Sarajevo Linac Project

MARIUSZ SAPINSKI (SEEIIST)

HEAVY ION THERAPY SCHOOL, MAY 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Situation and Motivation

There is a limited experience in accelerator techniques in the South East Europe region e.g.:

- Electrostatic machines in Ruđer Bošković Institute in Croatia
- Cyclotrone for radioisotope production in Macedonia
- Cosylab (Slovenia) – accelerator control software company recognized world-wide
- i-tech (Slovenia) – another world-wide recognized company specialized in accelerator electronics

New accelerators will surely appear in the region, so there is a need of education in various related techniques:

Vacuum, RF-systems, beam measurements, ion sources, etc.

This is how the idea of accelerator laboratory at University of Sarajevo was born

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The story

Beginning 2020 - Yiota and Eddy discuss ways to support and develop University of Sarajevo

around May 2020 - idea of establishing new accelerator labolatory is born

June 2020 – first proposal is written, it foresees ECR ion source in first phase and RFQ in second phase
main application: accelerator laboratory, extraction system optimization; future SEEIIST hub

October 2020 – two students: Fehima and Benjamin start working on the project, doing market research and
looking at application of light ions

November 2020 – establishing task force at University of Sarajevo (E. Hasovic, A. Gazibegovic-Busuladzic)
to coordinate the project

January 2021 – discussions with experts at CERN to establish basic source specification

April 2021 – preparing technical specification for phase I; CERN-UNSA-Cosylab collaboration agreement

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Baseline proposal

WEPRO083 Proceedings of IPAC2014, Dresden, Germany

IMPLEMENTATION OF A SUPERCONDUCTING ELECTRON BEAM ION SOURCE INTO THE HIT ION SOURCE TESTBENCH

E. Ritter*, A. Silze, DREEBIT GmbH, Großröhrsdorf, Germany
G. Zschornack, TU Dresden and Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany
R. Cee, T. Haberer, A. Peters, T. Winkelmann, HIT, Heidelberg, Germany

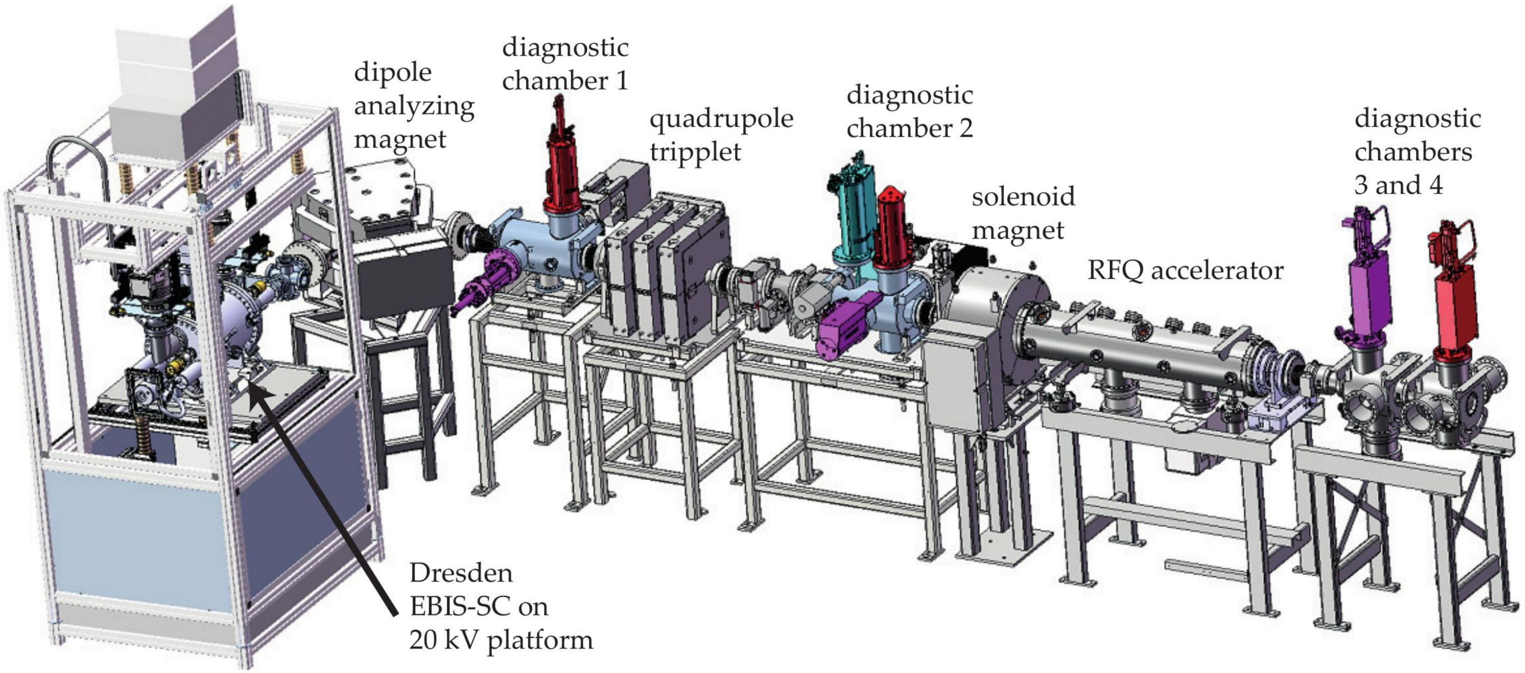

Figure 1: 3D CAD model of the testbench with the Dresden EBIS-SC (from left: EBIS-SC with 20 kV-platform, dipole analyzing magnet, diagnostic chamber one with profile grid 1, analyzing slits, and Faraday cup 1, quadrupole tripplet, diagnostic chamber two with pepper pot, profile grid 2, and Faraday cup 2, solenoid magnet, RFQ accelerator, diagnostic chambers three, and four with a set of 3 phase probes, profile grid 3, and Faraday cup 3). The Faraday cups are colored in red, the grid profile monitors are colored in purple, and the pepper pot is colored in blue.

Inspired by:
Heidelberg Ion Therapy center testbench

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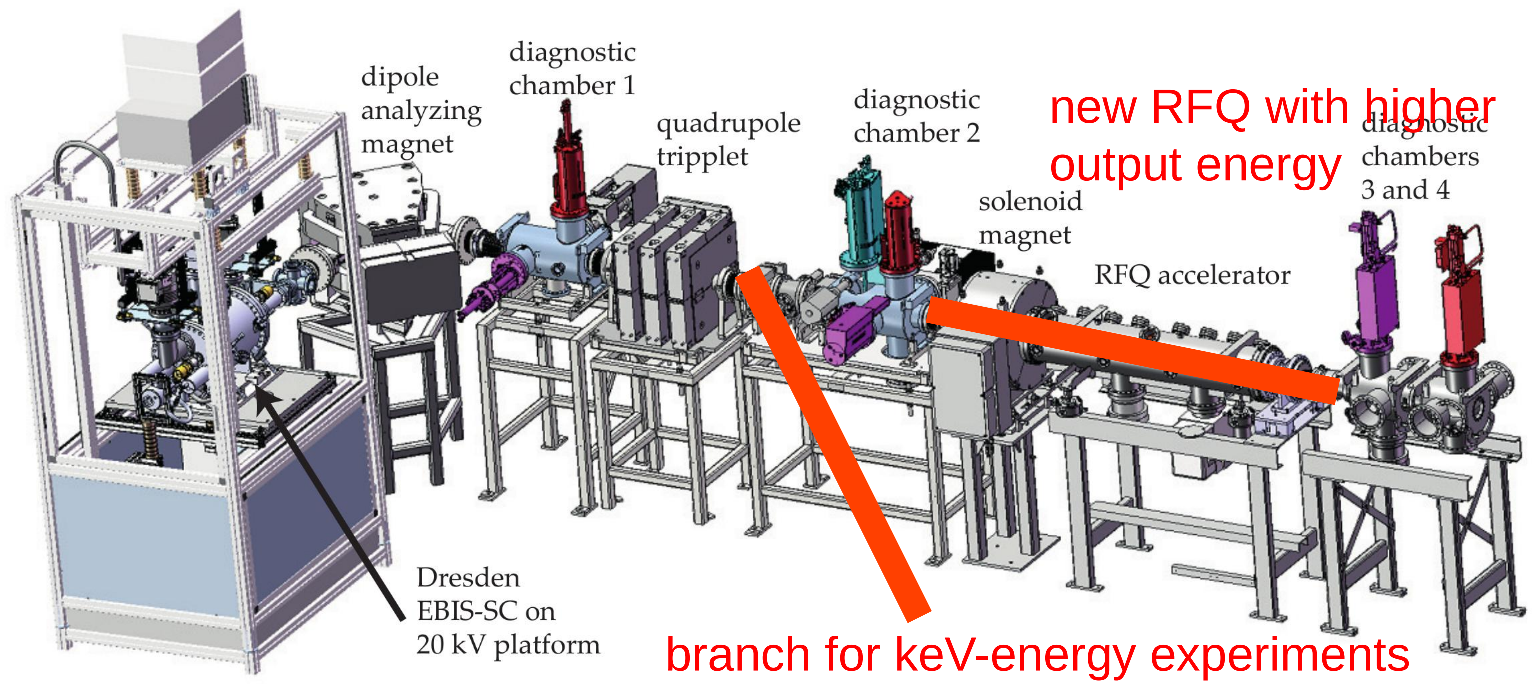

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- Phase I:
- ion source, analyzing magnet, beam transport and matching to RFQ
- Phase II:
- RFQ and beam transport to experimental stations

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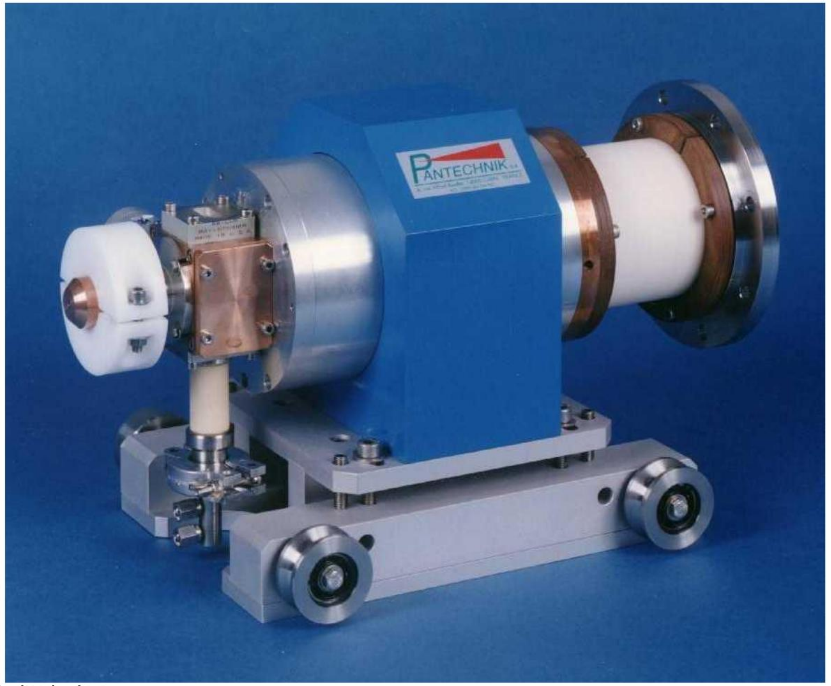
Phase I: Ion source

- Decided for ion source able to produce 100 µA $^{4}He^{2+}$ ion beam – eg. Nanogan from Pantechnik
- It is significantly smaller, easier to handle and cheaper than Supernanogan sources used to produce carbon beams at HIT, CNAO, MedAustron
- It can still produce measurable intensity of carbon beams and large intensity of protons
- Proposed usage: mainly PIXE and RBS methods (see Fehima’s presentation, Friday)
- Simulation of beam transport ongoing (see Benjamin’s presentation, Tuesday)



The source body includes:

- The magnetic structure of the source. Axial and radial field generated by permanent magnets.
- One plasma chamber copper made. The plasma chamber is leak checked before mounting on the source. Leak rate must be bellow 2.10^{-9} mbar.l/s. The plasma chamber is aligned with +/-0.2 mm respect to the beam axis.
- One plasma electrode ‘standard’ with 4 mm diameter.
- A RF cube: copper made cube to optimize the RF power transmission.
- A fixed RF fine tuner is mounted on the RF cube to match the source impedance, reduce the reflected power and optimize the beam extracted from the source.
- A pressurized quartz RF window makes the junction between the high vacuum and the atmospheric pressure.
- The gas is injected through a ceramic insulator.
- A DC bias system: in order to increase the efficiency of the source for high charge state ion beams, the coaxial tube, used for RF injection, is biased from few to hundreds of volts.
- The source is leak tested. A leak rate below 2.10^{-9} mbar.l/s is guaranteed.

The Nanogan® is about 11 kg weight.

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Phase I: Ion source – example of performance

ion / Q	1	2	4	6	8	9	12	14
H	1000							
He	1000	100						
Ar	300		140	45	40	10		
Xe							10	5
Ta					10		10	5
Au			10	9	8	6		2

Table 2: Maximum intensities obtained with Nanogan® ECR ion source. These intensities can be obtained once the source is well out-gased and with optimum conditions.

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Phase I: Timeline

- June 2021 – order out to the industry
- June 2022 – source delivered to CERN
- July 2022 – January 2023 – source tested at CERN; also used to test new 750 MHz M/Q RFQ which maybe the RFQ for Phase II
- End of 2022 – decision on the RFQ, ordering RFQ (phase II)
- January 2023 – source moved to UNSA
- May 2023 – Phase I setup commissioned at UNSA

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Phase I: control system and instrumentation

- Control system will be realized by Cosylab and UNSA; must be done in partnership with company providing the source
- The Cosylab control system will be used already for tests at CERN
- Tests at CERN: no need for instrumentation nor analyzing magnet (will use CERN ones)
- Instrumentation and analyzing magnet will be acquired separately for UNSA
- Instrumentation in collaboration with i-tech company

Local companies are involved from the beginning.

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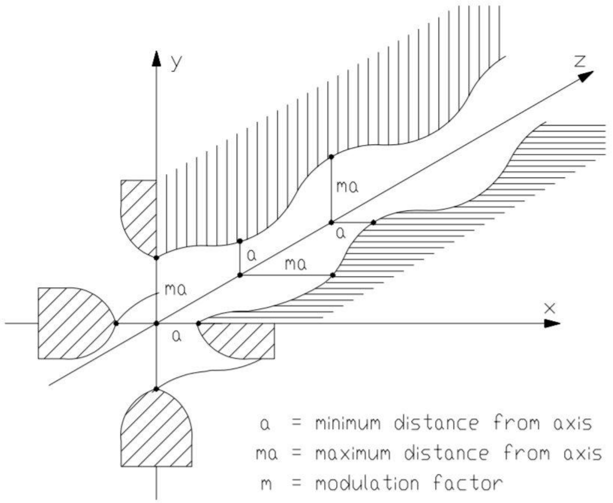
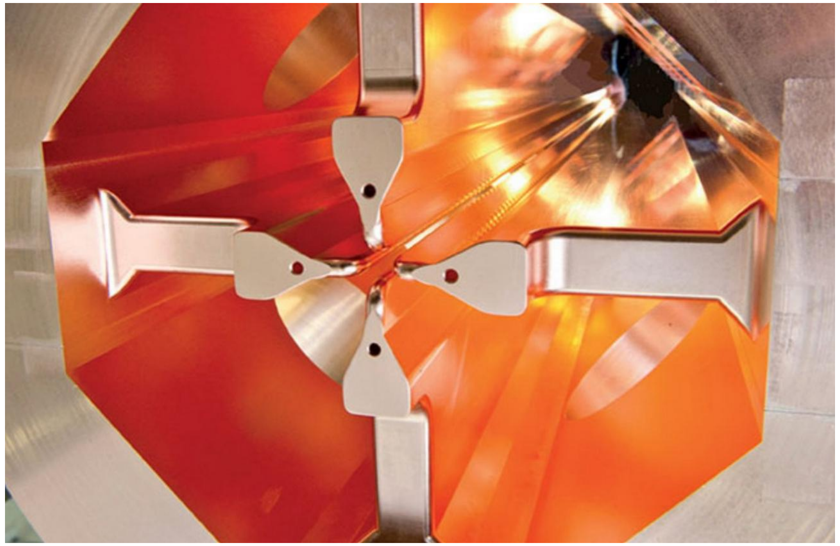
Phase II: RFQ

- RFQ – Radio-Frequency Quadrupole
- Special device usually providing “energy bridge” between ion source (~10 keV/u) and Drift Tube Linac (~1 MeV/u)
- Can use MV electrostatic accelerator, but…
- RFQ is much more compact, allows for better focusing and better transmission
- It contains both: focusing and accelerating fields
- RFQ idea: 1970 by Kapchinskij and Teplyakov
- Discussed by Giovanni Bisoffi on Wednesday





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Phase II: RFQ for Sarajevo Linac

- Principal requirements by Ion Beam Analysis (see Fehima's presentation):
  - **Energy: 2 MeV protons, 1 MeV/u $^{4}He^{2+}$**
  - **Duty factor: >10%** (pile-up and efficiency for PIXE measurement)
- RFQ technology not yet decided (frequency, geometry)
- A good candidate is 750 MHz RFQ being now developed at CERN
- Another RFQ: 325 MHz being developed by Bevatech
- Other options will be investigated

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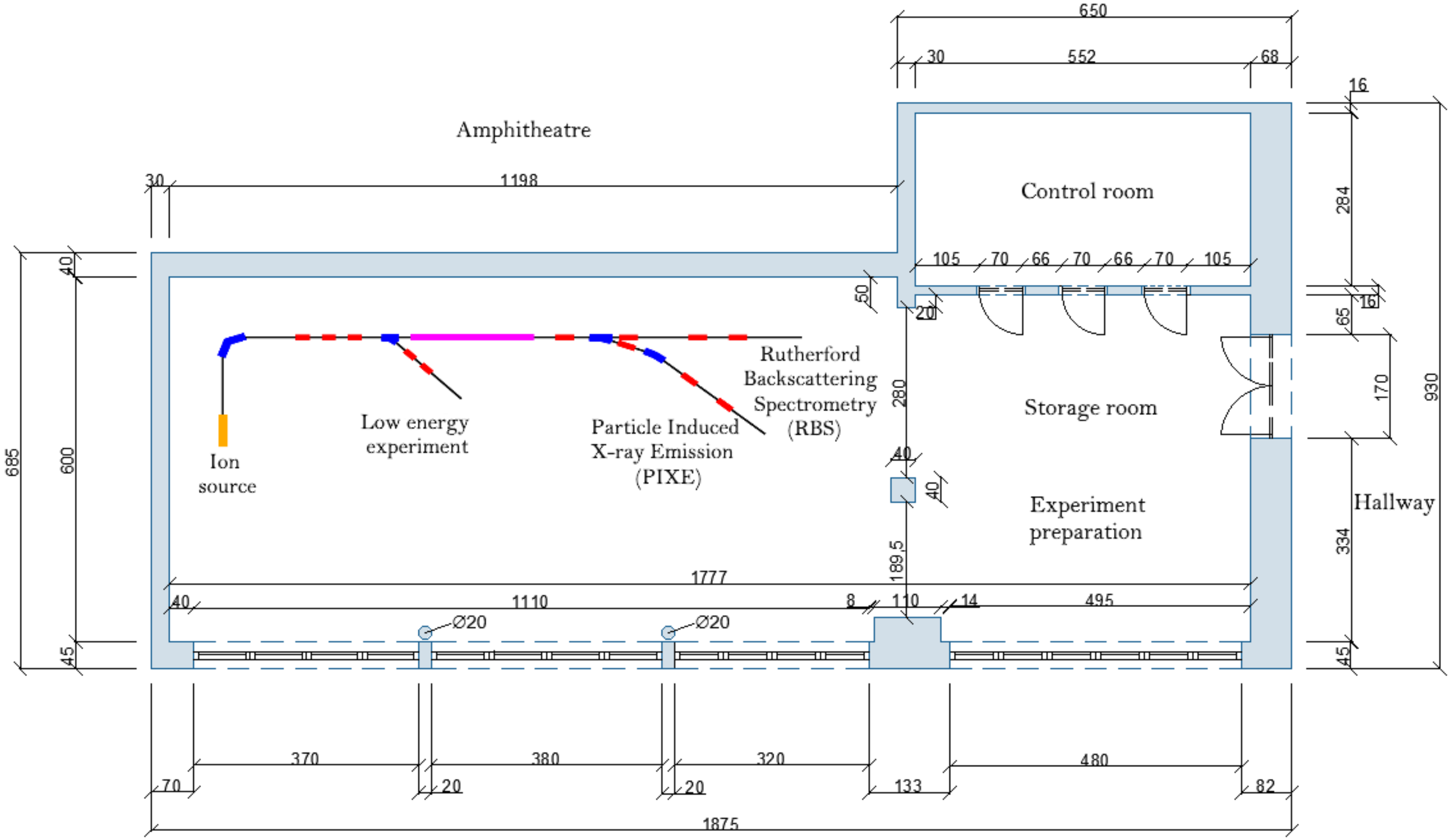
Final layout



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Conclusions

- Sarajevo Linac project will provide University of Sarajevo with interesting research opportunities
- It will participate in capacity building in the region
- It may become accelerator technology hub of SEEIIST
- Project is funded, details are being work on
- A university position associated with the project is funded as well
- Laboratory space is designated
- Beam expected in 2023

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Thank you for your attention

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