A SEARCH FOR MASSIVE GLUINOS AT A 20 TeV FIXED TARGET MACHINE

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We sketch an experiment to search for massive particles which decay into weakly interacting neutral particles. Specifically we consider the reaction

gluon + gluon → gluino + gluino

where the gluinos are massive and decay into a weakly interacting photino or goldstino and quarks. The signal for this reaction is quite distinctive.

- large missing energy carried by the photinos
- high transverse momentum due to the final state quarks
- no final state leptons.

This type of experiment is unique to a fixed target machine due to the possibility of containing the entire event with good calorimetric energy resolution and high efficiency lepton identification. In a hadron-hadron collider, in constrast to a fixed target machine, one expects a large fraction of the total energy to disappear down the beam pipes. In addition 4π lepton identification is difficult in colliders. The design we present is for a 20 TeV fixed target experiment to search for these rare events.

The gluino detector must:

- have large acceptance
- be short to minimize π and κ decays
- efficiently identify leptons
- measure event transverse momentum, (P_T).

The length scale of the spectrometer is set by the requirement that angles be measured well enough to determine transverse momentum. Typical position resolution in a hadron calorimeter at $\sim$50 GeV is 1 cm and improves slowly with energy. Both the signal and background processes are rapidly falling functions of P_T and a 10% mismeasurement of P_T will cause a factor of $\sim$2 increase in the background. If we assume this is acceptable we can calculate the length of the spectrometer using a typical angle (θ) of $1/\gamma$ for our high P_T events:

$$.1 = \frac{\delta\theta}{\theta} \simeq \frac{\Delta r}{r}, \quad r = \ell\theta$$

$$\theta_{TYP} = 1/\gamma = 10 \times 10^{-3} \text{ rad.}$$

$$\delta\theta = 1 \times 10^{-3} \text{ rad.}$$

$$\ell = \frac{\Delta r}{\delta\theta} = \frac{.01 \text{ meter}}{1 \times 10^{-3} \text{ rad.}} = 10 \text{ meters}$$

where:

ℓ = total length of the spectrometer before the calorimeter
Δr = radial impact point in the calorimeter
$\theta = \theta_{TYP}$ = typical angle of emission for high P showers ($1/\gamma$ cm).

We assume a hadron calorimeter with energy resolution limited by calibration to .5-1% and conventional electron and muon identification. A sketch of the spectrometer is shown in figure 1.

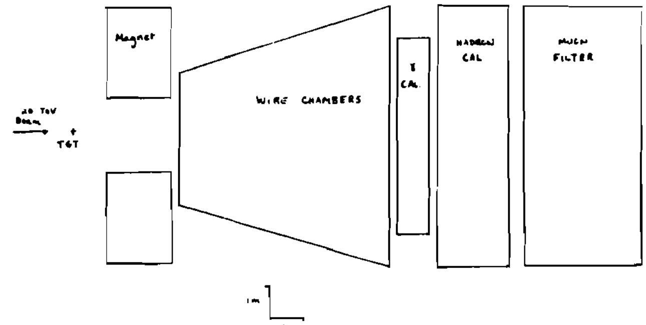


FIGURE 1
GLUINO DETECTOR

The system must be kept short of minimize missing energy due to pion and kaon decays. A 2 TeV pion has $\gamma c\tau$ of 113 x 10^3 meters.

The production cross sections for gluinos as a function of gluino mass are shown in figure 2. In our calculation we will make the simplifying assumption that the gluino is produced at x = 0 and that the undetected photino carries off approximately 1/3 of the gluino energy. In this approximation the missing energy as a function of gluino mass is:

Mass	<E missing>
10 GeV	600 GeV
15 GeV	900 GeV
20 GeV	1200 GeV
25 GeV	1500 GeV
30 GeV	1800 GeV

These events will contain 4 jets each with transverse momenta $\gtrsim$ 1/3 of the gluino mass.

The large missing energies combined with muon detection in the spectrometer virtually eliminate backgrounds from $\pi \to \mu\nu$ decay. Semileptonic decays of charmed particles can generate significant amounts of missing energy, especially if the charmed particles are at high X_F. Again, we can tag a good fraction of these events by identifying final state leptons. If, however, one is searching for massive gluino decays the high transverse momentum is an important feature of the interaction. The bulk of charm production is at moderate transverse momentum and will not simulate gluino decay. If we require both missing energy and high transverse momentum we expect that the primary background is a leading charmed particle produced in 2 jet events. We can then calculate the backgrounds using the known 2 jet cross sections.

We assume:

- Ten percent of two jet events have leading charmed particles.
- High energy electrons and muons are identified with 90% efficiency.
- A charmed particle must have a laboratory momentum $\gtrsim$2 x <E missing> to simulate gluino decay.

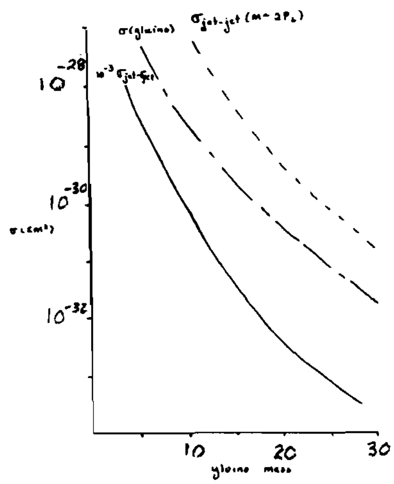
We then calculate background cross sections

$$\sigma(\text{false } \tilde{g} \text{ decay}) = \sigma(\text{jet } P_T > m/2) \times A \times B \times C \times D$$

where

A = Fraction of produced charm with energy greater than 2 x <E missing> .
B = Branching ratio for charm into leptons ∿.1.
C = Detection inefficiency for muons and electrons ∿.1.
D = Fraction of jets with "leading charm" ∿.1.

The cross section for the calculated background, as well as the gluino production cross section is displayed in figure 2.



CROSS SECTION FOR √s = 800 gluino production

It seems background rejections of 10^{-3} or more can be achieved.

This calculation is intended as an existance proof and not as a detailed analysis. In particular no consideration has been given to calorimeter resolution tails, lepton identification details, and careful analysis of the charm background. One may decide, for example, that electron identification is too difficult and simply subtract twice the muon background assuming μ - e symmetry. It is clear, however, that the constraints on this reaction are quite powerful and one can imagine looking for thresholds in missing energy or examining in more detail the 4 jet topology to further reject backgrounds.