SLAC Status in Accelerator Structures Production and Analysis of Structure Changes after High Power Tests

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4th X-Band Structure Collaboration Meeting

March 5, 2010

Outline

1. Work Status
   - Past
   - Ongoing
   - Future
2. Measurement and Analysis of Structure Changes after High Power Tests
   - Three Structures: T18_VG2.4_DISC SLAC-1
     T18_VG2.4_DISC KEK-1
     TD18_VG2.4_DISC SLAC-1
   - Comparison with NLC/GLC structures
   - Discussion

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1. Work Status

Work Done Since the Collaboration

1. Eleven structures have been made and five high power tested
   - 1 x T28_vg2.9 (T26) Structure
     Used T53VG3MC components and completed by the end of May, 2008
     High power tested in the NLCTA since June 2008.
   - 4 x T18_VG2.4_DISC Structures #1, #2, #3, #4
     Two with SLAC flanges, high power tested successfully at NLCTA
     One with KEK flanges has also been successfully tested at KEK
   - 2 x TD18_VG2.4_DISC Structures #1, #2
     Fabrication completed (with SLAC and KEK flanges) and high power tested.
   - C10 Structures: 2 x C10_VG 1.35 #1, #2 and 2 x C10_VG 0.7 #1, #2
     Fabrication completed, one VG1.35 of four structures tested.
2. Five CERN made test structures high power tested

   SLAC Provided RF feed and related components for tank versions
   - HDX11 Cu Structure and Mo Structure
     Electrical polishing and reassembly and Microwave evaluation
   - T18_VG2.6_QUAD
     Cooling tube flanges brazed at a hydrogen furnace with 25/75 Au/Cu alloy
     Four quadrant assemblies vacuum baked at 650°
   - T18_VG2.6_DISK Assembled in the tank at SLAC
   - T24_VG2.4_DISK Assembled in the tank at SLAC

Ongoing Work

1. One more of C10 structures 1xVG0.7 was completed and ready for the high power test.
2. The high power test of T18_VG2.4_SLAC #2 is not completed (300 hours) due to the klystron broken-down and other program in the test station – it may be used for a resonant ring test.
3. One of T24_VG1.8_DISC is under assembly and will be completed by middle of May. Due to three damaged discs, the second T24 will be completed by the end of May. Its high power test will by in late of June. The shipping of KEK T24 structure also will be sometime second half of June.
4. I will push TD18 structures assembly work, hopefully they can be completed by the end of July and the high power tests can start by the end of August.

T24 Structure Fabrication

Couplers Brazing

Body diffusion bonding

Work in the Near Future will be discussed and Finalized

1. Two more C10 Structures 1xVG1.35 and 1xVG0.7
   - Microwave tuning and High power testing
2. Four more C10 Structures 2xVG2.25 and 2xVG3.3
   - All parts ordered
   - SLAC Assembly, tuning and High power testing
3. TD18_VG2.4_DISK
   - CERN made using similar way of KEK/SLAC fabrication
   - High Power Testing at SLAC
4. TD18_VG2.4_DISK
   - CERN made in a can. High Power Testing at SLAC
5. TD24_VG1.8_DISK
   - CERN made. High power testing at SLAC
6. CD10 2 x VG1.35
   - CERN made. High power testing at SLAC
7. CD10 2 x VG1.35
   - KEK machining
   - Assembly, Tuning art SLAC and High power testing at SLAC/KEK
8. T-500GeV
   - CERN made and High power testing at SLAC

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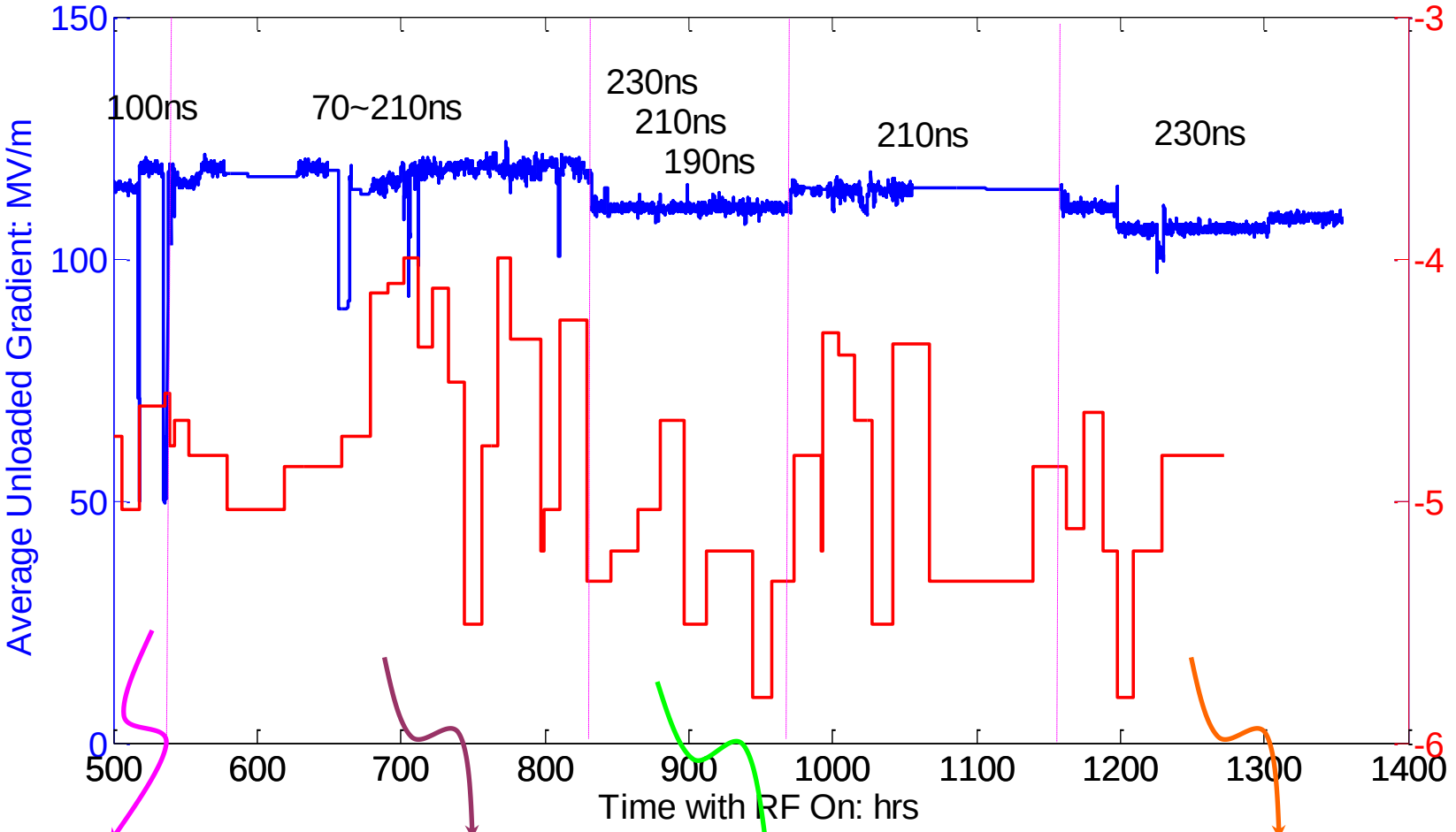
2. Measurement and Analysis of Structure Changes after High Power Tests

T18-SLAC #1 High Power Test



Short pulse higher gradient condition

Pulse shape dependence BKD study.

BKD pulse width dependence study at 110MV/m.

BKD gradient dependence study at 230ns pulse width

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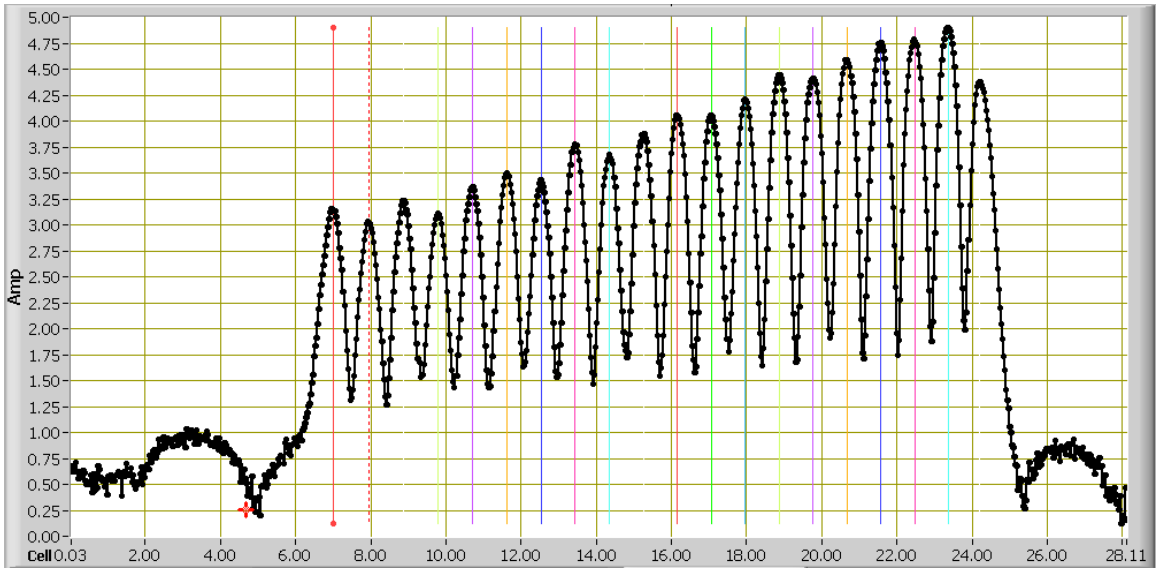
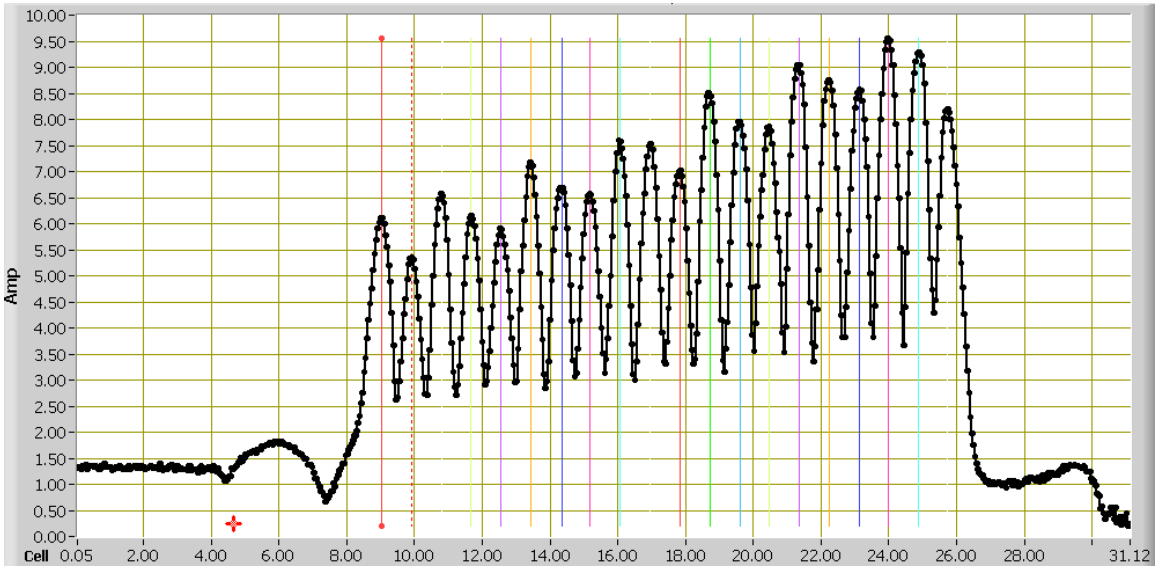
Amplitude Measurement of T18-SLAC #1 Before and After High Power Test

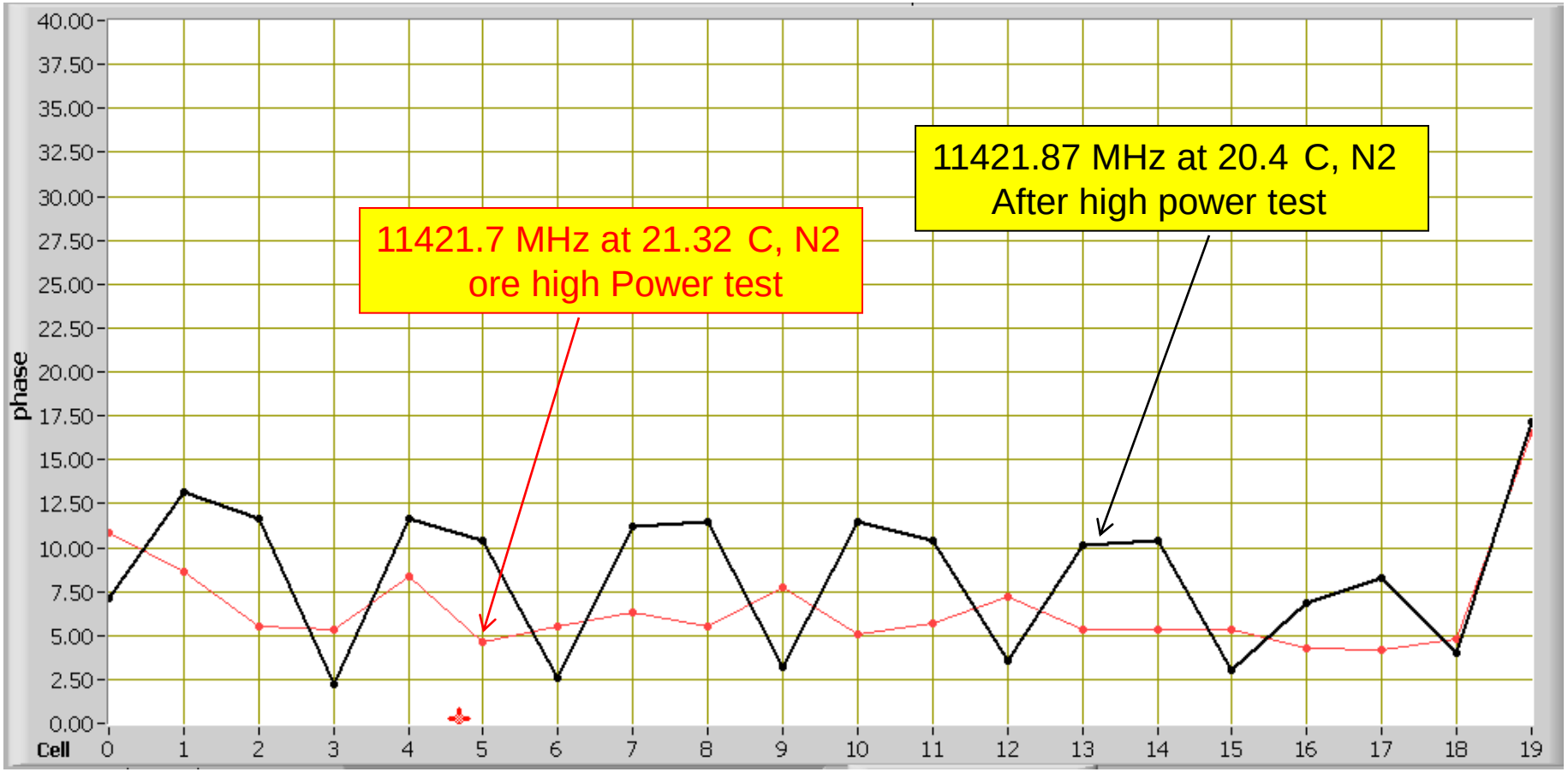
11421.7 MHz at 21.32 C, N2
Before high Power test



11421.87 MHz at 20.4 C, N2
After high power test



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



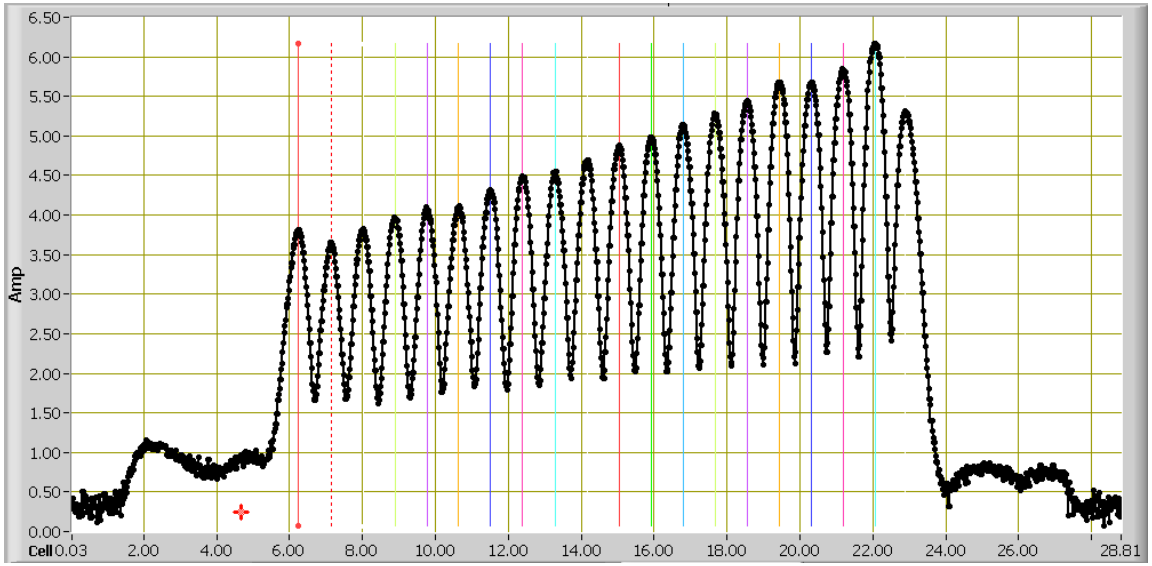
Comments on T18-SLAC #1 Before and After High Power Test

- From the Standing wave pattern, the output part was "damaged", it can be due to the "damage" by the high power test of backward feeding in order to compare with the single cavity tests.
- In general, there was no frequency change of 2π/3 mode at similar operation condition.
- Is this a related factor?

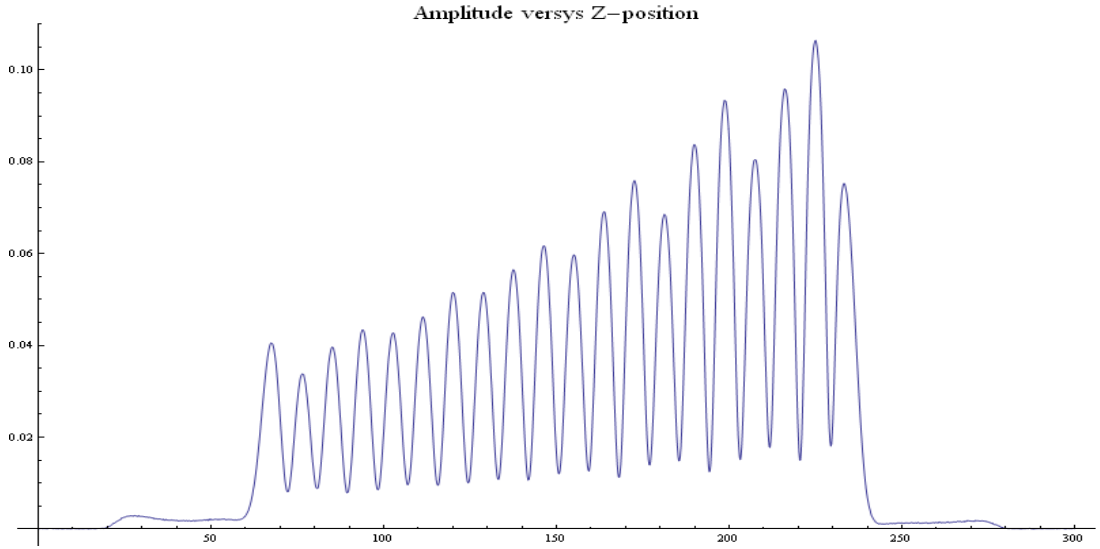
The frequency of high power test was ~ 3 MHz higher than the tuned frequency. Because the structure is a nice band-pass filter, the field pattern and S12 almost no change. Only the mode phase advance was not 2π/3.

Amplitude Measurement of T18-KEK Before and After High Power Test

11421.7 MHz at 21.1 C, N2
Before high Power test at SLAC

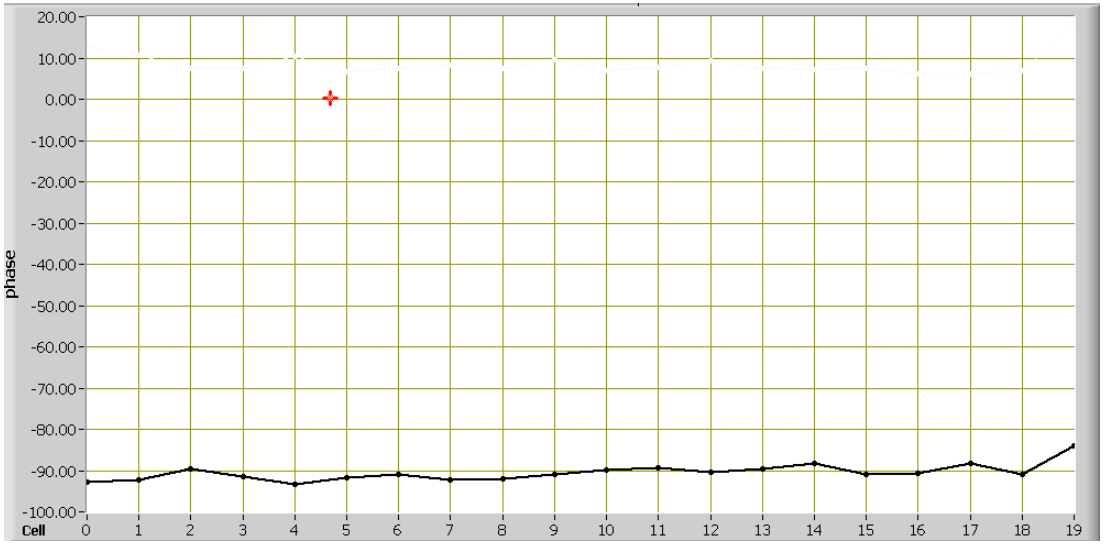


11422 MHz at 21.1 C, N2
After high power test at KEK
by Toshi



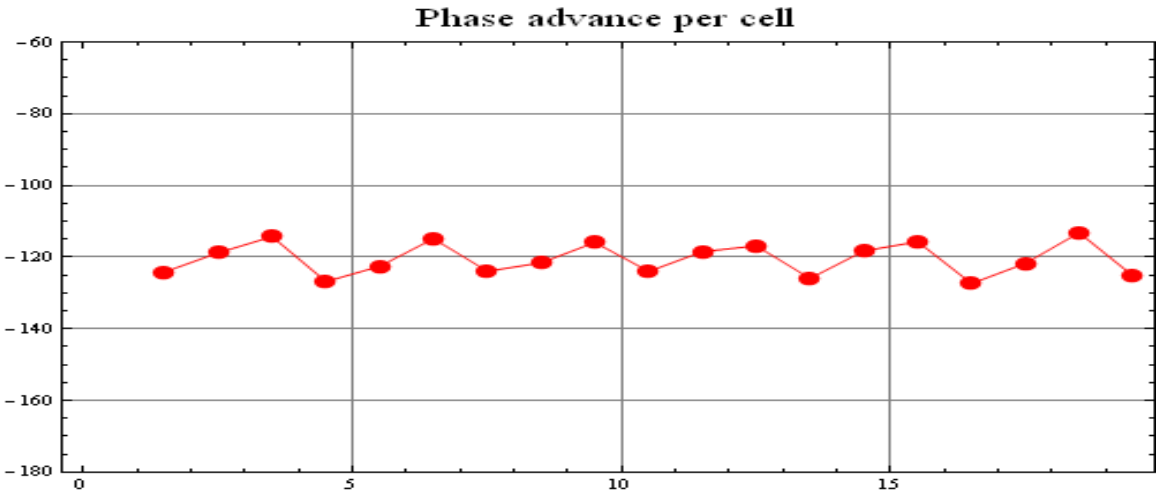
Phase Measurement of T18-KEK Before and After High Power Test

11421.7 MHz at 21.1 C, N2
Before high Power test at SLAC



Considering the string perturbation and temperature correction, the frequency was increased by 1.2 MHz (Toshi calculated 1.1 MHz).

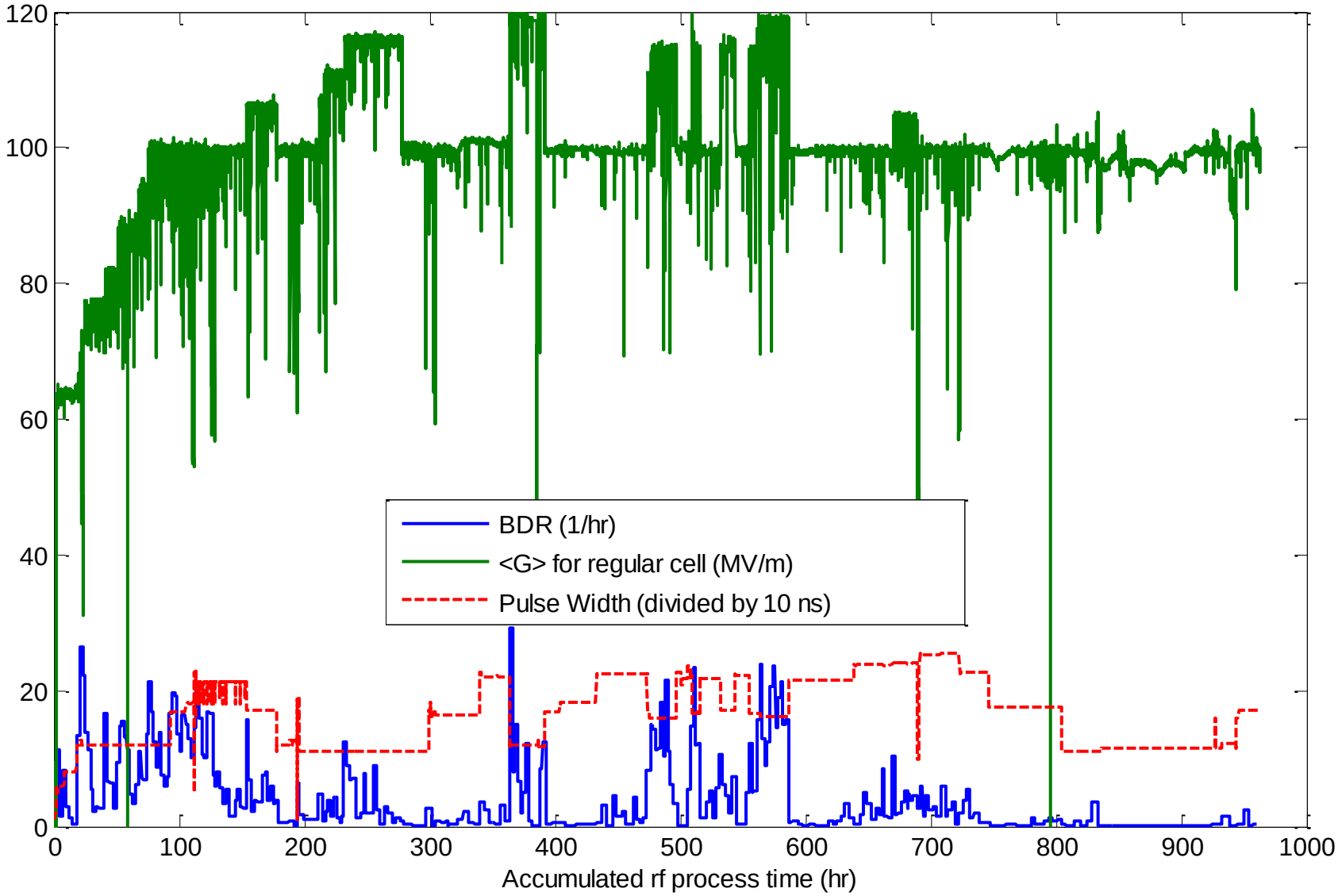
11423.2MHz at 22.7deg C in N2
After high power test at KEK by Toshi



Comments on T18-KEK Before and After High Power Test

- From the Standing wave pattern, the output part and some cells were “damaged”.
- In general, there was a 1MHz frequency increase of 2π/3 mode at similar operation conditions. In another words, the cumulated phase drift was about 15 at frequency at similar operation conditions
- The total high power test time was 4000 hours, is it a reason to cause more “damage” in comparison with T18-SLAC?

TD18-SLAC High Power Test



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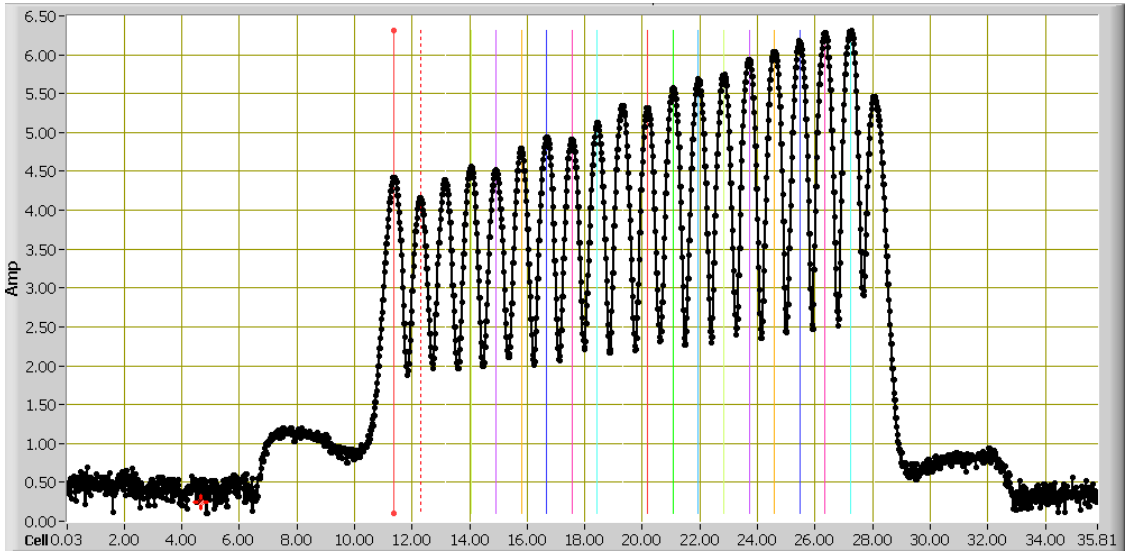
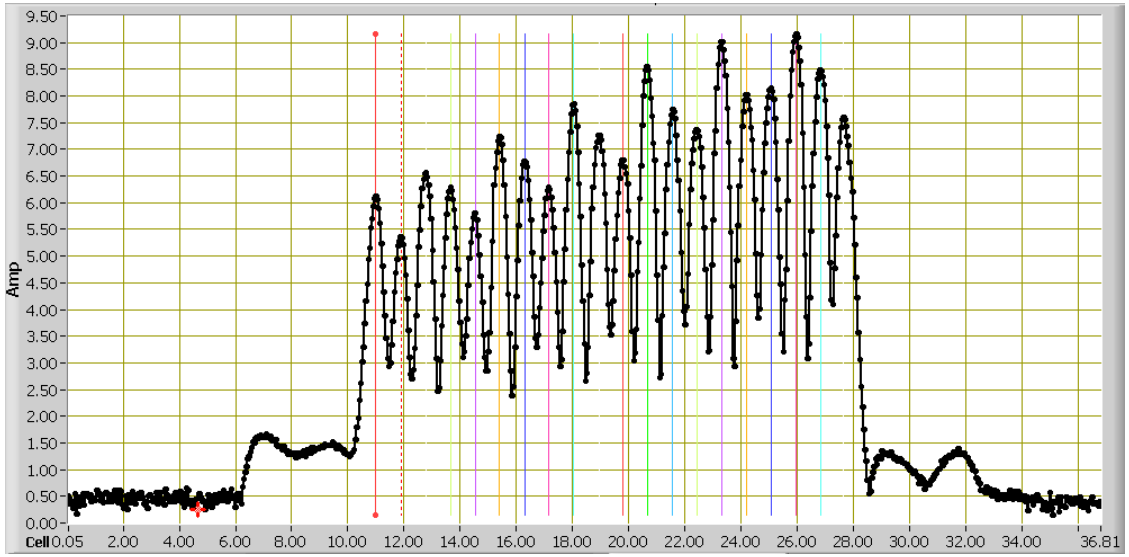
Amplitude Measurement of TD18-SLAC Before and After High Power Test

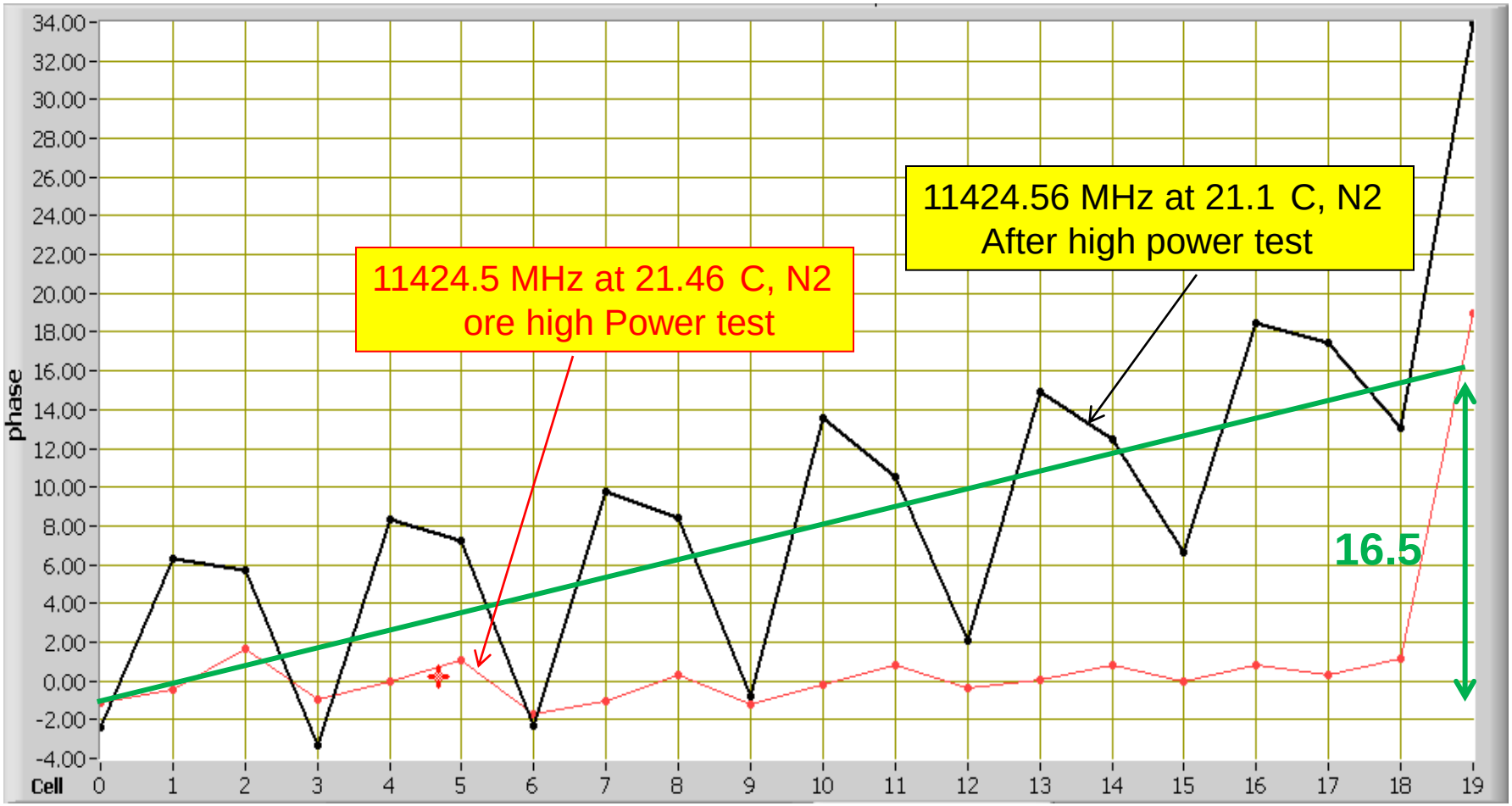
11424.5 MHz at 21.46 C, N2
Before high Power test



11424.56 MHz at 21.1 C, N2
After high power test

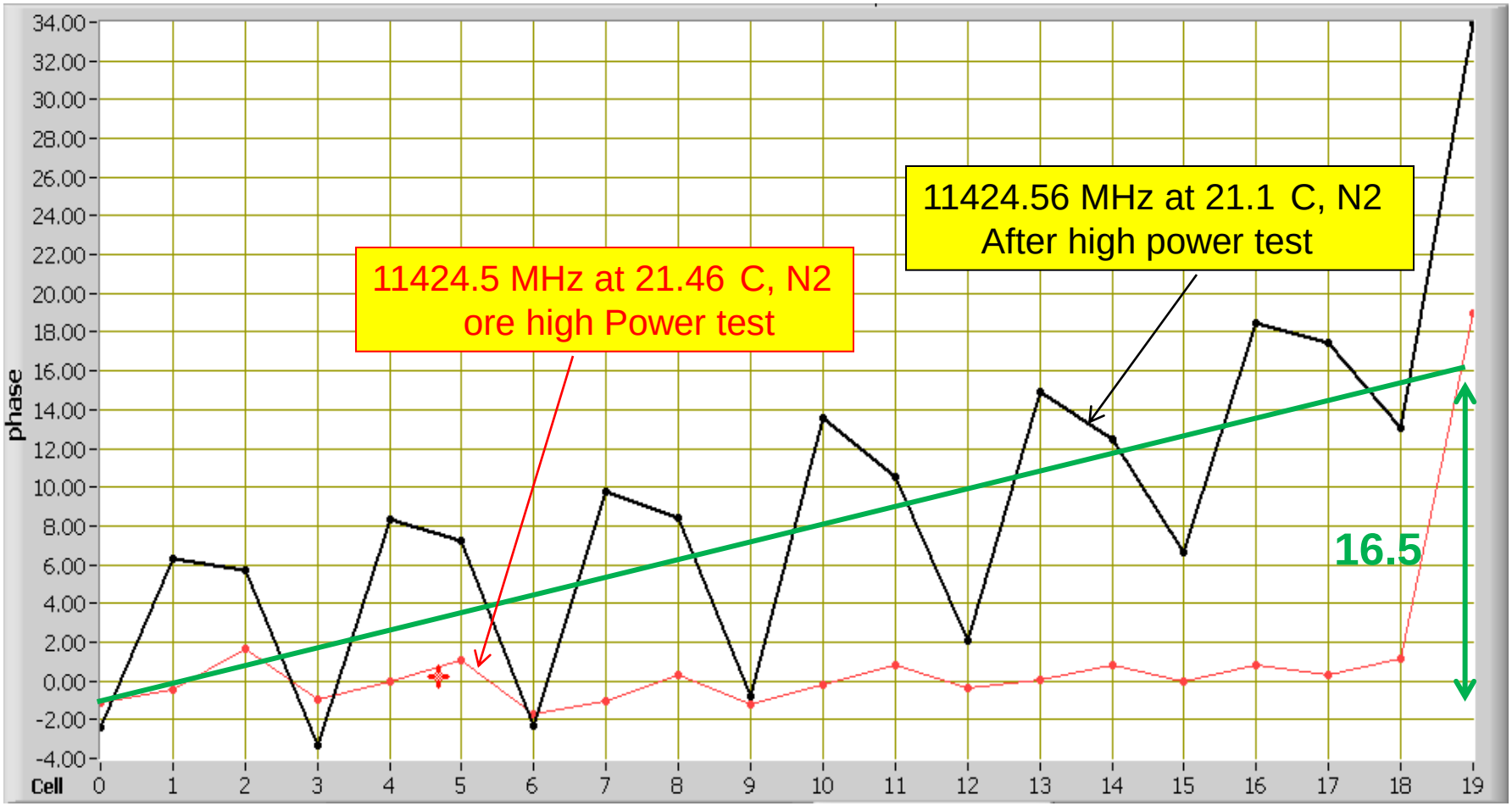


Phase Measurement of T18-KEK Before and After High Power Test



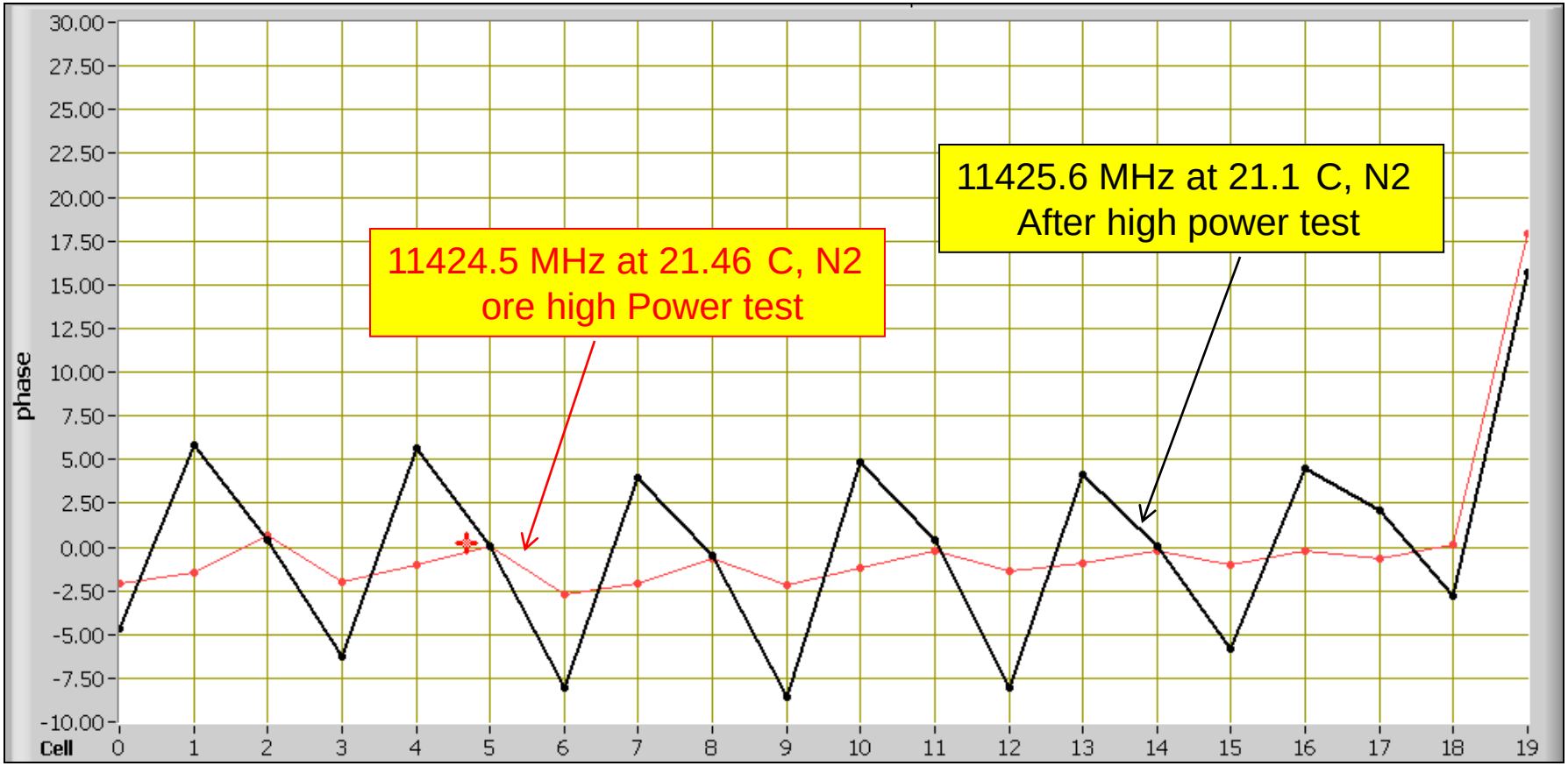
Select bead pulling frequencies based on the same measurement condition for both before and after high power test

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



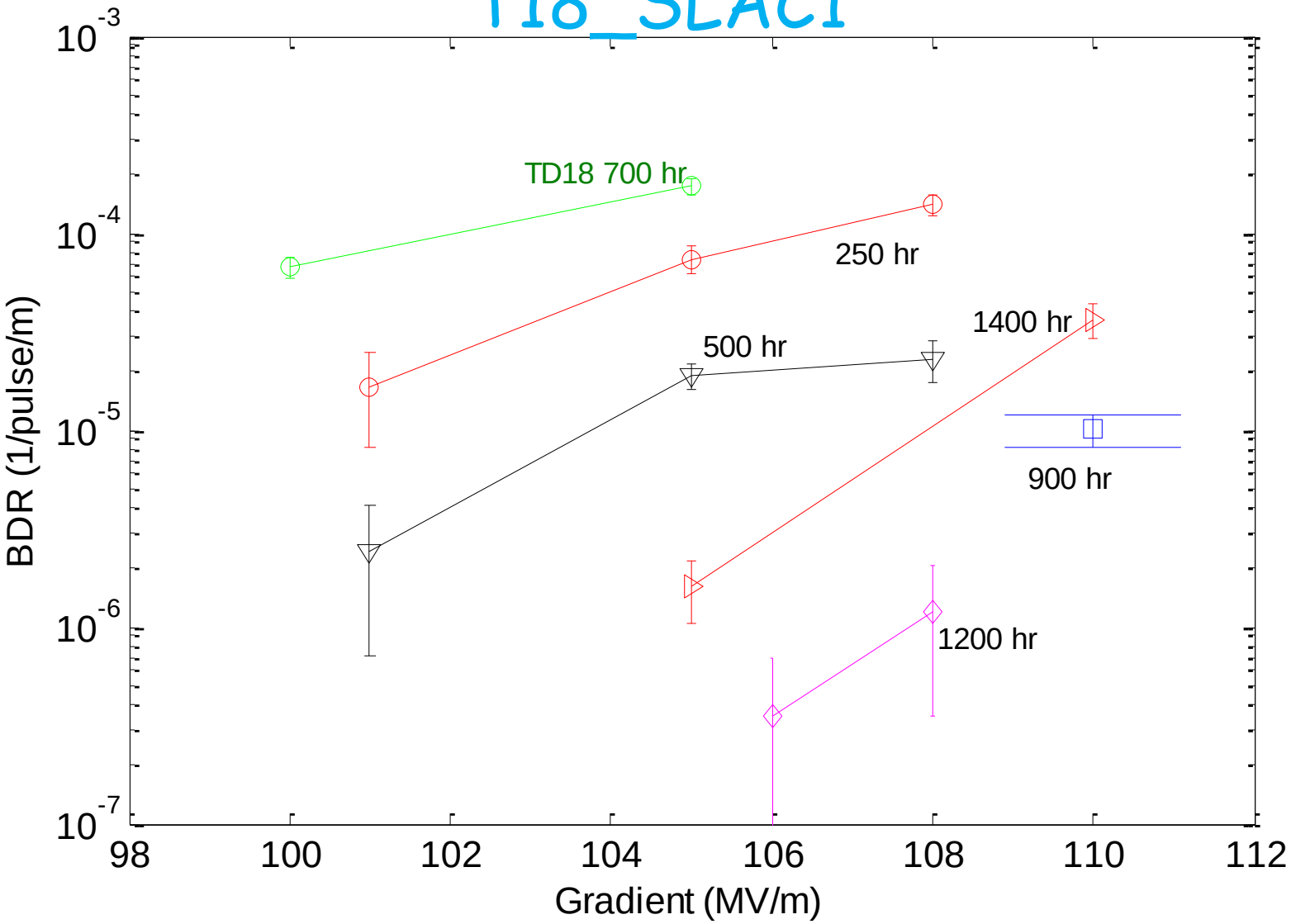
Select bead pulling frequencies based on the same measurement condition for both before and after high power test

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



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

RF Process Results Comparison with T18_SLAC1



Pulse width 230ns, Green line for TD18, Others for T18

Comments on TD18-SLAC Before and After High Power Test

- From the standing wave pattern, the output part and some cells were “damaged”.
- In general, there was a 1MHz frequency increase of 2π/3 mode at similar operation conditions. In another words, the cumulated phase drift was about 16 at frequency at similar operation conditions
- The pulse heating for TD18 structure is higher, but it is believed that the “damages” were still on the disc irises.
- The total breakdown event recorded was more than 4000 – only twice higher than T18 SLAC #1, but the TD18 breakdown rate measured after 700 hours was higher than T18 SLAC #1 by factor of 100. The “damage” can be caused at higher power and full pulse width in stead of the process beginning with lower power and short pulse width?

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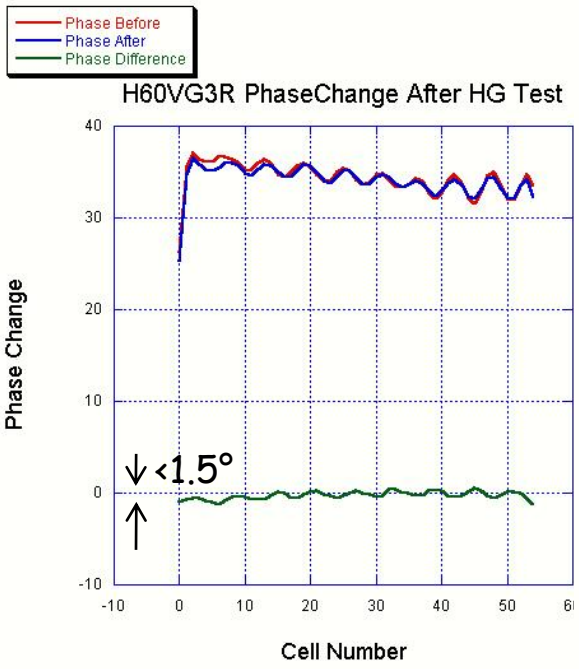
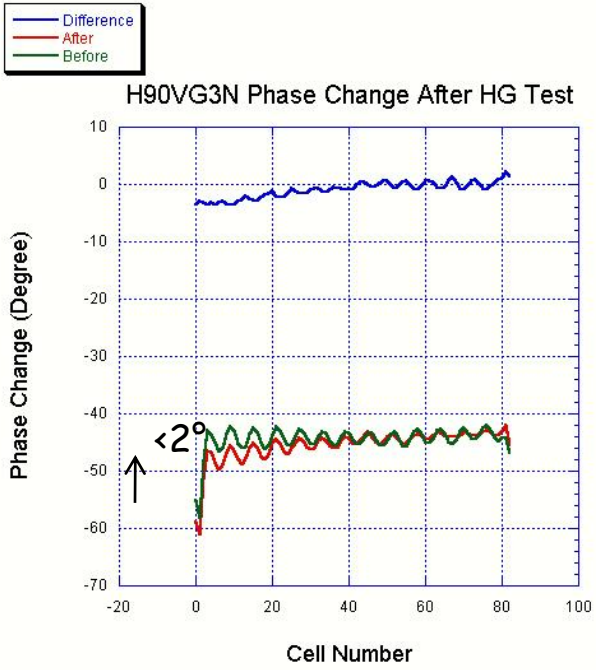
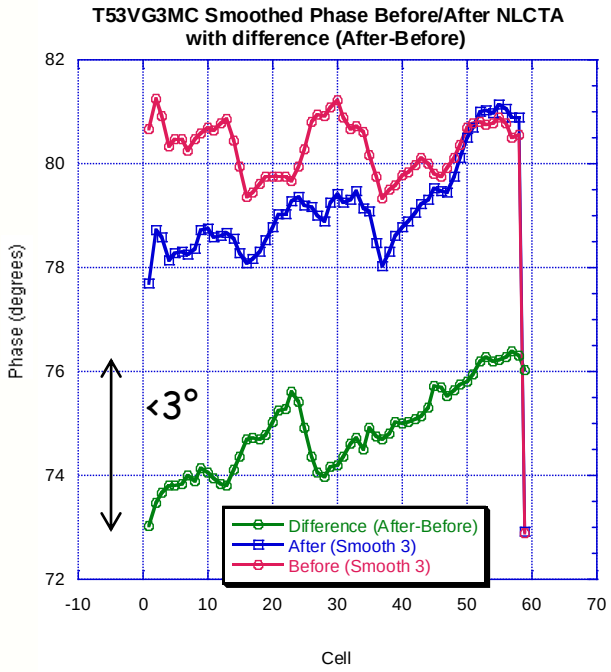
Recall of NLC/GLC structures

Historical Information for the NLC/GLC Structures in Comparison Before and After High Power Tests





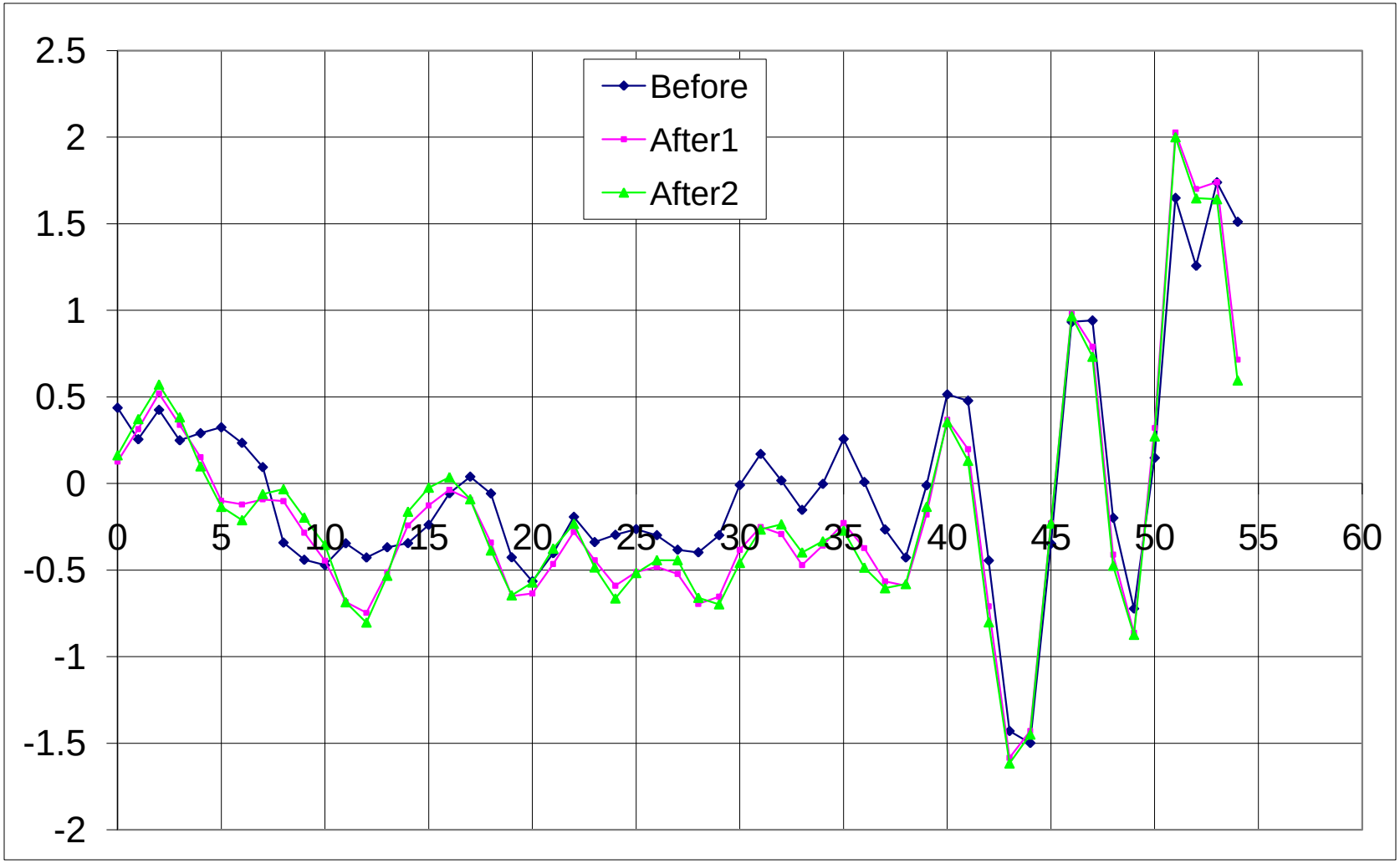


H60VG3R
1000 Hours RF on (65MV/m, 400ns)
8000 Body Breakdown

H90VG3N
1600 Hours RF on (65 MV/m, 400 ns)
9500 Body Breakdown

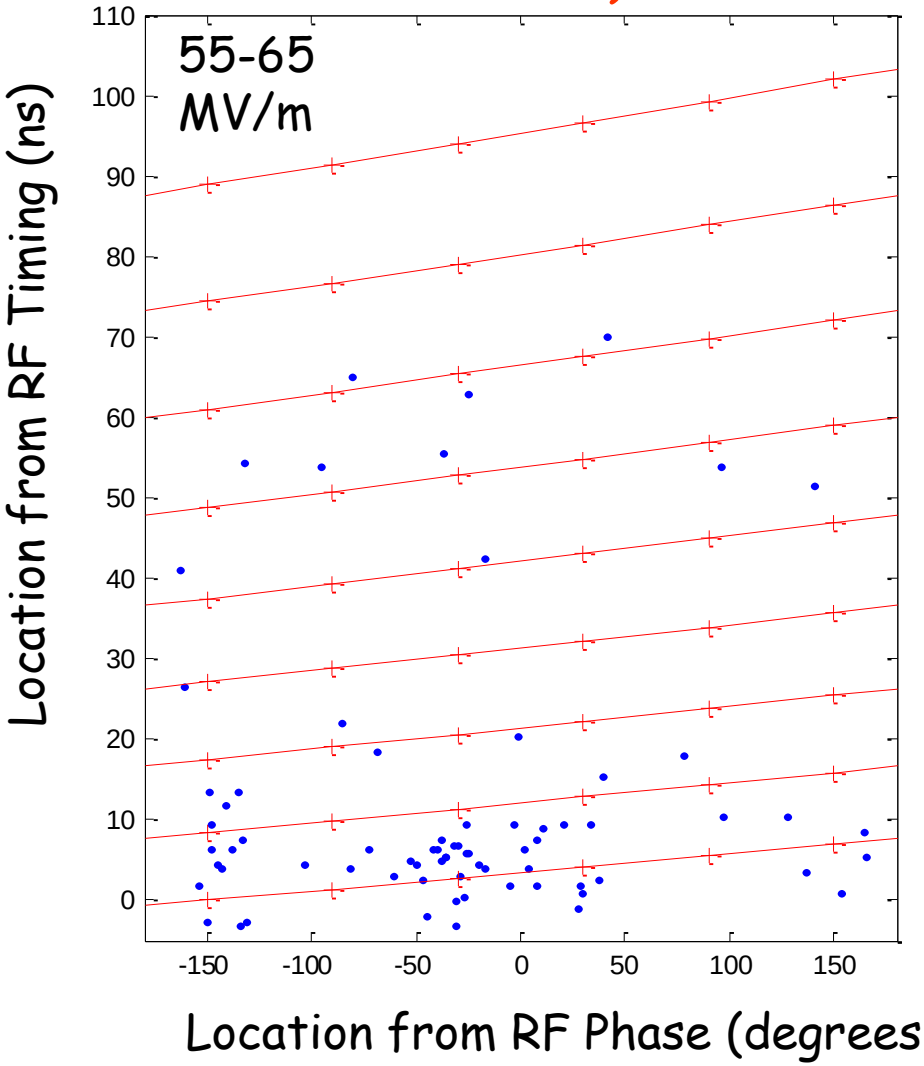
T53VG3MC
900 Hours RF on (92MV/m., 400ns)
1600 Body Breakdown

Bead-Pull Phase Advance Measurements of H60VG3 (FXB2)
Before and After 300 Hours of Processing to 70 MV/m
(7000 Breakdowns, 300 Hours RF On)

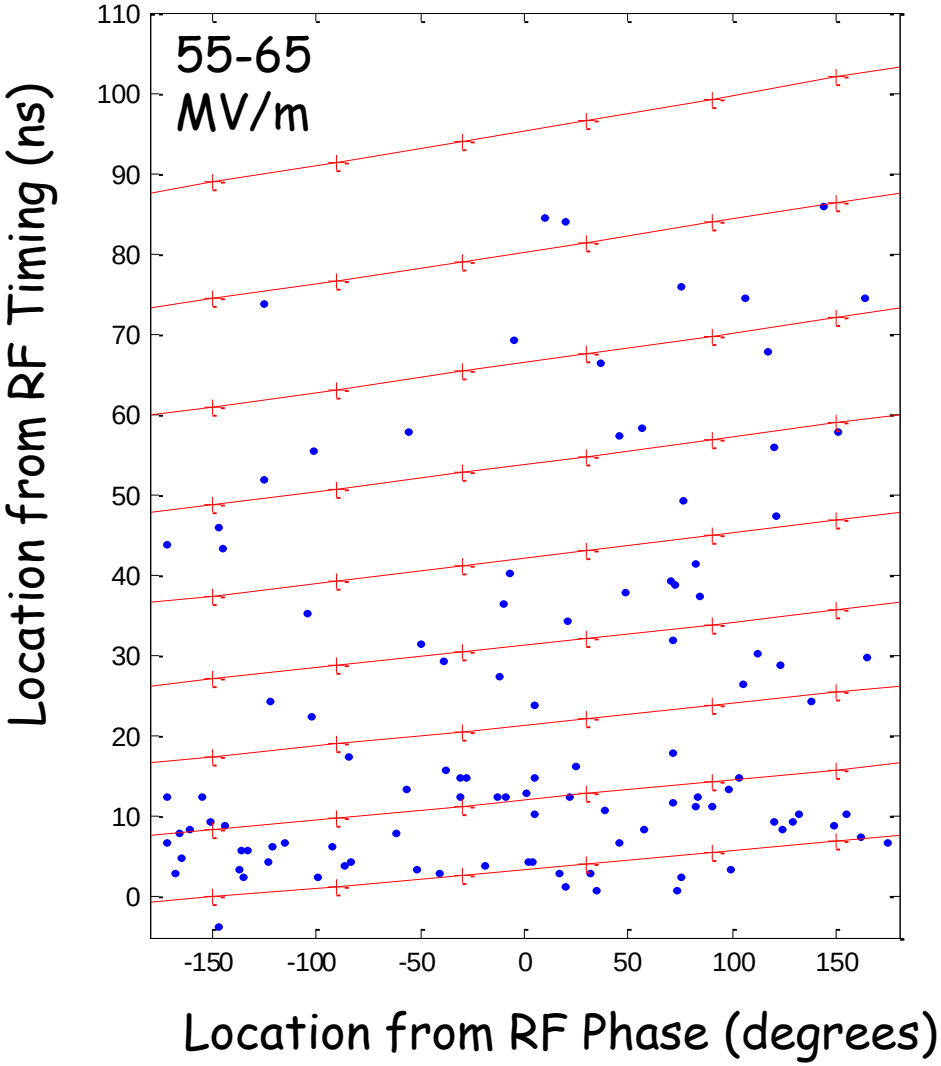


Breakdown Locations: After ~1 Week of Processing Reached 65 MV/m at 400 ns (Few per Hour Trip Rate)

H60VG3S18 (Fully Slotted)



H60VG3 FXB4



Comments on the History of NLC/GLC Structures Before and After High Power Test

- There was no much increased standing wave pattern, the phase plots in output parts could be used to fit together in order to compare the phase change before and after high power tests.
- In general, there was no frequency change for designed mode 2π/3 or 5π/6 at similar operation conditions. In another words, the cumulated phase drifts for those long structures were very few degrees at frequency at similar operation conditions

Conclusion

We need pay close attention on the measurement (surface and microwave) and analysis of the structure status before and after high gradient operation. It always is a critical issue for the life time and stabilization of the high gradient accelerating structures.