A Study of RF breakdown of Narrow Wave Guide

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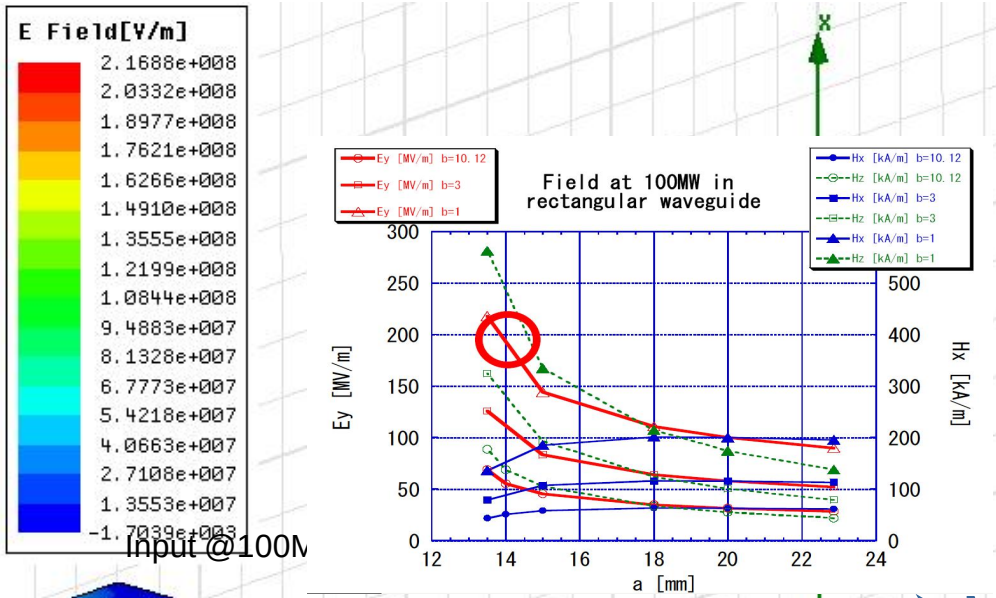
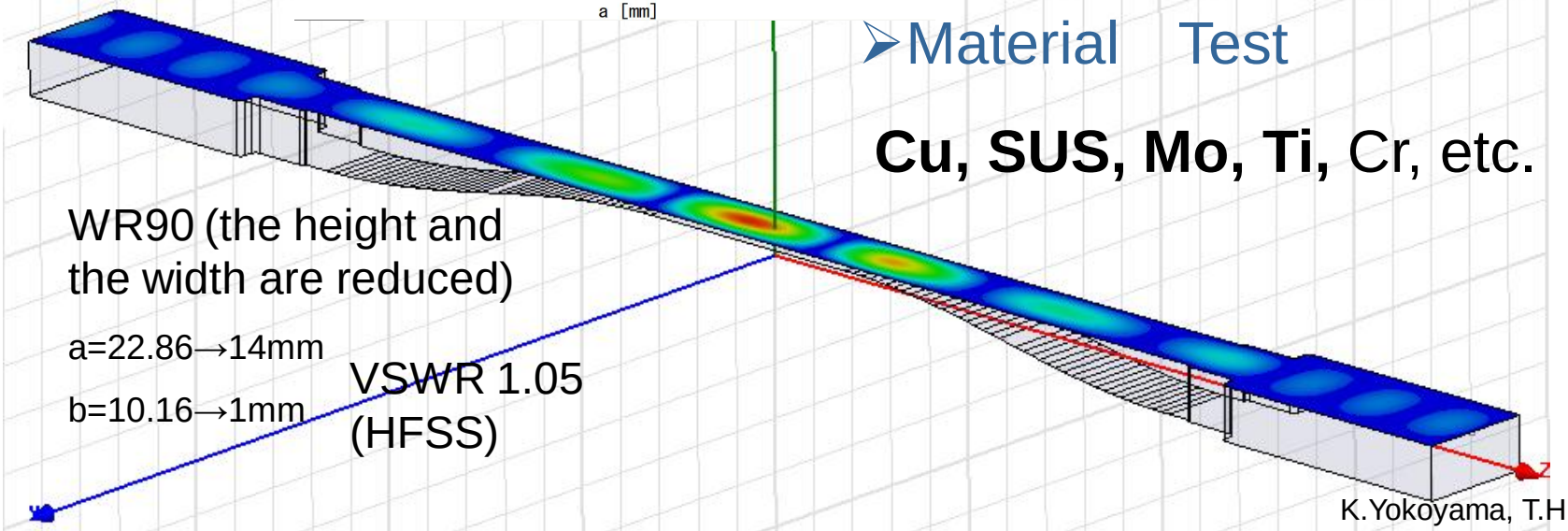
Design of the Narrow Waveguide

Type of Cu002



Input @100M



- Material Test

Cu, SUS, Mo, Ti, Cr, etc.

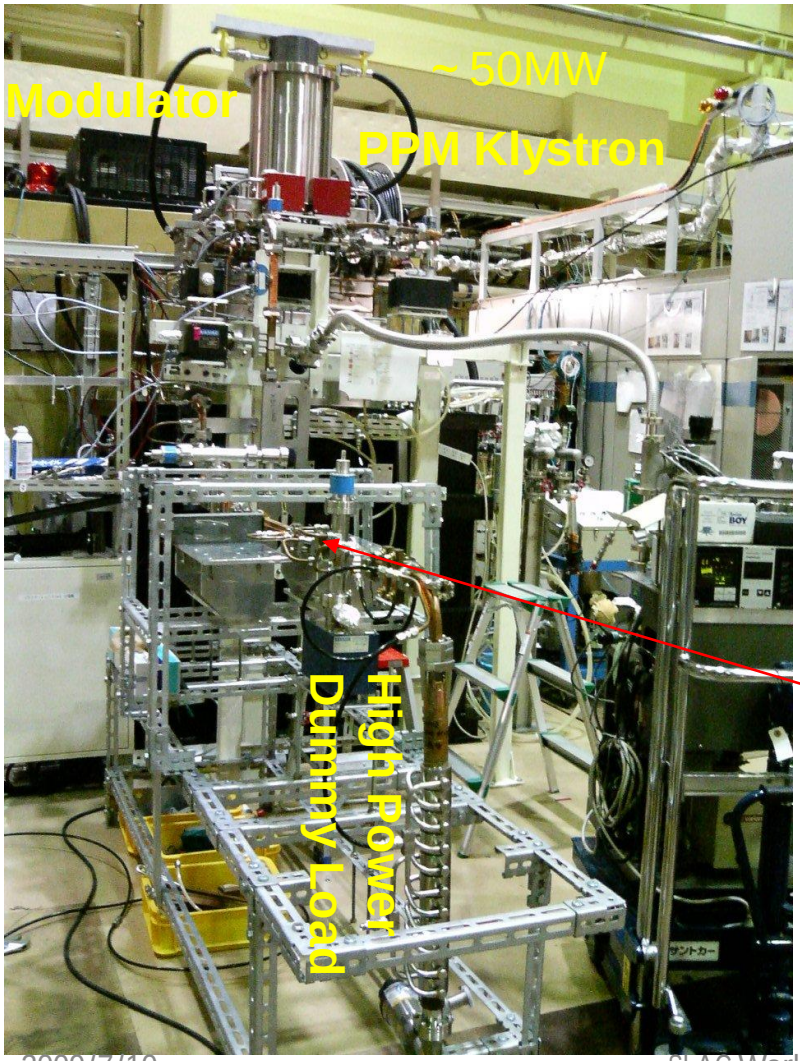
WR90 (the height and the width are reduced)

a=22.86→14mm

b=10.16→1mm

VSWR 1.05 (HFSS)

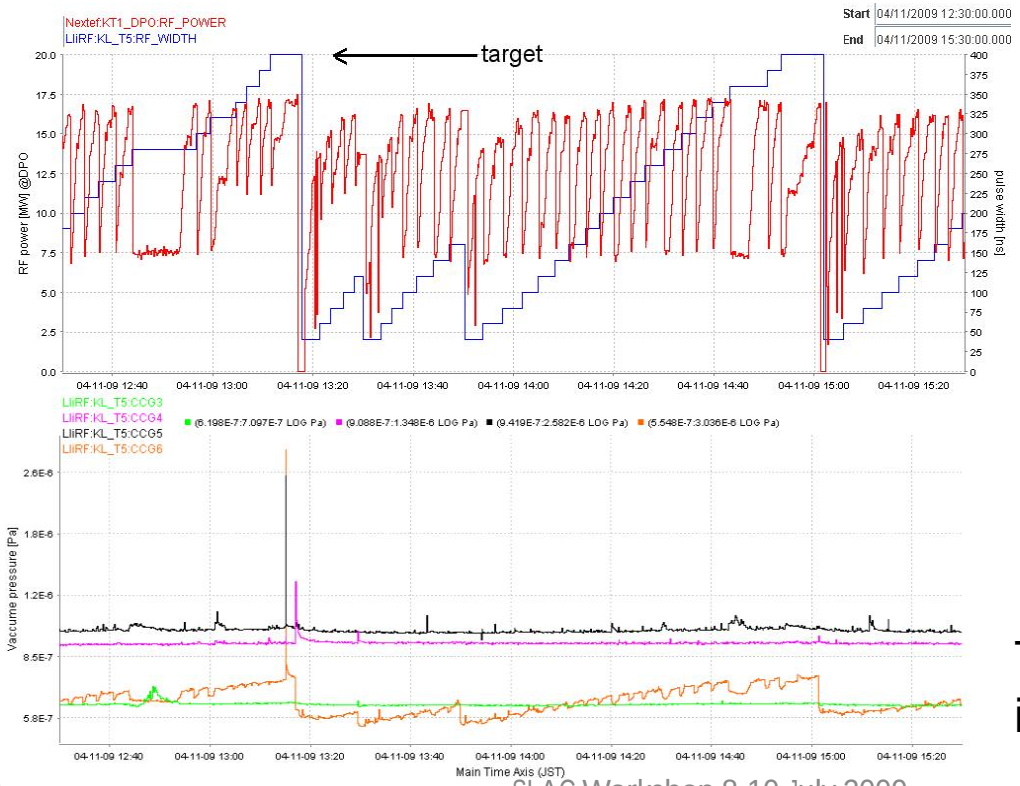
Narrow Waveguide Test Setup @KT-1 50MW test station



5mm thick Lead Shield Box

BDR Measurement

•Keep both the power and the pulse width to be the specified values(“target”)for 24Hr.
•If a breakdown event happens, wait until the vacuum being normal and ramp up to the target. (power goes up and down while the pulse width monotonically increases. See below.)
•The ramping process may be suspended or cancelled if the vacuum becomes bad.



Pulse width: blue line
Power : red line

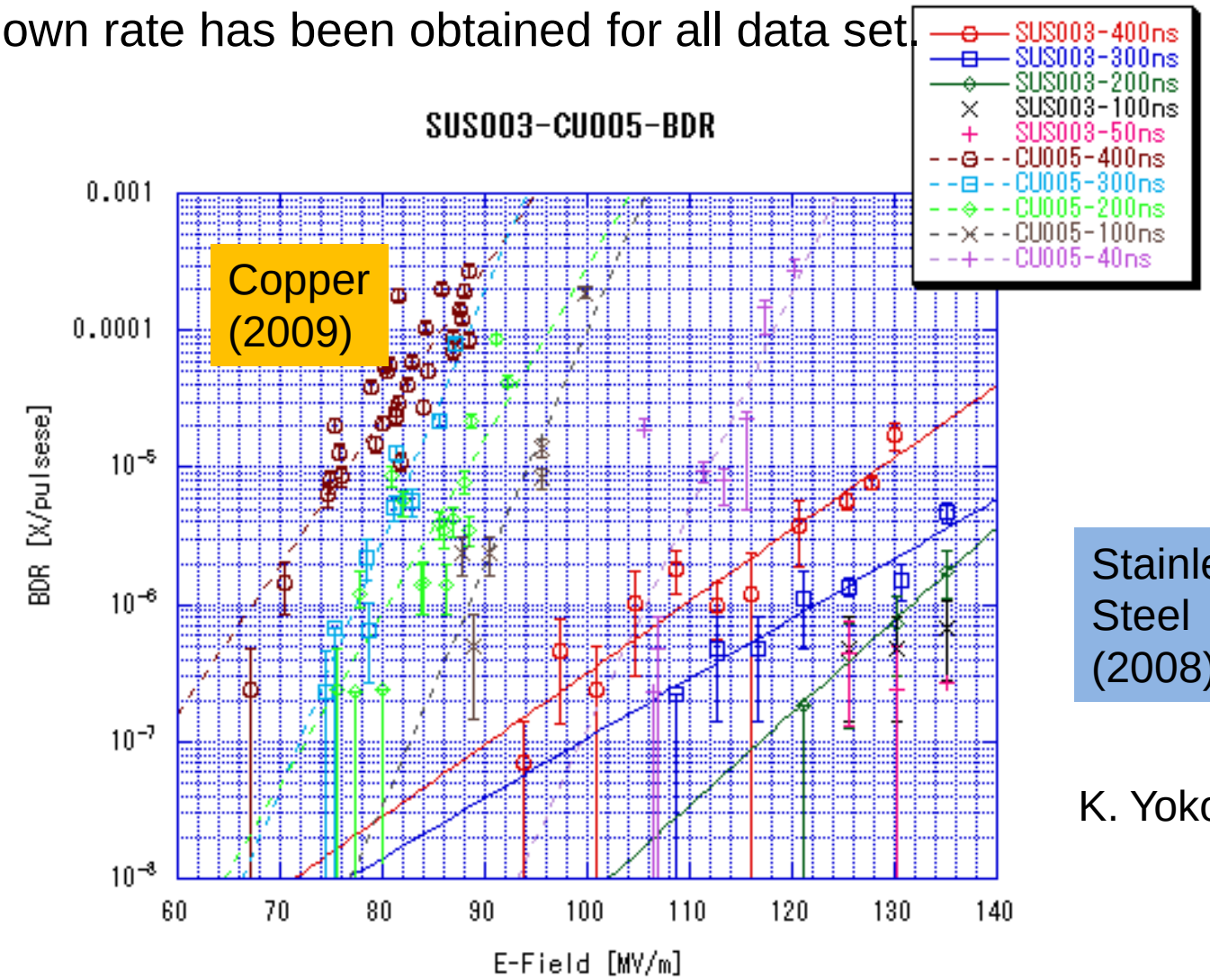
Typical example of variations in pulse width and RF power.

BDR

•Every data point represents the result of the 24Hr run, under fixed power and pulse width (=target).
•In the experiment, we follow the way of ramping to get to the target .
•Collect the time spans from the target being set and the BD event takes place.

BDR = # of BDs / summation of the time spans.

The high power test of Copper –Made NWG (CU005) has finished.
Breakdown rate has been obtained for all data set.



Stainless Steel (2008)

K. Yokoyama

•The gradient reached with stainless-steel waveguide was much higher than the copper one. Comparing the two materials at a BDR of 10^{-6} level, the gradient of stainless-steel is much higher (more than 100 MV/m) than that of copper (only 60~80 MV/m).

Two things we are looking at.

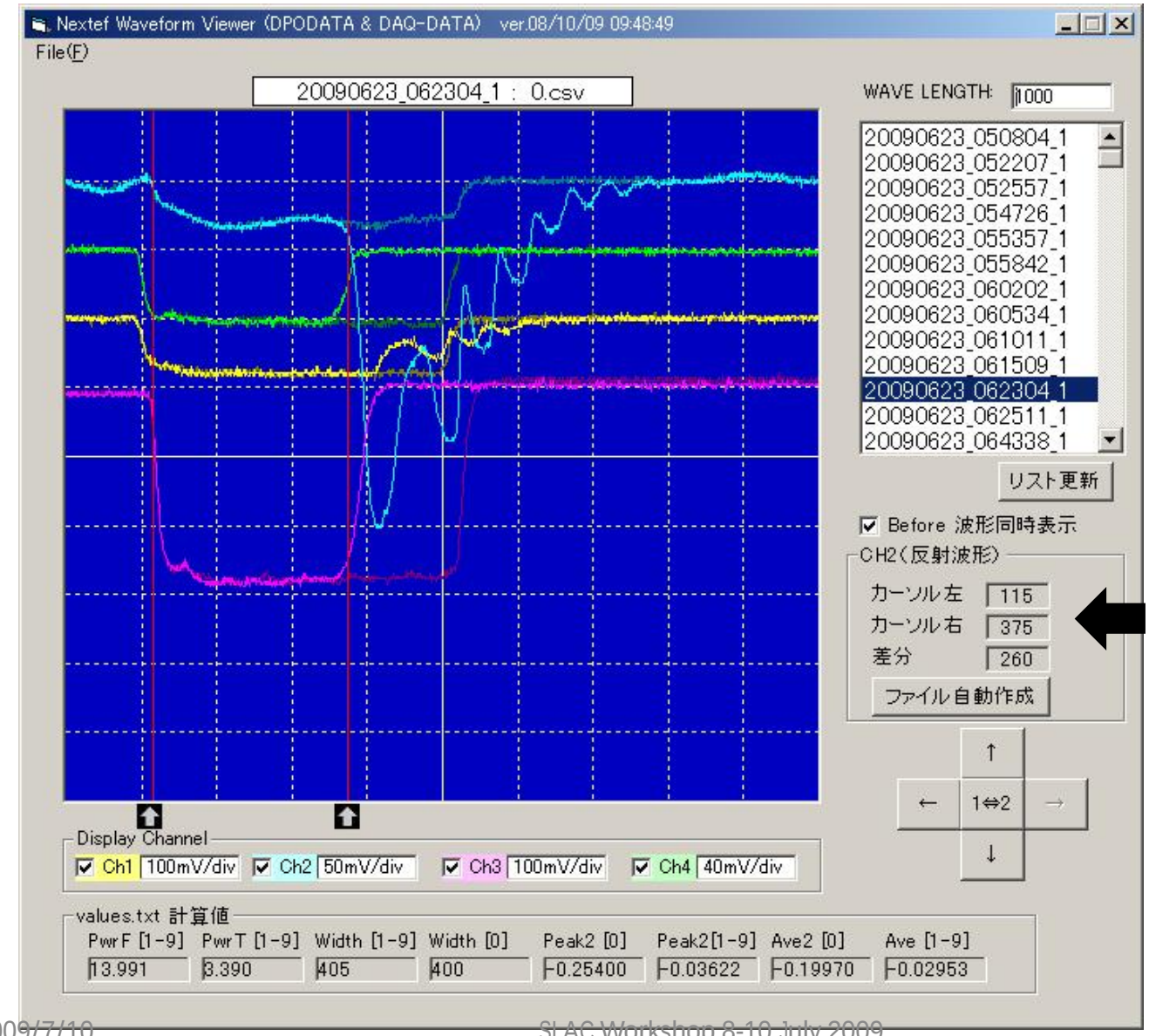
1) BD location in time within RF pulse. How does it distribute?

2) Does BDR look as the random process? Let us see the distribution of the time spans of all BD events.

Breakdown timing within RF pulse

- Tek DPO Oscilloscope records all RF waveforms (forward and backward, ten pulses prior to the BD pulse).
- Measure the time of RF reflection begins.

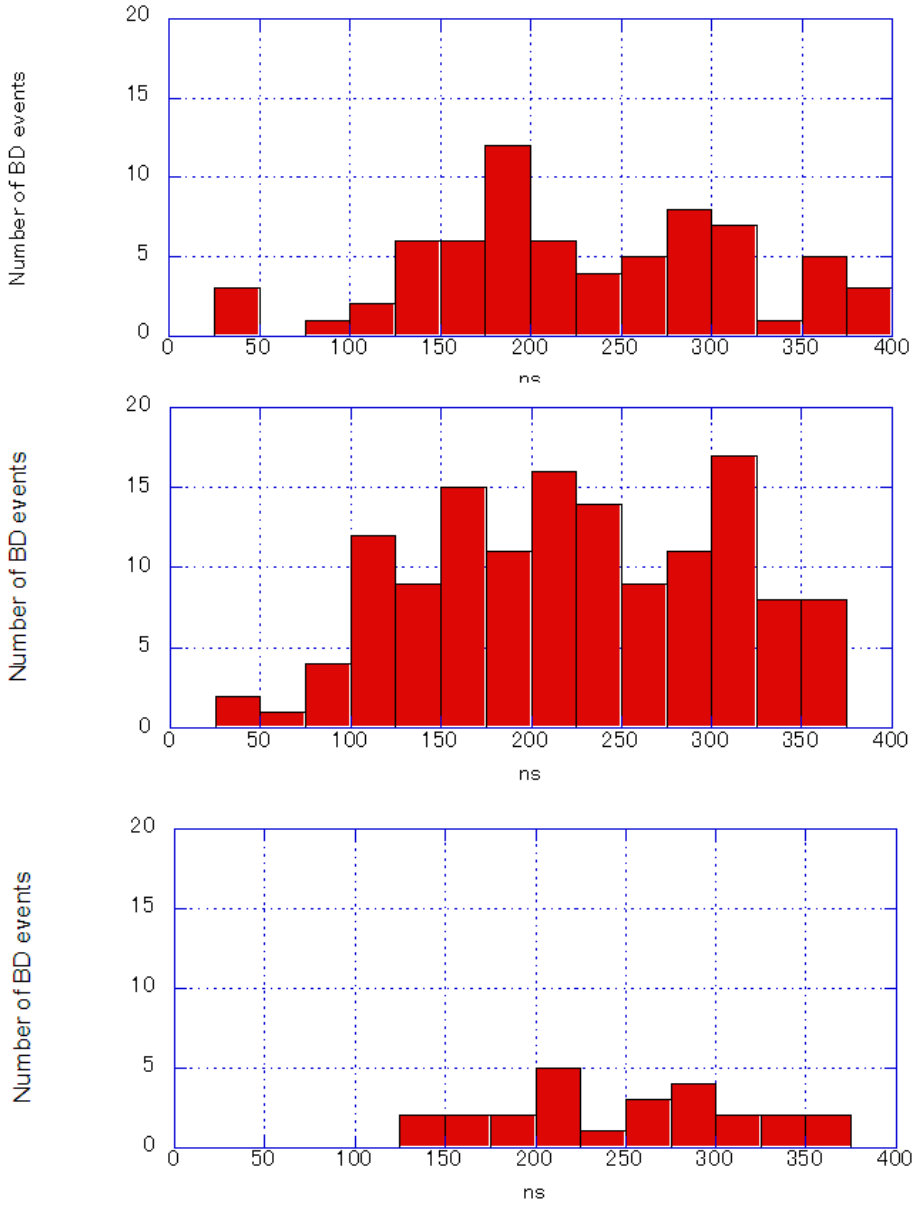
Program to measure the timing: Compare the breakdown pulse and the previous pulse, set the cursor at the BD location (=reflection).



The result comes out here. (Numbers are dumped in a file)

S.Ushimoto

Analysis of 400ns pulse width data, histogram of the BD locations

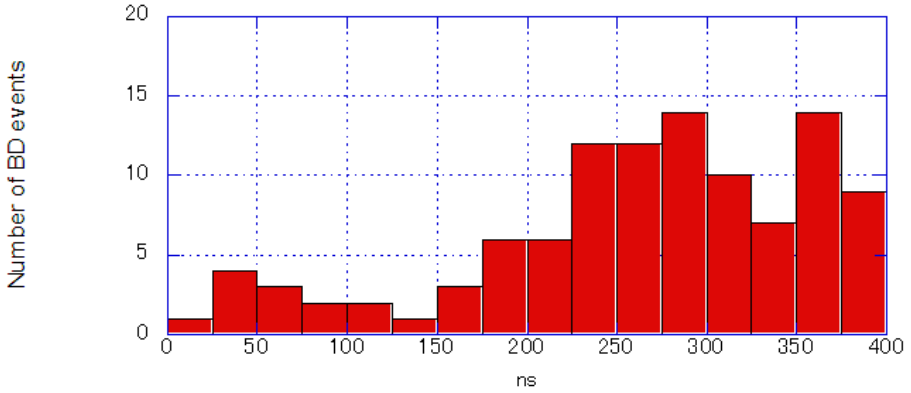


RUN01：
86.9MV/m, R= 66/5.2Hr = 7.07e-5

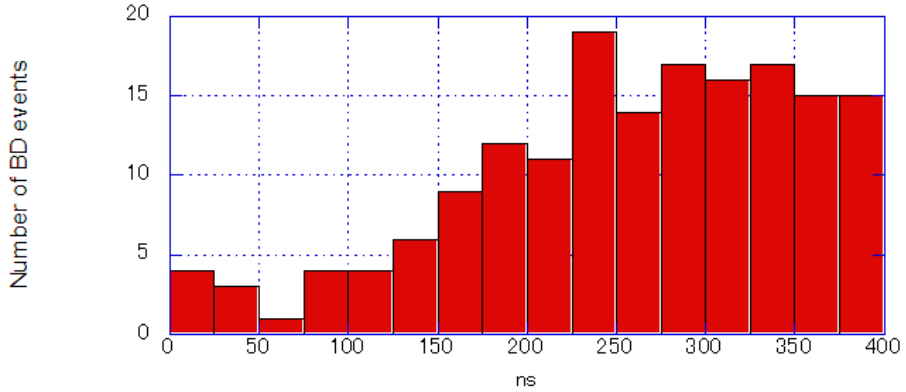
RUN03：
81.6MV/m, R= 132/4.0Hr = 13.9e-5

RUN06：
74.8MV/m, R= 25/23.3Hr = 0.86e-5

Other 400ns pulse width data also shows the same behavior.

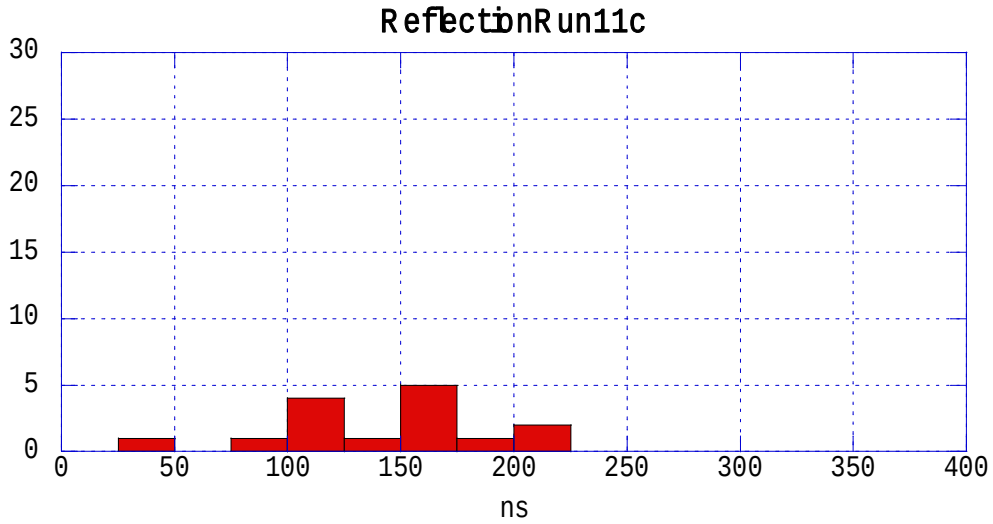


RUN16 :
78.9MV/m, R= 105/15.3Hr = 3.81e-5

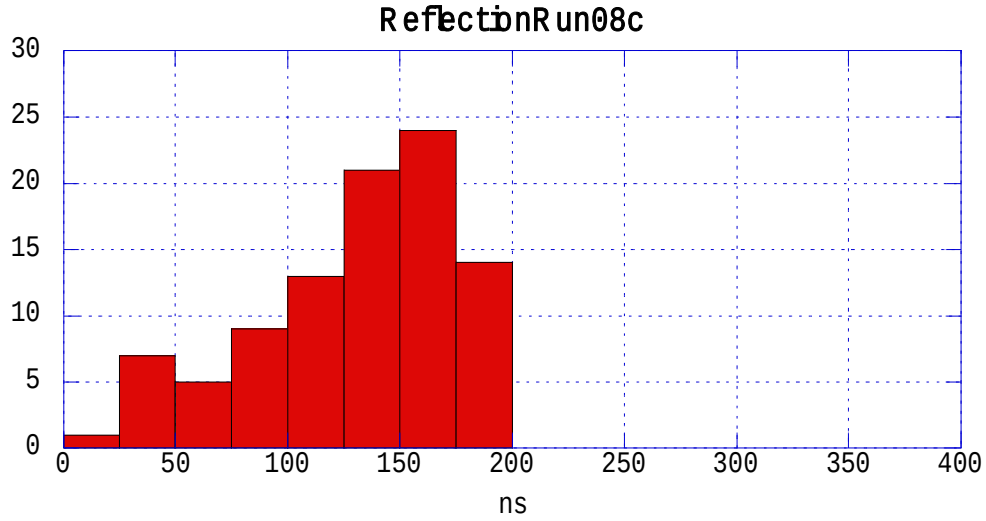


RUN17 :
85.9MV/m, R= 167/4.7Hr = 19.9e-5

Example of 200ns pulse width data



88.4MV/m, BDR=3.55e-6



92.3MV/m, BDR=42.5e-6

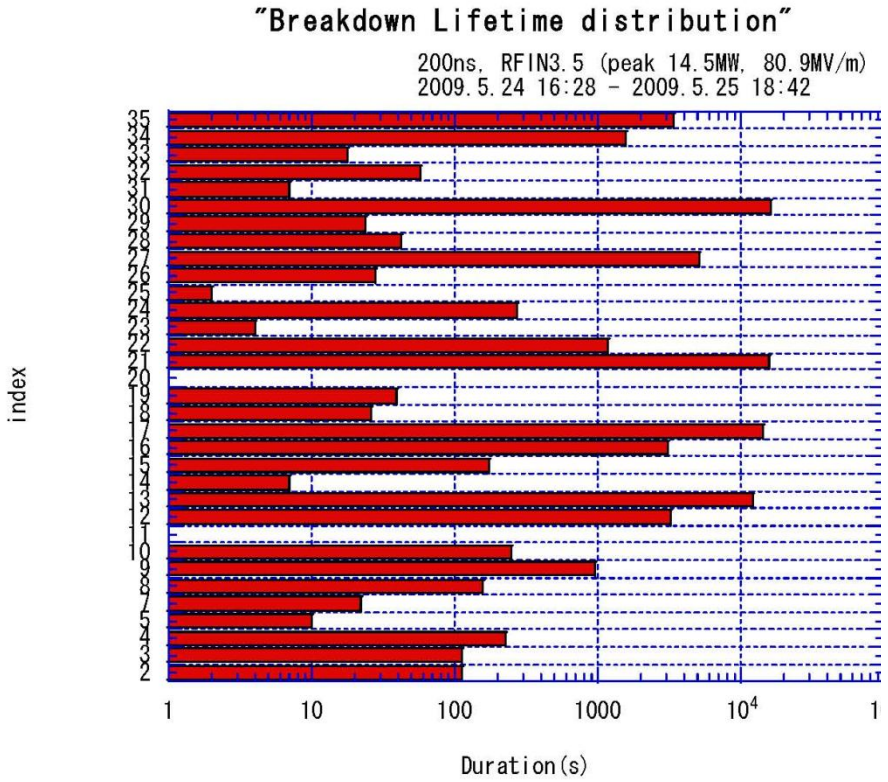
Still we see the same behavior

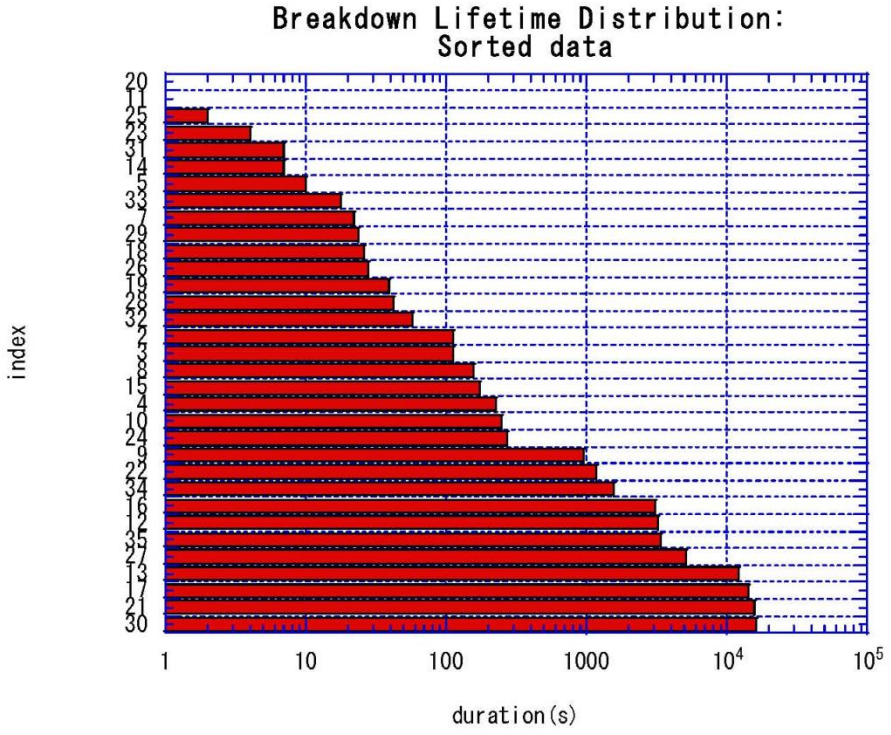
Discussion

- NWG Breakdown does not occur uniformly in time within RF pulse. Breakdowns look “suppressed” at the beginning (should be confirmed.)
- Rise time of the RF power may have the influence, but it does not seem to explain this behavior (should be confirmed).

Time duration from the target on to BD

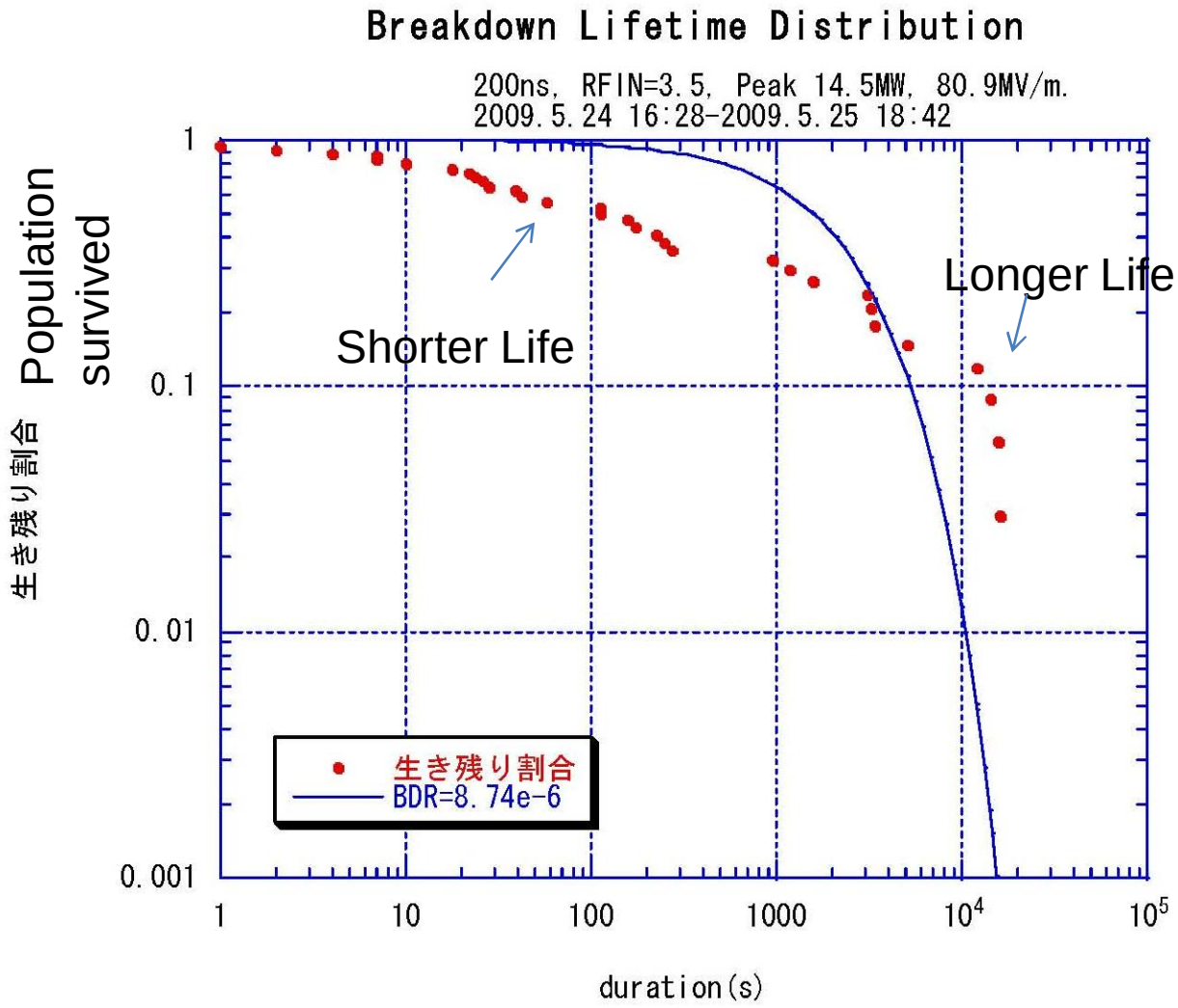
200ns, 80.9MV/m. 35events/ 24Hr. Each BD is numbered.





Sorted

Compare to the simple decay curve



Things to be done

- These analysis is ongoing. Continue them for all data available.

- Analysis of the signals of acoustic sensors.
- Analysis of X-ray detectors.