A global analysis of 1 fb^{-1} of CDF Run II data

Vista

(Spanish, Italian)

panoramic view

model-independent

Sleuth

(British)

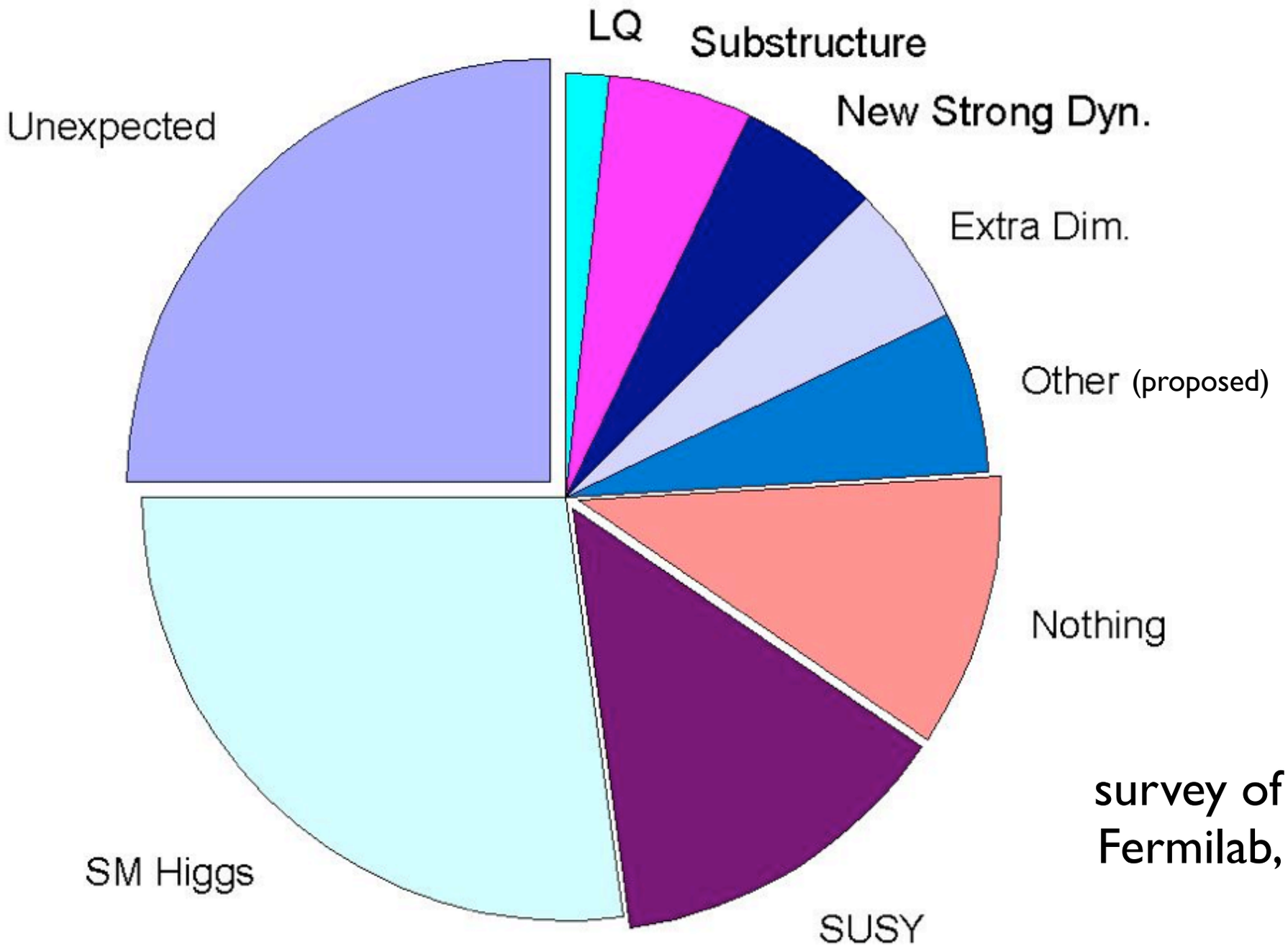
detective

quasi-model-independent

CDF Collaboration

April 2007

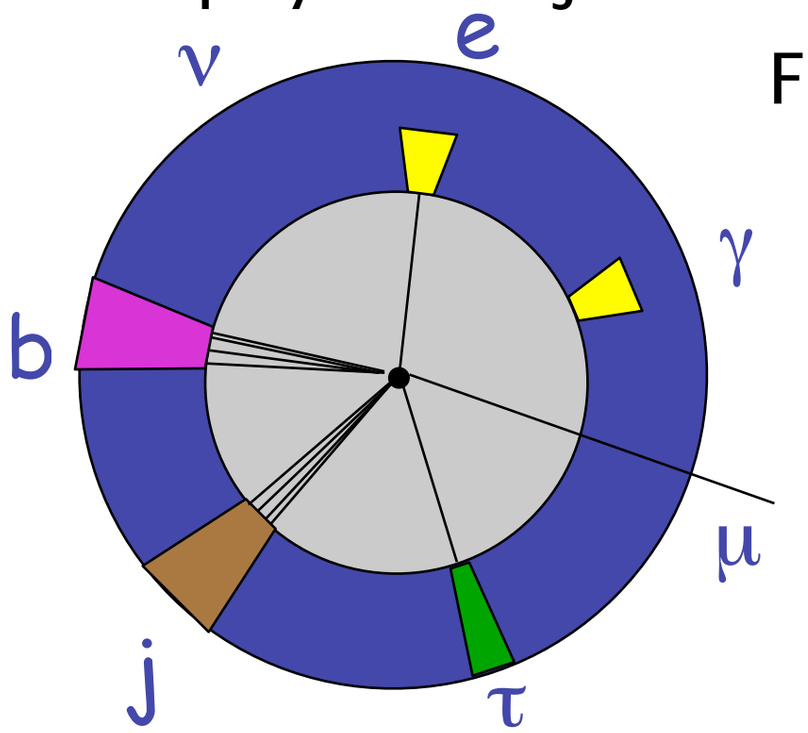
What will the first sign of new physics be?



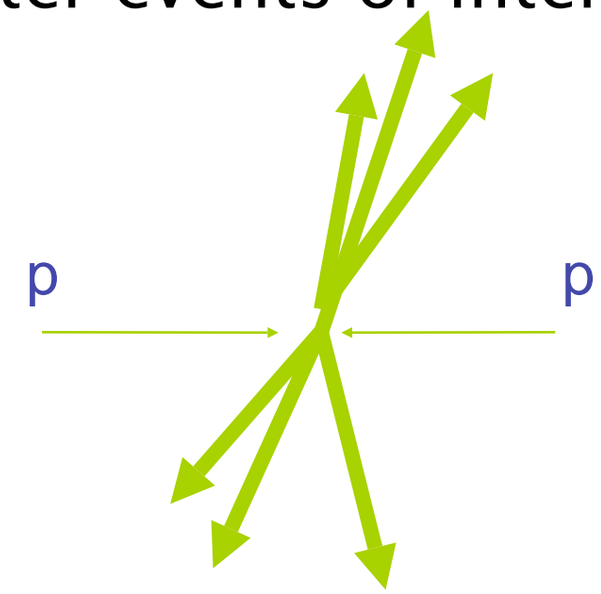
survey of physicists at Fermilab, ~300 votes

Vista algorithm

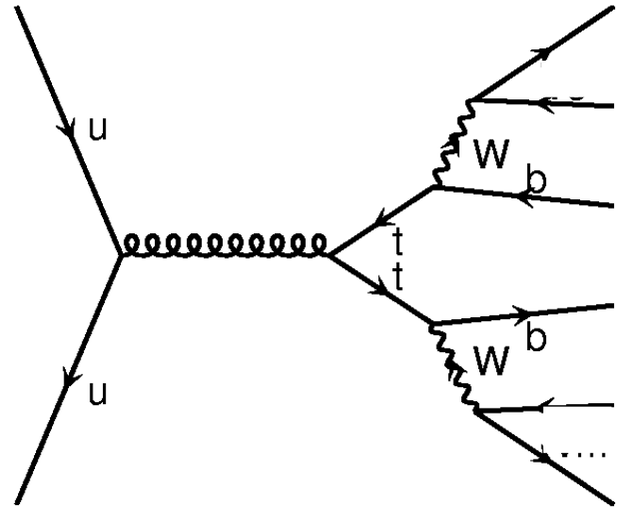
Define physics objects



Filter events of interest

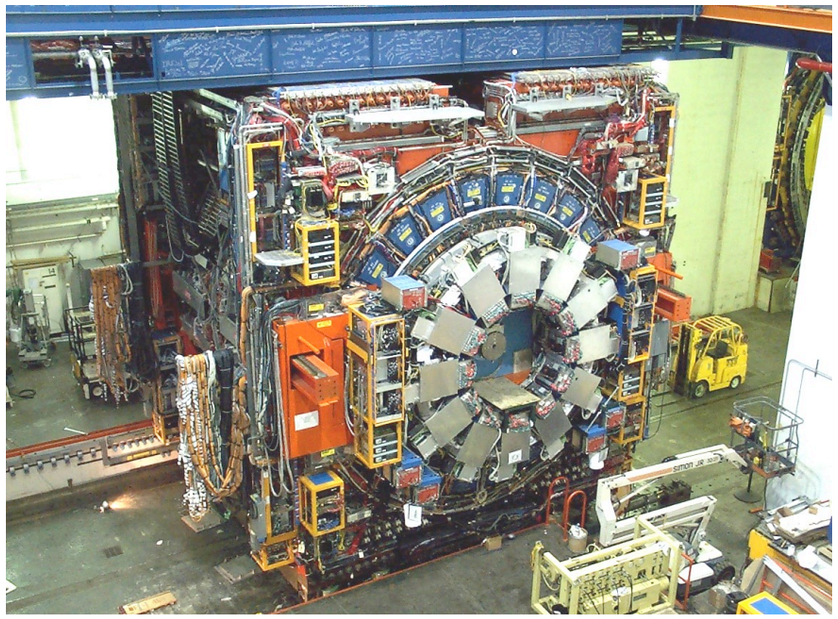


Estimate backgrounds



Fit for experimental & theoretical correction factors

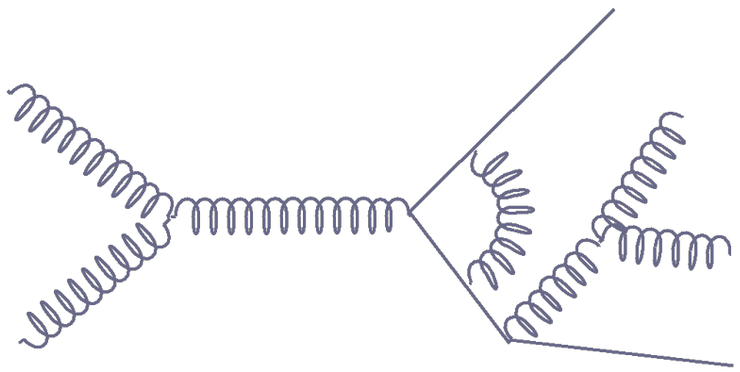
Simulate detector response



(mis)Id reconstructed

true

	e	μ	τ	γ	j	b
e	0.66		2e-3	0.02	0.28	
μ		0.51				
τ	0.02	0.01	0.04		0.90	6e-3
γ	0.03			0.68	0.21	
j	1e-4	1e-5	3e-3	3e-4	1	2e-2
b	1e-4	1e-4	1e-4	5e-5	0.65	0.35



Vista output

Table of final states

CDF Run II preliminary (927 pb^{-1})

Final State	Plots	Observed	Expected (stat. uncertainty only)	Discrepancy (σ)	SM composition	Discrepant Distributions (σ)
3j1tau+	[plots]	71	113.7 +- 3.6	-2.3	Pythia jj 40 < pT < 60 = 27.5, Pythia jj 60 < pT < 90 = 18.2, Pythia jj 18 < pT < 40 = 17.8, Pythia jj 200 < pT < 300 = 17.7, Pythia jj 150 < pT < 200 = 15.7, Pythia jj 90 < pT < 120 = 6.8, Pythia jj 120 < pT < 150 = 3.8, Pythia bj 40 < pT < 60 = 1.4, Pythia jj 300 < pT < 400 = 1.3, Pythia bj 60 < pT < 90 = 1, Pythia bj 200 < pT < 300 = 0.7, Pythia bj 150 < pT < 200 = 0.4, Pythia bj 18 < pT < 40 = 0.3, Pythia gamma j 80 < pT = 0.2, Pythia bj 120 < pT < 150 = 0.2, Pythia bj 90 < pT < 120 = 0.1, Pythia gamma j 22 < pT < 45 = 0.1	
5j	[plots]	1661	1902.9 +- 50.8	-1.7	Pythia jj 40 < pT < 60 = 685.8, Pythia jj 18 < pT < 40 = 553.4, Pythia jj 60 < pT < 90 = 429.9, Pythia jj 90 < pT < 120 = 98.8, Pythia bj 40 < pT < 60 = 41.2, Pythia bj 60 < pT < 90 = 28.2, Pythia bj 18 < pT < 40 = 27, Pythia jj 120 < pT < 150 = 17.4, Pythia jj 150 < pT < 200 = 6.4, Pythia bj 90 < pT < 120 = 6.1, Overlaid events = 5.5, Pythia bj 120 < pT < 150 = 1.2, Pythia bj 150 < pT < 200 = 0.7, MadEvent W(→ev) jjjj = 0.5, Pythia jj 200 < pT < 300 = 0.5, Herwig ttbar = 0.2	mass(j2)/j2_pt 7.1 mass(j1) 6.7 mass(j3)/j3_pt 6.2 mass(j2,j3) 4.4 mass(j2,j3,j4) 4.2 mass(j1)/j1_pt 3.9 mass(j2,j3,j5) 3.5 deltaR(j2,j3) 3.4 mass(j2,j3,j4,j5) 3.3 mass(j2) 2.8 mass(j4)/j4_pt 2.5
2j1tau+	[plots]	233	296.5 +- 5.6	-1.6	Pythia jj 40 < pT < 60 = 95.9, Pythia jj 18 < pT < 40 = 67.3, Pythia jj 60 < pT < 90 = 54.3, Pythia jj 200 < pT < 300 = 30.9, Pythia jj 150 < pT < 200 = 19.6, Pythia jj 90 < pT < 120 = 10.8, Pythia jj 120 < pT < 150 = 5.4, Pythia bj 40 < pT < 60 = 4, Pythia jj 300 < pT < 400 = 2, Pythia bj 18 < pT < 40 = 1.6, Pythia bj 60 < pT < 90 = 1.5, Pythia bj 200 < pT < 300 = 0.8, Pythia bj 150 < pT < 200 = 0.5, Pythia bj 90 < pT < 120 = 0.4, Pythia Z(→ττ) = 0.3, Pythia gamma j 80 < pT = 0.3, MadEvent Z(→ee) j = 0.1, Pythia gamma j 22 < pT < 45 = 0.1, Pythia bj 120 < pT < 150 = 0.1	mass(tau+,j1,j2) 3.7 sumPt 3.5 mass(tau+,j2) 3 mass(tau+,j1) 2.7 clusteredObjectsRecoil_pt 2.6 j1_pt 2.5
2j2tau+	[plots]	6	27 +- 4.6	-1.4	Pythia jj 18 < pT < 40 = 11.7, Pythia jj 40 < pT < 60 = 9.5, Pythia jj 60 < pT < 90 = 4.1, Pythia bj 40 < pT < 60 = 0.8, Pythia jj 90 < pT < 120 = 0.7, Pythia bj 18 < pT < 40 = 0.1	
1b1e+1j	[plots]	2207	2015.4 +- 28.7	+1.4	Pythia jj 40 < pT < 60 = 411.6, Pythia bj 40 < pT < 60 = 295.7, Pythia jj 60 < pT < 90 = 233.5, Pythia jj 18 < pT < 40 = 225.5, Pythia bj 18 < pT < 40 = 162.8, Pythia bj 60 < pT < 90 = 155.8, MadEvent W(→ev) jj = 91.4, Pythia gamma j 22 < pT < 45 = 79.7, MadEvent Z(→ee) j = 74.4, Pythia jj 90 < pT < 120 = 55.5, Pythia gamma j 45 < pT < 80 = 27.5, Pythia bj 90 < pT < 120 = 26.6, Pythia gamma j 12 < pT < 22 = 26.5, MadEvent Z(→ee) jj = 23.4, Alpgen W(→ev) bb = 13.3, MadEvent W(→ev) j = 12.4, Pythia jj 120 < pT < 150 = 11.6, Pythia gamma j 80 < pT = 10.4, MadEvent W(→ev) jjj = 10.4, MadEvent Z(→ee) = 9.6, Alpgen W(→ev) bb j = 8.8, Pythia W(→τ ν) = 8.8, Pythia jj 150 < pT < 200 = 7.5, Herwig ttbar = 5.1, MadEvent Z(→ee) gamma = 4.8, Pythia bj 120 < pT < 150 = 4.5, MadEvent Z(→ee) bb = 4.1, MadEvent Z(→ee) jjj = 2.9, Alpgen W(→ev) bb jj = 2.1, Pythia bj 150 < pT < 200 = 1.8, Pythia jj 200 < pT < 300 = 1.5, MadEvent W(→ev) jjjj = 1.1, MadEvent W(→ev) gamma = 0.8, Overlaid events = 0.8, MadEvent W(→ev) = 0.6, Pythia bj 10 < pT < 18 = 0.6, Pythia ZZ = 0.5, MadEvent gamma gamma jj = 0.3, Pythia bj 200 < pT < 300 = 0.3, Pythia Z(→ττ) = 0.3, Pythia WZ = 0.2	mass(b)/b_pt 9.9 mass(b) 7.2 mass(j)/j_pt 4.3 deltaR(j,b) 4.1 minMass(j) 3.9 mass(j,b) 3.6 uncl_pt 3.5
3j_sumPt0-400	[plots]	35436	37294.6 +- 524.3	-1.1	Pythia jj 18 < pT < 40 = 18129.1, Pythia jj 40 < pT < 60 = 12273.7, Pythia jj 60 < pT < 90 = 3950.7, Pythia bj 18 < pT < 40 = 751.6, Pythia jj 10 < pT < 18 = 749, Pythia bj 40 < pT < 60 = 540.5, Pythia jj 90 < pT < 120 = 520.8, Pythia bj 60 < pT < 90 = 179.5, Pythia jj 120 < pT < 150 = 96.7, Pythia jj 150 < pT < 200 = 27.6, Pythia bj 90 < pT < 120 = 19.7, Pythia gamma j 22 < pT < 45 = 13.8, Pythia bj 10 < pT < 18 = 13.8, Overlaid events = 7.9, Pythia gamma j 12 < pT < 22 = 7.9, MadEvent Z(→ee) jj = 3.9, Pythia gamma j 8 < pT < 12 = 2, Pythia bj 120 < pT < 150 = 2, MadEvent W(→ev) jjj = 2, MadEvent W(→ev) jjjj = 2	minDeltaR(j,j) 9.9 mass(j2,j3) 9.9 deltaR(j2,j3) 9.9 deltaEta(j2,j3) 9.9 mass(j2)/j2_pt 9.9
1e+3j1pmiss	[plots]	1954	1751.6 +- 42	+1.1	MadEvent W(→ev) jj = 705.6, MadEvent W(→ev) jjj = 595.3, MadEvent W(→ev) j = 132.6, MadEvent W(→ev) jjjj = 85, Pythia W(→τ ν) = 56.4, MadEvent W(→ev) = 45.8, Herwig ttbar = 26.7, MadEvent Z(→ee) jj = 25.9, Alpgen W(→ev) bb j = 10.3, MadEvent Z(→ee) jjj = 9.2, MadEvent W(→ev) gamma = 8.1, MadEvent Z(→ee) j = 7.7, Alpgen W(→ev) bb = 6.8, Pythia jj 60 < pT < 90 = 5.8, Alpgen W(→ev) bb jj = 5.1, Pythia jj 90 < pT < 120 = 4.4, Overlaid events = 3.6, Pythia jj 40 < pT < 60 = 2.2, Pythia gamma j 80 < pT = 1.9, Pythia jj 150 < pT < 200 = 1.5, Pythia jj 120 < pT < 150 = 1.5, Pythia jj 200 < pT < 300 = 1.3, Pythia bj 60 < pT < 90 = 1.3, Pythia gamma j 45 < pT < 80 = 1.2, MadEvent Z(→ee) bb = 0.7, Pythia bj 40 < pT < 60 = 0.7, MadEvent Z(→ee) gamma = 0.6, Pythia WZ = 0.6, Pythia Z(→ττ) = 0.5, MadEvent gamma gamma jj = 0.5, Pythia bj 90 < pT < 120 = 0.4, Pythia bj 150 < pT < 200 = 0.4, Cosmic (photon_25_iso) = 0.4, Pythia bj 18 < pT < 40 = 0.4, Pythia ZZ = 0.3, MadEvent W(→μν) gamma = 0.3, MadEvent Z(→νν) gamma = 0.2, MadEvent W(→μν) jjj = 0.2	mass(j2)/j2_pt 3.4

Vista output

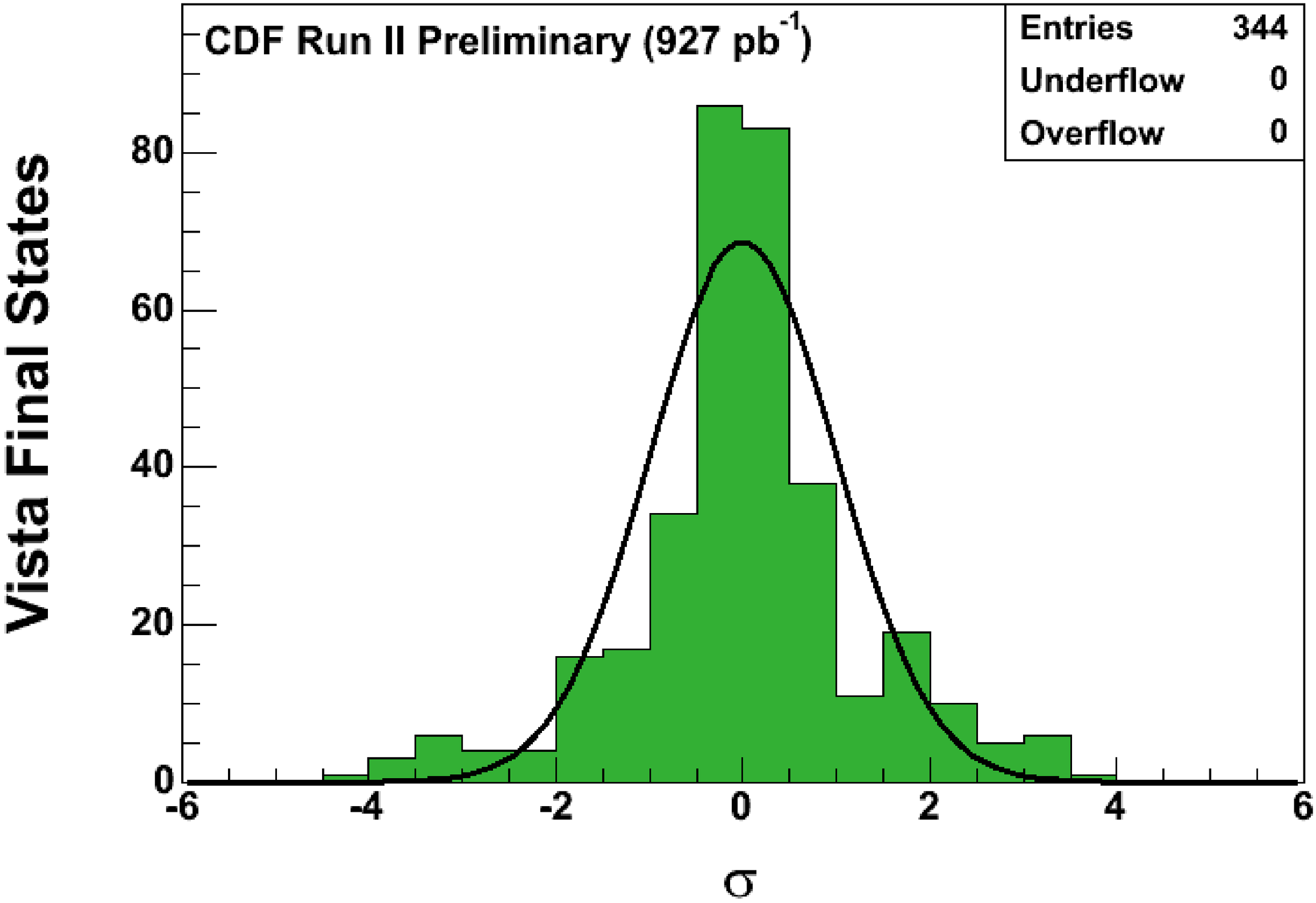
CDF Run II preliminary (927 pb^{-1})

Final State	Data	Background
3j τ+	71	113.7 ± 3.6
5j	1661	1902.9 ± 50.8
2j τ+	233	296.5 ± 5.6
be+j	2207	2015.4 ± 28.7
3j Σp_T < 400 GeV	35436	37294.6 ± 524.3
e+3j$\not{p}$	1954	1751.6 ± 42
be+2j	798	695.3 ± 13.3
3j$\not{p}$ Σp_T > 400 GeV	811	967.5 ± 38.4
e+μ+	26	11.6 ± 1.5
e+γ	636	551.2 ± 11.2
e+3j	28656	27281.5 ± 405.2
b5j	131	95 ± 4.7
j2τ+	50	85.6 ± 8.2
jτ+τ-	74	125 ± 13.6
b$\not{p}$ Σp_T > 400 GeV	10	29.5 ± 4.6
e+jγ	286	369.4 ± 21.1
e+j$\not{p}$τ-	29	14.2 ± 1.8
2j Σp_T < 400 GeV	96502	92437.3 ± 1354.5
be+3j	356	298.6 ± 7.7
8j	11	6.1 ± 2.5
7j	57	35.6 ± 4.9
6j	335	298.4 ± 14.7
4j Σp_T > 400 GeV	39665	40898.8 ± 649.2
4j Σp_T < 400 GeV	8241	8403.7 ± 144.7
4j2γ	38	57.5 ± 11
4jτ+	20	36.9 ± 2.4
4j$\not{p}$ Σp_T > 400 GeV	516	525.2 ± 34.5
4jγ$\not{p}$	28	53.8 ± 11
4jγ	3693	3827.2 ± 112.1
4jμ+	576	568.2 ± 26.1
4jμ+$\not{p}$	232	224.7 ± 8.5
4jμ+μ-	17	20.1 ± 2.5
3γ	13	24.2 ± 3
3j Σp_T > 400 GeV	75894	75939.2 ± 1043.9
3j2γ	145	178.1 ± 7.4
3j$\not{p}$ Σp_T < 400 GeV	20	30.9 ± 14.4
3jγτ+	13	11 ± 2
3jγ$\not{p}$	83	102.9 ± 11.1
3jγ	11424	11506.4 ± 190.6
3jμ+$\not{p}$	1114	1118.7 ± 27.1
3jμ+μ-	61	84.5 ± 9.2
3jμ+	2132	2168.7 ± 64.2
3bj Σp_T > 400 GeV	14	9.3 ± 1.9
2τ+	316	290.8 ± 24.2
2γ$\not{p}$	161	176 ± 9.1
2γ	8482	8349.1 ± 84.1
2j Σp_T > 400 GeV	93408	92789.5 ± 1138.2
2j2γ	645	612.6 ± 18.8
2jτ+τ-	15	25 ± 3.5
2j$\not{p}$ Σp_T > 400 GeV	74	106 ± 7.8
2j$\not{p}$ Σp_T < 400 GeV	43	37.7 ± 100.2
2jγ	33684	33259.9 ± 397.6
2jγτ+	48	41.4 ± 3.4
2jγ$\not{p}$	403	425.2 ± 29.7
2jμ+$\not{p}$	7287	7320.5 ± 118.9
2jμ+γ$\not{p}$	13	12.6 ± 2.7
2jμ+γ	41	35.7 ± 6.1
2jμ+μ-	374	394.2 ± 24.8
2jμ+	9513	9362.3 ± 166.8

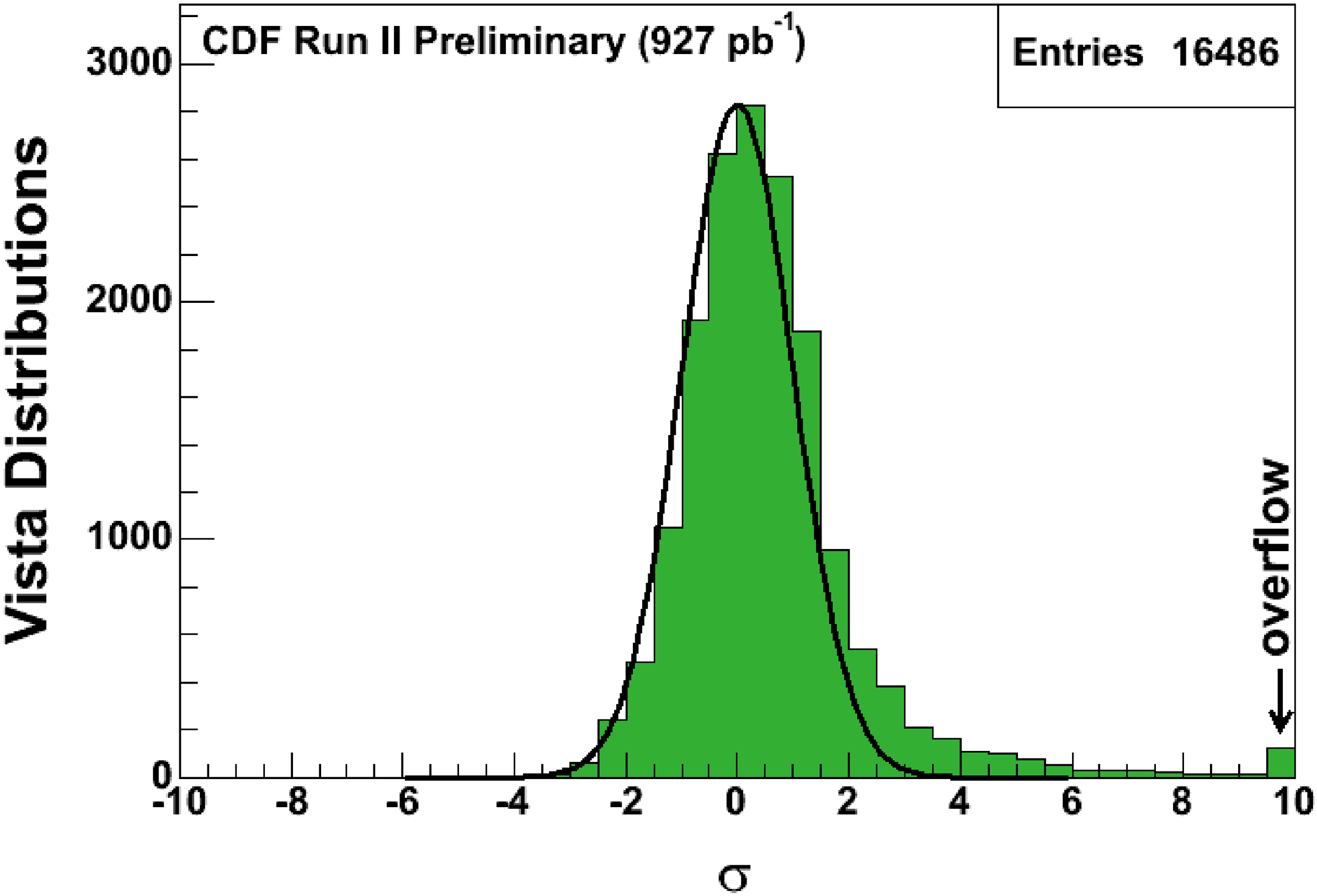
Final State	Data	Background
2e+j	13	9.8 ± 2.2
2e+e-	12	4.8 ± 1.2
2e+	23	36.1 ± 3.8
2b Σp_T > 400 GeV	327	335.8 ± 7
2b Σp_T < 400 GeV	187	173.1 ± 7.1
2b3j Σp_T < 400 GeV	28	33.5 ± 5.5
2b2j Σp_T > 400 GeV	355	326.3 ± 8.4
2b2j Σp_T < 400 GeV	56	80.2 ± 5
2b2jγ	16	15.4 ± 3.6
2bγ	37	31.7 ± 4.8
2bj Σp_T > 400 GeV	415	393.8 ± 9.1
2bj Σp_T < 400 GeV	161	195.8 ± 8.3
2bj$\not{p}$ Σp_T > 400 GeV	28	23.2 ± 2.6
2bjγ	25	24.7 ± 4.3
2be+2j$\not{p}$	15	12.3 ± 1.6
2be+2j	30	30.5 ± 2.5
2be+j	28	29.1 ± 2.8
2be+	48	45.2 ± 3.7
τ+τ-	498	428.5 ± 22.7
γτ+	177	204.4 ± 5.4
γ$\not{p}$	1952	1945.8 ± 77.1
μ+τ+	18	19.8 ± 2.3
μ+τ-	151	179.1 ± 4.7
μ+$\not{p}$	321351	320500 ± 3475.5
μ+$\not{p}$τ-	22	25.8 ± 2.7
μ+γ	269	285.5 ± 5.9
μ+γ$\not{p}$	269	282.2 ± 6.6
μ+μ-$\not{p}$	49	61.4 ± 3.5
μ+μ-γ	32	29.9 ± 2.6
μ+μ-	10648	10845.6 ± 96
j2γ	2196	2200.3 ± 35.2
j2γ$\not{p}$	38	27.3 ± 3.2
jτ+	563	585.7 ± 10.2
j$\not{p}$ Σp_T > 400 GeV	4183	4209.1 ± 56.1
jγ	49052	48743 ± 546.3
jγτ+	106	104 ± 4.1
jγ$\not{p}$	913	965.2 ± 41.5
jμ+	33462	34026.7 ± 510.1
jμ+τ-	29	37.5 ± 4.5
jμ+$\not{p}$τ-	10	9.6 ± 2.1
jμ+$\not{p}$	45728	46316.4 ± 568.2
jμ+γ$\not{p}$	78	69.8 ± 9.9
jμ+γ	70	98.4 ± 12.1
jμ+μ-	1977	2093.3 ± 74.7
e+4j	7144	6661.9 ± 147.2
e+4j$\not{p}$	403	363 ± 9.9
e+3jτ-	11	7.6 ± 1.6
e+3jγ	27	21.7 ± 3.4
e+2γ	47	74.5 ± 5
e+2j	126665	122457 ± 1672.6
e+2jτ-	53	37.3 ± 3.9
e+2jτ+	20	24.7 ± 2.3
e+2j$\not{p}$	12451	12130.1 ± 159.4
e+2jγ	101	88.9 ± 6.1
e+τ-	609	555.9 ± 10.2
e+τ+	225	211.2 ± 4.7
e+$\not{p}$	476424	479572 ± 5361.2
e+$\not{p}$τ-	48	35 ± 2.7
e+$\not{p}$τ+	20	18.7 ± 1.9

Final State	Data	Background
e+γ$\not{p}$	141	144.2 ± 6
e+μ-$\not{p}$	54	42.6 ± 2.7
e+μ+$\not{p}$	13	10.9 ± 1.3
e+μ-	153	127.6 ± 4.2
e+j	386880	392614 ± 5031.8
e+j2γ	14	15.9 ± 2.9
e+jτ+	79	79.3 ± 2.9
e+jτ-	162	148.8 ± 7.6
e+j$\not{p}$	58648	57391.7 ± 661.6
e+jγ$\not{p}$	52	76.2 ± 9
e+jμ-$\not{p}$	22	13.1 ± 1.7
e+jμ-	28	26.8 ± 2.3
e+e-4j	103	113.5 ± 5.9
e+e-3j	456	473 ± 14.6
e+e-2j$\not{p}$	30	39 ± 4.6
e+e-2j	2149	2152 ± 40.1
e+e-τ+	14	11.1 ± 2
e+e-$\not{p}$	491	487.9 ± 12
e+e-γ	127	132.3 ± 4.2
e+e-j	10726	10669.3 ± 123.5
e+e-j$\not{p}$	157	144 ± 11.2
e+e-jγ	26	45.6 ± 4.7
e+e-	58344	58575.6 ± 603.9
b6j	24	15.5 ± 2.3
b4j Σp_T > 400 GeV	13	9.2 ± 1.8
b4j Σp_T < 400 GeV	464	499.2 ± 12.4
b3j Σp_T > 400 GeV	5354	5285 ± 72.4
b3j Σp_T < 400 GeV	1639	1558.9 ± 24.1
b3j$\not{p}$ Σp_T > 400 GeV	111	116.8 ± 11.2
b3jγ	182	194.1 ± 8.8
b3jμ+$\not{p}$	37	34.1 ± 2
b3jμ+	47	52.2 ± 3
b2γ	15	14.6 ± 2.1
b2j Σp_T > 400 GeV	8812	8576.2 ± 97.9
b2j Σp_T < 400 GeV	4691	4646.2 ± 57.7
b2j$\not{p}$ Σp_T > 400 GeV	198	209.2 ± 8.3
b2jγ	429	425.1 ± 13.1
b2jμ+$\not{p}$	46	40.1 ± 2.7
b2jμ+	56	60.6 ± 3.4
bτ+	19	19.9 ± 2.2
bγ	976	1034.8 ± 15.6
bγ$\not{p}$	18	16.7 ± 3.1
bμ+	303	263.5 ± 7.9
bμ+$\not{p}$	204	218.1 ± 6.4
bj Σp_T > 400 GeV	9060	9275.7 ± 87.8
bj Σp_T < 400 GeV	7236	7030.8 ± 74
bj2γ	13	17.6 ± 3.3
bjτ+	13	12.9 ± 1.8
bj$\not{p}$ Σp_T > 400 GeV	53	60.4 ± 19.9
bjγ	937	989.4 ± 20.6
bjγ$\not{p}$	34	30.5 ± 4
bjμ+$\not{p}$	104	112.6 ± 4.4
bjμ+	173	141.4 ± 4.8
be+3j$\not{p}$	68	52.2 ± 2.2
be+2j$\not{p}$	87	65 ± 3.3
be+$\not{p}$	330	347.2 ± 6.9
be+j$\not{p}$	211	176.6 ± 5
be+e-j	22	34.6 ± 2.6
be+e-	62	55 ± 3.1

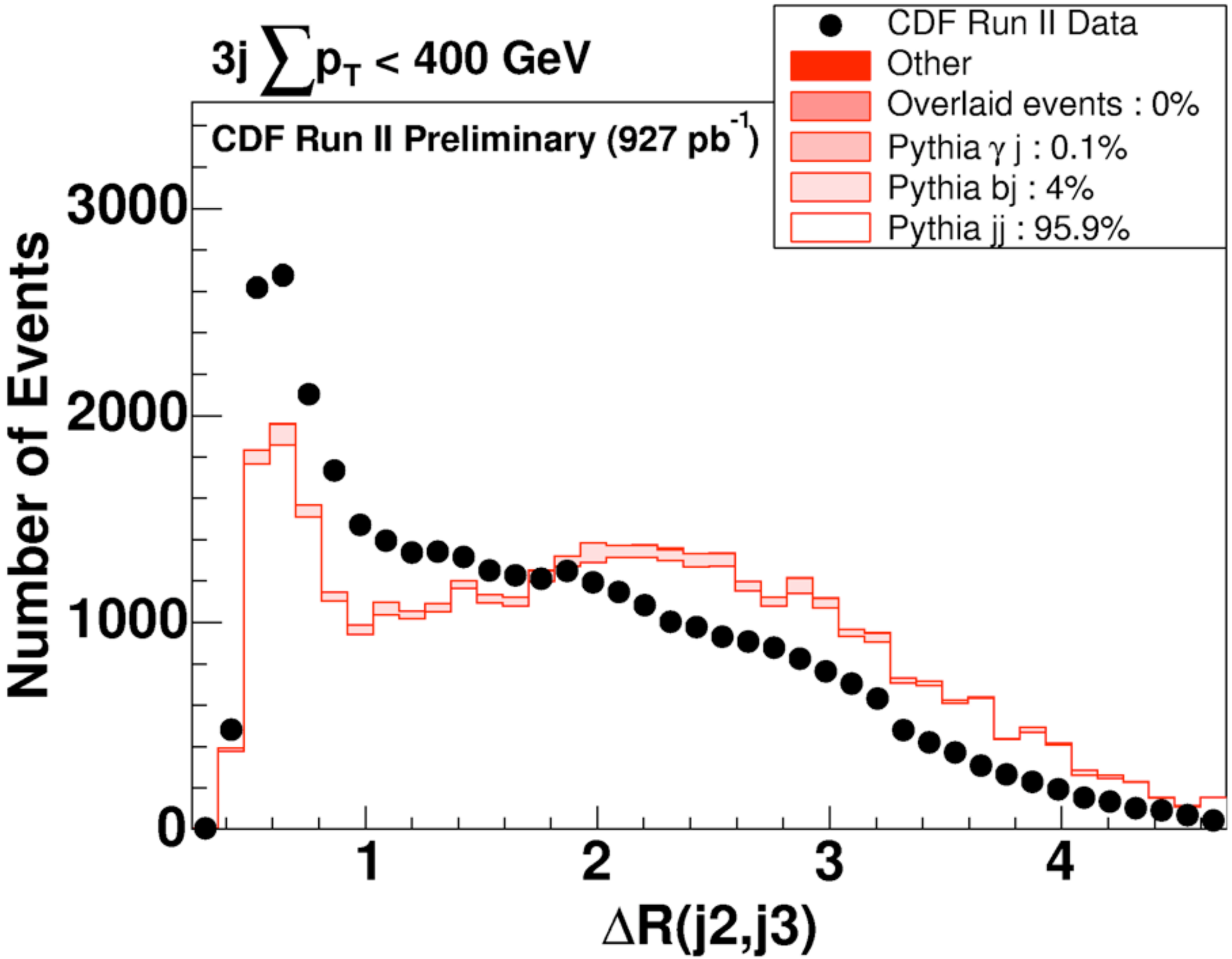
Vista final state normalizations



Vista kinematic shapes



Sample discrepant distribution

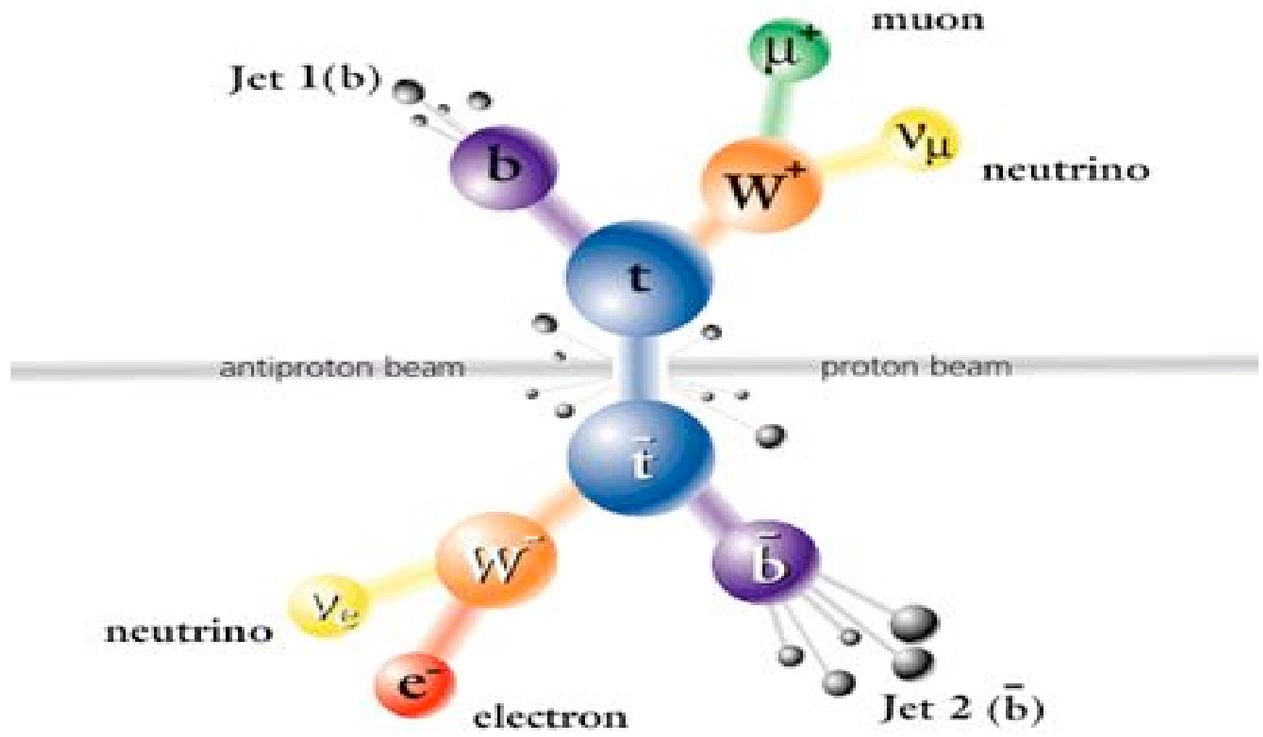


Sleuth

a quasi-model-independent search strategy for new physics

Assumptions:

1. Exclusive final state
2. Large $\sum p_T$
3. An excess



$$\int_{0001001}^{\text{present}} \text{(prediction) d(hep-ph)}$$

Rigorously compute the trials factor associated with looking everywhere

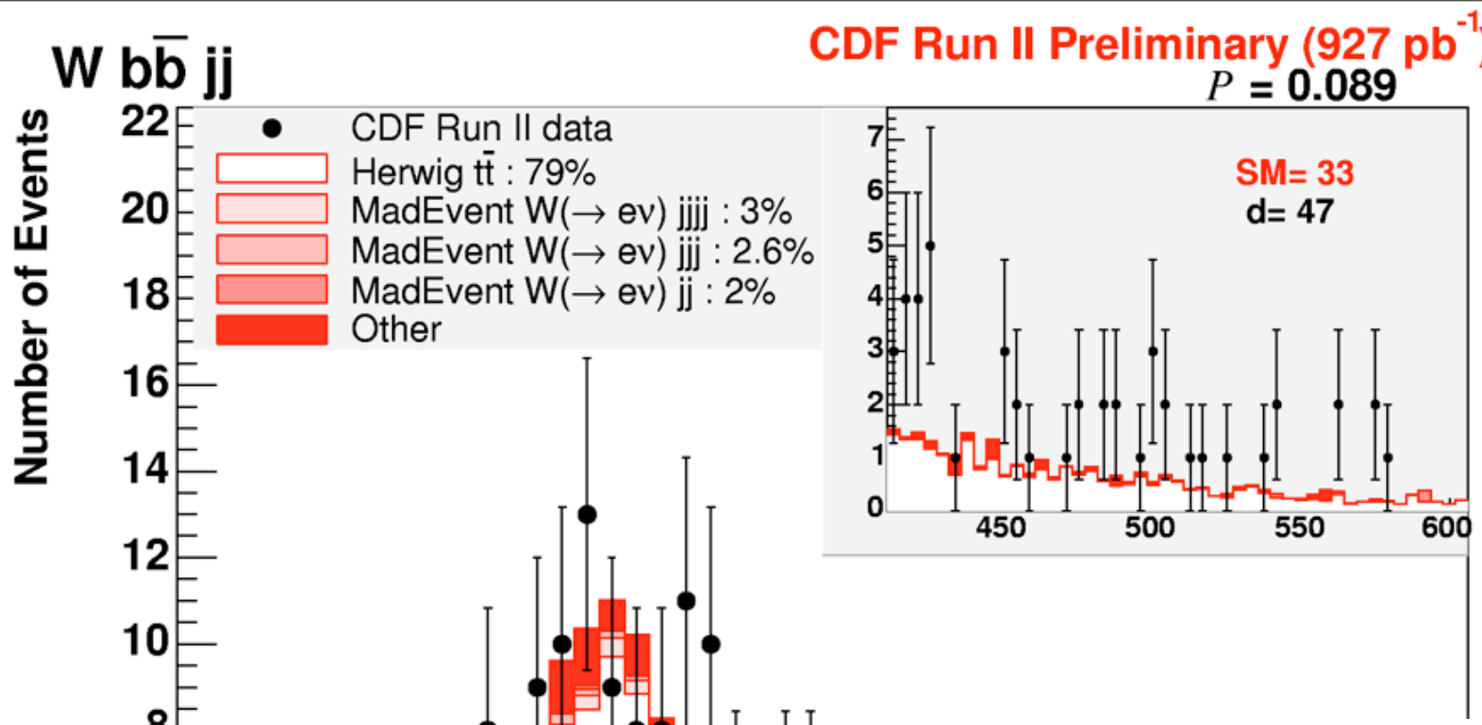
Sleuth Sensitivity

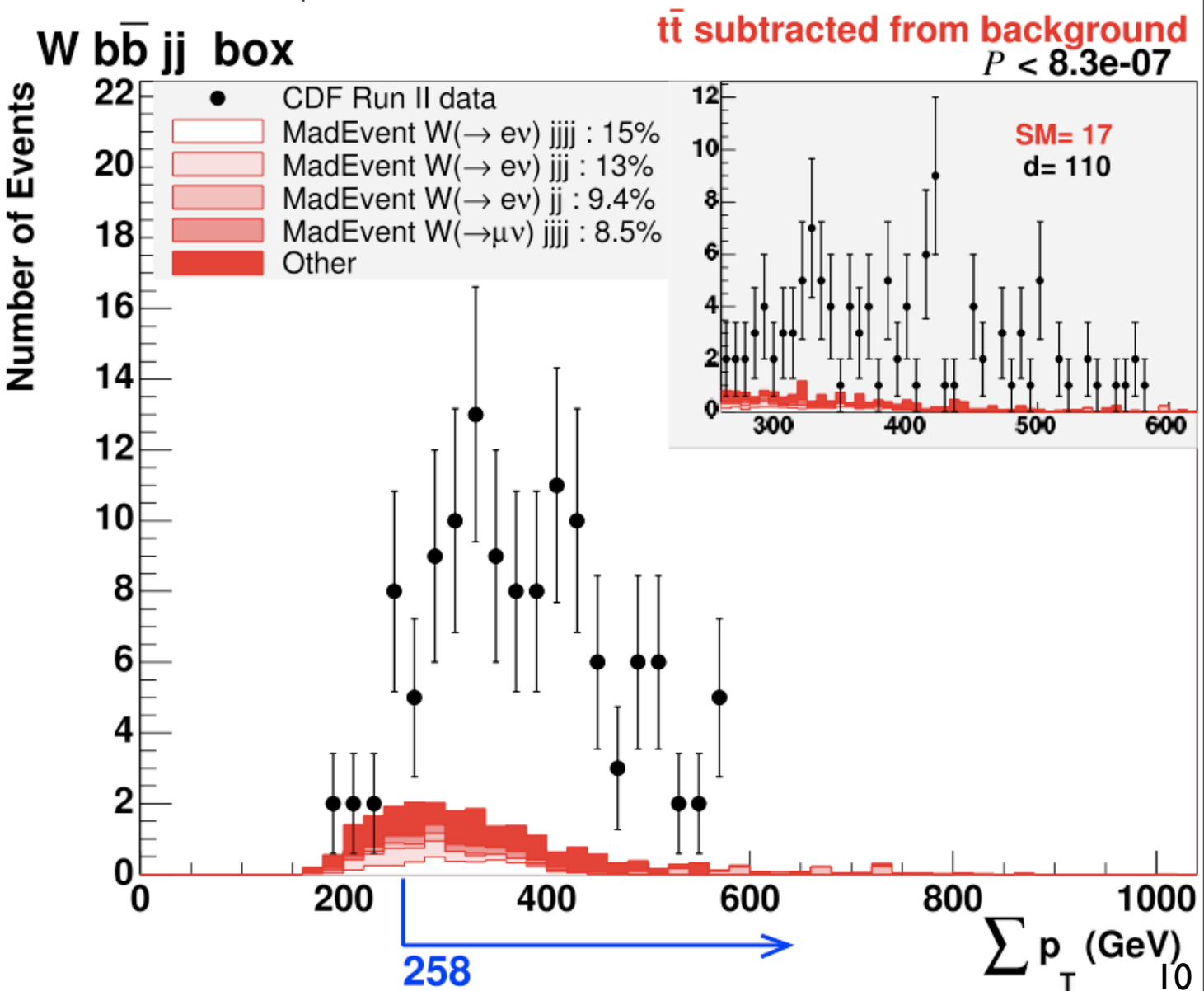
Q: Would Sleuth have found the top quark?

A: Yes.

Expected Run II discovery luminosity ~80 pb^{-1}

(Run I discovery 67 pb^{-1})





Sleuth@CDFIIa result

(top 5)

SLEUTH Final State	$\mathcal{P}$
$b\bar{b}$	0.0055
$j \not{p}$	0.0092
$\ell^+ \ell'^+ \not{p} j j$	0.011
$\ell^+ \ell'^+ \not{p}$	0.016
$\tau \not{p}$	0.016

$$\tilde{\mathcal{P}} = 0.46$$

- Sleuth finds no significant excess in 1fb^{-1} of CDF Run II high-p_T data
- 46% of pseudo experiments are expected to be as interesting
- This does not prove there is no new physics present

Summary

A global analysis of 1 fb^{-1} of CDF Run II data has been performed

Vista

model-independent
searches the bulk of distributions

Sleuth

quasi-model-independent
searches the high-Σp_T tails

This global analysis has revealed no new physics in 1 fb^{-1}
Tevatron Run II will provide 10x more data yet to be searched