Detuning of T18 after high power test

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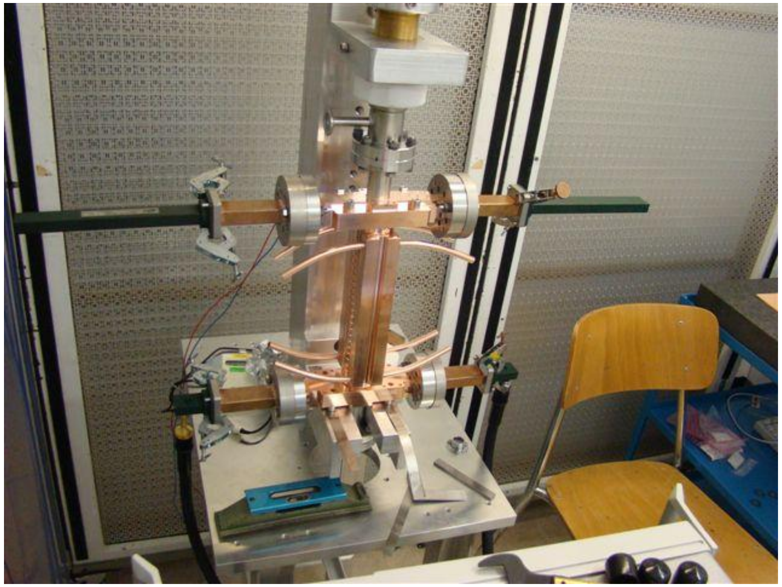
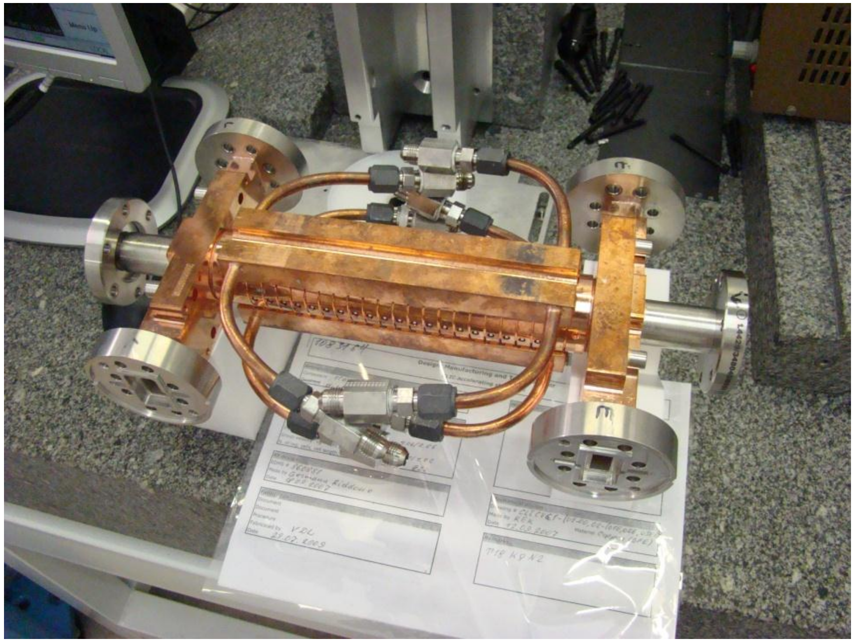
Outline

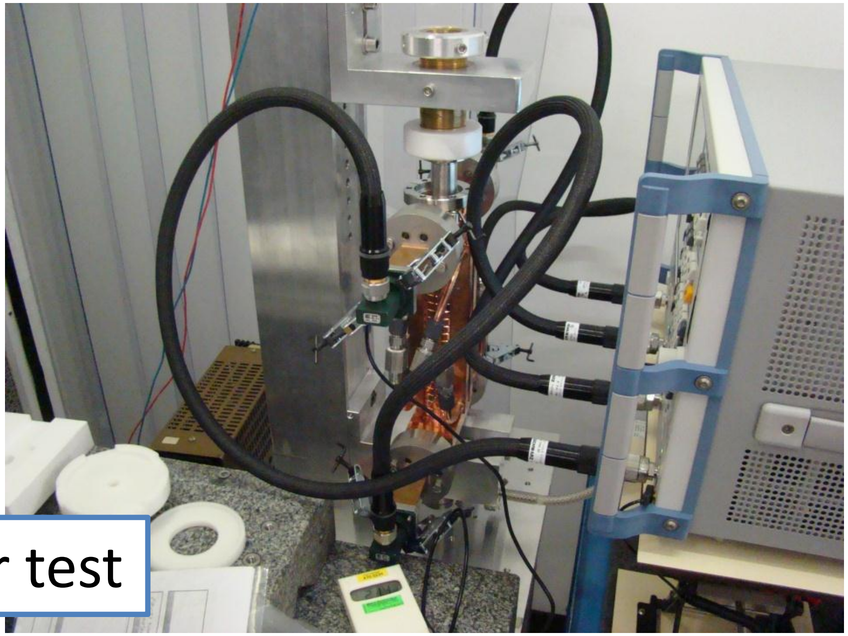
- RF measurement of CERN-Build T18
  - Comparison before and after high power test
  - Detuning Analysis
- Old results
  - (From Juwen Wang and Toshiyasu Higo)
- Related simulation
- Geometry Change and analysis

CERN built T18



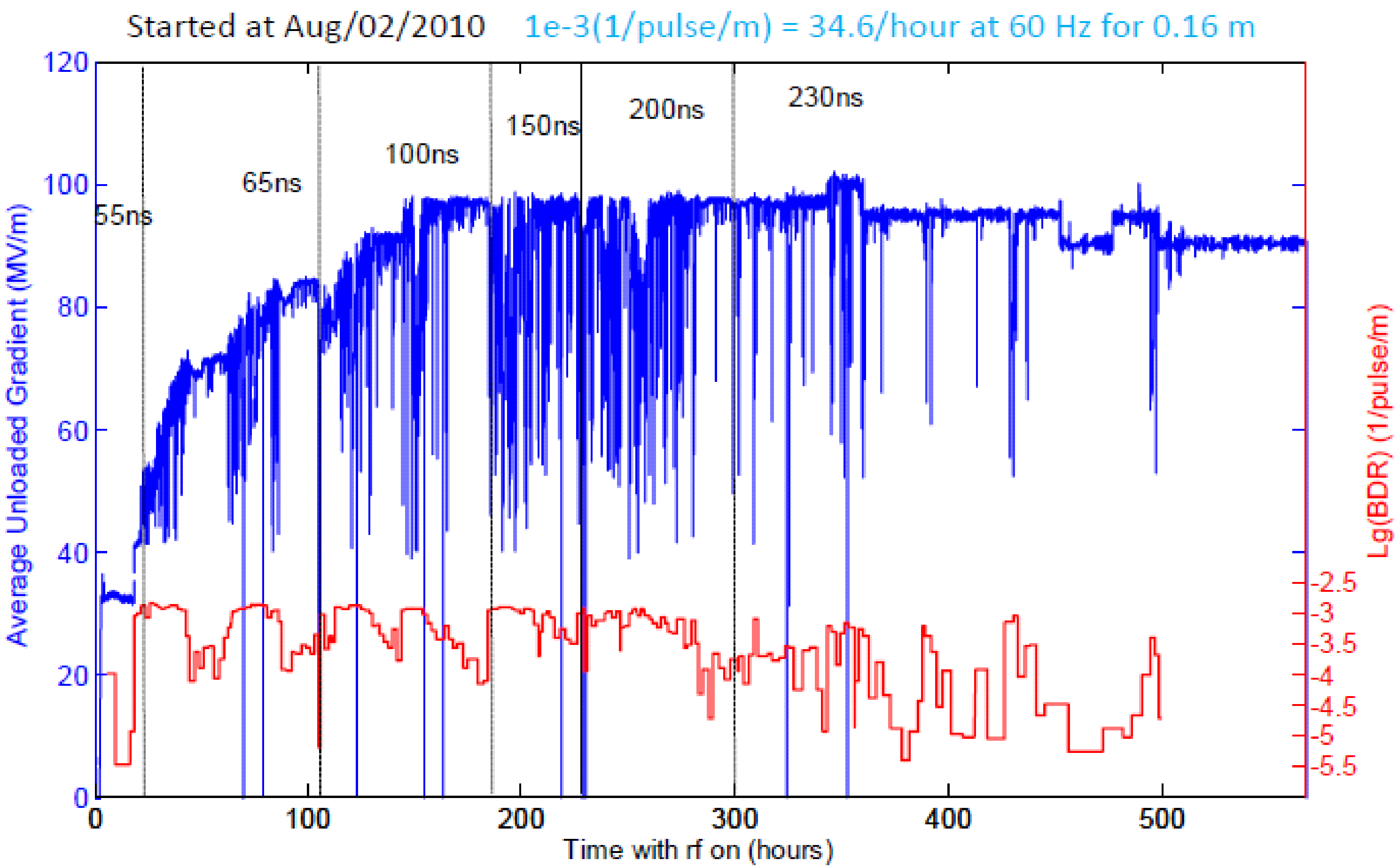
RF measurement
Before high power test





after high power test

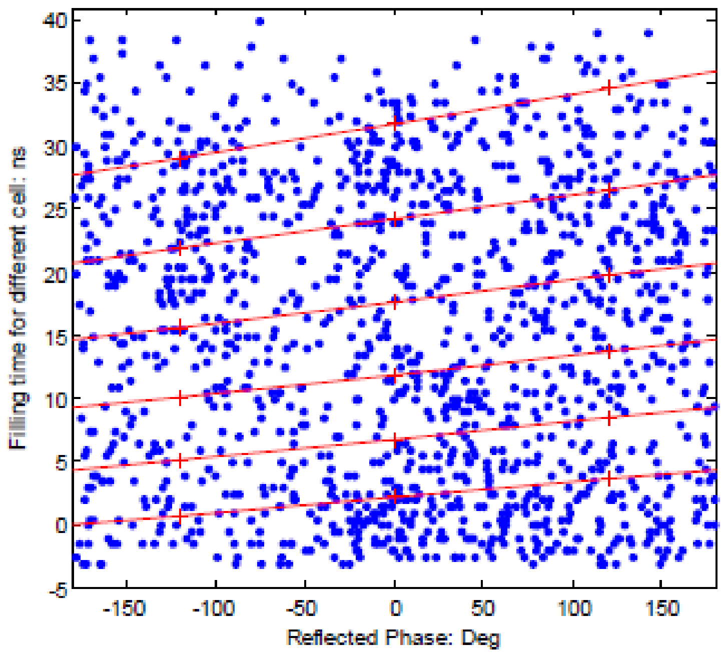
RF Process Results T18_Disk_2 Made by CERN

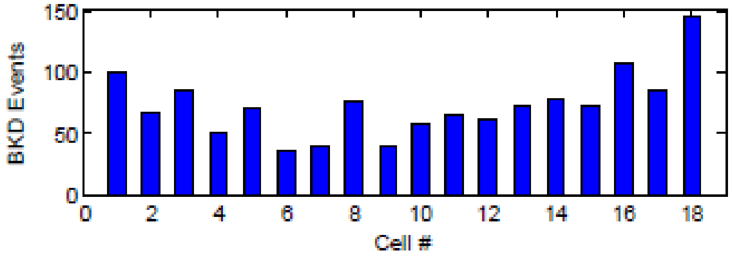


Final BDR at 90 MV/m@230ns is 1.3e-6/pulse/m

Faya Wang @ SLAC

All Breakdown Distribution for T18_CERN_2

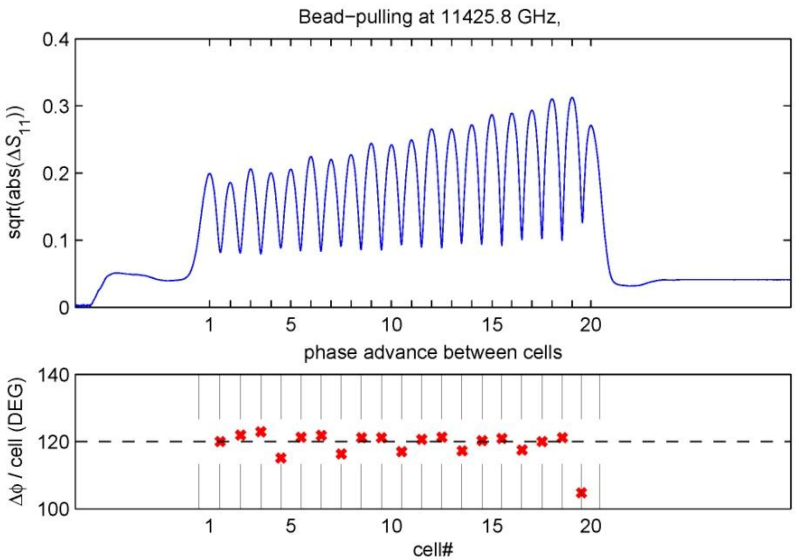


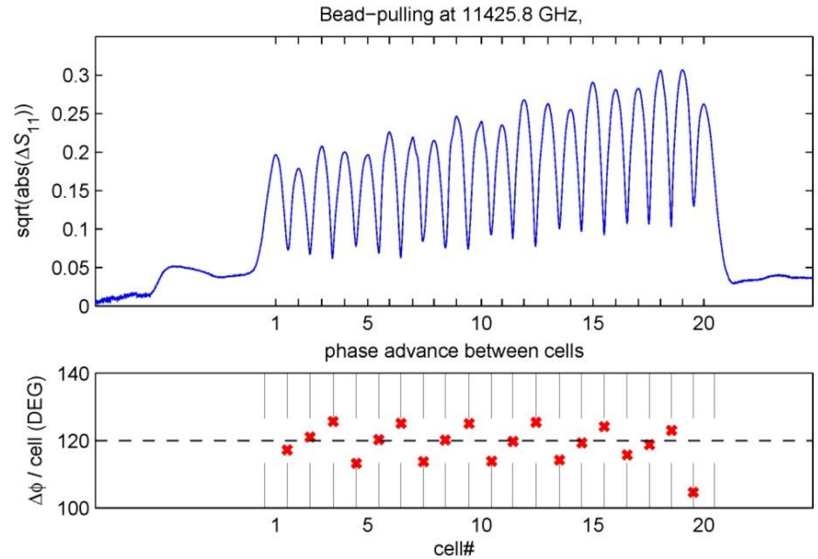


Faya Wang @ SLAC

Before high power test

After high power test





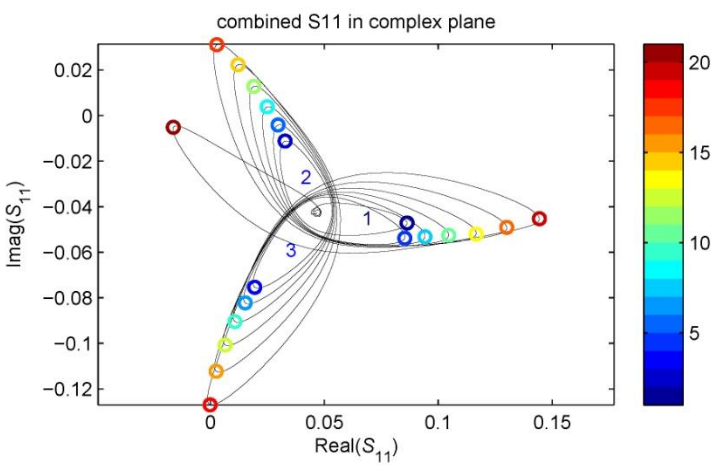


Figure 9: Bead-pulling at 11425.8 GHz

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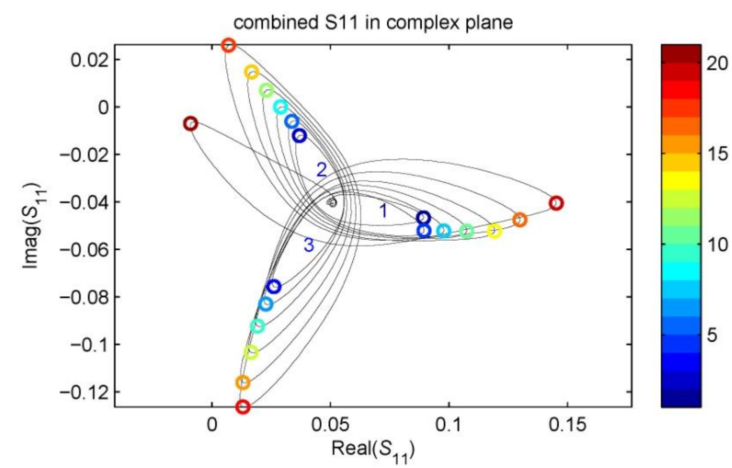

Figure 10: Bead-pulling at 11425.8 GHz

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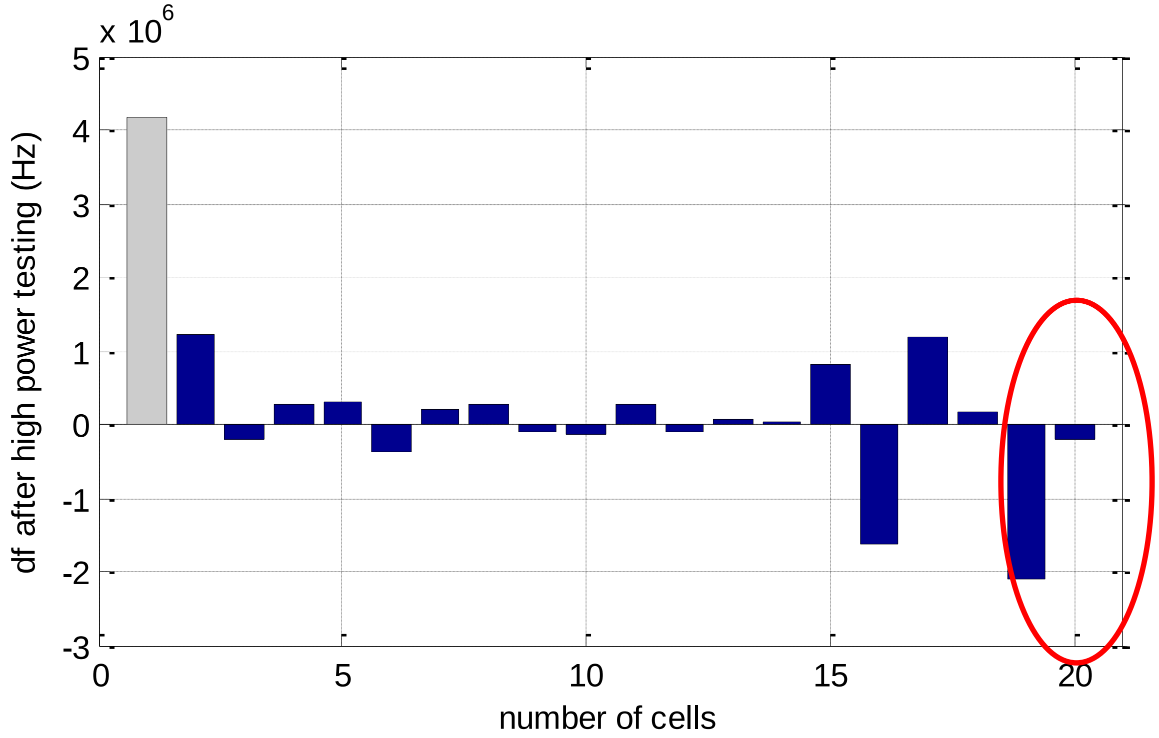
Increased standing wave

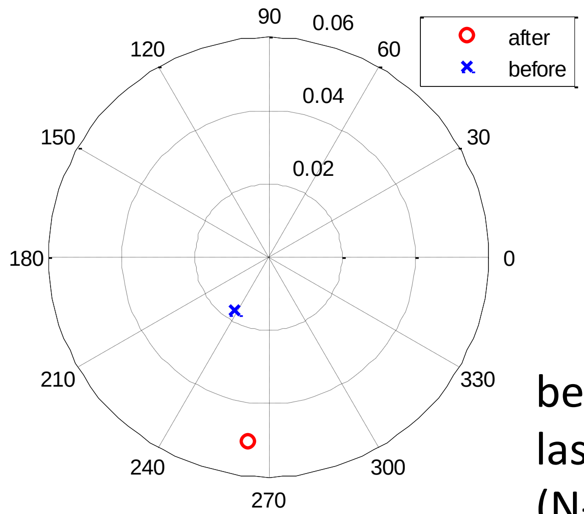
Regular cells are fine

Analysis using the code for tuning from bead-pull data

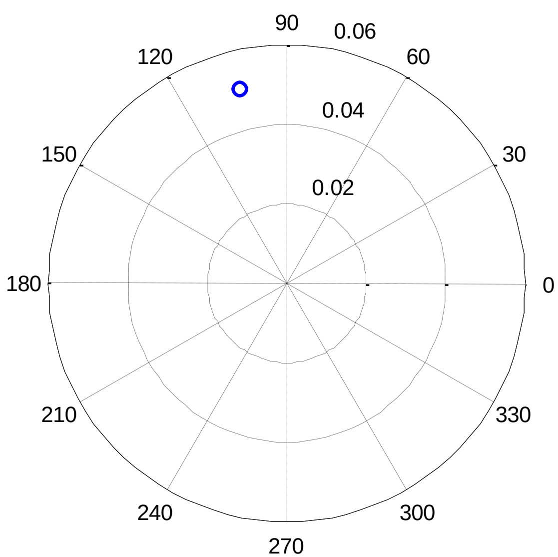


- See detuning of input matching cell
- The detuning of last two cells are calculated from the standing wave patter, or the reflection from the output matching. Details next slides. (Note: while tuning, these two cells are tuned to correct the standing wave).

Standing wave pattern
→Reflection (both phase and amplitude)



before
last regular cell
(N-1)



before
Matching cell
(N)

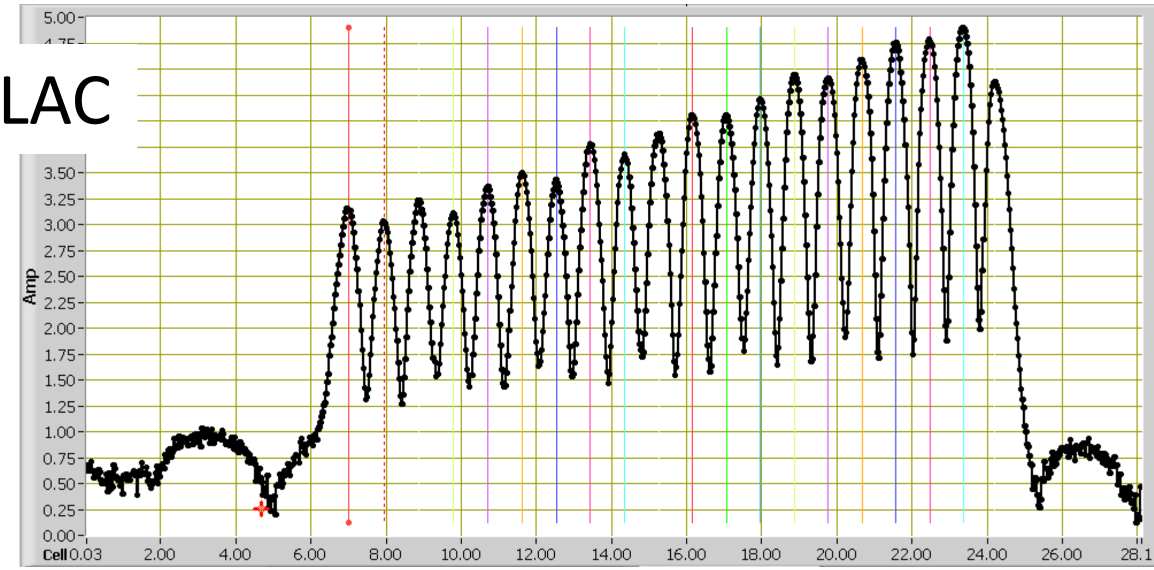
- The imaginary part of this reflection can come from detuning of the last regular cell cell(N-1). Decrease of frequency
- Or the matching cell: Cell(N) Increase of frequency:
- Important note: the phase advance between the last two cells is ~100deg. Not 120 deg!

- Note: imag part of reflection comes from detuning, while real part of reflection comes from unmatched coupling

Amplitude Measurement of T18-SLAC #1 Before and After High Power Test

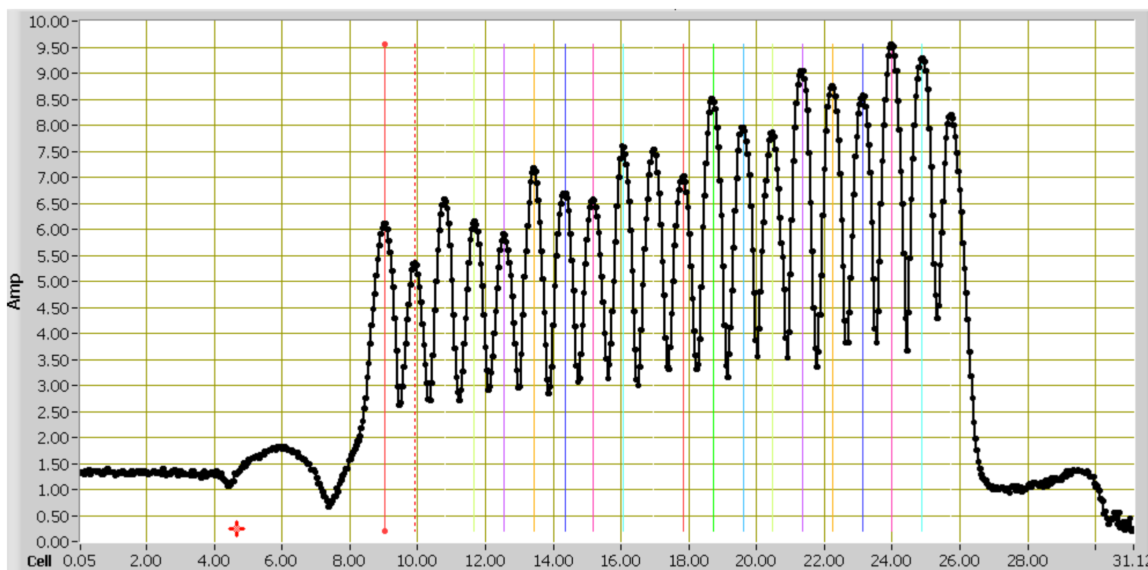
Juwen Wang @ SLAC

11421.7 MHz at 21.32°C, N2
Before high Power test

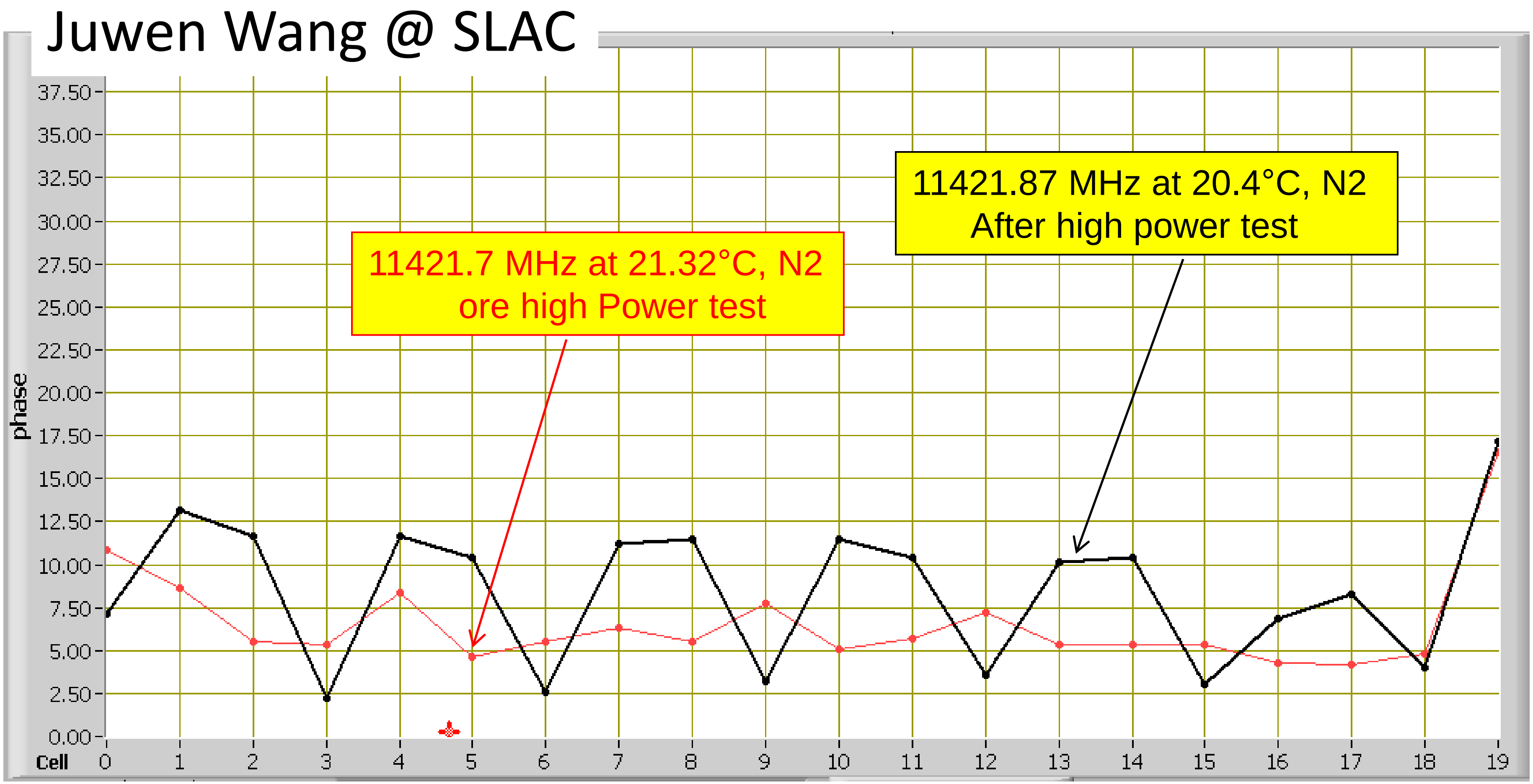


1350 hours

11421.87 MHz at 20.4°C, N2
After high power test



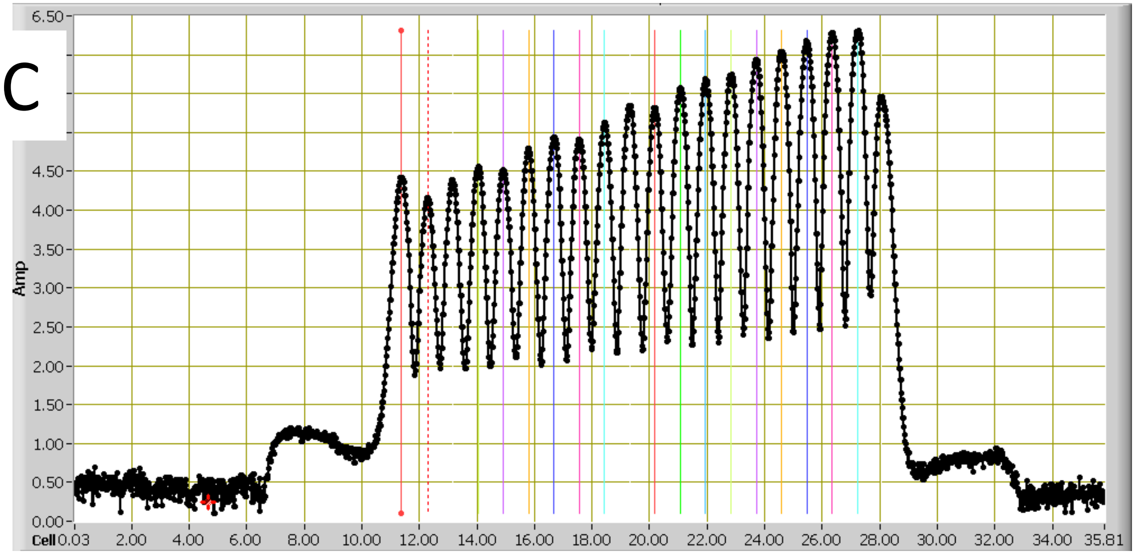
Phase Measurement of T18-SLAC #1 Before and After High Power Test



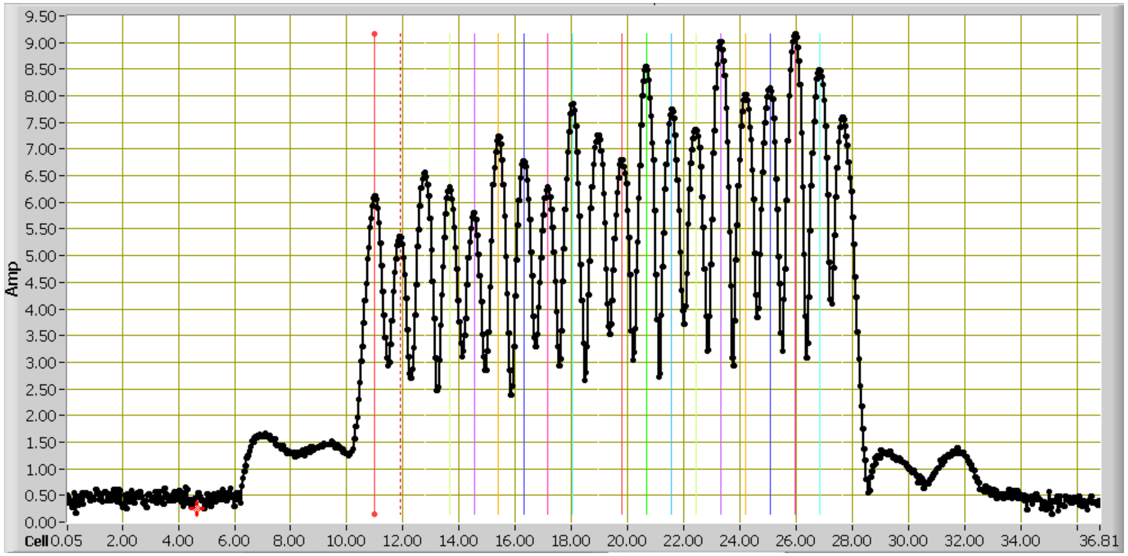
Amplitude Measurement of TD18-SLAC Before and After High Power Test

Juwen Wang @ SLAC

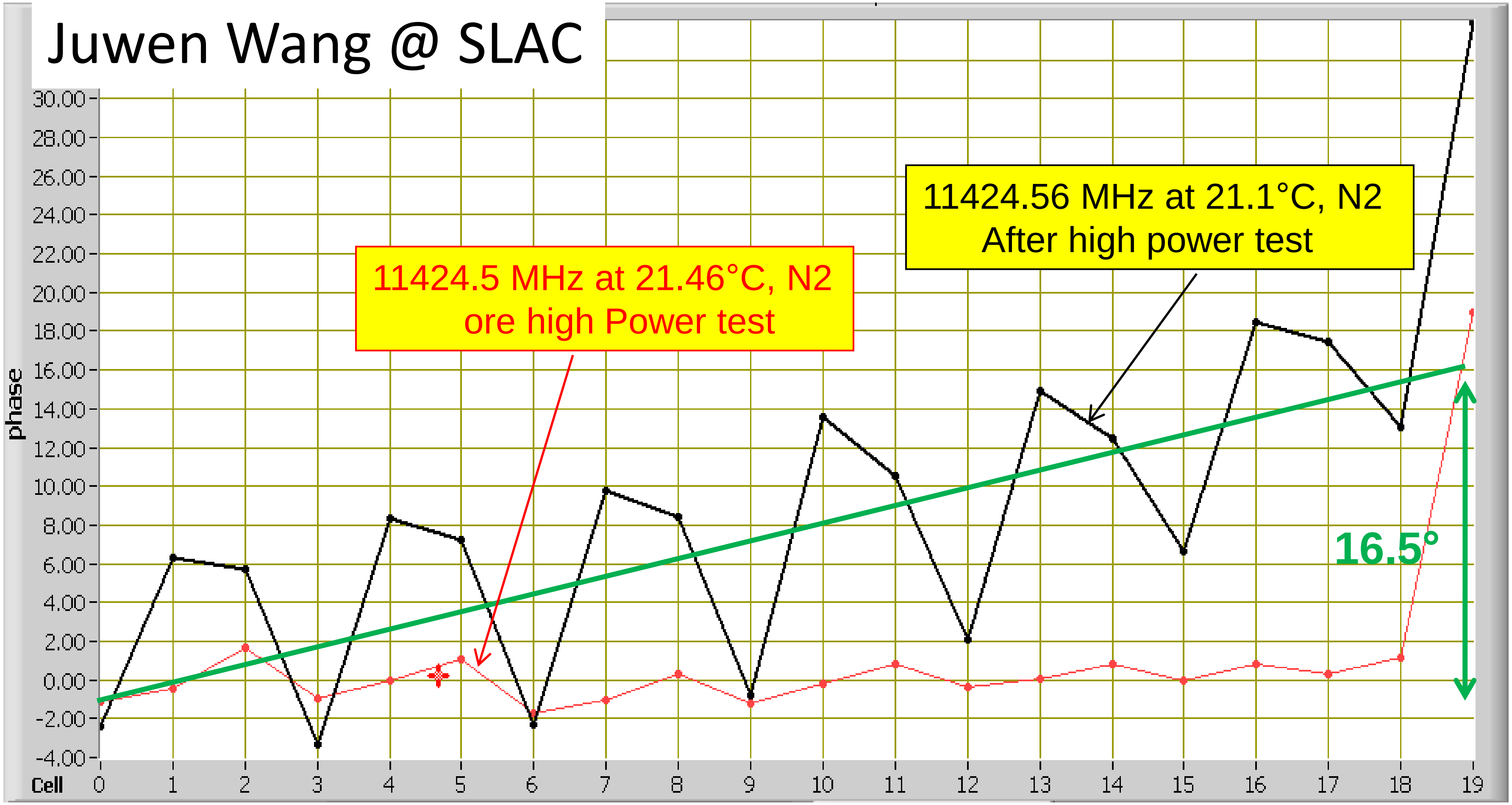
11424.5 MHz at 21.46°C, N2
Before high Power test



11424.56 MHz at 21.1°C, N2
After high power test



Phase Measurement of TD18-SLAC Before and After High Power Test



Select bead pulling frequencies based on the same measurement condition for both before and after high power test

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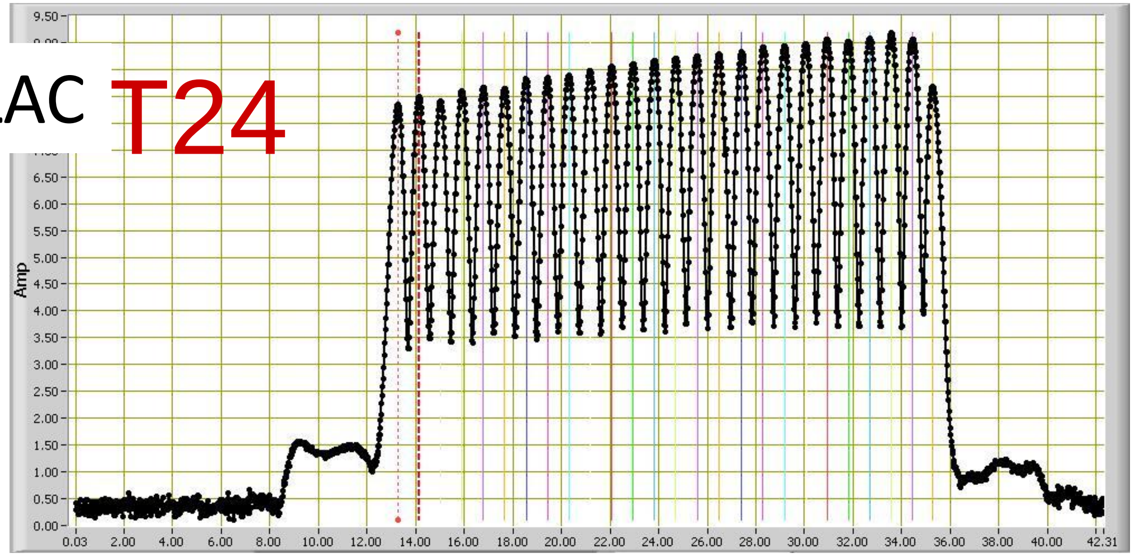
Amplitude Measurement of T18-SLAC #1 Before and After High Power Test

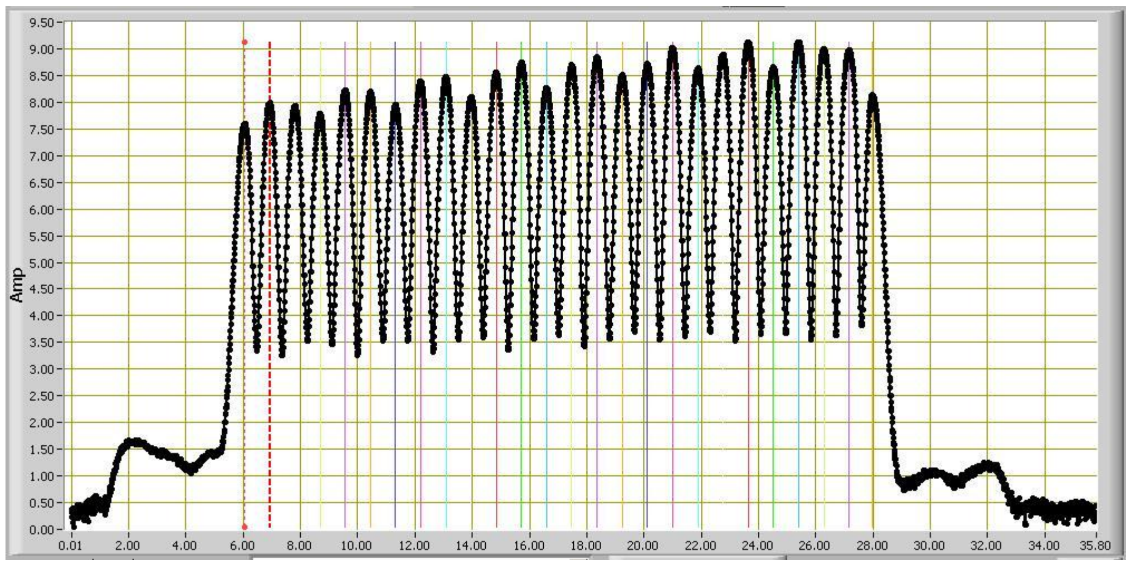
Juwen Wang @ SLAC

T24

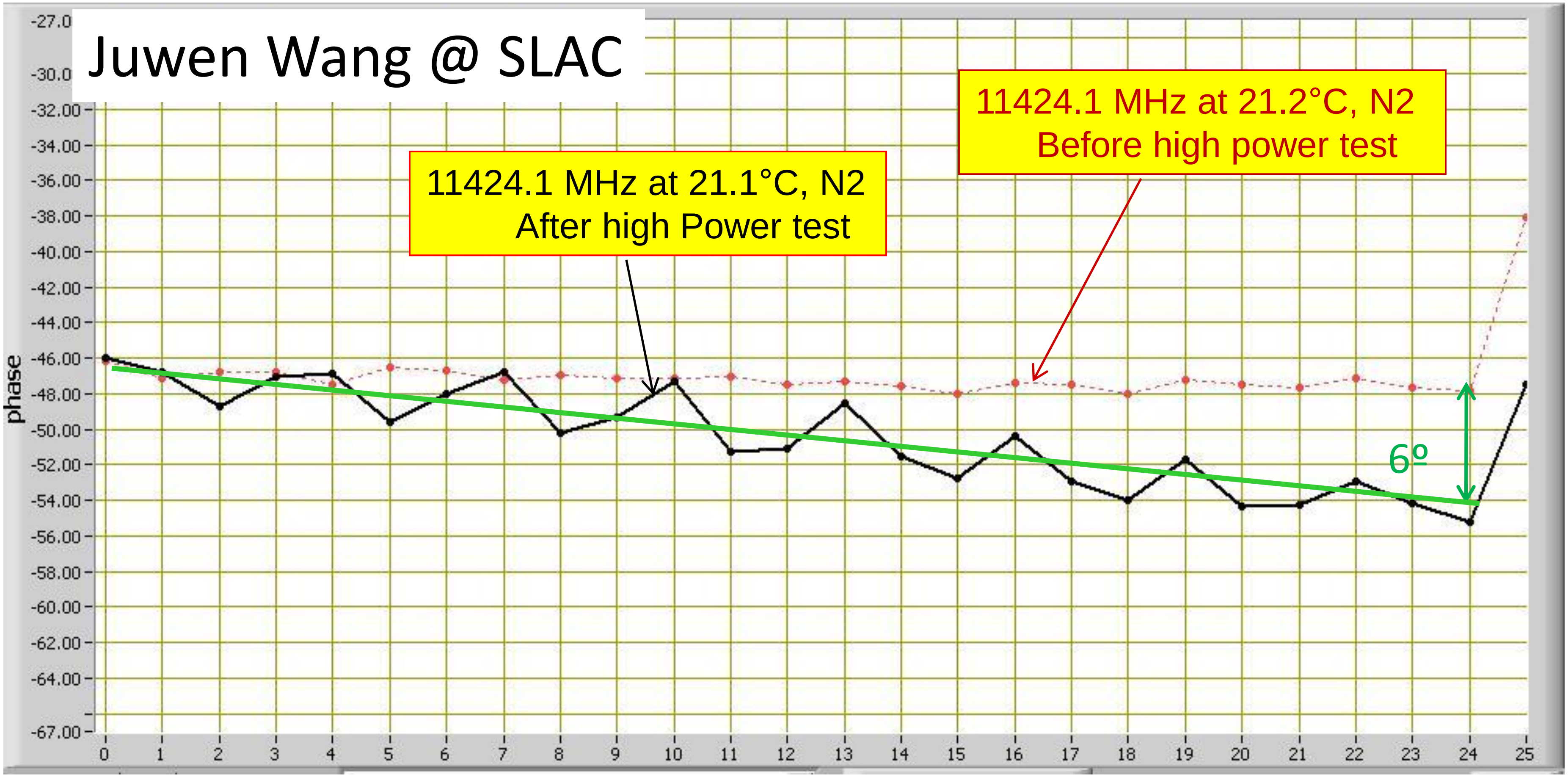
11424.1 MHz at 20.02°C, N2
Before high Power test



11424.15 MHz at 20.4°C, N2
After high power test

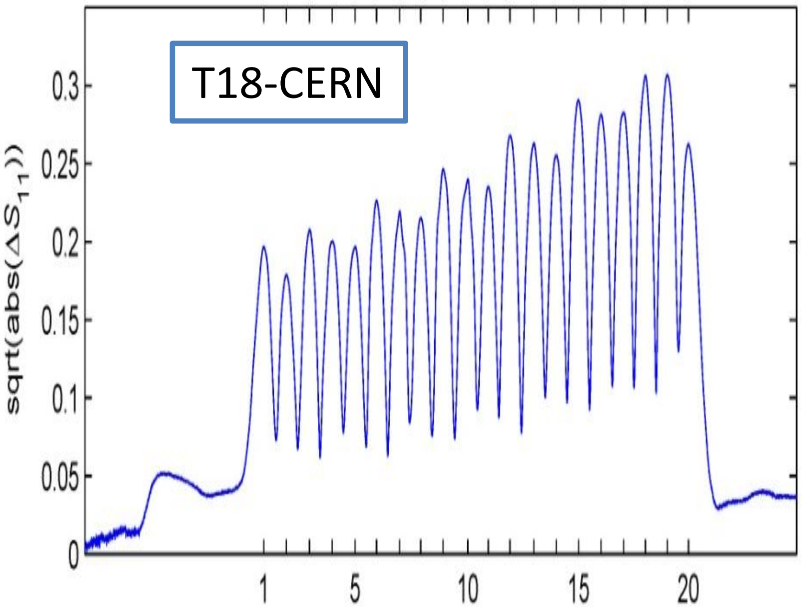


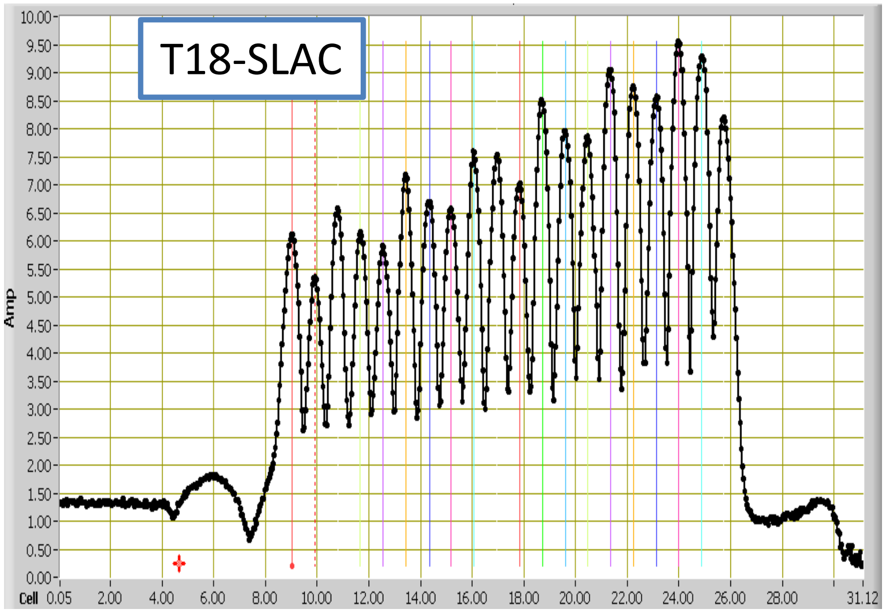
Phase Measurement of T24-SLAC Before and After 800 Hours High Power Test

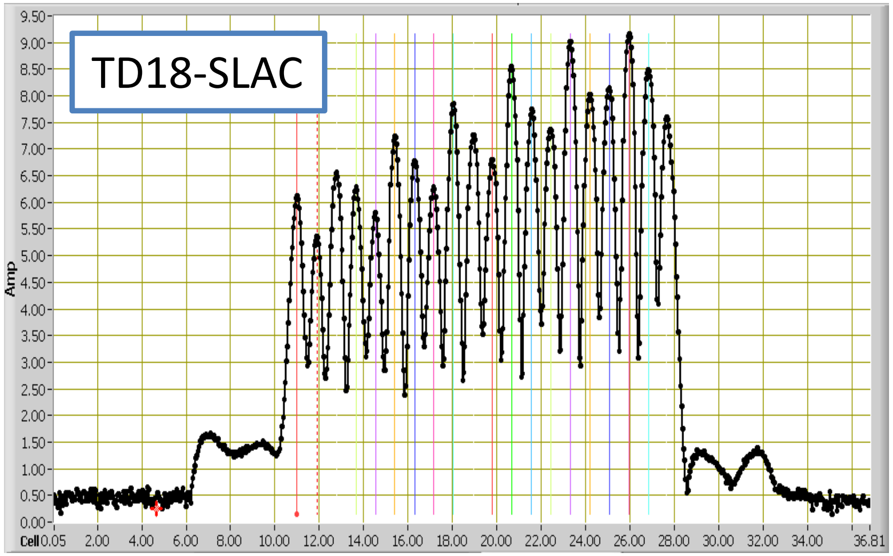


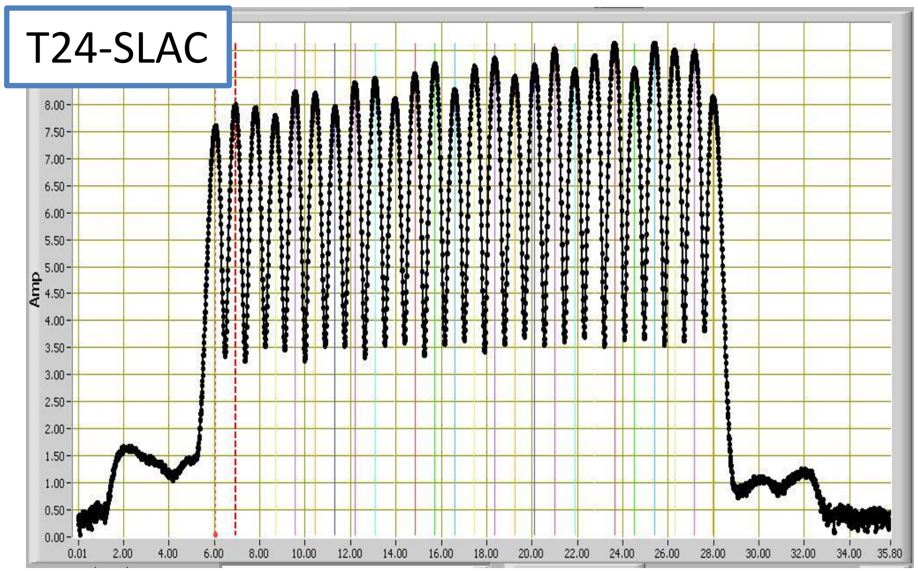
Select bead pulling frequencies based on the measurement condition to get 2π/3 phase advance for both before and after high power test

Similar Standing-Wave pattern for T(D)18









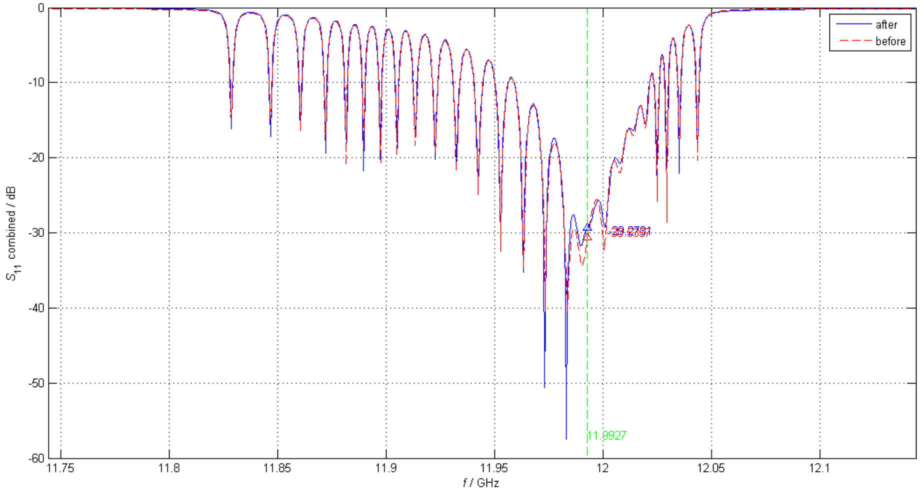
Summary of the detuning

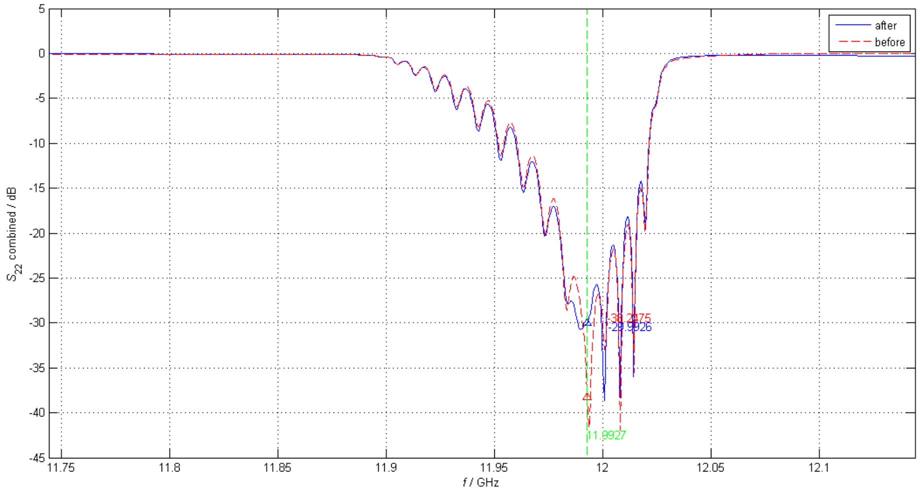
	T18 SLAC N1	TD18 SLAC	T24 SLAC	T18 CERN N2
Measured at	SLAC	SLAC	SLAC	CERN
Output matching				
Standing Wave (SWR)	1.06	1.2	1.05	1.1
(reflection)	0.03, -30dB	0.1,-20dB	0.025, -32dB	0.05, -26dB
Estimate df if one cell detuned	2MHz	7MHz	2.5MHz	3MHz
from standing wave pattern	+F@N cell *or* -F@N-1 cell	+F@N cell *or* -F@N-1 cell	+F@N cell	+F@N cell *or* -F@N-1 cell
Regular cells				
Total phase shift		-16 deg	+6 deg	
~df		+1 MHz	-0.3 MHz	

Note: T(D)18 structures have similar design where the phase advance between last two cells is ~100 deg. Making it hard to tell at Nth or at N-1th cell. It seems at the last cell.

RF measurement before/after baking

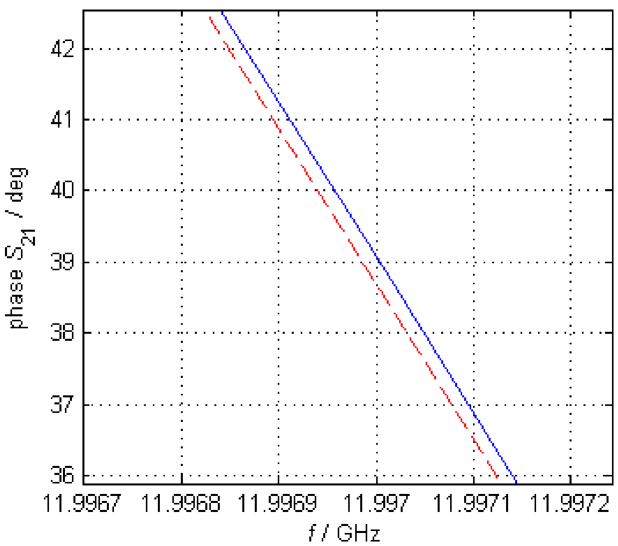
- T24 12G N1
  - Same configration
  - Temperature df calculated

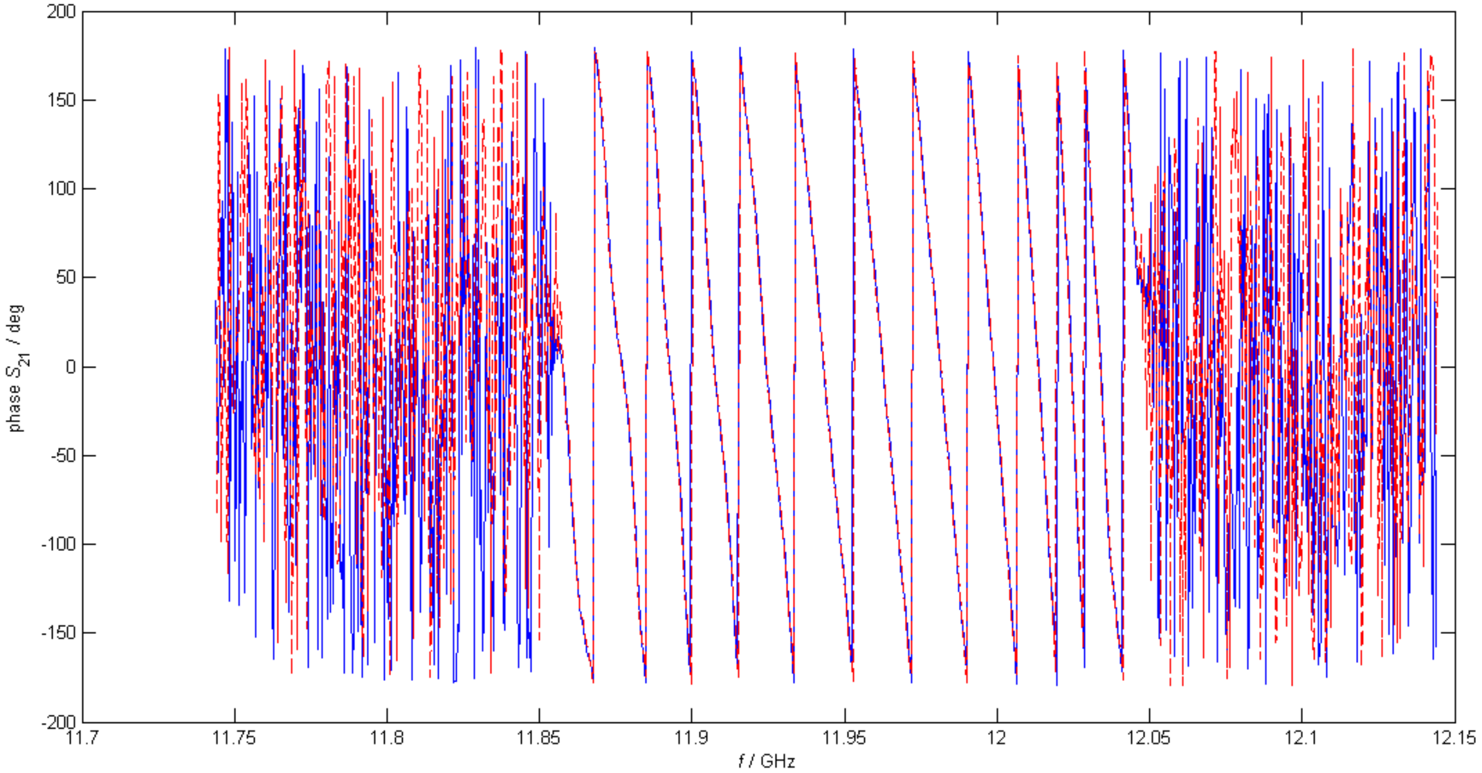




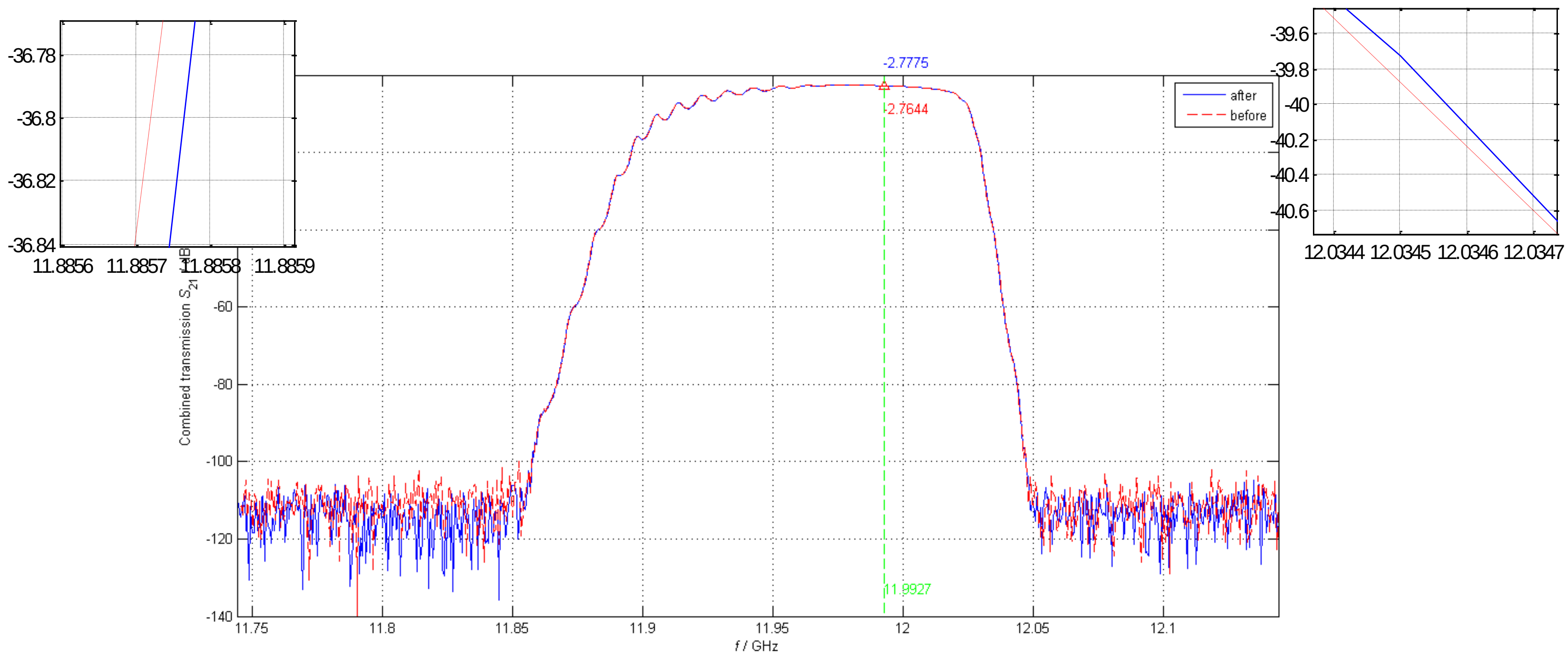
Phase S21

- Delta f ~10kHz

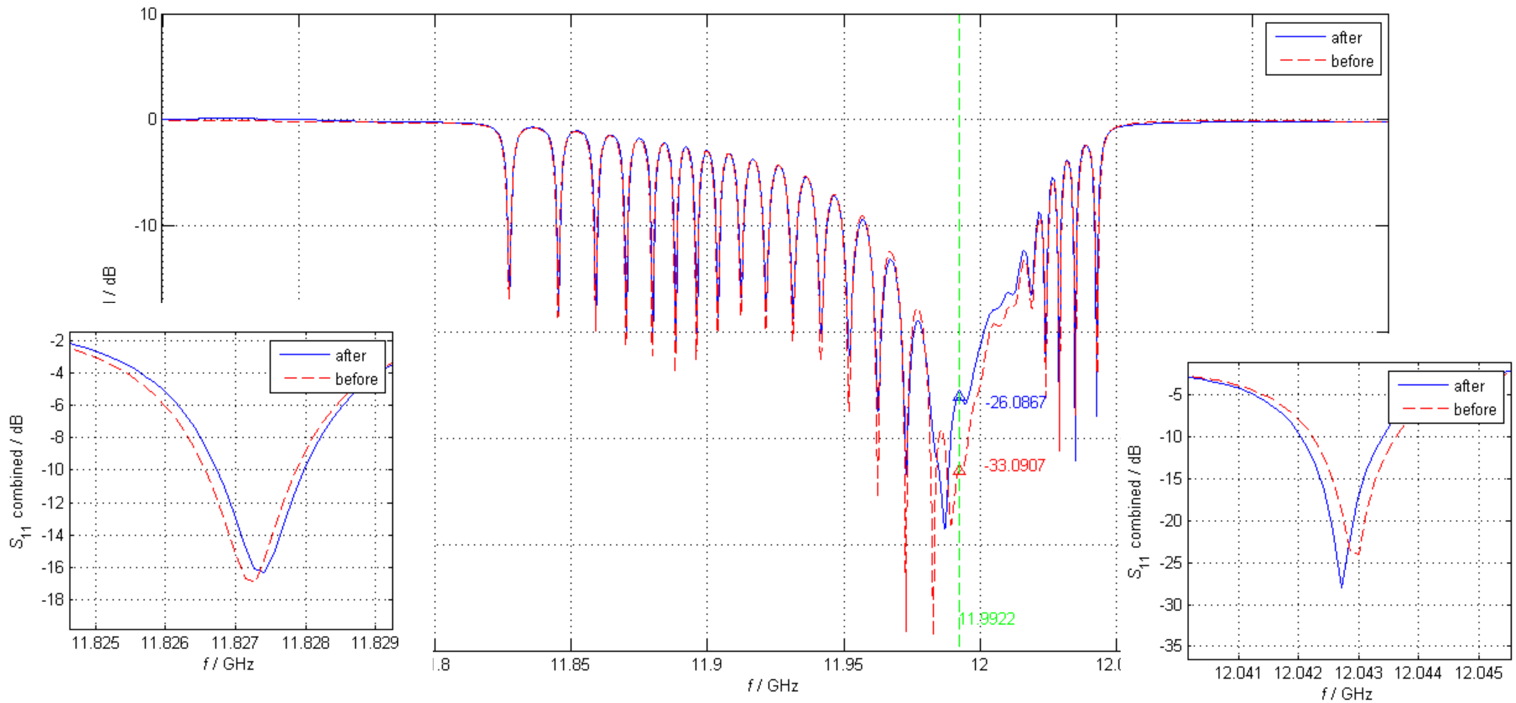




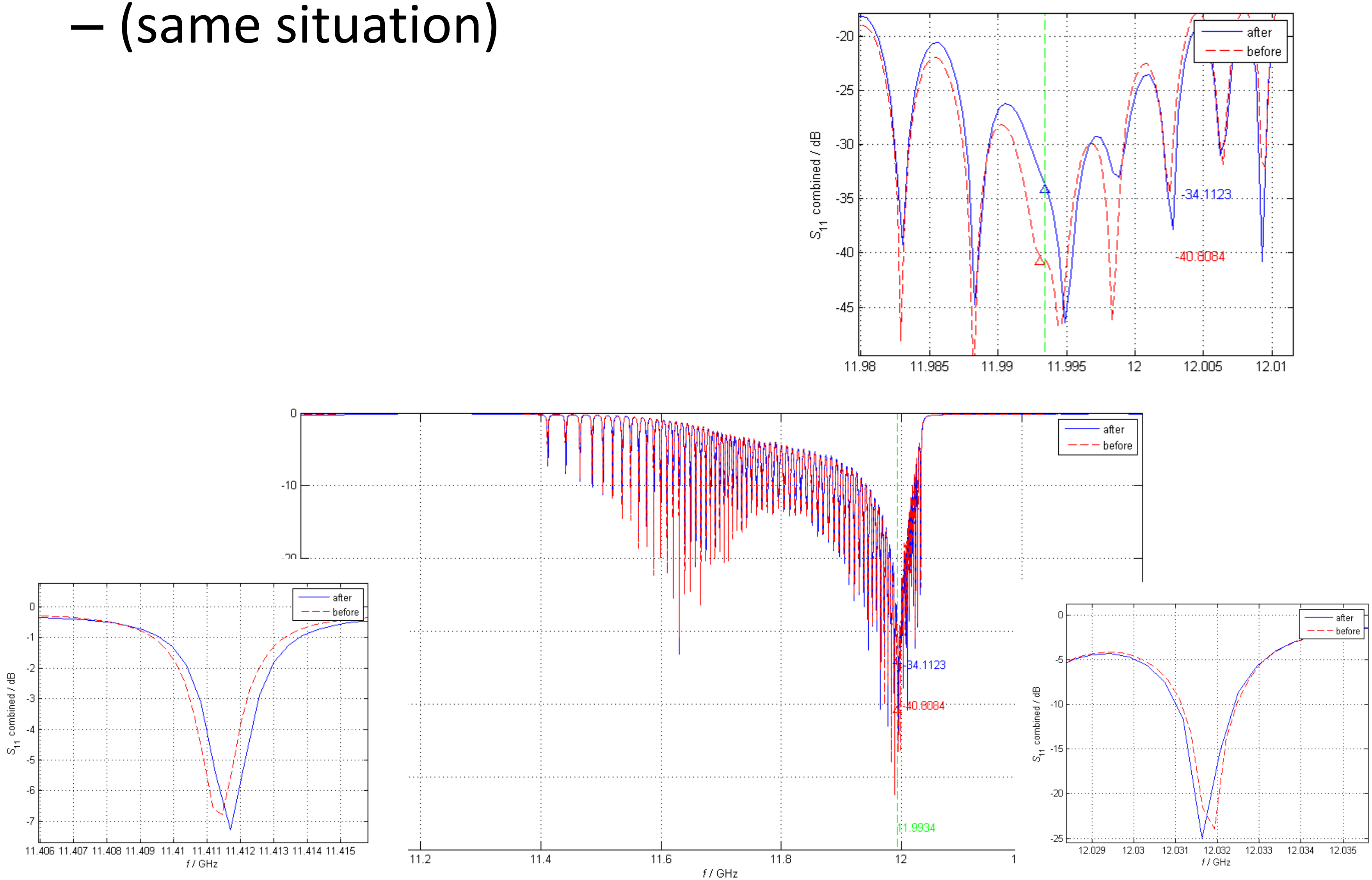
S21 mag
df ~30kHz



- T24 12G N2, leak fix at mode launcher
  - With and without wire, no direct comparison
  - Phase compare N/A because change of RF flange adapter
  - df < 50kHz, Reflection increase

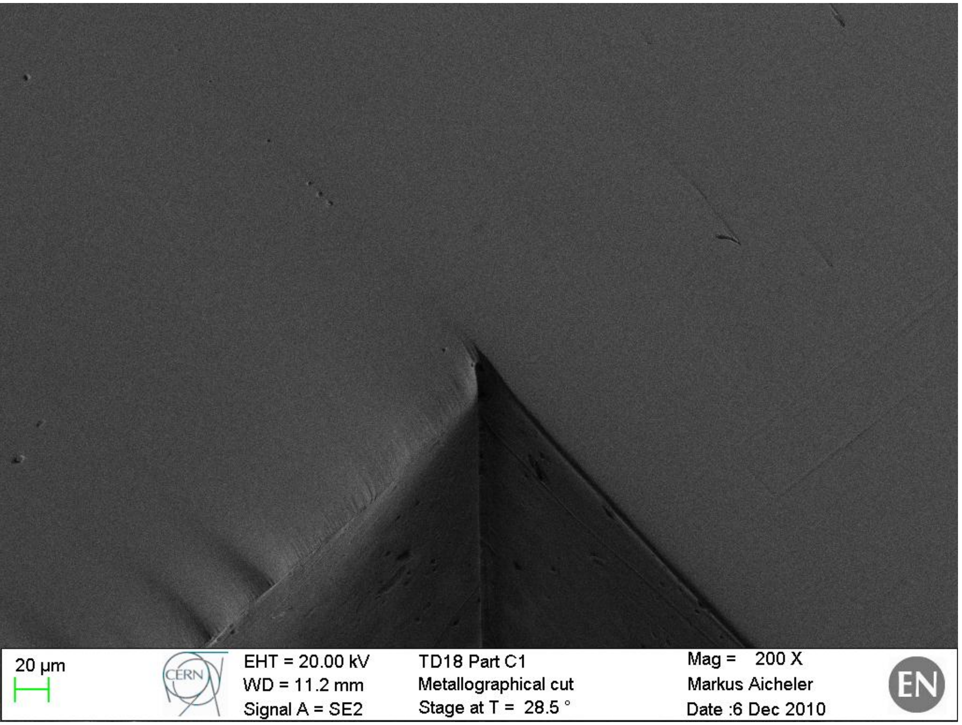


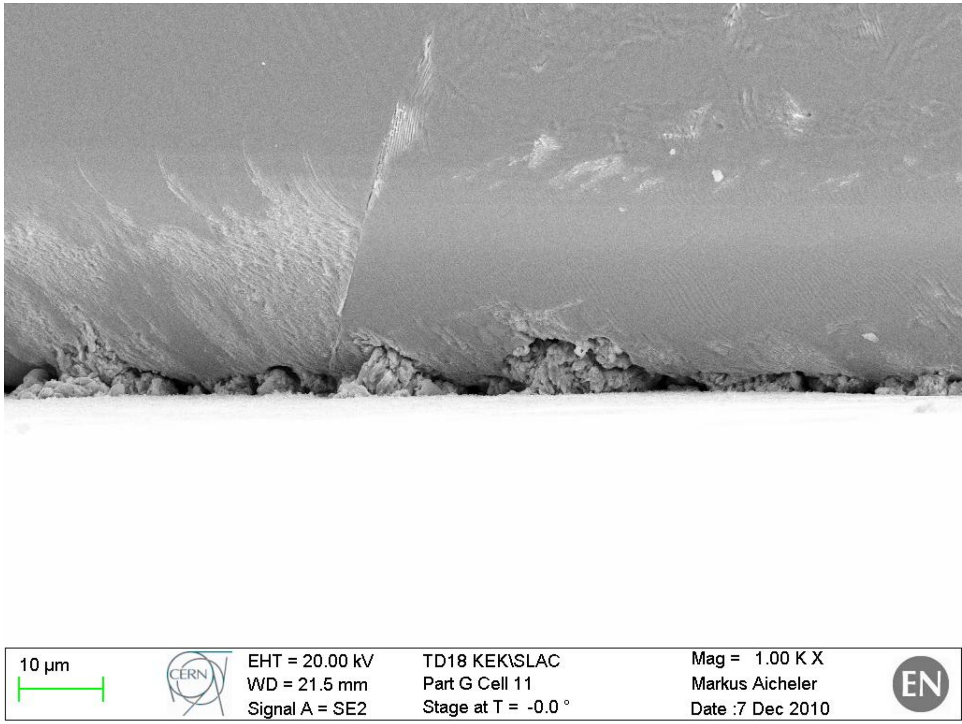
- CERN PSI N2 after baking, df<100kHz
  - (same situation)



TD18 post-HPT @CERN

- TD18 post-HPT (High Power Test) analysis
  - 1. Chamfer

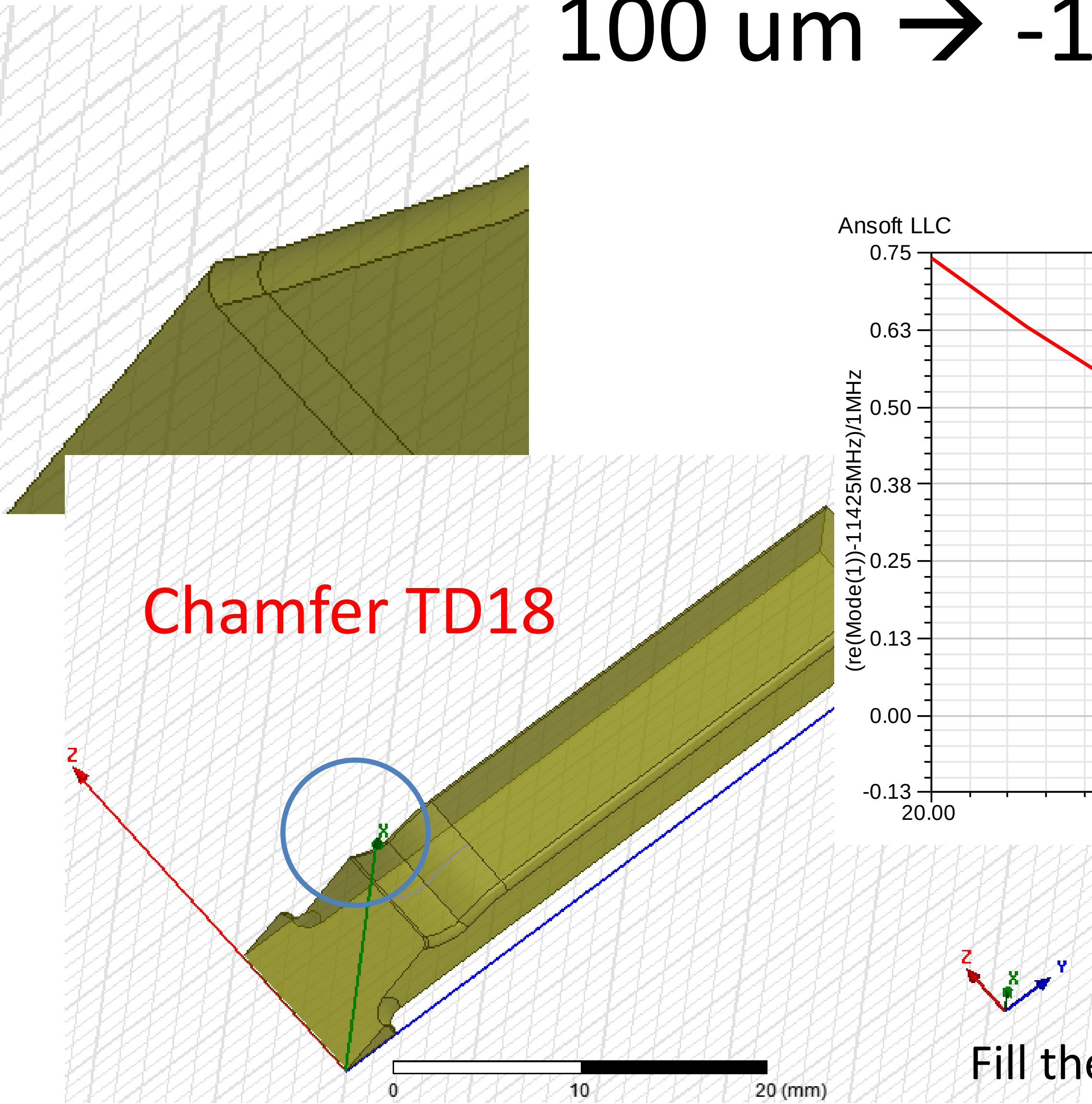


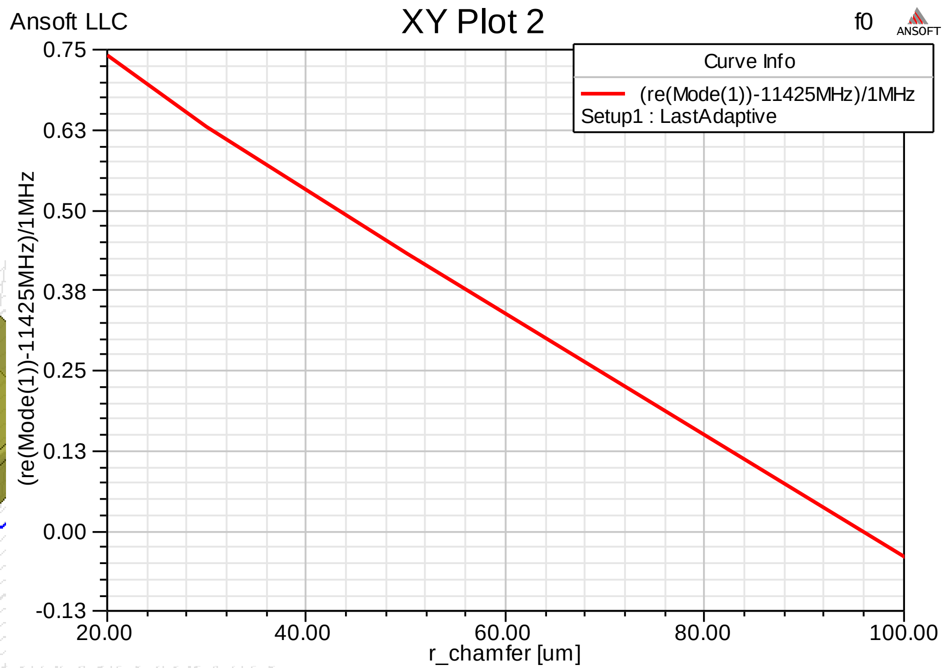


From: Markus Aicheler

TD18 Chamfer

100 um → -1MHz

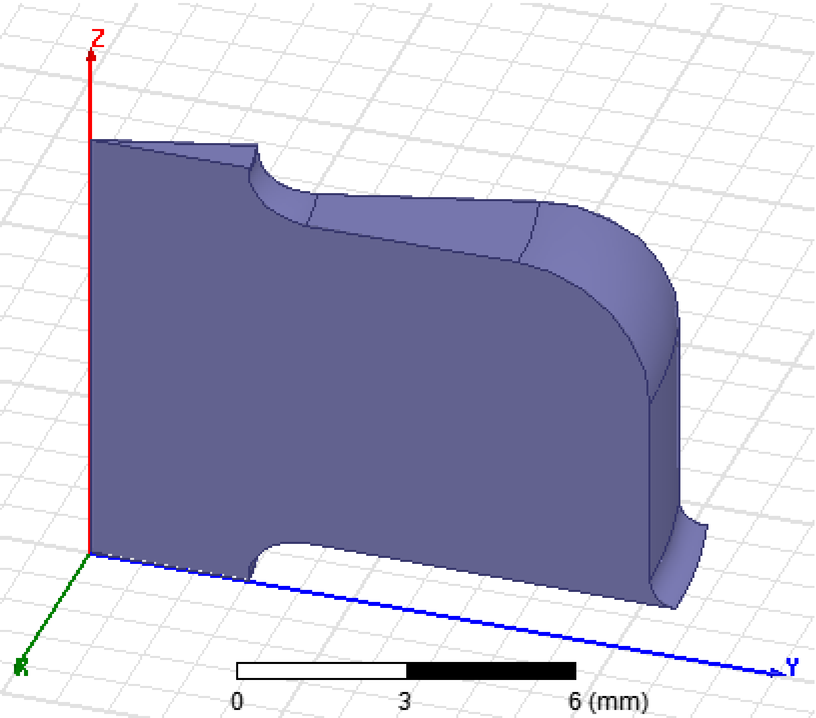


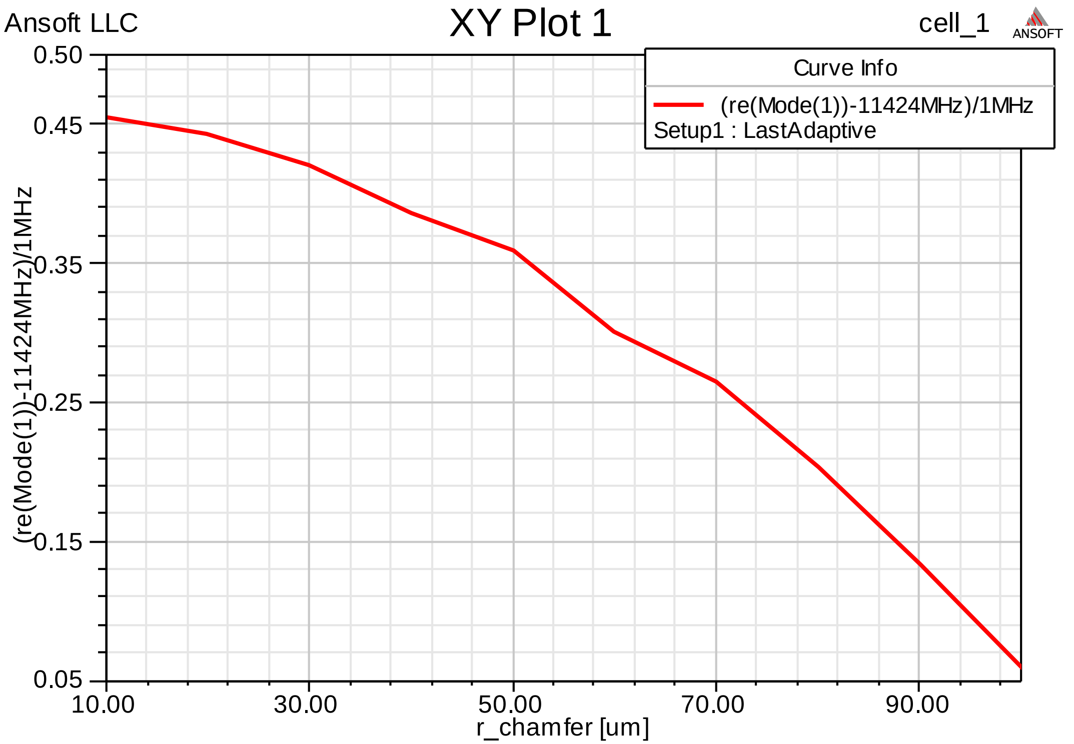


Fill the 100um Chamfer → +1MHz

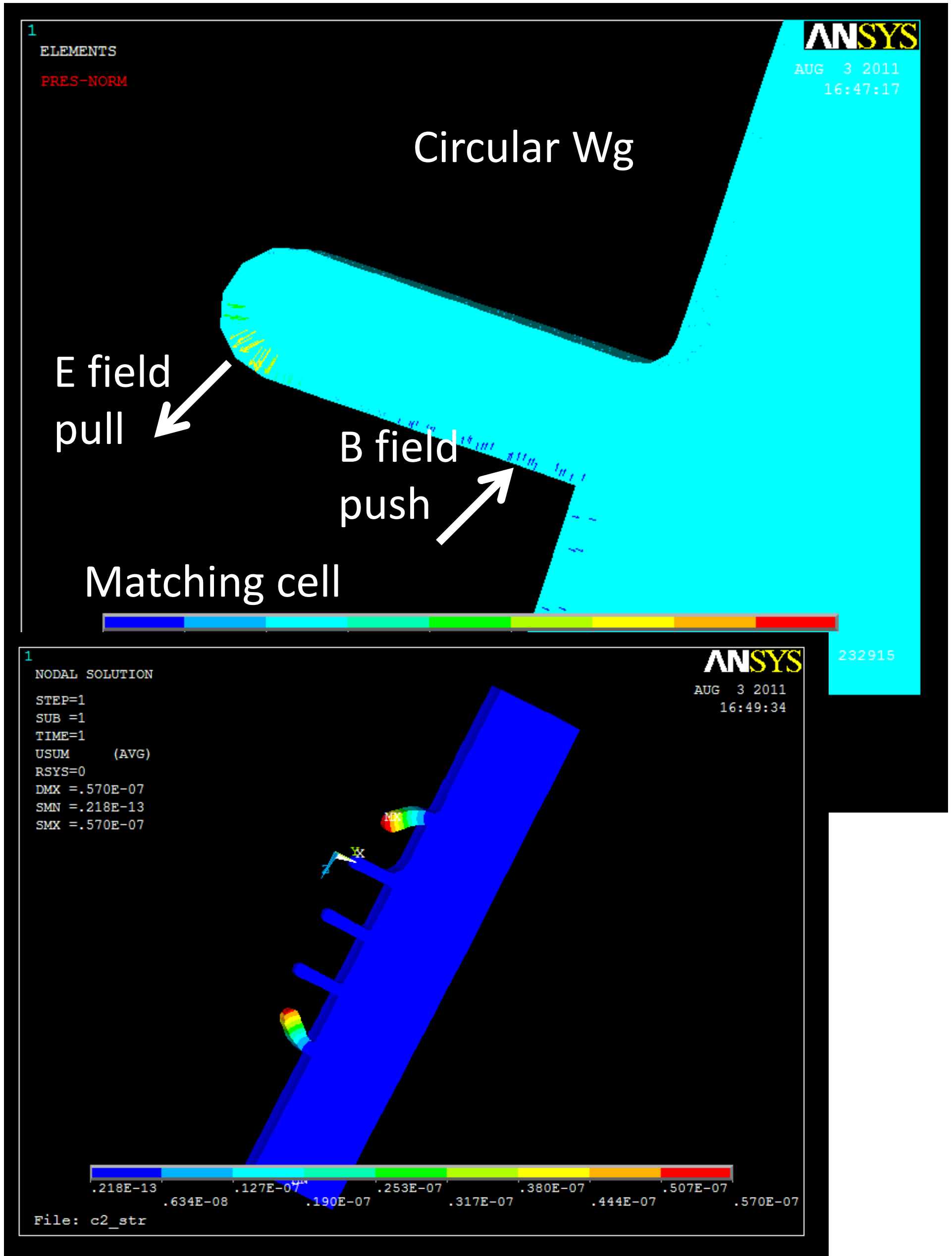
T18 chamfer

100 um → -0.5MHz



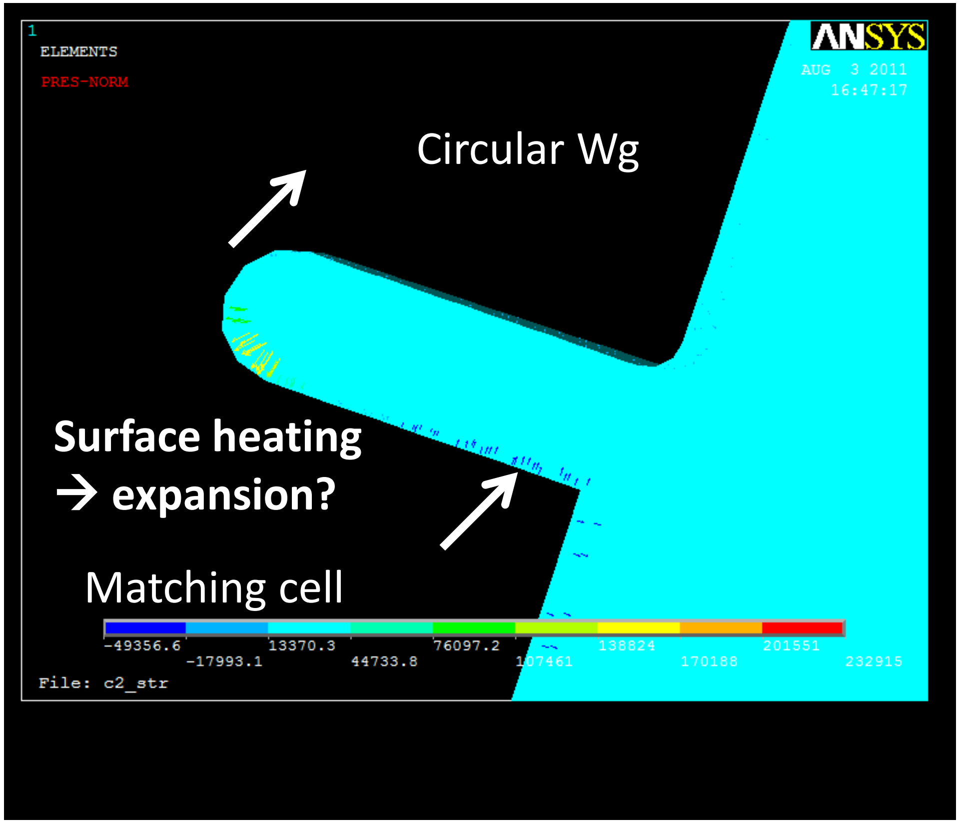


Electromagnetic field



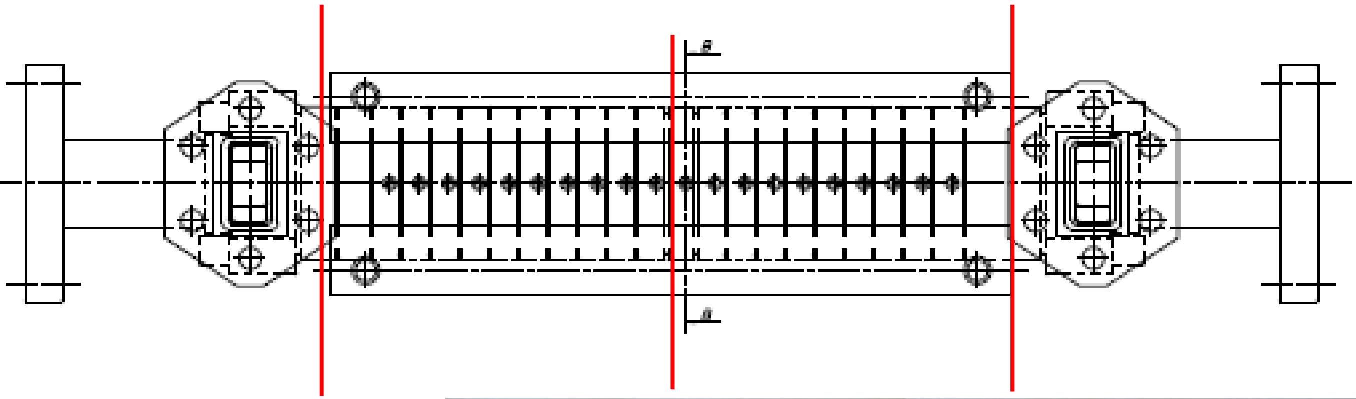
- Scaled to 150 MV/m Eacc
- P = (-epsilon0 E^2 + mu0 H^2)/4
- static simulation
- Material: Copper E = 110GPa
- Max deform: 0.06um, very small.
- 0.06um→ 12kHz
- not the right direction
- HFSS result: Iris deform 10um → ~ 2MHz

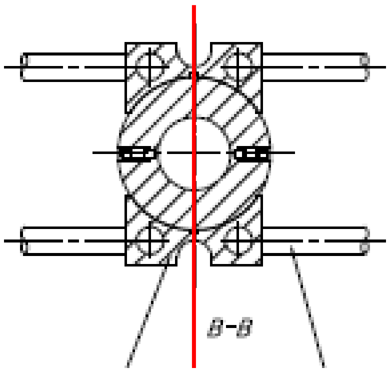
Asymmetry heating?

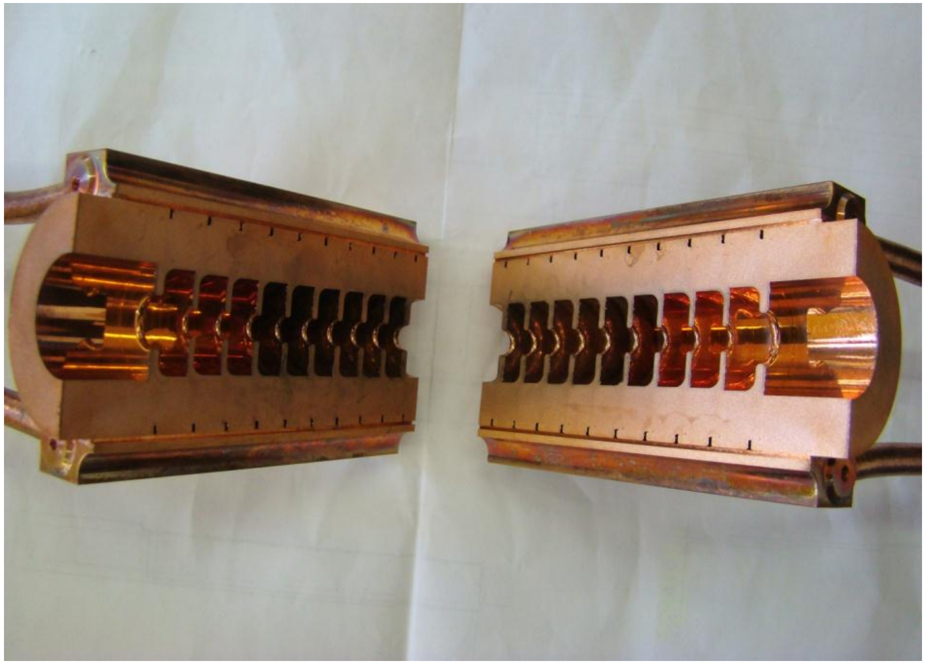


- The source of detuning is not clear, but we find that. The MHz detuning corresponds to a geometry change that can be measured!
- The structure is cut open and critical dimensions are measured

T18 CERN N2 Cut

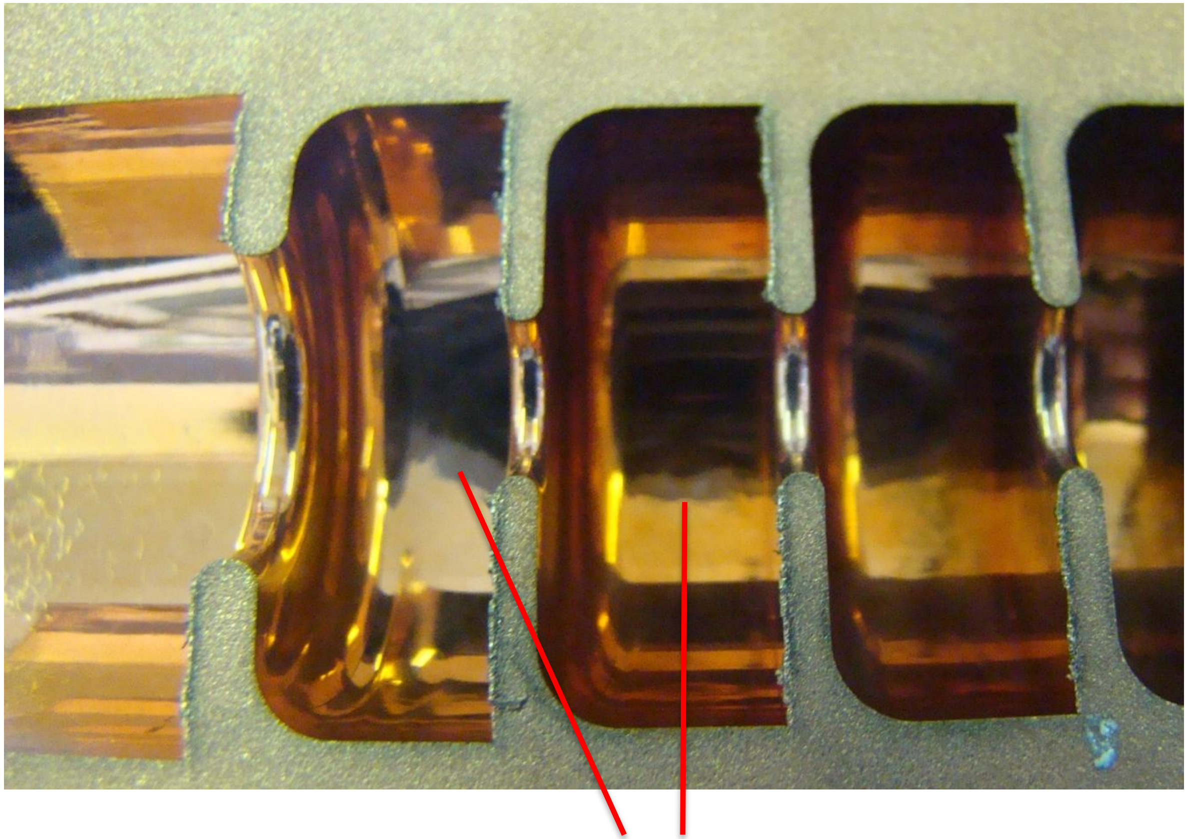






T18 CERN N2 Cut

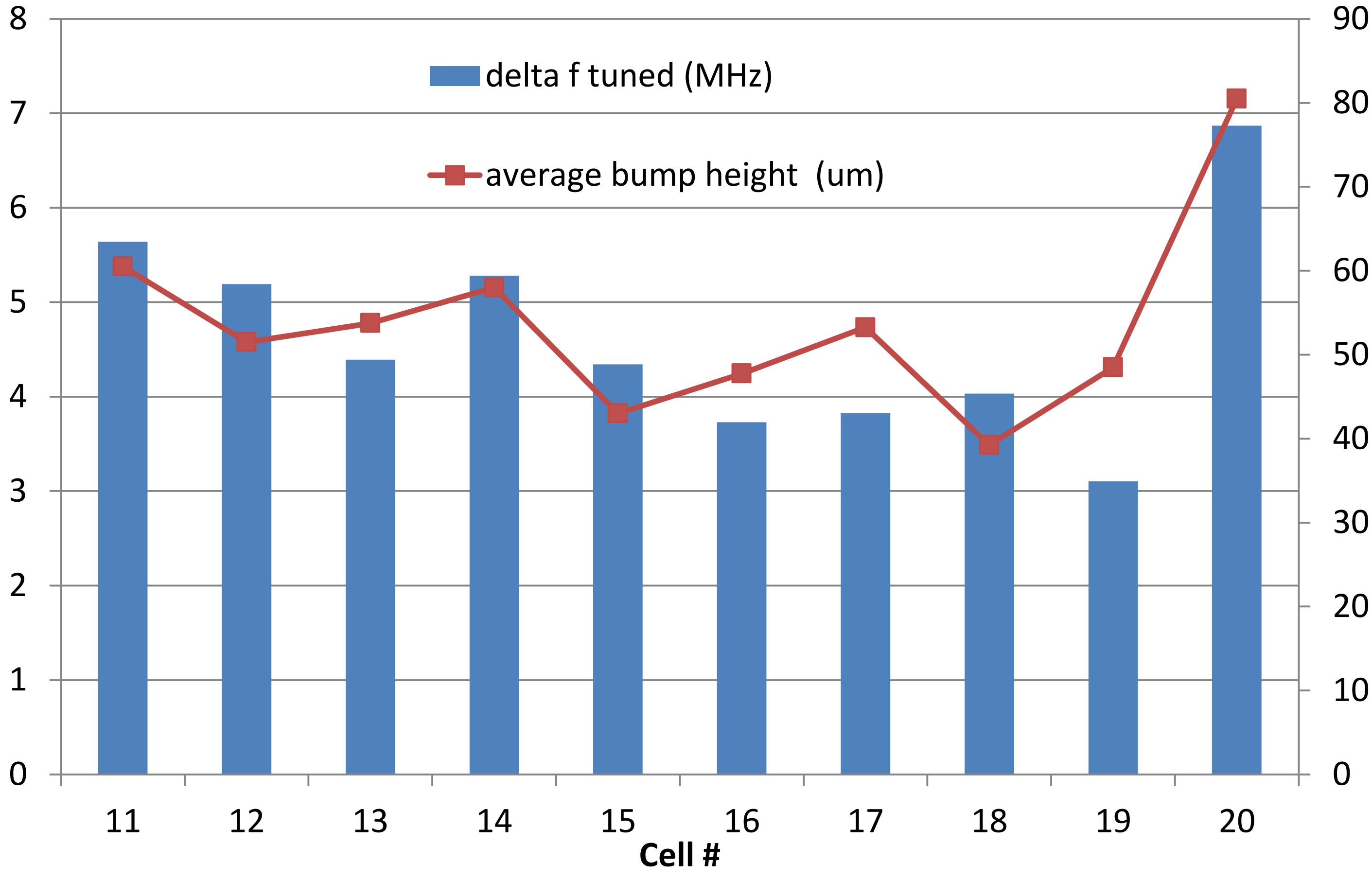
- 1: measure the profile of tuning bump, compare with the tuning history



Tuning bump visible by eye

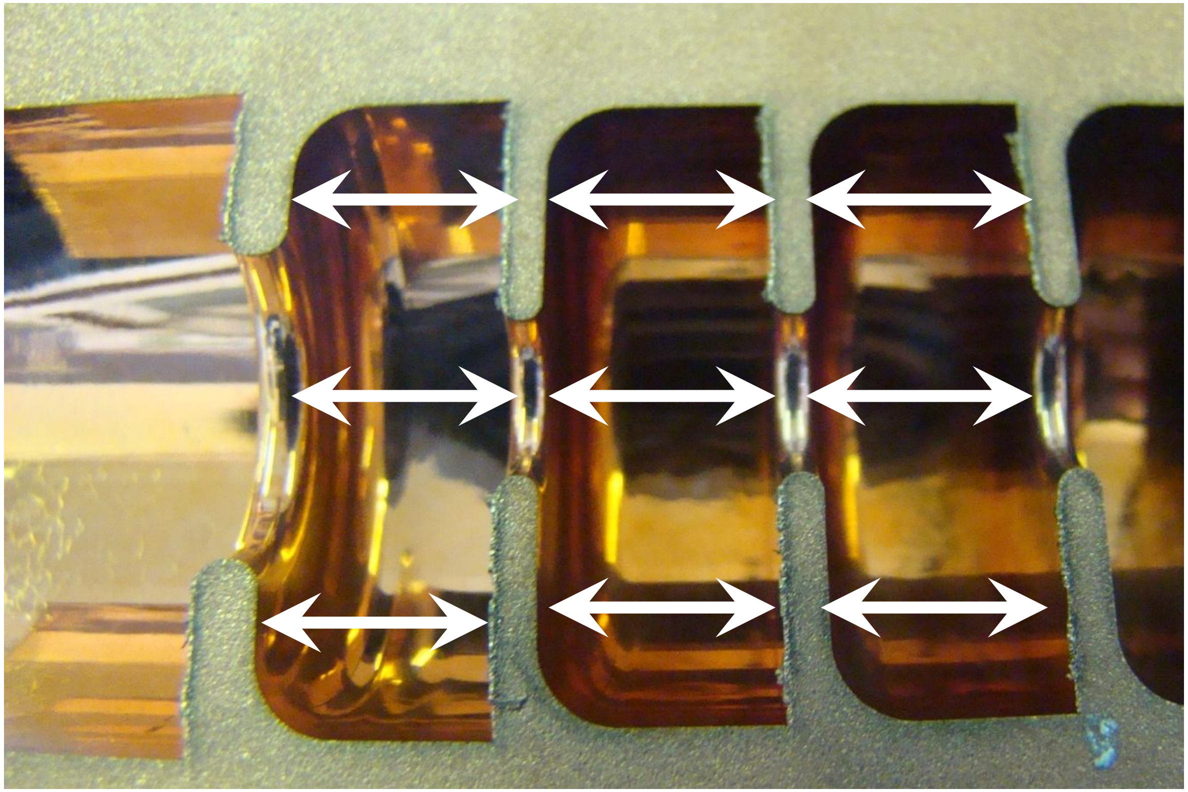
Height of tuning bump v.s. recorded tuning

- Good agreement “< +/- 1MHz”

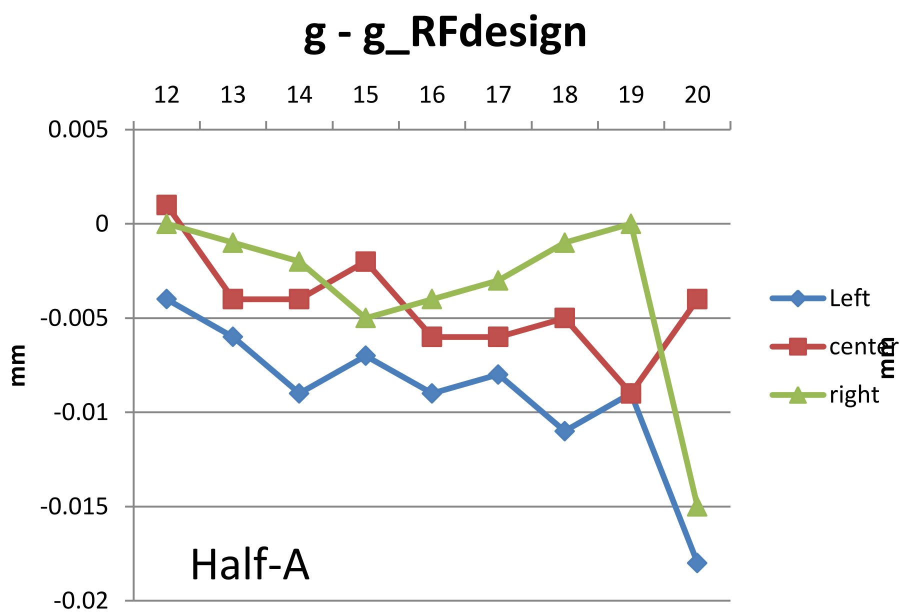


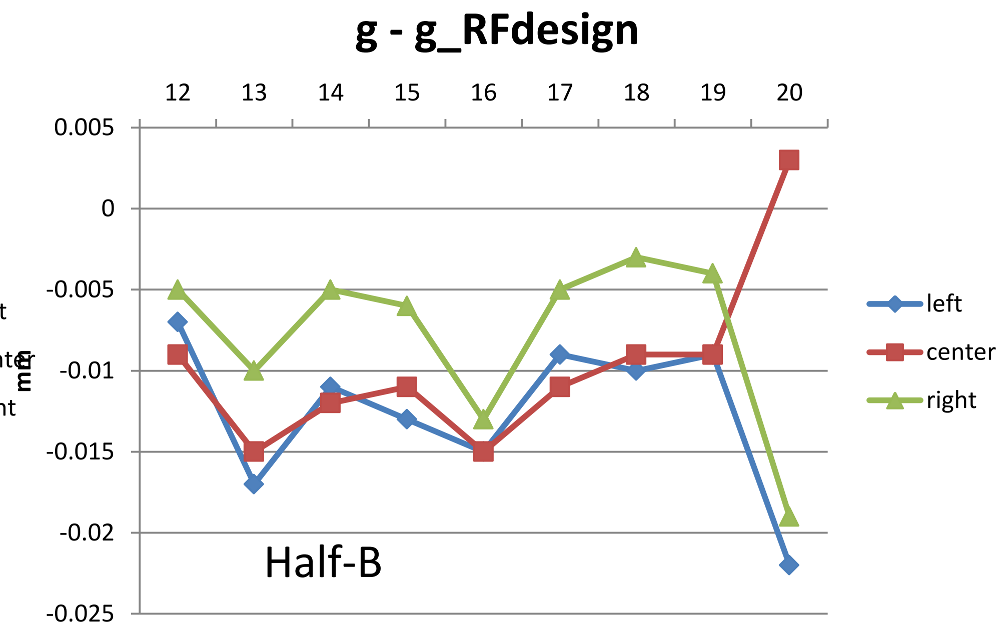
T18 CERN N2 Cut

- 2: measure the distance between irises.

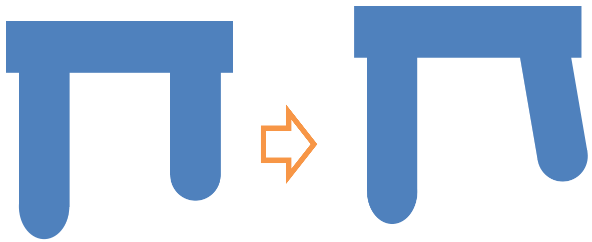


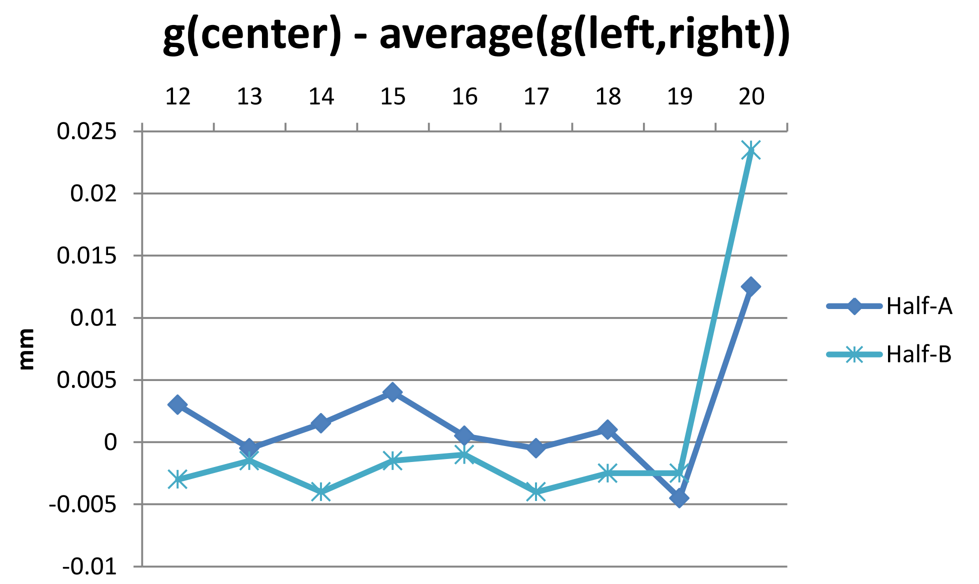
Distance between irises (gap)



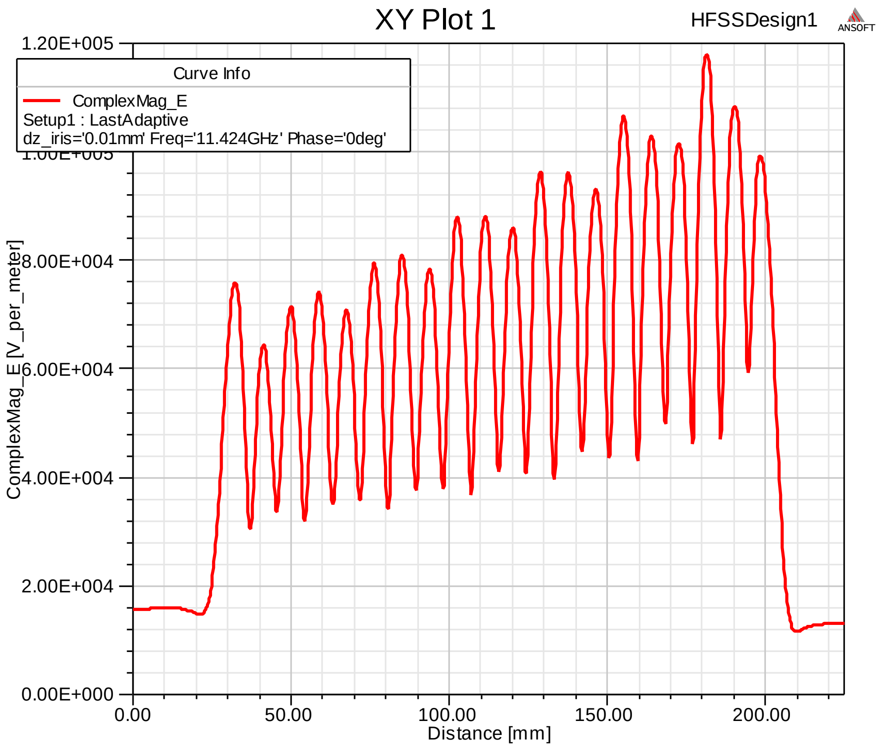


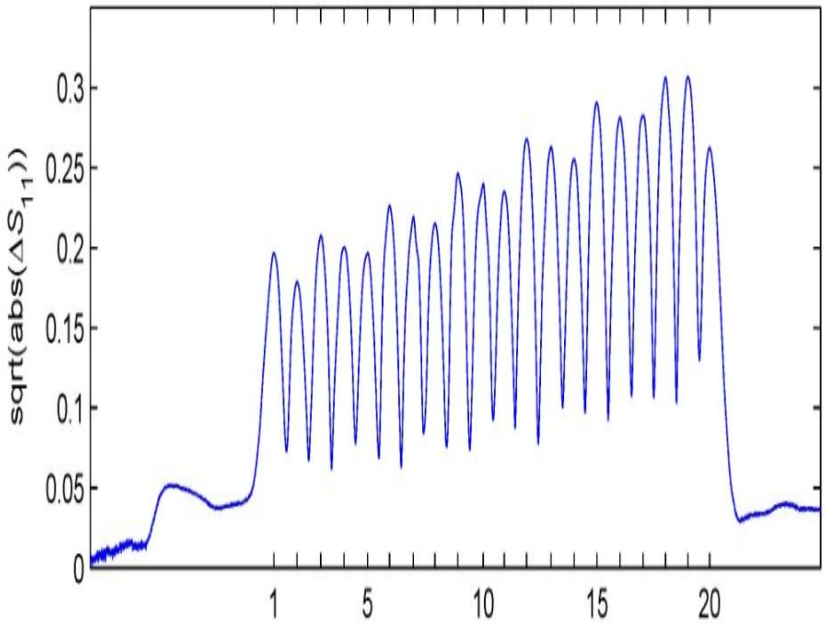
Error +-3 um. Three points are measured:
“left” and “right” close to the cell wall,
“center” close to the iris region
Last cell is longer in “center”.





Simulation with deformed output matching iris in HFSS





- Single cell simulation gives 3MHz detuning from ~15 um “iris deform”.
- Full structure simulation shows similar standing wave pattern.

Summary (1)

- It’s a critical issue for the reliability and the lifetime of the accelerating structures.
- Almost every structure has an increased reflection from output, causing a standing wave pattern. For the same type of structure, the patterns are very similar.
- Geometry measurement on the T18 (CERN N2) shows deformation on the output matching iris This explains the increased reflection. (Most probably, this is also the case for the other 3 structures)
- In CLIC nominal design with compact coupler from the side, there will be no iris with such field asymmetry.

- Input side, cut into halves? Or take it iris by iris. Measure the profile of the whole input matching iris
- multiple-physics-coupled simulation: the deform of matching iris and the asymmetrical pulsed heating.

Summary (2)

- Frequency change of regular cells is observed in several structures, in TD18, but not in T18s; in T24s. in TD24?
- To be analyzed in near future: TD24 taken out from TBTS.
  - RF measurement, Cut, and dimensional control.