Model Independent Search for New Phenomena in $p\bar{p}$ Collisions at $s^{1/2}$ = 1.96 TeV

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On behalf of the DØ Collaboration

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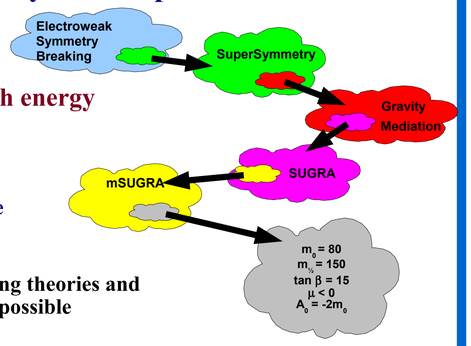
Standard Model is successful yet incomplete

- Gravity not incorporated
- Higgs mass fine-tuned
- No unification of forces at high energy

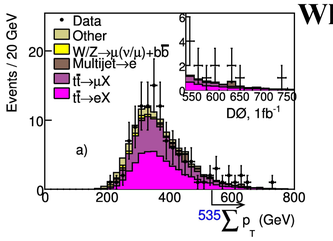
We are at the edge of an energy scale where we expect to find something new... but what?

Many theories devised to explain these problems with unique signals and characteristics

Have to prioritize – too many competing theories and insufficient resources to check all possible combinations of parameters



A Model Independent Search is a Search for Deviations from the Standard Model



What can cause a deviation?

Statistical fluctuation

Keep careful count of how many final states and distributions are checked and apply trials factor

$$\tilde{P} = 1-(1-p_{fs})^{N_{fs}} \overset{p_{fs}\ll 1}{\approx} p_{fs}\times N_{fs}$$

MC simulation accurate here?

Detector modeling or event reconstruction?

New Physics?

To minimize MC and detector modeling issues:

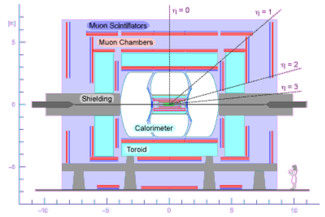
- Use standard DØ MC (PYTHIA and ALPGEN + PYTHIA)
- Use common collaboration-wide object definitions and scale factors
- Fit for normalization factors

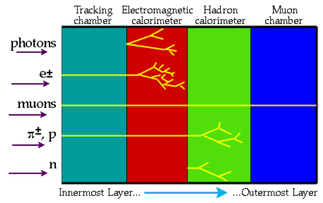
The DØ Experiment

A multipurpose particle detector at the Tevatron

Innermost detectors are the trackers, followed by calorimetry and the muon chambers

This analysis uses data corresponding to 1.1 fb^{-1} of integrated luminosity





We consider events containing at least one electron or muon

We also consider any additional tau lepton, light jet, b-tagged jet, or significant missing transverse energy (MET) in the event

Events with photons are excluded

Step 1. Inclusive Comparison and Fits

We divide our dataset into 7 inclusive subsets

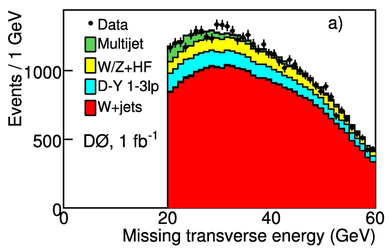
1. e + jets + MET
2. μ + jets + MET
3. ee + X, X = any additional jets, electrons, or MET
4. μμ + X, X = any additional jets, muons, or MET
5. μe + X, X = any additional jets, electrons, muons, or MET
6. μτ + X, X = any additional jets, muons, taus, or MET
7. eτ + X, X = any additional jets, electrons, muons, taus, or MET

In each subset, we perform a fit of the Standard Model backgrounds to the data

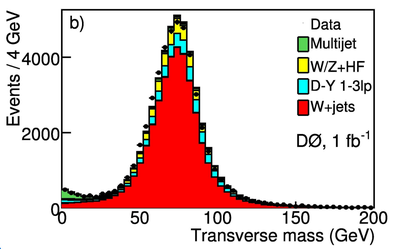
The fit accounts for the effects of systematic uncertainties, normalizes data-driven multijet background

Events with high p_T objects excluded from the fits, to avoid bias in SLEUTH

We fit to shapes of some kinematic distributions, e.g., lepton and jet p_T, MET, and Δφ(l, MET)



μ + jets + MET fit histogram

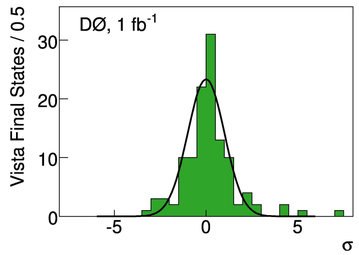


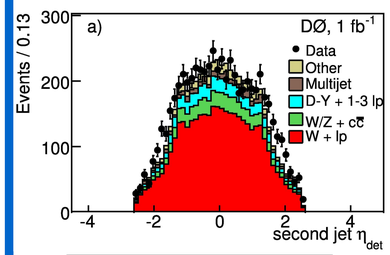
μ + jets + MET check histogram

More complex variables, such as di-lepton invariant mass, the transverse mass of the lepton + MET, and dilepton p_T are excluded from these fits

The effect of the fits on the excluded distributions are used to assess the quality of the fits

Step 2. Exclusive Comparison Using VISTA





VISTA Final State	Histogram	σ
$\mu^\pm$ + 2 jets + $\not{E}_T$	$M_T(W,j_2)$	4.4
	$\Delta\mathcal{R}(\mu,j_2)$	4.4
	$M(\mu,j_2)$	4.0
	$\Delta\eta(j_1,j_2)$	3.8
$\mu^\pm$ + 1 jet + $\not{E}_T$	$p_T(W)$	8.1
	Σp_T	5.1
	$p_T(\mu)$	4.1
	$M_T(\mu^\pm,\not{E}_T)$	4.1
	$\Delta\phi(\mu,j)$	3.1
$e^\pm$ + 2 jets + $\not{E}_T$	$\Delta\eta(j_1,j_2)$	4.2
	$M_T(j_2,\not{E}_T)$	4.0
	$M_T(W,j_2)$	3.0
$e^\pm$ + 1 jet + $\not{E}_T$	$\Delta\phi(e^+,j)$	5.5
	$p_T(e^\pm)$	4.4
	$p_T(W)$	3.8
	$\not{E}_T$	3.1

We divide the inclusive final states into exclusive final states

For example, ee + X → e^+e^+ + 1jet, $e^+e^-e^+$, e^+e^- + MET + 2 jets, etc.

7 inclusive final states → 117 exclusive finals states, 5543 kinematic distributions

First check for discrepancies in total number of events per final state

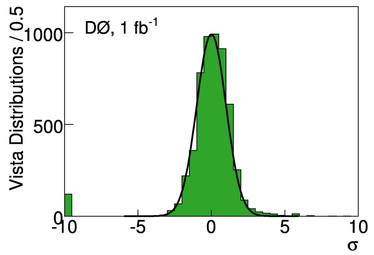
Find 2 final states with discrepancies exceeding 3σ – $\mu^+\mu^-$ + MET (6.7σ) & μ + 2 jets + MET (4.5σ)

The $\mu^+\mu^-$ + MET discrepancy is associated with difficulties modeling the momentum distributions of high p_T μ

The μ + 2 jets + MET discrepancy is associated with known issues modeling ISR/FSR jets in forward η region, can be resolved with SHERPA MC

Next check shape distributions with K-S test

All >3σ discrepancies related to ISR/FSR modeling



Step 3. SLEUTH

SLEUTH algorithm assumes new physics more likely to be found in high p_T events

We also assume light lepton universality and rebin in the number of jets – reduces number of final states from 117→31

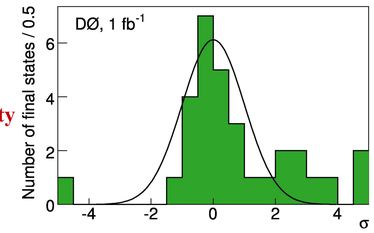
Considers the Σp_T of all objects in the event, including MET

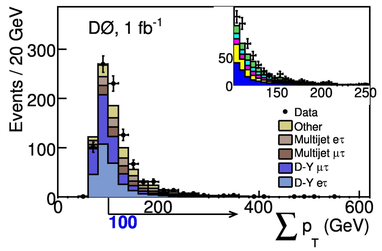
We look for an excess in the tail of the Σp_T distribution

We find an excess in the 2 final states with number discrepancies in VISTA

No additional discrepancies in excess of 3σ found

Most discrepant final state in SLEUTH not found in VISTA is $l^+\tau^-$ + MET





Results and Conclusions

We have done a global study of DØ high p_T data corresponding to 1.1 fb^{-1} of integrated luminosity to search for significant deviations from Standard Model expectations.

Discrepancies seen in VISTA consistent with known modeling issues

No additional significant discrepancies seen in SLEUTH

We do not claim evidence of any significant deviation from the Standard Model