Chapter 3

Data Collection and Processing

One may imagine two general techniques for searching for new particles. One of these is to look for a dramatic signal not expected from known physics, without specification of a model for the cause of the deviation being required. The other is to consider a given model, and to see what signatures it predicts that are inconsistent with known physics. Because of the subtlety of the signature involved a search for gluinos and squarks falls of necessity into the latter class.

3.1 Squark and Gluino Event Signature

The cascade decay of gluinos and squarks can produce, in the final state, a large number of quarks and gluons. Their pair production always produces a pair of LSPs. Thus squarks and gluinos are seen in the detector as jets produced by the quarks and gluons and as an imbalance of the transverse energy distribution, called missing transverse energy ($\not{E}_T$), caused by the nonmeasurement of the LSPs. Thus a signal for which one may look is multiple jets and $\not\!\!E_T$.

3.2 Triggering

The data used in this analysis were collected during the August 1992—May 1993 run of the Tevatron (Run IA); this was the inaugural run of the DØ detector.

Several triggers were used to collect the data for this analysis. Each trigger required some combination of $\not\!\!E_T$ and jets, and during the course of the run, each was implemented with several different thresholds. We label the trigger MISSING_ET if there is no Level 2 jet requirement, and JET_MISS if there is a Level 2 jet requirement. The complete specification of these triggers, and the corrected integrated luminosity collected by each, is given in Table 3.1. The luminosity corrections are explained in sections 5.1.1 and 5.1.2. The codes used for describing the Level 1 trigger specifications are the following:

- **JT**(n, x) Requires at least n trigger towers with $E_T \geq x$ GeV,
- **MS**(x) Requires $\not\!\!E_T \geq x$ GeV,

and for Level 2:

- **L2J**(n, x, r) Requires at least n jets with $E_T \geq x$ GeV, using a cone jet algorithm with radius r,
- **L2MS**(x, s) Requires $\not\!\!E_T \geq x$ GeV and $\not\!\!E_T$ significance $\geq s$.

Config. name	MISSING_ET specification	JET_MISS specification	$\int \mathcal{L}\, dt$ (pb^{-1})
A	JT(1,3) + MS(35) L2MS(40,0)	JT(1,7) + MS(20) L2J(1,30,0.3) + L2MS(20,5)	0.148
A2	JT(1,3) + MS(35) L2MS(40,0)	–	0.045
B	JT(1,3) + MS(30) L2MS(40,0)	JT(1,7) + MS(20) L2J(1,30,0.3) + L2MS(20,5)	0.057
B2	JT(1,3) + MS(30) L2MS(40,0)	–	0.994
C	JT(1,3) + MS(30) L2MS(40,0)	JT(1,7) + MS(20) L2J(1,30,0.3) + L2MS(25,0)	0.824
D	JT(1,3) + MS(30) L2MS(35,0)	JT(1,7) + MS(20) L2J(1,20,0.5) + L2MS(25,0)	1.177
D2	JT(1,3) + MS(30) L2MS(35,0)	–	0.345
E	JT(1,3) + MS(30) L2MS(35,0)	JT(3,5) + MS(20) L2J(3,20,0.5) + L2MS(25,0)	4.143

Table 3.1: The trigger configurations used in this analysis and their associated integrated luminosities.

The $\not\!\!E_T$ significance is defined as the ratio of the $\not\!\!E_T$ for the event divided by the estimate of the $\not\!\!E_T$ resolution for the event, as determined from the total scalar E_T of the event [25].

3.3 Data Processing

In the DØ online cluster, data is written to two *online streams*; these data streams are written to different series of tapes, to allow faster handling of a small subset of the whole event sample. These streams are the *Express* (EXP) stream and the *All* (ALL) stream. The EXP stream comprises a select set of triggers, and represents about one tenth of the full data sample. The ALL stream, as the name indicates, includes all the events taken including those sent to the EXP stream. The triggers used for this analysis were not included in the EXP stream.

3.3.1 Event Reconstruction

The online streams consist of event in the raw data format. This format contains digitized values that describe the response of the individual detector elements rather than the physical quantities, such as particle momenta, we wish to measure. A complex FORTRAN program, DØRECO, is used to translate the raw data into such things as calorimeter energy deposits or hit locations on wires, and then to analyze these to produce physics objects such as jets, electrons, muons, and $\not\!\!E_T$. The reconstruction of jets and $\not\!\!E_T$ are described in detail in Chapter 4.

The ALL stream events were reconstructed on a farm of Silicon Graphics computers. In this analysis, we use the results of DØRECO v10, the first version to be used on the complete Run IA data sample. Because of the large number of events (13 million in Run IA) and because of the large size (about 20 kilobytes) of even our 'small' format Data Summary Tape (DST) events, it was not possible to store all the Run IA events on disk. Therefore, after reconstruction, the events were further filtered and segregated into *offline* streams. The RGE stream, which consisted of events passing one or more of a large array of offline filters, was stored on disk on the DØ file server cluster. One of the filters which contributed to this sample (called the SQGL filter) was constructed specifically for the collection of gluino and squark signal events. Later developments in the run made the retention of the complete RGE sample impractical; a further filtering and streaming of the events was then done. One of the filters used in this process (the SSY filter) was constructed for the retention of gluino and squark events.

3.3.2 Filtering

The SQGL and SSY filters were designed to keep the efficiency for the gluino and squark signal as high as possible, while reducing the rate to acceptable levels. To this aim, each filter was designed both to require a 'softened' version of the signal characteristics and to reject a major source of background.

The main background sources rejected by the SQGL and SSY filters were noise due to discharges in the calorimeter cells and energy deposits from particles associated with the Main Ring, which passes through the outermost (Coarse Hadronic) layer of the calorimeter. Both of these sources can produce 'jets' which are not associated with particles from an interaction. Although rare when compared to the rate of production of real jets, such jets produce $\not\!\!E_T$ in direct proportion to their E_T. Thus the $\not\!\!E_T$ trigger sample is highly enriched in such events.

To reject these events, the most basic technique used took advantage of the segmentation of the DØ calorimeter by considering the longitudinal profile of each jet. We considered the fraction of the total jet E_T which was contained in the electromagnetic calorimeter; this fraction is call the *electromagnetic fraction*, or EMF, of the jet. Jets with very high or very low EMF are suspect. Rejection based upon the EMF of the jets has a second beneficial effect. Since electrons are seen in the DØ calorimeter as highly electromagnetic jets, the rejection of events with such jets is also an extremely efficient method of rejecting electrons, such as those present in the decay $W \to e\bar{\nu}$, one of the significant backgrounds to a search based on $\not\!\!E_T$. To enhance the rejection of QCD events with $\not\!\!E_T$ due to mismeasured jets, we also rejected events in which a jet was found to be nearly back-to-back in azimuth with the direction of the $\not\!\!E_T$. And finally, we rejected events containing an electromagnetic cluster that passed a loose electron shape cut. The details of the cuts in the SQGL and SSY filter are listed below.

The SQGL filter required

- $\not\!\!E_T > 25$ GeV,

- leading E_T jet must have EMF > 0.05,

and the SSY filter required

- $\not{E}_T \geq 25$ GeV,

- at least 3 jets with $E_T \geq 15$ GeV,

- 3 highest E_T jets must satisfy $0.05 <$ EMF < 0.90 and $|\eta| < 3.5$.

Furthermore, the SSY filter *rejected* any event with one or more of the following:

- a jet with E_T (uncorrected) > 15 GeV and $|\eta| \leq 3.5$ and EMF < 0.05;

- any of the 3 leading E_T jets with $|\delta\varphi_k - \pi| < \pi/64$;

- $\sqrt{(\delta\varphi_1 - \pi)^2 + (\delta\varphi_2)^2} < 0.25$

- an electron or photon candidate with $E_T > 20$ GeV and $\chi^2 < 200$.

where we define $\delta\varphi_k$ as the azimuthal angle between $\vec{\not{E}}_T$ and the jet k, with the jets labelled in order of decreasing E_T. The quantity χ^2 is determined using a covariance matrix technique [26, 27]. For electrons with $E_T > 25$ GeV the efficiency of the χ^2 cut has been measured as greater than 95% [28].

Runs in which one of the detector subsystems was known to have malfunctioned were excluded from this analysis. There was a total of 9625 MISSING_ET and JET_MISS triggers in the SSY event sample.