Institution: University of Sheffield

Unit of Assessment: 9 – Physics

a. Context

The unit has a well-established record of active engagement with a wide variety of non-academic user groups including industry, government departments, policy makers and the public at large via its significant outreach activities. Research in the unit has supported two spin-out companies that build on its strengths in applied physics research (Ossila and Infinitesima case studies), has enhanced the performance of existing businesses and industrial processes (e.g. quantum cascade lasers case study), has contributed to reducing the risks to the security of nation states (see example below), and has stimulated public discourse, interest and engagement in science (e.g. nanotechnology case study).

Over the REF2014 period there have been collaborations with a wide range of industrial companies and governmental organisations (incl. **AWE, DECC, Dyson, E.ON, Hitachi, Home Office, IBM Zurich, National Physical Laboratory, Premier Oil, Procter & Gamble, Rolls Royce Aerospace, Sanyo, TataCorus, Toshiba, Unilever**), ranging from consultancies to major industrial R&D programmes that have attracted significant levels of external funding. The unit's staff have delivered more than 350 talks to schools, the general public and policy makers, the majority directly based on the research activities in the unit. Several high-profile press releases and web-based campaigns have further added to the reach of our impact activities.

Recently the unit has further increased its outward focus via the appointments of a new lecturer from industry (Dr Alastair Buckley), an STFC- and University of Sheffield-funded Business Fellow (Dr Richard Holmes), and an Impact Champion (Dr Alexander Tartakovskii), as well as the development of the £1.2M Sheffield Science Gateway, and the greater emphasis within the PPPA group on the application of previously developed technology via collaborations with industry. Our post-REF2014 strategy will build on these major investments and developments in order to further enhance the reach and significance of our impact.

b. Approach to impact

All staff are supported and expected, where possible, to achieve full non-academic impact for their work. Impact forms an item of their annual Review and Development meeting, and is a component of promotion cases. Sessions on impact are included in the bi-annual faculty-wide weeks which staff are expected to keep clear for proposal writing. Opportunities are presented at staff meetings by the Impact Champion and relevant faculty and university staff. Study leave is available to support impact. For example, Thompson was recently awarded one year's study leave to support his leadership of a major knowledge exchange project involving the application of muon detector technology to Carbon Capture and Sequestration (CCS) monitoring (see below).

Over the assessment period, 15 staff have engaged in research collaborations with more than 70 industrial companies and government organisations, and EPSRC/KTA and HEFCE/HEIF grants held by the University of Sheffield have been used to fund 15 KE projects in the unit (total value: £450k). EPSRC-funded research has supported two spin-out companies that exploit the unit's expertise in soft matter research (Ossila and Infinitesima case studies), as well as a major industrial collaboration to improve gas sensors, based on research in the inorganic semiconductor group (quantum cascade lasers case study); it has also led to significant public discourse and engagement in the issues surrounding the application of nanotechnology (nanotechnology case study). However, an important development over the REF period has been the growing importance of the STFC area. For example the Particle Physics & Particle Astrophysics (PPPA) group has roughly tripled its KE activities since 2009; currently running 7 projects in the energy, security and environmental areas with impact on at least 15 UK companies. Highlights include:

- a major new £1.9M programme (Sheffield share £0.6M) involving Thompson, Spooner and Kudryatsev in collaboration with researchers from the University of Durham, Bath and Newcastle on the application of particle physics muon detector technology to the climate change topic of CCS (in collaboration with **DECC and Premier Oil**);
- a £970k funded project to spin out expertise from dark matter searches into sensitive fast neutron detection directed at new technology for homeland security and crime prevention (in

collaboration with **TataCorus Ltd, Home Office and EPSRC**);

- a £380k STFC-funded project to apply PPPA detector development expertise to the construction of unique TIG orbital welding system and associated transfer of welding techniques with applications in the aerospace and power generation industries (in collaboration with **VBC Instrument Engineering and Rolls Royce Aerospace)**;
- a long-standing collaboration with **Cleveland Potash Ltd (CPL)** that has aided development of the deep underground Palmer laboratory at the Boulby Mine – originally funded through a Sheffield grant – into a new interdisciplinary low radiation background E-futures laboratory for radio assay and climate research that has attracted £750k in funding;
- collaboration on new underground deep cavern technology (with **Alan Auld Engineering Ltd, Rhyal Engineering Ltd and Technodyne Ltd)** attracting €450k funding.

Researchers in the unit are also encouraged to undertake outreach activities that stimulate public interest, discourse and engagement in science. Activities include press releases, school visits, in-house workshops for teachers and school pupils, and talks to scientific societies. Over the REF2014 period researchers in the unit have delivered more than 350 separate talks to schools, scientific societies and policy fora, the majority based on their research activities. Some specific examples of public engagement activities include the following.

- **The Sheffield Solar Farm (**http://www.sheffieldsolarfarm.group.shef.ac.uk/**).** The appointment of Dr Alastair Buckley to a lectureship directly from industry has led to a major initiative in photovoltaic research. A need was identified for trusted sources of information with respect to the performance of photovoltaic electricity generation in the UK. In 2010 the *Sheffield Solar Farm* project was initiated using HEIF funds (£120k) to translate university expertise in solar energy to value for commercial and private stakeholders. The project was timely, given the substantial interest in photovoltaic micro-generation stimulated by DECC's newly announced feed-in tariff scheme, and has attracted £950k in funding to date (HEIF, E.ON, EPSRC). The project has run around 20 public (incl. attendance of 5 of DECC's "British Energy Challenge Roadshows") and school workshops. Its centre of gravity is a web-based tool to which UK wide home PV system users donate solar energy generation data (www.microgen-database.org.uk) in exchange for feedback on their systems' performance; 6000 installations are registered. The site also includes a forum for discussion of technical issues, which has had >120,000 views. Key industrial collaborators include **E.ON Ltd, Saft Ltd, SolarMass Ltd, PassivSystems Ltd, Polysolar, Energence Ltd, and NAPIT Ltd**.
- **Monster Stars** (http://www.eso.org/public/news/eso1030). The press release associated with the identification of the most massive stars by Crowther and collaborators (Crowther et al., 2010, MNRAS 408, 731) led to considerable world-wide media interest, including Channel 4 News, Sky News, BBC Radio 4 Today, BBC World Service, UK broadsheets, plus US networks (NBC, CNN, NPR, New York Times), and resulted in a total of 788 news articles worldwide. This engagement is ongoing, with clear evidence of sustained media impact (e.g. http://www.eso.org/public/news/eso1117, BBC's Sky at Night; NHK's Cosmic Front); Crowther's involvement with Brady Haran's Deep Sky Videos YouTube channel has resulted in the production of a film about Monster Stars that has already attracted 110k views.
- **The Higgs boson.** The discovery of the Higgs boson from the turn-on of the LHC in 2008, through the announcement in July 2012, to the Nobel prize award in October 2013, has generated huge media interest. Members of the Sheffield ATLAS team have played a very active role in publicising this story, much of which stems directly from the work of Anastopoulos and Paganis in the ATLAS Higgs to 4-lepton analysis team. This has generated exposure in a wide variety of print media (Daily Telegraph, Yorkshire Post, New York Times etc.) and in studio interviews with local and national broadcasters, including Channel 4 News, CNN, Radio 4 Today, Radio 5 Live, BSB, BBC Radio Sheffield and ITV Calendar news. Tovey filmed a piece with John Parrott on the physics of particle collisions and the Higgs boson as part of the 2013 BBC World Snooker Coverage.

To streamline and coordinate the University of Sheffield support to research users, it has established five accessible gateways. These are outward looking, aligned to the external user environment rather than our internal structure, and enable cross-departmental and/or cross-faculty collaborations. Of particular relevance to Physics & Astronomy is the Sheffield Science Gateway

(**SSG:** http://ssg.sheffield.ac.uk), which was established in 2011 and now comprises five business managers and an administrator (total funding: £1.2M between 2011/12 and 2014/15). The unit's new Business Fellow (Richard Holmes) also acts as a Business Manager in the SSG, thus ensuring the unit's close involvement in this faculty-wide initiative. The unit is using the experience and relationships developed by the SSG to identify opportunities to broaden the impact of its research by connecting with users locally, nationally and internationally.

c. Strategy and plans

Our strategy is to continue to perform world-leading science across all four research groups, maximising the impact of this research via both increased industrial links and public engagement. We will build on the substantial progress made over the REF2014 period to further increase and embed impact, creating a culture where staff view impact as a critical step in the research process. In particular, we aim to further increase the number of companies we work with (section a), develop promising existing activities (section b) to fully maximise their impact, and encourage new developments from existing and future research which will form a pipeline of activities.

Led by the Impact Champion, and supported by the Business Fellow, the following specific activities are planned to further advertise our research, enhance links with industry, and support staff engaged in impact and outreach.

* **Facilitating face-to-face meetings between members of the unit and potential industrial partners** via bi-annual "Meetings with Industry" events. Representatives from industry will be invited to visit the unit to give presentations, open to all academic staff, and hold meetings with research group leaders and interested individuals. This will enable efficient exchange of ideas between industrial organisations and the unit's staff, potentially leading to joint activities.
* **Enhancing the visibility of the unit to key external organisations** through web presence at two networking sites (LinkedIn and the TSB-coordinated _connect), and the active participation of the unit's Business Fellow in large trade shows relevant to the research of the unit.
* **Providing further targeted sabbaticals to staff engaged in impact-related activities**.
* **Continuing our strong engagement with university/faculty support facilities** (e.g. the SSG), with opportunities advertised via regular presentations at staff meetings.
* **Building on a new £375k university-wide initiative led by Richard Jones, unit member and PVC Research, and funded through the RCUK Catalyst for Public Engagement with Research programme "Remaking the civic university: creating new cultural standards for public engagement".** The unit will access the resources, experience and skills of the newly established Public Engagement Team to allow academic staff to focus on impact delivery, with an emphasis on moving beyond communication towards integrating collaboration and co-creation of research.
* **Encouraging outreach by inclusion as an element of the unit's Workload Allocation Model.**
* **Monitoring the unit's engagement with external partners.** Ensure that the effectiveness and quality of the unit's KE activities are monitored from an end-user perspective. Using the facilities of the SSG, the unit's Business Fellow will solicit feedback from companies; this feedback will inform the development of the unit's approach to impact.

d. Relationship to case studies

Our four selected impact case studies illustrate the variety of ways in which the unit's policies help translate research into impact. The Ossila and Infinitesima case studies illustrate how the unit and university support interaction with spin-out companies, in the former case in an area – photovoltaics – where we have made strategic investments in impact activities through the Sheffield Solar Farm. The quantum cascade lasers case study demonstrates how impact has arisen from working in close partnership with the private sector, while the public engagement nanotechnology case study demonstrates how our extensive public engagement activities have had a real and significant impact on policy and the quality of public discourse. In the future, we also expect to develop case studies that are based on our rapidly expanding STFC-based KE activity.