Science and Technology Facilities Council

The University of Manchester

CLS Grid
Brief Description

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Compact Light Source Grid

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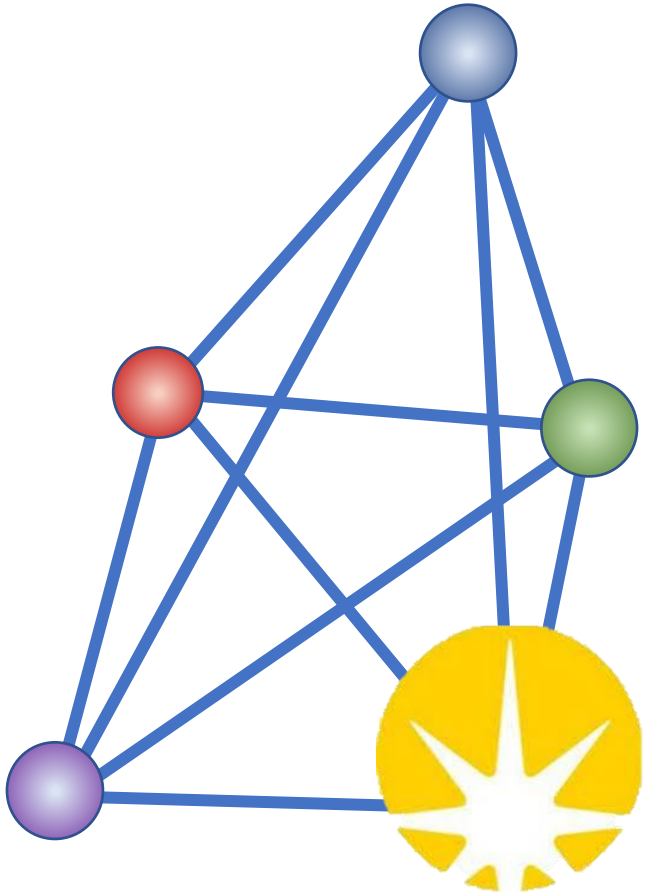
World-leading mid-scale X-ray sources:

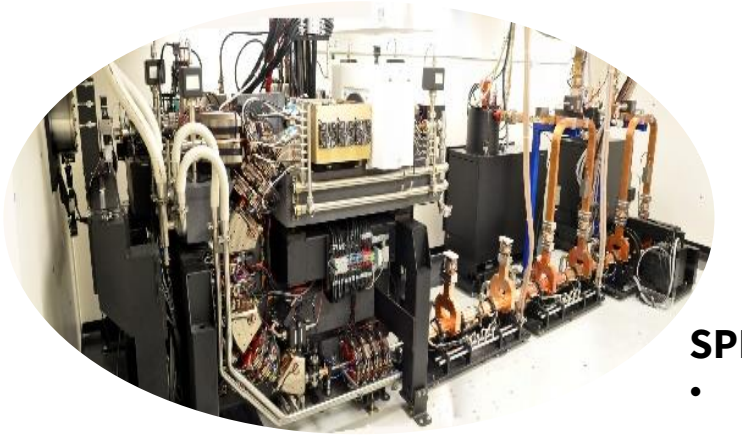
- Each with different scientific and technological drivers and capabilities
- Each representing a local/regional centre of excellence linked to industry/academic needs and clusters of expertise
- Each administered locally complementing the other nodes and the capabilities of DLS



World-class synchrotron-like capability

DIFFRACTION

- **Macromolecular crystallography**
  Protein Structure
- **Single crystal diffraction**
  Structure / orientation
- **Powder diffraction**
  Material / phase identification
  Mapping strains



SCATTERING

- **Small angle x-ray scattering**
  Size / shape of nano-scale objects
- **Pair distribution function**
  short-medium term order

IMAGING / TOMOGRAPHY

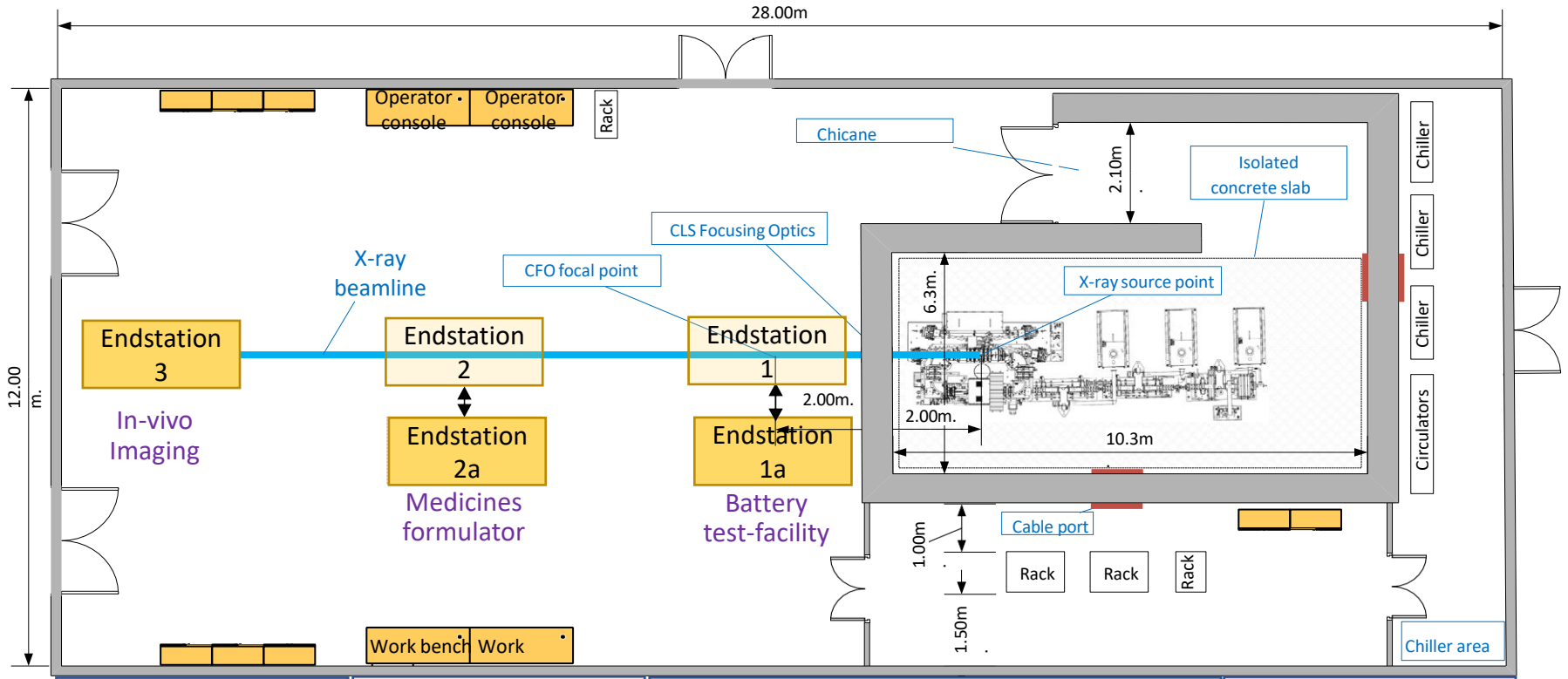
- **Absorption Contrast**
  Quantitative density, elemental contrast
- **Spectroscopic Imaging**
  Elemental concentration, functional labels
- **Grating Phase Contrast**
  Sub-resolution structure, quantitative phase
- **Propagation Phase Contrast**
  Low-contrast high-resolution features

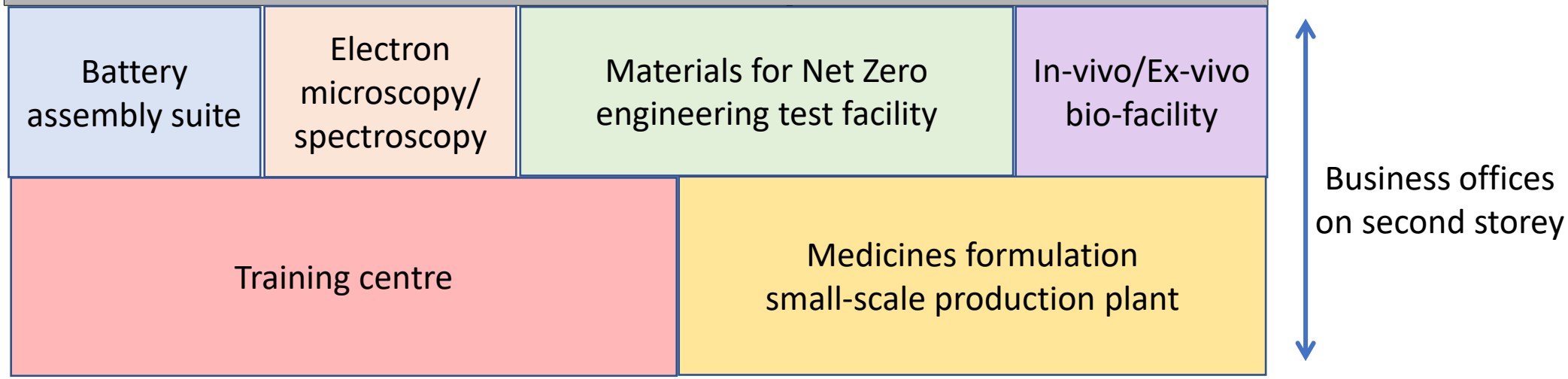
SPECTROSCOPY

- **X-ray Fluorescence Mapping**
  Elemental distribution
- **Absorption / Fluorescence Spectroscopy**
  Chemical state, coordination

Access to multiple modalities → Comprehensive characterization

Compact light sources: what might a node look like?





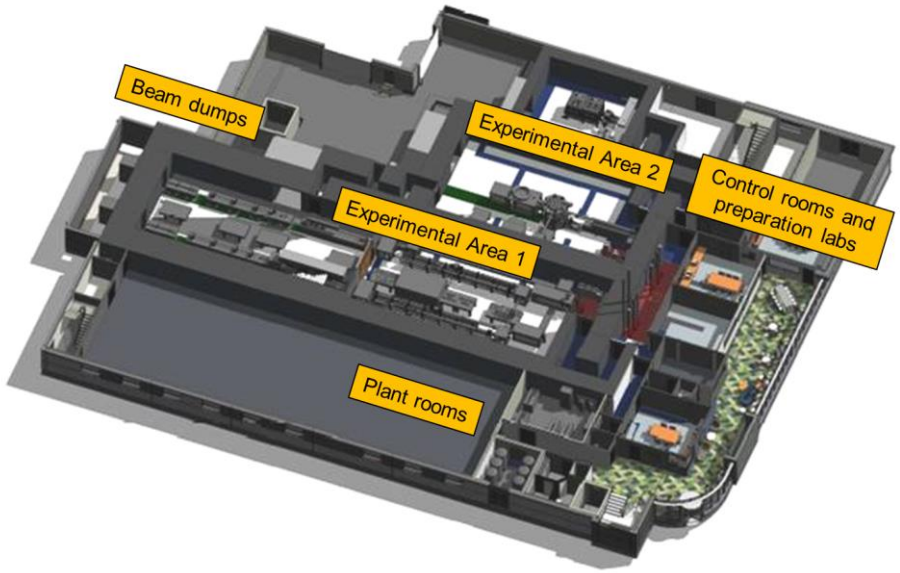
Construction will use STFCs life cycle analysis of sustainable construction, operation and decommissioning

(Design based on existing facilities)

CLS Grid Timeline?

Possible timeline (no project plan yet):

- Oct 2025 – Oct 2027: Preliminary Activity > CDR
- 2028 – 2030: TDR
- 2030 - 2033: Construction of first node
- 2033: operation of first node
- 2035: operation of 2nd node



Additional Material

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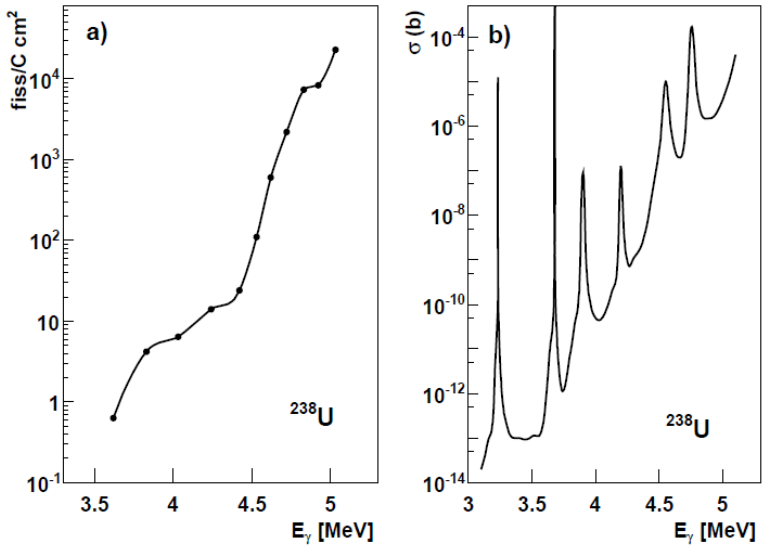
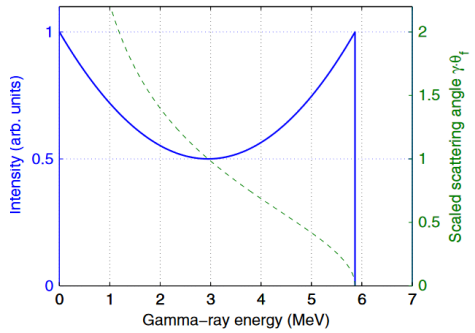
Gammas @ UK-XFEL

Aim: examine whether there is a case for and design of a 1-100 MeV gamma source for the UK-XFEL project

Main points:

Current sources generally based on bremsstrahlung – signal to noise limit and dose limit

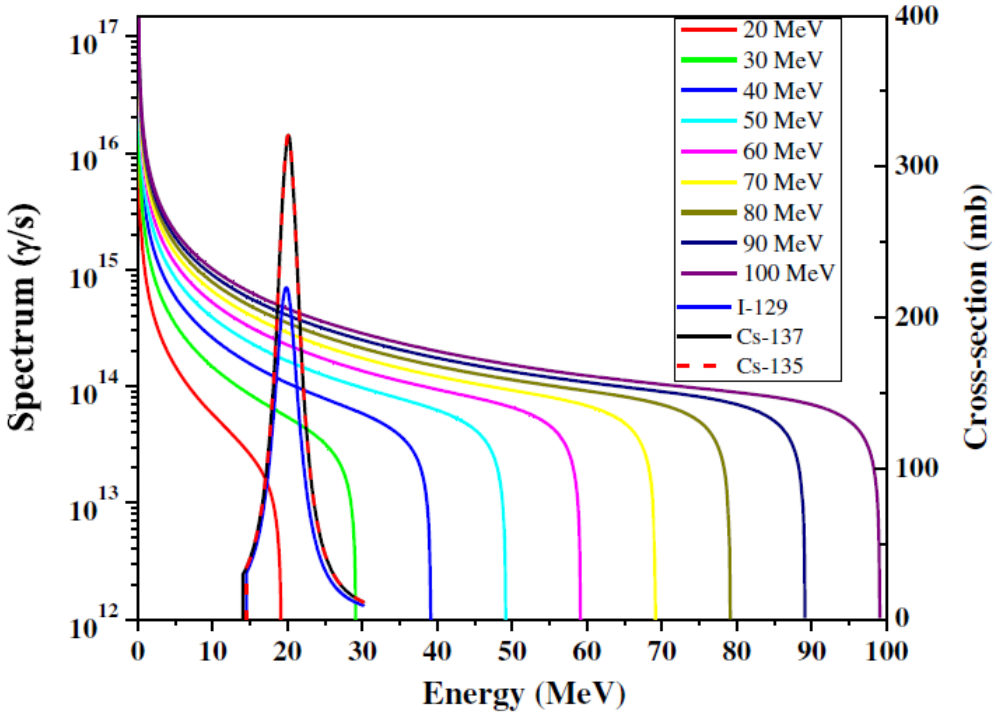




"Perspectives for photofission studies with highly brilliant, monochromatic γ-ray beams" P. G. Thirolf et. al., EPJ Web of Conferences **38**, 08001 (2012)

Brem spectra compared to example dipole resonances of I-129 and Cs-135/137

REHMAN ET AL.



- Gammas also generated by active sources, such as Co-60, these **are** monoenergetic, but have fixed energy, isotropic emission and low flux

A Gamma Source at UK-XFEL?

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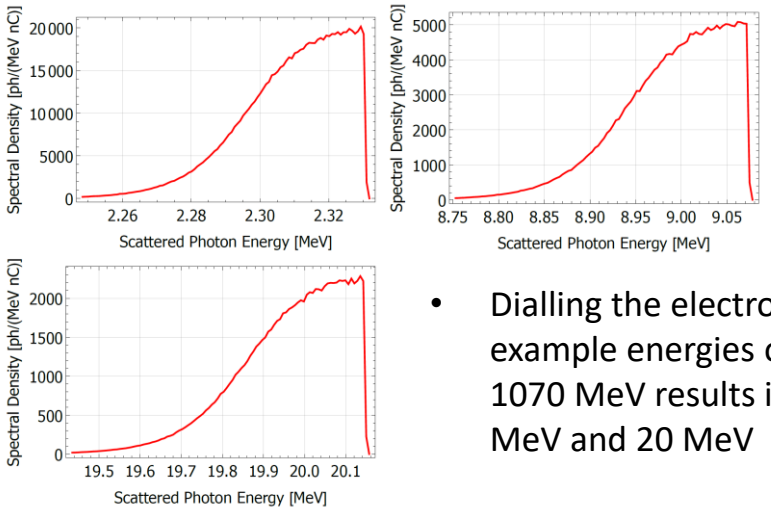
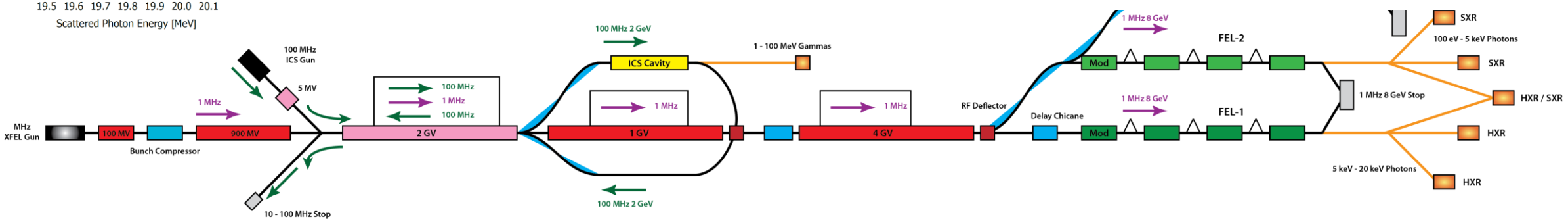
- What gamma properties can such a source provide? Central energy of gammas is proportional to **square** of electron beam energy, linearly proportional to laser photon energy. E.g. vary electron beam energy from ~500 MeV to 2 GeV – and have perhaps two laser cavities of 1064 / 532 nm gives us variability from ~1 to ~100 MeV

$$E^{\gamma}_{\max} = \frac{4\gamma^2 E_{\text{laser}}}{1+X}$$



- Dialling the electron energy down to three example energies of 360 MeV, 720 MeV and 1070 MeV results in gammas at 2.3 MeV, 9 MeV and 20 MeV

	Electron Kinetic Energy (MeV)			
	362	717	1072	
γ-ray peak energy	2.33	9.06	20.11	MeV
	Baseline			
Source size (x/y)	10.72/10.72	8.00/8.00	6.65/6.65	μm
Uncollimated flux	5.77×10^{10}	6.02×10^{10}	6.08×10^{10}	ph/s
Spectral density	2.48×10^{5}	6.65×10^{4}	3.03×10^{4}	ph/s eV
Average brilliance	5.64×10^{12}	2.05×10^{13}	4.45×10^{13}	ph/s mm^{2}mrad^2 0.1% bw
Peak brilliance*	4.44×10^{18}	1.62×10^{19}	3.50×10^{19}	ph/s mm^2 mrad^2 0.1% bw
	0.5% rms bandwidth			
Source Size (x/y)	19.36/12.54	19.35/12.52	19.33/12.50	μm
Collimated flux	1.30×10^{9}	1.29×10^{9}	1.29×10^{9}	ph/s 0.5% bw



Exemplar: Life and Biomedical Sciences Centre

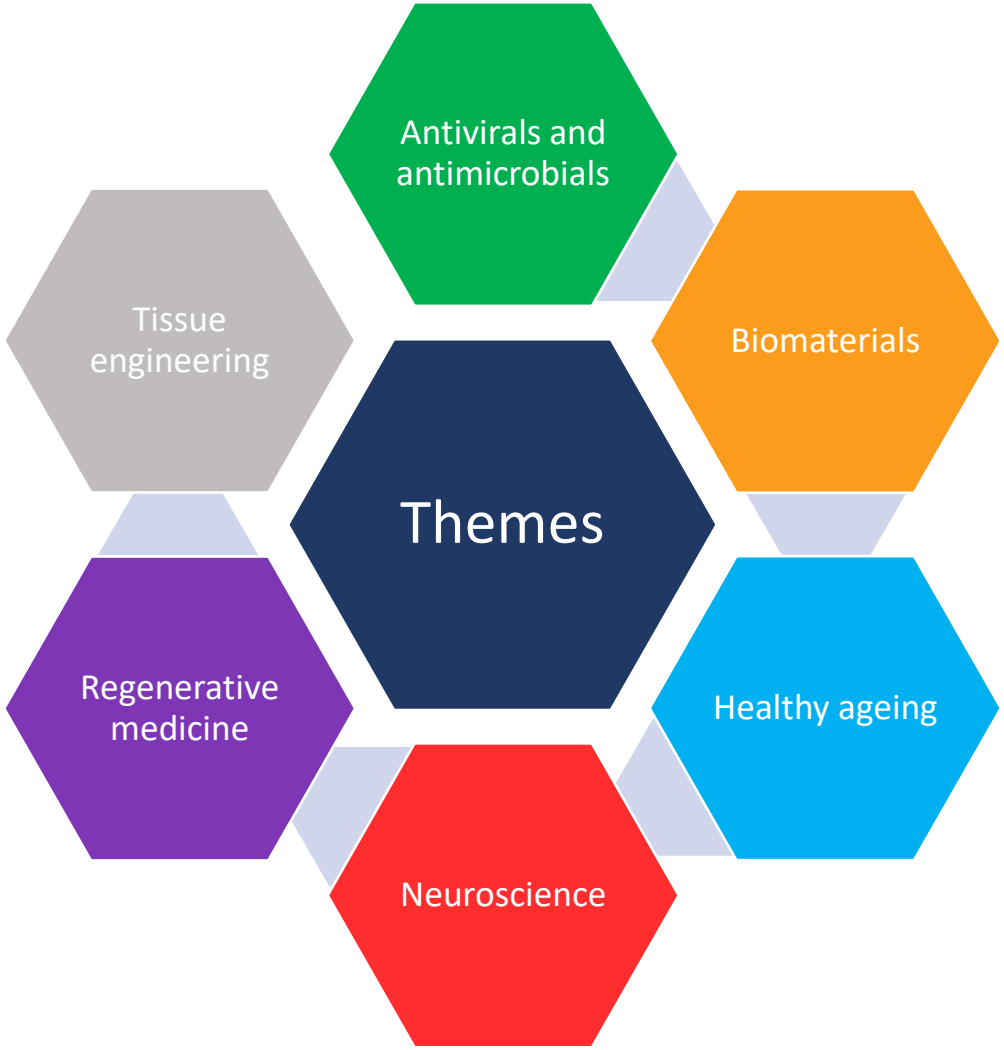
A medium-resolution CLS imaging facility for in-vivo and ex-vivo research, longitudinal studies, and correlative workflows

Science Challenges:

- Understanding biological organisation and coordination across length scales
- Understanding mechanisms of disease, tissue injury, and repair
- Developing new diagnostic X-ray pathology techniques
- Multiscale correlative workflows

Technical Challenges

- Flexible scheduling for integration within correlative and longitudinal workflows
- Allowing repeat measurements of biological replicates
- establishing direct connections with biomedical, life, and clinical scientists



Ancillary Facilities:

- Electron microscopy (EM)
  - including volume EM
- In-situ/in-operando experimental rigs
- Sample preparation and maintenance/preservation

Adjacency with existing biomedical infrastructure

- research hospitals
- correlative facilities
- biomedical research groups
- expertise in sample preparation

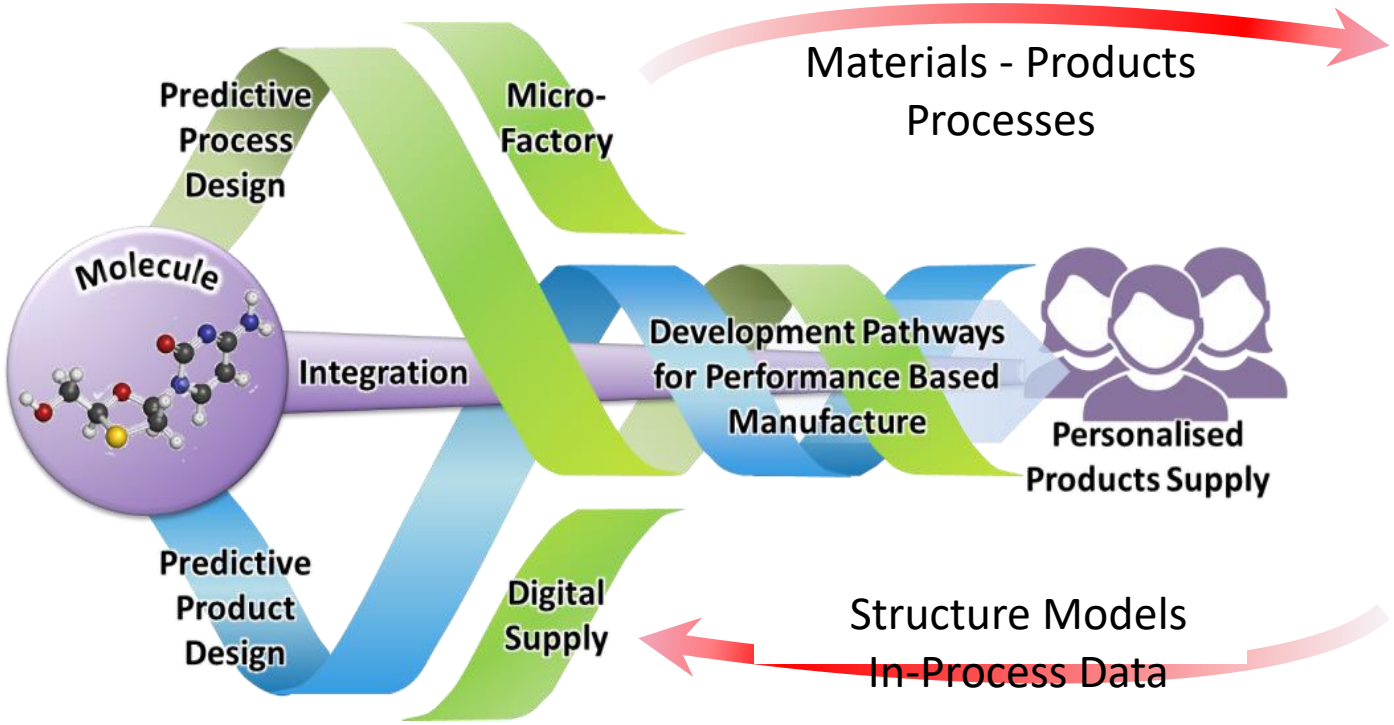
Regional strengths: Crick, Purbright, Edinburgh/Glasgow, North West……..

Exemplar: Advanced Medicines Manufacturing Facility

Technical Challenge

- Endstation with in situ drug manufacturing micro-factory
- Collecting massive datasets

Data-driven
advanced process technologies



Materials - Products
Processes

Structure Models
In-Process Data

At-line (local) – Fast turnaround – Automation
In situ/Operando – Process Equipment

- 4D X-ray imaging – all length & time scales
  Multiple contrast modalities: XRD, XPCI, XPDF, SAXS; ptychography
- X-ray scattering – molecular structure; XRD - XPDF
  noncrystalline phases - melts – solutions – composites
- X-ray spectroscopies – speciation / surface analysis
  Ambient pressure Photoelectron (HAXPES) and absorption spectroscopies (NEXAFS)

Digital Design
Process – Products – Control Systems

Strengths in Scotland, North West, South East…

CMAC
FUTURE MANUFACTURING RESEARCH HUB