Global Analysis of High-p_T Data

The problem

The solution

- Vista
- Sleuth
- Surprise!
- Bard
- Quaero
- TurboSim

Bruce Knuteson

The problem

model space is really, really big

10^{105}

The solution: Look everywhere

	e	μ	τ	$\not{p}_T$	γ	jj	bb	e e	e μ	e τ	e $\not{p}_T$	e γ	e jj	e bb	μ μ	μ τ	μ $\not{p}_T$	μ γ	μ jj	μ bb	τ τ	τ $\not{p}_T$	τ γ	τ jj	τ bb	$\not{p}_T$ γ	$\not{p}_T$ jj	$\not{p}_T$ bb	γ γ	γ jj	γ bb
bb bb																															
jj bb																															
jj jj																															
γ bb																															
γ jj																															
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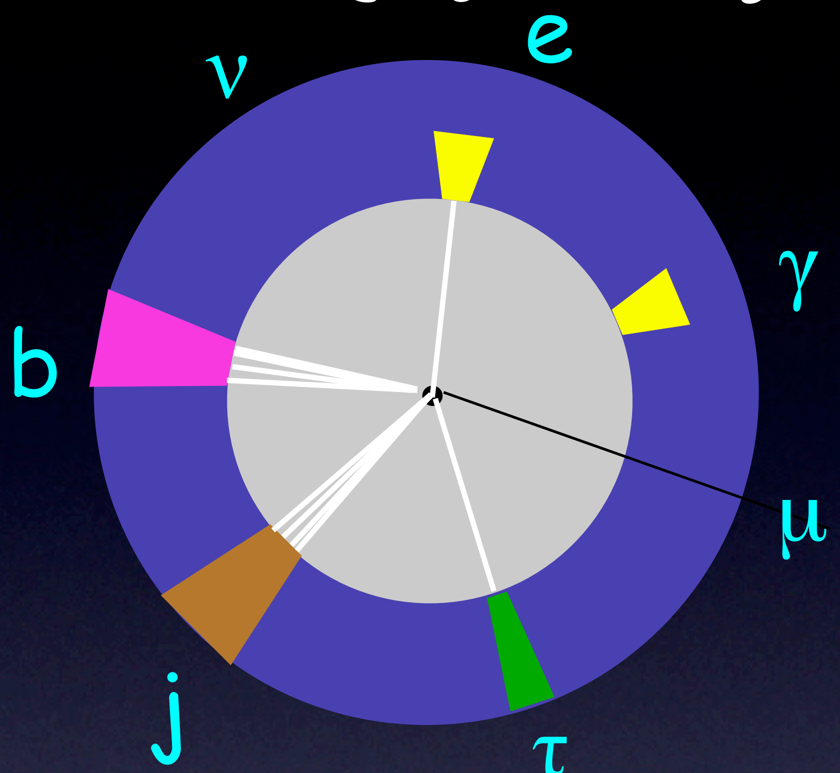
e e						LQ																									
bb											π_T																				
jj																															
γ																															
τ	A																														
μ																															
e	Z’			W’																											

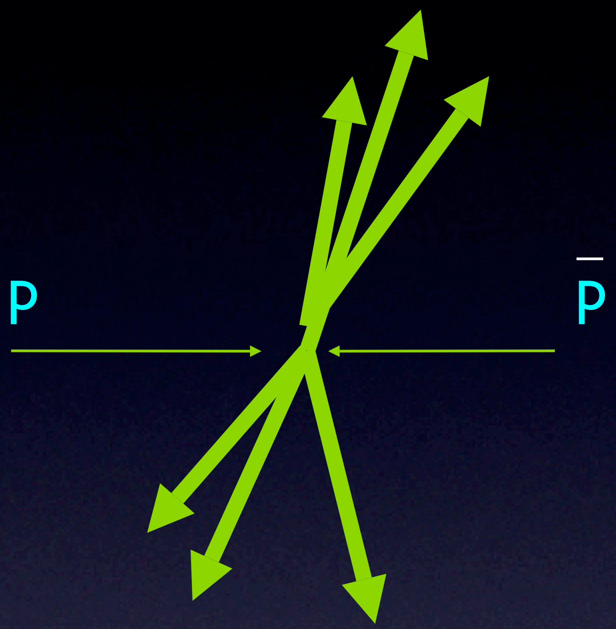
VISTA ALGORITHM

hep-ex/0402029
hep-ex/0504041
arXiv:0712.1311
arXiv:0712.2534

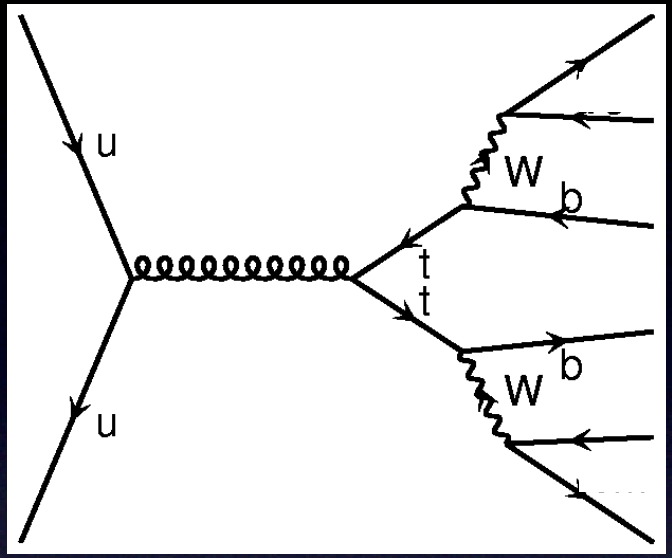
Define physics objects



Filter events of interest

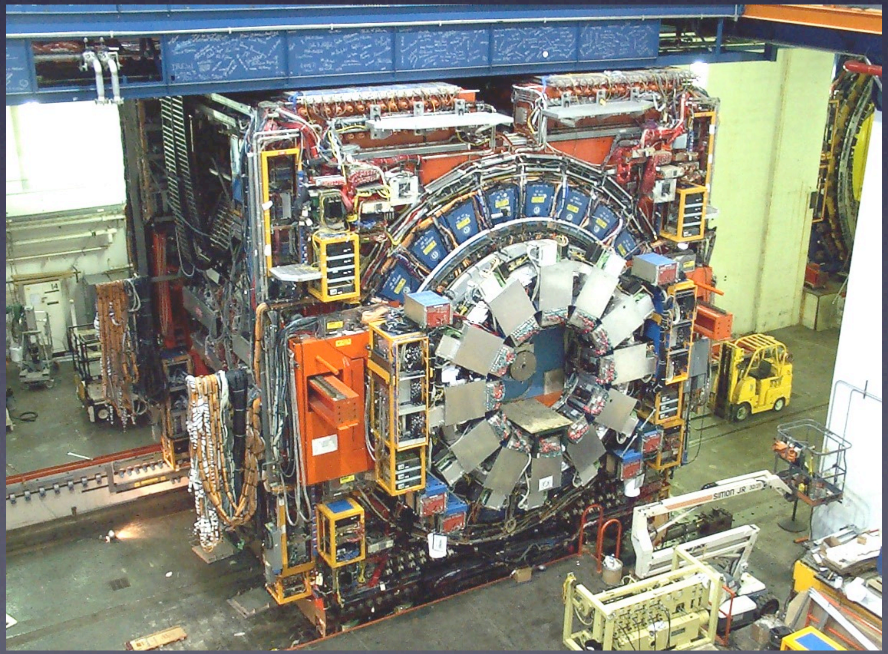


Estimate backgrounds



Fit for experimental & theoretical factors

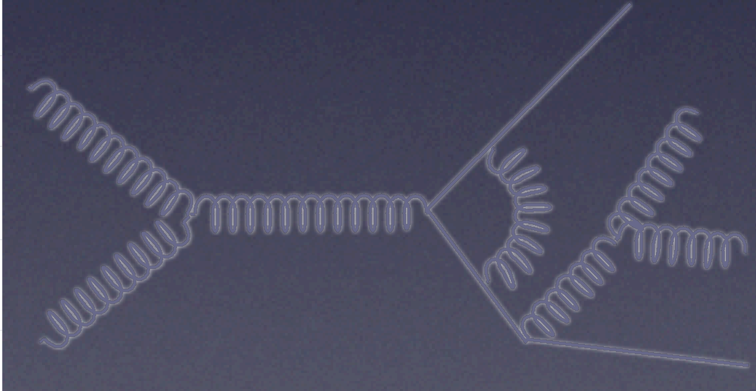
Simulate detector response



(mis)Id **reconstructed**

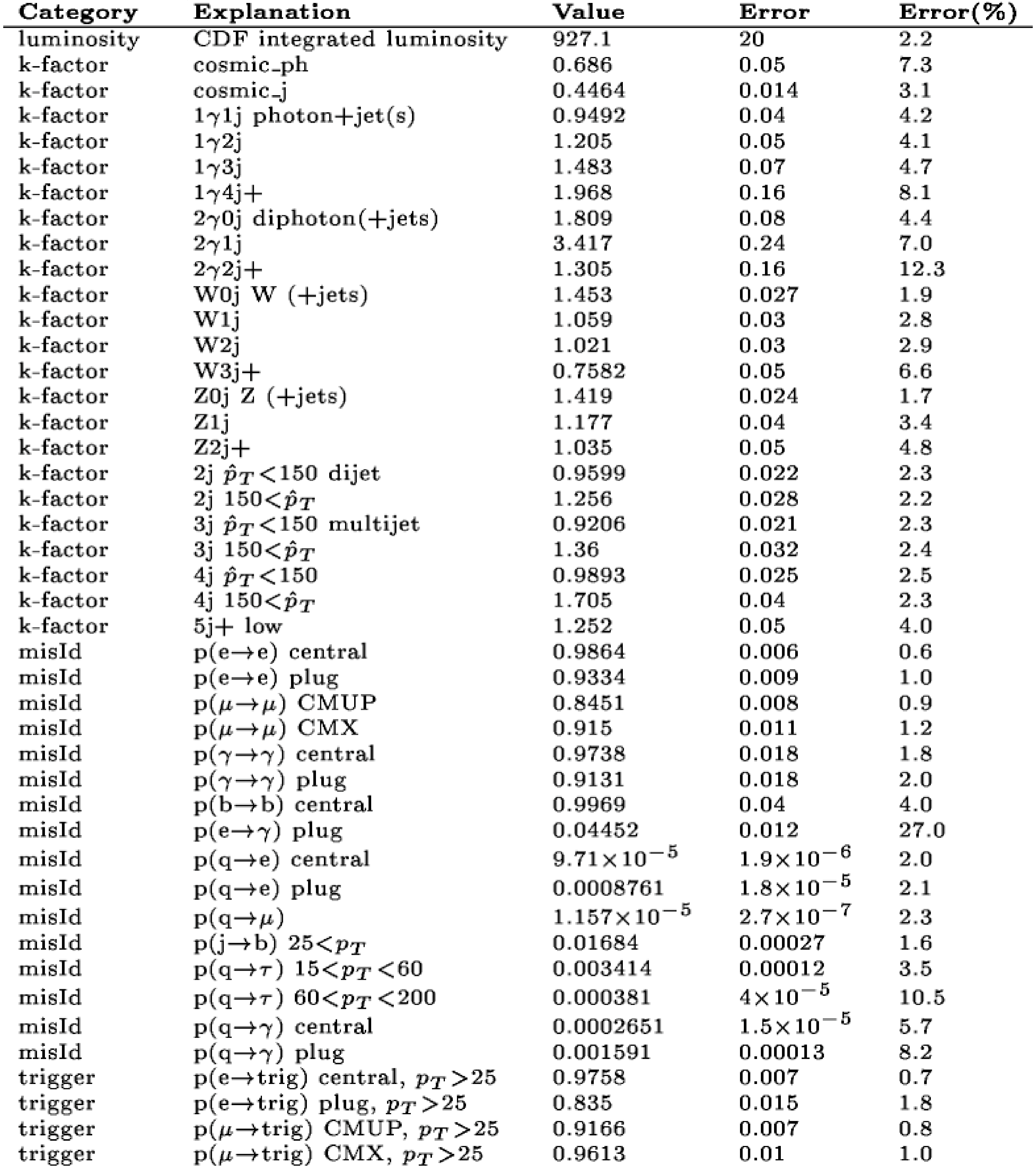
true

	e	μ	τ	γ	j	b
e	0.62		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 correction factors (global fit)

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



Category	Explanation	Value	Error	Error(%)
luminosity	CDF integrated luminosity	927.1	20	2.2
k-factor	cosmic_ph	0.686	0.05	7.3
k-factor	cosmic_j	0.4464	0.014	3.1
k-factor	$1\gamma1j$ photon+jet(s)	0.9492	0.04	4.2
k-factor	$1\gamma2j$	1.205	0.05	4.1
k-factor	$1\gamma3j$	1.483	0.07	4.7
k-factor	$1\gamma4j+$	1.968	0.16	8.1
k-factor	$2\gamma0j$ diphoton(+jets)	1.809	0.08	4.4
k-factor	$2\gamma1j$	3.417	0.24	7.0
k-factor	$2\gamma2j+$	1.305	0.16	12.3
k-factor	W0j W (+jets)	1.453	0.027	1.9
k-factor	W1j	1.059	0.03	2.8
k-factor	W2j	1.021	0.03	2.9
k-factor	W3j+	0.7582	0.05	6.6
k-factor	Z0j Z (+jets)	1.419	0.024	1.7
k-factor	Z1j	1.177	0.04	3.4
k-factor	Z2j+	1.035	0.05	4.8
k-factor	2j $\hat{p}_T<150$ dijet	0.9599	0.022	2.3
k-factor	2j $150<\hat{p}_T$	1.256	0.028	2.2
k-factor	3j $\hat{p}_T<150$ multijet	0.9206	0.021	2.3
k-factor	3j $150<\hat{p}_T$	1.36	0.032	2.4
k-factor	4j $\hat{p}_T<150$	0.9893	0.025	2.5
k-factor	4j $150<\hat{p}_T$	1.705	0.04	2.3
k-factor	5j+ low	1.252	0.05	4.0
misId	$p(e\rightarrow e)$ central	0.9864	0.006	0.6
misId	$p(e\rightarrow e)$ plug	0.9334	0.009	1.0
misId	$p(\mu\rightarrow\mu)$ CMUP	0.8451	0.008	0.9
misId	$p(\mu\rightarrow\mu)$ CMX	0.915	0.011	1.2
misId	$p(\gamma\rightarrow\gamma)$ central	0.9738	0.018	1.8
misId	$p(\gamma\rightarrow\gamma)$ plug	0.9131	0.018	2.0
misId	$p(b\rightarrow b)$ central	0.9969	0.04	4.0
misId	$p(e\rightarrow\gamma)$ plug	0.04452	0.012	27.0
misId	$p(q\rightarrow e)$ central	9.71×10^{-5}	1.9×10^{-6}	2.0
misId	$p(q\rightarrow e)$ plug	0.0008761	1.8×10^{-5}	2.1
misId	$p(q\rightarrow\mu)$	1.157×10^{-5}	2.7×10^{-7}	2.3
misId	$p(j\rightarrow b)$ $25<p_T$	0.01684	0.00027	1.6
misId	$p(q\rightarrow\tau)$ $15<p_T<60$	0.003414	0.00012	3.5
misId	$p(q\rightarrow\tau)$ $60<p_T<200$	0.000381	4×10^{-5}	10.5
misId	$p(q\rightarrow\gamma)$ central	0.0002651	1.5×10^{-5}	5.7
misId	$p(q\rightarrow\gamma)$ plug	0.001591	0.00013	8.2
trigger	$p(e\rightarrow trig)$ central, $p_T>25$	0.9758	0.007	0.7
trigger	$p(e\rightarrow trig)$ plug, $p_T>25$	0.835	0.015	1.8
trigger	$p(\mu\rightarrow trig)$ CMUP, $p_T>25$	0.9166	0.007	0.8
trigger	$p(\mu\rightarrow trig)$ CMX, $p_T>25$	0.9613	0.01	1.0

THE VISTA RESULT

arXiv:0712.1311 (submitted to PRD 10-Dec-2007)
arXiv:0712.2534 (submitted to PRL 15-Dec-2007)

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Vista output

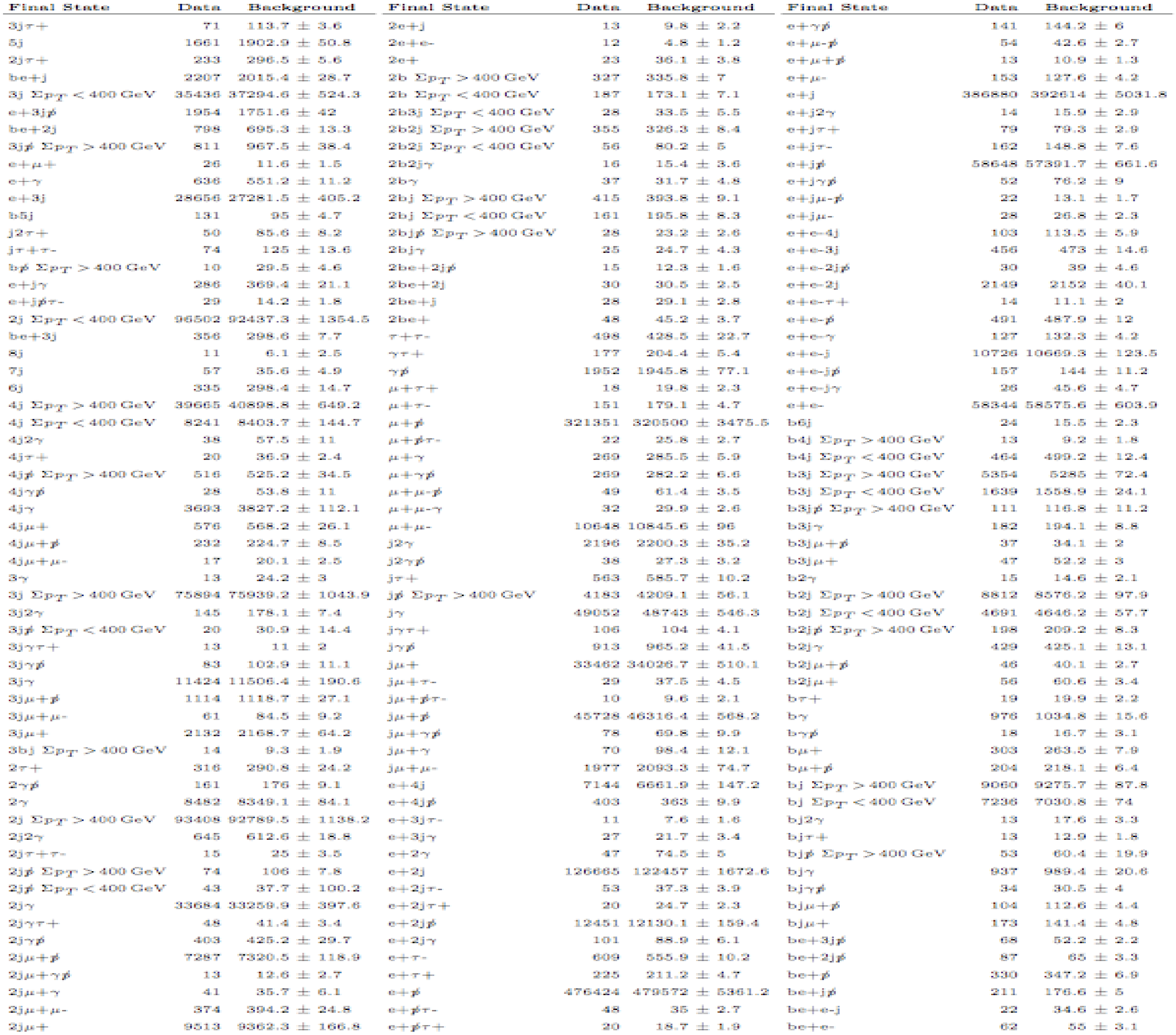
Table of final states

CDF Run II (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(→eν) 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(→τ τ) = 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(→eν) 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(→eν) bb = 13.3, MadEvent W(→eν) j = 12.4, Pythia jj 120 < pT < 150 = 11.6, Pythia gamma j 80 < pT = 10.4, MadEvent W(→eν) jjj = 10.4, MadEvent Z(→ee) = 9.6, Alpgen W(→eν) 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(→eν) bb jj = 2.1, Pythia bj 150 < pT < 200 = 1.8, Pythia jj 200 < pT < 300 = 1.5, MadEvent W(→eν) jjjj = 1.1, MadEvent W(→eν) gamma = 0.8, Overlaid events = 0.8, MadEvent W(→eν) = 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(→τ τ) = 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(→eν) jjj = 2, MadEvent W(→eν) 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(→eν) jj = 705.6, MadEvent W(→eν) jjj = 595.3, MadEvent W(→eν) j = 132.6, MadEvent W(→eν) jjjj = 85, Pythia W(→τ ν) = 56.4, MadEvent W(→eν) = 45.8, Herwig ttbar = 26.7, MadEvent Z(→ee) jj = 25.9, Alpgen W(→eν) bb j = 10.3, MadEvent Z(→ee) jjj = 9.2, MadEvent W(→eν) gamma = 8.1, MadEvent Z(→ee) j = 7.7, Alpgen W(→eν) bb = 6.8, Pythia jj 60 < pT < 90 = 5.8, Alpgen W(→eν) 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(→τ τ) = 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

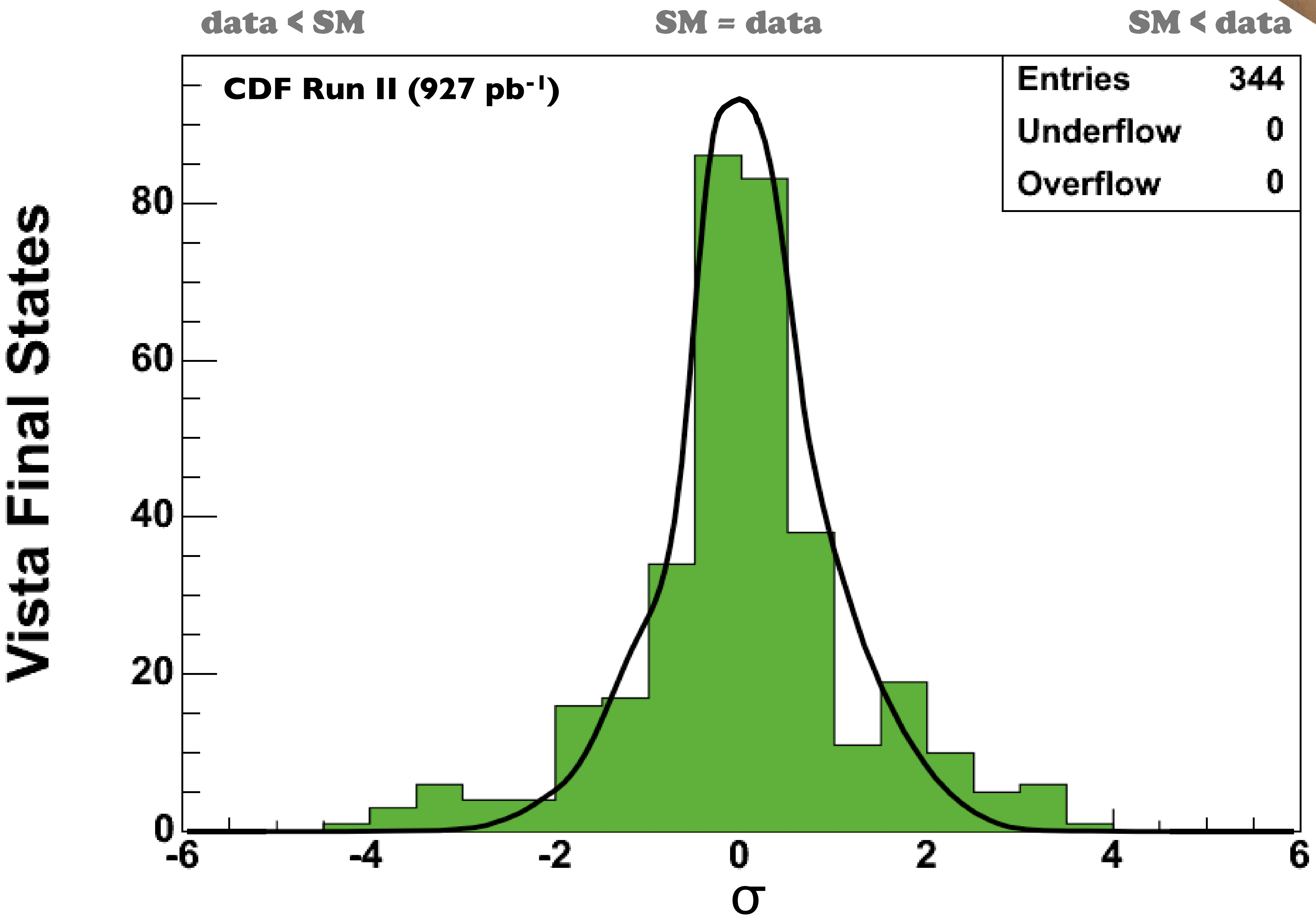
Vista output

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

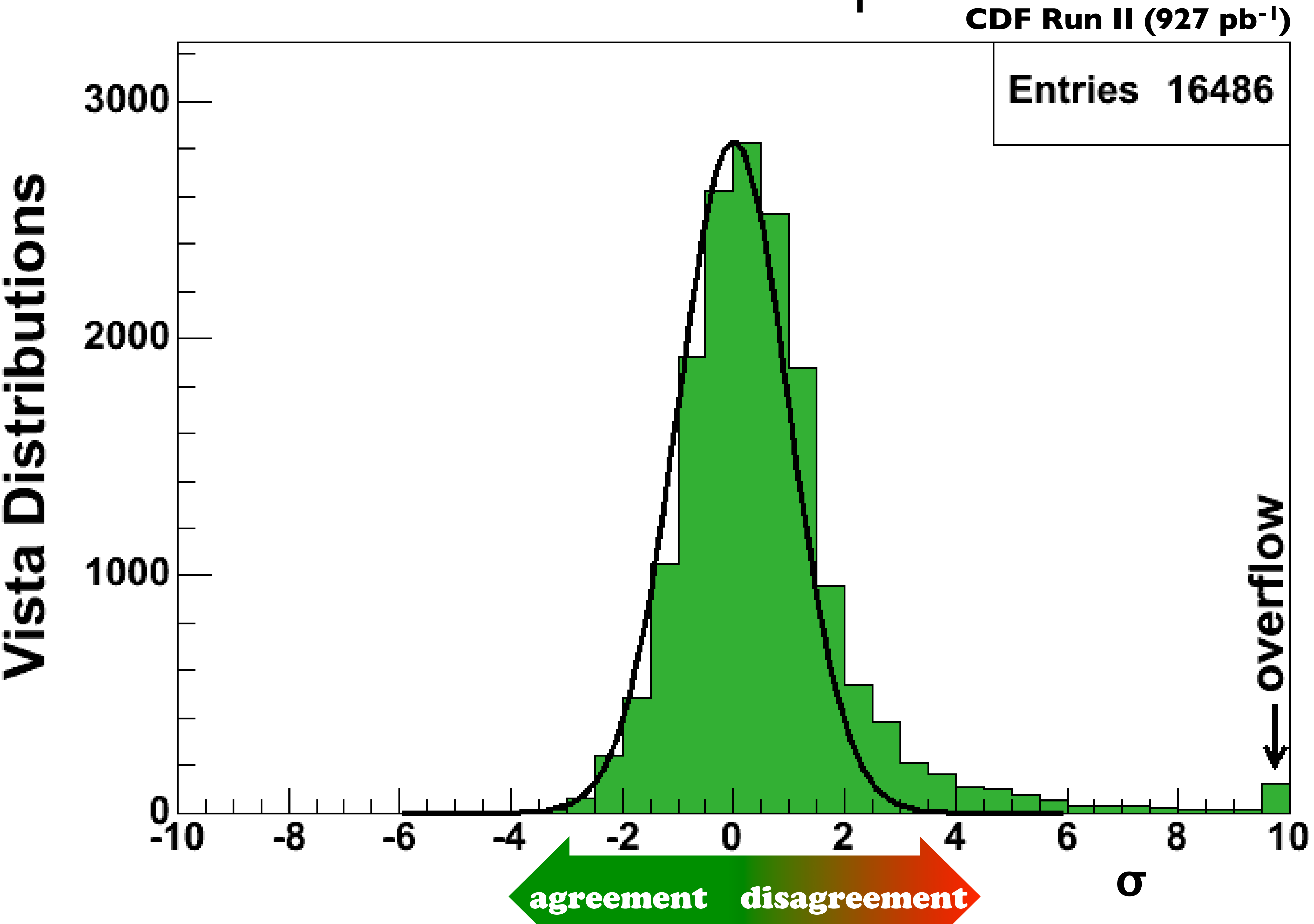


Final State	Data	Background	Final State	Data	Background	Final State	Data	Background
$3j\tau+$	71	113.7 ± 3.6	$2e+j$	13	9.8 ± 2.2	$e+\gamma\not{p}$	141	144.2 ± 6
$5j$	1661	1902.9 ± 50.8	$2e+e-$	12	4.8 ± 1.2	$e+\mu-\not{p}$	54	42.6 ± 2.7
$2j\tau+$	233	296.5 ± 5.6	$2e+$	23	36.1 ± 3.8	$e+\mu+\not{p}$	13	10.9 ± 1.3
$be+j$	2207	2015.4 ± 28.7	$2b\ \Sigma p_T > 400$ GeV	327	335.8 ± 7	$e+\mu-$	153	127.6 ± 4.2
$3j\ \Sigma p_T < 400$ GeV	35436	37294.6 ± 524.3	$2b\ \Sigma p_T < 400$ GeV	187	173.1 ± 7.1	$e+j$	386880	392614 ± 5031.8
$e+3j\not{p}$	1954	1751.6 ± 42	$2b3j\ \Sigma p_T < 400$ GeV	28	33.5 ± 5.5	$e+j2\gamma$	14	15.9 ± 2.9
$be+2j$	798	695.3 ± 13.3	$2b2j\ \Sigma p_T > 400$ GeV	355	326.3 ± 8.4	$e+j\tau+$	79	79.3 ± 2.9
$3j\not{p}\ \Sigma p_T > 400$ GeV	811	967.5 ± 38.4	$2b2j\ \Sigma p_T < 400$ GeV	56	80.2 ± 5	$e+j\tau-$	162	148.8 ± 7.6
$e+\mu+$	26	11.6 ± 1.5	$2b2j\gamma$	16	15.4 ± 3.6	$e+j\not{p}$	58648	57391.7 ± 661.6
$e+\gamma$	636	551.2 ± 11.2	$2b\gamma$	37	31.7 ± 4.8	$e+j\gamma\not{p}$	52	76.2 ± 9
$e+3j$	28656	27281.5 ± 405.2	$2bj\ \Sigma p_T > 400$ GeV	415	393.8 ± 9.1	$e+j\mu-\not{p}$	22	13.1 ± 1.7
$b5j$	131	95 ± 4.7	$2bj\ \Sigma p_T < 400$ GeV	161	195.8 ± 8.3	$e+j\mu-$	28	26.8 ± 2.3
$j2\tau+$	50	85.6 ± 8.2	$2bj\not{p}\ \Sigma p_T > 400$ GeV	28	23.2 ± 2.6	$e+e-4j$	103	113.5 ± 5.9
$j\tau+\tau-$	74	125 ± 13.6	$2bj\gamma$	25	24.7 ± 4.3	$e+e-3j$	456	473 ± 14.6
$b\not{p}\ \Sigma p_T > 400$ GeV	10	29.5 ± 4.6	$2be+2j\not{p}$	15	12.3 ± 1.6	$e+e-2j\not{p}$	30	39 ± 4.6
$e+j\gamma$	286	369.4 ± 21.1	$2be+2j$	30	30.5 ± 2.5	$e+e-2j$	2149	2152 ± 40.1
$e+j\not{p}\tau-$	29	14.2 ± 1.8	$2be+j$	28	29.1 ± 2.8	$e+e-\tau+$	14	11.1 ± 2
$2j\ \Sigma p_T < 400$ GeV	96502	92437.3 ± 1354.5	$2be+$	48	45.2 ± 3.7	$e+e-\not{p}$	491	487.9 ± 12
$be+3j$	356	298.6 ± 7.7	$\tau+\tau-$	498	428.5 ± 22.7	$e+e-\gamma$	127	132.3 ± 4.2
$8j$	11	6.1 ± 2.5	$\gamma\tau+$	177	204.4 ± 5.4	$e+e-j$	10726	10669.3 ± 123.5
$7j$	57	35.6 ± 4.9	$\gamma\not{p}$	1952	1945.8 ± 77.1	$e+e-j\not{p}$	157	144 ± 11.2
$6j$	335	298.4 ± 14.7	$\mu+\tau+$	18	19.8 ± 2.3	$e+e-j\gamma$	26	45.6 ± 4.7
$4j\ \Sigma p_T > 400$ GeV	39665	40898.8 ± 649.2	$\mu+\tau-$	151	179.1 ± 4.7	$e+e-$	58344	58575.6 ± 603.9
$4j\ \Sigma p_T < 400$ GeV	8241	8403.7 ± 144.7	$\mu+\not{p}$	321351	320500 ± 3475.5	$b6j$	24	15.5 ± 2.3
$4j2\gamma$	38	57.5 ± 11	$\mu+\not{p}\tau-$	22	25.8 ± 2.7	$b4j\ \Sigma p_T > 400$ GeV	13	9.2 ± 1.8
$4j\tau+$	20	36.9 ± 2.4	$\mu+\gamma$	269	285.5 ± 5.9	$b4j\ \Sigma p_T < 400$ GeV	464	499.2 ± 12.4
$4j\not{p}\ \Sigma p_T > 400$ GeV	516	525.2 ± 34.5	$\mu+\gamma\not{p}$	269	282.2 ± 6.6	$b3j\ \Sigma p_T > 400$ GeV	5354	5285 ± 72.4
$4j\gamma\not{p}$	28	53.8 ± 11	$\mu+\mu-\not{p}$	49	61.4 ± 3.5	$b3j\ \Sigma p_T < 400$ GeV	1639	1558.9 ± 24.1
$4j\gamma$	3693	3827.2 ± 112.1	$\mu+\mu-\gamma$	32	29.9 ± 2.6	$b3j\not{p}\ \Sigma p_T > 400$ GeV	111	116.8 ± 11.2
$4j\mu+$	576	568.2 ± 26.1	$\mu+\mu-$	10648	10845.6 ± 96	$b3j\gamma$	182	194.1 ± 8.8
$4j\mu+\not{p}$	232	224.7 ± 8.5	$j2\gamma$	2196	2200.3 ± 35.2	$b3j\mu+\not{p}$	37	34.1 ± 2
$4j\mu+\mu-$	17	20.1 ± 2.5	$j2\gamma\not{p}$	38	27.3 ± 3.2	$b3j\mu+$	47	52.2 ± 3
3γ	13	24.2 ± 3	$j\tau+$	563	585.7 ± 10.2	$b2\gamma$	15	14.6 ± 2.1
$3j\ \Sigma p_T > 400$ GeV	75894	75939.2 ± 1043.9	$j\not{p}\ \Sigma p_T > 400$ GeV	4183	4209.1 ± 56.1	$b2j\ \Sigma p_T > 400$ GeV	8812	8576.2 ± 97.9
$3j2\gamma$	145	178.1 ± 7.4	$j\gamma$	49052	48743 ± 546.3	$b2j\ \Sigma p_T < 400$ GeV	4691	4646.2 ± 57.7
$3j\not{p}\ \Sigma p_T < 400$ GeV	20	30.9 ± 14.4	$j\gamma\tau+$	106	104 ± 4.1	$b2j\not{p}\ \Sigma p_T > 400$ GeV	198	209.2 ± 8.3
$3j\gamma\tau+$	13	11 ± 2	$j\gamma\not{p}$	913	965.2 ± 41.5	$b2j\gamma$	429	425.1 ± 13.1
$3j\gamma\not{p}$	83	102.9 ± 11.1	$j\mu+$	33462	34026.7 ± 510.1	$b2j\mu+\not{p}$	46	40.1 ± 2.7
$3j\gamma$	11424	11506.4 ± 190.6	$j\mu+\tau-$	29	37.5 ± 4.5	$b2j\mu+$	56	60.6 ± 3.4
$3j\mu+\not{p}$	1114	1118.7 ± 27.1	$j\mu+\not{p}\tau-$	10	9.6 ± 2.1	$b\tau+$	19	19.9 ± 2.2
$3j\mu+\mu-$	61	84.5 ± 9.2	$j\mu+\not{p}$	45728	46316.4 ± 568.2	$b\gamma$	976	1034.8 ± 15.6
$3j\mu+$	2132	2168.7 ± 64.2	$j\mu+\gamma\not{p}$	78	69.8 ± 9.9	$b\gamma\not{p}$	18	16.7 ± 3.1
$3bj\ \Sigma p_T > 400$ GeV	14	9.3 ± 1.9	$j\mu+\gamma$	70	98.4 ± 12.1	$b\mu+$	303	263.5 ± 7.9
$2\tau+$	316	290.8 ± 24.2	$j\mu+\mu-$	1977	2093.3 ± 74.7	$b\mu+\not{p}$	204	218.1 ± 6.4
$2\gamma\not{p}$	161	176 ± 9.1	$e+4j$	7144	6661.9 ± 147.2	$bj\ \Sigma p_T > 400$ GeV	9060	9275.7 ± 87.8
2γ	8482	8349.1 ± 84.1	$e+4j\not{p}$	403	363 ± 9.9	$bj\ \Sigma p_T < 400$ GeV	7236	7030.8 ± 74
$2j\ \Sigma p_T > 400$ GeV	93408	92789.5 ± 1138.2	$e+3j\tau-$	11	7.6 ± 1.6	$bj2\gamma$	13	17.6 ± 3.3
$2j2\gamma$	645	612.6 ± 18.8	$e+3j\gamma$	27	21.7 ± 3.4	$bj\tau+$	13	12.9 ± 1.8
$2j\tau+\tau-$	15	25 ± 3.5	$e+2\gamma$	47	74.5 ± 5	$bj\not{p}\ \Sigma p_T > 400$ GeV	53	60.4 ± 19.9
$2j\not{p}\ \Sigma p_T > 400$ GeV	74	106 ± 7.8	$e+2j$	126665	122457 ± 1672.6	$bj\gamma$	937	989.4 ± 20.6
$2j\not{p}\ \Sigma p_T < 400$ GeV	43	37.7 ± 100.2	$e+2j\tau-$	53	37.3 ± 3.9	$bj\gamma\not{p}$	34	30.5 ± 4
$2j\gamma$	33684	33259.9 ± 397.6	$e+2j\tau+$	20	24.7 ± 2.3	$bj\mu+\not{p}$	104	112.6 ± 4.4
$2j\gamma\tau+$	48	41.4 ± 3.4	$e+2j\not{p}$	12451	12130.1 ± 159.4	$bj\mu+$	173	141.4 ± 4.8
$2j\gamma\not{p}$	403	425.2 ± 29.7	$e+2j\gamma$	101	88.9 ± 6.1	$be+3j\not{p}$	68	52.2 ± 2.2
$2j\mu+\not{p}$	7287	7320.5 ± 118.9	$e+\tau-$	609	555.9 ± 10.2	$be+2j\not{p}$	87	65 ± 3.3
$2j\mu+\gamma\not{p}$	13	12.6 ± 2.7	$e+\tau+$	225	211.2 ± 4.7	$be+\not{p}$	330	347.2 ± 6.9
$2j\mu+\gamma$	41	35.7 ± 6.1	$e+\not{p}$	476424	479572 ± 5361.2	$be+j\not{p}$	211	176.6 ± 5
$2j\mu+\mu-$	374	394.2 ± 24.8	$e+\not{p}\tau-$	48	35 ± 2.7	$be+e-j$	22	34.6 ± 2.6
$2j\mu+$	9513	9362.3 ± 166.8	$e+\not{p}\tau+$	20	18.7 ± 1.9	$be+e-$	62	55 ± 3.1

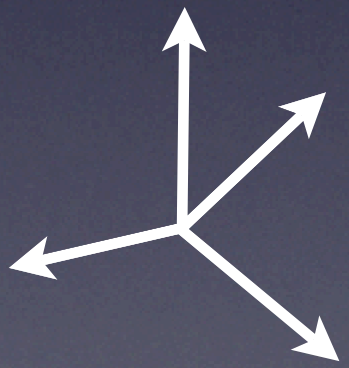
Vista final state normalizations



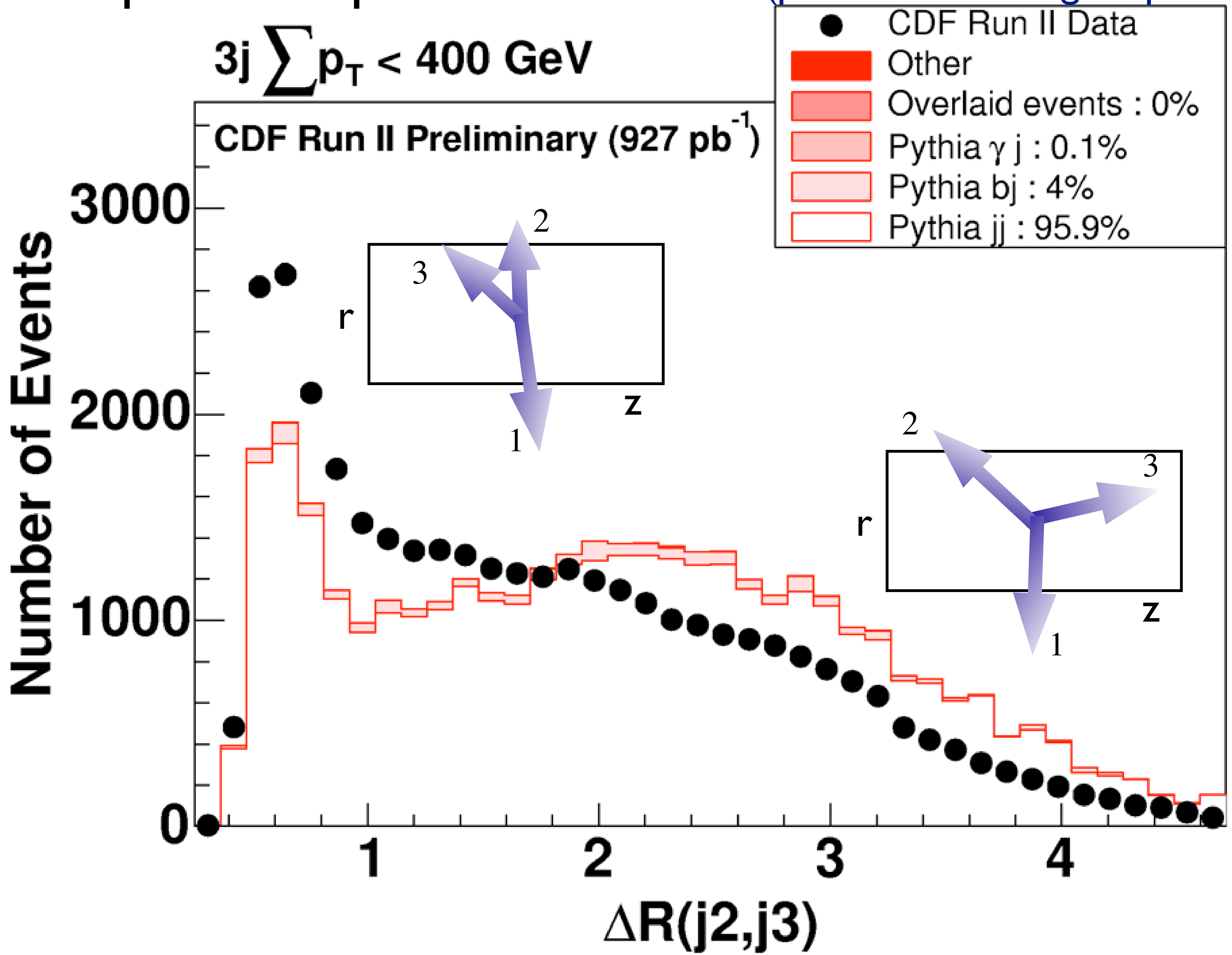
Vista kinematic shapes



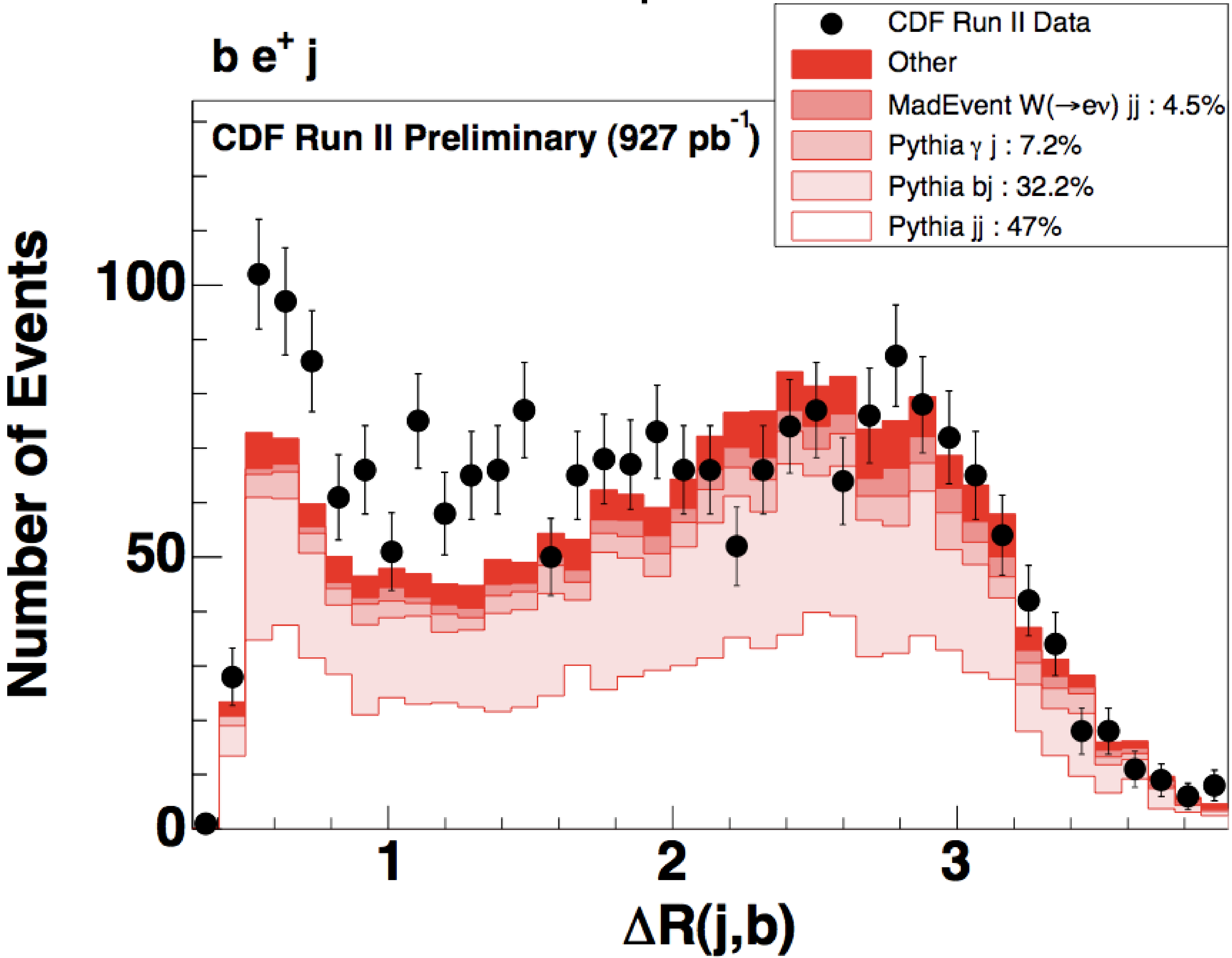
1. **Statistical fluctuation**
2. **Detector effect**
3. **Poor prediction**
4. **Plausible interpretation**



Sample discrepant distribution (parton showering suspected)



Related discrepant distribution



$\sum p_T$ statistic

Sleuth

a quasi-model-independent search strategy for new physics

Assumptions:

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

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

DØ Run I

Phys.Rev.D 62:092004,2000
Phys.Rev.D 64:012004,2001
Phys.Rev.Lett.86:3712,2001

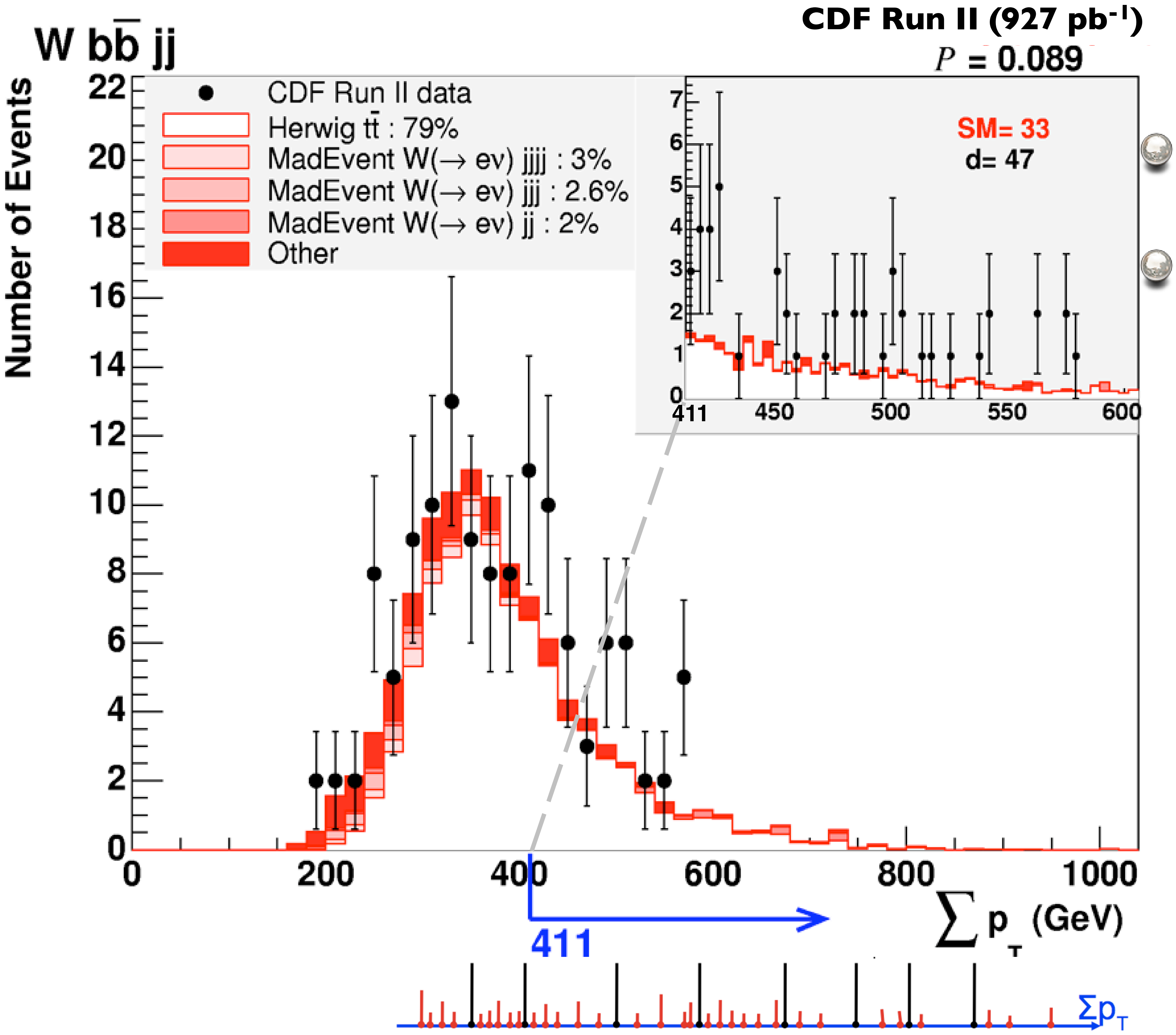
H1 General Search

Phys.Lett.B 602:14-30,2004
arXiv:0705.3721 (summer 2007)

CDF Run II

arXiv:0712.1311 (submitted to PRD)
arXiv:0712.2534 (submitted to PRL)

Rigorously compute the trials factor associated with looking everywhere



- Find the most interesting tail
- Produce pseudo experiments to assess significance

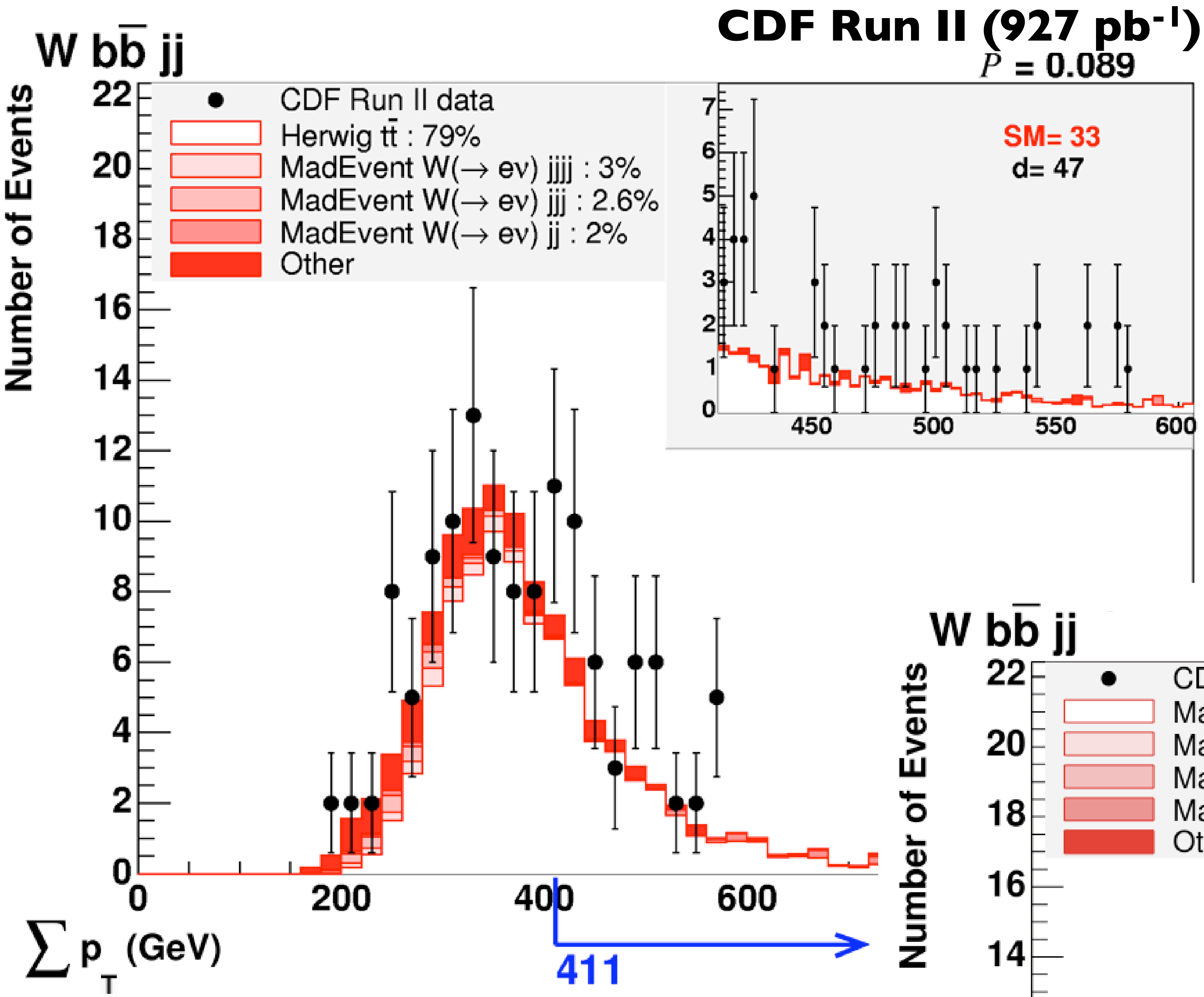
Sleuth Sensitivity

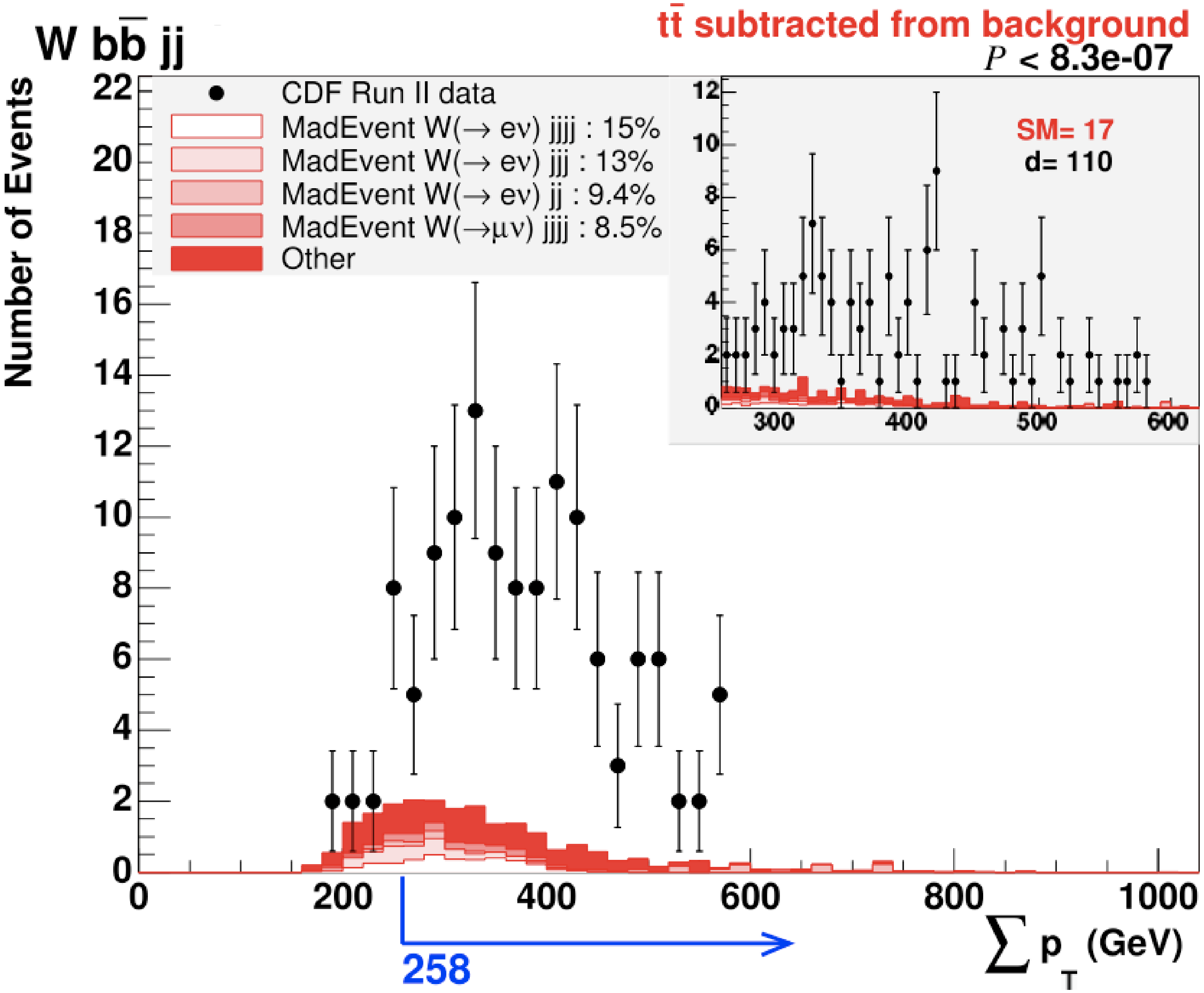
Q: Would Sleuth have found the top quark?

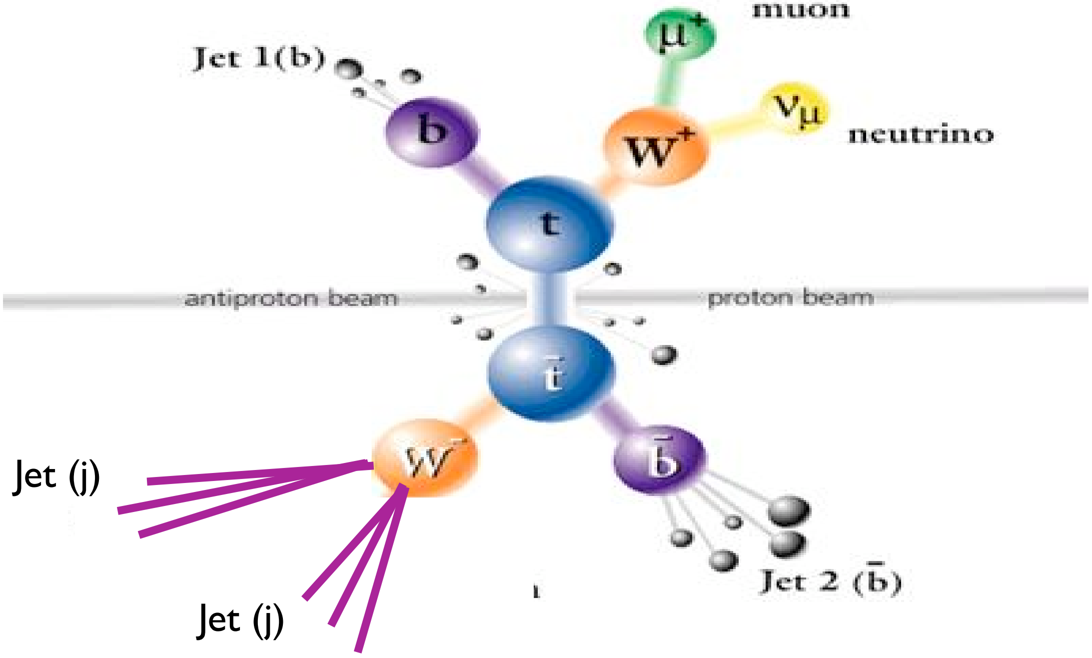
A: Yes.

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

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

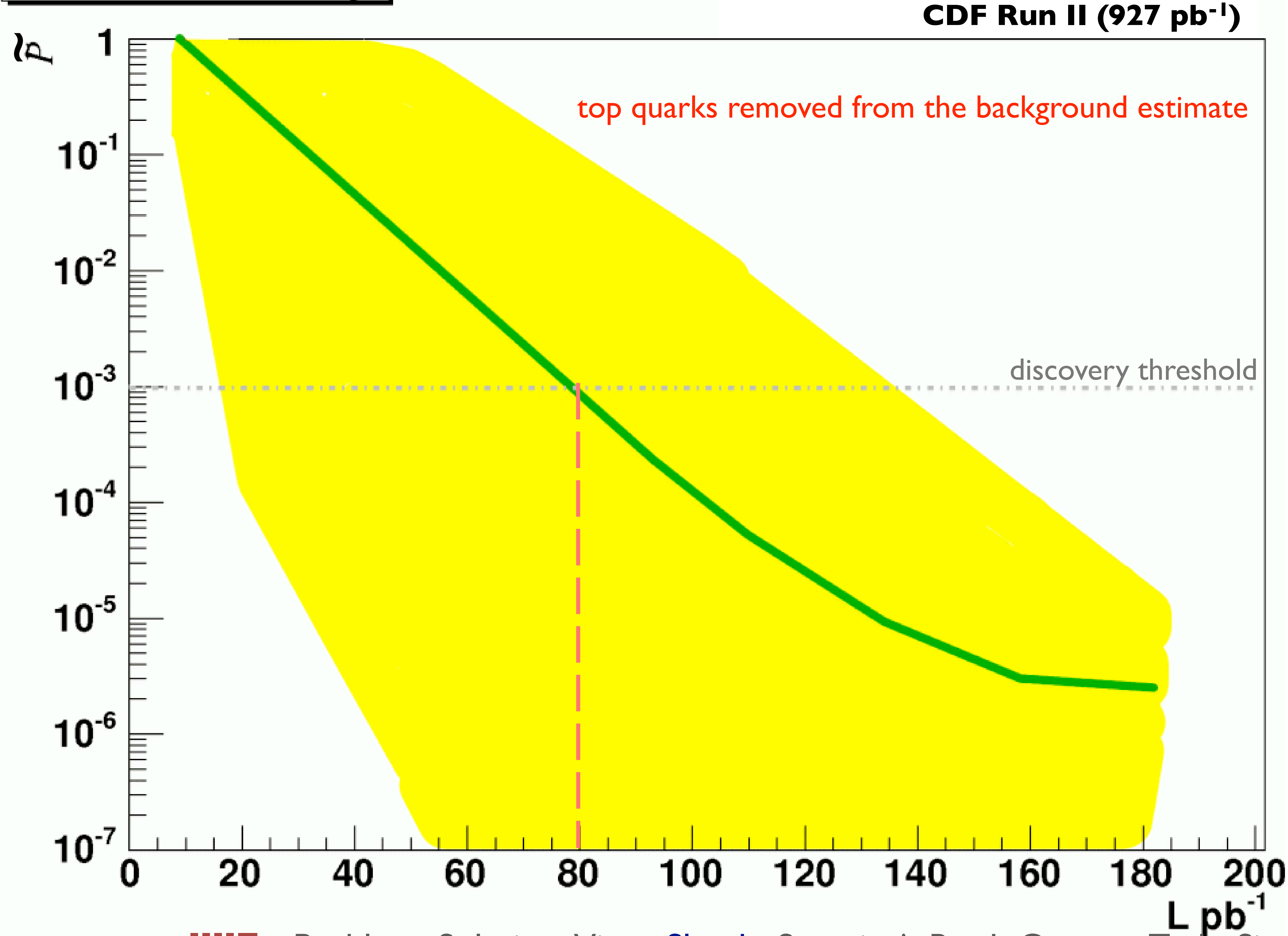






Bruce Knuteson

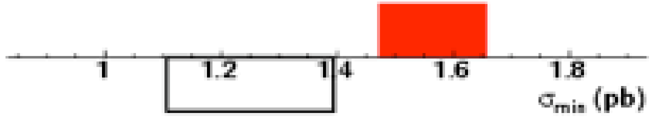
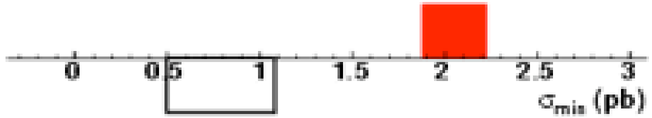
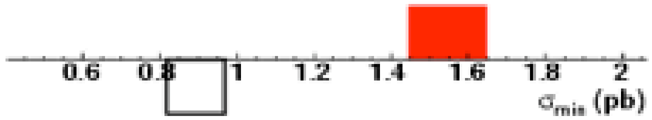
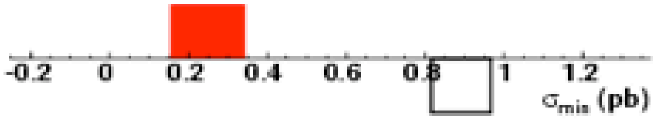
$\tilde{P}$ vs Luminosity



Sample comparison of **Sleuth** to targeted searches

🟥 Sleuth
☐ targeted search

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

Name	Description	Sensitivity
Model 01	GMSB, $\Lambda = 82.6$ GeV, $\tan\beta = 15$, $\mu > 0$, 1 messenger of $M = 2\Lambda$	
Model 02	$Z'_{(250\,\mathrm{GeV}/c^2)} \to \ell\bar{\ell}$, with $\ell \neq \nu$	
Model 03	$Z'_{(700\,\mathrm{GeV}/c^2)} \to q\bar{q}$	
Model 04	$Z'_{(1\,\mathrm{TeV}/c^2)} \to q\bar{q}$	
Model 05	mSUGRA, $M_0 = 100$ GeV, $M_{1/2} = 180$ GeV, $A_0 = 0$, $\tan\beta = 5$, $\mu > 0$	
Model 06	mSUGRA, $M_0 = 284$ GeV, $M_{1/2} = 100$ GeV, $A_0 = 0$, $\tan\beta = 5$, $\mu < 0$	
Model 07	mSUGRA, $M_0 = 300$ GeV, $M_{1/2} = 200$ GeV, $A_0 = 0$, $\tan\beta = 5$, $\mu < 0$	

For models satisfying the assumptions on which Sleuth is based, Sleuth is comparable in sensitivity to a targeted search

better ⟷ worse

$\sigma_{discovery}$ (pb)

THE SLEUTH RESULT

$\sum p_T$ statistic

arXiv:0712.1311 (submitted to PRD)
arXiv:0712.2534 (submitted to PRL)

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

Sleuth@CDFII result

(top 5)

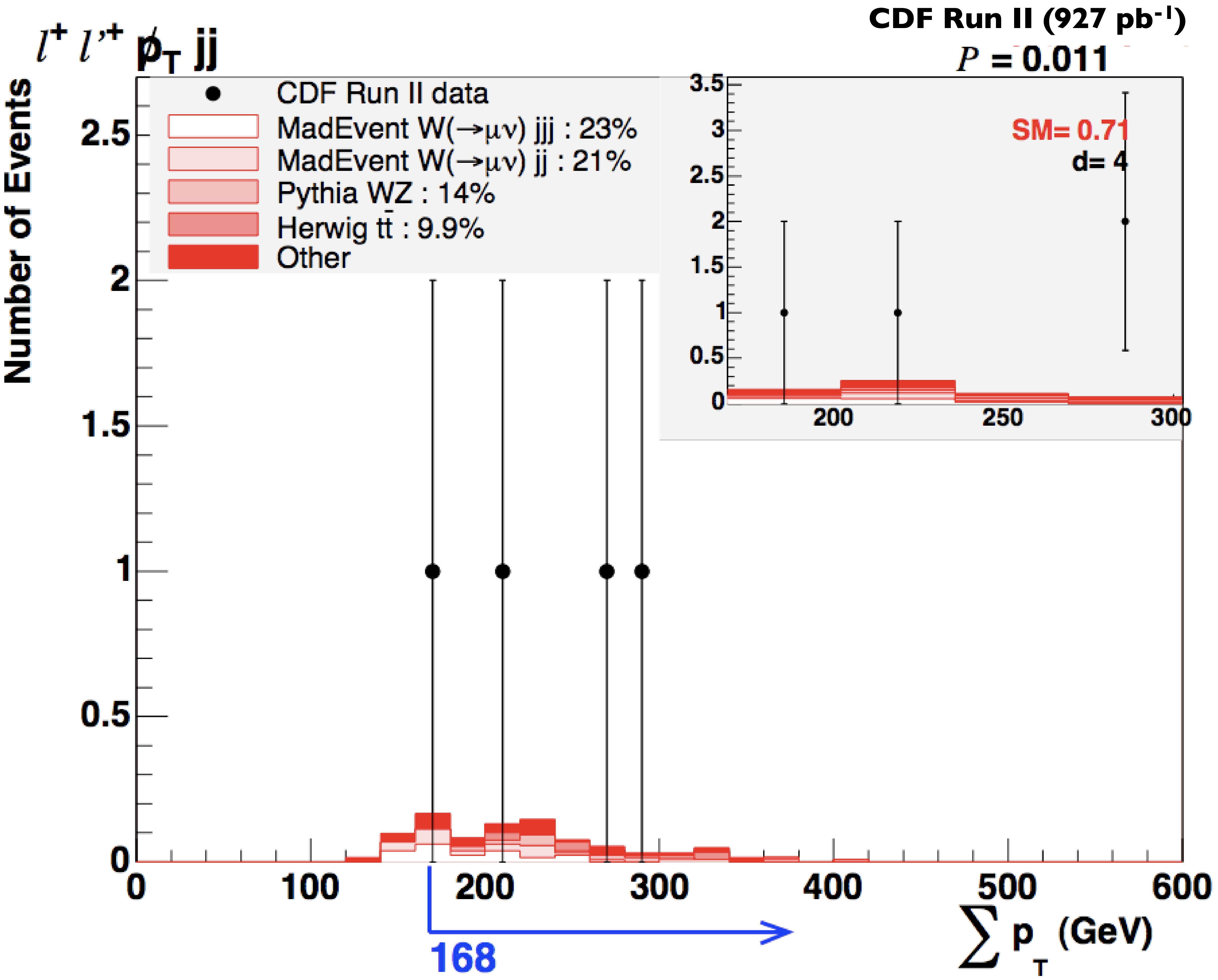
fraction of pseudo experiments in this final state as interesting as CDF data

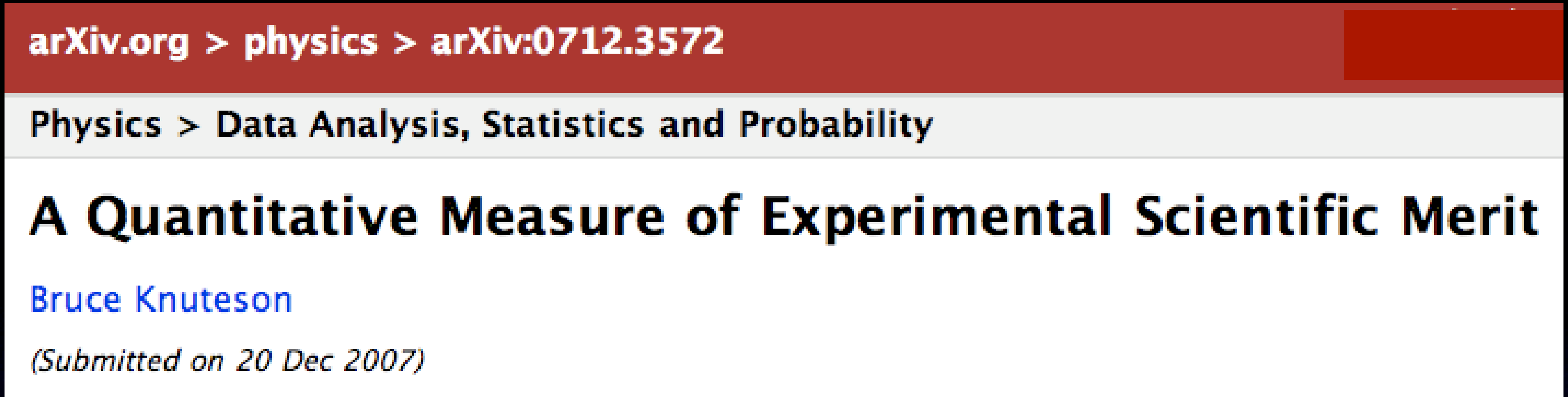
fraction of pseudo experiments in any final state as interesting as CDF data

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

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

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


CDF Run II (927 pb^{-1})
$l^+ l'^+ \not{p}_T$ jj
P = 0.011
Number of Events
CDF Run II data
MadEvent W(→μν) jjj : 23%
MadEvent W(→μν) jj : 21%
Pythia WZ : 14%
Herwig $t\bar{t}$: 9.9%
Other
SM= 0.71
d= 4
3.5
3
2.5
2
1.5
1
0.5
0
200
250
300
0
100
200
300
400
500
600
$\sum p_T$ (GeV)
168



arXiv.org > physics > arXiv:0712.3572

Physics > Data Analysis, Statistics and Probability

A Quantitative Measure of Experimental Scientific Merit

Bruce Knuteson

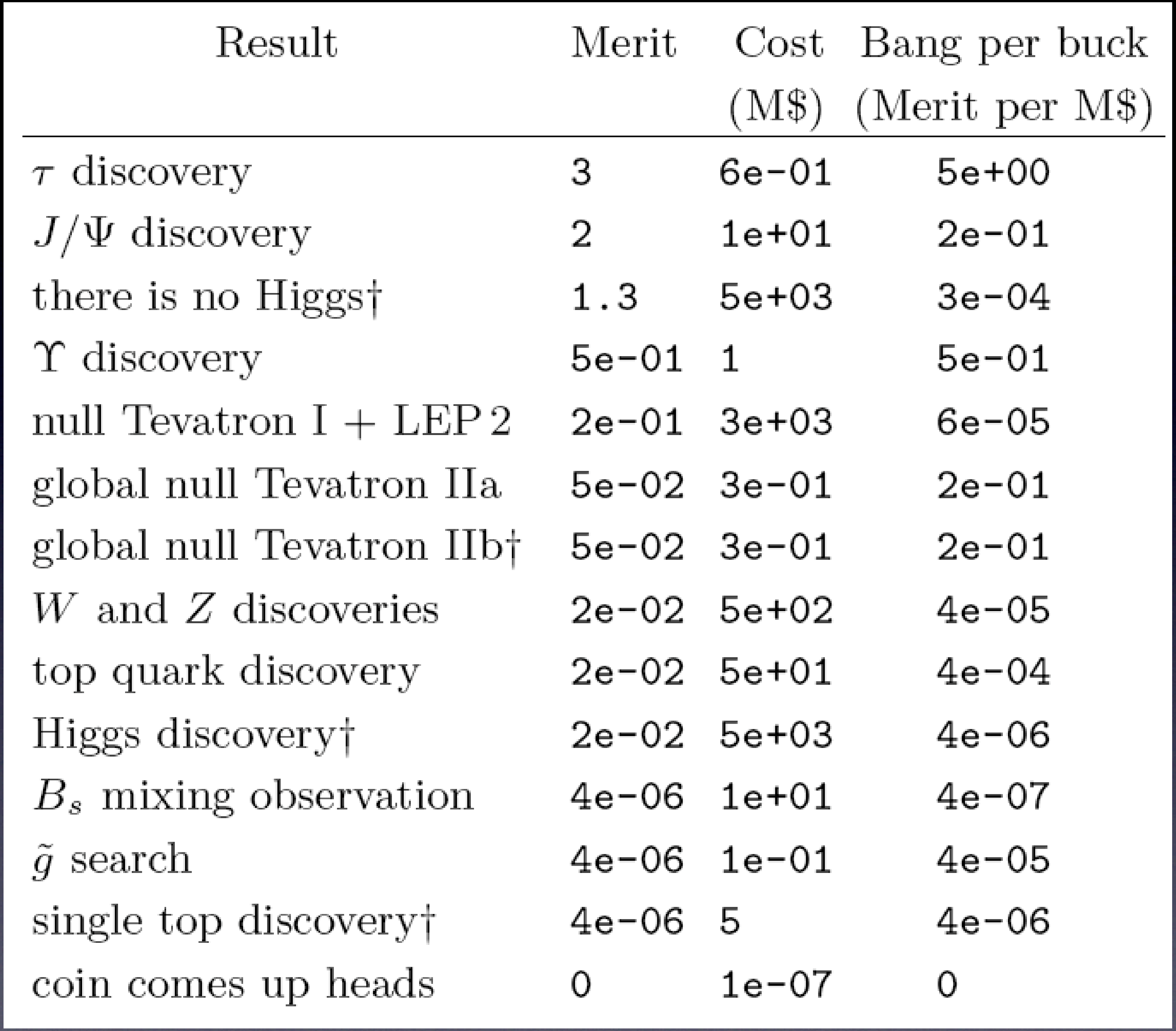
(Submitted on 20 Dec 2007)

Scientific Merit = how much you learn

= how surprised you are at the result

= surprisal

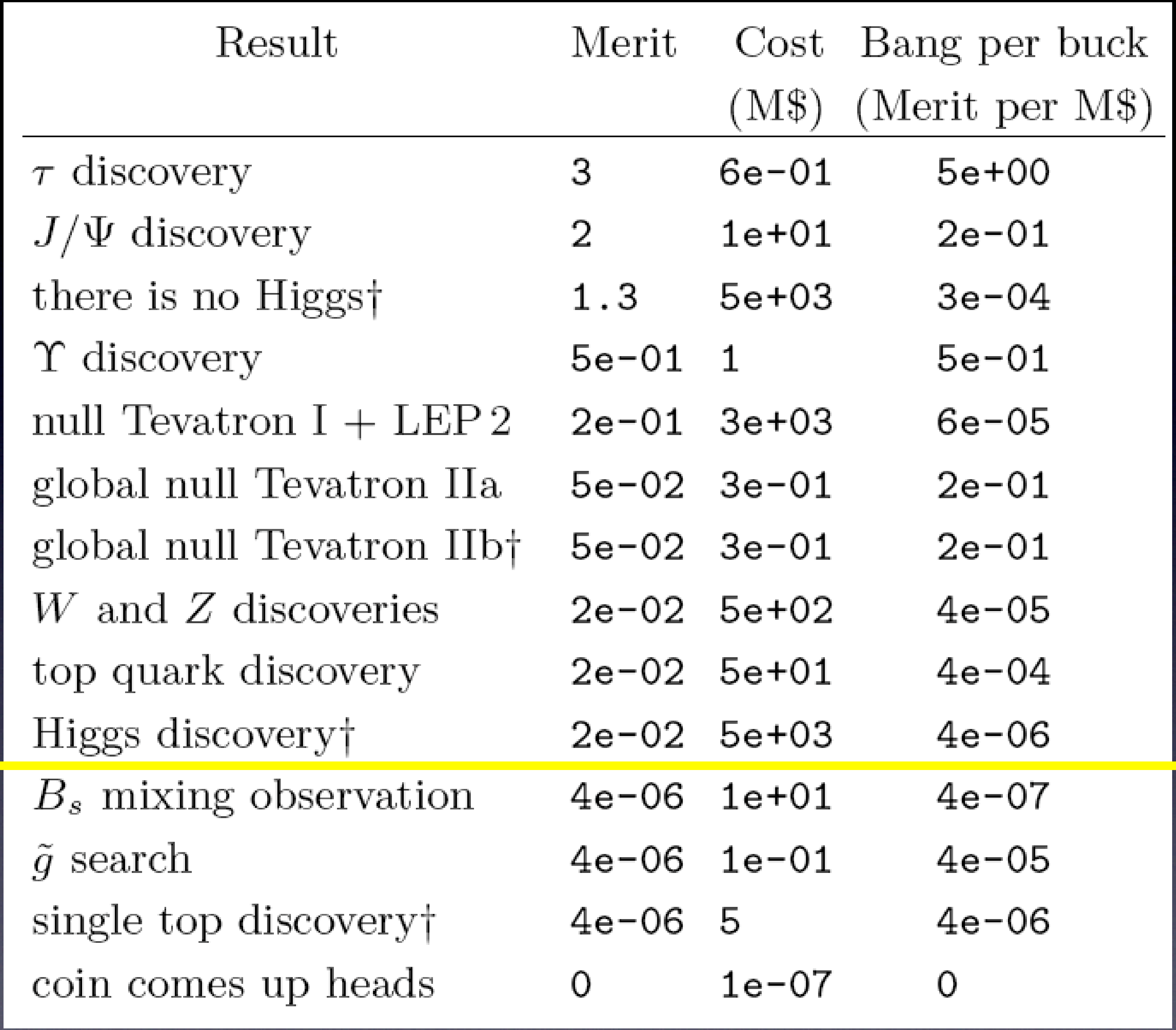
= $-\log_{10}(p)$



Result	Merit	Cost (M$)	Bang per buck (Merit per M$)
τ discovery	3	6e-01	5e+00
J/Ψ discovery	2	1e+01	2e-01
there is no Higgs†	1.3	5e+03	3e-04
Υ discovery	5e-01	1	5e-01
null Tevatron I + LEP 2	2e-01	3e+03	6e-05
global null Tevatron IIa	5e-02	3e-01	2e-01
global null Tevatron IIb†	5e-02	3e-01	2e-01
W and Z discoveries	2e-02	5e+02	4e-05
top quark discovery	2e-02	5e+01	4e-04
Higgs discovery†	2e-02	5e+03	4e-06
B_s mixing observation	4e-06	1e+01	4e-07
$\tilde{g}$ search	4e-06	1e-01	4e-05
single top discovery†	4e-06	5	4e-06
coin comes up heads	0	1e-07	0

Table II, pg 8

† Hypothetical future result



Result	Merit	Cost (M$)	Bang per buck (Merit per M$)
τ discovery	3	6e-01	5e+00
J/Ψ discovery	2	1e+01	2e-01
there is no Higgs†	1.3	5e+03	3e-04
Υ discovery	5e-01	1	5e-01
null Tevatron I + LEP 2	2e-01	3e+03	6e-05
global null Tevatron IIa	5e-02	3e-01	2e-01
global null Tevatron IIb†	5e-02	3e-01	2e-01
W and Z discoveries	2e-02	5e+02	4e-05
top quark discovery	2e-02	5e+01	4e-04
Higgs discovery†	2e-02	5e+03	4e-06
B_s mixing observation	4e-06	1e+01	4e-07
$\tilde{g}$ search	4e-06	1e-01	4e-05
single top discovery†	4e-06	5	4e-06
coin comes up heads	0	1e-07	0

Nobel Prize contenders

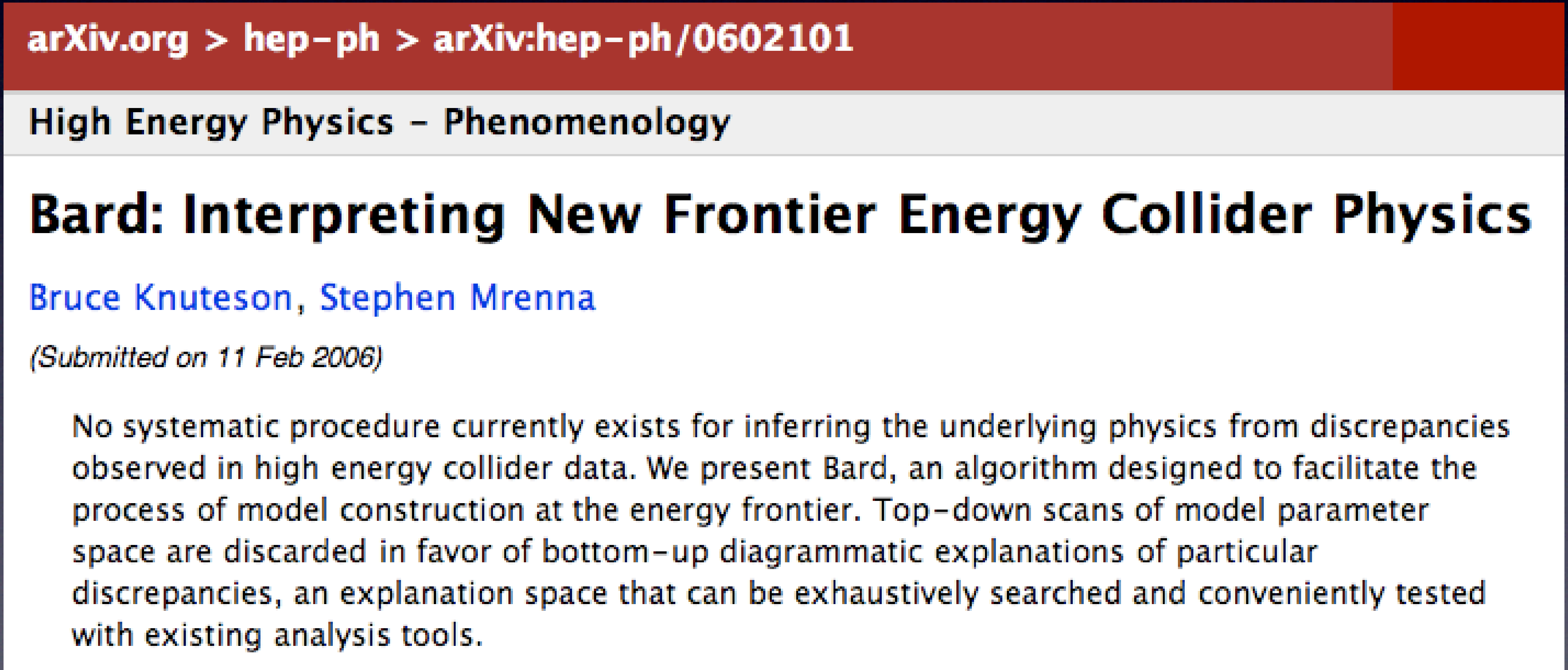
Table II, pg 8

† Hypothetical future result

Bard

hep-ph/0602101

Knuteson, Mrenna



arXiv.org > hep-ph > arXiv:hep-ph/0602101

High Energy Physics - Phenomenology

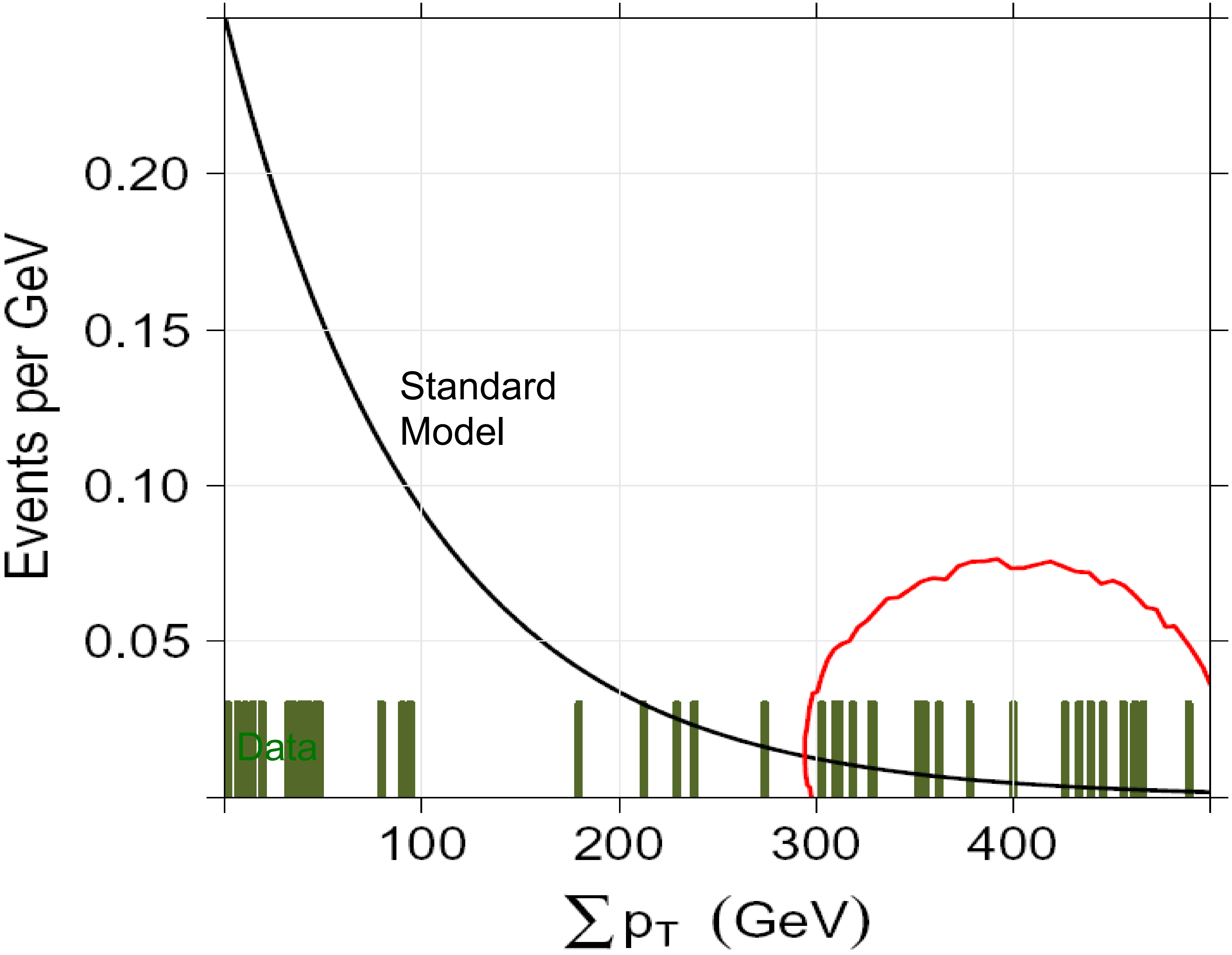
Bard: Interpreting New Frontier Energy Collider Physics

Bruce Knuteson, Stephen Mrenna

(Submitted on 11 Feb 2006)

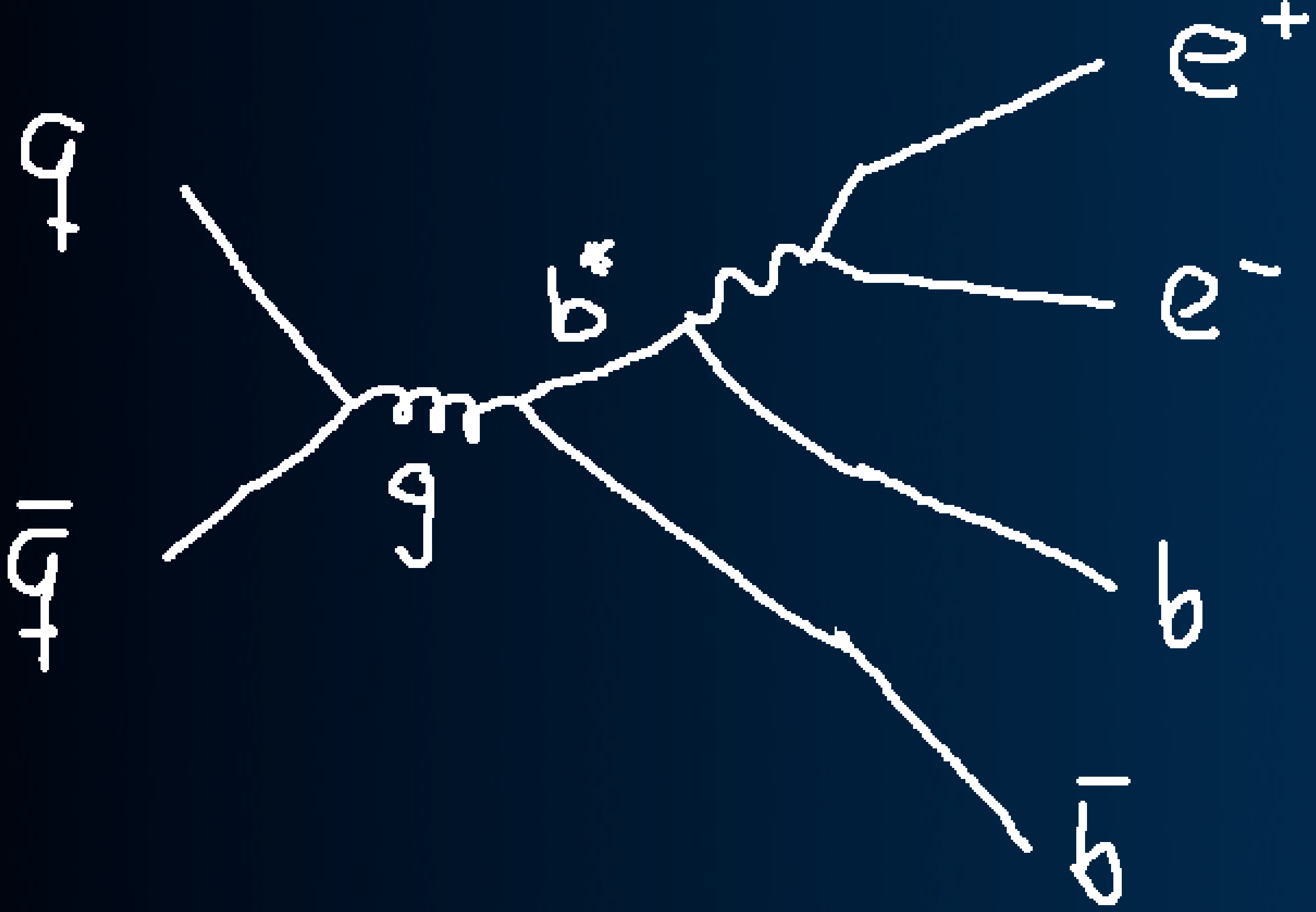
No systematic procedure currently exists for inferring the underlying physics from discrepancies observed in high energy collider data. We present Bard, an algorithm designed to facilitate the process of model construction at the energy frontier. Top-down scans of model parameter space are discarded in favor of bottom-up diagrammatic explanations of particular discrepancies, an explanation space that can be exhaustively searched and conveniently tested with existing analysis tools.

$e^+ e^- b\bar{b}$ Final State

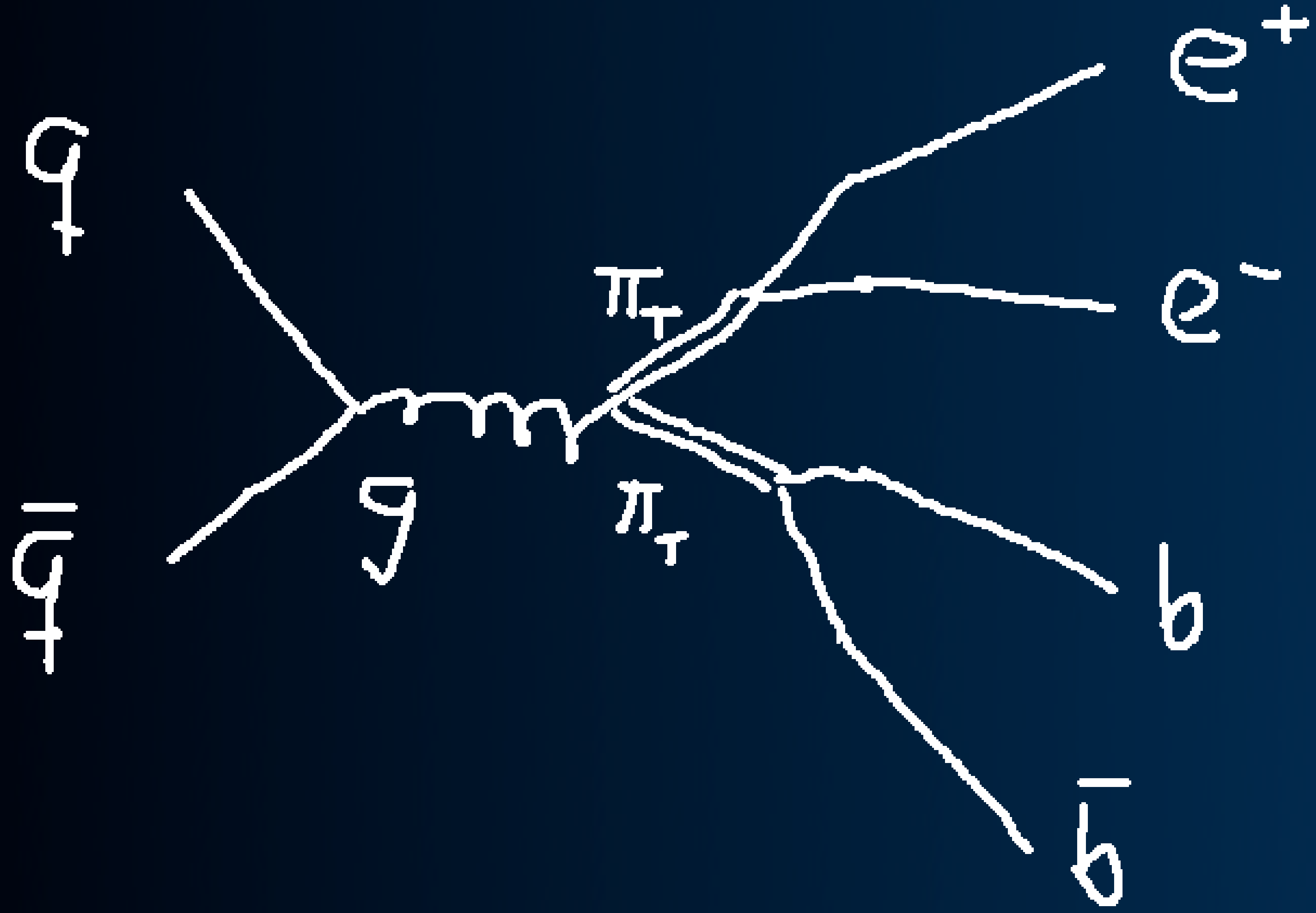


Bard

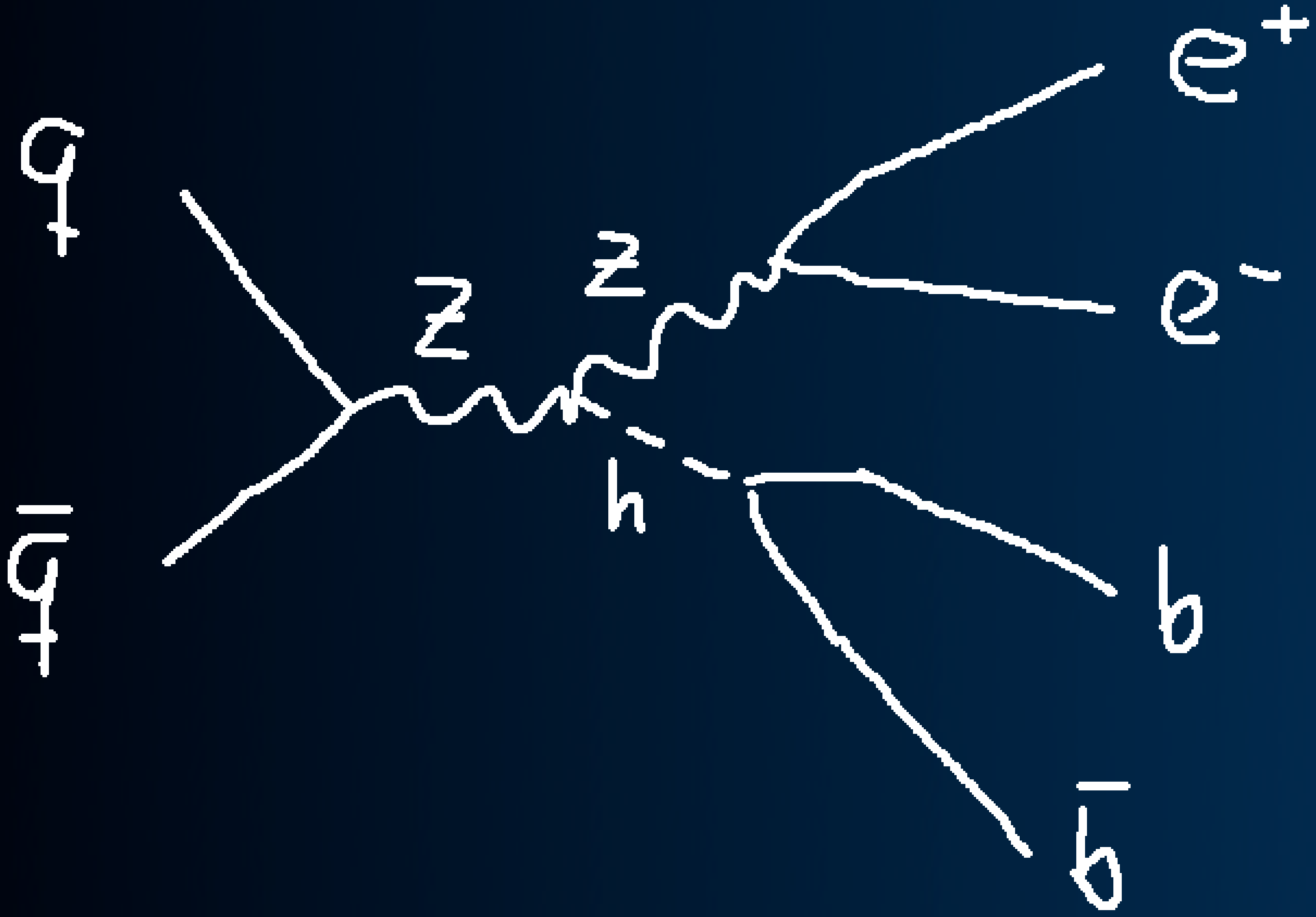
Bard



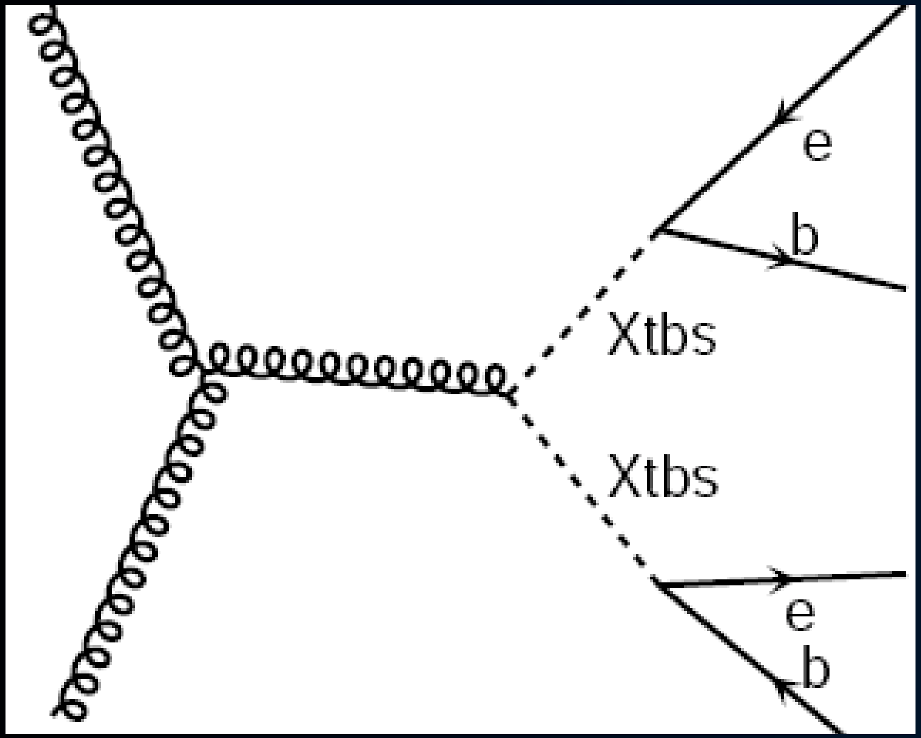
Bard

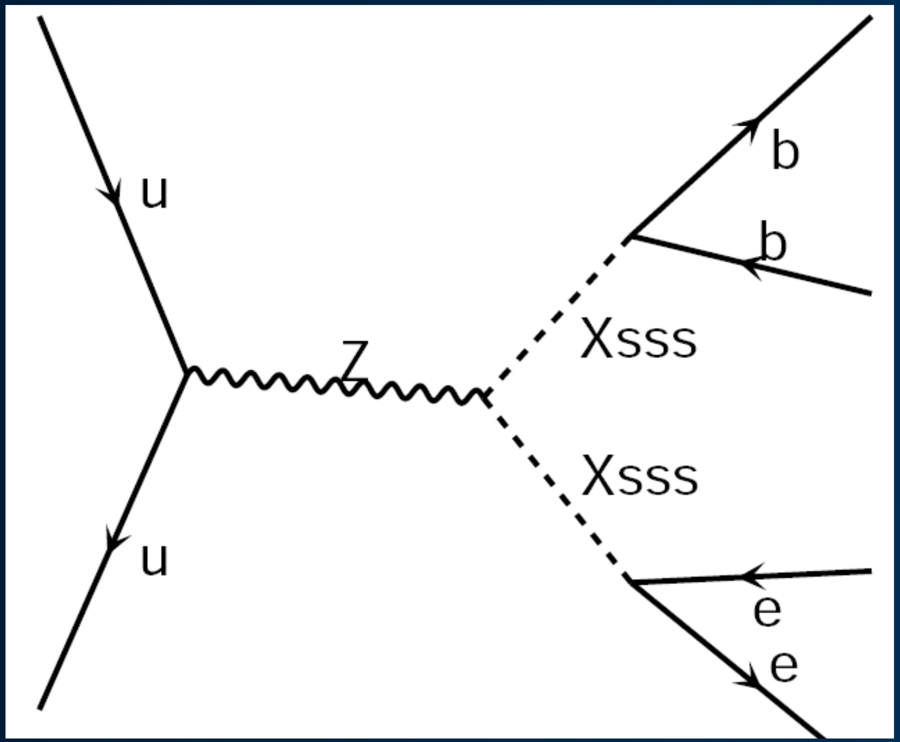


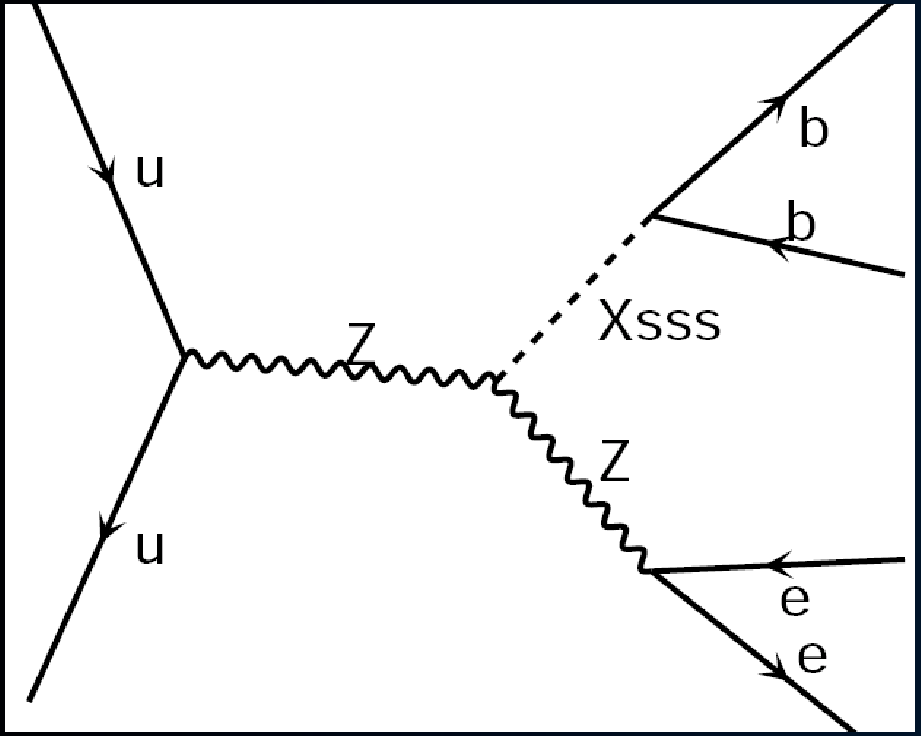
Bard

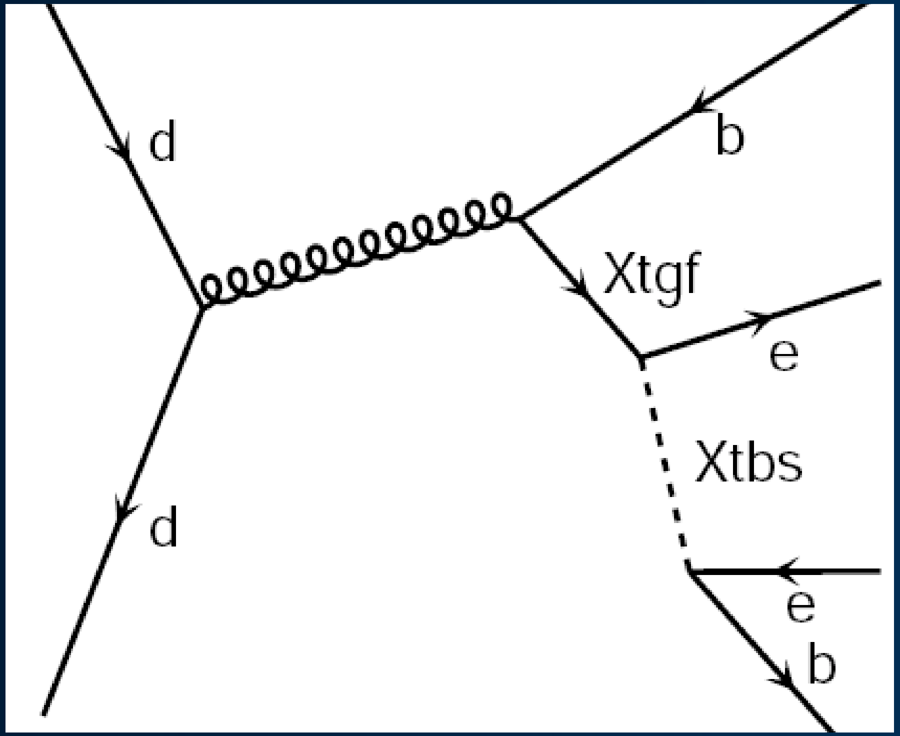


Bard stories



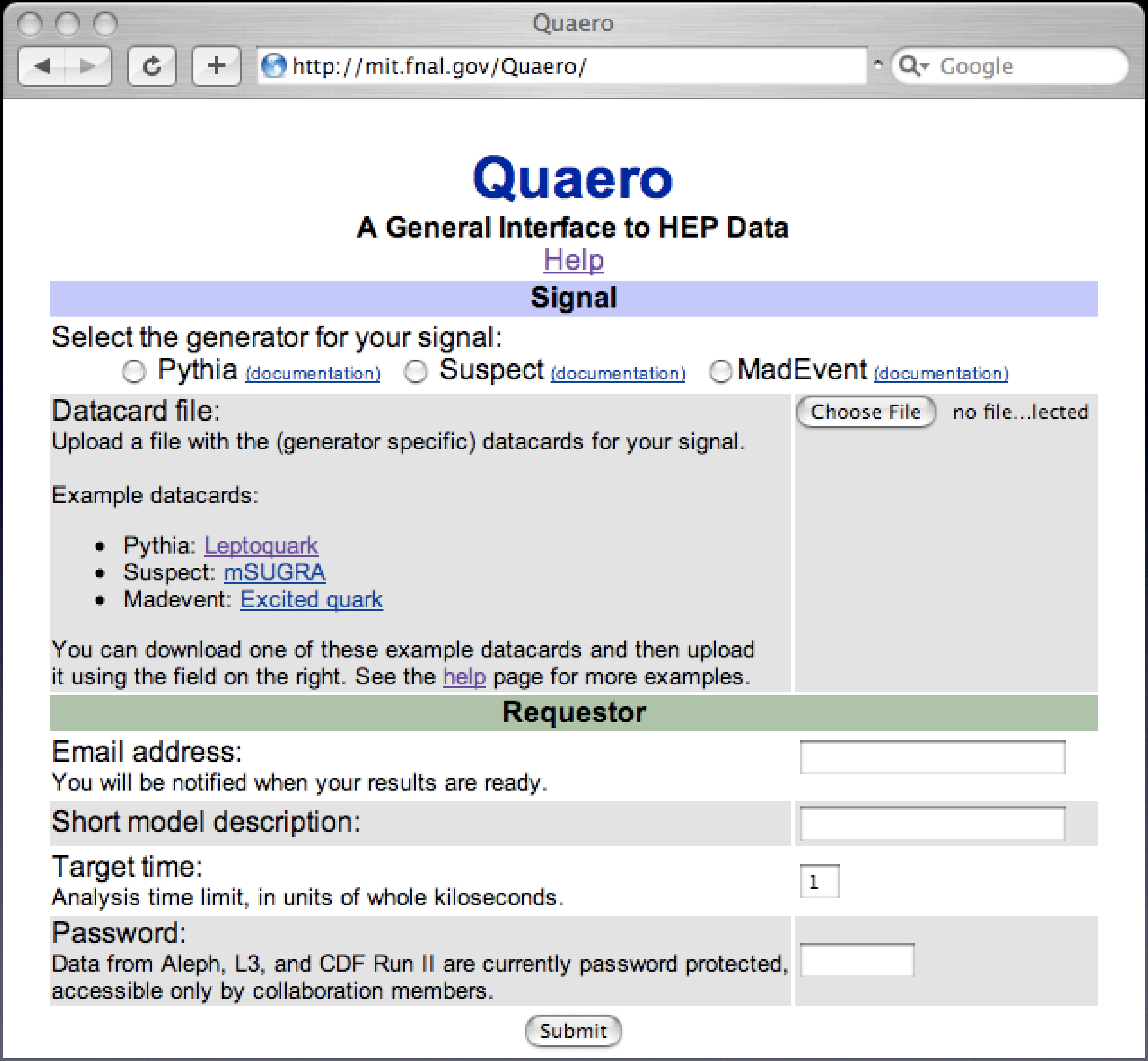






Quaero@D0RunI
DØ Collaboration
Phys.Rev.Lett.87:231801,2001

Quaero@H1
S. Caron, B. Knuteson
Eur.Phys.J.C53:167-175,2008



Quaero

A General Interface to HEP Data

Help

Signal

Select the generator for your signal:

○ Pythia (documentation) ○ Suspect (documentation) ○ MadEvent (documentation)

Datacard file: Upload a file with the (generator specific) datacards for your signal. Example datacards: • Pythia: Leptoquark • Suspect: mSUGRA • Madevent: Excited quark You can download one of these example datacards and then upload it using the field on the right. See the help page for more examples.	Choose File no file...lected

Requestor

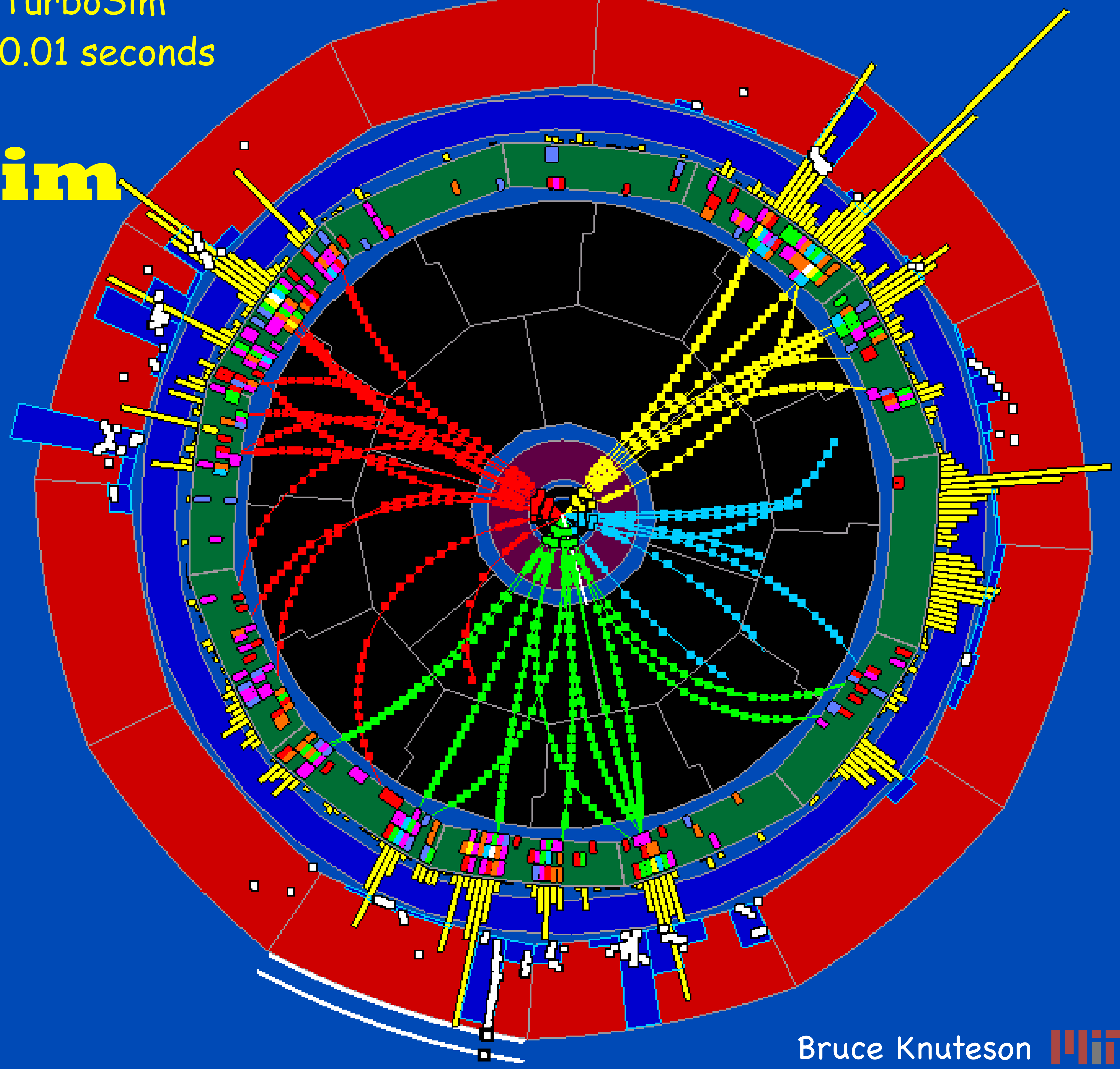
Email address: You will be notified when your results are ready.	
Short model description:	
Target time: Analysis time limit, in units of whole kiloseconds.	1
Password: Data from Aleph, L3, and CDF Run II are currently password protected, accessible only by collaboration members.	

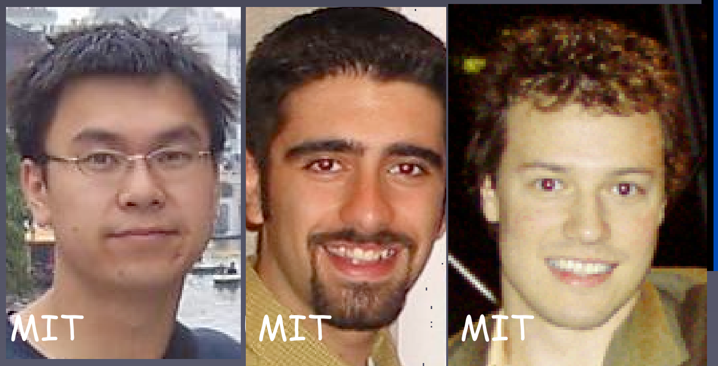
Submit

Full simulation	TurboSim
100 seconds	0.01 seconds

TurboSim

A fast detector simulation that *tunes itself* to any experiment's detailed detector simulation





If a core group of 4 people pursue Vista, it is an endgame

If a core group of 24 people pursue Vista, it is an opening gambit

Summary

Global Analysis of High-p_T Data

The problem

The solution

- Vista
- Sleuth
- Surprise!
- Bard
- Quaero
- TurboSim