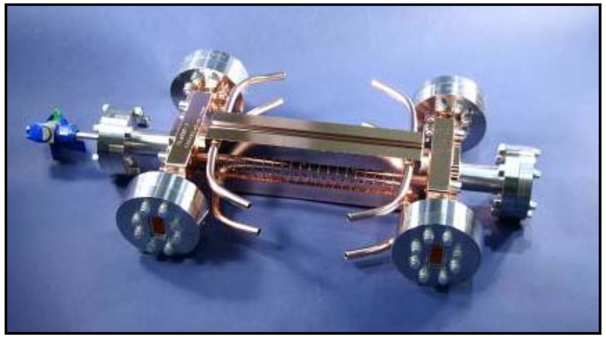
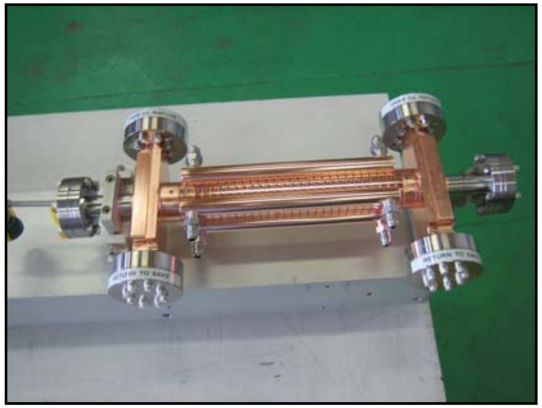
Recent Results on CLIC X-band prototype accelerating structures

- Introduction
- T18_vg2.6_disk, forward and backwards
- TD18_vg2.4_quad
- T28_vg3.3_disk
- Comparison and conclusions



T18_vg2.6_disk

TD18_vg2.4_quad



T28_vg2.9_disk

Steffen Döbert, X-band rf structure and beam dynamics workshop, Cockcroft Institute

Introduction

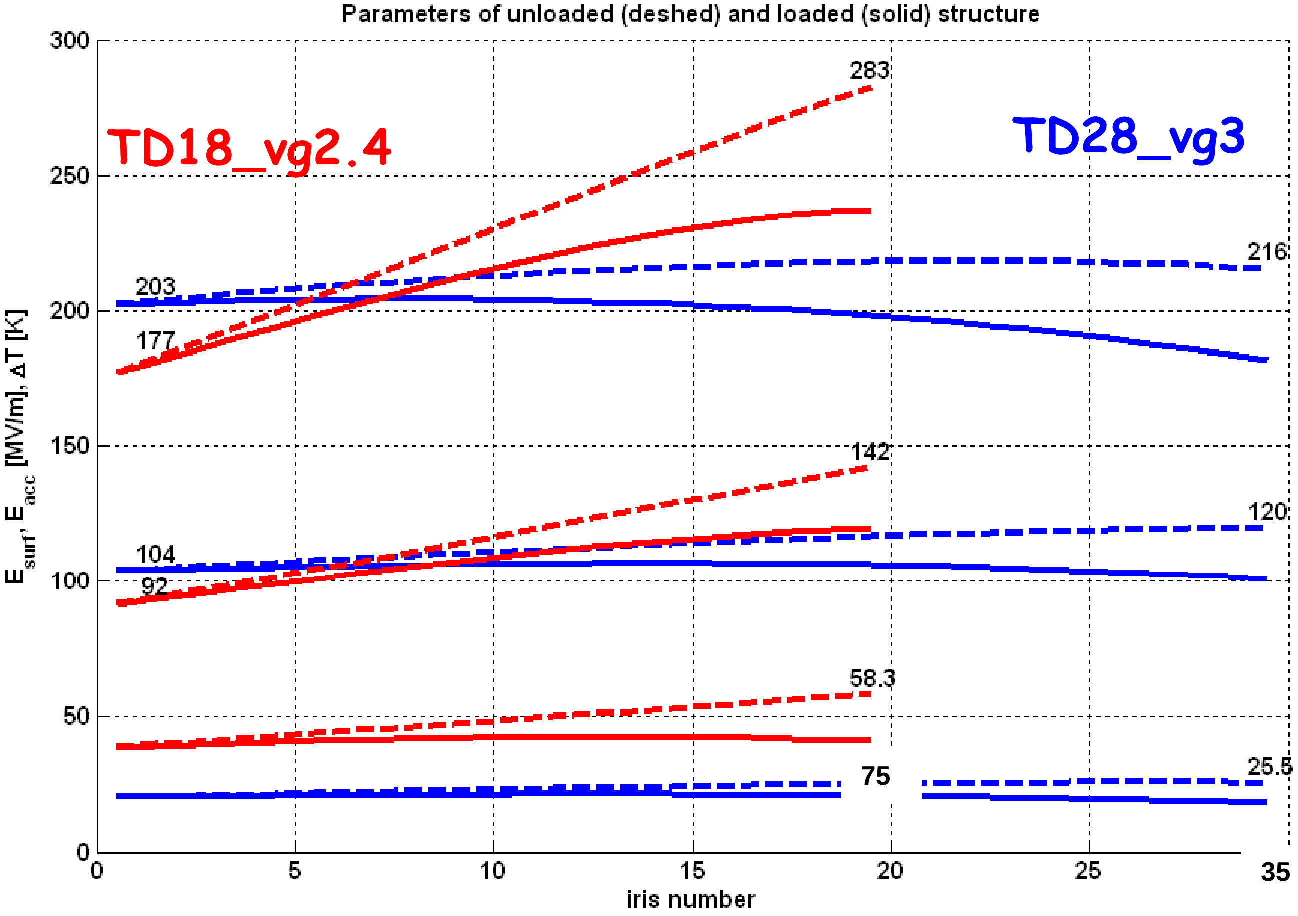
CLIC prototype structures are designed, manufactured and tested
in Collaboration between KEK, SLAC and CERN
Thanks to everybody involved !

CLIC requirements: 100 MV/m loaded gradient (312 bunches 3.7 10^9 e^-)
very strong HOM damping (0.5 ns bunch spacing)
high efficiency > 20 %
high reliability, trip rate < 3 10^{-7}/m

Goal: CLIC feasibility demonstration until 2010

Structure parameters

Rf parameters along the structure for T18 and T28 design

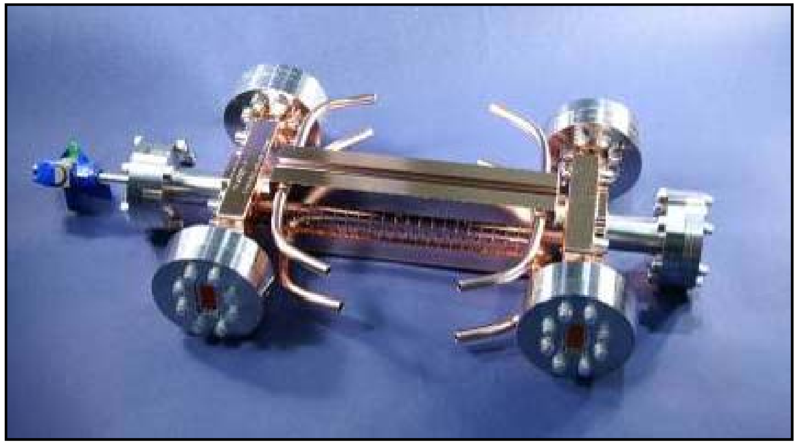


Structure design aimed for low group velocity, small aperture and low input power

T18_vg2.6_disk

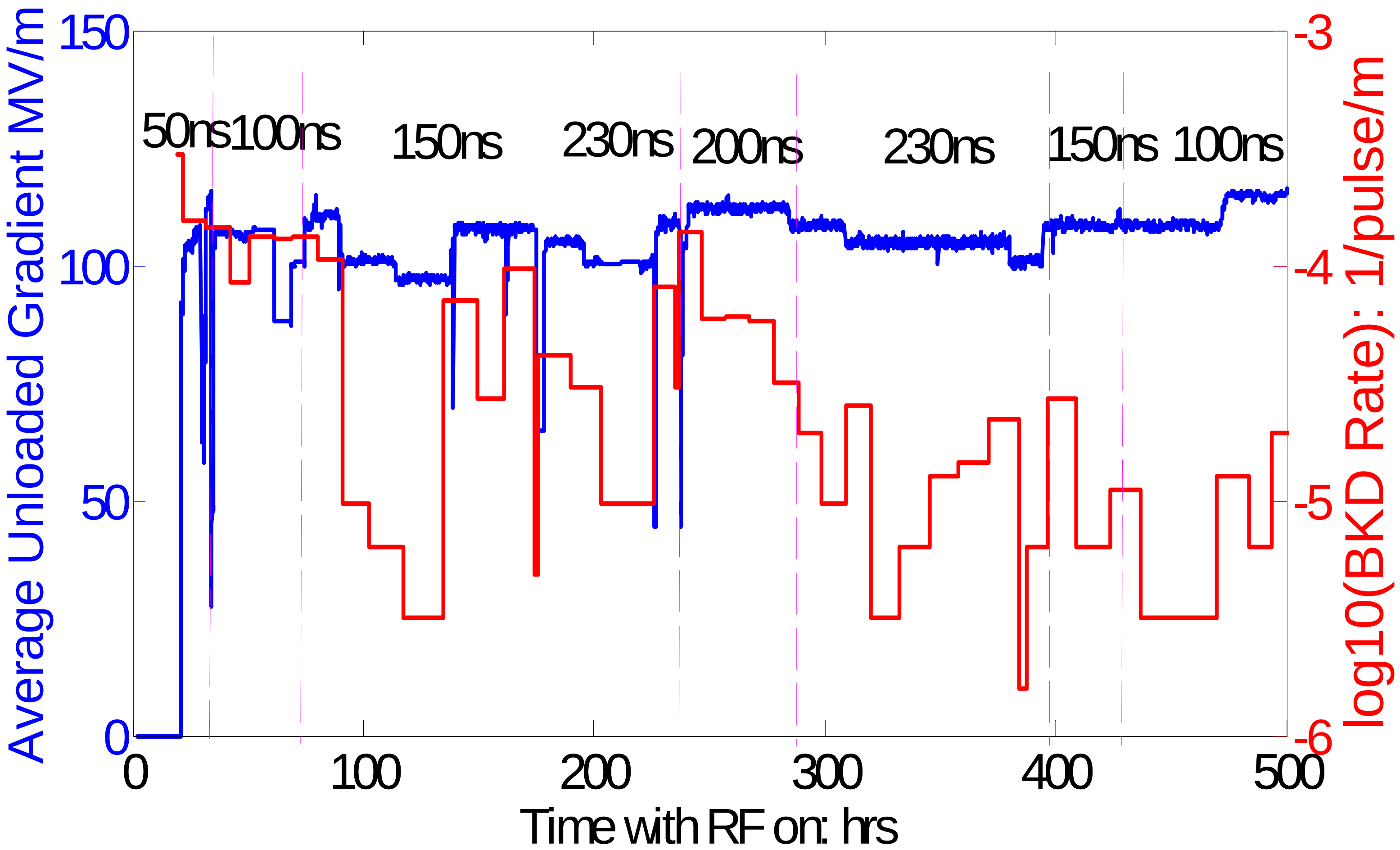
Collaboration between KEK, SLAC and CERN
Design by CERN, fabrication by KEK,
surface prep., bonding and testing at SLAC

Frequency:	11.424 GHz
Cells:	18+2 matching cells
Filling Time:	36 ns
Length: active acceleration	18 cm
Iris Dia. a/λ	0.155~0.10
Group Velocity: vg/c	2.6-1.0 %
Phase Advace Per Cell	2π/3
Power for <Ea>=100MV/m	55.5 MW
Unloaded Ea(out)/Ea(in)	1.55
Es/Ea	2



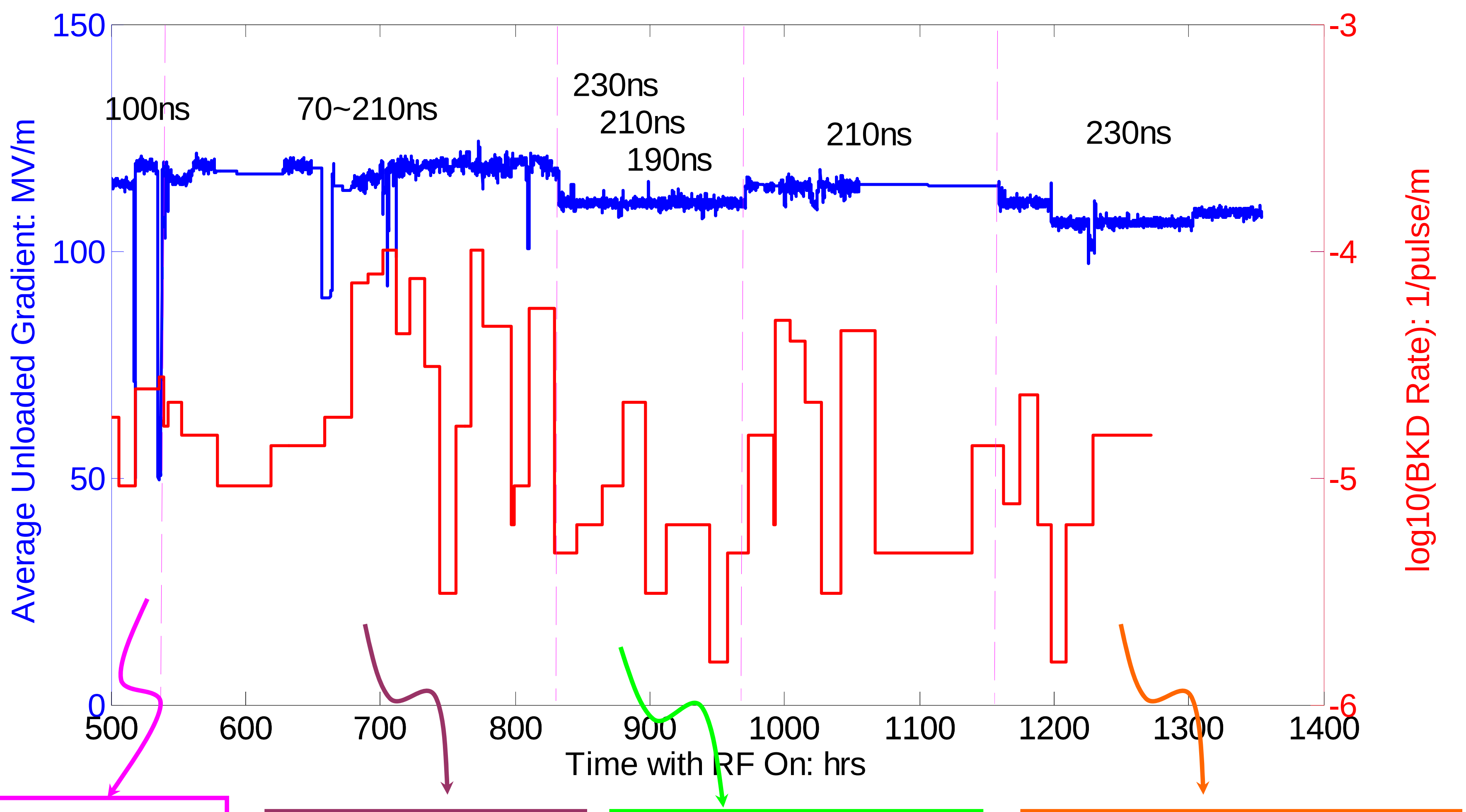
Second structure with identical preparation currently under test at KEK
(see T. Higo talk)

Conditioning history of T18_disk



Faya Wang

Conditioning history of T18_disk



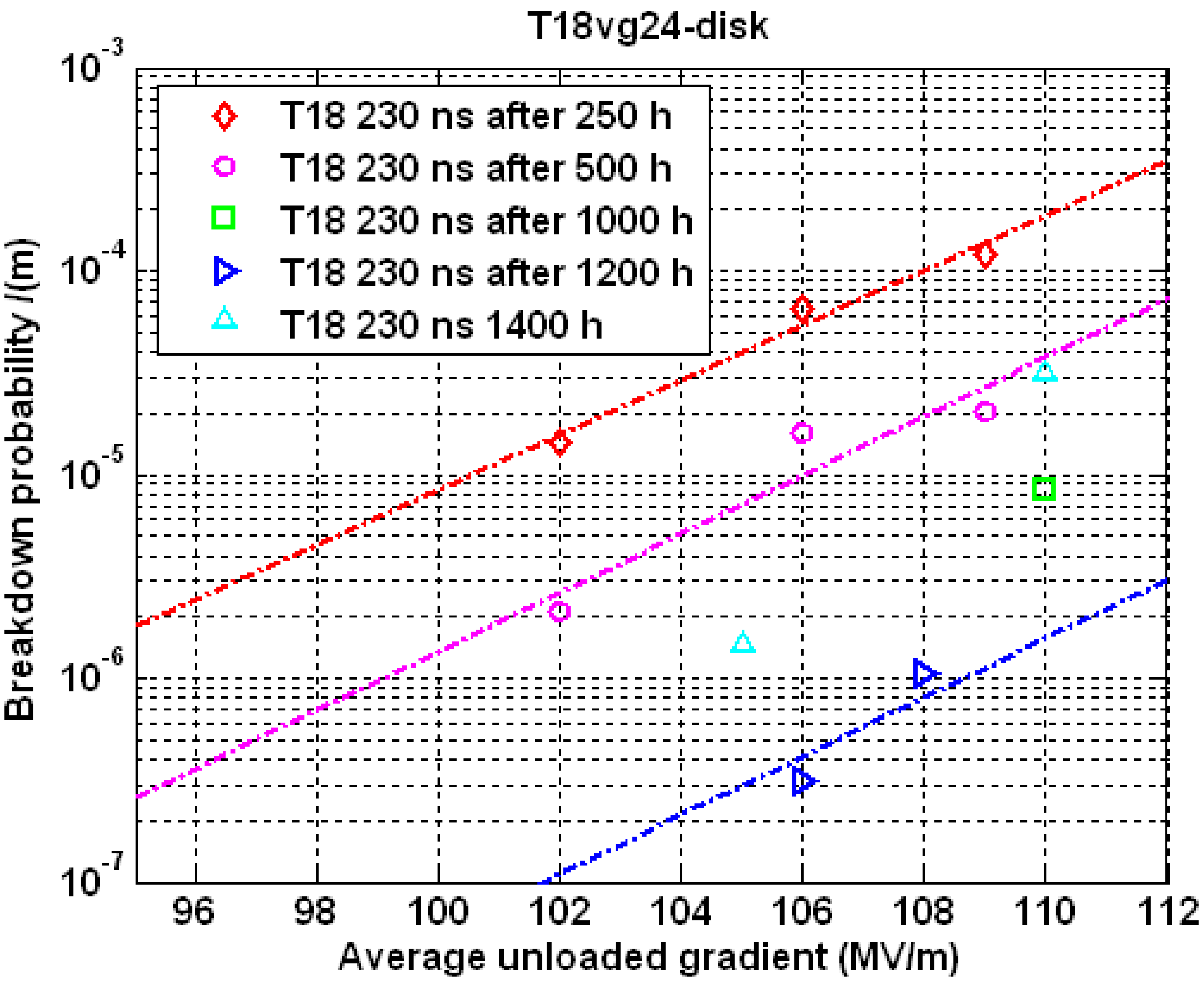
Short pulse higher gradient condition

Pulse shape dependence BKD study.

BKD pulse width dependence study at 110MV/m.

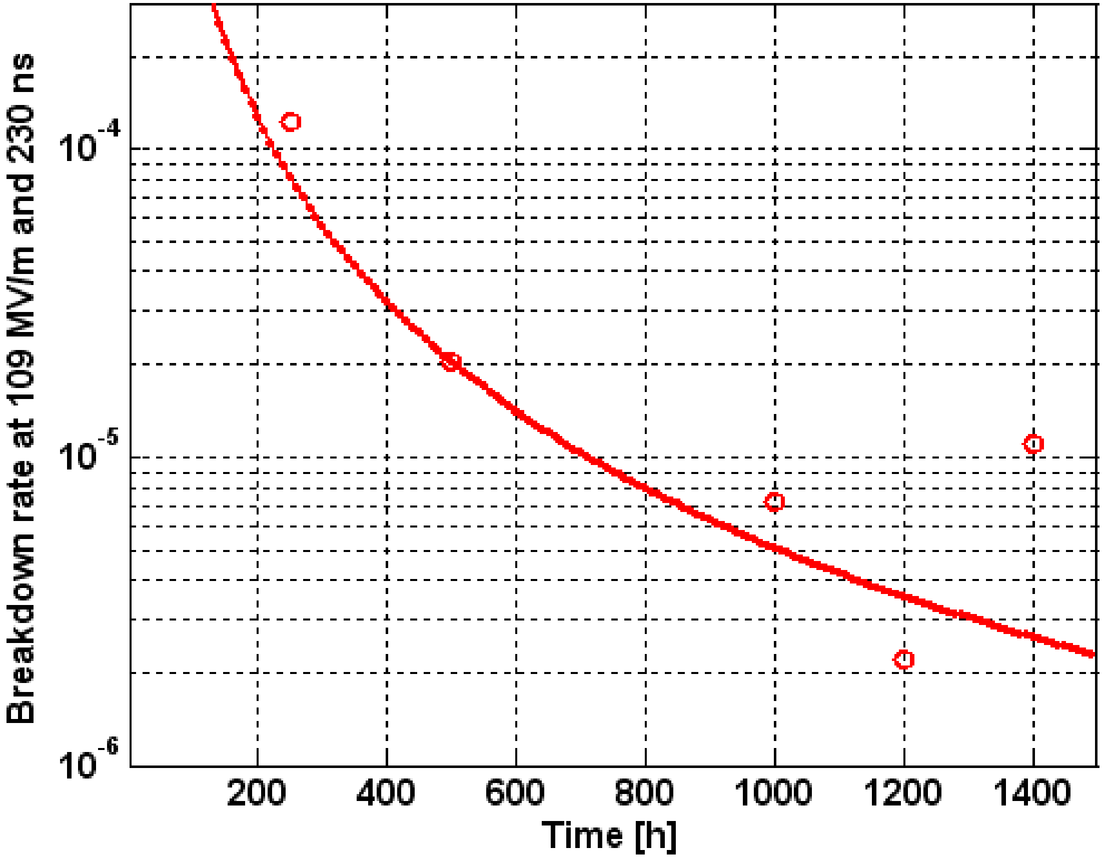
BKD gradient dependence study at 230ns pulse width

T18_vg2.6_disk results



CLIC goal: trip rate < 3 10^{-7}/m

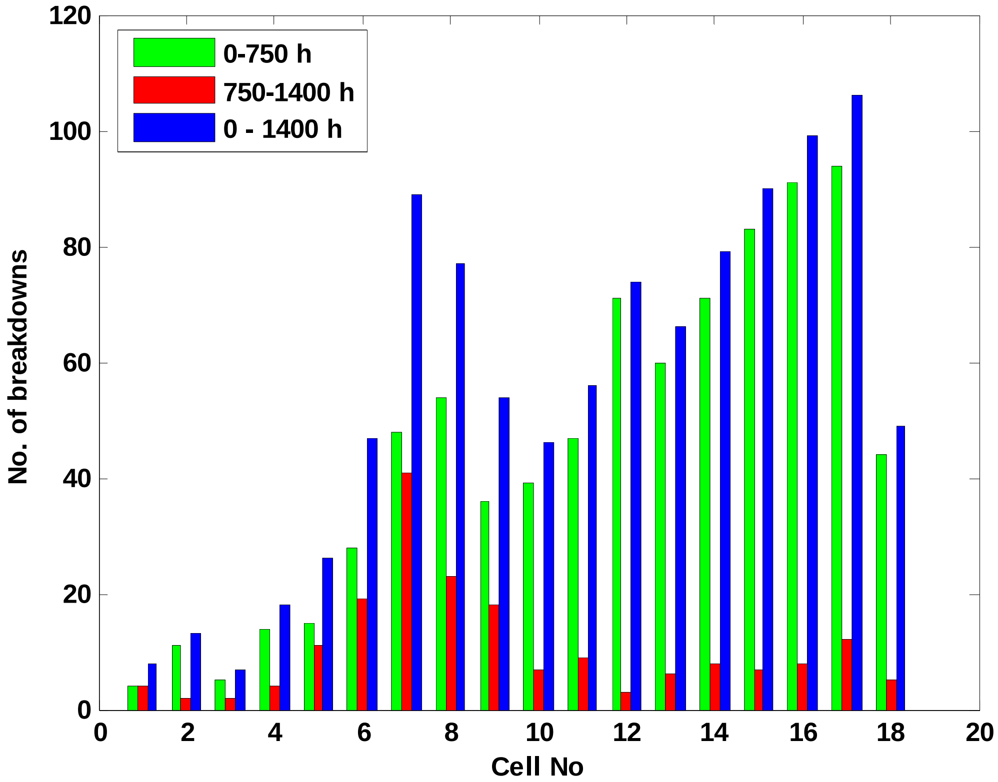
Long term operation

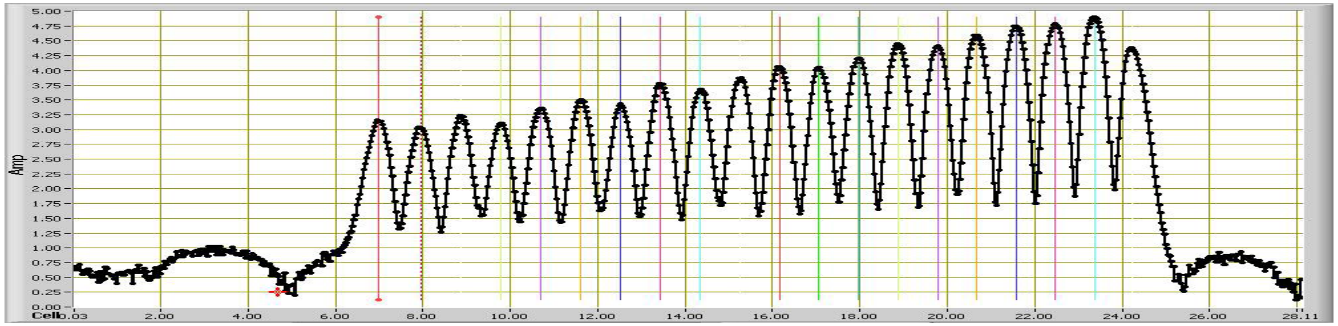


t^{-2} fit

→~ factor 50-100 improvement during conditioning
(5-10 observed during NLC/GLC R&D)

Break down distribution along the structure





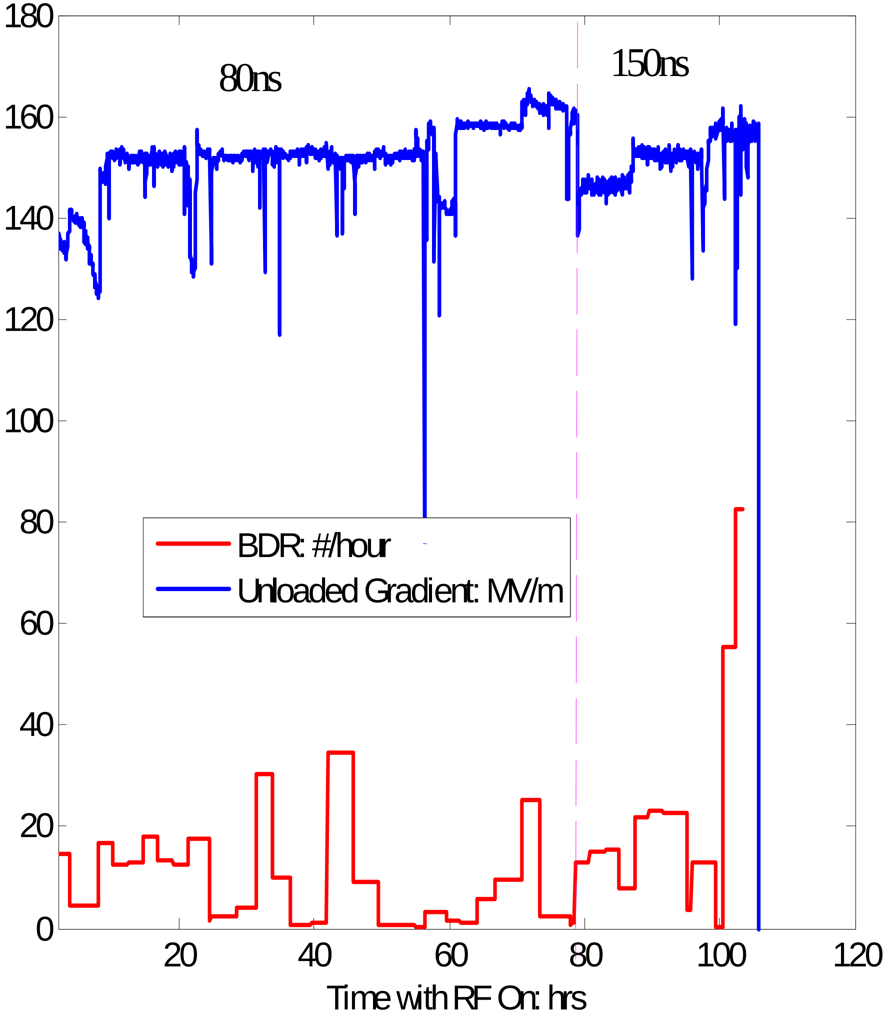
Bead pull

→ Structure seems to be limited at the end where the fields are highest

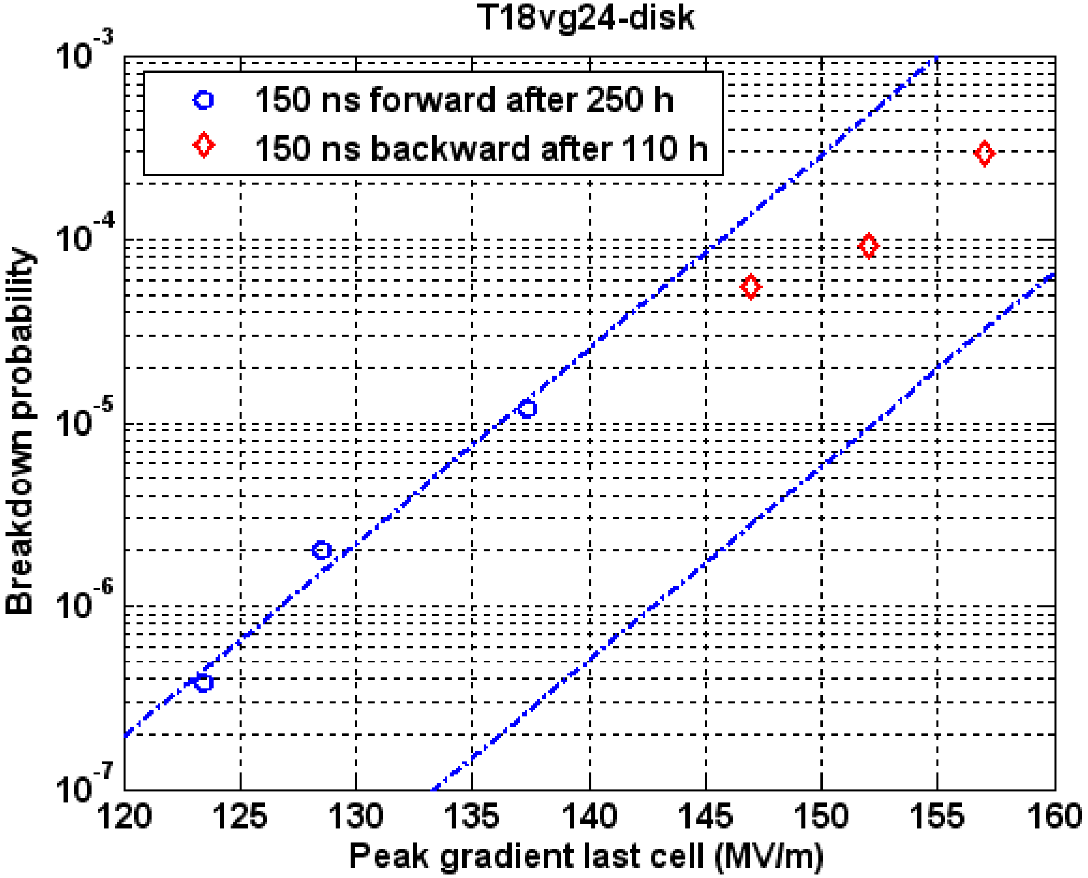
T18_vg2.6_disk backwards

Structure was turned around and tested shortly again to see at which level the output cell would be limited

Conditioning history



T18_disk, backward vs forward

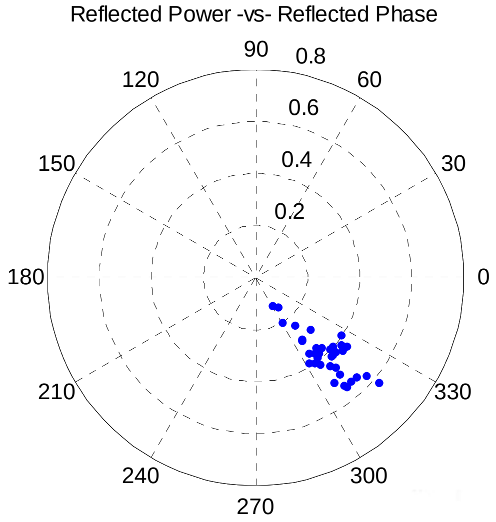


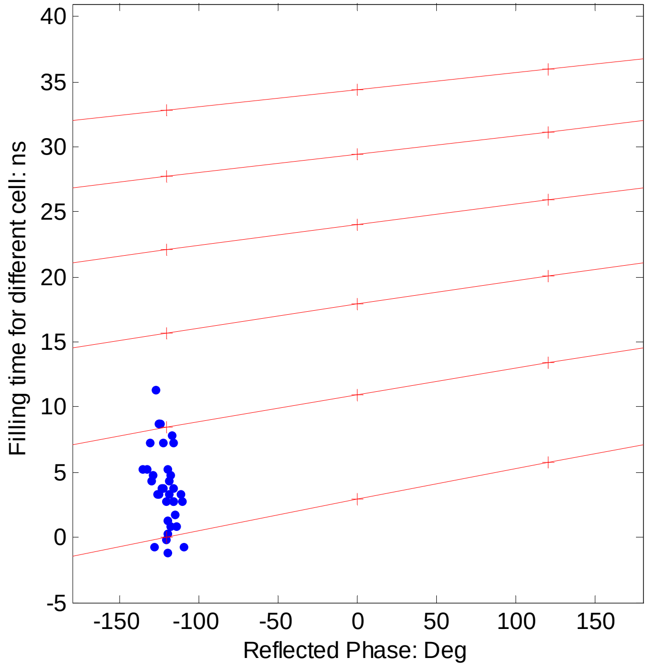
→ given the very different conditioning times and strategies a very consistent result

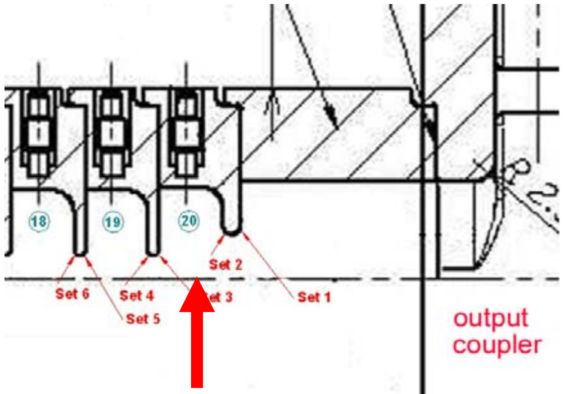
Confirms that T18_disk was limited by its last cell

T18_vg2.6_disk backwards

Break down distribution



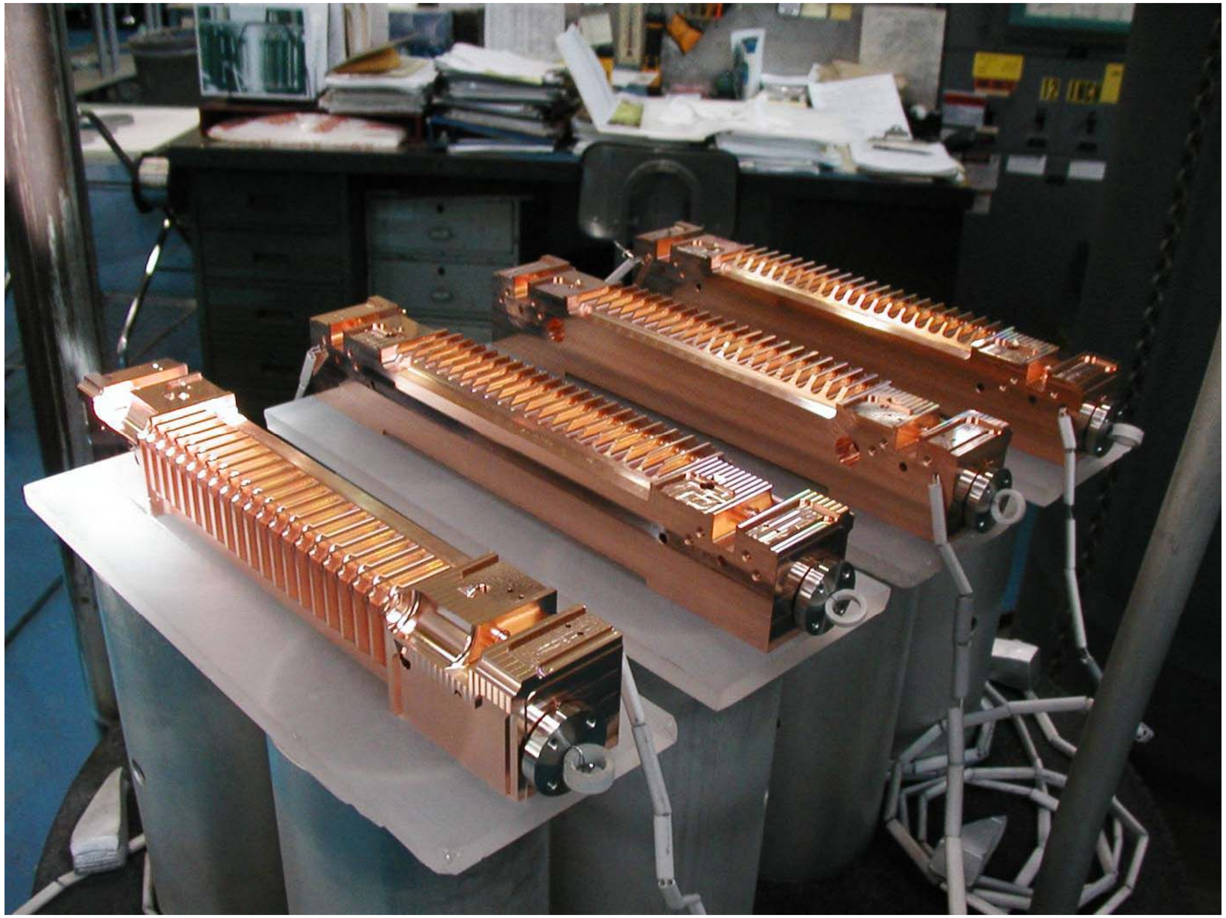




→ Almost all the breakdowns are in the first (former last) cell post mortem endoscope inspection showed mainly damage between the last regular iris and the matching iris

TD18_vg2.4_quad

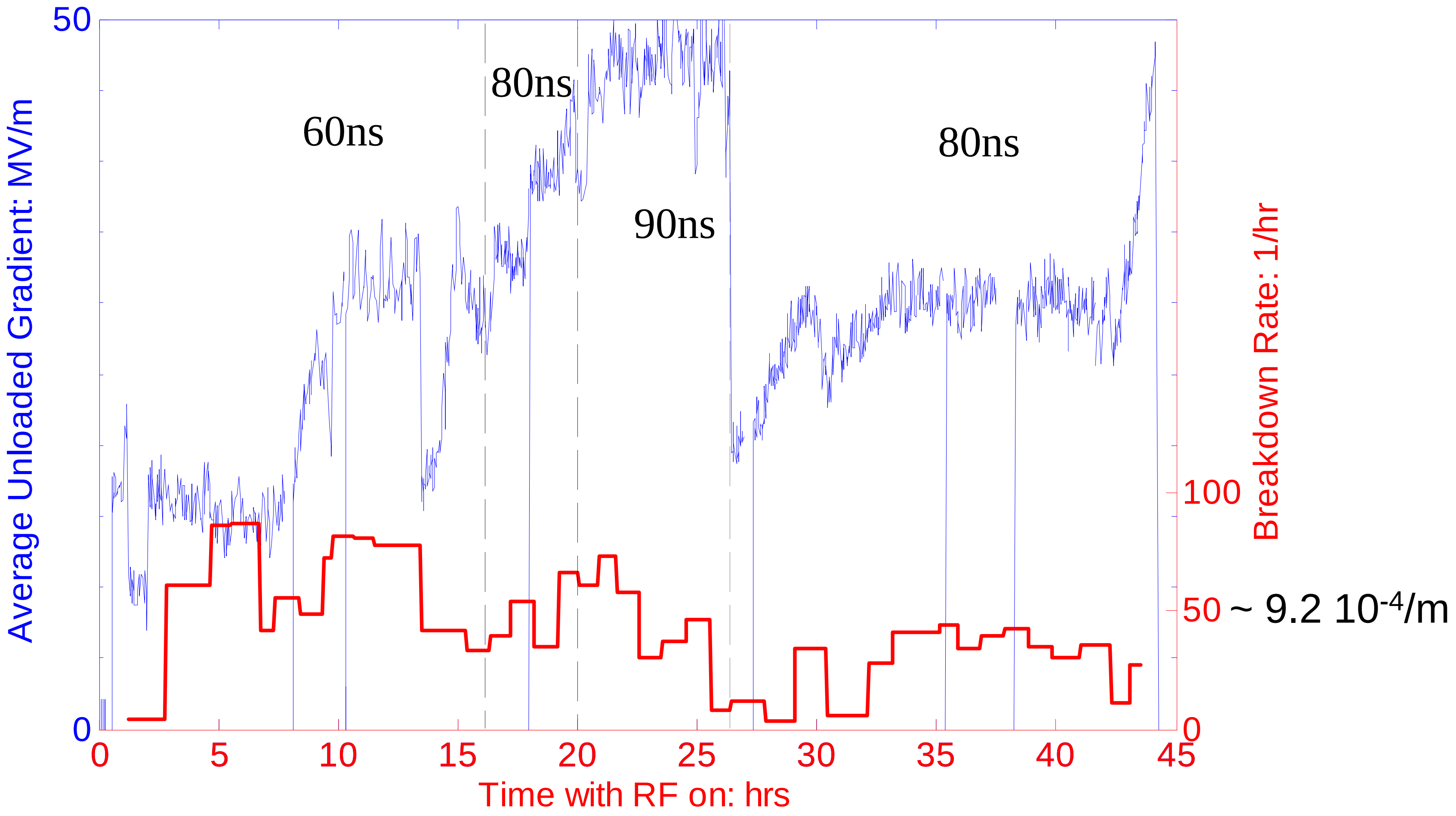
Same rf parameter as T18_disk but HOM damping
Structure made out of 4 milled bars



T18_vg2.4_QUAD Structure Assembly

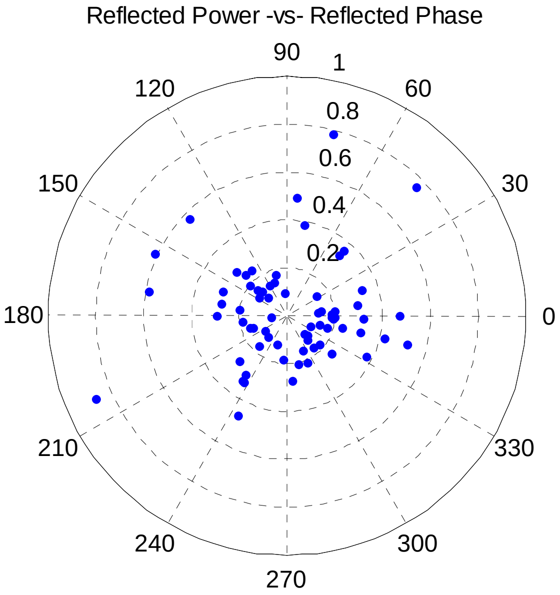
Surface Preparation, brazing and assembly done at SLAC
identical to disk structures

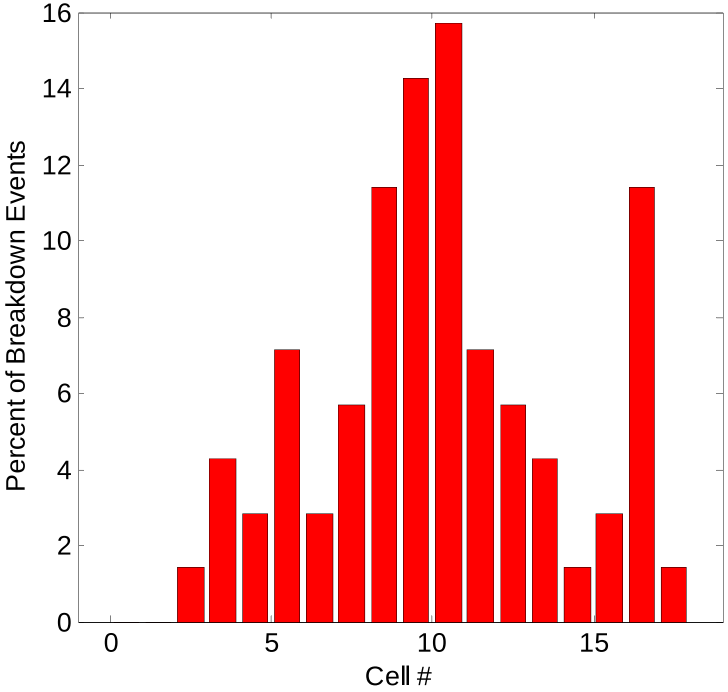
TD18_vg2.4_quad, results



→ **1000 Breakdowns after 25 hours**
Structure shows poor performance at low gradient and short pulse length, strong outgasing

TD18_vg2.4_quad, results

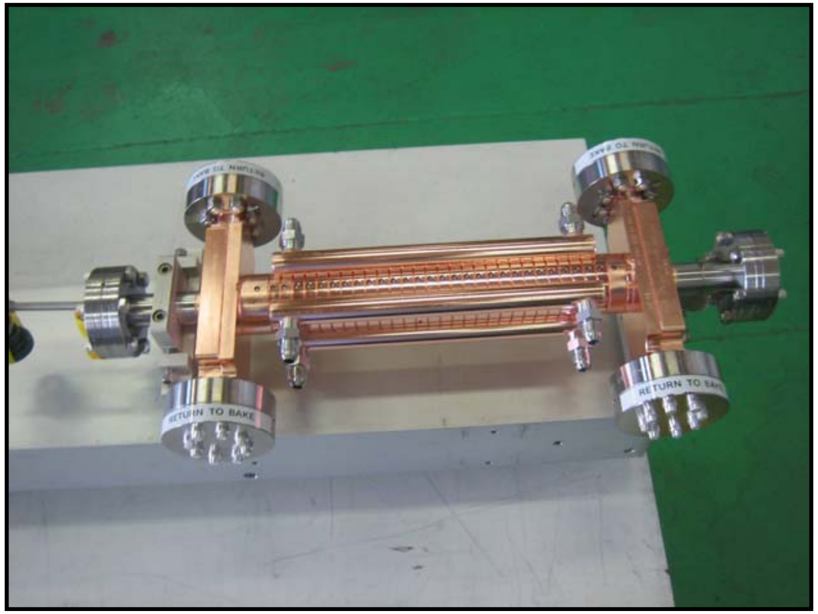


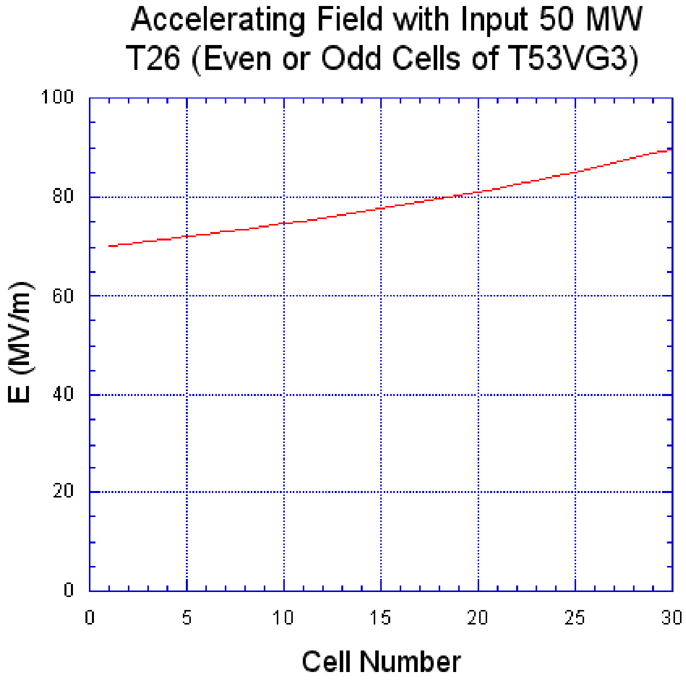


→ clear difference in breakdown location compared to disk structure therefore likely different limitation mechanism compared to disk version

T28_vg3.3_disk

Structure Type	L (cm)	Total Acc. Cells	v_g % c	2a mm	T mm	r MW/m	t	Q_{ave}	T_f ns
Even Cell Of T53VG3	26	30	3.30-1.62	7.8-6.3	1.66	92-107	0.19	6843	35.8

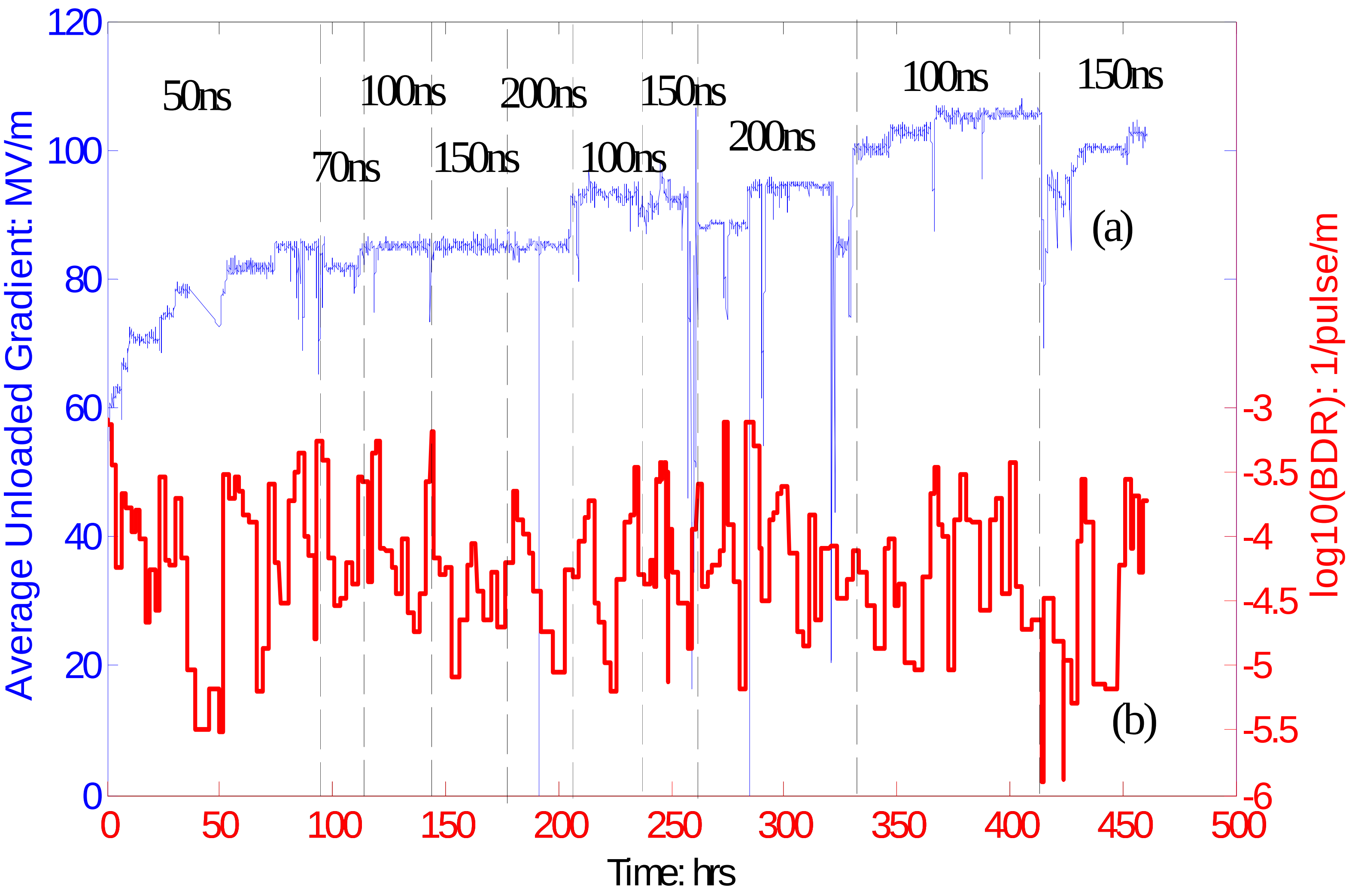




Structure entirely made by SLAC using NLC T53 cells

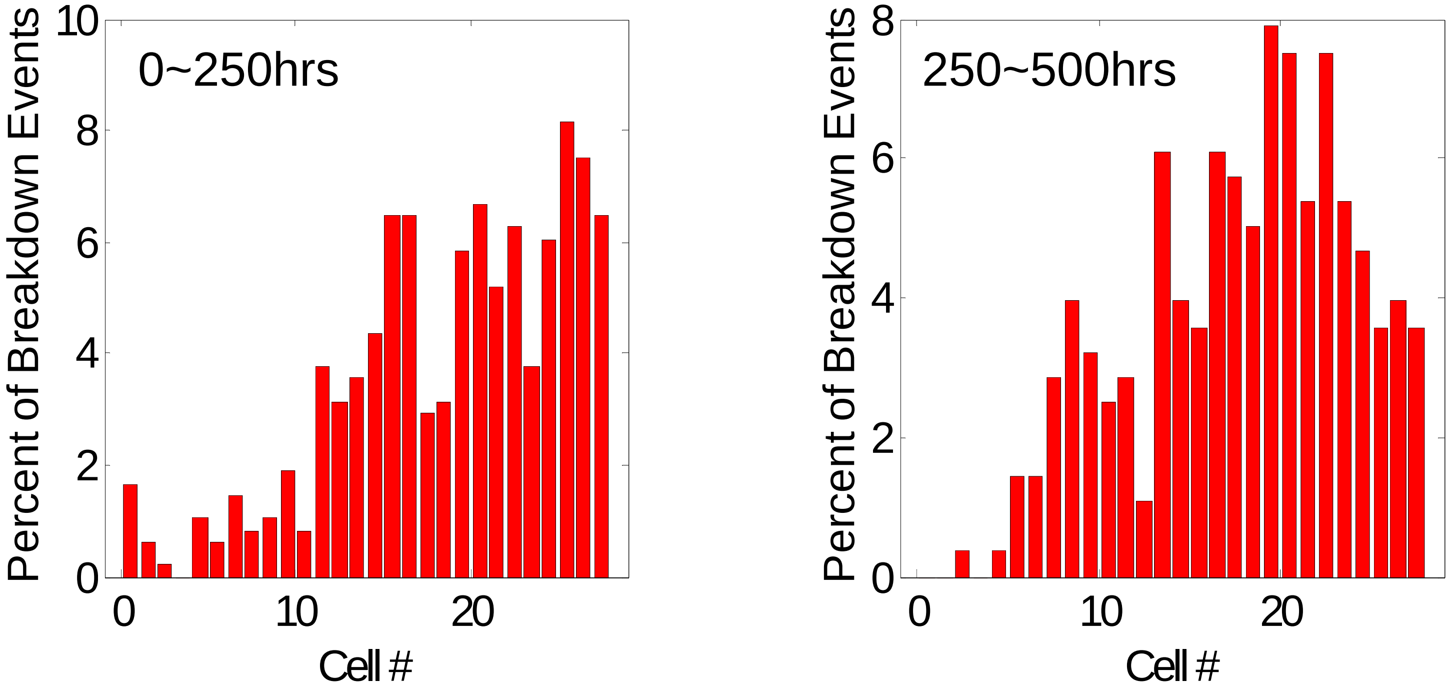
Juwen Wang

T28, conditioning history



(a) The average unloaded gradient. (b) normalized breakdown rate.

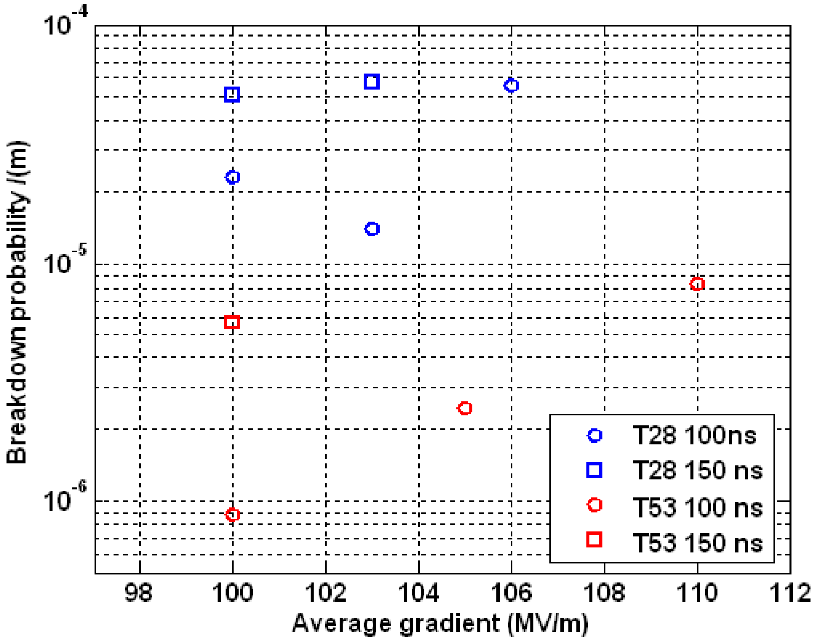
T28, breakdown position



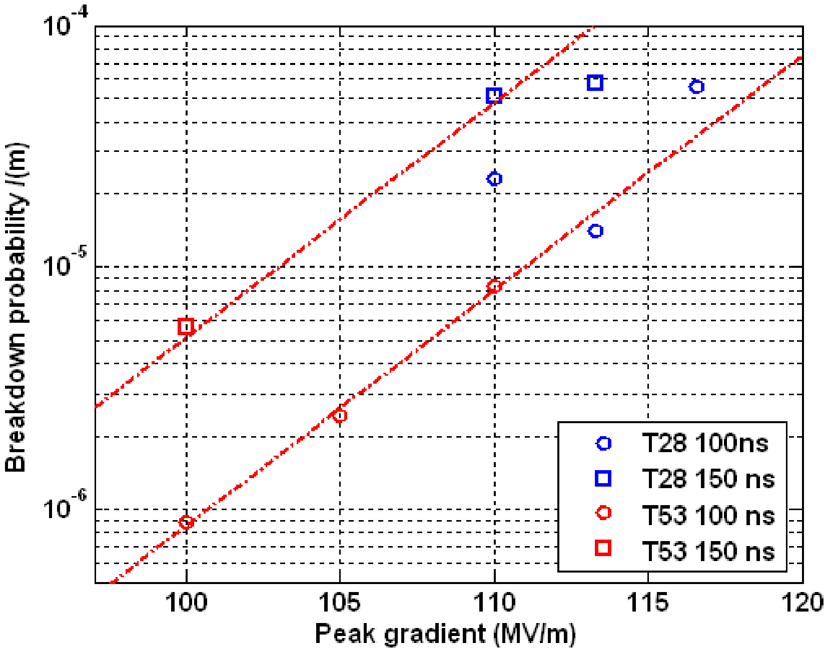
Similar to T18_disk behavior

T28, trip rate vs gradient

Average gradient



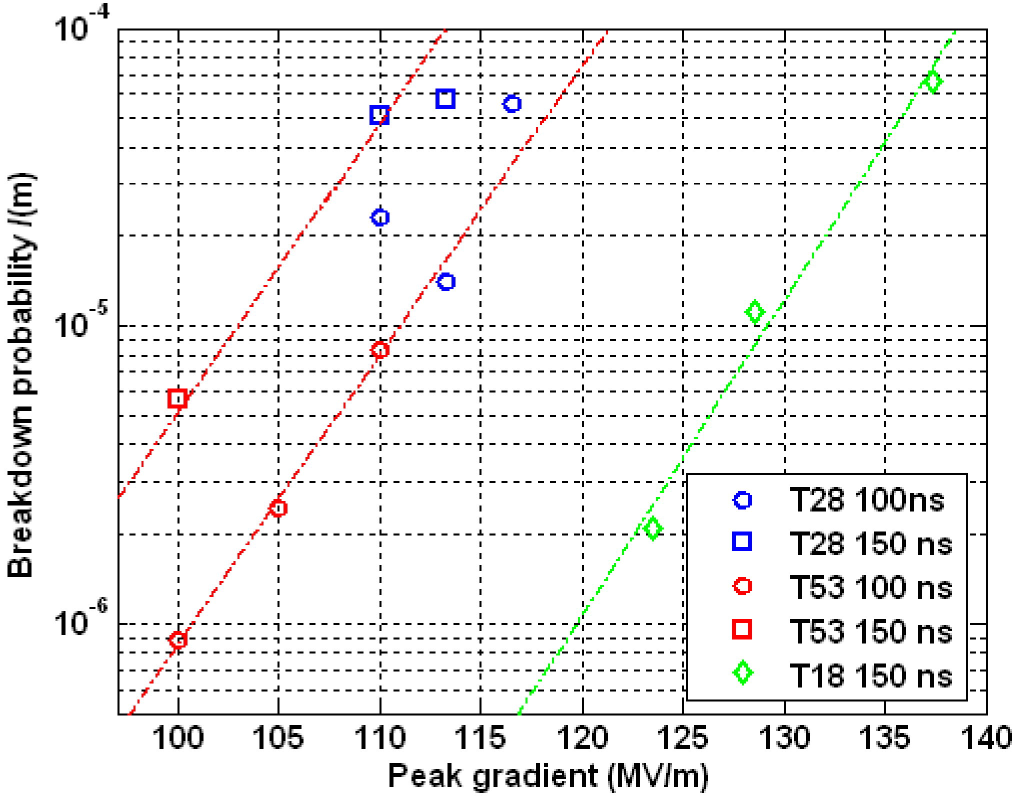
Peak gradient



→ factor 10 more breakdowns for same average gradient but in terms of peak gradient not very different performance

Structure comparison

Peak gradient



→ smaller apertures sustain higher surface fields

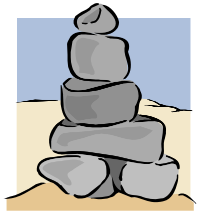
Conclusions

- We basically reached our first milestone (100 MV/m unloaded with good break down rate and pulse length without damping and optimum efficiency)
- Damping is the next big milestone
- Disk technology gives clearly better performance
- Very high temperature treatment and baking does not make the difference
- T28 results unexpected
- Tapering (surface field, power flow ?), did we go to far in T18
- New T24vg1.7_disk seems still to be the right structure for the next step towards a prototype CLIC structure

- CLIC X-Band collaboration works great !

The END

Mile stones and decision points



- 100 MV/m average gradient for CLIC pulse length with good breakdown rate and acceptable efficiency > 10 % ✓
- Similar performance with damping
- Similar performance, damping, better efficiency 'CLIC prototype structure T24vg1.7'
- Fully featured structure HOM loads and s-BPM's integrated (ASSET test ?)

- Review manufacturing technology, optimization strategy, baseline geometry, rf parameters
- Review damping options and parameter optimization

Structure testing program

10.10.2008		2008						2009							
		Jul	Aug	Sept	Oct	Nov	Dez	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Facility	Structure														
SLAC Station 1	T18_vg2.4_disk[1]	🟧	🟧	🟧	🟧										
11.4 GHz	TD18_vg2.4_quad[1]					🟧									
	T18_vg2.4_disk[5]							🟧	🟧						
SLAC Station 2	T28_vg2.9			🟧	🟧										
	TD18_vg2.4_disk[1]							🟧	🟧						
	T24vg1.7_disk									🟧	🟧				
	TD24vg1.7_disk											🟧	🟧		
SLAC ASTA	PETS 11.4 GHz				🟧	🟧									
	C10vg0.7[1]							🟧							
	C10vg1.3[1]									🟧					
	C10vg3.3[1]											🟧			
	C10vg2.2_thick[1]													🟧	
KEK NEXTEF															
	T18_vg2.4_disk[2]				🟩	🟩	🟩								
	T18_vg2.4_disk[3]														
	TD18_vg2.4_quad[2]							🟩	🟩						
	TD18_vg2.4_disk[2]										🟩	🟩			
CLEX 12 GHz															
	Pets 12 GHz				🟦	🟦	🟦								
	Pets [2] 12 GHz										🟦	🟦	🟦		
	T24_vg1.7_disk										🟦	🟦	🟦		
	TD24_vg1.7_disk													🟦	🟦

Structure parameters

Name	**T24_vg1.8_disk**	**T18_vg2.6_disk**	**TD18_vg2.4_quad**	**TD18_vg2.4_disk**
Name	**11WNSDGCu**	**11WNSDvg1Cu**	**11WDSQvg1Cu**	**11WDSDvg1Cu**
N cell	**24**	**18**	**18**	**18**
$a_{in,out}$ (mm)	**3.307/2.467**	**4.06/2.66**	**4.06/2.66**	**4.06/2.66**
$Vg_{in/out}$	**1.82/0.93**	**2.61/1.02**	**2.41/0.92**	**2.24/0.87**
$T_{filling}$ (ns) (full structure)	**59**	**36**	**39**	**41**
P_{in} unloaded (MW) (100 MV/m) (only regular cells)	**42.9**	**53.9**	**55.5**	**58.1**
P_{in} unloaded (MW) (100 MV/m) (full structure)	**44.2**	**55.5**	**57.3**	**60.0**
Bunch population: N	**3.72*10^9**	**3.72*10^9**	**3.72*10^9**	**3.72*10^9**
Number of bunches/train	**312**	**312**	**312**	**312**
Nrf	**6**	**8**	**8**	**8**
P_{in} loaded (MW) (100 MV/m) (only regular cells)	**54**	**61.7**	**63.6**	**66.4**
P_{in} loaded (MW) (100 MV/m) (full structure)	**55.7**	**63.7**	**65.6**	**68.5**
Pulse length (ns)	**236.8**	**267.4**	**272.9**	**276.4**
P/c (Wu)	**14.7**	**15.0**	**15.5**	**16.2**
Efficiency (%) (no coupler included)	**30.5**	**17.7**	**16.8**	**15.9**

Parameters of new structure TD24vg1.7

Structure	TD24vg1.7
Frequency: f [GHz]	12
Average iris radius/wavelength: $\langle a \rangle/\lambda$	0.11
Input/Output iris radii: $a_{1,2}$ [mm]	3.15, 2.35
Input/Output iris thickness: $d_{1,2}$ [mm]	1.67, 1.00
N. of reg. cells, str. length: N_c, l [mm]	24, 229
Bunch separation: N_s [rf cycles]	6
Luminosity per bunch X-ing: $L_{b\times}$ [m^{-2}]	1.22×10^{34}
Bunch population: N	3.72×10^{9}
Number of bunches in a train: N_b	312
Filling time, rise time: τ_f, τ_r [ns]	62.9, 22.4
Pulse length: τ_p [ns]	240.8
Input power: P_{in} [MW]	63.8
$P_{in}/Ct^{P}_{p}{}^{1/3}$[MW/mm ns$^{1/3}$]	18
Max. surface field: E_{surf}^{max} [MV/m]	245
Max. temperature rise: ΔT^{max} [K]	53
Efficiency: η [%]	27.7
Figure of merit: $\eta L_{b\times}/N$[a.u.]	9.1