RIGA TECHNICAL UNIVERSITY

VPP Valsts pētījumu programma

VPP-IZM-CERN-2022/1-0001

RTU dalība paātrinātāju projektos un sadarbība ar CERN

Andris Ratkus

Paātrinātāju grupas vadītājs

26.04.2023

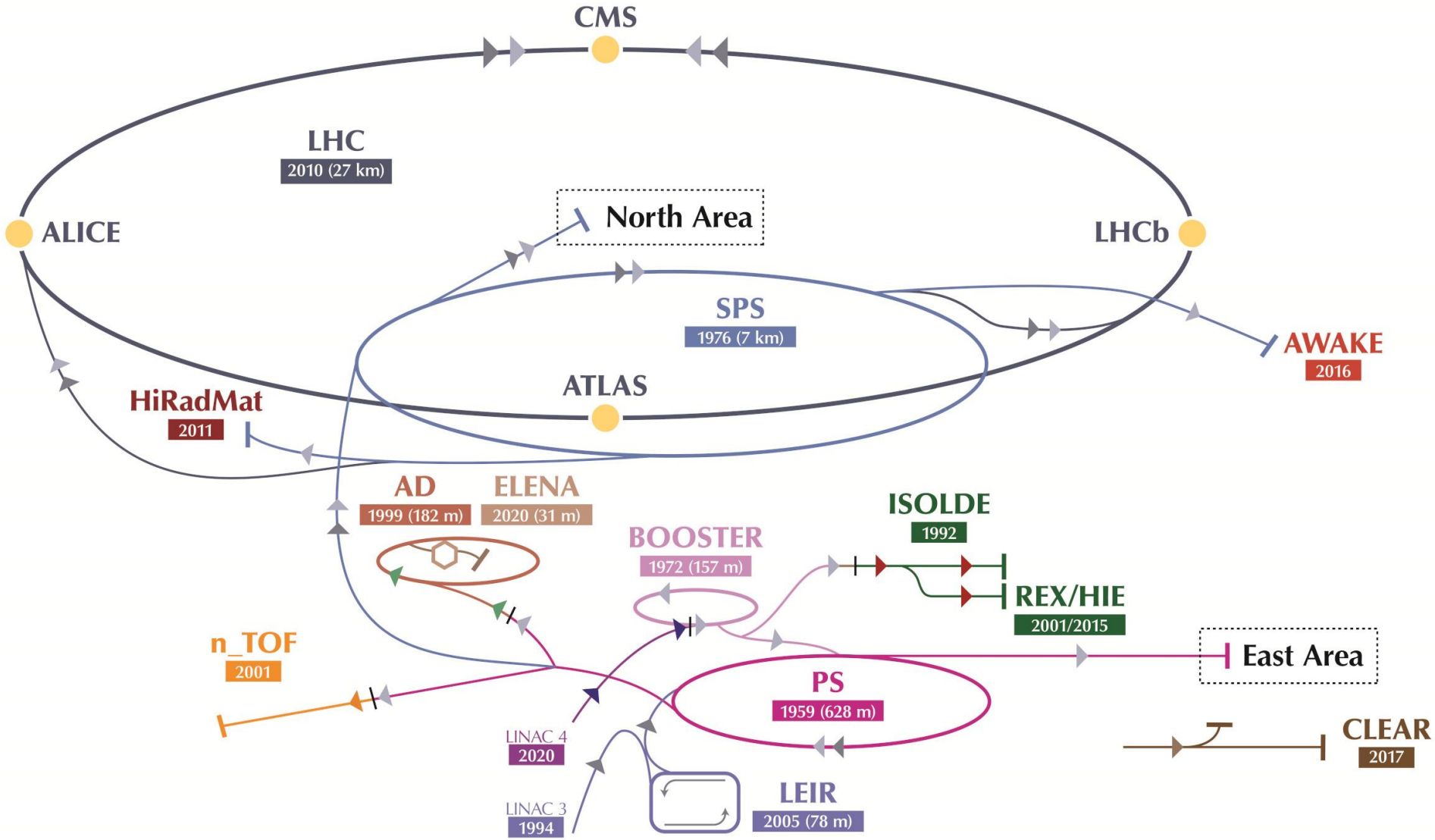
«Physics is beautiful and useful»

/Ugo Amaldi,

founder of Hadron Therapy project and TERA organization

Courtesy: Kristaps Paļsks

The CERN paātrinātāju kompleks



The CERN paātrinātāju kompleks

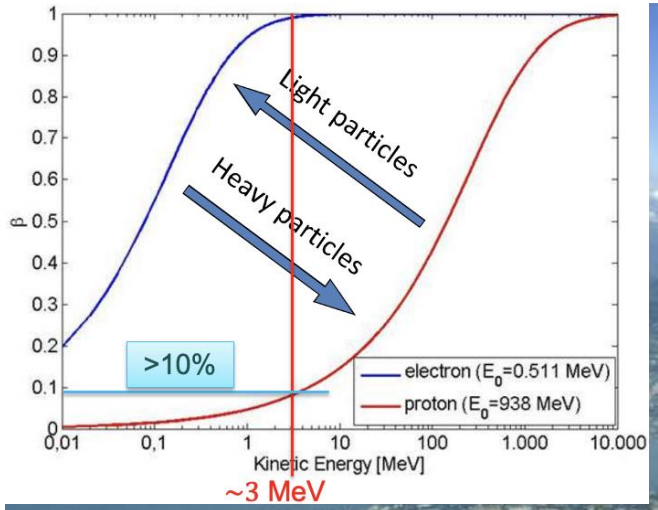
Attīstība

CERN un zinātnes kontekstā:

- Lielākas enerģijas;
- Vairāk novērojamo sadursmju;
- Mazākas izmaksas;
- Ilgtspēja;
- Jauni materiāli;
- Jauni konceptu pārbaudīsāna;
- **Fundamentālo atklājumu pielietojamība sabiedrības interesēs**;
- etc.

Next Ion Medical Machine Study

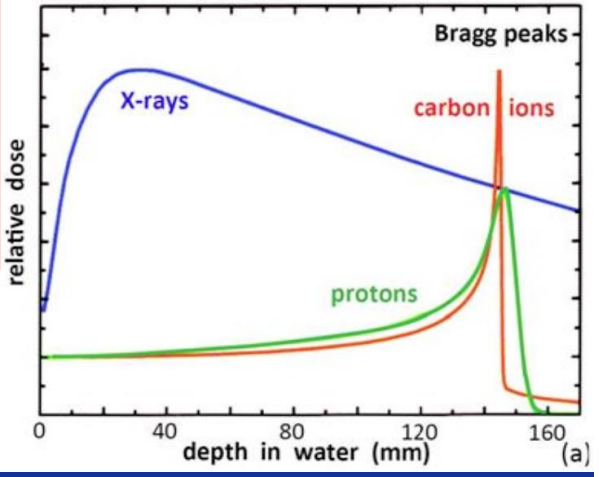
nimms



The CERN high-frequency RFQ

Developed using Linac4 technology, for medical and societal applications (2 years, 1.5 MCHF shared between CERN and industrial partner)

The beauty of the Bragg peak

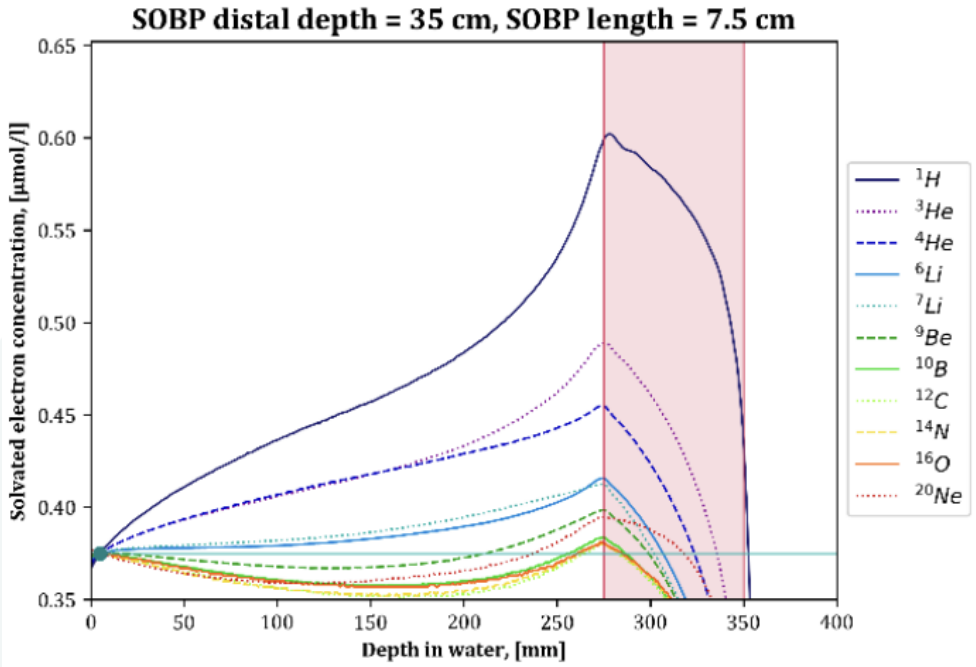


CERN

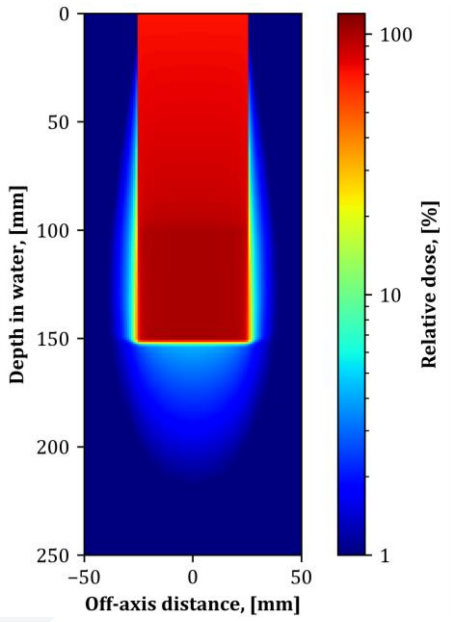
Courtesy: M. Vretenar

Next Ion Medical Machine Study

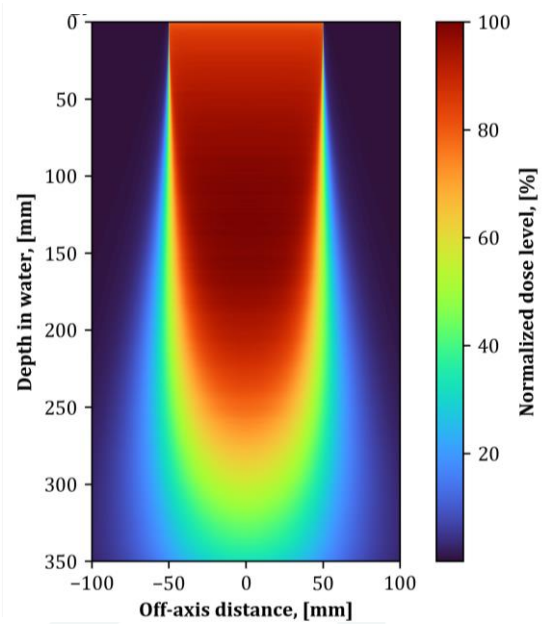
- **Kristaps Paļskis PhD thesis:** Studies of different ion types and their use for radiation therapy, *FLASH* therapy aspects. Optimization of ion beam parameters for very high dose rate (FLASH) radiotherapy



FLASH effect modeling for Ions



SFUD field



VHEE field

Courtesy: K. Palskis

Heavy Ion Therapy Research Integration

HITRI plus
Heavy Ion Therapy Research Integration

22 partneri

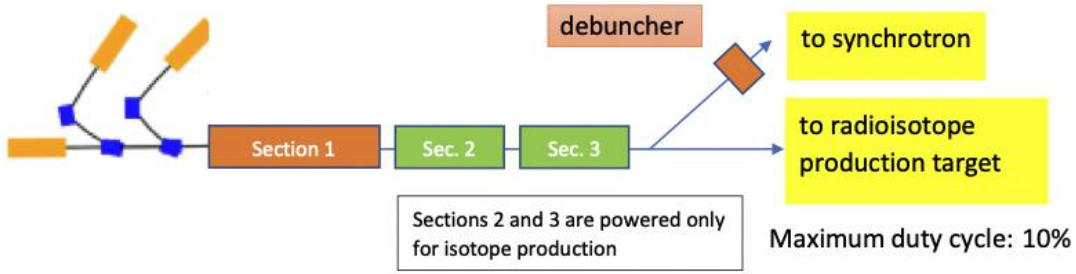
CNAO
BEVATECH
cea
CERN European Organisation for Nuclear Research
Laboratorio Nacional de Fusión Ciemat
COSYLAB
GSI Helmholtzzentrum für Schwerionenforschung
INFN Istituto Nazionale di Fisica Nucleare
MedAustron
PAUL SCHERRER INSTITUT PSI
1862 RIGA TECHNICAL UNIVERSITY
SEE ST South East European International Institute for Sustainable Technologies
UKGM UNIVERSITÄTSKLINIKUM GIESSEN UND MARBURG
UNIVERSITÄTSKLINIKUM HEIDELBERG
L-Università ta' Malta
Philipps Universität Marburg
UPPSALA UNIVERSITET UPPSALA UNIVERSITY SWEDEN
wigner
KLINIČKI CENTAR Crne Gore
Jožef Stefan Institute
SENIS magnetic & current measurement
Cyril and Methodius University in Skopje

HITRI plus
Heavy Ion Therapy Research Integration

Heavy Ion Therapy Research Integration

Heavy Ion Therapy Research Integration

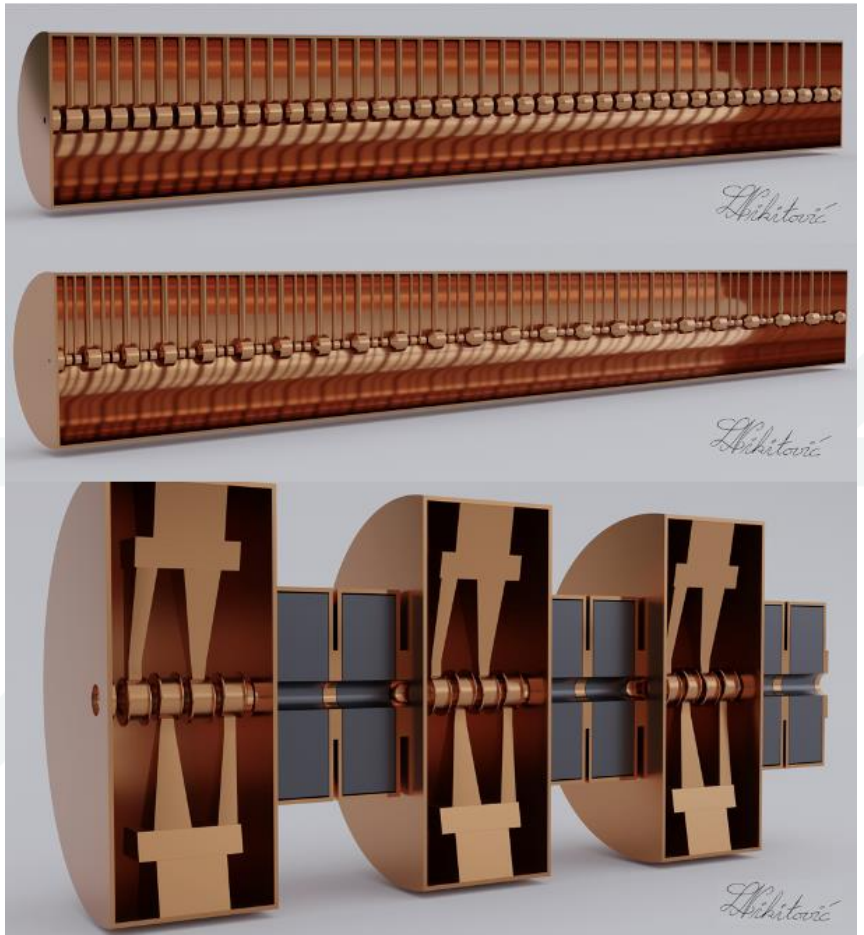
- **Lazar Nikitović PhD thesis:** Design study of a high-frequency linear accelerator for the purposes of injection into a therapy synchrotron and parallel production radioisotopes



3 ion sources	Linac section1	Linac section2	Linac section3
$^{12}C^{4+}$, 600 μA, 0.25 π mm mrad, 45 kV	q/m=1/3	q/m=1/2	q/m=1/2 or 1
$^{4}He^{2+}$, *0.5 mA*, 0.3 π mm mrad	W_{in}=15 keV/u	W_{in}= 5 MeV/u	W_{in}= 7.1 MeV/u
p or H_2^+, 5 mA, 0.2-0.3 π mm mrad	W_{out}= 5 MeV/u	W_{out}= 7.1 MeV/u	W_{out}= 10 MeV/u

baseline : 217 MHz

alternative : 352 MHz

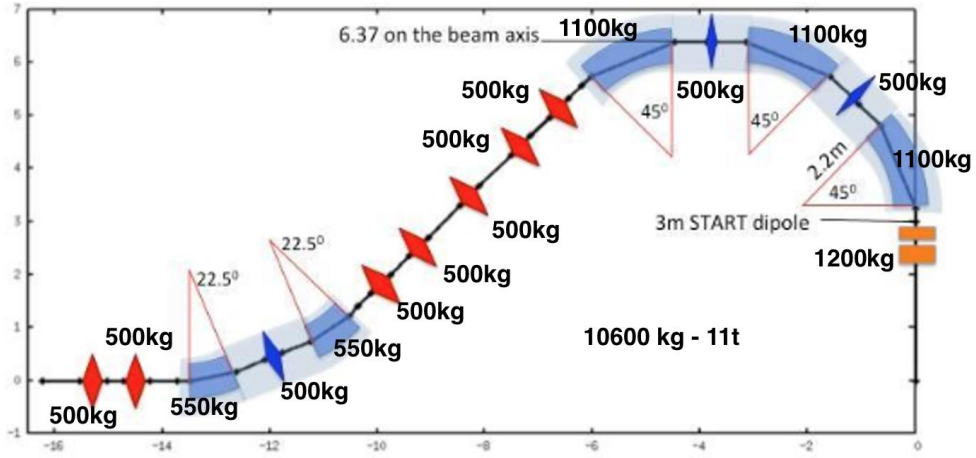


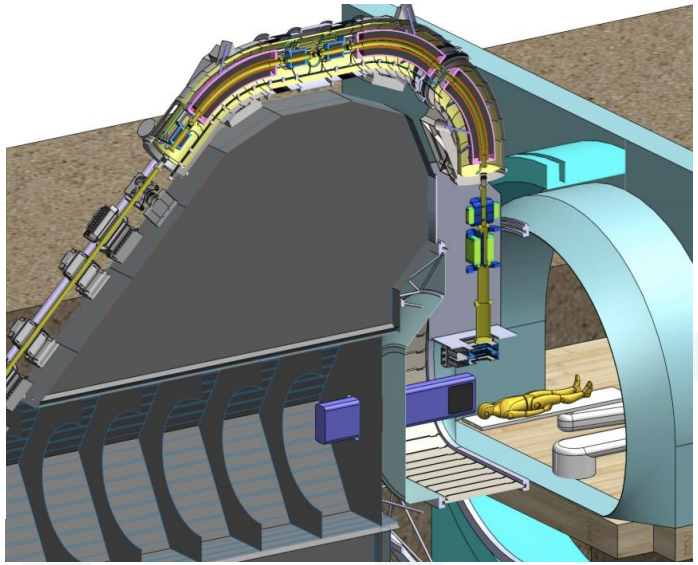
Courtesy: M. Vretenar

Heavy Ion Therapy Research Integration

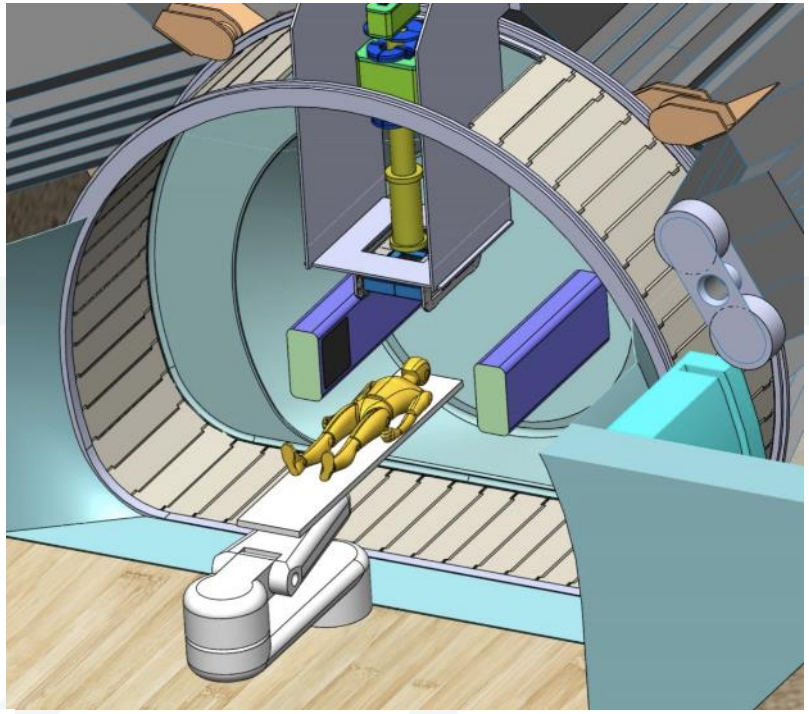
HITRI plus
Heavy Ion Therapy Research Integration

- **Luca Piacentini PhD thesis:** Development of the rotational (mobile) cryostat system for the superconducting magnets in the hadron therapy installations





>100t Rotating (360°) Gantry (~R=7m)



Courtesy: L. Piacentini

I.FAST

Innovation Fostering in Accelerator Science and Technology

Innovation Pilot, A new pilot instrument to demonstrating the role of Research Infrastructures in the translation of Open Science into Open Innovation, an evolution of our R&D programmes towards more industry participation, supported by the European Commission.

- **48 beneficiaries of EC funding:** 8 large RI operators, 12 national research centres, 12 universities, 15 industrial partners (**1/3**, including 11 SMEs) - from 15 European Countries, supported by 12 partner organisations and >20 collaborating institutions.
- **40 R&D** Tasks to develop a portfolio of technologies for the next generation of particle accelerators, 15 with industry participation.

WP	
1	Coordination, dissemination
2	Training, communication, outreach
3	Industry engagement
4	Managing Innovation, new Materials
5	New concepts, performance improvements
6	Novel particle accelerators concepts and technologies
7	High brightness synchrotron light sources
8	Innovative superconducting magnets
9	Innovative superconducting cavities
10	Advanced accelerator technologies
11	Sustainable concepts and technologies
12	Societal applications
13	Technology Infrastructure
14	Ethics Requirements

Innovation Fostering in Accelerator Science and Technology (I.FAST)

- **WP1: Management, coordination and dissemination**
  - Task 1.2: Information Flow Management and Cross-coordination (Task Leader RTU)
- **WP9: Innovative superconducting thin film coated cavities**
  - Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation (Task Leader RTU)
- **WP10: Advanced Accelerator Technologies** (Coordinator RTU)
  - Task 10.1: Coordination and Communication (Task Leader RTU)
  - Task 10.2: Additive Manufacturing - Survey of applications and potential developments
  - Task 10.3: Refurbishment of accelerator components by AM technologies (Task Leader RTU)
  - Task 10.6: Machine learning techniques for accelerator and target instrumentation
- **WP12: Societal Applications**
  - Task 12.1 sub task 3: Environmental applications of electron beam

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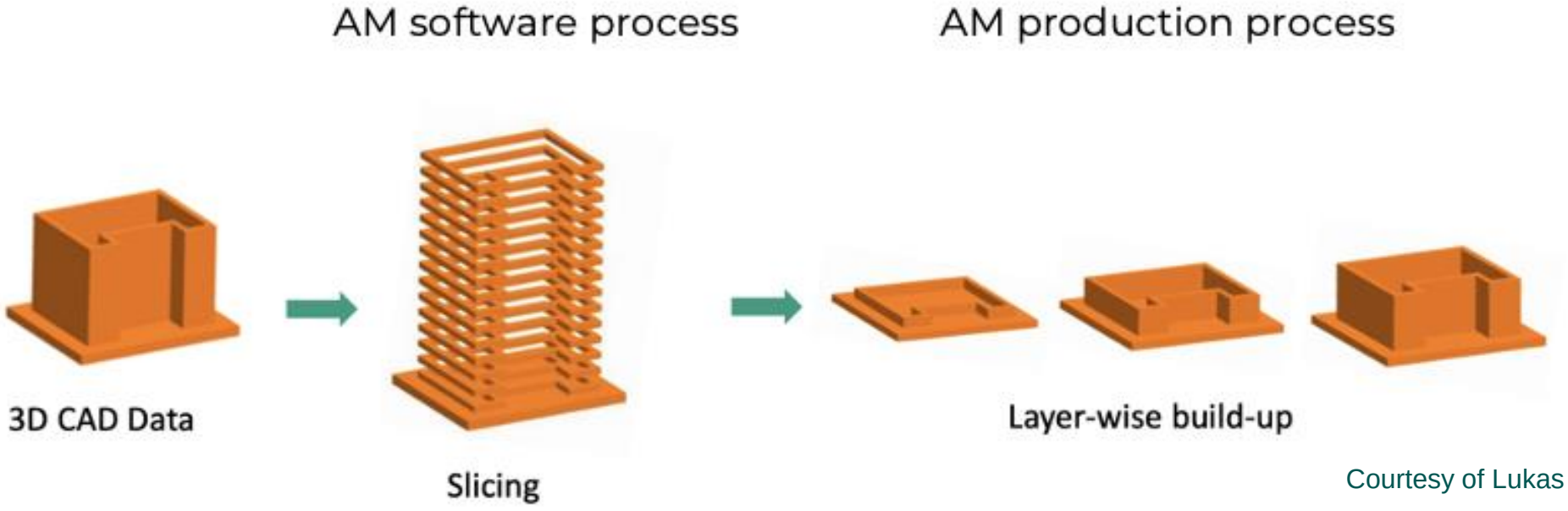
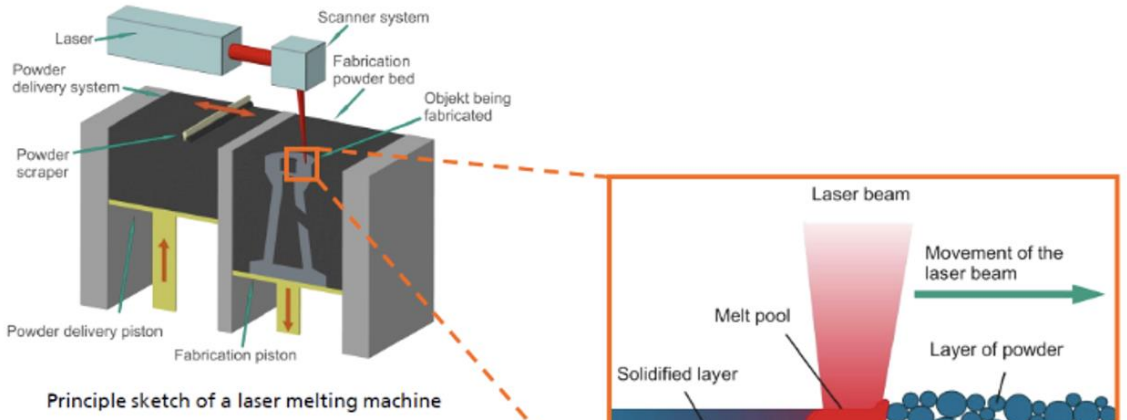
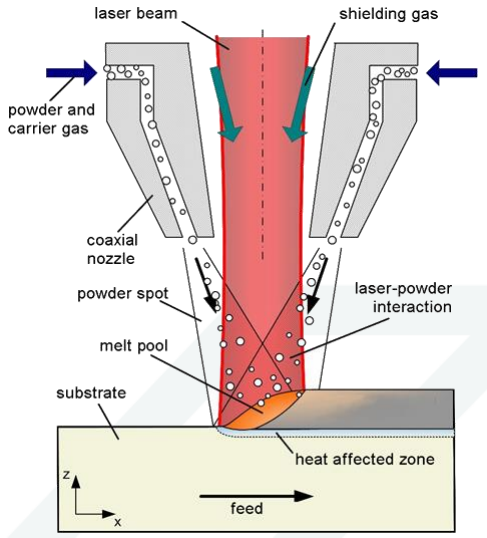
AM ražošana

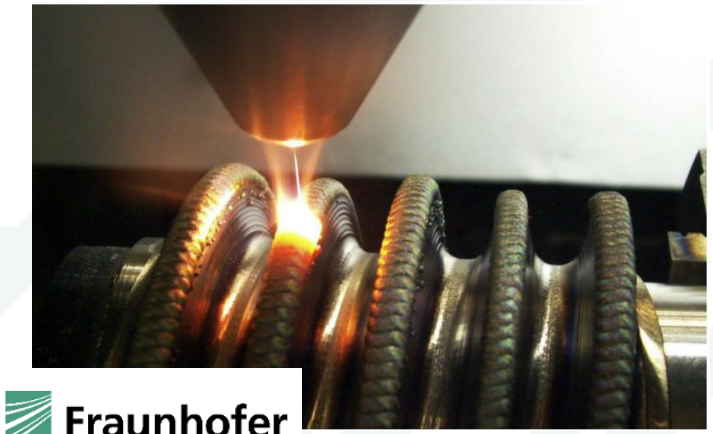


Courtesy of Lukas Stepien



Source: Fraunhofer IWU

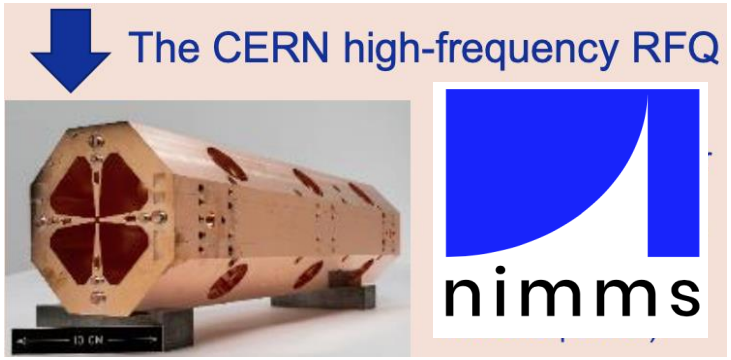




Fraunhofer IWS

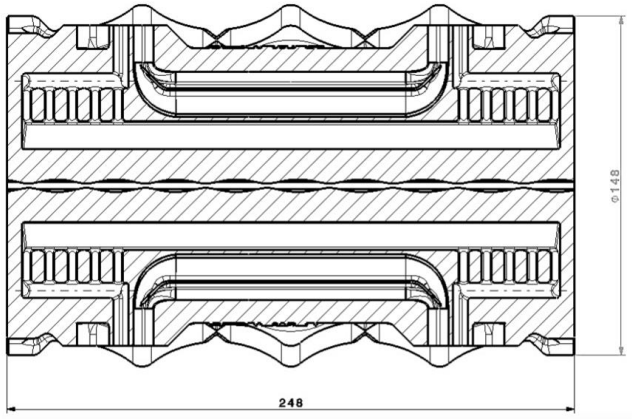
Source: joanneum.at

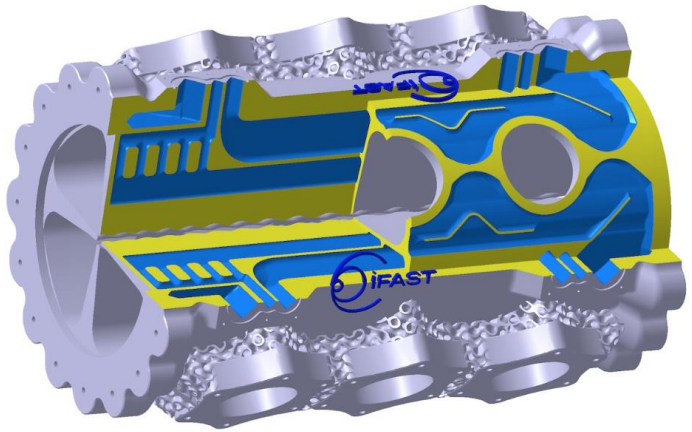
Our I.FAST achievements



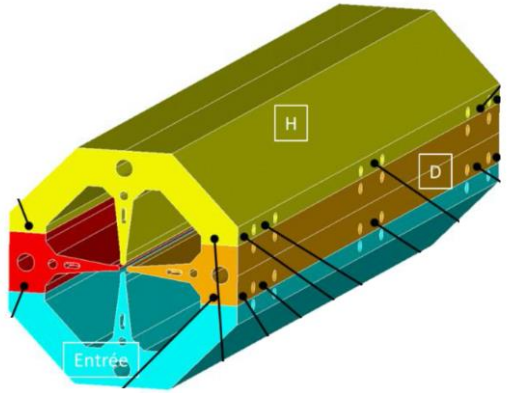
- Pure Cu (Cu-ETP) Full RFQ manufactured by AM

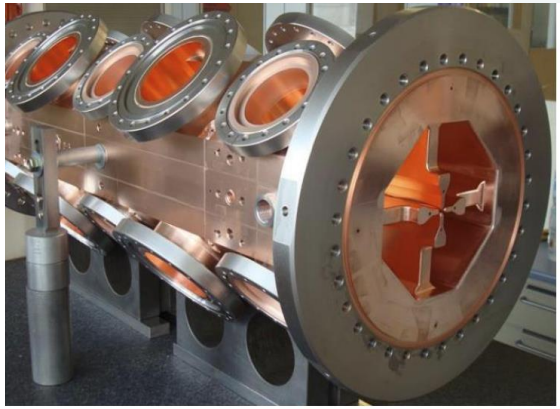
AM Design





Conventual Design

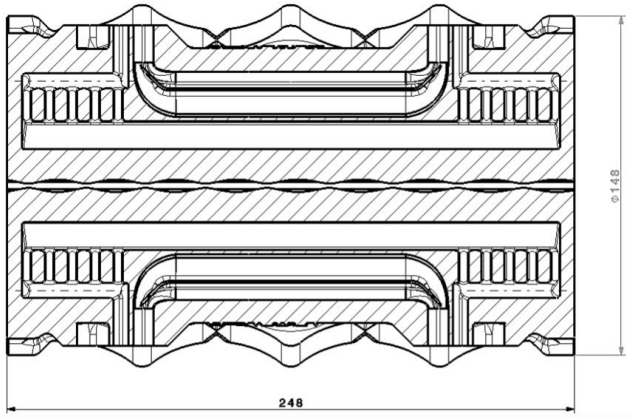


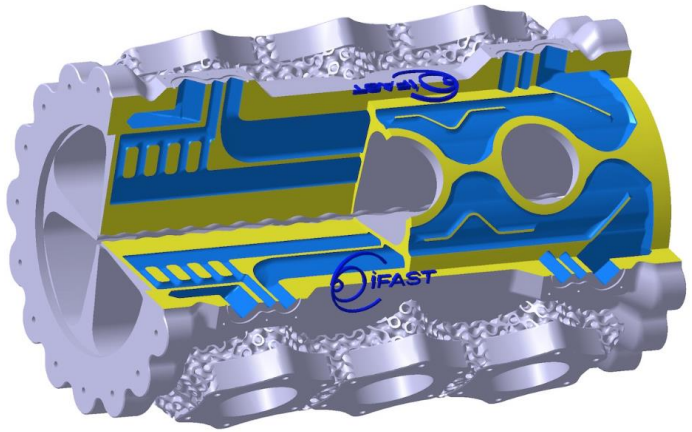


CERN · RÖSLER finding a better way ... · POLITECNICO MILANO 1863 · 1862 RIGA TECHNICAL UNIVERSITY · TRUMPF · Fraunhofer IWS · IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis · CERN · EN · EN/MME MATERIALS & METROLOGY

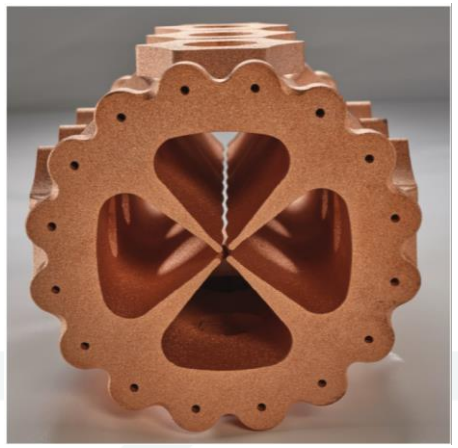
Our I.FAST achievements

- Pure Cu (Cu-ETP) Full RFQ manufactured by AM

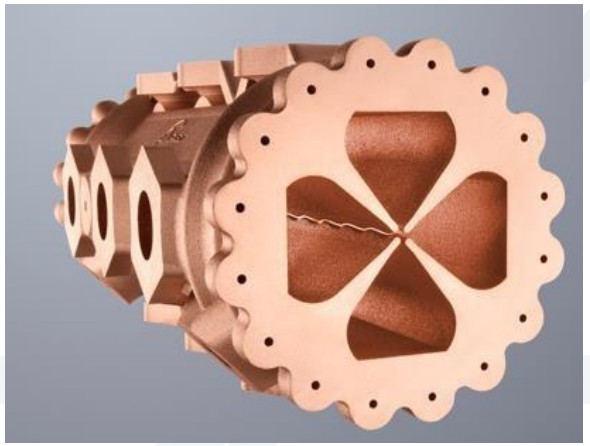




L= 250 mm

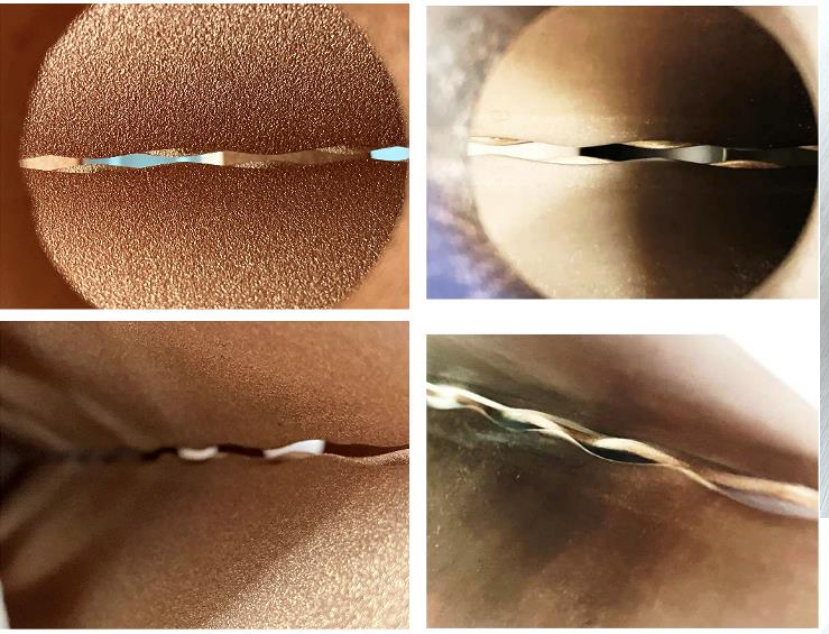


L= 390 mm



Our I.FAST achievements

- Pure Cu (Cu-ETP) Full RFQ manufactured by AM



Before Post-procesing

After

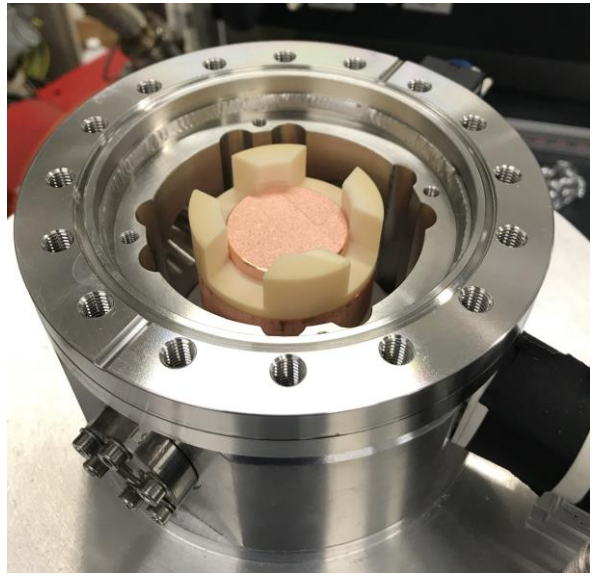
Post-procesed and machined

Vacuum tests

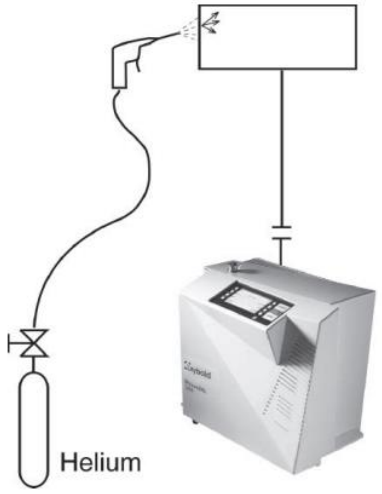
Goals within I.FAST and beyond it

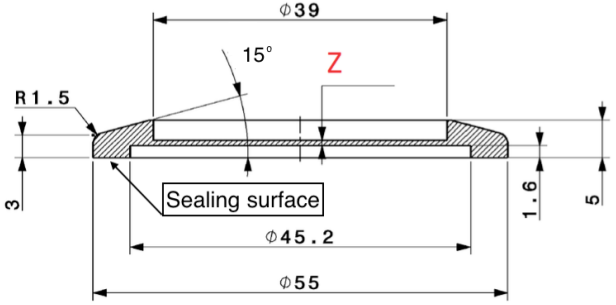
- **Activities closly releted to I.FAST and CERN**

HV holding tests



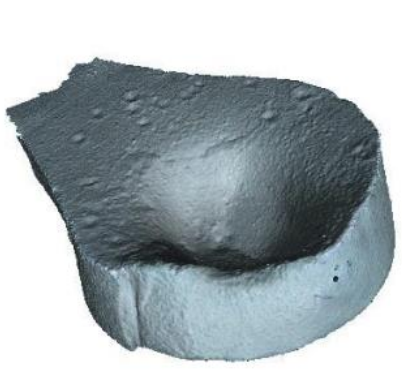
He leak test (UHV)

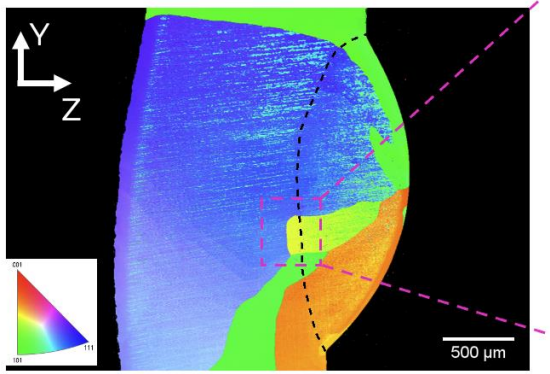


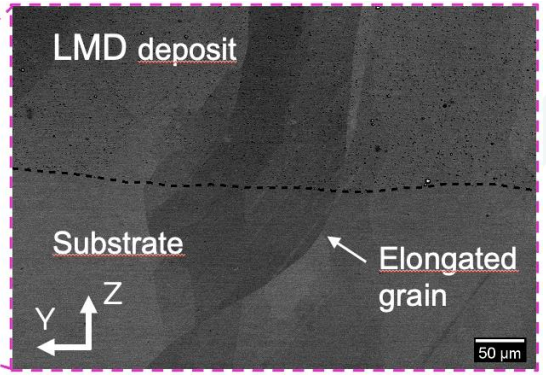


Our I.FAST achievements

- Ta cathodes repair by two AM technologies







Hardness: 315.3 ± 10.3 $HV_{0.05}$

Goals within I.FAST and beyond it

- **Activities between Accelerator Research institution, Projects + IFAST WP10 Partners**
  - R&D activities
  - The consortium for the next EU project calls

CERN Summer Student Programm

- >3. gada studentiem (Bakalauri, Maģistri, **ne PhD**) 8-13 nedēļas lekcijas + darbs pie projekta +…

+ socializēšanās

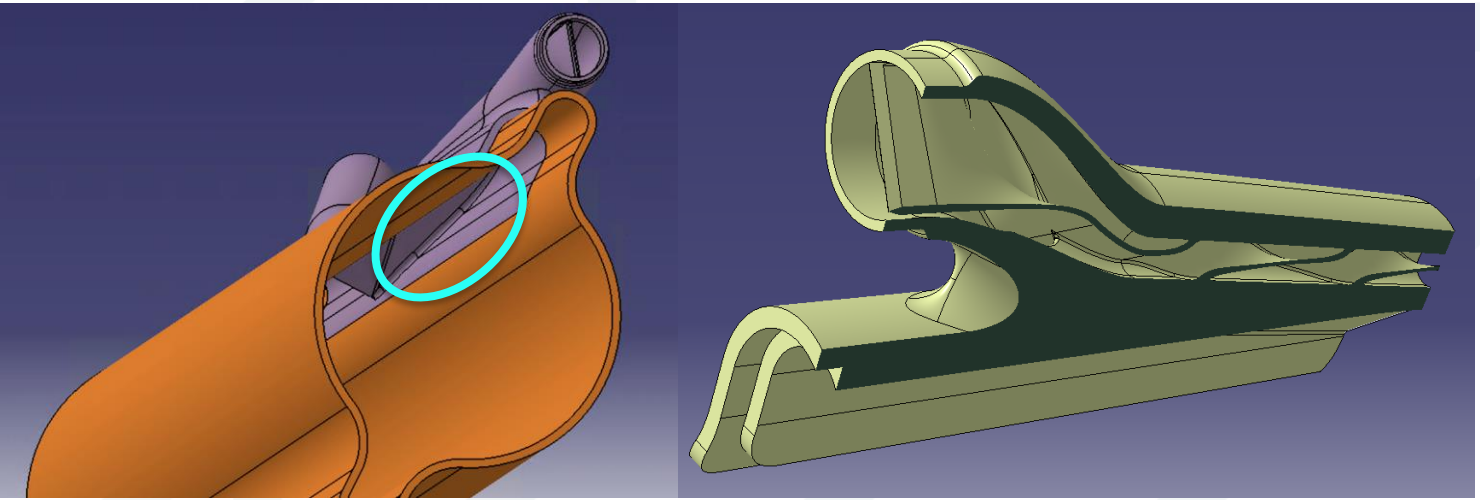
CERN Summer Student Programm

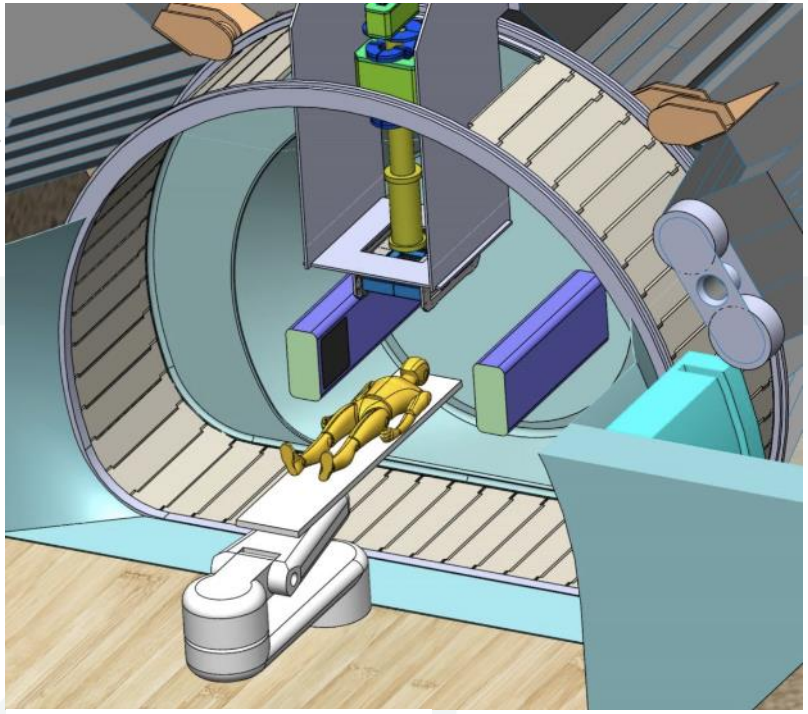
RTU AT Programms:

- Additive manufacturing applications for particle accelerator components
- Mechanical design of lightweight stiff structures for medical applications of particle accelerators

FUTURE CIRCULAR COLLIDER

HITRI plus
Heavy Ion Therapy Research Integration





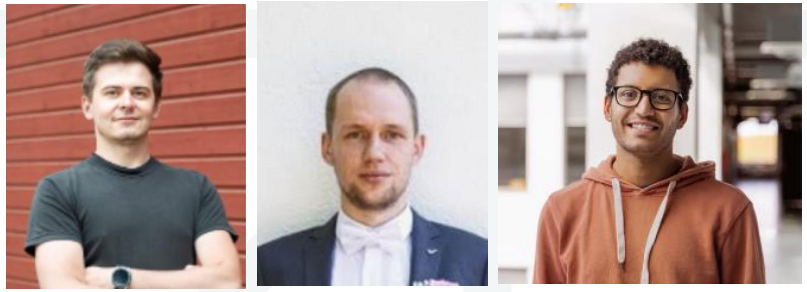
Courtesy: L. Piacentini

Accelerator Technology Team

- Prof. Toms Torims
- Guntis Pikurs PhD student
- Dr. Andris Ratkus

- Jānis Vilcāns PhD student
- Luca Piacentini PhD student*
- Lazar Nikitović PhD student*

- Kristaps Paļskis PhD student*
- Viesturs Lācis MSc student
- Tobia Romano (PoliMi/ RTU) PhD student*

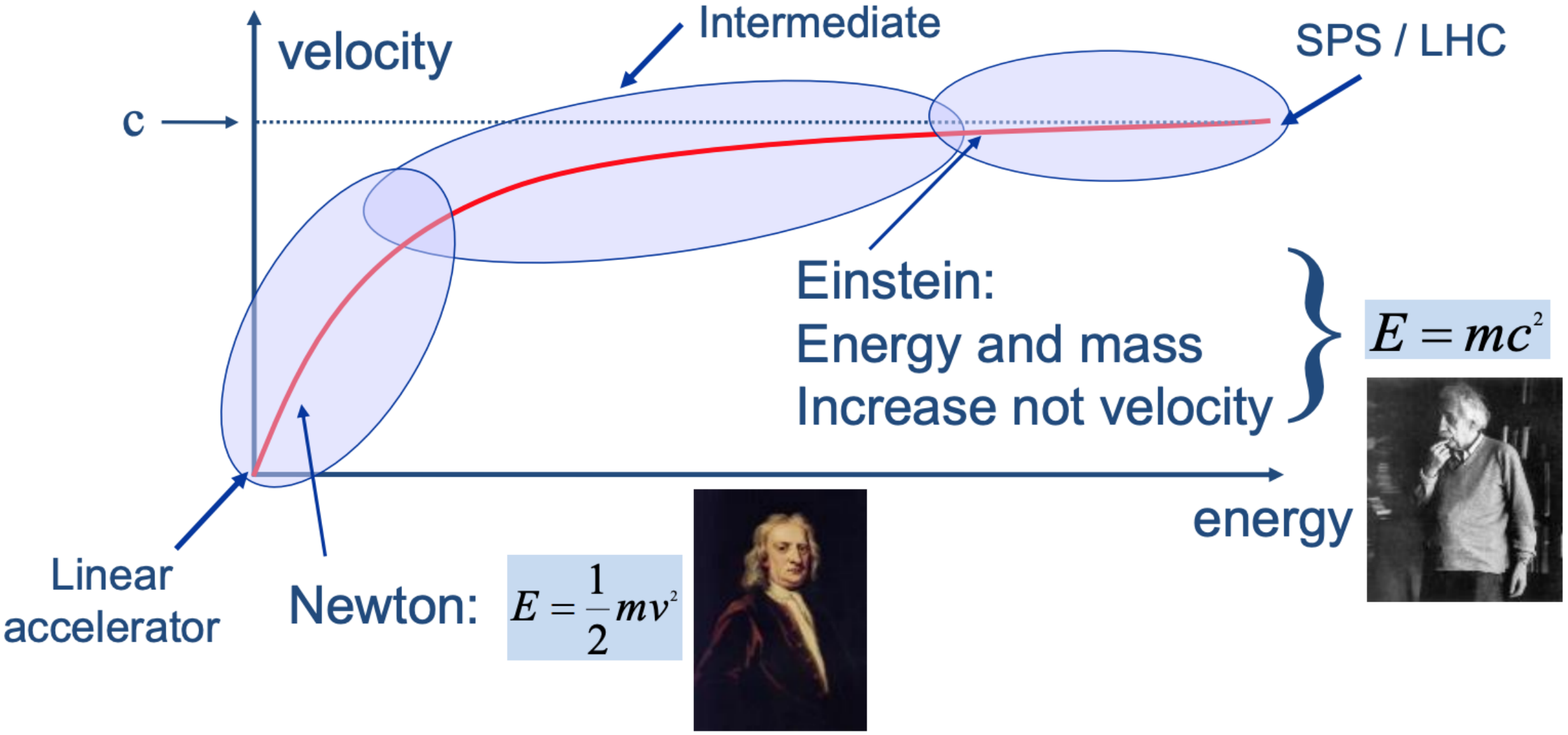


* RTU/UL Particle Physics and Accelerator Technologies study programme

Thank you!

Andris Ratkus

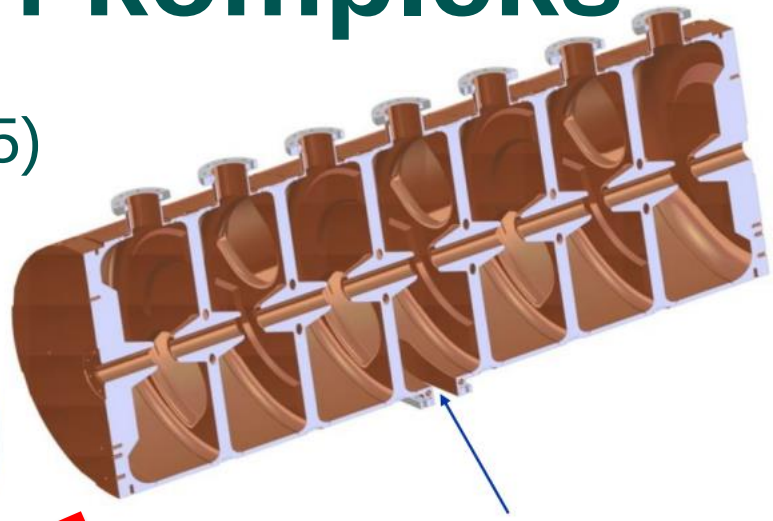
andris.ratkus@rtu.lv



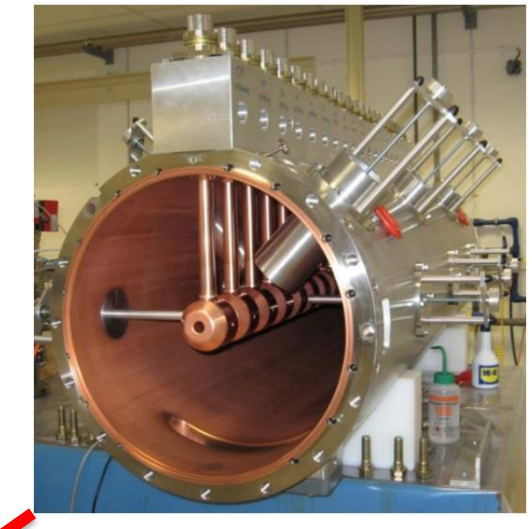
Courtesy: Maurizio Vretenar (CERN)

CERN LINAC 4 kompleks

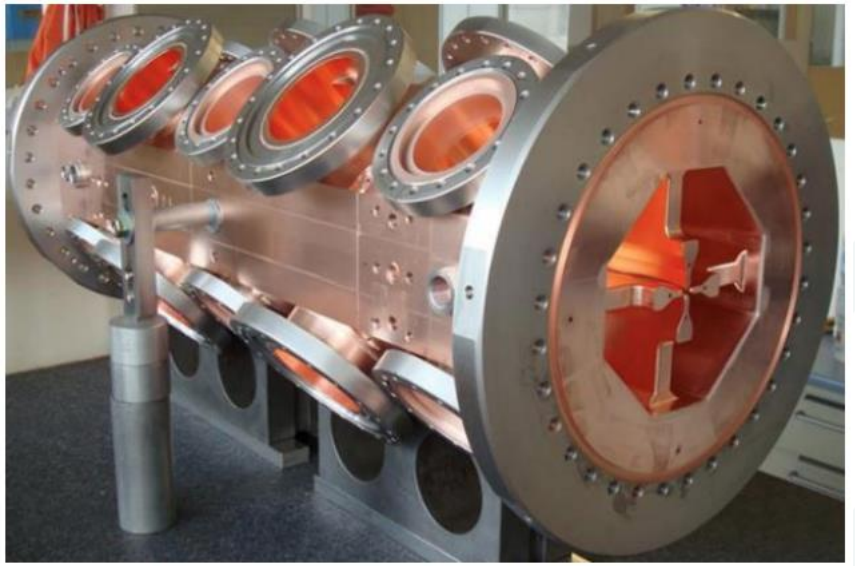
PIMS (β = ~0,5)



DTL (β = ~ 0,3)



RFQ (β = ~ 0,01)

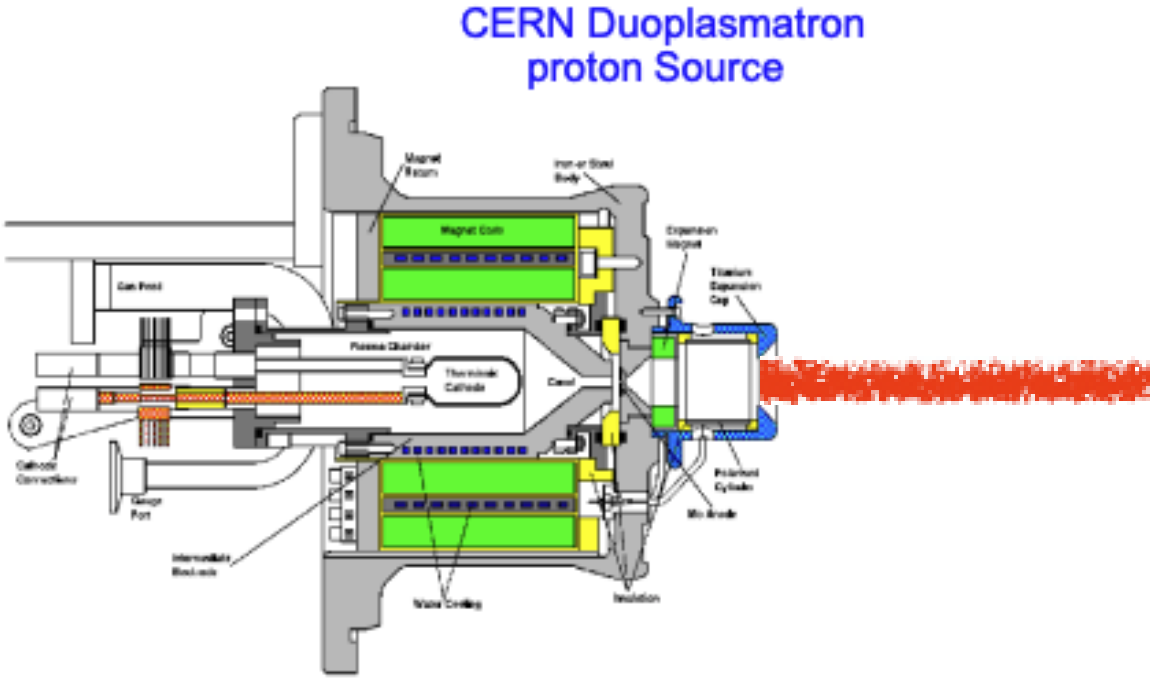


Section	Output Energy [MeV]	Number of consecutive identical cells	Distance between quadrupoles
RFQ	3	1	-
DTL	50	1	$\beta\lambda$
CCDTL	100	3	4 $\beta\lambda$
PIMS	160	7	5 $\beta\lambda$

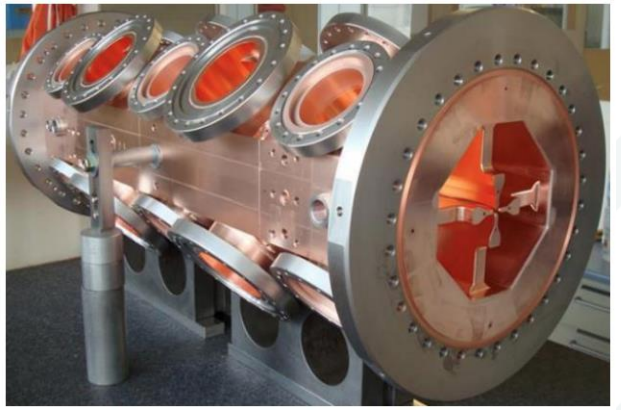
JP.Corso le 16.10.2008

Courtesy: Maurizio Vretenar (CERN)

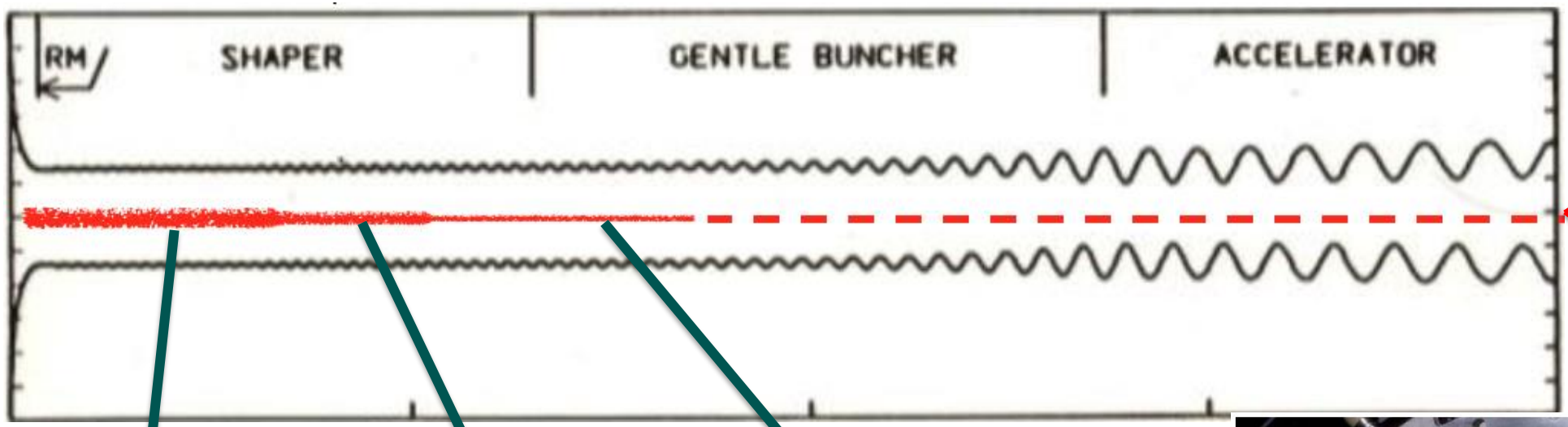
Sākums eksperimentam: Daļiņu avots

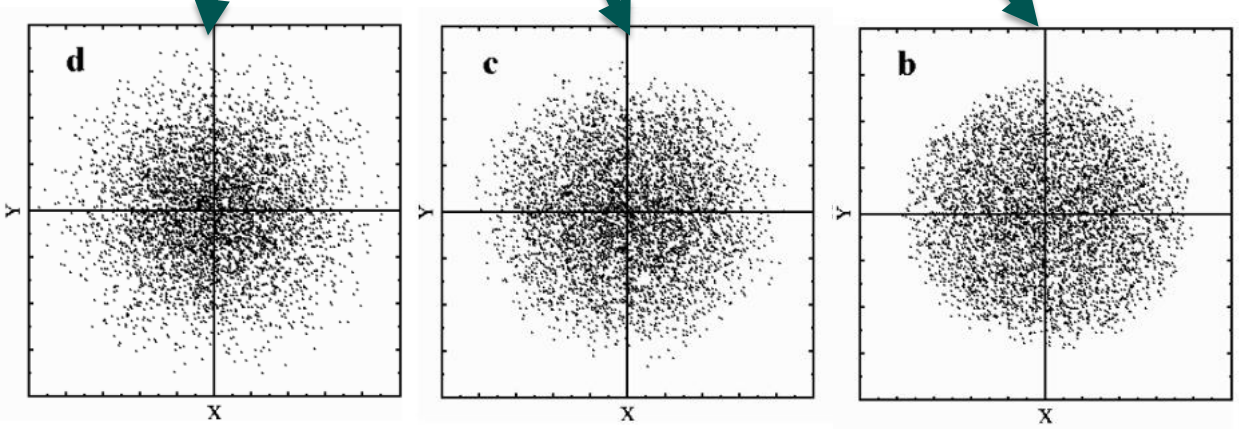


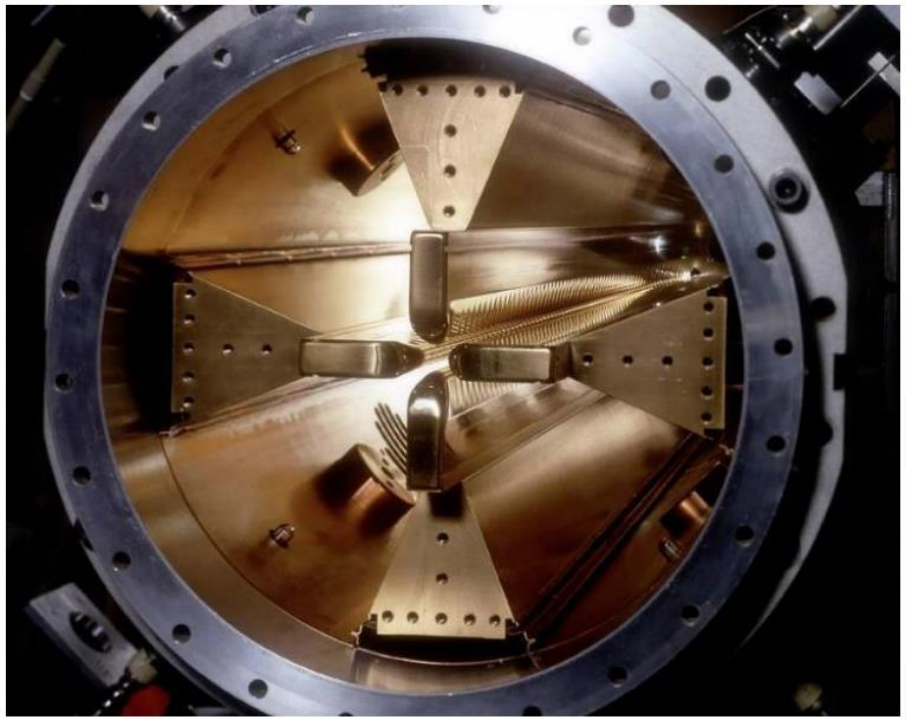
RFQ



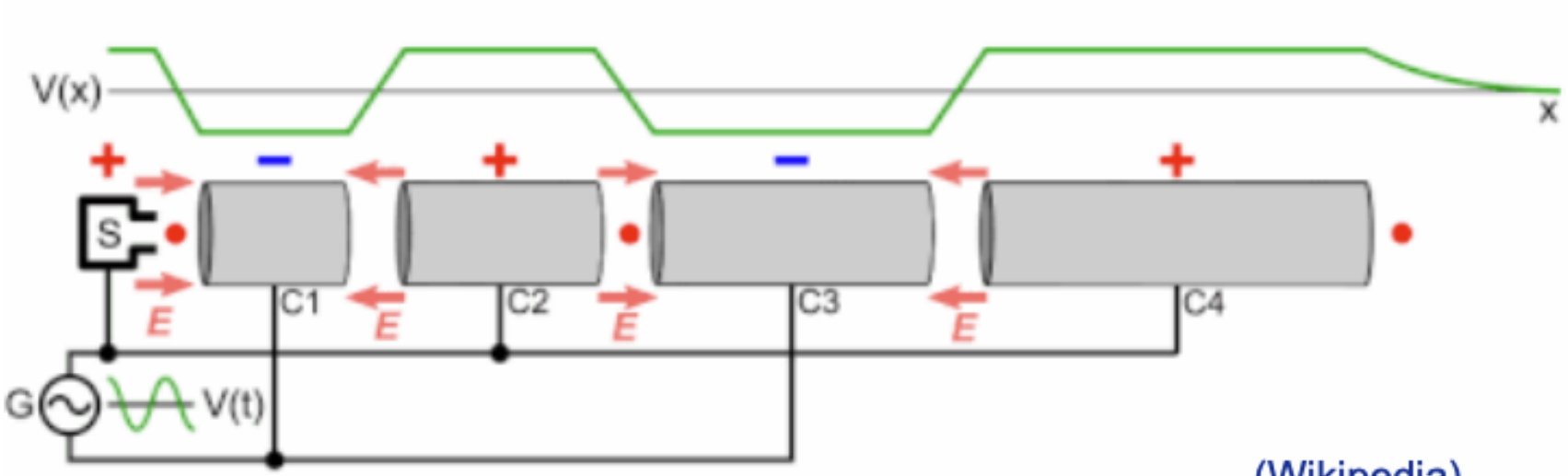
Radio Frekvences Kvadrapols (RFQ)



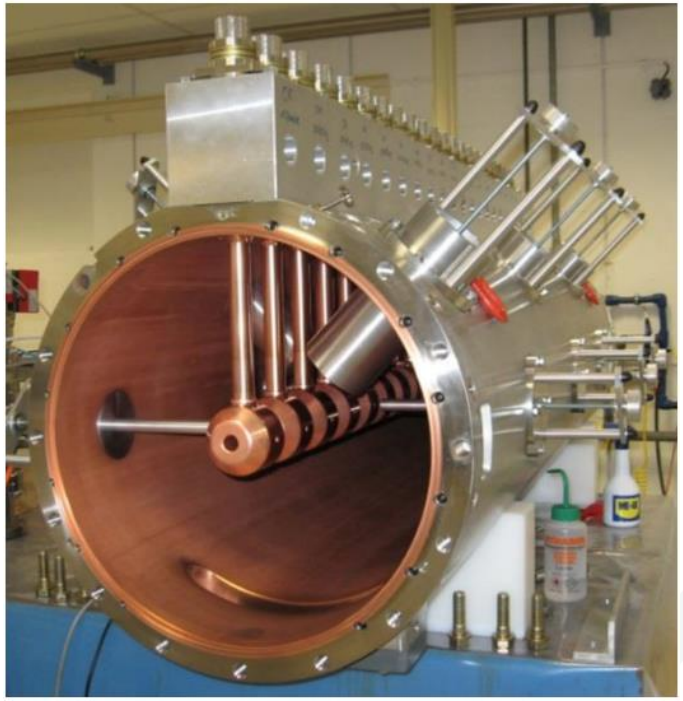




DTL (Drift Tube Linac) darbības princips

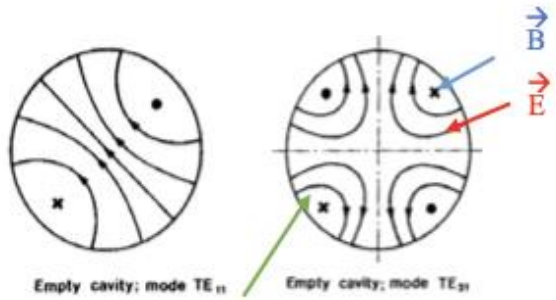


(Wikipedia)

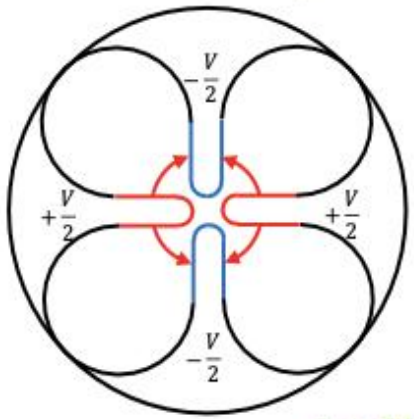


1) RF – RF accelerator – RFQ

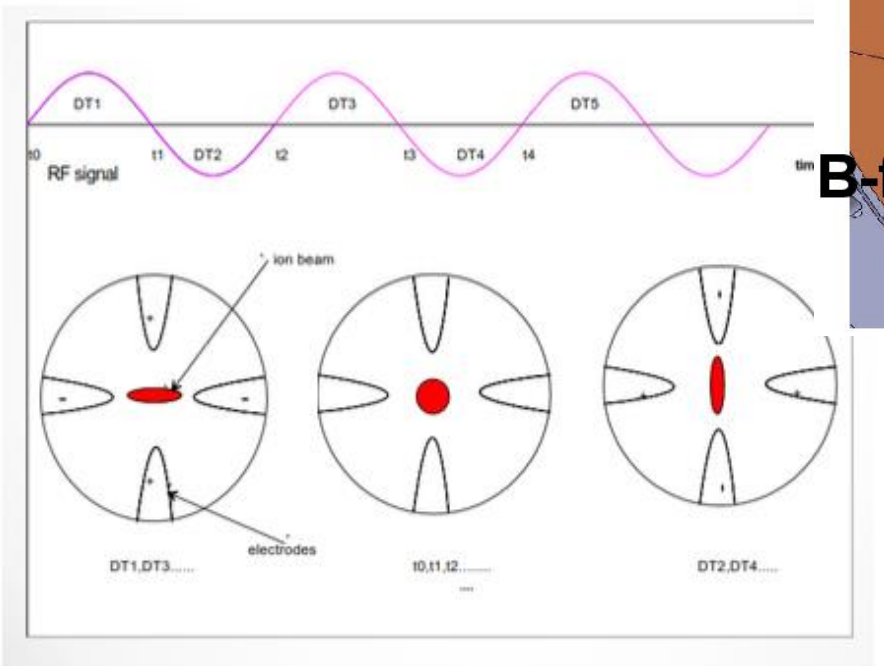
1.5: The use of Transverse Electric Mode (TE)

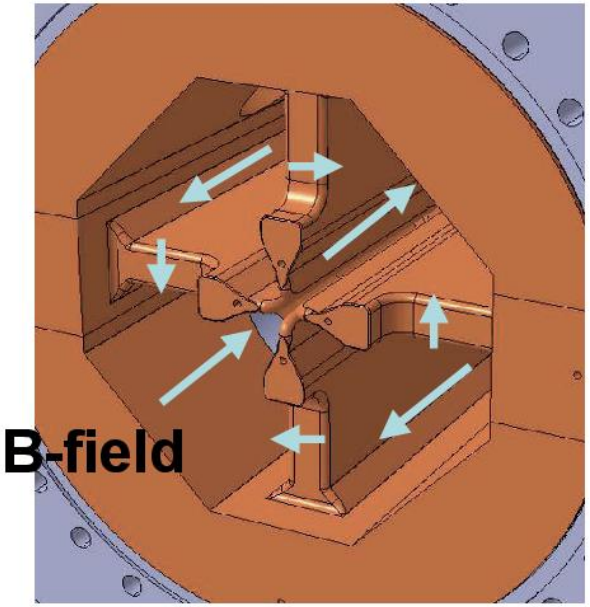


Quadrupolar mode



With **Electrodes** (Vanes)

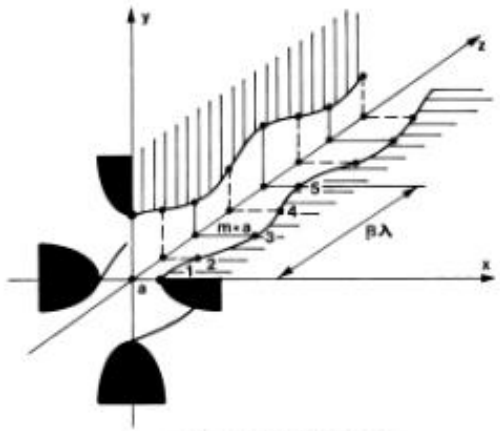




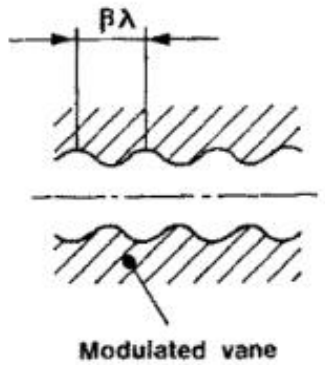
→ RF Field produces alternating gradient focusing (Electric Quadrupole)

1) RF – RF accelerator – RFQ

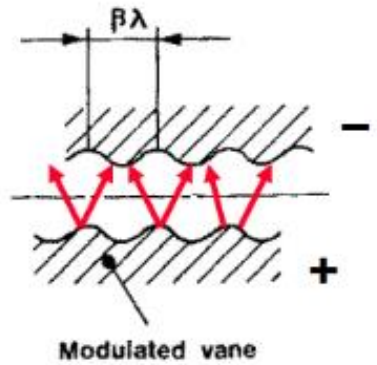
1.6: Electromagnetic wave in an RFQ (Radio Frequency Quadrupole)



a: minimum distance from axis
m·a: maximum distance from axis
m: modulation factor
βλ: modulation period



Opposite vanes (180°)



Adjacent vanes (90°)

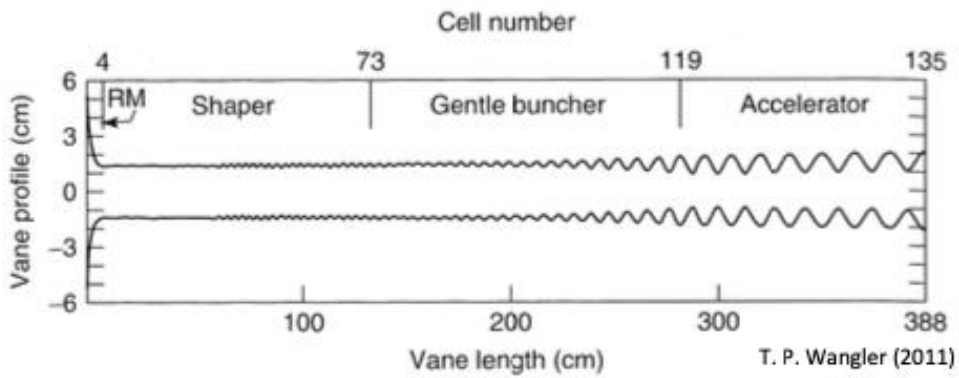
Perturbation (Modulation*) of the Electrodes (Vanes) produces a longitudinal electric field for the acceleration of the ions.

RFQ Performances:

- The RF field allows the Focusing, Bunching and Acceleration

- Is the only linear accelerator accepting a low energy continuous beam

- Acceleration up to 5 - 10 MeV for protons



T. P. Wangler (2011)