SCOTTISH UNIVERSITIES PHYSICS ALLIANCE
PHASE II

Annual Report to the Scottish Funding Council

For the period 1 August 2015 to 31 July 2016

Including:

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

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

CONTENTS **PAGE NO**

PART 1

SUPA PHASE II – Report to the Scottish Funding Council for the period 1 August 2015 until 31 July 2016

EXECUTIVE SUMMARY **1**

1 GENERAL

1.1 Performance Indicator Tables 2
1.2 Consortium Progress towards Objectives/Recommendations as outlined in Strategy document of 2010 5
1.3 Conditions of Grant, Annex C 5
1.3.1 Main Purpose of Grant 5
1.3.2 Review of Strategic Vision 7
1.3.3 Governance Proposals 7
1.3.4 Monitoring, Evaluation and Reporting 8
1.4 Key Achievements
1.4.1 Research Excellence and Leadership 8
1.4.2 Strategic Developments 9
1.4.3 Update on SUPA-II Facility Investments 9

2 THEME REPORTS

2.1 Astronomy and Space Science 13
2.2 Condensed Matter and Materials Physics 15
2.3 Energy 16
2.4 Nuclear and Plasma Physics 18
2.5 Particle Physics 21
2.6 Photonics 24
2.7 Physics and Life Sciences 26
2.8 Graduate School 27
2.9 Knowledge Transfer Activities 28

3 COLLABORATION AND ENGAGEMENT ACTIVITIES

3.1 Academic 30
3.2 Associate Membership of SUPA 30
3.3 The Research Excellence Framework 2021 30
3.4 External Partners 30

4 OUTPUTS

4.1 New Staff Posts Created During 2014/2015 31
4.2 Number of Research Students Graduating and Destination 31
4.3 Size of Early Career Research Community 31
4.4 Events, Meetings, Workshops and Conferences 32
4.5 Interventions which may Benefit other Sectors including Industry 32
4.6 Outreach and Public Understanding 32

5 GRANT INCOME 33

6 OUTCOMES 33

7 SUSTAINABILITY 33

8 CONCLUSION 34

PART 2

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

1 Restored Funding SUPA Industrial Placement Scheme Ref: HR09008 35

GRANT INCOME – ANNEX B

PART 1

EXECUTIVE SUMMARY

The period 2015-16 has been a year of high celebration for SUPA with the announcement in February of the first observation of gravitational waves. This is an immense scientific breakthrough and a huge technical challenge, with SUPA physicists playing key and vital roles as part of the international LIGO consortium in achieving this incredible result; SUPA researchers from Glasgow, Strathclyde, West of Scotland and Edinburgh Universities made contributions to this project. Key technical advances that made this new form of astronomical observation possible were made within SUPA putting an international spotlight on the high quality of physics research in Scotland as well as placing Scotland in a prime position for the future development of this entirely new area of observation. SUPA is delighted that the Director of the Institute of Gravitational Research leading the Scottish effort from University of Glasgow, Professor Sheila Rowan, has been appointed as Chief Scientific Advisor to the Scottish Government.

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. All 8 partners agree that SUPA is a permanent feature of Scottish Physics. REF2014 results and 36 ERC grants give ample evidence of success. The focus in 2015/16 has been to refresh the image, build interdisciplinary and industry directed relationships, and plan for a future beyond the SUPA II funding period which ends on 31st July 2017.

A major effort was placed during 2015/16 on the upgrade of the SUPA network of video classrooms which have been in continuous operation since 2004. This upgrade of both hardware and software was successfully completed on time for the new semester to provide a high bandwidth/high resolution backbone for the pan-Scotland live relay of over 50 SUPA Graduate School Advanced Courses. The increased flexibility of the new system is allowing SUPA to develop new partnerships on course and lecture provision with other organisations, such as NPL and SUSSP, and other research pools with overlapping interests. The number of Graduate students registered with the SUPA Graduate School continues to rise and now stands at 626. Other new initiatives during the period have been a monthly SUPA Newsletter and a refresh of the SUPA website. The recognition of physics research continues to rise based on citations and research grant income.

An application to SFC for Further Funding from 1st August 2017 awaits a decision.

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

• Total Academic Staff	313
• Total Research Staff	393
• Total Graduate Students	626
• Collaborative Grant Income Cumulative	£348.3 M
• Non Collaborative Grant Income Cumulative	£195.5 M
• Number of Prestigious Fellows	211
• Number of ERC grants	36

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 in all areas of SUPA-II over the reporting period. First, to address our key performance indicators:

a) **Publications**

SUPA has in the past employed Web of Knowledge to analyse publication performance. We are now adopting Elsevier SciVal as a more powerful software with a wider publication database to analyse publication and citation performance. Previous results using Web of Knowledge giving publication numbers by academic year are reported below. Note that only peer reviewed journal articles are counted.

Publication Rates – Source of Data: Web of Knowledge Per Academic Year

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

Citation Rate – Source of Data: Web of Knowledge 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 numbers in the tables below use SciVal for the first time. Again, only peer reviewed journal articles are included in the analysis and publications/citations are listed by calendar year in this case (note that 2016 is only part-year).

Publication Rates – Source of Data: SciVal Per Calendar Year

Year	2010	2011	2012	2013	2014	2015	2016
Number of Publications	1066	1242	1424	1312	1345	1203	830

Citation Rate - Source of Data: SciVal Per Calendar Year

Year of Publication	2010	2011	2012	2013	2014	2015	2016
Citation Rate in 2016	31.2	25.2	31.3	20	11.2	4.9	1.2

Sci-Val shows a dramatically different (improved) citation performance for SUPA. This needs further analysis, but the use of the SciVal software will give us with the ability to provide numerical comparison of citation performance against the rest of the world and specific top competitions in the SUPA II final report.

b) **Grant Income**

Current Annual Income since start of SUPA-II

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Collaborative Grant Income	**not available**	161 M	205 M	276 M	320 M	348.3 M
Non Collaborative Grant Income	122 M	50 M	100 M	123 M	163 M	195.5 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	2015-2016
Chairs & Professors	73	96	107	128	151*	174
Other Academic Staff	116	139	160	167	163	139
Fellows, Post Docs & Research Assts	264	327	349	386	434	393
Total	**453**	**562**	**616**	**681**	**748**	**706**

Prestigious Fellows:

2015-2016 Personnel Numbers include:

Total Number of Fellows of the Royal Society		11
Total Number of Fellows of the Royal Society of Edinburgh		64
102 Personal Research Funded Fellowships:		
	Royal Society	29
	Royal Society of Edinburgh	6
	EC Marie Curie	17
	Other	50
University Chancellor's/Leadership Fellowships		21
RSE Young Academy/Global Academy		13
	TOTAL	211

Total SUPA Funded Personnel Numbers

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Chairs	4	6	8	8	10	11
Fellowships	8	15	17	15	13	7
Readers	4	5	5	5	5	5
Lecturers	4	7	14	13	11	11
Res Assistants	7	7	8	8	8	5
Total	**27**	**40**	**52**	**49**	**47**	**39**

Research Student Numbers

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Total Research Students	522	517	534	543	596	626
Total completed applications SUPA Prize Studentships	320	329	291	314	233	293
Total Prize Studentships Awarded	16	10	4	5 + 19*	12 + 5*	16
				***Titular Awards**	***RCUK**	

The number of PGR students registered with the SUPA Graduate School continues to rise year-on-year and now stands at a very healthy 626. Collectively, this is one of the largest cohorts of Physics PhD students in the world and SUPA has strived to

pitch the Graduate School at the highest achievable level for quality provision, to be attractive to excellent students. The SFC component of the Prize Studentship fund was fully allocated several years ago (although separate Higgs funded studentships were allocated in 2015). 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. The full list of applicants are shared with all 8 SUPA partners for selection. (SUPA also provides this centralised service to the EPSRC CM-CDT). SUPA continues 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 around 300 in recent years. The number of applications far exceeds the numbers of Physics PhD students that can be accommodated each year in Scottish HEIs, an annual intake of around 140-150.

Diversity Initiatives

University	Athena Swan Dept	Athena Swan Inst	Juno	Stonewall
Aberdeen	Bronze	Bronze	Supporter	Champion
Dundee	Bronze	Bronze		
Edinburgh	Silver	Silver	Champion	Champion
Glasgow	Silver	Bronze	Champion	Champion
Heriot-Watt	Bronze	Bronze	Supporter	-
St Andrews	Bronze	Bronze	Practitioner	Champion
Strathclyde	Bronze	Bronze	-	-
UWS	-	Bronze	Applied	-

Edinburgh is also a member of Business Disability Forum

KT Interactions

Year	Dec09-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Number of support projects to Scottish SMEs under SEEKEIT/ERDF grant (SUPA Start)	11 + 1 SUPA Start Plus	13	8	5	**No further funds**	**No further funds**	**No further funds**
Number of Industrial Studentships placed under INSPIRE	9	5	**No further funds**	**No further funds**	**No further funds**	**No further funds**	**No further funds**
Number of INSPIRE Placements	0	0	5	2	0	1	**No further funds**
Number of engagements with Scottish SMEs through PEER	n/a	n/a	n/a	7	4	2	3[1]
Number of STFC KE schemes awarded across SUPA partners	2	2	3	4	5	6	4
Number of Industrial Placements from Restoration	n/a	n/a	n/a	5	10	2	6

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. A formal associate member agreement has been established with the UK Astronomy Technology Centre, Edinburgh. A similar associate member agreement is being negotiated with Fraunhofer CAP and the International Max Plank Partnership (IMPP).
(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 at 0.5 FTE. The additional 0.5 Graduate School Co-Ordinator, Dr Anne Pawsey, was appointed on 9 April 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.
(d)	Establishment of a **Knowledge Transfer Directorate** to co-ordinate and boost the economic impact of SUPA.	See previous reports for change to KT strategy. Mat Wasley is the SUPA KE Co-ordinator covering this topic.
(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. The video classroom network has undergone a hardware and software upgrade during 2016, in all 8 partner HEIs.
(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. Further information in Section 1.4 Key Achievements
(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 four Distinguished International Visitors were funded by SUPA: Prof Edward Brash, Christopher Newport University; Dr Crystal Brogan & Dr Todd Hunter, National Radio Astronomy Observatory US; Dr Alan McConnachie, Herzberg Institute of Astrophysics, Canada; Prof David Miller, Stanford.

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 Celso Grebogi, University of Aberdeen; Prof Tim Newman, University of Dundee; Prof Richard Kenway, University of Edinburgh; Prof Chris Pearce, University of Glasgow; Prof Gareth Pender, Heriot-Watt University; Prof Derek Woollins, University of St Andrews; Prof Stephen McArthur, University of Strathclyde; Prof Eshan Mesbahi, 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 50 courses per annum.
(d) 2)	Knowledge Transfer .	The Industry Focus Group looking into how to take industry engagement forward has had three meetings during the year and has reported findings to SUPA EC and SUPA BoD.
(d) 3)	Outreach and Public Engagement Co-ordination Group	The outcome of the SUPA Education and Outreach Focus Group meetings in 2015/16 was to create a SUPA Education and Outreach Network with an open membership of academic and research staff and GS members.

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 Research Excellence and Leadership

- **Gravitational Waves Breakthrough**

  The outstanding achievement during this reporting period was the announcement in February 2016 of the epic first observation of gravitational waves. The huge international media coverage recognised this as an immense scientific breakthrough accomplished by solving huge technical challenges. SUPA physicists played crucial roles as part of the international LIGO consortium in achieving this incredible result. SUPA researchers from Glasgow, Strathclyde, West of Scotland and Edinburgh Universities made major contributions to this project over the years since the creation of the LIGO project. Key technical advances that made this new form of astronomical observation possible has placed an international spotlight on the high quality of physics research in Scotland This also positions Scotland, with the Institute of Gravitational Research at University of Glasgow leading the Scottish effort, in a prime position for future development of this entirely new method of astronomical observation

- **Research Policy**

  SUPA is delighted that the Director of the Institute for Gravitational Research, Professor Sheila Rowan, has been appointed as Chief Scientific Advisor to the Scottish Government. Other key advisory roles of SUPA researchers are held by Richard Kenway (Edinburgh) on STFC Council and the Board of the Alan Turing Institute; Christine Davies (Glasgow), Rory Duncan (Heriot-Watt) and Peter Clarke (Edinburgh) as STFC Science Board Core Members, and Ifor Samuel (St Andrews) as a member of the EPSRC Strategic Advisory Group. SUPA also engages regularly on government policy and other issues with the celebrated astrophysicist, Dame Jocelyn Bell Burnell, in her role as President of the Royal Society of Edinburgh

- **Research Income**

  The accumulated collaborative research income over the SUPA II period now stands at £348.3M, compared to the non-collaborative income of £195.5M demonstrating the benefit of building collaboration across Scottish institutions

- **Fellowships**

  With 11 FRS and 64 FRSE along with many other distinguished Fellowships (IoP, APS, IEEE, OSA, etc), SUPA researchers have high visibility in professional societies. The performance of SUPA researchers in the stiff competition for EPS Fellowships has been phenomenal at 36 so far over the SUPA II period. It is also highly satisfying to be able to note the success of early career researchers within SUPA, winning over 100 prestigious Research Fellowships from bodies such as RS,

RSE, RCUK, etc) to allow them to build their independent research careers, while 21 have won University Chancellor's and Leadership Fellowships. 13 SUPA physicists have succeeded in the competition to become members of the RSE Young Academy

1.4.2 Strategic Developments

The agreed strategy for SUPA for the next 5 years places the SUPA Graduate School as the highest priority. In the past year, SUPA has been concentrating its efforts on planning and putting in place a sustainable structure for the continuation of a successful Graduate School. The Graduate School is covered in detail in a separate section below, but here are the key achievements in the past year:

- **Upgrade of Video Classroom Network**

  A complete hardware and software upgrade of the 12 year old SUPA video classroom network has been achieved over summer 2016 and ready for classes to resume at the beginning of September. The higher quality of the system has immediately been recognised, and the extra flexibility offers exciting new opportunities for CPD and engaging with other pools, international summer schools, external bodies both in and outside Scotland. Negotiations are under way with NPL and the Cockroft Institute to share courses

- **SUPA Annual Gathering**

  A refreshed version of the former SUPA AGM now called the 'SUPA Annual Gathering' took place at the Strathclyde Technology Innovation Centre in May 2016 with a new format bringing talks by distinguished speakers on latest developments in physics. The meeting incorporated an 'Exhibition of Physics Impact' attracting 29 exhibits of physics-based companies, spin-outs, research partners and facilities, and other forms of impact. The end of the day included a public event open to IoP members

- **Communication**

  A monthly SUPA Newsletter was launched in January 2016 which has now been coupled with a refresh of the SUPA web site to provide better dissemination of activities and research advances across our 1200+ strong community of researchers

- **Provision of Advanced Courses (PhD level) in Physics**

  Over 60 advanced courses (800+ hours of lectures) are provided across the upgraded video classroom network in 2016/17, and additional options for partnering with other organisations, research pools, CDTs, CPD lectures are being actively pursued. SUPA works closely with a number of EPSRC funded CDTs to provide courses, CPD lectures, etc. SUPA is in discussion with new renewal bids for CDTs

- **Associate Members of SUPA**

  The opportunities of working more closely with industry facing organisations are being actively pursued. An Associate Member category has been created with the UK Astronomy Technology Centre (Edinburgh) including the new Higgs Innovation Centre; the Fraunhofer Centre for Applied Photonics (Glasgow) and the International Max Plank Partnership becoming the first SUPA Associate Members

1.4.3 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 three 1m SUPAscopes are fully integrated with the Las Cumbres Observatory Global Telescope network (LCOGT), which includes ten (soon to be 12) 1m and two 2m robotic telescopes distributed around the globe. The network is ideal for monitoring spectral variability in Active Galactic Nuclei (AGN), often in parallel with x-ray and ultraviolet campaigns using space telescopes (HST, Swift) to measure light travel time delays that we decode to resolve micro-arcsecond structure of black

hole accretion flows in these objects. Recent highlights include the first fully robotic reverberation mapping of an active galactic nucleus (AGN), Arp 151, measuring the mass of its black hole. In NGC 5548 we detect continuum time delays increasing with wavelength and thereby measure the temperature-radius profile of its accretion disk, which appears to be hotter and with a steeper radial profile than predicted by current accretion disk theory. The SUPAscopes are also providing datastreams for detection of extra-solar planets based on two methods - microlensing for cool planets and transits for hot planets, as well as for studies of 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 scanning probe microscopes microscopes allowing imaging and study of individual atoms and atomic-scale magnetism in advanced materials, including superconductors which conduct electricity without losses, and quantum materials for next generation technologies. Since opening of the facility in May last year, three bespoke scanning tunnelling microscopes, which were developed by the research group of Dr Wahl, have been installed. The microscopes are operating at very low temperatures down to 7mK and in magnetic fields up to 14T, providing an energy resolution up to 10μeV. For characterization of the materials, a metal tip of a scanning tunnelling microscope is brought within a few atomic radii of a surface and held there with a stability on the order of picometers. It is this stability which is required over extended periods of time which necessitates the complex vibration isolation. The research carried out in the facility aims at understanding unconventional superconductivity in quantum materials and imaging the magnetic structure of quantum materials at the atomic scale. Access to the facility is enabled through collaborative projects with partners at SUPA universities and beyond. The facility benefits from embedding in the International Max-Planck-Partnership between Scottish universities and a number of Max-Planck-Institutes as well as from the recently established International Max-Planck Research School between University of St Andrews, the Max-Planck-Institute for the Chemical Physics of Solids and TU Dresden.

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

SCAPA is situated in a new 1200 m^2 building extension that 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 and radiation source technologies. A new 350 TW laser currently has been delivered and will be commissioned by the end of January 2017. An existing 40 TW laser and the new laser 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 well-equipped environment for studying laboratory astrophysics using high power lasers, high field physics and developing the next generation of 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

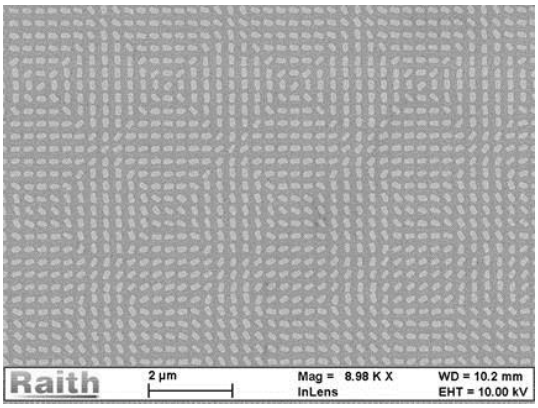
Since the £2.65M MagTEM microscope was officially unveiled on 2 July 2012 in the Kelvin Building, University of Glasgow, it has served to enable new insights into materials for researchers from across the physical sciences, engineering and life science disciplines. Housed in the Kelvin Nanocharacterisation Centre, and

supported by a range of sample preparation and fabrication instrumentation, it will shortly be supported by a new focused ion beam system based on noble gas ions, funded by a £1.1M EPSRC strategic equipment grant, which will transform the quality of specimens for atomic resolution characterisation.

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 £5.8M. MagTEM's unique capabilities have enabled collaborations with, researchers from Strathclyde, Heriot-Watt, St Andrews, UWS and Edinburgh as well as closer to home with the Particle Physics Experiment group at Glasgow. Active on-going projects are through UWS involving Ian MacLaren and Stuart Reid, through Strathclyde involving Damien McGrouther and Carol-Trager Cowan and through Heriot-Watt via a new EPSRC funded collaboration on thermoelectrics involving Donald MacLaren and Jan-Willem Bos. The Centre is also collaborating to produce new insight into influenza and the human RSA virus in a co-operation with the Glasgow MRC Centre for Virus Research. Participating in Knowledge Exchange, the Centre actively seeks collaborations with Scottish and UK firms enabling the development of existing and new commercial technologies. We maintain long term relationships with firms including Seagate, Amec and Doosan Babcock. Most recently, supported by an EPSRC Impact Acceleration account, McGrouther with Maneuski and O'Shea have partnered Quantum Detectors in order to commercialise particle physics detector technology, revolutionising capability in electron microscopy.

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

The SUPAII Nanofabrication Facility at Heriot-Watt has recently been incorporated into a newly refurbished cleanroom that combines three previously independent micro- and nanofabrication labs. The facility boasts full lithographic, fabrication (material deposition and etching), packaging, and characterization capabilities at the micro- and nano-scale in dielectric, metallic, or semiconducting materials. There is currently a wide user base and the facility underpins a large portfolio of grants across HWU with a strong concentration in the Institute of Photonics and Quantum Sciences (IPaQS). Further, an array of local industrial users take advantage of the wide-ranging capabilities. We highlight the recent work of Dr. Xianzhong (Sam) Chen of IPaQS. His research group has recently used the SUPAII electron beam lithography system (Figure 1) to fabricate a single metasurface, consisting of gold nanorods less than 100 nm in dimension (Figure 2), to achieve vector vortex beams of light for the first time. These results demonstrate unprecedented freedom in engineering the properties of optical wave with most efficient light utilization and a minimal footprint, empowering applications in quantum optics, particle manipulation, optical communication and integrated optics and photonics.



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. The HARPS-N team continues to characterise rocky exoplanets and – to date – has characterised almost half of all known rocky planets with reliable mass estimates. We are currently seeking a 5-year renewal of the project to characterise planets discovered with the Transiting Exoplanet Survey Satellite (TESS) due to launch in late 2017, or early 2018.

Since July 2015 we have also been monitoring the solar radial velocity for several hours each day using a fibre feed from a small solar telescope built at CfA, in order to quantify the contribution of plage and sunspot activity to the radial-velocity signal.

g) The SUPA PaLS Laboratory – Dr David McGloin

The PaLS Lab is an interdisciplinary research space within the School of Life Sciences at the University of Dundee set up to facilitate stronger research collaboration between physics staff and the leading research groups in life sciences at Dundee. The facility consists of a number of in-house designed experimental systems, including high resolution optical tweezers, TIRF optical tweezers, a Raman spectroscope, a STED microscope and a high resolution ultrasound imager. The systems are currently enabling collaborative projects to be carried out in areas such as cell mechanics and cell division as well as in drug discovery and in cancer diagnosis. The facility includes two large physics labs and a sample preparation lab, and is sited within the Dundee imaging facility, offering easy access to commercial imaging microscopes. In the coming year multiphoton imaging capability should be added to the PaLS Lab. The Lab has attracted funding from a number of charity funders, including the Wolfson Foundation and from the Wellcome Trust.

2 THEME REPORTS

2.1 Astronomy and Space Science

Theme Leader: Prof Ken Rice, University of Edinburgh

29 T&R academics, 64 research fellows/associates and 36 PDRAs at Edinburgh, Glasgow, Heriot-Watt and St Andrews.

The Astronomy and Space Sciences theme is a vibrant theme with activities at the Universities of Dundee, Edinburgh, Glasgow, and St Andrews. Across the different sites there are around 250 people involved in this research theme, and key areas of interest are Exoplanets, Active Galactic Nuclei, Extragalactic Astronomy & Cosmology, Gravitational Waves, Solar Physics, Star Formation, and Stellar Populations.

Highlights:

- Solar Physics: Glasgow's Astronomy and Astrophysics group continues to conduct leading research in solar plasma physics, with an emphasis on non-thermal electrons at the Sun and in space and on multi-wavelength observations of solar active regions and flares. They led the first publication on X-ray imaging spectroscopy of a solar active region with NASA's NuSTAR astrophysics mission, setting strong constraints on the distribution of hot (>5MK) plasma in these regions. They were also involved in the first tied-beam imaging of low-frequency solar radio bursts with LOFAR, finding an origin in a large trans-equatorial magnetic loop. Work with extreme UV and X-ray imaging and spectroscopy measurements has allowed them for the first time to infer the presence of non-Maxwellian distributions known as kappa-distributions, of both ions and electrons, during flares.
- Exoplanets: The HARPS-N collaboration (involving researchers in Edinburgh and St Andrews) announced the discovery of the closest transiting exoplanet, and also successfully characterized the composition of a number of other rocky exoplanets. This now means that the HARPS-N team has characterized almost half of the known rocky exoplanets with reliable mass estimates.
- Active Galactic Nuclei: St Andrews Astronomer, Keith Horne, used advanced echo mapping methods to break the diffraction limit, exploiting light travel time delays to resolve the micro-arcsecond anatomy of a black hole accretion flow. The AGN STORM campaign monitored the Seyfert galaxy NGC 5548 for 6 months in 2014 using HST, Swift, and a network of ground-based telescopes (including the three robotic SUPAscopes). Decoding the reverberating emission line profiles, Horne's velocity-delay maps reveal the first clear picture of the geometry of the broad emission-line region in an AGN.
- Extragalactic Astronomy and Cosmology: Edinburgh astronomer Michal Michalowski was lead author of a team who have found evidence that atomic gas – found in the voids between galaxies – can fuel star formation. This potentially overturns a long-standing theory that it is mainly molecular gas that fuels star formation. A team led by Edinburgh astronomers Jim Dunlop and Ross McLure also completed, and submitted, the first ever deep Atacama Large Millimeter Array (ALMA) mm-wavelength survey, in the Hubble Ultra Deep Field. Annette Ferguson, also from Edinburgh, was part of a team who have shown how galaxies grow by ingesting stars from neighbouring, smaller galaxies, helping to explain how galaxies like our own Milky Way have formed and evolved.
- Gravitational Waves: During the past year SUPA scientists made a major contribution to one of the most important scientific breakthroughs in the recent history of astronomy. On September 14, 2015 two detectors of the Laser Interferometer Gravitational wave Observatory (LIGO) simultaneously observed a transient gravitational-wave signal (GW150914) from the merger of two massive black holes at a distance of more than 1 billion light years. The LIGO observations demonstrated the existence of binary stellar-mass black hole systems and represents the first ever observation of a binary black hole merger - and marks the dawn of a new era of

gravitational-wave astronomy. A second confirmed detection, of another binary black hole merger, was reported in June 2016.

The contribution of SUPA scientists to this remarkable discovery was led by members of the Institute for Gravitational Research (IGR) at the University of Glasgow, working together with colleagues at the University of Strathclyde and the University of the West of Scotland. The IGR led a UK consortium, funded by the STFC, which carried out crucial upgrades to the LIGO detectors - particularly the development of the ultra-low noise suspensions and mirror coatings without which the detections could not have been made. SUPA scientists also made significant contributions to analysis of the first Advanced LIGO science run - including leading the search group that made the first identification of GW150914 as a candidate event.

Fellowships, Awards and New Appointments:

Professor John Brown has been awarded an OBE for services to the promotion of astronomy and science education.

Professor James Dunlop has been elected to the Fellowship of the Royal Society and has been awarded the Royal Astronomical Society's Herschel Medal.

Dr Michal Michalowski has been awarded the Royal Astronomical Society's Winton Capital Award and the Young Scientist Award by the Polish Astronomical Society.

Dr Natasha Jeffrey has been awarded the European Physical Society's thesis prize.

Dr Ryan Milligan has been awarded an STFC Ernest Rutherford Fellowship.

Major New Funding:

St Andrews astronomer Aleks Scholz received funding from NASA for analysis of lightcurves from the Kepler K2 mission (campaigns 4 and 5). The primary science goal is to analyse the rotational evolution and activity indicators of very low mass stars.

Outreach Activities and Visitors:

The "SUPAscopes" network of 1m robotic telescopes in collaboration with LCOGT (Goleta, CA), were portrayed in the photography exhibition "Deep dark – pale blue" by Florian Schwarz, held at Summerhall, Edinburgh, 24 June to 10 July 2016.

Richard Ellis and Doug Lin both had successful visits as part of their Carnegie Centenary Professorship awards. Doug Lin gave public talks in St Andrews and Edinburgh, and Richard Ellis gave a public talk in St Andrews, presented the keynote lecture at the SUPA Annual Gathering in Glasgow, and gave an invited lecture at the SPIE meeting in Edinburgh at the end of June.

Theme Future Plans

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 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 grants will continue to broaden the on-going activities funded through **STFC** and **SUPAII**.

The SUPAII investment in **SUPAscopes** and **HARPS-N** has already reaped rewards, and will ensure that SUPA retains a leading role in exoplanet science.

Glasgow will increase its activity and leadership in solar radio observations with LOFAR, and accompanying HPC simulations of solar radio emission. Planning for observations with the 4m Daniel K. Inouye Solar Telescope, which sees first light in 2019, is being stepped up, and activities developed with ALMA and SKA.

Edinburgh's Bob Mann is Project Leader for UK participation in the Large Synoptic Survey Telescope (LSST), for which STFC has committed an initial £18M, with further funding expected to support UK researchers after LSST sees First Light in 2019. The LSST:UK Consortium includes researchers from every astronomy group in the UK, with Edinburgh's Wide-Field Astronomy Unit prototyping a Data Access Centre to aid UK exploitation of LSST's revolutionary sky survey dataset.

WFAU is also developing, and will operate, an archive to manage data on satellites and orbital debris for the Advanced Technology Centre of the Lockheed Martin Space Systems Company. This project applies WFAU's long-standing experience in sky survey data management within a commercial context and is part of a collaboration with Lockheed Martin that follows from the company's participation in the consortium that took over control of the UK Infrared Telescope in Hawaii. As part of this collaboration, the University of Edinburgh recently hosted an international Space Traffic Management workshop, which brought together expertise from the academic, commercial and military sectors in the UK, US, Australia and Japan to debate the research and policy challenges for the development of a future global system to manage effectively the space environment, which, with every passing year, becomes more congested as well as more relied upon by society.

Over the last decade a team of scientists from the University of Glasgow's Institute for Gravitational Research developed, built, and tested the incredibly sensitive optical bench interferometer that lies at the heart of a major European Space Agency mission - LISA Pathfinder (LPF) - that was launched in December 2015. The mission was designed to prove many of the critical technologies that will be needed to fly the first space-borne gravitational waves observatory that is planned for the early 2030s

The first results from the LPF mission were announced in June this year and were spectacularly good. The overall mission target sensitivity was exceeded by a comfortable margin, and the Glasgow interferometer, in particular, exceeded its specifications by nearly two orders of magnitude. This outstanding LPF success is now propelling the field towards the real scientific goal of flying the full-scale observatory. Our plan is that Scotland will play a particularly leading role in this exciting future, with a teaming of the University of Glasgow and the UK Astronomy Technology Centre bidding to provide the optical metrology system that will be at the very heart of this major mission.

The Higgs Centre for Innovation, being built at the Royal Observatory, Edinburgh, is making good progress and is still scheduled for completion in mid-2017.

2.2 Condensed Matter and Materials Physics

Theme Leader: Dr Brendon Lovett, University of St Andrews

27 T&R Academics, 74 research fellows/associates, and 34 PDRAs at Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St. Andrews, Strathclyde universities.

The 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, the theory of non-equilibrium classical and quantum physics, 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.

Research Highlights:

- Numerous high profile publications in Journals such as Nature/Science family journals (Allen EDI, Marenduzzo EDI, Cates EDI, McWilliams EDI, Gregoryanz EDI, Waclaw EDI, McVitie GLA, Almeida GLA, MacGrouther GLA, Hadfield GLA, Chen HWU, Ferrera HWU, King StA, Hoefling StA, Mackenzie StA, Lee StA, Scott StA), Physical Review X (Keeling StA, Hoefling StA, Lee StA), Proceedings of the National Academy of Sciences (McGrouther GLA, Marenduzzo EDI)

- Many articles in Physical Review Letters (e.g. Jonson HWU, Ohberg HWU, Gerardot HWU, Hartmann HWU, Thomson HWU, Poon EDI, Keeling StA, Braunecker StA) Genome Biology, Nano Letters, etc.

- New MBE labs being installed in St Andrews (£1.8M project, part SUPA funded), new focused ion beam microscope in Glasgow (value £1.3M), New Leica confocal

microscope and TA Instruments ARES controlled-strain rheometer (Poon, EDI), EPSRC equipment grant for Measurement Platform for Materials at Multiple Extremes (£0.45M, Huxley EDI)

- Excellent level of grant income, including ERC consolidator (1.8 M Euro, Allen EDI), ERC advanced (2.3 M Euro, Ackland EDI) GLA attracted £2.6M from EU, Horizon-FET, EPSRC across fields such as spintronics, high strength steels, EPSRC future formulations for shear thickening (£1.5M Poon EDI)

Impact Highlights:

Prizes

James Scott (St A): UNESCO medal for "Contributions to Nanoscience"

Public Engagement

The International Year of Light continued throughout 2015 with SUPA contributing to many events. Included for example lecture by Chen (HWU) at closing ceremony. A special mention here for the efforts of SUPA Business Development Manager Mat Wasley (also Lee, Cassettari, St A, Martin STR)

- Chris Hooley (St A) along with SUPA prize student Helen Cammack (St A) have been working Gregor Steele to develop a teacher-training webinar for use by Scottish schoolteachers. This will be broadcast on 6th September, more details here:

http://www.sserc.org.uk/index.php/cpd-sserc/cpd-courses-sserc33/4078-physics-sserc-meet-semiconductors

Research highlighted in mainstream media: BBC Radio interview with Stuart McWilliams (EDI) about the work in Nature mentioned above – which performed laboratory studies of iron at very high temperatures and pressures, like those found in the Earth's core, enable a better understanding of the history of Earth's magnetic field.

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.

The research undertaken falls within three strands:

solar power
nuclear power
energy storage and efficiency

Highlights:

- Several articles from Steve Reynolds and colleagues at the University of Aberdeen, including on the spectroscopy of gasoline/ethanol blends in the journal Fuel, a Prototype Energy Autonomous Laboratory in the journal Sustainability and wind turbine power control for electrolysis applications in the journal Renewable Energy.
- Articles from T O'Donovan and colleagues at Heriot-Watt on Temperature stabilisation in Fischer–Tropsch reactors and on analysis of the impact of atmospheric parameters on the performance of solar cells in Energy Conversion and Management.
- Several high impact publications by Prof Paul McKenna's group (Strathclyde) on laser-plasma interaction topics relevant to advanced schemes for Inertial Fusion Energy. These include a paper on controlling plasma dynamics published in Nature Physics and a paper on laser-driven ion acceleration published in New Journal of Physics.
- Several papers by Prof Zheng-Ming Sheng (Strathclyde) and collaborators on aspects of laser-plasma interaction related to inertial fusion energy, including a paper

on laser-ion acceleration in Scientific Reports and plasma modulation in Nature Communications.

- A number of highlight publications from Prof Ifor Samuel and colleagues at St Andrews, on organic solar cell science, including papers in Science Advances (photophysics of a new class of efficient light emitting material for organic light-emitting diodes and hence lighting), Physical Chemistry Chemical Physics and Applied Physics Letters.
- Publications arising from an Innovate UK funded project at the University of the West of Scotland with Sharp Laboratories of Europe (SLE), regarding photovoltaic cell optimisation for indoor use.
- Dr N. Hunt's group (Strathclyde) have published a paper on the Journal of Physical Chemistry Letters on catalysing the production of molecular hydrogen.

Significant and notable new grant income, including:

- Paul Clegg, Wilson Poon and Job Thijssen (Edinburgh Physics) are part of a collaboration with Chemistry in St. Andrews, Birmingham and Bath, which has been awarded an £2.5M EPSRC Advanced Materials for Energy Generation and Transmission 4-year grant.
- Professor Mercedes Maroto-Valer (Heriot-Watt University) has received a €3m, European Research Council Advanced Award for project "Microscale Processes Governing Global Sustainability".
- New EPSRC funding for Ifor Samuel (St Andrews) and collaborators on Hybrid Polaritons (£5.1M Programme Grant, led by Southampton) and on light-emitting polymers (£400k).
- A collaborative grant led by Newcastle University and including Heriot-Watt University has been awarded circa £5m from EPSRC for a "Centre for Energy Systems Integration".
- Dr Tadhg O'Donovan (Heriot-Watt) in partnership with Soltropy Ltd and AES Solar Ltd have received circa £200k from Innovate UK, Energy Catalyst for their project "Reducing the Cost of Solar Thermal: Integrating a Novel Freeze Tolerance Approach with Flat Plate Solar Thermal Panels". Dr O'Donovan working together with Dukosi Ltd has also been awarded circa £250k from Innovate UK KTP for "Thermal Management of Batteries for Grid Level Storage".
- Dr Nick Bennett (Heriot-Watt) in partnership with Power Textiles Ltd have won circa £200k, EPSRC funding for a project titled "Vacancy-Rich Silicon as a Flexible Thermoelectric Material".

Awards and Fellowships:

- Prof Ifor Samuel (St. Andrews) was awarded the Chemical Dynamics Prize of the Royal Society of Chemistry.

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
- Prof M Federov (Strathclyde) has filed two USA patents with a large international oil and gas service company.
- Heriot-Watt University are working with the ESA and AES Solar and have won a "Sustained Partnership" award for their on-going relationship with Soltropy.
- UWS are also working with SLE and Scottish company Gas Sensing Solutions Ltd re deployment of the new indoor PV technology for powering of autonomous sensors.
- A PhD student from the University of Rochester, US started a project at UWS on plasma-assisted deposition of inertial confinement fusion laser coatings – this involves application to the laser driven fusion programmes in the US.

- Press interest and public engagement on laser-controlled plasma structures, based on a Nature Physics paper by Prof Paul McKenna and co-workers at Strathclyde.

2.4 Nuclear and Plasma Physics

Theme Leader: Prof Dino Jaroszynski, University of Strathclyde

The Nuclear and Plasma (NPP) Theme is supported by approximately 150 Researchers, which include ≈40 academics, 50+ PDRAs and 50+ PhD students at various stages of their studies. Together, they have published around 250+ papers in high impact journals, including Science, Nature family Journals, PRL, PR-A-B-C-D-STAB, Geophys. Res. Lett., APL, NJP, Opt. Express, PLB etc. They publish an average of 2.64 articles (1.33 in high impact journals) per staff member p.a. NPP research is supported by a grant portfolio of nearly £20m, giving an annual income of approx. £4.5m, which fluctuates. The NPP groups have a high profile and strong links with the most SUPA Themes, other Scottish University Pools, and national and international groups

One of the major NPP (SUPAII) projects is the Scottish Centre for the Application of Plasma-based Accelerators, SCAPA, which has been set up to provide state-of-the-art laser and radiation facilities in a unique environment for cross-disciplinary research. The fundamentally new types of sources, based on the interaction of intense lasers with plasma, will enable innovative high-impact research that should lead to new science, and economic and societal impact. NPP researchers are also taking advantage of the Extreme Light Infrastructure, ELI, to investigate ultra-relativistic plasma physics, laser-driven QED, high-field physics (e.g. radiation reaction and highly radiating systems) and new nuclear physics. The availability of new sources at ELI, SCAPA and the CLF at RAL will enable the development of detectors, particle beam radiotherapy, X-ray phase contrast imaging, probing dense matter and investigating fusion related topics and damage to material in hostile environments, which is relevant to materials in reactor and space borne equipment. NPP are promoting KE opportunities through several industrial collaborations

Strathclyde is also developing collaborations with NPL and has become a member of the Cockcroft Institute, which will provide links to the accelerator, standards and metrology communities.

NPP also has a healthy training programme through a CDT in the application of next generation accelerators, two university funded CDTs, the NPL Graduate School, a Nuclear Technology MSc & MSc in High Power RF and bilateral training agreements with ELI

The SUPA Flagship project SCAPA is well underway. The construction of the 1200 m2 SCAPA facility is complete and an existing 40 TW laser has been transferred to SCAPA and is operational. A 350 TW laser has been delivered and is currently being installed at SCAPA, and will be commissioned in January 2017. A NPP beamline is being installed to facilitate the first NPP experiments at the start of 2017. A £1.7m grant application has been submitted to the ESPRC Strategic Equipment Fund to establish further beamlines at SCAPA.

SCAPA is a unique laser-plasma accelerator facility:

- generalised synchrotron source concept ….
- …. but much more compact because the sources are based on lasers – that provide particles, and coherent and incoherent tuneable radiation.
- The laser-plasma accelerator is a transformative technology afforded by its compactness and unique properties (eg attosecond pulses), and ability to combine different sources on the same bench,
- they are competitive - much less expensive than conventional accelerators – have low running cost and a small footprint, and
- will lead to new opportunities to commercialise the sources and their applications.

Highlights:

- **Use of a plasma channel to control wakefield acceleration and synchrotron radiation** (ZM Sheng et al., Nature Light Science and Applications 2016, Strathclyde)
- **First ever application of (γ, $\gamma\gamma$) using γ^3 set up at HIgS facility** (B. Loeher et al., Phys. Lett B 2016, UWS)
- **β decay as new probe for Pygmy Dipole resonance - implications for reactor safety** (M. Scheck et al., PRL 2016, UWS)
- **Determination of shape of strongly octupole correlated (pear shaped) ^{144}Ba - time reversal symmetry violation -** (B. Buscher et al., PRL 2016, UWS – led by M. Scheck)
- **Lab in a bubble EPSRC grant** (4 year £4.5m, led by Strathclyde and involves Glasgow, St. Andrews and Lancaster and many Partners)
- **Helium burning and neutron sources in the stars - shows how underground measurements of reaction cross sections can lead to major advances** (M. Aliotta, et al., EPJ 2016, Edinburgh
- **Three new low-energy resonances in the ^{22}Ne(p,γ)^{23}Na reaction - demonstrates advantage of underground γ-ray measurements.** (F. Cavanna, R. Depalo, M. Aliotta, et al. PRL 2015: LUNA Collaboration, Edinburgh)
- **Optically controlled dense current structures driven by relativistic plasma aperture-induced diffraction** (B. Gonzalez-Izquierdo, …, P. McKenna et al., Nature Physics 2016, Strathclyde)
- **Towards optical polarization control of laser-driven proton acceleration in foils undergoing relativistic transparency** (B. Gonzalez-Izquierdo, …, P. McKenna et al., Nature Communications 2016, Strathclyde)
- **STFC Project: (£1.5M Jefferson Lab Upgrade to detectors in Halls A & B** (D. Ireland, Glasgow)
- **Muon Tomography: Detector built for imaging Intermediate Level Waste Barrels** (D. Ireland, et al., Research Frontiers in Decommissioning and Radioactive Waste Management Conf. 2015, Glasgow)
- **Forward Photon Tagger Hodoscope - Jefferson Lab's upgraded CLAS12 detector** (D. Watts et al., Edinburgh)
- **Sprites** in dusty atmospheres investigated – (D. Diver et al., Glasgow)
- **Ultra-high brightness bunches from hybrid plasma accelerators – experiments at FACET** (B. Hidding et al., Strathclyde)
- **Radiotherapy and medical radioisotopes produced by LWFA** (collaboration between Strathclyde, NPL, Glasgow, UWS and SINAPSE – led by Jaroszynski)
- **Extreme Light Infrastructure (ELI) –** attosecond pulse generation and high field physics - longitudinal and transverse cooling of relativistic electron beams in intense laser pulses (Jaroszynski & McKenna, Strathclyde)

Prestigious Fellowships and Collaboration Leadership:

- Edinburgh: P. Woods has ongoing GENCO award from the GSI laboratory Germany, and a 3 year visiting Professorship from the Chinese Academy of Sciences
- Strathclyde: P. McKenna has ongoing EPSRC Leadership Fellowship, started March 2012
- Glasgow: D Ireland is chair of the CLAS collaboration at JLAB

Current Academic Collaborations:

Edinburgh:

- P. Woods is the only non-US member of the programme panel on the US National Superconducting Cyclotron Facility that will host FRIB the biggest new accelerator project in the US
- P. Woods became deputy spokesperson of an international collaboration TSR@ISOLDE that will place a storage ring from the MPIK Heidelberg at the ISOLDE facility CERN where radioactive beams will be injected into it
- M. Aliotta is PI on the low-energy nuclear astrophysics studies with stable beams at LUNA and Caserta (Italy)
- M. Aliotta is PI for the 18O(p,a)15N reaction studies at astrophysical energies at the Laboratory for Underground Nuclear Astrophysics
- Edinburgh have a leading role in detector simulations for the development of a new generation detector at Jefferson Lab (SoLID), which will offer high acceptance at the intensity frontier

Glasgow:

- The Nuclear group is an active participant in a number of international collaborations:
    - Jefferson Lab (Newport News, Virginia, USA) - part of the CLAS collaboration (Ireland, Livingston, MacGregor, McKinnon, Sokhan), the Hall-A collaboration (Annand, Hamilton) and the GlueX collaboration (Ireland, Livingston).
    - Mainz, Germany - one of the user groups contributing to the Crystal Ball at MAMI collaboration (Annand, Hamilton, Livingston, MacGregor).
    - Involvement in the OLYMPUS experiment at DESY, Hamburg, Germany (Murray, Seitz) and MAXLab in Lund, Sweden (Annand, Seitz).
    - Nationally, the group has active links with SUERC, and is a collaborating group in SCAPA
- Plasma group:
    - Helling, Stark, Rimmer at St Andrews on planetary/cool star dust growth, charging and electrostatic discharging;.
    - EPHRAT consortium on relativistic beam formation in above-thundercloud plasma discharges (Bath, St Andrews, Strathclyde, Reading, Leicester, Lancaster, BAS, CNRS, CNES, RAL).

Strathclyde:

- ZM Sheng: collaborates with several Chinese laboratories and MPQ in Garching, Munich
- B Hidding: - experimental plasma physics – collaborates with the University of Hamburg, DESY and UCLA (FACET project)
- DA Jaroszynski – director of SCAPA: Construction of SCAPA laboratory completed. Collaboration includes all SUPA NPP partners.
- DA Jaroszynski: St Andrews, Dundee, Lancaster, Edinburgh, Oxford, Surrey, Beatson West of Scotland Cancer Centre, RAL, QUB, CERN (on AWAKE project), Lisbon, INFN, Austin Texas, ELI Bucharest, Korea, Academy of Sciences in China, Technical University of Eindhoven, Glasgow University, SINAPSE, Simon Cancer Center Department of Radiation Oncology University of Indianapolis, Tsinghai University Beijing, Shanghai Jiao Tong University, Gwangju Institute of Science & Technology Korea, Ecole Politechnique, Paris.
- DA Jaroszynski, P McKenna, ZM Sheng, B Hidding: Collaboration with ELI-ALPS (Hungary), ELI-NP (Romania) and ELI-Beamlines (Czech Republic)
- P McKenna: Collaborations with groups at Queens University Belfast, University of York, Imperial College London, Rutherford Appleton Laboratory, plus a number of international groups in the USA, Germany, Sweden, France, Italy and Spain.

- A Cross, K Ronald, W He: Construction of new microwave laboratory at the Strathclyde TIC in progress.

UWS

Steady stream of proposals to collaborate at REX-ISOLD, Jyväskylä and Argonne

- Dr K Spohr: Collaboration with the HAW Hamburg, and is supervisor of two German students who investigate applied laser plasma and medical applications.
- Dr M Scheck: led a collaboration at Institut Laue Langevin in France studying (n,γ) reactions with the EXILL gamma-ray spectrometer.
- Dr JF Smith:
    - Member of the AGATA collaboration, and is a member of the UK AGATA Management Board and of the (pan European) AGATA Collaboration Council.
    - Member of the NuSTAR Collaboration and a member of the UK NuSTAR Management Committee

Current commercial collaborations

- Glasgow (D Ireland): Active collaboration with the National Nuclear Lab (NNL) and Sellafield Ltd, as part of its applied nuclear science programme.
- Glasgow (D Diver): spin-out company, Anacail, which successfully attracted £750k private equity, and is lead partner in a £460k TSB (SMART award) multi-company grant
- Strathclyde (A Cross): DSTL Research into gyro-TWA amplifiers
- Strathclyde (DA Jaroszynski) collaborating with company (N-CC) to set up Proton Therapy Centre in Glasgow
- Strathclyde (DA Jaroszynski) collaborating with company to develop compact optically pumped CO_2 lasers as a driver for laser-driven accelerators

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 Particle Physics Theme is a collaboration of experimental and theoretical particle physicists focussed on determining the properties of the Higgs boson and the search for new physics beyond the Standard Model of Particle Physics. On the experimental side, it includes the exploitation of current experiments at Run 2 of the Large Hadron Collider (LHC) at CERN (ATLAS and LHCb), preparations for the high-luminosity upgrades of ATLAS and LHCb, preparation for new experiments at neutrino facilities, construction and exploitation of NA62 at CERN and MICE at RAL and searches for dark matter at a number of experiments (LUX, DBX, DRIFT and LUX-ZEPLIN). It also includes detector development for particle physics, with impact in other areas of science, and grid computing. On the theoretical side, the focus is on the exploitation of results from the LHC run 2 and from other experiments at the intensity frontier, by using theoretical tools, such as Lattice QCD and particle physics phenomenology. Collaboration between experimentalists and theoreticians is key to advancing techniques used in experiments and to interpret theoretically results obtained in the experiments. Furthermore, particle physics techniques and technology have applications into other areas of science

In the period 2015-16: about 64 theoretical/phenomenological papers, 58 lattice QCD papers, 200 ATLAS papers, 94 LHCb papers, 14 papers on Babar, 16 papers on CDF, 15 dark matter papers (LUX, BDX and LUX-ZEPLIN), 3 papers on MICE, 4 papers on neutrino factories, 2 papers on Hyper-Kamiokande, 3 papers on linear collider physics, 12 papers on semiconductor detectors for future LHC upgrades and other applications, 2 papers on RICH detection, 3 papers on PIENU and 5 papers on Grid computing (for a total of 495 papers) were published in peer-reviewed journals.

Highlights of the Experimental Programme:

- Combined measurement of the Higgs boson mass with the ATLAS and CMS experiments (Phys.Rev.Lett. 114 (2015) 191803), $m_H = 125.09 \pm 0.21(stat) \pm 0.11(syst)\ GeV$
- Search for resonances in di-photon events using 3.2 fb-1 of data from the ATLAS 2015 run at 13 TeV (arXiv:1606.03833), which shows a small hint of a resonance at ~750 GeV with a significance between 2,1 and 3.9 standard deviations, depending on the assumptions. (Note: this resonance was not confirmed from data presented at the International Conference for High Energy Physics, ICHEP, held in Chicago in August.
- Searches for top-antitop resonances using the ATLAS detector (JHEP 1508 (2015) 148).
- Search for the Standard Model Higgs boson decaying into $b\bar{b}$ pairs produced in association with top quarks decaying hadronically in pp collisions at √s=8 TeV with the ATLAS detector (JHEP 1605 (2016) 160). This is the first paper on the ttH all-hadronic analysis and includes the final combined ttH result from Run 1.
- Search for single production of vector-like quarks decaying into Wb in pp collisions at √s=8 TeV with the ATLAS detector (Eur. Phys. J. C (2016) 76: 442). This is the first result and world-leading limit on this decay mode
- Simultaneous measurements of the t-tbar, W+W−, and Z/γ∗ →ττ production cross-sections in pp collisions at s√=7 TeV, (Phys.Rev. D91 (2015) 5, 052005).
- Search for Standard Model Higgs boson produced in association with top quarks and decaying to $b\bar{b}$ pairs (Eur. Phys. J. C (2015) 75:349)
- Measurement of spin correlation in top-antitop quark events and search for stop quark pair production in proton--proton collisions at sqrt(s) = 8 TeV using the ATLAS detector, Phys.Rev.Lett. 114 (2015) 142001
- Discovery of the rare $B^0 \to \mu^+\mu^-$ decay from the combined analysis of CMS and LHCb data, with more than 6 standard deviation (Nature 522 (2015) 68-72). This is the rarest decay of the B_s^0 ever observed and its agreement with the Standard Model sets very important constraints on the theory of Super-symmetry. Note: The Standard Model result for $B^0 \to \mu^+\mu^-$ uses Lattice QCD calculations dominated by a calculation carried out by the Glasgow group (Phys.Rev.Lett. 110 (2013) no.22, 222003
- Observation of J/ψp resonances consistent with pentaquark states in $\Lambda_b^0 \to J/\psi K^- p$ decays in LHCb (Phys.Rev.Lett. 115 (2015) 072001). This paper constitutes the first discovery (with more than 6 standard deviations) of a five-quark state, known as a pentaquark. Based on its decay mode, its quark assignment is found to be $uudc\bar{c}$.
- LHCb published the most precise paper on the weak phase ϕ_s in decays of $B_s \to J/\psi\ \phi$ mesons (Phys. Rev. Lett. (2015) 114, 041801.
- Two papers for improved limits on WIMP scattering from LUX from 2013 data (Phys.Rev.Lett. 116 (2016) no.16, 161301 and 161302) and recent results from a search for dark matter with 332 live days of exposure at LUX (arXiv:1608.07648)
- Publication of the Lux-Zeplin (LZ) Conceptual Design Report (arXiv:1509.02910) and the BDX proposal for a dark matter search in a beam-dump experiment at Jefferson Lab (arXiv:1607.01390)
- Publication of the physics potential for a long-baseline neutrino oscillation experiment using a J-PARC neutrino beam and Hyper-Kamiokande (PTEP 2015 (2015) 053C02) and publication of the physics potential of the TITUS intermediate detector for Hyper-Kamiokande (arXiv:1606.08114)
- Two MICE papers documenting the pion contamination of the muon beam (JINST 11 (2016) no.03, P03001) and the MICE Electron Muon Ranger (JINST 10 (2015) no.12, P12012)
- Paper highlighting the physics programme of the nuSTORM facility and how it could lead towards a future muon collider: Ann.Rev.Nucl.Part.Sci. 65 (2015) 145-175.

- Updated baseline for a staged electron-positron Compact Linear Collider, CLIC (arXiv:1608.07537) and the Higgs physics capabilities at CLIC (arXiv:1608.07538)

Highlights of the Theoretical/Phenomenological Programme:

- Hadronic vacuum polarization disconnected contribution to the anomalous magnetic moment of the muon from Lattice QCD (Phys. Rev. D 93(7), 074509)
- The size of the pion from full Lattice QCD from physical u, d, s and c quarks (Phys. Rev. D 93(7), 054503)
- Calculation of the hadronic vacuum polarization disconnected contribution to the muon anomalous magnetic moment using Lattice QCD (Phys.Rev.Lett. 116 (2016) no.23, 232002)
- Standard Model Prediction for Direct CP Violation in $K \to \pi\pi$ Decay using Lattice QCD (Phys.Rev.Lett. 115 (2015) no.21, 212001)
- LHAPDF6: parton density access in the LHC precision era, Eur.Phys.J. C75 (2015) 3, 132
- Next-to-leading order predictions for WW+jet production (Phys. Rev. D 92, 014033)
- Global fit of top quark effective theory to data (Phys. Rev. D 92, 091501) and constraining top quark effective theory in the LHC run II era (JHEP 1604 (2016) 015)
- Physics at the electron-positron linear collider (Eur.Phys.J. C75 (2015) no.8, 371)
- Higgs coupling measurements at the LHC (Eur.Phys.J. C76 (2016) no.7, 393)
- Global parton distribution functions for LHC Run I and Run II (J.Phys. G42 (2015) 103103 and Nuovo Cim. C38 (2016) no.4, 127)
- Determination of intrinsic charm in a matched general-mass scheme (Phys.Lett. B754 (2016) 49-58), charm in deep inelastic scattering (JHEP 1511 (2015) 122) and a determination of the charm content of the proton (arXiv:1605.06515)
- The computation of the electric dipole moment of the neutron from 2+1 flavor Lattice QCD (Phys. Rev. Lett. 115 (2015) 062001
- Relationship between QCD and gravity, through the “double copy” yields links between QCD amplitudes and black holes (Int.J.Mod.Phys. D24 (2015) no.09, 1542008), to the TAUB-NUT solution in gravity (Phys.Lett. B750 (2015) 272-277) and to Bremmstrahlung and accelerating black holes (JHEP 1606 (2016) 023
- First complete two-loop five-gluon helicity amplitude in Yang-Mills theory (including non-planar diagrams), which is a step towards NNLO QCD phenomenology (JHEP 1510 (2015) 064
- Production of di-lepton pairs from Z/γ^* in association with multiple hard jets in high energy collisions (JHEP 1605 (2016) 136
- $B \to V\ell^+\ell^-$ form factors in the Standard Model from light-cone sum rules (JHEP 1608 (2016) 098), essential to determine helicity amplitudes for measurements, at B factories and LHCb.

Multidisciplinary Highlights:

- Chris White (Particle Physics Theory group at Glasgow) has established a collaboration with the Glasgow Optics group that resulted in an EPSRC Grant “Telescope windows: low-vision aids to cloaks” to apply the mathematics from General Relativity to the design and construction of novel optical materials, for new medical spectacles to alleviate retinal disorders and macroscopic invisibility cloaks. Three publications have resulted so far:
    - “Large-scale, white-light, transformation optics using integral imaging”, Journal of Optics (2016), 18, 044009;
    - “Omnidirectional transformation-optics cloak made from lenses and glenses”, Journal of the Optical Society of America A: Optics Image Science and Vision, (2016) 33(6), pp. 1032-1040

- "Law of refraction for generalised confocal lenslet arrays", Optics Communication (2014) 313, pp. 119-122

- Development of semiconductor systems for microscopy, synchrotron sources, positron emission tomography and biological applications
  - "Medipix3 Demonstration and understanding of near ideal detector performance for 60 & 80 keV electrons", arXiv:1608.07586;
  - "Positron detection in silica monoliths for miniaturised quality control of PET radiotracers", Chemical Communications, (2016) 52(45), pp. 7221-7224;
  - "Pixelated detectors and improved efficiency for magnetic imaging in STEM differential phase contrast", Ultramicroscopy (2016), 165, pp. 42-50;
  - "Digital direct electron imaging of energy-filtered electron backscatter diffraction patterns", Physical Review B, (2016) 92(20), 205301
  - "Edge pixel response studies of edgeless silicon sensor technology for pixellated imaging detectors", JINST 10 (2015) no.03, P03018

Other News from the SUPA Particle Physics Theme

- Outreach activities: Masterclasses at Glasgow and Edinburgh, 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.
- Fabiola Gianotti, an honorary professor at Edinburgh University, took up her tenure as CERN Director General in January 2016.
- The 2016 winner of the Royal Society of Edinburgh Lord Kelvin Medal was Professor Anthony Doyle, University of Glasgow, "for his outstanding contribution to the field of experimental particle physics, through developing critical analysis methods, which has led to major developments that have made possible the recent discovery of the Higgs Boson, and for his extensive public engagement activities".
- Appointment of Chris Bouchard to a lectureship in Theoretical Particle Physics at the University of Glasgow.
- Publication during 2015 of the Proceedings of the Beauty 2014 conference, NUFACT 2014 conference and the 69th Scottish Universities Summer School in Physics: LHC.
- Phenomenology (SUSSP69)
- Nine international workshops in 2015 and six international workshops in 2016 were organized by the Higgs Center for Theoretical Physics, University of Edinburgh.

2.6 Photonics

Theme Leaders: **Dr Robert Thomson, Heriot-Watt University**
Dr Jennifer Hastie, Strathclyde

Personnel

The following table presents a crude headcount (taken on 1st September 2016) of those directly involved in photonics research across the SUPA core physics institutes. The numbers do not include those working in non-physics departments e.g. Engineering, and some researchers are shared with other SUPA themes e.g. PaLS, Condensed Matter, Energy. Furthermore, the numbers do not include students not listed on research group websites. They are therefore unlikely to include a significant number of the ~50 EngD students in the HWU-led EPSRC Centre for Doctoral Training in Applied Photonics (who are primarily based in companies), or the students in the Glasgow-led EPSRC CDT in Sensors and Measurement.

Institution	Academics	Res Assoc & Fellows	Ph.D students
Heriot Watt	33	37	108
St Andrews	12	41	41
Glasgow	5	12	19
Strathclyde & IOP	29	19	65
Dundee	9	8	13
West of Scotland	6	2	8
Total	94	**119**	**254**

Publications:

In order to crudely assess the academic impact of SUPA institutes in the photonics area, WoS was used to find the highest impact factor journals in the "Optics" area of research. A separate search was then performed for each journal to find the number of papers from Scottish institutes between 1st Aug. 2015 – 31st July 2016.

Journal Rank	Journal Name	No.
1	*Nature Photonics*	3
2	Light-Science and Applications	1
3	Advances in Optics and Photonics	1
4	Laser & Photonics Reviews	3
5	Advances in Atomic Molecular and Optical Physics	0
6	ACS Photonics	3
7	Optica	8
8	Advanced Optical Materials	4
9	Nanophotonics	0
10	Journal of Biophotonics	3
11	IEEE Journal of Selected Topics in Quantum Electronics	16
12	Biomedical Optics Express	8
13	Photonics Research	0
14	Optics express	39
15	Optics Letters	33

Given their probable importance in the Physics assessment for REF2020, a specific search was also conducted for the "top" multidisciplinary scientific journals - *Science, Science Advances, Nature* and *Nature Communications.* (The author notes that Science Advances is yet to receive an impact factor, but it is likely to be high, and is likely to be judged as one of the most prestigious journals).

Journal Name	No.
Science	0
Science Advances	5
Nature	1
Nature Communications	12

Grants Awarded: In recent years, SUPA photonics researchers have been exceptionally successful in securing major and prestigious research grants, including ERC Fellowships (Cataluna, Gather), EPSRC Quantum Hubs (e.g. QUANTIC), EPSRC Quantum Fellowships (e.g. Buller, Fedrizzi, and Pritchard), and EPSRC Interdisciplinary Research Collaborations (e.g. PROTEUS). This success has continued, albeit at a more "normal" level, and the following table details the RCUK photonics-related grants (>£100K) held by Scottish Physics researchers, that started during the 1st Aug. 2015 – 31st July 2016 period. The data were obtained using Research Gateway.

Principle Investigator	Inst.	Start Date	Funder	Project Reference	Value
Robert Thomson	HWU	Sept 15	STFC	ST/M007839/1	£286,631
Carlos Penedo	ST A	Feb 16	EPSRC	EP/N009886/1	£397,795
Vassilis Sboros	HWU	Mar 16	STFC	ST/M007804/1	£210,440
Derryck Reid	HWU	Mar 16	EPSRC	EP/N002547/1	£539,278
Robert Thomson	HWU	Apr 16	STFC	ST/N000625/1	£490,110
Derryck Reid	HWU	Jul 16	STFC	ST/N006925/1	£102,880
Alan Kemp	IOP	Aug 16	EPSRC	EP/P00041X/1	£729,656
Jonathan Taylor	GLA	Aug 16	EPSRC	EP/N029917/1	£100,899
Jonathan Shephard	HWU	Aug 16	EPSRC	EP/N02494X/1	£628,460
Derryck Reid	HWU	Sep 16	EPSRC	EP/P005446/1	£543,361
Dino Jaroszynski	STRA	Apr 16	EPSRC	EP/N028694/1	£4,494,680
Ian MacLaren	GLA	Jul 16	EPSTC	EP/P001483/1	£1,081,830

In addition to the RCUK grants listed above, there have been ERC successes for Scottish photonics researchers, including John Travers (HWU), "High Energy Optical Soliton Dynamics for Efficient Sub- Femtosecond and Vacuum- Ultraviolet Pulse Generation" ERC-Starter 2016

2.7 Physics and Life Sciences

Theme Leader: Prof Gail McConnell, University of 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:

- Prof Kishan Dholakia awarded the Optical Society of America (OSA) R.W. Wood Prize 2016. The award was made in recognition for his pioneering research into optical micromanipulation using shaped light for interdisciplinary photonics-based applications

- Prof Rory Duncan (Heriot-Watt) appointed as a member of the STFC Science Board
- Papers in high impact interdisciplinary journals, e.g. Nature Photonics, Scientific Reports, Optica, PNAS, PLoS One

Appointments:

- Two new appointments in advanced optical microscopy have been made at the University of Strathclyde. Dr Brian Patton & Dr Sebastian van de Linde join the University of Strathclyde from Oxford and Wuerzburg respectively

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:

- Innovate UK award between Prof. Kishan Dholakia (University of St. Andrews) and M-Squared Lasers, "Airy Light Sheet Microscopy for Neurological Imaging", £117,528.
- Dr Neil Hunt (University of Strathclyde) consultancy with UCB Celltech Ltd

Funding Highlights:

- Epithelial Sheet Dynamics during Primitive Streak Formation as Active Matter. K. Weijer, R. Sknepnek (Dundee), S. Henkes (Aberdeen) BBSRC £705k
- Synthetic gene circuits to measure and mitigate translational stress during heterologous protein expression. C. Romano (Aberdeen). BBSRC £850k
- Extension to Genting TauRx Diagnostic Centre Sdn Bhd Dementia Project. B Schelter (Aberdeen). £363k (total funding now £1.2M)
- Optimising biotechnological protein expression through predictive management of cellular translation. C. Romano (Aberdeen) £113k
- H2020 MSCA Fellowship. M. Gather (St. Andrews)
- Single-molecule studies of light-emitting polymers: observing and manipulating polymer conformation in solution. C. Penedo (St. Andrews) £**398k**
- Lab in a bubble, D. Jaroszynski (Strathclyde), £ **4.5M**
- Multi-photon microscopy without scanning for faster than video-rate fluorescence imaging of live cells, G. McConnell (Strathclyde) £110k

2.8 SUPA Graduate School

The Graduate School continued to fulfil a key role for the SUPA physics departments and steps were taken to keep the offerings to students relevant and interesting. A key development this year is the upgrade of all the SUPA Video Conference classrooms (SUPA rooms) significantly upgrading our capabilities and safeguarding the resource for the future. The GS has had input into the three SUPA Focus Groups, and has been particularly involved with the setting up of a 'Public Engagement Network', an outcome of the Education and Outreach Focus Group.

Courses

The course provision has been refreshed during this period, resulting in 60 courses that will run in 2016/17.

2 new courses have been developed in 2015/16 to be run for the first time in 2016/17:

- A new Pals/Photonics course: Biomedical Applications of Lasers, Beams and Radiation; Bernhard Hidding, Strathclyde
- A new CMMP course: Matrix product state and tensor networks approaches to many body systems, Luca Tagliacozzo, Strathclyde

In the CMMP theme Surface Topology 1 and 2 have merged to become Modern Topics in Condensed Matter Physics. In particle physics The Standard Model course has become Gauge Theories in Particle Physics. These changes are due to changes in the Undergraduate provision of the respective universities.

Due to scheduling clashes of between SUPA institutions, Advanced Cosmology ran as a distance learning course (no live lectures) and Semi-classical Theory of Atom Light Interactions was unable to run this year. These courses are final year undergraduate courses and cannot be easily rescheduled. We hope to be able to use the ability of the upgraded video conference system to broadcast courses in parallel to avoid this situation in future years

Only one course, Monte Carlo Radiation Transport will no longer run

The GS has been involved in discussions with the NPL Postgraduate Institute to explore the possibility of offering shared courses and other cross-institution activity

Welcome Event

The SUPA induction event was rebranded as a welcome event, in recognition of the fact that the students already attend several inductions. The event included talks by SUPA Graduate student Tushar Choudhary, Dr Susanne McEndoo of University of Strathclyde and John Nichols of M2 Lasers. As well as opportunities for the students to network. The event was attended by 130 students.

VC Room Upgrade

In September 2016 we completed an upgrade of the SUPA room systems, with improved audio, HD video, fast content channel transfer, and a more flexible software-approach. The upgrade will also allow students to join from their personal computers, although further development is needed before rolling this out widely. Similarly, there are plans to implement parallel courses in some instances, which will reduce the impact of courses becoming UG and therefore not under the scheduling control of SUPA – often resulting in clashes

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 626 research students in 2015/16 – an increase of 20 from the previous year.
- There were 293 applications for SUPA Prize Studentships in 2014/15, an increase of 60 from the previous year. Of these applicants 16were awarded Prize Studentships

Plans for Improvements in AY2015/2016

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

- The formation of a Student Forum
- A thorough review of course provision by Theme Leaders
- Make full use of the upgraded website
- Planning for running GS courses in parallel
- Investigate the possibility of shared courses with the NPL PGI

2.9 Knowledge Transfer Activities

Since the 2014-15 Annual Report the SUPA Commercial Manager and the STFC IPS Fellow completed their contracts, with the SUPA Business Development Manager remaining in post. Following the approval of the SUPA strategic plan 2016-2021, Knowledge Exchange activity has been assimilated into the graduate school and is focussed on the development of impact across SUPA

An Industry Focus Group was established in December 2015. The Group comprised a representative from each SUPA university and has met three times to consider how best to shape KE activity across the pool. To some extent this has also been considered by the Education and Outreach Focus Group (the International Year of Light being an example of overlap between industrial engagement and outreach). Over three meetings, the Industry Focus Group considered a number of KE activities and began to prioritise these. Following this initial activity it is intended that the Group will become an Industrial Advisory Board, likely including representation from industry and other non-academic organisations.

International Year of Light

The International Year of Light (IY) concluded during the reporting period. A comprehensive report on the SFC-funding IYL activity has been submitted separately. Key points are:

- 17 activities directly funded from SFC IYL funds.
- Over 8,000 people attended events with the funded IYL activity as the main focus.
- Over 1,000 people attended events involving SFC-funded exhibits as part of a wider activity.
- Around 1,200 school children attended funded events with IYL as the sole focus. Lab in a Lorry exclusively targeted schools and reached a further 6,208 pupils
- SFC funding was matched by cash and in-kind contributions from universities and industry and comprised just under 25% of the total funding
- It was noted in the UK IYL final report that there were a disproportion amount of events in Scotland and this was attributed to the SFC IYL funding and the consequent leverage of other support.

Technology Scotland and Scottish Optoelectronics Association

Technology Scotland has been formally launched and is gathering momentum as a trade body for key enabling technologies in Scotland. The Scottish Optoelectronics Association continues to exist as a group within Technology Scotland and represents the photonics interests of industry and academia in the country. As reported previously, SUPA KT's management contract with SOA came to successful conclusion, and SUPA and Technology Scotland continue to work closely together

Physics Impact Exhibition at the SUPA Annual Gathering

2016 saw a new format for the SUPA Annual Gathering and as part of this an exhibition on physics impact ran alongside the meeting. The exhibition proved popular with SUPA's partners and featured displays and demonstrators from nine companies, eight partner organisations, and sixteen exhibits from SUPA

Industrial Placements

SUPA's industrial placements have proved to be very successful. In addition to the "restoration" funding, industrial placements has also been supported by the INSPIRE programme, PECRE and the universities themselves. The restoration funding is almost complete, with twenty three total awards having been made of which nineteen went ahead (the others were not able to proceed due to various contractual or visa issues). Three placements finished early due to the secondee being offered a post elsewhere. The Industrial Advisory Board will be considering options to continue the placement programme following the completion of restoration funding, possibly through industrially funded placements

PEER

The PEER funding continues be successful in developing European programmes. In 2016 the fund was used strategically to support a number of academics taking part in Photonics 21 activities to shape the future funding and direction of European photonics. Clearly the UK's decision to leave the European Union will have an effect on SUPA's ability to participate in European programmes, although participation in European facilities will

continue to be possible. SUPA provided a written submission to the House of Commons Science and Technology Select Committee Inquiry into Leaving the EU

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:

- The Quantum Technology Hubs
- International Max Planck Partnership
- 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
- National Physical Laboratories
- Cockcroft Institute
- CERN

3.2 Associate Membership of SUPA

An Associate Membership category has been created in 2016 for organisations that collaborate closely with SUPA in order to provide a platform for joint activities of mutual benefit.

A formal agreement was signed in 2016 with the UK Astronomy Technology Centre which sets out areas of collaboration and opportunity in order to re-enforce this relationship.

Agreements are also under preparation with the Fraunhofer Centre for Applied Photonics and the International Max-Planck Partnership

3.3 The Research Excellence Framework 2021

Outstanding results (see 2015 Annual Report) for Scottish physics submissions in REF2014 (compared to pre-SUPA performance) and the first joint submission in physics in the UK, has encouraged continuation of a collaborative approach. SUPA has contributed to consultations on the future REF and now awaits the outcome in terms of rules and regulations for REF2021 to allow a strategy to be developed.

3.4 External Partners

SUPA physicist influence policy decisions in research in a multitude of ways, through professional societies, research funding bodies, etc. With 11 FRS, 64 FRSE and 13 RSE

YAS, SUPA is extremely well represented in our national academies. In addition, Richard Kenway (Edinburgh) was elected to STFC Council in 2016, while Christine Davies (Glasgow), Rory Duncan (Heriot-Watt) and Peter Clarke (Edinburgh) are STFC Science Board Core Members. Ifor Samuel (St Andrews) was elected as a member of the EPSRC Strategic Advisory Group. Richard Kenway, contributed to the establishment of the new Alan Turing Institute and is now a Board Member.

SUPA is building a relationship with NPL (Teddington) via collaboration between the SUPA Graduate School and the NPL Postgraduate Institute; opportunities are also being explored with the NPL Scottish Hub which is the process of being created.

The SUPA CEO is Co-Director of the Scottish Crucible, the award winning leadership and development programme; 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, also the treasurer for IoP. 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 is actively pursuing opportunities for working across the boundaries between research pools. For instance, CPD lectures to industry have been trialled across the physics-engineering boundary using the upgraded VC classrooms through collaboration with the CDT on Integrative Sensing and Measurement.

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 2015/2016

No new posts created in 2015/2016

4.2 Number of Research Students Graduating and Destination

Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Students Graduating	92	80	104	70	105	135
Destination:						
Academic	51	47	59	27	35	25
Teaching	1	2	2	0	0	14
Industry	17	11	21	2	0	15
Finance	1	5	1	1	1	2
Technology	3	2	0	3	4	5
Legal	0	1	2	0	0	2
Career Break/Travelling	2	2	4	1	1	2
Unemployed/Applying for Posts	1	4	10	5	1	11
*Other	5	1	3	0	3	6
Not Known	11	5	2	31	60	55

***Publishing/Outreach/Military/Sport/Music**

4.3 Size of Early Career Research Community

The SUPA community includes around 1000 early career researchers (over 600 postgraduate research students and almost 400 contract research staff), all of whom are well catered for by the training and career events in SUPA discussed earlier supplemented by the training provided by the individual Universities.

4.4 Events, Meetings, Workshops and Conferences

- SUPA launched a new 'Annual Gathering' in 2016 which included an 'Exhibition of Physics Impact' with the intension of providing a forum for bringong together the whole physics community in Scotland. This reached capacity of 300 attendees and 29 exhibitors in the TIC Building at the University of Strathclyde. Key notes, plenaries and short talks covered latest developments and breakthroughs in physics (such as gravitational waves and recent results from CERN) combined with applications of physics into manufacturing, health and other sectors.
- The 2016 SUPA Annual Gathering and Exhibition was turned into a public event in the evening in cooperation with IoP Scotland to demonstrate the societal value of research in physics in Scotland (see Section 4.6).
- SUPA organises an annual Welcome event for all incoming PhD students from across Scotland (around 140 annually). This provides an opportunity to explain SUPA to incoming students, expose them to some of SUPA's top researchers, and provide a chance to network with other PhD students in other SUPA institutions
- Within the GS programme, SUPA holds summer schools on specialist topics; it is planned to integrate the Scottish Universities Summers School in Physics (SUSSP), which has been running annual prestigious international summer schools since 1960, with the SUPA GS. The 2016 Summer School, SUSSP72, held in St Andrews was a SUPA sponsored event organised by the EPSRC CDT in Applied Photonics.
- See separate PEER and PECRE reports for scientific and industry visits and exchanges.

4.5 Interventions which may Benefit other Sectors including Industry

- SUPA Associate Members benefit from meetings, placements, outreach and employment of graduate students and PDRAs: STFC UK Astronomy Technology Centre, Fraunhofer Centre for Applied Photonics and International Max-Planck Partnership.
- PG student placements in a variety of industries and education bodies.
- Quantum Technology hubs.
- Contributing to the formation of the Alan Turing Institute.
- 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).
- SUPA Exhibition of Impact, May 2016 (see below).

4.6 Outreach and Public Understanding

SUPA is very active in Outreach and Public Understanding – activities are too numerous to list here. With the launch of the monthly SUPA Newsletter in January 2016, public engagement events and activities are now reported regularly via the Newsletter and on the SUPA website.

It must be noted that the global media coverage created by the announcement of the first observation of gravitational waves involving Scottish physicists very prominently. Virtually every news outlet across the world reported on this (often on the most unexpected outlets); the BBC covered the Scottish contributions extensively both nationally and internationally.

The 2015/16 period saw the conclusion of International Year of Light in which SUPA played the leading role in Scotland (see Section 2.9). A list of events that took place in the 2014/15 reporting year appeared in the 2015 Annual Report; a highly successful final event was held at the Heriot-Watt University campus in December 2015.

A new public event was introduced into the SUPA Annual Gathering in May 2016 by combining the IoP Scotland in hosting an Exhibition of Physics Impact coupled with a lecture by Professor DAB Miller from Stanford University.

A SUPA Focus Group was created late in 2015 on the topic 'Education and Outreach' with representation from all 8 partner institutions. Following 3 meetings, and discussions at EC and IAC, a SUPA Public Engagement Network has been launched.

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 and continuing outstanding success in ERC competitions in 2015/16. Accumulated collaborative grant income over SUPA II now stands at £348.3 M, plus £195.5M in non-collaborative grants. The EPSRC funded CDTs continue to provide substantial support for research studentships within SUPA.

6 OUTCOMES

The first gravitational wave observation will be recorded in history as one of the biggest breakthroughs of science in the 21st Century; it is a testament to the Scottish physicists who played such a major role and never gave up on their belief that they could overcome such a major technological challenge to prove Einstein correct on his theory for gravity on the 100th anniversary of the General Theory of Relativity. This opens up an entirely new window on the universe (astronomy normally depends on electromagnetic signals from space, but gravitational waves are fundamentally different). A pleasing result of this challenge has been the number of practical applications of the technologies developed to achieve this spectacular result.

CDTs and major international partnerships and collaborations (CERN, International Max Planck Partnership, Fraunhofer CAP) are all visible successes of SUPA-II funding to date. The major capital investments made by SFC and the partner institutions (SUPAscopes, Ultralow Vibration Lab, SCAPA, MagTEM, Nanofabrication Facility, HARPS-N Spectrograph) are all adding to the reputation and competitiveness of Scottish Physics (see individual sections in the report for more details).

The SUPA Graduate School continues to ride high in the list of SUPA's successes. The SUPA Prize studentship scheme continues to attract very high quality applicants from across the world in increasing numbers. The number of registered PGR students in the SUPA GS has reached 626 in 2016. In the 2016/17 academic year, SUPA will offer 60 courses (over 800 hours of lectures) across Scotland, being able to draw on world experts to deliver the courses in all of our areas. The VC classrooms, upgraded to modern standards in 2016 (see Section 2.8), now offers not only high definition and high bandwidth connectively, but also flexibility to offer courses live to recipients anywhere in the world via the internet

7 SUSTAINABILITY

All SUPA partner institutions are committed to SUPA as a permanent feature of Scottish physics. The power and sustainability of SUPA lies within the leadership and creativity of its 1200+ membership of researchers – the largest grouping of research physicists in the UK. The role of SUPA is to provide opportunity for this network to perform at its highest level of international competitiveness.

EC and BoD have approved a "Strategic Plan 2016-2021". The strategy will recognise, update and adapt to the key external drivers facing Physics in Scotland, including a greater emphasis on innovation, enterprise and industry engagement via the Graduate School while furthering international recognition of research and opportunities. 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.

The Graduate School report, above, gives the staffing and other updates/changes for the 2016/17 academic year; SUPA partner HEIs have agreed to fund 16 Prize studentships commencing in 2016/17 from their own resources and to continue the Prize Studentship

competition in future with a single centralised application process, allowing excellent students to be badged as SUPA Prize students. The upgraded VC rooms provide a major resource for SUPA in the future, enabling an extension of its reach into partner organisations and industry, while offering an attractive operational system for future CDT bids.

SUPA created three 'Focus Groups' in 2015/16 to initiate discussion on future directions and sustainability of SUPA with representation from all 8 partners and some external participants. These are 'Industry', 'Research Fore-sighting', and 'Education and Outreach'. The latter has now evolved into a SUPA 'Public Engagement Network', while the other two are ongoing discussion groups identifying opportunities and recommending future activities and directions.

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. SUPA is now equipped with state-of-the-art video classrooms which significantly improves quality while offering flexibility to work more effectively with partner organisations around the world. The graduate School continues to attract PGR students of the highest quality which is a key metric for research health. Grant winning (including ERC) remains highly successful in spite of a challenging environment. 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, work more effectively across disciplinary and other boundaries, 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: 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 six calls so far with an estimated spend of £413,499. The progress with these calls and the resulting placements is detailed below.

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 Centre 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. Following the allocation, some of the Centres found they could not use all the funding and so some of the funds were returned by to the central pot allowing further calls to be issued.

As can be seen below, not all the placements ran their full course, and some were not able to start. Difficulties with placements general fall into one of the following categories

- Contract negotiation. Commercial confidentiality or IP considerations prevented the placement starting in a few cases.
- Visa issues. Many of the secondees were not UK nationals, which caused a problem in placing them in non-UK companies as they needed a visa to enter the placement country and then another to return to the UK. There were also issues with US work visas in some cases
- Secondee leaving for another post. In some cases the secondee was offered an RA post, which they that they could not turn down so left the placement early

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 & St Andrews	This project has also suffered considerable visa challenges which have finally (Aug 2013) been overcome. The project has completed.

Company	University	Comments
Pixium Vision, Paris	Dundee, with collaborations with Strathclyde & 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 Nonlinear 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 & 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 presented a challenge, but this project is aiming to start before the end of 2015.

Call 5 – August 2015

Company	University	Comments
BCF	Dundee	Project terminated early due to difficulties in IP negotiation
Croda	Edinburgh	Secondee left placement early to take up another post. A replacement is currently in place.

Call 6 – February 2016

Company	University	Comments
Chromacity	Heriot-Watt	Placement ongoing
Helia Photonics	Dundee	Placement ongoing

Call 7 – May 2016

Company	University	Comments
Razorbill	Glasgow	Placement ongoing
Optos	Strathclyde	Placement ongoing

GRANT INCOME – ANNEX B

Grant income:	**2015-2016**	**Cumulative Total**
Awarded to a single institution within the pool	32,514,669	195,610,810
Awarded jointly to two or more institutions within the pool	2,052,012	89,838,917
Awarded jointly to two or more institutions across two or more pools	1,007,798	99,289,198
Other, please specify	25,254,272	159,377,809
Total	**60,828,751**	**544,116,734**

*Single SUPA Institutional with external partners

Grant Source	**Scottish**		**UK**		**European**		**Other international**		**Total**	
	AY2015/2016	**Cumulative**	**AY2015/2016**	**Cumulative**	**AY2015/2016**	**Cumulative**	**AY2015/2016**	**Cumulative**	**AY2015/2016**	**Cumulative**
Research Councils			42,598,050	388,774,220	6,846,666	37,800,639			49,444,716	426,574,859
European Framework Programmes					2,868,019	61,637,797			2,868,019	61,637,797
Other public bodies*	4,235,784	8,116,179	1,610,334	32,934,180	0	864,827	0	1,745,649	5,846,118	43,660,835
Charities	0	528,510	726,055	2,573,557	0	0	67,386	67,386	793,441	3,169,453
Industry	134,927	1,363,246	1,217,834	4,910,009	0	187,328	0	516,125	1,352,761	6,976,708
Other (please detail)	0	0	0	463,139	209,367	209,367	314,329	1,424,577	523,696	2,097,083
Total	4,370,711	10,007,935	46,152,273	429,655,105	9,924,052	100,699,958	381,715	3,753,737	60,828,751	544,116,735

*Central government/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/

31 October 2016

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 2015 until 31st July 2016.

Your sincerely,

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

Printed on 75% recycled paper *Registered Scottish Charity No SC013683*

UNIVERSITY OF DUNDEE

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

Professor Timothy Newman,

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

16th November 2016

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

Dear Professor Miller,

I am writing to confirm my approval of the information within the SUPA Annual Report pertaining to the University of Dundee.

Yours Sincerely,

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

31 Oct 16

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

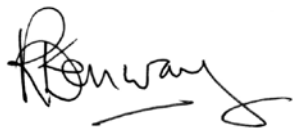
Professor Alan Miller FRSE, FInstP, FIEEE, FOSA
Chief Executive Officer
SUPA

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 2015 to 31 Jul 2016.

Yours sincerely,



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

The University of Edinburgh is a charitable body, registered in Scotland, with registration number SC005336

University of Glasgow

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

3 November 2016

Dear Alan

SUPA Phase II Annual Report to the Scottish Funding Council
(For the period 1 August 2015 to 31 July 2016)

On behalf of the University of Glasgow, I approve the content of the above report to the Scottish Funding Council.

Yours sincereley,

Professor Chris Pearce

Professor of Computational Mechanics
RAEng / EDF Energy Research Chair
Dean of Research and Deputy Head of College of Science and Engineering

College of Science and Engineering

Rankine Building, University of Glasgow, Glasgow G12 8LT
Tel: +44 (0)141 330 5207 Fax: +44(141) 330 4557
Email: Chris.Pearce@glasgow.ac.uk Web: www.glasgow.ac.uk

The University of Glasgow, charity number SC004401

3rd November 2016

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 2015 to 31st July 2016

Yours sincerely

Professor Garry Pender FREng, FRSE
Deputy Principal (Research and Innovation)
Member of SUPA Board of Directors

Heriot-Watt University Edinburgh EH14 4AS United Kingdom
Telephone +44 (0)131 449 5111 Fax +44 (0)131 449 5153 www.hw.ac.uk

Edinburgh Campus • *Scottish Borders Campus* • *Dubai Campus*

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

1 November 2016

Dear Alan

SUPA Annual Report 2015-16

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

The University of St Andrews is a charity registered in Scotland, No: SC013532

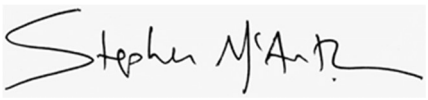
21st November, 2016

Professor Alan Miller
Chief Executive Officer
SUPA

Dear Professor Miller,

On behalf of the University of Strathclyde, I can confirm that I approve the SUPA Annual Report for the period of 1st August 2015 until 31st July 2016.

Yours sincerely,



Professor Stephen McArthur
Deputy Associate Principal (Research, Knowledge Exchange and Innovation)
University of Strathclyde
204 George Street, Glasgow G1 1XW

Email: s.mcarthur@strath.ac.uk
Telephone: 0141 548 4838

REF UK TOP 20 RESEARCH-INTENSIVE UNIVERSITY
THE UK UNIVERSITY OF THE YEAR WINNER
THE UK ENTREPRENEURIAL UNIVERSITY OF THE YEAR WINNER

The place of useful learning

The University of Strathclyde is a charitable body, registered in Scotland, number SC015263

EM/lk
1 November 2016

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

Dear Alan

SUPA II Annual Report AY2015-2016

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

Yours sincerely

Professor Ehsan Mesbahi
Vice Principal and Pro Vice Chancellor (Research and Enterprise)

Paisley Campus
Paisley PA1 2BE
Scotland UK

Tel +44 (0)141 848 3000
www.uws.ac.uk

Executive Group
Principal and Vice-Chancellor Professor Craig Mahoney

University of the West of Scotland is a registered Scottish charity. (Charity number SC005520)