Confusions in Cascades – Disentangling New Physics in LHC cascades

Jürgen Reuter

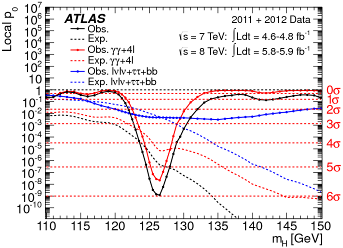
DESY Hamburg

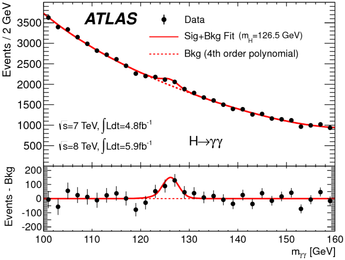
JRR/Wiesler, 1212.5559 [hep-ph], EPJC 73 (2013) 2355; Pietsch/JRR/Sakurai/Wiesler, JHEP 1207 (2012) 148; JRR/Wiesler, PRD84 (2011) 015012; Hagiwara/Kilian/Krauss/Ohl/Plehn/Rainwater/JRR/Schumann, PRD73 (2006) 055005

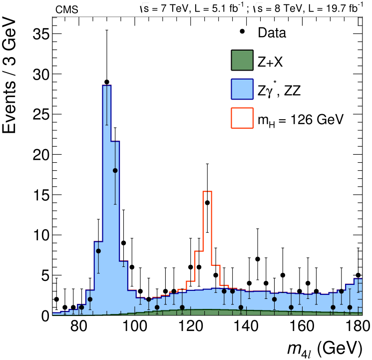
Seminar, Universität Wien, Wien, May 24th, 2016

Standard Model Triumph:

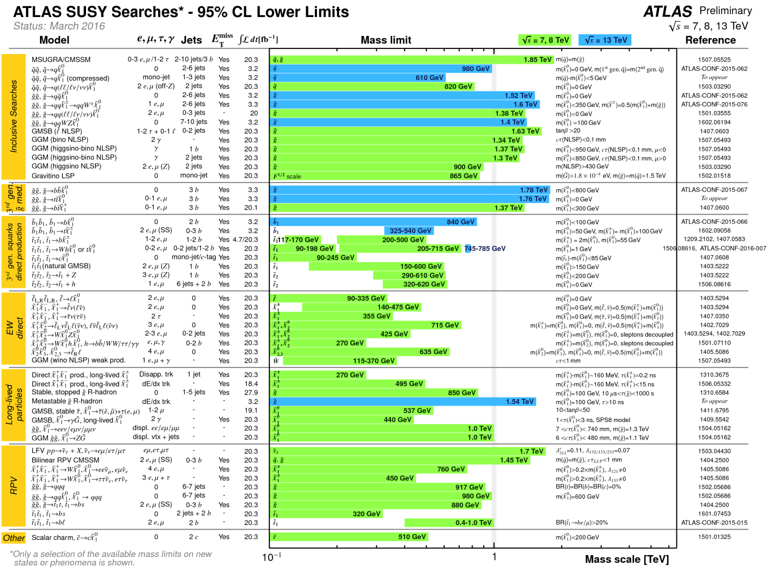
- 2012: Discovery of a Higgs boson







... and what now?



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: March 2016

ATLAS Preliminary

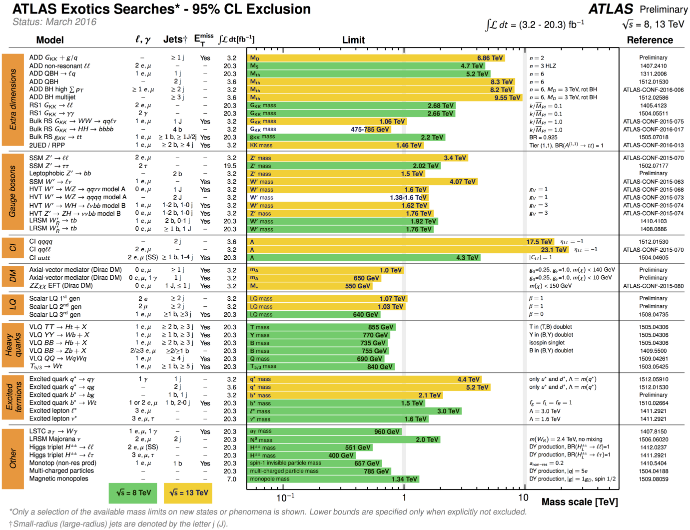
$\sqrt{s}$ = 7, 8, 13 TeV

🟩 $\sqrt{s}$ = 7, 8 TeV 🟦 $\sqrt{s}$ = 13 TeV

	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	🟩 $\tilde{q},\tilde{g}$ 1.85 TeV	$m(\tilde{q})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$	0	2-6 jets	Yes	3.2	🟦 $\tilde{q}$ 980 GeV	$m(\tilde{\chi}^0_1)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	ATLAS-CONF-2015-062
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$ (compressed)	mono-jet	1-3 jets	Yes	3.2	🟦 $\tilde{q}$ 610 GeV	$m(\tilde{q})$-$m(\tilde{\chi}^0_1)$<5 GeV	*To appear*
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}^0_1$	2 e,μ (off-Z)	2 jets	Yes	20.3	🟩 $\tilde{q}$ 820 GeV	$m(\tilde{\chi}^0_1)$=0 GeV	1503.03290
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0	2-6 jets	Yes	3.2	🟦 $\tilde{g}$ 1.52 TeV	$m(\tilde{\chi}^0_1)$=0 GeV	ATLAS-CONF-2015-062
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^{\pm}_1\to qqW^{\pm}\tilde{\chi}^0_1$	1 e,μ	2-6 jets	Yes	3.3	🟦 $\tilde{g}$ 1.6 TeV	$m(\tilde{\chi}^0_1)$<350 GeV, $m(\tilde{\chi}^{\pm})$=0.5($m(\tilde{\chi}^0_1)$+$m(\tilde{g})$)	ATLAS-CONF-2015-076
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}^0_1$	2 e,μ	0-3 jets	-	20	🟩 $\tilde{g}$ 1.38 TeV	$m(\tilde{\chi}^0_1)$=0 GeV	1501.03555
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqWZ\tilde{\chi}^0_1$	0	7-10 jets	Yes	3.2	🟦 $\tilde{g}$ 1.4 TeV	$m(\tilde{\chi}^0_1)$ =100 GeV	1602.06194
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	🟩 $\tilde{g}$ 1.63 TeV	tanβ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	🟩 $\tilde{g}$ 1.34 TeV	$c\tau$(NLSP)<0.1 mm	1507.05493
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	🟩 $\tilde{g}$ 1.37 TeV	$m(\tilde{\chi}^0_1)$<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	🟩 $\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}^0_1)$<850 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	1507.05493
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	🟩 $\tilde{g}$ 900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	🟩 $F^{1/2}$ scale 865 GeV	$m(\tilde{G})>1.8\times10^{-4}$ eV, $m(\tilde{g})=m(\tilde{q})$=1.5 TeV	1502.01518
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{b}\tilde{\chi}^0_1$	0	3 b	Yes	3.3	🟦 $\tilde{g}$ 1.78 TeV	$m(\tilde{\chi}^0_1)$<800 GeV	ATLAS-CONF-2015-067
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	Yes	3.3	🟦 $\tilde{g}$ 1.76 TeV	$m(\tilde{\chi}^0_1)$=0 GeV	*To appear*
	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{t}\tilde{\chi}^+_1$	0-1 e,μ	3 b	Yes	20.1	🟩 $\tilde{g}$ 1.37 TeV	$m(\tilde{\chi}^0_1)$<300 GeV	1407.0600
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}^0_1$	0	2 b	Yes	3.2	🟦 $\tilde{b}_1$ 840 GeV	$m(\tilde{\chi}^0_1)$<100 GeV	ATLAS-CONF-2015-066
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}^{\pm}_1$	2 e,μ (SS)	0-3 b	Yes	3.2	🟦 $\tilde{b}_1$ 325-540 GeV	$m(\tilde{\chi}^0_1)$=50 GeV, $m(\tilde{\chi}^{\pm}_1)$= $m(\tilde{\chi}^0_1)$+100 GeV	1602.09058
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}^{\pm}_1$	1-2 e,μ	1-2 b	Yes	4.7/20.3	🟩 $\tilde{t}_1$ 117-170 GeV 🟩 200-500 GeV	$m(\tilde{\chi}^{\pm}_1)$ = 2$m(\tilde{\chi}^0_1)$, $m(\tilde{\chi}^0_1)$=55 GeV	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}^0_1$ or $t\tilde{\chi}^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3	🟩 $\tilde{t}_1$ 90-198 GeV 🟩 205-715 GeV 🟦 745-785 GeV	$m(\tilde{\chi}^0_1)$=1 GeV	1506.08616, ATLAS-CONF-2016-007
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}^0_1$	0	mono-jet/c-tag	Yes	20.3	🟩 $\tilde{t}_1$ 90-245 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}^0_1)$<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	🟩 $\tilde{t}_1$ 150-600 GeV	$m(\tilde{\chi}^0_1)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.3	🟩 $\tilde{t}_2$ 290-610 GeV	$m(\tilde{\chi}^0_1)$<200 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+h$	1 e,μ	6 jets + 2 b	Yes	20.3	🟩 $\tilde{t}_2$ 320-620 GeV	$m(\tilde{\chi}^0_1)$=0 GeV	1506.08616
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0	Yes	20.3	🟩 $\tilde{\ell}$ 90-335 GeV	$m(\tilde{\chi}^0_1)$=0 GeV	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1$ 140-475 GeV	$m(\tilde{\chi}^0_1)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}^{\pm}_1)$+$m(\tilde{\chi}^0_1)$)	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1$ 355 GeV	$m(\tilde{\chi}^0_1)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}^{\pm}_1)$+$m(\tilde{\chi}^0_1)$)	1407.0350
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 715 GeV	$m(\tilde{\chi}^{\pm}_1)$=$m(\tilde{\chi}^0_2)$, $m(\tilde{\chi}^0_1)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}^{\pm}_1)$+$m(\tilde{\chi}^0_1)$)	1402.7029
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1Z\tilde{\chi}^0_1$	2-3 e,μ	0-2 jets	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 425 GeV	$m(\tilde{\chi}^{\pm}_1)$=$m(\tilde{\chi}^0_2)$, $m(\tilde{\chi}^0_1)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1h\tilde{\chi}^0_1$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 270 GeV	$m(\tilde{\chi}^{\pm}_1)$=$m(\tilde{\chi}^0_2)$, $m(\tilde{\chi}^0_1)$=0, sleptons decoupled	1501.07110
	$\tilde{\chi}^0_2\tilde{\chi}^0_3$, $\tilde{\chi}^0_{2,3}\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	🟩 $\tilde{\chi}^0_{2,3}$ 635 GeV	$m(\tilde{\chi}^0_2)$=$m(\tilde{\chi}^0_3)$, $m(\tilde{\chi}^0_1)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}^0_2)$+$m(\tilde{\chi}^0_1)$)	1405.5086
	GGM (wino NLSP) weak prod.	1 $e,\mu+\gamma$	-	Yes	20.3	🟩 $\tilde{W}$ 115-370 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	Disapp. trk	1 jet	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1$ 270 GeV	$m(\tilde{\chi}^{\pm}_1)$-$m(\tilde{\chi}^0_1)$~160 MeV, $\tau(\tilde{\chi}^{\pm}_1)$=0.2 ns	1310.3675
	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	dE/dx trk	-	Yes	18.4	🟩 $\tilde{\chi}^{\pm}_1$ 495 GeV	$m(\tilde{\chi}^{\pm}_1)$-$m(\tilde{\chi}^0_1)$~160 MeV, $\tau(\tilde{\chi}^{\pm}_1)$<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	🟩 $\tilde{g}$ 850 GeV	$m(\tilde{\chi}^0_1)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	1310.6584
	Metastable $\tilde{g}$ R-hadron	dE/dx trk	-	-	3.2	🟦 $\tilde{g}$ 1.54 TeV	$m(\tilde{\chi}^0_1)$=100 GeV, τ>10 ns	*To appear*
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}^0_1\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	🟩 $\tilde{\chi}^0_1$ 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}^0_1\to\gamma\tilde{G}$, long-lived $\tilde{\chi}^0_1$	2 γ	-	Yes	20.3	🟩 $\tilde{\chi}^0_1$ 440 GeV	1<$\tau(\tilde{\chi}^0_1)$<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	🟩 $\tilde{\chi}^0_1$ 1.0 TeV	7 <$c\tau(\tilde{\chi}^0_1)$< 740 mm, $m(\tilde{g})$=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	🟩 $\tilde{\chi}^0_1$ 1.0 TeV	6 <$c\tau(\tilde{\chi}^0_1)$< 480 mm, $m(\tilde{g})$=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	20.3	🟩 $\tilde{\nu}_\tau$ 1.7 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1503.04430
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	🟩 $\tilde{q},\tilde{g}$ 1.45 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1$ 760 GeV	$m(\tilde{\chi}^0_1)$>0.2×$m(\tilde{\chi}^{\pm}_1)$, $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.3	🟩 $\tilde{\chi}^{\pm}_1$ 450 GeV	$m(\tilde{\chi}^0_1)$>0.2×$m(\tilde{\chi}^{\pm}_1)$, $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqq$	0	6-7 jets	-	20.3	🟩 $\tilde{g}$ 917 GeV	BR(t)=BR(b)=BR(c)=0%	1502.05686
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to qqq$	0	6-7 jets	-	20.3	🟩 $\tilde{g}$ 980 GeV	$m(\tilde{\chi}^0_1)$=600 GeV	1502.05686
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	🟩 $\tilde{g}$ 880 GeV		1404.2500
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	🟩 $\tilde{t}_1$ 320 GeV		1601.07453
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\ell$	2 e,μ	2 b	-	20.3	🟩 $\tilde{t}_1$ 0.4-1.0 TeV	BR($\tilde{t}_1\to be/\mu$)>20%	ATLAS-CONF-2015-015
Other	Scalar charm, $\tilde{c}\to c\tilde{\chi}^0_1$	0	2 c	Yes	20.3	🟩 $\tilde{c}$ 510 GeV	$m(\tilde{\chi}^0_1)$<200 GeV	1501.01325

*Only a selection of the available mass limits on new states or phenomena is shown.

... and what now?



ATLAS Exotics Searches* - 95% CL Exclusion

Status: March 2016

ATLAS Preliminary

$\int\mathcal{L}\,dt$ = (3.2 - 20.3) fb^{-1}

$\sqrt{s}$ = 8, 13 TeV

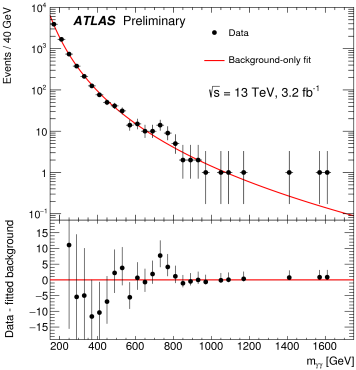
	Model	ℓ, γ	Jets†	E_T^{miss}	$\int\mathcal{L}\,dt[\text{fb}^{-1}]$	Limit			Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	≥ 1 j	Yes	3.2	🟨 M_D	6.86 TeV	$n = 2$	Preliminary
	ADD non-resonant $\ell\ell$	2 e, μ	–	–	20.3	🟩 M_S	4.7 TeV	$n = 3$ HLZ	1407.2410
	ADD QBH $\to \ell q$	1 e, μ	1 j	–	20.3	🟩 M_{th}	5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	3.6	🟨 M_{th}	8.3 TeV	$n = 6$	1512.01530
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	3.2	🟨 M_{th}	8.2 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	ATLAS-CONF-2016-006
	ADD BH multijet	–	≥ 3 j	–	3.6	🟨 M_{th}	9.55 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1512.02586
	RS1 $G_{KK} \to \ell\ell$	2 e, μ	–	–	20.3	🟩 G_{KK} mass	2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \to \gamma\gamma$	2 γ	–	–	20.3	🟩 G_{KK} mass	2.66 TeV	$k/\overline{M}_{Pl} = 0.1$	1504.05511
	Bulk RS $G_{KK} \to WW \to qq\ell\nu$	1 e, μ	1 J	Yes	3.2	🟨 G_{KK} mass	1.06 TeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2015-075
	Bulk RS $G_{KK} \to HH \to bbbb$	–	4 b	–	3.2	🟨 G_{KK} mass	475-785 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-017
	Bulk RS $g_{KK} \to tt$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	20.3	🟩 g_{KK} mass	2.2 TeV	BR = 0.925	1505.07018
	2UED / RPP	1 e, μ	≥ 2 b, ≥ 4 j	Yes	3.2	🟨 KK mass	1.46 TeV	Tier (1,1), BR($A^{(1,1)} \to tt$) = 1	ATLAS-CONF-2016-013
Gauge bosons	SSM $Z' \to \ell\ell$	2 e, μ	–	–	3.2	🟨 Z' mass	3.4 TeV		ATLAS-CONF-2015-070
	SSM $Z' \to \tau\tau$	2 τ	–	–	19.5	🟩 Z' mass	2.02 TeV		1502.07177
	Leptophobic $Z' \to bb$	–	2 b	–	3.2	🟨 Z' mass	1.5 TeV		Preliminary
	SSM $W' \to \ell\nu$	1 e, μ	–	Yes	3.2	🟨 W' mass	4.07 TeV		ATLAS-CONF-2015-063
	HVT $W' \to WZ \to qq\nu\nu$ model A	0 e, μ	1 J	Yes	3.2	🟨 W' mass	1.6 TeV	$g_V = 1$	ATLAS-CONF-2015-068
	HVT $W' \to WZ \to qqqq$ model A	–	2 J	–	3.2	🟨 W' mass	1.38-1.6 TeV	$g_V = 1$	ATLAS-CONF-2015-073
	HVT $W' \to WH \to \ell\nu bb$ model B	1 e, μ	1-2 b, 1-0 j	Yes	3.2	🟨 W' mass	1.62 TeV	$g_V = 3$	ATLAS-CONF-2015-074
	HVT $Z' \to ZH \to \nu\nu bb$ model B	0 e, μ	1-2 b, 1-0 j	Yes	3.2	🟨 Z' mass	1.76 TeV	$g_V = 3$	ATLAS-CONF-2015-074
	LRSM $W'_R \to tb$	1 e, μ	2 b, 0-1 j	Yes	20.3	🟩 W' mass	1.92 TeV		1410.4103
	LRSM $W'_R \to tb$	0 e, μ	≥ 1 b, 1 J	–	20.3	🟩 W' mass	1.76 TeV		1408.0886
CI	CI $qqqq$	–	2 j	–	3.6	🟨 Λ	17.5 TeV	$\eta_{LL} = -1$	1512.01530
	CI $qq\ell\ell$	2 e, μ	–	–	3.2	🟨 Λ	23.1 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2015-070
	CI $uutt$	2 e, μ (SS)	≥ 1 b, 1-4 j	Yes	20.3	🟩 Λ	4.3 TeV	$\lvert C_{LL}\rvert = 1$	1504.04605
DM	Axial-vector mediator (Dirac DM)	0 e, μ	≥ 1 j	Yes	3.2	🟨 m_A	1.0 TeV	g_q=0.25, g_χ=1.0, $m(\chi) < 140$ GeV	Preliminary
	Axial-vector mediator (Dirac DM)	0 e, μ, 1 γ	1 j	Yes	3.2	🟨 m_A	650 GeV	g_q=0.25, g_χ=1.0, $m(\chi) < 10$ GeV	Preliminary
	$ZZ_{\chi\chi}$ EFT (Dirac DM)	0 e, μ	1 J, ≤ 1 j	Yes	3.2	🟨 M_*	550 GeV	$m(\chi) < 150$ GeV	ATLAS-CONF-2015-080
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	3.2	🟨 LQ mass	1.07 TeV	$\beta = 1$	Preliminary
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	3.2	🟨 LQ mass	1.03 TeV	$\beta = 1$	Preliminary
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	🟩 LQ mass	640 GeV	$\beta = 0$	1508.04735
Heavy quarks	VLQ $TT \to Ht + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	🟩 T mass	855 GeV	T in (T,B) doublet	1505.04306
	VLQ $YY \to Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	20.3	🟩 Y mass	770 GeV	Y in (B,Y) doublet	1505.04306
	VLQ $BB \to Hb + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	🟩 B mass	735 GeV	isospin singlet	1505.04306
	VLQ $BB \to Zb + X$	2/≥3 e, μ	≥2/≥1 b	–	20.3	🟩 B mass	755 GeV	B in (B,Y) doublet	1409.5500
	VLQ $QQ \to WqWq$	1 e, μ	≥ 4 j	Yes	20.3	🟩 Q mass	690 GeV		1509.04261
	$T_{5/3} \to Wt$	1 e, μ	≥ 1 b, ≥ 5 j	Yes	20.3	🟩 $T_{5/3}$ mass	840 GeV		1503.05425
Excited fermions	Excited quark $q^* \to q\gamma$	1 γ	1 j	–	3.2	🟨 q^* mass	4.4 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.05910
	Excited quark $q^* \to qg$	–	2 j	–	3.6	🟨 q^* mass	5.2 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.01530
	Excited quark $b^* \to bg$	–	1 b, 1 j	–	3.2	🟨 b^* mass	2.1 TeV		Preliminary
	Excited quark $b^* \to Wt$	1 or 2 e, μ	1 b, 2-0 j	Yes	20.3	🟩 b^* mass	1.5 TeV	$f_g = f_L = f_R = 1$	1510.02664
	Excited lepton ℓ^*	3 e, μ	–	–	20.3	🟩 ℓ^* mass	3.0 TeV	$\Lambda = 3.0$ TeV	1411.2921
	Excited lepton ν^*	3 e, μ, τ	–	–	20.3	🟩 ν^* mass	1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	LSTC $a_T \to W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	🟩 a_T mass	960 GeV		1407.8150
	LRSM Majorana ν	2 e, μ	2 j	–	20.3	🟩 N^0 mass	2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \to \ell\ell$	2 e, μ (SS)	–	–	20.3	🟩 $H^{\pm\pm}$ mass	551 GeV	DY production, BR($H_L^{\pm\pm} \to \ell\ell$)=1	1412.0237
	Higgs triplet $H^{\pm\pm} \to \ell\tau$	3 e, μ, τ	–	–	20.3	🟩 $H^{\pm\pm}$ mass	400 GeV	DY production, BR($H_L^{\pm\pm} \to \ell\tau$)=1	1411.2921
	Monotop (non-res prod)	1 e, μ	1 b	Yes	20.3	🟩 spin-1 invisible particle mass	657 GeV	$a_{\text{non-res}} = 0.2$	1410.5404
	Multi-charged particles	–	–	–	20.3	🟩 multi-charged particle mass	785 GeV	DY production, $\lvert q\rvert = 5e$	1504.04188
	Magnetic monopoles	–	–	–	7.0	🟩 monopole mass	1.34 TeV	DY production, $\lvert g\rvert = 1g_D$, spin 1/2	1509.08059

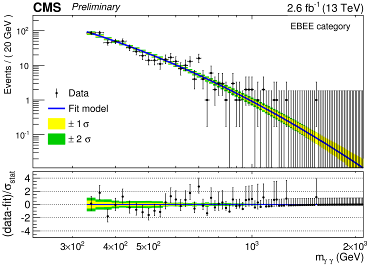
🟩 $\sqrt{s}$ = 8 TeV 🟨 $\sqrt{s}$ = 13 TeV

*Only a selection of the available mass limits on new states or phenomena is shown. Lower bounds are specified only when explicitly not excluded.

†Small-radius (large-radius) jets are denoted by the letter j (J).

... return of the diphotons ??





Electroweak vacuum stability / Hierarchy Problem

- Most recent analysis: Metastable vacuum with lifetime longer than the age of the universe Degrassi et al., arXiv:1205.6497

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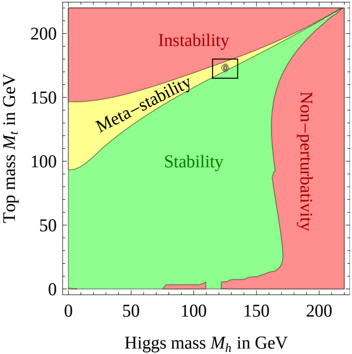

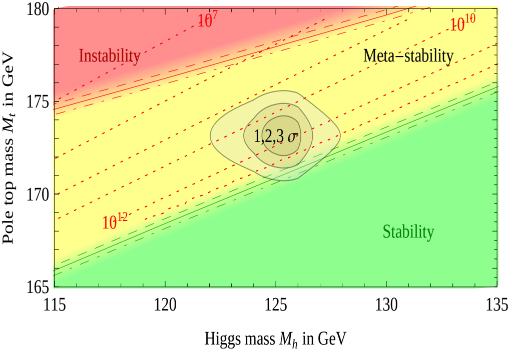

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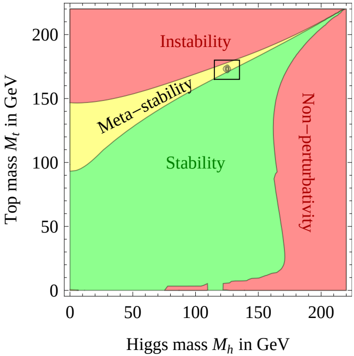
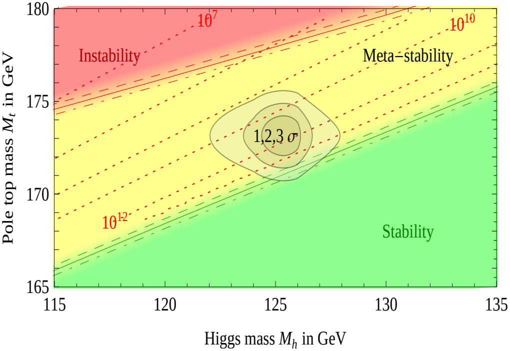


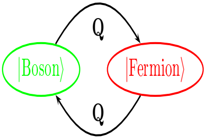


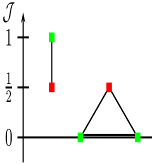
- What generated/stabilized the hierarchy?

Supersymmetry

Spin-Statistics: M_H stabilized to all orders

connects space-time & gauge symmetries





Partner particles shifted by half-integer in spin

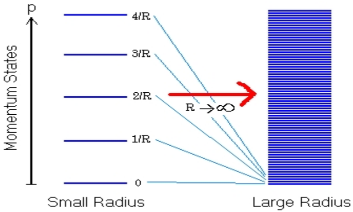
Grand Unification: weak interactions to very high scales

R-Parity: Dark Matter

XDim./Compositeness

Hierarchy problem solved by elimination of hierarchy

New gauge interaction / Higher-dim. space-time symmetry



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Possible strong interactions at TeV scale

$\mathbb{Z}_2/KK$-Parity: Dark Matter

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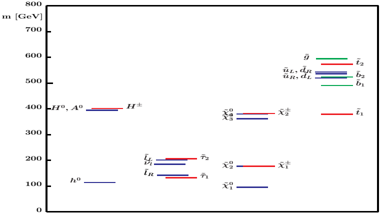

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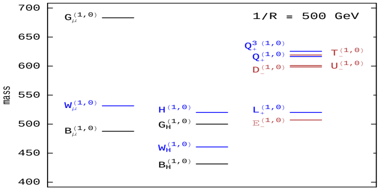

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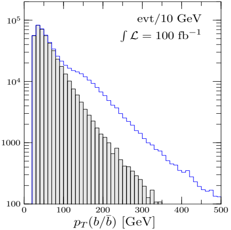
Search for New Particles



Decay products of heavy particles:

- high-p_T Jets
- many hard leptons

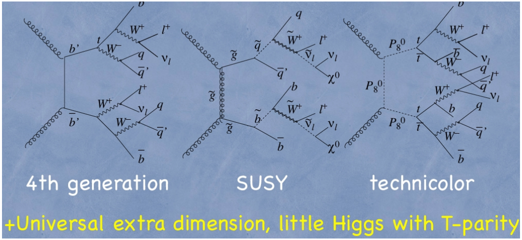
Production of colored particles

weakly interacting particles only in decays

Dark Matter $\Leftrightarrow$ discrete parity (R, T, KK)

- only pairs of new particles $\Rightarrow$ high energies, long decay chains
- Dark Matter $\Rightarrow$ large missing energy in detector ($\not{E}_T$)

Different Models/Decay Chains — same signatures



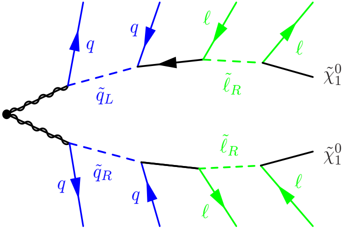
4th generation

SUSY

technicolor

+Universal extra dimension, little Higgs with T-parity

Search for New Particles



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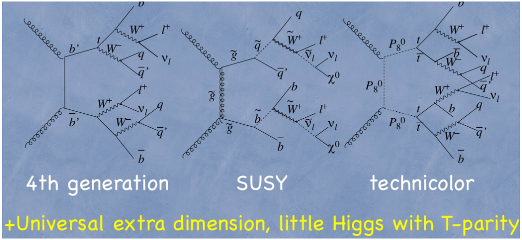

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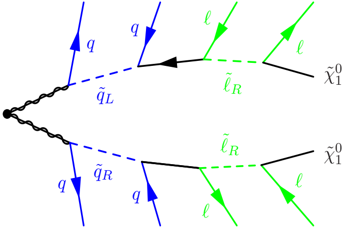

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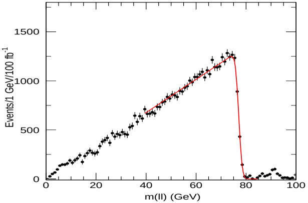
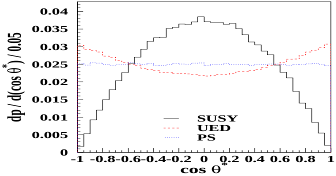
Mass of new particles: end points of decay spectra





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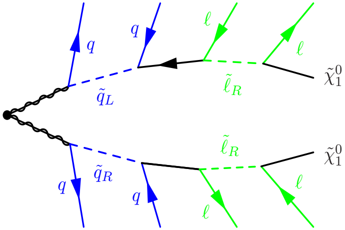

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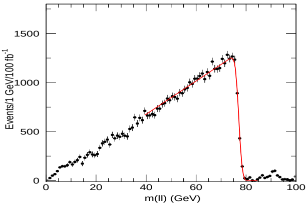
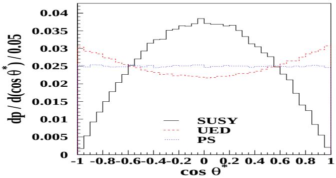
Spin of new particles: Spin of new particles: angular correlations, . . .





LHC Warm-Up: Sbottom Production

Hagiwara/…/JRR/…, PRD 73 (2006) 055005

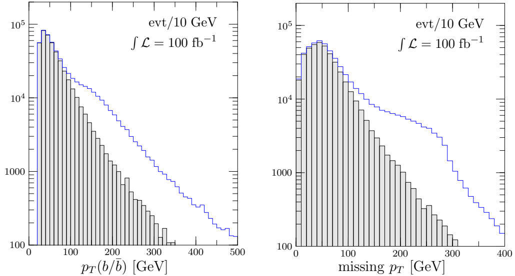
$\tilde{b}_1$ production with subsequent decay $\tilde{b}_1 \to \tilde{\chi}_1^0 b$

Process $A_1 A_2 \to P^{(*)} \to F_1 F_2$, 3 different steps:

Narrow Width (NWA) $\sigma(A_1 A_2 \to P) \times \mathrm{BR}(P \to F_1 F_2)$

Breit-Wigner $\sigma(A_1 A_2 \to P) \times \frac{M_P^2 \Gamma_P^2}{(s - M_P^2)^2 + \Gamma_P^2 M_P^2} \times \mathrm{BR}(P \to F_1 F_2)$

Full matrix element $\sigma(A_1 A_2 \to F_1 F_2)$



$pp \to b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0$

Main background:
$gg \to b\bar{b}\nu\bar{\nu}$

Signal jets harder

LHC Warm-Up: Sbottom Production

Hagiwara/.../JRR/..., PRD 73 (2006) 055005

$\boxed{\tilde{b}_1 \text{ production with subsequent decay } \tilde{b}_1 \to \tilde{\chi}^0_1 b}$

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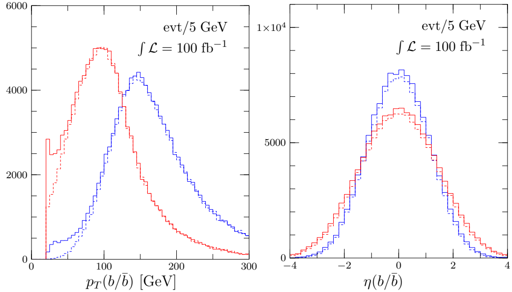


PS: Harder jet more central

Off-shell effects ($b\bar{b}Z^*$): only for low $p_{T,b}$ ⟶ cut out

Not generally guaranteed

ISR: Bottom Jet Radiation

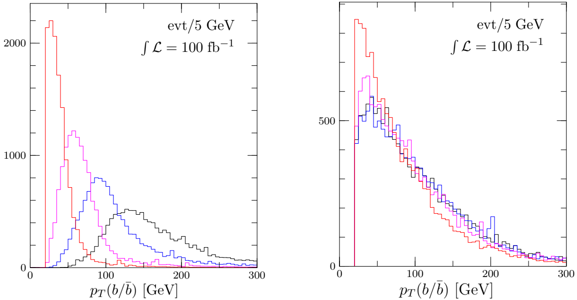
Hagiwara/. . . /JRR/. . . , PRD 73 (2006) 055005

$g \to b\bar{b}$-Splitting, b-ISR as combinatorial background

$pp \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 b\bar{b}b\bar{b}$: 32112 diagrams, 22 color flows, ~ 4000 PS channels

$\sigma(pp \to b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0) = 1177$ fb $\longrightarrow$ $\sigma(pp \to b\bar{b}b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0) = 130.7$ fb

Forward discrimination of ISR and decay-b jets difficult:



Only the most forward b jet is softer

ISR: Bottom Jet Radiation

Hagiwara/.../JRR/..., PRD 73 (2006) 055005

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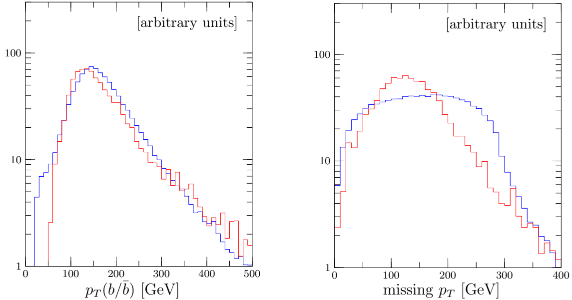
Only small differences in $p_{T,b}$, PDF: maximum at a smaller value



shifted to smaller $\not{p}_T$: light particles balance out the event

WHIZARD

Kilian/Ohl/JRR: DESY/Freiburg/Siegen/Würzburg, hep-ph/0102195, EPJC 71 (2011) 1742

- All simulations in this talk done with **WHIZARD**
- **Multi-Purpose event generator for collider physics**
  - Fast adaptive multi-channel Monte-Carlo integration
  - Very efficient phase space and event generation
  - Optimized/-al matrix elements
    uses the color flow formalism Kilian/Ohl/JRR/Speckner, JHEP 1210 (2012) 022
  - Recent version: 2.2.8 (22.11.2015) [2.3.0 will come 07/2016]
    `http://whizard.hepforge.org/`
  - Parton shower ($k^\perp$-ordered and analytic) Kilian/JRR/Schmidt/Wiesler, JHEP 1204 (2012) 013
  - NLO QCD for lepton and hadron collisions
  - 2.2 Features: ME/PS matching, cascades, top threshold matching
  - Upcoming: general Lorentz structures, UFO support etc.
- Interface to `FeynRules` & `SARAH` Christensen/Duhr/Fuks/JRR/Speckner, EPJC 72 (2012) 1990
- Versatile input language: SINDARIN

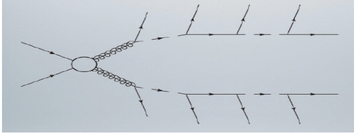
I: Off-Shell Effects

Confusions from Off-Shell Effects: Fat Gluinos

- SUSY: weakly coupled + discrete parity $\Longrightarrow$ Narrow resonances
- Exception: some Higgses ... and **Gluino**
- Width-to-mass ratio $\gamma := \Gamma/M \sim$ few to 15-20 %
  Theoretical upper limit $\gamma \sim 32\%$ (without invisible or exotic decays)
- Example realization: GMSB $\boxed{M_{\tilde{g}} \sim 2\,\text{TeV} \qquad \Gamma_{\tilde{g}} \sim 240\,\text{GeV}}$
- Plan: scan over "fat gluinos" in "full" simulation
- Comparison between SUSY vs. UED
- Generic scan over 5 values: $\gamma \in \{0.5\%, 2.5\%, 5\%, 10\%, 15\%\}$
- Look for impact on mass and spin observables

Gluinos beyond factorization

- Standard Gluino Cascade: $2 \to 10$ Numerically challenging (PS!!!)



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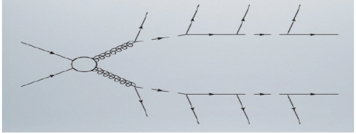
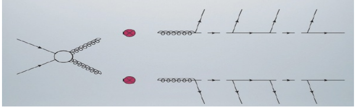


- Factorization in Narrow-Width-Approximation (NWA)



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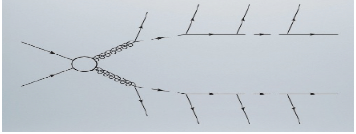

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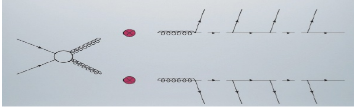
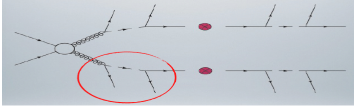


- Trade-off accuracy vs. speed



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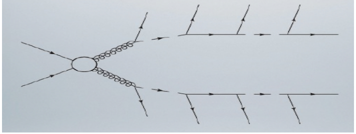

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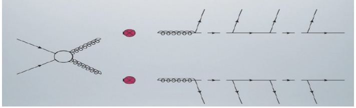

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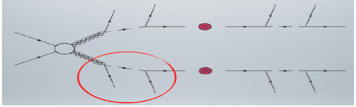


- Simulate production and first decay with full matrix elements
- Factorize additional decays with NWA

Simulation Setup

- Parton level studies with WHIZARD

  Kilian/Ohl/JRR, EPJC 71 (2011) 1742

- Investigation of ISR, combinatoris, detector effects later

  Pietsch/JRR/Sakurai/Wiesler, JHEP 1207 (2012) 148

- For each point (UED and SUSY) normalized sets (5k events)

  Corresponds roughly to event numbers for 300 fb^{-1}

  To study statistics vs. systematics some samples for 25k events

- pMSSM19 benchmark scenario

M_1	M_2	M_3	A_t	A_b	A_τ	μ	M_A	$m_{\tilde{l}_L}$	$m_{\tilde{\tau}_L}$
150	250	1200	4000	4000	0	1500	1500	1000	1000

$m_{\tilde{l}_R}$	$m_{\tilde{\tau}_R}$	$m_{\tilde{q}_L}$	$m_{\tilde{q}^3_L}$	$m_{\tilde{q}^u_R}$	$m_{\tilde{q}^d_R}$	$m_{\tilde{t}_R}$	$m_{\tilde{b}_R}$	$\tan\beta$	
200	1000	1000	1000	1000	1000	4000	1000	10	

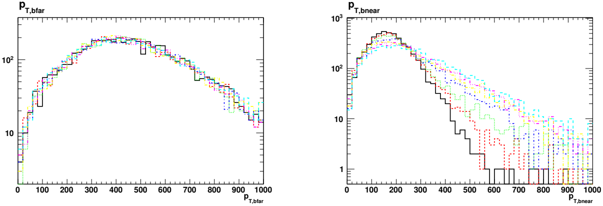
- … and similar datapoint for UED (for spin determination)

- Setup of (exclusive) decay chains

$$\begin{aligned} \tilde{g}[1] \quad & \to b\tilde{b}_i \to b\bar{b}\tilde{\chi}^0_2 \to b\bar{b}l^\pm\tilde{l}^\mp_R \to b\bar{b}l^\pm l^\mp\tilde{\chi}^0_1 \\ \tilde{g}[2] \quad & \to d\tilde{d}_L \to d\bar{d}\tilde{\chi}^0_1 \end{aligned}$$

Mass determination and "fat" gluinos

- Decay chain: $\tilde{g}[1] \to b\tilde{b}_i \to b\bar{b}\tilde{\chi}_2^0 \to b\bar{b}l^\pm\tilde{l}_R^\mp \to b\bar{b}l^\pm l^\mp\tilde{\chi}_1^0$
- Far b jet not affected, but the near one! black: 0.5%, red: 2.5%, green: 5%, blue: 10%, yellow: 15%



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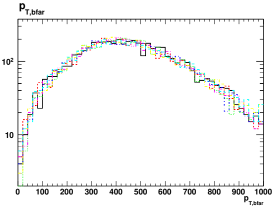
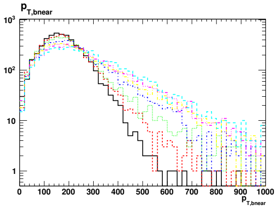
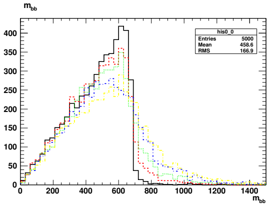
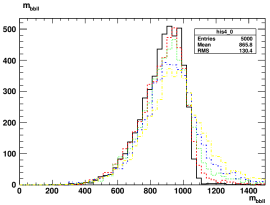




- Mass edges: . . . two b jets . . . or . . . two bs, two leptons

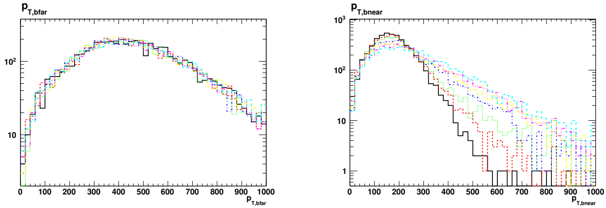
$$(m_{bb}^{max})^2 = \frac{(m_{\tilde{g}}^2 - m_{\tilde{b}}^2)(m_{\tilde{b}}^2 - m_{\tilde{\chi}_2}^2)}{m_{\tilde{b}}^2} = 680 \text{ GeV} \qquad (m_{bb\ell\ell}^{max})^2 = 1093 \text{ GeV}$$





Mass determination and "fat" gluinos

- Decay chain: $\tilde{g}[1] \to b\tilde{\bar{b}}_i \to b\bar{b}\tilde{\chi}_2^0 \to b\bar{b}l^\pm\tilde{l}_R^\mp \to b\bar{b}l^\pm l^\mp\tilde{\chi}_1^0$
- Far b jet not affected, but the near one! black: 0.5%, red: 2.5%, green: 5%, blue: 10%, yellow: 15%



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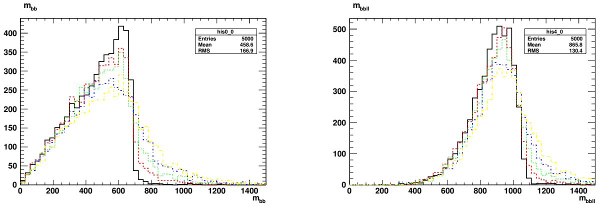

- ▶ **Uncertainties of several hundreds of GeV**

Numerical Endpoint Estimation: Edge-to-bump method

- Trying to find edges by fitting lines very human-biased and error-prone
- Idea: do a naive kink fit $\mathcal{O}(1000)$ times
- Edge-to-bump method Curtin, 2012

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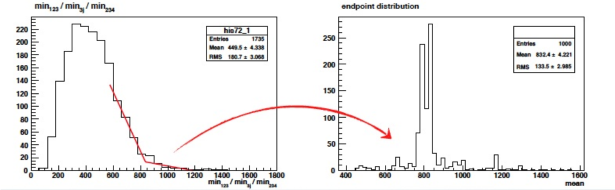

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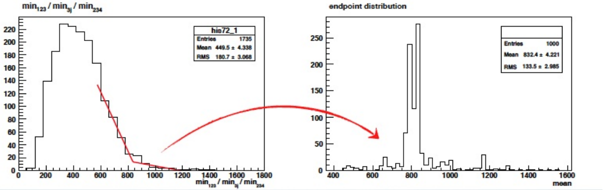
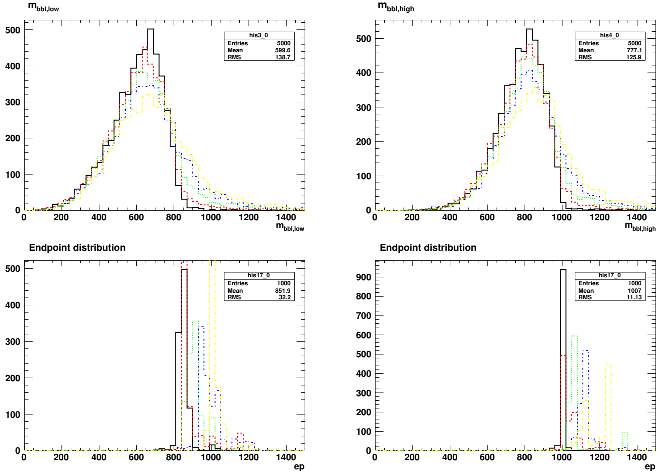


- Analyze resulting distribution of fit values
- Distribution of values measure/estimate for uncertainty

More Examples

- $m_{bb\ell}^{low}$, $m_{bb\ell}^{high}$: two endpoints in $m_{bb\ell}$



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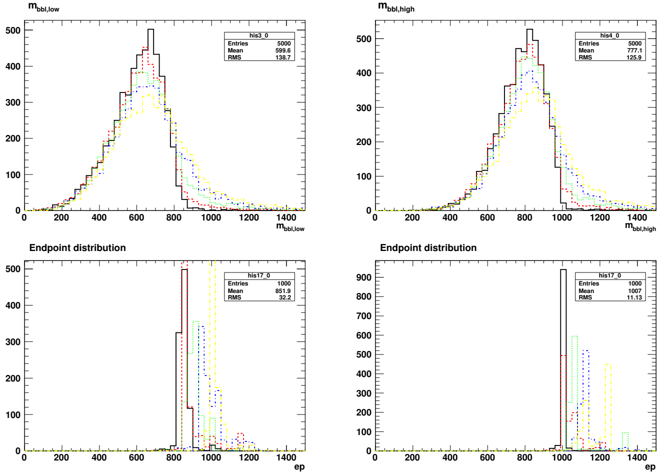

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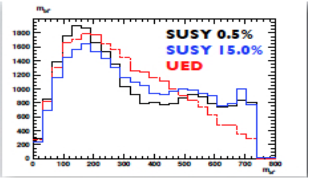
- Endpoints severely degraded (at parton level!!)

Spin Determination (I)

- **Method I**: Shape asymmetry of $m_{b\ell}$

$$\boxed{A^{\pm}[m_{b\ell}] = \frac{d\sigma/dm_{b\ell^+} - d\sigma/dm_{b\ell^-}}{d\sigma/dm_{b\ell^+} + d\sigma/dm_{b\ell^-}}}$$



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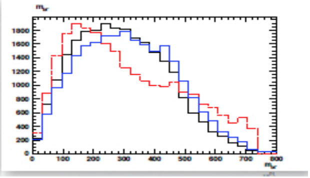

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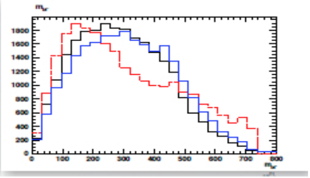

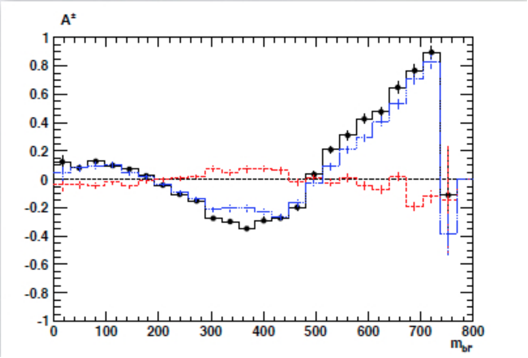

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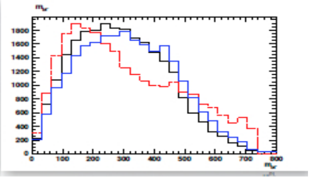

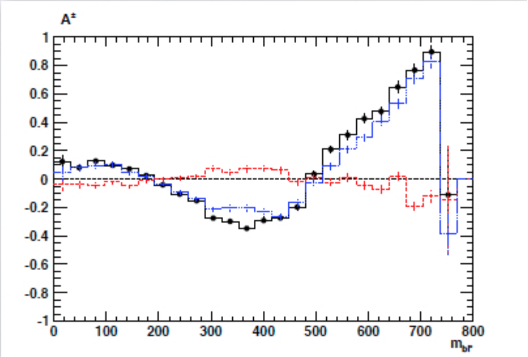

- **Shape asymmetry not affected by fat gluino!**

Spin Determination (II)

- **Method II**: Angular correlations and asymmetries

1. $$\boxed{\cos\theta^*_{jj} = \tanh\left(\frac{\Delta\eta_{jj}}{2}\right)}$$

Moortgat-Pick/Rolbiecki/Tattersall, 2011

2. $$\boxed{\Delta\phi_{bb} = |\phi(b_1) - \phi(b_2)|}$$

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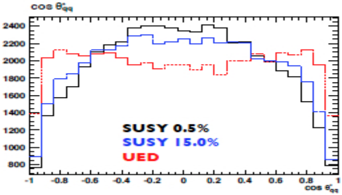

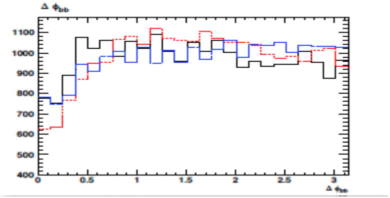

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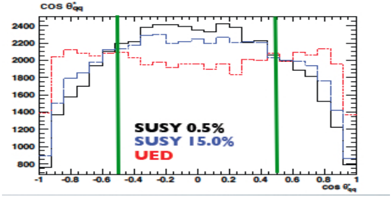

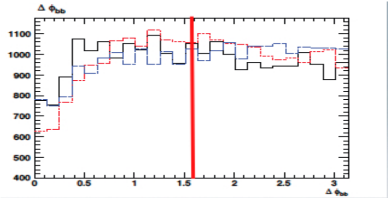

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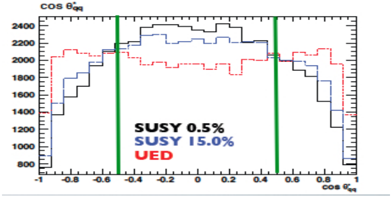

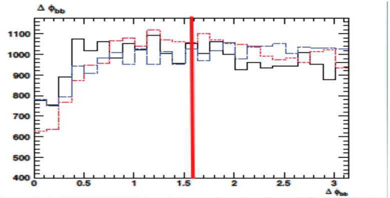

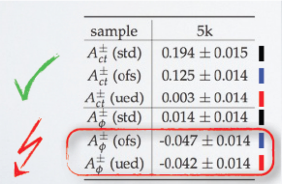

sample	5k	
$A^{\pm}_{ct}$ (std)	0.194 ± 0.015	■
$A^{\pm}_{ct}$ (ofs)	0.125 ± 0.014	🟦
$A^{\pm}_{ct}$ (ued)	0.003 ± 0.014	🟥
$A^{\pm}_{\phi}$ (std)	0.014 ± 0.014	■
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II. Combinatorics

Generic Backgrounds

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- Dijet itself suffers a lot from both backgrounds

- Motivation: Study fully inclusive dijet measurement

Pietsch/JRR/Sakurai/Wiesler, JHEP 1207 (2012) 148

Simplified Models and Scenarios

- Sleptons, Higgsinos, third generation decoupled
- Higgs at 125 GeV ⇒ heavy scalars, light gauginos
- Gauginos fix, vary squark masses in three scenarios

$m_{\tilde{g}}$	$m_{\tilde{w}}$	$m_{\tilde{b}}$
1200 GeV	400 GeV	200 GeV

Scenario	**A**	**B**	**C**
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A
- Small mass difference
- Associated production dominant
- Squark decay to light gauginos
- One signal gluino / squark bg

B
- Moderate mass difference
- Associated and pair production
- Squark decay also to gluino
- Two signal gluinos / many jets

C
- Squarks decoupled
- Pair production only
- Two signal gluinos
- Lowest combinatorial bg

Technicalities

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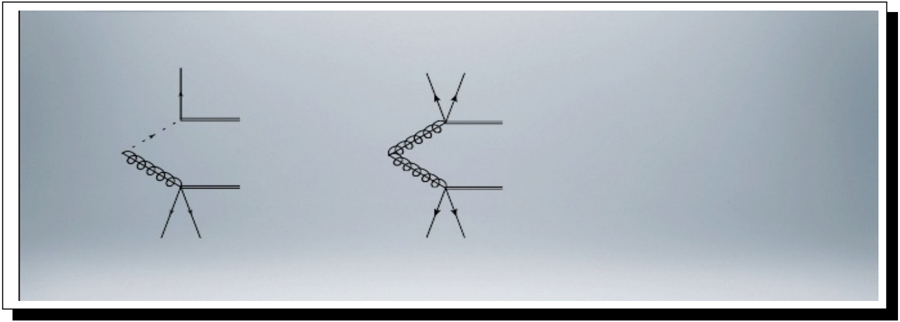
- Baseline selection CMS-SUS-10-005
  - $H_T > 800$ GeV
  - $E_T^{miss} > 200$ GeV
  - $\Delta\phi(j_{1,2}, E_T^{miss}) > 0.5$

Event topologies



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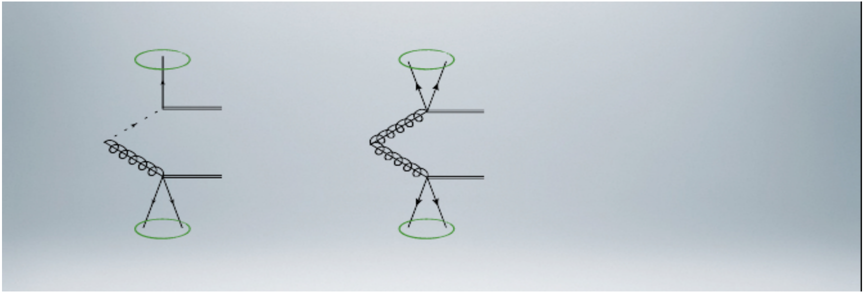

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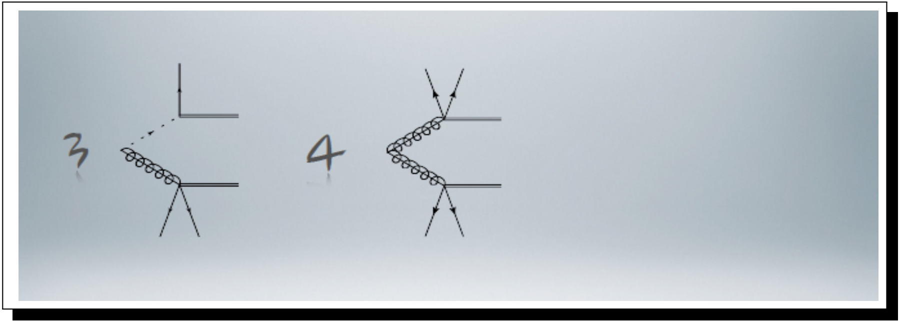

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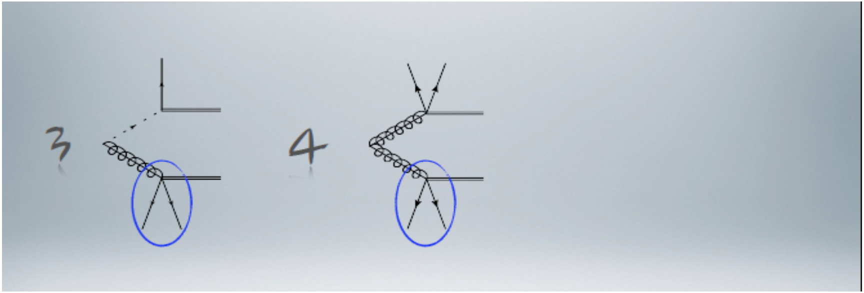

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ONLY bino edges in 3-4 partons

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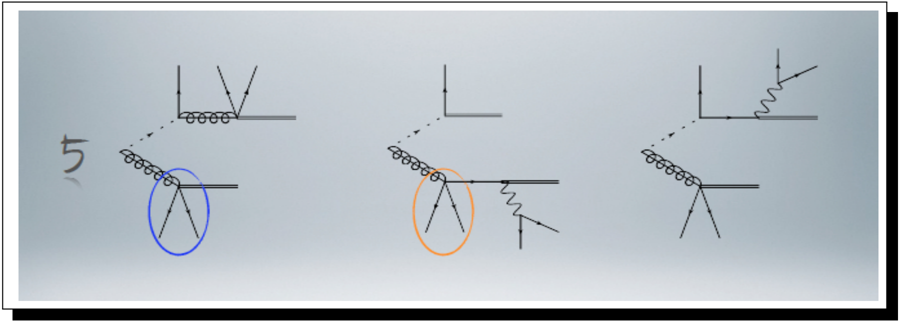

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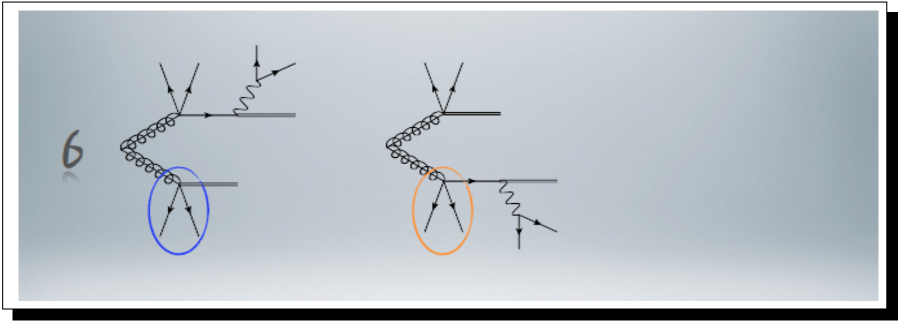

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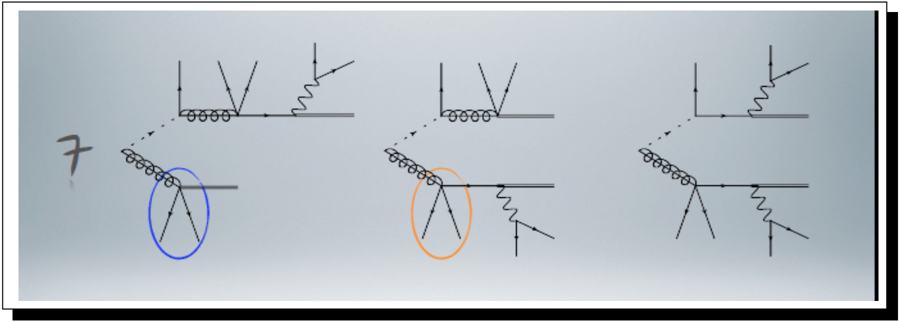

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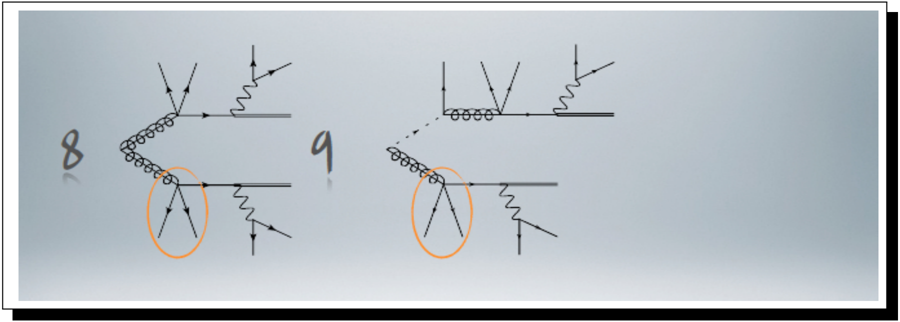

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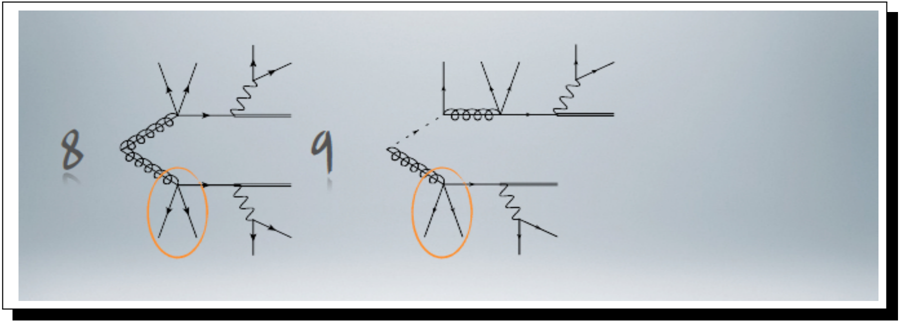

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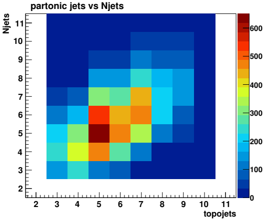
- Use selection criterion

≤ 4 particles	$\longleftrightarrow$	bino edge
≥ 8 particles	$\longleftrightarrow$	wino edge

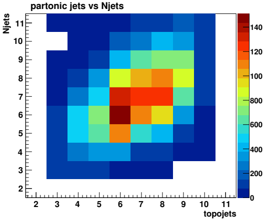
Parton-Jet Correspondence

- This was parton level? What about hadron level?

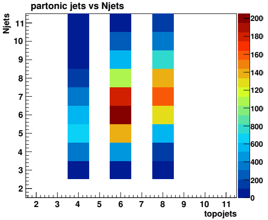
A



B



C



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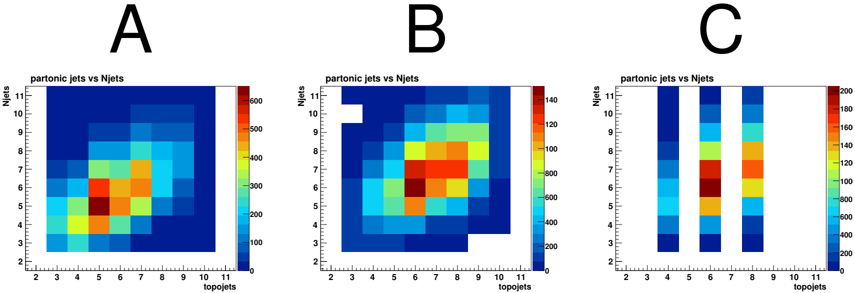


⇒ Substantial correlation of parton and detector level jets

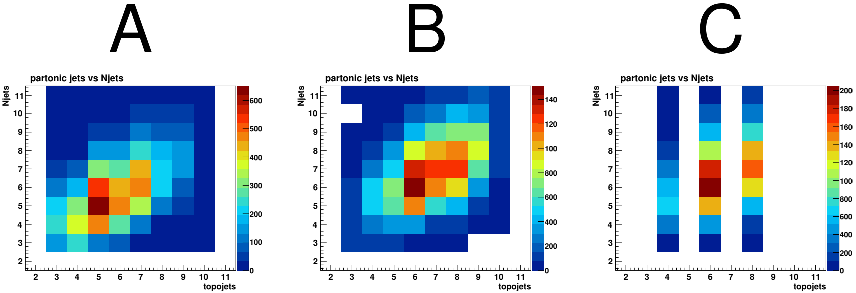
- Refine selection criteria

Bino: 4-5 jets lepton veto

Wino: $\geq$ 6 jets one lepton

Parton-Jet Correspondence

- This was parton level? What about hadron level?



$\Rightarrow$ Substantial correlation of parton and detector level jets

- Refine selection criteria

Bino: 4-5 jets lepton veto

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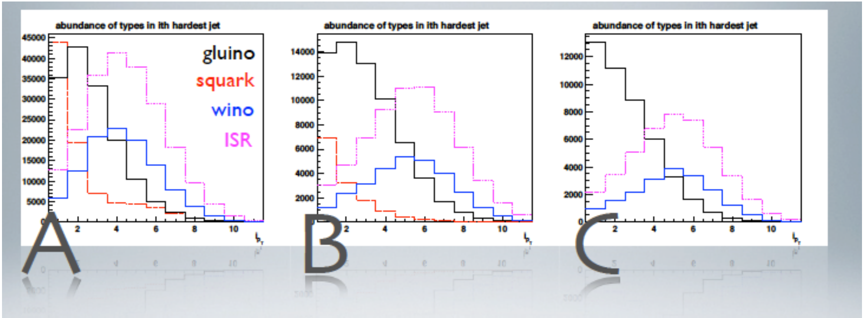
- Lepton indicates presence of wino
- Fewer jets $\Rightarrow$ less combinatorics

Origin of Jets

- Abundances of jet origins in the ith hardest jet



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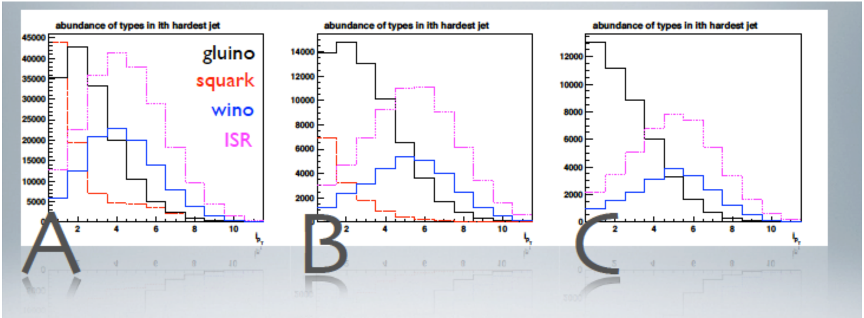


- Gluino jet very likely in the first 3 bins
- Severe squark contamination for $i = 1$ in scenario A & B
  - Define new variables
  - min procedure reduces impact on combinatorics

$$\begin{aligned} min_{3j} &= \min_{k=1,2} m_{3,k} \\ min_{123} &= \min_{i,j=1,2,3} m_{i,j} \\ min_{234} &= \min_{i,j=2,3,4} m_{i,j} \end{aligned}$$

Compare to existing methods

- Hemisphere method CMS TDR 2007

  1. Hemisphere algorithm to divide event
  2. Combine two hardest objects from each side

$$\boxed{m_{12}^{1/2}}$$

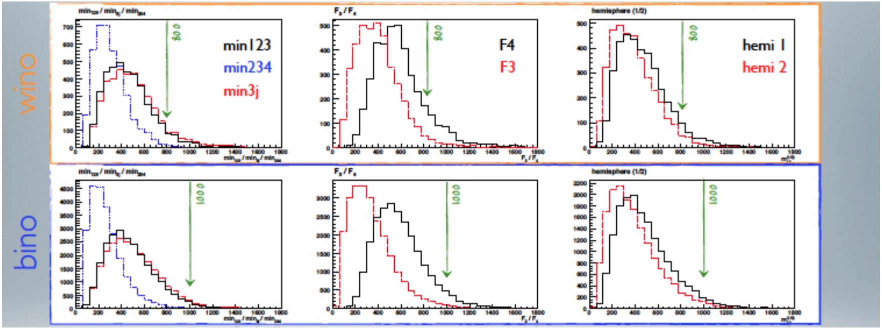
- Topology method (for exclusive 4 jets + MET) Bai/Cheng, 2011

  - Dijet variables for identification of topology 3+1 or 2+2

$$F_3(p1, p2, p3, p4) = m_{k,l}, \quad \text{for } \epsilon_{ijkl} \neq 0 \text{ and } \max_{r,s=1,\dots,4}\{m_{r,s}\}$$

$$F_4(p1, p2, p3, p4) = \min_{i,j=1,\dots,4}\{\max(m_{i,j}, m_{k,l})\}, \quad \epsilon_{ijkl} \neq 0$$

Scenario A



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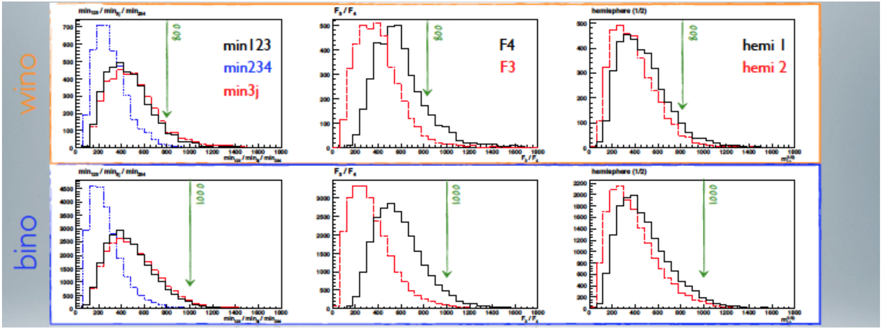

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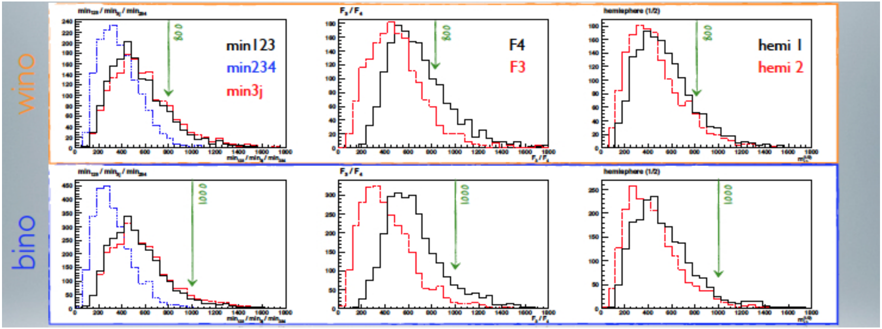
Scenario B



- Bino selection: shallow endpoints, only vague kink structure
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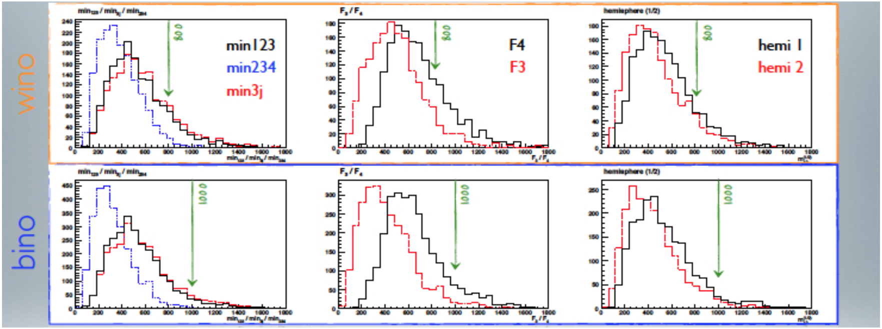
Scenario B



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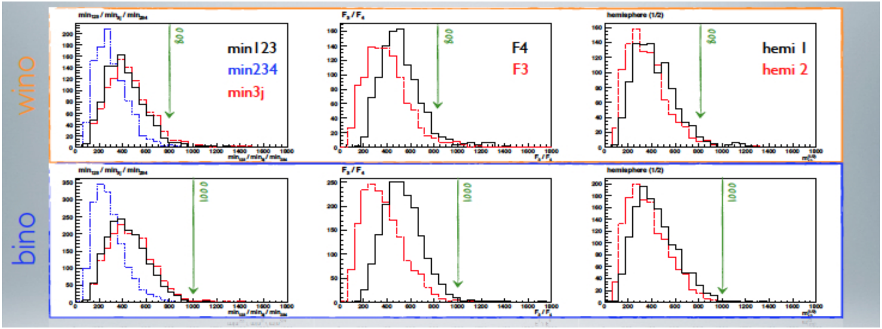

- Bino selection: clear endpoints, slight underestimation
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- all variables promising, good control of backgrounds

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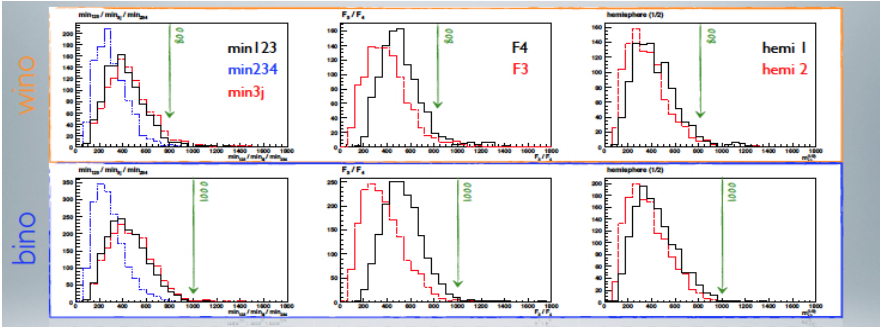

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Numerical Endpoint Estimation

Pietsch/JRR/Sakurai/Wiesler, JHEP 1207 (2012) 148

endpt.	min_{123}	min_{234}	min_{3j}	$m_{12}^{(1)}$	$m_{12}^{(2)}$	F_3	$F4$
scenario A							
bino	1106 ± 52	570 ± 14	1125 ± 106	822 ± 21	**1012 ± 104**	686 ± 33	1191 ± 132
wino	908 ± 83	665 ± 34	948 ± 99	932 ± 31	**780 ± 26**	**794 ± 33**	1031 ± 53
scenario B							
bino	**986 ± 36**	773 ± 147	**1028 ± 34**	**1010 ± 6**	794 ± 49	766 ± 25	1046 ± 66
wino	895 ± 23	**748 ± 68**	892 ± 18	958 ± 10	**819 ± 47**	911 ± 51	928 ± 37
scenario C							
bino	812 ± 24	545 ± 8	**921 ± 37**	816 ± 29	721 ± 90	708 ± 22	**894 ± 57**
wino	778 ± 23	577 ± 19	**804 ± 6**	769 ± 47	764 ± 14	708 ± 38	**793 ± 7**

- Accurate estimates in all scenarios possible
- slight underestimation for bino in scenario A
- Very important to choose the correct variable!

III. Combinatorics (fake)

Fake combinatorics from exotic particles

- Fake combinatorics: Wrong underlying model assumptions

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Kilian/JRR, PLB 642 (2006) 81; Braam/Knochel/JRR, JHEP 1006 (2010) 013

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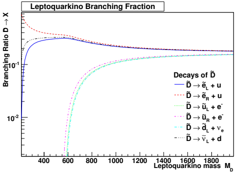

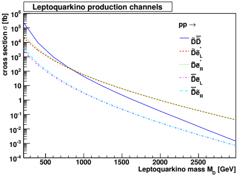

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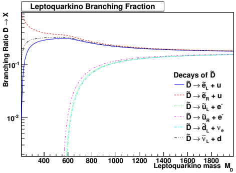
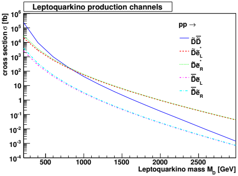
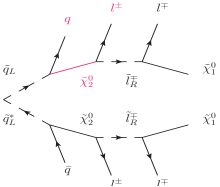


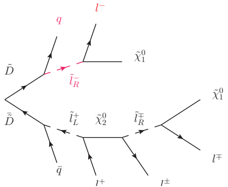
Leptoquarkino Branching Fraction



Leptoquarkino production channels

- Identical exclusive final states:



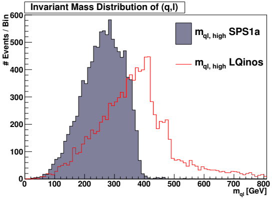


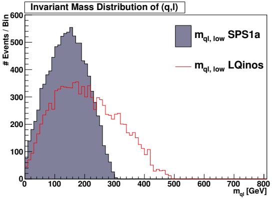
Mass Edges for Leptoquarkinos

JRR/Wiesler, PRD84 (2011) 015012

- Mass edges clearer due to missing spin correlations

$$m_{ql,high} = \max\{m_{ql+}, m_{ql-}\} \qquad m_{ql,low} = \min\{m_{ql+}, m_{ql-}\}$$





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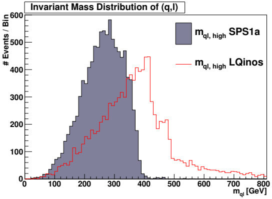
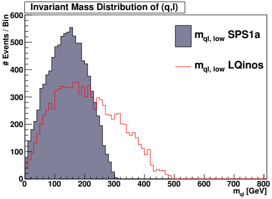
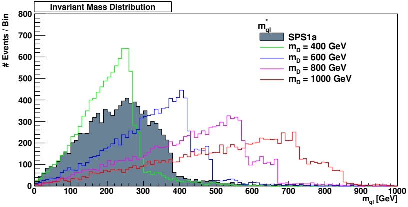




- Combinatorial background: combine softest jet and hardest lepton:

$$m^*_{ql} = m(\min_E\{q_1, q_2\}, \max_E\ \{l^+, l^-\})$$



Discrimination from standard SUSY

JRR/Wiesler, PRD 2011

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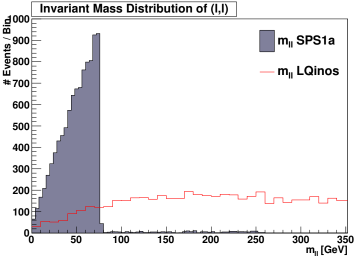
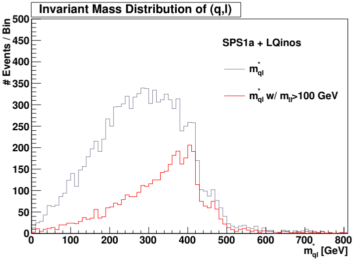
- Cut on kinematic edge in standard dilepton spectra





- S/B estimate, 100 fb^{-1}, 2 OSSF, 2 hard jets, $\not{E}_T$

$m_{\tilde{D}}$	# N(LQino) & N(SUSY)	# N_{cut}	S / $\sqrt{\text{S+B}}$
400	8763	5061	54
600	1355	540	15
800	684	102	4
1000	594	24	1

Summary/Conclusions

- New Physics motivated by Hierarchy Problem/Vacuum Stability
- SUSY cascades as standard candles at LHC
- Combinatorial background and smearing from
  - ISR/FSR
  - Combinatorics through presence of two cascades
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  - Wrong model assumptions
- Full analysis including all channels/backgrounds with **`Whizard`**
- Generally trade-off between precision and speed

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- First time in 50 years with only one high energy machine!
- Will the LHC be the first hadron machine to find the unexpected ?

One Ring to Find them ... One Ring to Rule them Out

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