IFIGENEIA

Innovative Facility for Isotope GENeration with Efficient Ion Accelerator

CERN for IFIGENEIA

Y. Papaphilippou, Accelerator and Beam Physics group leader, CERN

Kick-off meeting
3-4 March 2025
Thessaloniki, Greece

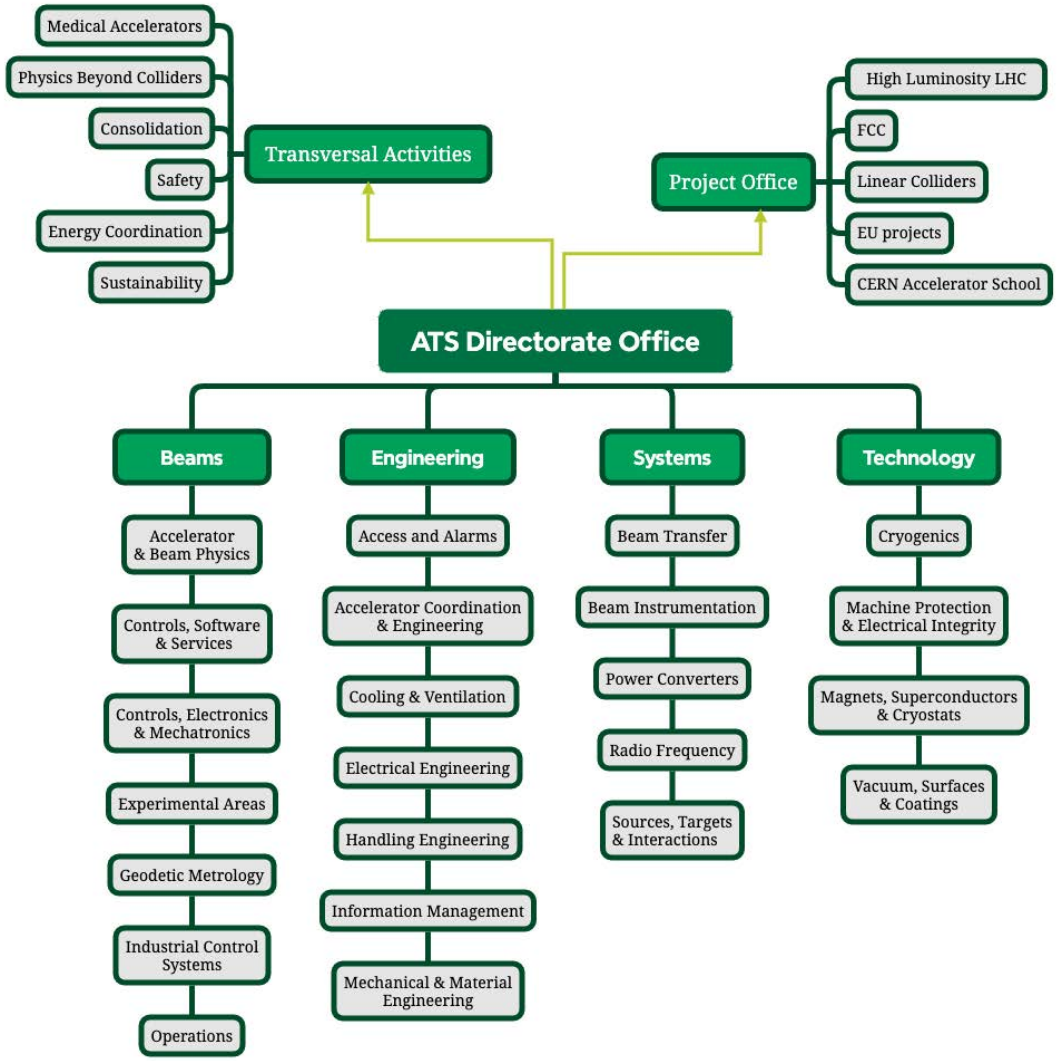
This project has received funding from the European Union's Horizon Europe Framework Programme for Research and Innovation under grant agreement no 101186921.

Accelerator and Techology Sector structure and Demographics

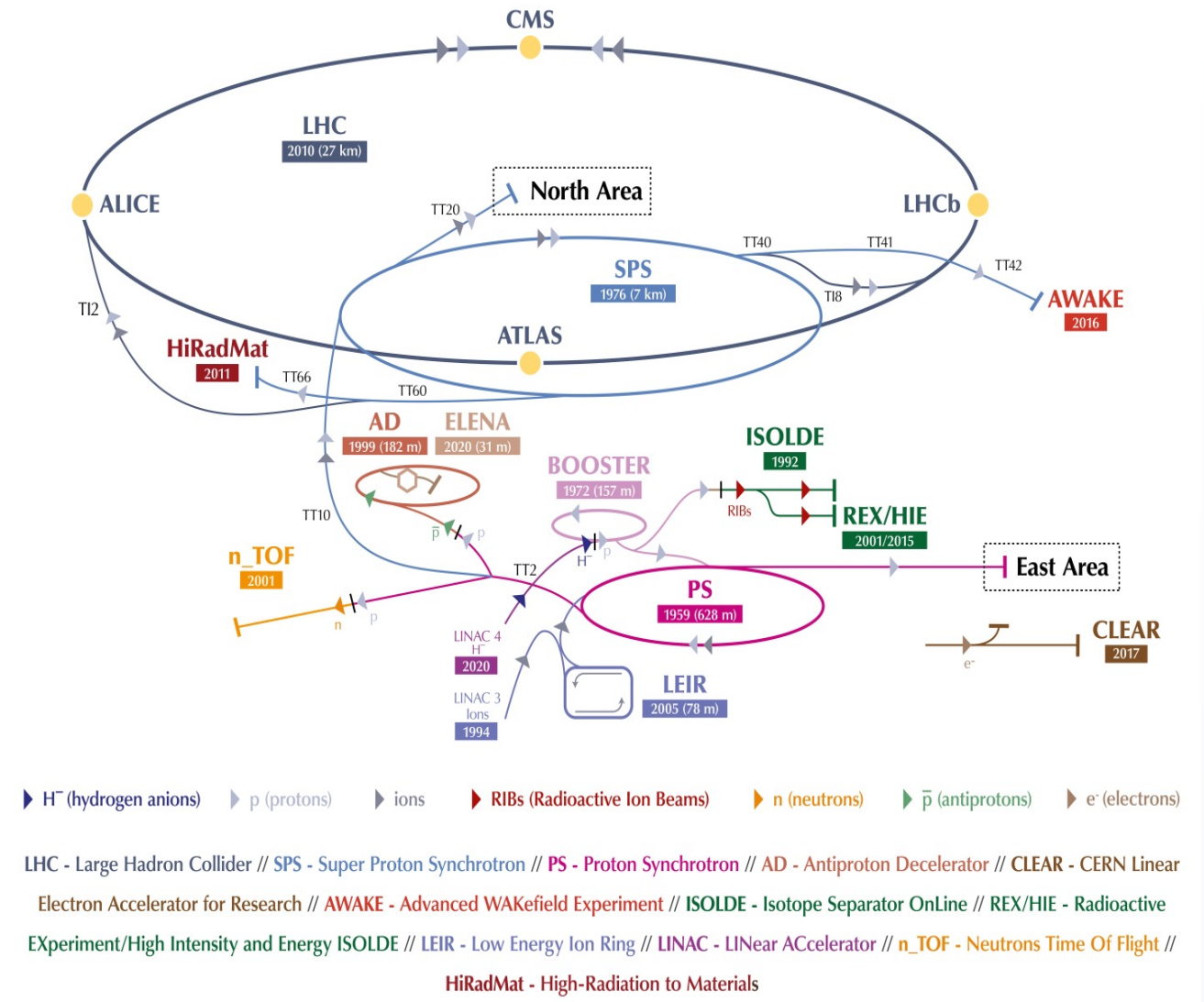
- Operates, maintains, consolidates, upgrades the world's largest accelerator complex and associated technical infrastructure++

- 1289 staff (~13% women)
- 475 fellows/graduates (~26% women)
- 520 associates (~26% women)
- Contract personnel

- ~50% of CERN Annual budget (M+P)
- Facilities used by 12,000 scientists from around the world



CERN Accelerator Complex



LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKefield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE - Radioactive EXperiment/High Intensity and Energy ISOLDE // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials

CERN Proton chain

1. **LINAC-4** 160MeV (**H-**)
2. **Proton Synchrotron Booster** 2GeV
3. **Proton Synchtrotron** 26GeV
4. **Super Proton Synchrotron** 450 GeV
5. **Large Hadron Collider** 7Tev

CERN Ion chain

1. **LINAC-3**
2. **Low Energy Ion Ring**
3. **Proton Synchtrotron**
4. **Super Proton Synchrotron**
5. **Large Hadron Collider**

Other facilities & experiments: n_TOF, ISOLDE, East Area, North Area, HiRadMat, AWAKE, CLEAR (electrons), AD & ELENA (Antiprotons)

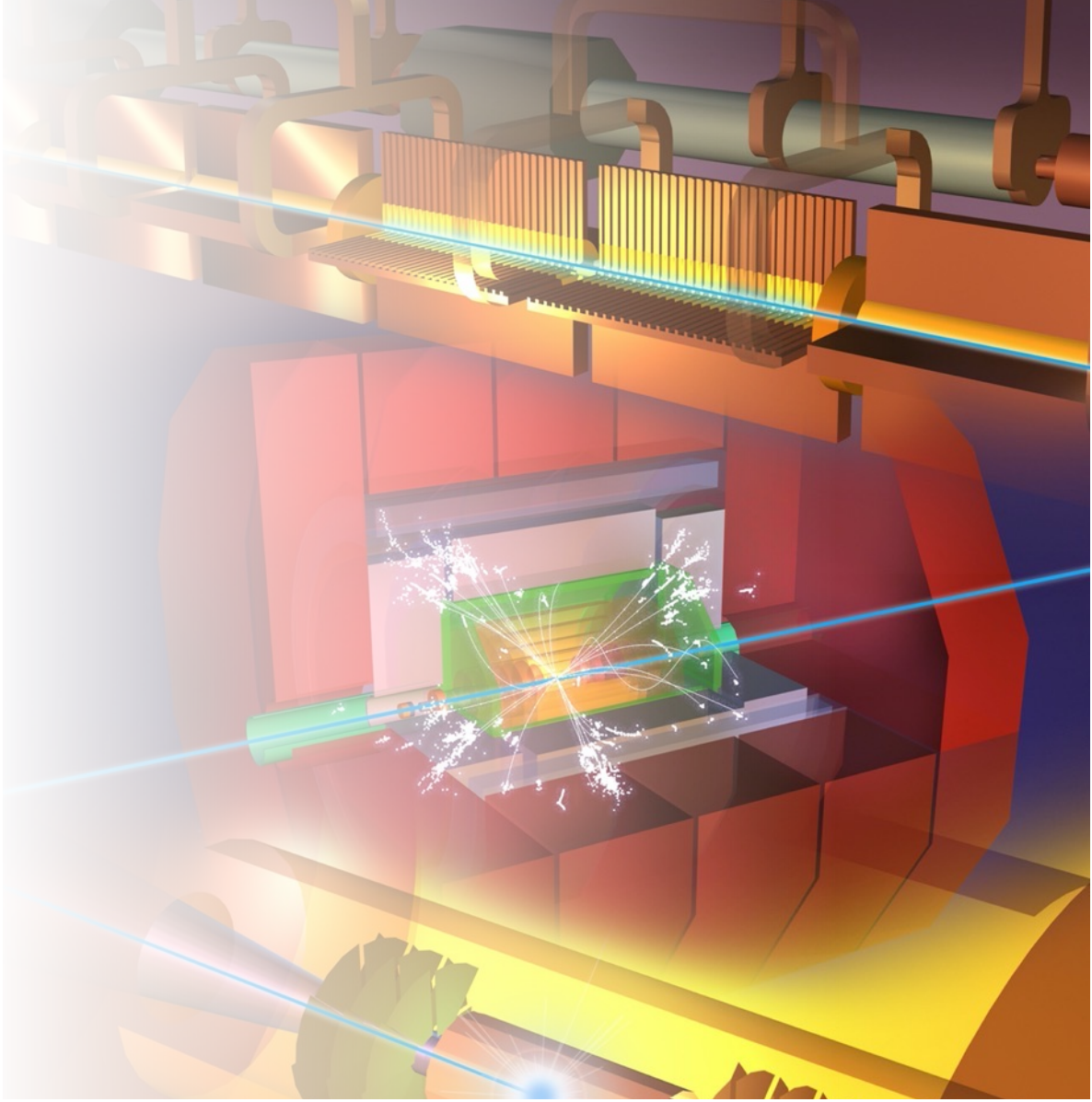
Future Collider Options

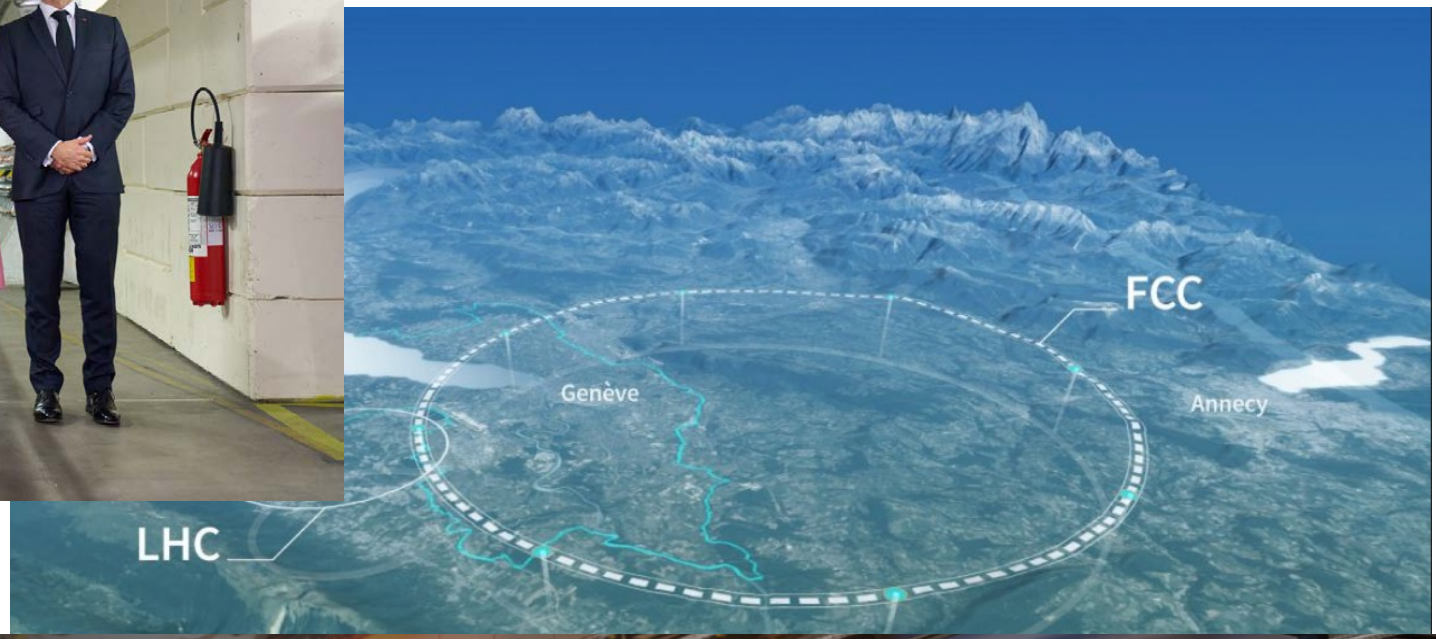
Within specified timeframe (start ops. ~2045)

- FCC-ee
- CLIC-380
- (ILC-250, LEP3, LHeC, HE-LHC)

Outside specified timeframe

- FCC-hh (natural follow-on to FCC-ee)
- Muon Collider





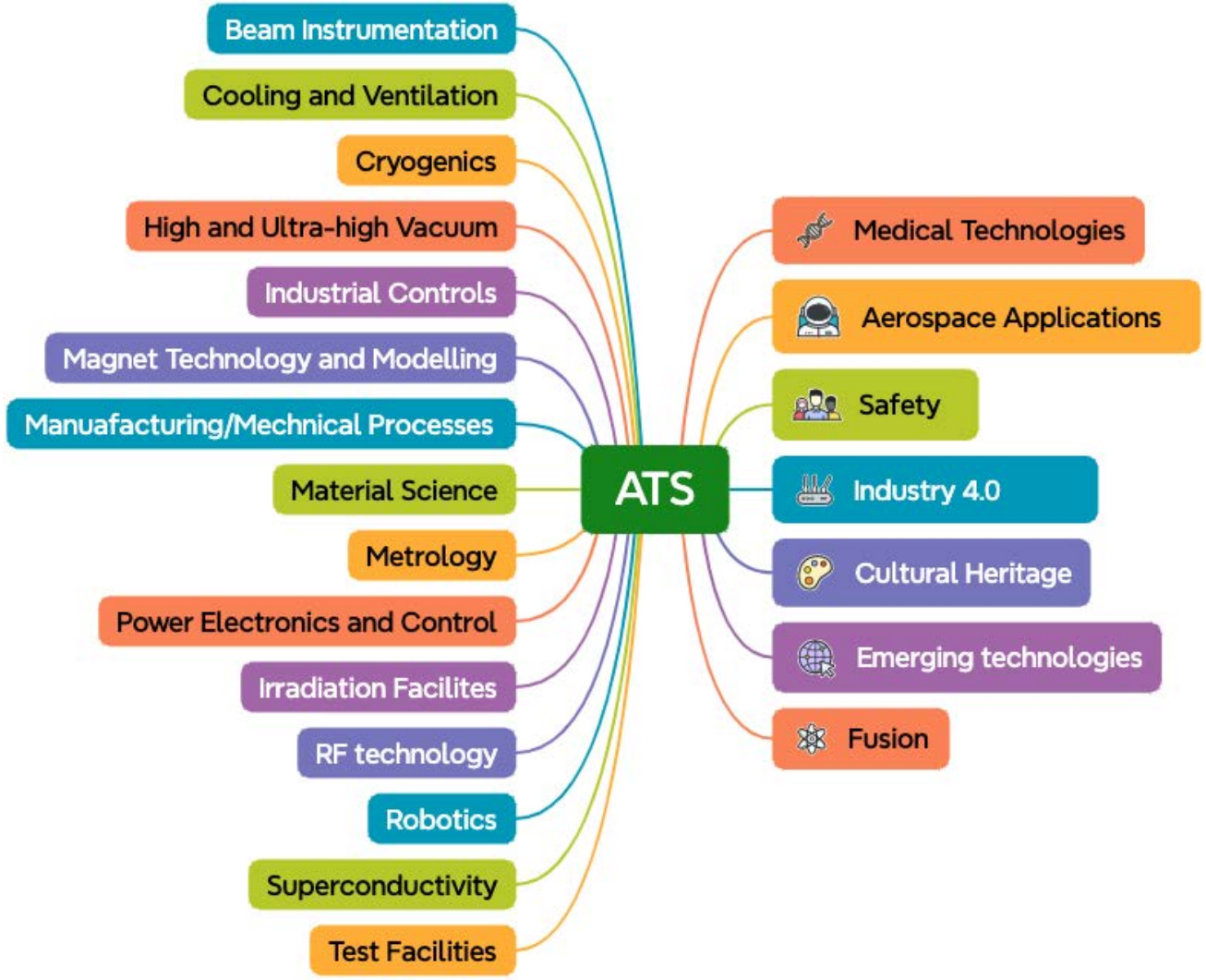
Final report on the FCC feasibility study

The report will serve as input for the European Strategy for Particle Physics

Read more →

Knowledge Transfer

Lots going on…

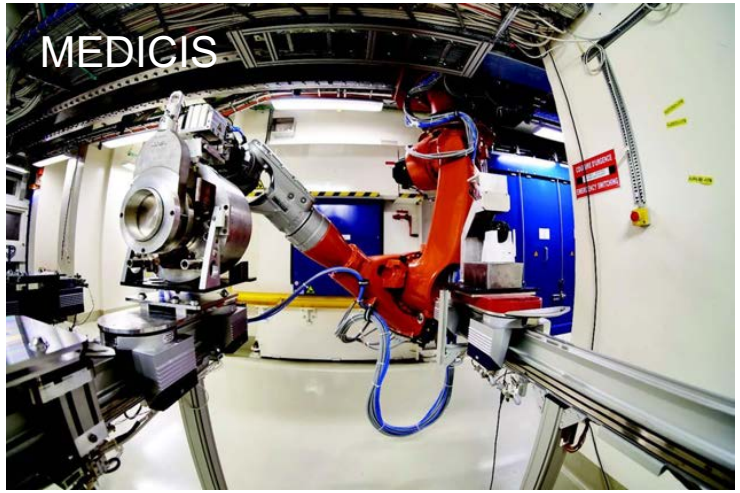


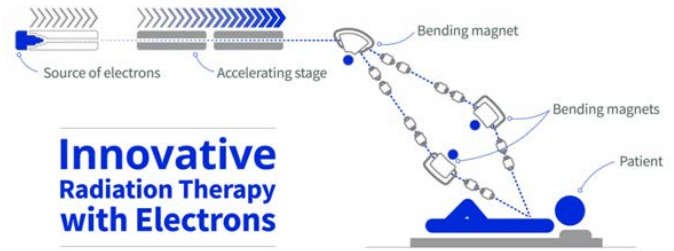
ATS – significant engagement in HORIZON

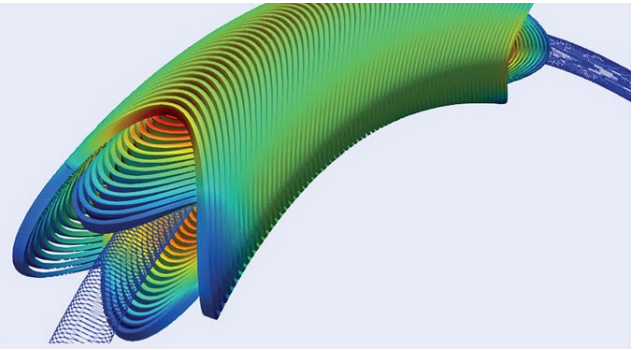
All of these projects back by European wide collaboration

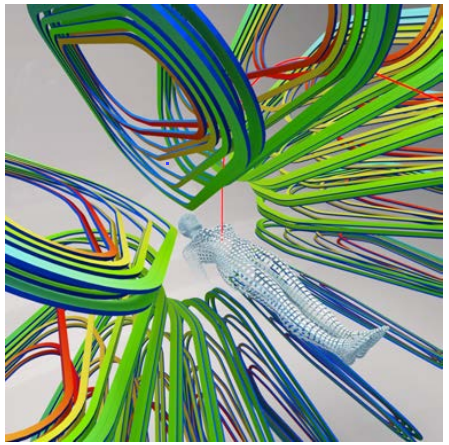
HORIZON		
	CALL	SUBJECT
PRISMAP	INFRAIA-2020	European medical isotope programme: Production of high purity isotopes by mass separation
HITRIplus	INFRAIA-2020	Heavy Ion Therapy Research Integration plus
POSEIDON	CL5 CLIMATE	POwer StoragE In D OceaN
HEARTS	CL4 SPACE	High-Energy Accelerators for Radiation Testing and Shielding
TRUSTroke	HLTH-2022-STAYHLTH	TRUSTWORTHY AI FOR IMPROVEMENT OF STROKE OUTCOMES
LISA	H2020-MSCA-ITN	Laser Ionization and Spectroscopy of Actinide elements
FCCIS	INFRADEV-2019	Future Circular Collider Innovation Study
RADNEXT	INFRAIA-2020	RADiation facility Network for the EXploration of effects for indusTry and research
I.FAST	INFRAINNOV-2020	Innovation Fostering in Accelerator Science and Technology
EURO-LABS	INFRA-2021-SERV	EUROpean Laboratories for Accelerator Based Science
MuCol	INFRA-2022-DEV	Design Study for a Muon Collider complex at 10+ TeV center of mass

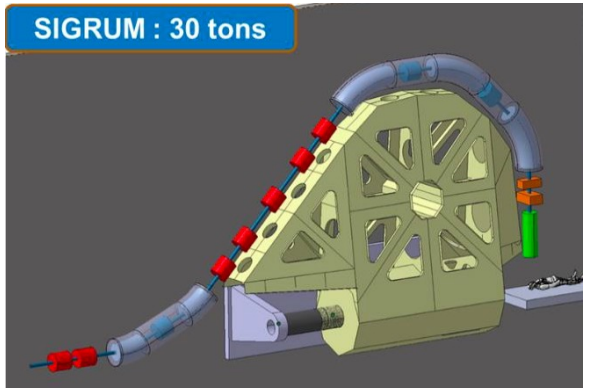
And now **IFIGENEIA**











Medical

Wide range of initiatives!

MARCHESE
Machine learning based human recognition and health monitoring system

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ABP structure and Demographics

ABP
Accelerators & Beam Physics
GL: Y. Papaphilippou
DGL: R. Scrivens

GAO (BE-HDO-ADM)
S. Palluel
V. Demiri (ADMIN)

CEI
Coherent Effects & Impedances
SL: G. Rumolo
X. Buffat
L. Mether
E. Metral
N. Mounet
D. Schulte
C. Zannini
LD staff opening (10/2025)
D. Amorim (FELL)
C. Antuono (GRAP)
L. Giacomel (FELL)
P. Kisciny (GRAP)
R. Taylor (GRAP)
M. Bozatzis (DOCT)
E. De La Fuente Garcia (DOCT)
D. Gibellieri (DOCT)
F. Groenvold (DOCT)
C. Lannoy (DOCT)
E. Macchia (DOCT)
A. Mostacci (COAS)
M. Nielsen (TRNE)
L. Sabato (COAS)
L. Sito (DOCT)
R. Soos (DOCT)
B. Stechauner (DOCT)

CAP
Computational Accelerator Physics
SL: G. Iadarola
R. De Maria
L. Deniau
A. Latina
F. Van Der Veken
LD staff opening (06/2025)
S. Lopaciuk (FELL)
F. Murgia (GRAP)
B. Abreu Figueiredo (DOCT)
I. Angelis (DOCT)
S. Buijsman (DOCT)
P. Desire Valdor (DOCT)
V. Mussat (DOCT)
L. Pauwels (DOCT)
A. Scurria (TECH)
S. Solstrand (TECH)
S. Van Der Schueren (DOCT)

HSL
Hadron Sources & Linacs
SL: J.-B. Lallement
G. Bellodi
S. Bertolo
F. Di Lorenzo
D. Kuchler
A. Lombardi
C. Mastrostefano
M. O'Neil
E. Sargsyan
M. Koopmans (FELL)
E. Pasino (GRAP)
B. Subhash Bhasi Bhaskar (GRAP)
A. Ajanovic (COAS)
P. Calvo Portela (COAS)
J. Etxebarria Erdoiza (COAS)
D. Gavela Perez (COAS)
J. Gomez Palomino (COAS)
A. Kjushkoski (COAS)
O. Khrul (TECH)
A. Mamaras (DOCT)
T. Thiboud (ENTC)

INC
Incoherent Effects
SL: H. Bartosik
F. Asvesta
C. Carli
S. Kostoglou
I. Efthymiopoulos
G. Sterbini
F. Zimmermann
T. Prebibaj (FELL)
F. Soubelet (GRAP)
M. Vanwelde (GRAP)
M. Topp–Mugglestone (GRAP)
J. Belanzer (COAS)
A. Fornara (COAS)
V. Gawas (DOCT)
H. Huttunen (DOCT)
I. Mases Sole (DOCT)
T. Mori (COAS)
G. Pittau (TECH)
A. Radoslavova (DOCT)
J. Salvesen (DOCT)
V. Tsiantis (TECH)
E. Waagaard (DOCT)

LNO
Linear & Non-linear Optics
SL: R. Tomas
F. Carlier
S. Fartoukh
E. Maclean
J. Keintzel
G. Roy
K. Skoufaris
LD staff opening (04/2025)
J. Dilly (FELL)
V. Cilento (COAS)
J. Cardona (COAS)
V. Ferrentino (DOCT)
C. Garcia Jaimes (COAS)
C. Goffing (DOCT)
J. Gray (DOCT)
S. Horney (DOCT)
S. Jagabathuni (DOCT)
L. Kennedy (DOCT)
K. Oide (COAS)
M. Stefanelli (DOCT)
L. Van Riesen-Haupt (COAS)
Y. Wu (COAS)

NDC
Non-linear Dynamics & Collimation
SL: S. Redaelli
R. Alemany Fernandez
R. Bruce
M. Giovannozzi
P. Hermes
E. Mahner
R. Cai (GRAP)
A. Donadon Servelle (GRAP)
G. Perez Segurana (FELL)
T. Pugnat (FELL)
M. Slupecki (FELL)
N. Triantafyllou (FELL)
M. Aquilina (PJAS)
R. Babu (COAS)
G. Broggi (DOCT)
B. Lindstorm (PJAS)
C. Maccani (DOCT)
M Monikowska (DOCT)
C. E. Montanari (PJAS)
O. Naumenko (DOCT)
G. Nigrelli (DOCT)
M. Orwat (TECH)
M. Rakic (DOCT)
D. Veres (DOCT)

PEC
Plasmas, Electron facilities, Cooling
SL: E. Gschwendtner
R. Corsini
D. Gamba
W. Farabolini
B. Holzer
M. Turner
F. Wenander
K. Andre (FELL)
M. Azevedo Trocado Moreira (GRAP)
A. Gilardi (GRAP)
J. Bateman (COAS)
M. Bergamaschi (PJAS)
R. Dadashi (COAS)
J. Farmer (COAS)
L. Forthomme (COAS)
A. Gunnarsson (TECH)
A. Hussain (COAS)
E. Jaworska (TECH)
P. Korysko (COAS)
P. Kruyt (DOCT)
A. Malyzhenkov (COAS)
F. Pannell (COAS)
A. Petersson (TECH)
V. Rieker (COAS)
G. Tangari (DOCT)
N. Van Gils (DOCT)
N. Zikos (TECH)

7 sections
50 Staff
3 LD staff openings in 2025
24 Fellows/Quest
~50 Students
~35 Associates

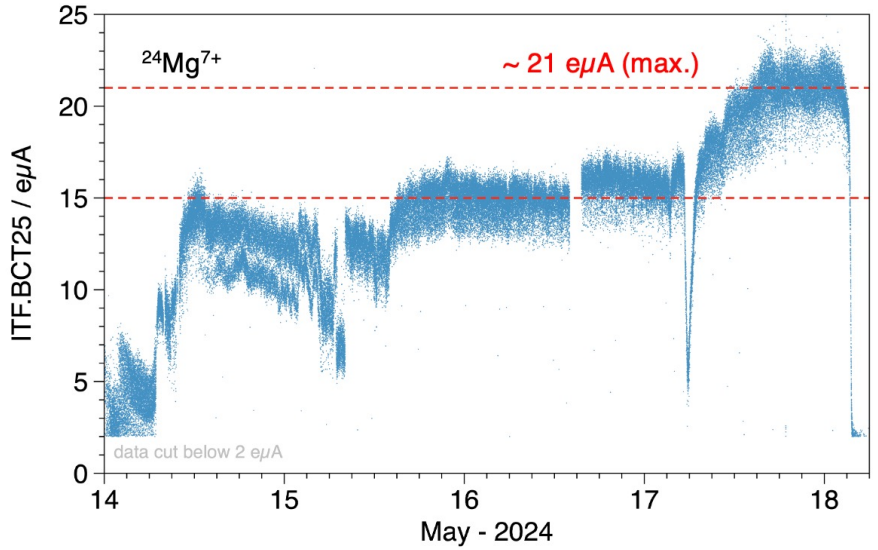
~35 Visitors,
~50 External collaborators

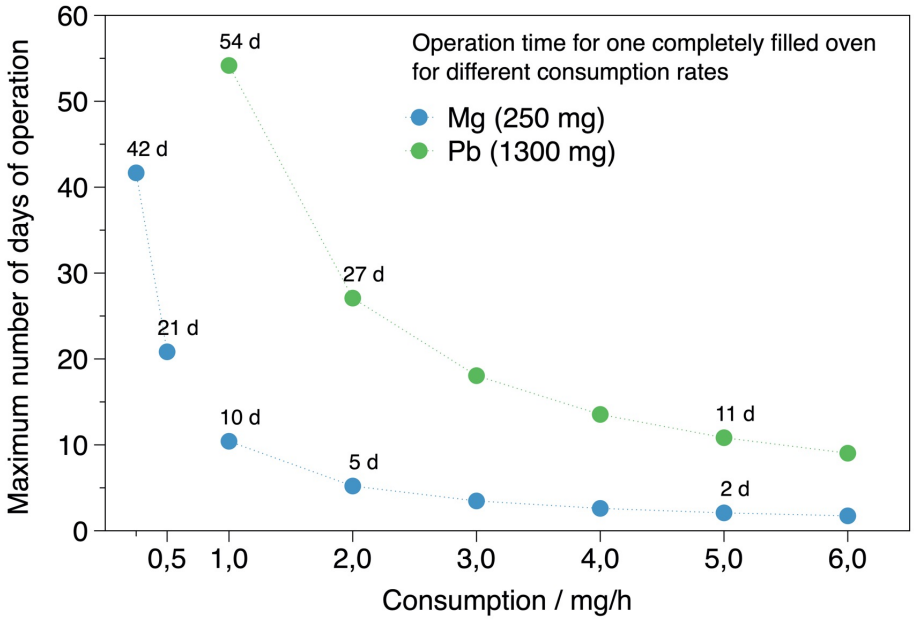
Linac 3 - Magnesium (new) and Lead in 2024

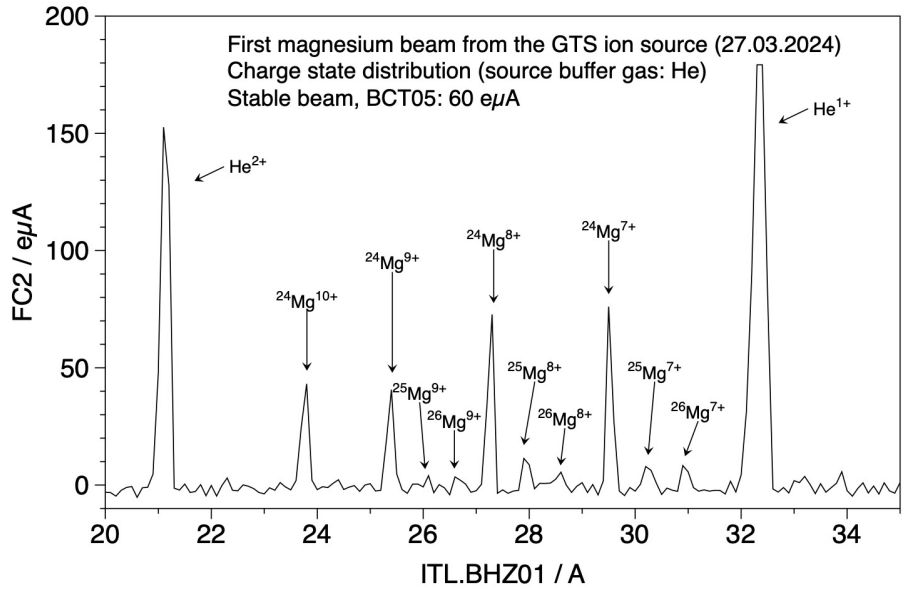
Magnesium development -> new Mg^{7+} beam, 8 weeks of successful source and linac tests, including 2 weeks of Mg beam delivered to LEIR and PS.

Results -> good stability and performance of GTS ion source, intensity of up to **21 eμA** achieved out of linac. Short oven run time (2 - 5 days) due to high Mg consumption (frequent oven refills)

Future -> more Mg tests to increase time between oven refills



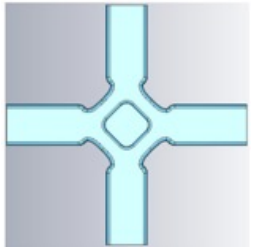




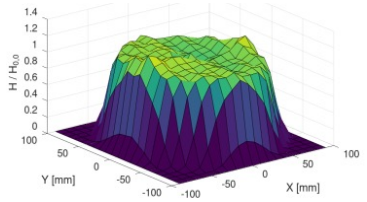
An innovative FLASH VHEE radiotherapy facility

Ongoing collaboration between CERN, CHUV and THERYQ for the design and construction of a radiotherapy facility using a unique accelerator based on CLIC technology (DEFT).

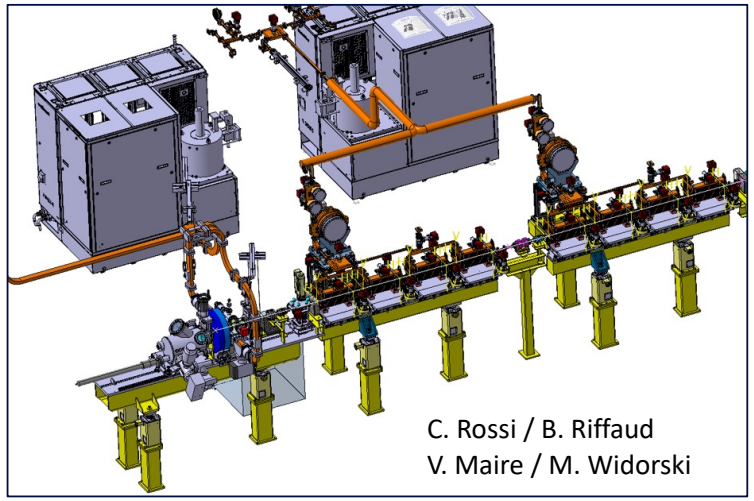
A. Latina / A. Malyzhenkov / A. Grudiev



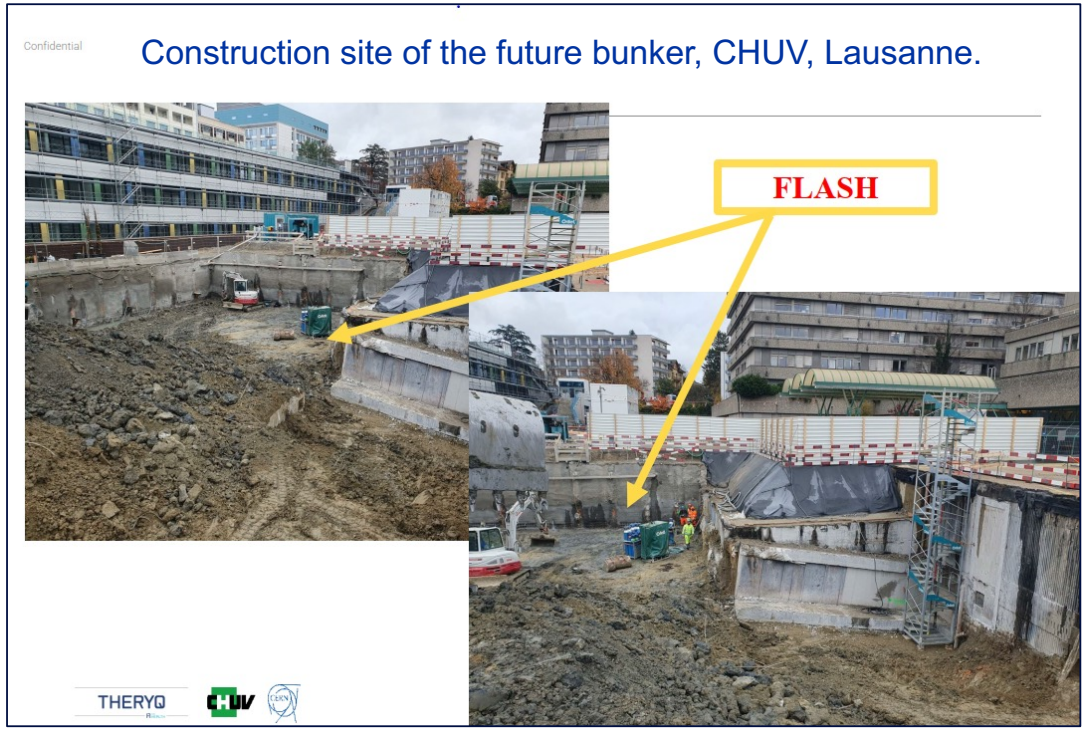
New accelerating cell design to compensate octupolar effect



The RF design and beam dynamics for DEFT are <u>VERY</u> challenging -> uniformity with the large required field



C. Rossi / B. Riffaud
V. Maire / M. Widorski



First clinical trials ~2027

Acknowledgments – Walter Wuensch, Olivier Brunner

CLEAR Medical activities

Studies on beam delivery and dosimetry technologies for clinical readiness of VHEE/FLASH Radiotherapy.

The CLEAR team has developed in the last years methods and tools dedicated to VHEE and FLASH studies, including dosimetry techniques, sample handling, and beam delivery. In collaboration with external institutes these activities are being further extended.

Many irradiation experiments on chemical and biological samples were performed in collaboration with external institutes, in order to clarify the mechanisms at the root of the FLASH effect, by comparing the effects of UHDR with conventional dose rates on controlled samples.

Typical test set-up for biological studies
(in this picture, Zebra Fish Eggs (ZFE) irradiations (HUG/CERN)

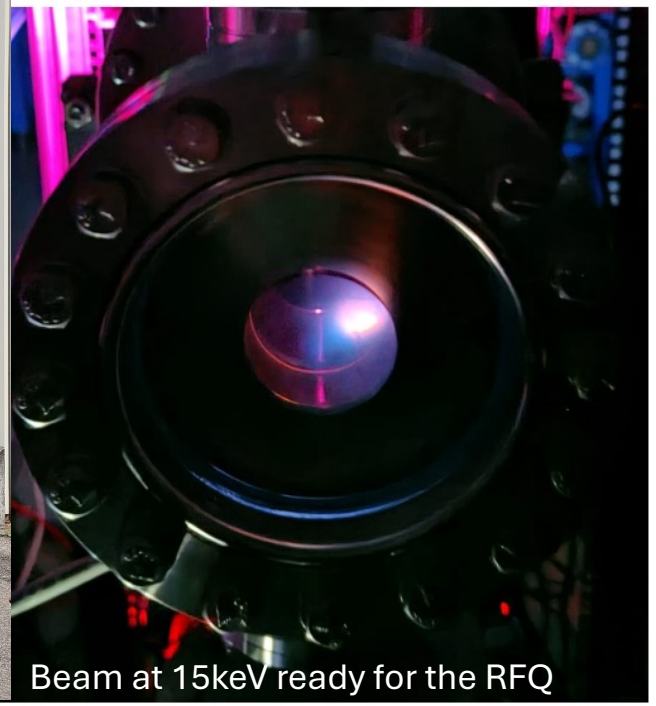
Studies of radiotherapy delivery plan using an anatomical phantom (Manchester University)

Dosimetry & beam delivery: Spacially fractionated RT by scanning, collimator and insert materials, beam delivery to anatomical phantom, flash diamond and fiber dosimeters, chemical dosimetry

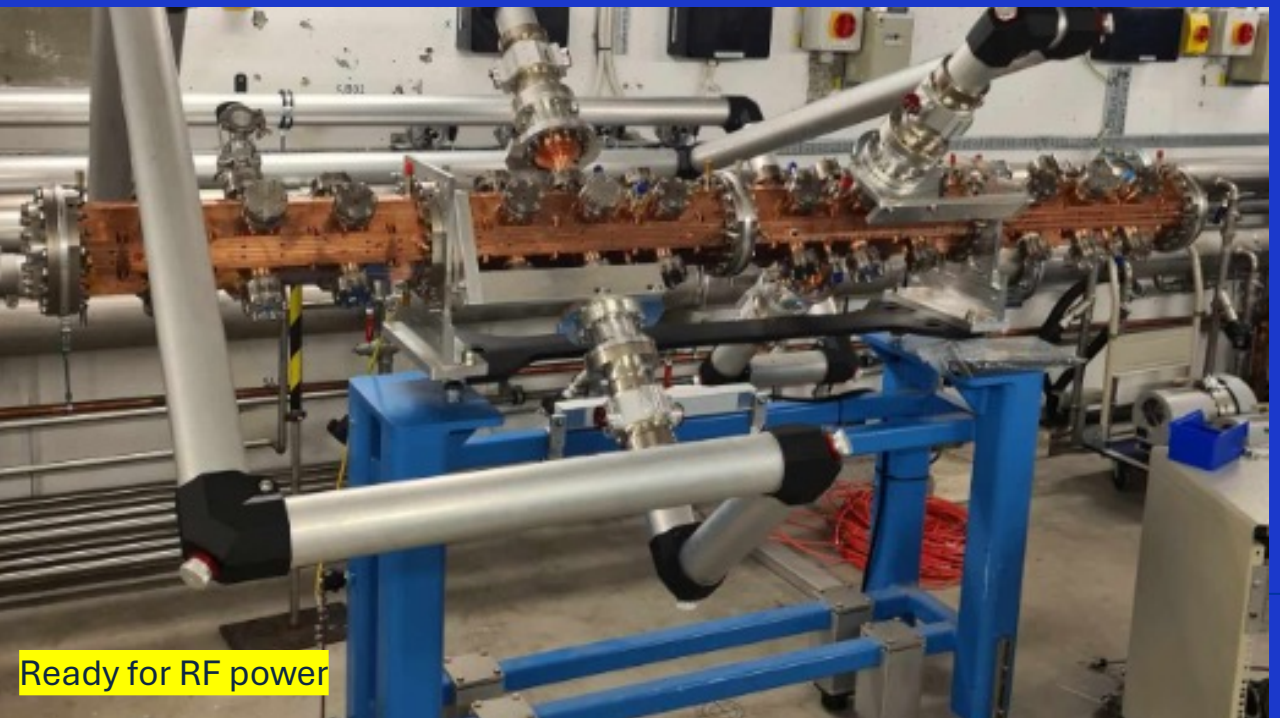
Chemistry: Production of H2O2 and O-15 in water

Biology: Plasmids, human tumoral and healthy cell cultures, zebra fish eggs, drosophila larvae

Institutes: CHUV, HUG, Victoria University, Manchester University, Strathclyde University, West of Scotland University, University Rome Tor Vergata, Institut G. Roussy.



Beam at 15keV ready for the RFQ



Ready for RF power

Medical and societal application for hadrons

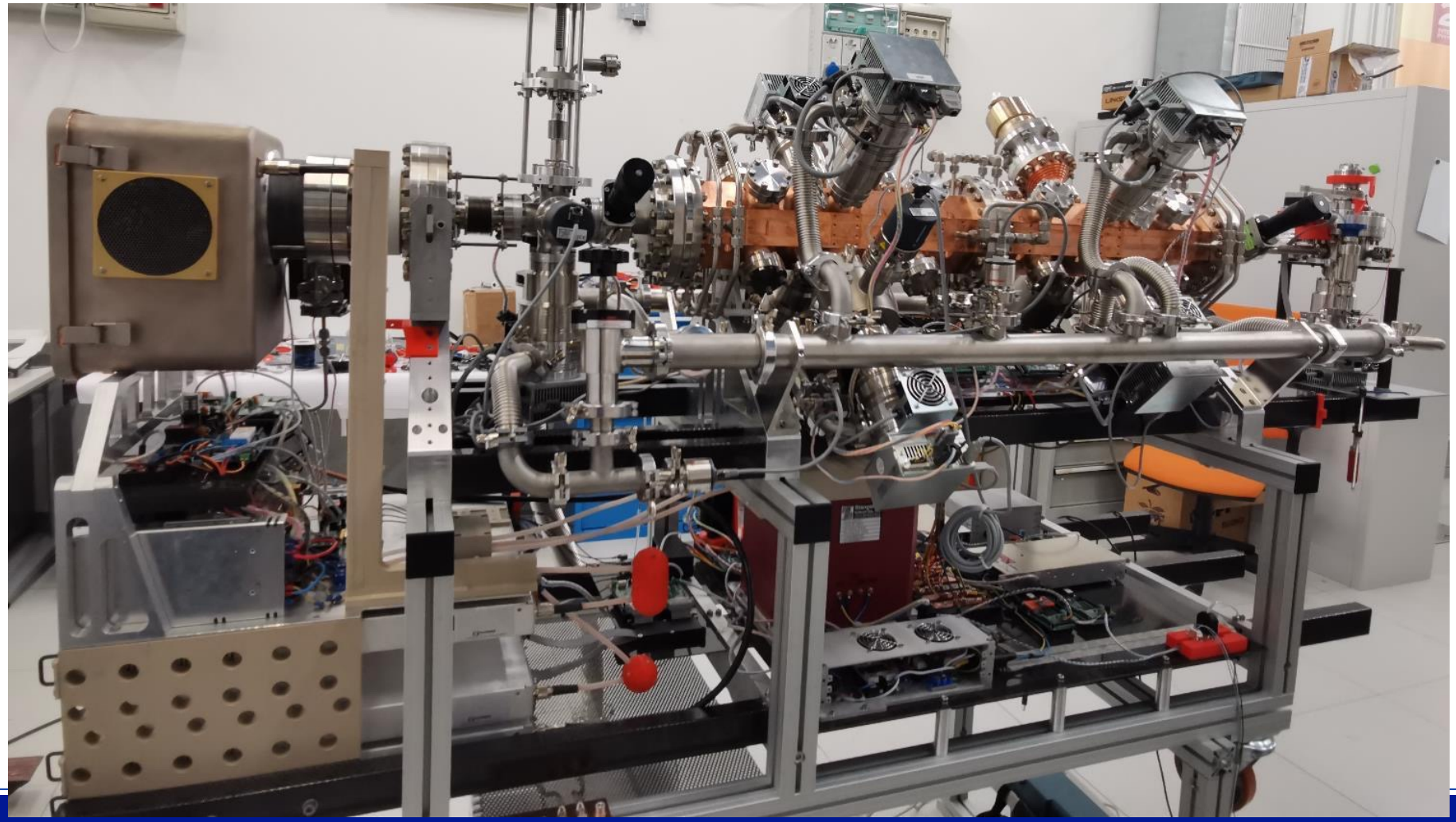
A compact source for injecting protons directly into the RFQ

A 750MHz Radio Frequency Quadrupole for helium and carbon ions as pre-injector for a LINAC-based carbon facility

CERN

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

MACHINA - Movable Accelerator for Cultural Heritage In-situ Non-destructive Analysis



NIMMS (Next Ion Medical Machine Study)

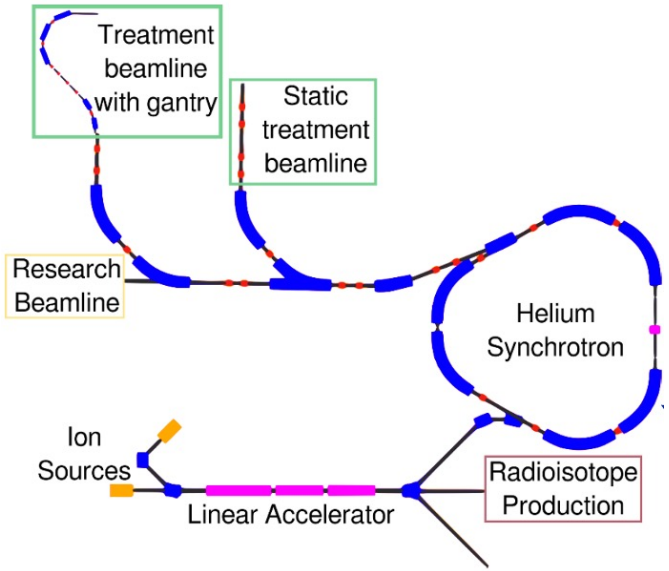
Building on CERN expertise to develop **a portfolio of technologies** that can be used in a next generation facility

Multi-ion synchrotron (beyond p and C-ions)
Compact and cheaper superconducting synchrotron
Compact ion linac
Superconducting gantries
Higher beam intensity, faster extraction; real time imaging

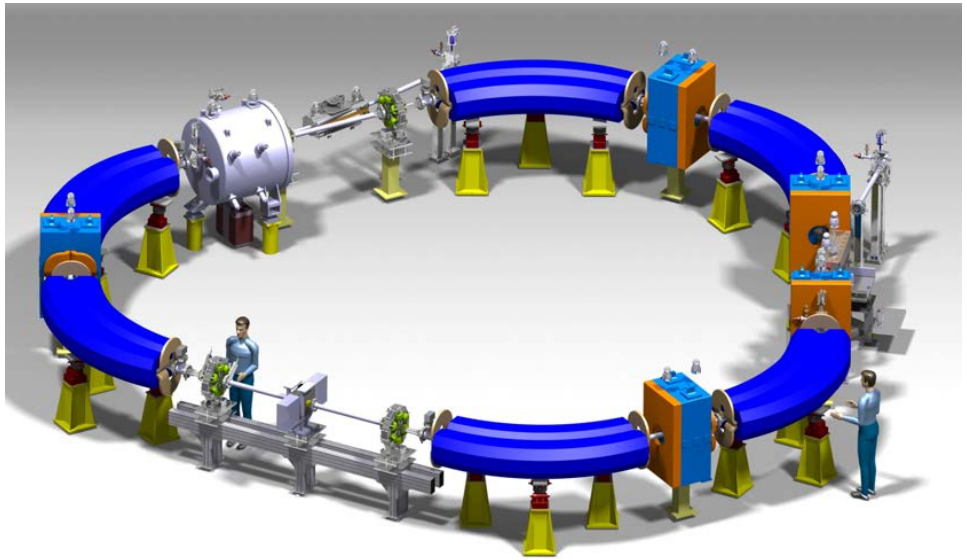
Interest in the Baltic States for an Advanced Particle Therapy Centre

CERN Baltic Group

Draft concept paper
Advanced Particle Therapy Center for the Baltic States



HeLICS (Helium & Light Ion Compact Synchrotron)



T3.2 Beam parameters and hardware specifications for different operational scenarios

Start Date:	**M1**	**Task Leader:**	**CERN**
End Date:	M36	**Task Contributors:**	AUTH, UCY, UNSA, DKFZ, CERN

Del.	Deliverable Title	Lead Partner	Diss. Level	Due On
D3.3	Beam parameters and hardware specifications (Document, report)	AUTH		M24

Mx	Milestone Title	Lead Partner	Mean of verification	Due On
	Beam parameters and hardware specifications	AUTH		M24

CERN persons involved

F. Antoniou, Project associate from **AUTH**
A. Lombardi principal accelerator physicist,
Y. Papaphilippou principal accelerator physicist, ABP GL
other members of the **Hadron Sources and LINACs section**, including **students**

See F. Antoniou's presentation