

THE SOUTH AFRICAN ISOTOPE FACILITY



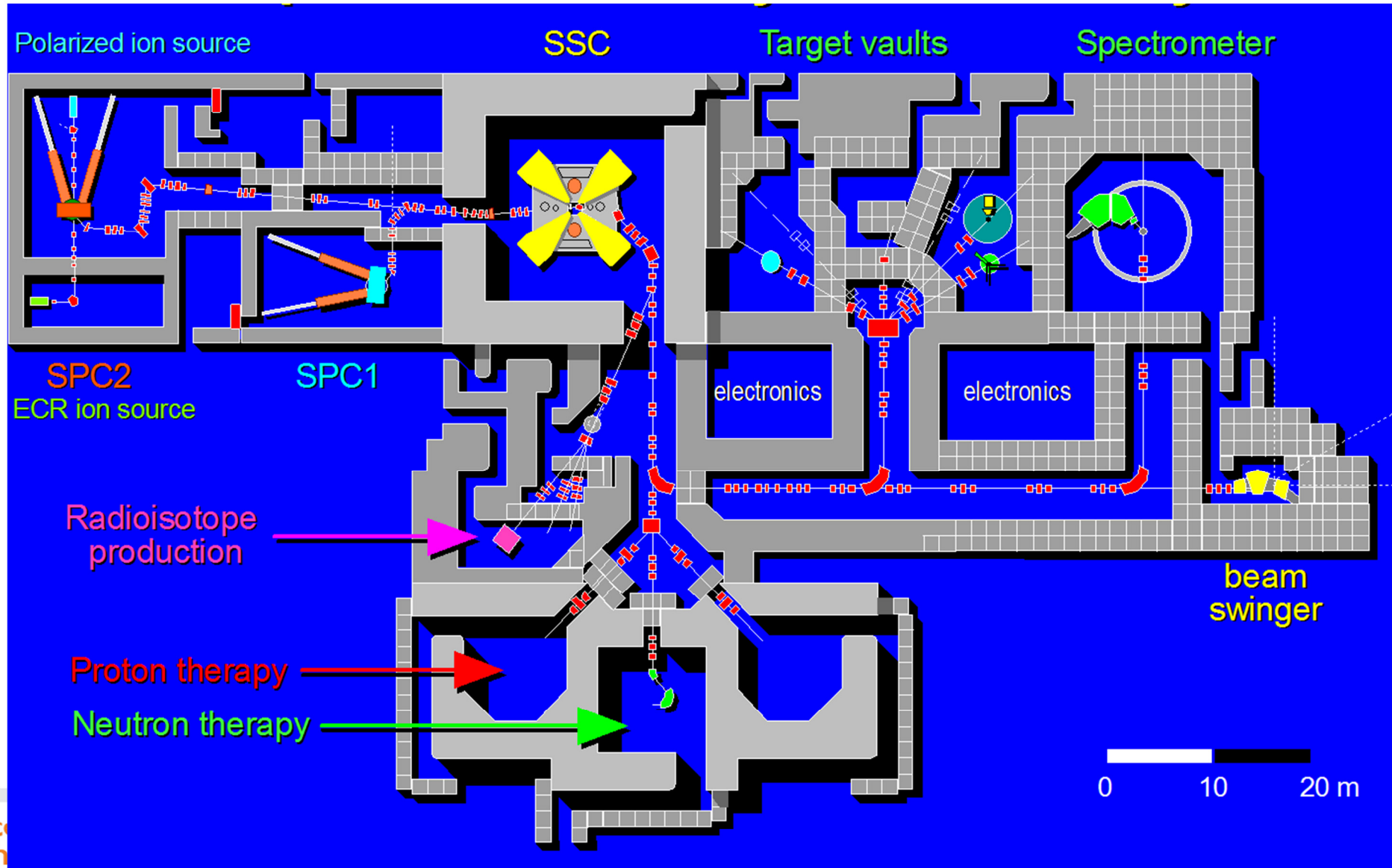
J.L. Conradie, L. Anthony, F. Azaiez, S. Baard, R. Bark, A.H. Barnard, P. Beukes, J.I. Broodryk, J. Cornell, J.G. De Villiers, H. Du Plessis, W. Duckitt, D.T. Fourie, P.G. Gardiner, M. Hogan, I. Kohler, J.J. Lawrie, C. Lussi, N.R. Mantengu, R. McAlister, J. Mira, K.V. Mjali, H. Mostert, C. Naidoo, F. Nemulodi, M. Sakildien, V. Spannenberg, G.F. Steyn, N. Stodart, R.W. Thomae, M.J. Van Niekerk, P. van Schalkwyk
(iThemba LABS, Somerset West)

Outline of the talk

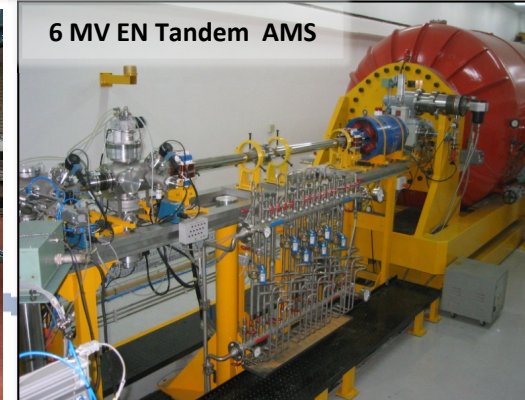
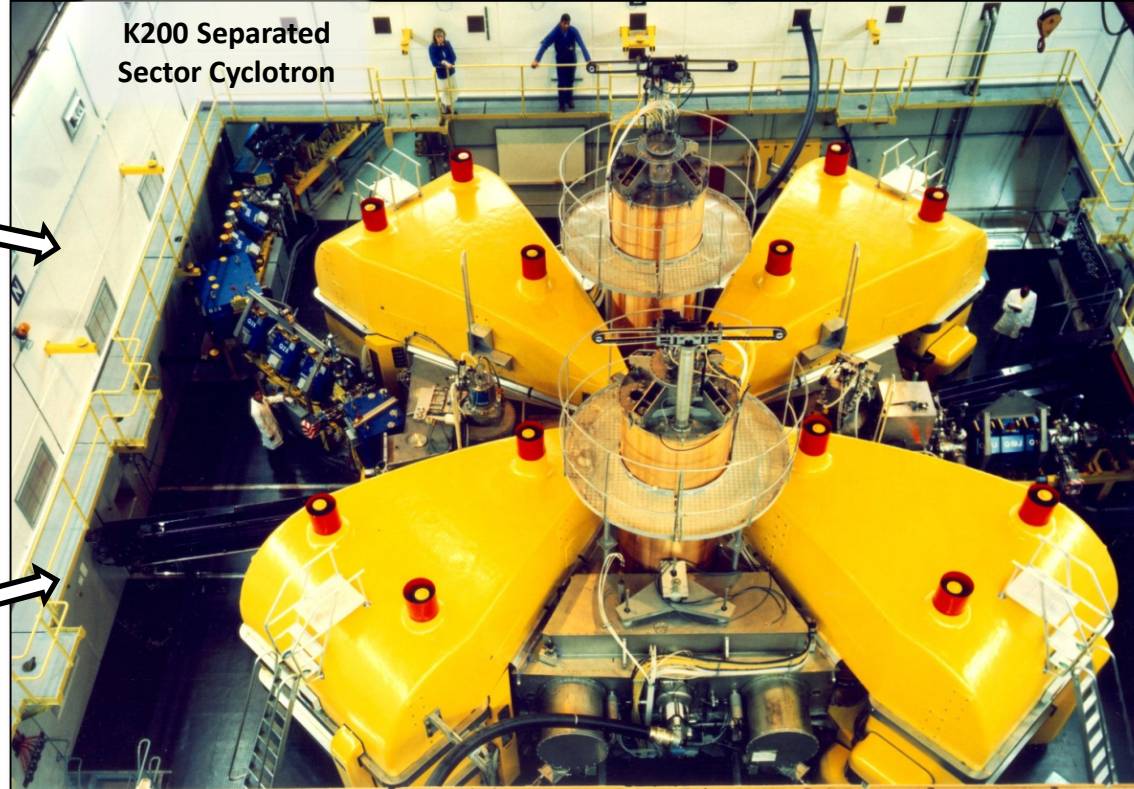
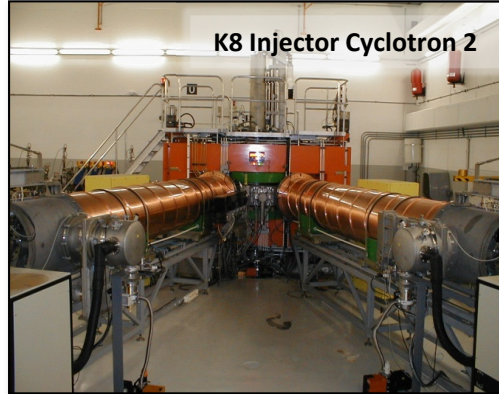
- iThemba LABS accelerators (current status)
- Proposed future facilities
- Facilities for isotope production
- Facilities for the production of radioactive ion beams



Layout of iThemba LABS' Cyclotron Facility



Accelerators at iThemba LABS



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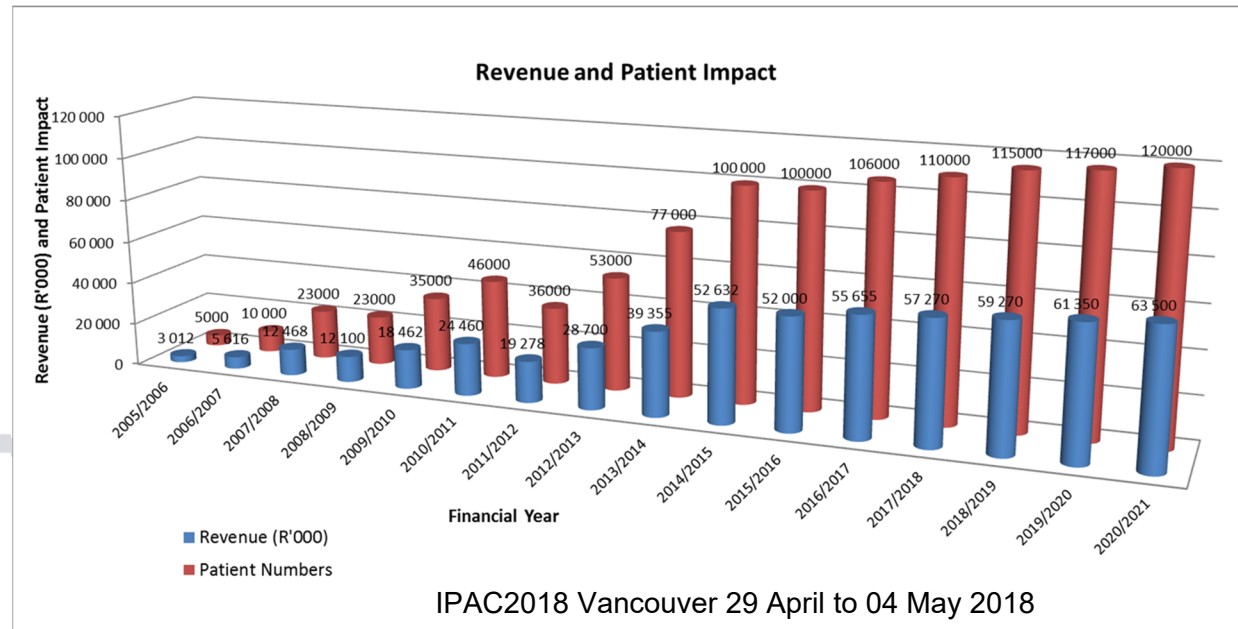
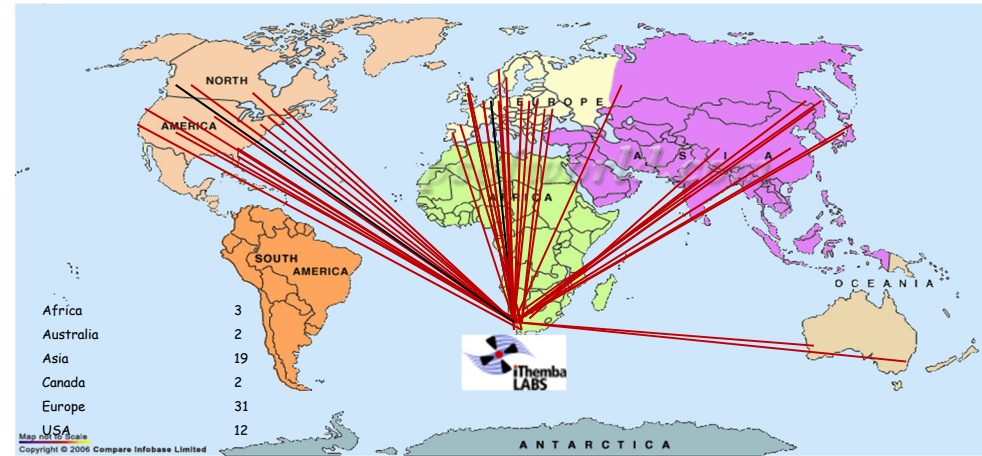
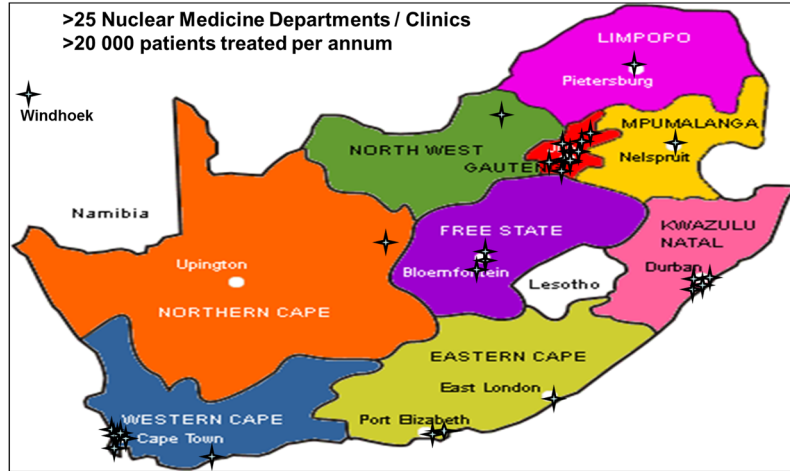
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iThemba LABS:

International Accelerator Produced Radioisotopes for Medicine

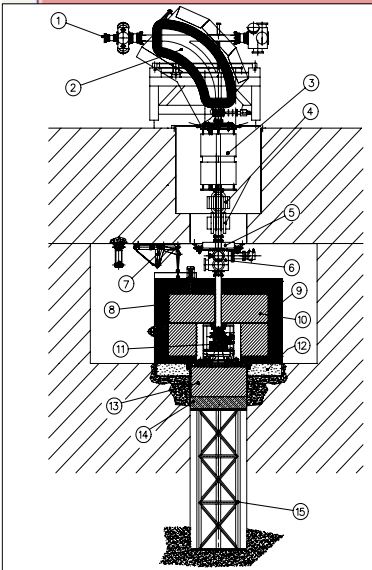
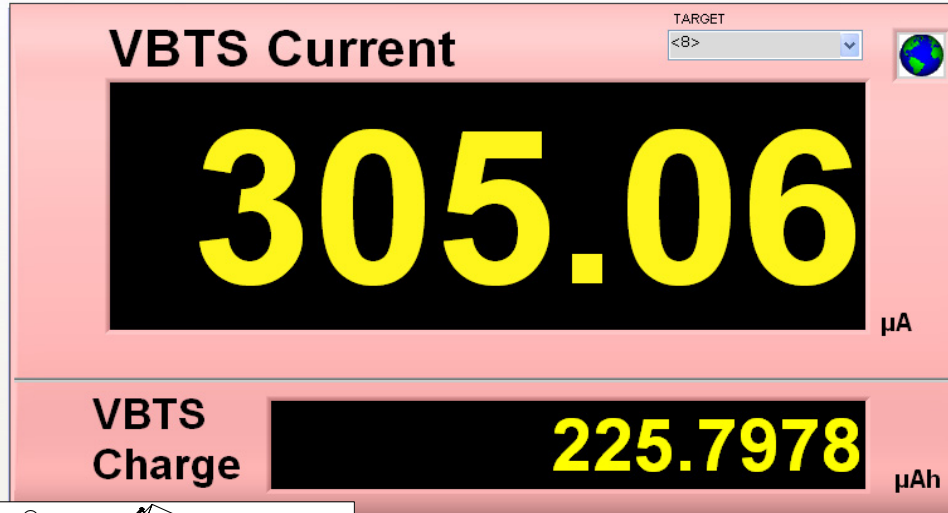
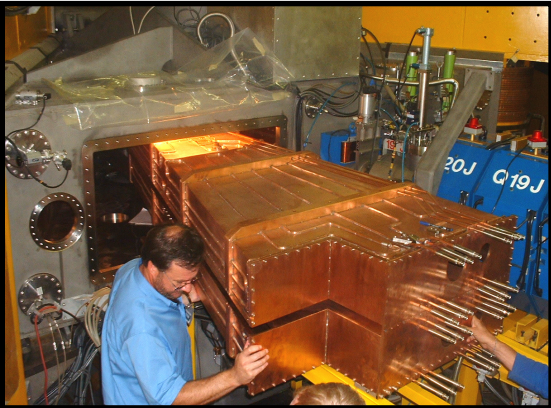
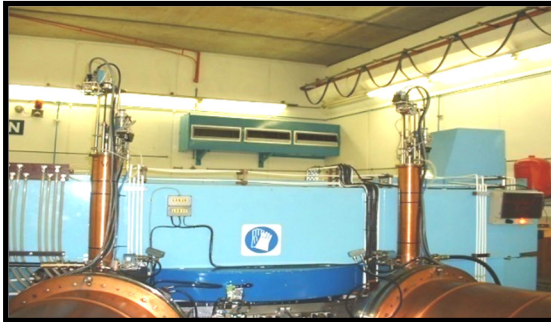


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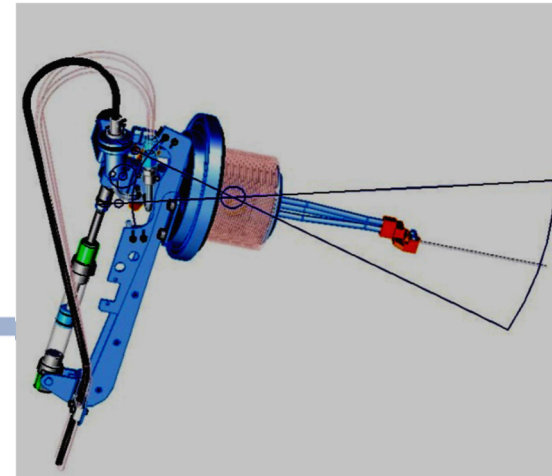
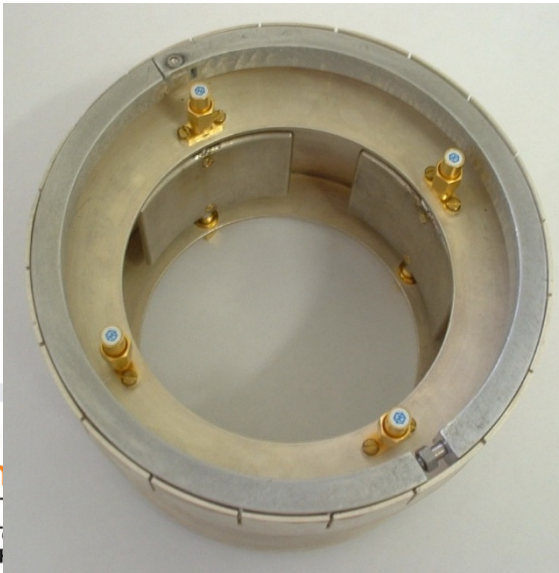
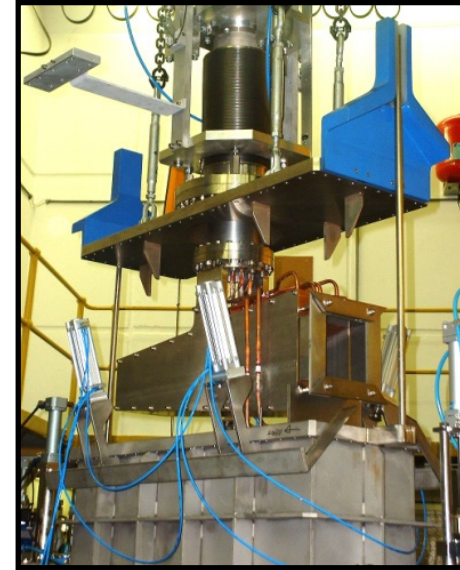
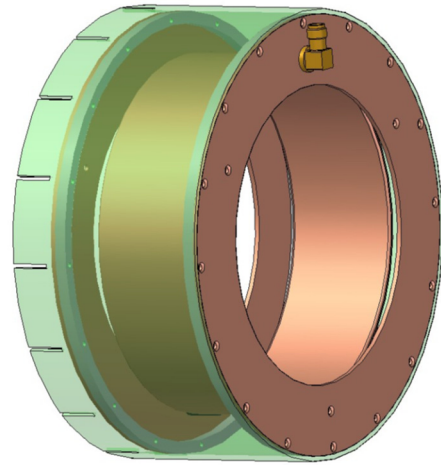
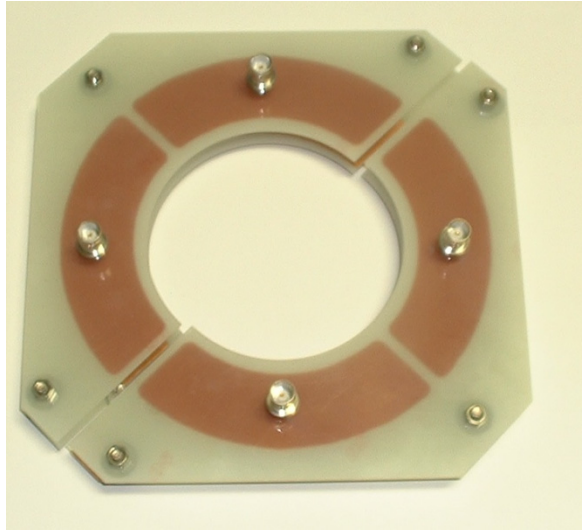
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Beam diagnostics developed for high beam intensities



2017 marks 30 years of operation of the Separated Sector Cyclotron



SSC supported science has resulted in globally relevant research and impacted on the needs of society over 3 decades

- 2300 patients treated with neutron and proton therapy
- Rare isotopes for early detection and treatment of certain cancers & other ailments:
more than 900 000 patients



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The current challenges place iThemba LABS at a cross roads



The Facility is currently faced with two options:

1. Maintaining the *status quo*.
2. Embark on a sustainable and globally competitive research facility through *research infrastructure renewal*.



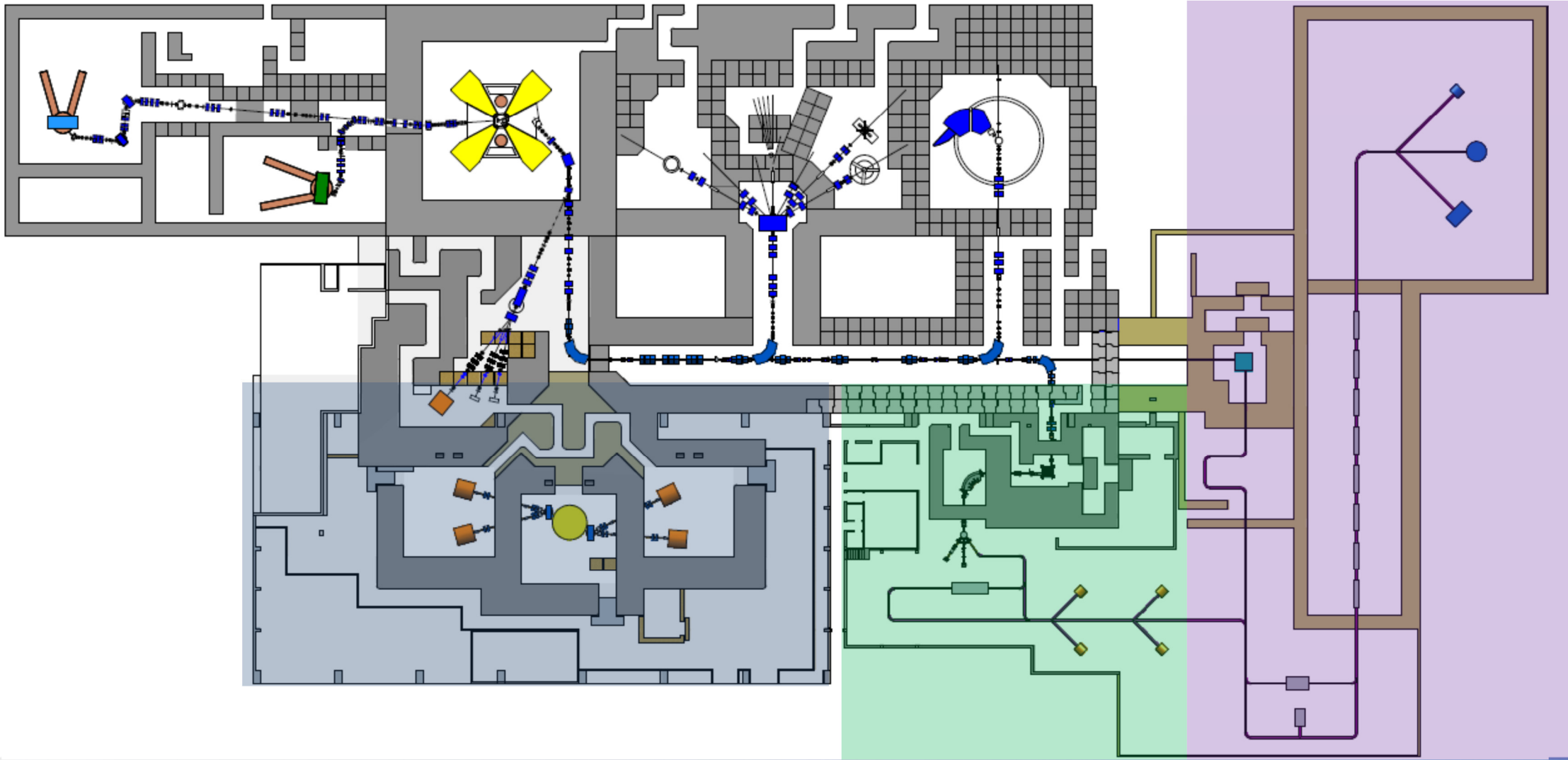
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South African Isotope Facility (SAIF)



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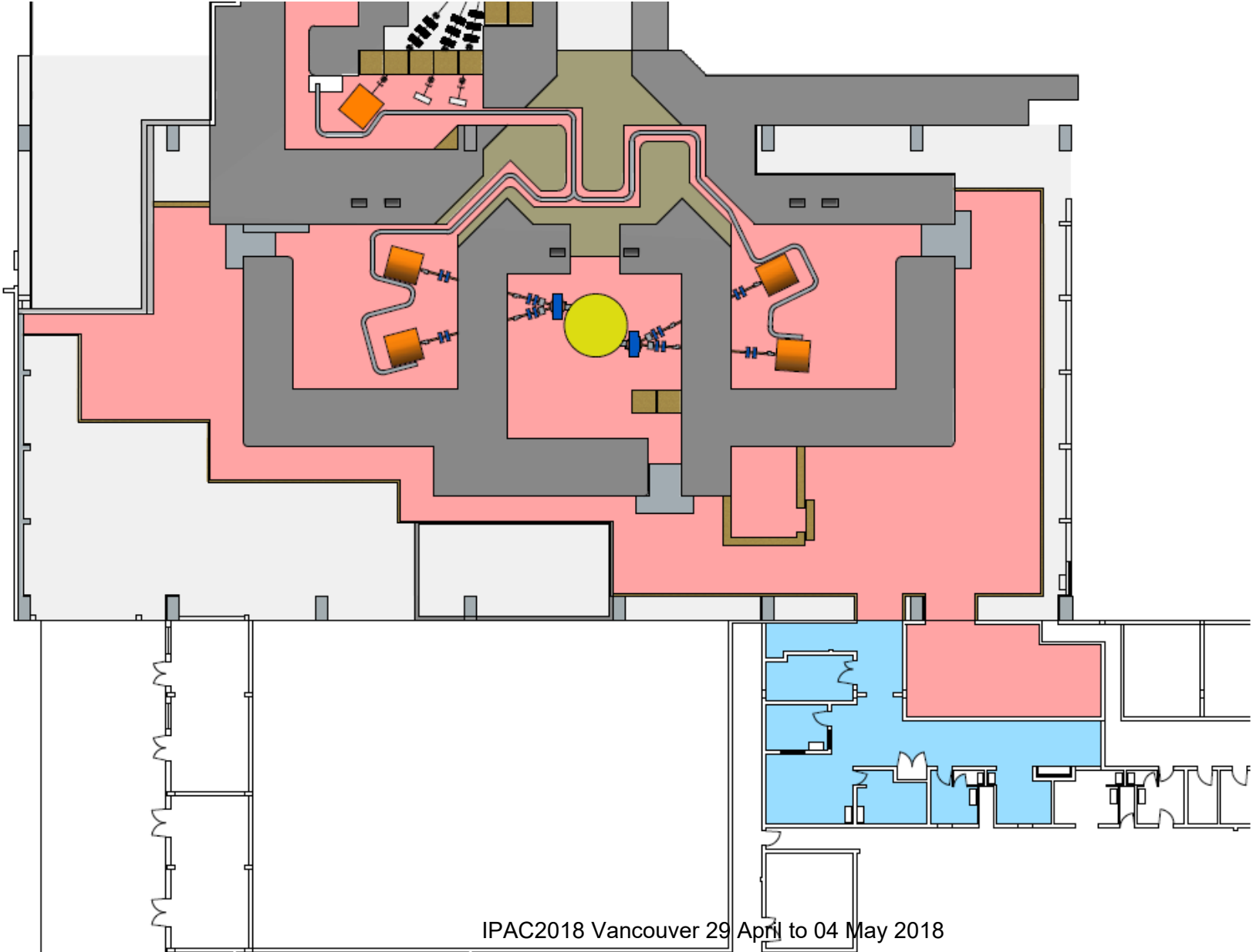
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Accelerator Centre for Exotic Isotopes (ACE Isotopes)



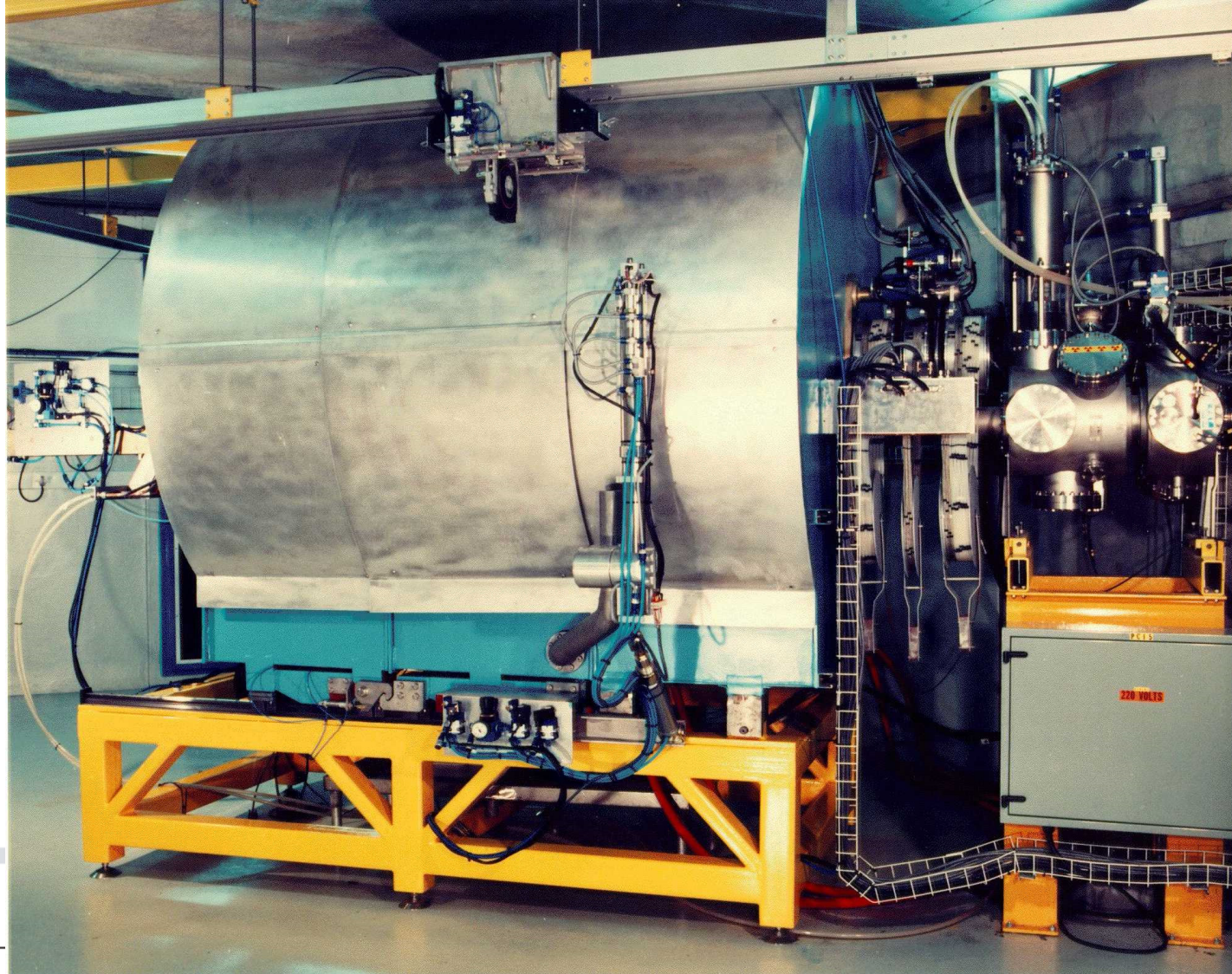
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Bombardment Station



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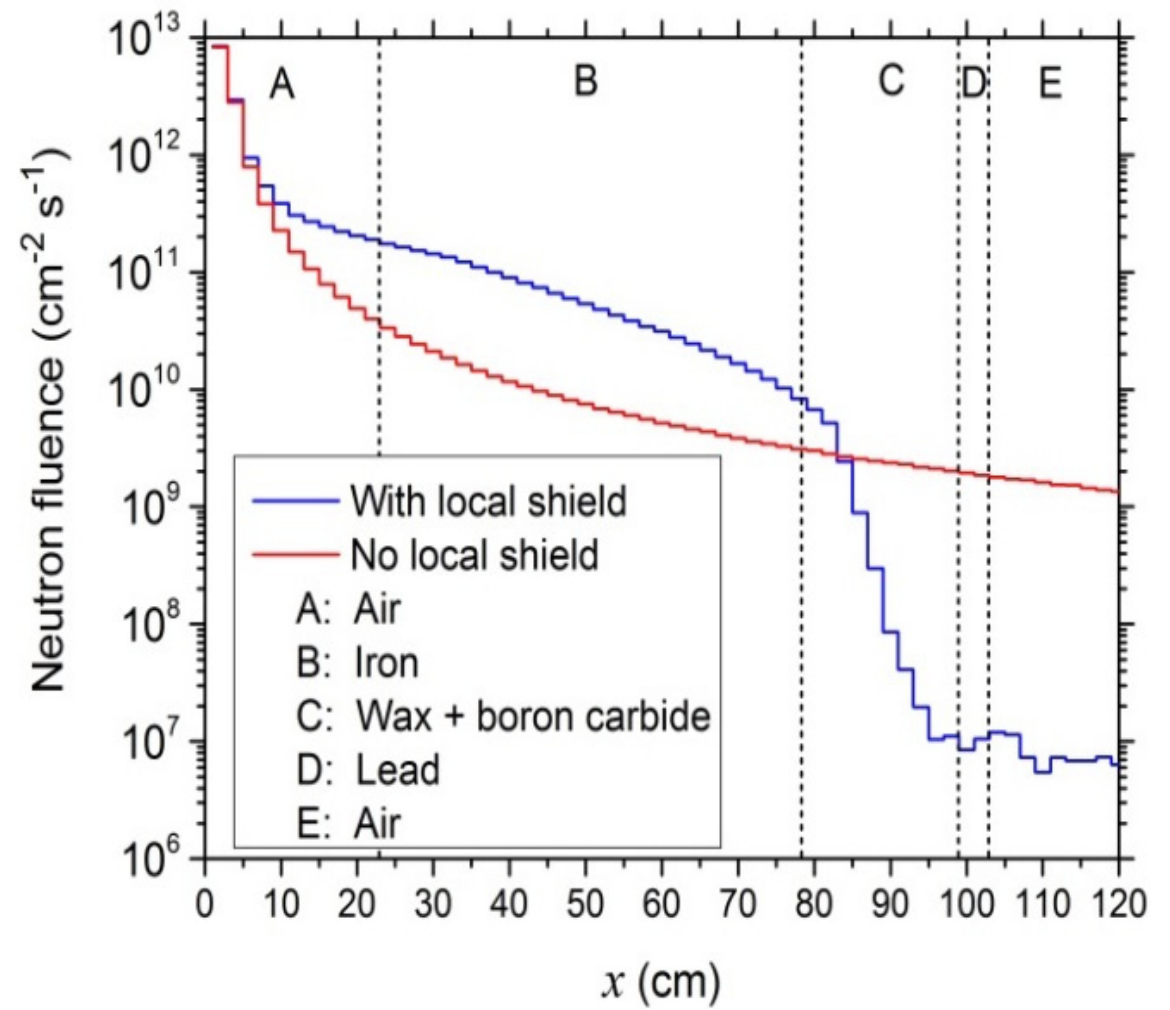
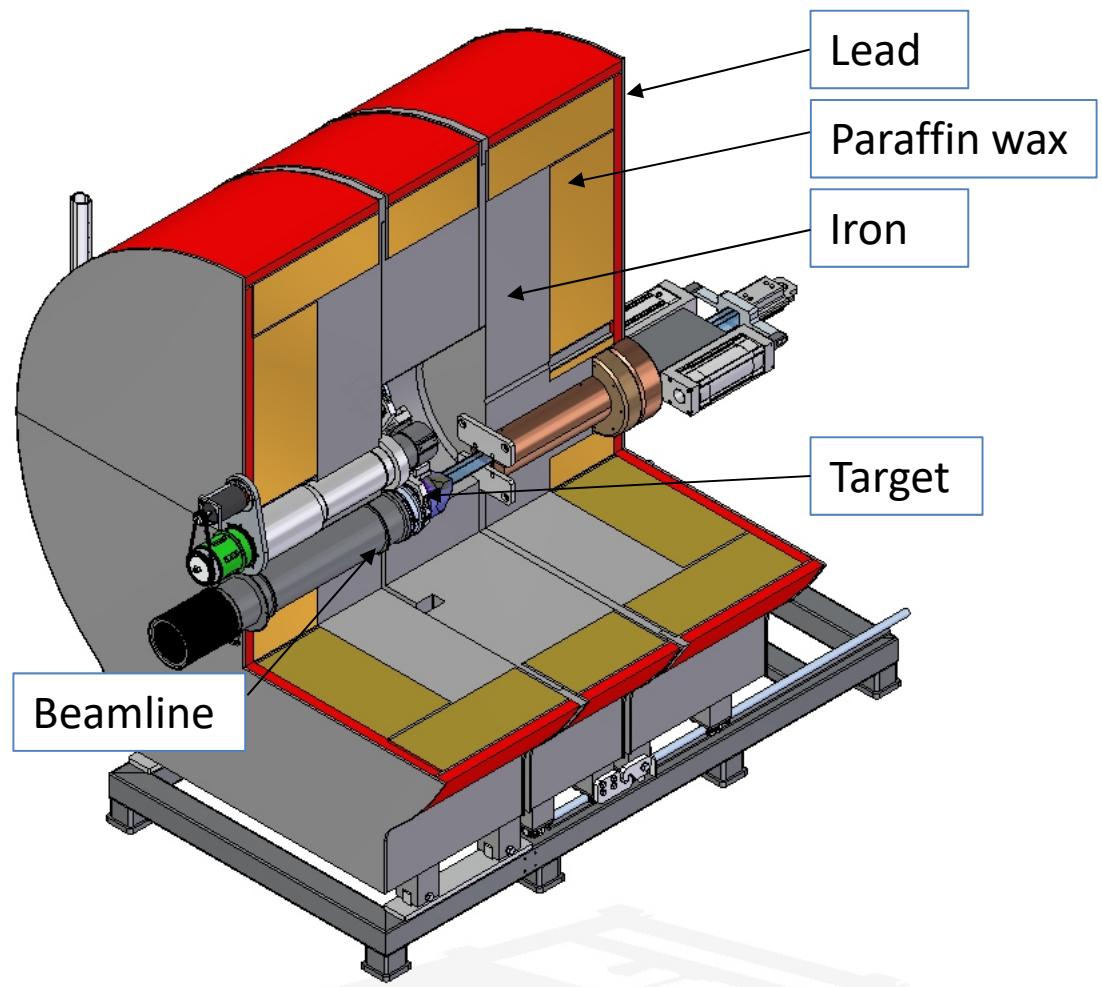
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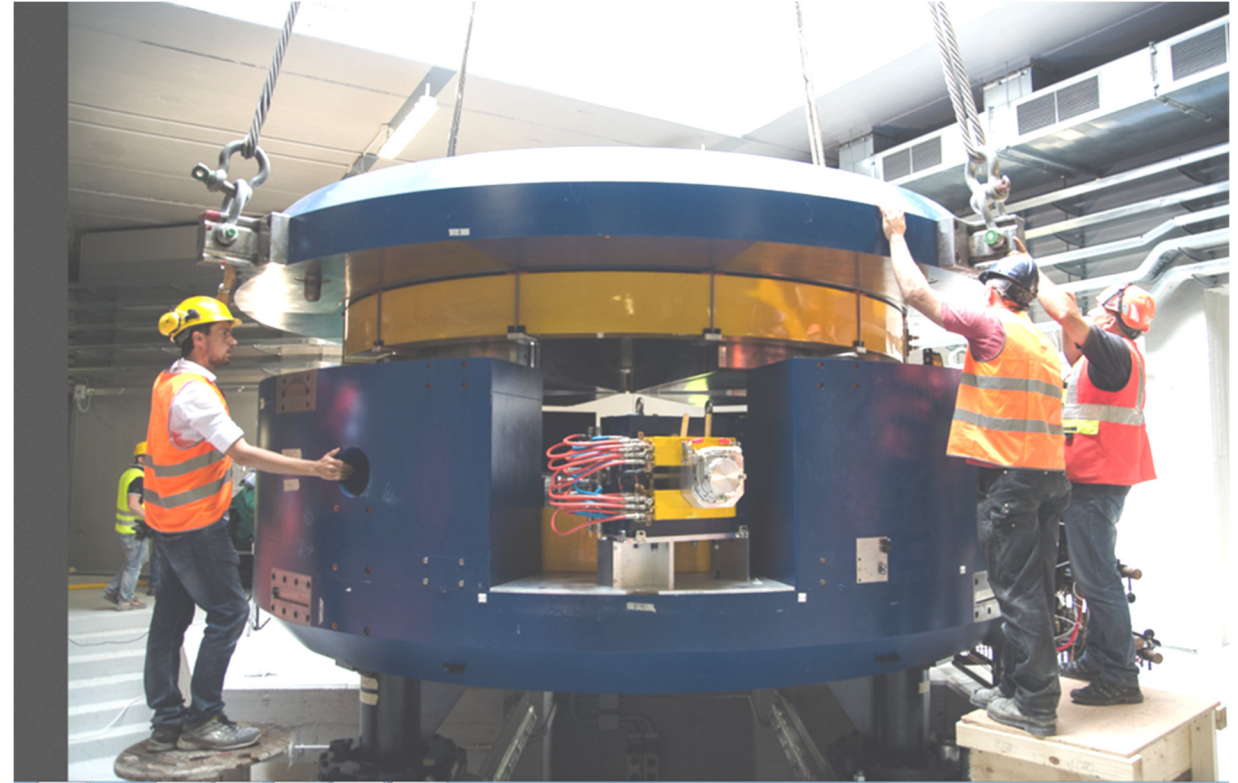
Design of isotope production target station



Company: IBA Cyclone® 70P



Company: Best Cyclotron Systems BEST 70p Cyclotron



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IBA Cyclone® 70P

Isochrones cyclotron with 4 sectors

RF: 61 MHz

Harmonic number 4

Mean Acceleration Voltage: 55 kV

Max magnetic field : 1.6 T

Max kinetic energy/n: 30 - 70 MeV

Total beam current $\geq 700 \mu\text{A}$ proton beam



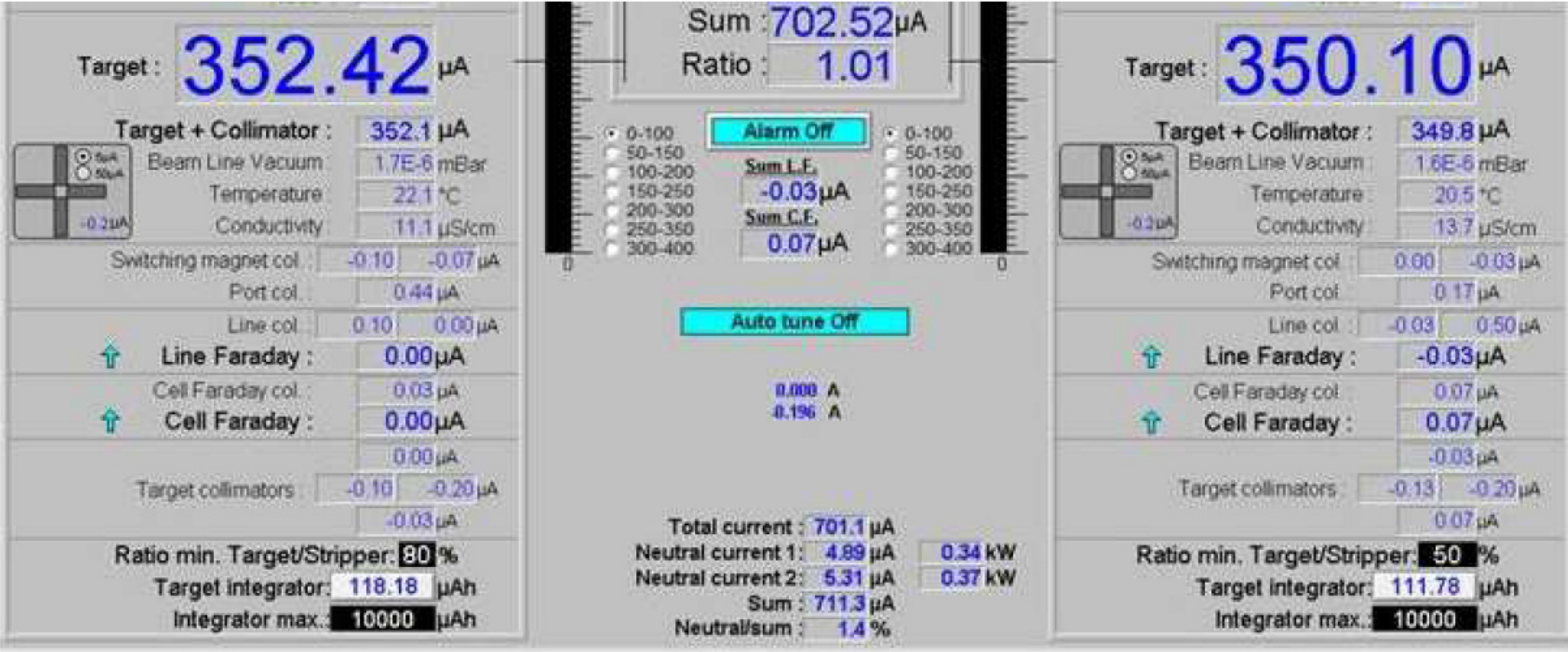
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IBA Cyclone 70P First full beam extraction (dual beam)



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BEST 70p Cyclotron - specifications



Type of Cyclotron

- Negative hydrogen ion (H⁻)
- External ion source, multi-cusp 15-20mA Simultaneous double beam extraction
- Up to 6 beam lines

Beam Current

≥700 μA, combined beam current

Beam Energy

35 to 70 MeV variable energy extraction

Magnet

Magnet coil	~35 kAT
Magnet weight	~155 tons
Maximum magnetic field	1.6 T
Geometry	4 Sector, deep valley
Hill sector angle	50°
Hill gap	4.5 cm (minimum)

RF System

Number of Dees	2
Dee Voltage	60 to 72 kV
RF frequency	56 MHz, 4th harmonic
Power required	21 kW (nominal)

Vacuum System

Ion source	<1 x 10 ⁻⁵ Torr
Main tank	<1 x 10 ⁻⁷ Torr
Pumps (main tank).....	4 cryogenic pumps



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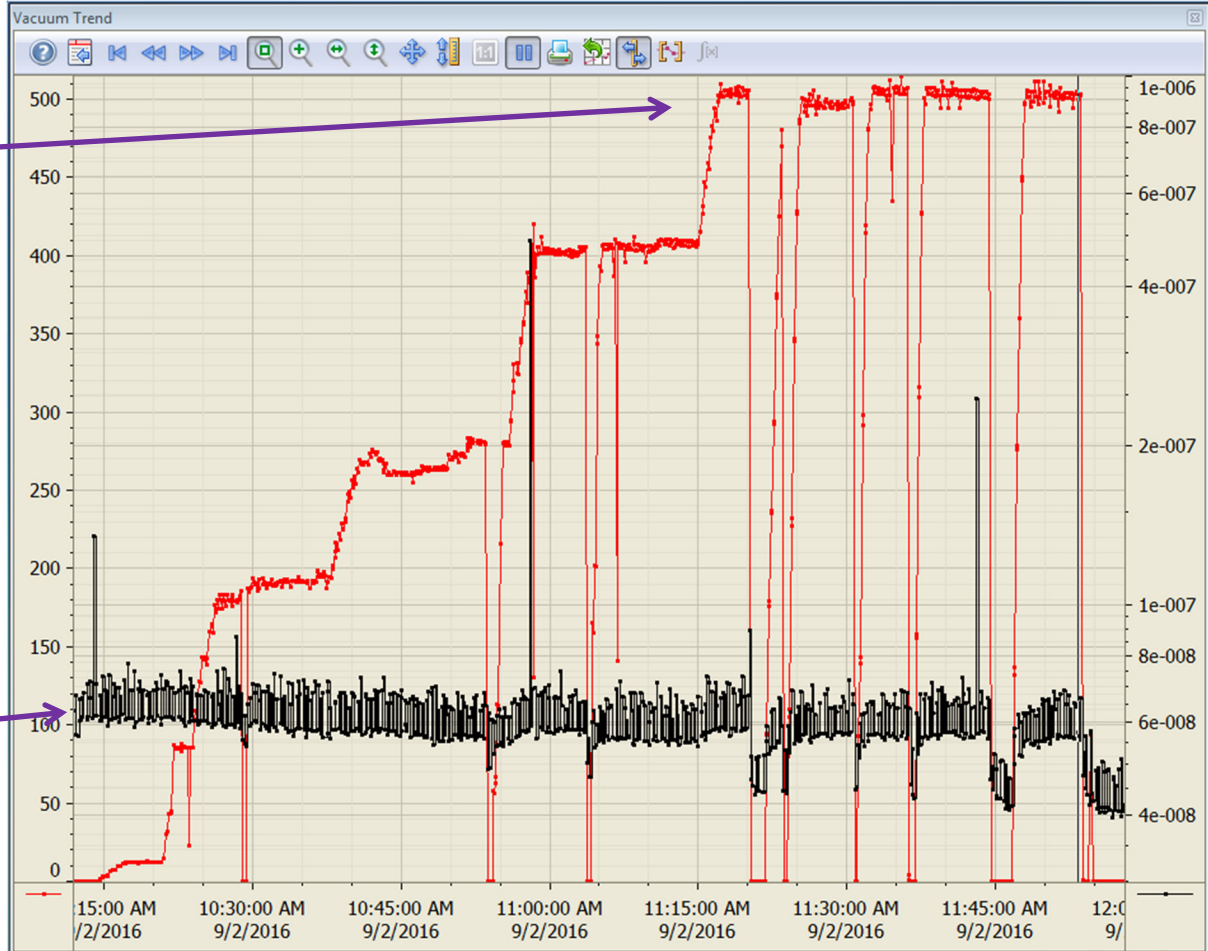
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Beam test on 50kW INFN target

Vacuum:

500 μ A

6×10^{-8} Torr



Current Radionuclides in routine production

Radionuclide	Half-Life (days/years)	Nuclear Reaction	Product	Main Use
^{82}Sr	25 days	$\text{Rb}(p,xn)^{82}\text{Sr}$	Produced as a radionuclide	Used to manufacture $^{82}\text{Sr}/^{82}\text{Rb}$ generators
^{68}Ge	271 days	$\text{Ga}(p,xn)^{68}\text{Ge}$	Produced as a radionuclide	Used to manufacture $^{68}\text{Ge}/^{68}\text{Ga}$ generators or used for calibration of gamma camera's or PET CT scanners
^{88}Y	106.6 days	$\text{Sr}(p,xn)^{88}\text{Y}$	Produced as a radionuclide	Non –medical application
^{109}Cd	453 days	$\text{Ag}(p,xn)^{109}\text{Cd}$	Produced as a radionuclide	Non-medical application
^{22}Na	2.602 years	$\text{Mg}(p,n)^{22}\text{Na}$	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	$^{15}\text{O}(p,n)^{18}\text{F}$	^{18}F -FDG	Glucose metabolic studies
^{67}Ga	78.3	$\text{Zn}(p,xn)^{67}\text{Ga}$ $\text{Ge}(p,x)^{67}\text{Ga}$	^{67}Ga -citrate	Localization of certain tumours and inflammatory regions
$^{81}\text{Rb}/^{81\text{m}}\text{Kr}$	4.58	$\text{Kr}(p,xn)^{81}\text{Rb}$	$^{81}\text{Rb}/^{81\text{m}}\text{Kr}$ generator	Lung ventilation studies
^{123}I	13.2	$^{127}\text{I}(p,5n)^{123}\text{Xe} \rightarrow ^{123}\text{I}$	^{123}I -sodium iodide ^{123}I -MIBG	Thyroid studies Localization of certain tumours such as neuroblastoma, pheochromocytoma



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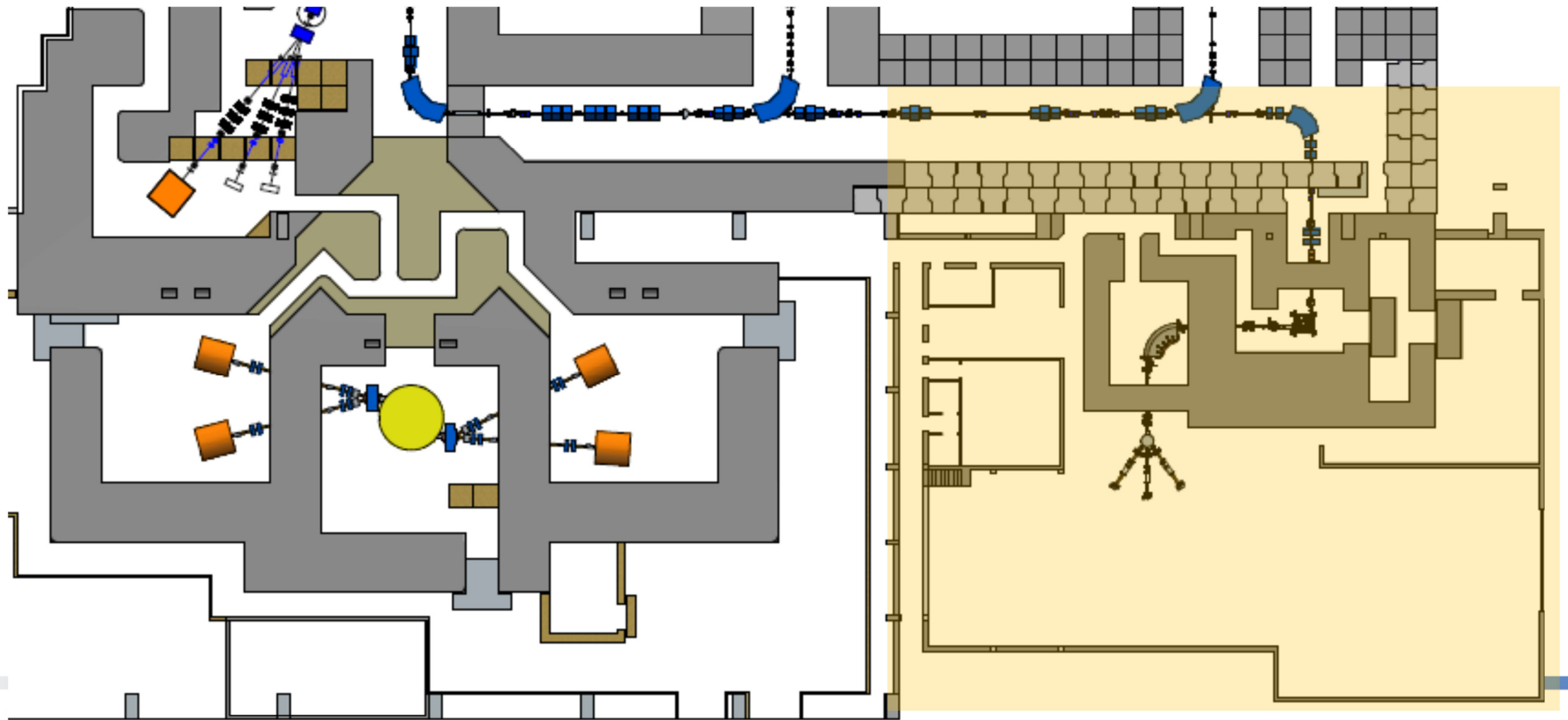
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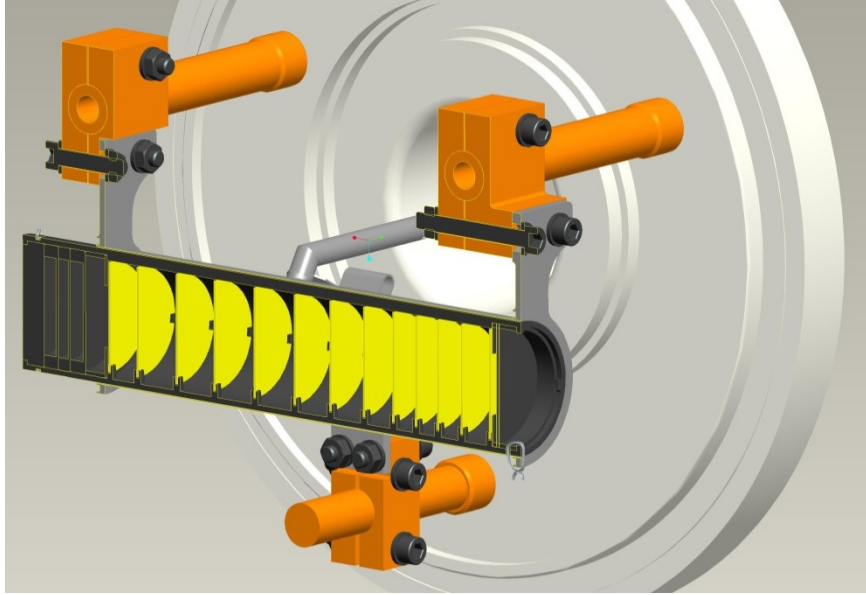


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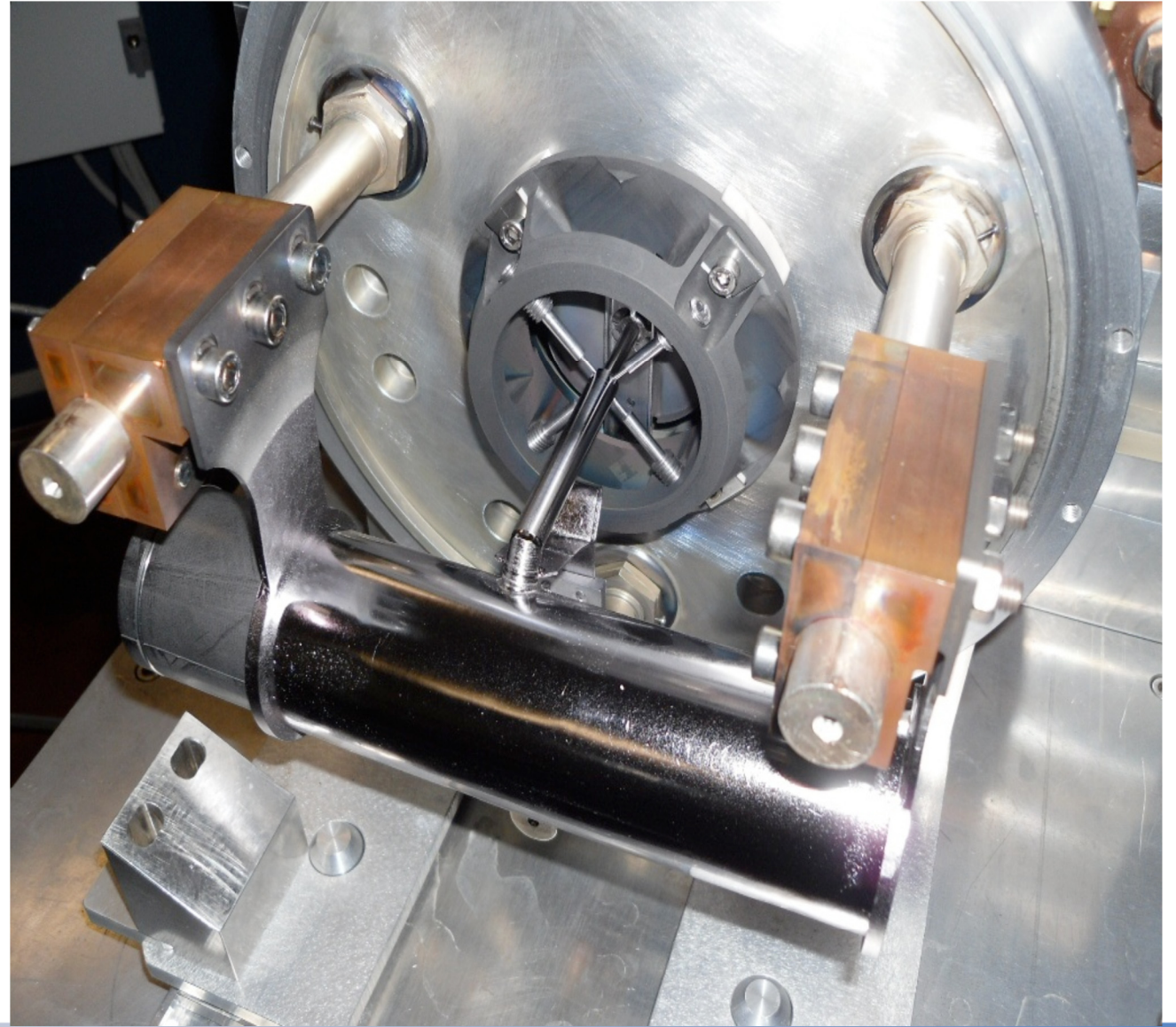
Low energy radioactive ion beam (LERIB)



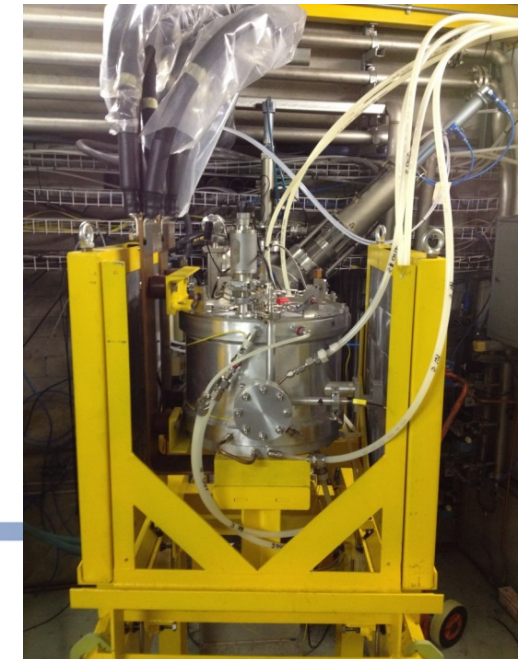
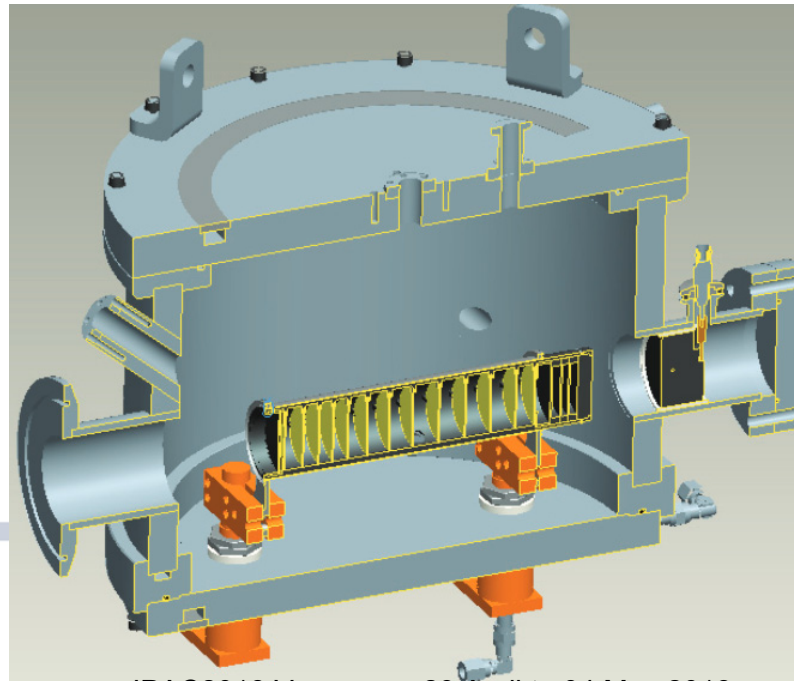
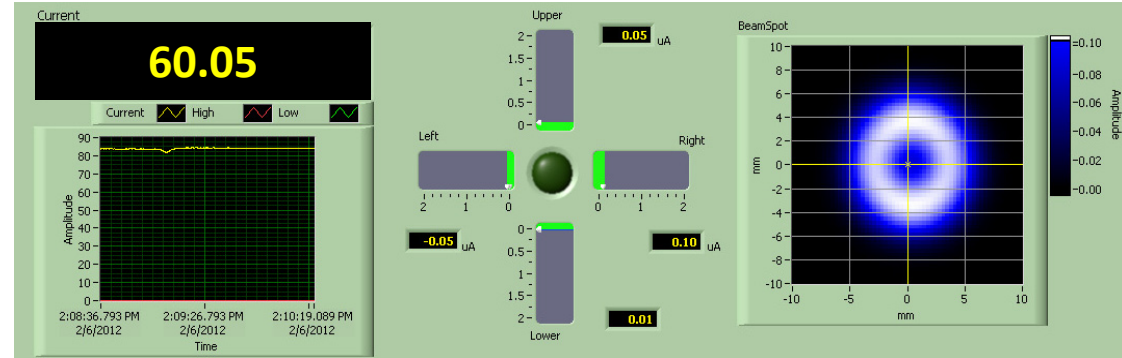
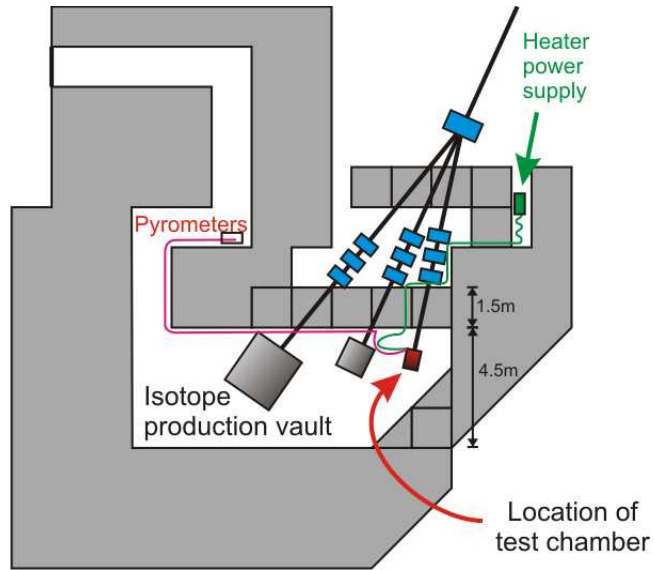
The SPES target (chamber lid removed), designed for a 70 MeV proton beam entering from the right. The heating current flows through the Ta tube, between the copper clamping bars at each end



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).



Online test with silicon carbide discs, 60 micro ampere, 66 MeV proton beam



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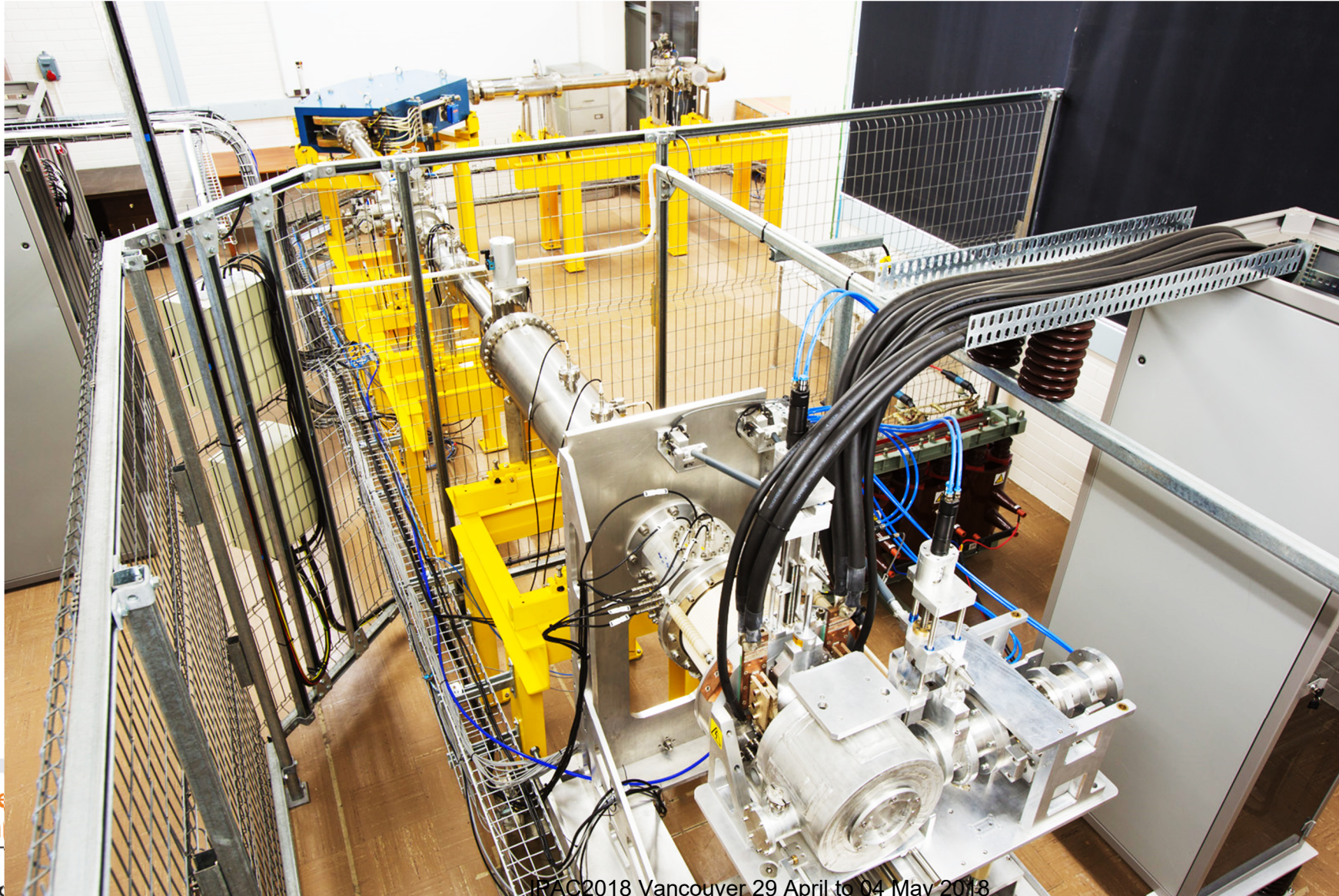
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Target ion source test stand



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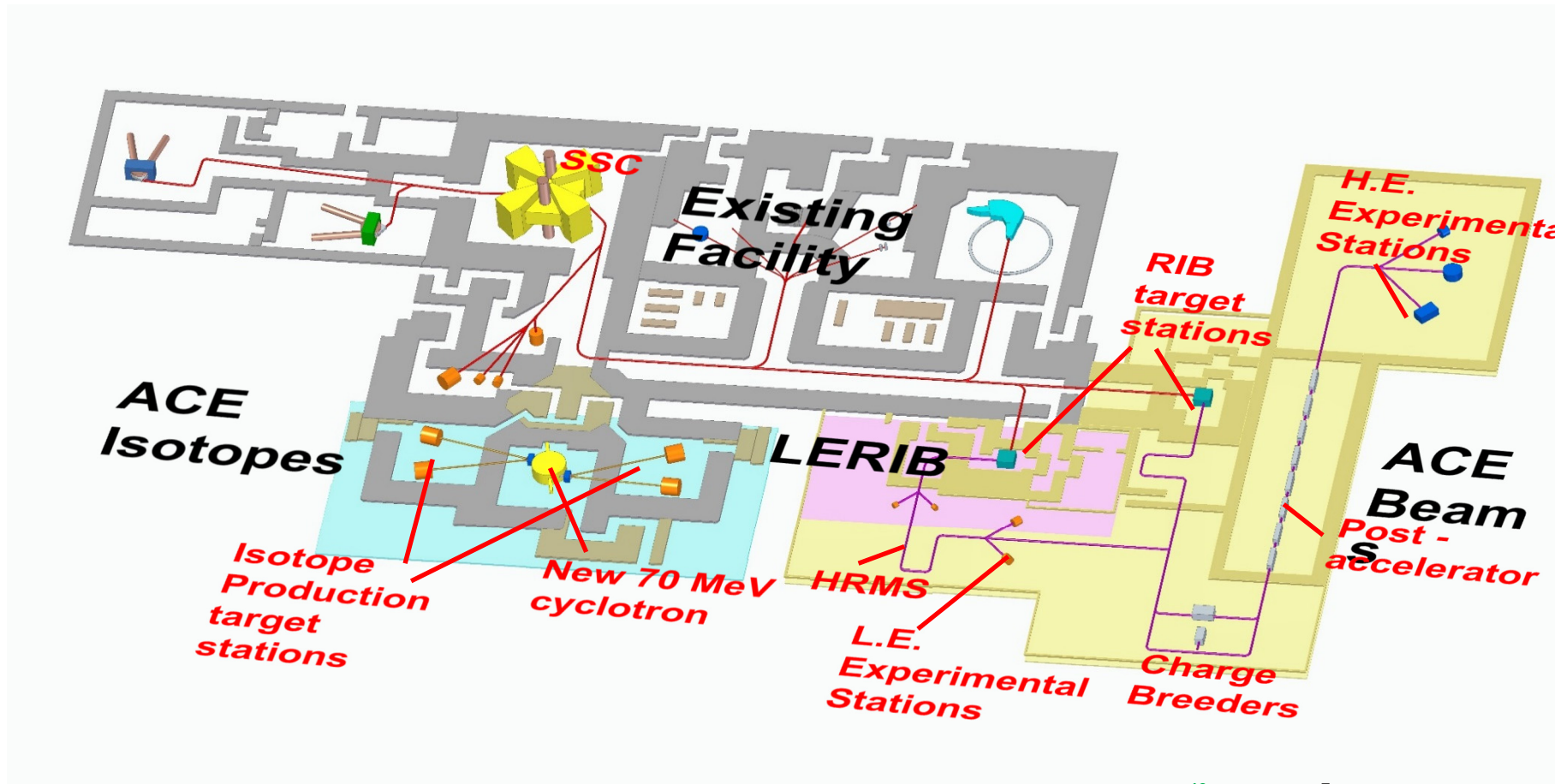
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iThemba LABS (ACE Beams)	70 MeV	150 μ A	10.5 kW	2×10^{13}	7
iThemba LABS (LERIB)	66 MeV	50 μ A	3.3 kW	6.7×10^{12}	



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