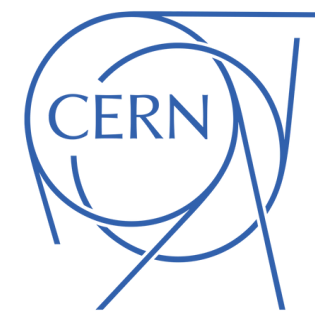


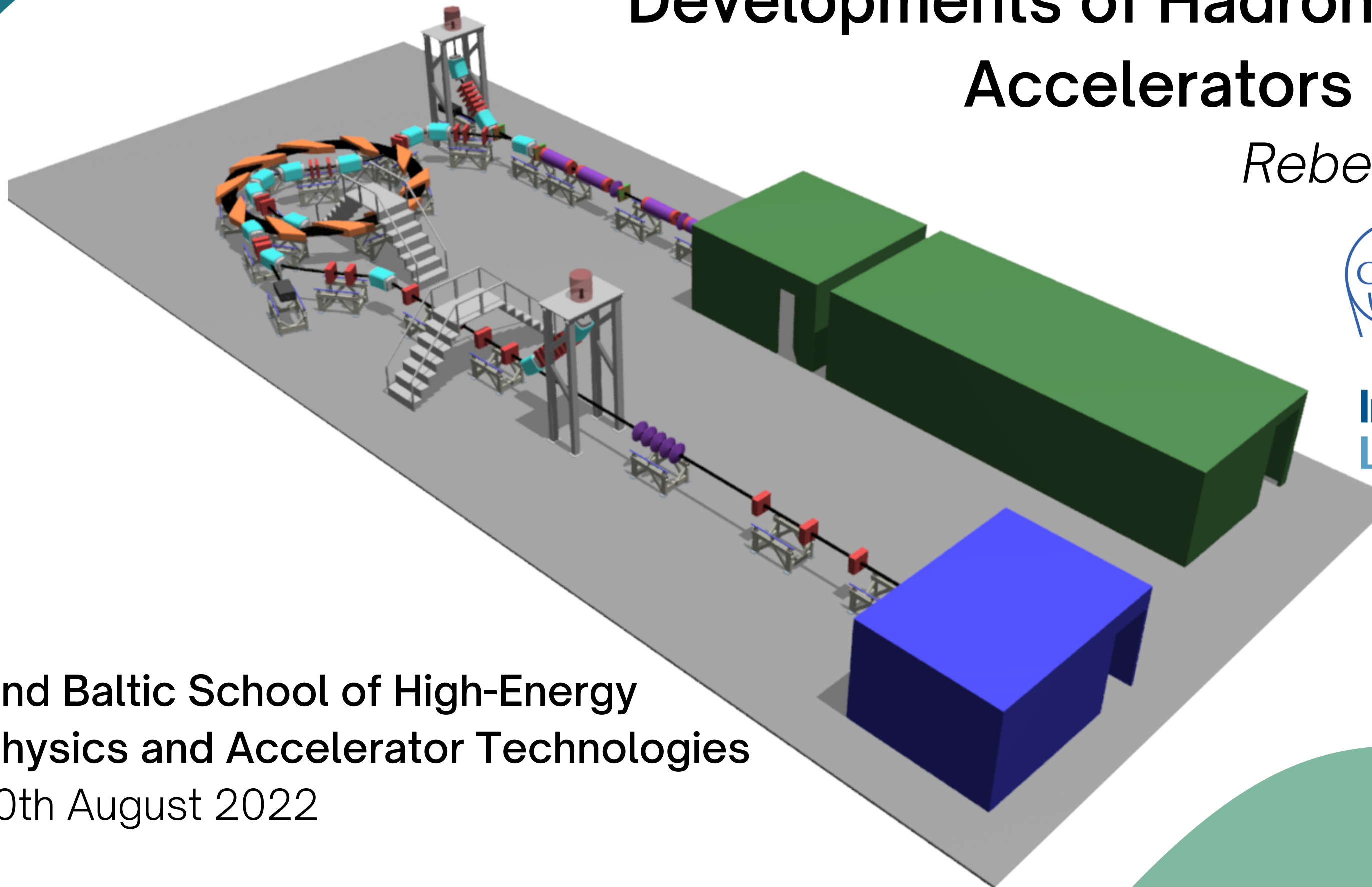
Developments of Hadron Therapy Accelerators in the UK

Rebecca Taylor



**Imperial College
London**

2nd Baltic School of High-Energy
Physics and Accelerator Technologies
10th August 2022



Overview

Hadron Therapy

Motivations

Multidisciplinary
Collaborations

Accelerator Options

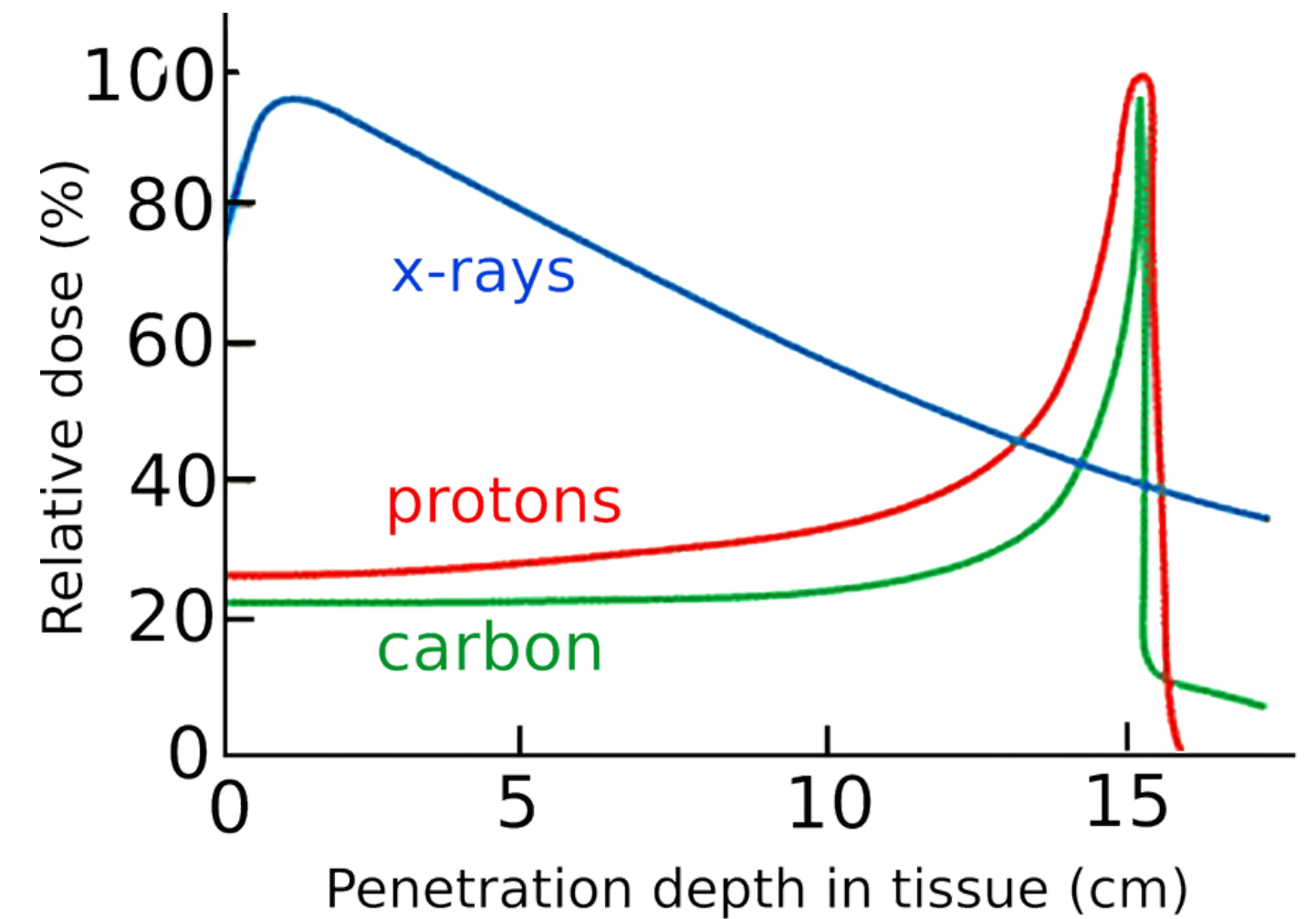
Technological Developments

Future of Hadron Therapy

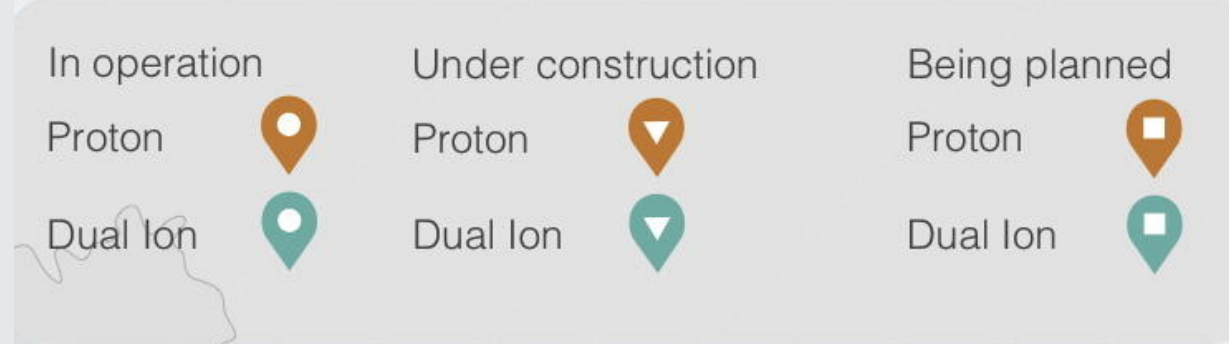
Hadron Therapy

History

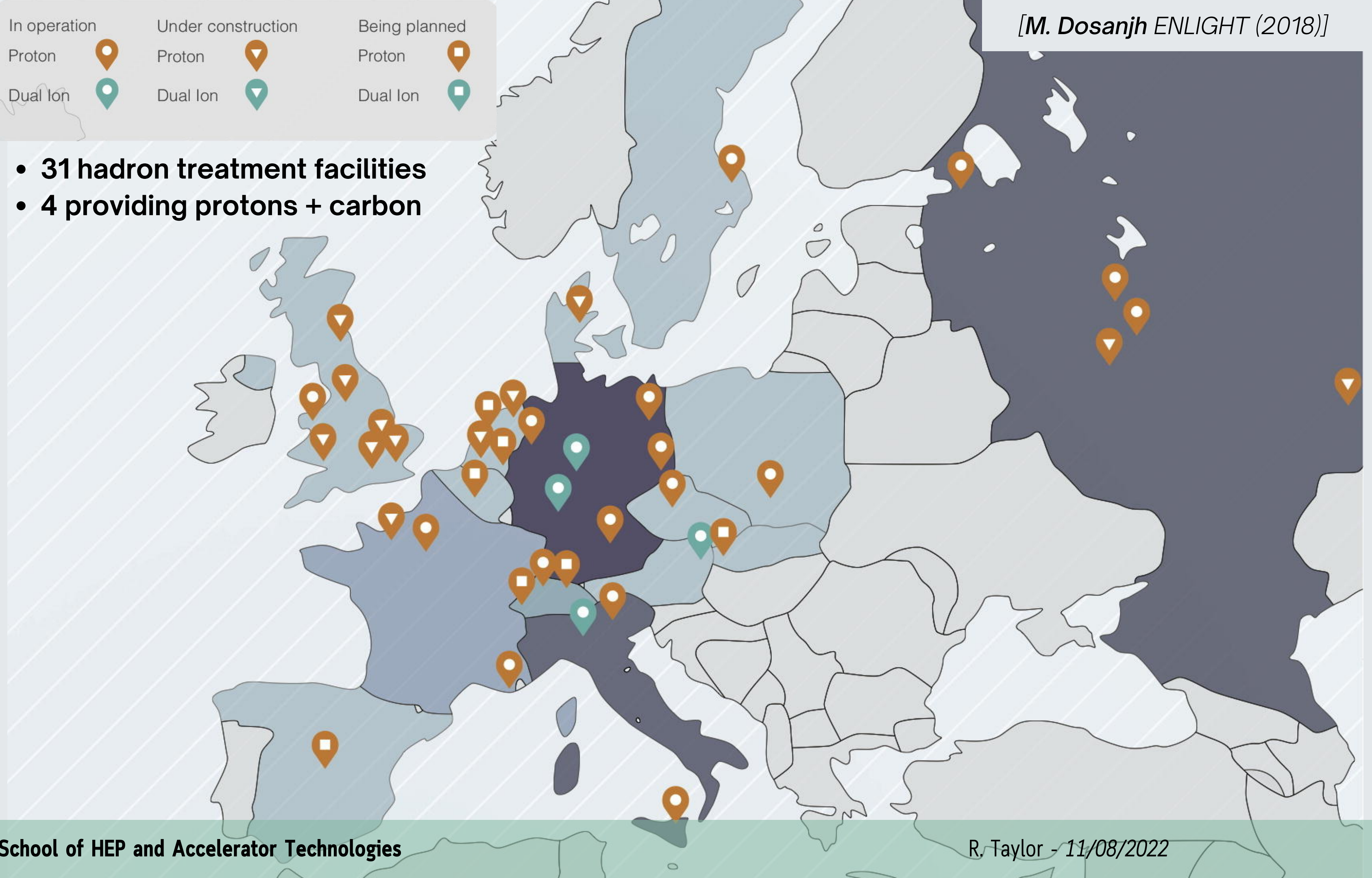
- 1903 - Bragg curve reported
- 1930 - Cyclotron invented by E. Lawrence
- 1947 - 184-inch cyclotron built at Berkley (350 MeV)
- 1952 - Proton synchrotron invented by M. Oliphant
- 1954 - First patient treated with proton therapy



*1500 patients treated
from 1954 - 1986*

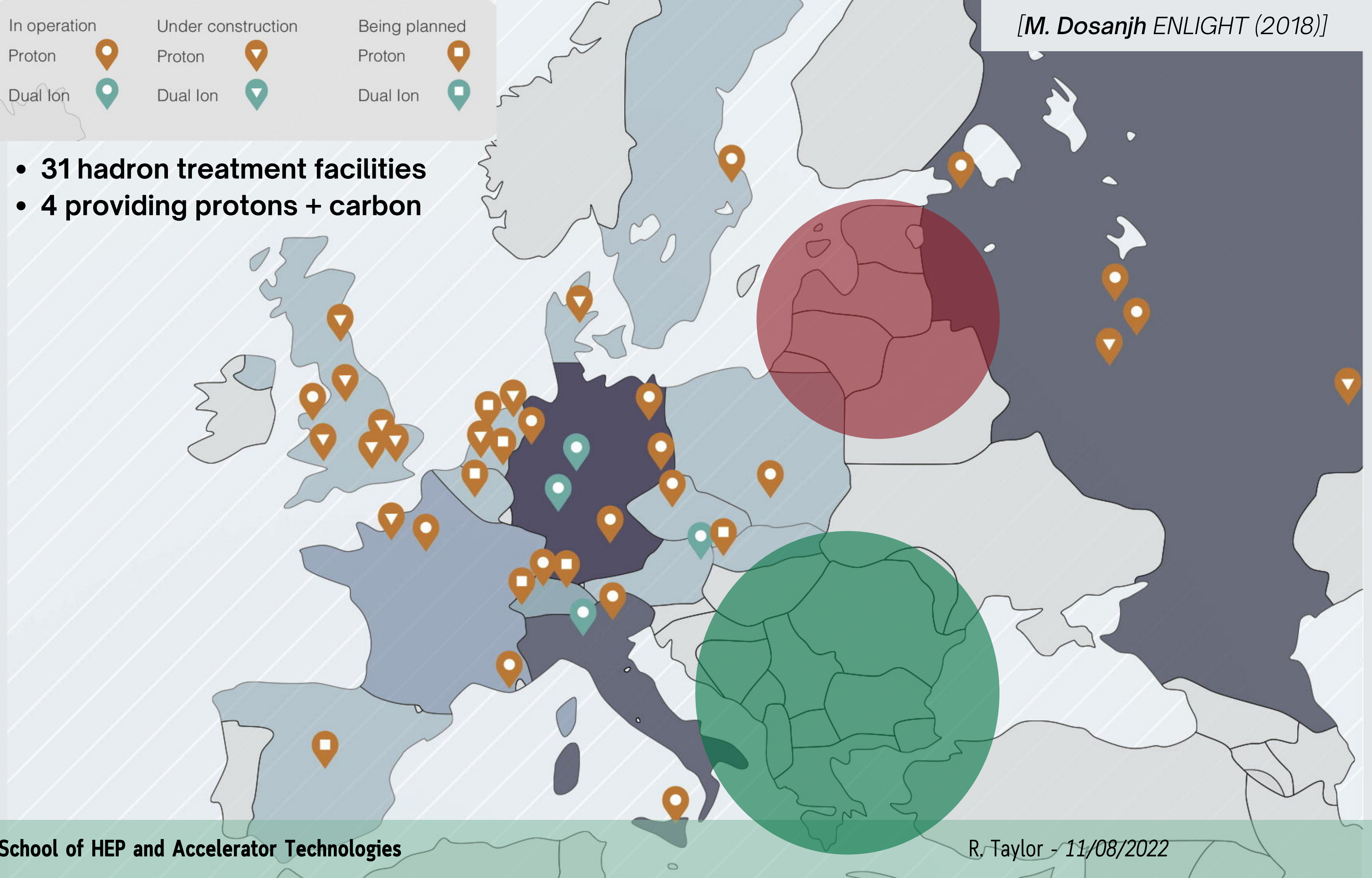


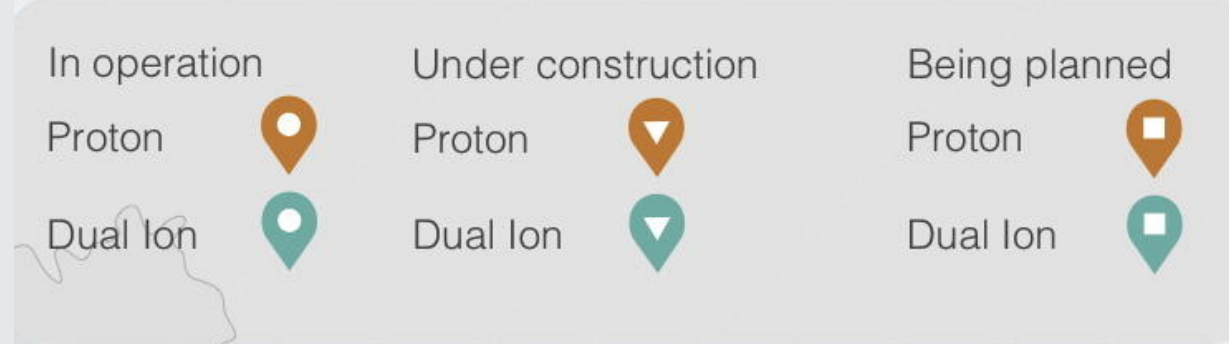
- 31 hadron treatment facilities
- 4 providing protons + carbon



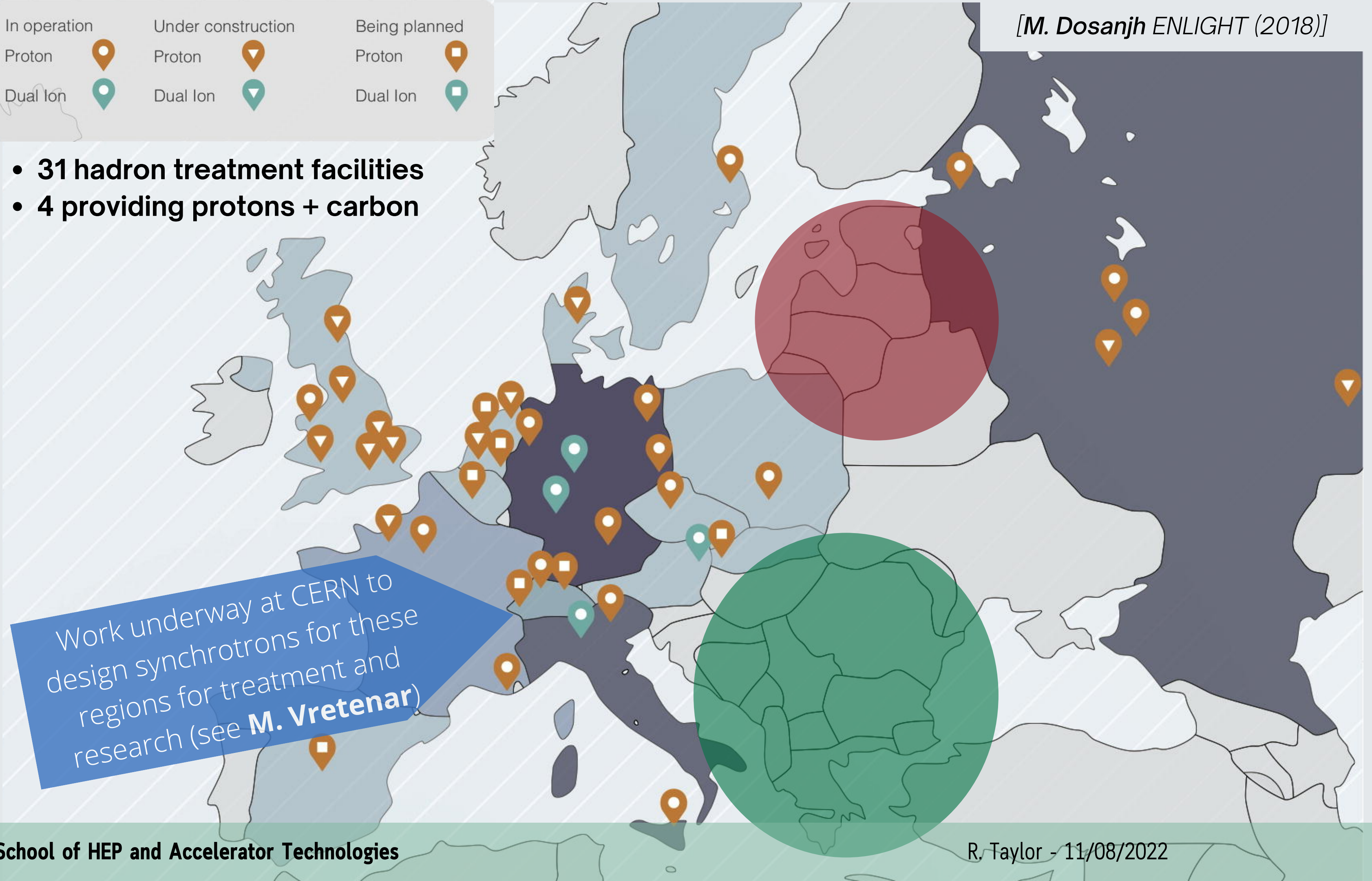


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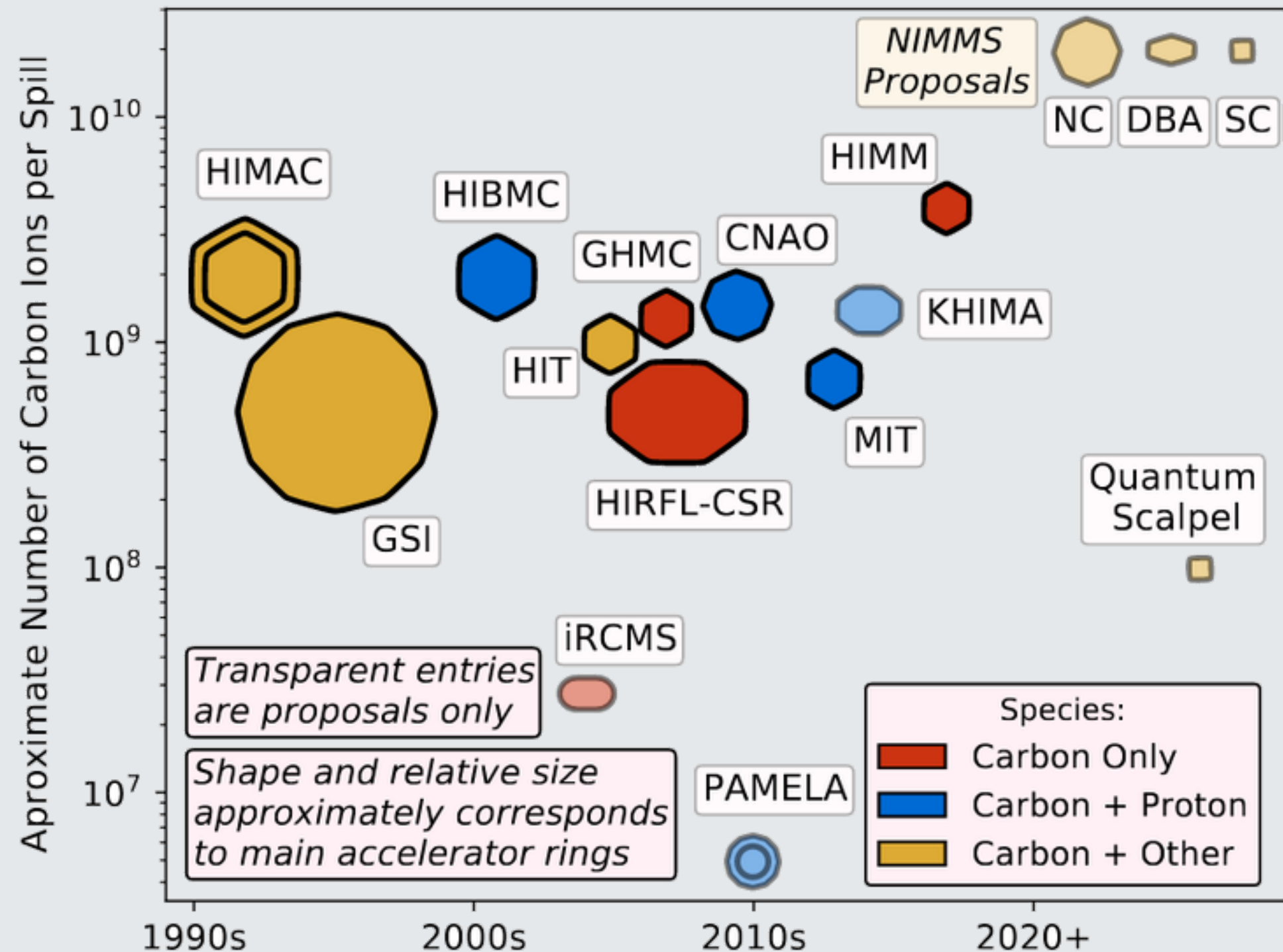
- 31 hadron treatment facilities
- 4 providing protons + carbon



Existing Facilities

HIMAC	Japan	1994
PIMMS	<i>Study</i>	1998
CNAO	Italy	2012
HIT	Germany	2012
MedAustron	Austria	2019

~ 60 - 250 MeV protons
 ~ 120 - 400 MeV/u ions



Motivations

Many unanswered questions on the radiobiological effects of hadron therapy

Effects of new ion species

RBE/LET at different energies

Effect of delivery timescale

FLASH effect limits

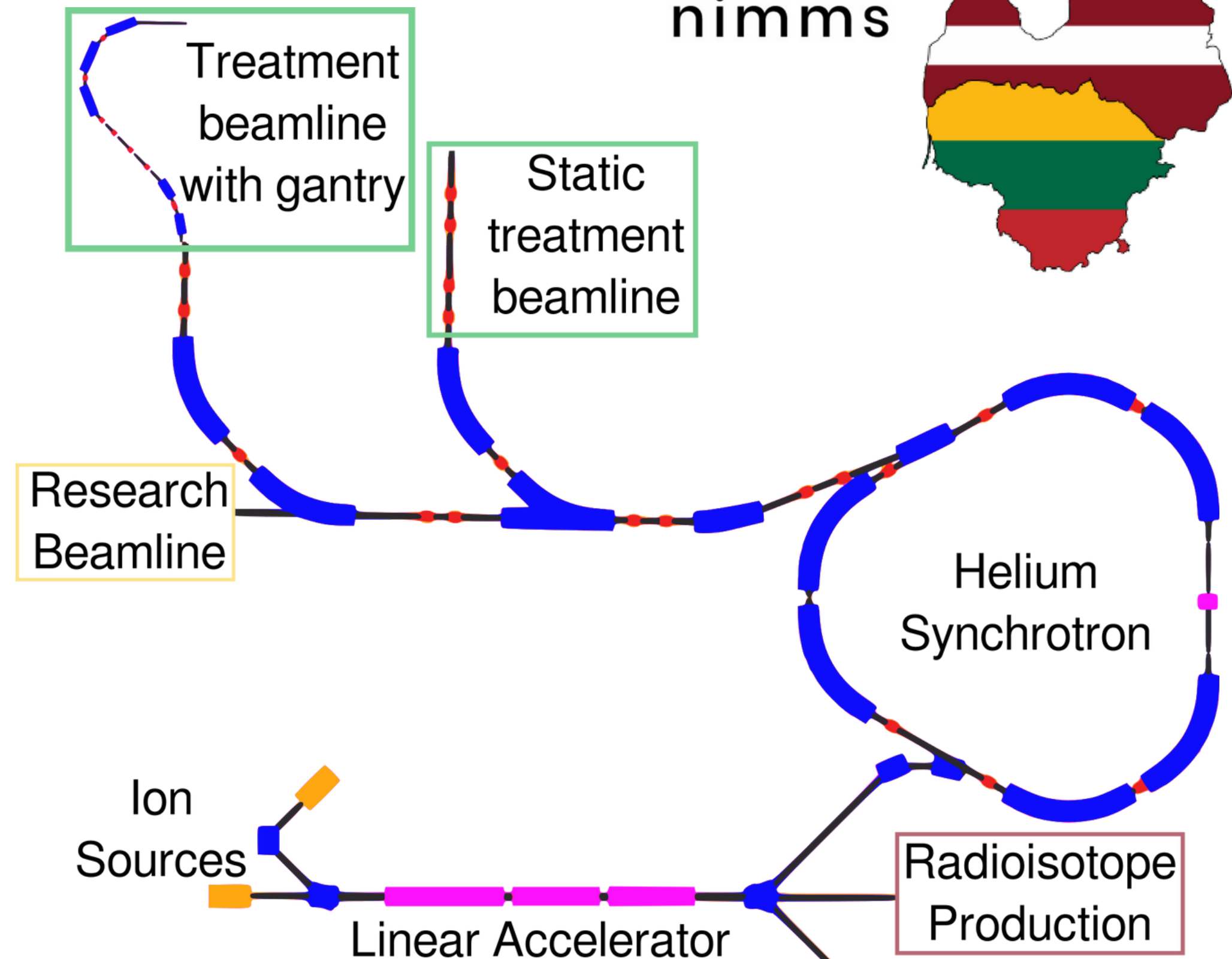
Response of tissue types

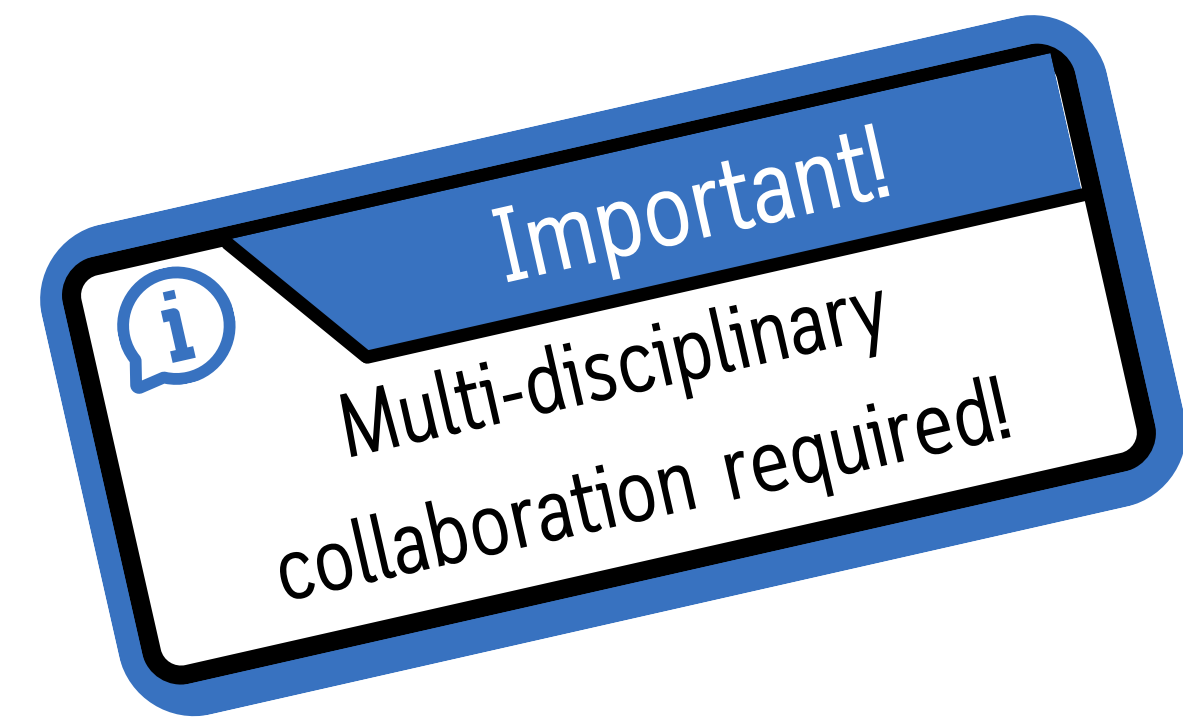
Testing samples and species

Flexible research facility to test these effects

Helium Synchrotron

- Designing proton + helium therapy synchrotron
- Aiming to locate in Baltics
- Flexible facility for both **radiobiological** research and **clinical treatment**

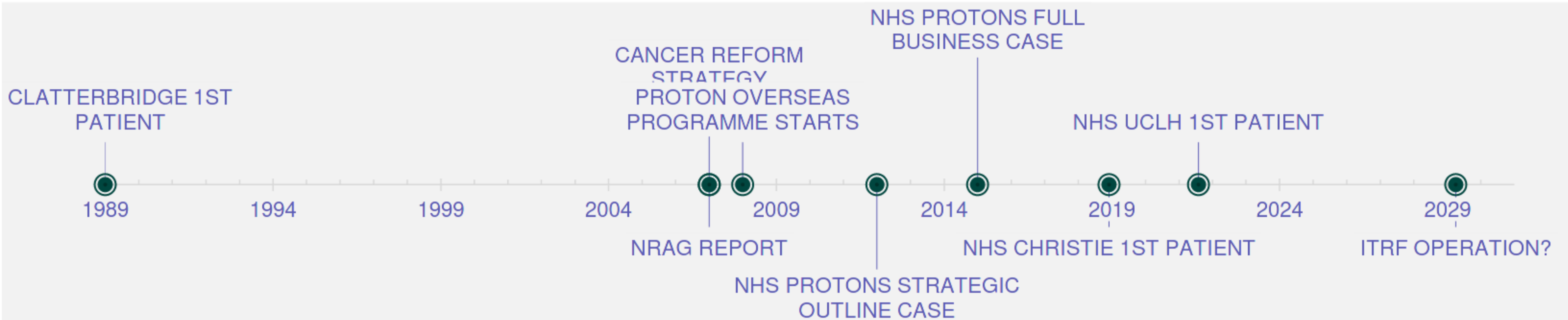




What do radiobiologists, clinicians and medical physicists want and need from this facility?

- Building new facilities requires wide breadth of knowledge and research
- Important to connect with the future user-base during the initial design stages.

UK Situation



- Started in 2018 to "*develop the technologies, systems, techniques and capabilities necessary to deliver a paradigm shift in the clinical exploitation of particles.*"

Imperial College
London

ICR The Institute of
Cancer Research

Medical
Research
Council
UKRI
Oxford Institute for
Radiation Oncology



JAI
John Adams Institute
for Accelerator Science



Imperial College
Academic Health
Science Centre



IMPERIAL
CENTRE

Imperial College Healthcare
NHS Trust



NHS Trust

MANCHESTER
1824

The University of Manchester



UNIVERSITY OF
BIRMINGHAM



UNIVERSITY OF
LIVERPOOL

NHS
University Hospitals
Birmingham
NHS Foundation Trust

NHS
The Clatterbridge
Cancer Centre
NHS Foundation Trust

NHS
The Christie
NHS Foundation Trust

institut
Curie



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UCL
MEDICAL PHYSICS
& BIOMEDICAL
ENGINEERING



NETHERLANDS
CANCER
INSTITUTE
ANTONI VAN LEEUWENHOEK

HAMPTON UNIVERSITY
PROTON THERAPY INSTITUTE
FIGHTING CANCER. SAVING LIVES

University of
Strathclyde
Glasgow
DEPARTMENT
OF PHYSICS



Lancaster
University



UKRI
Science and
Technology
Facilities Council



ASTeC
Daresbury Laboratory
Particle Physics Department
ISIS Neutron and Muon Source

INFN
CATANIA

UNIVERSITY OF
BIRMINGHAM

CYCLOTRON
FACILITY

POSITRON
IMAGING CENTRE

Corerain
鯤云科技

LEO
Cancer Care

MAXELLER
Technologies
Maximum Performance Computing

The Rosalind
Franklin Institute

NPL
National Physical Laboratory

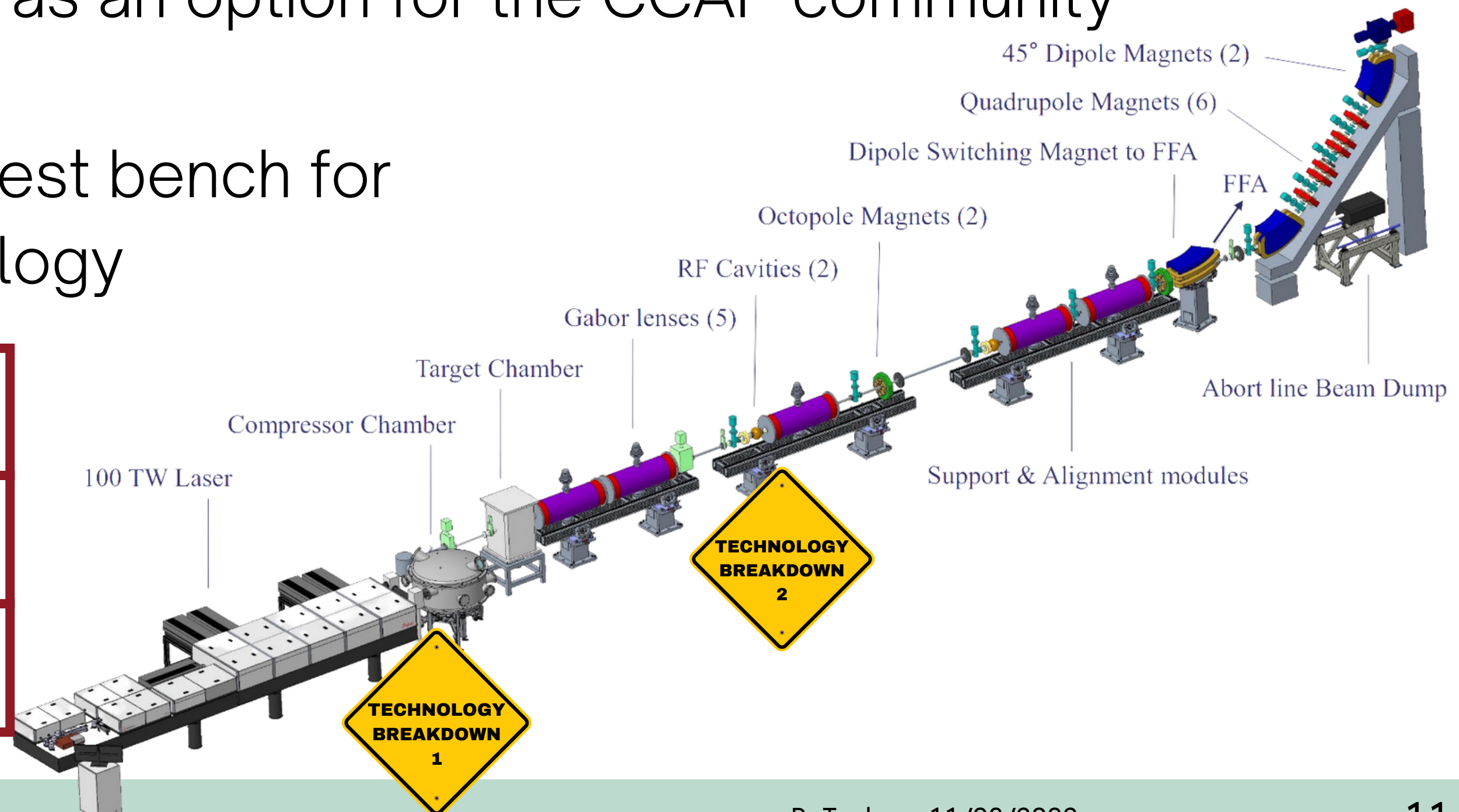
The Cockcroft Institute
of Accelerator Science and Technology



Introducing LhARA

- **LhARA:** Laser-hybrid Accelerator for Radiobiological Applications
- Accelerator project as an option for the CCAP community
- Stage 1:
 - 15 MeV in-vitro test bench for cellular radiobiology

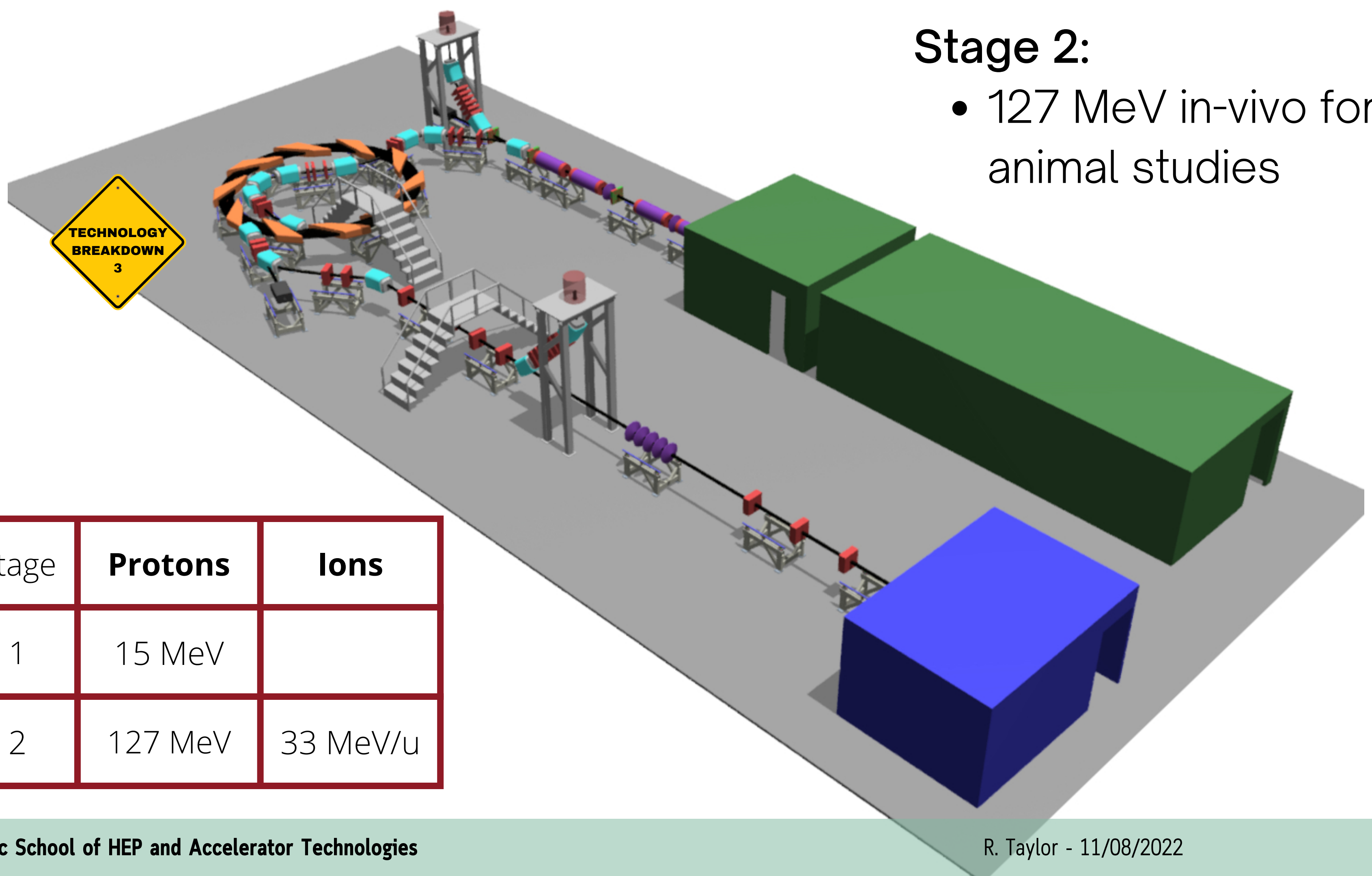
Stage	Protons	Ions
1	15 MeV	
2	127 MeV	33 MeV/u



Stage 2:

- 127 MeV in-vivo for animal studies

Stage	Protons	Ions
1	15 MeV	
2	127 MeV	33 MeV/u

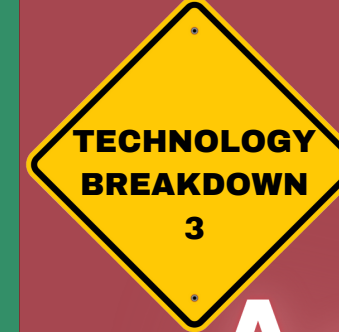




Laser Accelerator



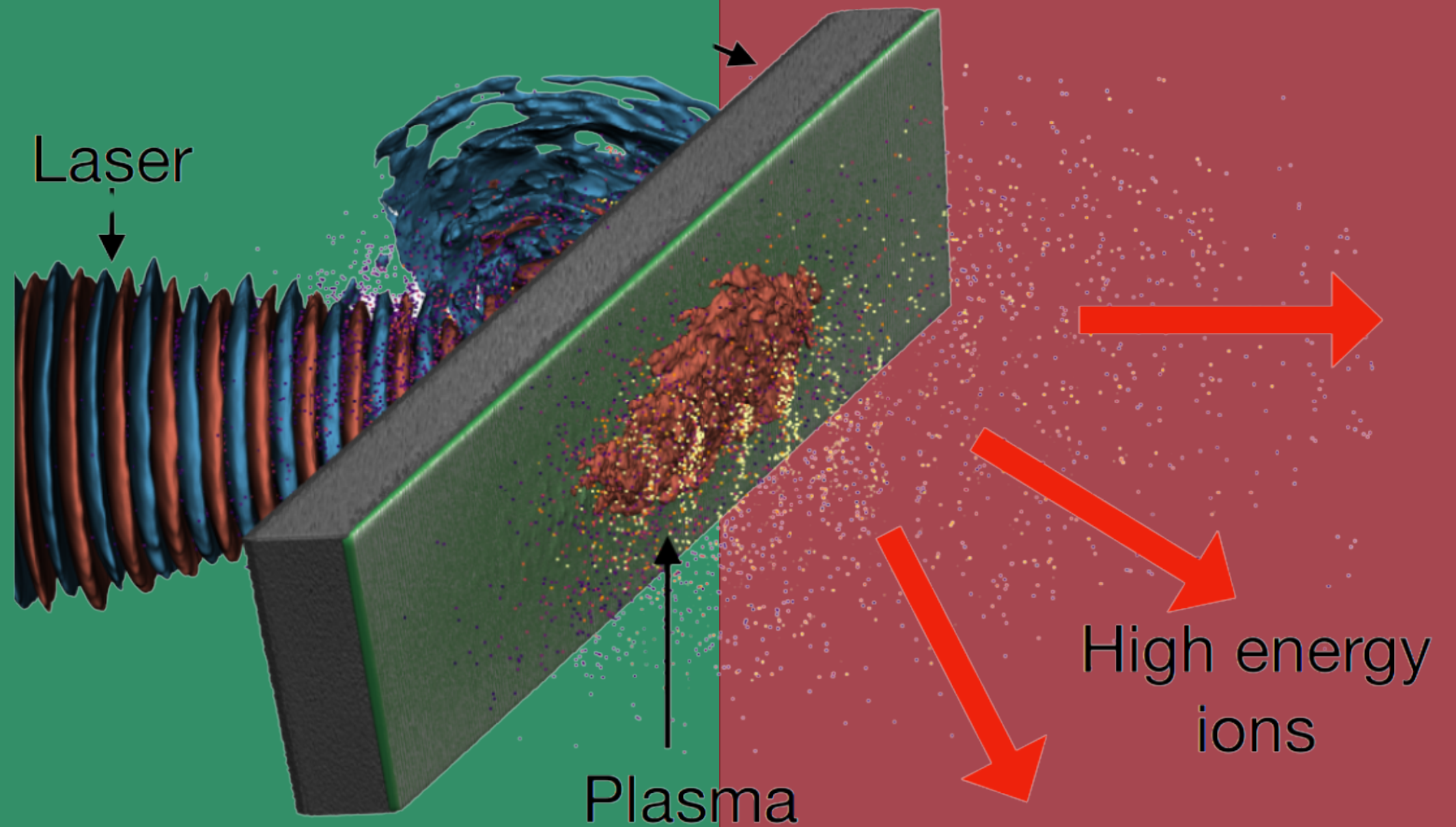
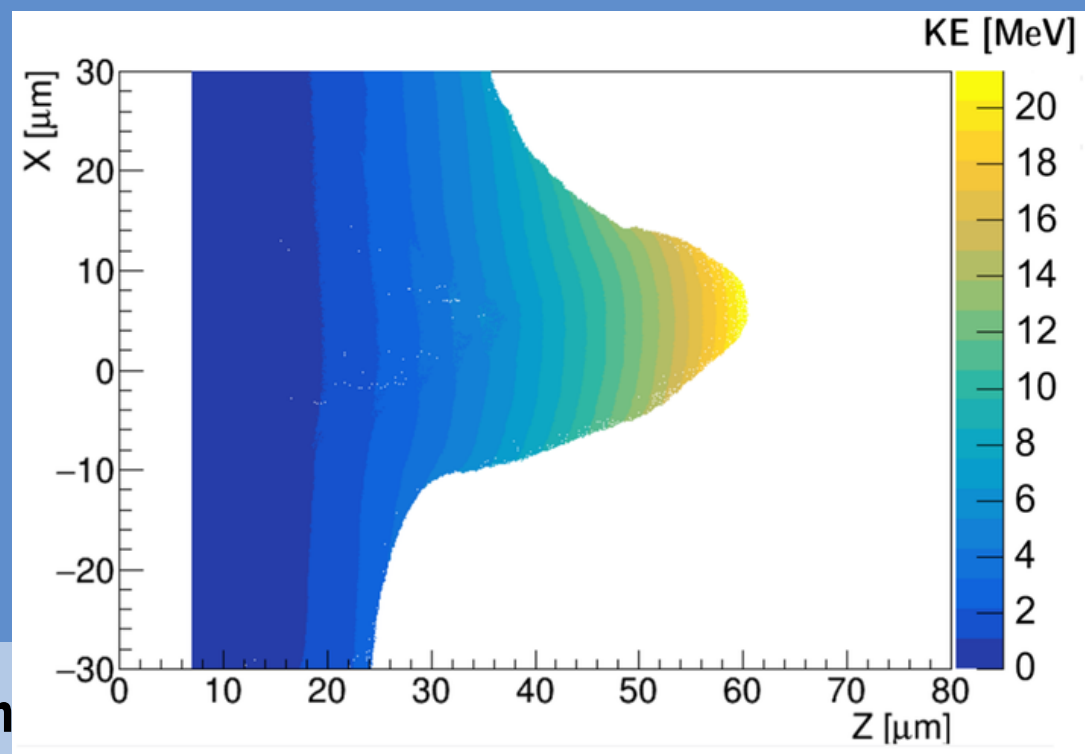
Gabor Lens



FFA Accelerator

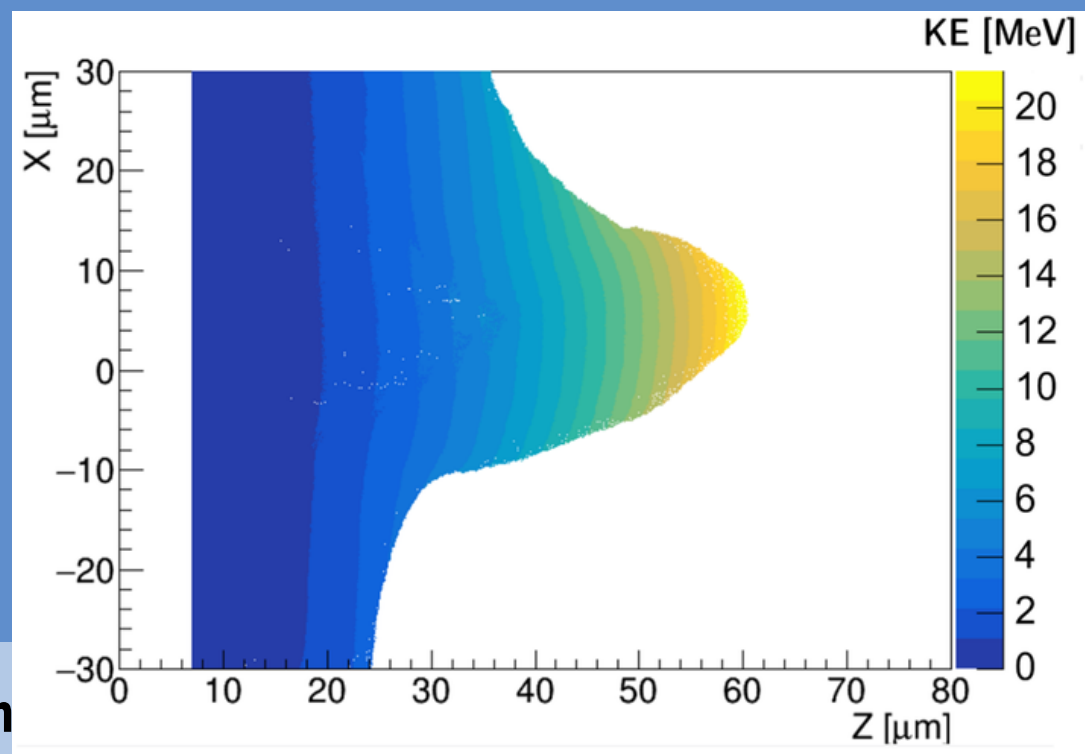
Laser Accelerator

- Multi-TW commercial laser
- 15 MeV protons
- 25 fs pulses
- 10 Hz repetition rate
- 10^{10} per shot
- Tape to change species



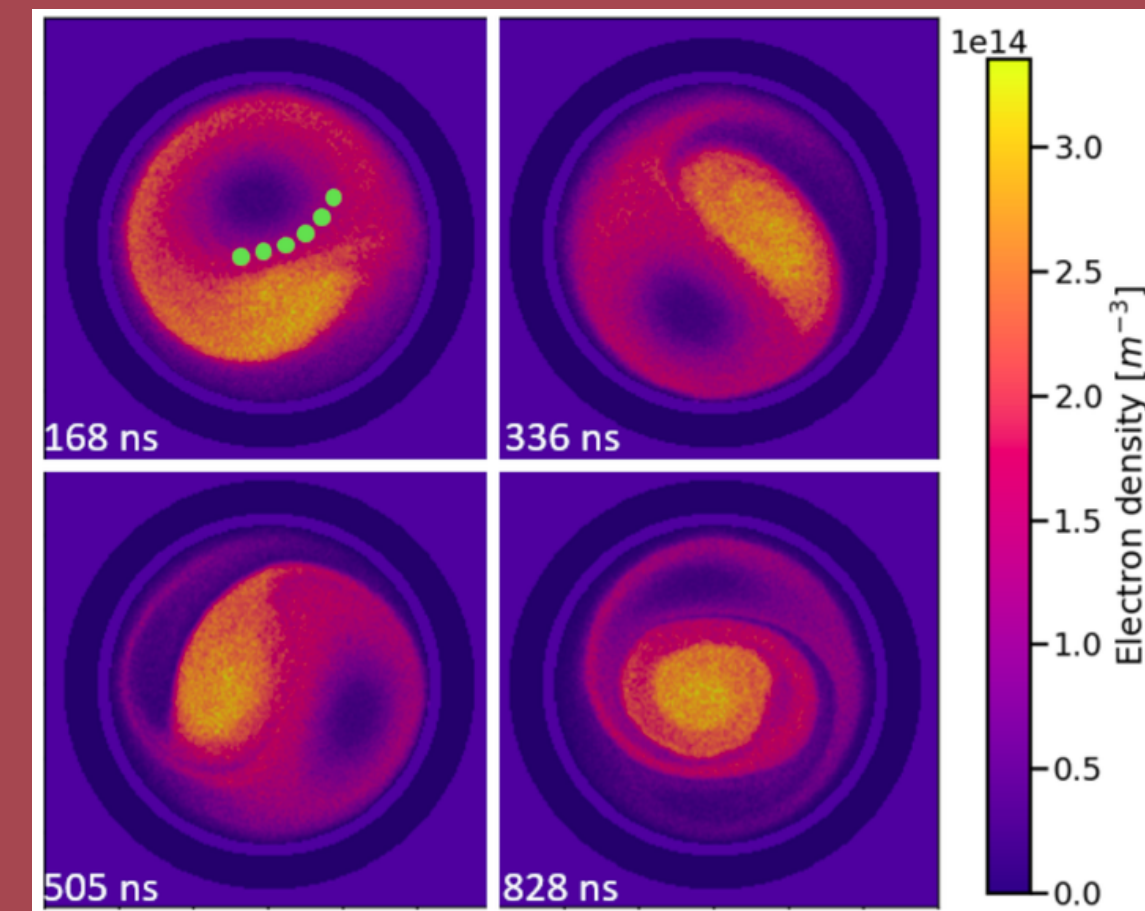
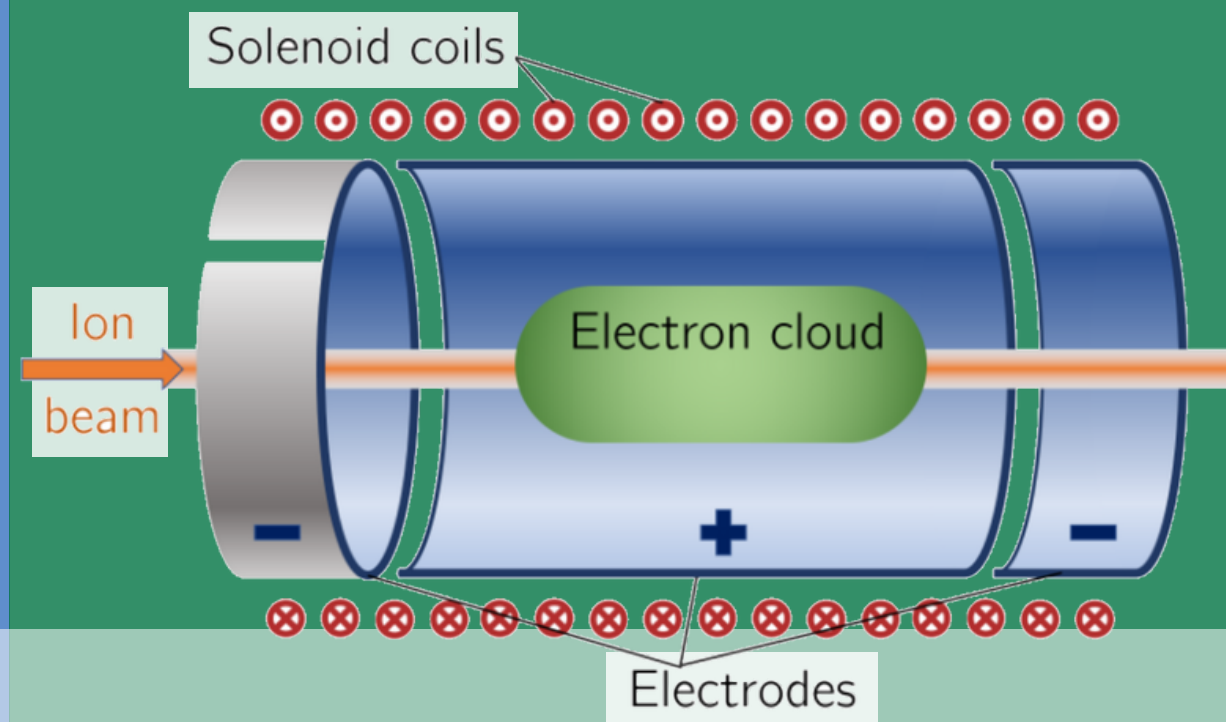
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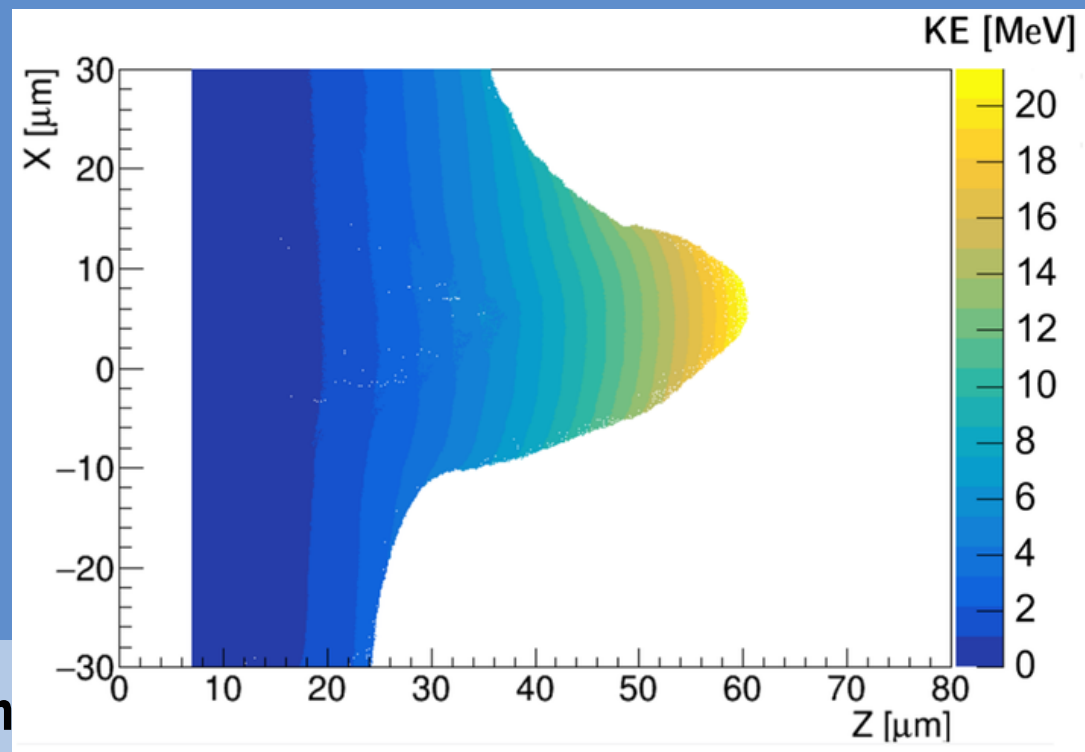
Gabor Lens

- Plasma lens to focus charged particles
- Electron cloud trapped by weak solenoidal fields
- Strong focusing for low energy



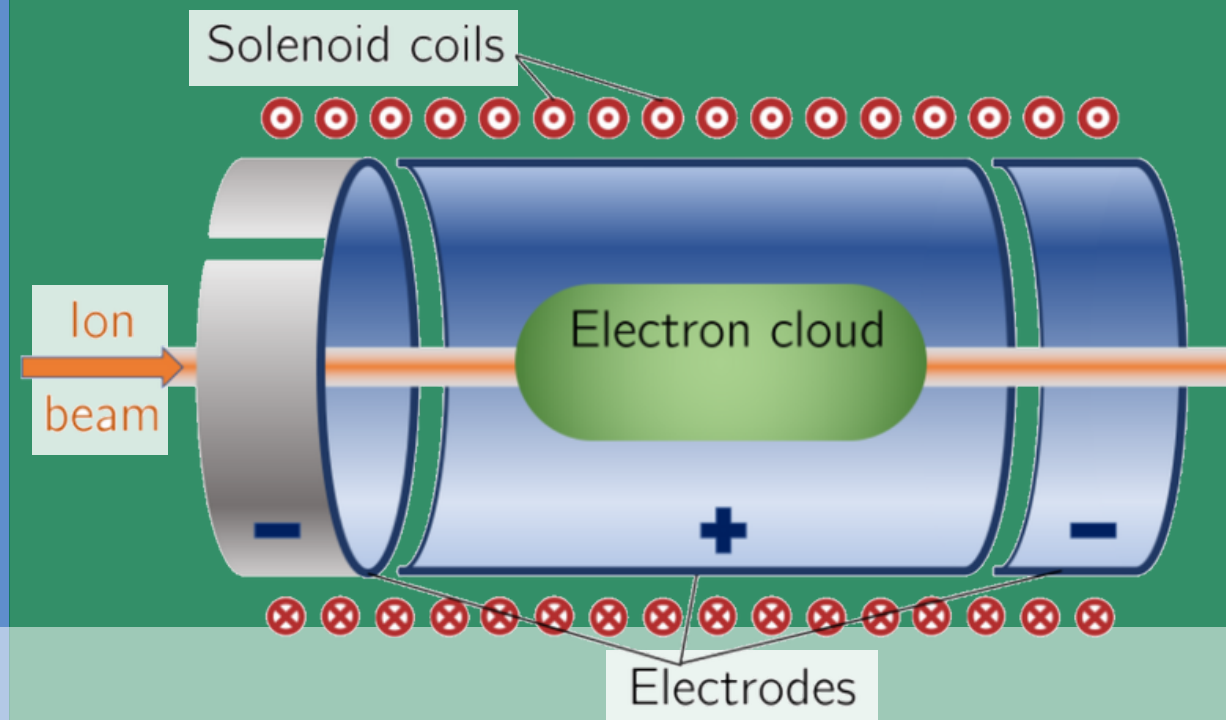
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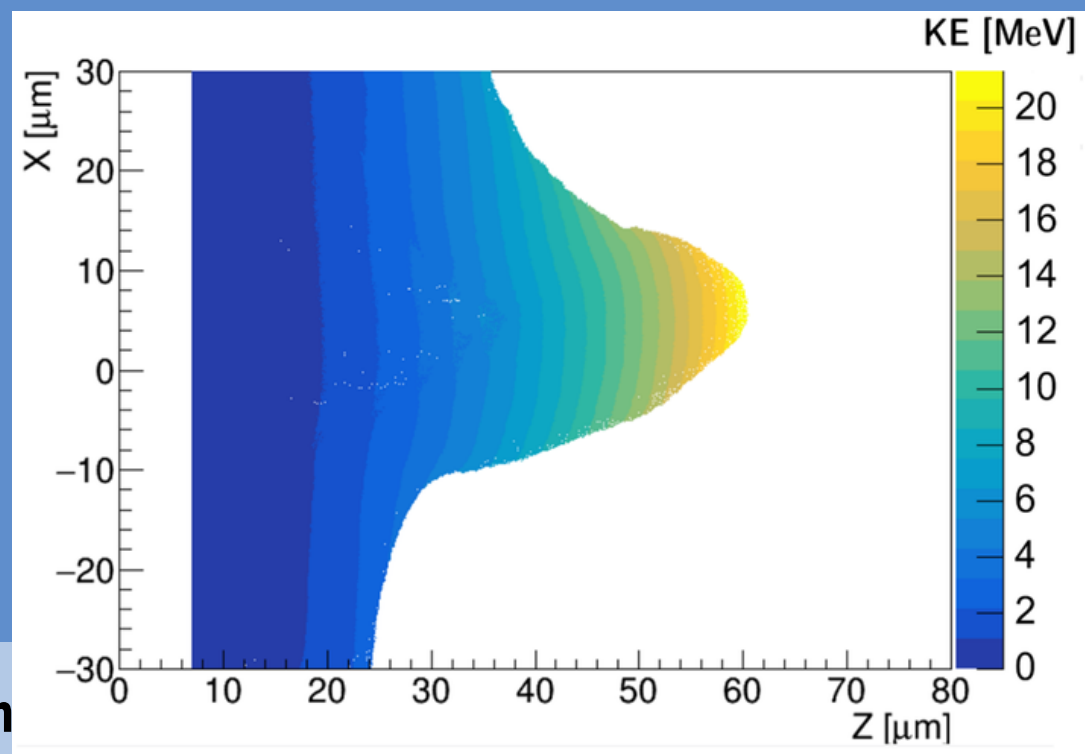


FFA Accelerator

- Fixed-field alternating gradient
- Constant magnets. Particles experience stronger field with higher energy
- Can maintain time structure of laser-induced beam

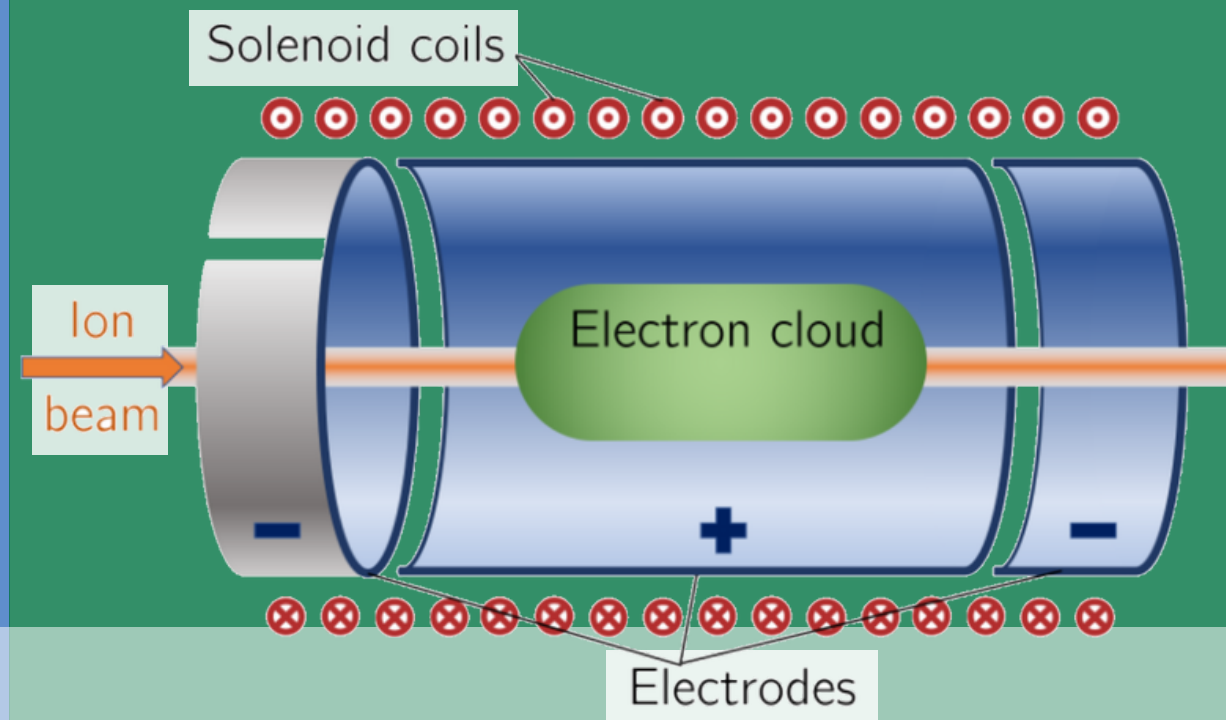
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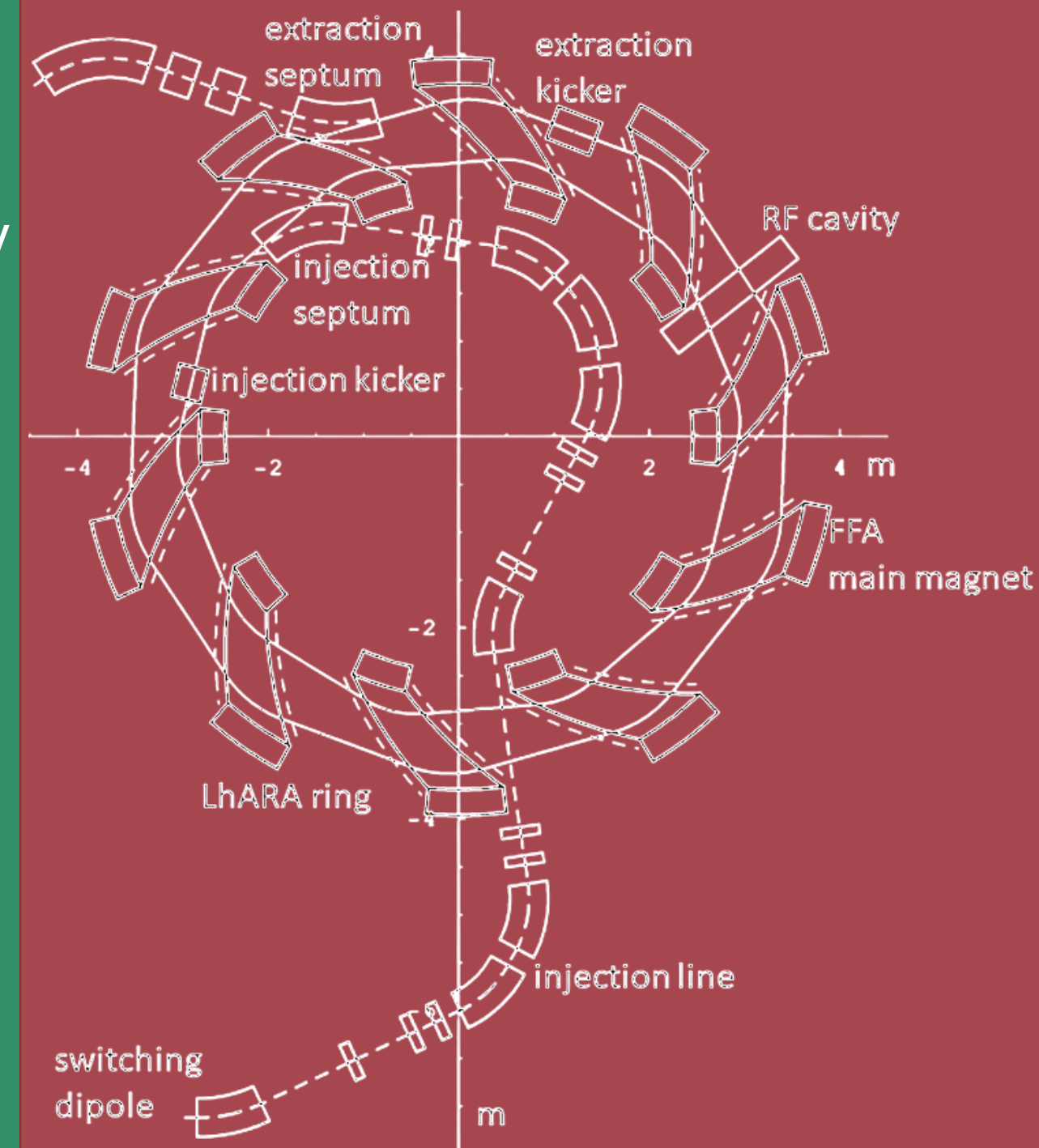


Gabor Lens

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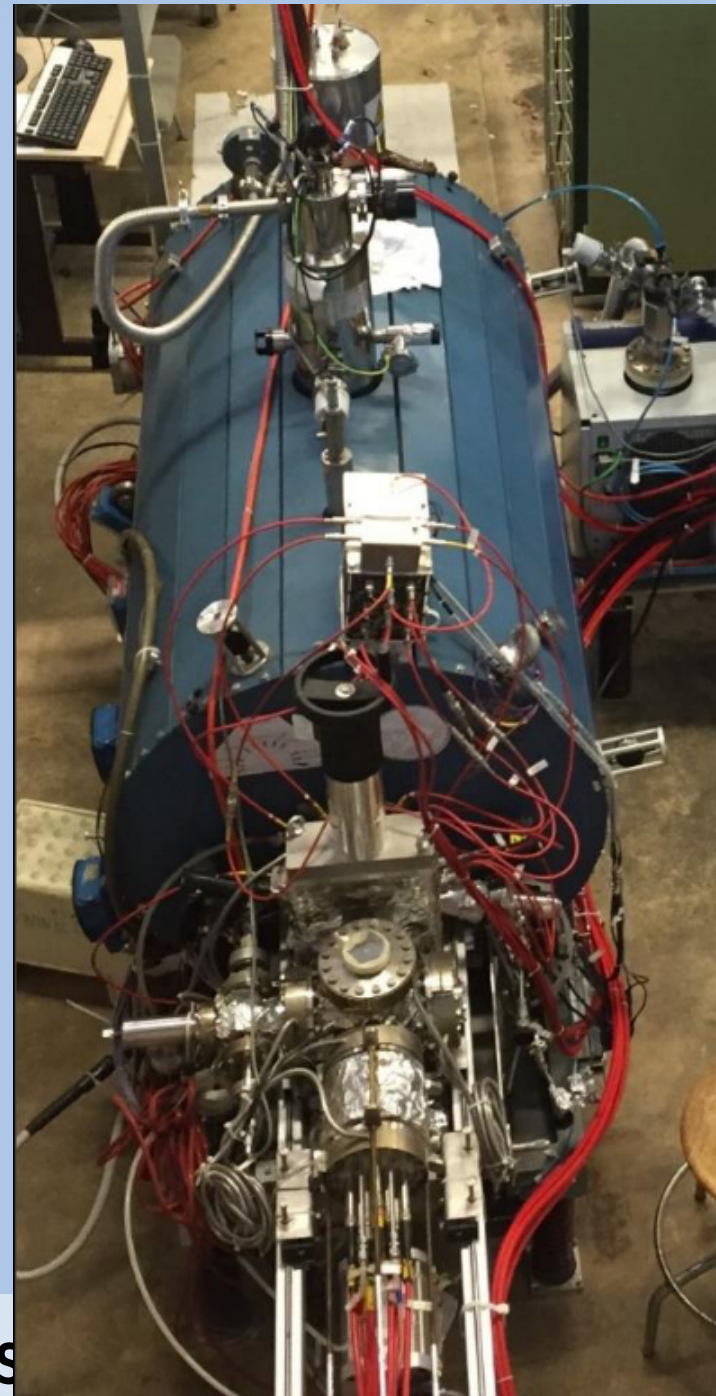


FFA Accelerator

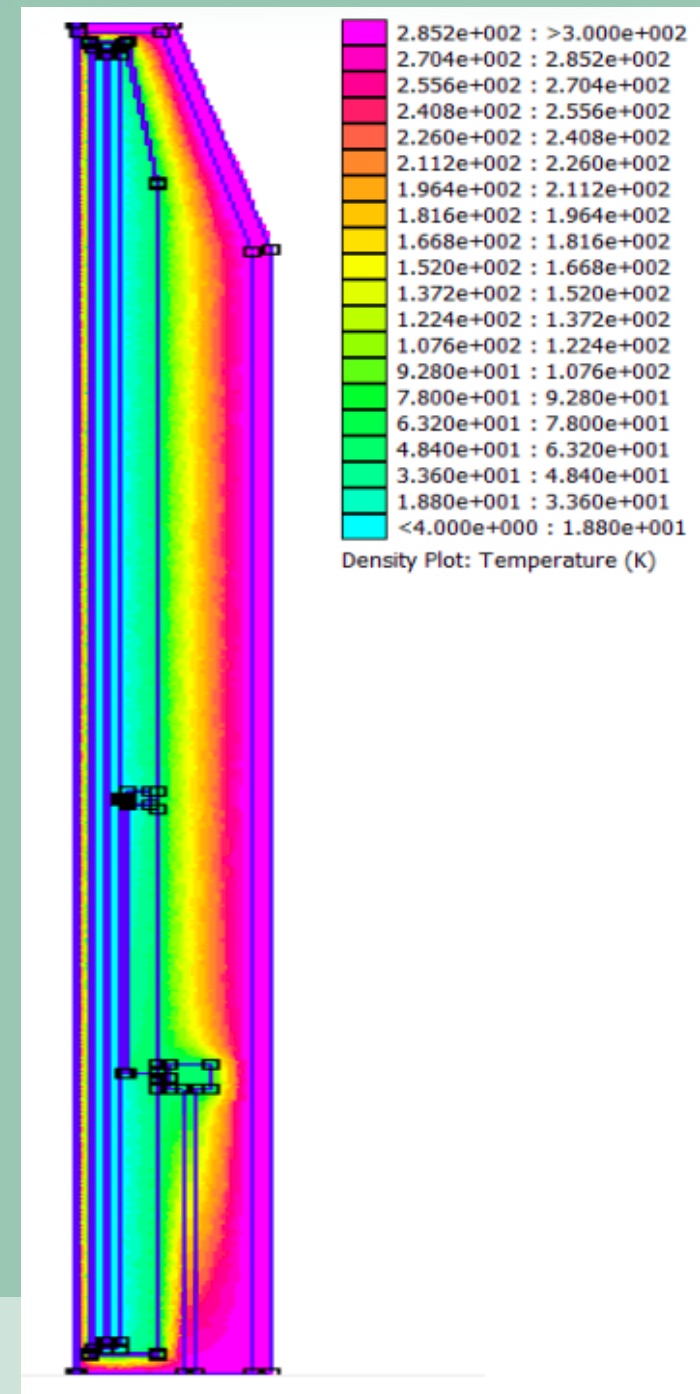


Back-up Technology Options

Electron Beam Ion Source

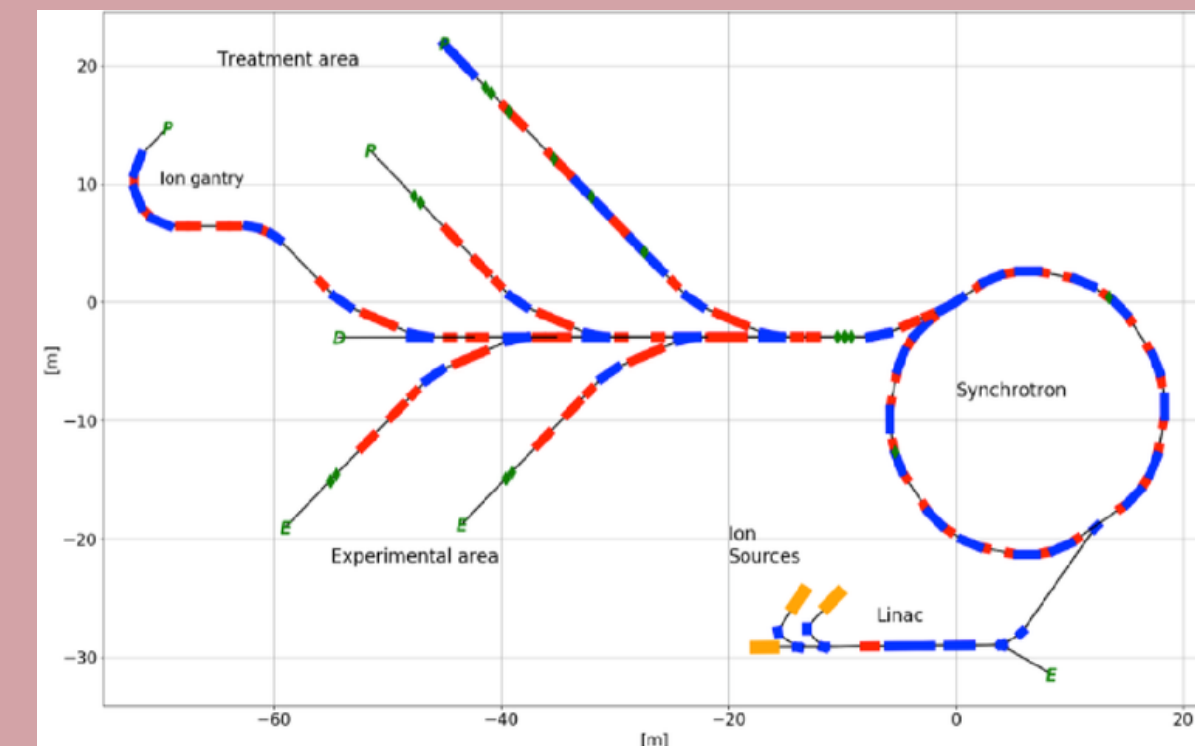


Superconducting Solenoid



Synchrotron

- Normal conducting or superconducting
- Access to NIMMS design information and collaboration



UK Ion Therapy Research Facility (ITRF)

- Funding obtained through UK Research Institute last month
 - £2 million over two years
- Preliminary Activity to compare technology options
- Develop CDR for design
- Defining end station & beam parameters to support a biomedical research programme



A nighttime aerial view of London, featuring St Paul's Cathedral illuminated with vibrant rainbow lights. The surrounding city is lit up with various lights, and a construction crane is visible on the left. The text "Thank you for listening" and "I welcome any questions!" is overlaid in white.

Thank you for listening I welcome any questions!