

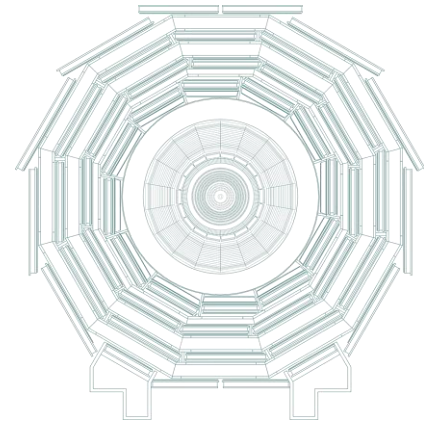


Institute of Particle Physics and
Accelerator Technologies

Overview of the Riga Technical University Institute of Particle Physics and Accelerator Technologies

Kārlis Dreimanis
Andris Ratkus

Visit of the CERN director for Research and Computing
6th of June, 2024



- *Institute of Particle Physics and Accelerator Technologies* (IPPAT) was established on April 1st, 2023, as a scientific institute within the *Faculty of Natural Sciences and Technologies* at the Riga Technical University (RTU).
- IPPAT is the leading scientific institution in Latvia vis-à-vis cooperation with CERN and the only scientific institution dedicated to the research in particle physics, accelerator physics, and particle detector and accelerator technologies.
- IPPAT is involved in several CERN-based or CERN-related scientific collaborations and projects:
 - Compact Muon Solenoid (CMS) experiment;
 - Future Circular Collider (FCC) collaboration;
 - International Muon Collider Collaboration (IMCC);
 - Innovation Fostering in Accelerator Science and Technology (I.FAST) project;
 - Heavy Ion Therapy Research Integration plus (HITRIplus) project;
 - Next Ion Medical Machine Study (NIMMS).

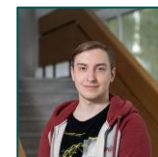
- At present, the CMS group at IPPAT comprises 10 research personnel:

Staff:

- Assoc. prof. Kārlis Dreimanis (group-leader)
- Dr Markus Seidel (senior researcher)
- Mr Guntis Pikurs (research engineer)

PhD students:

- Mr Andris Potrebko (4th year PhD)
- Ms Antra Gaile (3rd year PhD)
- Mr Conrado Munoz-Diaz (2nd year PhD)
- Mr Dimitrios Sidiropoulos Kontos (2nd year PhD)
- Ms Dace Osīte (2nd year PhD)
- Mr Ojārs Mārtiņš Eberliņš (1st year PhD)
- Mr Robert Pleše (1st year PhD)



- We are working towards recruiting two more post-doctoral researchers and expect to have 1-2 PhD students joining in the academic year 2024/25.

- IPPAT team leads the CMS-Latvia group, a consortium of RTU and the University of Latvia;
- The group is complemented by assoc. prof. Elīna Pajuste and a 4th year PhD, Mr Normunds Ralfs Strautnieks.



- **Primary scientific directions:**

- Top quark physics;
- Higgs boson physics;
- MIP Timing Detector (MTD).

- **Secondary scientific direction:**

- Standard Model physics.

- **Expertise in physics object groups:**

- Jet energy corrections;
- Jet flavour response;
- PF hadron calibration;
- Low- p_T lepton reconstruction.



- Short-term goal: to establish leadership in Top PAG and strong visibility in the Higgs PAG.

- Medium-term goal: to drive the CMS Top physics strategy and to lead HH analyses.

- Finally, since yesterday, Latvia has its own operational CMS Tier-2 site! (*fresh of the press* & not covered here)

Ongoing analyses

Top physics:

- Top quark / anti-quark mass difference measurement
- LFU measurement in top quark decay
- Study of b-fragmentation in top decays
- Measurement of the boosted Top quark mass
- Study of the dead-cone effect in b-jets in top quark decays
- Study of softQCD effects in top quark decays

[A.Potrebko]

[N.R.Strautnieks]

[D.Sidiropoulos Kontos]

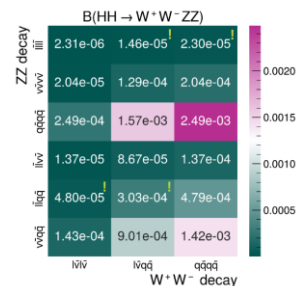
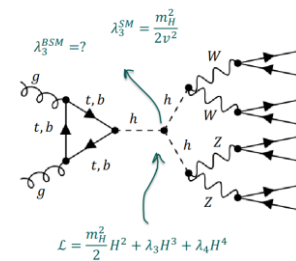
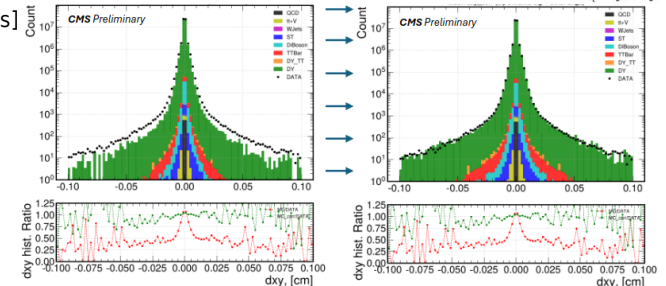
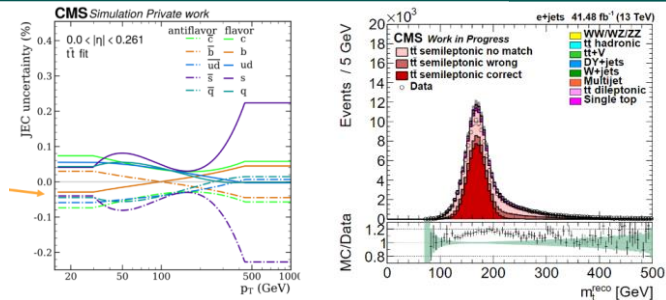
[C. Munoz Diaz]

[D.Osité]

[R.Pleše]

Higgs & SMP physics:

- Measurement of the di-Higgs production in the WWZZ decay channel [A.Gaile]
- Study of FSR in Z boson decays [O.M.Eberliņš]
- W mass measurement [M.Seidel]



Ongoing analyses

Top physics:

- Top quark / anti-quark mass difference measurement
- LFU measurement in top quark decay
- Study of b-fragmentation in top decays
- Measurement of the boosted Top quark mass
- Study of the dead-cone effect in b-jets in top quark decays
- Study of softQCD effects in top quark decays

[A.Potrebko]

[N.R.Strautnieks]

[D.Sidiropoulos Kontos]

[C. Munoz Diaz]

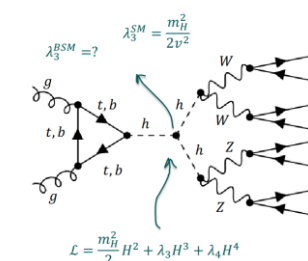
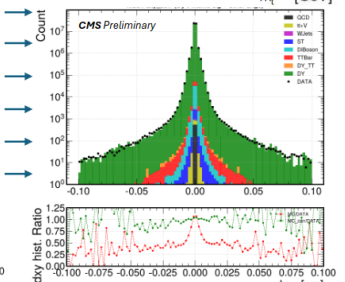
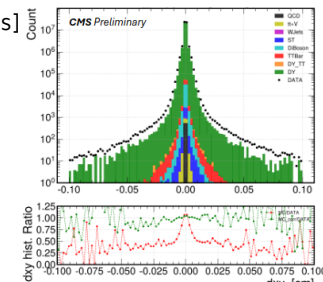
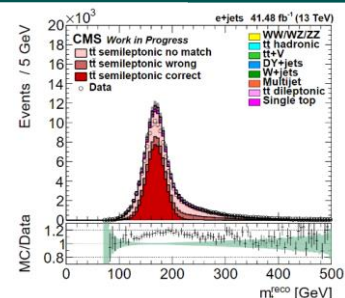
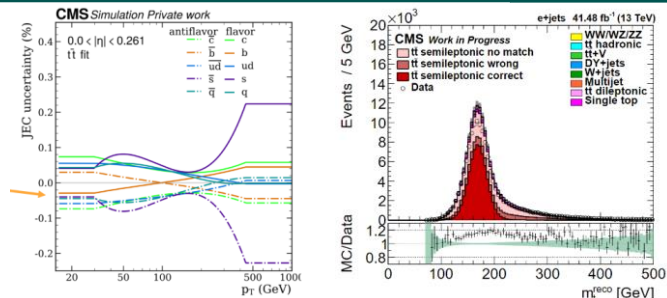
[D.Osité]

[R.Pleše]

Higgs & SMP physics:

- Measurement of the di-Higgs production in the WWZZ decay channel [A.Gaile]
- Study of FSR in Z boson decays [O.M.Eberliņš]
- W mass measurement [M.Seidel]

**Flagship measurement for CMS!
RTU (via Markus) a major contributor!**



B(HH → W⁺W⁻ZZ)

llll	2.31e-06	1.46e-05	2.30e-05
llνν	2.04e-05	1.29e-04	2.04e-04
qqll	2.49e-04	1.57e-03	2.49e-03
llνν	1.37e-05	8.67e-05	1.37e-04
llqq	4.80e-05	3.03e-04	4.79e-04
ννqq	1.43e-04	9.01e-04	1.42e-03

W⁺W⁻ decay

- MIP Timing Detector (MTD) will be a new sub-system at CMS introduced for Run 4.

- MTD will provide CMS with a track-time resolution of $\langle \sigma_t \rangle \sim 35\text{ps}$ (70ps) at the start (end) of life.

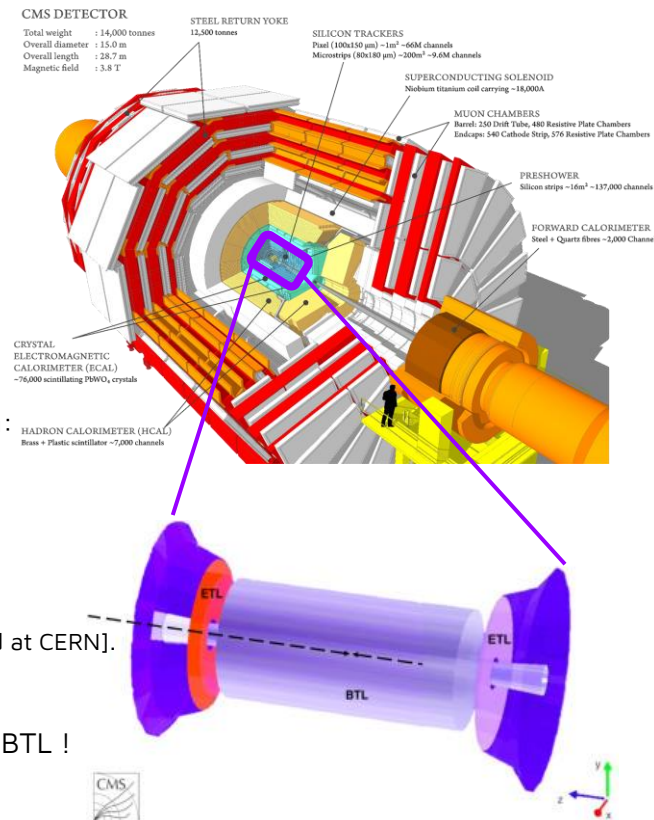
- The detector is split into the barrel and endcap layers (BTL and ETL).

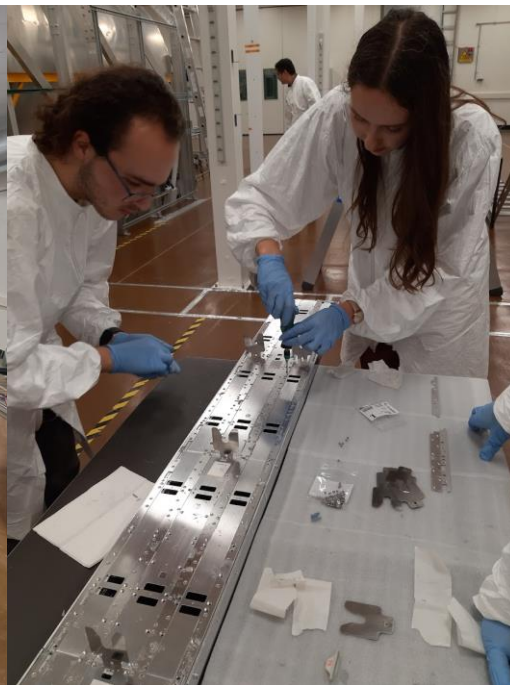
- CMS-Latvia group has established itself as a key member of the MTD BTL sub-system:

- *Mechanics, Assembly and Interfaces* task co-coordinator [K.Dreimanis].
- Leading BTL DCS/DSS developer [A.Gaile].
- MTD detector description integration into CMSSW [N.R.Strautnieks].
- MTD assembly at the Tracker Integration Facility [all personnel when based at CERN].

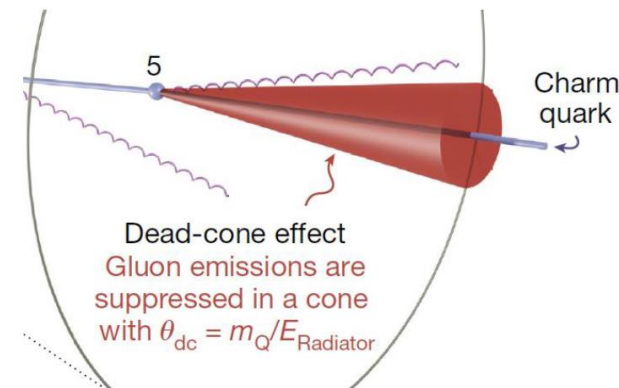
- Our team will be instrumental in the successful assembly, QA/QC & integration of the BTL !

- Following installation, we expect to remain as a leading MTD institute until the end of the HL-LHC era!





- We have been lucky to recruit Yuri Dokshitser to help with development of particle physics in Latvia!
- Retired to Riga from CNRS, Yuri is still an absolute **world-class expert in QCD**.
- Yuri provides the students with a particle physics study course as well as providing ideas for physics analyses, we could initiate at CMS.
- Yuri is the original proponent of the dead-cone effect in hadronic decays!
[\[https://iopscience.iop.org/article/10.1088/0954-3899/17/10/023\]](https://iopscience.iop.org/article/10.1088/0954-3899/17/10/023)
- Observed in charm decays at ALICE.
[\[https://www.nature.com/articles/s41586-022-04572-w\]](https://www.nature.com/articles/s41586-022-04572-w)
- Dace Osīte's thesis should be the first observation of this effect in beauty decays!



- Prof. Toms Torims
- Dr. Alberto Degiovanni
- Dr. Andris Ratkus



- Guntis Pikurs PhD student
- Luca Piacentini PhD student*
- Lazar Nikitović PhD student*
- Kristaps Paļskis PhD student*



- Tobia Romano (Polimi/ RTU) PhD student*
- Vincenzo Alberto Sansipersico PhD student*
- Aurēlija Viņķe Bachelor student
- Dairis Rihards Irbe Bachelor student



* RTU/UL Particle Physics and Accelerator Technologies study programme

- Innovation Fostering in Accelerator Science and Technology
- Heavy Ion Therapy Research Integration Plus
- Next Ion Medical Machine Study



Innovation Fostering in Accelerator Science and Technology

WP1: Management, coordination and dissemination

- Task 1.2: Information Flow Management and Cross-coordination (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)

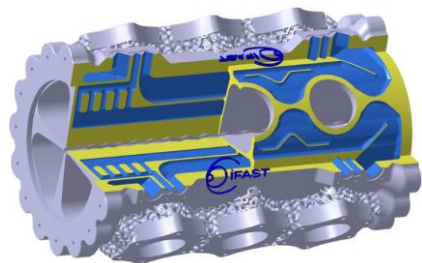
WP12: Societal Applications

- Task 12.1 sub task 3: Environmental applications of electron beam

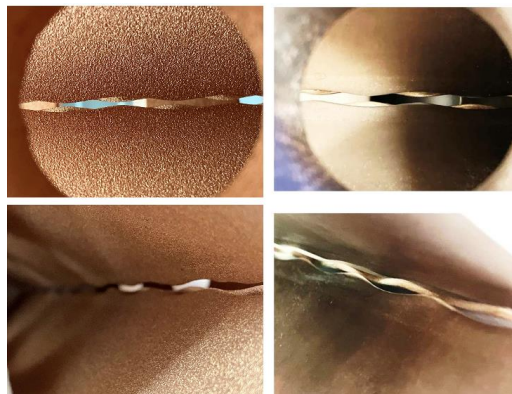
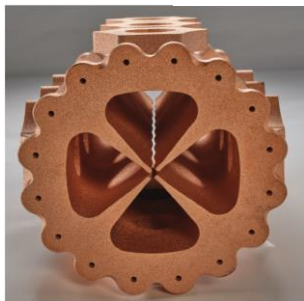


WP10: Advanced Accelerator Technologies (Coordinator RTU)

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



L= 250 mm



Before
Post-procesing



Post-processed and machined

Vacuum tests: The leak detector threshold value was set at $1 \cdot 10^{-10} \text{mbar} \cdot \text{l} \cdot \text{s}^{-1}$



POLITECNICO
MILANO 1863



WP10: Advanced Accelerator Technologies (Coordinator RTU)

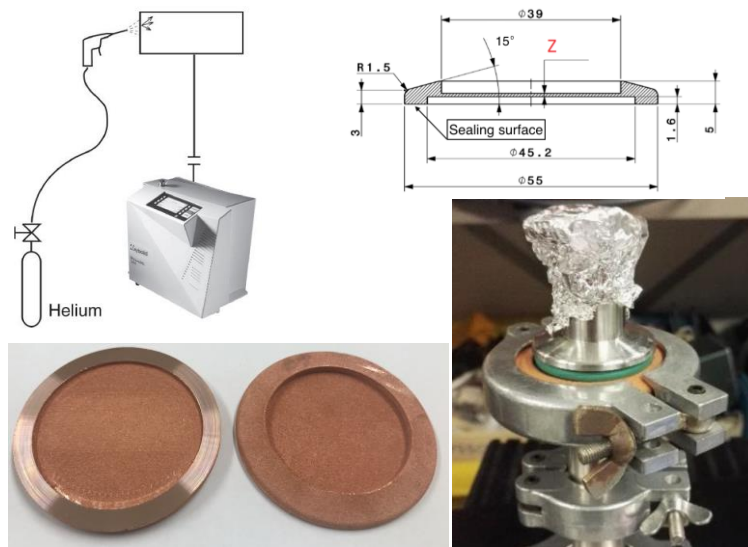
- Activities closely related with CERN teams

SY-RF
Walter WUENSCH



HV holding tests

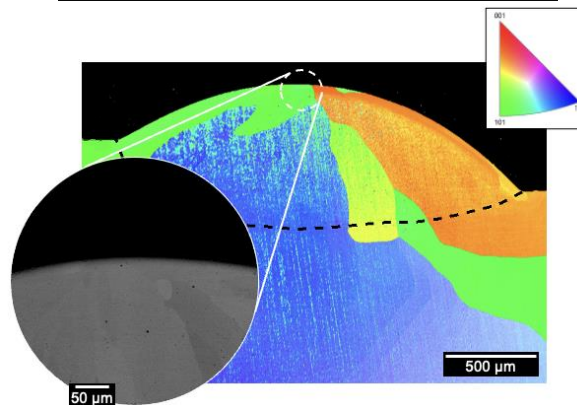
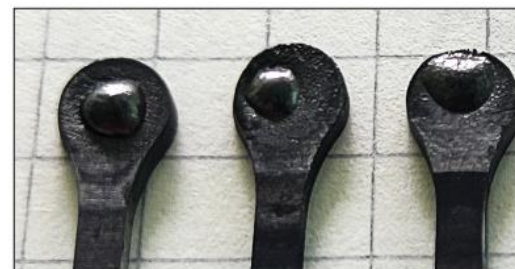
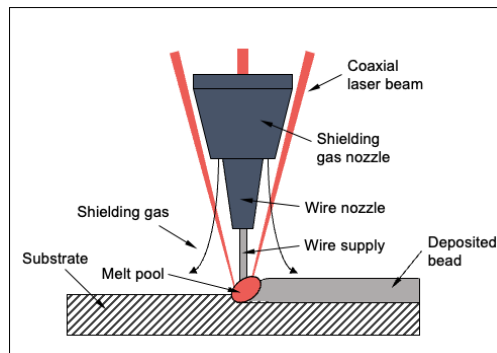
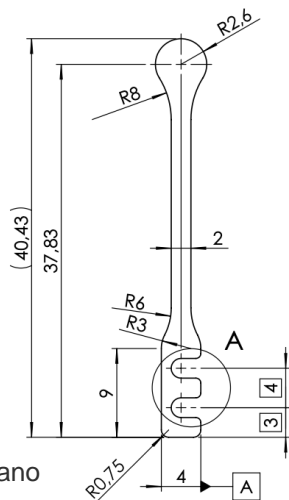
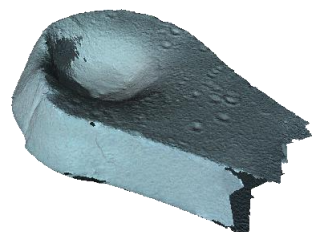
TE-VSC
Cedric GARION



He leak test (UHV)

WP10: Advanced Accelerator Technologies (Coordinator RTU)

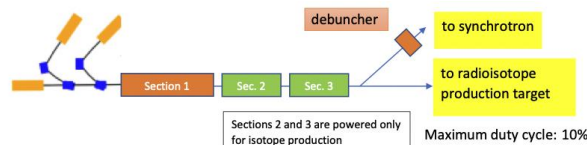
- AM repair demonstration for the Ta cathode



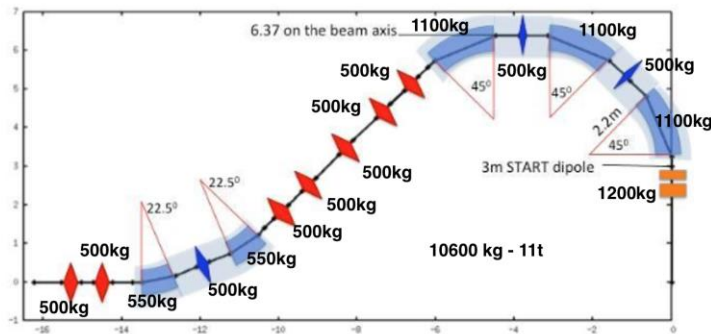
Courtesy: T. Romano

WP 7: Advanced accelerator and gantry design

- **Task 7.4:** Injector Linac Design
- **Task 7.5:** Integration of an innovative superconducting gantry: optics, mechanics, beam delivery



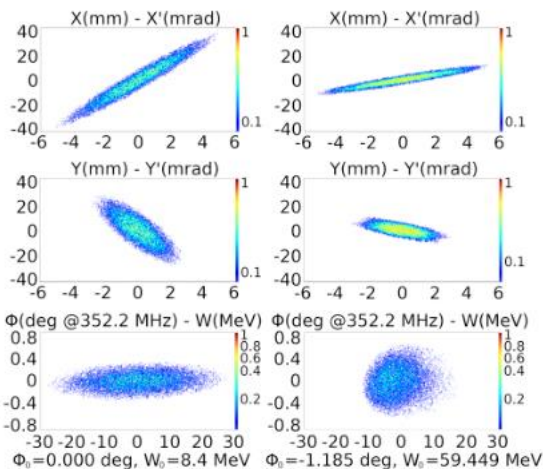
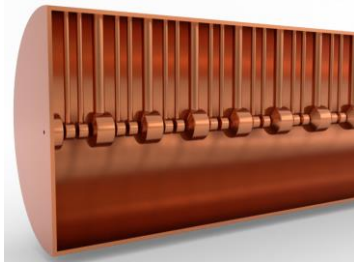
3 ion sources $^{12}\text{C}^{4+}$, 600 μA , 0.25 π mm mrad, 45 kV $^4\text{He}^{2+}$, 0.5 mA, 0.3 π mm mrad <p>or</p> p or H_2^+ , 5 mA, 0.2-0.3 π mm mrad	Linac section1 $q/m=1/3$ $W_{in}=15$ keV/u $W_{out}=5$ MeV/u	Linac section2 $q/m=1/2$ $W_{in}=5$ MeV/u $W_{out}=7.1$ MeV/u	Linac section3 $q/m=1/2$ or 1 $W_{in}=7.1$ MeV/u $W_{out}=10$ MeV/u
	baseline : 217 MHz alternative : 352 MHz		



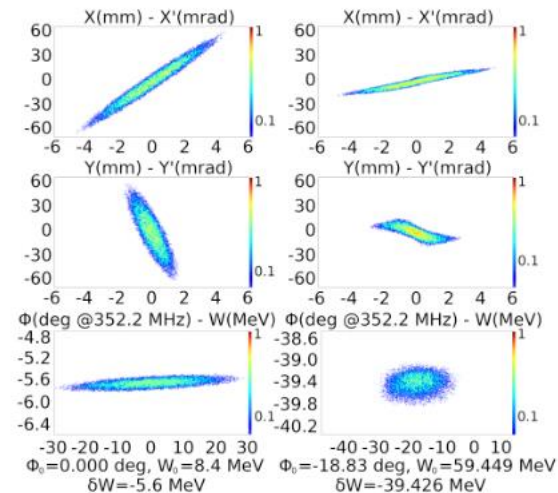
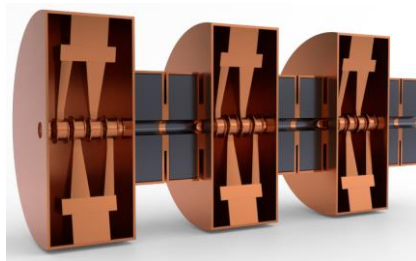
WP 7: Advanced accelerator and gantry design

- Task 7.4: Injector Linac Design**

Quasi-Alvarez Drift Tube LINAC (QA-DTL)



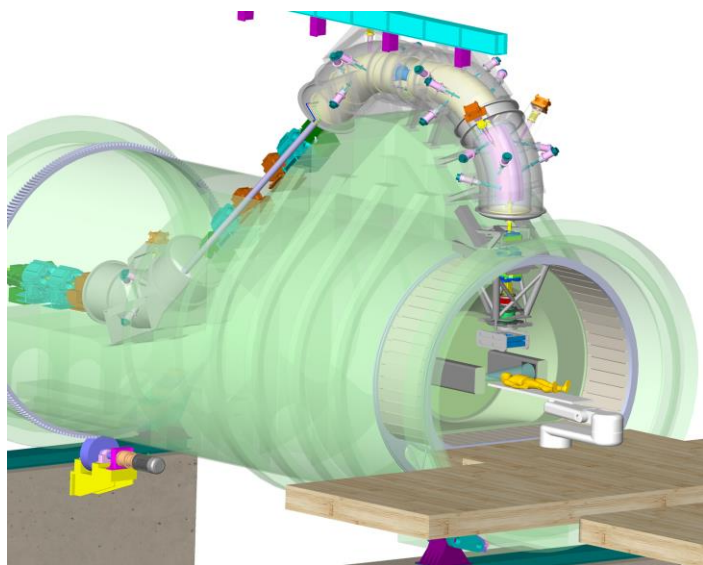
Separated Interdigital H-mode DTL (S-IH-DTL)



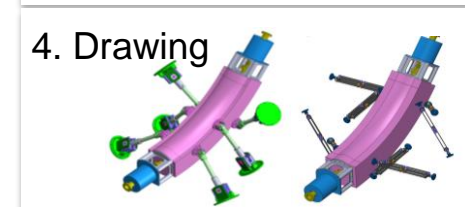
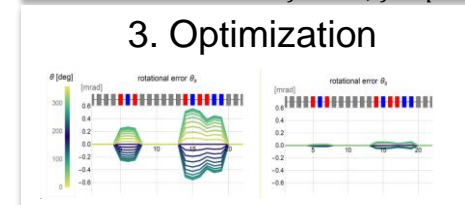
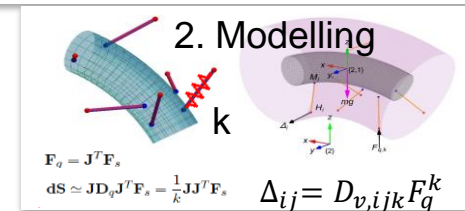
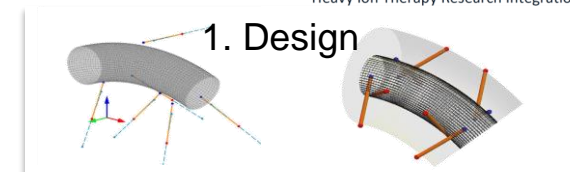
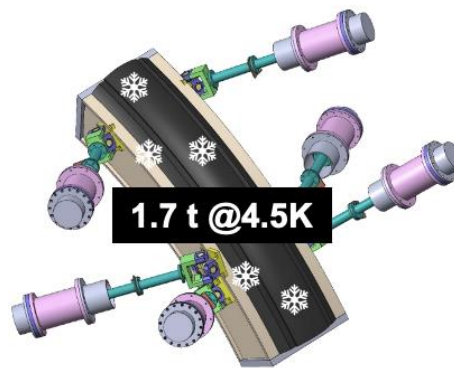
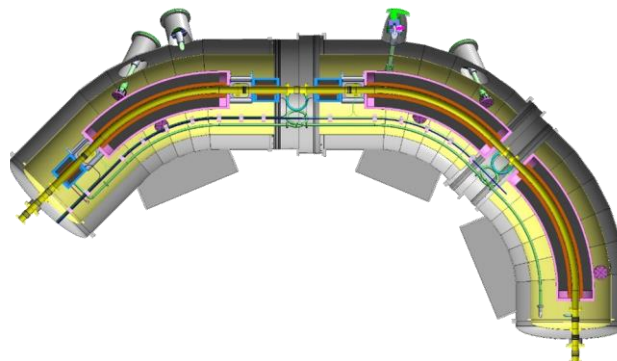
Courtesy: L. Nikitovic

WP 7: Advanced accelerator and gantry design

- Task 7.5:** Integration of an innovative superconducting gantry: optics, mechanics, beam delivery



~220t



Courtesy: L. Piacentini

HITRIplus Annual meeting



www.hitriplus.eu

26 – 28 June 2023
 Riga Technical university, Latvia
 Domus auditorialis,
 Zunda krastmala 8, Riga
 107. auditorium, 1st floor

<https://indico.cern.ch/event/1246177/>

HITRI Heavy Ion Therapy Research Integration
CNAO The National Center for Oncological Hadrontherapy
RIGA TECHNICAL UNIVERSITY

Workshop: Clinics and research: considerations to create a novel particle therapy center (within HITRIplus Event)



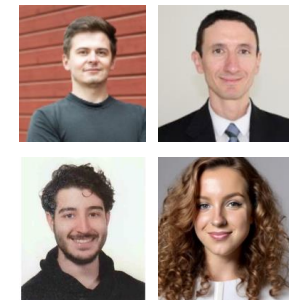
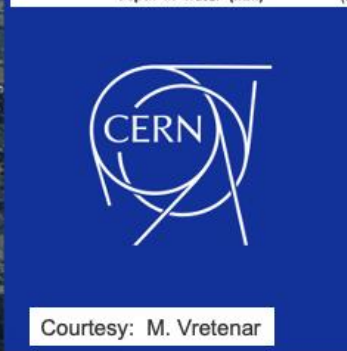
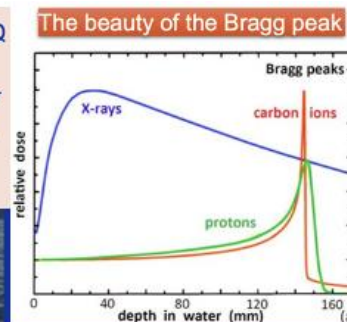
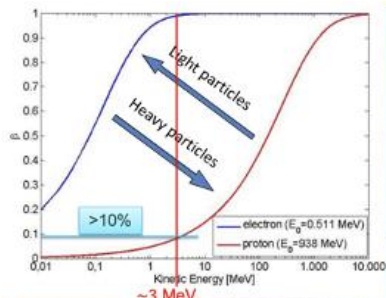
Wednesday 28 Jun 2023, 10:00 → 15:45 Europe/Riga

Domus auditorialis, Zunda krastmala 8

<https://indico.cern.ch/event/1256528/>

Next Ion Medical Machine Study

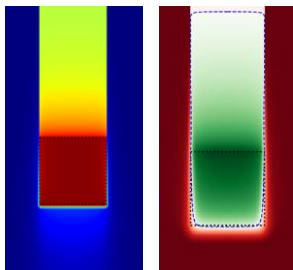
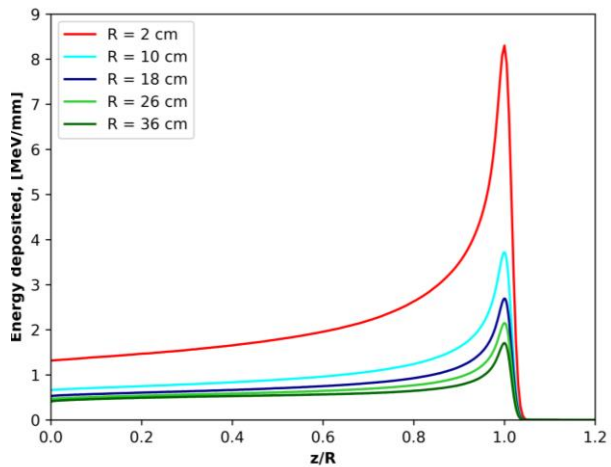
- Developing new technologies for the future generation of accelerators for cancer therapy



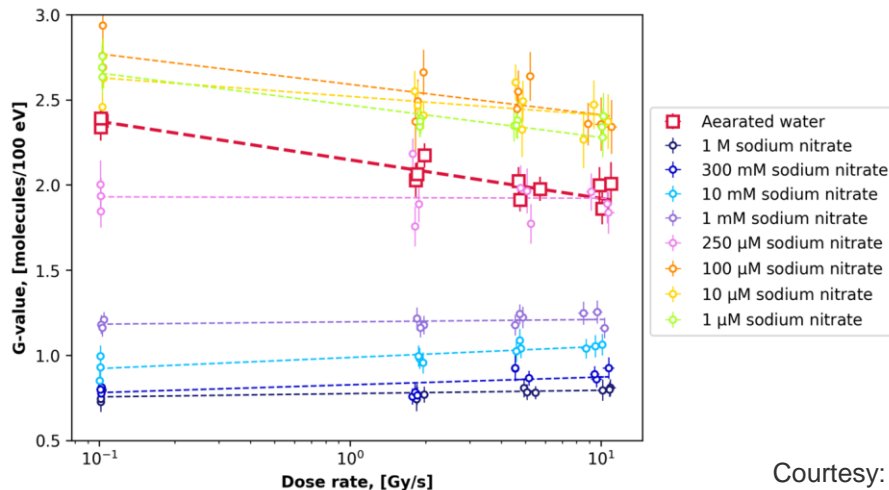
Next Ion Medical Machine Study: Ion FLASH therapy



Simulations

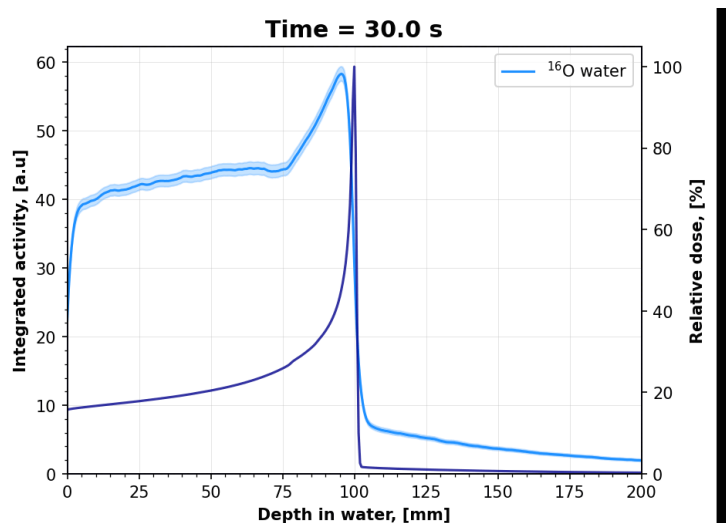


Experiments

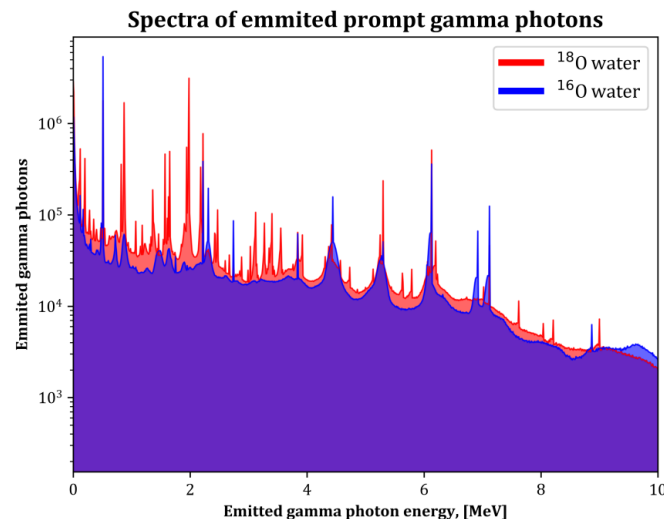


Courtesy: K.Paļšis

Next Ion Medical Machine Study: Imaging for helium ion therapy



PET imaging



Prompt gammas

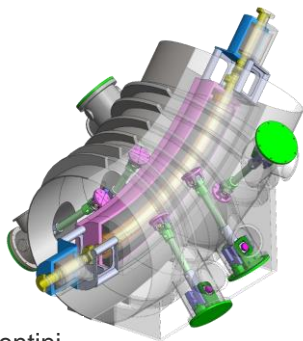
Courtesy: K.Paļskis

Project initiative: Advanced Particle Therapy centre in the Baltic States

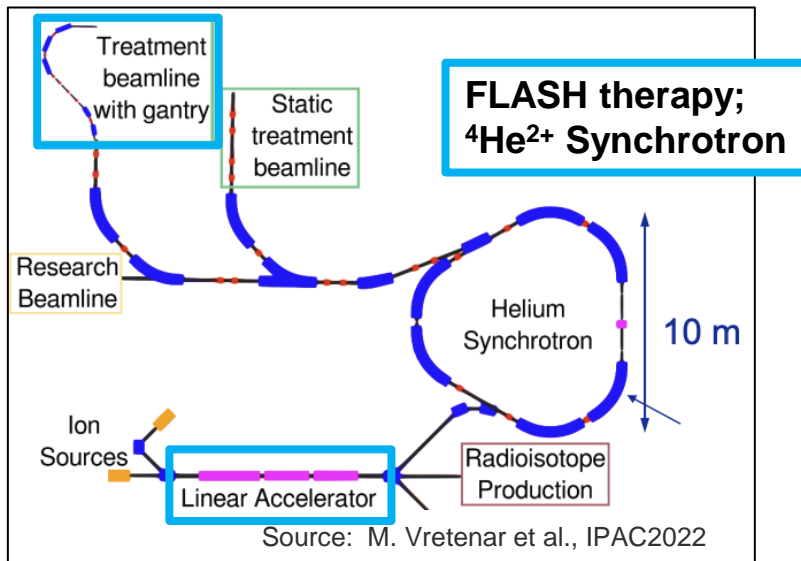


CERN Baltic Group

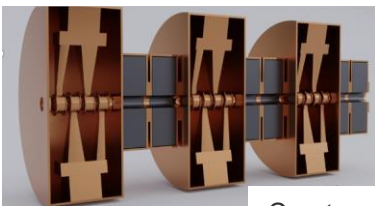
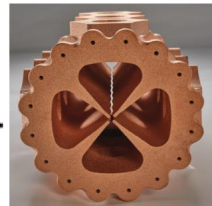
Gantry



Courtesy: L. Piacentini

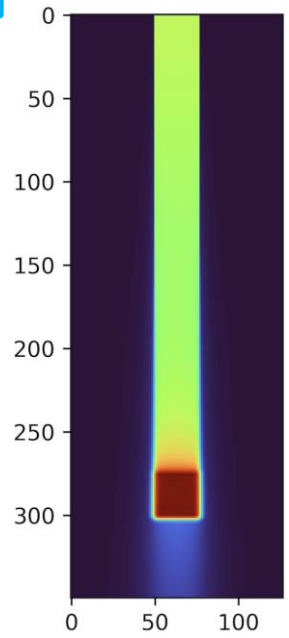


RFQ



HF-LINAC

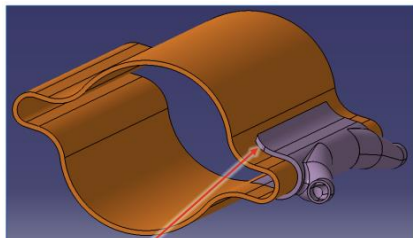
Courtesy: L. Nikitovic



Courtesy: K. Paļšis



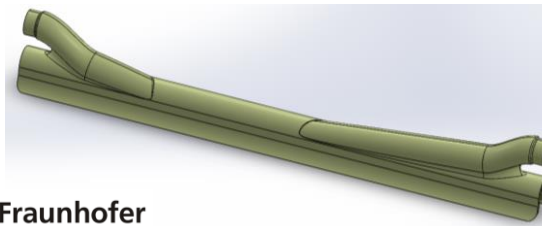
Future Circular Collider



SR Absorber to be laser welded along outer profile

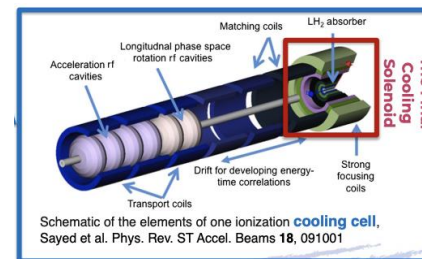


Fraunhofer IWS



International Muon Collaboration

The Memorandum of Understanding has been signed by RTU
Planned Student research on the Final Cooling Solenoid



Innovate for Sustainable Accelerating Systems

Probable contribution in High-Order Mode (HOM) damper design and fabrication (WP4)



iSAS

Innovate for Sustainable Accelerating Systems

- Main tool for the research capacity building – a dedicated state research programme (SRP).
- First project period (2020 – 2022) successfully completed!
- Second project period (2023–2026) ongoing:
 - Three partner institutions – RTU, University of Latvia (UL) and the UL Institute of Solid-State Physics.
 - Total annual budget: ~ 350 kEur.
 - Annual budget allocated to IPPAT : ~ 240 kEur [approximate 50/50 split between HEP and accelerator projects].
- The SRP funding has been invaluable for increasing our scientific & research capacity:
 - HEP research capacity: 2 personnel in 2020; 10 personnel today !
 - Accelerator tech. research capacity: 2 personnel in 2020; 9 personnel today ! (+ a couple of undergraduates)
- Further increase in such dedicated funding is essential for solidifying our group and establishing scientific leadership !



- RTU, together with the CERN Baltic Group partners, have initiated the development of a new MSc programme: *"European Master in particle Physics and Accelerator Technologies for Research and Industry"* (EMPATRI).
- Clearly identified by ECFA as a critical need for the future of the field of HEP [see R&D roadmap document, Task Force 9: <https://cds.cern.ch/record/2784893>];
- RTU was awarded 55 kEur from the Erasmus+ call Erasmus Mundus Design Measures in October 2022. Project concluded on May 31st, 2024.

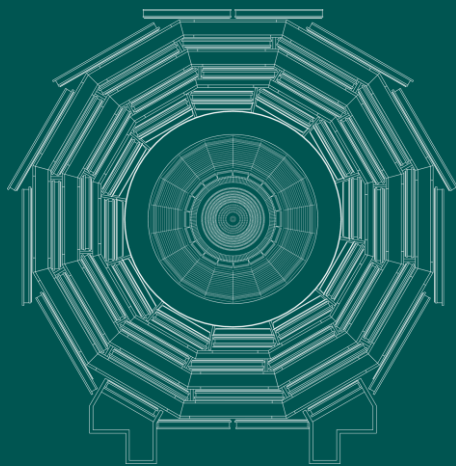
- Initial consortium created by five universities within the CBG:

- Riga Technical University [LV, lead];
- University of Latvia [LV];
- University of Tartu [EE];
- Kaunas University of Technology [LT];
- Vilnius University [LT].



- We aim to prepare a submission for an Erasmus Mundus Joint Master's (EMJM) call expected in February!
- Potential multi-million euro support for 7 years of implementation of EMPATRI (including stipends to prospective students) !
- First cohort of students expected for the academic year 2026/27 !

- **IPPAT is the leading research institution for high-energy physics in Latvia !** (and soon, if not already, in the Baltics!)
- IPPAT and its predecessor have grown the total scientific research capacity in high-energy particle physics and accelerator technologies from 4 research personnel in 2020 to almost 20 (5-fold increase in 5 years!)
- **CMS remains our flagship HEP experiment**, with a vast array of activities ongoing (including Tier-2!).
- **Our involvement in high-profile accelerator technology research collaborations is significant and growing !**
- We benefit from positive attitude & outlook from the funding agency (Ministry of Education and Science).
- With essential additional funding we could consolidate our current progress and continue our growth !
- **IPPAT and Latvia are excellently placed to take up leadership positions in the development of the next generation of flagship experiments at CERN !**



Thank you