



Collaboration Workshop

Advanced Topics of Brilliant Light Facilities

Long-range Wakes For SwissFEL Two-beam Operation

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Introduction

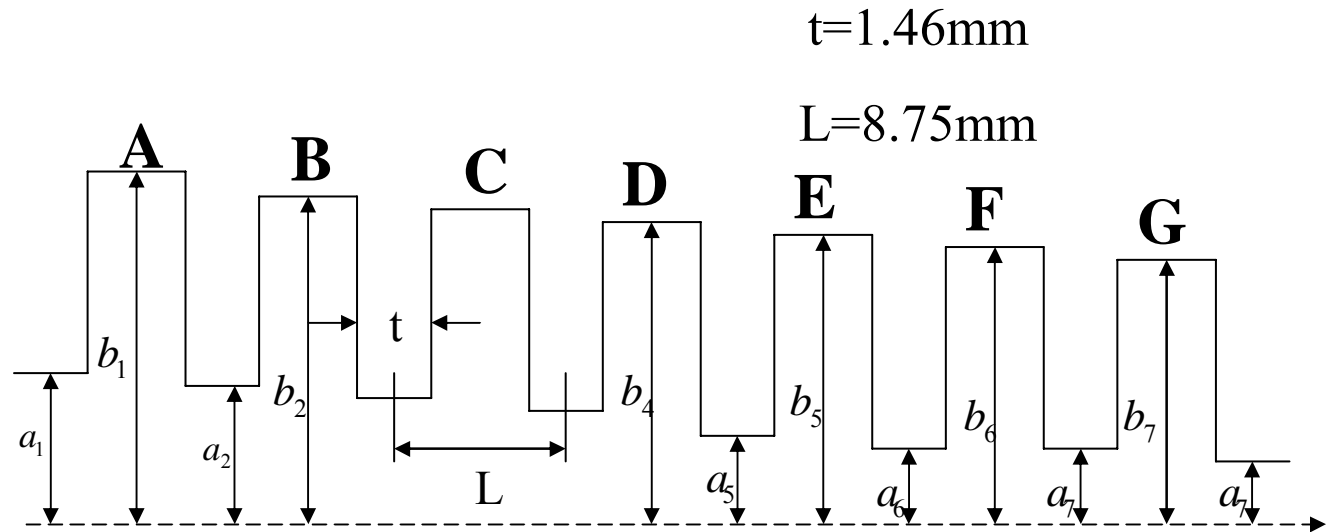
- Long-range Wakes Calculation by ECHO
Example of Calculation for X-band 7-cell Cavity. Simple method to perform transition to shorter bunch wake from bigger one.
- Calculation for C-band 119 cell Cavity
- Conclusion

Long range wake calculation for X-band (12GHz) disk loaded structure. (arbitrary chosen structure with 7 cell)

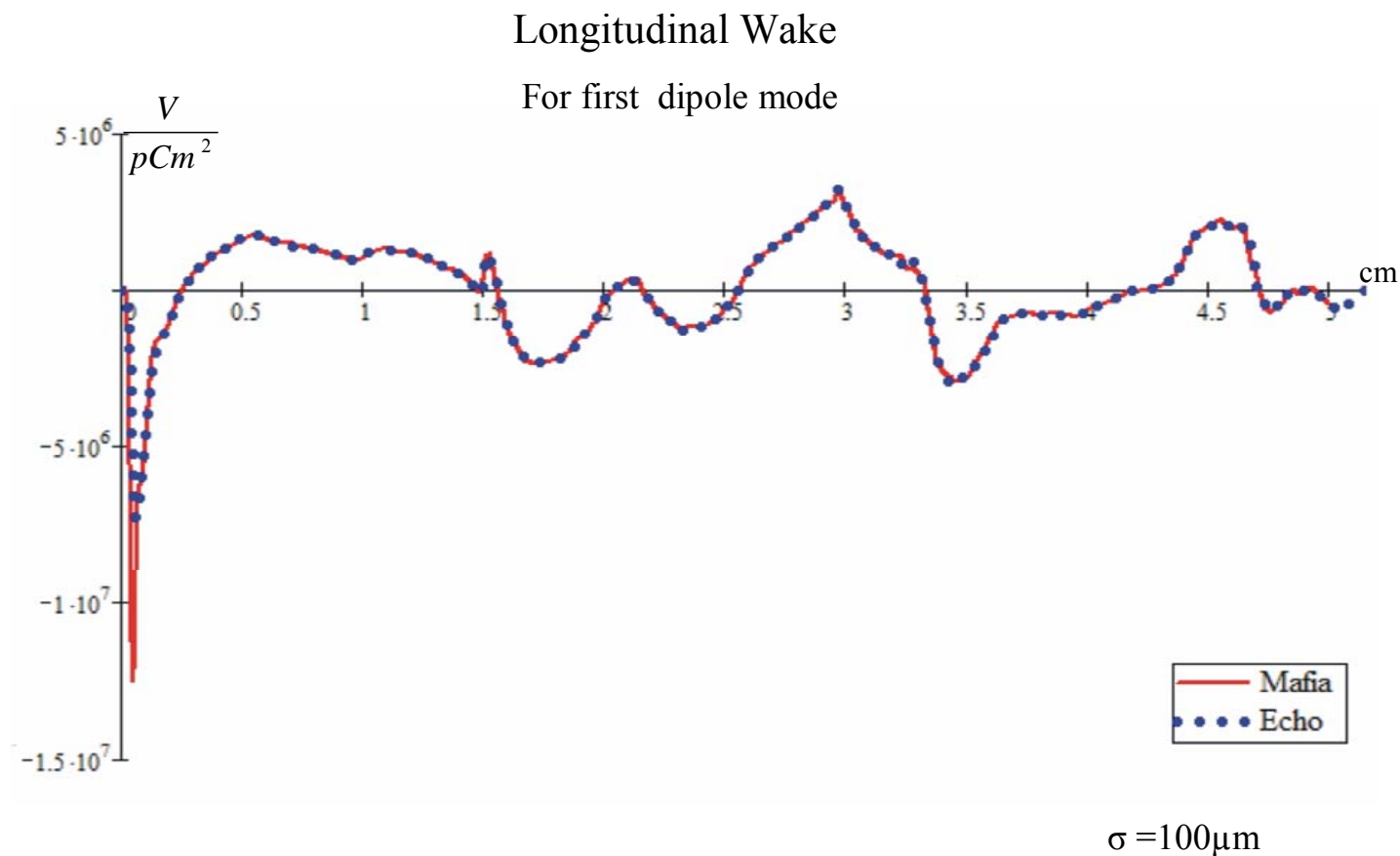
Structure geometry example.

MAFIA calculations results provided by Micha Dehler.

Label	a (mm)	b (mm)
A	6.500	11.8
B	5.875	11.44
C	5.250	11.12
D	4.625	10.83
E	4.000	10.58
F	3.375	10.39
G	2.750	10.24



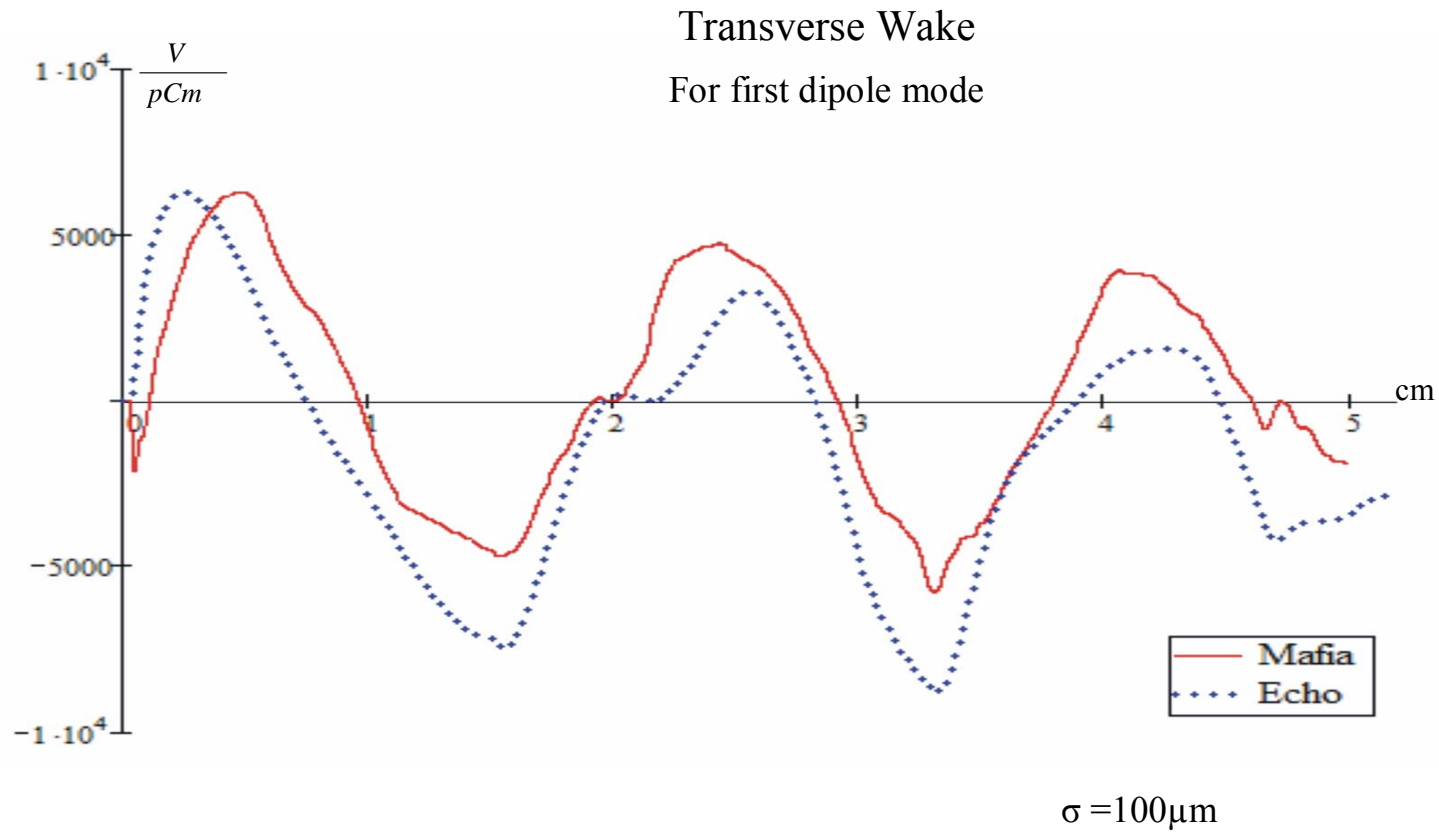
Comparison of calculations between longitudinal wake by using MAFIA and ECHO



Comparison of calculations between transverse wake ECHO and MAFIA

ECHO calculates transverse wake from Longitudinal wake by using **Panofsky-Wenzel** theorem.

MAFIA calculates the transverse wake **numerically**.



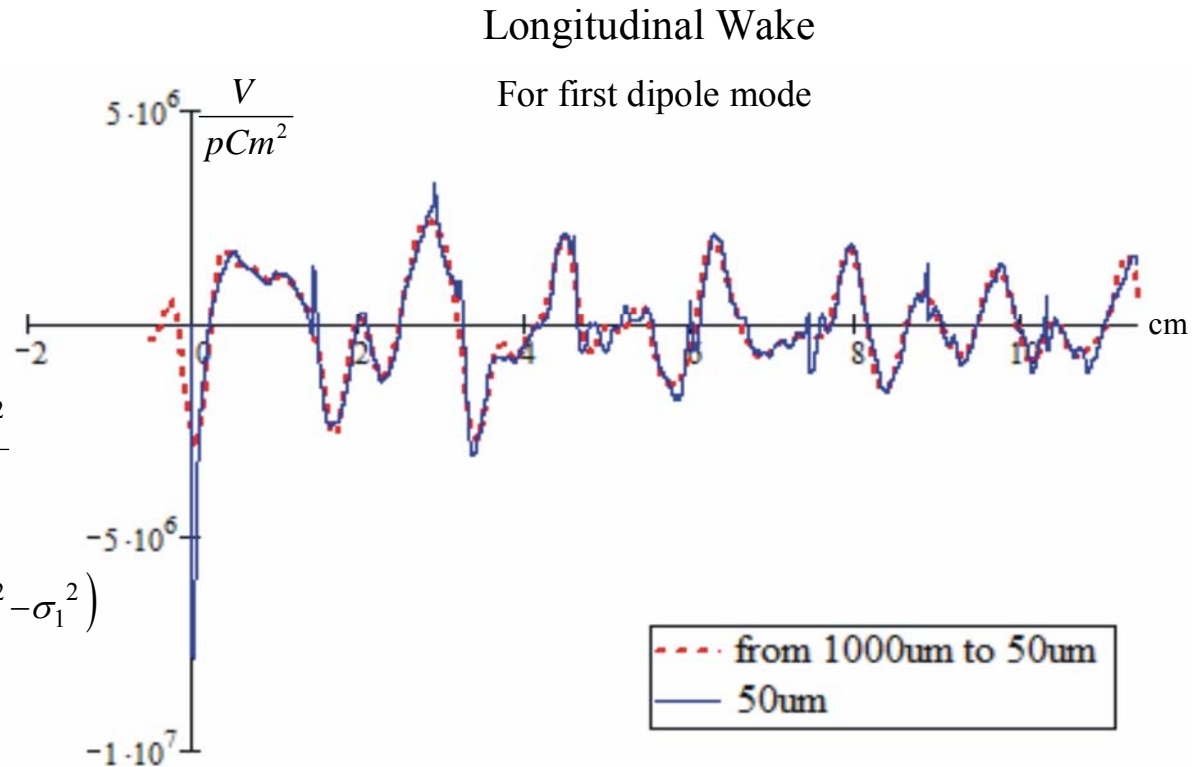
Comparison between original calculated wake for rms. bunch length 50μm and wake obtained from rms. bunch length 1000μm for 50μm.

$$Z(k) = Z_0(k)e^{-\frac{(k\sigma)^2}{2}}$$

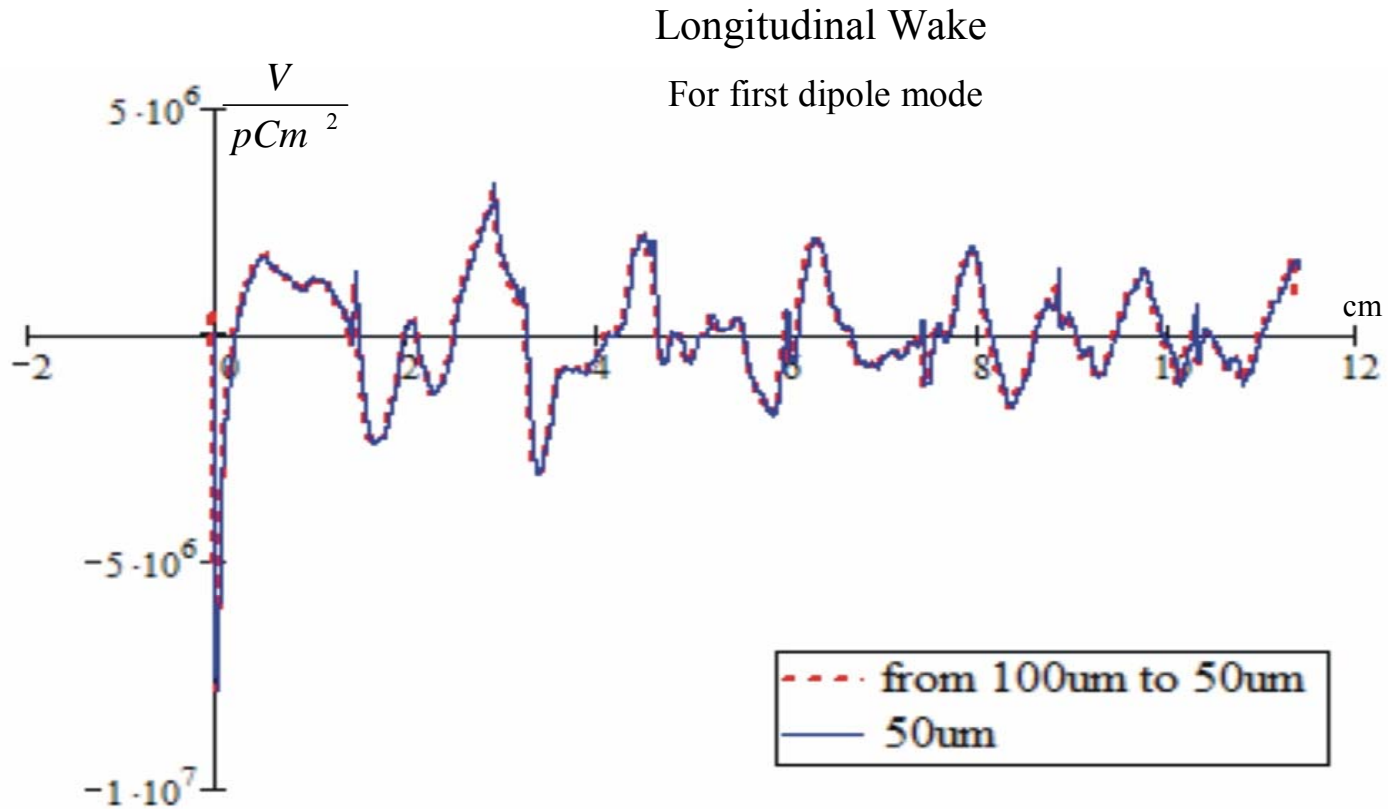
$$Z_1(k) = Z_0(k)e^{-\frac{(k\sigma_1)^2}{2}}$$

$$Z_2(k) = Z_0(k)e^{-\frac{(k\sigma_2)^2}{2}}$$

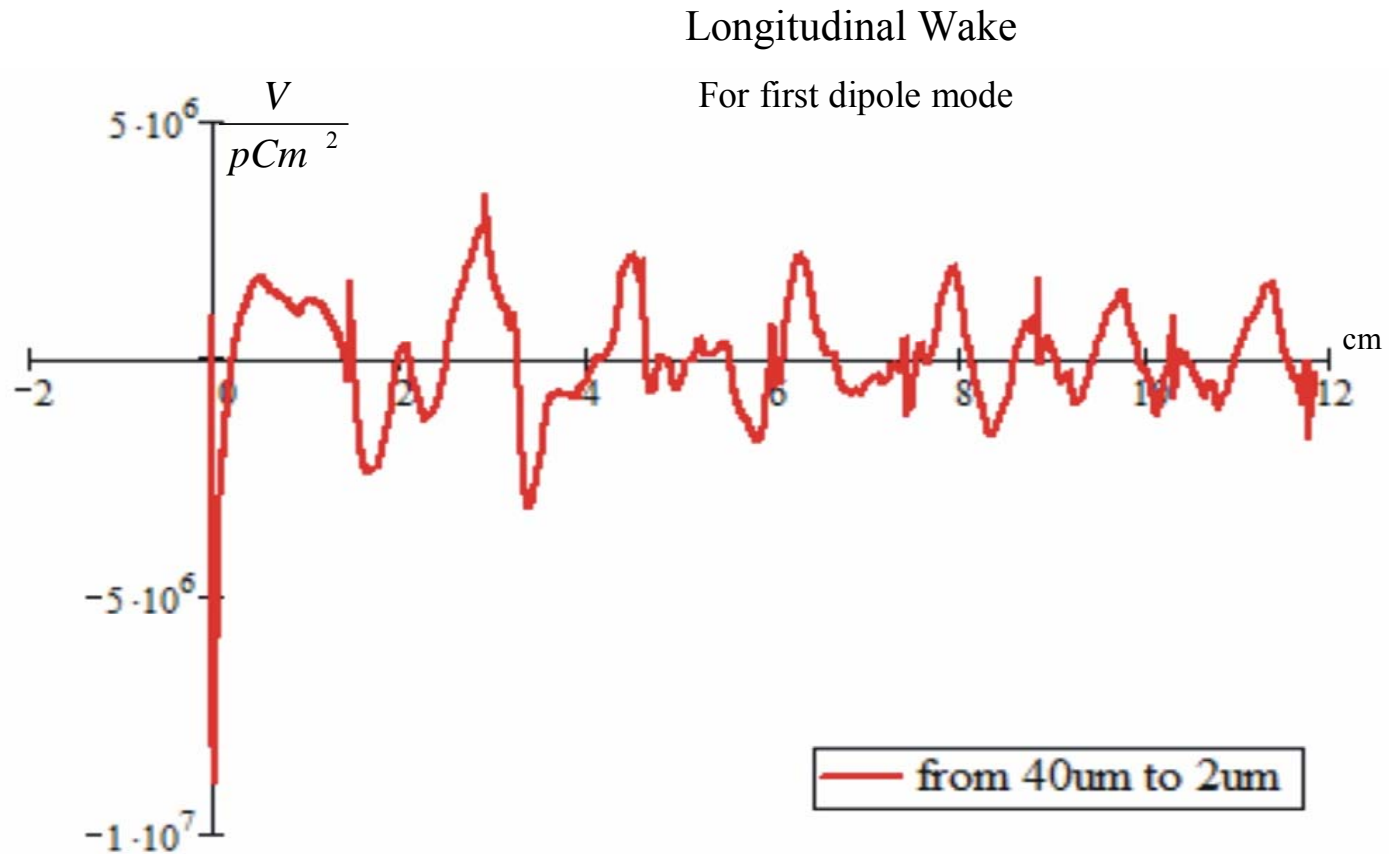
$$Z_2(k) = Z_1(k)e^{-\frac{k^2}{2}(\sigma_2^2 - \sigma_1^2)}$$



Comparison between original calculated wake for rms. bunch length $50\mu\text{m}$ and wake obtained from rms. bunch length $\sigma = 100\mu\text{m}$ for $50\mu\text{m}$.



Longitudinal Wake transition from rms. bunch length $40\mu\text{m}$ to $2\mu\text{m}$.

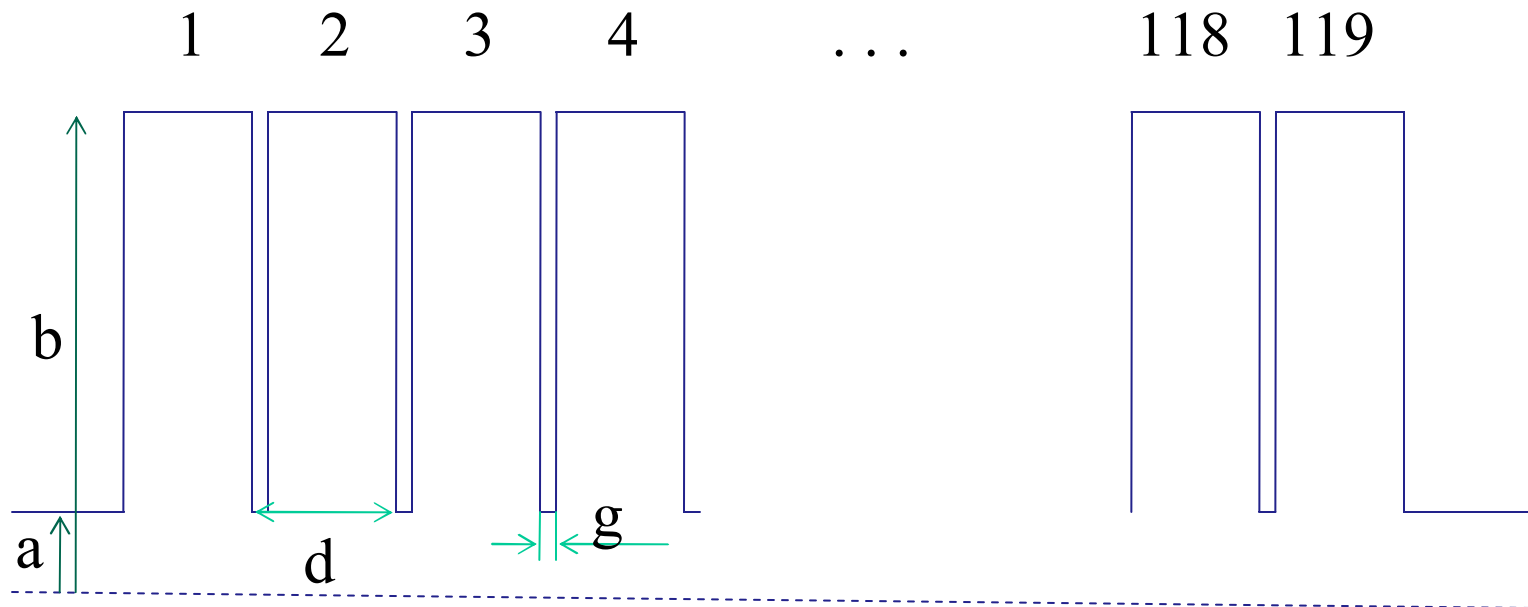


SwissFEL C-Band (6 GHz) 119 Cell Cavity (Mitsubishi option) Geometry (Same cells with Average Dimensions)

$$a = 6.954 \text{ mm (7.907-6.001)}$$

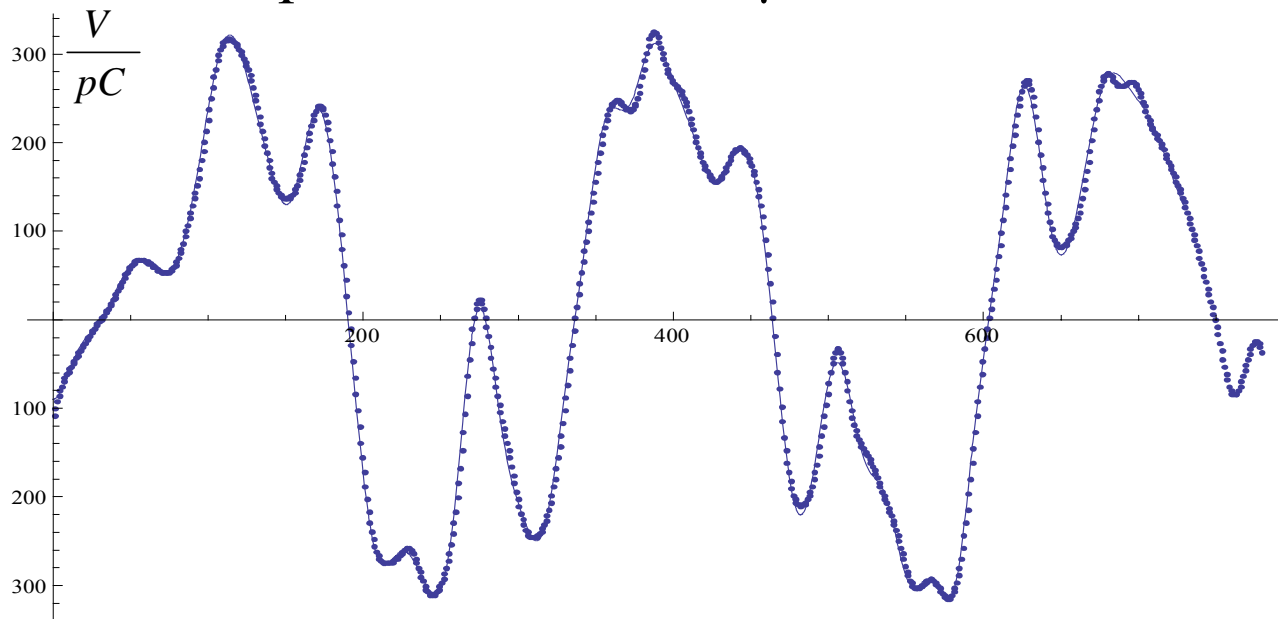
$$b = 22.405 \text{ mm,}$$

$$d = 16.666 \text{ mm, } g = 4 \text{ mm}$$



Monopole

$\sigma = 1000 \mu\text{m}$

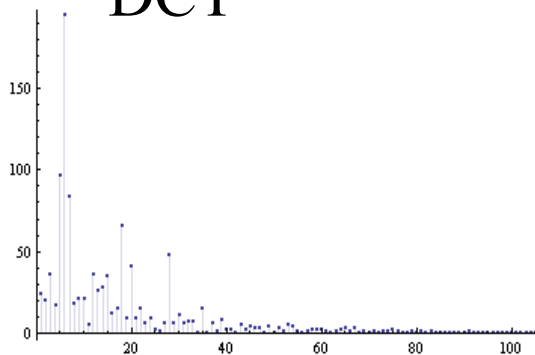


$N=1000$

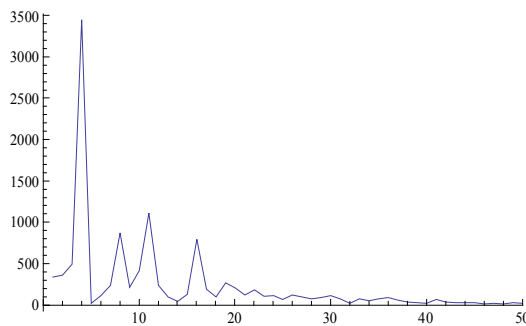
$L=16 \text{ cm}$

$k_{\text{max}} = \pi N/L$

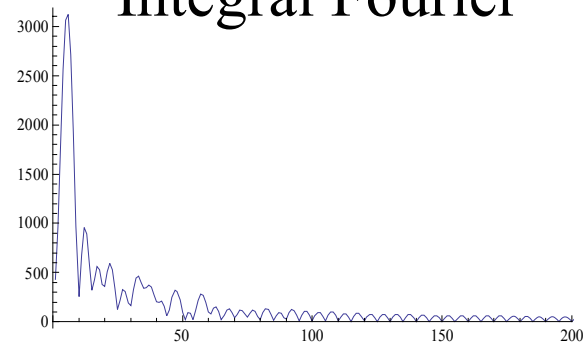
DCT



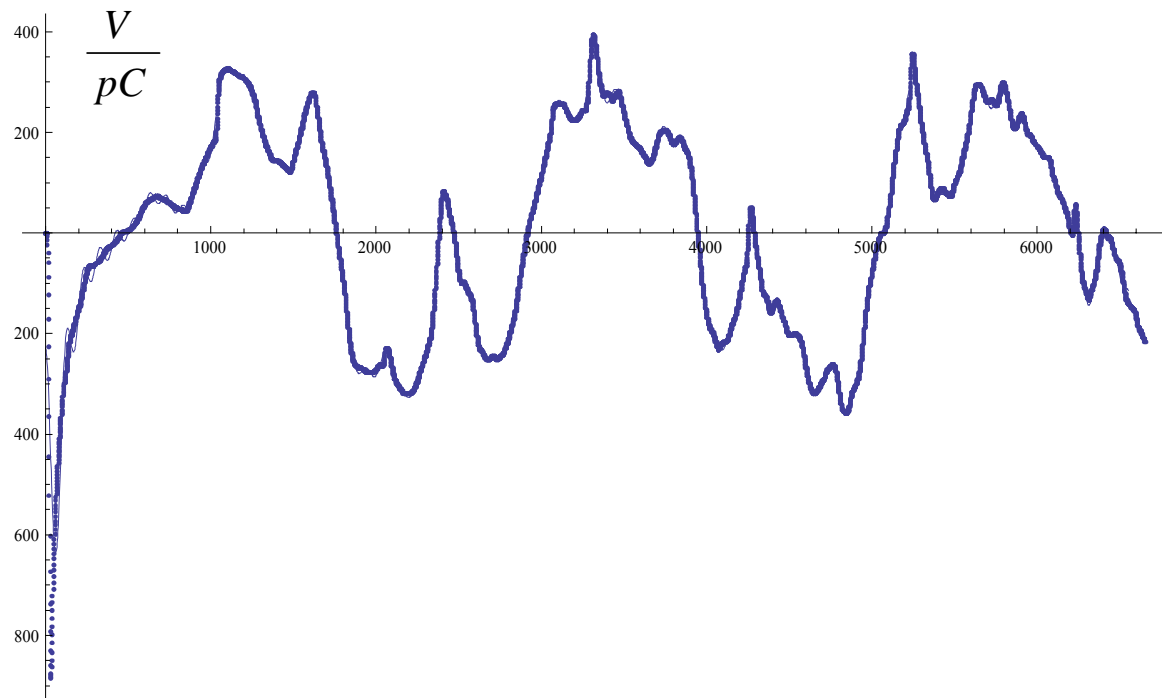
FFT



Integral Fourier

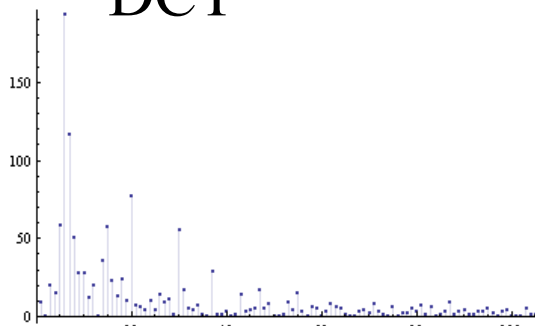


Monopole $\sigma = 125 \mu\text{m}$

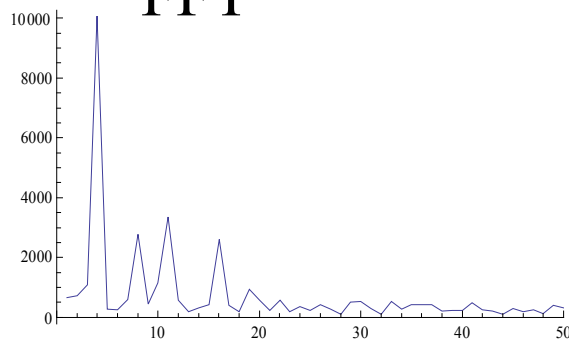


$N=6600$
 $L=16 \text{ cm}$
 $k_{\text{max}} = \pi N/L$

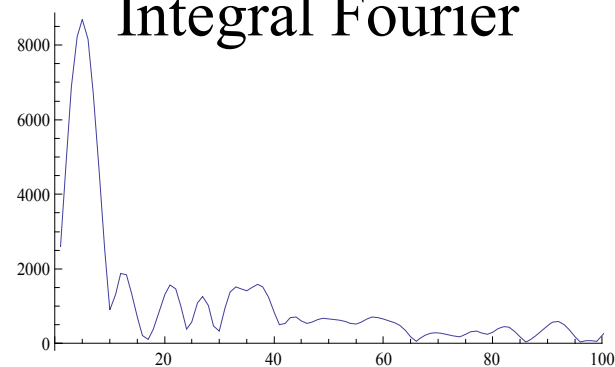
DCT



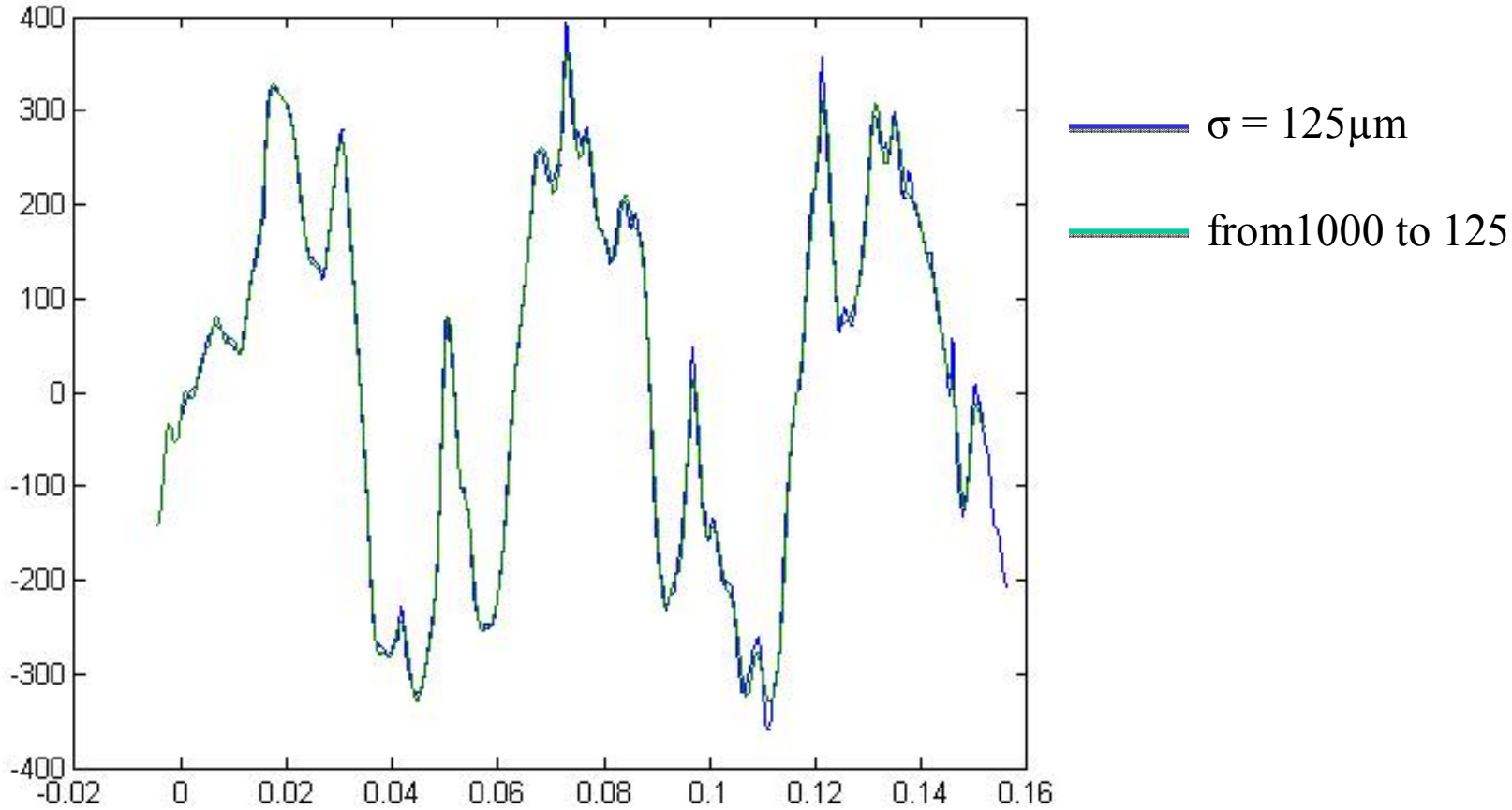
FFT



Integral Fourier

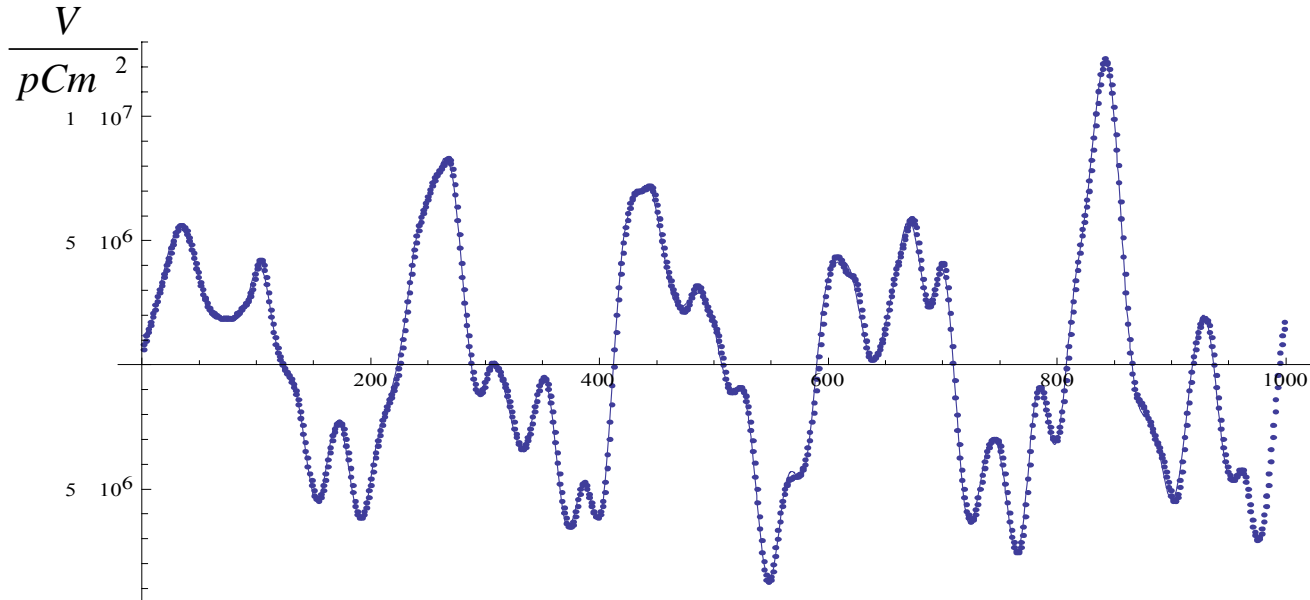


Comparison between original calculated wake $\sigma = 125\mu\text{m}$ and wake obtained from $\sigma = 1000\mu\text{m}$ for $125\mu\text{m}$.



Dipole

$\sigma = 1000 \mu\text{m}$



$N=1000$

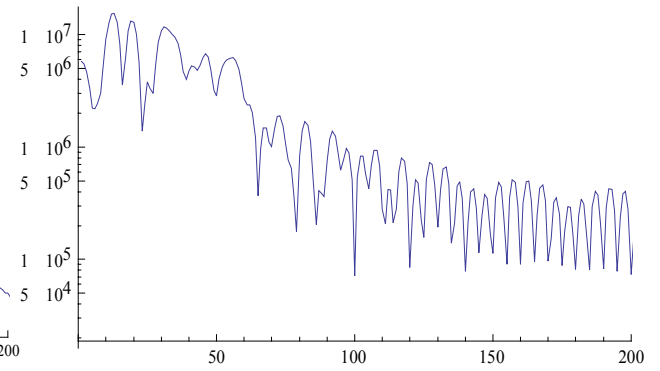
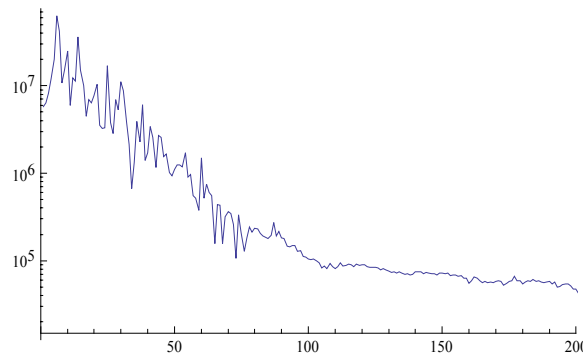
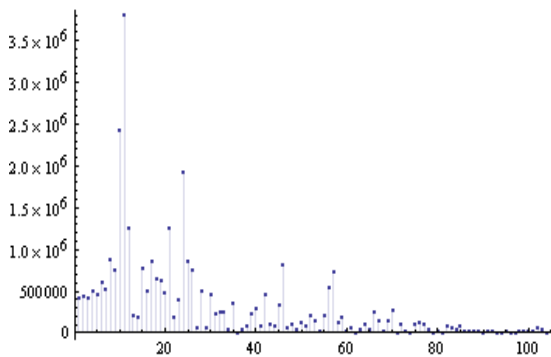
$L=20 \text{ cm}$

$k_{\text{max}} = \pi N/L$

DCT

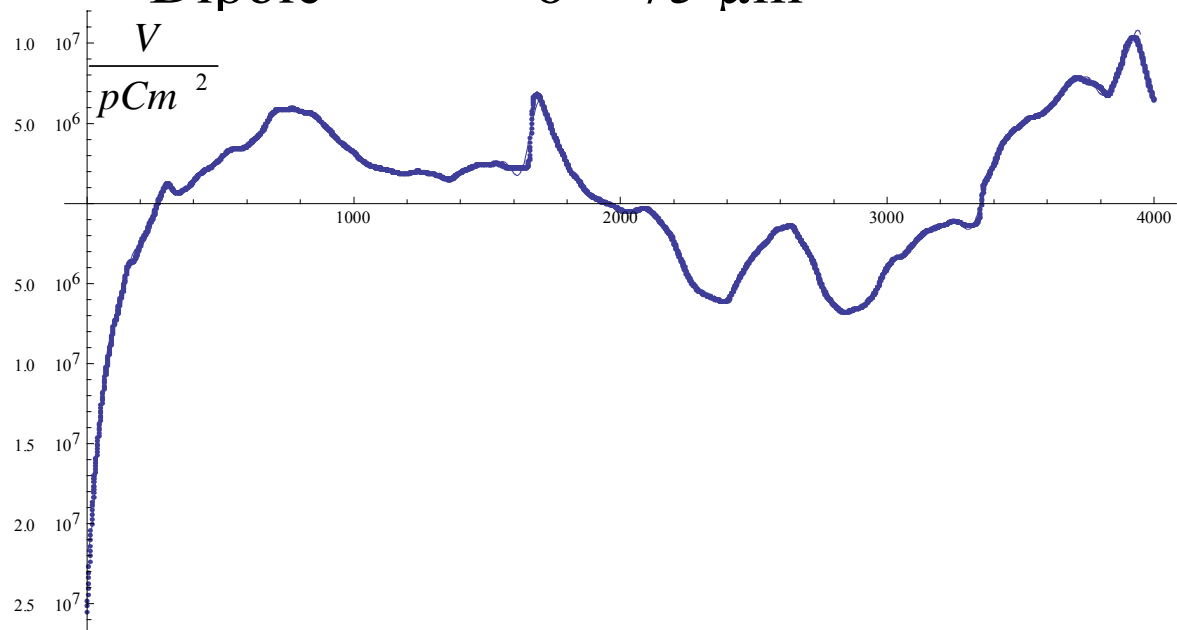
FFT

Integral Fourier



Dipole

$\sigma = 75 \mu\text{m}$

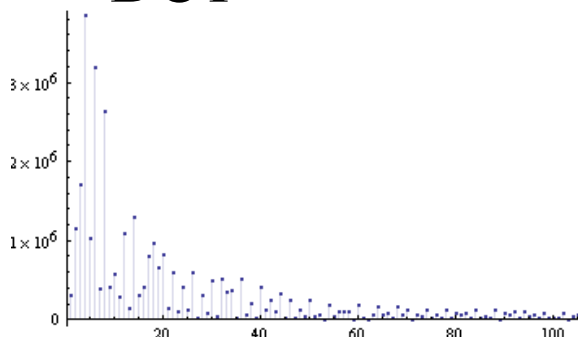


$N=4000$

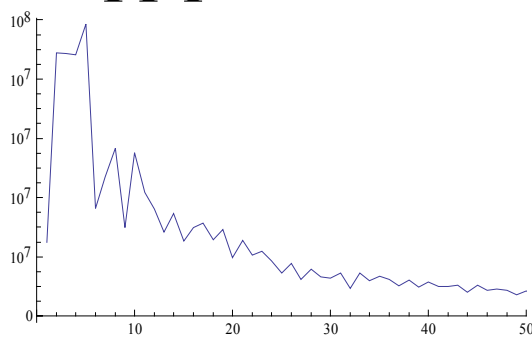
$L=6 \text{ cm}$

$k_{\text{max}} = \pi N/L$

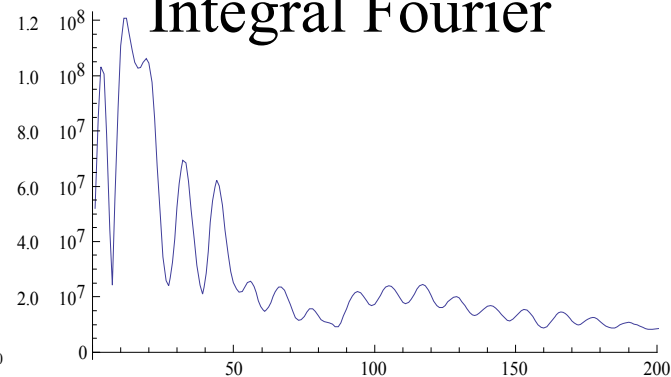
DCT



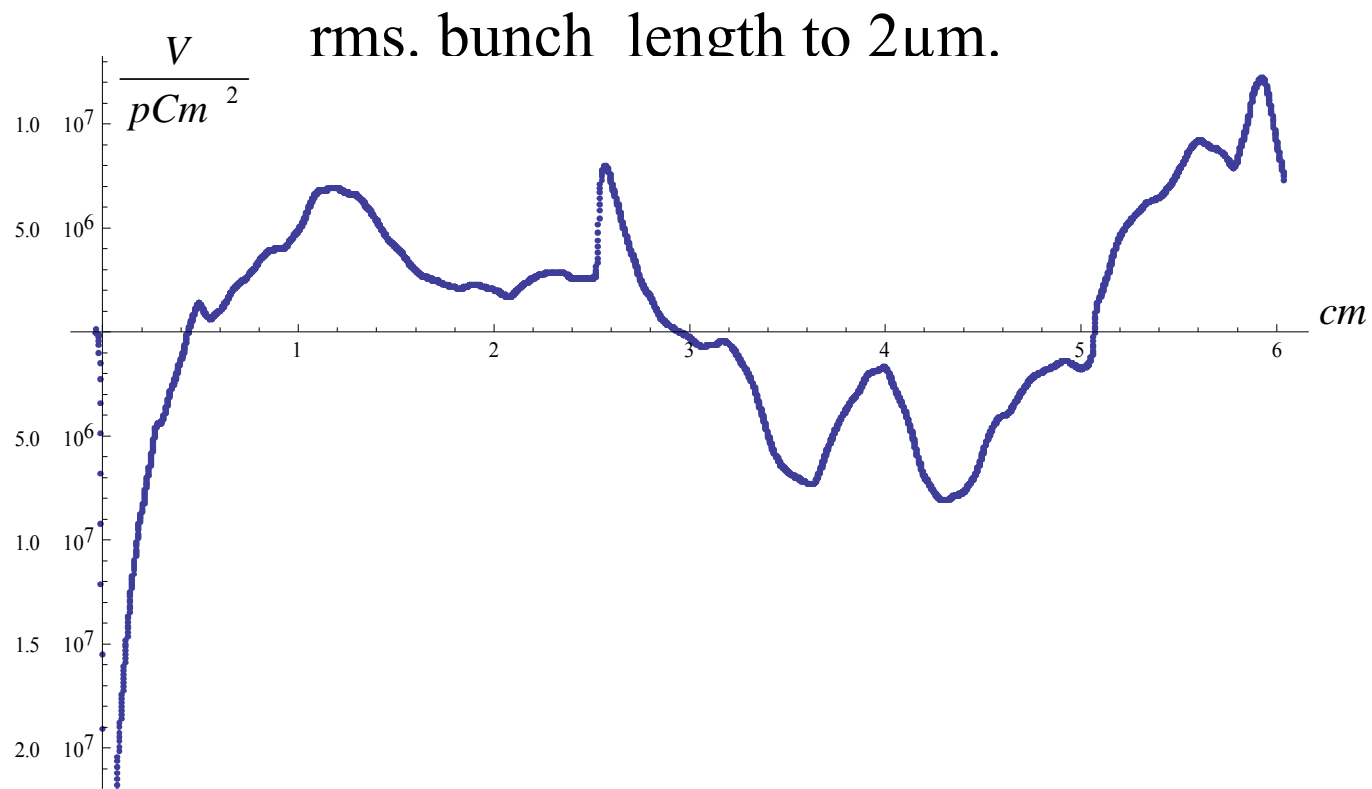
FFT



Integral Fourier



Longitudinal Wake transition from $\sigma = 75\mu\text{m}$



Conclusion

- Performed calculations have shown the possibility to perform transition from bigger bunch wake to the shorter one. Further calculations have to be done to improve the method. Comprisable calculations among higher modes will be done further.
- Other methods (particularly equivalent circuit chain method) have to be developed for further calculations.