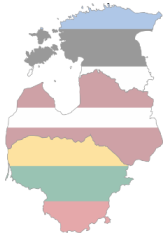
Advanced Particle Therapy center in the Baltic States

Maurizio Vretenar (CERN)
Prof. Toms Torims (Riga Technical University)
Kristaps Palskis (Riga Technical University, CERN)

** presenting*

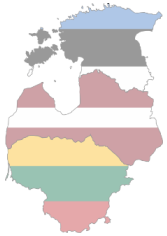


Mandate

On April 12th 2022 within CERN Baltic Group 9th general meeting at CERN

the **Advanced Particle Therapy Center in Baltic States Working Group**

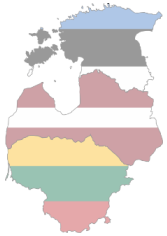
has been established



Acknowledgments

CERN NIMMS

Thankful to all of the NIMMS collaboration and especially to **Maurizio Vretenar, Elena Benedetto, Giovanni Bisoffi** and **Mariusz Sapinski** for sharing their knowledge and experience and providing us with invaluable inputs



Acknowledgments

CERN NIMMS

Next **I**on **M**edical **M**achine **S**tudy

Scientific collaboration for development of next generation particle accelerators for cancer treatment with ion therapy

- Building on experience of PIMMS
- Federating large number of partners for key technology development
- **Partners can use the NIMMS technologies to assemle their own optimized facility**

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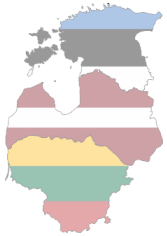


Outline of the presentation

I Concept and technical aspects

- Reasoning and rationale for particle therapy
- Particle therapy: why helium ions?
- Overall perspective of the conceptual design
- Not just a clinical facility

II The present and future outlook

- Beyond clinical aspects
- Current status of the project
- Future steps of the project

Reasoning: Cancer mortality and particle therapy in Europe

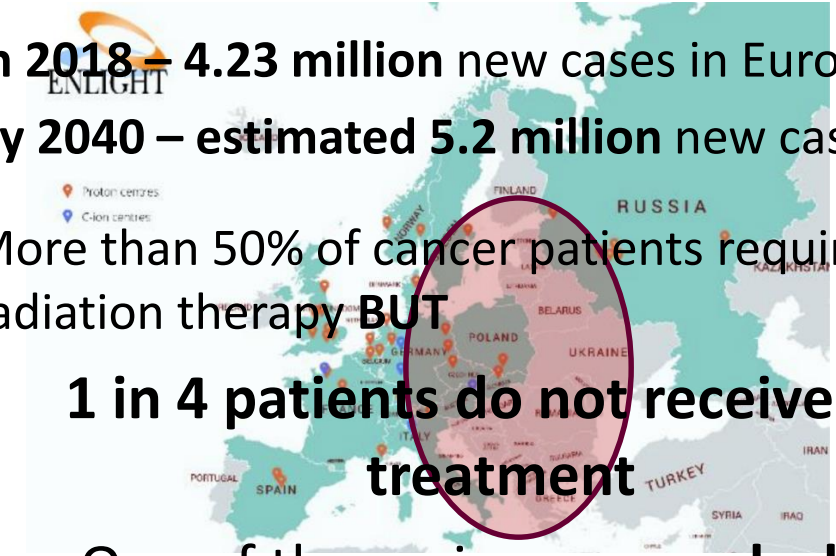
In 2018 – 4.23 million new cases in Europe

By 2040 – estimated 5.2 million new cases

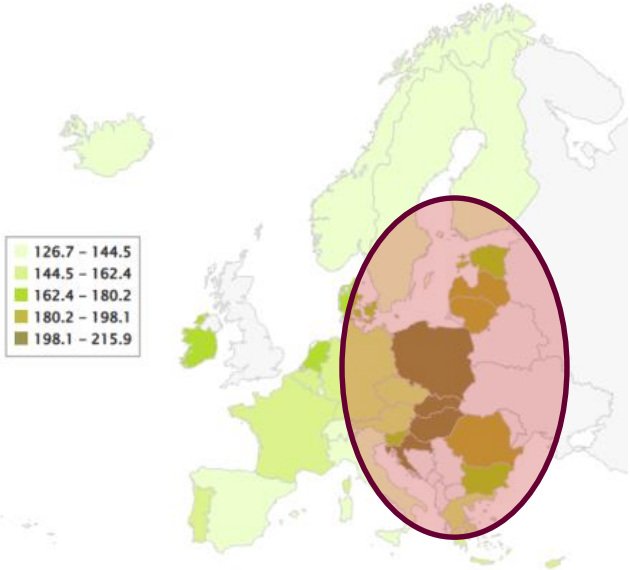
More than 50% of cancer patients require radiation therapy **BUT**

1 in 4 patients do not receive the treatment

One of the main causes – **lack of technology**



Particle therapy centre geography in Europe, ENLIGHT 2022



Cancer mortality rate in Europe per 100000 inhabitants, data of 2020

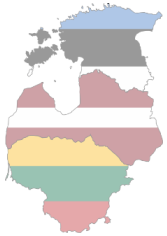
Reasoning: Particle therapy

Physical interactions of **protons** and **positively charged ions** with matter create more favourable dose distributions compared to conventional radiotherapy with high energy photons – **the Bragg peak**

In clinic, particle therapy has already shown benefits in treatment of

- **paediatric oncological malignancies**
- **brain and head and neck region tumors**
- **other localizations in vicinity of critical vital organs**

Heavy ions – possibility to treat tumors that are otherwise radioresistant to conventional radiation therapy, such as gliomas and sarcomas.



Reasoning: Facility options

Possibilities for a particle therapy center

A new advanced facility with different ions and new treatment techniques

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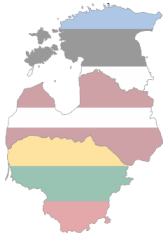
A circular particle accelerator in development by NIMMS collaboration

- Acceleration of protons and helium ions to treatment energies
- Higher energy protons for ion radiography purposes
- Possibility for heavy ion acceleration (carbon, oxygen) for biophysics research
- Possibility of ultra-fast dose rate delivery (*FLASH*)
- Possibility of parallel production of therapeutic and diagnostic radioisotopes

On initial design: **M. Vretenar**, E. Benedetto, M. Sapinski, M. E. Angoletta, G. Bisoffi, J. Borburgh, L. Bottura, K. Paļskis, R. Taylor, G. Tranquille: *A Compact Synchrotron for Advanced Cancer Therapy with Helium and Proton Beams*

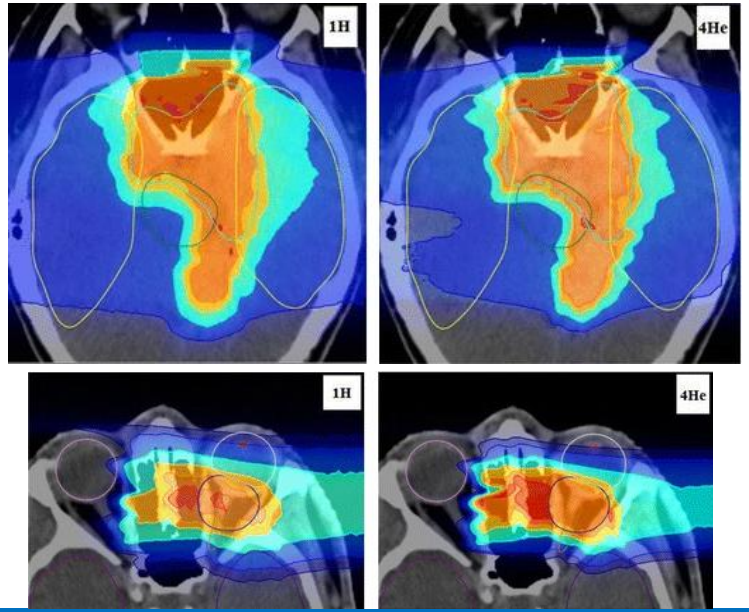


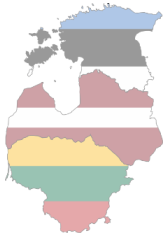
Clinical perspective: Why helium ion therapy?

Helium ions are «returning» to the horizon of novel particle therapy treatments

Why **helium-4 ions** over **protons?**

- Decreased lateral scattering and range straggling – **better conformality**
- **Increased radiobiological** effect
- **Increased LET** – possibilities to **overcome low-level hypoxia**
- *From physics perspective* – lower neutron dose associated risks



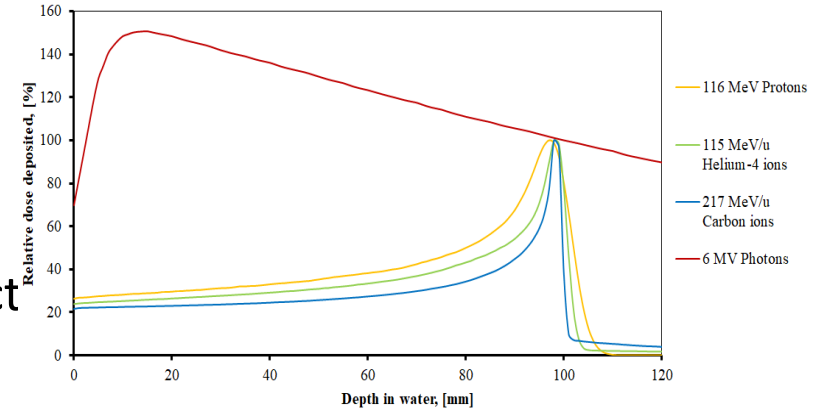


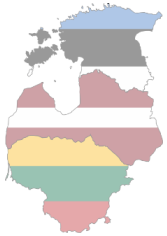
Clinical perspective: Why helium ion therapy?

Helium ions are «returning» to the horizon of novel particle therapy treatments

Why **helium-4 ions** over **carbon ions?**

- **Deacreased neutron** production
- LET does not result in cell *overkill*
- **Decreased distal dose** due to decreased fragmentation
- **Decreased uncertainties** for biological effect estimations
- *Under research* – better suited for *FLASH*





Clinical perspective: Why helium ion therapy?

Among the different particles considered for ion therapy

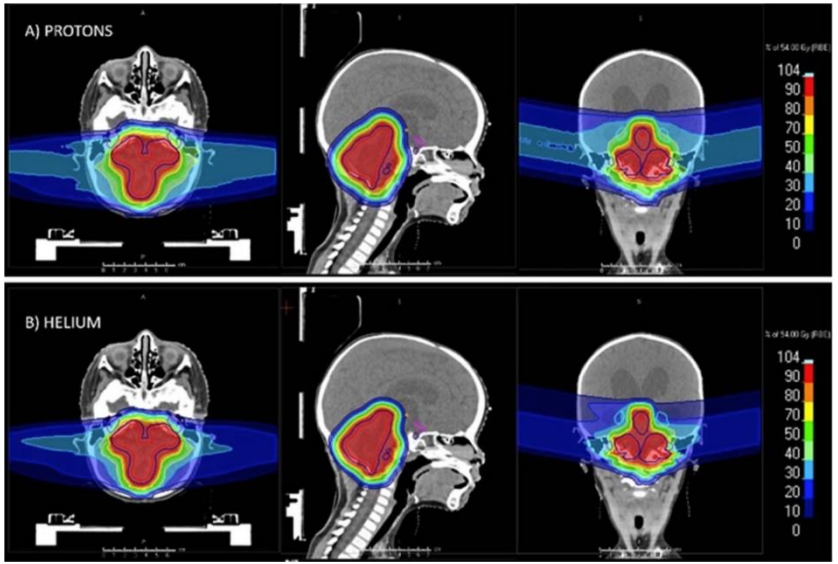
- Heavier particles result in an **increased biological effect**
- **BUT** with the increase of nuclear fragmentation – **dose conformality is decreased**

Helium ions stand as a candidate for **compromise between biological effect and dose conformality**

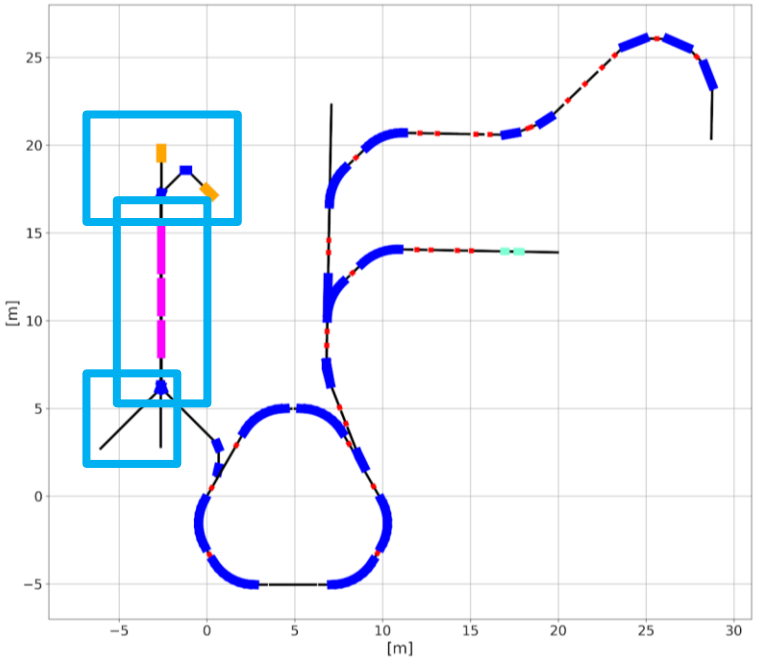
The overall clinical perspective

Why **helium-4 ions?**

- Novel treatment option with research opportunities, as currently used only at Heidelberg Ion Therapy center and being commisioned at other ion therapy centres
- Clinically helium-4 ion beams offer **better normal tissue sparing** and **lower integral dose** compared to proton beam therapy, proving highly beneficial in treatment of **tumors in vicinity of critical organs** and applications in **paediatric cancer** treatment



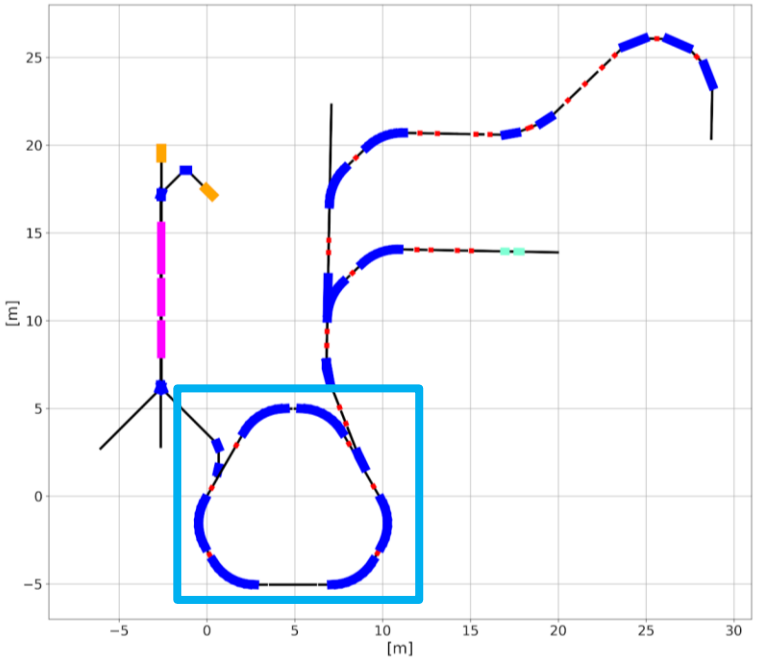
The overall technical concept



Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*

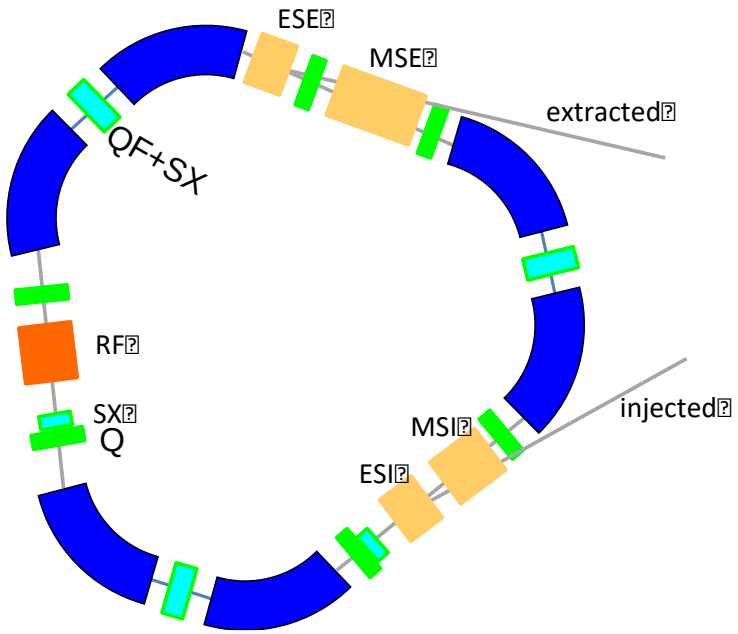
- Ion sources providing both **protons** and **helium-4** ions, option to use heavier ions (carbon, oxygen) for biophysical research in the future *(EBIS or ECRIS type source)*
- Linear accelerator for particle injection: *(presented by **L. Nikitović** tomorrow)*
  - 10 MeV for protons
  - 5 MeV/u for He-4 ions
- Possibility for parallel radioisotope production (*investigated – 7 MeV/u alphas)*

The overall technical concept

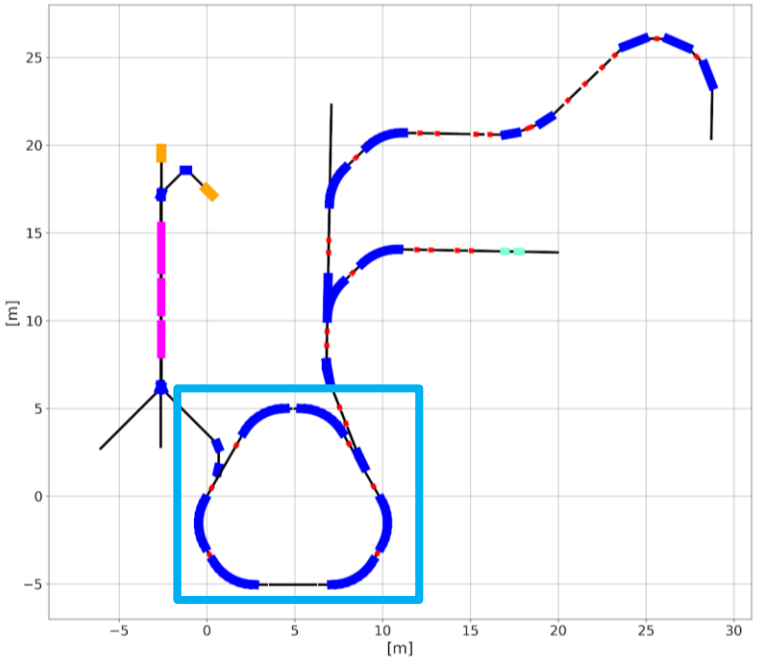


Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*

The helium synchrotron



The overall technical concept



Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*

The helium synchrotron

6 dipoles of **60º** bend with **magnetic field** strength of **1.65 T**

Beam rigidity of **4.5 T*m***:

- He-4 ions: max 220 MeV/u

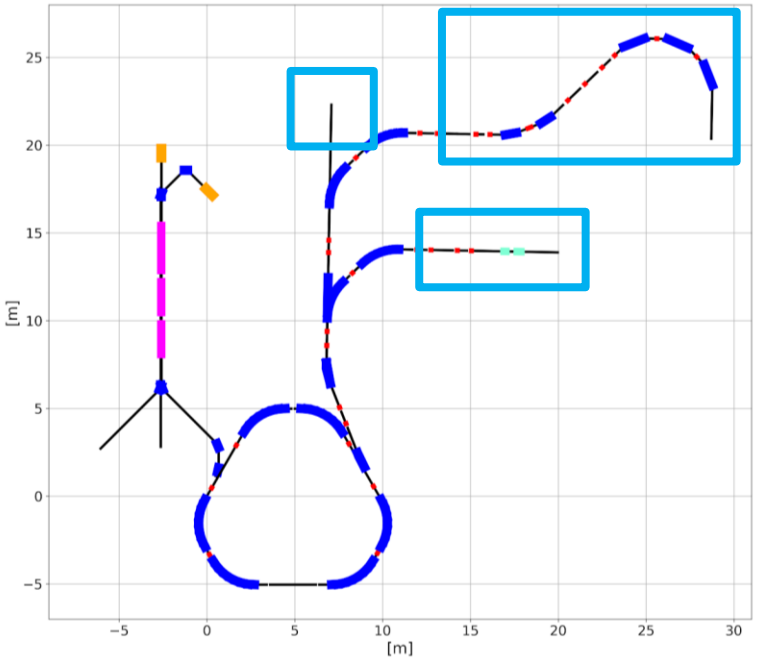
(30 cm treatment range)

- He-4 ions: max around 700 MeV

(possibilities for proton radiography)

Three straight sections – injection, extraction and RF

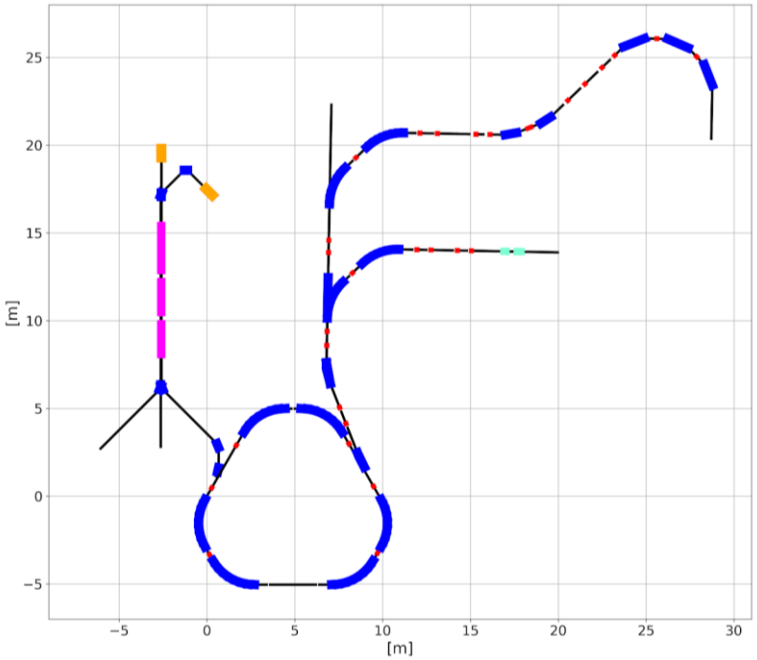
The overall technical concept



Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*

- **One static horizontal beam-line**, for possibility of expanding with rotating couch/chair system + vertical CT
- **One rotating gantry beam-line**, for multiple angle delivery *(next presentation by **L. Piacentini**)* – **decreasing to 2.8 T** superconducting magnets
- **One beam-line dedicated for research**

The overall technical concept



Design by *Mariusz Sapinski, Elena Benedetto and Maurizio Vretenar*

Initially:

50 % treatment with protons +

50 % research with He ions

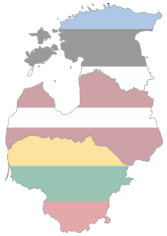
All research efforts for full scale helium therapy

Initially:

25 % treatment with protons +

50 % treatment with He ions +

25 % research with He ions



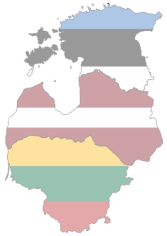
Novel clinical perspectives: Radioisotope production

Why **linear accelerator based production?**

Compared to conventional cyclotron production, linear accelerators could offer more efficient and less demanding *(decreased beam losses and lower shielding neccessities)* **especially** for production with **alpha and deuteron beams**

The need to couple particle therapy with nuclear medicine …

Diagnostics capabilities **essential for modern cancer therapy** ([^{18}F]-FDG) and **possibilities of providing novel treatment techniques** – dose painting, selective avoidance of functionally active organ-at-risk regions, tumor hypoxia estimation and incorporation in treatment planning etc.



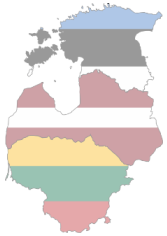
Novel clinical perspectives:
Radioisotope production

Theranostic and therapeutical radioisotopes

Main possible radioisotope options for linear accelerator based production have been identified by NIMMS group also for targeted therapies (*alpha and Auger electron*) and theranostics approaches

***«Large room»* for research opportunities**

Radioisotope	Usage of radioisotope
Scandium-43	Diagnostic – PET
Scandium-44	Diagnostic – PET
Cobalt-57	Diagnostic – SPECT
Copper-64	Theranostic (β^-)
Copper-67	Theranostic (β^-)
Indium-111	Diagnostic – SPECT
Tin-117m	Theranostic (β^-)
Samarium-153	Theranostic (β^-)
Rhenium-186	Theranostic (β^-)
Astatine-211	Therapeutic (α)



Not just a clinical facility: Proposed research directions

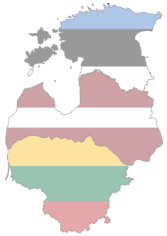
All necessary clinical and pre-clinical research for helium therapy

Ion therapy treatment associated research directions:

- Medical physics aspects and dosimetry, radiobiology
- Material science, nuclear physics
- Accelerator technology and physics
- Novel treatment technique development activities

Other research directions:

- Radioisotope production, radiation chemistry
- Material science for target design of radioisotope production

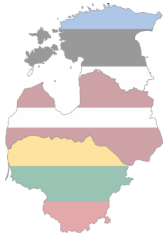


Not just a clinical facility: Industry sector involvement

First ever infrastructure in the Baltic States for accelerator technologies

Involvement of relevant industry sectors in delivering the center itself, working in close collaboration with CERN and expanding capacity and *know-how* in accelerator technology field within the Baltic States

Infrastructure provides future options for technological innovations of medical accelerators and associated equipment, addressing the needs of particle therapy community



Partnership

Center would be done following NIMMS *main idea* – **using the developed technologies within NIMMS collaboration in order to create a unique treatment center**

Project has been already started in a framwork of working in close collaboration with NIMMS and CERN together in delivering the facility

The proposed project would be one of the leading in Baltic States *porfolio* of collaborations with CERN

Current status of the project

A dedicated concept paper has been developed

CERN Baltic Group

Draft concept-paper

Advanced Particle Therapy Center for the Baltic States

Background

This concept-paper is prepared following the collegial decision of the CERN Baltic Group (CBG) General meeting of 23 August 2021 "To develop a concept-paper on **Advanced Particle (Cancer) Therapy Center** in the Baltic States, in close cooperation with CERN and relevant stakeholders".

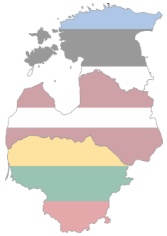
During the 23 August general meeting, based on the previous discussions, the CBG has reiterated a clear need for one **strategic regional research project** related to the (so far *de facto* non-existent) major Research Infrastructure undertaking in the Baltic States. General meeting unanimously agreed that a very good candidate for this is the Advanced Particle Therapy Center in the Baltic States. It has been agreed to elaborate in this direction and to initiate an open discussion between CBG and CERN, also engaging stakeholders from Baltic medical physics, radiotherapy, and oncology communities[1].

Such meeting "Advanced particle therapy options for Baltics" was organised in liaison with CERN on 8 October 2021[2]. Meeting agreed that the best possible option for the Baltic States would be development of the "**The Helium synchrotron**" technology in collaboration with CERN.

During the subsequent CBG General meeting on 22 November 2021 "a **need for the joint CBG flagship project** and joint coordinated actions was emphasised. CBG shall build on its success and use the momentum of Estonia and Latvia joining CERN". Meeting agreed "to persuade the idea of the potential Flagship project - **Advanced Particle (Cancer) Therapy Center in the Baltic States**, in close cooperation with CERN and relevant stakeholders".

This concept has been also presented to the Baltic Assembly[3] at CERN on 8 Oct 2022. Idea was presented to LIAA and EM in Brussels – full support received. Idea was presented to the ministry of education and science of Latvia – summer 2021

Chairman of the CERN Baltic Group
Prof. **Toms Torims**



Current status of the project

A dedicated concept paper has been developed

Presented:

21st meeting of the TIARA Collaboration Council (March 29th , 2022)

Internally within CERN NIMMS collaboration, with approval of collaboration lead

Stakeholder support gained in the Baltic States.

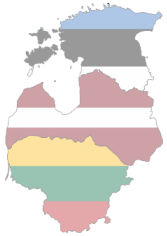
Baltic scientific community: 9th CERN Baltic Group General Meeting

Baltic political stakeholders: Meeting of the Health, Welfare and Family Committee of the Baltic Assembly.

Baltic Assembly letters adressed to prime ministers of Baltic States

Baltic States ambassadors within EU COREPER I

Investment and innovations agencies within the Baltic States



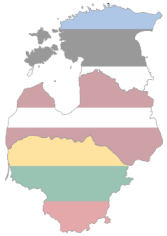
Further steps of the project

Addressing the medical community

7th of October – **presentation at 8th Baltic Congress of Radiology**

14:00 - 15:30	Plenary session, Parallel session, Woodblock Hall **S3-5 Interventional Oncology** Chairperson: Sergei Nazarenko (Estonia) On the conceptual design of advanced particle therapy center in the Baltic States *Kristaps Palskis (Latvia)* Interventional oncology TACE/embolization, needle guided biopsy and ablations

Planning CERN Baltic Group Project working group bilateral meetings with radiation oncologists, radiologists, medical physicists and research institutions from each of the Baltic States.



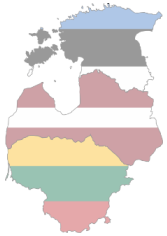
Further steps of the project

Addressing the medical community

First of these meetings **– 18th October in Riga**

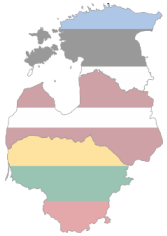
To hold these meetings in Estonia and Lithuania by the end of 2022, preferably – November

With one of the main goals - **identifying the community representatives for the future of the project development**



Criteria for site selection

- Clear and undivided **support to the project from the national medical community**
- Strong and continuous **political support**
- **Sustained stakeholder engagement** and participation
- Integral **part of the major oncology hospital**
- Physical **proximity and access to the existing infrastructure** critical
- **Proximity to the international airport** – maximum of 50 km distance
- **Accessibility to all Baltic countries** and beyond – **accessible from the *RailBaltica* and major roads**
- Direct **hosting facilities for the patients**
- **EC support for the chosen site**



Take-away messages

Creating visionary and long term goals for the Baltic States

Flagship project for the Baltics and leading collaboration with CERN

Idea supported by both CERN, EU and relevant communities

Corresponding to development strategies of the Baltics and overall EU priorities

Comercially viable option for a novel cancer treatment

Project would prevent *brain-drain* from the Baltics and increase scientific capacity within the region

An exciting and uniting opportunity not to be missed…

Thank you for your attention!