

LAWRENCE R. SULAK - CURRICULUM VITAE

EDUCATION

1971	Ph.D., 1968 A.M., Physics, Princeton University, Advisor: Val L. Fitch, 1980 Nobel Laureate Thesis: "A Precise Measurement of the $K_1^0 - K_2^0$ Mass Difference" (the first at the 0.5% level, cited 15 times)
1966	B.S., Physics, Carnegie Mellon University, citation: "highest academic record in the class of 1966" Advisor: Lincoln Wolfenstein

POSITIONS & ASSOCIATIONS AFTER HIGHEST DEGREE

CURRENT

2013-present	CMS/HCAL Advisory Board
2010-present	Attaché scientifique, Physicien, European Center for Nuclear Research (CERN), Geneva, Switzerland
2009-present	Member, Boston Energy & Environment Forum: BU, Harvard & MIT physicists and engineers providing evaluation to Congress and the public energy and environmental security; co-author of white paper
2009-present	Founding Director, Boston University/CERN Undergraduate Physics Semester Abroad Program, only one in the world
2008-present	"Keep Physicist Bill Foster in Congress," Finance Committee Member
1990-present	David M. Myers Distinguished Professor, Boston University Endowed Chair

PAST

2014-15	Chairman, US CMS/HCAL Institution Board
2013-15	HCAL Radiation Damage Task Force
2012-2014	US CMS Upgrade Steering Committee, member
2013-2014	Search Committee for Fermilab Director, Fermi Research Alliance
2012-14	HCAL Upgrade 1 Implementation Committee, reporting to Slawek Tkaczyk
2011-2014	Board of Directors, Fermi Research Alliance (operator of Fermilab for the DOE)
2011-2013	Chairman, US/CMS/HCAL Collaboration Board
2011-2013	Member, CERN Delegation with Ecuador to sign Protocol for Collaboration on Education, Science and Engineering
2011-2013	Lead delegate, CERN Delegation to Tunisian to draft Protocol for Collaboration on Education, Science and Engineering
2011-13	CMS Upgrade Steering Committee, for Jeff Spalding and Didier Contrado
2010-12	Ass't to Project Manager of CMS HCAL at CERN, Fermilab funding
2010-2014	Technical Advisor to CMS-HCAL Project Manager, to CMS-HCAL Integration Manager, and to CMS Upgrade Manager
2009-2011	CMS HCAL Upgrade Taskforce
2007-2008	External Advisory Board, Member, "Physics Frontier Center" Proposal, Institute for Advanced Study, Princeton, NJ
2006-2011	Board of Directors, University of Quito, Ecuador, in part for initiating BU/Quito scientific collaborations
2003-2005	Guggenheim Foundation Fellow. Project: launching Antares Neutrino Observatory and scaling it to Km^3
2003-2005	Visiting Professor, University of the Mediterranean, Luminy, Marseille, France
2003-2005	Senior Research Scientist, Center for Particle Physics of Marseille (CPPM), Marseille, France
2003	Institut de Français, Villefranche-sur-Mer, France, Diplôme de la langue française
2001-2007	Fellow, University Professors Program, Boston University
1993-1994	Distinguished Visiting Scientist, IN2P3 and CEA, Centre d'Etude, Saclay, Gif-sur-Yvette, France
1985-2005	Chairman, Professor of Physics, Boston University; built Physics and facilities to rank among all private US institutions: 1st in citations/paper and 9th or better in # of refereed papers, # of citations, and in external funding (2003 statistics from Spirex, AIP, and the Institute for Scientific Information)
1979-1981	Harvard University, Visiting Professor of Physics, Cambridge, MA
1979-1984	Associate Professor of Physics (with tenure), University of Michigan, Ann Arbor, MI
1975-1979	Harvard University, Associate Professor of Physics, Cambridge, MA
1974-1978	Guest Associate Physicist, Brookhaven National Laboratory, Upton, NY
1971-1976	Visiting Physicist, Fermi National Accelerator Laboratory, Batavia, IL
1971-1975	Harvard University, Assistant Professor of Physics, Cambridge, MA
1970-1971	Chargé de Recherche, Département de Physique Nucléaire et Corpusculaire, Université de Genève
1970-2010	Visiting Scientist, European Center for Nuclear Research (CERN), Geneva, Switzerland

AWARDS & HONORS

2017	Panofsky Prize, the top APS award for an experimental physicist. For the invention of massive ring-imaging Cherenkov calorimetry, the critical technology for some 10 detectors on 4 continents studying neutrino oscillations and searching for proton decay. LRS has also evolved this technology into the forward quartz calorimeter of CMS at the LHC.
2017	Instrumentation Prize, American Physical Society, Division of Particles & Fields. Citation similar to that of Panofsky Prize.
2015	Founding co-PI of Super-K, honored by the Nobel Prize in Physics for the Discovery of Neutrino Oscillations. Both Super-K and the SNO detector, which shared the prize, are second-generation versions of IMB, the pioneering ring-imaging calorimeter invented and developed by LRS.
2015	Physics Breakthrough Prize in Fundamental Physics, shared with SNO and collaborators in Super-K
2011	Distinguished Lecture, "Recreating the Big Bang", All Ecuador Science Convocation, including radio interview
2006	Most Distinguished Alumnus Award, Carnegie Mellon University
2006	All University Lecture, Carnegie Mellon University
2005	Marseille Research Award, for Seminal Contributions to Antares Neutrino Observatory
2001-2007	Fellow, University Professors Program, Boston University
1998	One of 10 "Greatest Science Achievements of 1998: Discovery of neutrino mass," awarded by <i>Popular Science</i> to Super-K
1998	ASAHI Prize, "Discovery of the Finite Mass of Neutrinos," shared with Super-K collaborators
1992	"Faces & Names to Watch..." <i>Boston Magazine</i> (see Vol. 48, No. 12, 1992)

1992-present	Who's Who in Science and Engineering
1990-present	David M. Myers Distinguished Professor, Boston University
1989	Bruno Rossi Prize, American Astronomical Society for "Discovery of Neutrinos from Supernova 1987a" awarded to the IMB collaboration
1984	Outstanding Young Scientist Award, "America's 100 Brightest Scientists," <i>Science Digest</i> (December 1984)
1984-1986	Faculty Research Honorary Society, University of Michigan Research Club
1984-present	Fellow, American Physical Society
1966-1970	National Science Foundation Fellow, Princeton University
1966-present	Omicron Delta Kappa National, Leadership Honor Society
1963	1963 Outstanding Freshman Physicist, awarded by Carnegie Mellon University
1962-1966	Alfred Noyes Smith Scholar, Carnegie Mellon University

PUBLICATIONS

Before papers appeared from CMS at the LHC in 2012, LRS played a role in > 500 papers cited > 40,000 times. He played a significant role in 22 renown (500+ cites in INSPIRE*), 15 famous (250-499 cites), 52 very well-known (100-249), 58 well-known (50-99), and 203 known papers (10-49 cites). This was on research with neutrinos at Fermilab and Brookhaven, with muons at the g-2 ring at BNL, and with ring-imaging Cherenkov calorimetry, proton decay and neutrino oscillations in IMB, Macro, Super-K, and Antares.

Since 2011, LRS has papers from CMS on the quartz fiber calorimetry and on the Higgs boson discovery. Since the start of LHC publications, LRS appears in the CMS author list of > 330 additional published papers with > 17,000 citations.

In 2015 LRS was co-author on 139 refereed journal articles, essentially all with CMS collaborators, in the top particle physics journals, Phys Rev, PRL, and Phys. Let. These were cited over 3,470 times. The LRS was instrumental in 9 of those papers. 2016 was similar to 2015.

RESEARCH FUNDING

2011-present	DOE awards as co-PI for 1) Super-K and T2K and 2) Physics with CMS Detector at the Large Hadron Collider at CERN 3) The BU Undergraduate Internship Program at CERN
2010-12	Fermilab funding, Ass't to Project Manager of CMS HCAL, CERN
1986	Initiator of U.S. Department of Energy Grant at Boston University; PI or Co-PI of 3 tasks 1) Proton Decay and Neutrino Astrophysics (including IMB to '90, MACRO to '96, Antares Neutrino detector 2003-05), 2) Muon g-2 Experiment, 3) CMS Forward Cherenkov Calorimeter
1978-1984	Founder of IMB Proton Decay DOE Task at University of Michigan, transferred from initial work at Harvard
1971-1978	Particle Physics Contract, US DOE, Neutrino Task for National Accelerator Lab and Brookhaven, Harvard University

SELECTED RECENT SCIENTIFIC PRESENTATIONS

2017	"Directional Calorimetry for Massive Detectors", APS Award Ceremony, Annual DPF Meeting, Fermilab
2017	"Discovery of The Source of mass at the LHC Collider", STARS 2017 Conference, Havana Cuba
2016	"Back from the Nobel Prize Ceremony: Gigatesque Detectors Weigh the Lightest of Particles," public lecture, BWI.
2015	Nobel Ceremony Colloquium, Uppsala University, "Pioneering History of the Discovery of Neutrino Oscillations"
2015	"Catching Neutrinos from the Stars", External Examiner Presentation, PhD candidature of Rikard Strom, Uppsala University
2014	Colloquium Boston College, "It really looks like, and quacks like, the Boson of Peter Higgs"
2013	"Gerontocracy in Physics?" PBS News Hour interview by Paul Solomon, with Sheldon Glashow Saturday Morning Live, Goodwin House, Alexandria VA, "Without those 'sticky' Higgs bosons, you'd be traveling at light speed" Special Lecture, Maranatha Collegiate Academy, BWI, "The Discovery of the Origin of Mass" Distinguished Lecture, Dartmouth College, "Discovery of the Source of mass at the LHC?"
2012	IXth Latin American Symposium on High Energy Physics, "Jet Production and Properties at Hadron Colliders" Sao Paulo, Brazil, joint contribution for both CMS and ATLAS Collins Memorial Lecture, Massachusetts General Hospital "Without those 'sticky' Higgs bosons, you'd be traveling at light speed" Colloquium, Gran Sasso National Laboratory, "Observation of a new fundamental boson?...and future prospects, upgrades, etc." Seminar, US DOE, Germantown, "A head-start in international physics for American undergrads: The BU Internship at CERN" Seminar, US DOE, Germantown, "Fermilab as Viewed from Abroad"
2011	All Ecuador Symposium on Particle Physics, National Concert Hall, Quito "Recreating the Birth of our Universe," in Spanish Conference on CERN Physics, Ministry of Education and Research, Quito, "CMS, CERN and Ecuador", in Spanish Conference on CERN Physics, Ministry of Technology and Higher Education, Tunis, "CMS, CERN and Tunisia", in French
2010	All BU Undergraduate Lecture, "From the Big Bang...to the death of the Universe," inaugural lecture, "Conversations with Physicists" series
2009	"Irradiation Studies of Silicon Photomultipliers," CMS Upgrade Workshop, Fermilab "Resuscitation of the CMS Forward Hadronic Calorimeter," HCAL Upgrade Workshop Inaugural talk, "Observations from the Antares Neutrino Telescope," Boston University Particle Physics Seminar Series "The Boston Junior Semester at CERN," University of Geneva, Switzerland
2008	Keynote presentation: "La naissance de l'astronomie du neutrino et son avenir," joint with R. Aymar, CERN Director General, at 25th Anniversary Symposium, Center for Particle Physics, Marseille, France (delivered in French) Colloquium, McGill University, "The Birth of Neutrino Astronomy," Montreal, Canada
2007	"Forward Cherenkov Calorimetry at CMS," Center for Particle Physics, University of Marseille, France University Professors Program Lecture, "Cosmology for the Layman: from the big bang to the demise of the universe,"
2006	Collins Lecture, "Are diamonds forever? the Demise of the Proton," Massachusetts General Hospital, Boston

- All University Lecture, Carnegie Mellon University, "From the Big Bang...to the demise of the Universe,"
- 2005 Invited talk, International Conference on the High Energy Frontier, "The Future of Cherenkov Ring-Image Calorimetry," HIF '05, Elba, France, May 28-June 1, 2005
- Biannual Antares Collaboration Meeting, CERN, "Status of Electronic Development for Antares," January 2005
- Invited presentation to Region of Aix-en-Provence, France: "The Value of the ITER Project to Science," Co-presenters: Mayor of Aix; President of Region of Aix; Director, Cadarache Nuclear Research Lab (French Los Alamos)
- Invited talk, 40th Rencontre de Moriond, "Searches for Proton Decay and Neutrino Oscillations: Physics from Cherenkov Ring-Image Calorimetry," French Physical Society International Conference, March 2005
- Invited talk, Rencontre d'Aosta, "Progress of the Antares Experiment," Italian Physical Society International Conference
- National Presbyterian School, Washington DC, November 21-26, 2005, series of 4 lecture/demonstrations
- 2004 Invited presentation, 25th International Neutrino Conference, Paris, France
- Invited speaker, CPPM Conference on the Future of Particle Physics in Europe, "Megaton and Cubic Kilometer Detectors: the non-accelerator future for particle physics,"
- Featured speaker to Ministers of Science from France, Germany, Italy, Great Britain, and Spain, Inauguration of Antares Neutrino Observatory
- Invited presentation, Ecole Polytechnique, Rene Turlay Memorial Conference, Paris
- 3 Invited talks, Int'l School for Particle Astrophysics, Erice, Italy: on Super-K, K2K, and Antares

SELECTED SCIENTIFIC PUBLICATIONS

Discovery of a Fundamental Boson, consistent with the Higgs particle that completes the Standard Model, with collaborators at CMS. Invented and prototyped the forward Cherenkov quartz-fiber calorimeter essential to observing the boson produced in the vector boson fusion channel. "Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC," CMS Collaboration (Serguei Chatrchyan (Yerevan Phys. Inst.) et al.). Jul 2012. Phys.Lett. B716 (2012) 30-61. j.physletb.2012.08.021. e-Print: arXiv:1207.7235. LRS contributed to the H → WW → lνlν analysis. (>680 cites)

Discovery of Oscillation of Neutrinos and of Neutrino Mass...first physics beyond the Standard Model 1978 - 1998

First proposal for a massive underground ring-imaging water Cherenkov detector, focusing on both the detection of proton decay and the identification of the critical signature for neutrino oscillations (the ratio of muon- to electron-neutrino induced events).

"Studies of a Detector to Test for Baryon Stability to a Lifetime of 10^{33} Years," L. R. Sulak, Proceedings of the Seminar on Proton Stability, Madison (D. Cline, ed.) 8 December 1978, p. A1; also Harvard University Particle Physics Preprint HUPP 252. "A Nucleon Decay Search: Design of a New Experiment Sensitive to a Lifetime of 10^{33} Years," B. Cortez et al., Int'l Conf. on Neutrino Physics 1979 (A. Haadtuft and C. Jarlskog, ed.), Trykk: Astvedt Industrier A/S, Vol. 3 (1979), p. 121.

First proposal of the up/down asymmetry technique to search for neutrino oscillations, which led to their discovery.

"A Long Baseline Neutrino Oscillation Experiment Sensitive to Mass Differences of Hundredths of an Electron Volt", B. Cortez and L.R. Sulak, Unification of the Fundamental Particle Interactions (S. Ferrara, J. Ellis, and P. Van Nieuwenhuizen, eds.) Erice, March 17-24, 1980, Plenum Press, (1980), pp. 661-671.

"The Irvine-Michigan-Brookhaven Nucleon Decay Facility: Status Report on a Proton Decay Experiment Sensitive to a Lifetime of 10^{33} Years," and a Long Baseline Neutrino Oscillation Experiment Sensitive to Mass Differences of Hundredths of an Electron Volt, L. Sulak, First Workshop on Grand Unification (Paul H. Frampton, Sheldon L. Glashow, Asim Yildiz, eds.), April 10-12, Math Sci. Press, University of New Hampshire, (1980), p. 163.

"Neutrino Oscillation Search With Cosmic Ray Neutrinos," D.S. Ayres, B. Cortez, T. K. Gaisser, A.K. Mann, R. E. Shrock, L. R. Sulak. Phys. Rev. D29:902,1984. (>30 cites)

With the IMB detector, the first observation of a muon deficit in the cosmic ray atmospheric neutrino, after only one live year of data taking.

"A Search for Nucleon Decay Into Lepton and K^0 ," B. Cortez, Harvard University Ph.D. Thesis, PhD advisor: LRS, September 1983

First refereed publication of a deficit of atmospheric muon neutrinos (relative to the number of electron neutrinos), precursor to the discovery of neutrino oscillations:

"Calculation of Atmospheric Neutrino Induced Backgrounds in a Nucleon Decay Search," T.J. Haines et al., Phys. Rev. Lett. 57, (1986) (107 cites)

"Measurement of Atmospheric Neutrino Composition with IMB-3, D. Casper *et al.*, Phys. Rev. Lett. 66, p 2561, 1991. PhD thesis, LRS as PhD advisor. (>570 cites)

"The Electron-neutrino and muon-neutrino content of the atmospheric flux," R. Becker-Szendy *et al.* Phys.Rev.D46:3720-3724, 1992. (>750 cites)

"Neutrino measurements with the IMB detector," R. Becker-Szendy *et al.* 1995, Nucl.Phys.Proc.Suppl.38:331-336, 1995. (>180 cites)

"A Search for muon-neutrino oscillations with the IMB detector," R. Becker-Szendy *et al.* Phys.Rev.Lett.69:1010-1013,1992. (>170 cites)

"IMB-3: A Large water Cherenkov detector for nucleon decay and neutrino interactions," R. Becker-Szendy *et al.* Nucl. Instrum. Meth. A324:363-382,1993. (>35 cites)

Super-K high statistics proof of the oscillation of muon neutrinos and the unexpected non-zero mass of the neutrino, the first observation of physics beyond the standard model. This paper cited >3400 times; the series of papers on this topic has been cited over 4600 times, the most highly cited

experimental particle physics work ever. "Evidence for Oscillation of Atmospheric Neutrinos," Y. Fukuda et al., Phys. Rev. Lett. 81 (1998) p. 1562-1567. (>3400 cites)

"Measurement of a small atmospheric muon-neutrino / electron-neutrino ratio," By Super-Kamiokande Collaboration (Y. Fukuda *et al.*). Phys.Lett.B433:9-18,1998. e-Print: hep-ex/9803006 (>815 cites)

Super-K demonstration that oscillations of muon neutrinos most likely into tau neutrinos. "Tau Neutrinos Favored Over Sterile Neutrinos in Atmospheric Muon Neutrino Oscillation," S. Fukuda et al., Super-Kamiokande Collaboration, Phys. Rev. Lett. (2000). (>760 cites)

Accelerator muon-neutrinos from KEK to Super-K (the K2K experiment) oscillate as atmospheric neutrinos 1998

Confirmation that accelerator muon-neutrinos oscillate with the same characteristics as atmospheric neutrinos.

"Detection of accelerator produced neutrinos at a distance of 250-km," by K2K Collaboration (S.H. Ahn *et al.*). Phys.Lett.B511:178-184, 2001. e-Print: hep-ex/0103001 (>270 cites)

"Evidence for muon neutrino oscillation in an accelerator-based experiment," by K2K Collaboration (E. Aliu *et al.*). Phys. Rev. Lett.94:081802, 2005. e-Print: hep-ex/0411038 (>360 cites)

"Measurement of Neutrino Oscillation by the K2K Experiment," by K2K Collaboration (M.H. Ahn *et al.*) Phys.Rev.D74: 072003, 2006. e-Print: hep-ex/0606032 (>270 cites)

Discovery of Neutrinos from a Supernova collapse 1987

First observation of extra-galactic neutrinos from the gravitational collapse of a supernova (also observed by the Kamiokande Detector).

"Observation of a Neutrino Burst in Coincidence with Supernova 1987A in the Large Magellanic Cloud," R.M. Bionta, *et al.*, Phys. Rev. Lett., Vol. 58, No. 14 (6 April 1987), p. 1494. Bionta was LRS' postdoc (>773 cites)

"Angular Distribution Of Events From SN1987a," by IMB Collaboration (C.B. Bratton *et al.*) Phys.Rev.D37:3361,1988. (>105 cites)

Searches for the Ultimate Decay of the Proton and for Grand Unification 1983

First limit on proton lifetime at Grand Unification scale, 5 orders of magnitude better than previous measurements. Elimination of simplest and most elegant theory, SU5. LRS PI, originator of technology and founding advocate of H₂O ring-imaging Cherenkov calorimetry.

"A Search for Proton Decay into $e^+ \pi^0$," R.M. Bionta *et al.*, Phys. Rev. Lett., Vol. 51, No. 1, 27 (4 July 1983) (>150 cites)

"Search for Nucleon Decay into $\mu^- K^0$ and νK^0 ," B. G. Cortez et al., Phys. Rev. Lett., Vol., 52 (26 March 1984). (>30 cites)

Limits on 44 decay modes of the nucleon, many remain world records to date.

"A Search for Nucleon Decay Using the IMB-3 Detector," C. McGrew *et al.*, Phys. Rev. D59 (1999) p. 5204.

"Massive Cherenkov neutrino facilities: their evolution, their future," Celebration of Twenty-five years of international neutrino conferences. L.R. Sulak (Boston U. & Marseille, CPPM). 2005. 10pp. 21st International Conference on Neutrino Physics and Astrophysics (Neutrino 2004), Paris, France, 14-19 Jun 2004. Published in Nucl. Phys. Proc. Suppl. 143:317-326, 2005. Also in "Paris 2004, Neutrino physics and astrophysics" 317-326

Neutrino astronomy: Development of Massive Water Ring-Imaging Calorimetry for IMB, Super-K, and Antares 1976 - present

First conceptual design for a massive undersea ring-imaging water Cherenkov detector

"Signatures of High Energy Neutrino Interactions and their Detection Via Cherenkov Light", L.R. Sulak et al., Proceedings of the 1976 DUMAND Summer Study, (A. Roberts, ed.) Honolulu, 6-19 September 1976, p. 297

"Search for dark matter wimps using upward through-going muons in Super-Kamiokande," S. Desai *et al.* Phys. Rev. D70:083523, 2004, Desai was LRS's PhD student; this is his thesis work.

"High energy neutrino astronomy using upward-going muons in Super-Kamiokande-I," K. Abe *et al.* Astrophys. J.652:198, 2006.

"First results of the Instrumentation Line for the deep-sea ANTARES neutrino telescope," by ANTARES Collaboration (J.A. Aguilar *et al.*). Astropart. Phys.26:314-324, 2006. e-Print: astro-ph/0606229 (>35 cites)

"Search for Diffuse Astrophysical Neutrino Flux Using Ultrahigh Energy Upward-Going Muons in Super-Kamiokande I," By Super-Kamiokande Collaboration (Molly E.C. Swanson *et al.*). Jun 2006. 10pp. Astrophys. J.652:206-215,2006. e-Print: astro-ph/0606126

Muon g-2 Experiment - development of fast waveform digitizers and fiber calorimetry at BU for the SSC + excellent physics

"Precise measurement of the positive muon anomalous magnetic moment," Muon g-2 Collaboration (H.N. Brown *et al.*). Feb 2001. Phys.Rev.Lett.86:2227-2231,2001. e-Print: hep-ex/0102017 (587 cites)

Development of Novel Detectors and their Technologies

"Very Large Proportional Drift Chambers With High Spatial And Time Resolutions," D.C. Cheng, W.A. Kozanecki, R.L. Piccioni, C. Rubbia, L.R. Sulak, H.J. Weedon, J. Whittaker *In the Proceedings of International Conference on Instrumentation for High-Energy Physics, Frascati, Italy, 8-12 May 1973, pp 268-274.* (>30 cites)

"A Liquid-Scintillator Total Absorption Hadron Calorimeter for the Study of Neutrino Interactions," A.C. Benvenuti *et al.*

Nucl.Instrum.Meth.125:447,1975. (>40 cites)

First demonstration of acoustic detection of particle showers, and its development

"Experimental Studies Of The Acoustic Signature Of Proton Beams Traversing Fluid Media," L. Sulak *et al.* Nucl.Instrum.Meth.161:203,1979. (>25 cites)

"Studies of a full-scale mechanical prototype line for the ANTARES neutrino telescope and tests of a prototype instrument for deep-sea acoustic measurements," M. Ageron *et al.* Nucl.Instrum.Meth.A581:695-708,2007.

Invention of wavelength shifting plates directly coupled to photomultipliers

"A Wave Shifter Light Collector For A Water Cherenkov Detector," R. Claus *et al.* Nucl.Instrum.Meth.A261:540-542, 1987. (>30 cites) (invented by LRS and Claus, his MS thesis student)

Complete development of Quartz - Fiber Cherenkov Calorimetry for Collider Detectors for GEM at SSC and CMS at LHC

"Beam test results from a fine-sampling quartz fiber calorimeter for electron, photon and hadron detection," N. Akchurin *et al.* Nucl. Instrum Meth.A399:202-226, 1997. (14 cites)

"Test beam results of CMS quartz fibre calorimeter prototype and simulation of response to high-energy hadron jets," N. Akchurin *et al.* Nucl.Instrum.Meth.A409:593-597,1998.

"Design, performance and calibration of the CMS forward calorimeter wedges," G. Bayatian *et al.* Eur.Phys.J.C53:139-166, 2008.

"CMS technical design report, volume II: Physics performance," by CMS Collaboration (G.L. Bayatian *et al.*). CERN-LHCC- J.Phys.G34:995-1579, 2007. (>360 cites)

The first observations of Neutral Currents

As lead analysis person of the first observations, concurrently with Gargamelle at CERN "Measurement of Rates for Muonless Deep Inelastic Neutrino and anti-neutrino Interactions," B. Aubert *et al.* Phys.Rev.Lett.32: 1457,1974. (>125 cites)

As co-spokesman and lead physicist in designing and building the world's largest drift chambers (4x4m) and calorimeter (100 T)

"Observation of Elastic Neutrino-Proton Scattering," D. Cline, A. Entenberg, W. Kozanecki, A.K. Mann, D.D. Reeder, C. Rubbia, J. Strait, L. Sulak, H.H. Williams, Phys.Rev.Lett.37:252-255,1976. (>140 cites)

"Observation of Elastic anti-neutrino - Proton Scattering," D. Cline, A. Entenberg, W. Kozanecki, A.K. Mann, D.D. Reeder, C. Rubbia, J. Strait, L. Sulak, H.H. Williams, Phys.Rev.Lett.37:648,1976. (>120 cites)

SELECTED SCIENTIFIC ADVISORY PANELS, EXPERIMENT SPOKESMANSHIPS, AND CONFERENCE ORGANIZATION

2012-present	US CMS Upgrade Steering Committee
2011-present	PAC Reviewer for CMS HCAL papers
2011-2013	Chairman, US/CMS/HCAL Collaboration Board
2011-2012	CMS co-organizer of 3 Production Readiness Reviews, CERN, for 1) Castor, 2) HCAL-HO, and 3) HCAL-HF
2011	Organizer, CMS HCAL Upgrade Workshop, Boston University
2010	NSF Educational Programs, Biennial review committee
2009	Rapporteur, Habilitation Committee for J. Brunner, "Neutrinos: From Oscillations to Astronomy," University of Marseille
2007	Review Board, NASA 5-Year Plan for Astrophysics Experiments
2002	Experts Panel on Physics in Next 10 Years, Canadian Foundation for Innovation. Funded expansion of SNO Laboratory
1998	Convener of Astrophysics Sessions, International Conference on High Energy Physics,
1997	Advisory committee, Int'l Workshop in Supernova Early Detection Network
1995-1996	Int'l Advisory Committee, Int'l Workshops on Proton Decay and Neutron-Antineutron Oscillations,
1994-1996	Technical Board, CMS Detector for the Large Hadron Collider (LHC) at CERN
1994-present	Collaboration Council of CMS
1994-1996	Spokesman, Forward (Quartz Fiber) Calorimetry Detector Group, CMS Collaboration, LHC, CERN
1994-1996	Co-Spokesman of the Forward Calorimeter, CMS
1993-1994	Ten Year Review Committee, French National Plan for Science and Education Policy
1993-1994	Program Advisory Committee, Dep't of Physics, Astrophysics and Instrumentation, Centre d'Etude, Saclay
1993-1995	Co-chairman, United Nations OECD Forum on Megascience, Commission on Astroparticle Physics
1990-1992	Int'l Advisory Committee, Theoretical and Phenomenological Aspects of Underground Physics
1988-1992	Co-Spokesman, TEXAS Detector for the Superconducting Super Collider
1987-1991	HEPAP member, U.S. Department of Energy High Energy Physics Advisory Panel
1984-1988	Scientific Program Committee, National Institute of Nuclear Physics, Italy, Gran Sasso National Laboratory
1984-1985	National Science Policy Committee, Interministerial Commission for Scientific Research, Spain
1984-1986	Executive Committee, Division of Particles and Fields, American Physical Society
1983	Natural Sciences & Engineering Research Council, Committee on New Canadian Projects in Particle Physics
1981	HEPAP subpanel on Long Range Planning, U.S. Department of Energy High Energy Physics Advisory Panel
1980-1982	Executive Committee, Division of Particles and Fields, American Physical Society,

FORMER STUDENTS now accomplished physicists (and their current affiliations)

Former undergraduate mentees: Prof. H. Baranger (Duke), Steve Biller (Oxford), Mark Bregman (VP, Symantec), Rob Cormac (MGH), Prof. George Gollin (Illinois), Prof. David Hanna (McGill), Michael Hedges (Hawaii), Prof. Kay Kinoshita (Kentucky), Harold Lessure (Carnegie-Mellon), Prof. Leonid Levin (Lausanne & PSI), Mike Levy (LBL), Prof. Peter Meyers (Princeton), Prof. Rene Ong (UCLA), Prof. Mark Robbins (Johns Hopkins), Prof. Martin Rocek (Rockefeller), Prof. Marjorie Shapiro (former Physics Chair, Berkeley), Prof. Wesley Smith (Wisconsin, CMS Trigger Director), Prof. Alan Sokal (NYU), Prof. A. Strominger (Harvard)

Former PhD advisees and post-doctoral fellows: Dr. Richard Bionta (Lawrence Livermore Lab), Prof. Dave Casper (Irvine), Dr. Rick Claus (SLAC), Dr. Bruce Cortez (AT&T), Dr. Shantanu Desai (Penn State), Prof. Steve Dye (U. of Hawaii), Dr. Bill Foster (US Congressman & former Fermilab Director of Research), Mark Greenberg, Prof. A. Heister (Aachen), Prof. Joe Incandella (UCSB, former spokesman of CMS), Prof. Soo-Bong Kim (Seoul National), Dr. Witold Kozanecki (SLAC & Saclay), Phil Lawson (Jaguar/Land Rover Labs), Dr. Andre Rosovsky (Saclay), Kate Scholberg (Duke), Prof. Sally Seidel (New Mexico), Dr. Jim Strait (Accelerator Director, Fermilab), William Worstell (PhotoDiagnostic, Inc.), Prof. Chris Walter (Duke).

Former graduate student mentees: Dr. Douglas Brown (KEK, Japan), Dr. Sandra Ciocio (Lawrence Berkeley Laboratory) Dr. Robert Cormac (Head, Radiation Oncology, Harvard Med), Fanny Dufour (University of Geneva), Prof. Chris Henley (Cornell), Sonia Karkar (University of Strasbourg), Prof. Charling Tao (Univ. Marseille and Tsinghua)

Former undergrad mentees, now high school physics teachers: Barbara Kerosky Franks, Dan Welty

SELECTED REFEREED PAPERS PAPERS ON LHC/CMS, BEFORE 2017 Papers where LRS played a significant role are listed below, all utilizing the Forward Cherenkov Calorimeter of CMS, invented by LRS initially for the SSC. These were selected from the 126 papers produced by the very large CMS authorship, and have been cited 2299 times, including 3 very well known (100-249), 5 well-known (50-99), and 64 known papers (10-49 cites).

Vector boson fusion channel of Higgs production, using, in part, tagging jets of the forward calorimeter

1) “Observation of a new boson with mass near 125 GeV in pp collisions at $\sqrt{s} = 7$ and 8 TeV” CMS Collaboration (Serguei Chatrchyan et al.). Mar 19, 2013. 117 pp. Published in JHEP 1306 (2013) 081, e-Print: arXiv:1303.4571 [hep-ex] 76 cites

Missing Energy Signatures, using the hermiticity provided by the forward calorimeters

2) “Search for new physics in events with opposite-sign leptons, jets, and missing transverse energy in pp collisions at $\sqrt{s}=7$ TeV” CMS Collaboration (Serguei Chatrchyan et al.). Published in Phys.Lett. B718 (2013) 815-840, e-Print: arXiv:1206.3949 [hep-ex] 31 cites

3) “Search for a standard-model-like Higgs boson with a mass in the range 145 to 1000 GeV at the LHC” CMS Collaboration (Serguei Chatrchyan et al.). Mar 31, 2013. Published in Eur.Phys.J. C73 (2013) 2469, e-Print: arXiv:1304.0213 [hep-ex] 29 cites

4) “Studies of jet mass in dijet and W/Z + jet events” CMS Collaboration (Serguei Chatrchyan et al.). Mar 19, 2013. 49 pp. Published in JHEP 1305 (2013) 090, e-Print: arXiv:1303.4811 [hep-ex] 16 cites

5) “Search for pair-produced dijet resonances in four-jet final states in pp collisions at $\sqrt{s} = 7$ TeV” CMS Collaboration (Serguei Chatrchyan et al.). Feb 3, 2013. 23 pp. Published in Phys.Rev.Lett. 110 (2013), e-Print: arXiv:1302.0531 [hep-ex] 19 cites

6) “Search for new physics in final states with a lepton and missing transverse energy in pp collisions at the LHC” CMS Collaboration (Serguei Chatrchyan et al.). Feb 12, 2013. 25 pp. Published in Phys.Rev. D87 (2013), e-Print: arXiv:1302.2812 [hep-ex] 7 cites

7) “Search for supersymmetry in pp collisions at $\sqrt{s}=7$ TeV in events with a single lepton, jets, and missing transverse momentum” CMS Collaboration (Serguei Chatrchyan et al.). 57 pp. Published in Eur.Phys.J. C73 (2013) 2404, e-Print: arXiv:1212.6428 [hep-ex], 12 cites

8) “Search for supersymmetry in events with photons and low missing transverse energy in pp collisions at $\sqrt{s}=7$ TeV” CMS Collaboration (Serguei Chatrchyan et al.). Published in Phys.Lett. B719 (2013), e-Print: arXiv:1210.2052 [hep-ex] 14 cites

9) “Search for new physics in events with photons, jets, and missing transverse energy in pp collisions at $\sqrt{s}=7$ 13 TeV” CMS Collaboration (Serguei Chatrchyan et al.). 49 pp. Published in JHEP 1303 (2013), e-Print: arXiv:1211.4784 [hep-ex], 14 cites

Studies of Jets, with major contributions from Phil Lawson, LRS’s graduate student

10) “Studies of jet mass in dijet and W/Z + jet events” CMS Collaboration (Serguei Chatrchyan et al.). Mar 19, 2013. 49 pp. Published in JHEP 1305 (2013) 090, e-Print: arXiv:1303.4811 [hep-ex] 16 cites

REFEREED PUBLICATIONS in 2017 in which LRS played a significant role:

Physics Results using CMS Hadron Forward Calorimeter, developed by LRS.

1) “Electroweak production of two jets in association with a Z boson in proton-proton collisions at $\sqrt{s} = 13$ TeV.” CMS Collaboration (Albert M Sirunyan (Yerevan Phys. Inst.) et al.). Dec 28, 2017. CMS-SMP-16-018, CERN-EP-2017-328. e-Print: arXiv:1712.09814. Submitted to Eur. Phys. J. C.

2) “Measurements of differential production cross sections for a Z boson in association with jets in pp collisions at $\sqrt{s} = 8$ TeV.” CMS Collaboration (Vardan Khachatryan (Yerevan Phys. Inst.) et al.). Nov 11, 2016. 72 pp. Published in JHEP 1704 (2017) 022 CMS-SMP-14-013, CERN-EP-2016-256. DOI: 10.1007/JHEP04(2017)022. e-Print: arXiv:1611.03844

Physics Results from Super-K, a detector whose technology was developed by LRS

3) “Atmospheric neutrino oscillation analysis with external constraints in Super-Kamiokande I-IV.” Super-Kamiokande Collaboration (K. Abe (Yokohama Natl. U. & Kamioka Observ.) et al.). Oct 25, 2017. 22 pp. e-Print: arXiv:1710.09126

4) “Search for nucleon decay into charged antilepton plus meson in 0.316 megaton-years exposure of the Super-Kamiokande water Cherenkov detector.” Super-Kamiokande Collaboration (K. Abe (Kamioka Observ. & Tokyo U., IPMU) et al.). May 19, 2017. 18 pp. Published in Phys.Rev. D96 (2017) no.1, 012003 DOI: 10.1103/PhysRevD.96.012003 e-Print: arXiv:1705.07221

5) “Search for proton decay via $p \rightarrow e + \pi^0$ and $p \rightarrow \mu + \pi^0$ in 0.31 megaton-years exposure of the Super-Kamiokande water Cherenkov detector.” Super-Kamiokande Collaboration (K. Abe (Kamioka Observ. & Tokyo U., IPMU) et al.). Oct 12, 2016. 10 pp. Published in Phys.Rev. D95 (2017) no.1, 012004. DOI: 10.1103/PhysRevD.95.012004. e-Print: arXiv:1610.03597 [hep-ex]

Instrumentation of CMS Hadron Calorimeter, with contributions from LRS and his grad and undergrad students

6) “Jet energy scale and resolution in the CMS experiment in pp collisions at 8 TeV.” CMS Collaboration (Vardan Khachatryan (Yerevan Phys. Inst.) et al.). Jul 13, 2016. 92 pp. Published in JINST 12 (2017) no.02, P02014. CMS-JME-13-004, CERN-PH-EP-2015-305. DOI: 10.1088/1748-0221/12/02/P02014. e-Print: arXiv:1607.03663.

7) “Radioactive source calibration test of the CMS Hadron Endcap Calorimeter test wedge with Phase I upgrade electronics.” CMS HCAL Collaboration (S. Chatrchyan (Yerevan Phys. Inst.) et al.). 2017. Published in JINST 12 (2017) no.12, P12034

PHYSICS EDUCATION INITIATIVES

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|--------------|---|
| 2017-present | BU/CERN/Saudi Partnership for Empowerment of Women in Physics and Engineering, with HRS Princess Lolowah, founder, and President Haifa, Effat University, Jeddah, dedicated to the empowerment of undergraduate women students. |
| 2015-present | Designing an experiential MA Degree in Physics, based on e-Lab, AdLab, Computational Physics, and Materials Characterization, with many elective courses, with C. Chamon and K. Ludwig. |
| 2012-2016 | Transforming senior and graduate level “ <i>Electronics for Scientists</i> ” PY371/681 from a course based on 1988 technology to one emulating current work in the departments Scientific Facility, including C programming of microprocessors, with E. Hazen and D. Gastler. |
| 2010-present | Modernizing senior and graduate level “ <i>Advanced Laboratory</i> ” PY581. to one with state-of-the-art research stations and electronic data acquisition, with S. Ahlen and G. Zimmerman. |
| 2009-present | Conceiving, organizing and obtaining DOE funding for the only long duration undergraduate internship program at CERN, jointly with the Physics Department, University of Geneva. From January through August 15 juniors perform a research project side-by-side with a CERN mentor. During the school term, these are the only undergrads at CERN among the 5000 researchers. |
| 2005-2008 | “ <i>What every educated citizen should know: From the Big Bang to the Demise of the Universe,</i> ” developing and presenting modern physics lectures for large audience freshman non-scientists in the BU Core Curriculum. |

*Citation numbers are from the inSPIRE database of Stanford Linear Accelerator Center.