

Cheryl Patrick

Curriculum Vitae

University College London, Department of Physics & Astronomy,
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CURRENT POSITION

2016- University College London
Research Associate, SuperNEMO experiment

EDUCATION

2010-2016 Northwestern University, Evanston, IL, USA
PhD in Physics, advisor Heidi Schellman
2012 Northwestern University, USA
MS in Physics
1994-1997 Magdalen College, University of Oxford, UK
BA(hons) in Physics (first class) (MA, 2001)

EXPERIENCE IN INDUSTRY

2008-2010: **Web developer, Cabana A/S, Denmark**
Design and development in ASP.NET (C#); technical documentation in English and Danish
2003-2008: **Software engineering contractor, PIPS Technology Ltd, UK** Java and database development, serial communications
2000-2003: **Team leader / senior design engineer, Telsis Ltd, UK**
Team management of four engineers; lead technical ownership and project management for two server products; database design and development in SQL Server, C++ programming
1997-2000: **IT Consultant, Hampshire County Council IT Services, UK**
REXX programming, database design, project management, training course design and presentation

PRIZES AND AWARDS

2017: Springer thesis prize
2014: School competition winner- NuSTEC Neutrino Generator School
2012: Northwestern Integrated Science Programme – award for service to the programme through teaching
1997: Oxford University – certificate of commendation for practical work

TEACHING AND MENTORING

- 2017-8: **University College London, UK**
Mentoring graduate students and undergraduate interns on SuperNEMO
- 2017: **Code First: Girls, London UK**
Volunteer instructor teaching women HTML and CSS programming
- 2016-7: **University College London, UK**
Demonstrator in Python course
- 2015: **Northwestern University, Evanston, USA**
Workshop leader, new teaching assistant conference
- 2015: **Fermilab, Batavia, USA:**
Mentored researcher to take over MINERvA's data management
- 2015: **Artifice, Chicago, USA:**
Mentor at weekly after-school club teaching programming skills to children from low-income areas
- 2014: **Fermilab, Batavia, USA:**
Trained PhD student to manage calibration and monitoring at MINERvA
- 2011-12: **Northwestern University, Evanston, USA**
Teaching assistant, integrated science: designed and taught lectures
- 1998: **Hampshire County Council, Winchester, UK**
Developed/presented training course on in-house programming system

MAJOR RESEARCH ACHIEVEMENTS

- 2018-: **Analysis coordinator, SuperNEMO experiment**
Deputy physics coordinator, SuperNEMO experiment
- 2017-8: **Deputy analysis coordinator, SuperNEMO experiment**
Responsible for coordinating SuperNEMO's analysis efforts, identifying software and reconstruction requirements and developing and documenting the experiment's analysis tools.
- 2013-16: **Thesis analysis: Double-differential charged-current quasi-elastic antineutrino scattering cross section at MINERvA.**
Supervisor: Prof Heidi Schellman
Performed a multi-dimensional analysis of the charged-current quasi-elastic scattering process for antineutrinos on CH scintillator at Fermilab's MINERvA detector. This key signal process for oscillation experiments cannot currently be accurately simulated in the few-GeV region due to the presence of poorly-understood nuclear effects. The measurement includes the effects of more than forty sources of systematic uncertainty. It is used to evaluate alternative nuclear models from the GENIE and NuWro generators, and will be made available for global fits to reduce cross section model uncertainties, the largest systematic uncertainty for neutrino oscillation experiments.
- 2014: **Computed single-differential quasi-elastic scattering cross section for neutrinos and antineutrinos and compared with the latest theoretical models for presentation at NuInt14.**

Compared data with alternate nuclear model predictions, generated by the GENIE and NuWro simulations, using a chi-squared fit that included bin-bin correlations, showing hints that a model containing additional nucleon-nucleon correlations may be favoured. Computed a combined correlation matrix between neutrino and antineutrino data, to enable a joint comparison with models.

2012-13: **Developed multivariate fitting algorithm to extract axial mass from quasi-elastic cross section data**

The axial mass, M_A , is used to parameterise the cross section for quasi-elastic neutrino scattering from free nucleons. Wildly differing best-fit values of this parameter from low- and high-energy experiments scattering from heavy nuclei led to the belief that this was not a valid fit parameter when scattering from a nucleus. A multivariate fit to GENIE's Relativistic Fermi Gas model confirmed that MINERvA's cross section data indeed does not conform to the free-nucleon prediction for any value of the M_A , suggesting the presence of nuclear effects.

OTHER RESEARCH ACTIVITIES

- 2016-7: Worked with graduate students to evaluate sensitivity of SuperNEMO demonstrator and estimate the effects of backgrounds
- 2017-: Creation and maintenance of SuperNEMO website
- 2016-17: Construction and integration testing of SuperNEMO demonstrator module
- 2014,15: Designed and implemented presentations and activities to teach students and postdocs how to calculate cross sections and evaluate systematic uncertainties at the MINERvA 101 training week.
- 2014: Invited to serve on internal paper review committee for *Measurement of muon plus proton final states in ν_μ Interactions on Hydrocarbon at $\langle E_\nu \rangle = 4.2$ GeV*, Phys. Rev. D 91, 071301
- 2013-14: Developed script to back up all MINERvA's data and simulation to the FTS tape storage system. Transitioned MINERvA's data cataloguing scripts to use Fermilab's new SAMWEB metadata interface, using Python.
- 2013-15: Responsible for MINERvA's offline data processing, archiving and cataloguing of over 400TB of data
- 2012-14: Responsible for calculating the gain of MINERvA's 500 photomultiplier tubes on a regular basis, to be used in detector response calibration and to identify faulty hardware, using scripts in C++ and Perl.
- 2012-13: Participated in the analysis team that produced MINERvA's first published cross-section measurements: *Measurement of Muon Antineutrino Quasi-Elastic Scattering on a Hydrocarbon Target at $E_\nu \sim 3.5$ GeV*, Phys. Rev. Lett. 111, 022501 (43 citations). Calculated detector resolutions in various variables, evaluated tracking efficiency due to pile-up in the MINOS muon spectrometer.
- 2011-15: More than 500 hours spent with sole responsibility for monitoring MINERvA's detector status and data acquisition

2010-11: Developed PLACE event-length algorithm for the MINERvA detector, using C++ and ROOT

PUBLICATIONS

Conference proceedings

- C. Patrick and F. Xie. *Status of the SuperNEMO $0\nu\beta\beta$ experiment* arXiv:1704.06670 NuPhys 2016, to be published in SLAC eCONF
- C. Patrick, *Recent Results from MINERvA* Proceedings of the 50th Recontres de Moriond, Electroweak Interactions and Unified Theories, ARSIF (2015)
- C. Patrick, *Charged-current quasi-elastic scattering at MINERvA*, Proceedings of Science (EPS-HEP 2013) 526
- C. Patrick, *MINERvA neutrino detector calibration* Volume 1663: NuINT12: The 8th International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region, AIP Publishing

Books

- Cheryl E. Patrick, *Measurement of the Antineutrino Double-Differential Charged-Current Quasi-Elastic Scattering Cross Section at MINERvA*, ISBN 978-3-319-69086-5

Journal articles

2018:

- R. Arnold et al (NEMO-3 collaboration) *Final results on ^{82}Se double beta decay to the ground state of ^{82}Kr from the NEMO-3 experiment*, Eur. Phys. J. C 78: 821 (2018)
- X.-G. Lu et al (MINERvA collaboration) *Measurement of final-state correlations in neutrino muon-proton mesonless production on hydrocarbon at $\langle E_\nu \rangle = 3$ GeV*, Phys. Rev. Lett. 121, 022504 (2018)
- R. Gran et al (MINERvA collaboration) *Anti-neutrino charged-current reactions on scintillator with low momentum transfer*, Phys. Rev. Lett. 120, 221805 (2018)
- C.E. Patrick et al (MINERvA collaboration), *Measurement of the muon anti-neutrino double-differential cross section for quasi-elastic scattering on hydrocarbon at $E_\nu \sim 3.5$ GeV*, Phys. Rev. D 97, 052002 (2018)

2017:

- O. Altinok et al (MINERvA collaboration), *Measurement of ν_μ charged-current single n^0 production on hydrocarbon in the few-GeV region using MINERvA*, Phys. Rev. D 96, 072003 (2017)
- R. Arnold et al (NEMO-3 collaboration) *Search for neutrinoless quadruple- β decay of ^{150}Nd with the NEMO-3 detector*, Phys. Rev. Lett. 119, 041801
- M. Betancourt et al (MINERvA collaboration), *Direct Measurement of Nuclear Dependence of Charged Current Quasielastic-like Neutrino Interactions using MINERvA*, Phys. Rev. Lett. 119, 082001 (2017)
- L. Ren et al (MINERvA collaboration), *Measurement of the antineutrino to neutrino charged-current interaction cross section ratio in MINERvA*, Phys. Rev. D 95, 072009 (2017)

- C.M. Marshall et al (MINERvA collaboration), *Measurement of neutral-current K^+ production by neutrinos using MINERvA*, Phys. Rev. Lett. 119, 011802 (2017)

2016:

- J. DeVan et al (MINERvA collaboration), *Measurements of the Inclusive Neutrino and Antineutrino Charged Current Cross Sections in MINERvA Using the Low- ν Flux Method*, Phys. Rev. D 94, 112007 (2016)
- L. Aliaga et al (MINERvA collaboration), *Neutrino Flux Predictions for the NuMI Beam*, Phys. Rev. D 94, 092005 (2016) (Impact factor 4.643)
- Z. Wang et al (MINERvA collaboration), *Evidence of Coherent K^+ Meson Production in Neutrino-Nucleus Scattering*, Phys. Rev. Lett. 117, 061802 (2016)
- C.M. Marshall et al (MINERvA collaboration), *Measurement of K^+ production in charged-current ν_μ interactions*, Phys. Rev. D 94, 012002 (2016)
- J. Wolcott et al (MINERvA collaboration), *Evidence for neutral-current diffractive neutral pion production from hydrogen in neutrino interactions on hydrocarbon*, Phys. Rev. Lett. 117, 111801 (2016)
- J. Park et al (MINERvA collaboration), *Measurement of Neutrino Flux from Neutrino-Electron Elastic Scattering*, Phys. Rev. D 93, 112007 (2016)
- J. Mousseau et al (MINERvA collaboration), *Measurement of Partonic Nuclear Effects in Deep-Inelastic Neutrino Scattering using MINERvA*, Phys. Rev. D 93, 071101 (2016)
- P.A. Rodrigues et al (MINERvA collaboration), *Identification of nuclear effects in neutrino-carbon interactions at low three-momentum transfer* Phys. Rev. Lett. 116, 071802 (2016)
- J. Wolcott et al (MINERvA collaboration), *Measurement of electron neutrino quasielastic and quasielastic-like scattering on hydrocarbon at $\langle E_\nu \rangle = 3.6$ GeV*, Phys. Rev. Lett. 116, 081802 (2016)

2015:

- T. Le et al (MINERvA collaboration), *Single neutral pion production by charged-current anti- ν_μ interactions on hydrocarbon at average E_ν of 3.6 GeV*, Phys.Lett. B 749 (2015) 130-136
- T. Walton et al (MINERvA collaboration), *Measurement of muon plus proton final states in ν_μ Interactions on Hydrocarbon at $\langle E_\nu \rangle = 4.2$ GeV*, Phys. Rev. D 91, 071301 (2015)
- L. Aliaga et al (MINERvA collaboration), *MINERvA neutrino detector response measured with test beam data*, arXiv:1501.06431 [physics.ins-det], accepted by Nucl. Inst. Meth. A

2014:

- A. Higuera et al (MINERvA collaboration), *Measurement of Coherent Production of π^\pm in Neutrino and Anti-Neutrino Beams on Carbon from E_ν of 1.5 to 20 GeV*, Phys. Rev.Lett. 113, 261802 (2014)
- B. Eberly et al (MINERvA collaboration), *Charged Pion Production in ν_μ Interactions on Hydrocarbon at $\langle E_\nu \rangle = 4.0$ GeV*, Phys. Rev. D 92, 092008 (2015)

- B.G. Tice et al (MINERvA collaboration), *Measurement of ratios of ν_μ charged-current cross sections on C, Fe, and Pb to CH at neutrino energies 2–20 GeV*, Phys. Rev. Lett. 112, 231801 (2014)

2013:

- G.A. Fiorentini et al (MINERvA collaboration), *Measurement of Muon Neutrino Quasi-Elastic Scattering on a Hydrocarbon Target at $E_\nu \sim 3.5$ GeV*, Phys. Rev. Lett. 111, 022502 (2013)
- L. Fields et al (MINERvA collaboration), *Measurement of Muon Antineutrino Quasi-Elastic Scattering on a Hydrocarbon Target at $E_\nu \sim 3.5$ GeV*, Phys. Rev. Lett. 111, 022501 (2013)

PRESENTATIONS

Invited conference presentations and posters

- 2018: **DBD18**, Hawai'i, USA.
Presentation: "The SuperNEMO project, and final results from NEMO-3"
- 2018: **Neutrino 2018**, Heidelberg, Germany.
Poster: "SuperNEMO $0\nu\beta\beta$ sensitivity studies"
- 2018: **IoP 2018**, Bristol, UK.
Presentation: "Status of the SuperNEMO double-beta decay experiment"
- 2017: **NuFact2017**, Uppsala, Sweden.
Presentation: "Charged-current quasi-elastic scattering at MINERvA"
- 2016: **NuPhys2016**, London, UK.
Poster: "Status of the SuperNEMO $0\nu\beta\beta$ experiment"
- 2015: **IceCube Particle Astrophysics Symposium**, Madison, USA.
Presentation: "Recent results from MINERvA"
- 2015: **Rencontres de Moriond**, Electroweak Session, La Thuile, Italy.
Presentation: "Recent results from MINERvA"
- 2014: **NuInt14**, Surrey, UK.
Presentation: "Charged-current quasi-elastic scattering at MINERvA"
Poster: "Quasi-elastic scattering at MINERvA"
- 2013: **EPS-HEP 2013**, Stockholm, Sweden.
Presentation: "Charged-current quasi-elastic scattering at MINERvA"
- 2012: **NuInt12**, Rio de Janeiro, Brazil.
Poster: "MINERvA neutrino detector calibration"

Invited seminars

- 2018: "SuperNEMO and the mystery of matter", 8th November, University of Sussex, UK
- 2018: "SuperNEMO and the mystery of matter", 2nd November, University of Edinburgh, UK
- 2018: "SuperNEMO and the mystery of matter", 20th June, University of Brussels, Belgium
- 2018: "SuperNEMO and the mystery of matter", 24th April, Fermilab (Neutrino Seminar Series), USA
- 2018: "SuperNEMO and the mystery of matter", 23rd April, Northwestern University, USA
- 2016: "Charged-Current Quasi-Elastic Double-Differential Antineutrino Scattering Cross Section at MINERvA", 17th June, Fermilab Wine and Cheese Seminar, USA
- 2015: "Neutrino interactions on nuclei at MINERvA", 22nd May, University of Oregon, USA
- 2015: "Neutrino interactions on nuclei at MINERvA", 10th April, University College London, UK
- 2015: "Neutrino interactions on nuclei at MINERvA", 27th March, Queen Mary University of London, UK
- 2015: "Neutrino interactions on nuclei at MINERvA", 25th March, Imperial College London, UK

Other presentations and posters

- 2018: **UK Double-beta decay workshop**, Oxford, UK.
Presentation: "SuperNEMO status"
- 2014: **New Perspectives**, Fermilab, USA.
Presentation: "Quasi-elastic neutrino scattering at MINERvA"
- 2013: **Fermilab Users' Meeting**, Fermilab, USA.
Poster: "Charged-current quasi-elastic scattering at MINERvA"

SCHOOLS AND TRAINING ATTENDED

- 2014: NuSTEC training in neutrino nucleus scattering physics, Fermilab, USA
- 2014: NuSTEC neutrino generator school, Liverpool, UK
- 2012: 19th CTEQ summer school on QCD and electroweak phenomenology,
Lima, Peru
- 2011: International Neutrino Summer School, Geneva, Switzerland

TECHNOLOGIES

Programming languages

C++, C, Python, C#, Java, ASP.NET, SQL, JavaScript, REXX, bash

Databases

SQL Server, Oracle, PostgreSQL, Sybase, SAM (Fermilab database)

Other computing

ROOT, LATEX, MS Office, Linux, Keynote, CVS, SourceSafe, Subversion, Github, HTML, Jekyll

PUBLIC ENGAGEMENT

- 2018: Nine Lessons and Carols for Curious People: Wrote and performed a song about the Standard Model at a public performance organised by the Cosmic Shambles Network.
- 2018: Cosmic Shambles Network: Interviewed for documentary *All Genius. All Buffoon*, about Richard Feynman.
- 2018: Pint of Science: Wrote and performed a musical about SuperNEMO for the public.
- 2017: Particle Physics Masterclass: presented introduction to neutrino physics for high school students and helped with ATLAS masterclass.
- 2014: Introduction to Graduate Education, Northwestern University: Presented poster at event to recruit underrepresented minorities into STEM PhD programmes.
- 2013: Science Works: Hot Careers, Museum of Science and Industry, Chicago. Neutrino physics demonstrations for school students.
- 2012: Chicago Area Undergraduate Research Symposium: Judge.

REFERENCES

Heidi Schellman, Professor and Department Chair
Oregon State University, Department of Physics,
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+1 (541) 737-4631 schellmh@science.oregonstate.edu

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