LHC-MKI (Injection Kicker Magnet) Impedance Simulations - Update and Summary

H. Day, B. Salvant, M. Barnes, E. Metral, F. Caspers

January 25, 2012

Introduction

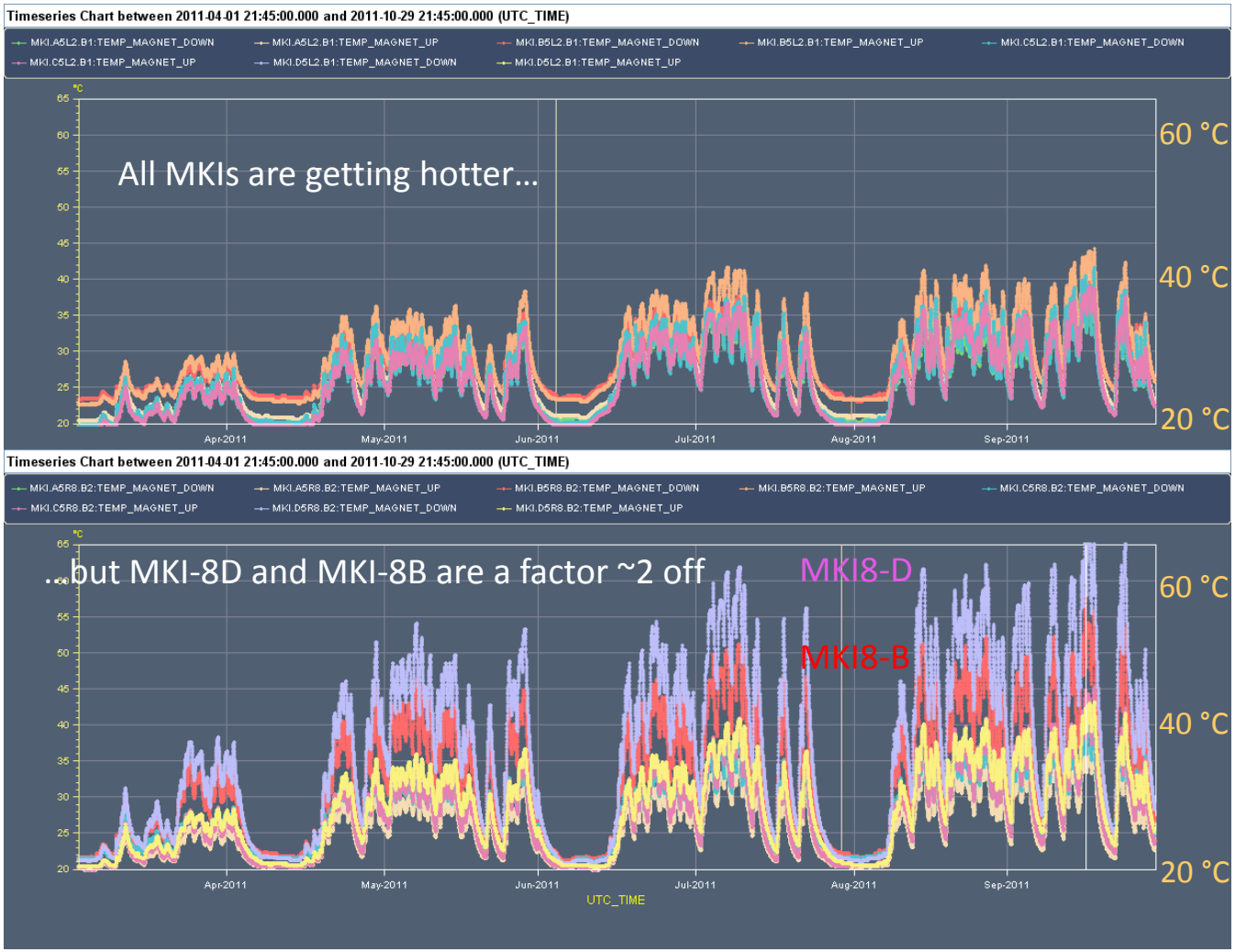
Background - During the 2011 run heating and pressure increases were noted in the LHC-MKI which could be attributed to beam-induced heating. Required to reevaluate the impedance model of the LHC-MKI and past heating estimates
AIM:

- To acquire a simulation model of the LHC-MKI that reproduces the results of existing coaxial wire measurements
- To use the simulation model to obtain heating estimates for the LHC-MKI using diffierent beam screen configurations
- To examine alternative beam screen designs to see if they improve the heating situation

MKIs: steady temperature increase over 2011

MKI in point 2

MKI in point 8

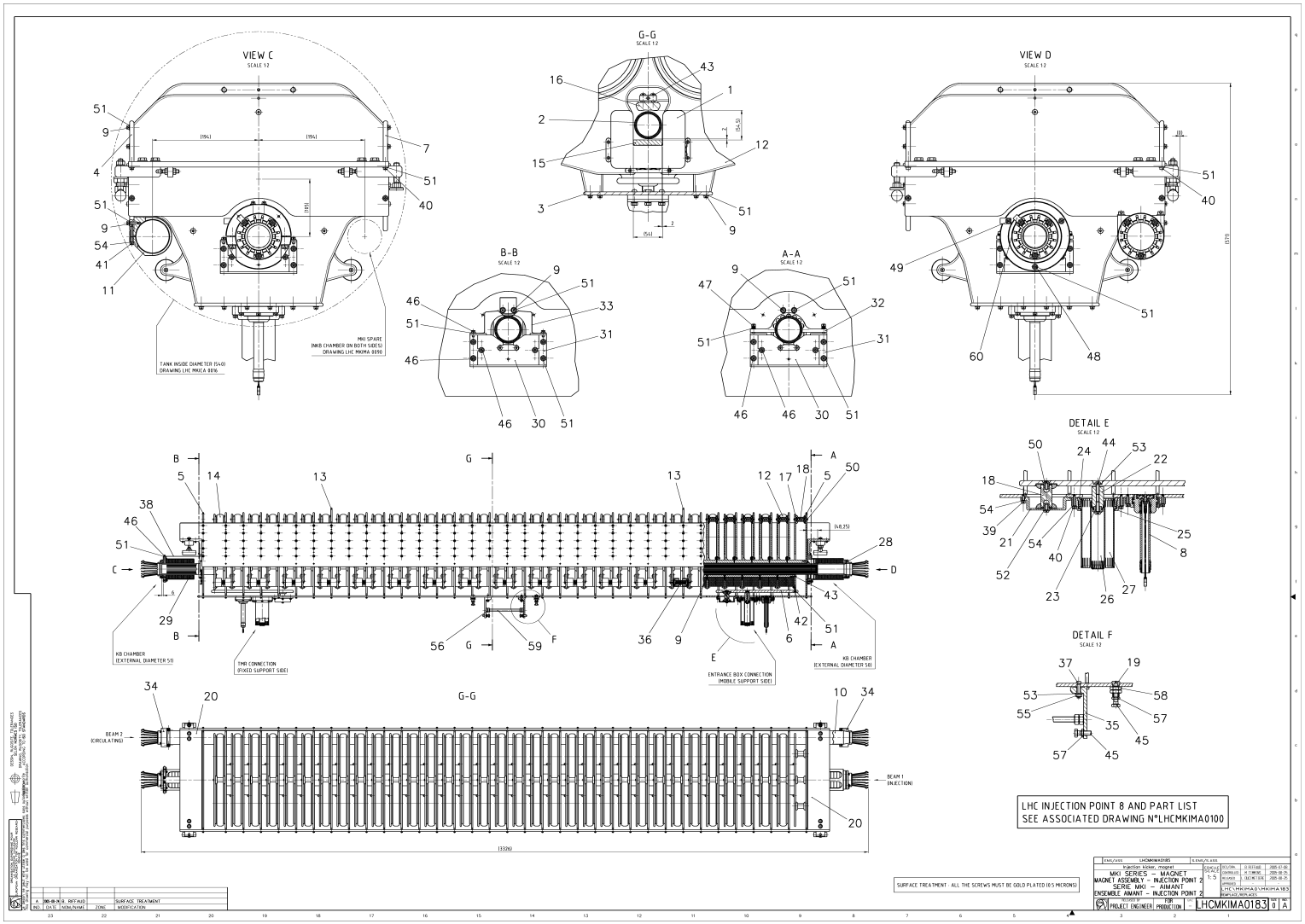


April 1st 2011 → October 31st 2011

LHC-MKI Structure

- The LHC-MKI is a very complex internal structure (See Fig. 2).
- Some 3m of transmission line kicker magnet, with components varying in scale from order of metres to tenths of a millimetre - Very difficult to mesh properly
- Structure has a mixture of resistive wall impedances (ferrite blocks) and cavity-like impedances (vacuum tank and conductive strips) - integrated wakelength must be long to correctly evaluate both (integrated wakelength of 15m used for all simulations)

Simulation Model



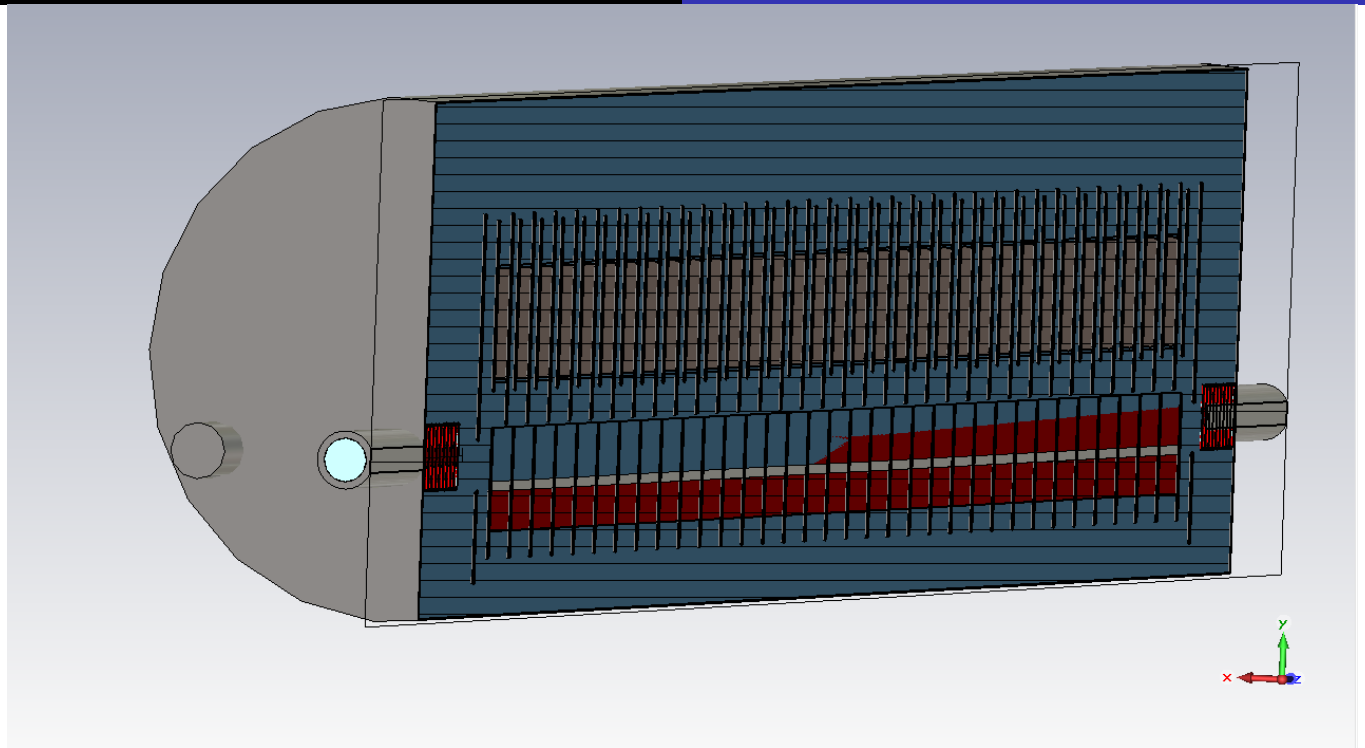


Figure 3: Simulated MKI Geometry. Yes that does say 24 million mesh cells

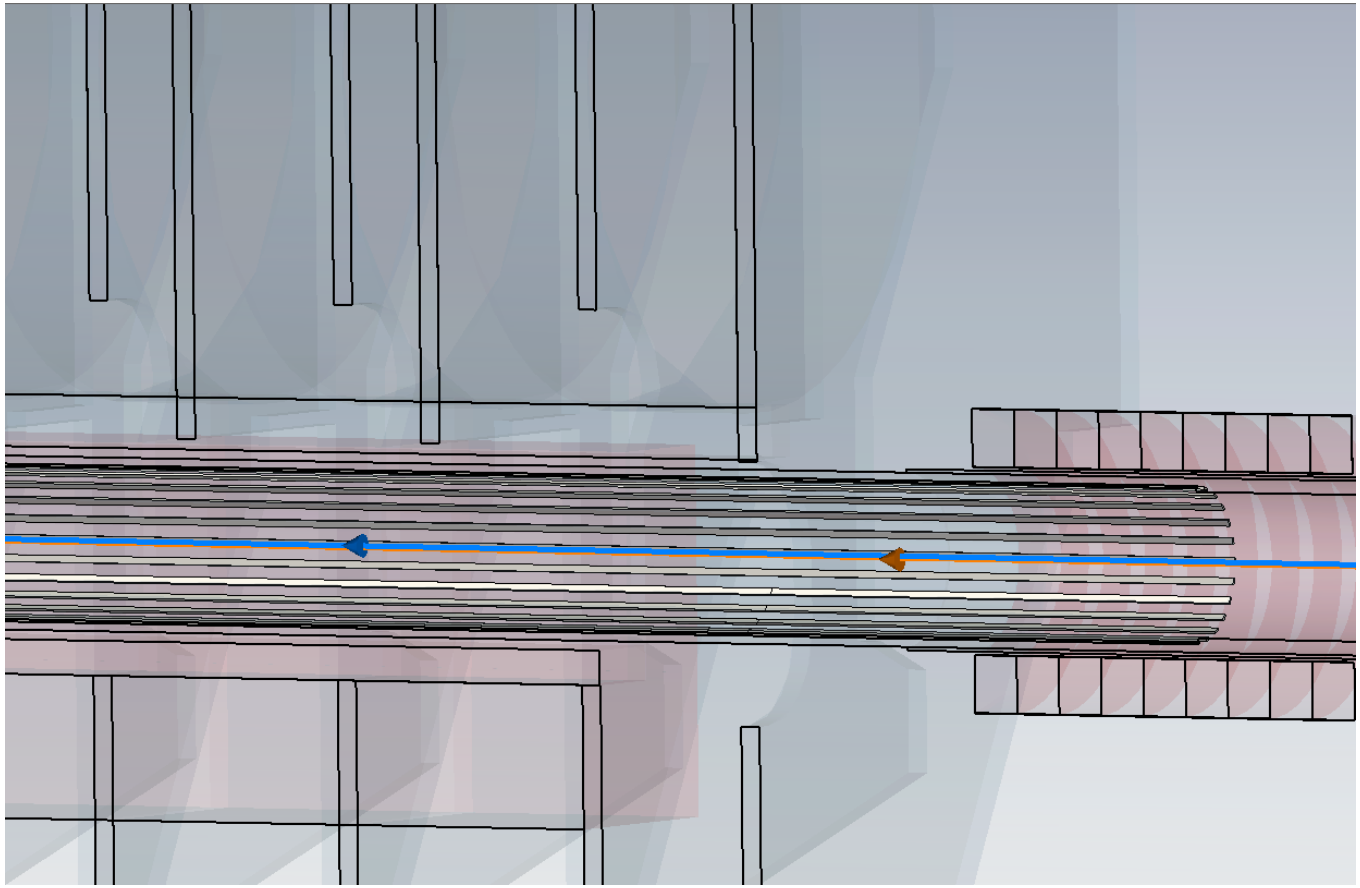


Figure 4: Conductive strips in the MKI

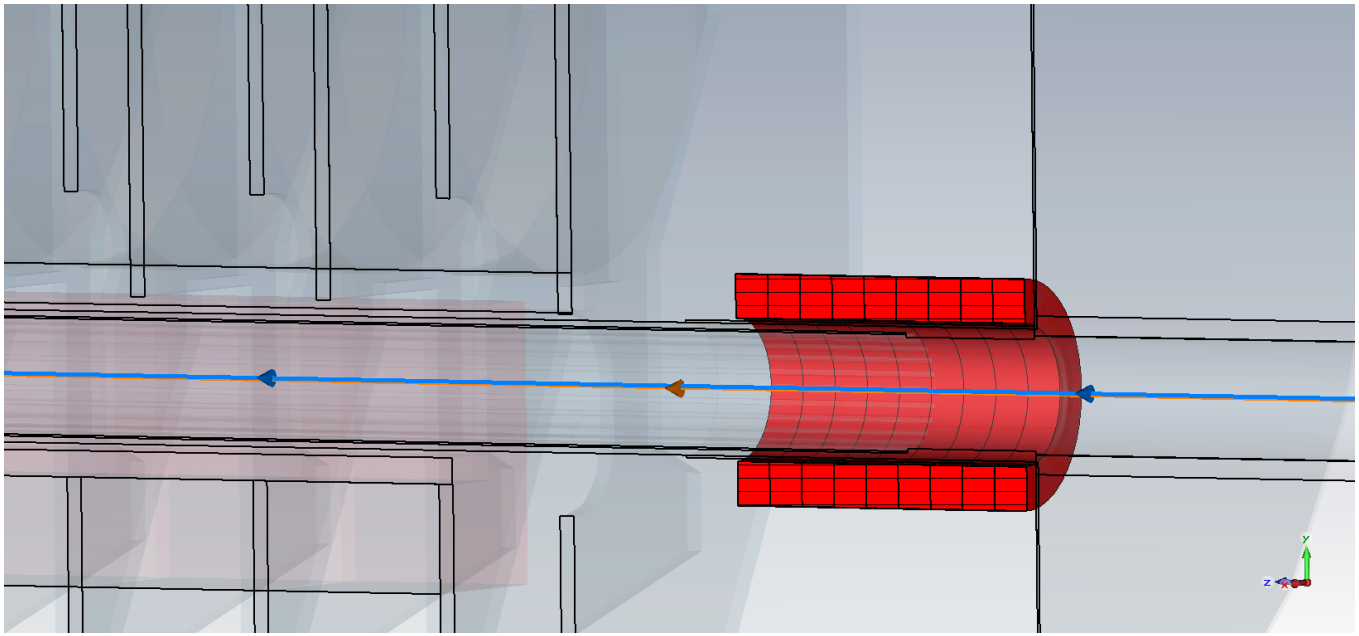


Figure 5: Damping ferrites in the MKI

- We try a number of varieties of the geometry to try and understand how the impedance changes dependant on different components
  - 24 screen conductors (original design)
  - 15 screen conductors (current design in most MKIs due to electrical breakdown)
  - 15 full screen conductors, 9 short screen conductors (In place in MKI8a)
  - No screen conductors
  - No beam screen
  - No end metalisation
  - No damping ferrites
  - Alternative design 1 - Capacitive coupling at both ends for most screen conductors, but a pair are conductively linked to beam pipe - voltage between screen conductors is lower - all 24 conductors back in MKI

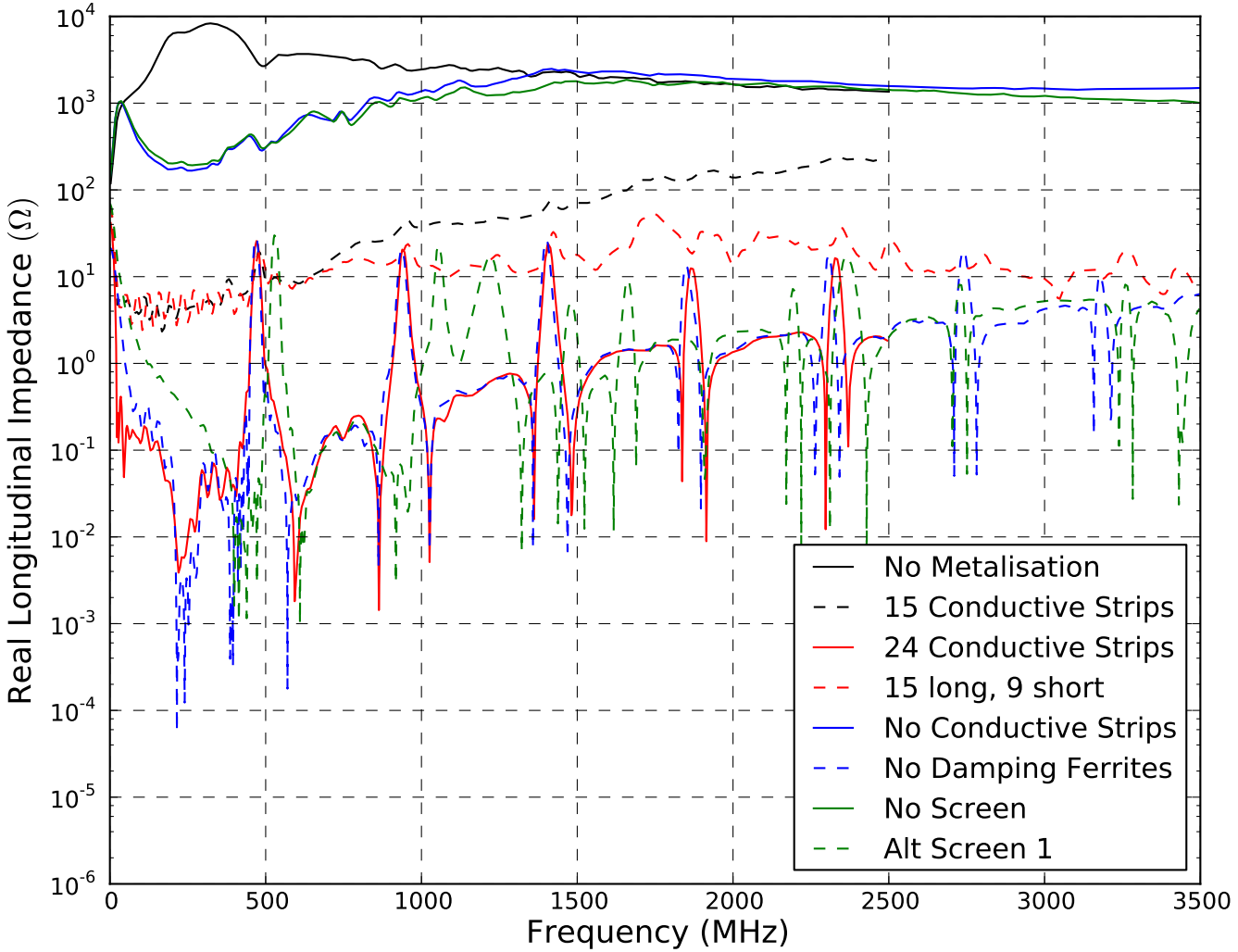


Figure 6: Longitudinal impedance of different permutations of LHC-MKI

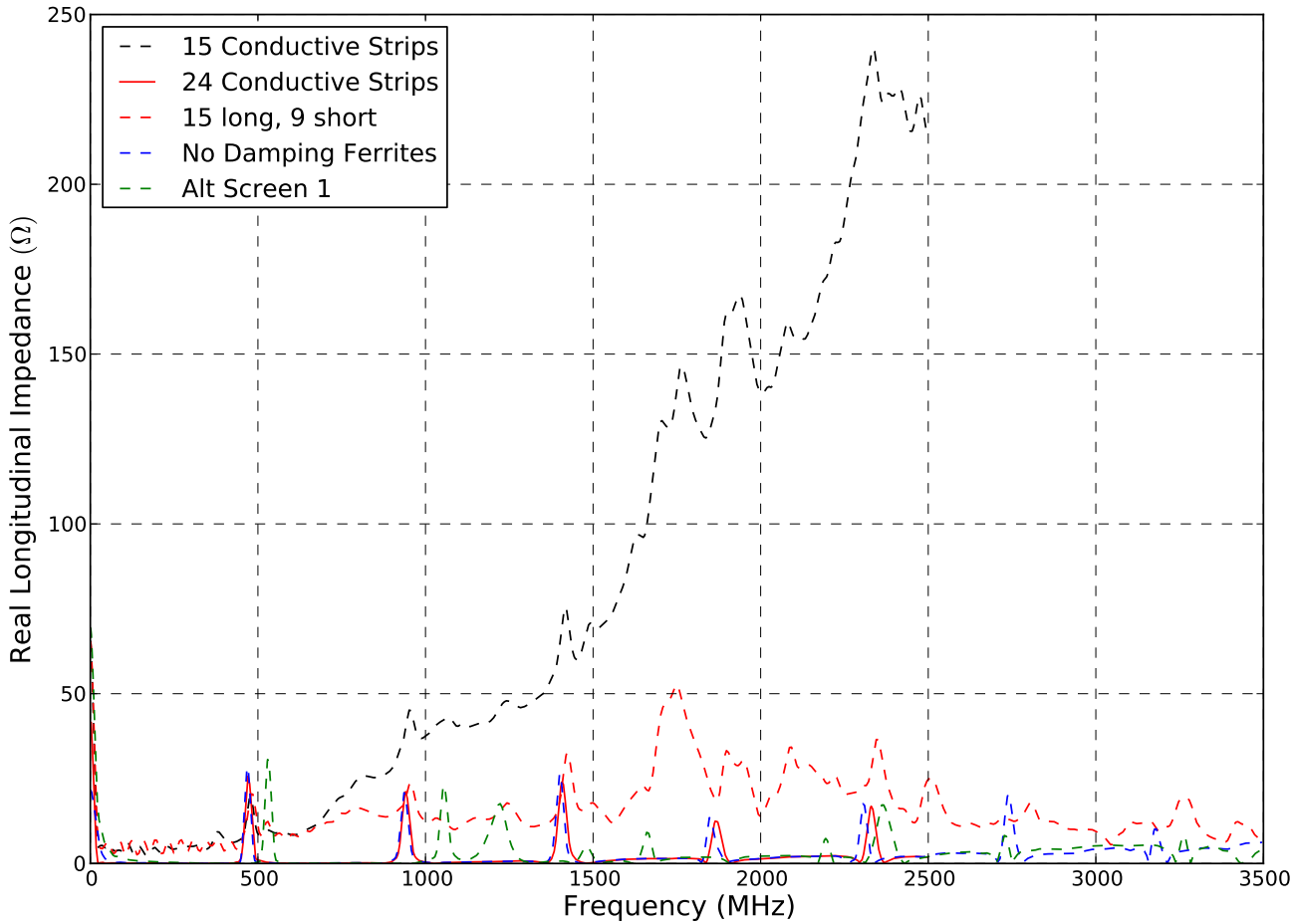


Figure 7: Focus of longitudinal impedance of realistic setups of LHC-MKI

Comparison to Measurements

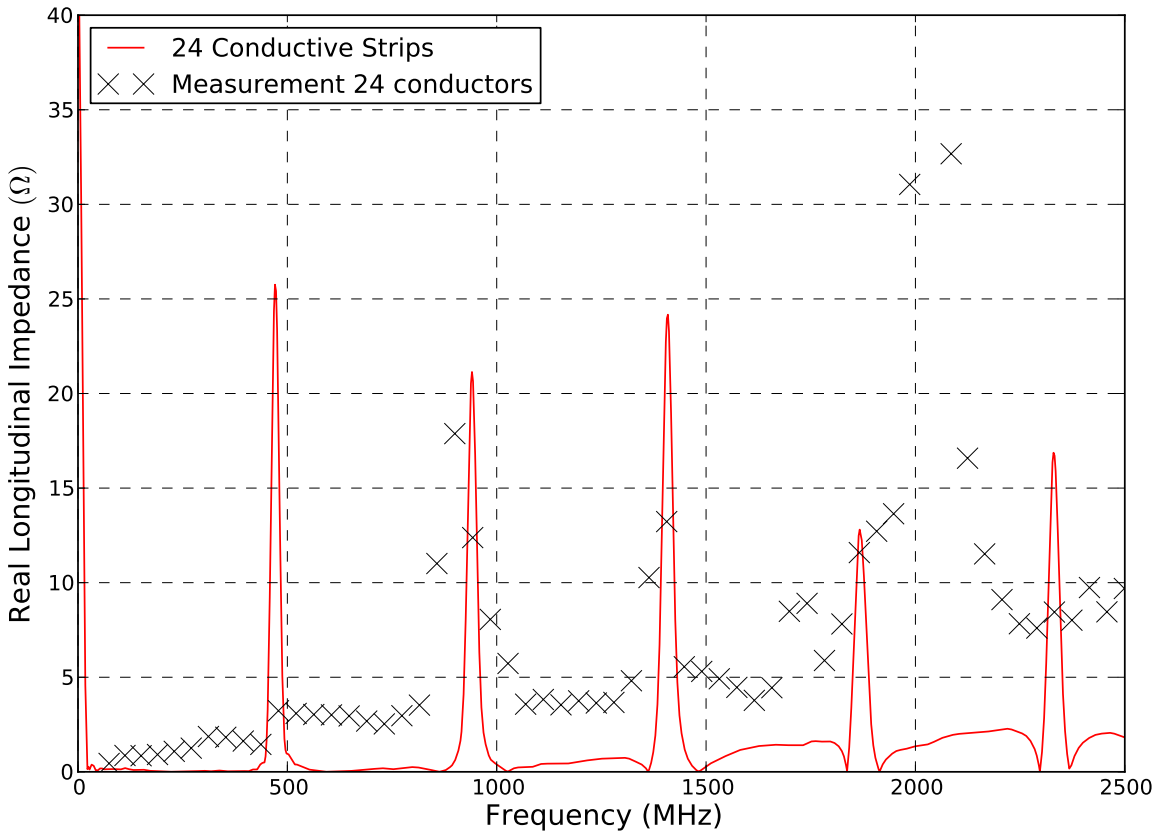


Figure 8: Comparison between simulations and measurements of the MKI with 24 screen conductors

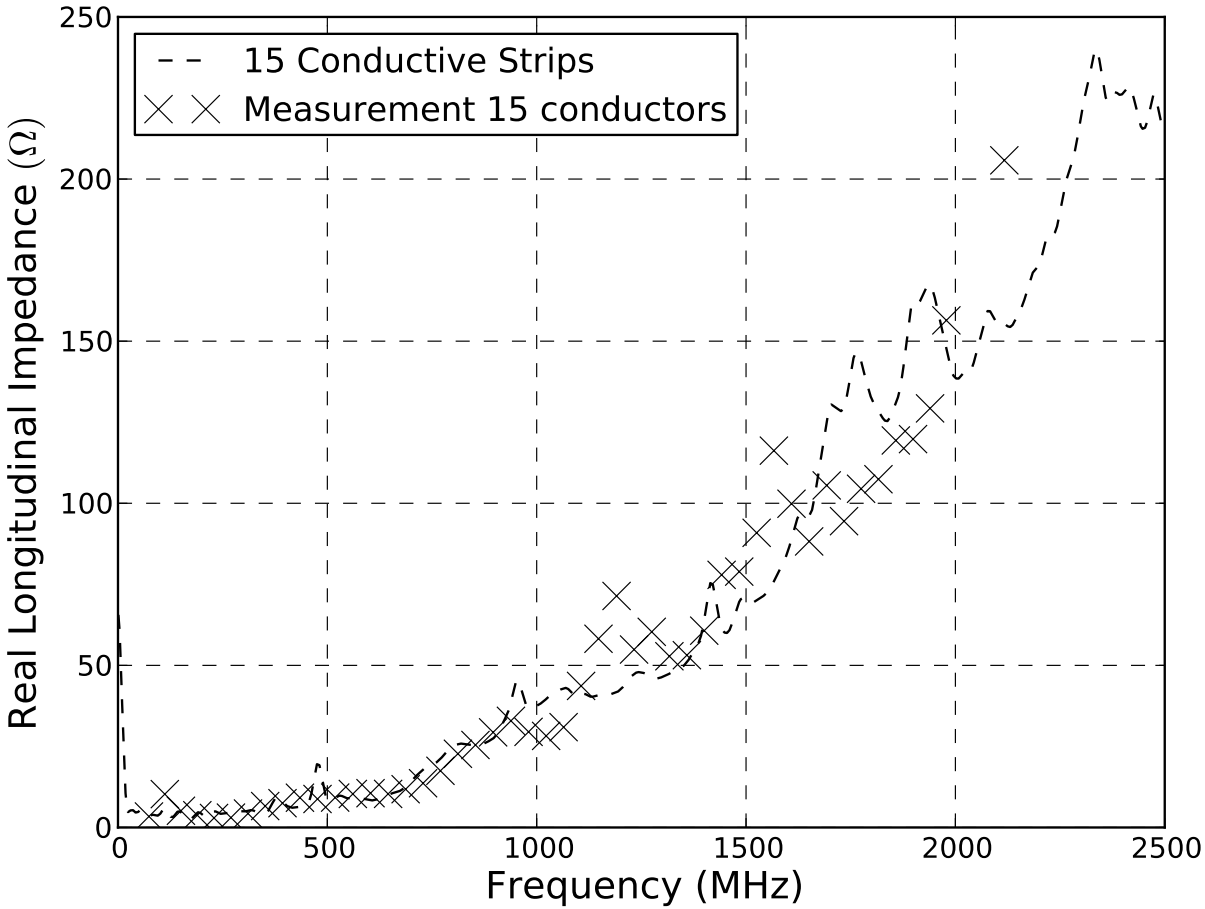


Figure 9: Comparison between simulations and measurements of the MKI with 15 screen conductors

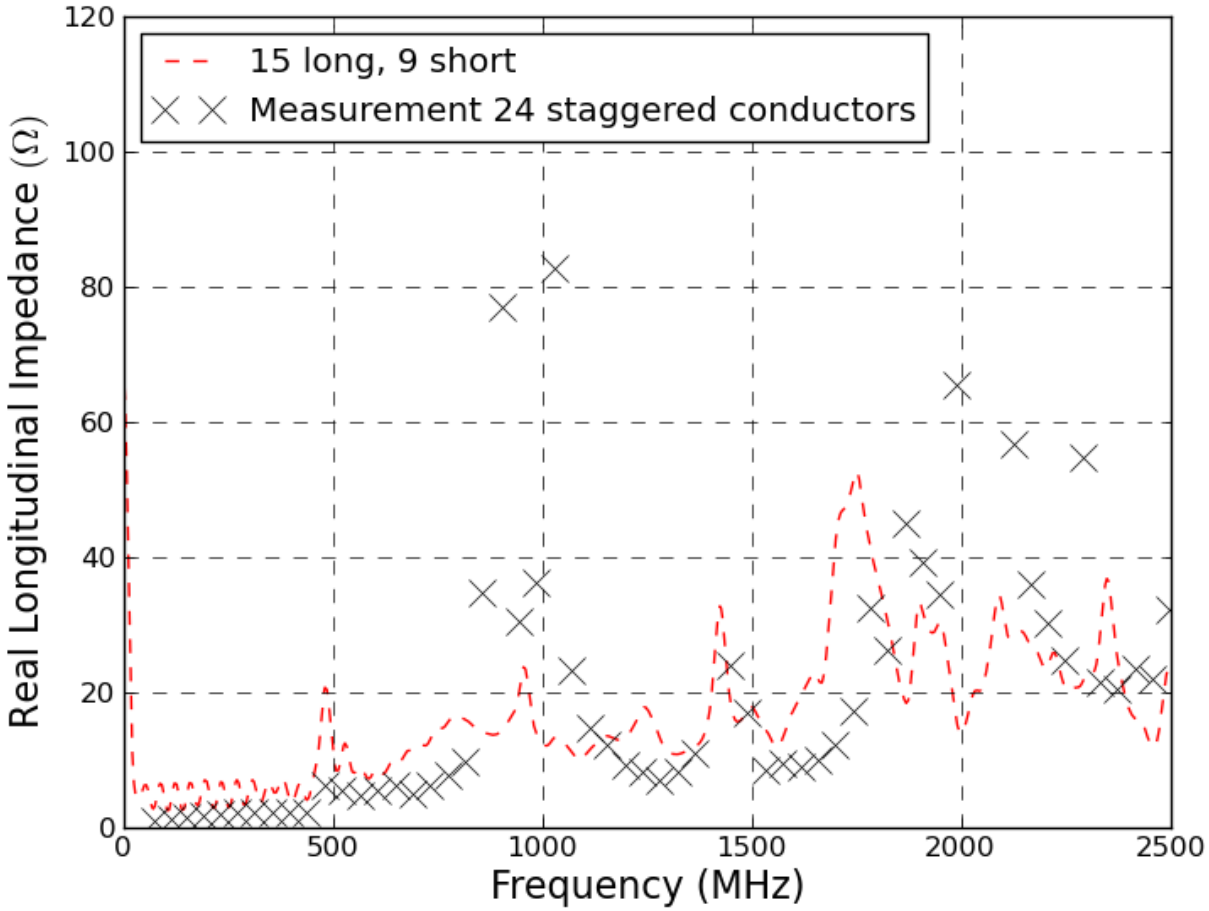


Figure 10: Comparison between simulations and measurements of the MKI with 15 long and 9 short screen conductors

Heating Estimates

- All heating estimates are done with nominal LHC bunch parameters (bunch population $N_b = 1.15 \times 10^{11}$)
- For 50ns spacing number of bunches $n_{bunches} = 1368$, for 25ns $n_{bunches} = 2808$
- Power loss is quadratic with bunch population
- We assume a parabolic bunch distribution for these estimates
- Due to the broadband nature of the impedances the estimates using a $\cos^2$ and measured spectra are similar to those from parabolic estimates

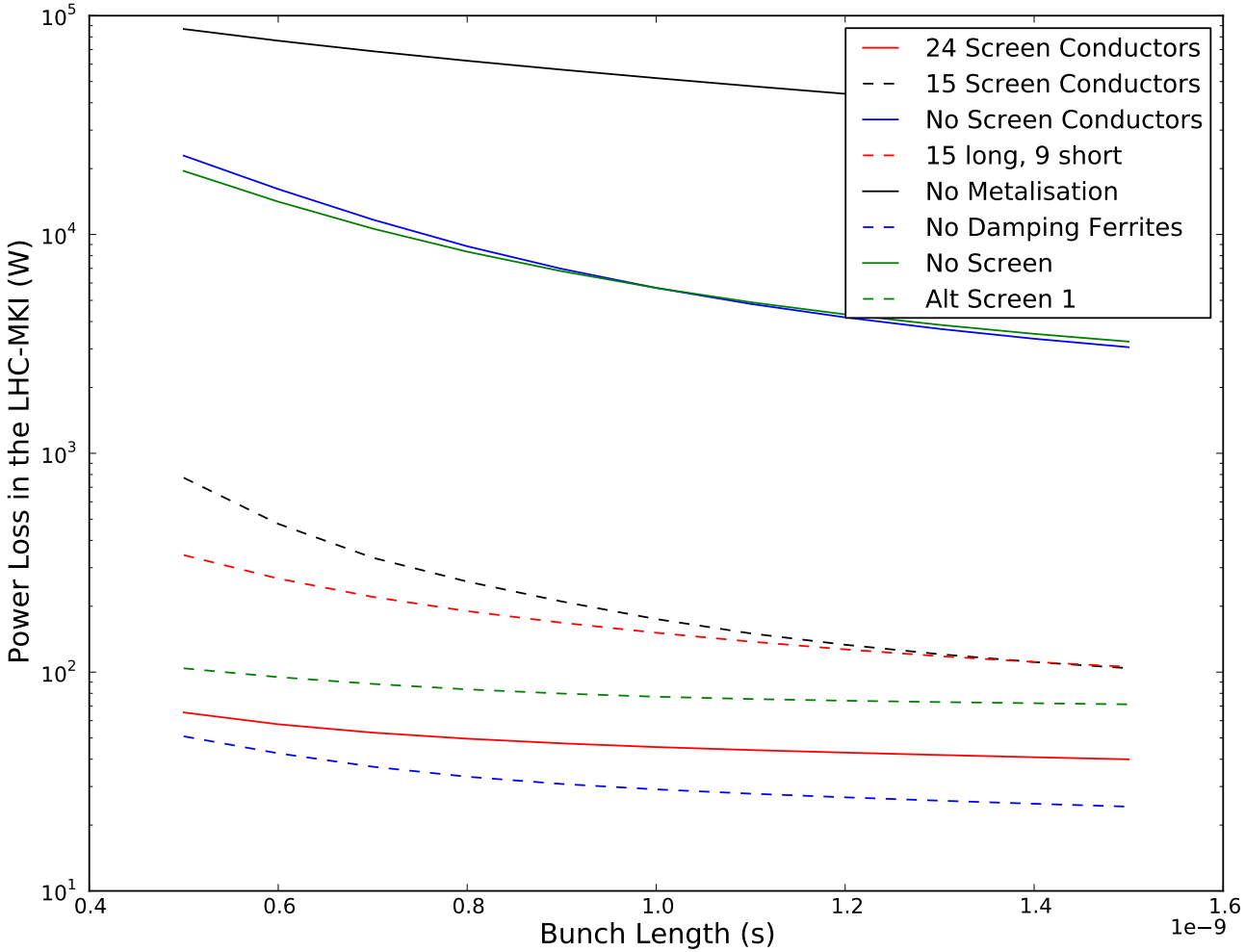


Figure 11: Heating estimates for 25ns bunch spacing

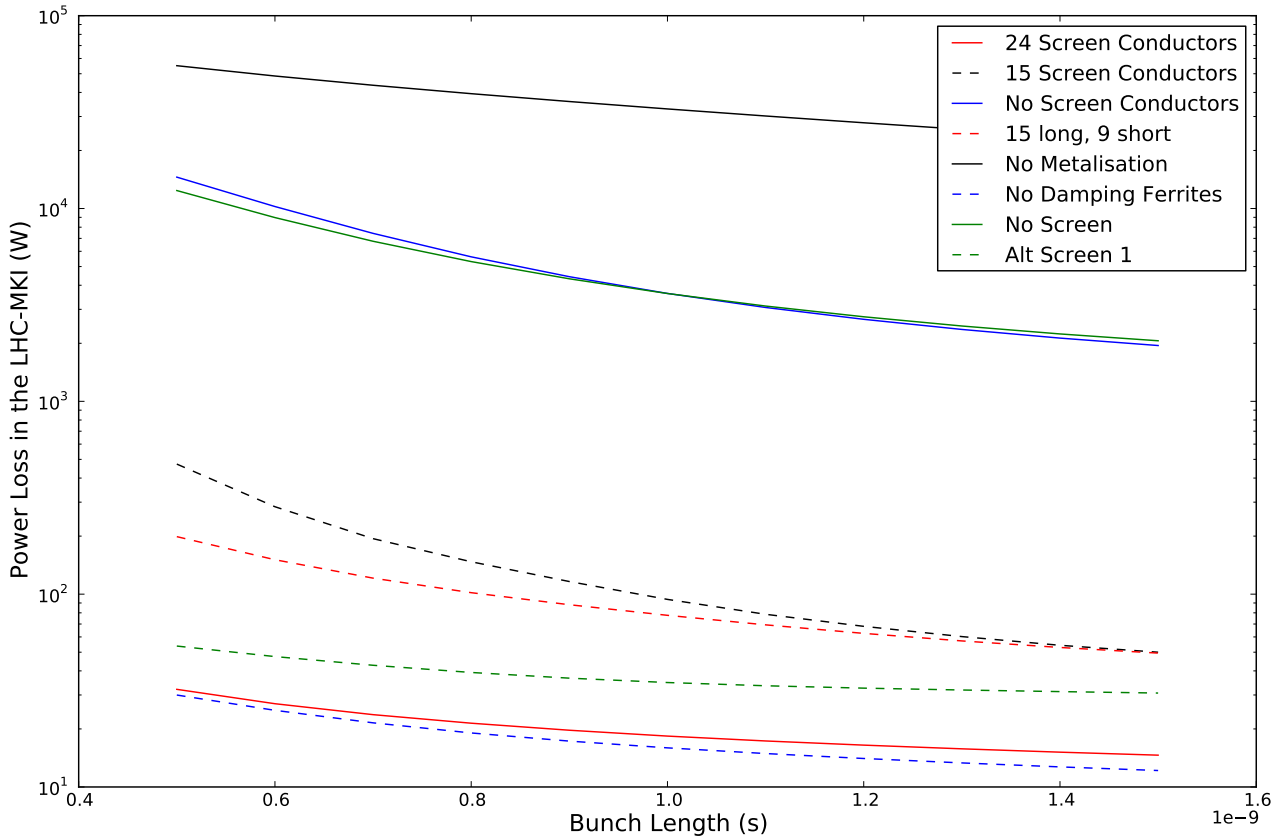


Figure 12: Heating estimates for 50ns bunch spacing

	25ns		50ns	
	1.1ns (W)	1.2ns (W)	1.1ns (W)	1.2ns (W)
24 Screen Conductors	44	43	17	16
15 Screen Conductors	150	133	78	68
No Screen Conductors	4817	3703	3067	2663
15 long, 9 short	138	127	69	62
No Metalisation	47660	40637	30187	27841
No Damping Ferrites	28	27	15	14
No Screen	4904	4314	3120	2745
Alt Screen 1	75	74	33	33

Summary

- We have shown that we can successfully simulate the full structure of a large kicker magnet (and other devices)
- Having heating estimates - We can show that the screen is definitely needed, and a screen with 24 conductors is better than with fewer
- Atleast one alternative beam screen gives better performance than existing solutions
- Other designs to be investigated. Also would like to extend the model to include RF fingers at interconnects