AN OVERVIEW OF THE SOUTH AFRICAN ISOTOPE FACILITY (SAIF) PROJECT

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Background

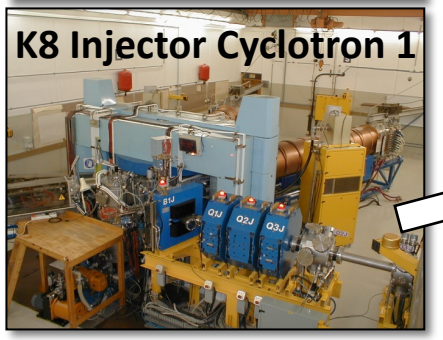
iThemba LABS is a national facility of the National Research Foundation in South Africa:

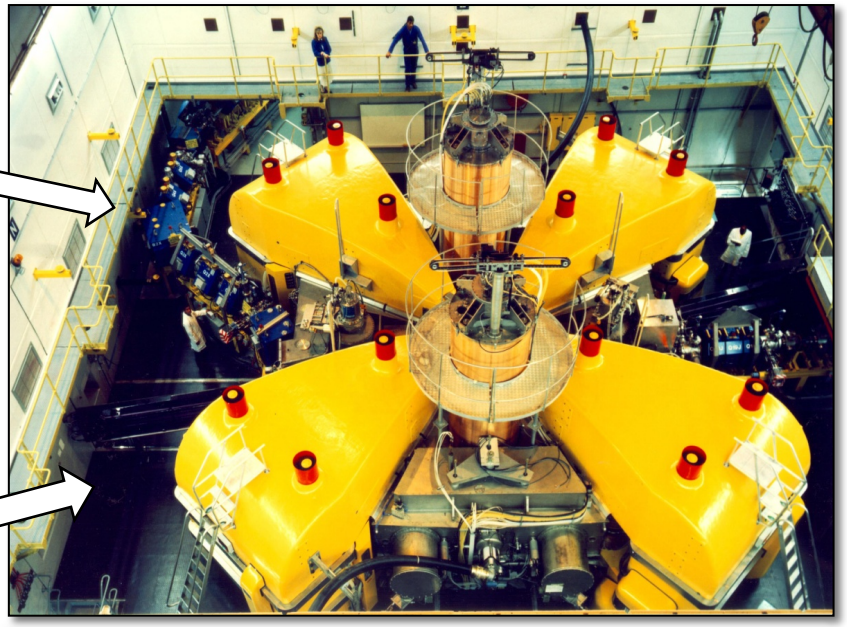
Mandate	Beam Time Allocation	
	Historically	Present Time
Sub-atomic physics research	33%	10%
Radioisotope production	33%	90%
Particle therapy – neutron/proton protocols	33%	Discontinued

Ageing facility no longer compatible with modern treatment protocols

Our existing facilities:

- 200 MeV separated-sector cyclotron (SSC)
- Two solid-pole injector cyclotrons (different ion sources)
- K600 spectrometer
- Experimental beam lines (Aphrodite facility, neutron beam facility, radiation biophysics facility
- Hotlabs for chemical extraction and cGMP production of radioisotopes and radiopharmaceuticals
- 11 MeV cyclotron for F-18 production
- 3 MV Tandetron accelerator for materials science research (Cape Town)
- 6 MV Tandem accelerator for materials research and AMS (Johannesburg)





K200 Separated Sector Cyclotron

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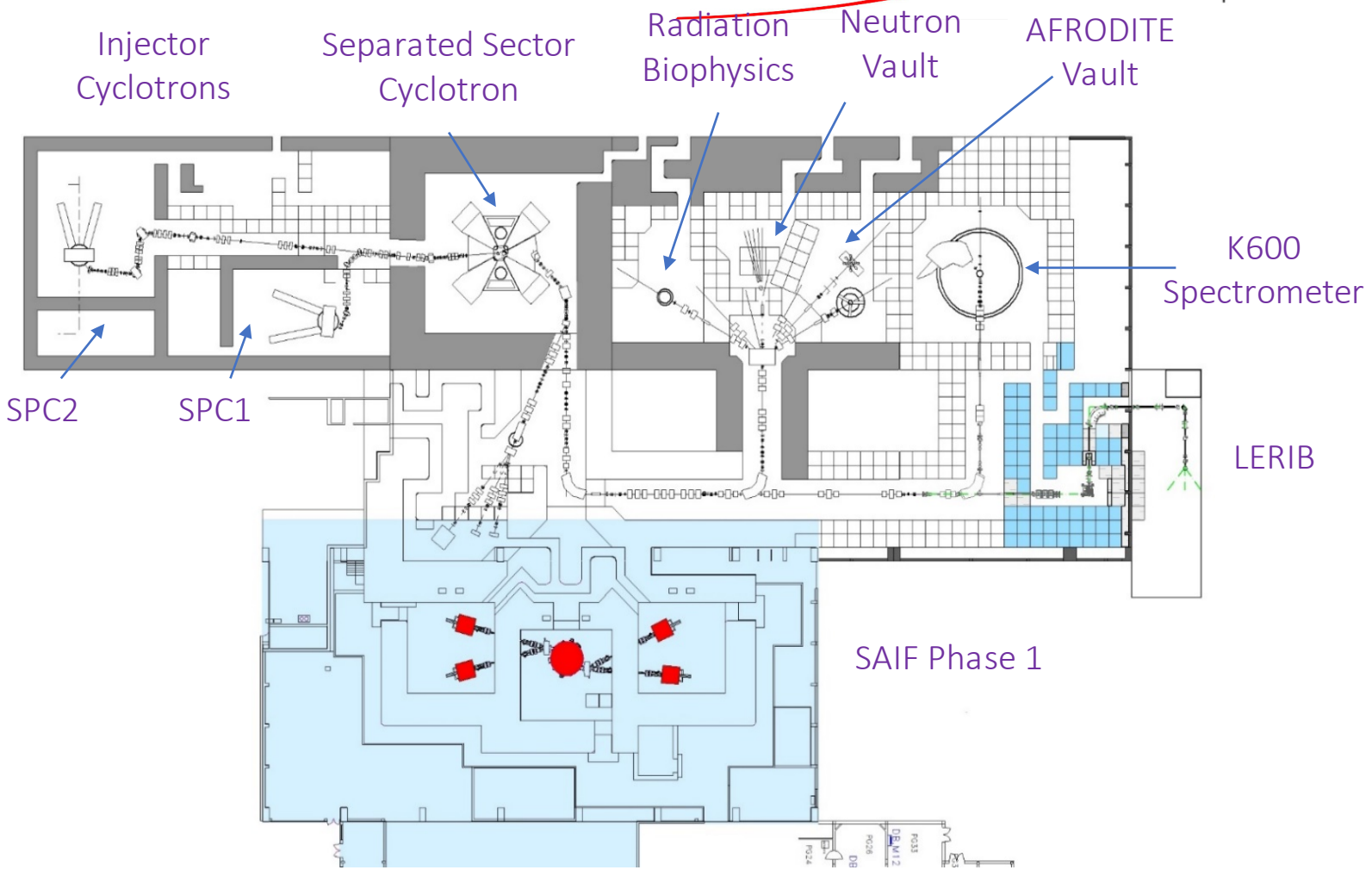
Motivation for SAIF Project

Objective = Establish a dedicated facility for radioisotope production:

- New facility to be retrofitted in 3 existing un-utilised vaults on site which realises significant savings
- Installation of a new 70MeV cyclotron and beam lines for isotope production
- Migration of the radioisotope production programme from the existing SSC to the 70MeV cyclotron;
- Increase the beam time availability at existing SSC complex for physics research

Implementation workstreams:

- 70 MeV cyclotron procurement
- New beamlines procurement
- New target stations manufacturing
- New buildings for utility services, waste disposal
- Regulatory licensing



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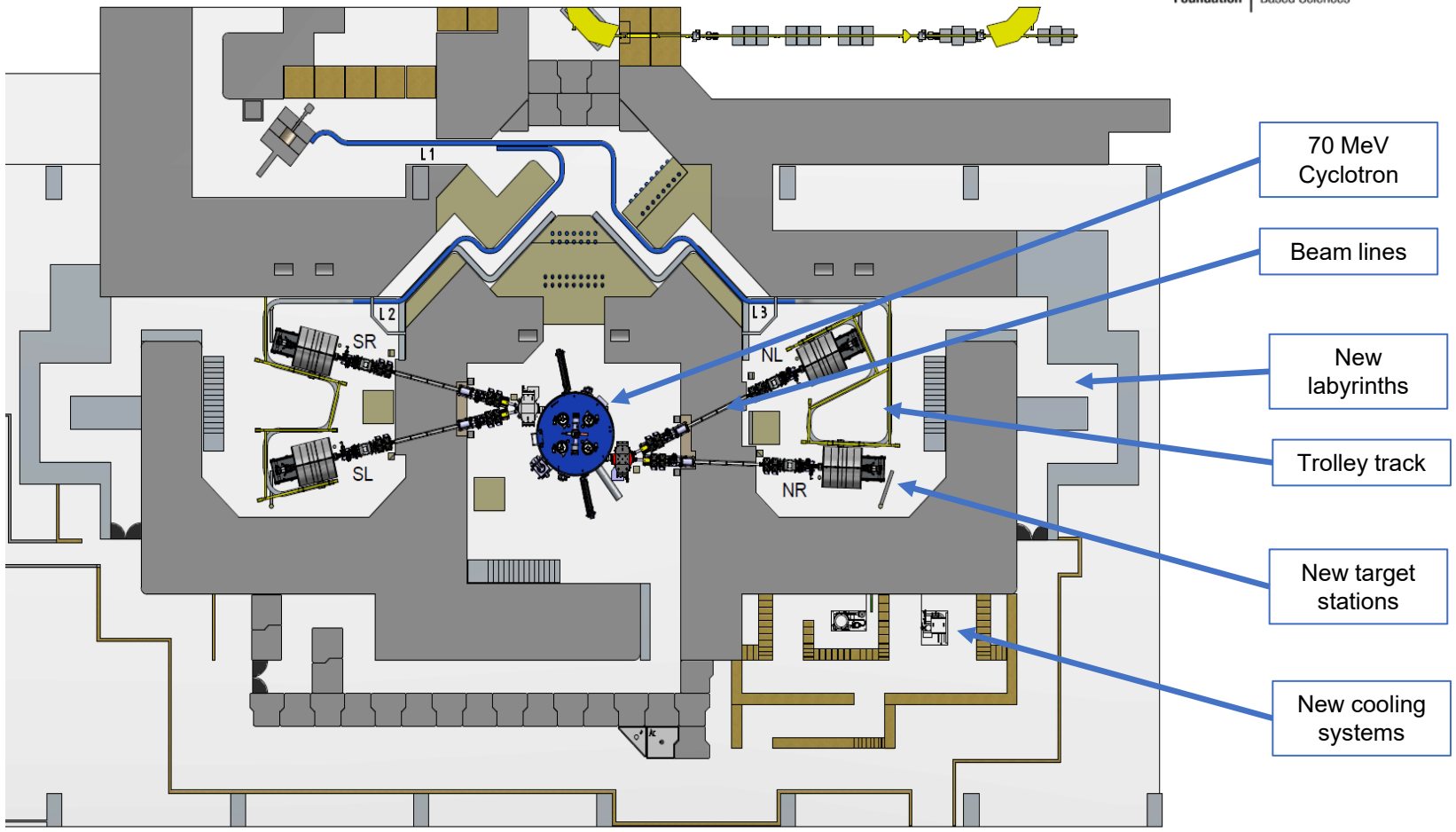

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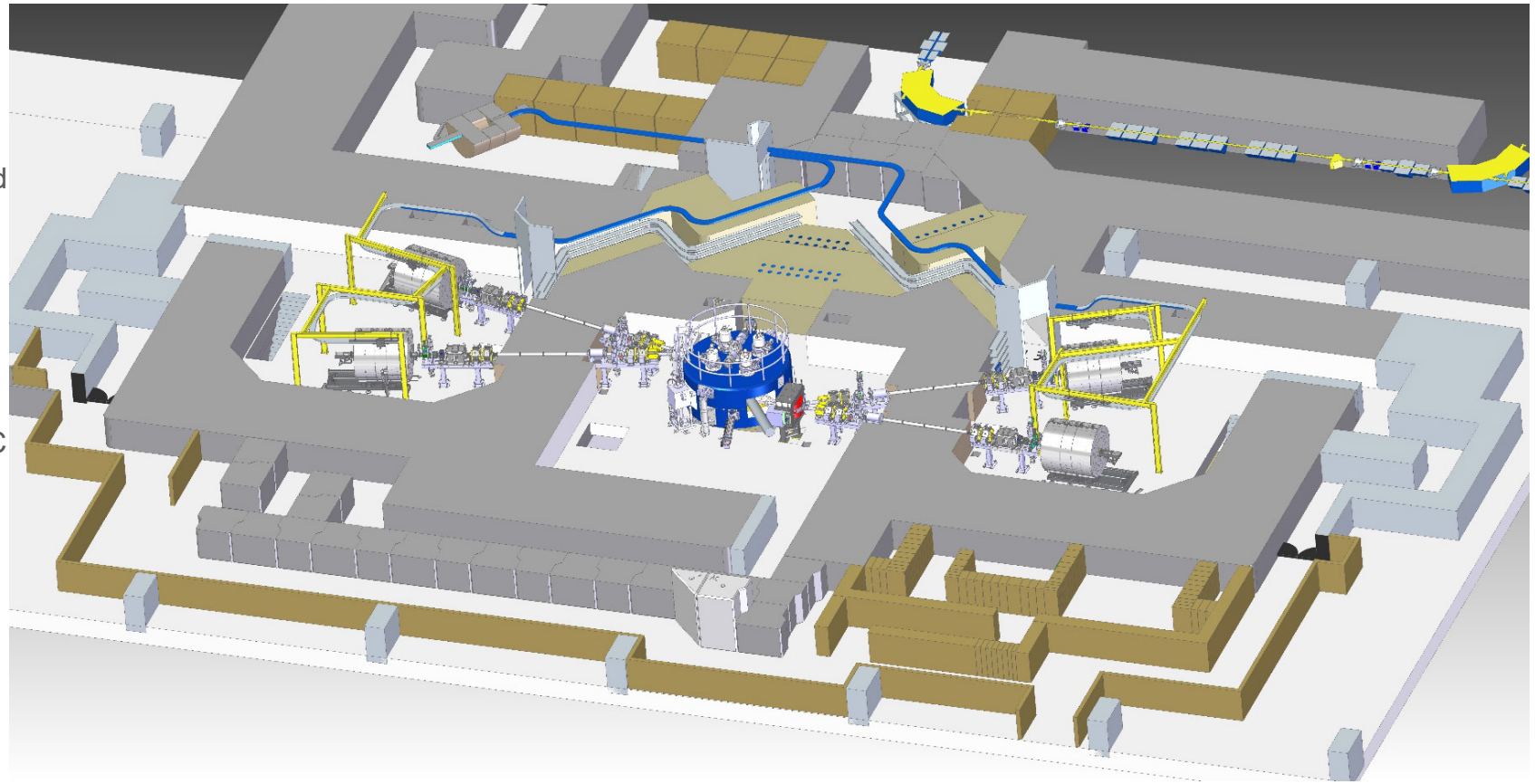

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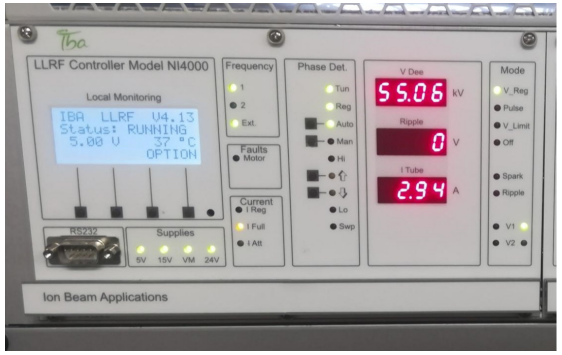
70 MeV cyclotron

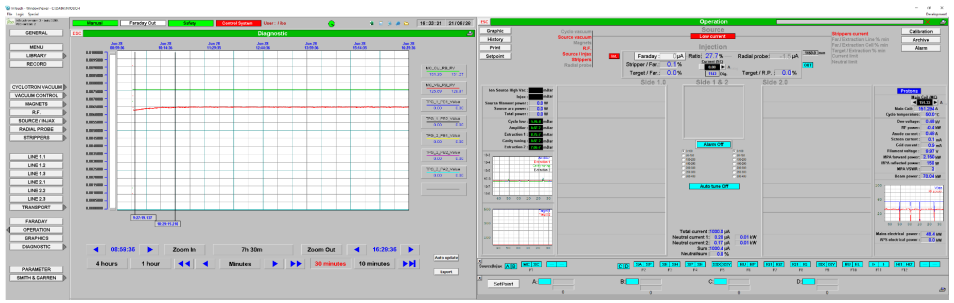


Cyclone 70P supplied by IBA Radiopharma Solutions

- Variable energy proton beams (30 – 70 MeV)
- Multicusp ion source with 10 mA of injected H- current
- High-intensity proton beams up to 375 μA per extraction port
- Dual extraction ports for simultaneous beam delivery
- 4-sector magnet of 1.6 Tesla
- Directly coupled 100 kW RF system with 2 dees (4th harmonic mode)
- 4 beam transport lines with beam diagnostics, Faraday cups and neutron shutters

Status of C70 manufacturing & installation

- Factory acceptance tests completed in Belgium in July 2021
- Delivered to port of Cape Town in December 2021
- Installed into the vault in April 2022



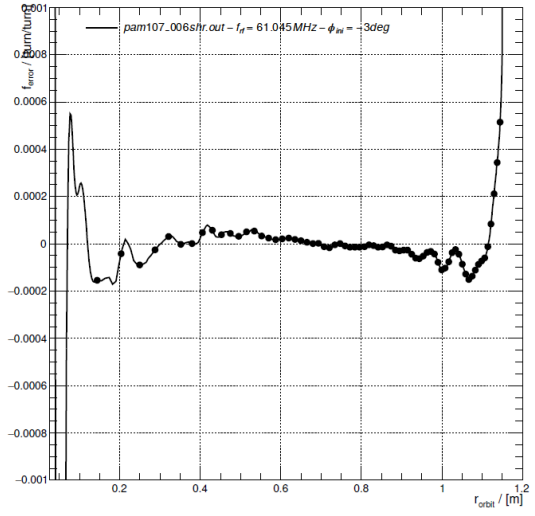


Figure 7: CYCLONE®70p, PAM107 project, H^-: The frequency error $\Delta f/f$ as a function of the average closed equilibrium orbit radius r_{orbit}.

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Installation of C70 cyclotron and beam transport lines

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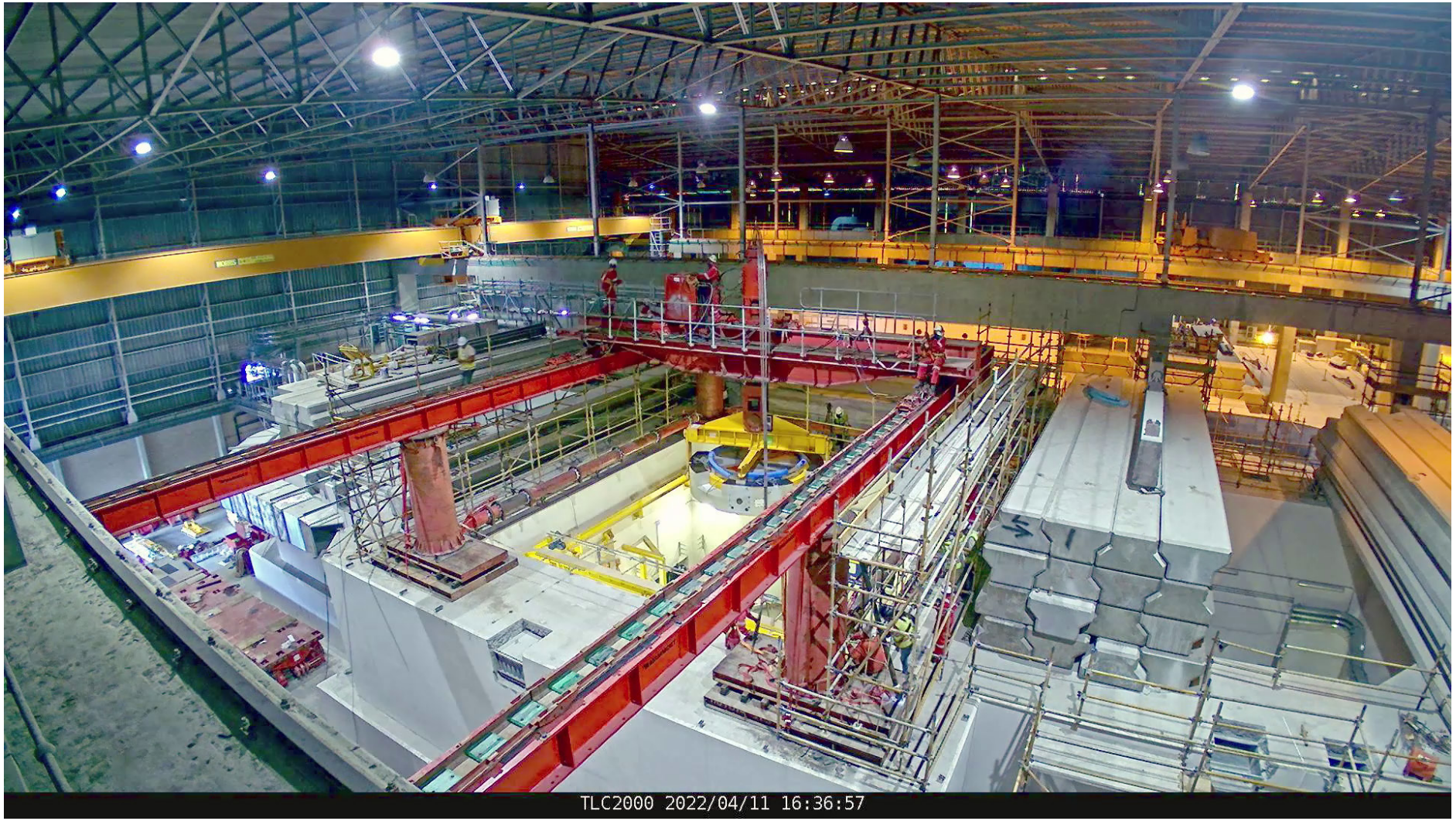

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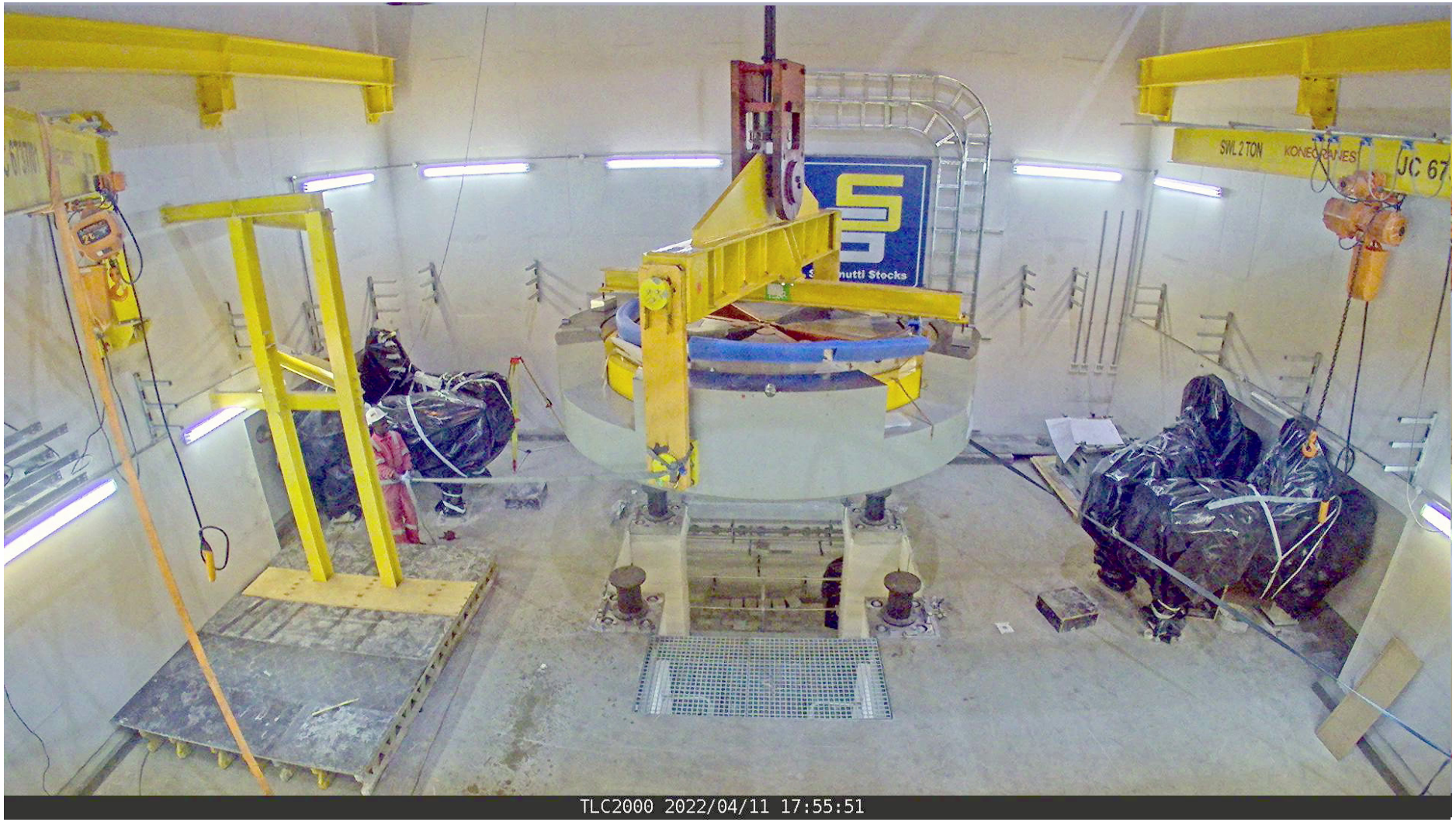

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Installation of C70 cyclotron and beam transport lines

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Installation of C70 cyclotron and beam transport lines

- Mechanical assembly of C70 99% completed
- Wiring and cabling of cyclotron and beam line equipment completed
- IBA field engineers on site for PLCs and system testing

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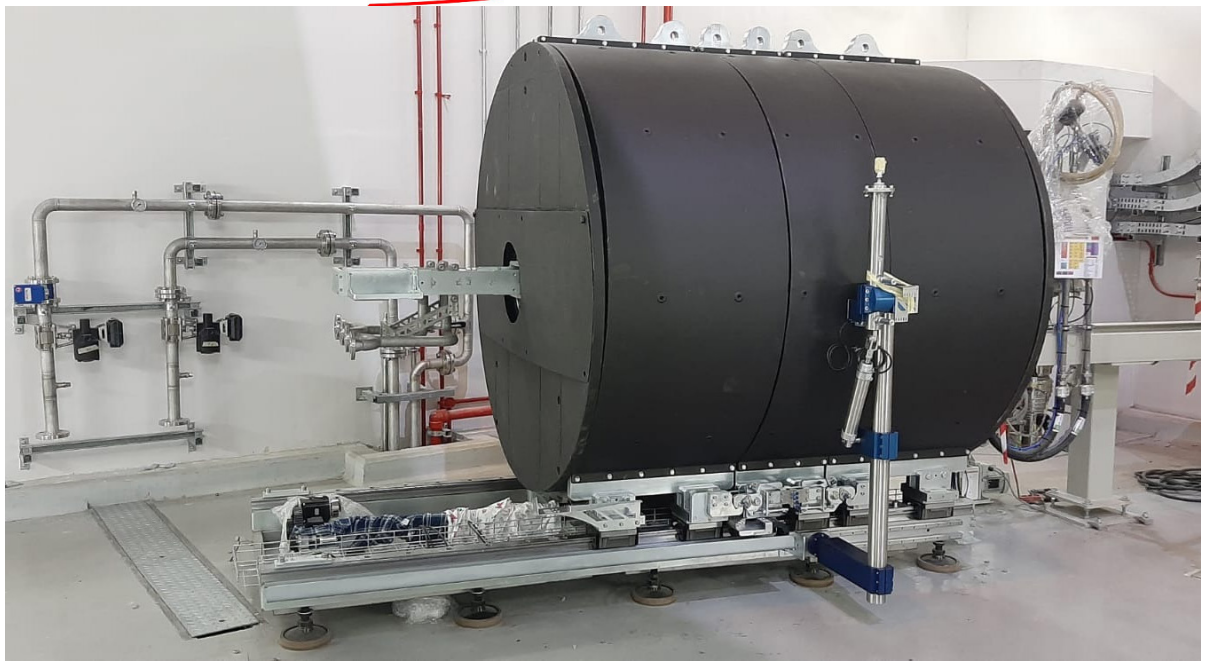
Target Systems

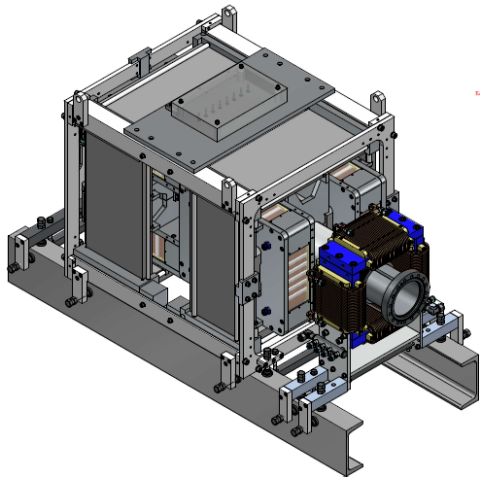
In-house design of target station

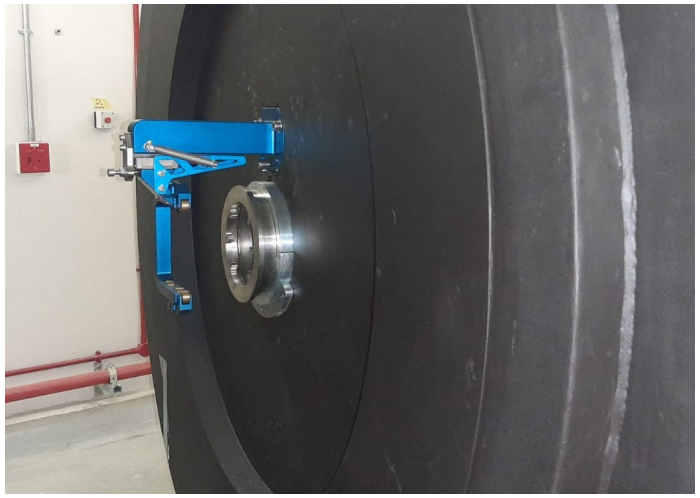
- Provide local radiation shielding (steel, lead, borated wax)
- Accommodate solid targets of Rb/Ga in tandem (for ^{82}Sr and ^{68}Ge production) or Mg/Ga in tandem (for ^{22}Na and ^{68}Ge production)
- Water-cooled target capsules (up to 26 kW heat removal)
- Helium-cooled vacuum window
- Robotic transfer of target from target stations to chemical processing facility

In-house design of sweeper / steerer magnets*:

- H-type dipole magnets with 90° phase difference to sweep the beam in a circular pattern to provide heat dissipation to the vacuum window and target capsule







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Infrastructure

Construction works entailing the following:

- Structural modifications to cyclotron vault and 2x target vaults
- Facilities to house power supplies, electronics and control rooms
- Mechanical plant room for central water cooling plant
- Electrical plant room for power distribution and RUPS
- Radioactive waste storage facility (processing & storage of solid & liquid wastes)
- HVAC for specified air changes and pressure cascades in controlled areas
- Cyclotron and beam transport line cooling systems
- Target cooling systems
- Supervisory control systems for vault clearance and safety interlocking

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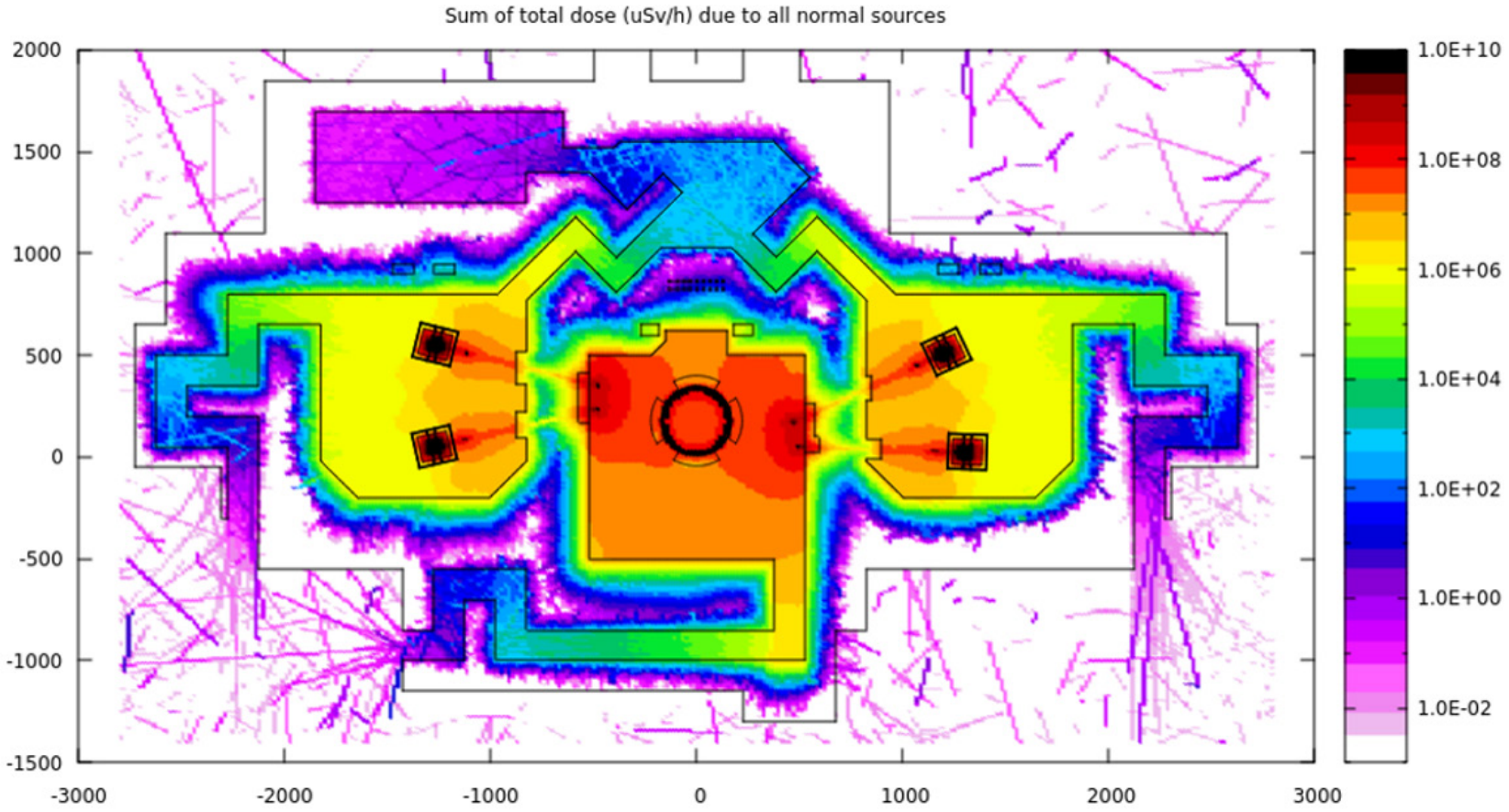
Infrastructure

Vault Modifications – Verification of Design for Radiation Shielding*:

- Worst case fluence to dose conversion factors used (FLUKA option EWT74) based on data sets from ICRP74
- Acceptable Radiation Levels:
  - Unrestricted blue areas (ground level outside vaults): < 2.5 µSv/h
  - Restricted blue areas (on roof): < 15 µSv/h



* H. Barnard: IAEI International Conference on Accelerators for Research and Sustainable Development 23-27 May 2022

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Remaining work:

Activity	Estimated completion date
C70 cyclotron: Final assembly of mechanical/electrical systems	Dec 2022
Commission central services (HVAC, cooling systems, electrical power)	Completed
C70 cyclotron: RF start	Jan 2023
C70 cyclotron: First beam extraction	Feb 2023
Complete radioactive waste handing facility	Feb 2023
Commission 2x target stations	Mar 2023
C70 cyclotron: Beam transport line commissioning	Feb 2023
C70 cyclotron: Site acceptance testing	Apr 2023
Complete regulatory licensing process	Apr 2023

Thank you

Acknowledgements

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National Research Foundation

IBA Radiopharma Solutions