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Projectile Energy Degradation at 14.5 GeV/u

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Introduction :

The generation of states of high energy density hinges on the question of nuclear stopping or, in other words, on the rapidity lost by the projectile as it ploughs through the target. Recent data have shown [1- 2] that, at 10 and 14.5 GeV/u, the total neutral (E^0_{TOT}) and transverse energy (ET) distributions can be used to infer complete stopping, as measured by the inability of targets heavier than Cu to yield additional neutral energy. An alternative measurement of projectile stopping would rely on the absence of significant residual projectile energy along its direction of motion.

We present experimental evidence showing that the flow of forward energy is a valuable probe of nuclear stopping and that, at 14.5 GeV/u, the projectile energy is completely degraded for central collisions in heavy targets. The forward energy observed is shown to be adequately reproduced by simple geometrical calculations. The correlation of the forward energy with E^0_{TOT} , will be shown to provide information on the number of projectile participant nucleons.

Experimental :

A beam of Si^{28} at 14.5 GeV/u was delivered by the Brookhaven National Laboratory Tandem-AGS accelerator complex during April 1987. A typical beam spot size of 2 X 2 mm was obtained, with an intensity of 3-5 x 10^4 particles/sec and beam purity of better than 99 %. During this run we have used Al and Au targets of thicknesses 3 and 1 % interaction lengths, respectively.

The full experimental setup is described elsewhere [3]; here we only discuss the Zero Degree Calorimeter (ZCAL) and the Lead Glass Array (PBGL). The Lead Glass detector and data obtained in an earlier run have already been described [1].

The ZCAL is an Fe/Scintillator calorimeter essentially built as a replica of WA80's Uranium ZDC [4]. ZCAL was positioned at zero degrees, about 8 meters downstream of the target, where it subtended an angle of +/- 2.1 degrees (pseudorapidity > 4.0).

A minimum bias trigger (INT) was built using the signals of scintillators located along the beam line. A central collision trigger (PB2) was constructed by selecting events with the upper 2 % of the neutral transverse energy distribution, ET. This signal is derived from the sum of the outputs of all PBGL modules, 244 in this experiment, subtending a 2π coverage in azimuth, and a pseudorapidity range of 1.3 to 2.4.

Results :

In Figure 1 is shown the probability of observing a specific Kinetic Energy in ZCAL, for Al and Au targets, for the minimum bias (INT) and central collision (PB2) triggers. For the INT trigger and Au target the data in Fig 1a exhibit, over most of its dynamic range, a flat distribution. We also notice a sharp increase in the number of events at zero energy, supposedly produced by events where the projectile loses all its energy in the target. What is the physical information encoded in that rise at zero energy deposition in ZCAL? A possible explanation (consistent with [1]) would be that the projectile energy degradation saturates for a ra[illegible]

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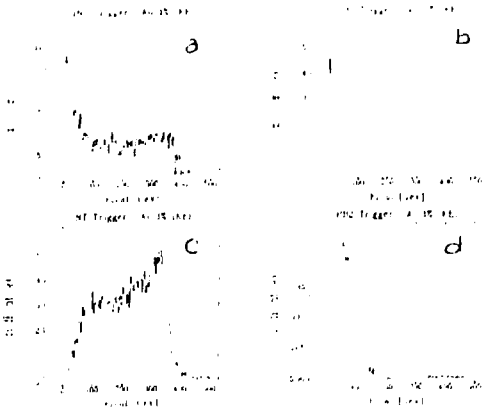

Fig 1.- Kinetic Energy distribution measured in ZCAL for Al and Au targets and INT and PB2 triggers (See text).

pact parameters.

A consistency check of the previous conclusion develops with the central collision trigger PB2. If the projectile energy is completely degraded for central collisions, then ZCAL should not measure anything (LUND simulations reveal that, for central collisions, the forward spray of particles contributes, on the average, about 30 GeV of energy [5]). This is what we observe in Fig 1b.

Because geometry is known to play a significant role in collisions at relativistic energies, we should expect that, for Si on Al, even for the most central collisions, the incomplete overlap of these two nuclei should result in the 'survival' of projectile spectators (Fig 1c). For the PB2 trigger (Fig 1d), we find not only that the total energy deposit significantly increases for the Al target - with respect to the Au-, but also that its distribution exhibits a peak about 60 GeV (for an energy loss of about 86 %). The fact that some projectile spectator nucleons reach the ZCAL, means that there are no events for which the projectile degradation is complete. Thus, we observe no events with zero energy deposition in ZCAL.

From Fig 1, we also conclude that, for the Au target and for a significant number of collisions, all of the projectile energy was completely degraded.

Intuitively we should expect that a small forward energy flow should be accompanied with a large neutral energy production, detected in our PBGL. Figure 2 shows the correlation between these two devices, for both the Al and Au targets. For the Al target a roughly linear correlation is observed over most of the dynamic range.

For the Au target, however, events for which the forward energy is small (about 50 GeV) show a sharp increase in the PBGL signal. A possible explanation of this result will be presented.

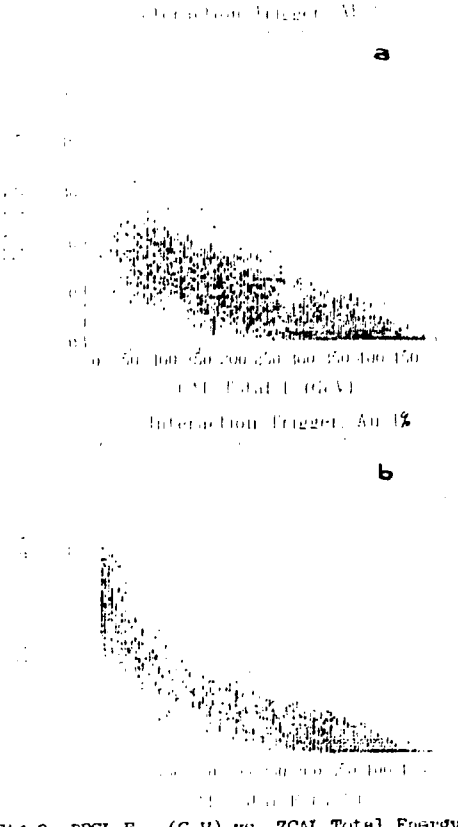

Fig 2. PBGL E (GeV) vs. ZCAL Total Energy (GeV), Al (a) and Au (b). (See text).

E^*_{TOT} spectra obtained for selected values of forward energy detected in ZCAL, can be used, in a model dependent way, to gain some insight into the number of participant projectile nucleons.

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