Scottish Funding Council
Promoting further and higher education

SUPA

SCOTTISH UNIVERSITIES PHYSICS ALLIANCE
PHASE II

Annual Report to the Scottish Funding Council

For the period 1 August 2014 to 31 July 2015

Including:

Interim Report PEER: Ref H11003 and Postdoctoral Early Career Researcher Exchanges Ref: H11004 (Tranche Three)

Interim Report PEER: Ref H11003 and Postdoctoral Early Career Researcher Exchanges Ref: H11004 (Tranche Four)

Interim Report Use of Restored Funding – SUPA Industrial Placements Scheme Ref: HR09008

Prof Alan Miller FRSE, FInstP, FIEEE, FOSA
Chief Executive Officer

University of Aberdeen · University of Dundee · The University of Edinburgh · University of Glasgow · Heriot-Watt University · University of St Andrews · University of Strathclyde Glasgow · UWS University of the West of Scotland · Science & Technology Facilities Council UK Astronomy Technology Centre

CONTENTS **PAGE NO**

PART 1

SUPA PHASE II – Report to the Scottish Funding Council for the period 1 August 2014 until 31 July 2015

PART 1

EXECUTIVE SUMMARY

The Scottish Universities Physics Alliance (SUPA), launched in 2004 with the aim of placing Scotland at the forefront of research in Physics through co-ordinated promotion and pursuit of excellence, has been highly successful over the past decade in establishing Scotland as a recognised international leader in research and advance post-graduate training in Physics. SUPA-II funding (SFC and the 8 HEI partners, 2010-2017) has provided investment to allow expansion of the Scottish Physics research base through a strategic approach to collaboration base on recruitment of research leaders, construction of state-of-the-art facilities and laboratories, joint international and industry engagements, and a unique and highly successful pan-Scotland SUPA Graduate School (now approximately 600 PGR students) providing prize studentships and a wide range of advanced courses delivered via a network of video classrooms.

The most tangible evidence for SUPA's success to date is the outcome of REF2014. The five SUPA partners that submitted to UoA9/Physics all improved on their overall Grade Point Averages (GPA), and all performed well in the new category of 'impact'. The REF2014 panel report highlighted the 'pioneering' approach of SUPA going from 'strength-to-strength'; the combined 'Research Strength' of SUPA exceeds that of Oxford, Cambridge, Imperial or UCL; the first joint submission in Physics to any RAE/REF exercise, PHYESTA (Edinburgh & St Andrews), attained 2nd top GPA in the UK for output quality, and University of Strathclyde achieved overall top place in Physics in the UK when output quality, impact and environment GPA are combined. Many physicists within SUPA made significant submissions to other disciplines such as Engineering and Mathematics.

In 2014-15, SUPA research output, in terms of numbers of journal publications, rose by 60% to a record high of 1663. Research awards remain strong, in spite of a very challenging UK funding environment, at a total of £88m for 2014-15 with 21 awards exceeding £1m. SUPA added another 5 major European Research Council grants bringing the total to 31. Notably, SUPA researchers have been central to the development of the UK' s new £270M Quantum Technologies initiative; the outcome of this competition finds SUPA (Edinburgh, Glasgow, Heriot-Watt, Strathclyde and Fraunhofer CAP) involved in all 4 Hubs, one led by Glasgow, and the others led by Birmingham, Oxford and York.

A priority for the SUPA Executive in 2014-15 has been the agreement of a Sustainability Plan that will maintain the key functions of the SUPA support operation beyond the SUPA-II funding envelope, and the creation of a new 5 year Strategic Plan. All 8 partners agree that SUPA is a permanent feature of Scottish Physics.

A snapshot of the current status of SUPA is shown in the table below:

• Total Academic Staff	314
• Total Research Staff	434
• Total Graduate Students	596
• Collaborative Grant Income Cumulative	£320 M
• Non Collaborative Grant Income Cumulative	£163 M
• Number of Prestigious Fellows	117
• Number of ERC grants	31

For further information including the metadata and publications list for this report see: http://www.supa.ac.uk/reports/2015.

1 GENERAL

1.1 There has been major progress within all areas of SUPA-II over the reporting period. Firstly to address our key performance indicators:

Publication Rates

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Number of Publications	1100	1300	1378	1038	1663

These are peer reviewed publications. The number of publications has risen by approximately 600 per year during the period under review

Citation Rate Per Calendar Year

Year of Publication	2010	2011	2012	2013	2014	2015
Citation Rate in 2010	1.9					
Citation Rate in 2011	5.1	2.4				
Citation Rate in 2012	6.3	5.7	2.9			
Citation Rate in 2013	5.1	4.6	5.9	1.3		
Citation Rate in 2014	2.7	2.6	3.9	2.5	0.7	
Citation Rate in 2015	1.6	2.4	3.3	2.3	2.3	0.6

The citation rate for 2015 is noticeably high. The citation rates per calendar year provide some evidence of the impact of Scottish Physics but needs more thorough analysis to extract meaningful interpretation.

Grant Income

Current Annual Income since start of SUPA-II

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Collaborative Grant Income	**not available**	161 M	205 M	276 M	320 M
Non Collaborative Grant Income	122 M	50 M	100 M	123 M	163 M

Much fuller information on grant source, new and cumulative grant income, including completed grants, is given in the grant information Annex B.

Research Staff, Post Doc and Support Numbers

Total Personnel Numbers:

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Chairs & Professors	73	96	107	128	151*
Other Academic Staff	116	139	160	167	163
Fellows, Post Docs & Research Assts	264	327	349	386	434
Total	**453**	**562**	**616**	**681**	**748**
					***22 Emeritus, 2 Honorary**

Prestigious Fellows:

2010-2011 personnel numbers include approximately 24

2011-2012 personnel numbers include approximately 50

2012-2013 personnel numbers include approximately 74

2013-2014 personnel numbers include approximately 87

2014-2015 personnel numbers include approximately 117

Total SUPA Funded Personnel Numbers

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Chairs	4	6	8	8	10
Fellowships	8	15	17	15	13
Readers	4	5	5	5	5
Lecturers	4	7	14	13	11
Res Assistants	7	7	8	8	8
Total	**27**	**40**	**52**	**49**	**47**

Research Student Numbers

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Total number of Research Students	522	517	534	543	596
Number of completed applications for SUPA Prize Studentships	320	329	291	314	233
Number of Prize Studentships Awarded	16	10	4	5 + 19*	12 + 5*
				***Titular Awards**	***RCUK**

The total number of PGR students registered with the SUPA Graduate School continues to rise and now approaches a very healthy 600. Collectively this is one of the largest cohorts of Physics PhD students anywhere in the world and SUPA has strived to pitch the Graduate School at the highest achievable level for quality provision, attracting excellent students. The SFC component of the Prize Studentship fund has been exhausted, but all SUPA partner institutions are keen to see the continuation of the centralised SUPA application process which attracts good quality applicants from around the world. SUPA will continue to select and badge the top entrants to the Graduate School as 'SUPA Prize' students with funding for studentships provided from either institutional or external sources at a level of at least 15 per annum, as per the SUPA-II agreement. The number of applicants for Prize studentships has fluctuated in recent years and dropped significantly, to 233 in 2014/15. This is likely to be because students and potential supervisors recognise that the central fund for studentships has been depleted, but nevertheless, the number of applications far exceeds the numbers of Physics PhD students that can be accommodated each year in Scottish HEIs.

Diversity Initiatives

University	Athena Swan	Juno
Aberdeen	Bronze (institutional)	Supporter
Dundee	Bronze (institutional)	Supporter
Edinburgh	Silver (Bronze Institutional)	Champion
Glasgow	Silver	Champion
Heriot-Watt	Bronze (institutional)	Supporter
St Andrews	Bronze (institutional)	Practitioner
Strathclyde	Bronze	-
UWS	Application 2015	Application on Hold

KT interactions

Year	Dec09-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Number of support projects to Scottish SMEs under SEEKEIT/ERDF grant (SUPA Start)	11 + 1 SUPA Start Plus	13	8	5	n/a	n/a
Number of Industrial Studentships placed under INSPIRE	9	5	**No further funds**	**No further funds**	**No further funds**	**No further funds**
Number of INSPIRE Placements	0	0	5	2	0	1
Number of engagements with Scottish SMEs through PEER	n/a	n/a	n/a	7	4	2[1]
Number of STFC KE schemes awarded across SUPA partners	2	2	3	4	5	6
Number of Industrial Placements from Restoration	n/a	n/a	n/a	5	10	2

[1] Scottish SME engagement was not mandatory from PEER2 onwards. A total of 8 PEER awards were made in the period of which 2 involved Scottish SMEs. Most Horizon 2020 calls were closed for 6 months of the reporting period.

1.2 Consortium progress towards Objectives/Recommendations as outlined In the Strategy Document of 2010

While there were no milestones set in the SUPA-II definitive document there were a set of objectives/recommendations outlined in the Strategy document of 2010 and these are outlined and progress commented upon below:

1 Effects of Research Council Funding in The Programme Areas of Astronomy, Particle Physics, Nuclear And Plasma Physics – Strategy Document December 2010: Section 3.1 The Science Case (recommendations from the Advisory Committee)

Complete

2 Energy Theme: to be Refined and Scotland's Low Carbon Strategy to be Built into the Programme

Complete

3 PaLS Programme: Should Address Developing Substantive Academic Involvement and Collaborations with Clinical Medical Community, an Integrated Approach to Biological Challenges, Appointing Young Emerging Stars and making use of National Facilities Such as Diamond

Complete

4 Astronomy Programme: Recommended that a more Focussed Programme be Developed, Concentrating upon Areas of Existing Excellence

Complete

1.3 Conditions of Grant, Annex C

In addition, as per the original conditions of the grant award letter, Annex C, information is given below as to progress made towards these conditions:

Table 1.3.1 Main Purpose of Grant

Point	Main Purpose of Grant, Grant Conditions Annex C, point 30	Progress made towards Grant Conditions, Annex C
30(a)	**Enhancement of the partnership**: Universities of Aberdeen and Dundee to join SUPA-II.	The universities of Aberdeen and Dundee joined SUPA-II with effect from 1 December 2009.
(b)	**SUPA Central infrastructure** to include the appointment of a CEO, Director of Graduate School and 3 administrative support staff.	Prof James Hough resigned from the post of CEO in February 2015. Prof Alan Miller was appointed CEO, with effect from 1st May 2015, 0.5 FTE. The Graduate School Director, Avril Manners, completed her contract on 31 July 2015. The SUPA CEO post now incorporates directorship of the Graduate School. Dr Christian Killow was appointed Graduate School Co-ordinator, 0.5 FTE, on 3 August 2017. It is anticipated that the additional 0.5 FTE Graduate School Co-ordinator will be appointed at the beginning of 2016. The KE Co-ordinator, IT Officer, SUPA Administrator, GS Secretary and SUPA Admin Assistant are under contract until 31 July 2017.
(c)	**Appointments** to include: 6 Chairs, 20 Advanced Fellows, 3 Fellows, 12 Lecturers, 4 Professors, 4 Readers and 6 Research Assistants	Stretching of the SUPA-II budget over seven years together with the cut to SFC funding in 2011-2012 has resulted in a modified profile which includes: 8 Chairs/ Professors, 5 Readers, 14 Lecturers, 18 Advanced Fellows, and 8 Research Assistants. All of these positions have been filled. Many more additional posts have been funded by partner universities. There have been a total of 67 new posts during the reporting period.

(d)	Establishment of a **Knowledge Transfer Directorate** to co-ordinate and boost the economic impact of SUPA.	The KT Directorate has been integrated with the Graduate School agenda within SUPA Central Infrastructure. The Knowledge Transfer Director, Dr Roy Clarke, resigned his position in August 2014. Keith Dingwall, supported by STFC IPS Fellowship, completed his contract on 31 June 2015. Richard Mosses, KT BDM, partly supported by SOA, completed his contract on 31 July 2015. Mat Wasley is under contract as SUPA KE Co-ordinator until 31 July 2017.
(e)	Enhancement of the PG training offered by SUPA and expansion of the Prize Studentship Scheme to 15 studentships per annum from 2010 onwards.	The PG training offered by SUPA has continued to be enhanced and further information is given on this later in this report. In order to continue to meet the target of 15 prize studentships per annum we have introduced a scheme of awarding 'titular' positions to the best HEI, RCUK and other funded students.
(f)	Enhancement of the structure of SUPA-II to create Strategic Research Initiatives which will cross the research theme boundaries.	The current operating structure is encouraging initiatives particularly across the Photonics, Life Sciences, Energy and Nuclear boundaries. Further engagement is being actively pursued with other Research Pools and Innovation Centres.
(g)	The addition of a further Strategic Research Initiative on Physics and Life Sciences, including greater multi-disciplinary working with the Scottish Universities Life Sciences Alliance (SULSA).	The Physics and Life Sciences theme (PaLS) that was initiated in 2009 has developed significantly and there are strong interactions with members of SULSA in research and graduate training, with joint courses being offered. A senior member of SULSA currently sits on the SUPA Board of Directors. Dundee have completed their Biophotonics Laboratory refurbishments.
(h)	An expansion of the International Visitor Programme.	During the reporting period a total of 7 Distinguished International Visitors were funded by SUPA. However a large number of visitors were funded by the Physics Schools themselves. Notable amongst these successes has been the award of two Carnegie Professors to SUPA: Prof Richard Ellis, Caltech and Prof Douglas Lin, Professor of Astronomy and Astrophysics, University of California, Santa Cruz.

Table 1.3.2 Review of Strategic Vision

Point	**Grant Conditions, Annex C, points 31 and 32**	**Progress made towards Grant Conditions, Annex C**
31	Review of Strategic Vision within six months of grant start date, Grant Conditions Annex C, point 31.	Review of Strategic Vision: See Review of Strategic Vision already submitted in December 2010.

32	SUPA Advisory Committee to be fully engaged.	International Advisory Committee is fully engaged with the Chair Prof Malcolm Longair taking a lively interest in all areas of operation. SUPA has strived to attain a more equal gender balance on the IAC.

Table 1.3.3 Governance Proposals

Point	**Governance Review: Grant Conditions Annex C, point 33.**	**Progress towards proposals made by Governance Review Panel in 2009**
33 (a)	SUPA to introduce a Board of Directors with membership from each Institution at Vice-Principal level.	The Board of Directors currently comprises: Prof Richard Kenway (Chair), University of Edinburgh; Prof Celso Grebogi, University of Aberdeen; Prof Tim Newman, University of Dundee; Prof David Cumming, University of Glasgow; Prof Duncan Hand, Heriot-Watt University; Prof Derek Woollins, University of St Andrews; Prof Deepak Uttamchandani, University of Strathclyde; Prof Ian Allison, University of West of Scotland.
(b)	SUPA Executive Committee to be chaired by the new CEO.	Prof Alan Miller, CEO, has been chairing the SUPA EC Meetings, since his appointment in May 2015.
(c)	The International Advisory Committee should continue to have an important role in advising SUPA.	SUPA CEO is in regular contact with the Chair of the International Advisory Committee which meets annually.
(d) 1)	Graduate Training	Graduate Training and Support are firmly embedded in the ethos of SUPA and continue to develop and be a success. SUPA Graduate School currently offers approximately 70 courses per annum.
(d) 2)	Knowledge Transfer .	KT is under review; a new Industry Focus Group looking into how to take industry engagement forward has been formed with a broader remit covering social as well as economic benefit
(d) 3)	Outreach and Public Engagement Co-ordination Group	An Outreach Group, Chaired by Prof Martin Hendry has been co-ordinating outreach and public engagement. Outreach and Education is currently being reviewed by the newly formed SUPA Education and Outreach Focus Group which supercedes the existing Outreach Group.

Table 1.3.4 Monitoring, Evaluation and Reporting

Point	**Governance Review: Grant Conditions Annex C, points 34,38,39,41.**	**Monitoring, Evaluation and Reporting**
34	SFC to be represented on the International Advisory Committee.	The Director of the Research and Innovation Group at SFC, is a member of the International Advisory Committee.

38	SUPA's Key Performance Indicators	See earlier section
39	EU Framework Programmes – maximising opportunities.	There is significant activity in this area funded by PEER and this is reported on later.
41	Sustainability – how will this be met?	Further information on this can be found in Section 7 of the report.

1.4 Key Achievements

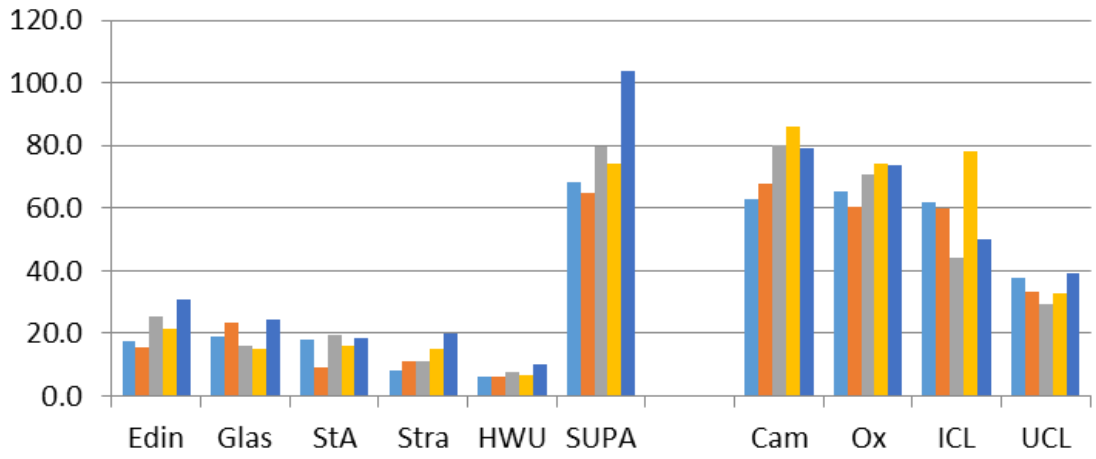
1.4.1 REF 2014 Results

Feedback from the UoA9/Physics sub-panel states, *"There was increasing evidence for pooling of resources in regional groupings, as pioneered during the period of RAE2008 by the Scottish Universities Physics Alliance (SUPA). SUPA has gone from strength to strength and resulted for the first time in a joint submission in Physics (Edinburgh and St Andrews) to an RAE or REF exercise"*.

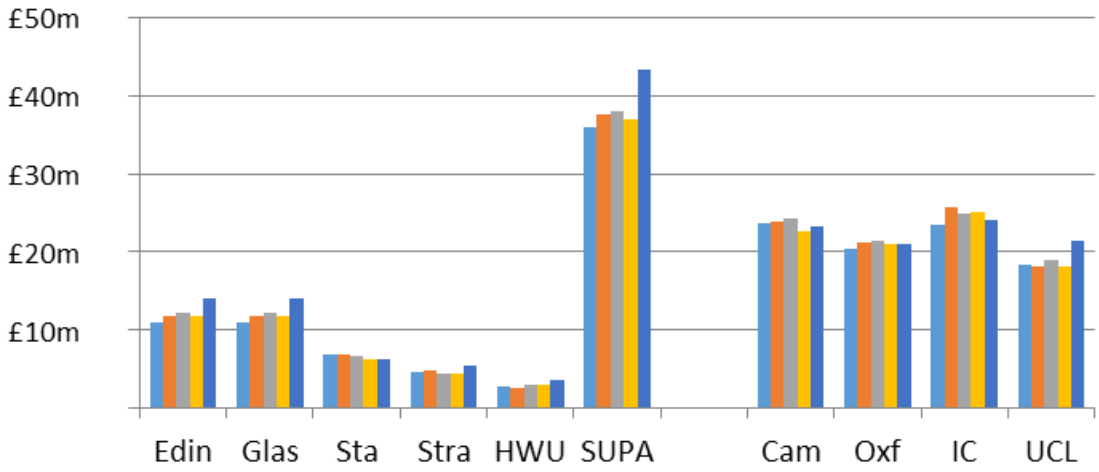
The five SUPA partners that submitted to UoA9/Physics all improved on their overall Grade Point Averages (GPA) between RAE2008 and REF2014, and all performed well in the new category of 'impact'. The Strathclyde submission achieved the top 'overall' GPA for Physics in the UK out of a total of 41 submissions, with the Edinburgh/St Andrews joint submission, PHYESTA, coming 3rd equal. On 'output' quality, PHYESTA was rated 2nd in the UK, while on 'impact' all Scottish submissions are in the top 15 in the UK with Strathclyde in 2nd place. The research strength of SUPA collectively (overall GDA x FTE submitted) exceeds that of the big 4 in England, i.e. Oxford, Cambridge, Imperial and UCL, and PHYESTA alone is fourth, ahead of UCL in research power.

Interdisciplinary contributions of physicists are very apparent in Scottish REF2014 submissions. Three alliance partners submitted all of their physicists to other UoAs: Aberdeen (Mathematics), Dundee (Engineering & Life Sciences) and West of Scotland (Engineering) while Heriot-Watt and Strathclyde both submitted a significant number of their Physics academics to Engineering. It is also recognised that a number of Electrical Engineering and Mathematics Schools/Departments include staff with Physics backgrounds/PhDs.

The bar charts below compares reported numbers of SUPA PhD graduations and research income during the REF2014 assessment period.



Number of Physics PhD graduations reported for each year of the REF2014 assessment period, 2008-09 to 2012-13.



Research income by spend (excluding in-kind contributions, PGR and SFC funding) reported for each year of the REF2014 assessment period, 2008-09 to 2012-13.

1.4.2 Update on SUPA-II Facility Investments

a) **SUPAscopes** 1m Robotic telescope (St Andrews) – Prof Keith Horne

The SUPA-II investment in SUPAscopes puts SUPA at the forefront of robotic telescope networks with leading research in the areas of time-variable astrophysics. The full network is now in place and will continue microlensing studies to determine the cool-planet mass/orbit distributions down to Earth-mass planets. Of particular interest is the ability to use the SUPAscopes in conjunction with the Spitzer Space Telescope to obtain parallaxes of the lensing events. This provides a precise determination of the planetary mass and lens distance, in order to measure the planet abundance distributions of the Galactic bulge and disc. The SUPAscopes are also providing datastreams for echo mapping of black hole accretion disks, exoplanet transit lightcurves, variability in young stellar objects, and transient events.

b) **Low Vibration and Clean Room Facilities** (St Andrews) – Dr Peter Wahl

Education Secretary Angela Constance officially opened the £3.7M Ultra-low Vibration (ULV) laboratory and Clean Room on 21 May 2015. The event was attended by over 100 colleagues and guests. The St Andrews ULV labs are the most advanced in the UK and one of just a handful worldwide. The labs are designed to provide an ultra-low vibration environment for the custom-built microscopes developed in the group allowing imaging and study of individual atoms in advanced materials, including superconductors which conduct electricity without losses, and quantum materials for next generation technologies. Access to the facility is enabled through new collaborative projects with partners at SUPA universities and beyond. It further benefits from embedding in the recently established International Max-Planck-Partnership between Scottish universities and a number of Max-Planck-Institutes. The School's new Research Clean Room facility provides 120 m2 of micro- and nano-fabrication space, allowing research teams working across the SUPA themes of Photonics, PALS, Energy, and Condensed Matter and materials Physics to expand their research in nanophotonics, solar power, displays, sensors, communications and healthcare.

c) **SCAPA** (Strathclyde) – Prof Dino Jaroszynski

A new 1200 m^2 building extension includes state-of-the-art laboratories provided with high power lasers, laser-driven plasma accelerators and radiation sources. Research is focussed on the development and application of next generation accelerator technology. A new 350 TW laser currently under order (delivered by the end of 2016 and commissioned in January 2017) will be used in a variety of industrial, medical and scientific applications, such as electron and X-ray

diffraction, radiation detector development, nuclear medicine, nuclear physics, condensed matter physics, medical imaging and molecular biology. It will provide a fascinating environment to study laboratory astrophysics using high power lasers, high field physics and develop the next generation coherent X-ray sources. It will be possible to test materials under extreme conditions similar to those encountered in nuclear fission and fusion reactors and in space, as well as contribute to the development of new types of nuclear fission reactors and the assay of stored nuclear waste. The facility will provide unique opportunities for SUPA partners in both nuclear and plasma physics.

d) **MagTEM** (Glasgow) – Prof Bob Stamps

The £2.65M MagTEM microscope was officially unveiled on 2 July 2012 by Dr Alasdair Allan, the Scottish Government's Minister for Learning, Science and Scotland's Languages in the Kelvin Building, University of Glasgow. The microscope is one of a select number worldwide and has been further customized for improved resolution, making it unique. It is the latest addition to the University's Kelvin Nanocharacterisation Centre, which is home to a range of equipment that allows researchers from across the physical sciences and engineering disciplines to create and examine materials on the atomic scale.

Research from the Centre has contributed to the development of a wide range of products, particularly in microelectronic and data-storage applications. In terms of overall external grant funding, the Centre facilitates a current portfolio of over £15M (including the £5.9M EPSRC SuperSTEM facility), of which the Glasgow Physics and Astronomy share directly held by members of the Centre totals approximately £4M. The unique capabilities of the new instrument have led to usage by, and new collaborations with, researchers from Strathclyde, Heriot-Watt, St Andrews, UWS and Edinburgh. Two of the most active on-going projects are through UWS involving Ian MacLaren and Stuart Reid, and through Strathclyde involving Damien McGrouther and Carol-Trager Cowan. The Centre also supports a number of industrial contracts with Scottish and UK firms, including Amec and Doosan Babcock. Most recently the Centre has begun efforts designed to produce new insight into influenza and the human RSA virus in a co-operation with the Glasgow MRC Centre for Virus Research.

e) **Nanofabrication Facility** (Heriot-Watt) – Prof Brian Gerardot

This facility, installed in 2010, consists of a state-of-the-art electron beam lithography system (£0.5M Raith Pioneer) and an inductively coupled plasma reactive ion etcher (£0.25M Oxford PlasmaLab100). Together, these machines allow features down to 20nm to be patterned into semiconductor, dielectric, or metallic materials. A laser interferometer-controlled stage allows nanoscale features to be patterned faithfully over mm areas. The instrument is being used to create advanced nanophotonic structures in collaboration with partners in academia and industry.

f) The HARPS-N Spectrograph (Edinburgh) – Prof Ken Rice

The HARPS-N spectrograph is a high-precision radial-velocity instrument, similar to HARPS on the 3.6-m ESO telescope in Chile, located in the Northern hemisphere and installed at the TNG on La Palma Island (Canary Islands). The main scientific rationale of HARPS-N is the characterization and discovery of terrestrial planets by combining transit and Doppler measurements. The HARPS-N Project is a collaboration between the Astronomical Observatory of the Geneva University (lead), the CfA in Cambridge, the Universities of St. Andrews and Edinburgh, the Queens University of Belfast, and the TNG-INAF Observatory. It has been operating since 2013, will run until 2018, and has had a number of recent successes. This includes characterising the most Earth-like, in terms of composition, exoplanet (Kepler-78b) and discovering a 4 planet system around a nearby bright star (HD219134), one of which also happens to be the closest transiting exoplanet.

2 THEME REPORTS

2.1 Astronomy and Space Science

Theme Leader: Prof Ian Bonnell, University of St Andrews

52 T&R academics, 74 research fellows/associates and 77 graduate research students at Edinburgh, Glasgow, Heriot-Watt and St Andrews.

The Astronomy Theme strategy continues to target world-leading research across a broad range of astronomical and space science targets. The success of this strategy is evident from the continued funding from UKRC and European Research Council (ERC) grants received across the areas from planetary atmospheres, star formation, galaxies, cosmology and instrumentation for detecting gravitational waves. These ERC grants will continue to broaden the on-going activities funded through STFC and SUPA-II.

Highlights:

- Solar Physics: The Glasgow astronomy and astrophysics group continues to conduct leading research in solar and astrophysical plasmas, with an emphasis on non-thermal electrons at the Sun and in Space (supported by LOFAR) and on multi-wavelength observations of flares and flare dynamics. Fletcher leads F-CHROMA, a 7-institute FP7 project on solar flare chromospheres, while Kontar is Co-Chair of the SKA Solar, Heliospheric & Ionospheric Physics working group. Labrosse co-ordinates the ALMA simulations team on Prominences and Hannah is on the team, which has made the first solar observations with NASA's NuSTAR X-ray satellite.
- Exoplanets: HARPS-N continues to deliver superbly stable radial-velocity performance, leading the world in precise mass determinations for small planets discovered with NASA's Kepler and K2 missions. The HARPS-N team published mass determinations for three transiting super-Earth planets and the first fully-characterised hot Neptune. The three super-Earths have densities consistent with an Earth-like iron-silicate composition. One of them was discovered with HARPS-N around HD219134, the closest (at 6.5pc) and brightest star yet found to host a transiting exoplanet. The transits were detected in follow-up observations from the Spitzer Space Telescope. The brightness and proximity of the host star will make it a prime candidate for future atmospheric characterisation studies with the James Webb Space Telescope and the European Extremely Large Telescope. The Mass determination of 51 Earth masses, and a transit-determined radius of six Earth radii, make the hot super-Neptune Kepler-101b the first fully-characterised super-Neptune. Its properties indicate that it probably has a significant fraction of heavy elements in its interior.
- Our 3 SUPAscopes became operational in 2014 as part of the LCOGT global network (currently 9 x 1m and 2 x 2m robotic telescopes), and are now delivering lightcurves for time-domain astrophysics experiments, often in tandem with data from space missions (HST, Spitzer, Kepler, Gaia). The scientific goals are 1) the discovery of small cool planets by gravitational microlensing; 2) the characterisation of hot planets transiting their host stars; 3) echo mapping of black hole accretion flows in active galaxies; 4) the variable structure of brown dwarfs and young stellar objects; and 5) follow-up studies of transient events (e.g. supernovae).
- Extragalactic Astronomy and Cosmology: Edinburgh astronomers have conducted a survey of 72 galaxy cluster collisions to show that dark matter does not interact with either itself or regular baryonic matter. Using HST and gravitational lensing to detect the dark matter and stars, and Chandra to detect the gas, they found that dark matter was less self-interactive than expected in many current models of dark matter with a maximum cross section of 0.47 cm2/g. Gravitational lensing has also been used to detect dust in galaxies at high redshifts. The large magnification from the foreground cluster of galaxies allowed the study to see the significant dust component indicating a very fast dust production within a timeframe of only 100 Myrs.

- Using the HST Hubble Frontier Fields to study galaxies in the distant Universe, SUPA astronomers based in Edinburgh have shown that there is a significant population of galaxies at redshifts ~9. This population is higher than had been earlier claimed and supports the idea that early galaxy evolution is sufficient to explain the reionisation of the Universe.
- Gravitational wave detection continues to be an active area of research in SUPA, with the delivery of the fused-silica suspensions for the LIGO detectors, increasing the sensitivity by a factor of 15 so that binary neutron star mergers can be detected to 300 Mpc and black hole mergers to a redshift of z~0.4. The detection of gravitational waves also promises to open up new avenues for astrophysical research. SUPA astronomers in Glasgow have published a theoretical study of how we can use the gravitational waves from inspiraling binary neutron stars as a direct probe of the cosmological parameters. Using the tidal perturbation on the post-merger system can break the mass-redshift degeneracy otherwise present and allow for an independent measurement of the redshift and distance and hence the cosmological parameters.

Fellowships, Awards and New Appointments:

Shaw Prize: Edinburgh astronomer John Peacock is the joint recipient of the 2014 Shaw Prize in Astronomy together with Shaun Cole and Daniel Eisenstein awarded “for their contributions to the measurements of features in the large-scale structure of galaxies used to constrain the cosmological model including baryon acoustic oscillations and redshift-space distortions”. This work was from the 2 Degree Field (2DF) galaxy redshift survey that John Peacock led, measuring over 220,000 redshifts and significantly impacting our view of the large scale structure of the Universe.

Professor Martin Hendry has been awarded an MBE for services in the Public Engagement of Science; Lyndsay Fletcher was appointed President of IAU Commission E2 (Solar Activity). Eduard Kontar was elected to the Organising Committee of Division E (Sun and Heliosphere) and Nicolas Labrosse was elected to the Organising Committee of Commission E.1 (Solar Radiation). Dr. Natasha Jeffrey has been appointed as an STFC postdoc in Glasgow. Drs J.Lama, C. Koeperfl and C.Bacynski have been appointed STFC PDRAs in St Andrews. Dr Marina Cortes was awarded the Butchalter Cosmology Prize for her paper entitled “The Universe as a process of unique events”. This paper explores time as the fundamental concept out of which emerges cosmology and quantum gravity

Major New Funding:

John Peacock (Edinburgh) has been awarded a 2.3M euro ERC Advanced grant “Cosmological Structure Formation in the Multiverse” (2015-2020).

St Andrews (PI M Jardine) have been awarded an STFC Consolidated grant worth £1.6M. (2015-2018)

Glasgow received an STFC PPRP grant (£42K) for the UK involvement in DKIST

2.2 Condensed Matter and Materials Physics

Theme Leader: Dr Brendon Lovett, University of St Andrews

55 T&R academics, 65 research fellows/associates, and 77 graduate research students at Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St. Andrews, Strathclyde universities.

CMMP research is wide-ranging, from fundamental to applied, and creates large impacts, from high profile publications to potential spin-out companies and providing highly skilled graduates for industrial employment. Broad research topics with critical mass in SUPA include both experimental and theoretical investigations of atomic resolution spectroscopy of correlated electrons, exploring matter at extreme conditions, high resolution characterization of novel materials, soft condensed matter and solid-state physics at the single quantum level. Additionally, the theme overlaps strongly with the Photonics, Energy, PaLS and Astronomy themes.

Highlights:

- Opening of the SUPA ultra-low vibration labs at St Andrews provides state-of-the-art facilities for imaging of advanced materials, see Section 1.4.2; inauguration of SUPASTEM 3 microscope facility (Daresbury, Glasgow is a partner); a £1M clean room refurbishment is almost complete (Heriot-Watt).
- The EPSRC Centre for Doctoral Training: Condensed Matter won a £340K EPSRC Capital Equipment grant focussed on Advanced Materials Design: a new computer cluster for our computational materials physics course, an Atomic Layer Deposition system now installed in St Andrews, and a multichannel picosecond event timer module already in active use at Heriot-Watt. A state-of-the-art student mechanical workshop in Edinburgh which is available for use by all CM-CDT students and builds upon core transferable skills training for experimental students.
- Numerous high profile publications in Journals such as the Nature family of journals (Huxley Edinburgh; Marenduzzo Edinburgh; Cates Edinburgh; King St Andrews; Lovett St Andrews & Gauger Heriot-Watt; Gregoryanz Edinburgh; Valiente Heriot-Watt), and Proceedings of the National Academy of Sciences (McWilliams Edinburgh; Poon Edinburgh; Marenduzzo & MacPhee, Edinburgh); many articles in Physical Review Letters (eg Stamps Glasgow; Ohberg Heriot-Watt; Gerardot Heriot-Watt; Hartmann Heriot-Watt), Advanced Materials (e.g. Martin Strathclyde), Applied Physics Letters, New Journal of Physics etc.
- Former SUPA prize student Tjhung (Edinburgh) has published this year in Nature Communications.

Knowledge Exchange & Impact:

- Industry and enterprise: Collaboration with IQE Ltd, Plessey Semiconductors and TopGaN on the characterisation and development of III-Nitride materials and devices (Strathclyde); a rheo-imaging module we invented and licensed to TA Instruments reached the market in 2014-15, being marketed as a 'modular microscope accessory' for their new Hybrid Rheometer, see: http://upgrade.tainstruments.com/DHRaccessories/mma.html (Edinburgh); following successful completion of a £0.4M 3-year contract with a major confectionary manufacturer, the company has given Edinburgh another contract, worth £0.3M over the next 3 years to explore new aspects of the science arising from the first period of research (Edinburgh)
- The CM-CDT's first spin-out company was created by two CM-CDT students, Razorbill Instruments (http://razorbillinstruments.com). They have gone on to win several funding prizes including awards at the Converge challenge, an S.E. SMART award and 1st place in the Mercia business pitch competition in the West Midlands. One of the co-founders Alex Ward has also won a RSE Enterprise Fellowship.
- Launch of the International Year of Light at the RSE, highest attended event there in recent memory - a special mention here for the efforts of SUPA KE Co-ordinator Mat Wasley (also Lee, Cassettari, St Andrews, Martin Strathclyde).
- Jon Riley (group of King, St Andrews) presented a poster at Houses of Parliament for SET for Britain competition. He was also asked to deliver one of three talks highlighting the Diamond light source to journalists; Maxwell lecture at King's College London on "Nitrides – the Rainbow Material" (Trager Cowan, Strathclyde).
- One of those awarded the 2014 Physics Nobel Prize for developments of GaN LEDs (Prof Shuji Nakamura, UCSB) held a Visiting Professorship in Strathclyde Physics from 1998-2004.

Major New Funding:

Excellent level of grant income, including

- ERC consolidator (1.5 M Euro, Marenduzzo, Edinburgh)

- EPSRC programme grant on hybrid polaritonics (£5.1M lead Southampton, St Andrews major partner), EPSRC capital equipment on oxide MBE (£1.8M, St Andrews), CM-CDT and SOFI CDT capital equipment grants, EPSRC on magnetic domain wall motion (£810K, McVitie Glasgow), EPSRC-JSPS (Japan) award for advanced materials with spin chirality (~£1.5M, Stamps et al. Glasgow).

2.3 Energy

Theme Leader: Prof Paul McKenna, University of Strathclyde

35 T&R academics, 30 research fellows/associates, and up to 40 graduate research students at Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St Andrews, Strathclyde and UWS.

Physics provides the theoretical foundation for essentially all of the technologies and processes involved in energy conservation and generation. The SUPA Energy Theme builds on the existing high-quality research across all alliance universities in key areas including; solar, nuclear, energy conservation and management, and, emerging power sources. The research undertaken within the Theme falls within three strands, (i) solar power, (ii) nuclear power and (iii) energy demand and sustainability

Highlights:

Numerous high impact publications and others of notable interest across the energy research portfolio, including:

- Several high impact publications in the area of photovoltaics by Prof I Samuel and co-workers at St Andrews. These include articles in: Advanced Materials on electron transfer rates in photovoltaic materials; Chemical Science on phosphorescence in organic light-emitting diodes; Nanoscale on emissive quantum dots in small organic molecules; and in the Journal of Materials Chemistry on the electrical properties of materials for organic solar cells.
- Advanced Materials article by Prof R Martin's group (Strathclyde) on organic down-converter molecules for white light conversion.
- Nature Communications article on the self-assembly of switchable colloid blue-phase composites by K Statford et al (Edinburgh). This new class of material can be applied in the development of energy efficient LCDs.
- Two Physical Review Letters on different aspects of fast electron transport in dense plasma for inertial confinement fusion, by Prof P McKenna's group (Strathclyde).
- Two Physical Review Letters and an article in Scientific Reports on theory and simulations of fast electron transport and closely related topics, by Prof Z-M Sheng's group (Strathclyde).
- Electrochemistry Communications article on charge-driven structural transitions in ionic liquids by Prof M. Fedorov (Strathclyde) and co-workers
- A paper in Optica on optically-pumped semiconductor lasers for solar pumping of semiconductor lasers by Dr K Wilcox and Dr A Quarterman (Dundee).
- Two new papers on characterising encapsulated nuclear waste using cosmic-ray muon tomography by Prof D Ireland and co-workers at Glasgow
- A publication in Biomass and Bioenergy on pathogen reduction in biogas by L M Avery et al (Aberdeen)

Knowledge Exchange & Impact:

- Continuing industrial funding attracted by Prof D Ireland to build a full-scale prototype system for non-destructive assay of nuclear waste by muon tomography
- Joint ETP PhD studentship Strathclyde (Prof M Fedorov's group), Aberdeen and Schlumberger as an industrial partner

- Press interest and public engagement on optically-pumped semiconductor lasers for solar pumping of semiconductor lasers by Dr K Wilcox and Dr A Quarterman (Dundee).
- Press coverage of the ADAS-EU project (see for example the Horizon2020 website)

Awards and Fellowships:

- Dr Nicolas Rubido, a SUPA Prize student in the group of Dr M da Silva Baptista at Aberdeen has been awarded a Springer Prize to publish his PhD thesis on the mathematical principles behind the transmission of Energy and Synchronisation in Complex Networks as a book.
- Dr David MacLellan, a SUPA Prize student in the group of Prof P McKenna (Strathclyde), won the 2015 Institute of Physics Culham thesis Prize for his PhD project work on the physics of fast electron transport for the fast ignition approach to inertial confinement fusion.

Major New Funding

- New EPSRC responsive mode grants to Prof R Martin (Str) for advanced III-nitride materials for next generation UV emitters (£500K) and collaborators, and to Prof P McKenna (Strathclyde) on high field physics at the focus of ultra-intense laser pulses (£285K), which includes fundamental physics relevant to the development of advanced schemes for inertial confinement fusion.
- New STFC Consolidated grant (£380K) to the UWS. Activities include nuclear energy-relevant research
- A new grant funded by the African Union led by Dr J Smith (Aberdeen) to investigate the potential of biodigesters to produce gas for energy applications in Africa.
- International supercomputer grant within the cross-European PRACE program to Prof M Fedorov (Strathclyde) to model electrochemical storage (indirect value ~£1M).

2.4 Nuclear and Plasma Physics

Theme Leader: Prof Dino Jaroszynski, University of Strathclyde

38 T&R academics, 52 research fellows/associates, 54 graduate research students at Edinburgh, Glasgow, Strathclyde and UWS. NPP has strong links with SULSA and SINAPSE and other themes within SUPA, ie Astronomy & Space Physics, Energy, Particle Physics and Photonics.

NPP emphasizes cross-disciplinarity and diversity through the SUPA flag-ship project SCAPA, which brings together NPP, Themes from all Pools and other collaborators to undertake high-impact research. Combination of nuclear and plasma physics results in applications of economic and societal relevance and new science. Nuclear and plasma physics researchers are taking advantage of the Extreme Light Infrastructure, ELI, to investigate high-field physics and new nuclear physics. In addition, the new sources that are becoming available at ELI and SCAPA gives a host of new applications of radiation sources and particle beams for the development of detectors, particle beam radiotherapy, X-ray phase contrast imaging, probing dense matter and investigating fusion related topics including damage to material in hostile environments. There are many KE opportunities and NPP has more than 7 industrial collaborations.

Highlights:

- NPP have published 238 papers including 1 Science, 3 Nature Scientific Reports, 36 PRL, 60 PR-A-B-C-D, 2 Geophys. Res. Lett., 2 APL, 9 NJP, 1 Opt. Express, 6 PLB (note that there may be a small number of duplications of nuclear physics publications as the groups collaborate and have reported separately)

- The 1200 m2 SCAPA facility has been constructed; a 350 TW laser, which will be the main laser used for research, has been ordered and will be delivered by the end of 2016. SCAPA is developing collaborations with NPL and the Cockcroft Institute to provide links to the accelerator, standards and metrology communities.
- Wide range of results involving attosecond laser pulses, high power mm-waves (THz) through to UV, VUV and X-ray pulse generation, chirped-pulse Raman amplification, laser-plasma accelerator, polarimeter and detector development, laser-wakefield acceleration, energy-spread in electron bunches, magnetically assisted fast ignition, neutron-deficient isotopes, direct ionization of hydrogen atoms, mega-Ampere electron current propagation, cross sections of 2H(alpha,gamma)6Li/ big bang energies, Pygmy Dipole Resonance.

Knowledge Exchange & Impact:

- STFC Follow-on Fund "PET imaging" £120K completed in April 2014. (D Watts, Edinburgh) (Collaboration with CRIC at the Royal Infirmary Edinburgh to progress this work. Employed new RA (G. Smith) on 1 year position);
- Collaboration with the National Nuclear Lab (NNL) and Sellafield Ltd, as part of its applied nuclear science programme (D Ireland, Glasgow);
- Spin-out company, Anacail, which successfully attracted £750K private equity, and is lead partner in a £460K TSB (SMART award) multi-company grant, D Diver (Glasgow);
- Radiotherapy and medical radioisotopes produced by LWFA – collaboration between Strathclyde, Glasgow, UWS and SINAPSE;
- Radiobiology and dosimetry being developed for health care; radiotherapy using high energy electron and proton beams; dosimetry of very high energy electrons (VHEE) for radiotherapy applications (Strathclyde);
- CDT in the application of next generation accelerators, another university funded energy related CDT, The NPL Graduate School, a Nuclear Technology MSc & MSc in High Power RF and bilateral training agreements with ELI.

Current academic collaborations:

Wide international engagement: US National Superconducting Cyclotron Facility, Argonne National Laboratory, Laboratory for Underground Nuclear Astrophysics, Jefferson Lab (Newport News, Virginia, USA), Washington University, RIKEN laboratory, Japan, MPIK Heidelberg, Mainz, MPQ in Garching, Munich, DESY and UCLA (FACET project), University of Hamburg, (Germany), ELI-ALPS (Hungary), ELI-NP (Ro-mania) and ELI-Beamlines (Czech Republic), ISOLDE facility CERN, LUNA and Caserta (Italy), Institut Laue Langevin (France), JYFL Accelerator Laboratory in Jyväskylä (Finland) and a number of international research consortia, TSR@ISOLDE, the Hall-A, CLAS and GlueX, Crystal Ball at MAMI collaborations the OLYMPUS experiment at DESY, MAXLab in Lund, Sweden, NuSTAR, EPHRAT and AGATA collaborations.

Awards, Fellowships and New Appointments:

- P Woods (Edinburgh) has ongoing GENCO award from the GSI laboratory Germany, and a three year visiting Professorship from the Chinese Academy of Sciences;
- P McKenna (Strathclyde) has ongoing EPSRC Leadership Fellowship, started March 2012;
- D Ireland (Glasgow) is chair of the CLAS collaboration at JLAB;
- G. Simpson (UWS) spokesperson of EXOGAM at ILL (120 users).

Major New Funding

- Grant portfolio: current >£18M portfolio of grants, ie an income of around £5-6M per annum;
- Wide range of sources of funding, STFC, EPSRC, British Council, Sellafield, DSTL, EOARD, EU FP7, Leverhulme Trust, and Industry;
- Strathclyde (£3.2M): EPSRC: EP/J018171/1 Critical Mass: 2012-15; Collective radiation-beam-plasma interactions at high intensities; PI: D A Jaroszynski;
- Strathclyde (£1.3M): EPSRC: EP/J003832/1: Multi-PetaWatt Laser-Plasma Interactions: PI: P McKenna;
- STFC Consolidated Grants at Edinburgh (£1.09M), Glasgow (£1.7M), UWS (£380K);
- Joint Edinburgh/Glasgow (£1.3M): STFC Project grant for Jefferson Lab;
- Edinburgh (£1.01M) PPRP ISOL CERN grant 7;
- Joint Glasgow/Edinburgh (£1.4M) – JLAB project grant.

2.5 Particle Physics

Theme Leader: Prof Paul Soler, University of Glasgow

33 T&R academics, 16 honorary academics, 60 research fellows/associates and 77 graduate research students at Edinburgh and Glasgow.

The main research is focussed on determining the properties of the Higgs boson and the search for new physics beyond the Standard Model of particle physics. The interplay between the SUPA theoretical and experimental particle physics efforts is very beneficial for both areas. The LHC experiments (ATLAS and LHCb) have started taking data for the LHC Run II and have already produced results at the increased 13 TeV Centre of Mass energy. The LHC upgrades are the main focus for future projects, with the ATLAS Phase II and LHCb upgrades recently approved by STFC. There is also an increasing effort in the search for dark matter and future neutrino projects. Lattice QCD and particle physics phenomenology are the main focus of the Edinburgh and Glasgow theoretical groups.

Highlights:

- About 46 theoretical/phenomenological papers, 67 lattice QCD papers, 178 ATLAS papers, 113 LHCb papers and 66 other experimental particle physics papers in 2014-15.
- Glasgow and Edinburgh are playing key roles in the determination of the Spin-Parity assignment of the Higgs boson (JP=0+) and in the precision measurement of the mass of the Higgs boson, consistent with the Standard Model UPA; Glasgow and Edinburgh have leading roles in the DIRAC-3.
- The Muon Ionization Cooling Experiment (MICE), with leadership by Glasgow and Strathclyde, started data taking in June 2015.
- Edinburgh played a leading role in the measurement of the Higgs boson mass from $H \rightarrow ZZ^* \rightarrow 4\ell$ channel. In an analysis led by Edinburgh, LHCb performed the most precise measurement of the branching fraction of $B_s \rightarrow \phi\,\phi$ and improved the limit on $B_d \rightarrow \phi\,\phi$ by a factor of seven; led on the most precise measurements of the weak phase ϕ_s in decays of $B_s \rightarrow J/\psi\,\phi$ mesons.
- Glasgow worked on the combination of the WH and ZH vector boson fusion channels; had a leading role in the world's best limit on CP violation from two-body charm decays; led the analysis on "Effective lifetime measurements in the $B_s \rightarrow K^+K^-$, $B^0 \rightarrow K^+\pi^-$ and $B_s \rightarrow \pi^+K^-$ decays", with the world's most sensitive measurements of effective lifetimes of Bs and B0 decays; contributed to the design and physics performance of the best performing Neutrino Factory facility, and determined the sterile neutrino sensitivity of the nuSTORM facility

- The Lux-Zeplin (LZ) dark matter consortium passed a major US milestone on 28 April 2015: the LZ was approved through 'Critical Decision CD1/3a' by the Department of Energy (DoE), USA. In the UK, STFC approved funding for a major UK contribution to LZ, with a significant Edinburgh component.
- First complete two-loop five-gluon helicity amplitude in Yang-Mills theory (including non-planar diagrams), which is a step towards NNLO QCD phenomenology. All non-planar diagrams are simple linear combinations of planar diagrams, so full colour diagrams are no harder than leading colour (Badger et al).
- The computation of the electric dipole moment of the neutron from a fully dynamical simulation of lattice QCD with a non-vanishing theta term (Guo, Horsley et al.,).
- A recent paper ("Black holes and the double copy", R. Monteiro et al, in JHEP shows that a recently discovered relationship between QCD and gravity extends to classical solutions, including the well-known Schwarzschild and Kerr black holes; this provides compelling evidence for a deep underlying relationship between the two theories, and indicates that quarks and gluons may allow us to understand quantum gravity.
- The paper "On-shell interference effects in Higgs boson final states", C. Englert, I. Low and M. Spannowsky, was a PR Editor's choice article.
- The world's best determination of charm and strange masses from lattice QCD using the most realistic calculations of QCD to date was published in PRL and was chosen as editor's choice in Physical Review D.
- The first full determination of the T and T' leptonic decay rates from lattice QCD was published in PR). This is linked to further work that gives a complete picture of decay constants across the full meson spectrum from from π to T.

Knowledge Exchange & Impact:

- Outreach activities include Masterclasses at Glasgow and Edinburgh, extensive Continuous Professional Development (CPD) for teachers, the award of Higgs prizes for school children by the Scottish Government and IoP to visit CERN and its facilities, and taking pupils and teachers from high SIMD (Scottish Index of Multiple Deprivation) areas in the West of Scotland to CERN.
- Development of dosimetry systems for medical cyclotrons using the MEDIPIX chip developed for particle physics, in collaboration with Gartnavel Hospital at Glasgow.
- Edinburgh hosted the Beauty 2014 conference in July 2014 and Glasgow hosted the NUFACT 2014 conference and the International Neutrino Summer School in August 2014 (all sponsored by SUPA).
- The Higgs Centre organized the Higgs Symposium on Scientific Challenges and Big Computing in January 2015.
- Development of the Intel® Parallel Computing Center at The Higgs Center for Theoretical Physics, the University of Edinburgh, for QCD calculations.

Awards, Fellowships and New Appointments:

- Fabiola Gianotti, an honorary professor at Edinburgh University, has been selected as the next CERN Director General.
- Victoria Martin (Edinburgh) was appointed to membership of the Royal Society of Edinburgh Young Academy of Scotland in July 2014, and became co-chair in December 2014.
- Peter Clarke (Edinburgh) was appointed as a core member of Science Board in October 2014.

Major New Funding

- A new collaboration between Chris White (Glasgow) and the Optics group (Glasgow) has resulted in an EPSRC Grant "Telescope windows: low-vision aids to cloaks." This involves applying the mathematics from General Relativity to the design and construction of novel optical materials, whose applications include new medical spectacles to alleviate retinal disorders.
- The LHCb upgrade has been funded with a grant of £432K (Edinburgh) and £167K (Glasgow), which will allow Edinburgh to play a major role in the construction of the photon detectors for the upgraded RICH systems and Glasgow to deliver the high-speed data tapes and electro-optical boards for the Vertex Locator (VELO) readout system.
- Edinburgh has been awarded a grant to work on R&D for the Hyper-Kamiokande future neutrino oscillation experiment in Japan.

2.6 Photonics

Theme Leaders: Prof Gerald Buller, Heriot-Watt University
Prof Martin Dawson, University of Strathclyde

68 T&R academics, 90 research fellows/associates and 160 graduate research students at Glasgow, Heriot-Watt, St Andrews and Strathclyde – some of these researchers are shared with PaLS and Energy.

Photonic research in Scotland ranges from fundamental quantum mechanical interactions to applications of lasers in manufacturing and healthcare. The photonics theme overlaps with other SUPA Themes and works at the interface with engineering (SPRe), life sciences (SULSA, SINAPSE) and Healthcare (SU2P/Health Theme). Industry engagement is high and the area has triggered innovation and enterprise with a track record of company creation in Scotland over the past 40 years.

Highlights:

- Quantum Technology continues to be a key theme for SUPA Photonics, with SUPA staff in three institutions (Heriot-Watt, Strathclyde, Glasgow) central to the development of the UK' s £270M Quantum Technologies Initiative. SUPA is involved in all four of the QT Hubs which started in late 2014. Prof Miles Padgett leads the University of Glasgow Quantum Technology Hub in Quantum-Enhanced Imaging including partners at Heriot-Watt, Strathclyde, Fraunhofer CAP and Edinburgh. The Quantum Communications Hub led by York includes partners at Heriot-Watt and Strathclyde. Universities of Strathclyde, Glasgow, and Fraunhofer CAP and are also partners in the UK Quantum Technology Hub for Sensors and Metrology led by the University of Birmingham. Strathclyde and Edinburgh are also partners in the Networked Quantum Information Technology Hub led by Oxford.
- EPSRC Centre for Doctoral Training in Applied Photonics, AP-CDT, has started its first cohort of doctoral students. Heriot-Watt leads the CDT with partners in St Andrews, Glasgow, Strathclyde and Dundee.

Knowledge Exchange & Impact:

- Fraunhofer Centre for Applied Photonics (CAP) continues its strong development, having now up to 20 staff (14 of whom have PhD or EngD) and 12 PhD students. Staff are in most cases drawn from SUPA partner universities and students have their academic base at several SUPA institutions. Over 20 R&D projects (including 14 TSB/Innovate and 4 EU) have been competitively-won by F-CAP to date with total value to Fraunhofer approaching £4M, in areas including environmental sensing, life sciences, renewable energy, industrial instrumentation and (as mentioned above) quantum technology.
- Applied Photonics CDT has both PhD and EngD projects and has projects with over 30 companies in the UK including leading Scottish-based companies, including a number of University spinouts companies in the photonics field. Examples of

companies involved are Selex, Optos, Thales, Renishaw, Seebyte, Cascade Technologies, Edinburgh Instruments and Powerphotonic.

- International Year of Light: SUPA/Photonics has been heavily involved in celebrations for the International Year of Light. A major launch event for the IYL in Scotland was held at the Royal Society of Edinburgh on 23rd February 2015. Numerous events have been held throughout the country, much of which have involved SUPA Photonics Theme members. An event on 4th November 2015 with a keynote from Dame Ann Dowling will celebrate the 20th anniversary of the founding of Strathclyde's Institute of Photonics. The closing event will be held at Heriot-Watt on 2nd December 2015, and includes a public lecture by Jim Al-Khalili, physicist and broadcaster.

Awards, Fellowships and New Appointments:

- Quantum Technology is attracting excellent new academic appointments: eg Alessandro Fedrizzi and Erik Gauger (Heriot-Watt), Luca Tagliacozzo, Antonio Hurtado and Paul Griffin (Chancellor's Fellows at Strathclyde).
- Scottish HEIs won 5 of the 10 Quantum Technology Fellowships from EPSRC; Established Career 5 year Fellowship to Gerald Buller, Heriot-Watt, and Early Career 5 year Fellowships to Alessandro Fedrizzi, Heriot-Watt, and Jonathan Pritchard, Strathclyde. Doug Paul, a physicist in EEE at Glasgow and Elham Kashefi in Informatics at Edinburgh, also winners of EPSRC QT Fellowships, work closely with QT Hub researchers within SUPA at Glasgow and Strathclyde.
- Heriot-Watt staff host two five-year RSE Fellowships – Erik Gauger and Mohammed Saleh.
- Strathclyde host two Marie Skłodowska-Curie Fellowships - Marco Piani and Bruno Peaudecerf.
- Professor Kishan Dholakia St Andrews (PALS/Photonics Themes) was awarded a Royal Society Leverhulme Trust Senior Fellowship.

Major New Funding

Success in securing substantial roles in all four UK Quantum Technology Hubs by Edinburgh, Glasgow, Heriot-Watt and Strathclyde brings considerable income to SUPA partners with opportunities for expanding PGR recruitment, capital equipment and industry income.

2.7 Physics and Life Sciences

Theme Leader: Prof Kishan Dholakia, University of St Andrews with Deputies Prof Tim Newman, Dundee, and Prof Maxim Fedorov, Strathclyde

60 T&R academics, 85 research fellows/associates and 90 graduate research students at Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St Andrews, Strathclyde and UWS – some of these researchers are shared with Photonics and Energy.

Highlights:

- Award of a Royal Society Leverhulme Trust Fellowship, Kishan Dholakia;
- SUPA physics PhD student Lewis MacKenzie (Glasgow) was the winner of the FameLab competition (www.famelab.org) for Scotland. His talk, "Seeing red to save lives" discussed measuring the oxygen saturation of blood in the brain using the eye as a portal. Lewis will represent Scotland in the Famelab UK final in London on 22nd April 2015.
- Papers in high impact journals, e.g. Nature Photonics, Scientific Reports, Optica

New Facilities

- New laboratory facilities are being established across Scotland within the PALS initiatives; new clean room facilities at St Andrews and Heriot-Watt, and a Biophotonics Laboratory at Dundee.

Knowledge Exchange & Impact:

- New major licensing agreements between M Squared Lasers and St Andrews for their Biophotonics Portfolio.
- Dr D Diver and Dr H Potts, Glasgow School of Physics and Astronomy, founded the company Anacail in 2011 using plasma sources to generate ozone for the purpose of sterilization. Their technology is currently undergoing testing for its effectiveness in sterilizing food and increasing its shelf life.

Major New Funding

- Excellent level of grant income >£5M grants from Industry, EU and EPSRC to Aberdeen, Dundee, Heriot-Watt, St Andrews, Strathclyde; EU Horizon 2020
- €1.5M ERC Starter Grant for Malte Gather, St Andrews; £715K to Charles Cockell, Edinburgh, "Search for planetary habitability";
- £1M to Davide Marenduzzo, Edinburgh, ERC consolidator on chromosome modelling
- "SEERS: Multi-aperture spectral imaging", €3,750,535 (€360,000 Glasgow) Prof A Harvey PI.

2.8 Graduate School

The Graduate School continues to thrive within SUPA with new physics courses, new careers events, success in the EPSRC CDTs, increase in studentships and two new developments:

The Graduate School continued to fulfil a key role for the SUPA physics community and steps were taken to keep the offerings to students relevant and interesting. New developments this year included the setting up of a recruitment website and initial planning for an Education and Outreach focus group.

Courses

The course provision has been refreshed during this period, resulting in 69 courses that will run in 2015/16.

Two new courses have been developed in 2014/15 to be run for the first time in 2015/16:

- Physics of Biological Evolution: this will be a Physics and Life Science Theme course discussing biological evolution with examples of how physics contributes to the field.
- The Sun's Atmosphere: this will run as part of the Astronomy Theme course offerings and will cover topics such as the solar atmosphere; solar radiation and plasma diagnostics; plasma physics; and solar activity.

The Condensed Matter DTC rationalised the Materials Physics Theme courses, resulting in the discontinuation of four courses (Light Matter Interactions: Quantum Optics for Condensed Matter Physicists; Advanced Condensed Matter; Disordered Systems; and Advanced Condensed Matter). Two courses, Magnetism, and Quantum Phase Transitions, have been combined into one course for 2015/16.

Optical Control, which was a Photonics Theme course, has been discontinued for 2015/16.

Careers Events

A careers event open to graduate students and postdoctoral researchers was held at Selex ES, Edinburgh, on 14th February 2014. There were 20 participants and the event was well received.

A postgraduate careers event was held at Dynamic Earth on 29th April 2015. This was run jointly by the Graduate School and the Institute of Physics, with over 100 attendees.

Student and Prize Student Numbers

Student numbers presented are for students in years 1 to 4, with the data collected from the SUPA departments in July 2015.

- There were 596 research students in 2014/15 – an increase of 53 from the previous year.
- There were 233 applications for SUPA Prize Studentships in 2014/15, a drop of 81 from the previous year. Of these applicants 17 were awarded Prize Studentships

Recruitment Website

A new recruitment website has been set up to bring graduate students and employers together. See link to website below:

http://connect.supa.ac.uk/

There are 131 individuals registered who are interested in connecting with companies, 19 companies have registered. Thirty jobs (including seven placements) have been listed, eight of which are still current.

Plans for Improvements in AY2015/2016

Early plans have been discussed to enhance the performance of the Graduate School in the coming year, including:

- VC facilities update (Project Team);
- Inter-pool graduate school forum;
- Added emphasis on impact in SUPA Graduate School courses; and
- Benefit from social media channels.

2.9 Knowledge Transfer Activities

The SUPA KT team was supported from both from SUPA Central funds and from external KT-related funds. The external funding included

- STFC IPS Fellowship (Innovations Partnership Scheme)
- INSPIRE (SFC SPIRIT programme in Physics and Life Sciences)
- PEER (Pools Engagement in European Research)

SUPA KT is responsible for delivery of the SUPA PEER fund for Horizon 2020 engagement, the SUPA Industrial Placement scheme, and other externally funded activities such as the International Year of Light fund in 2015.

International Year of Light

In December 2013, a UNESCO resolution was passed to proclaim 2015 the International Year of Light (IYL2015). In 2014, recognising the importance of this to Scottish physics, and the many links to Scotland, SUPA sought to establish a distinct Scottish contribution to the Year's activities, as well as playing a role in the UK and global programmes. This activity was supported by SUPA KT as part of an ongoing strategy to achieve a broader range of impact. In September 2014, SUPA, with the support of IOP Scotland and the Royal Society of Edinburgh, made a case to SFC to support a core programme of IYL2015 events in Scotland. SFC's funding of £50K was more than matched by the SUPA universities, together with contributions from RSE, M Squared Lasers, the Knowledge Transfer Network, Gas Sensing Solutions and others. A sample of activities supported to date includes:

- A Scottish launch event at the Royal Society of Edinburgh on 23rd Feb 2015. Approximately 100 school children attended during the day and approximately 200 adults in the evening.
- An eclipse viewing event at Sumburgh Head lighthouse in Shetland.
- Talks at the University of St Andrews, and in schools in Caithness and Fife, by the astronaut Duane Carey about the mission to service the Hubble Space Telescope.

- A dual resonant solid state tesla coil that will generate a spark taller than Maxwell himself for use in a show to bring together electricity, magnetism and light Maxwell's Torch.
- An interactive laser halo harp designed and built by the University of Glasgow in collaboration with Glasgow School of Art. The harp has proved so popular that a second version of the harp is being built to be on permanent display in the National Museum of Scotland.
- Six months of operation for a "Lab in a Lorry", kitted out with light-related activities. In the funded period, the Lorry reached 6,208 pupils from 42 schools, 64.3% in areas designated accessible small towns or more remote; 57.14% in areas of socio-economic deprivation.
- An "RSE @ Scottish Borders" event entitled 'Women and the Stars' featuring Dame Jocelyn Bell Burnell, Prof Monica Grady, Dr Mhairi Stewart and Dr Claire Brock.

In addition, SUPA has contributed to IYL2015 by establishing a website for Scottish IYL activities (light2015.scot) and a Twitter feed for up to date information on events and activities (@light2015scot)

Scottish Optoelectronics Association

In 2015 the Scottish Optoelectronics Association (SOA), together with NMI, a UK-wide electronics systems trade association, submitted a proposal to Scottish Enterprise to form a new "Cluster Organisation" in Scotland called Technology Scotland. This proposal was accepted, subject to contract negotiations, which are ongoing at the time of writing. As a consequence, SUPA KT's management contract with SOA has come to a successful conclusion, with SOA continuing under the Technology Scotland umbrella. The existing good relationship between SUPA's photonics community and the SOA will continue under Technology Scotland, and SUPA's links with the new organisation are likely to be strengthened as other key enabling technologies are included.

SUPA STFC IPS Fellowship

The SUPA STFC IPS Fellowship concluded in June 2015. The fellowship helped to enable SUPA spin-out companies, including ANACAIL (Glasgow) and Blackford Analysis (Edinburgh) and Chromacity (Heriot-Watt). Four innovation partnership scheme (IPS) and four CLASP scheme projects were initiated, with two CLASP Healthcare in the recent (2014) call. Three STFC Follow-on-fund projects were funded including an application from UWS in collaboration with Heriot-Watt, UKATC and Renishaw. A KTP with Gooch and Housego was completed, which led on to several further collaborations being funded. Four STFC Global Challenge Concepts Fund projects were funded to the value of £50K each and a Global Challenge Studentship at UWS was funded. Three SUPA institutions are in receipt of STFC Impact Acceleration Account funding which was supported by the Fellowship. Finally, SUPA received an STFC Global Challenge Exploration Award to run a series of workshops on Medical Imaging in cooperation with SINAPSE. This activity proved to be very successful and led to SUPA, SINAPSE and the University of Leicester submitting a Global Challenge Network Plus proposal centred on medical imaging.

Other Achievements

The SUPA KT team met with each of the Innovation Centres to discuss ways to support greater collaboration. The team produced a guide to the Innovation Centres for SUPA academics. SUPA has existing projects with CENSIS and IBioIC and discussions on collaborations with the Innovation Centres are ongoing.

The SUPA INSPIRE project was successfully completed and the final report submitted to SFC. An evaluation report was commissioned from Optimat. The report concluded that INSPIRE had been successful and was a mechanism that should be used again. The report found that tangible benefits had accrued to participating companies, academics and students.

The industrial “restoration” placement scheme continues to be popular and has been successful at generating new industrial collaborations as well as strengthening existing ones. To date, nine placements have been completed in companies in the UK and overseas, with a further three currently ongoing.

3 COLLABORATION AND ENGAGEMENT ACTIVITIES

Most areas of physics are highly collaborative in nature, partly due to the use of large-scale facilities, and thus, as demonstrated by the publications, all of our themes have academic partners in the major scientific countries of the world. Within SUPA academic collaboration has been boosted by:

- the Distinguished Visitor program.
- the Prize Studentship competition which has recruited many very high quality students from abroad. These students continue to collaborate when they return home.
- the PEER initiative, encouraging Scottish academics to collaborate with SMEs and colleagues in Europe.

3.1 Academic

There are a number of areas worthy of particular note:

- International Max Planck Partnership (Cross theme)
- Collaboration Agreement with CNISM (Condensed matter)
- Aberdeen-Lanzhou-Tempe Joint Research Centre for Computation and Complexity (PaLS)
- Edinburgh Super Resolution Imaging Consortium (ESRIC)
- The Peter Higgs Institute for Advanced Study (PHIAS) an over-arching activity spanning all different themes
- The Higgs Centre for Innovation, including an industry incubator
- The Higgs Centre for Ideas, £4 M funding from SFC: £2 M capital; £2 M studentships

3.2 New Academic Partners

- The Quantum Technology Hubs

3.3 The Research Excellence Framework 2020

Early planning for REF2020 will be addressed in the coming year.

3.4 External Partners

Professor Richard Kenway, School of Physics and Astronomy, University of Edinburgh, contributes to the establishment of the new Alan Turing Institute, which will have its headquarters in London. Prof Kenway will lead the Edinburgh contribution to the initiative.

The SUPA CEO is Co-Director of the Scottish Crucible, the award winning leadership and development programme, and is also a member of the CM CDT Management Group. Prof Jim Hough continues to be Chair of IoP in Scotland Education Committee. Prof Martin Hendry is Chair of the IoP (Scotland) Committee. Dr Christian Killow, SUPA GS Co-ordinator, sits on the advisory panel for SEPNET. Mat Wasley, SUPA KE Co-ordinator, is a member of the White Rose Industrial Physics Academy Advisory Panel, so the treasurer for IoP Scotland and been very active in the International Year of Light Committees. In addition Prof Julian Jones is Honorary Treasurer of the IoP Council.

SUPA continues to work collaboratively with SU2P, bringing Edinburgh, Glasgow, Heriot-Watt, St Andrews and Strathclyde together in a collaborative engagement with Stanford and Caltech, in Photonics.

SUPA partner universities and students contribute to and participate in International Max Planck Partnership events: a very successful IMPP lecture week took place in Scotland at Crieff Hydro in June 2015 in collaboration with the International Max Planck Research School (IMPRS); IMPP workshops in Condensed Matter Systems and Open Quantum Systems took place in August and October 2014 respectively.

4 OUTPUTS

Some of the outputs are already covered in Section 1 and the remainder are listed here.

4.1 New Staff Posts Created During 2014/2015

	All HEIs incl SUPA appts	SUPA
Chairs & Professors	23	0
Other Academic Staff	0	0
Fellows, Post Docs & Research Assts	48	0
Total	**71**	**0**

4.2 Number of Research Students Graduating and Destination

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Number of students graduating	92	80	104	70	105
Destination:					
Academic	51	47	59	27	35
Teaching	1	2	2	0	0
Industry	17	11	21	2	0
Finance	1	5	1	1	1
Technology	3	2	0	3	4
Legal	0	1	2	0	0
Career Break/Travelling	2	2	4	1	1
Unemployed/Applying for Posts	1	4	10	5	1
Other *Publishing/Outreach/Military/Sport/Music	5	1	3	0	3
Not Known	11	5	2	31	60

4.3 Size of Early Career Research Community

This comprises 86 lecturers, 434 research staff and 596 research students, all of whom are well catered for by the training events in SUPA discussed earlier and the training provided by the individual Universities.

4.4 Events, Meetings, Workshops and Conferences

SUPA Graduate School has supported 7 physics events plus 2 careers events and 2 summer schools during the reporting period. SUPA has also supported numerous International Year of Light activities contributing to events at Heriot-Watt, Strathclyde, St Andrews and Glasgow in addition to the IYL Lab in a Lorry which visited 42 schools. A series of three SUPA/SINAPSE workshops for medical imaging and related techniques also took place during the reporting period. SUPA also participated in the IMPP IMPRS Lecture week and IMPP workshops.

4.5 Interventions which may Benefit other Sectors including Industry

In addition to those such as Fraunhofer discussed last year, we have:

- University of Edinburgh contributing to the formation of the Alan Turing Institute
- Funding of the Higgs Innovation Centre at the ATC which, among other developments, will support an incubator for start-up companies
- The 5 CDTs: Applied Photonics, Condensed Matter, Sensors, Soft Matter and Photonic Integration, which involve a range of local companies
- The EPSRC based Centre for Innovative Manufacturing in Laser-Based Production Processes led by Heriot-Watt (with Cambridge, Cranfield, Liverpool and Manchester)
- The Scottish contributions to the Quantum Technology hubs.

4.6 Outreach and Public Understanding

SUPA is very active in Outreach and Public Understanding, particularly during this year with the associated International Year of Light events. The list below is a brief selection of some of the events that have taken place during the reporting period.

- RSE IYL Launch; IoP IYL Lab in a Lorry; RSE@Scottish Borders "Women and the Stars"; Glasgow Science Festival – Festival of Light, featuring a film about the life of James Clerk Maxwell which also appeared at Wigtown Book Festival and the Edinburgh Science Festival; The Maxwell Torch project, touring nationwide at science festivals, science centres and museums; Halo Harp exhibited at various events throughout the country including the Orkney and Shetland Science Festival.
- Curriculum for Excellence: teacher CPD in areas of fundamental physics such as relativity and particle physics, delivering broadcast sessions via the IOP teacher network and across the Education Scotland Glow network; running a training day with SSERC; and making short films in association with Education Scotland; Annual pupil astrophysics and particle physics masterclasses; CERN visit competition targeted at low-opportunity areas in the West of Scotland; Advanced Higher Rotational Motion workshops attended by students from Dundee, Fife, Angus, and Perth & Kinross (and Clackmannanshire) districts; Optics and Wave Particle Duality sessions in Aberdeen.
- The Scotland-wide programme EXPLORATHON brought together the Universities of Strathclyde, Glasgow, Aberdeen and the Beltane Network (Edinburgh/Heriot-Watt) to simultaneously stage public engagement events across Scotland: Discovery Zones; Science Busking; Café Scientifique; Skeptics in the Pub; Bright Club; Meet a Researcher. Venues spanned science centres, museums, art galleries, exhibition spaces, libraries, cinemas, shopping centres, leisure centres, cafes and bars. In addition Heriot-Watt held an event open to the public at Dynamic Earth featuring talks, exhibits and demonstrations relating to current research.

Some individual achievements:

- Jon Reilly of St Andrews presented a poster at the Houses of Parliament for the SET for Britain competition. He was also asked to deliver one of three talks highlighting the diamond light source to journalists.
- Carol Trager-Cowan delivered the Maxwell lecture at King's College London on 'Nitrides – the Rainbow Material'.
- Lewis MacKenzie of Glasgow was the winner of the FameLab competition for Scotland. His talk, 'Seeing Red to Save Lives', was about measuring the oxygen saturation of blood in the brain using the eye as a portal. He represented Scotland in the Famelab UK final in London.

5 GRANT INCOME

Grant income success continues to be strong in an increasingly challenging funding environment across the UK, with an encouraging number of large (>£1M) awards in 2014/15. Strong performances have been illustrated (and headway against the English big 4) in the bar charts in section 1.4.1. Over the REF2014 assessment period, the average research income (by spend) across SUPA increased to almost £200K per annum per FTE submitted to UoA9/Physics (excludes in-kind, SFC and PGR funding), which is above both Oxford and Cambridge in Physics. A reduction in total grant awards in 2014/15 compared to 2013/14 is partly due to the dip in European funding during the transition from FP7 to Horizon 2020.

6 OUTCOMES

Outstanding results in REF2014, research grant income success, continued expansion of the SUPA Graduate School with just short of 600 PGR students in 2015/16, CDTs and major international partnerships and collaborations (CERN, International Max Planck Partnership, Fraunhofer CAP) are all visible successes of SUPA-II funding to date. In this report we have also provided an update on the major capital investments made by SFC and the partner institutions (SUPAscopes, Ultralow Vibration Lab, SCAPA, MagTEM, Nanofabrication Facility, HARPS-N Spectrograph) which are all adding to the reputation and competitiveness of Scottish Physics.

7 SUSTAINABILITY

SUPA is currently developing a new “Strategic Plan 2015-2020” with a target for sign-off by the SUPA Board of Directors in early 2016. This plan will recognise, update and adapt to the key external drivers facing Physics in Scotland, including a greater emphasis on innovation, enterprise and industry engagement while furthering international recognition of research and opportunities such as Horizon 2020. The key function of SUPA will continue to be to facilitate greater success within the partner HEIs through strategic collaboration and common issues such as equality and diversity, leadership development.

7.1 Graduate School

The Graduate School report, Section 2.8 above, gives the staffing and other updates/changes for the 2015/16 academic year; SUPA partner HEIs have agreed to fund 15 studentships per year from their own resources and to continue the Prize Studentship competition which will allow excellent students to be badged as SUPA Prize students. The recommendation of the SUPA International Advisory Committee and Board of Directors to cut back on the Graduate School administration from summer 2015, together with closer alignment with the KT agenda, have been implemented. Consistent with promises made to SFC previously, the new SUPA Strategic Plan currently under development will guarantee to continue the Graduate School operation beyond the formal end of SUPA-II in 2017. A Project Group has been created to oversee the transition to an updated, web based software approach to video provision of SUPA Graduate School courses across all 8 partner HEIs and provide the opportunity of wider distribution to extend the reputation of SUPA beyond Scotland.

7.2 SUPA Knowledge Transfer

The KT report, Section 2.9 above, gives the staffing and other updates/changes in the past year. As stated in Section 7.1 above, KT activities are now closely aligned with the Graduate School Agenda. The importance of the broader KE agenda (including societal benefit as well as economic development) and specifically the ‘Impact’ agenda of both REF and RCUK is recognised and will be addressed in the new SUPA Strategic Plan currently under development. As part of the plan, a newly formed SUPA Industry Focus Group will review how SUPA can most effectively engage with industry and government initiatives bodies such as Innovation Centres and Catapults; SUPA is open to exploring strategies and opportunities jointly with other Scottish Research Pools.

7.3 SUPA CEO

Professor Alan Miller took over from Professor Jim Hough as SUPA CEO on 1st May 2015 on a 3 year contract (in the first instance with option of extension depending on continued financial support) via the University of Glasgow. He is Professor Emeritus at Heriot-Watt University with previous experience at a number of UK and US universities, the Scientific Civil Service, as Head of School of Physics and Astronomy and Vice Principal Research at St Andrews University, and as Deputy Principal for Research and Knowledge Transfer at Heriot-Watt University. He has served as Chair of the Physics Panel, as Research Awards Convener, as Fellowship Secretary and as a member of Council of the Royal Society of Edinburgh, and was a member of SFC/R&KE Committee from 2003 to 2010.

8 CONCLUSION

This has been another highly successful year for SUPA on all fronts with the success of involvement in all four Quantum Technology Hubs funded, and with Glasgow the lead partner in one of these being particularly exciting. In terms of sustainability, all partners are committed to a slimmer but highly efficient organisation in place post 2017 that will continue to build and strengthen infrastructure, attract top researchers and PGR students and so maintain SUPA's position at the forefront of research in Physics by working collectively and strategically.

PART 2

Final Report PEER: Ref H11003 and Postdoctoral Early Career Researcher Exchanges Ref: H11004 (Tranche 3)

Interim Report PEER: Ref H1103 and Postdoctoral Early Career Researcher Exchanges Ref: H11004 (Tranche 4)

1.1 FINAL REPORT PEER3: Ref H11003

SUPA HEI	Industry Partner	Call*	Detail
Glasgow	Various potential	LEIT- SPACE	Networking meeting for H2020 Space theme in Sheffield
Strathclyde	Various potential	ICT2015	Networking: P21 WG4 meeting in Brussels
Heriot-Watt	Various potential	ICT2015	Networking: P21 WG7 meeting in Berlin
Edinburgh	Codeplay (Scottish SME), Intel and Nvidia, Eurotech	H2020-EINFRA-2015-1	Meeting: pre-submission consortium workshops in Italy and Germany
Heriot-Watt	Various potential	ICT2015	Networking: P21 WG4 meeting in Brussels
Glasgow	Holoxica	EUROSTARS	Consultant support for proposal. **SUCCESSFUL**
Edinburgh	Various potential	NMP-06-2015	Networking in Brussels and then pre-submission consortium meeting in Barcelona
Heriot-Watt	Various potential	ICT or SPACE	Pre-submission consortium meeting in Granada
Heriot-Watt	Chromacity	FETOPEN-2015	Consultant support for proposal
Strathclyde	ATDBio	FETOPEN-2015	Pre-submission consortium meeting at Heathrow
Heriot-Watt	Various potential	ICT2015	Networking: EPIC meeting in Paris

PEER funding was used to help SUPA academics travel to a number of Photonics21 work group meetings. Photonics21 is a European Technology Platform and represents the European Photonics Industry in a public private partnership with the European Commission (EC). Essentially, Photonics21 proposes photonics R&D topics to the EC and it is therefore important for SUPA to be represented at its meetings. PEER funding allowed SUPA academics to attend various work group meetings in order to understand and influence future European photonics funding calls. The funding was also used for the SUPA BDM to attend Photonics21 to represent a SUPA academic in a meeting and gather intelligence more widely.

As in previous years, PEER was promoted to SUPA universities through a series of talks at departmental colloquia and other meetings. Information on the development of the Horizon 2020 programme, call announcements and other funding activity was also sent to the SUPA mailing list as well as targeted communications to academics and business development staff. Topics included:

- Draft work programmes – information before calls were announced for planning purposes – ICT, FET and NMBP

- Details of calls across Horizon 2020 including ICT, ITN, FET and Fast Track to Innovation

Typically it takes several months from the proposal detail for the results to be available. For this reason the outcome of most of the proposal activities listed above is not known. The exception is the proposal to the Eurostars competition which operates on faster timescales. This proposal was successful, resulting in funding for the Scottish SME Holoxica and the University of Glasgow.

Proposals and networking events supported under previous tranches are followed up on a regular basis. We are therefore aware that PEER funding resulted in successful proposals in both tranches 1 and 2. Furthermore, the majority of funded networking activities eventually led to collaborations being established, with applications submitted to Horizon2020 as well as Innovate UK and other funders.

PEER4: Ref H11003

The majority of Horizon 2020 2014/15 calls closed in the early part of 2015, with the 2015/16 calls due to open around October. In the meantime, the various work programmes have been going through various stages of draft and approval. Since PEER Tranche 4 was awarded in April 2015, with additional funds in July 2015, there has been little opportunity to support proposals in this period. Instead, SUPA KT has been keeping up to date with the draft work programmes and circulating to academics as appropriate so that they can be ready as the first calls open.

It is anticipated that there will be increased activity in the coming months as PEER funding is used to support proposal development and pre-proposal networking opportunities.

2 PECRE: Postdoctoral and Early Career Researcher Exchanges

The strategic fund awarded by the Scottish Funding Council (SFC) for Postdoctoral and Early Career Researcher Exchanges in the year 2012/13 for use in the AY 2012/13 and 2013/14 of £22.5K (Tranche 2) was further supplemented by an award of £25K in the year 2013/14 to be used in AY 2013/14 and AY 2014/15 (Tranche 3) and £25K in the year 2014/5 to be used in AY 2014/15 and AY 2015/16 (Tranche 4).

2.1 PECRE: Final Report Ref: 11004 (Tranche 3)

Calls for applications were put out via the all SUPA mailing list, setting out the criteria as specified by SFC, in April 2014 and Feb 2015. These calls resulted in 30 applications (10 Post Docs and 20 PhDs). Applications were made on a standard form and the selection process was carried out by a sub-group of the Impact and Training Committee (IATC). As a result, twelve awards were made (4 Post Docs and 8 PhDs). £25K was committed to support the following projects:

Postdoctoral and Early Career Researcher Exchange Awards – Tranche 3

Name & HEI	Partner Institution	Project	Date of Visit
S Bartrum Edinburgh	Gravitation Group, University of Aviero, Portugal	Scalar fields	6th - 20 Nov 14 and 14 Apr - 30th Apr 15
S Cipiccia Strathclyde	TRIUMF and Nordion Corportate, Vancouver	Radioisotope targetry	9 Aug - 10 Sept 14 and 7 -14 Mar 15
S Corsetti, Dundee	ETH Zurich, Switzerland	Nanoparticle manipulation	3 Mar – 25 Apr 15
M Harley, Edinburgh	University of Turin, Italy	High energy particle scattering	1Sep 14: 3 months
N Jha Heriot-Watt	CSIR - Central Glass and Ceramics Research Institute, Kolkata, India	Multicore optical fibres	20 May - 30 Jun 15
I Magdau, Edinburgh	IBM TJ Watson Research Centre, NY, USA	Modeling and development of the Piezoelectric transistor (PET)	15 Apr 15: one month
M Nicholson Edinburgh	Harvard University, USA	Probabilistic modelling of the development of drug resistance and metastasis during the cancer process	20 Apr - 22 May 15
K O'Shea, Glasgow	Institute of Nanostructured materials, CNR, Bologna, Italy	Material growth techniques	6 Jul 14: 4 weeks
P Yip, Strathclyde	HORIBA Scientific, Edison, New Jersey	Nanometrology and super-resolution microscopy	19 Oct 14 - 12 Jan 15

Please see following detailed confidential reports which must be kept confidential.

2.1 PECRE: Interim Report Ref: H11004 (Tranche 4)

Calls for applications were put out via the all SUPA mailing list, setting out the criteria as specified by SFC, in April 2015. This call resulted in 10 applications (6 Post Docs and 4 PhDs). Applications were made on a standard form and the selection process was carried out by a sub-group of the Impact and Training Committee (IATC). As a result, eight awards were made (5 Post Docs and 3 PhDs). £19,772K has been committed to support the following projects:

Postdoctoral and Early Career Researcher Exchange Awards – Tranche 4

Name & HEI	Partner Institution	Project	Date of Visit
J Abreu St Andrews	NRC Herzberg Astronomy and Astrophysics, Canada	Unveiling the formation of dwarf galaxies through their three-dimensional shape	19 Sep – 5 Nov 15: 6 weeks
C Bruno Edinburgh	Physique Nucléaire Théorique et Physique Mathématique, Université Libre de Bruxelles, CP229, B1050 Brussels, Belgium	Familiarisation and application of the R-matrix formalism for nuclear interactions (TBC)	Sep 15: one month
C Bryce, Strathclyde	CNRS - CRHEA (Centre de Recherche sur l'Hetero-Epitaxe et ses Applications)	Growth, fabrication and characterisation of GaN-based nanostructures	31 May – 1 Jul 15
G Manahan Strathclyde	Stanford Linear Accelerator Centre, National Accelerator Laboratory, California, USA	First proof of principle experiments of the Trojan Horse Plasma Wakefield Acceleration (TH-PWFA), at the SLAC facility	9 May – 9 Jun 15
F Pisano Strathclyde	Santa Cruz Institute for Particle Physics, University of Santa Cruz, California, USA	Implementing an experimental procedure for optogenetic characterization of the retinal ganglion cell layer (*TBC*)	19 May 15: 8 weeks
A Quarterman Dundee	Universidade Nova de Lisboa, Lisbon	Field testing of the solar pumped lasers (*TBC*)	17 Aug 15/1 May 16: 6 weeks
Y Qui Dundee	Materials Research Institute, Penn State University, USA	Development of PMUT arrays with back-side released diaphragm transducer elements	1 Apr - 30 Jun 15
D Vogel Aberdeen	Rutgers, The State University of New Jersey, USA	Robust estimation in structured covariance models (*TBC*)	10 Aug 15: one month

SUMMARY REPORTS

J Abreu: NRC Herzberg Astronomy and Astrophysics, Canada
21st September 2015 - 6 weeks

This visit sought to advance the current understanding of galaxy formation by carrying out analytical studies of dwarf galaxies. Discussion and planning to steer the future collaboration has been carried out, resulting in a plan to apply for observing time at the Gemini observatory – which is not open to the UK research community directly. Numerical models are being built in line with the project aims.

C Bruno: Physique Nucléaire Théorique et Physique Mathématique, Belgium
September 2015 - one month

The project involved gaining an understanding of the R-matrix formalism to describe nuclear interactions; this was achieved through discussions made possible by the visit. The theory was applied to data and it is expected that this will lead to publications. The technique will also be used in ongoing research.

C Bryce: CNRS – CRHEA
31st May - 1st July 2015

This visit provided an opportunity for Bryce to gain a deeper understanding of the growth process of semiconductors to complement existing knowledge in material measurements. This was made possible by visiting a laboratory with an active semiconductor growth programme. Bryce also took advantage of serendipitous opportunities to attend relevant meetings and discuss research with experts during the visit.

G Manahan: Stanford Linear Accelerator Centre, USA
4th May - 9th June 2015

The visit allowed Manahan to participate in time of arrival and spatial overlap experiments with the aim of improving the performance of plasma accelerators. This is of interest to future particle accelerator efforts due to the potential to create high energy accelerators on a relatively small scale. Manahan took part in experiments during the visits, which will lead to further collaboration and publications.

F Pisano: Santa Cruz Institute for Particle Physics, USA
19th May 2015 - 8 weeks

The visit had the aim of implementing an experimental procedure for optogenetic characterization of the retinal ganglion cell layer. The developed experimental method relies on synergic application of complementary expertise and advanced technologies. Several experiments of spatio-temporally resolved optogenetic stimulation were been performed on different lines of genetically modified mice. Preliminary results from on-going data analysis are encouraging. Whilst corroborating a successful collaboration and exploiting technology developed at Strathclyde in an international research framework, the visit has proven useful in increasing research and team-working skills of the Pisano.

A Quarterman: Universidade Nova de Lisboa, Lisbon
17th August 2015/1st May 2016 - 6 weeks

This project is to enable field testing of solar pumped lasers. There are various components needed to attempt to realise a solar pumped semiconductor laser. Progress has been made during this project in designing and arranging for the fabrication of the optical concentrators and laser samples needed for a practical demonstration. This will feed into a visit to Lisbon in 2016 at a time with high likelihood of suitable weather for field testing.

Y Qui: Materials Research Institute, Penn State University, USA
1st April 2015 - 30th June 2015

The main objective of the visit was to develop high performance 30 MHz thin film piezoelectric micromachined ultrasonic transducer arrays with back-side released diaphragms, particularly taking advantage of piezoelectric film deposition. These have advantages over traditional micromachined ultrasonic transducers, but have as yet to achieve their theoretical performance. During the visit the layer configuration and thickness of the membrane were determined. A 5-level mask was designed for the fabrication of multiple ultrasound device configurations within single 4'' wafers. Thin film PZT has been sputtered on wafers with high dielectric constant and low loss. In further work at Penn State, with funding from sources outwith SUPA, the fabrication processes will be completed with devices from the fabricated wafers eventually used in testing in the UK. One publication has already resulted with more to follow.

D Vogel: Rutgers, The State University of New Jersey, USA
10th August 2015 - one month

This visit has enabled work on various aspects of multivariate data analysis for physical applications. Two projects areas were highlighted that address the challenging research question of how to devise and analyse high-dimensional data-analytical methods that combine robustness, efficiency at heavy-tailed distributions, and appealing computational properties. Two journal papers are planned as a result and Vogel gave a presentation to faculty staff.

PART 3

Interim Report Use of Restored Funding – SUPA Industrial Placements Scheme - Ref: HR09008

1 Restored Funding - SUPA Industrial Placement Scheme Ref: HR09008

SUPA was granted £450,999 by SFC to design and deliver an industrial placement scheme which would address the following three objectives:

- enhance the employability, entrepreneurial skills and leadership abilities of SUPA early career researchers.
- raise the international profile of SUPA.
- increase the likelihood of lasting engagement of SUPA and/or the early career researcher with industry.

There have been four calls so far with an estimated spend of £356,480. The progress with these calls and the resulting placements is detailed below. After review, it was found that there were sufficient funds to launch a fifth call in August 2015.

A total of £60,000 was offered to the four Doctoral Training Centres to enable the doctoral students to spend up to three months in an industrial setting as part of their studies. The funds were offered on condition that the Centres were able to meet the objectives above. The Centres each run slightly differently and not all four were able to make use of the funds. Therefore only £45,000 was allocated, leaving funds for a further call.

Call 1 – January 2013 - Awards

The first call closed on 31 January 2013 with 12 applications. These were assessed by a panel comprising the CEO, the GS Director and the KT Director. Five applications were selected as most closely matching the objectives, as follows:

Company	University	Comments
Ankon Technologies (China and California)	Heriot-Watt	The staff member is Chinese and this has created significant visa challenges. These have now been satisfactorily overcome and the placement has completed.
IBM (USA)	Edinburgh	Placement completed.
Nanovation (France)	Heriot-Watt Nanovation also has collaborative links with Strathclyde and St Andrews	This project has also suffered considerable visa challenges which have finally (Aug 2013) been overcome. The project has completed.
Pixium Vision, Paris	Dundee, with collaborations with Strathclyde and Stanford	This was scheduled to start in Sept 2013 but on the final day for commitment (Jul 31st) the decision was taken by Dundee to postpone the project as they were not satisfied the company had made sufficient commitment to the programme. This placement has not gone ahead.
Unilever (UK)	Edinburgh	Unfortunately, both parties felt it necessary not to go ahead.

Call 2 – September 2013 - Awards

Company	University	Comments
Diagnostic Sonar Ltd Livingston, Scotland	Dundee	Placement completed.
Ceimig Ltd Dundee, Scotland	Dundee	Placement completed
Ipsen France	Edinburgh (PaLS)	Placement underway, expected completion September 2014
Boulder Nonliner Systems USA	Glasgow	6 week placement. Placement completed
Versatilis USA	Heriot-Watt	Placement completed.
Gas Sensing Solutions Glasgow, Scotland	West of Scotland	Placement underway. First part to complete in September 2014, the second part scheduled for January and February 2015

Call 3 – February 2014 – Awards – 7 Applications were Received

Company	University	Comments
Gas Sensing Solutions Glasgow, Scotland	West of Scotland	In a different project area involving a Chinese company as well. Placement running August 2014 to April 2015
L'Oreal, Paris	Edinburgh	ECR left, company offered a replacement but decided to complete early.
Optos, Dunfermline	Glasgow	Placement delayed; discussions ongoing.
Toshiba, Glasgow and USA	Dundee and Edinburgh	Although provisional funding was agreed, discussions did not reach a successful outcome and the placement did not proceed

Call 4 – August 2014

Company	University	Comments
Noliac	West of Scotland	Project completed. Final report being written.
Optofluidics	Dundee	Visa difficulties presenting challenge, but the project is aiming to start before the end of 2015.

GRANT INCOME – ANNEX B

Grant income:	2014-2015	Cumulative Total
Awarded to a single institution within the pool	39,656,933	163,096,141
Awarded jointly to two or more institutions within the pool	8,679,604	87,786,905
Awarded jointly to two or more institutions across two or more pools	16,887,697	98,281,400
Other, please specify*	18,429,599	134,123,537
Total	**83,653,833**	**483,287,983**

*Single SUPA Institutional with external partners

Grant Source	Scottish		UK		European		Other International		Total	
	AY2012-13	Cumulative	AY 2014/2015	Cumulative	AY 2014/2015	Cumulative	AY 2014/2015	Cumulative	AY 2014/2015	Cumulative
Research Councils			59,281,050	346,176,170	6,016,126	30,953,973			65,297,176	377,130,143
European Framework Programmes					5,172,515	58,769,778				58,769,778
Other public bodies*	1,577,390	3,880,395	8,465,256	31,323,846	0	864,827	669,687	1,745,649	10,712,333	37,814,717
Charities	50,584	528,510	334,469	1,847,502	0	0	0	0	385,053	2,376,012
Industry	215,492	1,228,319	1,010,193	3,692,175	0	187,328	0	516,125	1,225,685	5,623,947
Other (please detail)	0	0	0	463,139	0	0	861,071	1,110,248	861,071	1,573,387
Total	1,843,466	5,637,224	69,090,968	383,502,832	11,188,641	90,775,906	1,530,758	3,372,022	78,481,318	483,287,984

*Central govt/ local authorities, health and hospital authorities

1 4 9 5
UNIVERSITY OF ABERDEEN

School of Natural and Computing Sciences
Meston Building
Meston Walk
Aberdeen AB24 3UE
Scotland
United Kingdom
Tel: +44 (0)1224 272910
Fax: +44 (0)1224 273105
http://www.abdn.ac.uk/ncs/

04 November 2015

Professor Alan Miller
Chief Executive Officer
Scottish Universities Physics Alliance (SUPA)

Dear Professor Miller,

I, on behalf of the University of Aberdeen, approve the contents of the SUPA Annual Report for the period 1st August 2014 until 31st July 2015.

Yours sincerely,

Celso Grebogi
University of Aberdeen Representative in the SUPA Board of Directors

UNIVERSITY OF DUNDEE

Vice-Principal (Research, Knowledge Exchange and Wider Impact)

Professor Tim Newman

Professor Alan Miller
SUPA CEO
School of Physics and Astronomy
Kelvin Building
University of Glasgow
Glasgow G12 8QQ
Scotland
United Kingdom

2nd November 2015

Dear Professor Miller

Personal Assistant
Nicky Millar
t +44 (0)1382 383561
n.x.millar@dundee.ac.uk

I can confirm that the information pertaining to the University of Dundee on the SUPA Annual Report is accurate to my knowledge.

Yours sincerely,

Professor Tim Newman
Vice-Principal (Research, Knowledge Exchange and Wider Impact)

28 Oct 15

SCHOOL *of* PHYSICS and ASTRONOMY

The University of Edinburgh
James Clerk Maxwell Building
Peter Guthrie Tait Road
Edinburgh EH9 3FD
Scotland

Telephone (direct dial): +44 (0)131 650 5245
Email: r.d.kenway@ed.ac.uk

PA: +44 (0)131 650 5249
Email: Carol.Borthwick@ed.ac.uk

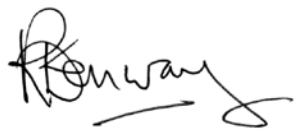
Professor Alan Miller FRSE, FInstP, FIEEE, FOSA
Chief Executive Officer
SUPA

Dear Alan,

SUPA II Annual Report

On behalf of the University of Edinburgh, I approve the contents of the SUPA II Annual Report for the period 1 Aug 2014 to 31 Jul 2015.

Yours sincerely,



Professor Richard Kenway OBE FRSE FInstP FLSW
Vice-Principal for High Performance Computing & Tait Professor of Mathematical Physics

University of Glasgow

College of Science & Engineering

DC/jmr

27 October 2015

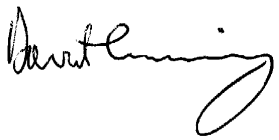
Professor Alan Miller
Chief Executive Officer
SUPA
Kelvin Building
University of Glasgow
GLASGOW

Dear Alan,

SUPA Phase II Annual Report to the Scottish Funding Council (For the period 1 August 2014 to 31 July 2015)

I, on behalf of the University of Glasgow, approve the contents of the above report to the Scottish Funding Council.

Yours sincerely,



Professor David Cumming FRSE, FIEEE, FIET
Dean of Research and Knowledge Transfer, College of Science and Engineering

Room 310 Boyd Orr Building
College of Science & Engineering
University of Glasgow
Glasgow G12 8QQ UK
Tel +44 (0) 141 330 4462 Fax +44 (0) 141 330 2359
Email: David.Cumming.2@glasgow.ac.uk

United Kingdom | Dubai | Malaysia

HERIOT WATT UNIVERSITY

Our Ref: RES/DH/AK

2nd November 2015

Professor Alan Miller
Chief Executive Officer,
SUPA

Dear Alan,

SUPA Annual Report

I, on behalf of Heriot-Watt University, approve the contents of the SUPA Annual Report for the period 1st August 2014 until 31st July 2015.

Yours sincerely,

Duncan Bland

Member of SUPA Board of Directors

Research and Enterprise Services
Scott Russell Building Gait 3 Heriot-Watt University Edinburgh EH14 4AS United Kingdom
Telephone +44 (0)131 451 3070 Fax +44 (0)131 451 3193 Email RES@hw.ac.uk www.res.hw.ac.uk

University of St Andrews | FOUNDED 1413

Office of the Principal
Derek Woollins
Vice-Principal (Research)

Professor Alan Miller
CEO, SUPA
School of Physics & Astronomy
Kelvin Building
University of Glasgow
Glasgow
G12 8QQ

28 October 15

Dear Alan

SUPA Annual Report 2014-15

I am delighted to approve this report on behalf of the University of St Andrews.

Yours sincerely

Derek Woollins
Vice-Principal (Research)

Professor J D Woollins
Office of the Principal, University of St Andrews, College Gate, North Street, St Andrews, Fife, KY16 9AJ, Scotland
Tel: +44(0)1334-463202 Fax: +44(0)1334-462543; e-mail: vpresearch@st-andrews.ac.uk

12 November 2015

Professional Alan Miller
Chief Executive Officer
SUPA

Dear Alan

On behalf of the University of Strathclyde, I am writing to approve the contents of the SUPA II report covering the period 1 August 2014 to 31 July 2015.

Yours sincerely

Professor D Uttamchandani

Associate Deputy Principal (Research)

E: d.uttamchandani@strath.ac.uk

T: 0141 548 2211

UNIVERSITY OF THE WEST of SCOTLAND

Direct 0141 848 3301
Fax 0141 848 3404
E-mail ian.allison@uws.ac.uk

School of Engineering
and Computing
Paisley Campus
Paisley PA1 2BE
Scotland

Tel 0141 848 3101
Fax 0141 848 3404

Ref: IA/BAC
Date 30th October 2015

Professor Alan Miller
Chief Executive Officer
Scottish Universities Physics Alliance (SUPA)

Dear Alan

SUPA 11 Annual Report

I, on behalf of the University of the West of Scotland, approve the contents of the SUPA 11 Report.

Yours sincerely,

Professor Ian Allison
Dean of School
School of Engineering and Computing.