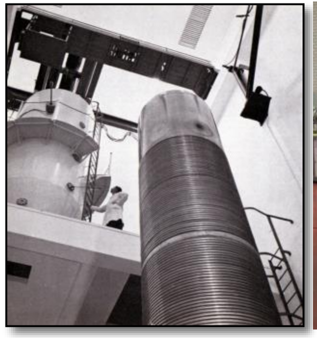
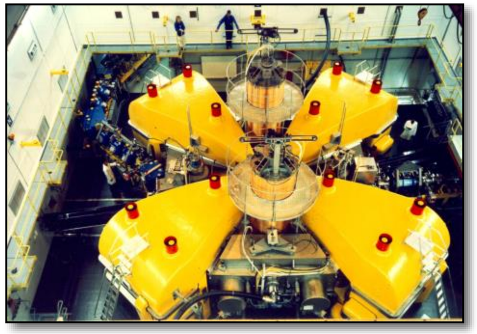


Recent Developments and Proposed Applications with the Accelerators at iThemba LABS

J.L. Conradie, L.S. Anthony, F. Azaiez, S. Baard, F. Balzun, G Bardenhorst, R.A. Bark, A.H. Barnard, P. Beukes, J.I. Broodryk, J. Crafford, G. Darries, J.G. De Villiers, C. Doyle, H. Du Plessis, W. Duckitt, D.T. Fourie, P.G. Gardiner, M.E. Hogan, I.H. Kohler, J. Lawrie, C. Lussi, N.R. Mantengu, S. Marsh, V. Mbele, R.H. McAlister, J.P. Mira, H.W. Mostert, C.B. Mtshali, A.S. Miller, S.M. Mullins, C. Naidoo, F. Nemulodi, M.M. Nkosi, O. Pekar, C.A. Pineda-Vargas, W.J. Przybylowicz, M. Sakildien, G.F. Steyn, N.P. Stodart, R.W. Thomae, M.J. Van Niekerk, P.A. van Schalkwyk, T.P. Sechogela, S. Winkler and S. Woodborne

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

ANS Conference
13th International Topical Meeting on Nuclear Applications of Accelerators
Hilton, Quebec, Quebec City, Quebec, Canada
31 July – 4 August 2017

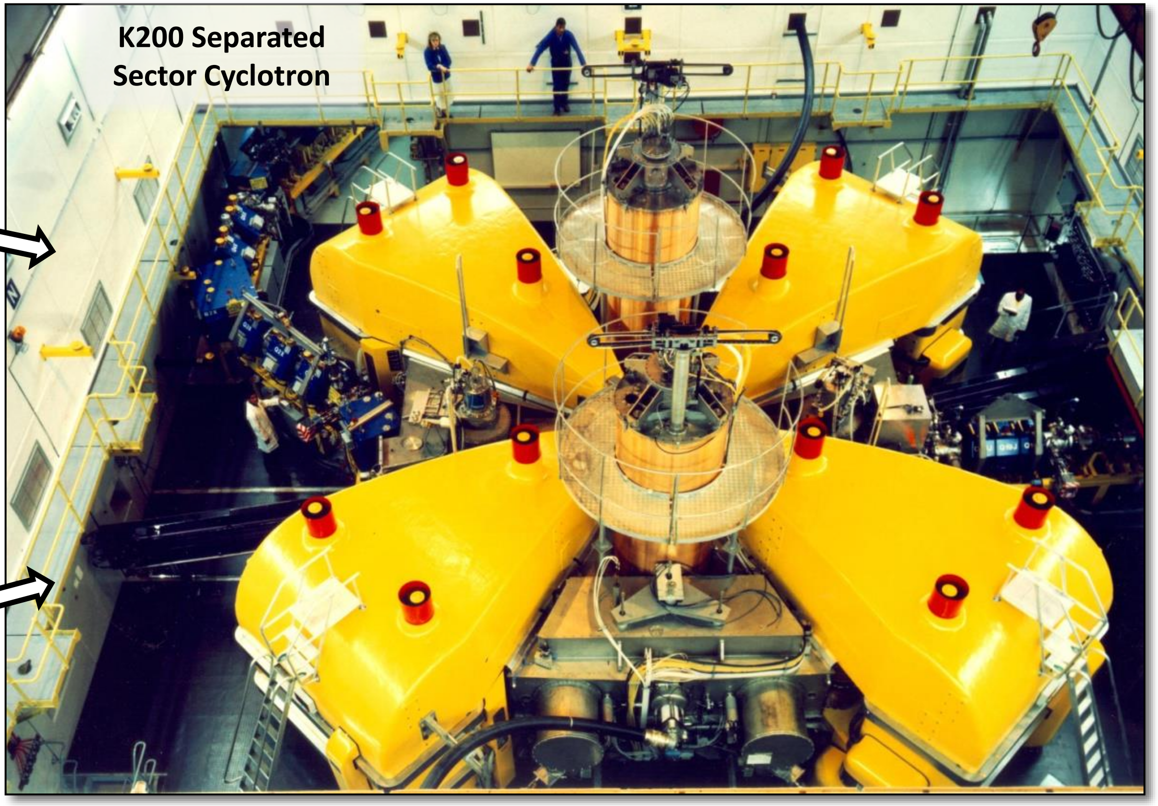
National Research Foundation
iThemba LABS
Laboratory for Accelerator Based Sciences

Cape Town – “Mother City”

Officially founded on 6 April 1652

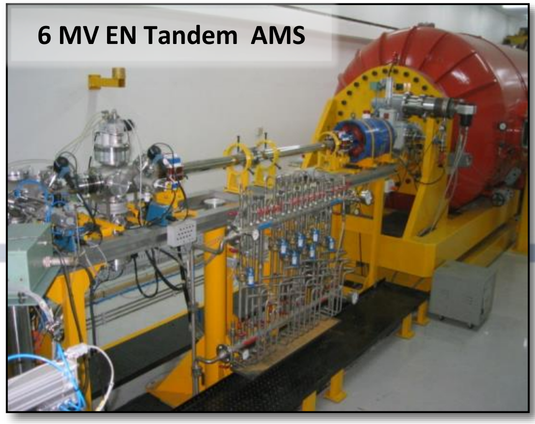
Accelerators at iThemba LABS


K8 Injector Cyclotron 2


K200 Separated Sector Cyclotron


K8 Injector Cyclotron 1


3 MV Tandetron

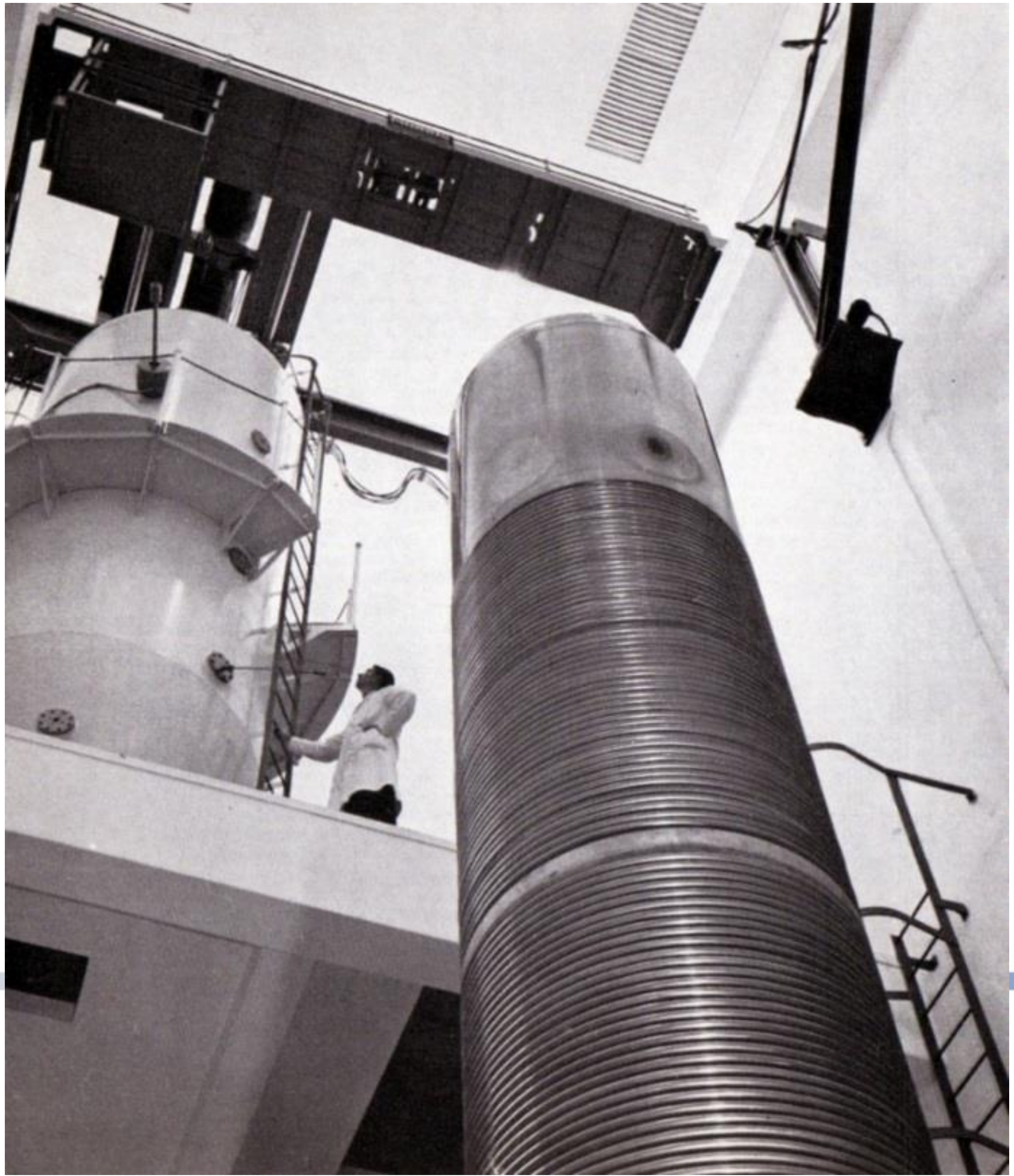

6 MV EN Tandem AMS


K11 Cyclotron - FDG PET Isotopes

Outline of the Talk

- New tandetron accelerator and applications
- AMS applications with 6 MV tandem accelerator
- Proposed new isotope production facilities
- New radioactive ion beam facility

Replacement of the 52 years old Van de Graaff

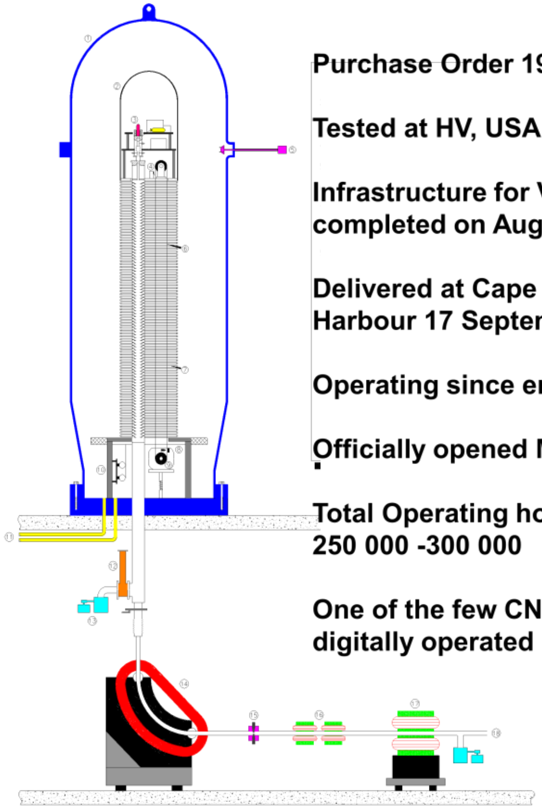


New tandetron accelerator installed

- Commissioned in May 2017 .
- With 6 MeV proton delivered from multicusp ion source with 200 µA current
- With Multicusp source for He-ions production
- With Cesium sputtering source for heavy ions, tested with Si-ions

ION-BEAM INTERACTION AND SURFACE CHARACTERIZATION OF MATERIALS BY ION BEAMS
Materials Research Department (MRD)

CN 6 MV Van de Graaff accelerator



Purchase Order 1961

Tested at HV, USA: August 1963

Infrastructure for VDG
completed on August 1963

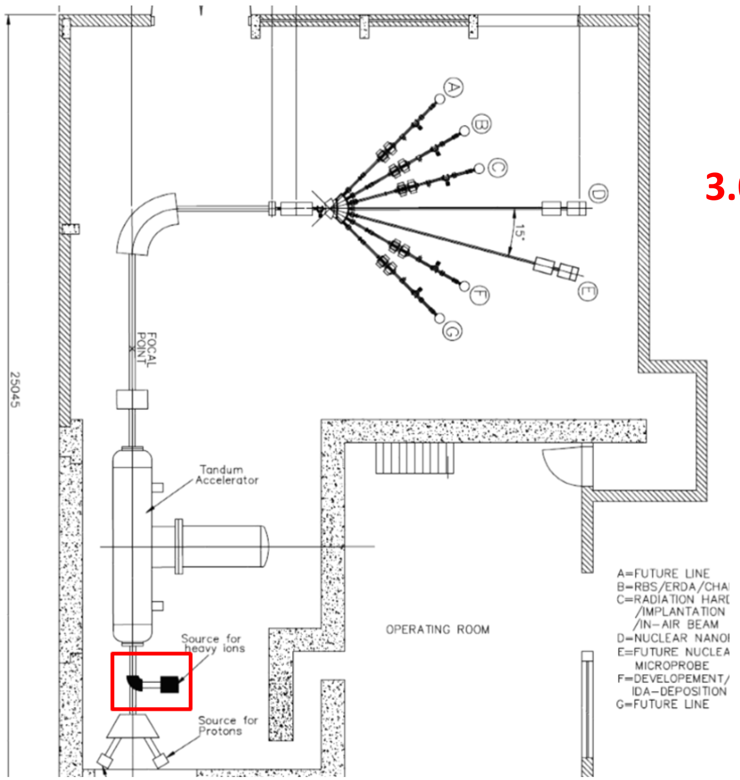
Delivered at Cape Town
Harbour 17 September 1963

Operating since end 1963

Officially opened May 1964

Total Operating hours:
250 000 -300 000

One of the few CN 5.5 MV VDG
digitally operated



3.0 MV TANDETRON

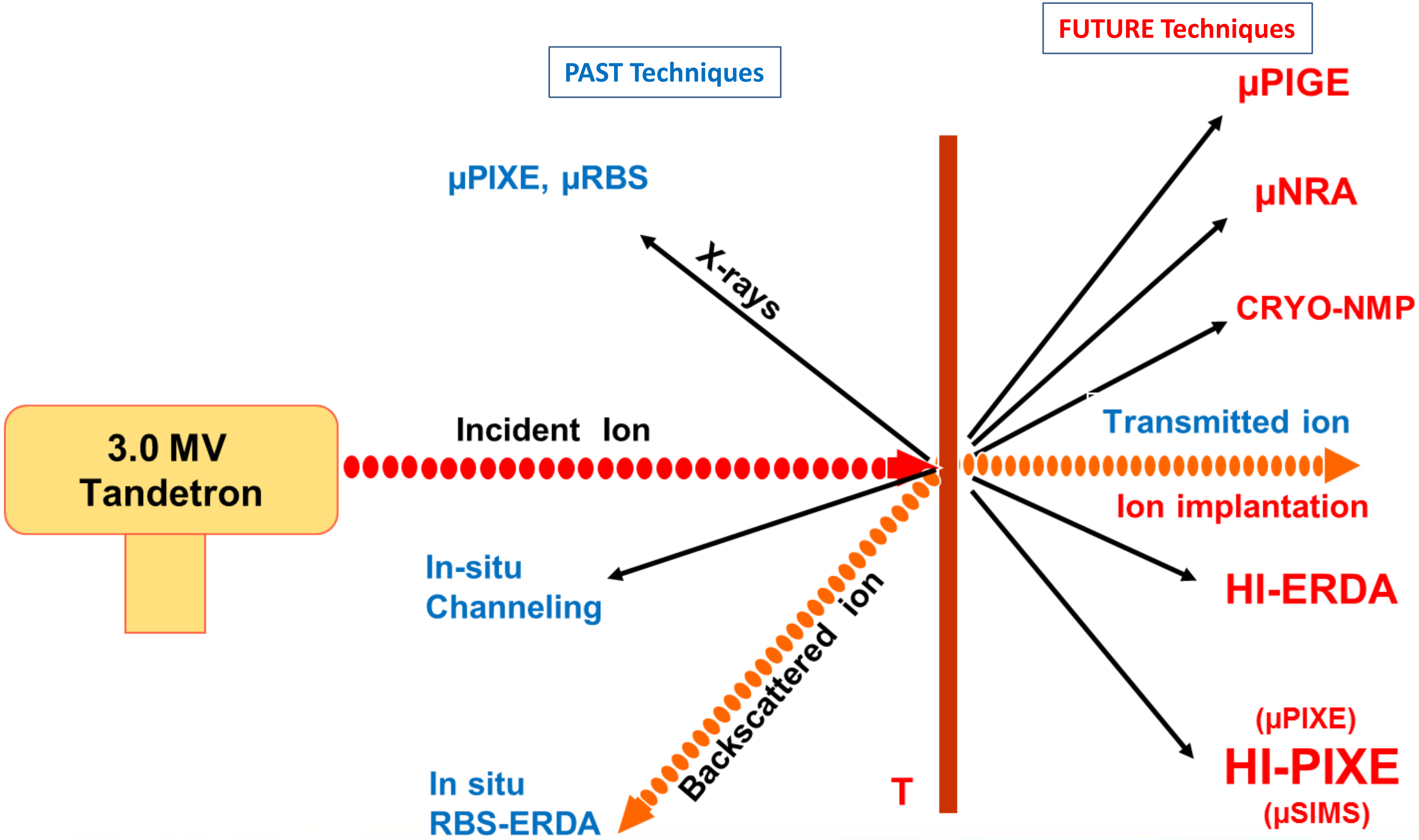
The FUTURE:

- Low energy nuclear reactions for Astrophysics
- Chatracterization of nano-structures materials with nanometer ion beams sizes
- Ion Beam Analysis: *in-situ* RBS, Cryo-NMP, HI_ToF_ERDA, HE-PIXE
- IBA in tandem with e-beam deposition
- External beam for Archeaometry and materials sciences
- Ion implantation, radiation hardness
- Enviromental sciences

The past 50-years:

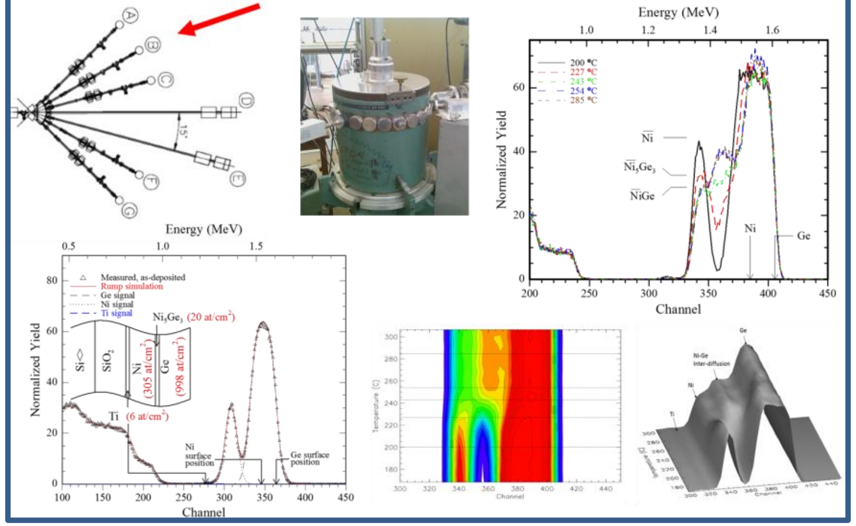
- Low energy nuclear physics
- Nuclear analytical chemistry
- Ion Beam Analysis (RBS, NMP)

SURFACE CHARACTERIZATION OF MATERIALS BY ION BEAM ANALYSIS
Materials Research Department (MRD)

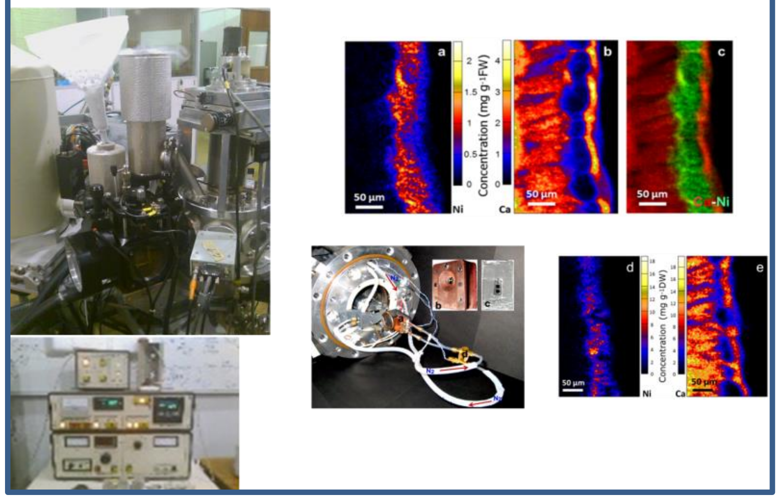


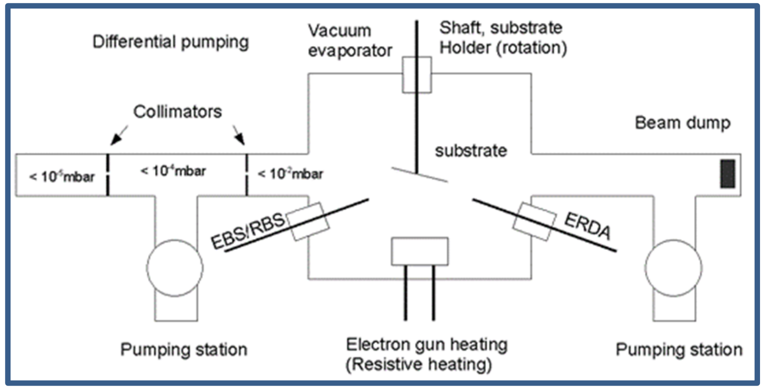
SURFACE CHARACTERIZATION OF MATERIALS BY ION BEAM ANALYSIS
Materials Research Department (MRD)

In-situ RBS-ERDA-CHANNELING



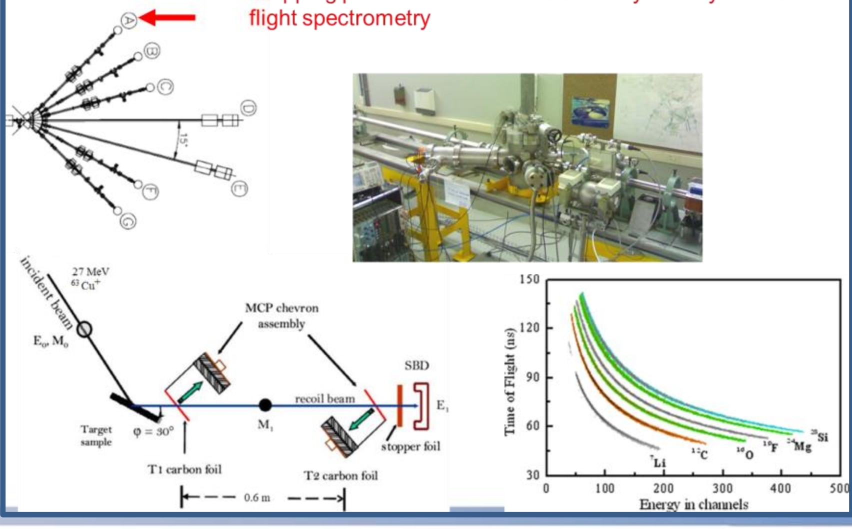
CRYO - NMP





Thin layer deposition and real time characterisation using EBS, RBS and ERDA techniques.

Stopping power measurements of heavy ions by time-of-flight spectrometry



ANS Conference
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science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

National Research Foundation

iThemba LABS
Laboratory for Accelerator Based Sciences

www.tlabs.ac.za

6 MV Tand
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Spectrom

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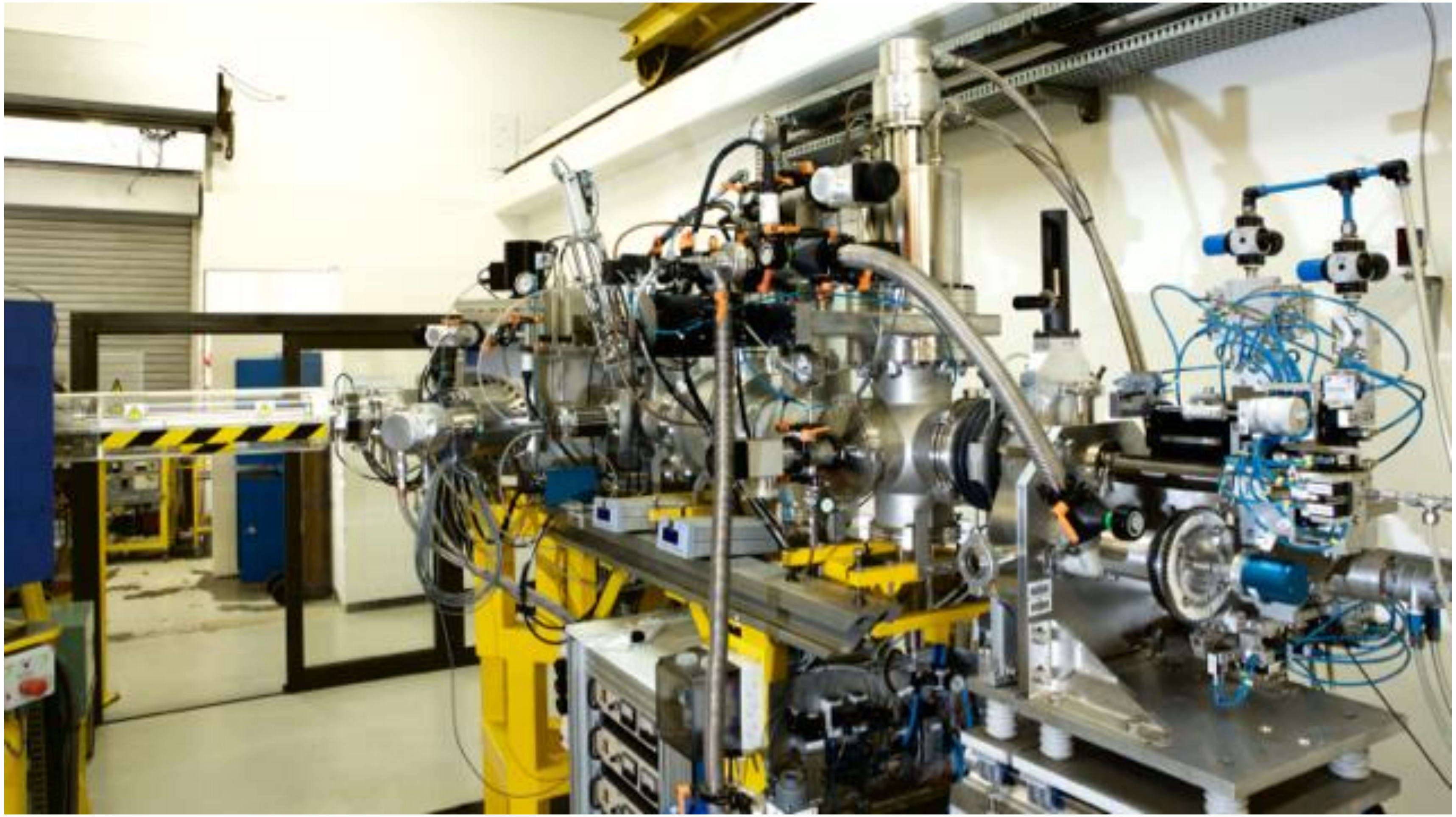
celerator Mass

Accelerator Mass Spectrometry (AMS) Facility Unveiled in 2014

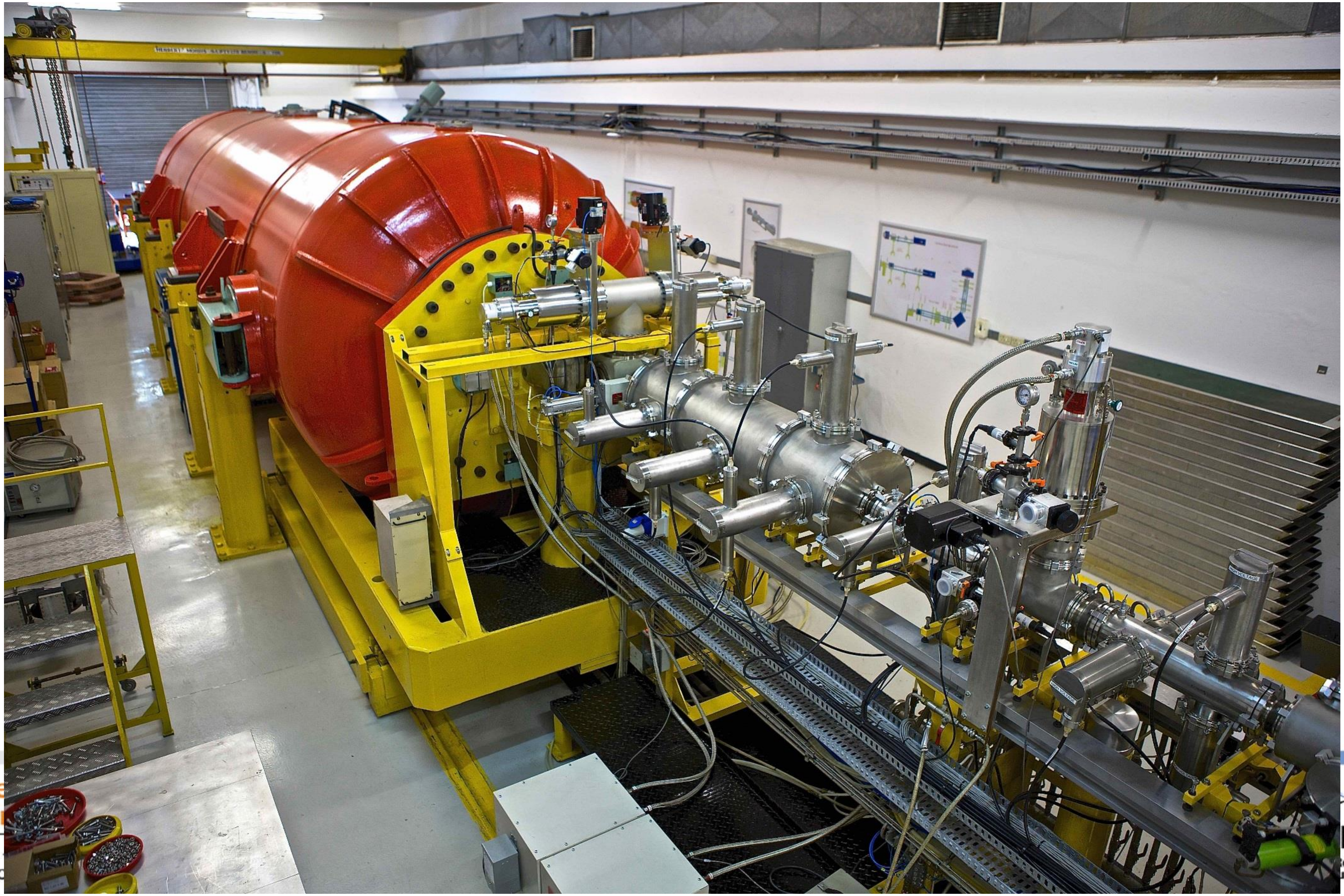
^{14}C dating: 60 000 years

Other isotopes (^{10}Be, ^{36}Cl, ^{26}Al): 1 – 10 My

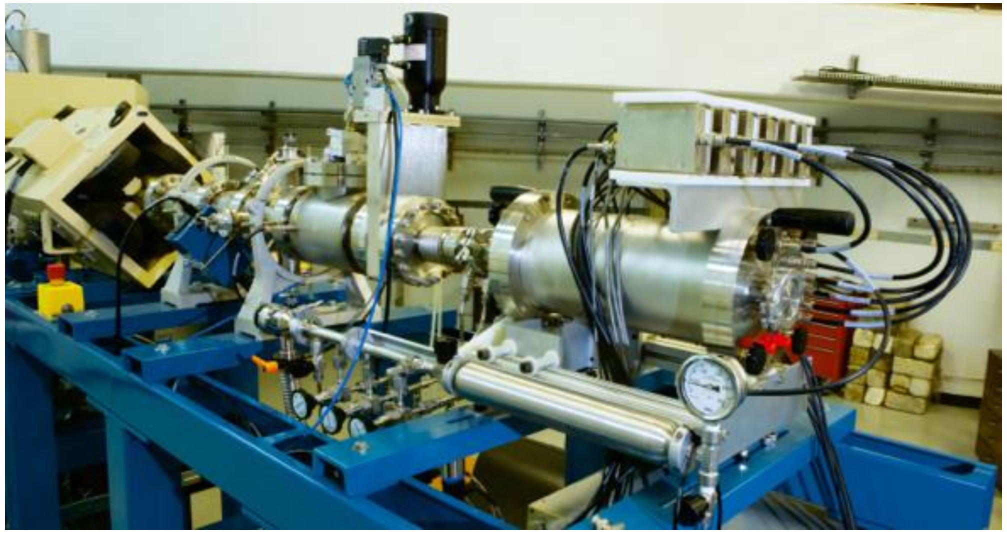
SNICS Ion Source

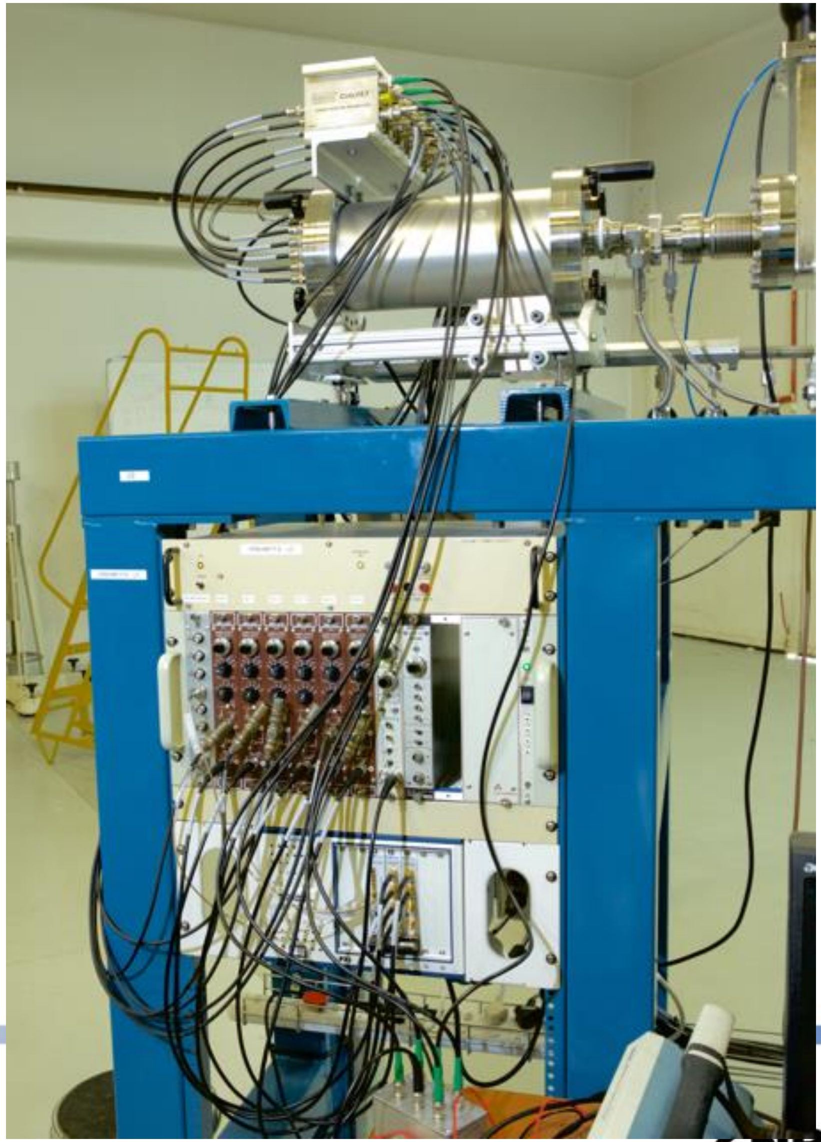


High-energy extraction



Detector for AMS





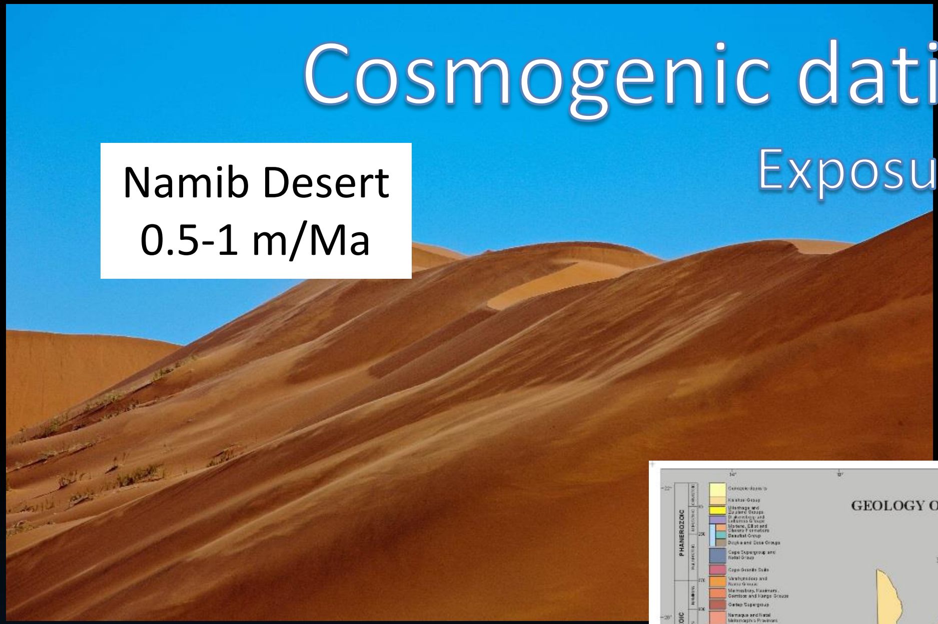
The South African Strategy for the Palaeosciences

Incorporating Palaeontology, Palaeo-anthropology and Archaeology

"Support the country's universities to produce a critical mass of palaeoscience researchers with a range of research, technical, curatorial, public engagement and managerial skills and drive knowledge production and exploitation to make South Africa a world centre of scientific excellence in the palaeosciences"

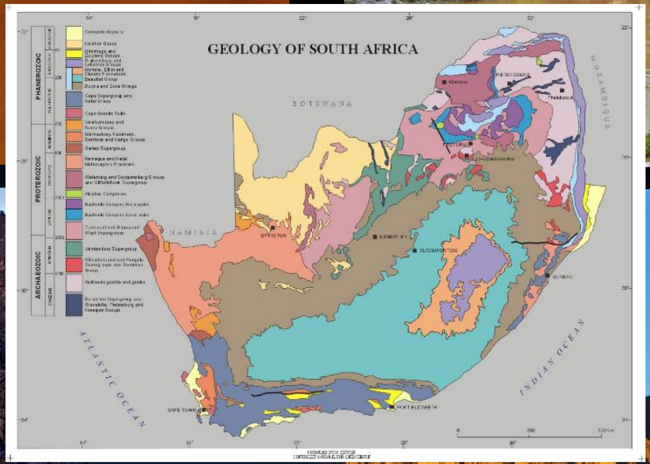
Cosmogenic dating in South Africa

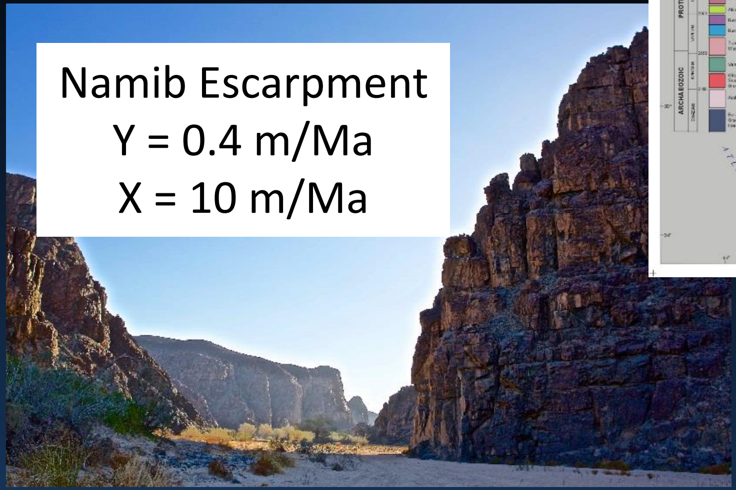
Exposure Dating



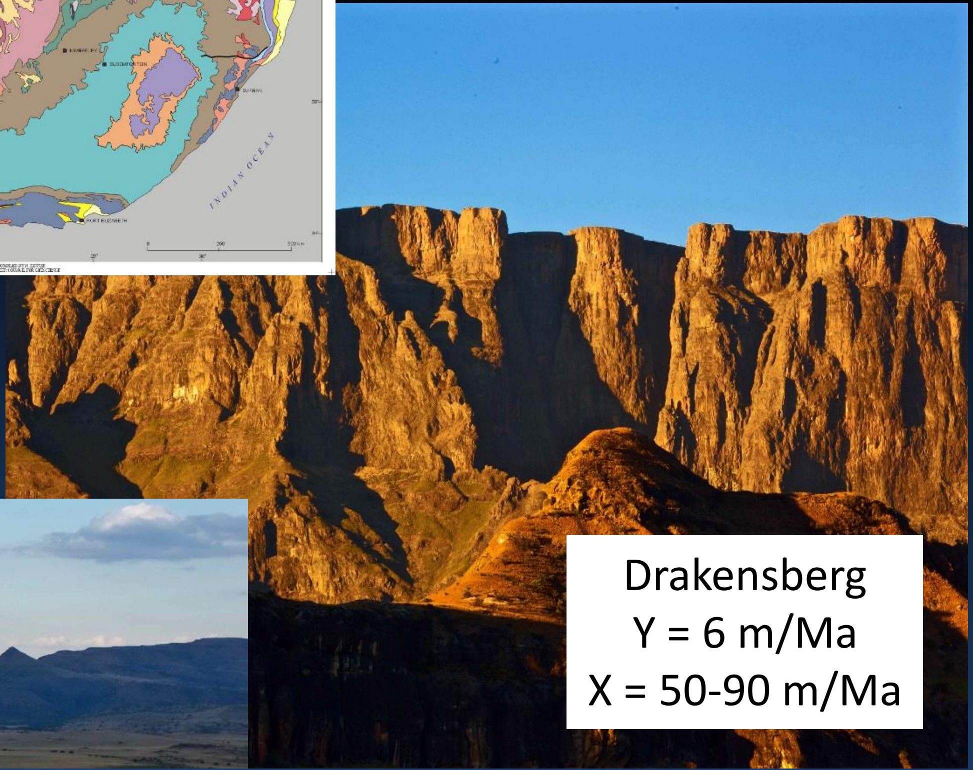
Namib Desert
0.5-1 m/Ma

Kruger National Park
3-6 m/Ma





Namib Escarpment
Y = 0.4 m/Ma
X = 10 m/Ma



Drakensberg
Y = 6 m/Ma
X = 50-90 m/Ma

SA Interior
1.5-3 m/Ma
<4 m/Ma

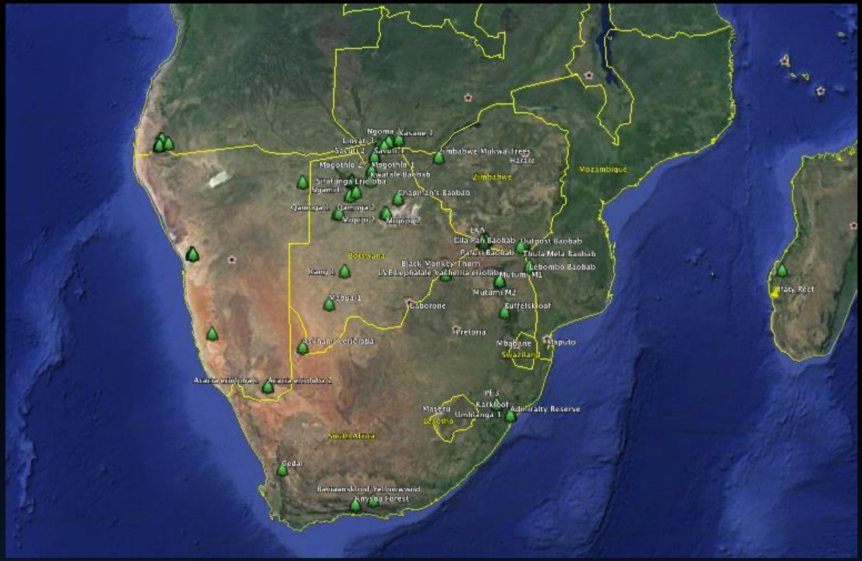
Cosmogenic dating in South Africa

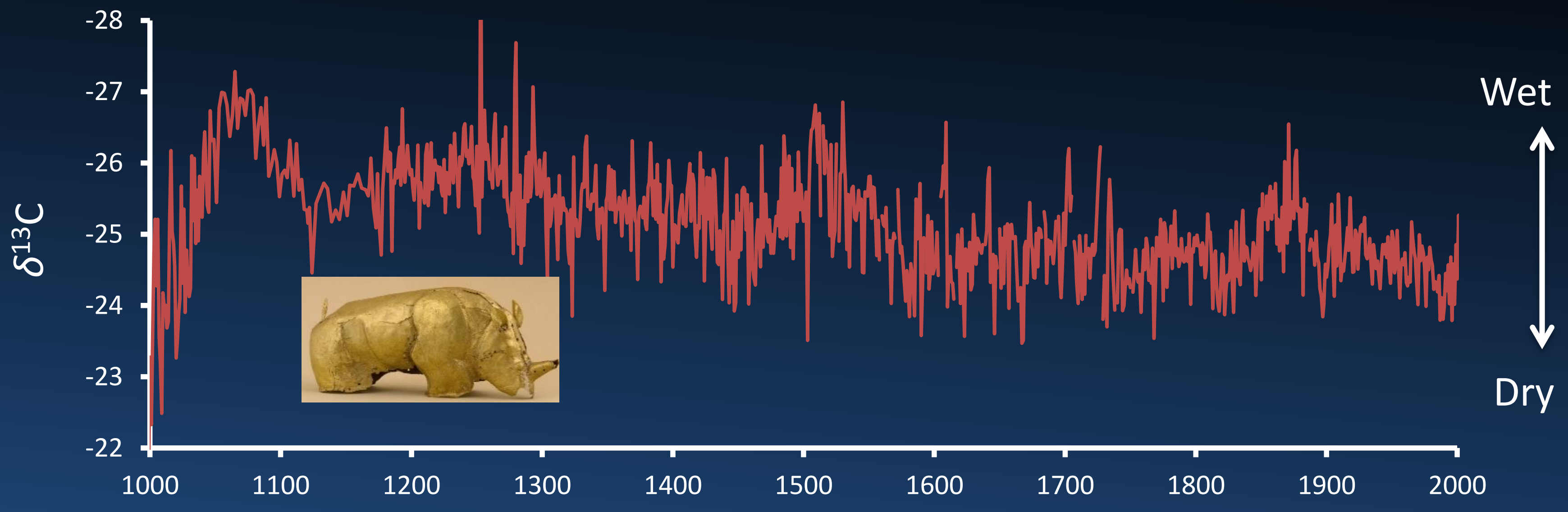
Burial Dating

Stw 573 – “Littlefoot”
Sterkfontein
4.02 Ma
(Partridge et al. 2003)

Australopethicus sediba
Malapa
1.95 - 1.78 Ma
(Dirks et al. 2003)

iThemba AMS-based Research





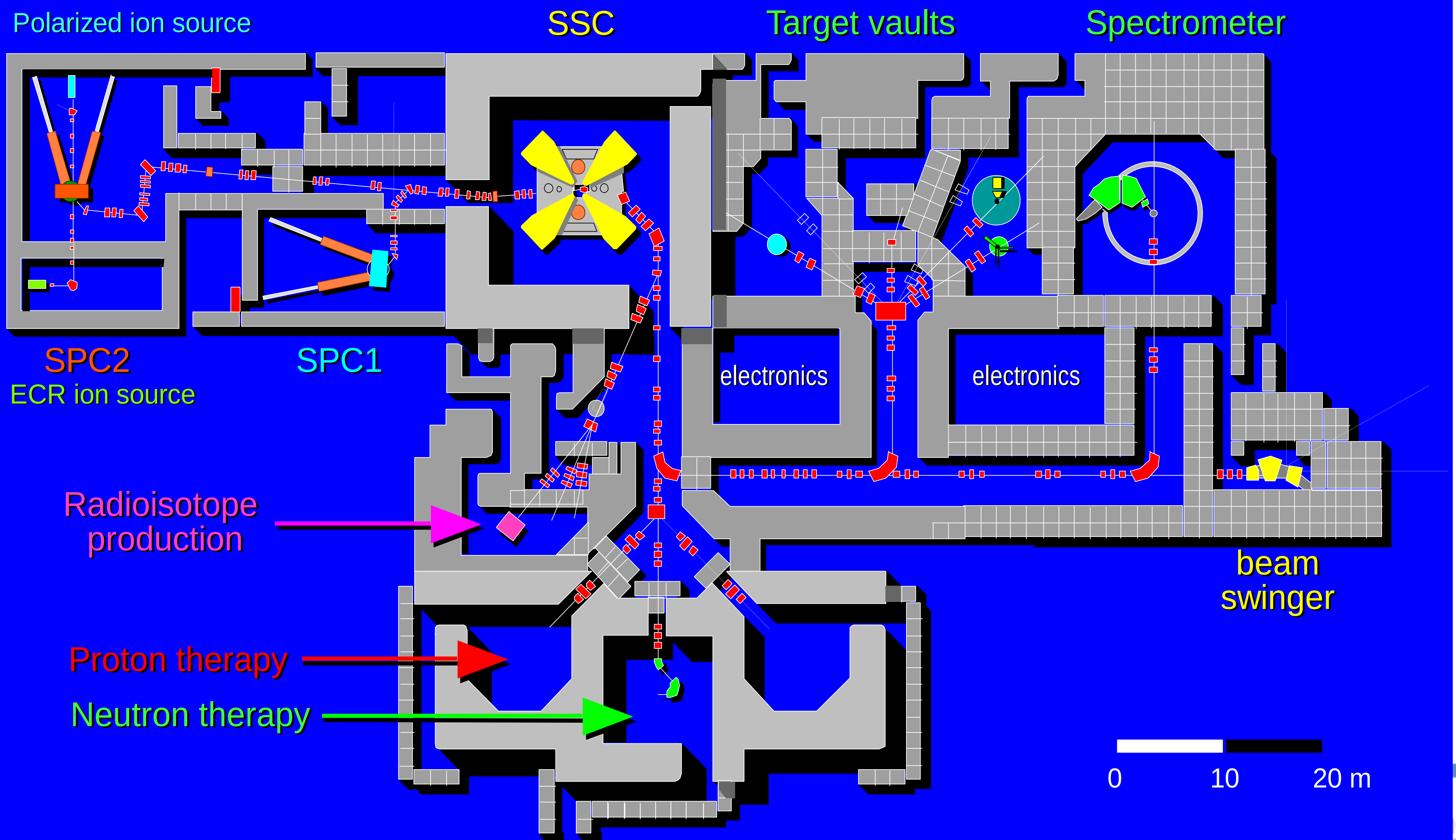
environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

SANAP

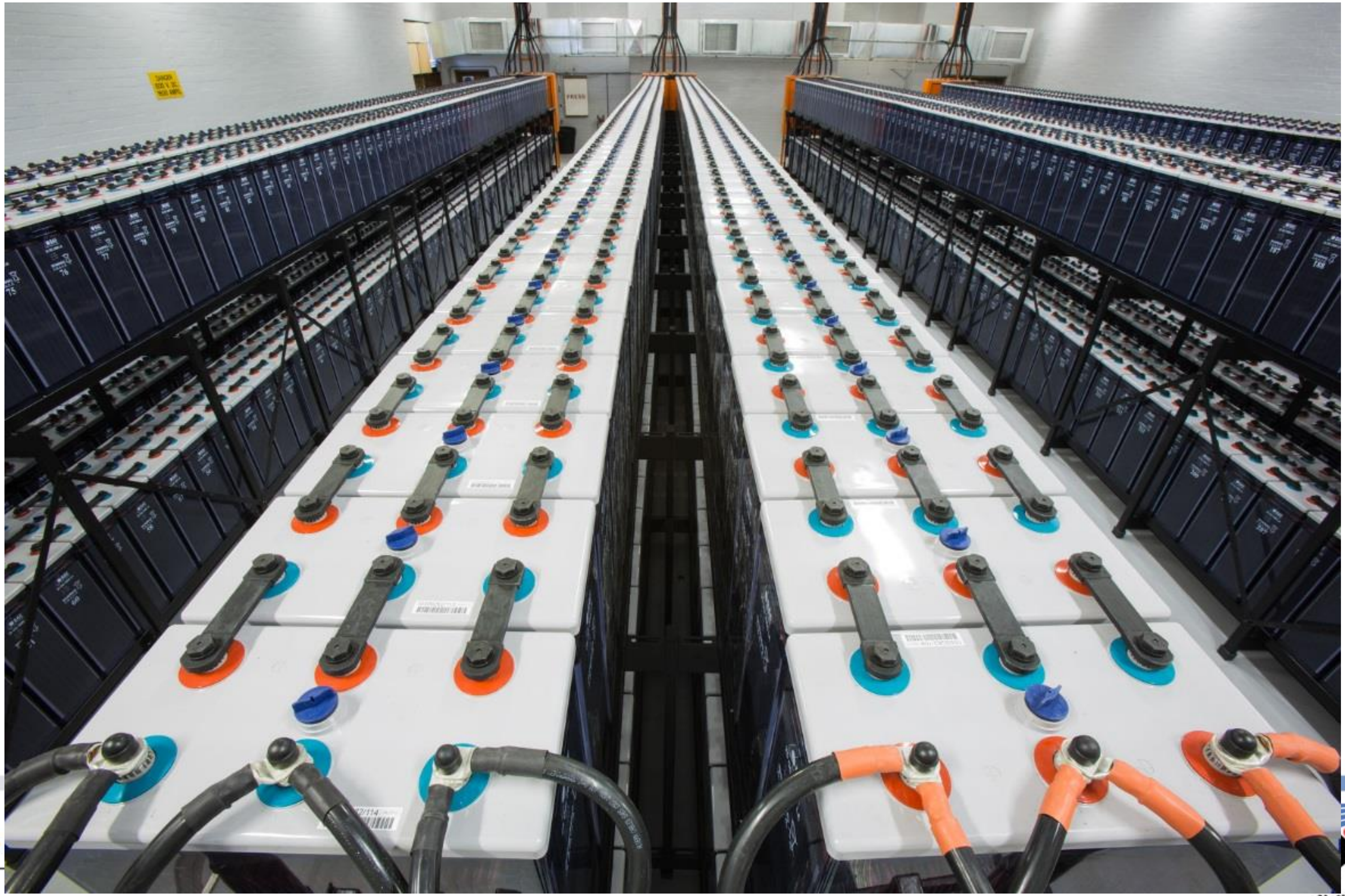
Antarctic Program

11 MeV Cyclotron for PET isotope production

Separated-Sector Cyclotron Facility



4.4 MVA Uninterruptible Power Supply
New Battery Bank for the UPS



New Digital Low Level RF Control System

- Modular Design
- Digitally programmable
- 16 bit Amplitude resolution
- Operates between 5 and 100 MHz
- Programmable in steps of 1 μHz
- Phase resolution in steps of 0.0001º
- EPICS based

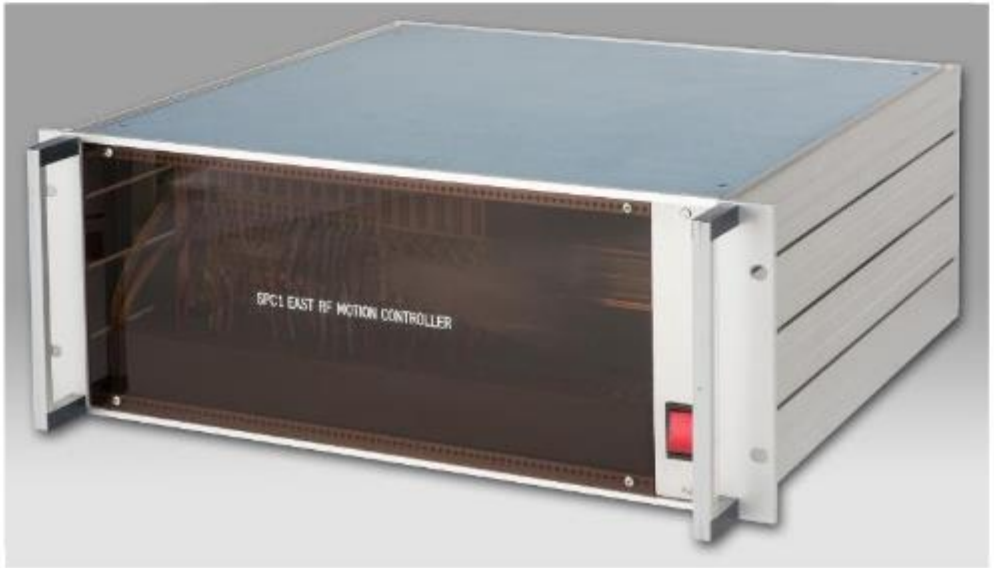
Complete Solution

iThemba LABS

RF Control

&

Beckhoff

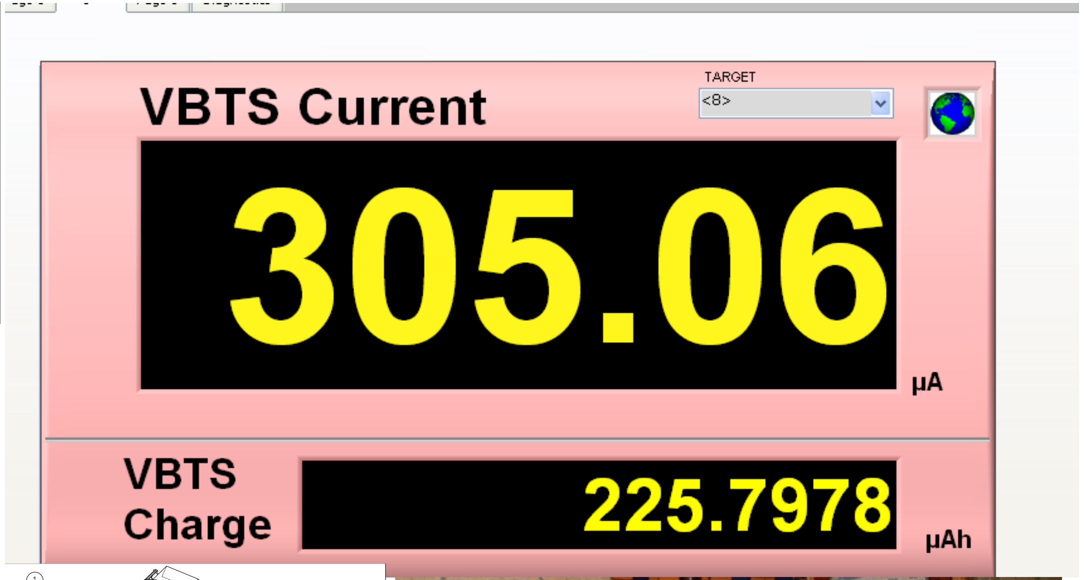


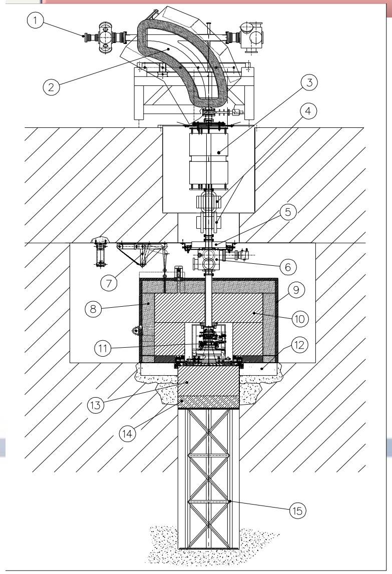
Power amplifier, anode,
grid, trimmer, coupling capacitor
and short circuit plate control


Chubb


SSC AC MAIN CAPS

Increase beam intensity (66 MeV protons) for isotope production





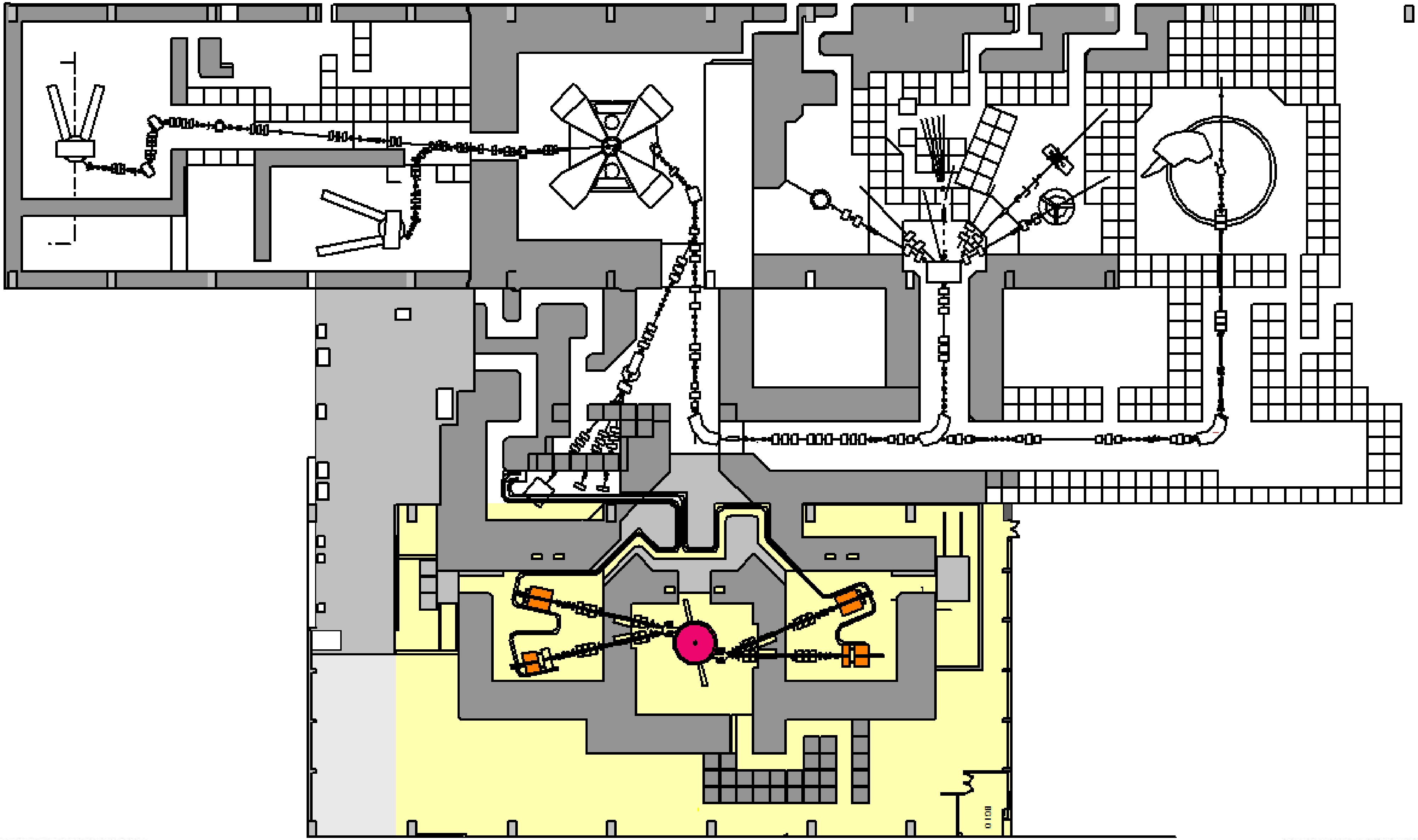
Current Radionuclides in routine production list continue

Radionuclide	Half-Life (days/years)	Nuclear Reaction	Product	Main Use
^{82}Sr	25 days	$Rb(p,xn)^{82}Sr$	Produced as a radionuclide	Used to manufacture $^{82}Sr/^{82}Rb$ generators
^{68}Ge	271 days	$Ga(p,xn)^{68}Ge$	Produced as a radionuclide	Used to manufacture $^{68}Ge/^{68}Ga$ generators or used for calibration of gamma camera's or PET CT scanners
^{88}Y	106.6 days	$Sr(p,xn)^{88}Y$	Produced as a radionuclide	Non –medical application
^{109}Cd	453 days	$Ag(p,xn)^{109}Cd$	Produced as a radionuclide	Non-medical application
^{22}Na	2.602 years	$Mg(p,n)^{22}Na$	Produced as a radionuclide	Positron Annihilation Studies

Current Radiopharmaceuticals in routine production

Radionuclide	Half-Life (hours)	Nuclear Reaction	Radiopharmaceutical Product	Main Use
^{18}F	1.83	$^{15}O(p,n)^{18}F$	^{18}F-FDG	Glucose metabolic studies
^{67}Ga	78.3	$Zn(p,xn)^{67}Ga$ $Ge(p,x)^{67}Ga$	^{67}Ga-citrate	Localization of certain tumours and inflammatory regions
$^{81}Rb/^{81m}Kr$	4.58	$Kr(p,xn)^{81}Rb$	$^{81}Rb/^{81m}Kr$ generator	Lung ventilation studies
^{123}I	13.2	$^{127}I(p,5n)^{123}Xe \rightarrow {}^{123}I$	^{123}I-sodium iodide ^{123}I-mIBG	Thyroid studies Localization of certain tumours such as neuroblastoma, pheochromocytoma

New Isotope Production Facilities for iThemba LABS



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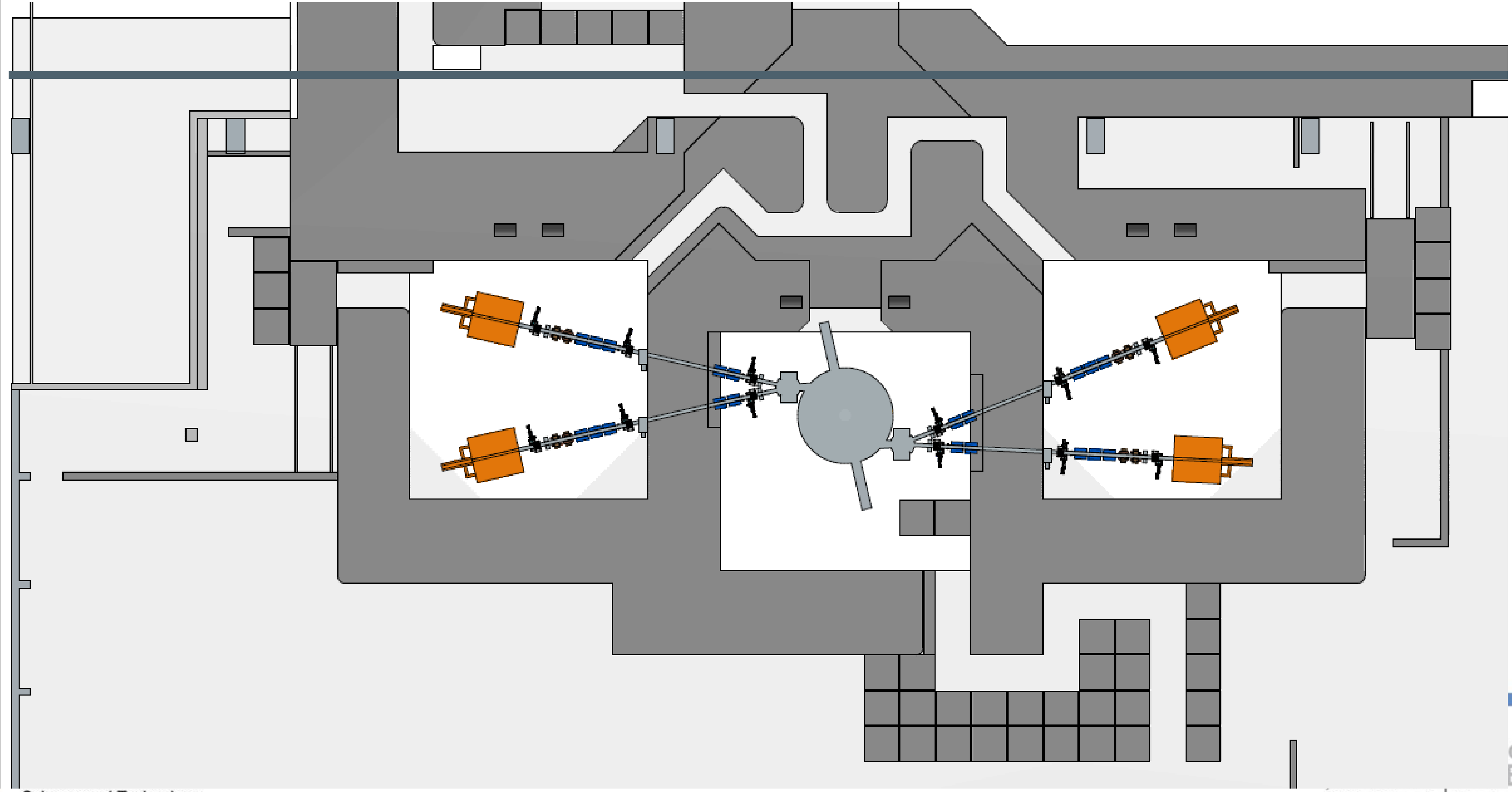
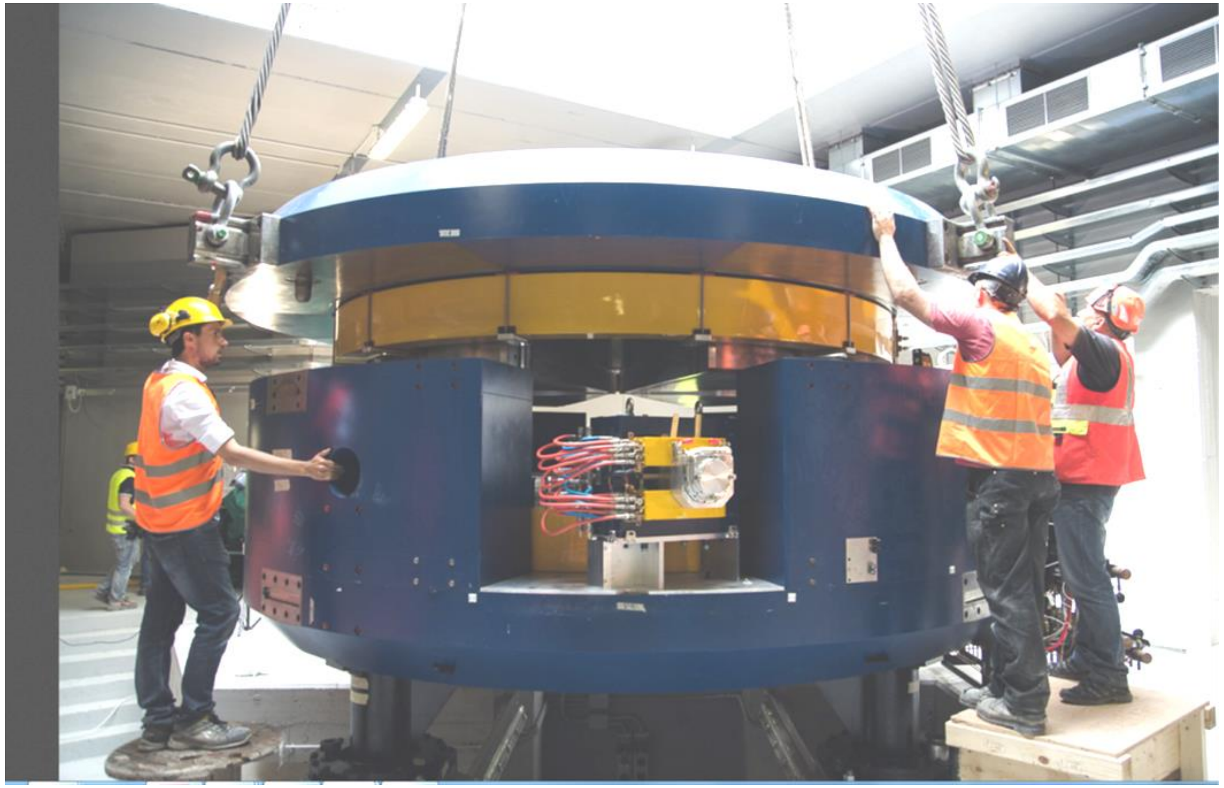
ACE Isotopes



Company: IBA
CYCLOTRON 70

Company: Best Cyclotron Systems
BEST 70p Cyclotron

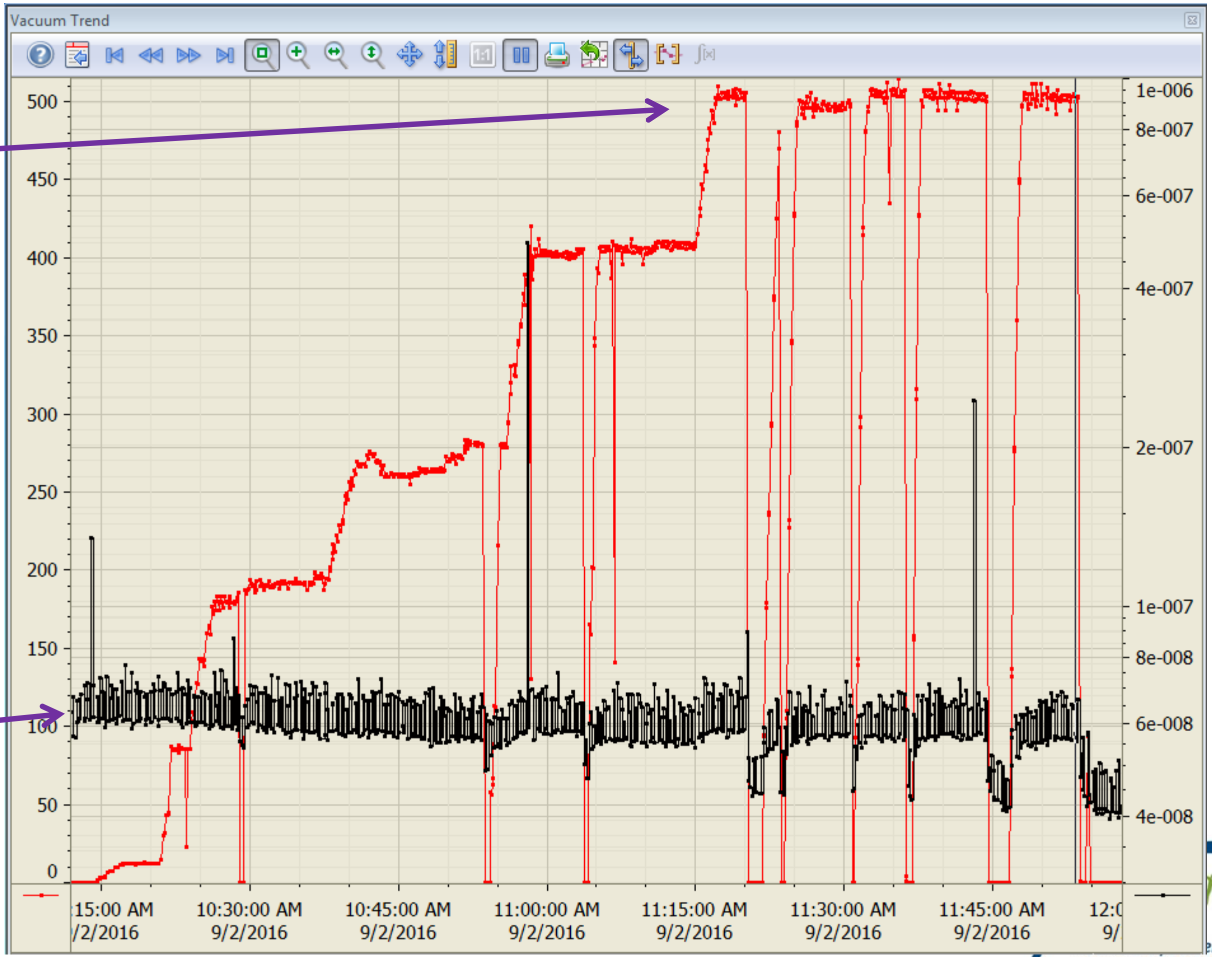


Beam test on 50kW INFN target

Vacuum:

500μA

$6x10^{-8}$ Torr



Best Cyclotron Systems, Inc.

TeamBest Your True Partner

Beam line losses

Beam losses measured at various current.

$$\textit{Beam losses} = \frac{\textit{Unaccounted Beam currents}}{\textit{Extracted Beam currents}} \quad [\%]$$

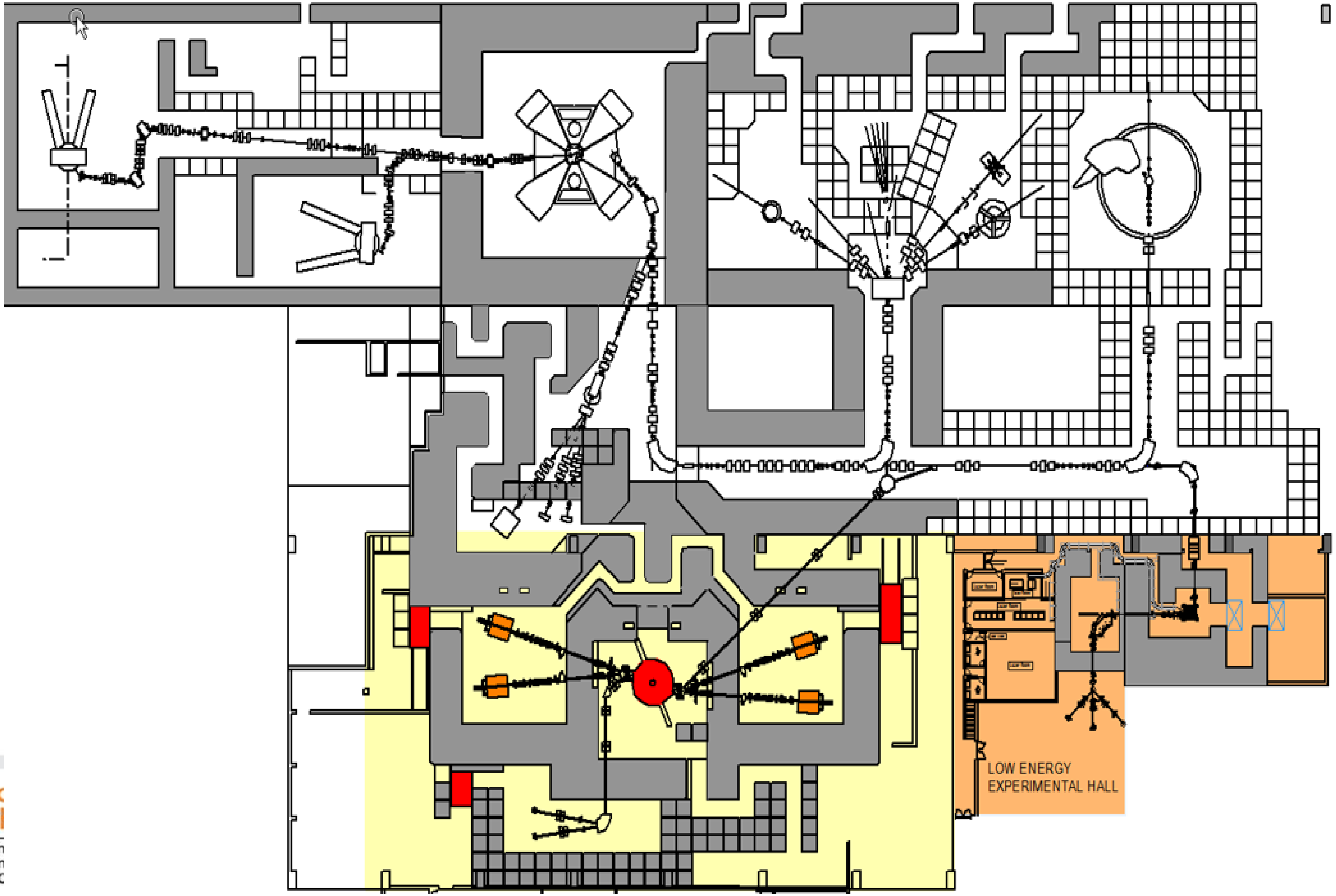
Unaccounted currents have been measured as the difference between extractor probe current and sum of all beam line currents (slits, baffles and target currents)

Beam current on target	Value
300 µA	0.2%
400 µA	0.5%
500 µA	0.5%

Best Cyclotron Systems, Inc.

healthcare for everyone TeamBest Your True Partner

Low Energy Rare Isotope Beam Facilities at iThemba LABS



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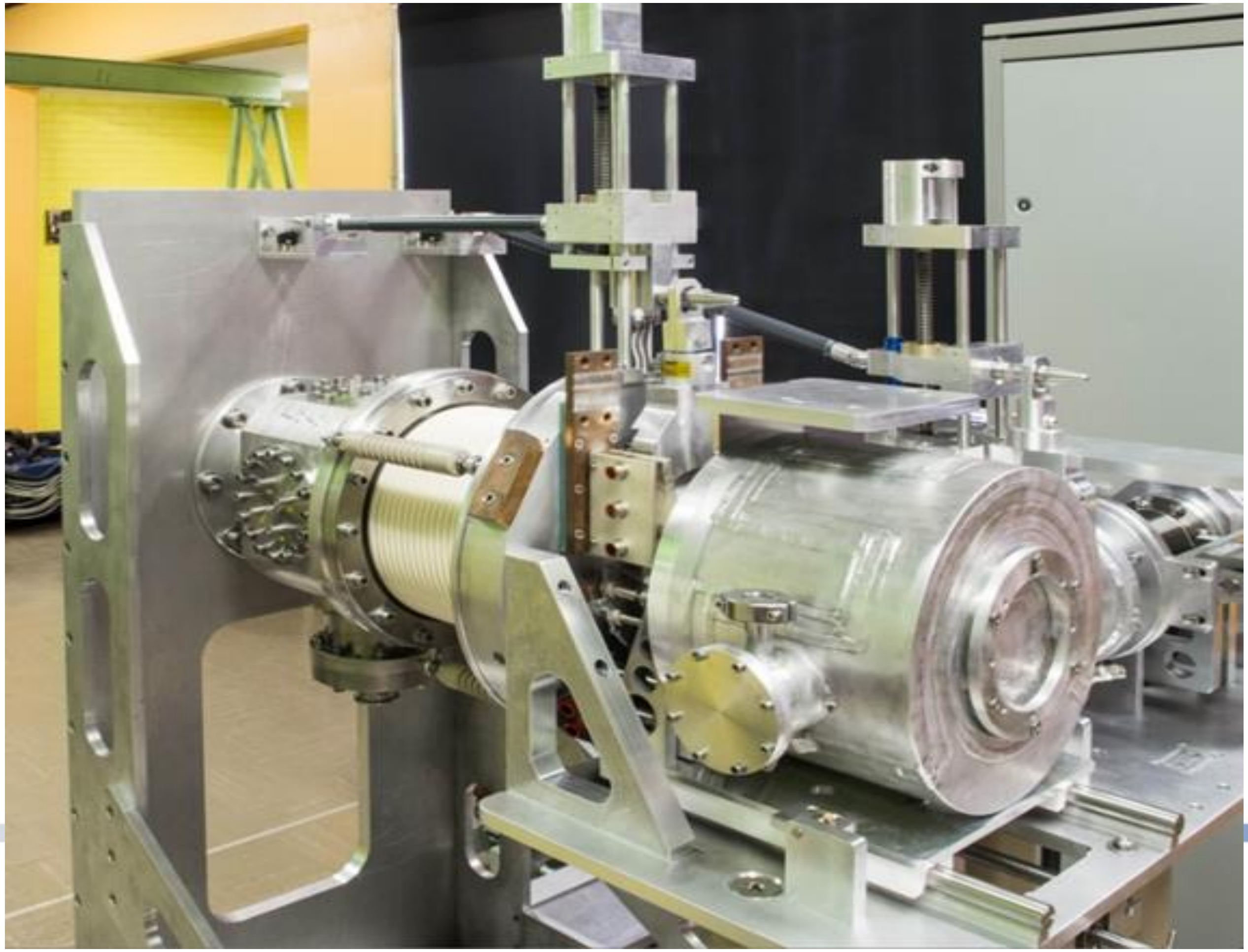
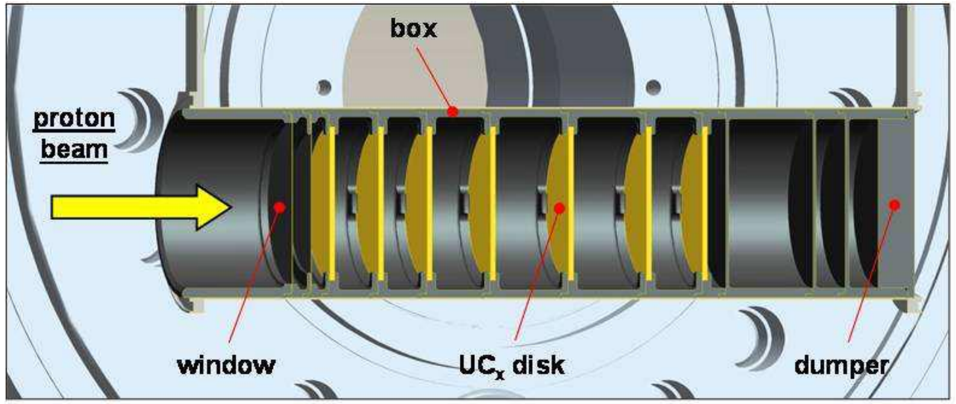
Based Sciences

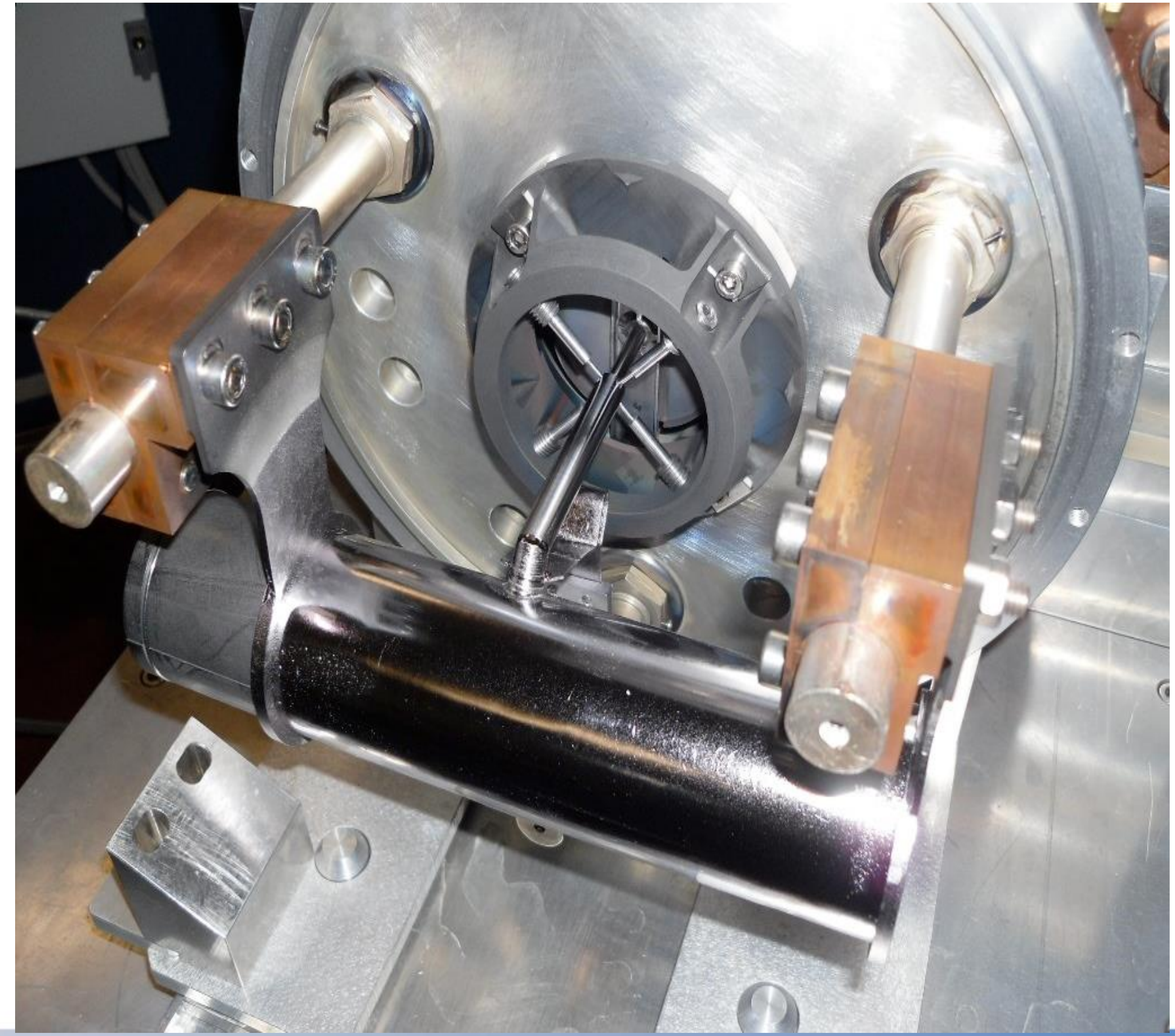
Front End assembly as installed in the RIB off-line test facility at iThemba LABS



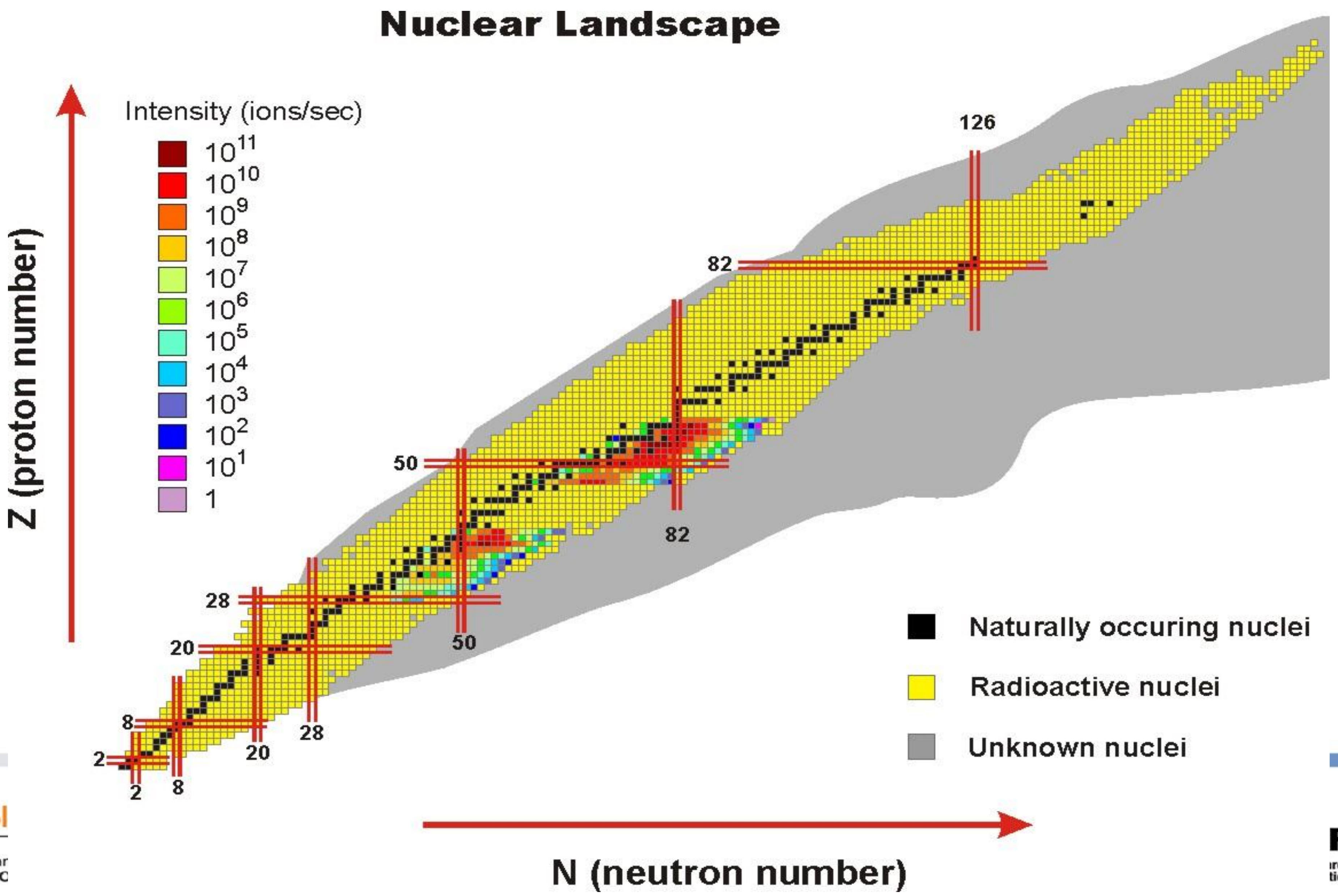
The SPES target (chamber lid removed), designed for a 40 MeV proton beam entering from the right. The heating current flows through the Ta tube, between the copper clamping bars at each end. The small central tube connects the target chamber to the ion source. [Andrighetto 2011]



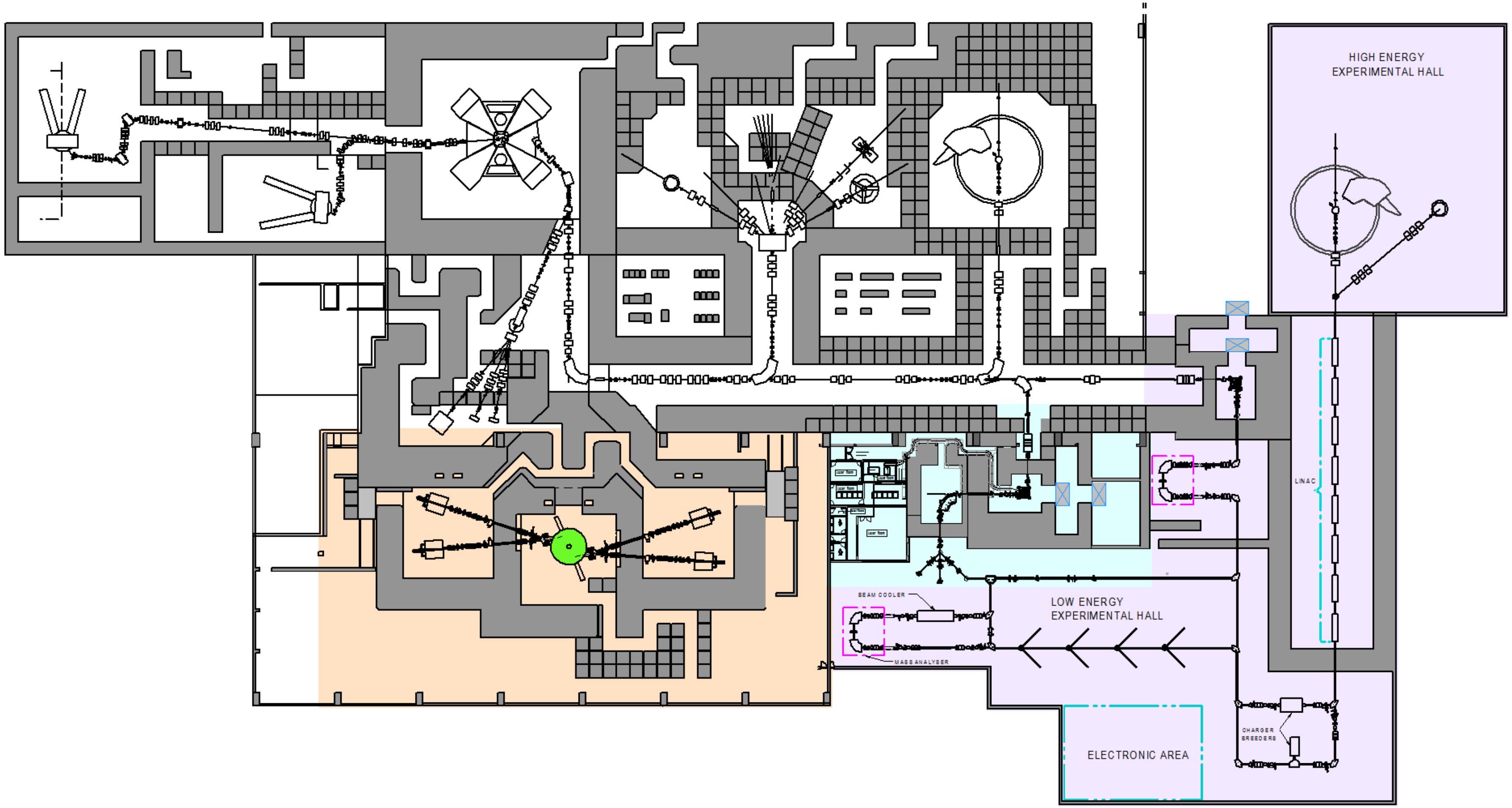
CAD drawing of the SPES target assembly, showing the UC_x disks (yellow) in a graphite tube and also the beam dump disks (dark grey). [SPES 2010]



Expected yields of singly-charged radioactive ions from the LERIB target-ion-source, when a UC_x target is bombarded by 50μA of 70 MeV protons



ACE-Beams - Phase 2



Thank You