Chapter 3

Data reduction

In this chapter I briefly describe the method used to process the data in order to reconstruct the dimuon events and compute the related physical quantities. The 1992 S-U and 1996 Pb-Pb data have been organised in subsamples corresponding to different bins of transverse energy E_T, which are also listed at the end of the chapter.

3.1 Run selection

Raw Data Tapes are first analysed with a dedicated program[1] which reconstructs the dimuon tracks and gives all useful informations on the related kinematic quantities. When important intensity oscillations or hard-ware problems or related anomalies have been detected, the corresponding runs, defined as a single slot of raw data, are rejected. For instance, during pA data taking periods the ratio of the number of collected J/ψ over the number of incident particles is constantly checked in every run. This ratio is strictly related to the J/ψ production cross-section and gives an immediate picture of its evolution during data taking periods. In fig.3.1 the J/ψ over argonium ratio is shown for the pAl data taking period. Argonium detectors are only used during proton-nucleus data taking in order to measure the beam intensity. The number of argonium counts is directly related to the number of incident particles via a known calibration constant ($C_{argo} = 6750$). At low intensity ($\approx 2{\cdot}10^8$ proton/burst) the measured J/ψ over argonium ratio is larger because the MWPC track reconstruction efficiency is 100%, whilst at higher intensity the MWPC reconstruction efficiency is reduced by the large number of tracks which have to be processed in order to reconstruct a single dimuon event. This systematic effect can be corrected off-line, using the low intensity runs as a normalisation in the calculation of the absolute cross-sections.

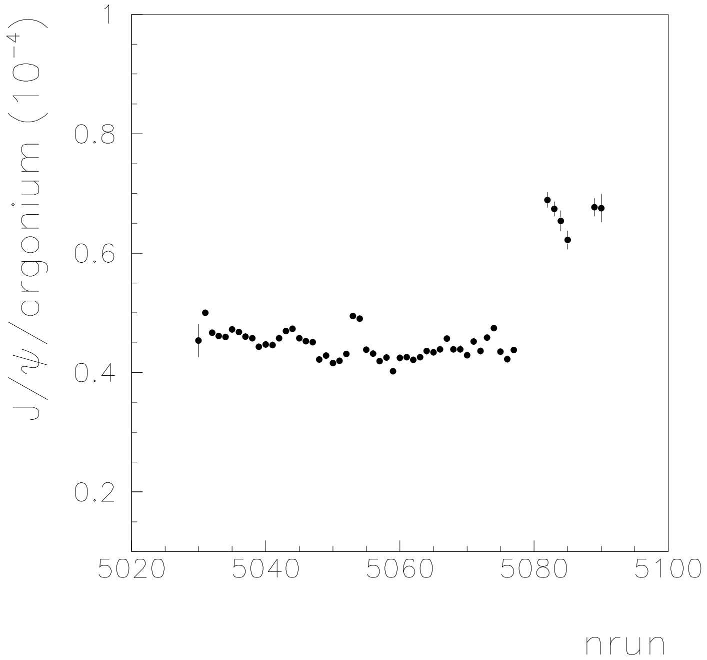

Figure 3.1: *Ratio* $\frac{J/\psi}{argonium}$ *vs. the run number for the pAl data taking period. The MWPC reconstruction efficiency was 100% during the low intensity beams, where a larger* $\frac{J/\psi}{argonium}$ *has been measured.*

3.2 Dimuon track reconstruction

A dimuon event is found when at least two tracks have been reconstructed from the hits in the MWPC's. The dimuon event is accepted if it has been signalled by the trigger hodoscopes and if the reconstructed tracks do not cross the magnet iron support.

During nucleus-nucleus data taking periods, the target detector system ensures a very precise vertex determination. On the other hand, during proton-nucleus data taking periods the single thick target does not allow for vertex recognition; thus, the vertex is always assigned at the centre of the target itself. This does not affect the quality of the invariant mass computation since the length of the targets used in p-A periods never exceeds some centimetres.

An additional cut is then applied on the final set of events in order to ensure that the acceptance of the spectrometer is independent of the electric charge of the detected muons. This additional selection is obtained cutting all events where one of the muon would have been rejected if it had the opposite charge when entering the magnet. For the same reason the magnetic field sign is regularly changed during data taking periods. Another selection can also be applied at the vertex level. The distance DTARG between the vertex, which coordinates are (x,y,z)$\equiv$(0,0,z_V) and the muon track at (x_T,y_T,$z_T = z_V$) is computed; x_T and y_T are the generic x and y coordinates of the track starting point. Since multiple scattering depends on the particle momentum, a direct cut on DTARG would differently affect tracks with different momenta. Therefore, the variable PxDTARG is obtained multiplying the muon track DTARG by the corresponding muon momentum P, and the χ^2 distribution of the PxDTARG variable is constructed for each considered set of events. The cut is then applied on the χ^2 distribution obtained for the specific set of events. When a x% cut on PxDTARG is applied, events with a χ^2 probability ¿x% are accepted. The PxDTARG selection ensures the elimination of dimuons generated outside the target region which would be reconstructed at a much higher or lower mass than their actual one. For the same reason it also ensures a partial cleaning of the background from pion and kaon decays. The effect of a 1% PxDTARG cut on the pAl set of data is shown in fig.3.2.

3.3 Event selection

An additional selection is applied on nucleus-nucleus events in order to ensure a good evaluation of the centrality of the events. The centrality selection uses the information given by the centrality detectors, the target vertex recognition system and the Beam Hodoscope, as briefly explained hereafter. One and only one interaction in one of the 7 sub-targets must have been signalled by the vertex recognition system, otherwise the event is eliminated because corresponding to the interaction of more than one ion or to the re-interaction of a projectile fragment. A stricter selection can be applied requesting that one and only one incoming Pb ion has been

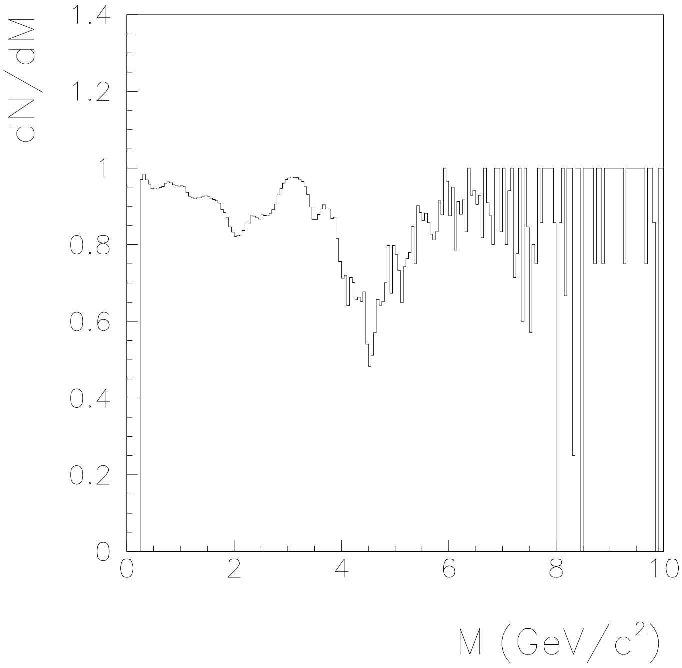

Figure 3.2: *Ratio of dimuon mass spectra with and without 1% PXDTARG cut for the pAl data set.*

detected by the BH and by the ZDC within the 20 ns trigger gate. Although the beam cut based on the BH ensures the selection of pile-up free events, it also induces the loss of a large fraction of events ($\approx$ 28% of the total number of events in the 1996 PbPb data taking period). Notice that, when inefficiency are neglected, the selections based on the ZDC and on the BH are by definition redundant. All events presenting interaction in the BH, in the BHI or in the anti-halo counters are also eliminated.

3.4 Kinematic cuts

In order to compute the dimuon kinematic variables, the two muon tracks are assigned to the centre of the identified sub-target. The invariant mass M, the rapidity y, the transverse momentum p_T and the polar and azimuthal angles θ_{CS} and ϕ_{CS} in the Collin-Soper reference frame are then calculated. The Collin-Soper reference frame is defined in the following way : if $\vec{P_1}$ and $\vec{P_2}$ are the projectile and target momenta in the dimuon centre of mass, the CS $\hat{z}$ axis is defined as the bisector of $\vec{P_1}$ and -$\vec{P_2}$ and the CS $\hat{y}$ axis is parallel to $\vec{P_1} \times \vec{P_2}$.
In order to eliminate dimuons coming from kinematic regions where the acceptance of the apparatus is very low, kinematic cuts are applied on the dimuon rapidity y and $cos\theta_{CS}$. Tab.3.1 lists the kinematic domain D within which events are accepted

System	$P_{projectile}$ $(AGeV/c)$	$\sqrt{s}$ (GeV)	y_{cms}	y^* $[min : max]$	$cos\theta_{CS}$ $[min : max]$
pA	450	29.05	3.43	[-0.52:0.48]	[-0.5:0.5]
PbPb	158	17.22	2.91	[0.:1.]	[-0.5:0.5]
SU	200	19.37	3.03	[0.:1.]	[-0.5:0.5]

Table 3.1: *Kinematic cuts imposed on the dimuon kinematic variables.*

for all the studied systems. The rapidity in the centre of mass reference frame can be obtained from the rapidity in the laboratory system, and vice-versa, with the following equation,

$$y_{lab} = y^* + y_{cms} \tag{3.1}$$

where y^* is the rapidity in the centre of mass reference system and y_{cms} is the rapidity of the centre of mass system in the laboratory frame.
Fig.3.3 and 3.4shows the mass, rapidity, p_T and $cos\theta_{CS}$ differential distributions of the accepted events for the pAl and PbPb systems. For the SU system see[2].

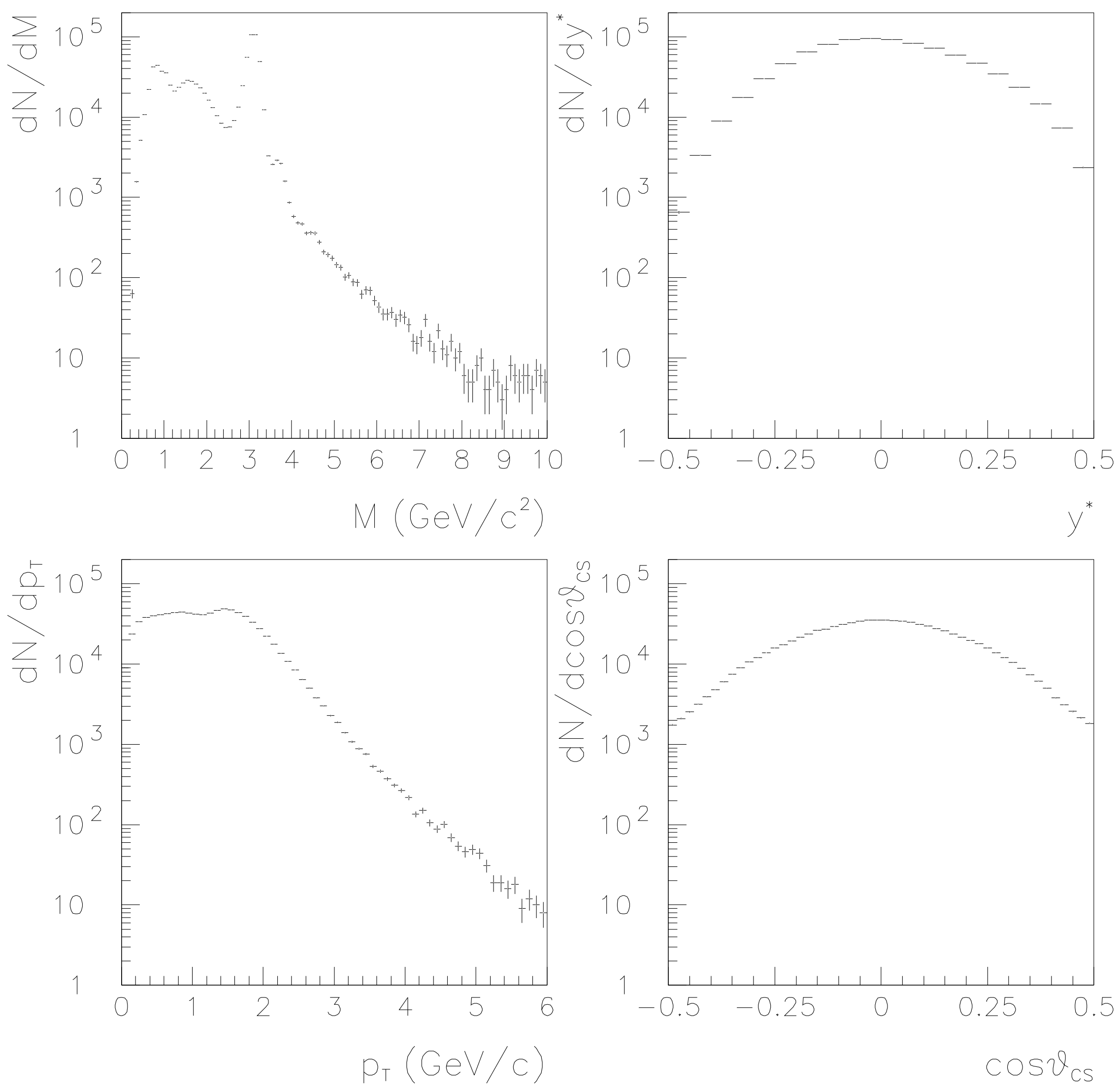

Figure 3.3: *Mass, rapidity, p_T and $cos\theta_{CS}$ distributions of accepted events for pAl.*

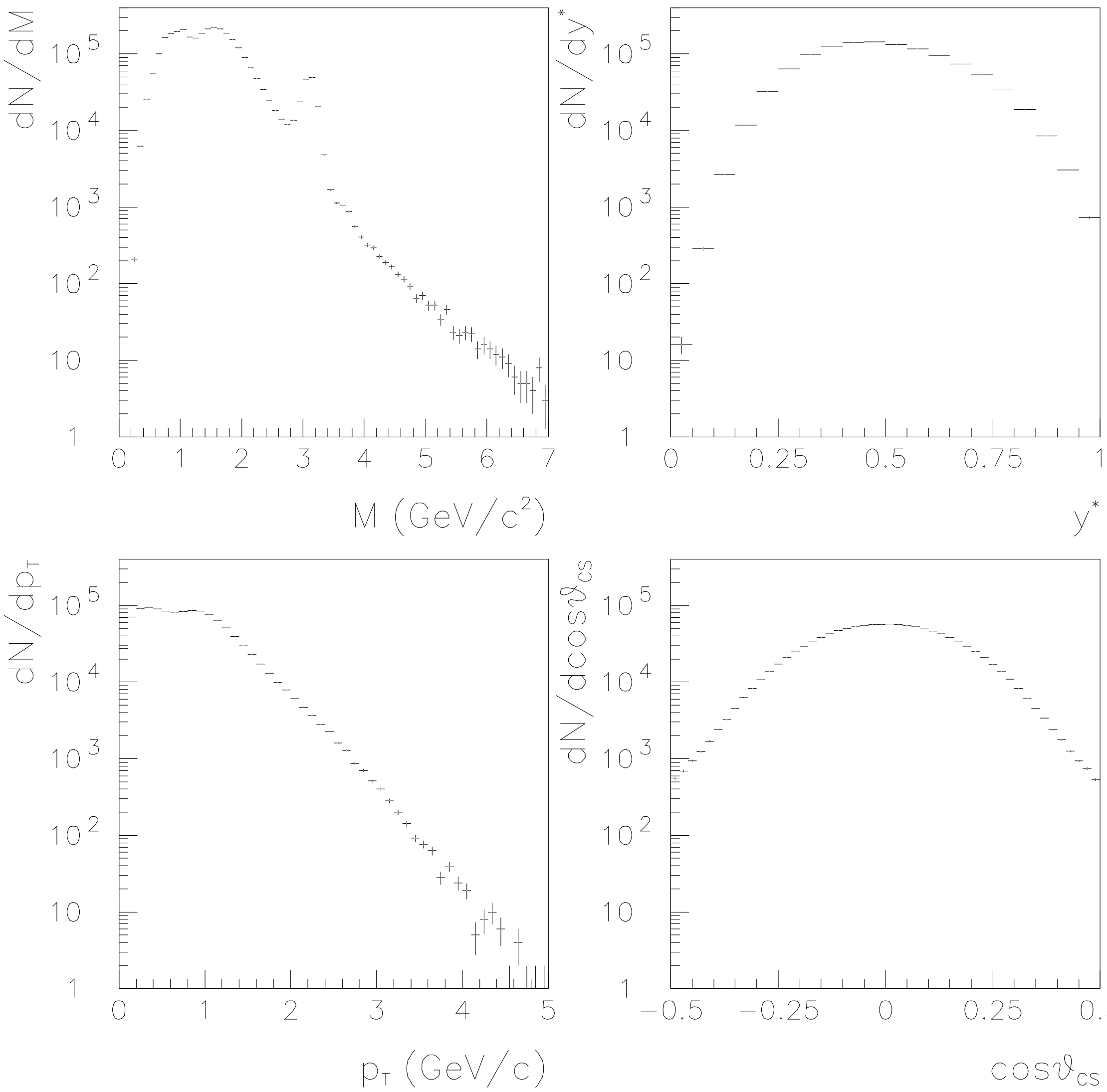

Figure 3.4: *Mass, rapidity, p_T and $cos\theta_{CS}$ distributions of accepted events for PbPb.*

3.5 Pb-Pb and S-U final selection

3.5.1 The PbPb sub-target identification cut

The PbPb sub-target identification system consists of two independent quartz blades placed after each of the 7 sub-targets; the two quartz blades gives two independent signals. When the interaction vertex has not been identified the corresponding event is rejected. The very weak signal associated with peripheral events can often be detected by only one of the two sub-targets. In this case, the independent behaviour of the two blades can be used to relax the cut at the vertex recognition level. Fig.3.5 shows the different effect of the single blade and the two blades cuts on the PbPb E_T distribution. In very peripheral events ($E_T < 25$ GeV) the two blades cut induces a loss of $\simeq 30\%$ with respect to the single blade one.

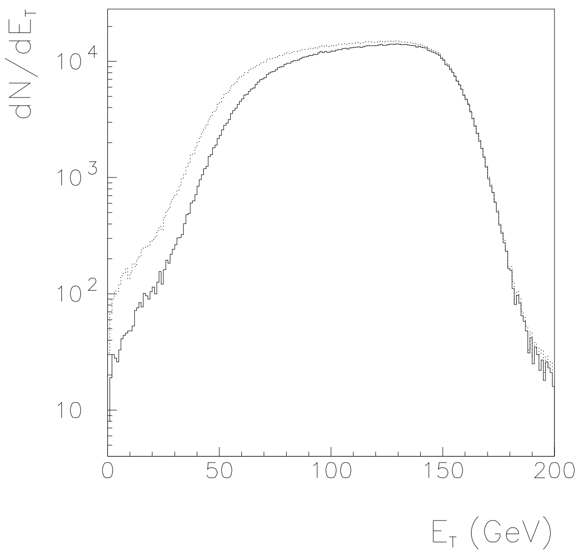

Figure 3.5: *Differential E_T distribution for OS dimuons with target selection : 2 blades recognised (full line) and 1 blade only (dashed line). Kinematic cuts have been applied.*

The top left part of fig.3.6 shows the E_T.vs.E_{ZDC} correlation when the cut at the vertex recognition level has not been applied. Since peripheral and central events follow the same E_T vs. E_{ZDC} correlation, the cut at the target level can be replaced with a simple geometrical cut excluding events with $E_T < 5GeV$ and outside of the main E_T.vs.E_{ZDC} correlation area, as shown in the bottom right part of fig.3.6. This geometrical cut, called the "banana" cut, has been applied on the PbPb data. In fig.3.6 the E_T versus E_{ZDC} energy correlation is also shown after the 1 blade (top right) and 2 blades (bottom left) cut at the vertex recognition level.

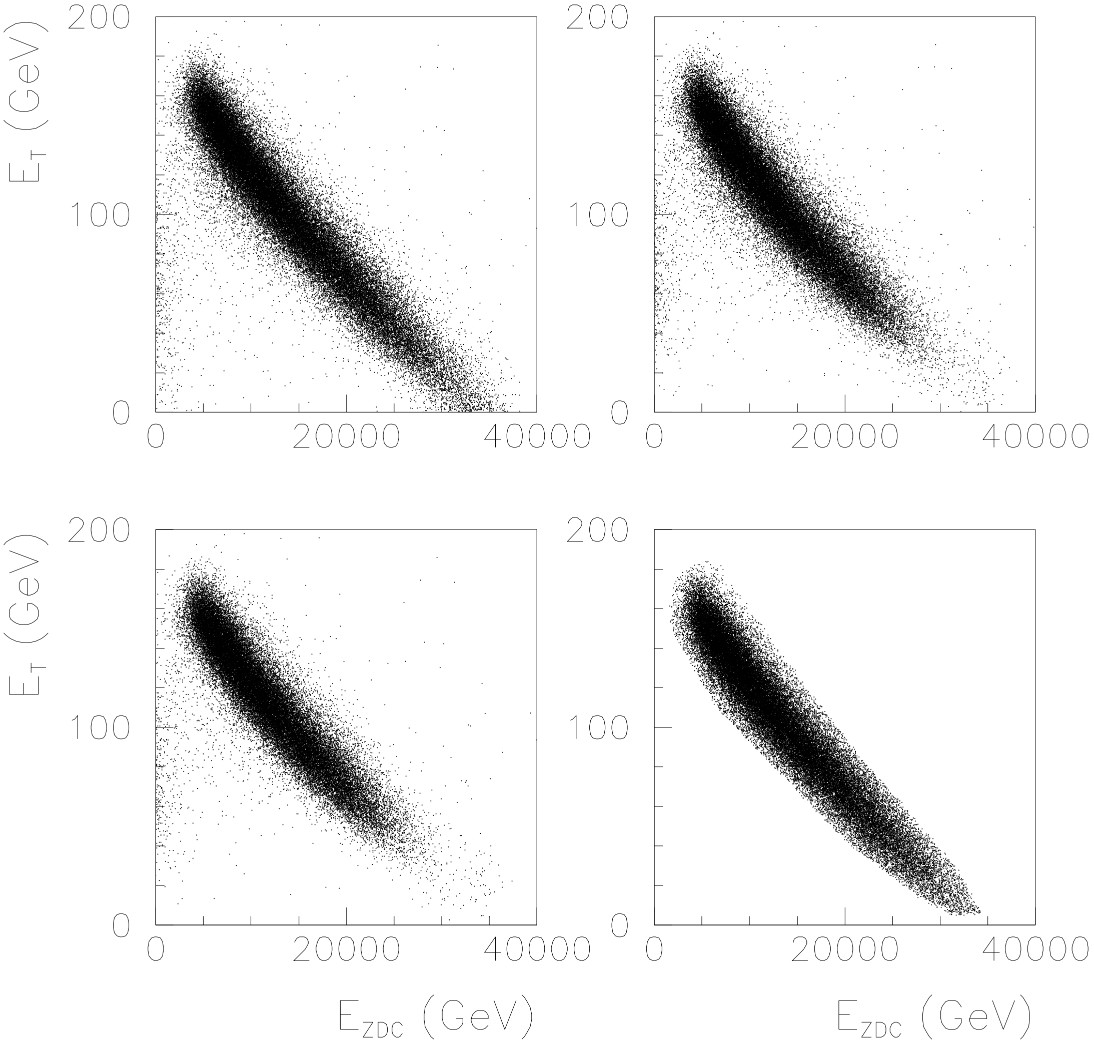

Figure 3.6: *Correlation E_T vs. E_{ZDC} for opposite-sign dimuons without any target cut (top left), with 1 blade cut (top right), with 2 blades cut (bottom left) and with the banana cut (bottom right). The shown correlations refer to the PbPb data. Kinematic cuts have been applied.*

System	energy ($AGeV/c$)	E_T bin	E_T $[min : max]$
SU	200	1	13 : 34
SU	200	2	34 : 50
SU	200	3	50 : 64
SU	200	4	64 : 77
SU	200	5	77 : 88
PbPb	158	1	< 25
PbPb	158	2	25 : 40
PbPb	158	3	40 : 55
PbPb	158	4	55 : 70
PbPb	158	5	70 : 85
PbPb	158	6	85 : 100
PbPb	158	7	100 : 115
PbPb	158	8	115 : 130
PbPb	158	9	> 130

Table 3.2: *E_T binning used in the analysis of the PbPb and SU sets of data.*

3.5.2 PbPb and SU centrality bins

Both the PbPb and SU sets of data have been analysed as a function of centrality. Central collisions are characterised by large E_T and low E_{ZDC} values, and vice-versa for peripheral ones. The all E_T data can be organised in smaller samples corresponding to different E_T bins. These smaller samples of data can be then separately analyzed in order to study the evolution of the measured physical processes with the collision centrality. In table 3.2 the E_T bins corresponding to the subsamples of events used in the analysis of the PbPb and SU data are listed.

Bibliography

[1] DIMUREC USER GUIDE 2.00/02 (1997)

[2] Amir Borhani, PhD Thesis, April 1996, Paris

[3] Frederic Fleuret, PhD Thesis, April 1997, Paris