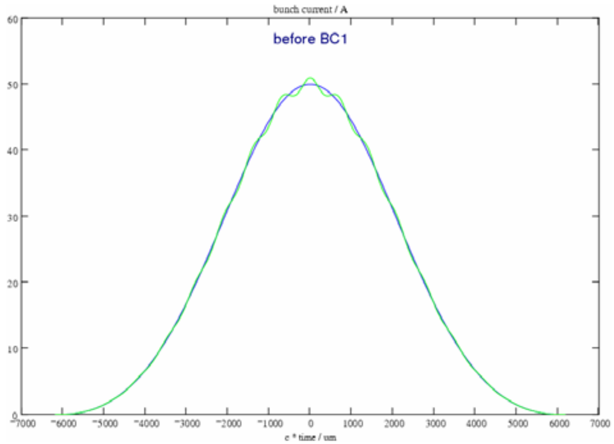
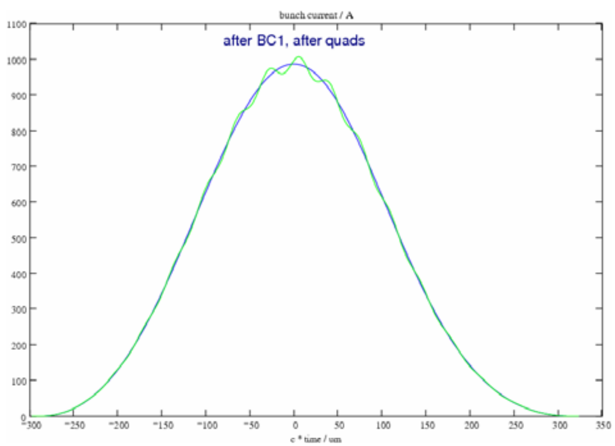
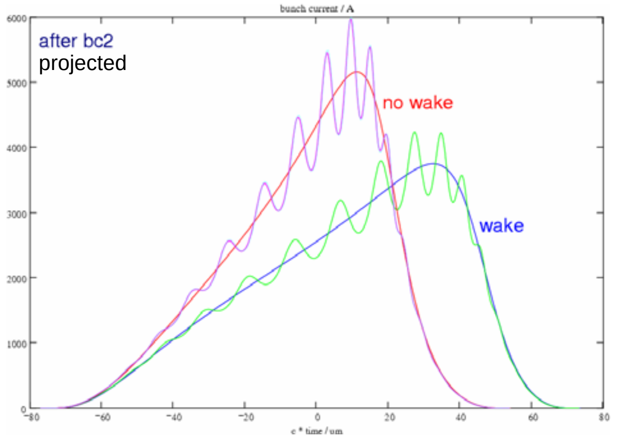
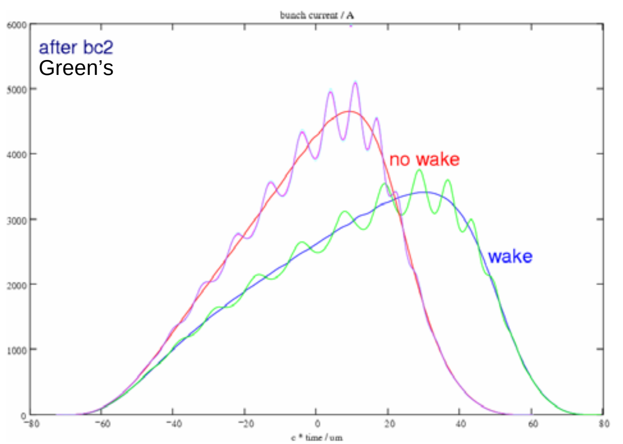
µ-bunch stability

CSR stability: see s2e-meeting march 2005; Erms = 5keV @ 50A → G <~ 8





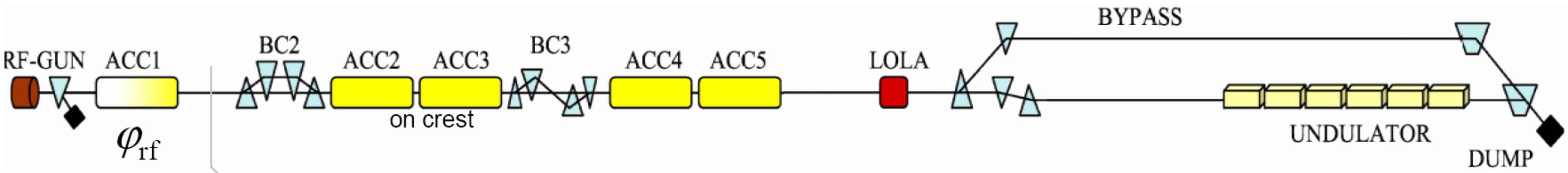


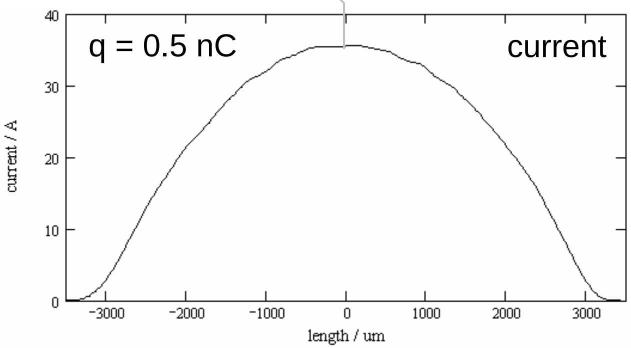


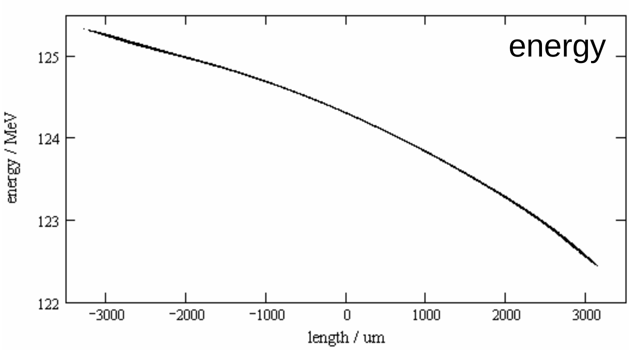
Erms << 5keV ??? 500eV

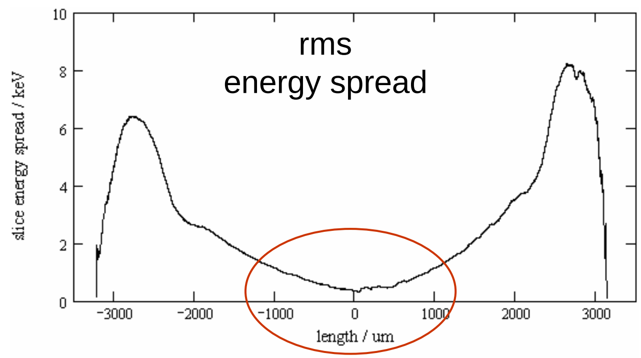
SC stability

e.g.: TTF2 s2e simulation



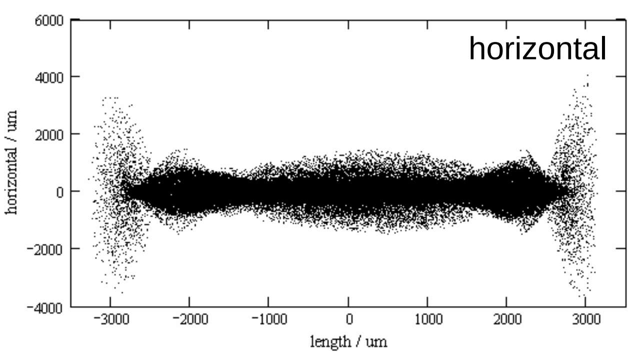


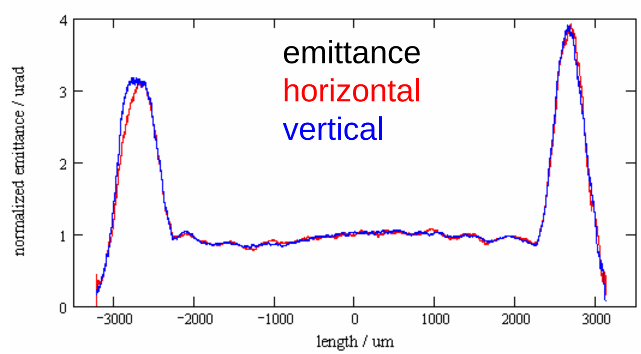




!

Erms ≈ 500V @ 35A





e.g.: old XFEL simulation

Start-to-End Simulations

TTF1, TTF2 and XFEL

•TTF1

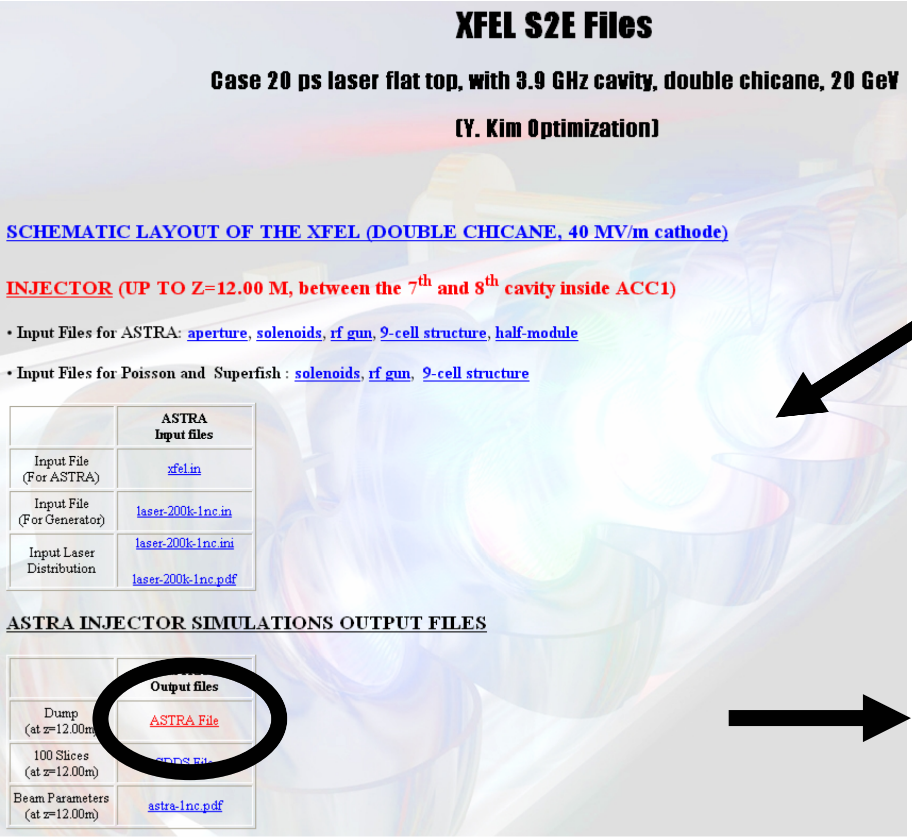
- Start-to-End Simulations of SASE FEL at the TESLA Test Facility, Phase 1.

•TTF2

- Optimized version (6.4 nm, 1GeV)
- Operation wihout 3.9 GHz cavity : Case 0.5 nC, 4 ps sigma, magnetic compression
- Operation without 3.9 GHz cavity : Case 1.0 nC, 4 ps sigma, velocity bunching
- Operation without 3.9 GHz cavity : Case 1.0 nC, 20 ps flat top, velocity bunching

• XFEL

- Benchmark S2E workshop, August 2003 (20.5 GeV, 3 chicanes, 12 kA peak)
- ESFRI XFEL workshop, October 2003 (20.0 GeV, double chicane, 5 kA)



XFEL S2E Files

Case 20 ps laser flat top, with 3.9 GHz cavity, double chicane, 20 GeV

(Y. Kim Optimization)

SCHEMATIC LAYOUT OF THE XFEL (DOUBLE CHICANE, 40 MV/m cathode)

INJECTOR (UP TO Z=12.00 M, between the 7th and 8th cavity inside ACC1)

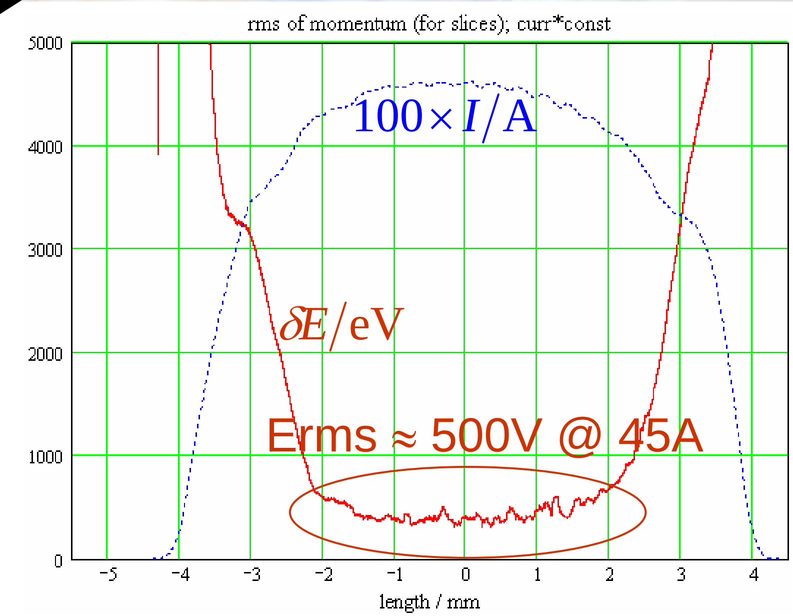
• Input Files for ASTRA: aperture, solenoids, rf gun, 9-cell structure, half-module

• Input Files for Poisson and Superfish : solenoids, rf gun, 9-cell structure

	ASTRA Input files
Input File (For ASTRA)	xfel.in
Input File (For Generator)	laser-200k-1nc.in
Input Laser Distribution	laser-200k-1nc.ini laser-200k-1nc.pdf

ASTRA INJECTOR SIMULATIONS OUTPUT FILES

	Output files
Dump (at z=12.00m)	ASTRA File
100 Slices (at z=12.00m)	SDDS File
Beam Parameters (at z=12.00m)	astra-1nc.pdf



SC Gain in XFEL

theory:

Longitudinal Space Charge Driven Microbunching Instability in TTF2 Linac

E. Saldin, E. Schneidmiller, M. Yurkov

/ S2E Workshop, Zeuthen, August 18, 2003 /

density modulation $\rightarrow$ energy modulation:

impedance

$$I = I_0 \left(1 + \rho_i \cos kz\right) \quad \rightarrow \quad \Delta\gamma = \frac{q_0 Z_0}{m_0 c^2} \frac{\boxed{Z(k)}}{Z_0} I_0 \rho_i$$

energy modulation $\rightarrow$ density modulation:

$$\frac{\Delta I}{C I_0} = \boxed{jkCr_{56}} \cdot \boxed{\exp\left(-\frac{1}{2}\left(kCr_{56}\frac{\sigma_\gamma}{\gamma}\right)^2\right)} \cdot \frac{\Delta\gamma}{\gamma}$$

E$\rightarrow$D gain

E-spread smearing

(I_0, k, σ_γ before compression !)

modulation gain:

$$G = \frac{\Delta I}{\rho_i} = I_0 \cdot \frac{q_0 Z(k)}{\gamma m_0 c^2} \cdot jkCr_{56} \cdot \exp\left(-\frac{1}{2}\left(kCr_{56} \frac{\sigma_\gamma}{\gamma} \right)^2 \right)$$

SC impedance:

$$Z(k) = \int \frac{E_z(k, \sigma, \gamma, R_{\text{pipe}})}{I} dz$$

straw beam:

$$E_{z,s}(r, R, k, \gamma) \propto \begin{cases} \dfrac{I_0(kr/\beta\gamma)}{I_0(kR/\beta\gamma)} & \text{for } r < R \\[2ex] \dfrac{K_0(kr/\beta\gamma)}{K_0(kR/\beta\gamma)} & \text{for } r > R \end{cases}$$

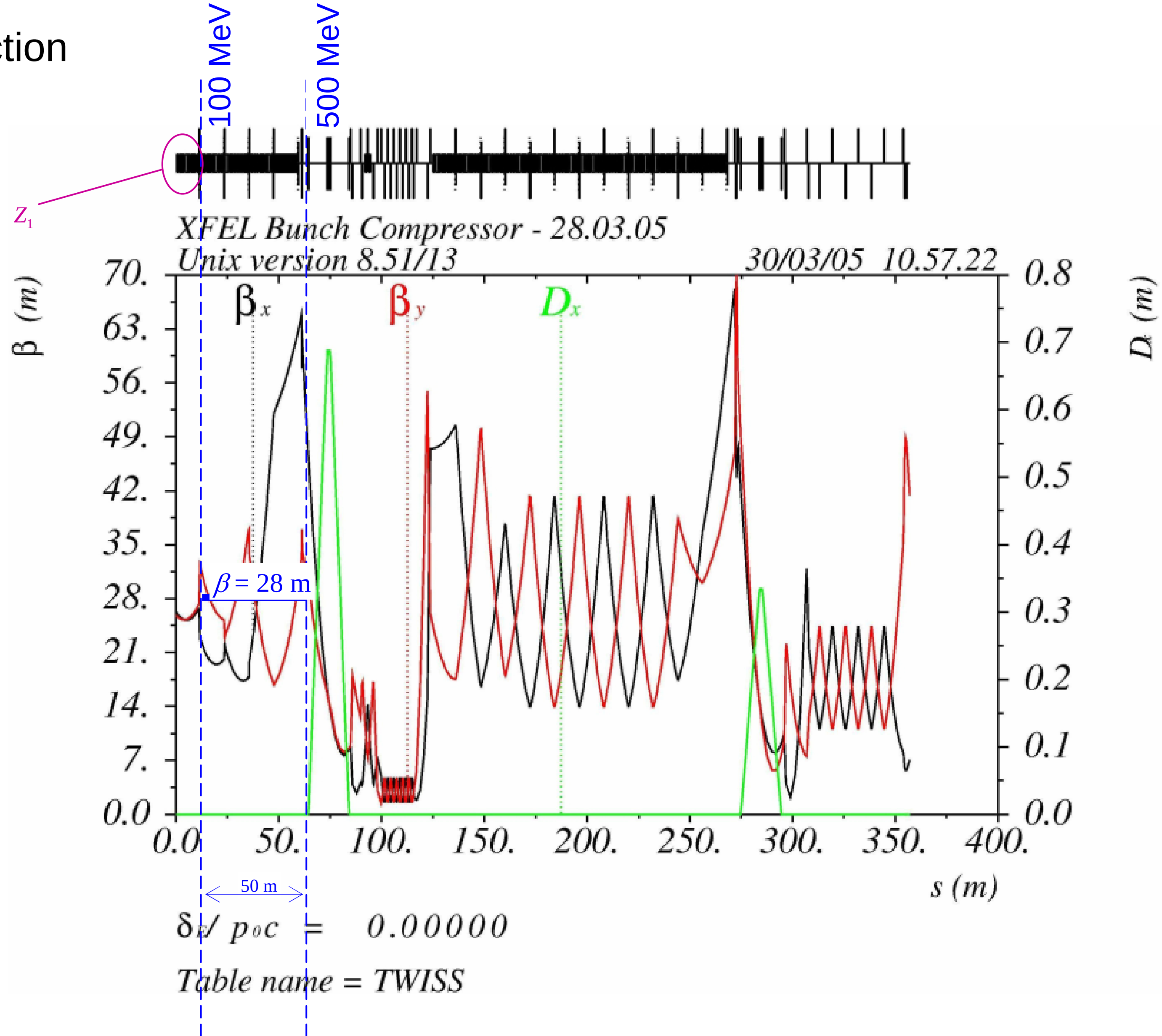
I_0, K_0 = modified Bessel functions

$\rightarrow$ Gaussian beam in pipe

preliminary

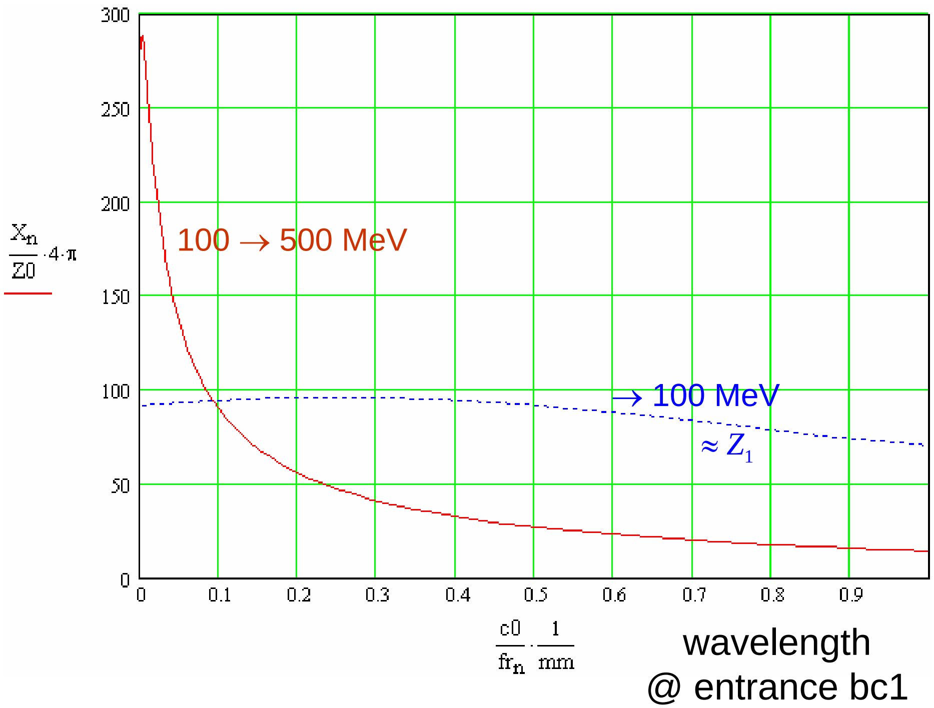
G1 = impedance(before BC1) + BC1

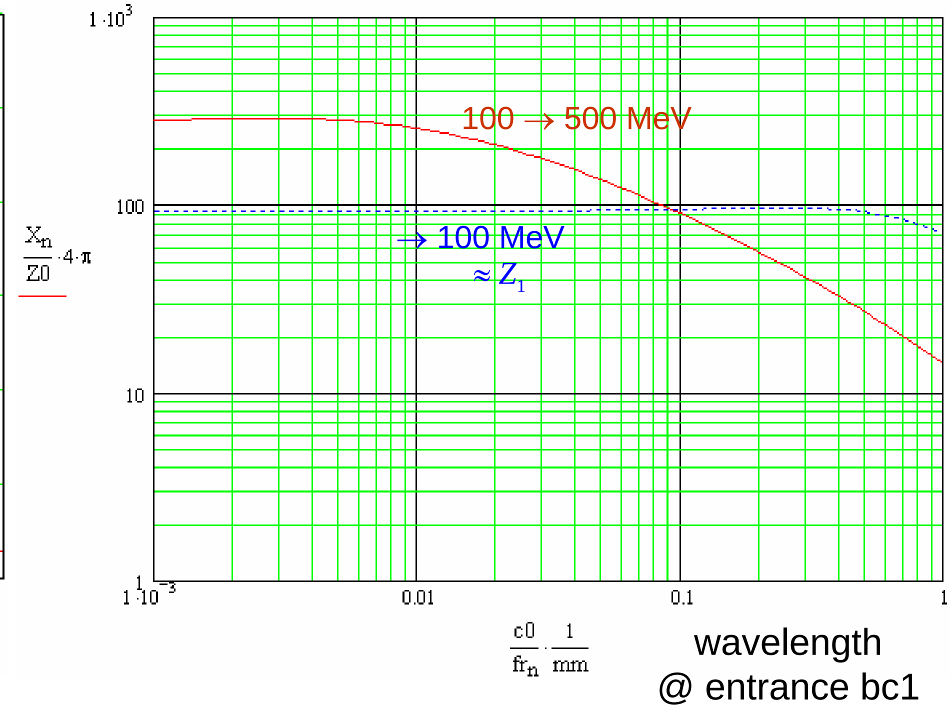
averaged β function



preliminary

impedance





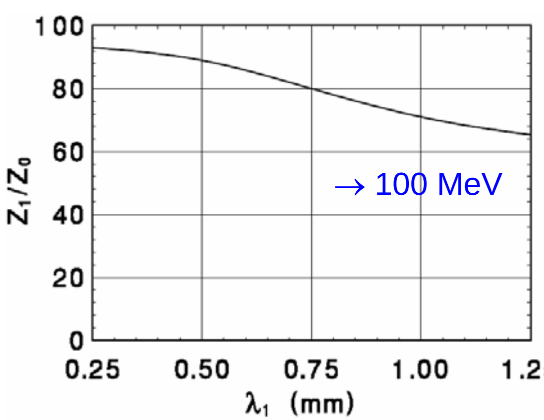


Fig. 1. The LSC impedance in ACC1 (numerical simulations)

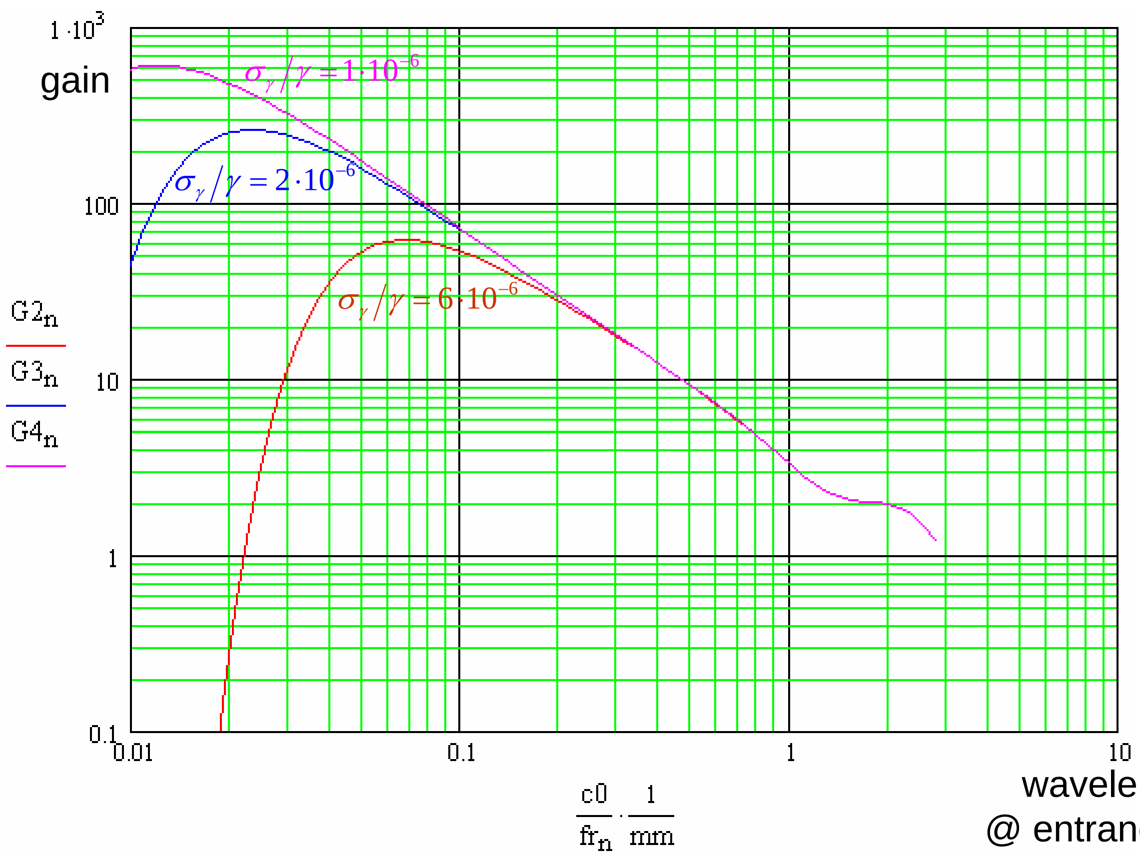
preliminary

gain G1 = impedance(before BC1) + BC1

$C = 20$ $\gamma = 978.474$

$I0 = 50$ $r56\_1 := 103.237 \cdot mm$

$$G2_n := C \cdot k_n \cdot r56\_2 \cdot \frac{I0}{\gamma \cdot Ia} \cdot \frac{Xtot_n}{Z0} \cdot 4 \cdot \pi \cdot \exp\left[\frac{-1}{2} \cdot \left(C \cdot k_n \cdot r56\_2 \cdot \frac{\sigma\gamma}{\gamma}\right)^2\right]$$



300 keV @ 5 kA
100 keV @ 5 kA
50 keV @ 5kA

wavelength
@ entrance bc1

preliminary

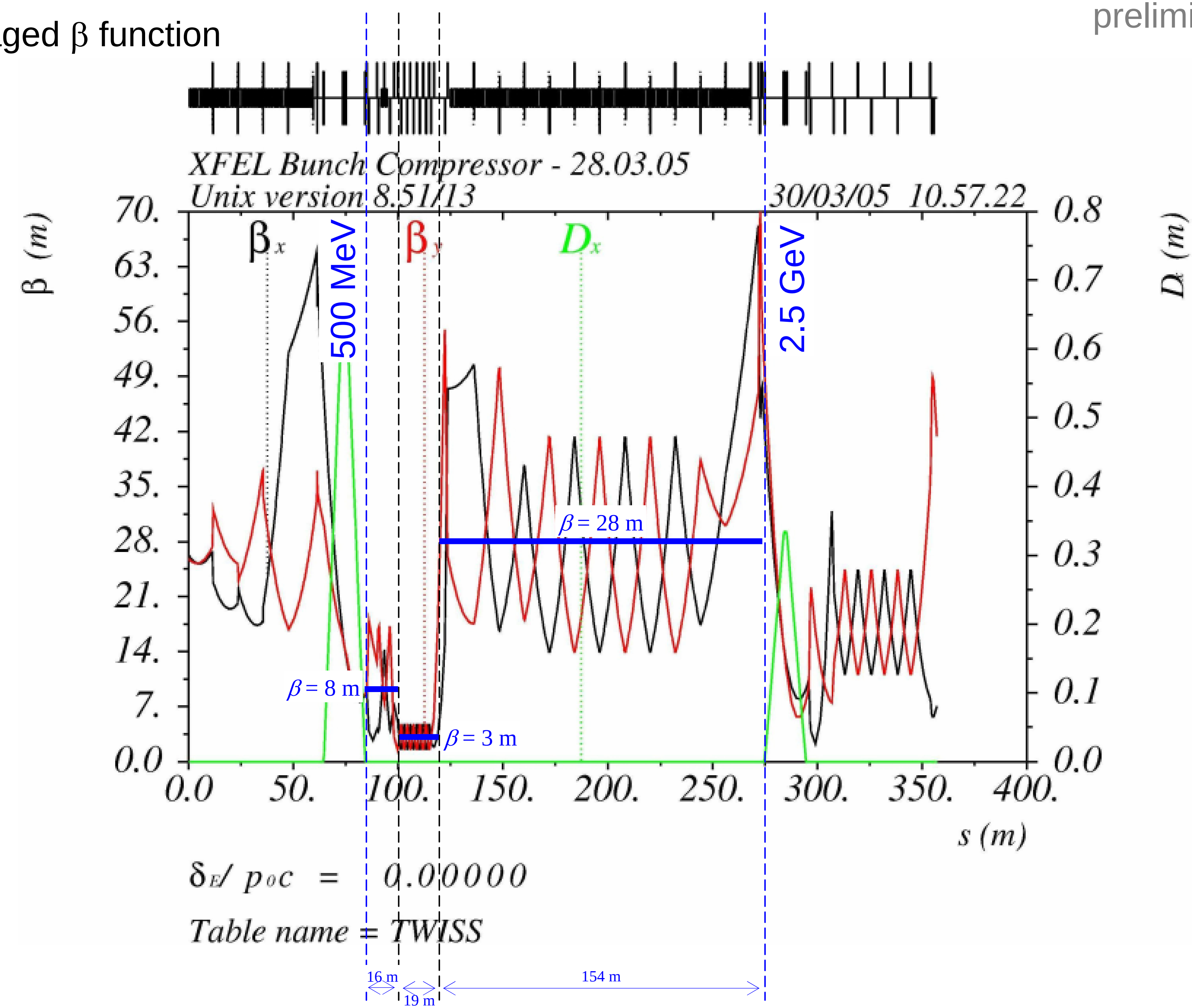
G2 = impedance(BC1 to BC2) + BC2

setup: E1=500MeV, C1=20, R56_1=-103.2mm
rf of LINAC E1 $\rightarrow$ E2 is 20 deg of crest
E2=2.5GeV, C2=5, R56_2=-17.9mm

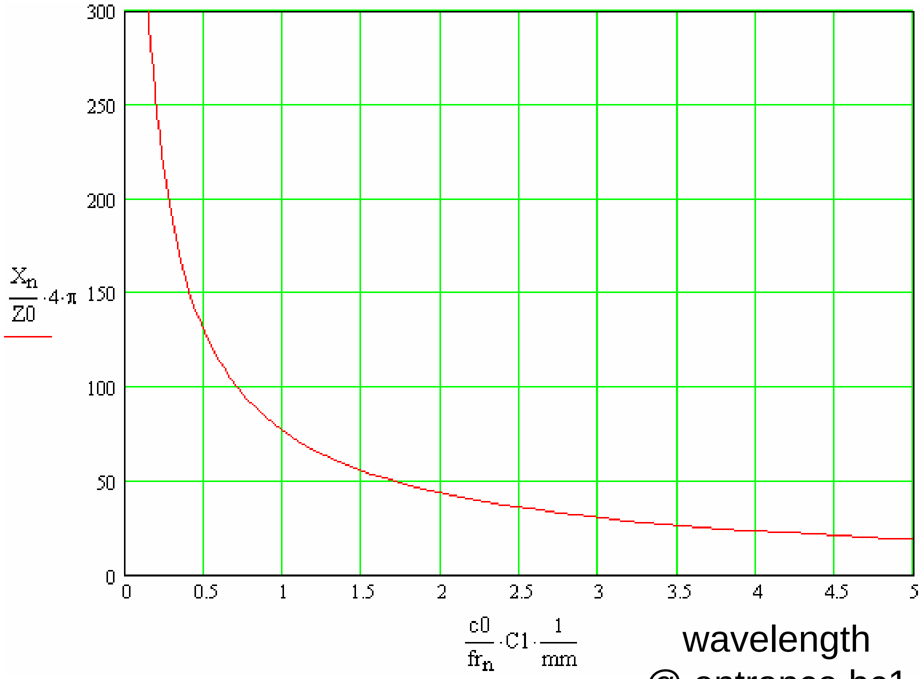
norm. emittance $= 10^{-6}$ m
pipe radius $= 39$ mm

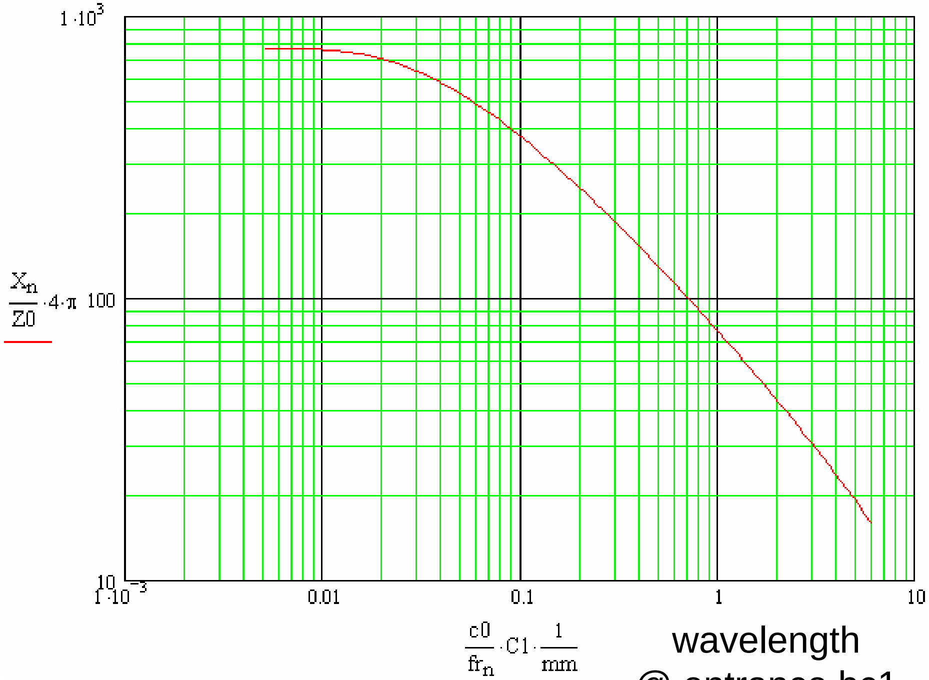
averaged β function

preliminary



impedance of section between bc1 and bc2
(imaginary part)





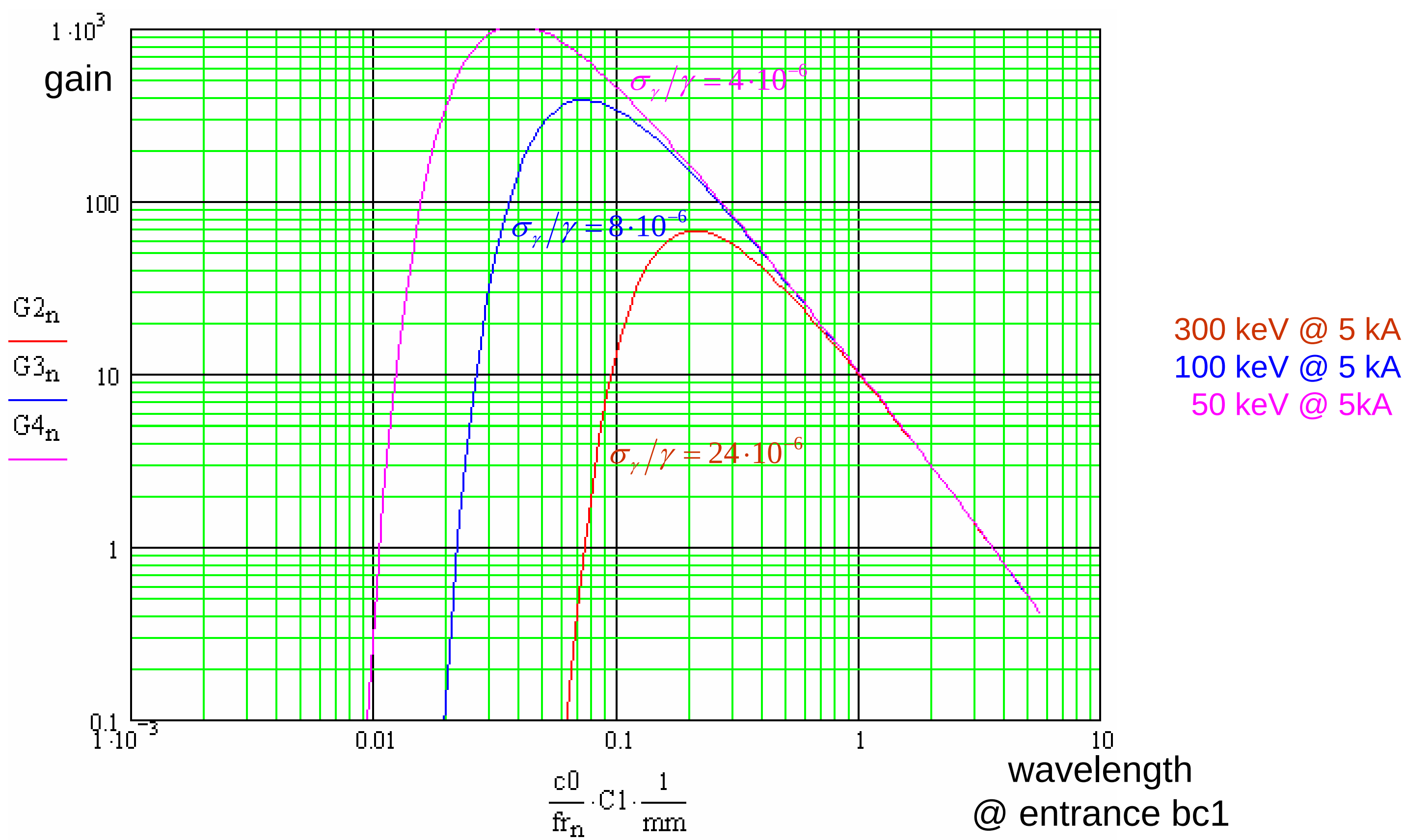
preliminary

gain G2 = impedance(BC1 to BC2) + BC2

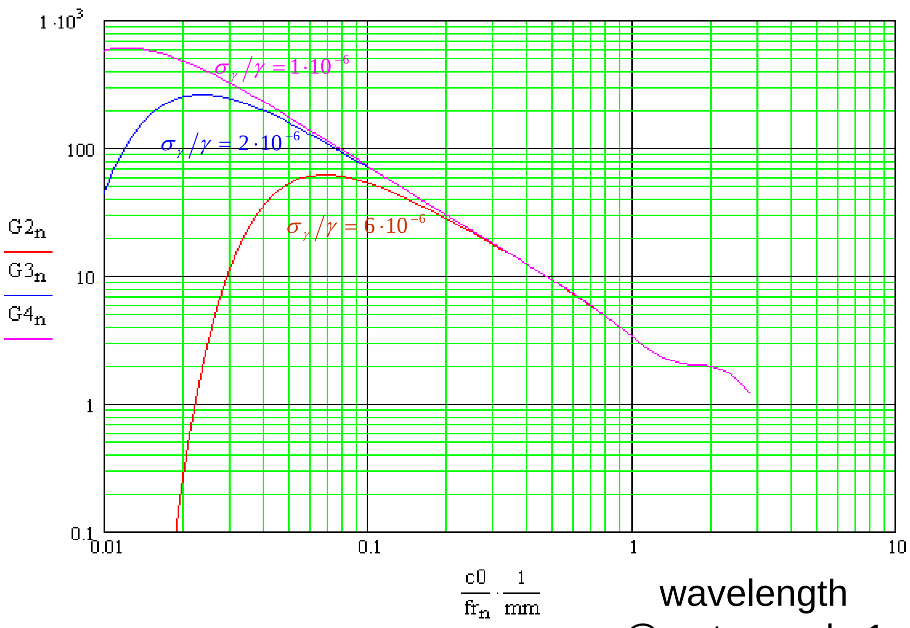
$C2 = 5 \qquad \gamma = 4.892 \times 10^{3}$

$I0 = 1 \times 10^{3} \qquad r56\_2 := 17.874 \cdot mm$

$$G2_n := C2 \cdot k_n \cdot r56\_2 \cdot \frac{I0}{\gamma \cdot Ia} \cdot \frac{X_n}{Z0} \cdot 4 \cdot \pi \cdot \exp\left[\frac{-1}{2} \cdot \left(C2 \cdot k_n \cdot r56\_2 \cdot \frac{\sigma\gamma}{\gamma} \right)^2 \right]$$

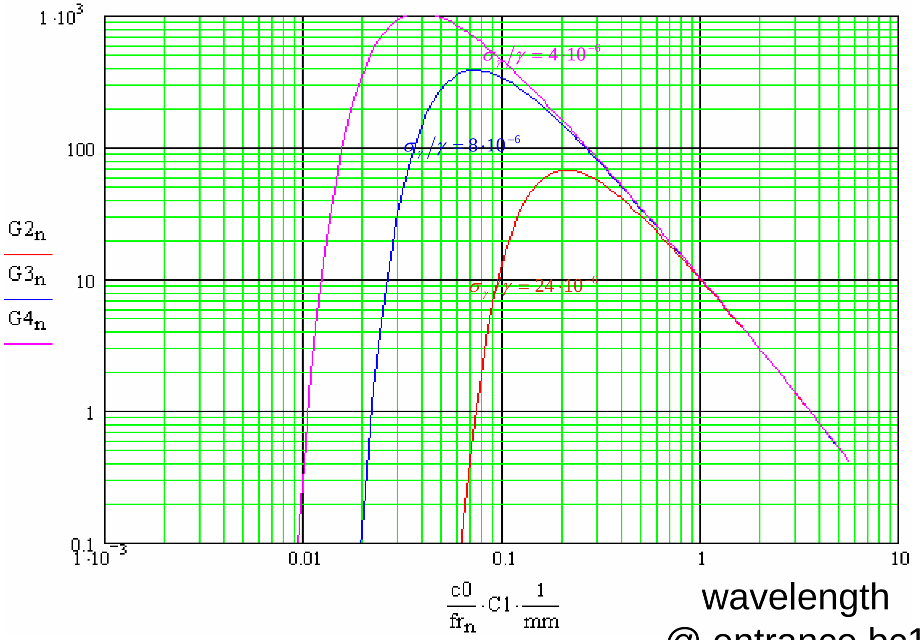


gain G1



wavelength
@ entrance bc1

gain G2



wavelength
@ entrance bc1