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The Vertex Spectrometer of the Multiparticle Argo Spectrometer System at BNL*

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The need for definitive studies of high multiplicity, high momentum transfer reactions in the 30 GeV energy range prompted us to design and build a Vertex Spectrometer (VS) which combined the large solid angle advantage of a bubble chamber with the triggerability and digitized readout capability of an electronic system. We have made operational such a detector and used it as an integral part of the Multiparticle Argo Spectrometer System (MASS) at Brookhaven in an experiment which studied pp interactions at 28.5 GeV/c. Our VS consists of a nested set of 9 cylindrical wire spark chambers surrounding a 20 cm long hydrogen target located in a ten kG magnetic field (Fig. 1). The field volume measures 1.5 x 1 x 1 m^3. The chambers have radii varying from 15 cm to 47 cm with an active height of 74 cm. The axis of the cylinders is perpendicular to the beam. Dip angles of ± 50° in respect to the beam are covered. High multiparticle efficiency is accomplished by pulsing the chambers in a transmission line mode. Digitization is obtained by means of magnetostrictive lines located inside the magnet and shielded from the ten kG field.

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A computer code - PITRACK - has been developed to provide us with automatic pattern recognition capability. It was written in Fortran IV and requires 77K octal words on a CDC 6600 computer. Reconstruction time depends strongly on prong number N and can be parametrized by

$$t\ (\text{CP sec}) = .4 + .04N^2$$

An 8-prong event-as found by PITRACK-is displayed in Fig. 2. The reliability of PITRACK was evaluated by scanning a sample of events in the following way: An event's digitizings were displayed an a screen with the "PITRACK - solution" superimposed. The scanner - by examining the event in various perspectives - either verified or improved upon the solution. 94% of all tracks were found to be correctly associated by PITRACK, among them 3% required small modifications like addition or deletion of one or two digitizings. Among the 6% of unassociated tracks are program failures and some effort will be made in the future to reduce that number. 1% of the associated tracks were found by the scanner to be spurious. To evaluate the hardware efficiency of the spark chambers we have PITRACKED a sample of events, calculated the number of sparks expected for each track and compared it with the number of sparks actually found. The sample was then broken up according to number of prongs. The result of this analysis is shown in Fig. 3. Efficiencies so calculated could possibly be biased by the fact that the track has to be found first before the efficiency gets computed. We have therefore checked our efficiency in two ways, both independent of track reconstruction:

1. We have tracked back from one of the external magnetic spectrometers into the VS and asked the question, how often a so predicted digitizing was present. The answer is 96.5% for events with an average prong number of 5.

2. We have selected events and predict from the information on the fast forward proton detected in one of the external magnetic spectrometers where the recoil proton has gone. This 2 prong efficiency turns out to be 99.7%. The fact that this efficiency is slightly higher than the one in Fig. 3 can be attributed to the non-minimum ionization of the particle.

The angular resolution of the VS has been evaluated and found to be ± 1 mrad in dip angle; in azimuthal angle the resolution is ± 1 mrad for forward going tracks and ± 6 mrad for sideward going tracks.

The fact that the VS operated in a magnetic field enabled us to use charge conservation to study and correct for missed tracks. The analysis showed that the total number of tracks lost amounts to 17% being caused by particles escaping up-down or backwards, particles stopping in the target, software inefficiencies as mentioned earlier etc.

Most losses of particles can be corrected for on an event by event basis using charge conservation; losses of two particles of opposite charge were determined from the known losses of two particles of equal charge and corrected for in an overall way.

The question arises how close such a corrected PITRACK multiplicity comes to the "true" multiplicity. The most crucial and conclusive test is to compare our average charged multiplicity and the multiplicity distribution with the one of the bubble chamber under as similar conditions as possible. We have carried out such a comparison by taking our small momentum transfer data in 28.5 GeV/c pp collisions and confronting them with bubble chamber data at the same energy. Since our acceptance cut off the high missing mass end of the spectrum, we have made a similar cut on the bubble chamber data. For missing masses between 2.0 and 3.0 GeV/c the bubble chamber mean charged multiplicity was found to be $\overline{N}_{BC} = 3.65 \pm .10$ while ours was $\overline{N}_{VS} = 3.83 \pm .04$. The multiplicity distributions are shown in Fig. 4. We attribute the ~ 5% difference to undetected secondary interactions in the hydrogen target, gamma conversion close to the vertex, etc. We have also compared with the bubble chamber the number of 4C fits we get from four prong events. The number turns out to be ~ 10% in both instruments.

In conclusion we want to state that we have designed, built, made operable and used in a high energy experiment the first fully automatic, triggerable almost 4π magnetic vertex spectrometer; this system detects, reconstructs and momentum analyzes multiparticle final states with high efficiency.

Figure Captions

Fig. 1 Spark chamber assembly forming the VS (bottom) and individual chamber (top); in the background the ARCO magnet.

Fig. 2 8 prong event reconstructed by PITRACK. Top view.

Fig. 3 Spark chamber efficiency vs. multiplicity.

Fig. 4 Charged multiplicity distributions
Top: Data from the VS of MASS
Bottom: Data from BC
$2.0 \leq MM \leq 3.0$ GeV in both sets of data.

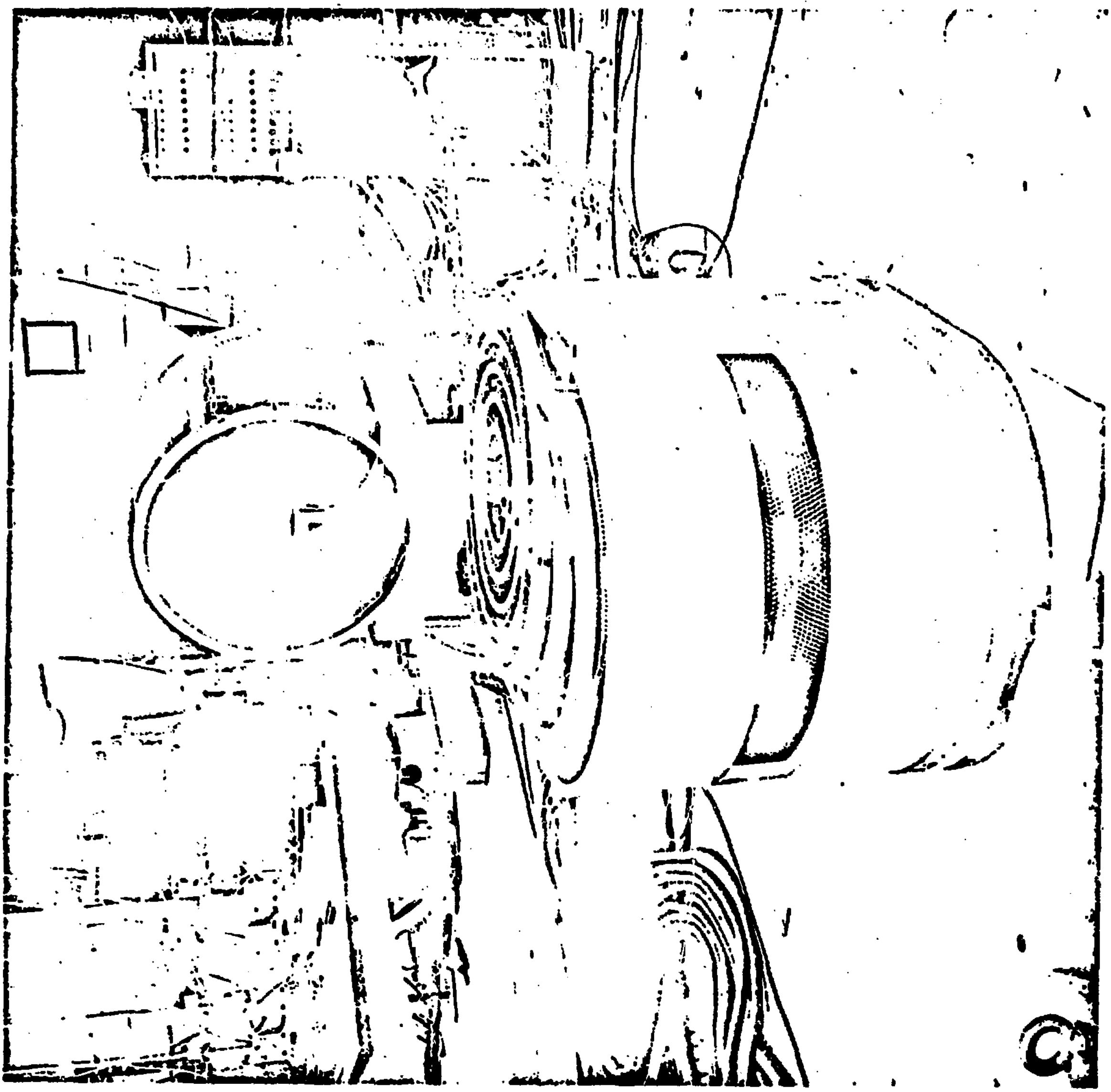

Fig. 1

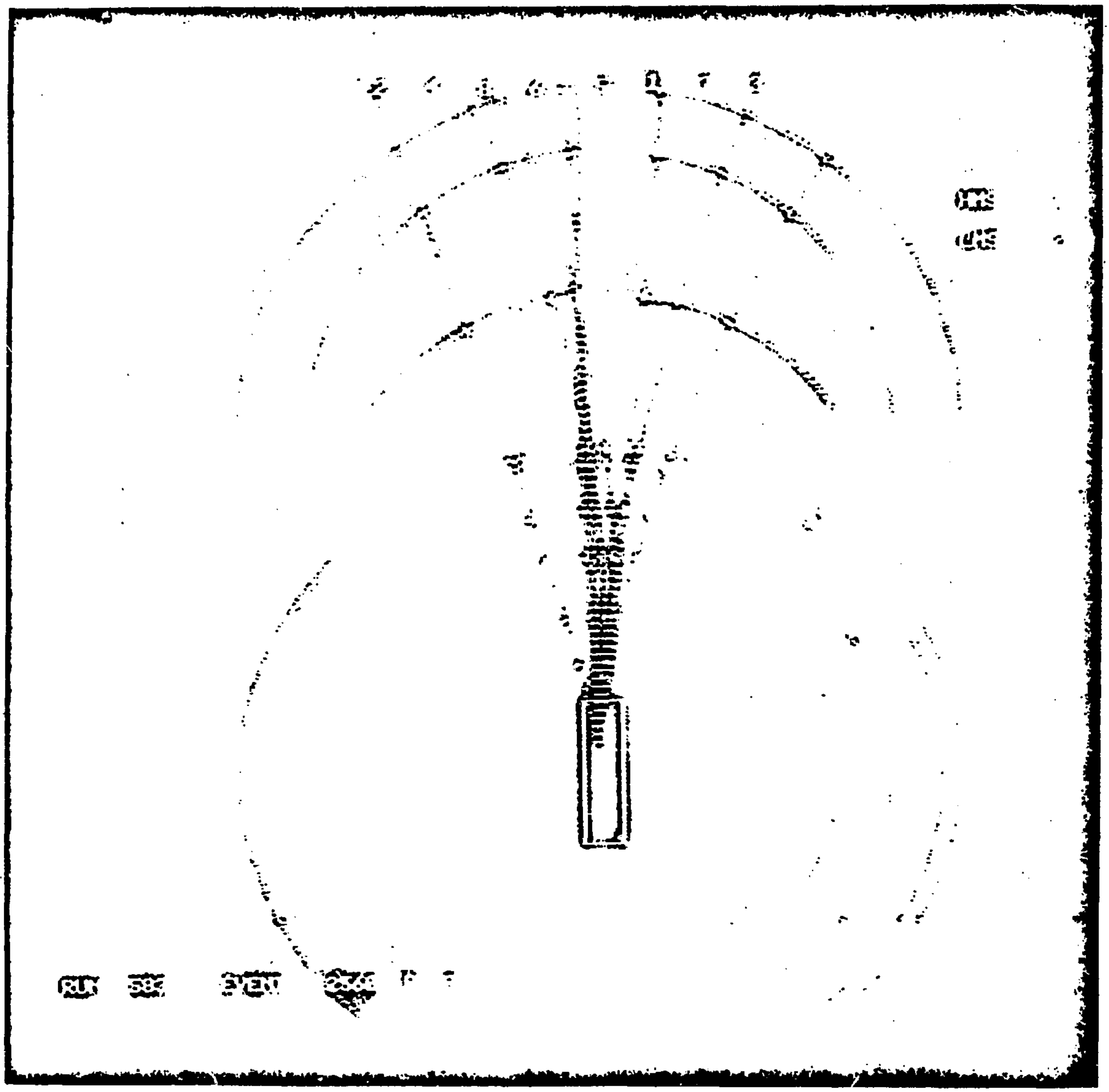

Fig. 2

ARGO CHAMBER EFFICIENCY
(INTEGRATED OVER THE 6 FULL ROUND CHAMBERS)

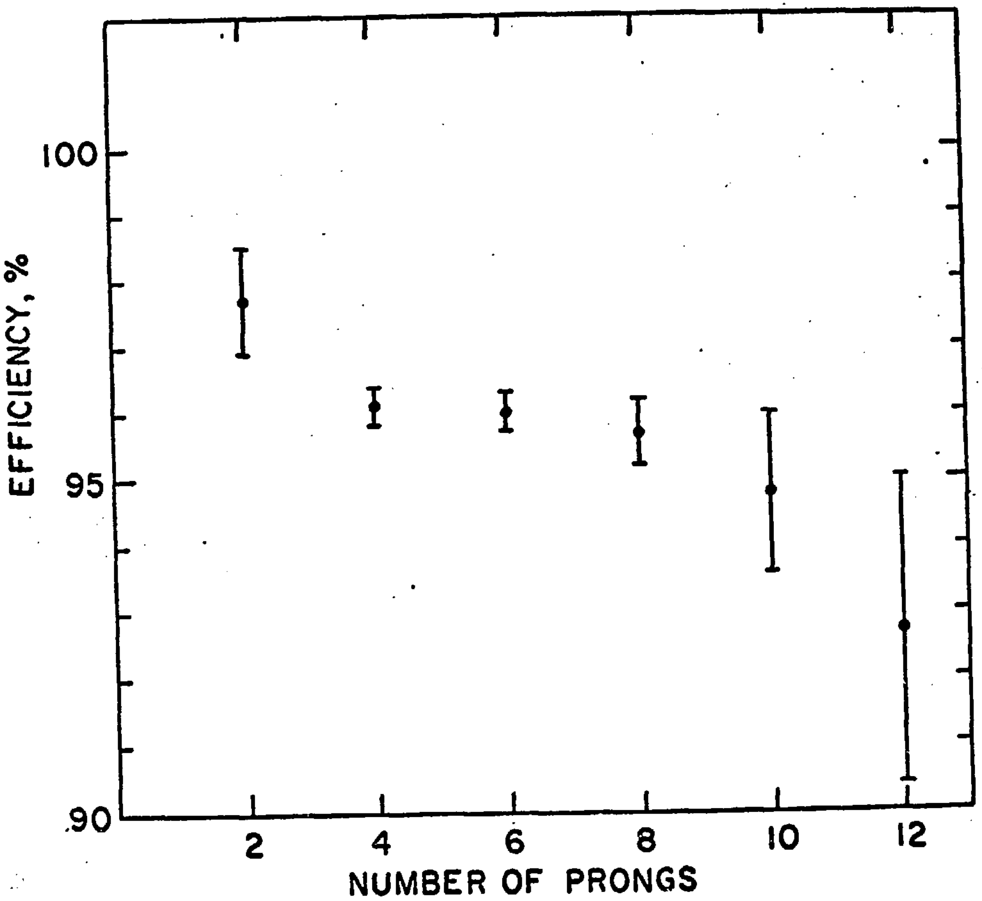

Fig. 3

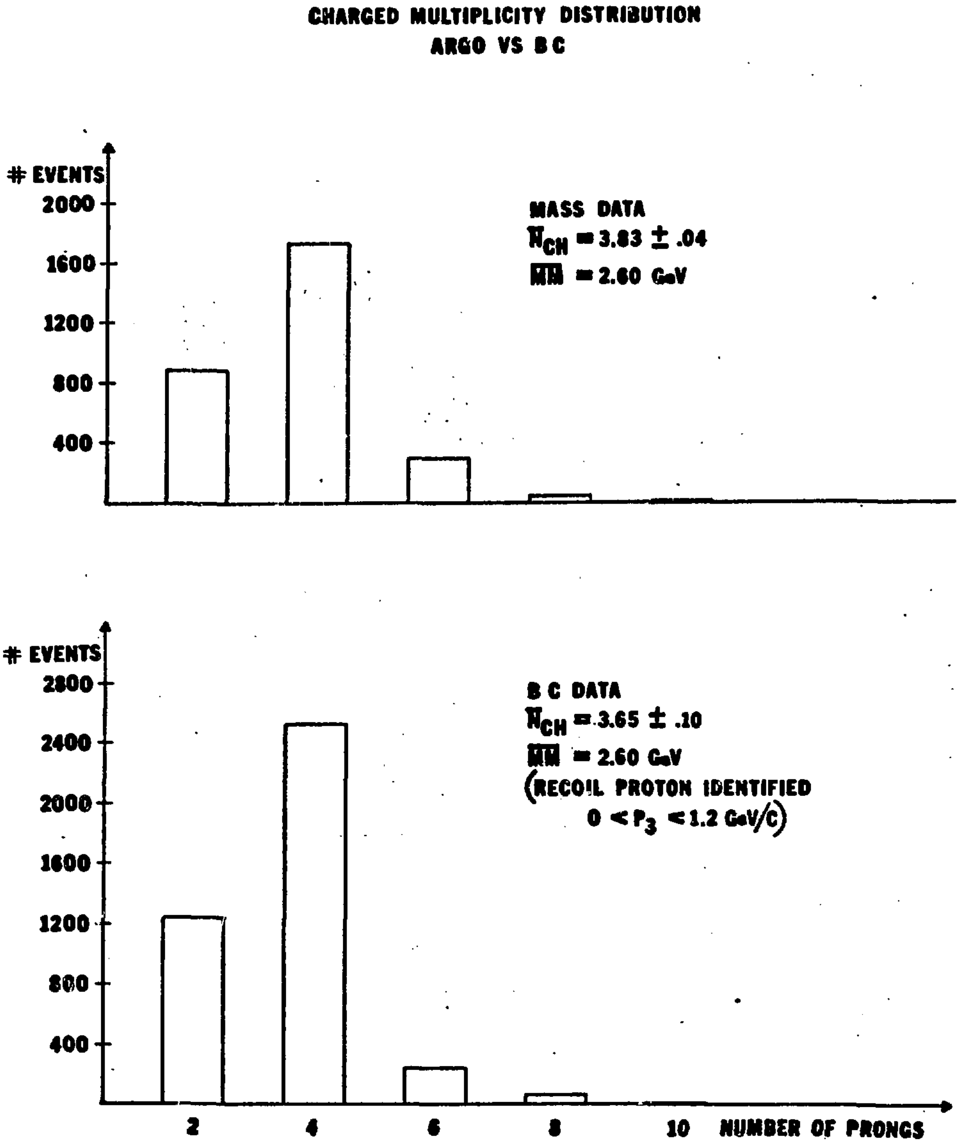
CHARGED MULTIPLICITY DISTRIBUTION
ARGO VS B C
EVENTS
2000
1600
1200
800
400
MASS DATA
$\bar{N}_{CH} = 3.83 \pm .04$
$\overline{MM} = 2.60$ GeV
EVENTS
2800
2400
2000
1600
1200
800
400
B C DATA
$\bar{N}_{CH} = 3.65 \pm .10$
$\overline{MM} = 2.60$ GeV
(RECOIL PROTON IDENTIFIED
$0 < P_3 < 1.2$ GeV/C)
2
4
6
8
10
NUMBER OF PRONGS

Fig. 4