Global Search for New Physics at CDF

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SLAC
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Goal

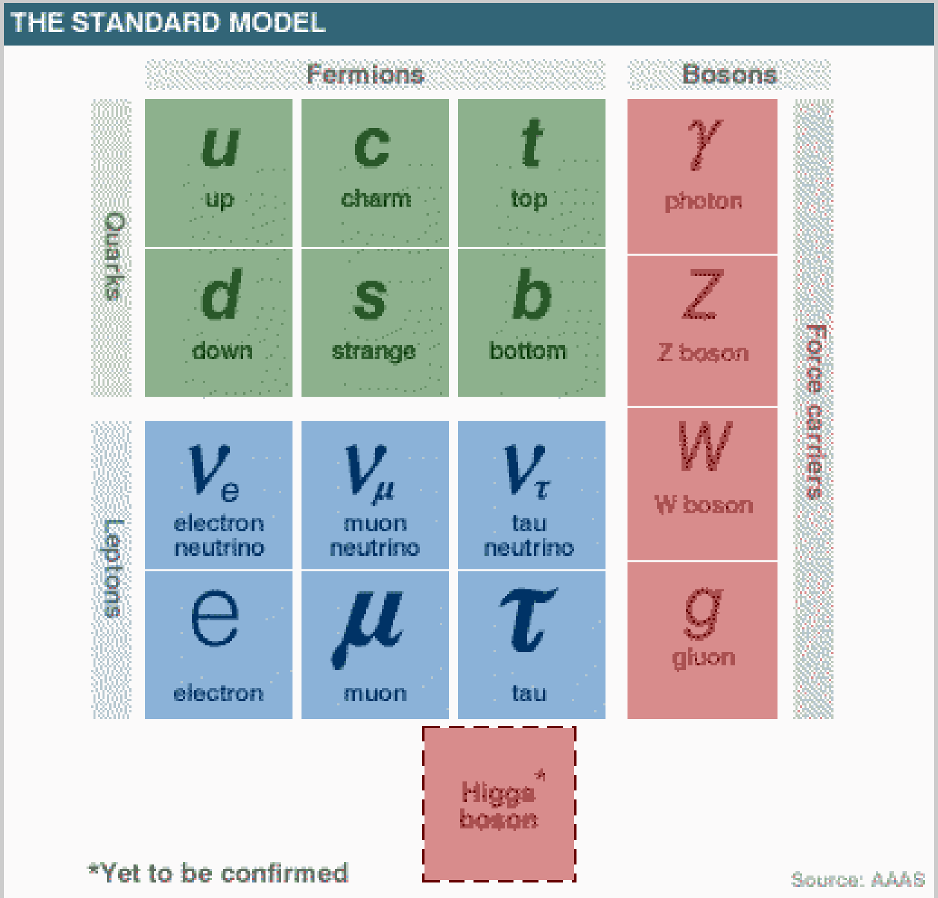
Search for significant discrepancies with the Standard Model

Scope

All high-p_T data

All kinematic quantities

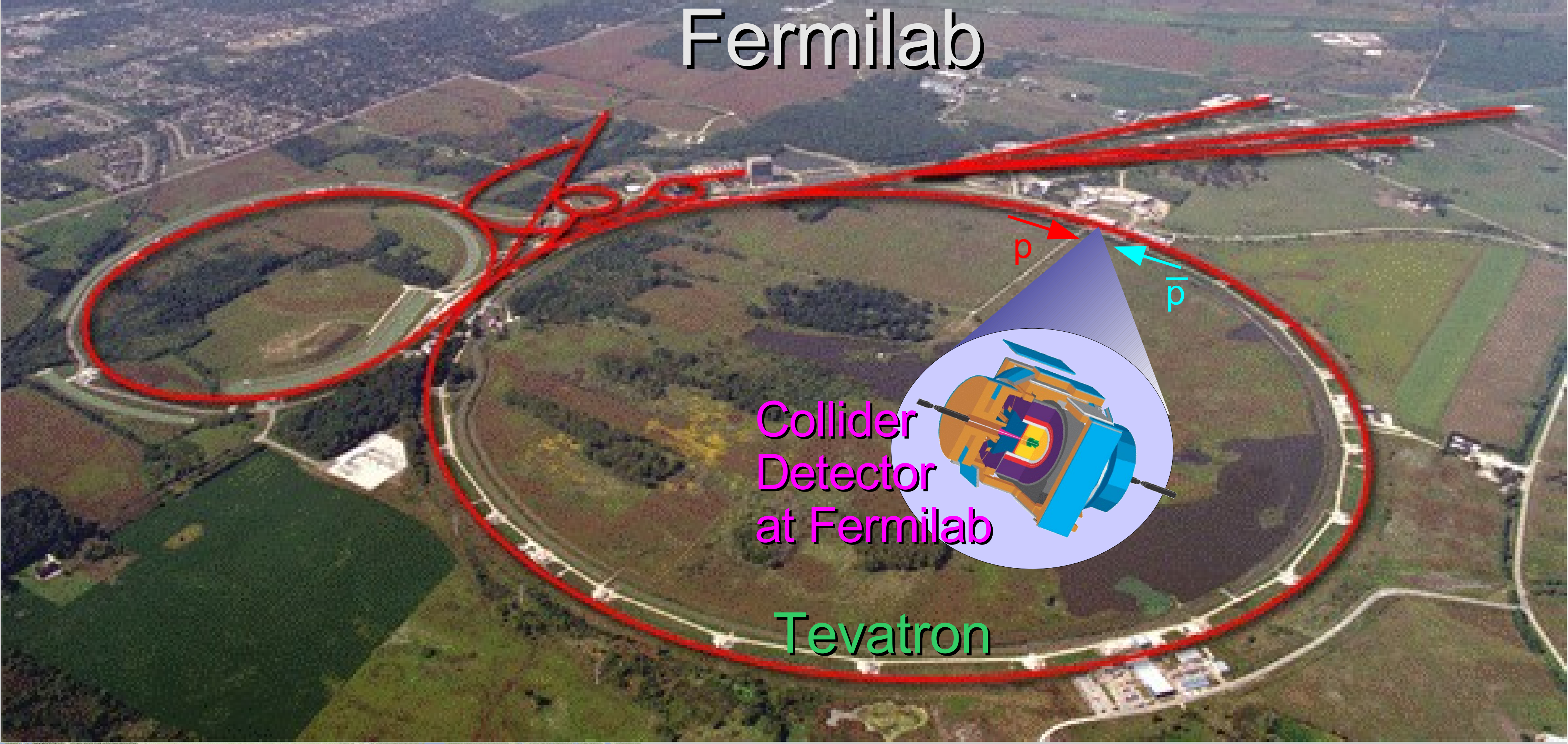
Motivation

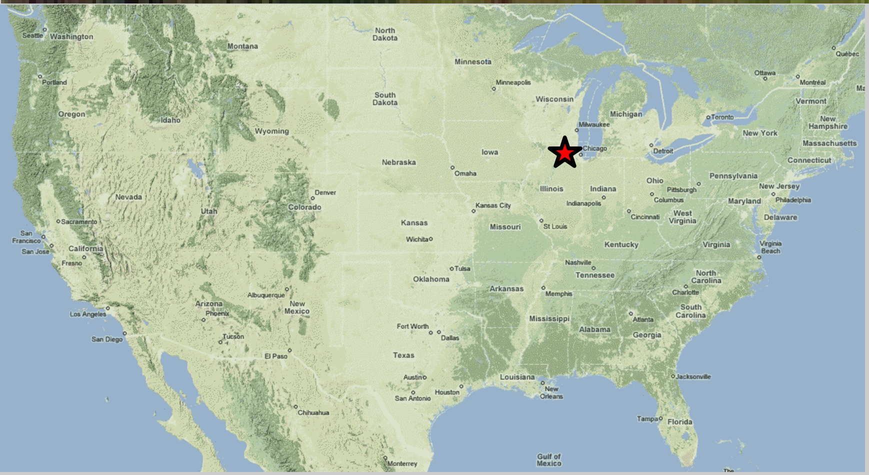


- Hierarchy problem
- Fine tuning of Higgs mass
- CP violation
- Dark Matter
- Dark Energy

There has to be physics beyond the Standard Model.

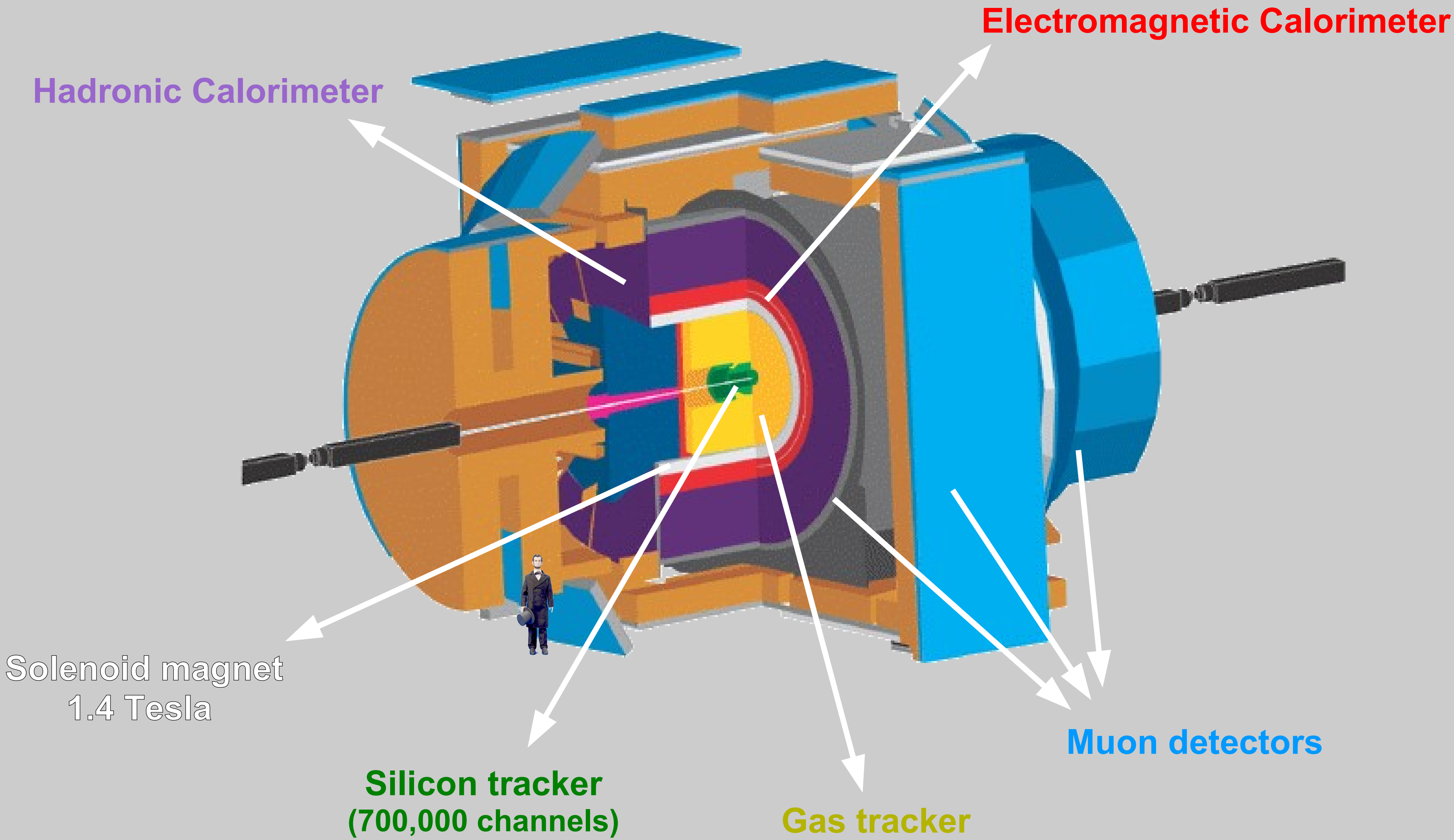
Fermilab





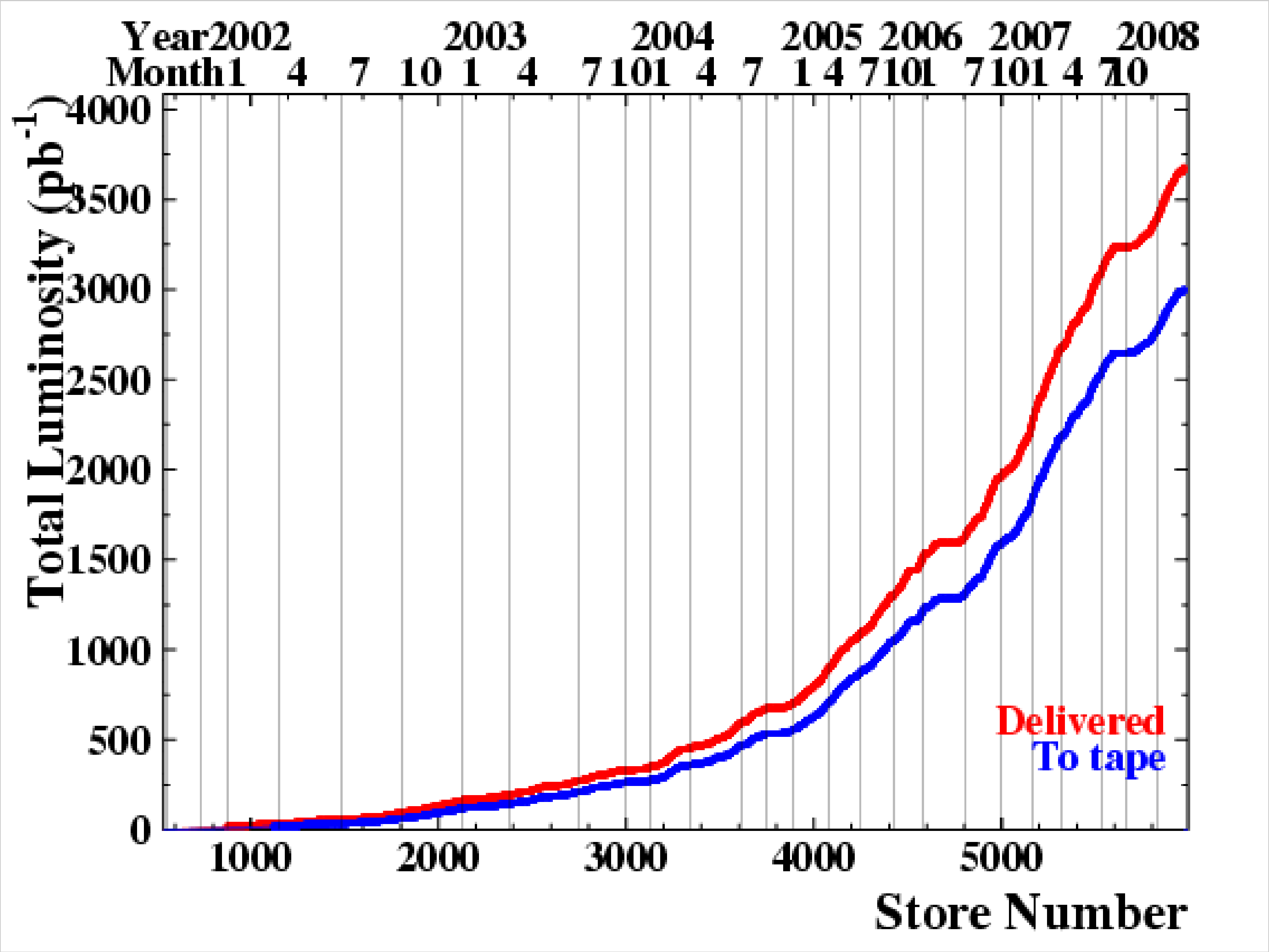
Energy = 1.96 TeV

CDF anatomy



Electromagnetic Calorimeter
Hadronic Calorimeter
Solenoid magnet
1.4 Tesla
Silicon tracker
(700,000 channels)
Gas tracker
Muon detectors

CDF Integrated Luminosity



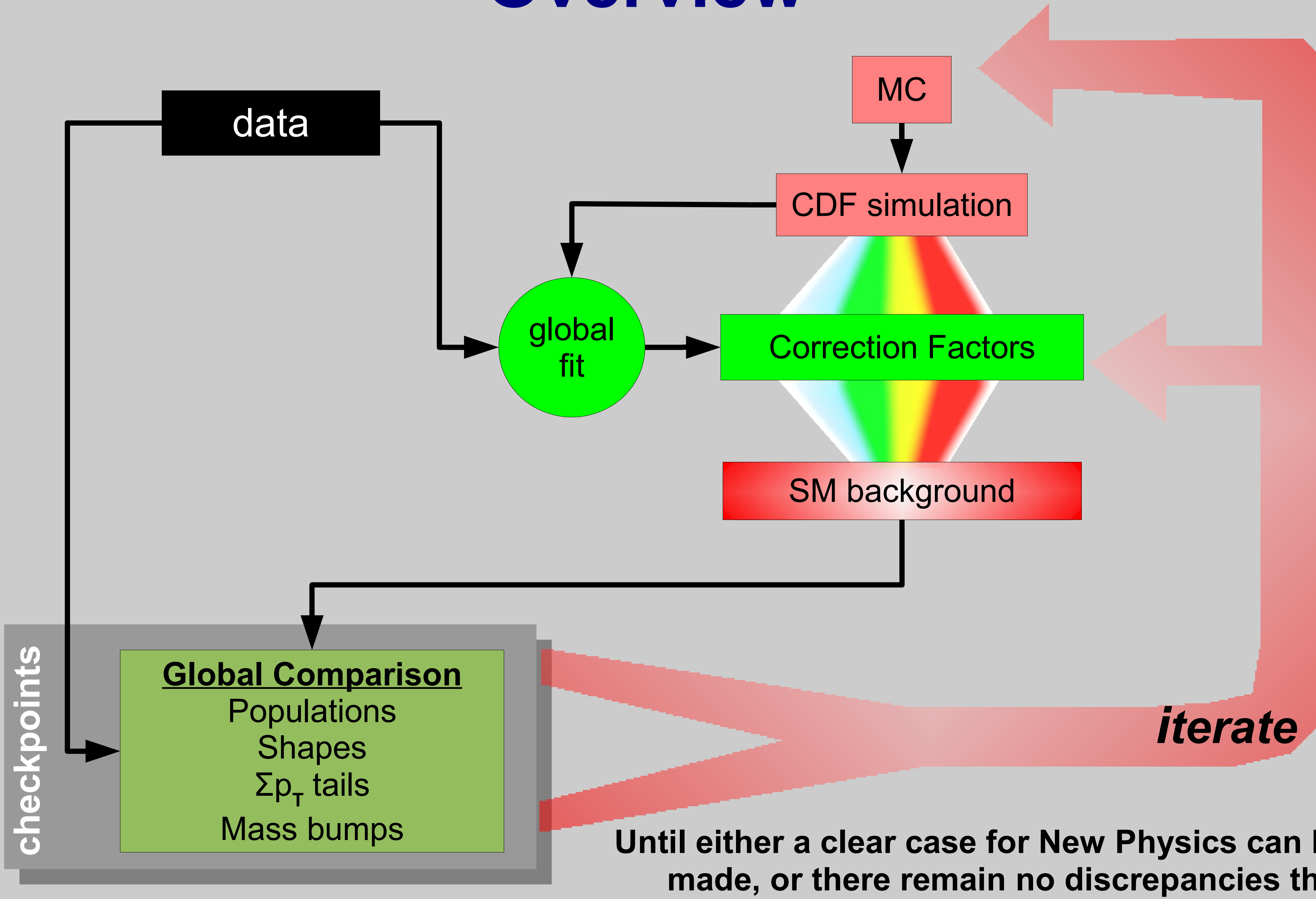
Brief History

- First embryonic version: DØ Run I, Fermilab
- "General Search" in H1, DESY
- Currently work underway in CMS, ATLAS, and DØ Run II

- CDF Run II global search:
  - 2007: 1 fb^{-1}
  - **2008: 2 fb^{-1}**

Bibliography (CDF Run II, 1 fb^{-1})
http://arxiv.org/abs/0712.2534 (PRL)
http://arxiv.org/abs/0712.1311 (PRD)
http://arxiv.org/abs/0710.2372 (SUSY07, Eur.Phys.J.C)
http://arxiv.org/abs/0710.2378 (SUSY07, Eur.Phys.J.C)

Overview



Until either a clear case for New Physics can be made, or there remain no discrepancies that motivate a case for New Physics

Correction factors (2 fb^{-1})

CDF Run II Preliminary (2.0 fb^{-1})

Code	Category	Explanation	Value	Error	Error(%)
0001	luminosity	CDF integrated luminosity	1990	50	2.6
0002	k-factor	cosmic_ph	0.83	0.05	6.0
0003	k-factor	cosmic_j	0.192	0.006	3.1
0004	k-factor	$1\gamma1j$ photon+jet(s)	0.92	0.04	4.4
0005	k-factor	$1\gamma2j$	1.26	0.05	4.0
0006	k-factor	$1\gamma3j$	1.61	0.08	5.0
0007	k-factor	$1\gamma4j+$	1.94	0.16	8.3
0008	k-factor	$2\gamma0j$ diphoton(+jets)	1.6	0.08	5.0
0009	k-factor	$2\gamma1j$	2.99	0.17	5.7
0010	k-factor	$2\gamma2j+$	1.2	0.09	7.5
0011	k-factor	W0j W (+jets)	1.38	0.03	2.2
0012	k-factor	W1j	1.33	0.03	2.3
0013	k-factor	W2j	1.99	0.05	2.5
0014	k-factor	W3j+	2.11	0.09	4.3
0015	k-factor	Z0j Z (+jets)	1.39	0.028	2.0
0016	k-factor	Z1j	1.23	0.04	3.2
0017	k-factor	Z2j+	1.02	0.04	3.9
0018	k-factor	2j $\hat{p}_T<150$ dijet	1.003	0.027	2.7
0019	k-factor	2j $150<\hat{p}_T$	1.34	0.03	2.2
0020	k-factor	3j $\hat{p}_T<150$ multijet	0.941	0.025	2.7
0021	k-factor	3j $150<\hat{p}_T$	1.48	0.04	2.7
0022	k-factor	4j $\hat{p}_T<150$	1.06	0.03	2.8
0023	k-factor	4j $150<\hat{p}_T$	1.93	0.06	3.1
0024	k-factor	5j low	1.33	0.05	3.8
0025	k-factor	1b2j $150<\hat{p}_T$	2.22	0.11	5.0
0026	k-factor	1b3j $150<\hat{p}_T$	2.98	0.15	5.0
0027	misId	$p(e\rightarrow e)$ central	0.978	0.006	0.6
0028	misId	$p(e\rightarrow e)$ plug	0.966	0.007	0.7
0029	misId	$p(\mu\rightarrow\mu)$ CMUP+CMX	0.888	0.007	0.8
0030	misId	$p(\gamma\rightarrow\gamma)$ central	0.949	0.018	1.9
0031	misId	$p(\gamma\rightarrow\gamma)$ plug	0.859	0.016	1.9
0032	misId	$p(b\rightarrow b)$ central	0.978	0.021	2.1
0033	misId	$p(\gamma\rightarrow e)$ plug	0.06	0.003	5.0
0034	misId	$p(q\rightarrow e)$ central	7.09×10^{-5}	1.9×10^{-6}	2.7
0035	misId	$p(q\rightarrow e)$ plug	0.000766	1.2×10^{-5}	1.6
0036	misId	$p(q\rightarrow\mu)$	1.14×10^{-5}	6×10^{-7}	5.2
0037	misId	$p(b\rightarrow\mu)$	3.3×10^{-5}	1.1×10^{-5}	33.0
0038	misId	$p(j\rightarrow b)$ $25<p_T$	0.0183	0.0002	1.1
0039	misId	$p(q\rightarrow\tau)$	0.0052	0.0001	1.9
0040	misId	$p(q\rightarrow\gamma)$ central	0.000266	1.4×10^{-5}	5.3
0041	misId	$p(q\rightarrow\gamma)$ plug	0.00048	6×10^{-5}	12.6
0042	trigger	$p(e\rightarrow trig)$ plug, $p_T>25$	0.86	0.007	0.8
0043	trigger	$p(\mu\rightarrow trig)$ CMUP+CMX, $p_T>25$	0.916	0.004	0.4

The Global Fit

Minimize:

$$\chi^2(\vec{s}) = \left(\sum_{k \in \text{bins}} \chi_k^2(\vec{s}) \right) + \chi^2_{\text{constraints}}(\vec{s})$$

e.g. theoretical estimation of k-factors

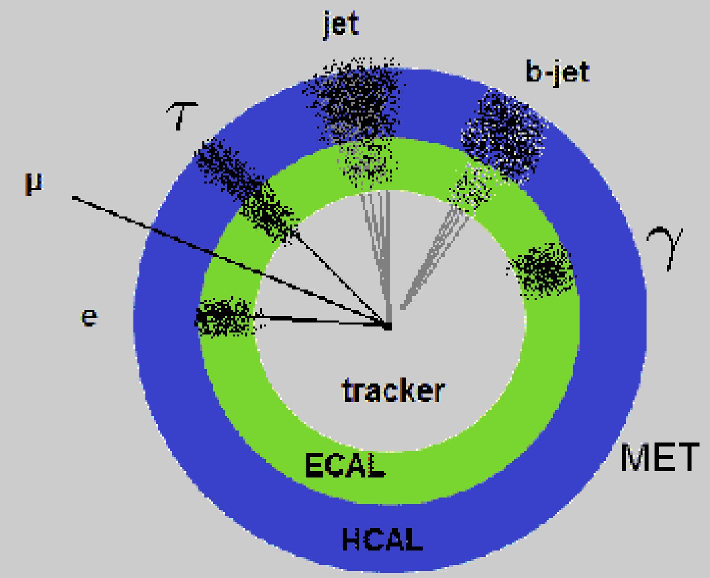
$\vec{S}$ = set of correction factors

$$\chi_k^2(\vec{s}) = \frac{(\text{Data}[k] - \text{SM}[k])^2}{\sqrt{\text{SM}[k]}^2 + \delta\text{SM}[k]^2}$$

SM = Integrated Luminosity × Acceptance ×
{σ_{LO} × k-factors} ×
{ID and misID probabilities} ×
{Trigger Efficiencies}

- All the data are used during the fit, and all the correction factors are found simultaneously.

Object and Event selection



Physics Objects

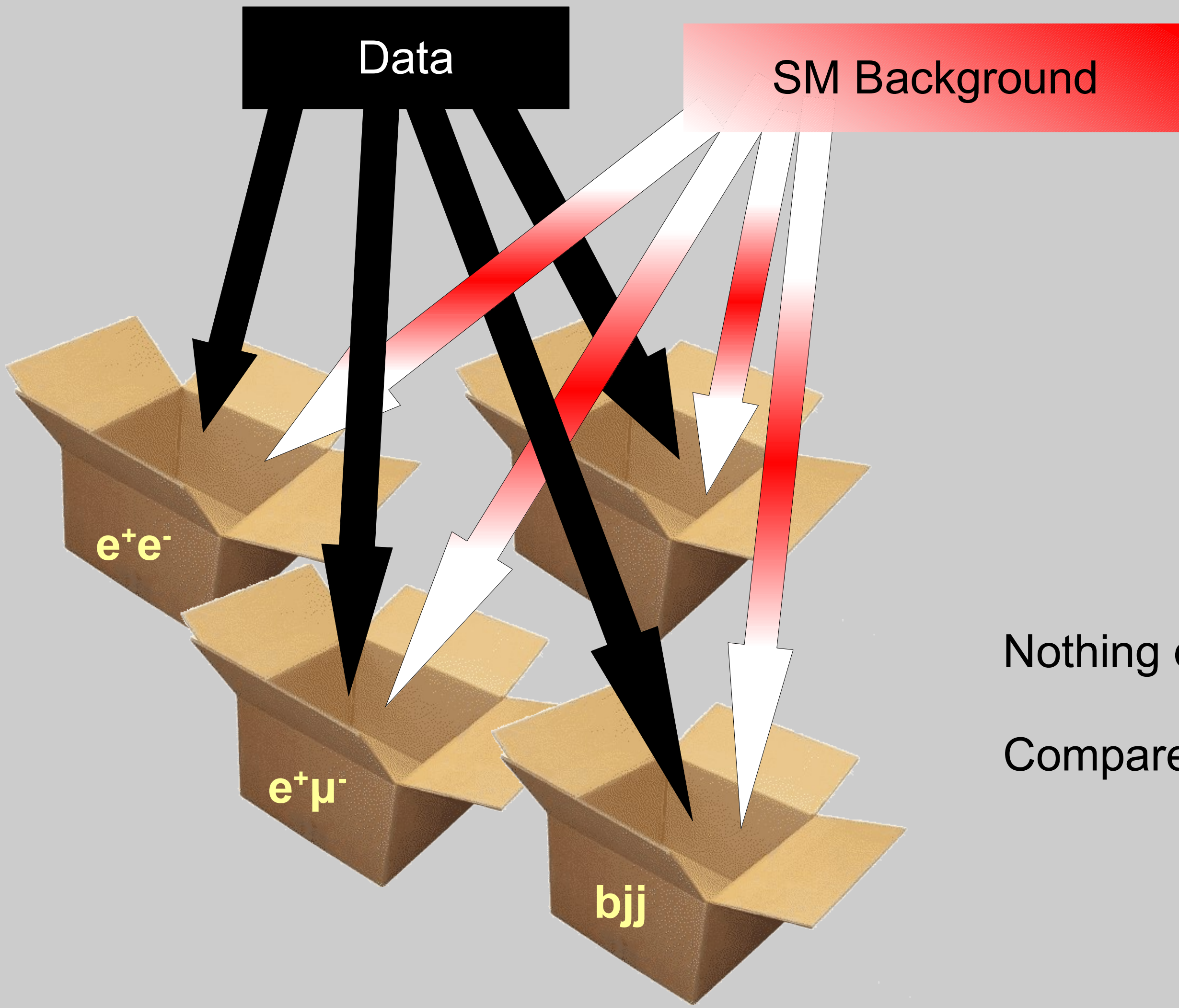
- e, μ, τ, jet, b-jet, γ, Missing E_T
- Consider objects of $p_T > 17$ GeV

Event selection

- e, $p_T > 25$ GeV
- μ, $p_T > 25$ GeV
- γ, $p_T > 60$ GeV
- jet, $p_T > 40$ GeV
- additional two-object triggers

} 4.3×10^6 events

Partition in Exclusive Final States



Nothing dropped

Compare “apples to apples”

399 final states; a lot of information

- Table including all Vista final states with at least 10 data events
- Background uncertainties are statistical.

CDF Run II Preliminary (2.0 fb^{-1})
The calculation of σ accounts for the trials factor

Final State	Data	Background	σ
$be^{\pm}\not{p}$	690	817.7 ± 9.2	−2.7
$\gamma\tau^{\pm}$	1371	1217.6 ± 13.3	+2.2
$\mu^{\pm}\tau^{\pm}$	63	35.2 ± 2.8	+1.7
$b2j\not{p}$ high-Σp_T	255	327.2 ± 8.9	−1.7
$2j\tau^{\pm}$ low-Σp_T	574	670.3 ± 8.6	−1.5
$3j\tau^{\pm}$ low-Σp_T	148	199.8 ± 5.2	−1.4
$e^{\pm}\not{p}\tau^{\pm}$	36	17.2 ± 1.7	+1.4
$2j\tau^{\pm}\tau^{\mp}$	33	62.1 ± 4.3	−1.3
$e^{\pm}j$	741710	764832 ± 6447.2	−1.3
$j2\tau^{\pm}$	105	150.8 ± 6.3	−1.2
$e^{\pm}2j$	256946	249148 ± 2201.5	+1.2
$2bj$ low-Σp_T	279	352.5 ± 11.9	−1.1
$j\tau^{\pm}$ low-Σp_T	1385	1525.8 ± 15	−1.1
$2b2j$ low-Σp_T	108	153.5 ± 6.8	−1
$b\mu^{\pm}\not{p}$	528	613.5 ± 8.7	−0.9
$\mu^{\pm}\gamma\not{p}$	523	611 ± 12.1	−0.8
$2b\gamma$	108	70.5 ± 7.9	+0.1
$8j$	14	13.1 ± 4.4	0
$7j$	103	97.8 ± 12.2	0
$6j$	653	659.7 ± 37.3	0
$5j$	3157	3178.7 ± 67.1	0
$4j$ high-Σp_T	88546	89096.6 ± 935.2	0
$4j$ low-Σp_T	14872	14809.6 ± 186.3	0
$4j2\gamma$	46	46.4 ± 3.9	0
$4j\tau^{\pm}$ high-Σp_T	29	26.6 ± 1.7	0
$4j\tau^{\pm}$ low-Σp_T	43	63.1 ± 3.3	0
$4j\not{p}$ high-Σp_T	1064	1012 ± 62.9	0
$4j\gamma\tau^{\pm}$	19	10.8 ± 2	0
$4j\gamma\not{p}$	62	104.2 ± 22.4	0
$4j\gamma$	7962	8271.2 ± 245.1	0
$4j\mu^{\pm}\not{p}$	574	590.5 ± 13.6	0
$4j\mu^{\pm}\mu^{\mp}$	38	48.4 ± 6.2	0
$4j\mu^{\pm}$	1363	1350.1 ± 37.7	0
$3j$ high-Σp_T	159926	159143 ± 1061.9	0
$3j$ low-Σp_T	62681	64213.1 ± 496	0
$3j2\gamma$	151	177.5 ± 7.1	0
$3j\tau^{\pm}$ high-Σp_T	68	76.9 ± 3	0
$3j\not{p}$ high-Σp_T	1706	1899.4 ± 77.6	0
$3j\not{p}$ low-Σp_T	42	36.2 ± 5.7	0
$3j\gamma\tau^{\pm}$	39	37.8 ± 3.6	0
$3j\gamma\not{p}$	204	249.8 ± 24.4	0
$3j\gamma$	24639	24899.4 ± 372.4	0
$3j\mu^{\pm}\not{p}$	2884	2971.5 ± 52.1	0
$3j\mu^{\pm}\gamma\not{p}$	10	3.6 ± 1.9	0
$3j\mu^{\pm}\gamma$	15	7.9 ± 2.9	0
$3j\mu^{\pm}\mu^{\mp}$	175	177.8 ± 16.2	0
$3j\mu^{\pm}$	5032	4989.5 ± 108.9	0
$3b2j$	23	28.9 ± 4.7	0
$3bj$	82	82.6 ± 5.7	0
$3b$	67	85.6 ± 7.7	0
$2\tau^{\pm}$	498	512.7 ± 14.2	0
$2\gamma\not{p}$	128	107.2 ± 6.9	0
2γ	5548	5562.8 ± 40.5	0
$2j$ high-Σp_T	190773	190842 ± 781.2	0
$2j$ low-Σp_T	165984	162530 ± 1581	0
$2j2\tau^{\pm}$	22	40.6 ± 3.2	0
$2j2\gamma\not{p}$	11	8 ± 2.4	0
$2j2\gamma$	580	581 ± 13.7	0
$2j\tau^{\pm}$ high-Σp_T	96	114.6 ± 3.3	0

Final State	Data	Background	σ
$2j\not{p}$ high-Σp_T	87	80.9 ± 6.8	0
$2j\not{p}$ low-Σp_T	114	79.5 ± 100.8	0
$2j\not{p}\tau^{\pm}$	18	13.2 ± 2.2	0
$2j\gamma\tau^{\pm}$	142	144.6 ± 5.7	0
$2j\gamma\not{p}$	908	980.3 ± 63.7	0
$2j\gamma$	71364	73021.4 ± 595.9	0
$2j\mu^{\pm}\tau^{\mp}$	16	19.3 ± 2.2	0
$2j\mu^{\pm}\not{p}$	17927	18340.6 ± 201.9	0
$2j\mu^{\pm}\gamma\not{p}$	31	27.7 ± 7.7	0
$2j\mu^{\pm}\gamma$	57	58.2 ± 13	0
$2j\mu^{\pm}\mu^{\mp}\not{p}$	11	7.8 ± 2.7	0
$2j\mu^{\pm}\mu^{\mp}$	956	924.9 ± 61.2	0
$2j\mu^{\pm}$	22461	23111.4 ± 366.6	0
$2e^{\pm}j$	14	13.8 ± 2.3	0
$2e^{\pm}e^{\mp}$	20	17.5 ± 1.7	0
$2e^{\pm}$	32	49.2 ± 3.4	0
$2b$ high-Σp_T	666	689 ± 9.4	0
$2b$ low-Σp_T	323	313.2 ± 10.3	0
$2b3j$ low-Σp_T	53	57.4 ± 6.5	0
$2b2j$ high-Σp_T	718	803.3 ± 12.7	0
$2b2j\not{p}$ high-Σp_T	15	21.8 ± 2.8	0
$2b2j\gamma$	32	39.7 ± 6.2	0
$2b2j\mu^{\pm}\not{p}$	14	17.3 ± 1.9	0
$2b2j\mu^{\pm}$	22	21.8 ± 2	0
$2b\mu^{\pm}\not{p}$	11	14.4 ± 2.1	0
$2bj$ high-Σp_T	891	967.1 ± 13.2	0
$2bj\not{p}$ high-Σp_T	25	31.3 ± 3.1	0
$2bj\gamma$	71	54.5 ± 7.1	0
$2bj\mu^{\pm}\not{p}$	12	10.7 ± 1.9	0
$2be^{\pm}2j\not{p}$	30	27.3 ± 2.2	0
$2be^{\pm}2j$	72	66.5 ± 2.9	0
$2be^{\pm}\not{p}$	22	19.1 ± 2.2	0
$2be^{\pm}j\not{p}$	19	19.4 ± 2.2	0
$2be^{\pm}j$	63	63 ± 3.4	0
$2be^{\pm}$	96	92.1 ± 4.1	0
$\tau^{\pm}\tau^{\mp}$	856	872.5 ± 19	0
$\gamma\not{p}$	3793	3770.7 ± 127.3	0
$\mu^{\pm}\tau^{\mp}$	381	440.9 ± 7.3	0
$\mu^{\pm}\not{p}\tau^{\mp}$	60	75.7 ± 3.4	0
$\mu^{\pm}\not{p}\tau^{\pm}$	15	12 ± 2	0
$\mu^{\pm}\not{p}$	734290	734296 ± 4897.8	0
$\mu^{\pm}\gamma$	475	469.8 ± 12.5	0
$\mu^{\pm}\mu^{\mp}\not{p}$	169	198.5 ± 8.2	0
$\mu^{\pm}\mu^{\mp}\gamma$	83	60 ± 3.1	0
$\mu^{\pm}\mu^{\mp}$	25283	25178.5 ± 86.5	0
$j2\gamma\not{p}$	36	30.4 ± 4.2	0
$j2\gamma$	1822	1813.2 ± 27.4	0
$j\tau^{\pm}$ high-Σp_T	52	56.2 ± 2.5	0
$j\tau^{\pm}\tau^{\mp}$	203	252.2 ± 8.7	0
$j\not{p}$ high-Σp_T	4432	4431.7 ± 45.2	0
$j\gamma\tau^{\pm}$	526	476 ± 9.3	0
$j\gamma\not{p}$	1882	1791.9 ± 72.3	0
$j\gamma$	103319	102124 ± 570.6	0
$j\mu^{\pm}\tau^{\mp}$	71	98 ± 3.9	0
$j\mu^{\pm}\tau^{\pm}$	15	12 ± 2	0
$j\mu^{\pm}\not{p}\tau^{\mp}$	26	30.8 ± 2.6	0
$j\mu^{\pm}\not{p}$	109081	108323 ± 707.7	0
$j\mu^{\pm}\gamma\not{p}$	171	171.1 ± 31	0
$j\mu^{\pm}\gamma$	152	190 ± 39.3	0

Final State	Data	Background	σ
$j\mu^{\pm}\mu^{\mp}\not{p}$	32	32.2 ± 10.9	0
$j\mu^{\pm}\mu^{\mp}\gamma$	14	11.5 ± 2.6	0
$j\mu^{\pm}\mu^{\mp}$	4852	4271.2 ± 185.4	0
$j\mu^{\pm}$	77689	76987.5 ± 930.2	0
$e^{\pm}4j\not{p}$	903	830.6 ± 13.2	0
$e^{\pm}4j\gamma$	25	29.2 ± 3.6	0
$e^{\pm}4j$	15750	16740.4 ± 390.5	0
$e^{\pm}3j\tau^{\mp}$	15	21.1 ± 2.2	0
$e^{\pm}3j\not{p}$	4054	4077.2 ± 63.6	0
$e^{\pm}3j\gamma$	108	79.3 ± 5	0
$e^{\pm}3j$	60725	60409.3 ± 723.3	0
$e^{\pm}2\gamma$	41	34.2 ± 2.6	0
$e^{\pm}2j\tau^{\pm}$	37	47.2 ± 2.2	0
$e^{\pm}2j\tau^{\mp}$	109	95.9 ± 6.8	0
$e^{\pm}2j\not{p}$	25725	25403.1 ± 209.4	0
$e^{\pm}2j\gamma\not{p}$	30	31.8 ± 4.8	0
$e^{\pm}2j\gamma$	398	342.8 ± 15.7	0
$e^{\pm}2j\mu^{\mp}\not{p}$	22	14.8 ± 1.9	0
$e^{\pm}2j\mu^{\mp}$	23	15.8 ± 2	0
$e^{\pm}\tau^{\pm}$	437	387 ± 5.3	0
$e^{\pm}\tau^{\mp}$	1333	1266 ± 12.3	0
$e^{\pm}\not{p}\tau^{\mp}$	109	106.1 ± 2.7	0
$e^{\pm}\not{p}$	960826	956579 ± 3077.7	0
$e^{\pm}\gamma\not{p}$	497	496.8 ± 10.3	0
$e^{\pm}\gamma$	3578	3589.9 ± 24.1	0
$e^{\pm}\mu^{\pm}\not{p}$	31	29.9 ± 1.6	0
$e^{\pm}\mu^{\mp}\not{p}$	109	99.4 ± 2.4	0
$e^{\pm}\mu^{\pm}$	45	28.5 ± 1.8	0
$e^{\pm}\mu^{\mp}$	350	313 ± 5.4	0
$e^{\pm}j2\gamma$	13	16.1 ± 3.9	0
$e^{\pm}j\tau^{\mp}$	386	418 ± 18.9	0
$e^{\pm}j\tau^{\pm}$	160	162.8 ± 3.5	0
$e^{\pm}j\not{p}\tau^{\mp}$	48	44.6 ± 3.3	0
$e^{\pm}j\not{p}\tau^{\pm}$	11	8.3 ± 1.5	0
$e^{\pm}j\not{p}$	121431	121023 ± 747.6	0
$e^{\pm}j\gamma\not{p}$	159	192.6 ± 10.9	0
$e^{\pm}j\gamma$	1389	1368.9 ± 38.9	0
$e^{\pm}j\mu^{\mp}\not{p}$	42	33 ± 2.9	0
$e^{\pm}j\mu^{\pm}\not{p}$	16	9.2 ± 1.9	0
$e^{\pm}j\mu^{\mp}$	62	63.8 ± 3.2	0
$e^{\pm}j\mu^{\pm}$	13	8.2 ± 2	0
$e^{\pm}e^{\mp}4j$	148	159.1 ± 7	0
$e^{\pm}e^{\mp}3j$	717	743.6 ± 24.4	0
$e^{\pm}e^{\mp}2j\not{p}$	32	41.4 ± 5.6	0
$e^{\pm}e^{\mp}2j\gamma$	10	11.4 ± 2.9	0
$e^{\pm}e^{\mp}2j$	3638	3566.8 ± 72	0
$e^{\pm}e^{\mp}\tau^{\pm}$	18	16.1 ± 1.7	0
$e^{\pm}e^{\mp}\not{p}$	822	831.8 ± 13.6	0
$e^{\pm}e^{\mp}\gamma$	191	221.9 ± 5.1	0
$e^{\pm}e^{\mp}j\not{p}$	155	170.8 ± 12.4	0
$e^{\pm}e^{\mp}j\gamma$	48	45 ± 3.9	0
$e^{\pm}e^{\mp}j$	17903	18258.2 ± 204.4	0
$e^{\pm}e^{\mp}$	98901	99086.9 ± 147.8	0
$b6j$	51	42.3 ± 3.8	0
$b5j$	237	192.5 ± 7.1	0
$b4j$ high-Σp_T	26	23.4 ± 2.6	0
$b4j$ low-Σp_T	836	821.7 ± 15.9	0
$b3j$ high-Σp_T	12081	12071 ± 84.1	0
$b3j$ low-Σp_T	2974	2873 ± 31	0

Ways to look for discrepancies

Population discrepancies

Shape discrepancies

Mass resonances

High Σp_T excesses

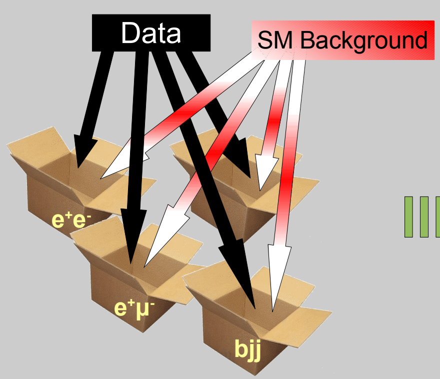
Population discrepancies

Using Poisson statistics

Expected b
Observed d

$$\text{p-val}=\begin{cases} \text{if } d \geq b, & \sum_{n=d}^{\infty} \frac{b^n}{n!} e^{-b} \\ \text{if } d < b, & \sum_{n=0}^{d} \frac{b^n}{n!} e^{-b} \end{cases}$$

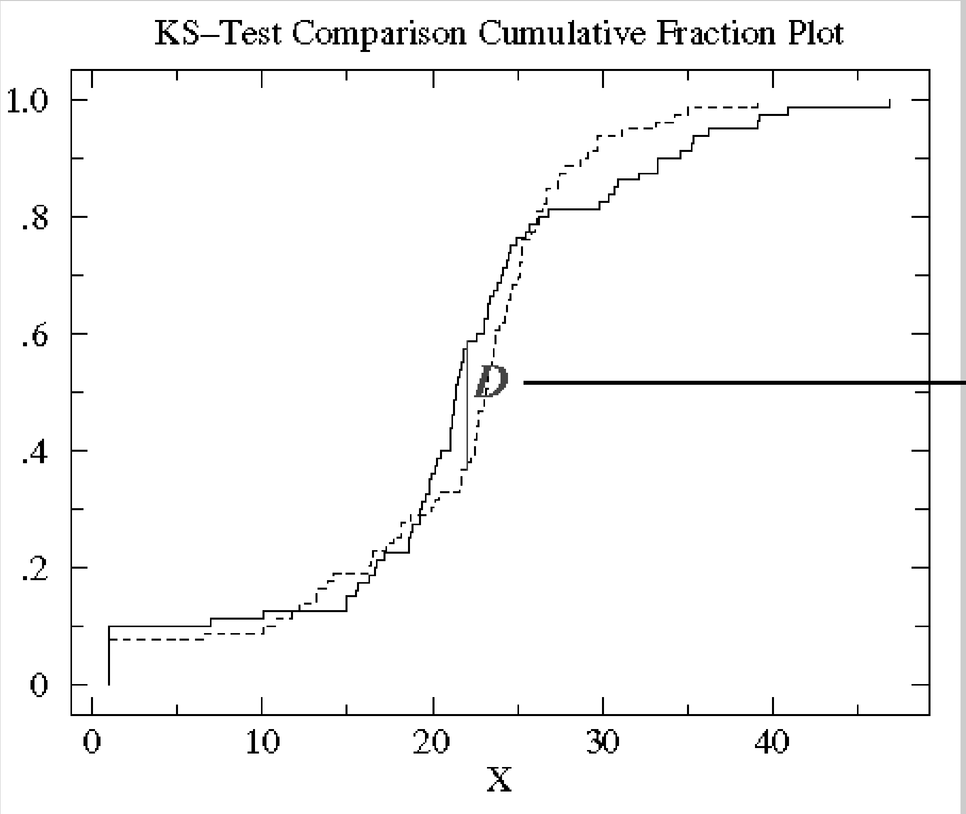
(Not mentioning convolution with uncertainty in b.)



399 final states → 399 populations

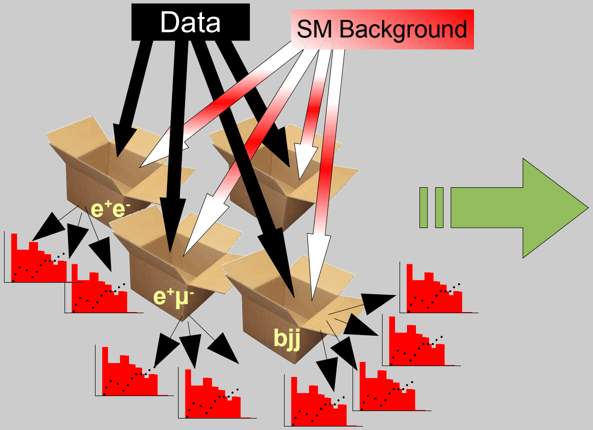
Shape discrepancies

Using Kolmogorov-Smirnov test



D: "*KS statistic*"

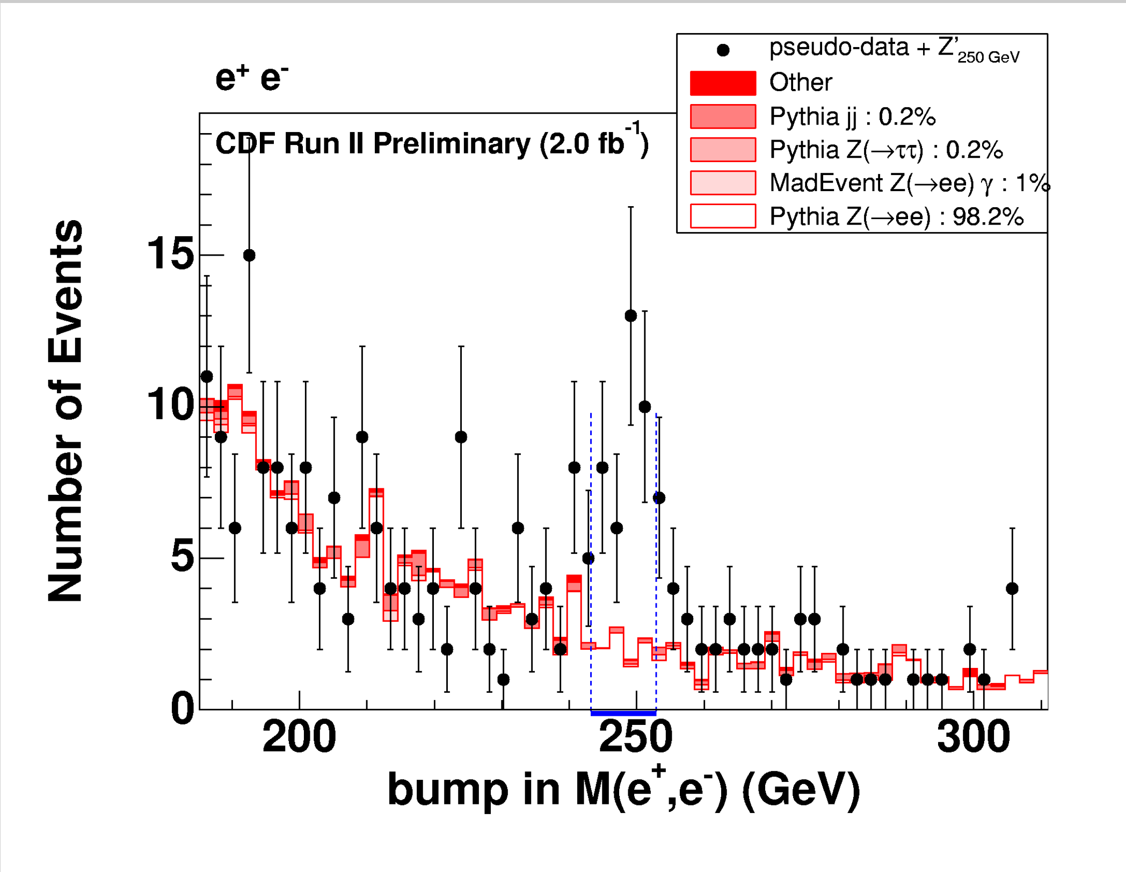
From D we find *KS probability* (that shapes are consistent)



399 final states × ~49 kinematic distributions each ≈ 20,000 shapes

For example: masses, p_T, Σp_T, η, φ, ΔR etc.

Mass resonances



Target: Narrow mass resonances

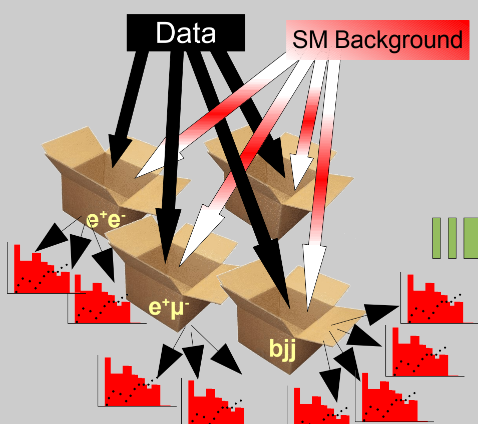
Scan all mass spectra with a window.
Window size follows mass resolution.
Sidebands have to agree more than center.

Each bump has a p-value

$$\sum_{n=d}^{\infty} \frac{b^n}{n!} e^{-b}$$

Most interesting window : p-val$_{min}$
Repeat for all mass variables.
Evaluate significance, given trials factor.

Discovery threshold: 3σ after trials factor.



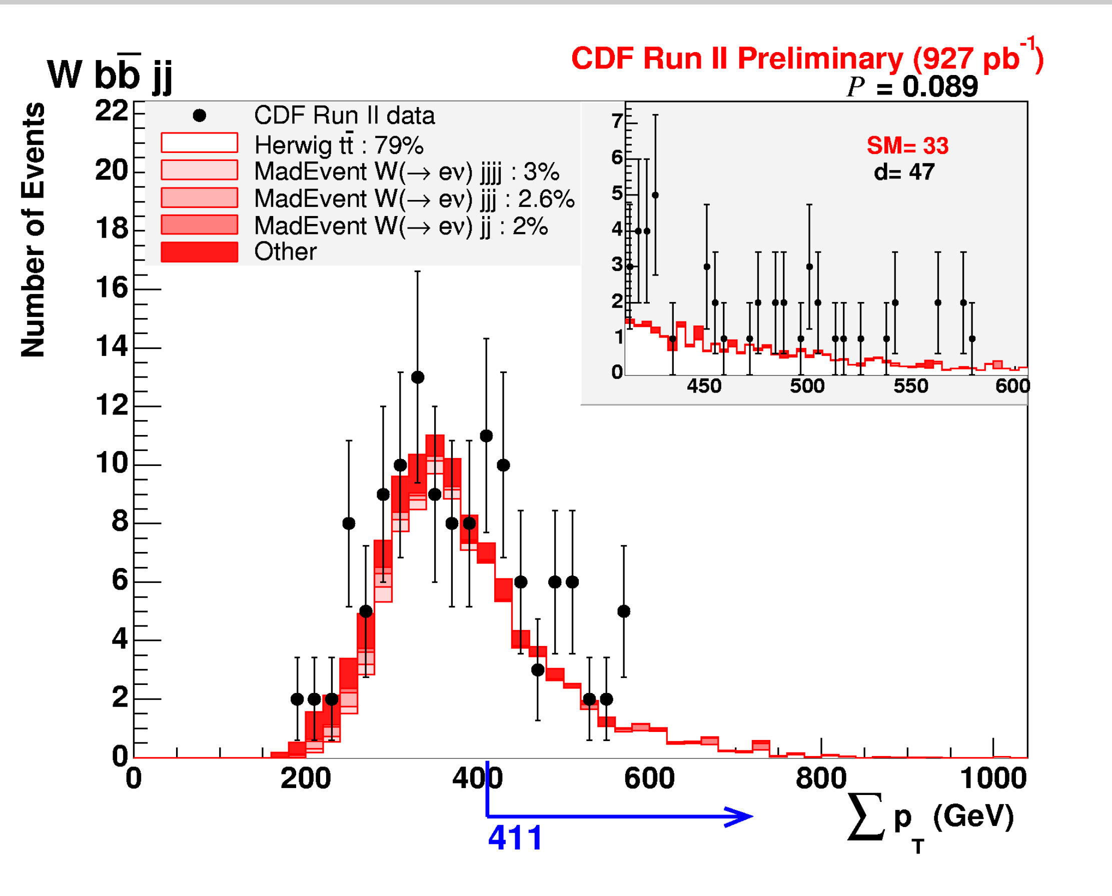
399 final states : ~20,000 shapes : ~5,000 mass variables

High-Σp_T excesses

-Why Σp_T?

-Sensitive: New physics → Heavy objects → High-Σp_T products

-Universal: Every event has a Σp_T.



In each tail we expect b and observe d.
Find p-val of all tails.

$$\sum_{n=d}^{\infty} \frac{b^n}{n!} e^{-b}$$

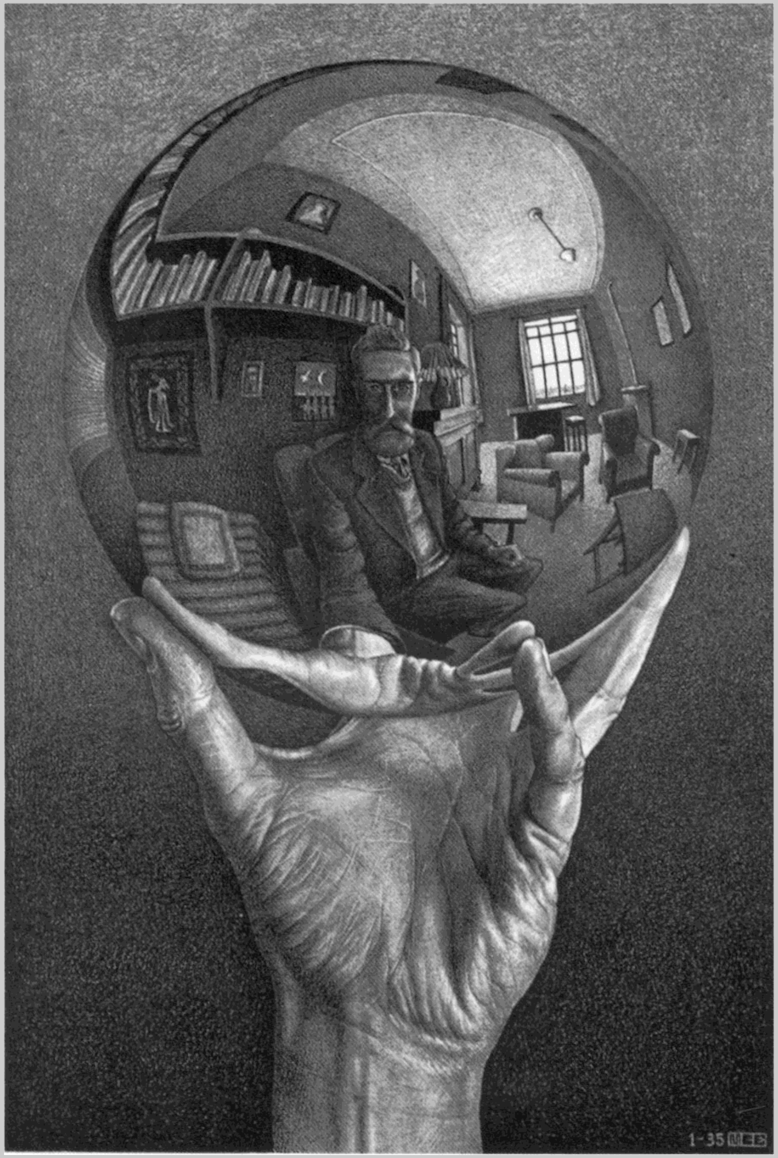
Mark most interesting (p-val$_{min}$).

Repeat for all final states.

Evaluate significance, given trials factor.

Discovery threshold: 3σ after trials factor.

We have it all at our fingertips



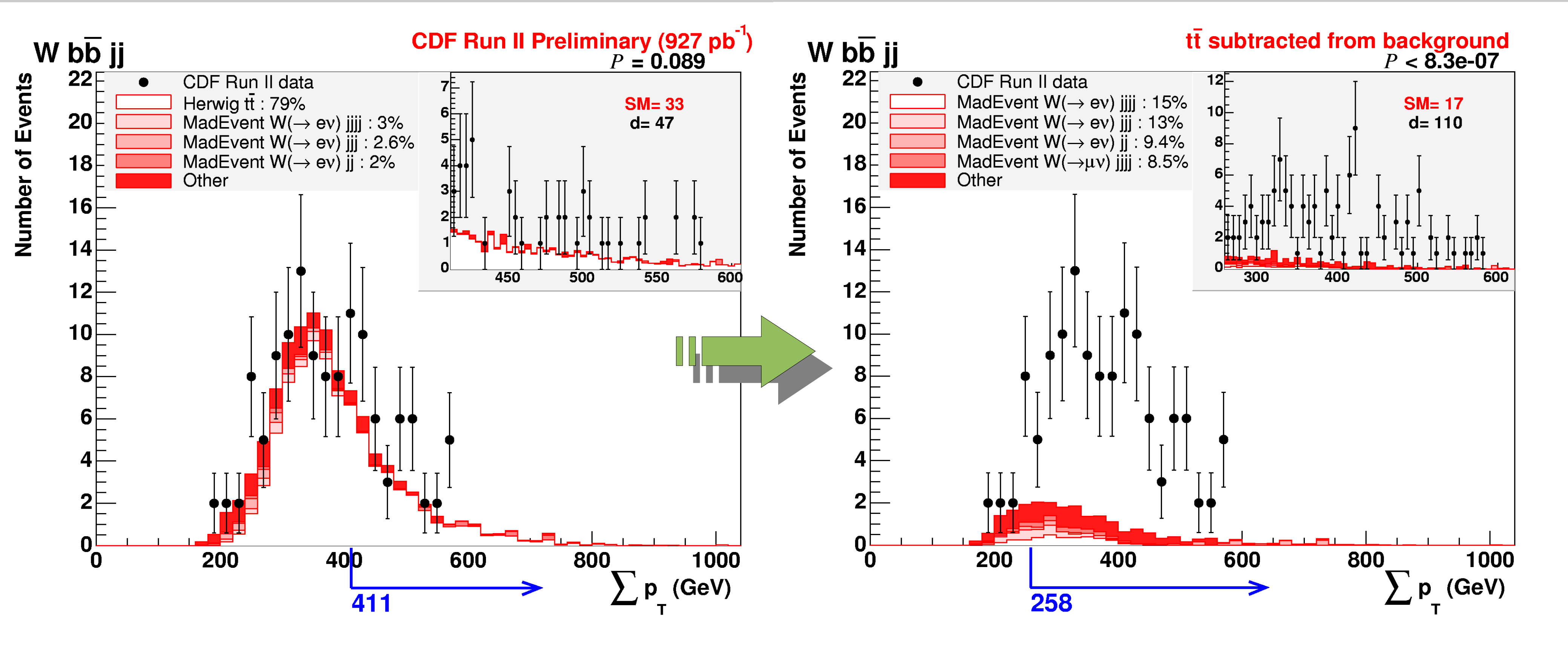
Interesting features are listed first

All plots are 2 clicks away

CDF has a complete view of its high-p_T data

Would this have found top?

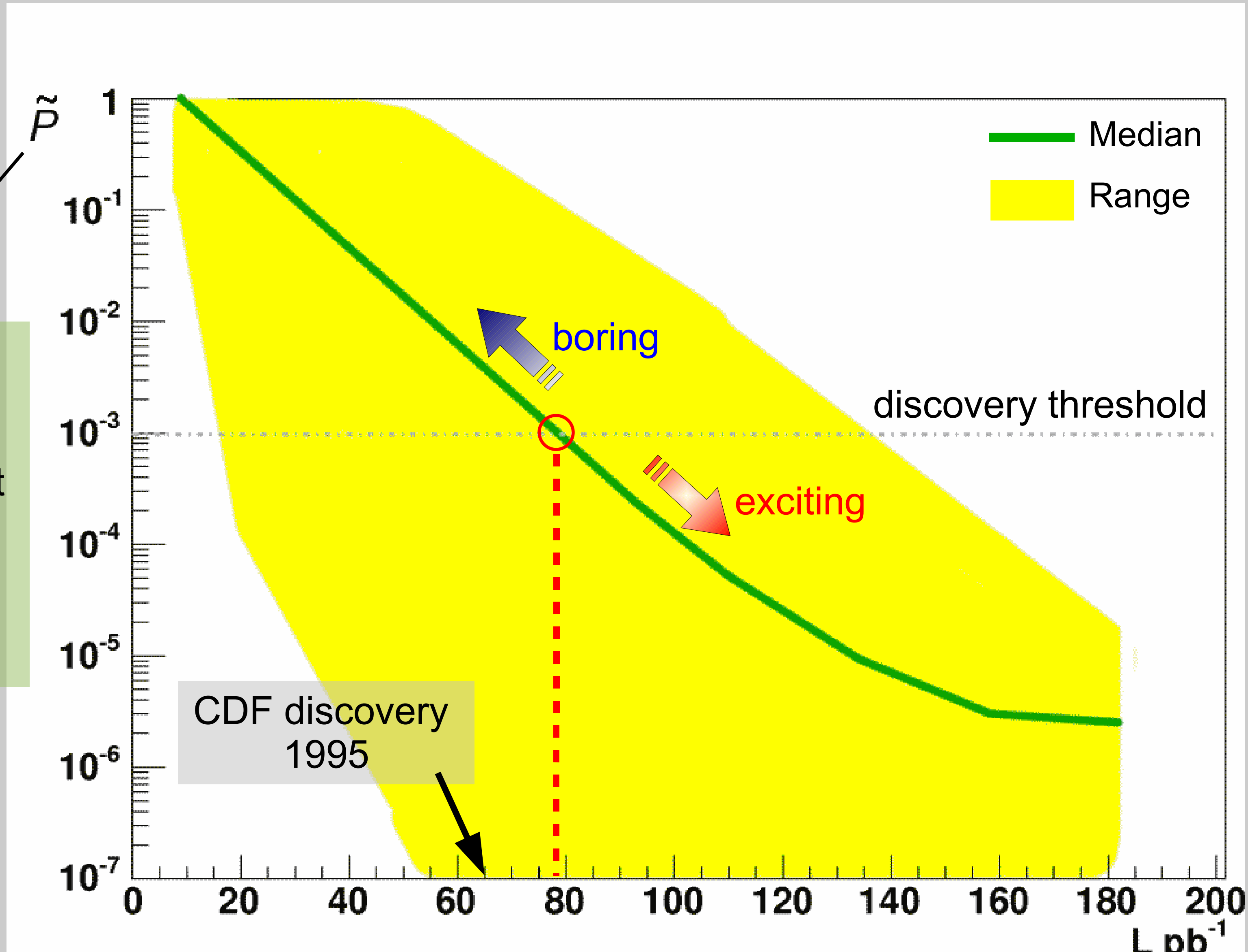
Remove top quark from Standard Model, refit correction factors, search!



Easily finding top in 1 fb^{-1}

How much would it have taken?

Top quark removed from background.
Scale integrated luminosity.

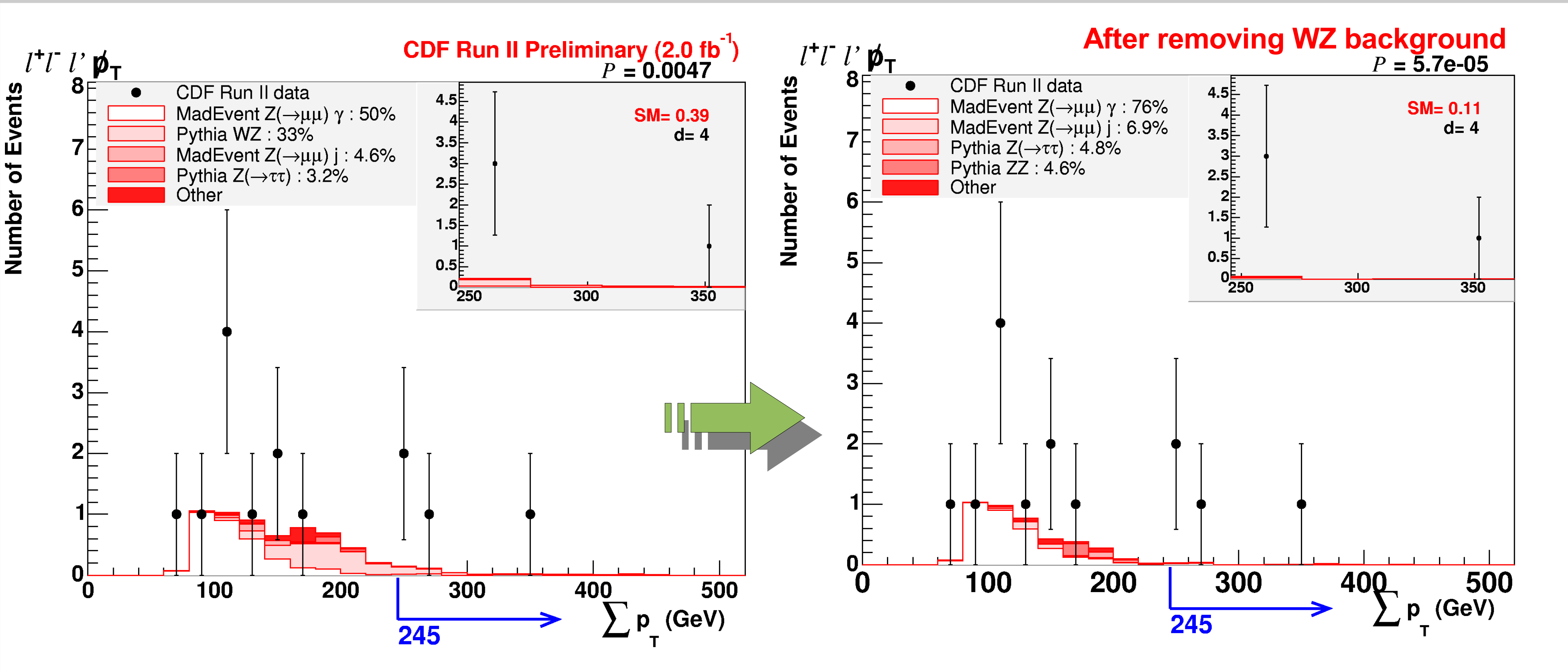


Probability that the most interesting excess is just a fluctuation.

(trials factor included)

WZ

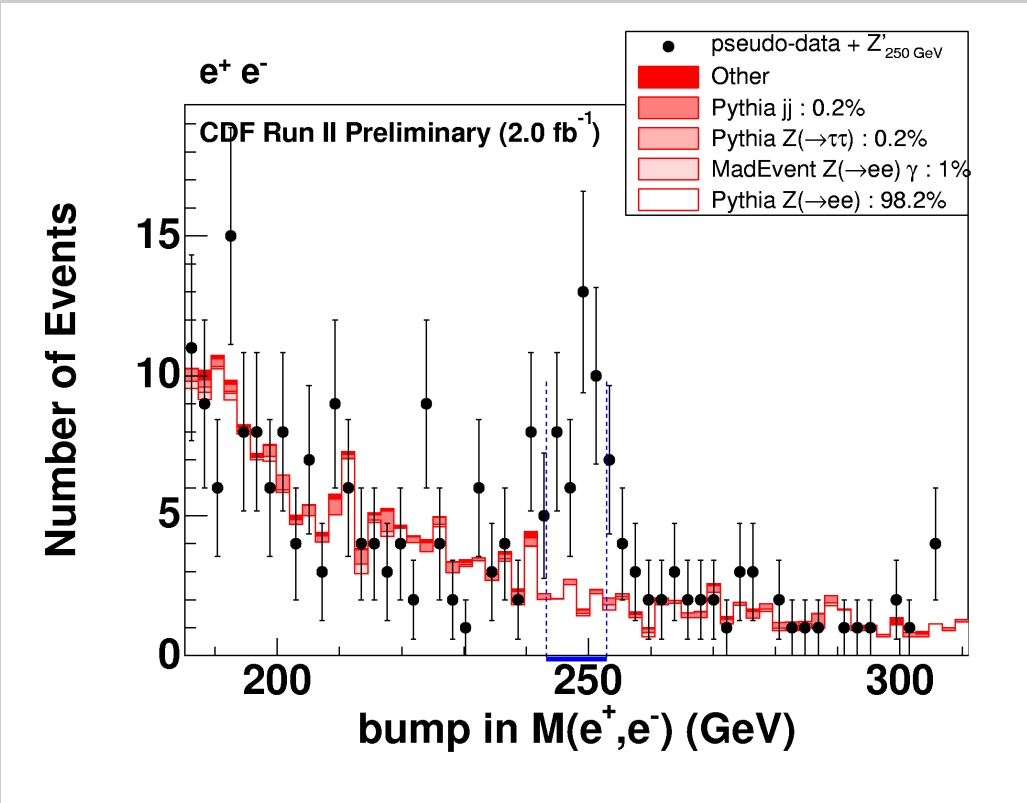
example of a signal we don't see with this analysis

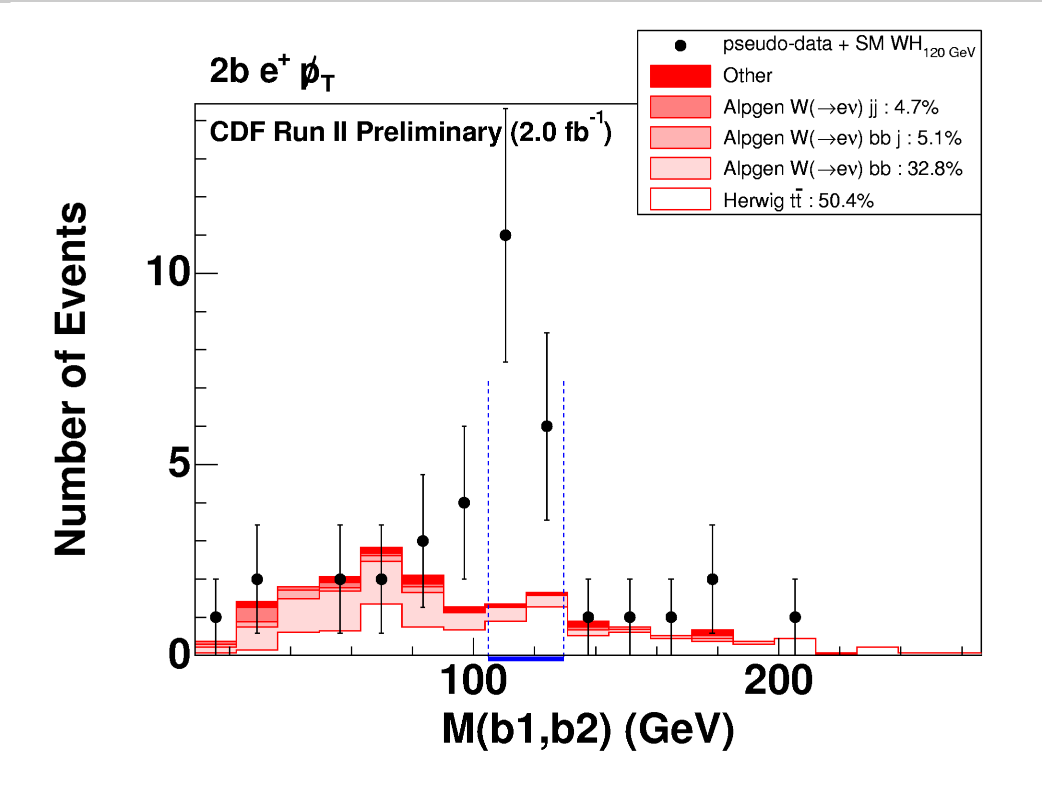


$\tilde{P}$ becomes 1%, corresponding to (only) 2.3σ effect.

CDF observed WZ (at 6σ significance) with 1.1 fb^{-1} [Phys. Rev. Lett. 98, 161801 (2007)].

Sensitivity to bumps?





$Z'_{250} \rightarrow$ charged leptons

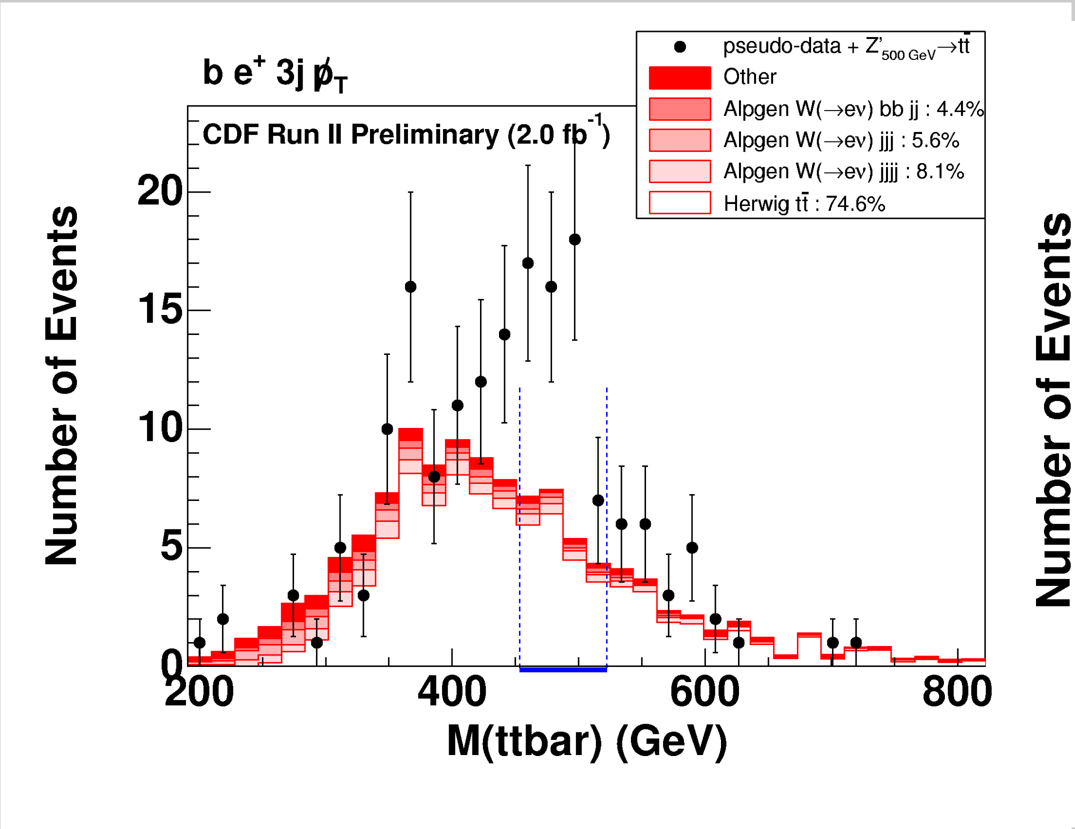
5σ discovery if σ×BR ≈ 0.325 pb.

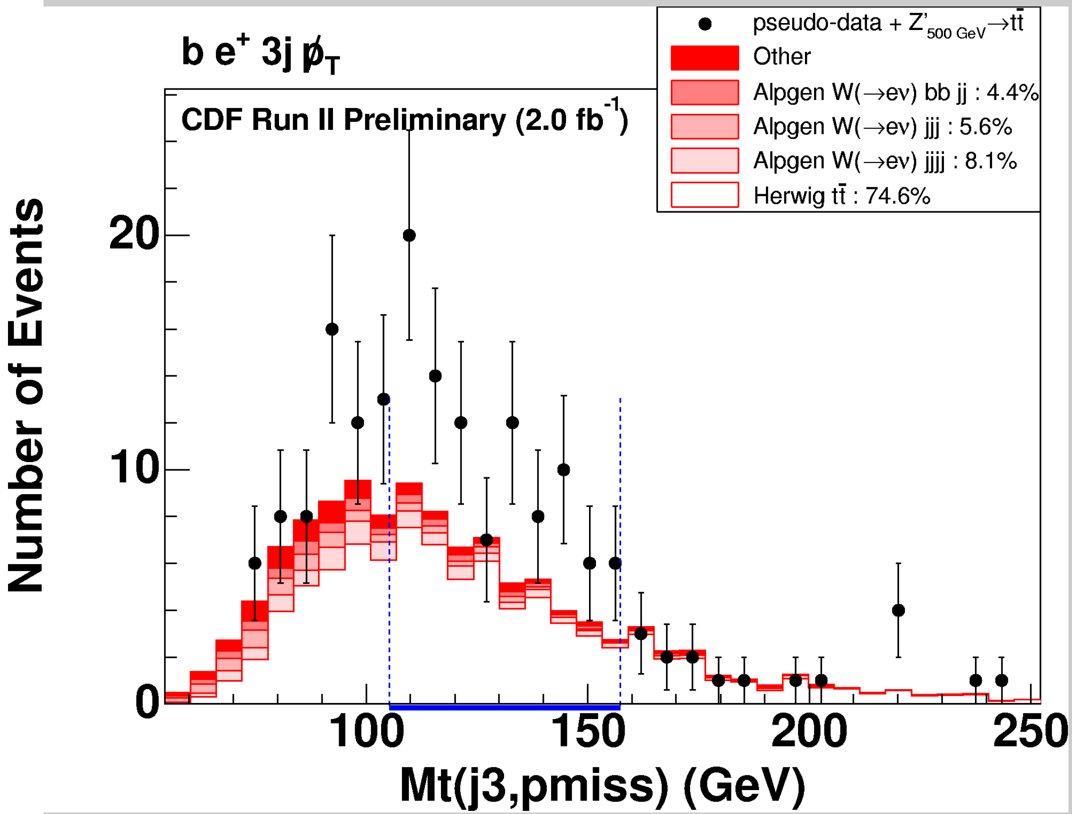
$WH_{120} \rightarrow \ell\nu b\bar{b}$

5σ discovery if σ ≈ 14 pb.

(Standard Model predicts 0.159 pb.)

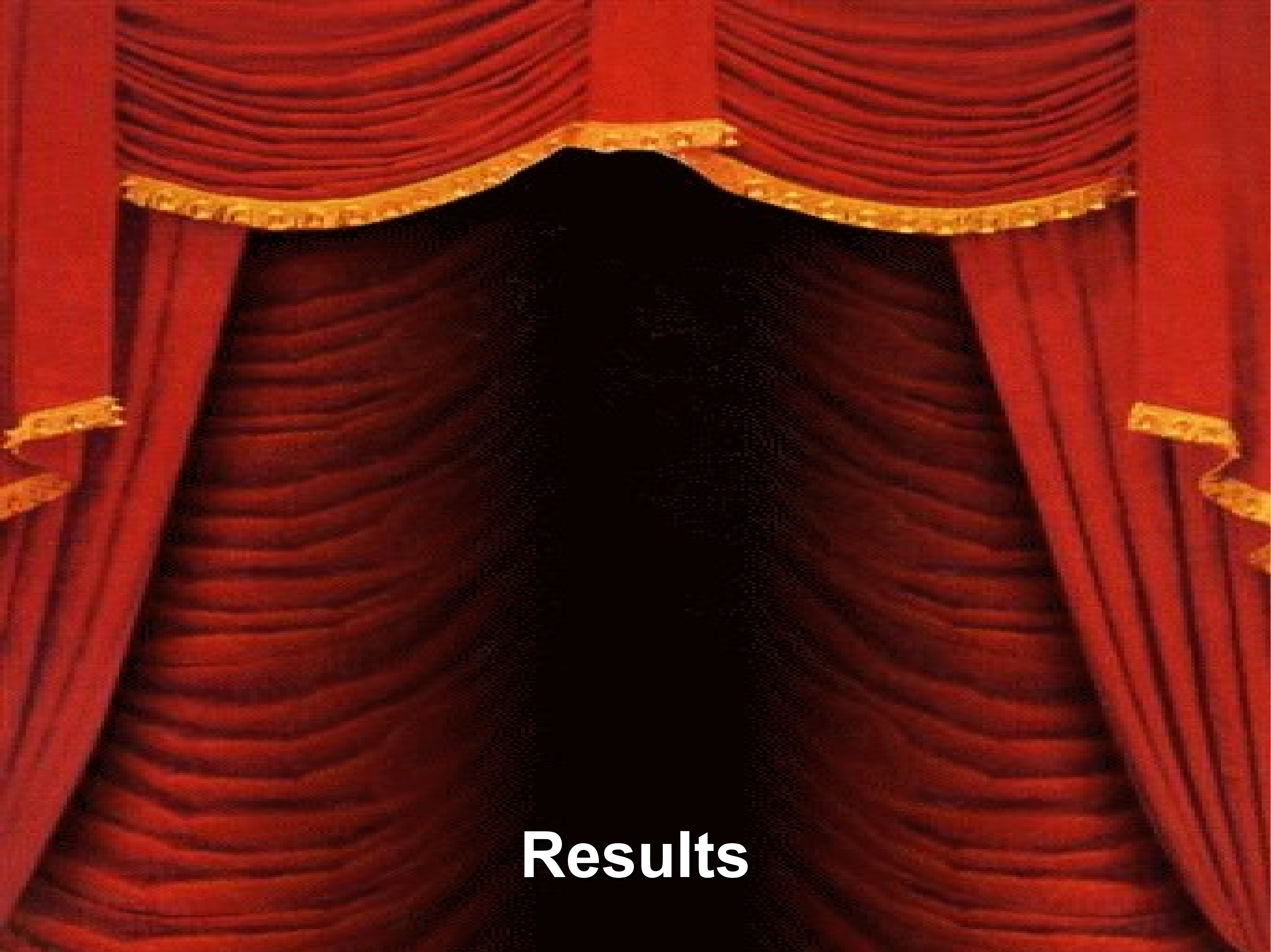
Z' (500GeV) → $t\bar{t}$





5σ discovery if σ×BR=2.2pb

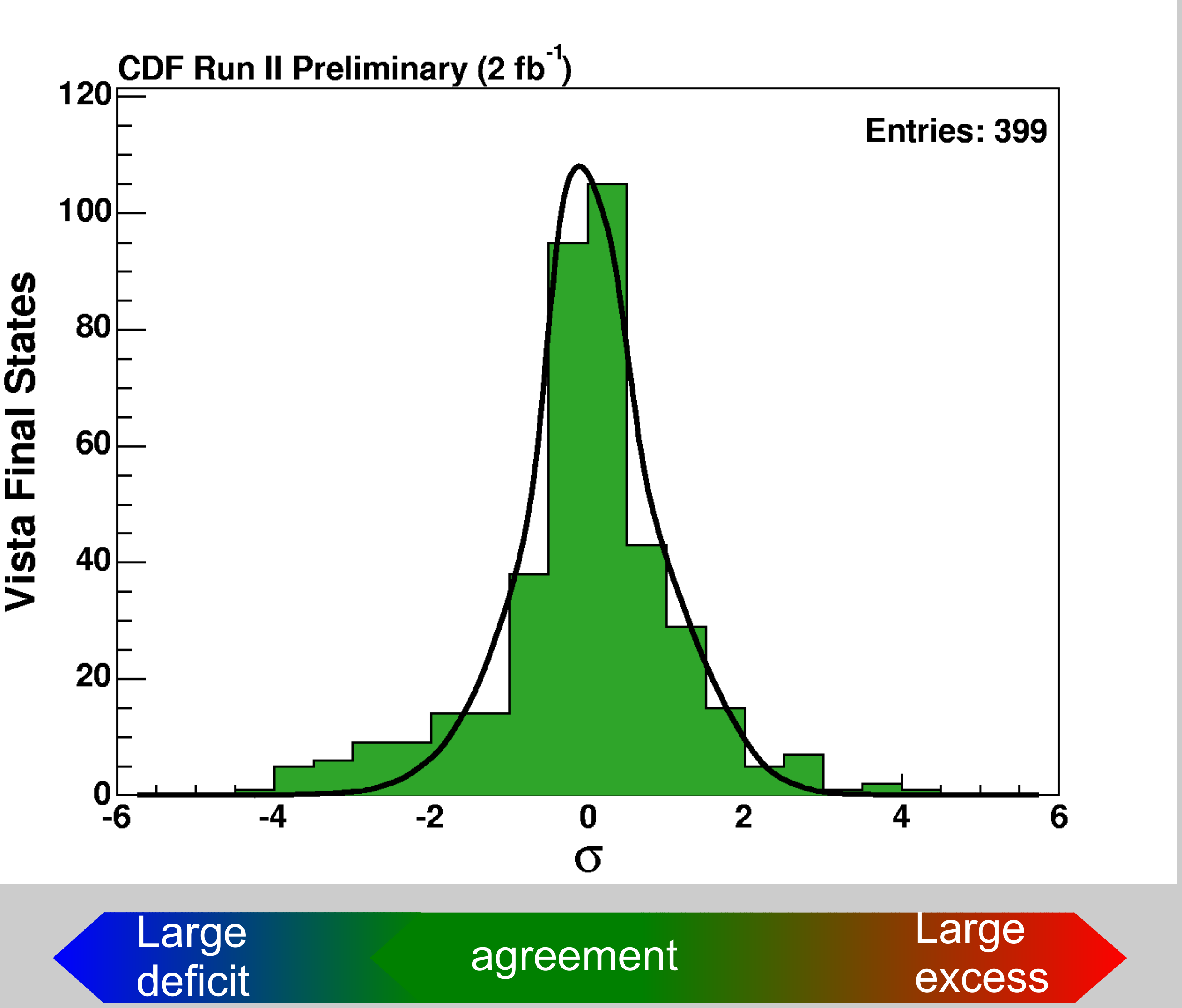
The same signal can appear in different variables.



Results

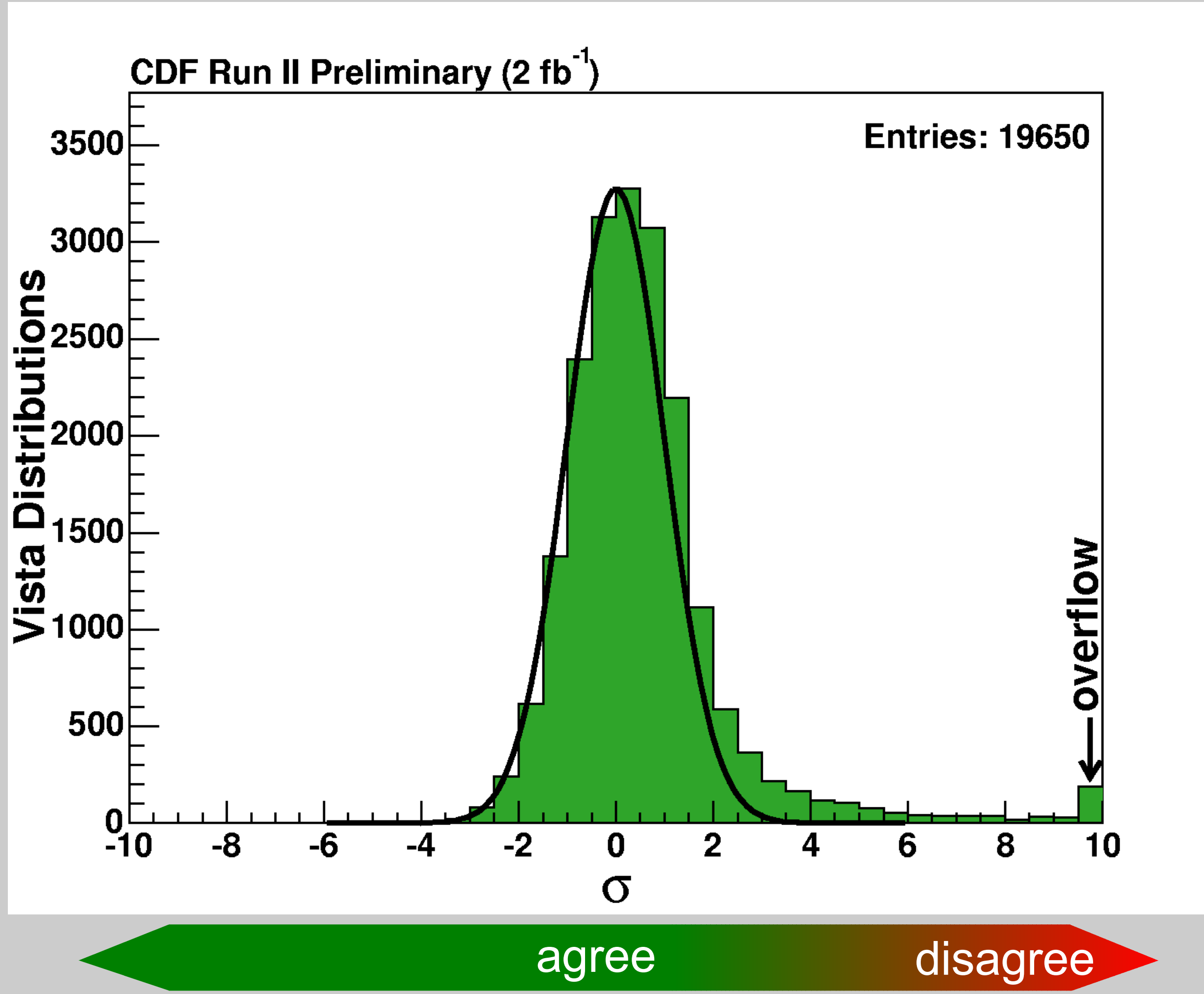
Populations

- The Poisson probability that the SM population in a final state would fluctuate above (or below) the observed population in the data.
- This probability is expressed in units of standard deviation (σ).
- These probabilities plotted do not yet take into account the **trials factor**: We examined 399 final states. Accounting for this reduces the significance of every observed discrepancy.
- After taking into account the trials factor, the greatest population discrepancy is only a **2.7σ** deficit of data.



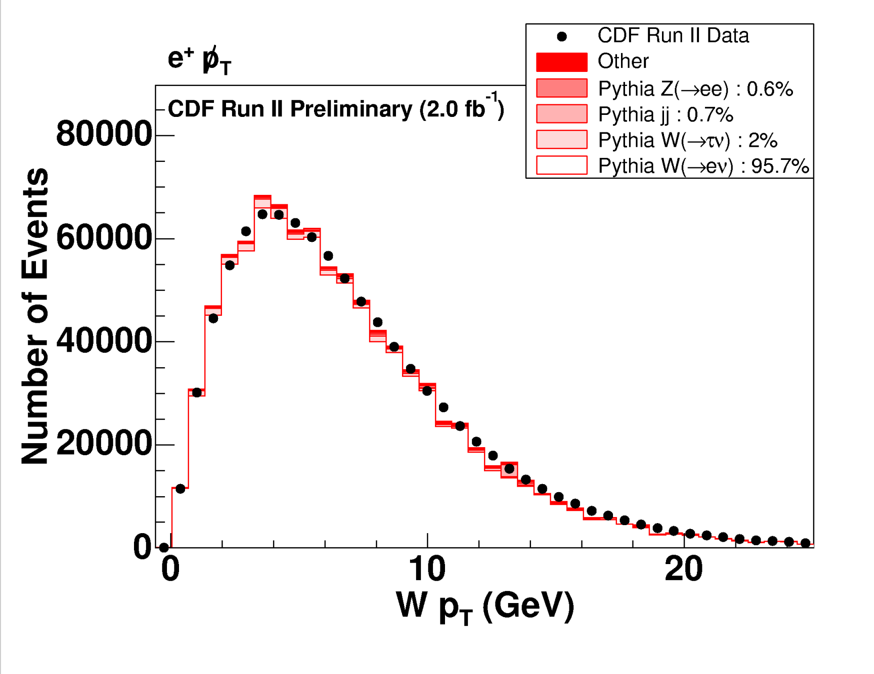
Distribution Shapes

- Vista automatically produces and examines ~20,000 distributions of kinematic variables.
- Their consistency with the background is tested using Kolmogorov-Smirnov test.
- The KS probability P (that two distributions are consistent) is expressed in units of standard deviation (σ).
- In the probabilities plotted here, the trials factor due to examining thousands of distributions has not yet been accounted for.

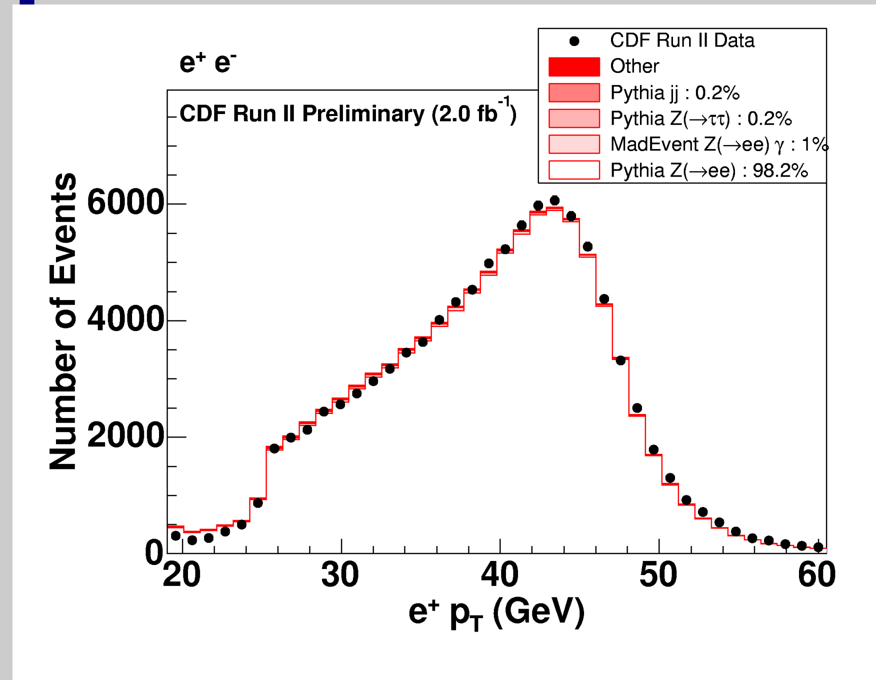


– Interest is focused on outliers showing significant disagreement

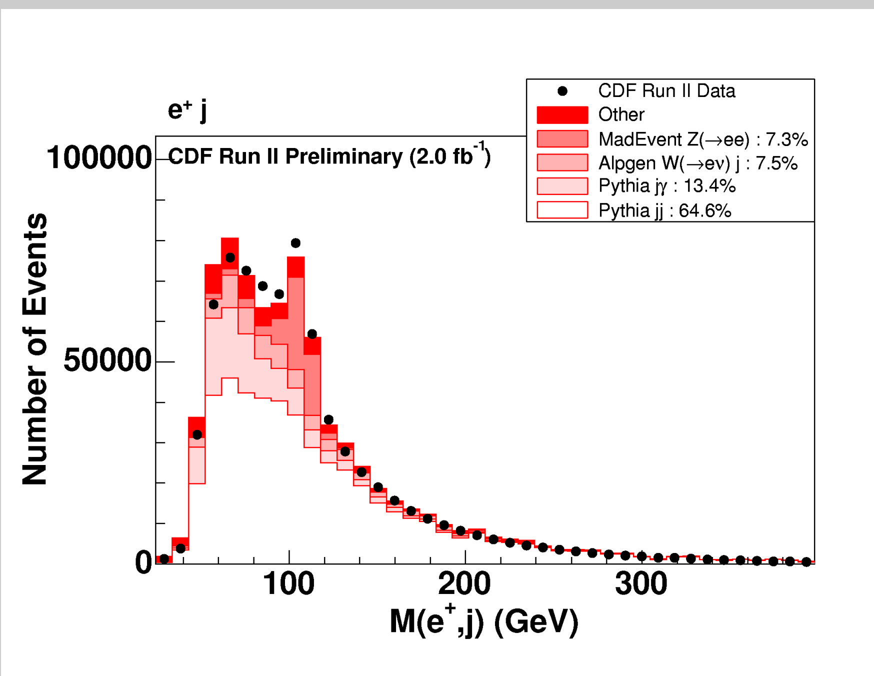
Examples



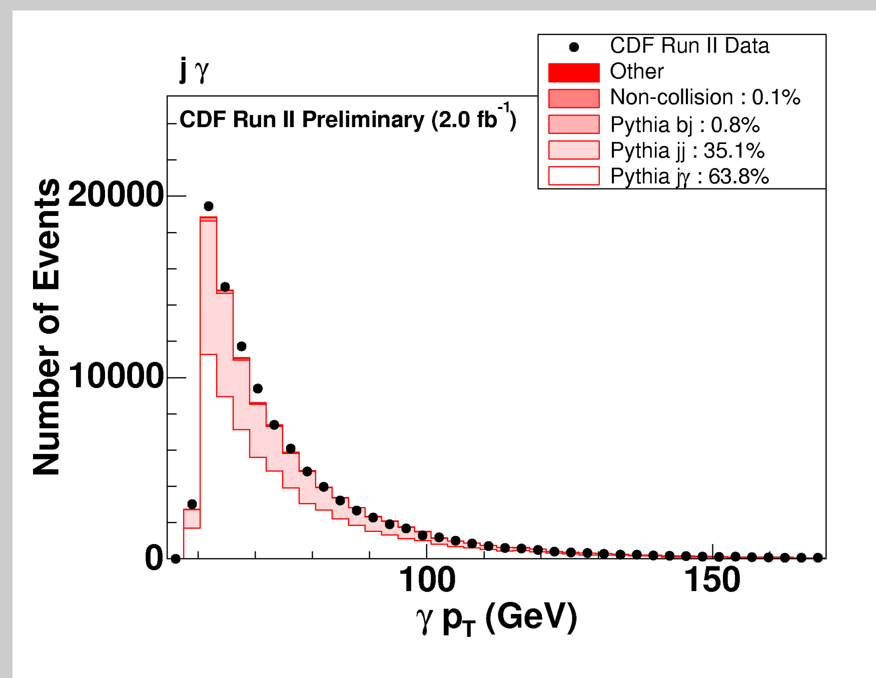
e+ $\not{p}_T$
CDF Run II Preliminary (2.0 fb-1)
CDF Run II Data
Other
Pythia Z(→ee) : 0.6%
Pythia jj : 0.7%
Pythia W(→τν) : 2%
Pythia W(→eν) : 95.7%
Number of Events
0
20000
40000
60000
80000
0
10
20
W pT (GeV)



e+ e-
CDF Run II Preliminary (2.0 fb-1)
CDF Run II Data
Other
Pythia jj : 0.2%
Pythia Z(→ττ) : 0.2%
MadEvent Z(→ee) γ : 1%
Pythia Z(→ee) : 98.2%
Number of Events
0
2000
4000
6000
20
30
40
50
60
e+ pT (GeV)

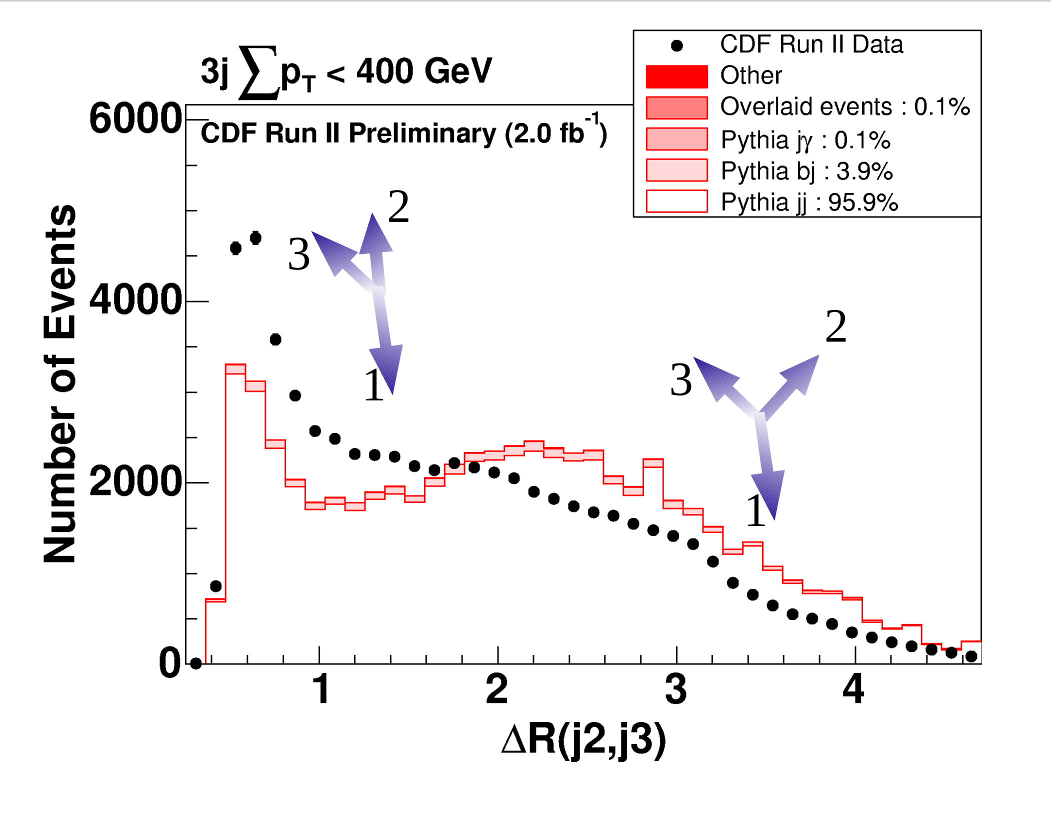


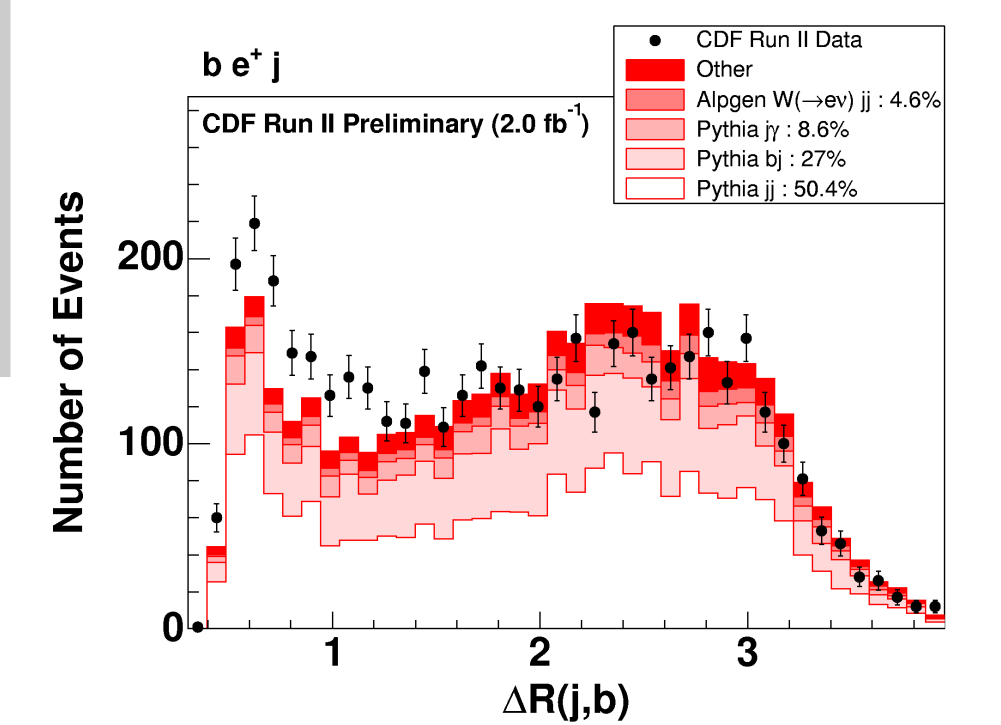
e+ j
CDF Run II Preliminary (2.0 fb-1)
CDF Run II Data
Other
MadEvent Z(→ee) : 7.3%
Alpgen W(→eν) j : 7.5%
Pythia jγ : 13.4%
Pythia jj : 64.6%
Number of Events
0
50000
100000
100
200
300
M(e+,j) (GeV)

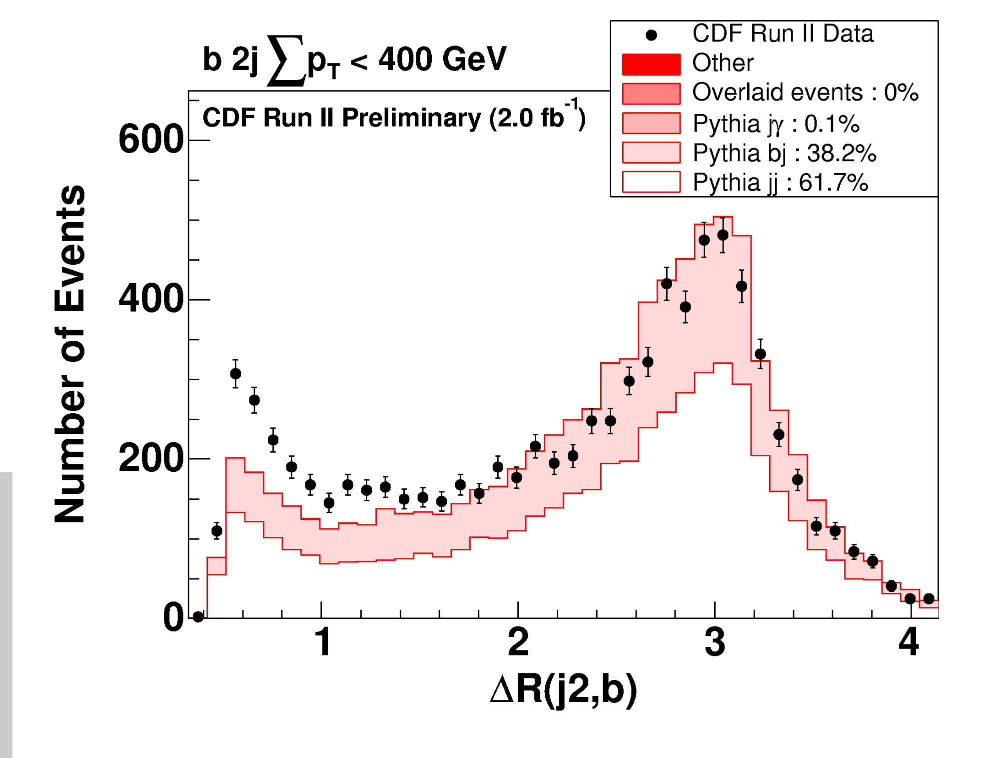


j γ
CDF Run II Preliminary (2.0 fb-1)
CDF Run II Data
Other
Non-collision : 0.1%
Pythia bj : 0.8%
Pythia jj : 35.1%
Pythia jγ : 63.8%
Number of Events
0
10000
20000
100
150
γ pT (GeV)

The "3-jet" discrepancy

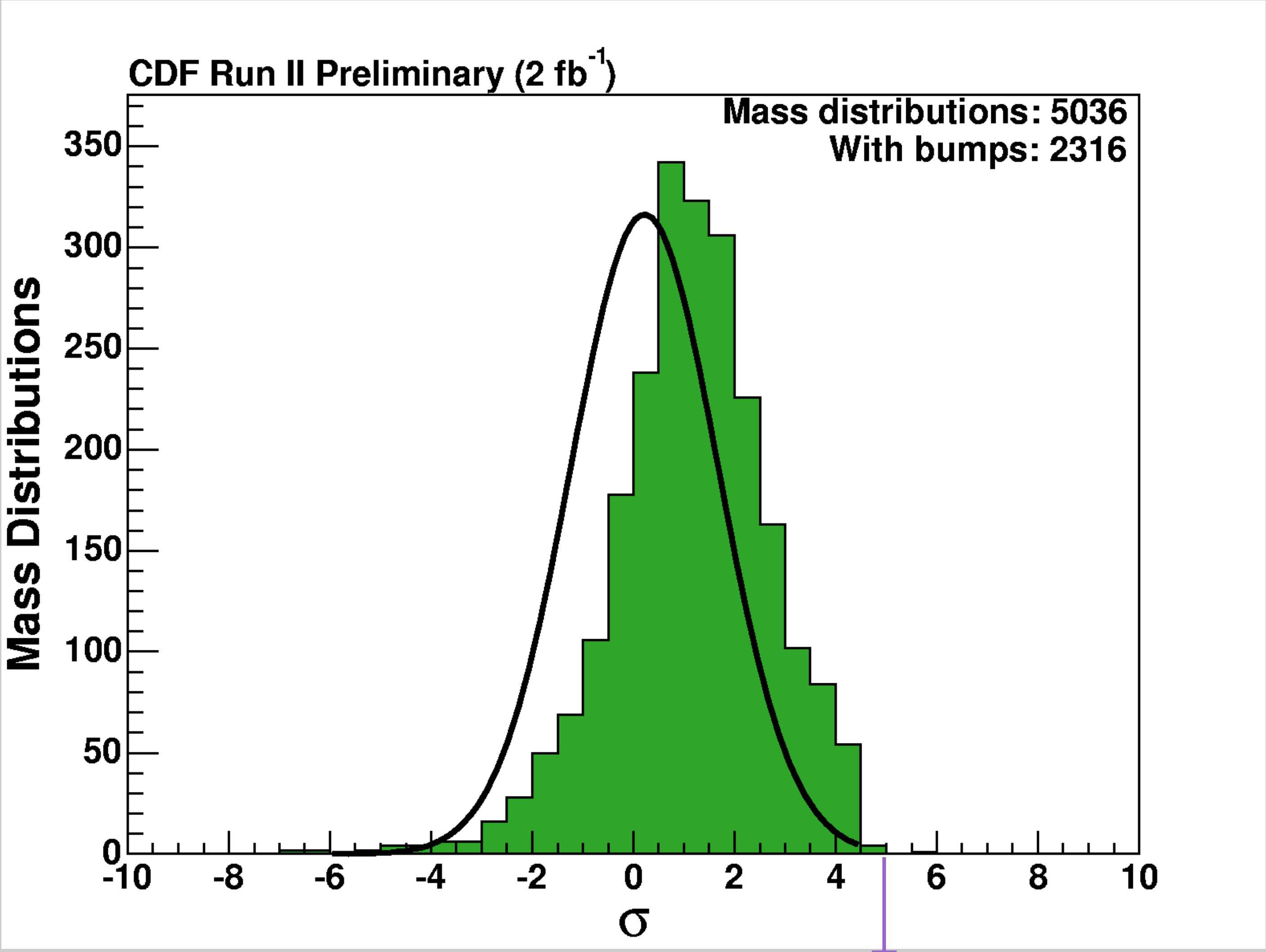






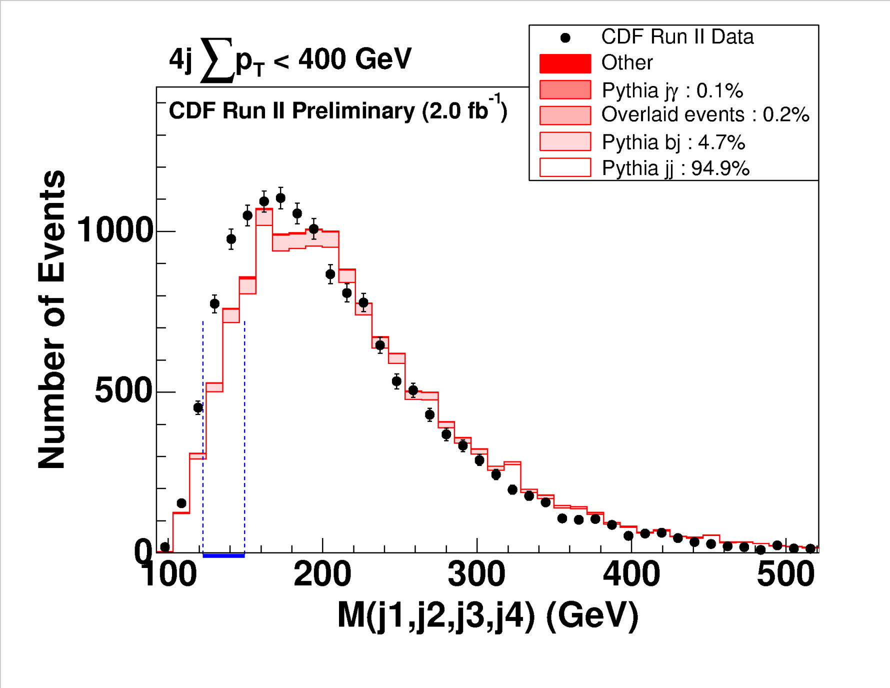
Parton showering parameters being investigated.

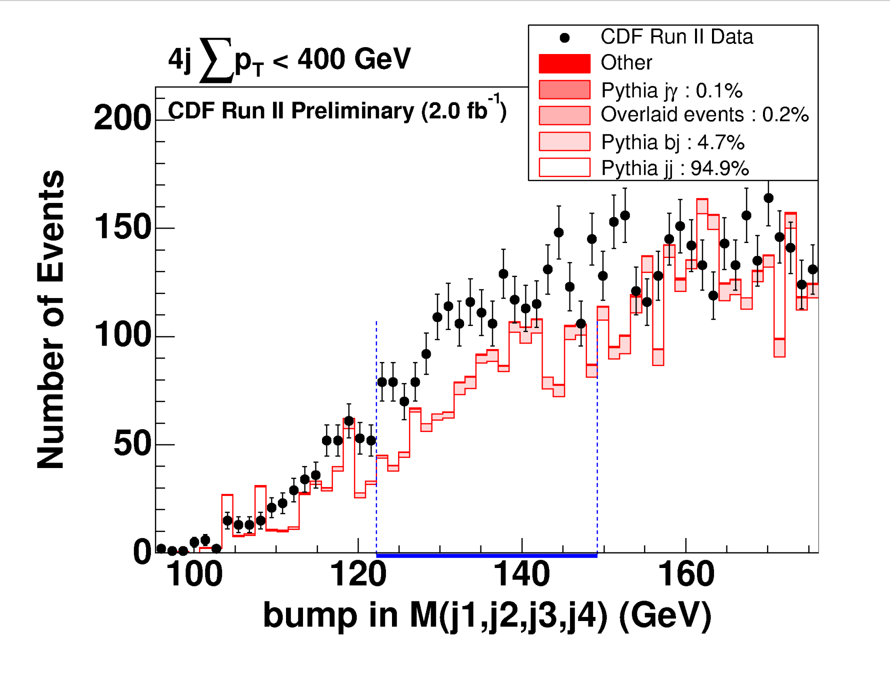
Summary of plot discrepancies

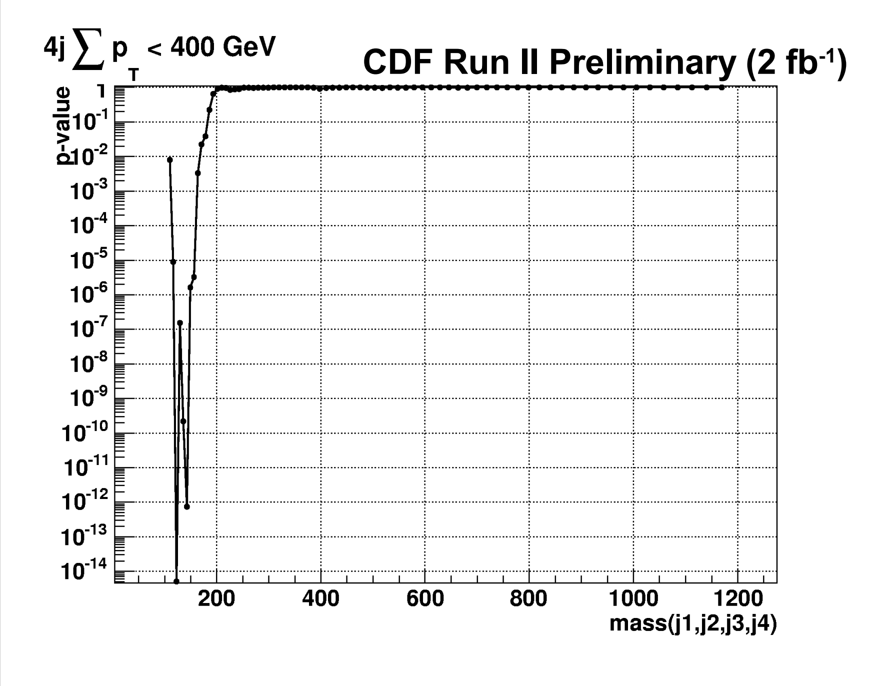


Discovery threshold

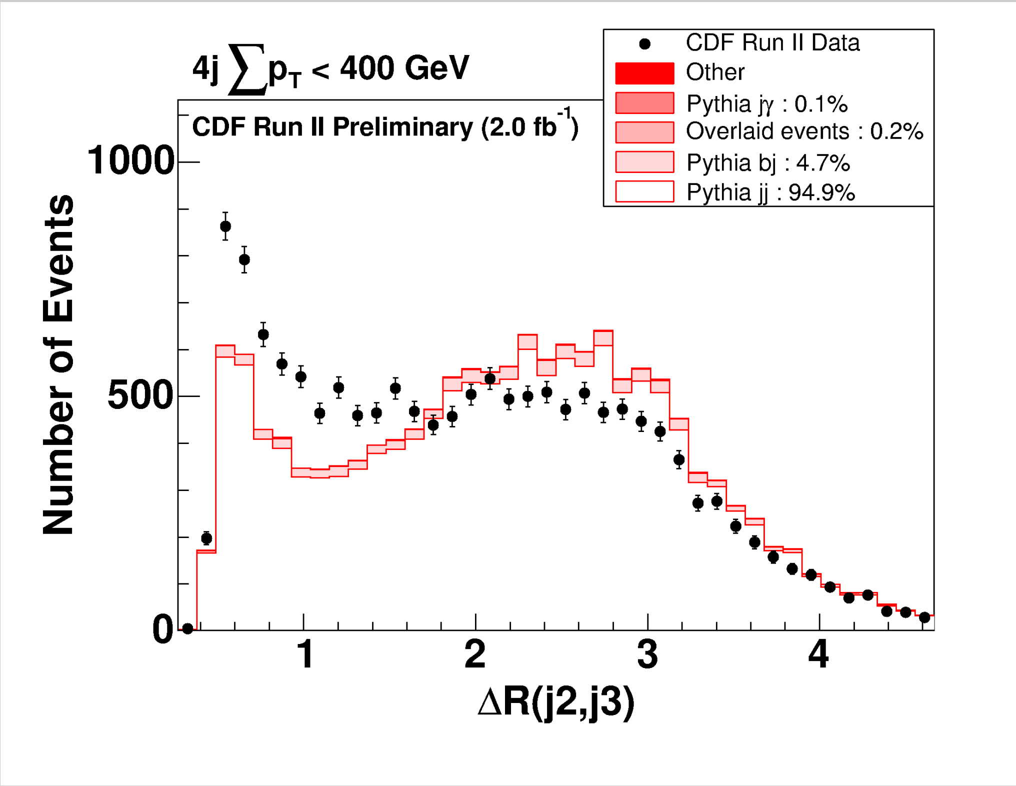
The only significant mass bump

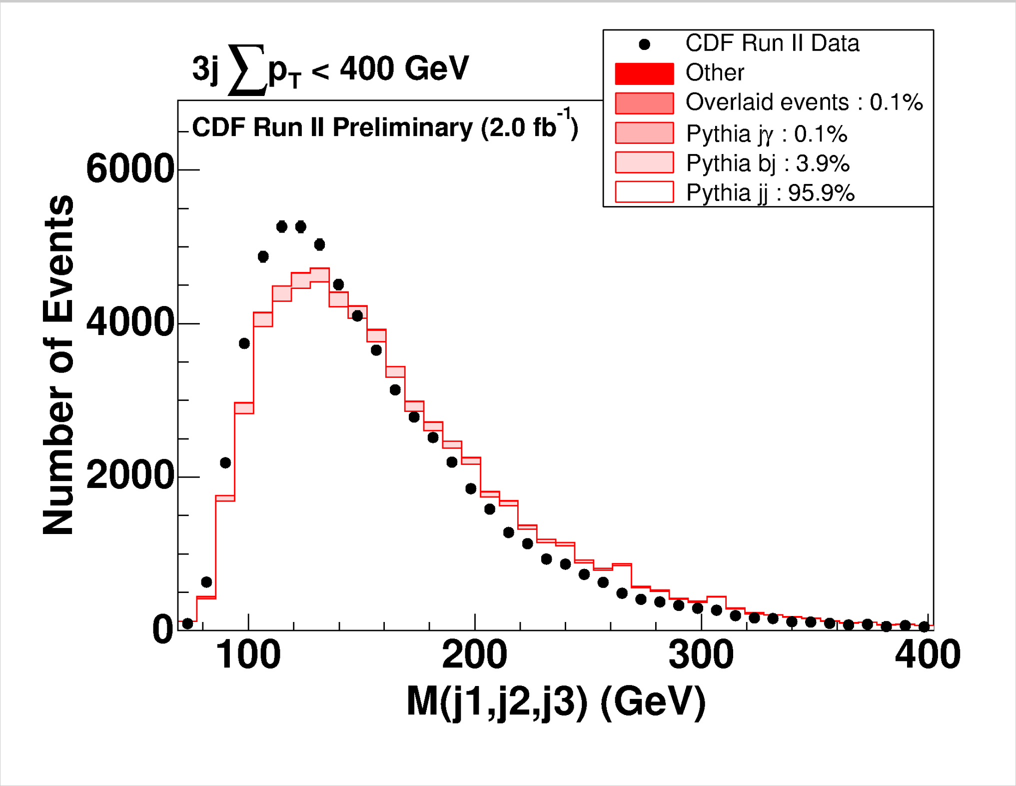




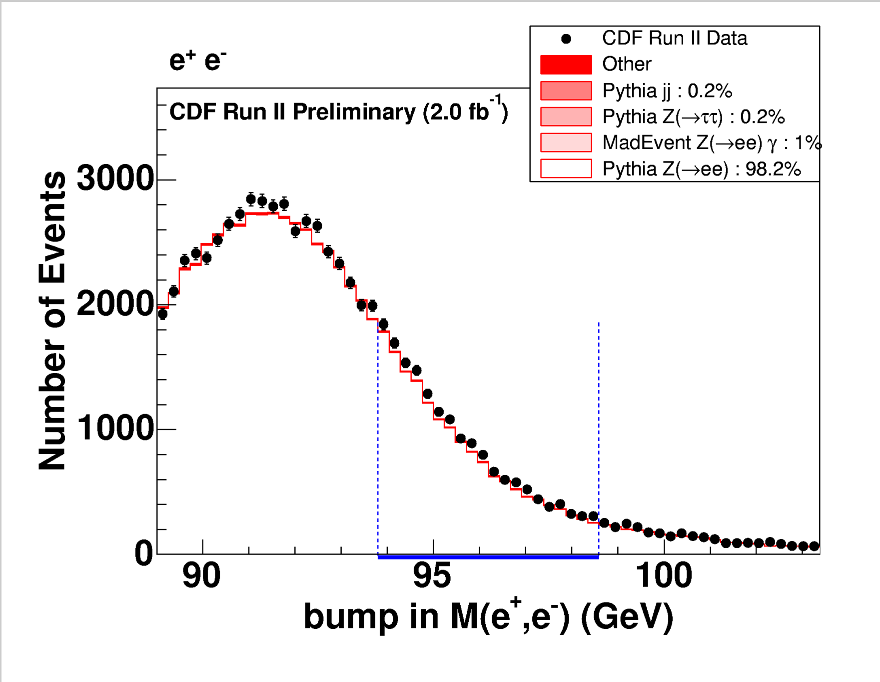


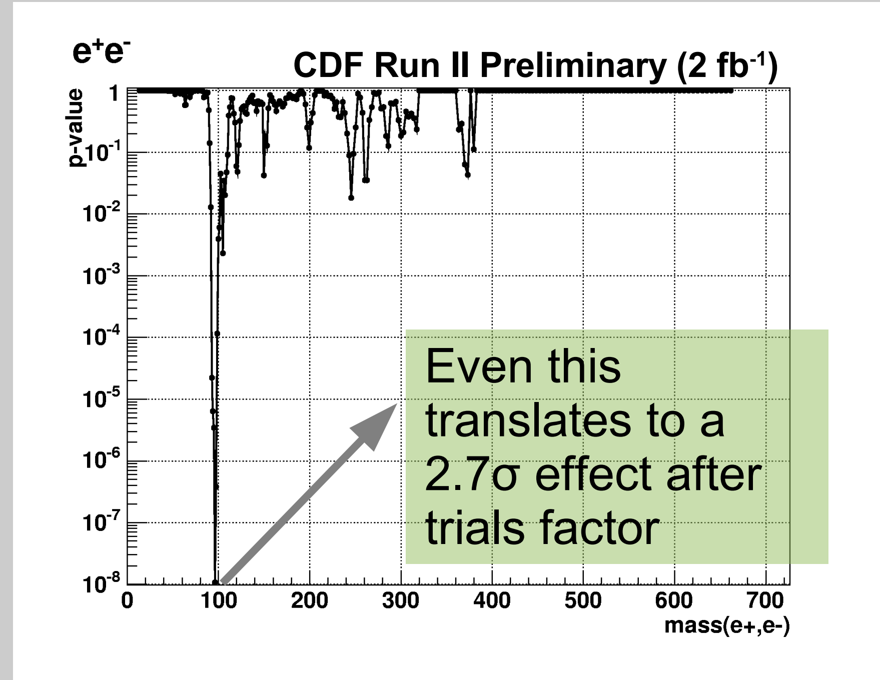
It is the same "3-jet" effect

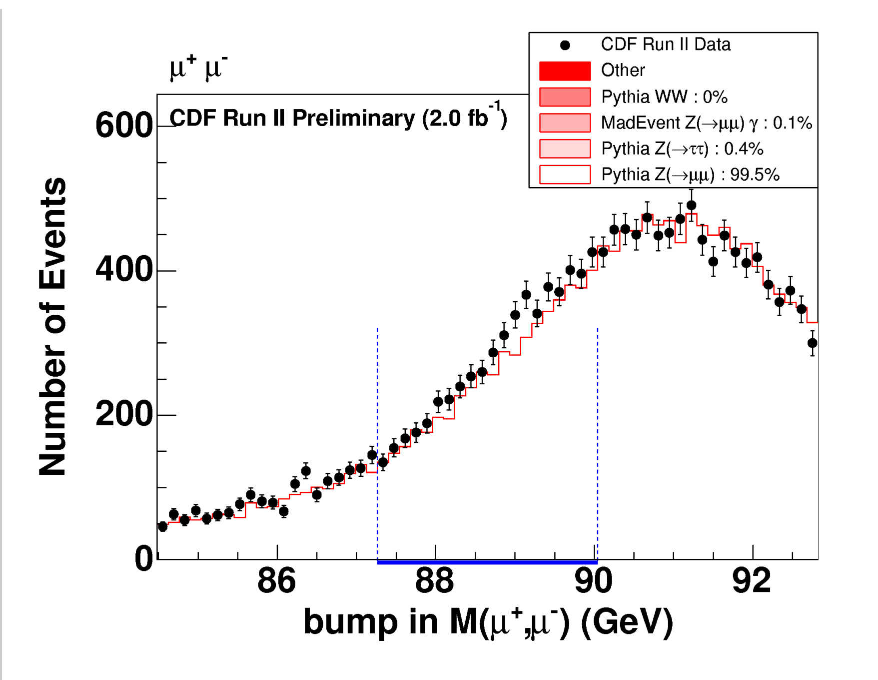


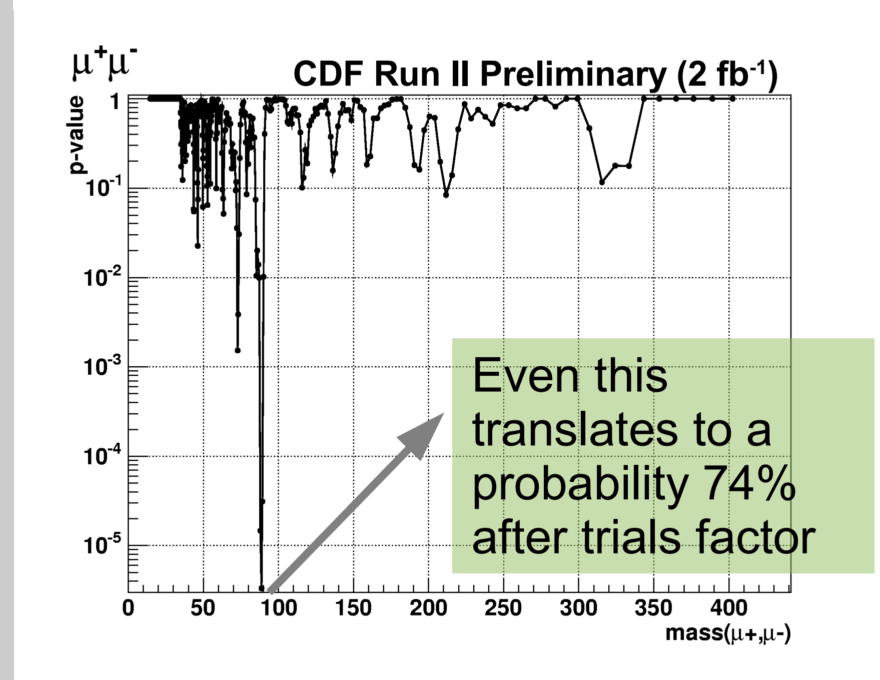


Anything like Z' → e^+e^- or $\mu^+\mu^-$?

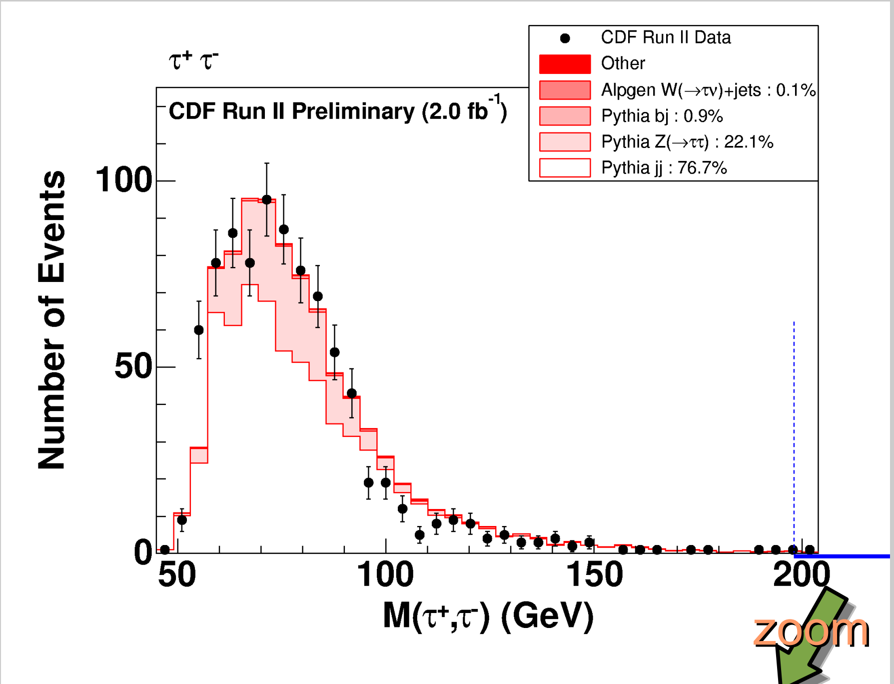


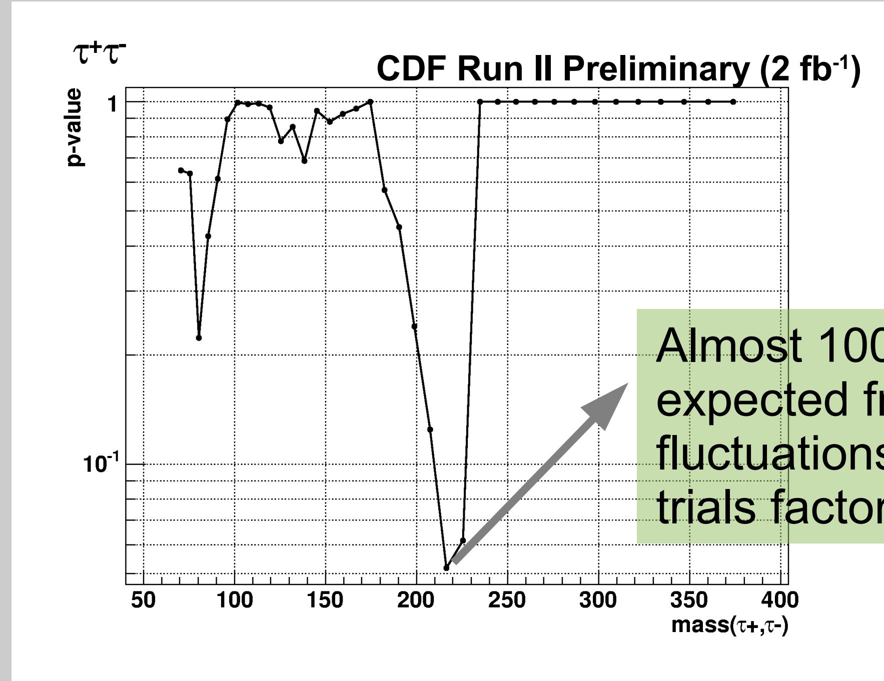




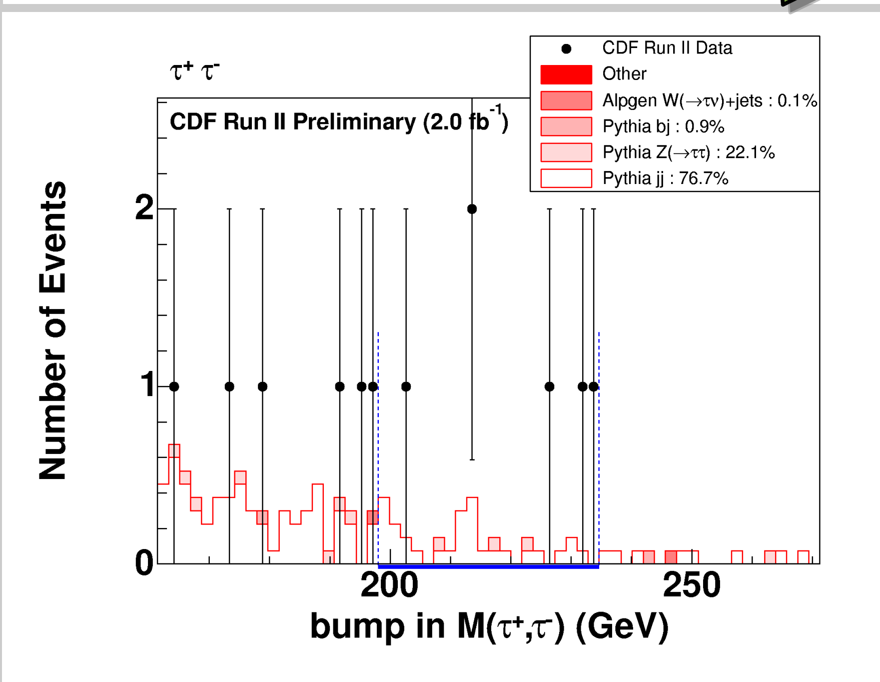


same for $\tau^+\tau^-$

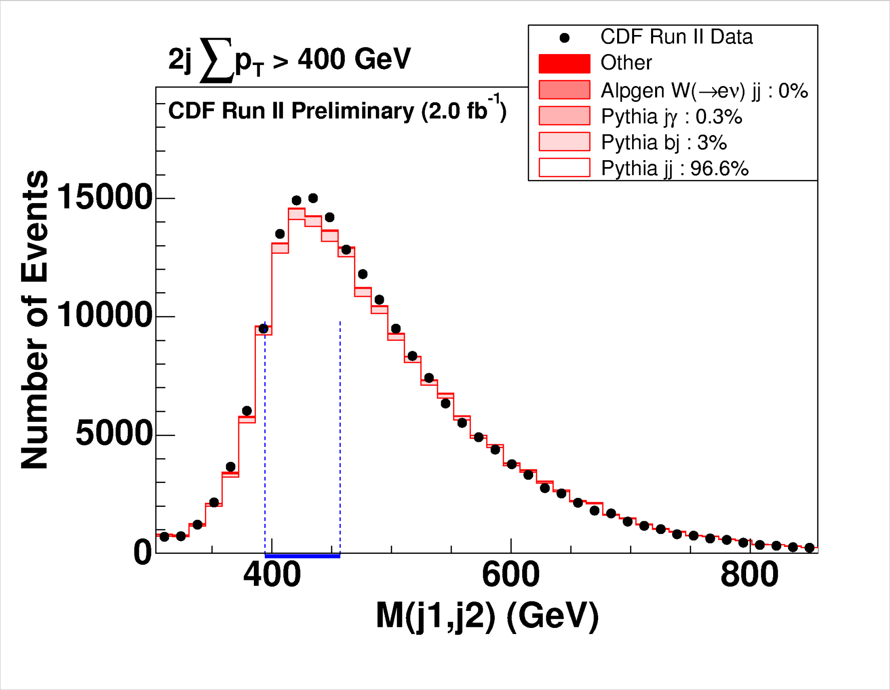


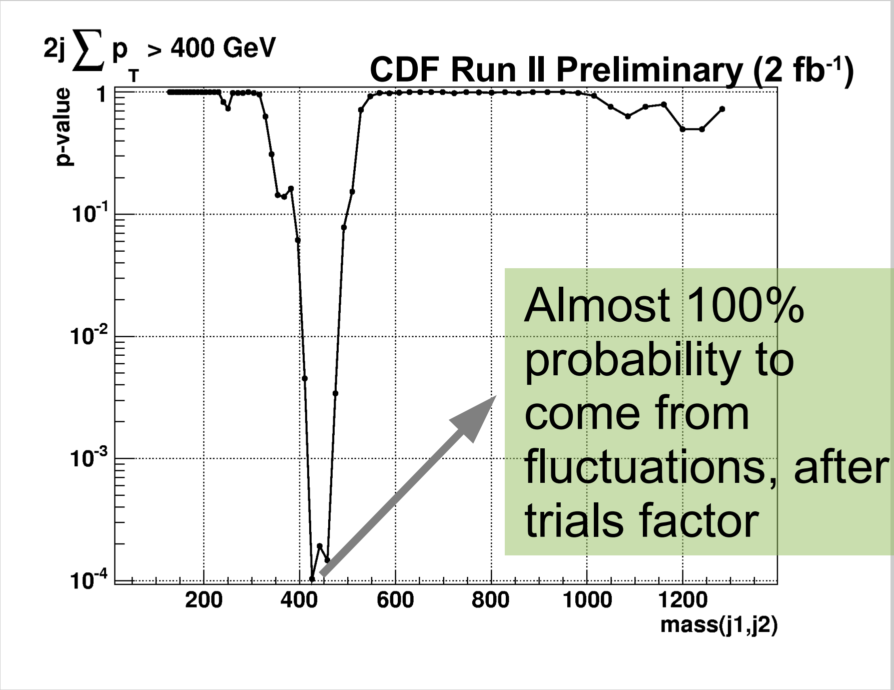


Almost 100% expected from fluctuations, after trials factor



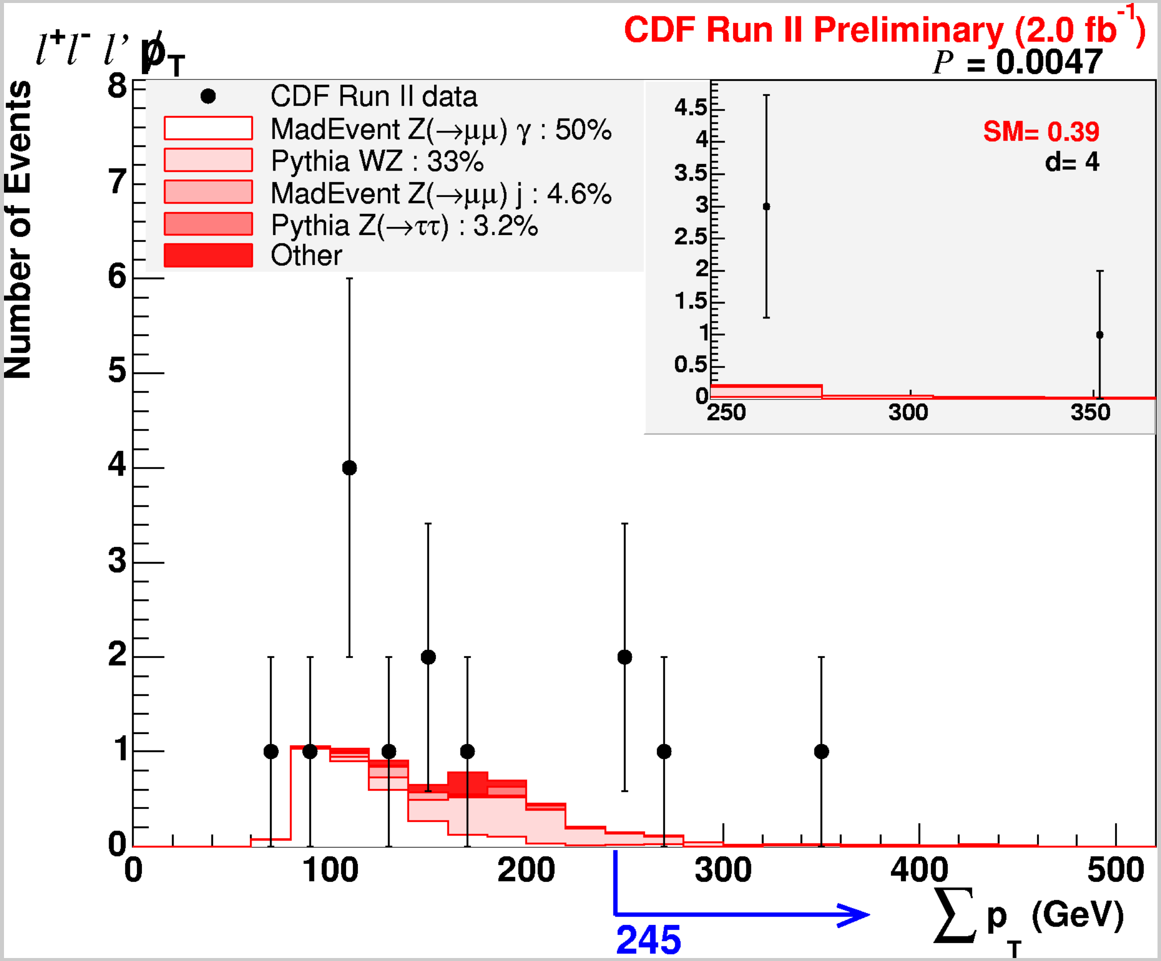
high-Σp_T dijets?





Almost 100% probability to come from fluctuations, after trials factor

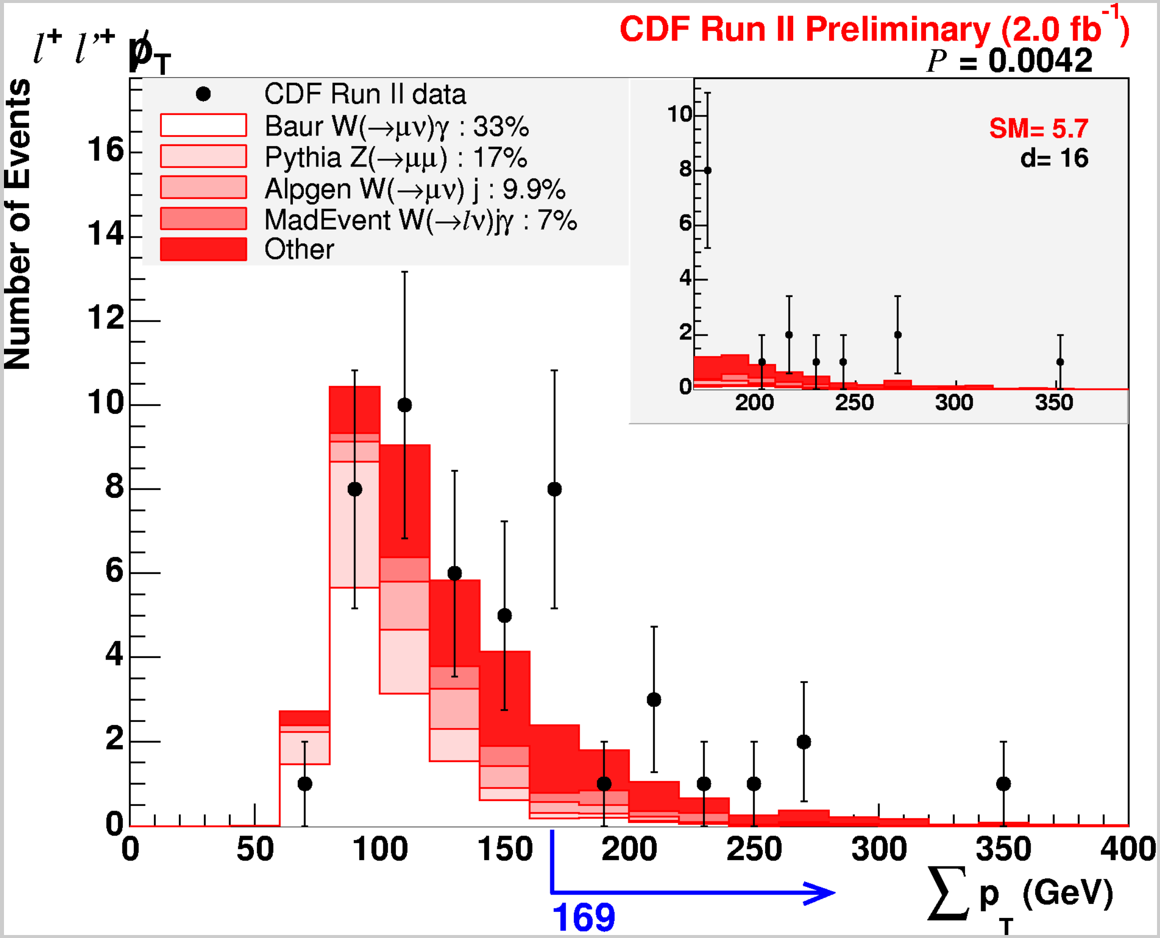
Most significant Σp_T tails



#4

p-value=3.2σ. Within the distribution 2.6σ. Given all distributions, probability is 50%.

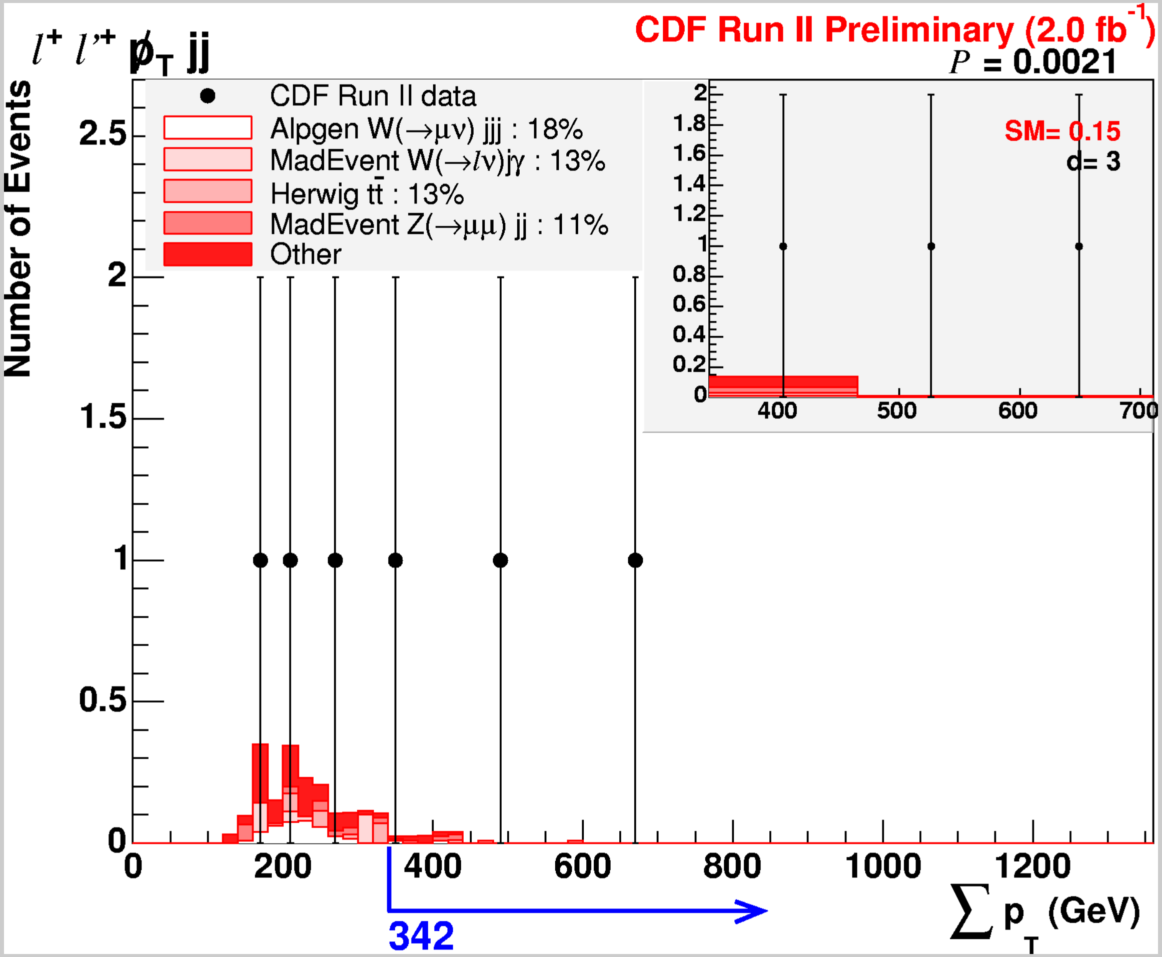
Most significant Σp_T tails



#3

p-value=3.4σ. Within the distribution 2.6σ. Given all distributions, probability is 46%.

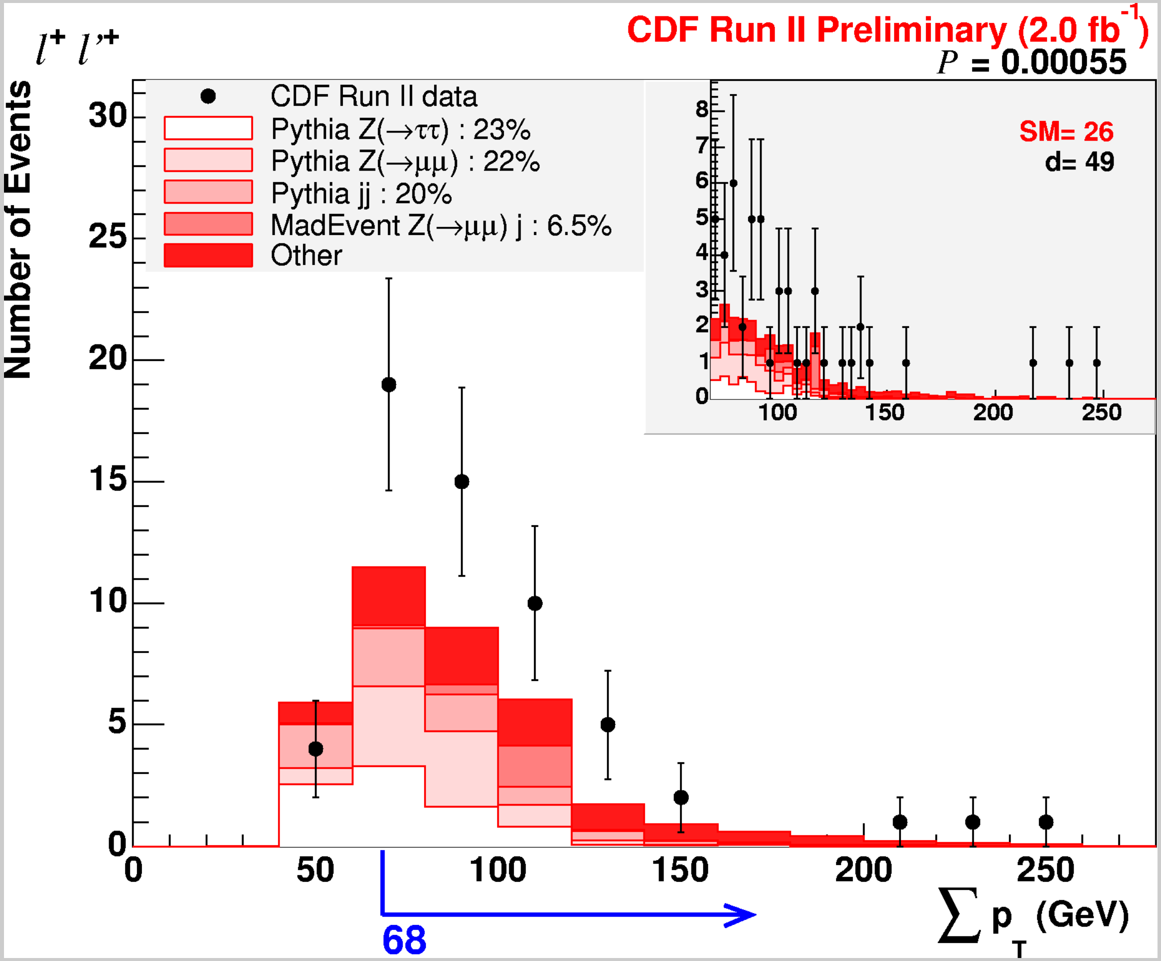
Most significant Σp_T tails



#2

p-value=3.3σ. Within the distribution 2.86σ. Given all distributions, probability is 27%.

Most significant Σp_T tails



#1

p-value=3.96σ. Within the distribution 3.26σ. Given all distributions, probability is 8.5%.

Summary of Σp_T tail excess

CDF Run II Preliminary (2.0 fb^{-1})

SLEUTH Final State	$\mathcal{P}$
$\ell^+\ell'^+$	0.00055
$\ell^+\ell'^+\not{p}jj$	0.0021
$\ell^+\ell'^+\not{p}$	0.0042
$\ell^+\ell^-\ell'\not{p}$	0.0047

Probability that the most interesting excess seen in each Σp_T distribution is just a fluctuation.

(trials factor included)

$$\tilde{\mathcal{P}} = 0.08$$

This is only a 1.3σ effect.

Probability that the most unlikely Σp_T distribution ($\ell^+\ell'^+$) is just a fluctuation.

(trials factor included)

Summary

- We searched for new physics globally in 2 fb^{-1} of CDF II data
- We gained an overview of all high-p_T data
- Found nothing significant enough in populations
- Most (97%) distributions agree well with prediction
  - The rest is QCD not modeled perfectly
- No significant mass bumps
- No significant excess at high Σp_T

"It is a testimonial to the integrity of experimentalists that they don't always find what they expect."

-- Steven Weinberg, Dreams of a Final Theory