EPS 2009

Global searches at the Tevatron

Peter Renkel: Southern Methodist Uni.

on behalf of D0 and CDF Collaborations. July 2009

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

Strategy

Data

MC

$1fb^{-1}$

$2fb^{-1}$

QCD from Data

QCD from MC

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

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

Phys.Rev.D79:011101, 2009

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

Global fit factors

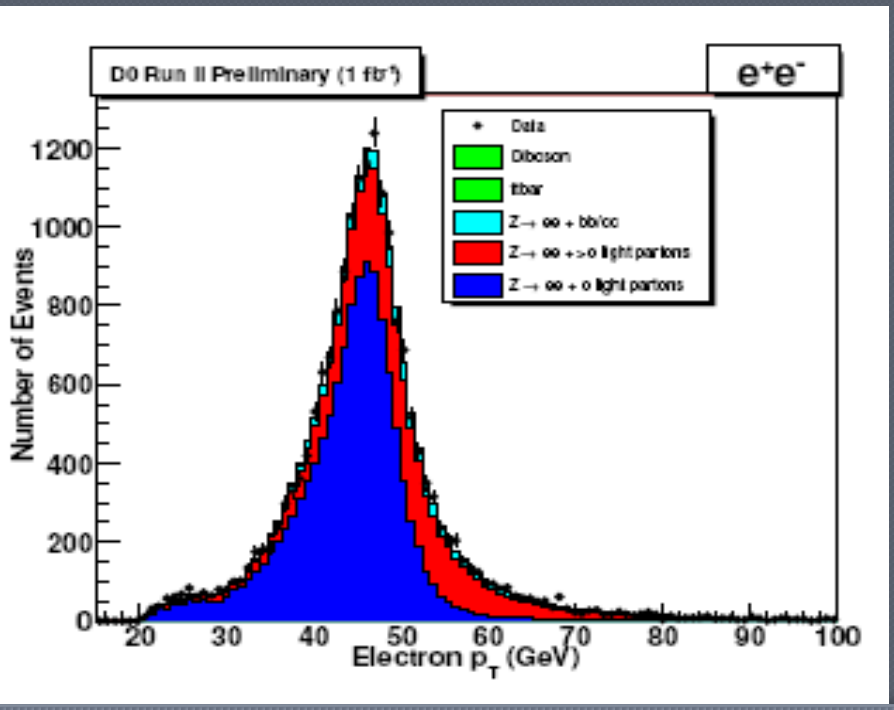
Search for specific new physics high p_T tails, SLEUTH

Resonances (Bump hunter)

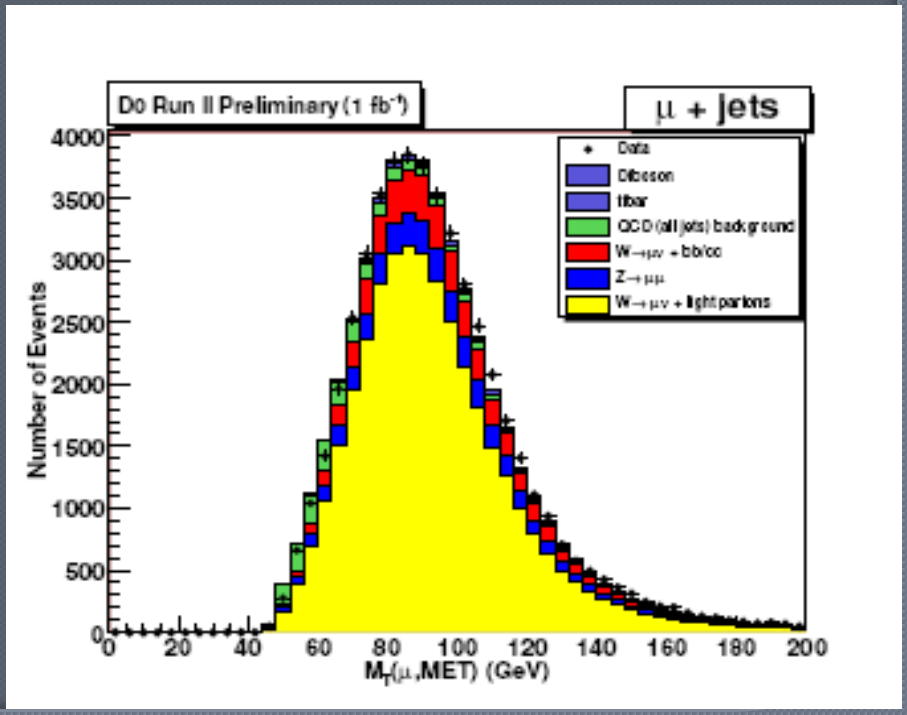
Example: D0 fit factors

- 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
  - Tails are out of the fit

Basic variable

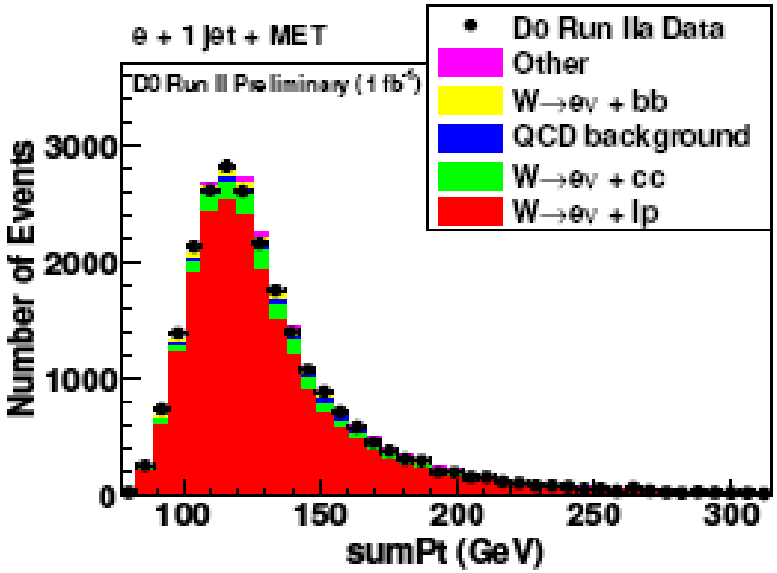


Variable to check



Vista

- Divide data into 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)



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

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

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

Vista results

- Total final states – 180
- Discrepant final states – 4

- Total distributions – 9335
- Shape discrepancies - 24

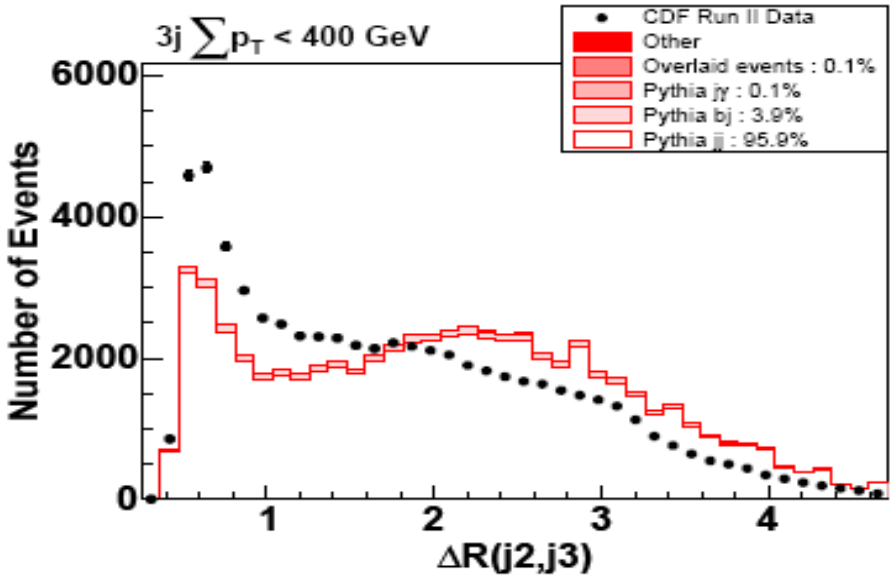
- Modeling issues
  - η – dependent trigger efficiencies
    - μ + jets + MET
  - Resolutions for high p_T muons
    - μμ + MET
  - Jets fake photons
    - γ states

DØ Final State Population Discrepancies	σ After Trials Factor
$\mu + 2\,\text{jets} + \not\!\!E_T$	9.3
$\mu + \gamma + 1\,\text{jet} + \not\!\!E_T$	6.6
$\mu^{\pm}\mu^{\mp} + \not\!\!E_T$	4.4
$\mu^{\pm}\mu^{\mp} + \gamma$	4.1

- Total final states – 399
- Discrepant final states – 0
  - Global fit factors

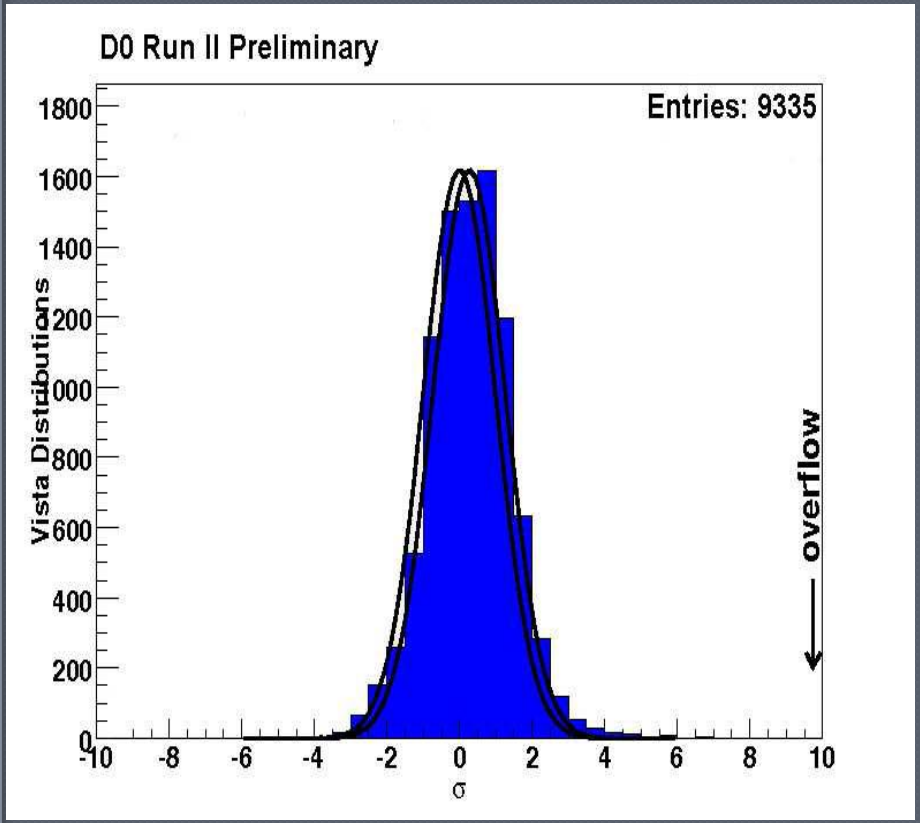
- Total distributions – 19650
- Shape discrepancies - 555

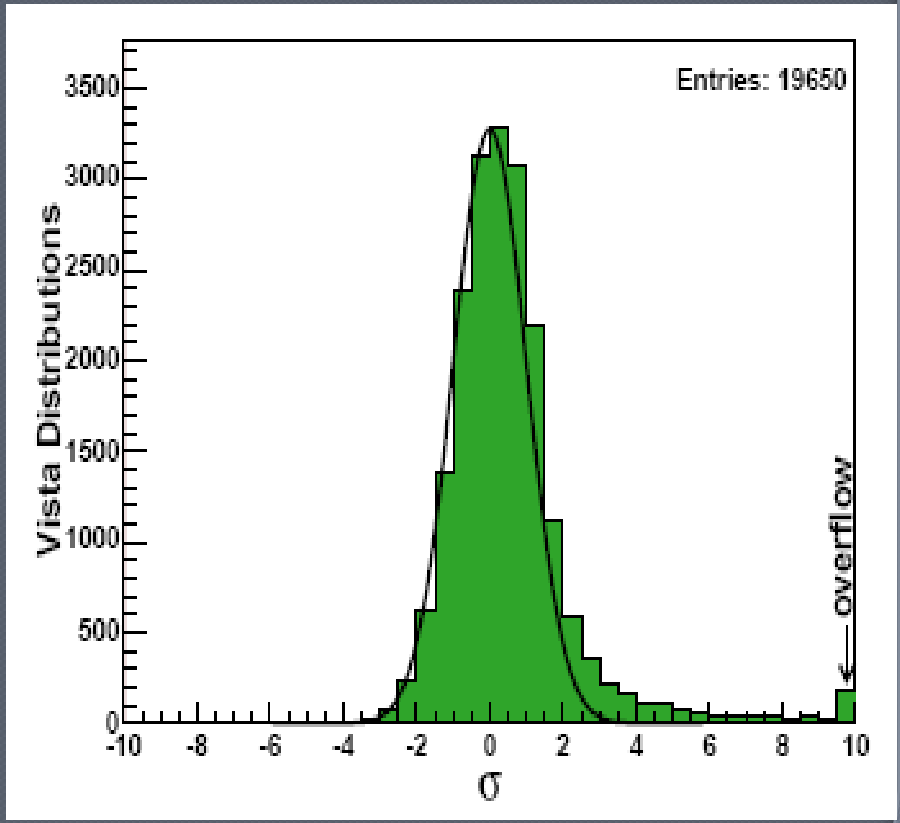
- Modeling issues
  - QCD modeling



Vista shape agreement

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



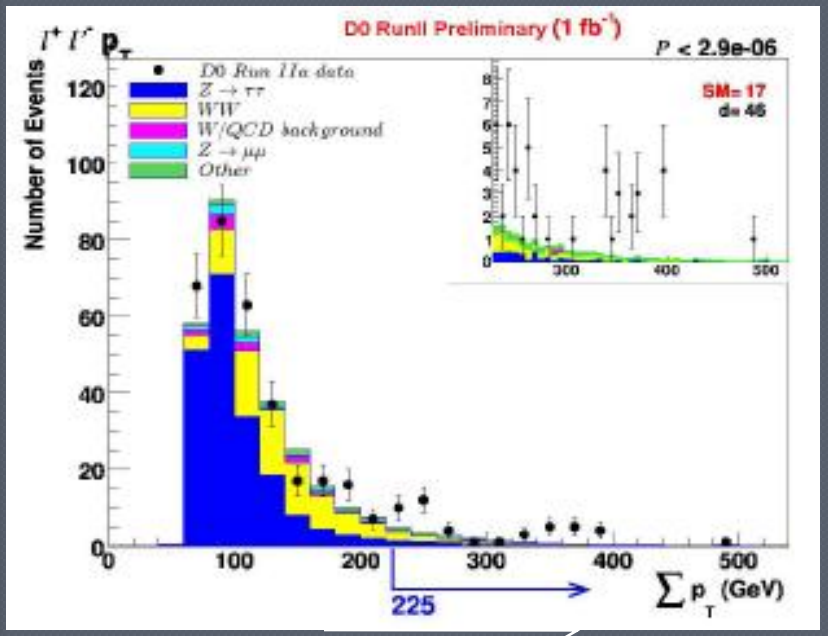


D0: no high σ tail tail since
only leptonic final states are considered

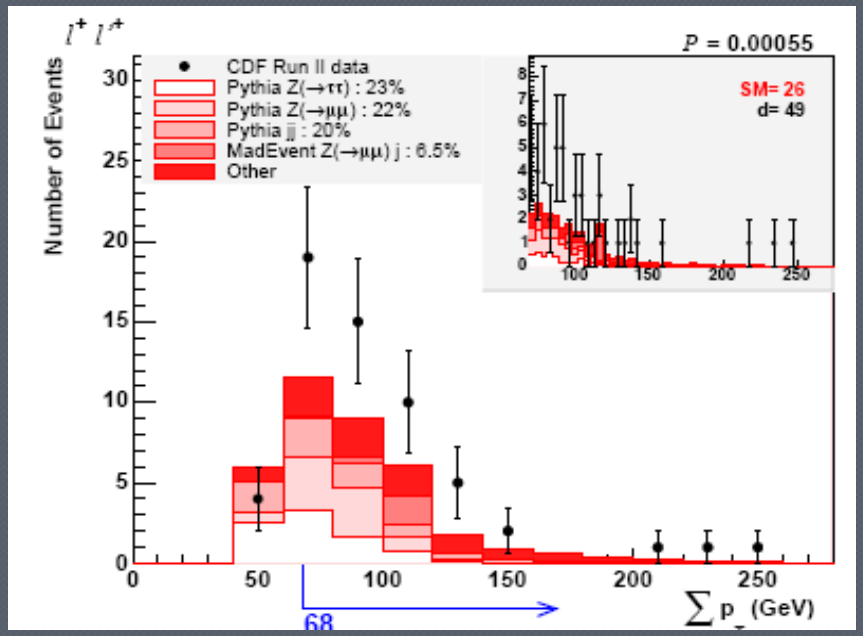
CDF: high σ tail (QCD)

High p_T tails. Sleuth

- Merge Vista final states
  - Lepton universality
  - Charge conjugation
- Search for Data excess in Σp_T
  - CDF includes unclustered scalar E_T
- Cut $\Sigma p_T > C_0$ that gives the most significant excess
- Correct for the trial factors



D0: eμ final state discrepant after trials (muon high p_T resolution)

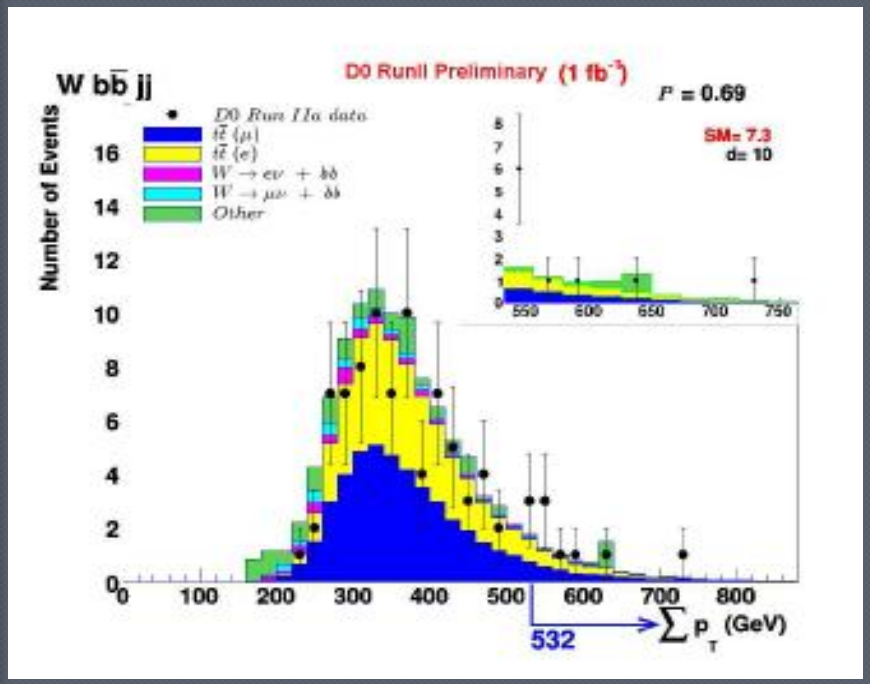


CDF: SS final states after trials – 2 σ. Interesting, but not a discovery

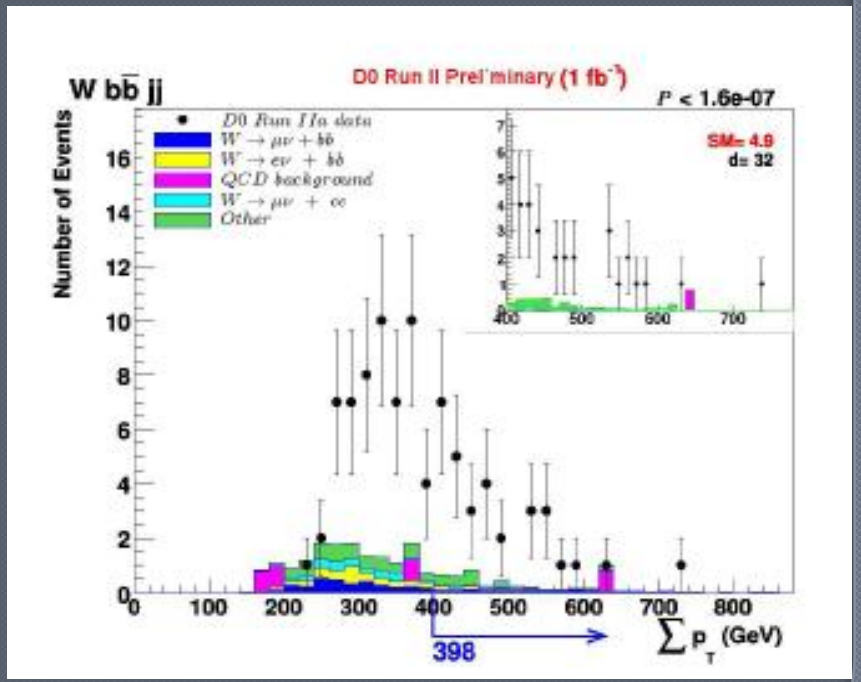
Tests of the method

- Are we able to re-discover $t\bar{t}$ pairs?
  - Remove $t\bar{t}$ MC
  - Run SLEUTH
- Obvious discrepancy shows that SLEUTH can re-discover top pairs.

$t\bar{t}$ included



$t\bar{t}$ not included

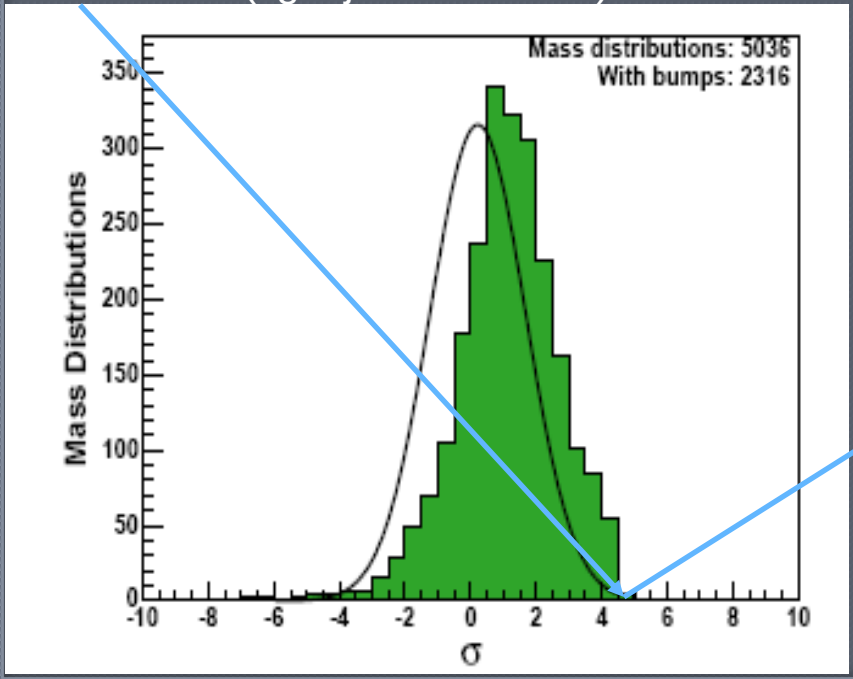


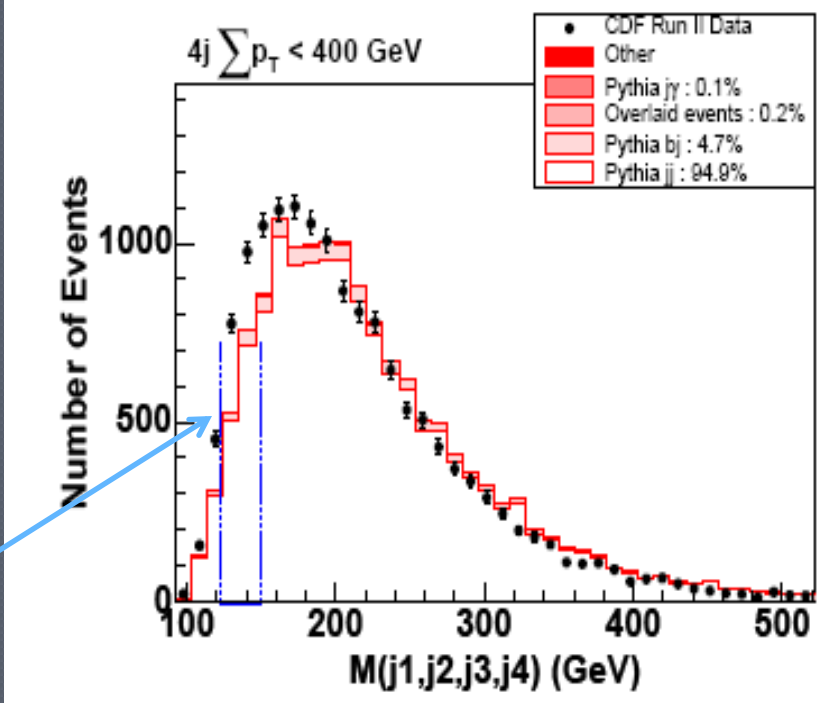
$\tilde{P} \sim 1.6 \times 10^{-7} << 10^{-3}$

Bump hunter

- Search for narrow resonances in mass distributions
- Width of search window – 2 * detector resolution
  - At least 5 data events required
  - Side bands – consistent
  - Correct for trial factors

One bump beyond thresholds (light jet emission?)





Most discrepant SLEUTH final states

DO	CDF
$l^+ l'^- + \text{MET}$	$l^+ l'^+$
l+MET	$l^+ l'^+ + jj + MET$
$l^+ l'^-$	$l^+ l^+ + MET$
$l^+ \tau^- + \text{MET}$	$l^+ l'^- l^+ + \text{MET}$
$l^+ \tau^+$	

Only one D0 final state passes the threshold of 3σ

Conclusion

- Performed Model-Independent search in D0 and CDF data
- Most states agree after trials
- The discrepant states/distributions are most likely due to modeling issues
- CDF Bump Hunter – search for mass resonances
  - No discoveries
- SLEUTH – search for high p_T tails.
  - One D0 excess most probably due to muon resolutions modeling
- More luminosity to be analyzed

Backup

Most discrepant states

Final State	$\mathcal{P}$
$\ell^+\ell'^-$ + MET	2.9 E-6
ℓ + MET	.00082
$\ell^+\ell'^-$	.0031
$\ell^+\tau^-$ + MET	0.006
$\ell^+\tau^+$	0.0066

Preselection and Corrections

- Alpgen and PYTHIA
- Multijet from Data

1fb^{-1}

- Leptonic final states
- Channel specific kinematic cuts

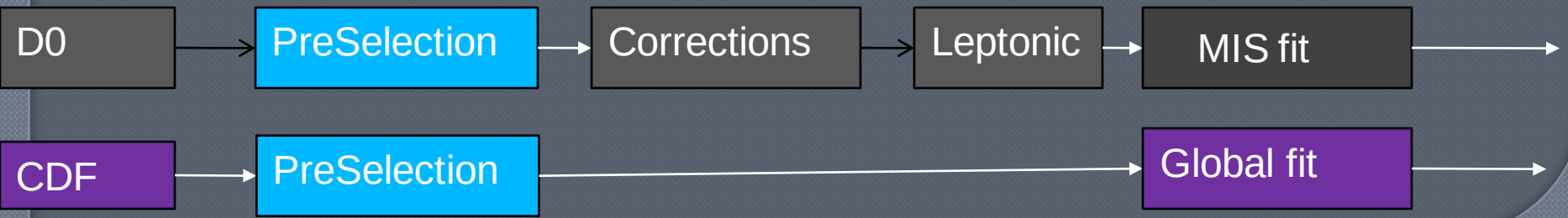
- Collaboration-wide corrections
  - K-factors
  - Trigger efficiencies
  - Lumi reweighting

- PYTHIA and MadEvent
- Multijet from MC

2fb^{-1}

- Channel specific kinematic cuts

- Corrections later at Vista level
  - Constrained global fit
  - 43 fit parameters



Example: Channel specific cuts for D0

MIS Final State	Object	Min p_T (GeV)	Max $\|\eta\|$
e + jets + X[a]	e	35	1.1
	jet	20	2.5
	MET	20	NA
μ + jets + X[b]	μ^h	25	1.7
	jet	20	2.5
	MET	20	NA
ee + X[c]	e	15	1.1
$\mu\mu$ + X[d]	μ^h	15	2.0
$\mu\tau$ + X[e]	μ^h	15	2.0
	τ	15	2.5
eτ + X[f]	e	15	2.5
	τ	15	2.5
μe + X[g]	μ^h	15	2.0
	e	15	2.5