Summary of WG4: Main Linac and normal conducting RF

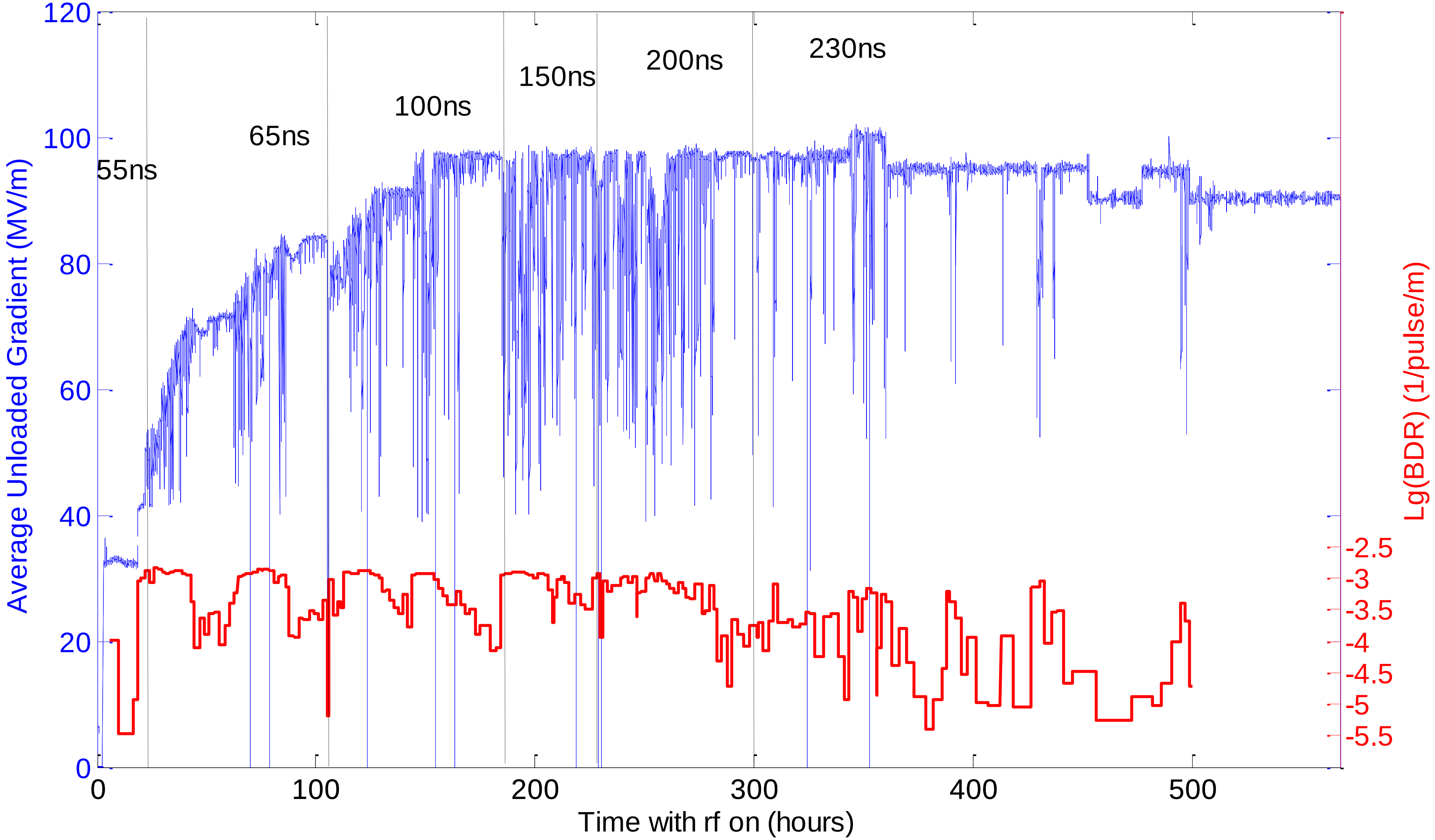
22/10/2010

A.Grudiev (CERN)

Report from NLCTA
Chris Adolphsen (*SLAC*)

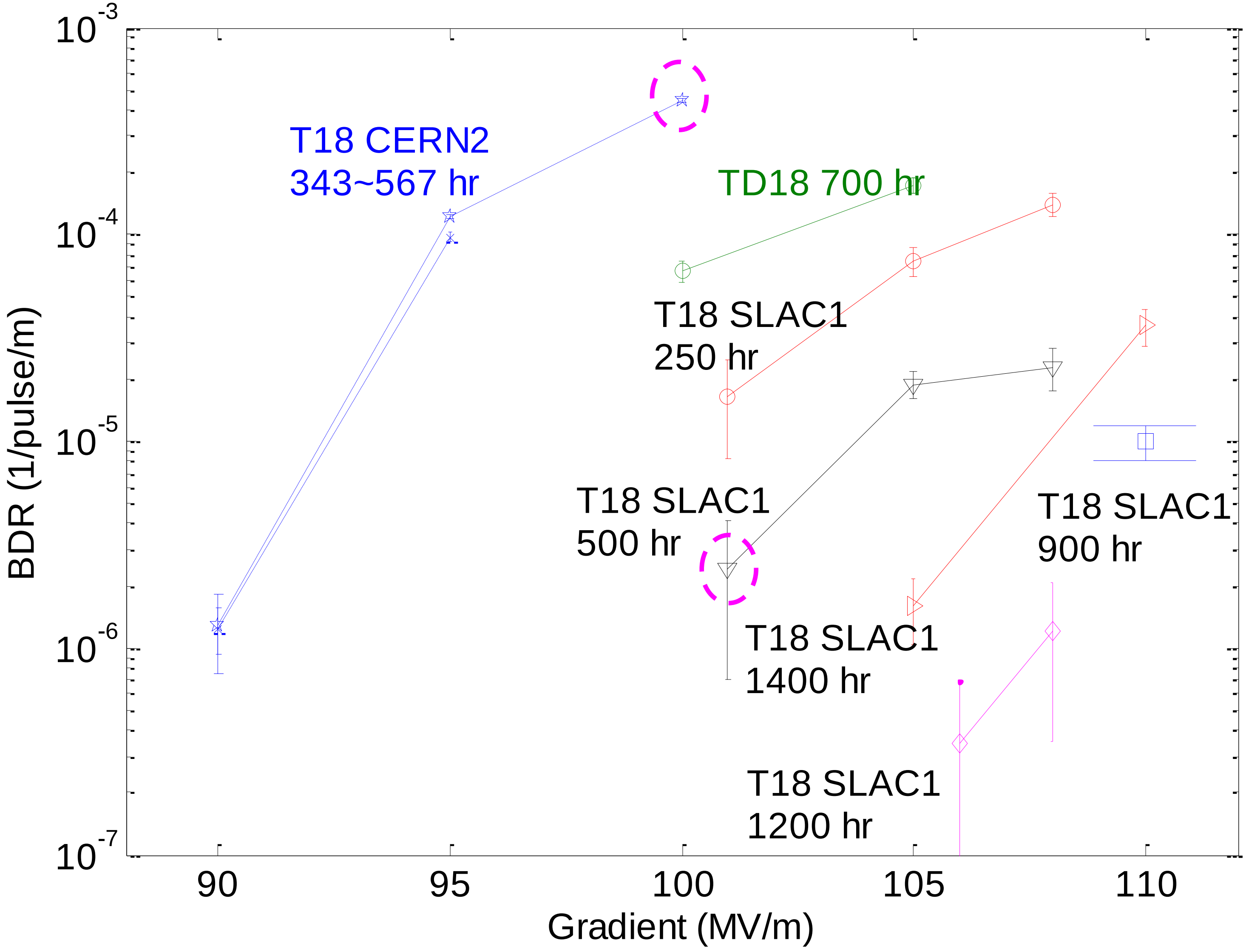
Processing History of T18_CERN_2

1e-3(1/pulse/m) = 34.6/hour at 60 Hz for 0.16 m

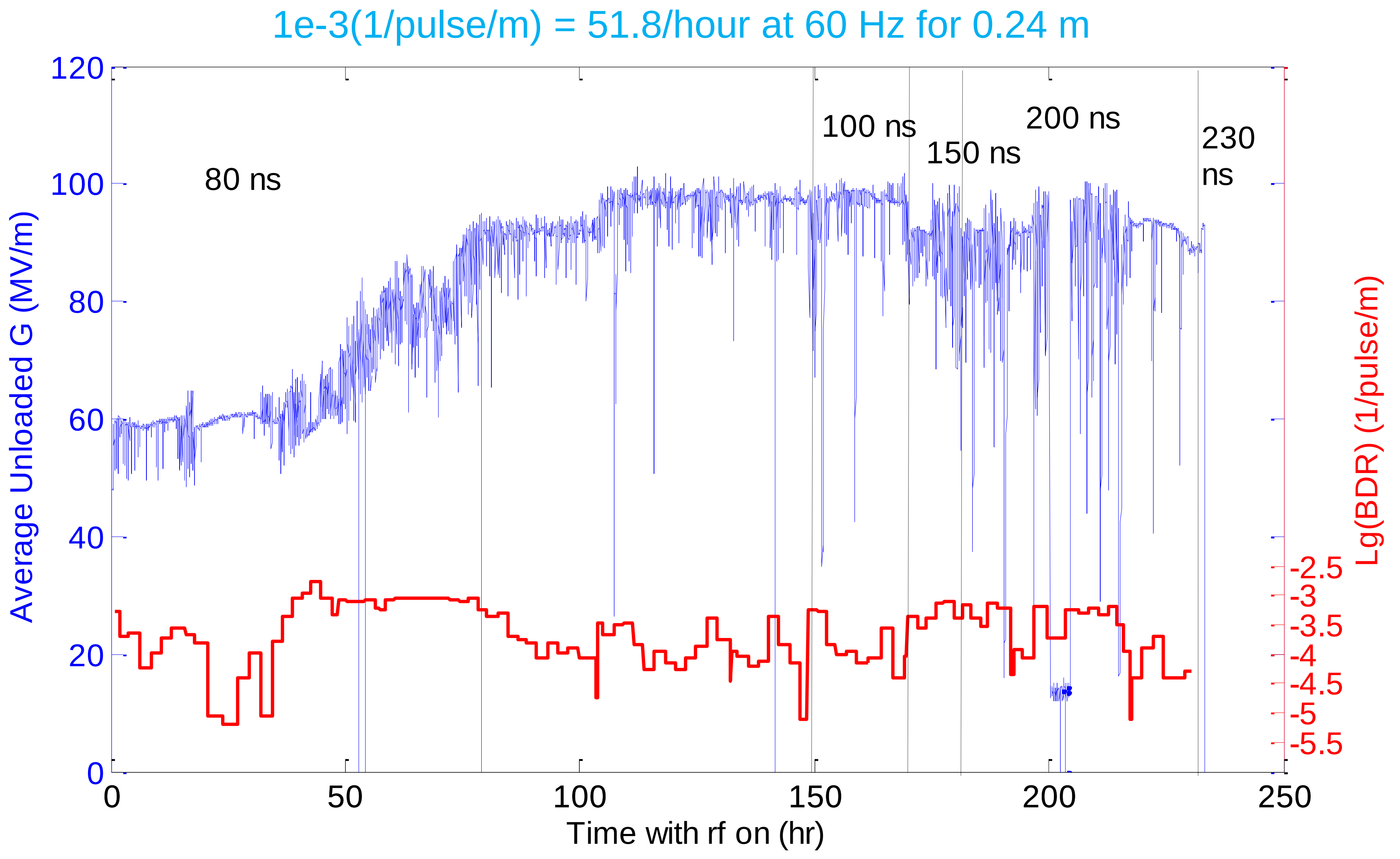


Final BDR at 90 MV/m@230ns is 1.3e-6/pulse/m

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



T24_SLAC_Disk1 RF Processing Results



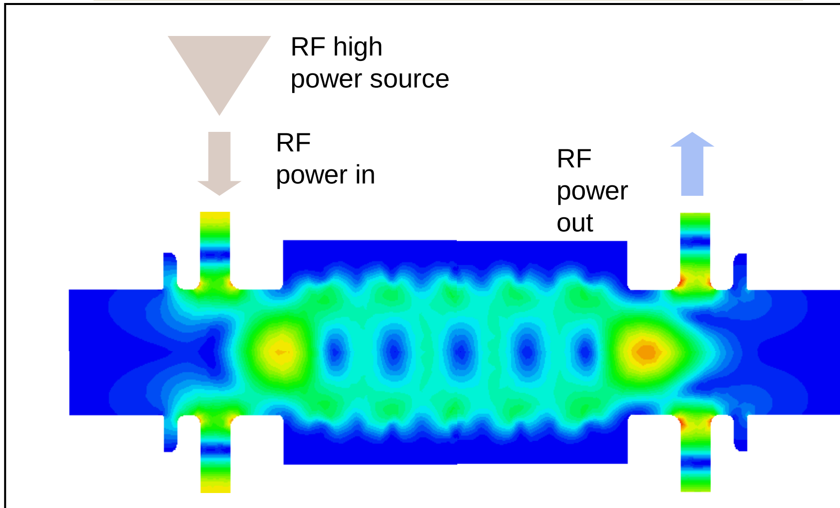
Currently BDR at 92 MV/m@200ns is 9.8e-5/pulse/m (~5BKD/hr)

Report from ASTA
Alessandro Cappelletti (CERN)

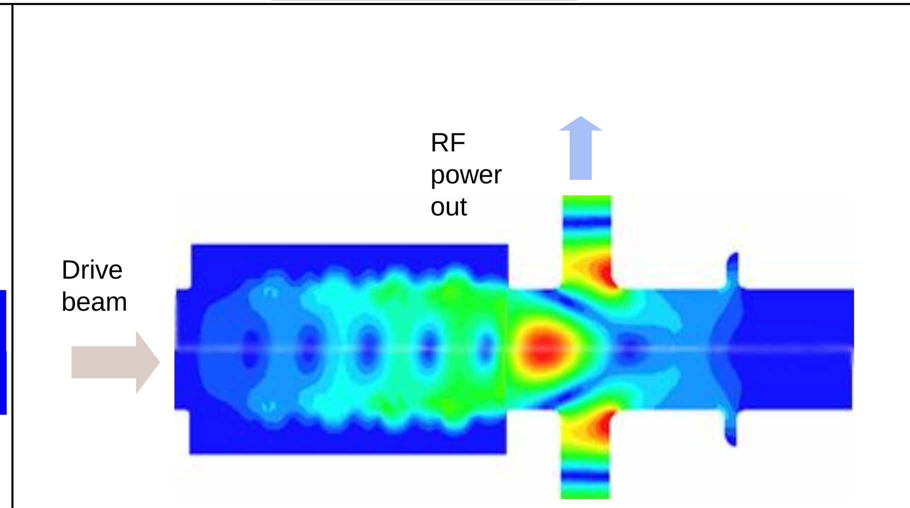
PETS testing program

RF power sources

External RF power source



Drive beam*



ASTA (SLAC)

Objective: to understand the limiting factors for the PETS ultimate performance and breakdown trip rate.

- Access to the very high power levels (300 MW) and nominal CLIC pulse length.
- High repetition rate – 60 Hz.

CTF3 (CERN + Collaborations)

Two beam test stand (CERN + Collaborations)

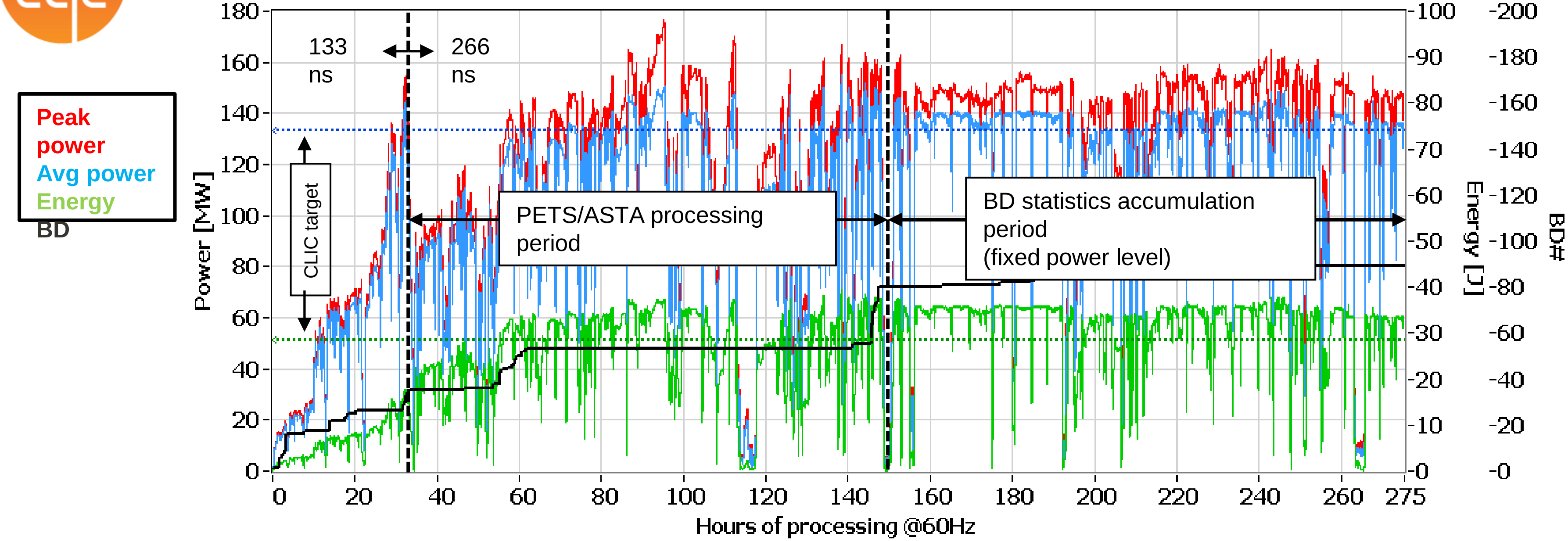
Objective: to demonstrate the reliable production of the nominal CLIC RF power level through the deceleration of the drive beam.

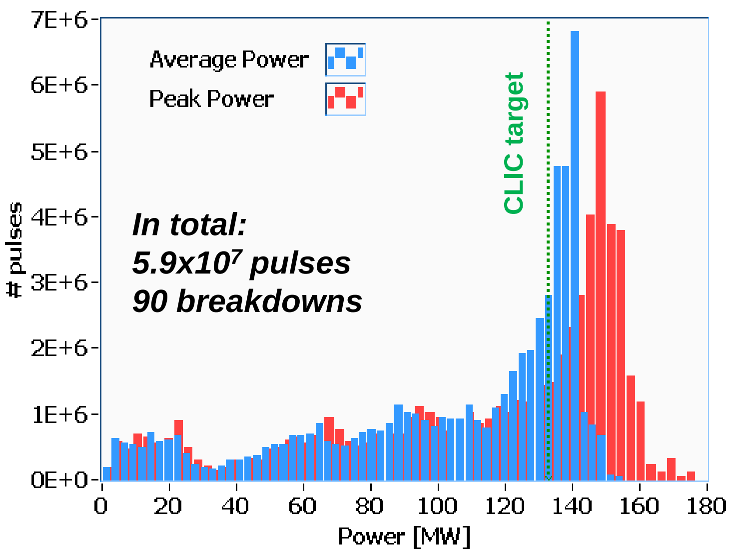
Test beam line (CERN + Collaborations)

Objective: to demonstrate the stable, without losses, beam transportation in a presence of strong (50%) deceleration.

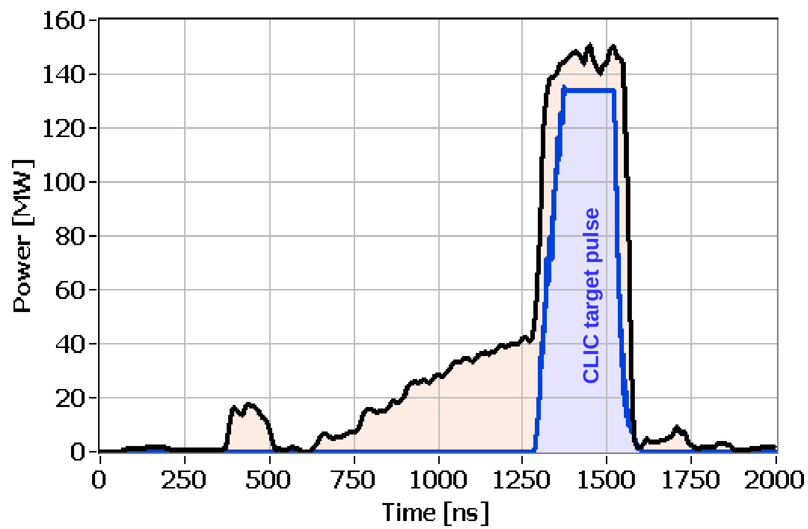
****See I. Syratchev's and E. Adli's presentations***

PETS processing history





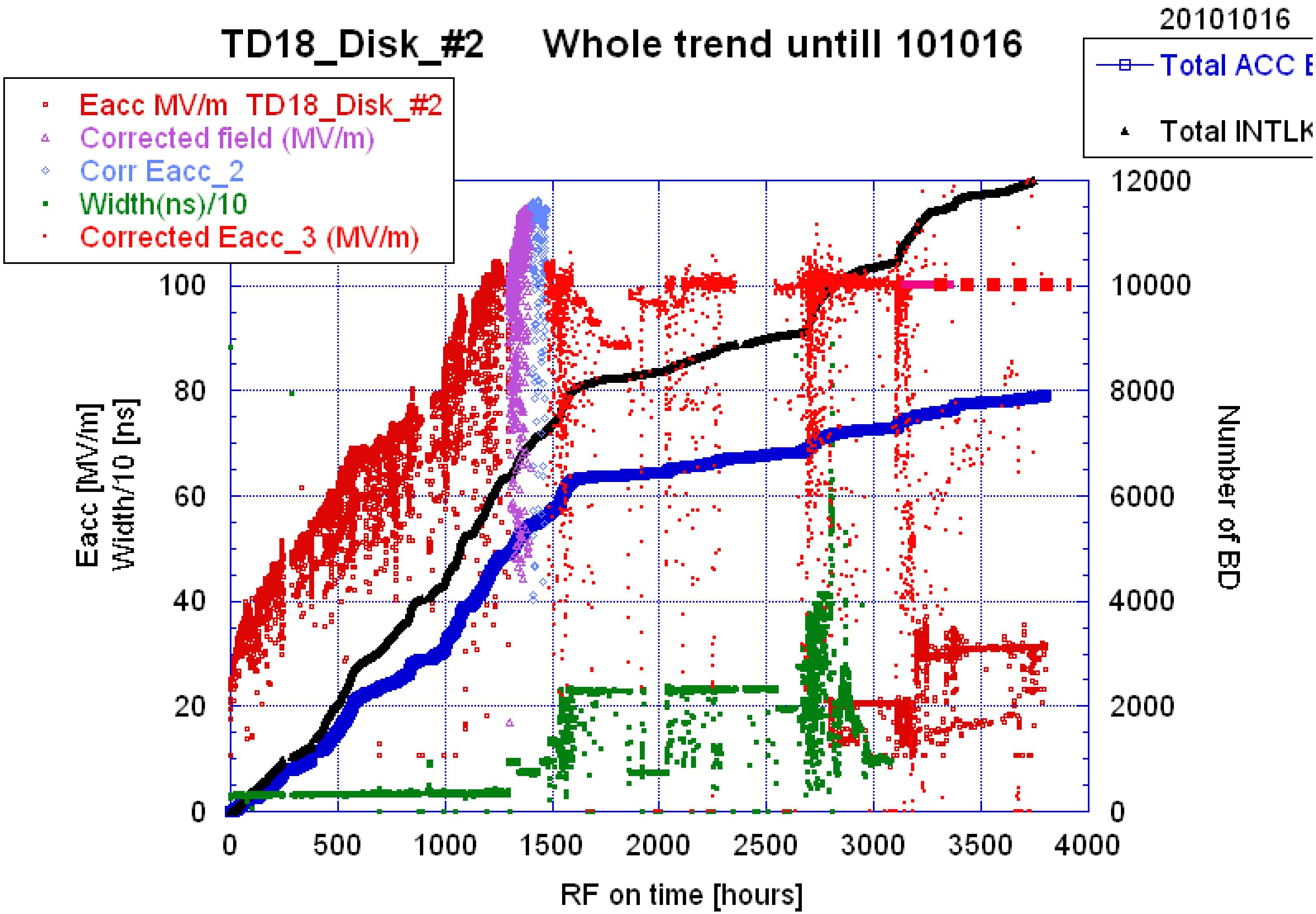
Average and peak power distributions



Typical RF pulse shape in ASTA during the last 125 hours of operation

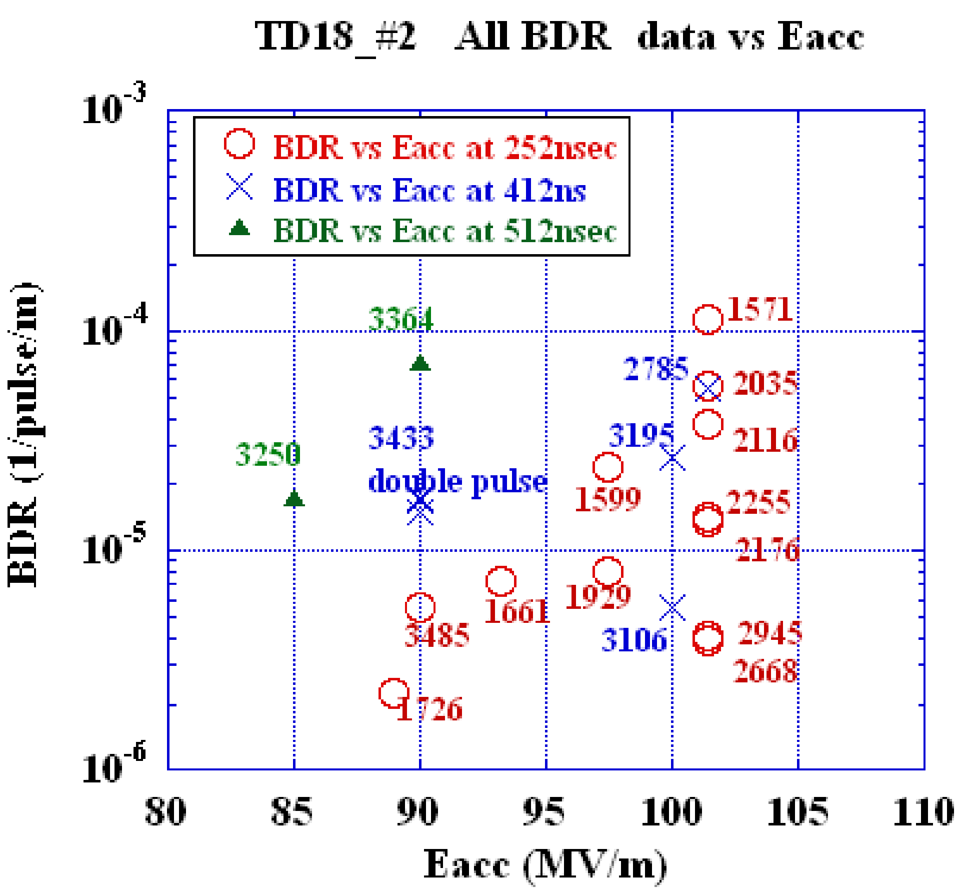
Report from NEXTEF

Toshiyasu Higo (*KEK*)



TD18_Disk_#2 Whole trend untill 101016
20101016
Total ACC E
Total INTLK
Eacc MV/m TD18_Disk_#2
Corrected field (MV/m)
Corr Eacc_2
Width(ns)/10
Corrected Eacc_3 (MV/m)
Eacc [MV/m]
Width/10 [ns]
Number of BD
RF on time [hours]
0
20
40
60
80
100
0
2000
4000
6000
8000
10000
12000
0
500
1000
1500
2000
2500
3000
3500
4000

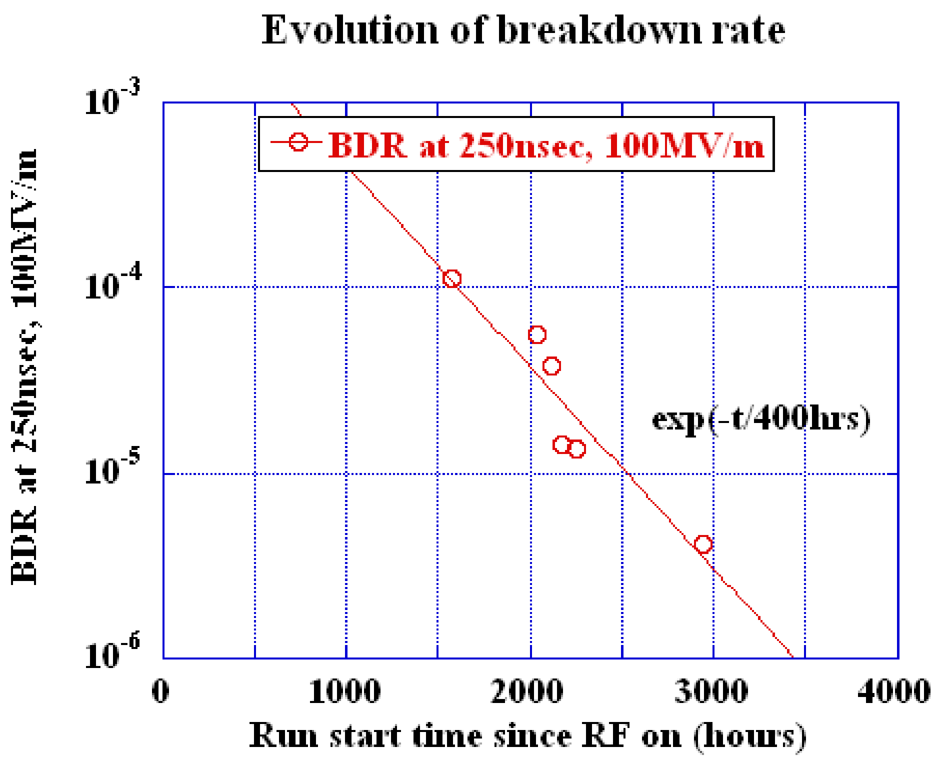
TD18_#2 all BDR vs Eacc



It seems difficult to get a smooth curve as function of Eacc by collecting all data points scattered in time and in operation parameter space.

Usually we get a smooth curve by measuring intentionally with focusing to take data of BDR vs Eacc!?

TD18_#2 Evolution of breakdown rate

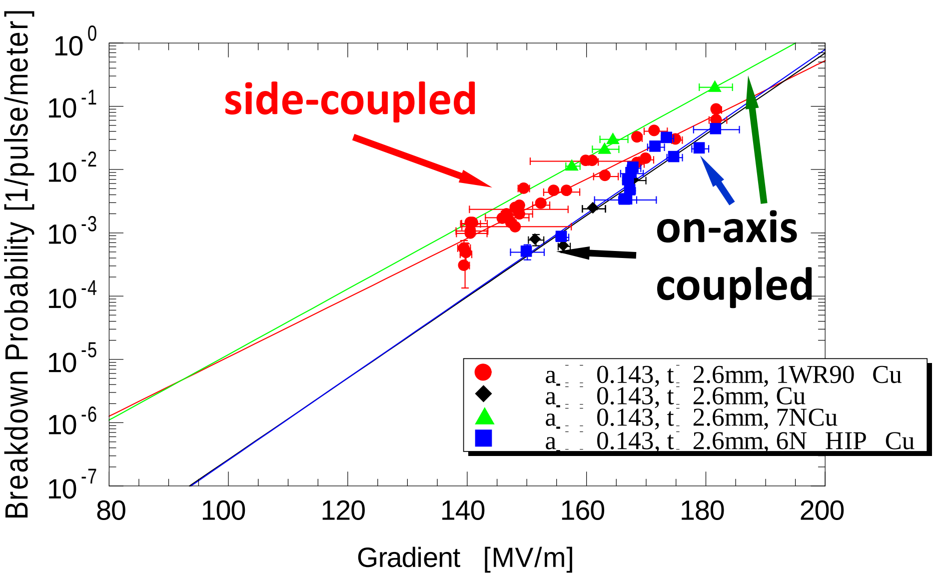


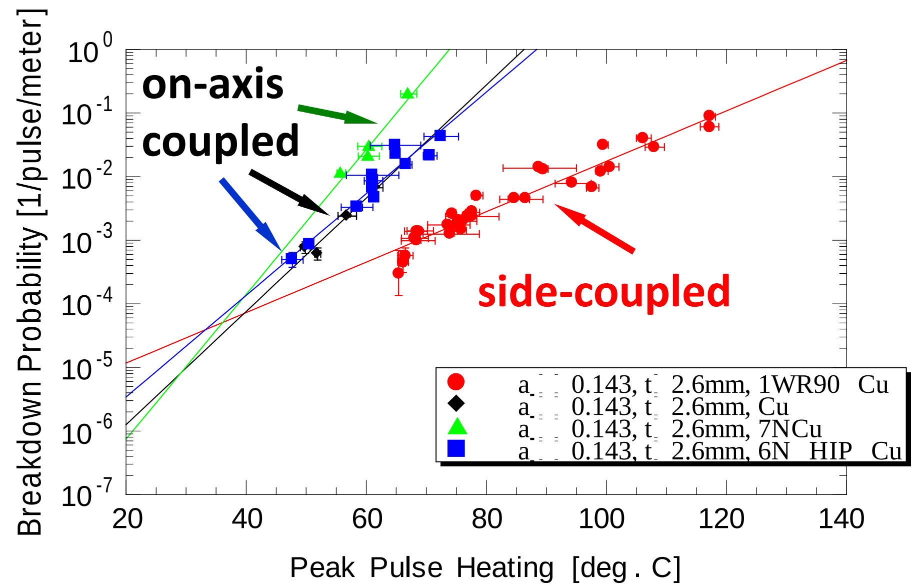
Keep decreasing, but slow or already saturated?

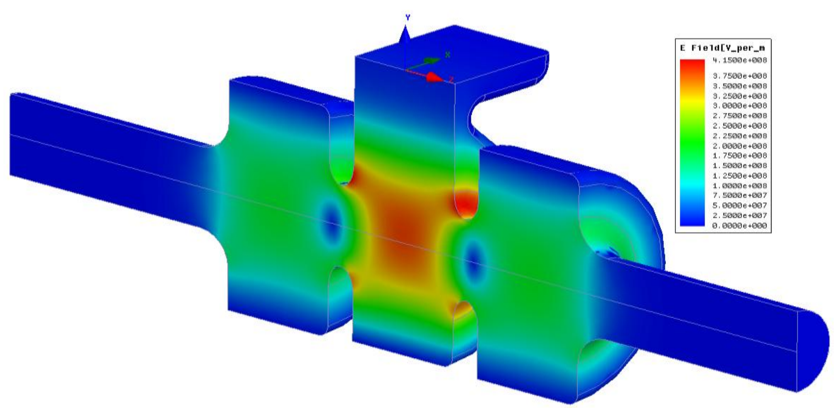
Report from single-cell test area

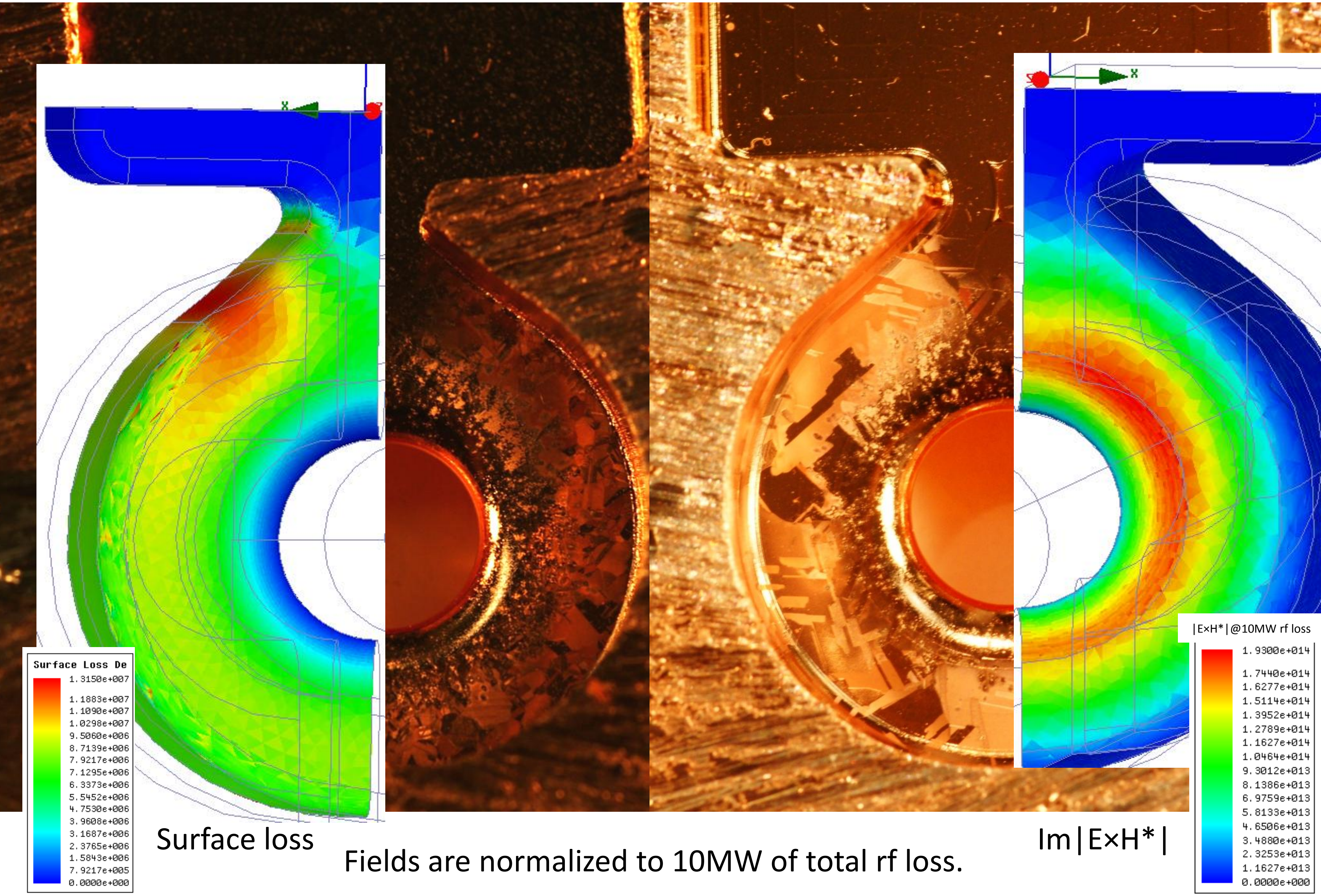
Valery Dolgashev (*SLAC*)

Comparison of one side-coupled copper structure with three on-axis coupled copper structures of same iris geometry (1C-SW-A3.75-T2.6-Cu), shaped pulse with 150 ns flat part





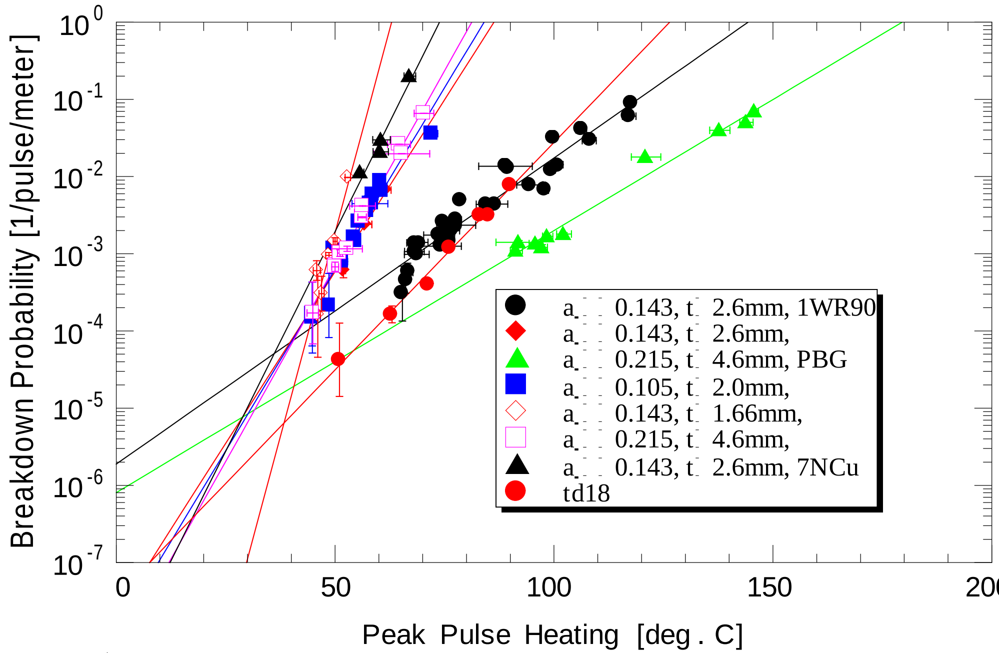


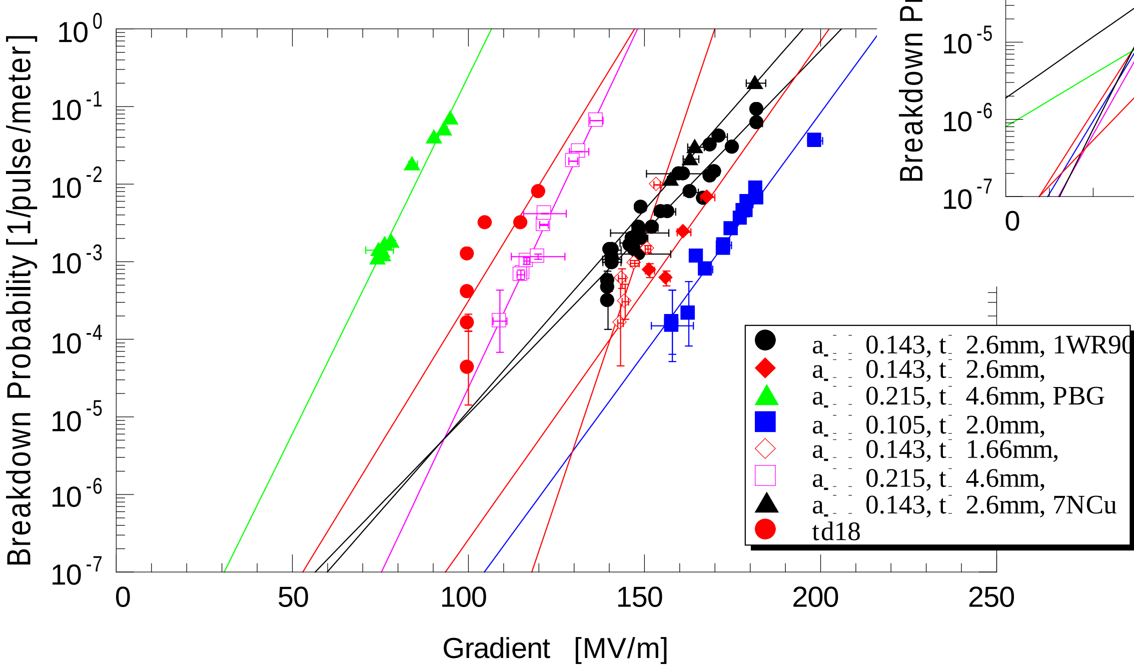


Fields are normalized to 10MW of total rf loss.

Coupling cell of 1C-SW-A3.75-T4.6-1WR90-Cu-SLAC-#1

Summary of breakdown rate vs. pulse heating for different structures, including TD18 and PBG





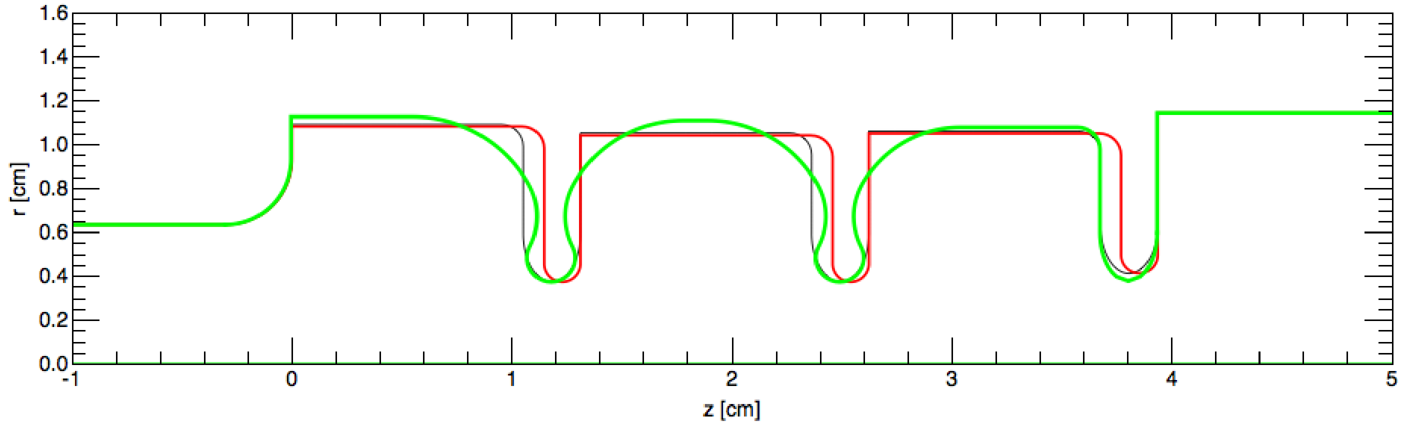
V.A. Dolgashev, 18 October 2010

Planned Breakdown Test of SW Accelerator Cavity with Shaped Iris

J.M Neilson (*SLAC*)

SW Cells a/λ =0.143, π Phase Shift
Field Normalized for 100MeV/m Acceleration

Iris profile designed to maximize shunt impedance, minimize peak surface magnetic field



Parameter	T=1.66 Round Iris	T=2.6mm Elliptical Iris	T=2.2mm Shaped Iris
Stored Energy [J]	0.189	0.189	0.186
Q-value	8820	8560	10090
Shunt Impedance [MOhm/m]	**85.2**	**82.6**	**99.2**
Max. Mag. Field [KA/m]	**314**	**325**	**294**
Max. Electric Field [MV/m]	266	203	268
Losses in one cell [MW]	1.54	1.59	1.32
Hmax*Z0/Eacc	1.18	1.22	1.11
Max. Im{E x H*} W/μm²	**42.8**	**44.4**	**56.5**
Max. Im{E x H*}/H²	417	407	650

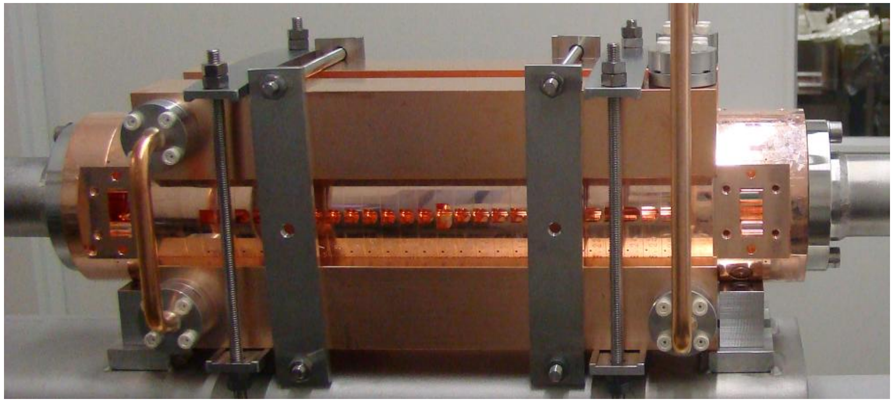
SLAC NATIONAL ACCELERATOR LABORATORY

Report from TBTS

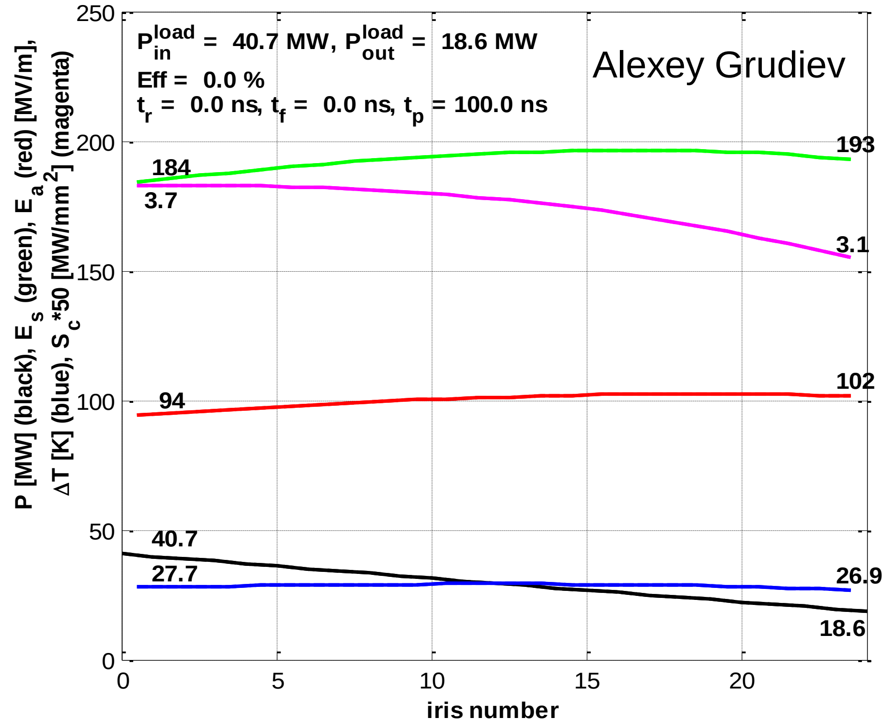
Syratchev Igor (*CERN*)

TD24_vg1.8_disk accelerating structure in TBTS

- 24 regular + 2 coupler cells with damping features
- L_{acc} = 200.0 mm (regular cells)
- filling time = 65 ns
- 42 MW input power for 100 MV/m (unloaded) (57 MW loaded)



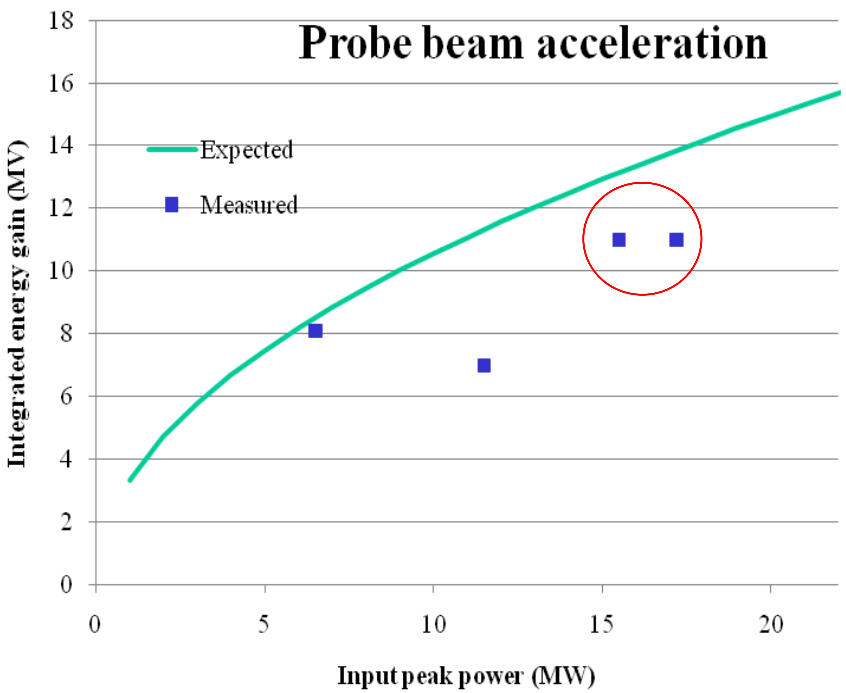
Average unloaded gradient of 100 MV/m

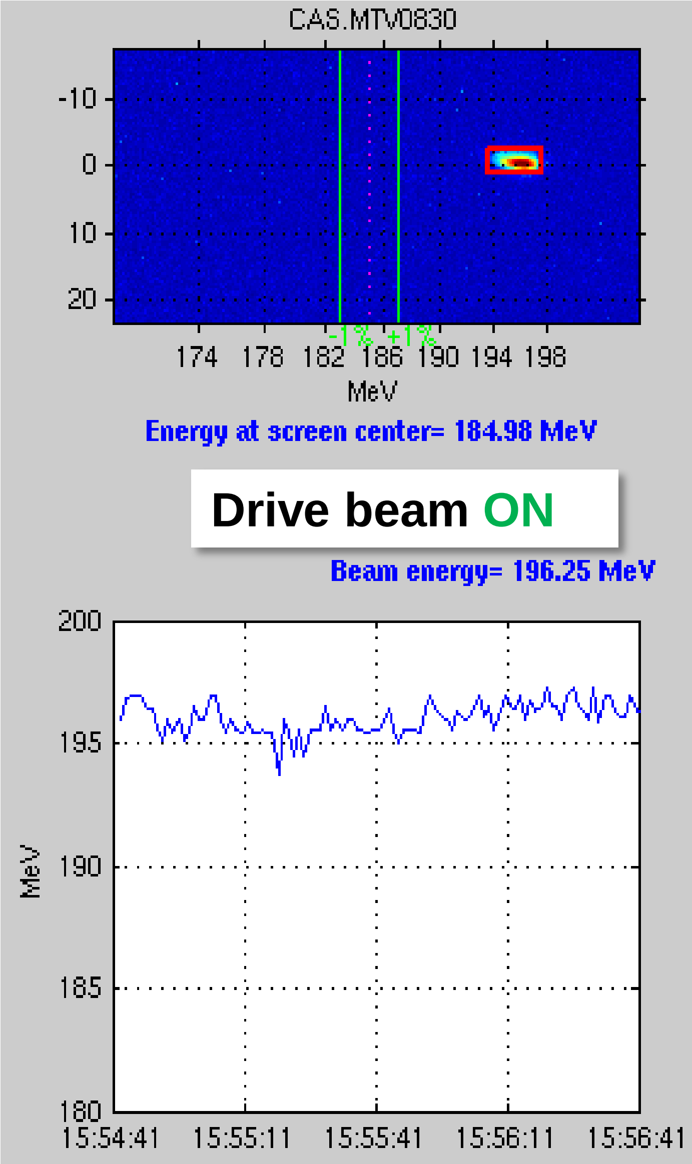


I. Syratchev, IWLC, Geneva 10.2010

First two-beam acceleration in CTF3

The 11 MeV probe beam energy gain was measured after acceleration over 0.2 m structure, demonstrating **55 MV/m** accelerating gradient.



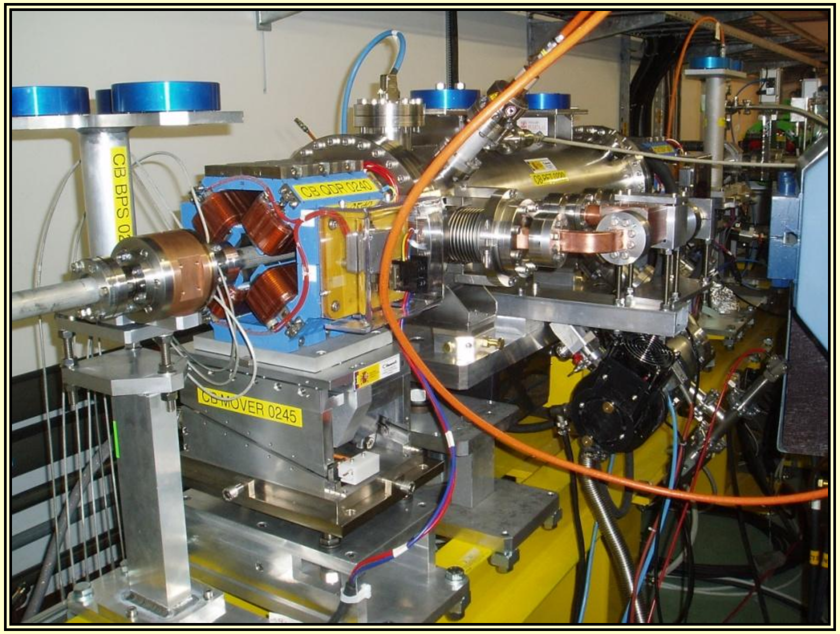


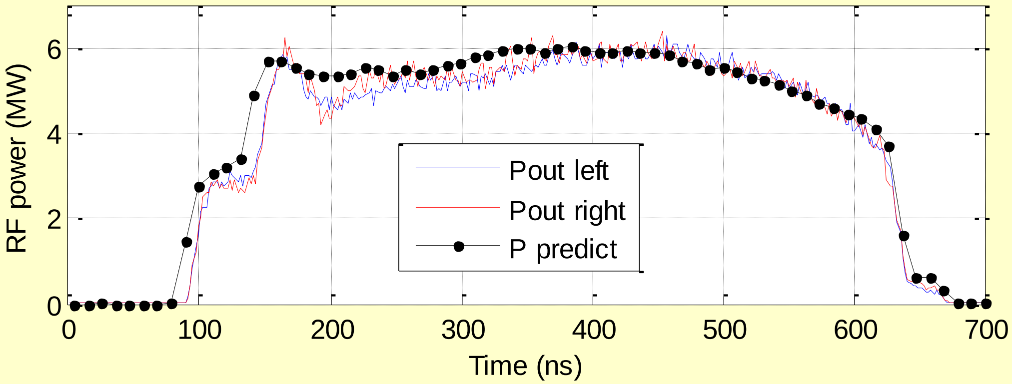
I. Syratchev, IWLC, Geneva 10.2010

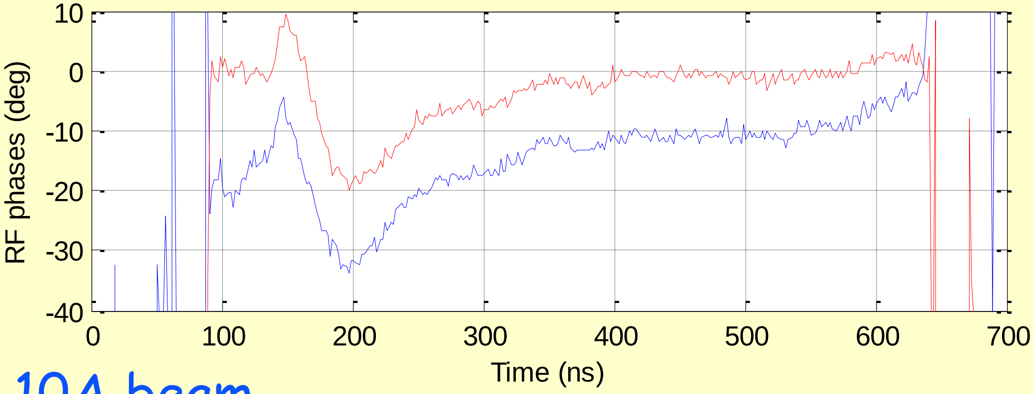
Report from TBL

Steffen Doebert (CERN)

PETS, beam driven test TBL







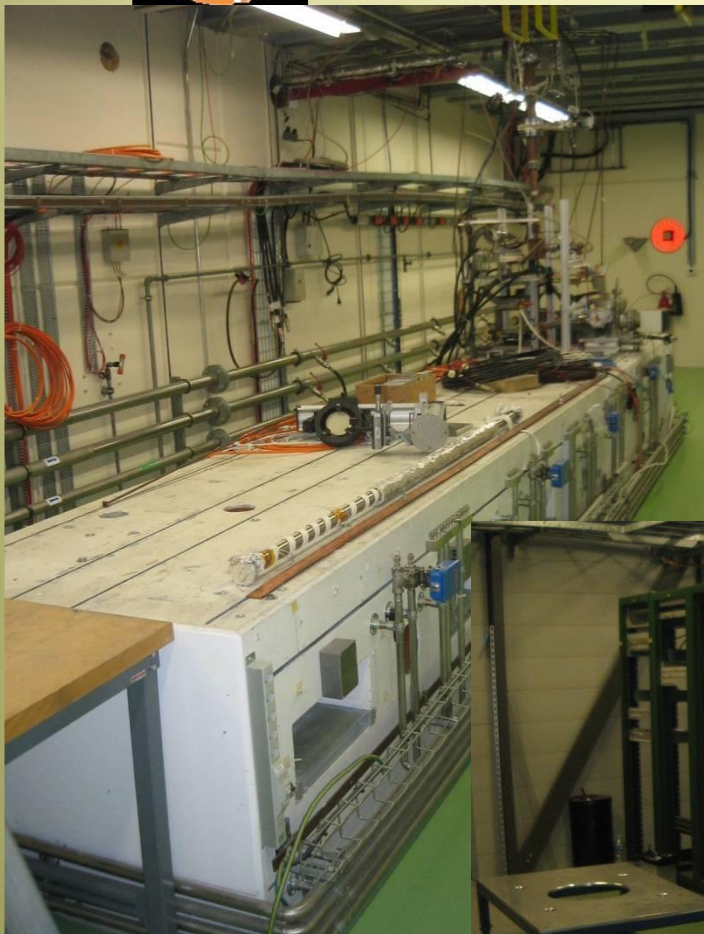
- 20 MW power produced with a 10A beam according to predictions, form factor 0.9
- PETS is a very sensitive diagnostics for the longitudinal beam structure,

IQ-detectors used for power measurements

Report from CLIC-klystron test area

Karl-Martin Schirm (CERN)

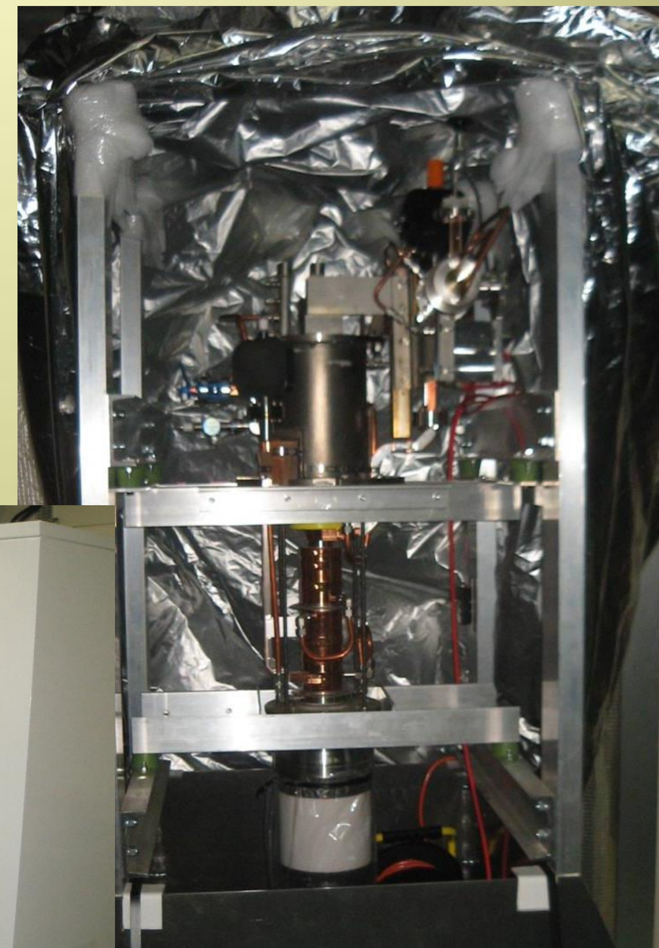
Installation Progress



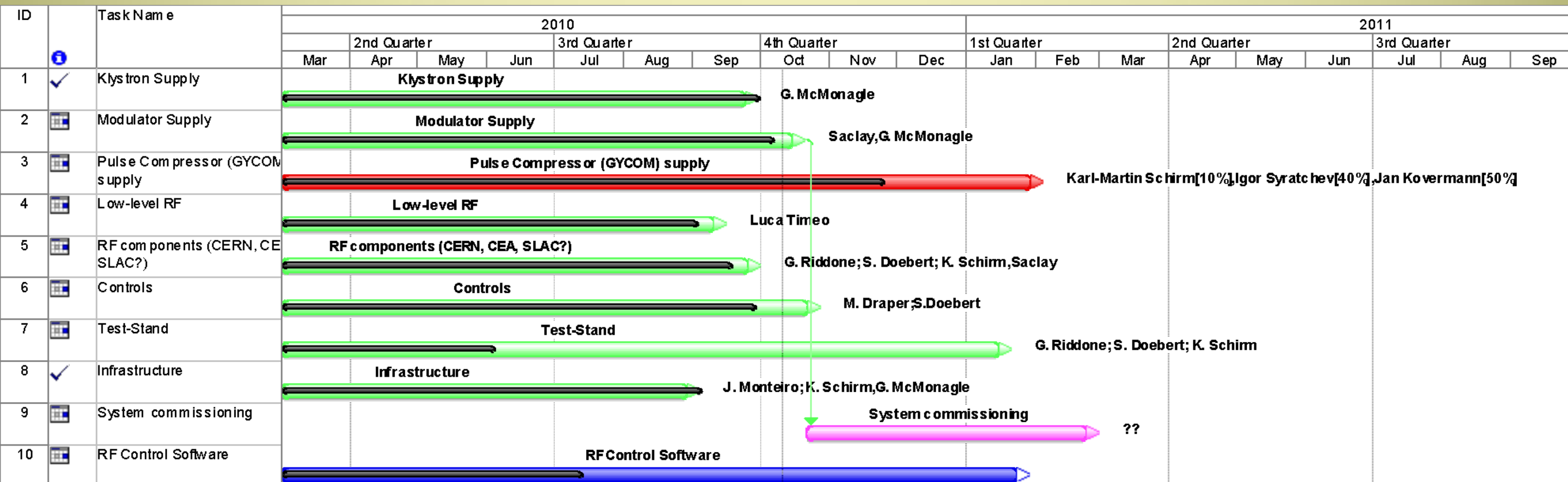
⇐CTF2 test bunker

XL5 @ CERN ⇒

Modulator in gallery



Schedule (10/2010)



! Klystron and Modulator commissioning now driving the schedule (►G. McMonagle)

! Cavity Pulse Compressor requires refurbishing (► J. Kovermann – Poster)

! 12 GHz power (without compression) should be available in CTF2 in **Dec. 2010**

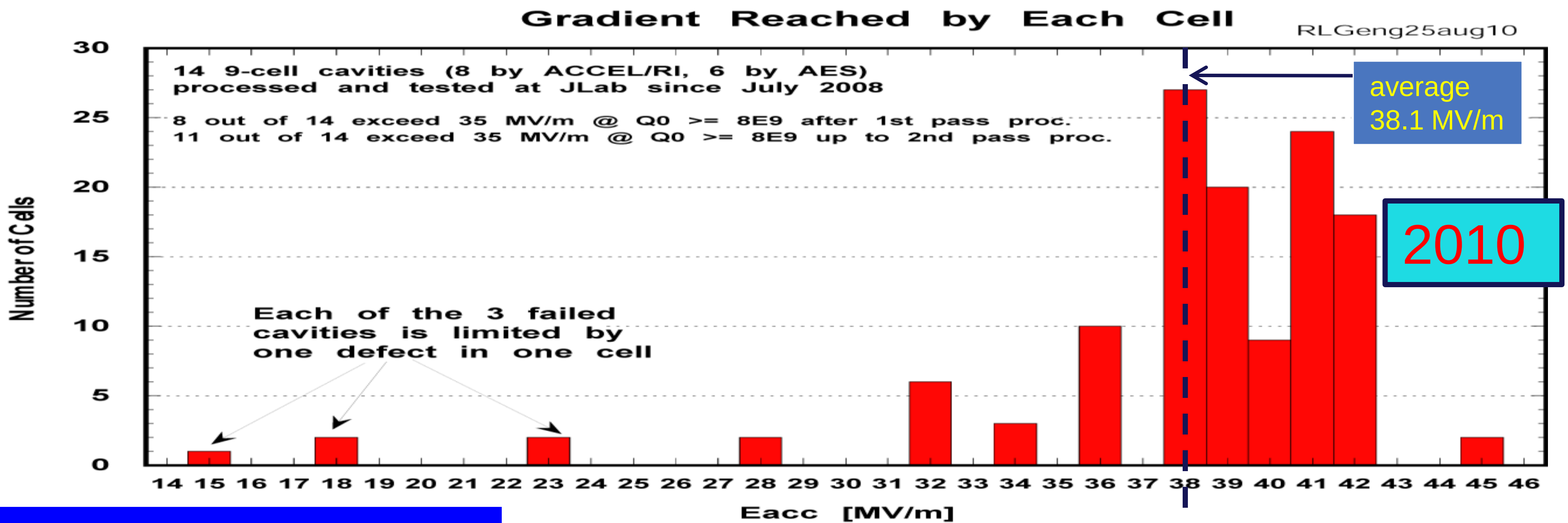
Poster Session

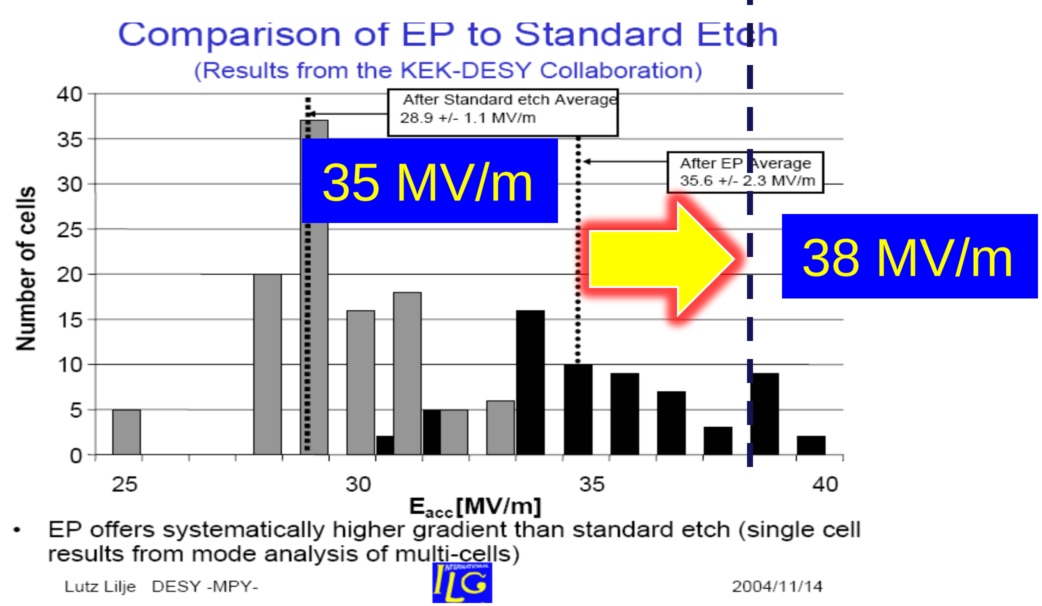
1. Design and fabrication update on PSI/Trieste x-band phase-space rotator structure (D. Gudkov, A. Samoshkin, JINR, Dubna, Russia, G. Riddone, R. Zennaro, S. Atieh, CERN, Geneva, Switzerland, M. Dehler, J-Y. Raguin, PSI, Villigen, Switzerland) (01')
2. Engineering design and fabrication of X-band damped detuned structure (V. Soldatov, D. Gudkov, A. Samoshkin (JINR); G. Riddone, A. Grudiev, S. Atieh, A. D'Elia (CERN); V. F. Khan, R. M. Jones (UMAN/Cockroft) (01')
3. Engineering design and fabrication of X-band ac. structure TD24 with WFM (F. Peauger, P. Girardot, CEA Saclay, France, A. Andersson, G. Riddone, S. Atieh, CERN, Geneva, Switzerland, A. Samoshkin, A. Solodko, D. Gudkov, JINR, Dubna, Russia, R. Zennaro, PSI, Villigen, Switzerland) (01')
4. Engineering design and fabrication of X-band ac. structures TD24 R05 and TD24 R05 SiC (G. Riddone, A. Grudiev, S. Atieh, CERN, Geneva, Switzerland, A. Solodko, A. Samoshkin, D. Gudkov, JINR, Dubna, Russia) (01')
5. Engineering design and fabrication of PETS (D. Gudkov, V. Soldatov, , A. Samoshkin, A. Olyunin (JINR); S. Atieh, I. Syratchev, G. Riddone (CERN)) (01')
6. Conceptual design X-band ac. structure TD26 CC SiC (A. Grudiev, G. Riddone, CERN, Geneva, Switzerland, A. Samoshkin, A. Solodko, D. Gudkov, JINR, Dubna, Russia) (01')
7. Fabrication of X-band RF accelerating structures at CERN (S. Lebet, Ph. De Souza, M. Aicheler, M. Malabaila, M. Taborelli, S. Atieh, CERN, V. Sibue, BODYCOTE) (01')
8. Engineering design and Production of X-band RF components (G. Riddone, I. Syratchev, CERN, Geneva, Switzerland, I. Kossyvakis, NTUA, Greece, M. Filippova, A. Solodko, A. Olyunin, JINR, Dubna, Russia) (01')
9. Integration of RF structures in the two-beam module (A. Samoshkin, D. Gudkov JINR, Dubna, Russia, G. Riddone, CERN) (01')
10. Thermo-mechanical model of two-beam module (R. Nousiainen, G. Riddone, K. Österberg) (01') 14:10 Studies on high-precision machining and assembly of CLIC RF structures (J. Huopana, S. Atieh, G. Riddone, K. Österberg) (01')
11. Manufacturing and Test folder for RF structures and RF components (H. Tiainen, R. Bray, M. Saifoulina, M. Filippova) (01')
12. A DAMPED AND DETUNED STRUCTURE FOR THE MAIN LINACS FOR CLIC (V. F. Khan, A. D'Elia, A. Grudiev, R. M. Jones, G. Riddone, V. Soldatov, W. Wuensch, R. Zennaro, School of Physics and Astronomy, The University of Manchester, Manchester, U.K., The Cockcroft Institute of Accelerator Science and Technology, Daresbury, U.K.,CERN, Geneva, Switzerland, JINR, Dubna, Russia, PSI, Villigen, Switzerland) (01') (Poster)
13. A HIGH PHASE ADVANCE DAMPED AND DETUNED STRUCTURE FOR THE MAIN LINACS OF CLIC (V. F. Khan, A. D'Elia, A. Grudiev, R. M. Jones, W. Wuensch, School of Physics and Astronomy, The University of Manchester, Manchester, U.K., The Cockcroft Institute of Accelerator Science and Technology, Daresbury, U.K., CERN, Geneva, Switzerland) (01') (Poster)

Joint WG 3+4
Summary and issues of cold linac

Hitoshi Hayano (*KEK*)

Gradient State-of-the-art then and now





2004

2004 DESY EP 9-cell cavities
Gradient distribution in cells from
pass-band measurements (~ 8 cavities)

Joint WG 3+4
The main issues for CLIC main linac rf structures

Walter Wuensch(*CERN*)

Objective

I will select aspects of CLIC rf structure work for which I believe are common to both our projects and for which we could potentially establish some kind of joint activities.

The list

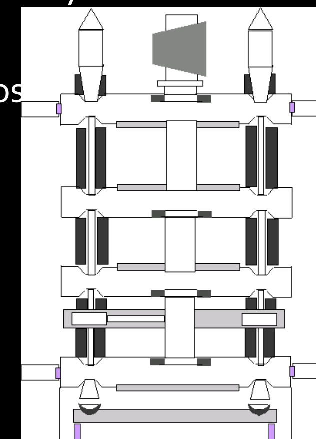
1. rf computation
2. Damping materials
3. Simulation of high-power effects
4. Surface preparation and assembly procedures
5. L-band technology and power sources (covered in next session)

Joint WG 4+6
What is the ideal power source for a linear collider?

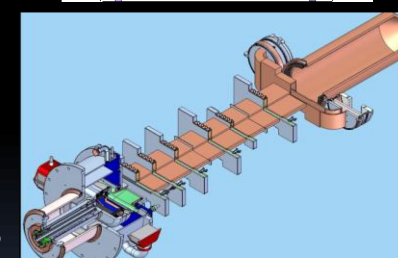
Erk Jensen (CERN)

High η power source contenders (1):

- Standard (pencil-beam) klystrons?
  - Lower individual power, much larger number, but those would be extremely well studied and reliable objects.
    - Several companies would participate. Competition plus quantity could keep cos
    - Potentially allows system design with graceful degradation.
    - Uncorrelated noise decreases by factor $\sqrt{n}$!

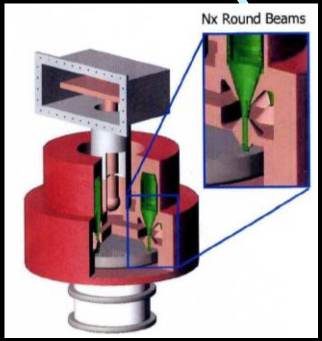


- MBK?
  - Closest to existing, ready-to-use technology! Larger η calls for more beamlets and higher voltage. When would it become too complex?
- Sheet-beam klystrons?
  - They promise to be much cheaper for larger quantities, but there is no demonstration today that would support this claim.

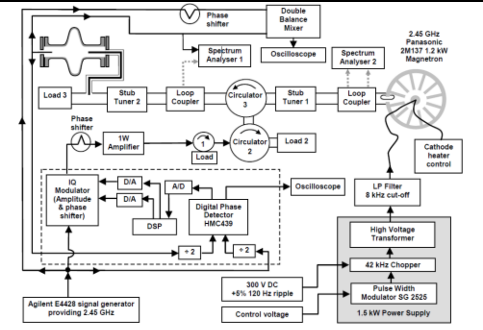


- Klystrons with multi-stage depressed collectors?
  - Allows to recover beam energy and thus increase η, even for zero RF drive.
  - Allows to operate klystron below saturation with high η.
  - Complexity?

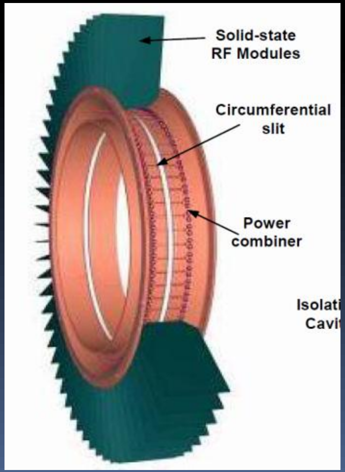
High η power source contenders (2):



- IOT's?
  - Present day IOT's: ≈ 80 kW. Reliability? Less gain! Large η possible!
  - HOM-IOT?
- Magnetrons?
  - Not an amplifier, but injection-locked oscillator,
  - Potentially better η, but phase noise ?
  - How long for the magnetron pulse to stabilise? Unused part of pulse reduces effective η!



- Direct Solid-state drive?
  - Many solid state modules close to the cavity,
  - Use the cavity as power combiner
  - Compatible with radiation? Transistors fast enough? Decoupling?

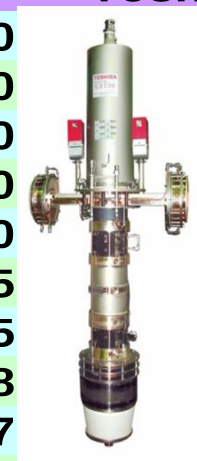


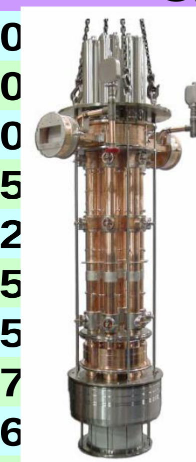
Joint WG 4+6
Introduction to L-band klystrons for the ILC

Shigeki Fukuda (*KEK*)

MBK Comparison with three companies

Item	Unit	TH1801 Thales	E3736 Toshiba	VKL-8301 CPI
Frequency	MHz	1300	1300	1300
Output Peak Power (max)	MW	10	10	10
Output Average Power (ma	kW	150	150	150
Beam Voltage	kV	110	115	114
Beam Current	A	130	132	131
Pulse width	ms	1.5	1.5	1.5
Efficiency	%	65	>65	65-67
Gain	dB	48	47	47
Number of beam		7	6	6
Beam micro-perveance	uA/V^3/2	3.5	3.38	3.4
Single beam micro-perv.	uA/V^3/2	0.50	0.56	0.57
Cavity numbers		6	6	6
Cathode loading	A/cm^2	<2	<2.1	<2.1





Interaction between cavity and beam

TH2108(Thales) **One cylindrical cavity interacts to 7 beamlets. 7 beams couple to FM(fundamental mode) -TM010.**

VKL8301(CPI) **Input and output cavities are annular cavity which M010. Intermediate cavity is cylindrical of TM010.**

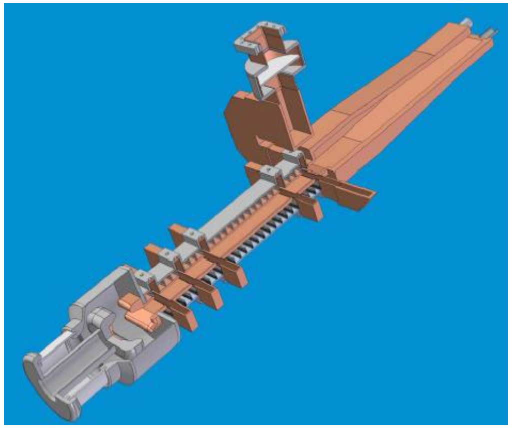
E3736(Toshiba) **All are annular cavities and TM010 couples to 6 beamlets. Third cavities are harmonic cavity.**

Accelerator Laboratory, KEK

Alternative 1.3GHz RF Source

10 MW Sheet Beam Klystron (SBK)

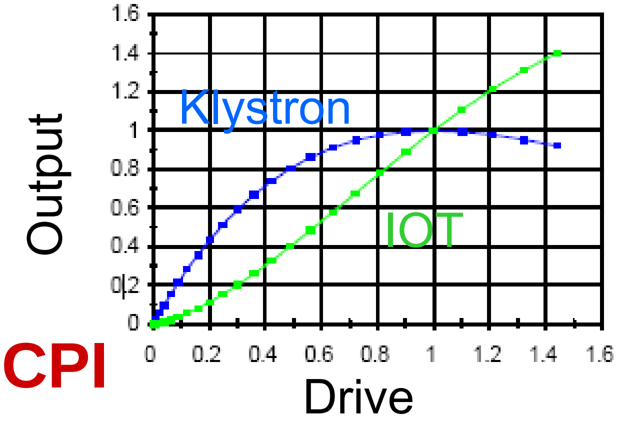
Parameters are similar to 10 MW MBK



SLAC

5 MW Inductive Output Tube (IOT)

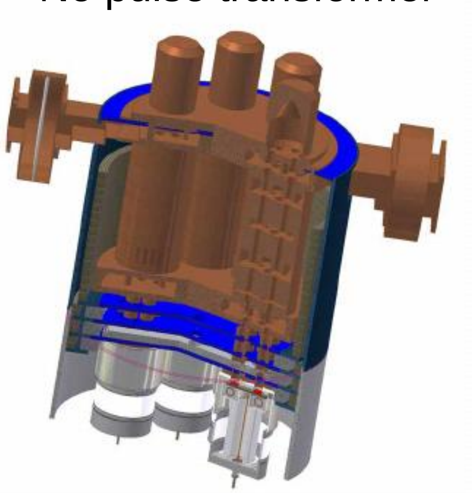
Peak Output Power	5	MW (min)
Average Output Power	75	kW (min)
Beam Voltage	115	kV (nom)
Beam Current	62	A (nom)
Current per Beam	5.17	A (nom)
Number of Beams	12	---
Frequency	1300	MHz
1dB Bandwidth	4	MHz (min)
Gain	22	dB (min)
Efficiency	70	% (nom)



CPI

Low-voltage 10 MW MBK

voltage 65 kV
Current 238A
Many beamlet such as 30-40
No pulse transformer



KEK

Joint WG 4+6

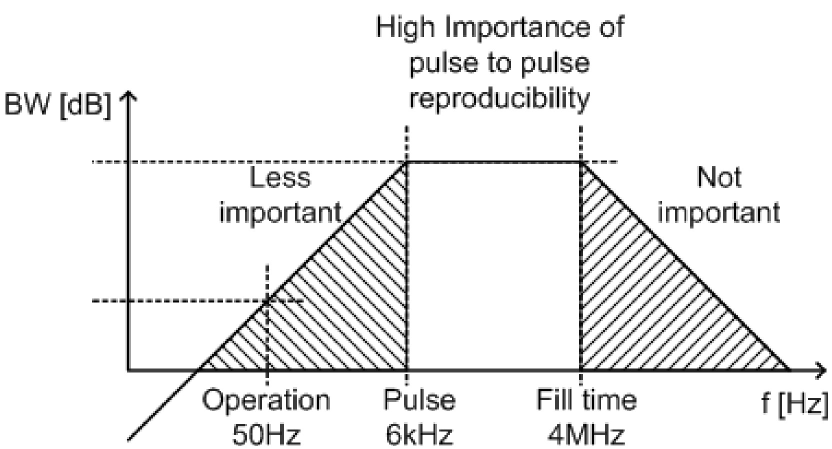
Modulators for the CLIC drive beam accelerator

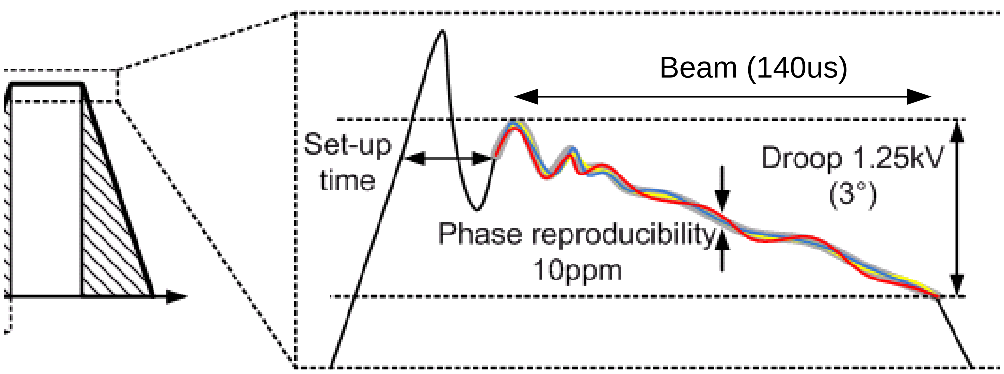
David Nisbet (*CERN*)

Klystron modulators

- Modulator requirements and characteristics

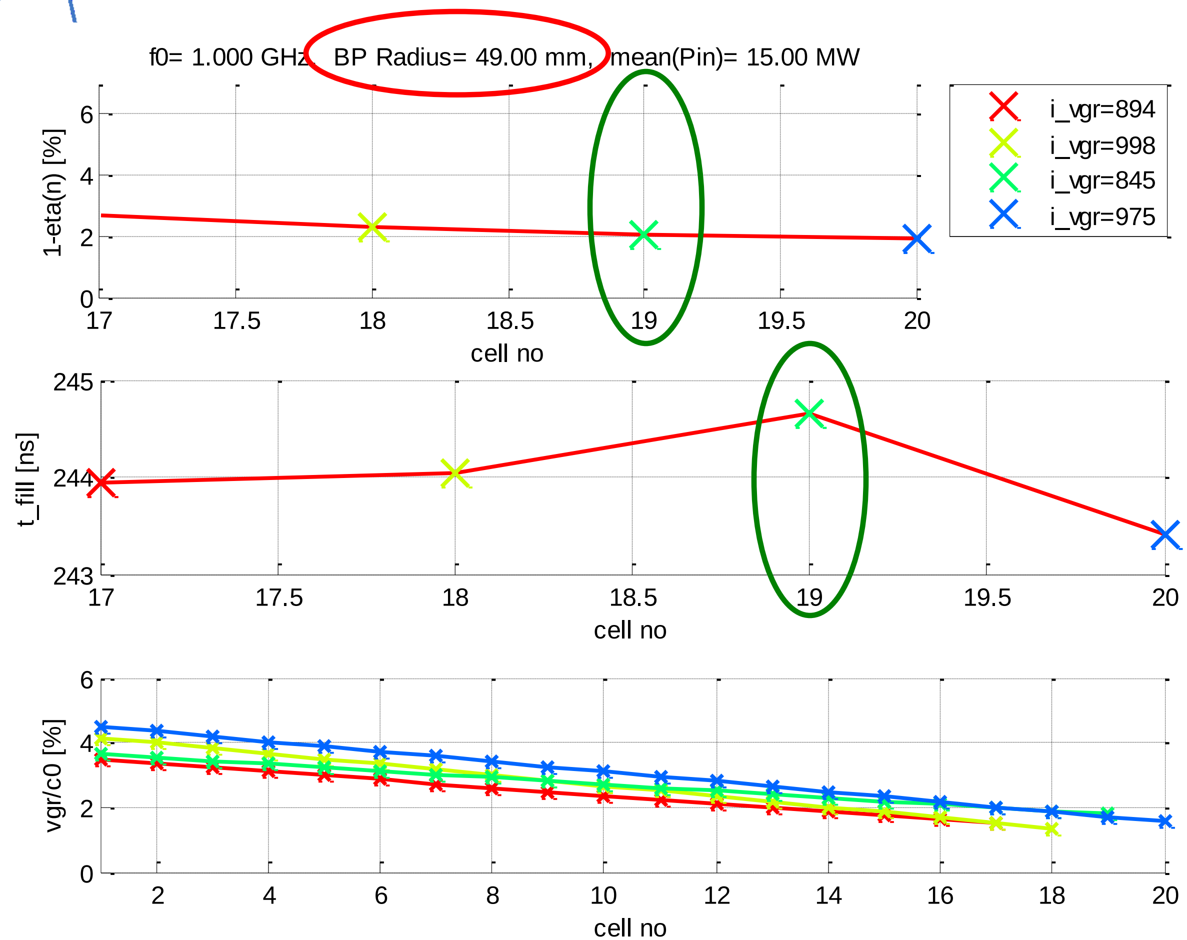
Peak power/modulator	23.1 MW (15MW@ 65% efficiency)
Output voltage	150 kV
Pulse to pulse reproducibility	10^{-5} between 6kHz and 4MHz
Droop (including harmonics)	3° (1.25 kV or <0.85%)
Pulse characteristics	20us rise/fall; 30us set-up; 140us beam
Average power/modulator	243.6 kW @ 90% efficiency



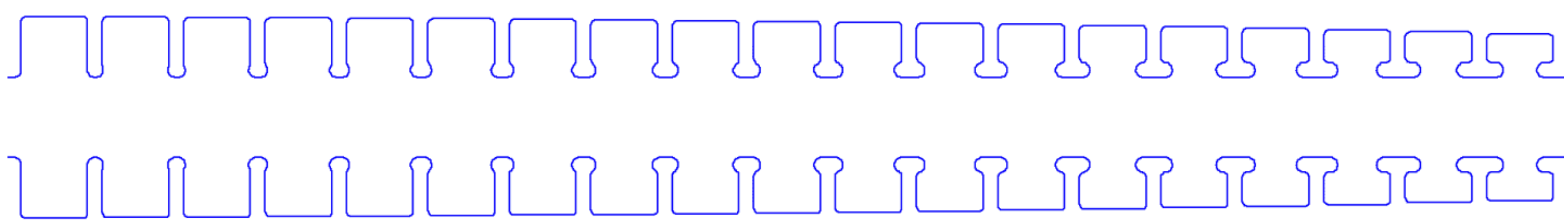


Joint WG 4+6
Drive beam accelerating structures
Rolf Wegner (*CERN*)

Baseline structure, 19 cells, RB=49 mm

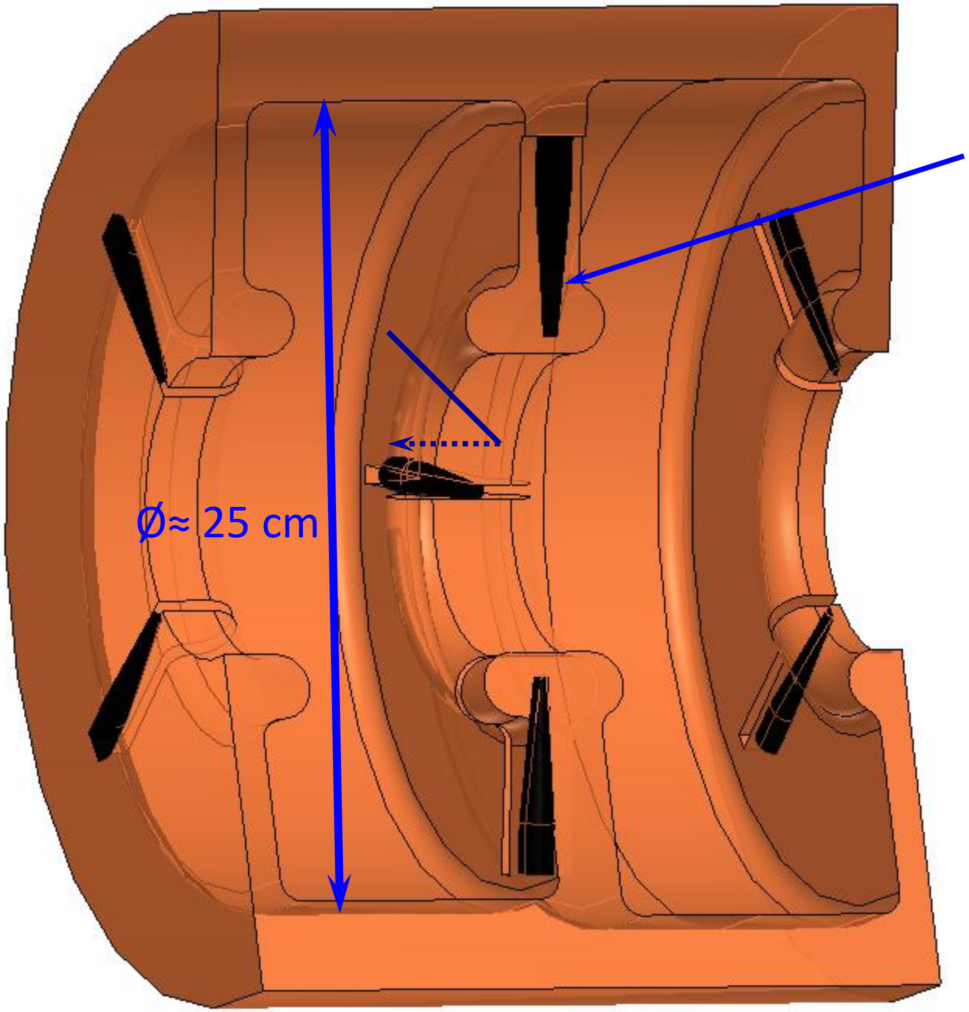


P_{in} = 15 MW
RB = 49 mm,
N = 19 cells



damping and detuning

reduction of transverse wakefields by damping and detuning



Alexej Grudiev's idea:
dampers in web (~18 mm tick)

acc. mode

Q_0= 2.2 ·10^4, Q_{ext}= 3.7·10^7

distorted, 0.1 <=> 0.1 mm @ nose

Q_{ext}= 1.5 ·10^6

$P_{ext,peak}$= 110 W, $P_{ext,avg}$= 0.83 W

($P_{cell,peak}$= 30 kW, d.c. 0.75%)

concerns:

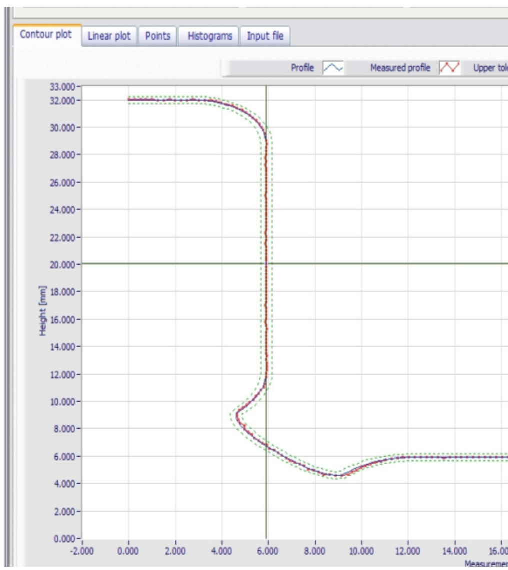
- **damper close to beam axis**
- **peak power in damper**

Engineering aspects and technical systems of CLIC rf structures

Germana Riddone (*CERN*)

DETUNED DAMPED DISK FROM VDL (TD24)

germana.riddone@cern.ch



Enabling Technologies Group — Inspection Report

Drawing no.	CLIAAS110337 Standard Cell Disk 21	Prod. Nr.
Description	11 WDSDVG1.8KEK Standard cell	

Dimensions

Measurand	Description	Nominal	Upper	Lower	Actual	Deviation	Pass √	Fail √
1	Ref A ⏥ 0.002	0.0000	0.0020	0.0000	0.0011	0.0011	√	
2	Outer diameter Ref B	74.0000	0.0025	-0.0025	74.0015	0.0015	√	
3	⌭ 0.002	0.0000	0.0020	0.0000	0.0009	0.0009	√	
4	⊥ 0.002 A	0.0000	0.0020	0.0000	0.0006	0.0006	√	
5	ø 70	70.0000	0.0000	-0.0100	69.9957	-0.0043	√	
6	ø70 ◎ 0.005 B	0.0000	0.0050	0.0000	0.0010	0.0010	√	
7	Diameter 2xa	5.1901	0.0025	-0.0025	5.1900	-0.0001	√	
8	Distance d	8.7327	0.0020	-0.0020	8.7334	0.0007	√	
9	Plane at distance d ⏥ 0.002	0.0000	0.0020	0.0000	0.0020	0.0020	√	
10	ø 70	70.0000	0.0150	0.0100	70.0133	0.0133	√	
11	ø70 ◎ 0.005 B	0.0000	0.0050	0.0000	0.0007	0.0007	√	
12	Distance t	1.1569	0.0025	-0.0025	1.1562	-0.0007	√	
13	Distance g	7.5758	0.0025	-0.0025	7.5765	0.0007	√	

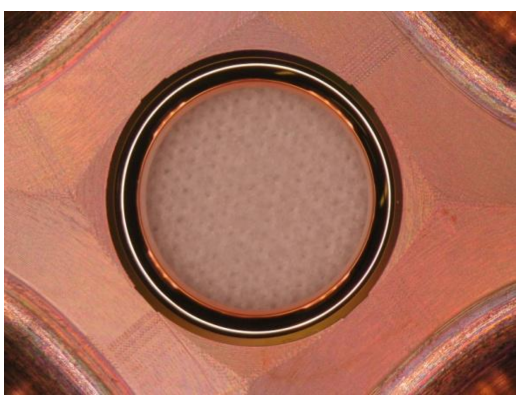
- **Shape accuracy 5 µm**

2.6 µm achieved

- **Roughness Ra 0.025**

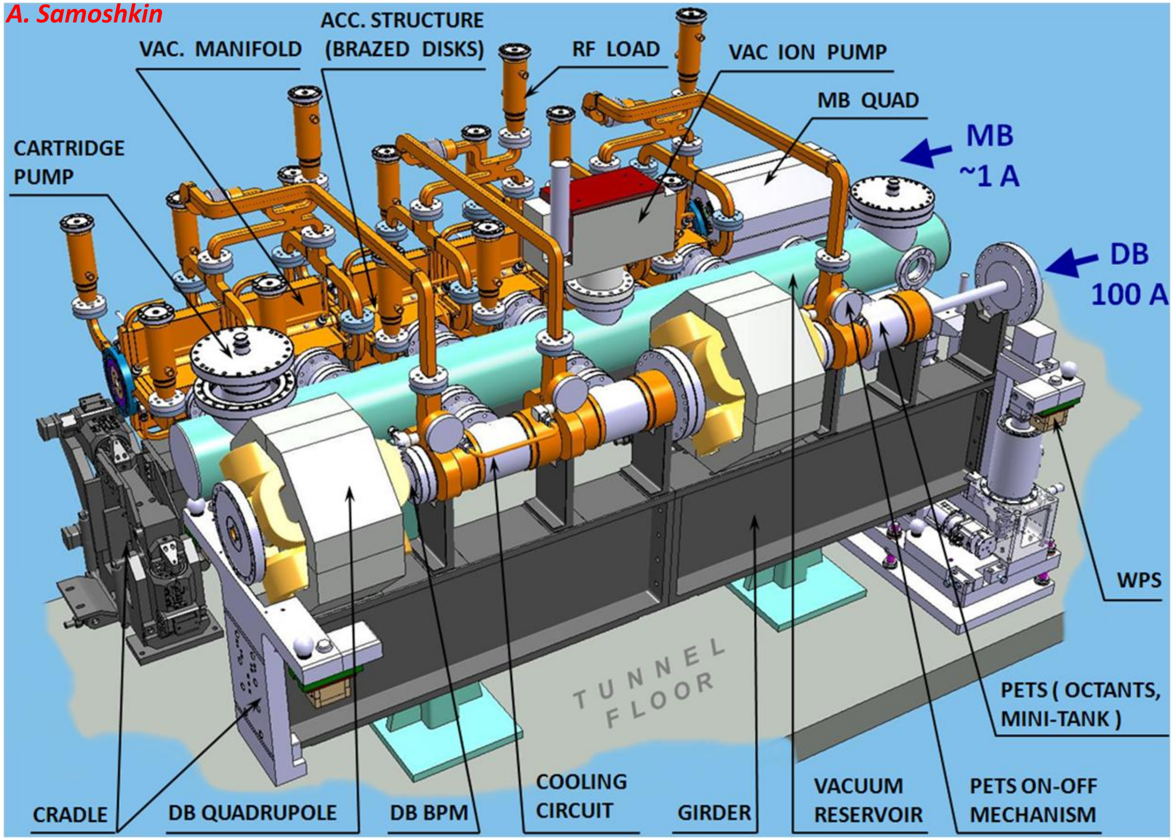
Iris region achieved Ra 0.016

Zeiss CMM, free state measurement



CLIC TWO-BEAM MODULES

germana.riddone@cern.ch



Up to 8 accelerating structures and 4 PETS in a two-beam module
Design takes into account CLIC requirements and integration with other technical systems

Review of breakdown studies
Helga Timko (*University of Helsinki*)

Electrical breakdown in multi-scale modeling approach

Kai Nordlund, Flyura Djurabekova

Avaz Ruzibaev — **Stage 1:** Charge distribution at the surface
Method: DFT with external electric field — **~few fs**

Flyura Djurabekova — **Stage 2:** Atomic motion & evaporation ;
Joule heating (electron dynamics)
Method: Hybrid ED&MD model (includes Laplace and heat equation solutions) — **~few ns**

Aarne Pohjonen — **~ sec/min** — **Stage 3a:** Onset of tip growth;
Dislocation mechanism
Method: MD, analysis of dislocations

Stefan Parviainen — **~ sec/hours** — **Stage 3b:** Evolution of surface morphology due to the given charge distribution
Method: Kinetic Monte Carlo

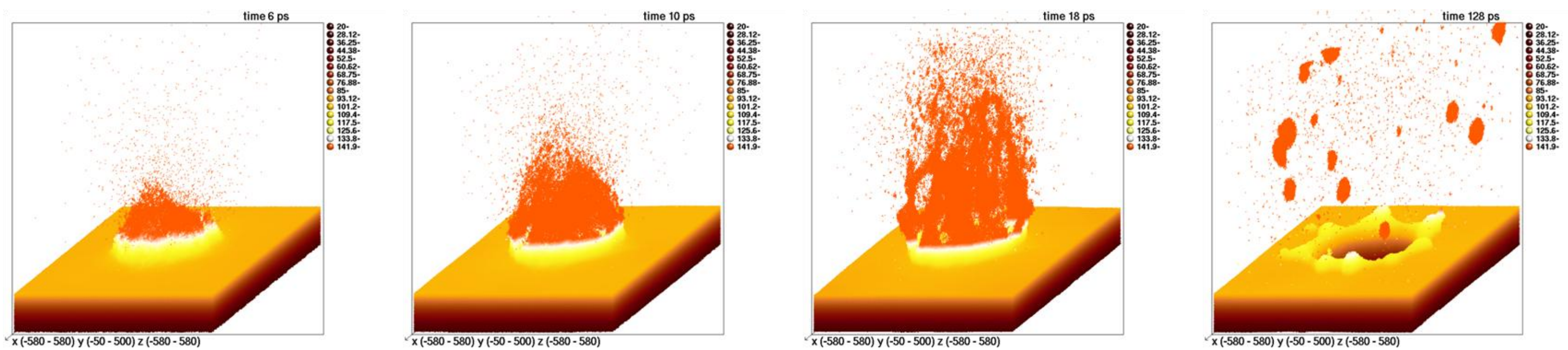
Helga Timkó — **Stage 4:** Plasma evolution, burning of arc
Method: Particle-in-Cell (PIC) — **~10s ns**

Juha Samela
Leila Costelle — **Stage 5:** Surface damage due to the intense ion bombardment from plasma
Method: Arc MD — **~100s ns**

PLASMA ONSET

Stage 5: Cathode damage due to ion bombardment

- Knowing flux & energy distribution of incident ions, erosion and sputtering was simulated with MD
- Flux of ~10^{25} $cm^{-2}s^{-1}$ on e.g. r=15 nm circle ⇒ 1 ion/20 fs



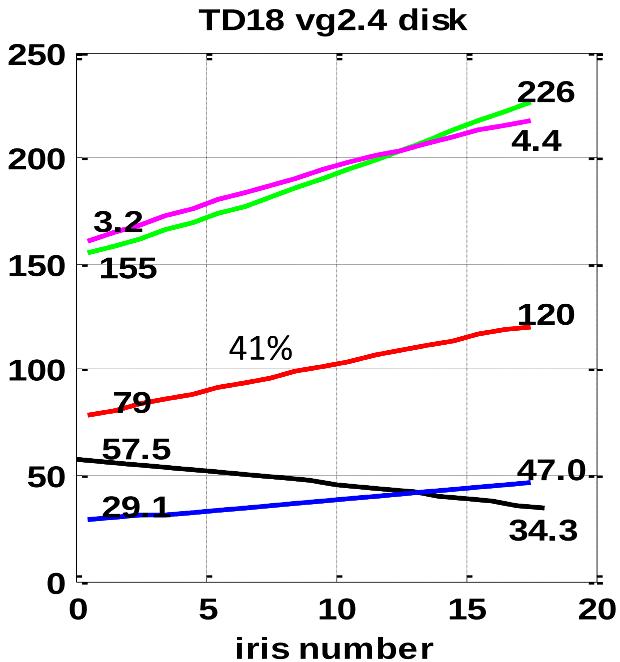
H. Timko, F. Djurabekova, K. Nordlund, L. Costelle, K. Matyash, R. Schneider, A. Toerklep, G. Arnau-Izquierdo, A. Descoeudres, S. Calatroni, M. Taborelli , and W. Wuensch, "*Mechanism of surface modification in the plasma-surface interaction in electrical arcs*", **Phys. Rev. B 81**, 184109 (2010)

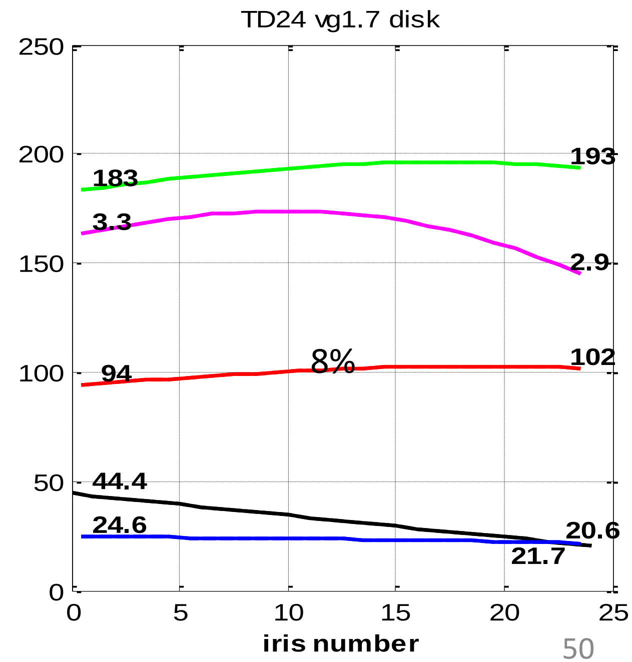
Future directions for accelerating structures

Alexej Grudiev (*CERN*)

Beyond CLIC_G

- Next step in rf design will be a structure with a degree of tapering lower than TD18 (41%) and TD24 (8%)
- For example, ~ 20-25 %
- It will probably have bigger average aperture if CLIC main beam bunch charge can be increased accordingly.
- A detailed optimization of the parameters and rf design will be done soon



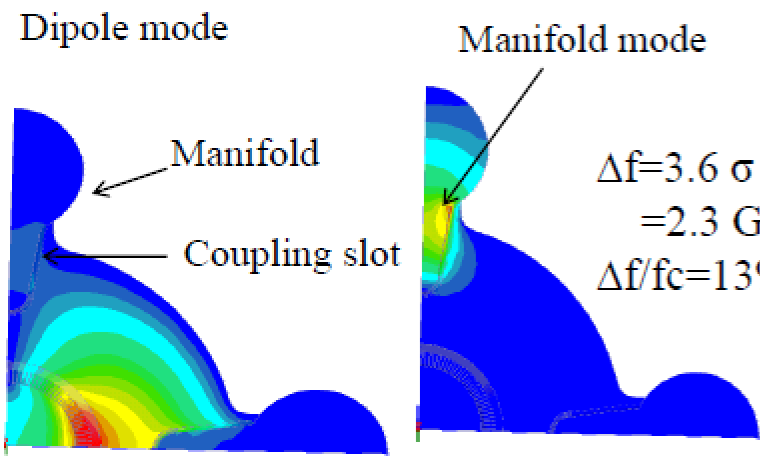


Update on CLIC DDS structure

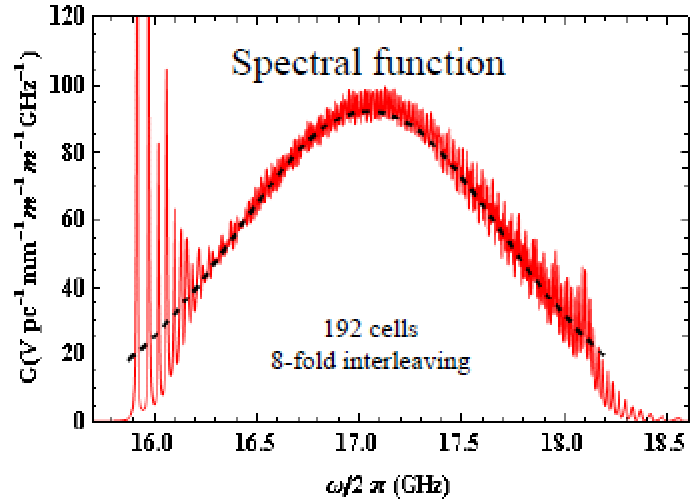
Roger Jones

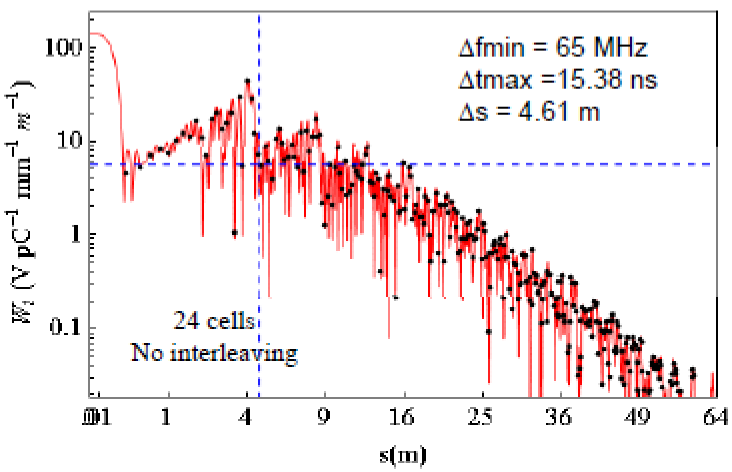
(*University of Manchester/Cockcroft*)

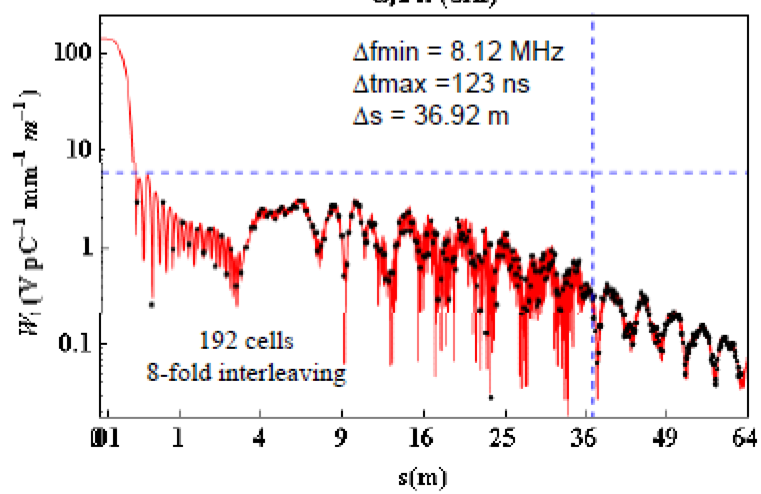
Damped Detuned Structure for CLIC



Δf=3.6 σ
=2.3 GHz
Δf/fc=13%





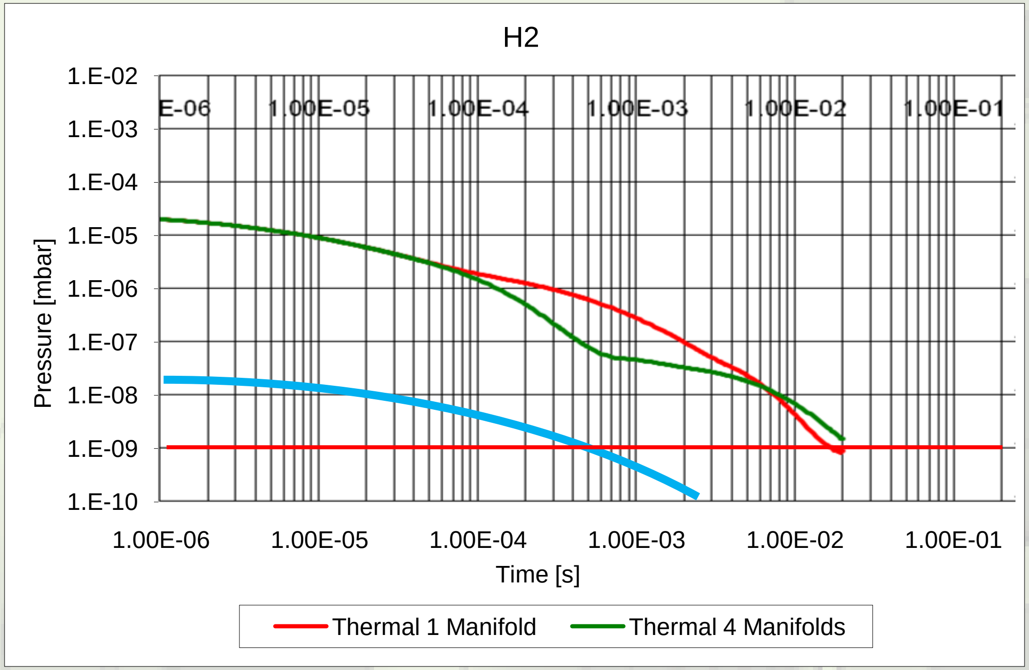


The Cockcroft Institute
of Accelerator Science and Technology

Progress on investigation of dynamic vacuum

Sergio Calatroni (*CERN*)

Dynamic vacuum I – Results



Pressure goes to < 10^{-9} mbar in less than 1 msec !
This is faster than the sampling time of common vacuum gauges...

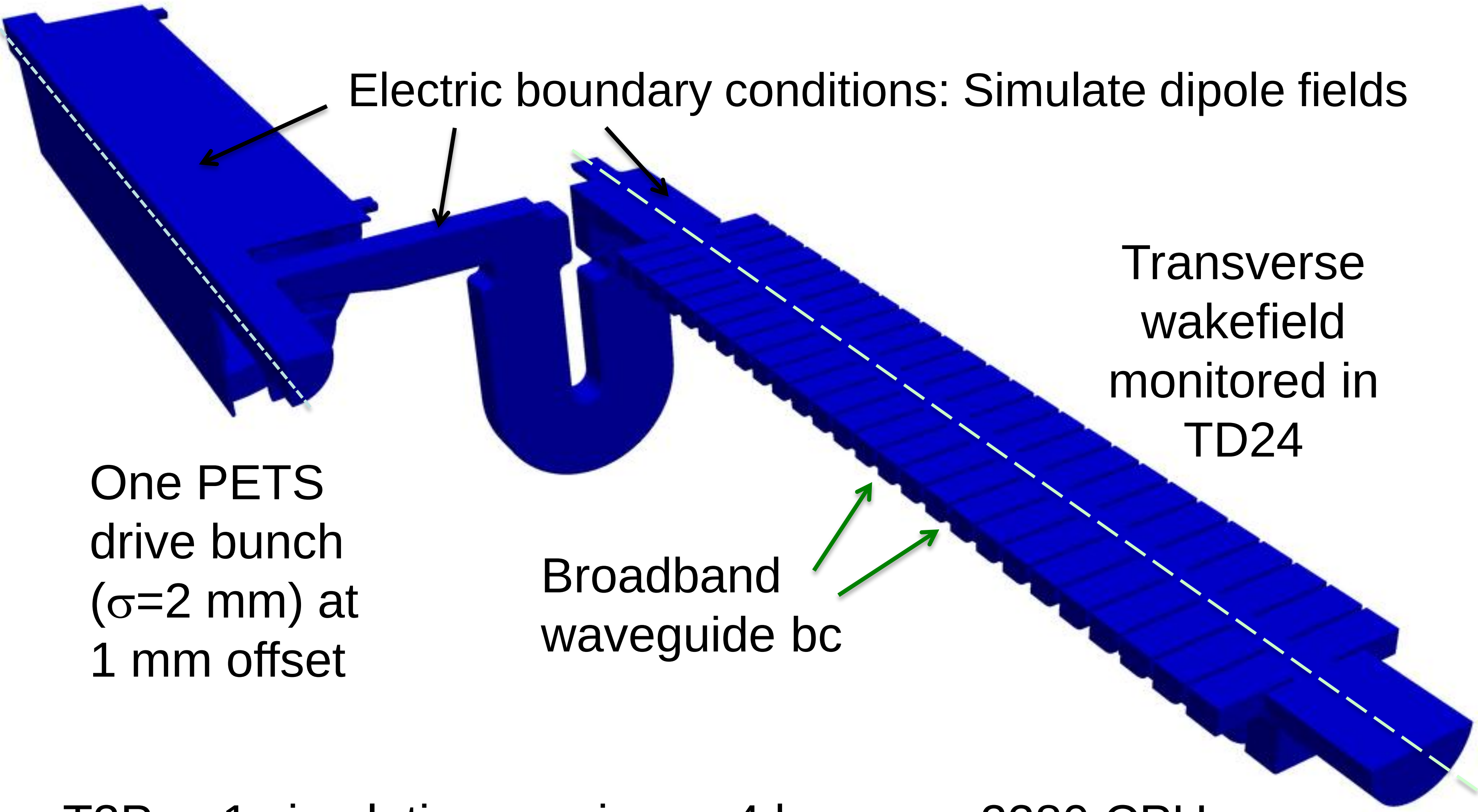
Same plot as for dynamic vacuum due to breakdowns ($2x10^{12}$ molecules released)

Extrapolating to 1000 less molecules released due to ESD

Progress on investigation of dynamic vacuum

Arno Candel (*SLAC*)

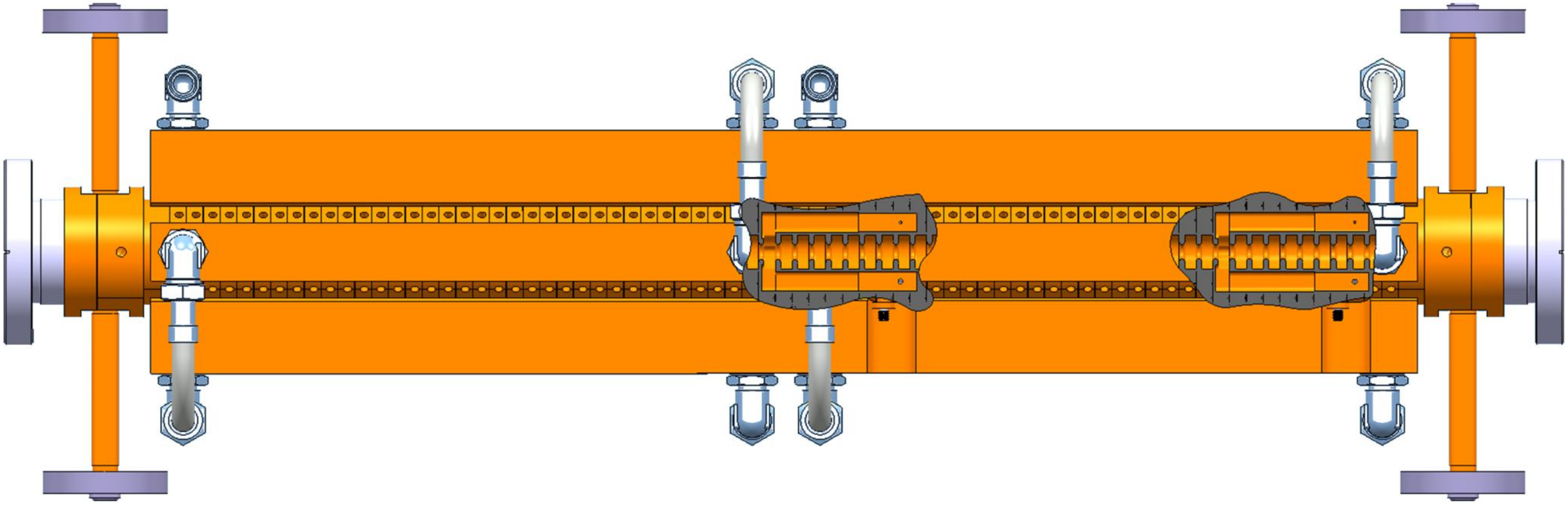
T3P: Wakefield Coupling PETS <-> TD24



T3P p=1 simulation requires ~ 4 hours on 2280 CPUs

Design and fabrication update on PSI/Trieste X-band phase-space rotator structure

Dmitry Gudkov *(JINR)*

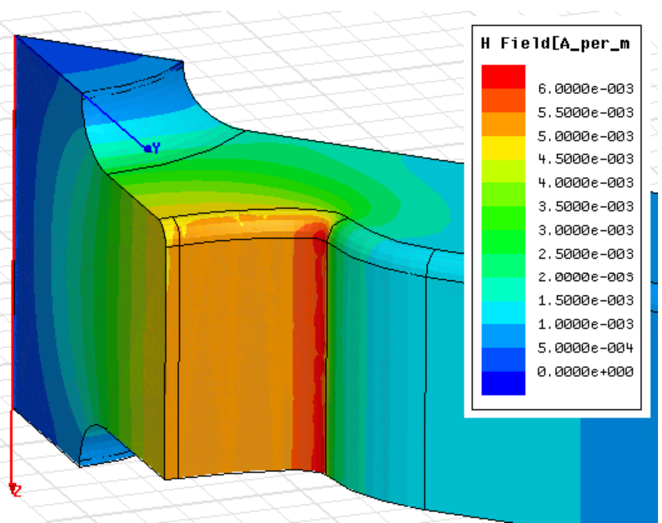


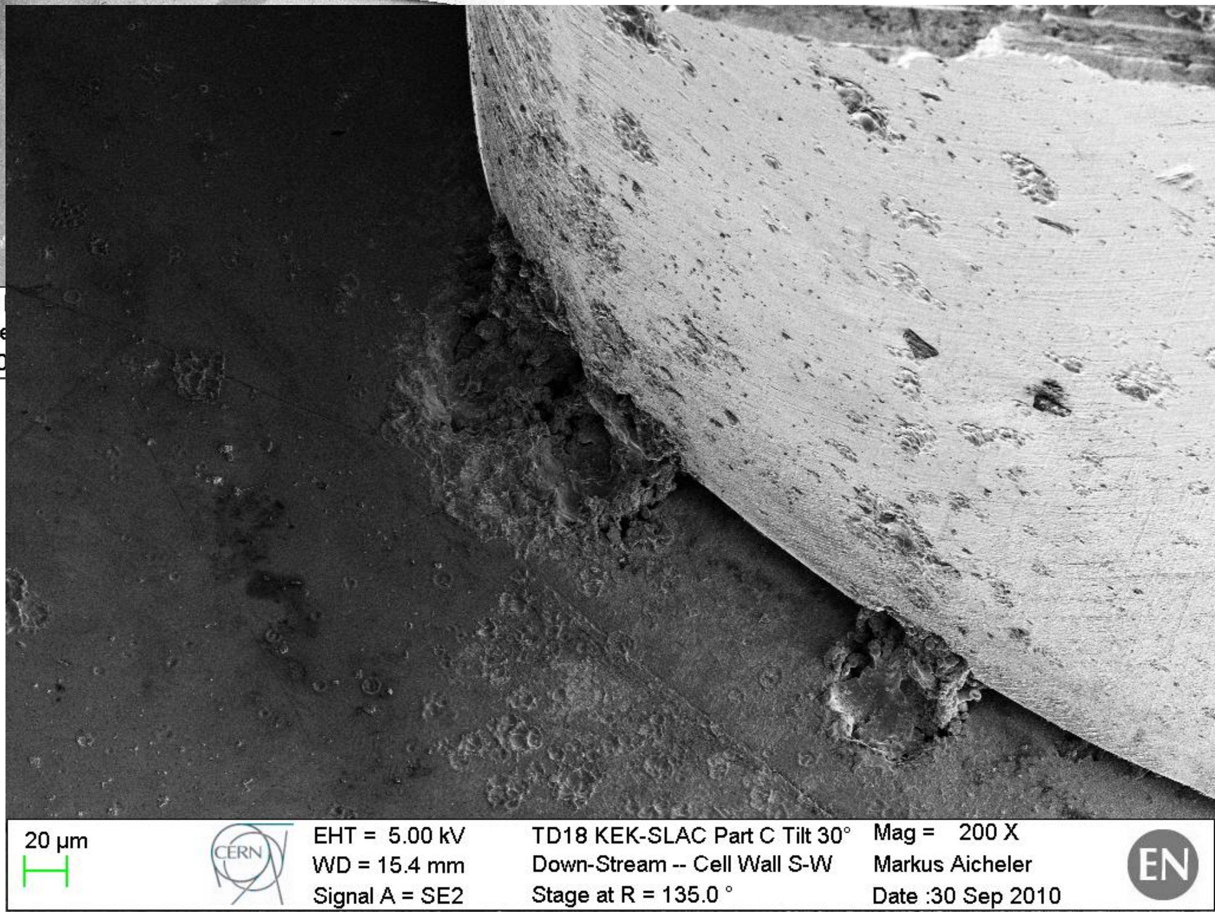
- The accelerating structure consists of two coupler subassemblies, 73 disks and includes a wakefield monitor and diagnostic waveguides;
- The engineering study includes the external cooling system, consisting of two parallel cooling circuits;
- RF tuning system, which allows phase advance tuning of the cell by deforming the outer wall;
- The engineering solution for the installation and sealing of the wake field monitor feed-through devices that are integrated in the accelerating structure are presented.

SEM images from the test structure program

Markus Aicheler *(CERN)*


100 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC
Down-Stream -- Ce
Stage at R = 135.0


H Field[A_per_m
6.0000e-003
5.5000e-003
5.0000e-003
4.5000e-003
4.0000e-003
3.5000e-003
3.0000e-003
2.5000e-003
2.0000e-003
1.5000e-003
1.0000e-003
5.0000e-004
0.0000e+000
Y
Z


20 µm
EHT = 5.00 kV
WD = 15.4 mm
Signal A = SE2
TD18 KEK-SLAC Part C Tilt 30°
Down-Stream -- Cell Wall S-W
Stage at R = 135.0 °
Mag = 200 X
Markus Aicheler
Date :30 Sep 2010

Some critical issues in CLIC-SLAC-KEK collaboration structures

Juwen Wang (*SLAC*)

Tuning Status for T24_VG1.8 **OK**

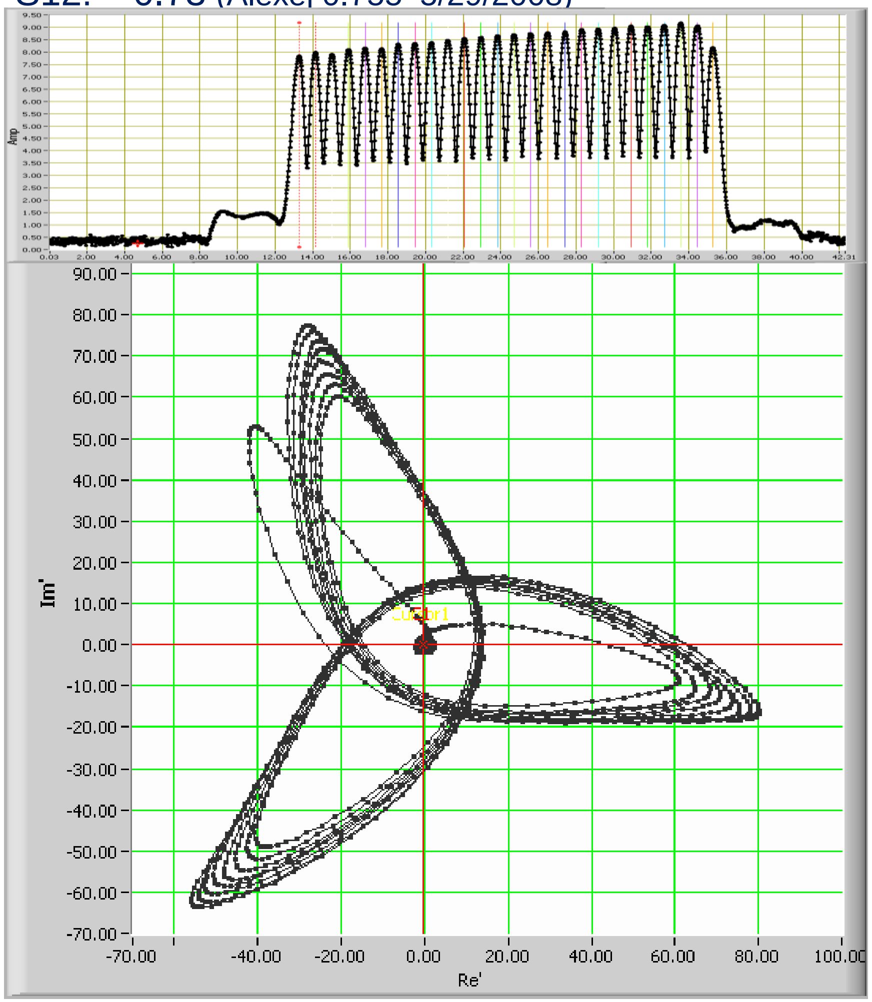
With SLAC Flanges

Target frequency: 11424 MHz at 45 C and vacuum after tuning the frequency by 5.6 MHz higher.

Filling time: 57.5 ns

S11: ~ 0.01

S12: 0.73 (Alexej 0.755 5/29/2008)



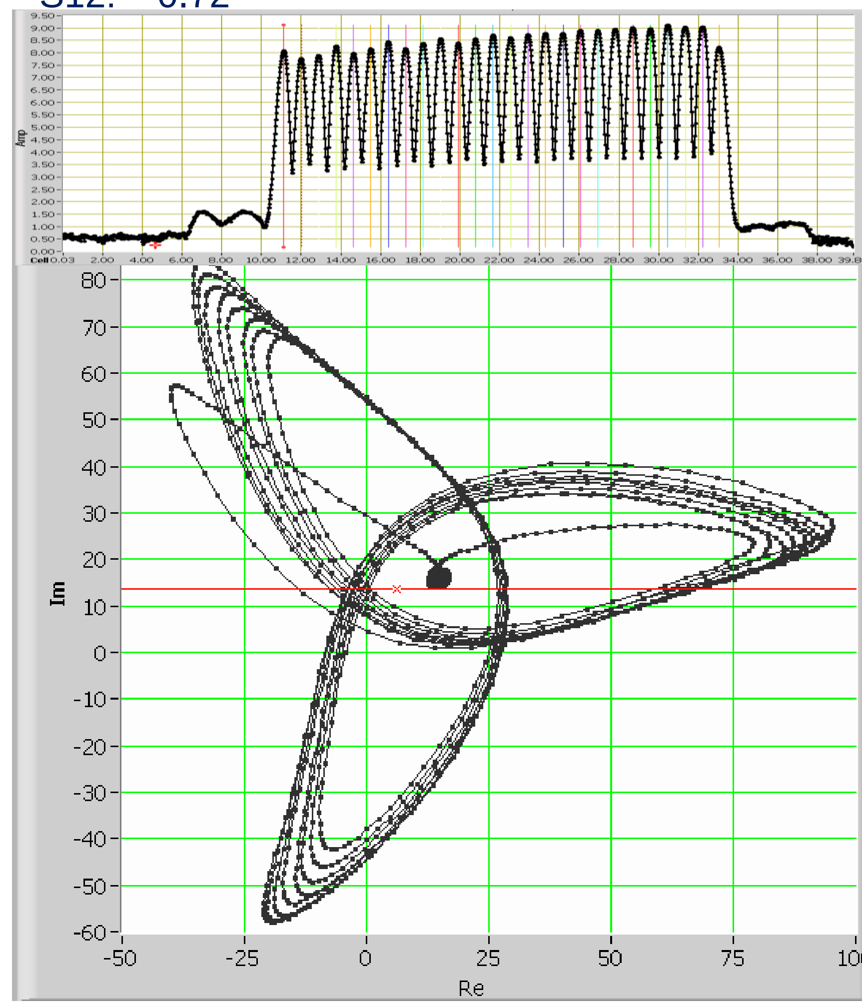
With KEK Flanges

Target frequency: 11424 MHz at 30 C and vacuum after tuning the frequency by 2.5 MHz higher.

Filling time: 57.5 ns

S11: ~ 0.025

S12: 0.72



TD24 Structure Assembly

Microbalance Results

AFM Average Roughness Values

Poly-diamond Machined

Coupon #	143	144	145	146
Bare machining (nm)	128.73	100.63	123.95	130
After ETCH (nm)	105.12 (5")	40.42 (30")	44.41 (60")	90.48 (120")
Heat treatment (nm)	67.15	35.63	31.32	53.06

SC-diamond Machined

Coupon #	137	138	139	140
Bare machining (nm)	4.73	6.27	8.67	3.35
After ETCH (nm)	4.74 (0")	6.32 (5")	12.46 (30")	21.33 (60")
Heat treatment (nm)	/	8.00	19.83	20.60

I'd like to confirm the time of heavier etching for TD24 Cups. 30 seconds?