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Study of High Energy Nucleus Nucleus Collisions

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Achim Franz, LBL, for the WA80 - Collaboration

GSI - LBL - LUND - ORNL - MÜNSTER

Introduction

The CERN experiment WA80 studies ultrarelativistic heavy ion collisions by calorimetry and charged particle measurements over a large fraction of 4π. The setup and its components are shown in Fig.1 and described elsewhere in detail [1]. Global observables like the transverse

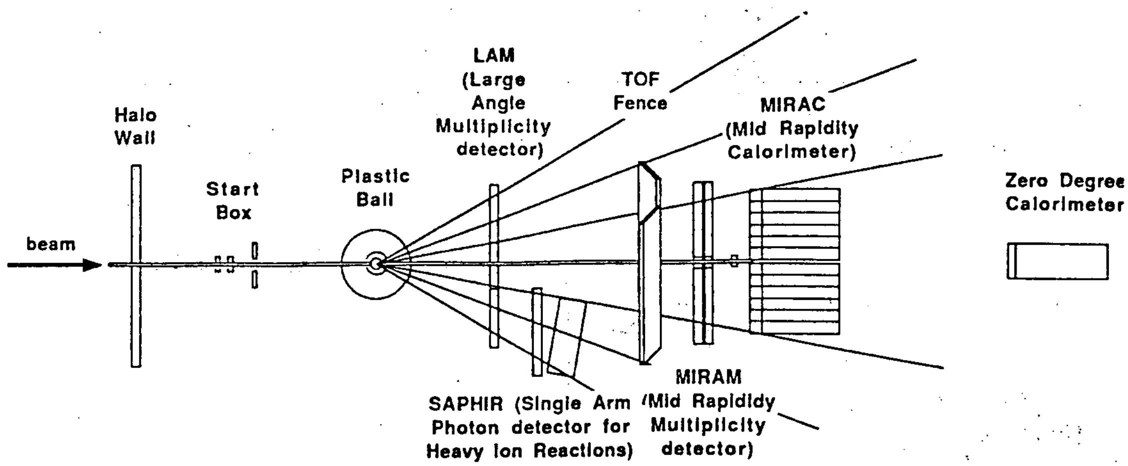


Figure 1: WA80 setup

energy distribution, charged particle multiplicities and p_T distributions for photons and neutral pions are published in [2,3,4]. Here I want to concentrate on a closer study of nucleus nucleus collisions and recent results from the lead glass spectrometer Saphir.

Target Spectators and Participants

The Plastic Ball can identify target fragments in the angular range of $30° \leq \vartheta \leq 160° (-1.7 \leq \eta \leq 1.3, \eta = -ln(tan(\vartheta/2.)))$, together with the Zero Degree Calorimeter (ZDC), which measures the energy flow in the beam direction ($\vartheta \leq 0.3°$) one can get an insight into what happens to the target nucleus in a central collision with the $3.2TeV^{16}O$ projectile. Fig.2 shows the number of baryons measured by the Plastic Ball as a function of the energy in the ZDC, which is a measure of the centrality of the event. The bands for the four different targets, ^{197}Au, ^{108}Ag, ^{64}Cu and ^{12}C, indicate the error mainly due to double hit corrections. For low energy in the ZDC, i.e. central collisions, the Plastic Ball measures about 120 baryons from the ^{197}Au target, including a N/Z corrections for the neutrons, about 60 from ^{108}Ag and 30 from ^{64}Cu. These baryons emerging from the target are called spectators, because they are not directly involved in the collision, i.e. they don't lie in the pathway of the projectile. Even though the mean transverse energy, for the protons as measured by the PB is with $175MeV$ higher than for target participants in $800AMeV^{197}Au +^{197}Au$ collisions measured by the PB at the Bevalac [5]. The number of participants in the collisions studied at CERN can be related to the energy in the ZDC by:

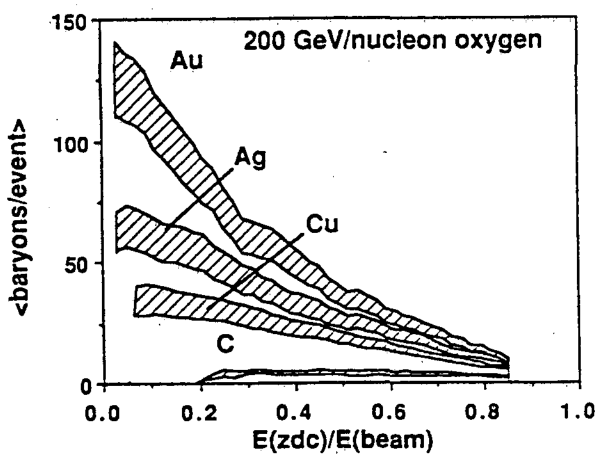
- Comparing it with FRITIOF, the LUND Monte Carlo for nucleus nucleus collisions

- Assuming a monotonic dependence of the number of participants on the ZDC energy.

These procedures are described in detail in [2] and one example, $200GeV/A^{16}O +^{197} Au$, is shown in Fig.3. If one assumes that the participant nucleons are boosted into the angular range between the PB and the ZDC $\Delta\vartheta = 29.7°(\Delta\eta = 4.7)$ the sum of the spectators measured by the PB and the number of participants from the ZDC gives an insight into what happens to the target nucleus. These numbers are:

Target	nucleons	spectators + participants
Au	197	174
Ag	108	104
Cu	64	64

This indicates that the whole target nucleus is disintegrated into small fragments.



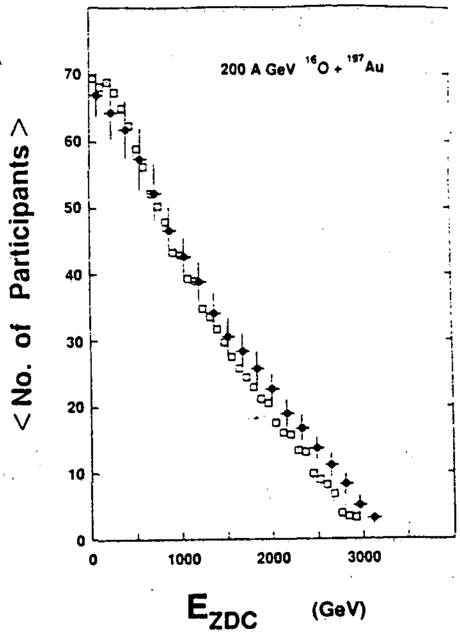


Figure 2: Average number of baryons measured in the Plastic Ball (left)

Figure 3: Number of participants for 200AGeV O+Au collisions (right)

Average E_T per particle

Two other detector components are used to analyse the produced particle flow:

- Streamer tubes with capacitively coupled pad readout to measure charged particles, covering $1.7° \leq \vartheta \leq 32°(1.2 \leq \eta \leq 4.8)$ set up as three individual planes (LAM, MIRAM1 and MIRAM2 in Fig.1)

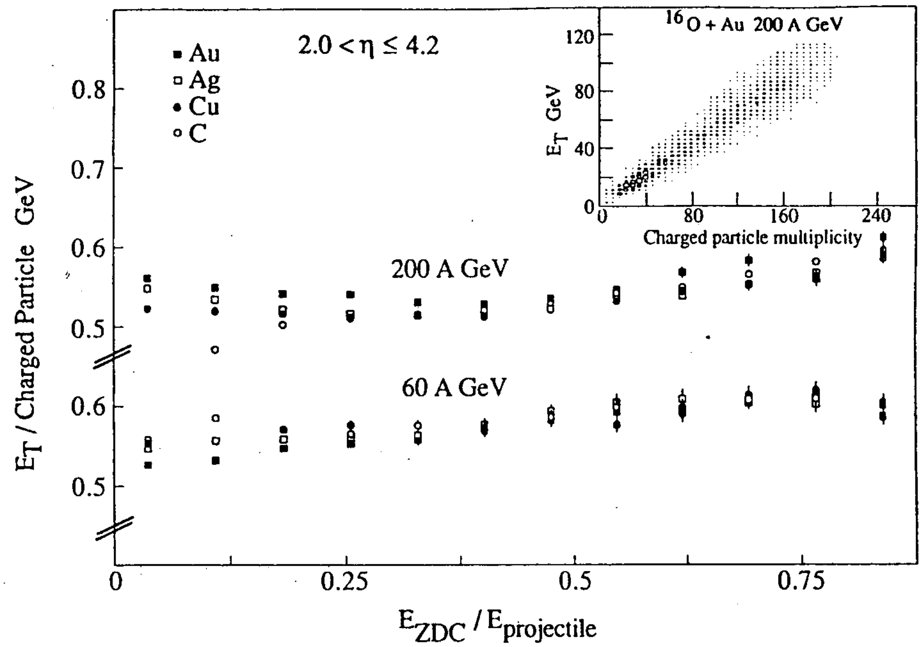


Figure 4: Average transverse energy per charged particle, see text for details

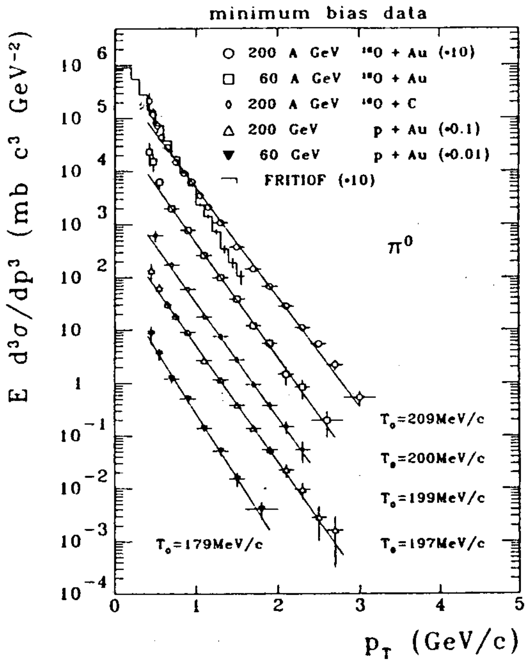
- Pb-Scintillator - Fe-Scintillator Mid-Rapidity Calorimeter, MIRAC see [6] for details, covering $0.4° \leq \vartheta \leq 12.6° (2.4 \leq \eta \leq 5.5)$ with full polar angle coverage.

The insert in Fig.4 shows the number of charged particles detected in a pseudorapidity interval of $2.4 \leq \eta \leq 4.0$ plotted against the transverse energy, E_T, measured by MIRAC in the same region. The correlation between these observables, with an average of $550 MeV/charged\ particle$, is striking. This number corresponds to $370 MeV/particle$ if one assumes equal production for all three charges. In the main part of Fig.4 this correlation is shown for the two beam energies, $200 AGeV/c$ and $60 AGeV/c$, the four targets used, ^{197}Au, ^{108}Ag, ^{64}Cu and ^{12}C, and plotted against the energy in the ZDC. Under all those different conditions the average E_T per charged particle stays constant.

<u>*Saphir*</u>

The invariant cross section for neutral pions as a function of p_T was published in [4] and is shown in Fig.5. The plot is a combination of oxygen and proton induced interactions of ^{197}Au and ^{12}C targets at $200 AGeV/c$ and $60 AGeV/c$. The inverse slope (T_0) of these exponential distribution $(1/p_T)dN/dp_T \sim exp(-p_T/T_0)$ is also included and shows only slow variation going from $200 AGeV/c\,^{16}O+^{197}Au$ collisions to $60 GeV/c p+Au$. The data in this plot is a summary of all "minimum bias" events, which in our case corresponds to less than 88% of the beam-energy measured in the ZDC plus at least one charged particle measured in the multiplicity arrays.
To investigate changes of the p_T distribution on the centrality the cross section as a function of p_T for $200 AGeV/c\,^{16}O+^{197}Au$ is plotted in Fig.6 for central and medium plus peripheral collisions separately. The centrality of the collision is again defined by the energy observed in the ZDC. Here events selected as central collisions have less than 30% of the beam energy left in the forward direction. The change in inverse slope between the peripheral and central collisions are compatible with going from $200 AGeV/c\,^{16}O+^{197}Au$ to $60 AGeV/c\,p+^{197}Au$ collisions.
More details about the source of the π^0 and a possible single photon signal are currently under

investigation. A preliminary study of the correlation length for π^0 pairs done with HBT correlation indicate a rather small size of $\sim 1fm$. For the single photon signal more investigations have to be done to understand the signal coming from misidentification of photon pairs coming from resonances like π^0's and η's. The current analysis indicate a π^0 to η ratio within the expected limits.



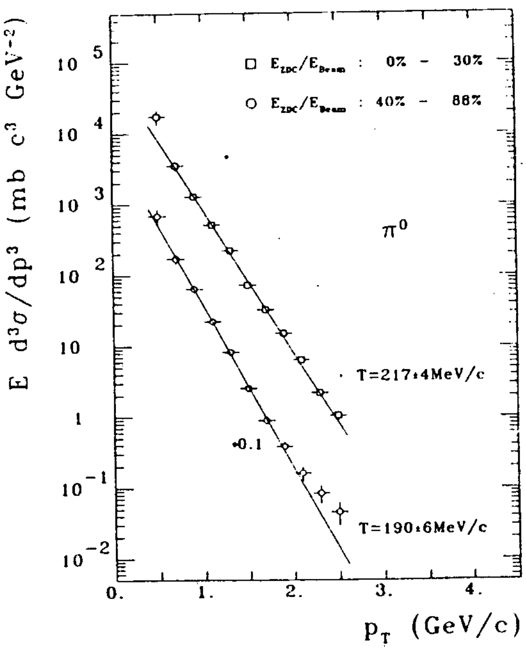


Figure 5: π^0 invariant cross section as a function of p_T (left)

Figure 6: π^0 invariant cross section for $200AGeV/c\ ^{16}O +^{197} Au$ separated for peripheral and central collisions (right)

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[5] K.G.R. Doss et al., "Transverse Energy Production in High Energy Nuclear Collisions and the Equation of State of Nuclear Matter," to be published in Modern Phys. Letters.

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