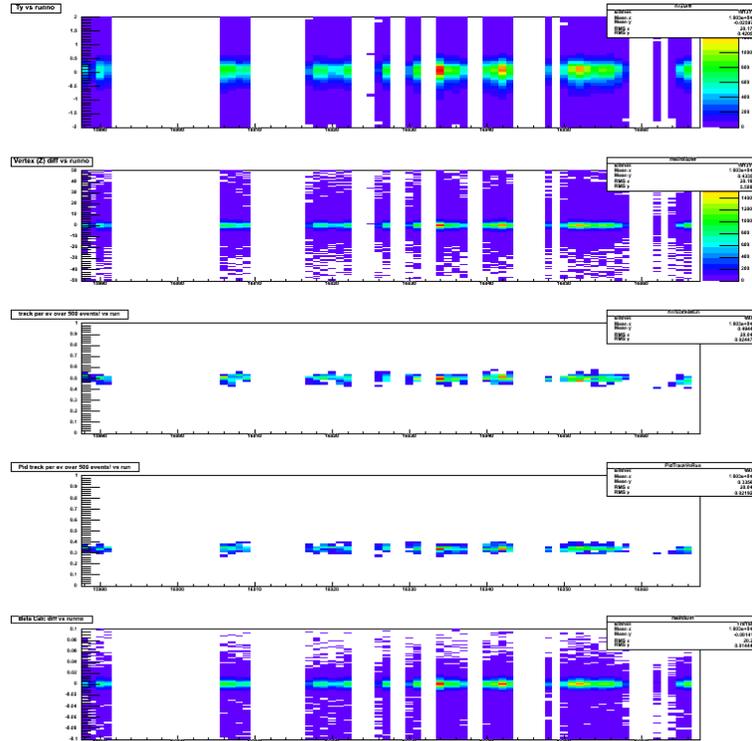
Figure 22:
Summary plots vs. runnumber for 45 deg. B700 field setting