Developments in Manufacturing Technologies Research

Co-operation between Riga Technical University and CERN

RTU Prof. Toms TORIMS - CERN Scientific Associate

Content

- Latest developments in Additive Manufacturing technologies
  - Case study 1: Application of laser cladding technology to the innovative in-situ repairs of the marine diesel engines
  - Case study 2: CERN experience - additive manufacturing of super-high-tech components of the particle accelerators

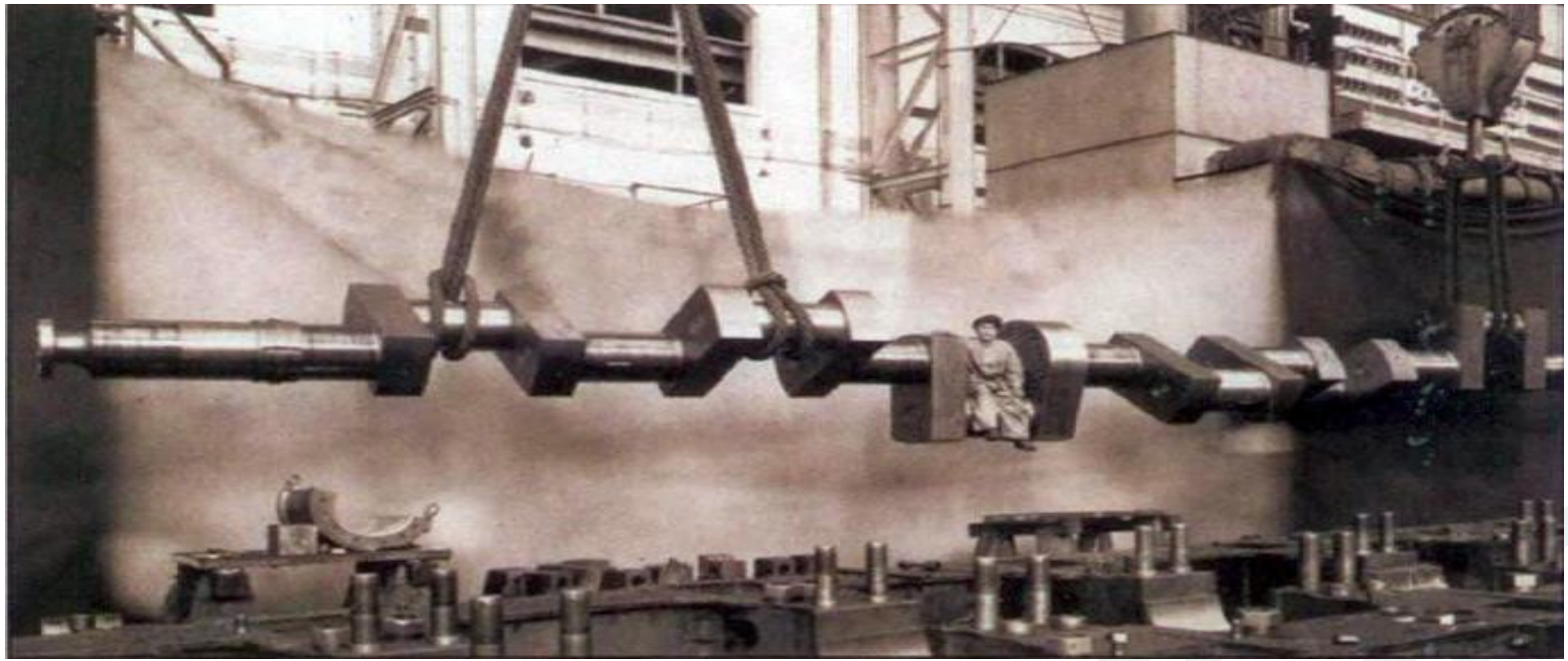
- Co-operation between RTU and CERN – road to success and opportunities for the science and industry
  - Big science and our place in it
  - Joint projects of novel technology developments – case of ARIES project
  - Opportunities for young scientists and engineers

In the context of

- **Collaborative Technological Innovation**
- **Combining New technologies with New Business Models**

Case study 1: Application of laser cladding technology to the innovative in-situ repairs of the marine diesel engines

Marine diesel engine crankshaft



1913 - A worker poses for this picture, from the MAN factory, in Nurnberg

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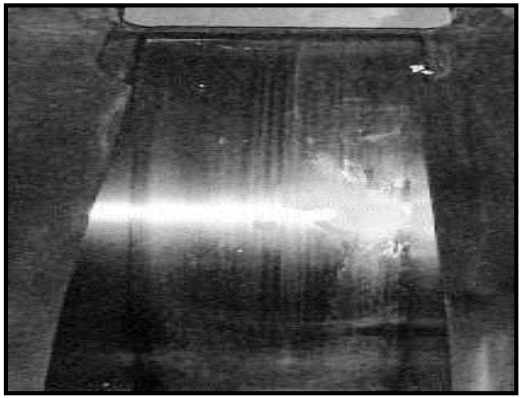
Common damages

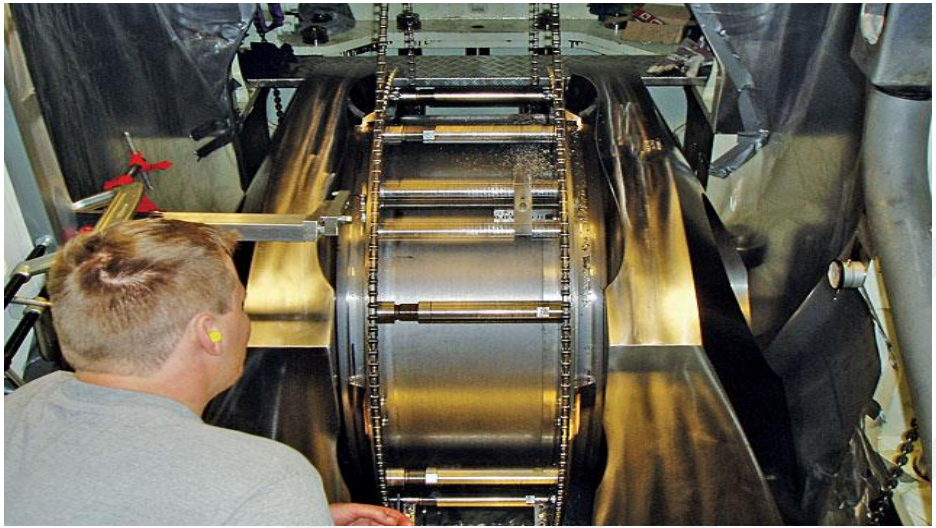


http://orianaof1995.blogspot.be/2011/08/orianas-unique-repair.html

Conventional grinding technology?

http://ngureco.hubpages.com/hub/Worlds-Biggest-Engine-Most-Powerful-Engine-Emma-Maersks-170-Million-Investment-Worlds-Largest-Ship

In-stu crankshaft grinding technology?



http://www.metalock.dk/insitu_crankpins.html

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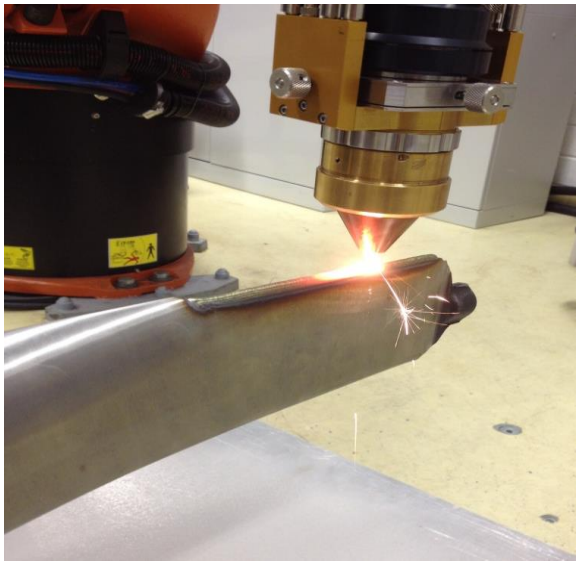
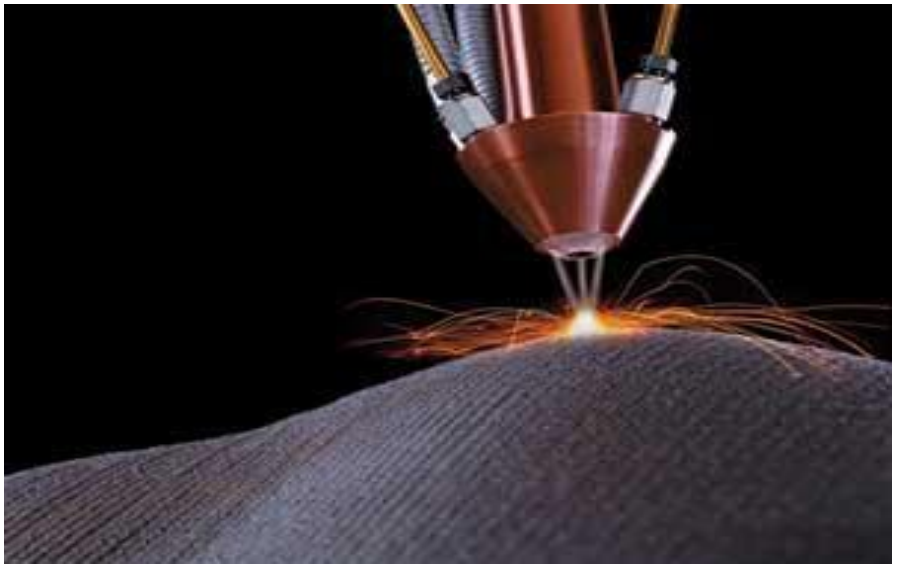
Additive Manufacturing
Laser cladding technology





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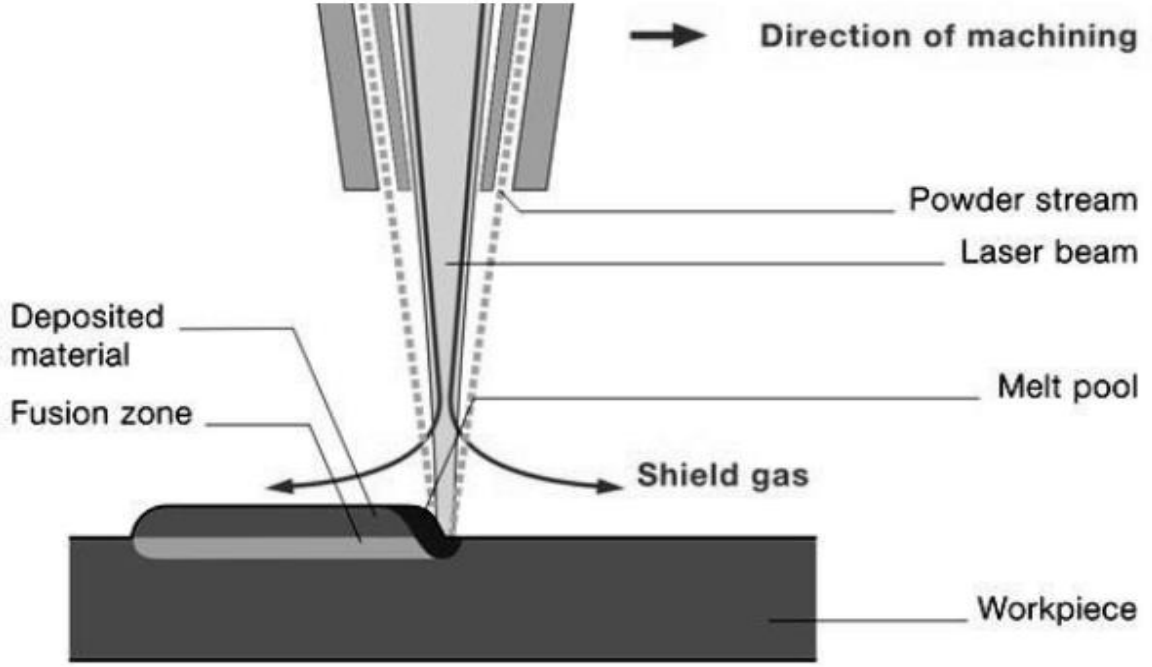
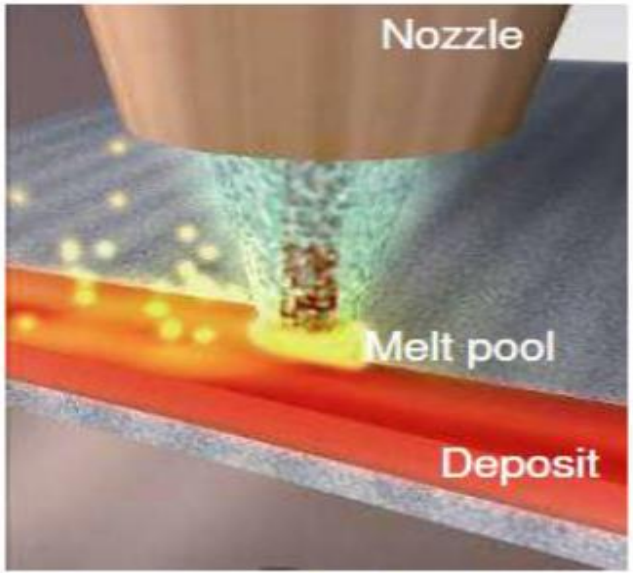
Laser cladding





3D representation of the laser cladding process

Courtesy of TRUMPH

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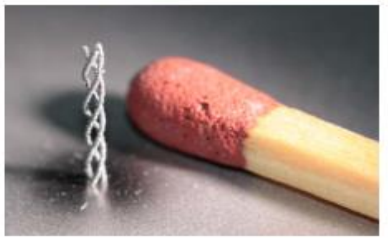
Laser cladding

- Surface cladding
  - 100 μm to 2 mm thickness
  - 100 μm to 2 mm single truck with cladding area range of sq/m
- Repairs
  - 100 μm to 2 mm single truck with
  - Multi-layer build-up
  - Exact material delivery
- Additive manufacturing
  - 3D material build-up
  - 30 μm to 1 mm lateral resolution



Fraunhofer

- rapid design changes – very flexible
- direct generation of complex parts made from eventually any material

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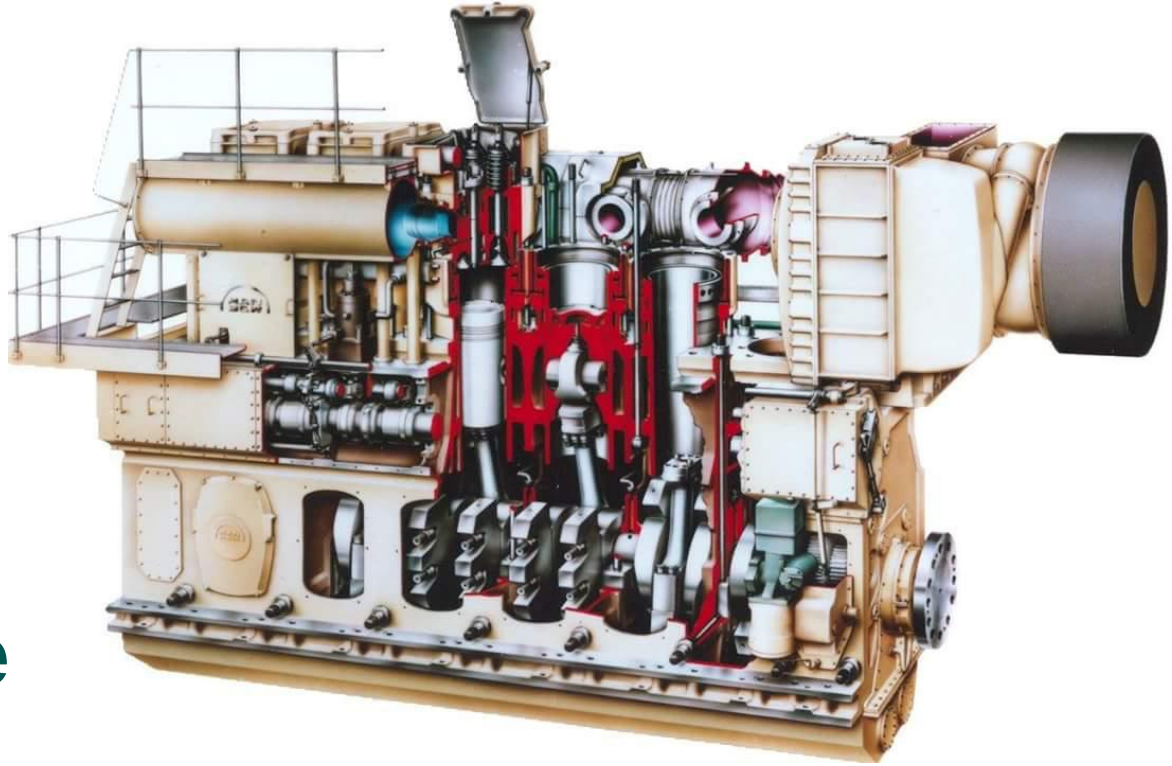
Current applications

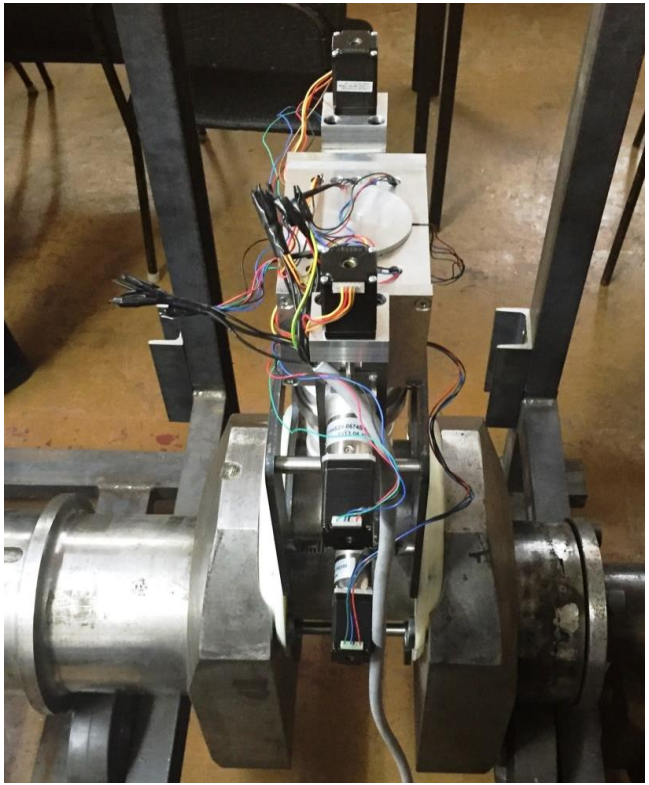
- Repair and refurbishment of high value components (e.g. tools, turbine blades, gas turbine and engine parts)
- Metallic coatings, rapid prototyping, layered metal deposition and nano-scale manufacturing
- Three main fields of application:
  - surface cladding
  - repair welding
  - generative manufacturing

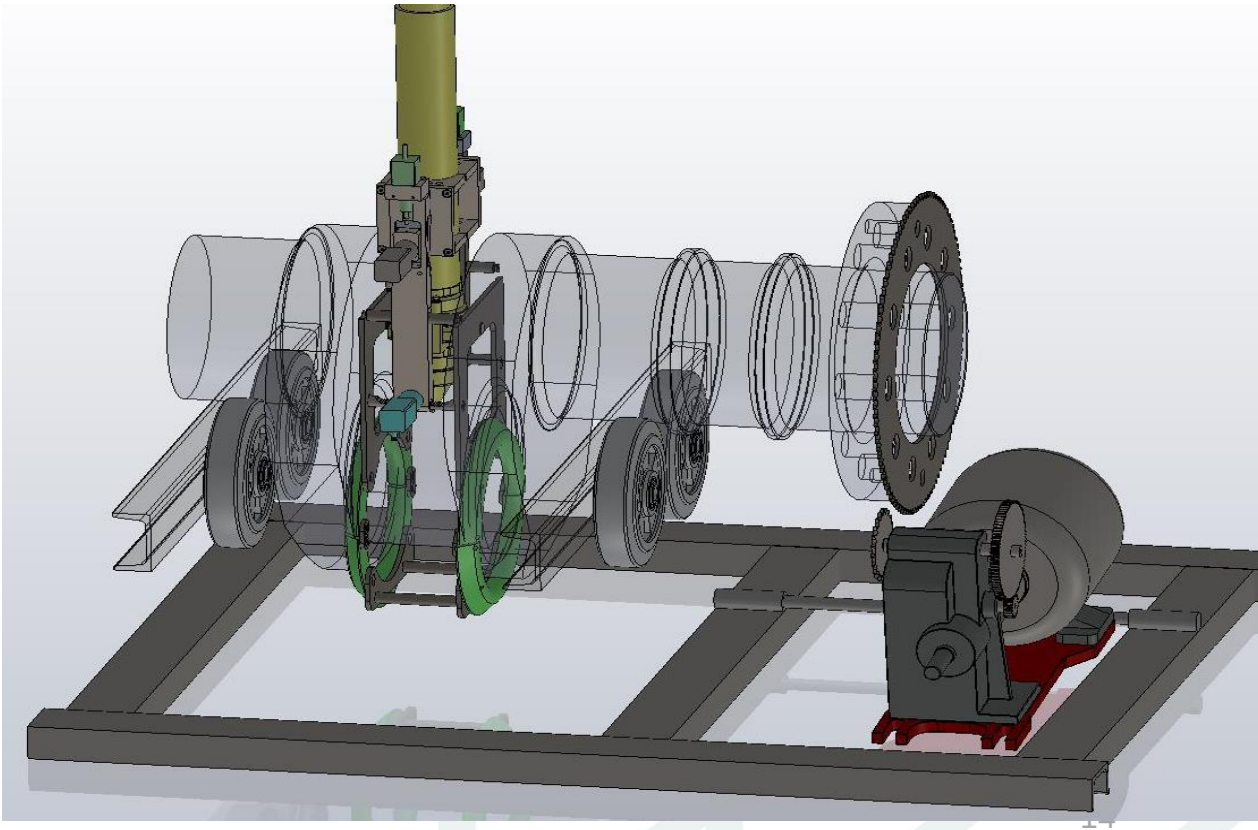
Idea behind and EU/USA patent

Principal design of in-situ laser cladding device



Prototype device





Innovation

- platform can be placed directly on the crankshaft bearing surface to be repaired
- by fitting a laser cladding head onto this platform, the crankshaft surface, can be refurbished directly in the engine housing
- will generate considerable economic benefits
- no major technological or constructive obstacles were identifyed

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Summary of Case study 1

- Collaborative – stakeholders
- Technological – novel and provides for the solution
- Innovation – patent and knowledge transfer

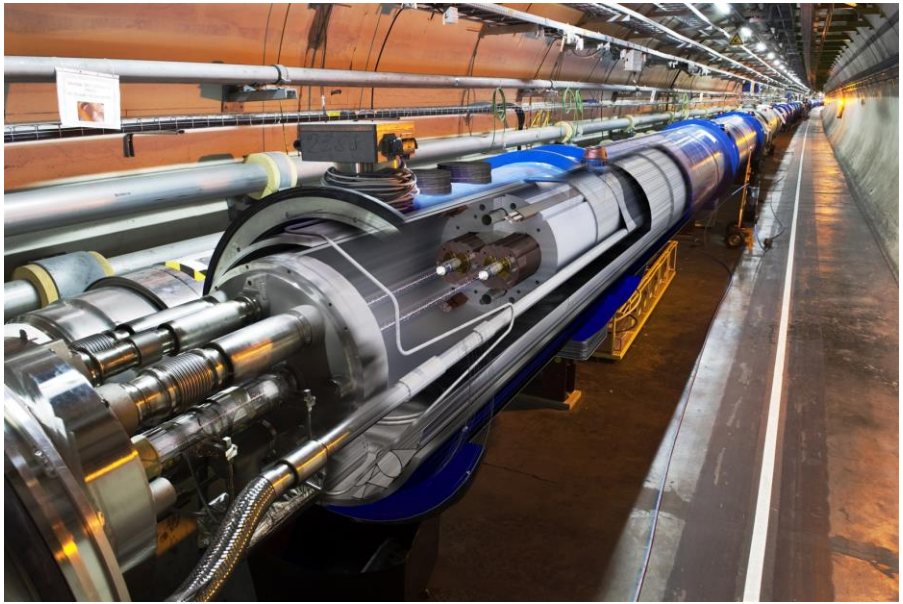
- Combining New technologies with New Business Models?

Case study 2: CERN experience – additive manufacturing of super-high-tech components of the particle accelerators

case of dipole End-Spacers

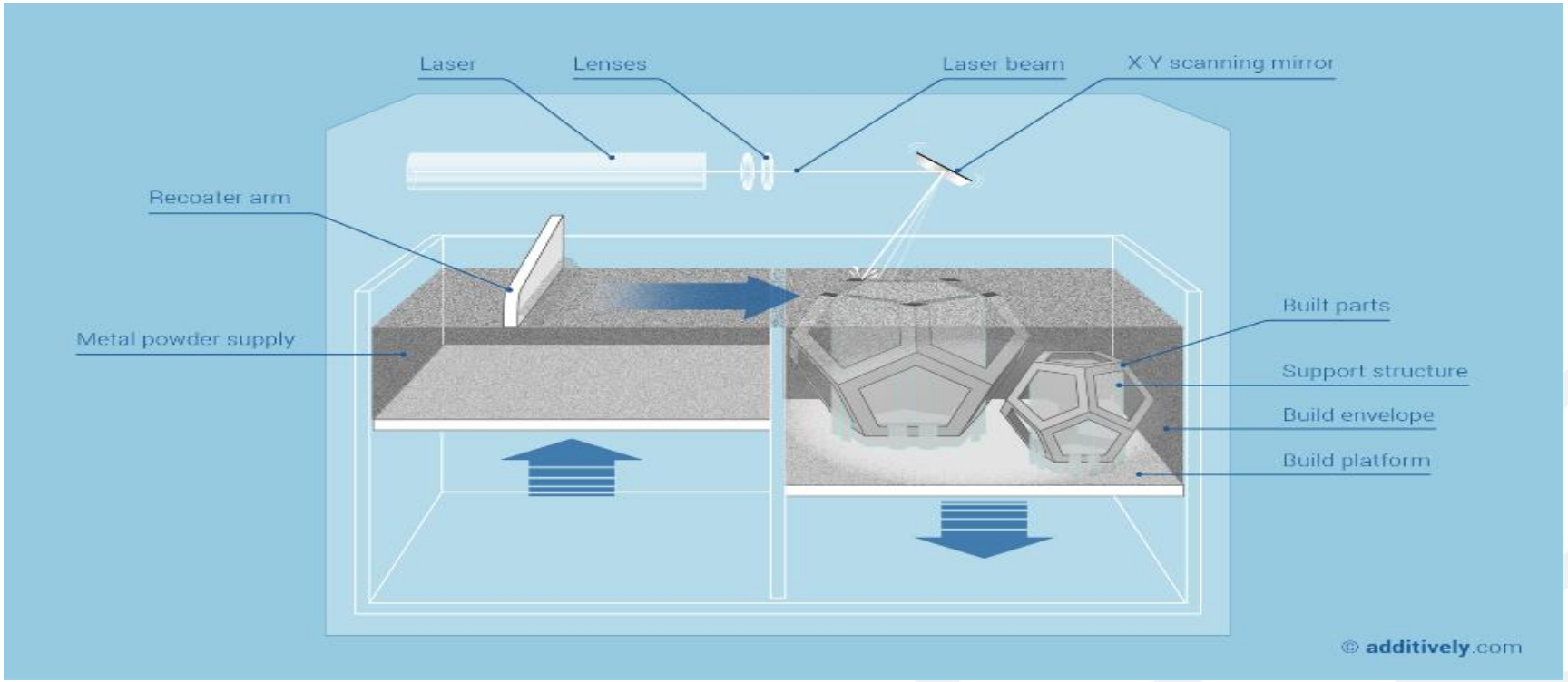
Thanks to CERN EN-MME Group and Arturs Vēvers

LHC Dipole magnets end-spacers



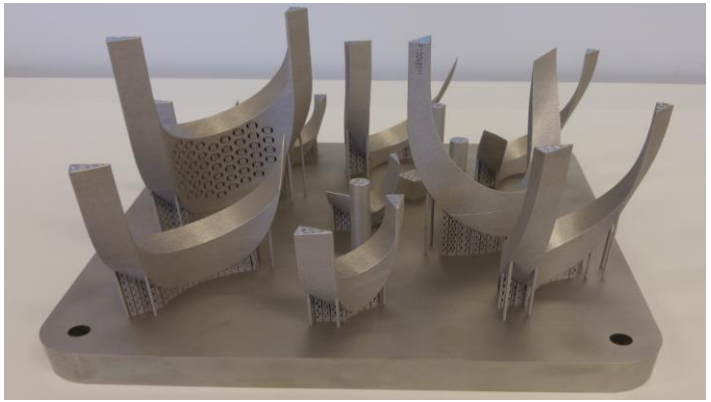
Another kind of Additive Manufacturing

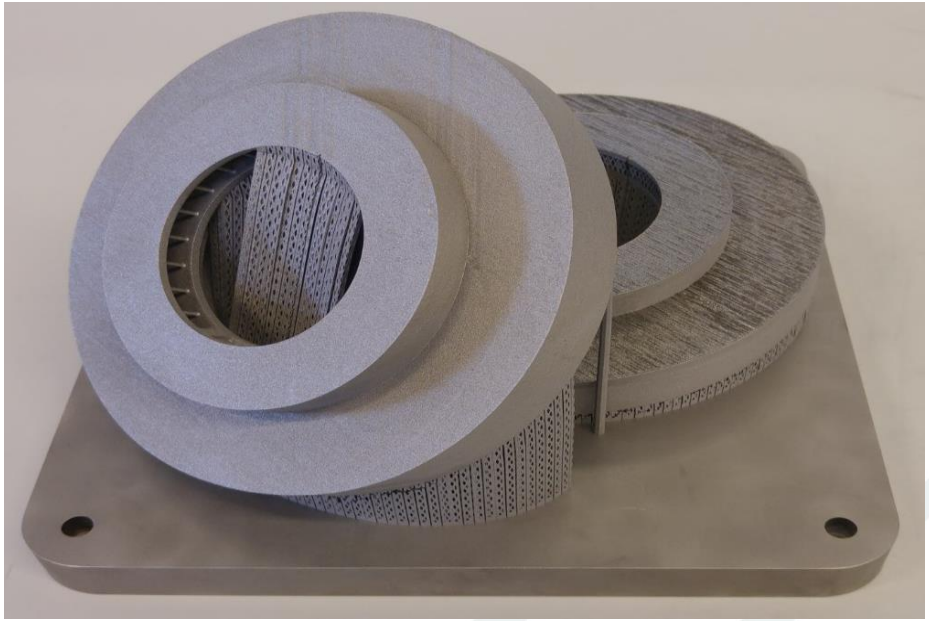
Selective Laser Melting (SLM)



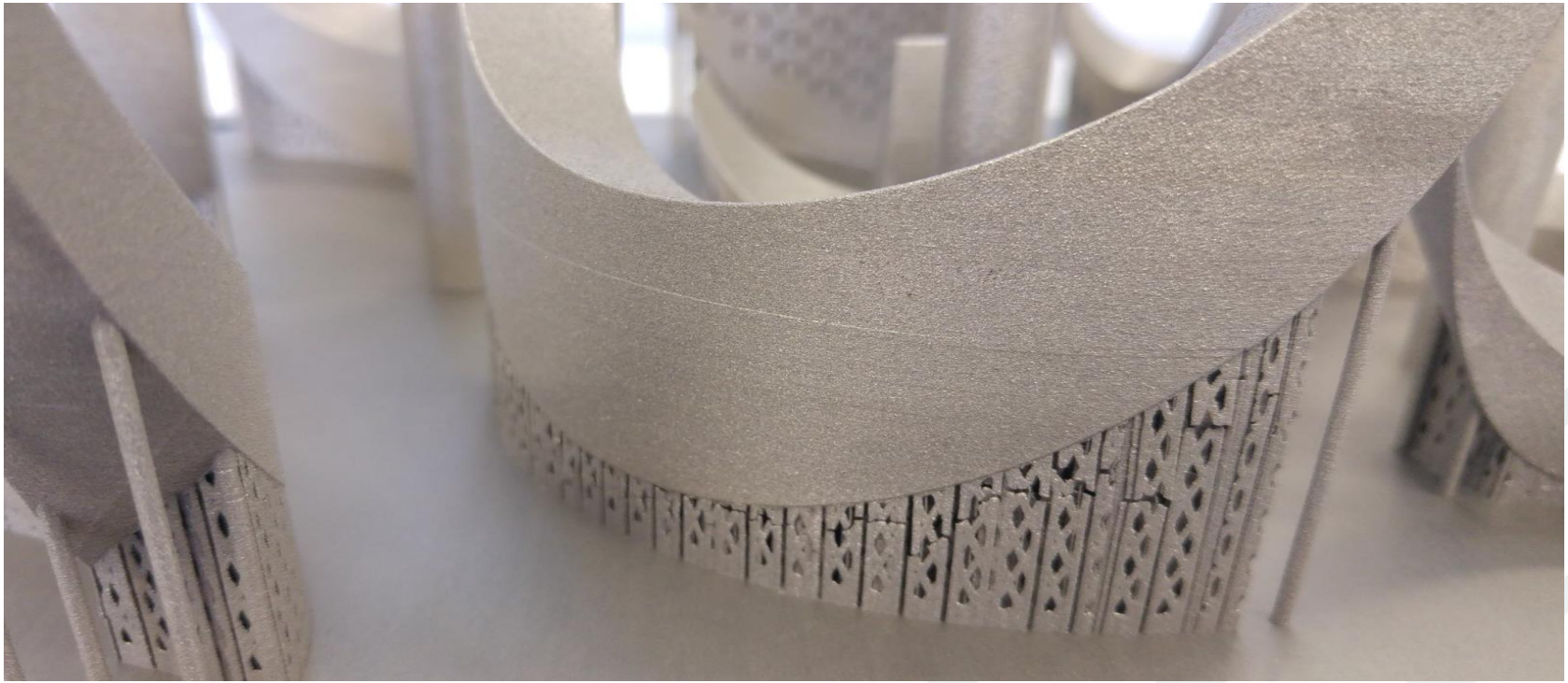
AM problems

- Support failure
- Deformation

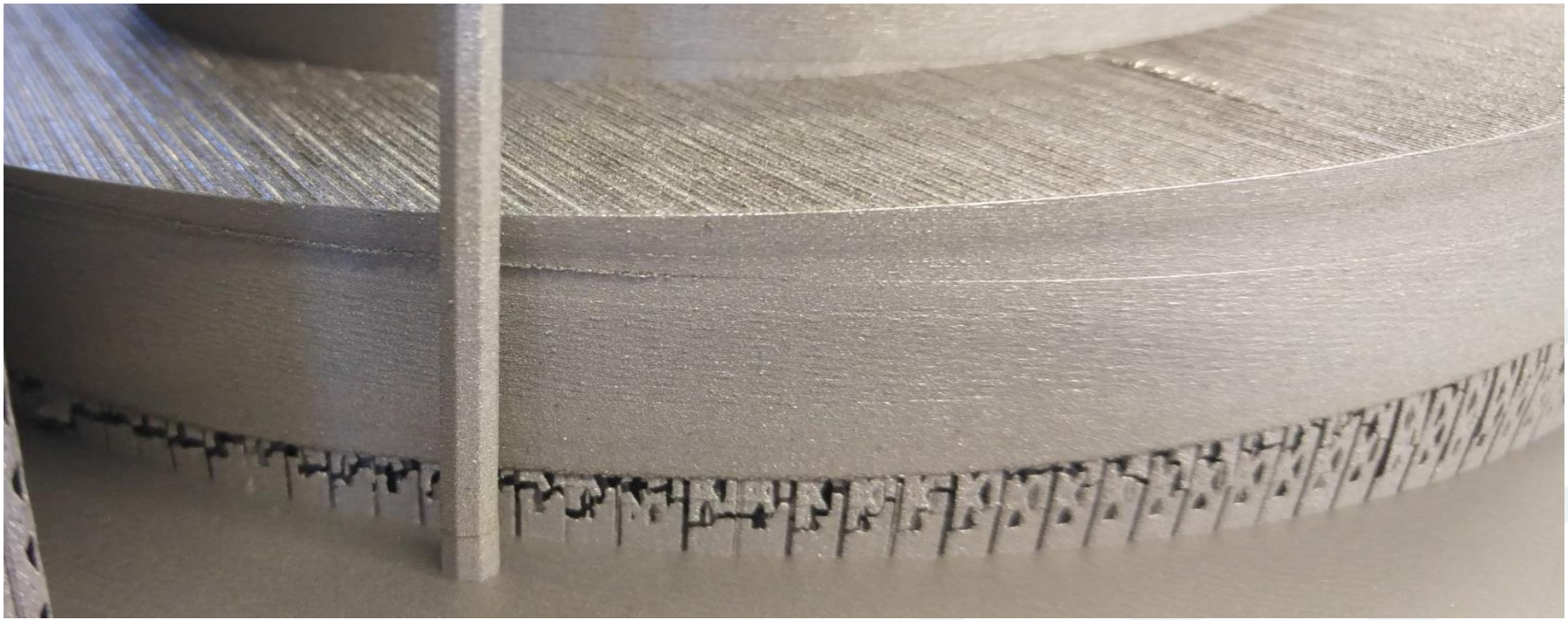




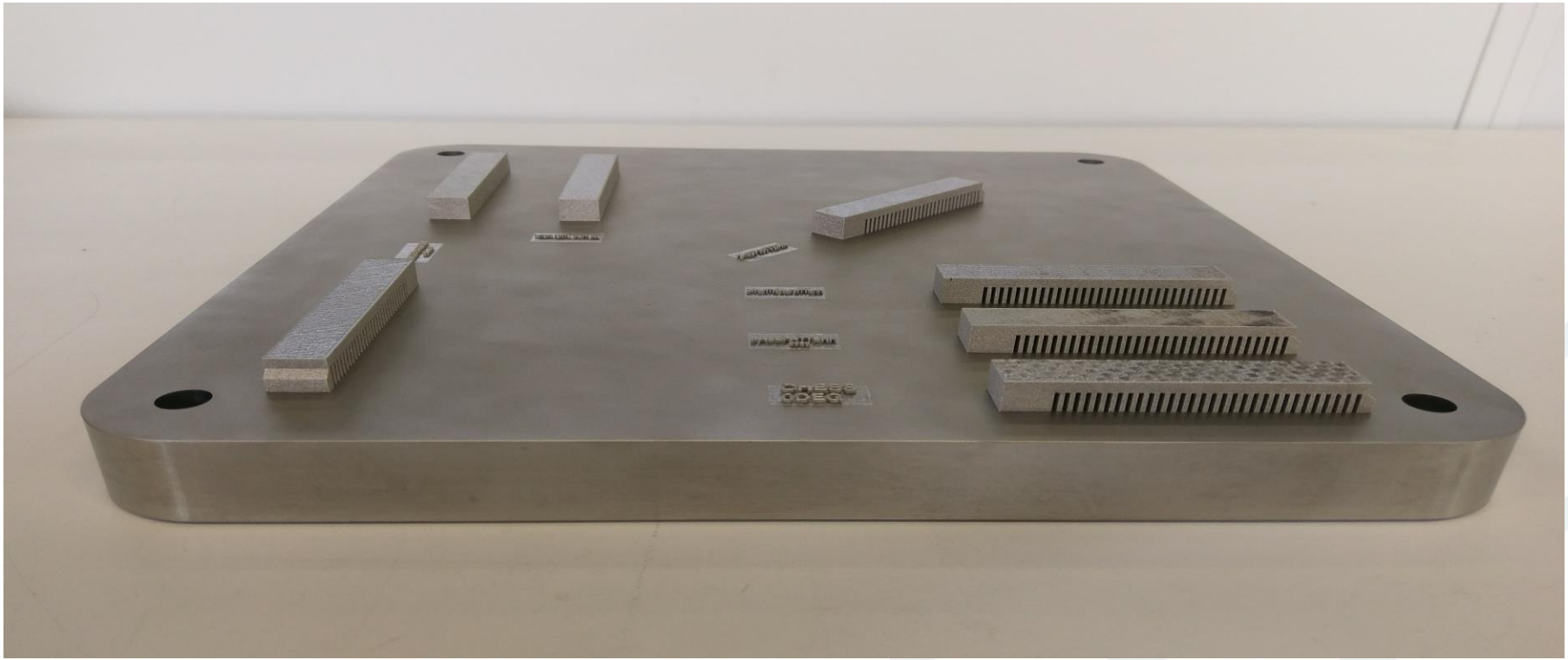
AM problems



AM problems

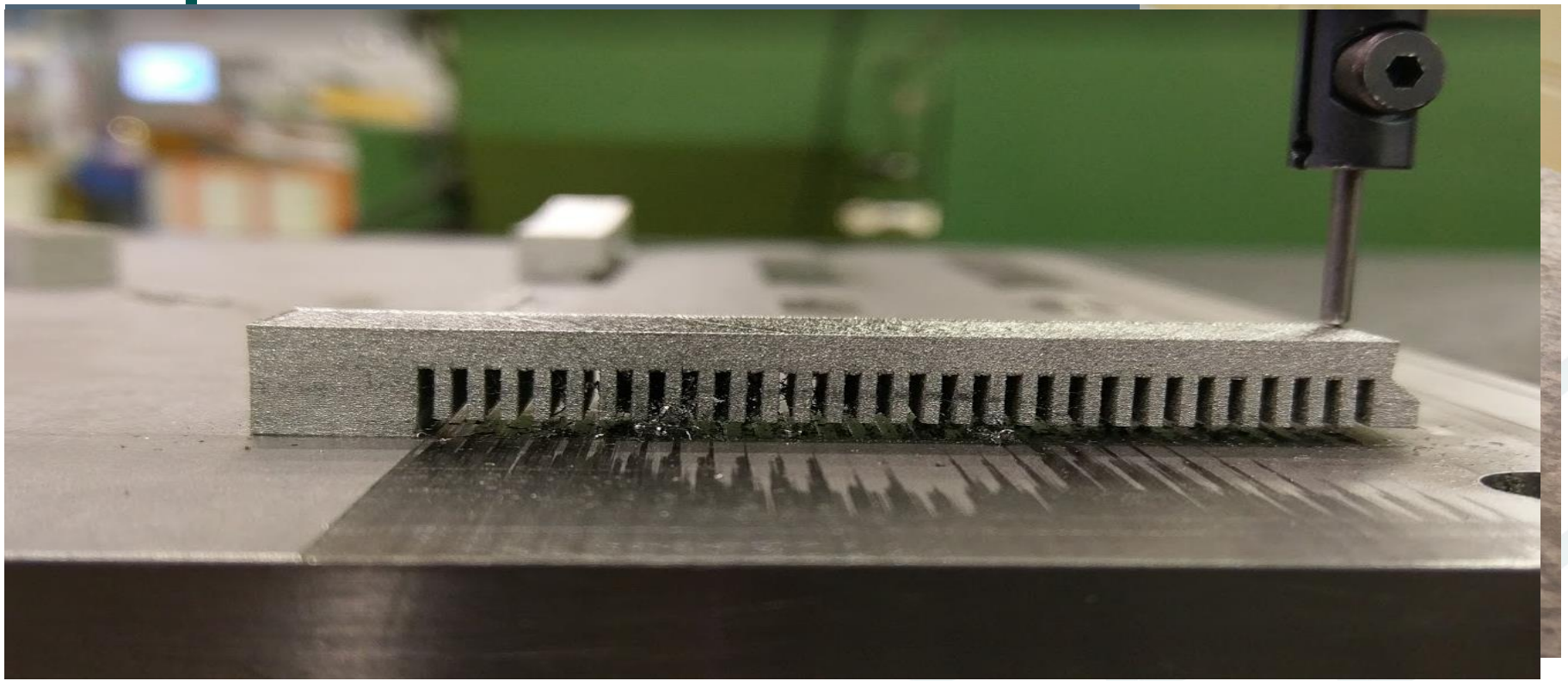


AM problems



AM problems

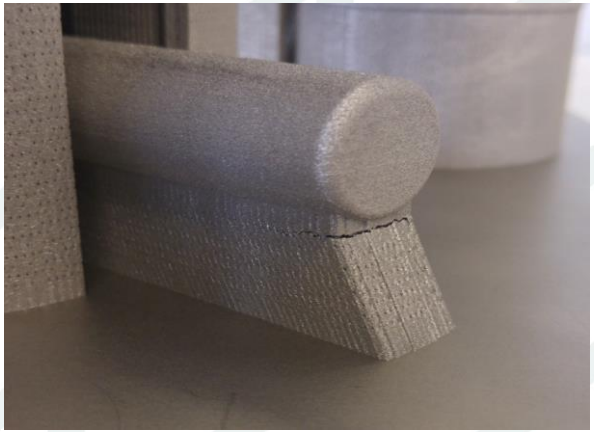
AM problems



Objective: no deformation after HT

Why do you need AM simulation software?

- Predict deformation to design better supports and use optimal positioning
- Save time in manufacturing iterations
  - Higher chance to success on the first try
- Minimize scrap percentage

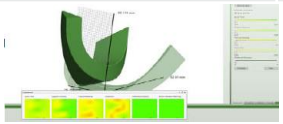
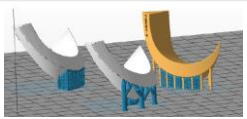
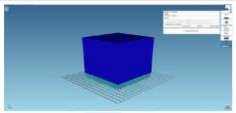
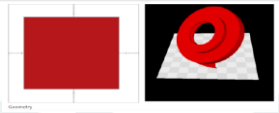
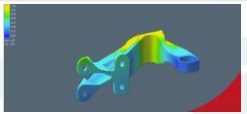


Main tasks:

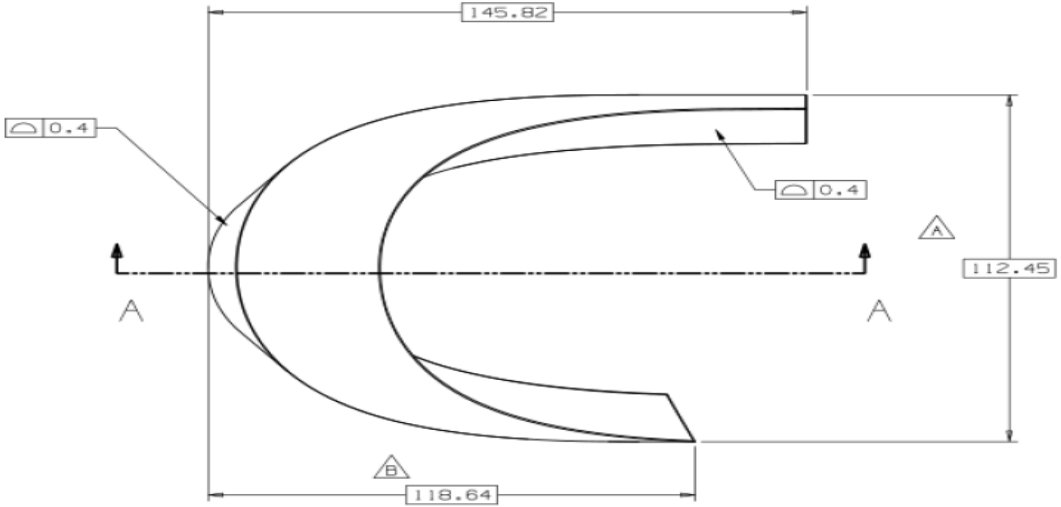
- Review and compare available AM simulation software
- Simulate parts and compare results with scanned data
- Benchmarking of software with titanium End-Spacer
- What about Niobium?

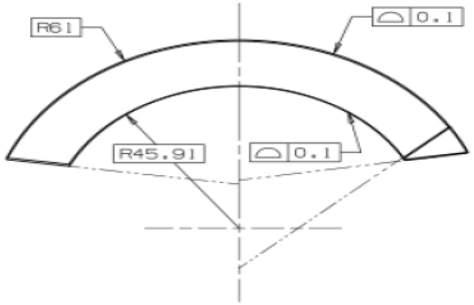
Software comparison

	Amphyon	Netfabb	Virfac	Exasim	Simufact
File formats	STL	Many	Many	STL	Many
Cloud based simulation	No	Yes	No	Yes	No
Calculation type	CPU/GPU	CPU	GPU	Cloud	CPU
Optimized positioning module	Yes	Yes	No	No	No
Support generation	No	Yes	No	Yes	Yes
Support import	Yes	Yes	Yes	No	Yes
Support export	Yes	No	Yes	Yes	Yes
Support structure type	Standard	Advanced	Standard	Standard	Standard
Simulated parameters	Many	Many	Only temp.	Many	Many
Possibility to change process parameters	No	Yes	Yes	No	Yes
Simulate more than 1 part	No	Yes	No	No	No
Topology optimization	No	Yes	No	No	No
SLM build support	No	Yes	No	No	No
Calibration	Yes	No	No	No	Yes
Result export	Yes	Yes	Yes/can't export deformed STL	Yes/can't export deformed STL	Yes

End spacer F10049011 vertical





Summary

- Simulation software shows very close results to scanned part data
- In longer period with more investigation it would be possible to fine-tune software parameters for even more precise results
- **Software helps to minimize unsuccessful projects**
- Each part are different and there isn’t a magic recipe for all parts

Summary of Case study 2

- Collaborative – stakeholders – feedback to the industry
- Technological – *terra incognita*
- Innovation – well 15T… Ti…Ni

- Combining New technologies with New Business Models?

RTU and CERN

Co-operation between RTU and CERN – road to success and opportunities for the science and industry

- Big science and our place in it
- Joint projects of novel technology developments – case of ARIES project
- Opportunities for young scientists and engineers

CERN: founded in 1954: 12 European States

"Science for Peace"

Today: 22 Member States

- ~ 2500 staff
- ~ 1800 other paid personnel
- ~ 13000 scientific users

Budget (2017) ~ 1100 MCHF

Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

Associate Members in the Pre-Stage to Membership: Cyprus, Serbia, Slovenia

Associate Member States: India, Pakistan, Turkey, Ukraine

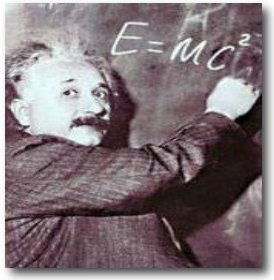
Applications for Membership or Associate Membership: Brazil, Croatia, Lithuania, Russia

Observers to Council: Japan, Russia, United States of America; European Union, JINR and UNESCO

The Mission of CERN

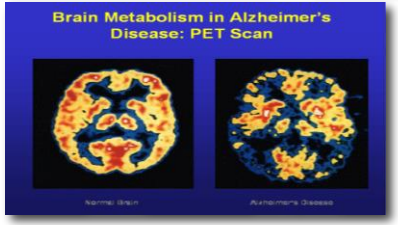
- Push back the frontiers of knowledge

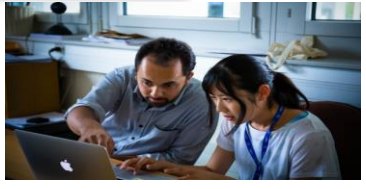
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- Develop new technologies for accelerators and detectors

  - Information technology - the Web and the GRID
  - Medicine - diagnosis and therapy



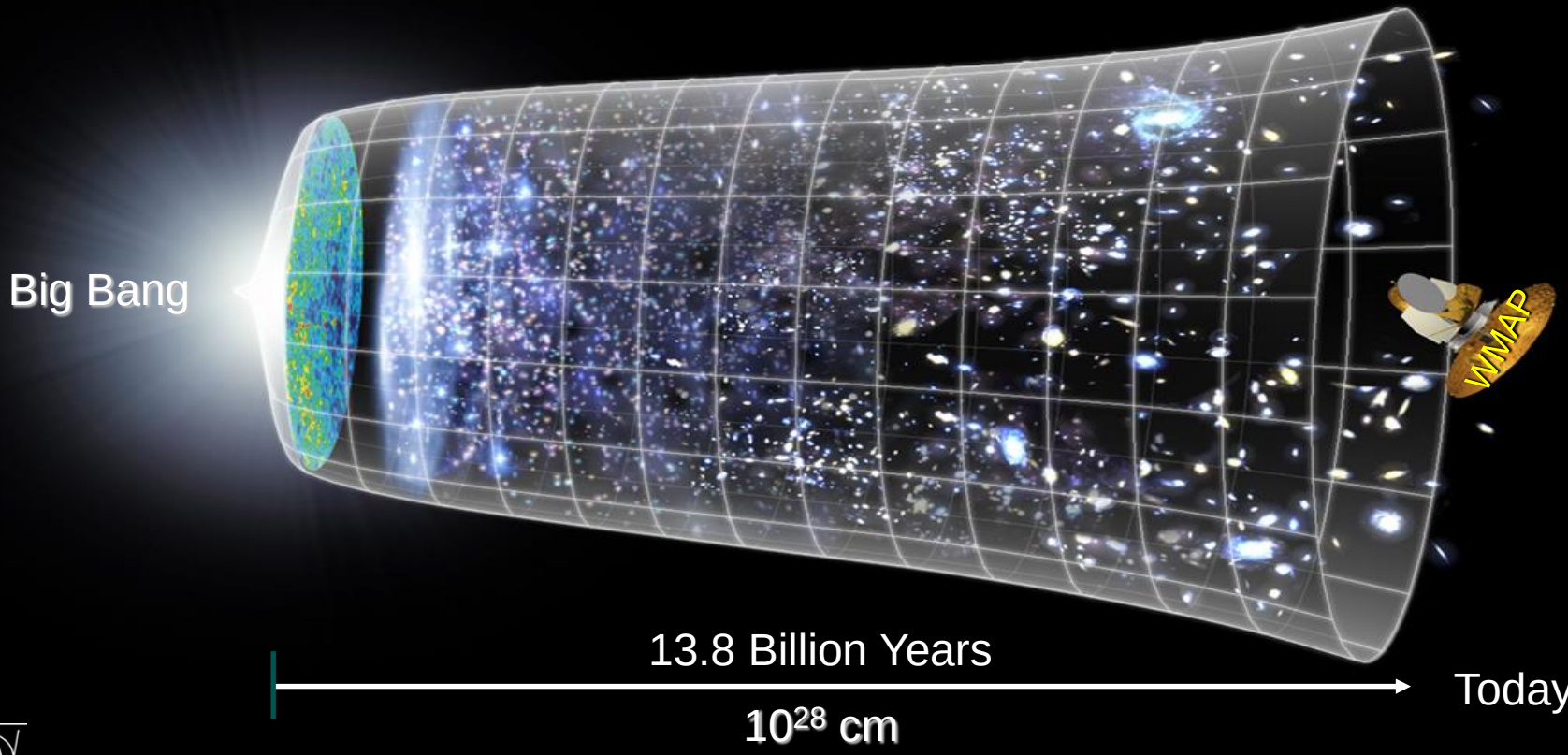


- Train scientists and engineers of tomorrow

- Unite people from different countries and cultures

Next Scientific Challenge:

to understand the very first moments of our Universe after the Big Bang



2010: a New Era in Fundamental Science

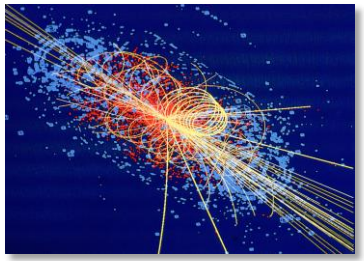
Exploration of a new energy frontier
in p-p and Pb-Pb collisions

CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation

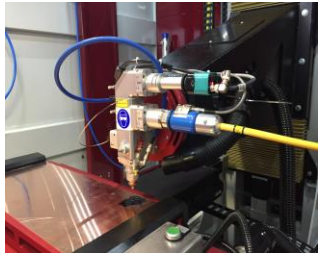
Accelerating particle beams



Detecting particles

Large-scale computing (Grid)

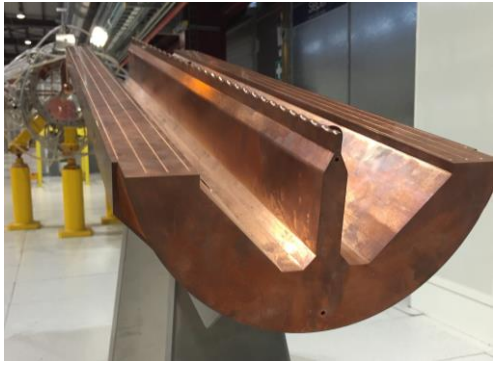
RTU – CERN co-operation



- Sine 2012 RTU has Framework Collaboration Agreement with CERN

scientific cooperation areas

  - Power electronics and energetics
  - Material processing technologies
  - Robotics
  - Material science
  - IT, Data and computer science



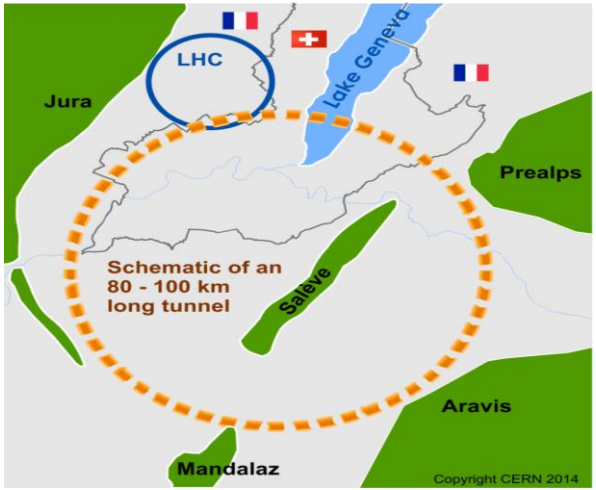
- Today two PhD students working on their doctoral thesis based on this agreement

Future scientists @ CERN

- 2013 – first Latvian PhD students visit to CERN. Participants - PhD students from RTU and other Latvian universities. Hereafter once a year such visits take place.

RTU is partner in FCC

- 2015 – RTU signs Memorandum of Understanding with CERN about FCC (Further Circular Collider) research project



Memorandum of Understanding
for the Future Circular Collider (FCC)
Study hosted by CERN

THE INSTITUTES, LABORATORIES, UNIVERSITIES AND THEIR FUNDING AGENCIES AND OTHER SIGNATORIES OF THIS MEMORANDUM OF UNDERSTANDING AND CERN AS THE HOST LABORATORY **("the Participants")**

Whereas

At a dedicated session of the CERN Council held on 30 May 2013, the Council adopted the Update of the European Strategy for Particle Physics which included *inter alia* the following statement:

"…Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14TeV will be available. CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide."

The conceptual design study (the "FCC Study") must be available in time for the next update of the European Strategy for Particle Physics foreseen to take place in 2018,

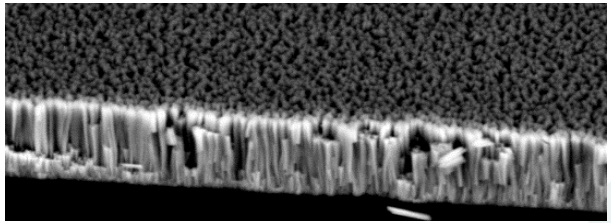
RTU plays in highest league

- together with other top 40 European scientific Institutes participates in ARIES project coordinated by CERN
- RTU:
  - technologies – improved coating for particle accelerators working surfaces
  - development of innovative radio frequency modulator – energy particle accelerator beam
  - Learning and development
- 2017 May 1st project started – RTU is partner in 3 WP. Total 500 000 eur.

ARIES project - I

- technologies – improved coating for particle accelerators working surfaces

Riga Technical University



SEM image of a NbN thin film

INFN

STFC ASTeC

UNIVERSITÄT SIEGEN

ELÚ

HZB Helmholtz Zentrum Berlin

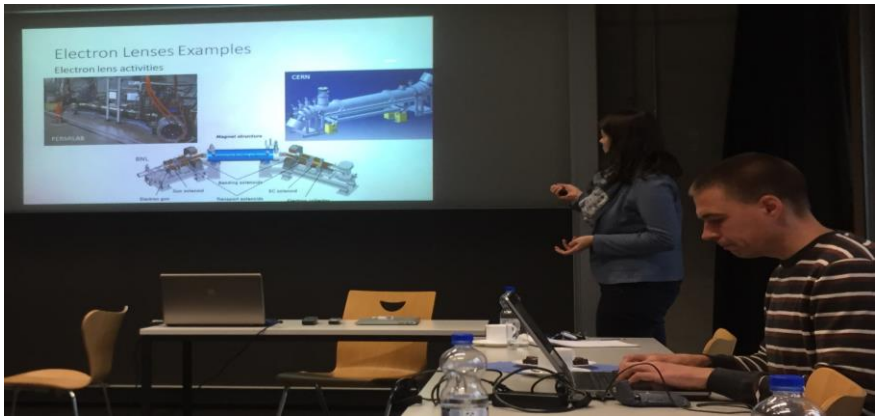
cea

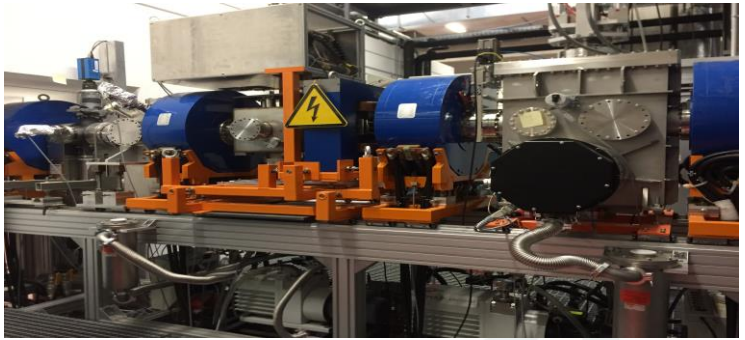
1862 RIGA TECHNICAL UNIVERSITY

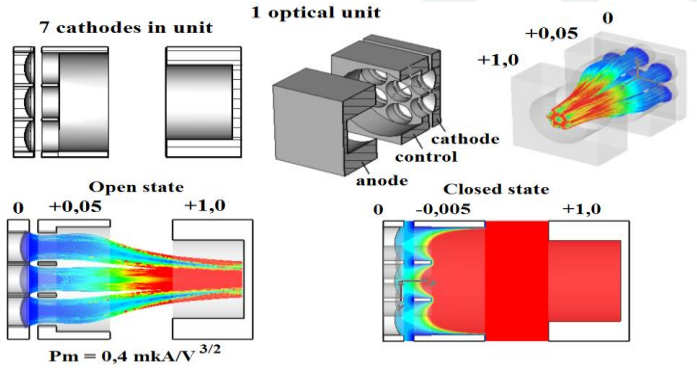
CERN

ARIES project - II

– development of innovative radio frequency modulator – energy particle accelerator beam





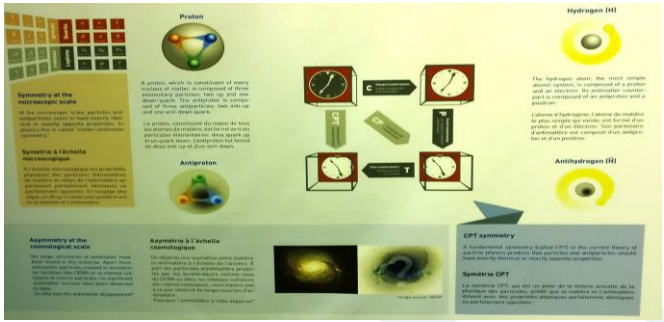


Partners: GSI – Darmstadt, Frankurt University, CERN

Riga Technical University

ARIES project - III

- Education and training – online course about particle accelerators
- RTU is developing online platform



Business at CERN

innovative concrete technology – R&D project

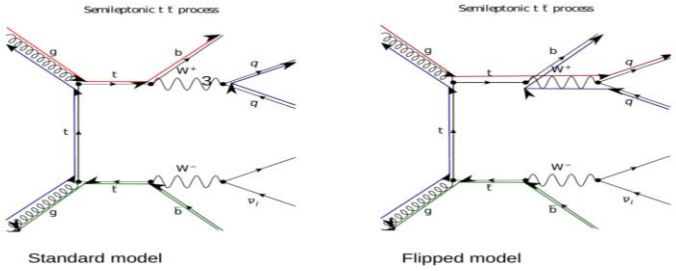
- ”Primekss”
- RTU
- University of Latvia

RTU scientists at CERN

Viesturs Veckalns

- Quoting young physician: *«We are investigating how color link between two can be observed in the CS detector».*

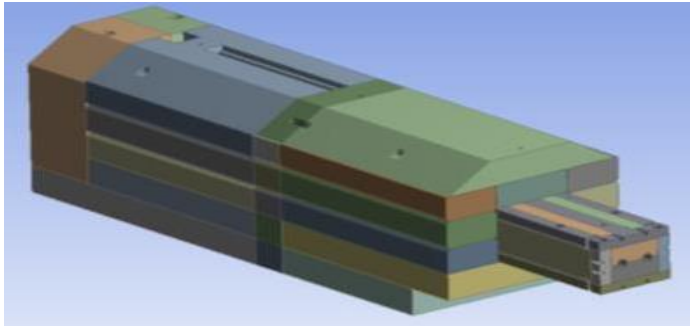
- Perspective after PhD defense in RTU – work at CERN (CMS experiment) as project associate – 2018.

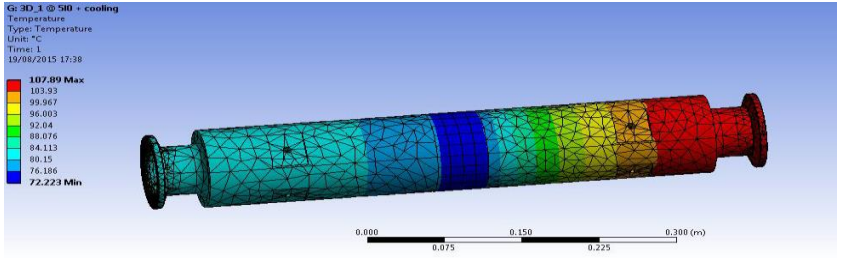


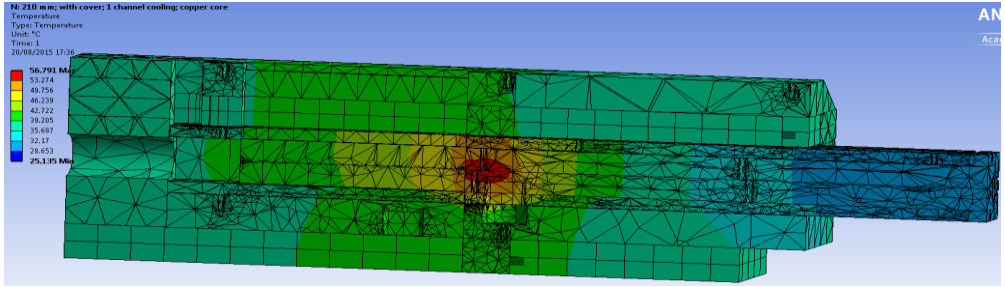
Involved in CERN CMS experiment since 2014. Represents RTU according to the agreement signed in 2012.

Stepans Šķ̧ariks

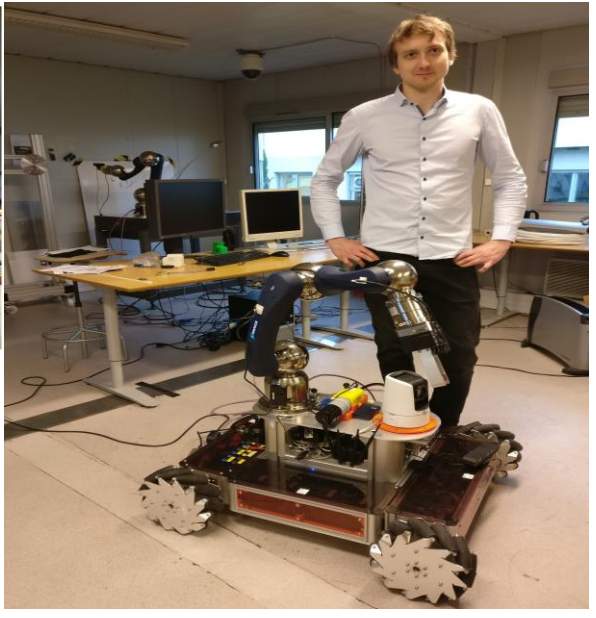
«Collimator thermal function analysis»







Artūrs Ivanovs



Field of Research

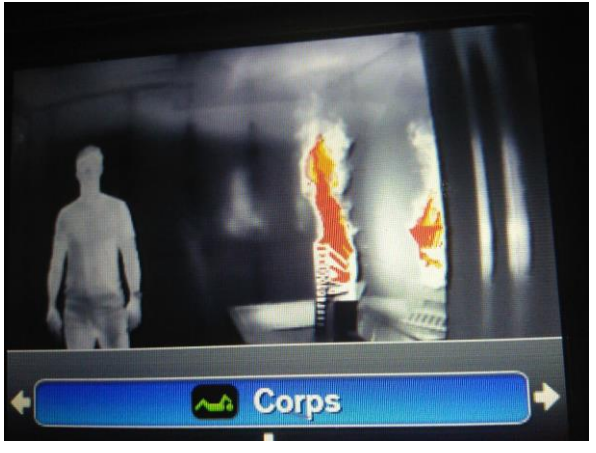
Machine Learning for Robotics Applications

PhD Thesis

Development of a system for human recognition and wireless vital parameter monitoring in harsh environments

Expected outcome

Robotic platform with mounted sensors used by first-response brigades to locate people and monitor their vital parameters before sending in the rescue team.



Artūrs Vēvers

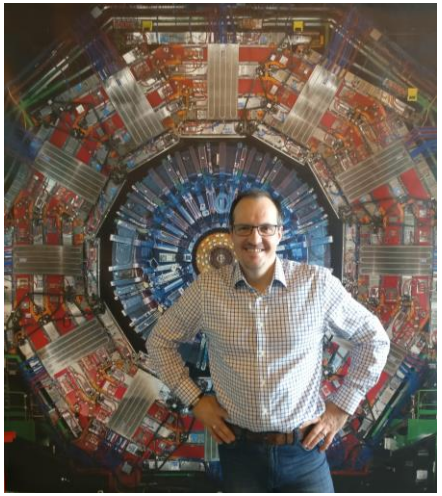
- *Engineering Department - Mechanical & Materials Engineering Group*
- Is investigating and comparing currently available simulation programs for 3D printing process simulations
- Is developing "End spacer" part simulation and creates supporting structure, that would provide minimal deformation during the printing process

Toms Torims

CERN scientific associate

-Responsible for accelerator and related technology analysis. The aim is to identify fields, where these technologies can be beneficial for needs of society as well as production (i.e. medicine, mechanical engineering and machine construction)

-Latvian representative at CERN

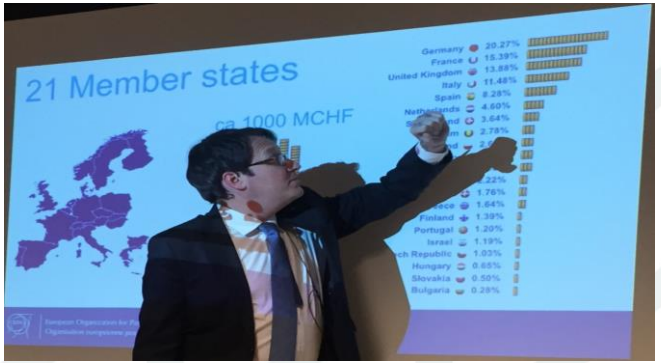


World class scientists in Latvia

- Highly appreciated and well attended guest lecturers of leading CERN scientists in RTU CERN. Students from RTU as well as other universities in 2012., 2013., 2015. un 2016.

Dr. Paul Collier

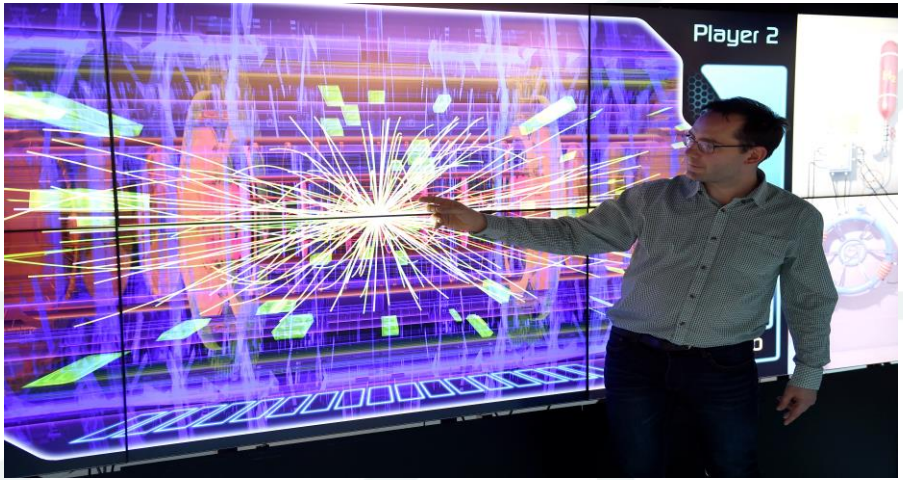
Dr. Tadeusz Kurtyka



Dr. Christoph Schaefer

CERN science week in Latvia

22 - 26 May, 2017



Thank you!