STFC Balance of Programme Evaluations 2018/19

Introduction and Process

Introduction

1. The STFC Balance of Programme (BoP1) exercise, published in 2017, looked at the balance of funding between the Frontier Science research disciplines (Accelerators, Astronomy, Computing, Nuclear Physics, Particle Astrophysics, Particle Physics). A process was agreed, by both Science Board and Executive Board, stating that in addition to this 3 yearly exercise, more detailed programme evaluations of the specific research disciplines should be carried out. In June 2017, the relevant Programmes Directorate (PD) staff met to discuss the method and timetable to undertake the required evaluations. The recommendations paper that emerged from this meeting was approved by Science Board at their June 2017 meeting (SB.17.61.06).

2. The purpose of the programme evaluations was to look at the portfolio and science strategy to define a balanced programme of excellent science within a realistic financial planning envelope for each scientific discipline within the Frontier Science programme.

3. The evaluations have generated detailed, standardised information and data on specific research disciplines and will be used to feed into the next Balance of Programmes (BOP2) exercise, which is due to begin in 2020. The evaluations complement the evaluation of skills that was recently undertaken within STFC.

4. The evaluations ranked projects, experiments and facilities (type of activity depends on the subject area) and outlined scientific priorities within their area. The evaluations provide advice on the shape of the discipline within the overall Frontier Science programme. The evaluations also looked at funding levels for new ideas and technology development.

5. The evaluations were led by staff within the PD. Each evaluation was carried out by its own panel. The evaluation panels are each chaired by a representative from Science Board. Three members of Science Board, Professor Ofer Lahav, Professor Don Pollacco and Professor Tara Shears, were each assigned to chair two evaluations, to ensure consistency between the evaluations and to help build knowledge and experience ahead of BoP2. The Science Board members established a core group that met amongst themselves to discuss the process to aid consistency, share information and knowledge to feed into BoP2.

6. Whilst the aim has been to feed standardised information into the evaluations, it was acknowledged that some additional pieces of information - such as tensioning new projects and looking at the programme remit - were specific to certain research disciplines and consequently a certain level of flexibility was required. Each programme evaluation obtained details of the possibilities/consequences of a + / – 10% funding scenario over the next 5 years.

7. Consideration was given as to whether each project still sat within the appropriate research area for future budgetary tensioning due to the shifting scientific landscape. Consideration was also given to ensuring that projects for which STFC has supported construction can receive appropriate support for exploitation and return on investment.

8. The advice provided by the evaluation Panels will be used in framing its arguments to Executive Board for future budget allocations.

9. An executive summary of each of the STFC programme evaluations will be available to the public at the end of the evaluation cycle.

Process

Communication

10. The process for the evaluations communication plan was agreed with Chris Buratta (then of STFC External Communications). All of the STFC frontier science disciplines communities have been made aware of the evaluation programme through the community mailing lists. A website to continually inform the community about the progress of the evaluations has been set up at STFC Programme Evaluations. Updates were provided at town meetings as and when appropriate.

11. Appropriate panel members covered all areas of the discipline under review which were approved by Grahame Blair, Executive Director of Programmes Directorate. Whilst not always possible, the Panels ideally aimed to ensure geographically represented from around the UK and contained female representation of at least 30%.

The Meetings

12. The programme evaluations were carried out over three meetings by the individual review Panels. In addition to material provided by PD, information was sought from project PI and the relevant advisory and grants panels. Standard pro formas were devised to enable a level of consistency in the material that was provided.

13. The initial kick-off meeting for all of the evaluations was a teleconference. At this meeting, STFC outlined the requirements of the individual evaluation and how it fit into the overall evaluation process. The Panel looked at the generic pro formas and a list of the intended recipients and decided whether any additional information was required for their specific review, and if the list of recipients required amendment. After the meeting, the agreed pro formas were circulated to the agreed recipients who were given around six weeks to complete them.

14. The second meeting for each evaluation lasted two days. Various materials were provided for the evaluations. These included the latest Grant Panel reports, Advisory Panel Reports, returned pro formas, a briefing from the Programme Manager (including information on finance, gender breakdown and studentships) and publication data obtained from STFC/Research Fish.

15. The Chair from the relevant STFC advisory panel attended the first day. This enabled them to give a presentation on the area, add expertise, and to answer questions from the review panel, as well as providing clarification of complex issues. This meeting also provided an opportunity to highlight any additional information or evidence which might be required to inform their deliberations. Any requested further information was provided for the third meeting. The Panel discussed the completed pro formas and agreed provisional rankings.

16. Funded projects, experiments and facilities within each discipline were ranked. The ranking criteria and weighting mechanism was largely based on those previously used by STFC, namely “alpha” rankings for projects/experiments and “g” rankings for science exploitation themes within consolidated grants. In addition a new “i” ranking will be introduced to cover evaluation of impact for the economy and society. Further information on the ranking procedure is available in Annex 2.

17. The panel members were asked to consider the strategic value of the projects, experiments and facilities and how highly aligned they were to the future vision of STFC. Consideration was given to the international standing and the potential for world leadership of the area under review. Additional values, such as synergies within the Frontier Science programme were also taken into account.

18. The Panels were asked to score each of the projects, experiments and facilities before the meeting. The rankings were then discussed and agreed by the panels. The Computing panel, who only had to rank two projects, discussed the rankings for the first time at the meeting.

19. The final reports were drafted during the period between the second and third meeting.

20. At the third meeting, the Panel received an update from STFC with the additional information requested at the previous meeting and the results of any consultation. The Panel took into account the additional information and discussed the draft report, finalising the high level summary of their recommendations. After this meeting, the Panel Evaluation Chair produced an updated draft version of the report for circulation amongst the Panel. The agreed output is contained in this report for Science Board.

21. Conflicts of interest were dealt with by the Panel Chairs in accordance with STFC guidance.

Output

22. The output of the evaluation is a report presented to Science Board. The report considers the Panel’s findings.

Programmes Directorate Summary

As part of STFC's greater remit STFC programmes Directorate comprises and supports of a number of areas. These include, but are not restricted to the following:

- Studentships & Fellowships;
- Public Engagement;
- STFC Global Challenges;
- Open Access Initiatives;
- External Innovations;
- Frontier Science Programme (PPAN);
- Global Challenges Research Fund;
- Newton Fund.

Annex 1 – Panel Membership

Computing

- Professor Ofer Lahav (Science Board) - Chair
- Professor Paul Alexander (Cambridge)
- Dr Andreas Juettner (Southampton)
- Professor Victoria Martin (Edinburgh)
- Dr Andrew McNab (Manchester)
- Dr Jacqueline Pallas (Kings College London)
- Dr Andrew Sansum (Rutherford Appleton Laboratory)
- Dr Debora Sijacki (Cambridge)

Particle Astrophysics

- Professor Tara Shears (Science Board) – Chair
- Professor Richard Battye (Manchester)
- Professor Garret Cotter (Oxford)
- Professor Giles Hammond (Glasgow)
- Professor Alex Murphy (Edinburgh)
- Dr Morgan Wascko (Imperial)

Nuclear Physics

- Professor Don Pollacco – (Science Board) – Chair
- Professor Mike Bentley – (York)
- Professor Jon Billowes – (Manchester)
- Dr Maria Borge – (Spanish National Research Council)
- Professor Alison Bruce – (Brighton)
- Professor Peter Jones – (Birmingham)
- Professor Jordi Jose – (Universitat Politècnica de Catalunya)
- Dr Paul Stephenson – (Surrey)

Particle Physics

- Professor Ofer Lahav (Science Board) – Chair
- Professor Chris Allton (Swansea)
- Professor Henrique Araujo (Imperial)
- Professor Gary Barker (Warwick)
- Professor Monica D'Onofrio (Liverpool)
- Professor Lars Eklund (Glasgow)
- Dr Nick Evans (Southampton)
- Dr Julie Kirk (RAL PPD)
- Professor Jocelyn Monroe (RHUL)
- Professor Dave Newbold (RAL PPD)

Astronomy

- Professor Don Pollacco – (Science Board) – Chair
- Professor Malcolm Bremer (Bristol)
- Professor Ineke de Moortel (St Andrews)
- Dr Leigh Fletcher (Leicester)
- Dr Nina Hatch (Nottingham)
- Professor Melvin Hoare (Leeds)
- Professor Alberto Vecchio (Birmingham)
- Professor David Wands (Portsmouth)
- Dr Chris Watson (Queen's University Belfast)

Accelerators

- Professor Tara Shears (Science Board) – Chair
- Dr Rob Appleby (CI Manchester)
- Dr Stephen Gibson (JAI RHUL)
- Professor Simon Hooker (Oxford)
- Professor Carsten Welsch (CI Liverpool)
- Mr Alan Wheelhouse (AsTEC)

Annex 2 Ranking Process for Programme Evaluations

Ranking Scoresheet for Programme Evaluations 2018/19

During the 2017/18 Programme Evaluations, projects, experiments and facilities within each discipline will be ranked. The ranking criteria will cover scientific excellence, exploitation within grants, and impact/industrial engagement. The exercise will look at all funded projects, experiments and facilities and ensure each is considered at whatever its stage of the exploitation cycle.

The panels will consider the merits or otherwise of supporting areas currently receiving STFC investment. This will include consideration of international engagement and subscriptions.

The ranking criteria will be largely based on those previously used by STFC, namely **α** rankings for projects/experiments and "g" rankings for science exploitation themes within grants as used in the last Programmatic Review. In addition a new "i" ranking will be introduced to cover evaluation of impact for the economy and society.

The Panel will be asked to consider the strategic value of the projects/experiments/ facilities that submitted pro formas and how highly aligned they are to the mission of STFC. Consideration should also be given to the international standing and the potential for leadership of the area under review. Additional value, such as synergies within the STFC frontier science disciplines (Particle Physics, Astronomy, Nuclear Physics, Particle Astrophysics, Computing, Accelerators) programme should also be taken into account.

The Panel will be asked to score each of the projects, experiments and facilities on the following criteria and submitted 2 days before the meeting.

The Panel member should complete section 1 and 4 below for each pro forma. A marking should be given for either section 2 or 3, dependent on which is most appropriate.

The below wording is generic for the six evaluations and may be slightly modified to suit the specific requirements of the individual reviews.

1. **What is the life cycle stage of the Project/Experiment/Facility?**

Early / Developing / Mature

2. **Scientific Excellence of Project/Proposal**

α5 - Highly innovative and very likely to result in seminal changes in knowledge.
α4 - Likely to substantially advance the subject.
α3 - Likely to make an important contribution to the subject.
α2 - Competent, worthy science.
α1 - Interesting science but outcomes considered doubtful.
β - Poor quality, flawed or unlikely to deliver meaningful or interesting results.

3. **Exploitation**

Projects in the science exploitation phase are funded via grant panels. Three categories are defined, intended as strategic guidance to the peer review carried out by grant panels. Please consider the value of exploitation when the area under evaluation reaches maturity.

g3 - A project with high strategic importance in the STFC programme, which has received substantial investment. We would expect to see it adequately funded via grants after peer review
g2 - A project with high potential for excellent science which should be considered via peer review
g1 - A project which is not well matched to the STFC programme, we would be surprised if it were to receive funding via the grants panel.

4. **Impact and Engagement**

Please consider if there is important impact within industry and/or wider society that STFC should be looking to exploit and that will otherwise not happen elsewhere.

i5 - Very exciting impact already under IP management or a close working partnership or exchange with non-academic partners is already in place.
i4 - Very exciting opportunities proposed, with some first connections made.
i3 - Interesting opportunities suggested but needs significant further work.
i2 - Little opportunity, although some could evolve in near future.
i1 - Little opportunity and unlikely to develop significantly in near future.
i0 - No apparent opportunities at all.

Annex 3 Requested Pro formas

Pro formas were requested from the following to help with the Computing evaluation:

ALMA, CASU, CTA (Not Received), DiRAC, DUNE, ELT, E-Merlin, EUCLID, GAIA, HEP-GridPP, IPPP, LSST, LUX ZEPLIN, SKA, UKT0, WFAU.

Pro formas were requested from the following to help with Particle Astrophysics evaluation:

Advanced LIGO A+ Upgrade, CMB, CTA, Dark Matter Generation 3 R&D, DarkSide, Gravitational Waves Consortium (current) and ALIGO operations, Ground-based Gravitational Waves programme and ALIGO Operations, Lux Zeplin, SuperNEMO, SNO+.

Pro formas were requested from the following to help with Nuclear Physics evaluation:

ACPA (ELI-NP), AGATA , ALICE Upgrade, DRACULA, Fission, ISOL-SRS, JLab 2, JLAB Upgrade, Jyvaskyla (Not Received), Neutrino Nucleus, NuSTAR 2, R&D EIC, *STA @ RIKEN*

Pro formas were requested from the following to help with the Astronomy evaluation

ALMA RC, CMB, CTA, DESI, DKIST, ELT, e-MERLIN, Gaia, HARPS3, ING, JCMT, JIVE, Liverpool Telescope, LOFAR (UK), LSST, MOONS, NGTS, SKA, SOXs, WEAVE, WFA CASU, WFA WFAU

Pro formas were requested from the following to help with the Particle Physics evaluation

ATLAS (Operations, Phase 1 Upgrade, Phase 2 R&D), ATLAS Upgrade (Phase 2 construction), CMS (Operations, Phase 1 Upgrade, Phase 2 R&D), CMS Upgrade (Phase 2 construction), Darkside, eEDM (including upgrade), g-2, GridPP, Hyper-K Construction, IPPP, LBNF/DUNE (R&D, preconstruction, ProtoDUNE, construction), LHCb (Operations, Phase 1 Upgrade), LHCb Upgrade Phase 1b/2, Lux Zepplin, MoEDAL (SoI), Mu2e, Mu3e, NA62, NoVa, SBND/MicroBooNE, SHiP, SNO+, SuperNemo, 3rd Generation Dark Matter, T2K

Pro formas were requested from the following to help with the Accelerator evaluation

ASTeC, AWAKE, Cockcroft, HL LHC & LESS, John Adams Institute, LBNF DUNE PIP 11, LBNF DUNE TARGET, MICE, PWFA-FEL, UK FLUX

Additional pro formas were also sent to the advisory panels for each discipline.

Annex 4 -Generic Terms of Reference for the programme evaluations are:

- Consider the STFC science drivers that will be important in the next decade and their relevance to this discipline. Identify the highest priority science questions for this field. Comment on whether the current balance between R&D, theory, construction and scientific exploitation across the scientific discipline is correct.

- Assess the quality of projects within the discipline and allocate appropriate ranking. The ranking will apply to the whole lifetime (R&D/construction) of the project. Future opportunities should also be ranked where enough information is available.

- Assess the quality of the exploitation programme.

- Identify the most appropriate balance between the project/experiment/facilities.

- Comment on whether there is appropriate breadth within the scientific discipline for development of future opportunities and establishing / maintaining leadership expertise.

- Recommend the appropriate programme for the research area for the following financial scenarios - Flat cash and Flat cash + / - 10% over the next five years.

- Comment on key Technologies and Technology Development required for the programme.

- Comment on the current and potential 'Societal and Economic Impact' within the programme.

- Consider how other sources of funding are utilised and how new funding streams, such as GCRF, can be effectively used.

- Comment on, within the discipline, whether the overall programme achieves its aim of delivering high quality economic impact and enables current and future investments to be sufficiently exploited

Annex 5 – Publications Statement

Publications statement

ResearchFish is an online system which is pivotal in demonstrating the case for investment in science. STFC has a responsibility to demonstrate the value and impact of research supported through public funding. By using ResearchFish STFC has a central means for researchers to log the outputs, outcomes and impacts that have been realised through STFC's research funding. Outputs are then made available through the Research Councils' 'Gateway to Research' portal. Whilst the current number of papers recorded on Research Fish that are credited to the various experiments can be obtained, they were not viewed as useful by the Panel. Research Fish provided the caveat that not all of the submitted publications will appear, this is because they wouldn't have been in their database. This is likely to be because they are not journal articles but something else e.g. poster presentation, conference proceeding etc. Other caveats expressed by Research Fish are:

- Outputs can be attributed to more than one award. Each output has its own ID, unique outputs can be identified by removing the duplicates from the ID field.
- For the spin outs section, PIs can report New or recently formed private sector organisations (whether for profit or not-for-profit), where your research has contributed significantly to the organisation's development or growth (e.g. significant shifts in strategy or business model, impact on turnover). It doesn't necessarily mean they have started the company
- The 'Use of Faciliies' section requires cleaning, PIs may have entered using the same facility under different names
- STFC enter large projects into Researchfish as separate entities e.g. ATLAS. Any outputs attributed to these projects are then linked to any STFC grant that is associated to that project e.g. ST/K001388/1 is linked to ATLAS so will have the outputs entered onto ATLAS as part of its Researchfish outputs. These can be identified using the 'Linked Agreement' field. For much of the particle physics (and some Astronomy) that STFC supports, work is done collaboratively by Universities across the UK. Hence the reason for sharing outputs. Preferably, analysis should be done at a project level rather than an award level.
- An issue with the Researchfish API to the Crossref database has meant that special characters in the title of a publication are not appearing e.g. 'Measurements of Wγ and Zγ production in pp collisions at √s=7 TeV with the ATLAS detector at the LHC appears' as ' Measurements of and production in collisions at with the ATLAS detector at the LHC '
- LHC '

If STFC wishes to accurately measure the number of publication citations that are generated by its science a more accurate method of recording the statistics is required.

Annex 6 - Glossary

4GLS – Fourth generation accelerator-based light sources

4MOST - The 4-metre Multi-Object Spectrograph Telescope, second-generation instrument built for ESO's 4.1-metre Visible and Infrared Survey Telescope for Astronomy (VISTA) telescope based at the Paranal Observatory in northern Chile.

AAP – Astronomy Advisory Panel. Provide a link between the Science board and the astronomy community and represent the needs of the community to STFC

AccPE - Accelerator Programme Evaluation

ACE - Advanced Composition Explorer

ACPA – Advanced Charged-Particle Array. An EU-funded electron accelerator under construction at STFC's Daresbury Laboratory

ACT - Atacama Cosmology Telescope

ADMX – Axion Dark Matter Experiment

ADS – Astrophysics Data System

ADSRs - Accelerator Driven Subcritical Reactors

AGATA – Advanced Gamma Tracking Array. A collaborative European project to construct and operate a gamma-ray tracking spectrometer.

AGN – Active galactic nuclei

AGP – Astronomy Grants Panel. The panel assess and make recommendations to the STFC Executive on all research grant applications in astronomy

ALICE – A Large Ion Collider Experiment. One of the seven detector experiments at the LHC at CERN which focuses on understanding the physics of strongly interacting matter at extreme energy densities.

A (Advanced) LIGO – Advanced Laser Interferometer Gravitational-Wave Observatory. A second generation gravitational wave laser interferometer, expected to routinely observe and study gravitational waves from cosmic sources

ALMA – Atacama Large Millimeter/Submillimeter Array. A radio interferometer in the Atacama Desert in Chile designed to study the Universe at millimeter and submillimeter wavelengths

ALS-U : 4th generation light source

ANITA – Antarctic Impulse Transient Antenna

ANTARES – Astronomy with a Neutrino Telescope and Abyss Environmental Research

APPEC – Astroparticle Physics European Consortium

APS- U: 4th generation light source

ARA – Askaryan *Radio* Array

ARIEL - Atmospheric Remote-sensing Exoplanet Large-survey, is one of the three candidate missions selected by ESA for its next medium class science mission

ARCHER - Advanced *Research Computing High End Resource*

ASKAP - Australian Square Kilometer Array Pathfinder

ASTeC – Accelerator Science and Technology Center. A facility that studies all aspects of the science and technology of charged particle accelerators

Astra Gemini - high power, ultra-short pulse, high repetition-rate laser.

ATLAS – A Toroidal LHC Apparatus. One of two general-purpose detectors at the LHC investigating the research of particle physics beyond the Standard Model.

AWAKE – UK Advanced Wakefield Experiment

AWE – Atomic Weapons Establishment

BEIS - Department for *Business, Energy and Industrial Strategy*

BepiColombo – A European mission to Mercury set to launch in 2018

Big Bear – Solar Observatory

BIS - Business, Innovation and Skills

BiSON - Birmingham Solar-Oscillations Network

BICEP - Background Imaging of Cosmic Extragalactic Polarization

BoP - Balance of Programmes, review which looked at the balance of funding between the Frontier Science research disciplines.

BOSS - Baryon Oscillation Spectroscopic Survey

CAP – Computing Advisory Panel

CASU - Cambridge Astronomical Survey Unit

CDR - Critical Design Review

CDT - Centre for Doctoral Training

CERN – European Organisation for Nuclear Research. A European research organisation operating the largest physics laboratory in the world

CGPS - Capital Grants to the Private Sector

CHANDRA - The Chandra X-ray Observatory, previously known as the Advanced X-ray Astrophysics Facility, is a Flagship-class space observatory launched on STS-93 by NASA

CHEOPS - CHaracterising ExOPlanets Satellite, is a planned European space telescope for the study of the formation of extrasolar planets

CHIPS - CHerenkov detectors In mine PitS. Uses a unique concept in neutrino oscillations physics as it aims to build megaton neutrino detectors cheaply and flexibly

CI – Cockcroft Institute. An international center for Accelerator Science and Technology in the UK

CLARA - Compact Linear Accelerator for Research and Applications

CLASP – Challenge Led Applied Systems Programme

CLIC – Compact Linear Collider. A proposed collider which will collide electrons and positrons at energies of several TeV to study the underlying physics between these interactions

CLOVER - Collaboration between Cardiff AIG, Oxford Astrophysics and the Cavendish Astrophysics Group, aiming to build the next generation of CMB polarimeter.

Cluster - An ESA Cornerstone mission launched in 2000 with the primary aim to make major breakthroughs in the understanding of how the Earth's magnetosphere works and the Earth's response to the ever changing solar-wind and the influence exerted by the ionosphere

CMB - Cosmic Microwave Background

CMB S4 - a concept for the ultimate ground-based CMB observatory

CMOS – Complementary metal–oxide–semiconductor

CMS – Compact Muon Solenoid. A general purpose detector at the LHC with a broad physics programme ranging from studying the Standard Model to dark matter

COBE - Cosmic Background Explorer

COMET – Coherent Muon to Electron Transition. An experiment which aims to measure muon to electron conversion in the presence of a nucleus with unprecedented accuracy.

This process is forbidden by the Standard Model of particle physics, however models beyond the Standard Model predict this to exist

CNSA – China National Space Administration

COSMOS - Super Computer located in the Stephen Hawking Centre for Theoretical Cosmology (CTC) at Cambridge University, is dedicated to research in cosmology, astrophysics and particle physics

COSMOMC - Fortran 95 Markov-Chain Monte-Carlo (MCMC) engine to explore the cosmological parameter space, plus a Python suite for plotting and presenting results.

COST Actions – COST Actions are bottom-up science **and technology networks, open to researchers and stakeholders** with a duration of four years.

CPU - *central processing units.*

C-RSG - Computing Resources Scrutiny Group. The purpose of the C-RSG is to inform the decisions of the Computing Resources Review Board (C-RRB) for the LHC experiments

CSR - Comprehensive Spending Review

CTA – Cherenkov Telescope Array. A project to build the next generation ground-based very high energy gamma-ray instrument providing a deep insight into the non-thermal high-energy Universe

DAMA – DArk Matter

DAQ - Data acquisition

DARA – Development in Africa with Radio Astronomy

DEAP - The DEAP-3600 experiment is located 2 km underground at SNOLAB

DEAP – Dark Matter Experiment using Argon Pulseshage discrimination

DES – Dark Energy Survey

DESI – Dark Energy Spectroscopic Instrument. An instrument which will measure the effect of dark energy on the expansion of the Universe

DFSZ – Dine-Fischler-Srednicki-Zhitnitsky

DLA - Dielectric Laser Accelerator

DLS - Diamond Light Source - UK's national synchrotron science facility, located at the Harwell Science and Innovation Campus in Oxfordshire.

DiRAC – Distributed Research utilising Advanced Computing. The integrated supercomputing facility for theoretical modelling and HPC-based research in astronomy, particle physics and cosmology

Diamond II - 4th generation light source

DKIST – Daniel K. Inouye Solar Telescope. A collaboration of 22 institutions in which the construction phase of the project to build the next ground-based solar telescope is now underway

DM-ICE – A NaI(Tl) direct detection dark matter experiment

DM-TPC – Dark Matter Time Projection Chamber

DOE CD-1/2/3/4 – Department of Energy's Critical Decision

DRIFT – Directional Recoil Identification from Tracks

DSCOVR - Deep Space Climate Observatory is a NOAA space weather, space climate, and Earth

DTC – Doctoral Training Centre

DUNE – Deep Underground Neutrino Experiment. A proposed international experiment for neutrino science and proton decay studies

E203 - Single-Shot Determination Of the Profile of FS Long Bunches

E210 - E210 - Trojan Horse InjecDon for High Brightness Beam GeneraDon &DiagnosDc System

E&T – Education and Training

ECFA - European Committee for Future Accelerators

ECR – Early Career Researcher

eEDM experiment – Electron Electric Dipole Moment Experiment. An experiment looking to measure the electric dipole moment of the electron

E-ELT – European Extremely Large Telescope. A telescope under construction which will have a 39-m main mirror and will be the largest optical/near-infrared telescope in the world. First light is targeted for 2024

EGI – European Grid Initiative

EIC – Electron-ion collider

Electra-II - 4th generation light source

ELI-NP – Extreme Light Infrastructure Nuclear Physics. ELI-NP will consist of both a very high intensity laser system and a very intense brilliant γ beam both of which will create a new European laboratory with a broad range of science covering fundamental physics, nuclear physics and astrophysics

e-MERLIN – Multi-Element Radio Linked Interferometer Network. A radio interferometer consisting of seven radio telescopes run from the Jodrell Bank Observatory by the University of Manchester

EPAC - Extreme Photonics Application Centre

EPSRC - Engineering and Physical Sciences Research Council

ERC – European Research Council. A public body for the funding of scientific and technological research conducted within the European Union

ERF - Ernest Rutherford Fellowships

ERIC - European Research Infrastructure Consortium

ESA – European Space Agency. An international organisation that comprises programmes designed to research the Earth, its space environment, our Solar System and the Universe and which develops satellite-based technologies and services

ESF EuroCORES – The European Collaborative Research Scheme is to enable researchers in different European countries to develop collaboration and scientific synergy in areas where European scale and scope are required to reach the critical mass necessary for top class science in a global context.

ESFRI – European Strategy Forum on Research Infrastructures

ESO – European Southern Observatory. ESO provides research facilities to astronomers and astrophysicists by building and operating powerful ground-based telescopes enabling important scientific discoveries

ESRF - European Synchrotron Radiation Facility

ESS – European Spallation Source. A research facility currently under construction that will contain the world's most powerful neutron source

ET – Einstein Telescope. A proposed third-generation ground-based gravitational wave detector that will test Einstein's theory of general relativity and build on precision gravitational wave astronomy

EU - European Union

Euclid - A planned joint ESA/NASA project space telescope, its goal is to map the large scale distribution of dark matter and characterize properties of dark energy

EuPRAXIA – European Plasma Accelerator with superior Beam quality

EVN - European VLBI Network

FAIR – Facility for Antiproton and Ion Research. A new international accelerator facility for the research using antiprotons and ions. It is currently under construction.

FEE – Front-end electronics

FETS – Front End Test Stand

FCC – Future Circular Collider. The FCC study explores the feasibility of different particle collider scenarios with the aim of significantly expanding the energy and luminosity of future detectors

FEC - Full Economic Costing

FEL – Free Electron Laser. A type of laser in which the medium consists of very high speed electrons moving freely through a magnetic structure

FNAL – Fermi National Accelerator Laboratory, USA

FP - Framework Programmes. Funding programmes created by the European Union/European Commission to support and foster research in the European Research Area

FTE - Full Time Equivalent

G3 - Generation-3

GAIA – An ESA mission to map the three-dimensional view of our Galaxy revealing its composition, formation and evolution.

GCRF – Global Challenges Research Fund

GCT – Gamma-ray Cherenkov Telescope

GEO-HF – UK/German gravitational wave detector - High Frequency

GeV – gigaelectronvolt

GOTO - Gravitational-wave optical transient observatory

GPU – Graphics processing unit

GR - Einstein's General Theory of Relativity

GrEAT - Gravitational-wave Excellence through Alliance Training

GRETA – Gamma-Ray Energy Tracking *Array*

GTC – Gran Telescopio Canarias

GTO – Guaranteed Time Observations

GUT – Grand unified theory

GW – Gravitational waves. Ripples in the curvature of spacetime which propagate as a wave, travelling outward from the source

GridPP – Grid for UK Particle Physics. A collaboration of particle physicists and computer scientists based in the UK and at CERN who contribute to the development of new open source software and applications needed to power large-scale distributed computing for particle physics and beyond

H2020 - Horizon 2020. The biggest EU Research and Innovation programme with nearly €80 billion of funding available over 7 years (2014 to 2020)

H2020 – INFRAIA – Horizon 2020 related call for integrating and opening Research Infrastructures of European interest.

HARMONI - is a visible and near-infrared (0.47 to 2.45 μm) integral field spectrograph, providing the E-ELT's core spectroscopic capability

HARPS3 - UK-lead international project to build an instrument that will search for Earth-like planets around other stars. It will be placed on the Isaac Newton Telescope, a 2.5m telescope run by the ING, in 2021.

HAWC – High-altitude Water Cherenkov (observatory)

HDR Imaging - High-dynamic-range imaging

HE LHC – High Energy – Large Hadron Collider

HEPS - 4th generation light source

HESS – High Energy Stereoscopic System

HET – Hobby Eberly Telescope

HIC - Heavy Ion Collisions

HINODE - The Solar-B mission, was launched in September 2006, carrying instruments developed by Japan, the USA and the UK. Building on the highly successful SOHO and YohKoh solar missions, Hinode is studying the fundamental question of how magnetic fields interact with plasma to produce solar variability.

HiRES – High Resolution Echelle Spectrometer. A spectrograph which operates between 0.3 and 0.1 microns at the Keck Observatory and has been used for the detection of exoplanets and to test our model of the Big Bang theory

HL-LHC – High-Luminosity Large Hadron Collider. An upgrade to the LHC which aims to increase the luminosity by a factor of 10 beyond the LHC's design value

HoD – Head of Department

HPC – High Performance Computing. The use of parallel processing for running advanced application programmes efficiently, reliably and quickly

HST – Hubble Space Telescope

HTC - High Throughput Computing

HV – High vacuum

Hyper-K – **Hyper-Kamiokande detector**. The detector consists of a megaton scale water tank and ultra-high sensitivity photosensors. Neutrinos are used to make observations of elementary particles and also the Sun and supernovae

IAB - Innovation Advisory Board

IACT - Imaging Air Cherenkov Telescope

ICEC - International Cancer Expert Corps

IceCube - South Pole neutrino observatory, is a cubic-kilometer particle detector made of Antarctic ice and located near the Amundsen-Scott South Pole Station.

ICP-MS - Inductively coupled plasma mass spectrometry

ILSF - 4th generation light source

ING-INT – Isaac Newton Group of Telescopes

INT – Isaac Newton Telescope

IP – Intellectual Property

IRIS - is an image processing software for astrophotography. IRIS is free for non-commercial usage.

ISIS Neutron Source - world-leading centre for research in the physical and life sciences at the STFC Rutherford Appleton Laboratory near Oxford in the United Kingdom

ILC – International Linear Collider. The proposed ILC would complement the LHC at CERN and would consist of two linear accelerators to further our understanding of the nature of dark matter and dark energy

IoP - Institute of Physics

IPPP – Institute for Particle Physics Phenomenology. An international center for research in particle physics phenomenology – the bridge between theory and experiment in the study of the tiny building blocks of all matter in the universe and of the fundamental forces that operate between them

IPS - *Innovations Partnership Scheme*

IR – infrared

ISCF – Industrial Strategy Challenge Fund

ISOL-SRS – ISOL Beam Storage Ring Spectrometer. A proposed spectrometer which will aid in precision studies of the reactions and properties of unstable nuclei across the vast range of masses and isotopes produced by the ISOLDE radioactive beams facility at CERN

ISRO – Indian Space Research Organisation

JAI – John Adams Institute. The John Adams Institute for Accelerator Science provides expertise, research, development and training in accelerator techniques, promoting advanced accelerator applications in science and technology

JAXA – Japan Aerospace Exploration Agency. Japan's national aerospace agency

JCMT - James Clerk Maxwell Telescope is a submillimetre-wavelength telescope at Mauna Kea Observatory in Hawaii.

JES – Joint Electronic System

JET - Joint European Torus at Culham

JISC – Joint Information Systems Committee

JIVE - is the Joint Institute for VLBI (Very Long Baseline Interferometry) ERIC (European Research Infrastructure Consortium).

JLab – Thomas Jefferson National Accelerator Facility (Jefferson Lab). One of 17 national laboratories funded by the US Department of Energy. Its mission is to conduct basic research of the atom's nucleus using the lab's accelerator

JUICE – Jupiter Icy Moon Explorer. A planned ESA spacecraft to visit the Jovian system, focussed on studying Jupiter's Galilean moons

JVLA - Karl Jansky Very Large Array

JWST – James Webb Space Telescope. The successor to the Hubble Space Telescope, the JWST is a major space observatory currently under construction and scheduled to launch in 2018. It will operate at wavelengths ranging from 0.6-27μm

Kaon - Any of a group of four mesons (subatomic particles made of one quark and an antiparticle version of a quark)

KM3NET – Cubic Kilometre Neutrino Telescope

KSP – Key Science Projects

LAr – Liquid Argon

Lattice QCD - A non-perturbative (see Perturbation Theory) approach to solving the QCD

LBNE - Long Baseline Neutrino Experiment. A high energy physics project, currently in its design phase that will combine the world's most intense long-distance neutrino beam and

world's largest particle detector to reach unprecedented sensitivity and precision in measuring quantum mechanical mixing in the neutrino sector

LBNF - Long Baseline Neutrino Facility

LCLS - *Linac Coherent Light Source*

LHC – Large Hadron Collider. The world's largest and most powerful particle collider located at CERN

LHCb – Large Hadron Collider beauty. A study undertaken at CERN's LHC to investigate b and anti-b quark decays

LHCC – LHC Experiments Committee. A committee created to interact with LHC collaborators to discuss detector designs and to review the construction, installation and commissioning of the experiments

LHeC –Large Hadron Electron Collider. A project under design for combining the intense hadron beams of the LHC and possible future Circular Hadron Collider with a new electron accelerator at CERN

LIDAR - Light Detection And Ranging. Surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor.

LIGO – Laser Interferometer Gravitational-Wave Observatory. A national facility for gravitational wave research comprising two interferometers, one in Washington and one in Louisiana. The detectors use laser interferometry to measure the ripples in space-time caused by passing gravitational waves from astrophysical sources

LINAC - Linear accelerator

LISA – Laser Interferometer Space Antenna (NASA/ESA). A proposed ESA mission designed to detect and accurately measure gravitational waves. It has been re-named to eLISA

LiteBIRD – The light satellite for the studies of B-mode polarisation and inflation from cosmic background radiation detection

LJMU – Liverpool John Moors University

LOFAR – Low Frequency Array. A radio telescope working at the lowest frequencies accessible from Earth. The array is currently under construction and, when completed, will be able to survey wide areas of sky simultaneously

LSC-Virgo – LIGO Scientific Collaboration - Virgo

LSST – Large Synoptic Survey Telescope. Currently under construction in Chile, the LSST will be used to image the sky at optical wavelengths and will be able to detect faint astronomical objects with unprecedented resolution

LT - Liverpool Telescope. A 2-metre fully robotic Ritchey–Chrétien telescope that observes autonomously

LWFA – Laser Wakefield Acceleration

LZ – Lux Zeplin. Large Underground Xenon (LUX) ZonEd Proportional Scintillation in Liquid Noble gasses (ZEPLIN). A next generation dark matter experiment to search for Weakly Interacting Massive Particles (WIMPS)

M&O - Maintenance and Operation

MAGIC - Major Atmospheric Gamma-ray Imaging Cherenkov Telescope

MAPS – Monolithic Active Pixel Sensors

MAX IV – 4^{th} generation light source

mDOMs – Digital Optical Modules

MeerKat - Karoo Array Telescope. Radio telescope under construction in the Northern Cape of South Africa, will be an array of 64 interlinked receptors

METIS – is a powerful spectrograph will allow astronomers to investigate the basic physical and chemical properties of exoplanets

MICE – Muon Ionization Cooling Experiment. A high-energy physics experiment designed to demonstrate ionisation cooling of muons

MicroBooNE - a liquid argon time projection chamber (LArTPC) at Fermilab in Batavia, IL

MINOS – Main Injector Neutrino Oscillation Search. A long baseline experiment designed to study neutrino oscillations in a controlled accelerator experiment and to measure the oscillation parameters

MOONS – Multi Object Optical and Near-infrared Spectrograph. A large field, multi object instrument proposed for the VLT, which will conduct research into galactic structure and galaxy evolution up to the epoch of re-ionisation

MOS – Multi Object Spectrograph. Used to obtain the spectra of many objects simultaneously

MOASIC - a multi-object spectrograph

MPI – Max Planck Institute

MRC – Medical Research Council

Mu2e/Mu3e – Muon to Electron conversion experiments. Two experiments designed to observe muon-to-electron conversion which will better our understanding of why particles in the same family decay from heavy to lighter and more stable mass states

Muon – One of the fundamental particle of nature, essentially a sort lived heavier version of the electron

MWA - Murchison Widefield Array - joint project between an international consortia of organisations to construct and operate a low-frequency radio array.

NA62 - An experiment focused on precision tests of the Standard Model by studies of rare decays of charged kaons

NAMRC - Nuclear Advanced Manufacturing Research Centre

NARIT - National Astronomical Research Institute of Thailand

NASA - National *Aeronautics and Space Administration*

NDBD - Neutrinoless Double Beta Decay+

nEDM – Neutron Electric Dipole Moment. A measure for the distribution of positive and negative charge inside the neutron

NEI – National eInfrastructure

NEXTBAS - a concept for a low frequency array to measure the foregrounds which could hinder the extraction of the CMB polarization signal

NGTS – Next-Generation Transit Survey. A wide-field photometric survey designed to discover transiting exoplanets

NLS – New Light Sources

NOvA - NuMI Off-Axis νe Appearance. An experiment designed to detect neutrinos in Fermilab's NuMI beam

NP - Nuclear Physics

NPGP - Nuclear Physics Grants Panel

NSO – National Schools Observatory

NTEC – Nuclear Technology Education Consortium

NuCAR – Nuclear Astrophysics at Rings

NuPECC – Nuclear Physics European Collaboration Committee

NuSTAR – Nuclear Structure, Astrophysics and Reactions. A collaboration with the aim of exploiting the beams of short-lived radioactive species to study how the properties of nuclei and nuclear matter vary over a wide range of properties

NuSTORM – Neutrinos from Stored Muons. A proposed storage ring facility designed to provide measurements of neutrino and antineutrino nucleus scattering cross sections

PA - Particle Astrophysics

PAAP - Particle Astrophysics Advisory Panel. To provide a link between Science Board and the particle astrophysics community, and represent the needs of the community to STFC

PAPE – Particle Astrophysics Programme Evaluation

PB – Petabyte

PCP – Pre-Construction Phase

PD- Programmes Directorate

PDFs - Parton Distribution Functions

PDRA - Postdoctoral Research Assistant

PEP-X - 4th generation light source

PET - Positron Emission Tomography - scan is an imaging test that helps reveal how your tissues and organs are functioning.

Petra-IV - 4th generation light source

PhenoGrid - LCG virtual organisation dedicated to developing the phenomenological tools necessary to interpret the events produced by the LHC

PI – Principal Investigator

PINGU - *Precision IceCube Next Generation Upgrade*

PIP *- Proton Improvement Plan*

PLANCK *- Space observatory operated by the European Space Agency to study Cosmic Microwave Background (CMB) – the relic radiation from the Big Bang.*

PLATO *- PLAnetary Transits and Oscillations of stars (PLATO) is a space telescope under development*

PMT – Photomultiplier tube

Polarbear in Atacama - cosmic microwave background polarization experiment located in the Atacama Desert of northern Chile in the Antofagasta Region

PP - Particle Physics

PPAN - Particle Physics, Astronomy & Nuclear Physics

PPD - *Particle Physics Department* at *RAL*

PPE - Particle Physics Experimental

PPGP - Particle Physics Grants Panel. Responsible for assessing and making recommendations to the STFC Executive on research grant applications in particle physics covering scientific exploitation of facilities and projects, 'blue skies' technology research, theory, modelling, data handling and HPC access

PPRP - *Projects Peer Review Panel.* Responsible for the assessment of projects that are considered to have significant scientific priority in particle physics, nuclear physics, astronomy and particle astrophysics

PPT - *Particle Physics Theoretical*

PRD – Project, Research and Development grant

PRACE - Partnership for Advanced Computing in Europe

PRD - Project research & Development

PRISTINE - a proposed F-class ESA mission to measure spectral distortions of the CMB.

PSI - *Paul Scherrer Institute*

PWFA – FEL *- plasma electron-beam driven wakefield accelerator (PWFA) based free-electron-lasers (FEL).*

QCD – Quantum Chromodynamics. A theory of the strong interaction.

QED - Quantum Electro Dynamics

QFT - *Quantum field theory*

QUest at DASI (QUaD) *- QUEST at DASI, was a ground-based cosmic microwave background polarization experiment at the South Pole.*

RAC - *Resource Allocation Committee*

RAL - Rutherford Appleton Laboratory. One of the national scientific research laboratories in the UK operated by the Science and Technology Facilities Council

RAS – Royal Astronomical Society

RCUK - Research Councils UK

REF – Research Excellence Framework

ResearchFish –service for the collection and reporting of outcomes to enable research impact tracking.

RHESSI - Reuven Ramaty High Energy Solar Spectroscopic Imager

RIKEN – Institute of Physical and Chemical Research. A large research institute in Japan which conducts research in many areas of science including physics, chemistry, biology, engineering and medical science

ROSA - Resources for Open Science in Astronomy

RRB - Resources Review Boards

RSE – Royal Society of Edinburgh

RTT - Radiation Therapy Treatment

SABRE - Sodium-iodide with Active Background Rejection

SBND – Short Baseline Near Detector. One of three liquid argon neutrino detectors at Fermilab as part of the Short-Baseline Neutrino Program which will perform searches for neutrino oscillations

SCRF - Super Conducting Radio Frequency

SDO - Solar Dynamics Observatory is a NASA mission which has been observing the Sun since 2010.

SDP – Science Data Processor

SEAB - Skills and Engagement Advisory Board

SESAME - Synchrotron-light for Experimental Science and Applications in the Middle East

SEY - secondary electron yield

SGSO - Southern Gamma-ray Survey Observatory

SHiP – Search for Hidden Particles. A new general purposed fixed target facility located at CERN used to search for hidden particles such as very weakly interacting long lived particles

SiC – Silicon Carbide

SiP - Strength in Places Fund

SiPM – Silicon Photo MultipliersTERAS

SIRIUS - 4th generation light source

SKA – Square Kilometre Array. A radio interferometer currently under construction in Australia and South Africa which will address key topics in astrophysics, fundamental physics, cosmology and particle astrophysics

SK-Gd Project – Super-K-Gadolinium Project

SLAC FACET - Stanford Linear Accelerator Center, Facility for Advanced Accelerator Experimental Tests

SLS-II: 4th generation light source

SME – Small and Medium Enterprise

SNO – Sudbury Neutrino Observatory. Decommissioned in 2006, the SNO was an underground neutrino observatory located in Sudbury, Canada

SNO+ - Sudbury Neutrino Observatory +. A new kilo-tonne scale liquid scintillator detector that will study neutrinos

SNOLAB - Sudbury Neutrino Observatory

SO - Simons Observatory (SO): a ground-based observatory presently being constructed in Chile already with significant UK involvement

SoHO - Solar and Heliospheric Observatory is a spacecraft built by a European industrial consortium led by Matra Marconi Space

SOI – Statement of Intent

Solar Orbiter- a planned Sun-observing satellite, under development by the ESA

Solei-U - 4th generation light source

SoLiD - Short baseline Oscillation search with Lithium-6 Detector

SPECT/CT Scan - Single Photon Emission Computed Tomography / Computed Tomography

SPES – Società di Progettazione Elettronica e Software (Electronic Design and Software Company)

SPF - Strategic Priorities Fund

SPT – South Pole Telescope

SRF – Superconducting Radio Frequency

SSAP - Solar System Advisory Panel

SST - Small-Sized Telescope or Spitzer Space Telescope, a space telescope

STA - Scintillator Tracking Array

STEM - science, technology, engineering and mathematics

STEREO - Solar Terrestrial Relations Observatory, is a solar observation mission. Two nearly identical spacecraft were launched in 2006 into orbits around the Sun that cause them to respectively pull farther ahead of and fall gradually behind the Earth.

STFC – Science and Technology Facilities Council. A UK government body that carries out research in science and engineering and funds research in particle physics, nuclear physics, space science and astronomy

SuperNEMO – Super Neutrino Ettore Majorana Observatory Demonstrator. A next generation experiment to search for Neutrinoless Double Beta Decay, the only way to investigate the fundamental nature of the neutrino

SUSY – *supersymmetry*

SWFA *- Structured wakefield accelerators*

SWIFT *- multi-wavelength observatory dedicated to the study of gamma-ray burst (GRB) science.*

T2K – Tokai to Kamioka (collaboration). A long-baseline neutrino experiment in Japan to study neutrino oscillations

TARGET – TeV Array Readout Electronics with GSa/s sampling and Event Trigger

TERAS - TEchnologies for RAre event Searches

TESS - Transiting Exoplanet Survey Satellite, is a space telescope for NASA's Explorers

TDRs - Technical Design Reports

THEMIS - Thermal Emission Imaging System, a camera on the Mars Odyssey spacecraft

TOPCAT - software package widely used in astronomy with a worldwide user base.

THOR - Turbulence Heating ObserveR

THz - terahertz

TORCH – Time Of Internally Reflected Cherenkov Light

TRAPPIST 1 - ultra-cool red dwarf star that is slightly larger, but much more massive, than the planet Jupiter; it is located 39.6 light-years from the Sun in the constellation Aquarius.

TRL – Technology Readiness Level

TWI – The Welding Institute

UAV – Unmanned aerial vehicle

UCL – University College London

UCLA - University of California, Los Angeles

UHE – Ultra High Energy

UK AION – UK Atom Interferometer, Observatory Network

UKATC – UK Astronomy Technology Center. The national center for astronomical technology and part of the STFC. UK ATC designs and builds instruments for many of the world's major telescopes and carries out observational and theoretical research in astronomy and astrophysics

UK FEL - UK Free Electron Laser community

UKMHD - *Consortium* Super Computing facilities

UK PATT – Panel for Allocation of Telescope Time

UKRI – UK Research and Innovation

UKRI FIC – UKRI Fund for International Collaboration

UKSA – UK Space Agency. UKSA are responsible for all strategic decisions on the UK civil space programme

UKT0 - UK-Tier Zero

URF – University Research Fellowship

US NSF – United States National Science Foundation

UV – Ultra-Violet

UWS – University of the West of Scotland

VERITAS - Very Energetic Radiation Imaging Telescope Array System

VHE – Very high energy

VHEE - very high electron energy

VIRGO - Consortium for Cosmological Supercomputer Simulations

VISTA - Visible and Infrared Survey Telescope for Astronomy

VLA - Very Large Array

VLBI - Very Long Baseline Interferometry

VLT – Very Large Telescope. A telescope facility operated by ESO in the Atacama Desert in Chile. It comprises four optical telescopes used together to achieve very high angular resolution

VSA – Very Small Array

VST – VLT Survey Telescope

WEAVE – WHT Enhanced Area Velocity Explorer. A concept for a new wide-field spectroscopy facility for the 4.2-m Herschel Telescope

WFA – CASU - package of several programs that are routinely used on the pipeline processing at Cambridge Astronomical Survey Unit.

WFA-WFAU - Wide-Field Astronomy Unit at Edinburgh

WHT – William Herschel Telescope

WIMPs - Weakly Interacting Massive Particles

WLCG – Worldwide LHC Computing Grid

WMAP - Wilkinson Microwave Anisotropy Probe

XFEL – European X-ray Free Electron Laser. A subterranean X-ray research laser facility currently under construction which is planned to start operation in 2017

XMM-Newton – X-ray Multi-Mirror Mission – Newton. An ESA space mission which comprises three X-ray telescopes used to conduct research including the study of black holes and the origins of the Universe