

PERSONAL INFORMATION

Name: Iain David Moore

Date: 17th June 2015

Researcher ID: D-7255-2014

Date and place of birth: 7 November 1976; Buxton, UK

Nationality: British

Email address: iain.d.moore@jyu.fi

URL for web site: <https://www.jyu.fi/fysiikka/en/research/accelerator/igisol>

• EDUCATION

- 2002 Ph.D. in Nuclear Structure Physics
 “*Laser Spectroscopic Studies at the IGISOL On-Line Separator*”,
 Awarded February 20th 2002
 Supervisor: Prof. J. Billowes
 School of Physics and Astronomy, University of Manchester, UK
- 1998 Bachelor of Science (II.I) in Physics
 School of Physics and Astronomy, University of Manchester, UK
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• CURRENT EMPLOYMENT

- 2015 – 2016 Professor
 Fixed term 01.02.2015 – 31.01.2016
 Department of Physics, University of Jyväskylä, Finland
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• PREVIOUS EMPLOYMENT

- 2011 – 2016 University Lecturer (tenure track position, level 3)
 Fixed term 01.08.2011 – 31.07.2016; leave of absence from 01.02.2015
 Department of Physics, University of Jyväskylä, Finland
- 2006 – 2011 Senior Researcher (Erikoistutkija)
 Department of Physics, University of Jyväskylä, Finland
- 2004 – 2006 Researcher
 Department of Physics, University of Jyväskylä, Finland
- 2001 – 2003 Postdoctoral Research Scholar
 Argonne National Laboratory, USA
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• SUPERVISION EXPERIENCE

- 2004 – 2006 Supervision of two Ph.D. Marie Curie training fellows:
 B. Marsh, Ph.D. University of Manchester 2007
 B. Tordoff, Ph.D. University of Manchester 2007
- 2005 – Responsible supervisor for 4 Ph.D. students:
 T. Kessler, University of Jyväskylä (completion August 2008)
 M. Reponen, University of Jyväskylä (completion September 2012)
 V. Sonnenschein, University of Jyväskylä (completion December 2014, Custodian)
 I. Pohjalainen, University of Jyväskylä (expected completion 2016)
 3 Masters’ students (I. Pohjalainen, H. Khan, S. Geldhof (KU Leuven));
 1 Postdoc (A. Voss); 1 Marie Curie Fellow (P. Papadakis)
 Department of Physics, University of Jyväskylä, Finland
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• TEACHING AND PEDAGOGICAL COMPETENCE

- 2005 Lecturer of postgraduate study course (28 hours) – “*Spectroscopy of Nuclear Ground State Properties*”, Department of Physics, University of Jyväskylä, Finland
- 2011 Co-Lecturer – “*Techniques for Nuclear and Accelerator-Based Physics Experiments*”, Department of Physics, University of Jyväskylä, Finland
- 2011 Trial lecture for nomination to position of University Lecturer
Evaluation Board of Department of Physics awarded grade *very good* (4/5)
- 2012 – 2016 Lecturer in Master’s Studies in Nuclear and Particle Physics at JYFL – “*Nuclear Physics I*”, 8 ECTS, Department of Physics, University of Jyväskylä, Finland
- 2014 Co-Lecturer – “*Techniques for Nuclear and Accelerator-Based Physics Experiments*”, 10 ECTS, Department of Physics, University of Jyväskylä, Finland
- 2015 Completion of University Pedagogical Studies
10 ECTS credits, Faculty of Education, University of Jyväskylä, Finland
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• ORGANISATION OF SCIENTIFIC MEETINGS

- 2007 Organiser of the JYFL User’s Meeting, Jyväskylä, Finland
- 2007 Co-organiser of the EURONS Laser and Trap Collaboration Meeting, Finland
- 2008 Co-organiser of a European Centre for Theoretical Studies in Nuclear Physics (ECT*) workshop “*Scaling the heights of the $N=Z$ line above ^{56}Ni* ”
- 2010 Organiser of the JYFL Future Physics Workshop, Jyväskylä, Finland
- 2012 Co-organiser of an ExtreMe Matter Institute (EMMI) workshop “*The $^{229\text{m}}\text{Th}$ Nuclear Isomer Clock*”, GSI, Darmstadt, Germany
- 2012 – 2015 International Advisory Committee member for International Conference on Laser Probing (LAP), Paris, France (2012) and Michigan State University, USA (2015)
- 2014 – 2015 International Advisory Committee member for European Nuclear Physics Conference (EUNPC), Groningen, Netherlands (2015)
- 2015 International Advisory Committee member of the Colloque GANIL 2015
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• INSTITUTIONAL AND INTERNATIONAL SCIENTIFIC RESPONSIBILITIES

- 2005 – 2009 Steering committee member and Task Leader in EU–FP6 Joint Research Activity LASER, of the EURONS–I3 project
- 2006 – 2013 Scientific Secretary to the Programme Advisory Committee of the JYFL Accelerator Laboratory (JYFL–ACCLAB), University of Jyväskylä, Finland
- 2006 – 2013 Cyclotron beam time co-ordinator for JYFL–ACCLAB, Jyväskylä, Finland
- 2008 – 2013 Organiser of the Nuclear and Accelerator–Based Physics seminars, University of Jyväskylä, Finland
- 2008 – Deputy Spokesperson of the laser spectroscopy project, LaSpec, for NuSTAR, FAIR, Germany
- 2010 – 2015 Deputy Co–ordinator and Task Leader in EU–FP7 Joint Research Activity PREMAS, of the ENSAR project
- 2012 Member of the Ph.D. thesis committee, M. Ranjan, University of Groningen, Netherlands
- 2014 – Member of the International Master’s Degree Panel Board, Department of Physics, University of Jyväskylä
- 2014 – Coordinator of the Joint Research Activity RESIST, in the ENSAR–2 project, Horizon 2020
- 2014 – Member of the S^3 Low Energy Branch Management Board, SPIRAL–2, GANIL
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- **COMMISSIONS OF TRUST**

- 2008 – Referee for the following journals: Nature Communications, Physical Review Letters, Physical Review X, Physical Review C, Physics Letters B, Physical Review Special Topics, Journal of Physics G, Journal of Physics D, Nuclear Instruments and Methods in Physics Research A and B, Nuclear Physics A, New Journal of Physics, Hyperfine Interactions, Review of Scientific Instruments, European Physical Journal A, Physica Scripta
- 2010 Reviewer for Natural Sciences and Engineering Research Council (NSERC) Discovery Grants Program, Canada
- 2010 Reviewer for French National Research Agency (ANR), Equipex action for high-level structuring equipment, France
- 2011 Reviewer for NuPNET, an ERA-NET for Nuclear Physics Infrastructures
- 2011 External expert evaluator for Flerov Laboratory of Nuclear Reactions (FLNR), project for “*Production and study of heavy neutron-rich nuclei*”, Russia
- 2012 – National Representative for Finland on NuSTAR Resource Board, FAIR, Germany
- 2013 Editor for IGISOL Portrait, “*Three decades of research using IGISOL technique at the University of Jyväskylä*”, Springer
- 2013 Reviewer for Pegasus grant application to Research Foundation Flanders (FWO), Belgium
- 2014 Specialist reviewer for the Project Peer Review Panel (PPRP) of the Science and Technology Facilities Council (STFC), UK
- 2015 Reviewer for French National Research Agency (ANR) programme OH Risque 2014
- 2015 Reviewer for EPSRC Quantum Technology Fellowship application, UK
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- **PRIMARY SCIENTIFIC RESEARCH ACTIVITY**

My main research interest is in the study of fundamental ground and isomeric state nuclear structure, and in the efficient, selective production and manipulation of exotic radioactive ion beams. I have expertise in nuclear, atomic and laser physics and I combine methodology from all these fields to probe nuclei at the limits of stability, to selectively manipulate atoms for spectroscopy or trace analysis purposes utilizing novel laser spectroscopic techniques and Penning/Paul trap technologies.

Optical methods for the study of nuclear structure and radioactive ion beam production

My research involves a complementary set of techniques to extract nuclear spins, electromagnetic moments and the overall shape and size of the nuclear charge distribution of nuclei far from stability, namely:

Collinear laser spectroscopy

The workhorse of the field, a high-resolution technique performed on cooled and bunched ion beams. Optical manipulation of ions is achieved within Paul traps to assist in spectroscopy of metastable states. This work is performed in collaboration with the Universities of Manchester and Liverpool, UK. Future development for collinear atom spectroscopy is under discussion with experts from TRIUMF, Canada. I am currently expanding this collaboration to include GSI, in a wider effort to start a programme of research on heavy element laser ionization and collinear spectroscopy. This follows a very recent success on the heaviest element studied with collinear laser spectroscopy to date, namely Pu, performed by my group at JYFL.

Resonance ionization spectroscopy

A highly selective technique which utilizes the unique atomic fingerprint to excite and ionize the atom of interest. Spectroscopy may be efficiently performed either in-gas-cell for heavier elements, or in-gas-

jet. The latter approach offers unique advantages due to the suppression of atomic line broadening mechanisms. Resonant laser ionization may also be directly used to provide, in principal, isotopically and isomerically pure radioactive ion beams. This work is an international effort performed in close collaboration with KU Leuven, Belgium, and the University of Mainz, Germany. My standing in this field is reflected in my coordination of the new Joint Research Activity, RESIST (REsonance Ionization techniques for SeparATors), in ENSAR2. Additionally, JYFL is a key member of the In-Gas Laser Ionization and Spectroscopy NETwork, IGLIS-NET, launched in 2012 (<http://kekrgb.kek.jp/iglis-net/>).

Laser development

In order to exploit the spectroscopy, my research also involves development of solid-state laser technology. At JYFL we have developed a new injection-locked Ti:sapphire laser which offers considerably reduced laser linewidth while maintaining high power. The laser has been used at JYFL, Mainz and Louvain-la-Neuve. This laser is mandatory for gas-jet spectroscopy which is planned for the future S³ facility, SPIRAL2. An active international network exists among laboratories using Ti:sapphire technology including JYFL, Mainz, GANIL, TRIUMF, ISOLDE and Nagoya, Japan.

• NEW SCIENTIFIC RESEARCH ACTIVITIES

Towards a nuclear clock with ²²⁹Thorium

JYFL, led by I.D. Moore, has joined a consortium of six leading European research groups (the others are TU Wien, PTB, University of Munich, Max-Planck-Institute of Quantum Optics, Max-Planck-Institute for Nuclear Physics and TOPTICA PHOTONICS AG) covering specialized expertise in the fields of atomic and nuclear physics, quantum optics, metrology, as well as detector- and laser technology, in a new proposal to develop a nuclear clock based on a unique low-energy nuclear transition in ²²⁹Thorium. An application, “nuClock”, has been submitted to a research and innovation action, the Future and Emerging Technologies (FETOPEN) call in Horizon 2020. The collaboration will focus on two objectives; (i) to find clear evidence of the isomeric transition and to measure its frequency, and (ii) to develop all key components required for the operation of a nuclear clock. JYFL-ACCLAB participates as the sole large-scale facility. In the last 2 months this application has been favourably evaluated with a budget of almost 4M€ and will run over 4 years, commencing in July 2015.

Towards gamma-ray lasers via super-radiance in a Bose-Einstein condensate of ^{135m}Cs

I am developing a new research theme in collaboration with the ultra-cold atom group of Prof. Ferruccio Renzoni, University College London. The proposed research aims to experimentally demonstrate coherent gamma-ray emission in a Bose-Einstein condensate of ^{135m}Cs isomers, produced in proton-induced fission of uranium at IGISOL, JYFL-ACCLAB. Currently, Finland has no single research group running an experimental programme in cold atom physics and thus this would be a major boost to the research community. The UK on the other hand has no facilities for the production of radioactive beams and this new research would increase its activity in the emerging field of atomic physics with radioactive atoms. In 2015 we were successful in obtaining a Marie Curie Individual Fellowship for a researcher to work on the new project (Luca Marmugi). Prof. Renzoni and I have recently submitted a grant proposal to the Royal Society, UK, for a two year international exchange scheme. At the start of 2016, UCL will transport all laser and trapping technology to JYFL where it will be hosted at the IGISOL facility for the foreseeable future.

Development of a low-energy radioactive ion beam facility at the MARA recoil separator

I am leading a new proposal within JYFL-ACCLAB to uniquely combine a number of key methodologies to produce and measure properties of heavy nuclei close to the proton dripline. The immediate goal is in the provision of essential atomic mass input of key nuclei, critical for the study of the astrophysical rapid proton (rp) capture process. The research will combine a novel gas cell at the

focal plane of the vacuum-mode recoil separator MARA, which is currently under commissioning. Nuclei of interest will be stopped and delivered to a new low-energy radioactive ion beam facility. In 2014, I wrote a proposal for an ERC Consolidator Grant which will also be submitted to the Finnish Academy for personnel and infrastructure funding in the fall 2015. We have successfully applied for a Marie Curie Fellow, Philippos Papadakis, who started his position 1 February 2015, related to this project. International support has been agreed with the University of Leuven (ERC Advanced Grant holder Prof. Piet van Duppen) and GANIL, France. This long-term project will importantly branch the two main research groups within JYFL-ACCLAB, the IGISOL and RITU-GAMMA groups.

- **RESEARCH FUNDING**

1. Funding period: 1.1.2011–31.12.2012

Funding source: Finnish Research Infrastructure (FIRI) – Academy of Finland

Total funding 958,000€, Principal Investigator (I.D. Moore) share 130,000€

The grant allowed me to purchase a narrow bandwidth continuous wave (cw) solid state laser system which has been successfully locked to a pulsed solid state resonator, demonstrating high power tunable laser radiation with narrow bandwidth. The injection-locked laser has been used for spectroscopy on copper, plutonium and actinium. The cw laser will also be available for collinear laser spectroscopy, offering an alternative to the currently used dye laser system. Additional funding has been sought to develop the system further.

2. Funding period: 1.1.2010–31.12.2014

Funding source: ENSAR, Joint Research Activity “PREMAS”

Total funding 571,000€, Principal Investigator (I.D. Moore) share 34,000€

I have been a Task Leader for the PREMAS (Low energy beam preparation, manipulation and spectroscopy) Joint Research Activity in the ENSAR EU-FP7 proposal. My share has been combined with other funding sources to pay for one postdoctoral researcher, Dr. A. Voss, who currently works in my team as part of the IGISOL group.

3. Funding period: 1.1.2014–31.12.2015

Funding source: Finnish Research Infrastructure (FIRI) – Academy of Finland

Total funding 1 325,000€, Principal Investigator (I.D. Moore) share 225,000€

This funding is for a Multi-Reflection Time-of-Flight Mass Spectrometer, a cryocooler and a ^{252}Cf radioactive source. The MR-TOF-MS is a key planned instrument for IGISOL for isobaric purification and mass measurements of very short-lived exotic nuclei. It is planned to use the device at the future low-energy branch of the MARA recoil separator. The cryocooler will be coupled to the IGISOL gas cell to provide a sub-parts-per-billion level of impurity, as well as to increase the gas density to improve the stopping efficiency of fission fragments. The ^{252}Cf source will be installed in a specially-designed gas cell from Leuven to study the behaviour of the extraction efficiency of different elements as a function gas-cell temperature.

4. Funding period: 1.7.2015–1.7.2019

Funding source: Horizon 2020 FETOPEN call, European Commission

Total funding 3 970,328€, Principal Investigator (I.D. Moore) share 247,828€

The funding will cover the cost of a PhD student to work on the nuClock project for the duration of 4

years, as well as 1 month per year of technical staff salary. The student position has already been filled. Travels and subsistence are also covered.

- **PENDING RESEARCH FUNDING**

1. The Royal Society, International Exchanges Scheme – 2015/R1, 24 months
Total request 12,000€

The funding will cover travel and subsistence costs to Finland from the UK and vice-versa for the Marie Curie Fellow, I.D. Moore and F. Renzoni.

2. Horizon 2020, INFRAIA call 2014-2015, ENSAR2 – 2015/R1, 48 months
Joint Research Activity RESIST
Total request 448,000€, Principal Investigator share 72,375€

I am the coordinator for the RESIST Joint Research Activity within the ENSAR-2 application. The funding for JYFL will cover 11 months of a postdoctoral salary and additional funds for travel. To date, it appears that ENSAR2 has been funded however the final signatures are still pending. A first RESIST meeting has been organised for September 2015.

1. Funding period: 1.1.2016–31.12.2018
Funding source: Finnish Research Infrastructure (FIRI) – Academy of Finland
Total funding 1 445,000€, Principal Investigator (I.D. Moore) share 615,000€

This funding request from the Academy of Finland will cover the required infrastructure needed for the MARA Low Energy Branch project, led by myself. This includes vacuum, power supplies, dipole magnet, gas purification and so forth. 183,000€ of the PI's share will expand the cw solid state laser system with a high power pump laser, frequency doubler and new wavemeter. These investments will have a direct impact on the collinear laser spectroscopy programme at IGISOL.

- **INVITED TALKS AT INTERNATIONAL CONFERENCES AND SCHOOLS**

I have made 40+ invited oral presentations at conferences, workshops and seminars, and one invited public talk. Of these, 35 have been given within the last 5 years. Most recently I gave a series of lectures at the La Rabida International Nuclear Physics School in Spain. Further details are available on request.
