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DIVISION OF
COSMIC AND SUBATOMIC PHYSICS
DEPARTMENT OF PHYSICS
UNIVERSITY OF LUND

CERN/SPSLC 96-20
SPSLC/M 576
4 March, 1996

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Request for beam time for the experiment EMU12 at the heavy ion run in November/December 1996 at the SPS

The Experiment

In order to gain information on the general energy and mass dependence of multiparticle production in heavy ion interactions the EMU01-collaboration uses two different emulsion techniques; stacks and chambers. The stack technique is the conventional one where stacks of emulsion pellicles are exposed with the beam parallel to the emulsion plane. The emulsion chambers, normally equipped with thin target foils, are exposed perpendicular to the pellicles. Measurements in the chambers are performed using semi-automatical systems and automatized CCD-systems. The table below summarizes the data collected so far.

Collected data:

200	A GeV/c	O+Em (S+C), S+Em(S+C), S+Au (C), S+Ag (C)	at CERN SPS	EMU01
158	A GeV/c	Pb+Em (S+C), Pb+Pb (C), Pb+Ag (C)	at CERN SPS	EMU12
60	A GeV/c	O+Em (S+C)	at CERN SPS	EMU01
14.6	A GeV/c	O+Em (S+C), Si+Em (S+C), Si+Au (C)	at BNL AGS	E815
11.6	A GeV/c	Au+Em (S+C), Au+Pb (C), Au+Ag (C)	at BNL AGS	E863
4.5	A GeV/c	O+Em (S), Si+Em (S)	at Dubna	-

As can be seen in the table the data collected at the SPS is well complemented with data from the AGS and Dubna at lower energies.

Spokesman for the Experiment

From the 1st of January 1996 associate professor Evert Stenlund, Lund University, is the spokesman ot the experiment EMU12 and the EMU01 collaboration.

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Exposures during the 1996 Heavy-Ion Run

We would like to extend our data sample from 158 A GeV Pb-run with another exposure in 1996. Although the December run 1994 with lead ions was a great success there is a difference in quality within our exposed material, due to changing beam conditions during the exposure. A new run would help us to enlarge the data sample, specifically for central collisions.
The precision in the chamber measurements is high and we have shown that we can measure multiplicity and rapidity distributions with very high accuracy. To increase our sample of very central (≈ 3% of the cross section) Pb+Pb and Pb+(Ag,Br) collisions it is important for us to have access to a lead beam in the fall 1996.
If, furthermore, there are plans in the future to run with other ions or with Pb-ions at lower energies, we would be happy to make use of them. Our wish is then to use a lead beam at an energy in between the AGS- and the present SPS-energy, preferably around 30 - 40 A GeV where intra-nuclear cascading might still be important. At this energy the formation length is about twice as large as at the AGS and a large amount of the produced particles are formed inside the collision volume. Collective effects seen at AGS (flow etc.), yet not seen at the present SPS-energy, might still be of importance at 30 - 40 A GeV.

Requests

We need to expose **15 emulsion stacks**, two beamspots each.
We need to expose **50 emulsion chambers**, 4 beamspots each.
For this purpose we need **2 hours of beamtime**, preparation and tuning of the beam not included.

Motivation and Experimental Status

Already at the Quark Matter '95 conference in Monterrey in January 1995 we showed that we were able to measure also the most central lead-on-lead collisions (charged particle multiplicities ≈ 2000) with our chamber technique.
With the chamber measurements there seems to be no problems with the extreme multiplicities, and newly developed automatized measuring systems decrease the measurement time. Such a system consist of a microscope with a CCD-camera, equipped with a computer-controlled stage. Also the focusing is computer controlled. A special image processor makes image grabbing and analysis fast. The full 3-dimensional information of the event in a 200 micron layer is registered in some 100 images, and this is accomplished with a resolution of the order of a micron. Since the vertex point is known, the requirement that the tracks pass through this point, makes the signal-to-noise ratio very favourable. The

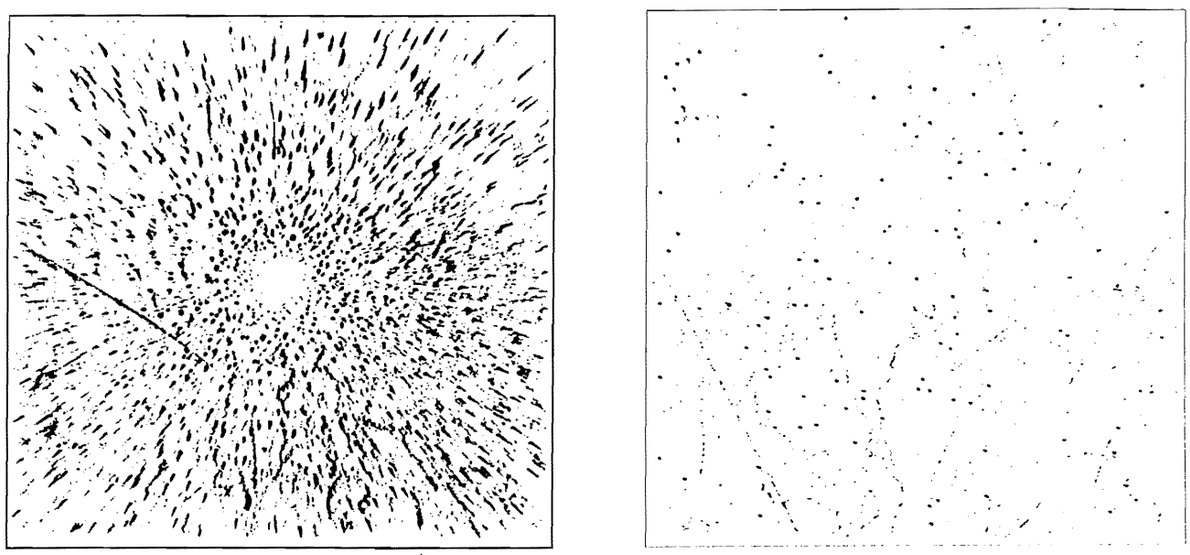
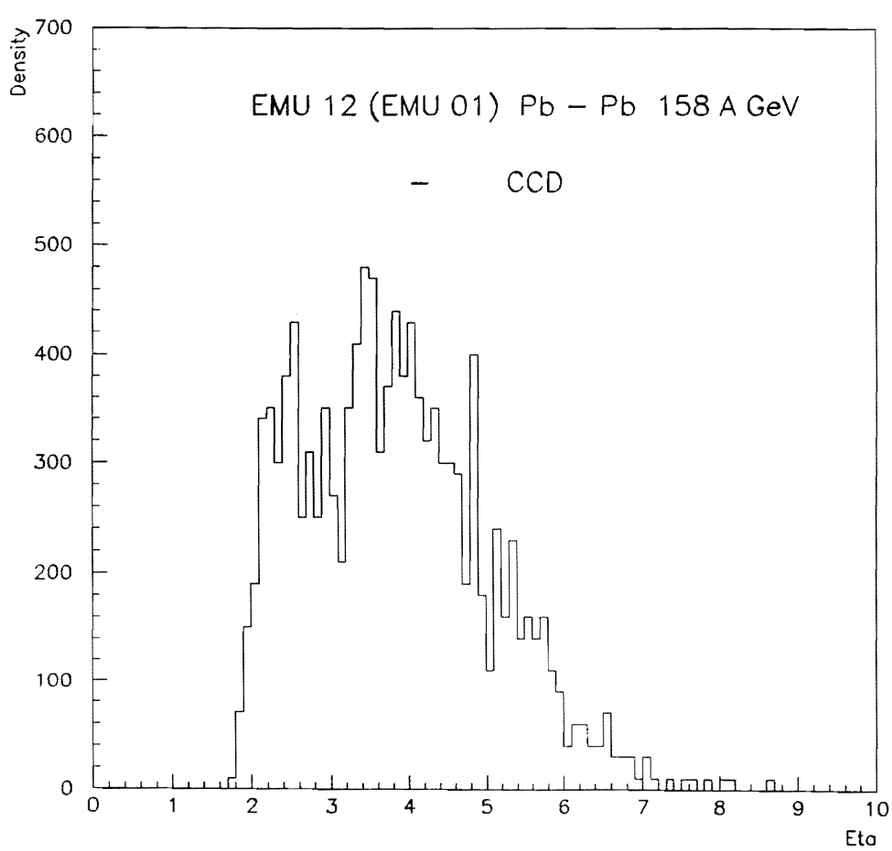


Figure 1: CCD-Images from two layers at different distances from the vertex.



Figur 2: Particle density distribytion from a central Pb+Pb interaction obtained from a measurement by the CCD-system. Note that only particles with emission angles less than 15° are measured.

measurement and analysis of one such layer takes only a few minutes. The whole chamber consists of ten layers. Tracking in between the layers is accomplished by conventional tracking-algorithms. As compared to the semi-automatic systems, which have been used for the lighter ions, measurements are done in about a tenth of the time and, furthermore, the operator only needs a fraction of the skills as compared to earlier measuring methods. Figure 1 shows two images, after filtering, one from a layer close to the vertex and one an from a layer far away from the vertex. Although these prints do not make full justice to the resolution of the images, it is clearly seen that the tracks comming from the vertex are much blacker then the backround tracks. Figure 2 shows a fully reconstructed event measured by the CCD-system. Note that only particles with emission angles < 15° are measured.
In order to increase the sample of central collisions, thereby taking full advantage of the new systems, we need to irradiate further emulsion chambers.

Results from the 1994 Pb-Run

During the last year the groups within the EMU01-collaboration have been occupied measuring events from the lead exposure. In parallel analysis work of the new data and data from previous runs has been going on. Among the different analysis projects we would like to mention studies of collective flow and reaction planes, non-statistical fluctuations of particles produced in the central rapidity region, emission of helium fragments from the projectile and rescattering in high-energy heavy-ion reactions.
Figure 3 a shows the particle density distribution in Pb+Pb events in which the projectile has disintegrated into singly charged particles or at most one alpha particle. This figure illustrates the very good spacial resolution of the detector, also in events with very large particle densities as obtained in central collisions with truly heavy ions.
In Figure 3 b, the particle density distribution from one central Au+(Ag,Br) event, from the conventional stack material, is displayed. This figure illustrates the fluctuations obtained, and shows that also with this technique it is possible to measure events with large multiplicities.
The local fluctuations in particle densities are directly studied in figure 4, where the second order intermittency indices for various interactions are plotted versus the average particle density. In this plot the Pb+Pb interactions are represented by the first measured central event, which has an intermittency index which is higher than expected by the general trend of the data for interactions between smaller nuclei.
The squared transverse momentum distribution of helium fragments from the projectile emitted in Pb+Pb interactions at 158 A GeV/c, is displayed in figure 5. Also shown is the same distribution from Au+Au interactions at 11.6 A GeV/c. As can be seen the two distributions are in good agreement, indicating that the

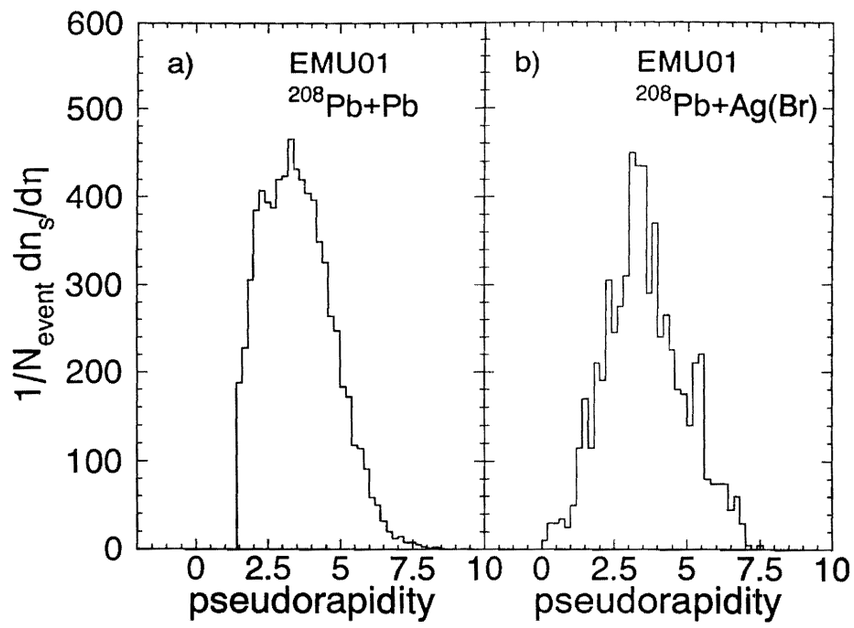


Figure 3: Particle density distribution in a) central Pb+Pb interactions (particles with $\eta > 1.4$), and b) one central Pb+(Ag,Br) interaction.

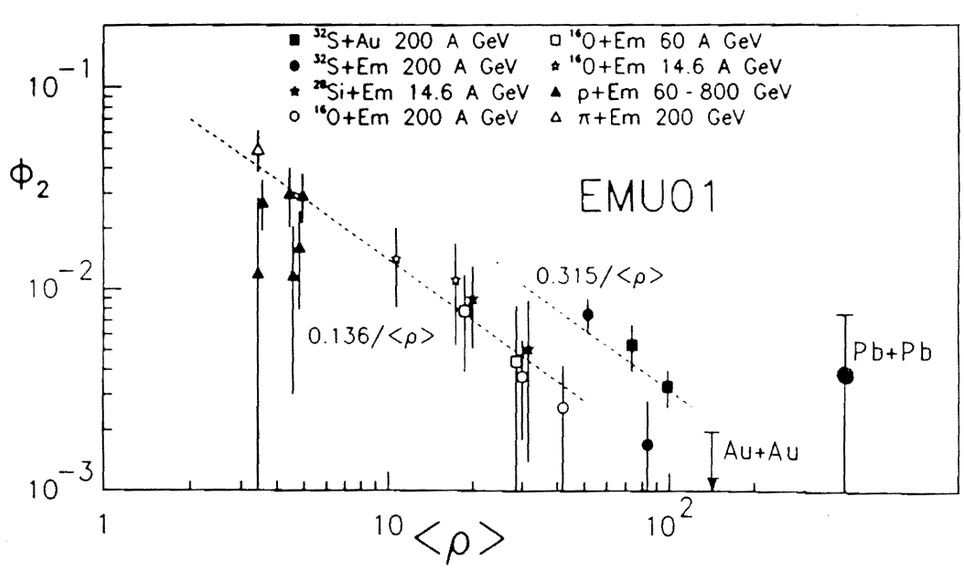


Figure 4: Second order intermittency indices, ϕ_2, for various interacting systems as a function of average charged particle density, $\langle\rho\rangle$. The dashed lines indicate $\phi_2 \propto 1/\langle\rho\rangle$.

mechanism responsible for projectile break-up into light fragments is energy independent. The distribution can be parametrized as the sum of two independent components, and the second is indicated by the dashed line. This second component corresponds to an extreme momentum transfer and no satisfactory explanation is readily available.
The target break-up in Pb+Em and Au+Em interactions is illustrated in figure 6, where the multiplicity distributions of slow target associated particles are shown. As can be seen the two distributions are very similar, indicating that also the target break-up is essentially energy independent.

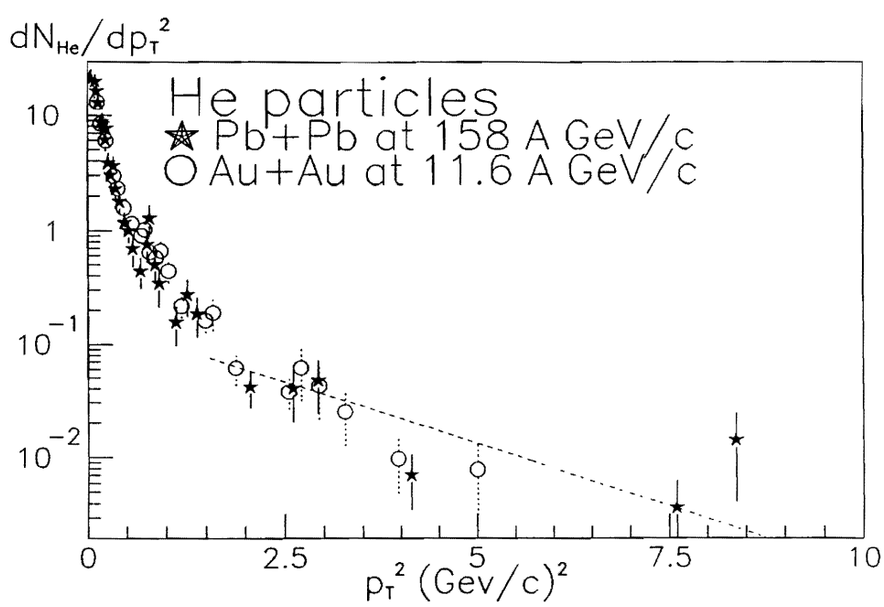


Figure 5: Squared transverse momentum distribution of helium fragments from the projectile in Pb+Pb and Au+Au interactions.

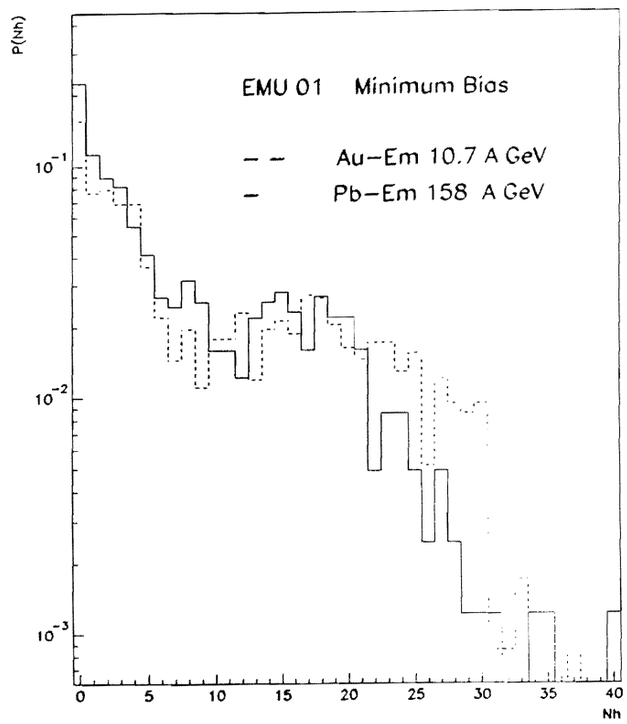


Figure 6: Multiplicity distributions of slow, target associated particles emitted in Pb+Pb and Au+Au interactions.

For the EMU01-collaboration:

Evert Stenlund	Kaj Söderström	Ingvar Otterlund
(Spokesman, EMU12 and EMU01 collaboration)	(Contact person and coordinator)	