The Physics of Nuclei, Nuclear Matter and Nucleosynthesis

Strategy of the Nuclear Physics Community
What are the Origins of the Elements?
How, and where, were the heavy elements synthesised?
What are the key reaction processes that drive explosive astrophysical events such as supernovae, and X-ray bursts?
What is the equation-of-state of compact matter in neutron stars?
What are the nuclear processes, and main astrophysical sites, that produce the γ-ray emitting radionuclides observed in our galaxy?
How do nuclear reactions influence the evolution of massive stars, and how do they contribute to observed elemental abundances?

What is the Nature of Nuclear Matter?
What are the limits of nuclear existence?
How do simple patterns emerge in complex nuclei?
Can nuclei be described in terms of our understanding of the underlying fundamental interactions?
What is the equation-of-state of nuclear matter?
How does the ordering of quantum states change in extremely unstable nuclei?
Are there new forms of structure and symmetry at the limits of nuclear existence?

How do the properties of hadrons and the quark-gluon plasma emerge from fundamental interactions?
What is the mechanism for confining quarks and gluons in strongly interacting particles (hadrons)?
What is the structure of the proton and neutron and how do hadrons get their mass and spin?
Can we understand the excitation spectra of hadrons from the quark-gluon interaction?
science
What is the nature of the quark-gluon-plasma?
What is the nature of the proton?
How does the proton get its spin?

99% of mass can be attributed to the strong interaction and not the Higgs
Can we understand the nuclear force?
Can we understand the nuclear force?
Science

Do we understand the collective properties?
Are the elements esised?
Nucleosynthesis in the r-process

Temperature: 1.50 GK
Time: 2.7e-14 s
Nuclear Physics Worldwide

BNL, USA, Germany

FAIR, GSI Germany

NIL/SPIRAL2, Netherlands

ISOLDE and ALICE, CERN
Nuclear Physics Worldwide
### Roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2013</td>
<td>NuSTAR: R3B, HISPEC, DESPEC, (AGATA)</td>
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<tr>
<td>2014</td>
<td>NuSTAR2: Upgrades (R3B, DESPEC), ILIMA, LaSpec</td>
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<tr>
<td>2015</td>
<td>ISOL beams</td>
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<tr>
<td>2016</td>
<td>AGATA-upgrade</td>
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<tr>
<td>2017</td>
<td>Precision measurements of hadronic systems</td>
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<tr>
<td>2018</td>
<td>Electron-Ion Collider (EIC)</td>
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<tr>
<td>2019</td>
<td>Relativistic heavy-ion collisions</td>
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<tr>
<td>2020</td>
<td>Stable beams</td>
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<tr>
<td>2021</td>
<td>ECOS</td>
</tr>
<tr>
<td>2022</td>
<td>EURISOL</td>
</tr>
<tr>
<td>2023+</td>
<td>Fragmentation beams</td>
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</tbody>
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**Structure and Astrophysics**
- At the extremes of stability
- Nuclear magic numbers
- Equation of State
- Neutron stars
- Nuclei and reactions
- Nuclear reactions

**Nuclear Physics**
- Universal Parton Distributions (GPDs)
- In Elec. and Mag. form factors
- and baryon spectroscopy
- Force in nucleons and nuclei
- Gluon plasma

**Existing Projects**
- Project start date

**Future Projects**
- Major technology developments

**Major Future International Facilities**
Silicon Tracker

ASICs

silicon sensors

mounting frame
Nuclear Physics: The UK influence
commendations:
The UK Nuclear Physics Community requires a balanced programme of projects across the areas of *Hadronic Physics* and *Nuclear Structure and Astrophysics*. Rather than prioritising between projects it is possible to accommodate a range of projects through profiling project spend – as illustrated in this report. An uplift in the number of nuclear physics projects and funding is required. STFC should seek to promote nuclear theory, through continuing existing support...