

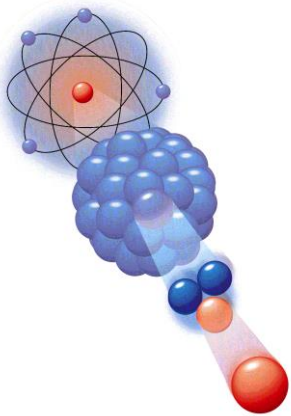
UK Nuclear Physics Update (2022)

- **UK Nuclear Physics Science include:**
 - Nuclear Structure and Nuclear Astrophysics
 - Hadronic Physics
 - Nuclear Theory
- **(Industrial) UK Nuclear Data Network**
- **NUclear SECurity Network ; Early Diagnosis Network.**
- **Public Engagement & Outreach**
- **Applications and Innovation**

Core UKRI funding comes via STFC (tensioned vs Particle Physics and Astronomy).

Some 'Big' Physics Questions?

- 1) What are the fundamental building block of matter ?
- 2) How can you see 'inside' an atomic nucleus / nucleons?
- 3) Where & when were the stable elements formed?
- 4) How do we measure very long / short radioactive decays?
- 5) What are some of the applications of nuclear science?



1 H hydrogen 1.008																	18 Ar argon 39.95	19 K potassium 39.10	20 Ca calcium 40.08	21 Sc scandium 44.96	22 Ti titanium 47.88	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38	31 Ga gallium 69.72	32 Ge germanium 72.64	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.90	36 Kr krypton 83.80																																																																																																																																																																																																																																																																																																																																																																																																								
3 Li lithium (6.94, 6.96)	4 Be beryllium 9.012	Key: atomic number Symbol standard atomic weight																13 B boron (10.81, 10.82)	14 C carbon (12.01, 12.02)	15 N nitrogen (14.01, 14.02)	16 O oxygen (15.99, 16.00)	17 F fluorine 18.99	18 Ne neon 20.18																																																																																																																																																																																																																																																																																																																																																																																																																				
11 Na sodium 22.99	12 Mg magnesium (24.31, 24.32)	13 Al aluminum 26.98	14 Si silicon 28.09	15 P phosphorus 30.97	16 S sulfur 32.07	17 Cl chlorine (35.45, 35.46)	18 Ar argon 39.95	19 K potassium 39.10	20 Ca calcium 40.08	21 Sc scandium 44.96	22 Ti titanium 47.88	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38	31 Ga gallium 69.72	32 Ge germanium 72.64	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.90	36 Kr krypton 83.80																																																																																																																																																																																																																																																																																																																																																																																																																		
37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.94	43 Tc technetium 98.01	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3	55 Cs cesium 132.9	56 Ba barium 137.3	lanthanoids				72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 196.9	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 208.9	84 Po polonium 209	85 At astatine 210	86 Rn radon 222																																																																																																																																																																																																																																																																																																																																																																																																					
87 Fr francium	88 Ra radium	89-103 actinoids				104 Rf rutherfordium 261	105 Db dubnium 262	106 Sg seaborgium 266	107 Bh bohrium 264	108 Hs hassium 277	109 Mt meitnerium 268	110 Ds darmstadtium 271	111 Rg roentgenium 272	112 Cn copernicium 285	113 Nh nihonium 284	114 Fl flerovium 289	115 Mc moscovium 288	116 Lv livermorium 293	117 Ts tennessine 294	118 Og oganesson 294					119 Uu ununennium 295	120 Uub ununbium 296	121 Uut ununtrium 297	122 Uuq ununquadium 298	123 Uup ununpentium 299	124 Uuh ununhexium 300	125 Uuq ununseptium 301	126 Uuh ununoctium 302	127 Uut ununnonium 303	128 Uuq ununtriacontium 304	129 Uuh ununtriundecium 305	130 Uut ununtridecium 306	131 Uuq ununquadecium 307	132 Uuh ununpentadecium 308	133 Uut ununhexadecium 309	134 Uuq ununseptadecium 310	135 Uuh ununoctadecium 311	136 Uut ununnonadecium 312	137 Uuq ununtriacontium 313	138 Uuh ununtriundecium 314	139 Uut ununtridecium 315	140 Uuq ununquadecium 316	141 Uuh ununpentadecium 317	142 Uut ununhexadecium 318	143 Uuq 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Size of the UK community

- There are ~70 academics / faculty staff @ 11 institutions carrying out nuclear physics research
 - Includes recent appointments via ERF, UKFLF, RS Fellows.
 - Almost all are University-based researchers
- 90 PhD Research students across the community
 - ~ 50 funded by STFC quota plus a few iCASE etc.
- Nuclear Physics Advisory Panel (Chair R.Page Liverpool)

<https://sites.google.com/view/stfccancerdiagnosis>

STFC Cancer Diagnosis Network+

Welcome to the STFC Cancer Diagnosis Network+

The Science and Technology Facilities Council (STFC) Cancer Diagnosis Network+ (CDN) is a multidisciplinary community with academic, clinical and industry members aiming to collaboratively address clinical challenges in the diagnosis of cancer. The Network+ is built upon four themes:

1. Early diagnosis
2. Precision and quantitative imaging
3. Multimodal techniques
4. Data science techniques applied to imaging and bioinformatics

The CDN ultimately seeks to enable researchers with expertise and knowledge developed through the STFC core science programmes and at STFC national facilities and laboratories to address one of the most important societal and economic global challenges of this century. The CDN therefore hosts multidisciplinary challenge led workshops and provides funding for scoping studies, proof of concept projects and PhD studentships to translate STFC innovations into clinical impact. There are also opportunities for Early Career Researchers to apply for travel awards to attend conferences and events, placements and MSc level training in medical physics and bioinformatics.



Science and
Technology
Facilities Council



UNIVERSITY OF
LIVERPOOL



University
of Glasgow



The Institute of
Cancer Research



Loughborough
University

UK Academic Network in Nuclear Security and Non-proliferation Skills

The STFC Nuclear Security Science Network (NuSec)

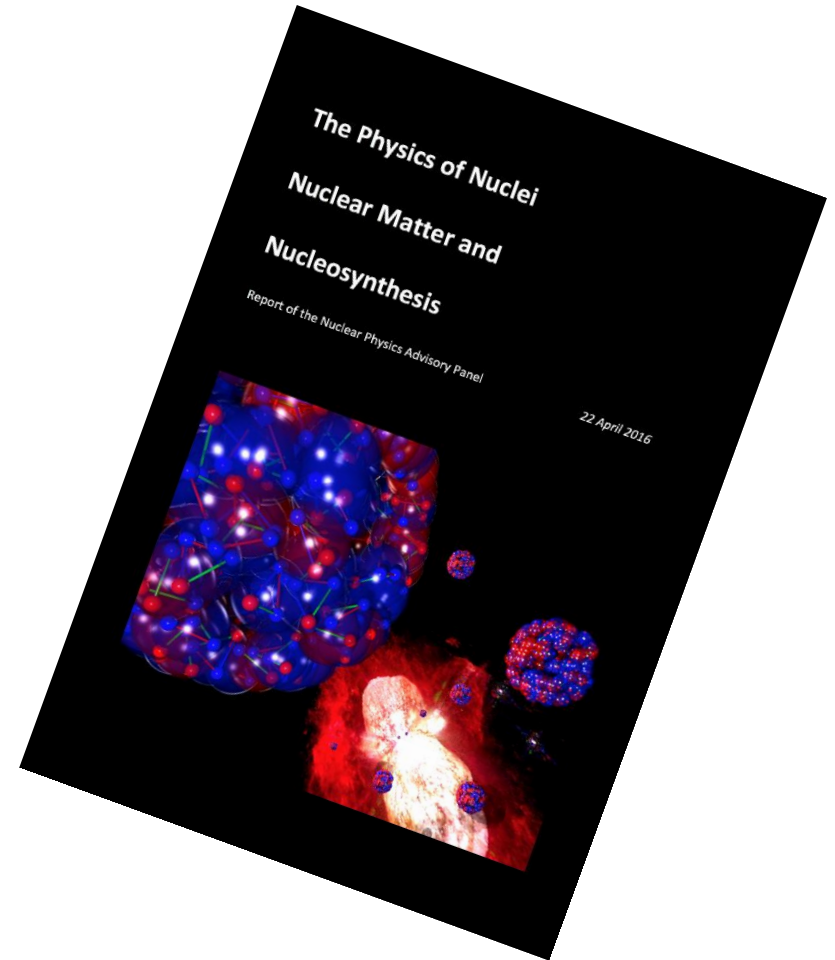
- **Novel imaging techniques, including compact gamma & neutron imaging systems; cosmic ray muon imaging of large objects.**
- **Radiation detection, detector development, digital pulse processing; new materials for radiation detectors.**
- **Advanced detection methods for nuclear fuel cycle monitoring.**
- **Robotics and remote inspection technologies.**
- **Non-proliferation technologies.**

For further information, see: www.nusec.uk/



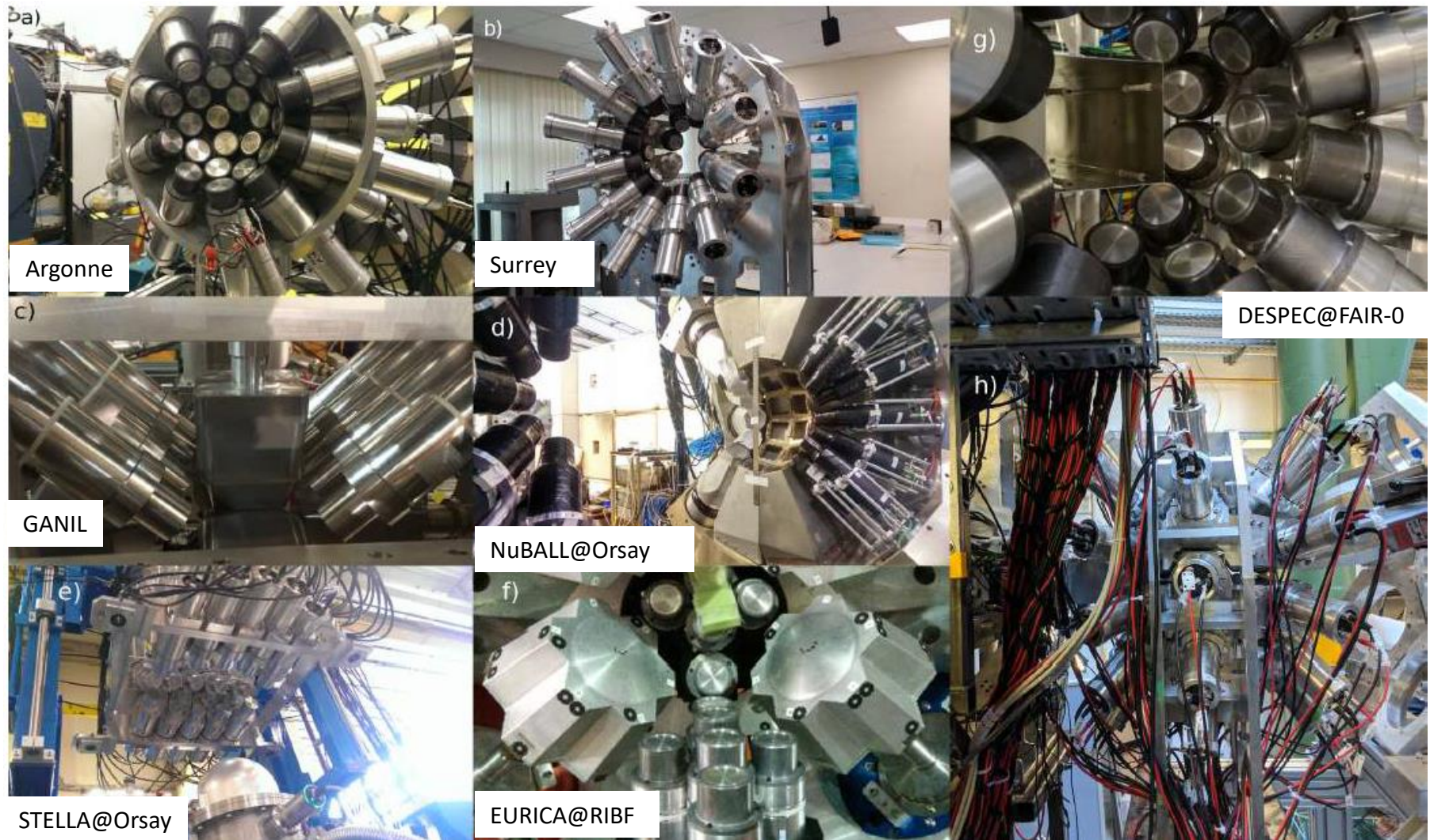
The Nuclear Physics Strategy document

- Scope and range of Physics
- Current projects
- Future projects
- Other issues
- 10 year horizon
- Last revision Oct 2019



<https://stfc.ukri.org/about-us/how-we-are-governed/advisory-boards-panels-committees/nuclear-physics-advisory-panel/>

**Design build and commission precision instrumentaton
(e.g. AGATA; J-LAB; ALICE at CERN; NuSTAR at FAIR....) and
used them for UK 'buy in' at labs around the world...**



M. Rudigier, Zs. Podolyák, P.H. Regan et al.

Nuclear Inst. and Methods in Physics Research, A 969 (2020) 163967

Roadmap for existing projects and future opportunities

	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
Hadronic Physics	ALICE exploitation							
	Jlab exploitation							
		Jlab 2			Jlab2 exploitation			
	EIC R&D			EIC				
							NG ALICE	
	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
Nuclear Structure & Astrophysics	ISOL-SRS exploitation							
	NuSTAR at FAIR				FAIR SFRS			
	AGATA			AGATA exploitation				AGATA 4 π
		FAUST @ FRIB				Exploitation at FRIB		
		STAR R & D	STAR @ RIKEN			Exploitation at RIKEN		
		JYFL MARA LEB + Array			Exploitation at JYFL			
		ISOL-2 R & D		ISOL-2 @ ISOLDE				
							EPIC/EURISOL	
							NuSTAR Upgrade	
	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
Nuclear Theory		Neutrino-nucleus						
		Fission						
		ongoing		future		exploitation		horizon
				R & D		exploitation at other facilities inc. GSI		

Update needs Nuclear Physics Forum discussion

STFC Postgraduate 'Summer' School in Nuclear Physics 2022

Held at University of Sheffield (27th March – 3rd April 2022)

58 PhD student attendees, *all residential* (STFC-funded students, other students, international students and industry)

- Well received event following isolation during lockdowns
- First in-person talk for many students
- Intense programme of lectures, tutorials etc (see below)



Science and
Technology
Facilities Council



Organised by

Daniel Doherty



UNIVERSITY OF
SURREY

Marina Petri



UNIVERSITY
of York

With thanks to

ORTEC | **AMETEK**

Programme

Nuclear Structure (Seweryniak, Crawford, Flanagan, Gezerlis)

Nuclear Astrophysics (Lotay, Kankeinan)

Reactions (Cortina, Diaz-Torres)

Hadron Physics (Hen, Bashkanov)

Applications (Harkness-Brennan, Watts)

Hands-on Tutorials - Nuclear Theory, Geant4, Data Analysis Techniques

Student Talk Sessions

Public Engagement (Diget)

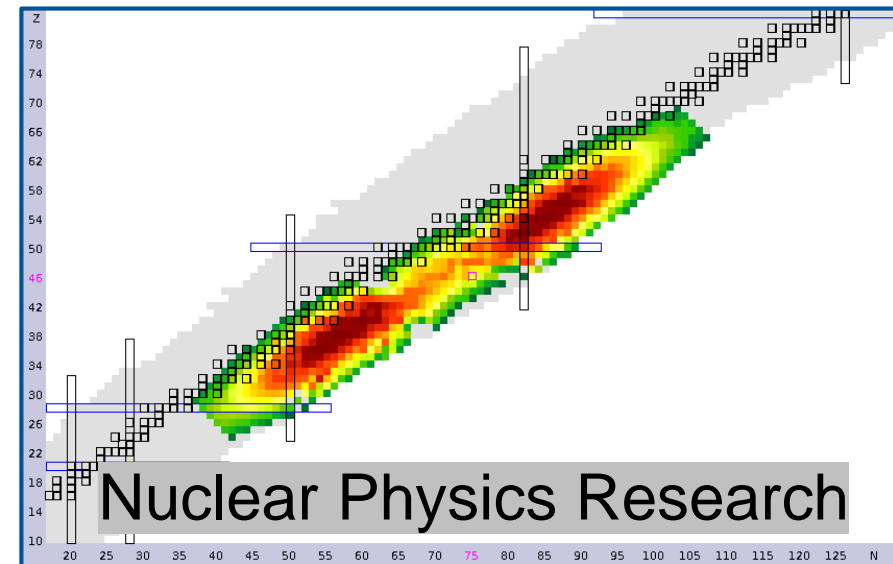
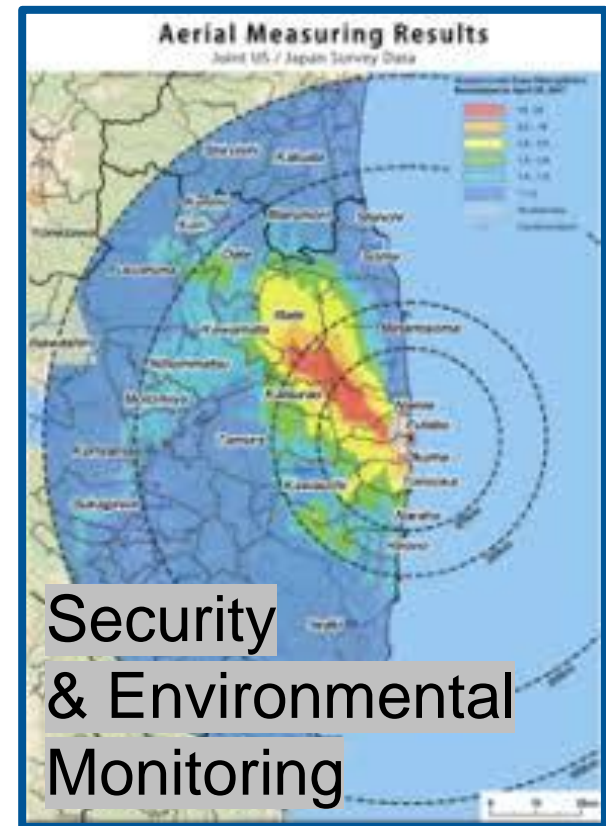
Career Session

Career's Panel



Organisers with Kayleigh Gates (Glasgow), winner of best 2nd year student talk

Impact from UK nuclear physics



Evaluated nuclear (decay) data underpins many areas.

Accueil LNHB | Reporter | Sommaire LNHB | Cosmétique | Radioactivité

Laboratoire National Henri Becquerel

Recommended data

Le LNHB est heureux de vous présenter son [nouveau site web](#).
(N'oubliez pas de mettre à jours vos liens.)

The LNHB is very pleased to present its [new website](#).
(Do not forget to update your bookmarks.)

This [introduction](#) presents a brief description of the radioactivity physical processes, the enumeration of the evaluation rules leading to the recommended values, and a summary of the symbols and terms used in all the publications.

Explanation on recommended data and their evaluation (in various languages):

Tables of evaluated data and comments on evaluation
Pages updated by the Laboratoire National Henri Becquerel
All questions about the data must be sent to the authors. See chapter [Addresses](#).

updated: 20th October 2017
newly added: Pr-142
recently updated: Sn-113
ASCII files updated on: 24/06/2016
(221 nuclides in table, sorted by [alphabetical order](#) / [atomic number](#) / [mass number](#) / [edition date](#))

[\(History of older evaluations, sorted by alphabetical order\)](#)

Subscribe to DDEP RSS feed

(Type of updates: **N** - new evaluation; 1 - update in comments only; 2 - minor update in table; 3 - major update in table)

Nuclide	Tables	Comments	ENSDF	PenNuc	Lara	Vol.	UpDate	Type
Ac-225	225Ac	table	comments	ensdf	pennuc	txt	5	25/08/2009
Ac-227	227Ac	table	comments	ensdf	pennuc	txt	4	16/02/2009
Ac-228	228Ac	table	comments	ensdf	pennuc	txt	6	22/01/2010
Ag-108	108Ag	table	comments	ensdf	pennuc	txt	3	4/09/2006
Ag-108m	108mAg	table	comments	ensdf	pennuc	txt	3	17/01/2012
Ag-110	110Ag	table	comments	ensdf	pennuc	txt	3	12/03/2004
Ag-110m	110mAg	table	comments	ensdf	pennuc	txt	1	24/03/2004
Al-26	26Al	table	comments	ensdf	pennuc	txt	9	24/07/2003
Am-241	241Am	table	comments	ensdf	pennuc	txt	5	20/08/2010
Am-242	242Am	table	comments	ensdf	pennuc	txt	5	18/01/2011
Am-242m	242mAm	table	comments	ensdf	pennuc	txt	6	18/01/2011
Am-243	243Am	table	comments	ensdf	pennuc	txt	5	26/02/2010
Am-244	244Am	table	comments	ensdf	pennuc	txt	5	18/01/2011
Am-244m	244mAm	table	comments	ensdf	pennuc	txt	5	18/01/2011
Ar-37	37Ar	table	comments	ensdf	pennuc	txt	9	16/10/2012
Ar-41	41Ar	table	comments	ensdf	pennuc	txt	6	4/05/2010
At-211	211At	table	comments	ensdf	pennuc	txt	6	6/04/2011

NNDC National Nuclear Data Center

BROOKHAVEN NATIONAL LABORATORY Site Index

NSR XUNDL ENSDF
NuDat Databases MIRD
Sigma CSIRS ENDF

Chart of Nuclides

Atlas of n Resonances

Empire

Nuclear Wallet Cards

Tools and Publications

Nuclear Data Sheets

Networks

CSEWG USNDP

Nuclear Data Sheets Special Issue

Nuclear Data Sheets

Nuclear Data Sheets Special Issue available!
Nuclear Data Week 2018
Nuclear Data Roadmapping and Enhancement Workshop

Main Structure & Decay Reactions Bibliography Networks & Links Publications Meetings

AMDC Atomic Mass Data Center, [Q-value Calculator](#)

Atlas of Neutron Resonances Parameters & thermal values

CapGam Thermal Neutron Capture γ -rays

Chart of Nuclides Basic properties of atomic nuclei

Covariances of Neutron Reactions

CSEWG Cross Section Evaluation Working Group

CSIRS alias EXFOR Nuclear reaction experimental data

ENDF Evaluated Nuclear (reaction) Data File, [Sigma](#)

ENSDF Evaluated Nuclear Structure Data File

IRDF International Reactor Dosimetry and Fusion File

MIRD Medical Internal Radiation Dose

NMMSS & DoE NMIRD

Safeguards & inventory decay data standards

NSR Nuclear Science References

Nuclear Data Sheets Nuclear structure & decay data journal, [Special Issues on reaction data](#)

NucRates MACS & Astro-physical reaction rates

NuDat Nuclear structure & decay Data

USNDP U.S. Nuclear Data Program

USNDP/CSEWG GForge Collaboration Server

Sponsored by the Office of Nuclear Physics - Office of Science - U.S. Department of Energy

Acknowledgments - About Us - Comments/Questions - Disclaimer

<https://www.nndc.bnl.gov/nudat2/>

<http://www.nucleide.org/DDEP.htm>

Boodiyk & Regan St. Peters 6 Oct 2020

Most recent (2017) NuPECC Long Range plan.

Chapter 6. APPLICATIONS AND SOCIETAL BENEFITS



- Energy production: fission, fusion.
- Health applications
 - therapy; imaging; radioisotope production; theranostics, etc.
- Radioprotection / health physics.
- Environmental radioactivity, space applications, climate science.
- Cultural Heritage science.
- Nuclear security; counter terrorism; Nuclear forensics.
- Materials science, nanotechnology.

http://www.esf.org/fileadmin/user_upload/esf/Nupecc-LRP2017.pdf

UK Nuclear Data Network+ (UKNDN)

“The revitalisation of the nuclear power industry offers important economic opportunities for the UK, which require unprecedented cooperation between government, industry and academia to be realised.”

Funded 16 nuclear-data projects at 11 research intuitions in competitive calls.

UK Membership
n_TOF @CERN

Nuclear Physics

Government's “Our Plan for Growth”

Supports UKNSF
76 members from
36 organizations

Community Detectors:

- STEFF @ n_TOF
- LaBr₃ Array
- FIFI2

Industrial nuclear data are those that underpin the safety and economics of industrial nuclear operations and processes.

Support for PhD studentships and Research travel funding

UK

NDN



UNIVERSITY OF
SURREY



UNIVERSITY
of York

Primary standard of radioactivity standard for ^{60}Co using γ - γ energy coincidences with NANA



Applied Radiation and Isotopes 134 (2018) 290–296

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

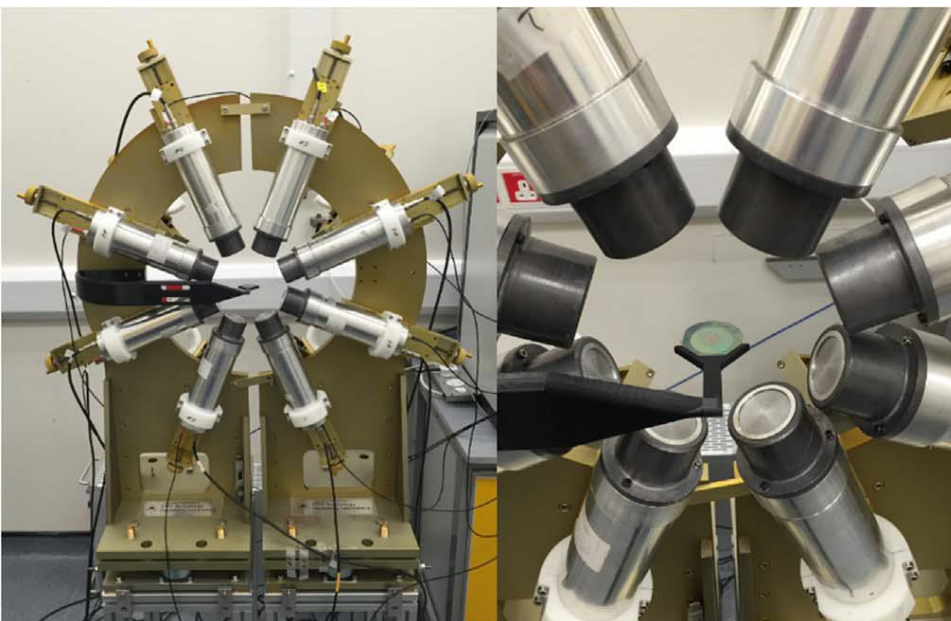
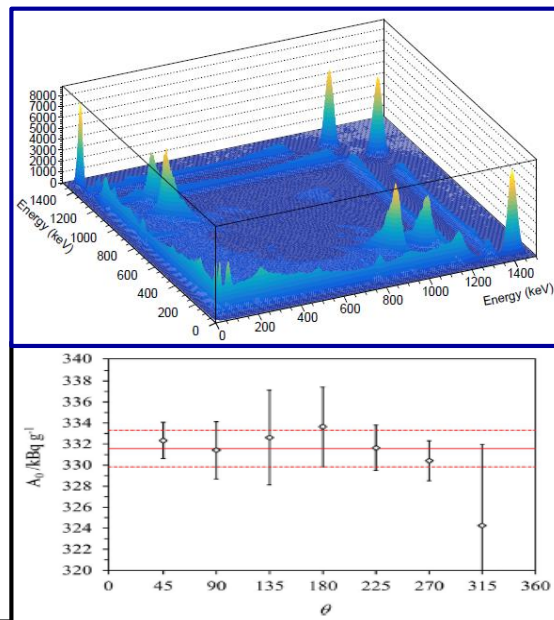


Investigation of γ - γ coincidence counting using the National Nuclear Array (NANA) as a primary standard

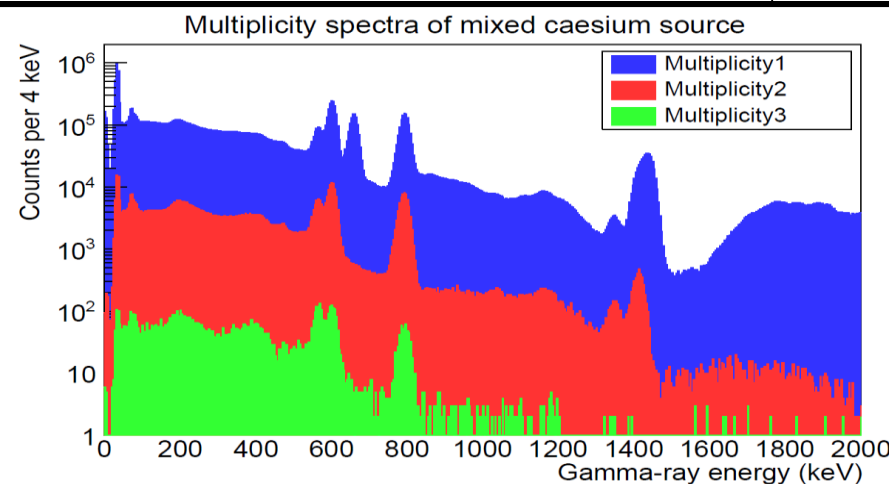
S.M. Collins^{a,b,*}, R. Shearman^{a,b}, J.D. Keightley^a, P.H. Regan^{a,b}

^a National Physical Laboratory, Hampton Road, Teddington, Middlesex TW11 0LW, United Kingdom

^b Department of Physics, University of Surrey, Guildford GU2 7XH, United Kingdom



Standardisation technique	A_0 /kBq g ⁻¹	$u(A_0)$ /kBq g ⁻¹
NANA γ - γ coincidence counting	330.8	± 1.0
4 π (LS)- γ DCC	330.92	± 0.86



Advances in the Direct Study of Carbon Burning in Massive Stars

G. Fruet,^{1,2} S. Courtin,^{1,2,3,*} M. Heine^{1,2,†} D. G. Jenkins,⁴ P. Adsley,⁵ A. Brown,⁴ R. Canavan,^{6,7} W. N. Catford,⁶
 E. Charon,⁸ D. Curien,^{1,2} S. Della Negra,⁵ J. Duprat,⁹ F. Hammache,⁵ J. Lesrel,⁵ G. Lotay,⁶ A. Meyer,⁵ D. Montanari,^{1,2,3}
 L. Morris,⁴ M. Moukaddam,⁶ J. Nippert,^{1,2} Zs. Podolyák,⁶ P. H. Regan,^{6,7} I. Ribaud,⁵ M. Richer,^{1,2} M. Rudigier,⁶
 R. Shearman,^{6,7} N. de Séréville,⁵ and C. Stodel¹⁰

¹IPHC, Université de Strasbourg, Strasbourg F-67037, France

²CNRS, UMR7178, Strasbourg F-67037, France

³USIAS/Université de Strasbourg, Strasbourg F-67083, France

⁴University of York, York YO10 5DD, United Kingdom

⁵Institut de Physique Nucléaire, CNRS/IN2P3, Université Paris-Sud, Université Paris-Saclay, 91406 Orsay Cedex, France

⁶Department of Physics, University of Surrey, Guildford GU2 7XH, United Kingdom

⁷National Physical Laboratory, Teddington, Middlesex TW11 0LW, United Kingdom

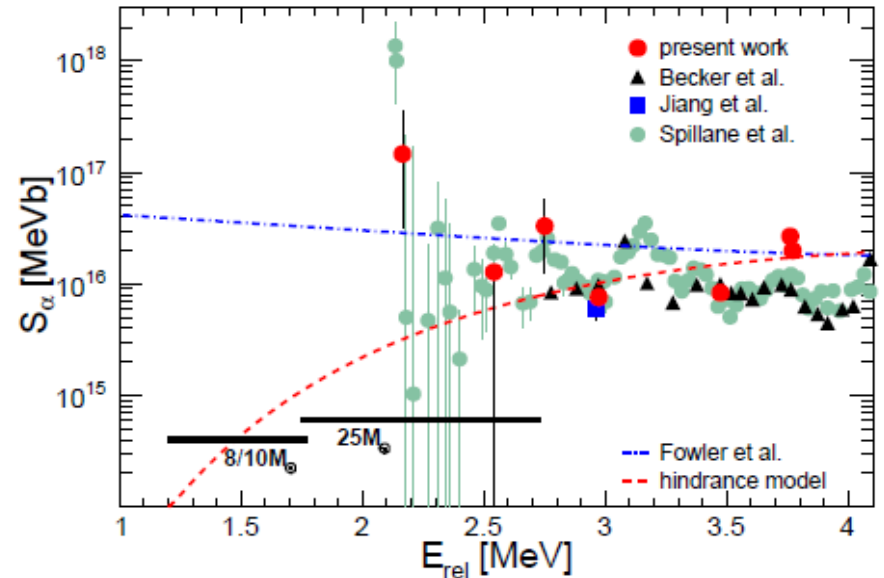
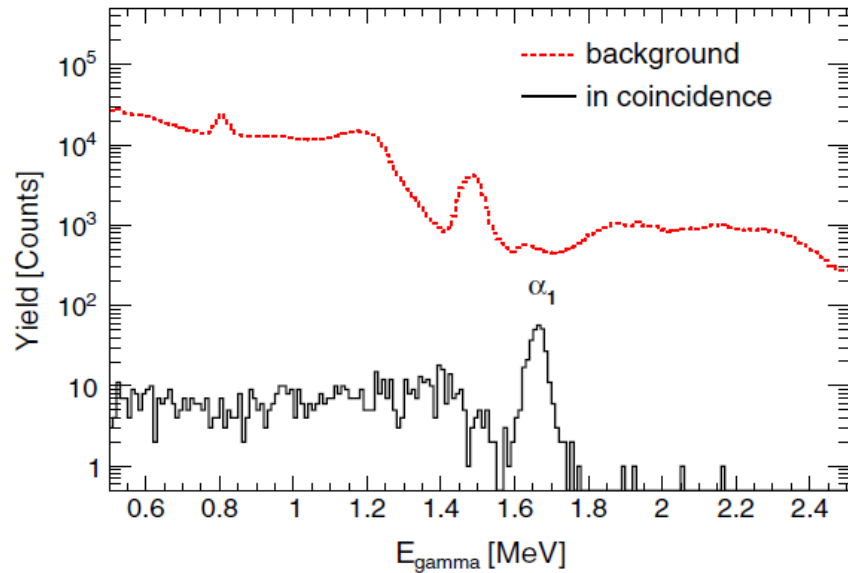
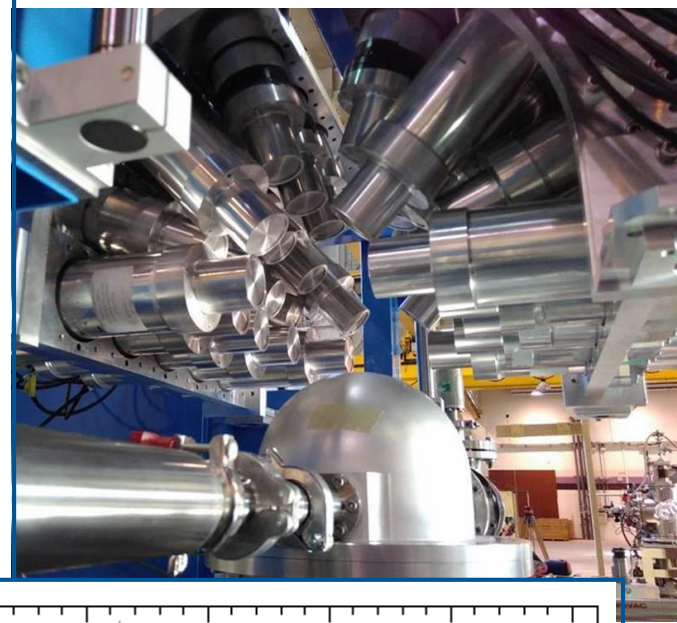
⁸NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay F-91191 Gif sur Yvette, France

⁹Centre de Sciences Nucléaires et de Sciences de la Matière (CSNSM), Université Paris Sud,

UMR 8609-CNRS/IN2P3, 91405 Orsay, France

¹⁰GANIL, CEA/DSM-CNRS/IN2P3, Caen F-14076, France

(Received 30 July 2019; revised manuscript received 27 September 2019; accepted 21 February 2020; published 12 May 2020)

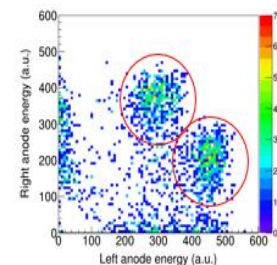
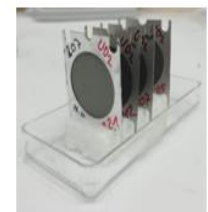
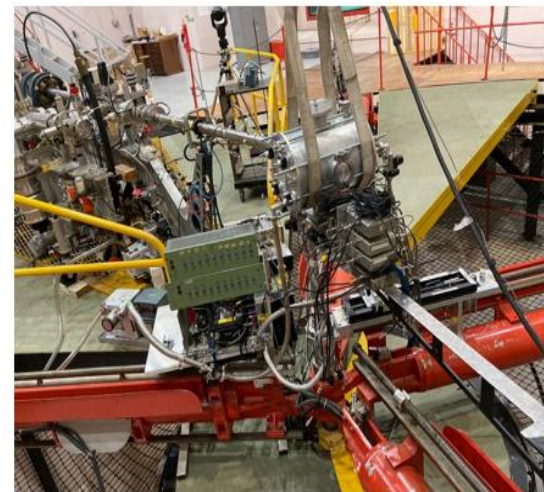
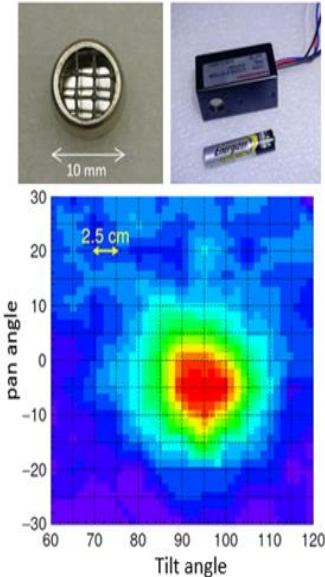


Understanding of the creation of Ne and Na in stellar burning.
 NANA detectors measure $^{12}\text{C}+^{12}\text{C}$ nuclear fusion probability.

Nuclear Data for Nuclear Power Generation.

- Design and construction of detector setup for alpha emitters in **Sellafield** Special Nuclear Material stores.
- Work was carried out in B47, enabling use of strong neutron sources e.g. ^{252}Cf .
- Applications for safety, security and decommissioning.
- Testing of novel ion chamber design with **U.Manchester** and **NNL**, along with investigation of ^{236}U cross sections.
- Support for **Advanced Fuel Cycle Programme**.

Giuseppe Lorusso & Michael Bunce



University of Manchester: STEFF @ n_TOF

Spectrometer for Exotic Fission Fragments: *A.G. Smith, T. Wright, N. Sosnin, S. Bennett, et al.*

Goal:

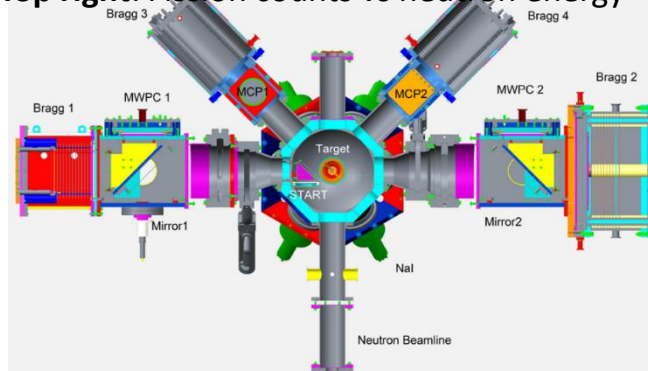
- Provide data for NEA HPRL entry on ^{235}U and ^{239}Pu Prompt Fission γ -Rays (average energies and multiplicities)

Realisation:

- Measure fission with 2E2v device STEFF and corresponding γ s with NaI and LaBr₃ detectors

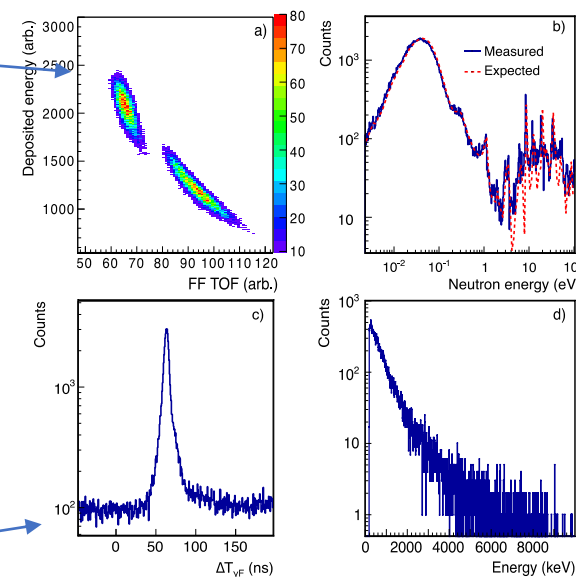
Top left: Fission fragment time-of-flight vs energy

Top right: Fission counts vs neutron energy



Bottom left: γ -ray counts vs fission time

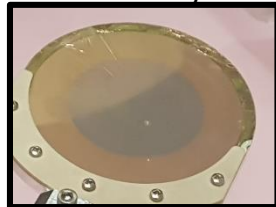
Top right: Fission γ -ray energy spectrum



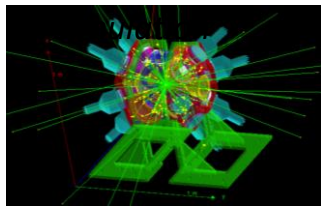
^{235}U target



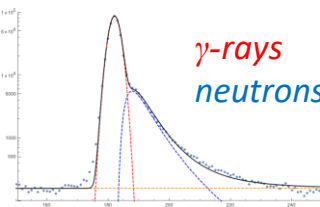
^{239}Pu target



Geant4



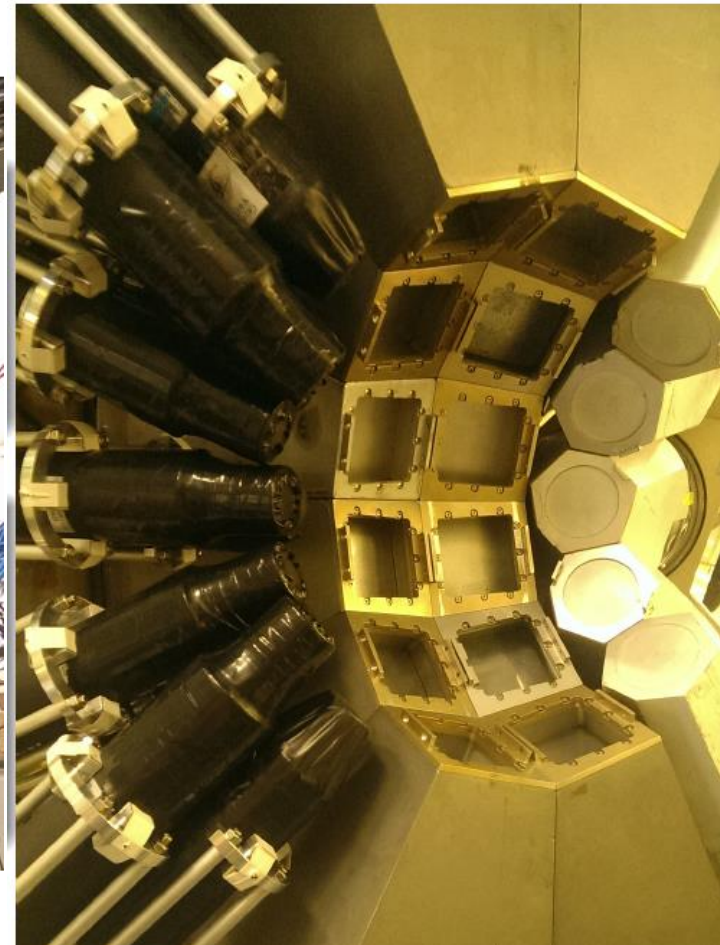
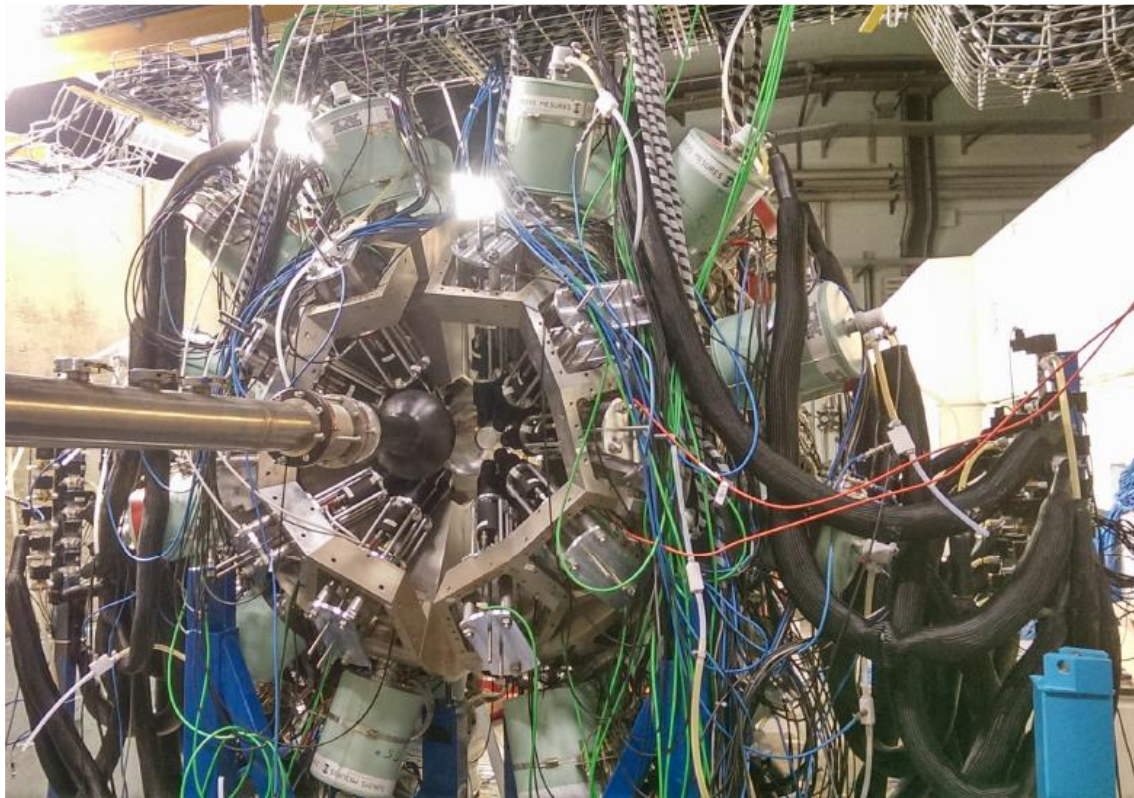
Fission neutron removal



N. Colonna et al., "The fission experimental programme at the CERN n_TOF facility: status and perspectives", *Eur. Phys. J. A* (2020) 56: 48. DOI: <http://dx.doi.org/10.1140/epja/s10050-020-00037-8>

ν -Ball at IPN-Orsay: 'Hybrid' HPGe -LaBr₃ combined array.

- 20 LaBr₃ detectors with from FATIMA -time resolution ~ 250 ps
- 24 HPGe clover detectors with BGO shielding for Compton Suppression
- 10 coaxial HPGe detectors with BGO shielding
- FASTER Digital DAQ; 500 MHz sampling for the LaBr₃ detectors; 125 MHz sampling for the HPGe and BGO detectors
- Internal pulse shape analysis



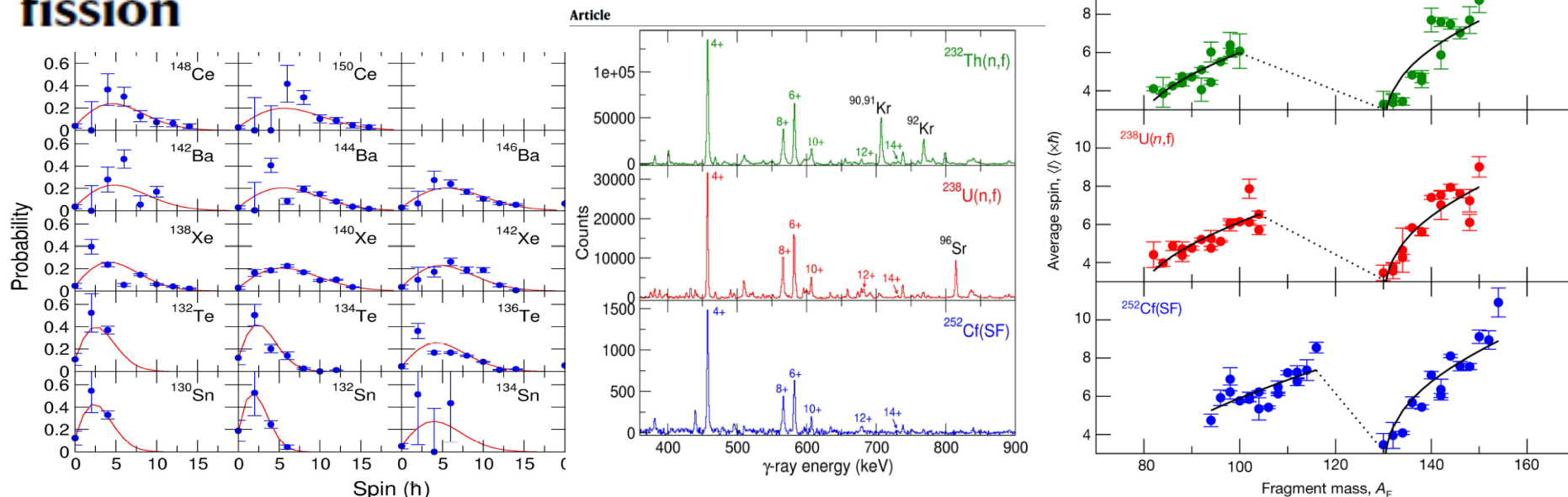
NuBall – Attacking an 80 year problem

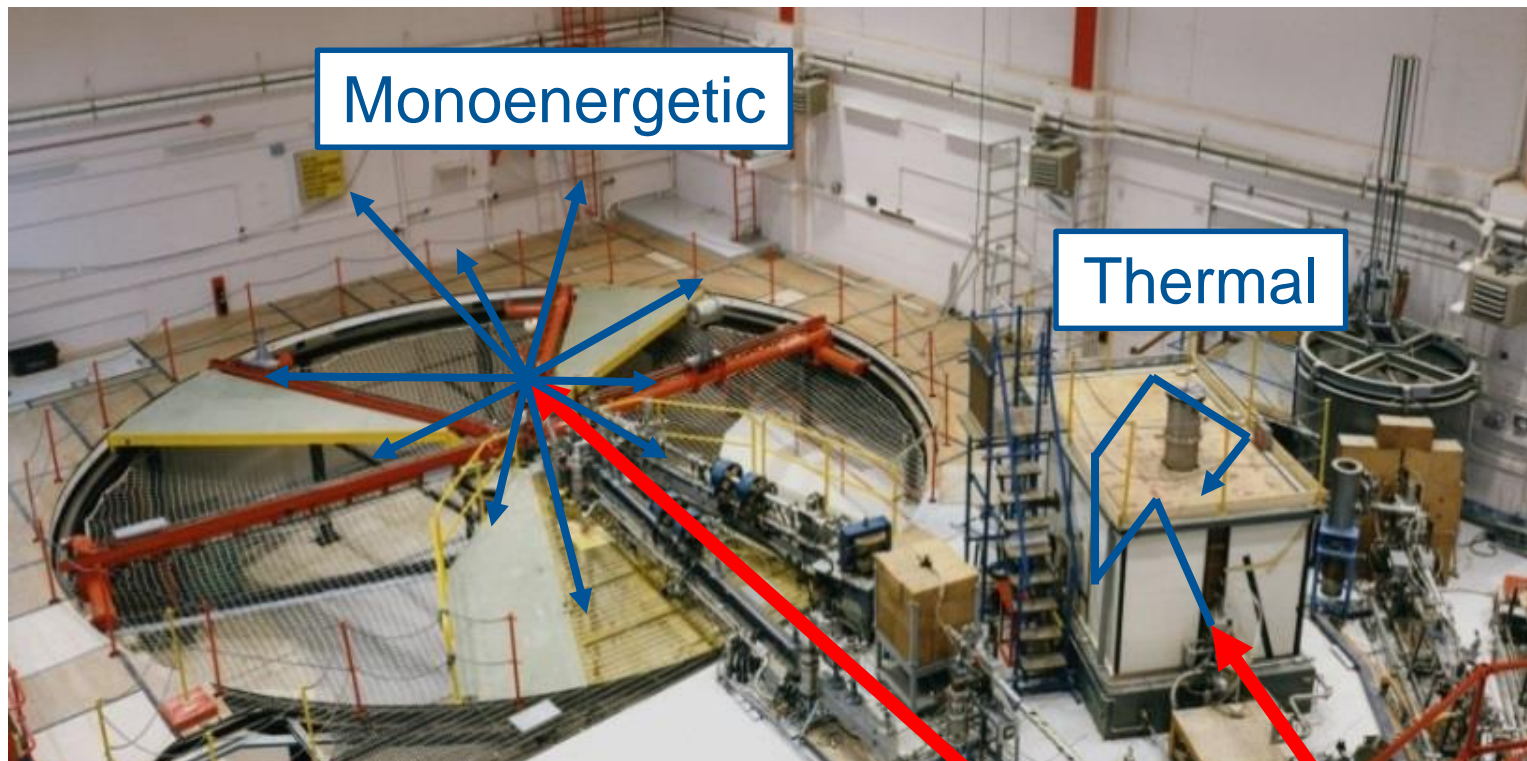
The generation of angular momentum in nuclear fission

- Fast-neutron fission on Th and U targets.
- Measure the angular momentum of fragments.
- Precision high-resolution ID of the coincident gamma cascades.
- The angular momentum between fragment pairs NOT correlated!
- Huge challenge to understanding of the nuclear fission process.

Article **566** | Nature | Vol 590 | 25 February 2021

Angular momentum generation in nuclear fission

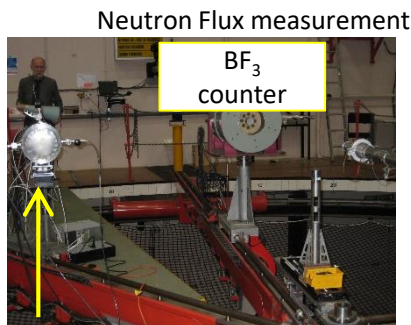
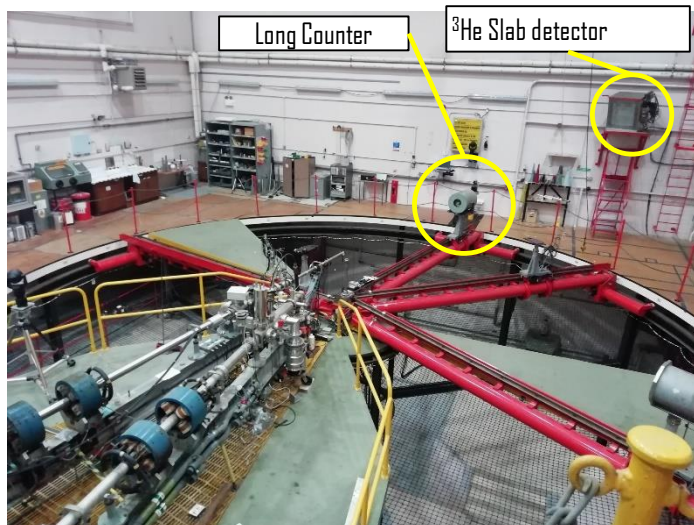




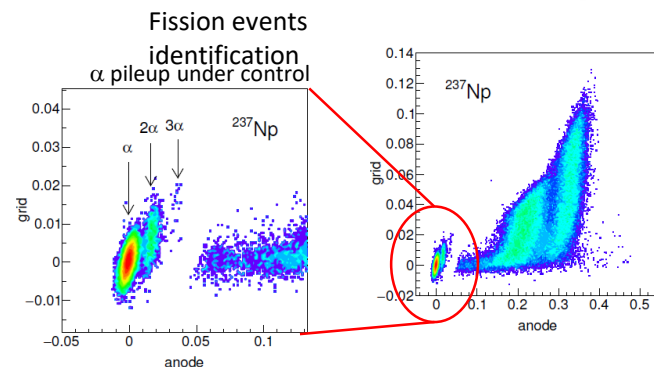
Beam Energy (MeV)*	Neutron Energy range (MeV)	Reaction	Max fluence at 1 m (cm ⁻² s ⁻¹)
2.905-2.945	0.001 → 0.05	$^{45}\text{Sc}(p,n)^{45}\text{Ti}$	~ 8
1.925-2.355	0.05 → 0.63	$^7\text{Li}(p,n)^7\text{Be}$	500 → 2000**
1.450-2.985	0.63 → 2.2	$\text{T}(p,n)^3\text{He}$	1200 → 2100**
0.880-2.740	4 → 6	$\text{D}(d,n)^3\text{He}$	~ 850
0.880-2.550	13 → 19	$\text{T}(d,n)^4\text{He}$	~ 620

Toward $^{237}\text{Np}(n,f)$ and $^{238}\text{U}(n,f)$ reference cross sections

- NPL Low scattering area 18m x 18m x 26m
- Well known neutron fluence (within 2%)



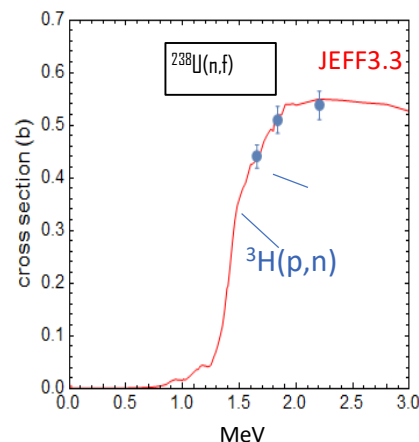
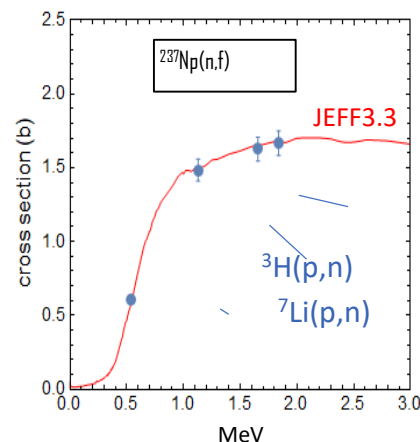
TFGIC and targets from JRC (Geel)



Results are promising, agree with current libraries, more work needed to:

- Improve reproducibility of the fission target position
- reduce error bars and more energies for $^{238}\text{U} \rightarrow$ more neutrons needed (working on this with AFCP)

- 2/3 of the GEN-IV reactors are fast reactors
- Fast $^{237}\text{Np}(n,f)$ $^{238}\text{U}(n,f)$ are better reference cross section than $^{235}\text{U}(n,f)$
- NPL **absolute** cross section will contribute the evaluation effort toward making ^{237}Np and ^{238}U standards



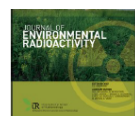
Can irradiate U targets for standardised noble gaseous radioactive (Kr, Xe) sources

Journal of Environmental Radioactivity 238–239 (2021) 106733



Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad



Production and measurement of fission product noble gases

Matthew A. Goodwin^{a,b,*}, Steven J. Bell^c, Richard Britton^d, Ashley V. Davies^a, Marc Abilama^c, Sean M. Collins^{b,c}, Robert Shearman^c, Patrick H. Regan^{b,c}

^a AWE Aldermaston, Reading, Berkshire, RG7 4PR, UK
^b Department of Physics, University of Surrey, Guildford, GU2 7XH, UK
^c National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK

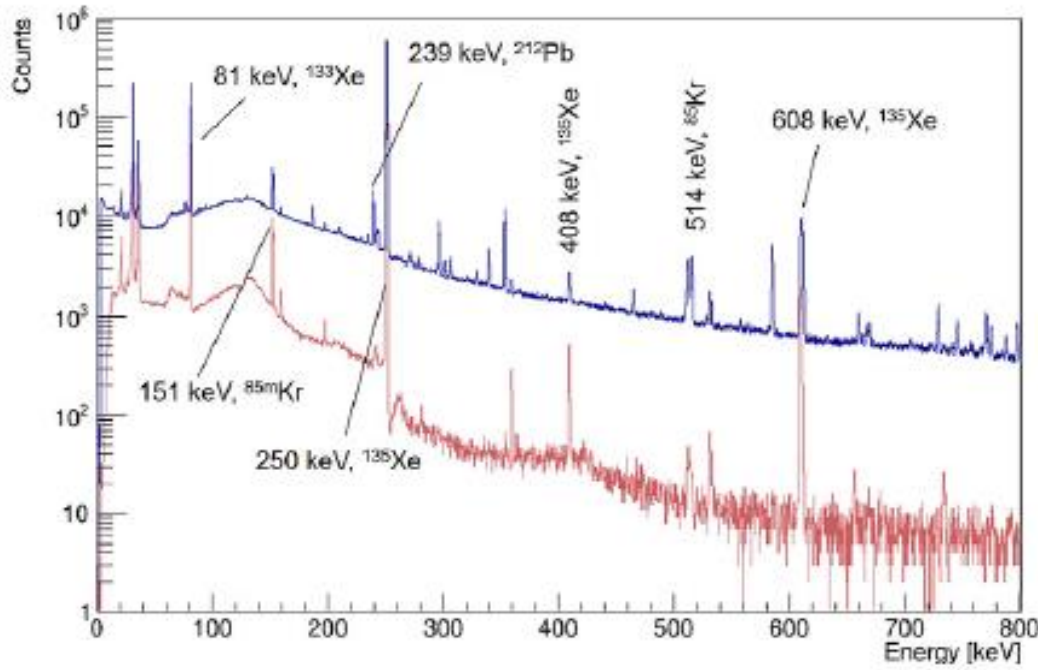


Table 3

Nuclide identification from a peak search of the γ -ray spectrum from Extraction 1 using the full acquisition ($t = 170,731$ s).[†] X-rays from Xe/Cs minus Ge fluorescence (escape peak). The relative γ -ray intensity is the full energy peak integral divided by the simulated γ -ray detection efficiency, decay-corrected to the start of the acquisition relative to the 250 keV ¹³⁵Xe peak (see Eq. (1)).

Fitted Energy (keV)	Parent Nucleus	Signature Type	γ -ray emission probability (%)	Rel. γ -ray Intensity (RGI) ($\times 1000$)	Comment
20.4	Xe/Cs [†]	$e^- - X$	–	–	Multiplet
30.7	Xe/Cs X	$e^- - X$	–	–	Multiplet
35.3	Xe/Cs X	$e^- - X$	–	–	Multiplet
80.9	¹³³ Xe	$\beta - \gamma$	37.3(4)	47.4(7.1)	81.0 + 79.6 keV
122.8	⁸⁶ Kr	$\beta - \gamma$	0.20(1)	0.807(12)	
129.1	^{85m} Kr	$\beta - \gamma$	0.30(8)	4.73(71)	
151.4	^{85m} Kr	$\beta - \gamma$	75.2(8)	38.1(5.7)	
158.6	¹³⁵ Xe	$\beta - \gamma$	0.29(1)	2.40(36)	
196.6	⁸⁶ Kr	$\beta - \gamma$	26(1)	4.42(67)	
233.4	^{133m} Xe	γ	10.1(2)	0.65(98)	
240.6	⁸⁶ Kr	$\beta - \gamma$	0.25(1)	0.78(12)	
250.2	¹³⁵ Xe	$\beta - \gamma$	90.0(3)	1000(7)	
305.1	^{85m} Kr	$\beta - \gamma$	14.0(4)	5.32(80)	^{85m} Kr > ⁸⁵ Kr
358.5	¹³⁵ Xe	$\beta - \gamma$	0.22(1)	1.94(29)	
390.0	⁸⁶ Kr	$\beta - \gamma$	0.64(5)	0.87(14)	
407.7	¹³⁵ Xe	$\beta - \gamma$	0.36(2)	5.83(88)	
438.9	⁸⁶ Rb	$\beta - \gamma$	0.015(4)	1.35(21)	
451.1	^{85m} Kr	$\beta - \gamma$	0.011(4)	0.88(14)	
454.4	¹³⁵ Xe	$\beta - \gamma$	0.004(1)	0.55(9)	
514.3	⁸⁵ Kr	γ	0.43(1)	4.76(72)	⁸⁵ Kr > ⁸⁵ Rb
526.4	^{135m} Xe	γ	80.6(6)	35.5(5.4)	
530.3	¹³³ I	$\beta - \gamma$	87(2)	2.81(42)	
608.3	¹³⁵ Xe	$\beta - \gamma$	2.9(1)	81.4(1.2)	²¹⁴ Bi Interference
731.9	¹³⁵ Xe	$\beta - \gamma$	0.055(4)	0.39(6)	
834.9	⁸⁶ Kr	$\beta - \gamma$	13(2)	6.75(10)	
898.2	⁸⁶ Rb	$\beta - \gamma$	14.4(2)	1.73(27)	
1836.5	⁸⁶ Rb	$\beta - \gamma$	22.8(1)	5.07(78)	

UK NP Radioactive Gas Metrology

UK Nuclear expertise in

- A) Neutron activation facility & source prep;
- B) Gas metrology, transport and engineering;
- C) Gamma-ray and electron spectrometry;
- D) Nuclear data analysis and interpretation.

Clear, direct impact in:

1) Energy & Environment: standardisations of radioactive Krypton. Real time signatures for reactor criticality .

2) Security & Resilience: New methodologies developed in collaboration with AWE & CTBTO for radioactive Xenon weapon signatures.



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Production and measurement of fission product noble gases

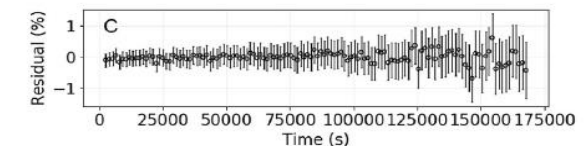
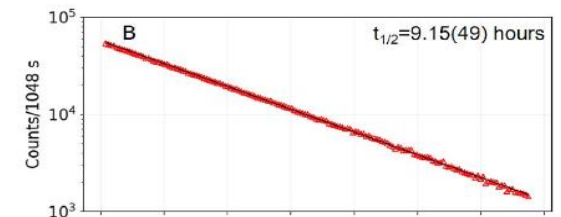
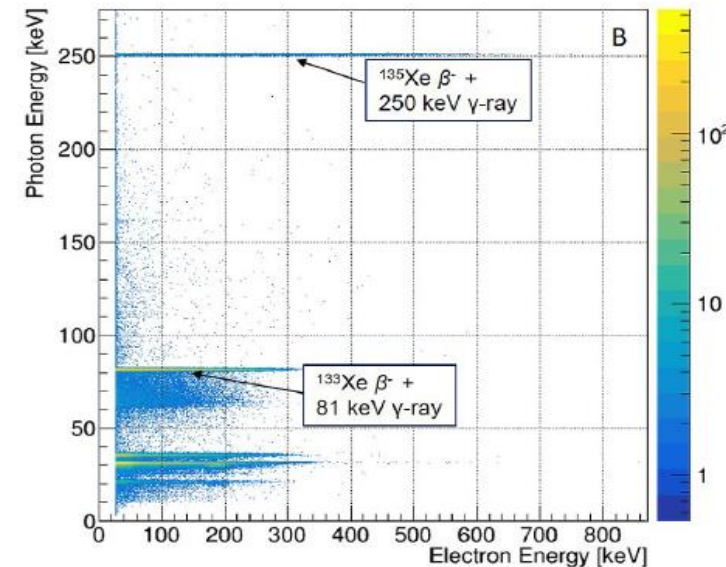
Matthew A. Goodwin^{a,b,*}, Steven J. Bell^c, Richard Britton^d, Ashley V. Davies^a, Marc Abilama^c, Sean M. Collins^{b,c}, Robert Shearman^c, Patrick H. Regan^{b,c}

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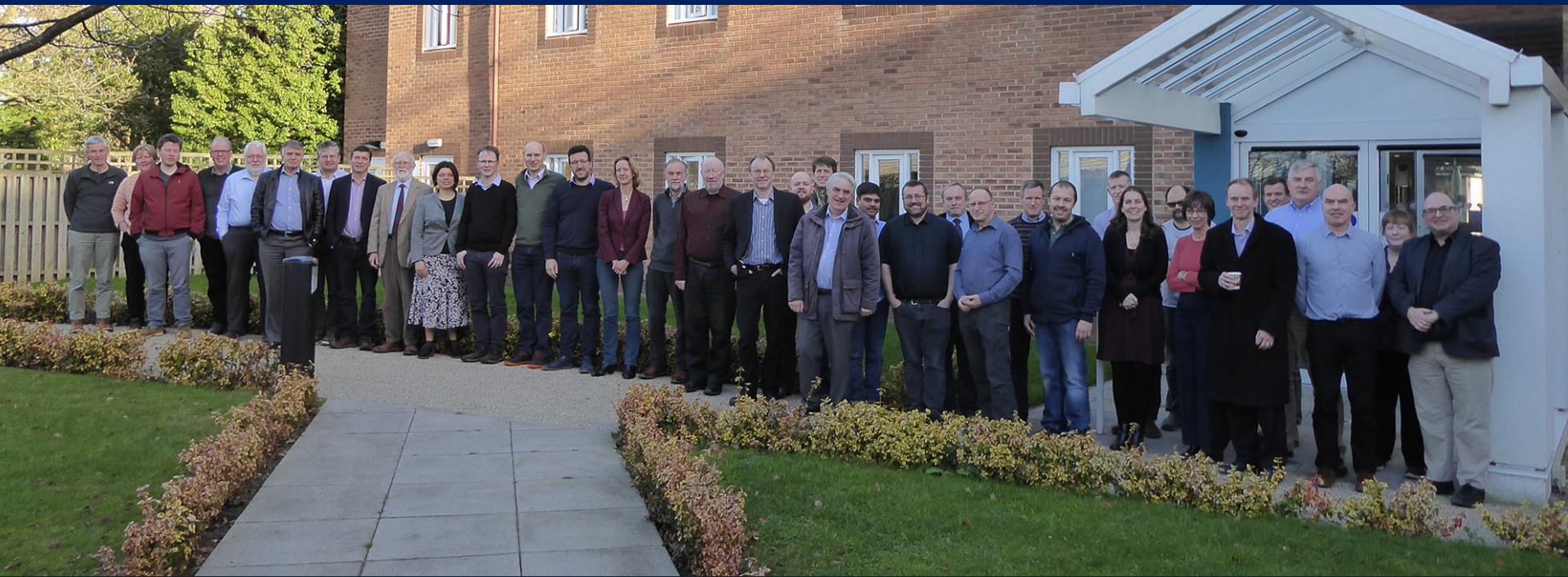
^b Department of Physics, University of Surrey, Guildford, GU2 7XH, UK

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UK Nuclear Physics



Next community meeting ~Jan 2023