
CERN

Motivations and opportunities for a new PIMMS initiative

Maurizio Vretenar, CERN

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CERN – European Organization for Nuclear Research

Founded in 1954 by 12 European States (Science for Peace)

Today: 22 Member States

~ 2500 staff
~ 1800 other paid personnel
~ 13000 scientific users

Budget (2017) ~ 1100 MCHF

The largest particle physics laboratory in the world. Mission:

- Push back the frontiers of knowledge
- Develop new technologies for accelerators and detectors
- Train scientists and engineers of tomorrow
- Unite people from different countries and cultures

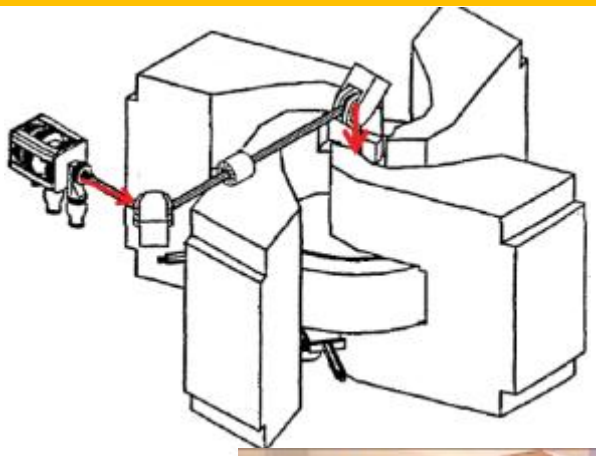
1. CERN has accumulated a wide competence in advanced accelerator and detector technologies

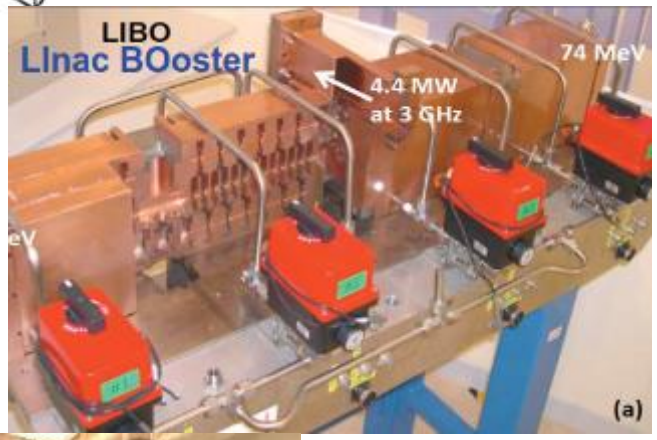
2. CERN is a neutral multinational laboratory where people meet and collaborate

How could society profit of this experience and working environment?

Medical accelerators at CERN

- Since the early 80's, CERN scientists have contributed to adapting CERN technologies to the development of medical accelerators.
- Similar organization: a study group at CERN that develops designs and prototypes for facilities built outside of CERN:
  - **Medicyc** 1982-1990 and **Eulima** 1985-1989 → Cyclotrons at Centre Lacassagne, Nice.
  - **LIBO** (Linac Booster) 1998-2001 → LIGHT linac being built by ADAM/AVO.
  - **PIMMS** 1996-2000 → CNAO and MedAustron proton&ion synchrotrons.
- The concentration of resources on LHC construction from 2002 has interrupted this long tradition.
- 16 years later, there is interest from CERN and some support from the management to restart a medical accelerator activity.
- But where should we go? Particle therapy has made an enormous progress in the last 20 years and the situation is very different from the initial pioneering years.





A success story – the PIMMS study

PIMMS = Proton-Ion Medical Machine Study

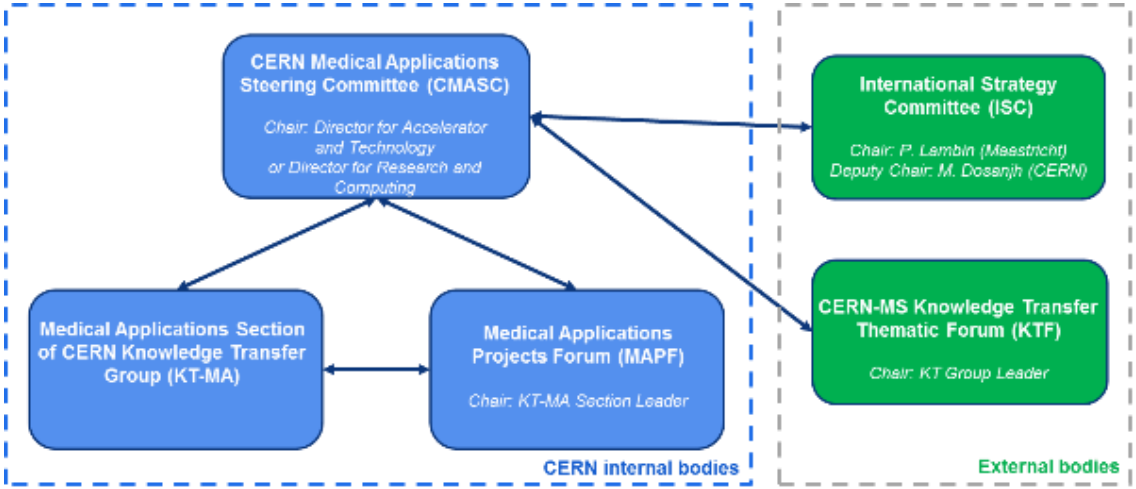
- Started in 1996 as a study group at CERN between CERN, TERA Foundation (Italy), and Med-AUSTRON (Austria) with initial close collaboration with GSI (Germany) for the design of a cancer therapy synchrotron.
- Goal: understanding key techniques to produce a smooth beam spill for conformal treatment of complex tumours (sub-millimetre accuracy by active scanning); developing the main technical components of the facility.
- In 2000 resulted in the publication of a Technical Design Report, with a CD-ROM of data and technical drawings.
- The PIMMS study was the basis for the construction of CNAO (Pavia, Italy) and MedAustron (Wiener Neustadt, Austria).

New CERN Medical Applications

- The limits to the CERN engagement are defined in the «Strategy and framework applicable to knowledge transfer by CERN for the benefit of medical applications» document approved by Council in March 2017.
- While CERN core mission is particle physics, maximising the societal impact of its research is an integral part of this mission. The goal is knowledge transfer (to society), not the development of a specific instruments or projects.
- A (limited) personnel and material budget is foreseen as seed funding for collaborative R&D projects (receiving additional support from EU or other sources), using technologies and infrastructures that are uniquely available at CERN.
- The selected projects must not overlap with activities in Member States or be in competion with industry, and must be driven by the requirements of the medical research community.

Funding and Organisational Structure

Medical accelerator programmes:
~ 0.1% of the CERN budget (Material and Personnel), administered and controlled by 5 Committees.



A less successful story - BioLEIR

BioLEIR:

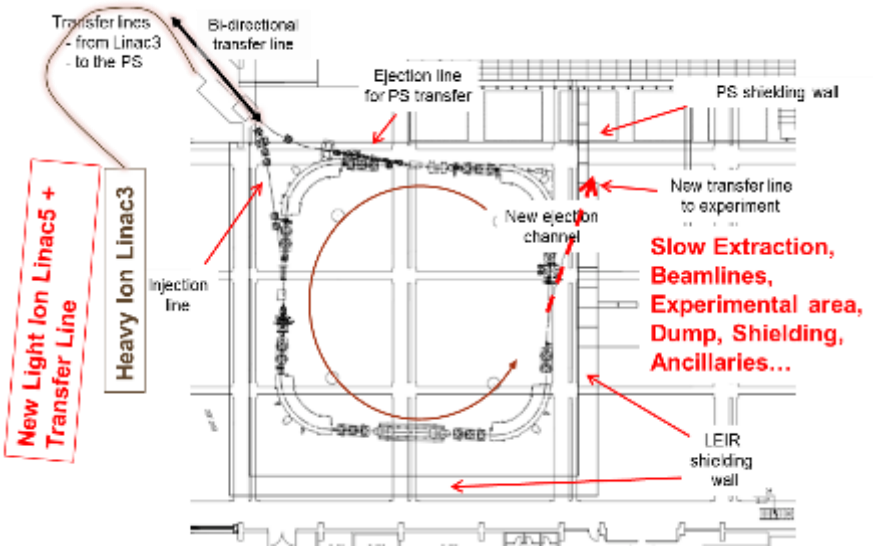
Proposal to add light ions to the CERN ion accumulator ring LEIR to provide beams for biomedical research when not operating for LHC.

First idea (U. Amaldi, M. Dosanjh) in 2005.
Goal: compare different ions (RBE, cancer effectiveness) → H, He, Li, Be, B, C, N, O
Measure particle range, ballistics, fragmentation.
No tests on animals or patient treatment.

Strong support from the biomedical community.

Working group, Feasibility Study published in 2017, estimate 29 MCHF + 119 FTE.

Project stopped because funding not available (nor from CERN, nor from external international sources)



Contributors

D. Abler[1,2], T. Amin[1,3], J. Axensalva[1], S. Baird[1], M. Battistin[1], N. Bellegarde[1], J. Borburgh[1], A. Broche[1], C. Carli[1], E. Carlier[1], O. Choisnet[1], J.-M. Cravero[1], M. Di Castro[1], J. Devine[1], M. Dosanjh[1], A. Dworak[1], R. Froeschl[1], J.M. Garland[1], A. Garonna[1,4], S. Ghithan[1], S. Gilardoni[1], B. Goddard[1], A. Gutierrez[1], A. Huschauer[1], E. Jensen[1], S. Jensen[1], J. Jowett[1], B. Jones[1,5], V. Kain[1], R. Kersevan[1], D. Küchler[1], J.-B. Lallement[1], M. Lazzaroni[1], A. Lombardi[1], R. Lopez[1], D. Manglunki[1], D. Mcfarlane[1], A. Milanese[1], Y. Muttoni[1], D. Nicosia[1], P. Ninin[1], M. Nonis[1], J. Osborne[1], S. Pasinelli[1], R. Rata[1], G. Riddone[1], G. Roy[1], I. Ruehl[1], S. Schuh[1], R. Scrivens[1], M. Silari[1], R. Steerenberg[1], M. Tavlet[1], V. Toivanen[1,6], G. Tranquille[1], A. Tursun[1], F. Valentini[1], M. Wilhelmsson[1]

Editorial Board Members

C. Carli[1], M. Dosanjh[1], S. Ghithan[1], B. Goddard[1], D. Manglunki[1], G. Roy[1], S. Schuh[1], R. Steerenberg[1]

Towards a PIMMS2 ?

Within the renewed Medical Applications, a small door is opening… but 20 years after PIMMS, can we imagine another seminal CERN contribution to medical accelerator research?

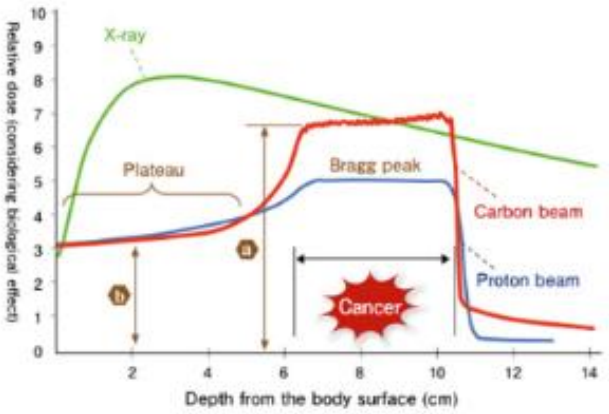
Yes, because:

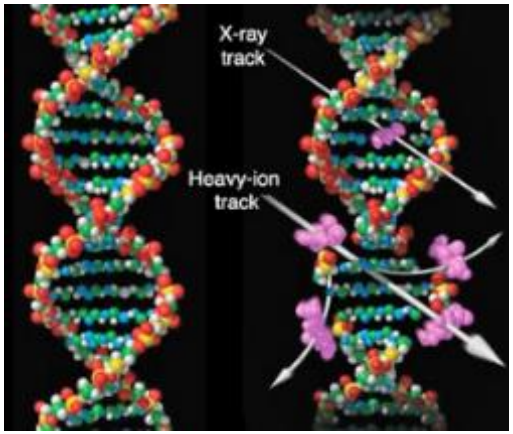
- One could build on the momentum generated by the BioLEIR intitiative, which has aggregated a large community leaving a number of questions unanswered.
- In this particular moment, it becomes urgent to show to the public the impact of the LHC construction and of particle physics in addressing societal issues.
- A new initiative should replicate the reasons for the success of the original PIMMS: be collaborative, inclusive, innovative, open access.
- Should not compete with industries and national programmes in CERN Member States.

But please note that **this Workshop is not a launching event for a second PIMMS**. We need to be **humble** and to acknowledge that in the last 18 years there was an enormous progress without us. We now want to see where and how we can contribute, profiting of our strenghts but without interfering with ongoing programmes.

Where and how we could contribute

- Proton therapy is rapidly progressing, thanks to the commercial availability of turn-key facilities. Research is oriented towards delivery systems and optimizing treatment; nobody questions the accelerator → Should not interfere with commercial companies.
- Instead, there is clear indication that **ion therapy has a strong potential** (higher RBE, effective with radio-resistant tumours) but to make it accessible to a larger fraction of the population some action is needed along three axis:
  - Collect more data from biomedical research with different types of ions *(the BioLEIR line, extended to tests on animals and possibly clinical trials)*.
  - Try to reduce size and cost of the facility, using some new accelerator design *(for carbon or lighter ions?).*
  - Further optimise the delivery system, including the gantry.





What Europe needs

To further advance ion therapy, we need:

- A multiple-ion therapy and research facility.
- Based on innovative accelerator technologies *- to become the test bench for a new standardised treatment facility*.
- Structured as a multi-national centre, addressing the entire European community

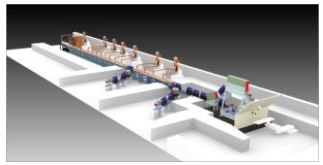
  no European country can afford building this facility alone.

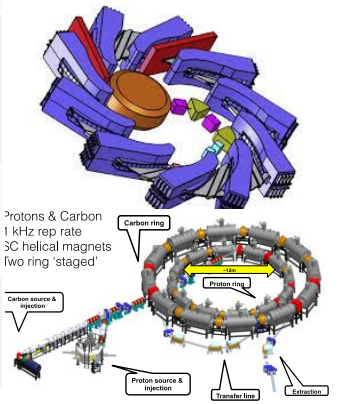
In this programme, CERN can:

1. within a new PIMMS initiative, contribute to identifying and developing new accelerator technologies
2. Offer a multinational environment to develop the multi-national collaboration.

Ion acceleration - technical options

	Pros	Cons	Status
Synchrotron	proven	size, complexity	4 operating
Linac	high rep. frequency, energy modulation, size	unproven	under development (TERA/ADAM/CERN)
Cyclotron	size	low flexibility (ions, energy), unproven	under development (IBA et al.)
FFAG	high rep. frequency	complexity (2 rings), unproven	under development (STFC)
New techniques (lasers, plasmas, etc.)	size	stability, long lead time	conceptual design





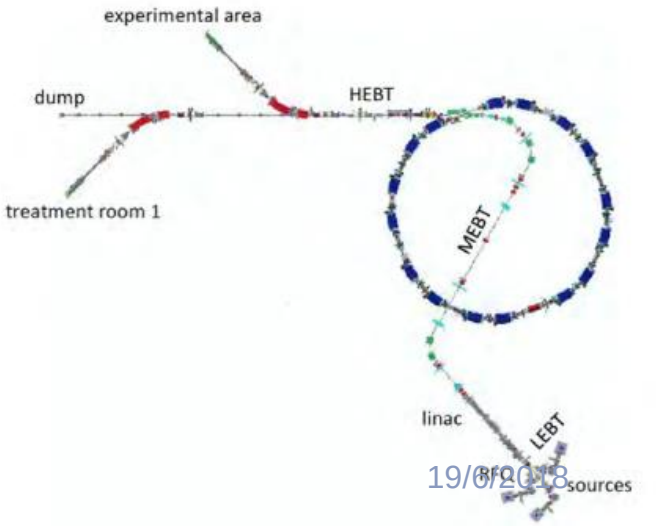
This workshop concentrates on the first two options, improved synchrotron and linac, which are more advanced (less development time needed), are within the CERN competences and are not in competition with commercial companies.

Two main options

might be explored in parallel

SYNCHROTRON

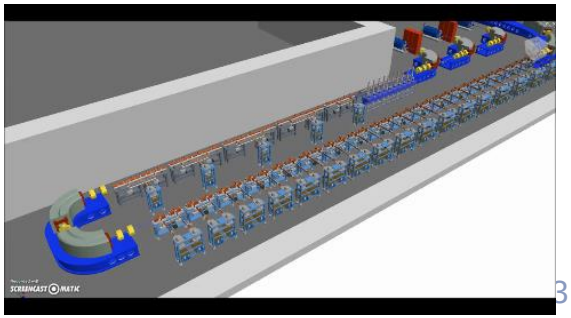
- Can directly profit of the experience of the 4 European ion therapy centers and of GSI.
- New features to explore:
  - Higher magnetic field (NC or SC).
  - Rapid cycling.
  - Smaller emittances.
  - Electron cooling.
  - …



LINAC

- Preliminary studies already made by TERA / ADAM / CERN (CABOTO design).
- Needs work on:
  - C6+ ion source
  - Design of intermediate energy structure.
  - Overall beam dynamics, including 180deg bend.
  - Optimisation of high energy structure.
  - (High-efficiency klystrons)
  - …

~50 m length, folded in 2 sections. Accelerator footprint ~200 m^2.



Some objectives for this Workshop

- Highlight the **potential of ion therapy** for cancer.
- **Share the current experience**: advantages and disadvantages of present implementations and ideas for future facilities. Identify potential directions for improvement. Identify synergies between the medical accelerators and other accelerator projects.
- Explore the possibility to advance towards the design for a **next generation medical research and therapy facility with ions in Europe**, identify a community that could contribute to this design, and assess the possibility to establish a dedicated collaboration resulting in a proposal to the European Commission.
- Identify some **basic parameters** for this facility, a set of **technical options**, and outline a possible **basic R&D programme**.

Our thanks go to all those who have made this event possible:
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The support team at CERN and ESI

And of course many thanks to all our distinguished speakers for accepting to take part in this event!

Thank you for your attention

maurizio.vretenar@cern.ch