Towards X-band structure prototype.

13.03.2007
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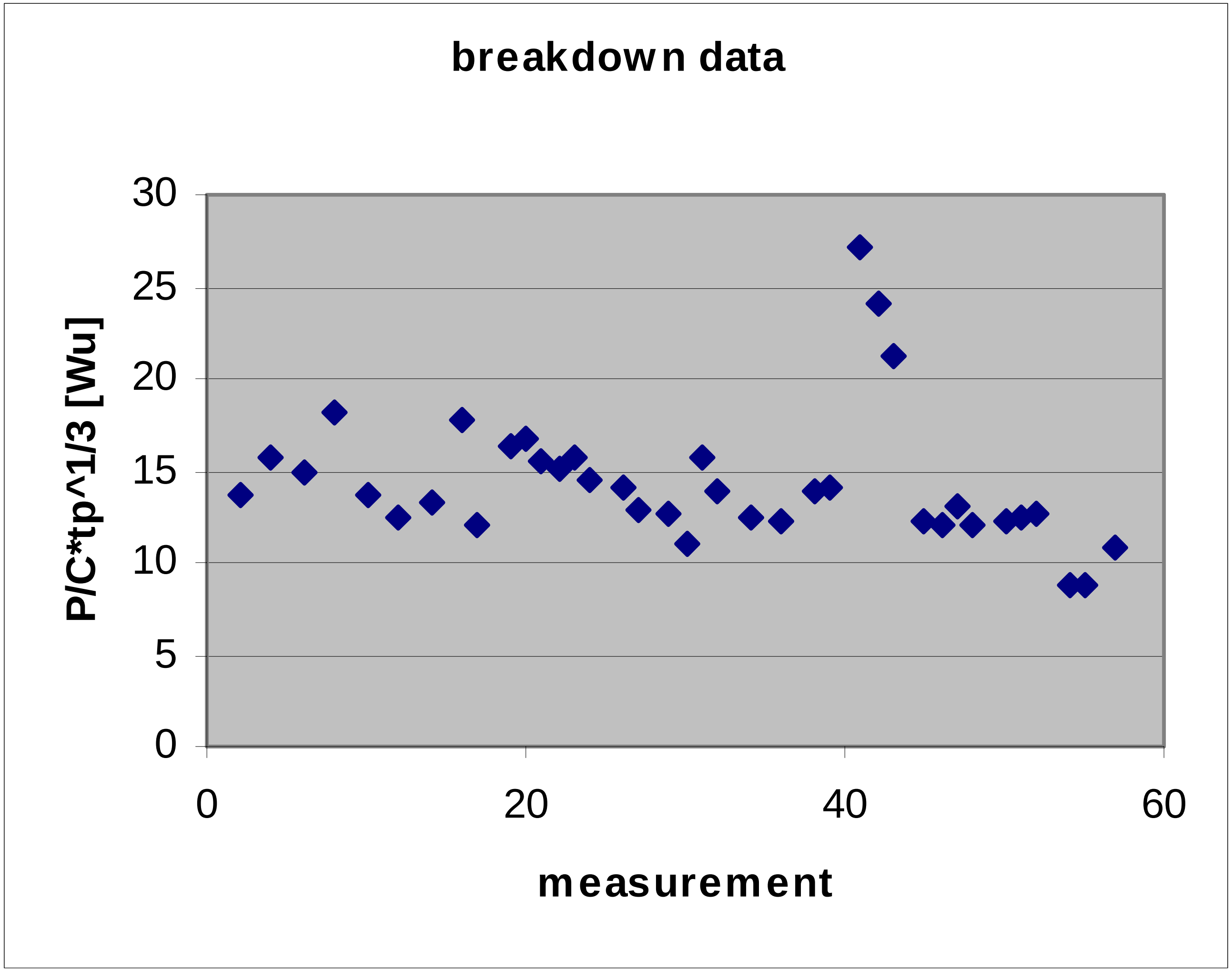
X-band BDR data



$P/C^{*}t_p^{1/3}$

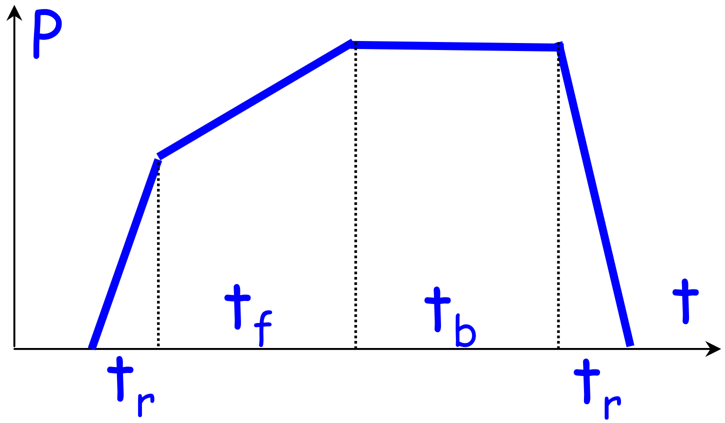
$@BDR=10^{-6}$

$=14.4 \pm 3.6$ Wu

10% lower for HDS: 13 Wu

Data are available in \\cern.ch\dfs\users\a\agrudiev\Public\Breakdown_data_v0.xcl

Pulse length dependence modifications



$$\eta \Rightarrow \eta'$$

$$t_p = t_f + t_b \Rightarrow t_p' = t_f + t_b + t_r$$

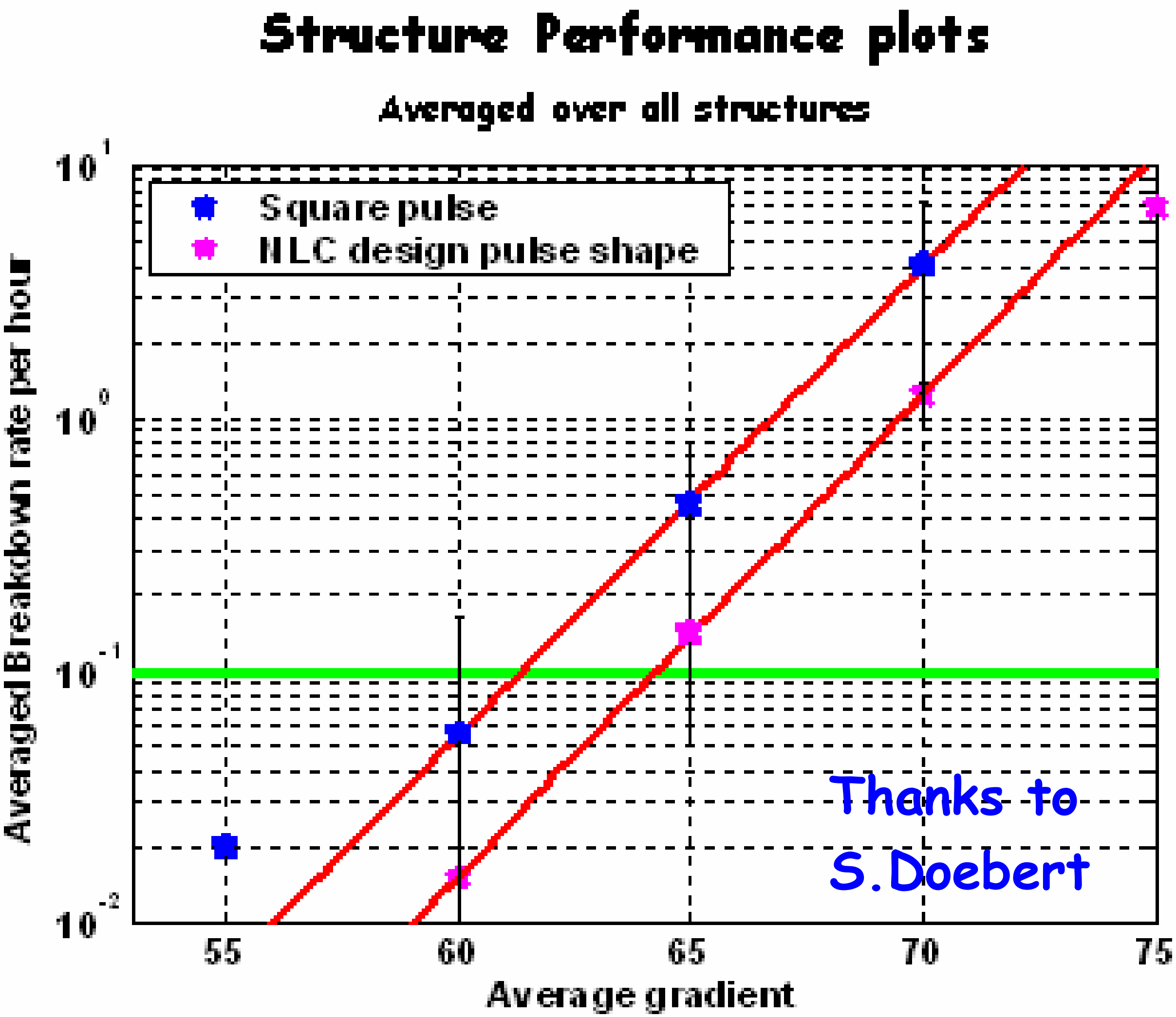
η: $\quad t_p = t_b + t_f + t_r$

Modified:

$\Delta T \sim (t^T_p)^{1/2}$: $\quad t^T_p = [(t_b + t_f + t_r)^{1/2} - 0.5(t_f + t_r)^{1/2}]^2$

$P/C^*(t^P_p)^{1/3}$: $\quad t^P_p = t_b + 0.2(t_f + t_r)$

Effective pulse length for breakdown



Thanks to S.Doebert

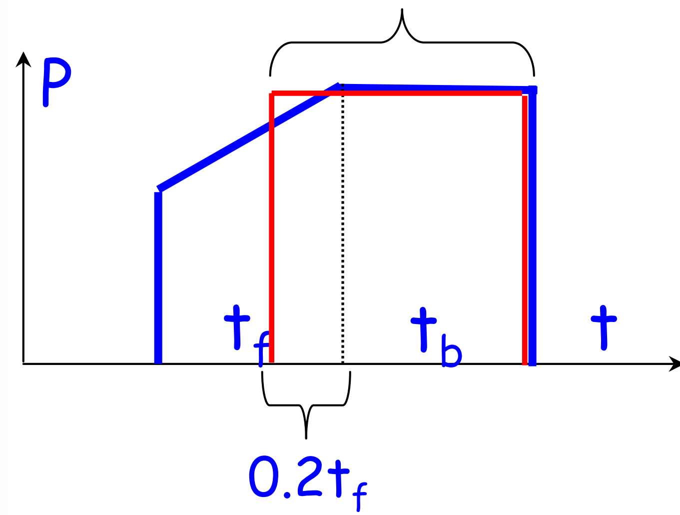
Rect-pulse => NLC-pulse

65 MV/m => 67.5 MV/m

Assuming:

$E_a * t_p^{1/6}$ = const

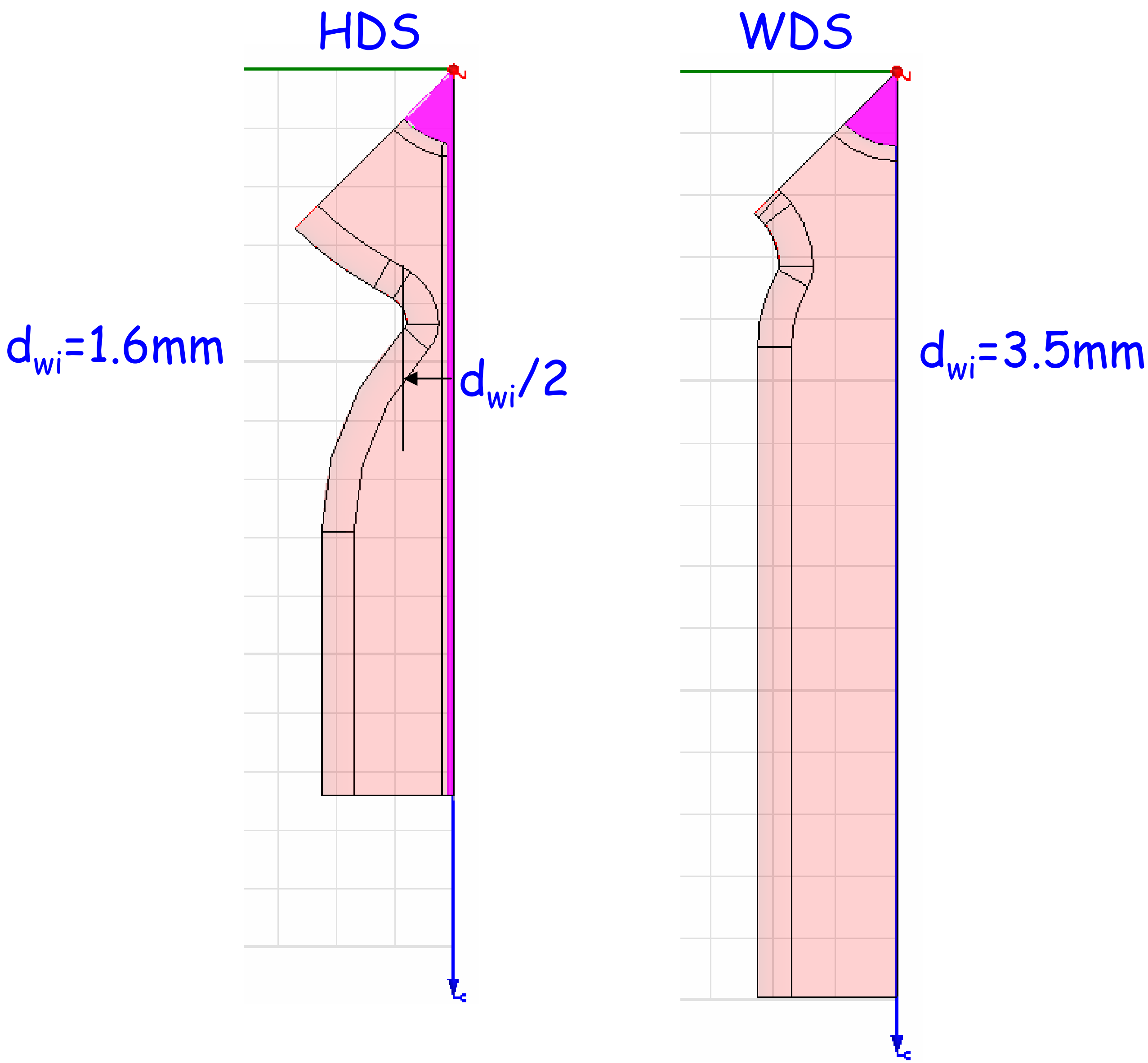
400ns => 320ns



NLC:

t_f = 100 ns; t_b = 300 ns

Different damping



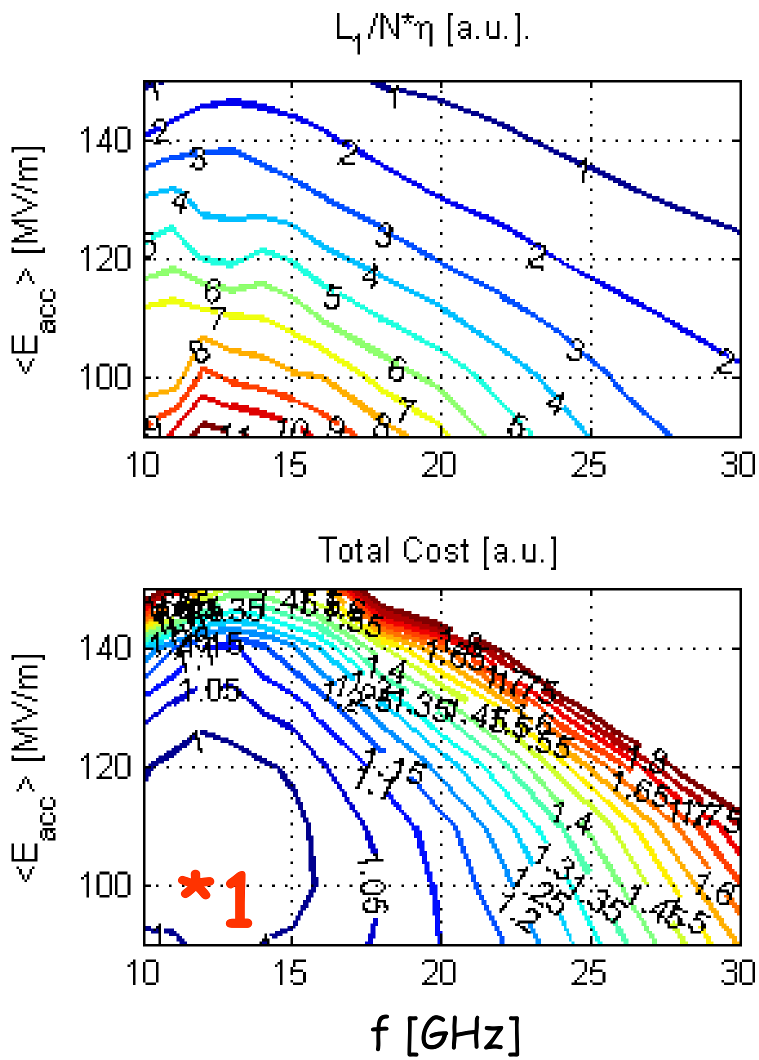
Parameters for different damping

a = 1.1 mm, f = 30 GHz

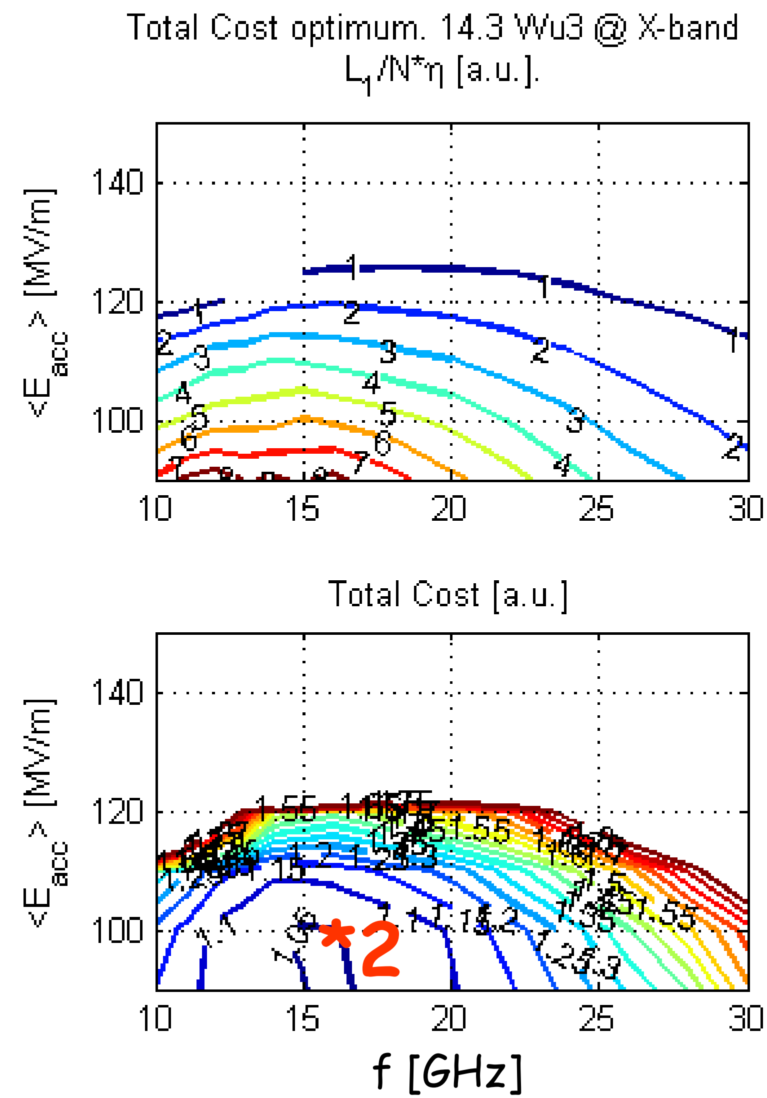
Name	nds70	hds70	hds150	nds150	wds150
$\Delta\varphi$ [°]	70	70	150	150	150
d [mm]	0.3	0.3	0.4166	0.4166	0.4166
e	1.7	1.7	1.0	1.09	1.09
r_i [mm]	1.1	2.2	1.4	1.1	1.1
Q^{Cu}	3022	2892	4980	4955	4452
v_g/c [%]	2.05	2.4	1.0	0.89	0.8
R'/Q [LinacΩ/m]	53631	52013	37195	38212	34560
E_{surf}^{max}/E_a	1.6	1.75	2.4	2.1	2.3
H_{surf}^{max}/E_a [mA/V]	2.25	2.45	2.8	2.6	4.3
P_{in} [MW] @ 100MV/m	6.1	7.3	4.3	3.7	3.7
Q_1	-	9.1	29.3	-	6.8
f_1 [GHz]	-	46.08	46.89	-	43.68
A_1[V/pC/mm/m]	-	2600	600	-	1500

Optimizing HDS, WDS150

HDS, 13 Wu @ X-band

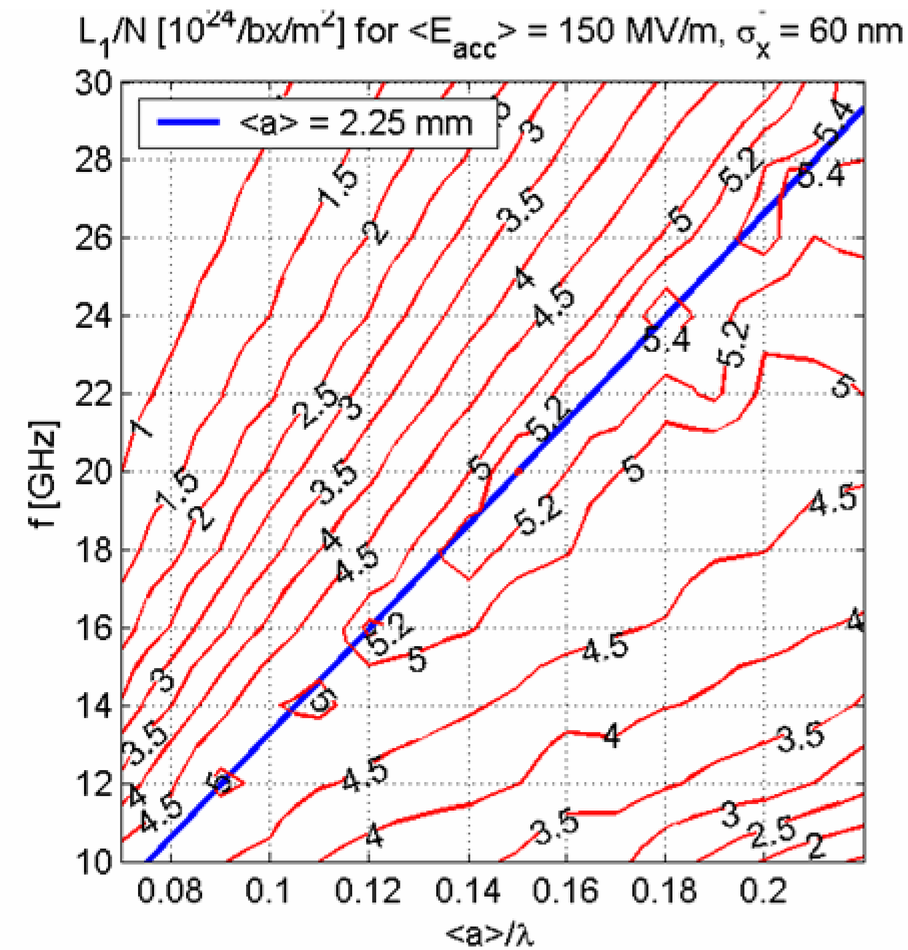


WDS150, 14.3 Wu @ X-band

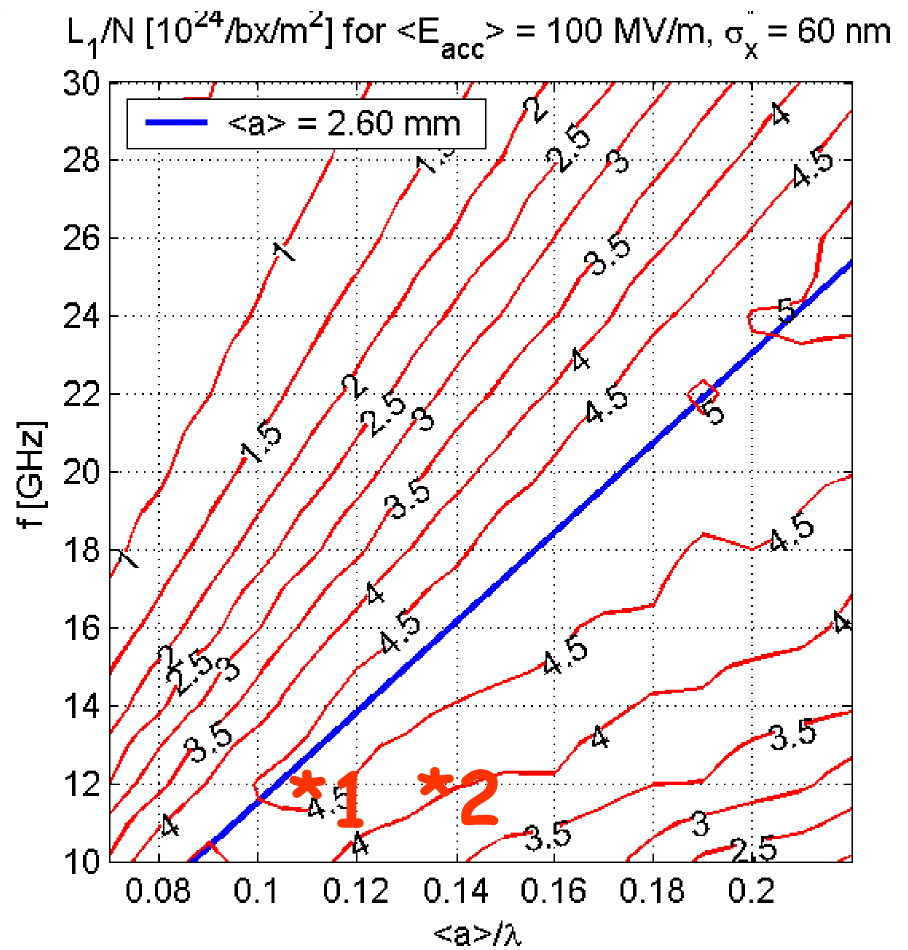


L_1/N for different gradients

$\langle E_{acc} \rangle$ = 150 MV/m



$\langle E_{acc} \rangle$ = 100 MV/m



Parameters of WDS for CLIC

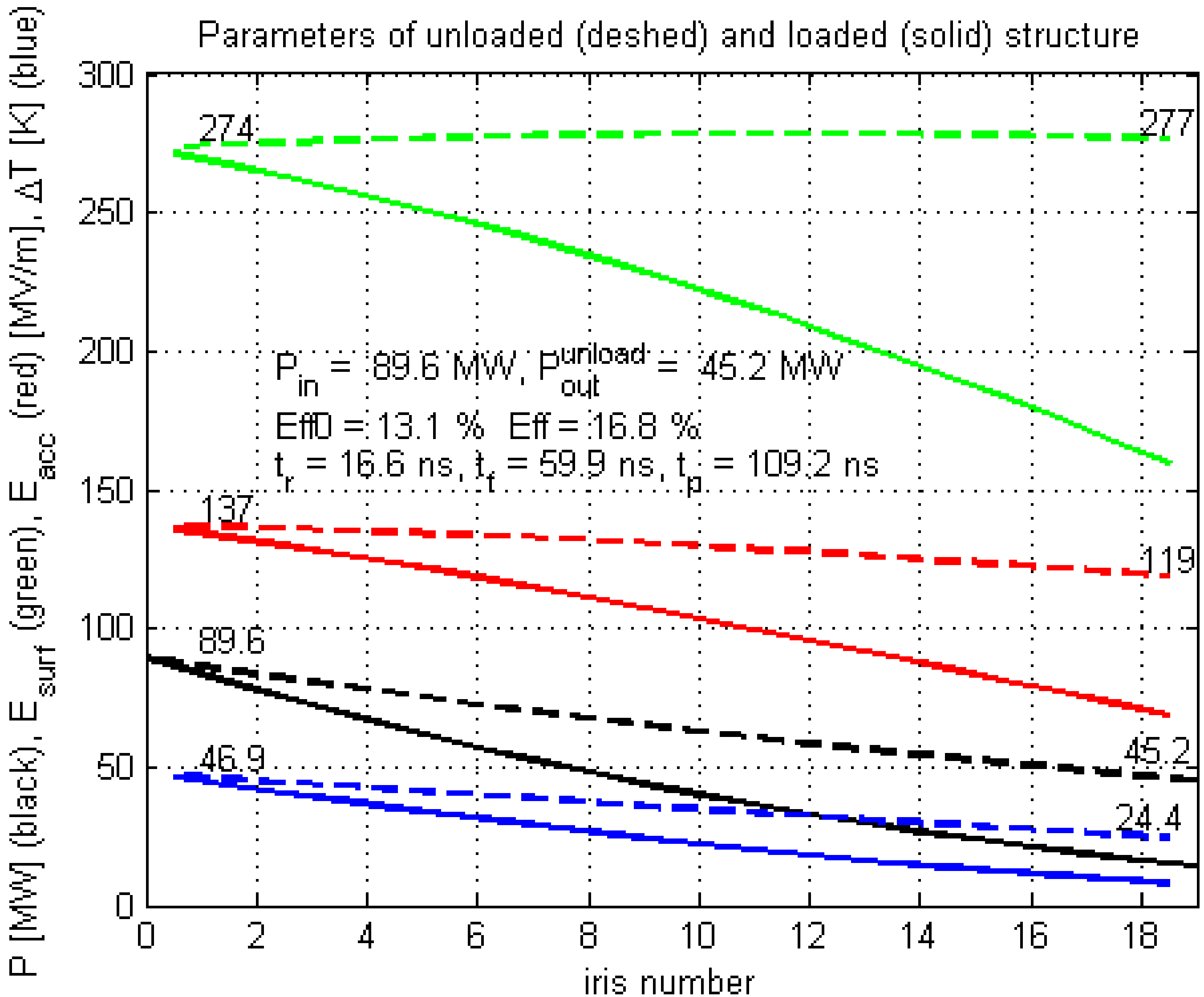
Structure number	0	1	2	3	4
RF phase advance per cell: $\Delta\varphi$ [º]	70	150	150	150	150
Average iris radius over wavelength: $<a>/\lambda$	0.09	0.115	0.13	0.135	0.14
Input/Output iris radii: $a_{1,2}$ [mm]	2.93, 1.58	3.18, 2.57	3.85, 2.65	3.73, 3.02	3.9, 3.1
Input/Output iris thickness: $d_{1,2}$ [mm]	0.625	1.25	2.5, 1.25	2.38, 1.25	3.25, 1.38
Group velocity: $v_g^{(1,2)}/c$ [%]	3.00, 0.48	1.21, 0.57	1.46, 0.63	1.35, 1.02	1.20, 1.05
Number of cells, structure length: N_c, l [mm]	28+3, 151	17, 177	19, 198	19, 198	19, 198
Bunch separation: N_s [rf cycles]	5	5	6	7	7
Number of bunches in a train: N_b	146	117	95	60	57
Pulse length, rise time: τ_p, τ_r [ns]	144.9, 44.1	156.4, 36.2	148.0, 31.5	108.3, 17.4	109.2, 16.6
Input power: P_{in} [MW], $P/C_{1,2}$ [MW/mm]	42, 2.2	65, 3.2, 1.8	80, 3.3, 2.2	86, 3.6, 2.4	91, 3.7, 2.3
Max. surface field: E_{surf}^{max} [MV/m]	236	313	315	284 (const)	276 (const)
Max. temperature rise: ΔT^{max} [K]	28	37 (const)	40 (const)	39	50
Efficiency: η [%]	16.0	17.7	18.3	15.0	15.1
Luminosity per bunch X-ing: $L_{b\times}$ [m^{-2}]	1.08×10^{34}	2.13×10^{34}	2.78×10^{34}	3.04×10^{34}	3.26×10^{34}
Bunch population: N	2.78×10^{9}	4.76×10^{9}	6.45×10^{9}	7.18×10^{9}	7.86×10^{9}
Figure of merit: $\eta L_{b\times}/N$ [a.u.]	6.23	7.9	7.9	6.37	6.26
	2006	v_g > 0.5%		v_g > 1%	

Parameters of WDS for CLIC

For CLIC design luminosity: $L_1 = 3.3\times10^{34} cm^{-2}s^{-1}$

Structure number	0	1	2	3	4
Frequency: f [GHz]	12	12	12	12	12
Repetition frequency: f_{rep} [Hz]	210	132	-	181	-
RF input power: P_l [MW/linac]	127	100	-	124	-
RF energy per pulse: P_l/f_{rep} [kJ/linac]	606	758	-	687	-
Electricity cost for 10 years: C_e [a.u.]	0.1	0.08	-	0.1	-
Investment cost: C_i [a.u.]	0.93	1.0	1.0	1.0	1.01

Parameters of WDS150#4



Parameters of HDS for CLIC

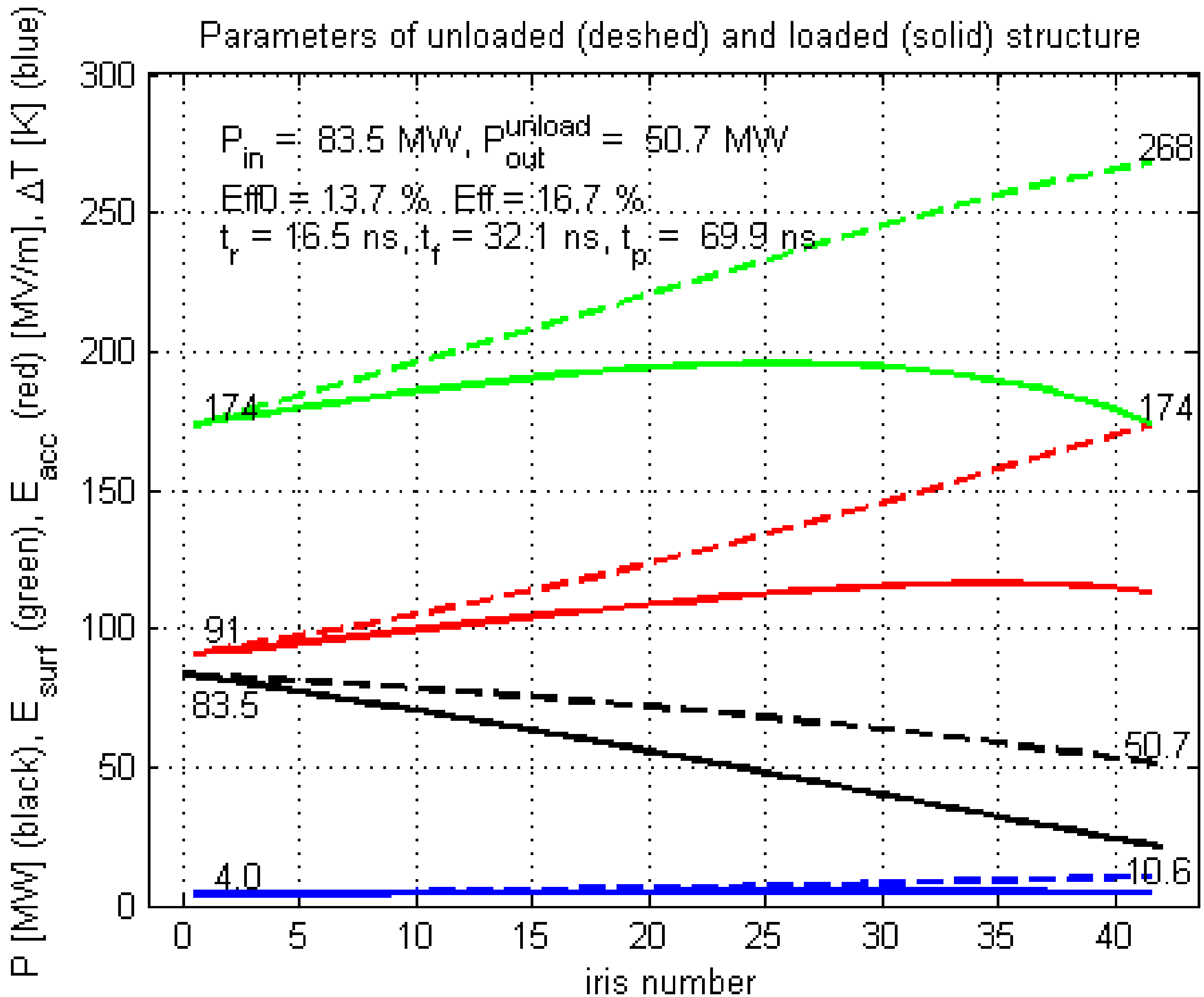
Structure number	0	1	2	3	4
RF phase advance per cell: $\Delta\varphi$ [º]	70	70	70	70	70
Average iris radius over wavelength: $\langle a\rangle/\lambda$	0.09	0.1	0.105	0.095	0.11
Input/Output iris radii: $a_{1,2}$ [mm]	2.93, 1.58	3.25, 1.75	3.4, 1.85	2.68, 2.07	3.44, 2.06
Input/Output iris thickness: $d_{1,2}$ [mm]	0.625	0.625	0.625	0.625	0.75, 0.625
Group velocity: $v_g^{(1,2)}/c$ [%]	3.00, 0.48	4.07, 0.65	4.60, 0.76	2.34, 1.06	4.55, 1.06
Number of cells, structure length: N_c, l [mm]	28+3, 151	37+3, 194	42+3, 219	38+3, 199	42+3, 219
Bunch separation: N_s [rf cycles]	5	5	5	6	5
Number of bunches in a train: N_b	146	135	83	80	52
Pulse length, rise time: τ_p , τ_r [ns]	144.9, 44.1	125.7, 30.7	97.5, 25.0	95.4, 16.4	69.8, 16.5
Input power: P_{in} [MW], $P/C_{1,2}$ [MW/mm]	42, 2.2	61, 3.0	73, 3.4	56, 3.3, 2.3	84, 3.9
Max. surface field: E_{surf}^{max} [MV/m]	236	257	267	205(const)	266
Max. temperature rise: ΔT^{max} [K]	28	17	15	8	11
Efficiency: η [%]	16.0	20.8	18.3	16.0	15.3
Luminosity per bunch X-ing: $L_{b\times}$ [m^{-2}]	1.08×10^{34}	1.62×10^{34}	1.87×10^{34}	1.41×10^{34}	2.14×10^{34}
Bunch population: N	2.78×10^{9}	3.61×10^{9}	4.11×10^{9}	3.27×10^{9}	4.64×10^{9}
Figure of merit: $\eta L_{b\times}/N$ [a.u.]	6.23	9.29	8.31	6.95	7.08
	2006	$v_g > 0.5\%$		$v_g > 1\%$	

Parameters of HDS for CLIC

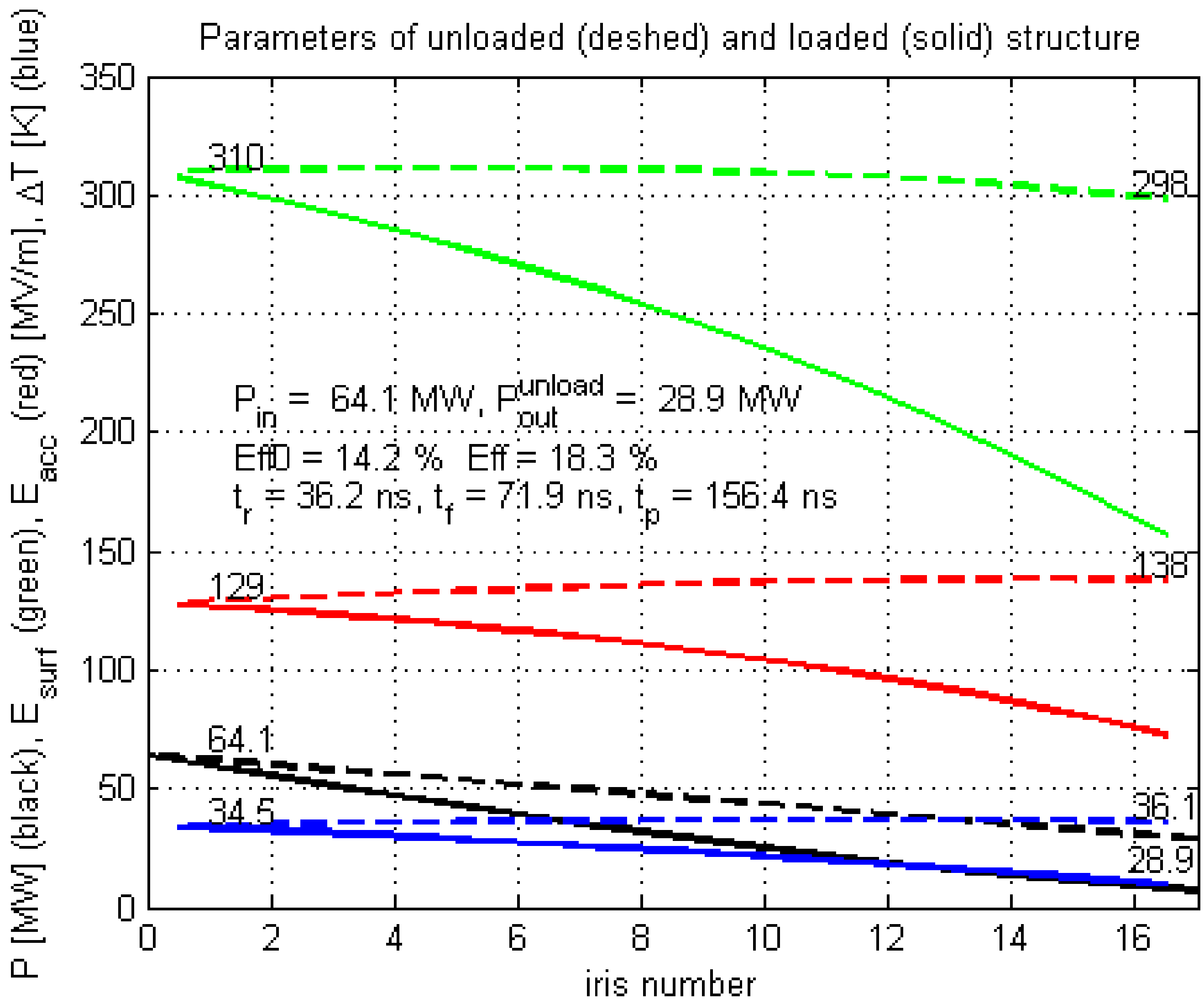
For CLIC design luminosity: $L_1 = 3.3\mathrm{x}10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

Structure number	0	1	2	3	4
Frequency: f [GHz]	12	12	12	12	12
Repetition frequency: f_{rep} [Hz]	210	151	213	292	296
RF input power: P_l [MW/linac]	127	85	95	114	113
RF energy per pulse: P_l/f_{rep} [kJ/linac]	606	564	448	391	377
Electricity cost for 10 years: C_e [a.u.]	0.1	0.075	0.083	0.092	0.092
Investment cost: C_i [a.u.]	0.93	0.9	0.88	0.89	0.9

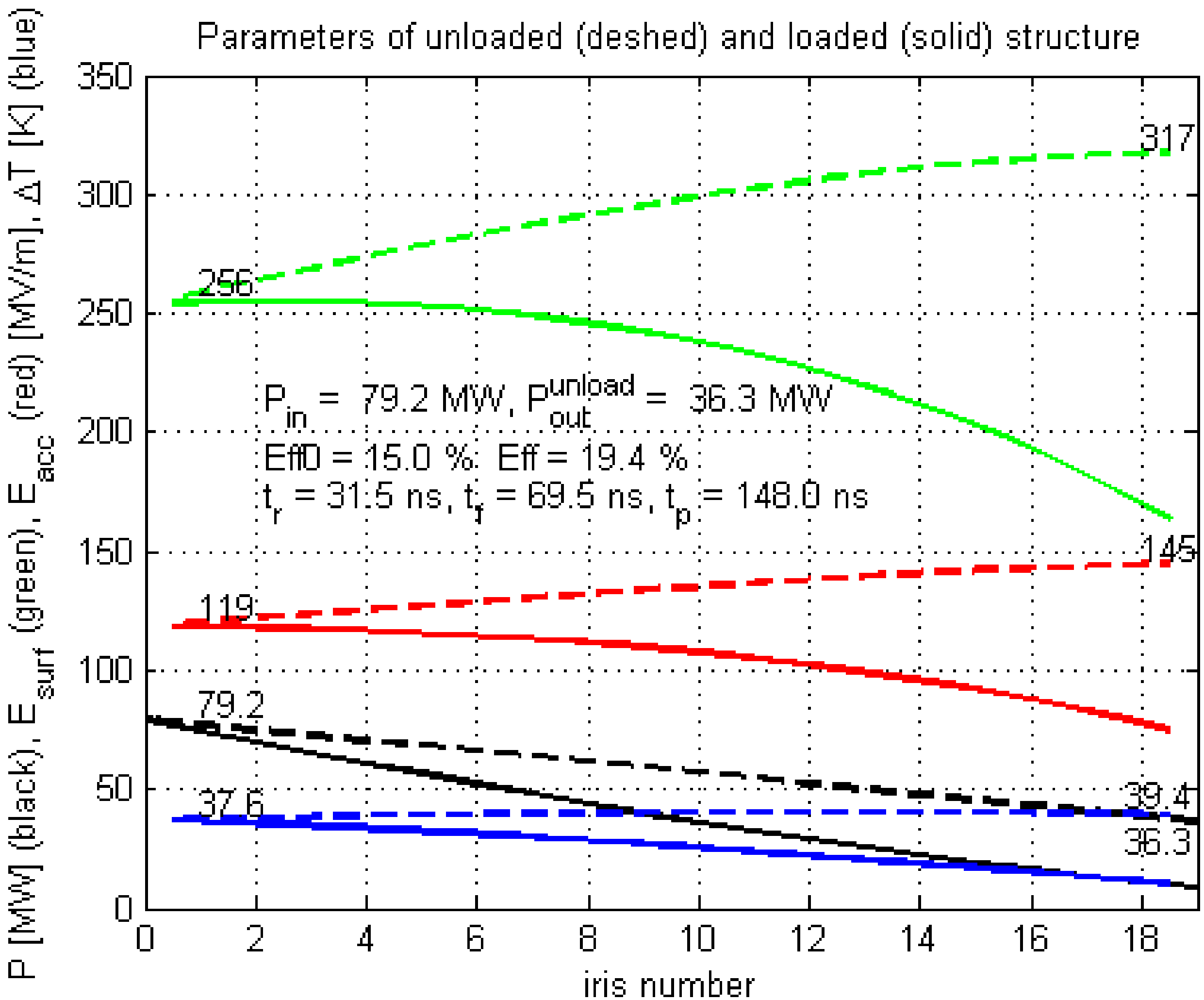
Parameters of HDS#4



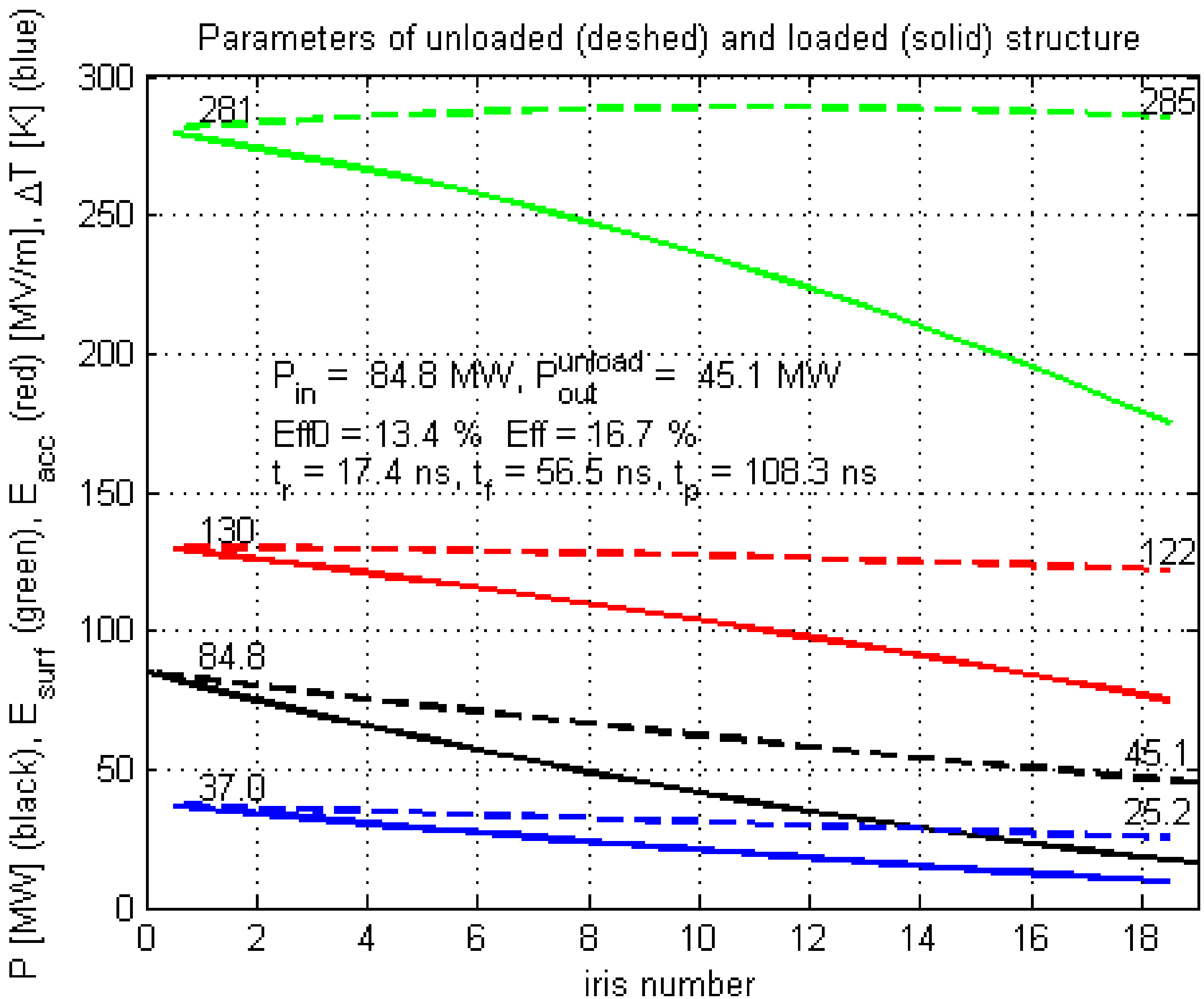
Parameters of WDS150#1



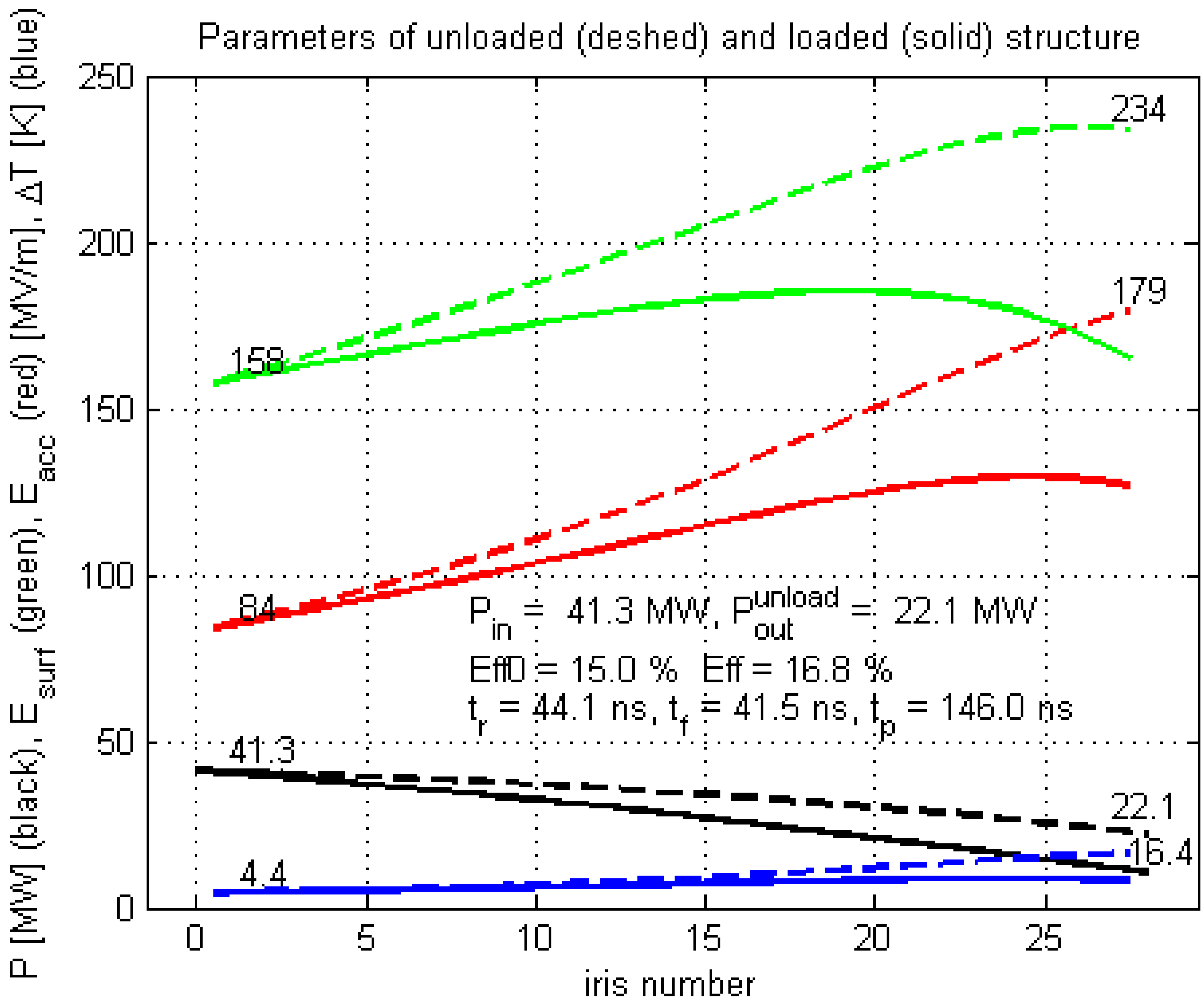
Parameters of WDS150#2



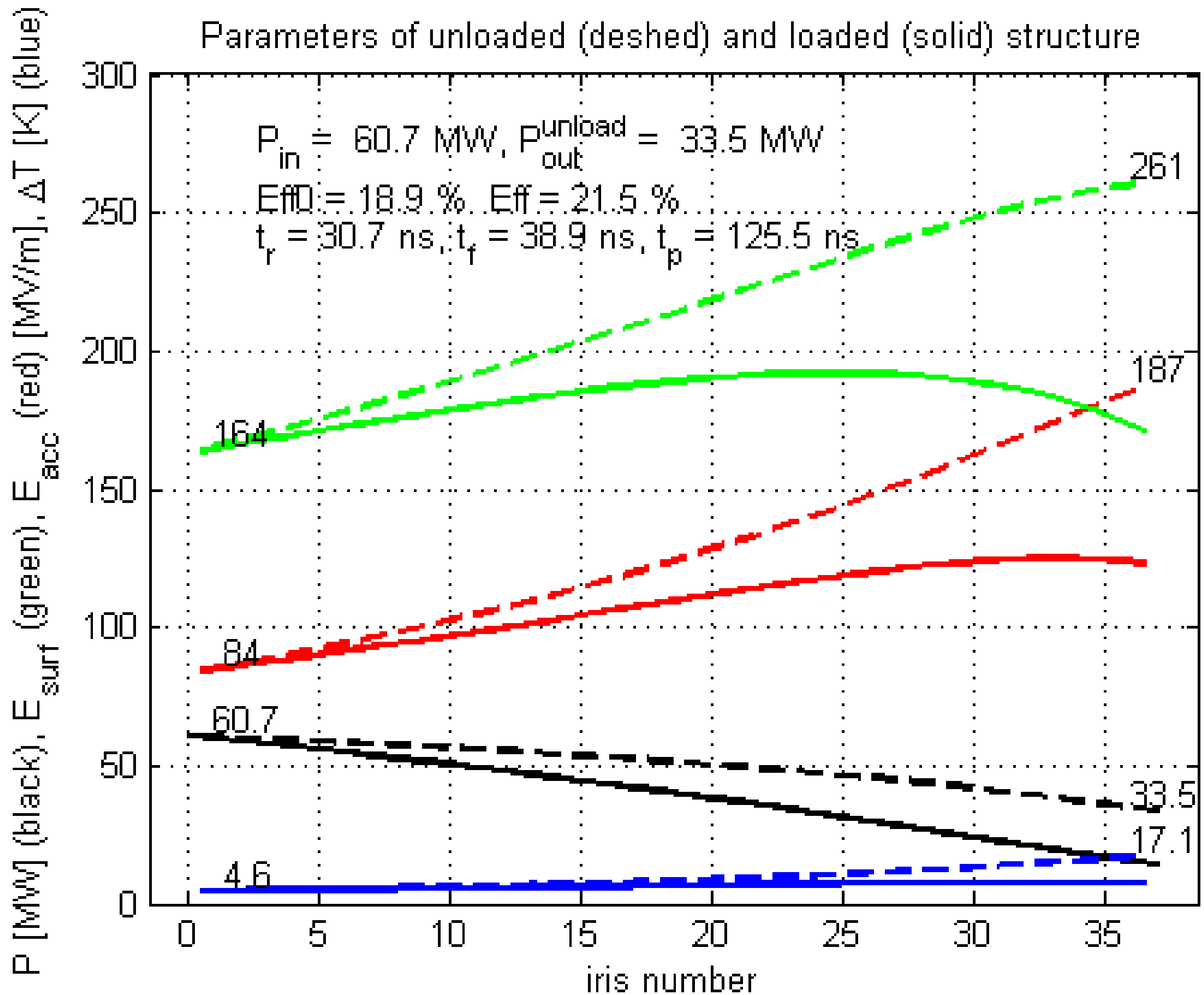
Parameters of WDS150#3



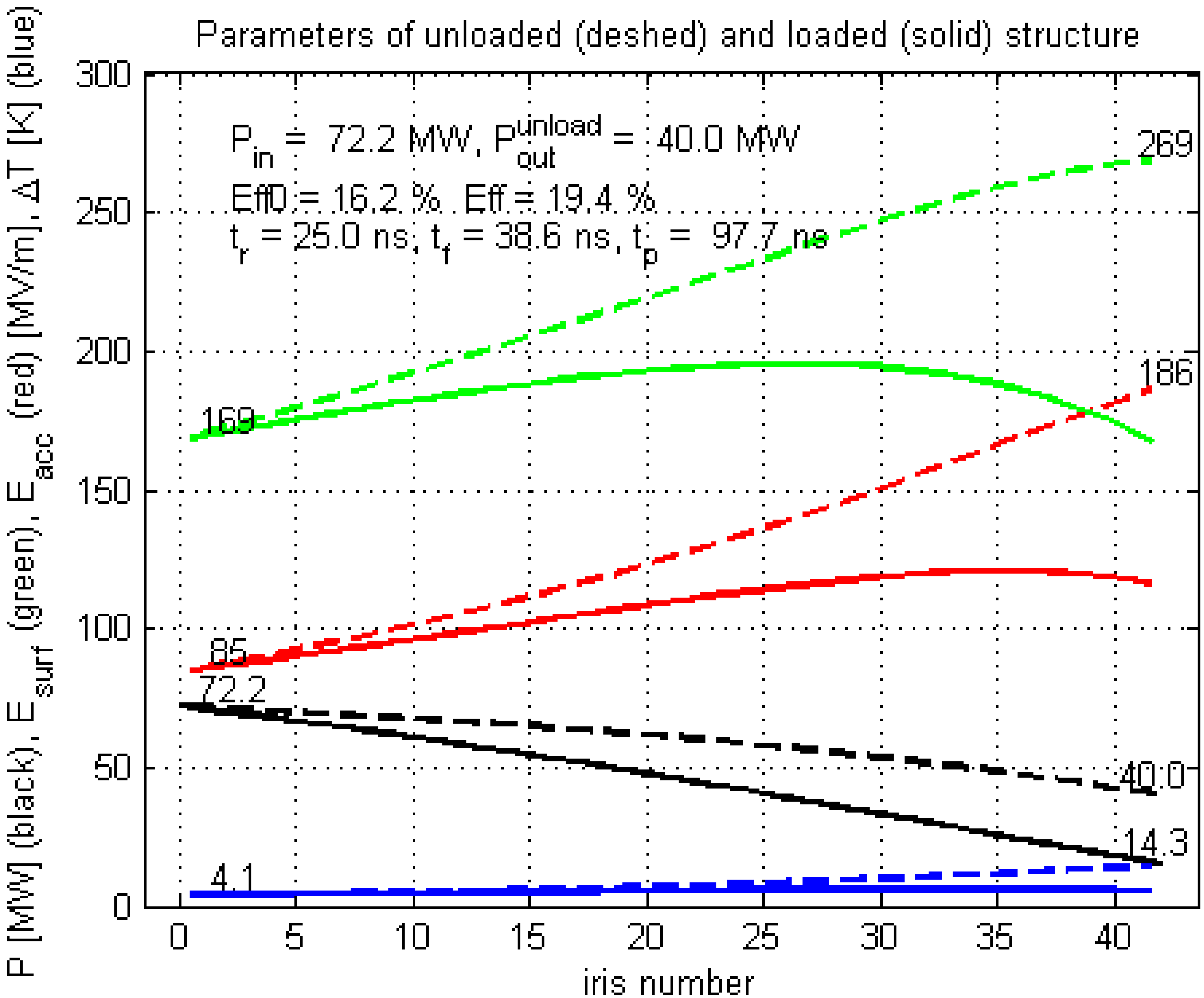
Parameters of HDS#0



Parameters of HDS#1



Parameters of HDS#2



Parameters of HDS#3