

Institution: Swansea University		
Unit of Assessment: 9		
Title of case study: Oriel Science: changing lives through public engagement		
Period when the underpinning research was undertaken: 2007 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
G. Aarts	Professor	2004 – present
C. Allton	Professor and Director of Oriel Science	1995 – present
M. Charlton	Professor	1999 – present
S. Eriksson	Professor	2007 – present
C.A. Isaac	Senior Lecturer	2012 – present
N. Madsen	Professor	2005 – present
C. Nunez	Professor	2005 – present
G. Tasinato	Associate Professor	2014 – present
D.P. van der Werf	Professor	1999 – present
Period when the claimed impact occurred: January 2014 – December 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact <p>Oriel Science has impacted 274,000 members of the public and school students in over 300 events in Wales and beyond. 17,000 visited our Pop-Up Science Centre, 206,000 our other Swansea-based events, and we had 41,000 Eisteddfod and 10,000 CERN visitors. We enhanced the younger generation's educational journeys and under-represented communities' engagement with science. We do this by packaging our University's research into exciting exhibits and visceral interactions and putting these in places people go. Begun in the Physics Department, we expanded to a University-wide public engagement project which showcases our research in the community. Oriel Science ran a Science Centre in the heart of Swansea, large-scale exhibitions in museums and galleries, school and CPD teacher visits to CERN's antimatter experiment and presentations in music and Science Festivals, schools and community events. Covid has delayed the launch of our new 500m² city centre venue.</p>		
2. Underpinning research <p>Our underpinning research spans our Particle Physics & Cosmology Theory (PPCT) and Atomic, Molecular & Quantum Physics (AMQP) groups.</p> <p>The PPCT group including Aarts, Allton (Director of Oriel Science), Nunez and Tasinato is one of the largest in the UK. Our research has considerable breadth. It includes string theory, especially dualities and holographic approaches, the physics of black holes, quantum information theory and applications to condensed matter systems, exemplified in [R1, G1]. We study theoretical cosmology and its interface with particle physics including inflation, dark energy, dark matter and the use of gravitational waves to understand the early and late universe, e.g. [R2, G1]. Our lattice researchers use supercomputer simulations to study strongly interacting matter, especially QCD at nonzero temperature and density, physics beyond the Standard Model and fermionic theories in lower dimensions, such as [R3, G1].</p> <p>The AMQP group (Charlton, Eriksson, Isaac, Madsen, van der Werf) at Swansea University is the leading group in the CERN-based ALPHA collaboration, founded in 2005. We contribute more members to ALPHA than any other institution as well as several key hardware components of the experiment. ALPHA makes antihydrogen using antiprotons from the CERN antiproton decelerator and positrons from a Swansea-built radioactive source. The collaboration is the internationally recognized leader in antihydrogen physics - being the first to e.g. trap antihydrogen, leading to world-wide publicity (2010) [R4, G2], observe an atomic transition in an antiatom (2012) [R5, G2] and measure of the effect of gravity on antihydrogen (2013) [R6, G2].</p> <p>Recognising the public's love of the "wow" factor of science, Oriel Science has taken this enthralling research in particle physics, black holes, cosmology and antimatter and built a significant public engagement programme.</p>		

3. References to the research

All papers have been peer-reviewed. All 6 papers have been published in Q1 journals (JCR 2019). Papers have received funding from external sources such as EPSRC, National Science Foundation, The Royal Society, STFC, Leverhulme Trust and the US Dept of Energy. **[R4]** was listed by the US Dept of Energy in 2017 as one of the top 40 papers from the previous 40 years.

[R1]. Caceres, E., **Nunez, C.**, Pando-Zayas, L.A. (2011) Heating up the baryonic branch: a unified picture of conifold black holes. Journal of High Energy Physics 1103:054, [https://doi.org/10.1007/JHEP03\(2011\)054](https://doi.org/10.1007/JHEP03(2011)054)

[R2]. Bartolo, N., Caprini, C., Domcke, V., **Tasinato, G.** et al. (2016) Science with the space-based interferometer LISA. IV: Probing inflation with gravitational waves. Journal of Cosmology and Astroparticle Physics 12:026, <https://doi.org/10.1088/1475-7516/2016/12/026>

[R3]. **Aarts, G., Allton, C.**, Kim, C., Lombardo, M.P. et al. (2011) What happens to the Υ and η_b in the quark-gluon plasma? Bottomonium spectral functions from lattice QCD. Journal of High Energy Physics 11:103. [https://doi.org/10.1007/JHEP11\(2011\)103](https://doi.org/10.1007/JHEP11(2011)103)

[R4]. ALPHA collaboration (including **Madsen, N., Charlton, M., van der Werf, D.P., Eriksson, S.**) (2010) Trapped antihydrogen. Nature 468: 673-676. <https://doi.org/10.1038/nature09610>

[R5]. ALPHA collaboration (including **Madsen, N., Charlton, M., van der Werf, D.P., Eriksson, S., Isaac, A.**) (2012) Resonant quantum transitions in trapped antihydrogen atoms. Nature **483**: 439–443. <https://doi.org/10.1038/nature10942>

[R6]. ALPHA collaboration (including **Madsen, N., Charlton, M., van der Werf, D.P., Eriksson, S., Isaac, A.**), Charman, A.E. (2013) Description and first application of a new technique to measure the gravitational mass of antihydrogen. Nature Communications 4:1785, <https://doi.org/10.1038/ncomms2787>

Representative Grants

[G1]. Shore, G (PI), **Aarts, G., Allton, C., Nunez C.**, et al (Col) [10.08 – 09.11] Quantum Field Theory: new ideas in strings, lattice and LHC physics. STFC, ST/G000506/1, GBP2,409,466

[G2]. **Charlton, M** (PI), Telle, H (Col) [02.06 – 01.10] Trapped Antihydrogen - Towards Spectroscopy. EPSRC, EP/D038707/1, GBP787,314

4. Details of the impact

Oriel Science (www.orielscience.co.uk) is an innovative and unique public engagement and outreach project which showcases our University's research in the community. Our impact is significant - from 2016 to December 2020, Oriel Science reached **274,000** (see Table 1) people in over **300 free events** primarily in Wales, but also in England, Europe and Indonesia. We delivered societal impact by:

(1) **enhancing the Future Generations' educational and career journeys**, and

(2) **targeting under-represented groups by enriching their engagement with science.**

We do this by taking Swansea University's amazing research, packaging it into inspiring and interactive exhibits, and putting these in places people go. "Oriel" is Welsh for "gallery".

Importantly, our approach is based on the Archer et al. "**Science Capital**" concept which measures people's familiarity and connectivity with science. This "ASPIRES" longitudinal study of 19,000 young people famously proved **that educational choices in the under-represented are enriched by building Science Capital.**

Oriel Science was founded by Swansea physics academics in 2016. Our project is led by three physicists: Allton, a particle physicist, Bryan, a laser physicist and Roberts, an astronomer. Since 2016 our project has **employed 50 demonstrator-ambassadors** and five administrative staff members. As Oriel Science grew, we enlisted academics from across Swansea University, establishing a significant, pan-University engagement operation with broad appeal which has showcased work from around **100 research groups**. At least 31 Swansea University research grant applications have included Oriel Science as a vehicle for impact via public engagement, bringing GBP10,500,000 funding to Swansea **[C1]**. Oriel Science provides a platform for public engagement and elevates our Swansea colleagues' public engagement skillset. Oriel Science has been **awarded GBP368,000 from 15 competitive public engagement grants**: 3 from Welsh Government, 5 STFC (the largest being a GBP119,000 Leadership Fellow in Public Engagement

[C2]), 2 EPSRC, 1 UKRI, 1 Prince's Trust and 2 from other charities. Oriel Science has a large media footprint with 96 media engagements since 2016 appearing on TV, radio and a newspaper front page [C1].

A. Establishing our Impact Model - Our Pop-up Science Centre

Our first project was a 400m² Pop-Up Science Centre in the heart of Swansea launched in September 2016 at 34 Princess Way. Amongst its 20 exhibits was the STFC Large Hadron Collider mock-up [R3], a "Back-to-the-Future" DeLorean sports car (the theme was "Time"!), a cloud chamber and other particle detectors, an animation of the history of the Universe since the Big Bang, and many non-physics interactive displays [R2].



Inside the Pop-Up: DeLorean & LHC mock-up

Impact 1 Future Generations: Our Pop-Up welcomed **15,924 public visitors over 100 days**, 34% of whom were children [C1]. Our venue's location and longevity encouraged repeat visits, crucial to building Science Capital. **83%** of children (N=280) and **93%** of adults (N=464) said they'd learnt more about Science from their visit. The word "interesting" was used by **57%** of children to describe their Oriel Science experience (N=570) [C1].

We also ran school visits for **892 students** from **18 schools** with **96%** of the **25** teachers surveyed saying our exhibit-focussed workshops were "*relevant to the curriculum*". In these school visits, 74% of primary students (N=592) and **100% of secondary students** (N=55) said they "learnt more about Science" from their visit [C1].

Impact 2 Under-representations: The venue was deliberately placed in the city centre adjacent to areas of social deprivation. Incredibly, a full **6,000** visitors (38%) said their **first ever University experience** was Oriel Science, objectively proving our impact on under-represented communities. A postcode analysis proved our **visitors were fully representative** of the Swansea population (N=197). **The percentage of Oriel Science visitors matched the Swansea region, in each of the Welsh Index of Multiple Deprivation 20% bins [C1]:**

	← Most deprived		Least Deprived →	
Oriel Science Visitors	28%	16%	16%	12%
Swansea population	26%	13%	17%	12%

These hugely significant results greatly contrast with visitor demographics to UK museums (e.g. the 2014/5 UK Department for Digital, Culture, Media and Sport 'Taking part' survey found that visit rates from the 20% most deprived were 48% lower than the 20% least deprived).

Amongst our visitors were A-level students who became **UCAS science degree applicants**, including to Swansea University [C2]. One visitor said her Oriel Science experience "*helped her choose a science career*" leading to a 1st class Biology degree from Oxford – and becoming the **first in her family to attend University** [C3]. A visitor commented

"A wonderful place to teach children about science, and very hands on" [C2]

The Leader of Swansea Council has noted:

"Swansea Council is delighted with the impact that Oriel Science has had in the community, particularly in bringing footfall into the city centre." [C4]

We tested our approach by running **10 separate surveys of 827 people**, including members of the public, students, social media users, students and parents/carers. **90%** indicated that they wanted Oriel Science to establish a permanent Science Centre. Four "Focus Groups" in 2020 with **50** contributors drawn from the public praised the design features we implemented in our Pop-Up [C1]. All of this evidenced our Pop-Up's impact.

We used our Pop-Up's success to establish a new long-term 500m² venue, 21-22 Castle St, Swansea. The planned launch was March 2020, but this was Covid-delayed. We were ready to open in December 2020, but Welsh regulations still forbid us opening as of February 2021.

17,000	Pop-Up (2016-7)
77,000	Swansea Museum (2019)
37,000	Glynn Vivian Art Gallery (2019-20)
99,000	Waterfront Museum (2014-20)
30,000	Other events inc. schools (2016-20)
41,000	Urdd Eisteddfod (2017,18,19)
10,000	CERN (2014-20)
274,000	TOTAL

Table 1: Numbers of People Engaged

B. Building on our Impact Success

Since the Pop-Up, we have engaged with **257,000** people at over **300** events, see Table. These have

included co-curated major exhibitions in the Swansea Museum and Glynn Vivian Art Gallery, exhibits in student careers fairs, community events and the London Science Museum, school and public tours of CERN's antimatter experiment, talks in targeted schools, and presentations in the Green Man Festival and the British, Cardiff, Merthyr and Swansea Science Festivals [C1].



New Oriel Science venue, Swansea

Impact 1 Future Generations: Oriel Science has a significant schools' outreach programme reaching **200 schools across South Wales** from years 3 to 13 (2016-2020), **130 schools in CERN visits** (2014-2020), and a further 5 schools in Borneo (2018). **10,000** young visitors interacted with our antimatter exhibit in the Welsh language in the 2017 Urdd Eisteddfod, one of Europe's largest Youth Festivals, with a further **18,000** in 2018 and **13,000** in 2019 [C1].

We used an indicative talk to 30 A-level students from Gower College Swansea (19/11/19) to measure the impact of our schools' programme. Before the talk, **52%** were likely to **apply for a Physics degree** increasing to **68%** afterwards. Using before and after questionnaires, students' understanding of the Large Hadron Collider increased by **39%** [C1].

School visits to the CERN antimatter experiment were led by Swansea physicists responsible for the underpinning research, with before/after surveys showing a doubling of students' knowledge of antihydrogen [C1].

"Such visits are very important in their career choice" - Finnish school co-ordinator. [C1]

We run annual Particle Physics Masterclasses which are spread over two days due to school demand. These typically have **200** attendees, but in our 2020 online event, this increased to **366** students from **98 schools** [C1]. The Head of Science, Bryn Tawe School, Swansea said:

"The workshops and lectures help enthuse our pupils and contribute in no small way to the numbers wishing to take Physics further." [C5]

We also deliver annual high school "Physics Christmas Lectures" to around **500 students** each year, with speakers including the former Project Lead of CERN's Large Hadron Collider. In a 2018 survey (N=169), the before/after percentage of students who correctly stated that the Higgs boson is responsible for the mass of fundamental particles **grew from 45% to 83%**.

Impact 2 Under-representations: Oriel Science targets schools from under-represented communities. For example, in a 2018 school visit programme designed around particle physics demonstrations, **7 of the 16** schools visited were in the 20% most deprived areas of Wales [C1].

We sought out other under-served communities – a 2019 talk on the Physics of gravity, relativity and GPS was delivered to **20 Swansea Prison inmates** [C1].

C. Reaching the public in National Waterfront Museum events

We have partnered with Swansea's National Waterfront Museum in March 2018, 2019 and 2020 to run our one-day Super Science Swansea Festival. These are timed to coincide with British Science Week. Footfalls for each year were **1987**, **3588** and **3232** respectively, amongst the largest daily footfalls in the museum's history [C1]. These events showcased our research with exhibits such as *"Would I die if I fell into a black hole?"* [R1]. In addition, our CERN antimatter simulator [R4-R6] was a very well-received part of the *Innovation Exhibition* (12/10/19 – 18/03/20)

and had a footfall of **90,000** [C6]. Finally, the Waterfront hosts our monthly “Oriel Science Café” public lectures which have engaged with **2,440** people (2014-2020) [C1].

“Oriel Science has been a wonderful partner for the Waterfront, enabling us to reach and engage with new audiences.” – Head, National Waterfront Museum [C6]

Impact 1 Future Generations: 70% of our annual Science Festivals’ visitors were in family groups and **29% were under 16** (2018, N=82). The impact of these festivals with interactive exhibits is clear. For example, the “Love a Maggot” demonstration in the 2019 Festival explained the use of maggots in wound healing. Surveys showed **46%** of children would agree to having this therapy before their engagement with this activity, rising to **90%** after (N=180).

“It’s the best science day in the world” – child, aged 6 [C1]

“My oldest two have thoroughly enjoyed all the science they have discovered” – parent [C1]

Impact 2 Under-representations: A postcode analysis of our 2020 event showed that 18% of visitors came from the most deprived 20% of Wales (N=35) greatly reducing the demographic underreach that traditional museums suffer from. Participants’ awareness of Swansea University research **increased by 87%** (N=84, 2018), **61%** (N=113, 2019) and **77%** (N=91, 2020). A survey one month after the 2019 event proved this impact survived with **75%** confirming that their awareness of our research had increased (N=16). We use these Festivals to celebrate International Women’s Day and partner with Women’s Equality Network who arrange a number of female scientists to give inspirational talks. Our Festivals were very well received, e.g., in 2018, **94%** said they would come again [C1].

D. Welsh Teacher CPD – the significance of education provision

Impact 1 Future Generations: Alarming, only 44% of Welsh A-level physics teachers have a physics degree. As Director of Oriol Science, Allton worked with the Welsh Government, the STEM Learning Centre and the former Project Lead of CERN’s Large Hadron Collider to address this poor Physics provision in schools. A **CPD programme** was devised, based around a **week-long visit by teachers to CERN**, with pre- and post-visit workshops in the Swansea Physics Department. This CPD is designed to enhance the confidence of non-specialist Physics teachers, so they go on to inspire their students, raising their Science Capital.

“This course was excellent providing me with examples to illustrate my lessons to show how physics is at the cutting edge of modern science.” – teacher, Cardiff [C7]

48 teachers took part in this programme from 2016 to 2017, and some were inspired to take their own students to visit CERN [C7]. An estimated **1,000 students** are taught by these teachers annually. The benefit of this CPD was highlighted by the Welsh Education Minister:

“Opportunities like this are vital if our teaching workforce is to better understand and communicate the application of real-world science and technology... The feedback we have received from last year’s group is that the knowledge and experience gained from this trip has made the teaching of physics much more enjoyable and meaningful for the students.” [C8]

5. Sources to corroborate the impact (indicative maximum of 10 references)

- [C1]. Details available from the Oriol Science database upon request
- [C2]. STFC Leadership Fellowship in Public Engagement “Public Engagement in Oriol Science” PI: **Allton, C.**, ST/R001227/1 [01.2018-12.2021], GBP119,277
- [C3]. Email testimonial, Oriol Science Visitor and University Graduate, available on request
- [C4]. Email testimonial, Leader of Swansea Council, available on request
- [C5]. Email testimonial, Head of Science, Bryn Tawe School, available on request
- [C6]. Correspondence from the National Waterfront Museum, available upon request
- [C7]. Excerpts from CPD feedback forms and videos, available on request
- [C8]. Welsh Government Press Releases, 2016 & 2017 <https://gov.wales/and-atom-welsh-teachers-wanted-cern-mission> <https://gov.wales/welsh-teachers-return-cern-teach-what-matters>