Brief update on DR RF demonstration

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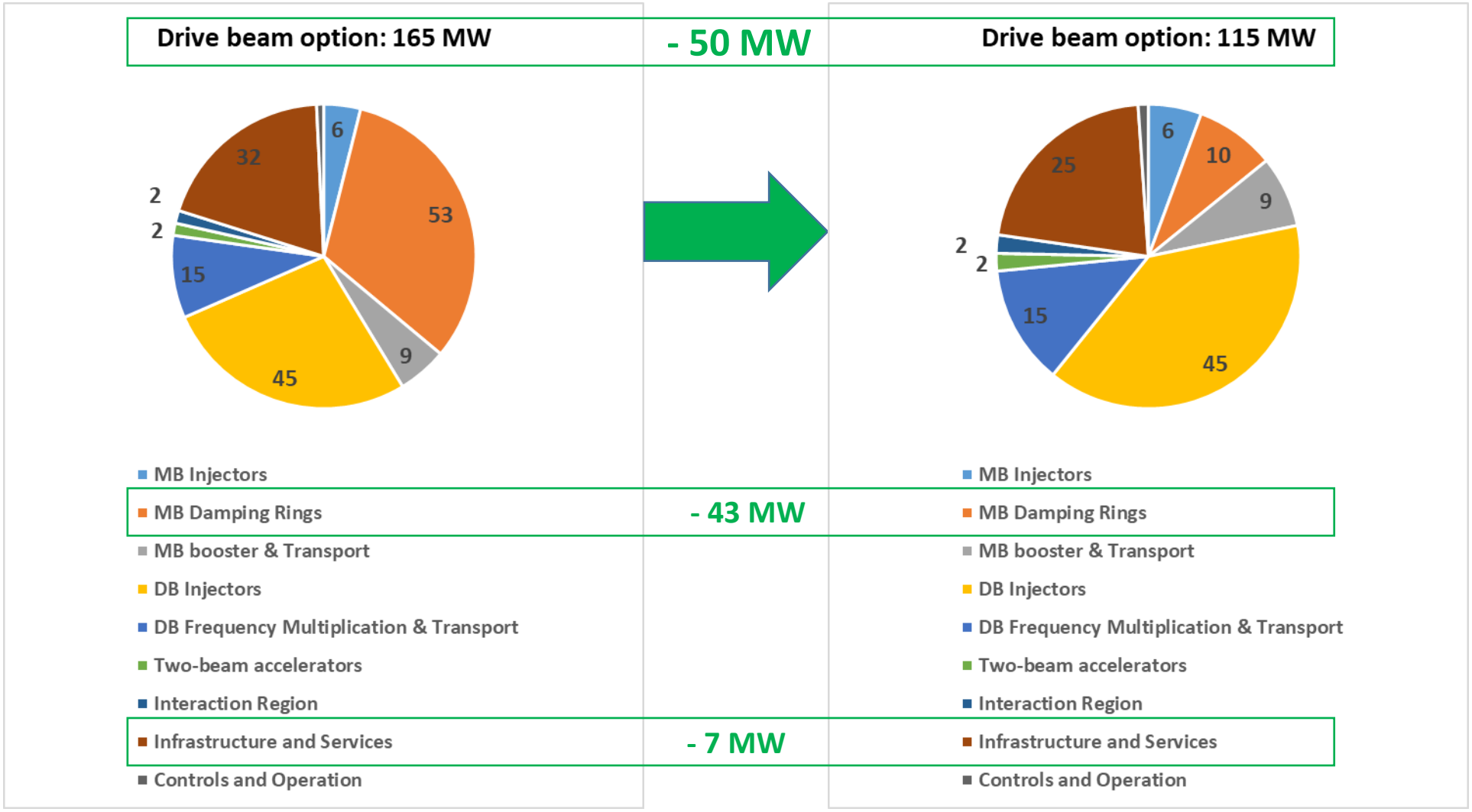
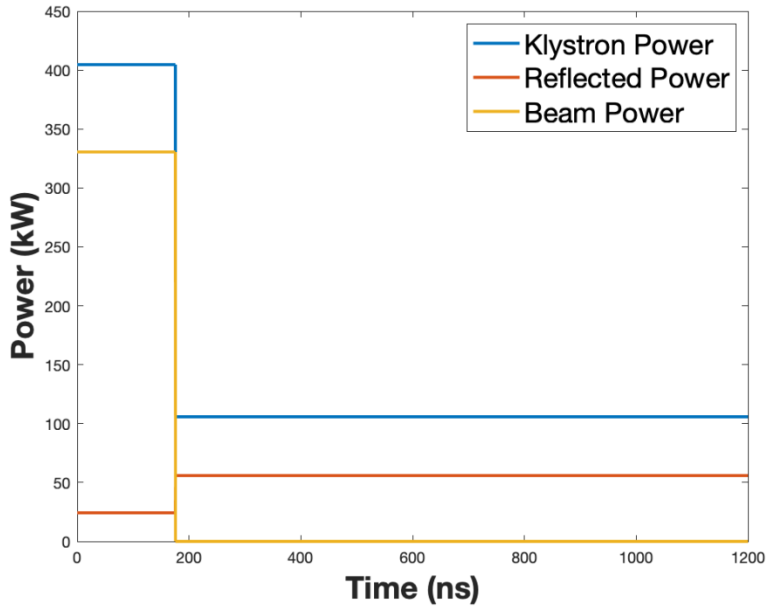
Comparison DR: PIP baseline vs new proposal

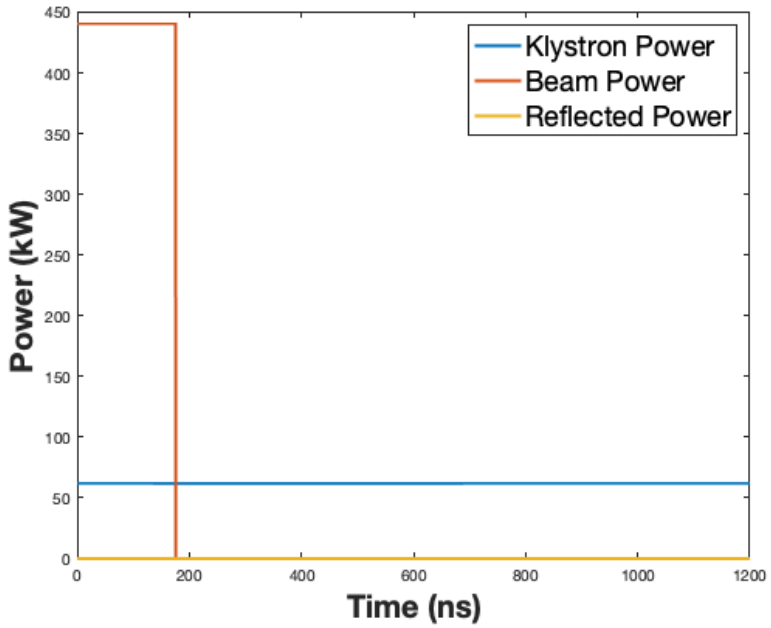


Comparison: PIP baseline vs new proposal

PIP baseline



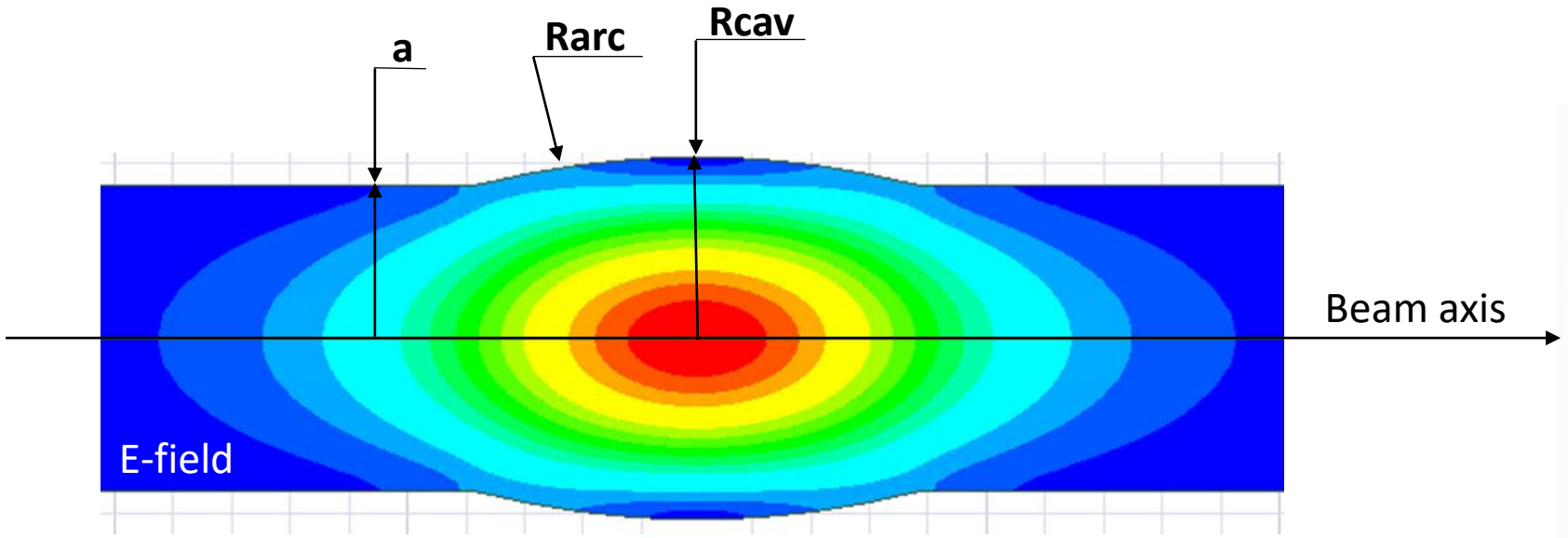
New proposed design #1



Cavity type	ARES	BCC
Cavity R/Q [Ω]	**7.5**	**0.6**
N of cavities	32	24
Peak input power [kW/cavity]	405	62.2
Total peak input power [MW]	**13**	**1.5**

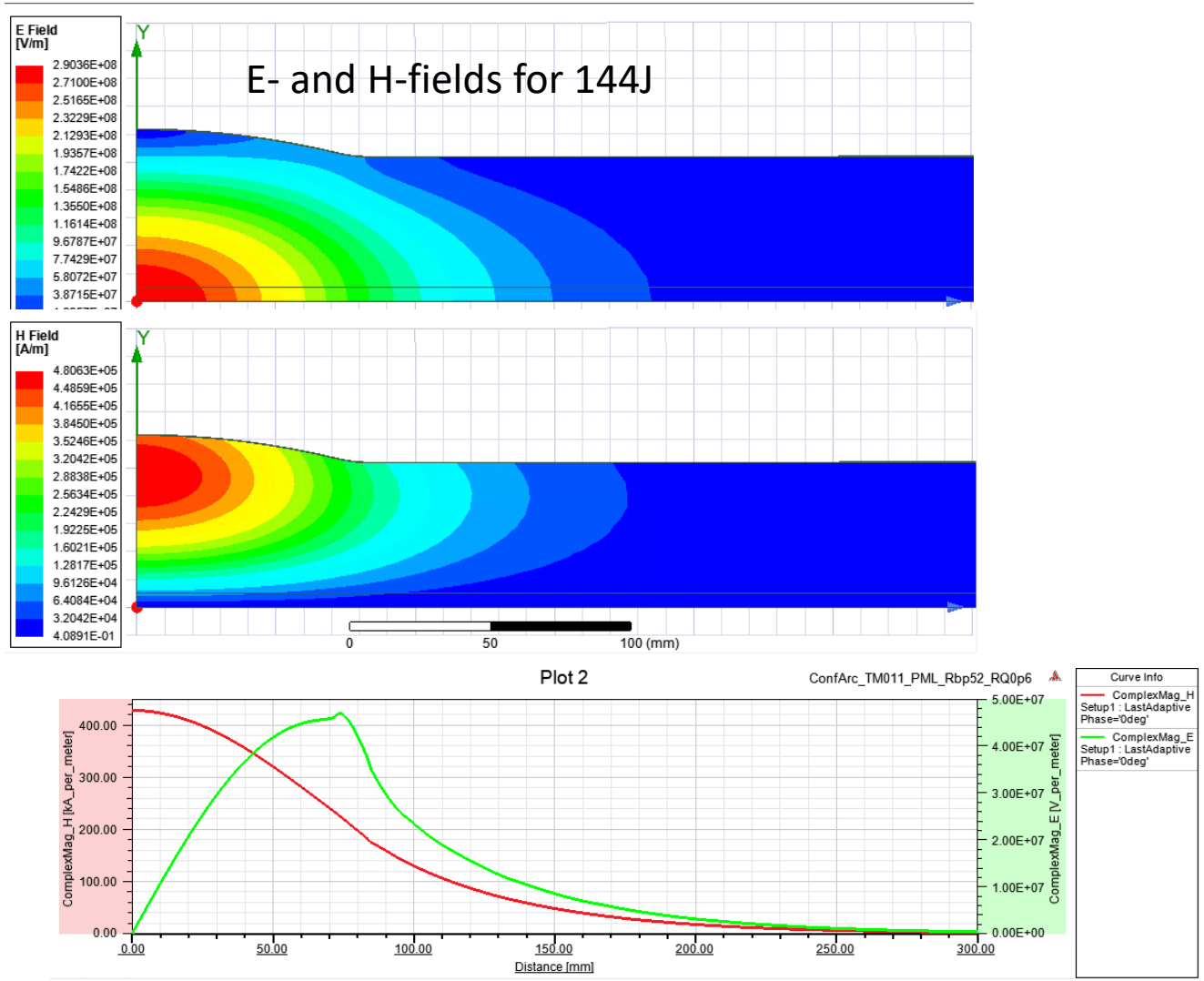
- **RF power match the average beam power => efficient**
- **No klystron power modulation => no large bandwidth**
- **Peak power requirements are SIGNIFICANTLY reduced => cost, size**

Novel cavity: Barrel Cell Cavity (BCC) geometry



- **Large aperture => low R/Q**
- **Long cell: ~λ => low transit time factor**
- **Low field on the cavity wall**

Design of the cavity for total R/Q=14.3Ω



TM011	
a [mm]	52
f [GHz]	2
a/λ	0.347
Lc [mm] (0.01Hmax)	~520
Rarc [mm]	307
Rcav [mm]	61.95
R/Q [Ω]	**0.6**
Emax/Vacc [1/m]	31.6
Hmax/Vacc [mA/Vm]	291

Hmax limit: 80kA/m
⇒ **Vmax = 0.275 MV**
⇒ Umax = 5.0 J
⇒ Emax = 8.7 MV/m

To get this design parameters, two conditions must be met:

R/Q per cavity is 14.3Ω/Ncav

AND

Vmax per cavity is 6.5MV/Ncav

Ncav = 24

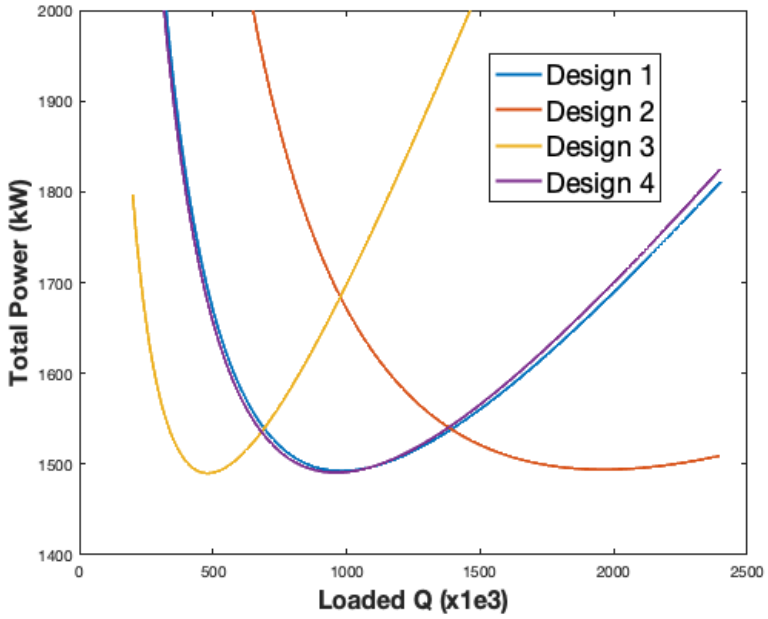
Summary table. More details : CLIC-note-1173, or in rf development meeting

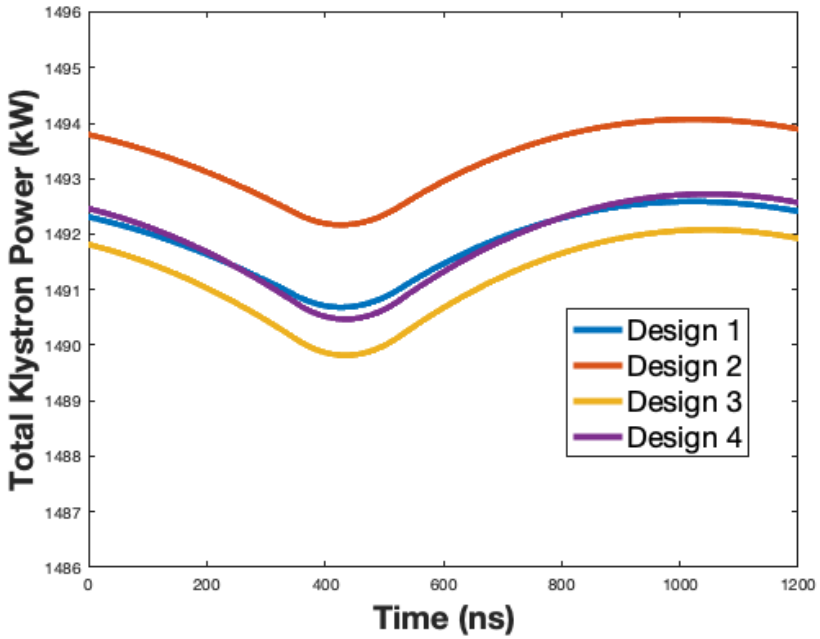
Case	1	2	3	4
Cavity R/Q [Ω]	0.6		2.04	
a [mm]	52		50	
Lc [mm] (0.01Hmax)	520		500	
Rarc [mm]	307		160	
Rcav [mm]	61.95		63.55	
Total R/Q [Ω]	14.3	7.15	28.6	14.3
Bunch phase variation [°] @2GHz	**1**	**0.5**	**2**	**1**
Ncav	**24**	12	14	7
Cavity input power Pin [kW]	60	120	103	**206**
Bmax [mT]	**100**	**200**	**100**	**200**
Hmax [kA/m]	80	160	80	160
Emax [MV/m]	8.7	17.4	11.7	23.4
Cavity voltage Vc [MV]	0.275	0.55	0.47	0.94
Cavity stored energy Uc [J]	5.0	20.0	4.3	17.1

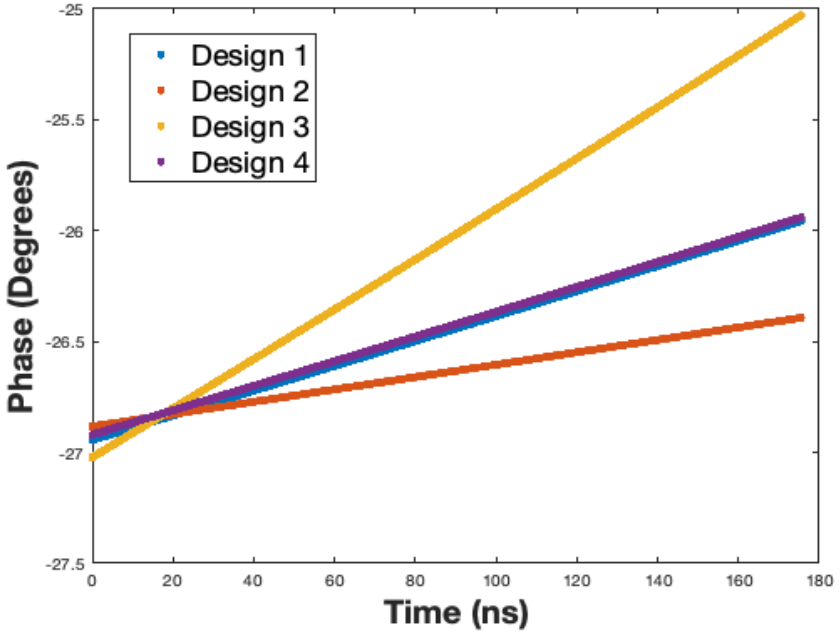
LLRF simulation results

Design	Δf (Hz)	Q_L	Peak power per klystron (kW)	Total peak power (MW)	ϕ_b	Δϕ
1	-514	983e3	62.2	1.49	-26.8°	**0.99°**
2	-257	1962e3	125	1.49	-26.8°	**0.49°**
3	-1020	496e3	107	1.49	-26.8°	**1.99°**
4	-510	990e3	213	1.49	-26.8°	**0.98°**

T. Mastoridis







Due to the very high cavity filling time, the closed-loop response of the RF/LLRF system is slow.
In addition, there is a 350 ns delay in the RF loop. Very small klystron power modulation

380 GeV CLIC DR parameters (PRAB22, 091601)

Parameter of DR		value	unit
Energy	E	2.86	GeV
Circumference	C	373.7	m
Revolution frequency	f_0	802	kHz
RF frequency	f_{RF}	2	GHz
Harmonic number	h	2493	
Energy loss per turn	eV_A	5.8	MeV
RF voltage	V_C	6.5	MV
RF stable phase	ϕ	-26.8	o
Bunch population	N_e	5.7	1e9
Number of bunches per train	N_b	352	
Number of trains	N_t	1	
Peak beam current	I_b	1.8	A

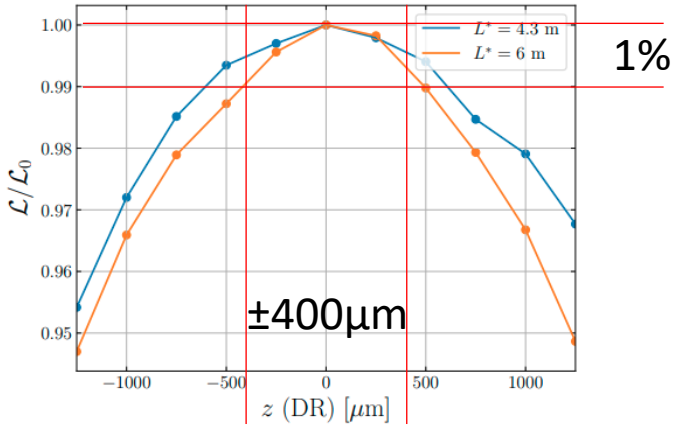


Figure 10: Luminosity against the longitudinal bunch position from the DRs.

Strict specifications on the bunch spacing variation: $\delta\phi_b < \pm 1^o$ at 2 GHz (±400μm) for Luminosity loss < 1% (CLIC-Note-1138)

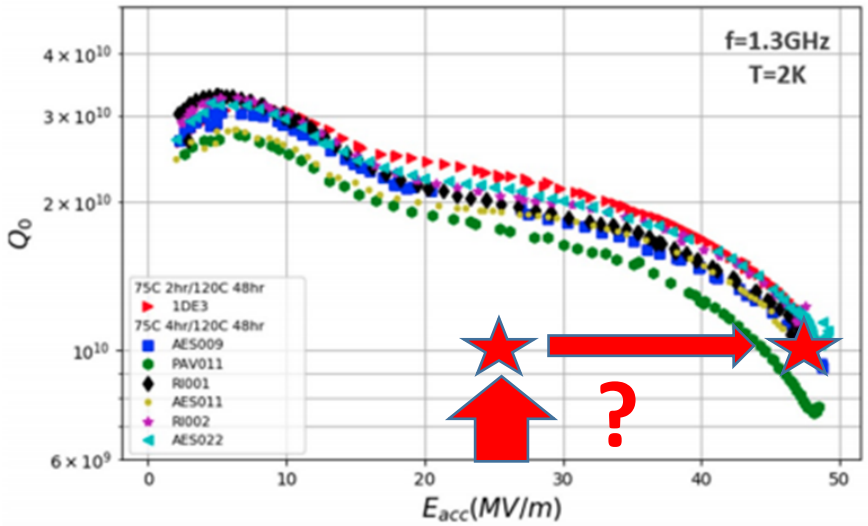
Beam dynamics simulations of the bunch train with linear bunch phase variation must be done from the DR exit to IP to evaluate the impact on the Luminosity

Motivation SRF cavity demonstrator

Q0 ~ 1e10 has been shown for **B ~ 200 mT**

Recent SRF High Gradient R&D: 75/120 C Bake

- Single cell cavities treated with 75/120 C bake have reached unprecedented accelerating gradients ~48-50 MV/m (~ 210 mT, TESLA shape)
- 75 C for ~4 hours, plus standard 48 hour 120 C bake – consistent results in single cells, still studying origin, possibly linked to hydrides
- 50 MV/m cavity sent around for confirmation studies: Cornell, JLab, KEK, DESY



See Grassellino et al. arXiv:1806.09824

A prototype must be built to measure achievable stored energy and Q0 of the cavity

Case 3:
total stored energy 4.3J x 14 cavities = **60J**
=> Total **RF power loss at 2K** with Q0~1e10: **75W**

Summary

- In order to validate the reduction of power consumption thanks to the novel DR cavity design, a demonstrator must be built and tested.
- This tests will allow to improve the design of the cavity and of the DR RF system.
- Design, fabrication and testing of a demonstrator is under evaluation at CERN.
  - Discussed with F. Gerick, O. Capatina, S. Atieh,
  - To be discussed with W. Venturini, …
- DR to IP simulation of the bunch train is necessary to accurately evaluate the impact in the luminosity and provide more accurate specification for the bunch phase variation at the exit of the DR.