On the optimisation of the conceptual design of the SPL (cont'd)

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References:

F. Gerigk (Editor), Conceptual design of the SPL II, CERN-2006-006, 12 July 2006

F. Gerigk, Formulae to calculate the Power Consumption of the SPL SC cavities AB-Note-2006-011 RF

Ph. Bernard E. Chiaveri, J. Tuckmantel, Technical and financial implications of the frequency choice for a superconducting accelerator section, unpublished

On the validation of simulation with Mathematica

Several SPL superconducting linac design parameters (from Yellow Book)		**Simulation with Mathematica**
Maximum peak surface electric field	50 MV/m	50 MV/m
Maximum peak surface magnetic field	100 mT	100 mT
Synchronous phase angle	20º	20º
Cavity quality factor at 2 K ($\beta = 0.65$)	**10^{10}**	**$0.7 \cdot 10^{10}$**
Cavity quality factor at 2 K ($\beta = 1$)	10^{10}	10^{10}
Loaded quality factor ($\beta = 0.65$)	**$0.9 \cdot 10^{6}$**	**$1.2 \cdot 10^{6}$**
Loaded quality factor ($\beta = 1$)	**$1 \cdot 10^{6}$**	**$1.3 \cdot 10^{6}$**
Accelerating gradient ($\beta = 0.65$)	19 MV/m	19 MV/m
Accelerating gradient ($\beta = 1.0$)	25 MV/m	25 MV/m
R/Q ($\beta = 0.65$) linac definition	290 Ω	288 Ω
R/Q ($\beta = 1.0$) linac definition	570 Ω	570 Ω
Frequency	704.4 MHz	704.4 MHz
Number of cells per cavity	5	5
Peak power at 704.4. MHz (beam)	135.2 MW	135.5 MW
Average SC power “neutrino baseline”	**6.0 MW**	**4.8 MW**
String length ($\beta = 0.65$)	85.8 m	84 m
String length ($\beta = 1$)	256.1 m	254 m
Total **installed** cryogenic capacity equivalent at 4.5 K (6 % duty cycle)	**15.8 kW**	**6 kW (needed)**
Cryo duty cycle	**4.6 %**	**5.8 %**
Number of cavities ($\beta = 0.65$)	42	42
Number of cavities ($\beta = 1$)	136	128

Deviations of more than 10 % in RED

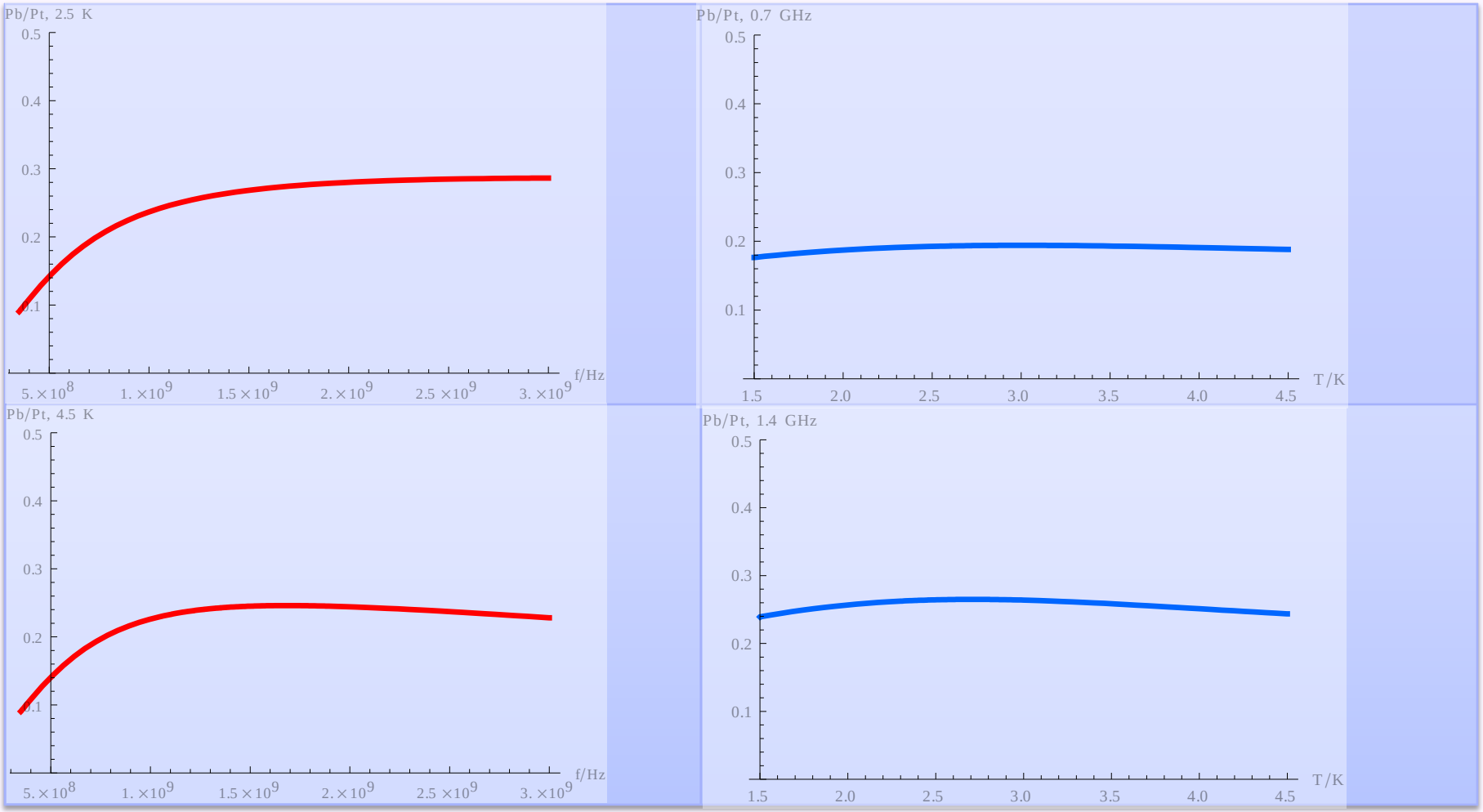
On the validation of simulation with Mathematica (2)

Fix parameters used in simulation with Mathematica	
Residual surface resistance at maximum gradient	24 nΩ
Static cryogenic losses	15 W/m
Real estate efficiency	50 %
Total RF efficiency	40 %
Thermodynamic efficiency	20 %

Equations used in Mathematica for the cost simulation
`ccav[f_]:=3.743/(f/10^6)^.37 (* MCHF in 1996per cavity made of bulk niobium, f in Hz *)`
`crf[p_,f_,b_]:=3.2*10^-3*(f/10^6)^.32*(p/10^3)^.667+0.025 *ntot[f,b](* MCHF in 1996 *)`
`ccryo[p_]:=2.5*(p/10^3)^0.6(* MCHF in 1996 *)`
`cel[p_,time_]:=0.07/10^6*p/1000*time (* MCHF in 1996 for time hours of operation; time = 10 year -> 40000 h *)`

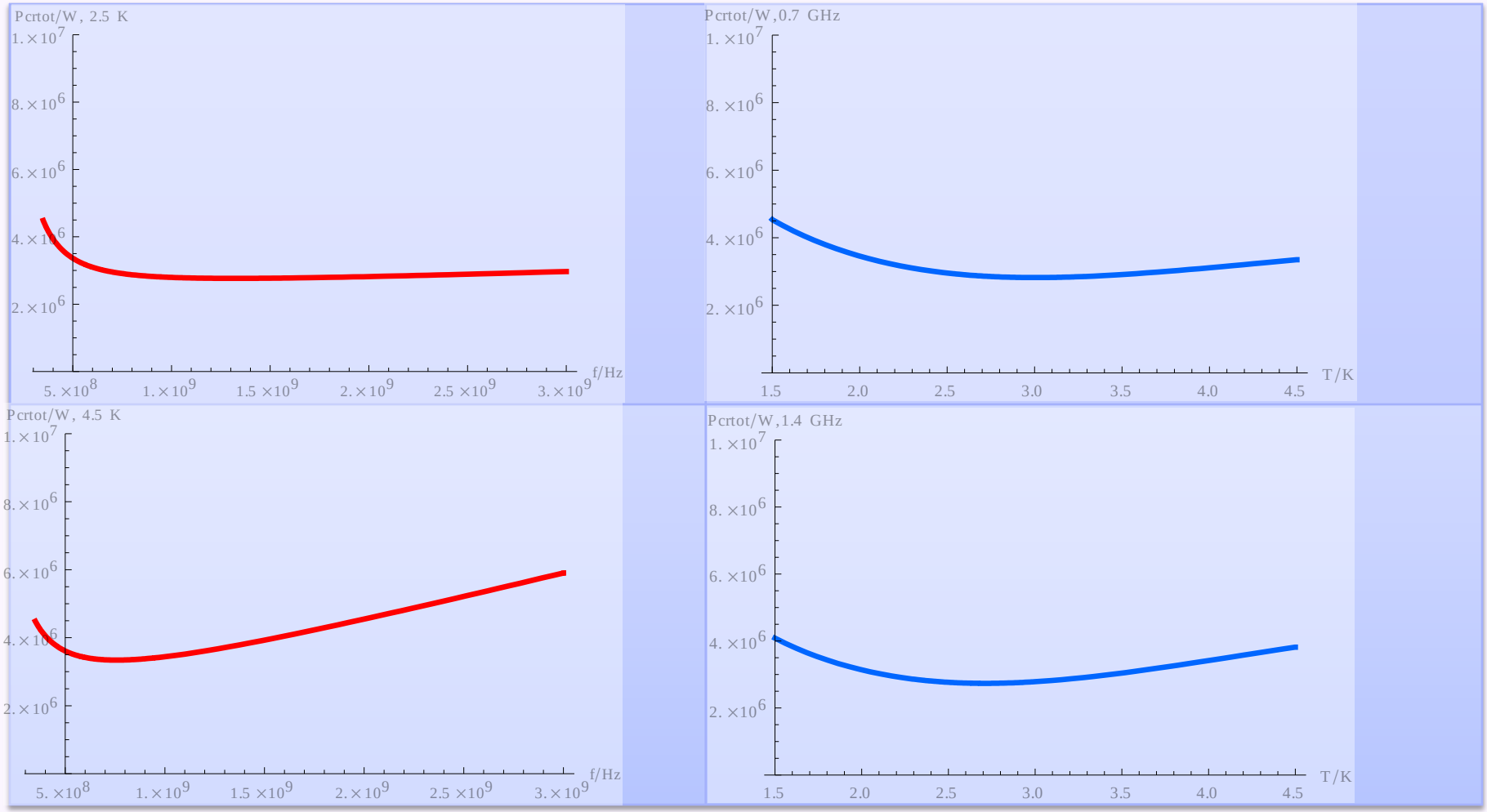
Optimization calculation related to the frequency and the operating temperature

Transfer efficiency electrical grid to beam



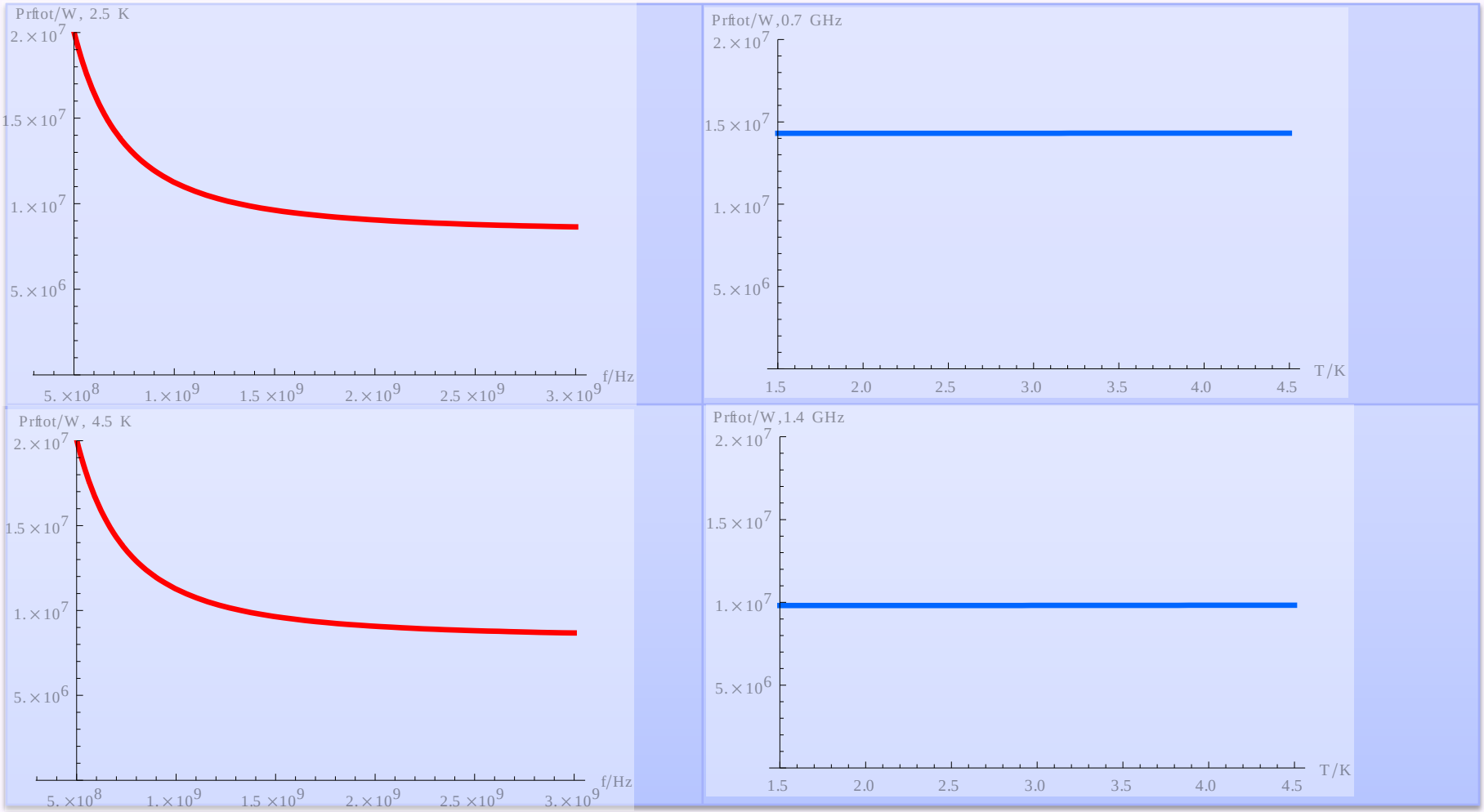
Optimization calculation related to the frequency and the operating temperature (2)

Electrical power needed to operate cryo-plant for whole linac



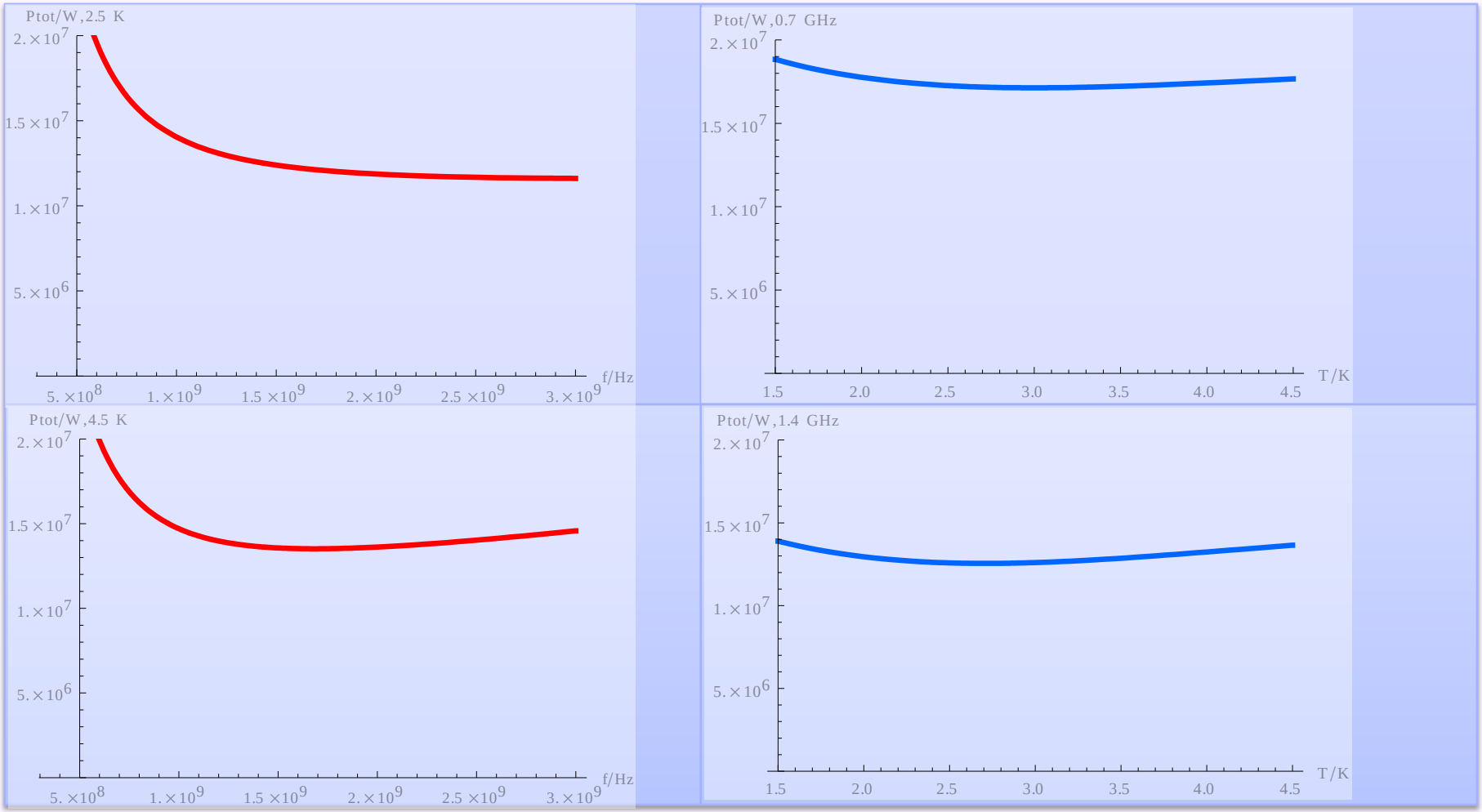
Optimization calculation related to the frequency and the operating temperature (3)

Electrical power needed to operate RF stations for whole linac



Optimization calculation related to the frequency and the operating temperature (4)

Total electrical power needed to operate whole linac



Optimization calculation related to the frequency and the operating temperature (5)

Total investment plus operation in 10 years