# Ilya Nemenman

born January 8, 1975, in Minsk, Belarus CV last updated on November 23, 2008 Current version available at: http://menem.com/~ilya/ Los Alamos National Laboratory PO Box 1663 CCS-3, MS B256 Los Alamos, NM 87545

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# **EDUCATION**

Princeton University, Physics, PhD 2000 San Francisco State University, Physics, MS 1997 Santa Clara University, Physics/Math, BS 1995 Belarusian State University, Theoretical Physics, 1991 – 1994

## **APPOINTMENTS**

| since 2008  | R&D Scientist 4 (the highest: 6), CCS-3, Los Alamos National Laboratory             |
|-------------|---|
| 2005 - 2008 | Technical Staff Member, CCS-3, Los Alamos National Laboratory                       |
| 2004 - 2005 | Associate Research Scientist (Research Assistant Professor), Joint Centers for Sys- |
| tems Biolo  | ogy, Columbia University Medical Center, New York                                   |
| 2001 - 2004 | Postdoctoral Scientist, Kavli Institute for Theoretical Physics, UC Santa Barbara   |
| 2000 - 2001 | Postdoctoral Scientist, NEC Research Institute, Princeton, New Jersey               |
| 1998 – 1999 | Research Scientist, Gravity Probe B (GP-B), HEPL, Stanford University.              |
| 1997 – 1997 | Student Researcher, L3 experiment, CERN/PPE, Geneva                                 |

# CONCURRENT APPOINTMENTS

| since 2008      | Information Science and Technology Center Science Council, LANL               |  |
|-----------------|---|--|
| since 2007      | Adjunct Assistant Professor, Department of Physics, University of New Mexico, |  |
| Albuquerque, NM |   |  |
| since 2007      | Visiting Scientist, New Mexico Consortium, Los Alamos, NM                     |  |
| since 2007      | Center for Nonlinear Studies Affiliate, Los Alamos National Laboratory        |  |

## TEACHING EXPERIENCE

- 2007 2008 The q-bio Summer School on Cellular Information Processing, organizer and instructor
- 2006 2007 Los Alamos Summer School, instructor
- 2004 2005 Columbia University, Department of Biomedical Informatics, co-instructor, *Computational Biology: Functional and Integrative Genomics*
- 2002 UCSB, Department of Statistics; NYU, Courant Institute, Bioinformatics group, visiting instructor, lecture series in *Statistical Inference*
- 1999 2001 Marine Biological Laboratory, Woods Hole, MA, teaching assistant, *Methods in Computational Neuroscience*
- 1997 1999 Princeton University, Department of Physics, teaching assistant
- 1995 1996 San Francisco State University, Department of Physics, teaching assistant

# HONORS AND AWARDS

National Science Foundation Scholar, StatPhys 22, 2004

Outstanding Teaching Assistant, Department of Physics, Princeton University, 1999

Graduate Student Distinguished Achievement Award, SFSU, 1997

Outstanding Teaching Assistant, Department of Physics, SFSU, 1996

Belarusian State University Honorary Stipend, 1993–1994

Belarusian National High School Physics Olympiad, Winner, 1991

## RESEARCH GRANTS

- DOE/LANL/LDRD/20090001DR "Synthetic Cognition Through Peta-scale Modeling of Mammalian Visual Cortex", co-PI, 2009–2012
- NSF-OCI-0749348 "Peta-scale computing infrastructure: High Performance Neural Computing", co-PI, 2008–2011
- NIH/NCI/1R01CA132629 "Differential Metabolic Analysis of Tumor Progression", PI (multiple PIs), 2007–2012
- DOE/LANL/LDRD/20080391ER "Stochastic Transport on Networks: Efficient Modeling And Applications to Epidemiology", PI, 2007–2010
- DOE/LANL/LDRD/20080138DR "Genomes to Behavior: Predicting Bacterial Response by Constrained Network Interpolation", co-investigator, 2007–2010
- DOE/LANL/LDRD/20070649PRD2 "Noise in Biochemical Networks: Rigorous Analysis with Field-Theoretic Tools", PI, 2007–2010
- NIH/NIGMS-1R21GM080216 "System-wide Study of Transcriptional Control of Metabolism", co-PI, 2007–2009
- NSF-ECS-0425850 "QSB: Optimal information processing in biological networks", co-PI, 2004–2008
- NSF-ECS-0332479 "SGER: Developing learning theory for genetic network inference", co-PI, 2003–2005

## SYNERGISTIC ACTIVITIES

- External Advising: DOE/GTL Knowledgebase; NIH/NCI "Physical Science and New Frontiers in Oncology" Think Tank
- Internal Advising: LANL Biological and Environmental Research / Systems Biology; New Mexico Consortium Neural Computing; LANL Neuroscience; LANL Information Science
- School organization: The q-bio Summer School on Cellular Information Processing, 2007-2008, Los Alamos, NM
- Conference organization: The q-bio Conference on Cellular Information Processing, 2007–2008, Santa Fe, NM; Principles of Biological Computation, 05/2008, Santa Fe, NM; CNLS Annual Conference on Information Sciences and Technology, 05/2008, Santa Fe, NM; Unconventional computation: Quo Vadis?, 03/2007, Santa Fe, NM; Grand Challenges in Neural Computation, 02/2007, Santa Fe, NM; NIPS'03 workshop on Estimation of entropy and information of undersampled probability distributions, 12/03, Whistler, BC

Long program organization: KITP program Understanding the brain

- Public events organization: The q-bio Public Lecture Series, Santa Fe, NM
- Grant refereeing: NSF: Computational Intelligence, Biomedical Engineering, Behavioral Systems Cluster, Cyber-enabled Discovery and Innovation; NIH/NCI; DOE SBIR/STTR; Israeli Science Foundation
- Software: NSB entropy estimation, nsb-entropy.sf.net
- Memberships: American Physical Society, New York Academy of Sciences

#### ADVISEES

- Postdocs: Nikolai Sinitsyn, Golan Bel, Brian Munsky (LANL)
- Graduate Students: Etay Ziv (PhD 2007), Sean Escola, Michael Vidne (Columbia), Ben Kunsberg (Stanford)
- Undergraduate Students: Aly Pesic (Stanford), Misha Shashkov (Berkeley), Pradeep Bandaru (Columbia)

# COLLABORATORS AND OTHER AFFILIATIONS

William Bialek (Princeton; thesis advisor), Andrea Califano (Columbia; postdoc advisor), Francis Alexander (LANL), Peter Balsam (Columbia), David Dreisigmeyer (Pittsburgh), Jeremy Edwards

(UNM), James Faeder (Pittsburgh), Randy Gallistel (Rutgers), Nicolas Hengartner (LANL), William Hlavacek (LANL), Andre Levchenko (Johns Hopkins), Jelena Stajic (Connecticut), Rob de Ruyter van Steveninck (Indiana University), Christof Teuscher (Portland State), Naftali Tishby (Hebrew), Cliff Unkefer (LANL), Pat Unkefer (LANL), Michael Wall (LANL), Chris Wiggins (Columbia)

## SUMMARY OF RESEARCH INTERESTS

Using methods of theoretical physics and machine learning to develop functional, coarse-grained models of information processing in systems biology, including: reverse-engineering cellular networks, creation of efficient tools for their modeling and analysis, studies of learning and adaptation in sensory systems, and development of large-scale neuromimetic signal processing systems.

Selected publications about our work

- 1. Supercomputer simulates human visual system. *slashdot.org*, June 13, 2008.
- 2. Roadrunner supercomputer puts research at a new scale. LANL Press Release, June 12, 2008.
- 3. Improving Metabolomic Measurement and Analysis. LANL Science, Technology, and Engineering (STE) Highlights, Nov 7, p. 2, 2007.
- 4. Language of A Fly Proves Surprising. PhysOrg.com, Mar 10, 2008.
- 5. The Mind of A Fly: Scientists Tap into The Brains of Flies in An Effort to Improve Artificial Intelligence. By S. Vorenberg, *The Santa Fe New Mexican*, Mar 20, 2008.
- 6. The Fly Code. By N. Maximov, Russian Newsweek, Mar 24, 2008 (in Russian).

## **PRESENTATIONS**

| Dec 2008     | Weizmann Institute, Condensed Matter Theory seminar                                 |
|--------------|---|
| Dec 2008     | Weizmann Institute, Neurobiology seminar  |
| Dec 2008     | Technion, Networks Biology Lab seminar  |
| Nov 2008     | Princeton University, Biophysics Theory seminar                                     |
| Nov 2008     | Columbia University, Neurotheory Center seminar                                     |
| Nov 2008     | Columbia University, C2B2 Computational Biology seminar                             |
| Nov 2008     | Emory University, Physics colloquium  |
| Jul 2008     | International Society for Bayesian Analysis World Meeting, contributed talk         |
| May 2008     | SFI "Principles of Biological Computation" workshop talk                            |
| Apr 2008     | Harvard Condensed Matter Theory seminar   |
| Mar 2008     | KITP/UCSB program on "Brain anatomy and development" talk                           |
| Mar 2008     | UCLA Biomathematics Department seminar  |
| Mar 2008     | Caltech Bio-circuits / Information Science and Technology seminar                   |
| Mar 2008     | APS March Meeting, Invited talk   |
| Mar 2008     | UC Irvine Physics Colloquium  |
| Feb 2008     | Duke University, Physics and Systems Biology Colloquium                             |
| Feb 2008     | Brown University Physics Colloquium   |
| Feb 2008     | University of Pittsburgh, Department of Computational Biology seminar               |
| Jan 2008     | Aspen Center for Physics, Decision Making in Single Cells conference talk           |
| Oct 2007     | Emory University, Computational Life Sciences seminar                               |
| Oct 2007     | UCSD Center for Theoretical Biological Physics seminar                              |
| Oct 2007     | Fall Western Section AMS Meeting, Methods for Heterogeneous Data Analysis Work-     |
| shop, invit  | ed talk   |
| Oct 2007     | Santa Fe Institute workshop on High-Level Perception and Low-Level Vision: Bridging |
| the Semanti  | <i>c Gap,</i> invited talk  |
| Oct 2007     | DOE/BER seminar, Washington, DC   |
| Jul 2007     | CNS'2007 workshop on Methods of Information Theory in Computational Neuroscience,   |
| invited tall | ς   |
| Jul 2007     | <i>CNS</i> <sup>2</sup> 2007, contributed plenary talk                              |

| May 2007     | 7th Understanding Complex Systems symposium, invited talk                           |
|--------------|---|
| Apr 2007     | UCLA Biomath department seminar   |
| Apr 2007     | Caltech CNS seminar   |
| Apr 2007     | KITP/UCSB program on Evolution of Molecular Networks seminar                        |
| Mar 2007     | CNLS conference on Unconventional Computation: Workshop on Neural Computation,      |
| invited tall | κ.  |
| Feb 2007     | UNM SIBBS: Seminar in Biological and Biomedical Sciences                            |
| Sep 2006     | LANL TSC capability workshop Advanced Methods for Data Analysis, contributed        |
| talk         |   |
| Sep 2006     | DIMACS workshop on Dialogue on Reverse Engineering Assessment and Methods           |
| (DREAM),     | contributed talk  |
| Aug 2006     | LANL TSC capability workshop <i>Complex Networks</i> , contributed talk             |
| Aug 2006     | UNM/CS seminar  |
| Aug 2006     | International Conference on Molecular Systems Biology, Munich, Germany, contributed |
| plenary tal  | k   |
| Apr 2006     | Indiana University Biocomplexity seminar  |
| Apr 2006     | Santa Fe Institute seminar  |
| Apr 2006     | UNM Cancer Research Center seminar  |
| Mar 2006     | New Mexico Bioinformatics Symposium, Santa Fe, NM                                   |
| Jan 2006     | LANL, D-1 seminar   |
| Dec 2005     | NIPS'05 Computational Biology Workshop, contributed talk                            |
| Nov 2005     | Baylor College of Medicine, Neuroimaging Laboratory seminar                         |
| Nov 2005     | Texas A&M College Station, Models for Genetic Regulatory Networks conference, in-   |
| vited talk   | 0 , , , , , , , , , , , , , , , , , , ,   |
| Nov 2005     | IAS, Princeton, Systems Biology seminar   |
| Oct 2005     | Rutgers, BioMaPs seminar  |
| Jul 2005     | University of Washington, Seattle, Biophysics and Physiology seminar                |
| Jun 2005     | UCSF, Computational Biology seminar   |
| Jun 2005     | CSHL, Computational Neuroscience seminar  |
| Jun 2005     | Columbia, C2B2 seminar  |
| Apr 2005     | LANL, CCS-3/CNLS seminar  |
| Apr 2005     | Cornell, LASSP/Physics colloquium   |
| Apr 2005     | IBM Watson research center, physics seminar   |
| Mar 2005     | Columbia, Computational Neuroscience seminar  |
| Feb 2005     | Harvard, Bauer Center for Genomics Research seminar                                 |
| Feb 2005     | University of Michigan, Ann Arbor, Physics colloquium                               |
| Ian 2005     | University of Maryland, College Park, Computational Neuroscience seminar            |
| Dec 2004     | Rutgers Statistical Mechanics Meeting, contributed talk                             |
| Dec 2004     | NIPS 2004 workshop on Computational Biology, Whistler, BC, contributed talk.        |
| Dec 2004     | LANL, Theoretical Biology/CNLS seminar  |
| Nov 2004     | NEU, physics colloquium   |
| Nov 2004     | BU, Biodynamics lab seminar   |
| Sep 2004     | UCSB, KITP, Understanding the Brain program seminar                                 |
| Apr 2004     | UCLA, IPAM, Proteomics colloquium   |
| Apr 2004     | UCSF, Keck neuroscience center seminar  |
| Mar 2004     | NYU, CS colloquium  |
| Mar 2004     | LANL, CNLS seminar  |
| Mar 2004     | Columbia, C2B2 seminar  |
| Mar 2004     | IBM Watson Research Center, Systems Biology and Functional Genomics group           |
| seminar      |   |
| Mar 2004     | Rockefeller University, Center for Studies in Physics and Biology colloquium        |
| Dec 2003     | NIPS'03 workshop on <i>Entropy Estimation</i> , opening talk                        |
| Nov 2003     | KITP, UCSB, Pattern formation program seminar                                       |
| Oct 2003     | Columbia University, Computational biology seminar                                  |
|              |   |

| Mar 2003      | KITP, UCSB colloquium  |
|---------------|--|
| Feb 2003      | UCSB, Statistics, short lecture series   |
| Dec 2002      | NIPS-2002 workshop on Universal learning, invited talk                               |
| Dec 2002      | NIPS-2002 workshop on Negative results and open problems, contributed talk           |
| Nov 2002      | CalTech's complexity club seminar  |
| Nov 2002      | Princeton, Theoretical biophysics group seminar                                      |
| Oct-Nov 2002  | Courant Institute, NYU, Bioinformatics group, short lecture series                   |
| Oct 2002      | Columbia University, Applied Mathematics seminar                                     |
| Oct 2002      | Courant Institute, NYU, Bioinformatics seminar                                       |
| May 2002      | UCSB, Statistics Department, colloquium  |
| Mar 2002      | ITP, UCSB, Director's blackboard lunch talk  |
| Dec 2001      | Contributed spotlight talk at NIPS-2001.   |
| Oct 2001      | ITP, UCSB colloquium   |
| Mar 2001      | Contributed talk at Conference on Frontiers in physics of complex systems, Dead Sea, |
| Israel        |  |
| May 2001      | NYU Courant Institute / Center for Neuroscience seminar                              |
| Feb 2001      | Rockefeller University, Center for Studies in Physics and Biology colloquium         |
| Jan 2001      | MIT Cognitive Science, seminar   |
| Nov 2000      | New England Complex Science Institute colloquium                                     |
| Nov 2000      | Contributed talk at NIPS-2000  |
| Apr, Aug 2000 | NEC Research Institute, Princeton, NJ, Biophysics seminar                            |
| Jan 2000      | Hebrew University, Machine Learning seminar  |
| Jul 1998      | Gravity Probe B, Theory Group seminar  |
| Aug 1997      | CERN/PPE/L3 seminar  |
| Jul 1994      | Belarusian State University, Theoretical Physics seminar                             |
|               |  |

## **PUBLICATIONS**

## Refereed publications

- 1. G Bel and I Nemenman. Anomalous diffusion and scaling in the dynamics of coupled stochastic processes. Submitted to *Phys. Rev. Lett.*, 2008.
- 2. I Nemenman. Gain control in molecular signaling: Lessons from neuroscience. Submitted to *Phys. Biol.*, 2008.
- 3. A Mugler, E Ziv, I Nemenman, and C Wiggins. Quantifying evolvability in small biological networks. Submitted to *IET Systems Biology*, 2008. arXiv:0811.2834.
- 4. WH de Ronde, BC Daniels, A Mugler, NA Sinitsyn, and I Nemenman. Statistical properties of multistep enzyme-mediated reactions. Submitted to *IET Systems Biology*, 2008. arXiv:0811.3283.
- 5. NA Sinitsyn, N Hengartner and I Nemenman. Coarse-graining stochastic biochemical networks: quasi-stationary approximation and fast simulations using a stochastic path integral technique. In revision for *PNAS*, 2008. arXiv:0808.4016.
- K Wang, M Saito, B Bisikirska, M Alvarez, P Rajbhandari, Q Shen, I Nemenman, K Basso, A Margolin, U Klein, R Dalla-Favera, and A Califano. Genome-wide identification of posttranslational modulators of transcription factor activity in human B-cells. Submitted to *Cell*, 2008.
- 7. A Mugler, E Ziv, I Nemenman, C Wiggins. Serially-regulated biological networks fully realize a constrained set of functions. *IET Syst. Biol.* **2**:313, 2008.
- 8. D Dreisigmeyer, J Stajic, I Nemenman, W Hlavacek, and M Wall. Determinants of bistability in induction of the *Escherichia coli lac* operon. *IET Syst. Biol.* **2**:293, 2008.
- 9. I Nemenman, GD Lewen, W Bialek, RR de Ruyter van Steveninck. Neural coding of natural stimuli: Information at sub-millisecond resolution. *PLoS Comput. Biol.* **4**(3): e1000025, 2008.

- Preliminary version available as: I Nemenman, G Lewen, W Bialek, and R de Ruyter van Steveninck. Neural coding of natural stimuli: information at sub-millisecond resolution. *BMC Neurosci.* **8** (Suppl 2):S7, 2007.
- 10. NA Sinitsyn and I Nemenman. A universal geometric theory of mesoscopic stochastic pumps and reversible ratchets. *Phys. Rev. Lett.* **99**:220408, 2007.
- I Nemenman, GS Escola, WS Hlavacek, PJ Unkefer, CJ Unkefer, ME Wall. Reconstruction of metabolic networks from high-throughput metabolite profiling data: *in silico* analysis of red blood cell metabolism. *Ann. N.Y. Acad. Sci.* 1115:102115, 2007.
- 12. E Ziv, I Nemenman, and C Wiggins. Optimal information processing in small stochastic biochemical networks. *PLoS ONE* **2**(10): e1077, 2007.
- 13. NA Sinitsyn and I Nemenman. Berry phase and pump effect in stochastic chemical kinetics. *EPL* 77, 58001, 2007.
- 14. A Margolin, K Wang, WK Lim, M Kustagi, I Nemenman, and A Califano. Reverse engineering cellular networks. *Nature Protocols* 1(2):663-672, 2006.
- 15. K Wang, I Nemenman, N Banerjee, A Margolin, and A Califano. Genome-wide discovery of modulators of transcriptional interactions in human B lymphocytes. In *Lecture Notes in Computer Science, '3909, Proceedings of Research in Computational Molecular Biology: 10th Annual International Conference, RECOMB 2006,* pp. 348 - 362 (Springer: Berlin / Heidelberg, 2006).
- A Margolin, I Nemenman, K Basso, U Klein, C Wiggins, G Stolovitzky, Riccardo D Favera, and A Califano. ARACNE: An algorithm for reconstruction of genetic networks in a mammalian cellular context. *BMC Bioinformatics* 7(Suppl. 1):S7, 2006.
- 17. I Nemenman. Fluctuation-dissipation theorem and models of learning. *Neural Comp.* **17**(9): 2006-2033, 2005.
- 18. I Nemenman, W Bialek, and R de Ruyter van Steveninck. Entropy and information in neural spike trains: Progress on the sampling problem. *Phys. Rev. E* **69**:056111, 2004.
- 19. C Wiggins and I Nemenman. Process pathway inference via time series analysis. *Experim. Mech.* **43**(3):361-370, 2003.
- 20. A Silbergleit, I Nemenman, and I Mandel. On the interaction of point charges in an arbitrary domain. *Techn. Phys.* **48**(2):146-151, 2003.
- 21. A Silbergleit, I Mandel, and I Nemenman. Potential and field singularity at a surface point charge. *J. Math. Phys.* **44**(10):4460-4466, 2003.
- I Nemenman, F Shafee, and W Bialek. Entropy and inference, revisited. In TG Dietterich, S Becker, and Z Ghahramani, editors, *Adv. Neural Inf. Proc. Syst.* 14 (MIT Press: Cambridge, MA, 2002).
- 23. I Nemenman and W Bialek. Occam factors and model-independent Bayesian learning of continuous distributions. *Phys. Rev. E* 65(2):026137, 2002.
  - Preliminary version available as: I Nemenman and W Bialek, Learning Continuous Distributions: Simulations With Field Theoretic Priors. In T Leen, T Dietterich, and V Tresp, eds. *Adv. Neural Inf. Proc. Syst.* 13, pp. 287-293 (MIT Press: Cambridge, MA, 2001).
- 24. W Bialek, I Nemenman, and N Tishby. Complexity through nonextensivity. *Physica A* **302**:89-99, 2001.
- W Bialek, I Nemenman, and N Tishby. Predictability, complexity, and learning. *Neur. Comp.* 13:2409-2463, 2001.
- 26. R Adler, I Nemenman, J Overduin, and D Santiago. On the detectability of quantum spacetime foam with gravitational-wave interferometers. *Phys. Lett. B* **477**:424-428, 2000.
- 27. J Naud, I Nemenman, M Van Raamsdonk, and V Periwal. Minimal subtraction and the Callan-Symanzik equation. *Nucl. Phys. B* **540**:533-539, 1999.

- 28. I Nemenman and A Silbergleit. Explicit Green's function of a boundary value problem for a sphere and trapped flux analysis in Gravity Probe B experiment. *J. Appl. Phys.* **86**:614-624, 1999.
- 29. A Minkevich and I Nemenman. On the influence of gravitating vacuum on dynamics of homogeneous isotropic models in gauge-theories of gravity. *Class. Quant. Grav.* **12**:1259-1265, 1995.
  - Preliminary version available as: A Minkevich and I Nemenman. On the influence of gravitating vacuum on dynamics of homogeneous isotropic models in gauge-theories of gravity. *Dokl. Akad. Nauk Belar.* **39**(2):45-51, 1995. In Russian.

## Views, Editorials, Books

- I Nemenman, W Hlavacek, J Edwards, J Faeder, Y Jiang, M Wall, Editorial: Selected papers from the First q-bio Conference on Cellular Information Processing. *IET Systems Biology* 2:203, 2008.
- C Teuscher, I Nemenman, and F Alexander. Novel Computing Paradigms: Quo Vadis? *Physica D* 237:10-11, 2008.
- 3. J Edwards, J Faeder, W Hlavacek, Y Jiang, I Nemenman, and M Wall. q-bio 2007: a watershed moment in modern biology. *Mol. Syst. Biol.* **3**:148, 2007.
- 4. I Nemenman. *Information Theory and Learning: A Physical Approach*. PhD thesis, Princeton University, Department of Physics, 2000. arXiv:physics/0009032.

## Unpublished work

- 1. K Wang, N Banerjee, A Margolin, I Nemenman, K Basso, R Dalla Favera, and A Califano. Conditional network analysis identifies candidate regulator genes in human B cells. Unpublished manuscript, 2005. arXiv:q-bio/0411003.
- A Margolin, N Banerjee, I Nemenman, and A Califano. Reverse engineering of yeast transcriptional network using the ARACNE algorithm. Unpublished manuscript, 2004. Available at menem.com/~ilya.
- 3. I Nemenman. Information theory, multivariate dependence, and genetic network inference. Technical Report NSF-KITP-04-54, KITP, UCSB, 2004. arXiv:q-bio/0406015.
- 4. I Nemenman. Inference of entropies of discrete random variables with unknown cardinalities. Technical Report, KITP. UCSB, 2002. arXiv:physics/0207009.
- 5. T Holy and I Nemenman. On impossibility of learning in a reparameterization covariant way. Technical Report NSF-KITP-03-123, KITP, UCSB, 2002. Available at menem.com/~ilya.
- 6. I Kominis and I Nemenman. BGO dead crystal correction and shower fitting. Tech. Rep. 2157, *CERN: L3*, 1997. Available at menem.com/~ilya.