

# RF Aspects of Quality Control for the European-XFEL Cavities.

(WG 1 Cavity Production)

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# Production Sequence

2/7

IPAC'11

**European XFEL**

**Description and First Experience with the RF Measurement Procedure for the European XFEL SC Cavity production**

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## Abstract

Cavity production for the European XFEL was recently started with first niobium sheets arriving. From this stage to the accelerating module being ready for the linac installation, many critical RF measurements are necessary.

During the mechanical cavity fabrication the cavity half-cells, dumb-bells and end-groups are measured and sorted. The cavity spectrum and field profiles are measured and tuned.

The HOM (Higher Order Modes) coupler filter tuning, vertical cavity RF tests, cavity checks during the sitting assembly and final cavity performance measurements in the module as well as the fundamental mode and HOM RF spectra measurements complete the sequence.

We present the procedures of the RF measurements and discuss the first results for the XFEL prototype modules with special attention for the cavity tuning.

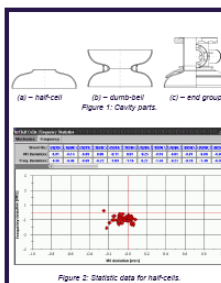
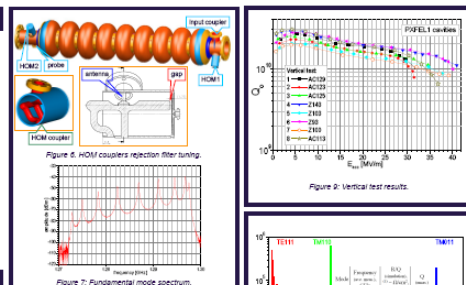
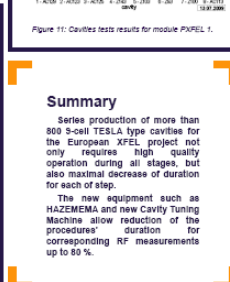
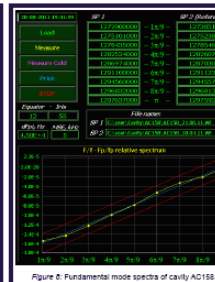
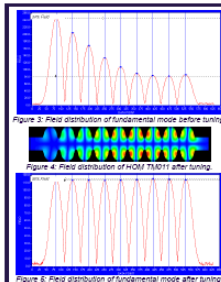


Table 1: RF Measurements for XFEL cavities.

Step	Measurements
Fabrication	<ul style="list-style-type: none"> <li>frequencies of half cells;</li> <li>frequencies of dumb-bells;</li> <li>frequencies of end groups;</li> <li>fundamental mode spectrum;</li> <li>fundamental mode spectrum;</li> <li>field profiles.</li> </ul>
Treatment	<ul style="list-style-type: none"> <li>HOM coupler filters characteristics;</li> <li>fundamental mode spectrum;</li> <li><math>Q_0</math> vs. <math>E_{acc}</math>;</li> <li><math>Q_0</math> vs. <math>E_{acc}</math> for cavity probe antenna.</li> </ul>
Cold RF Test	<ul style="list-style-type: none"> <li>fundamental mode spectrum;</li> <li>HOM coupler filters characteristics;</li> <li>fundamental mode spectrum;</li> <li>cable calibration;</li> <li>HOM spectrum;</li> <li><math>Q_0</math> vs. <math>E_{acc}</math>;</li> <li><math>Q_0</math> vs. <math>E_{acc}</math> for main input coupler.</li> </ul>
Assembly	
Module	
Test	



## Summary

Series production of more than 800 5-cell TESLA type cavities for the European XFEL project not only requires high quality operation during all stages, but also maximal decrease of duration for each of step.

The new equipment such as HAZEMEM and new Cavity Tuning Machine allow reduction of the procedures' duration for corresponding RF measurements up to 80 %.

## Production sequence:

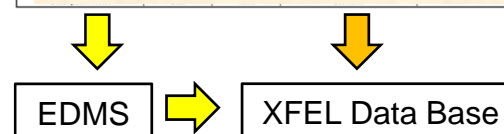
- Cavity parts fabrication,
- Cavity welding,
- Cavity tuning,
- Welding in helium tank (HT),
- Pressure test (PT).

**Inspection Sheet V\_F01**

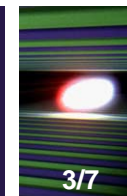
**Inspection Sheet V\_F02**

**Inspection Sheets for RF control:**

- V\_F01x16; ■ X\_HCP; ■ X\_F03;
- V\_F02; ■ X\_M01; ■ Y\_M01;
- V\_F03; ■ X\_F01; ■ Y\_F01;
- W\_F01x8; ■ X\_M02; ■ Y\_F02;
- W\_F02; ■ X\_F02; ■ Y\_F03.
- W\_F03; ■ X\_M03;

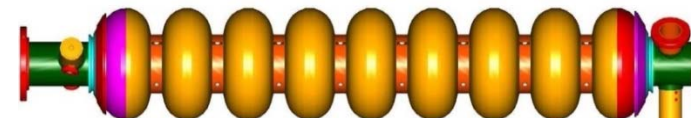


# The Parts Fabrication and Cavity Welding (Acceptance Level 1)



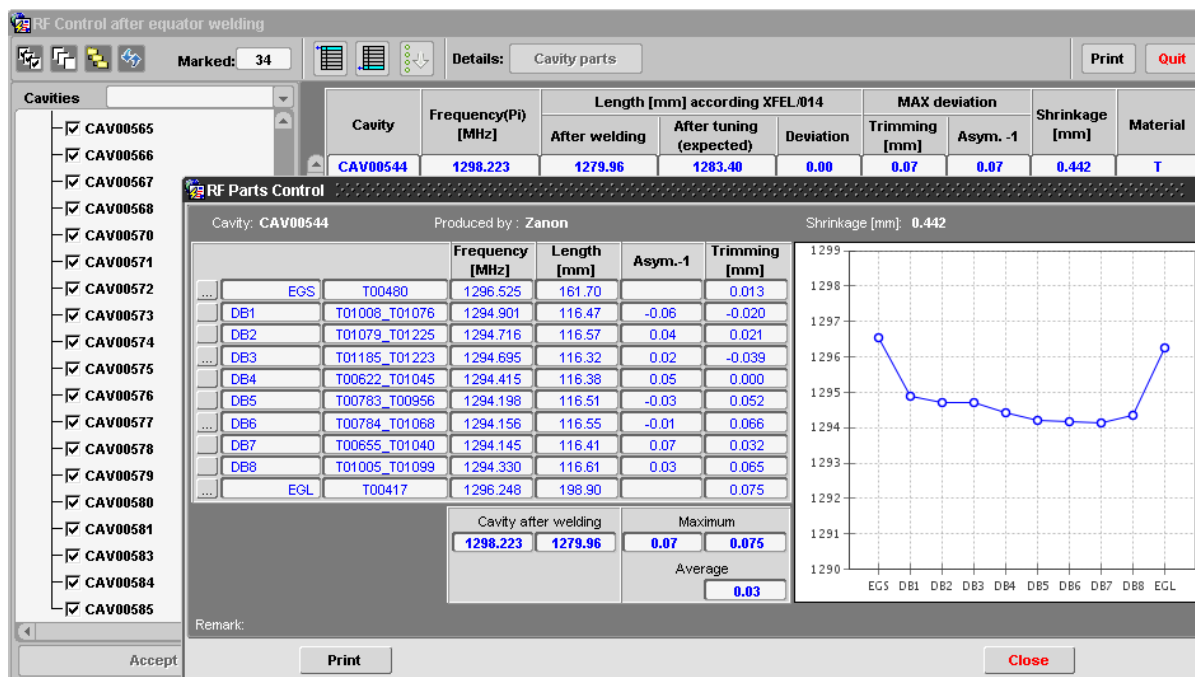
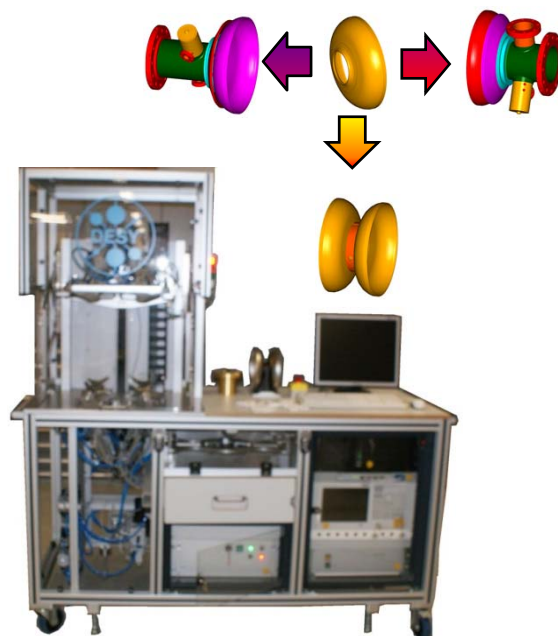
## Cavity parts fabrication:

- Shape control for half cells (HC), end groups (EG) and dumb-bells (DB);
- DBs asymmetry control;
- Calculation of optimal parts lengths;
- DBs sorting in cavity;
- Estimation of cavity length in helium tank.

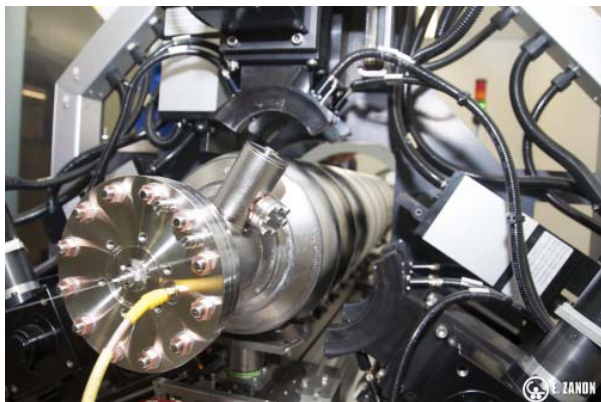
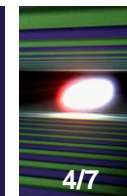


## After cavity welding:

- Measure the pi-mode frequency and cavity length;
- Control the welding parameters (shrinkage and deformation);
- Calculated the cavity length in helium tank.

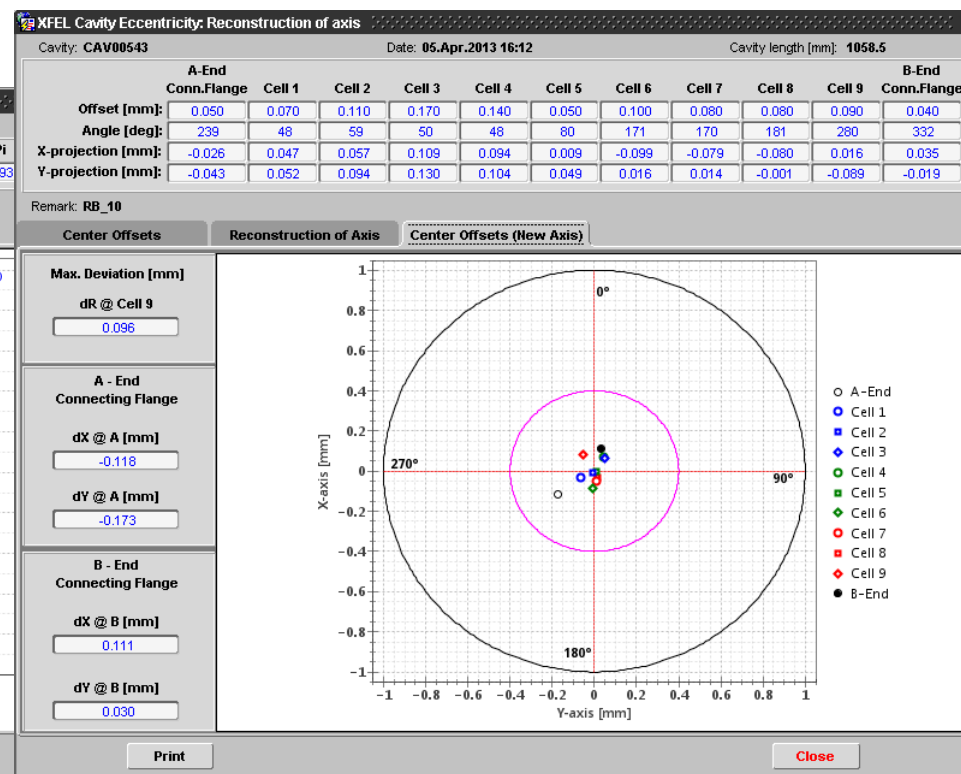
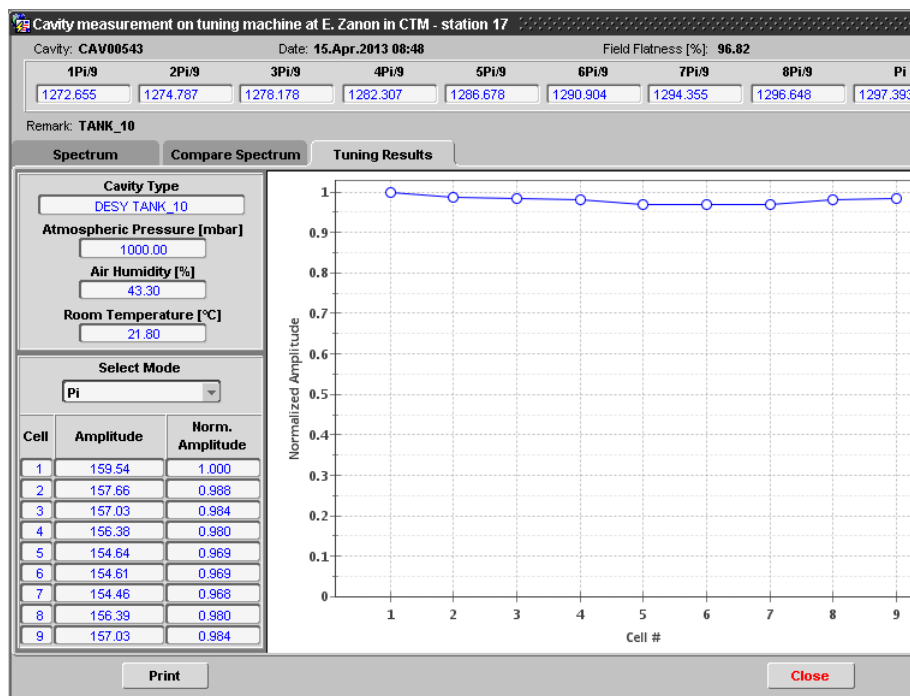


# Cavity Tuning

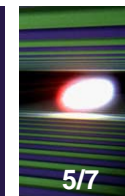


Values are controlled during cavity tuning:

- pi-mode frequency,
- field flatness (FF),
- cavity length,
- cavity cells eccentricity.

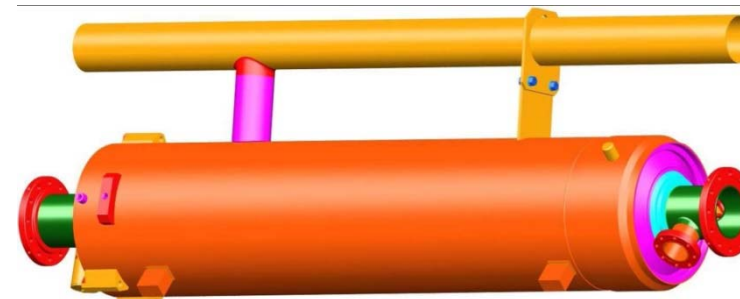


# Welding in Helium Tank and Pressure Test (Acceptance Level 2 and 3)



## Welding in helium tank, pressure test:

- Control of pi-mode frequency during the rings with bellow and helium tank welding;
- Checking of RF parameters (Fpi, FF) before and after assembly into helium tank and pressure test.



RF Control after Acceptance Level 3

Marked: 8

Details: Results from Protocols

Print Quit

Cavity	Frequency (Pi) [MHz]			Transmission [dB]	Spectrum deviation [kHz]	Field flat. (in HT)	Length [mm]	Maximum eccentricity [mm]	Warning
	Deviation (in HT)	in HT (Y_F02)	with vac (Y_F03)						
CAV00528									
CAV00529									
CAV00530									
CAV00531									
CAV00534									
CAV00535									
CAV00537									
CAV00538									
CAV00539									
CAV00540									
CAV00541									
CAV00543	0.037	1297.393	1297.680	124	2.5	0.97	1058.49	0.17	
CAV00544	0.042	1297.388	1297.680	126	2.5	0.96	1058.58	0.26	
CAV00545	0.055	1297.375	1297.681	126	5.0	0.94	1058.54	0.22	
CAV00546	0.028	1297.458	1297.738	126	1.9	0.97	1058.93	0.28	

Detail RF Data Control

Cavity: CAV00543 Produced by: Zanon

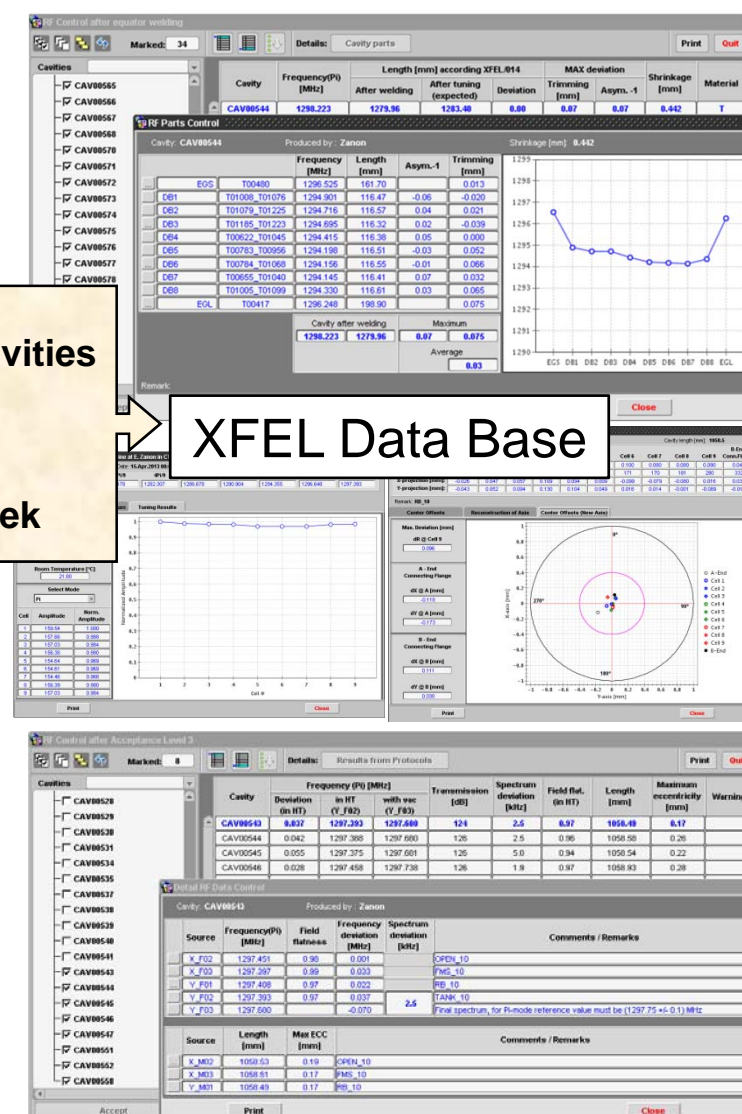
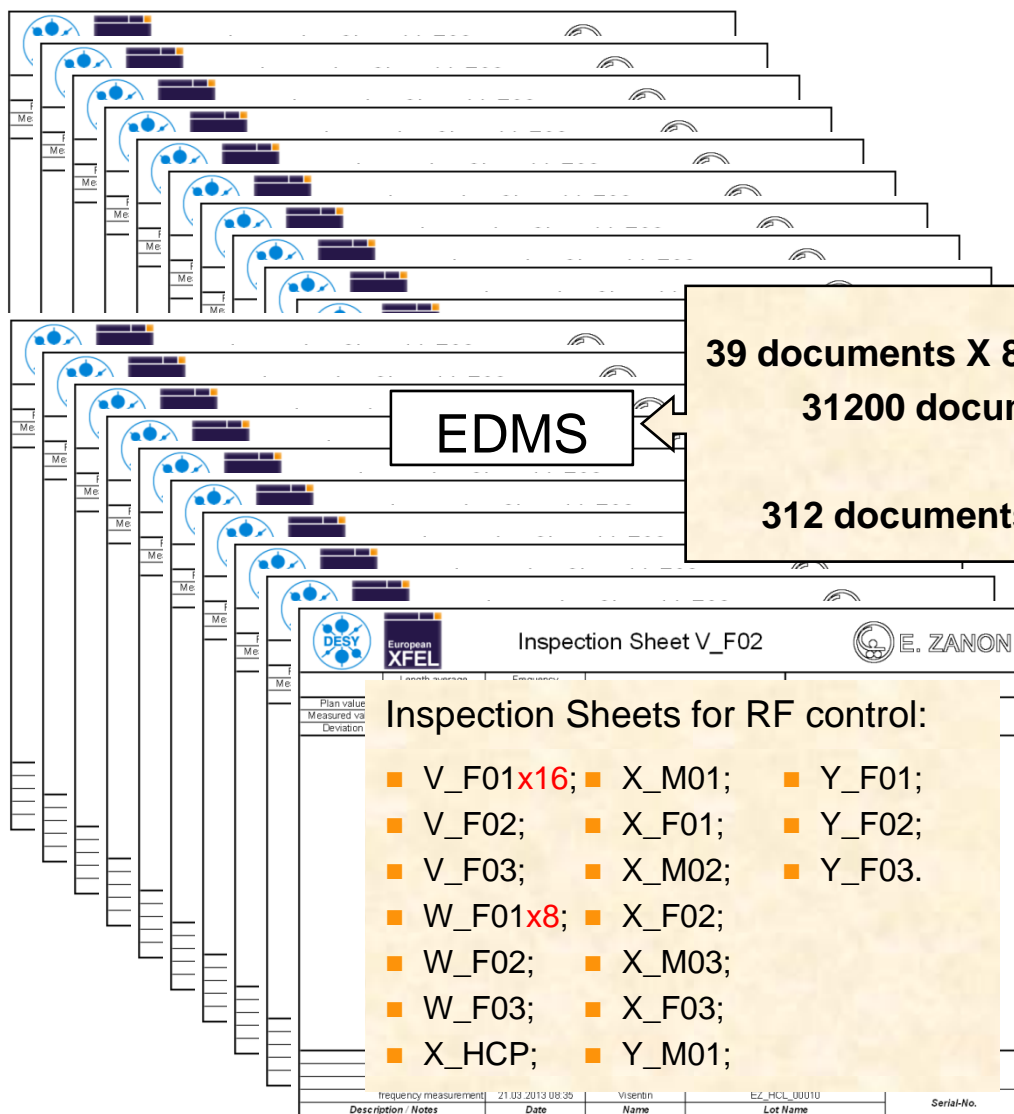
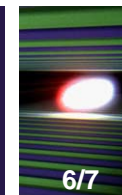
Source	Frequency(Pi) [MHz]	Field flatness	Frequency deviation [MHz]	Spectrum deviation [kHz]	Comments / Remarks
X_F02	1297.451	0.98	0.001		OPEN_10
X_F03	1297.397	0.99	0.033		FMS_10
Y_F01	1297.408	0.97	0.022		RB_10
Y_F02	1297.393	0.97	0.037	2.5	TANK_10
Y_F03	1297.680		-0.070		Final spectrum, for Pi-mode reference value must be (1297.75 +/- 0.1) MHz

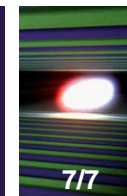
Source	Length [mm]	Max ECC [mm]	Comments / Remarks
X_M02	1058.53	0.19	OPEN_10
X_M03	1058.51	0.17	FMS_10
Y_M01	1058.49	0.17	RB_10

Accept Print Close



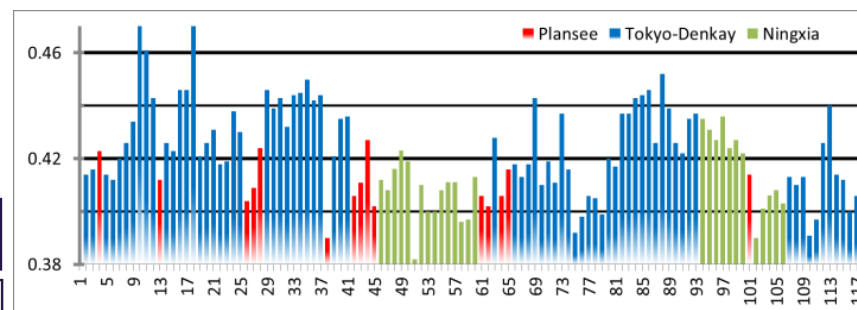
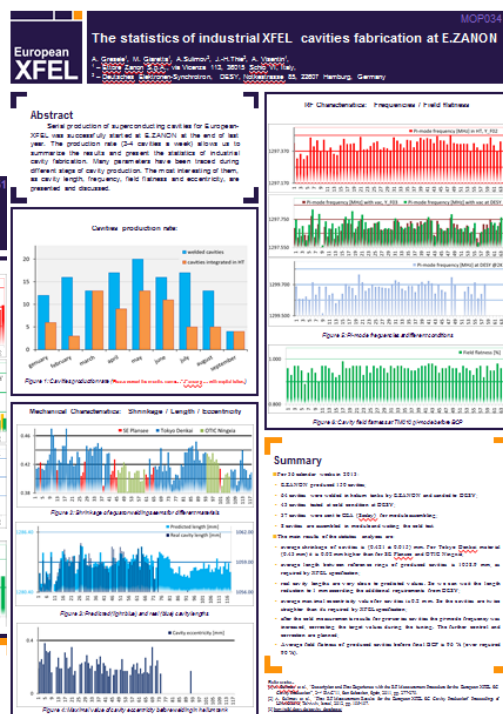
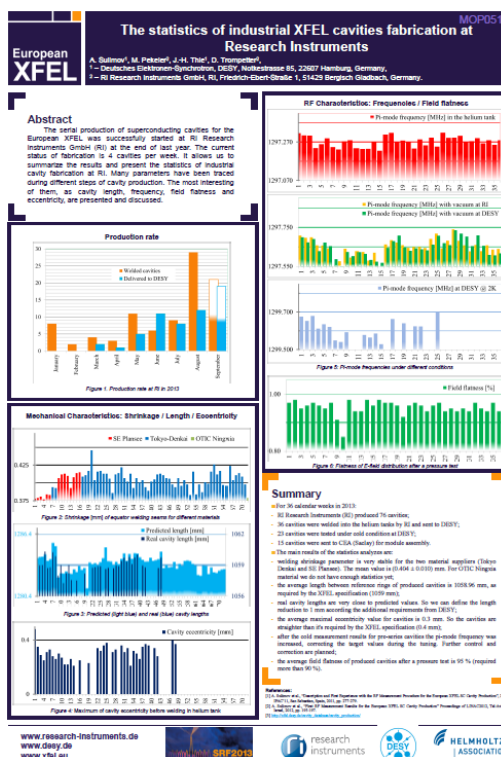
# Conclusion



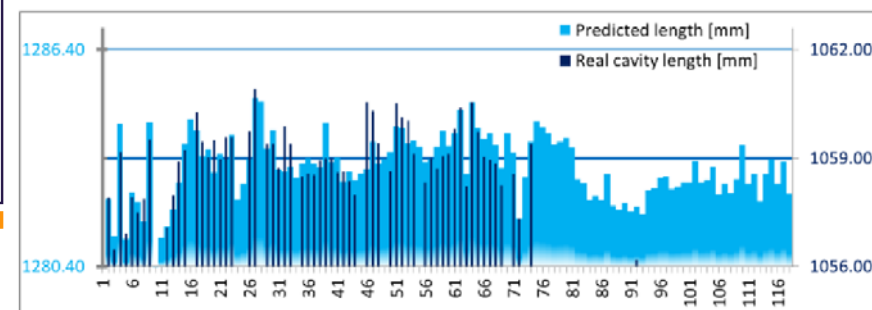


## Examples of the Statistics

SRF'13



## Shrinkage of equator welding for different materials



### Predicted and real cavities lengths