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MCT Beamline

IMBL@CT Workshop – Monday 18th March 2019

Andrew Stevenson, Adam Walsh, Mohamed Elrabiey, Tom Fiala, Christina Magoulas & Clinton Roy

Science. Ingenuity. Sustainability.

The MCT Team

Lead Scientist

Andrew Stevenson

Lead Engineer

Adam Walsh

Beamline Scientist

(To be recruited: March 2019)

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Project Manager

Mohamed Elrabiey

Senior Controls Engineer – contact

Tom Fiala

Senior Scientific Software Engineers – contacts

Christina Magoulas & Clinton Roy

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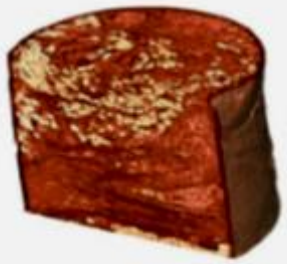
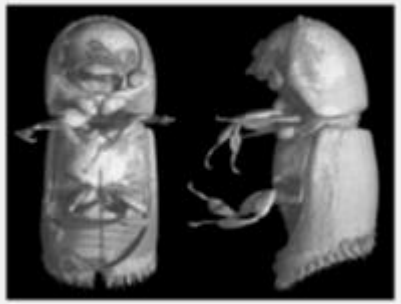
MCT User Community

Biological and Health Science



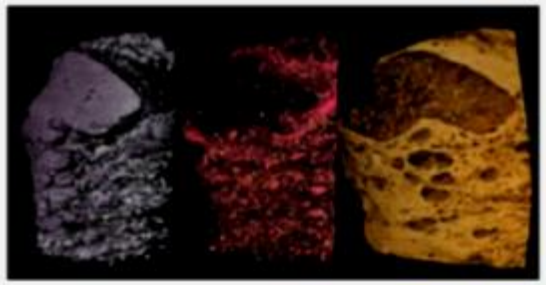
Biomedical micro-CT, 'virtual histology'

Palaeontology



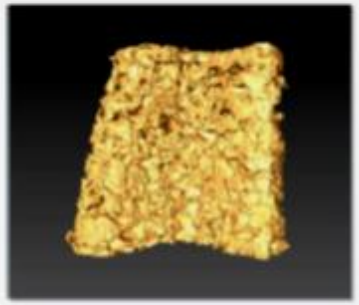
Micro-fossils, Amber Encapsulated Objects

Earth Sciences



Vulcanology, Mineral Processing

Materials Science



Soft-matter, biomedical materials, additive manufacturing

- development of new software algorithms, such as for phase retrieval;
- data-collection strategies, including triggering needs;
- remote access (during & after an experiment);
- the use of particular data formats such as HDF5;
- post-processing, segmentation & analysis of data as dictated by science drivers, e.g. obtaining quantitative measures of materials properties such as porosity, connectivity, surface areas;
- software scripting, especially for cases where data collection, processing & analysis tasks are similar & repetitive;
- streamlining of experiments involving interfacing of user-provided equipment & stages;
- outreach, workshops, training & SIGs.

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Scientific Aims for MCT Beamline

To deliver a world-class X-ray imaging/micro-computed tomography capability for the benefit of the Australian/NZ/international user community:

- non-destructive, 3D sample characterisation with sub-micron spatial resolution;
- supporting state-of-the-art IT infrastructure for rapid data processing, reconstruction, visualisation & analysis (including streamlined HPC pipelines);
- innovative phase-contrast modalities to improve sample information content;
- ability to utilise monochromatic, filtered-white & pink X-ray beams;
- high-throughput/high-speed sample mode;
- use of non-ambient sample environments;
- robotics for automatic sample change;
- efficient & standardised sample-mounting protocols.

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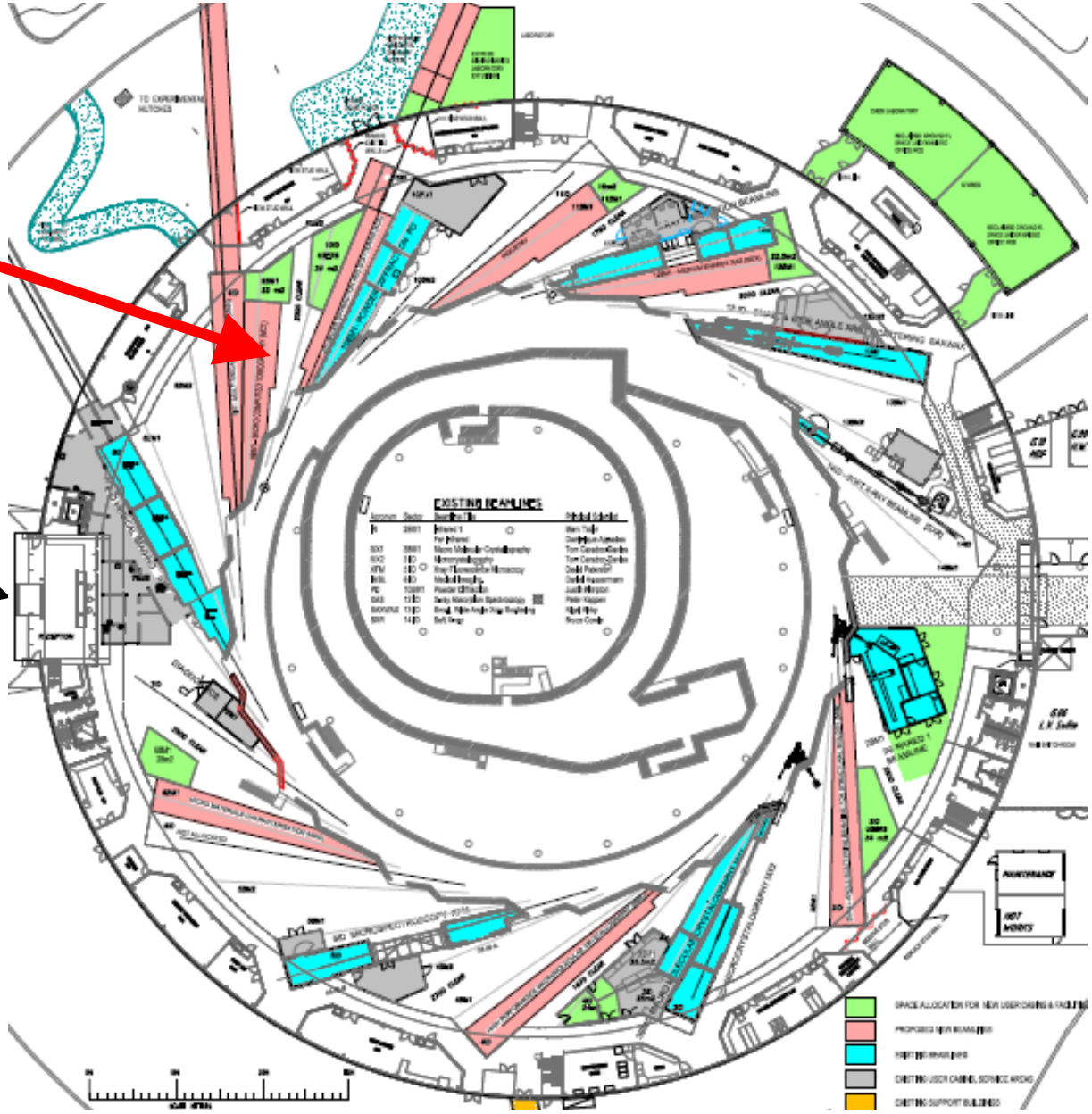
MCT Location

9-BM1 (MCT)

Synchrotron entrance



Beamline Advisory Panel (BAP)

BAP MEMBER	INSTITUTION	BACKGROUND
Sherry Mayo (Chair)	CSIRO, Victoria	Long-term user of IMBL; expert in lab-based & synchrotron X-ray imaging/CT, including phase-contrast.
Kaye Morgan	Monash University, Victoria	Frequent user of IMBL; expert in application of phase-contrast methods to soft tissue; grating-based imaging.
Andrew Rider	DST, Victoria	Materials characterisation, including X-ray imaging/CT, re aircraft bonded structures & application of composite repairs.
Ian Schipper	Victoria University, New Zealand	Frequent user of IMBL; expert in volcanology/petrology including volcanic eruption mechanisms & associated fluid dynamics.
Adrian Sheppard	Australian National University, ACT	Expert in development of improved methods for micro-CT; image processing, segmentation & morphological analysis; application to porous & granular materials .
Marco Stampanoni	TOMCAT, SLS, Switzerland	International X-ray imaging/CT expert; leads team responsible for development & running of TOMCAT beamline at Swiss Light Source.

Andrew Stevenson & Michael James have e*x officio* roles on the BAP

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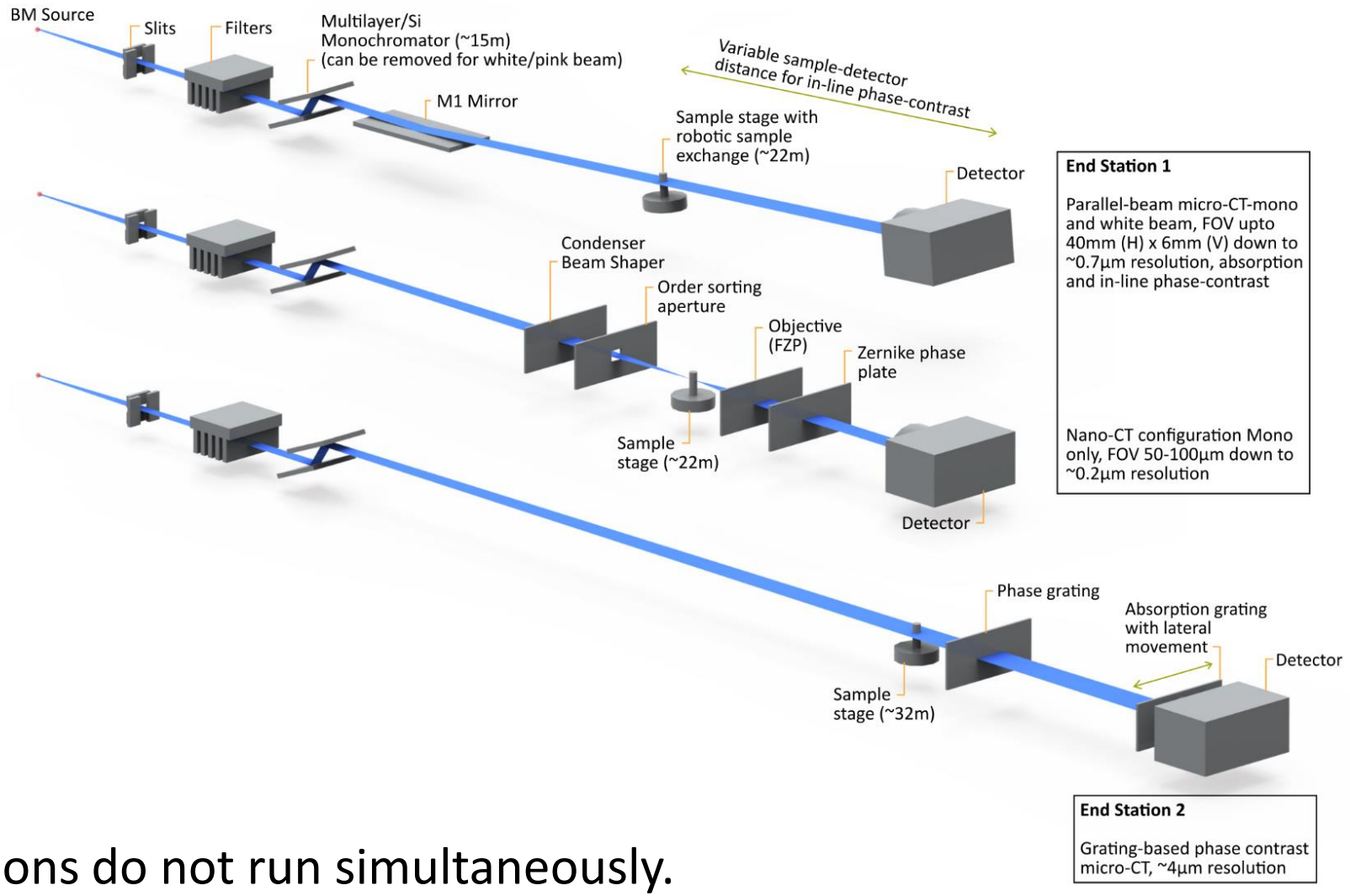
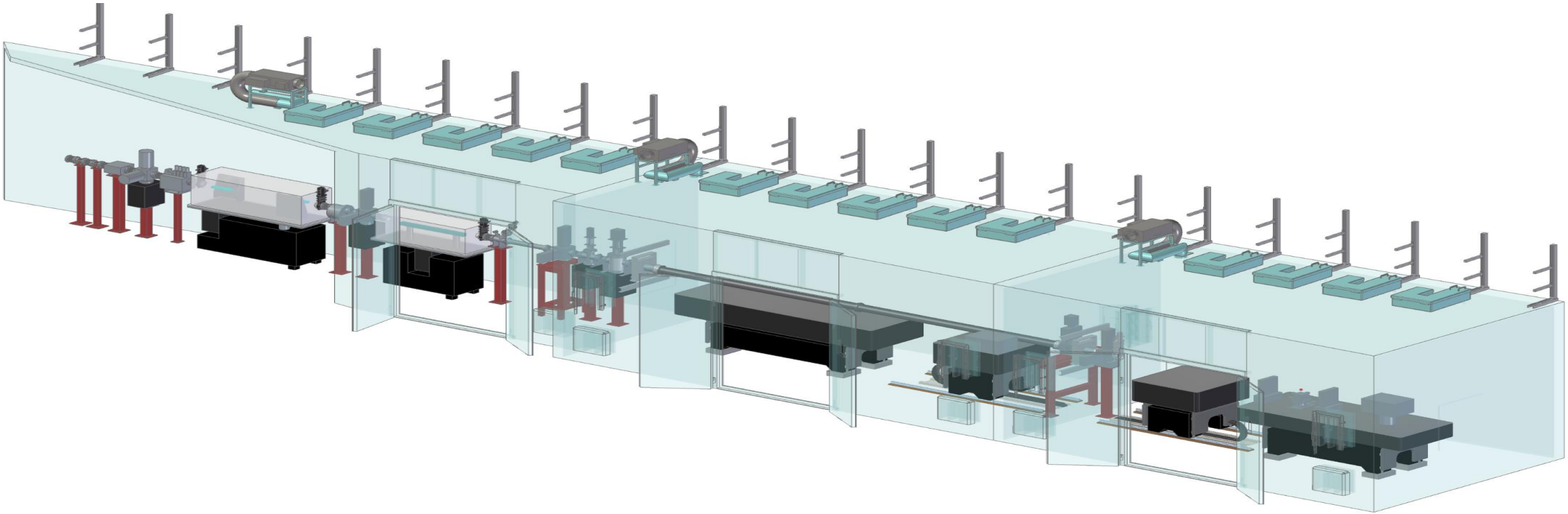
MCT Conceptual Design

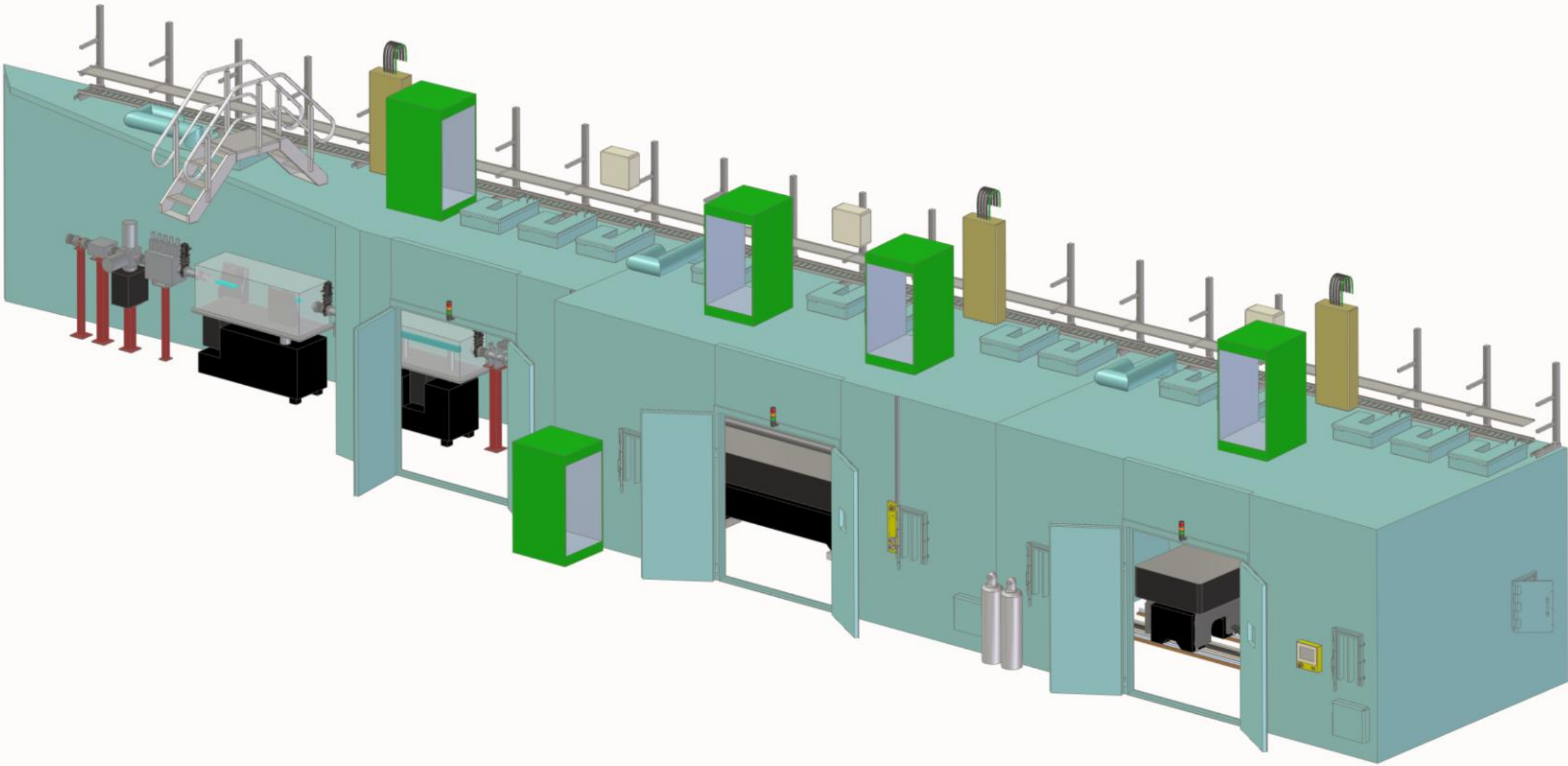


Two end stations do not run simultaneously.

MCT Conceptual Design



MCT Conceptual Design



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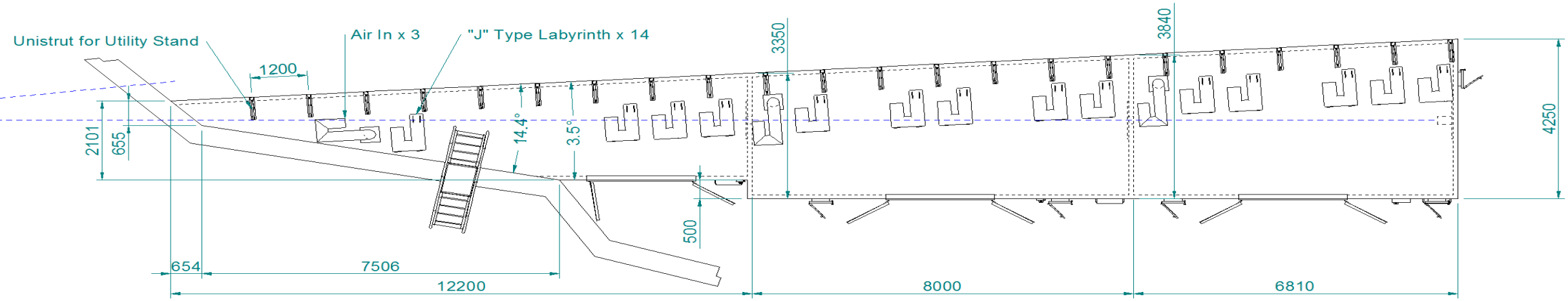

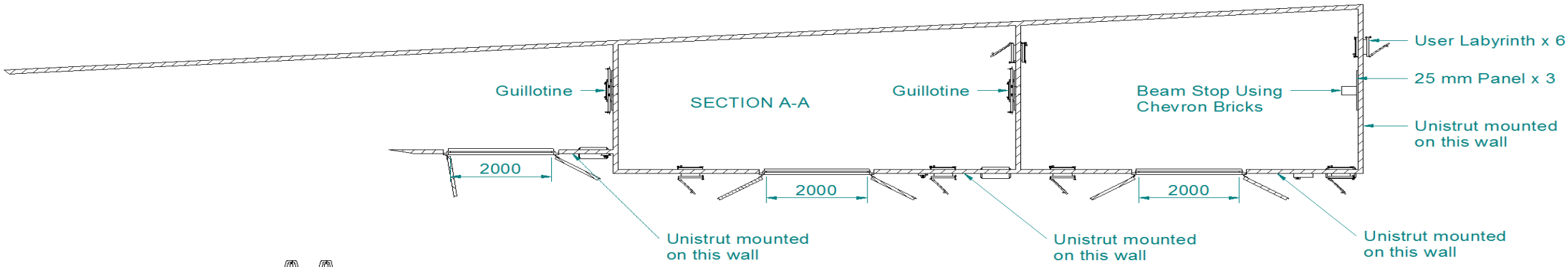

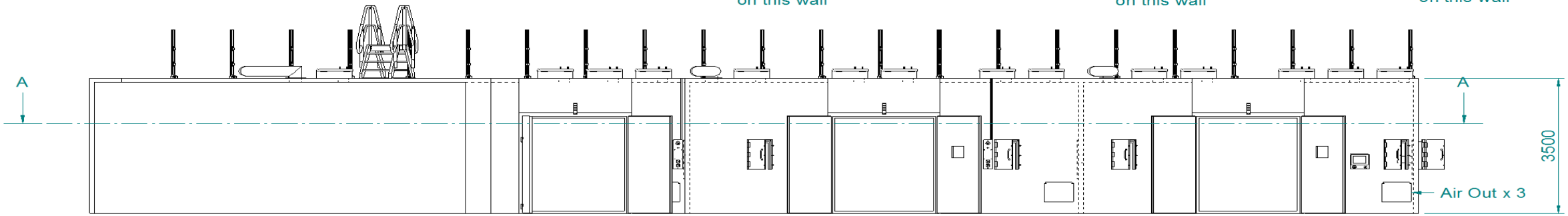

MCT Key Specifications

ITEM	SPECIFICATION
Source	Standard AS BM (1.3 T) – 9-BM1; critical energy 7.95 keV
Hutches	9-BM1-A (~15 m); 9-BM1-B (~24 m); 9-BM1-C (~31 m)
Energy Range	8 – 40 keV (also filtered-white & pink)
Integrated flux	~ 5 x 10^{16} ph/s unfiltered after mask* (~ 50 W)
Filters	5 paddles with 4 filters in each (PDS) - including C (graphene/ graphite/diamond), Al, Cu, Zr, Rh & Sn
Monochromator (DMM)	3 multilayer stripes: 2 (Ru/C & W/Si) with ΔE/E ~ 3 – 4% for 8 – 25 keV & 22 – 40 keV; 1 (V/B_4C) with ΔE/E ~ 0.5% for 8 – 20 keV
Mirror	Single-bounce vertical, pre-formed, bendable; Rh & Pt stripes
Slits	3 sets, low-scatter, white-beam; range 50 mm (H) x 80 mm (V)
Beam size	Max. *2.0 mrad (H) x 0.3 mrad (V) for filter-white or pink beams; max. 1.6 mrad (H) x 0.3 mrad (V) for mono. beam
Sample handling & environments	Robotic stage for automated sample exchange; environments to be finalised with users/BAP - likely to start with high-temp. & load cell
Detectors	CMOS- & CCD-based with scintillators & magnifying optics , e.g. pco.edge & Point Grey

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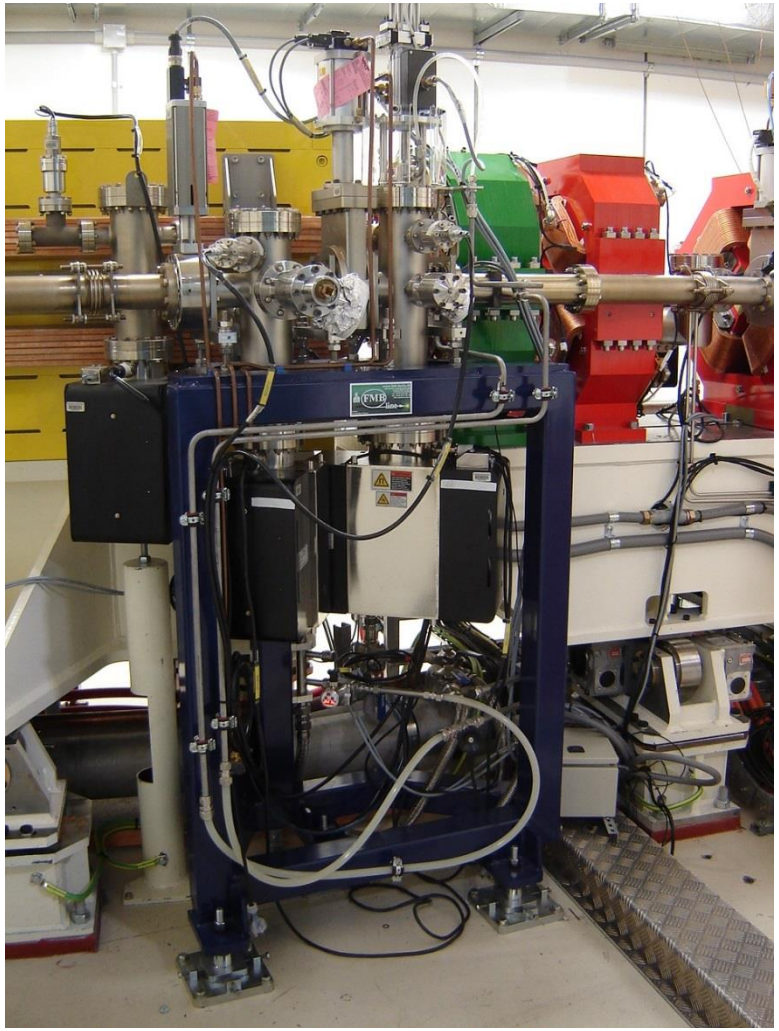
MCT Photon-Delivery System Items

MCT COMPONENT	DISTANCE (m)
BM source	0.0
fixed mask	10.0
GB collimator #1	10.4
high-heat-load slits (A)	10.9
filters	11.5
DMM	13.0
GB collimator #2	14.4
pre-mirror slits (B)	14.9
vertical-bounce mirror	16.1
diagnostics	17.3
beam-defining slits (C)	18.5
photon shutter	19.0
safety shutter	19.5
hutch wall	20.0
vacuum (Be) window	20.2

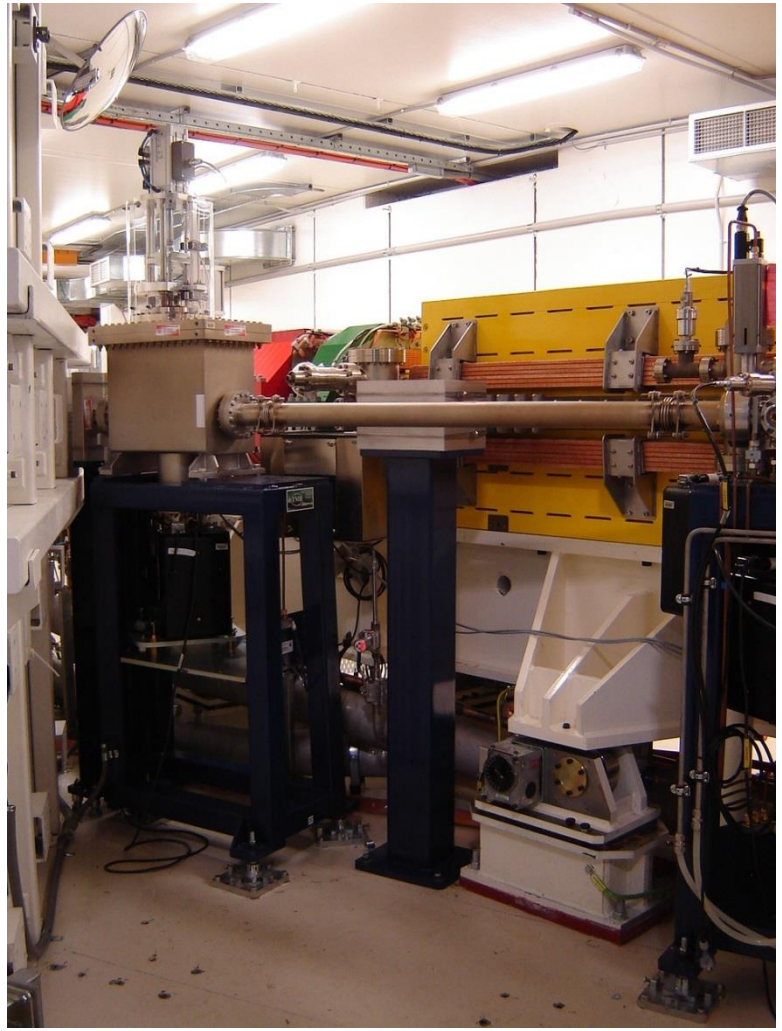
Important Practical Considerations (1)

MCT has strong inter-dependencies with other projects:

- Common Systems program, including standardisation of motion systems, instrumentation control, IT infrastructure & HPC, utilities, PSS & EPS, hutches & user cabins;
- facility PSS upgrade project;
- front-end project.



Important Practical Considerations (2)



- strongly linked & complementary to IMBL - also shares common interests with Dingo at OPAL;
- will require significant input from almost all areas of AS operations;
- will rely heavily on other specialist AS groups such as Optics & Detector Working Groups, RSAC;
- when fully operational, will be one of the heaviest users of IT & HPC resources;
- needs to be designed & implemented with stability (thermal & vibration) a key consideration;
- needs careful consideration of floor space & access requirements.

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MCT Budget

The Project budget (Capital Investment Case formally approved) is ~$8M.

Includes:

- photon delivery system (including monochromator & mirror);
- 2 complete end-stations (including detectors, sample environments (part), robotic stage & optical tables);
- IT infrastructure (part) (including 0.5 PB data storage, local server & software);
- science & engineering staff (part).

Excludes items in other projects:

- any front-end modifications;
- hutches;
- utilities & user cabin.

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MCT - Milestones

DATE	MILESTONE
1st July 2017	Project started
19th September 2017	Capital Investment Case endorsed at PRC
28th September 2017	Capital Investment Case approved at IRC
20th October 2017	First BAP meeting convened
18th June 2018	CDR endorsed
29th June 2018	EOI technical specifications for DMM completed
20th July 2018	EOI technical specifications for PDS (excluding DMM) completed
16th November 2018	RFT technical specifications for DMM completed
December 2018	RFT technical specifications for PDS (excluding DMM) completed
February 2019	Short-listed RFT responses for DMM evaluated
March 2019	Short-listed RFT responses for PDS (excluding DMM) evaluated
March 2019	TDR completion (staged; DMM & PDS sections earlier - in time for RFTs)
September 2020	All PDS items delivered & installed
November 2020	Commissioning without beam & regulator ARPANSA approval
December 2020	Radiation-safety tests & "first light"
April 2021	Commissioning tests with beam, including some “expert users”
30th June 2021	Documentation, handover & project closure

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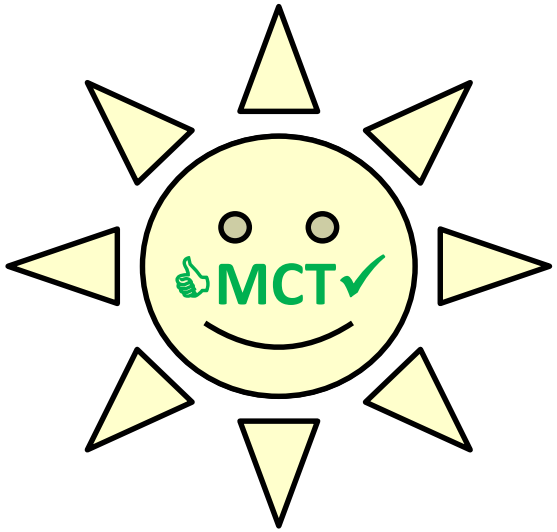
X-ray beam
- good stability
- static flat fields
- high flux/DMM reflectivity
- reduced scatter/background
- energy/bandpass tunability
- height variation
- low harmonic

Sample
- robotic exchange
- sub-pixel (sub-µm) (re-)location
- non-ambient environments
- standardised mounting
- laser alignment
- use of contrast media

Data
- HPC/"ASCI"
- file formats, e.g. HDF5
- preliminary & post-experiment
- (pre- & post-) processing
- special algorithms/corrections
- segmentation & reconstruction
- visualisation & analysis
- batch modes & scripting
- phase retrieval



Hutch environment
- extremely stable mechanics
- "mode" changes
- variable sample-to-detector distance
- ~50% RH/±0.5°C
- cameras

Operational modes
- fly/step-&-shoot/helical scans
- detector-triggering
- accommodate interfacing to user equipment

Detectors
- high frame rate/rapid read-out
- sub-µm resolution & zoom-able
- mono/pink/white-beam compatible
- FOV up to 60 mm horizontally
- ROI operation & binning

Control
- configurable/user-friendly GUIs
- compatibility/consistency (esp. IMBL)
- support for remote access & monitoring
- coordinated/synchronised motion
- EPS & PSS

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MCT Commissioning Plans

- PSS & EPS tests (C & H)
- valves & vacuum tests (C & H)
- radiation-safety tests (H)
- IT infrastructure tests (e.g. IOCs) (C & H)
- control-system tests (incl. EPICS, GUIs, PVs, etc.) (C & H)
- motion-control tests (incl. pseudo-motors, coordinated & synchronous operations) (C & H)
- detector tests (incl. triggering) (C & H)
- stability (vibration, temperature, flux, energy, etc.)
- functionality tests (e.g. cameras/alignment protocols/"point-&-click" integration) (C & H)
- workflow & software tests (incl. batch operations) (C & H)
- quality control tests (C & H)
- characterisation studies (e.g. DMM energy) (H)
- in-house pilot studies (H)
- expert-user pilot studies (H)
- documentation review (C & H)
- ion chambers & dosimetry (H)

C = cold commissioning
H = hot commissioning

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Thank you for your attention

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