STFC Science Programme

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Key Science Questions

A: How did the universe begin and how is it evolving?

A:1. What is the physics of the early universe?
A:2. How did structure first form?
A:3. What are the roles of dark matter and dark energy?
A:4. When were the first stars, black holes and galaxies born?
A:5. How do galaxies evolve?
A:6. How are stars born and how do they evolve?

B: How do stars and planetary systems develop and is life unique to our planet?

B:1. How common are planetary systems and is ours typical?
B:2. How does the Sun influence the environment of the Earth and the rest of the Solar System?
B:3. Is there life elsewhere in the universe?

C: What are the fundamental constituents and fabric of the universe and how do they interact?

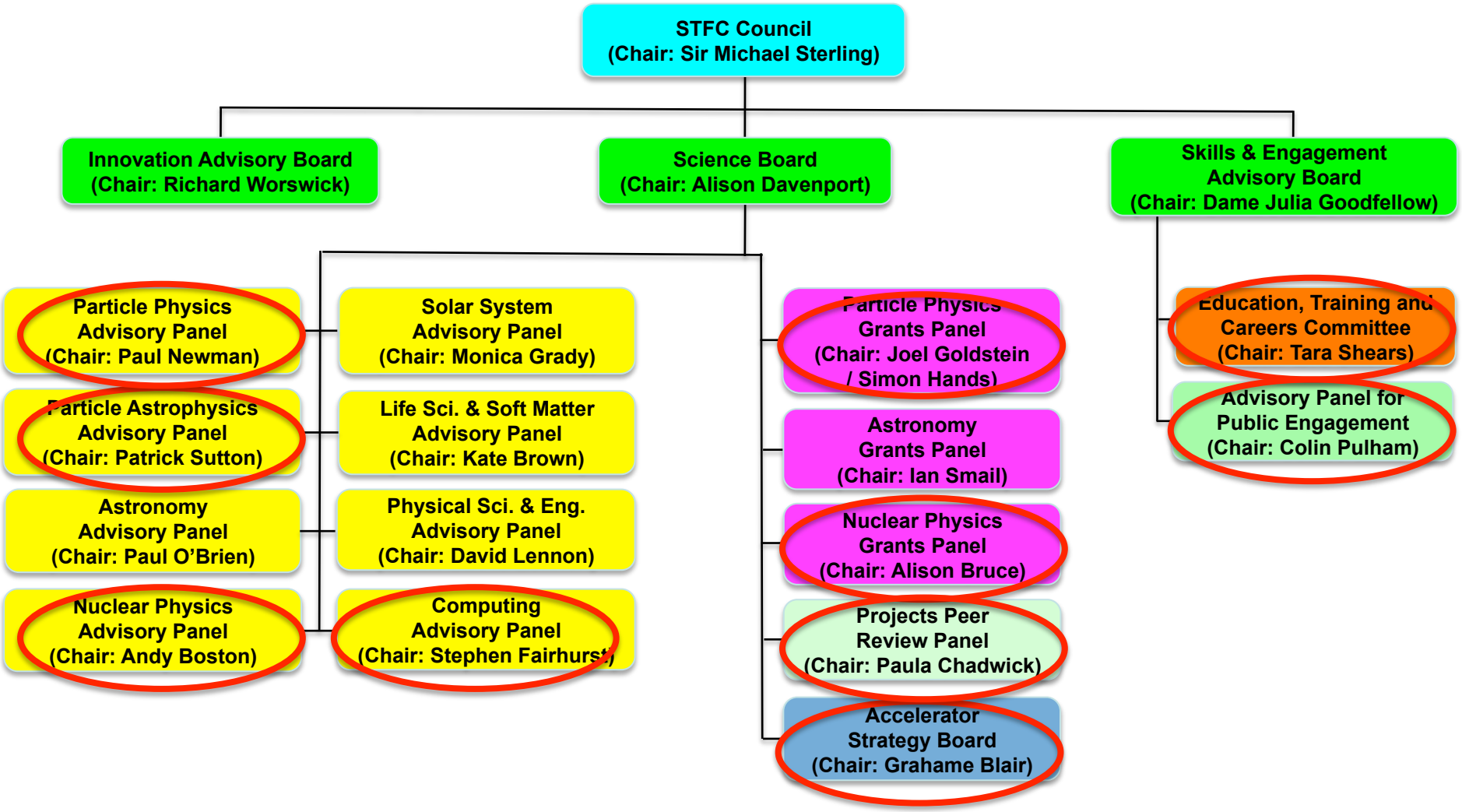
C:1. What are the fundamental particles?
C:2. What is the nature of space - time?
C:3. Is there a unified framework?
C:4. What is the nature of dark matter?
C:5. What is the nature of dark energy?
C:6. What is the nature of nuclear and hadronic matter?
C:7. What is the origin of the matter - antimatter asymmetry?

D: How can we explore and understand the extremes of the universe?

D:1. How do the laws of physics work when driven to the extremes?
D:2. How can high energy particles and gravitational waves tell us about the extreme universe?
D:3. How do ultra-compact objects form, what is their nature and how does extreme gravity impact on their surroundings?

http://www.stfc.ac.uk/questions

STFC Advisory Structure



- **This talk: focus on Particle, Astroparticle, Nuclear and Accelerator Physics**

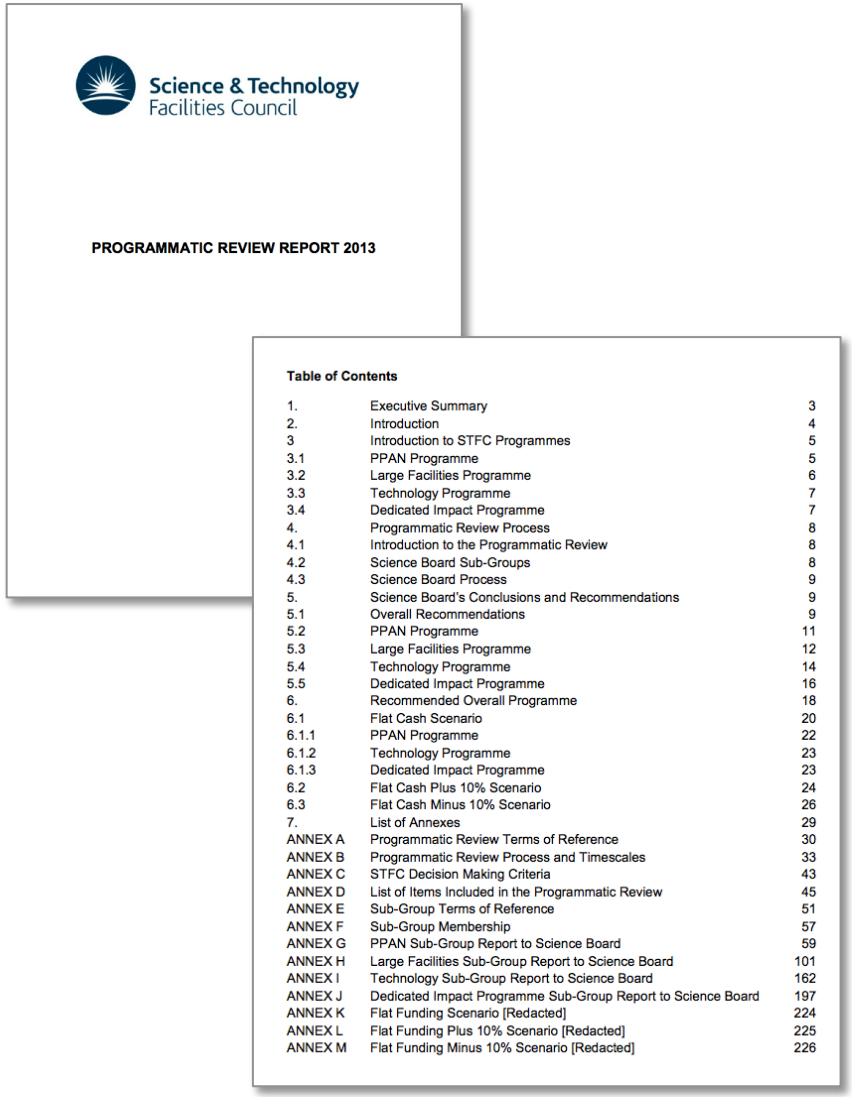
Community Input

- **Advisory Panels provide community view on science priorities in each area**
  - **Key input to Programmatic Review**
  - **Reports refreshed annually**
- **Regular Town Meetings**
  - **Annual IOP meetings (HEPP, Particle Astro, Nuclear, Accelerators and Beams)**
  - **RAS National Astronomy Meeting**
  - **Additional meetings as required**

STFC Programmatic Review

- Key process for identifying strategic priorities and setting budget envelopes
- Includes all aspects of science programmed including Particle Physics, Particle Astrophysics Astrophysics, Nuclear Physics, Facilities, Technology, Impact
- Most recent 2012/13
- Written and coordinated by Science Board

http://www.stfc.ac.uk/review



Science & Technology Facilities Council

PROGRAMMATIC REVIEW REPORT 2013

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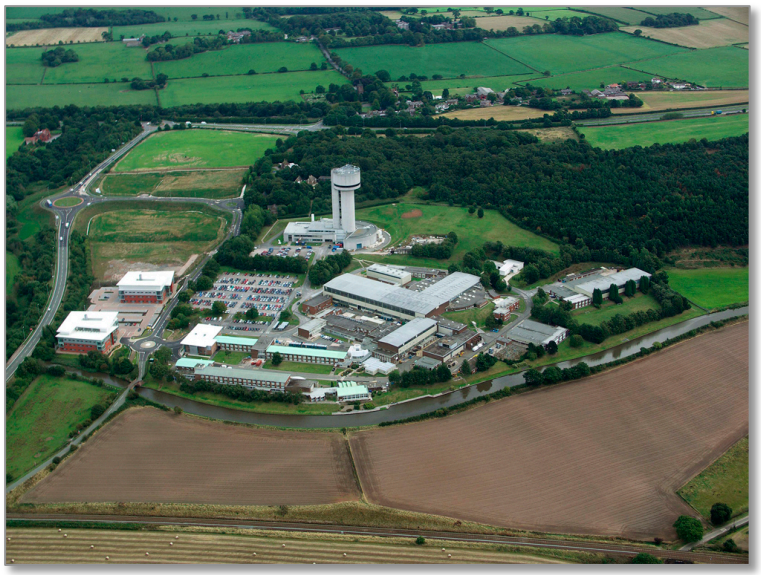
Science Support

- **STFC provides direct financial support through variety of routes:**
  - **Grants to institutes: mainly exploitation, basic R&D and theory**
  - **Project grants: design and construction of experiments**
  - **PRD grants: small-scale 'seed-corn' & technology R&D**
  - **Individual fellowships: science, impact and public engagement**
  - **PhD studentships**
- **International subscriptions**
- **Additional in-house support:**
  - **Particle Physics Department (RAL)**
  - **Technical Department (RAL)**
  - **Scientific Computing Department**
  - **Nuclear Physics Group (Daresbury)**
  - **ASTeC (Daresbury and RAL)**



Grants to Institutes

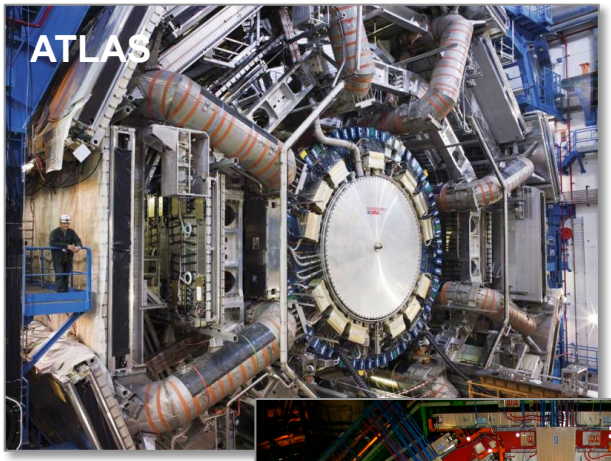
	Grants Line (£M p.a.)	No. Groups
Particle Physics Experiment	21.5 + 3.4 (PPD)	18
Particle Physics Theory	6.6	20
Nuclear Physics	4.2	10
Accelerator Science	3.6 + 8.3 (ASTeC)	7
Astronomy, including Astrophysics	30	45

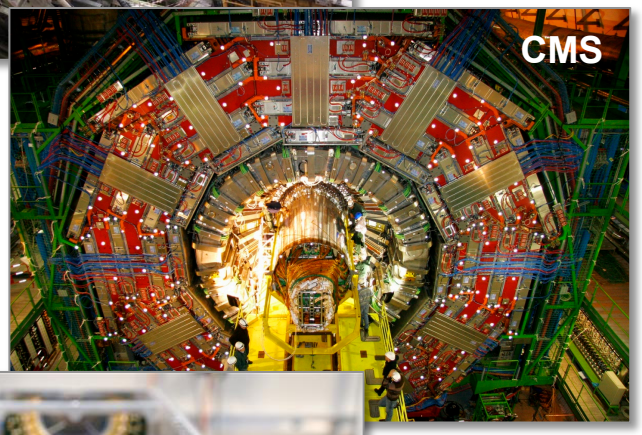
Notes:

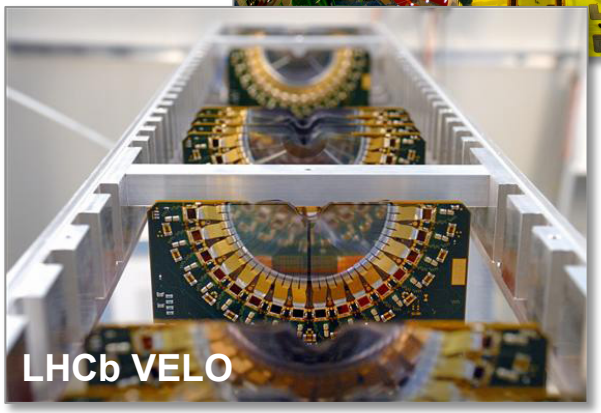
- Figures do not include funding for projects, or groups receiving only project funding
- Average group size varies greatly between fields
- Particle Astrophysics is generally included in Particle, Nuclear or Astrophysics lines
  - Exception for Gravitational Waves grants: £2M p.a.
- PP Experiment includes experiment M&O and low-level support for some projects
- PP Theory includes IPPP

Particle Physics

- Closely aligned with European Strategy for Particle Physics
- Highest priority is to fully exploit the LHC at CERN
  - Major UK contributions and leadership in ATLAS, CMS and LHCb (also ALICE – see later)
- LHC experiment upgrades strongly supported
  - ATLAS and CMS phase-1 upgrades construction and phase-2 R&D supported (total awards £34M & £12M respectively)
  - Bids for ATLAS and CMS phase-2 upgrade construction under preparation
  - LHCb upgrade construction funded (up to £9.2M)

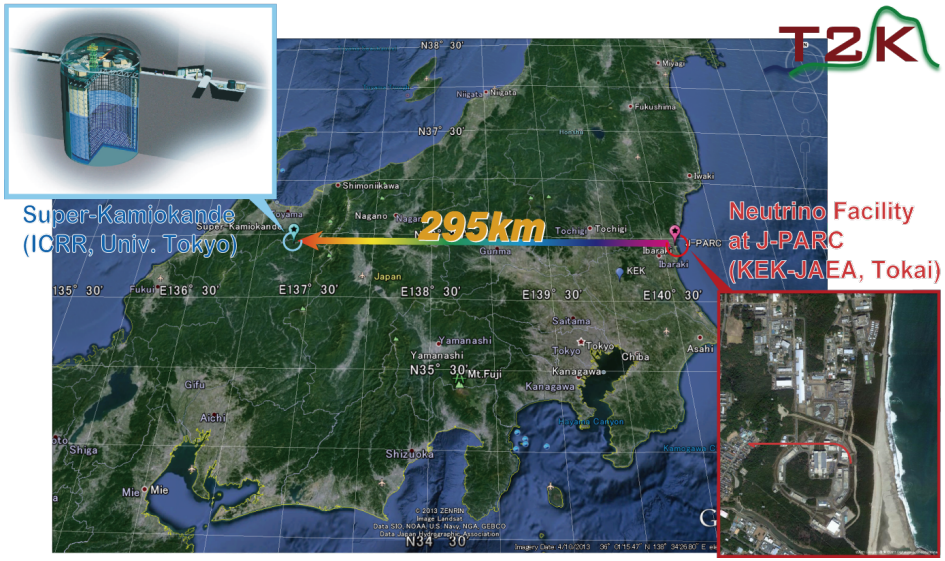


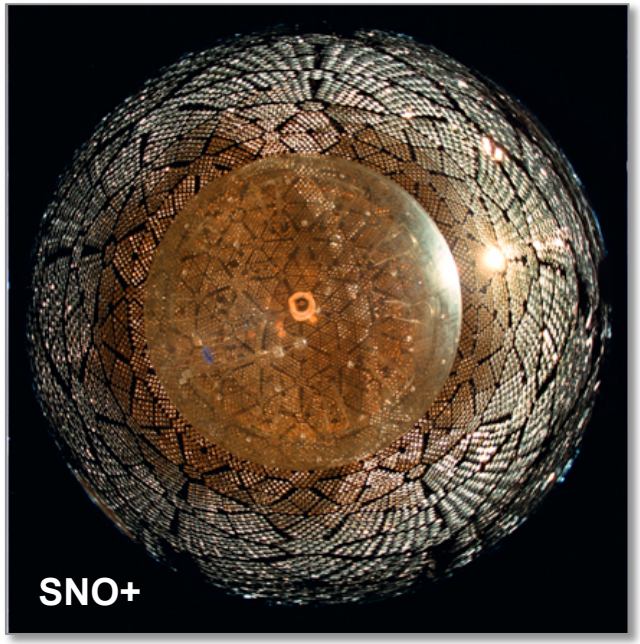




Particle Physics

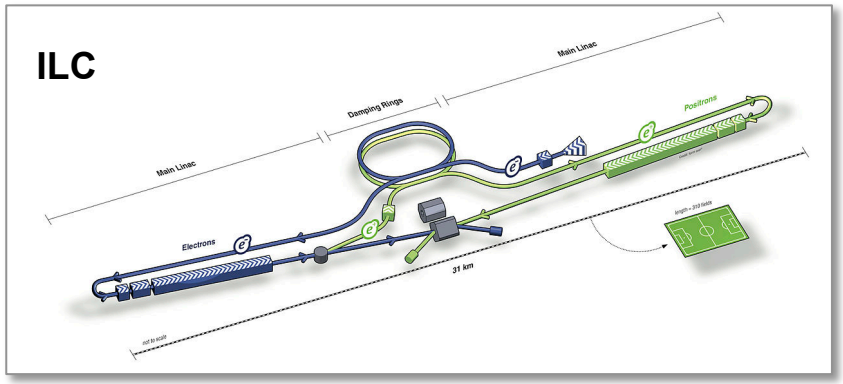
- **STFC fully supports the recent APPEC joint statement on neutrino physics**
  - **"*The agencies and laboratory directors … agreed that the understanding of the neutrino sector is a worldwide priority promising physics beyond the Standard Model.*"**
  - **http://www.interactions.org/cms/?pid=1033970**
- **Strongly supporting long baseline neutrino experiments**
  - **T2K and MINOS+ exploitation**
  - **R&D for LBNE/F, T2HK, CHiPS under consideration**
- **Supporting UK contributions to $0\nu\beta\beta$ experiments**
  - **SuperNEMO and SNO+**





Particle Physics

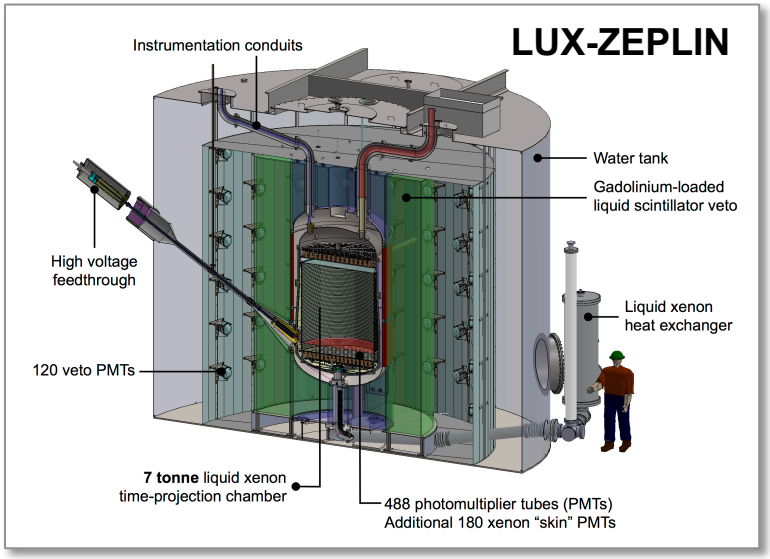
- Renewed support for UK ILC community engagement in advance of possible decision to host by Japan
- Recent support for UK participation in muon g-2 experiment at FNAL
- Support for experimental programme via Particle Physics and Technology Departments at RAL
- Support for theory via grants to universities and IPPP (Durham)




Muon g-2 ring arrives at FNAL

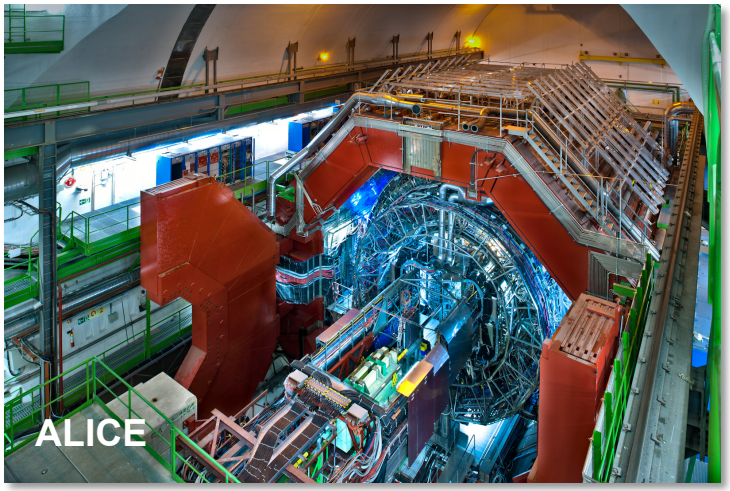
Particle Astrophysics

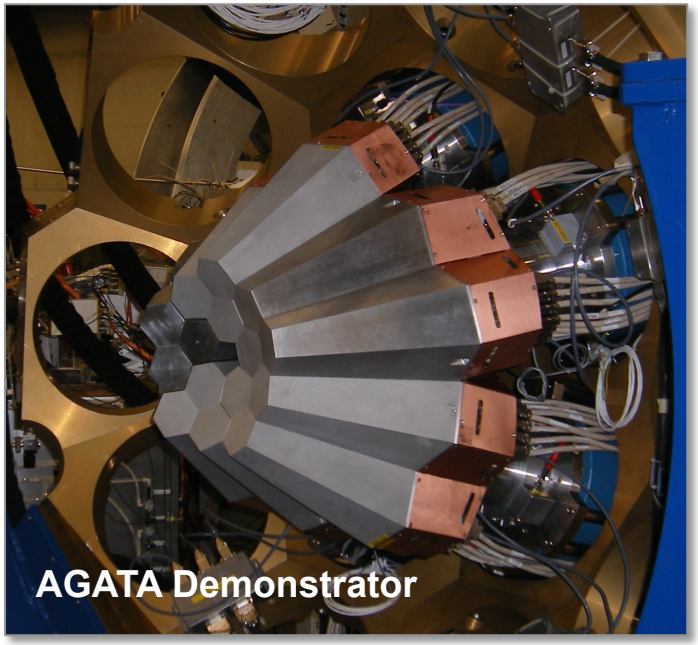
- Aligned with ASPERA roadmap
- Strong support for vibrant UK gravitational waves community:
  - Advanced LIGO construction is the highest priority particle astrophysics project: £8.9M
- CTA R&D supporting gamma-ray astronomy and indirect dark matter searches
- Direct dark matter searches with LUX-ZEPLIN
  - Ongoing R&D project
  - Construction bid under review
- Dedicated underground science facility at Boulby Mine
  - Low background screening (LZ)
  - Externally funded experiments



Nuclear Physics

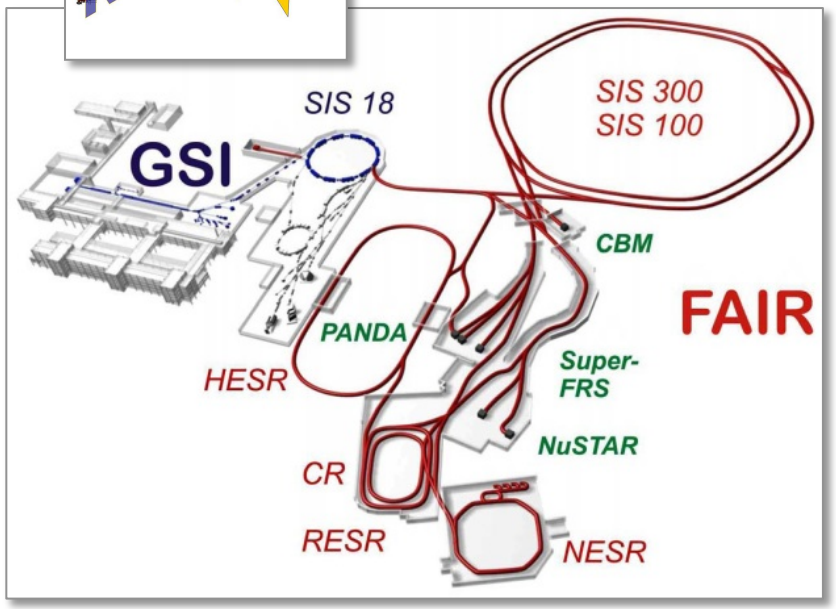
- Organised in two broad themes:
  - Nuclear structure and astrophysics
  - Hadronic physics
- Support for UK groups exploiting wide variety of international facilities
  - ISOLDE, Jyvaskyla, JLAB, GANIL etc.
  - Project support for AGATA and ALICE
- Additional support for community via
  - 'cross-community' instrumentation experts
  - Nuclear Physics group at Daresbury
- Strategic need for NP theory and modelling support identified by 2012 Institute of Physics review
  - Support for new NP theory group at York announced by STFC in September 2014





Nuclear Physics

- **Programmatic Review 2013:**
  - ***"We recommend that maintaining a balanced nuclear physics programme be a priority for the UK, enabling participation in new projects as well as exploitation of existing facilities."***
- **Top priority for the future is NuSTAR at FAIR (GSI)**
  - **UK became Associate Member of FAIR in May 2013**
  - **£8.1M STFC funding for 5-year NuSTAR construction phase**
- **Three additional NP projects currently under review:**
  - **JLAB upgrade**
  - **ALICE upgrade at CERN**
  - **ISOL-SRS at CERN**

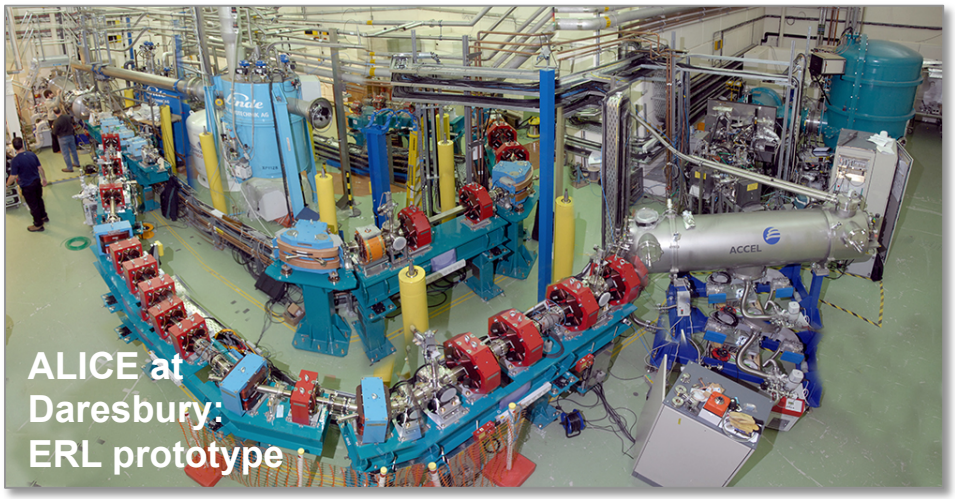


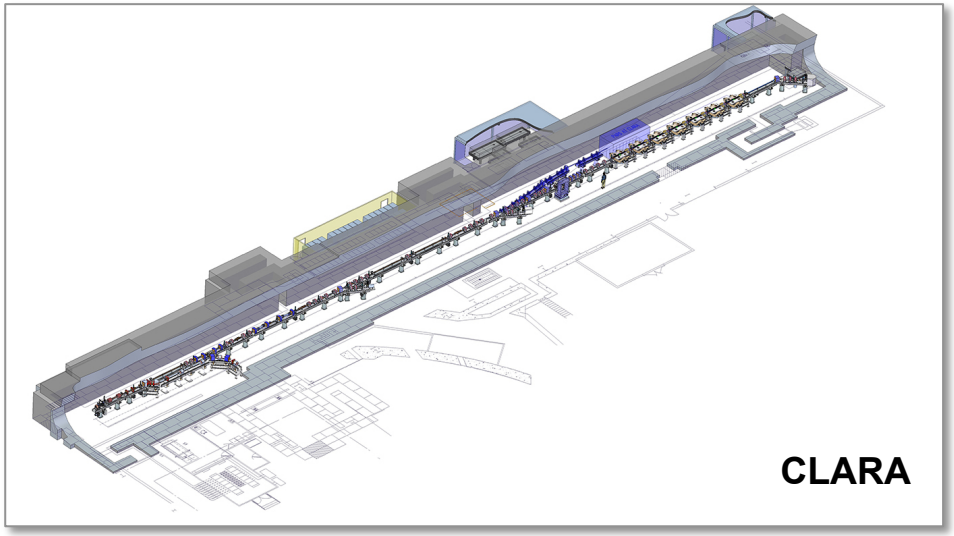
Accelerator Science

- UK accelerator science revitalised in 2004 with PPARC/ CCLRC support for two Accelerator Institutes
  - Cockcroft: ASTeC, Lancaster, Liverpool, Manchester
  - John Adams: Oxford, RHUL (+ Imperial College)
- STFC support for field via:
  - Direct grants to Institutes
  - Projects (MICE at RAL, AWAKE, FETS, Target Studies)
  - In house expertise (ASTeC)
  - UK facilities (ISIS, Diamond synchrotron light source)
- STFC currently reviewing UK accelerator science to guide evolution and identify priorities

Accelerator Science

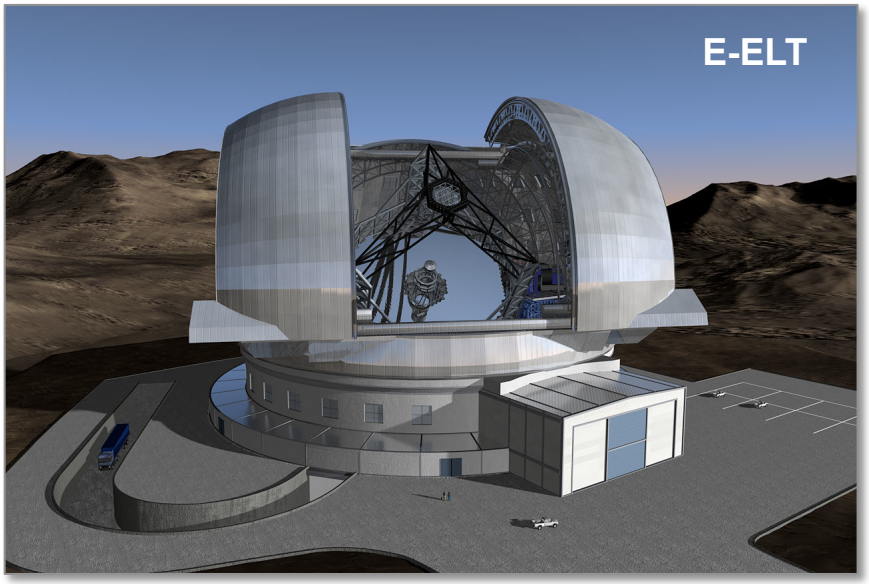
- Joint support from CERN, EU and other sources
  - e.g. HiLumi-LHC, CLIC
- Collaborative work with international and industrial partners
  - e.g. Siemens, Rapiscan, E2V, Swiss-FEL, L-FEL etc.
- UK has unique expertise in many areas, including Super-conducting RF, Energy Recovery Linacs etc
- Extensive R&D for future applications, especially a possible UK Free-Electron Laser
  - R&D for CLARA test-bed

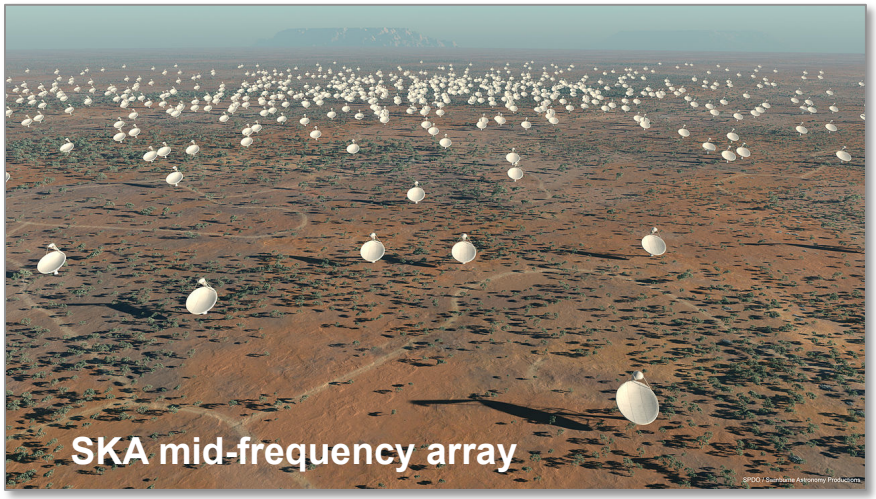




Astrophysics

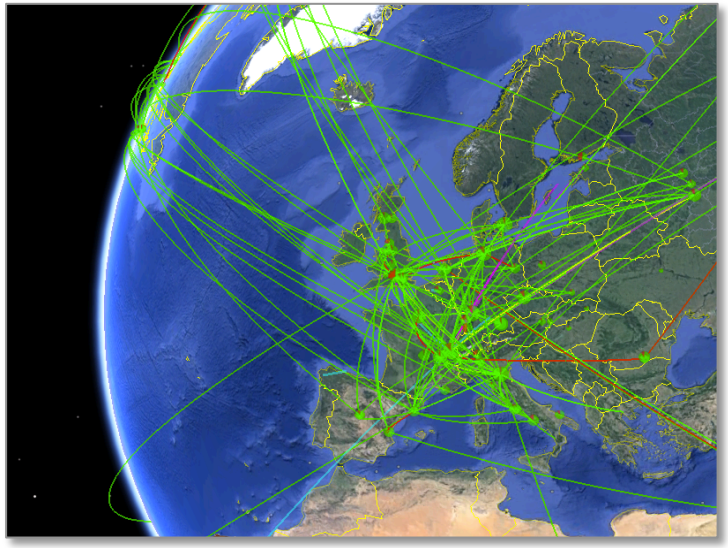
- Highest priority for current ground-based programme is to fully exploit UK membership of ESO (VLT, VISTA, ALMA)
- Top priority for next generation facilities is R&D for the European Extremely Large Telescope (E-ELT) and UK-led Square Kilometer Array (SKA)
- Space-based programme exploits UK membership of ESA
  - Pre-launch support from UK Space Agency
  - Post-launch support for e.g. Herschel, Planck, Gaia, JWST
  - Bilateral agreements with NASA and JAXA





Computing and Big Data

- Experimental particle physics community supported by GridPP (~£7M p.a.)
  - Tier-1 facility at RAL
  - 4 Tier-2 clusters (North, South, London, Scotland)
  - UK contribution to wLCG
  - Supporting a broad range of Virtual Organisations (not just PP)
- HPC support for theory with DiRAC
  - 5 nodes: Cambridge (x2), Leicester, Durham, Edinburgh
  - £15M upgrade to DiRAC-II in 2012
- Support for broader STFC science mission with Hartree centre (Daresbury)



Research Quality

Particle Physics

Year	No. publications & world ranking	Citation impact & world ranking
2008	1127, 4th	1.55, 1st
2009	1047, 3rd	1.49, 1st
2010	1030, 4th	1.55, 1st
2011	1231, 6th	1.43, 1st

Nuclear Physics

Year	No. publications & world ranking	Citation impact & world ranking
2008	372, 7th	1.51, 2nd
2009	347, 7th	1.55, 2nd
2010	347, 7th	1.62, 2nd
2011	296, 7th	1.72, 2nd

Astronomy

Year	No. publications & world ranking	Citation impact & world ranking
2008	2075, 2nd	1.48, 2nd
2009	2256, 2nd	1.75, 1st
2010	2411, 2nd	1.65, 1st
2011	2513, 2nd	1.26, 3rd

- **Taken from STFC Impact Report 2013**

Some Final Thoughts …

- STFC supports a broad, strong and vibrant UK science programme
- Enables UK researchers to play full and leading role in international community delivering excellent science
- It has been challenging to maintain excellence over years of flat cash funding, but communities have supported and engaged with difficult decisions
- Stress is now beginning to show in quality of science
  - Evidence of decreased citation impact in latest bibliometrics
- Cannot continue in this mode for further 4 years without significant damage to excellence and international standing
- Budget growth badly needed
  - Capital in 15/16 was very welcome – needs to be maintained