Case Study Work
Group 5

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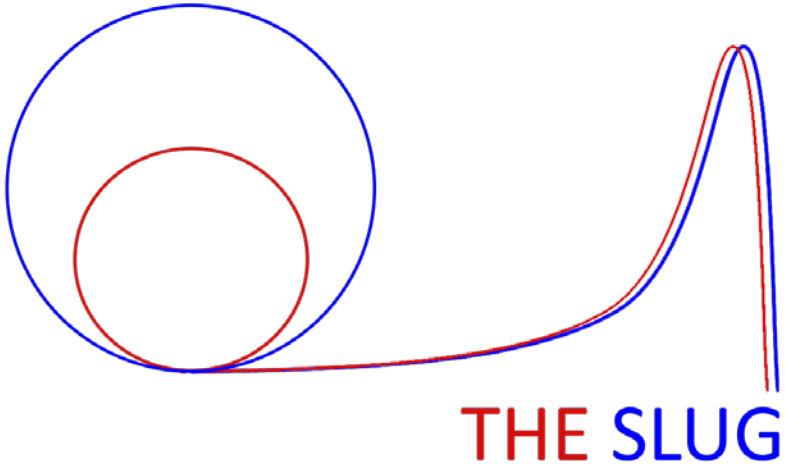
What we want

- build the first particle therapy facility in our country Neverland
- modular machine which could be duplicated in smaller solution
- a treatment facility and a research user facility

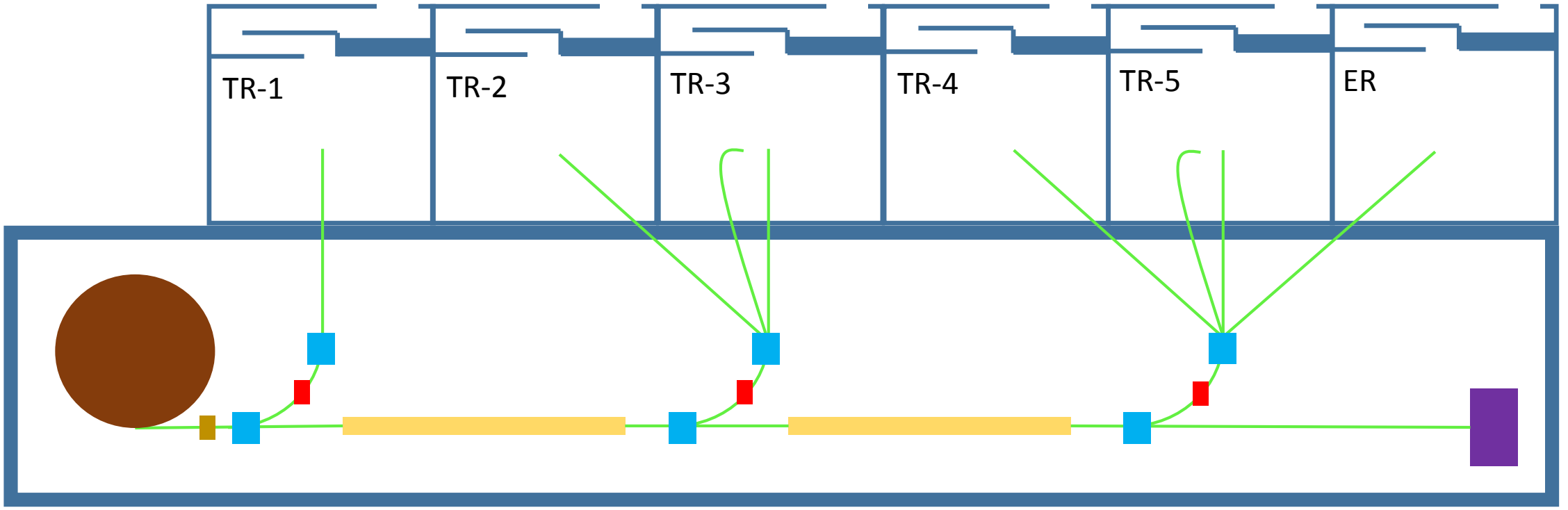
Our choice is a cyclinac

- to treat with protons and carbon ions
- to have 5 treatment rooms
- to have 1 room as user-facility purpose for clinical and non clinical research in which we will also provide helium and oxygen ions
- a modular and scalable design to improve its commissioning

THE SLUG CYCLINAC FACILITY

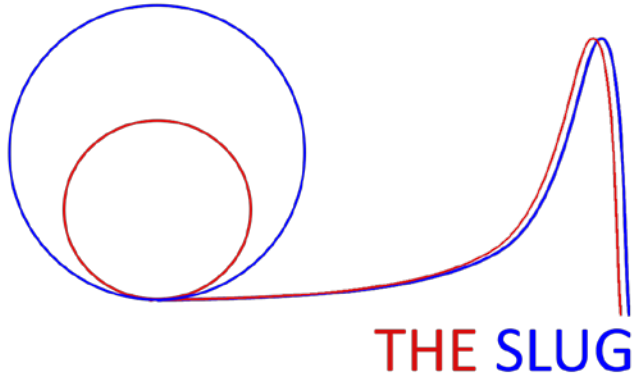


Building dimension: 70 m x 25 m



Control room, data center, PCO and klystron on the upper floor

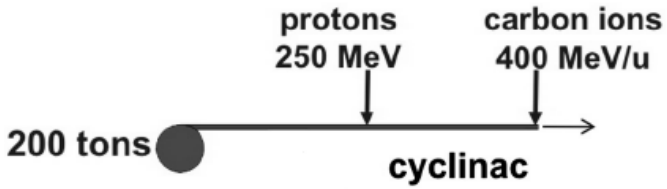
Why the SLUG cyclinac?

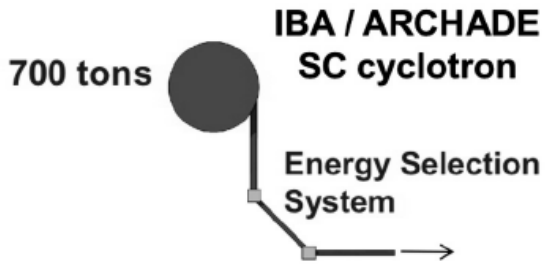


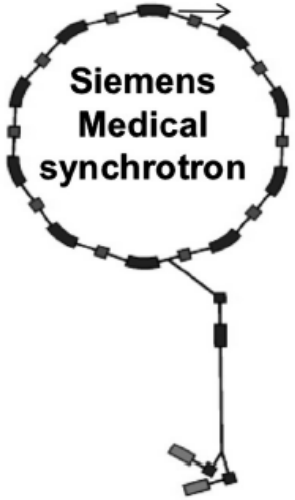
Compact and modular design

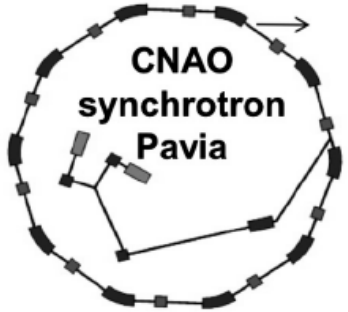
- Cyclotron diameter: 6m
- Total Linac length: 22m

- Smaller and cheaper bunker!
- 3 phases of commissioning!









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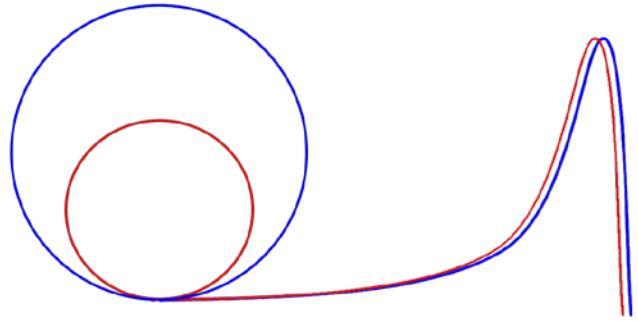


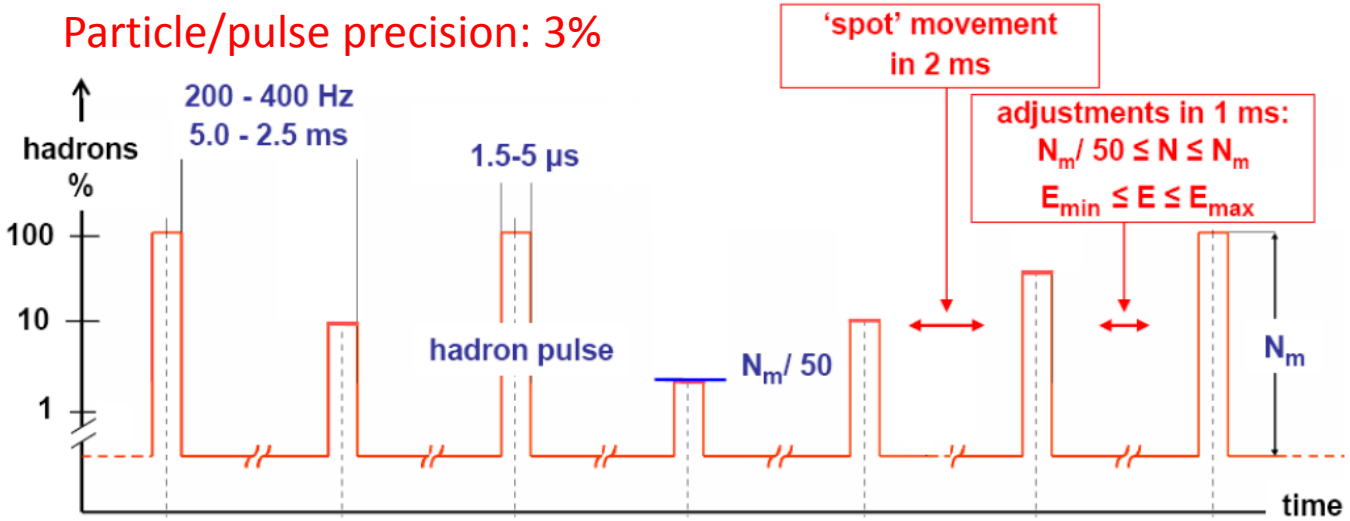
Beam time profile

- Active scanning system
- Spot-Scan: 4D Multipainting
- No carbon ions degrader!

- Time & count driven DDS!
- Short treatments! (<5 min.)
- Moving organs!

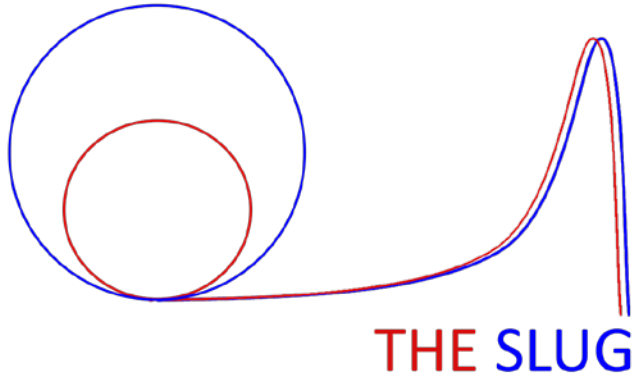
Accelerator	The beam is always present?	The energy is electronically adjusted?	What is the time to vary E_{max}?
Cyclotrons	Yes	No	≥50 ms
Synchrotrons	No	Yes	1 s
Cyclinacs	Yes	Yes	1 ms

Particle/pulse precision: 3%



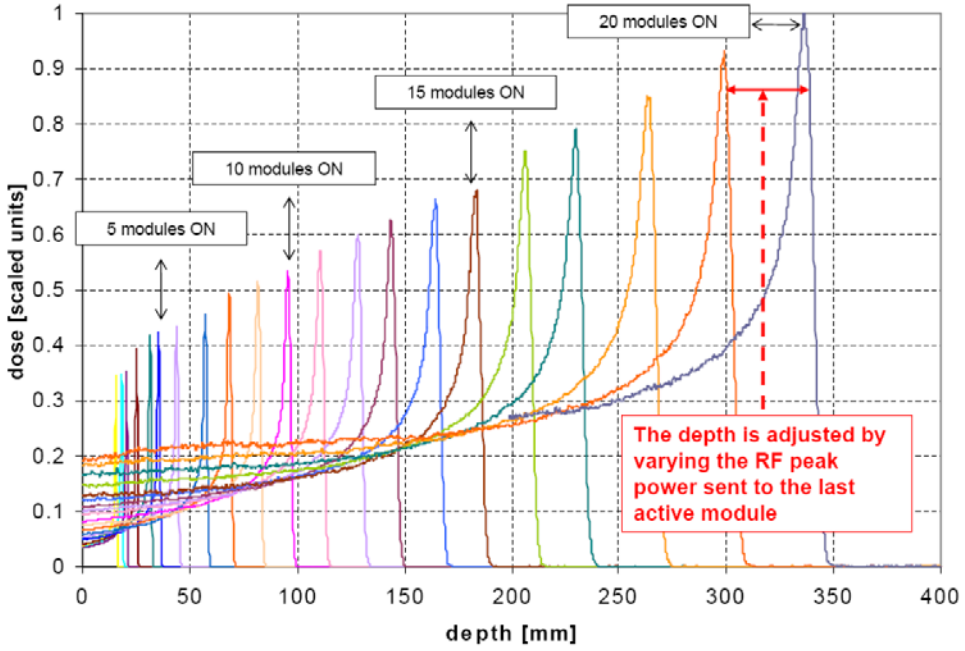
Spot size (FWHM): 12 mm @protons 173 MeV
5 mm @carbon ion 330 MeV

Technical specification

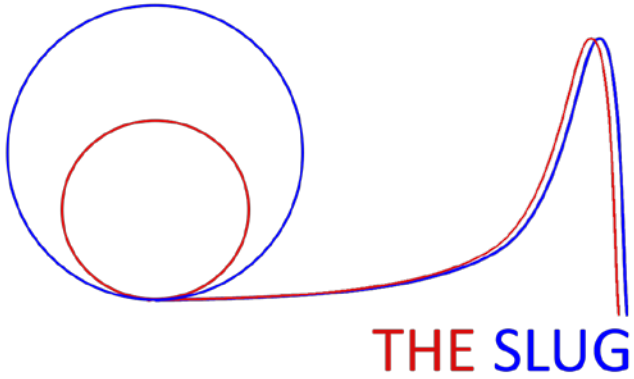


- 3+1 EBIS-SC Sources:
  - Species: H_2^+, C^{6+}, [O^{8+},He^{2+}]
  - Vertical injection
  - Beam intensity: 3.5 x 10^{11}/s @carbon ions – 1.1 x 10^{11}/s @protons
  - Repetition rate: 100 Hz / source
- Cyclotron: [commercially available]
  - Type: isochronous
  - Output beam energy: 150 MeV/u
  - Weight: 200 tons
  - Diameter: 6m
  - Magnet rigidity: 3.92 Tm
  - RF harmonic: 98 MHz
  - RF power supply: 110 kW
- Linac:
  - Full length: 22 m
  - RF: 5.7 GHz C-band standing-wave
  - Klystron power: 13 x 12 MW
  - Repetition rate: 300 Hz

Beam energy precision: 250 keV



TR-1 single room facility



Beam energy:
70 – 150 MeV @protons

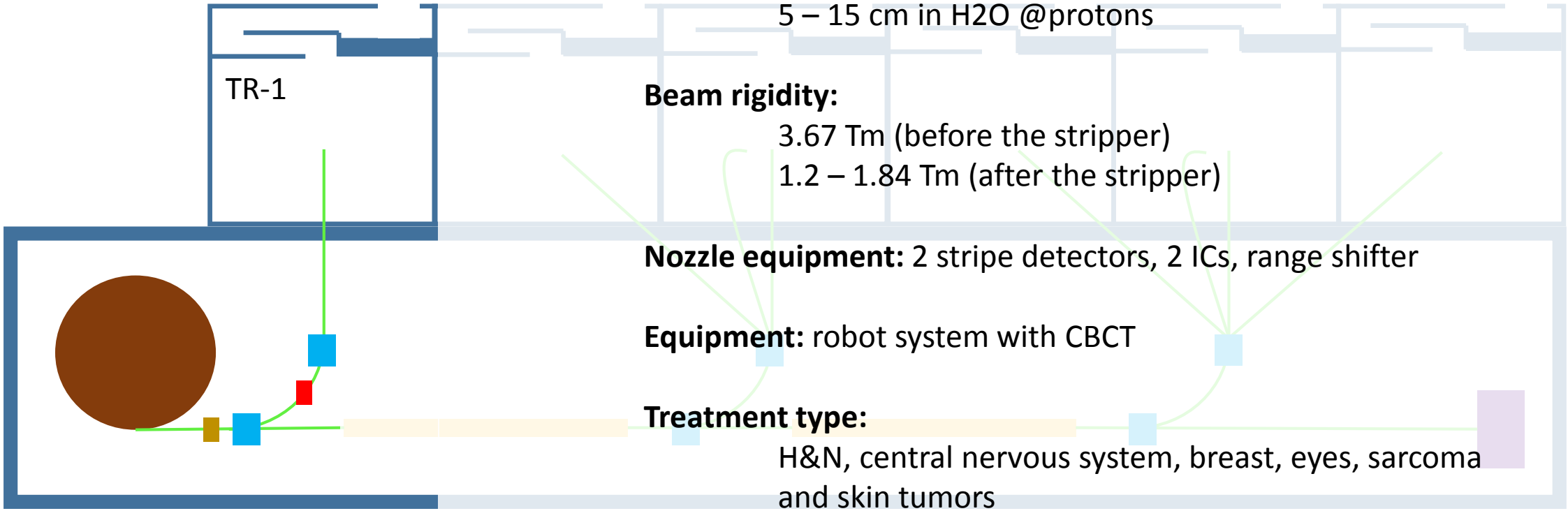
Beam range:
5 – 15 cm in H2O @protons

Beam rigidity:
3.67 Tm (before the stripper)
1.2 – 1.84 Tm (after the stripper)

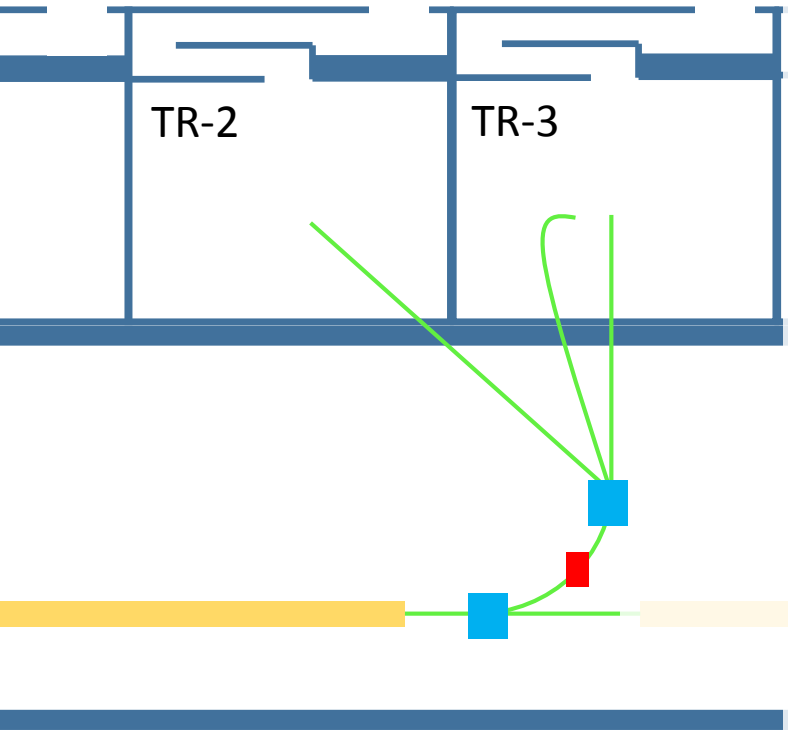
Nozzle equipment: 2 stripe detectors, 2 ICs, range shifter

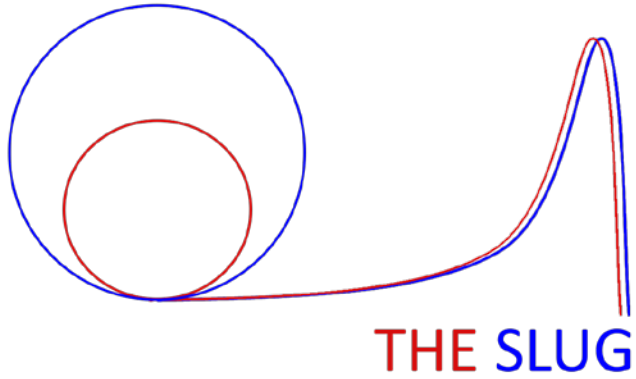
Equipment: robot system with CBCT

Treatment type:
H&N, central nervous system, breast, eyes, sarcoma and skin tumors



TR-2 and TR-3





Beam energy:
70 – 250 MeV @protons

Beam range:
5 – 37 cm in H2O @protons

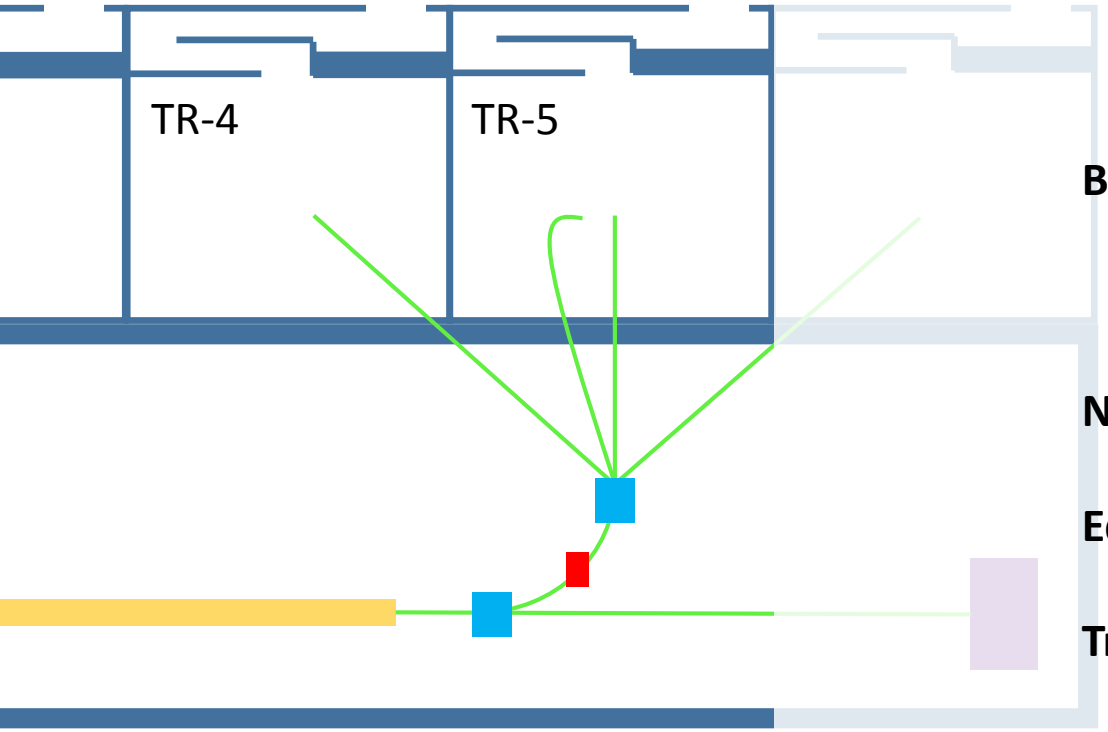
Beam rigidity:
3.67 – 4.86 Tm (before the stripper)
1.2 – 2.4 Tm (after the stripper)

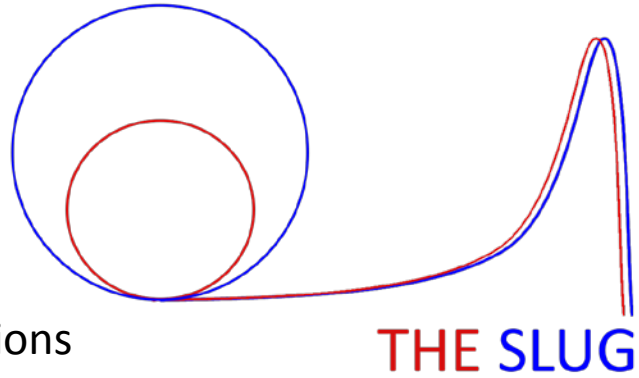
Nozzle equipment: 2 stripe detectors, 2 ICs, range shifter

Equipment: robot system with CBCT

Treatment type:
H&N, central nervous system, breast, eyes, sarcoma, skin, rectum, esophageal, uterus tumors

TR-4 and TR-5





Beam energy:

70 – 250 MeV @protons
150 – 400 MeV/u @carbon ions

Beam range:

5 – 37 cm in H2O @protons
2 – 27 cm in H2O @carbon ions

Beam rigidity:

3.67 – 6.36 Tm (before the stripper)
1.2 – 1.84 Tm (after the stripper only p+)

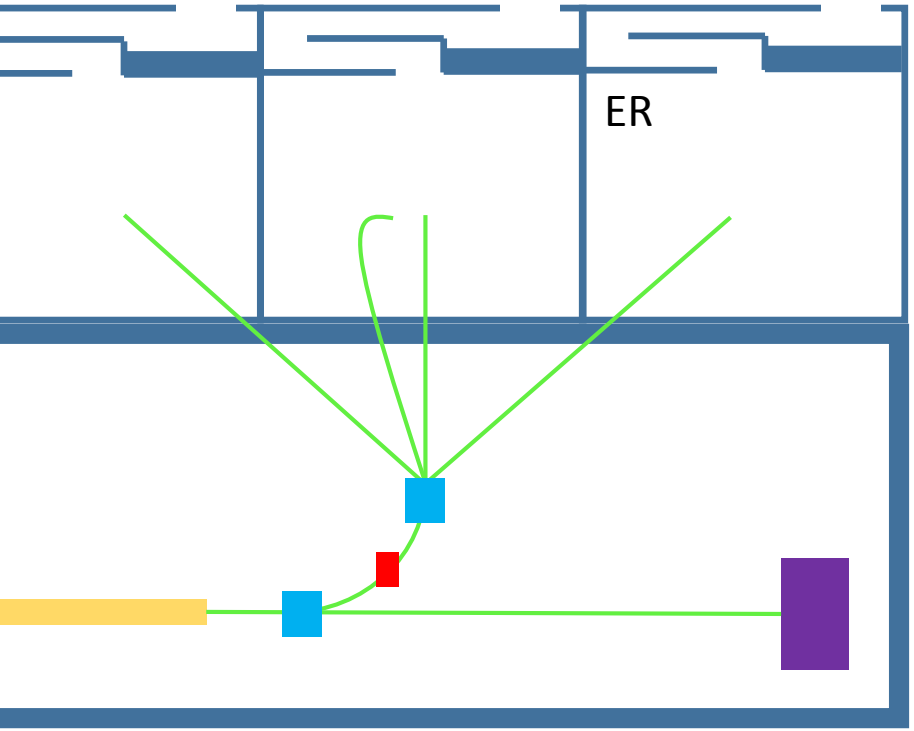
Nozzle equipment: 2 stripe detectors, 2 ICs, range shifter, ridge filter

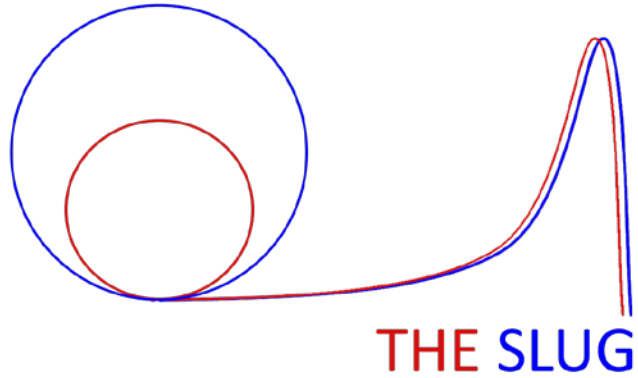
Equipment: robot system and 4DCT

Treatment type:

H&N, central nervous system, breast, eyes, sarcoma, skin, rectum, esophageal, uterus and lung tumors

ER user facility





Beam energy:

70 – 400 MeV protons
150 – 400 MeV/u helium
150 – 400 MeV/u carbon ions
150 – 400 MeV/u oxygen

Beam range:

5 – 82 cm in H2O @protons and helium
2 – 27 cm in H2O @carbon ions
3 – 20 cm in H2O @carbon ions

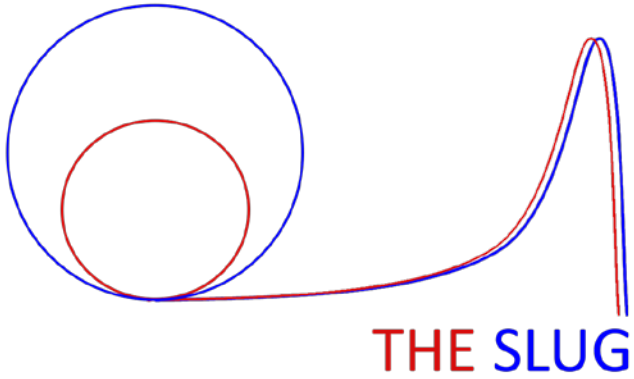
Beam rigidity:

3.67 – 6.36 Tm (before the stripper)
1.2 – 1.84 Tm (after the stripper only p+)

Nozzle equipment: 2 stripes detectors, 2 ICs, range shifter, ridge filter

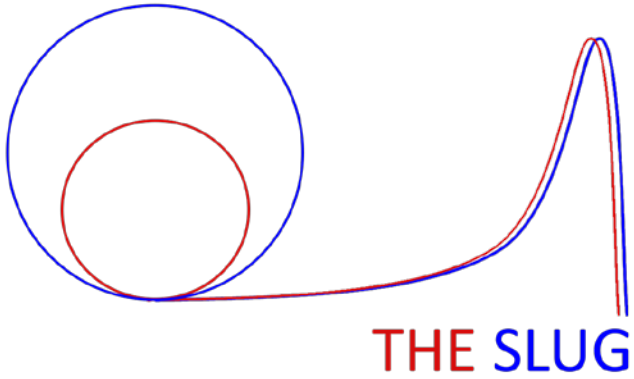
Research: QA, beam hardness, radiobiology, proton RX, etc…

Patients capacity



- Number of patients per year: about 2100
- Assumed number of fractions: 10 to 25 fractions
- Number of fields per fraction: 1 to 4
- Time needed per patient handling: 10 min
- Time dedicated to treatments: 4.5 h / patient
- Machine development and maintenance: weekends and 2 weeks / year

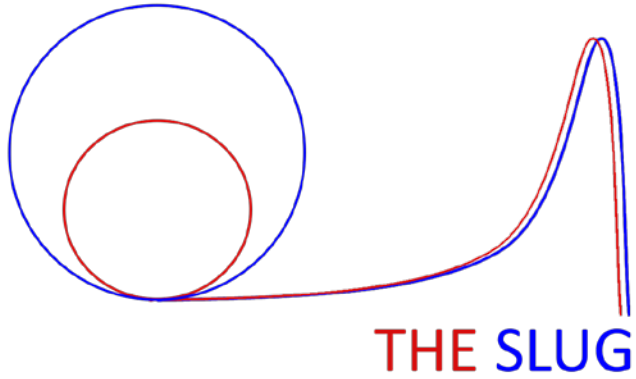
Time line after final design



- Construction: 2 years
- Accelerator commissioning: 2 + 2 + 1.5 years
- Beam qualification: 8 months
- Clinical trials: 1 year

Financial framework

Elements	Cost (Mio Euro)
Real Estate	40
4 Ion Sources	13
1 Cyclotron	30
2 Linacs	50
15 Dipoles 45deg + PCO	8
30 Quad + PCO	3
2 Dipole 90Deg + PCO	2
8 Scanning Magnets + PCO	2
200m of Beam pipes + Vacuum system	2.5
Beam Diagnostics	5
6 DDS + DDI	2.5
6 Irradiation Room equipment	15
TOTAL	**173**



Annual Revenue

- Income by imbursement fees: 42 Mio € (2100 patients for 20.000€)
- Research funding: 3 Mio € (depending on project amount)

Annual Expenses

- Employees: 9.6 Mio € (70 Workers)
- Facility maintenance: 2 Mio €
- Income tax: 10.5 Mio €
- Initial interest: 7.5 Mio € (5% of loan)


Grazie per l'attenzione!
Ačiū už Jūsų dėmesį!
Thank you for your attention!
Happy birthday Martina!!!
Vielen Dank fur Ihre Aufmerksamkeit!
Merci pour votre attention!