The Axial Field Spectrometer Collaboration (AFS)

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DISCLAIMER

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OPERATION OF THE AFS AT L = 1.4 x 10^{32} cm^{-2} sec^{-1}: A FIRST LOOK AT DATA AT HIGH LUMINOSITY FROM THE CERN ISR

The Axial Field Spectrometer Collaboration

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In December 1982 a run was made at the CERN ISR which utilized the superconducting low beta quadrupoles in intersection I8 at the ISR and achieved a luminosity of 1.4 x 10^{32} cm^{-2} sec^{-1} for 26 x 26 GeV pp collisions. At this luminosity the mean time between inelastic collisions is about 200 ns. A comparison run was also made at the same energy with a luminosity of 3.0 x 10^{30} cm^{-2} sec^{-1}. The luminosity under normal running conditions is typically 1.5 x 10^{31} cm^{-2} sec^{-1}. Data were collected with the Axial Field Spectrometer with a variety of calorimeter triggers. The calorimeter is a uranium-scintillator sandwich type with wavelength shifter readout[1] and covers the polar angle range 50° < θ < 130°. The shaping amplifiers used in the trigger have an integration time of 60 ns and the ADC gate for the photomultiplier signals has a length of 120 ns. The triggers ranged from a non-selective total transverse energy trigger (E_{TOT}) to more selective jet and single particle triggers. The jet trigger summed the transverse energy in an azimuthal range $\Delta\phi \approx 45°$.

We have compared several trigger rates at the two luminosities to see if the observed rates scale with the luminosity. This is given below for three different triggers as the ratio of the trigger rates divided by the luminosity for the two runs.

Trigger	$\frac{\text{Trigger Rate at } L_{high}/L_{high}}{\text{Trigger Rate at } L_{low}/L_{low}}$
Total Energy (E_T > 28 GeV)	4
Jet (E_T in a limited region > 9 GeV)	1.5
Two Electromagnetic Single Particle Clusters (E_{spc} > 4 GeV)	1.0

The high relative rate for the E_{TOT} trigger shows that this type of trigger is particularly sensitive to triggering on pileup events. The more selective localized energy triggers are much less sensitive to pileup and scale more closely with the luminosity.

A large fraction of the pileup events were identified with the use of the timing information from two arrays of 15 1/2 x 15 1/2 cm^2 scintillation counters surrounding each outgoing beam pipe. There are 39 separate counters in each array. After time slewing corrections the RMS time resolution for these counters is 0.7 ns. An algorithm was developed to recognize double events by first pairing counters whose time was within 3 ns for pairs within one array, or within 4 ns for a pair with one hit in one array and one in the other. Then the RMS for the mean time for the pairs was calculated from the times of all counters which were included in such pairs. A large value of this RMS indicates the presence of a double event. The fraction of triggers which were identified as double or multiple events for the E_{TOT} and jet trigger are listed below, along with the fraction found for an inelastic minimum bias trigger at normal luminosity.

Hi L E_{TOT}	66%
Lo L E_{TOT}	7%
Hi L Jet	28%
Lo L Jet	4%
Minimum Bias, Normal L	4%

These numbers suggest a lower pileup rate than would be calculated from the previously mentioned numbers since 1) not all inelastic events have hits in the counters which were used and 2) only those times within ± 17 ns of the event time were included in the analysis. Since the window for double events is approximately one half of the shaping amplifier integration time, we can estimate the expected ratio of the trigger rates by doubling the observed rate of pileup events. By this method, we obtain the values of 4.5 and 1.7 for the E_{TOT} and jet triggers, respectively. This procedure could be used to remove most of the pileup events from the high luminosity data. The timing information from elements of the barrel hodoscope and calorimeter could also be used in this manner to signify out of time events. In the case of jet and single particle triggers we expect the rate of clean events to scale roughly with the luminosity, while for the E_{TOT} trigger the fraction of events which must be rejected due to pileup may outweigh the gain due to the increased luminosity.

As an initial step we have analyzed the data from the two luminosities with a minimal number of cuts in order to see if it is possible to extract the same physics from the high luminosity data as from the low luminosity. For this we have chosen the jet trigger data where we expect a clean signature for the events. We attempted an analysis with the central drift chamber, but unfortunately the data suffered from a hardware readout problem unrelated to the higher luminosity. Therefore, after a short review of the chamber performance, we will concentrate on the analysis of the data from the 2π calorimeter.

Drift Chamber

The drift chamber was operated at reduced gain for the high luminosity run in order to maintain the chamber current at its nominal value. The wire layers at small radius, which received the highest flux, were operated at 18% of their normal gain, while the outer wire layers were operated at 80 - 100% of their full gain. We found the drift velocity remained unchanged at its normal value of 52 mm/ns. We were able to use our standard calibration programs with only a slight modification and calculate a position resolution for tracks found in the chamber. This increased to 320 μ per point from its normal value of 220 μ. The average number of found tracks per event was 15.7 for the high luminosity data, compared with 14.4 for the low luminosity. The average track length was 30.1 cm for the high luminosity compared with 37.6 cm for the low luminosity. The most difficult problem with the drift chamber data was a malfunction in one of the discriminator crates which rendered one quarter of the chamber inoperative for both luminosity runs. Mainly because of this we decided not to follow through with a physics analysis of the drift chamber data at this time.

Calorimeter

We compared the P_T distribution of energy clusters found in the uranium calorimeter for the two lumimosities for the jet triggered data. A description of the cluster finding algorithm can be found in Ref. 2. In order to set an upper limit on the effect of pileup events, we made no explicit cuts to eliminate multiple events. Fig. 1 shows the P_T distribution of the clusters appropriately normalized using the integrated luminosities of the two runs. At low P_T, there is an excess of clusters found in the high luminosity data as one would expect from the overlap of an extra inelastic event with a true jet event. However, at higher P_T ($P_T \gtrsim 5$ GeV/c) there is reasonable agreement between the two spectra. Above $P_T \approx 15$ GeV, there is a contribution from cosmic rays, particularly in the low luminosity data, as we have seen before in other low luminosity runs.[3] Rejection of cosmic ray background requires the data from the drift chamber. When the requirement that high P_T charged tracks from an event vertex point to the calorimeter jet is imposed, the cosmic ray background will be substantially reduced.

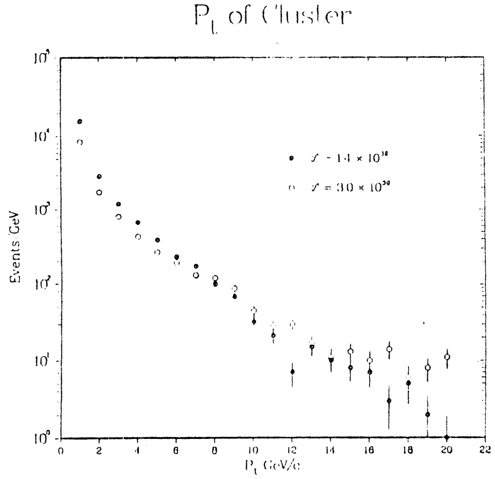

Fig. 1. P_T distribution of clusters in the AFS calorimeter at high and low luminosity.

We have also defined jets using the clusters according to a simple algorithm in order to compare the jet P_T distribution. A thrust direction was found which maximized the quantity $\sum_i \hat{T}\cdot\vec{P}_T^i/E_{TOT}$, where $\hat{T}$ is the thrust direction, $\vec{P}_T^i$ is the transverse momentum of each cluster within $\Delta y = 1/2$ and $\Delta\phi = 45°$ of $\hat{T}$ and E_{TOT} is the total energy. Once this direction was found the P_T of the clusters within $\Delta y = 1/2$ and $\Delta\phi = 45°$ of $\hat{T}$ were summed to define the P_T of the jet. Fig. 2 shows the P_T distribution of jets defined in this way for the two luminosities. Again the data have been normalized using the integrated luminosities and no cuts have been made to eliminate multiple events. One can see that above the trigger threshold ($P_T \gtrsim 10$ GeV/c), the two sets of data agree reasonably well. Below the trigger threshold there is an excess of events in the high luminosity data as one would expect from the overlap of a low P_T event with a high P_T event slightly below the threshold causing the trigger. Again, at the highest P_T there is a contribution from cosmic rays.

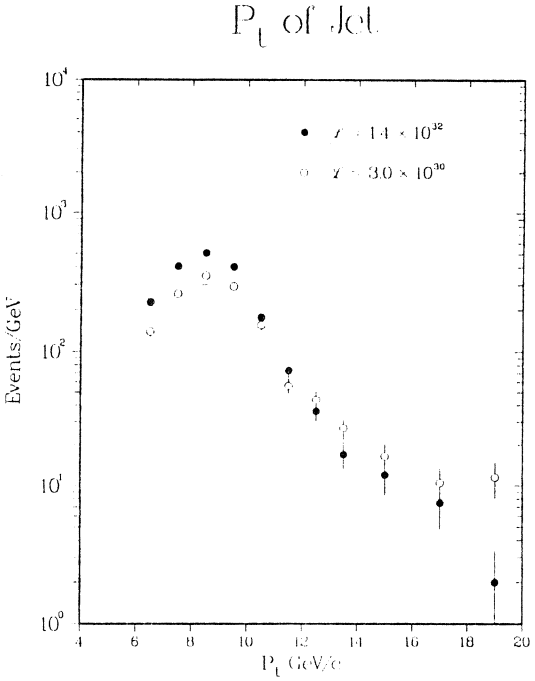

Fig. 2. P_T distribution for jets in the AFS calorimeter. See text for details.

In conclusion, we found that selective triggers such as jet or single particle triggers work well at a luminosity of 1.4×10^{32} and do not suffer severely from triggering on pileup events. In fact, the two single particle triggers will probably not be susceptible to pileup at even higher luminosity, allowing the search for high mass e^+e^- states, for example. Less selective triggers such as the total transverse energy trigger are sensitive to pileup and contain a large fraction of triggers due to the overlap of two lower E_T events. We found that our drift chamber was able to operate in a high luminosity environment and its performance was not seriously degraded. This is notable since the chamber was not designed for such high luminosity. The maximum drift time at the outer radius is 560 ns. With more closely spaced wires, the performance at high luminosity would be improved. We were able to compare the P_T spectrum of clusters and jets found in the calorimeter and found that while pileup events affected the number of events at low P_T due to our trigger definition, the spectra agreed at high P_T.

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References

1. H. Gordon et al., Nucl. Instr. & Meth. 196, 303 (1982).
2. T. Akesson et al., Phys. Lett. 118B, 185 (1982).
3. T. Akesson et al., Phys. Lett. 121B, 439 (1983).