

Report from NLCTA

Chris Adolfsen, 10/20/10

- CERN Built T18's
 1. 820 degC Vacuum Braze
 2. 1050 degC H2 Braze (SLAC procedure) - **New**
- T24s
 1. CERN Built (cells pre-fired)
 2. KEK/SLAC Built - **New**
 3. Comparison to T26
- NLCTA S-band Gun
 - Cathode breakdown damage and laser pulse heating - **New**

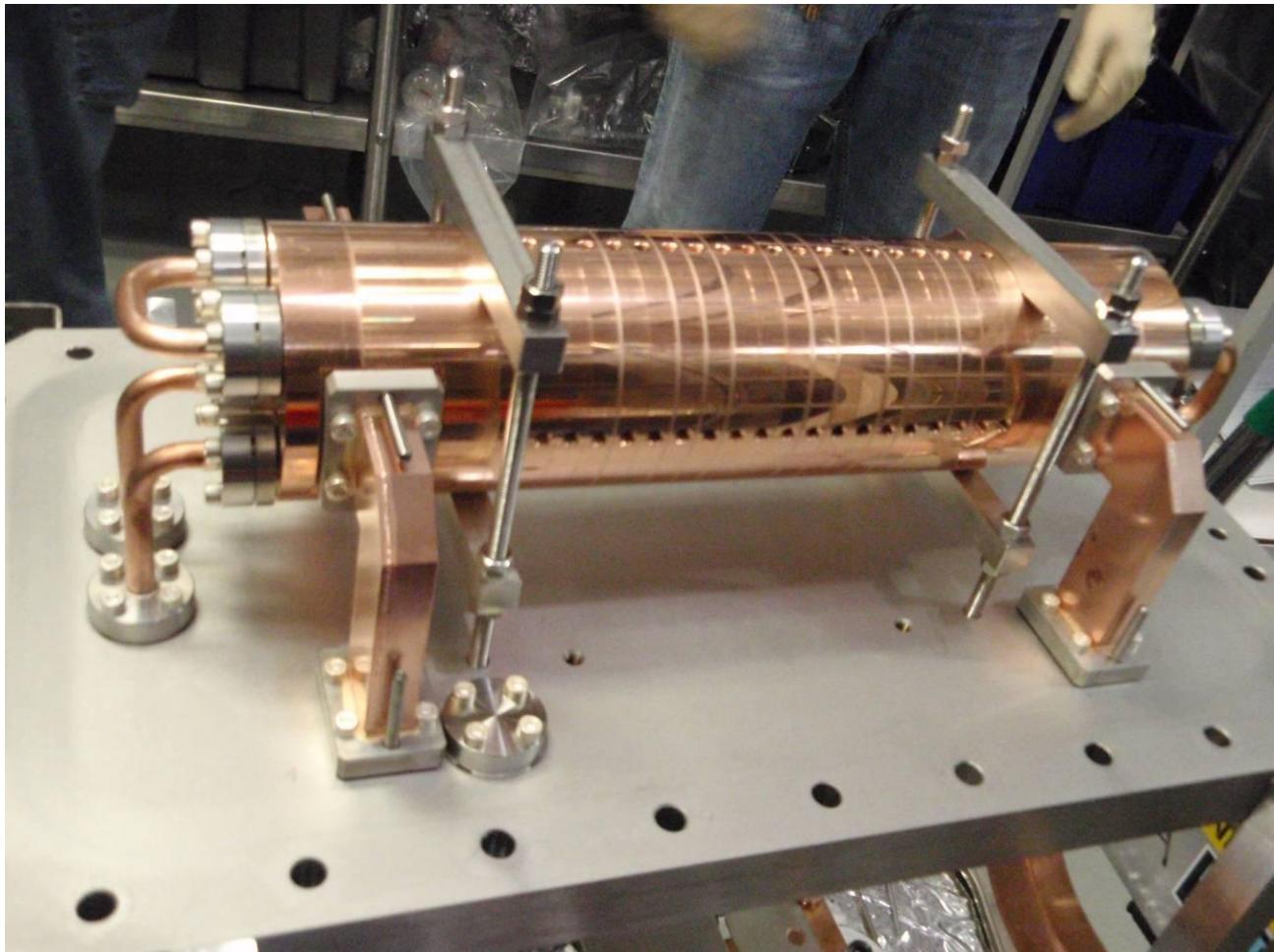
CERN Built T18

Cells made by Kugler, no etch, 820 degC vacuum braze at CERN,
installed in a vacuum can at SLAC

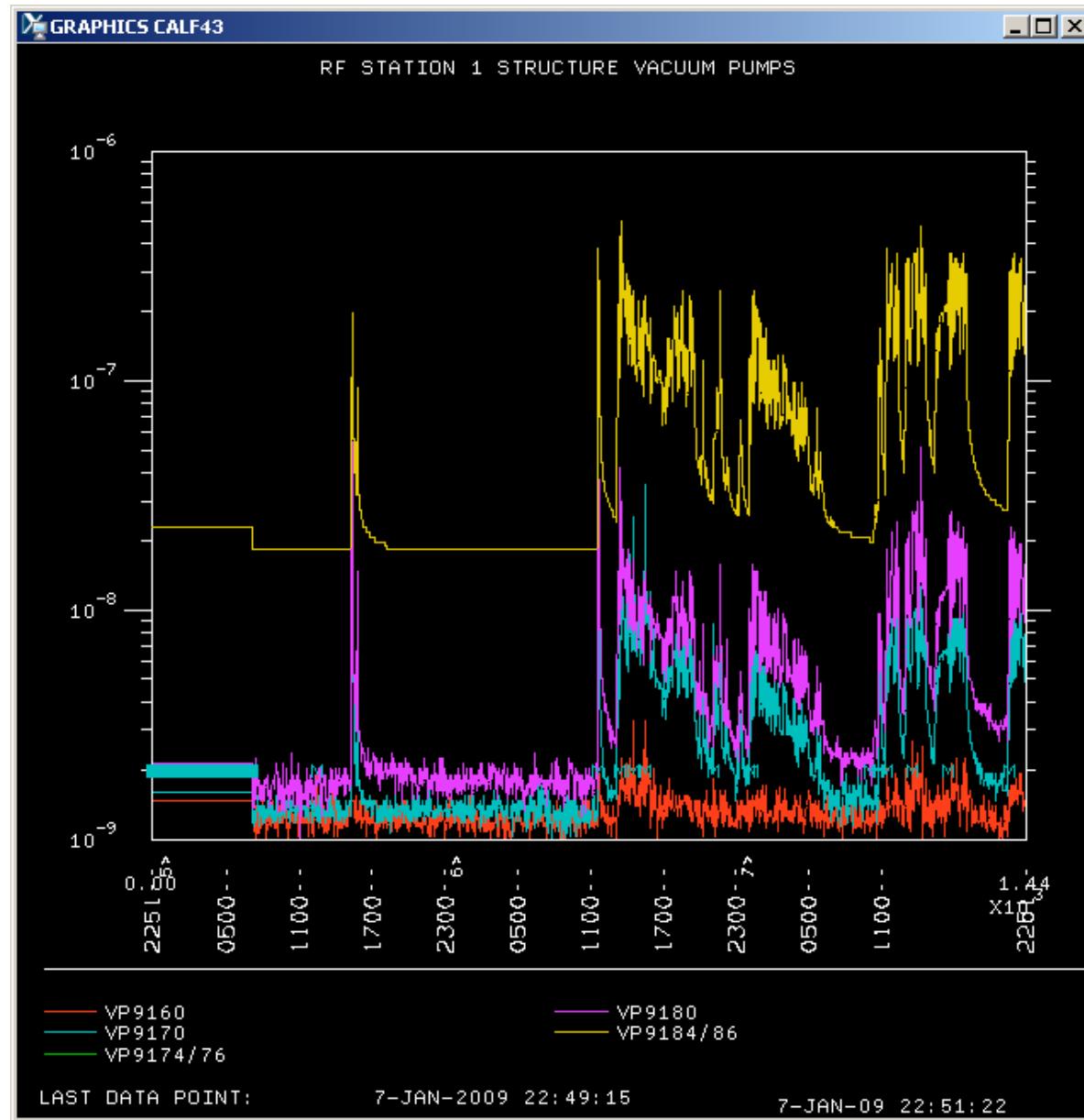
Copper grain size
small due to 'low'
braze temperature



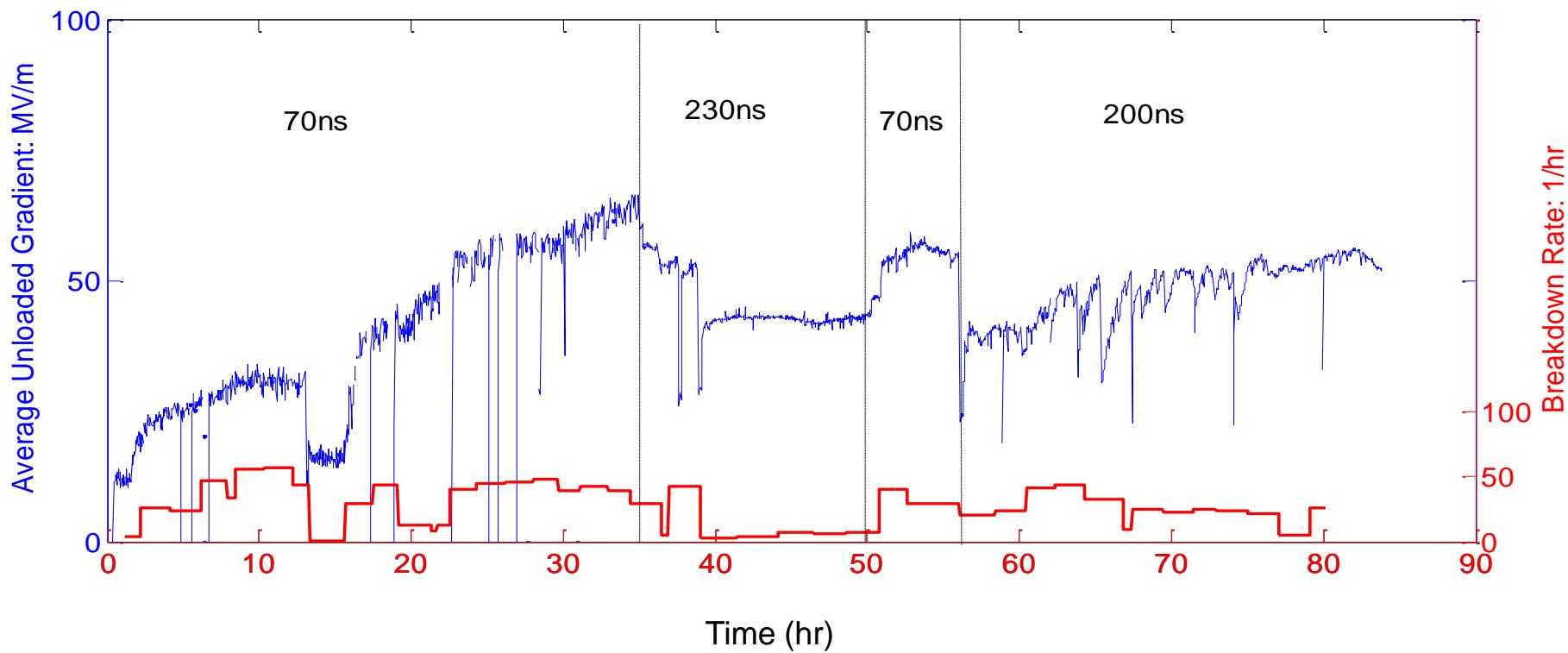
Photo of Iris



T18_CERN_Disk Vacuum History in Jan 09 During Operation



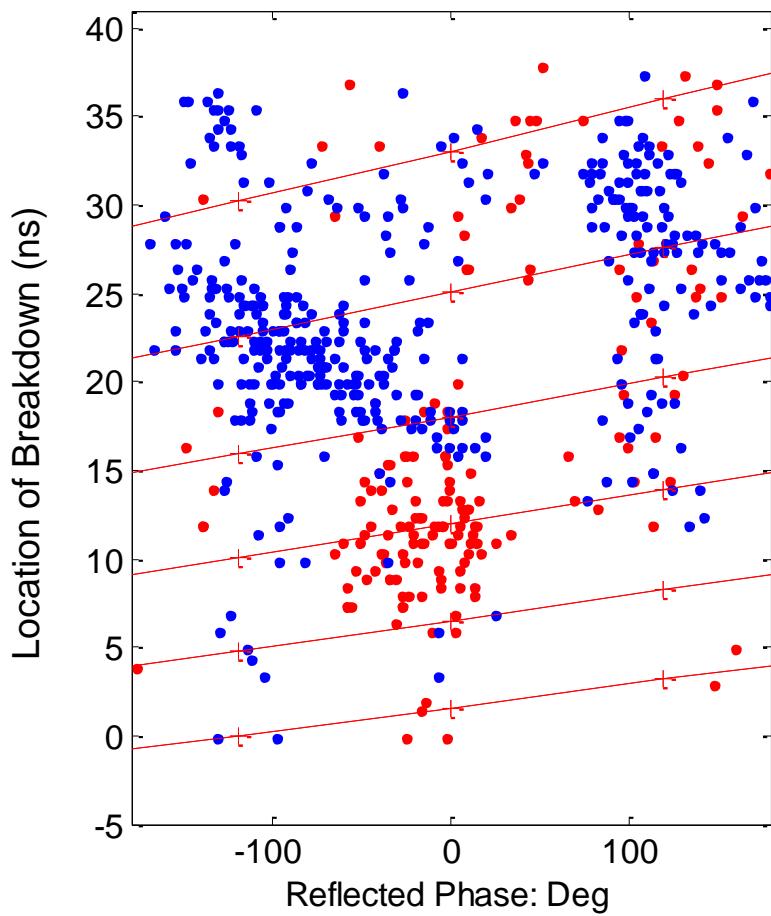
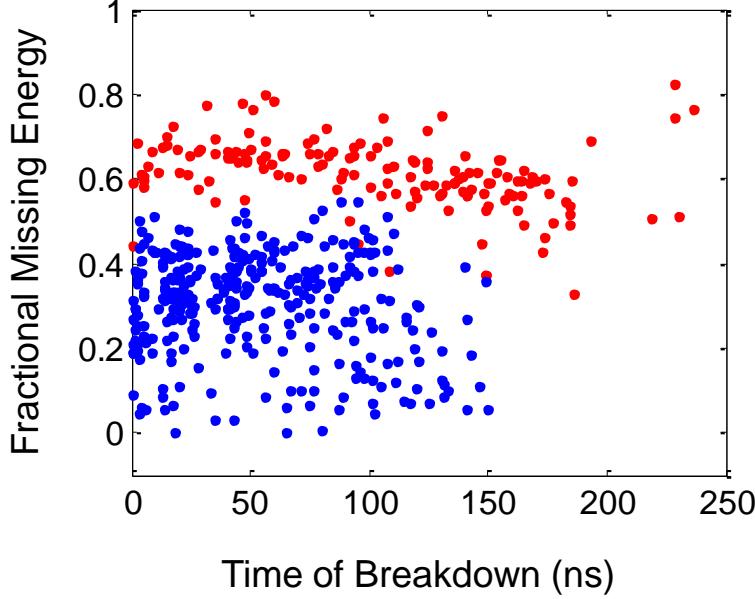
CERN T18 Processing History



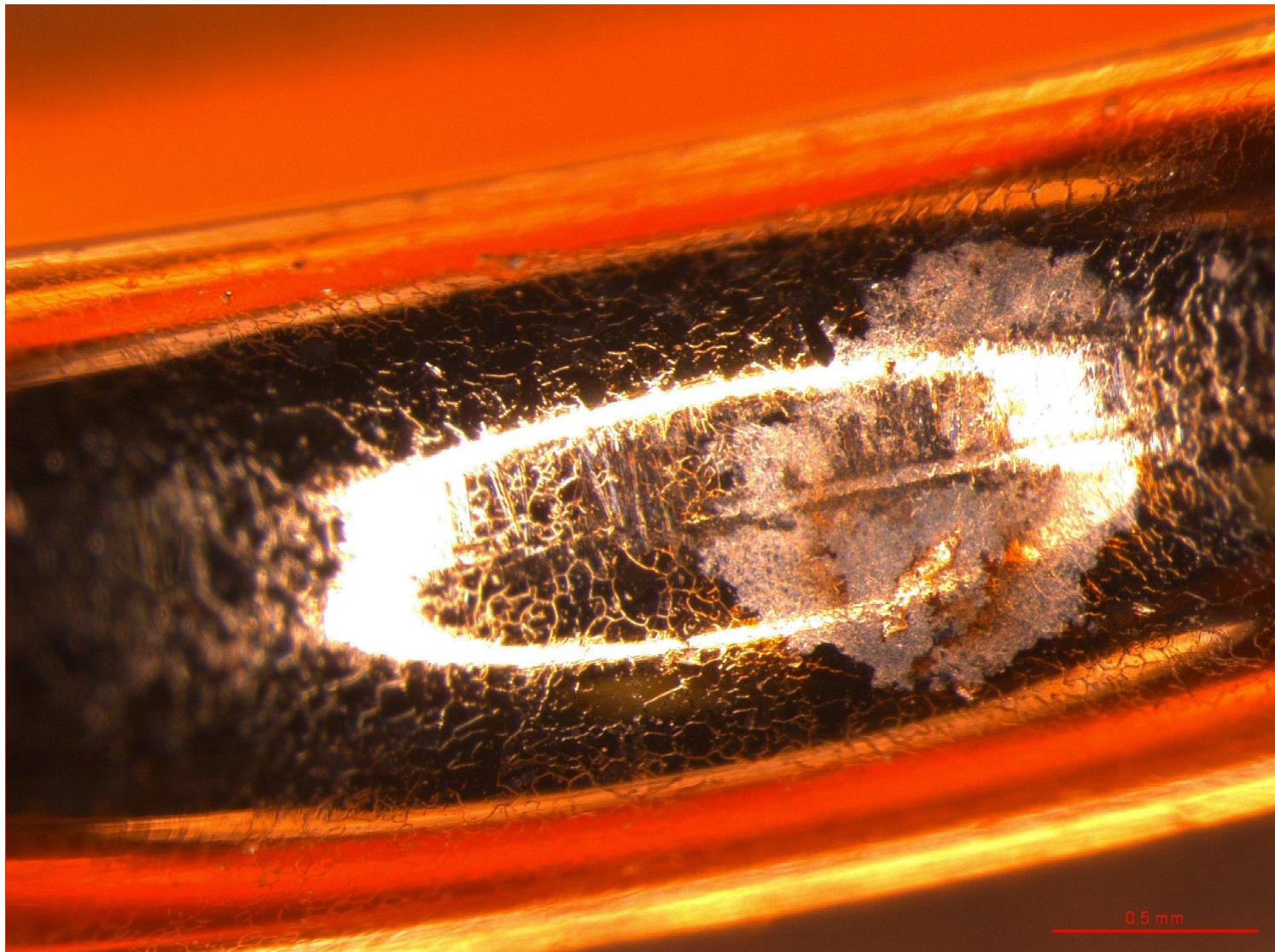
Breakdown Characteristics

T18_Disk_1 during last 500 hrs, ~ 115 MV/m, 220 ns

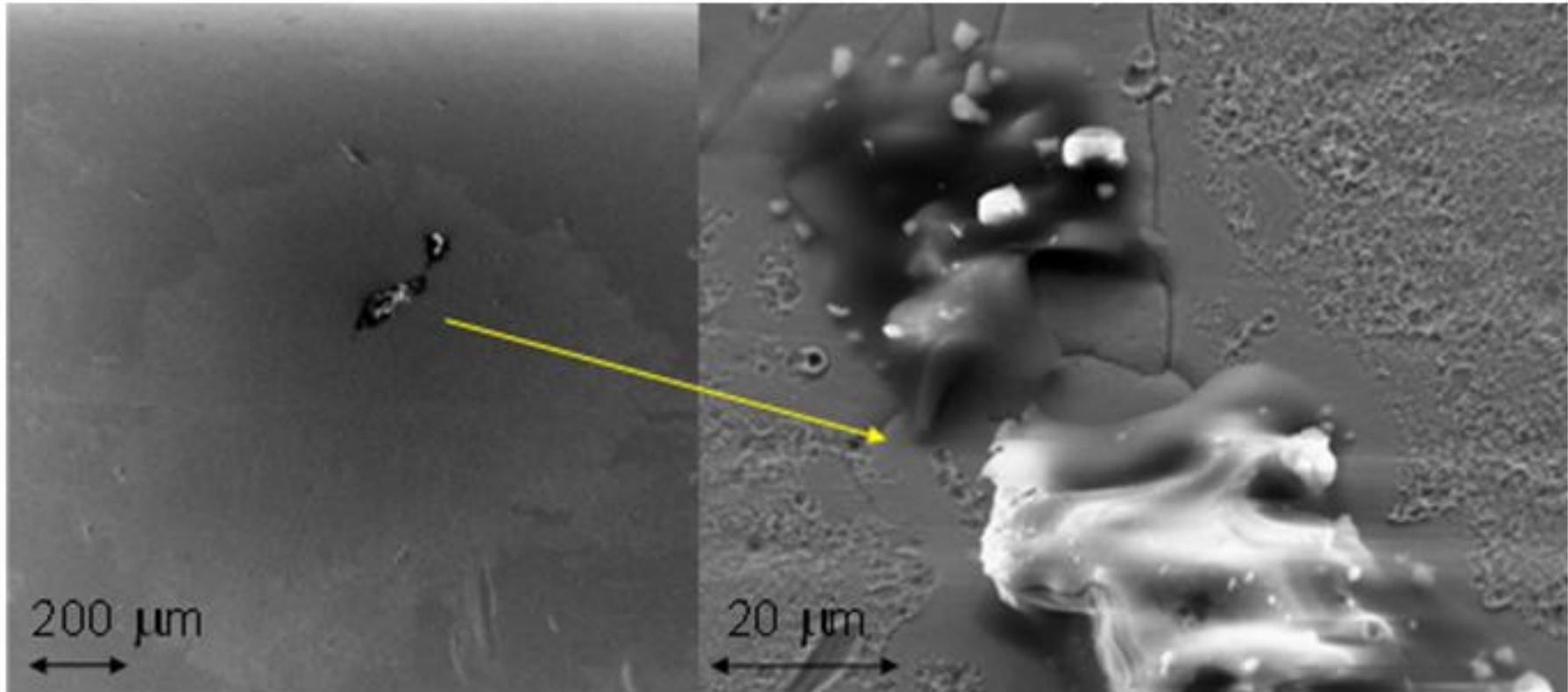
T18_Disk_CERN during last 40 hrs, ~ 50 MV/m, 200 ns



Iris 12 Autopsy

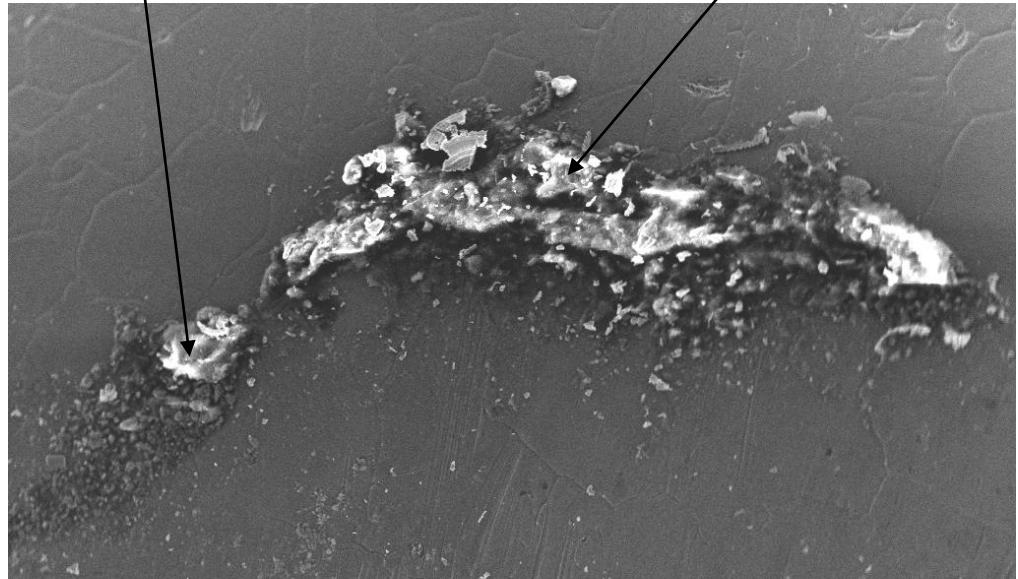
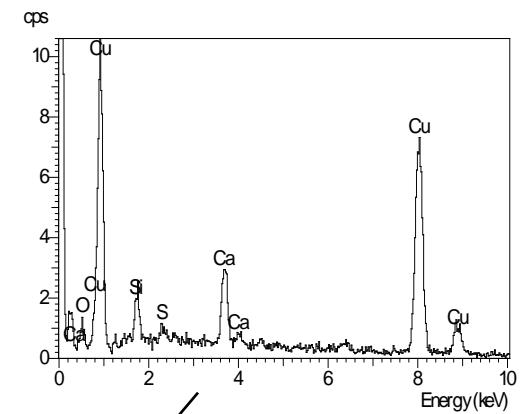
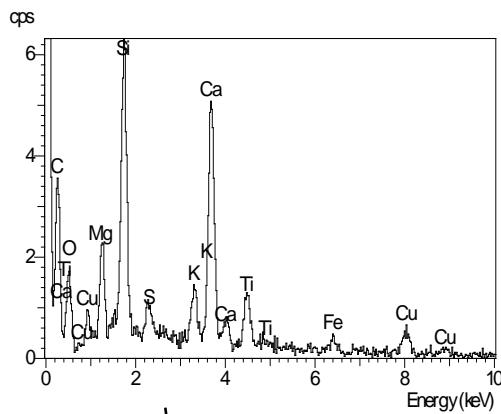
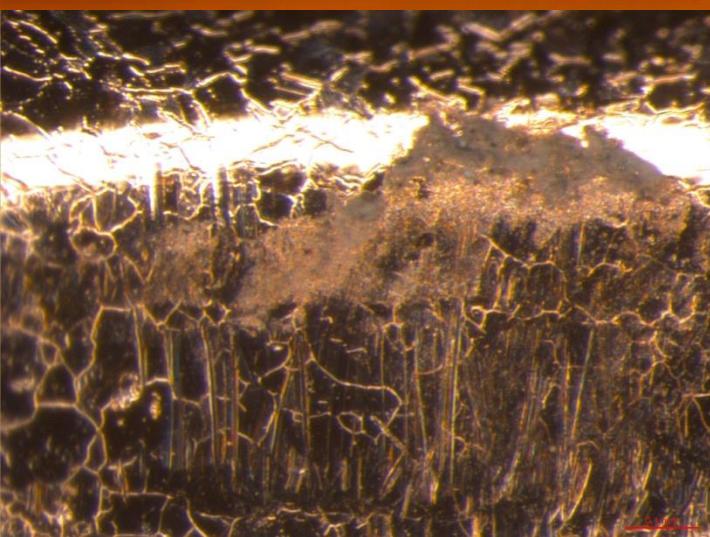


Iris 12 Autopsy



A 200 micron long calcium and carbon rich object that appears to have caused surface melting over a 1 mm wide area on this iris

Iris 11 Autopsy



Dirty region which came after the test ?

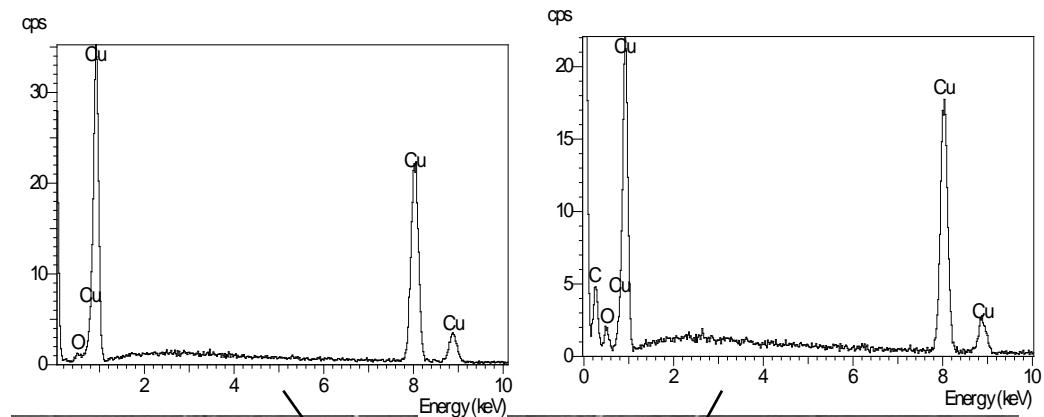
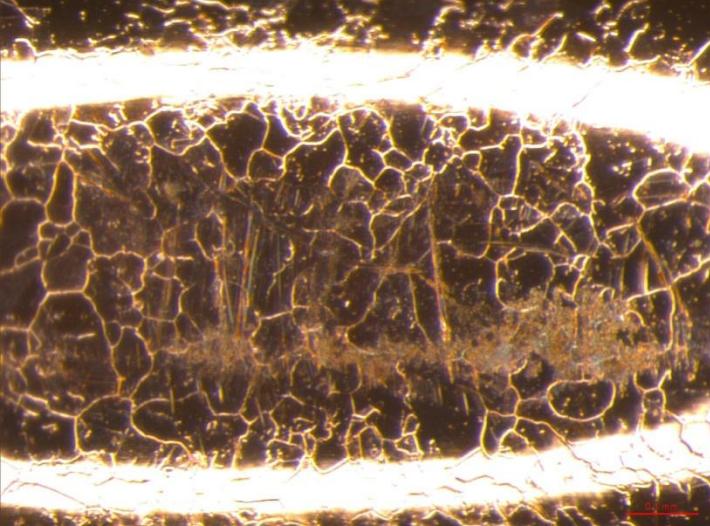
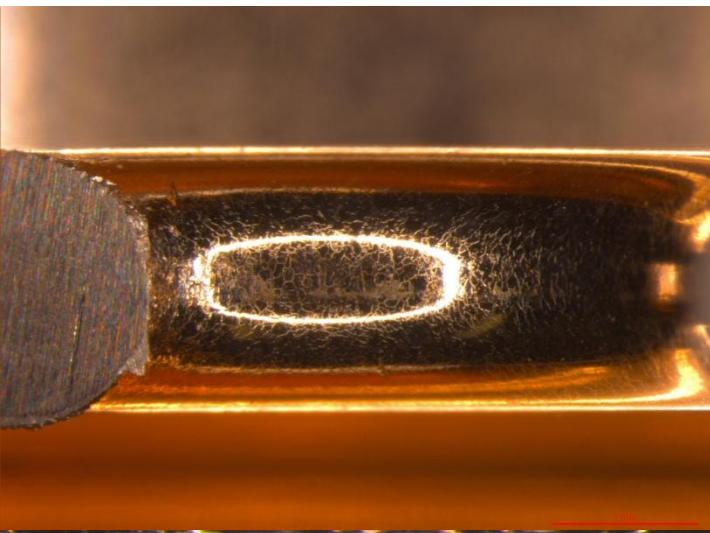
Mag = 200 X
Detector = SE1
EHT = 20.00 kV

100µm

11WNSDvg1, disk 11

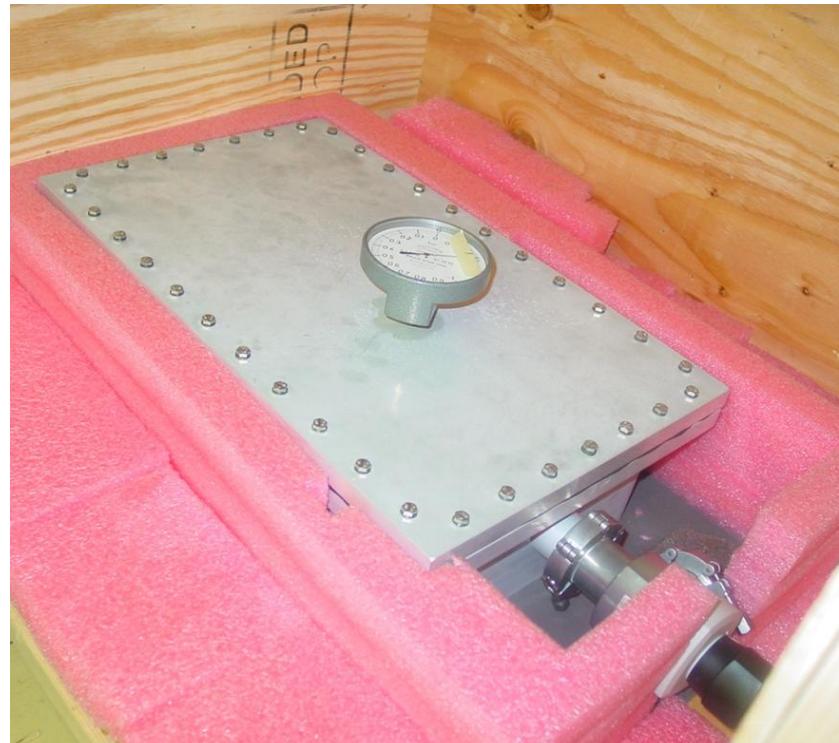
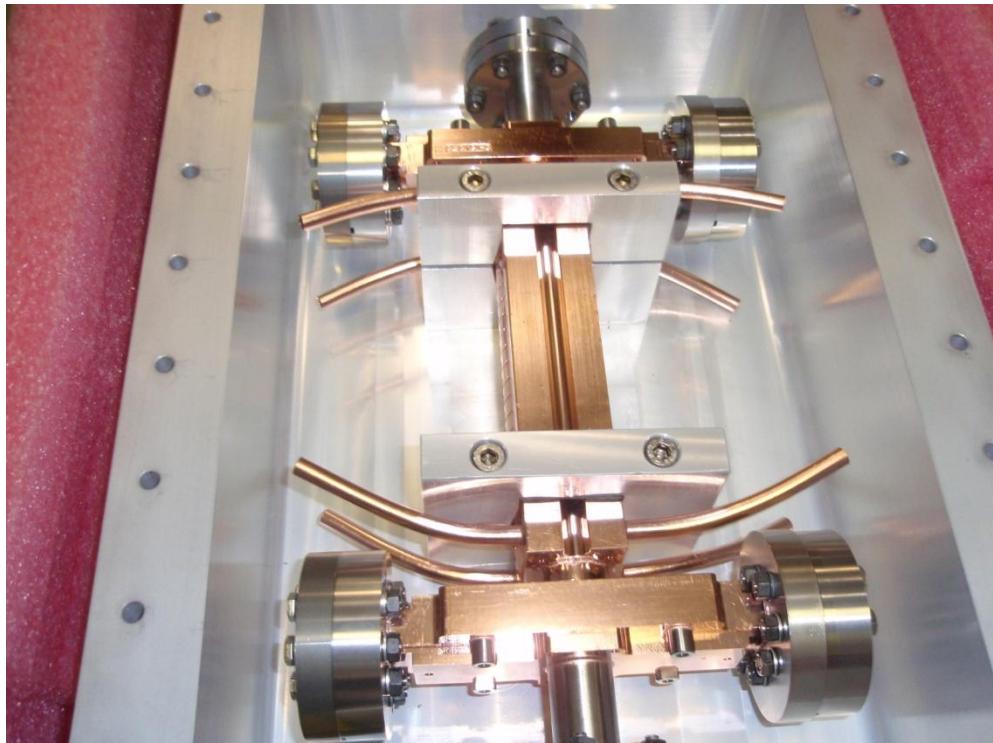
File Name = 11WNSDvg1-17
Date :12 Mar 2009
G. Arnau Izquierdo TS/MME

Iris 13 Autopsy

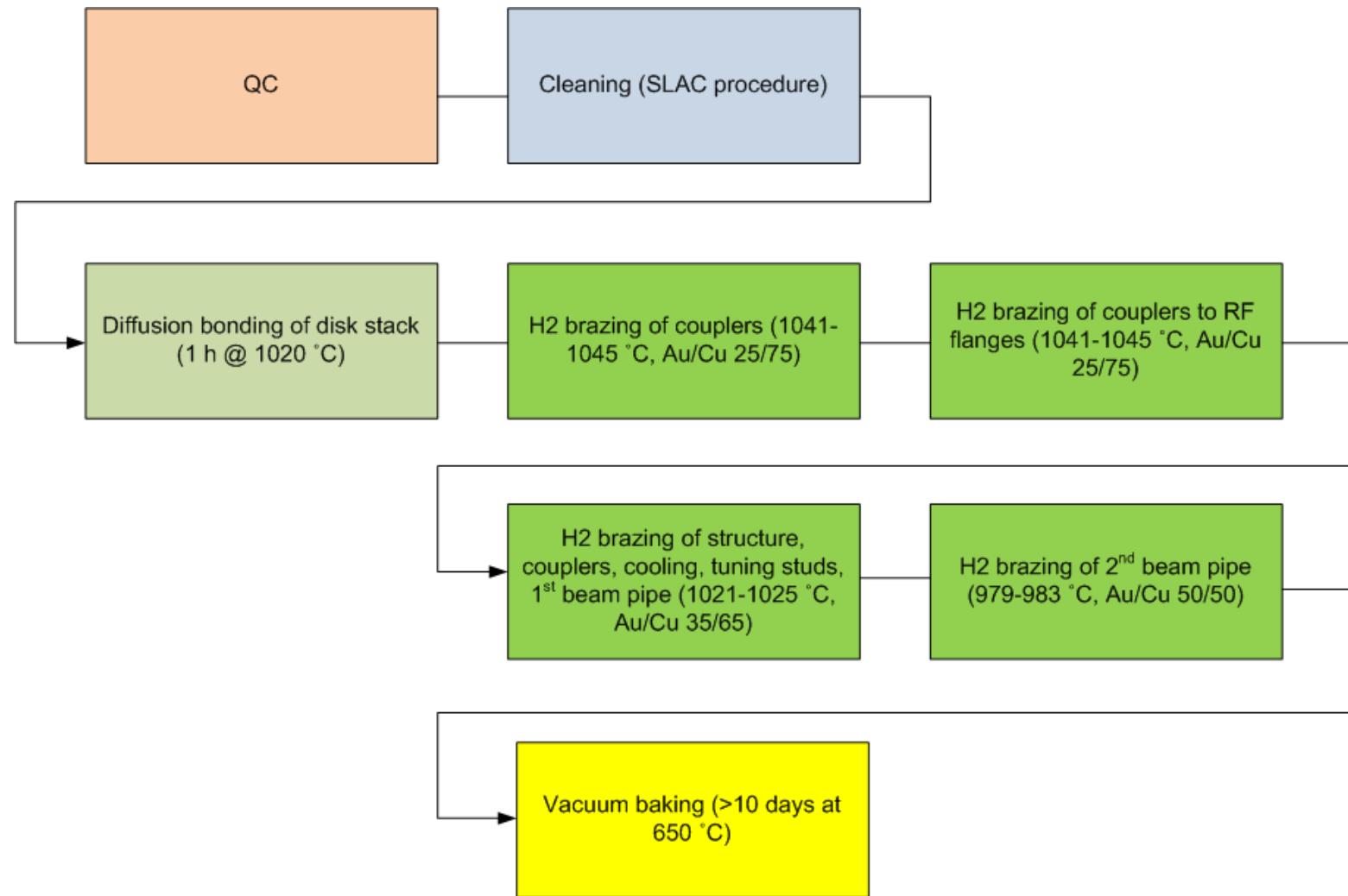


Second CERN-Built T18

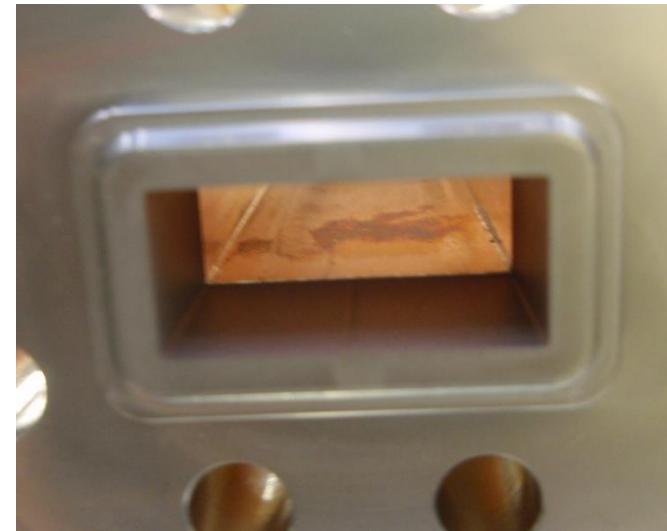
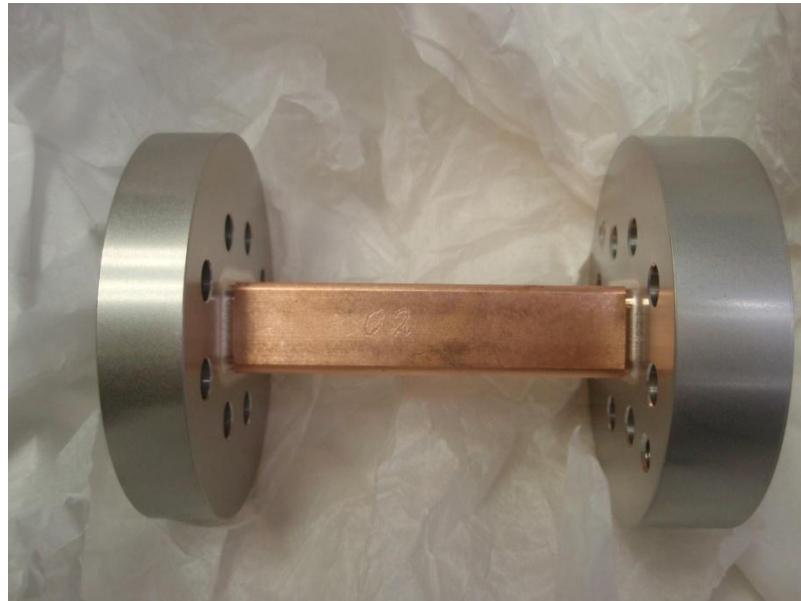
Improved Packaging



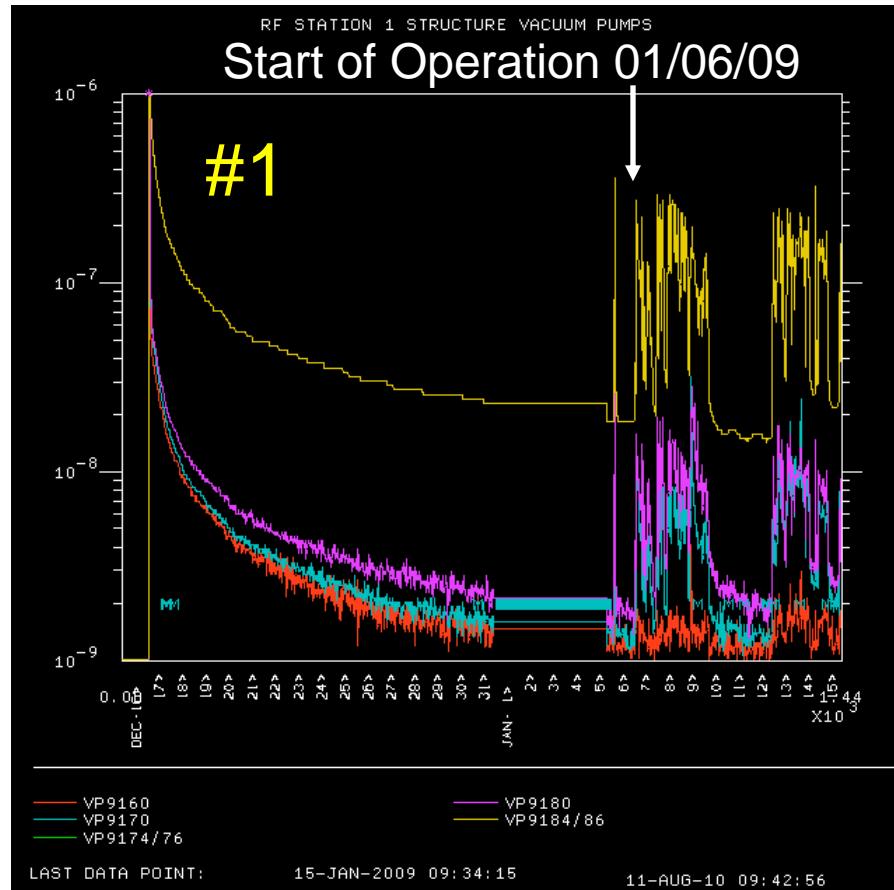
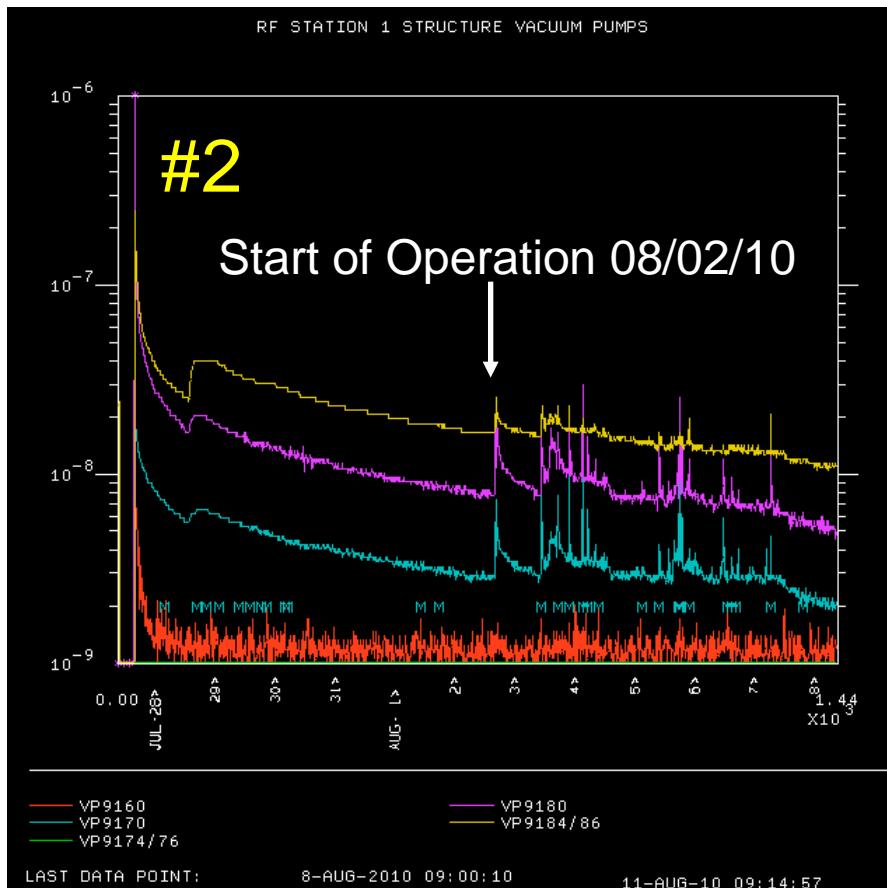
Use SLAC/KEK Assembly Cycle



The Adaptors That Launched a 1000 Emails

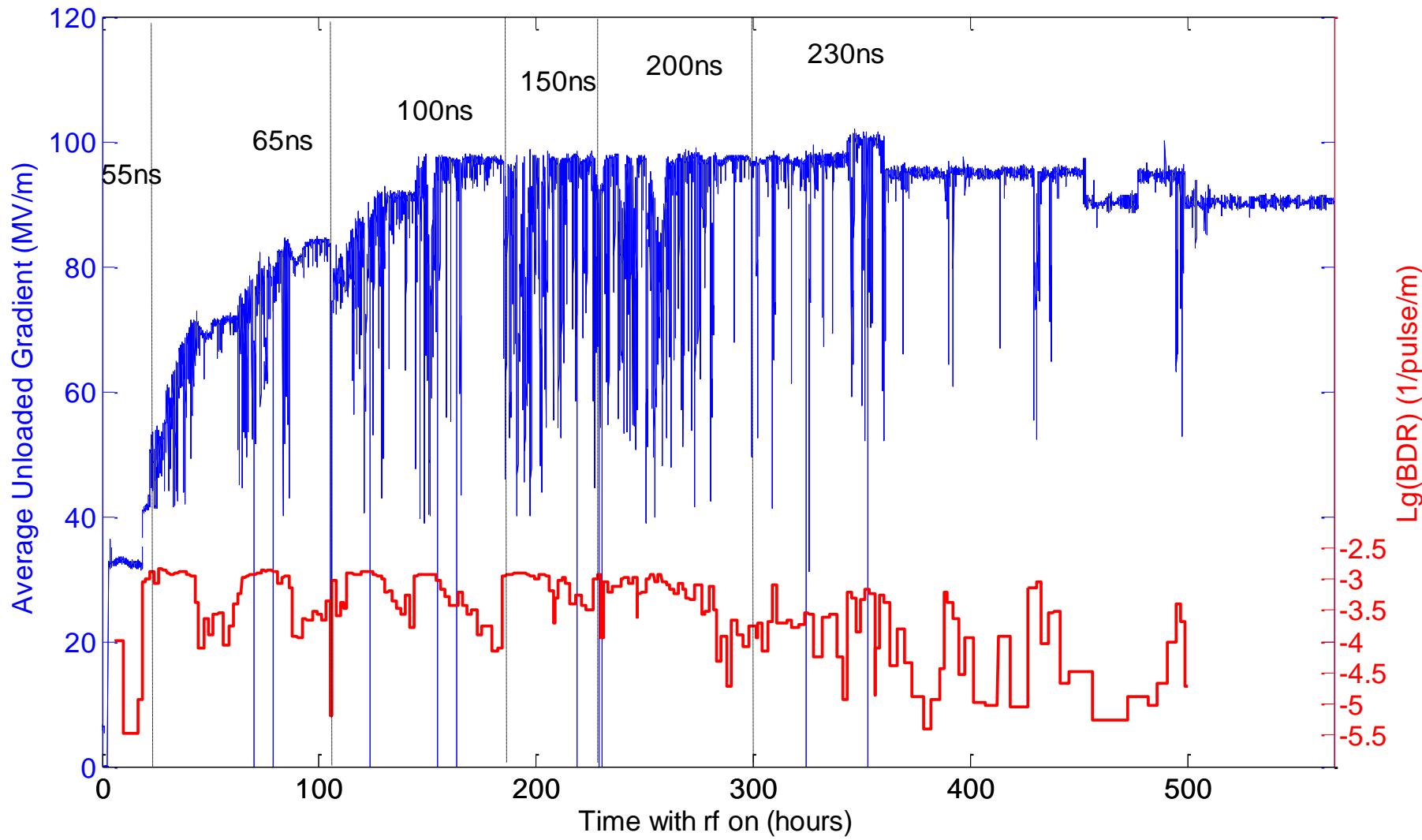


Vacuum History of Two T18_Disk Structures Made by CERN



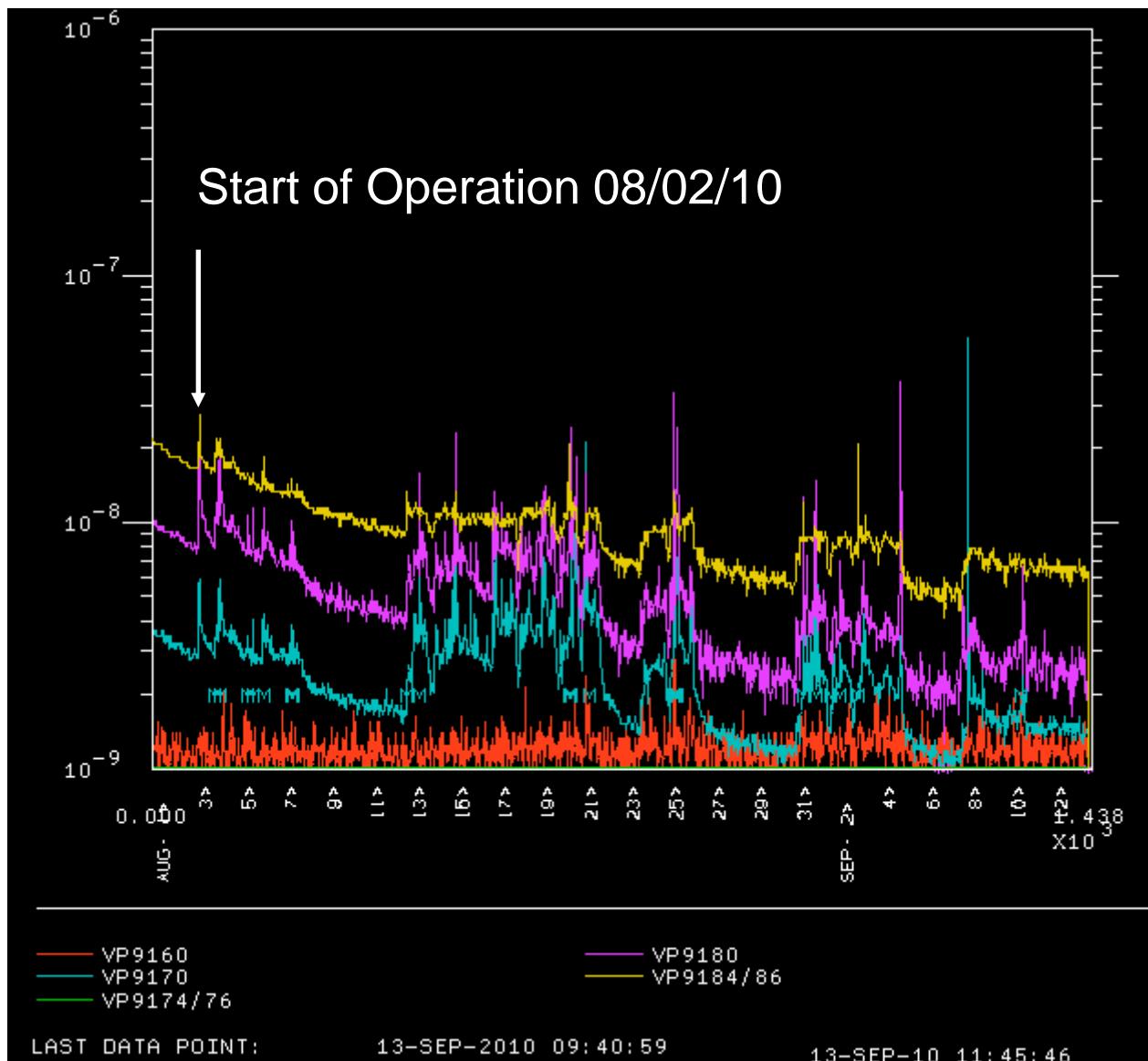
Processing History of T18_CERN_2

$1e-3(1/\text{pulse}/\text{m}) = 34.6/\text{hour}$ at 60 Hz for 0.16 m

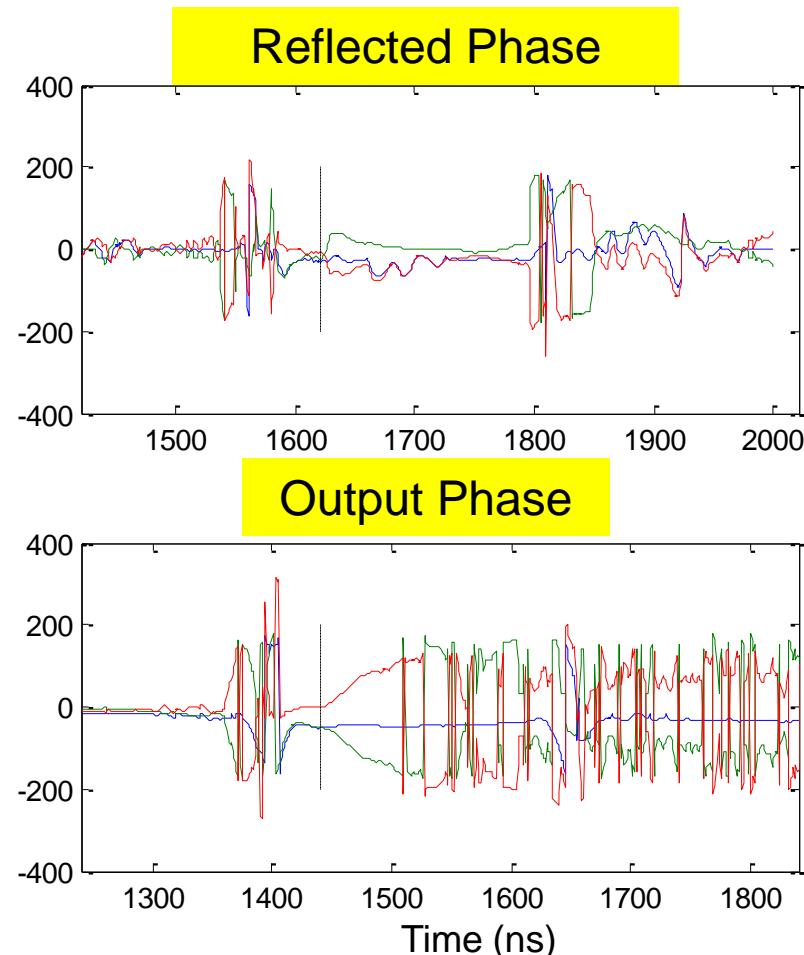
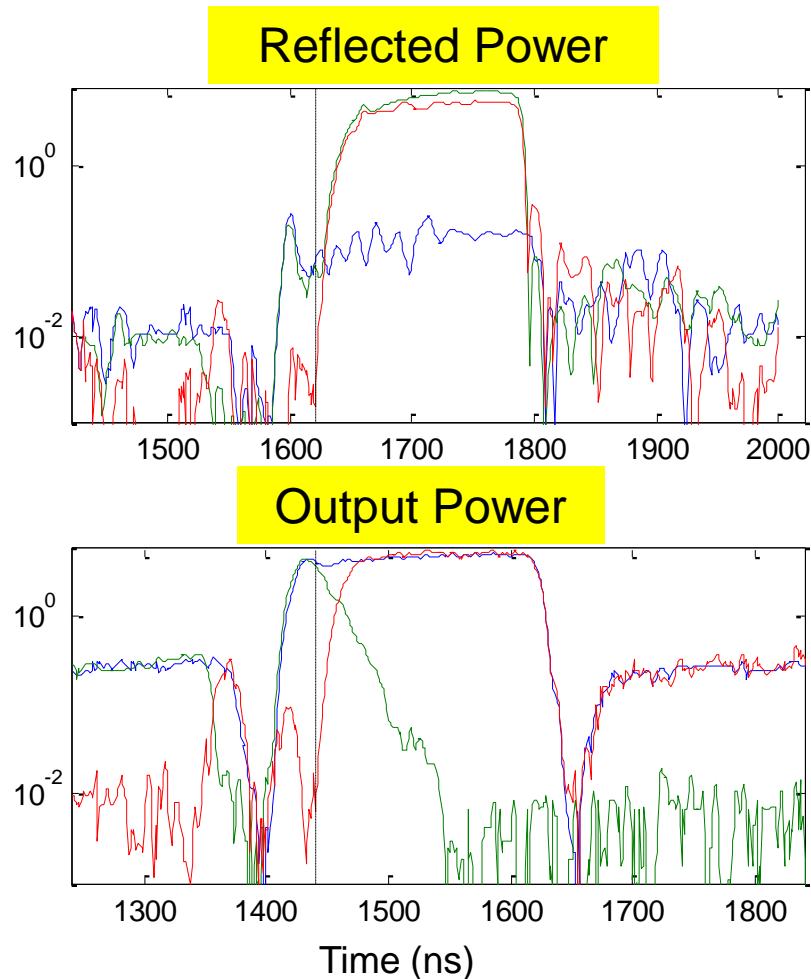


Final BDR at 90 MV/m@230ns is $1.3e-6/\text{pulse}/\text{m}$

Vacuum History of The Structure

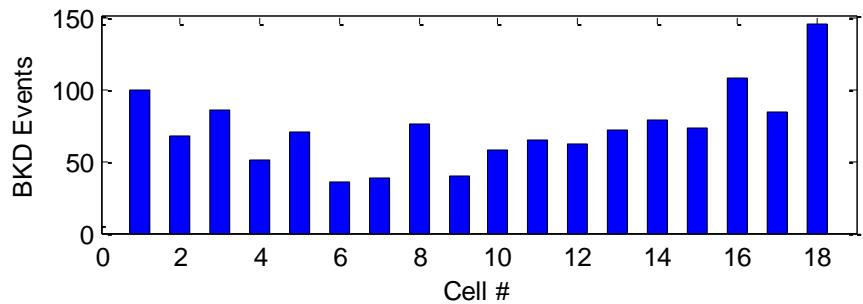
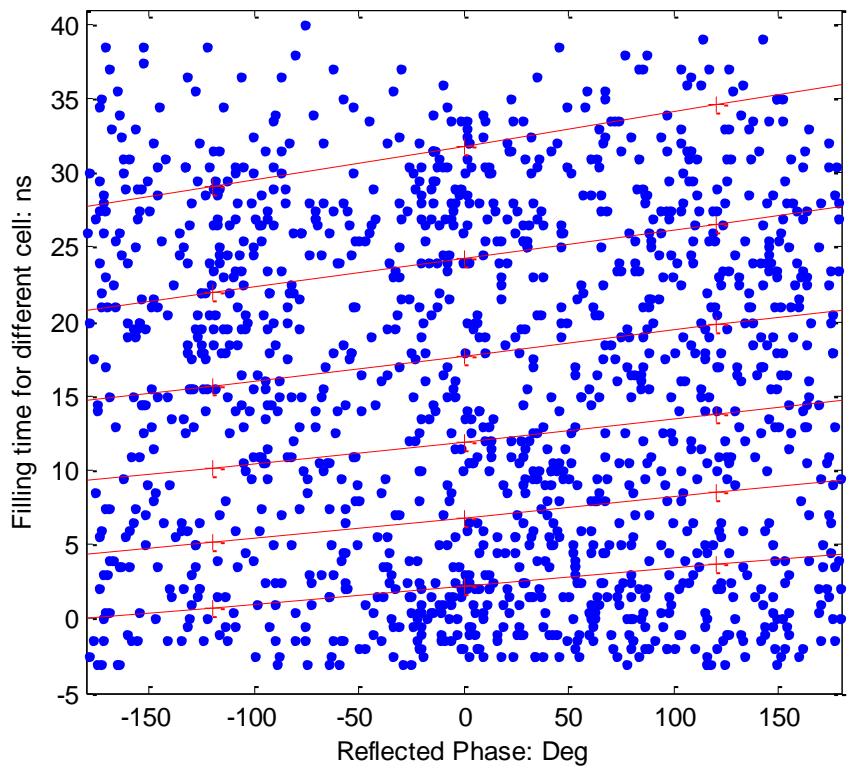


Breakdown Waveforms

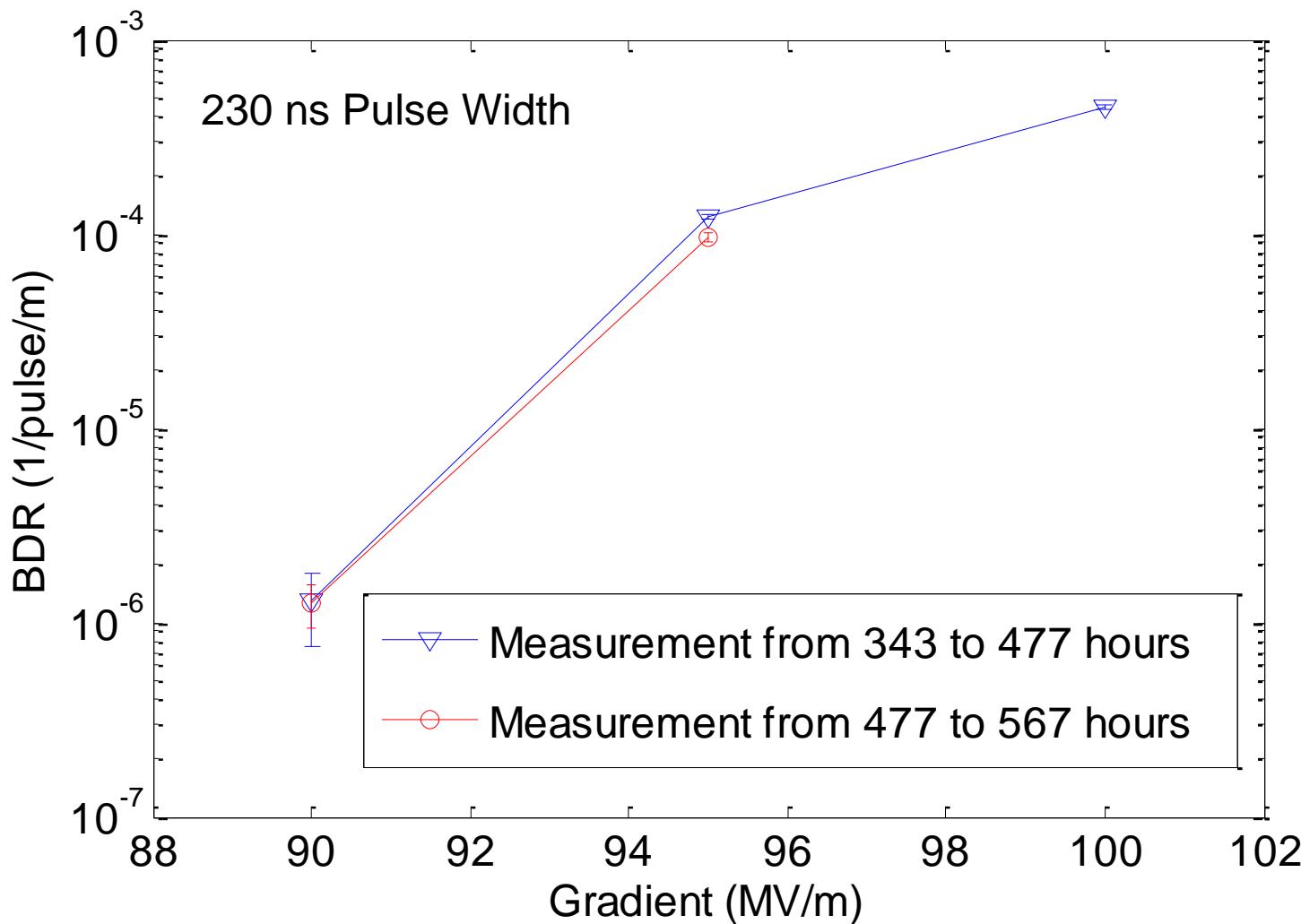


Blue: reference, Green: breakdown, Red: difference

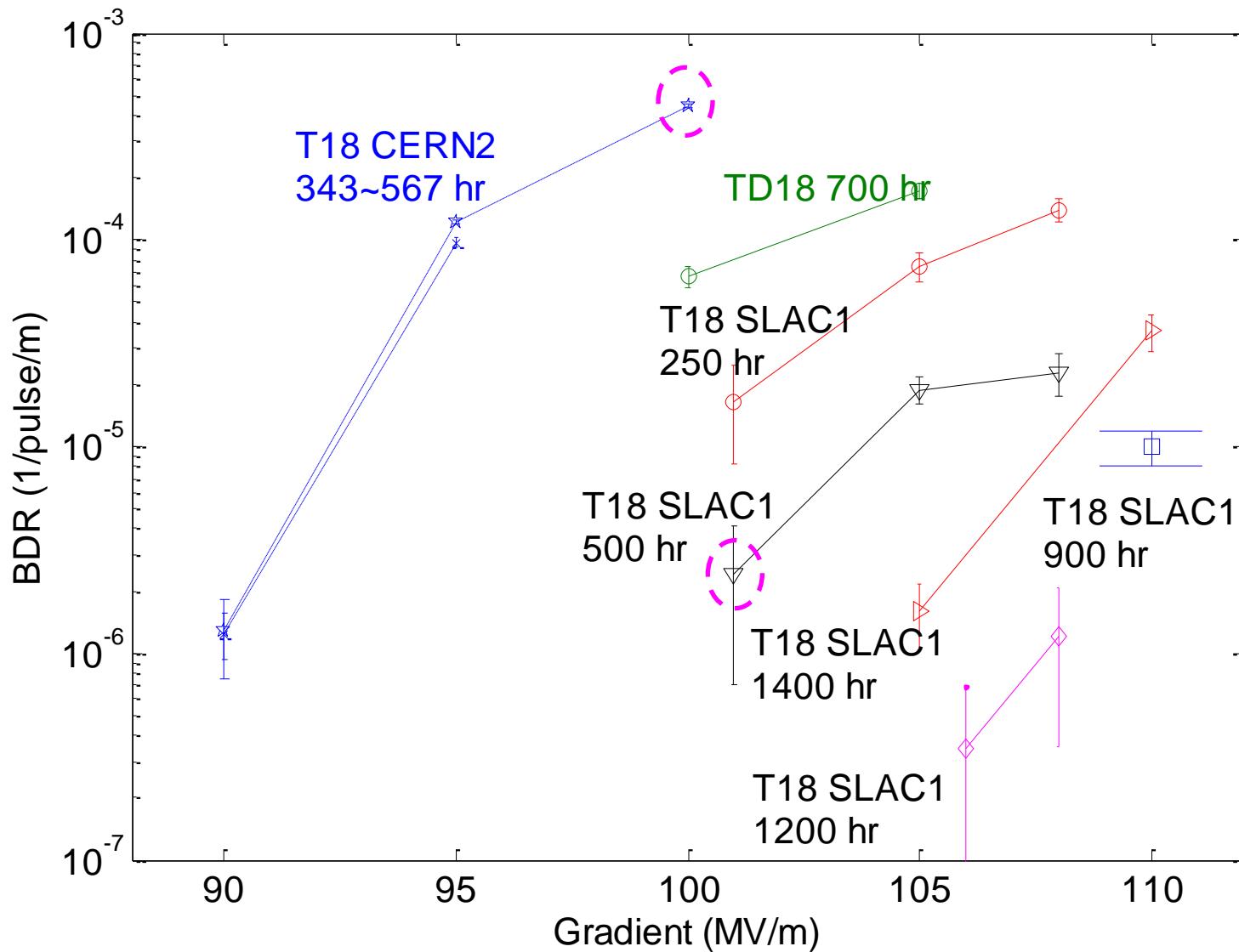
Breakdown Distribution for T18_CERN_2



BDR Gradient Dependence

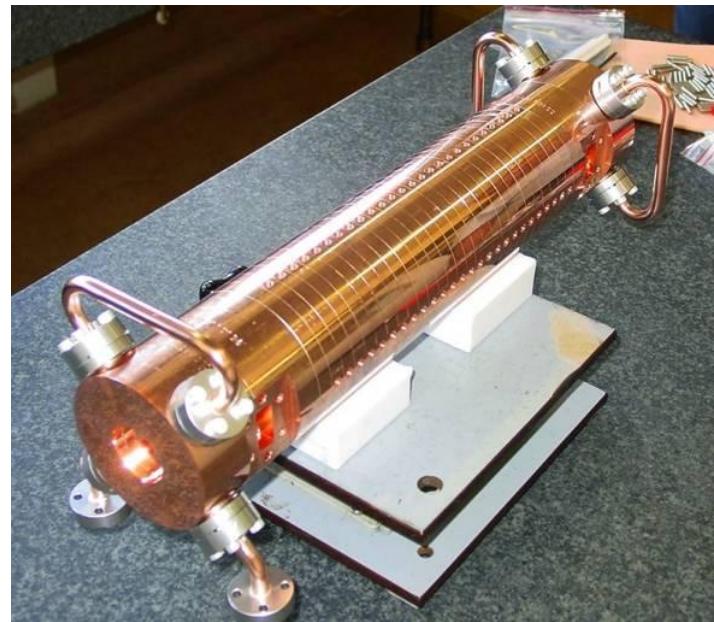
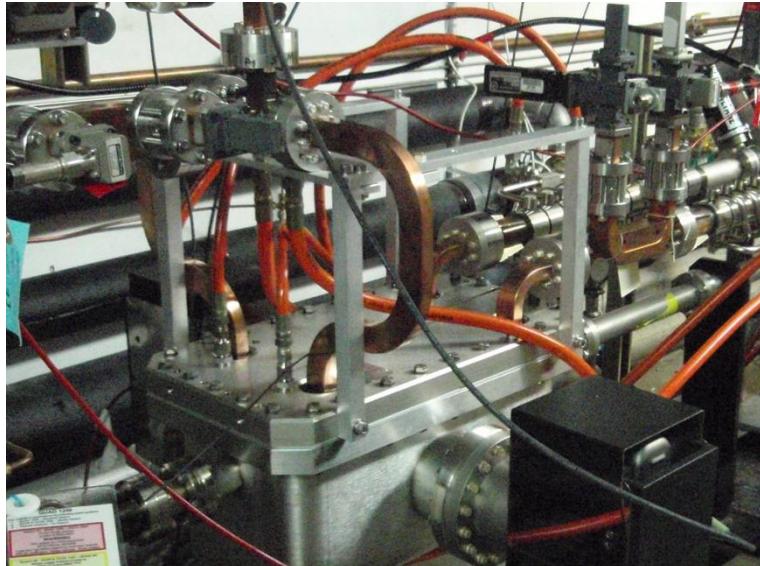


BDR Gradient Dependence for T18_CERN2, TD18, T18_SLAC1 at 230 ns

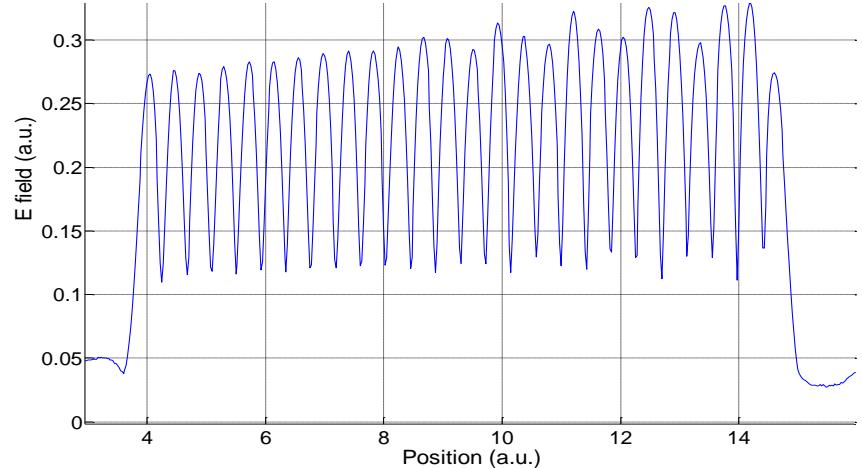


CERN-Built T24 Disk Structure

Cells	24+input+output
Filling Time: ns	61
a/λ (%)	12.6 - 9.4
v_g/c (%)	1.8 - 0.9
Phase Advance Per Cell	$2\pi/3$
Power Needed $\langle E_a \rangle = 100$ MV/m	42.4 MW
Unloaded $E_a(\text{out})/E_a(\text{in})$	108/90
E_s/E_a	2
Pulse Heating ΔT : K (<100MV/m>@100ns)	7.5 – 8.4

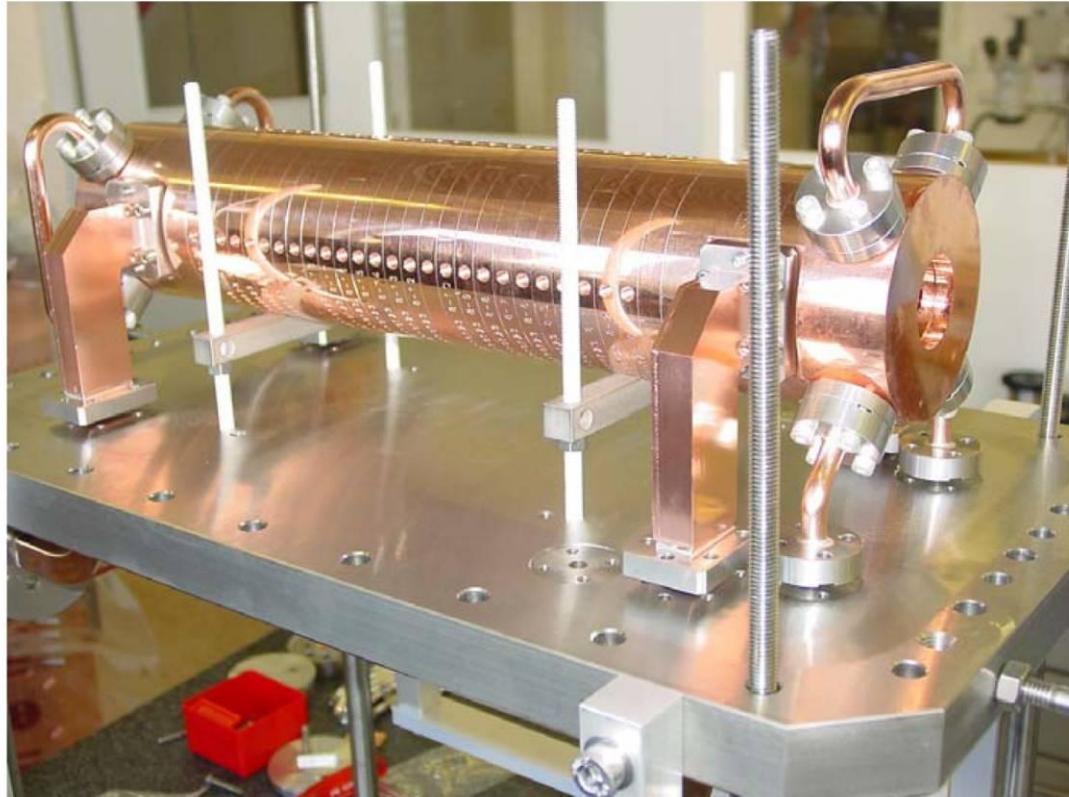


Field Profile Along the Structure

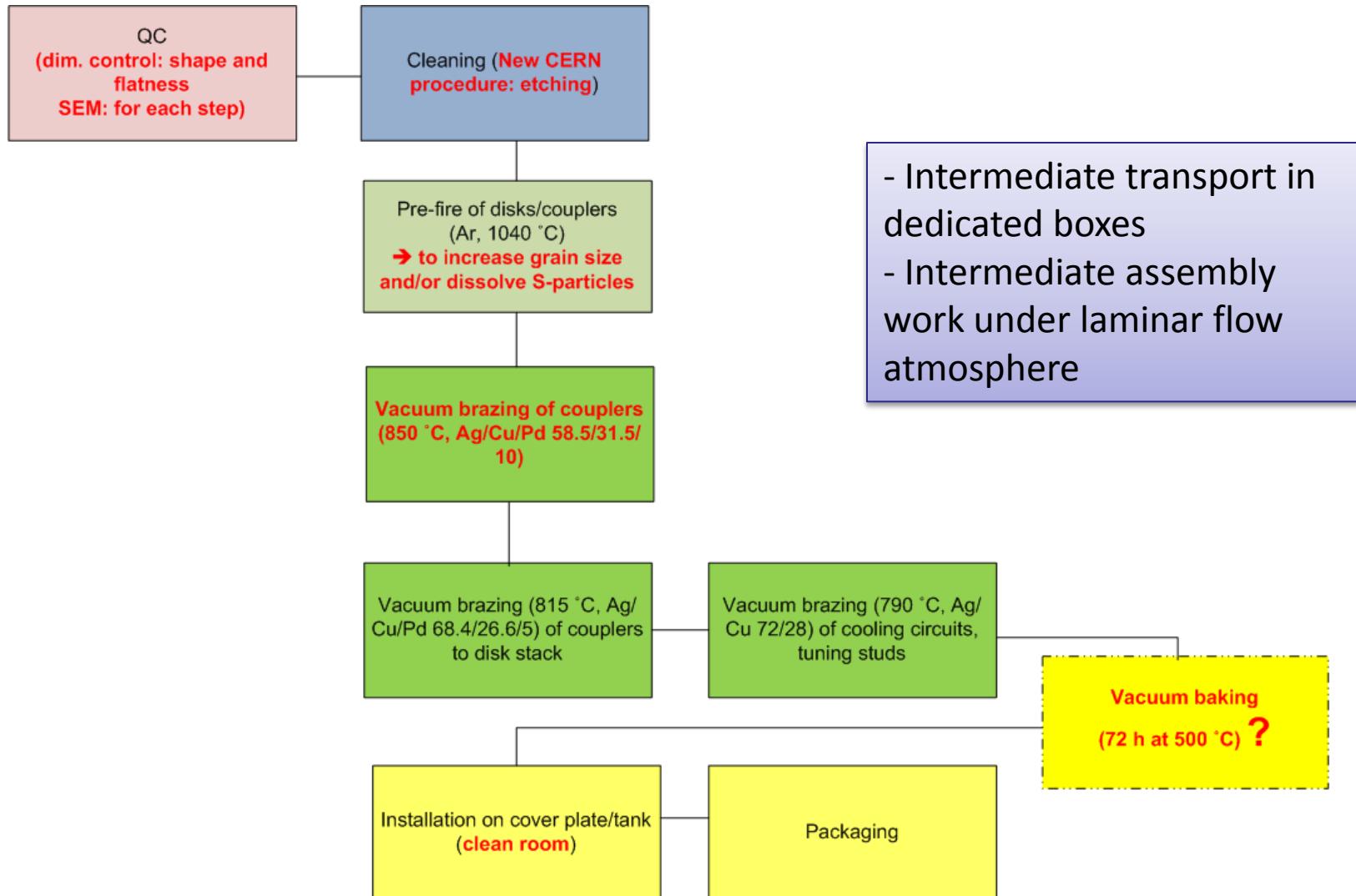


T24 Fabrication

- Manufactured at VDL, Q4 '08
- Assembly at CERN with “new” procedure (following T18 task force) Apr-Jun 09
- Pre-fire of disks at 1040 °C. Resulting uneven surface caused braze leaks
- Cells oxidized at one point but it was removed with 650 °C bake
- Now back at CERN for evaluation



Assembly Cycle



Pre-Fire and Brazing

COUPLERS

- Pre-fire of couplers at 1040 °C
- Brazing of couplers 850 °C, SCP2
- Machining of couplers

STRUCTURE

- Pre-fire of disks at 1040 °C
- Brazing of all structure 815 °C, SCP1
- Brazing of cooling circuit 790 °C,
eutectic AgCu – **spots of braze filler**

material



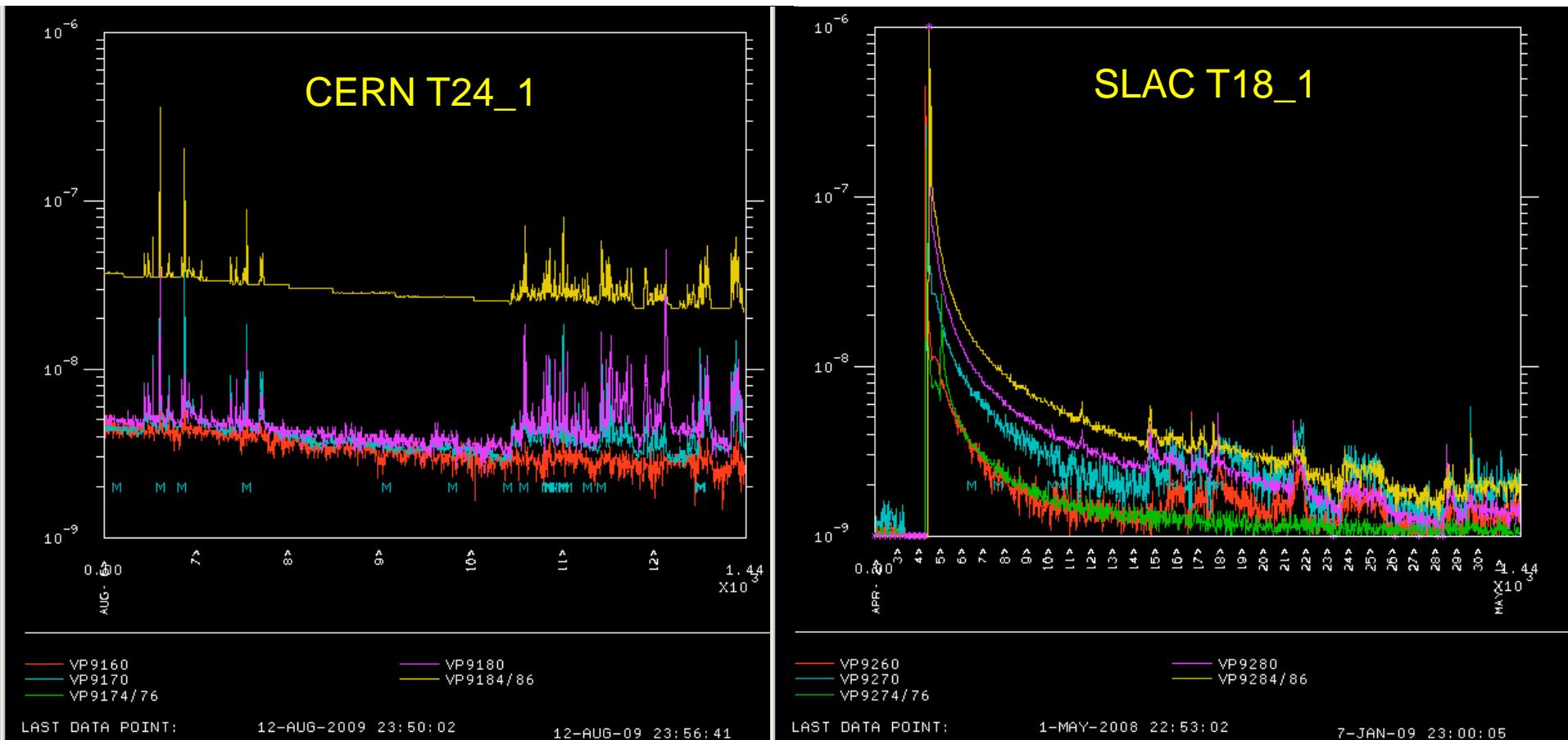
EDMS#10000659

EDS analysis of brazing filler metal dropped out - The drops of filler metal in structure 11WNSDvg1.8 have a composition close to the Ag-Cu eutectic with **no evidence of Pd.**

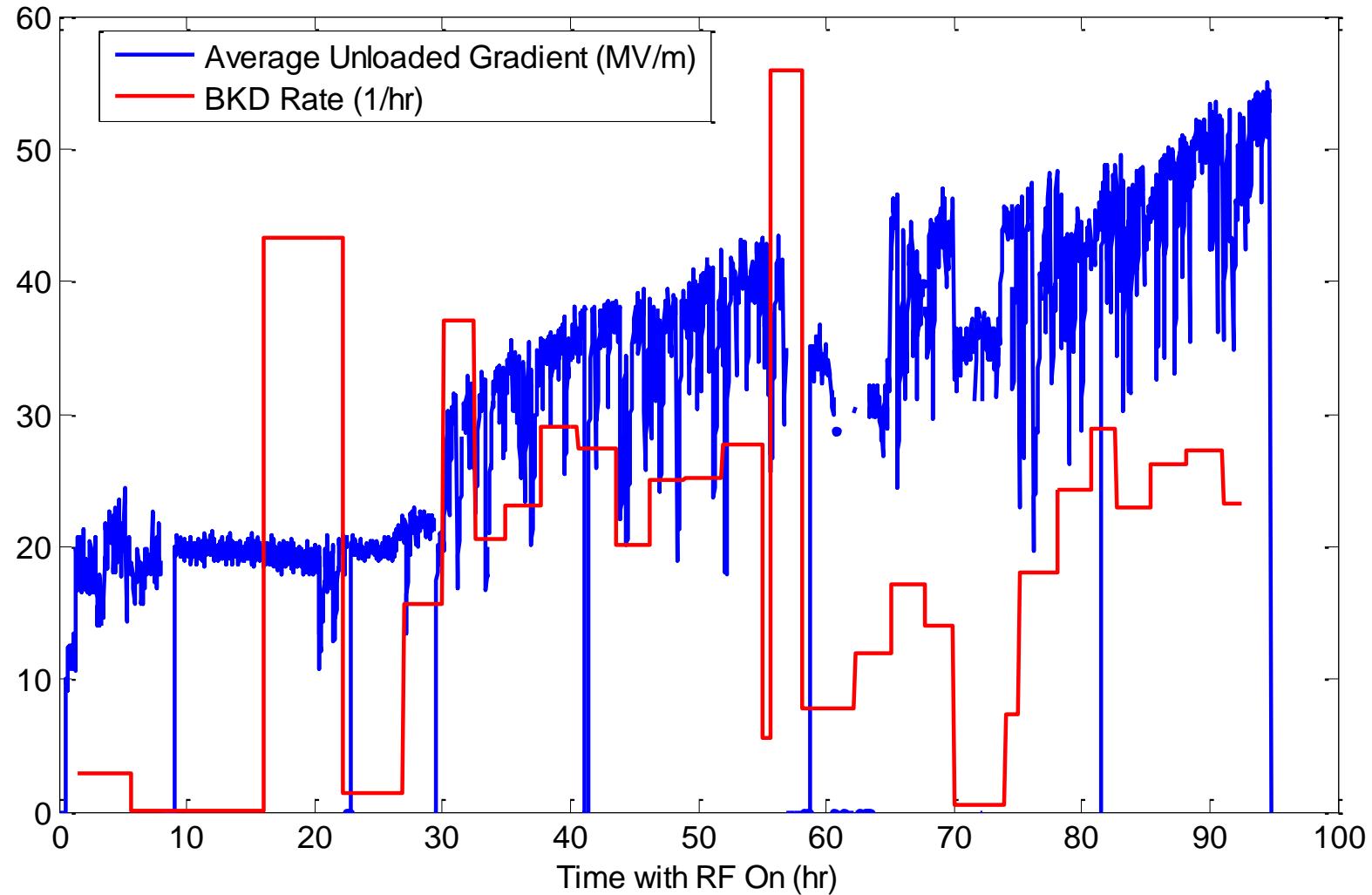
RF Check and Tank Installation

- RF check and tuning in building 112 clean room
- Problem occurred in the clean room: oxidation of the structure (all the parts made of annealed copper which were lying in the lab had blue or purple spots and those which were not annealed preserved their Cu color)
- Baking 650 °C for ½ day
 - Witness piece analyzed (EDMS#1009001) –
 - Before baking: traces of Cl and S
 - After baking: traces of S (traces of Cl disappeared)
- Installation in the tank to verify part compatibility (EDMS#1003726)
- Shipment to SLAC (all parts under N2) – cover design incompatible with transport loads

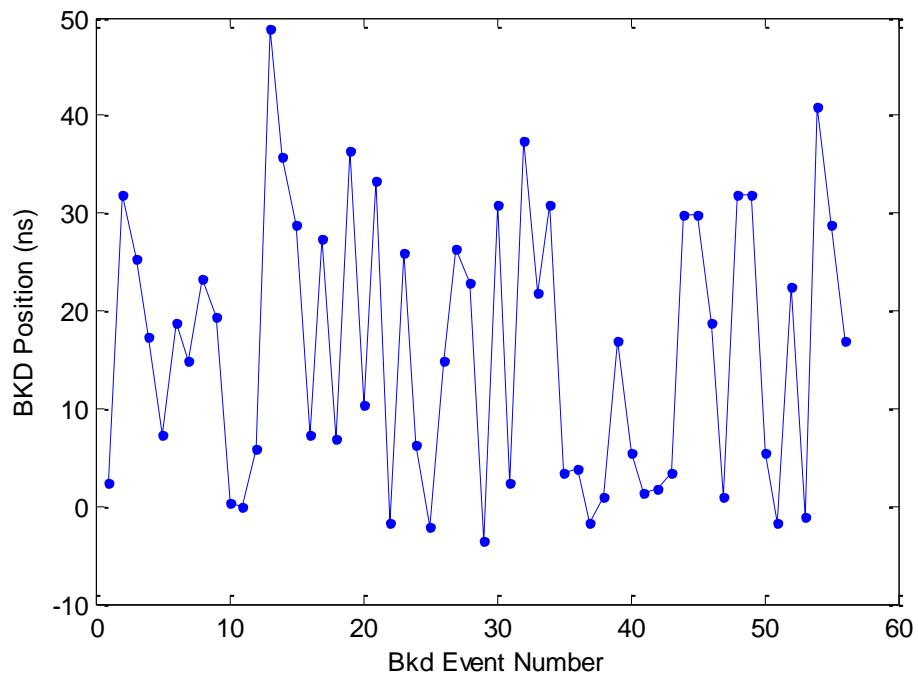
Vacuum Histories



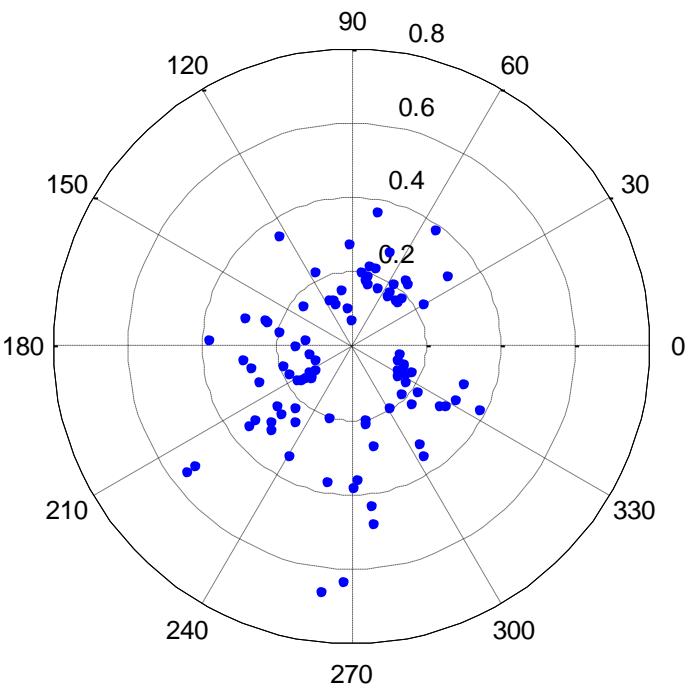
T24 Processing History at 100 ns and Shorter Pulse Lengths



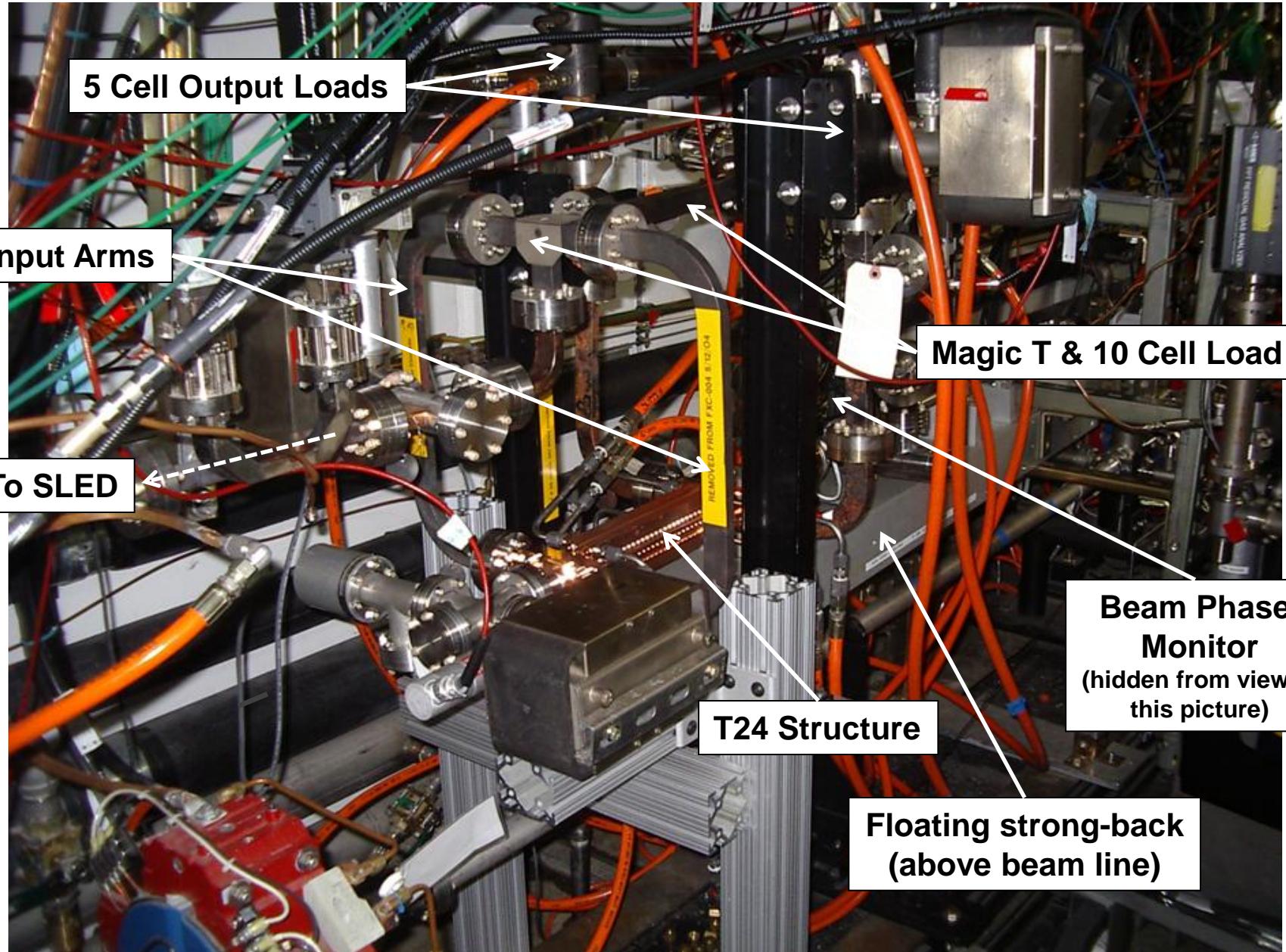
Breakdown Locations



Reflected Phase -vs- Reflected Power (max)

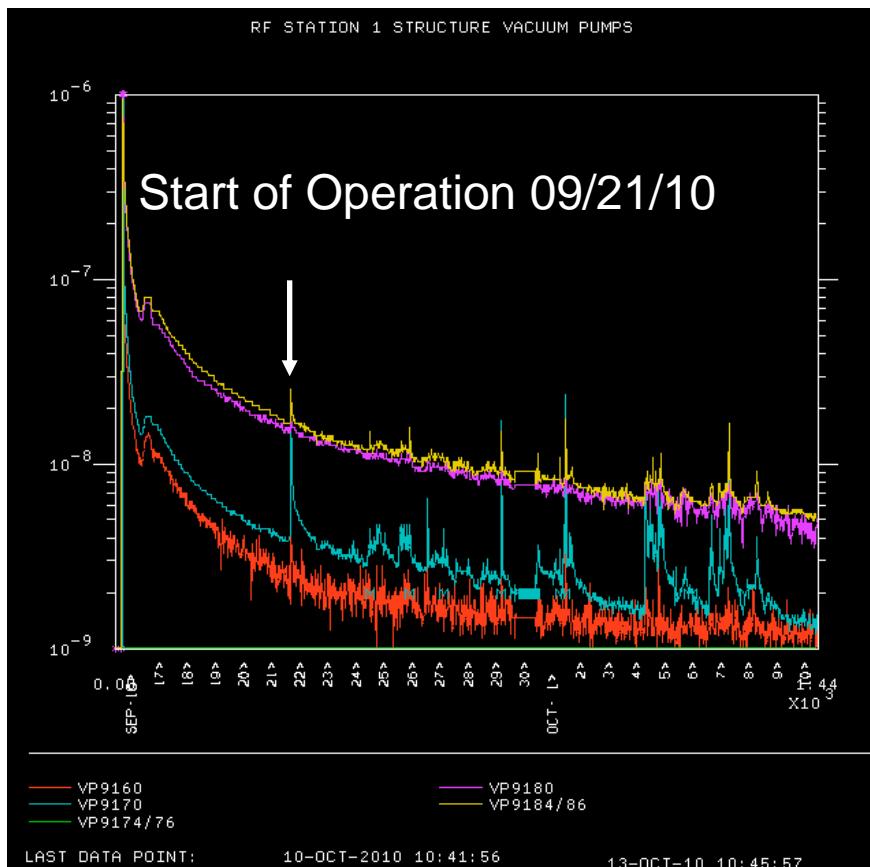


T24_SLAC_1 in NLCTA

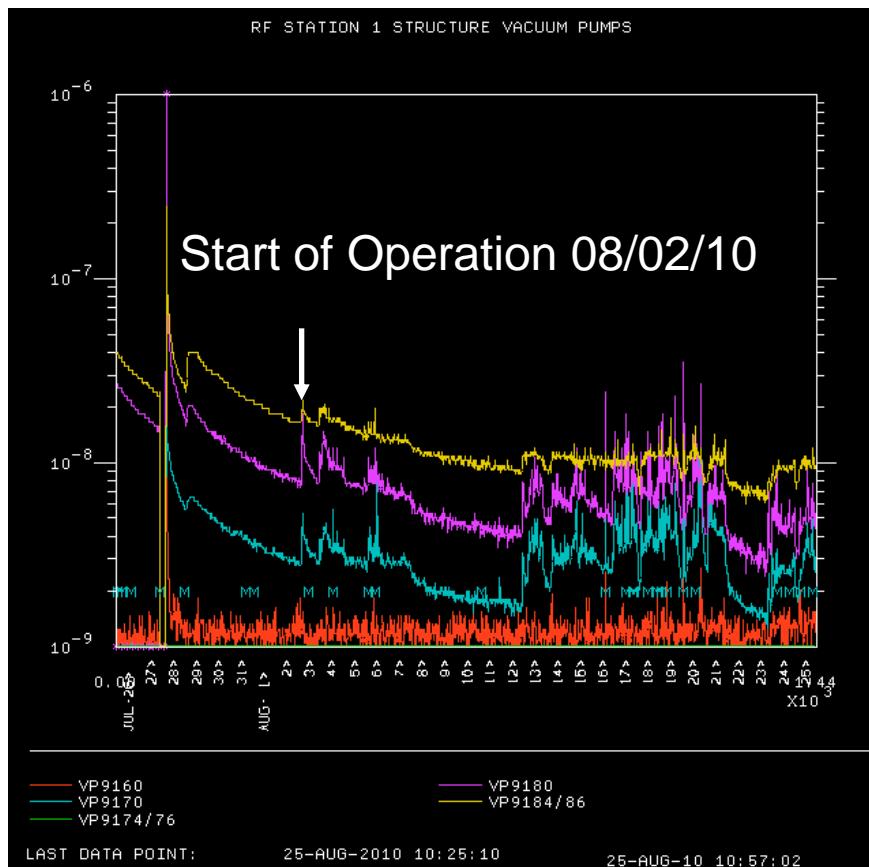


Vacuum History

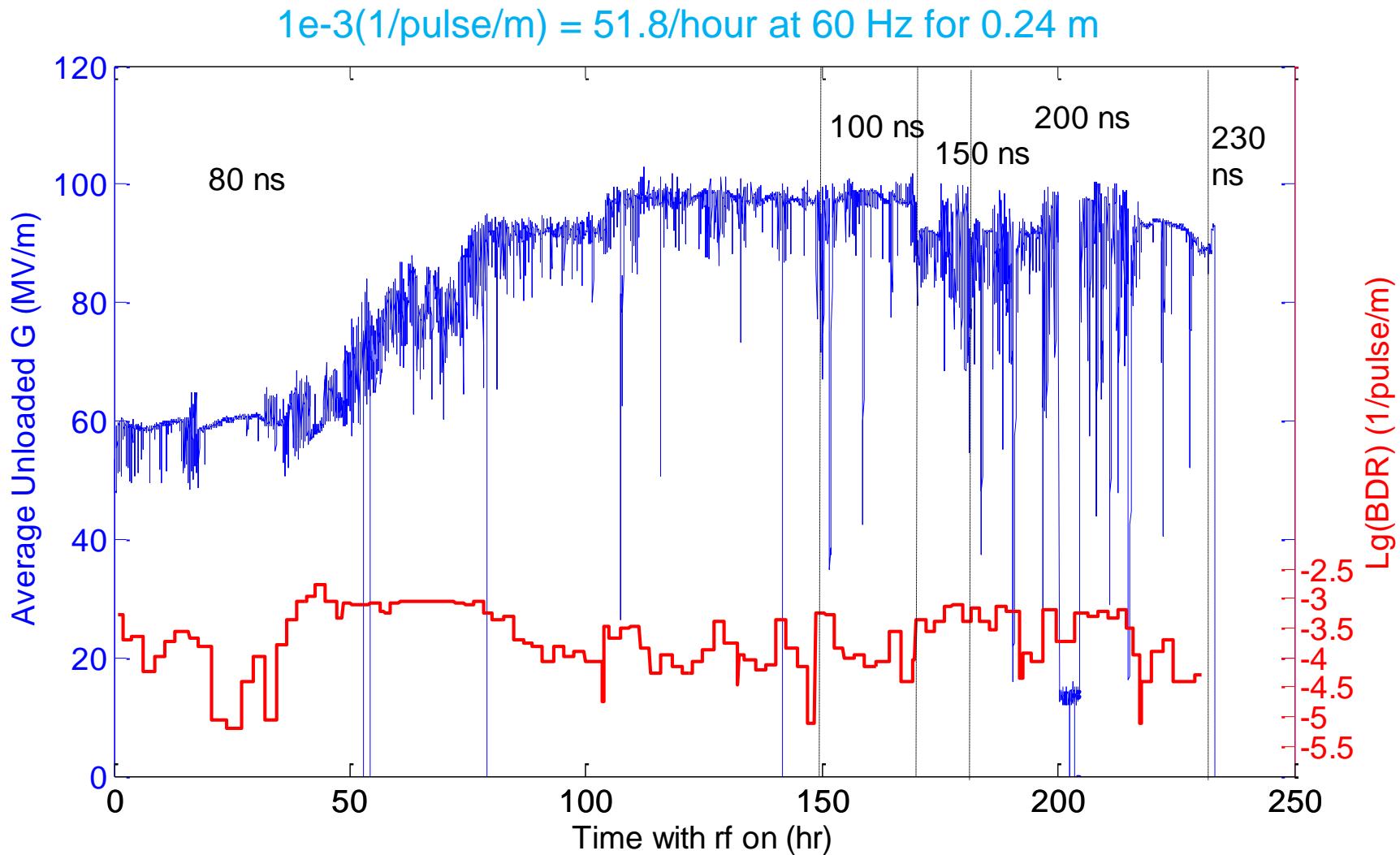
T24_SLAC_Disk1



T18_CERN_2



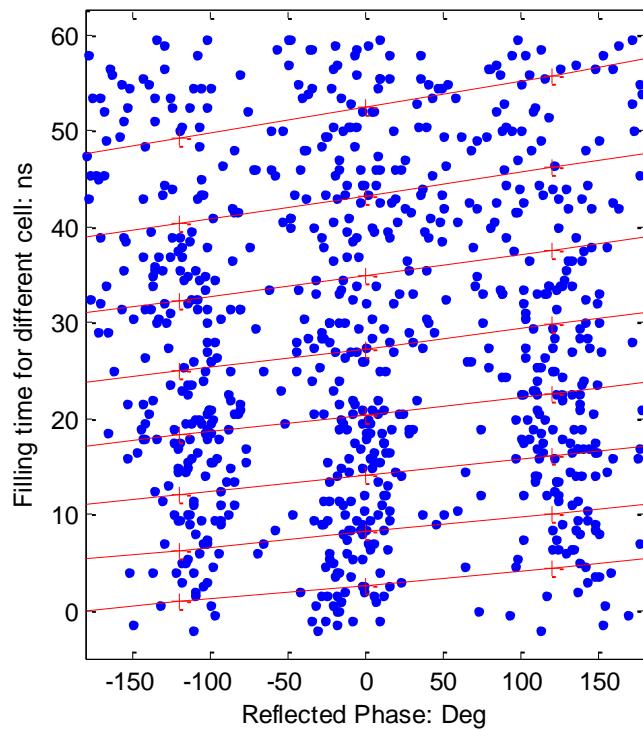
T24_SLAC_Disk1 RF Processing Results



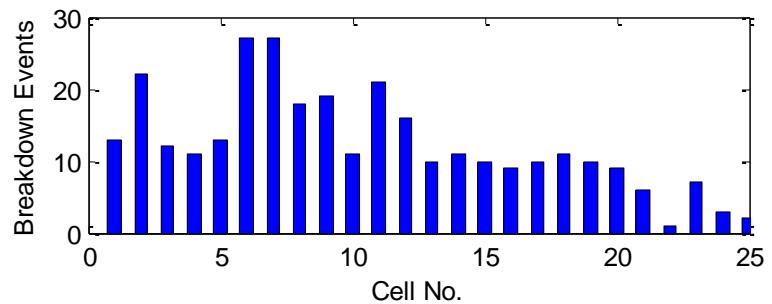
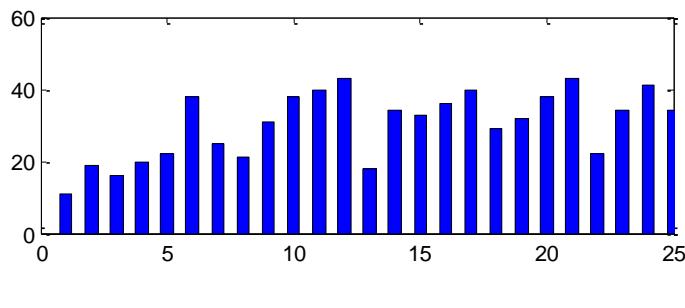
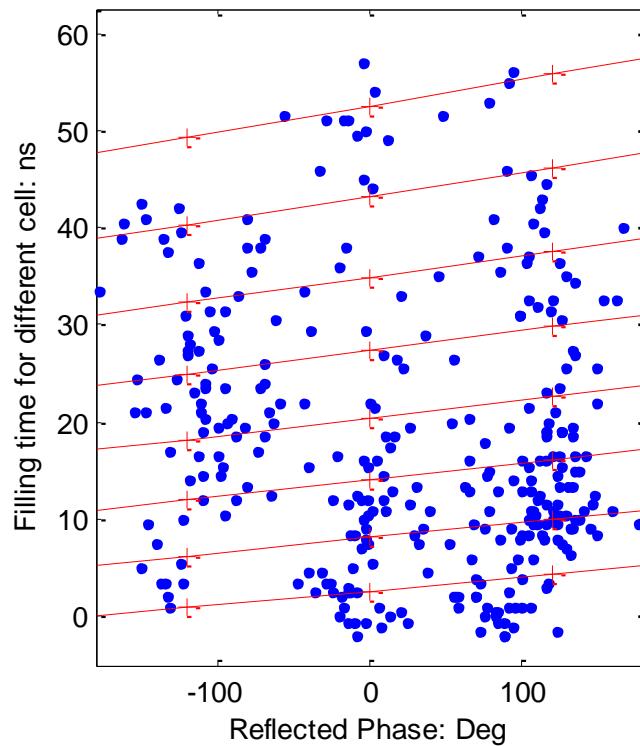
Currently BDR at 92 MV/m@200ns is 9.8e-5/pulse/m (~5BKD/hr)

Breakdown Distribution for T24_SLAC_Disk1

0 ~ 200 hours



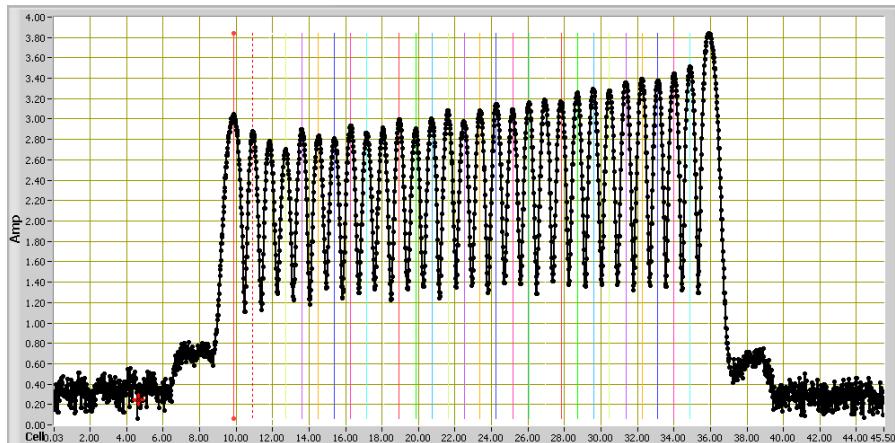
200 ~ 230 hours



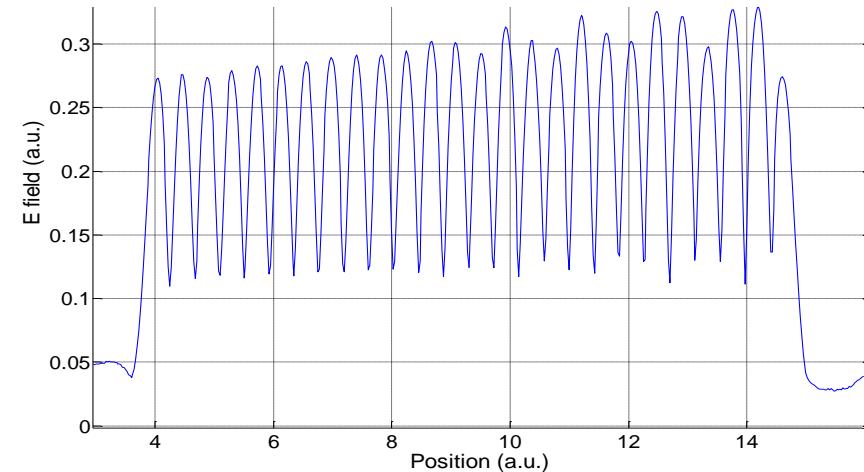
T26 vs T24 Parameters

Structure Type	Total Acc. Cells	v_g % c	2a mm	Pin for 100 MV/m	T_f ns
T26	30	3.30 - 1.62	7.8 - 6.3	84	36
T24	24	1.83 - 0.92	6.6 - 4.9	42	58

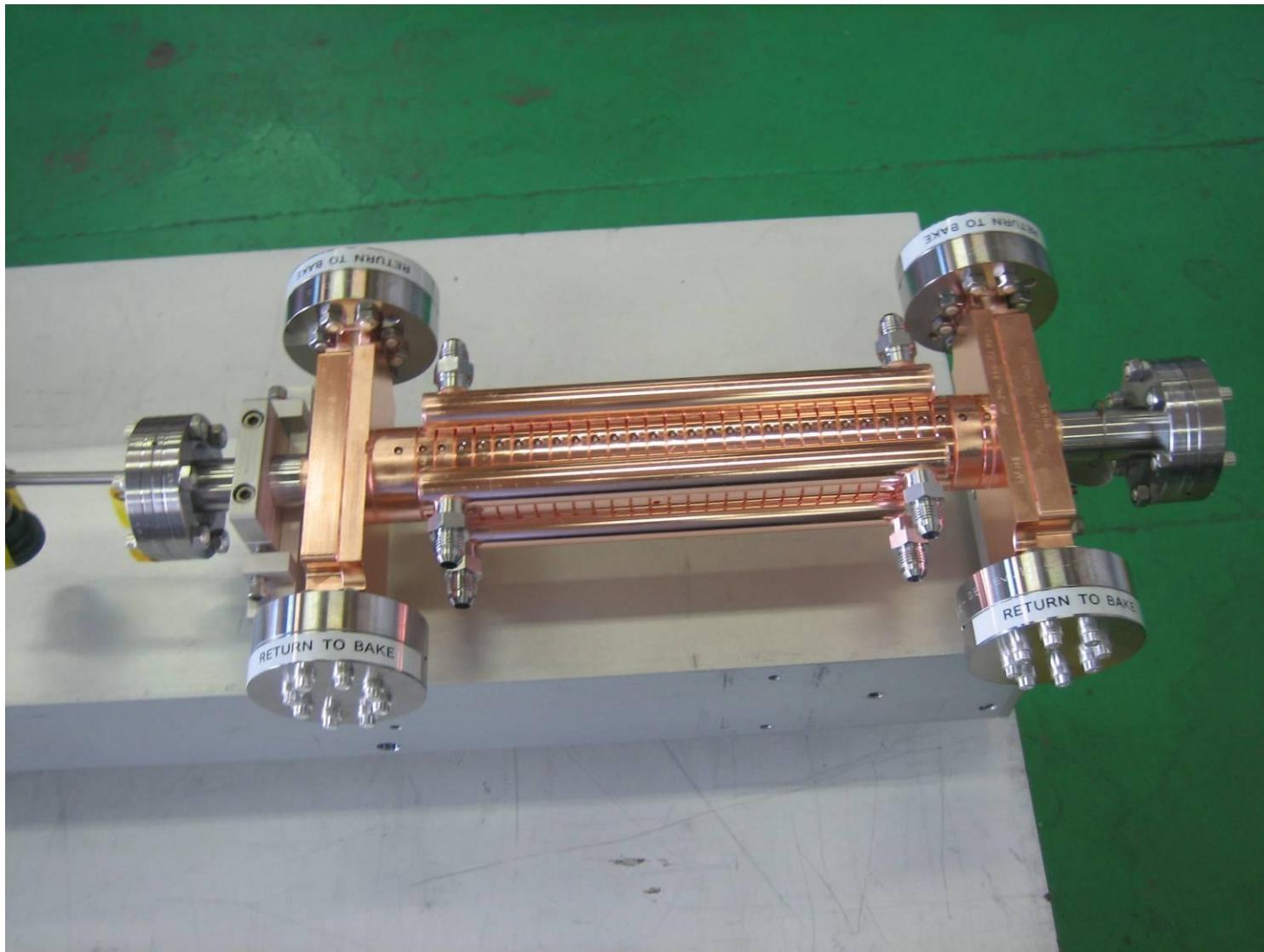
T26



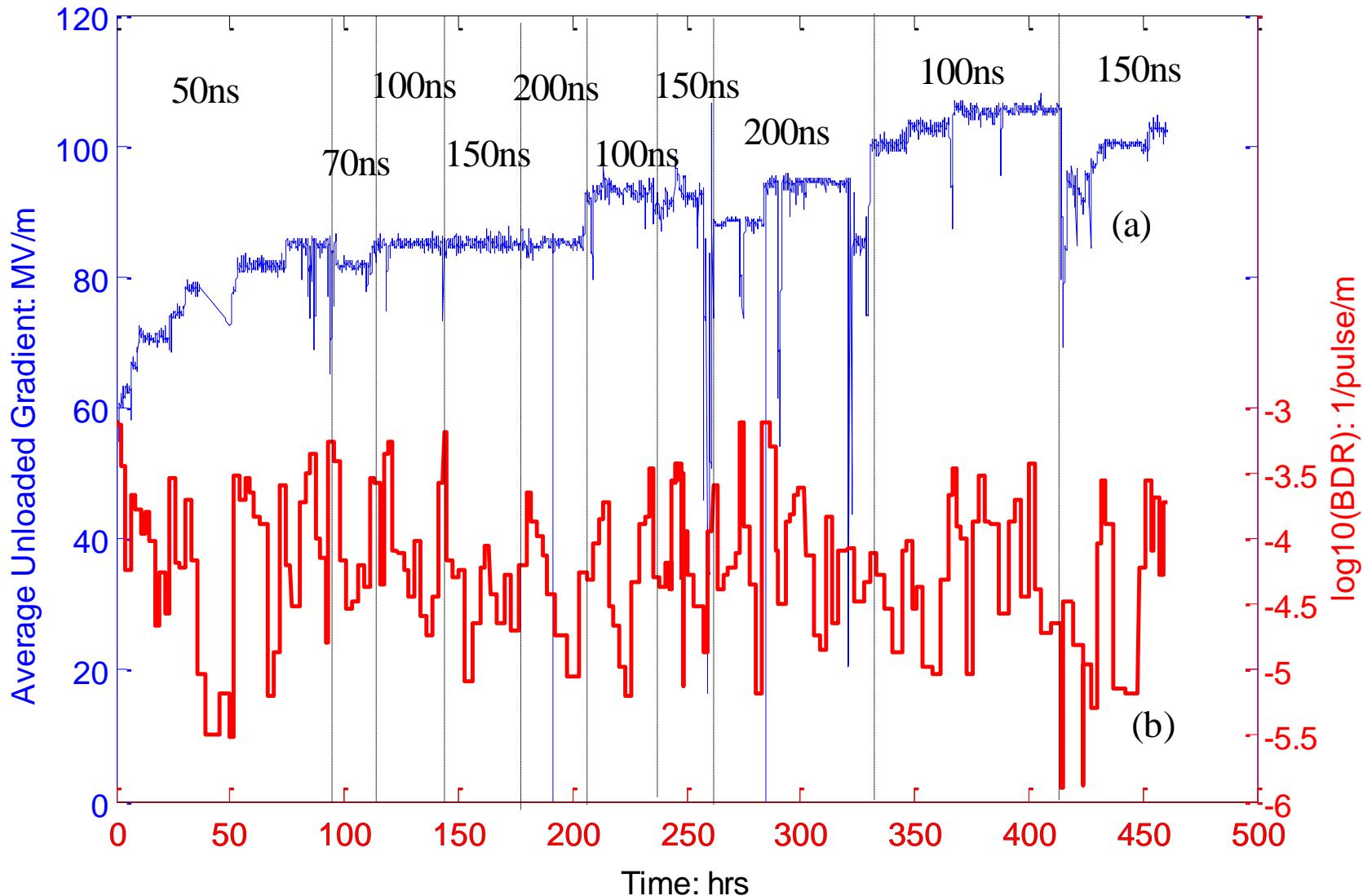
T24



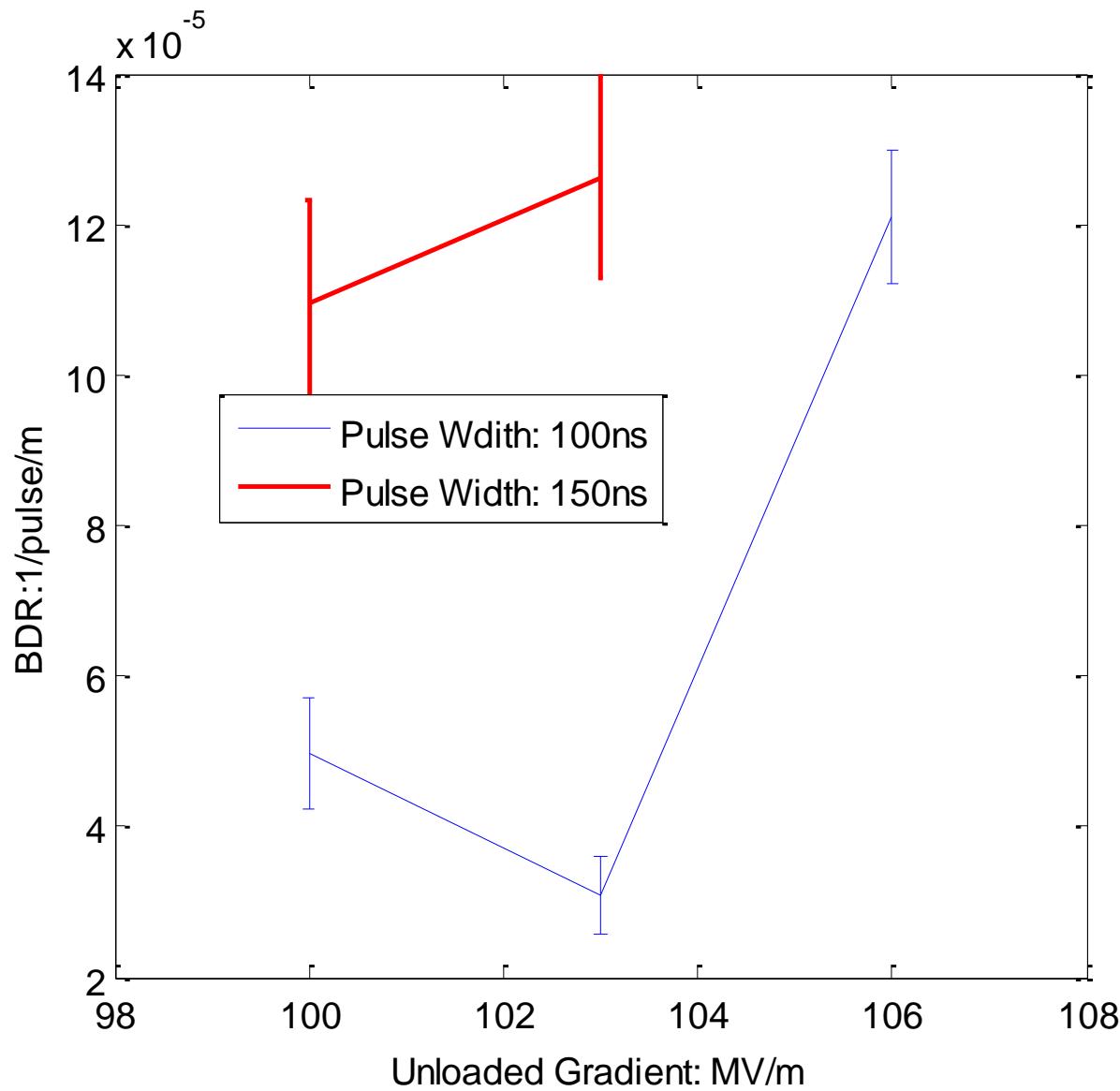
SLAC T26 (Even Number T53 cells)

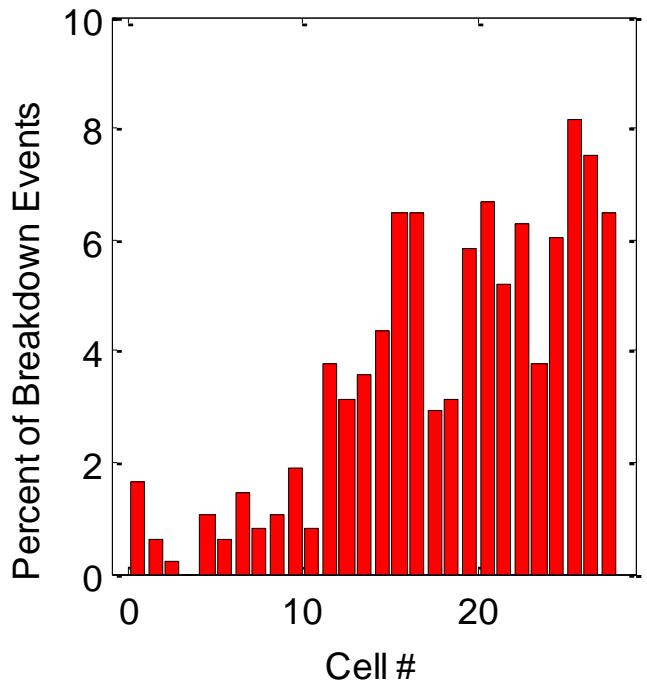


T26 Structure Process History Profile

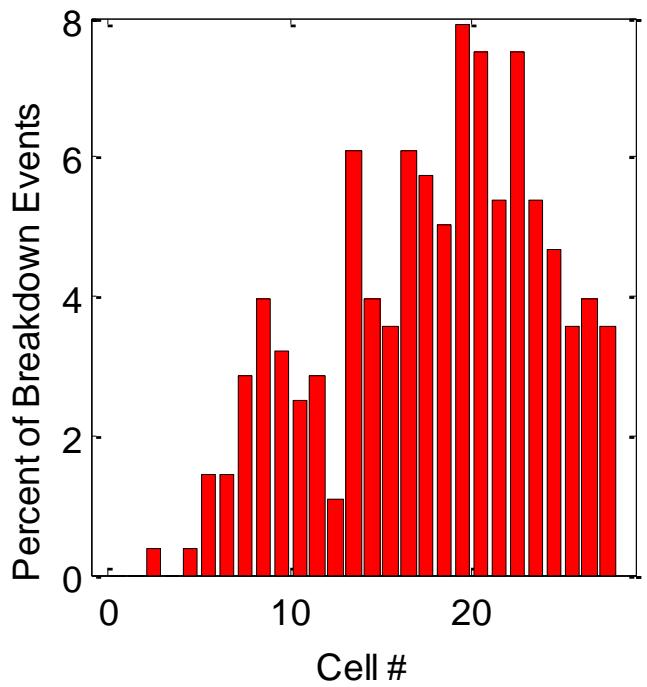
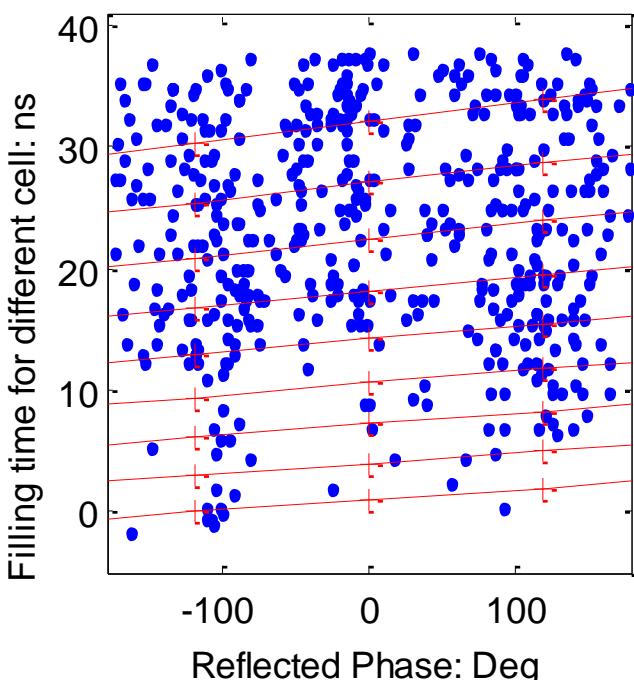


T26 BDR Gradient Dependence

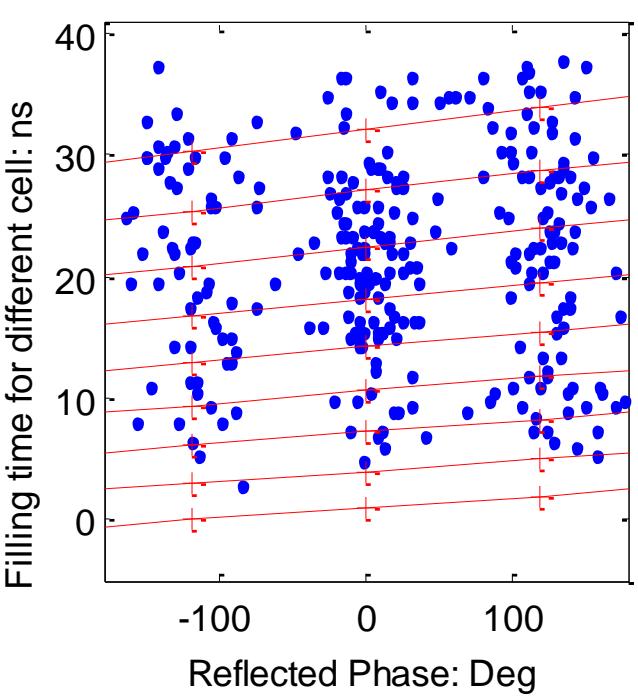




0~250hrs



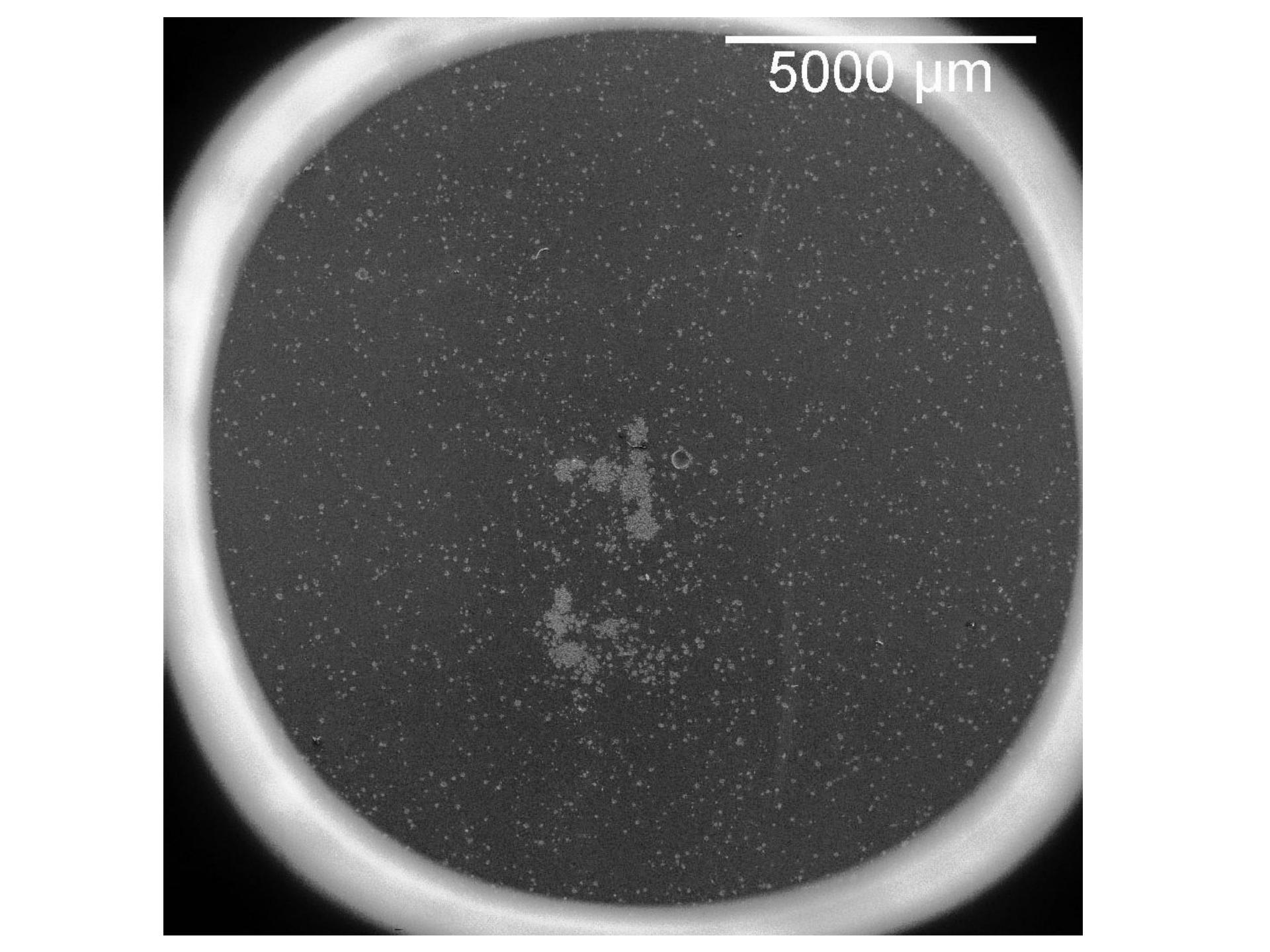
250~500hrs



NLCTA S-Band Gun Cathode

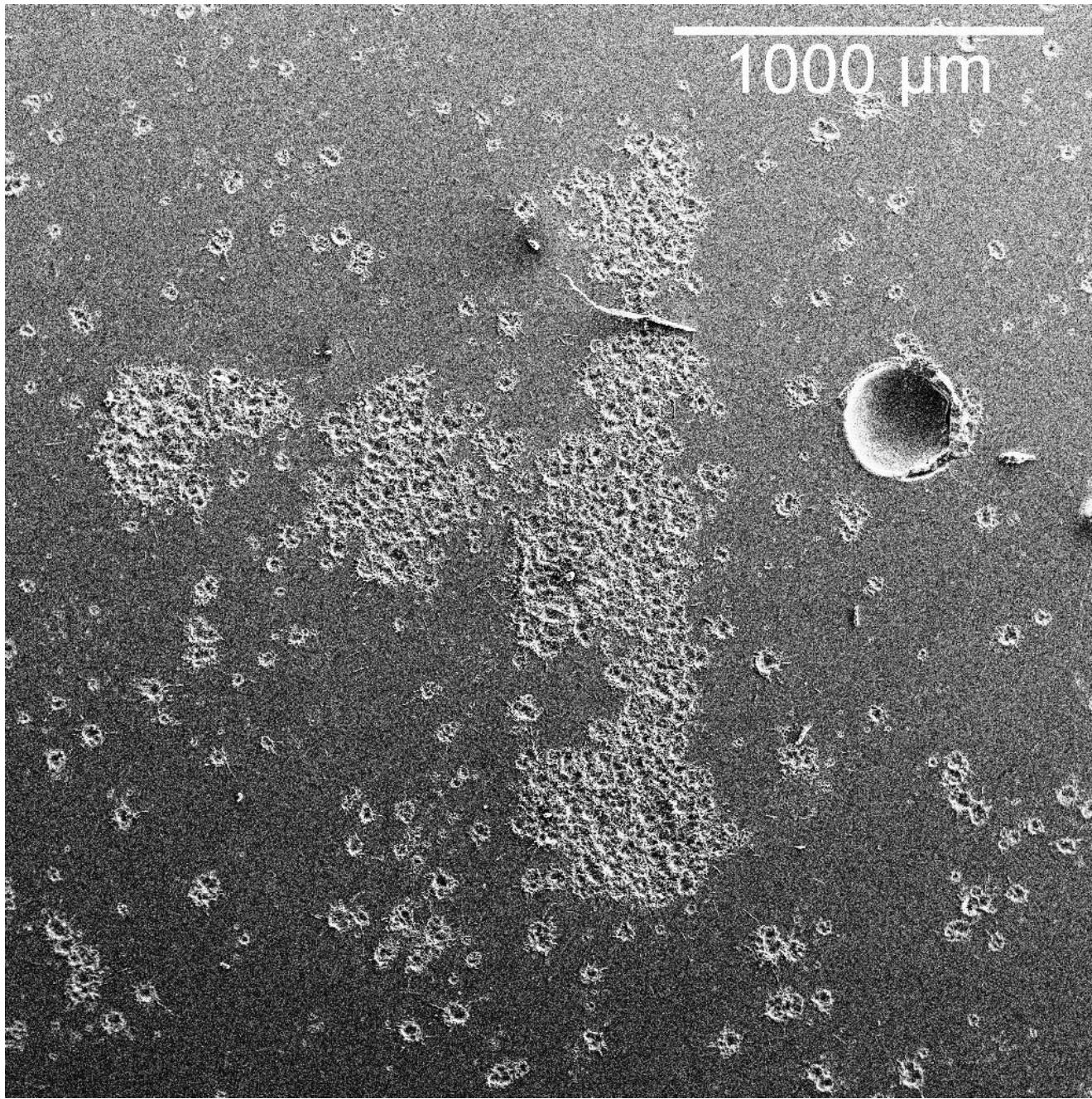
Ran at 105 MV/m without interlocks (~ 1 us fill)

Recently removed since dark current become too large



5000 μm

1000 μm



Laser Pulse Heating

- Estimate of pulse heating in the NLCTA S-band rf gun from the laser (1 ps, 260 nm):
- Assuming the laser induced heat does not diffuse much (< 14 nm) during the 1 ps laser pulse the temperature rise of the copper is (Laser energy * Absorption fraction / (Copper density * Heated Volume)) / Heat capacity where
 - Laser energy = 10 uJ
 - Copper density = 9 gm/cm³
 - Laser volume = $\pi * r^2 * \text{depth}$ where $r = 0.5$ mm and the laser penetration depth is 14.3 nm
 - Heat capacity = .38 J/(gm*K)
 - Absorption fraction = 50%
- This yields a pulse temperature rise of $10e-6 * 0.5 / (9 * \pi * 0.05^2 * 14.3e-7) / .38 \sim 130 \text{ degC}$

Laser Ablation

- As shown in a paper at the url below on short pulse (0.5 ps), 248 nm laser ablation of metals, they find it starts to occur (i.e. > 1 nm removal per pulse) at a laser fluence of about 100 mJ/cm² versus ~ 1 mJ/cm² for the NLCTA gun.
- They assume the threshold of ablation is when the evaporation enthalpy at 298 degK is exceeded, which is about 50 kJ/cm³ for copper - using the above copper heat capacity and density, this would be equivalent to a 14e3 degK temperature rise, and is thus consistent with the above computed temperature rise of 130 degC with 1/100 of the laser fluence.
- <http://www.springerlink.com/content/p6t732u61452t6t7/fulltext.pdf>

Summary

- Second CERN-built T18 did much better than the first, but has breakdown rate over two orders of magnitude larger than the SLAC/KEK built T18's for the same operation parameters and processing time
- The CERN-built T24 preformed poorly and the SLAC/KEK version is doing OK after 230 hours of processing
- Based on earlier T26 results, would expect better performance of the T24 thus far.
- Lasers pulses used for photocathodes can raise surface temperature above 100 degC. However, the pulses are only about 1 ps long, and the heat quickly dissipates. Nonetheless, cathode breakdowns appear clustered in the area exposed to the laser.