Mid-Range Facility Annual Report and Assessment Criteria

Context:

EPSRC defines a mid-range facility as a research facility which provides resources that are of limited availability to UK researchers for one of several reasons including:

- The relative cost of the kit
- Dedicated kit in every University is not needed
- Particular expertise is needed to operate the kit or interpret the results or
- Progress is enhanced by sharing information or software.

EPSRC support a range of mid-range facilities across the portfolio, usually on a 5 year contract. Since 2014, EPSRC offers research communities a yearly opportunity to submit a Statement of Need for a new mid-range facility. These Statements of Need are peer-reviewed and then ranked by an expert panel with in-depth knowledge of EPSRC's strategic drivers and EPSRC's funding routes for facilities and equipment.

During the 5 year contract period, EPSRC wishes to support the facilities in their endeavour to provide an optimal service to their users. For this reason, the Capital Equipment Strategic Advisory Team (Capital Equipment SAT) will assess the performance of all existing mid-range facilities on a yearly basis. A common template is provided to the facilities in order to facilitate this assessment. In addition, the EPSRC contact will provide a short summary of their own impression of the facility's performance.

The assessment is fed back to the facilities to enable them, together with their steering committee and EPSRC contact, to ensure the best possible service is provided to the user community and to position themselves for the next tender exercise. The prioritisation panel for new/to-renew Mid-range Facilities will have sight of an overall summary of the annual report assessments in order to give a context of the current ecosystem.

Only Mid-range Facilities that are not currently undergoing a renewal exercise are requested to submit a report.

Timeline 2014:

- Deadline for Annual Reports**: 22nd October 2015**
- Assessment by the Capital Equipment SAT**:**
- Summary provided to the Prioritisation Panel for new / to be renewed Mid-range Facilities: **January 2015**

Annual Report for EPSRC Mid-Range Facilities

Facility: XMAS Beamline at the ESRF

Address: XMaS (BM28) ESRF - The European Synchrotron, CS 40220, 38043 Grenoble Cedex 9 France

Directors: Prof. Chris Lucas (University of Liverpool) and Dr. Tom Hase (University of Warwick)

Facility Manager:_____

Description of the Facility (max. 1/2 page): Please give a brief description of the facility and its main objectives for a non-specialist audience.

The XMaS mid-range facility is a synchrotron x-ray beamline embedded in the heart of the European Photon and Neutron (EPN) Science Campus in Grenoble, France and is managed by the Universities of Liverpool and Warwick. The beamline is part of the European Synchrotron Radiation Facility (ESRF) which forms part of the EPN along with the other European institutes including the European Molecular Biology Laboratory (EMBL) and the Institute Laué-Langevin (ILL) neutron source. The original beamline was conceived primarily as a tool to study magnetic materials, hence the acronym **X**-ray **Ma**gnetic **S**cattering (XMaS). The beamline has been supporting users since 1997 but has a far broader remit than magnetic scattering and supports active research groups in over 20 UK universities (representing approximately 100 independent researchers) and covers research in materials science, physics, chemistry, soft condensed matter and biomaterials. The facility is an enabling tool serving the materials science community (including academic researchers, national research laboratories and industry). It plays a major role in underpinning interdisciplinary projects and contributes directly to societal challenges such as energy storage and recovery, the digital economy and advances in healthcare technologies as well as contributing to the UK research infrastructure.

The objectives of the facility are to provide access to the UK materials science community to a state-of-the-art x-ray facility (machine and experimental equipment) and to provide training for early career scientists as well as postgraduate and undergraduate students in advanced scientific methodologies, all embedded in a vibrant international environment.

Key Performance Indicators KPI (max. 2 pages): Please provide evidence of the facility's performance with regard to the KPIs identified in the contract over the last 12 months. For any targets that were not met, please provide an explanation and describe the steps taken to mitigate negative impact on users and measures taken to improve performance.

The following KPIs describe the activities on the facility covering the period 1st October 2014 through to 30th September 2015 [Quarters 9 through 12].

All targets set by the mid-range facility contract have been exceeded. A list of current quarter KPIs as well as full historical data is maintained on our web-page.

The number of Individual Researchers and University Research Groups visits.
There have been 114 individual researcher visits from a cumulative total of 52 UK and 11 International research groups in the reporting period and funded through the mid-range facility route. An additional 44 researcher visits from 6 UK and 15 international groups have accessed the facility through the ESRF public access route.

Over the lifetime of the mid-range facility, we have seen a total of 439 individual researcher visits from 149 UK research groups and 69 international research groups.

Uptime of the beamline in the previous 12 months
The percentage of uptime the beamline experienced in this reporting period was 97%, well above the 80% contractual target and an improvement on the historical average of 95.2% - our benchmark metric that we use internally. The uptime maintained through the current reporting cycle is also an improvement on the more recent 96.7% average achieved since the current mid-range facility funding began in 2012. However, an uptime of only 92.6% was reported for the fourth quarter of the operating year. This dip in performance was caused by some interface issues between our hardware and the new version of the ESRF control software which was updated during a shutdown. Unfortunately our beta testing did not find all the bugs and in 1 out of the 10 scheduled experiments we experienced some unavoidable problems. We are currently working closely with the ESRF controls group to iron out any remaining hardware/software issues, and expect to return to high performance levels for the next operational schedule.

Dips in performance levels experienced by the facility are a combination of facility instrumentation failures, user sample problems and external causes, such as failures in the synchrotron storage ring over which we have no control. The external factors contribute approximately 50% of the total down-time with the remaining 50% a combination of facility instrument failures and/or user sample failures. Onsite instrument failures typically result in a short down-time of an hour or so during which time we replace and/or repair the faulty component.

Number of user complaints: XMaS has received zero complaints in the last 12 months.

The Number of research outputs: There have been 23 published papers in 2014 and currently 17 for 2015. In addition there are a large number of conference and seminar presentations given by our staff and users. Figure 1 shows the annual and cumulative output of peer reviewed papers from the facility. We rely on users informing us of publications and make every effort to capture this important metric. Our publication record is comparable to, or even exceeds that, of similar beamlines at both the ESRF and DIAMOND. The research output of XMaS is rated highly by the ESRF management with highlights appearing often in their outputs. The director of research, Harald Reichert, states:

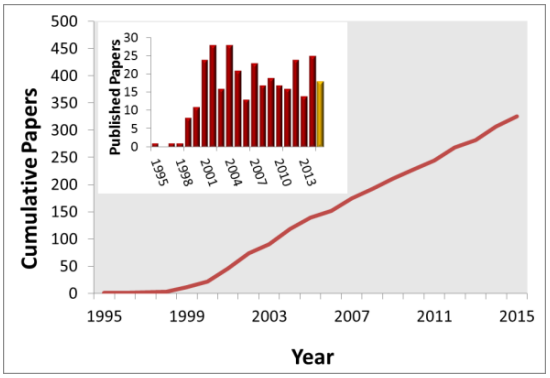


Figure 1: Cumulative outputs of peer reviewed publications. Inset, annual output.

"It is my pleasure to confirm that the UK CRG beamline BM28 (XMaS) contributes substantially, and on a competitive basis to the scientific output of the ESRF when compared to ESRF's public beamlines and to other CRGs doing similar work. The ESRF Management looks forward to your beamline's continued contribution in the future."

Comparison with past performance: The KPIs reported above are in line with previous reporting periods (Figure 2):

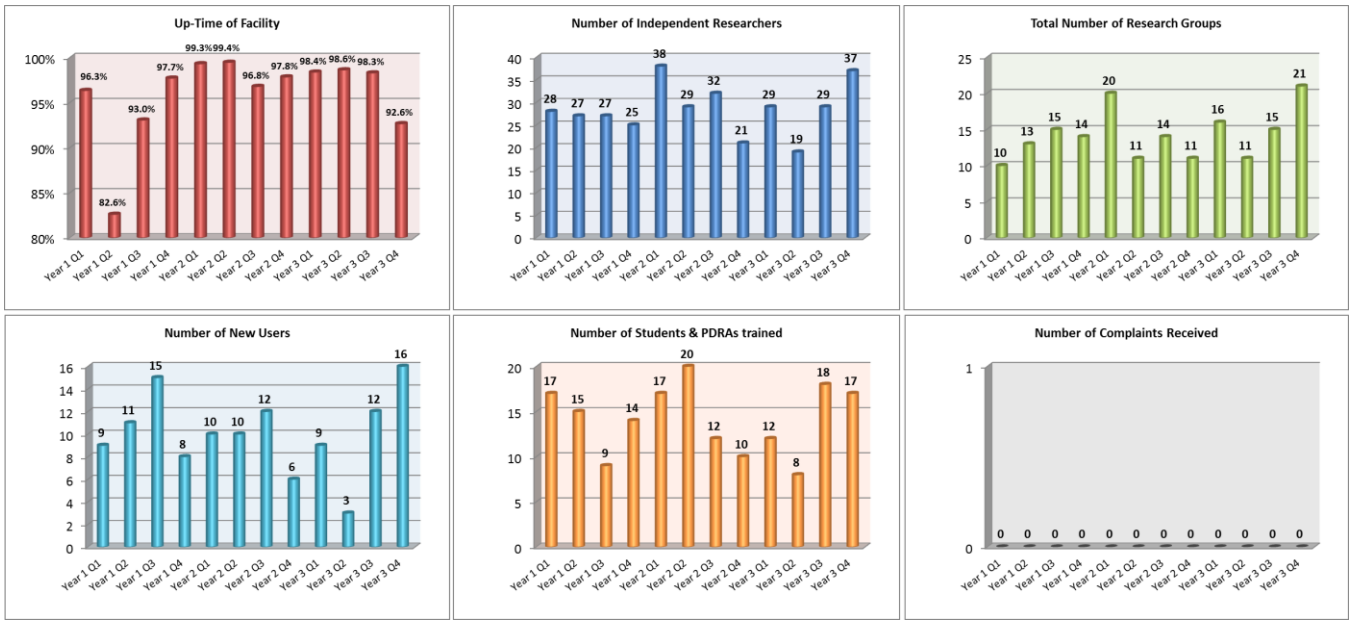


Figure 2: KPIs as a function of facility time displayed by operational quarter

Access Requests

Although not a designated KPI, the demand for the facility can be gleaned from our application data which, for the lifetime of XMaS as a mid-range facility, is shown in Figure 3:

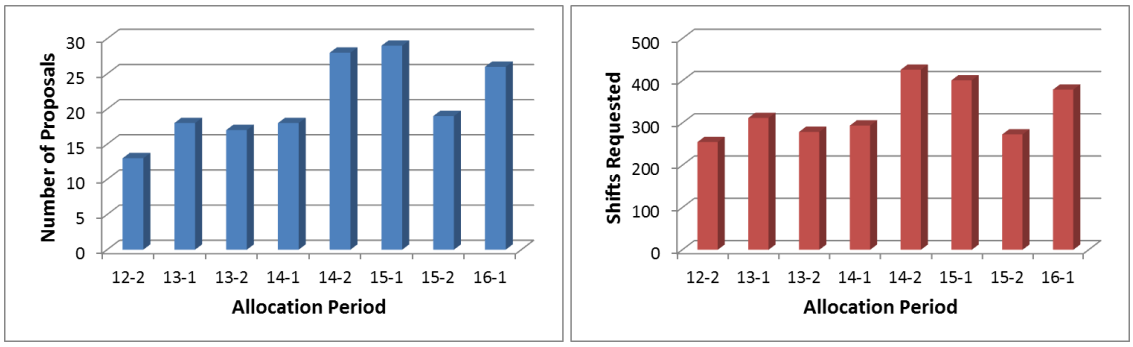


Figure 3: User access requested for the facility in terms of proposals (left) and shifts (right).

In the last reporting period we have achieved the highest ever number of user requests for beamtime (since the beamline began user operation in 1997). This can be attributed to some of our communication/outreach activities that have attracted new user communities. The increases seen during the last reporting cycle dipped a little in the first proposal round (15-2) as new users processed their data. However, in the last proposal round (proposal rounds occur on a 6 month cycle) we again saw over 25 proposals and the facility remains oversubscribed by a factor of ~2:1 when commissioning and development time is taken into account. Over the same reporting period the beamline also received a total of 32 proposals for the ~8 experiments allocated to the ESRF through the public access route (this allocation is part of the contract with the ESRF). This record number corresponds to an oversubscription rate of ~4:1, with the quality of science being ranked very highly at the ESRF peer review panels which consider applications for beamtime from a world-wide user community applying for beamtime at both the XMaS facility and other ESRF public beamlines.

Users (max. 1 page): Please provide data on the number of users of the facility over the last 12 months. Indicate the number of new users, academic vs. non-academic users, third party collaborations, and students using the facility. You may wish to provide data on user satisfaction and evidence of actions taken to promote the facility among new user communities, including non-academic users and business collaborations.

Our user statistics are derived from the data generated by the ESRF access protocols and by independent user feedback provided at the end of each experimental session. As part of the contract with the ESRF we provide 30% of the available uptime for public access. The KPI data returned below pertains to the 70% mid-range facility time only, the numbers for the remaining time are shown in parenthesis where appropriate.

Summary of Key Data covering the last 12 months

Number of user visits: **114 (44);** Number of new users: **40 (20);** Number of student visits: **43 (20);** Number of PDRA visits: **12 (7).** Number of complaints received: **0**, Number of peer reviewed Publications in reporting period: **17**.

Third Party Activities

XMaS is part of the EMRP funded *Nanostrain* Project. This collaboration, led by the National Physical Laboratory (NPL), brings together EU metrology labs along with industrial partners including IBM (New York) to explore new strain mediated transistor devices to replace current CMOS technology and overcome the current energy crisis in Si-based devices. This activity continues to be highlighted in several trade magazines and online resources. Our users often work with third parties such as British Petroleum and to improve our engagement with such groups, we are now asking our users to give specific details in their end of run surveys and these data will be collated in the next report. Following a direct request from an industrial user, we are exploring routes to deliver proprietary activities on the beamline, but recognise that contractual requirements mean that this needs to be conducted through official channels at the ESRF.

User feedback

End of run surveys returned by our users provide additional information about performance. These metrics, which are summarised in Figure 4 for the current reporting period, are scored out of 5 with 5 being the highest score. The data in this review period are consistent with the facility average, calculated on data obtained since 2012.

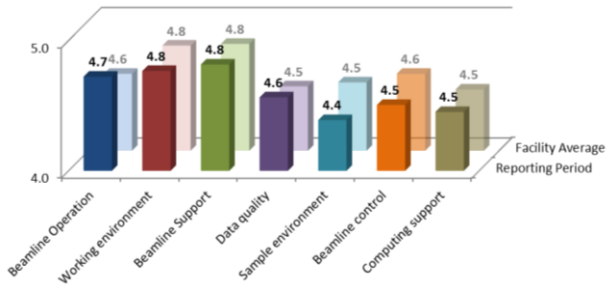


Figure 4: User feedback on facility operations covering the reporting period

Actions taken to develop the User community:

As well as hosting an annual user meeting, producing an annual newsletter and having a presence on the web and social media (@XMaSBeam) we have also sponsored some specific meetings in the UK to promote our activities and build new collaborations:

19th and 20th March - Sponsored event – **UK India workshop on Magnetism at University of Durham sponsored by UKIERI**. *Meeting to highlight how XMaS could support a topical new user community of young rising stars in magnetism from across the UK with the added benefit of including key Indian researchers and Institutes.*

3rd June - **User Meeting**: *Opportunity to see how XMaS operates as a mid-range facility and interact with the on-site team. Summary of new technical developments were presented and discussions of how the beamline can help users and their science were conducted.*

12th and 13th May - **Developing Synchrotron Sample Environments to Study Next-generation Field-driven Device Physics**. *Organized a satellite meeting at the Advance Photon Source User Meeting at Argonne National Lab to facilitate in the sharing of best practice and to build an international user base building on the success of the ERMP Nanostrain project. (Leading to >3 US groups applying for beamtime).*

We also encourage exploratory studies from new user communities to be instigated through in-house research programs and are open to designing, building and commissioning new sample environments to facilitate new opportunities for the wider community. We present out capabilities at focused meetings, such as at DIAMOND and other SR facilities, where we engage with the wider SR community.

Scientific excellence (max. 2 pages): Please provide examples on how the facility supports scientific excellence in the UK. This should be a short narrative, including important scientific breakthroughs, case studies and related articles in scientific journals and publications for a broader audience. You may include links where appropriate.

The XMaS facility provides access to synchrotron radiation (SR) to tackle many current and topical material science challenges faced by the UK research community. As materials and their intrinsic properties underpin most of the recent technological advances, a fundamental understanding of their structure is essential if the UK is to remain at the forefront of scientific excellence. A small subset of the interdisciplinary problems tackled over the last year include:

The **Energy problem:** This can only be solved through continuing materials development and understanding of fundamental processes. In the field of photovoltaics the incorporation of noble metal nanoparticles in the active area of donor-acceptor bulk organic heterojunctions is an industrially compatible light trapping strategy which gives better absorption of the incident photons and an efficiency improvement of ~20%. X-ray synchrotron grazing incidence X-ray diffraction has been used to investigate the effect that Au and Ag nanoparticles have on the crystallisation of the commercially important P3HT: PCBM blend (*Sci. Rep. 5, 10633 (2015)*). We continue to build a new academic and industrial (Johnson Matthey) user community interested in the chemistry of catalysis (*J. Am. Chem. Soc. 137, 4151–4157 (2015), Catalysis Today 229, 95-103 (2014)*) exploiting our recently developed *in-situ* EXAFS and XAS capabilities down to low energies and particularly the Ru, Pd, S and Cl K edges (*J. Synchrotron Rad. 22 (2015)*).

Fundamental studies of magnetic materials remain a key research area of the beamline with a range of experiments performed last year exploiting the high magnetic fields and energy ranges which are unique to the facility. Fundamental studies on the magnetic order in PrPtAl provided the first clear experimental observation of 'order by disorder' (*Nature Physics, 11, 321–327 (2015)*). Similarly, users have observed directly charge density waves in the high temperature superconductor YBCO whose presence had previously been a topical debate in the literature (*Nature Communications, accepted for publication (2015)*).

New **functional materials** underpin a plethora of emerging technologies ranging from mobile-phones to computer displays are now being developed and studies of these important materials were carried out on the facility along with continuing developments in sample environments used to measure them under routine operating conditions (temperature, humidity applied fields etc.). New organic photovoltaics as well as small angle scattering from the next generation of road paints are some examples. At the ESRF we are also one of only a few beamlines capable of performing white beam diffraction and, in a test experiment, the cuticles from a lobster tail were measured to determine the local texture. Safeguarding our **environment** and **archaeological preservation** of heritage artefacts are important and have direct and lasting socio-economic benefits to the UK as a whole. Experiments performed to understand corrosion mechanisms in the last year included studies on a range of heritage artefacts (*Talanta 132, 760-768 (2015), Heritage Science 3, 14 (2015), Corros. Sci. 91, 220-223 (2015)*) as well as investigating the effect of enhanced corrosion of spent nuclear fuel rods by water (*Faraday Discuss., 180, 301-311 (2015)*).

In the area of **healthcare** XMaS continues to support dental studies (*Mater. Today 17, 7, 312–313 (2014)*) and has recently been used to study a model system mimicking how nanoparticles enter cells and their subsequent impact on human anatomy (*Adv. Colloid. Interfac. 218, 48–68 (2015)*). The beamline has also been used to study new photonic materials that are to be used in the next generation of medical imaging detectors (*Nature Photonics, accepted for publication (2015)*).

From the above examples, it is clear that the XMaS facility is truly interdisciplinary with outputs impacting across a wide range of scientific disciplines. The research performed by our users is frequently singled out in the ESRF's Highlight/Spotlight publications, with no fewer than 3 XMaS highlights selected for the 2015 ESRF newsletter – more than any other similarly funded beamline at the ESRF. The work described above, as well as additional highlights from recent experiments, are currently being edited for our 2015 newsletter (available Feb. 2016). This annual newsletter is disseminated widely (>800 copies) and is sent to all UK physics departments and most UK chemistry departments. In addition we also send copies to many international facilities and all of our previous users. Here we include a summary of a subset of the content of the current 2014 newsletter:

- Dynamic in-situ electrical and interferometry measurement capability with high resolution x-ray diffraction synchronisation (Vecchini *et al. Rev. Sci. Instrum. 86, 103901 (2015)*): *The paper reports on the sample environment and control developments to enable simultaneous measurements of electrical polarisation, macroscopic displacements and*

crystalline lattice distortions in materials at frequencies up to 1 kHz. The work underpins a major output of the Nanostrain project.

- Measuring the Dzyaloshinskii-Moriya interaction in a weak ferromagnet (Dmitrienko *et al.* *Nat. Phys. 10, 202 (2014)*): *A report on using the interference between magnetic and charge scattering to determine the* sign *of the DM interaction which plays an important role in many magnetic systems.*
- Proximity induced magnetism in Pt/Co/Pt trilayers with heavy metal insertion layers (Rowan-Robinson *et al.*): *A resonant magnetic x-ray reflectivity scattering study looking at the magnitude and extent of induced magnetisation within Pt layers with and without a gold delta layer at the interface.*
- Sweet Corrosion Scaling (Joshi *et al.* *NACE Corrosion 2015*): *A report on the development on an in-situ electrochemical cell for temperature dependent grazing incidence x-ray diffraction characterization of corrosion in a model sweet oilfield environment showing the formation and temporal evolution of a multicomponent corrosion scale.*
- How molecules infiltrate ordered purple membrane films: An XRR study (Kaus *et al.* *J. Mater. Chem. C 2, 5447-5452 (2014)*): *A description of a surface X-ray scattering study probing the intercalation of aminopropyl silicic acid (APS) or aminopropyl-functionalised magnesium phyllosilicate (AMP) molecular clusters into purple membrane films.*
- Skeletal Cubic, Lamellar and Ribbon phases of Bundled Thermotropic Bolapolyphiles (Liu *et al.* *J. Am. Chem. Soc. 136, 6846-6849 (2014)*): *A paper describing the thermotropic liquid crystalline (LC) phases a series of T-shaped polyphilic molecules were investigated by grazing incidence x-ray diffraction.*
- Super-spreading fluids investigated by GISAXS (Martin *et al.*): *A scattering study on the "pearling effect" and the dynamic wetting behaviour of super-spreader and non super-spreader solutions on different polymer surfaces.*
- Crystal structure of conjugated polymers: a combined scattering and atomistic simulation approach (Guilbert *et al.* *Chem. Mater. 26, 1226-1233 (2014)*): *A description of a surface X-ray scattering study probing the intercalation of aminopropyl silicic acid (APS) or aminopropyl-functionalised magnesium phyllosilicate (AMP) molecular clusters into purple membrane films.*
- Structural evolution of photo-polymerised dimethacrylate resin systems (Martin *et al.*): *A grazing incidence small angle scattering study to explore the time dependant structural evolution of possible dental restorative materials.*
- Silver corrosion in real time (Wiesinger *et al.* *J. Anal. At. Spectrom. 30, 694-701 (2015)*): *An in-situ study of the corrosion of silver surfaces to anthropogenic gases in controlled relative humidity that mimic atmospheric conditions found in city centres.*

A full and up-to-date publication list is maintained on our web-page. Work at the facility has produced 23 published peer reviewed papers in 2014 and currently 17 (and counting) in 2015:

Thompson PBJ, et al. J. Synchrotron Rad. 22 (2015)
Vecchini C, *et al.* Rev. Sci. Instrum. 86, 103901 (2015)
Abdul-Jabbar G, *et al.* Nat. Phys. 11, 321–327 (2015)
Beddoes C, *et al.* Adv. Colloid. Interfac. 218, 48–68 (2015)
De Keersmaecker M, *et al.* Talanta 132, 760-768 (2015)
Dowsett M, *et al.* Heritage Science 3:14 (2015)
Elia A, *et al.* Appl. Phys. A-Mater 118(2), 449-455 (2015)
Grayburn R A, *et al.* Corros. Sci. 91, 220-223 (2015)
Wiesinger R, *et al.* J. Anal. At. Spectrom. 30, 694-701 (2015)
Gründer Y, *et al.* Surf. Sci. 631, 123-129 (2015)
Hase T P A, *et al.* Mater. Today 18, 7, 356–357
Joshi G R, *et al.* NACE Corrosion 2015,
Lilliu S, *et al.* Sci. Rep. 5, 10633 (2015)
McMitchell SRC, APL Mat. 3, 062301 (2015)
Sabbe P-J, *et al.* Appl. Surf. Sci. 332, 657–664 (2015)
Sherborne G, *et al.* J. Am. Chem. Soc. 137, 4151–4157 (2015)
Springell R. *et al.* Faraday Discuss., 180, 301-311 (2015)

Publications for a broader audience

A range of publications for a broader audience that are associated with XMaS have been published this year:

UCL web site - *London dental schools collaborate on novel imaging techniques at XMaS,* Maisoon Al-Jawad

XMaS Scientist Experience: Changing Perceptions about Careers through Interactions with Scientists at a Central Facility: Poster presentation at European Physical Society Conference on High Energy Physics as well as published articles in American Physical Society, Gazette 34 (2), 10 (2015), Proceedings of Science (EPS-HEP 2015) 355 and Mater. Today 18, 7, 356–357 (2015)

Nanostrain: New Scientist Article, Feb 2015 Need for speed: Why computers stopped getting faster

We are currently compiling a series of ~10 case studies for a general audience. These will be released with a press release in early 2016 and draw on scientific highlights achieved since 2012.

Impact (max. 1 page): Please provide evidence of the broader impact that the facility has on the research landscape in the UK. This can relate to training skilled people, work, collaborations and facility activities which have led/will potentially lead to benefits outside the core user community, including societal and economic impact as well as promoting Engineering and Physical Sciences to the wider public.

The XMaS project provides opportunities that underpin the UK material science community through novel research infrastructure. It delivers economic and commercial impacts (as highlighted in a recent ESRF news article and our 9 commercial licences), stimulates public discourse on science, transfers knowledge to a broad range of society, facilitates new experimental techniques, and provides training to UK and international stake holders. The facility supports the challenge themes of Energy, digital economy, healthcare technologies and environmental change. It provides diverse and wide-ranging training opportunities for students, PDRAs and senior researchers. Over the last year we have trained a total of 60 new users as well as supported 81 student/PDRA visits, ensuring that we train and inspire the next generation of material scientists with expertise in advanced synchrotron radiation techniques. The facility provides the UK science base with direct access to the EPN campus, placing EPSRC-funded science at the forefront of European research. Access to EPN support facilities (including the Partnership for Soft Condensed Matter) is guaranteed through our ESRF contribution and comes with no additional cost. Technological and scientific advances developed on the EPN campus can be rapidly transferred and implemented on XMaS prior to full commercial distribution. As the EPN institutes attract world-leading scientists, the facility is well placed to facilitate and foster strong international collaborations, greatly enhancing the research, impact and training quality for the UK community. The dissemination and visibility of XMaS science is also enhanced through the ESRF outreach activities, thereby receiving European wide impact and esteem. This wider European visibility is also enhanced by the 30% international access to the facility guaranteed through our contract with the ESRF.

Featured Articles: Examples of impact and outreach beyond the core users is typified by the list below:

- **ESRF News**: *Instrumentation gives ESRF the edge* - Matthew Chalmer, *EPN trip tackles gender bias: XMaS Scientist Experience* - Kayleigh Lampard, *Keeping nuclear waste safe,* Ross Springell and Sophie Rennie.
- **ESRF Spotlight***: Complex modulated magnetism in PrPtAl* – G. Abdul-Jabbar et al., *Transfer hydrogenation catalyst deactivation solved through in situ X-ray absorption spectroscopy* - Bao Nguyen et al.
- **ESRF Highlights (2106)**: *Modulated magnetism in PrPtAl* - G. Abdul-Jabbar *et al., X-ray imaging with scintillator-sensitized hybrid organic photodetectors* - P. Buchele *et al.*, *Activation and Deactivation of a Robust Immobilized Cp*Ir-Transfer Hydrogenation Catalyst: A Multi-element in-situ X-ray Absorption Spectroscopy Study* - G.J. Sherborne *et al*.

Promoting EPSRC to the wider public:

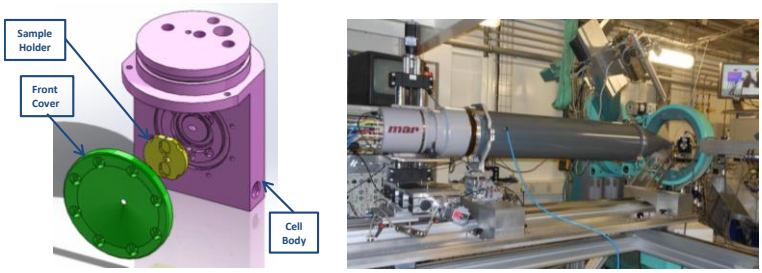
About 3,000 members of the public visit the ESRF annually and our on-site staff conduct tours highlighting the importance and relevance of science funded by EPSRC. In April 2015 we initiated a new outreach activity to tackle the gender bias in Physics. We selected 14 winners from a competition and took them on a life changing trip to visit the EPN campus and tour the ESRF, ILL and XMaS. The aim was to encourage young women to consider a career in science, by showing them the career opportunities available to them as well as introducing them to inspirational role models, in an international setting. A further evening Student Showcase highlighted that the students had a renewed enthusiasm for science and their confidence was boosted. The perceptions of parents, peers and family were all positively challenged. We have secured an additional £18k from the Widening Participation fund at the University of Warwick to re-run an extended and multi-faceted programme for the next two years with events taking place around the headline activity. The activity has received a lot of attention on social media (@XMaSSchoolTrip) as well as blogs on the WISE Campaign, plotr, Science grrl and girlmuseum. The project has been presented at the APS Spring Meeting, Baltimore and the European Physical Society Conference on High Energy Physics, Vienna, as well as being published widely in the literature and in school newsletters. We have formed strong a partnership with national organisations including STEMettes, Science grrl, WISE, plotr, BIG BANG, Uppsala University, CERN, IGGY, Ogden Trust Network and the National Science Centres. The winners have been invaluable in engaging with school students leading to presentations at events including Science grrl, the Big Bang fairs (~8000 pupils) and the Warwick Festival of the Imagination (~5000 visitors).

Figure 5: Competition winners visiting our staff at the ESRF

Improvement (max. 1 page): Please indicate steps that have been taken to improve the access, user experience and ensure the long term sustainability of the facility.

The facility is reliant upon the ESRF infrastructure, the reliability and performance of which has been a key element in the success of both the ESRF and XMaS. The long-term sustainability of the facility is thus inextricably linked to the quality of the synchrotron x-ray source. The ESRF has just completed a major upgrade which has delivered significant improvements to the x-ray source as well as facilitating new developments in both SR instrumentation and computing support. All of these improvements enhance our user experience and sustain the XMaS facility moving forward. The current upgrades have significantly increased the mean time between failures, reducing a major component to our downtime. Looking further ahead, the second upgrade phase, now due to start in 2019, is a complete replacement of the magnetic lattice. This will lead to significant changes for the facility from 2020 as the current bending magnet will be replaced by a multipole wiggler. This change represents a significant opportunity to enhance our operations as the current capabilities are extended and we incorporate new beam diagnostics and control software. This will further increase the throughput and number of users that can be supported. With our already newly designed cryogenically cooled monochromator and a new mirror that is already funded, the XMaS facility is well positioned to take advantage of the ESRF source upgrades. We are currently developing a conceptual design review (CDR) followed by a more detailed technical design review (TDR) which is being guided by the user feedback obtained from 4 focus group meetings (Hard Condensed Matter, Soft Condensed Matter, Chemistry and EXAFs and Surface & Electrochemistry) held in November 2014 to discuss the scientific possibilities opened up by the upgrade. The CDR will be presented to users during the 2016 User Meeting and then to the ESRF science advisory committee. We are planning a new transformative facility with a significant increase in brilliance and, more significantly, an increased operational energy range with new enhanced capabilities and increased capacity.

XMaS has a long history of both engaging with our existing user community and developing new user communities by designing and creating custom sample environments that allow us to expand our remit. This activity has continued over the past year with new metrology techniques for the *in-situ* study of materials using XAS at low energies (Fig. 6 (a)) as well as the commissioning our new fast 2D detectors. A newly designed (GI)-SAXS/XRR system (Fig. 6(b)) has just been commissioned providing enhanced operations in this key and growing area. These developments have led to significant increases in the number of users interested in the facility from both the UK and the wider ESRF communities, as evidenced by the number of new users and the large increase in the number of access requests. To support our new users we are also continually improving the computing support in terms of beamline control developments, data visualisation and data fitting. Efficiency gains, such as those derived from the new SAXS/XRR system, allow us to make more use of shorter experimental runs allowing us to increase the number of users we can support and the enhanced capacity keeps the over-subscription rate at a manageable level (~2:1).



(a) (b)

Figure 6: Recent developments on the beamline. (a) a flow cell for *in-situ* XAS studies at low energies and (b) a new (GI)-SAXS/XRR rail for combined grazing incidence studies.

In parallel to the development of the SR beamline we have also made significant developments to our suite of offline facilities for UK scientists who may not need access to SR to further their research. The principal developments are (1) An offline x-ray diffraction instrument based on a high power x-ray micro-source and utilizing an existing 4-circle Huber diffractometer providing x-ray diffraction capabilities that mimic the SR beamline and (2) offline access to our capital equipment, including the high magnetic and electric field measurements systems. The offline x-ray facility is now being used for diffraction studies and is being commissioned for XRR and SAXS studies. New metrologies have been added to our capital equipment laboratory including the PUND and SAWYER-TOWER methods of measuring electrical properties of multiferroic samples (developed with the NPL and University of Durham). A program of resistivity studies using anisotropic magneto resistance has also been added.

A relaunch of our web-site is planned for November with clearer signposting and a complete overhaul of content. New access mechanisms for the offline facilities will be finalised and usage documented in the next report.

Strategic Fit (max. 1 page): Please provide evidence on how the facility fits the strategic priorities of EPSRC and state any actions taken / will be taken to align the facility with these strategic priorities.

The principal aim of the XMaS facility is to support world-leading research, discovery and innovation by providing a set of unique materials research capabilities to the UK science base. The combination of a world class photon source, continual innovation in photon techniques, high quality technical and scientific support and a strong international user community has maintained the beamline at the leading edge of materials characterisation. The continuing development of novel sample environments enables XMaS to maintain a diverse scientific programme cutting across the challenge themes and complements and strengthens UK-based facilities. As materials discovery continues apace it is evident that the XMaS beamline has an important strategic role in providing fundamental and technologically relevant atomic-scale information to researchers in the physical and life sciences. Due to the location of the XMaS facility at the ESRF, which itself is part of the larger EPN campus, there is a natural environment for UK researchers to adopt an international approach and form collaborative projects, for example in seeking funding from the European Commission's Horizon 2020 programme.

Much of the scientific programme at the facility is contained within the Physical Sciences remit of EPSRC, but the facility is also an important component of the UK research infrastructure that underpins the wider materials science research communities. Although original conceived as a facility to probe magnetic materials and hard condensed matter, the flexibility of the original design coupled with technological developments has enabled an ever broadening range of scientific challenges to be addressed at the beamline (Figure 7). The demonstrable ability to adapt to the changing scientific challenges and landscape show that the facility remains flexible to the strategic requirements of EPSRC.

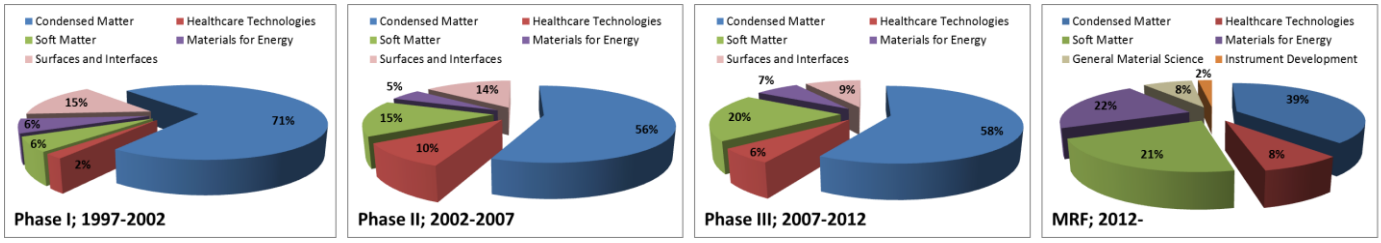


Figure 7: The evolution of the scientific areas supported by the XMaS facility.

The science supported on the XMaS beamline covers a much broader range of challenges than are normally found on a beamline at a SR source. Due to the multidisciplinary user community, which is stretched across Physics, Chemistry and Materials disciplines within the UK science base, there is a strong mapping to many of the science and technology areas that underpin EPSRC's remit. The user profile has also continually changed and expanded with the developing capabilities of the beamline as can be seen in Figure 8 which shows the research areas that are currently being studied. XMaS is in a unique position whereby the best practices of one community have been shared, adapted and implemented by others to the benefit of all. This knowledge transfer has also extended beyond the beamline itself and finds implementation at Diamond Light Source and other SR facilities worldwide.

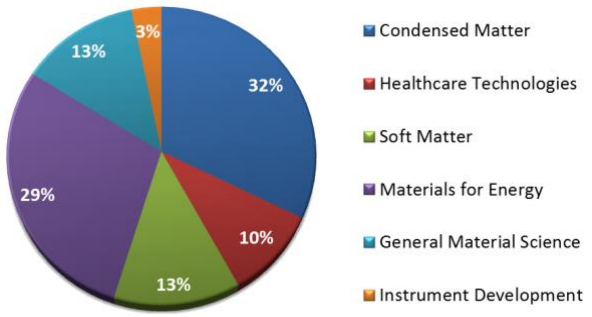


Figure 8: XMaS Experiments by research category as reported by our users for the current reporting period

The upgrade of the ESRF source opens up the possibility of adding hard energy capabilities to the beamline portfolio and we are actively building a community and user base to exploit this new capability in 2020 and beyond. The beamline continues to go from strength to strength and is in demand now more than it has ever been with its broad and interdisciplinary portfolio of capabilities.