Search for New Particles

Decaying to Two Jets

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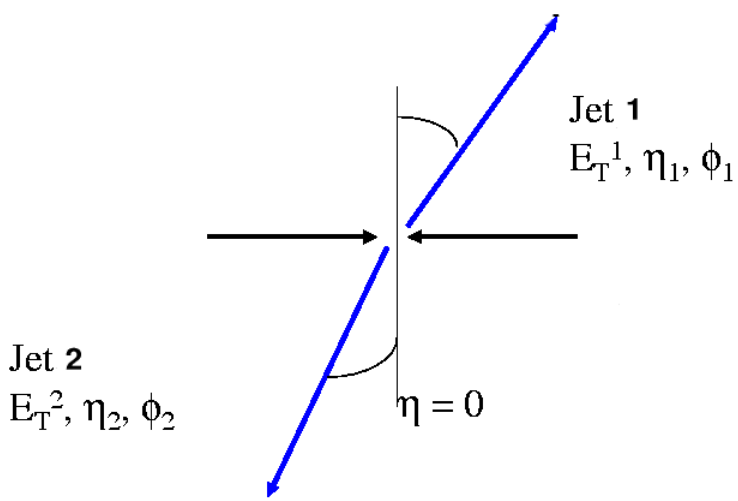
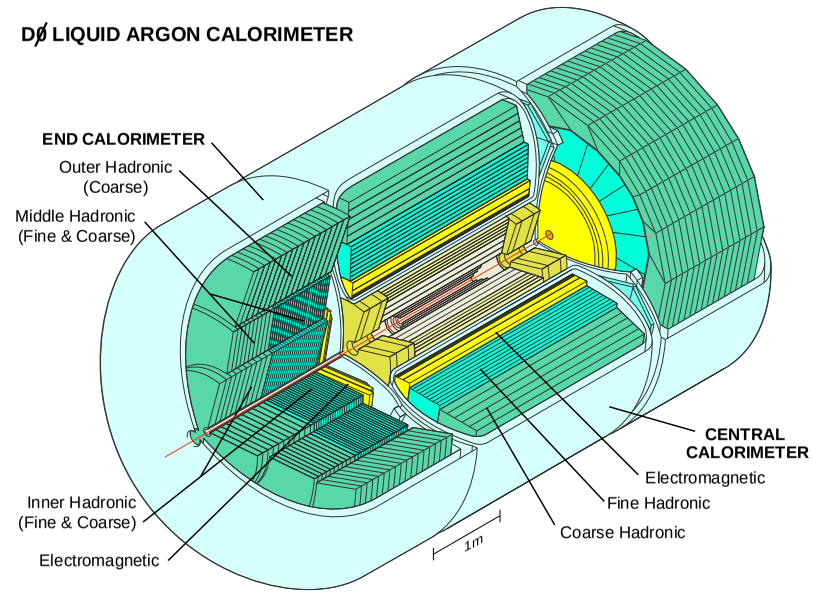
The DØDetector

- $M_{jj}^2 = 2 * E_{T_1} * E_{T_2} * (cosh(\Delta\eta) - cos(\Delta\Phi))$ (massless)
- E_T is the energy transverse to the beam. $E_T = Esin\theta$
- Pseudorapidity, $\eta = -ln(tan(\frac{\theta}{2}))$, the derivative of which is lorentz invariant, is used instead of θ.





- The DØ calorimeter measures the energy of "jets" produced from $p\overline{p}$ collisions at $(\sqrt{s}) = 1.8$ TeV
- $|\eta| < 4.2$
- Hadron resolution $\frac{0.15}{\sqrt{E}} + 0.003$

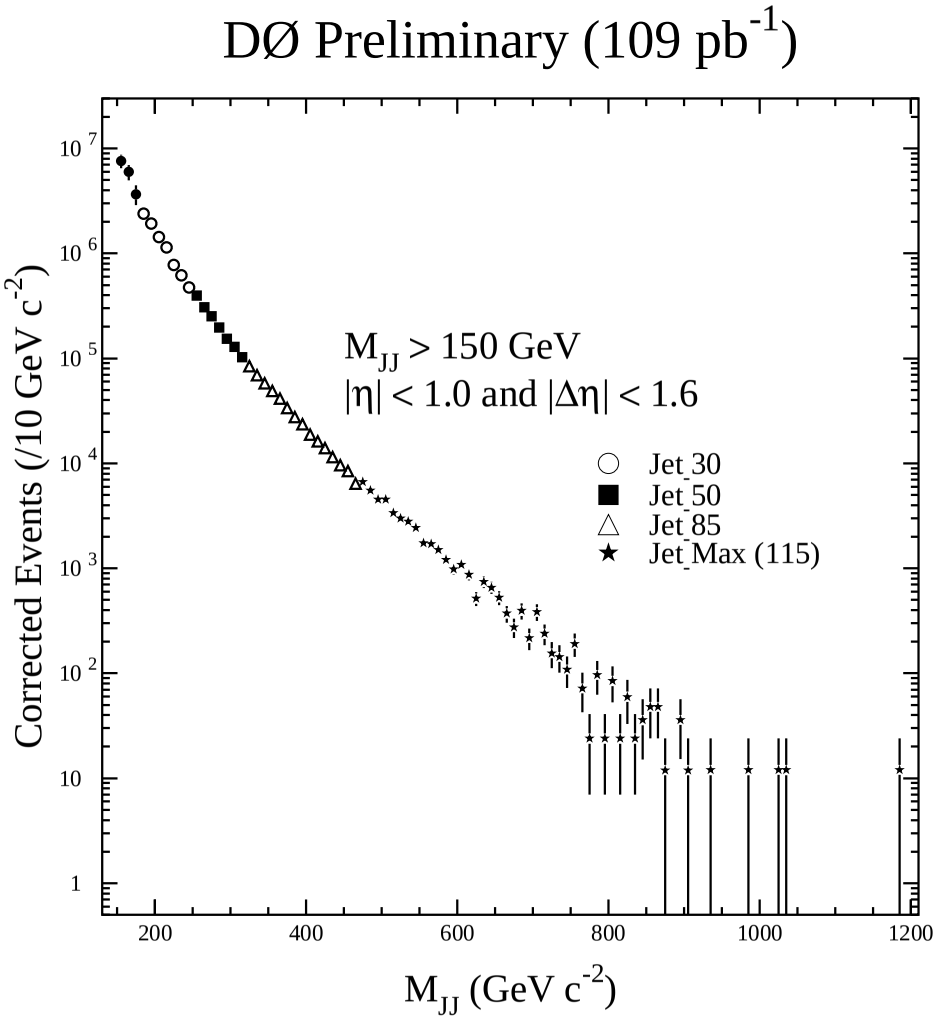


Figure 1: RunIa and b data, where corrected events $= \mathcal{L} \times \sigma \times acceptance$

Data Selection and Corrections

- Run Ia and Ib data, with a luminosity of 109 pb^{-1}.
- Cuts: $|\eta_{1,2}| < 1.0$ and $\Delta\eta = |\eta_1 - \eta_2| < 1.6$
- Standard Run I DØjet quality cuts and vertex cut efficiencies were used.
- Jet Energy Corrections (average corrections to jets) see Nuclear Instr. and Methods A424, 352 (1999).

Resolution Smearing of Simulated Signal and Background

The jet energy scale corrections make an average correction to the jets. Additional energy dependant corrections are needed.

Single Jet resolution

$$\frac{\sigma_E}{E} = \sqrt{\frac{N^2}{E^2} + \frac{S^2}{E} + C^2} \tag{1}$$

Applied to PYTHIA signal.

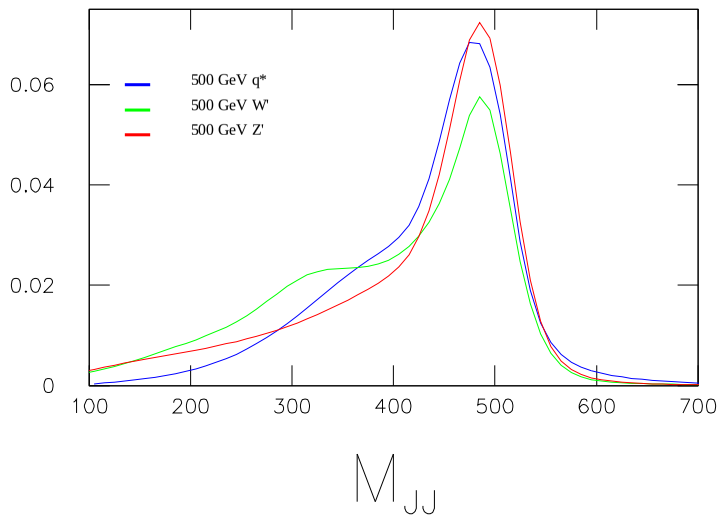
Dijet Mass Resolutions

Mass resolutions are determined by smearing every jet in a dijet Monte Carlo sample by the single jet resolution. Then the smeared(dijet mass)/unsmeared(dijet mass) is plotted and fitted with a gaussian distribution. The half width for each mass is plotted. The parameterized result follows:

$$\frac{\sigma_M}{M} = \sqrt{\frac{A^2}{M^2} + \frac{B^2}{M} + C^2 + D^2 M} \tag{2}$$

Applied to JETRAD background.

Signal Models



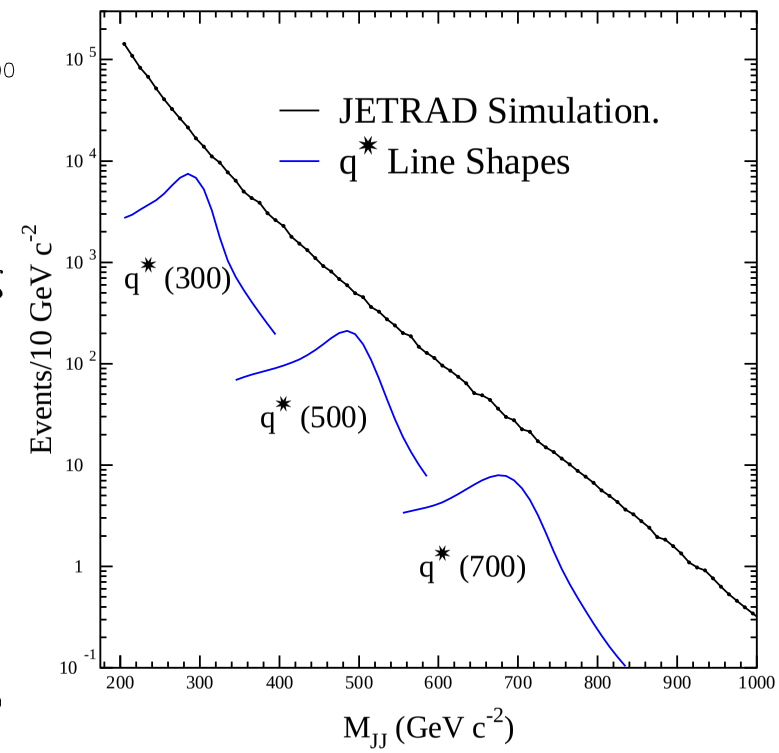
- The q* model was generated using PYTHIA for coupling constants $f = f' = f_s = 1.0$ and $\Lambda^* = M_{q*}$ (PYTHIA used for all signal)
- The Z' ($Z' \to q\overline{q}$) was allowed to decay into $d\overline{d}$, $u\overline{u}$, $s\overline{s}$, $c\overline{c}$, $b\overline{b}$ and $t\overline{t}$
- The W' ($W' \to q\overline{q}'$) was allowed to decay into $u\overline{d}$, $c\overline{s}$ and $t\overline{b}$.

Excited Quarks

$$q* \to qg(q = u, d) \tag{3}$$

$$\sigma = \frac{\pi^2 \alpha_s}{3\Lambda*} f_s^2 \tau \frac{dL^{qg}}{d\tau}, (\tau = \frac{M_{q*}^2}{s}) \tag{4}$$

Monte Carlo Simulation



Confidence Limits

The probability that N_i events were observed in a given mass bin is then given by (assuming that N_i follows a Poisson distribution):

$$P(N_1,\ldots,N_n|\sigma_{QCD_i},\sigma_X,N_{X_i},A,\mathcal{L},\epsilon_{vert},\omega_i,I) = \frac{e^{\mu_i}\mu_i^{N_i}}{N_i!} \qquad (5)$$

Applying Bayes' theorem to the left hand side of equation 5 yields:

$$P(\sigma_X|N_i,\sigma_{QCD_i},\sigma_X,N_{X_i},A,\mathcal{L},\epsilon_{vert},\omega_i,I;(i=1\ldots n)) \qquad (6)$$

- σ_{QCD} is the predicted JETRAD cross section
- A is a normalization factor for the QCD cross section
- N_{X_i} is the fraction of signal in the mass bin
- σ_X is the signal cross section
- ϵ_{vert} is the efficiency of the vertex cut
- ω_i is the event weighting based on the quality cuts
- I is all prior information

The confidence limit :

$$0.95 = \int_0^{U_L} P(\sigma_X)d\sigma \qquad (7)$$

Uncertainties

The uncertainties in the following values are taken care of by varying them randomly within a range of specified uncertainties over many iterations inside the confidence limit calculator.

- $\mathcal{L}$ for Run Ia and Run Ib
- Matching errors between Run Ia and Run Ib
- Matching errors between certain triggers
- Jet Energy Scale corrections, a correlation matrix is needed for these uncertainties.

Uncertainties on resolution smearing for generated signal and background are taken care of by generating a set of 61 curves that represent a sampling of smearings between $\pm 3\sigma$ and selecting the curves randomly during the confidence calculation.

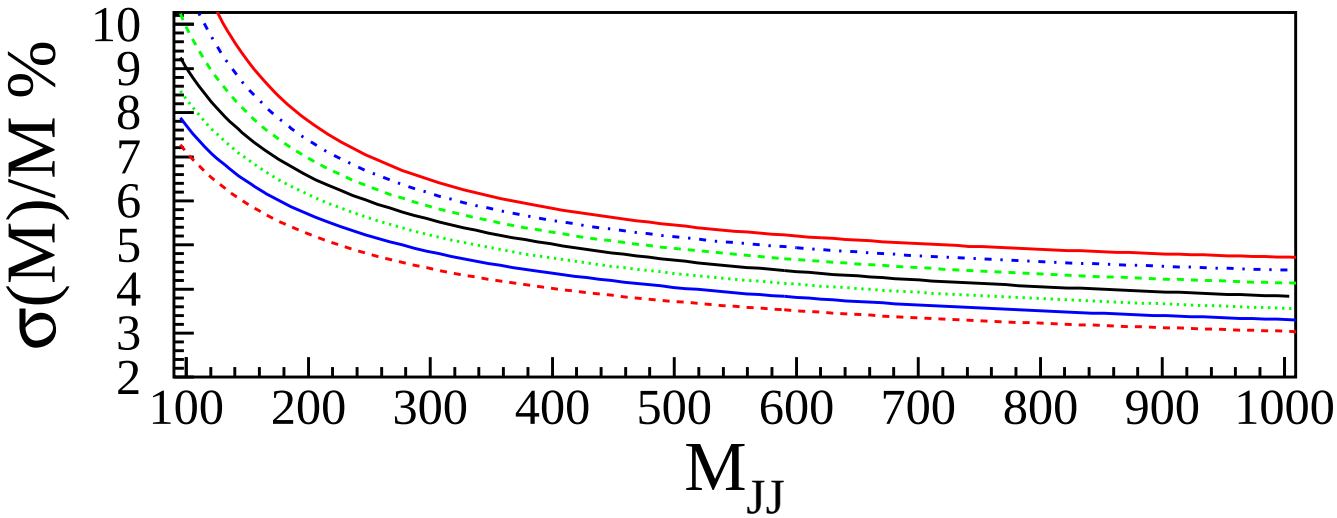


Figure 2: (Dijet mass resolutions)/M

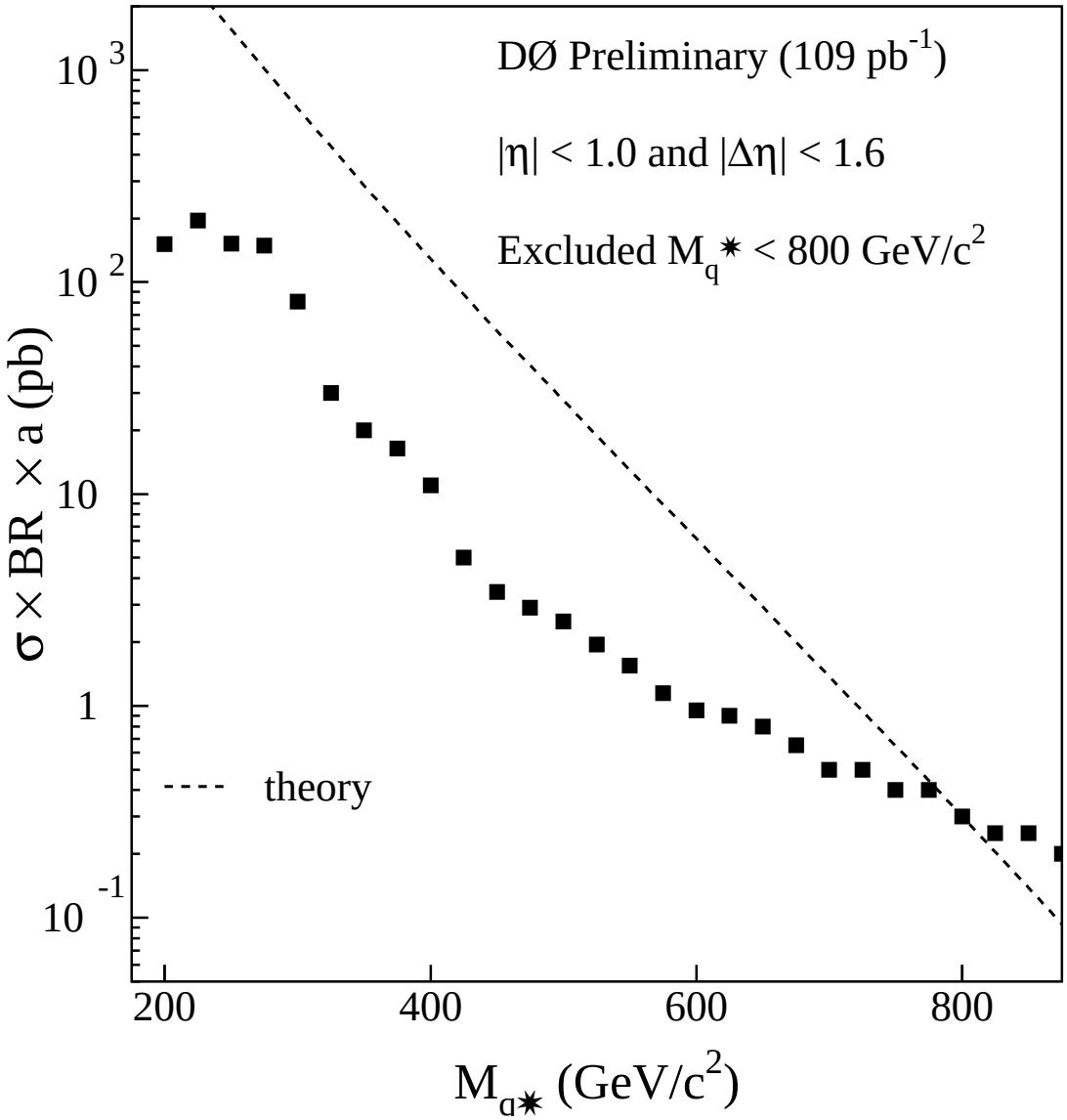


Figure 3: Comparison of q* 95 % confidence limits to theory, where $f = f' = f_s = 1$

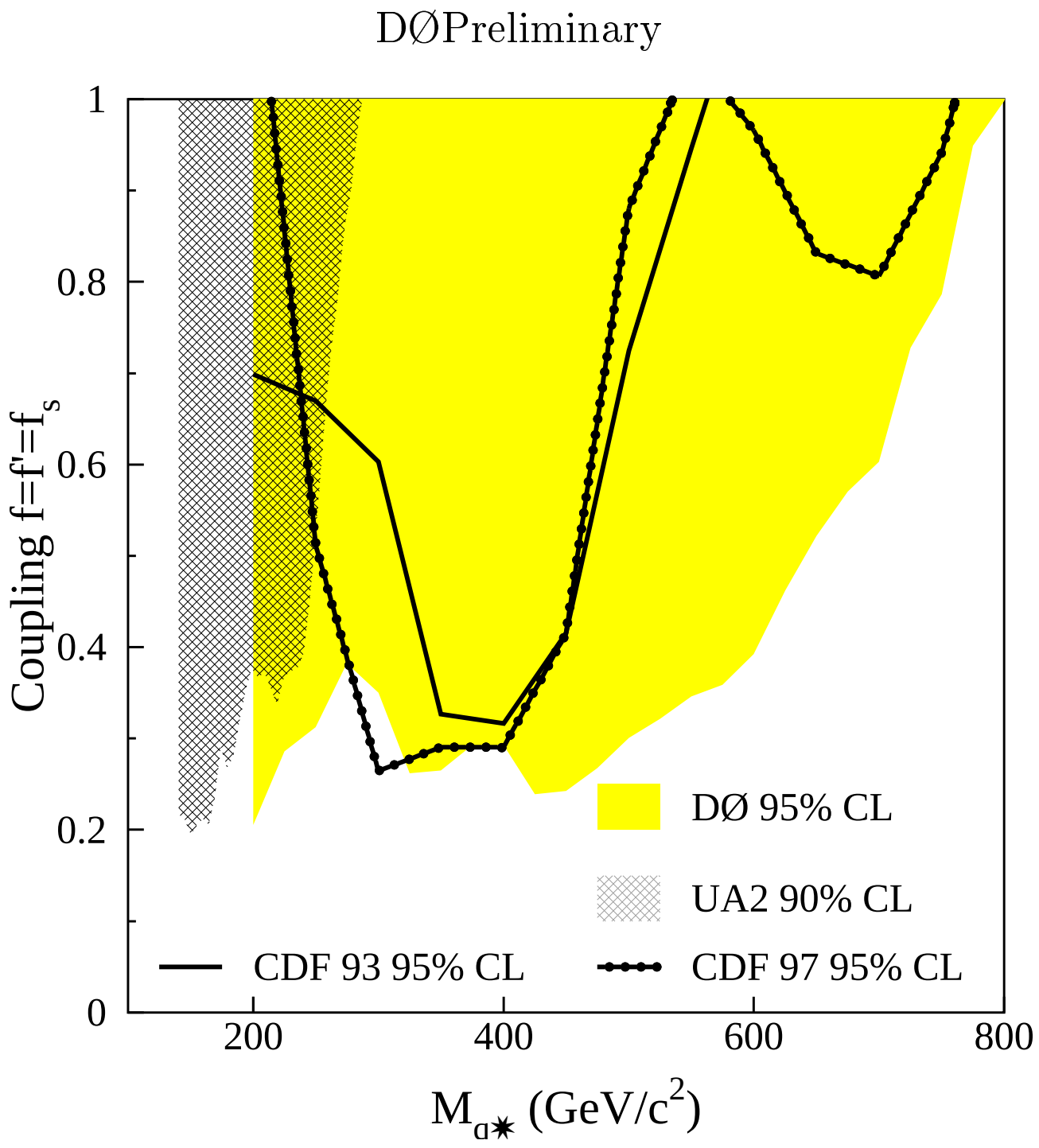


Figure 4: Comparison of limits for the excited quark model

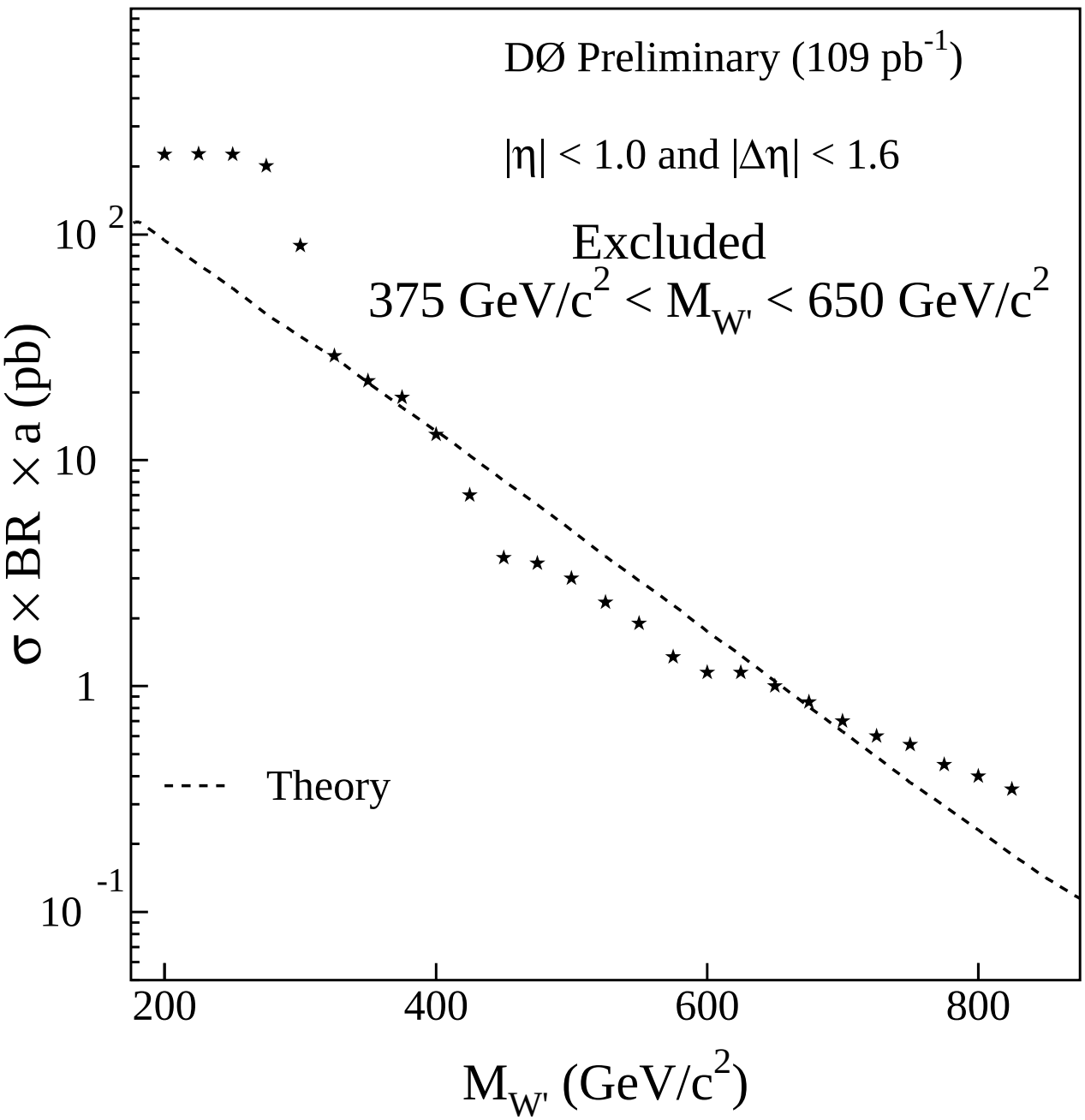


Figure 5: Comparison of W' 95 % confidence limits to theory

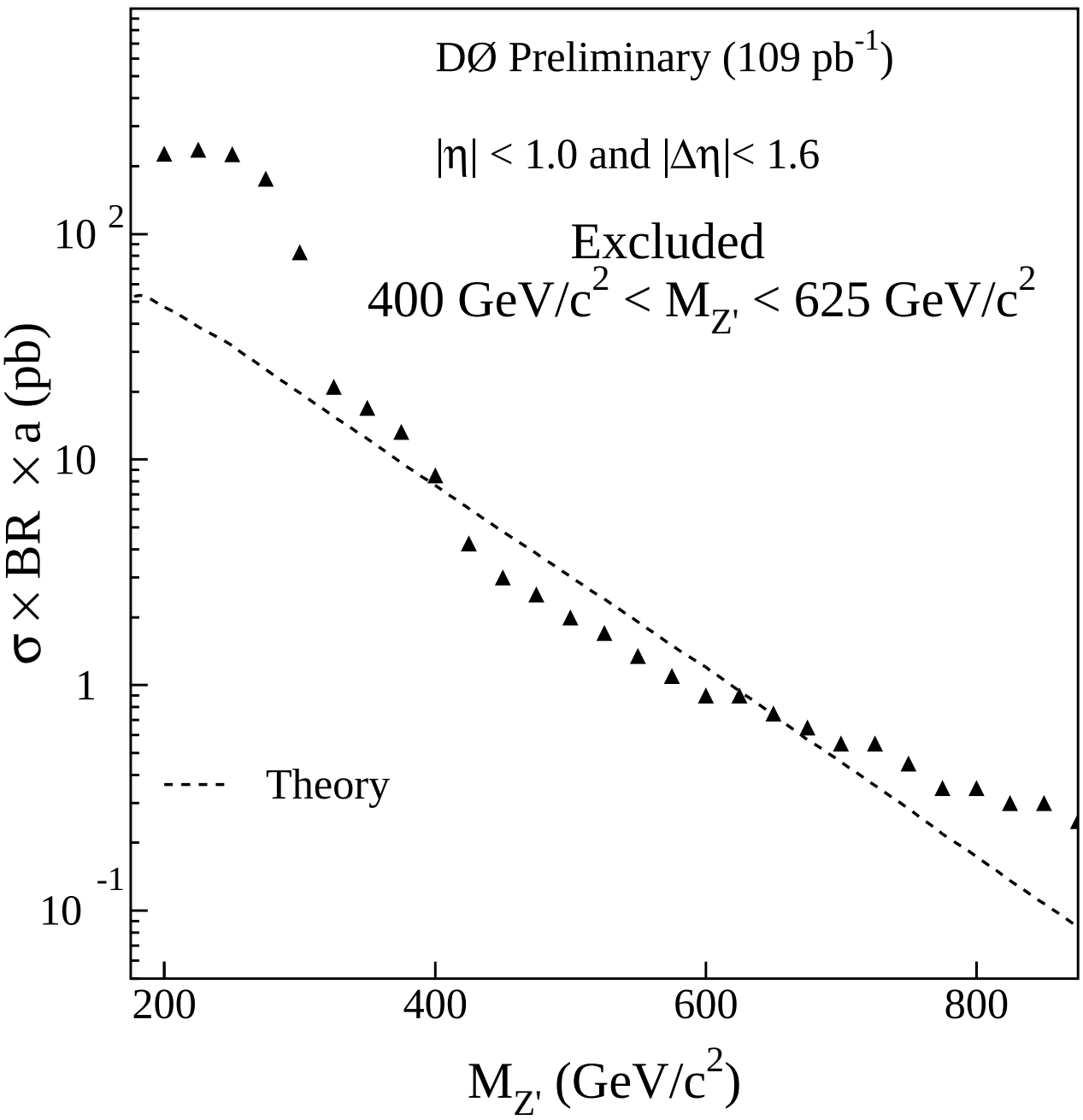


Figure 6: Comparison of Z' 95 % confidence limits to theory

Conclusion

Preliminary 95% confidence limits on the cross sections for various models have been measured. We see no evidence for new particles for the following regions and models:

- The q* model is excluded for $M_{jj} < 800$ GeV
- The W' model is excluded for 375 GeV$< M_{jj} < 650$ GeV
- The Z' model is excluded for 400 GeV$< M_{jj} < 625$ GeV

Future models to be studied are technirho ($\rho_T \to q\overline{q}$) and axial gluons ($G \to gg$).