

R-J. Standard model and new physics

Wigner research group

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Physics analyses. — Our group has been participating in the studies of the newly-discovered Higgs boson and have shown that its properties indeed correspond to the predictions of the Standard Model. We presented this result both at international conferences and institutional seminars, and also in two books.

We have performed searches for supersymmetric particles in 8 TeV proton-proton collision data which was collected in 2012. In these searches, we were looking for possible signatures of gluino-pair production and decays to top squarks where b-jets, a lepton, multiple light flavor jets, and missing transverse momentum were present. We also measured the reconstruction and identification efficiencies of electrons and muons by performing an auxiliary measurement of events where leptonically decaying Z bosons and multiple jets are produced. No excess was observed in these searches and the results were interpreted as exclusion limits on the mass parameter space of simplified models of on- (real) and off-shell (virtual) top squarks production via gluino pairs.

Theoretical work. — Theoretical activity in quantum and gravity foundations, as well as in open quantum system dynamics has been continued. The yet hypothetical gravity-related spontaneous wave-function collapse has been derived for the first time in acoustic modes of bulk matter. Proposals of various related experimental tests have been outlined including a specific Cavendish experiment to test a possible quantum-delay of Newton gravitational force.

Thorough investigations of the Gaussian class of non-Markovian open quantum systems have led to a general mathematical structure showing strong resemblance with the well-known and widely-used special Markovian case; that is to say, with the famous Lindblad structure and master equations.

Work on instrumentation. — Our team continued to contribute strongly to the operation, calibration, and data-reconstruction of the CMS Tracker detectors: the inner silicon pixel, and outer silicon strip detectors. We have provided a coordinator for the CMS Tracker Detector Performance group, and one for its CMS Pixel calibration and local reconstruction subgroup.

The two most important performance parameters of the pixel detector are hit detection efficiency and position measurement resolution. They determine the efficiency and accuracy of charged particle track reconstruction. Charged particle tracks are used in the determination of the secondary (decay) vertices of heavy flavor jets, which are produced in

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the supersymmetric events of our interest. We have found an efficiency loss at the per cent level in data acquired by the pixel detector which was not reflected by the simulation. We have improved the simulation of the CMS pixel detector and presented the results in a conference. We also measured the radiation damage experienced by the pixel detector. Radiation damage has an impact on the resolution of the hit position measurement. We found disagreement between the detector performance and its simulation in the official CMS software. We have implemented a new method which transforms the charge distribution of clusters in the pixel according to the expected radiation damage at given operational configuration (bias voltage, temperature, etc.) One of the most important aspects of detector readiness is the maintenance of the calibration databases which is entirely the responsibility of our group. We improved the resolution measurement also by introducing a new calibration object to correct for the apparent shift of cluster positions due to the presence of magnetic field as function of the irradiation in the silicon bulk.

Detector construction. — Radiation-induced damage of sensors and readout electronics degrades the resolution of position measurements in the CMS Pixel detector to the extent that the detector is rendered unusable. Therefore it will need to be replaced. This will happen in two steps in the next couple of decades called phase I and II upgrades. Our group has played a leading role in studying radiation effects and now we are also key contributors to the design of the new-generation pixel detector. We have designed and built the first prototypes for the control and readout electronics of the CMS Phase I Pixel upgrade detector.

The Liquid Argon Calorimeter is a basic component of the ATLAS detector. Its capabilities of detecting electrons, photons, jets and missing energy are crucial ingredients of discovering theoretically predicted new physics phenomena, like Supersymmetry, and of analyzing features of the Standard Model, including detailed experimental study of the Higgs boson. Because of the significant increase of the LHC luminosity in the coming years, the LAr Phase I Upgrade Project was defined and accepted to maintain and improve the performance of this detector. Being involved in the LAr group of CPPM, which is responsible for the upgraded back-end electronics of the level1 electromagnetic calorimeter's trigger system, we joined this effort with the aim of defining software algorithms to perform fast (trigger) electron selection. During data-acquisition, it is used in real-time identification of multi-lepton final states which are the result of associated production of charginos and neutralinos, while rejecting background as much as possible. This year, the first steps to reproduce the results of the TDR and check the existing software tools have been done and presented at several internal ATLAS working meetings.

Maintaining the CMS grid computing infrastructure. — The CMS computing grid is used in the reconstruction of both simulated and collision data which are analyzed in our searches for new physics. Stable operation of the T2_HU_Budapest grid site continued in 2014 giving us the third position in the site availability ranking of CMS T2 sites. Hardware developments included an upgrade of the external network connection to 10 Gbits/s, and the addition of 192 WN CPU cores and 40 TB disk storage.

Grant

OTKA K 109703: Consortial main: Hungary in the CMS experiment of the Large Hadron Collider (Ferenc Siklér, 2013-2016)

Publications

Articles

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2. Aghai-Khozani H, Barna D, Corradini M, Hayano R, Hori M, Kobayashi T, Leali M, Lodi-Rizzini E, Mascagna V, Prest M, Soter A, Todoroki K, Vallazza E, Venturelli L, Zurlo N: Experimental investigation of ≈ 130 keV kinetic energy antiprotons annihilation on nuclei. **HYPERFINE INTERACT**, 229:(1-3) p. 31-36. (2014)
4. Diósi L: Gravity-related wave function collapse - is superfluid He exceptional? **FOUND PHYS**, 44:(5) pp. 483-491. (2014)
5. Diósi L: Newton force from wave function collapse: Speculation and test. **J PHYS CONF SER**, 504:(1) Paper 012020. 7 p. (2014)
6. Diósi L: Equation and test of possible delay time of Newton force. **EPJ WEB CONF**, 78: Paper 02001. (2014)
7. Diósi L: Gravity-related spontaneous wave function collapse in bulk matter. **NEW J PHYS**, 16: Paper 105006. 9 p. (2014)
8. Diósi L, Ferialdi L: General Non-Markovian structure of Gaussian master and stochastic Schrödinger equations. **PHYS REV LETT**, 113:(20) Paper 200403. 5 p. (2014)
9. Diósi L: Hybrid quantum-classical master equations. **PHYS SCRIPTA**, 2014:(T163) Paper 014004. (2014)
10. Erhard M, Bauer S, Beglarian A, Bergmann T, Bonn J, Drexlin G, Goullon J, Groh S, Glück E, Kleesiek M, Haußmann N, Höhn T, Johnston K, Kraus M, Reich J, Rest O, Schlösser K, Schupp M, Slezák M, Thümmler T, Vénos D, Weinheimer C, Wüstling S, Zbořil M: High-voltage monitoring with a solenoid retarding spectrometer at the KATRIN experiment. **J INSTRUM**, 9:(6) Paper P06022. (2014)
11. Frankle FM, Glück E, Valerius K, Bokeloh K, Beglarian A, Bonn J, Bornschein L, Drexlin G, Habermehl F, Leber ML, Osipowicz A, Otten EW, Steidl M, Thummler T, Weinheimer C, Wilkerson JF, Wolf J, Zadorozhny SV: Penning discharge in the KATRIN pre-spectrometer. **J INSTRUM**, 9: Paper P07028. 23 p. (2014)
12. Hori M, Sótér A, Aghai-Khozani H, Barna D, Dax A, Hayano RS, Murakami Y, Todoroki K, Yamada H: Towards laser spectroscopy of pionic helium atoms at Paul Scherrer Institute. **POS - PROCEEDINGS OF SCIENCE**, TIPP2014 (Technology and Instrumentation

in Particle Physics 2014. Amsterdam, The Netherlands, 02.06.2014-06.06.2014), Paper 342. 5 p. (2014)

13. Horváth D: Twenty years of searching for the Higgs boson: Exclusion at LEP, discovery at LHC. **MOD PHYS LETT A**, 29: Paper 1430004. 20 p. (2014)
14. Horváth D: Broken Symmetries and the Higgs Boson. **EPJ WEB CONF**, 78: Paper 01003. (2014)
15. Konrad G, Ayala Guardia F, Baeßler S, Borg M, Glück F, Heil W, Hiebel S, Muñoz Horta R, Sobolev Y: The magnetic shielding for the neutron decay spectrometer aSPECT. **NUCL INSTRUM METH A**, 767: pp. 475-486. (2014)
16. Sótér A, Todoroki K, Kobayashi T, Barna D, Horváth D, Hori M: Segmented scintillation detectors with silicon photomultiplier readout for measuring antiproton annihilations **REV SCI INSTRUM**, 85:(2) Paper 023302. 10 p. (2014)
17. Sótér A, Hori M, Barna D, Hayano R, Dax A, Friedreich S, Juhász B, Pask T, Widmann E, Horváth D, Venturelli L, Zurlo N: Antiproton-to-electron mass ratio determined by two-photon laser spectroscopy of antiprotonic helium atoms. **EPJ WEB CONF**, 66: Paper 05020. 4 p. (2014)
18. Sótér A, Barna D, Todoroki K, Kobayashi T, Horváth D, Hori M: Segmented scintillators with SiPM readout for measuring antiproton annihilations. **POS - PROCEEDINGS OF SCIENCE**, TIPP2014 (Technology and Instrumentation in Particle Physics 2014. Amsterdam, The Netherlands, 02.06.2014-06.06.2014), Paper 286. 5 p. (2014)
19. Todoroki K, Hori M, Aghai-Khozani H, Barna D, Corradini M, Kobayashi T, Leali M, Lodi-Rizzini E, Mascagna V, Prest M, Soter A, Vallazza E, Venturelli L, Zurlo N, Hayano R: Beam diagnostics for measurements of antiproton annihilation cross sections at ultra-low energy. **EPJ WEB CONF**, 66: Paper 09020. 4 p. (2014)

Book chapter

20. Diósi L: Determination of the stationary basis from protective measurement on a single system. In: Protective Measurement and Quantum Reality: Towards a New Understanding of Quantum Mechanics, Ed.: Gao S, Cambridge: Cambridge University Press, 2014. pp. 63-67.

See also: R-P.1

ATLAS collaboration

Due to the vast number of publications of the large collaborations in which the research group participated in 2014, here we list only a short selection of appearances in journals with the highest impact factor.

1. Aad G et al. incl. Pasztor G, Toth J [2937 authors]: Search for dark matter in events with a hadronically decaying W or Z boson and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector

PHYS REV LETT, 112:(4) Paper 041802. 17 p. (2014)

2. Aad G et al. incl. Pasztor G, Toth J [2935 authors]: Search for quantum black hole production in high-invariant-mass lepton + jet final states using pp collisions at $\sqrt{s} = 8$ TeV and the ATLAS detector. **PHYS REV LETT**, 112:(9) Paper 091804. 20 p. (2014)
3. Aad G et al. incl. Pasztor G, Toth J [2881 authors]: Evidence for Electroweak Production of $W^\pm W^\pm jj$ in pp Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector. **PHYS REV LETT**, 113: Paper 141803. 20 p. (2014)
4. Aad G et al. incl. Pasztor G, Toth J [2899 authors]: Measurements of Four-Lepton Production at the Z Resonance in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with ATLAS. **PHYS REV LETT**, 112: Paper 231806. 20 p. (2014)
5. Aad G et al. incl. Pasztor G, Toth J [2919 authors]: Search for Invisible Decays of a Higgs Boson Produced in Association with a Z Boson in ATLAS. **PHYSICAL REVIEW LETTERS** 112: Paper 201802. 19 p. (2014)
6. Aad G et al. incl. Pasztor G, Toth J [2891 authors]: Search for Scalar Diphoton Resonances in the Mass Range 65-600 GeV with the ATLAS Detector in pp Collision Data at $\sqrt{s} = 8$ TeV. **PHYS REV LETT**, 113:(17) Paper 171801. 18 p. (2014)
7. Aad G et al. incl. Pasztor G, Toth J [2884 authors]: Observation of an excited B_c meson state with the ATLAS detector. **PHYS REV LETT**, 113:(21) Paper 212004. 19 p. (2014)
8. Aad G et al. incl. Pasztor G, Toth J [2935 authors]: Measurement of the top quark pair production charge asymmetry in proton-proton collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector. **J HIGH ENERGY PHYS**, (2) Paper 107. 38 p. (2014)
9. Aad G et al. incl. Pasztor G, Toth J [2898 authors]: Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector. **J HIGH ENERGY PHYS**, 2014:(4) Paper 169. 45 p. (2014)
10. Aad G et al. incl. Pasztor G, Toth J [2891 authors]: Search for top quark decays $t \rightarrow qH$ with $H \rightarrow \gamma\gamma$ using the ATLAS detector. **J HIGH ENERGY PHYS**, 2014:(6) Paper 008. 22 p. (2014)
11. Aad G et al. incl. Pasztor G, Toth J [2887 authors]: Search for supersymmetry at $\sqrt{s} = 8$ TeV in final states with jets and two same-sign leptons or three leptons with the ATLAS detector. **J HIGH ENERGY PHYS**, 2014:(6) Paper 035. 49 p. (2014)
12. Aad G et al. incl. Pasztor G, Toth J [2900 authors]: Search for direct top-squark pair production in final states with two leptons in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, 2014:(6) Paper 124. 61 p. (2014)
13. Aad G et al. incl. Pasztor G, Toth J [2886 authors]: Search for supersymmetry in events with large missing transverse momentum, jets, and at least one tau lepton in 20 fb⁻¹ of $\sqrt{s} = 8$ TeV proton-proton collision data with the ATLAS detector. **J HIGH ENERGY**

PHYS, (9) Paper 103. 54 p. (2014)

14. Aad G et al. incl. Pasztor G, Toth J [2875 authors]: Measurement of the production cross-section of $\psi(2S) \rightarrow J/\psi(\rightarrow + -)\pi^+\pi^-$ in pp collisions at $\sqrt{s} = 7$ TeV at ATLAS. **J HIGH ENERGY PHYS**, (9) Paper 079. 49 p. (2014)
15. Aad G et al. incl. Pasztor G, Toth J [2881 authors]: Search for microscopic black holes and string balls in final states with leptons and jets with the ATLAS detector at $\sqrt{s} = 8$ TeV. **J HIGH ENERGY PHYS**, (8) Paper 103. 48 p. (2014)
16. Aad G et al. incl. Pasztor G, Toth J [2886 authors]: Search for direct production of charginos, neutralinos and sleptons in final states with two leptons and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, (5) Paper 71. 52 p. (2014)
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18. Aad G et al. incl. Pasztor G, Toth J [2914 authors]: Measurement of the production cross section of prompt J/ψ mesons in association with a $W \pm$ boson in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, 04: Paper 172. 36 p. (2014)
19. Aad G et al. incl. Pasztor G, Toth J [2878 authors]: Search for squarks and gluinos with the ATLAS detector in final states with jets and missing transverse momentum using $\sqrt{s} = 8$ TeV proton-proton collision data. **J HIGH ENERGY PHYS**, (9) Paper 176. 52 p. (2014)
20. Aad G et al. incl. Pasztor G, Toth J [2892 authors]: Measurements of fiducial and differential cross sections for Higgs boson production in the diphoton decay channel at $\sqrt{s} = 8$ TeV with ATLAS. **J HIGH ENERGY PHYS**, (9) Paper 112. 61 p. (2014)
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22. Aad G et al. incl. Pasztor G, Toth J [2900 authors]: Measurement of the low-mass Drell-Yan differential cross section at $\sqrt{s} = 7$ TeV using the ATLAS detector. **J HIGH ENERGY PHYS**, (6) Paper 112. 46 p. (2014)
23. Aad G, et al. incl. Pasztor G, Toth J [2883 authors]: Search for strong production of supersymmetric particles in final states with missing transverse momentum and at least three b-jets at $\sqrt{s} = 8$ TeV proton-proton collisions with the ATLAS detector. **J HIGH ENERGY PHYS**, (10) Paper 24. 53 p. (2014)
24. Aad G et al. incl. Pasztor G, Toth J [2879 authors]: Measurement of the Z/γ^* boson transverse momentum distribution in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, (9) Paper 145. 47 p. (2014)

25. Aad G et al. incl. [Pasztor G](#), [Toth J](#) [2882 authors]: Search for new particles in events with one lepton and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, (9) Paper 037. 43 p. (2014)
26. Aad G et al. incl. [Pasztor G](#), [Toth J](#) [2883 authors]: Search for direct pair production of the top squark in all-hadronic final states in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, (9) Paper 015. 51 p. (2014)
27. Aad G et al. incl. [Pasztor G](#), [Toth J](#) [2960 authors]: Measurement of χ_{c1} and χ_{c2} production with $\sqrt{s} = 7$ TeV pp collisions at ATLAS. **J HIGH ENERGY PHYS**, (7) Paper 154. 52 p. (2014)
28. Aad G et al. incl. [Pasztor G](#), [Toth J](#) [2901 authors]: Measurement of the production of a W boson in association with a charm quark in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. **J HIGH ENERGY PHYS**, (5) Paper 068. 67 p. (2014)
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See also: R-H. CMS Collaboration, R-H. NA49 Collaboration, R-I. NA61/SHINE Collaboration