some tools for longitudinal phase space

LiTrack

random distributions $\rightarrow$ uncorrelated energy spread but with noise
rf, BCs, cavity wakes, non linear effects
MATLAB

improvements:
- S.Lange & M.Clemens, HSU
- GUI, optimizer (genetic alg.), ‘knobs’
- wish list: SC wakes, search insensitive working points, …

recursive µ-bunch analysis

SC impedance, linear working point, periodic boundary conditions
systematic distributions; energy profiles of laser heater
$\rightarrow$ gain curves
MathCAD

non linear effects without over-compression (MathCAD)

a) working point sensitivity without wakes; (polynomials)
b) shape sensitivity with cavity wakes and SC effects; (syst. distr.)

recursive μ-bunch analysis

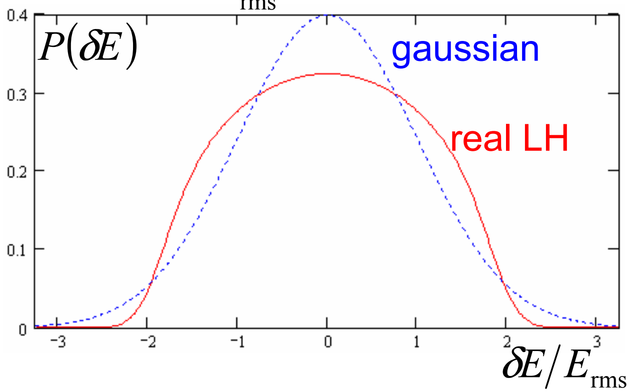
$$S = S(s, \delta E) = \frac{s}{\Pi_c} + \mathrm{Re}\{a \cdot e^{iks}\} + c\,\delta E \qquad a = a(\delta E)$$

$$E = E(s, \delta E) = E_0 + E_0' \frac{s}{\Pi_c} + \mathrm{Re}\{b \cdot e^{iks}\} + d\,\delta E \qquad b = b(\delta E)$$

BC	RF	impedance
$\tilde{S} = S - r_{56}(E - E_0)/E_0$ $\tilde{E} = E$	$\tilde{S} = S$ $\tilde{E} = E + \Delta E + \Delta E' S$	$\tilde{S} = S$ $\tilde{E} = E + \mathrm{Re}\{g e^{ik\Pi_c S}\}$
$\tilde{E}_0 = E_0$ $\tilde{E}_0' = C E_0'$ $\tilde{\Pi}_c = \Pi_c C$ $\tilde{a} = a - \frac{r_{56}}{E_0} b$ $\tilde{b} = b$ $\tilde{c} = c - \frac{r_{56}}{E_0} d$ $\tilde{d} = d$	$\tilde{E}_0 = E_0 + \Delta E$ $\tilde{E}_0' = E_0' + \Delta E'$ $\tilde{\Pi}_c = \Pi_c$ $\tilde{a} = a$ $\tilde{b} = a \Delta E' + b$ $\tilde{c} = c$ $\tilde{d} = c \Delta E' + d$	$\tilde{E}_0 = E_0$ $\tilde{E}_0' = E_0'$ $\tilde{\Pi}_c = \Pi_c$ $\tilde{a} = a$ $\tilde{b} = b + g e^{ik\Pi_c c \delta E}$ $\tilde{c} = c$ $\tilde{d} = d$

uncorrelated energy spread

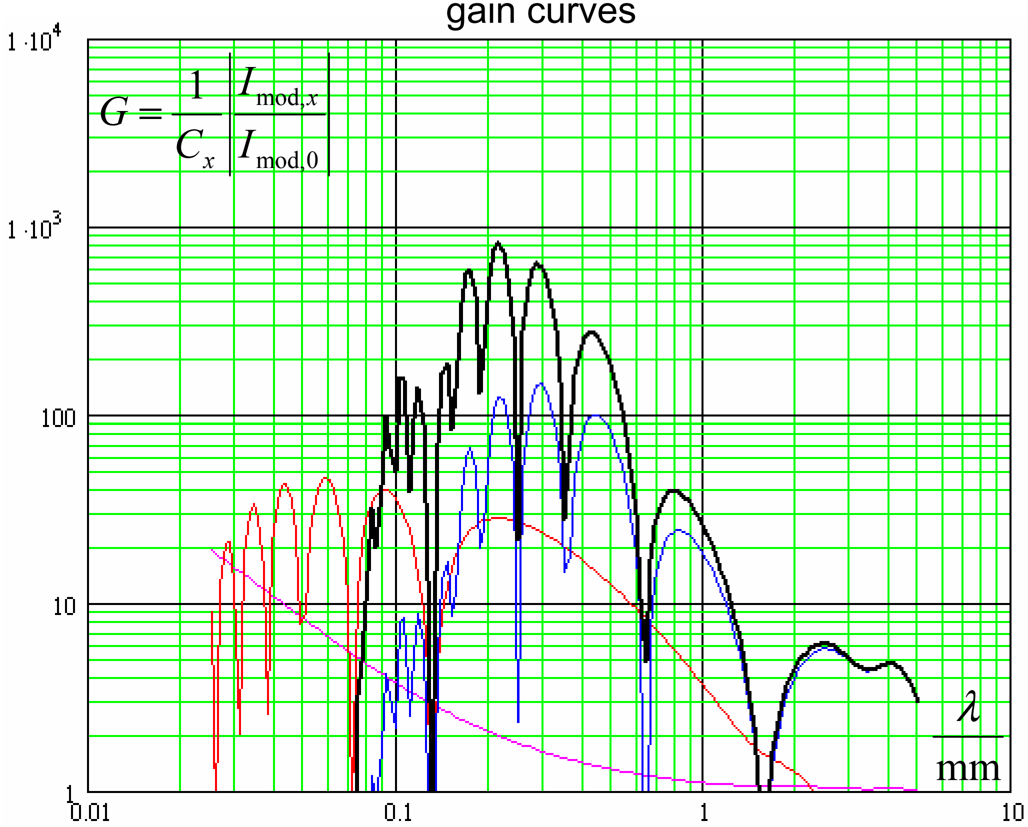
$E_{\mathrm{rms}} = 10\,\mathrm{keV}$



$$I_{\mathrm{noise,rms}} \approx \sqrt{\frac{eI}{\pi} \int_{\omega>0} |G|^2 \, d\omega}$$

$$\approx 210\ \mathrm{A}$$

gain curves



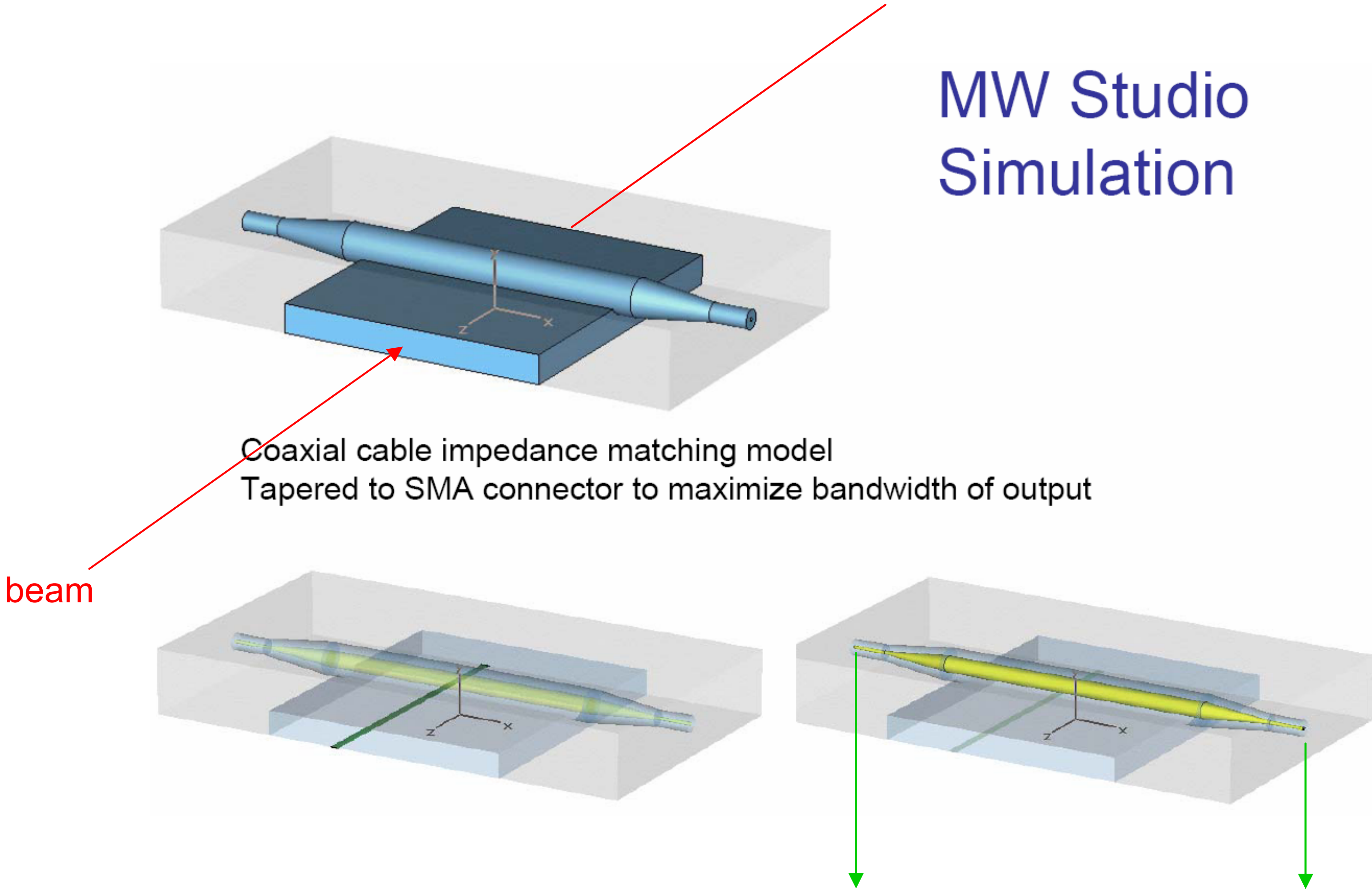
after dogleg
(r56=0.84mm)

after BC2
(C2=5,
r56=-20.7mm)

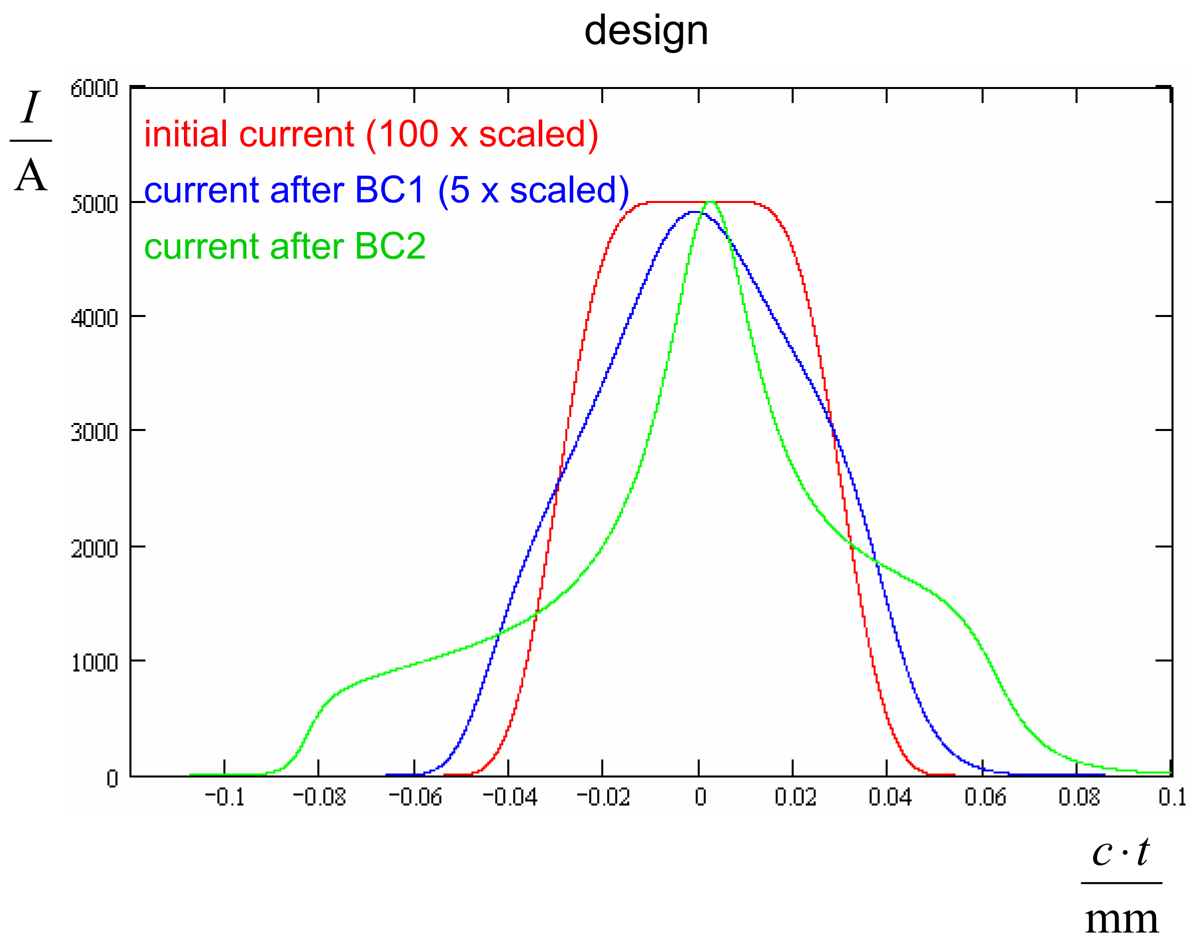
after BC1
(C1=20
r56=-103mm)

shape sensitivity

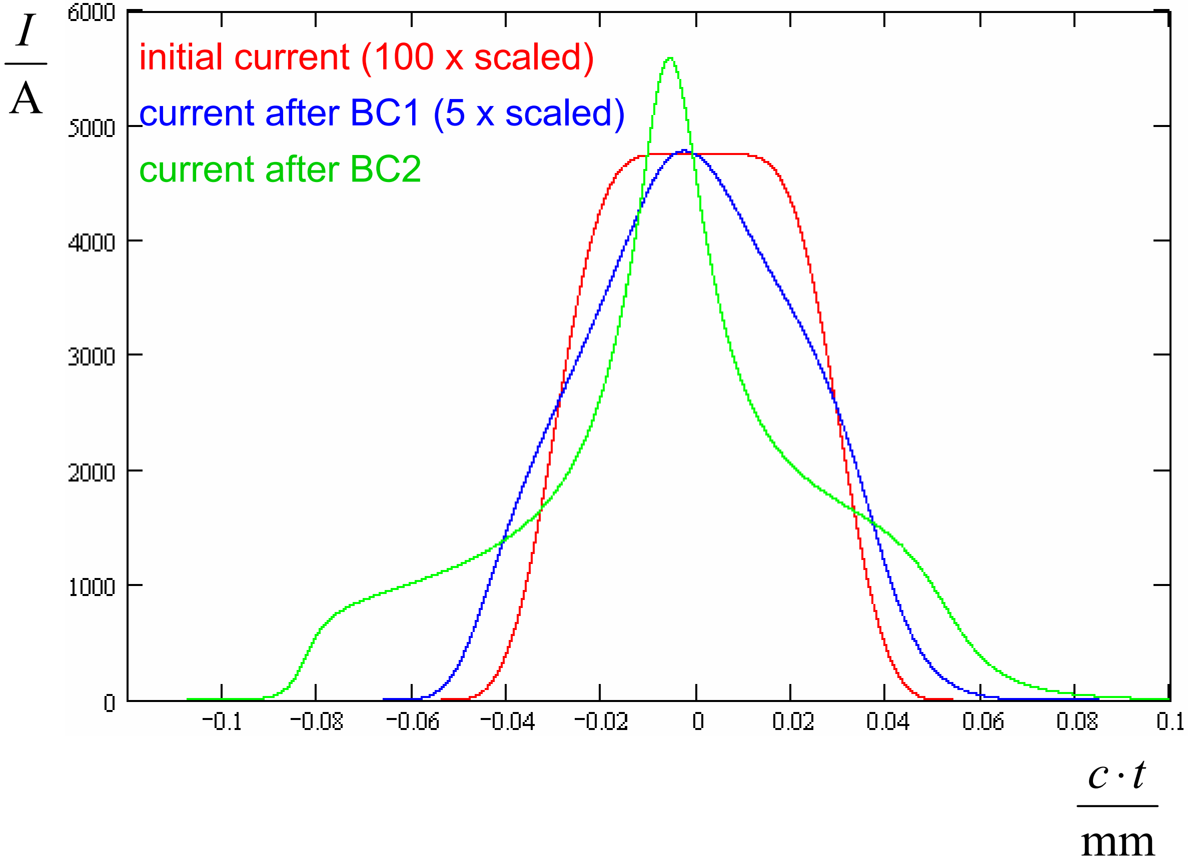
from Kirsten Hacker

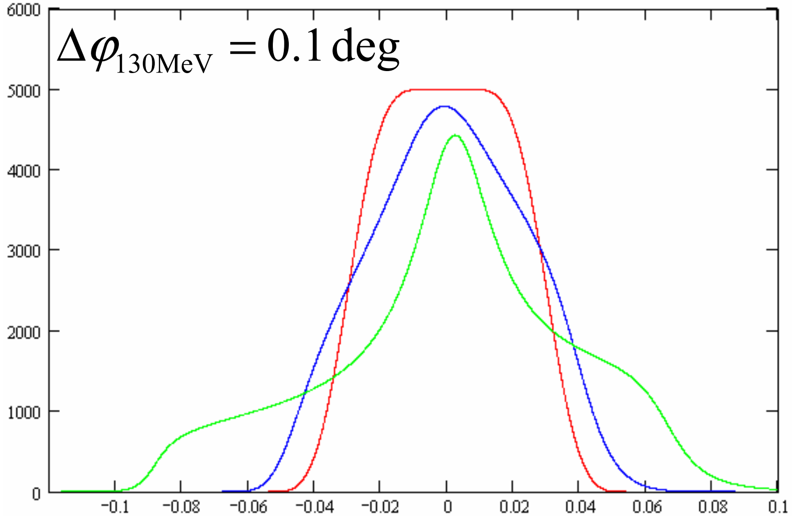


signal analysis (zero crossing)
→ center of mass of bunch
with very high resolution

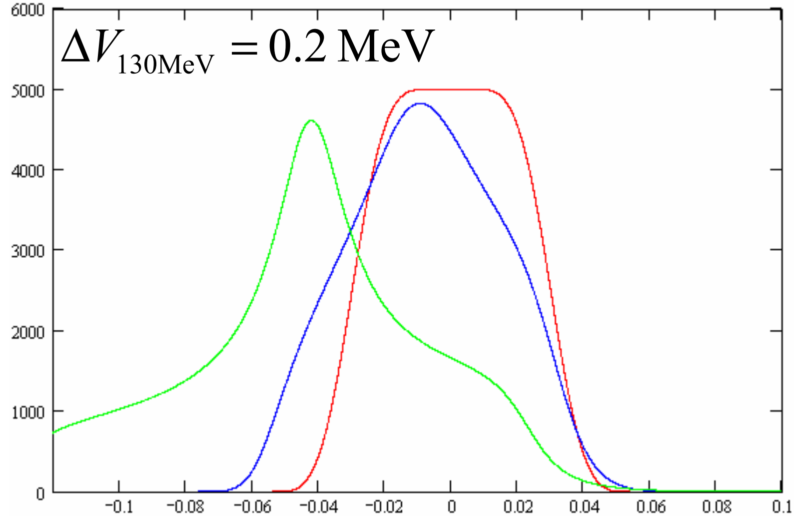

design
initial current (100 x scaled)
current after BC1 (5 x scaled)
current after BC2
$\frac{I}{A}$
6000
5000
4000
3000
2000
1000
0
-0.1
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1
$\frac{c \cdot t}{mm}$

bunch charge reduced by 5%

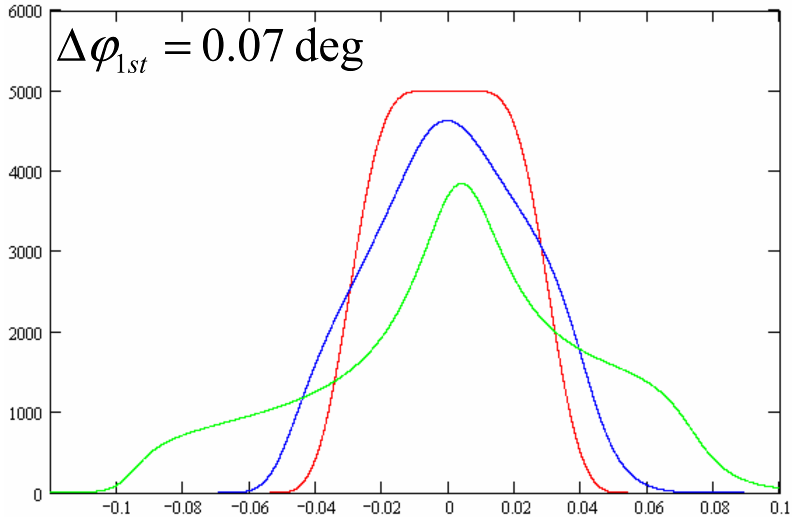




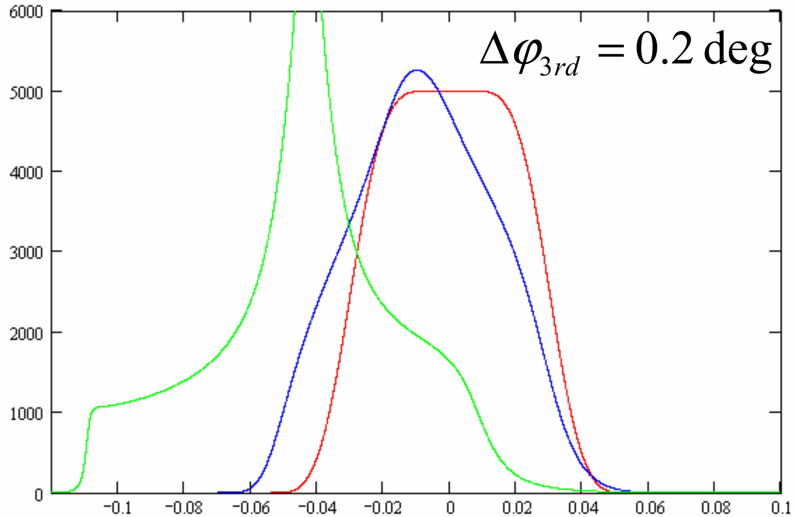
$\Delta\varphi_{130\mathrm{MeV}} = 0.1\ \mathrm{deg}$
6000
5000
4000
3000
2000
1000
0
-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1



$\Delta V_{130\mathrm{MeV}} = 0.2\ \mathrm{MeV}$
6000
5000
4000
3000
2000
1000
0
-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1

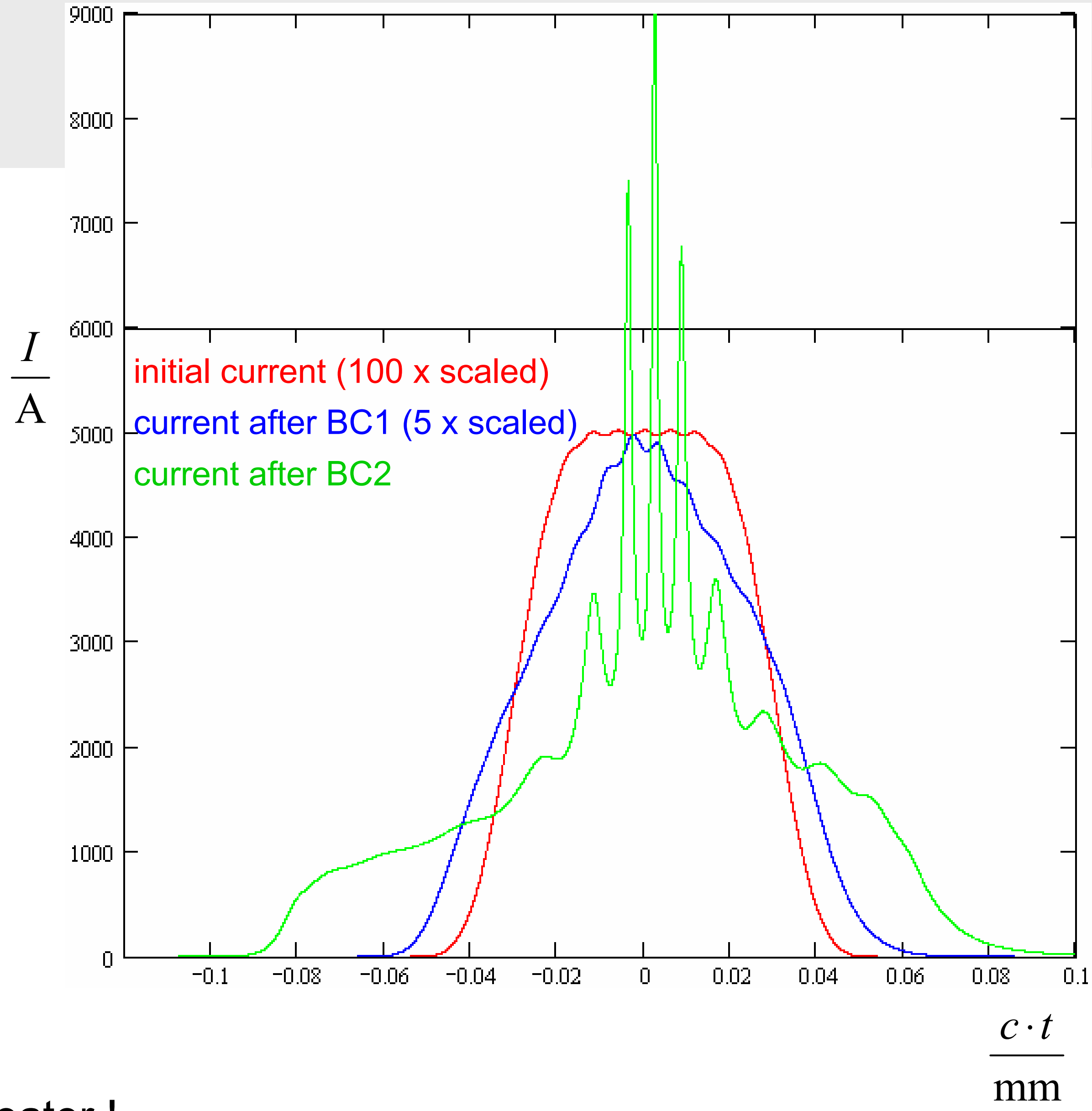


$\Delta\varphi_{1st} = 0.07\ \mathrm{deg}$
6000
5000
4000
3000
2000
1000
0
-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1



$\Delta\varphi_{3rd} = 0.2\ \mathrm{deg}$
6000
5000
4000
3000
2000
1000
0
-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1

modulation

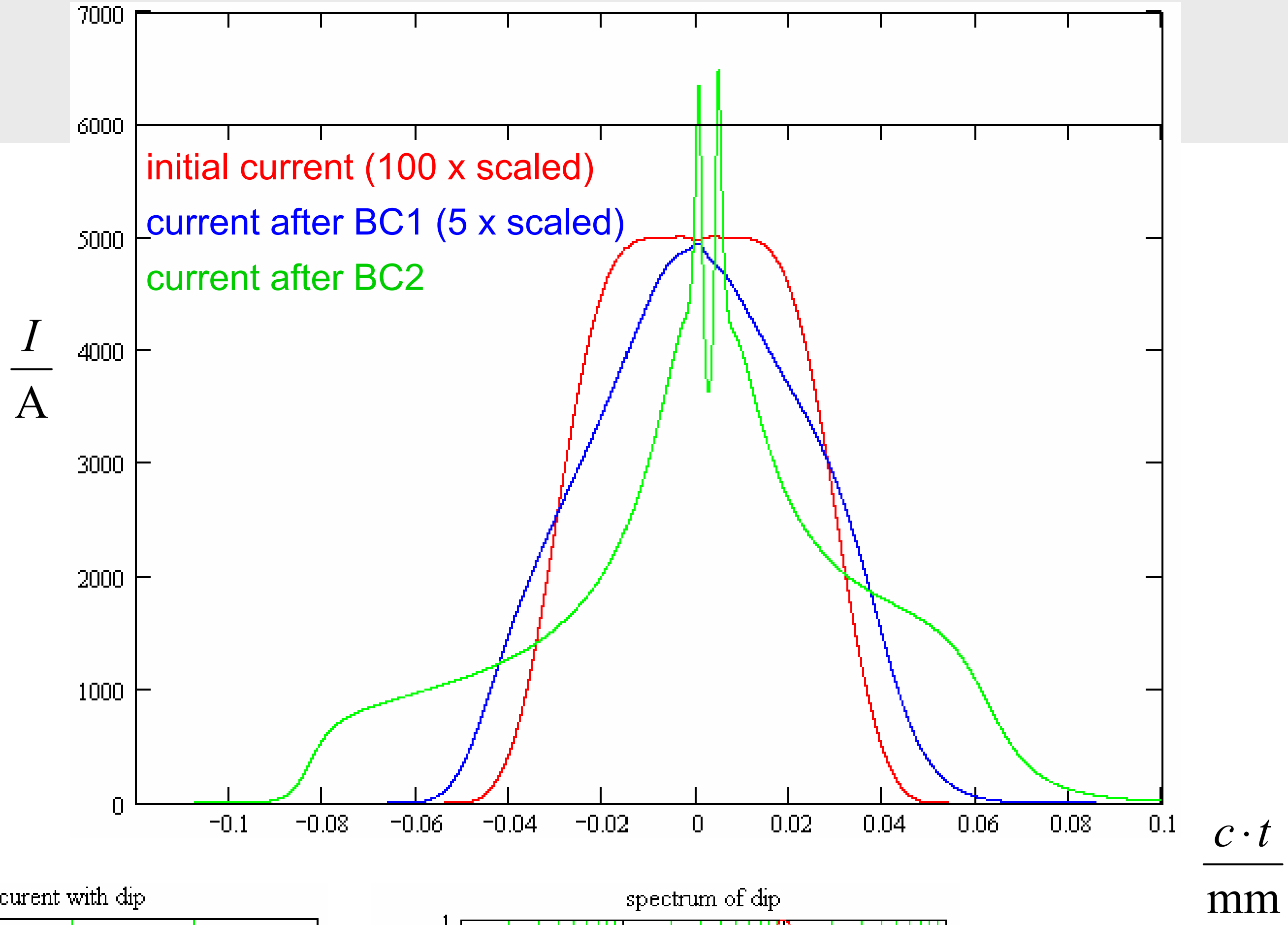


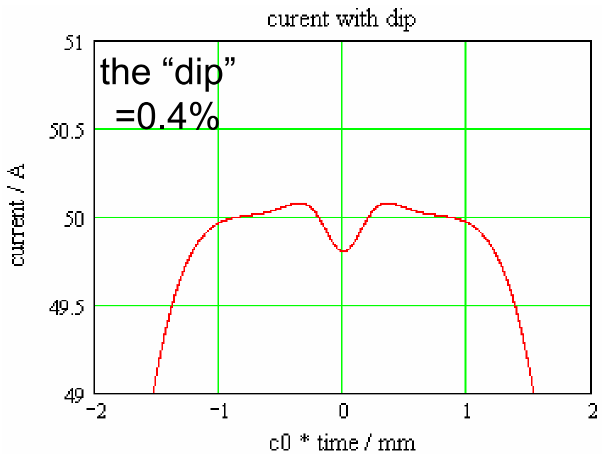
no laser heater !

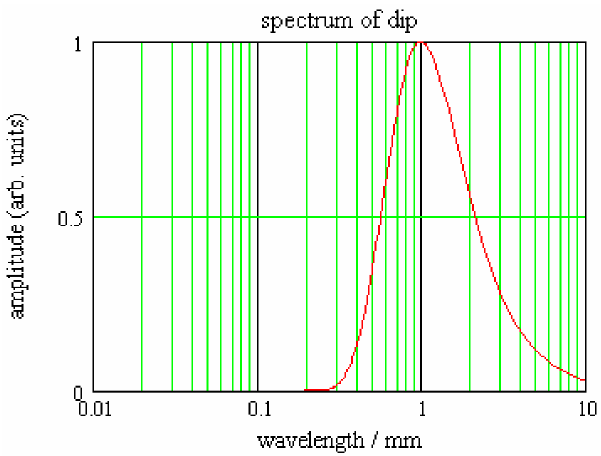
0.5% modulation at λ = 0.6 mm

gain without/with LH = 390 / 19

“dip”







no laser heater !
gain at λ = 1 mm
without/with LH = 39 / 18