

UK low-energy nuclear physics

STFC NPAP perspective

UK Nuclear Physics ECR Forum

November 2021

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Outline of presentation

- NPAP membership update
- Overview of UK Nuclear Physics
 - Overview of labs and facilities
- Projects status report
- Conclusion

Members of NPAP

| | |
|---------------------|------------------------------------|
| Robert Page (chair) | University of Liverpool |
| Pascal Reiter | University of Edinburgh |
| David O'Donnell | University of the West of Scotland |
| Arnau Rios Huguet | University of Surrey |
| Rachel Montgomery | University of Glasgow |
| Jacek Dobaczewski | University of York |

Thanks to Daria Sokhan & Phil Walker

Public web page (needs updating):

<http://www.stfc.ac.uk/about-us/how-we-are-governed/advisory-boards-panels-committees/nuclear-physics-advisory-panel/>

UK low-energy Nuclear Physics

- **Science Areas are:**
 - Nuclear Structure
 - Nuclear Astrophysics
 - Nuclear Theory
- **Industrial Nuclear Data**
- **Public Engagement & Outreach**
- **Applications and Innovation**

Concentrate research on key areas where the community can gain leadership and influence

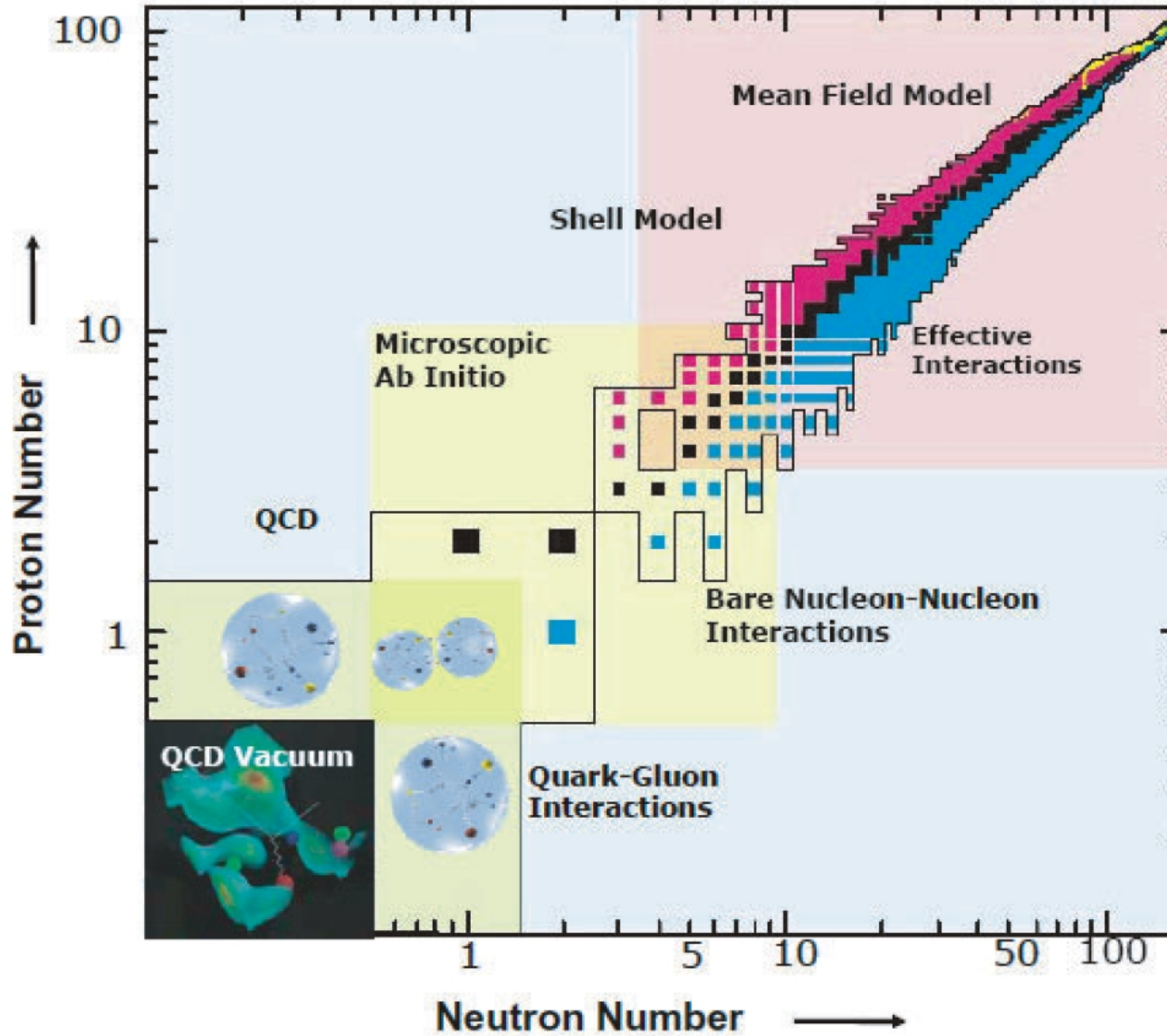
Size of the UK community

- There are ~70 academic/faculty staff @ 12 institutions carrying out nuclear physics research
 - Number has been growing with recent new appointments
 - All (except 4 at STFC Daresbury) are University funded
- There are ~60 Research and Professional staff supporting the academic staff
- There are ~90 Research students working with the academic staff
- Approximately 48 funded by STFC

Size of the UK community



Our Science



Key Science Questions

- What governs the structure and behaviour of atomic nuclei?
- What is the origin of the elements?
- What is the nature of nuclear matter?
- How do the properties of hadrons and the quark-gluon plasma emerge from fundamental interactions?

The first two questions are associated with “nuclear structure and nuclear astrophysics” and the final one “hadronic physics”

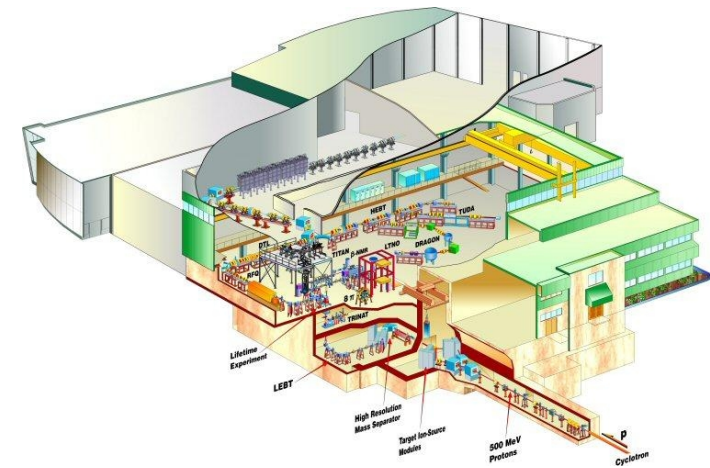
Low-energy nuclear facilities



TRIUMF – Vancouver, Canada



- Large range of high-intensity RIB provided by ISAC
- ISOL facility
- Nuclear structure studies
- Nuclear astrophysics
- Nuclear theory
- GRIFFIN, TIGRESS, laser spectroscopy,...



UK involvement/leadership:

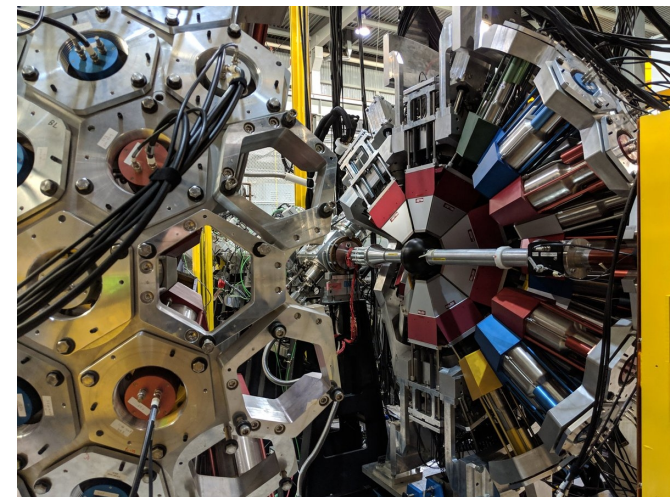
Prof. Alison Laird (York)



Dr Jack Henderson
(Surrey)



Dr Mike Bowry (UWS)



Argonne - Chicago, USA

- High-intensity stable and RIB beams available
- ATLAS and CARIBU facilities
- Nuclear structure studies
- Nuclear astrophysics
- Gammasphere, FMA, HELIOS, AGFA,...

UK involvement/leadership:

Dr Dan Doherty/Dr Gavin Lotay (Surrey)



Prof. Sean Freeman/Dr David Sharp (Manchester)



Prof. Phil Woods (Edinburgh)



Prof. John F. Smith (UWS)

Argonne 
NATIONAL LABORATORY



FRIB/NSCL – Michigan, USA

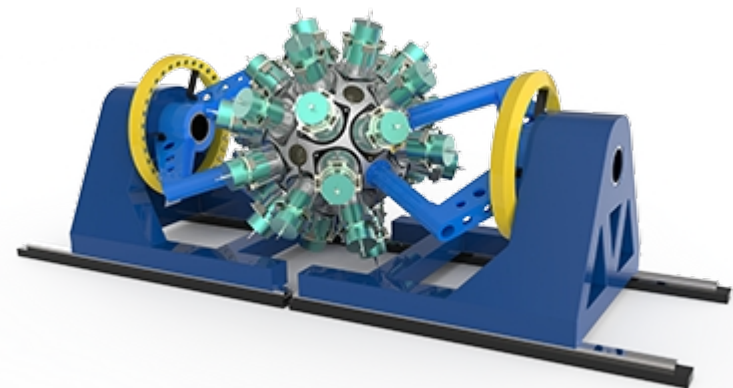
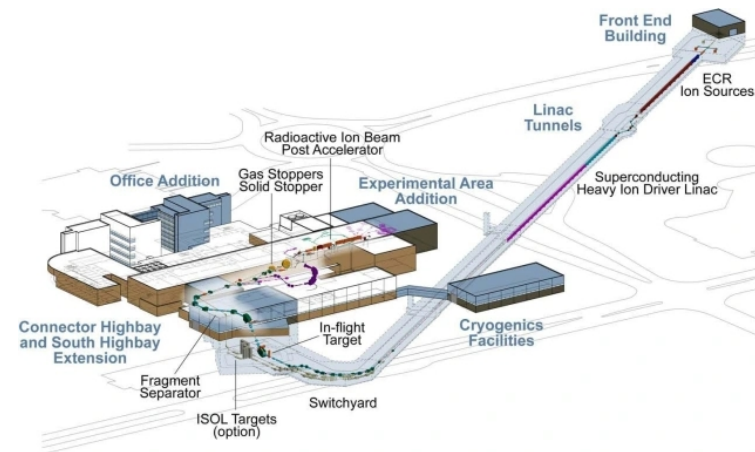
- Highest intensity, largest range RIBs
- Fragmentation-based facility
- Nuclear structure studies
- Nuclear astrophysics
- Nuclear theory
- GRETA, SECAR, CRIS, HELIOS,...

UK involvement/leadership:

Dr Gavin Lotay (Surrey)

Dr Dan Doherty (Surrey)

Prof. Wilton Catford
(Surrey)



FAIR/GSI – Darmstadt, Germany

- High-intensity RIBs and stable beams
- Fragmentation-based facility
- Nuclear structure studies
- Nuclear astrophysics
- Nuclear theory
- AGATA, AIDA, FATIMA, R3B,...

UK involvement/leadership:

Prof. Mike Bentley (York)



Prof. Robert Page
(Liverpool)



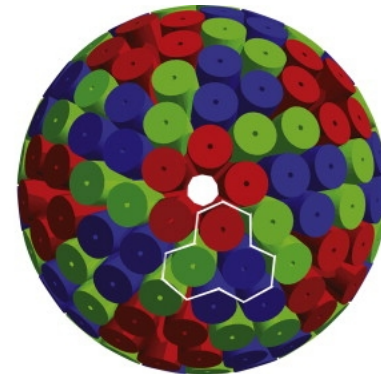
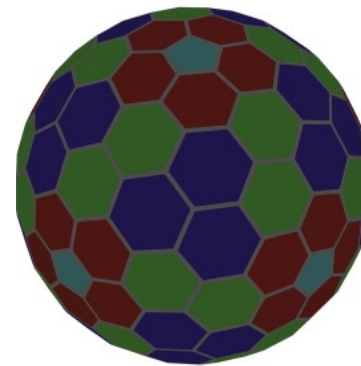
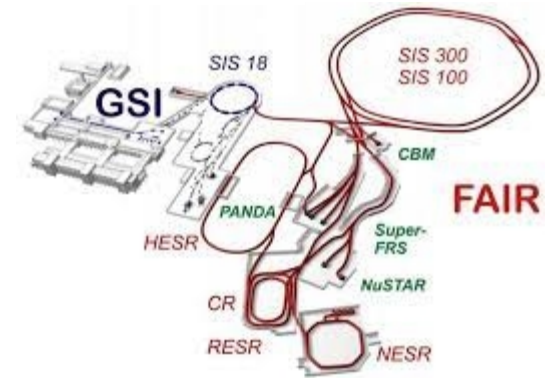
Prof. Paddy Regan (Surrey/
NPL)



Dr Tom Davinson
(Edinburgh)



Dr Marc Labiche (STFC
Daresbury)



JYFL – Jyväskylä, Finland

- High-intensity stable/low-energy RI beams
- Cyclotron-based
- Nuclear structure studies
- Nuclear astrophysics
- Nuclear theory
- JUROGAM, RITU, MARA, IGISOL,...

UK involvement/leadership:

Prof. Robert Page/Prof.
Dave Joss/Prof. Bradley
Cheal/Prof. Rodi Herzberg
(Liverpool)

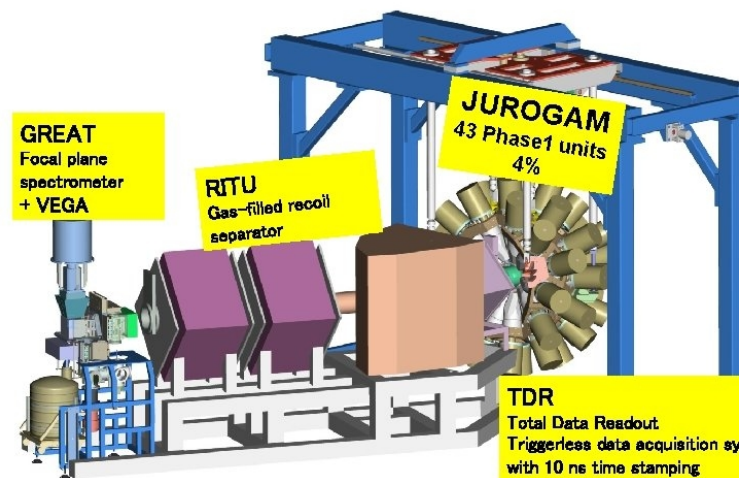
Dr Paul Campbell/Dr Dave
Cullen (Manchester)

Prof. John F Smith/Dr Nara
Singh Bondili (UWS)

Dr Philippos Papadakis
(STFC Daresbury)



RDT Instrumentation at JYFL



HIE-ISOLDE CERN – Geneva, Switzerland

- High-intensity reaccelerated RI beams
- ISOL, LINAC based
- Nuclear structure studies
- Nuclear astrophysics
- Medical applications
- MINIBALL, ISS, ISOLTRAP MRTof,...



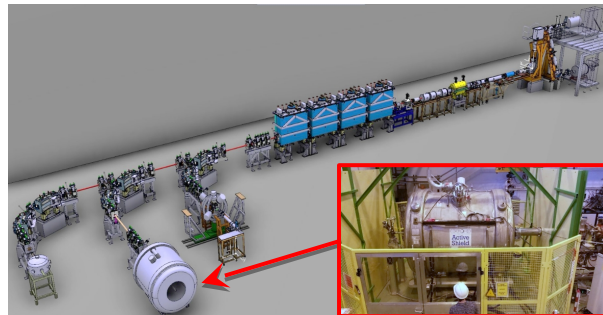
UK involvement/leadership:

Dr Liam Gaffney/Prof. Peter Butler (Liverpool)



Dr David Sharp/Dr Kieran Flanigan/Prof. Sean Freeman (Manchester)

Prof. Marcus Scheck (UWS)



Other facilities

- Legnaro National Laboratory - Legnaro, Italy
- Stable (TANDEM-ALPI) and RIBs (SPES)
- AGATA, PRISMA, GALILEO,...
- Prof. John F. Smith (UWS)



- RIKEN - Tokyo, Japan
- High-intensity stable (RILAC/AVF) and RIBs (BIG-RIPS)
- KISS, GARIS, SAMURAI,...
- Prof. Andrei Andreyev (York), Prof. Phil Walker (Surrey)

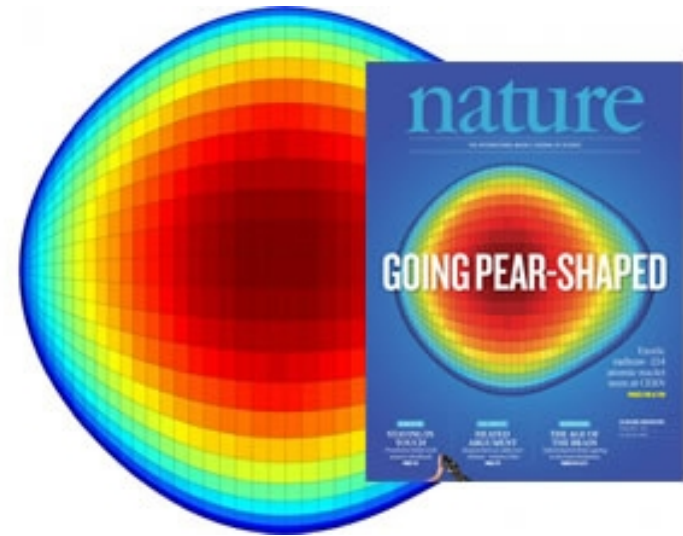
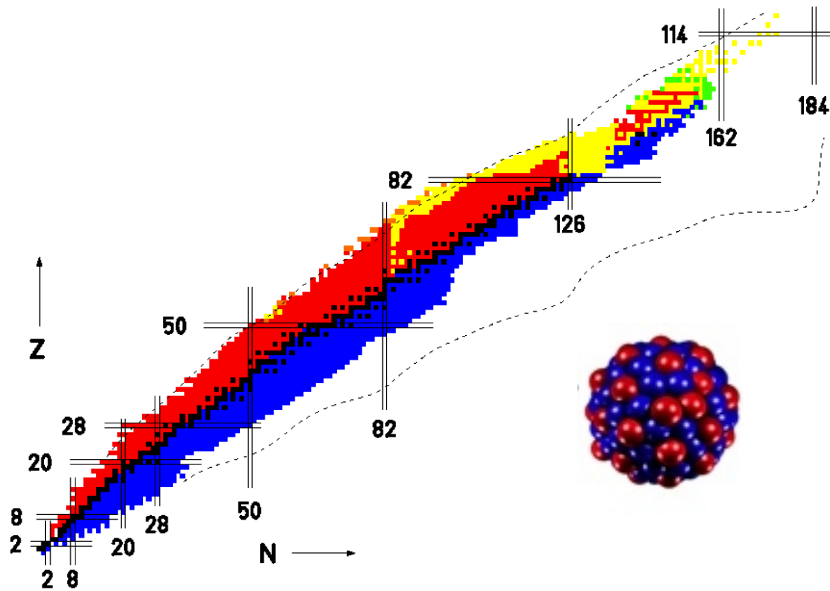


- iThemba – Cape Town, South Africa
- High-intensity stable isotope and neutron beams
- AFRODITE, K = 600 spectrometer,...
- Prof. Alison Bruce (Brighton)



- ANU – Canberra, Australia
- High-intensity stable beams
- CAESAR, Hyperfine Spectrometer,...
- Prof. Martin Freer (Birmingham)





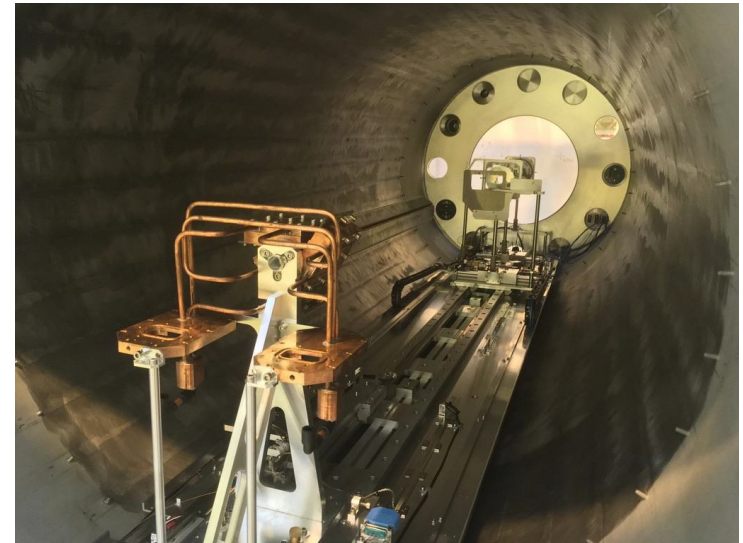
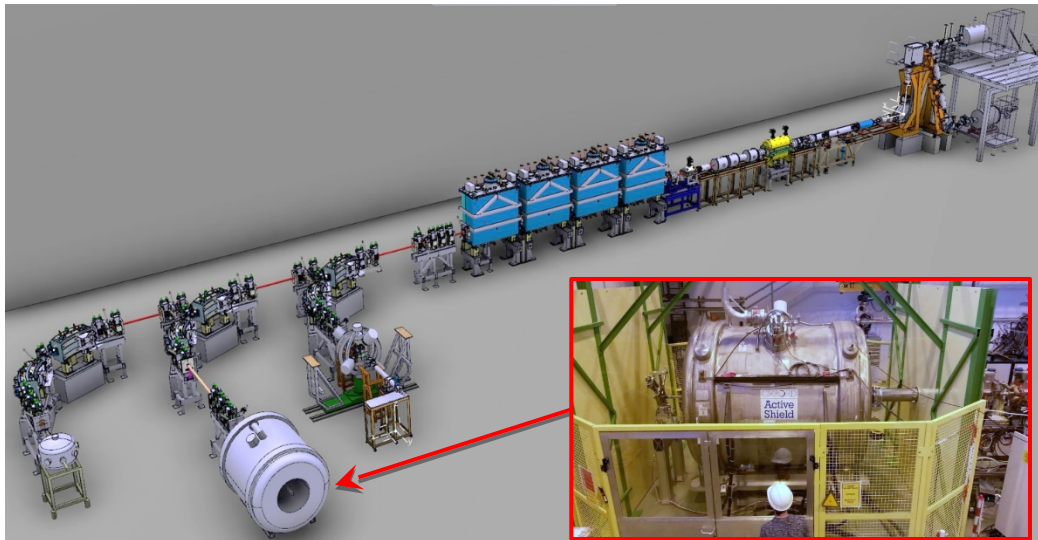
51 Academics at 10 Institutions (Birmingham, Brighton, Edinburgh, Liverpool, Manchester, Sheffield Hallam, STFC Daresbury Laboratory, Surrey, UWS, York)

NUCLEAR STRUCTURE & NUCLEAR ASTROPHYSICS

The Mystery of Creation to the Limits of Existence

Completed Project – ISOL-SRS

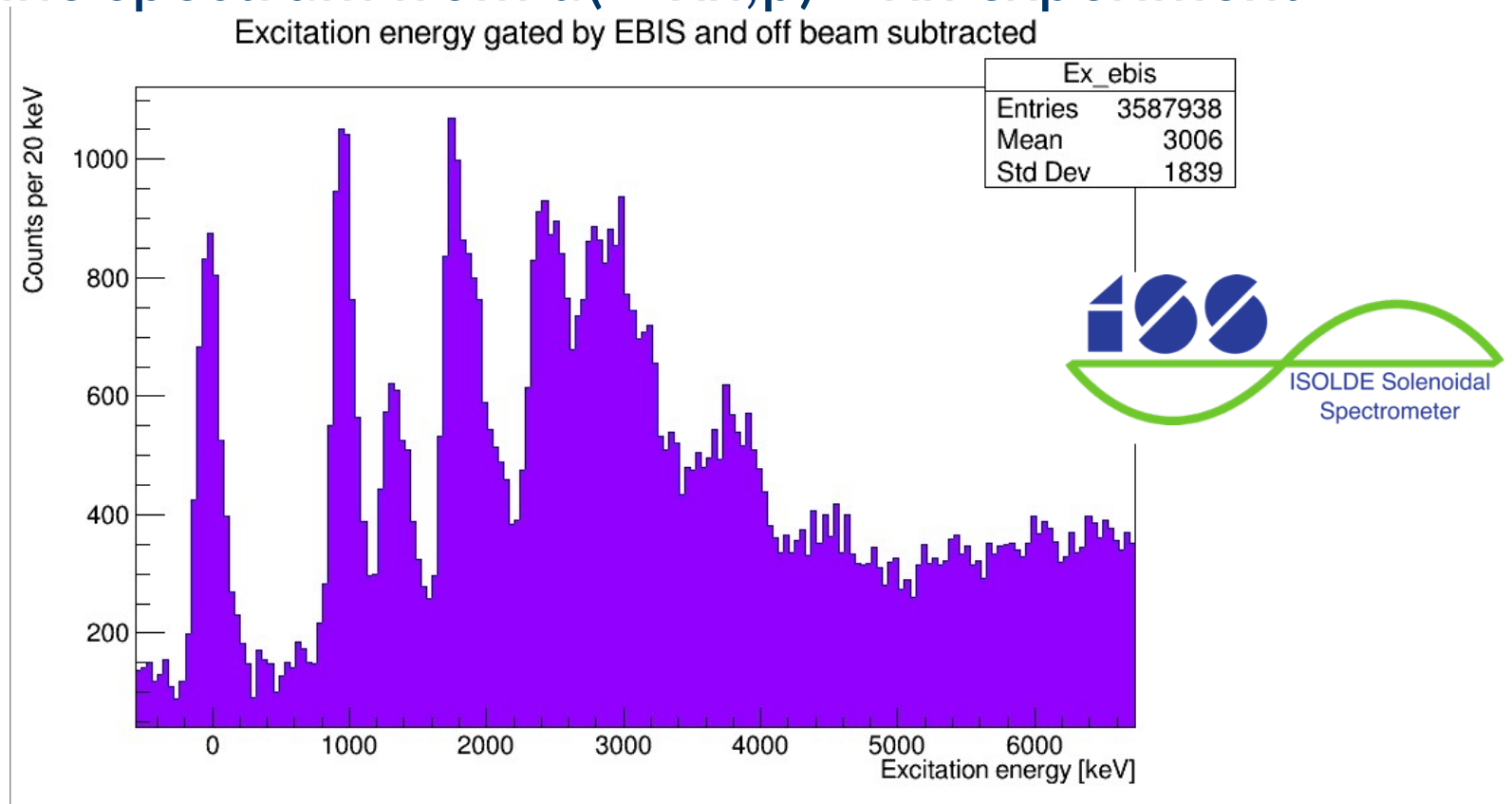
- ISOL-SRS: 5Y project 2015 – 2020
- Spectrometers for charged-particle reaction products
- 2021 campaign:
 - 2 experiments completed since LS2
 - 3rd starts in 2 weeks



ISOLDE Solenoidal Spectrometer

Completed Project – ISOL-SRS

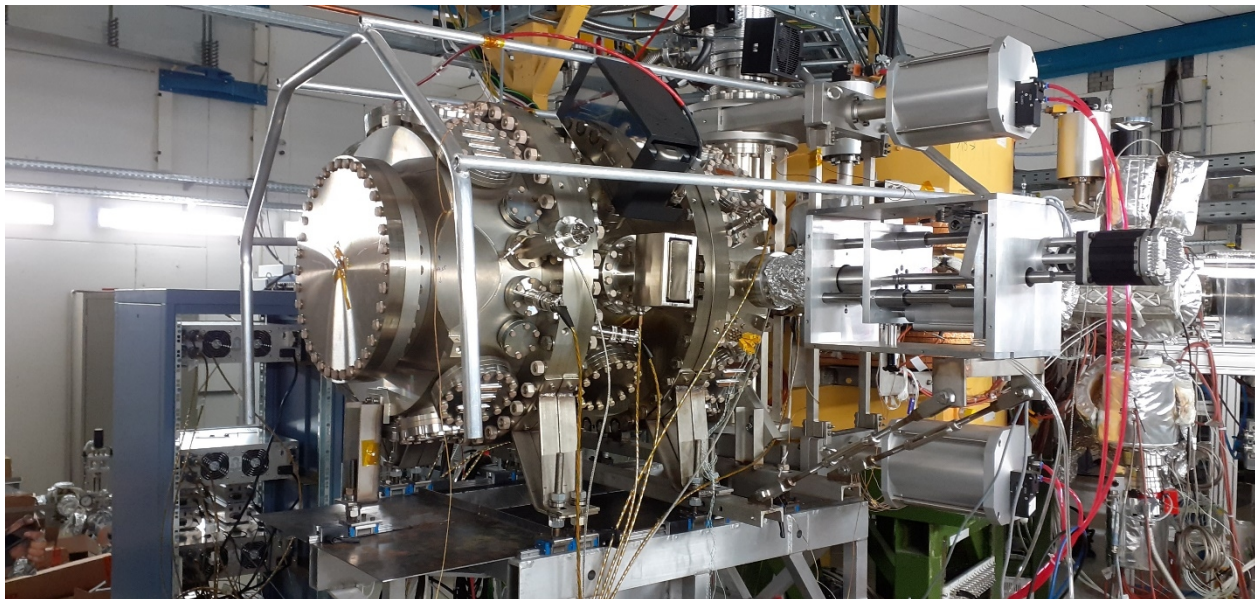
- On-line spectrum from $d(^{212}\text{Rn},p)^{213}\text{Rn}$ experiment



- Each peak = a single neutron state outside $N=126$ core
- Identify l transfers to assign to shell-model states

Completed Project – ISOL-SRS

- ISOL-SRS: 5Y project 2015 – 2020
- Spectrometers for charged-particle reaction products
- CARME installed on CRYRING at GSI during 2021
- First experiment expected February 2022



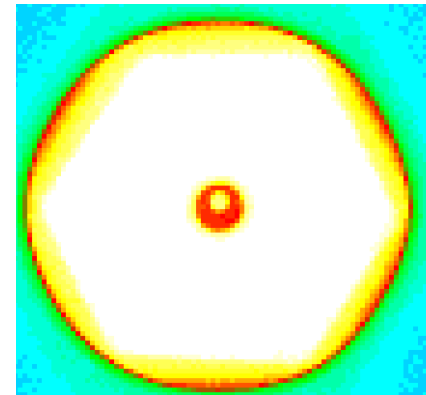
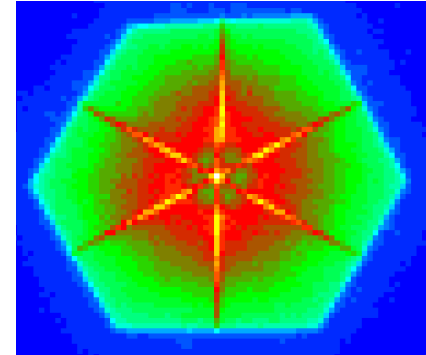
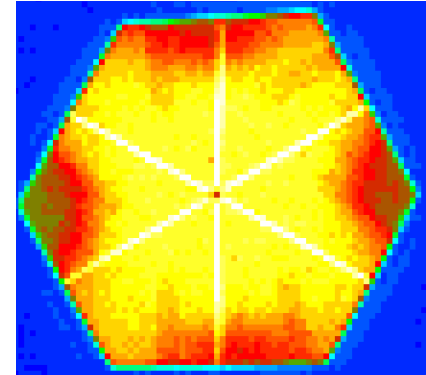
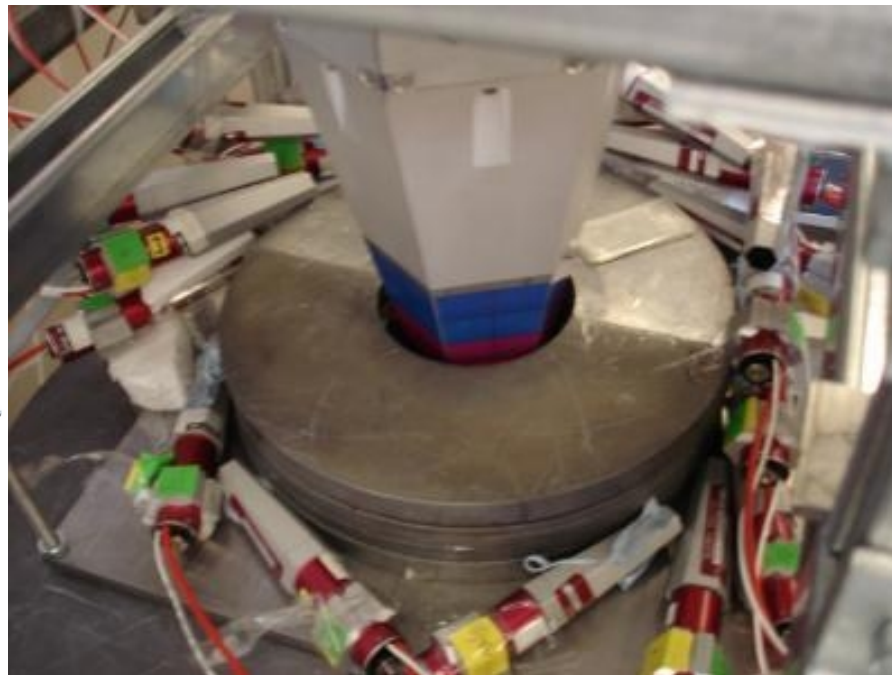
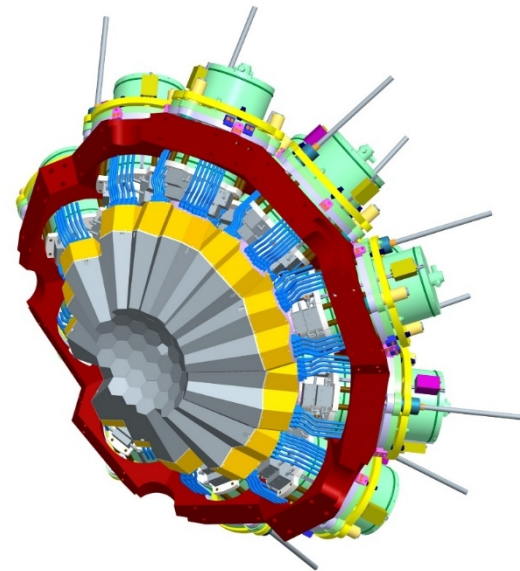
CRYRING Array for Reaction MEasurements – CARME

Completed Project – ISOL-SRS

- ISOLDE Solenoidal Spectrometer
 - 2 ERFs
 - David Sharp (Manchester)
 - Liam Gaffney (Liverpool)
 - Sean Freeman (Manchester) now leader of ISOLDE
- CARME
 - Chancellor's Fellowship
 - Carlo Bruno (Edinburgh)

Current Project – AGATA

- Advanced GAMMA Tracking Array
- 4Y project 2020 – 2024



Future projects and opportunities

Near-term

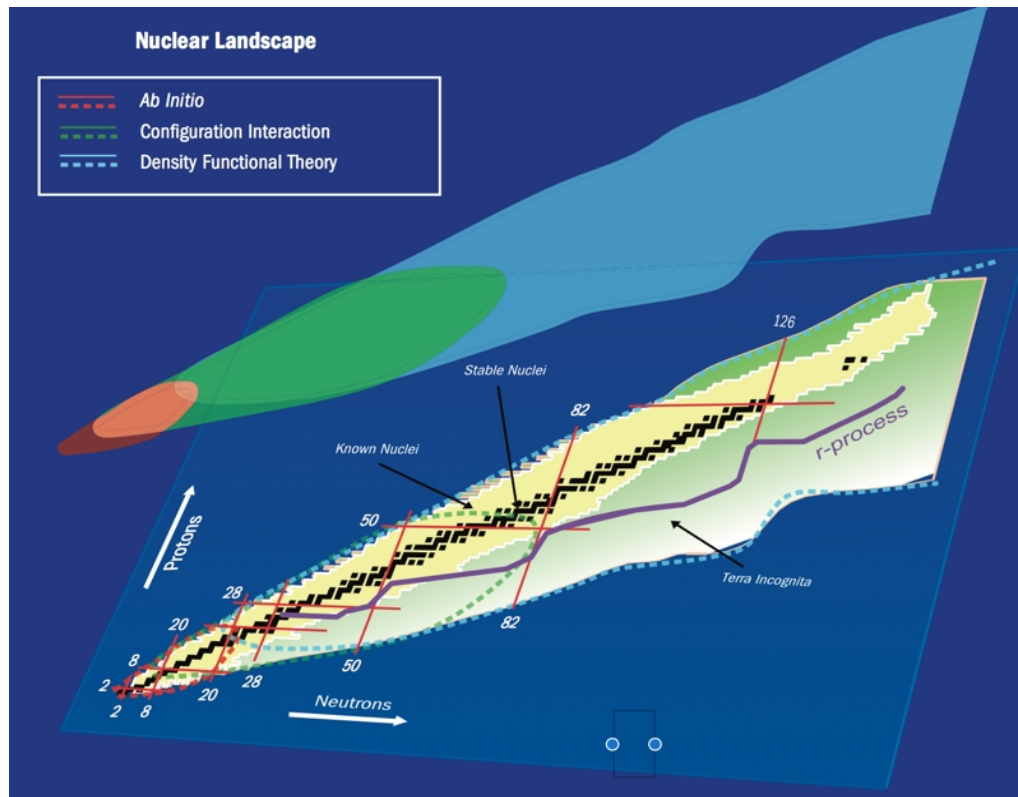
- FRIB Accelerated beams for UK Science and Technology (FAUST)
- JYFL MARA LEB + Array (Jyvaskyla)

Mid-term

- STAR – Scintillator tracking array (RIKEN)
- ISOL-2 – Expanding the capability of the ISOLDE Solenoidal Spectrometer

Horizon

- NuSTAR Upgrade
- EPIC/EURISOL
- AGATA 4π



11 Academics at 3 Institutions (Manchester, Surrey and York)

NUCLEAR THEORY

Future projects and opportunities

Near-term

- Neutrino-nucleus interactions
- Fission

Embryonic

- Quantum simulations for nuclear systems

Applications of Nuclear Physics

- University of Liverpool
- Detector development/characterisation
- AGATA/PET imaging/Homeland security
- Prof. Andy Boston, Prof. Laura Harkness-Brennan



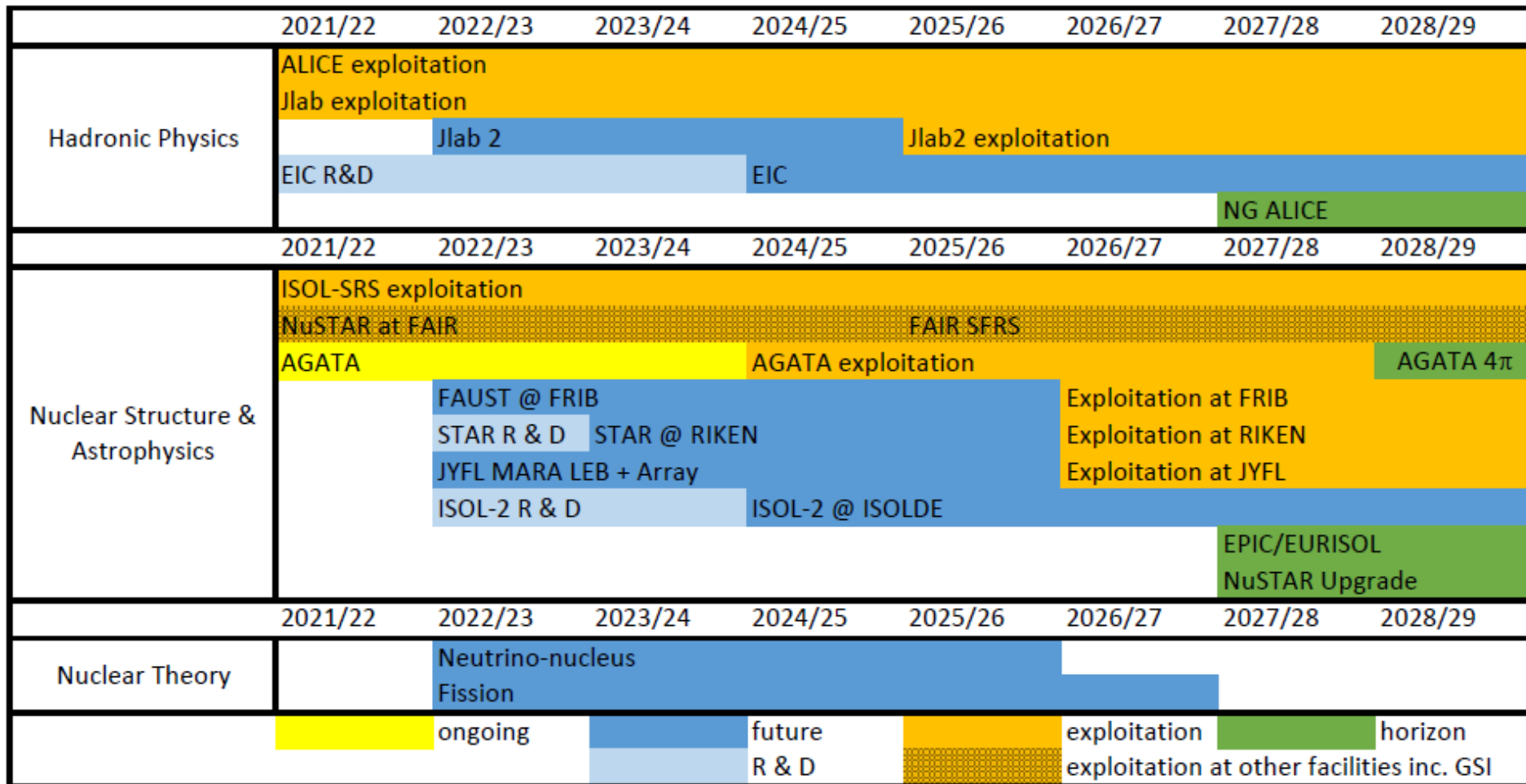
- University of York
- Detector development/characterisation
- PET imaging/Homeland security/AWE
- Prof. Dave Jenkins



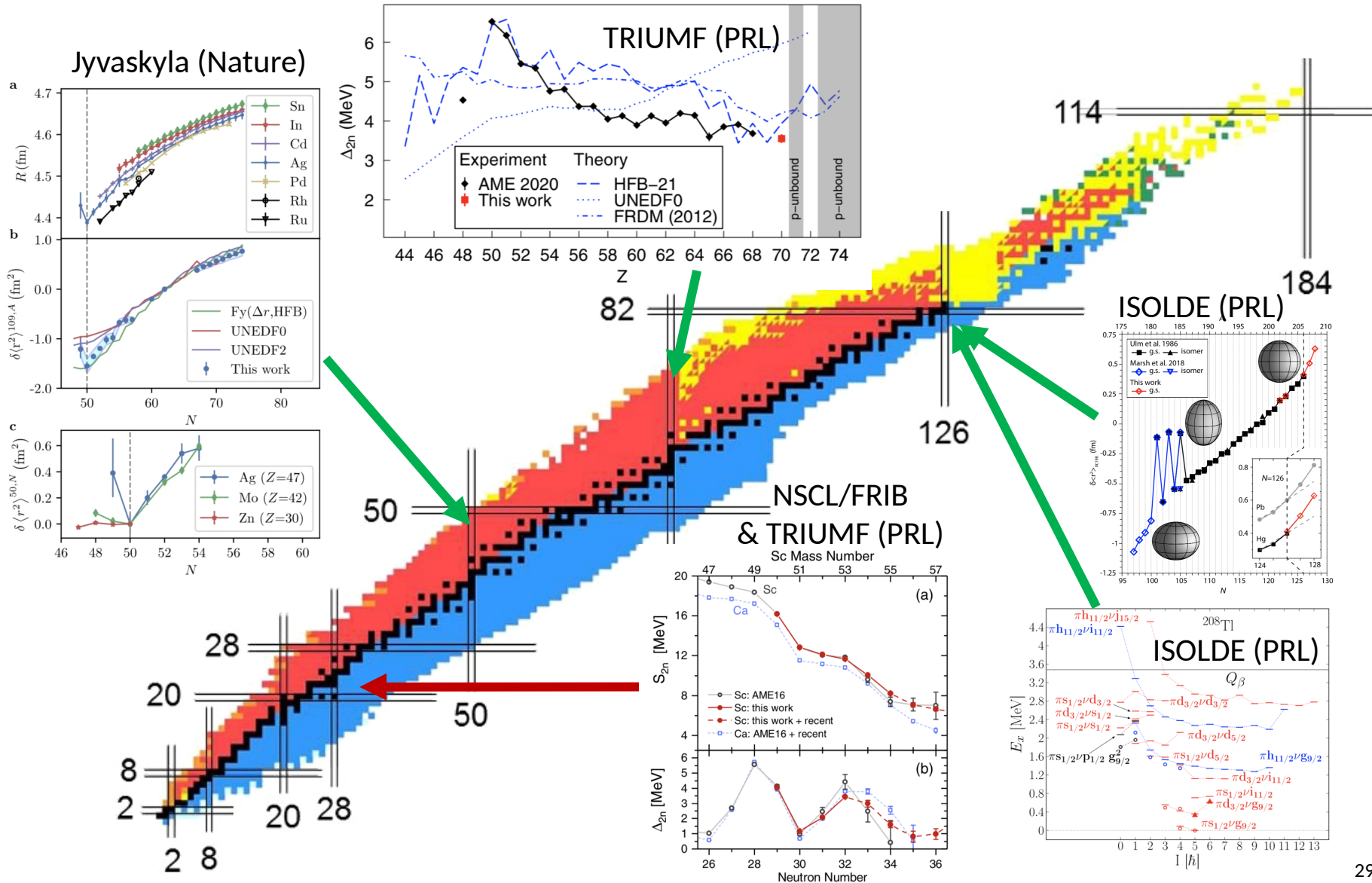
- University of Glasgow
- Detector development/characterisation
- AWE/radiotherapy/PET and SPECT imaging
- Dr Bjoern Seitz, Dr Richard Gray



Roadmap for existing projects and future opportunities



Some core programme highlights – nuclear structure at shell closures



Concluding Remarks

- UK Nuclear Physics: small but **vibrant** community
- Play an important role in many **international** projects
- Recognized international **leadership** and **expertise**
- Productive collaboration with **industry**
- Strong **professional development** and training programmes

Thanks for the invitation and for your attention.