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EXCLUSIVE MEASUREMENT OF THE Ne = Pb → $\pi^{\mp}$, H, He AT E/A = 400 AND 800 MeV

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Exclusive Measurement of Ne + Pb → $\pi^{\pm}$, H, He at E/A=400 and 800 MeV

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This work is part of a systematic investigation of Ne - nucleus collisions undertaken with the 4π detector Diogene(1) operated at the Saturne accelerator. The Diogene detector consists of a ~0.3-m³ Pictorial Drift Chamber (PDC), detecting charged particles emitted between 20° and 132°, and a scintillator "Plastic Wall" for the detection of reaction products emitted at less than 6° from the beam axis. The results presented here do not include the Plastic Wall data analysis, currently in progress. In order to restrict the results to a few key features, only data obtained with Ne at 400 and 800 MeV/A on Pb nuclei are presented.

The PDC is able to identify charged particles with a momentum resolution of Δp/p ~ 15% (for protons) and a detection threshold of ~ 25 MeV for pions and ~ 45 MeV/A for light nuclei (the detection threshold is constrained mainly by the thickness of the pipe separating the PDC from the beam line vacuum). The number of particles that can be resolved is limited by the double track resolution of the PDC to ~ 30 per event. The data set presented here was restricted to events with at least 2 particles of azimuthal separation Δφ > 24°, emitted at angles between 37° and 119°, and with sufficient energy to traverse the PDC and trigger two "barrel" scintillators (corresponding to a threshold of 50 MeV for pions and 80 MeV for protons).

Fig.1 shows the fractional yield (i.e., the ratio between the number of particles of a given species and the total number of charged particles detected) of all identified particle types as a function of the total charged particle multiplicity,

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taken as indicative of impact parameter. The multiplicity of all particles increases as a function of multiplicity but, in this normalized plot, the proportion of protons decreases to 50% at a multiplicity of 30, reflecting the increasing proportion of protons that are bound in H and He isotopes. The proportion of pions also decreases with increasing multiplicity, reflecting the decreasing share of the beam energy apportioned to the increasing number of participant nucleons in the overlap region of the colliding nuclei as the collision becomes more central, and the concomitant lower probability of pion production in nucleon-nucleon processes. The proportion of π^+ decreases faster than that of π^- because the overlap region contains an increasing fraction of target nucleons reflecting the neutron excess of the Pb target nucleus, which favors increased π^- production.

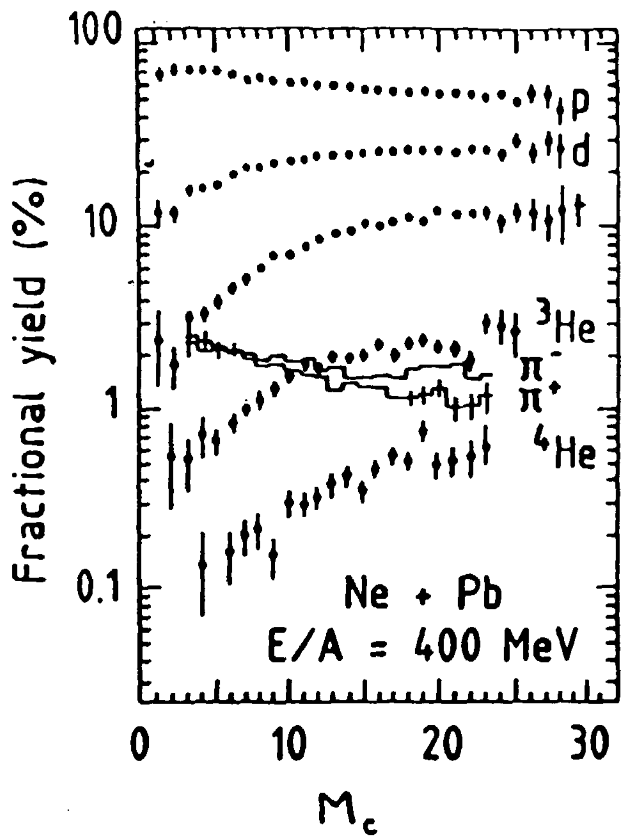

Fig.1 Fractional yield of the different particle types as a function of the total charged particle multiplicity detected in Diogene for the reaction Ne + Pb at E/A=400 MeV.

The experimental data are compared with the results of an Intranuclear Cascade Calculation[2] (INC) which takes into account nucleon binding, Pauli blocking and isospin[3]. A filter consisting of all the experimental cuts was applied to the INC results for comparison with experiment. The INC model does not distinguish between bound nucleons and free nucleons; accordingly, the bound protons and the free protons are grouped together as "pseudo-protons", $\tilde{p}$. The distributions of pseudo-proton multiplicity, $M_{\tilde{p}}$, are shown in Fig. 2. The $M_{\tilde{p}}$ distributions calculated with the INC are much broader than the experimental measurements, although the areas under the distributions, proportional to the event cross section, are approximately equal for calculation and experiment. The difference cannot be attributed to Diogene inefficiencies; these have been evaluated by Monte Carlo simulation and account for no more than half of the discrepancy.

In order to correlate the impact parameter with $M_{\tilde{p}}$, the experimental and the INC $M_{\tilde{p}}$ - distributions were divided into 5 intervals of approximately equal cross section. The cumulative fractional cross section is assumed to correspond to $1 - (b/b_{trig})^2$, where b is the impact parameter and b_{trig} is the maximum impact

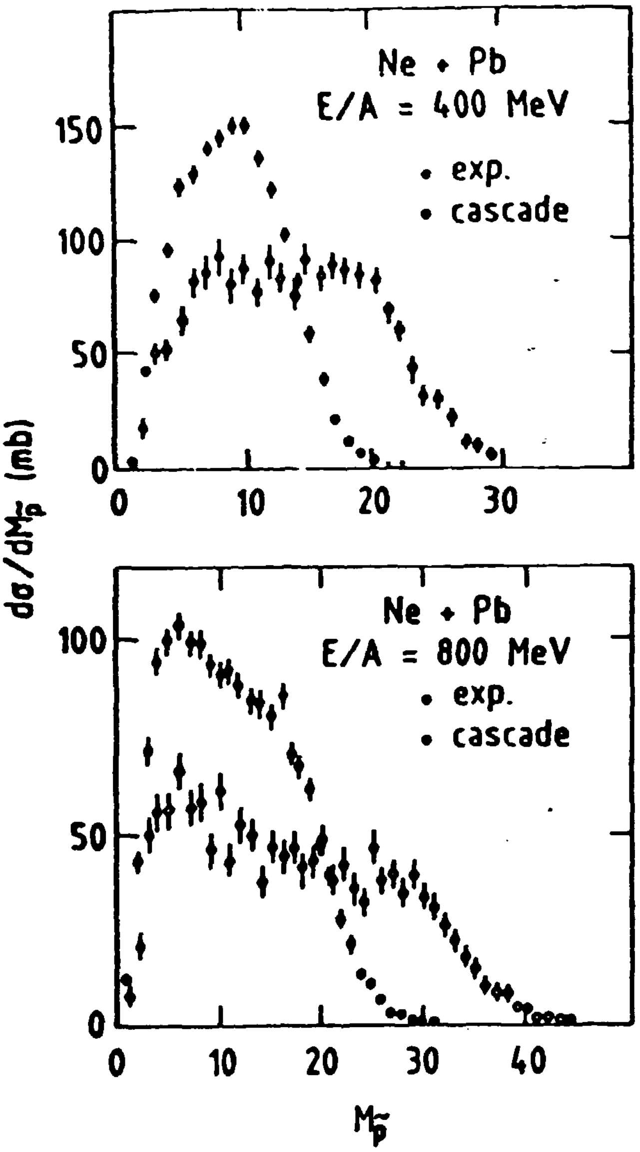

Fig.2 Pseudo-proton (free and bound protons) multiplicity distribution at E/A=400 and 800 MeV. The experimental data (•) are compared to INC calculation results (o).

parameter associated with detected events falling within the trigger acceptance (including data selection cuts). Figure 3 shows the mean pion multiplicity distributions as a function of this cumulative fractional cross section and, hence, impact parameter. The number of pions is systematically overestimated by the cascade calculation except for the largest impact parameters ("peripheral collisions"). This difference is greatest for the smallest impact parameters ("central" collisions). The discrepancy is greater for π^- especially at E/A=800 MeV.

As shown in Fig. 4, the total energy, as a function of $M_{\tilde{p}}$, is well reproduced by the INC at E/A = 400 MeV; the corresponding experimental values of transverse energy are reproduced almost equally well, although the experimental value is systematically slightly higher than the INC calculation.

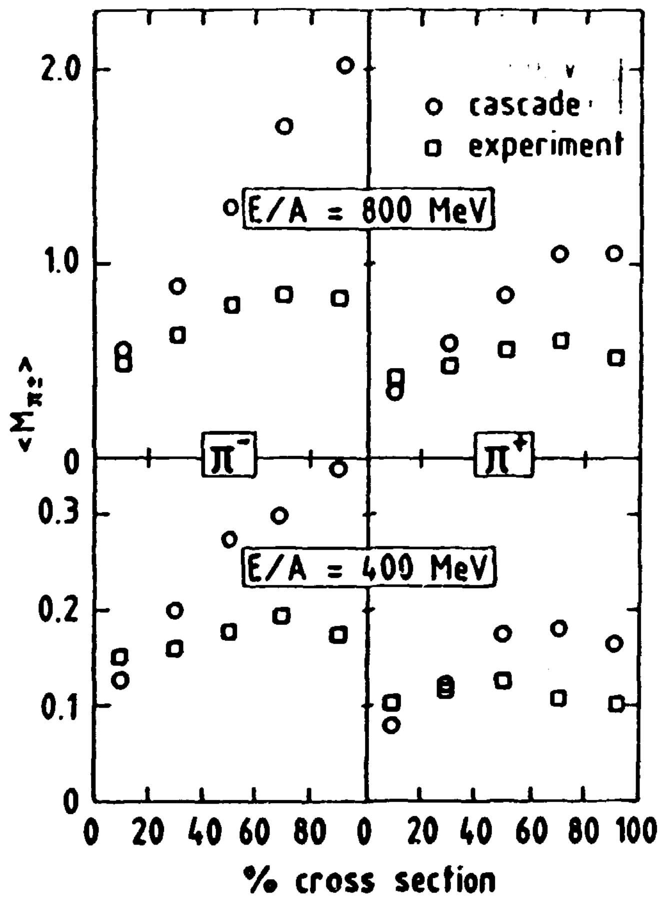

Fig.3 Average pion multiplicities as a function of the fraction of the integrated cross-section selected by the pseudo-proton multiplicity. Zero for the cross-section fraction corresponds to the lowest pseudo-proton multiplicity thus to the largest impact parameter.

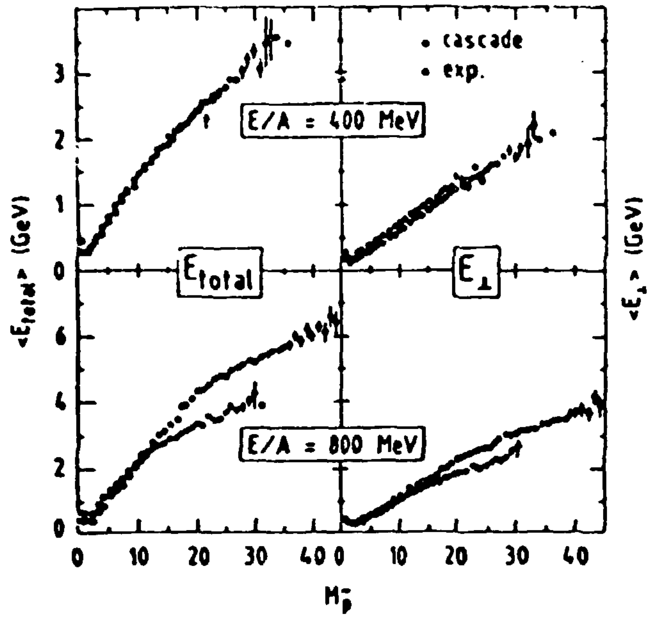

Fig.4 Average total energy (left hand-side) and transverse energy (right hand-side) as a function of pseudo-proton multiplicity.

At E/A=800 MeV, similar conclusions apply only for $M_{\tilde{p}}<12$, i.e. for peripheral collisions. The INC predictions increasingly exceed the experimental results as $M_{\tilde{p}}$ becomes greater than ~ 12.

The energy carried by the π^- agrees with the INC calculations at E/A=400 MeV while it is strongly overpredicted at E/A=800 MeV. At both beam energies the energy carried by the π^+ is systematically higher than that predicted by the INC. This difference may be ascribed to Coulomb effects, which are not included in the cascade calculation, and which would accelerate the emitted π^+ by repulsion from the residual protons. On the other hand, a similar reasoning leads to a slowing down of the π^- and implies that the agreement between the INC calculation and the observed total energy of π^- at E/A=400 MeV is fortuitous.

A similarly fortuitous agreement between INC calculations and π^- data can be seen in Fig.5, which shows the momentum distribution of π^+ and π^- measured in the most central cross-section interval at E/A=800 MeV. There is no difference in the cascade predictions for π^+ and π^-, but the slope of the π^+ momentum distribution is systematically higher for the INC calculation, whereas the π^- distribution seems to be in agreement with it.

The experimental and calculated distributions of pseudo-protons as a function of their total momentum and of their transverse momentum are shown in Fig. 6 for E/A=400 MeV and for several values of impact parameter; the results for E/A=800 MeV are similar. The shape of the experimental distributions in total proton momentum is independent of

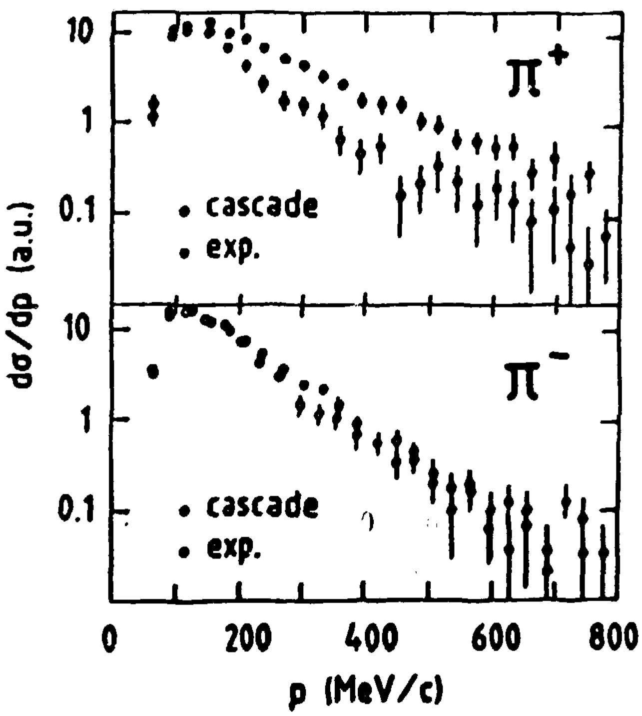

Fig.5 Momentum distribution of pions for the most central events at E/A=800 MeV.

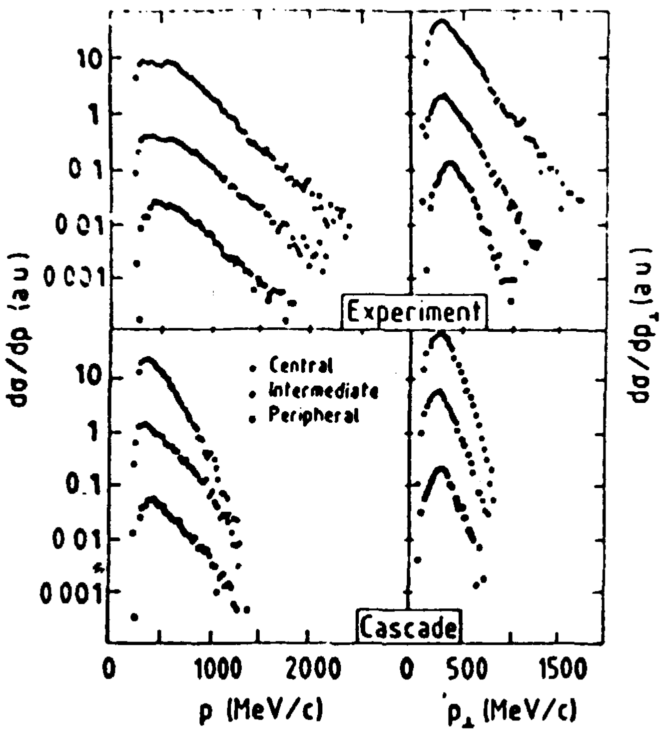

Fig.6 Momentum distribution and transverse momentum distribution of pseudo-protons for three sets of impact parameters at E/A=800 MeV.

impact parameter. The cascade prediction for the most peripheral collisions is similar to the experimental result; however, at smaller impact parameters the INC predicts distributions that become more steeply peaked with decreasing impact parameter than is measured. The INC predictions for the transverse momentum are similar, whereas the experimental slope decreases with decreasing impact parameter. If the slopes of the momentum distributions are interpreted in terms of a temperature, the INC would seem to yield a lower pseudo-proton temperature than is actually observed, except for peripheral collisions, where the prediction agrees with the data.

Similarly, in a flow analysis of the data (4) the agreement between INC predictions and the data is good for peripheral collisions but deteriorates for smaller impact parameters.

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