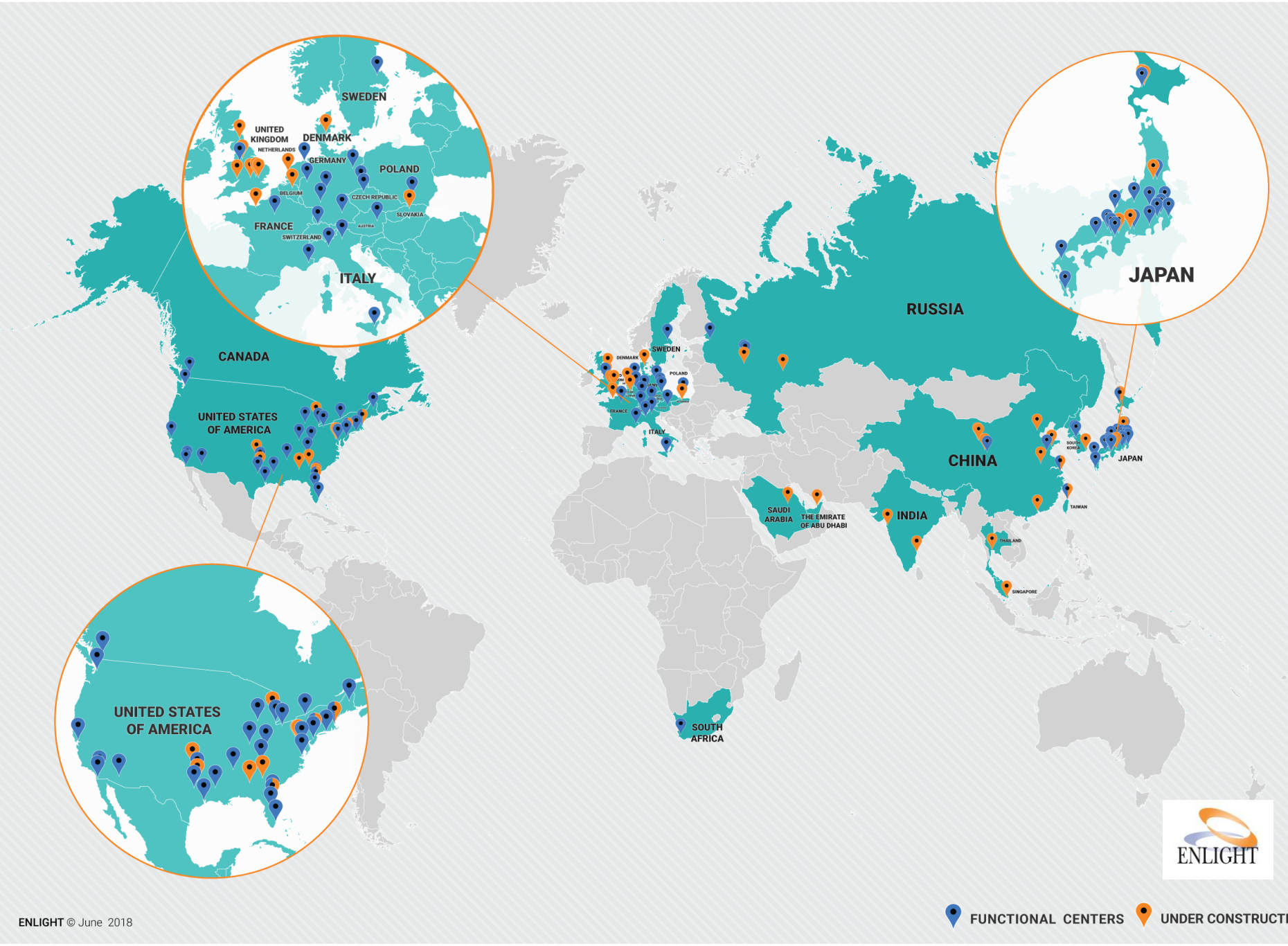
CERN and ENLIGHT:current developments in hadron therapy

MediNet Final Meeting,
Wiener Neustadt, 7-9 October 2019

Manjit Dosanjh
CERN & ENLIGHT



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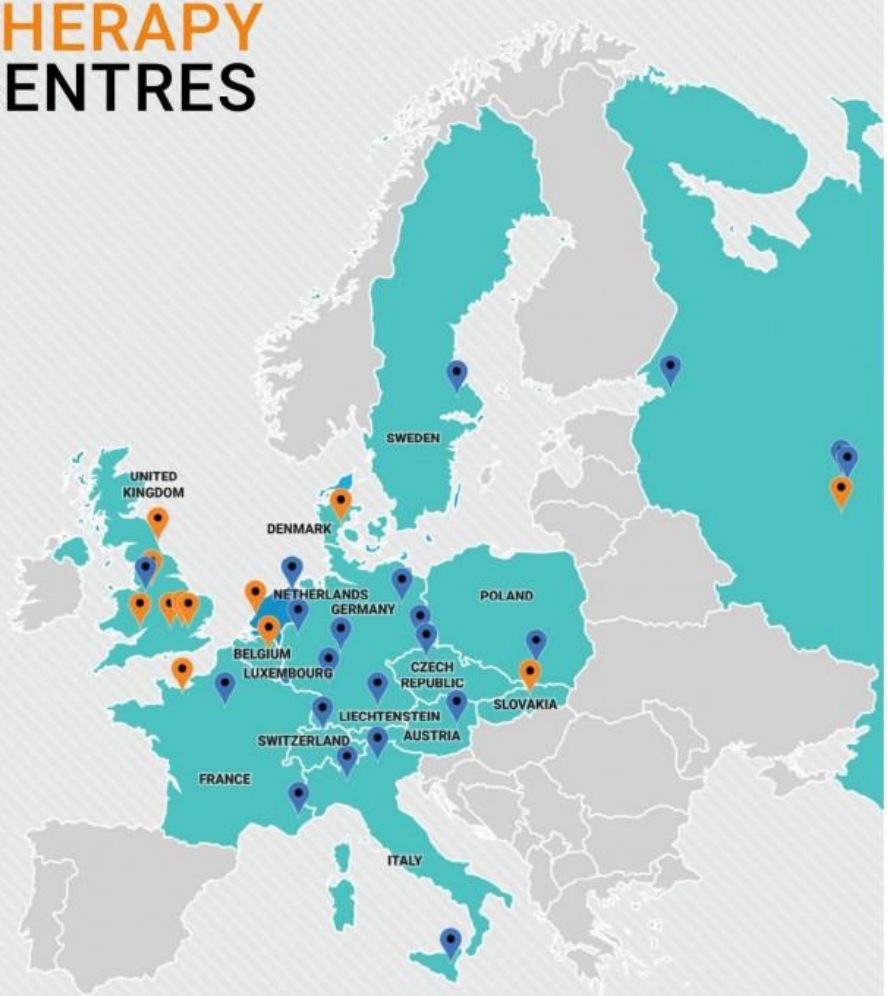
PARTICLE THERAPY CENTRES



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FUNCTIONAL CENTRES UNDER CONSTRUCTION

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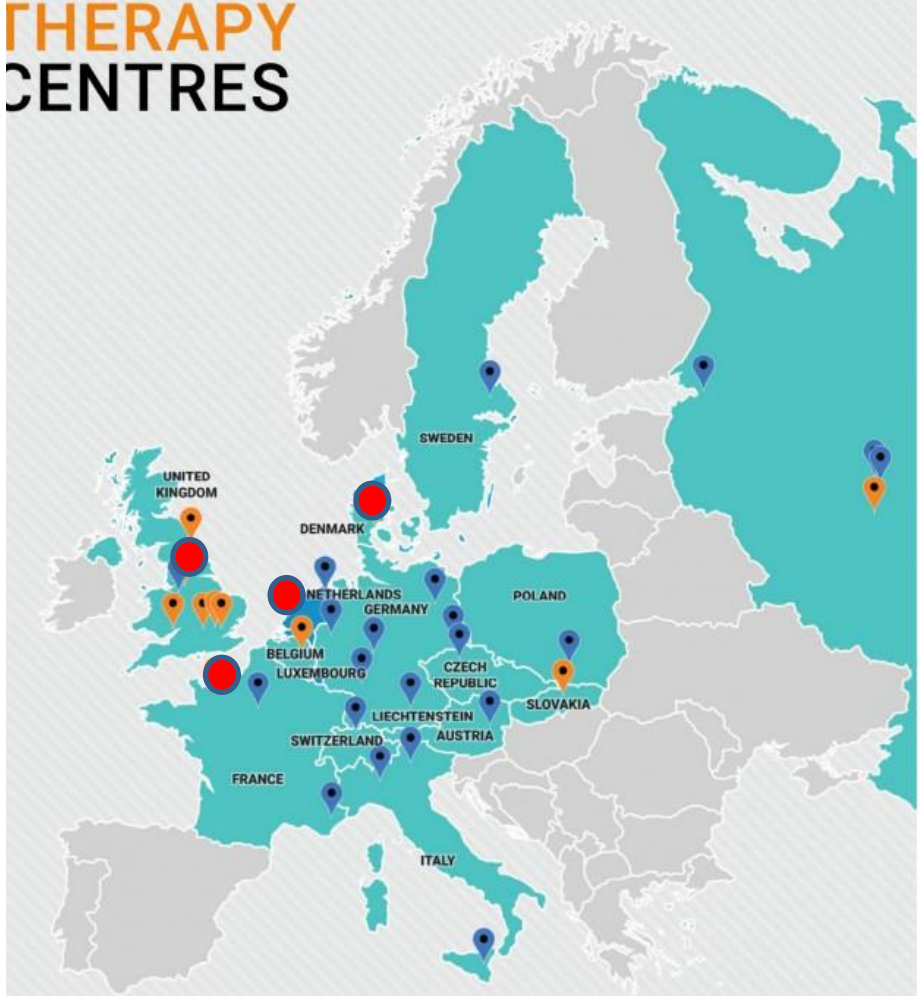
PARTICLE THERAPY CENTRES



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UNCTIONAL CENTRES UNDER CONSTRUCTION

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Facilities in Europe started in 2018-2019

COUNTRY	WHO, WHERE	PARTICLE	S/C/SC* MAX. ENERGY (MeV)	BEAM DIRECTIONS	START OF TREATMENT	TOTAL PATIENTS TREATED	DATE OF TOTAL
Austria	MedAustron, Wiener Neustadt	C-ion	S 403/u	2 horiz., 1 vertical fixed beam	2016 Carbon 2 July	400 pat 12 C	Sept-19
Denmark	Dansk Center for Partikelterapi, Aarhus	p	C 250	3 gantries, 1 horiz. fixed beam	2019	1st patient	Jan-19
England	Proton Partner's Rutherford CC, Newport	p	C 230	1 gantry	2018	1st patient	Apr-18
England	The Christie Proton Therapy Center, Manchester	p	C 250	3 gantries	2018	1st patient	Jan-19
France	CYCLHAD, Caen	p	C 230	1 gantry	2018	20	Dec-18
Russia	MIBS, Saint-Petersburg	p	C 250	2 gantries	2018	180	Dec-18
The Netherlands	UMC PTC, Groningen	p	C 230	2 gantries**	2018	99	Dec-18
The Netherlands	HollandPTC, Delft	p	C 250	2 gantries, 1 horiz. fixed beam	2018	first patient	Nov-18
The Netherlands	ZON PTC, Maastricht	p	SC 250	1 gantry	2019	first patient	Feb-19

Facilities recently started (2018-2019)
The Netherlands

HollandPTC (Delf)t
Varian ProBeam
- two 360° gantries with in-room CT and CBCT
- a horizontal beamline for eye treatments

September 2018 first patient

University Medical Center Groningen PTC
IBA Proteus Plus
- 2 gantries PBS

January 2018 first patient

Maastro (Maastricht)
- Mevion 250 MeV

February 2019 first patient

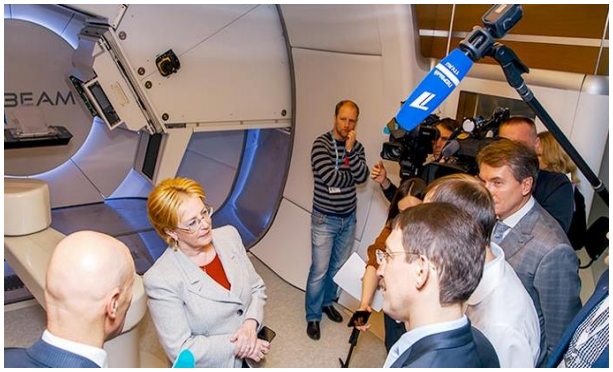
Facilities recently started (2018-2019)
Russia

Dr. Berezin Medical Institute, St. Petersburg

Varian ProBeam, 2 gantries

Cyber-Knife, Gamma-Knife, True-Beam

20.03.2018 – completed 1st patient treatment



Facilities recently started (2018 -2019)
France

The Normandy Proton Therapy Centre, Caen

IBA ProteusOne:

Installation of synchrocyclotron and equipment: 12 months

.

First patient on 31 July 2018

Facilities recently started (2018 – 2019)
United Kingdom

Rutherford Cancer Centre in Newport, South Wales.

IBA Proteus One

First patient treated 12 April 2018

Christie NHS Foundation Trust (Manchester)

Varian ProBeam

3 gantries
1 experimental line with PBS

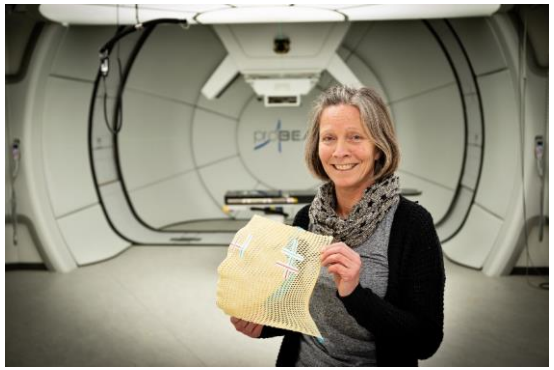
December 2018 first patient

Facilities recently started (2018-2019)
Denmark

Danish Centre for Particle Therapy (Aarhus)

Varian ProBeam 250 MeV
- Three 360° gantries
- one horizonthal beam
- 9,500 square metres building

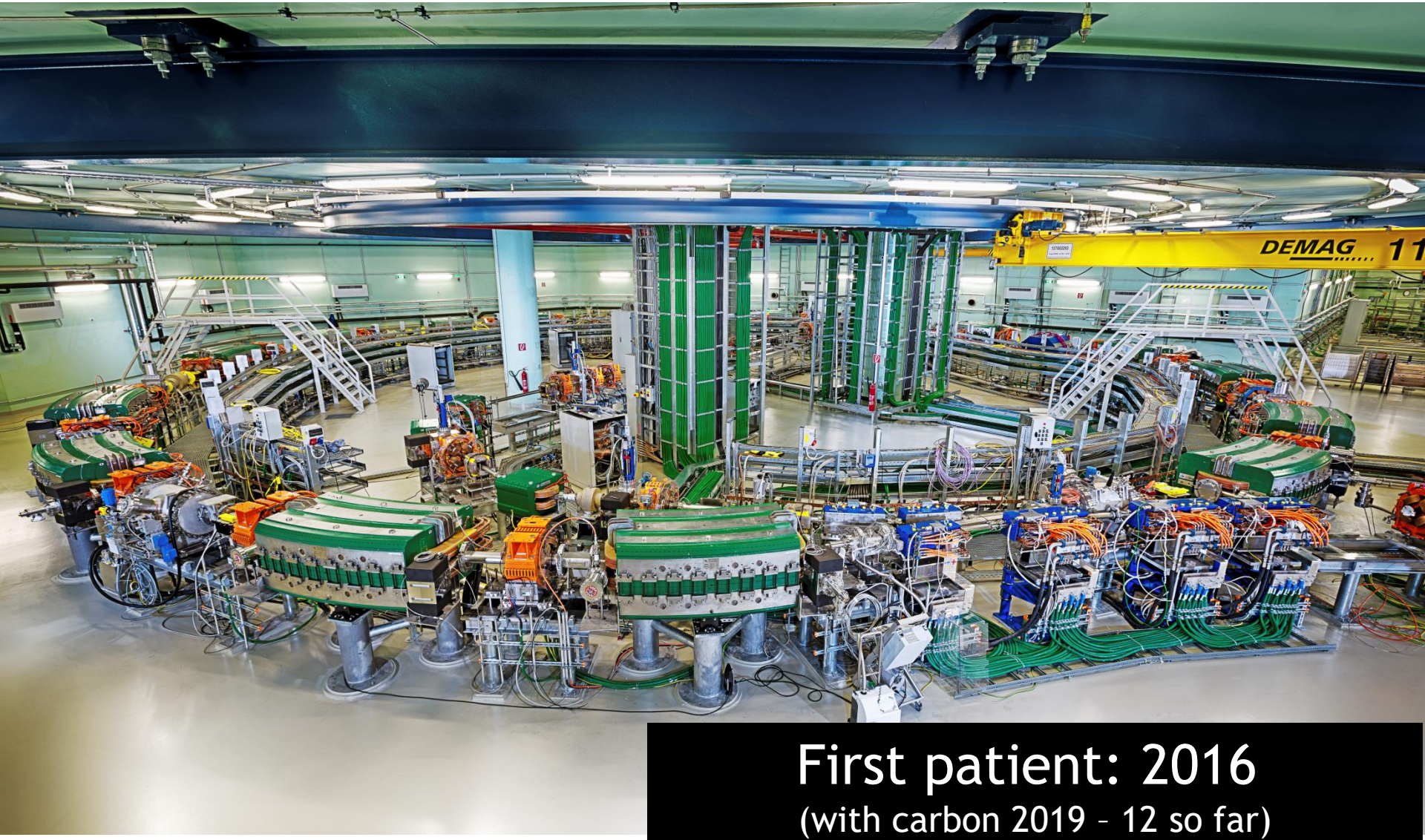
June 26, 2017 first gantry mounted



January 29, 2019 first patient

- January 2019 Opening
- **January 29, 2019 first patient**

Med-Austron: 1st carbon patient 2nd July 2019



(Courtesy of Peter Urschütz)

First patient: 2016

(with carbon 2019 – 12 so far)

So far more than 400 patients

Facilities in Europe in the construction stage

COUNTRY	WHO, WHERE	PARTICLE(S)	MAX. ENERGY (MeV) ACCELERATOR TYPE (VENDOR)*	BEAM DIRECTIONS	NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
Belgium	ParTICLe, Leuven	p	230 SC cyclotron (IBA)	1 gantry (PBS), 1 horiz. beamline (research)	2	2019
France	ARCHADE, Caen	C-ion	400/u cyclotron (IBA)	1 fixed beam (R&D)	1	2023
Russia	Federal HighTech Center of FMBA, Dimitrovgrad	p	230 cyclotron (IBA)	4 gantries	4	2019
Spain	Quirónsalud Hospital, Madrid	p	230 cyclotron (IBA)	1 gantry	1	2019
Spain	CUN, Madrid	p	220 synchrotron (Hitachi)	1 gantry	1	2020
United Kingdom	PTC UCLH, London	p	250 SC cyclotron (Varian)	3 gantries	3	2019
United Kingdom	Proton Partners Int., Northumbria	p	230 cyclotron (IBA)	1 gantry	1	2019
United Kingdom	Proton Partners Int., Reading	p	230 cyclotron (IBA)	1 gantry	1	2019
United Kingdom	Proton Partners Int., Imperial-West, London	p	230 cyclotron (IBA)	1 gantry	1	2019

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Facilities in Europe in the planning stage

COUNTRY	WHO, WHERE	PARTICLE	MAX. ENERGY (MeV), ACCELERATOR TYPE, (VENDOR)	BEAM DIRECTIONS	NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
Belgium	University Hospitals Wallonia, Charleroi	p	230, cyclotron, (IBA)	1 gantry	1	2021
Italy	European Institute of Oncology, Milan	p	230, cyclotron, (IBA)	1 gantry	1	2020
Norway	Norwegian Radium Hospital, Oslo	p	250, SC cyclotron, (Varan)	3 gantries, 1 fixed beam for clinical research	3	2023
Norway	Haukeland University Hospital, Bergen	p	250, SC cyclotron, (Varian)	1 gantry, 1 additional gantry as an option	1 (2)	2023-2025
Russia	Hospital No.63 PTC, Moscow	p	250, synchrotron, (Hitachi)	open	?	2020?
Switzerland	PTC Zürichobersee, Galgenen	p	230, cyclotron, (Sumitomo)	4 gantries	4	?
Switzerland	CHUV, Lausanne	p	250, SC synchro-cyclotron, (Mevion)	1 gantry	1	2021

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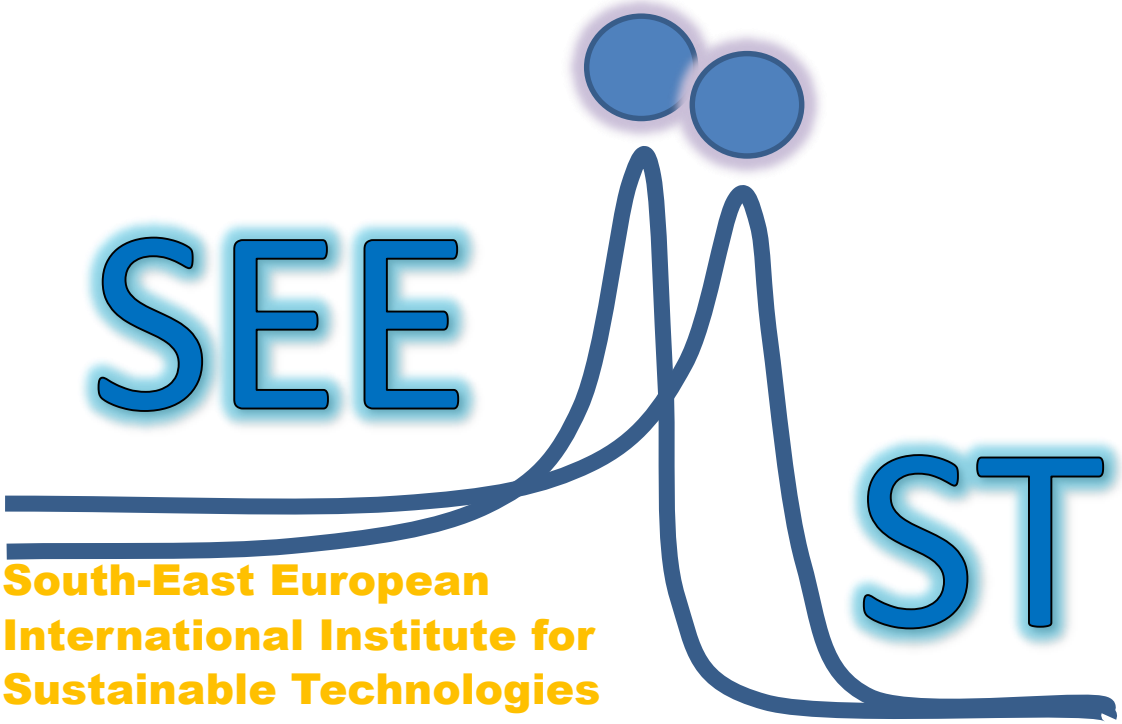
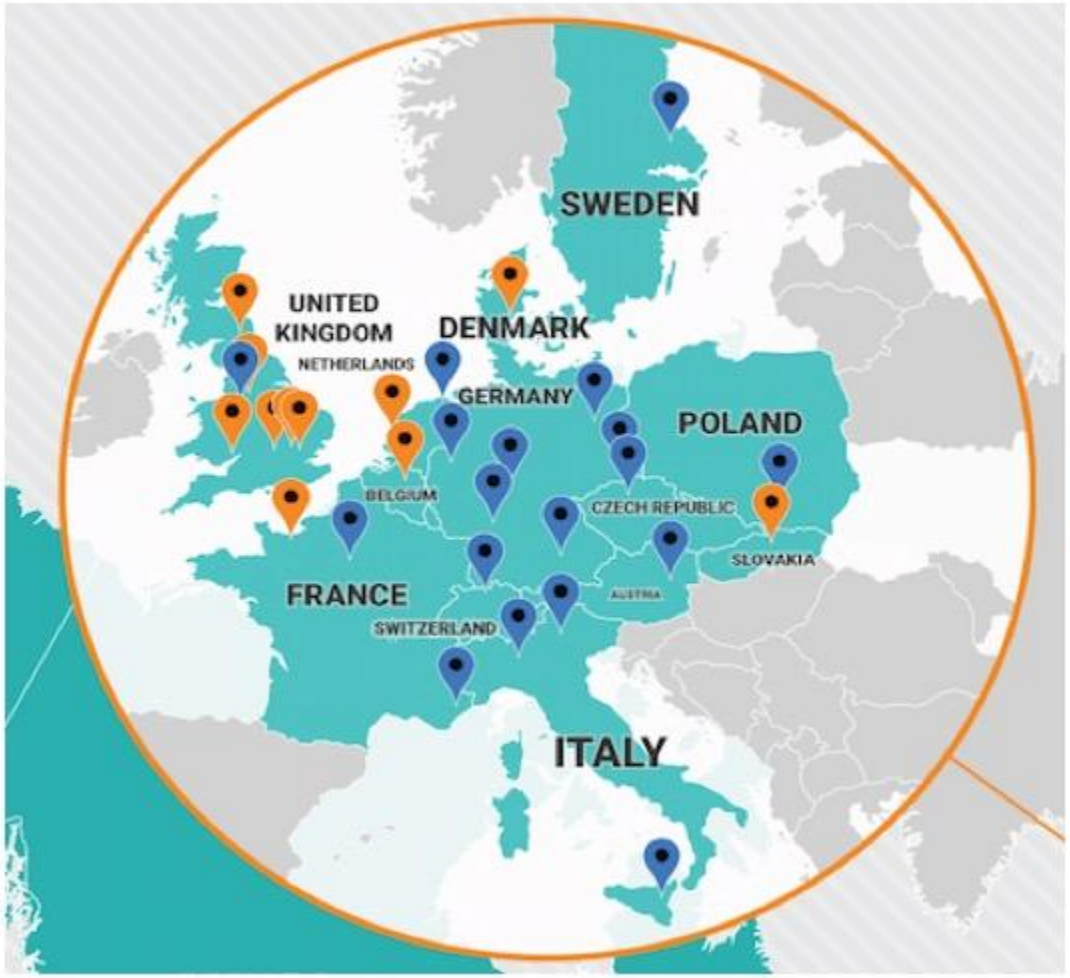


http://seeiist.eu/


SWEDEN
UNITED KINGDOM
DENMARK
NETHERLANDS
GERMANY
POLAND
BELGIUM
CZECH REPUBLIC
SLOVAKIA
FRANCE
AUSTRIA
SWITZERLAND
ITALY

Candidate Members for the South-East European International Institute for Sustainable Technologies

Republic of Albania

Bosnia and Herzegovina

Republic of Bulgaria

Republic of Croatia

Hellenic Republic

Kosovo*

FYR of Macedonia

Montenegro

Republic of Serbia

Republic of Slovenia

Signed a Declaration of Intent

Agreed 'ad referendum'

Observer

The main objectives of the Project

- To promote collaboration between science, technology and industry, but also to provide platforms for the development of the education of young scientists and engineers based on knowledge and technology transfer from European laboratories like CERN and others
- To mitigate tensions between countries in the region
- To form a research nucleus in the region of South-East Europe by bringing people from different countries to work together – not only scientists and engineers, but also industry and administration

The combination of all these tasks would imply another case of the 'CERN model' of 'Science for Peace'

Meet the goals with a Large Scale Facility based on the latest technologies to enable 'first class research' and thereby strongly revert brain drain and assure high competitiveness

A Facility for Tumour Therapy and Biomedical Research in South-Eastern Europe

U. Amaldi, TERA Foundation, Novara
J. Balosso, François Baclesse Centre, *Caen*
M. Dosanjh, CERN
B. Singers Sørensen, J. Overgaard, Dept Experimental Clinical Oncology, Aarhus
S. Rossi, CNAO Foundation, Pavia
M. Scholz, GSI, Darmstadt

CERN Yellow Report: September 2019
DOI: 10.23731/CYRM-2019-002

Building a Community in the SEE Region for the SEEIIST Facility leveraging ENLIGHT

Manjit Dosanjh, 18 September 2019

CERN

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The proposed accelerator facility for SEEIIST

With contributions from U. Amaldi, E. Benedetto and M. Sapinski

Maurizio Vretenar (CERN)

The present and the future of ion therapy accelerators

Europe has played a major role in the development of hadron therapy facilities

4 ion therapy facilities operating in Europe (but 3 in China and 6 in Japan!)

- 2 based on the PIMMS design started at CERN in 1996. 1st patient at CNAO in 2011.
- 2 based on the GSI-Siemens design started at GSI in 1998 . 1st patient at HIT in 2009.

The new SEEIIST Facility – present design (2018) is based on PIMMS

Particle accelerator technology has made a huge progress in the last 20 years, and Japan is progressing fast in the development of new more compact and less expensive ion therapy accelerator designs.

Building on the combined experience accumulated over the last 20 years by the European facilities, can we imagine revising our standard accelerator designs to profit of the last advance in accelerator technologies ?

Requirements for a new accelerator design

Requirements of the ion therapy community, expressed at the Archamps Workshop, June 2018

A new ion therapy accelerator should have:

- ❑ Lower cost, compared to present;
- ❑ Reduced footprint;
- ❑ Lower running costs;
- ❑ Faster dose delivery with higher beam intensity or pulse rate;
- ❑ A rotating ion gantry;

"Soft" advantages of a new innovative design:

- Can attract a wide support from the scientific community (including CERN !)
- Can increase the exchange SEE-WE and inside SEE thanks to stronger collaboration on scientific and technical issues;
- Can bring modern high technology to the region, with new opportunities for local industry and scientific institutions.

+ Specific requirements for SEEIIST:

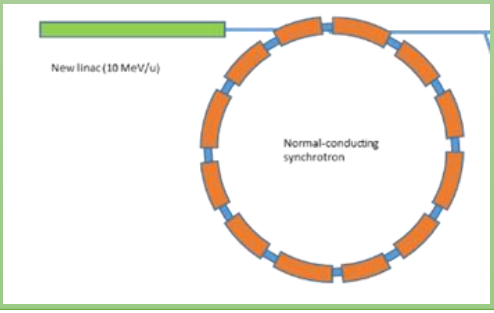
- ❑ Industrialization
- ❑ Reliability
- ❑ Easy operation
- ❑ Reduced risk
- ❑ Acceptable time to development

Accelerator design – the three options

Improved synchrotron (warm)

Equipped with several innovative features: multi-turn injection for higher beam intensity, new injector at higher gradient and energy, multiple extraction schemes, multi-ion.

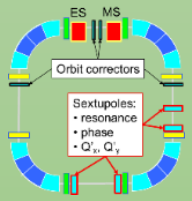
Circumference ~ 75 m

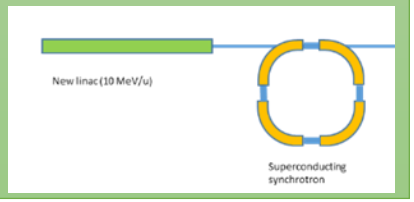


Improved synchrotron (superconducting)

Equipped with the same innovative features as warm, but additionally 90^0 superconducting magnets.

Circumference ~ 27 m

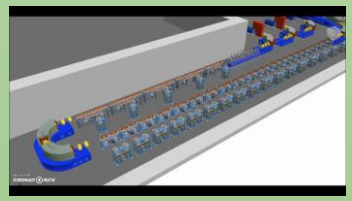


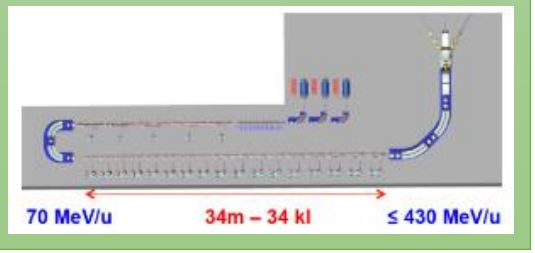


Linear accelerator

Linear sequence of accelerating cells, high pulse frequency.

Length ~ 53 m





The three accelerator options - comparison

The comparison of the three accelerator options is the subject of the Service Contract with DLR that starts now. The table below summarises the data collected so far:

	Construction Cost	Operation cost	Footprint	Performance	Time to development	Risk of development	Treatment protocols
Warm (new) synchrotron	Medium	Medium	Large	Good	Low	Low	Existing
Superconducting synchrotron	Lower	Lower	Small	Good	Medium	Medium	Existing
Linear accelerator	Lower	Lower	Small	Better	Long	Medium	To be developed

- The linear accelerator has best performance, but needs longer time for development of technology and of the specific treatment protocols.
- An improved warm synchrotron presents the lowest risk and the shortest development time.
- A superconducting synchrotron has somehow longer time and risk, but offers lower costs and lower footprint.

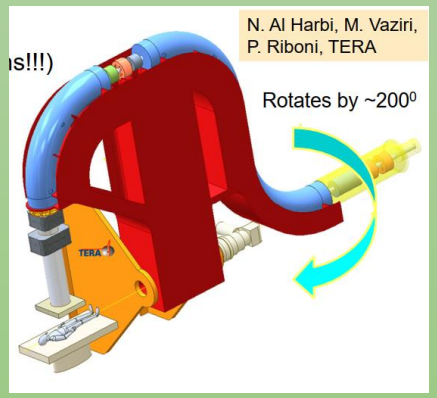
Alternative designs for the gantry

The medical community requires a gantry system to precisely align the beam on the patient

Rotational superconducting gantry

Equipped with CCT magnets similar to SC synchrotron, rotation by 200^0.

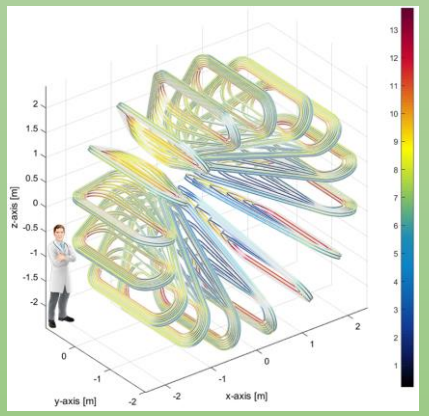
Weight ~ 150 tons



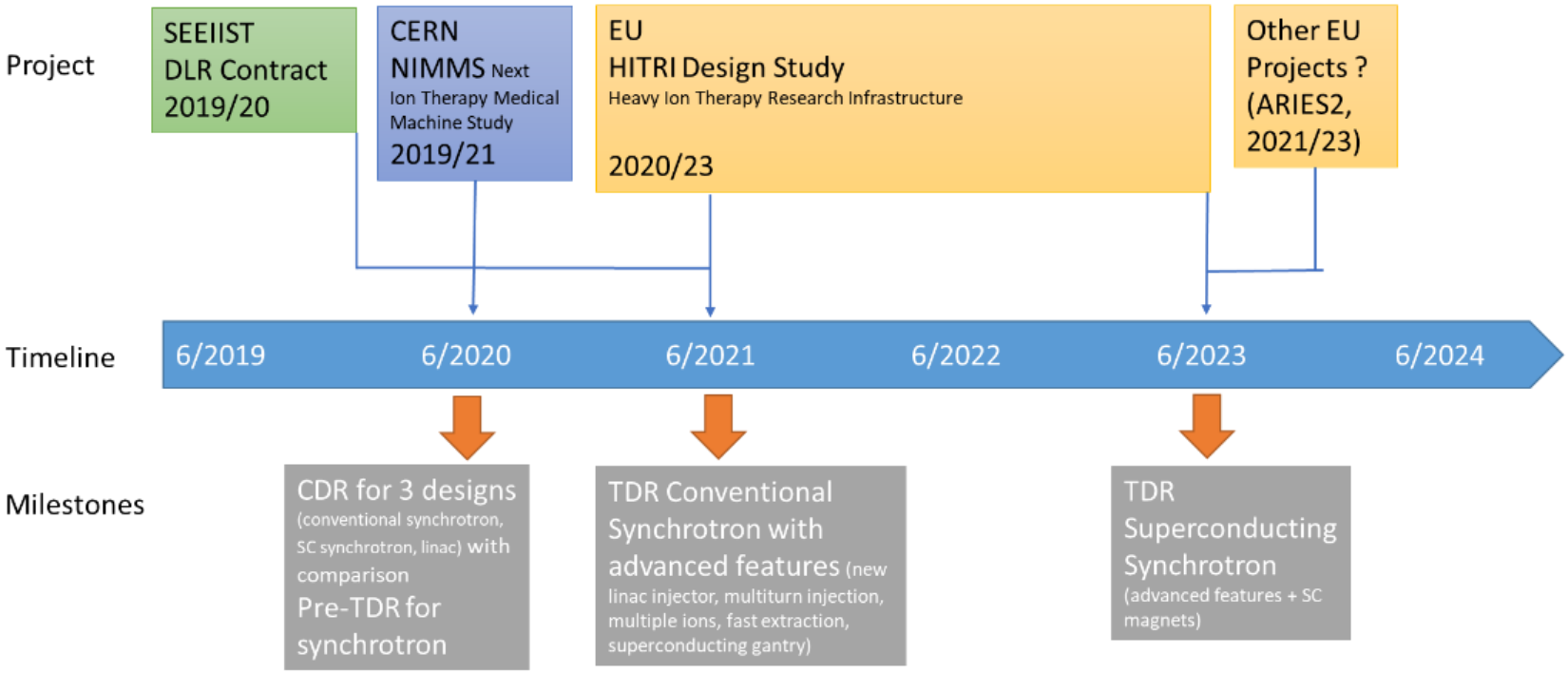
Toroidal gantry

Fixed superconducting toroidal magnet, no rotating parts (GaToroid, L. Bottura)

Radius 5 m, weight 50 tons



Accelerator Design Strategy – the timeline HITRI/SEEIIST



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- ***Annual meeting***, open, free
- Latest developments in the field
- Oral presentation for winning posters
- Networking
- Collaboration
- Exchanges
- Education and training at CERN
- Sharing and building bridges
- Raising awareness at international level
- Special day dedicated to training
- Biannual Magazine – ***Highlights***
- **@ENLIGHTNETWORK**

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LinkedIn Groups

www.cern.ch/enlight

18th ENLIGHT meeting, 22-24 June 2020, Bergen, Norway

ENLIGHT 2019 meeting at Centre Francoise Baclesse

Thank you to ENLIGHT Network