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Search for supersymmetry in the multijet and missing transverse momentum final state in pp collisions at 13 TeV

CMS Collaboration *

CERN, Switzerland

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ABSTRACT

A search for new physics is performed based on all-hadronic events with large missing transverse momentum produced in proton–proton collisions at $\sqrt{s} = 13$ TeV. The data sample, corresponding to an integrated luminosity of 2.3 fb^{-1}, was collected with the CMS detector at the CERN LHC in 2015. The data are examined in search regions of jet multiplicity, tagged bottom quark jet multiplicity, missing transverse momentum, and the scalar sum of jet transverse momenta. The observed numbers of events in all search regions are found to be consistent with the expectations from standard model processes. Exclusion limits are presented for simplified supersymmetric models of gluino pair production. Depending on the assumed gluino decay mechanism, and for a massless, weakly interacting, lightest neutralino, lower limits on the gluino mass from 1440 to 1600 GeV are obtained, significantly extending previous limits.

1. Introduction

The standard model (SM) of particle physics successfully describes a wide range of phenomena. However, in the SM, the Higgs boson mass is unstable to higher-order corrections, suggesting that the SM is incomplete. Many extensions to the SM have been proposed to provide a more fundamental theory. Supersymmetry (SUSY) [1–8], one such extension, postulates that each SM particle is paired with a SUSY partner from which it differs in spin by one-half unit. As examples, squarks and gluinos are the SUSY partners of quarks and gluons, respectively, while neutralinos $\widetilde{\chi}^0$ (charginos $\widetilde{\chi}^{\pm}$) arise from a mixture of the SUSY partners of neutral (charged) Higgs and electroweak gauge bosons. Radiative corrections involving SUSY particles can compensate the contributions from SM particles and thereby stabilize the Higgs boson mass. For this cancellation to be “natural” [9–12], the top squark, bottom squark, and gluino must have masses on the order of a few TeV or less, possibly allowing them to be produced at the CERN LHC.

Amongst SUSY processes, gluino pair production, typically yielding four or more hadronic jets in the final state, has the largest potential cross section, making it an apt channel for early SUSY searches in the recently started LHC Run 2. Furthermore, in R-parity [13] conserving SUSY models, as are considered here, the lightest SUSY particle (LSP) is stable and assumed to be weakly interacting, leading to potentially large undetected, or “missing”, transverse momentum. Supersymmetry events at the LHC might thus be characterized by significant missing transverse momentum, numerous jets, and — in the context of natural SUSY — jets initiated by top and bottom quarks.

This Letter describes a search for gluino pair production in the all-hadronic final state. The data, corresponding to an integrated luminosity of 2.3 fb^{-1} of proton–proton collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV, were collected with the CMS detector in 2015, the initial year of the LHC Run 2. Recent searches for gluino pair production at $\sqrt{s} = 8$ TeV, based on data collected in LHC Run 1, are presented in Refs. [14–16]. Because of the large mass scales and their all-hadronic nature, the targeted SUSY events are expected to exhibit large values of H_{T}, where H_{T} is the scalar sum of the transverse momenta (p_{T}) of the jets. As a measure of missing transverse momentum, we use the variable $H_{\mathrm{T}}^{\mathrm{miss}}$, which is the magnitude of the vector sum of the jet p_{T}. We present a general search for gluino pair production leading to final states with large H_{T}, large $H_{\mathrm{T}}^{\mathrm{miss}}$, and large jet multiplicity. The data are examined in bins of N_{jet}, $N_{\mathrm{b\text{-}jet}}$, H_{T}, and $H_{\mathrm{T}}^{\mathrm{miss}}$, where N_{jet} is the

* *E-mail address:* cms-publication-committee-chair@cern.ch.

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Table B.3
Observed numbers of events and prefit background predictions for $N_{\text{jet}} \geq 9$. These results are displayed in the rightmost section of Fig. 6. The first uncertainty is statistical and the second systematic.

Bin	H_T^{miss} [GeV]	H_T [GeV]	$N_{\text{b-jet}}$	Lost-e/μ	$\tau \to$ had	$Z \to \nu\bar{\nu}$	QCD	Total Pred.	Obs.
49	200–500	500–800	0	$0.99^{+0.59}_{-0.45} \pm 0.21$	$0.61^{+0.52}_{-0.23} \pm 0.09$	$0.26 \pm 0.26^{+0.12}_{-0.00}$	$0.92^{+0.54+0.80}_{-0.35-0.57}$	$2.8^{+1.3}_{-0.8} \pm 0.7$	2
50	200–500	800–1200	0	$2.12^{+0.72}_{-0.62} \pm 0.33$	$3.9 \pm 1.2 \pm 0.4$	$2.14 \pm 0.81^{+0.81}_{-0.64}$	$0.78^{+0.31}_{-0.23} \pm 0.55$	$9.0 \pm 2.0 \pm 1.1$	12
51	200–500	1200+	0	$0.58^{+0.54}_{-0.35} \pm 0.08$	$1.05^{+0.76}_{-0.61} \pm 0.15$	$0.42 \pm 0.30^{+0.18}_{-0.12}$	$3.9 \pm 0.7 \pm 2.5$	$6.0^{+1.5}_{-1.2} \pm 2.5$	8
52	500–750	500–1200	0	$0.00^{+0.34}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.15 \pm 0.15^{+0.11}_{-0.00}$	$0.00^{+0.11+0.04}_{-0.00-0.00}$	$0.15^{+0.82+0.11}_{-0.15-0.00}$	0
53	500–750	1200+	0	$0.14^{+0.36+0.05}_{-0.14-0.00}$	$0.02^{+0.46+0.01}_{-0.02-0.00}$	$0.00^{+0.76}_{-0.00} \pm 0.00$	$0.00^{+0.09+0.04}_{-0.00-0.00}$	$0.2^{+1.1+0.1}_{-0.2-0.0}$	0
54	750+	800+	0	$0.00^{+0.28}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.00^{+0.79}_{-0.00} \pm 0.00$	$0.00^{+0.08+0.03}_{-0.00-0.00}$	$0.0^{+1.1+0.1}_{-0.0-0.0}$	0
55	200–500	500–800	1	$1.36^{+0.66}_{-0.53} \pm 0.19$	$1.58^{+0.71}_{-0.54} \pm 0.19$	$0.19 \pm 0.19^{+0.10}_{-0.00}$	$0.09^{+0.22+0.15}_{-0.07-0.02}$	$3.2^{+1.4}_{-1.1} \pm 0.3$	6
56	200–500	800–1200	1	$3.19^{+0.99}_{-0.91} \pm 0.52$	$4.1 \pm 1.2 \pm 0.4$	$1.57 \pm 0.64 \pm 0.68$	$0.88^{+0.34}_{-0.25} \pm 0.64$	$9.7 \pm 2.2 \pm 1.2$	4
57	200–500	1200+	1	$1.70^{+0.85}_{-0.73} \pm 0.25$	$1.41^{+0.79}_{-0.65} \pm 0.25$	$0.31 \pm 0.22^{+0.15}_{-0.08}$	$2.4 \pm 0.5 \pm 1.6$	$5.8 \pm 1.6 \pm 1.7$	3
58	500–750	500–1200	1	$0.00^{+0.40}_{-0.00} \pm 0.00$	$0.05^{+0.46+0.02}_{-0.05-0.00}$	$0.11 \pm 0.11^{+0.08}_{-0.00}$	$0.00^{+0.11+0.04}_{-0.00-0.00}$	$0.16^{+0.88+0.09}_{-0.12-0.00}$	0
59	500–750	1200+	1	$0.00^{+0.41}_{-0.00} \pm 0.00$	$0.15^{+0.48+0.04}_{-0.14-0.00}$	$0.00^{+0.66}_{-0.00} \pm 0.00$	$0.00^{+0.09+0.03}_{-0.00-0.00}$	$0.2^{+1.1+0.1}_{-0.1-0.0}$	1
60	750+	800+	1	$0.00^{+0.33}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.00^{+0.68}_{-0.00} \pm 0.00$	$0.00^{+0.08+0.03}_{-0.00-0.00}$	$0.0^{+1.1+0.1}_{-0.0-0.0}$	0
61	200–500	500–800	2	$1.38^{+0.74}_{-0.62} \pm 0.18$	$1.51^{+0.77}_{-0.61} \pm 0.15$	$0.10 \pm 0.10^{+0.07}_{-0.00}$	$0.00^{+0.22+0.11}_{-0.00-0.00}$	$3.0^{+1.5}_{-1.2} \pm 0.3$	3
62	200–500	800–1200	2	$1.39^{+0.68}_{-0.57} \pm 0.20$	$2.20^{+0.92}_{-0.80} \pm 0.20$	$0.87 \pm 0.41^{+0.54}_{-0.46}$	$0.26^{+0.22+0.24}_{-0.13-0.13}$	$4.7^{+1.7}_{-1.4} \pm 0.6$	1
63	200–500	1200+	2	$0.28^{+0.48}_{-0.20} \pm 0.04$	$1.40^{+0.83}_{-0.70} \pm 0.19$	$0.17 \pm 0.13^{+0.11}_{-0.04}$	$1.38^{+0.45}_{-0.35} \pm 0.95$	$3.2^{+1.4}_{-1.0} \pm 1.0$	2
64	500–750	500–1200	2	$0.00^{+0.36}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.06 \pm 0.06^{+0.05}_{-0.00}$	$0.00^{+0.11+0.04}_{-0.00-0.00}$	$0.06^{+0.83+0.07}_{-0.06-0.00}$	0
65	500–750	1200+	2	$0.00^{+0.45}_{-0.00} \pm 0.00$	$0.01^{+0.46}_{-0.01} \pm 0.00$	$0.00^{+0.52}_{-0.00} \pm 0.00$	$0.00^{+0.09+0.03}_{-0.00-0.00}$	$0.0^{+1.1+0.1}_{-0.0-0.0}$	0
66	750+	800+	2	$0.00^{+0.43}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.00^{+0.52}_{-0.00} \pm 0.00$	$0.00^{+0.08+0.03}_{-0.00-0.00}$	$0.0^{+1.0+0.1}_{-0.0-0.0}$	0
67	200–500	500–800	3+	$0.30^{+0.48}_{-0.21} \pm 0.05$	$1.13^{+0.79}_{-0.64} \pm 0.16$	$0.02^{+0.03+0.03}_{-0.02-0.00}$	$0.00^{+0.22+0.09}_{-0.00-0.00}$	$1.5^{+1.3}_{-0.9} \pm 0.2$	0
68	200–500	800–1200	3+	$1.9 \pm 1.4 \pm 0.3$	$0.70^{+0.60}_{-0.38} \pm 0.09$	$0.18 \pm 0.13^{+0.24}_{-0.06}$	$0.27^{+0.22+0.25}_{-0.13-0.14}$	$3.1^{+2.0}_{-1.7} \pm 0.5$	1
69	200–500	1200+	3+	$0.46^{+0.64+0.06}_{-0.46-0.00}$	$0.32^{+0.54}_{-0.28} \pm 0.04$	$0.04 \pm 0.03^{+0.05}_{-0.00}$	$0.04^{+0.10+0.07}_{-0.03-0.01}$	$0.9^{+1.2+0.1}_{-0.8-0.0}$	0
70	500–750	500–1200	3+	$0.13^{+0.47+0.05}_{-0.13-0.00}$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.01^{+0.02+0.02}_{-0.01-0.00}$	$0.00^{+0.11+0.04}_{-0.00-0.00}$	$0.14^{+0.93+0.04}_{-0.13-0.00}$	0
71	500–750	1200+	3+	$0.00^{+0.41}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.00^{+0.30}_{-0.00} \pm 0.00$	$0.00^{+0.09+0.02}_{-0.00-0.00}$	$0.00^{+0.93+0.02}_{-0.00-0.00}$	0
72	750+	800+	3+	$0.00^{+0.44}_{-0.00} \pm 0.00$	$0.00^{+0.46}_{-0.00} \pm 0.00$	$0.00^{+0.28}_{-0.00} \pm 0.00$	$0.00^{+0.08+0.03}_{-0.00-0.00}$	$0.00^{+0.95+0.03}_{-0.00-0.00}$	0

References

[1] P. Ramond, Dual theory for free fermions, Phys. Rev. D 3 (1971) 2415, http://dx.doi.org/10.1103/PhysRevD.3.2415.
[2] Y.A. Golfand, E.P. Likhtman, Extension of the algebra of Poincaré group generators and violation of P invariance, JETP Lett. 13 (1971) 323.
[3] A. Neveu, J.H. Schwarz, Factorizable dual model of pions, Nucl. Phys. B 31 (1971) 86, http://dx.doi.org/10.1016/0550-3213(71)90448-2.
[4] D.V. Volkov, V.P. Akulov, Possible universal neutrino interaction, JETP Lett. 16 (1972) 438.
[5] J. Wess, B. Zumino, A Lagrangian model invariant under supergauge transformations, Phys. Lett. B 49 (1974) 52, http://dx.doi.org/10.1016/0370-2693(74)90578-4.
[6] J. Wess, B. Zumino, Supergauge transformations in four dimensions, Nucl. Phys. B 70 (1974) 39, http://dx.doi.org/10.1016/0550-3213(74)90355-1.
[7] P. Fayet, Supergauge invariant extension of the Higgs mechanism and a model for the electron and its neutrino, Nucl. Phys. B 90 (1975) 104, http://dx.doi.org/10.1016/0550-3213(75)90636-7.
[8] H.P. Nilles, Supersymmetry, supergravity and particle physics, Phys. Rep. 110 (1984) 1, http://dx.doi.org/10.1016/0370-1573(84)90008-5.
[9] R. Barbieri, G.F. Giudice, Upper bounds on supersymmetric particle masses, Nucl. Phys. B 306 (1988) 63, http://dx.doi.org/10.1016/0550-3213(88)90171-X.
[10] S. Dimopoulos, G.F. Giudice, Naturalness constraints in supersymmetric theories with nonuniversal soft terms, Phys. Lett. B 357 (1995) 573, http://dx.doi.org/10.1016/0370-2693(95)00961-J, arXiv:hep-ph/9507282.
[11] R. Barbieri, D. Pappadopulo, S-particles at their naturalness limits, J. High Energy Phys. 10 (2009) 061, http://dx.doi.org/10.1088/1126-6708/2009/10/061, arXiv:0906.4546.
[12] M. Papucci, J.T. Ruderman, A. Weiler, Natural SUSY endures, J. High Energy Phys. 09 (2012) 035, http://dx.doi.org/10.1007/JHEP09(2012)035, arXiv:1110.6926.
[13] G.R. Farrar, P. Fayet, Phenomenology of the production, decay, and detection of new hadronic states associated with supersymmetry, Phys. Lett. B 76 (1978) 575, http://dx.doi.org/10.1016/0370-2693(78)90858-4.
[14] ATLAS Collaboration, Summary of the searches for squarks and gluinos using $\sqrt{s} = 8$ TeV pp collisions with the ATLAS experiment at the LHC, J. High Energy Phys. 10 (2015) 054, http://dx.doi.org/10.1007/JHEP10(2015)054, arXiv:1507.05525.
[15] CMS Collaboration, Searches for supersymmetry using the M_{T2} variable in hadronic events produced in pp collisions at 8 TeV, J. High Energy Phys. 05 (2015) 078, http://dx.doi.org/10.1007/JHEP05(2015)078, arXiv:1502.04358.
[16] CMS Collaboration, Search for supersymmetry using razor variables in events with b-tagged jets in pp collisions at $\sqrt{s} = 8$ TeV, Phys. Rev. D 91 (2015) 052018, http://dx.doi.org/10.1103/PhysRevD.91.052018, arXiv:1502.00300.
[17] N. Arkani-Hamed, P. Schuster, N. Toro, J. Thaler, L.-T. Wang, B. Knuteson, S. Mrenna, MARMOSET: the path from LHC data to the new standard model via on-shell effective theories, arXiv:hep-ph/0703088, 2007.
[18] J. Alwall, P. Schuster, N. Toro, Simplified models for a first characterization of new physics at the LHC, Phys. Rev. D 79 (2009) 075020, http://dx.doi.org/10.1103/PhysRevD.79.075020, arXiv:0810.3921.
[19] J. Alwall, M.-P. Le, M. Lisanti, J.G. Wacker, Model-independent jets plus missing energy searches, Phys. Rev. D 79 (2009) 015005, http://dx.doi.org/10.1103/PhysRevD.79.015005, arXiv:0809.3264.
[20] D. Alves, N. Arkani-Hamed, S. Arora, Y. Bai, M. Baumgart, J. Berger, M. Buckley, B. Butler, S. Chang, H.-C. Cheng, C. Cheung, R.S. Chivukula, W.S. Cho, R. Cotta, M. D'Alfonso, et al., Simplified models for LHC new physics searches, J. Phys. G 39 (2012) 105005, http://dx.doi.org/10.1088/0954-3899/39/10/105005, arXiv:1105.2838.
[21] CMS Collaboration, Interpretation of searches for supersymmetry with simplified models, Phys. Rev. D 88 (2013) 052017, http://dx.doi.org/10.1103/PhysRevD.88.052017, arXiv:1301.2175.
[22] CMS Collaboration, Search for gluino mediated bottom- and top-squark production in multijet final states in pp collisions at 8 TeV, Phys. Lett. B 725 (2013) 243, http://dx.doi.org/10.1016/j.physletb.2013.06.058, arXiv:1305.2390.
[23] CMS Collaboration, Search for new physics in the multijet and missing transverse momentum final state in proton–proton collisions at $\sqrt{s} = 8$ TeV, J. High Energy Phys. 06 (2014) 055, http://dx.doi.org/10.1007/JHEP06(2014)055, arXiv:1402.4770.
[24] CMS Collaboration, The CMS experiment at the CERN LHC, J. Instrum. 3 (2008) S08004, http://dx.doi.org/10.1088/1748-0221/3/08/S08004.
[25] CMS Collaboration, Particle flow event reconstruction in CMS and performance for jets, taus and E_T^{miss}, CMS Physics Analysis Summary CMS-PAS-PFT-09-001, CERN, 2009, http://cdsweb.cern.ch/record/1194487.
[26] CMS Collaboration, Commissioning of the particle-flow event reconstruction with the first LHC collisions recorded in the CMS detector, CMS Physics Analysis Summary CMS-PAS-PFT-10-001, CERN, 2010, http://cdsweb.cern.ch/record/1247373.

I. Azhgirey, I. Bayshev, S. Bitioukov, D. Elumakhov, V. Kachanov, A. Kalinin, D. Konstantinov, V. Krychkine, V. Petrov, R. Ryutin, A. Sobol, S. Troshin, N. Tyurin, A. Uzunian, A. Volkov

State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia

P. Adzic [41], P. Cirkovic, D. Devetak, J. Milosevic, V. Rekovic

University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia

J. Alcaraz Maestre, E. Calvo, M. Cerrada, M. Chamizo Llatas, N. Colino, B. De La Cruz, A. Delgado Peris, A. Escalante Del Valle, C. Fernandez Bedoya, J.P. Fernández Ramos, J. Flix, M.C. Fouz, P. Garcia-Abia, O. Gonzalez Lopez, S. Goy Lopez, J.M. Hernandez, M.I. Josa, E. Navarro De Martino, A. Pérez-Calero Yzquierdo, J. Puerta Pelayo, A. Quintario Olmeda, I. Redondo, L. Romero, M.S. Soares

Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain

J.F. de Trocóniz, M. Missiroli, D. Moran

Universidad Autónoma de Madrid, Madrid, Spain

J. Cuevas, J. Fernandez Menendez, I. Gonzalez Caballero, E. Palencia Cortezon, S. Sanchez Cruz, J.M. Vizan Garcia

Universidad de Oviedo, Oviedo, Spain

I.J. Cabrillo, A. Calderon, J.R. Castiñeiras De Saa, E. Curras, M. Fernandez, J. Garcia-Ferrero, G. Gomez, A. Lopez Virto, J. Marco, C. Martinez Rivero, F. Matorras, J. Piedra Gomez, T. Rodrigo, A. Ruiz-Jimeno, L. Scodellaro, N. Trevisani, I. Vila, R. Vilar Cortabitarte

Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain

D. Abbaneo, E. Auffray, G. Auzinger, M. Bachtis, P. Baillon, A.H. Ball, D. Barney, P. Bloch, A. Bocci, A. Bonato, C. Botta, T. Camporesi, R. Castello, M. Cepeda, G. Cerminara, M. D'Alfonso, D. d'Enterria, A. Dabrowski, V. Daponte, A. David, M. De Gruttola, F. De Guio, A. De Roeck, E. Di Marco [42], M. Dobson, M. Dordevic, B. Dorney, T. du Pree, D. Duggan, M. Dünser, N. Dupont, A. Elliott-Peisert, S. Fartoukh, G. Franzoni, J. Fulcher, W. Funk, D. Gigi, K. Gill, M. Girone, F. Glege, S. Gundacker, M. Guthoff, J. Hammer, P. Harris, J. Hegeman, V. Innocente, P. Janot, H. Kirschenmann, V. Knünz, M.J. Kortelainen, K. Kousouris, M. Krammer [1], P. Lecoq, C. Lourenço, M.T. Lucchini, N. Magini, L. Malgeri, M. Mannelli, A. Martelli, F. Meijers, S. Mersi, E. Meschi, F. Moortgat, S. Morovic, M. Mulders, H. Neugebauer, S. Orfanelli [43], L. Orsini, L. Pape, E. Perez, M. Peruzzi, A. Petrilli, G. Petrucciani, A. Pfeiffer, M. Pierini, A. Racz, T. Reis, G. Rolandi [44], M. Rovere, M. Ruan, H. Sakulin, J.B. Sauvan, C. Schäfer, C. Schwick, M. Seidel, A. Sharma, P. Silva, M. Simon, P. Sphicas [45], J. Steggemann, M. Stoye, Y. Takahashi, D. Treille, A. Triossi, A. Tsirou, V. Veckalns [46], G.I. Veres [21], N. Wardle, A. Zagozdzinska [35], W.D. Zeuner

CERN, European Organization for Nuclear Research, Geneva, Switzerland

W. Bertl, K. Deiters, W. Erdmann, R. Horisberger, Q. Ingram, H.C. Kaestli, D. Kotlinski, U. Langenegger, T. Rohe

Paul Scherrer Institut, Villigen, Switzerland

F. Bachmair, L. Bäni, L. Bianchini, B. Casal, G. Dissertori, M. Dittmar, M. Donegà, P. Eller, C. Grab, C. Heidegger, D. Hits, J. Hoss, G. Kasieczka, P. Lecomte [†], W. Lustermann, B. Mangano, M. Marionneau, P. Martinez Ruiz del Arbol, M. Masciovecchio, M.T. Meinhard, D. Meister, F. Micheli, P. Musella, F. Nessi-Tedaldi, F. Pandolfi, J. Pata, F. Pauss, G. Perrin, L. Perrozzi, M. Quittnat, M. Rossini, M. Schönenberger, A. Starodumov [47], M. Takahashi, V.R. Tavolaro, K. Theofilatos, R. Wallny

Institute for Particle Physics, ETH Zurich, Zurich, Switzerland

T.K. Aarrestad, C. Amsler [48], L. Caminada, M.F. Canelli, V. Chiochia, A. De Cosa, C. Galloni, A. Hinzmann, T. Hreus, B. Kilminster, C. Lange, J. Ngadiuba, D. Pinna, G. Rauco, P. Robmann, D. Salerno, Y. Yang

Universität Zürich, Zurich, Switzerland