



Science Programme Prioritisation 2010-2015
Report from STFC Physical and Life Sciences Committee
January 2010

Background

1. The Science and Technology Facilities Council (STFC) undertook a prioritisation exercise which resulted in a prioritised science programme being recommended to Council in December 2009. To develop this programme, STFC sought advice from the Advisory Panels, Particle Physics, Astronomy and Nuclear Physics Science Committee ([PPAN](#)) and the Physical and Life Sciences Committee ([PALS](#)); and asked [Science Board](#) to consider their recommendations. This report provides further information on the recommendations given to Science Board by PALS.
2. In the prioritisation exercise PALS considered STFC facilities for the physical and life sciences. At its meeting on 15th-16th September 2009, PALS developed a preliminary prioritised list of facilities. To enable this, PALS used input from the Neutron Advisory Panel (NAP) and the Photon Advisory Panel (PAP); and written submissions from the facilities.
3. The input provided by the NAP and the PAP consisted of a report and presentation based on community consultation carried out over summer 2009. PALS thanked the community for their response to the consultation and the NAP and PAP for ensuring all responses were considered in the collation of the reports; and the short timescale in which to do this. The NAP and PAP reports can be found [here](#).
4. The preliminary prioritised list was presented to Science Board on 19th-20th October. Science Board developed strategic advice for PALS and asked the committee to confirm its prioritised list of facilities and develop recommendations for a prioritised programme within three given budget scenarios, at its meeting on 23rd-24th November 2009. PALS recommendations are generally based on facility/project operating costs and did not include an explicit budget for capital costs, though the capital implications of large investments were one of the factors considered in assessing their affordability and priority within the programme.

Prioritised Facility List

5. PALS developed a prioritised list using the following criteria. These are explained further here (<http://www.stfc.ac.uk/About/Stats/Rev/Criteria.aspx>)
 - a. Excellence
 - b. Economic Impact
 - c. Societal Impact
 - d. Leadership
 - e. Synergies.

6. The facilities considered and their final priority in alpha rankings is shown in **Table 1**. It should be noted that the list shows facilities in **alphabetical order** and not priority order within each ranking.

Table 1- Prioritised Facility List

RANKING	DESCRIPTION
Alpha 5	
Astra/Astra Gemini	Current operational costs for the Astra/Astra Gemini high power laser as part of the Central Laser Facility current operational budget.
Diamond Phases 1 and 2	Current requested STFC contribution to fully operate all beamlines currently operating / proposed for Diamond Phases 1 and 2.
European Synchrotron Radiation Facility (ESRF)	Current UK subscription cost to operate the ESRF and fund the minimal Phase 1 Upgrade as approved for by ESRF Council in Jun 08.
Institut Laue-Langevin (ILL)	Current UK subscription cost to operate the ILL and fund the on-going Millennium Phase 1 Upgrade.
ISIS LINAC	Cost to refurbish the current ISIS LINAC.
ISIS Target Station 1 and Target Station 2	Current operation cost of ISIS TS1 and TS2.
Vulcan 10PW	Additional cost required (over and above the current operational cost of Vulcan 1PW) to operate the Vulcan laser once it has been upgraded from 1PW to 10PW.
Alpha 4	
Diamond Phase 3	Additional requested STFC contribution to operate the proposed beamlines for Diamond Phase 3.
ESRF Phase 2	Additional UK subscription cost required to fund the minimal Phase 2 Upgrade to the ESRF.
ISIS TS1 Upgrade	Cost to exploit the engineering lessons learnt from ISIS TS2 to upgrade ISIS TS1.
ISIS TS2 phase 2, 3	Additional cost required to operate ISIS TS2 once the proposed Phases 2 and 3 have been completed.
New Light Source (NLS)	Requested funding for on-going research and development to allow the NLS project to reach the stage that it could obtain capital funding from the large facilities capital fund.
Alpha 3	
European Spallation Source (ESS)	Provision for a low level of R&D funding to contribute to the ESS project.
ISIS MW Upgrade	Provision for a low level of R&D funding.
Lasers for Science Facility	Current operational costs of the Lasers for Science Facility as part of the Central Laser Facility current operational budget.
Research Complex at Harwell	Maintenance of current level of commitment.
European X-Ray Laser Project (XFEL)	Estimated UK 'share' of operational costs from 14/15, based on proposed capital contribution.

Alpha 2	
Extreme Light Infrastructure (ELI)	No operational costs were anticipated during this period; on-going R&D / capital costs were expected to be funded externally to STFC.
ESRF Phase 1 Options	Additional UK subscription cost to fund the options proposed for Phase 1 of the ESRF Upgrade Programme.
ESRF Phase 2 Option A	Additional UK subscription cost to fund option A of Phase 2 of the ESRF Upgrade Programme.
Linac Coherent Light Source	This refers to any potential additional UK contribution to LCLS. No specific provision was considered; any future financial input would be linked to the development of XFEL.
Alpha 1	
DIPOLE	No operational costs were anticipated during this period; any development costs were expected to be funded via the R&D phase of the HiPER project.
European High Power Laser Energy Research Facility (HiPER)	Provision for a low level of R&D funding to the end of the FP7 Phase (2011) and into the development phase. No capital construction costs or future operational costs were anticipated during this period.
Vulcan 1PW	Current operational costs of the Vulcan 1PW laser system as part of the Central Laser Facility current operational budget.
Beta	
ALICE	Additional funding to run ALICE as a user operational facility as well as an accelerator and light source development facility.
High Magnetic Field Laboratory	Additional UK subscription costs to fund the building and operation of a High Magnetic Field Laboratory at the joint ESRF/ILL site as part of the ESRF Upgrade Programme (Phase 2 Option B) and the ILL Millennium Programme Phase 2.
Photon Science Research Institute	Continued support at the current level.
Deferred	
ILL M2	Additional UK subscription cost to fund Phase 2 of the Millennium Programme upgrade to the ILL.

Development of Prioritised Programme

7. During the development of the prioritised programme, PALS were mindful of the guidance from Science Board and followed a number of principles when developing the programmes. The principles were:
 - a. The exploitation of UK facilities with maximum effectiveness;
 - b. The consideration of future needs and not just immediate user needs. In some cases, it was noted that future needs would be met through the development of new beamlines at existing facilities and not just through wholly new facilities;
 - c. In the case of some lower ranked facilities, the science was still considered excellent but the lower ranking reflected higher levels of risk and/or that they were less timely;
 - d. PALS had taken on board the advice from the Advisory Panels during the prioritisation and where appropriate had modified their rankings. The Advisory Panels exclusively prioritised existing facilities over new facilities; however PALS attempted to take a longer term view.

Prioritised Programme

8. PALS recommended funding levels for the following prioritised programme:
 - **ASTRA/ASTRA Gemini (alpha 5)**

PALS considered ASTRA and ASTRA Gemini together as they are linked projects. PALS recognised that ASTRA Gemini is world leading in terms of capability with some high-level experiments and publications. The research community is small but has a high profile and the quality of science is maintained by strong peer review. The UK high-power laser community has a high impact internationally and UK trained high-power laser scientists are readily employed by overseas facilities. The UK has a strong leadership position in this field and has a high profile in international projects such as the National Ignition Facility (NIF) in the US.
 - **Diamond Phase 1 and 2 (alpha 5)**

Diamond is the UK's new synchrotron facility, a 3 GeV source of high brilliance that supports a large, active and diverse UK community carrying out research in areas including biology, medicine, materials, chemistry, physics, engineering, environmental science and cultural heritage. Much of the work carried out relates to projects supported by the research councils, UK industry and the Wellcome Trust. The first seven beamlines (Phase I) became operational only in 2007, yielding a number of high profile publications, particularly in the area of macromolecular crystallography. It is, however, too early to compare its overall scientific output with that of more mature facilities. PALS recognise that the research community is still in the early stages of development. Even so, the demand for beamtime outstrips supply across all disciplines, and the timeliness and quality of the research is continuously evaluated via proposal review at beamtime allocation panels.

- European Synchrotron Radiation Facility (alpha 5)**
 The European Synchrotron Radiation Facility (ESRF) is the internationally leading x-ray synchrotron facility. The UK has a 14% stake in ESRF and many scientific communities make use of the beamlines, e.g. biology, chemistry, geosciences, materials, physics. Timeliness of research is continuously maintained via allocation panels on which the UK is appropriately represented. The UK obtains high proportions of beamtime and publications in relation to its 14% shareholding so the value for money is excellent. Many high quality outputs are produced – the Nobel prize-winning ribosome work by Ramakrishnan (UK) and Yonath (Israel), some of which took place at ESRF is a notable highlight.
- Institut Laue-Langevin (alpha 5)**
 The Institut Laue-Langevin (ILL) is the world's most scientifically productive neutron facility of any type, producing around 600 publications per year, of which around 25% have one or more authors from the UK. Experiments performed at the ILL reactor are unique in several key respects, and in general are complementary to those performed at the ISIS spallation source. The ILL serves the needs of a very large (many thousands) and diverse user base drawn from chemistry, physics, biology, engineering, nanotechnology, etc. The UK has the largest national neutron user community in the world, and is world leading in many scientific and technological areas. Access to the preeminent neutron facilities at the ILL is an essential component in safeguarding this position.
- ISIS Target Station 1 and Target Station 2 (alpha 5)**
 ISIS is currently the world's leading spallation neutron and muon research facility. The threat to this position posed by new spallation sources in the US and Japan has been mitigated to a large extent by the commissioning of Target Station 2 which will help safeguard ISIS' competitiveness for at least the next decade. ISIS and ILL have evolved to be highly complementary to each other in their capabilities. ISIS produces over 400 papers per annum, making it one of the most productive facilities of its type in the world. These papers reflect the strength and depth of research performed at ISIS, with many papers in highly cited journals such as Nature, Science, Physical Review Letters, etc. ISIS serves the needs of a very large and diverse user community, with 79% of beamtime being awarded to the UK researchers. Typically there are 1500 user visits per year from biologists, chemists, earth scientists, engineers, and physicists, 35% of whom are PhD students.
- Vulcan 10PW (alpha 5)**
 PALS noted that if the Vulcan 10PW upgrade were built it would keep the UK at the forefront of the field of ultra-high intensity laser-matter interaction. The Vulcan 10PW upgrade was rated very highly by PALS when reviewed in February 2009 and was also very highly supported by Science Board. PALS noted that if the UK wished to maintain its world lead in this area and strengthen the UK community, then the 10PW upgrade would be its highest priority. As the world's most powerful laser Vulcan 10PW will have significant societal impact and media interest.

9. PALS noted funding for the following was already committed:

- **Research Complex at Harwell (alpha 3)**

The aim of the complex is to provide support for users at ISIS, Diamond and the Central Laser Facility through the provision of laboratory space and equipment. Whereas the Life Sciences part of the complex is well developed, it is apparent that the physical sciences part of the complex is less advanced. Due to the disparity in the development of the Life Sciences and Physical Sciences parts of the complex, there is currently a higher profile and higher potential science output in the Life Sciences part of the complex and stronger links with Diamond than with ISIS or the laser facilities.

10. PALS did not assess the following in detail but noted that funding was already committed:

- **Next Generation Facility Studentships**
- **STFC Futures Programme**
- **Gateway Centres**

11. PALS deferred consideration of the **Institut Laue-Langevin Millennium 2 upgrade** programme due to the current stage of development of detailed plans for the upgrade.

12. PALS noted that all of the alpha rated facilities provide excellent scientific opportunities; however with regret, the following could not be supported within the nominal budget allocation.

- **Diamond Phase 3 (alpha 4)**

PALS noted that Diamond is the UK's new synchrotron radiation facility, with a large and active research community who are just beginning to reap the rewards of the considerable investment in terms of time and money put into construction and equipping the facility. Diamond Phase 3 consists of 10 further beamlines that complement those built during Phases 1 and 2. If funded and built to the plan, these will become available to users between 2011 and 2016. The user communities for these new beamlines were considered to be large and to some extent distinct from those whose needs were met by Phases 1 and 2. Currently these users must rely on facilities overseas, which incurs additional expense and restricts the complexity of the experiments that can be achieved. The Photon Advisory Panel highlighted Diamond Phases 1 and 2 as higher priority than Phase 3, with a desire to see Phase 1 and 2 beamlines running optimally before Phase 3 follows-on. Accordingly, PALS ranked Diamond Phase 3 as alpha 4.

- **ESRF Phase 2 (alpha 4)**

PALS noted that the minimal ESRF Phase 2 will consist of six new beamlines plus completion of the instrumentation, detector and computing developments. PALS considered that Phase 2 will offer significant new scientific and technological opportunities. This continuation of the ESRF

upgrade is a high priority to ensure the ESRF remains a world-leading source for UK scientists. PALS ranked ESRF Phase 2 as alpha 4.

- **ISIS Target Station 1 Upgrade (alpha 4)**

PALS recognised the excellence of the proposed development for the ISIS Target Station 1 Upgrade and that the gain of factor of 2-3 in flux would allow more sophisticated time-resolved experiments and open up the study of smaller samples. Indeed, for certain instruments an effective gain of ~5 is projected, together with reduced maintenance costs. It was considered to represent very good value for money. It was recognised that the biological sciences output from ISIS is currently low, and the benefits for this community therefore need justification; the potential benefits for the physical sciences are however evidently significantly greater. PALS ranked ISIS Target Station 1 Upgrade as alpha 4.

- **ISIS Target Station 2 Phase 2 and 3 (alpha 4)**

The scientific excellence of the continuing development of ISIS Target Station 2 Phase 2 and 3 is qualitatively similar to that for Target Station 1 and Target Station 2 Phase 1. However, PALS overall ranking of these later phases of Target Station 2 development and exploitation was slightly lower than that for Target Station 2 Phase 1 due to the perceived need to prioritise the completion and full operation of the current (i.e. Phase 1) work. This decision also reflects the Neutron Advisory Panel's advice. PALS also considered the relative benefits of supporting more instruments via Phase 2, and more explicitly Phase 3 (for which no detailed instrumentation planning is currently available), compared to better flux on Target Station 1 via the proposed upgrade to its design. The Phase 3 element to this package was rated on the basis of needing detailed instrumentation planning and PALS noted that its further definition will involve consultation with the user community. PALS ranked ISIS Target Station 2 Phase 2 and 3 as alpha 4.

- **New Light Source (alpha 4)**

PALS noted that the New Light Source (NLS) project could have very high impact. It could have a major lead in both a national and international context. NLS could be a unique, world leading facility in the area of biological imaging and could open up exciting new research areas and develop new communities. PALS noted that NLS could develop significant synergies with other national and international facilities. PALS therefore ranked NLS as alpha 4.

- **European Spallation Source (alpha 3)**

PALS noted that the large increase in flux promised by the European Spallation Source (ESS) will have a major scientific impact in a wide range of neutron scattering techniques in the context of time-resolved/in situ studies, such as in small angle scattering. The ESS is, in contrast to current accelerator-based facilities such as ISIS (and the new sources in the USA and Japan), designed as a long-pulse source; its time-averaged flux would be comparable to the ILL and would exceed that of any current spallation sources worldwide. However, by making use of the residual

time structure, it would prove possible to gain significant complementary strengths with respect to a steady state source. There is, therefore, a high potential for excellence. However, the timeliness is such that it is arguably not immediately pressing; the ESS should remain on the roadmap, but its priority for the UK will depend on future development of ISIS. PALS ranked ESS as alpha 3.

- **ISIS MW Upgrade (alpha 3)**

Broadly speaking, PALS regarded the scientific excellence of the proposed ISIS MW Upgrade to be on a par with that of the ESS. There are, however, significant differences in the sense that the ISIS proposal will retain the relatively short pulse design paradigm of the existing source compared to the long-pulse option currently favoured by the ESS proposal; this has immediate implications in terms of realising significant complementary strengths with respect to a steady state source. Indeed, although the ESS is currently better defined, it was the view of the committee that a 5MW long-pulse source is unlikely to be built and that the ESS design may well evolve into a medium pulse-length proposal. PALS noted that it is difficult to imagine the availability of funding for three neutron facilities (ISIS, ILL, ESS). PALS ranked ISIS MW Upgrade as alpha 3.

- **Lasers for Science Facility (alpha 3)**

The Lasers for Science Facility (LSF), which is part of the Central Laser Facility, provides a range of lasers to users which are separate to the provision of high-power lasers already described. PALS noted that the LSF is planned to be transferred to the Research Complex at Harwell and was ranked very highly by the Photon Advisory Panel. The LSF has been a great benefit to a wide user community and has significant leverage from the other Research Councils. It was noted by PALS that the LSF has significant value in some areas such as the chemical sciences. Although it serves a diverse community, it is not a strategic facility. LSF has good spin out activities, is a good training facility and has burgeoning connections with industry. Accordingly PALS ranked LSF as alpha 3.

- **European XFEL (alpha 3)**

The European XFEL is currently being constructed and PALS noted that for this reason it was difficult to grade the potential scientific excellence with any degree of certainty. It was felt that XFEL is of interest to a small number of UK groups. It was felt that such a source may have a large UK community in the future and that it was worth keeping open the option of participating at a later date. PALS ranked XFEL as alpha 3.

- **Extreme Light Infrastructure (alpha 2)**

PALS noted that the Extreme Light Infrastructure (ELI) is an international project still at the design stage to produce a laser delivering the highest intensity for the study ultra-high intensity laser-matter interaction. It is planned to be operational sometime after the Vulcan 10PW and is designed to produce even higher intensities than the Vulcan 10PW laser. If funded, it will keep the UK at the forefront of research in the field of ultra-

high intensity laser-matter interaction. However it is unlikely that the UK would have leadership of this project unless a significant contribution is made by STFC. ELI may result in return for UK as a primary supplier although PALS considered that societal impact will be local to the laser (currently unlikely to be the UK). PALS ranked ELI as alpha 2.

- **ESRF Phase 1 Options (alpha 2)**
ESRF Phase 1 Options are to build two further beamlines and associated satellite buildings. These are worthwhile projects but PALS noted that they would be better tensioned against other options in the Phase 2 proposal. PALS ranked ESRF Phase 1 Options as alpha 2.
- **ESRF Phase 2 Option A (alpha 2)**
PALS noted that ESRF Phase 2 Option A involves the option to upgrade some straight sections of the ring to improve beam intensity. This may be of good value and should be considered within the Phase 2 development. PALS ranked ESRF Phase 2 Option A as alpha 2.
- **Linac Coherent Light Source (alpha 2)**
The Linac Coherent Light Source (LCLS) became the first hard x-ray FEL with a user program starting from September 2009. PALS noted the range of science to be pursued at LCLS is narrower than that proposed at XFEL and the UK representation is active but relatively small. PALS ranked LCLS as alpha 2.
- **DIPOLE (alpha 1)**
PALS noted that DIPOLE is a project which will develop enabling high repetition rate laser technology for HiPER. PALS recognised that DIPOLE may have other industrial applications and may therefore have major impacts but these are as yet unproven. DIPOLE is a technology demonstration project and as such there was limited community support for this project. As with HiPER, PALS noted the imminent Review of Fusion for Energy Research. Therefore PALS ranked DIPOLE as alpha 1.
- **HiPER (alpha 1)**
PALS noted that the UK leads the HiPER project and that if HiPER were fully supported it could put the UK at the centre of an international effort to produce power by inertial fusion energy over the coming decades. HiPER was considered to be a very ambitious project but it was noted that the main aim of the project is not to produce a user facility but to act as a technology demonstrator. The timeliness of this project depends on the outcome of work currently underway in the US at the National Ignition Facility (NIF). The economic impact of HiPER is potentially enormous but there are very significant risks. PALS felt unable to comment further on the potential of HiPER as a future source of energy and (as with DIPOLE) noted the imminent Review of Fusion for Energy Research. Therefore PALS ranked HiPER as alpha 1.

- **Vulcan 1 PW (alpha 1)**
 The Vulcan 1 PW laser has been a backbone of the high-power laser provision of the CLF. Vulcan 1PW has supported a broader range of science than ASTRA Gemini and to date has produced a number of high-profile publications. PALS recognised that despite resourcing issues the Vulcan 1PW system has had high scientific output. PALS noted that although there is still a significant future for the Vulcan 1PW system, it is recognised that the timeliness of the system may be starting to pass. It was noted that the user community would accept downtime of the Vulcan 1PW system if the Vulcan 10PW upgrade were to be pursued. Therefore, in light of the very high priority given to the Vulcan 10PW upgrade, PALS ranked Vulcan 1 PW as alpha 1.
- **ALICE (beta)**
 The ALICE facility was evaluated on the basis of the STFC funded component as a test-bed for accelerator based research. In terms of the science output of ALICE, it was felt that whilst some useful results may emerge from using ALICE the science case made was not compelling. The economic impact of the facility was assessed by PALS as being limited, although (as with the societal impact) the local effects may be greater. PALS ranked ALICE as beta.
- **High Magnetic Field Laboratory (beta)**
 The proposal to develop a world-leading High Magnetic Field facility at ESRF and ILL would have a significant cost and presently does not enjoy wide support in the UK community. The economic and societal benefits to the UK of this development are unclear. PALS ranked the High Magnetic Field Laboratory as beta.
- **Photon Science Research Institute (beta)**
 PALS noted that the Photon Science Research Institute (PSRI) was established to perform a pump priming activity and to provide a bridging role in seeding a UK user community for the new generation of FEL facilities. The Photon Advisory Panel noted that the photon community in the UK had limited awareness of the PSRI. From this point of view PALS felt it was timely that the activities performed by the PSRI, should now be supported by individual applications for funding from the Research Councils and other sources. Therefore PALS ranked the Photon Science Research Institute as beta.