DPF 2011

Model Independent Search for New Phenomena

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on behalf of the D0 Collaboration. August 2011

Any sign of new physics in Tevatron data?

- Do we see what we expect from Standard Model?
  - Is this excess statistically significant?
  - Do we correctly model our detector/physics?
  - New Physics?

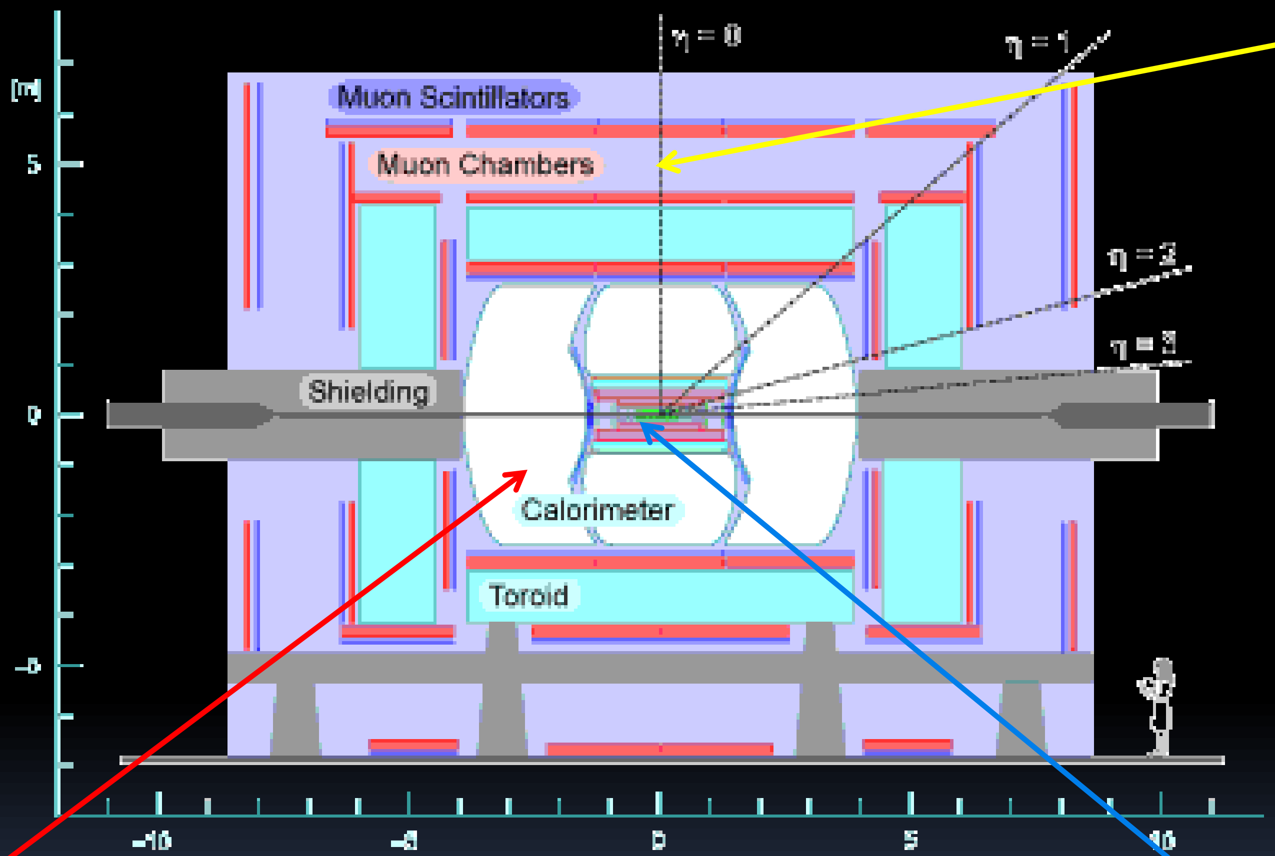
?

- Look in all Tevatron data
  - Split the Tevatron data into many final states
  - For each final state, examine multiple test distributions
  - If for a particular final state/test distribution see an excess, ask questions

- General, allows to analyze many final states, however not as sensitive as dedicated approaches

The D0 experiment

Muon system
muon tracking



Calorimeter
em objects

Fiber and Silicon
trackers

Strategy

Data

MC

$1 fb^{-1}$

Preselection (p_T > ~ 15 – 35 GeV)
corrections,
splitting into multiple final states

Leptonic
Corrections derived
from fitting MC to DATA
in 7 final states

QCD from
Data

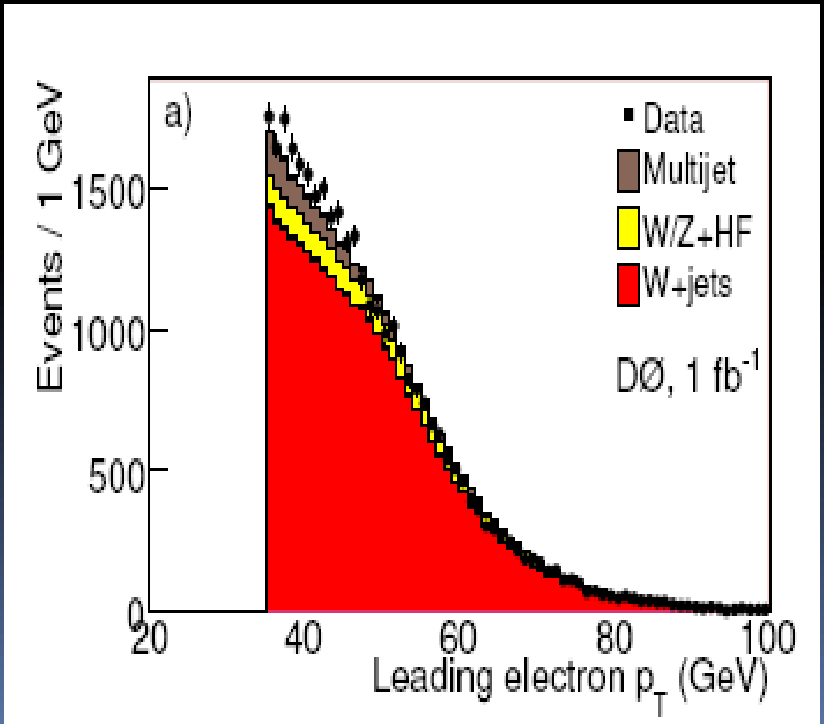
Vista.
Looking at DATA/MC shape/number agreement
for each of final states in the bulk

Search for specific new physics
high p_T tails, SLEUTH

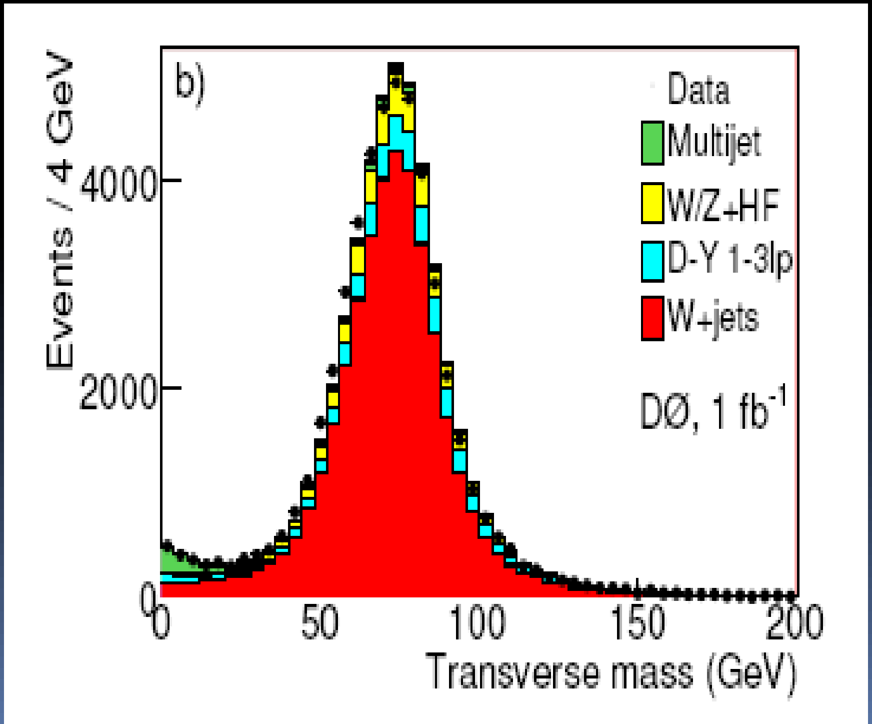
Fit factors

- Fit basic distributions (like objects p_T, η, φ) simultaneously and use more complex variables to check.
- 7 inclusive final states
  - ee, eμ, μμ, e(veto on second lepton), μ(veto on second lepton), eτ, μτ
  - High p_T tails are out of the fit

Basic variable



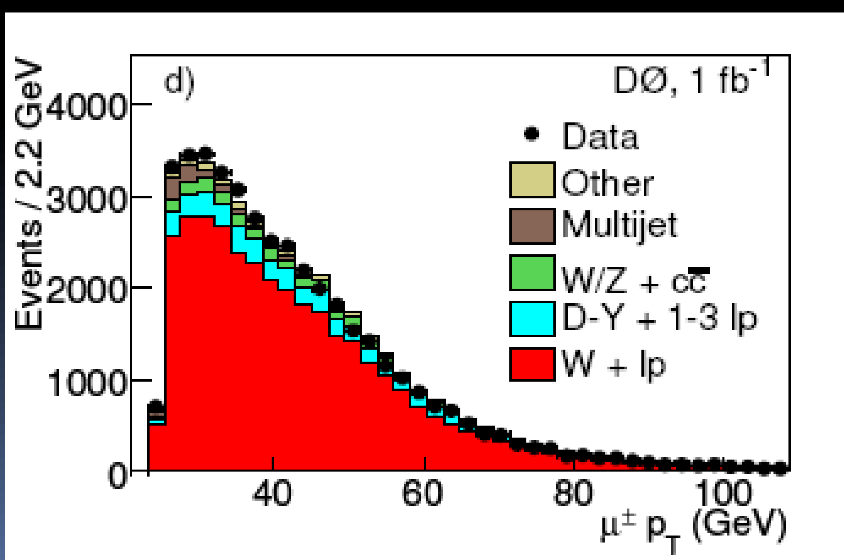
Variable to check



Vista

- Divide data into 117 exclusive final states
  - Based on high p_T objects
    - Jets, b-jets, electrons, muons, taus, MET
- For each final state and for each distribution, check:
  - Data/MC agreement
    - In number of events
    - In shape using Kolmogorov-Smirnov probabilities
  - Should account for large number of final states/distributions (trial factor)

Final State	Object	p_T^{min} (GeV)	$\lvert\eta\rvert^{max}$
e + jet(s) + X^a	e	35	1.1
	jet	20	2.5
	$\not{E}_T$	20	NA
μ + jet(s) + X^b	μ	25	1.5
	jet	20	2.5
	$\not{E}_T$	20	NA
$ee + X^c$	e	15	1.1
$\mu\mu + X^d$	μ	15	1.5
$\mu e + X^e$	μ	15	1.5
	e	15	1.1
$e\tau + X^f$	e	15	1.1
	τ	15	1.1
$\mu\tau + X^g$	μ	15	1.5
	τ	15	1.1



Probability to see the final state as unlikely as state i with probabiltity p_i:

$$\tilde{P} = 1 - \prod_{i}^{trials} (1 - p_i)$$

$\tilde{P} < 0.001$ corresponds to 3σ deviation

Probabilities

In this analysis, we analyze tenth of final states and hundreds of distributions

Therefore, the probability to observe a significant access is much larger than for a dedicated analysis

We correct for this effect taking into considerations the number of trials (final states or distributions)

$$\tilde{P} = 1 - \prod_{i}^{trials} (1 - p_i)$$

$$p_i = \int \exp\{ - (N - N_{SM})^2 / 2 \sigma_{SM}^2 \} dN \ \Sigma^{\infty}_{i=Ndata} N^i / i! \exp\{-N\}$$

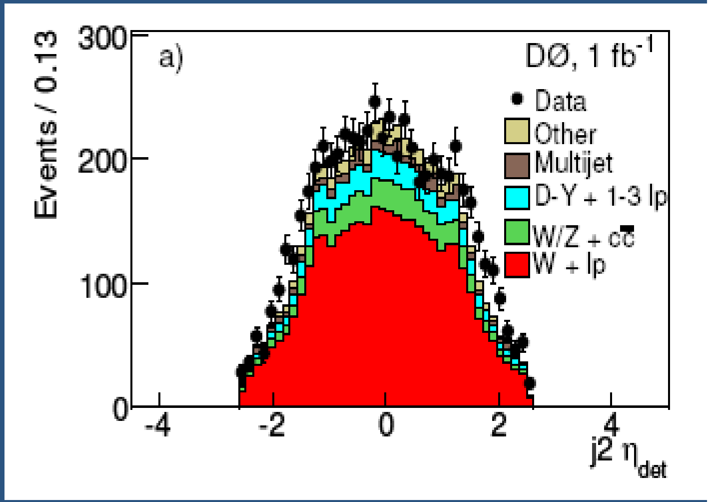
Gaussian :
Probability that N is average, when we expect N_{SM} from SM

Poisson :
Probability to observe at least N_{data} with average N

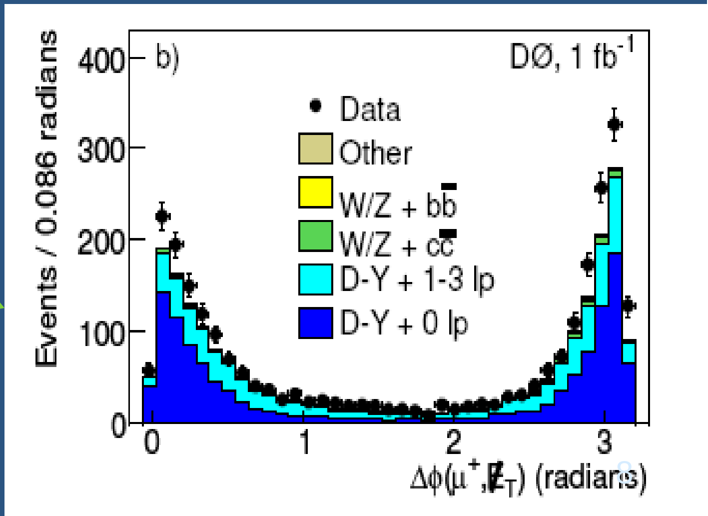
Vista results

- Total final states – 117
- Discrepant final states – 2 (3σ = discrepant)

- Total distributions – 5543
- Shape discrepancies - 16 (3σ = discrepant)



- Modeling issues (mostly spatial jet distributions)
  - No systematic effects are taken into account
  - Modeling jet recoil in the forward region
    - μ + 2 jets + MET
    - 4.5 σ
  - Resolutions for high p_T muons
    - $\mu^+\mu^-$ + MET
    - 6.7 σ



Most discrepant Vista distributions

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

Shown are distributions with discrepancies >3σ

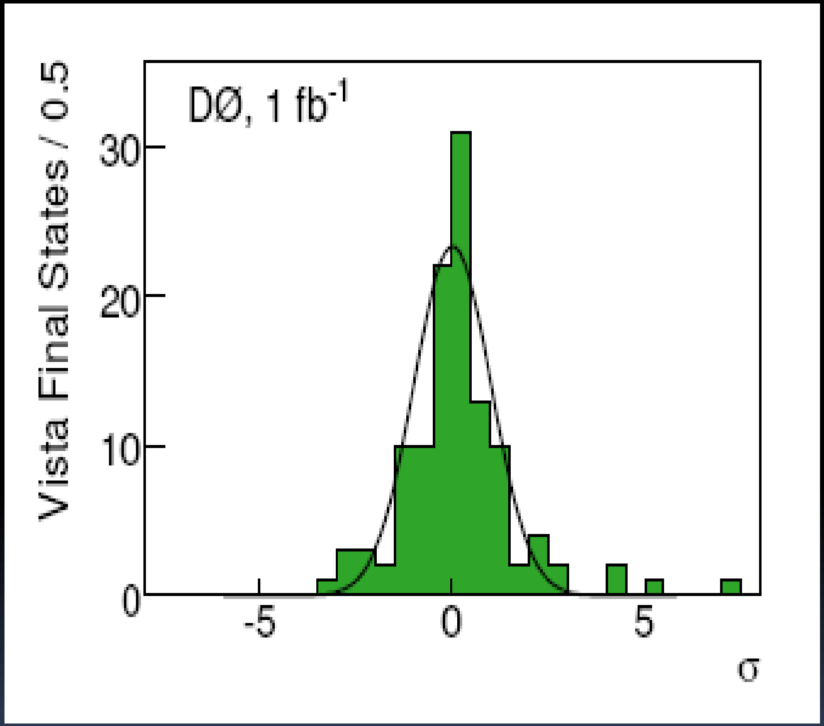
Mostly spatial distributions involving jets

Reminder: no systematics are considered

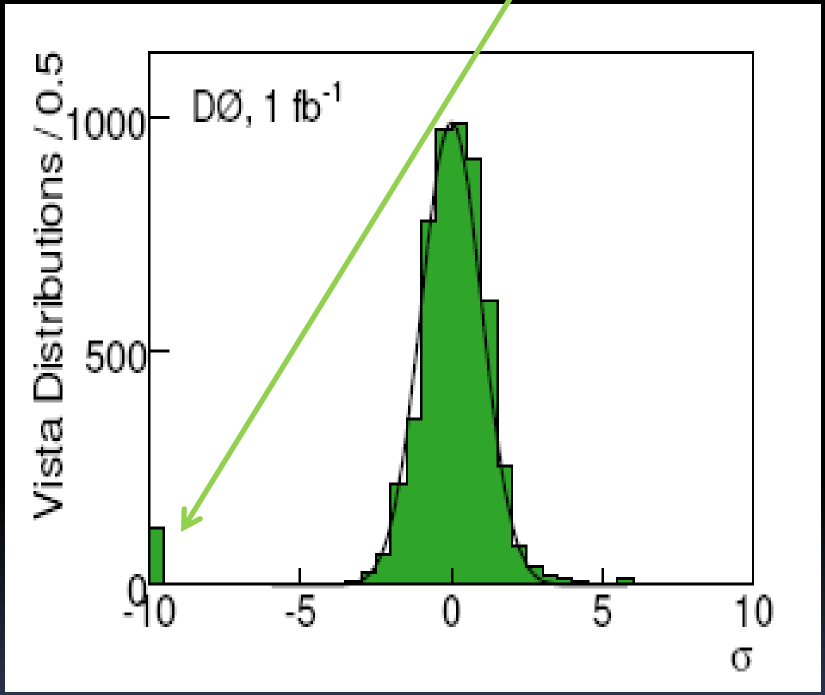
Vista comparison

Each entry in a histogram corresponds to the deviation for a distribution

perfect agreement



The σ distribution for the 117 final states

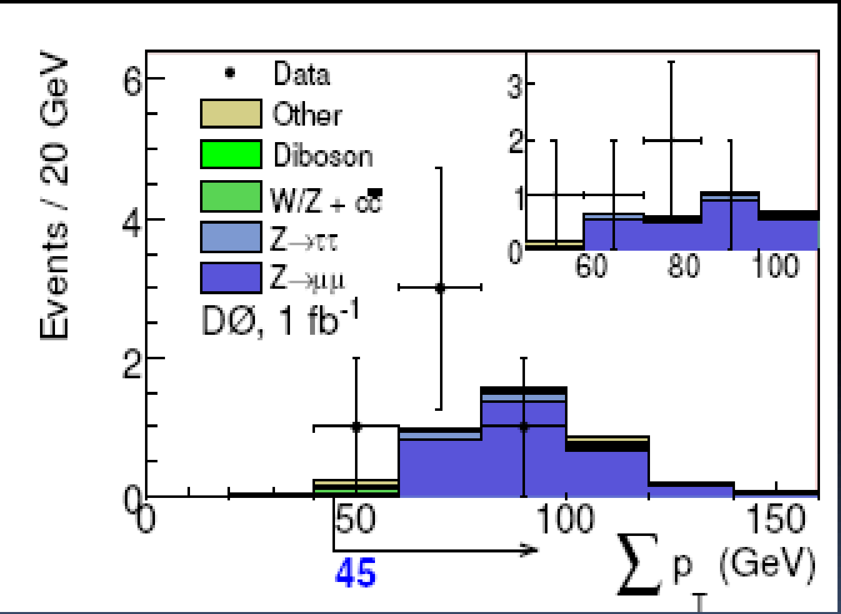


The σ distribution for the 5543 distributions

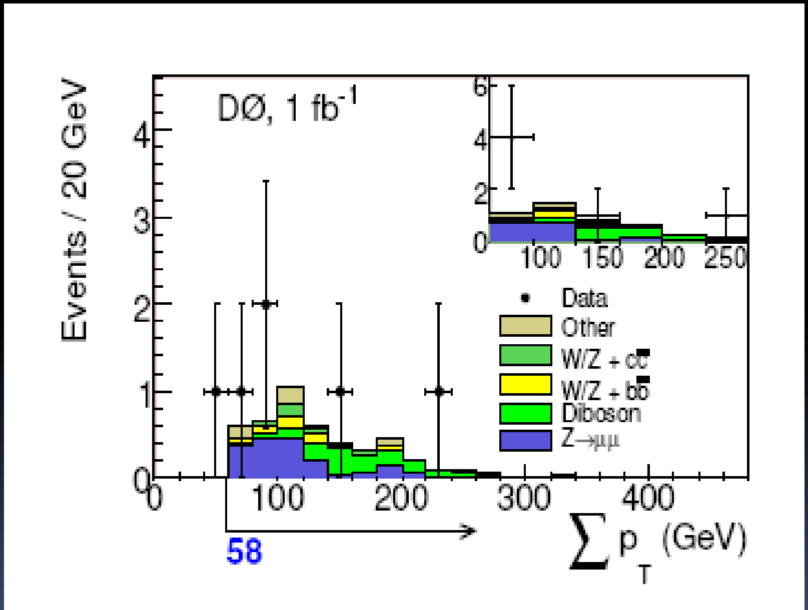
High p_T tails. Sleuth

Merge Vista final states
 Lepton universality
 Charge conjugation
 117 Vista final states -> 31 SLEUTH final states

Cut $\Sigma p_T > C_0$ that gives the most significant excess
Correct for the trial factors



OS eμ final state



OS eμ + MET final state

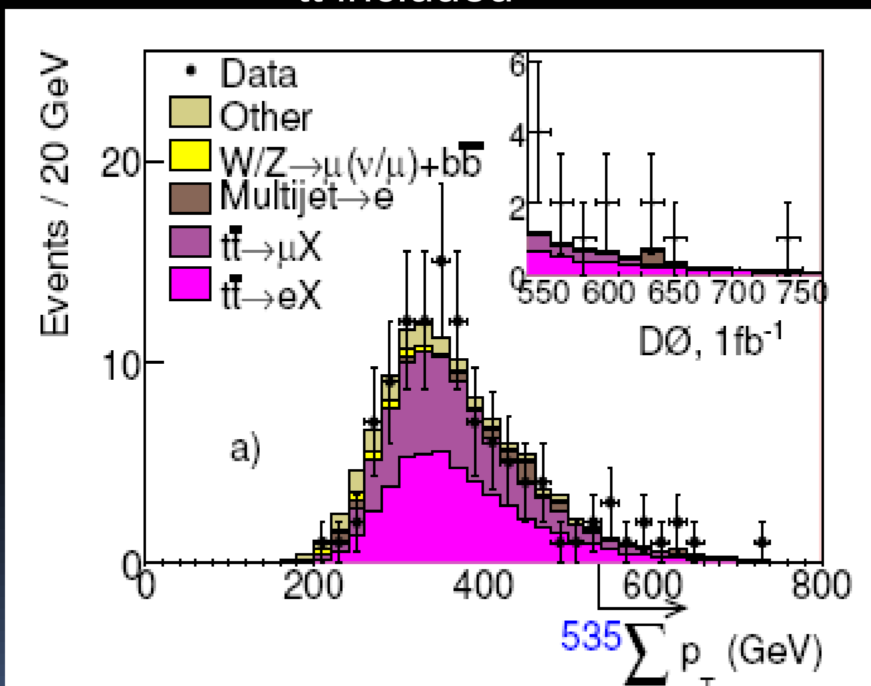
Tests of the method

Are we able to re-discover tt pairs?

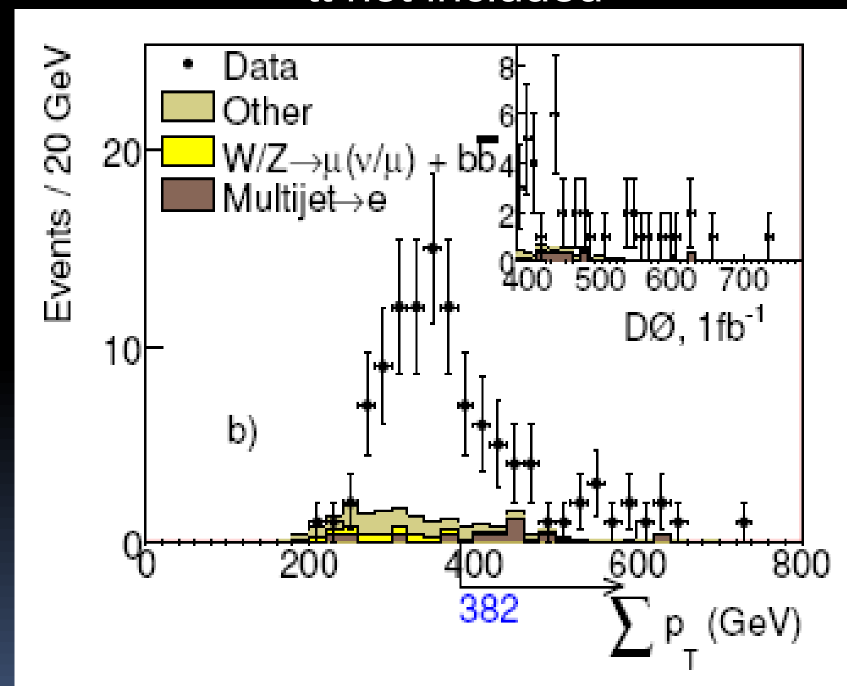
- Remove tt MC
- Run SLEUTH

Obvious discrepancy shows that SLEUTH can re-discover top pairs.

tt included



tt not included



$$\tilde{P} \sim 1.1*10^{-5} << 10^{-3}$$

Most discrepant SLEUTH final states

Final State	$\mathcal{P}$	$\tilde{\mathcal{P}}^a$
$\ell^+\ell^- + \not\!E_T$	$< 10^{-5}$	< 0.001
$\ell^\pm + 2j + \not\!E_T$	$< 10^{-5}$	< 0.001
$\ell^\pm + \tau^\mp + \not\!E_T$	8.9×10^{-5}	0.0050
$\ell^\pm + \not\!E_T + 1j$	0.00036	0.019
$e^\pm\mu^\mp + 2b + \not\!E_T$	0.0028	0.12
$\ell^\pm\tau^\pm + 2j + \not\!E_T$	0.0028	0.12
$\ell^\pm + 2b + \not\!E_T$	0.0077	0.3
$e^\pm\mu^\mp + \not\!E_T$	0.0081	0.31
$\ell^\pm\tau^\pm$	0.057	0.91
$\ell^\pm + 2b + 2j + \not\!E_T$	0.099	0.98

This passes the threshold of 3σ due to problems with detector modeling. Same as in VISTA

Conclusion

- Performed Model-Independent search in D0 data
- Most states agree after trials
- The discrepant states/distributions are due to modeling issues
- SLEUTH – search for high p_T tails.
  - No surprises

Backup

Preselection and Corrections

D0 ($1fb^{-1}$)

- Alpgen and PYTHIA
- Multijet from Data
- Leptonic final states
- Channel specific kinematic cuts
- Collaboration-wide corrections
  - K-factors
  - Trigger efficiencies
  - Lumi reweighting

CDF ($2fb^{-1}$)

- PYTHIA and MadEvent
- Multijet from MC
- Channel specific kinematic cuts
- Corrections later at Vista level
  - Constrained global fit
  - 43 fit parameters

D0 → PreSelection → Corrections → Leptonic → MIS fit →

CDF → PreSelection → Global fit →

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