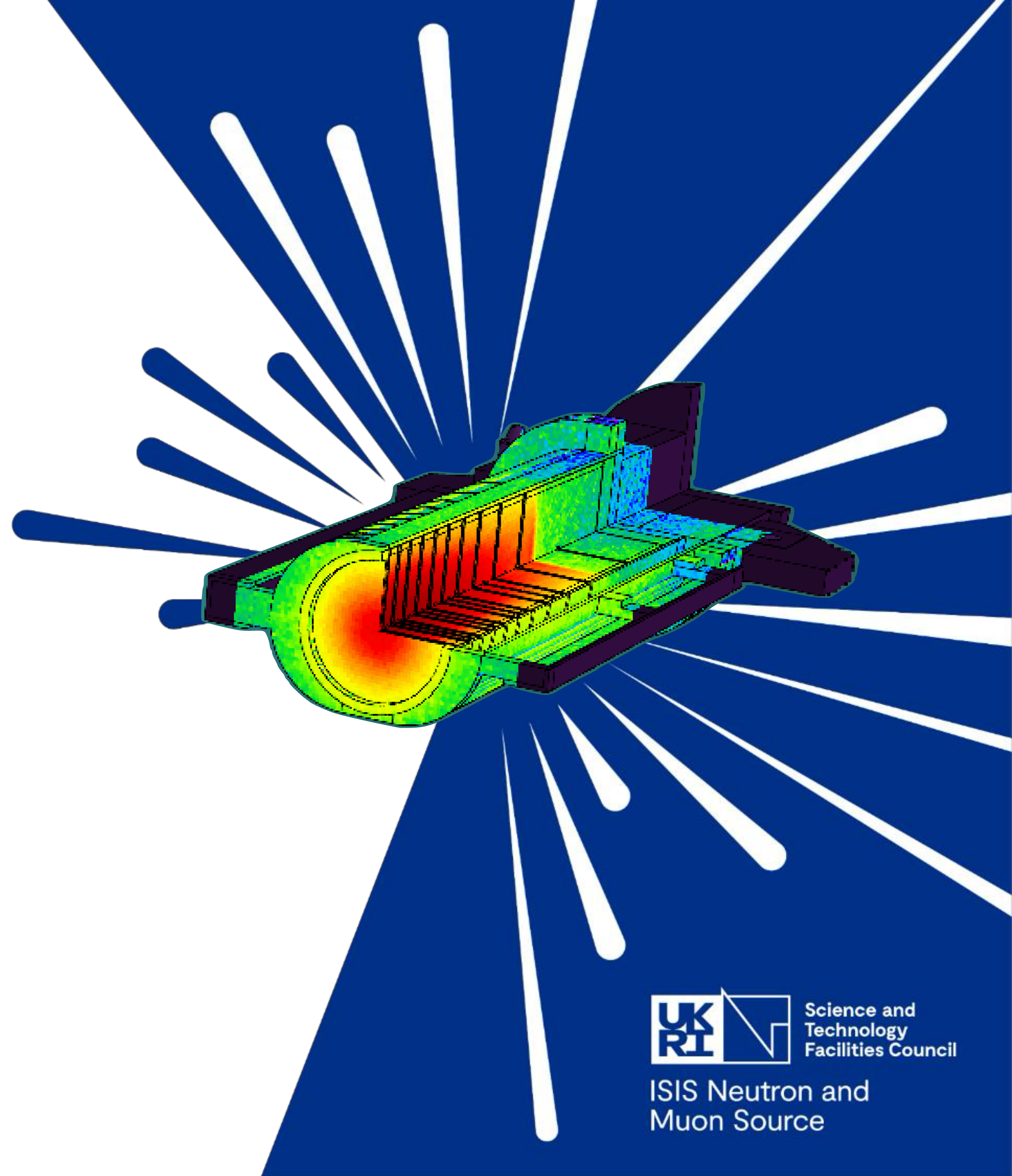


Building a Strategic FLUKA-STFC Collaboration

L. Quintieri¹



ISIS Neutron and
Muon Source

June 2, 2026, Rutherford Appleton Laboratory

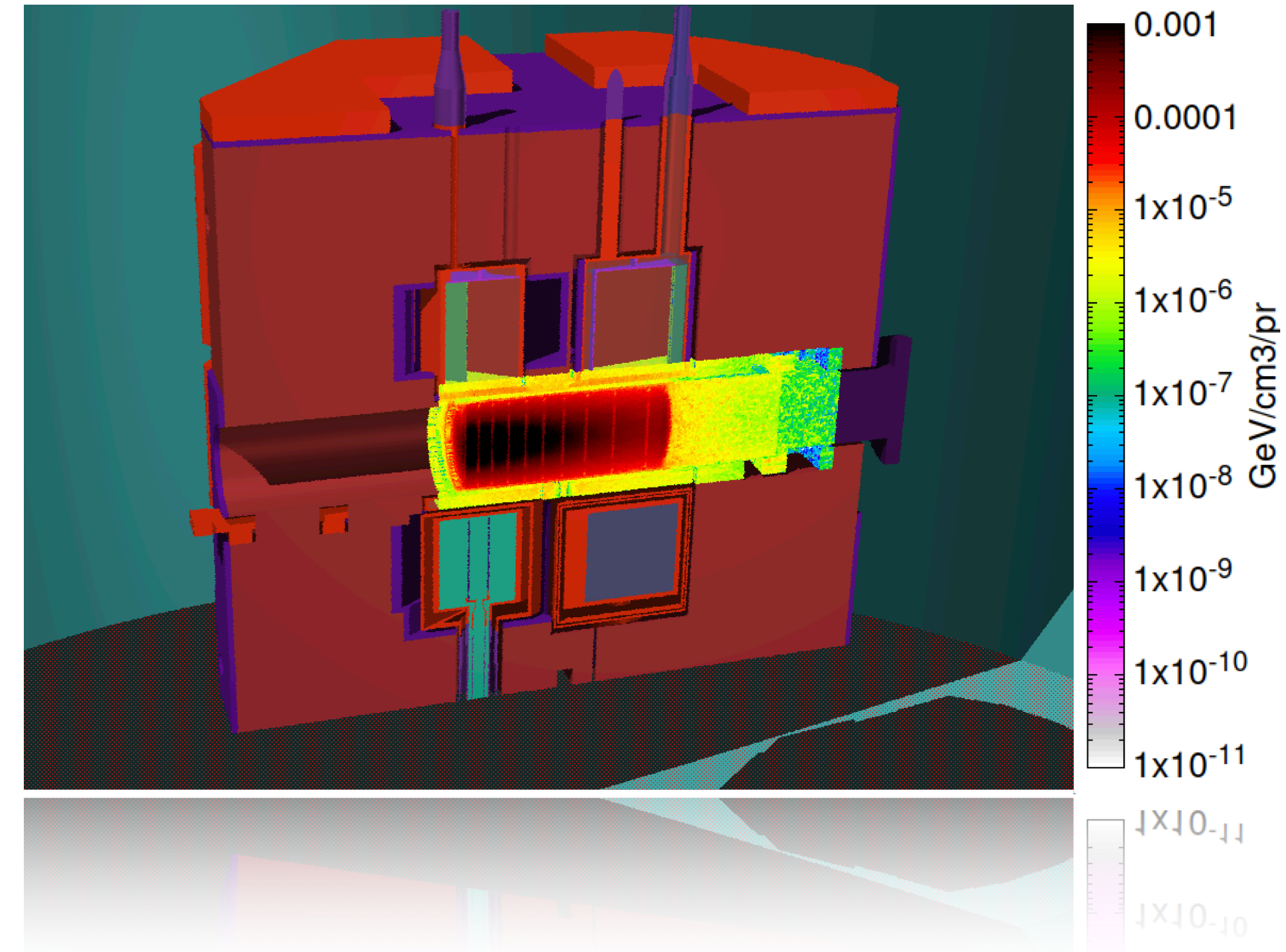
Agenda of the Meeting

08:30–08:45	Welcome and Neutronics	<i>Lina Quintieri</i>
08:45–09:00	Target Systems	<i>Michael Fitton</i>
09:00–09:15	Instrument Development	<i>Robert Dalgliesh</i>
09:15–09:30	Muons	<i>Chris Rogers</i>
09:30–10:00	FLUKA Developments and Future Perspectives	<i>Francesco Cerutti from CERN</i>
10:00–10:15	Discussion	
10:15–10:30	Health Physics and Facility Safety	<i>Xavier Queralt</i>

Overview

Context and motivations

- Context and reason for this meeting
- Activities of Neutronics group with FLUKA
Achievements and
Future developments



Science and
Technology
Facilities Council

ISIS Neutron and
Muon Source

UK Research and Innovation



Department for
Science, Innovation
& Technology
(DSIT)



UK Research
and Innovation



Science and
Technology
Facilities Council



Arts and
Humanities
Research Council



Engineering and
Physical Sciences
Research Council



Biotechnology and
Biological Sciences
Research Council



Economic
and Social
Research Council



Research
England



Natural
Environment
Research Council



Innovate
UK



Medical
Research
Council

The Science and Technology Facilities Council is a body of UKRI.

It is a UK government agency dedicated to advancing science and engineering.

STFC operates independent research premises and facilities across the UK, offering state-of-the-art infrastructure for cutting-edge experiments and scientific investigations.

It funds research in particle physics, nuclear physics, condensed matter physics, space science, and astronomy, and operates world-class research facilities across the UK.

STFC Sites

STFC is one of Europe's largest multidisciplinary research organisations.

STFC provides state-of-the-art facilities and expertise to drive advancements in science and technology across a wide range of disciplines.

The Science and Technology Facilities Council (STFC) operates several major research campuses and national laboratories across the UK.

RAL hosts the CLF, ISIS Neutron and Muon Source, devoted primarily to the study of condensed matter.

UK Astronomy Technology Centre
Edinburgh, Scotland



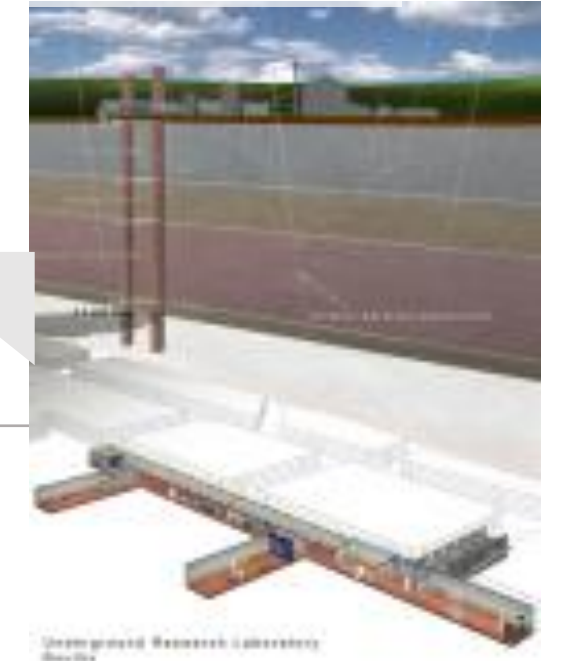
Polaris House
Swindon, Wiltshire



Chilbolton Observatory
Stockbridge, Hampshire



Boulby Underground Laboratory
North Yorkshire



Daresbury Laboratory
Sci-Tech Daresbury Warrington, Cheshire



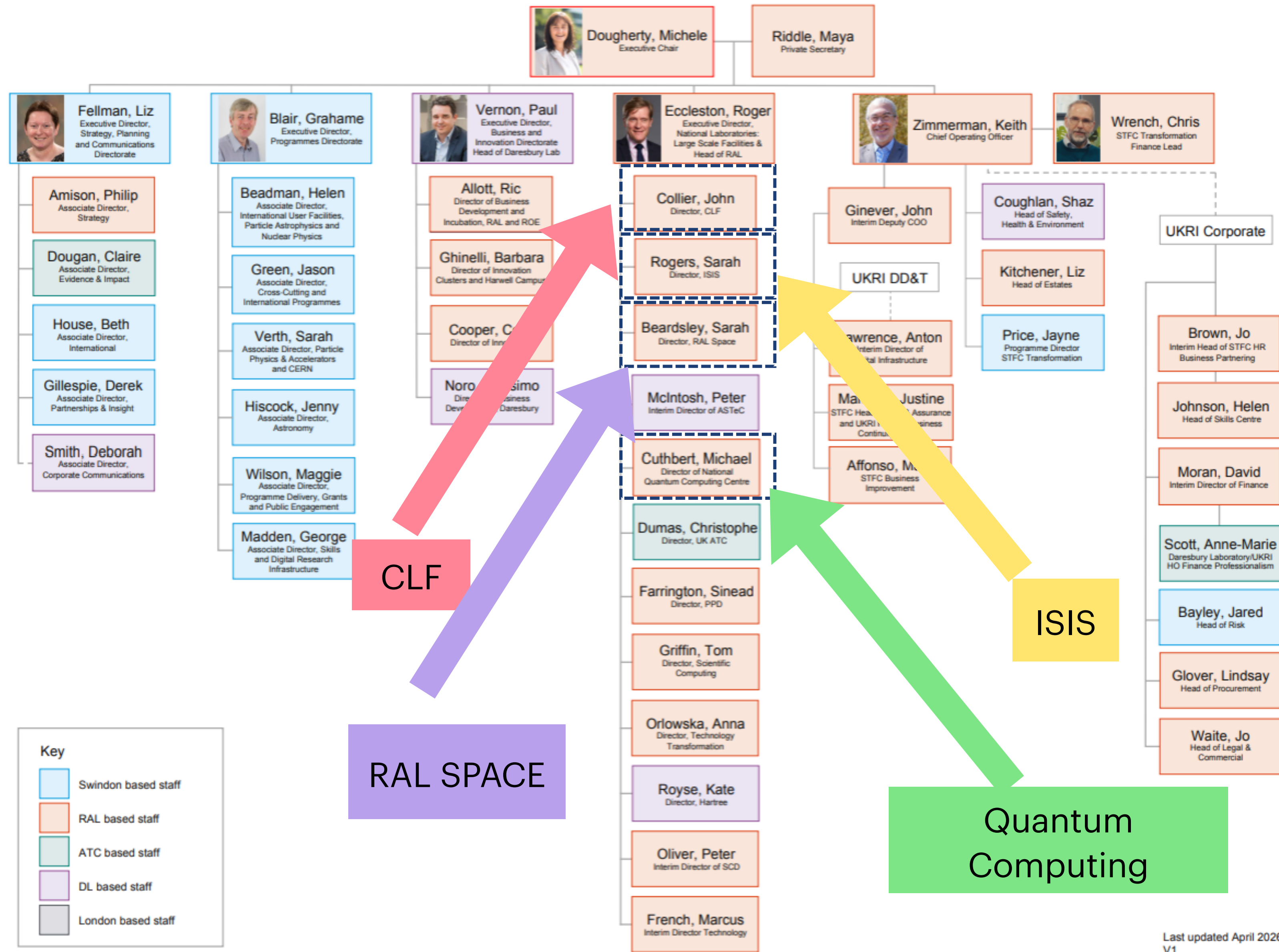
Rutherford Appleton Laboratory
Harwell Didcot, Oxfordshire



Executive Directors and Senior Staff Organogram

STFC's organisational structure consists of 6 directorates, each managing distinct aspects of its operations.

These include the Programmes Directorate, which defines science and technology strategy, and the **National Laboratories Directorate**, responsible for overseeing the UK's national laboratories,

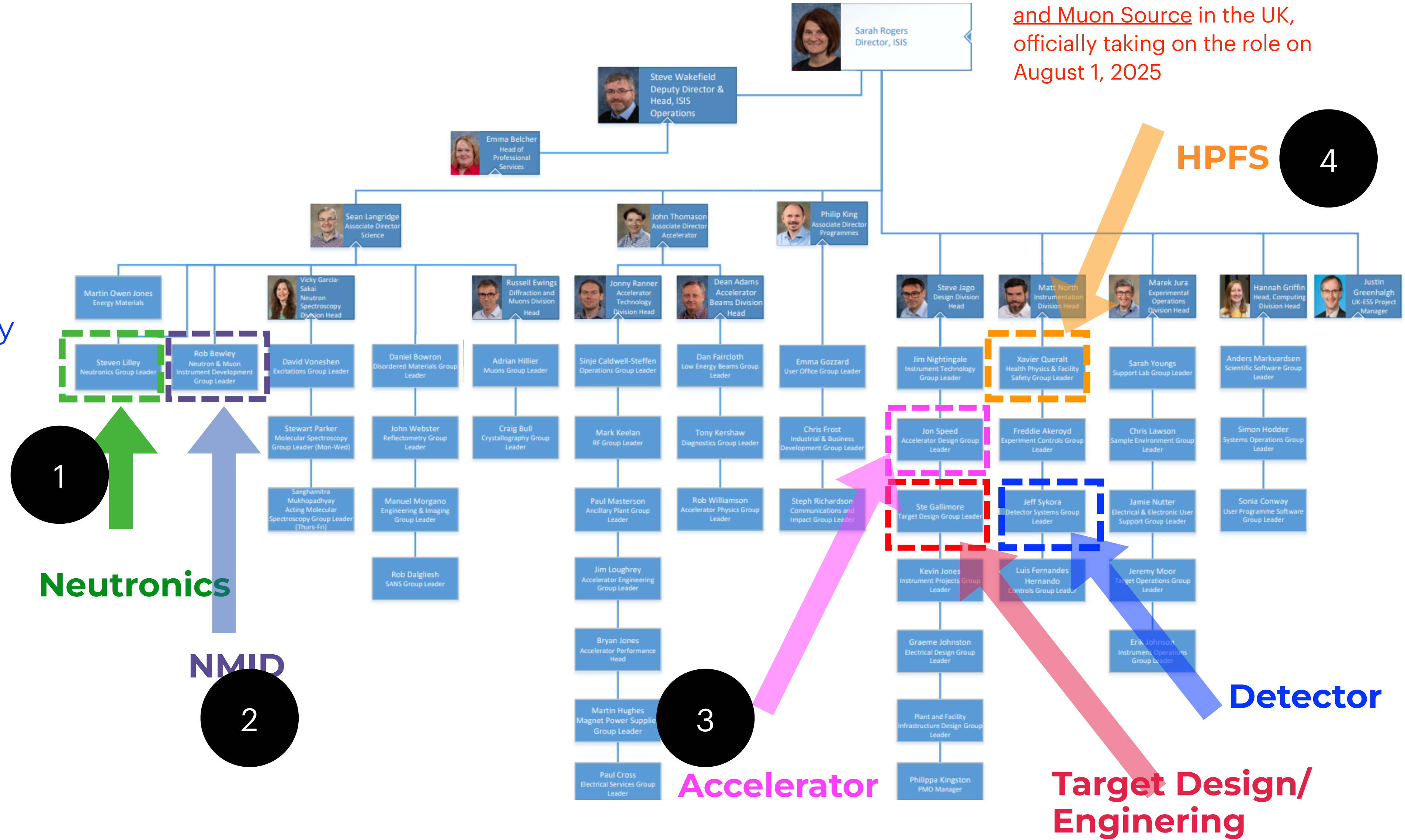


ISIS Senior Staff

ISIS staff are organized into specialized divisions that manage:

- Enginery materials
- Neutron spectroscopy
- Diffraction and muons,
- Accelerating Technology and Beams
- Engineering Design
- Experimental operation
- Computing
- Neutronics
- Neutron and muons Instrument developments

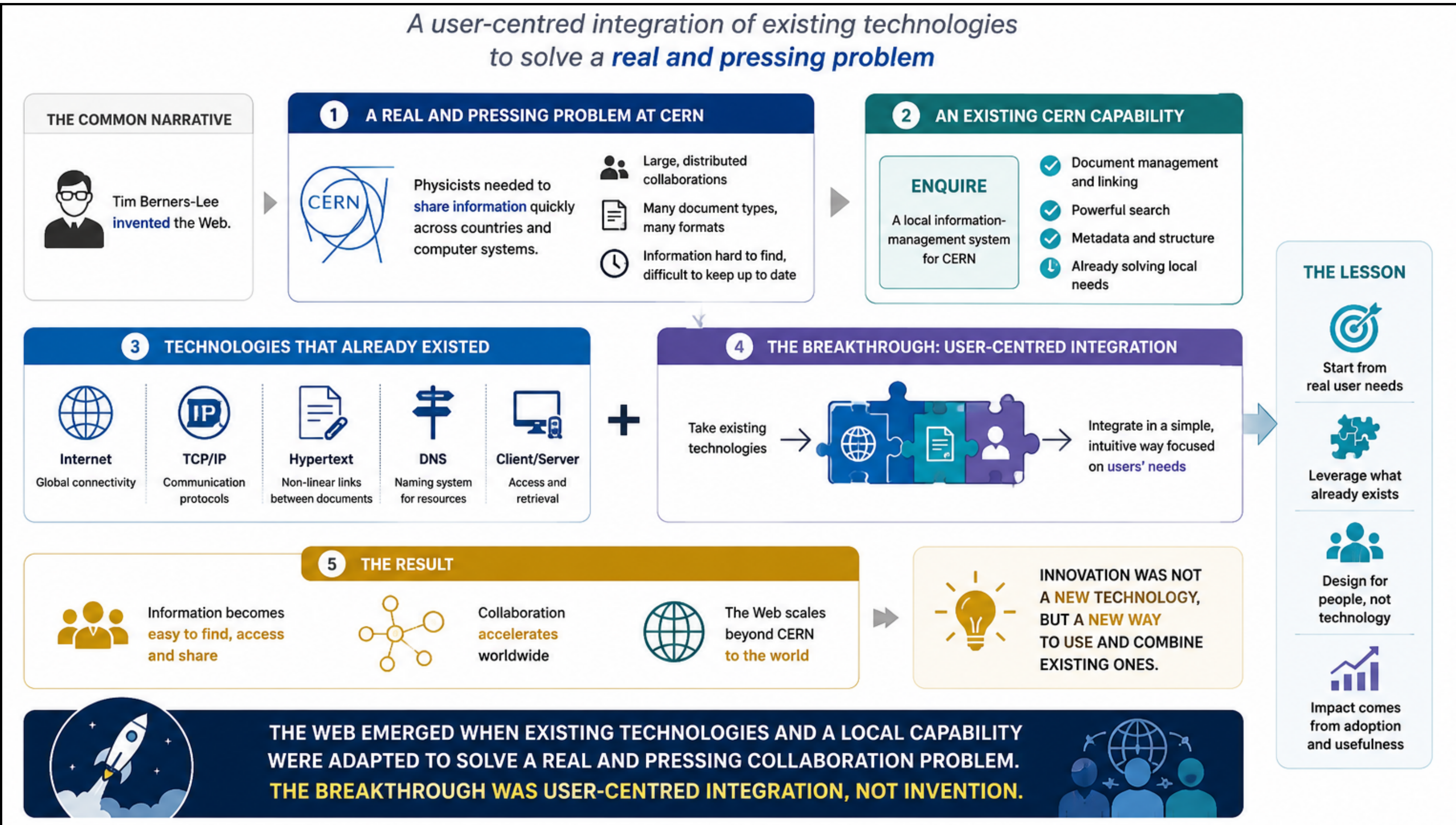
Dr. Sarah Rogers was appointed as the Director of the ISIS Neutron and Muon Source in the UK, officially taking on the role on August 1, 2025



There is significant interest across ISIS in using the FLUKA code.

Advantages of Assessing an Official Collaboration with FLUKA Team at CERN

- Direct support for ISIS and other relevant STFC activities
- Sharing of software tools and specialist expertise
- Joint projects to develop advanced modelling capabilities
- **Access to CERN expertise and know-how through collaborative studies and technical exchanges**
- Collaboration on feasibility studies and technology development programmes



"The Web is a perfect example of how existing pieces, when put together with a clear focus on users and a real problem, can create something far more powerful than the sum of their parts."

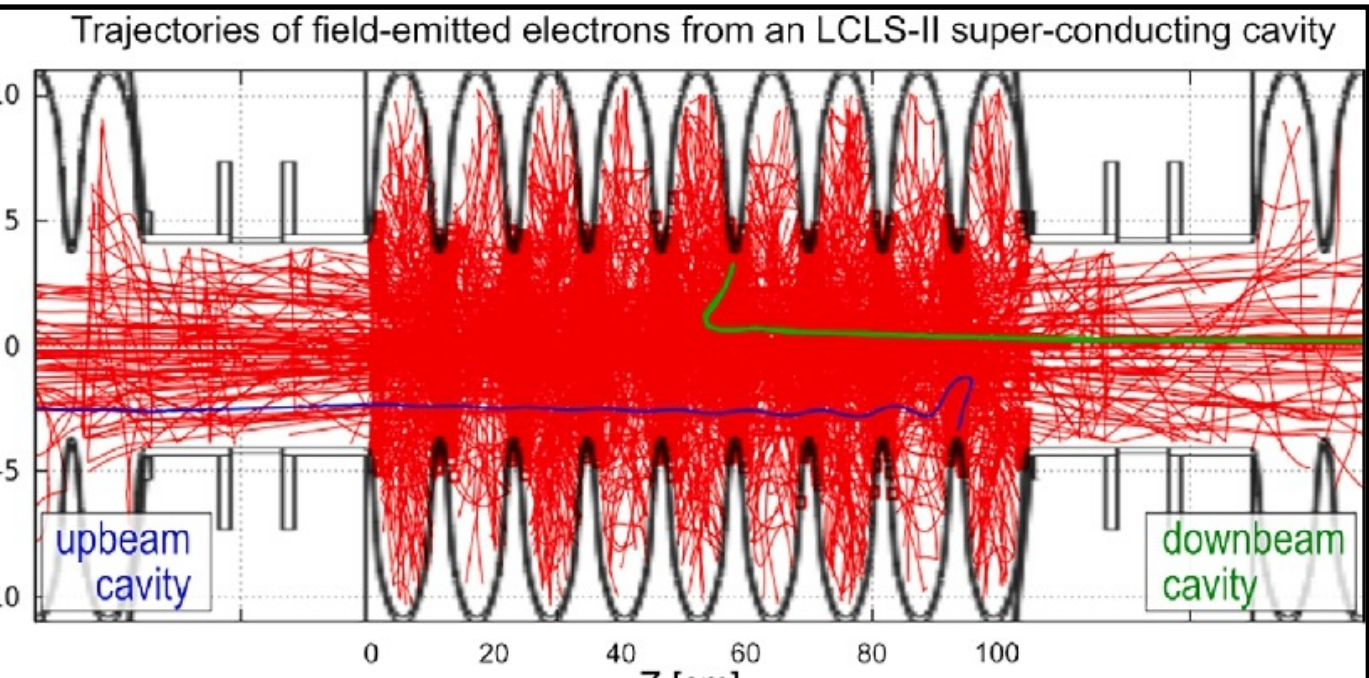
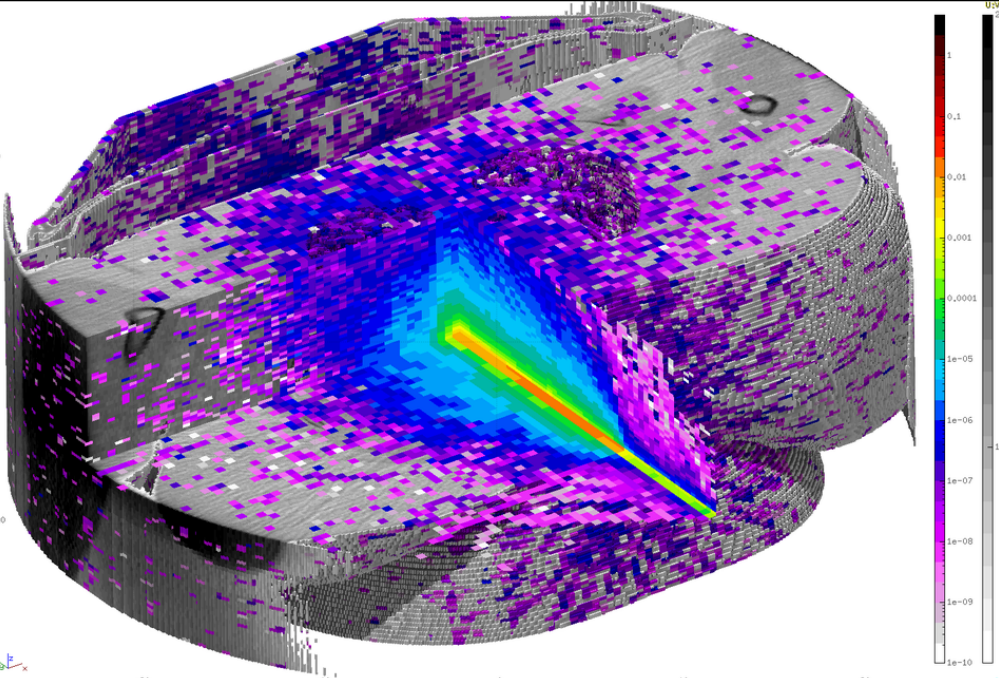
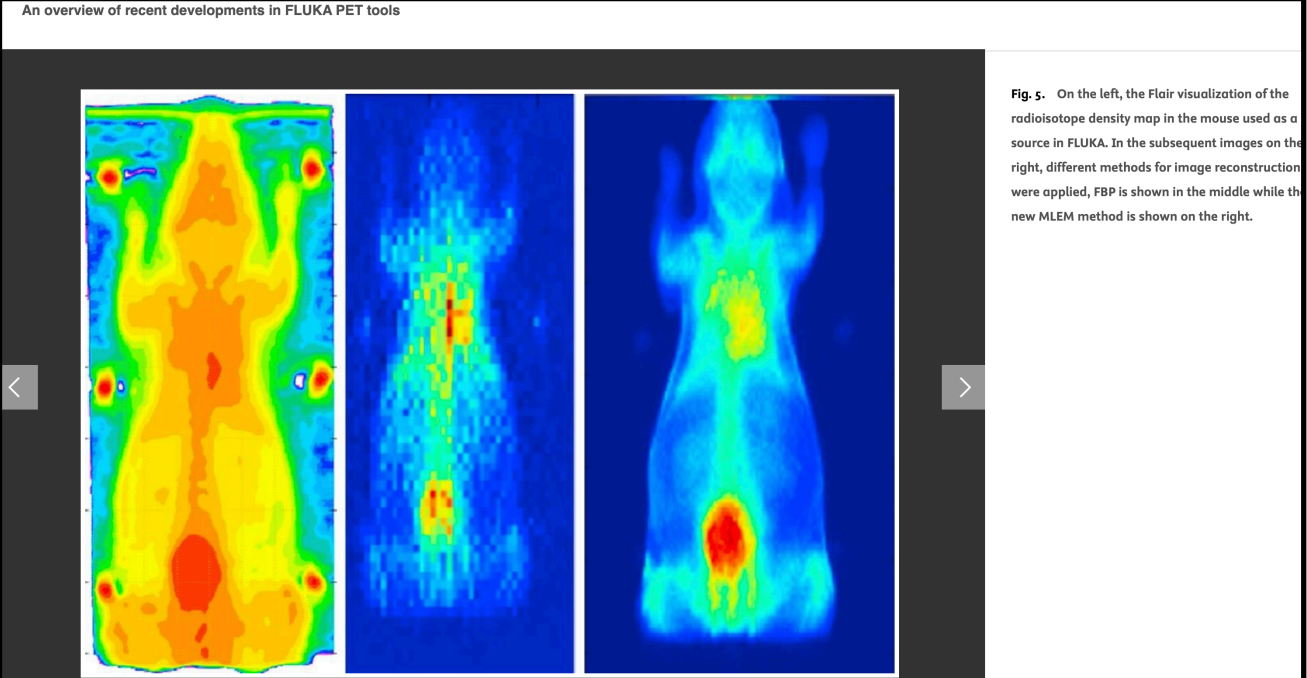
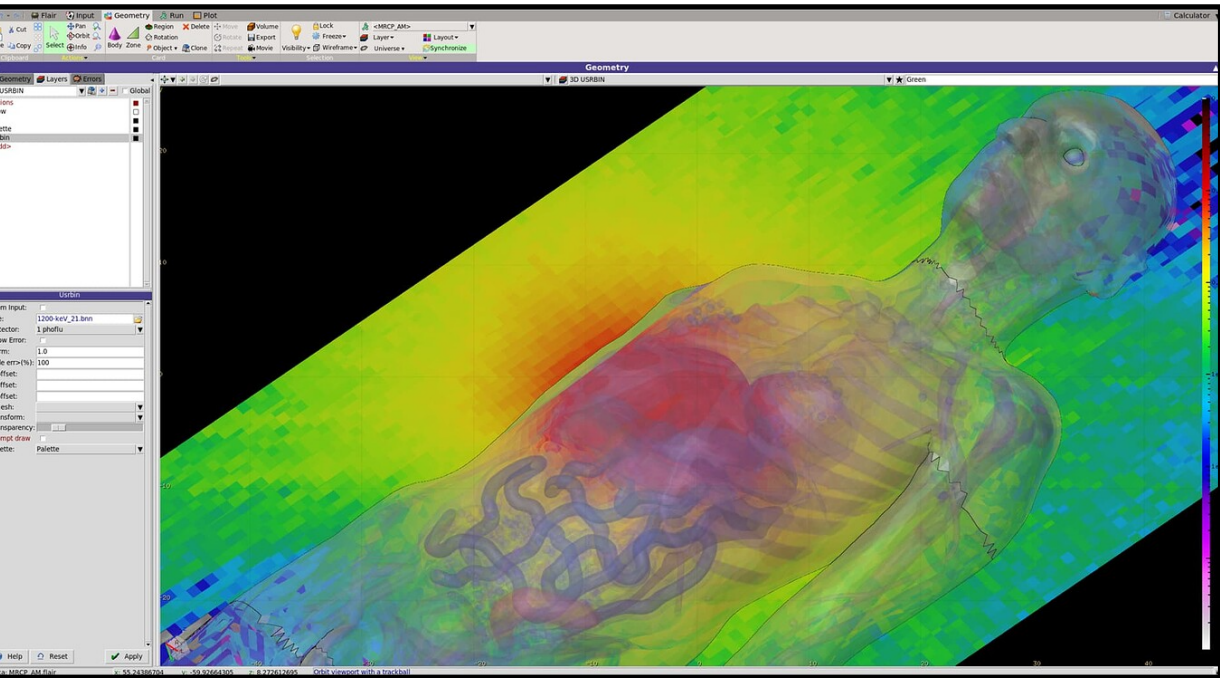
- Tim Berners-Lee

Nuclear codes evolution beyond their initial scope

Neither MCNP nor FLUKA became global reference codes because of their original applications alone.

Their long-term success resulted from continuous interaction with expanding user communities, whose evolving requirements drove the development of new capabilities far beyond the original reactor physics and high-energy physics domains.

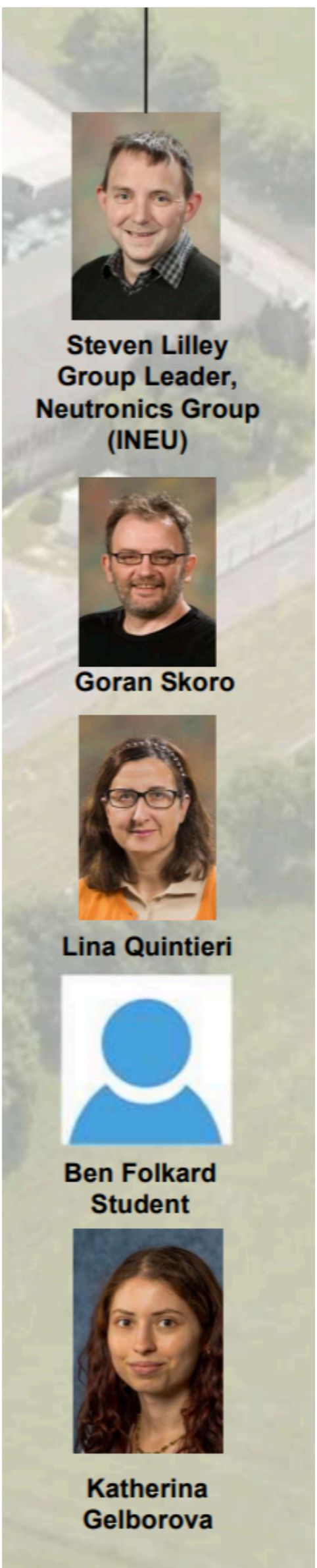
Code	Original development Scopes	Current user community driven multidisciplinary applications
MCNP	Reactor physics	Reactor design and safety, fusion systems, medical physics , radiation protection, homeland security, spent fuel analysis, space nuclear systems, neutron instrumentation, detector modelling
FLUKA	High energy Physics in accelerator context	Accelerator design, radiation protection, shielding, medical physics and hadron therapy , space radiation analysis, detector design , dosimetry, nuclear engineering, isotope production, activation studies



FLUKA in Neutronronics Activities

The screenshot shows the FLUKA website homepage. At the top is a dark blue navigation bar with the FLUKA logo on the left and the following menu items: HOME, DOWNLOAD, DOCUMENTATION, FLAIR, and SUPPORT. Below the navigation bar, the main content area is divided into several sections. On the left, there is a vertical list of news items, each with a date and a category label (e.g., 'Event', 'Release', 'Communication'). The central part of the page features a large 3D visualization of a particle accelerator component with a color-coded intensity map. To the right of this visualization is a sidebar containing a list of categories for user queries, such as 'Installing, Running and Runtime Errors', 'Flair', 'Source Definition', 'Geometry and Materials', 'Scoring and Biasing', 'Physics, Transport and Magnetic Fields', 'Advanced Features and User Routines', and 'Applications'. Below the sidebar, there are four smaller images with labels: 'Download' (showing the FLUKA logo), 'Documentation' (showing a 3D plot), 'Flair Graphical User Interface' (showing a software window), and 'Courses and events' (showing a classroom setting).

Neutronics Group in ISIS

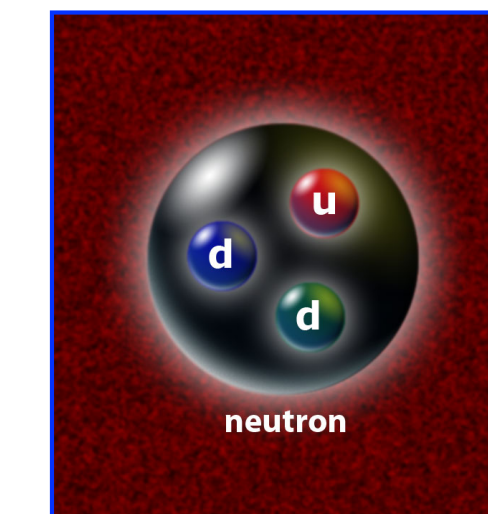
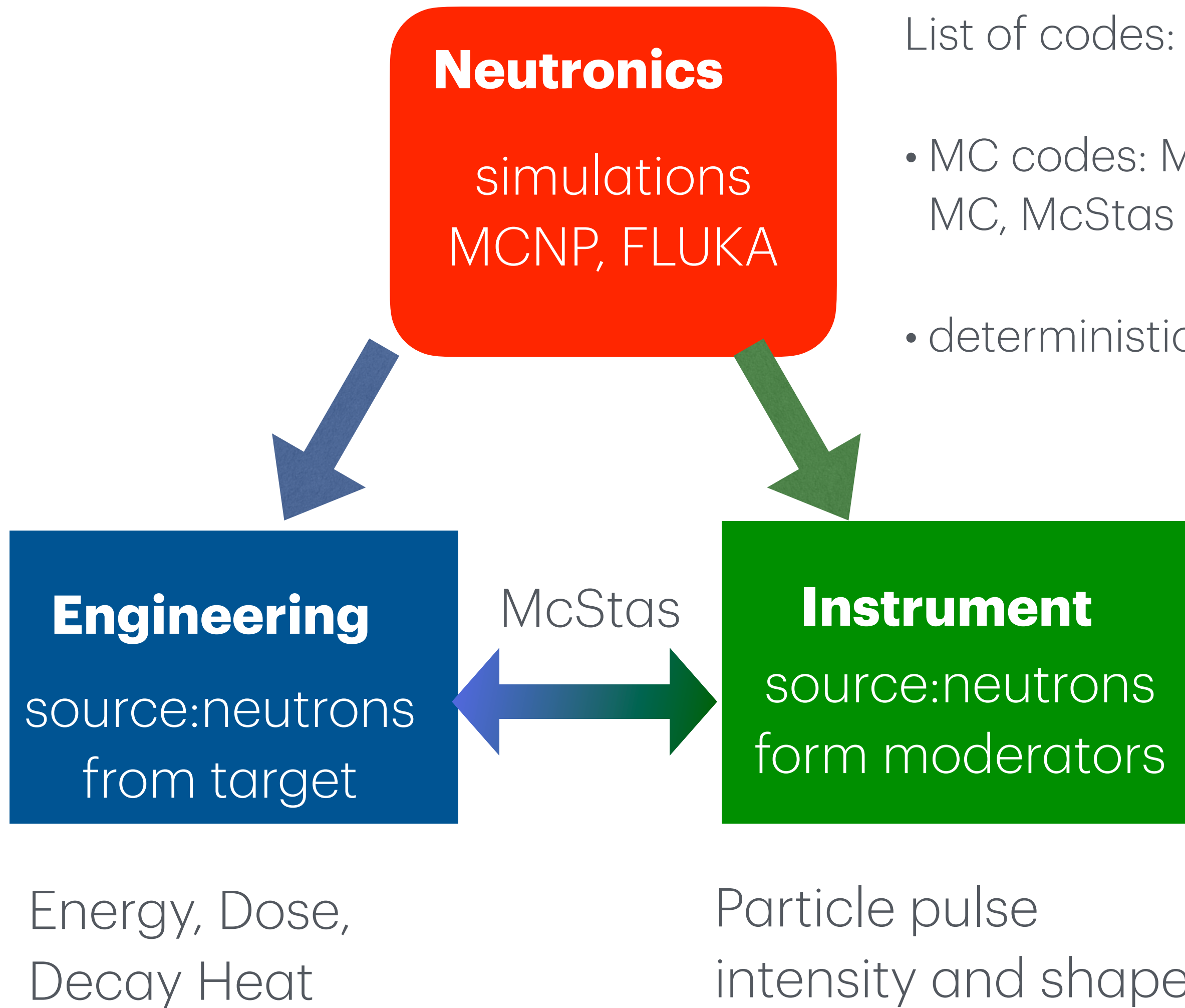


Neutronics

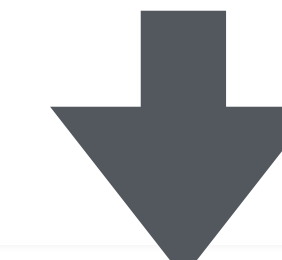
simulations
MCNP, FLUKA

List of codes:

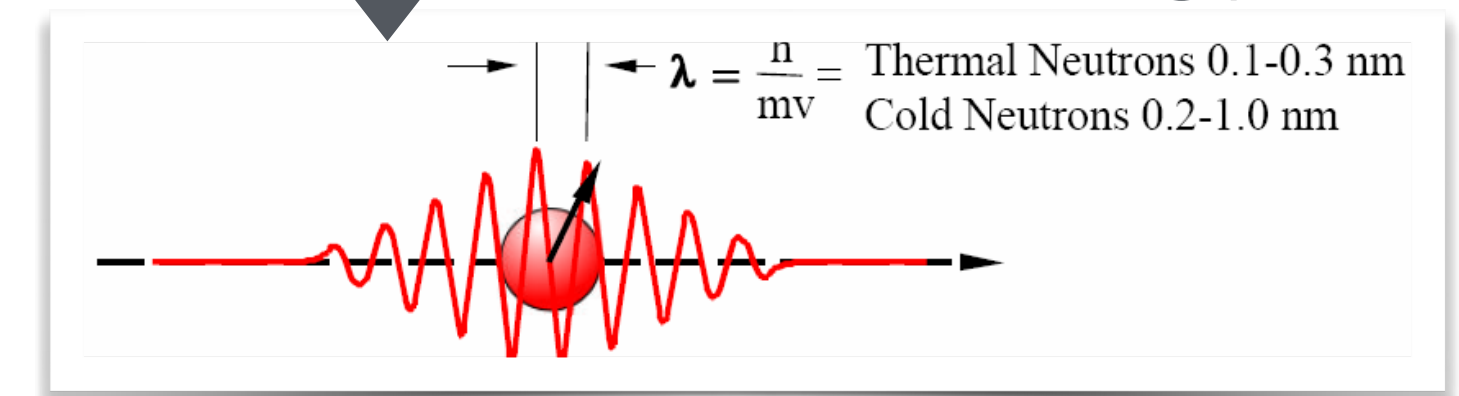
- MC codes: MCNP6, FLUKA, GEANT4, PHITS, Open MC, McStas
- deterministic: FETCH2



High energy



Low energy

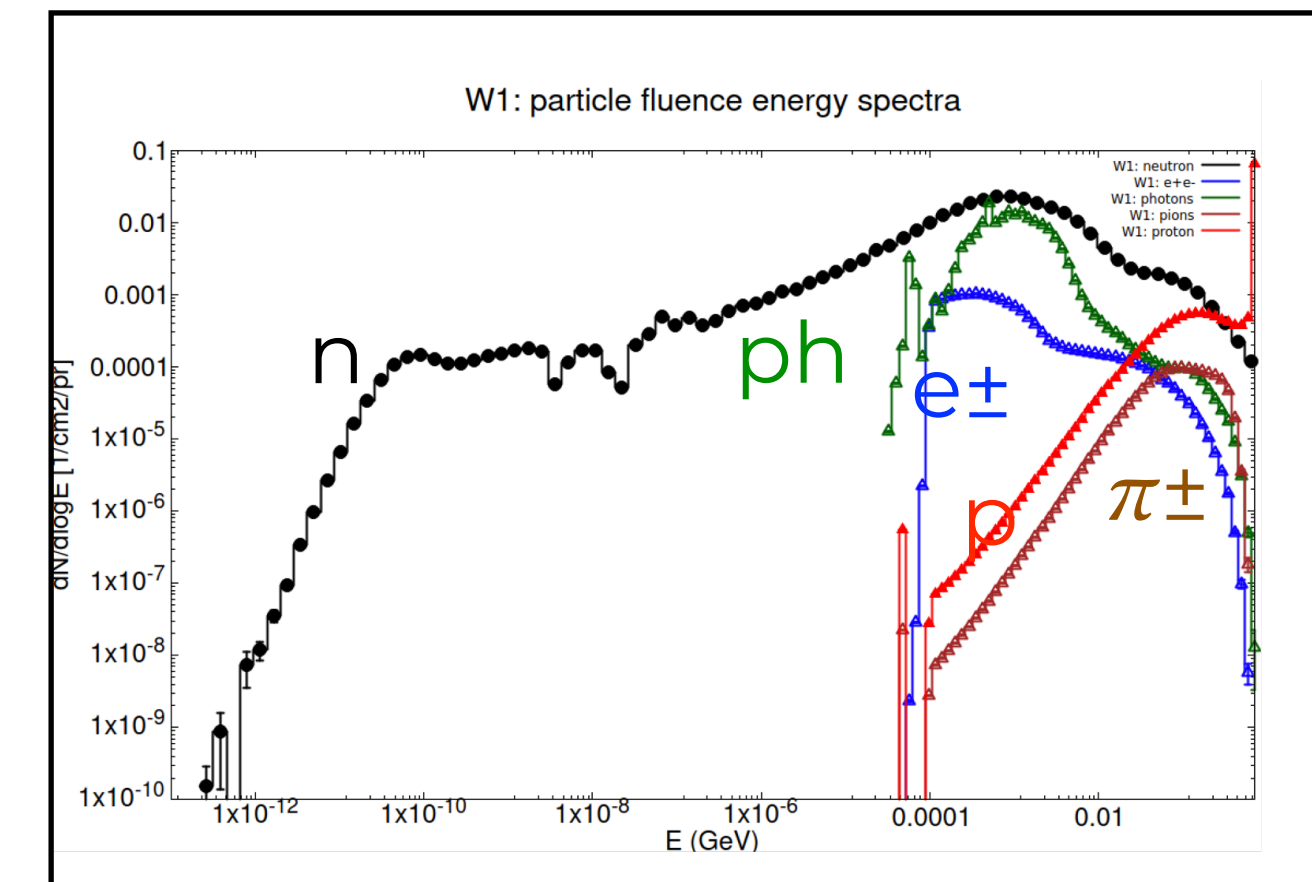
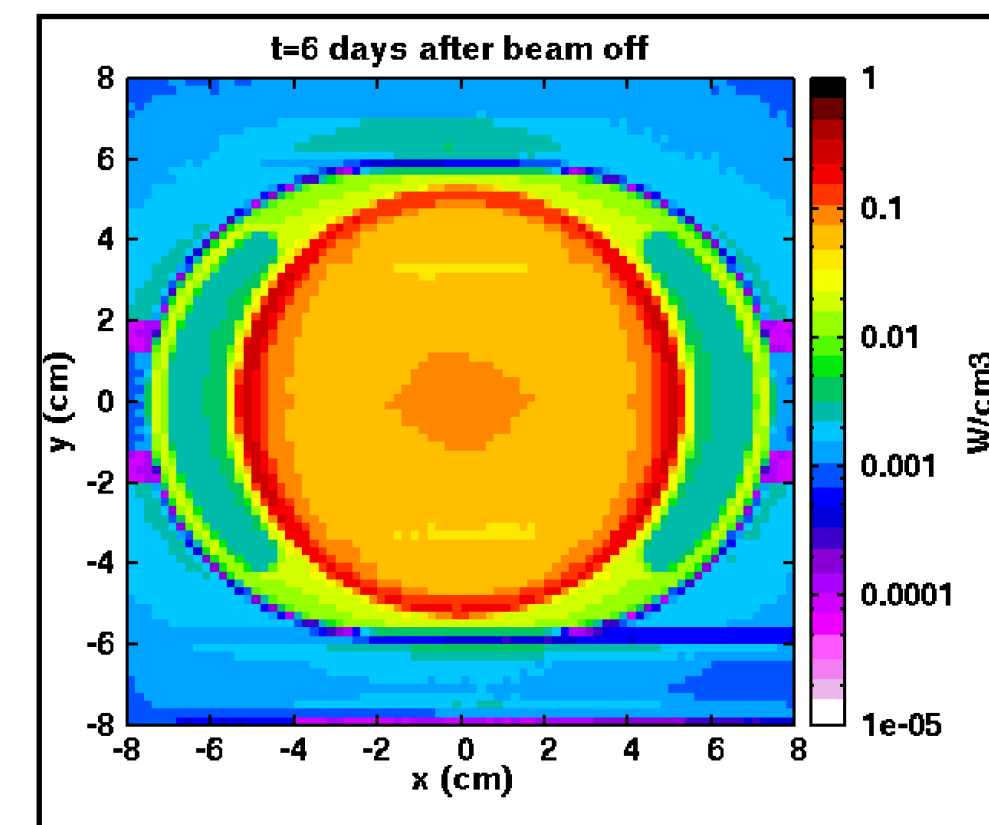
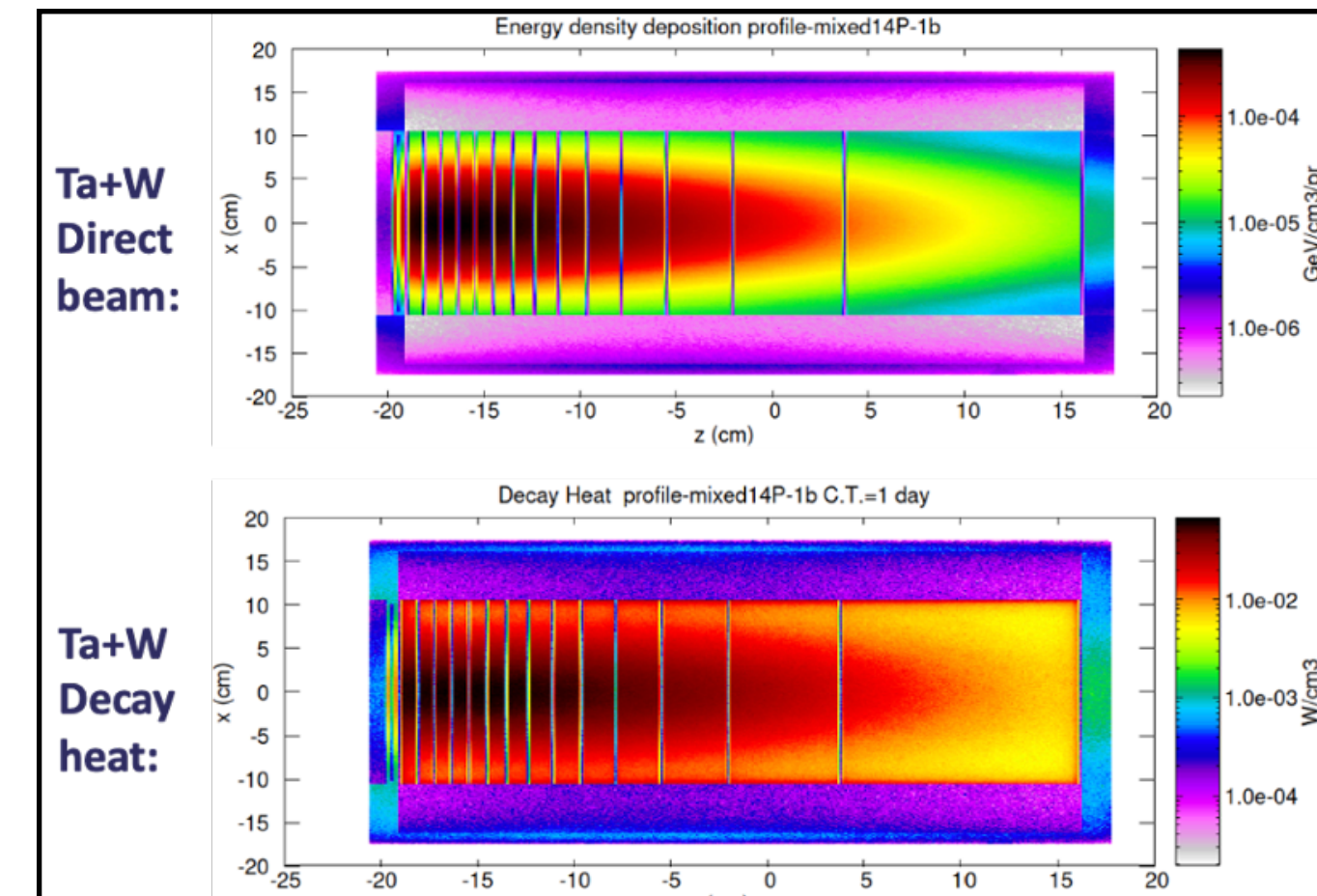
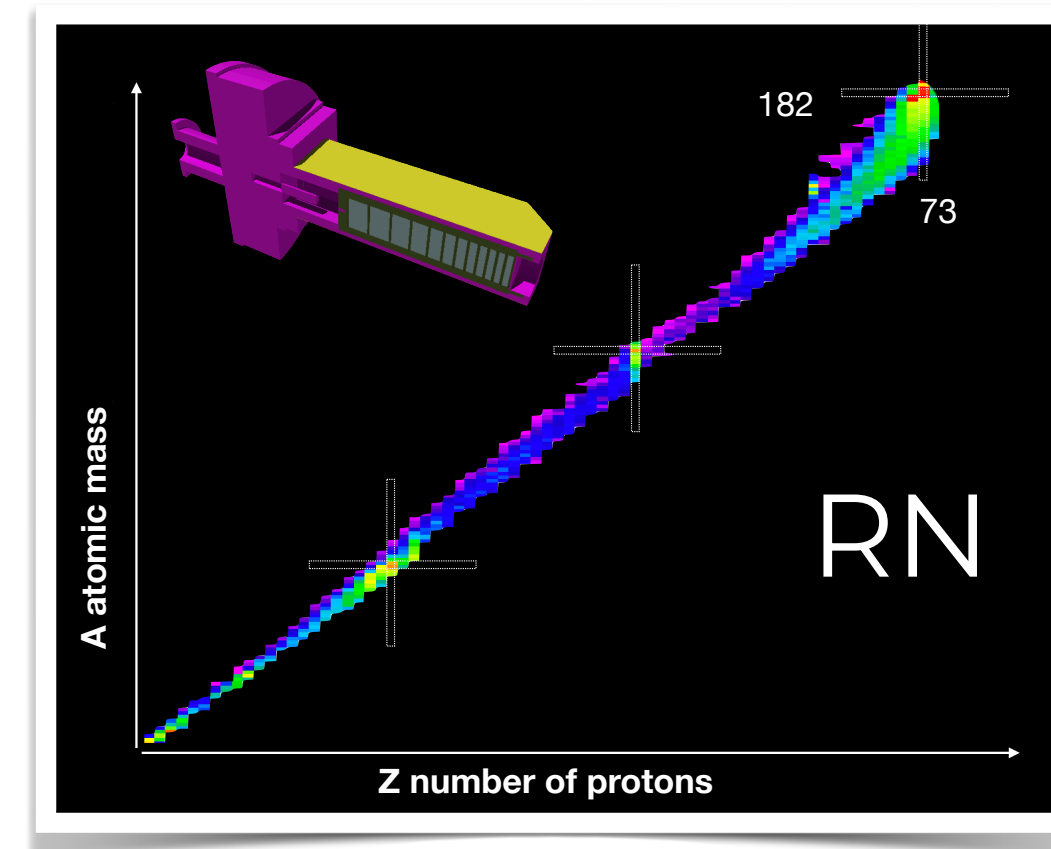


(Average energy fluence)

(Time dependent neutron fluence)

Why FLUKA?

- FLUKA is a Monte Carlo code capable of simulating the **transport of elementary particles and ions** in complex geometries and materials.
- It allows to estimate **prompt energy deposition and secondary particles production and interactions**
- Within the same input it is possible to carry out **decay heat calculation and radioactivity calculation as function of time** (no need to couple FLUKA with different codes to follow the evolution of the Radionuclei Inventory as a function of time)
- All the decay products can be explicitly transported** within FLUKA (alpha, beta, gamma, e-, e+)
- Radiation damage** (DPA, gas production, etc.) is enabled with advanced upgraded models (dpa-NRT, acrc-DPA)



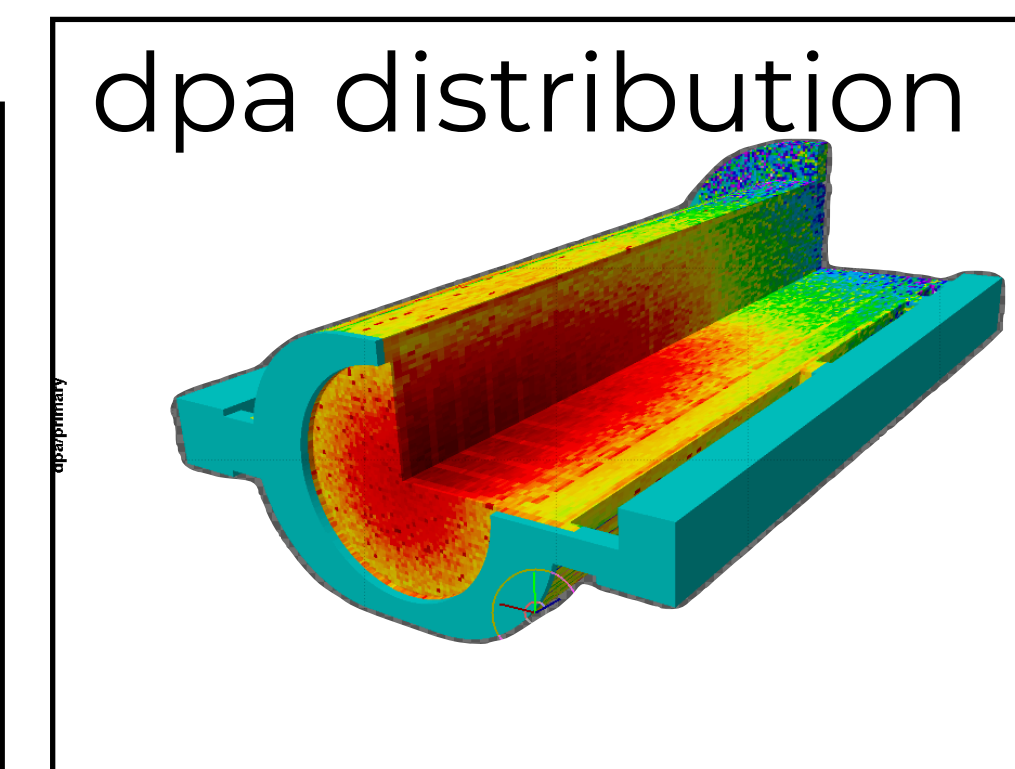
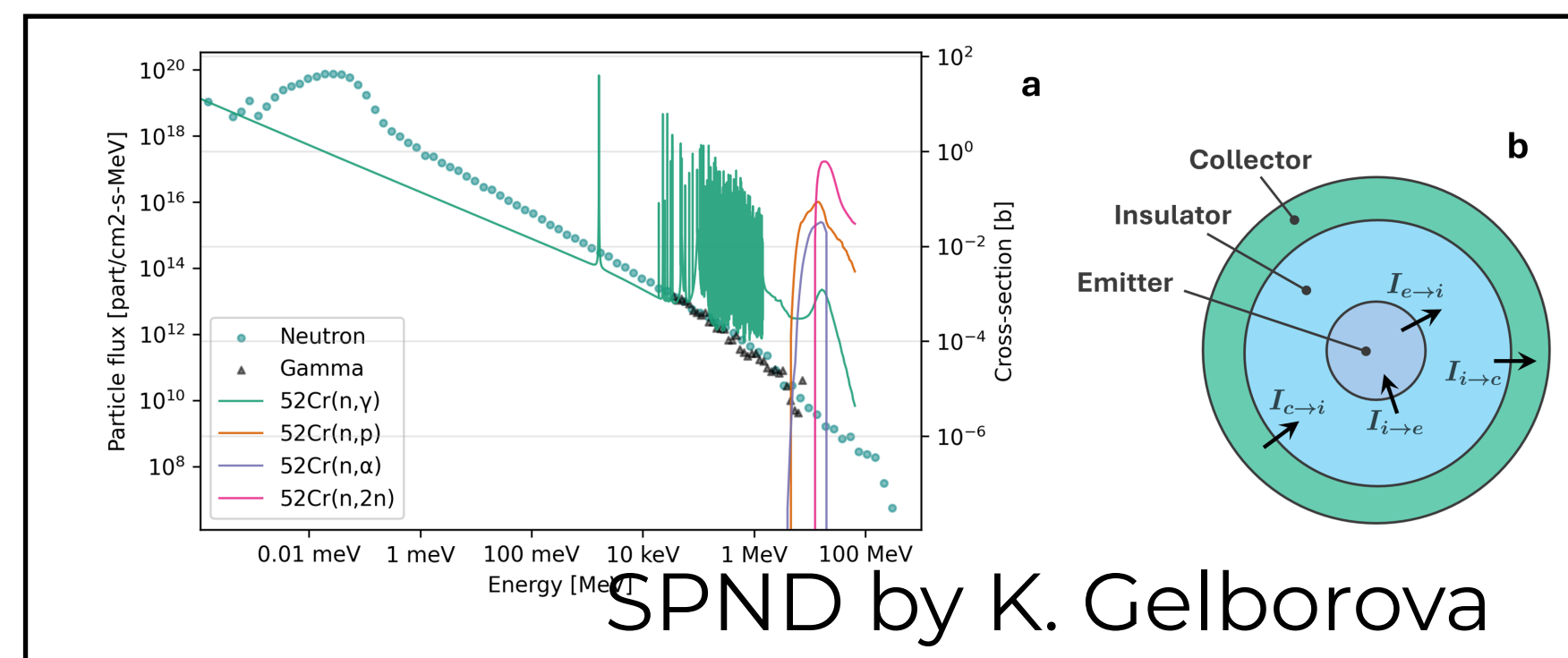
FLUKA handles the transport+interaction of:

Photons	Leptons e^\pm, μ^\pm, τ^\pm $\nu_X, \bar{\nu}_X$	Hadrons $\pi^*, K^*, \rho, \bar{p}$ $n, \bar{n}, \Lambda, \dots$	Ions $\frac{A}{Z}X$
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from the keV to the PeV
(γ down to 100 eV)
(n down to 0.01 meV)



ISIS Neutron and Muon Source

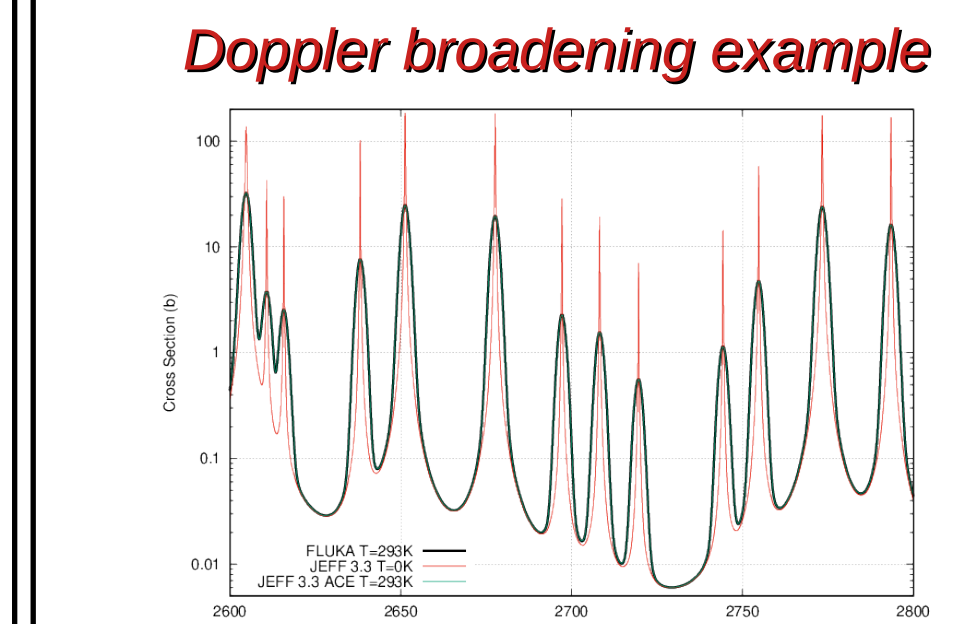
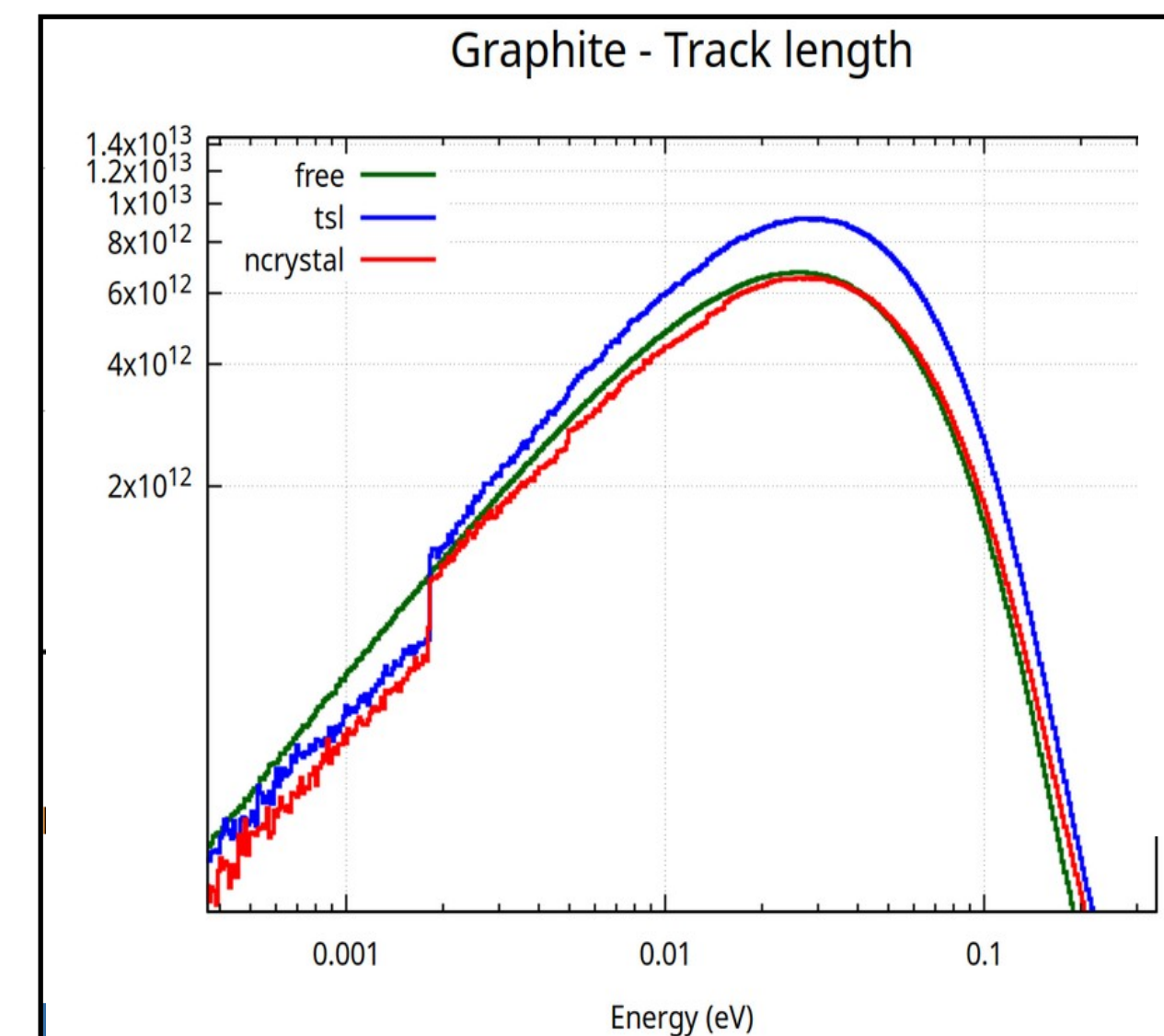
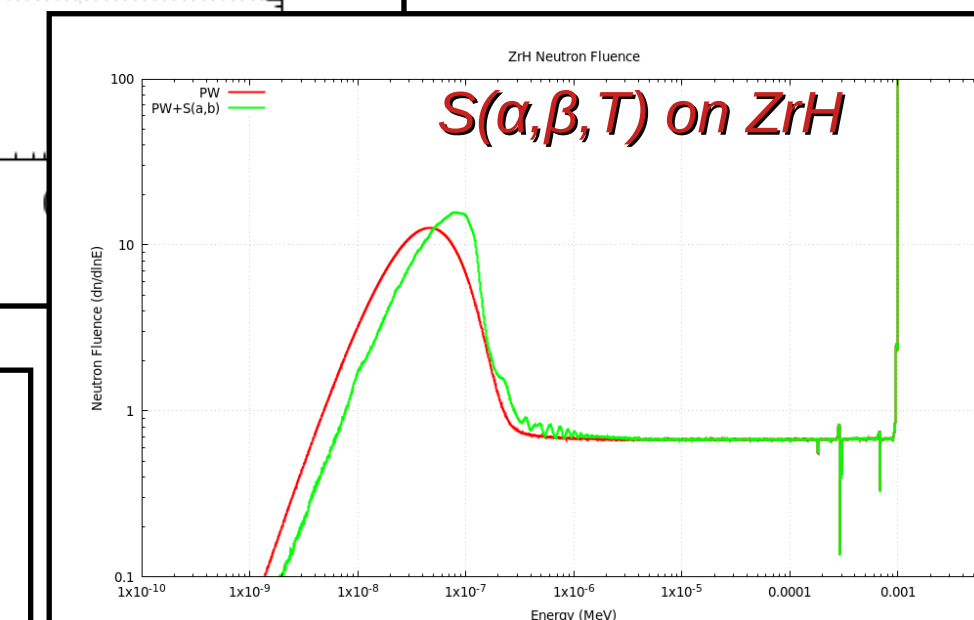
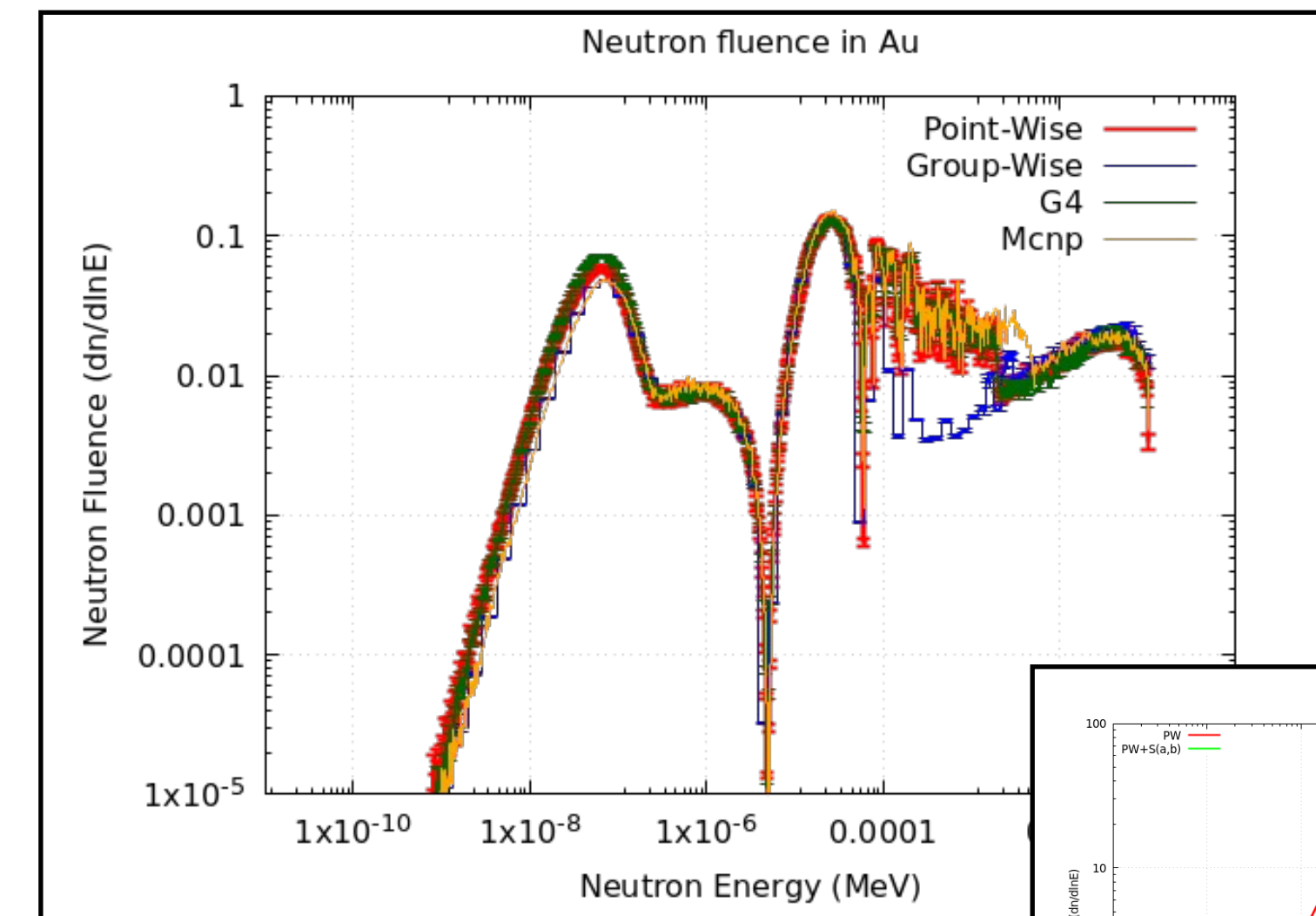


The FLUKA-CERN Updates on Neutronics

Recent important progress achieved in neutronics simulations with FLUKA.CERN

V.Vlachoudis

- **Implementation of Point-Wise XS** and treatment (this allows explicit transportation of secondaries of nuclear interactions).
- **Enhanced Capabilities at low energy/temperature:** Improved simulation of low-energy neutrons, particularly thermal and cold neutrons, with available scattering kernels $S(\alpha,\beta,T)$ XS for numerous materials at low temperatures at various fixed temperatures.
- Expanded Data Library: **Users now have the flexibility to select from various data libraries** (JEFF, ENDF, JENDL, BROND) and file formats (e.g., ACE), enriching FLUKA's capabilities.
- Integration of Ncrystal in FLUKA (in progress): Dynamic linking to NCRYSTAL data Library. This is within a collaboration among ISIS, ESS and CERN

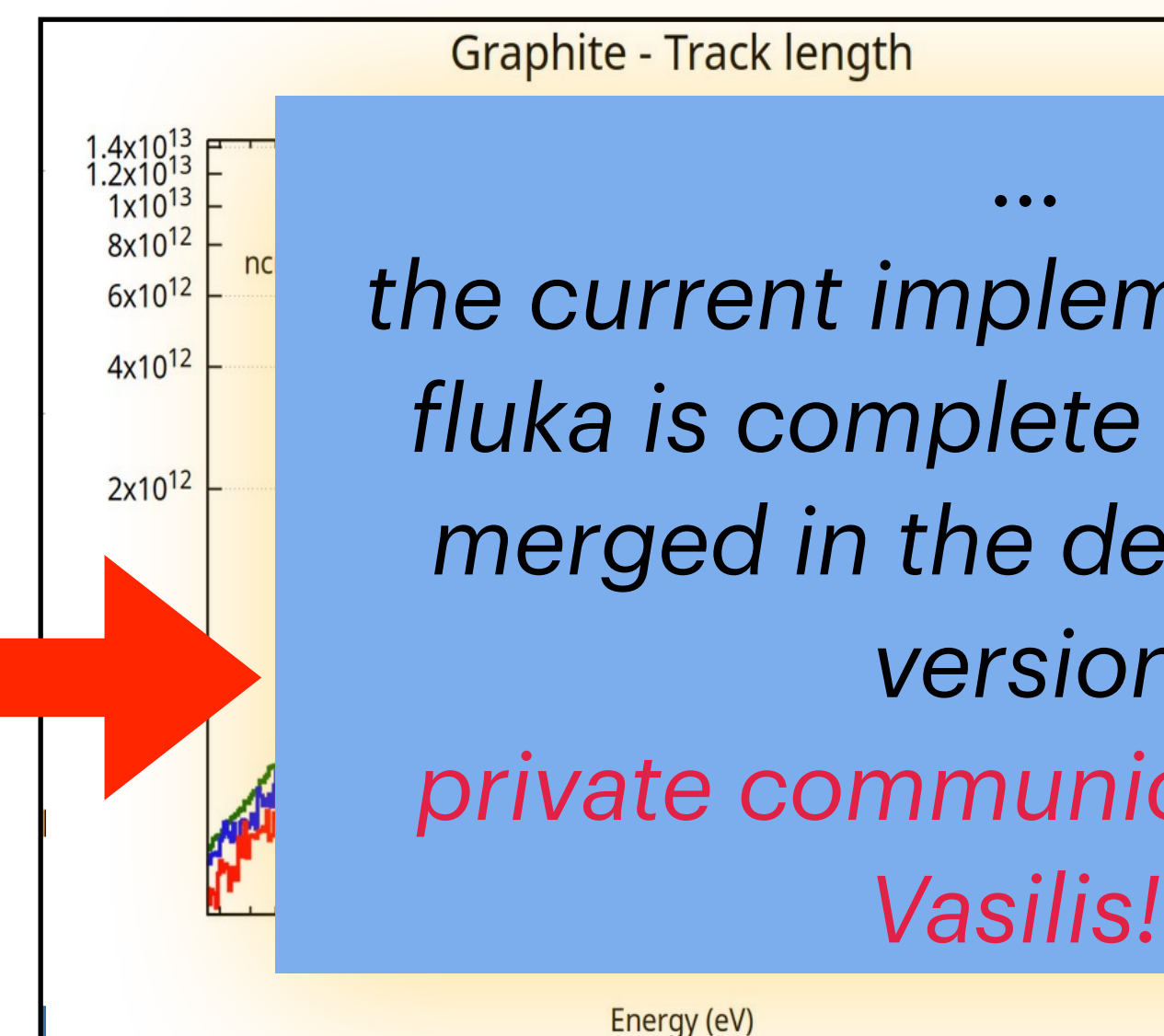
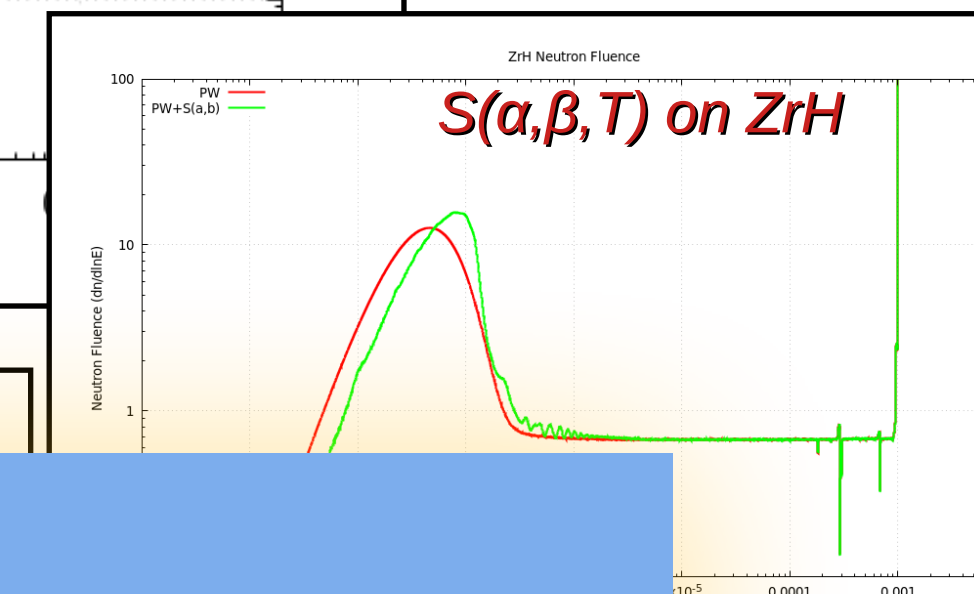
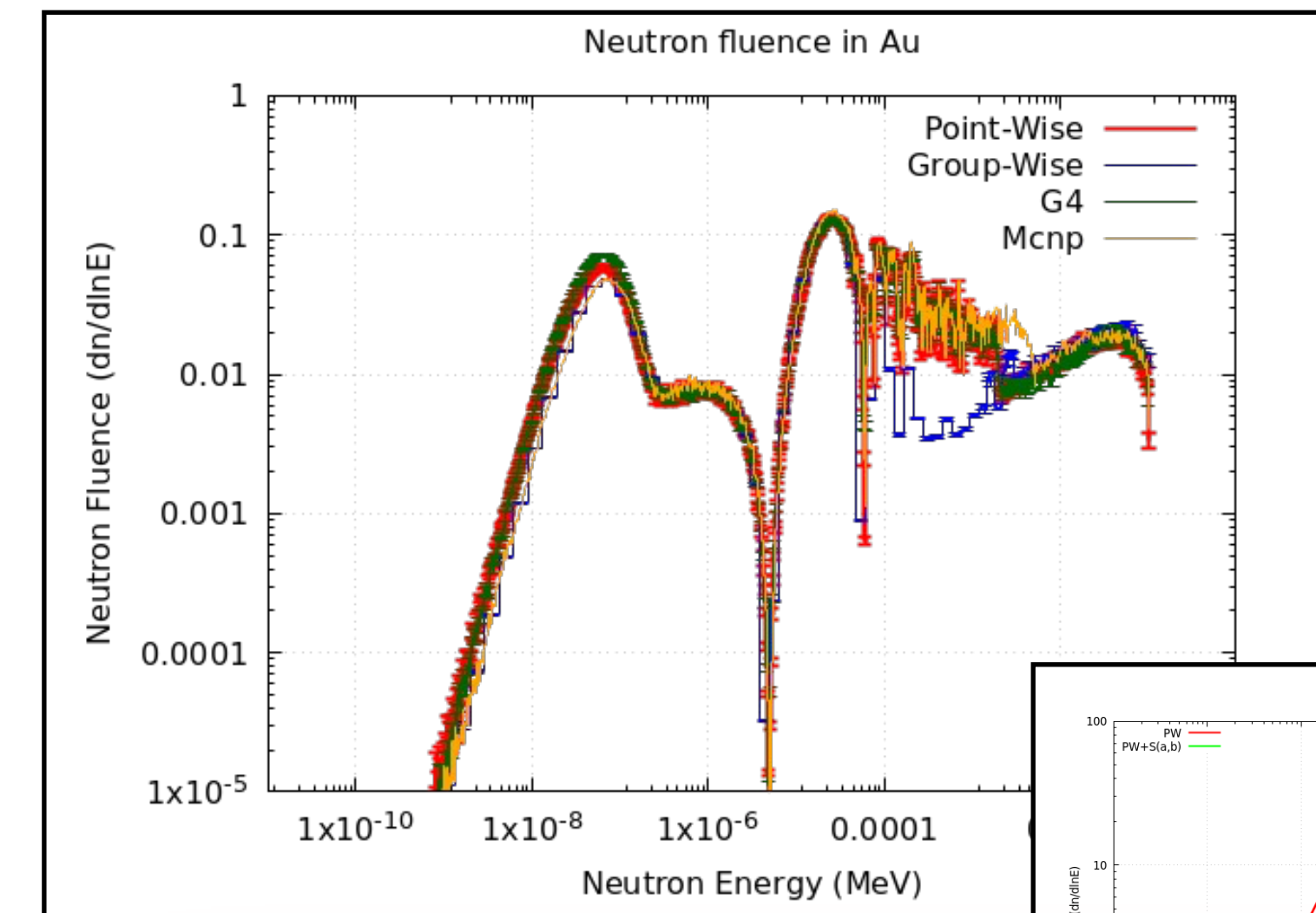


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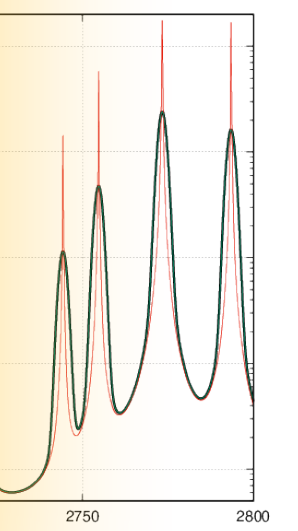
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...
the current implementation for fluka is complete and can be merged in the development version
private communication from Vasilis!!

g example



Benchmarking FLUKA Models of TS1 TRAM

Published works

Journal of Neutron Research 24 (2022) 313–327
DOI 10.3233/JNR-220030
IOS Press 313

Decay heat in ISIS spallation target: simulations and measurements

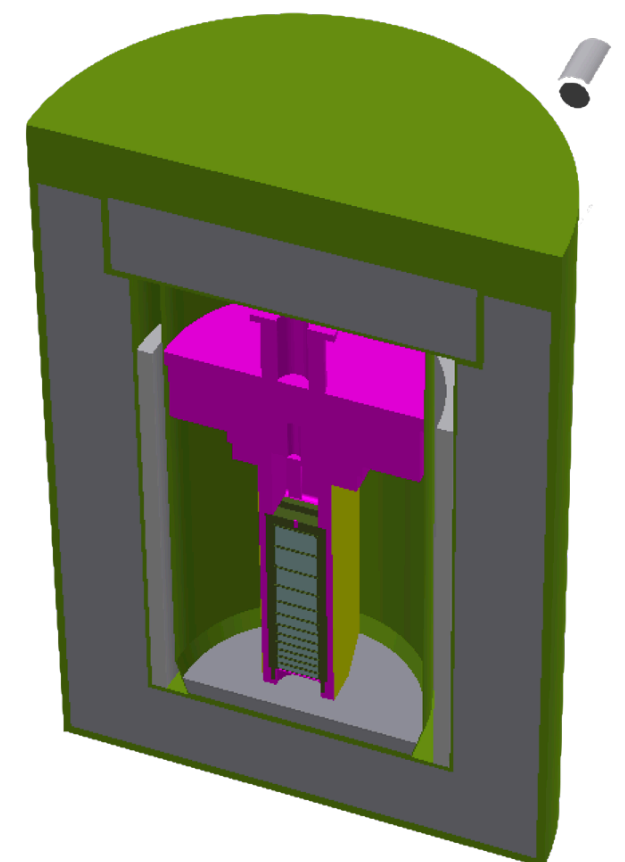
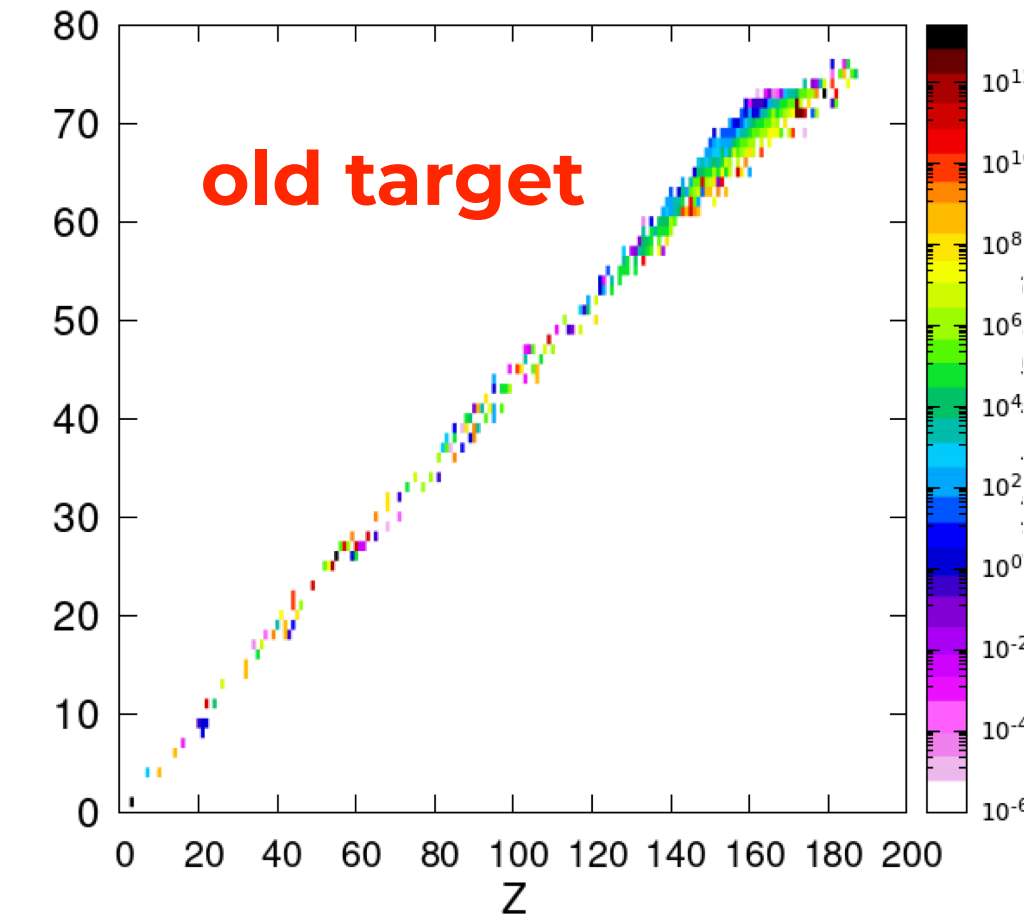
Lina Quintieri*, Steven Lilley, Dan Wilcox, David Findlay, David Jenkins, Stephen Gallimore and David Haynes
ISIS Neutron and Muon Source, Rutherford Appleton Laboratory STFC, OX11 0QX, Didcot, United Kingdom

D. Wilcox et al., "Simulated and measured performance of the ISIS TS-1 Project target", *Journal of Neutron Research*, vol. 26, pp. 47–58, 2024.

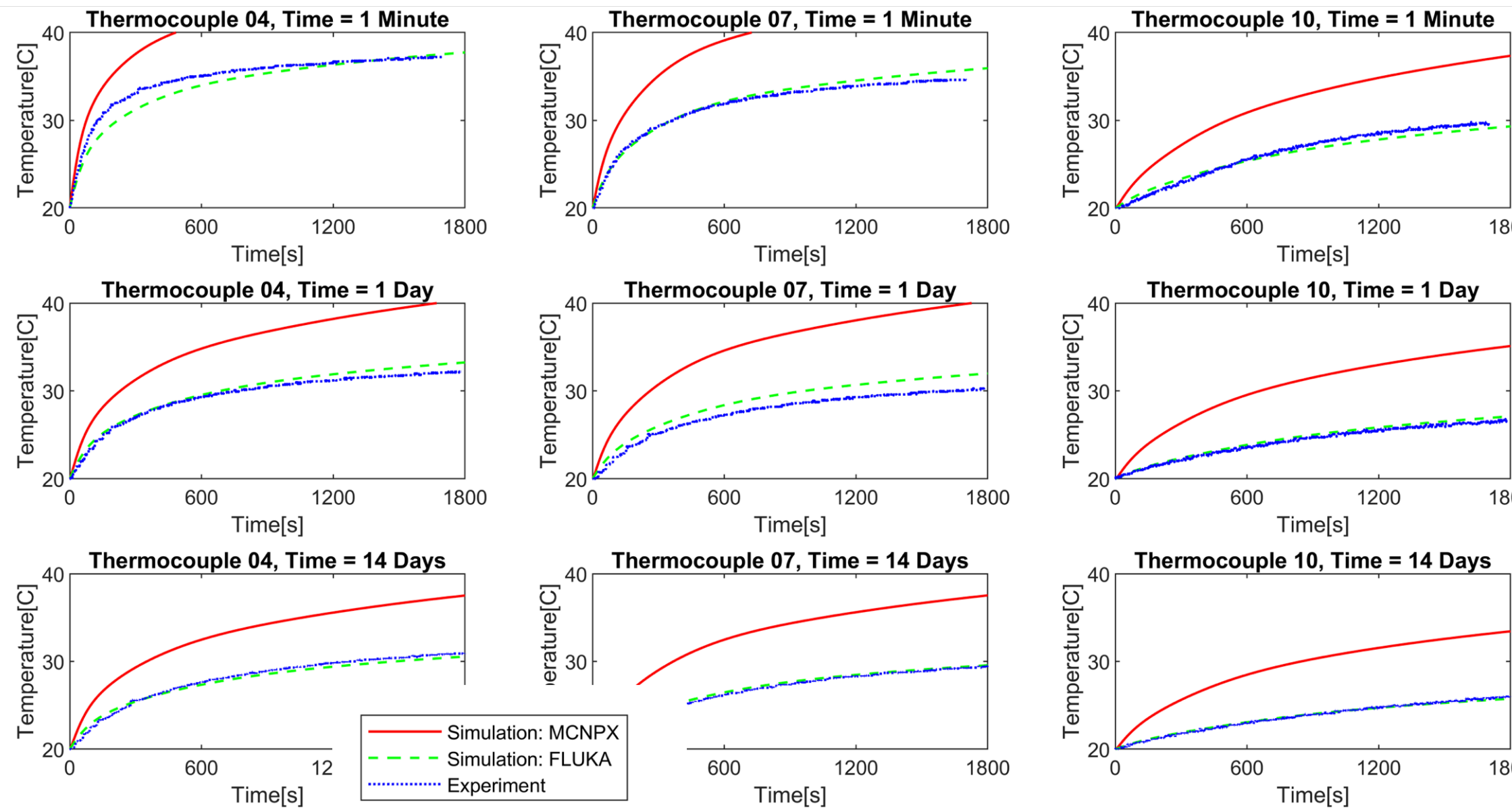
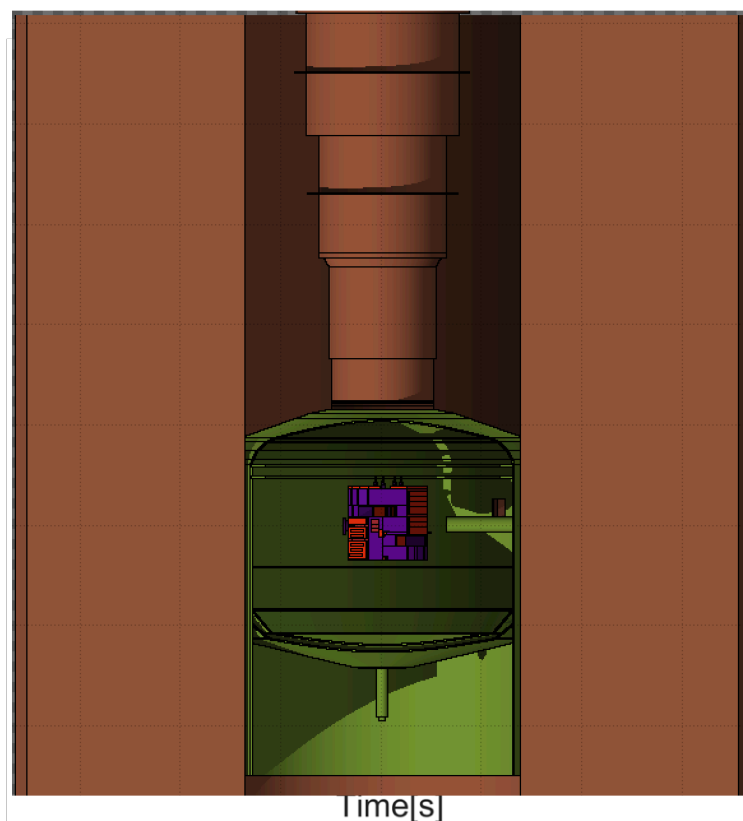
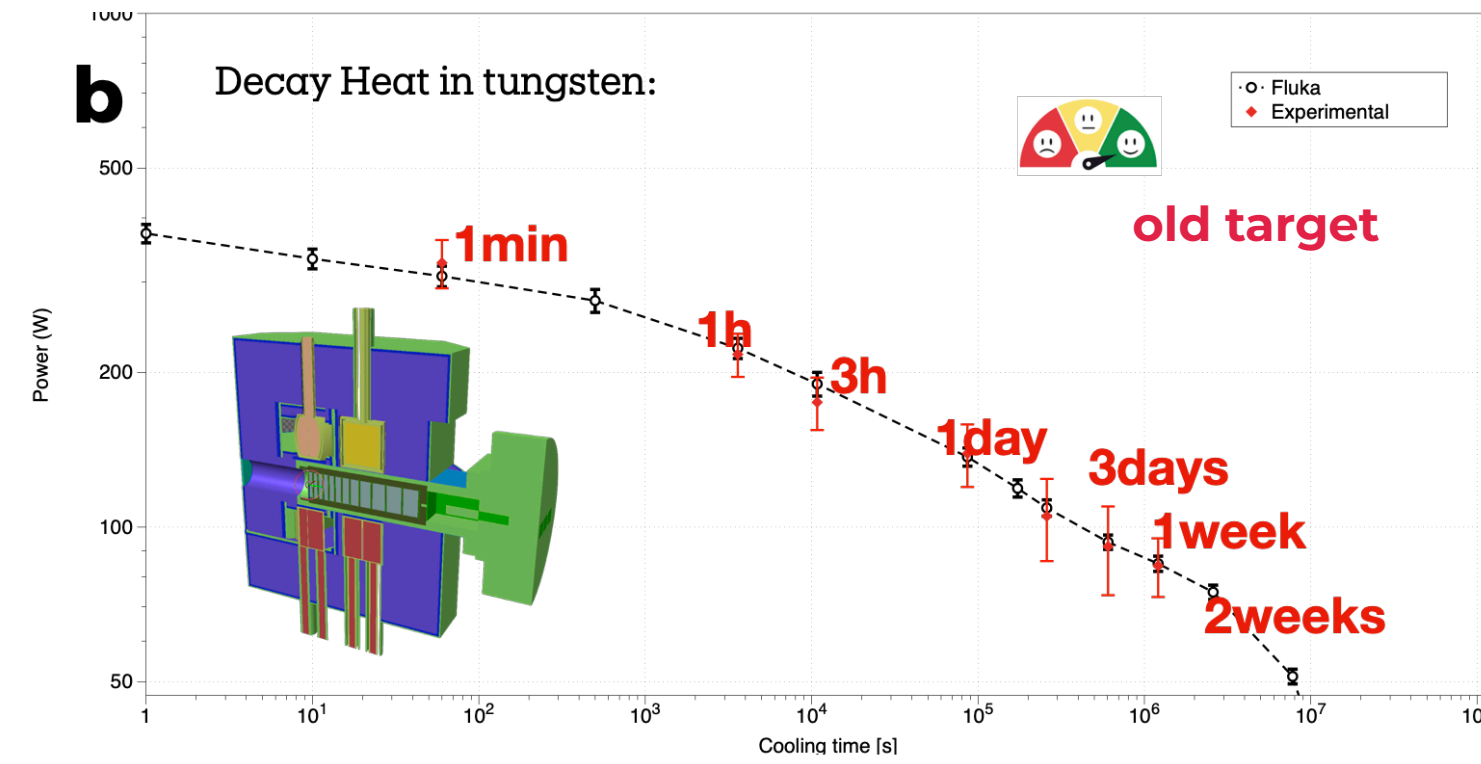
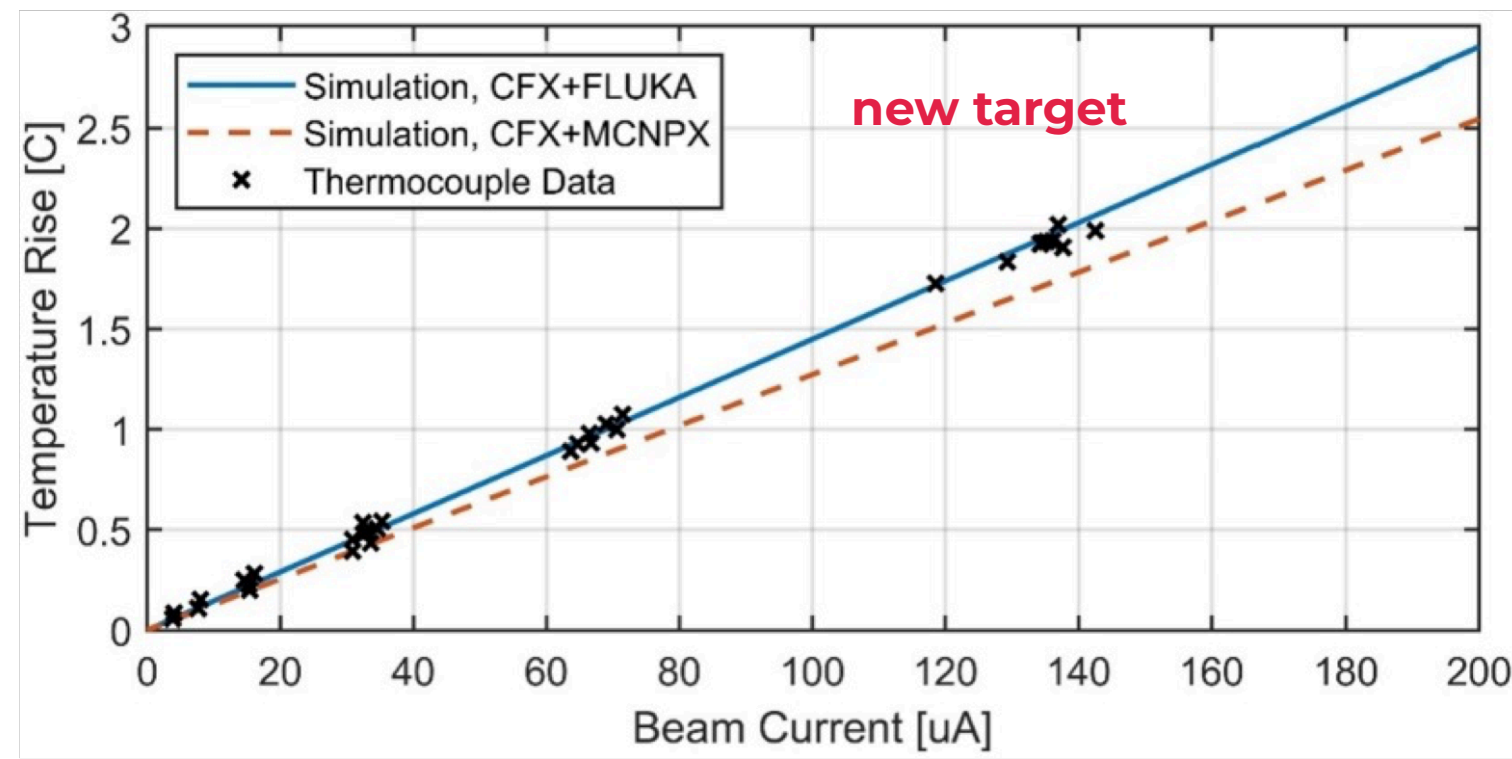
Radionuclei inventory in ISIS TS1 target: measurements and comparison with FLUKA-CERN predictions

Lina Quintieri^{1,*}, Steven Lilley¹, Dan Wilcox¹, Xavier Queralt², Gordon Burns¹, and Angelo Grossi²
¹ISIS Neutron and Muon Source, Rutherford Appleton Laboratory STFC, OX11 0QX, Didcot, United Kingdom
²ENEA- Dept. Fusion and Technologies for Nuclear Safety and Security, Centro Ricerche Casaccia, Anguillara (Roma), Italy

Activity on 22nd May 2019



Estimated overall RN activity in the target on



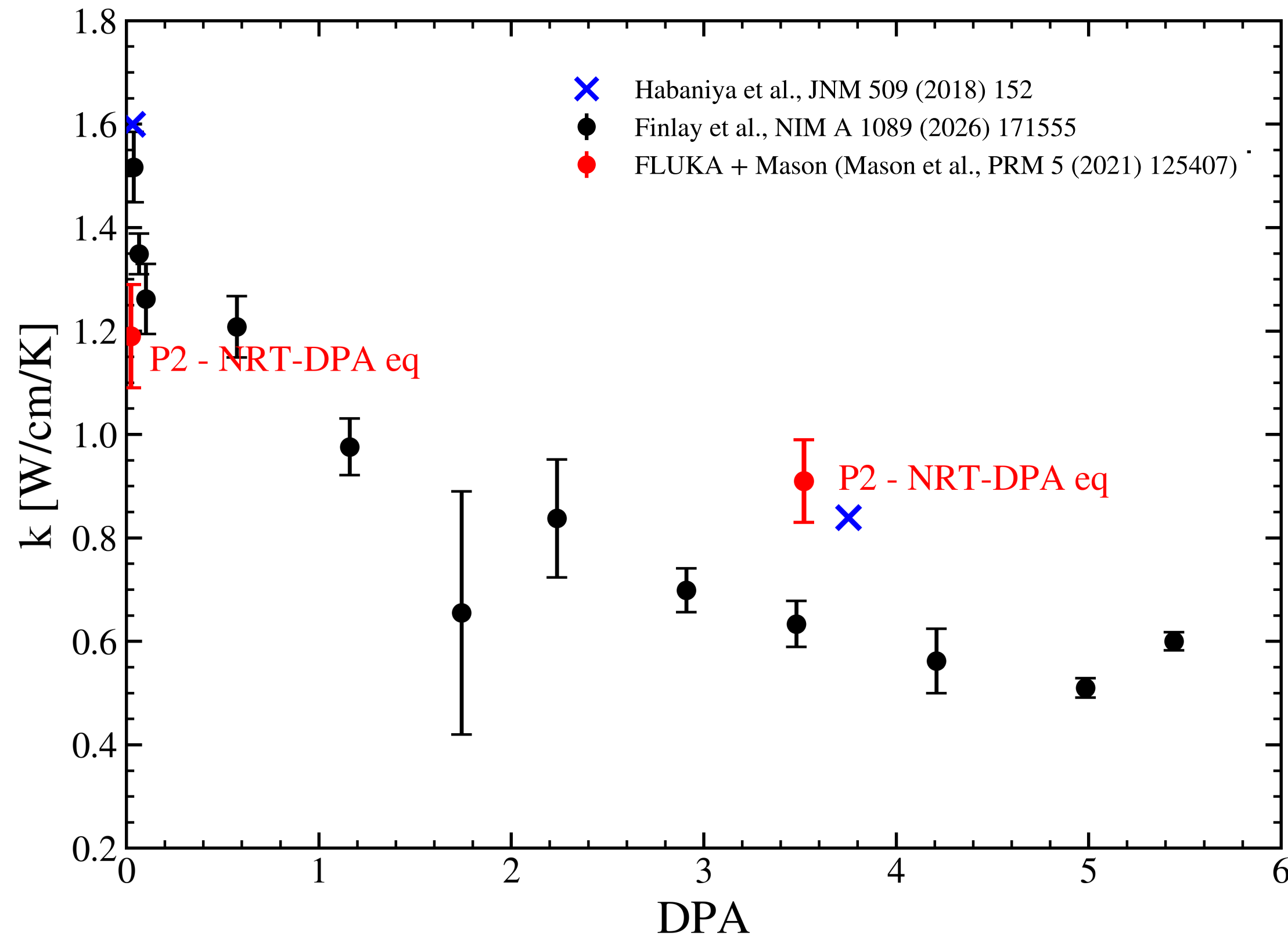
Science and Technology Facilities Council

ISIS Neutron and Muon Source

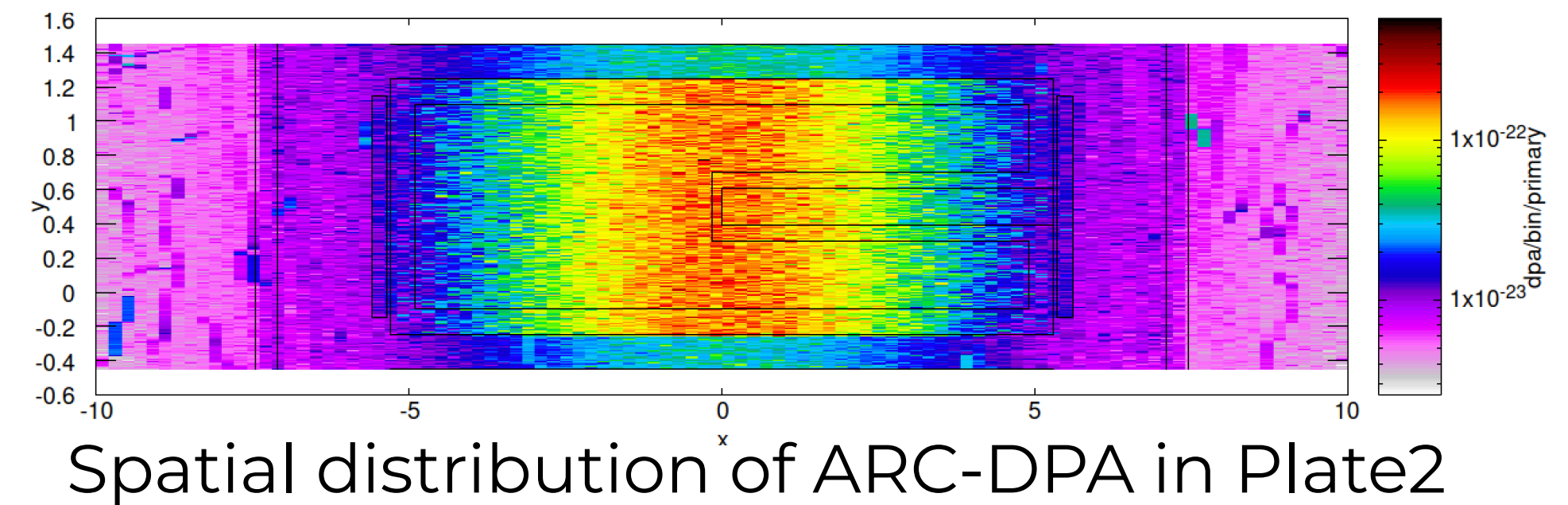
The FLUKA models of the TS1 targets (new and old) have been successfully validated wrt Power deposition, Decay Heat, RN inventory

Final Benchmarking k(DPA-NRT) for Tungsten in ISIS-TS1 target

Comparison with Habaniya values measured at PSI with LFA and D.Findaly at RAL



- The Mason K(cDPA) provides a model to link thermal conductivity with Arc-DPA
- FLUKA predictions on the plot have been located according the correspondence between DPA-NRT and ARC-DPA as reported in the table below (ARC-DPA almost a factor 4 lower than DPA-NBRT)



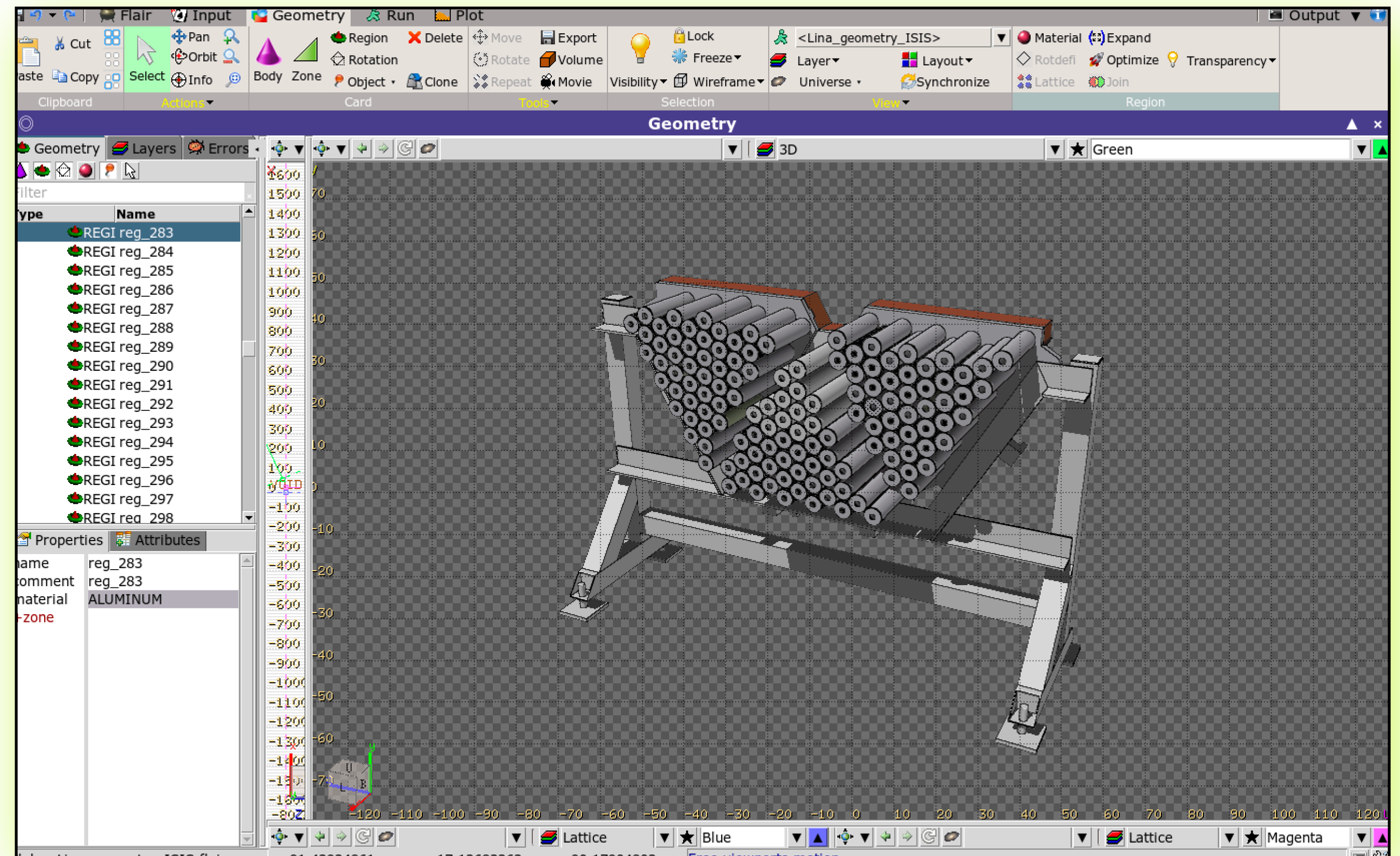
(contributions from Acc., Target division)

The thermal conductivity values derived from FLUKA predictions, using Model of Mason et al, are overall consistent with the experimental measurements, with good agreement within the associated uncertainties.

The main discrepancy is observed, for plate 2, at highly irradiated scenario (935 mA·h) case, where the calculations based on FLUKA predict a smaller degradation of thermal conductivity driven by the DPA contribution, **with a difference of less than 20%** between the experimentally inferred from temperature profile fitting (D. Findlay et al) in and calculated values of k.

Importing CAD Geometry into FLUKA: Recent Results for Vesuvio Detectors

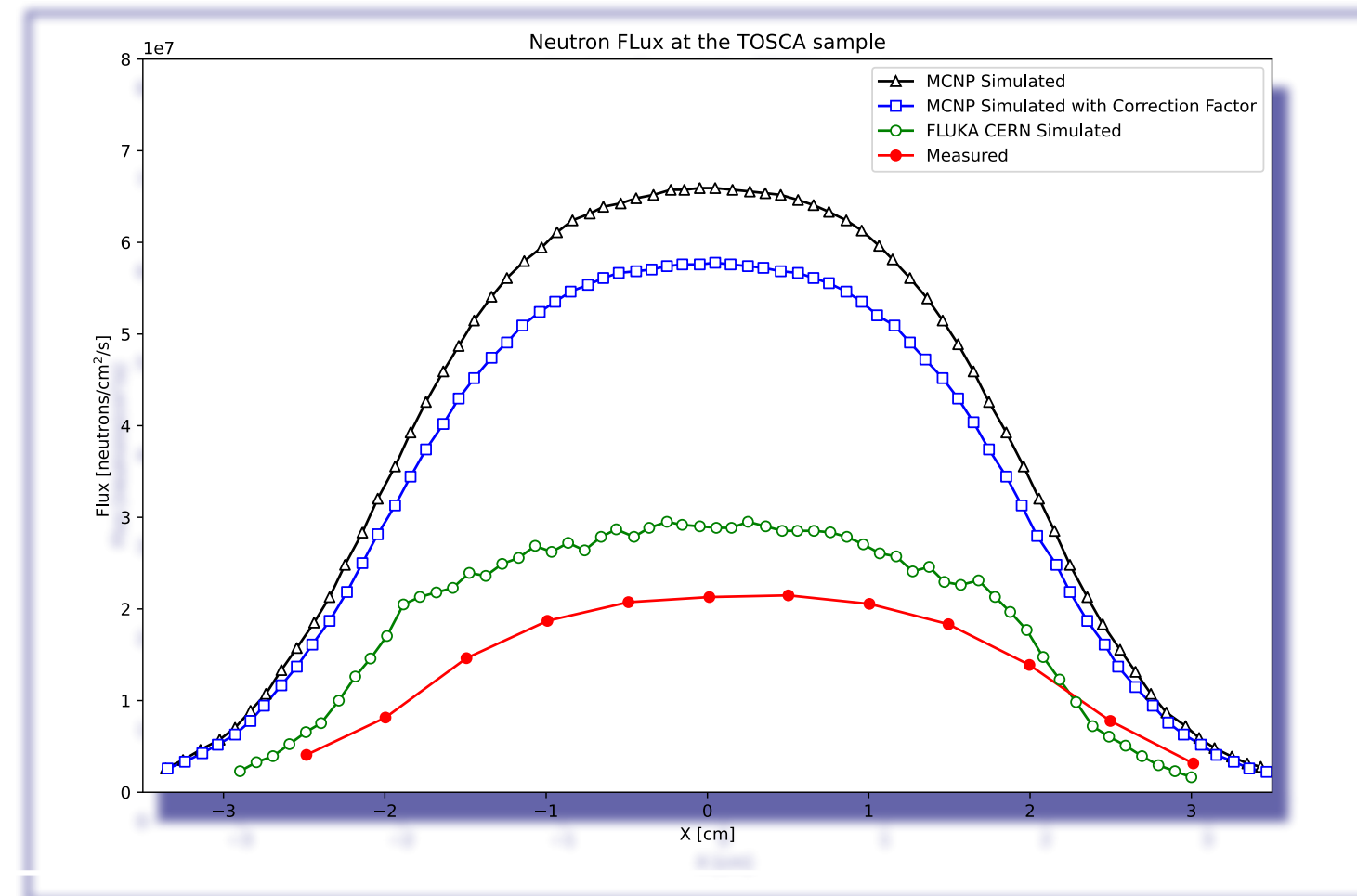
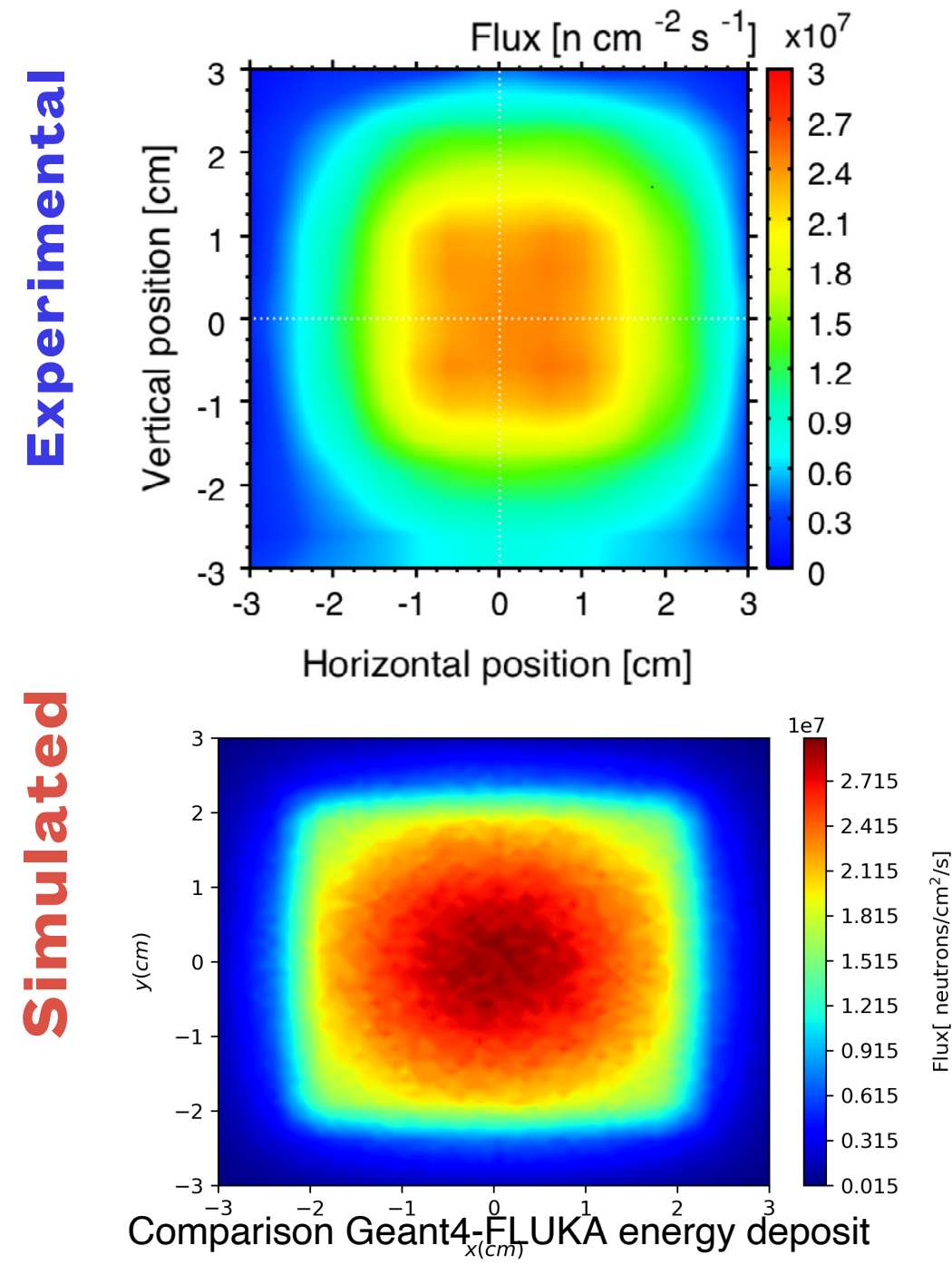
- **UNSTRUCTURED MESH importing:** We successfully implemented highly complex detector geometries in FLUKA, simplifying the model with Spaceclaim/Ansys and producing volume mesh with ANSYS (file.abaq).
- This highlighted the need of a consistent workflow between neutronics and mechanical engineers for enabling efficient geometry clean-up and preparation for Monte Carlo modelling.



Synergic interaction with engineering service.
(Thanks to P.Harrison)

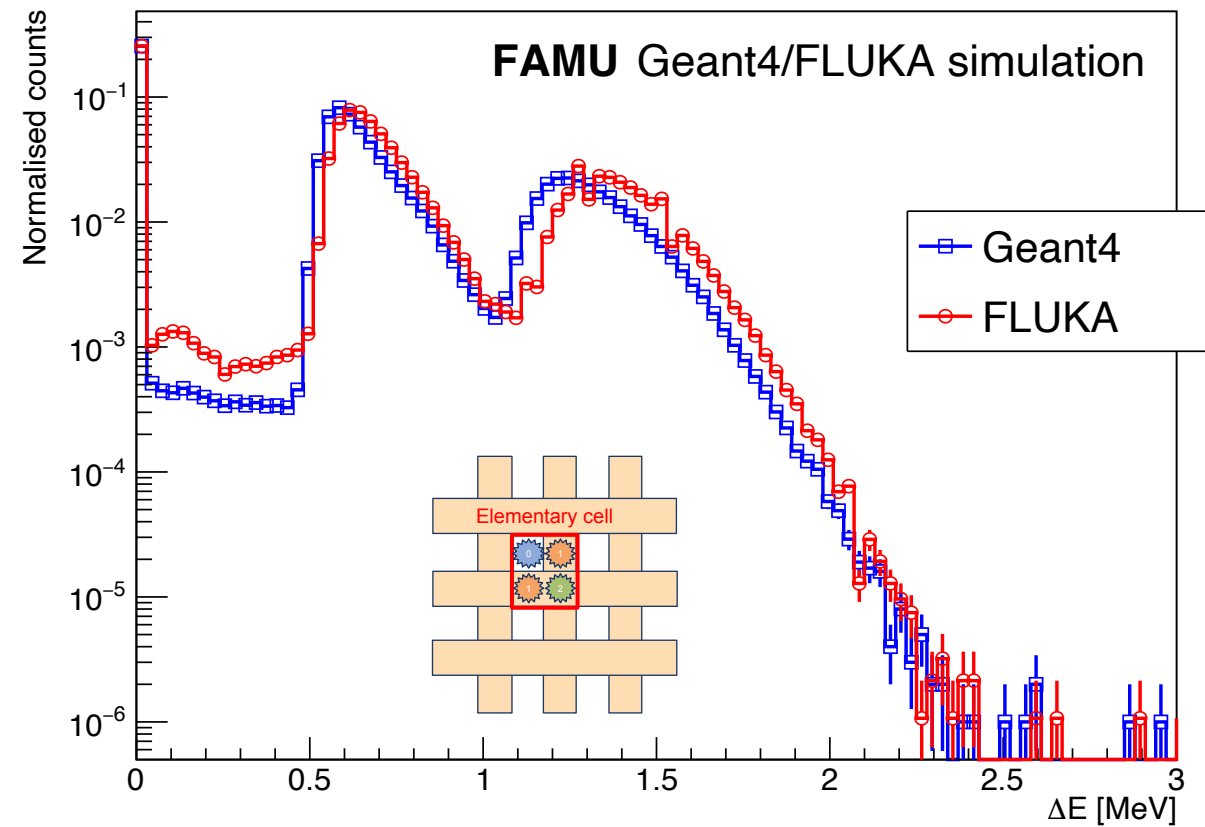
.....and Many Applications so far

Neutron map at the sample location in the TOSCA TSI instrument

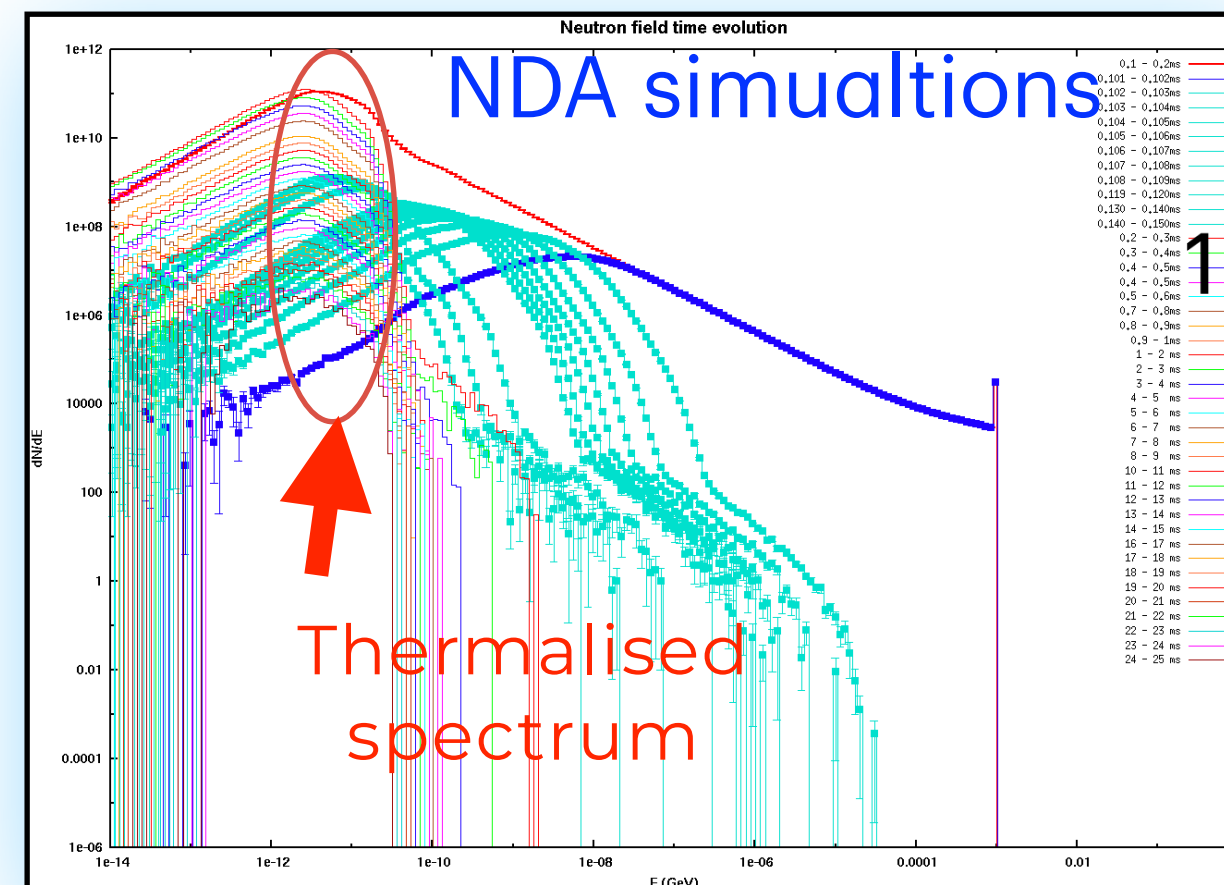


The measured and calculated neutron flux at the center of the sample, the (0,0) position of TOSCA instrument :

- $2.11 \times 10^7 \text{ n cm}^{-2} \text{ s}^{-1}$ (measured)
- $2.7 \times 10^7 \text{ n cm}^{-2} \text{ s}^{-1}$ (FLUKA/McStas calculated)
- $5.4 \times 10^7 \text{ n cm}^{-2} \text{ s}^{-1}$ (MCNP/McStas calculated)



Time evolution of neutrons spectrum in oho-para H



Spatial mapping of neutrons at NILE facility in several energy ranges

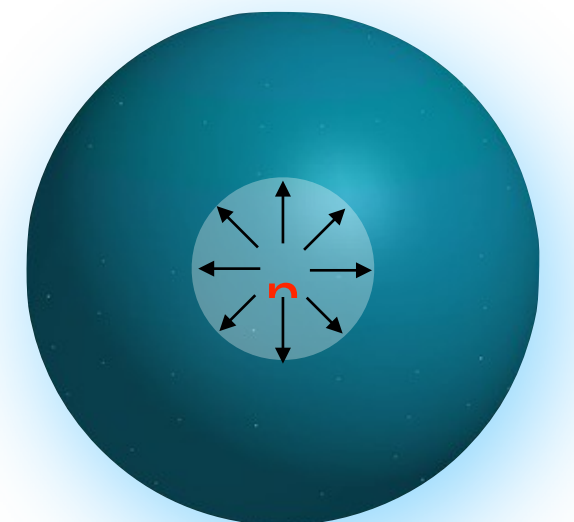
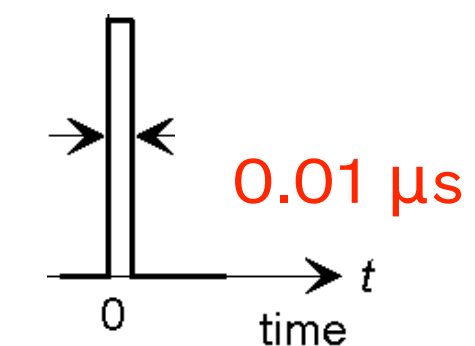
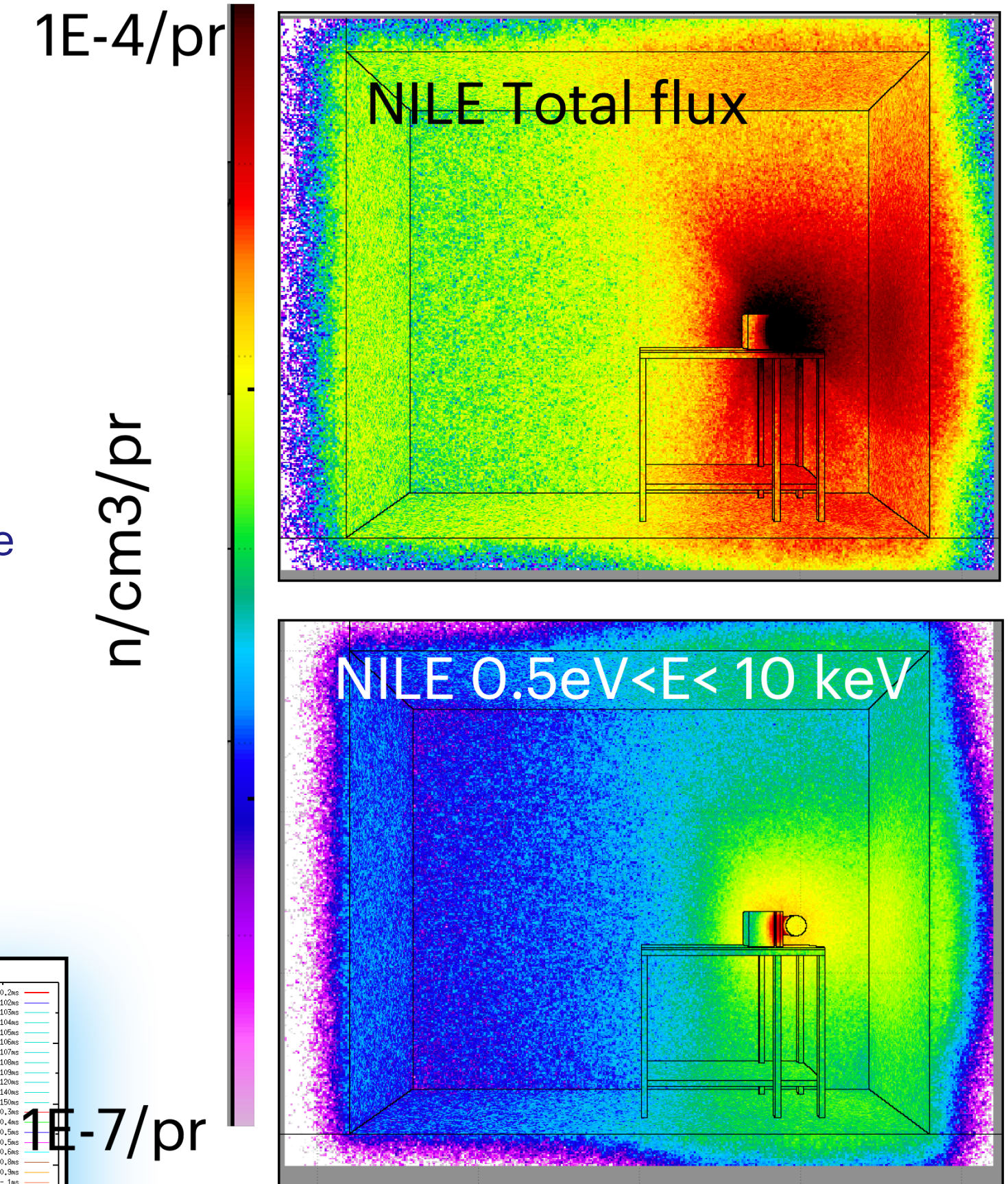


Figure 10. Comparison of Geant4 (blue squares) and FLUKA (red circles) simulated energy deposited in hodoscope fibres (10^6 events). The two energy peaks differ by 6-7%, which is considered good qualitative accordance between the two approaches. Fine differences between the spectra are currently being investigated.

Conclusions

- FLUKA -Cern is a fundamental tool for neutronics work
- Advanced features of neutronics make FLUKA a suitable code for designing cold moderators and supporting neutron instrument developments (Dynamic link to NCRYSTAL library)
- The FLUKA code features as a valuable tool for optimizing neutron source facilities by enabling comprehensive tracking of neutrons from the target to the sample
- FLUKA allows Energy deposition and DH calculation with the same simulation
- Successful implementation requires some advanced features and the development of an appropriate interface between the FLUKA model and optical simulation codes like McStas, which are used to simulate instruments. We are now in the phase of finalising the coupling between FLUKA model of TS1 and McStas instrument models

Research is a collaborative art, not a competition”

- Amar Bose

*Thanks to all the FLUKA.CERN team
for the excellent and remarkable work done,
that allowed important progress in the
ongoing neutronics key projects at ISIS.....*

- A special thank to Francesco, Vasilis, Gabrielle, Cesc, Volodymyr for their support

AD MAIORA!!

Thank you!



Neutrons and muons to advance knowledge and improve lives



Science and
Technology
Facilities Council

ISIS Neutron and
Muon Source

lina.quintieri@stfc.ac.uk

Neutronics Team- ISIS

Rutherford Appleton Laboratory