



HiLumi WP4 – Crab Cavities

Pre-tuner design – update

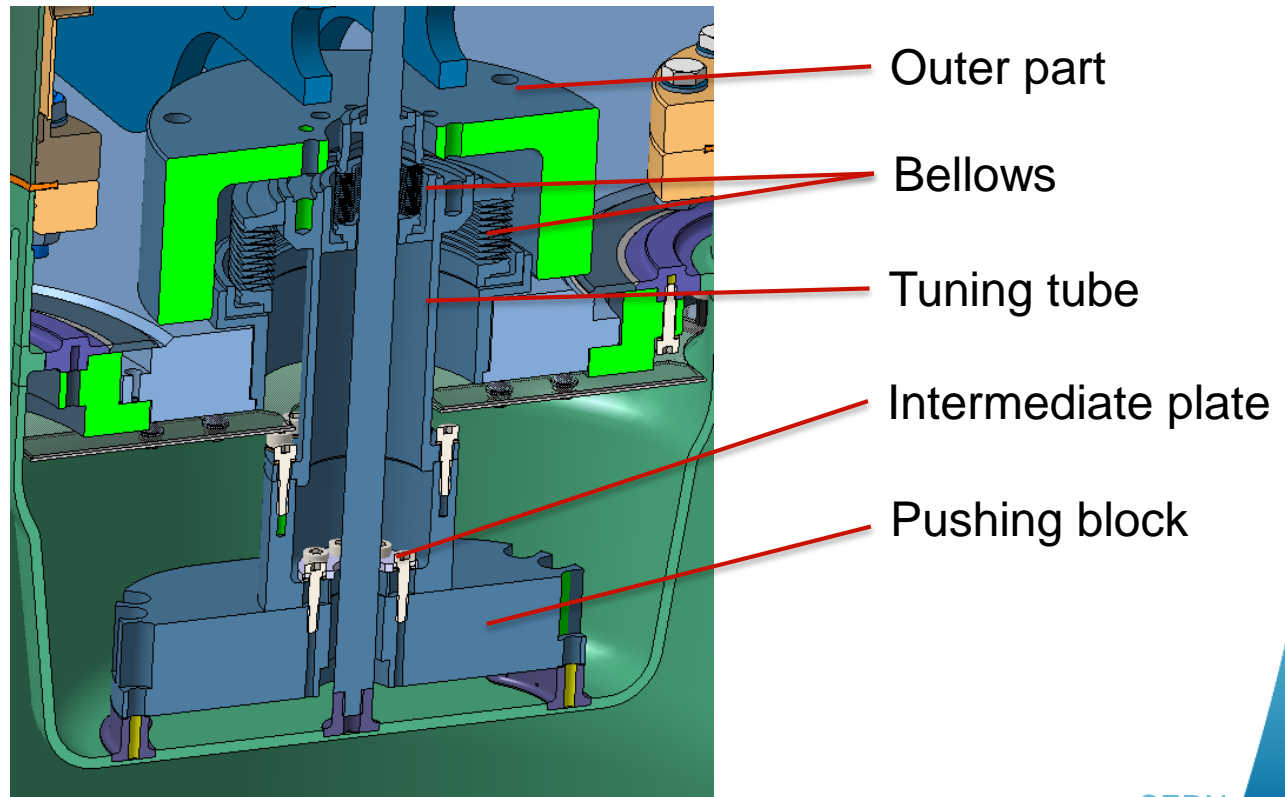
Joanna Swieszek, Kurt Artoos, Carlo Zanoni



27.10.2016

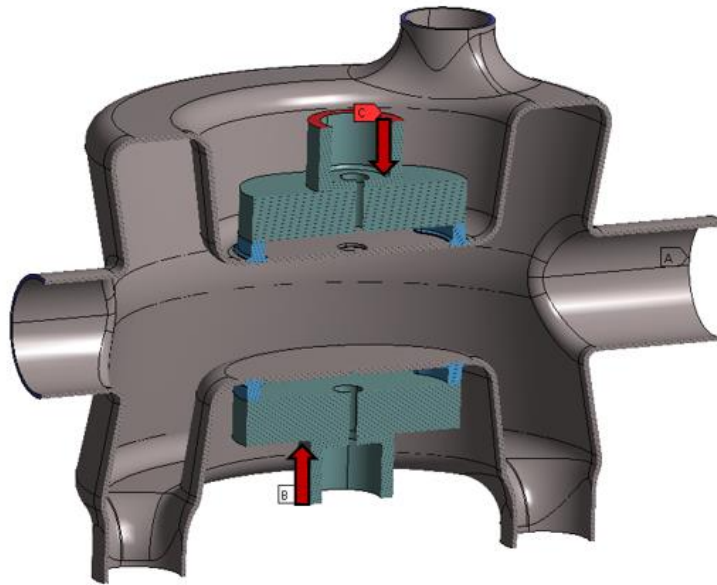
Purpose

- Improvements of the pre-tuner design
- Approval of the new design
- Analysing separately the critical parts
- Elasto-plastic analysis of whole assembly



Pushing block

- ↓ Tuning force 10000 N
- ▲ Fixed support in all cavity extremities

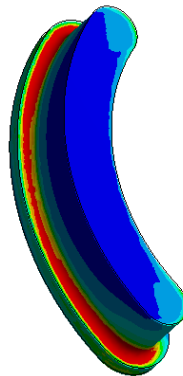


- Investigation of the stresses in bean shapes
- Decreasing pushing block thickness
- Elastic model (stresses values correct just for comparison purpose)

Thickness [mm]	Stress intensity in bean shape part [MPa]
33 (current)	228
20	252
10	267

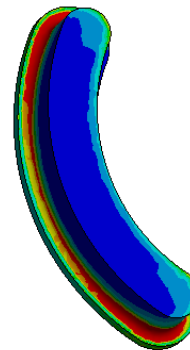
A: Static Structural
 Stress Intensity 3
 Type: Stress Intensity
 Unit: MPa
 Time: 1
 28/10/2016 14:20

227.95 Max
 100
 87.558
 75.116
 62.674
 50.232
 37.791
 25.349
 12.907
0.46496 Min



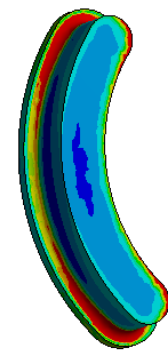
B: 20 mm block
 Stress Intensity 4
 Type: Stress Intensity
 Unit: MPa
 Time: 1
 28/10/2016 14:25

252.28 Max
 100
 87.58
 75.159
 62.739
 50.318
 37.898
 25.477
 13.057
0.63619 Min



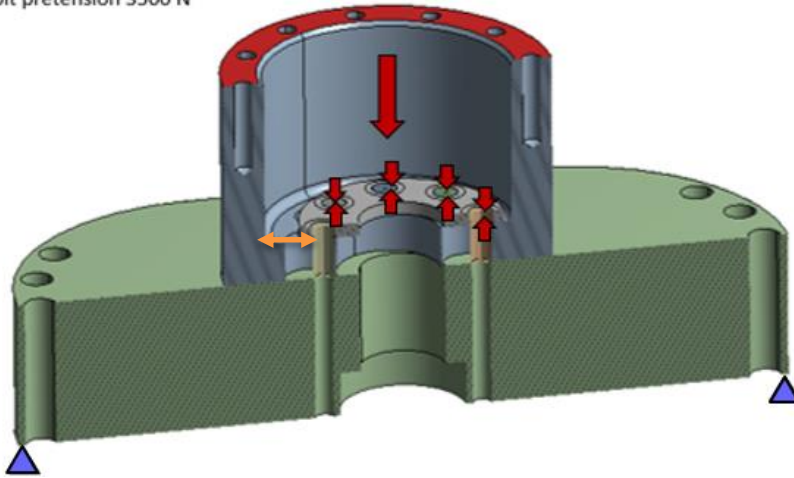
D: 10 mm block
 Stress Intensity 4
 Type: Stress Intensity
 Unit: MPa
 Time: 1
 28/10/2016 14:27

267.35 Max
 100
 87.605
 75.21
 62.815
 50.42
 38.025
 25.63
 13.236
0.84058 Min



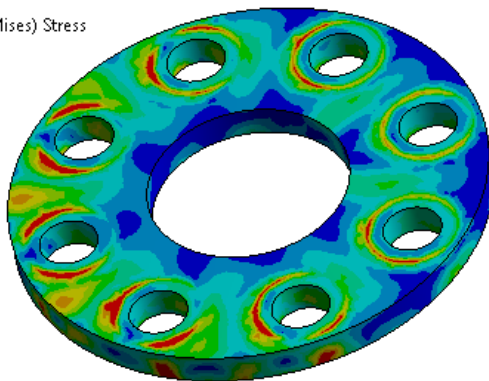
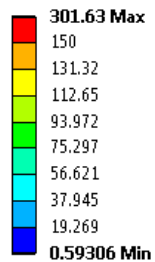
Intermediate plate

- ↓ Pre-tuning force 23000 N
- ▲ Fixed support
- ↓ Bolt pretension 3500 N

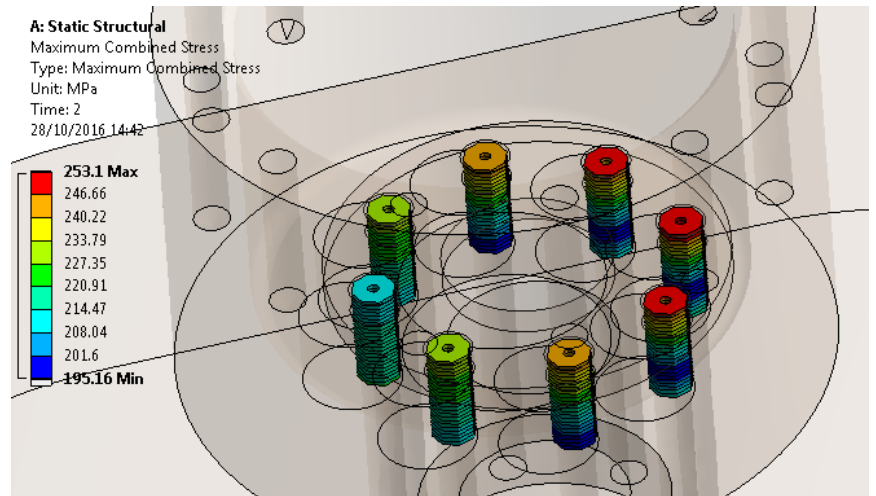
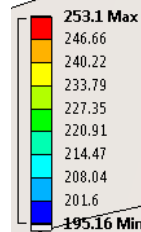


- Additional intermediate plate
- Allowing for **2 mm of offset** in case of misalignment
- Check of the stresses in the intermediate plate and in the screws

A: Static Structural
 Equivalent Stress 2
 Type: Equivalent (von-Mises) Stress
 Unit: MPa
 Time: 2
 28/10/2016 14:50

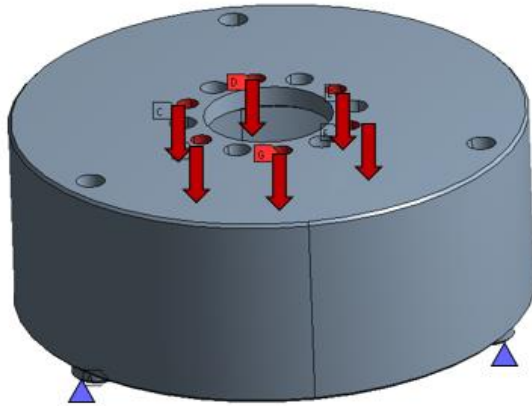


A: Static Structural
 Maximum Combined Stress
 Type: Maximum Combined Stress
 Unit: MPa
 Time: 2
 28/10/2016 14:42



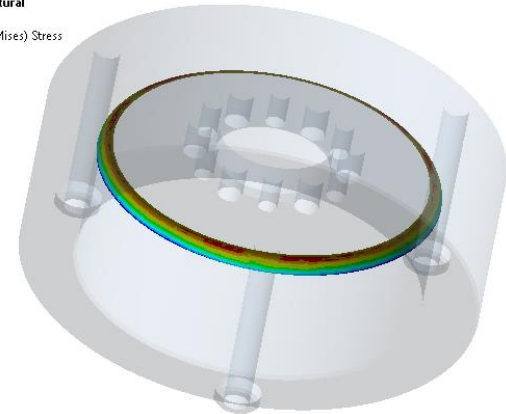
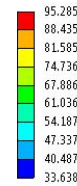
Outer part

- ↓ Force on each screw 6x 3833 N
- ▲ Fixed support



- Possibility to increase tuning resolution by decreasing part thickness (to give more flexibility)
- Parametric model to compare stresses for different thickness cases

B: Copy of Static Structural
 Equivalent Stress 2
 Type: Equivalent (von-Mises) Stress
 Unit: MPa
 Time: 1
 Custom
 28/10/2016 14:59



Thickness [mm]	Total Deformation Maximum [mm]	Equivalent Stress 2 Maximum [MPa]
12 (current)	0.11057	95.285
10	0.16319	128.41
8	0.27433	193.42
6	0.56577	329.35

- Screws connecting outer part with helium tank: 3x M8

Tension:

$$\sigma_z = \frac{F_s}{A_s}, \quad F_s = 7666 \text{ N}$$

$$\sigma_z = 220 \text{ MPa}$$

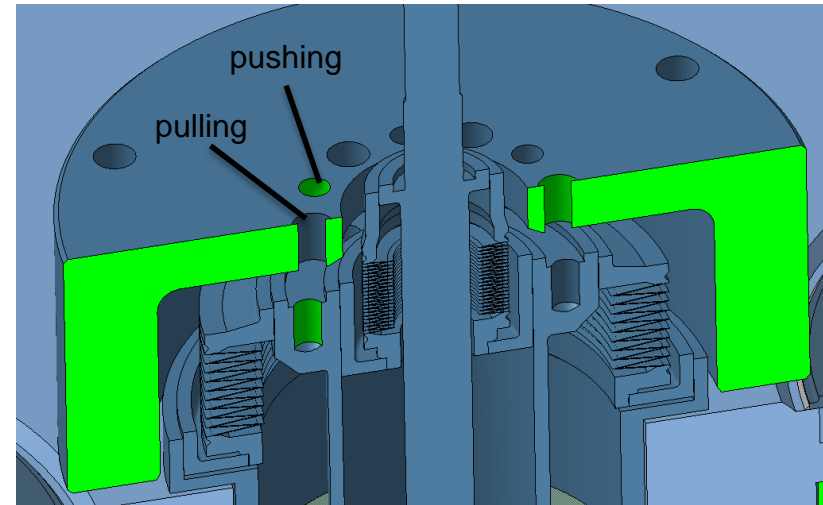
Bending stress:

$$\sigma_b = \frac{M \cdot \frac{d_1}{2}}{I_x}, \quad M = 3678 \text{ Nmm}$$

$$\sigma_b = 127 \text{ MPa}$$

Applying tuning force

- 6 screws for pushing
- 6 screws for pulling
- Maximum tuning force: 23kN (3833 N per screw)



M6 screw:

$$d_1 = 4.917 \text{ mm}$$

$$d_2 = 5.350 \text{ mm}$$

$$p = 1 \text{ mm}$$

Tension:

$$\sigma_z = \frac{F_s}{A_s}$$

$$\sigma_z = 202 \text{ MPa}$$

Torsional stress:

$$\tau = \frac{F_v \cdot d_2 \cdot \tan(\varphi^\circ + \rho^\circ)}{2 \cdot W_p}$$

$$K = \tan(\varphi + \rho) = 0.577$$

$$\tau = \frac{F_v \cdot d_2 \cdot K}{2 \cdot W_p} = 253.261 \text{ MPa}$$

Combined stress:

$$\sigma_V = \sqrt{\sigma_z^2 + 3 \cdot \tau^2} = 482.6 \text{ MPa}$$

M8 screw:

$$d_1 = 6.647 \text{ mm}$$

$$d_2 = 7.188 \text{ mm}$$

$$p = 1.25 \text{ mm}$$

Tension:

$$\sigma_z = \frac{F_s}{A_s}$$

$$\sigma_z = 110 \text{ MPa}$$

Torsional stress:

$$\tau = \frac{F_v \cdot d_2 \cdot \tan(\varphi^\circ + \rho^\circ)}{2 \cdot W_p}$$

$$K = \tan(\varphi + \rho) = 0.571$$

$$\tau = \frac{F_v \cdot d_2 \cdot K}{2 \cdot W_p} = 136 \text{ MPa}$$

Combined stress:

$$\sigma_V = \sqrt{\sigma_z^2 + 3 \cdot \tau^2} = 261 \text{ MPa}$$

Bigger safety factor

Elasto-plastic load: applied deformation

B: Push 1/1.33

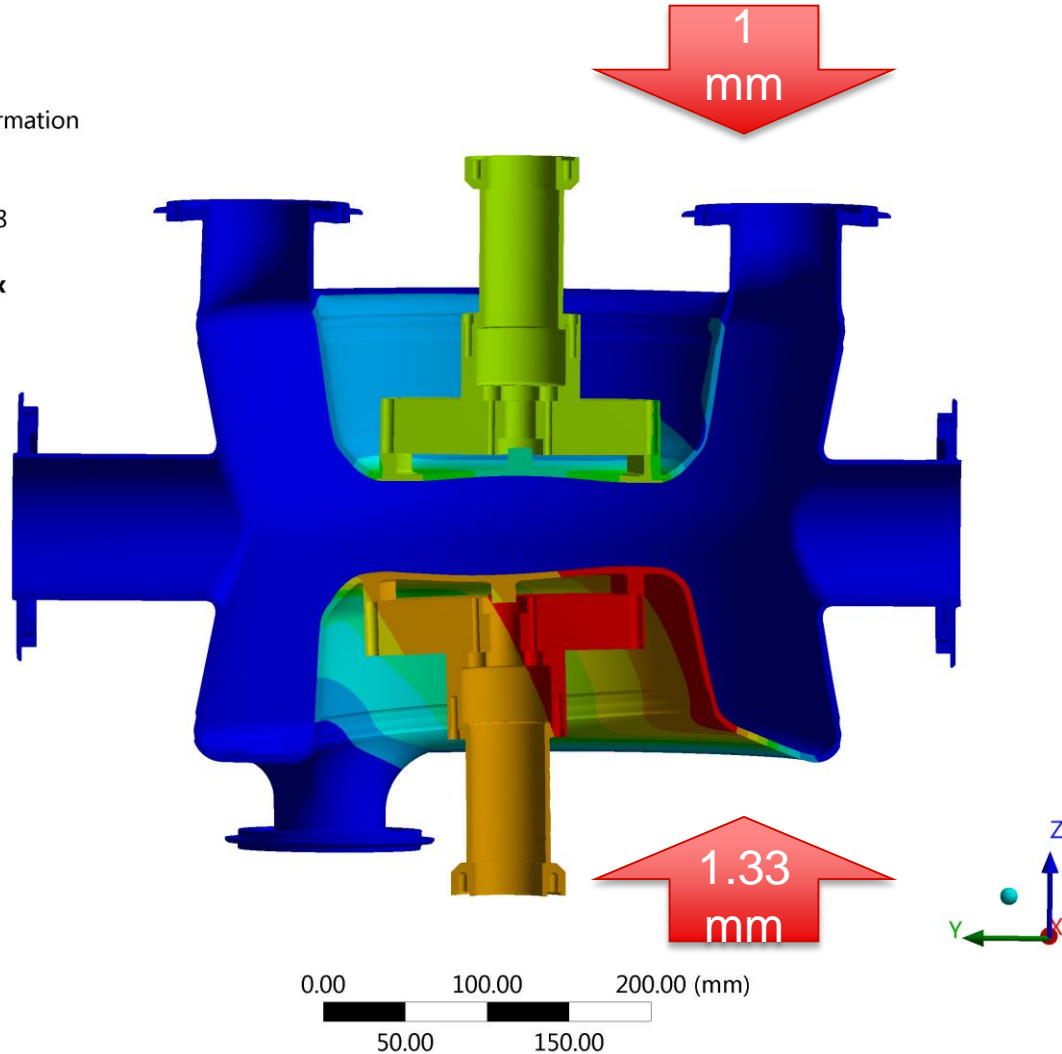
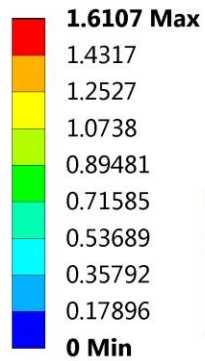
Figure

Type: Total Deformation

Unit: mm

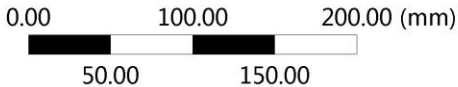
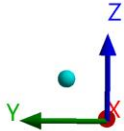
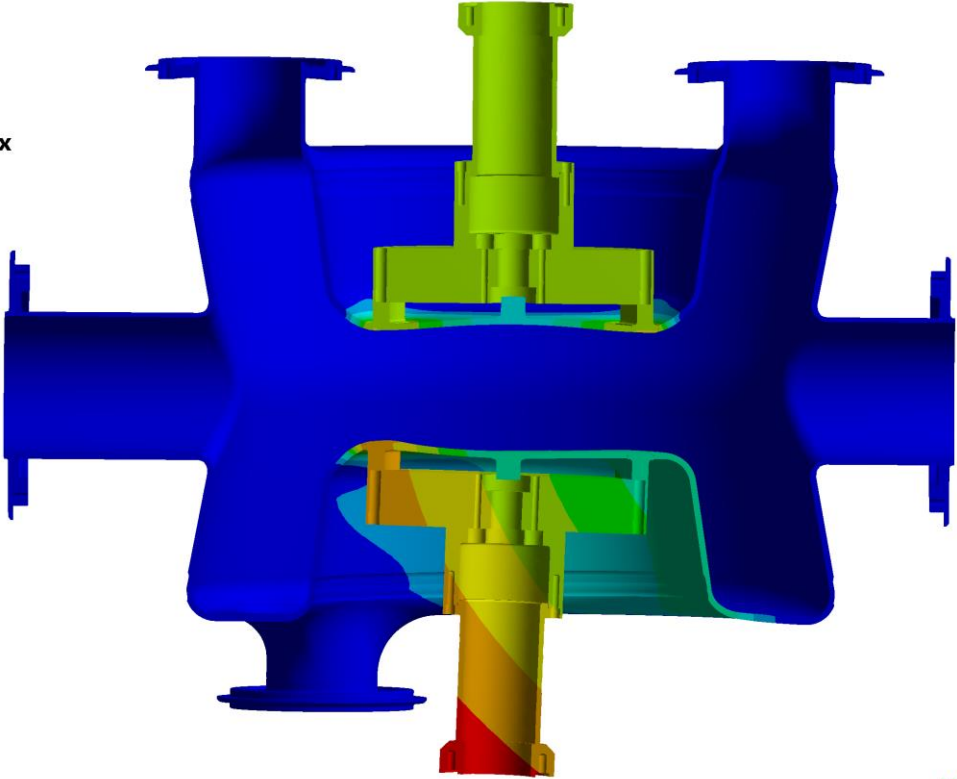
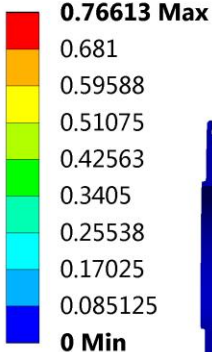
Time: 1

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Elasto-plastic load: residual deformation

B: Push 1/1.33
Figure
Type: Total Deformation
Unit: mm
Time: 2
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Elasto-plastic load: critical stress

B: Push 1/1.33

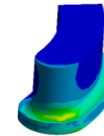
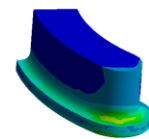
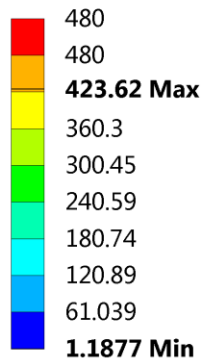
Figure

Type: Equivalent (von-Mises) Stress

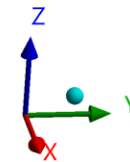
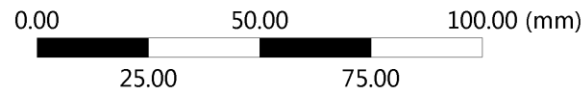
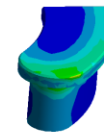
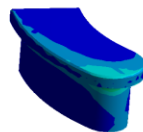
Unit: MPa

Time: 1

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$$\sigma_{y,NbTi} = 480 \text{ MPa}$$



Conclusions

- Elasto-plastic model approves pre-tuner improved design.
- Reducing pushing block thickness do not decrease stresses in the beam shapes, thick pre-tuner block was chosen.
- Improved design with intermediate plate allowing for assembly offset was approved.
- M8 screws guarantee bigger safety factor when applying the tuning force.
- To increase resolution, outer part connecting pre-tuner with helium tank could be more flexible.
- Francois Morel prepares 3D models and 2D drawings
ST0805441_01



Thank you for your attention!

