

**Please provide a brief summary of your experience of, or connection with, the research pooling initiative.**

Submitted on behalf of the SUPA Executive Committee (8 Heads of Physics + SUPA CEO).

- 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 15 years in establishing Scotland as a recognised international leader in research and advance post-graduate training in Physics.
- Physics is a key discipline underpinning any knowledge-based economy. Advancing our understanding of the fundamental laws and building blocks of nature feeds the development of new and disruptive technologies for wealth creation, while the procedures, techniques and skills of those trained in Physics research are widely applicable in many organisations including and beyond technology industries.
- SUPA has facilitated interdisciplinary collaborations with other disciplines including other Scottish Research Pools, whilst not diminishing the importance of physics as a discipline. SUPA is actively engaged in addressing Challenge Funding (UKRI, ISCF, SIFP, etc) opportunities in cooperation with other disciplines.
- SUPA is committed to Knowledge Exchange towards social, health, environmental and economic benefit working with industry-facing centres, innovation centres, technology companies, start-ups, education bodies, while incorporating these into graduate training and careers events.

The SUPA CEO:

- Coordinated the original SUPA submission (2003/4).
- Presented talks on research pooling to SSAC, RSE, HEFCE, SFC, Scottish Deans of S&E, US/RKEC/Research Training Sub-Committee.
- Chaired, MASTS Governing Council (2009-2015).
- Institutional responsibility for ERPem as DP at HWU (2009-2014).
- SUPA CEO and Director of the SUPA Graduate School (2015 to present, p/t).

## **Section 1: Initial research pooling initiative**

### **Q1a. What has been the impact of the initial research pooling initiative?**

**See attached 2018 report by the SUPA International Advisory Committee.**

***Evidence of meeting objectives in 4 sections:***

**A. A key driver for research pooling in 2004 was improved international competitiveness in Scottish physics research including RAE (now REF) performance.**

- In RAE2001 (pre-SUPA) there were no physics submissions from Scotland judged to be 5\* (RAE2001 scores ranged from 1 to 5\*). There were three submissions graded at 5, two at 4, and 1 at 3b, i.e. no submissions were in the top 6 in the UK. By RAE2008, 3 SUPA submissions (St Andrews, Edinburgh & Glasgow) were in the top 6, based on overall GPA.
- In REF2014, SUPA collectively exceeded the 'Research Power' of each of the 'big 4' in England (i.e. Oxford, Cambridge, Imperial College, UCL). Strathclyde achieved the highest 'Overall' GPA in the UK and the joint Edinburgh/St Andrews submission had 2nd highest GPA in the UK for 'Output Quality'; Strathclyde had the 2nd highest GPA in UK for 'Impact'. All physics submissions from SUPA partners achieved top 15 for 'Impact'.
- It is widely recognised (across the Scottish physics community and beyond) that SUPA was a major factor in the improved research performance assessed in RAE2008 and REF2014.
- **An independent endorsement comes from the REF2014 / Main Panel B Overview Report stating:** *"There was increasing evidence for pooling of resources in regional groupings, as pioneered during the period of RAE2008 by the Scottish Universities Physics Alliance (SUPA). SUPA has gone from strength to strength [during the REF20014 assessment period]..."*

**B. Enhancing world class reputation and performance / income and other metrics**

- Non-collaborative research grant/contract income during SUPA II totalled £232.6M across SUPA partners, while the total income to SUPA partners for collaborative research was £381.9M (collaborations between SUPA institutions and with external partners).
- 102 competitively won Personal Research Fellowships awarded to ECRs (29 RoySoc, 6 RSE, 17 EC Marie Currie and 50 others) between 2010 and 2017 benefited in their applications from the esteem of being part of SUPA, the SUPA Graduate school to attract top students, and an environment that encourages cross-university sharing of facilities and collaboration.
- SUPA researchers recruited during this period won a remarkable number of European Research Council (ERC) grants at 36 awards (each > 1M Euro) aided by SUPA as above.
- A collective supportive spirit across SUPA has led to many personal awards, prizes and distinctions helped by promotion of individuals by SUPA.
- The unique International Max Planck Partnership on "Measurement and Observation at the quantum limit" created in 2013 links 5 SUPA HEIs with 5 Max Planck Institutes in Germany; formally, IMPP is an Associate Member of SUPA.
- U.Glasgow leads one of the four UKRI funded Quantum Technology Hubs (a £270M UK investment) with SUPA researchers playing significant roles as partners in all four of the UK Hubs.
- In 2015, researchers at 4 SUPA partners, lead by Sir Jim Hough at U.Glasgow, made significant contributions to one of the most significant scientific breakthroughs of all time with the discovery of Gravitational Waves which opens up a whole new branch of Astronomy.
- The award of the 2013 Nobel Prize in physics to Peter Higgs at U.Edinburgh for his prediction of the Higgs Boson, work that was conducted well before the creation of SUPA, nevertheless puts SUPA researchers in a very prominent and respected position internationally, particularly at CERN where SUPA researchers have a major presence and influence.
- SUPA is responsible for the creation of 7 major new research facilities offering state-of-the-art equipment for researchers across Scotland and research visitors from abroad, and all

now attracting project grant funding: Scottish Centre for the Application of Plasma-based Accelerators (SCAPA); Ultralow Vibration Laboratory (St Andrews); HARPS-N Spectrograph (La Palma); SUPAScopes 1m Robotic Telescope (part of a Global Network); Biophotonics Laboratory (Dundee); MagTEM Microscope (Glasgow); Electron Beam Writer (HWU).

- The Annual SUPA Gathering with Impact Exhibition introduced in 2016 is now established as a showcase and celebration of physics research and impact in Scotland averaging ~300 delegates; a premier networking event for the Scottish research community, **the 2018 Gathering was sponsored by RBS at their Gogarburn campus (ALL venue and catering costs covered by RBS).**
- The Chief Scientific Advisor to the Scottish Government is SUPA researcher, Prof Sheila Rowan. Researchers from within SUPA are members of a number of UKRI / RC Strategy and Advisory Groups demonstrating that SUPA members are influential in UK science policy and provide feedback to SUPA EC on high level strategies and early warning of new funding policies and initiatives.
- SUPA researchers publish over 1000 journal papers annually; SUPA is included in the address of all publications.
- **An independent endorsement is an invitation from the American Physical Society to prepare a video about SUPA for the 2019 APS March meeting (11,000+ delegates expected) under the theme of “successful collaborations and partnerships” to be shown at various locations for the duration of the conference (Boston, 4<sup>th</sup> – 8<sup>th</sup> March 2019).**

### C. World Class Training:

- In a completely new and original approach, a dedicated, purpose-built video classroom network linking all partners was created at the launch of SUPA in 2004, drawing on the knowledge base and experience across partner HEIs to provide courses from world leading researchers open (and accessible) to all physics PhD students across Scotland.
- The VC system underwent a complete hardware and software upgrade in 2016 to give a state-of-the-art interactive system. SUPA works closely with the Scottish company, Ajenta, to optimise the Vscene software for applications in education.
- Over 50 advanced specialist (PhD level) courses - over 800 hours of lectures - are now annually broadcast to the largest cohort of physics PhD students in the UK (over 600 registered).
- Professional development training for students and PDRAs are offered by face-to-face, VC and distance courses.
- The reach of lectures and courses now extends beyond Scotland with Rutherford Appleton Laboratory, National Physical Laboratory, U.Newcastle and industry partners connected to lectures by VC.
- The SUPA Graduate School Management Committee has set formal minimum training requirements for all physics PhD students in Scotland that exceed HEI norms.
- SUPA has awarded 145 Prize Studentships (including SFC Higgs Studentships) since 2005 which has proved particularly valuable in attracting outstanding foreign students to Scotland.
- Collaboration is increasing with Chemistry, Engineering and Mathematics with courses now providing training across interdisciplinary interfaces.
- SUPA careers events are very successful (60 to 80 PhD and PDRA attendees per session); a new Industry skills course was introduced in 2018 with lectures given by industry personnel

via the SUPA VC network; Entrepreneurship Masterclasses arranged by Lucinda Bruce-Gardyne (RoySoc Entrepreneur-in-Residence) are offered to all SUPA researchers.

- SUPA has many examples of successfully funding PhD students and ECRs on visits to international laboratories and facilities, bringing distinguished visitors to Scotland for research to provide lectures and courses.
- Support for Industry placements, workshops and colloquia, for example, the annual Cormack Astronomy meeting is organised jointly with RSE.
- PECRE/PEER funding from SFC has been very effective in creating and supporting international visits, collaborations and preparations for funding calls (see case studies on the SUPA website: <https://www.supa.ac.uk/ke/case.php>)
- PhD students benefit from joint research initiatives (e.g. in quantum technologies, gravitational waves, biophotonics, etc).
- SUPA supports multi-university, EPSRC and STFC funded Centres for Doctoral Training in physics and physics related subjects in Scotland, providing access to courses, and funding for meetings, workshops, exhibitions careers events and placements.
- Scottish Universities Summer Schools in Physics (SUSSP), a joint initiative between Scottish Physics departments organising international PhD/PDRA level specialist schools since 1960, is now integrated with SUPA; the 2018 School (SUSSP74), “Innovation and Entrepreneurship in Photonics” featured top lecturers from across the UK, Europe and North America.

#### **D. Knowledge Exchange**

- REF2014 provided impressive Case Studies on physics impact (physics also contributed to submissions from other disciplines such as engineering) in a wide range of topics including; creation of a cluster of innovative laser companies serving global markets; applications of microwave and mm wave sources and amplifiers for defence, security and health sectors; development of ultrastable lasers for metrology, spectroscopy and imaging; Cascade Technologies laser spin out company; market leader in fluorescence spectrometers; commercial electron microscope developments; oil & gas prospecting technologies; X-ray detector developments.
- SUPA’s collaborative ethos was significant in the case for and creation of new physics-based, industry-facing institutes which are now Associate Members of SUPA; UK Fraunhofer Centre for Applied Photonics and Fraunhofer UK Research Ltd. (based at U.Strathclyde) opened in 2012, and the Higgs Centre for Innovation as part of the STFC Astronomy Technology Centre (Blackford Hill, Edinburgh) opened in 2018.
- SUPA was instrumental in the creation of SU2P, a collaborative initiative between 4 SUPA partners (Strathclyde, St Andrews, Glasgow and Heriot-Watt) and Stanford and CalTech universities which includes annual research workshops, symposia, and exchanges for ECRs, giving access to entrepreneurship and Silicon Valley companies for Scottish researchers.
- SUPA works closely with Technology Scotland and other industry facing organisations (Higgs Innovation Centre, Fraunhofer UK, etc) to support enabling technologies. SUPA has regular engagement with a wide range of companies based in Scotland from start-ups and SMEs through to large multinationals via placements, workshops, careers events, sponsorship, etc. Some examples are: Leonardo, Thales, Coherent, M2Lasers, Horiba, Chromacity, Optos (Nikon), Novosound, Blackford Analysis, Canon Medical Systems.
- **A positive endorsement of SUPA KE is the award in 2018 of a SFC Leverage grant as a joint venture between SUPA, SULSA and SINAPSE to enhance current strengths in the**

development of optical imaging for medical applications through the creation of a network that can better position Scotland in UK and EU Challenge Funding competitions that will supplement and sit alongside the work of the Scottish Innovation Centres.

- SUPA Education is a new initiative in 2018 that is bringing the Scottish physics research community together to work with Education Scotland, the Scottish Schools Education Research Centre (SSERC) and the IoP Teachers Network in Scotland to support teachers with Curriculum of Excellence topics and concepts.

### **Q1b. What lessons can be learnt from the research pooling initiative?**

- A combination of a clear strategy for physics in Scotland, critical mass, investments in collaborative facilities, joint recruitment strategy, cross university collaborations, Prize PhD studentships, a collective approach to researcher training, and sharing of good practise via SUPA resulted in a much improved research environment attractive to high quality staff and students.
- A strong graduate programme attracting high quality students is a vital factor in judging research health. The SUPA Graduate School is given our highest priority. Offering such a comprehensive range of specialist courses delivered by top researchers from across the SUPA partnership is unique in the UK, and the number of collaborating universities at this level is probably unique in the world. This gives significant advantage in recruiting high quality PhD students and is an important factor in funding bids to EPSRC, STFC, EU etc.
- Recruitment of top researchers into academic posts is very competitive in the sciences. The reputation of physics in Scotland, the value of the SUPA Graduate School; encouragement to collaborate across SUPA partners; sharing of equipment and facilities, were positive attractors for outstanding researchers to move to Scotland over the past 15 years.
- SUPA partners have continued to expansion well beyond the original SUPA budgeted research leader positions because of the overall improved research performance and the extended benefits offering collaborations and facilities across the SUPA network.
- Reputation has been enhanced by the many personal awards and distinctions (many proposed and promoted by SUPA), which includes a Nobel Prize, RSE Royal Medal, a Knighthood, OBE's, Honorary degrees, Citation Laureate Award, Royal Commission, Max Borne, IEEE Plasma & Science Applications Award, George Darwin Lectureship, Alexander von Humboldt Foundation Award, IoP (Honorary Fellowships, Paterson Medal, Gabor Medal & Prize, Education & Outreach, Hoyle Medal), Sir Arthur Clarke Award, RSC Chemical Dynamics Award, and more... Distinguished Fellowships include 11 FRS and 64 FRSE (including emeritus). 18 physicists have been elected to RSE Young Academy Membership.
- Having the SUPA 'brand' adds strength to large international collaborations where Scotland can now coordinate its international engagements with these key organisations with the help of SUPA. There are many examples whereby cooperation within the SUPA Themes strengthens engagement with international facilities such as CERN together with cooperation in bidding for international Telescope time for instance.

## **Section 2: Pooling now and in the future**

### **Q2a. In the current research landscape, what is the perception of, and role for, the pools?**

- Pooling fits well with the Scottish Government strategy of a connected Scotland.

- Scotland has limited resources to expand top class university research in comparison to the level of investments being made elsewhere, so that we need to build the critical mass in more innovative ways.
- As a small country with the ambition to be at the international 'top table' in research, our universities are continually competing with much larger departments and organisations outside Scotland (Oxbridge, MIT, Stanford, etc) and competition is increasing due to large infrastructure and facilities investments in the Far East; in other words, the real competition is from abroad not between ourselves! Research Pooling has proven itself to create the critical mass to compete internationally while avoiding expensive and often damaging mergers of departments or institutions.
- Pooling has proved itself (in spite of many initial doubters) as a successful experiment that can create critical mass and collaboration across HEIs with different priorities and positions in the HE 'marketplace'.
- At launch, Research Pooling was a unique, innovative and distinctively Scottish initiative which has helped to project Scotland as a strong 'brand' in many research areas. Scottish pooling demonstrated that strategic cooperation is possible and effective between universities. The pooling concept has been copied to an extent in some English regions (SEPNNet, N8 partnership as examples).
- Both discipline based and multi-subject based pools have been shown to work. Discipline based pools have the advantage of being able to map onto existing structures, but their remit should allow for and encourage working across disciplinary boundaries.
- Investments need to reflect the future research funding environment with an ambitious approach.
- Central to the case for pooling is the fact that joining forces to offer top class graduate training has obvious advantages; there are many areas of research (even in larger universities) with small numbers of PhD students such that offering top class and equitable advanced training is not easy. Pooling not only offers efficiency, but it provides students with access to top researchers in their field in other Scottish HEIs.
- SFC can be congratulated in investing in research pooling 15 years ago and we believe that the current leadership is well placed to continue to develop the model for today's research environment.

#### **Q2b. Should research pools have a continuing role in the Scottish research base?**

- The case for research pooling in Scotland is now stronger than in 2004 as evidenced by the answers given above.
- Combining forces to offer graduate education is cost effective and provides Scotland with an edge; we are able to offer training that would not be feasible otherwise.
- With an ever larger proportion of UKRI funding for PhD training going into Centres for Doctoral Training (CDT) research pooling strengthens the case in the competition for these centres.
- Over the period of SUPA's existence, we have moved from a situation in physics of our research metrics (e.g. number of graduating PhD students, research income, number of PDRAs) combined being less than the big four in England to now exceeding these metrics, for instance, now collectively graduating more PhD students.
- Competitive Prize studentship awards provided very effective ways of attracting top students from around the world (against UKRI policies which limit this) and creating esteem for the Graduate School. A funding stream in this direction would be very effective both for

the short term benefit, and in the longer term by bringing (and retaining) some of the brightest brains in the world to Scotland.

- Placements for PhD students in business, industry and government departments is an effective way of both building substantive and longer term links between academia and industry and at the same time providing career opportunities beyond the placement for the students involved.

### Section 3: Anything else

- We are concerned that Scotland is missing out on the really big capital oriented investments in new research institutes being made by UKRI and other funding such as Crick, Alan Turing, Henry Royce, Rosalind Franklin, Faraday and National Graphene Institutes. Only a very small number of Scottish Universities are partners in these large investments, but even then the centre-of-mass draws the main activities, and cash, into the central location. Although physics in Scotland has done well in the competition for Quantum Technology Hubs as a positive example, these are “distributed” hubs without a physical central location; pooling strengthens the argument for future funding of longer term investments in major facilities in Scotland.
- The launch of research pooling triggered open discussion and healthy argument about strategy and priorities for research across the Scottish research base, which contrasts with the norm for universities world-wide whereby research strategies tend to be restricted to internal and more limited development. Other countries did not think that pooling was possible at the time, and look at Scotland now with a degree of envy!
- It is clear that each of the current research pools has its own priorities and therefore emphasis appropriate to its own discipline or sector. The future model for pooling should be flexible enough to continue to allow for these differences of emphasis but at the same time allow for sharing of good practice across the sector.
- SUPA has adjusted its strategy over the past 15 years to match changes in UK and Scottish funding structures and priorities; we believe that each pool should continue to develop to maximise the benefit to its partner universities and Scotland as a whole.
- The SFC decision to create Innovation Centres was triggered by research pooling demonstrating the willingness of the HE sector to work collaboratively. Unfortunately, the model did not create substantive links between pools and ICs even although research pools have a great deal to offer in terms of their knowledge of their extended communities across Scotland and the ability to bring together networks.
- Continued funding of research pooling ensures that the value of the investment in shared world-leading research facilities (mentioned in the previous sections) is maximised and will continue to have impact by attract further funding and well qualified students.
- The expectations of pooling, even under the ‘Continued Development’ phase is very ambitious given the current very modest SFC funding. Future funding should better match the ambition of the initiative.