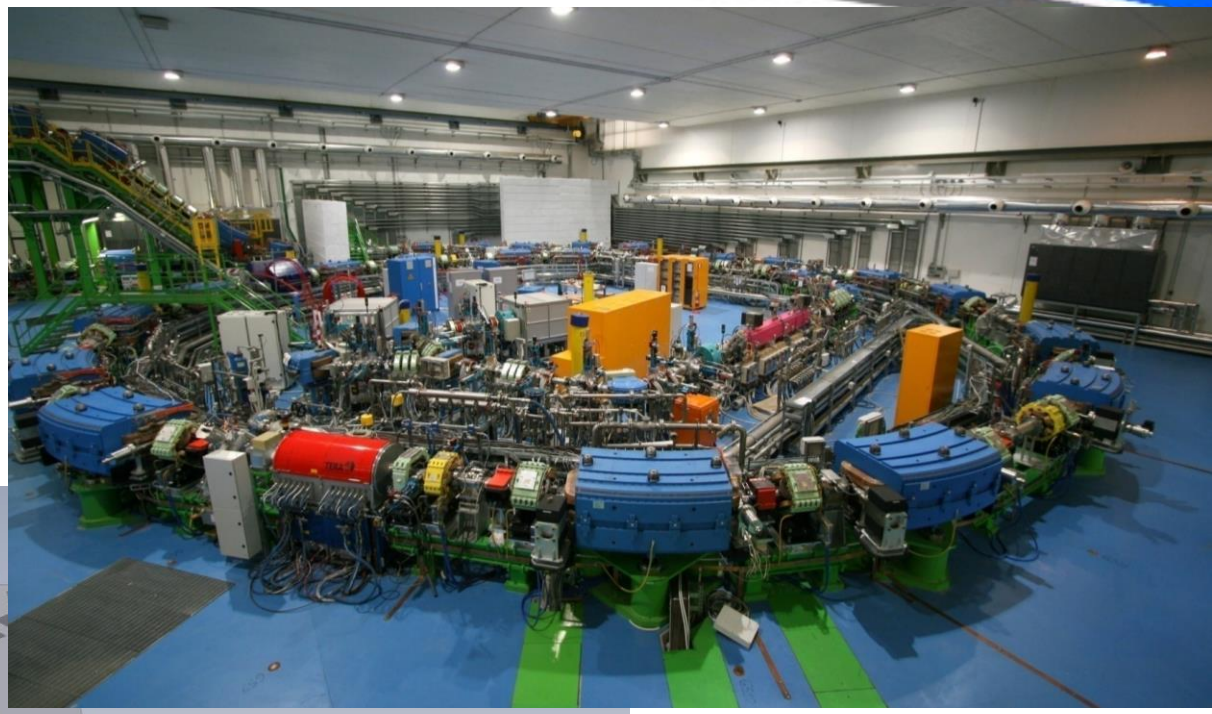
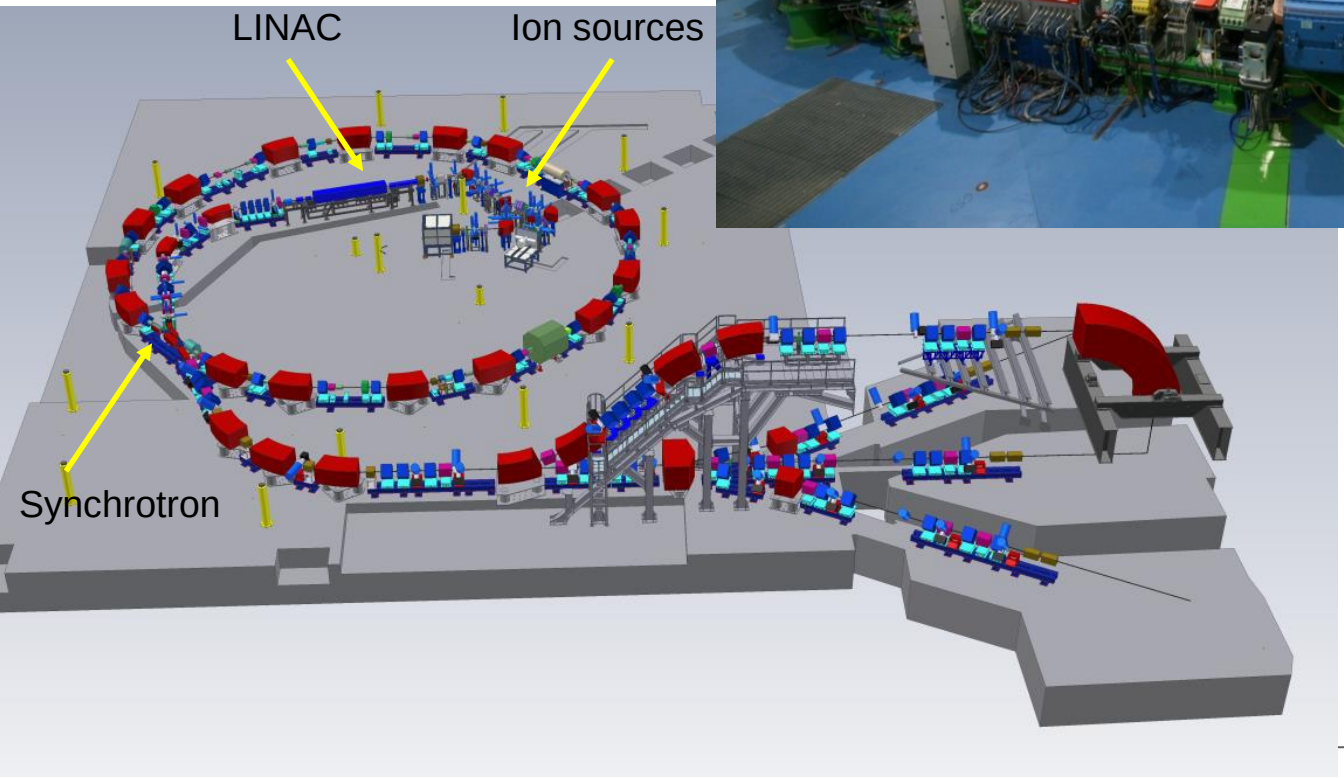
Possibilities of integration at CNAO

fondazione CNAO
Centro Nazionale di Adroterapia Oncologica

CNAO accelerator



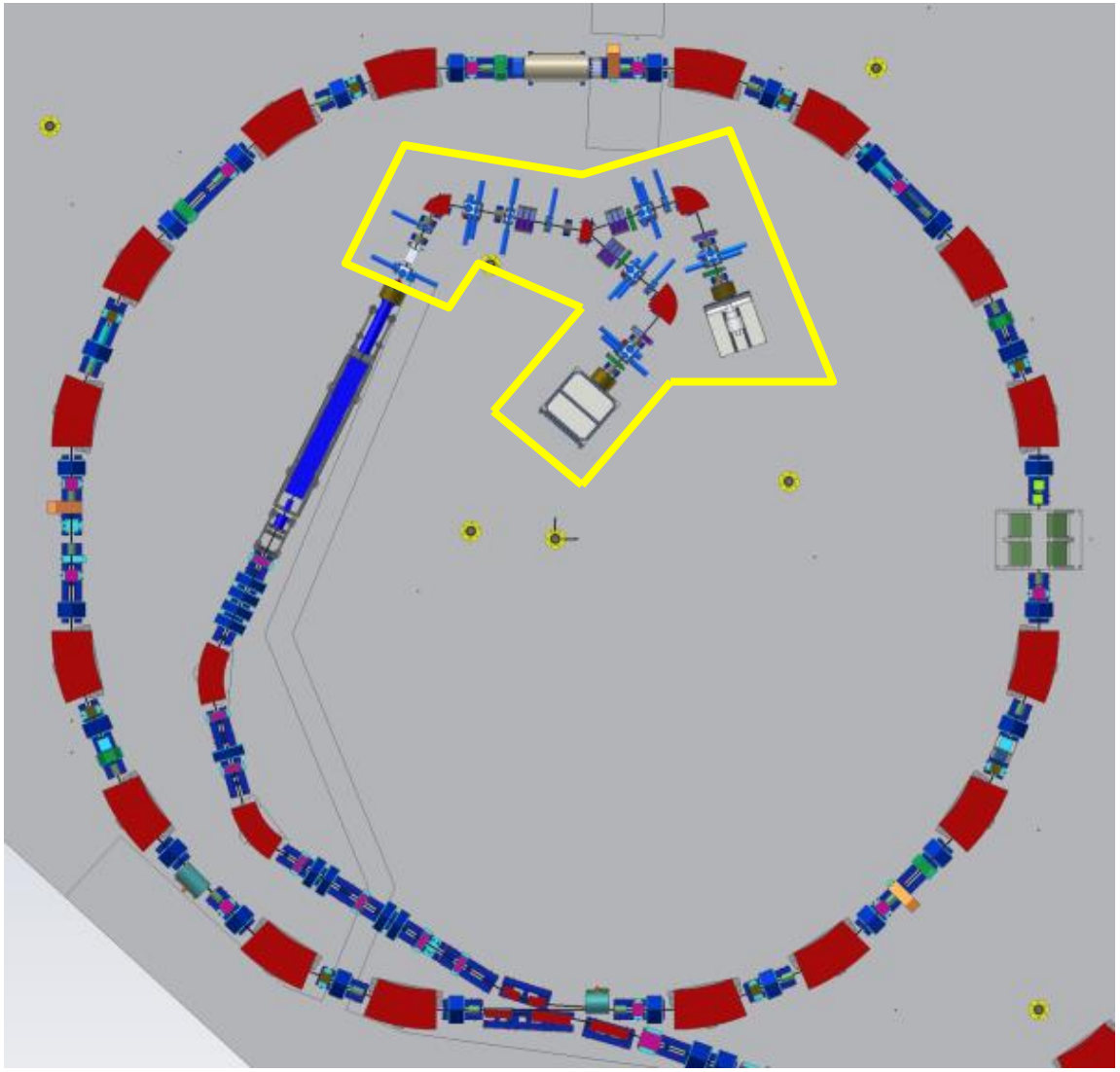


3 treatment rooms
4 beam lines

Design parameters

Beam particle species	p, He^{2+}, Li^{3+}, Be^{4+}, B^{5+}, C^{6+} (O^{8+}, Ar^{18+})
Beam range	from 3 g/cm^2 to 27 g/cm^2
Energy range	60 – 250 MeV for protons 120 – 400 MeV/u for carbon ions
Bragg peak modulation steps	0.1 g/cm^2
Range adjustment	0.1 g/cm^2
Adjustment/modulation accuracy	≤± 0.025 g/cm^2
Average dose rate	2 Gy in 2 liters in 3 minutes
Intrinsic dose delivery precision	≤± 2.5%
Nominal beam size	4 to 10 mm FWHM
Beam size stability	±10% or ± 1 mm (whichever is greater)
Minimum beam position step	0.1 mm
Field size	5 mm to 34 mm (diameter for ocular treatments) 2×2 cm^2 to 20×20 cm^2 (for H and V fixed beams)

LEBT



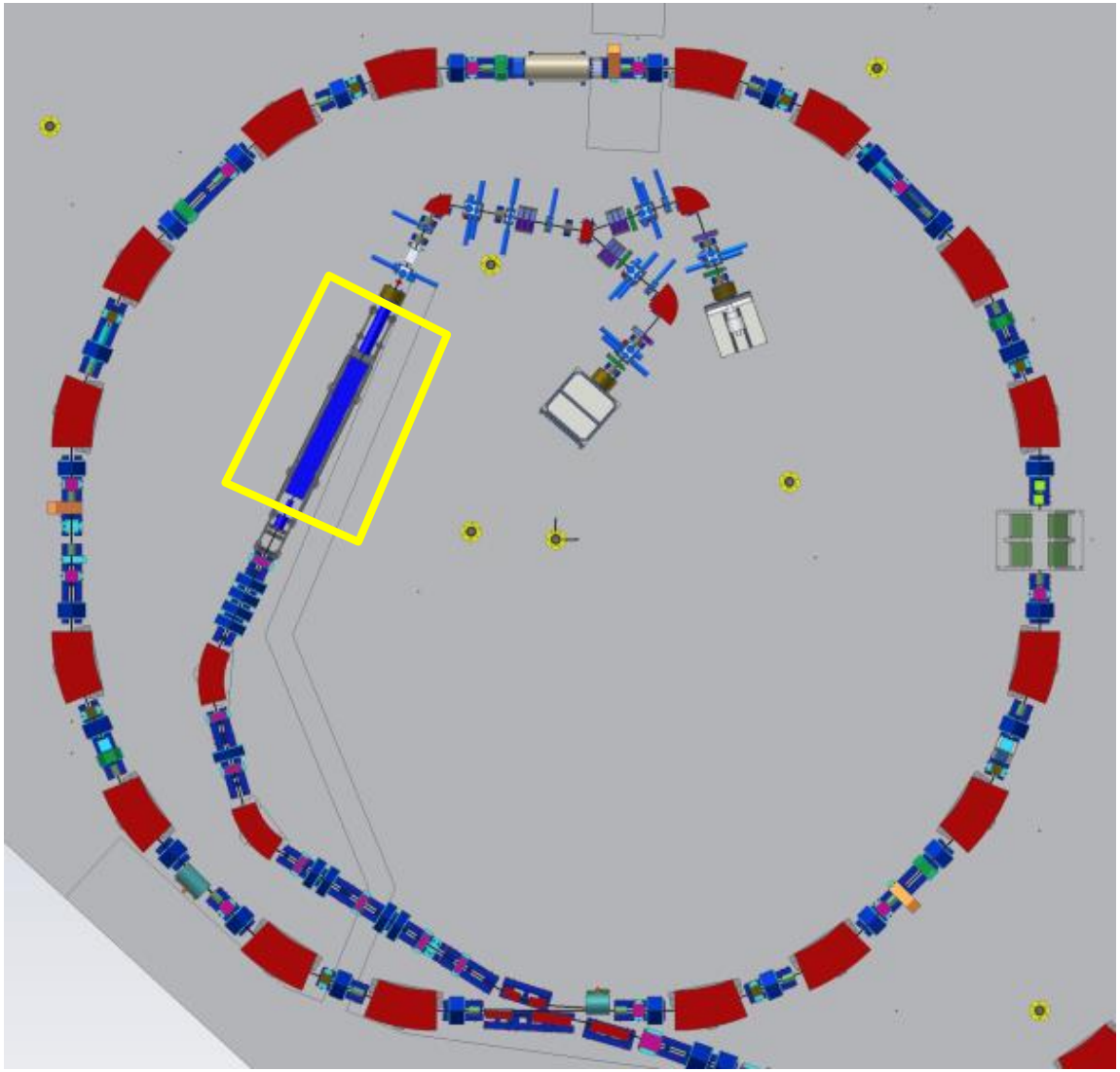
0.008 MeV/u H^{3+}
0.008 MeV/u C^{4+}

Two sources

Continuous beam

LEBT Chopper

RFQ-LINAC

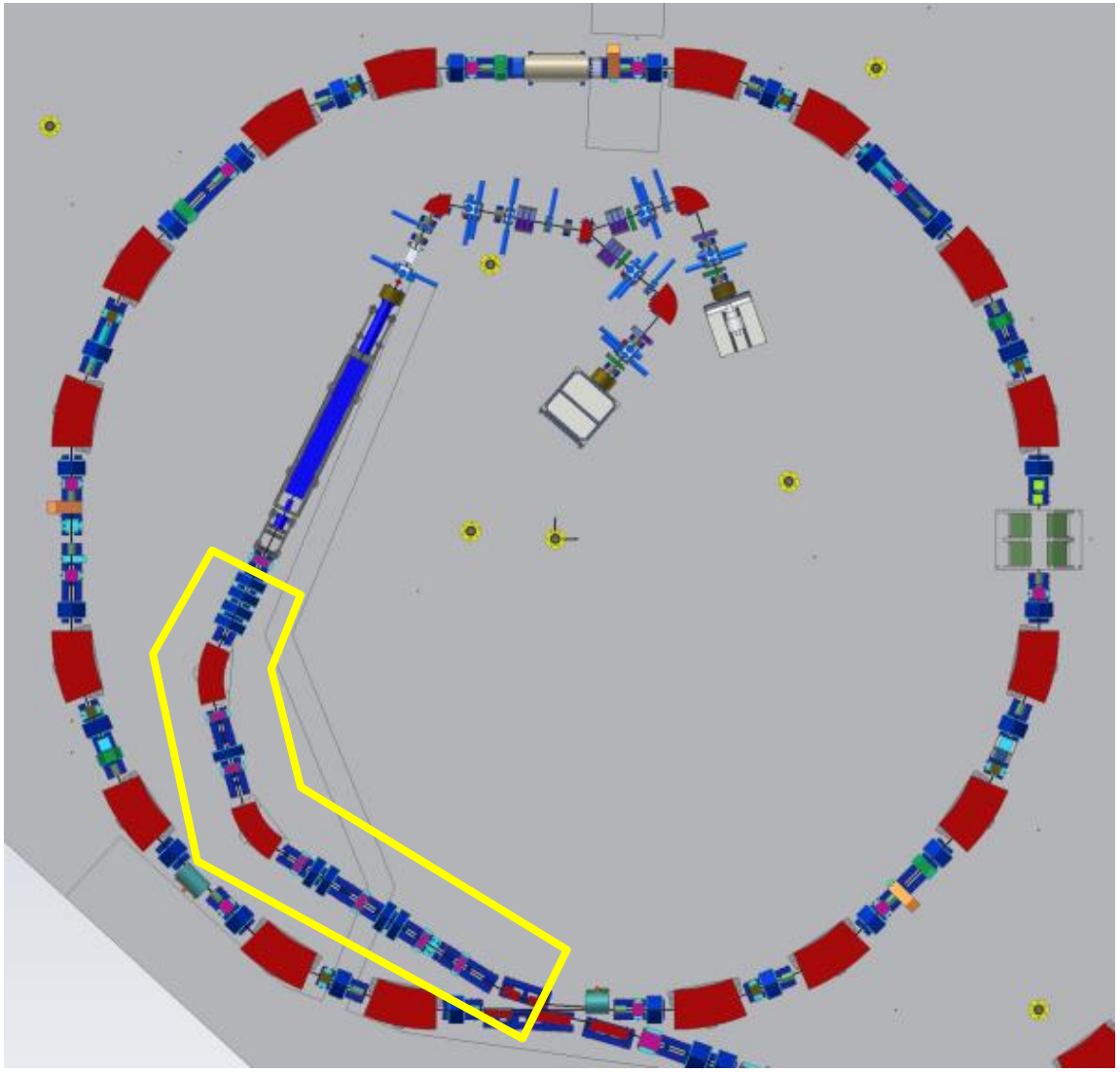


217 MHz

RFQ
0.008-0.4 MeV/u H^{3+}
0.008-0.4 MeV/u C^{4+}

LINAC
0.4-7 MeV/u H^{3+}
0.4-7 MeV/u C^{4+}

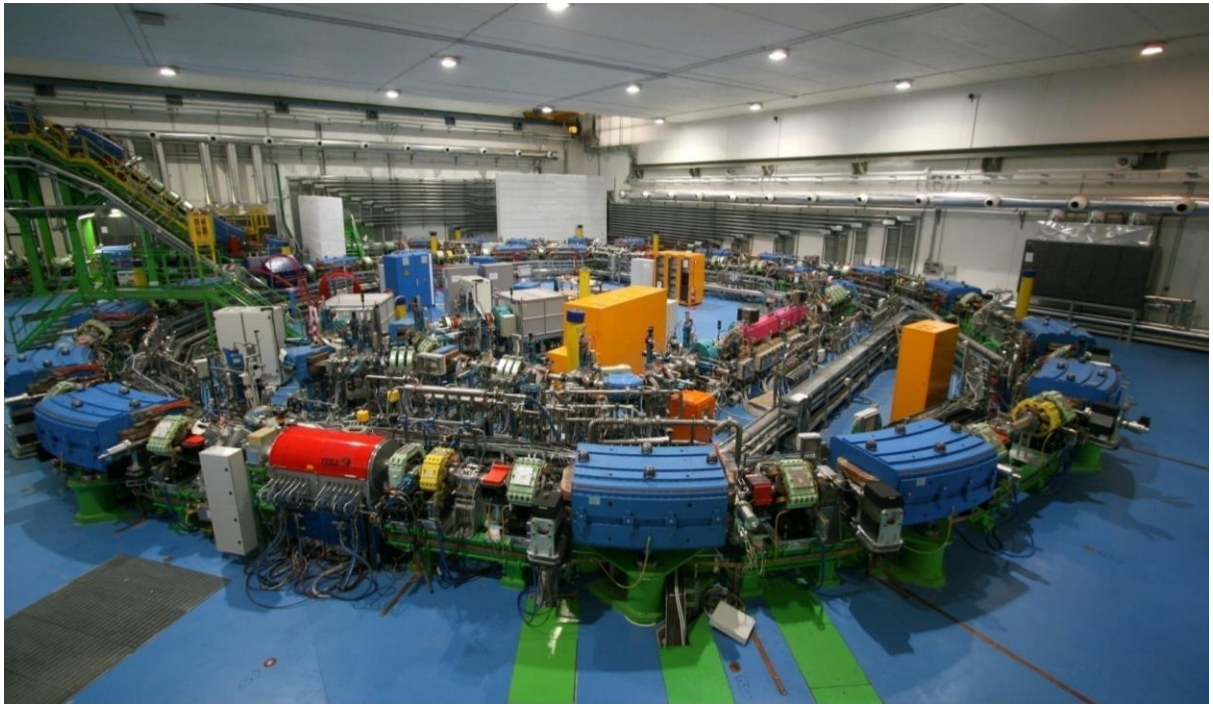
MEBT



Stripping foil

7 MeV p
7 MeV/u C^{6+}

- Injector inside ring, space limitations



Present performance

- 4 10^{8} ions/spill
- 100 μA of $^{12}C^{4+}$ to the LINAC, DC beam
  - used for < 100 μs => 10^{10} ions every 3s
- Present CO_2 consumption: 150 g/y (6.5 10^{16} s^{-1})
  - Different source needed…
- Turbo pumps on the source, gas to air

Requirements

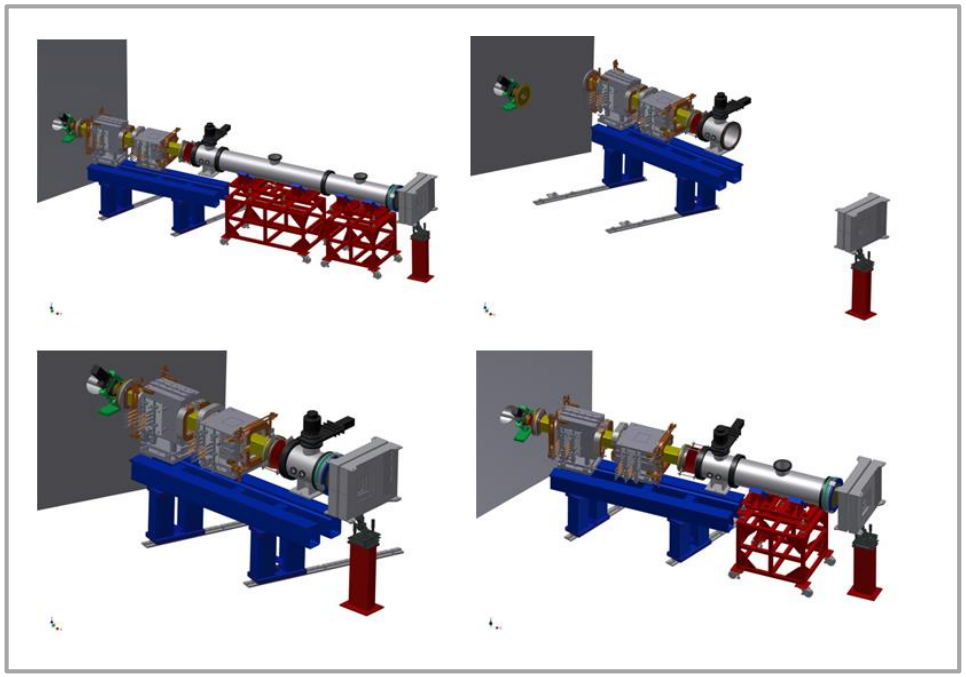
- 10 uSv/y to the public and at the fence
- 1 Bq/g for the air ejected out of the facility

- The output of the pumps must be collected and stored to let the ^{11}C decay before going to air

- We have to periodically scratch carbon away from faraday cups. It would become Boron in case of ^{11}C… (also elsewhere)

Ongoing and future developments

Experimental room



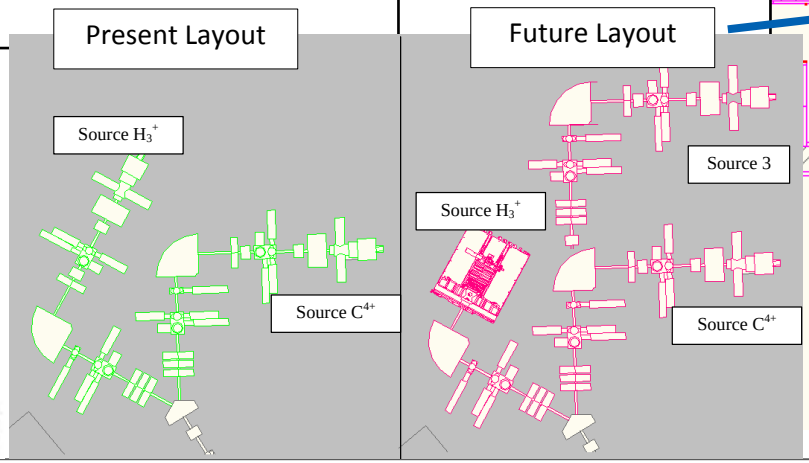
Installation in progress

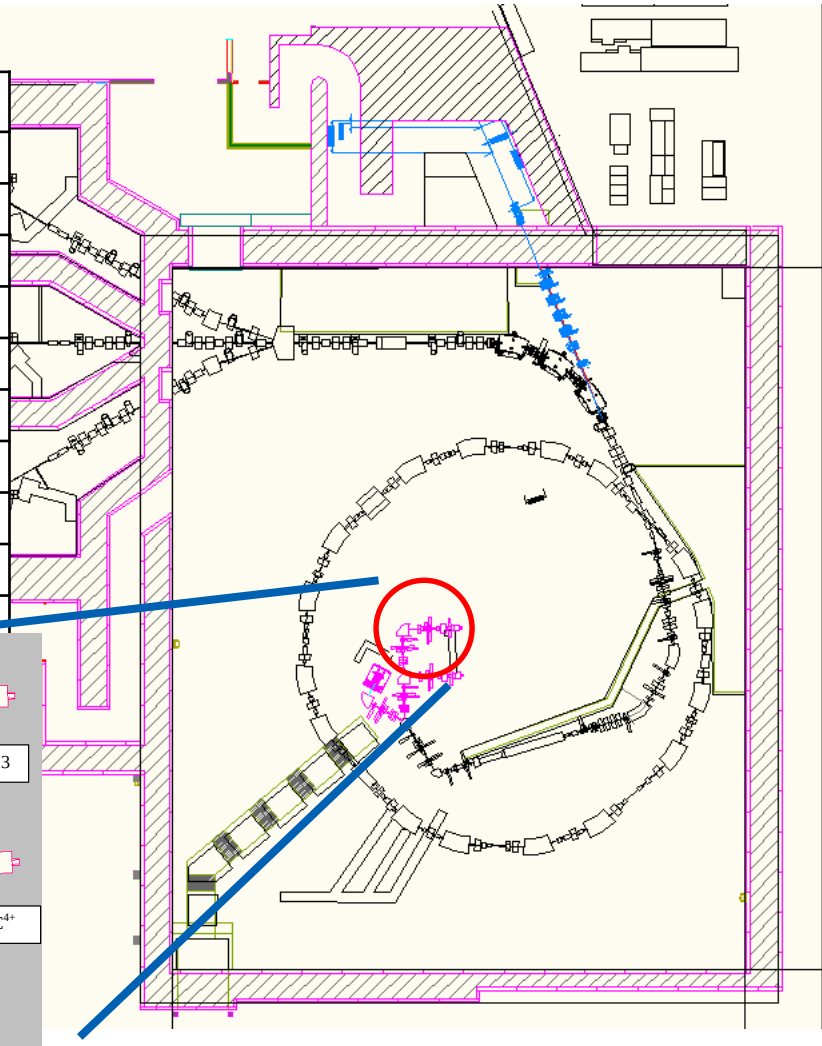
Experimental room – phase 2 – 3rd source

Additional ion species

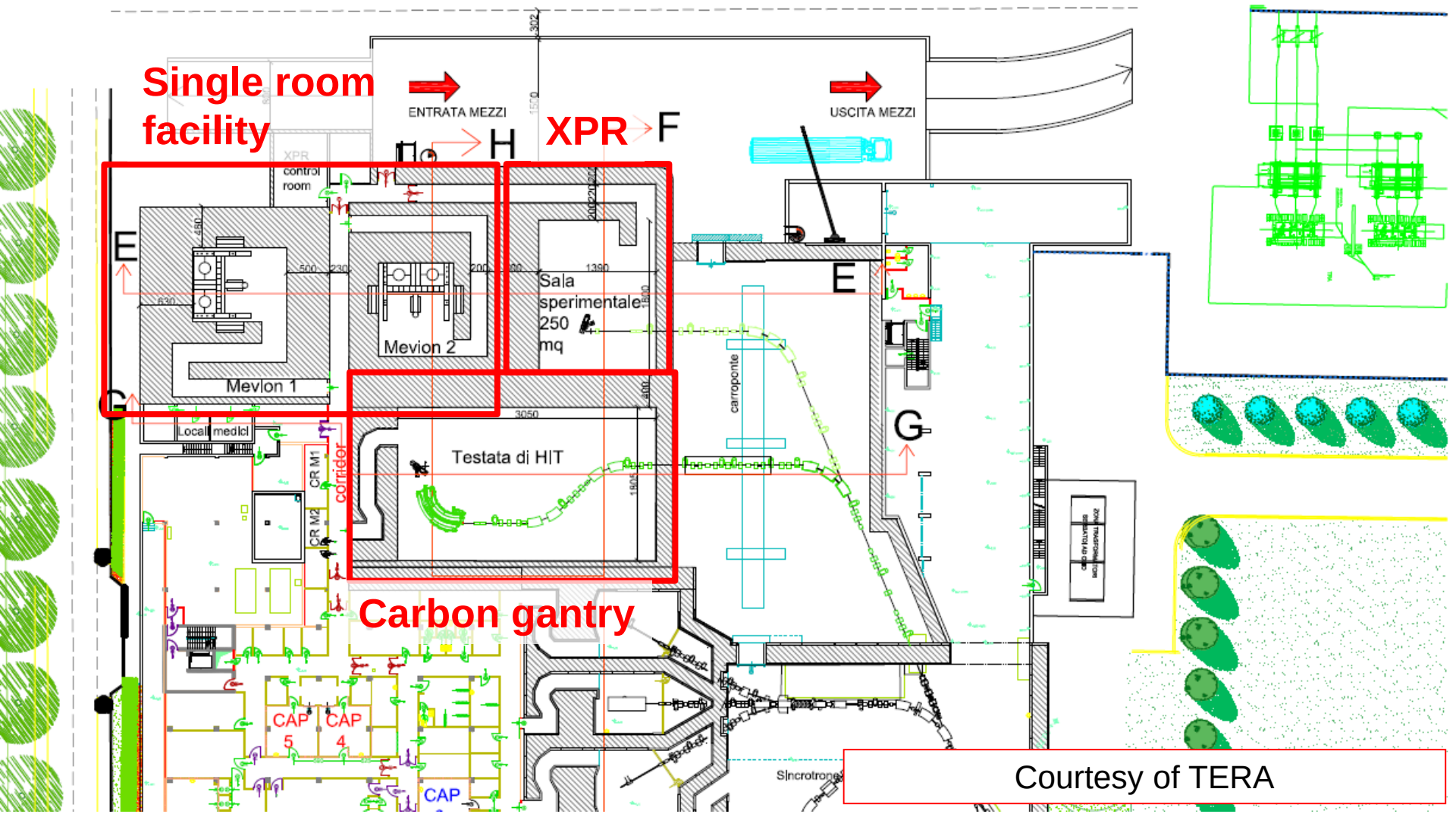
Higher performances source

Ion	SUPERNANOGAN (14.5 GHz)	AISHa (18 GHz + TFH)
	[μA]	[μA]
H^+	2000	4000
H^{2+}	1200	2000
H^{3+}	800	1000
$^3He^+$ - $^4He^+$	800	2000
$^{12}C^{4+}$	200	800
$^6Li^{2+}$	//	600
$^{18}O^{6+}$	250	1000
$^{16}O^{6+}$	400	1200
$^{21}Ne^{7+}$ -$^{20}Ne^{7+}$		





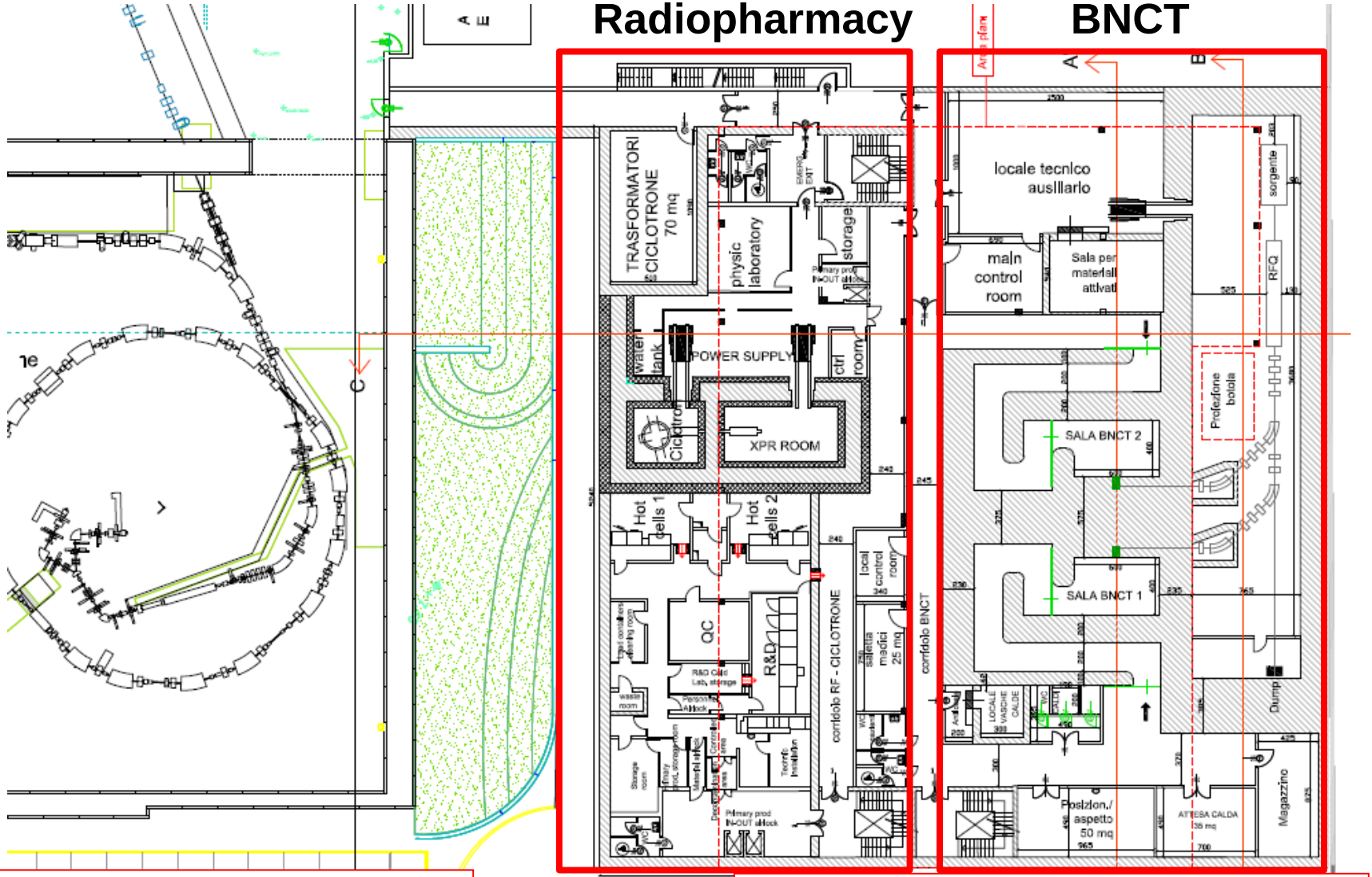
Expansion Area 1



Courtesy of TERA

Work in progress

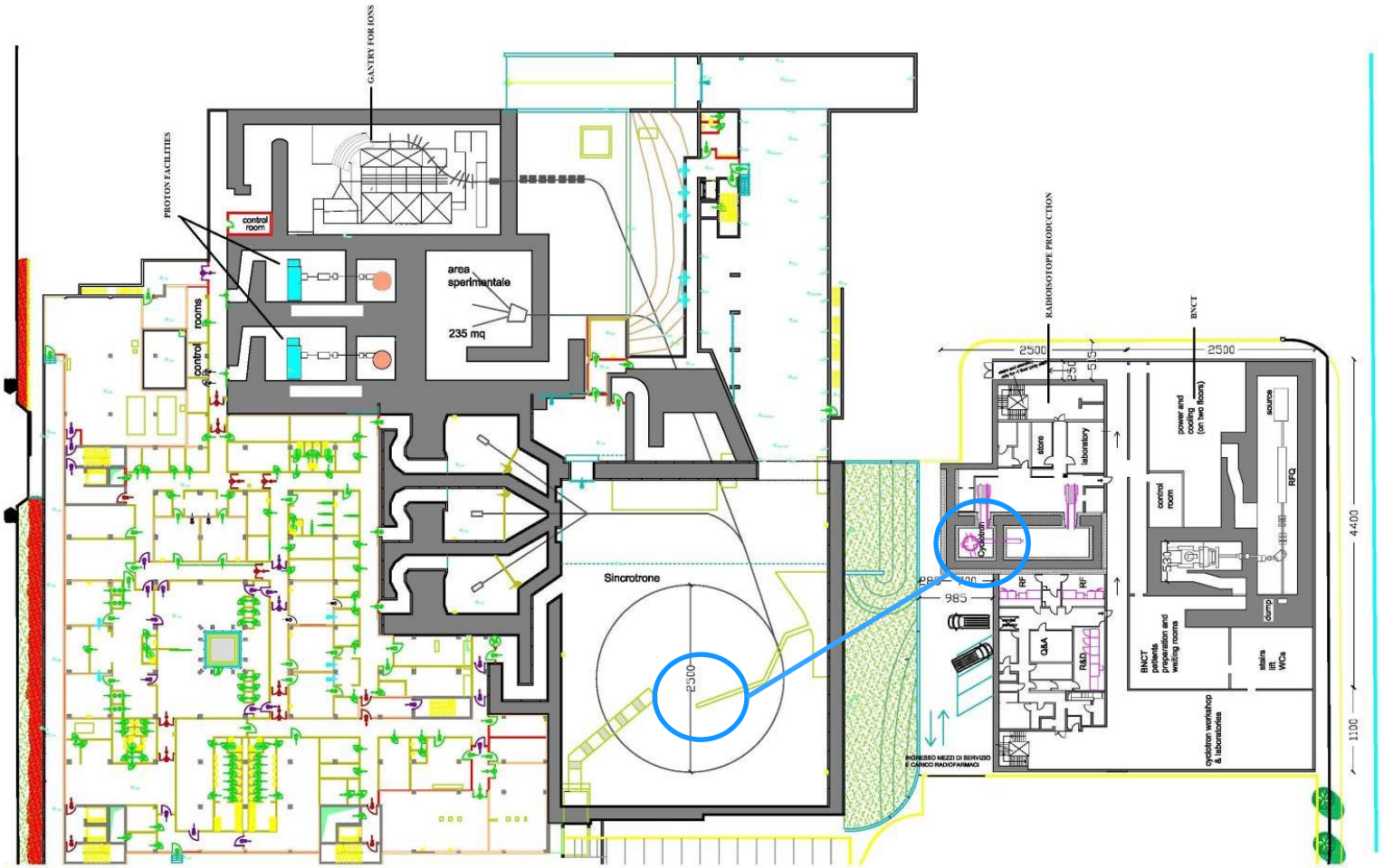
Expansion Area 2



Work in progress

Courtesy of TERA

C11 for improved online imaging?



Thank you for your attention

“Physics is like sex: sure, it may give some practical results, but that's not why we do it. ”

R. Feynmann

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