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DIOGENE: A 4Π DETECTOR FOR STUDYING CENTRAL COLLISIONS OF RELATIVISTIC HEAVY IONS

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Heavy ion beams up to 1.15 Gev/amu should soon be available at the Saturne II facility. In this prospect a small time projection chamber has been built which allows to reconstruct all the light charged particles (π,p,d...) tracks for large multiplicity events (~40). As a first test of the experimental set up, some data taking has already started with 4He-beams at 400, 600 and 800 Mev/amu.

Introduction: In 1977 it was already recognised that as extreme models as intra-nuclear cascades or hydrodynamic calculations would describe as well inclusive measurements of relativistic heavy ion collisions. The need for more exclusive correlation measurements called for new detection set up with large multiplicity capability. Such a 4Π, total absorption, detector was already planned by the "plastic ball" group 1) at Berkeley. In the prospect of heavy ion beams being available at the Saturne II facility, a collaboration was started between several groups in France (Saclay, Clermont-Ferrand, Strasbourg) to build a similar system. Time projection chamber (TPC) detectors, as developed in high energy physics, seemed rather attractive for our own specific use. They provide good light charged particle identification (including π^-). They are well adapted for large multiplicity events and they do not require any scanning which is a clear nuisance for other common track detectors. Our design is adapted from the internal detector of JADE 2) at the PETRA colliding beams in Hamburg. Two prototypes were tested before the final detector was built in 1982. The first measurements with the complete system were done in November 1982. Since then, we have undertaken a systematic program with ^{4}He-beams to improve our experimental set up and develop the software for trajectory reconstructions. The heavy ion program will start as soon as they become available in the next few months.

Detector description: A sketch of the overall system is shown on fig 1. A large solenoid provides a 1 tesla magnetic field parallel to the beam axis. Ten drift chambers with tranverse electric field are arranged in a cylindrical configuration. They are placed in a pressure vessel (4 mm thick stainless steel) filled with an argon-propane mixture up to 4 Atmospheres. The inner tube, which is connected to the beam pipe, is only 1.5 mm thick. This corresponds to a lower cut-off of 25 Mev for protons emitted at 90°. It is planned to improve this limit using carbon fiber technology. Each sector is equipped with 33 anode wires (Ni-Cr, 30 μ resistive wire) interspaced by field wires (Cu-Be, 100 μ). Because of cost limitations, only 16 anode wires are connected to the electronic set up. This has essentially been copied from the one developed for the JADE project 3). It was indeed an important motivation in the choice of our TPC design that we could benefit of the electronic development that had been made in Heidelberg. It allows 8 time + amplitude informations for each wire to be recorded for a single event. The 3-dimensional characteristics of the detector are obtained from the following informations for each track segment in a drift cell defined by two field wires:

1. r coordinate- distance from beam axis - the anode wire position.
2. $r\phi$ coordinate- transverse distance from the anode wire plane- drift time.
   - In fact, because of the magnetic field, the drift is not orthogonal to the anode plane, it is characterised by a drift angle which depends on both the electric and the magnetic field amplitudes.
   - Note also the "left-right" ambiguity with respect to anode planes.
3. z coordinate- distance along the beam axis- charge division at each end of an anode wire.

Drift times are measured with respect to a start signal provided by a trigger detector made of a barrel (hence the name Diogene) of 30 scintillators placed around the pressure vessel. This may be used as a multiplicity filter but it has been found more convenient to use a low multiplicity selection (>1), and to scale down the data according to each multiplicity by a fast on-line software rejection followed by a fast clear of the electronic coding sequence. The general characteristics of the detector are summarized below.

- solid angle: $0<\phi<2\pi$ $20<\theta<160°$ -forward detection will be improved by the addition of a plastic wall before summer 1984.

- multiplicity: estimated ~40 (absolute electronic maximum is 80) This figure is strongly dependent on the double track separation characteristics (7 mm).
- momentum resolution: typically ~15% (16 point tracks) up to $p_\perp \sim 1.5$GeV/c
- particle identification: good π v.s. p separation up to 600 MeV/c (see fig 3 below)

Present status: We are currently working to improve the track reconstruction program 4) which should be used in the near future to systematically analyse the data we have already taken: ^{4}He-beam at 400, 600 and 800 MeV/amu on C, Cu and Pb targets. A high multiplicity event from the ^{4}He (3.2GeV) + Pb run is shown on fig 2 together with the result of an automatic reconstruction of the tracks (typical time is 5 ms/track on an IBM 3081). Since this result was obtained, the "z" resolution has already been improved by an automatic calibration of all the amplitude channels. Notice the special "iris" configuration of the detector which is used to solve the "left-right" ambiguity. Once the tracks are reconstructed, particle identification is obtained from a <dE/dx> v.s. momentum plot as shown on fig 3. To get rid of the Landau tail for the least ionizing particles, one only takes into account the lower half of the dE/dx samples for each particle track.

Special attention was already given to a specific class of events which appear to us as rather frequent when scanning by eye through the data. Fig 4 shows one of these where all the tracks (but one) are focused in a narrow cone (same polar angle θ) with respect to the beam axis. On the base of the inclusive experimental θ distribution we have tried a Monte-Carlo simulation of such events. The observed rate has been found to agree with statistical fluctuations.

References:

1- A. Baders et al. NIM 203(1982) 189
2- J. Heintze NIM 156(1978) 227
3- W. Farr and J. Heintze NIM 196(1978) 301
4- J. Poitou NIM 217(1983) 373

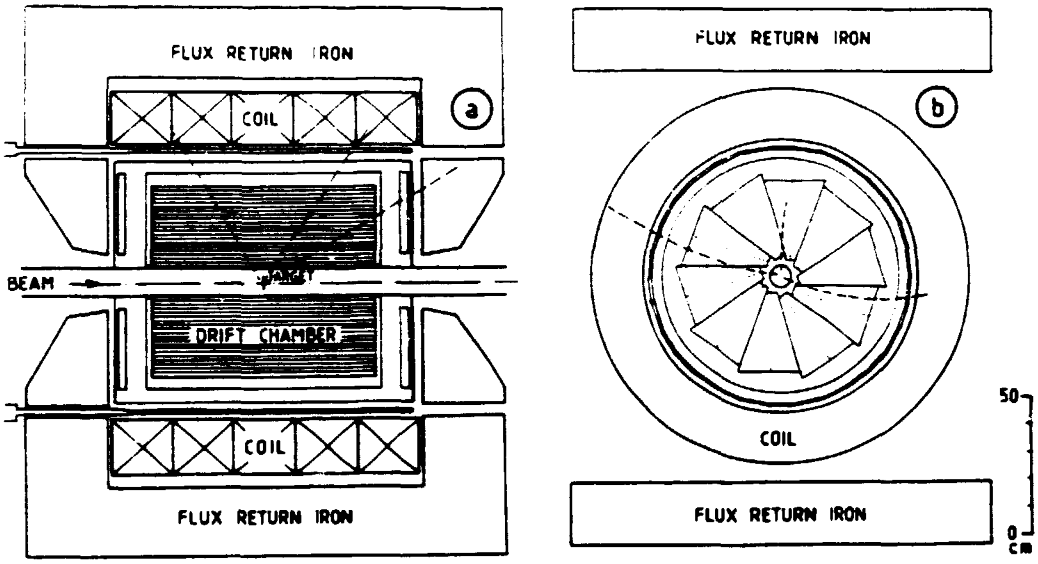

fig 1. - a/ Longitudinal cut of the Diogene detector
- b/ Transverse view. Notice the "iris" configuration of the 10 sectors

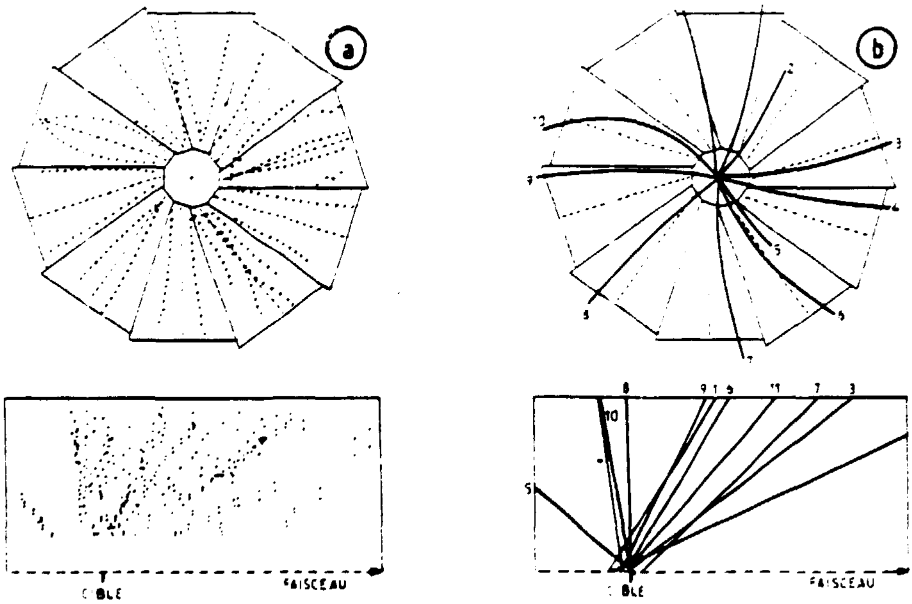

fig 2. Track reconstruction for a 4He(3.2GeV) + Pb event.

- a/- Top view is a projection on a plane perpendicular to the beam axis. These are on line raw data. At this stage, twice the number of tracks appear since the "left-right" ambiguity is not resolved.
  - Bottom view is a longitudinal projection in cylindrical coordinate (r,z).
- b/ Same as "a/" above, after track reconstruction.

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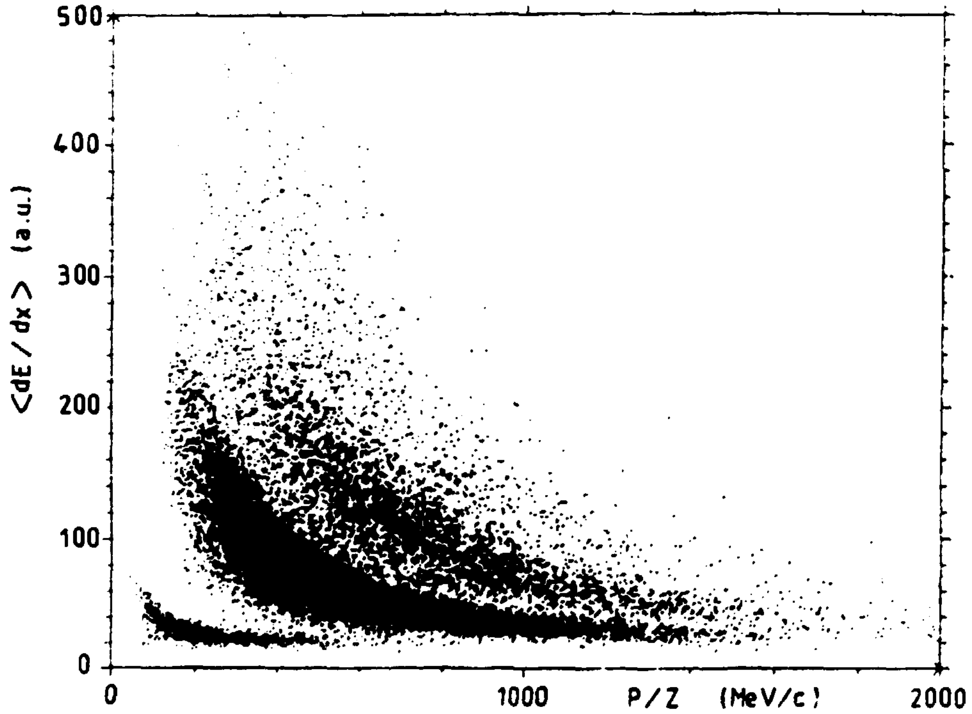

fig 3. Particle identification plot: 4He(3.2GeV) + Pb.
Truncated <dE/dx> v.s. momentum/charge.
One clearly sees the π^+ p, d ridges.

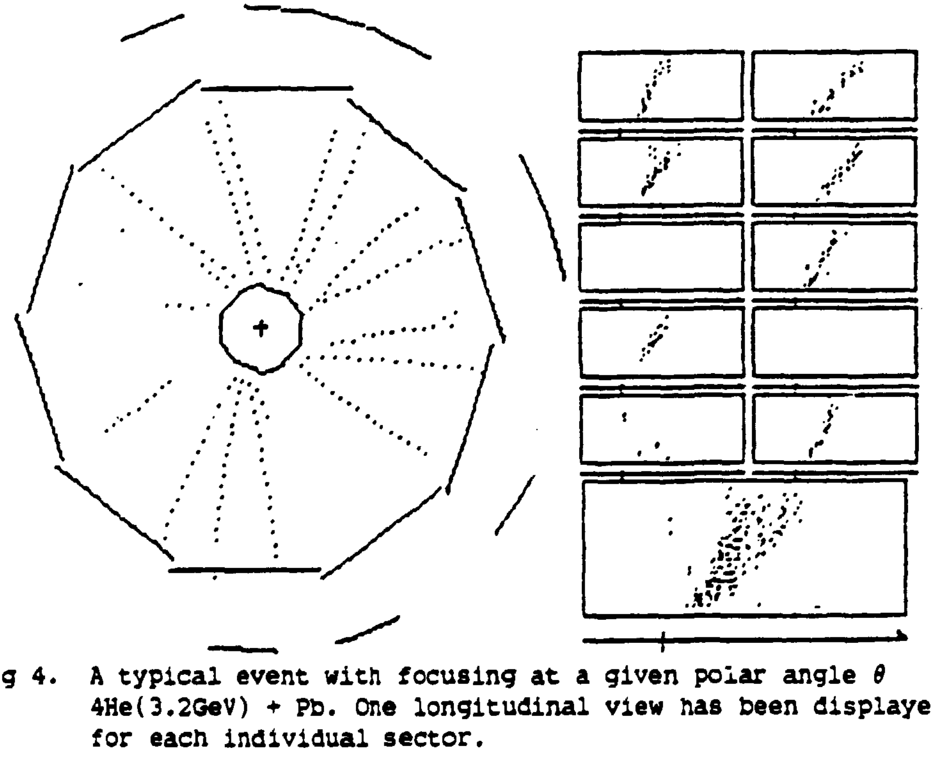

fig 4. A typical event with focusing at a given polar angle θ
4He(3.2GeV) + Pb. One longitudinal view has been displayed for each individual sector.