RĪGAS TEHNISKĀ UNIVERSITĀTE

# Research on design improvement of accelerator components by additive manufacturing

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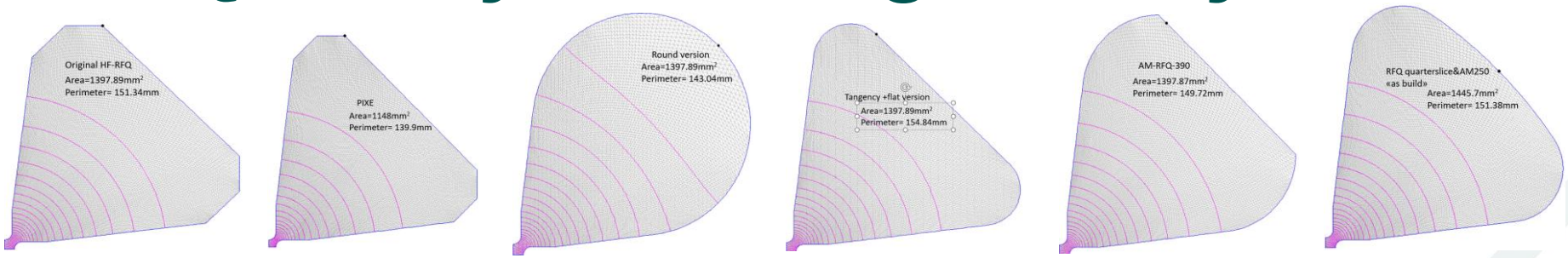
# Objective of research

- to proof scientifically that the additive manufacturing technology is viable solution for the production of complex particle accelerator components and that AM technology is able to reach the stringent requirements which are set to accelerator components

# Targets for AM RFQ

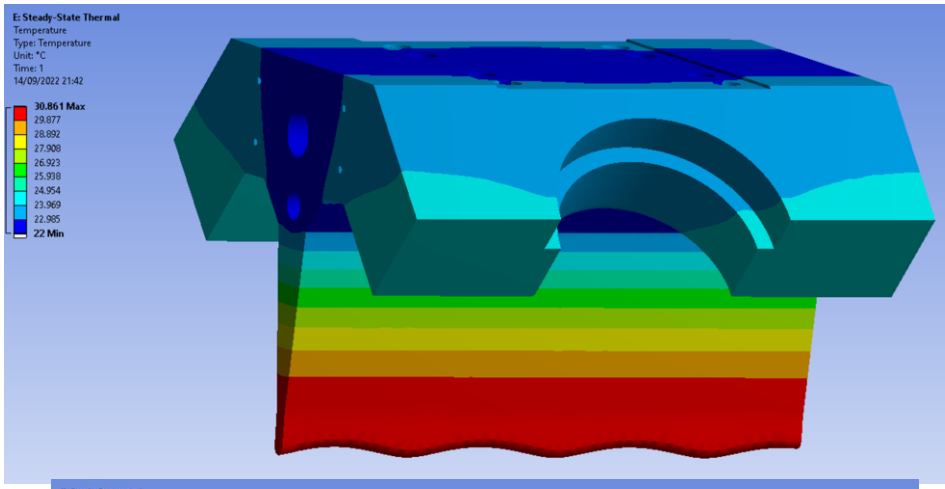
| | Challenge | Target |
|---|---|---|
| 1 | Porosity, degassing | vacuum $10^{-7}$ mbar |
| 2 | Manufacturing accuracy | 20μm on vane tip, 100μm elsewhere |
| 3 | Surface roughness | Ra0.4 for all inner surfaces of quadrupole |
| 4 | Electrical conductivity | 90% of pure copper |
| 5 | Inclusions, voltage holding | 80 kV |
| 6 | Dimensions | Cylinder ∅100-200 mm, length 200 mm |

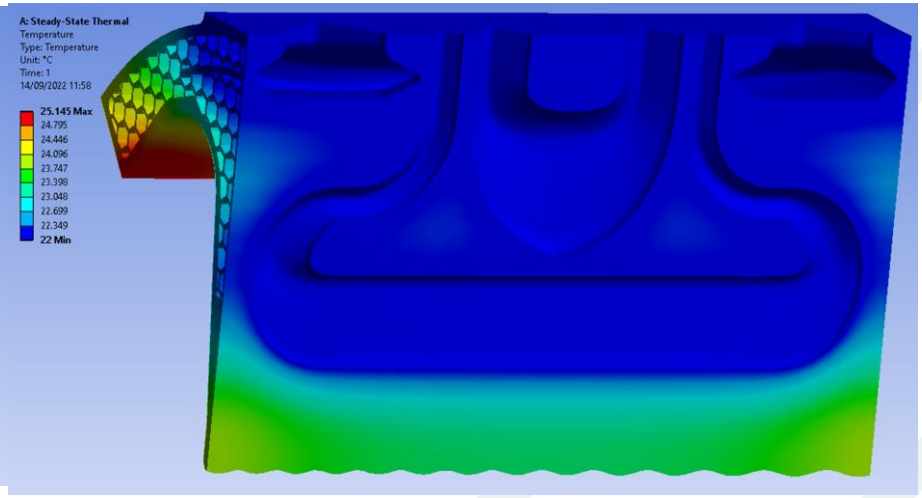
# RFQ cavity 2D design study

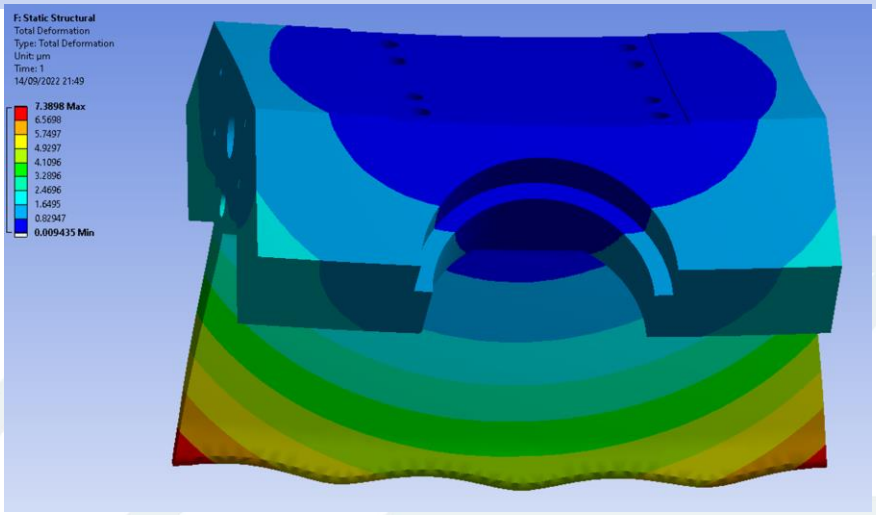


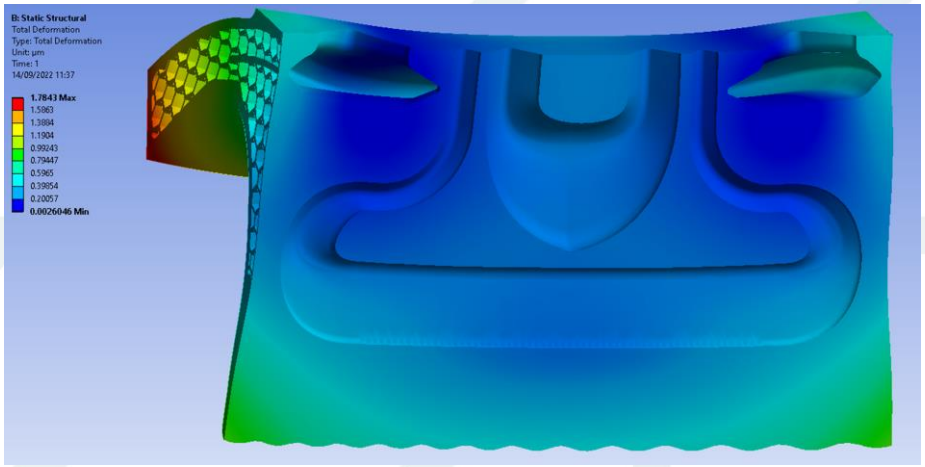

| Cavity design | Perimeter, mm | Area, $mm^2$ | Frequency, Hz | Q-value | Tip radiuss, mm | Aperture radiuss, mm | Shunt impedance, MΩ/m | Stored energy, $*10^{-5}$J/cm |
|---|---|---|---|---|---|---|---|---|
| HF-RFQ | 151.34 | 1397.89 | 716.56 | 8028.51 | 1.504 | 1.935 | 6303.894 | 6.8775 |
| PIXE | 139.9 | 1148 | 728.97 | 7156.49 | 1.439 | 1.439 | 6286.239 | 6.87484 |
| Carbon HF-RFQ | 142.15 | 1202 | 709.78 | 7273.45 | 1.411 | 1.411 | 6620.685 | 6.87443 |
| Round design | 143.04 | 1397.89 | 714.75 | 8608.20 | 1.504 | 1.935 | 6737.561 | 6.91407 |
| Tangency + flat | 154.84 | 1397.89 | 716.59 | 7811.74 | 1.504 | 1.935 | 6133.634 | 6.90091 |
| AM390 | 149.72 | 1397.87 | 716.44 | 8138.77 | 1.504 | 1.935 | 6388.894 | 7.55072 |
| AM250&QS | 151.38 | 1445.7 | 703.25 | 8254.51 | 1.504 | 1.935 | 6578.903 | 4.49217 |
| AM250&QS-200µm | 152.1 | 1475.2 | 736.70 | 8569.27 | 1.304 | 2.135 | 6574.460 | 4.36554 |

# Temperature distribution and Max total deformation for design versions(SteadyState Thermal +Static Structural)

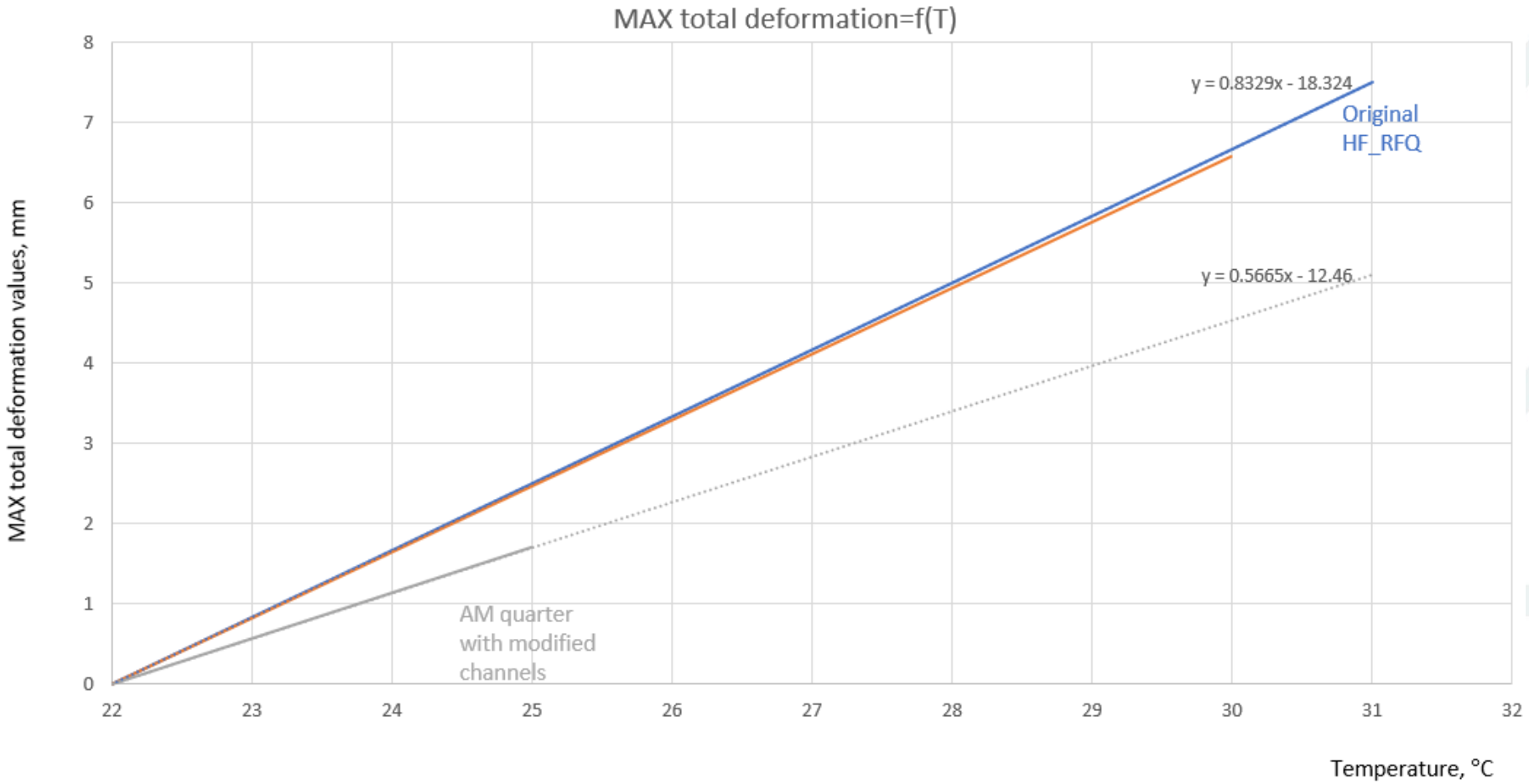


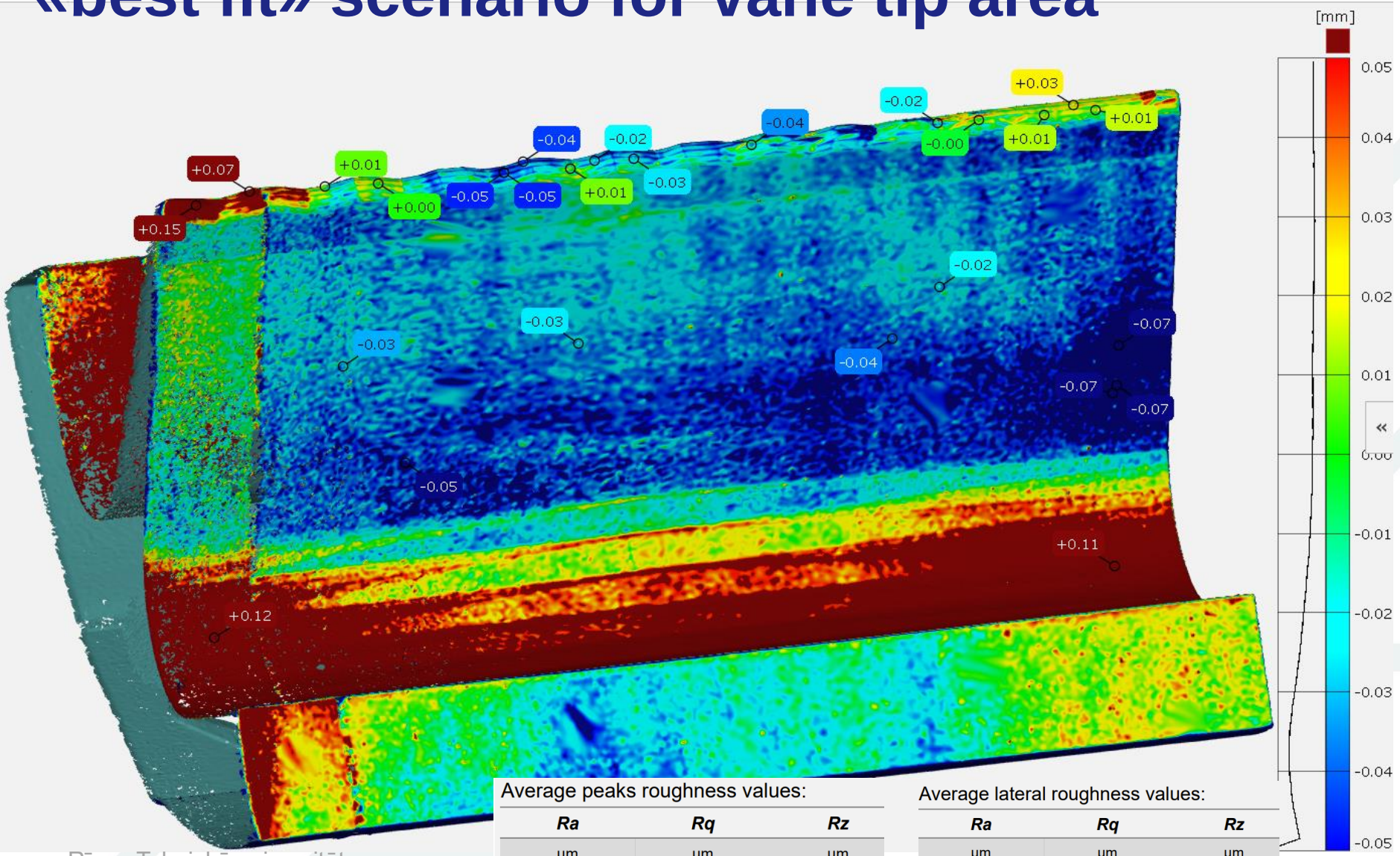



# Max total deformation as function from temperature



# First «as build» pointcloud vs CAD model «best fit» scenario for vane tip area



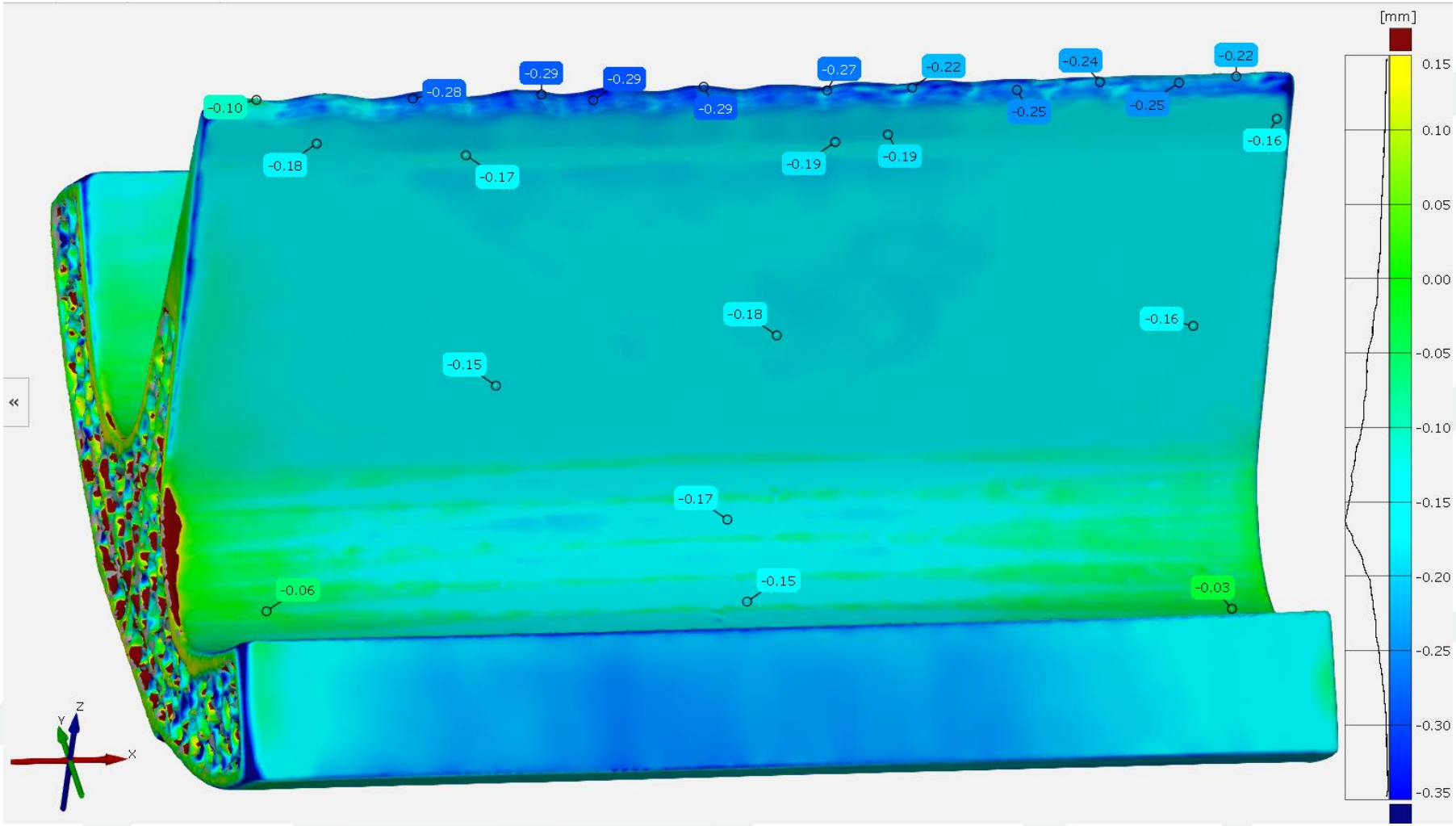

Average peaks roughness values:

| *Ra* | *Rq* | *Rz* |
|---|---|---|
| µm | µm | µm |
| 10,4 ± 2,7 | 13,1 ± 0,9 | 65,2 ± 3,9 |

Average lateral roughness values:

| *Ra* | *Rq* | *Rz* |
|---|---|---|
| µm | µm | µm |
| 12,4 ± 0,3 | 15,7 ± 0,2 | 98,2 ± 4,6 |

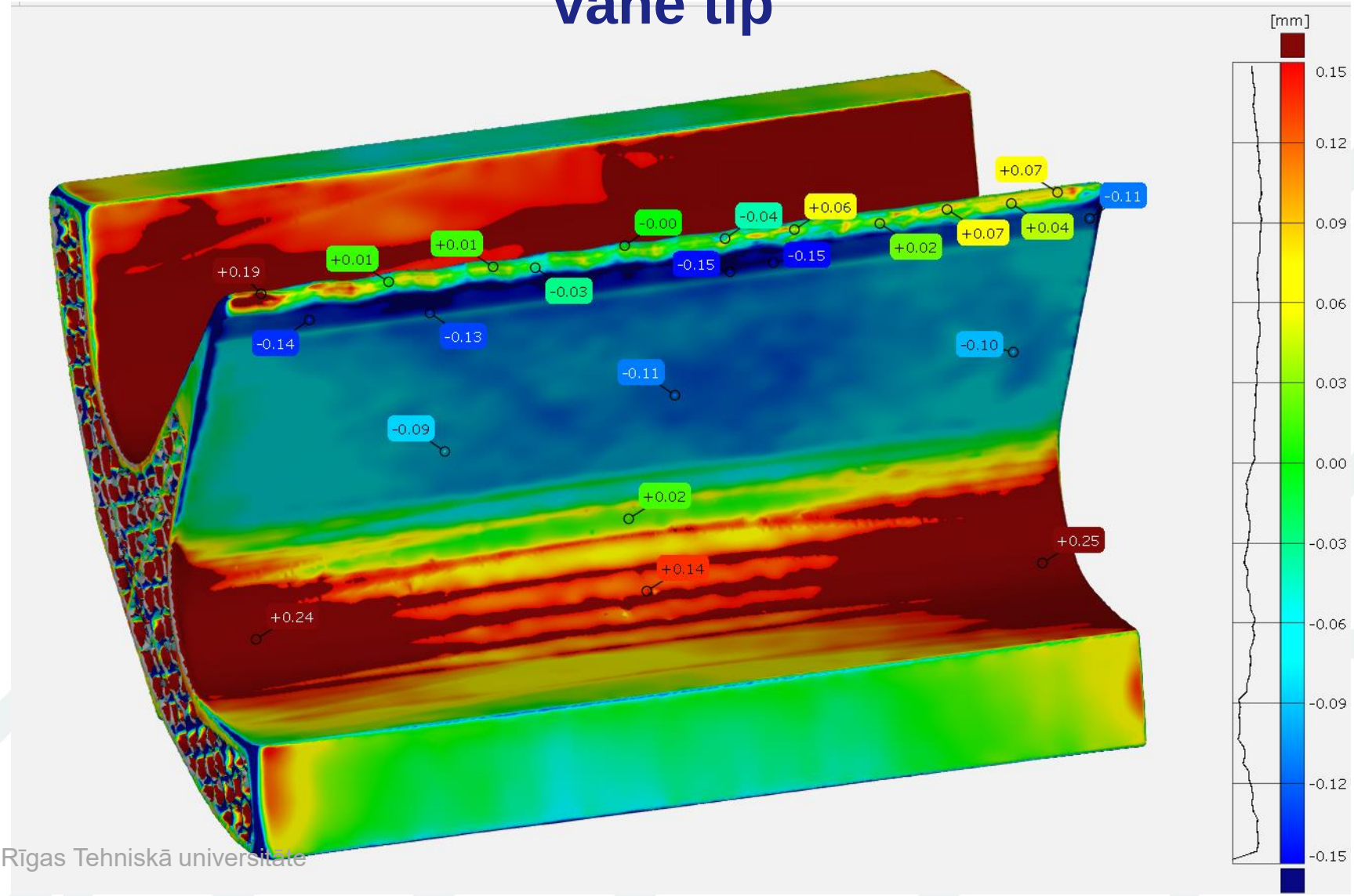
# Overall «best fit» scenario for postprocessed sample






On vane tip area Ra=0.1...0.4 measured at CERN EN-MME

# Postprocessed by MMP technology AM-RFQ pointcloud vs CAD model local «best fit» on vane tip



# Thank You for Your Time!