

# Nextef results

CLIC09, Oct. 12-16

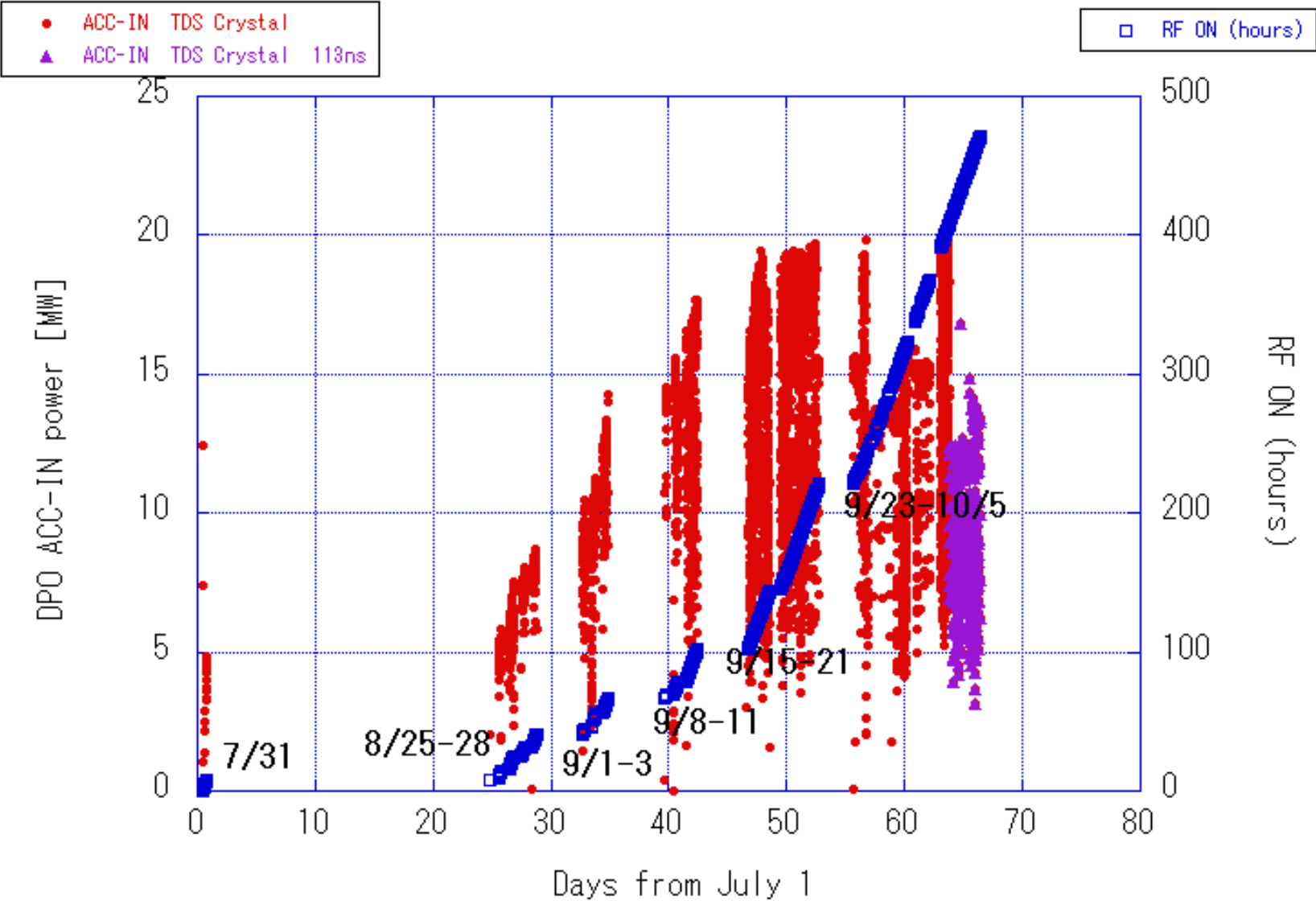
T. Higo (KEK)

# Contents

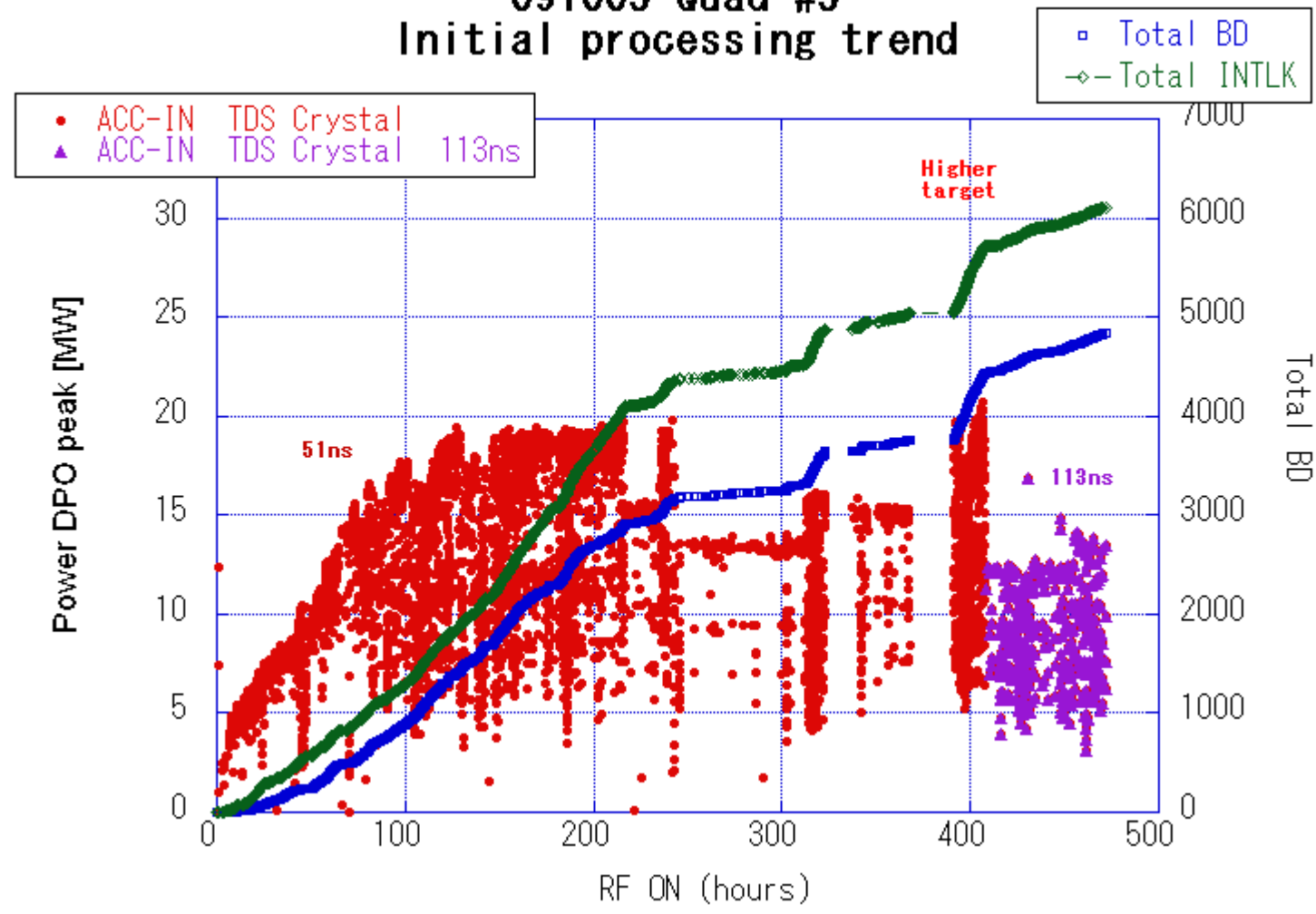
- Quadrant high gradient test status
  - Initial processing and power limit
  - VAC characteristics with Q-mass
  - Dark current
  - BD position
  - Light emission
- Change in T18 by high gradient processing
  - RF
  - Optical inspection
- Nextef plan

# Quad #5 status and near future plan

# Quad #5 Processing History



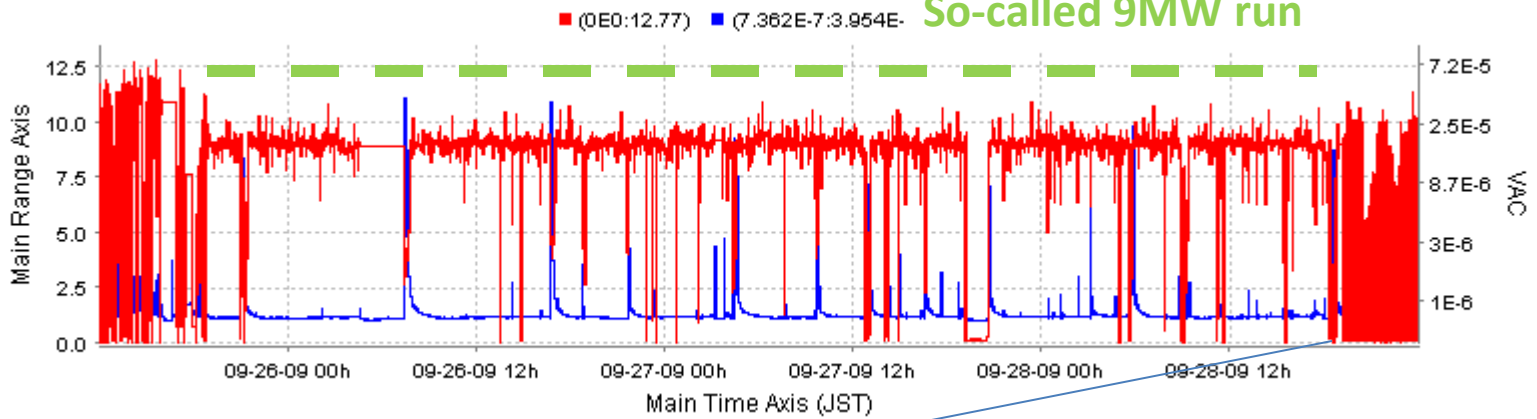
### 091005 Quad #5 Initial processing trend



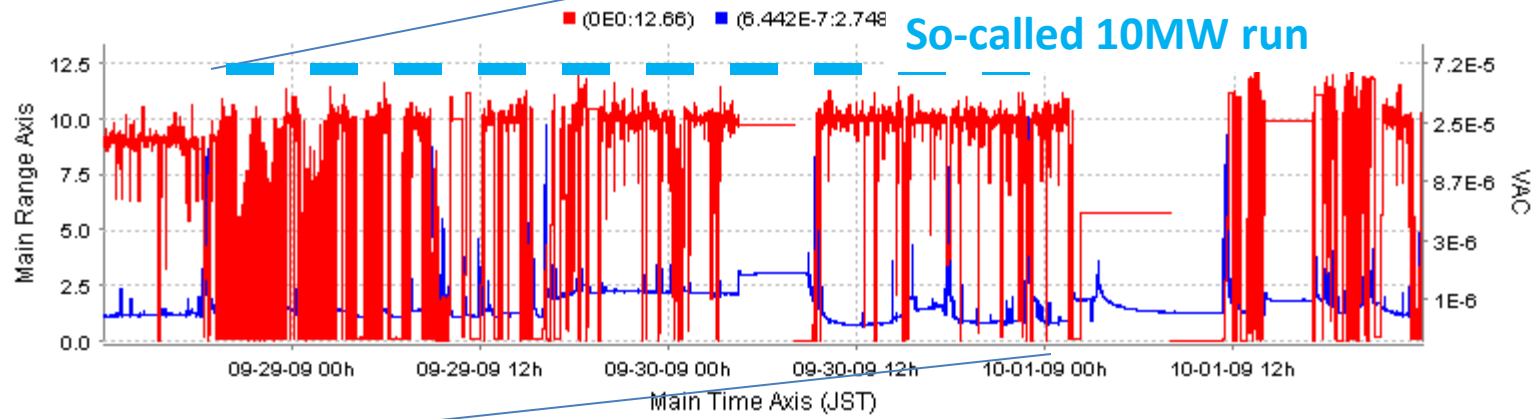
Red=power (arbitrary unit)

Blue = Chamber vacuum [Pa]

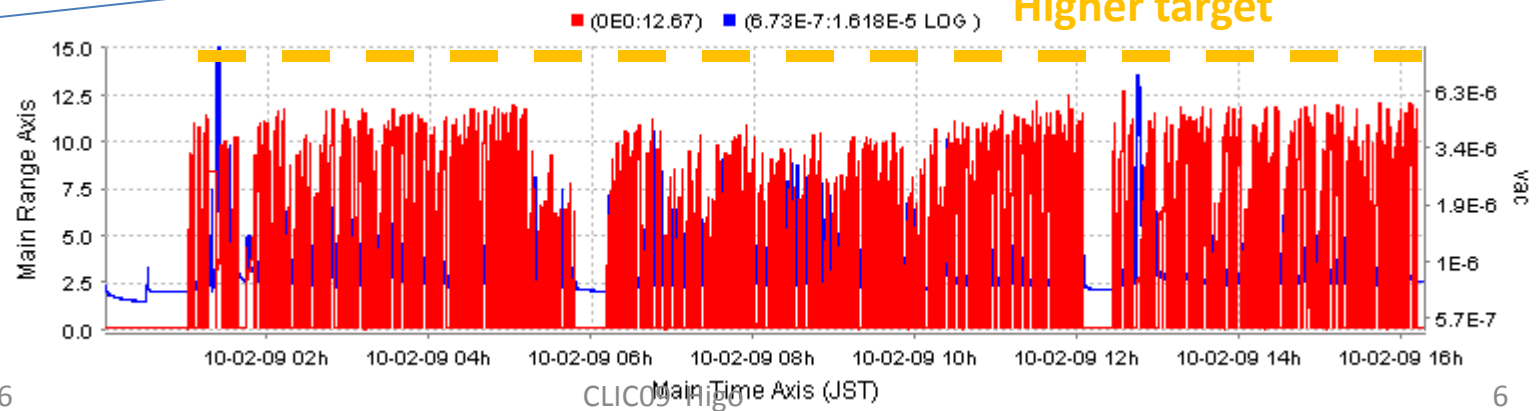
### So-called 9MW run



### So-called 10MW run

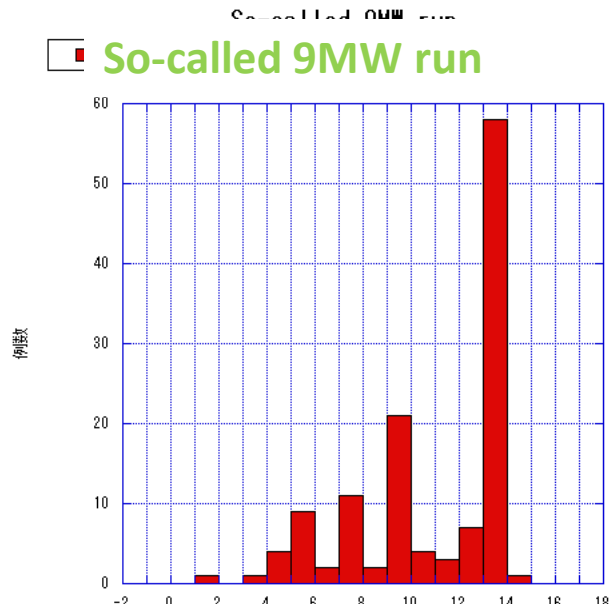


### Higher target

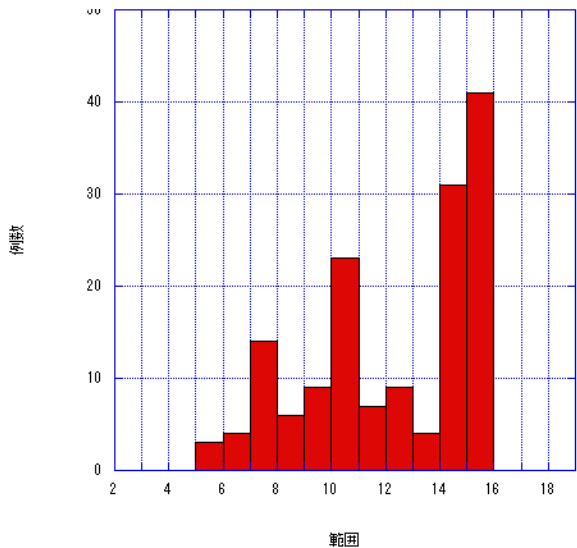


Target = 15MW

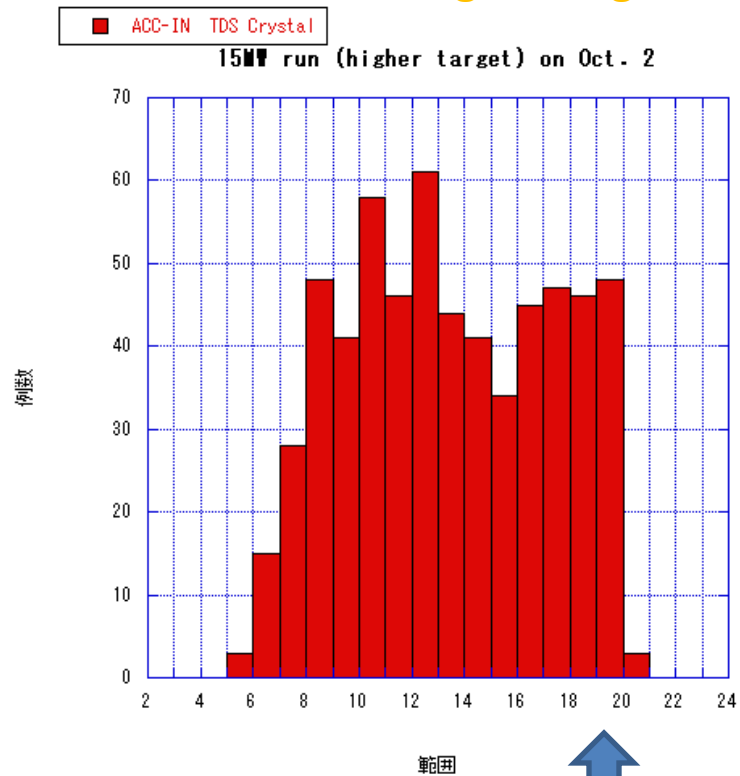
# Gradient limit at 50ns



So-called 10MW run



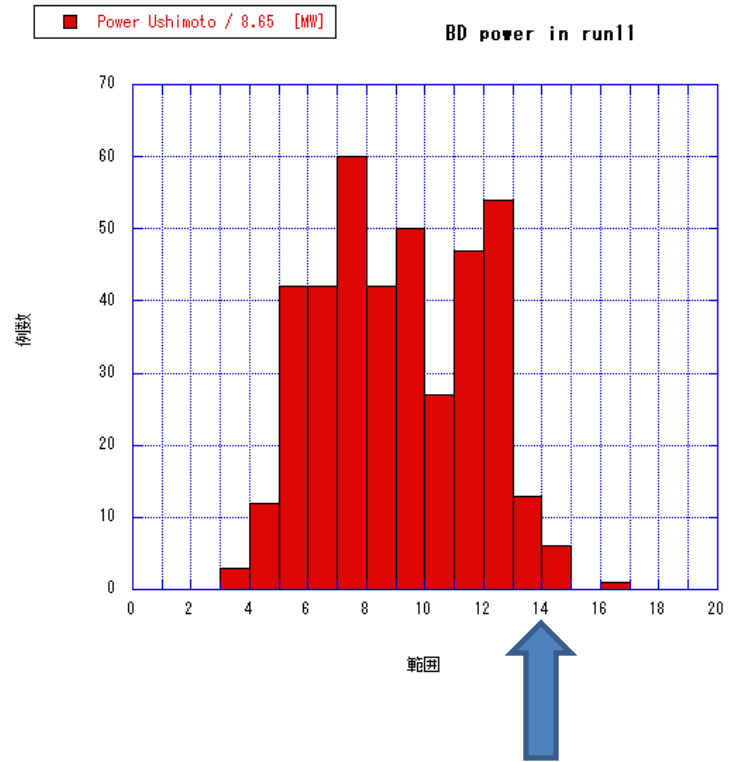
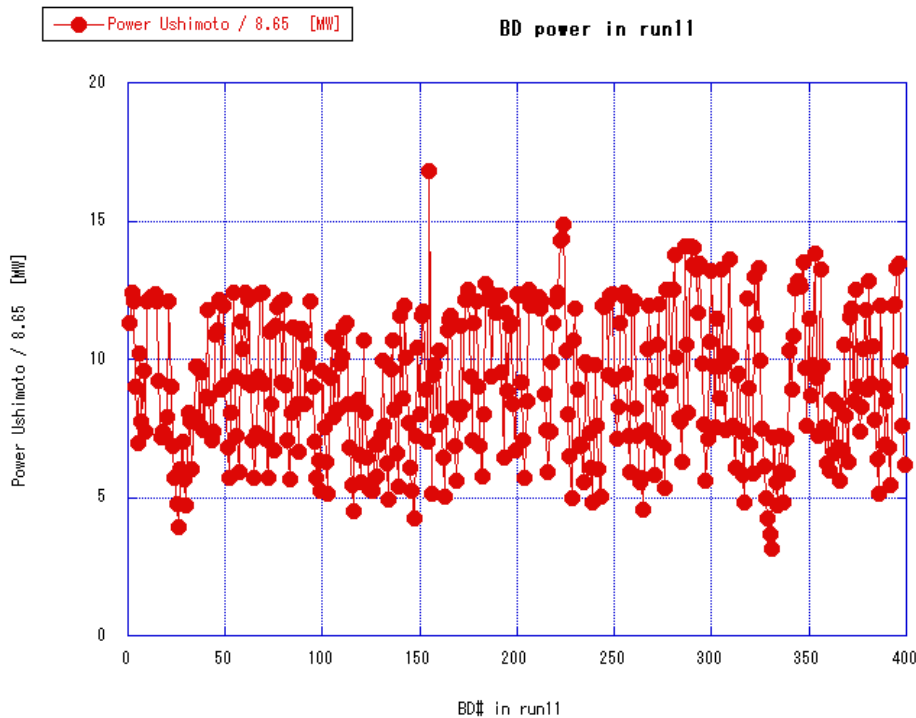
Higher target



Hard limit at 19MW,  
59MV/m, 50ns

# Run11 with higher target at 113ns

Powers at breakdown with 113ns pulse width for 60 hours



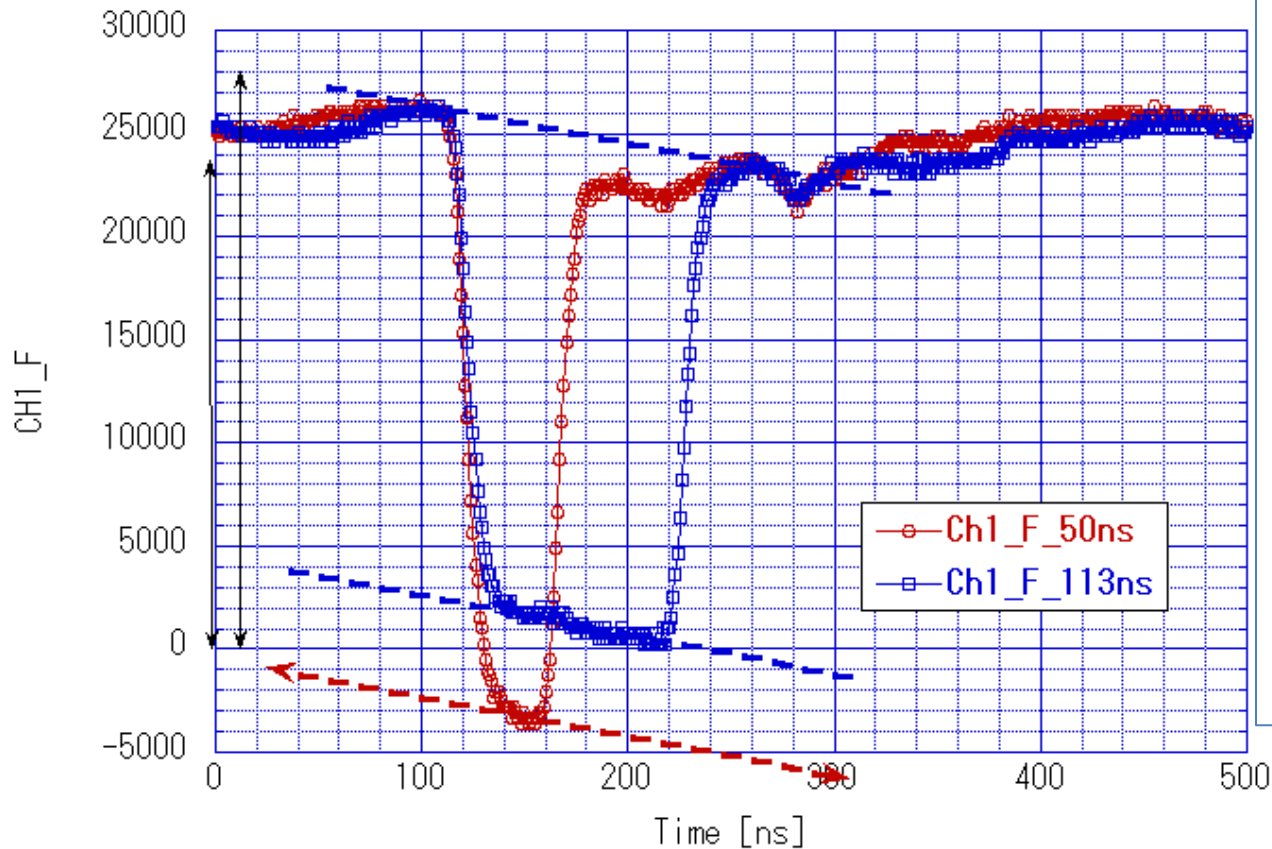
Hard limit at 14MW for 113ns pulse



# ACC-IN pulse at hard limit

Run4\_090926\_050209\_1 51ns

Run11\_091004\_19244 113ns



Tp(ns)

51 113

Power (MW)

19 14

Ea (MV/m)

59 50

Sqrt(Tp)\*Power

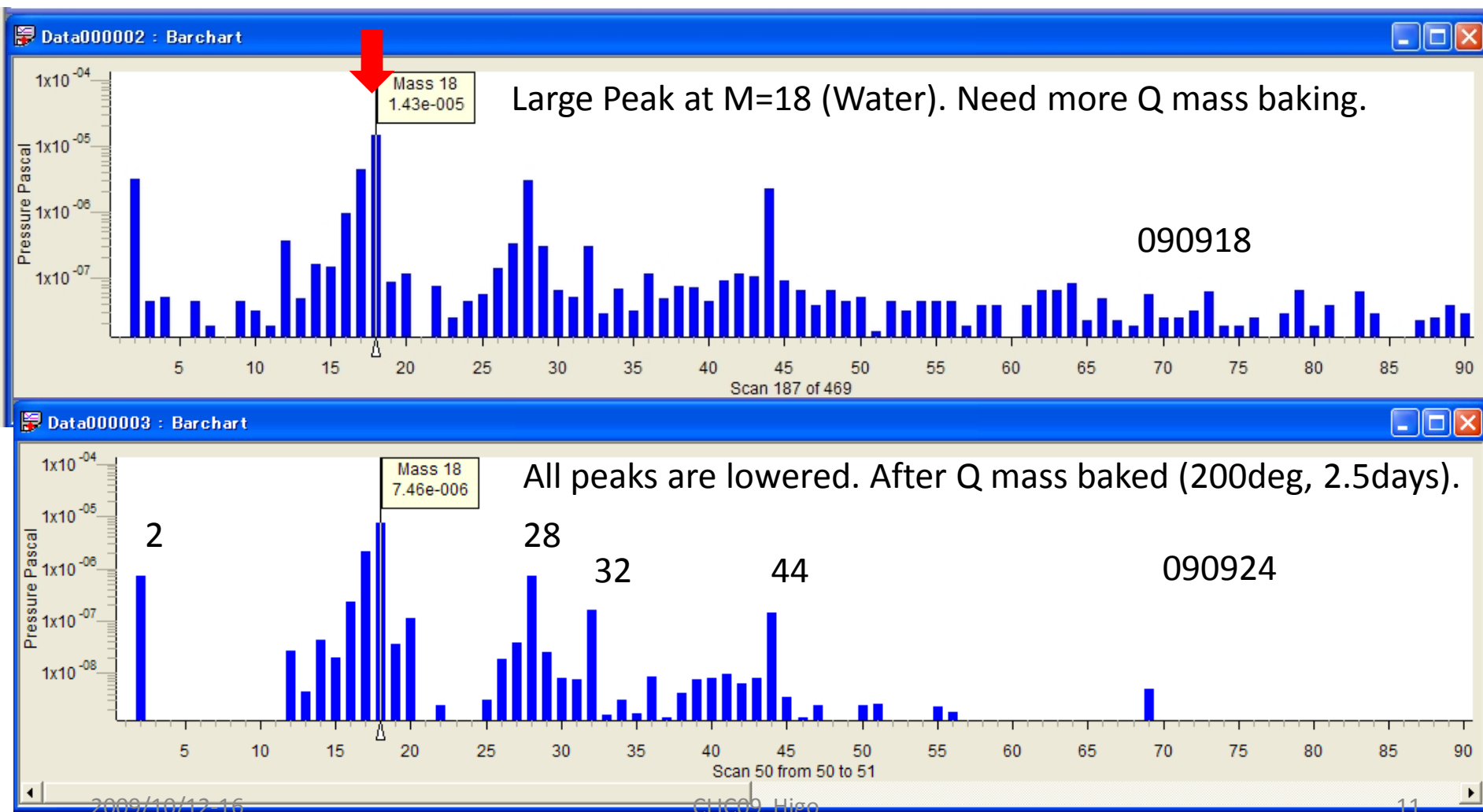
135 147

Limit at similar pulse heating temperature, but more precise comparison is needed.

# Vacuum characteristics

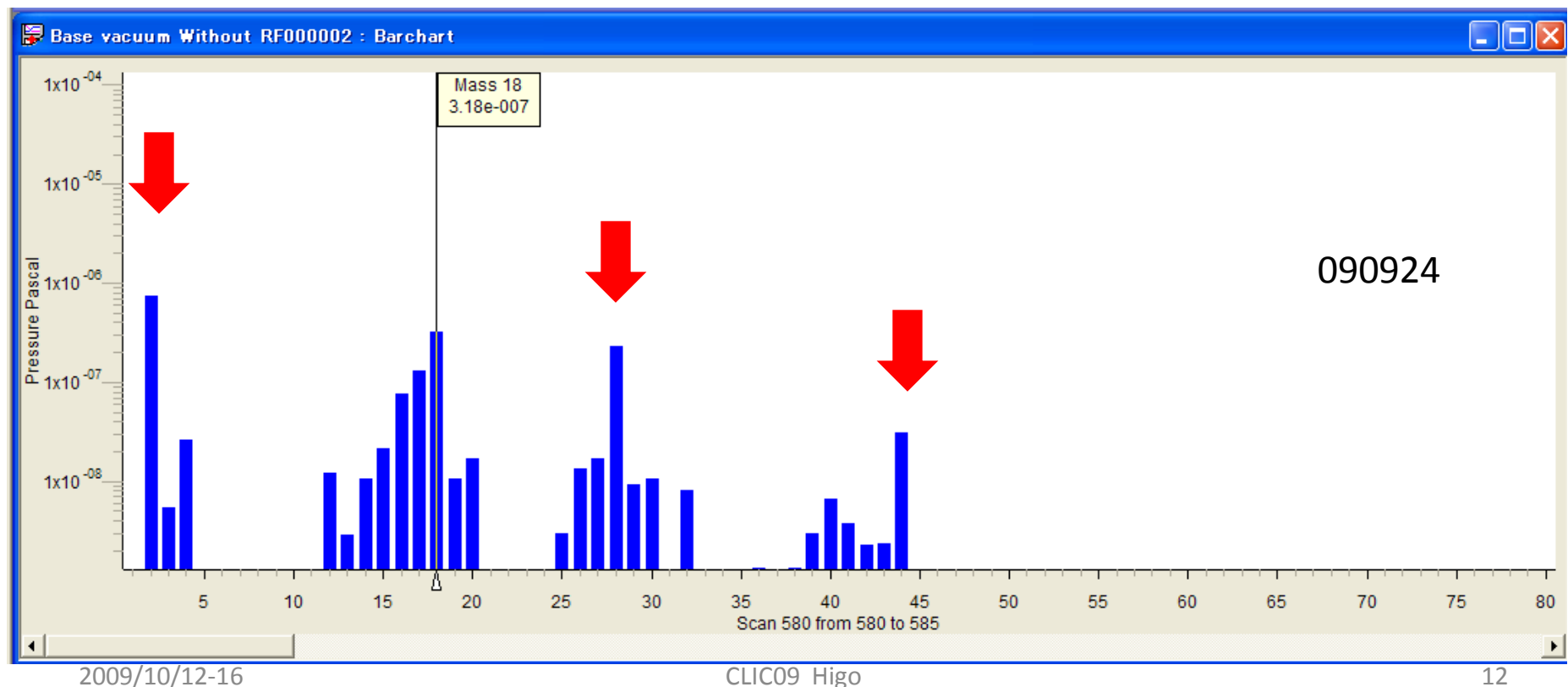
- Vacuum total pressure
  - Base pressure at  $<10^{-6}$ Pa
  - Typically processing below  $10^{-5}$ Pa
  - Increases every time at few to 5MW range if after RF-OFF for more than several hours
- Mass spectrum
  - M=2, 28 and 44 increase with RF-ON, but not M=18
    - Especially when reaching power limit
  - M=2 becomes dominant residual gas after an hour or so run
  - M=27 and 28 change in a similar manner as time, indicating hydrocarbon-origin surface contamination

# First and Second QMA observations. Check QMA vacuum. QMA-Acc Chamber valve closed.



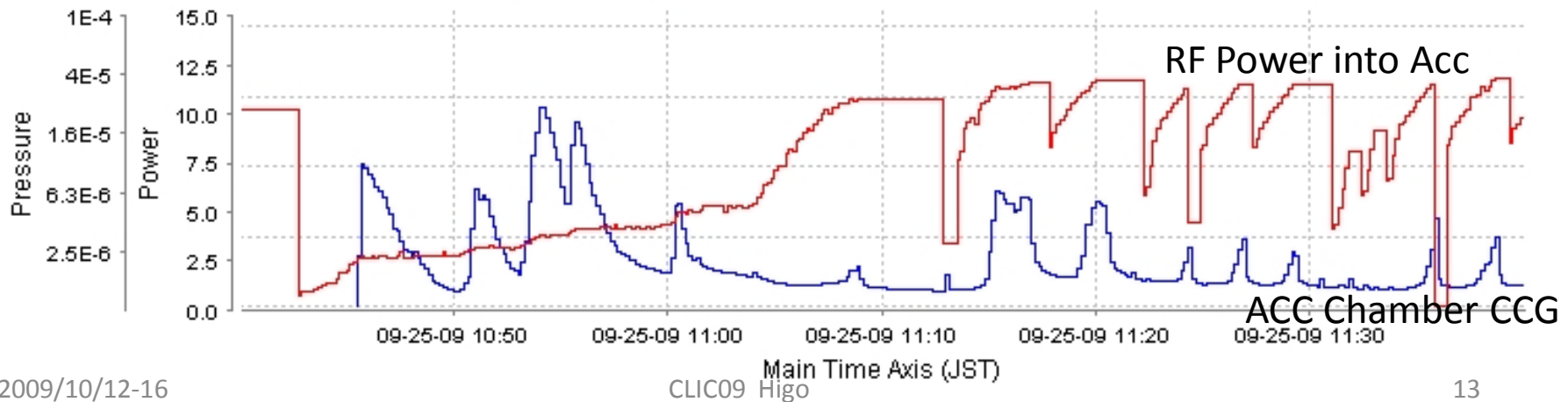
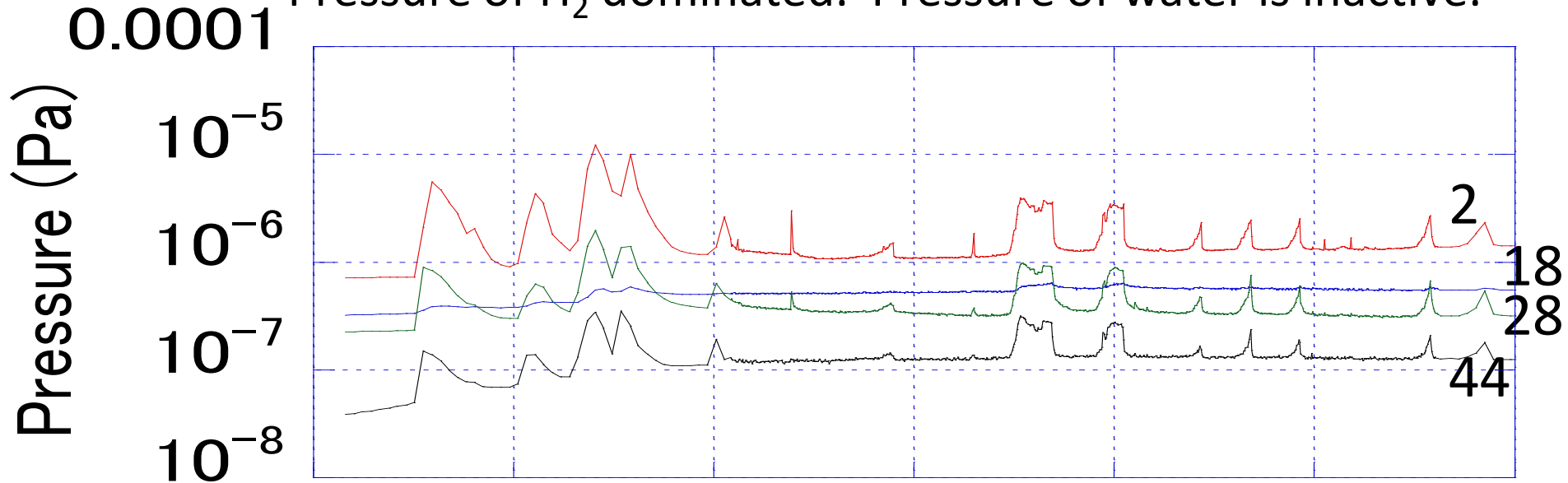
# First QMA observation with RF OFF. QMA- ACC Chamber valve opened.

Peak at M=2 (H<sub>2</sub>) largest. Water (18) becomes moderate. Others are M=28 (CO) and 44(CO<sub>2</sub>).



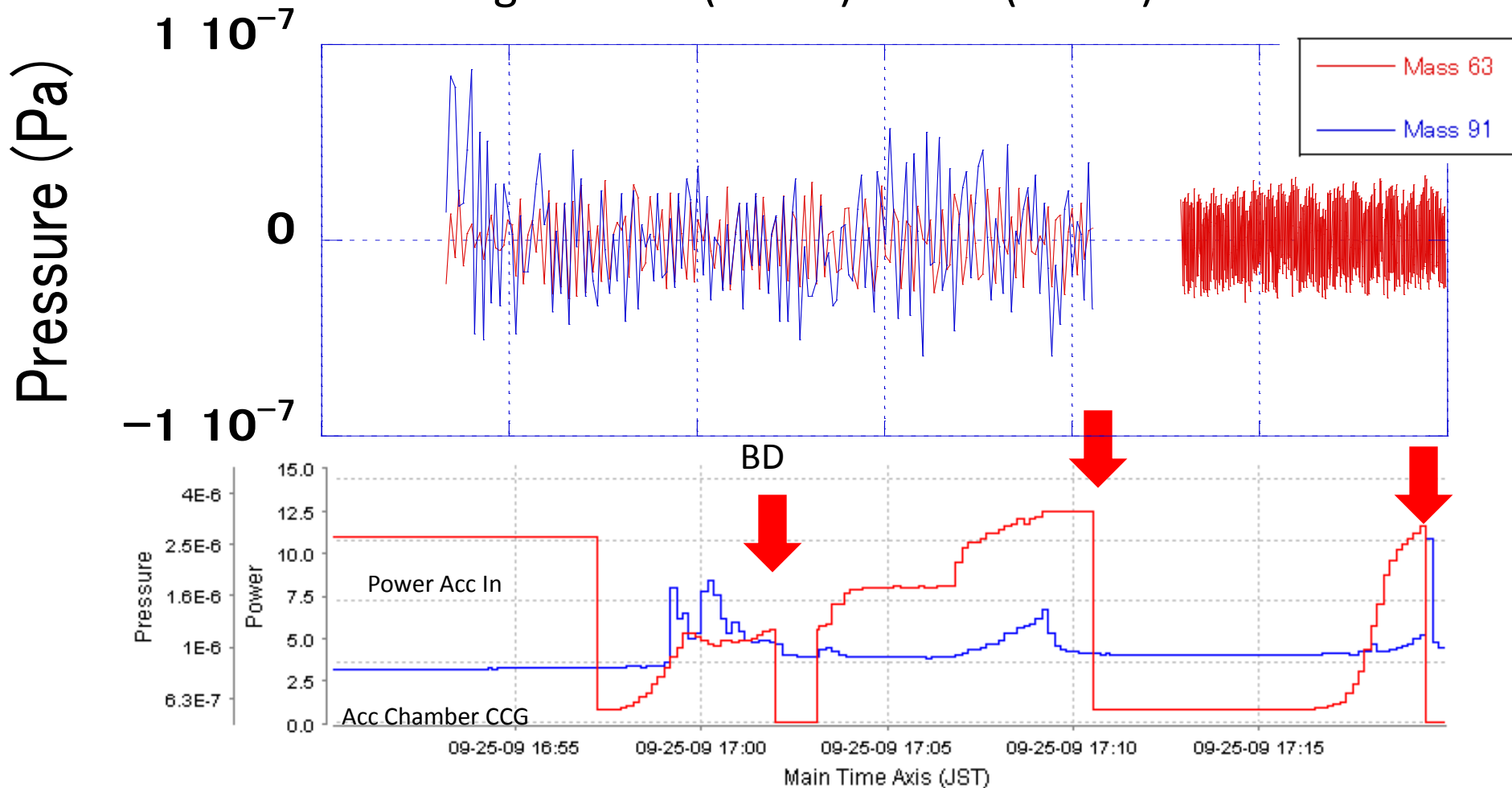
# QMS (1) :RF Power and gases

Pressure of H<sub>2</sub> dominated. Pressure of water is inactive.



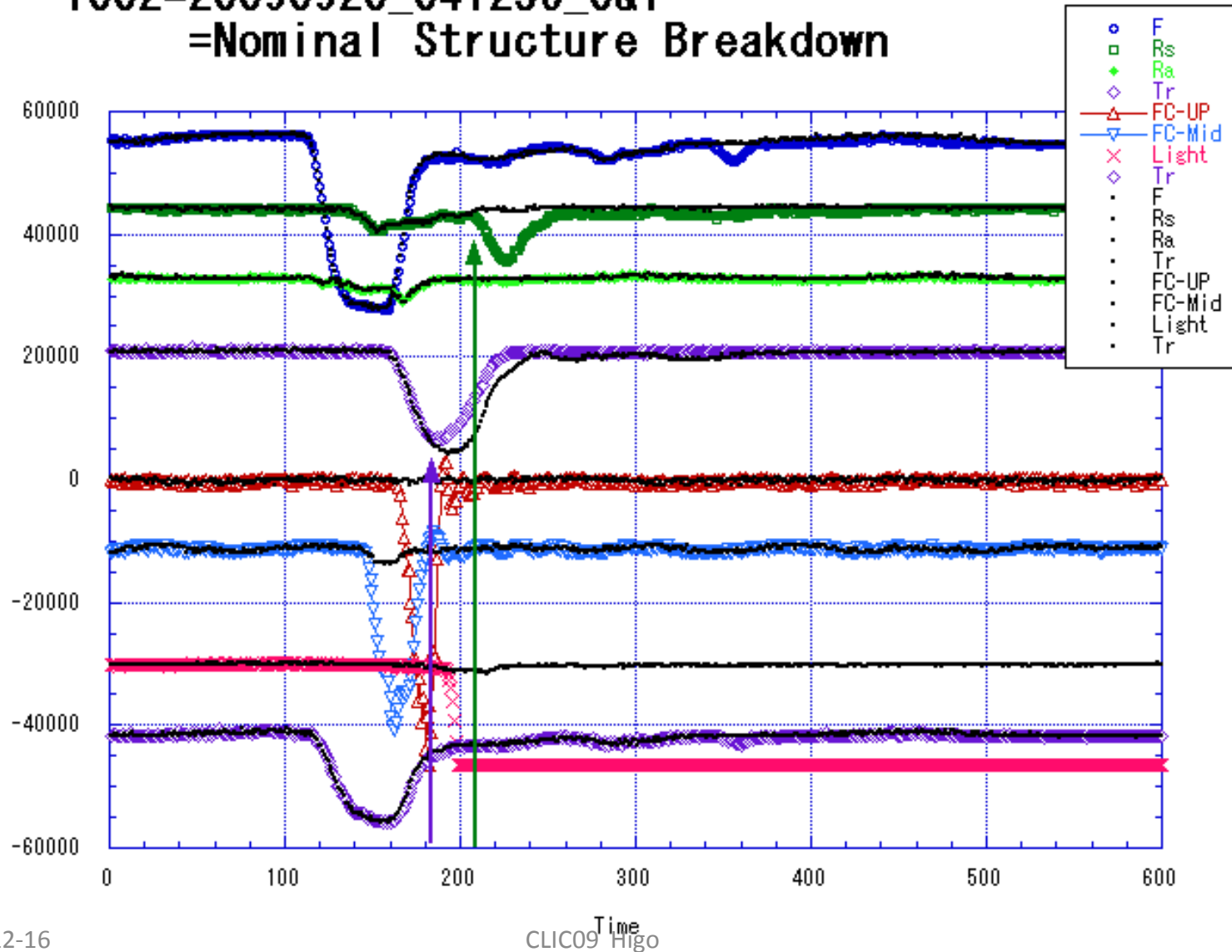
# QMS (2): Cu and Zr

No signal of Cu(M=63) nor Zr (M=89) .

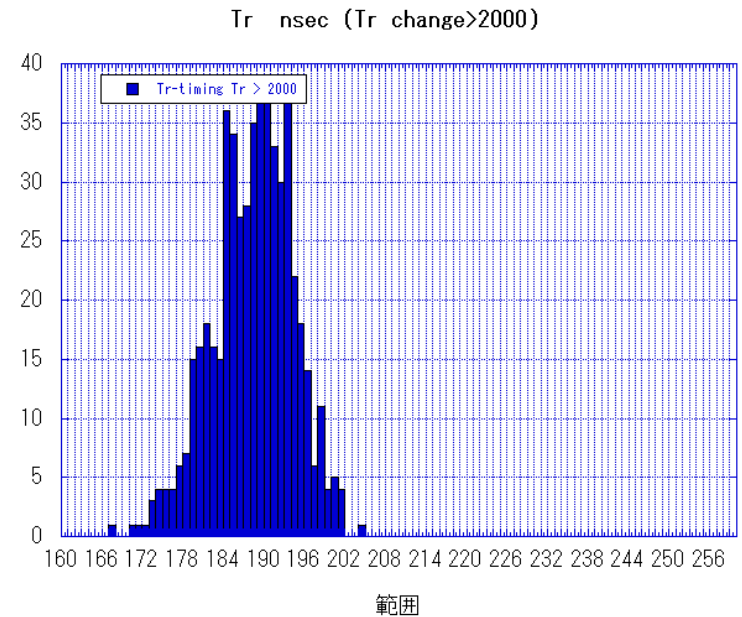
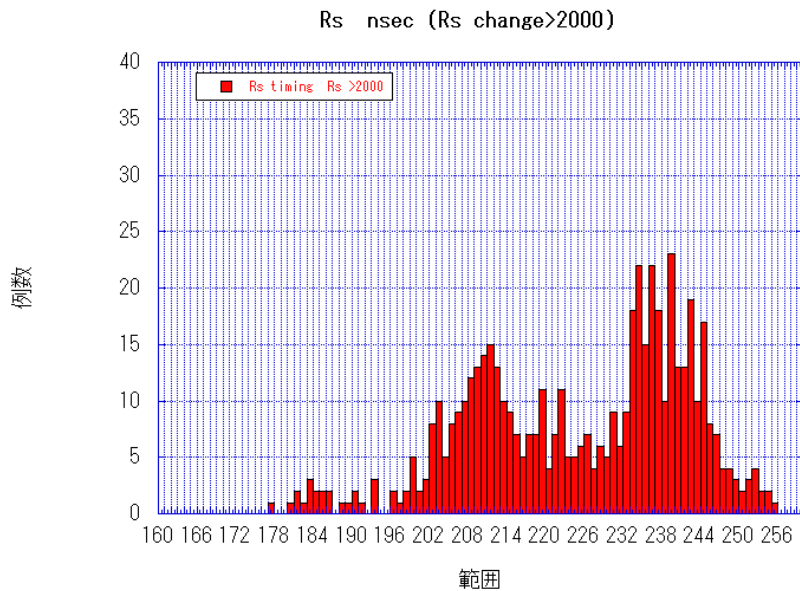


# Breakdown pulse analysis

1002=20090920\_041256\_0&1  
=Nominal Structure Breakdown

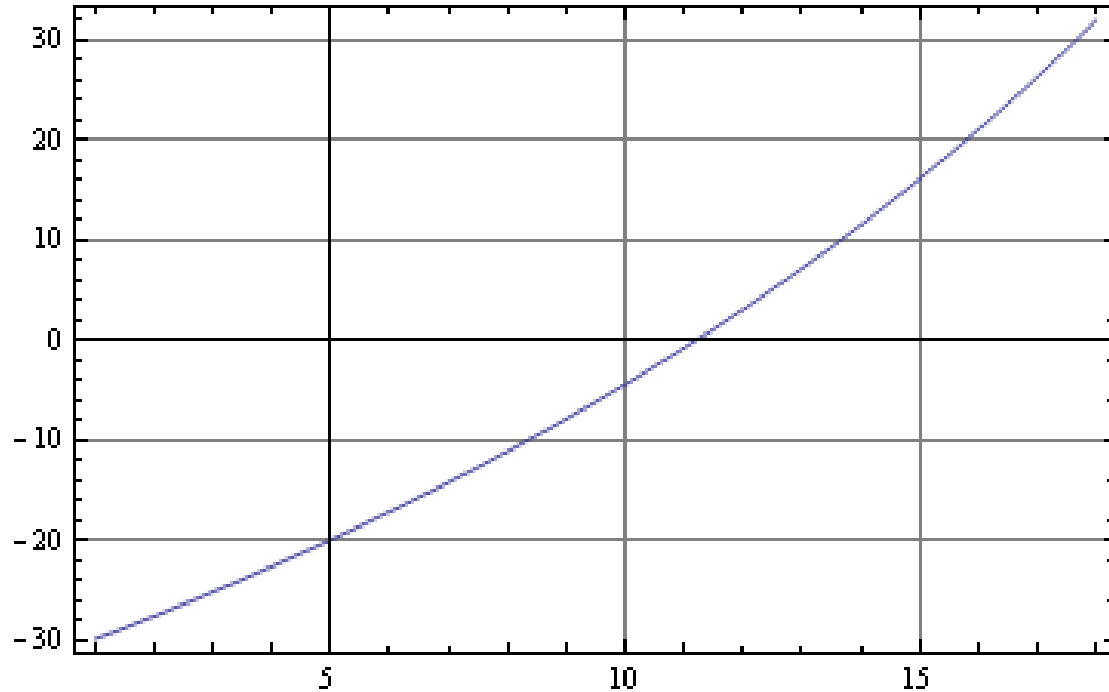


# Timing distribution for change>2000



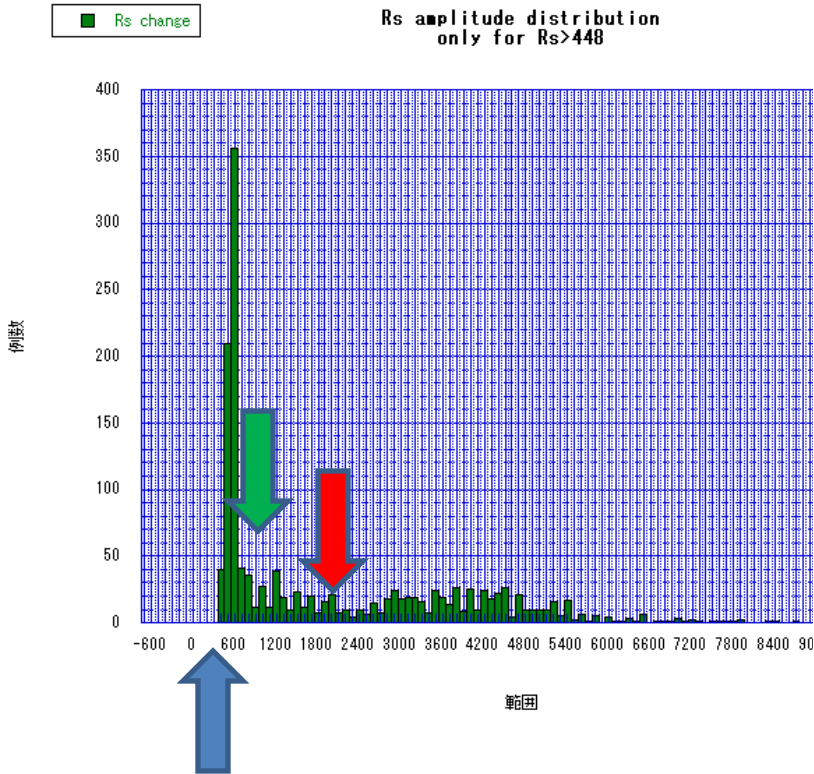


# T18 structure Function $F[z]$

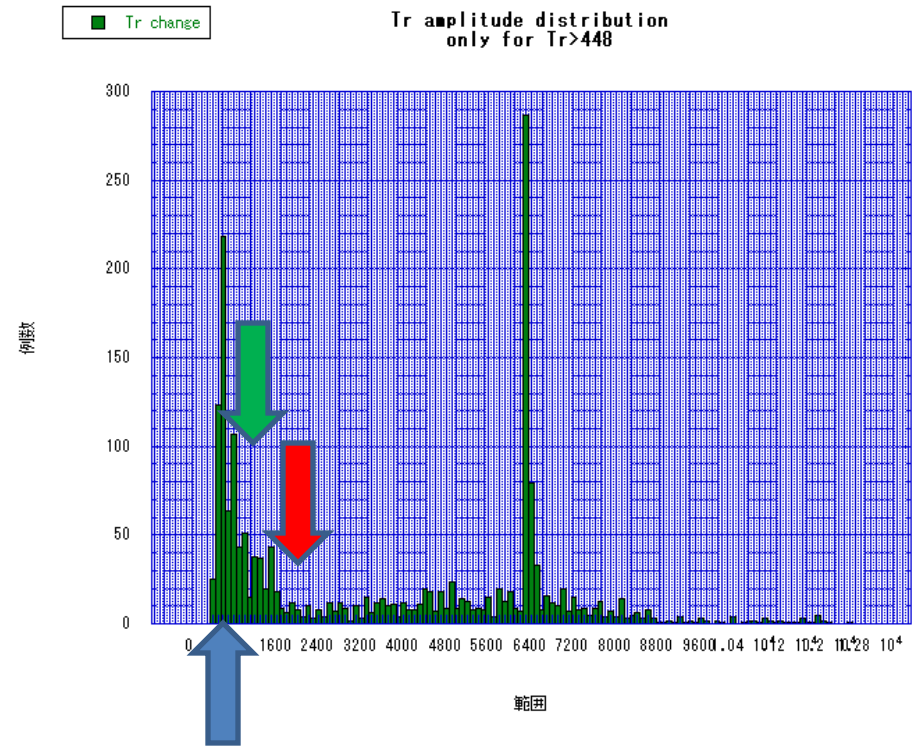


Use time difference  $R_s(\text{rise}) - T_r(\text{fall})$  to calculate BD position.  
Function  $F(z)$  is calculated from design  $v_g(z)$ .

# Pick up large Rs, Tr change with 50ns



Sampling cut at 448



Sampling cut at 448

Cut at 1000 or 2000 for timing analysis from next page.

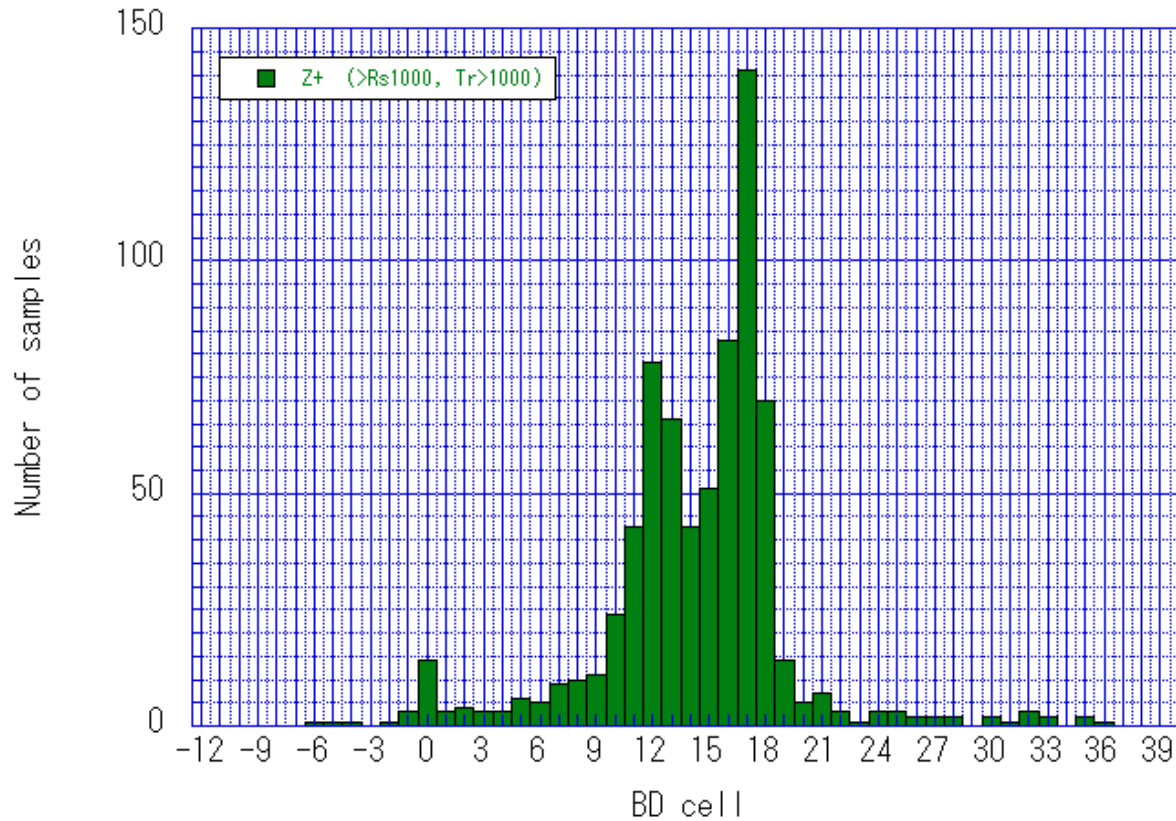
# Breakdown cell distribution >1000

090930 Analysis

## Quad #5 BD cell distribution

50ns higher target run

DPO Run4  
Rs>1000, Tr>1000



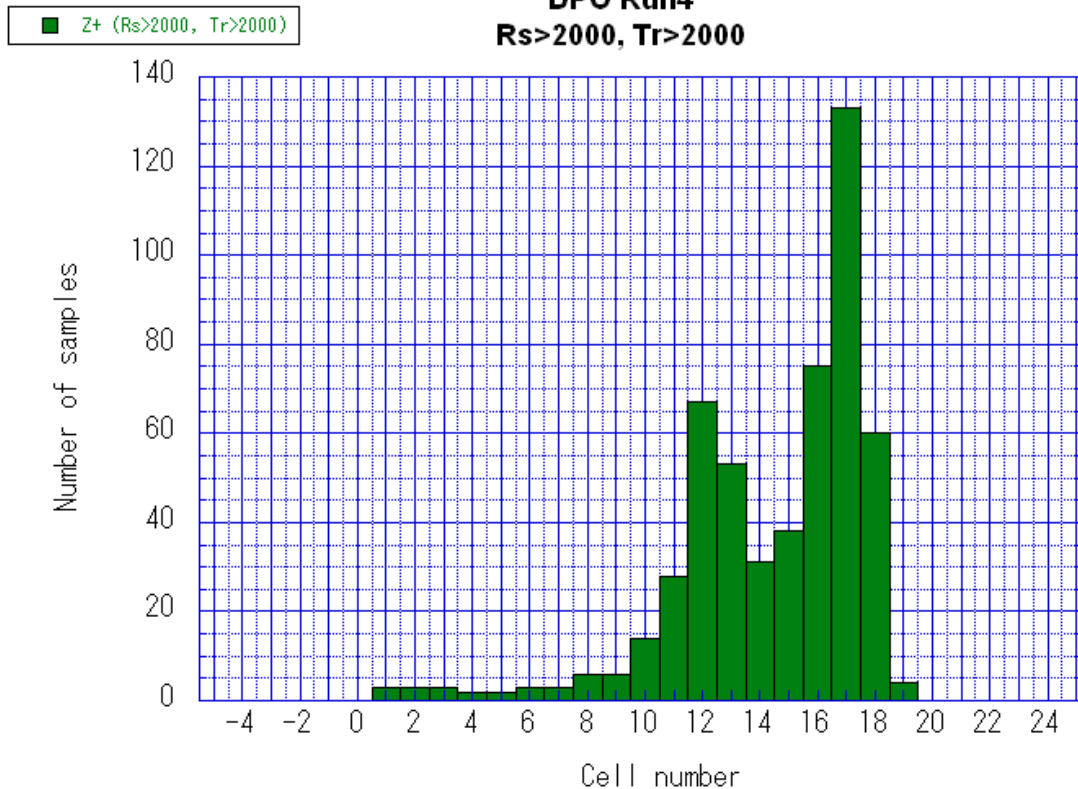
713 events were analyzed out of 1919 INTLK.

# Breakdown cell distribution >2000

50ns higher target run

090930 analysis

Quad #5 BD cell distribution  
DPO Run4  
Rs>2000, Tr>2000



Mostly  
downstream half.

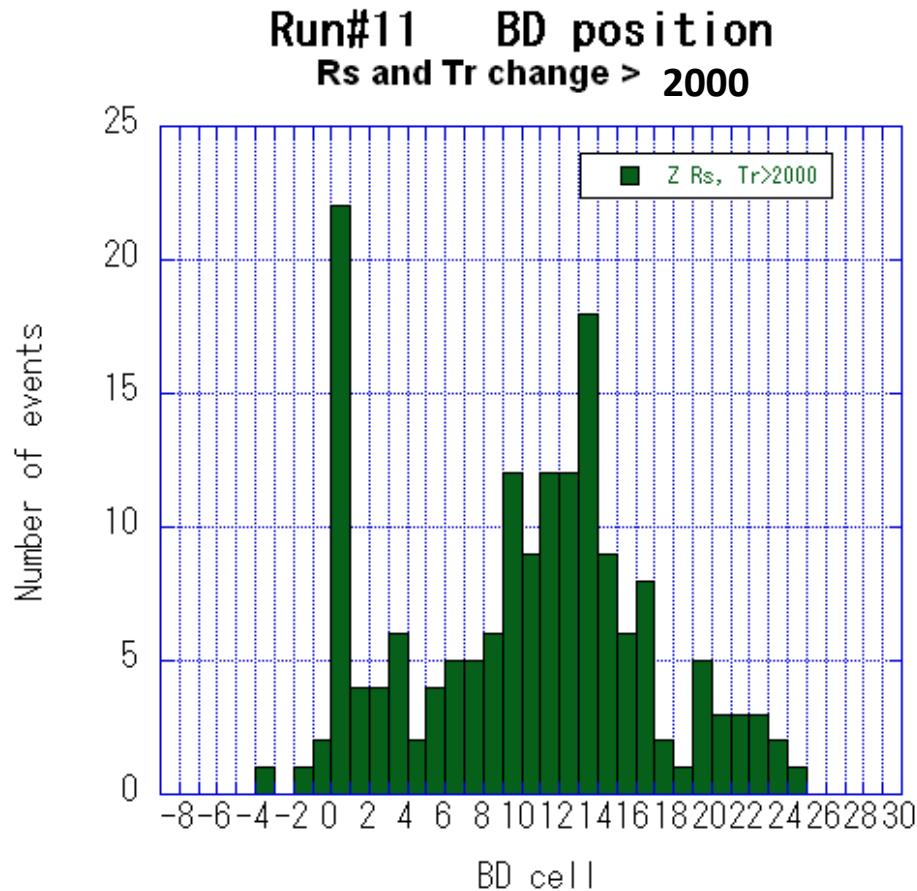
Simply increasing  
toward output  
end.

Indication of BD  
following some  
field gradient.

534 events were analyzed out of 1919 INTLK.

# BD position of run11 113ns, MW

113ns higher target run



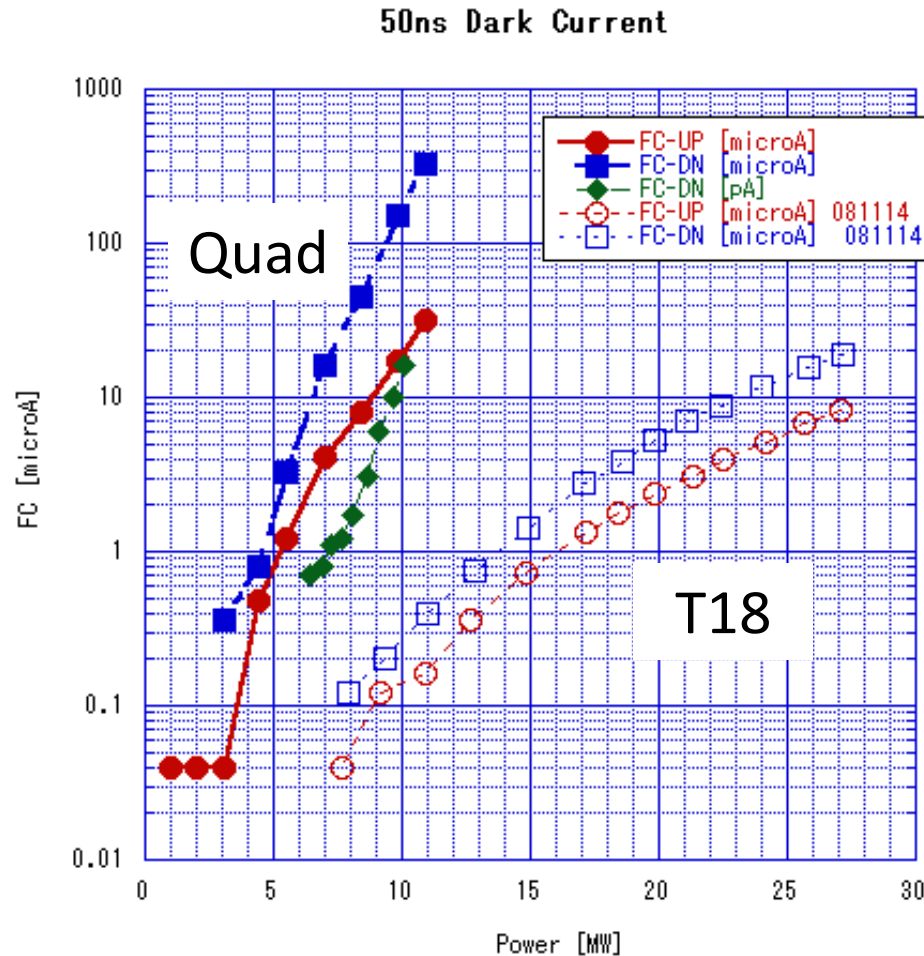
It is evident that there is difference than 50ns.

Not increasing toward output side.

Need to check the peak at cell#0.

Need to check those outside structure cell region.

# Quad dark current much larger than T18

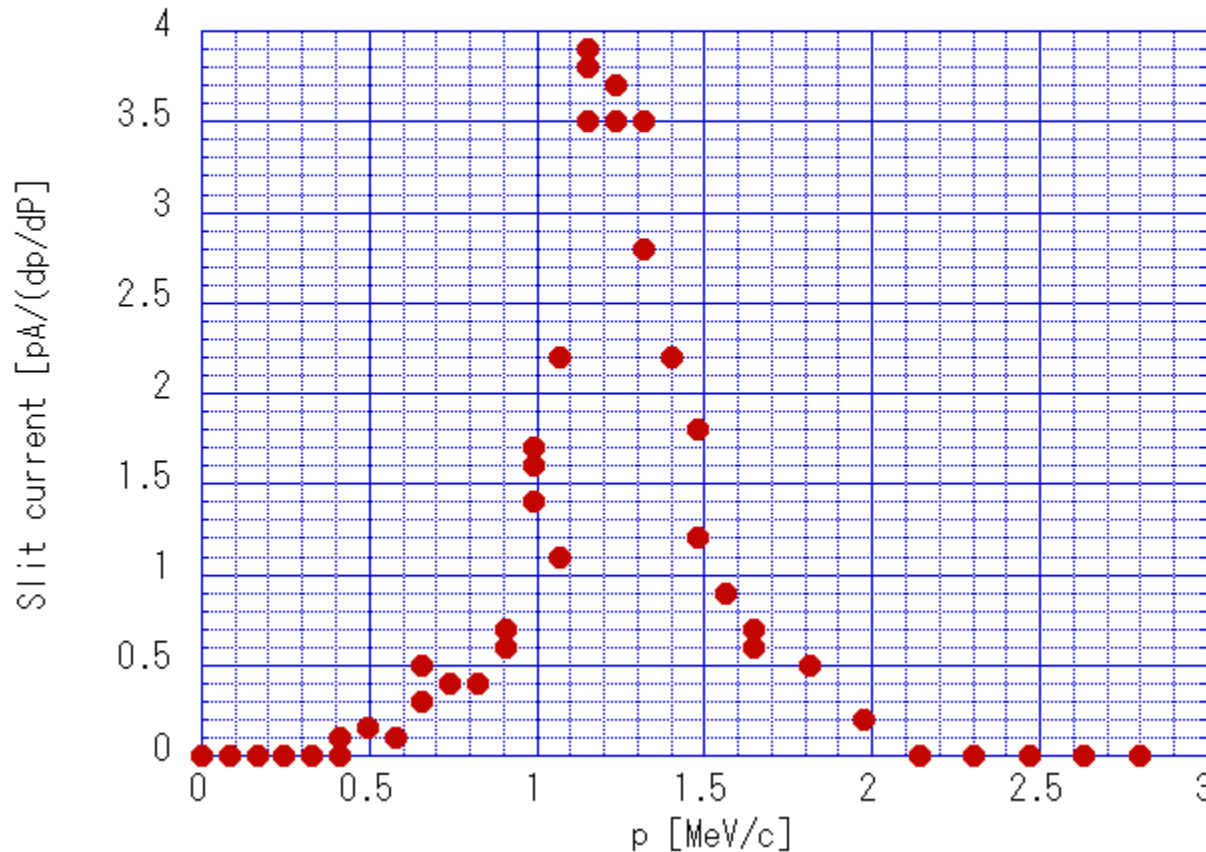


(Note: Power is just the value in the control program panel. Read 12MW as 19MW, though relative comparison between quad and T18\_disk is OK without this.)

# Spectrum peak at very low energy

090926

Quad #5 Dark current spectrum  
50ns, 19MW



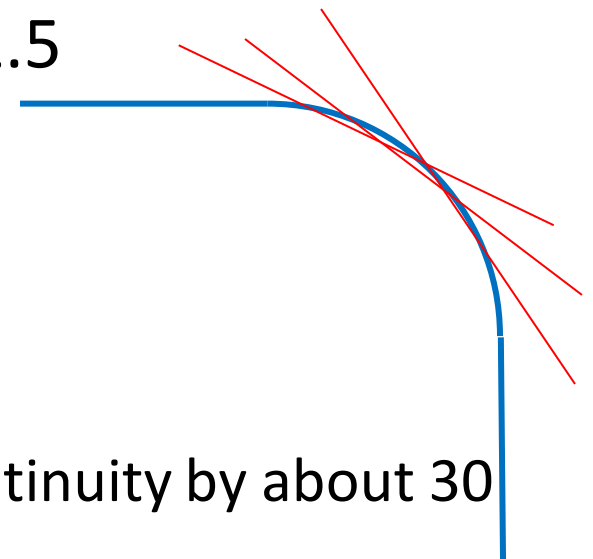
T18\_Disk  
Peaks at 8MeV/c  
and 4MeV/c with  
108MV/m

Present quad  
Peak at 1.2MeV/c  
with 19MW →  
59MV/m

# Possible cause of high dark current

## Field enhancement due to round chamfer

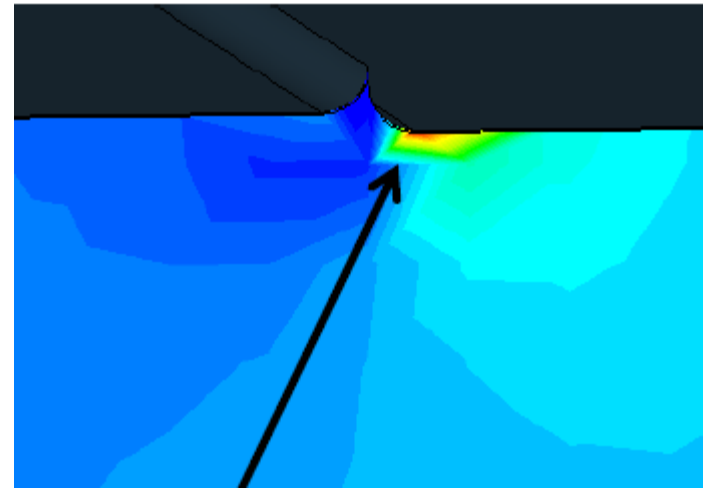
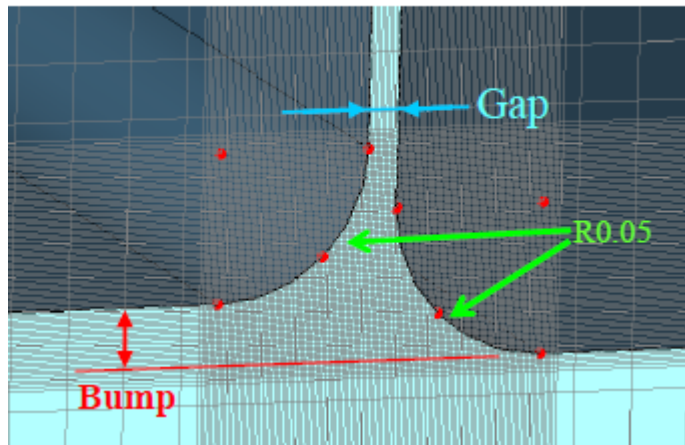
- Simulation of field enhancement
  - 1.4 ~ 1.6 at radius
  - with  $\text{gap} < \text{radius}/5$ ,  $\text{step} < \text{radius}/2.5$
- Only a few tool passes
  - to shape 50 micron radius
  - with radius tool of 2mm
    - If three passed  $\rightarrow$  tangential discontinuity by about 30 degree
    - Can be relaxed by such as EP in future





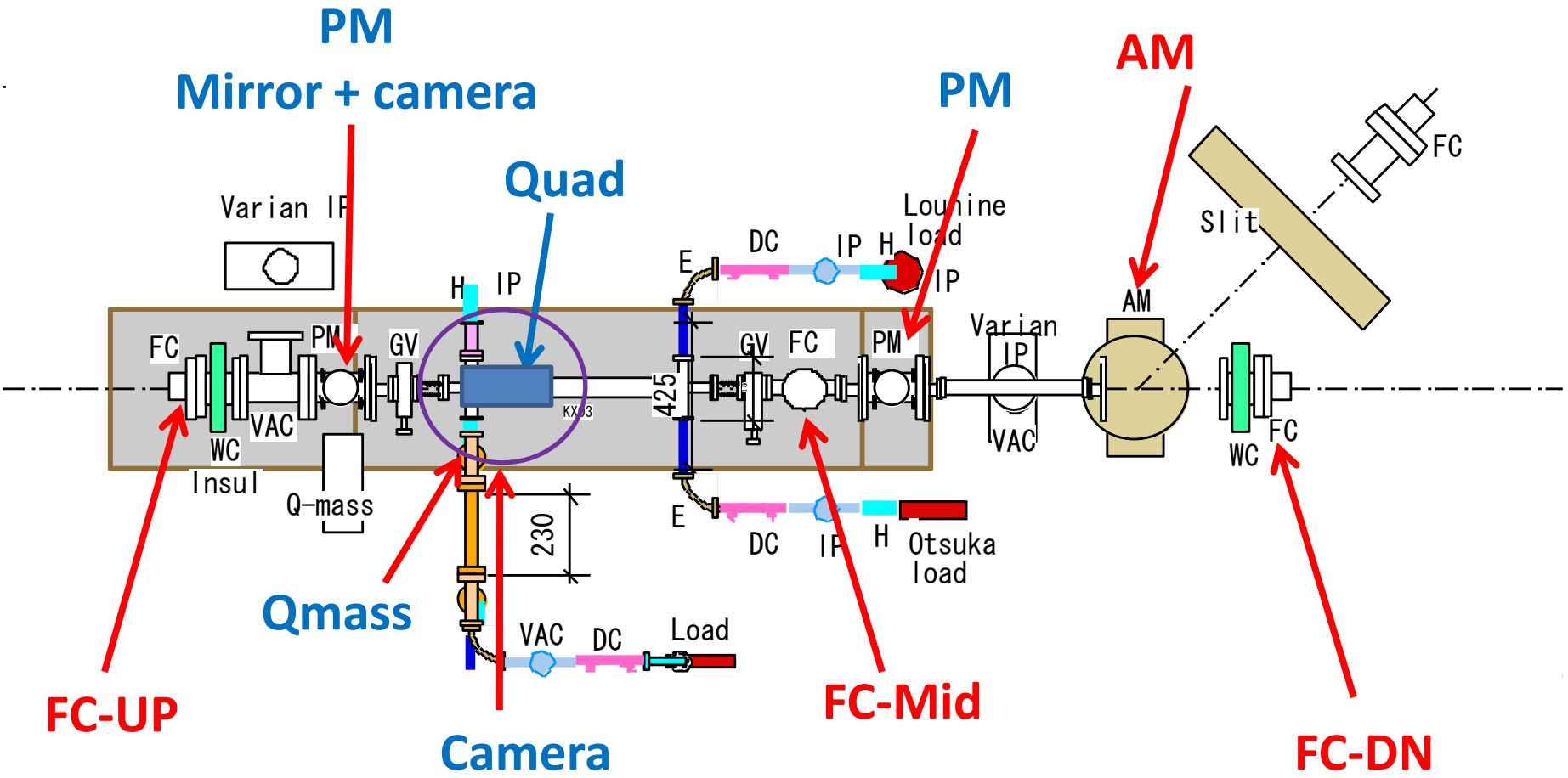
# Electric field enhancement in a shallow channel with round chamfer

Calculation done by T. Abe by CST MS. Waveguide field.



Gap (micron)	Bump (micron)	$E_{max} / E_{nominal}$
0	0	1.39
0	20	1.57
10	20	1.58

# Other monitors for quad



# Light emission observed by usual camera

- From side window
  - Can see several cells near center of structure
  - Found some BD events with a light emission from a particular cell
- View from upstream beam axis
  - Found a light emission
  - Pattern interpretation is not straightforward
  - Some event showed bright spot smaller than cell size
- Need better optical setup
  - Time gating, wider view, space resolution, etc.

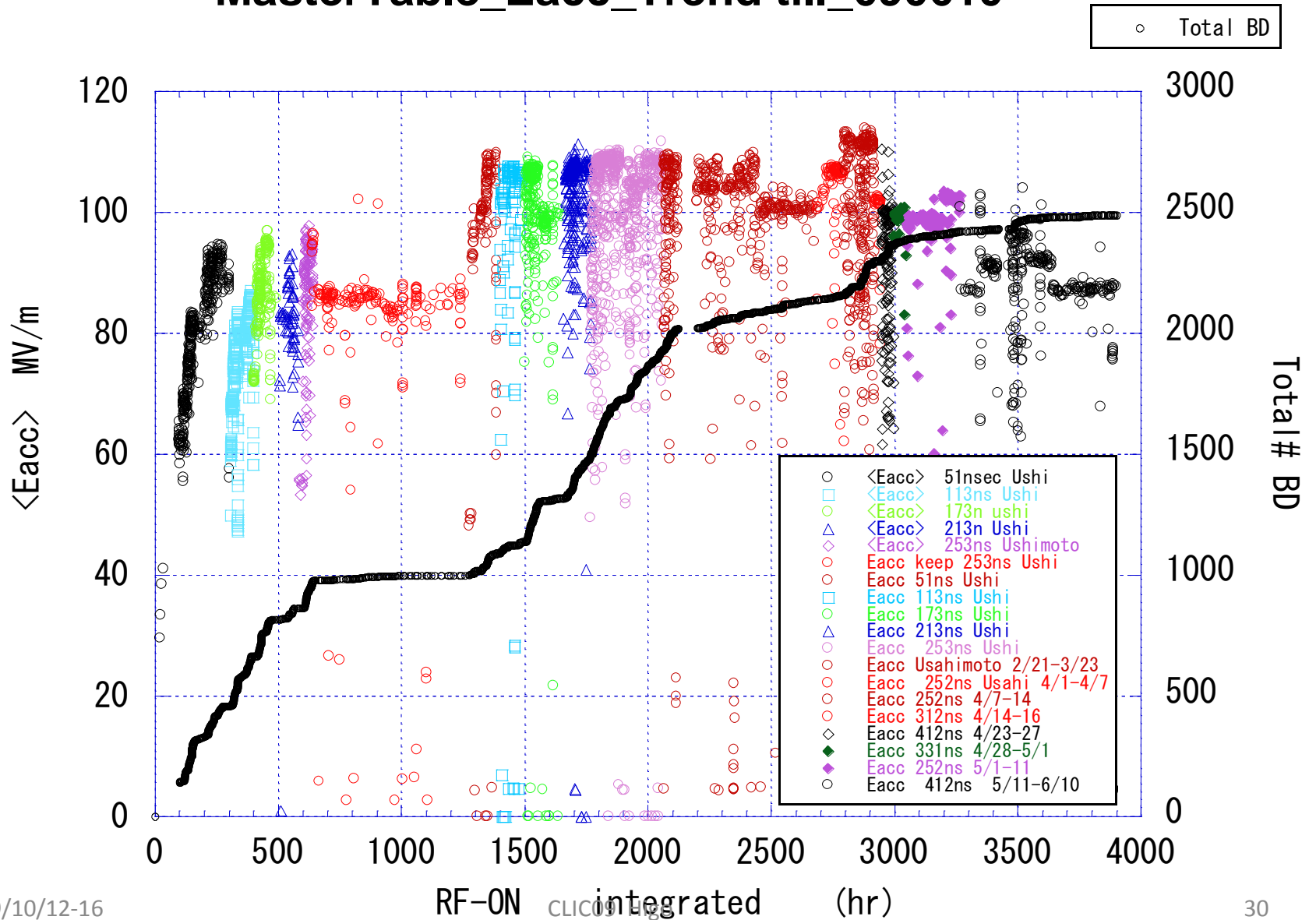
# Possible future program for quad #5

- NEG installation in progress in this week
- Further run
  - Longer pulse run at 173ns
  - Evolution of dark current
- Finish high gradient and --
  - RF check
  - Mechanical check
  - Optical inspection
  - SEM at CERN?
- Further treatment?
  - EP ?
- Further high gradient test
  - Improved optical inspection
  - Change in dark current
  - Possibly higher field?
- These become good lessons for us to understand breakdown phenomena.

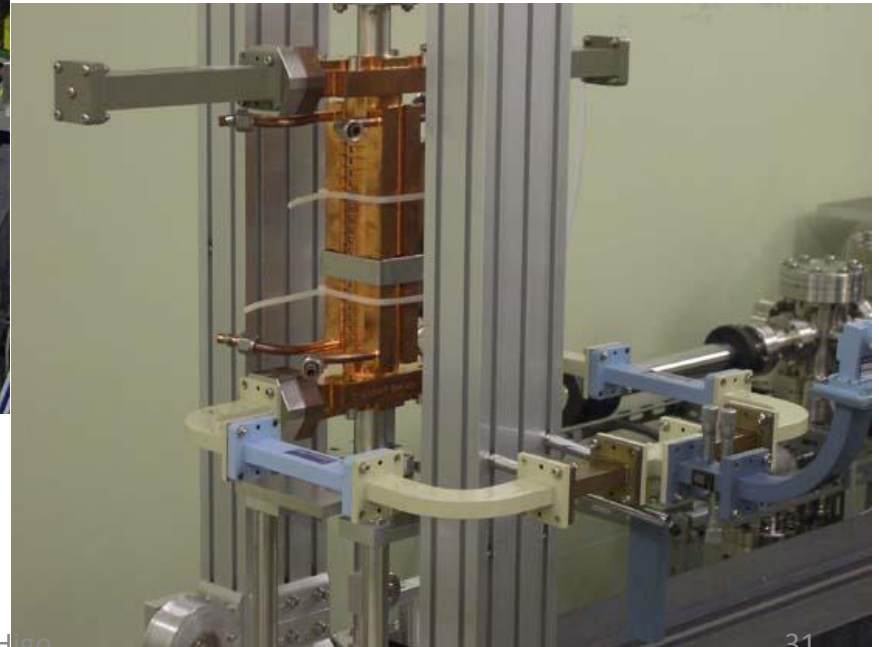
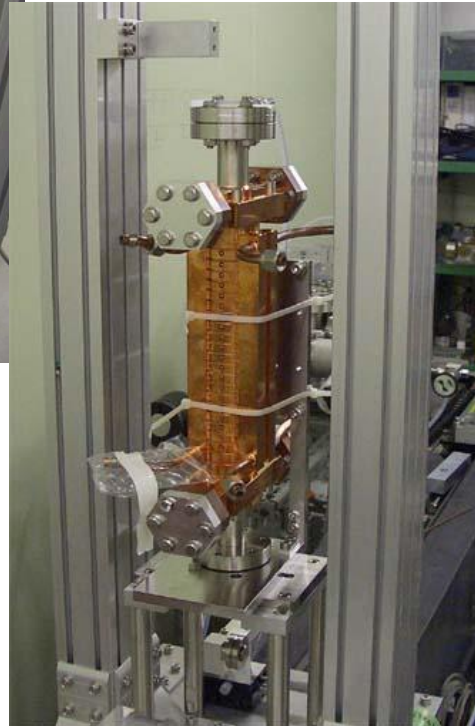
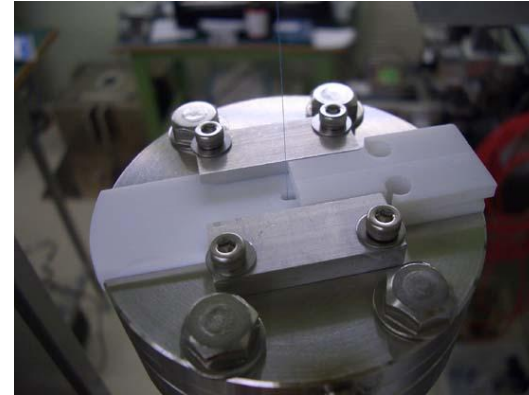
Change in T18  
through high gradient test?

# Whole history of processing of T18\_VG2.4\_Disk #2 090610

## MasterTable\_Eacc\_Trend till\_090610



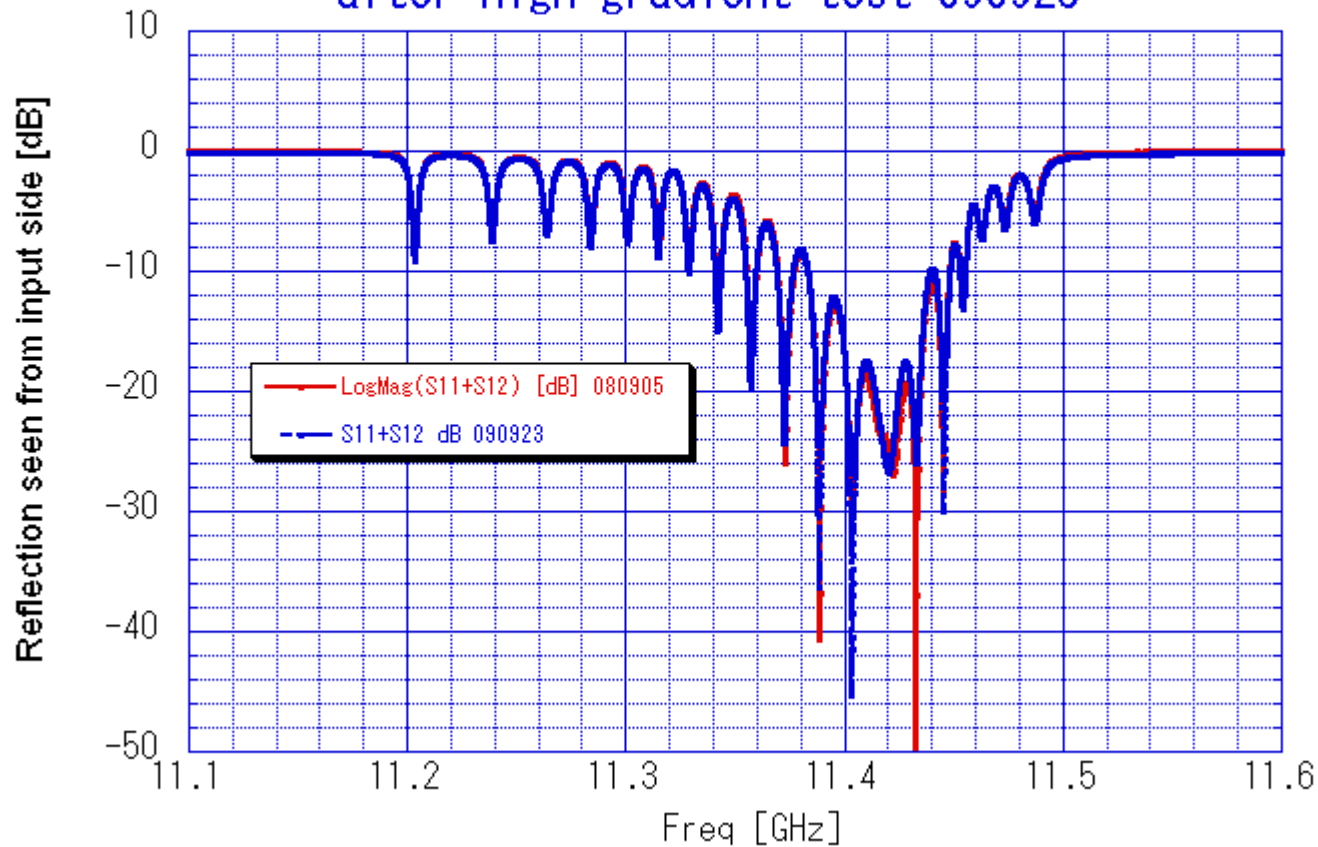
# RF check setup



# Input match not changed

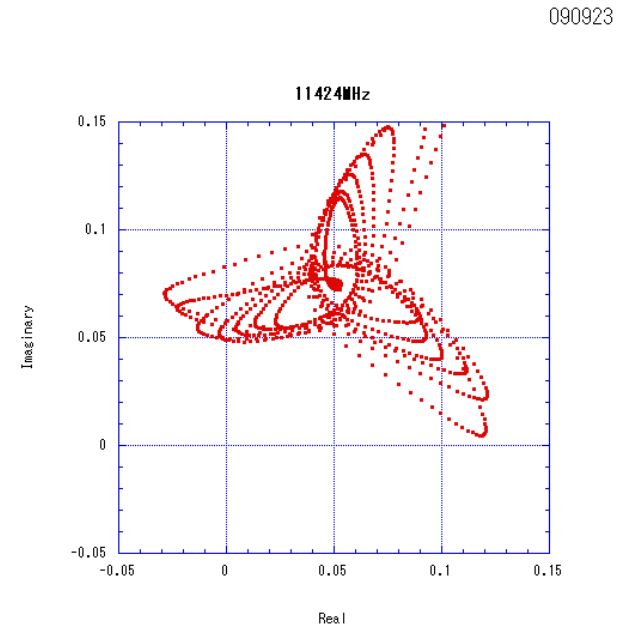
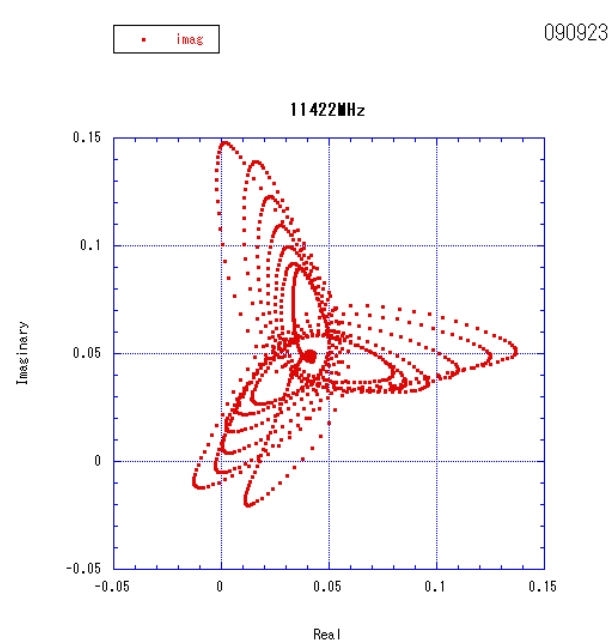
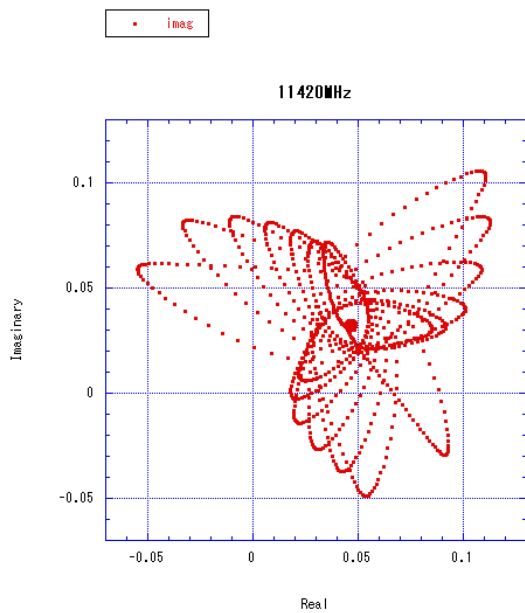
080905  
090923

T18\_VG2.4\_Disk\_#2 Input coupler matching  
before installation 080905  
after high gradient test 090923

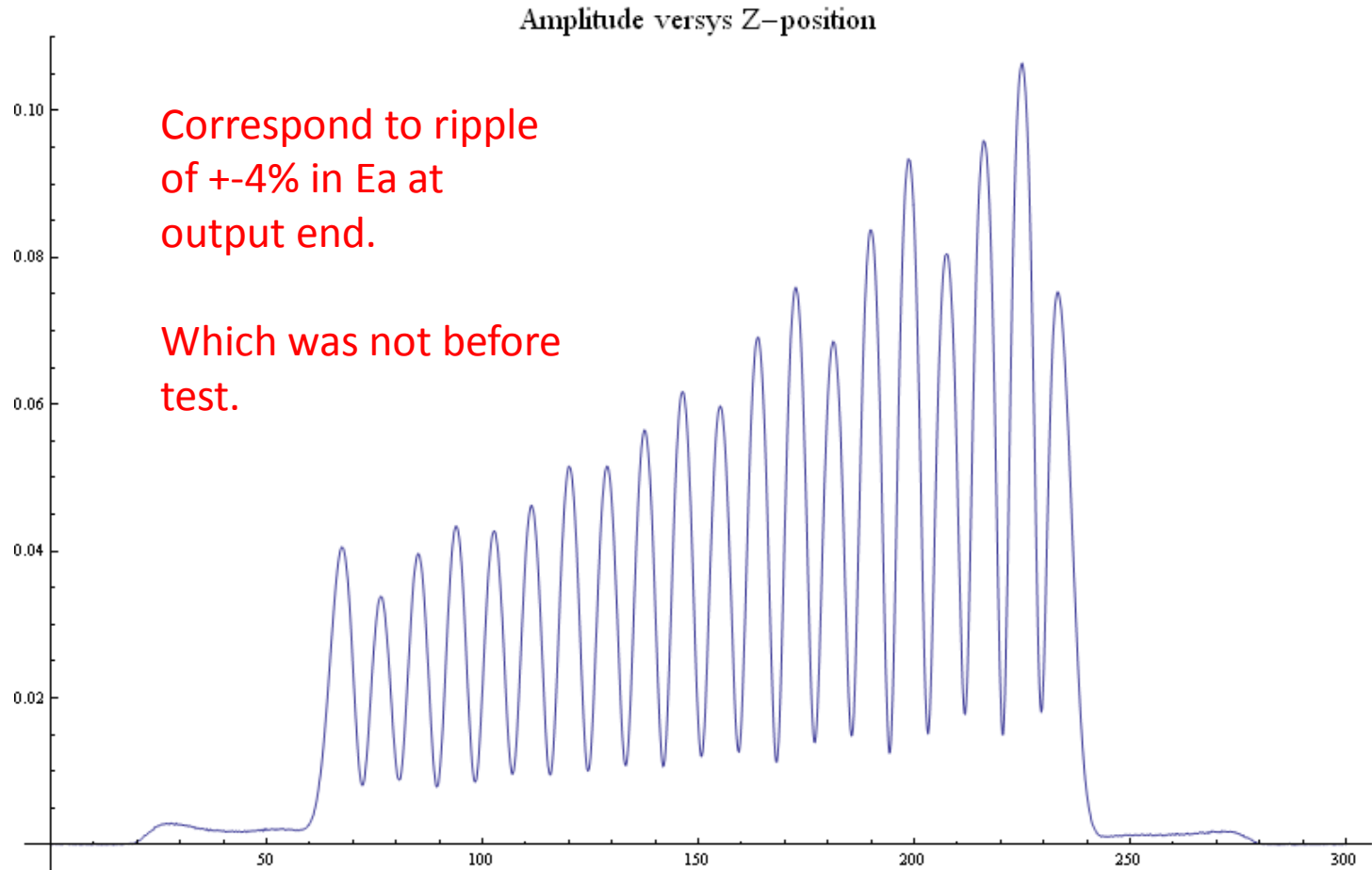




# Bead pull raw data on Sep. 23



# Bead pull amplitude plot 11422MHz



Correspond to ripple  
of  $\pm 4\%$  in  $E_a$  at  
output end.

Which was not before  
test.

Input side

Output side

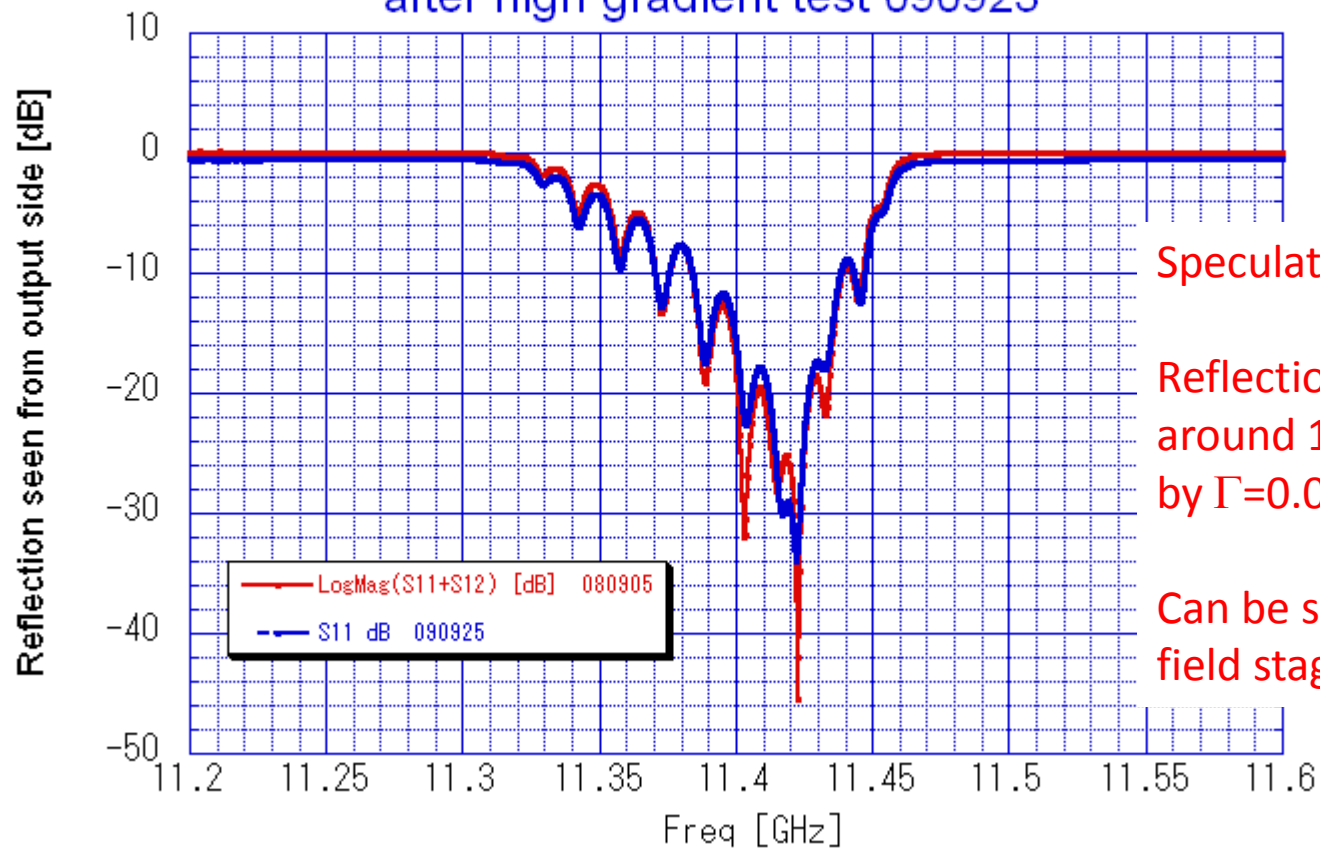
# Output match some change

T18\_VG2.4\_Disk\_#2 Output coupler matching

080905  
090925

before installation 080905

after high gradient test 090923

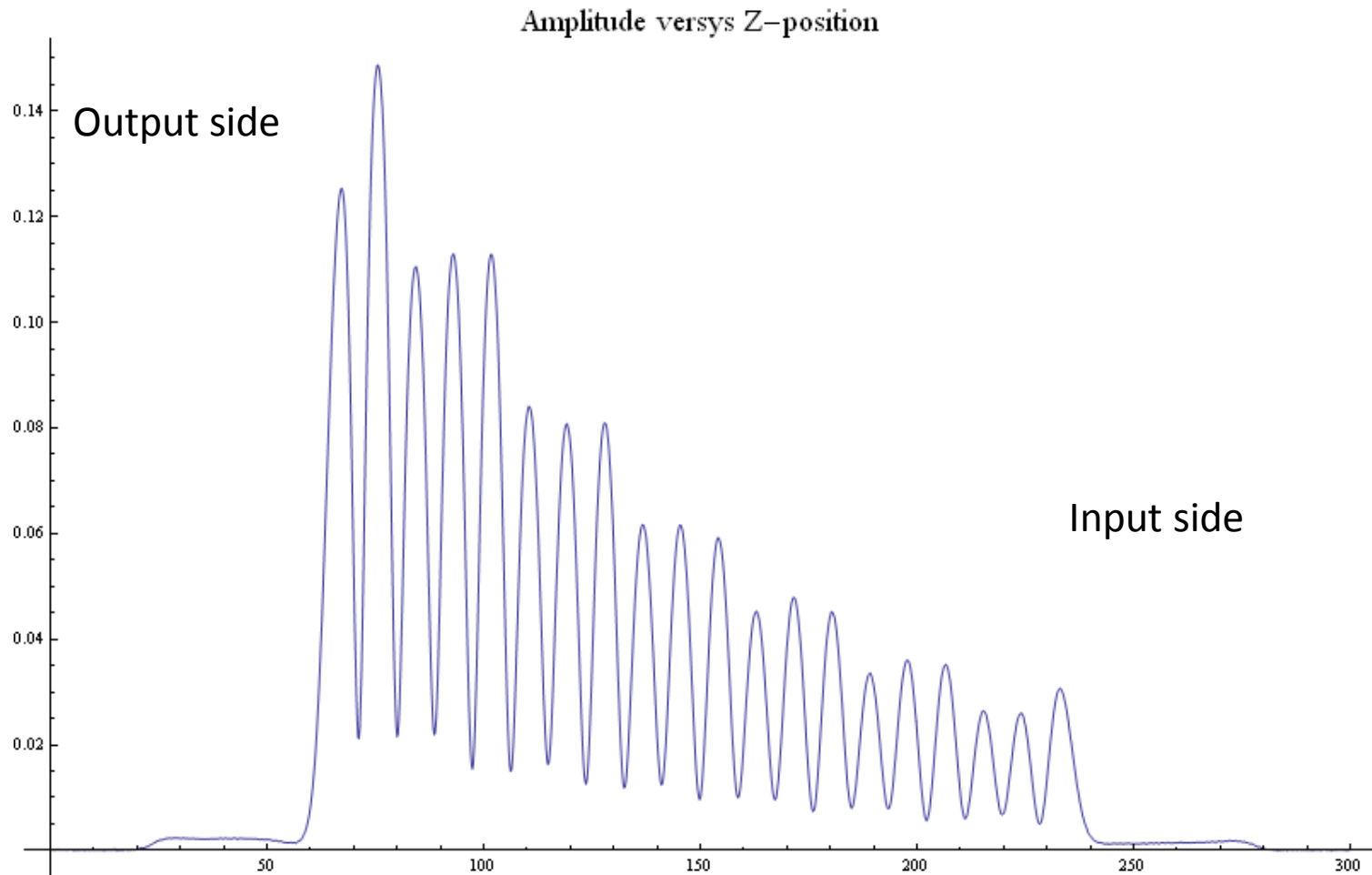


Speculation:

Reflection changed  
around 11424MHz  
by  $\Gamma=0.05$  level??

Can be source of  
field staggering

# Bead pull feeding from output side



# Phase advance per cell

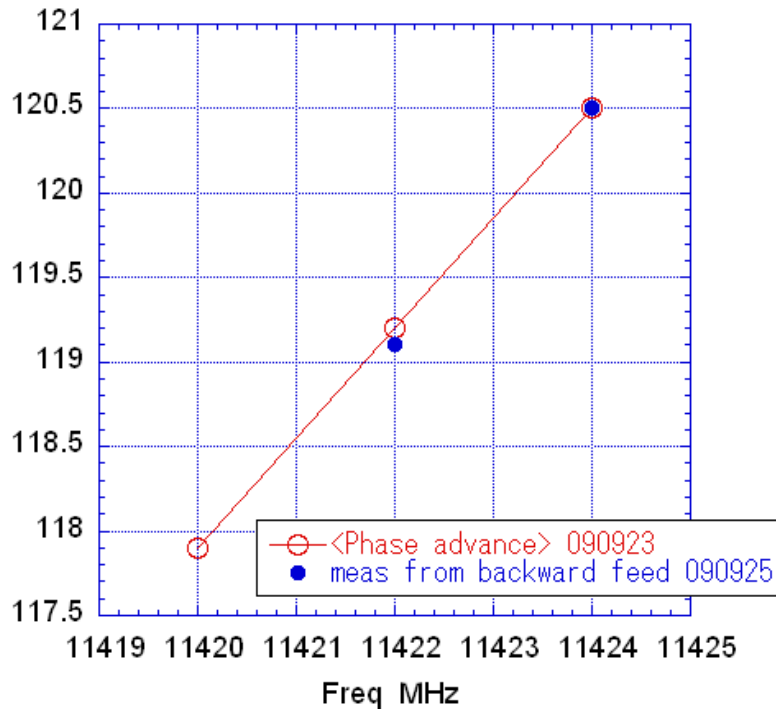
## Condition

at 22.7degC in Nitrogen

Bead pull result:

11423.2MHz  $\rightarrow$  120deg/cell

Phase advance per cell



delF 22.7  $\rightarrow$  30C -1.38MHz

delF N2  $\rightarrow$  VAC +3.12

delF string  $\rightarrow$  no string +0.2MHz

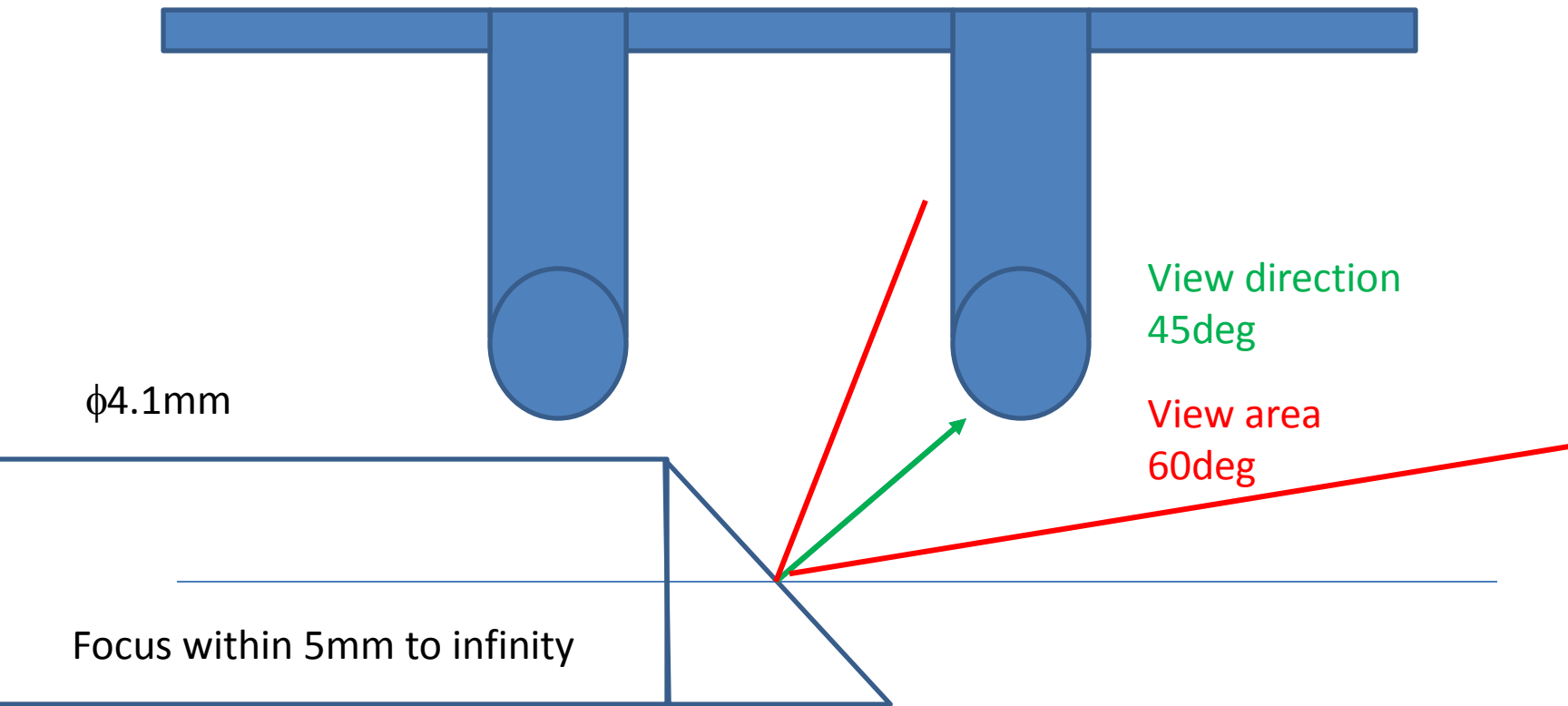
Total delF = 1.94MHz

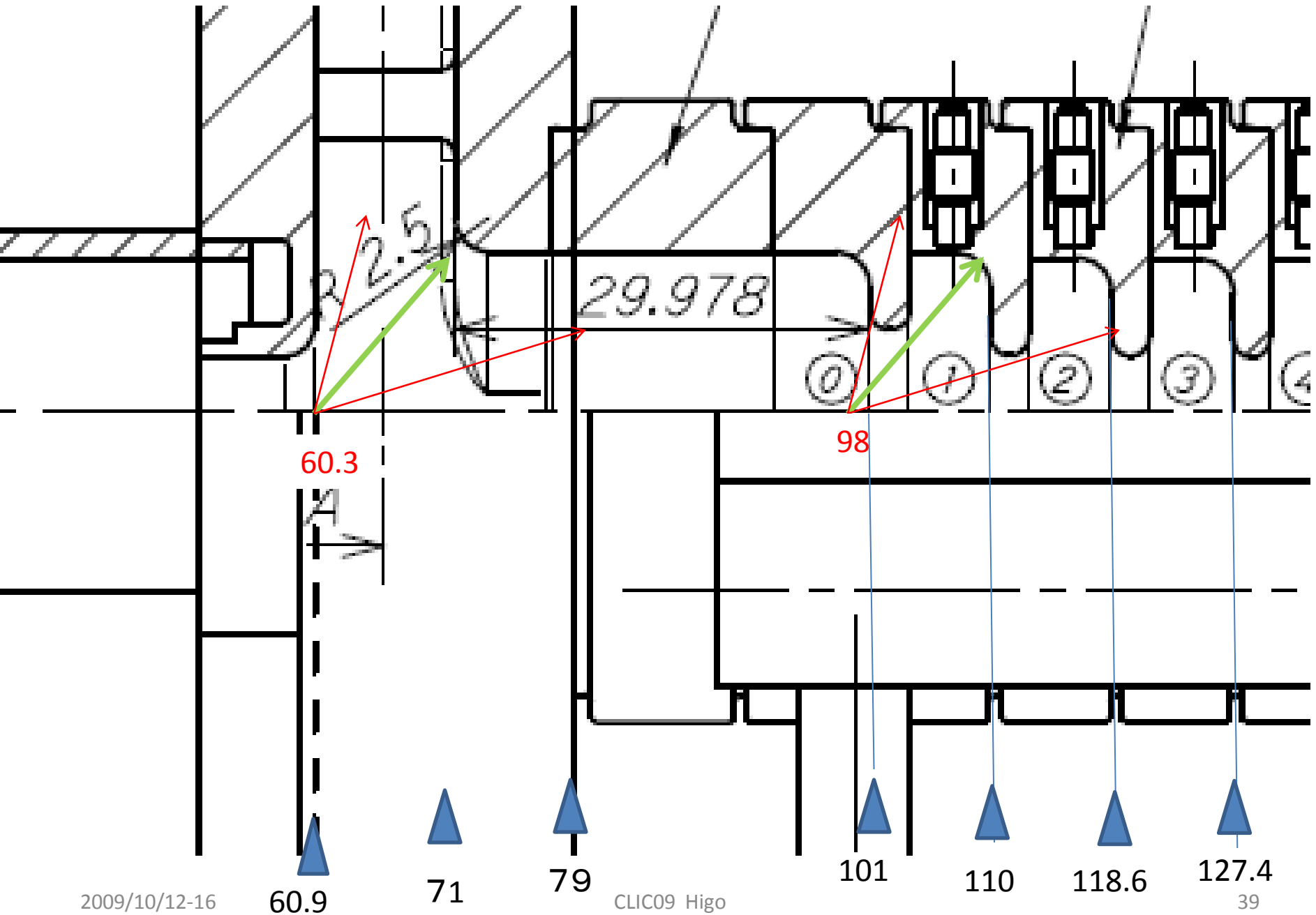
The structure now shows

120deg/cell at 11425.1MHz

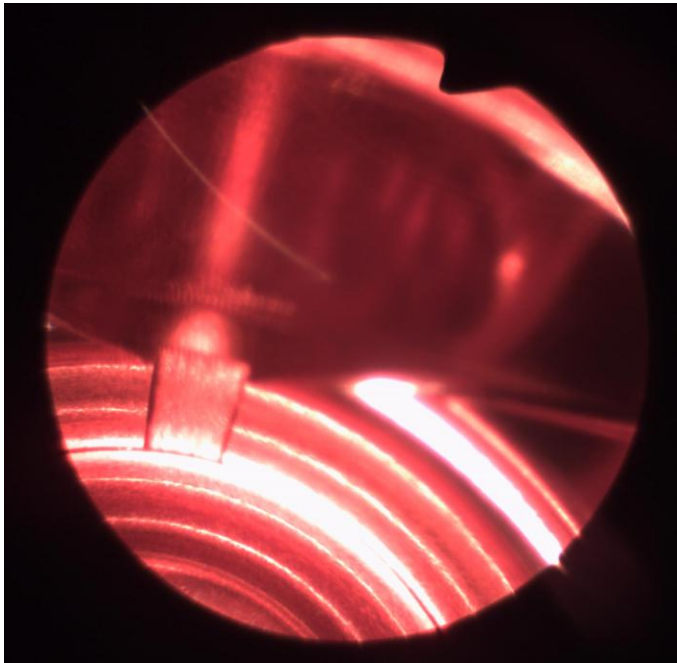
Changed by 1.1MHz through  
high gradient test!?!?

Should confirm carefully with  
SLAC tuning result.

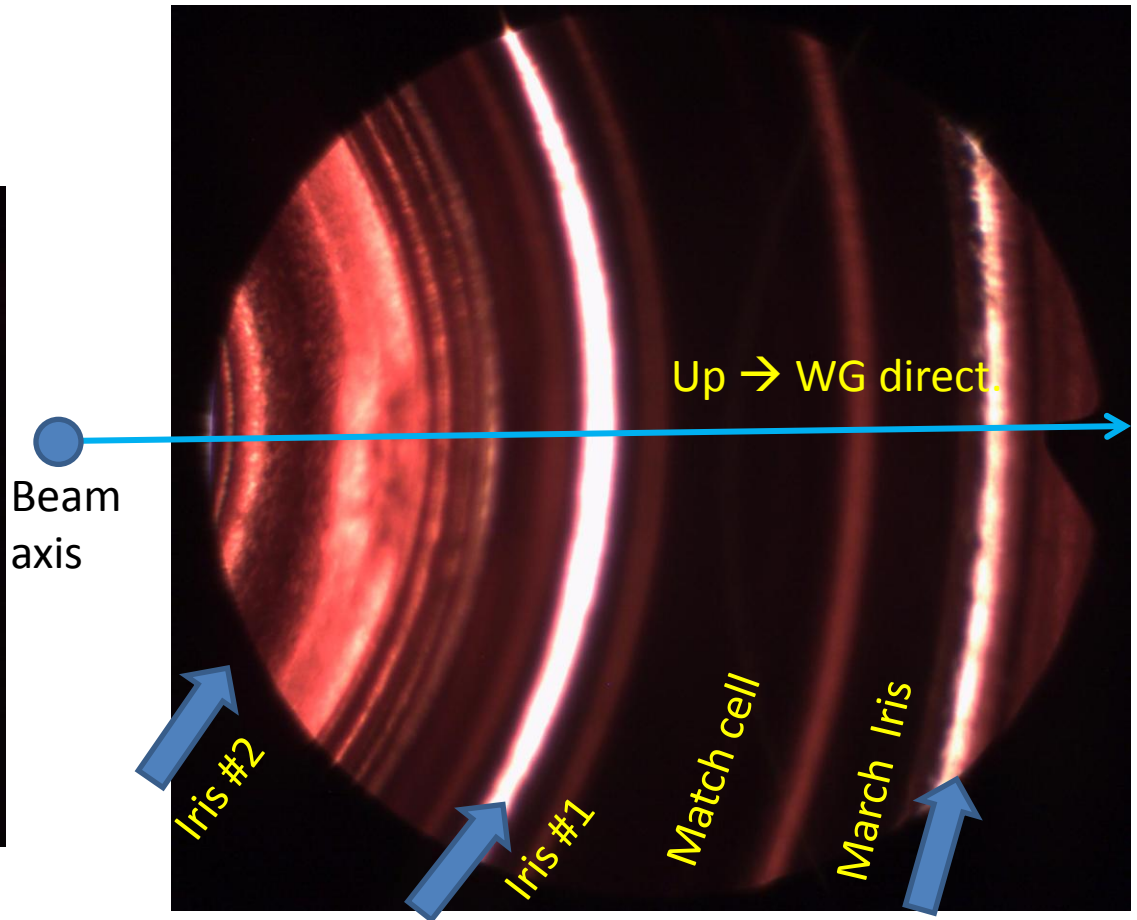




# Optical inspection upstream



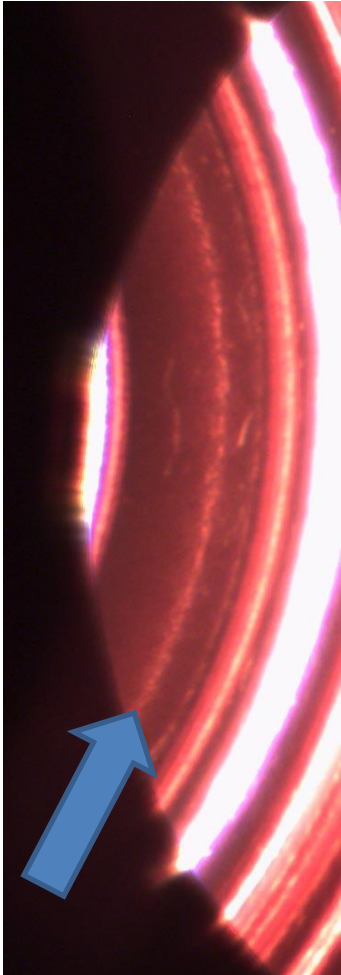
60.3mm  
Input coupler to cylindrical  
TM01 line



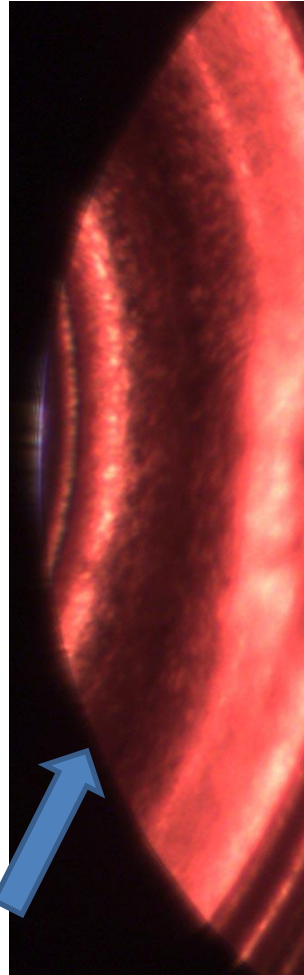
Insertion 98.0mm for observing Iris #2.  
This is the best we can now, only the  
forward iris at an enough distance.



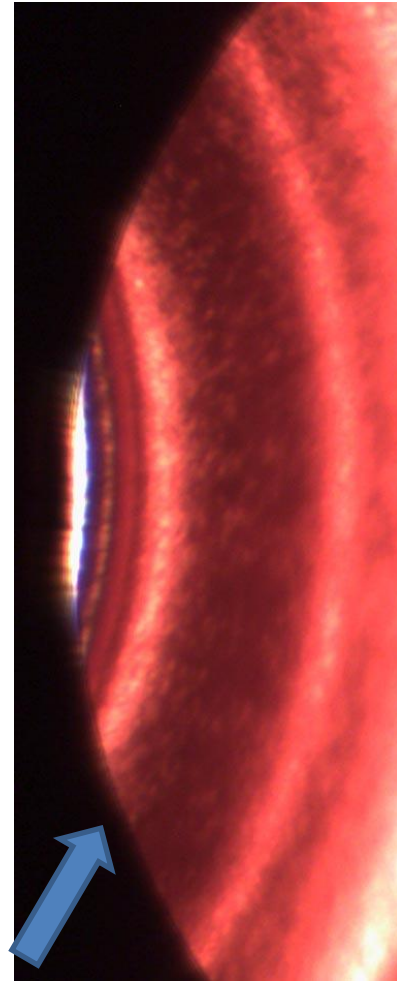
# Optical inspection upstream and middle



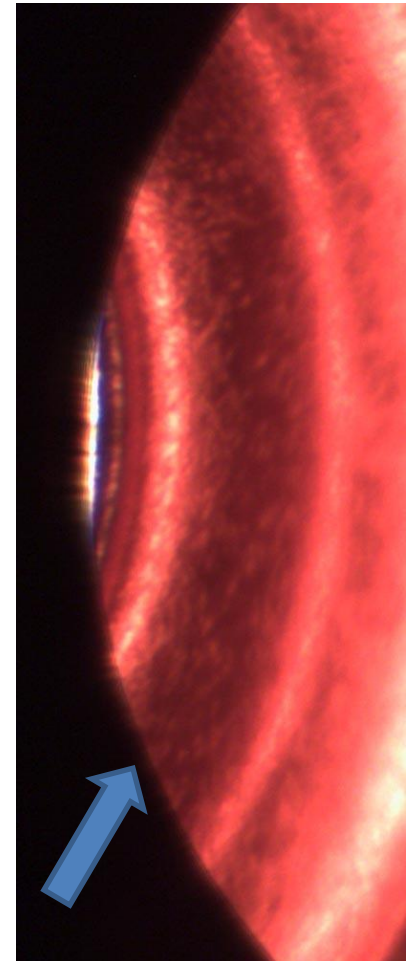
Insertion 82.7mm  
Iris #1 at match cell



Insertion 98.0mm  
Iris #2 at first  
regular cell

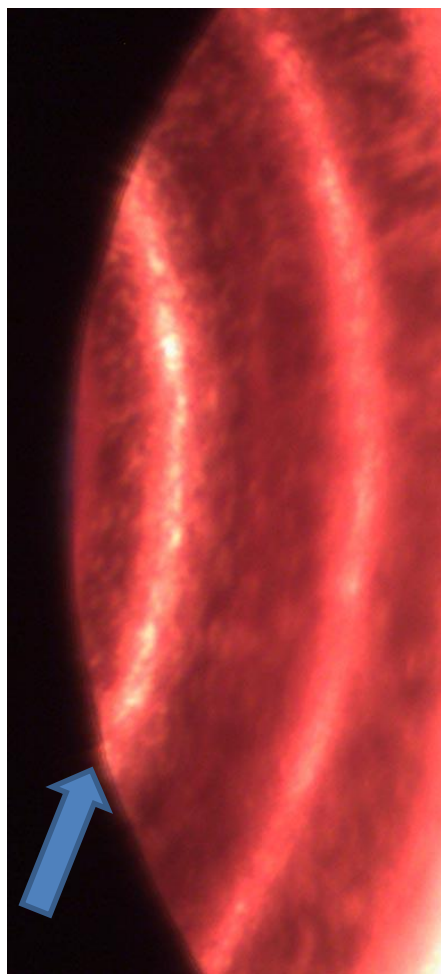


161.9mm Iris #9



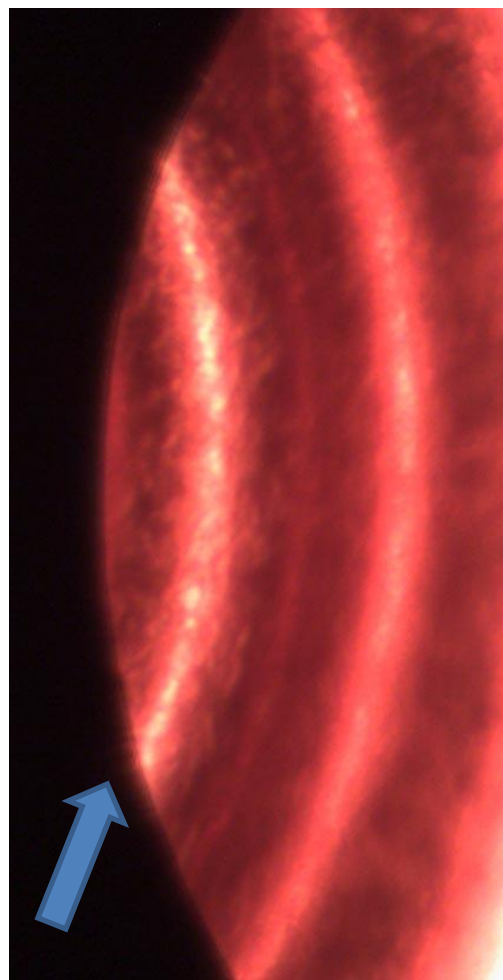
170.9mm Iris #10

# Optical inspection downstream end



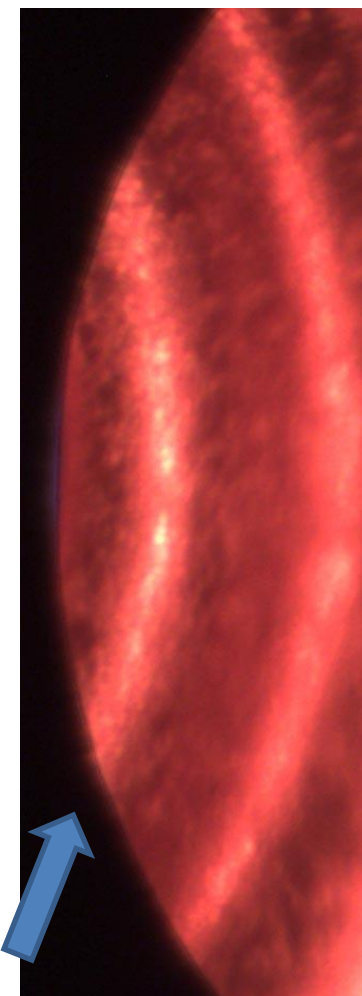
243.2mm Iris #18  
Upside iris of last regular  
cell

2009/10/12-16



252.2mm Iris #19  
Down side iris of last  
regular cell

CLIC09 Higo



261.3mm  
Last regular cell iris #20

# Optical inspection result and future

- No significant variation was observed
  - Comparing input to output but
- Need to inspect with better resolution
  - Change to straight bore scope?
  - Adjust focal plane?
  - Should be improved

# T18\_Disk\_#2 after high gradient test

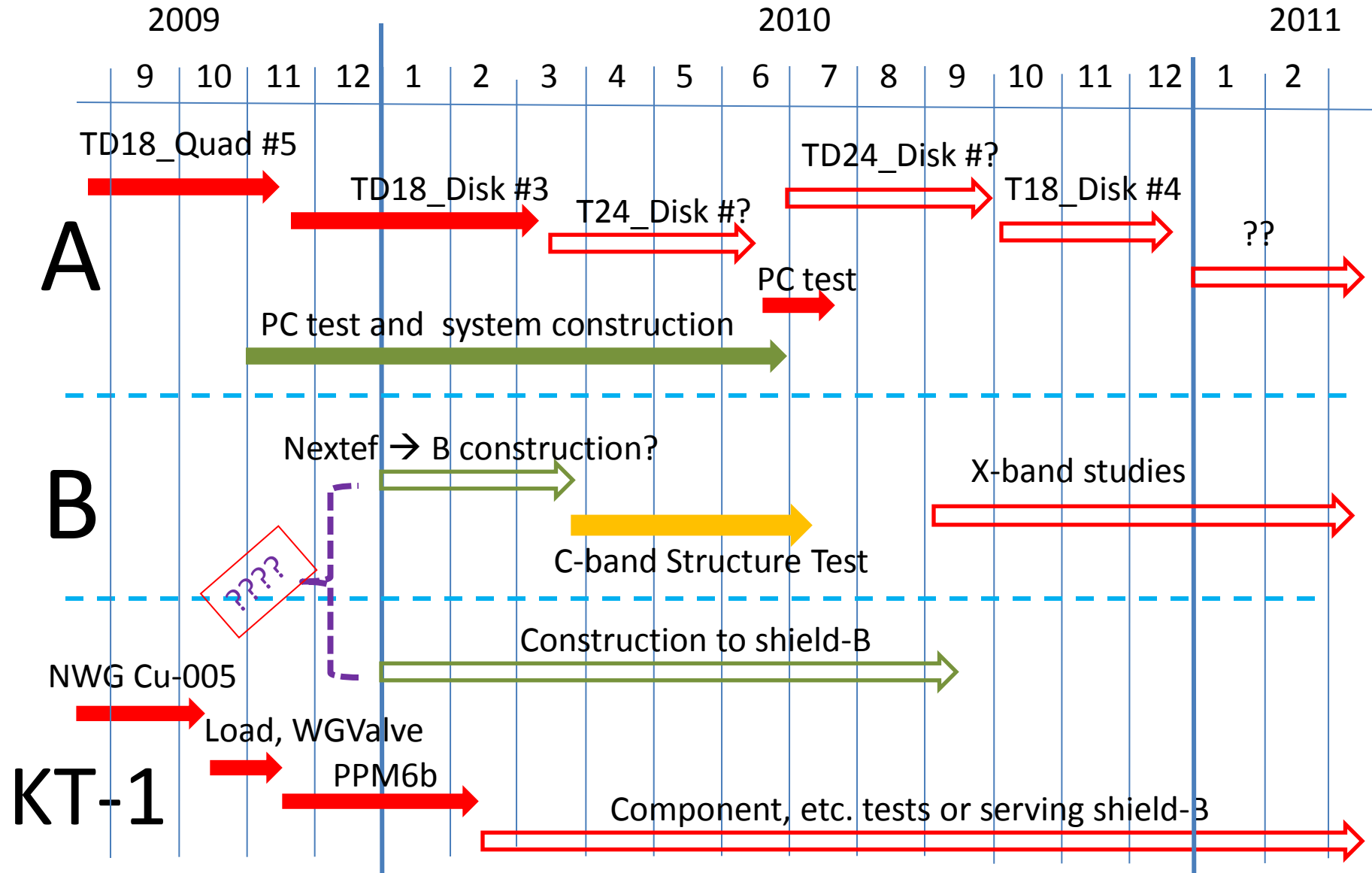
## tentative conclusion

- RF evaluated after high gradient test.
  - Input matching was kept.
  - Output matching changed by  $\Gamma=0.05$  level.
  - Average frequency increased by 1.1MHz.
  - Field ripple  $\pm 4.4\%$  near output end.
- Some change in RF performance was observed.
  - Need to compare carefully with SLAC data.

# Summary and next plan

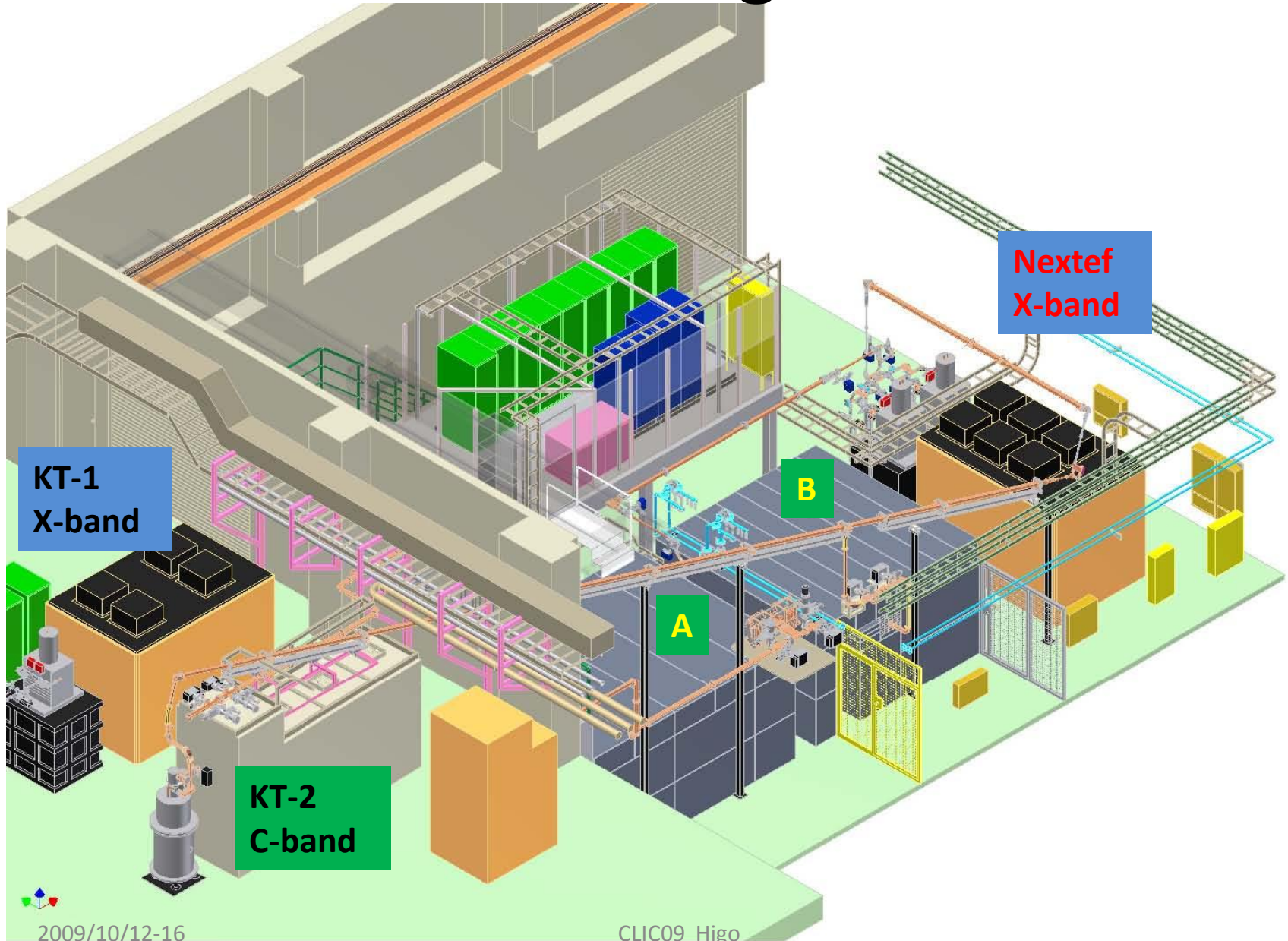
- Quad
  - Similar performance as quads tested at SLAC
  - More test in a few weeks
  - Inspection and think about the further test
- T18
  - Measurable change was observed
  - We need to remind this
- Next plan
  - TD18 is top priority
  - Then T24\_Disk, TD24\_Disk before CDR
  - followed by T18\_Disk#4, .....

# Nextef Planning revised as of CLIC09





# Nextef Configuration



# Conclusion

- Nextef will run fully dedicated for the feasibility study of CLIC 100MV/m
- Nextef will boost peak power and high power stability by introducing pulse compression system
- We try to construct a test area in addition to Nextef for key studies