S-Band Accelerating Cells Geometry Evaluation and Pre-Tuning by Resonant Characteristic Measurement

T. Markosyan

2022

Outlook

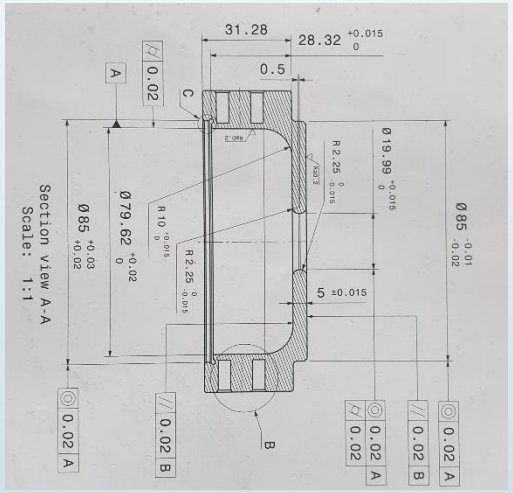
- Upgrade of RF system of AREAL accelerator
- Current status of accelerating structure fabrication
- Method of cell dimensions measurement
- Pre-tuning and selection of cells, before brazing
- Preliminary results and conclusions

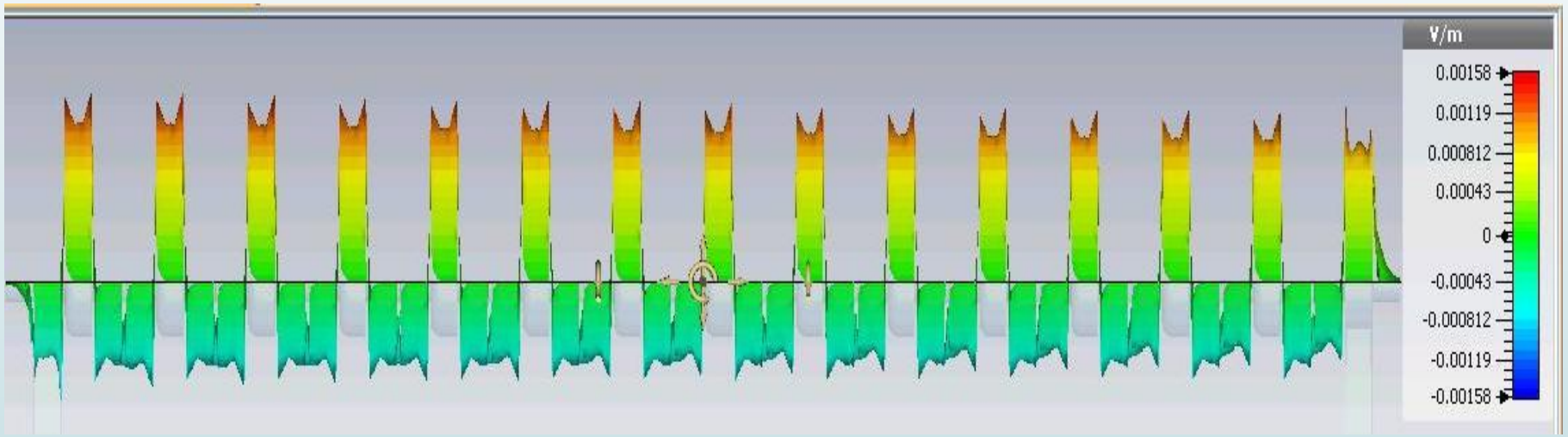
Upgrade of RF system

Main Goal is to increase the Beam Energy up to 50 MeV

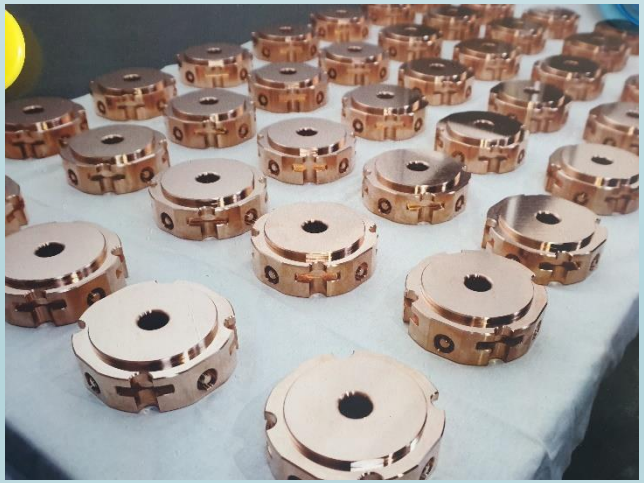
Necessary RF equipment for 50 MeV upgrade of AREAL accelerator	
Equipment	**Status**
Accelerating structure(s)	Designed and fabricated cells Brazing in process
Additional 2 RF stations: 1 klystron, HV modulator, a low-level RF system, preamplifier and an interlock and control system for each station.	HV modulator, klystron with oil tank moved to AREAL RF hall. Control and LLRF system will be based on µTCA (applications are ready). K1 ScandiNova Modulator under test Interlock, wiring in progress
RF power 7 MW for Gun and 45 MW for ACCs	Negotiations with ScandiNova for 45 MW modulator/klystron (waiting for funding)
Cooling system for 3 RF stations	Established, tested and operated for 1 RF station

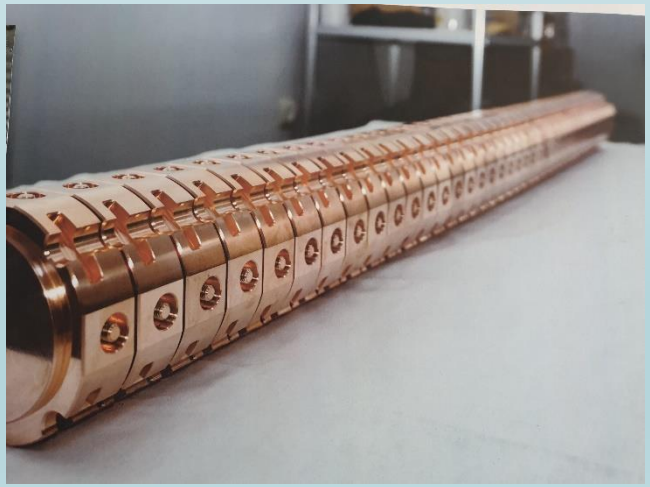
Simulations of ACC design





The simulations of 42 cell constant impedance structure



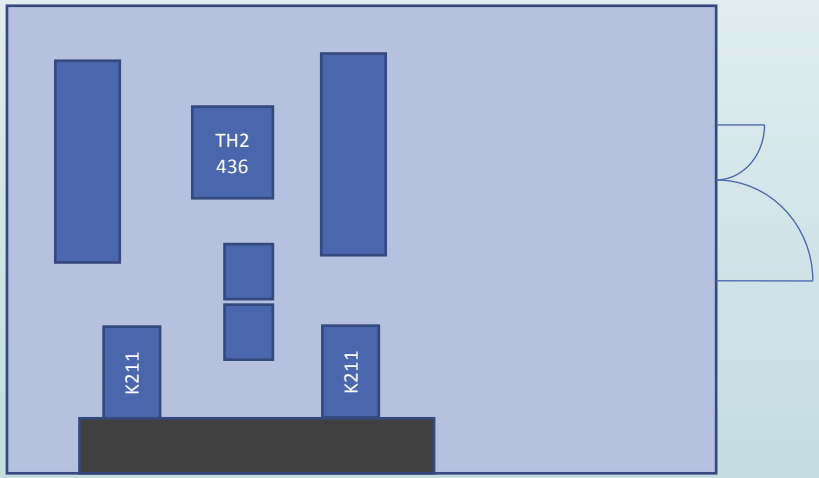


Cells, couplers and other component for first ACC

RF Hall Layout

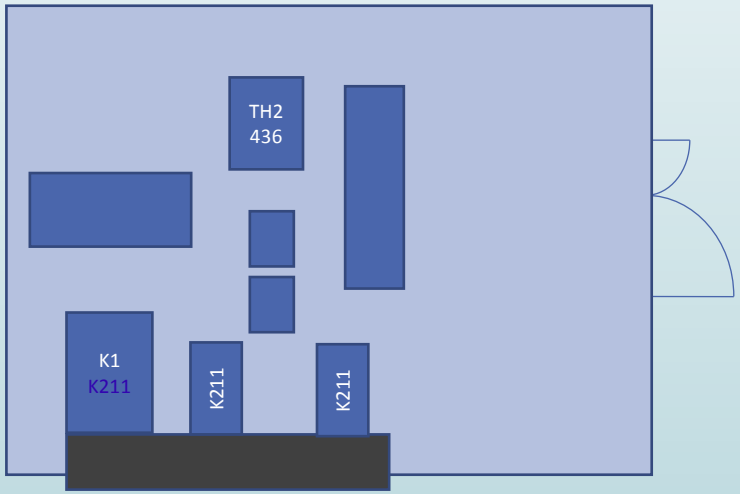
- MO and Libera rack moved back from Laser Room to RF Hall
- The µTCA in the same rack with thermal stabilization

stage 1



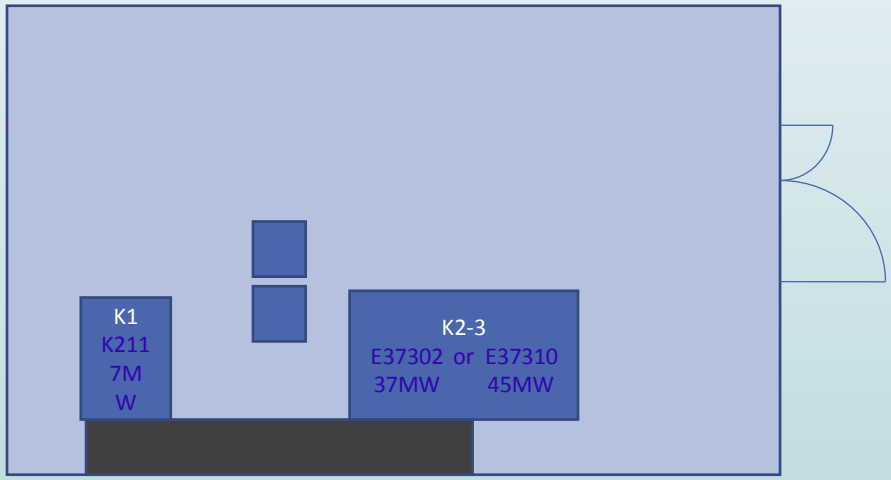
2nd 7MW station in RF hall, will supply first ACC to provide 20MeV acceleration

stage 2



- Gun RF supply will be changed into modern K1 ScandiNova Modulator
- 1st and 2nd 7MW stations will supply both sequent connected ACC's to provide 30MeV acceleration

stage 3

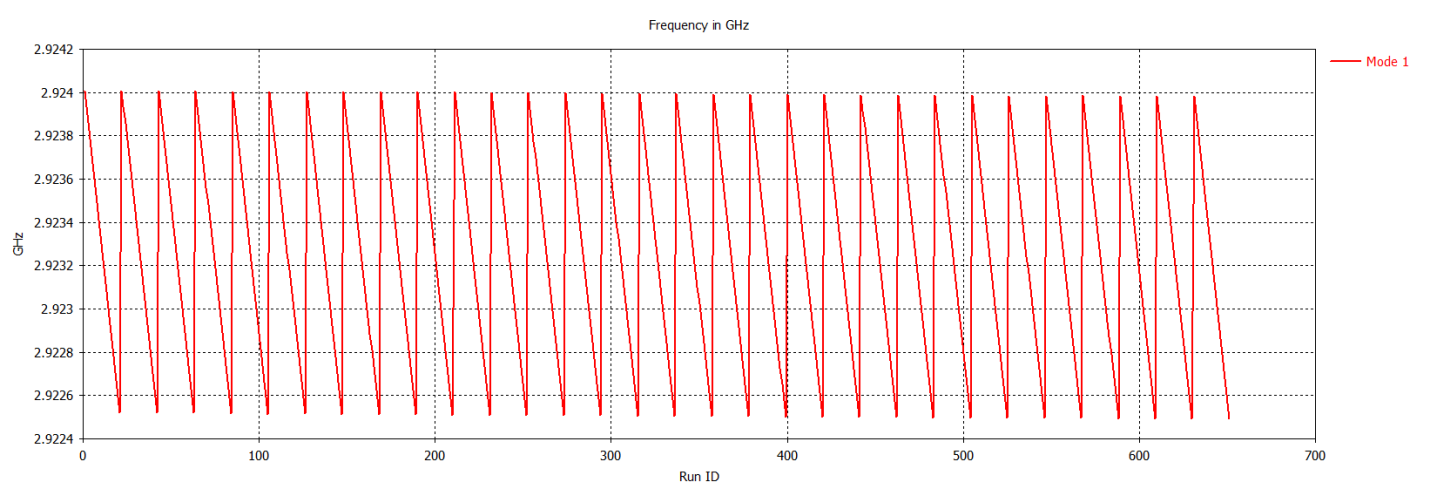


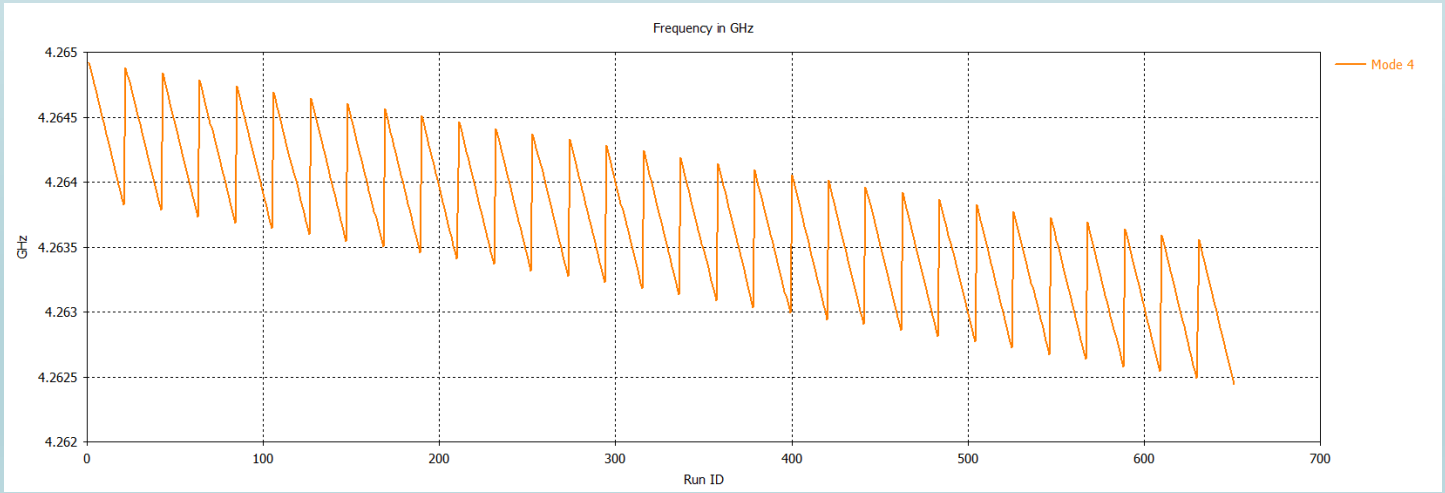
1st and 2nd 7MW stations will be replaced with one 37 MW klystron to provide 50MeV acceleration

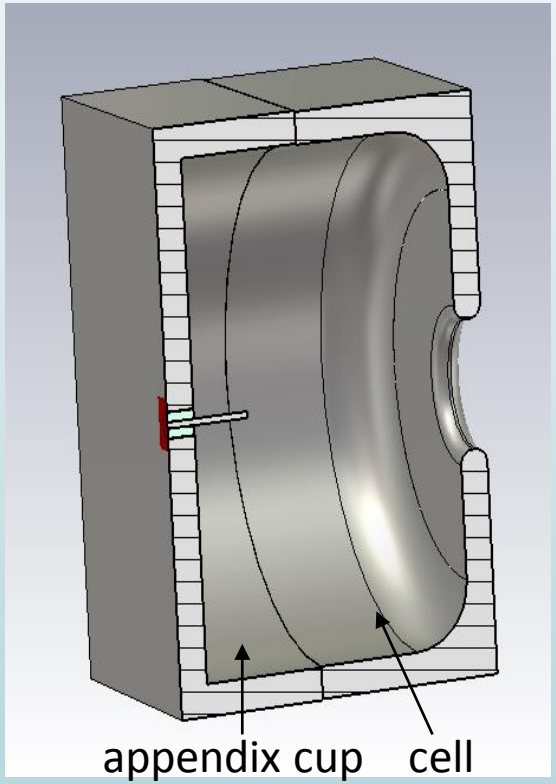
- **K211 Klystron with adjacent equipment will be moved to RF laboratory**
- **It is planned to create RF test stand for further ACC prototype testing**
- **The second modulator will serve as spare**

- **Cooling system modified to supply 3 RF station for together operation**
- **Maximum heat removal > 24 KW (upgrade opportunities up to 150 KW)**

Simulations of resonant modes of combined resonator



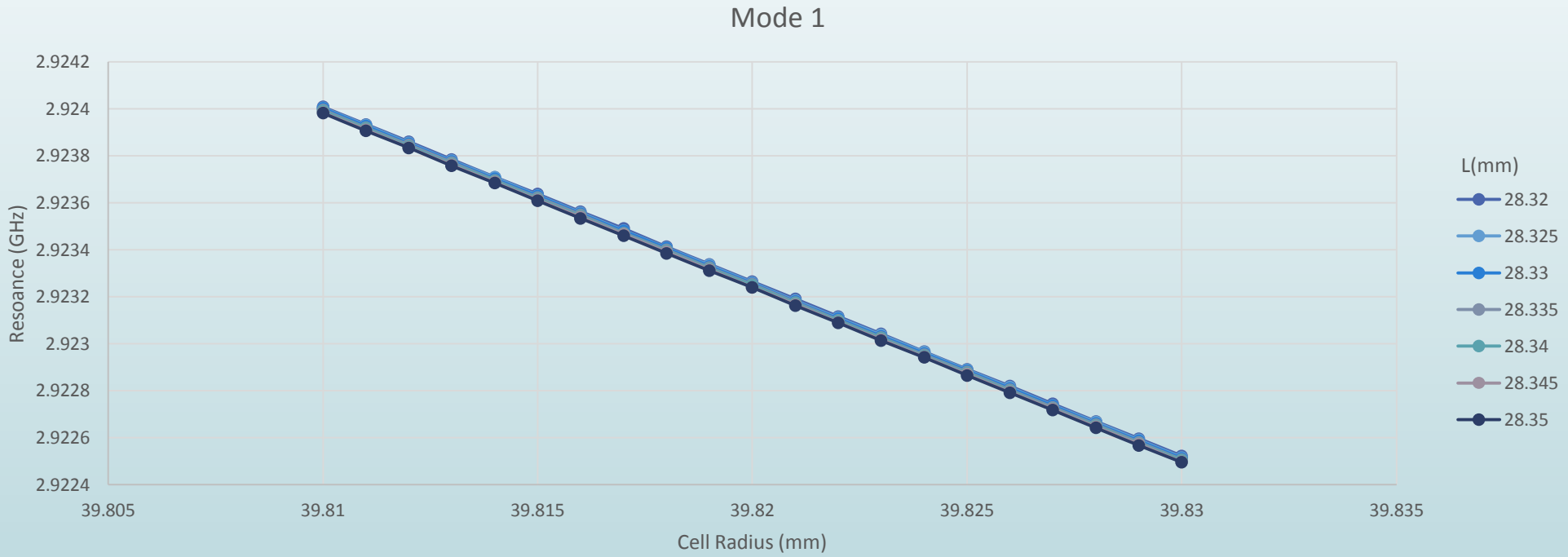


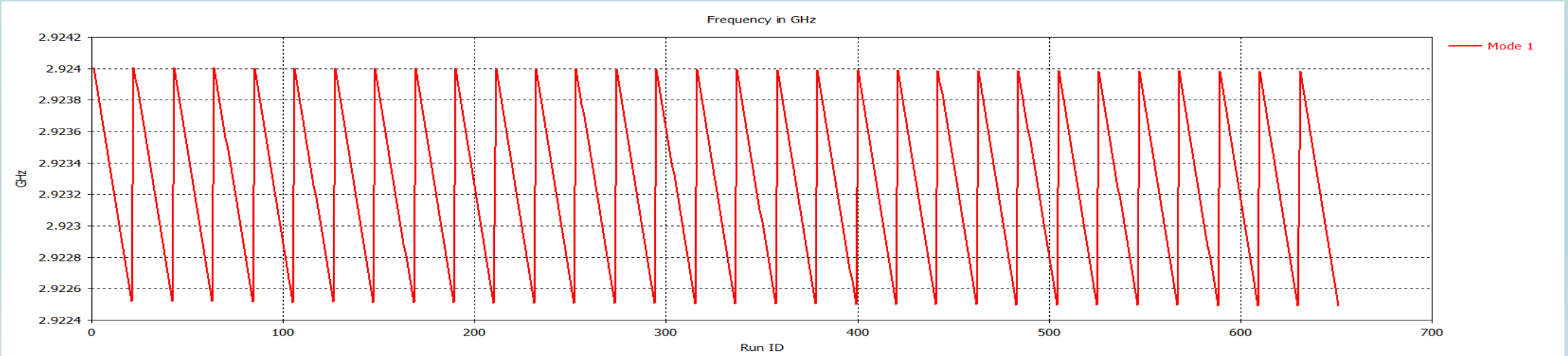


Appended cell parameters

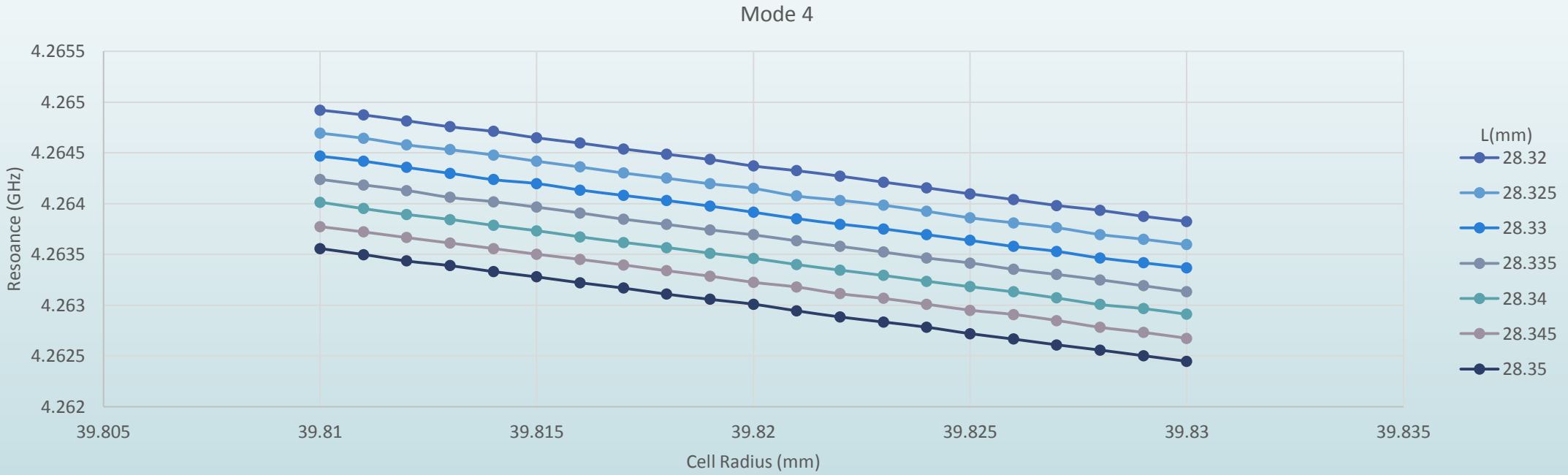
Radius	39,81 mm
Height	21,67 mm

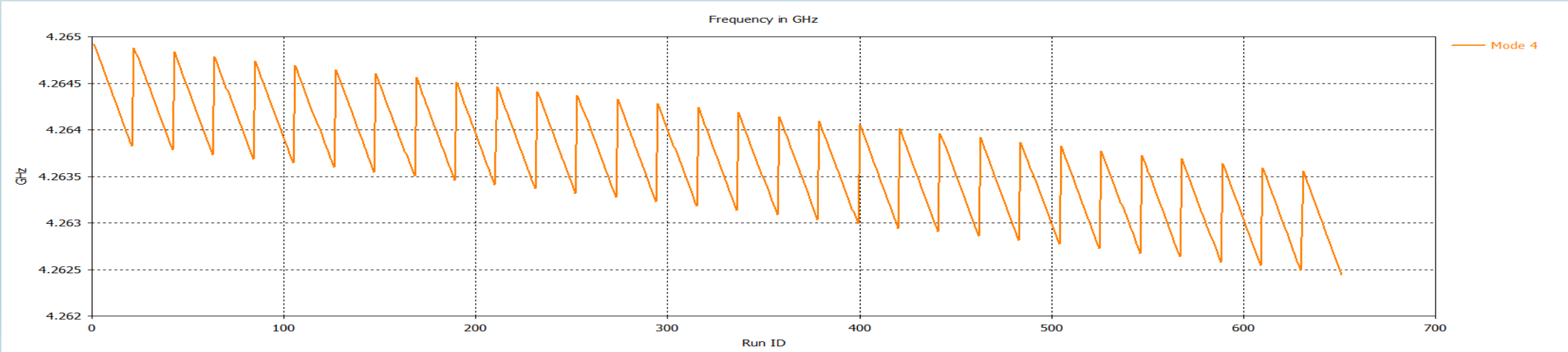
1st Resonant Mode





4th Resonant mode





Fitting results

For 1 st mode

$$\nu_1 = 5.88 - 0.0743R$$

$$R = 79.17 - 13.46\nu_1$$

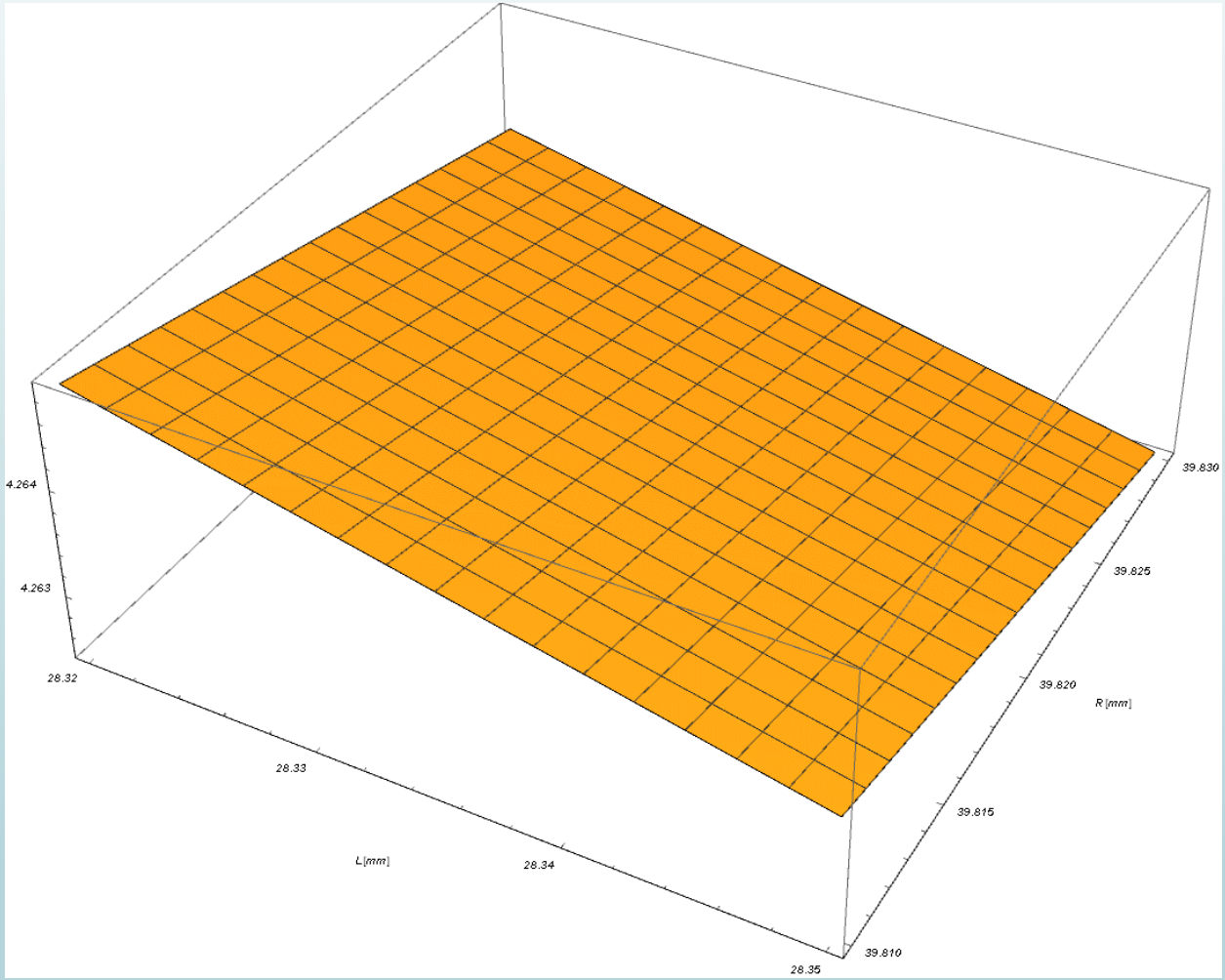
1 st mode frequency is not dependent on L

For 4th mode

$$\nu_4 = 7.753 - 0.045876L - 0.0551425R$$

L=73.918 - 21.821 ν_4 + 16.196 ν_1

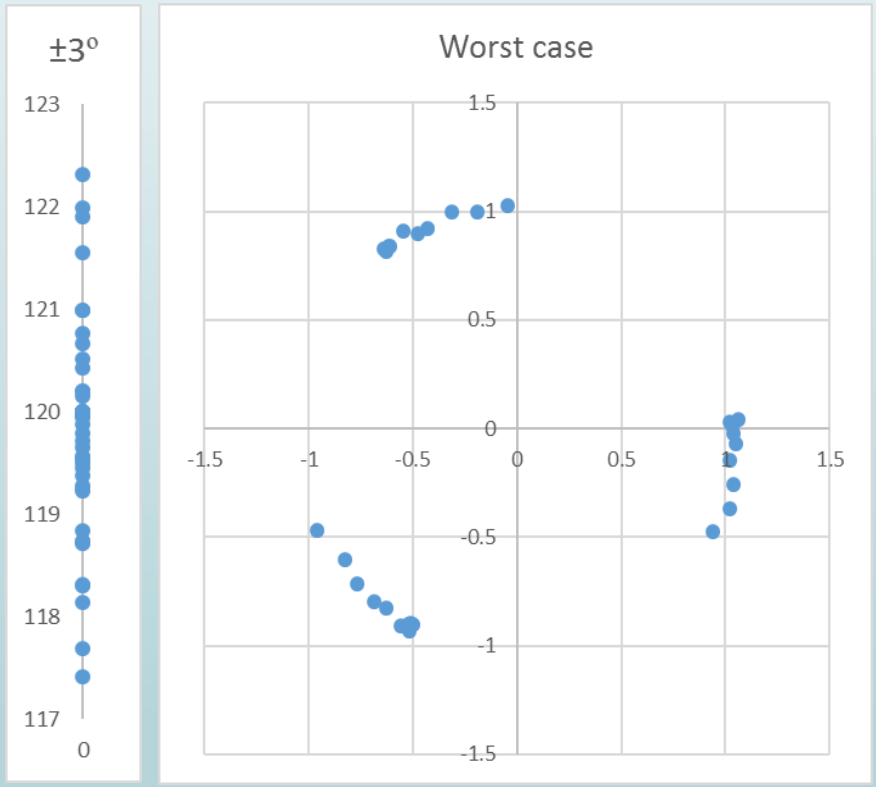
4th mode frequency is also linear with respect to R and L



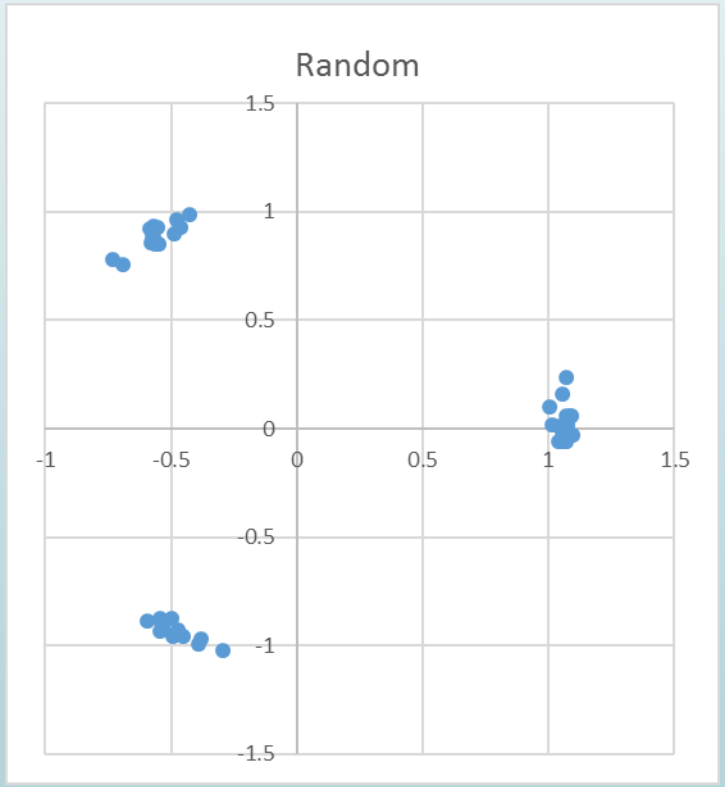
Resonant frequencies for 4th mode depend on radius and height of the cell

Selection algorithm: simple and smart arrangement of cells

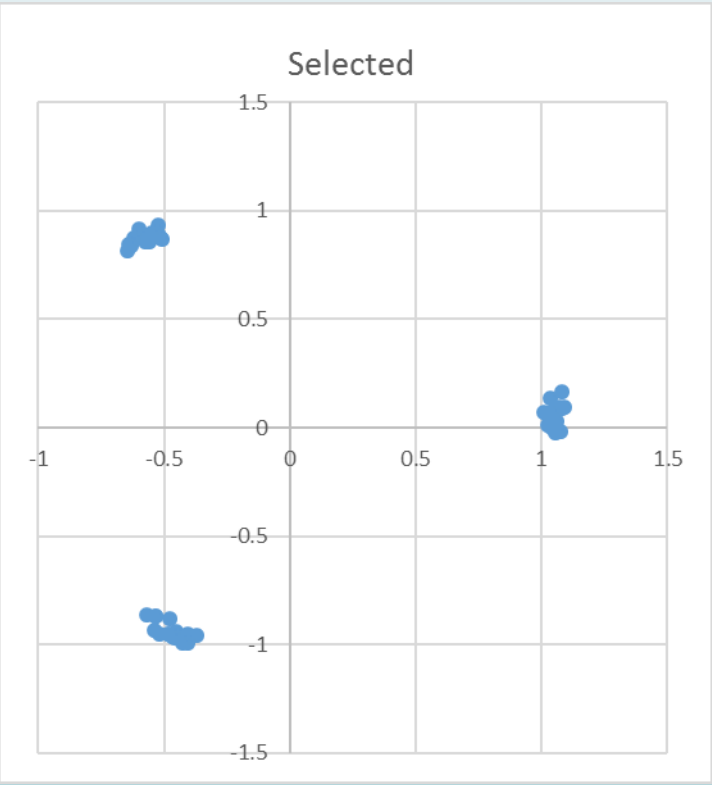
1. Selections done by choosing appropriate triplet, (small, mean, big)



Smallest to Largest arrangement

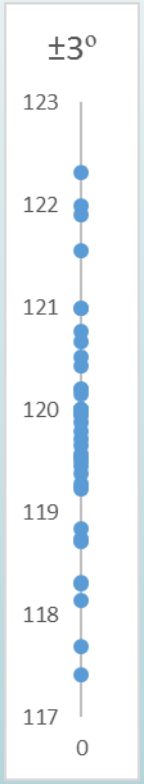


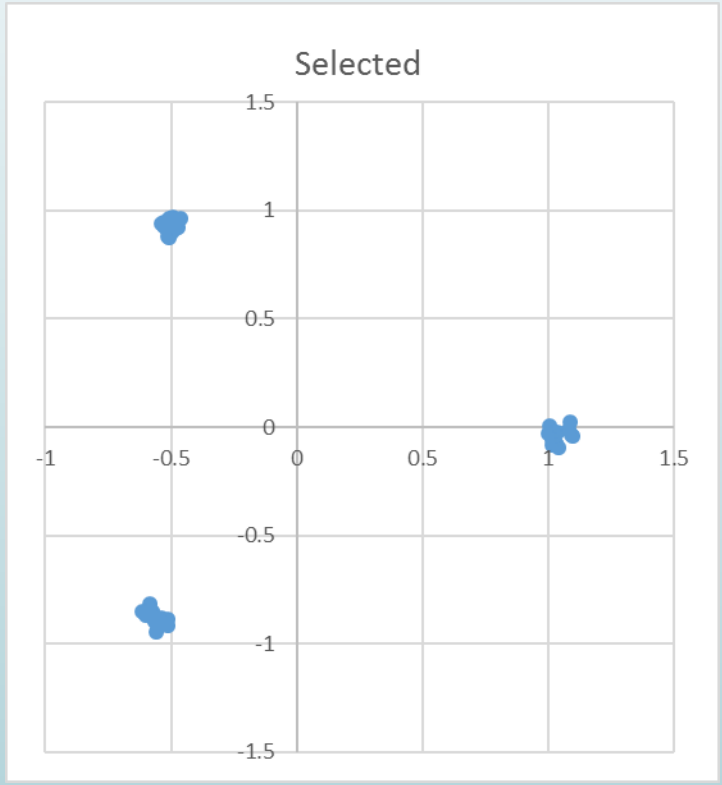
Arbitrary arrangement



Simple triplets (Max. Avg. Min.) was selected and randomly arranged

2. Each triplet selected by the same way before brazing.





Triplets are arranged by alternating large and small triplets

Pre-tuning procedure :

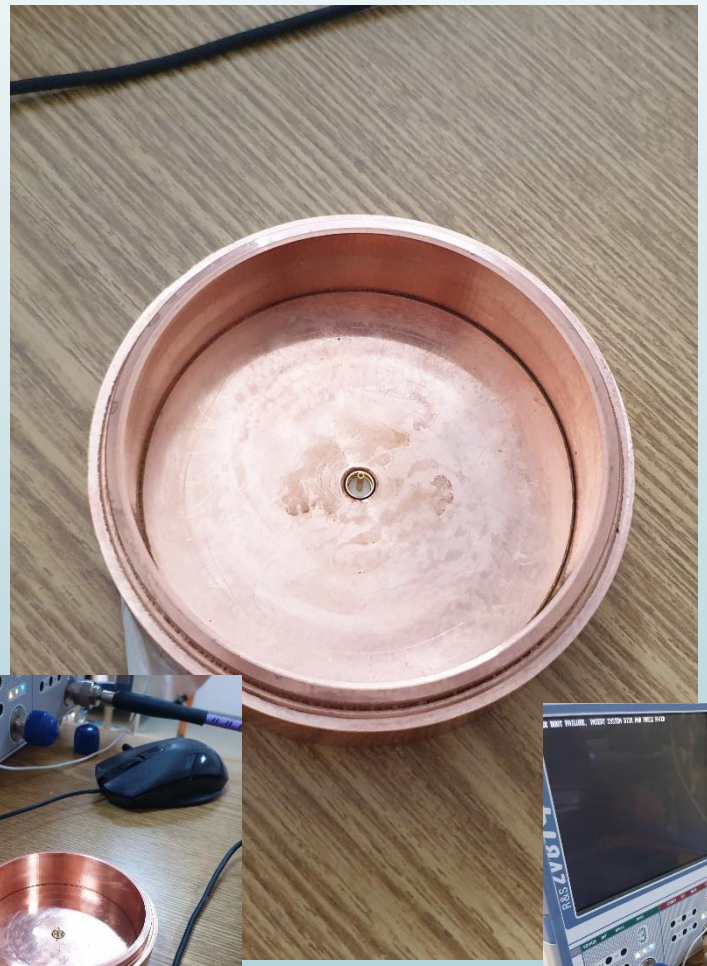
- Collected data for main frequencies by measurement
- Defining the mean value for resonant frequency
- Classifying cells respect to mean value
- The cell closer to mean value taken as reference
- Rest of cells tuned to the reference (pre-tuning)
- Repeating the measurement for compete selection procedure

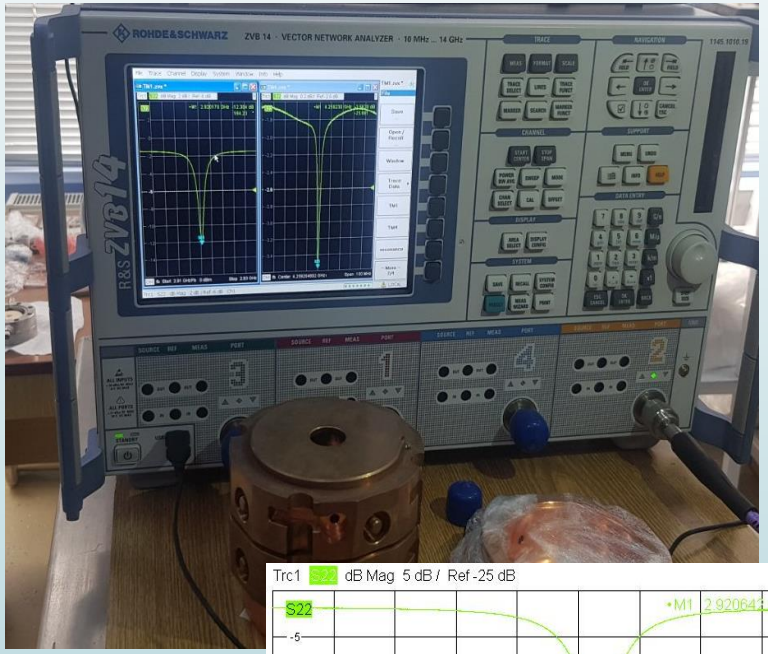
Advantages:

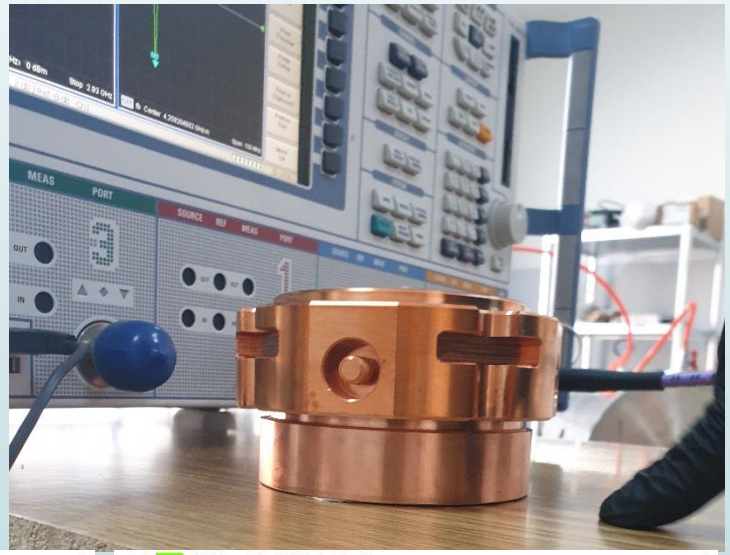
1. Specify working temperature in advance
2. In the case of foreseen brazing procedure **further routine tuning procedure can be avoided**

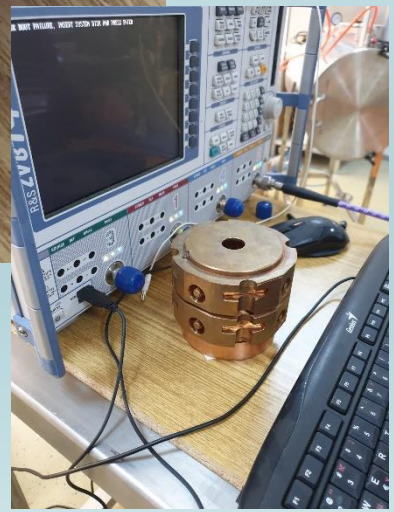
Pre-tuning of cells before brazing will significantly increase efficiency and facilitate tuning process of accelerating structures!!!

Experimental Setup









$R = 79.17 - 13.46\nu 1$

L=73.918 - 21.821ν4 + 16.196 ν1

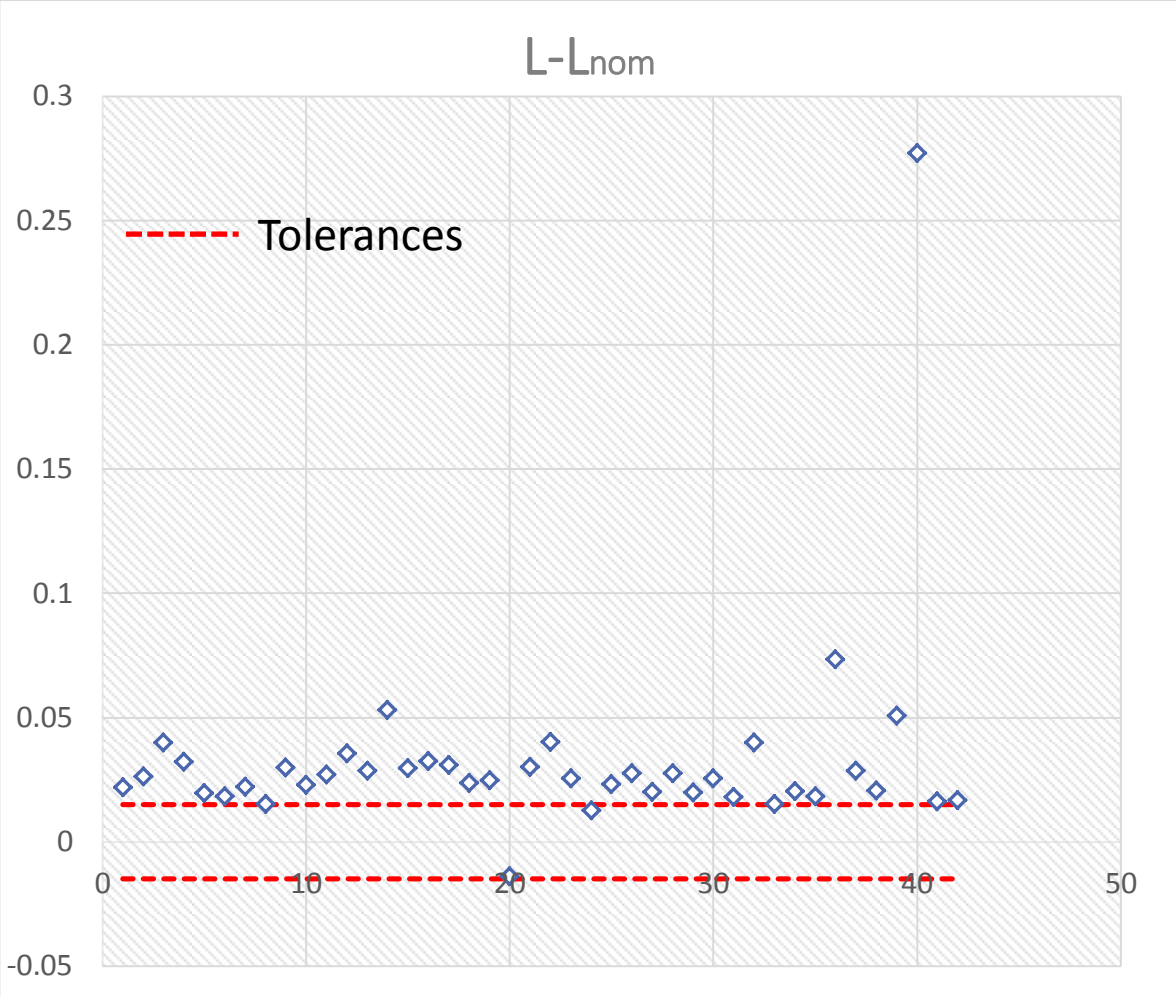
Measurement Process and Results

Measurement procedure

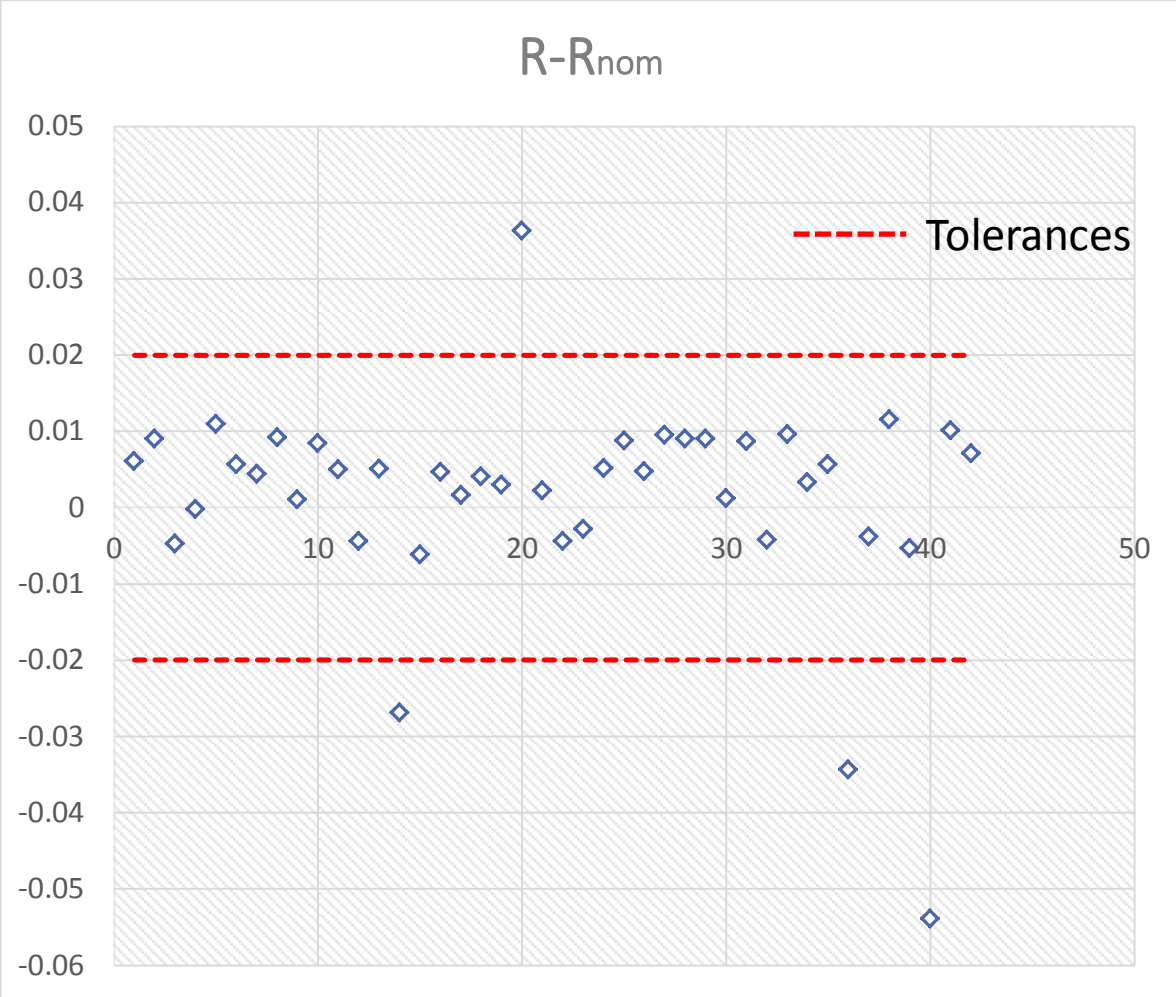
- Appended cup with its cabling fixed on test stand
- Provide stable temperature regime for all cells
- Each cell is placed on test stand one by one
- For best contact the resonant curve should be more than -40dB (combined resonator with high quality)
- Both mode frequencies are registered at once
- Each measurement repeated few time and averaged
- In parallel the ambient temperature is registered
- For the measured data analyses all frequency/dimensions normalized by same temperature

Number of Cells	Mode 1 (GHz)	Mode 1 signal (dB)	Mode 4 (GHz)	Temperature (C)
02	2.920052	-59	4.258679	23.9
03	2.9213036	-45	4.258629	23.9
04	2.918221	-45	4.258879	24.1
05	2.920221	-60	4.258879	24.0
06	2.920686	-52	4.258080	24.0
07	2.920649	-64	4.259030	24.1
08	2.921380	-51	4.259080	24.4
09	2.920679	-55	4.258979	24.1
10	2.920605	-55	4.258829	24.2
11	2.920458	-52	4.258829	24.2
12	2.921579	-62	4.258979	24.2
13	2.919402	-57	4.258729	24.1
14	2.921491	-59	4.259280	24.1
15	2.920937	-54	4.259180	23.9

Length and Radius Errors by Resonant Mode Measurements



Measured length of cells



Measured radius of cells

Conclusion

1. The infrastructure and equipment of RF system for AREAL upgrade is mainly complete
2. The new method for cell dimensions measurement by resonant frequencies is developed
3. The pre-tuning process to avoid further routine tuning procedure is proposed
4. The algorithm of cell selection and combination by triplet before brazing is developed
5. Detailed simulattion and measurement is necessary to prove the method validity

Thank You for Attention!!!