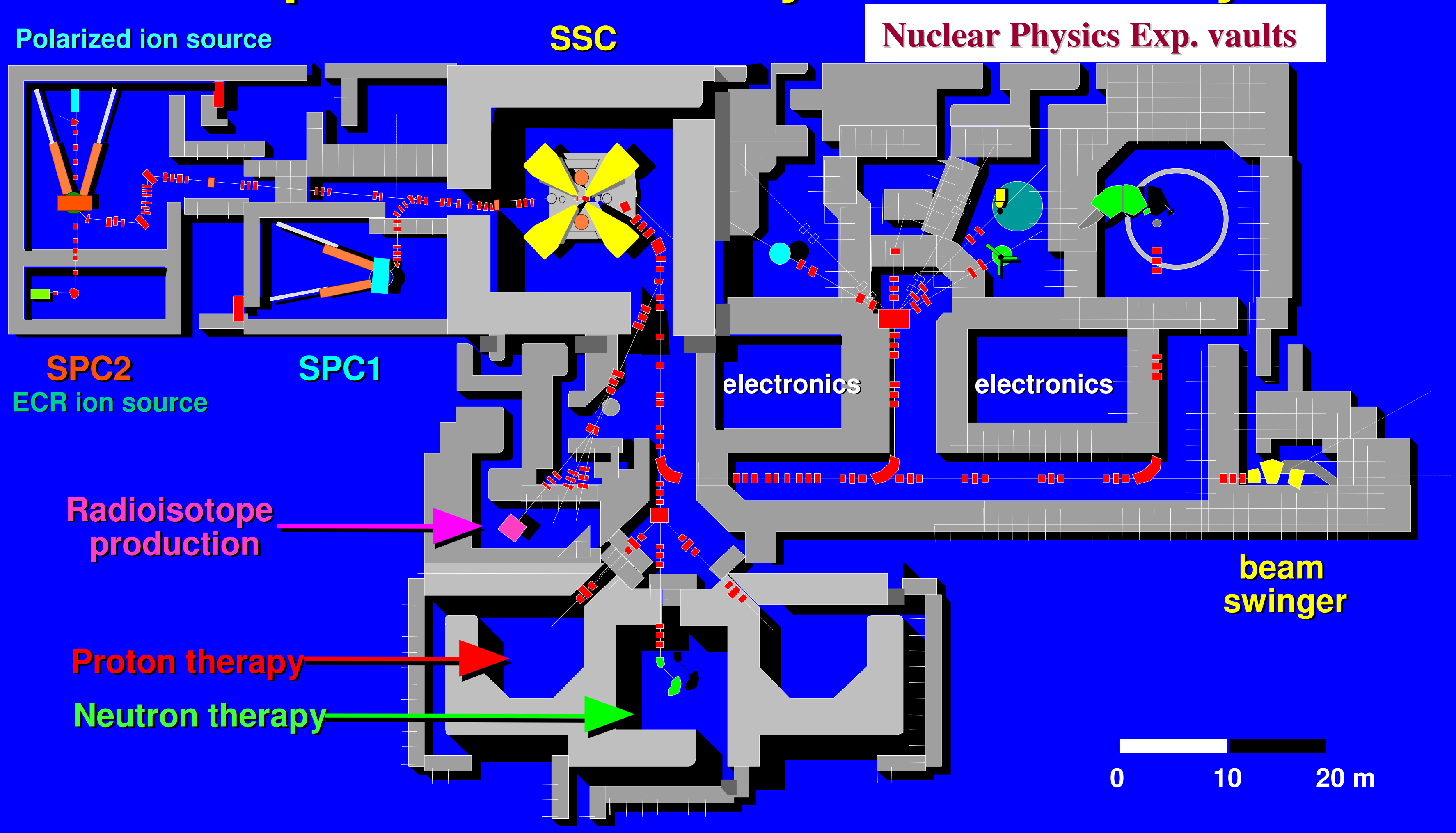
Upgrading of the accelerator facilities at iThemba Laboratory for Accelerator Based Sciences (iThemba LABS) to increase the production of radionuclides

Layout of the talk

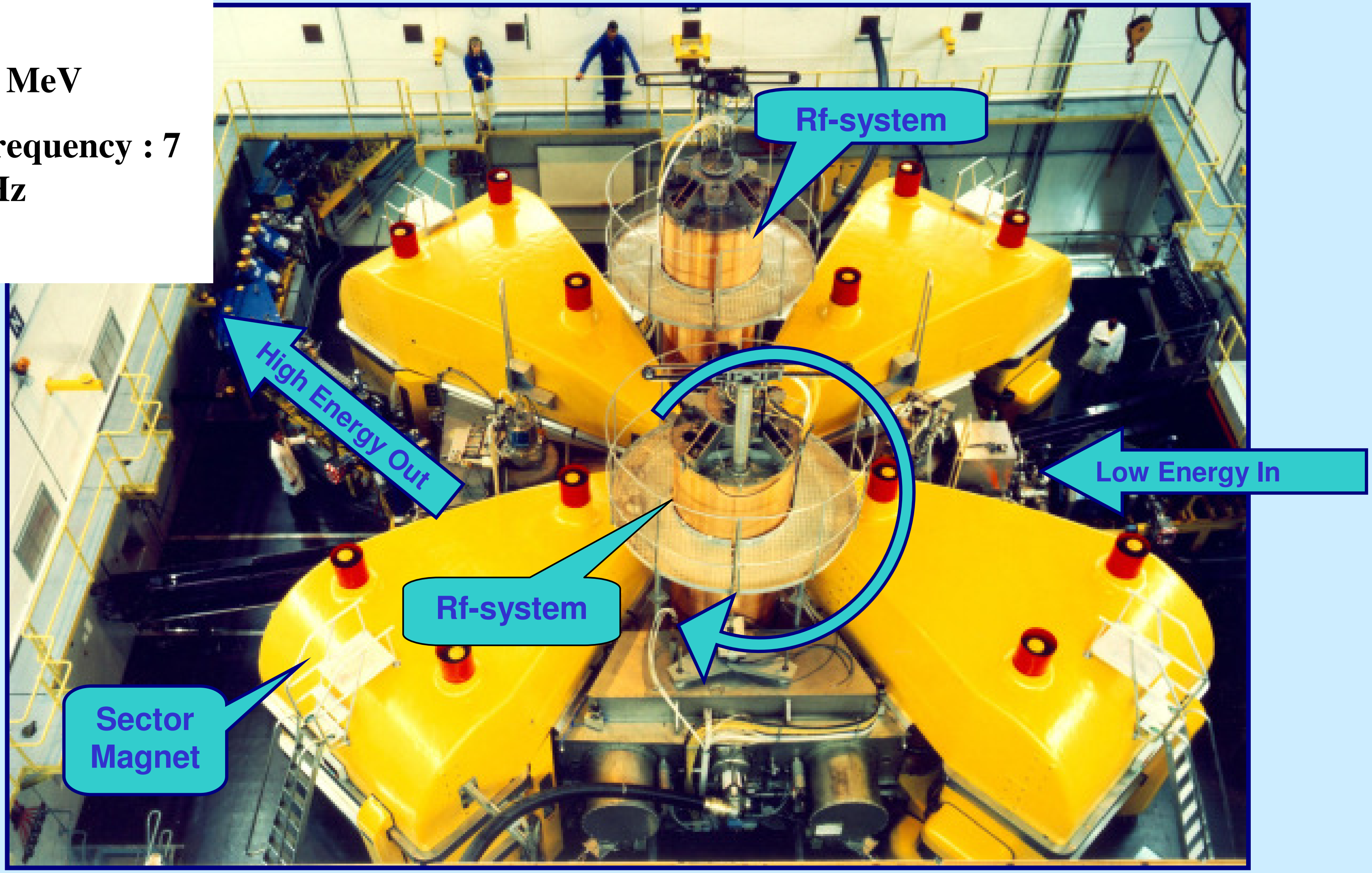
- Overview of facilities at iThemba LABS which operates a 200 MeV separated-sector cyclotron and two 8 MeV solid-pole injector cyclotrons
- A flat-top system for the light-ion injector cyclotron (SPC1)
- An additional buncher for the transfer beam line
- A flat-top system for the separated-sector cyclotron (SSC)
- A new vertical beam line for radionuclide production
- Beam splitting and an additional horizontal beam line for radionuclide production
- Diagnostic equipment for high-intensity beams:
    - Non-destructive beam position monitors
    - High intensity 50kW beam stop

Separated-Sector Cyclotron Facility



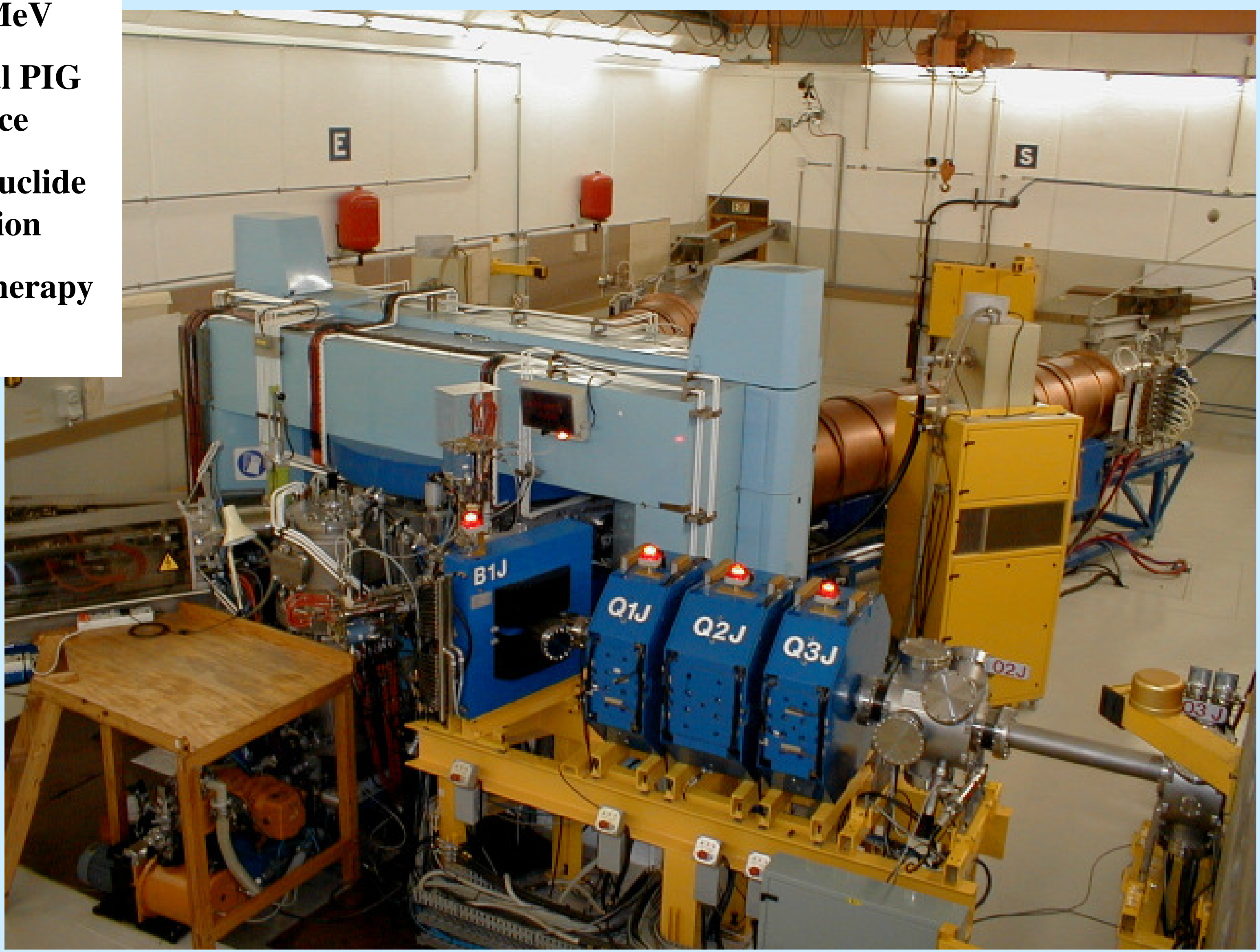
The SSC

- 4 separate sectors (SSC)
- Variable-energy machine
- K = 200 MeV
- RF frequency : 7 to 26 MHz

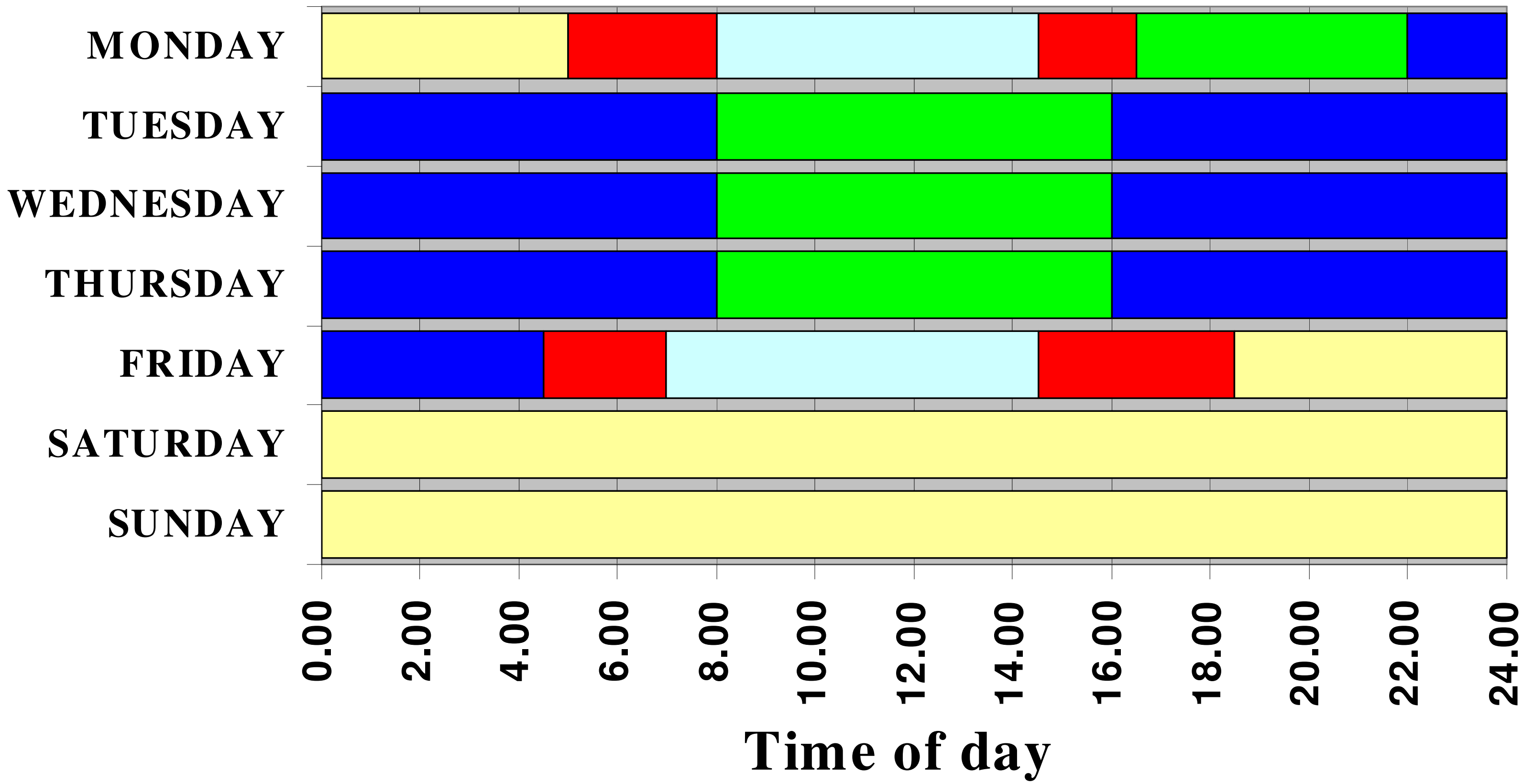


Solid-pole injector cyclotron 1 (SPC1)

- K = 8 MeV
- Internal PIG ion source
- Radionuclide production
- Radiotherapy

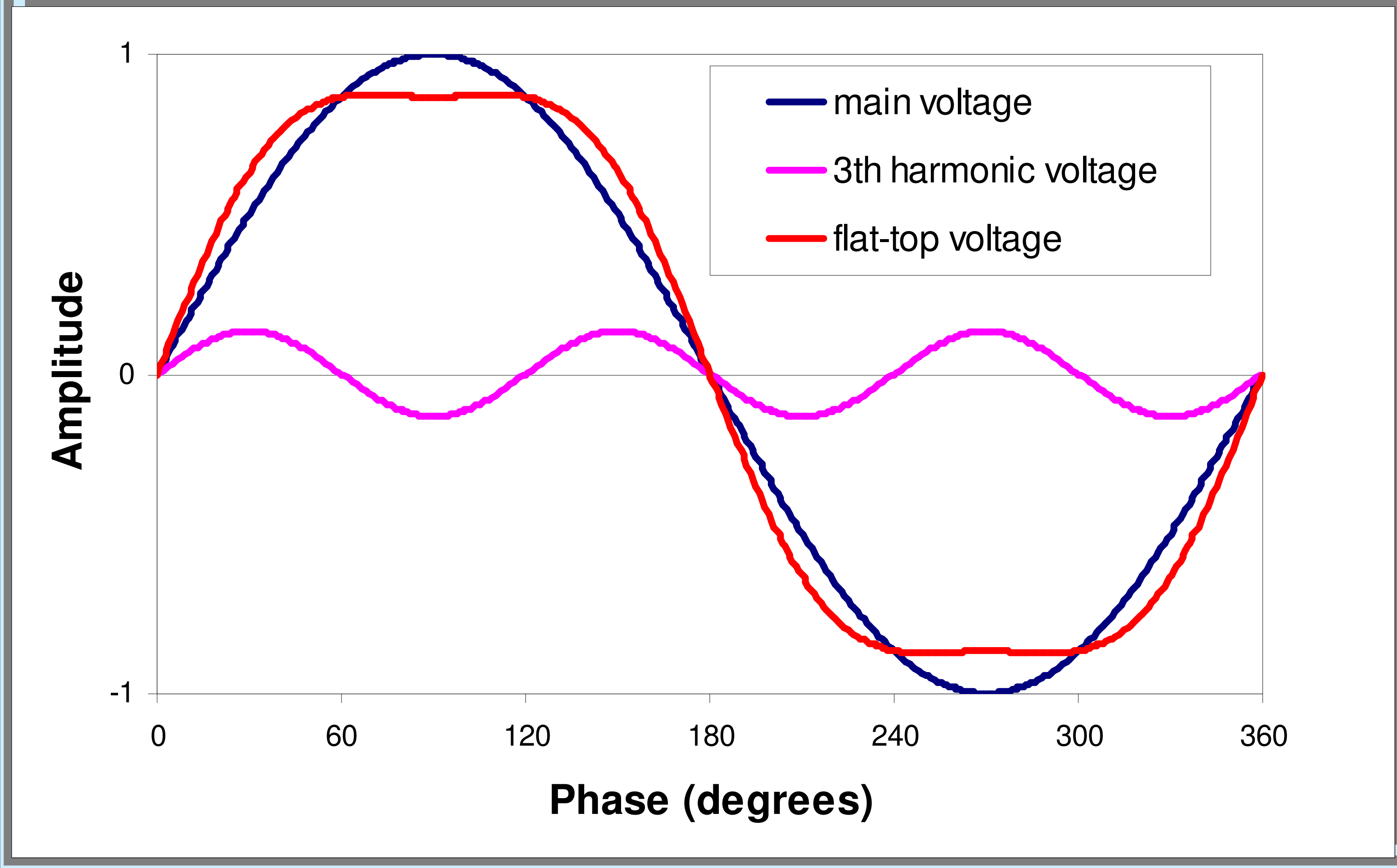


CYCLOTRON OPERATING SCHEDULE



NEUTRON THERAPY PROTON THERAPY ISOTOPE PRODUCTION NUCLEAR PHYSICS ENERGY CHANGE

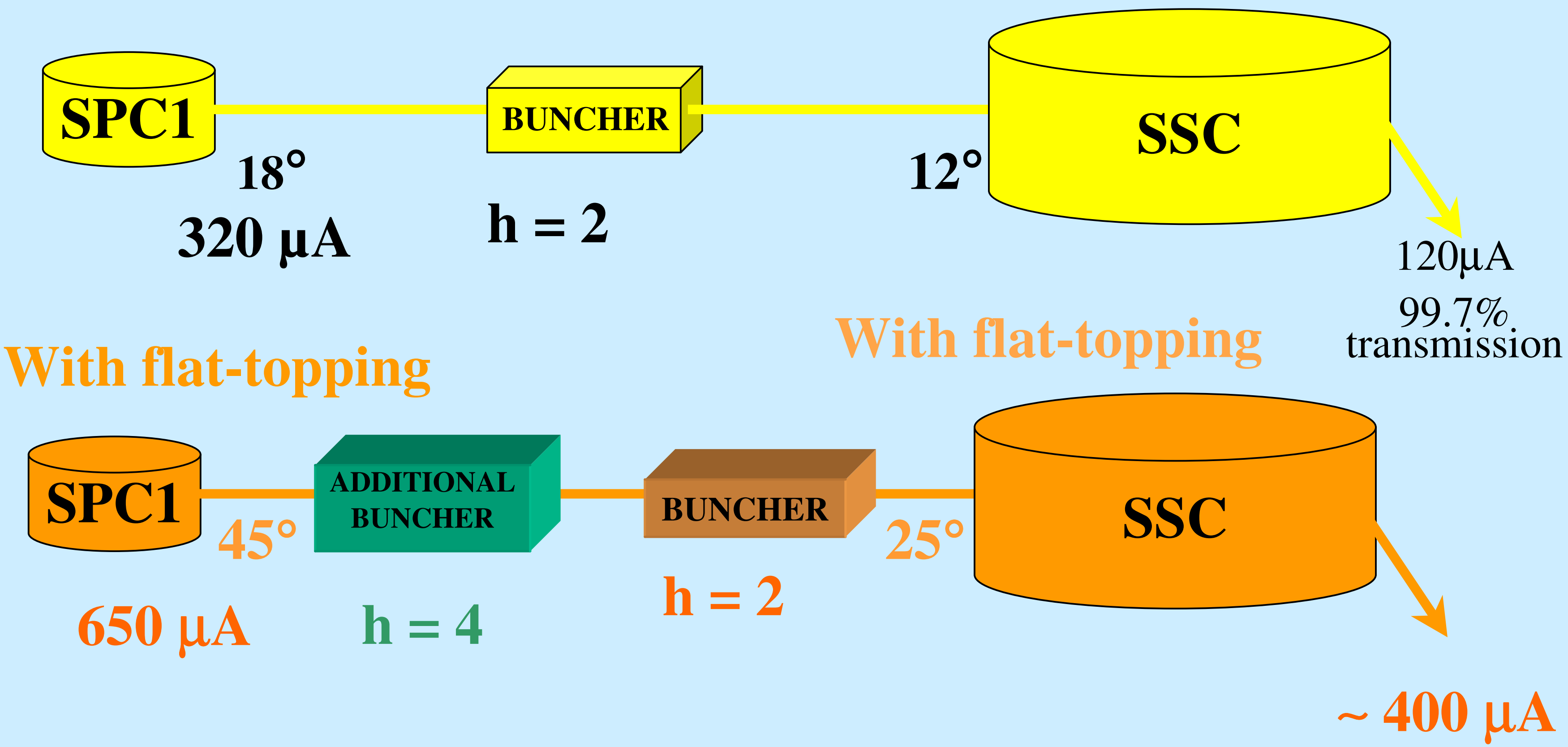
A higher-order harmonic is added to provide a flatter accelerating voltage for less energy spread, smaller beam widths and better beam extraction



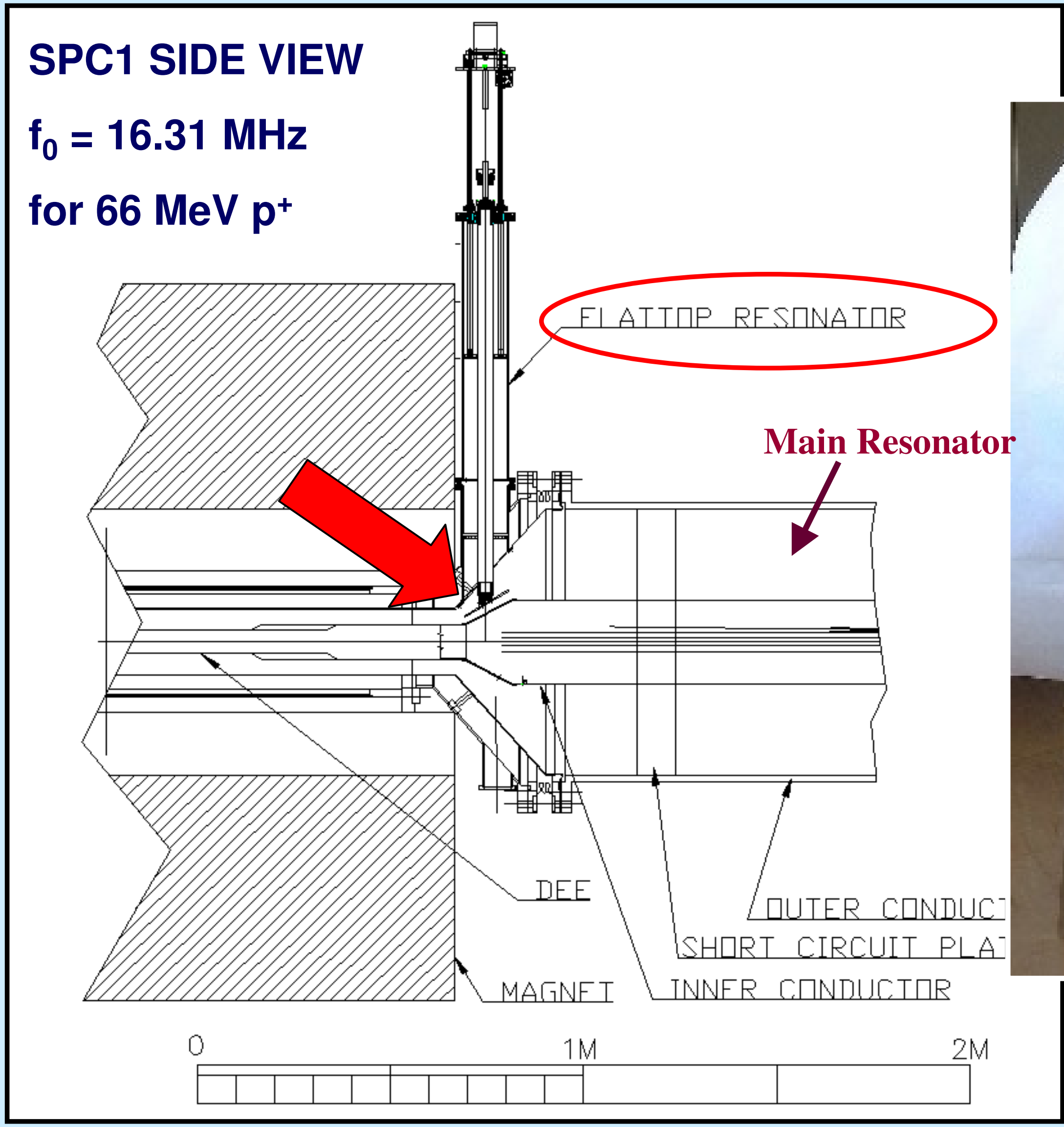
FLAT-TOPPING SYSTEMS AT iTHEMBA LABS

- **TO IMPROVE BOTH THE BEAM QUALITY AND INTENSITY OF THE 66 MeV p^+ BEAM FOR ISOTOPE PRODUCTION**

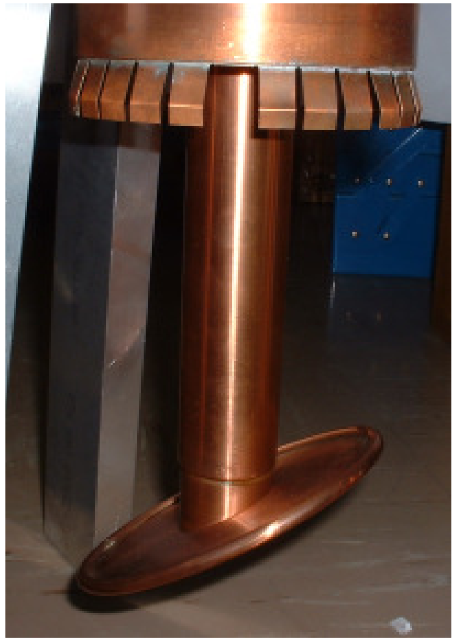
Without flat-topping



The flat-top system of SPC1



Capacitive Coupling

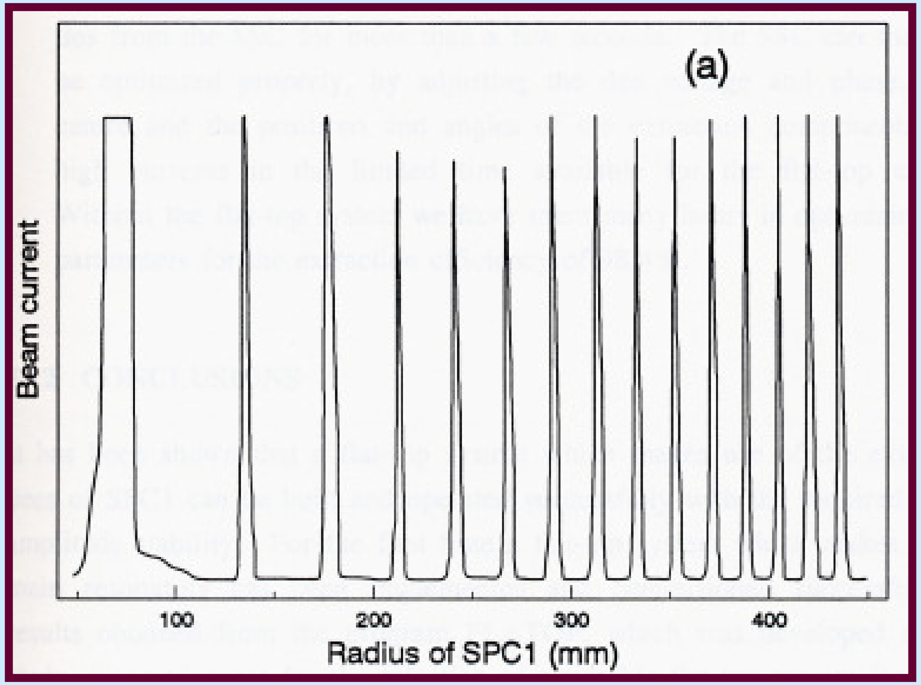


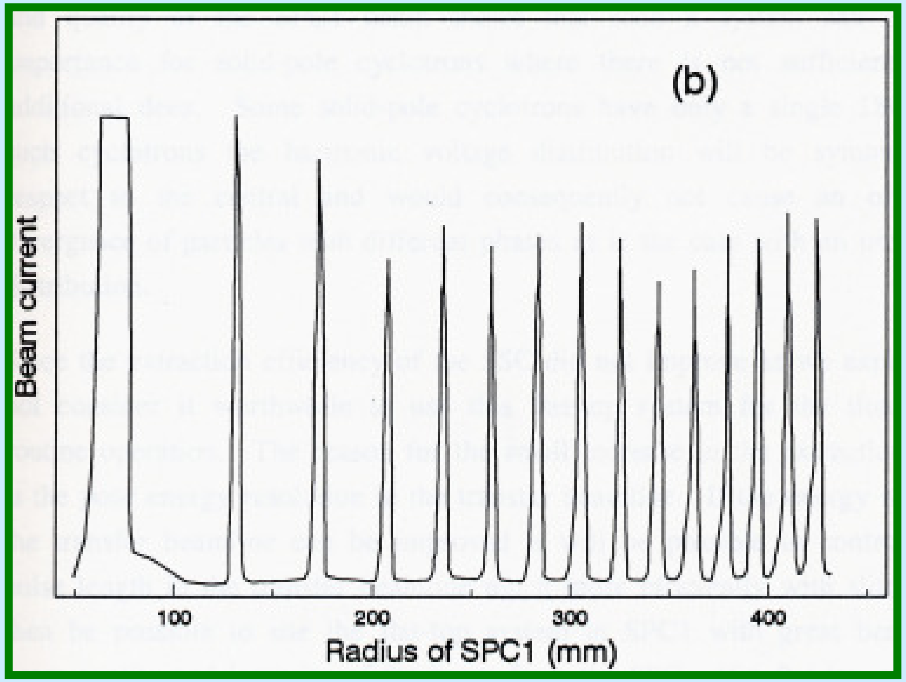
Tune the 2nd resonance of the “rf cavity” to the 5th harmonic of the fundamental frequency

Two SPC1 flat-top resonators

Advantages of flat-topping :

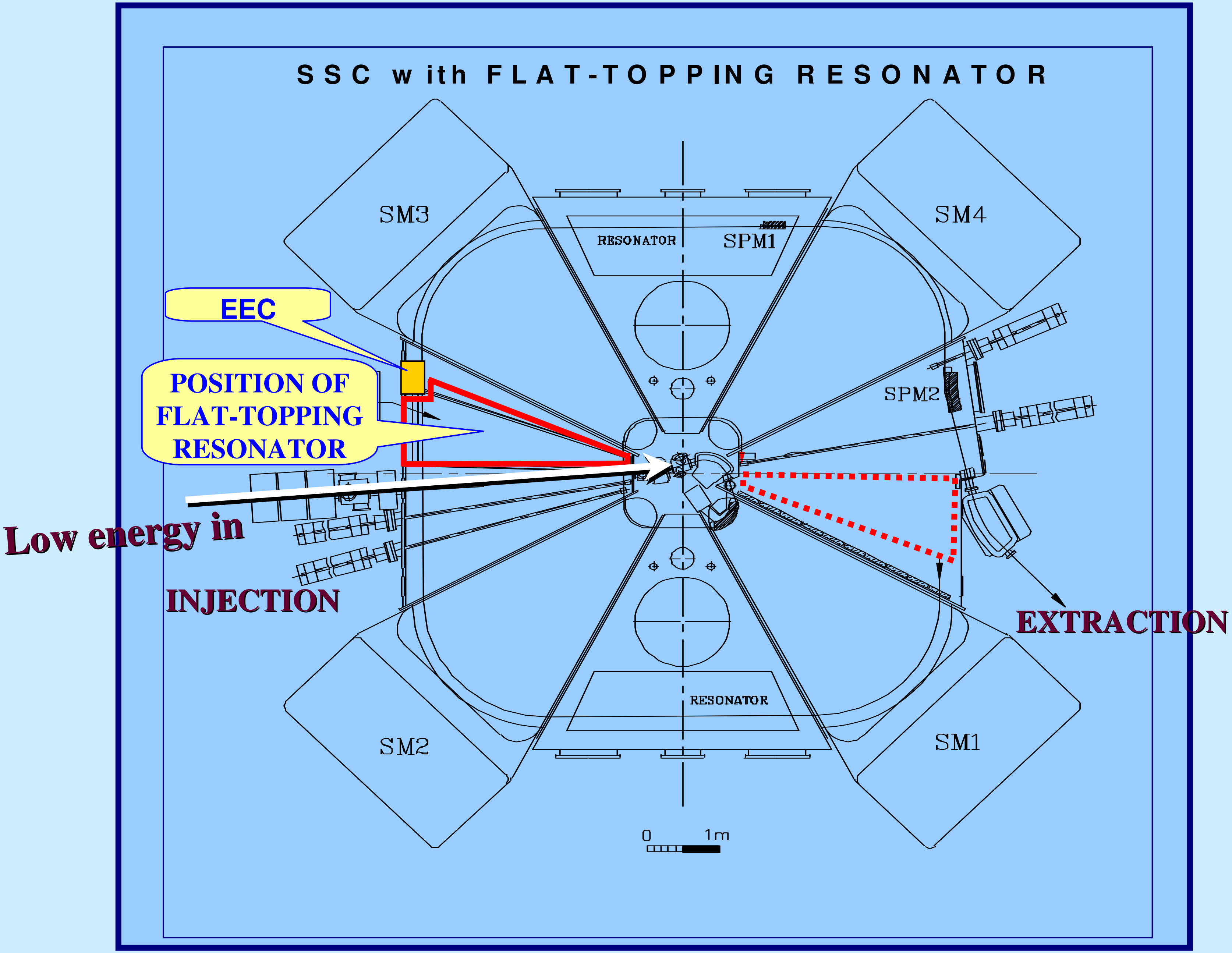
- •Higher beam intensity
- •Better beam quality – less energy spread



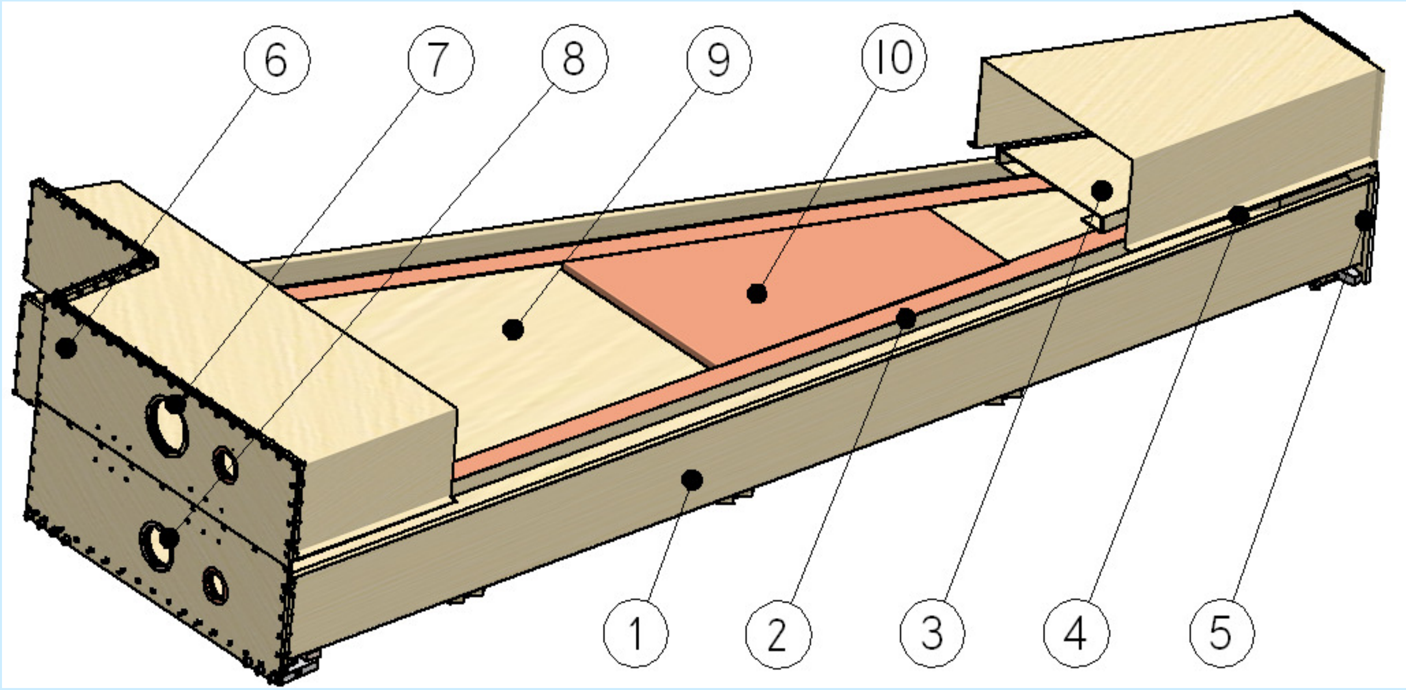


(a) Beam orbit pattern with the 5th harmonic flat-top system

(b) Beam orbit pattern without the 5th harmonic flat-top system

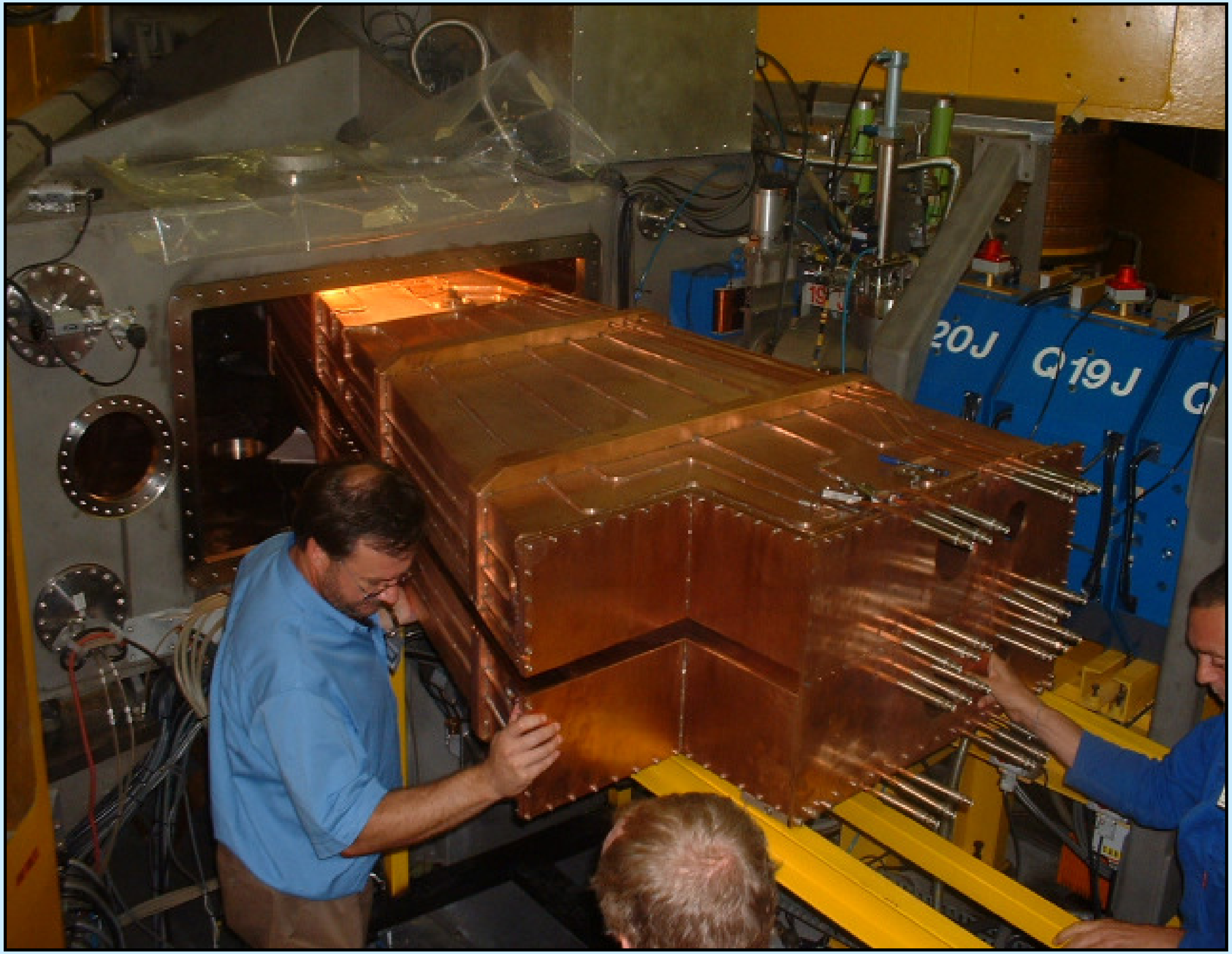

SSC with FLAT-TOPPING RESONATOR
SM3
SM4
RESONATOR
SPM1
EEC
POSITION OF FLAT-TOPPING RESONATOR
SPM2
Low energy in
INJECTION
EXTRACTION
RESONATOR
SM2
SM1
0
1m

The 3-D drawing of the SSC flat-top resonator

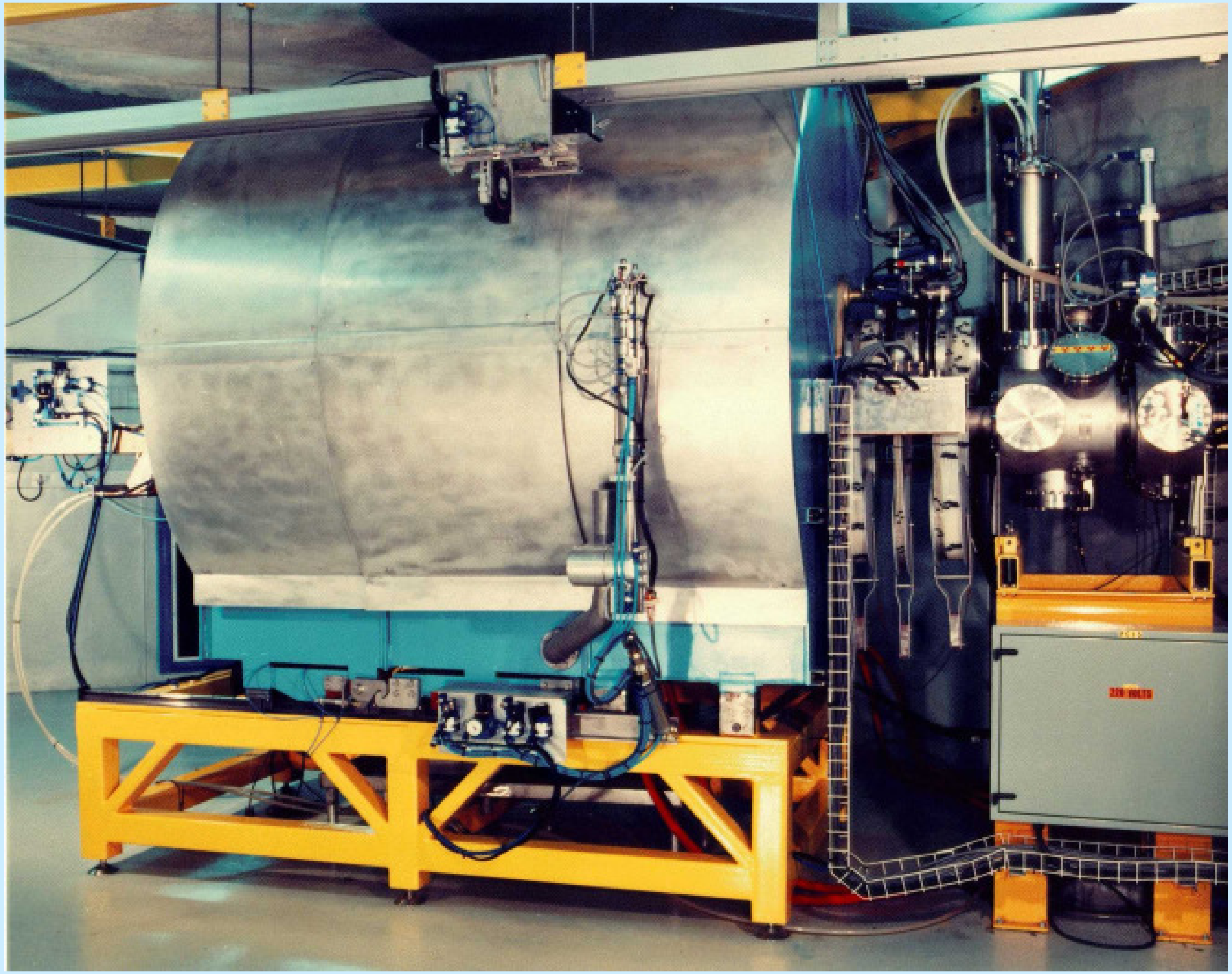


1. lower dee housing 2. acceleration gap 3. top of the upper dee plate 4. beam gap 5. short-circuit plate at injection 6. short-circuit plate at extraction 7. and 8. ports for coupling and tuning components 9. top of the bottom dee plate 10. plate for detuning of an unwanted resonance mode.

Installation of the flat-top resonator



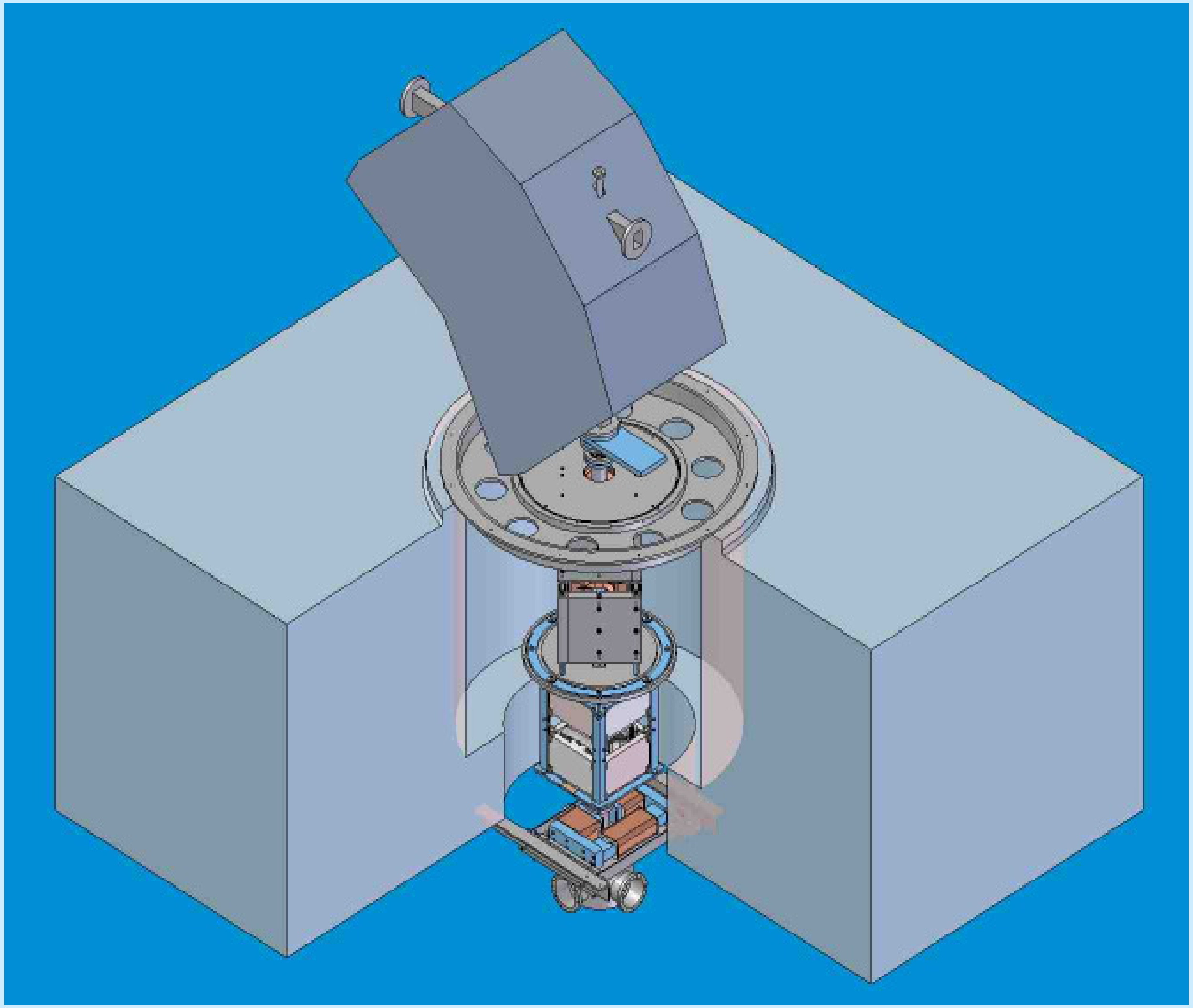
Bombardment station for radionuclide production



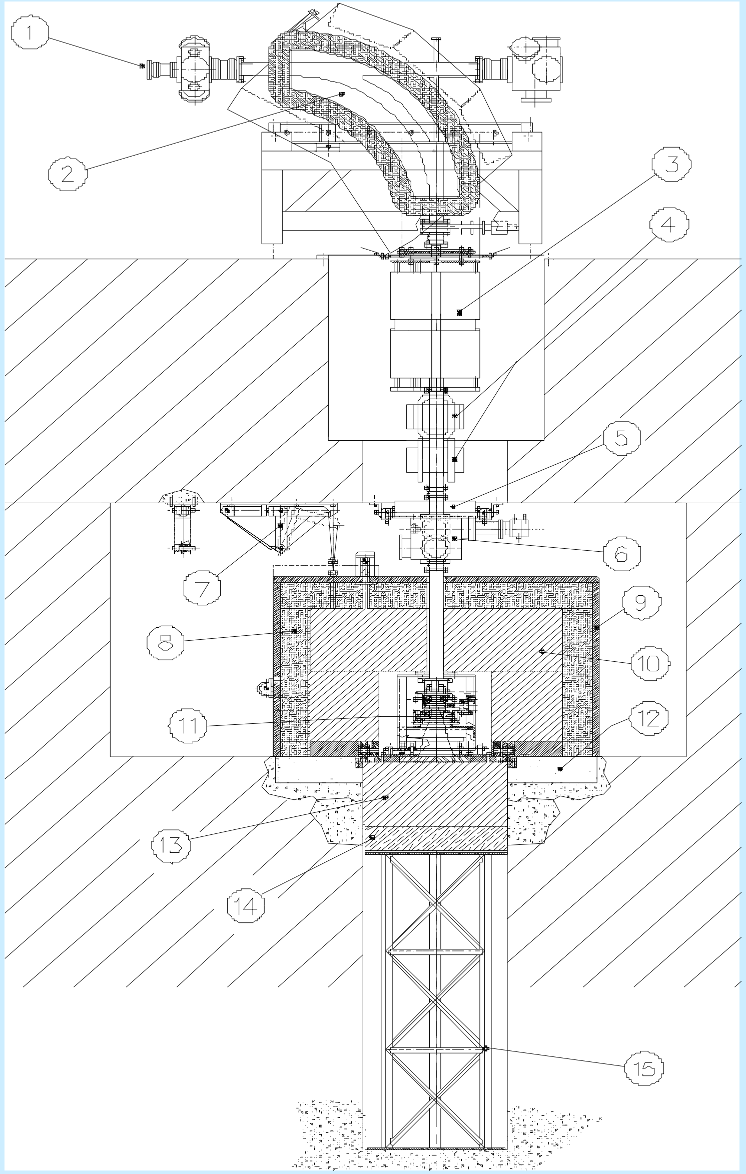
Thick target radionuclide production

Radionuclide	Target	Energy window (MeV)	Mass (gram)	Thickness (mm)	Diameter of disc (mm)
^{67}Ga	Zn Ge	$34.3 \rightarrow 18.1$ $60.7 \rightarrow 38.7$	4.4 7.4	2 6	20 20
^{68}Ge	^{69}Ga ^{71}Ga	$34.0 \rightarrow 2.4$ $62.6 \rightarrow 39.4$	5.0 5.0	4 4	20 20
^{81}Rb	RbCl	$62.6 \rightarrow 57.7$	1.3	3	15
^{82}Sr	RbCl	$61.5 \rightarrow 39.4$	8.6	9	20
^{103}Pd	Ag	$61.5 \rightarrow 20.0$	16.0	5	20
^{123}I	NaI	$62.6 \rightarrow 47.6$	7.0	6	20
^{201}Tl	Tl	$28.6 \rightarrow 21.0$	2.6	1.5	20
^{22}Na	Mg	$61.5 \rightarrow 40.0$	7.0	12	20
^{139}Ce	Pr	$61.5 \rightarrow 25.5$	15.0	7	20

3D drawing of the new vertical beam line



The new vertical beam line for radionuclide production

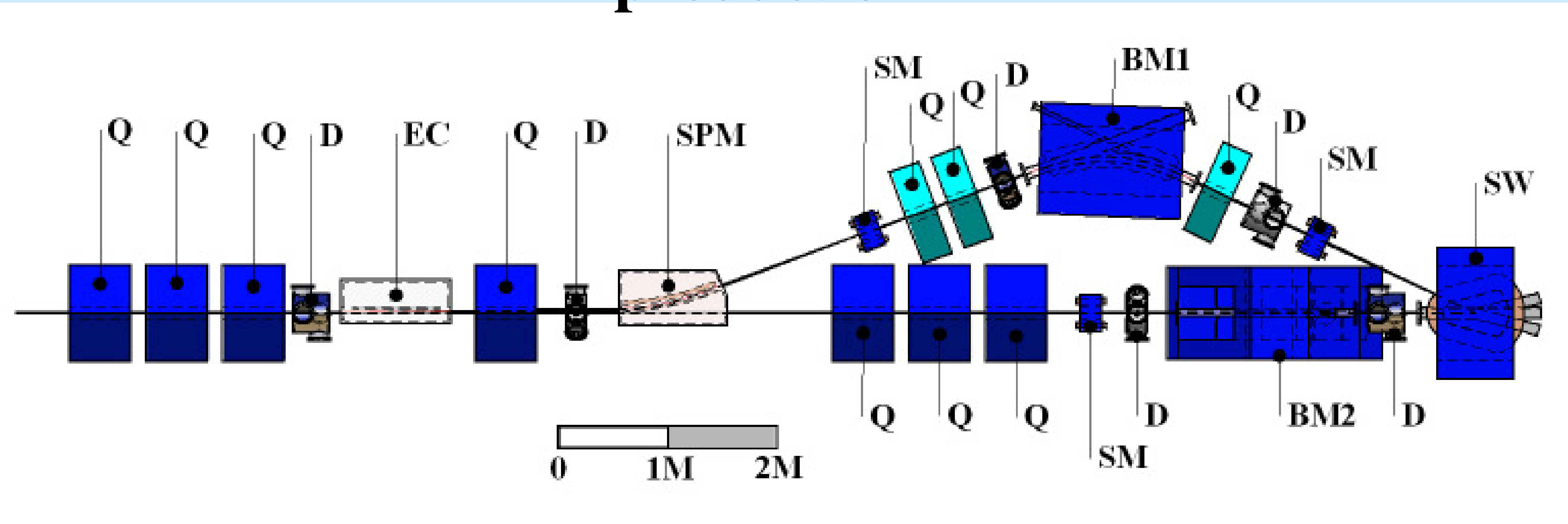


1. the horizontal beam line
2. the 90° bending magnet
3. two quadrupole magnets
4. sweeper magnets
5. steerer magnet
6. vacuum chamber for diagnostic equipment with a Faraday cup, harp and capacitive probe for current measurement
7. shielding lift mechanism for target exchanges

8. 9. and 10. inner iron shield

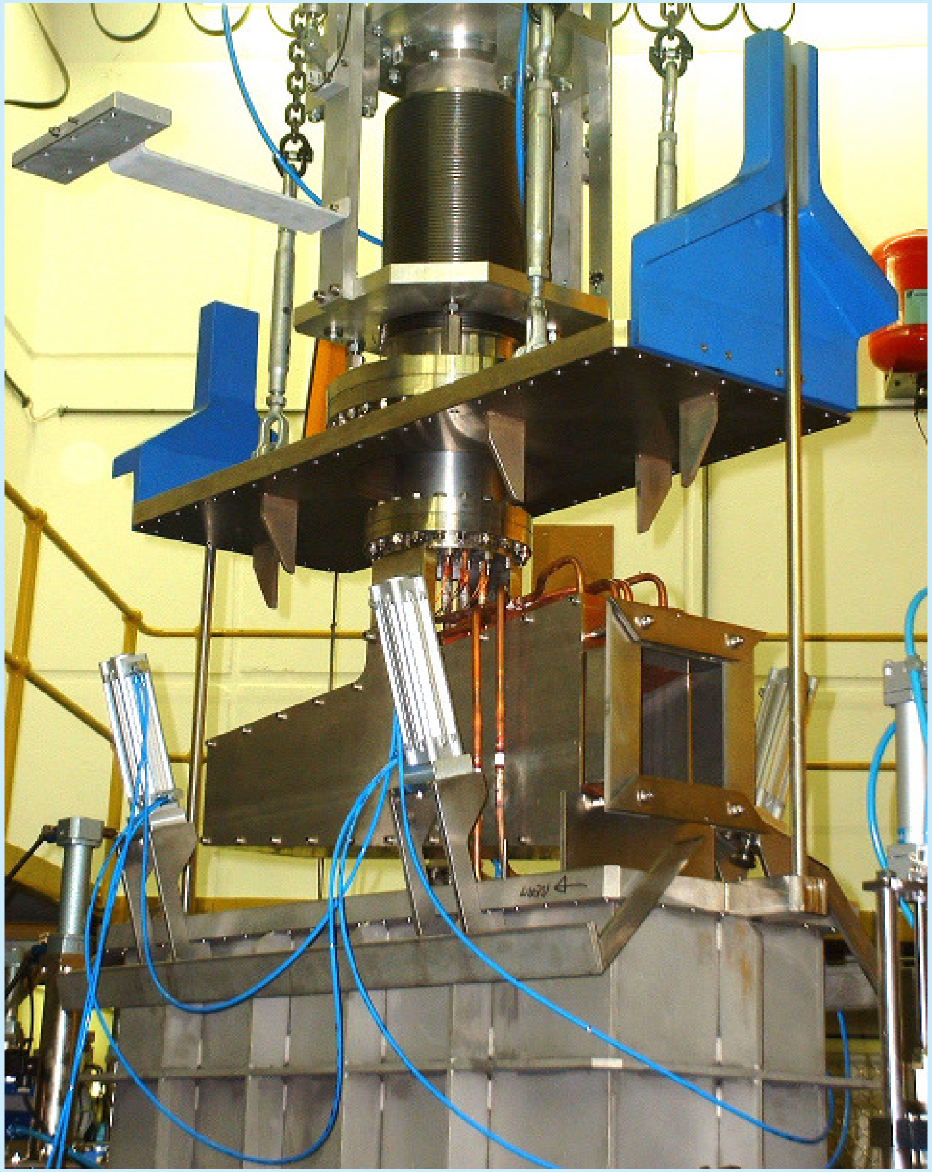
11. target
12. water tanks with a 4% ammonium pentaborate solution
13. iron shield
14. borated paraffin-wax shield
15. support structure.

New beam line with beam splitting for radioisotope production

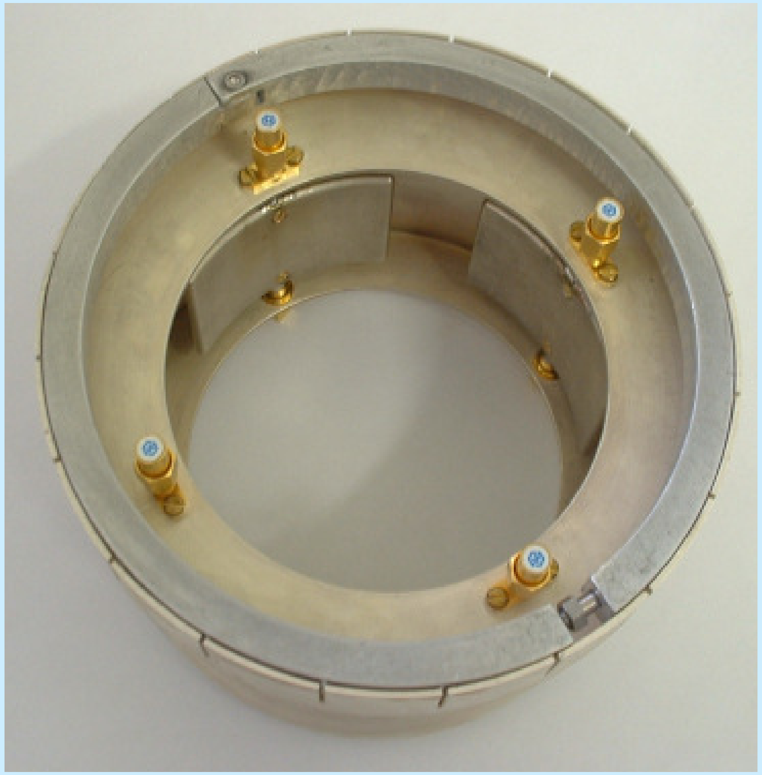


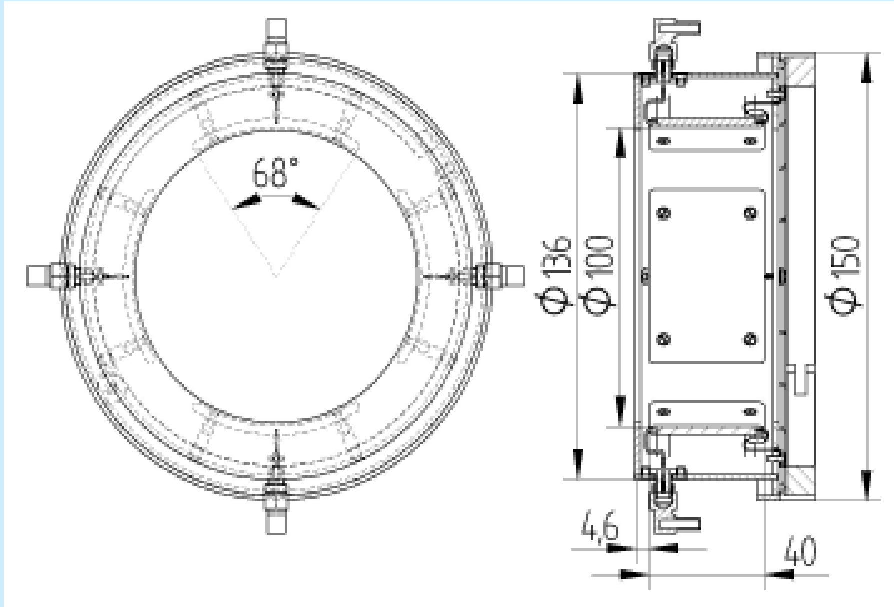
The planned beam lines for supplying two targets, simultaneously, with beam for radionuclide production. The main components are the electrostatic channel EC, the septum magnet SPM, the bending magnet BM1and the existing switcher magnet SW. The bending magnet BM2 deflects the beam downward into the vertical beam line. Q, SM and D designate quadrupole magnets, steering magnets and diagnostic vacuum chambers, respectively.

Installation of the new high-power beam stop

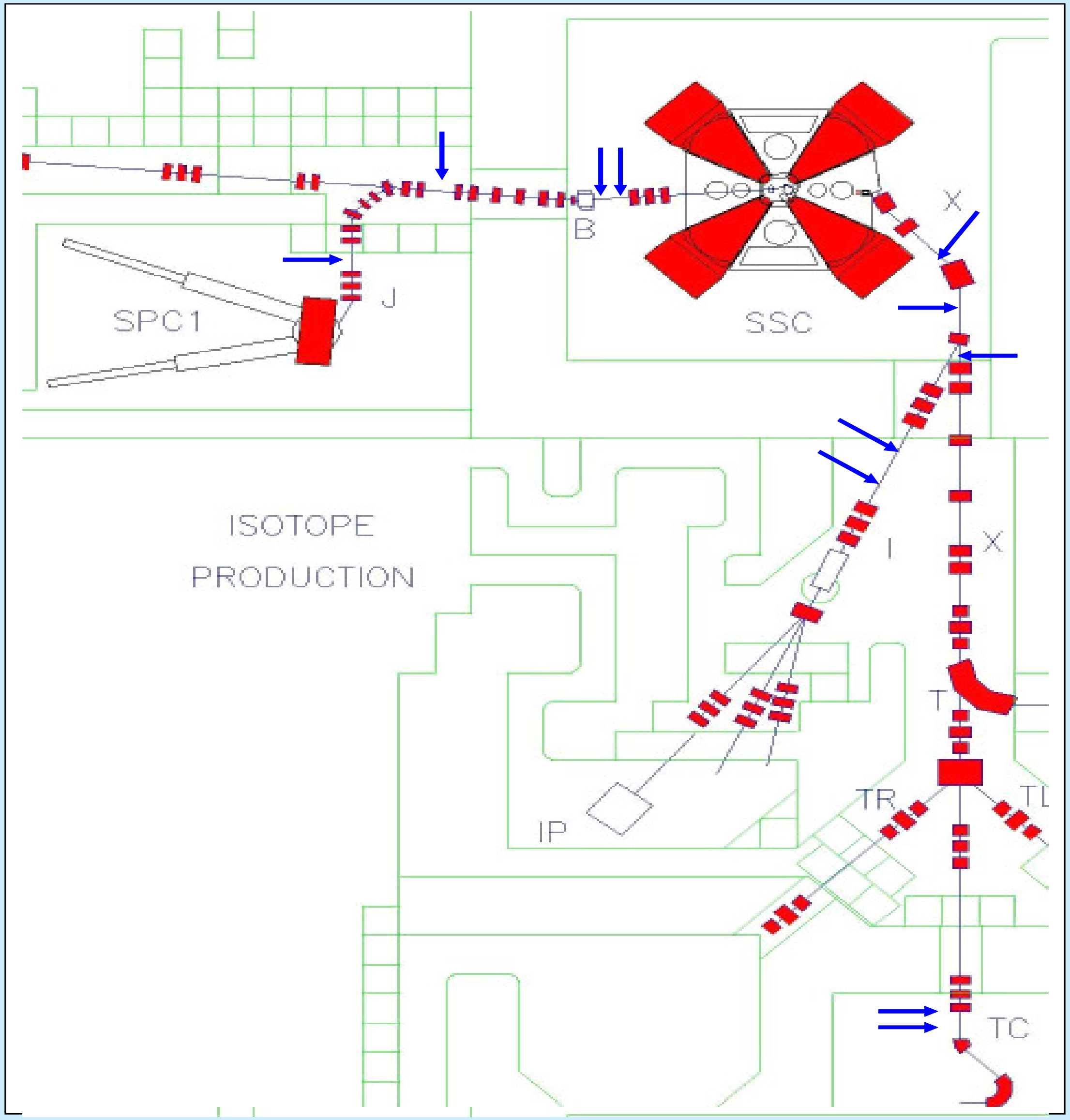


Non-destructive beam position monitor

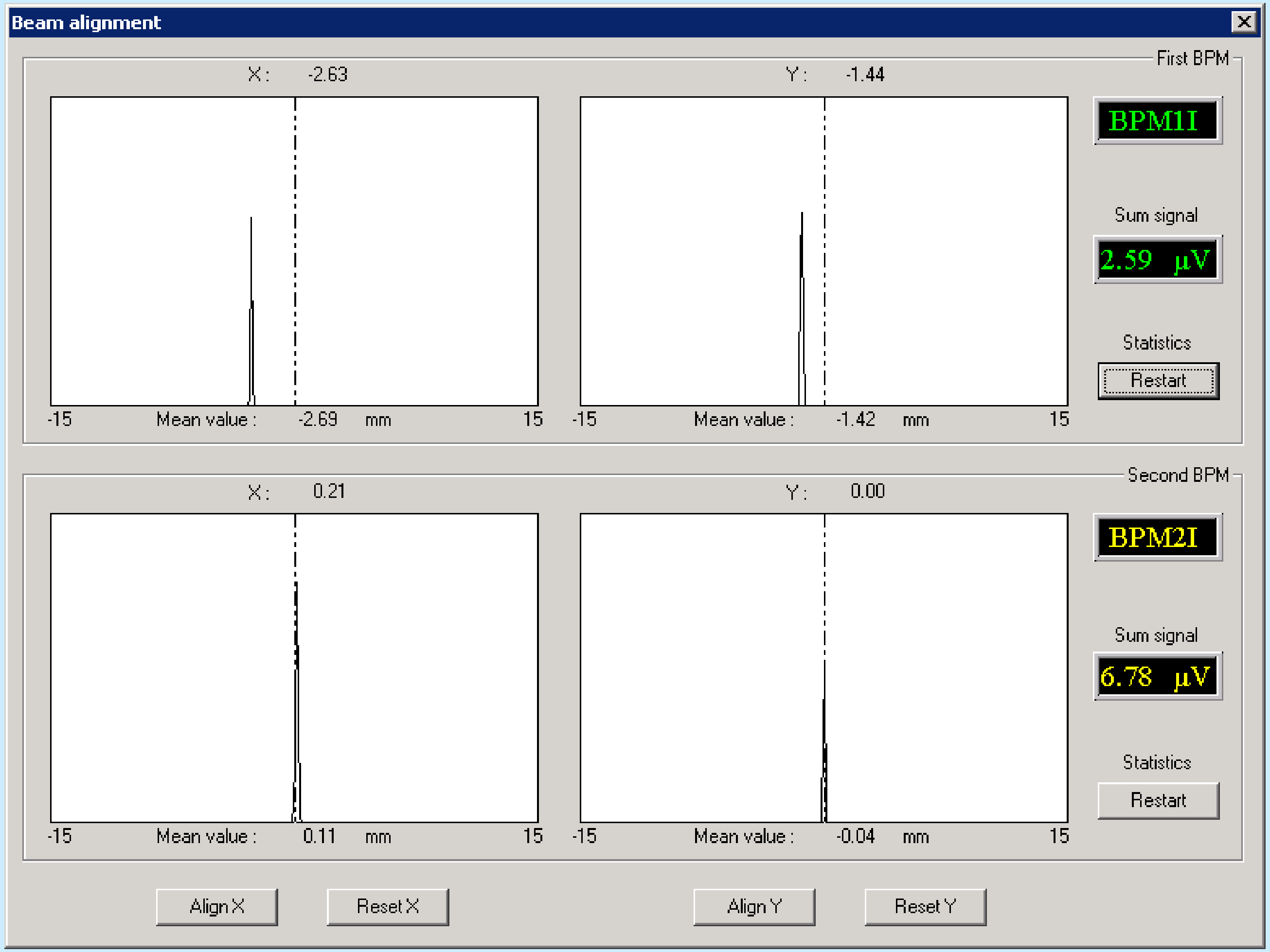




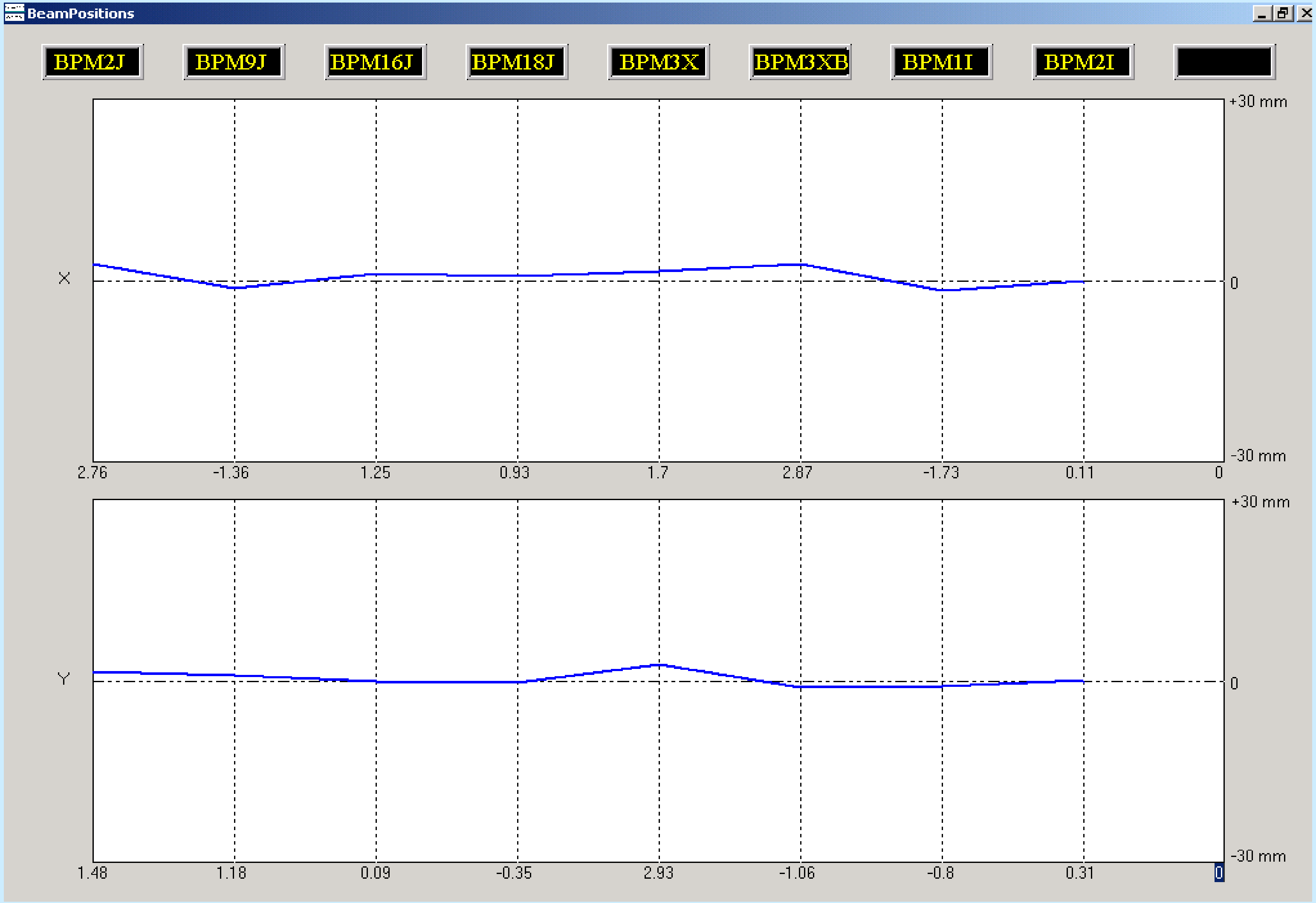
Positions at which BPMs have been installed



Beam position display with non-destructive beam position monitors after automatic alignment at the second monitor



Beam Alignment on x– and y– axes



The scale ranges are from minus to plus 30 mm.

I would like to thank the IAEA for the financial support.

Enkosi, Ngiyabonga, Kea le boga

Thank you !