BC1 design studies

C. Vaccarezza

Outline

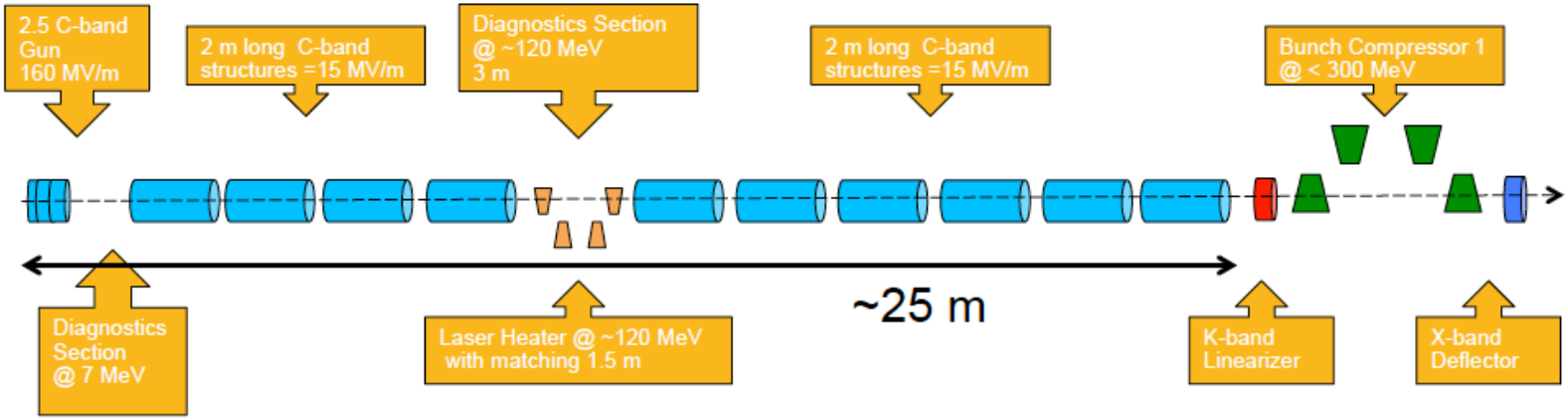
- The CSR effect has been taken into account for the ultimate layout WP of the machine up to BC1 exit, namely characterized by high repetition rate.
- The results have been obtained on the basis of the layout provided in the XLS-WP6 repository plus the insertion of the LH and 4 more C-band sections, and the 2.6 cell C-band RF-gun has been considered
- Looking at the entrance energy before the chicane, the basis for the C- band acc gradient has been:
  - Low rep rate $E_{acc} = 40 \frac{MV}{m}$
  - High rep rate $E_{acc} = 15 \frac{MV}{m}$ - The latter has been selected as the reference one.
  - Three main entranhce energyies have been taken into account:
    - 165 MeV– 210 MeV- 287 MeV
- The CSR effect has been studied with the Elegant code tracking 8.4 Mp through the BC1 chicane -a rough convergence test has been carried on-
- The SC effect has been studied with the GPT code tracking 220Kp through the BC1 chicane.
- CSR studies with GPT are ongoing with numerical MBI studies as well

Full C–band XLS Injector

Funded by the
European Union

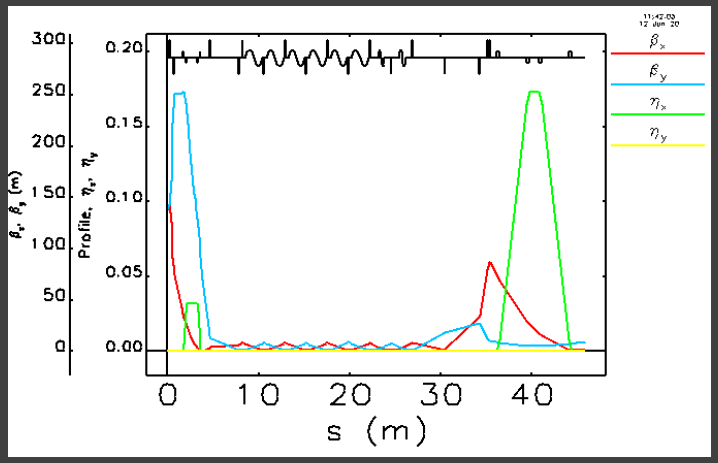
Compact

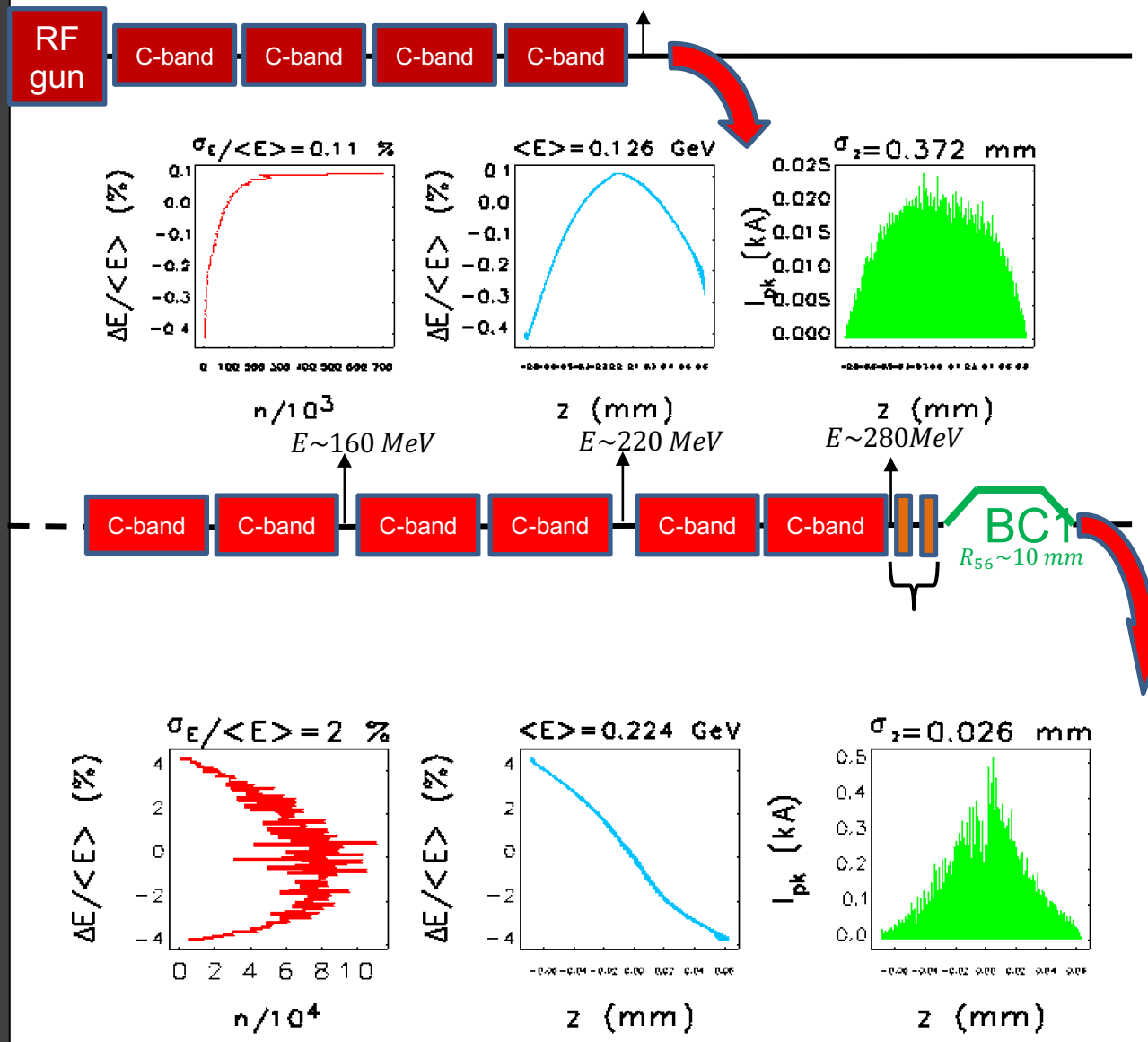
- One injector for all the operational modes (HRR and LRR)
  - 2.5 C-band gun with 160 MV/m cathode peak field => longer drift for diagnostics
  - Copper cathode and TiSa Laser
  - Same gradients 15 MV/m in the 2 m long C-band structures, max gain 30 MeV/structure
  - Same diagnostics positions (@ gun exit 7 MeV and in the drift parallel to the LH @ 120 MeV)
  - Same beam parameters at the linac exit
  - Matching with LH to be determined



- Optimal BC1 input energy (=> and position) to be determined
  - Without Velocity Bunching
  - With Laser Heater less than 2 m long
  - K-band Linearizer just before the BC1, X-band RFD downstream BC1
  - Same beam parameters at the BC1 exit

High rep rate oncrest beam from 2.6 cells PhInjector.





Total length

Undulator length: 8x3 = 24 cm

+

Screen length: 2x5 = 10 cm

+

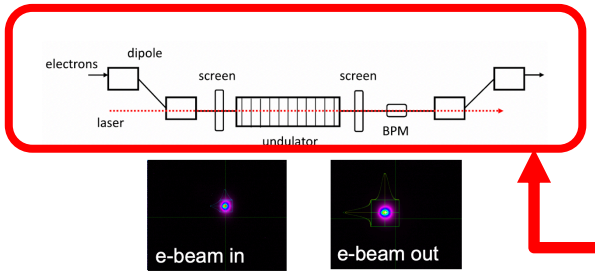
Button-BPM length: 3 cm

+

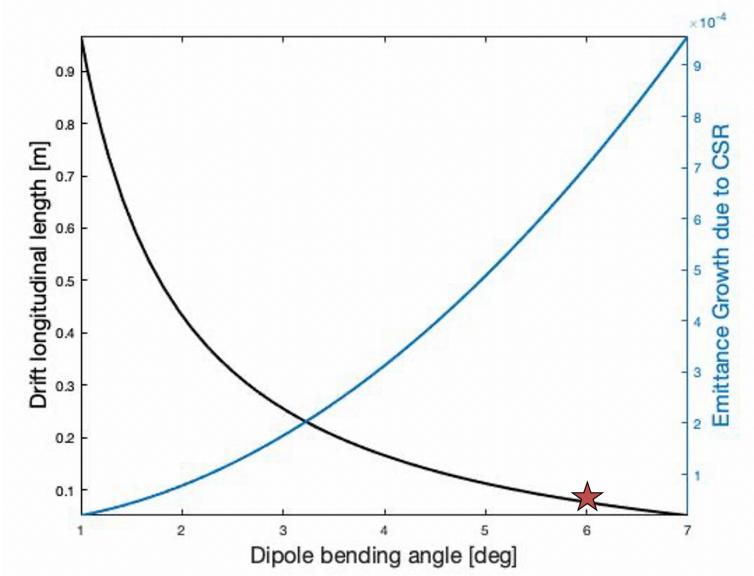
Dipole length: 4x10 = 40 cm

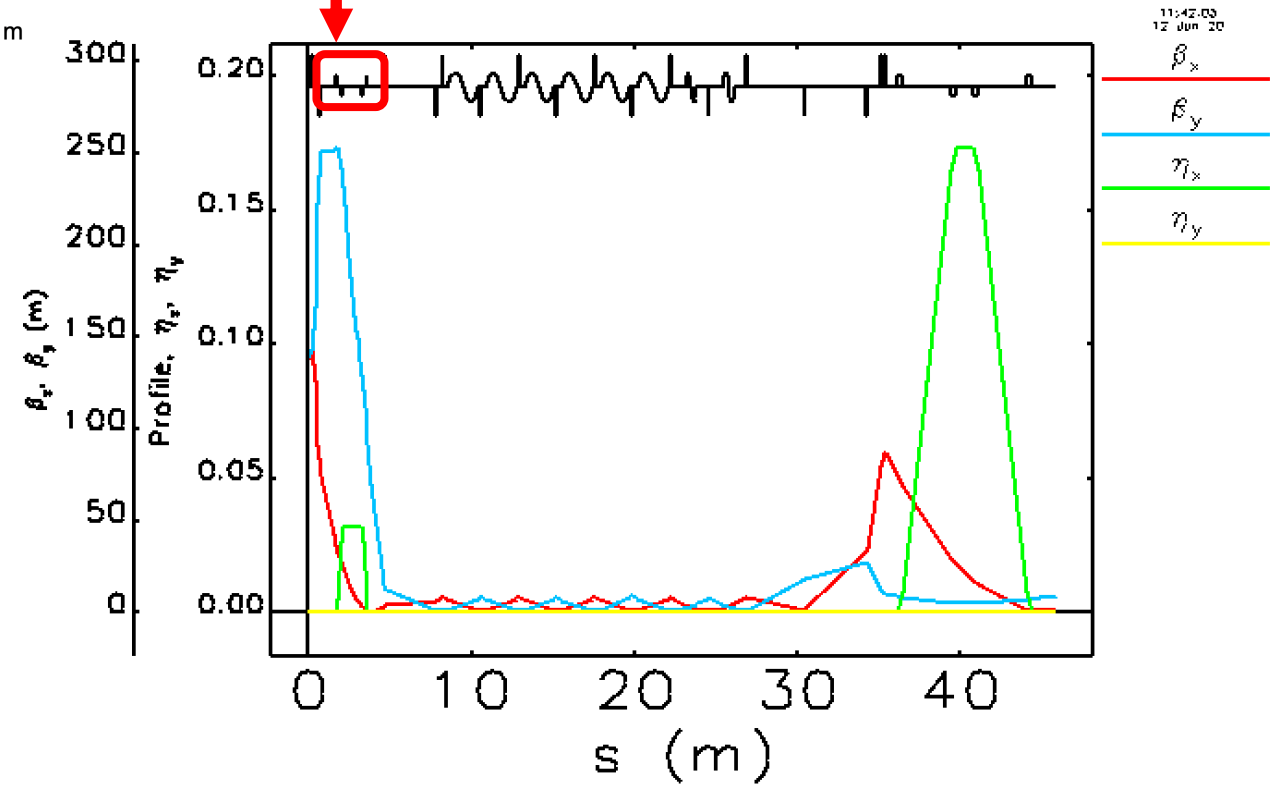
+

Drift length: 2x10 = 20 cm

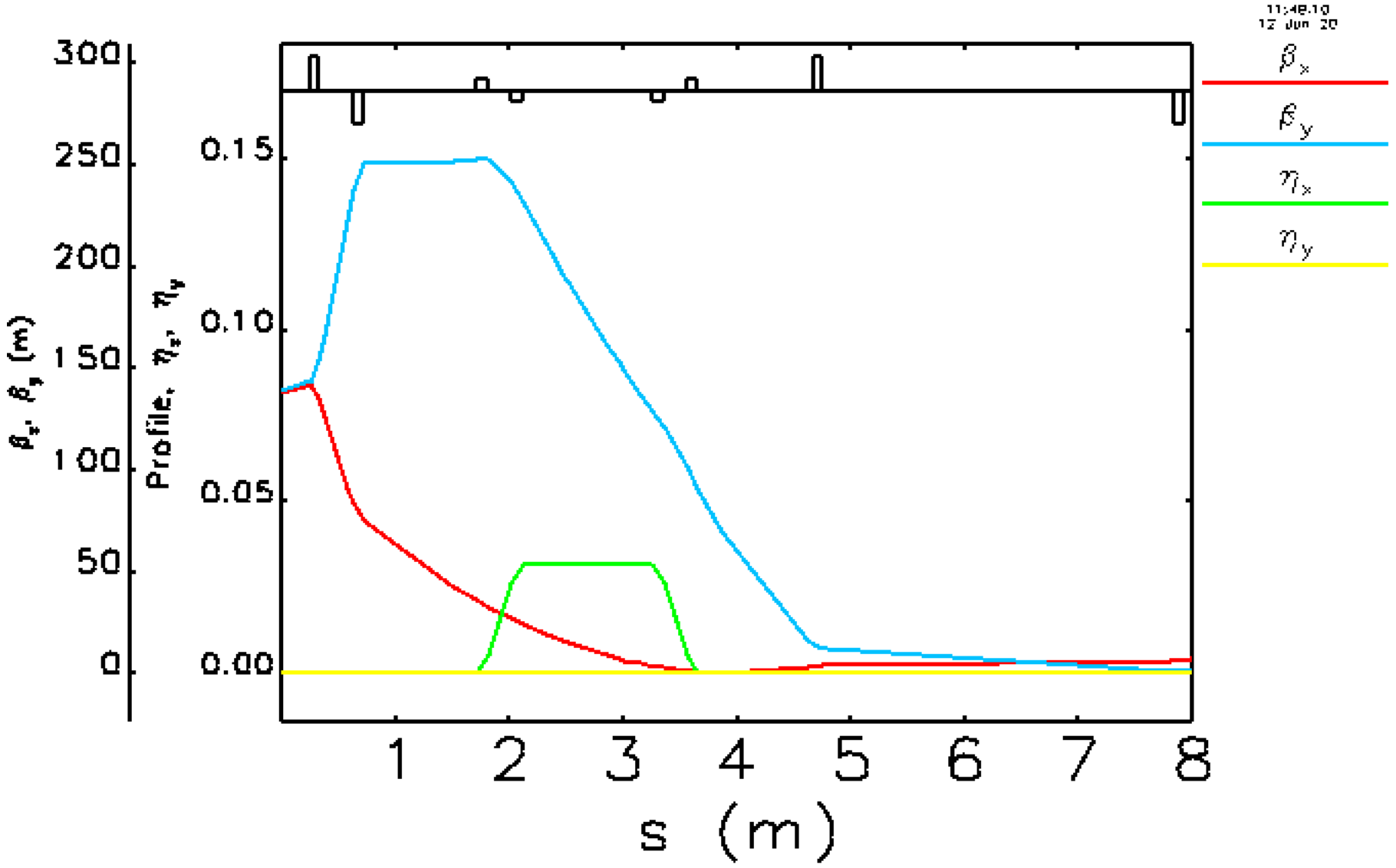


Total LH length ~ 1 m

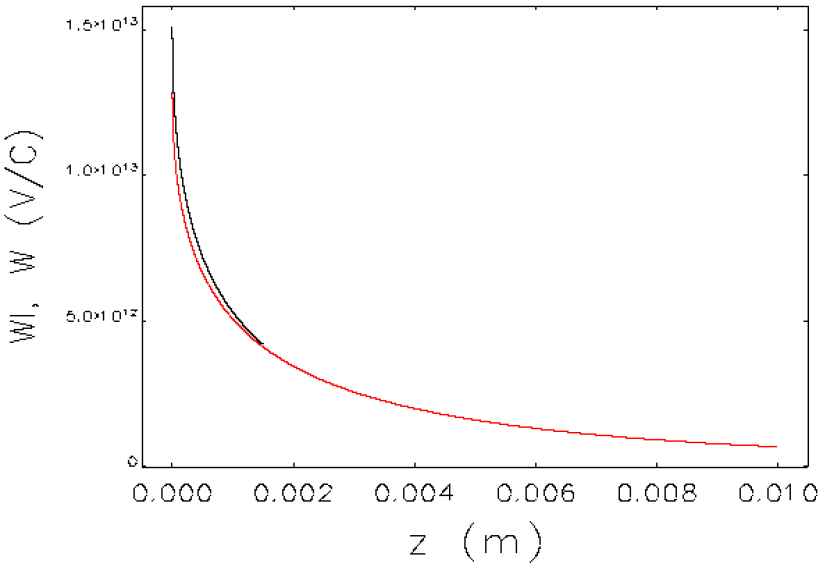




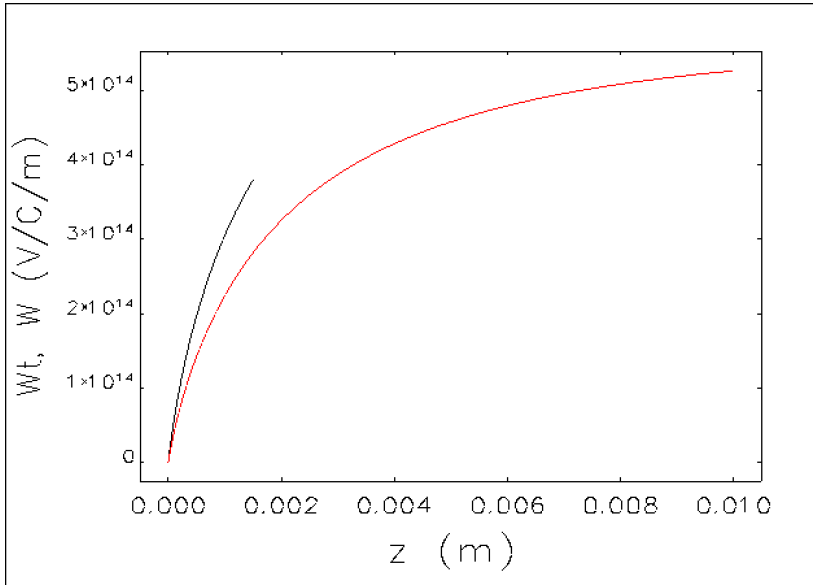
More in detail:



C-band wake comparison

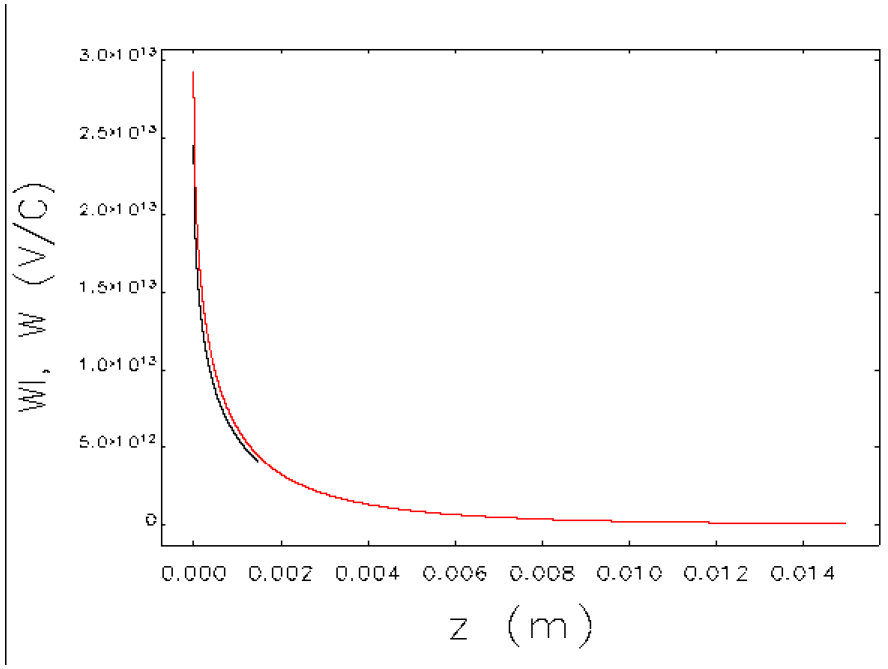


___ mine

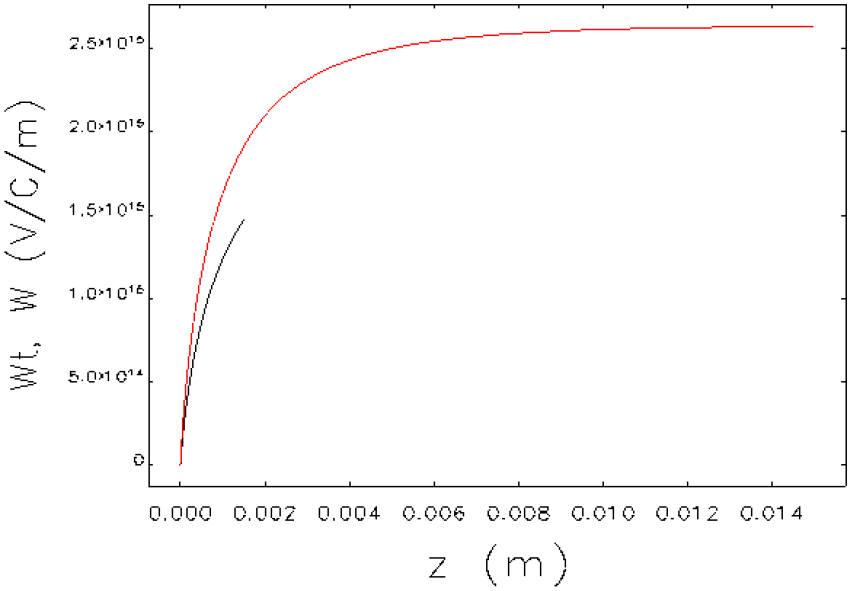


___ mine

X-band wake comparison

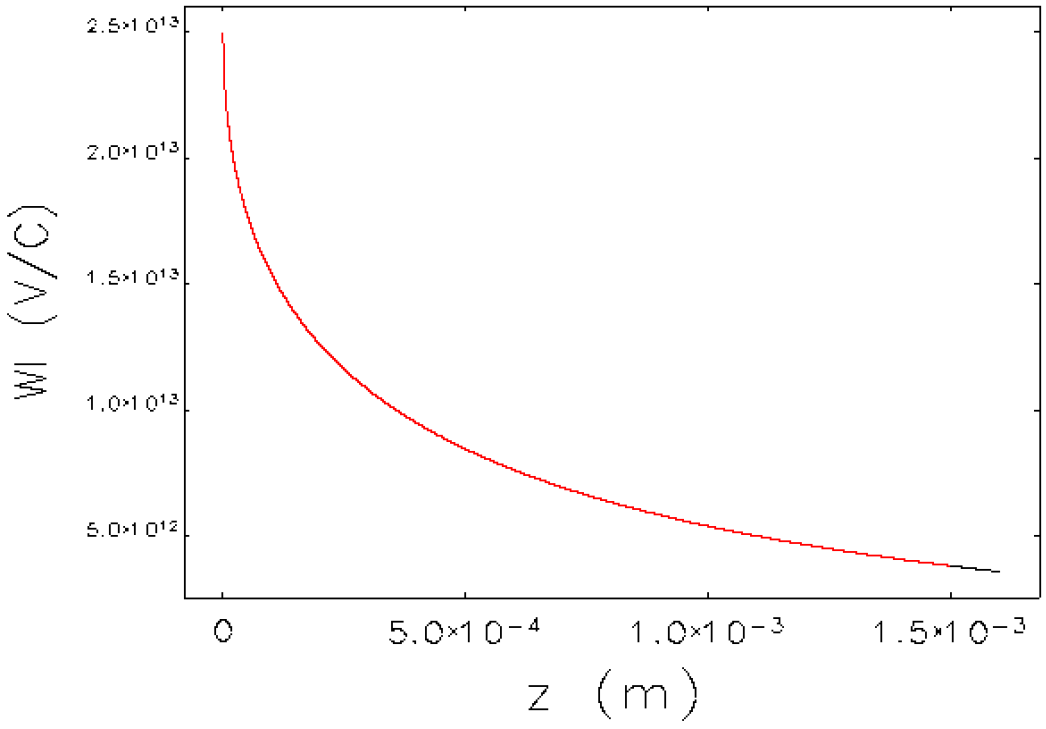


___ mine



___ mine

K-band wake comparison



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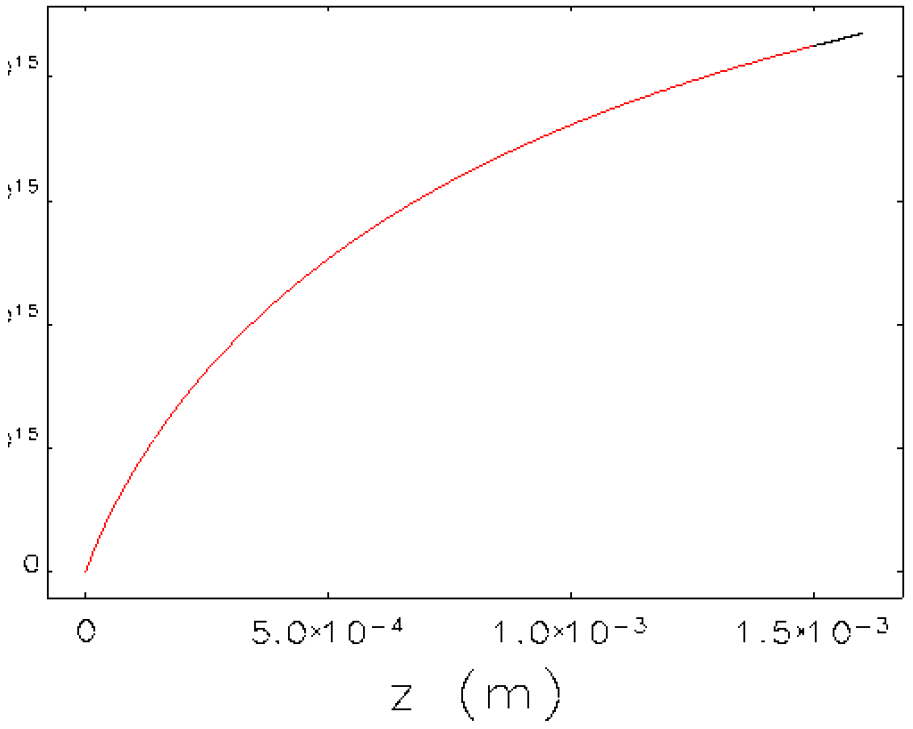
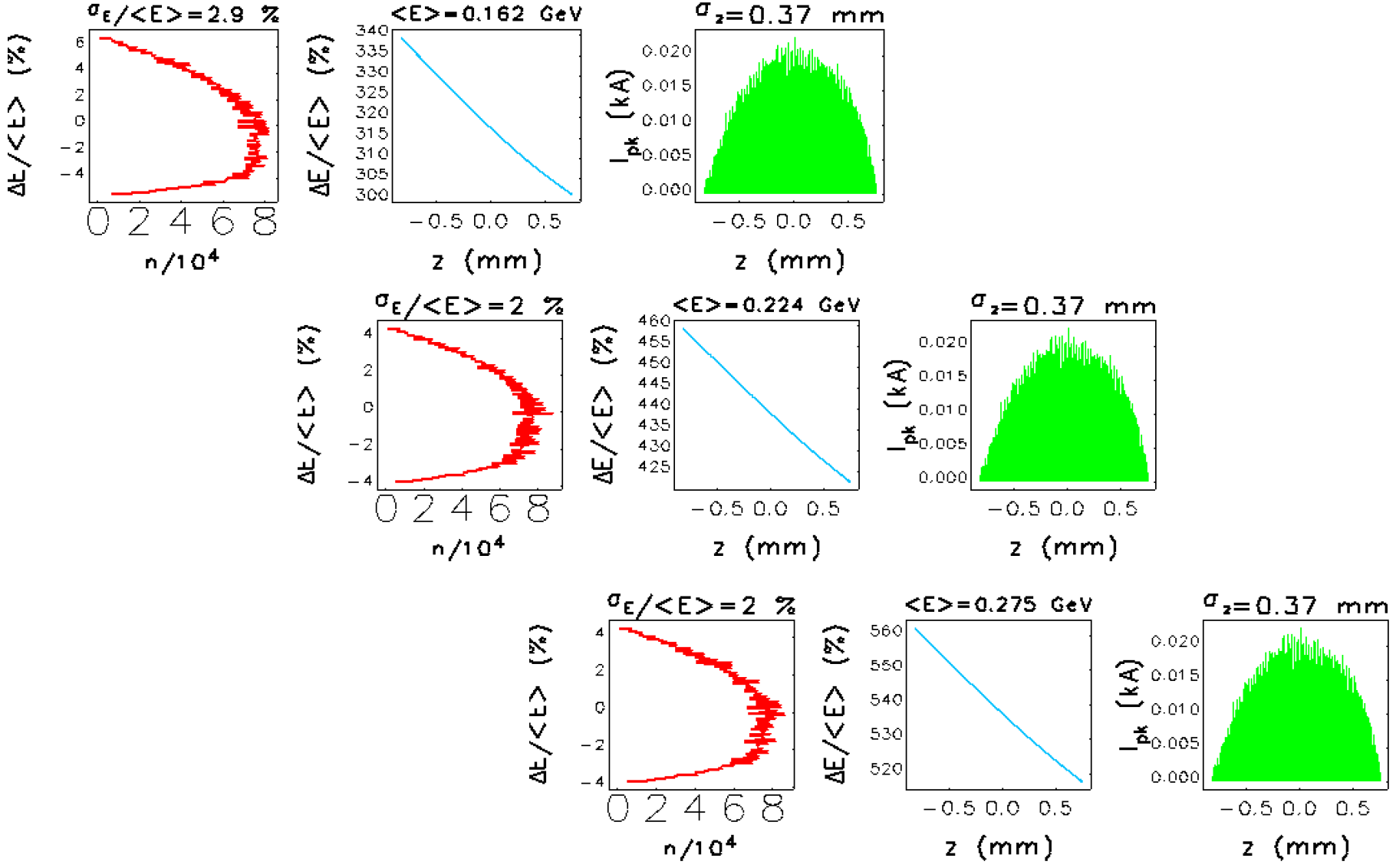
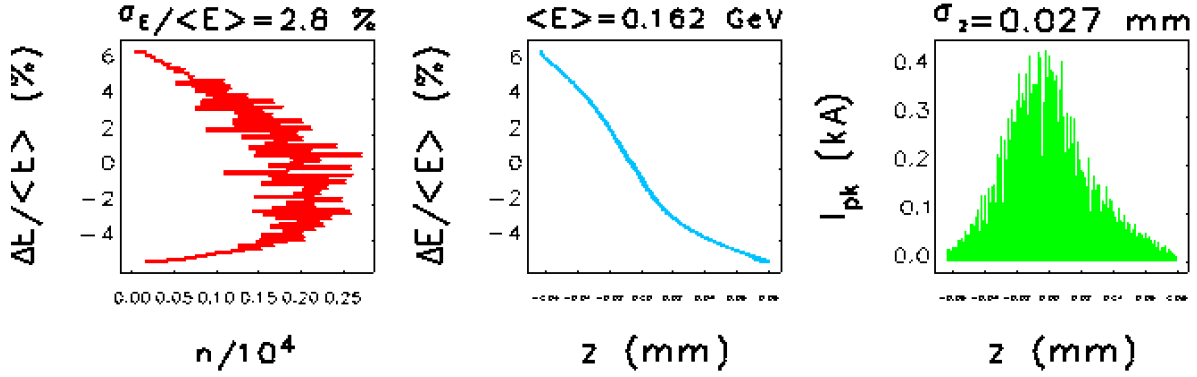


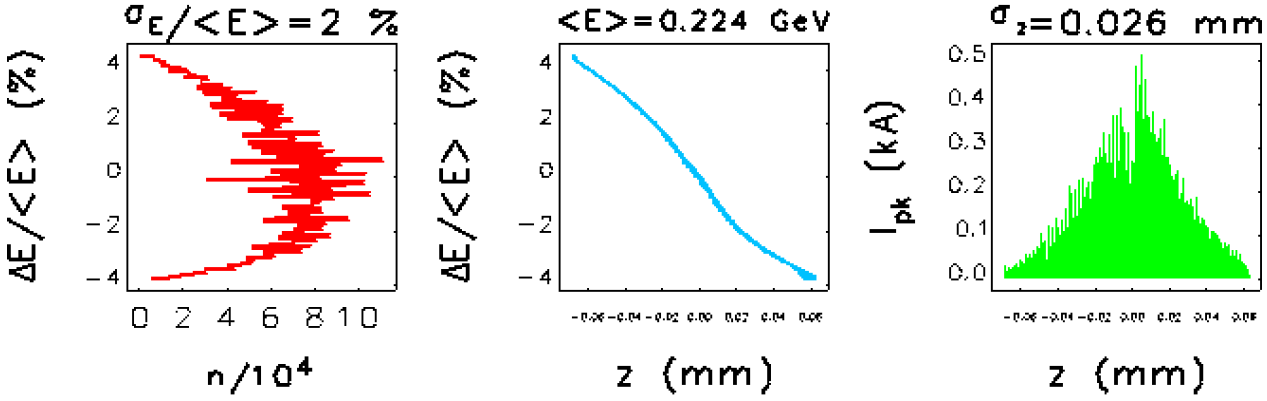
___ mine

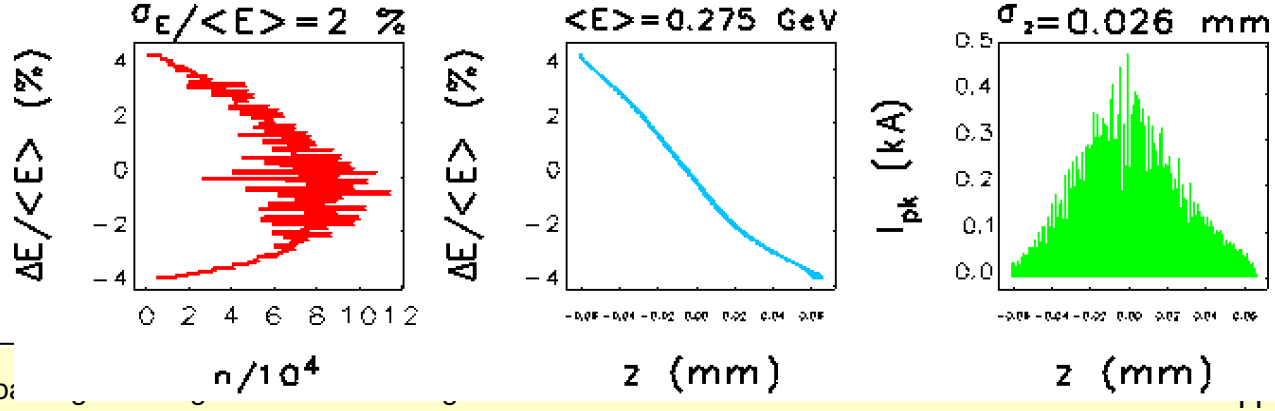
At BC1 entrance:



At BC1 exit:


σε/<E>=2.8 %
<E>=0.162 GeV
σz=0.027 mm
Δt/<t> (%)
ΔE/<E> (%)
Ipk (kA)
n/10⁴
z (mm)
z (mm)

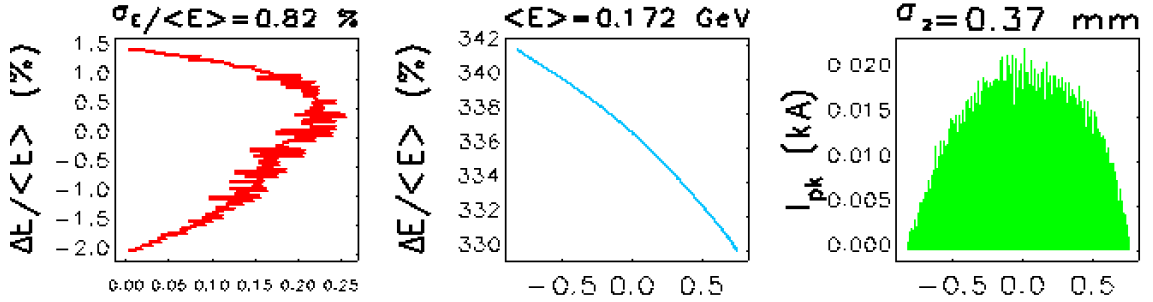

σε/<E>=2 %
<E>=0.224 GeV
σz=0.026 mm
ΔE/<E> (%)
ΔE/<E> (%)
Ipk (kA)
n/10⁴
z (mm)
z (mm)


σε/<E>=2 %
<E>=0.275 GeV
σz=0.026 mm
ΔE/<E> (%)
ΔE/<E> (%)
Ipk (kA)
n/10⁴
z (mm)
z (mm)

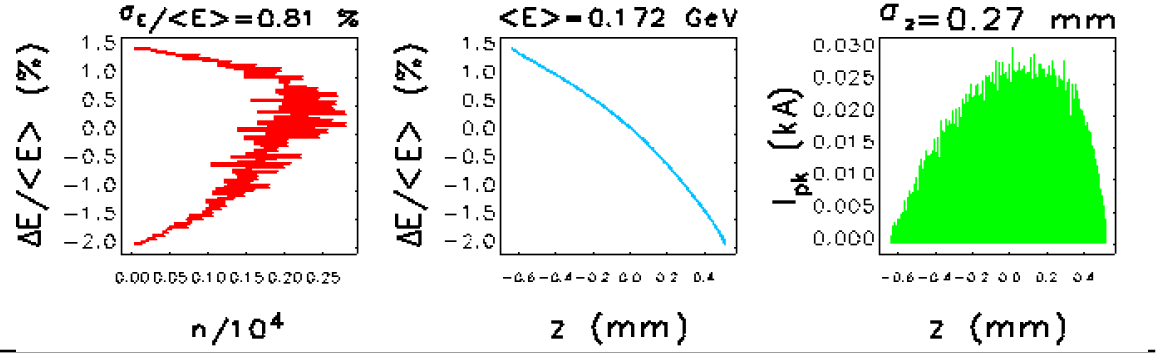
W &WO K band @160 MeV:

K-band off

BC1 in

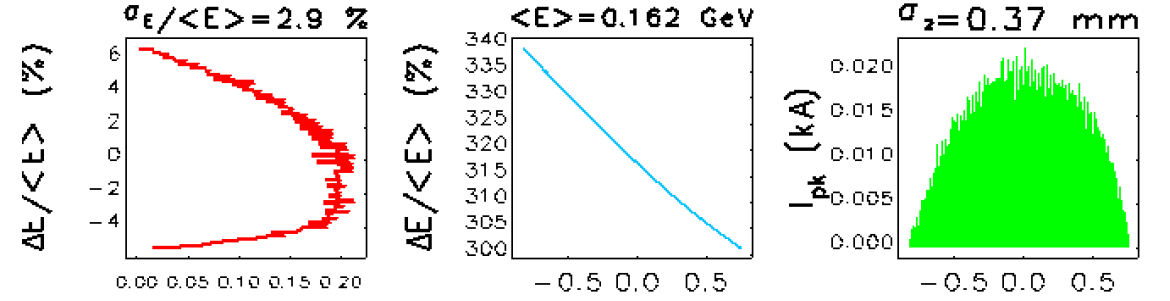


BC1 out

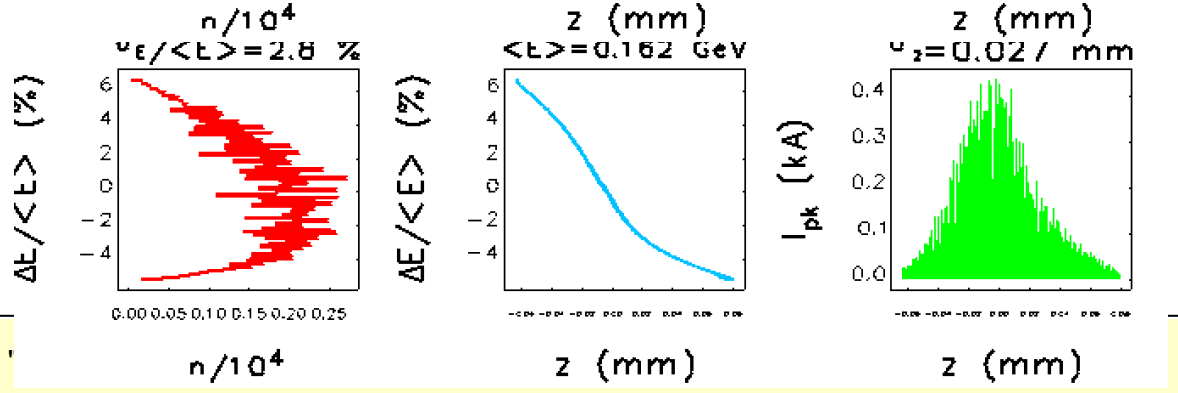


K-band ON

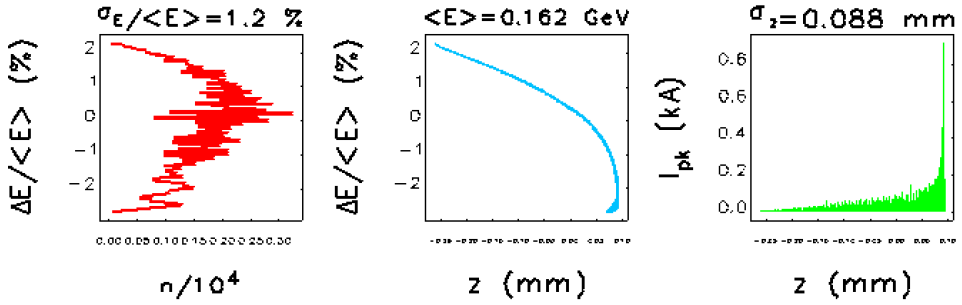
BC1 in



BC1 out



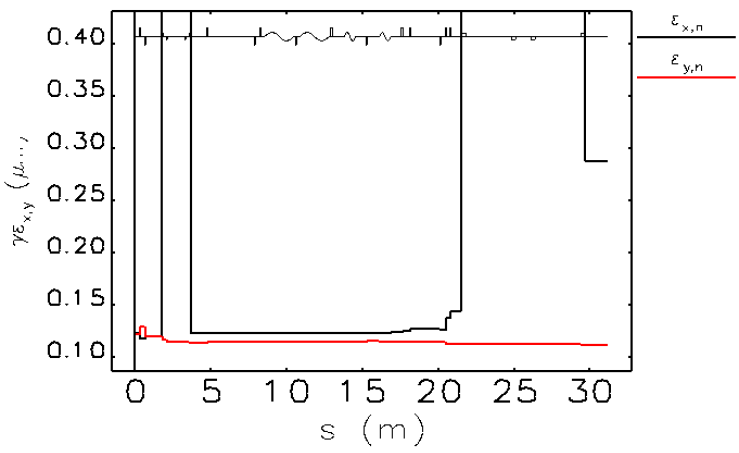
W &WO K band @160 MeV:

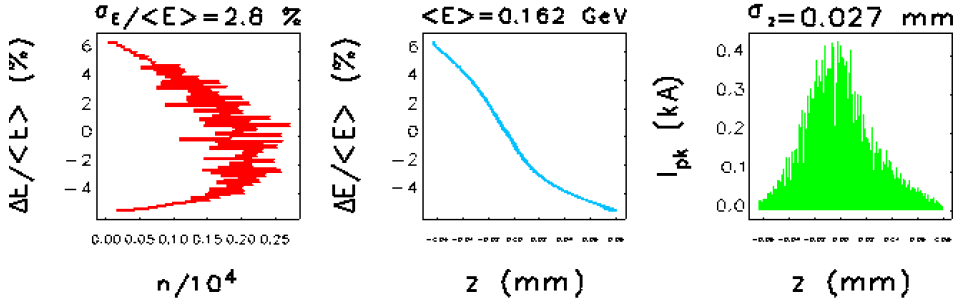


K-band off

BC1 out

θ_B=0.062

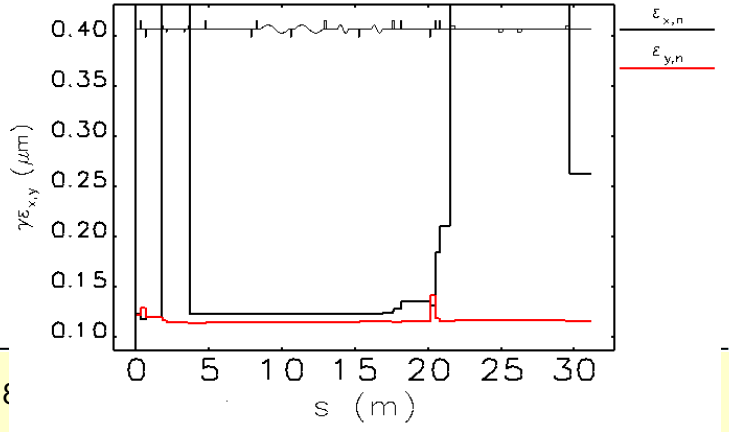




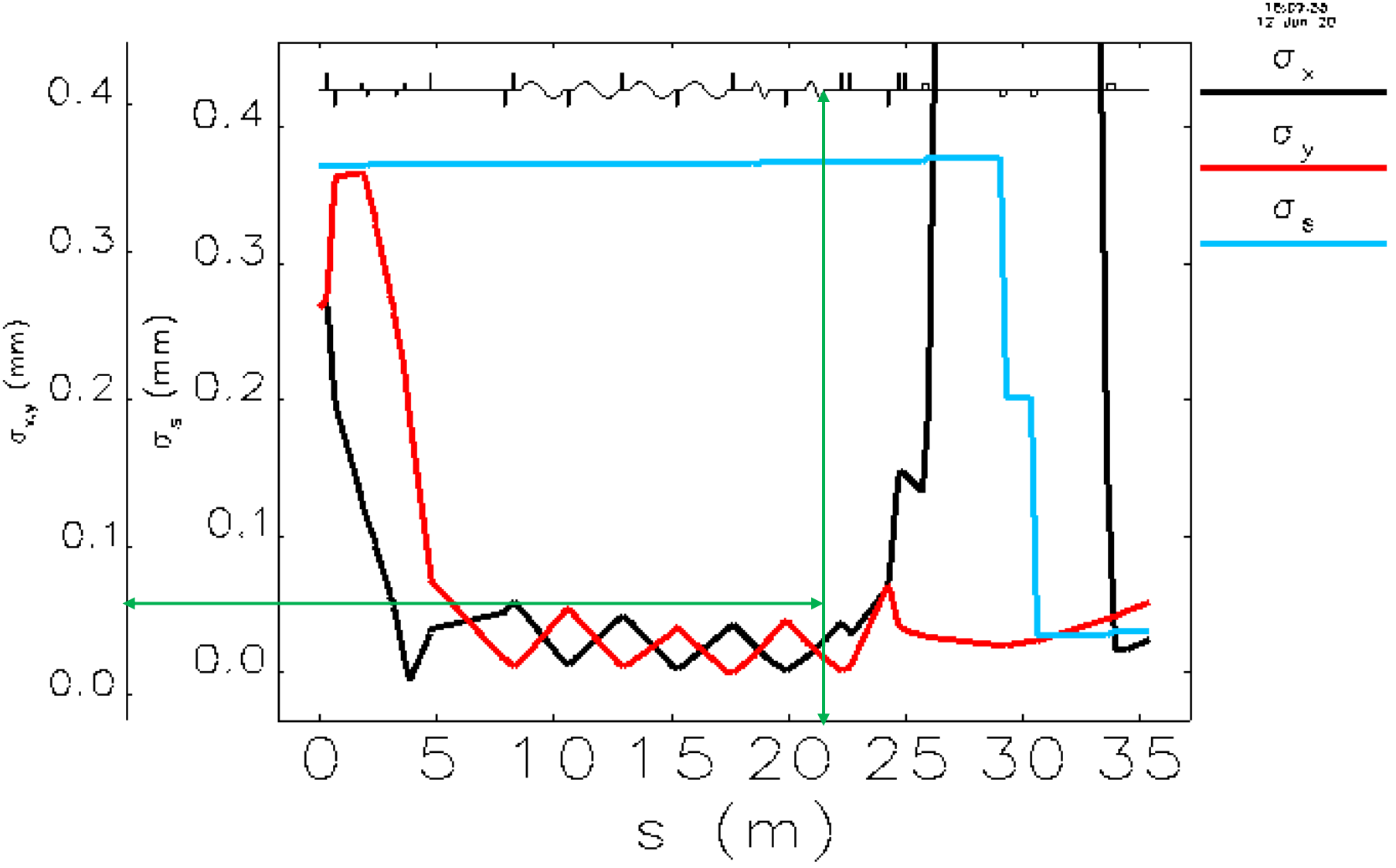
K-band ON

BC1 out

θ_B=0.043



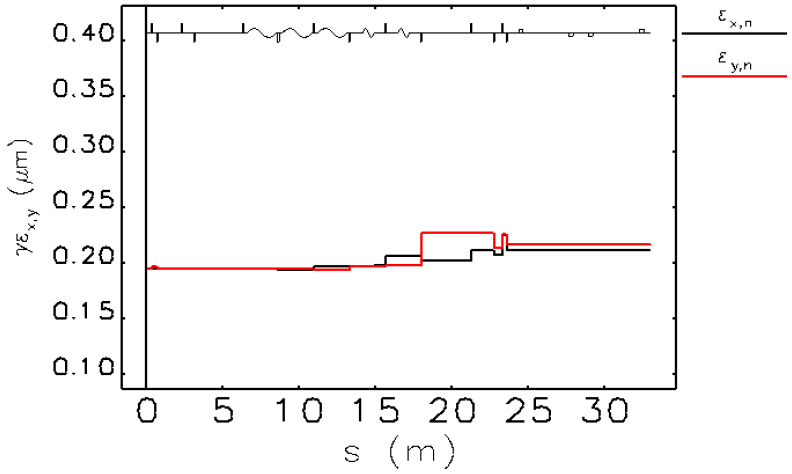
Beam dimension along the lattice



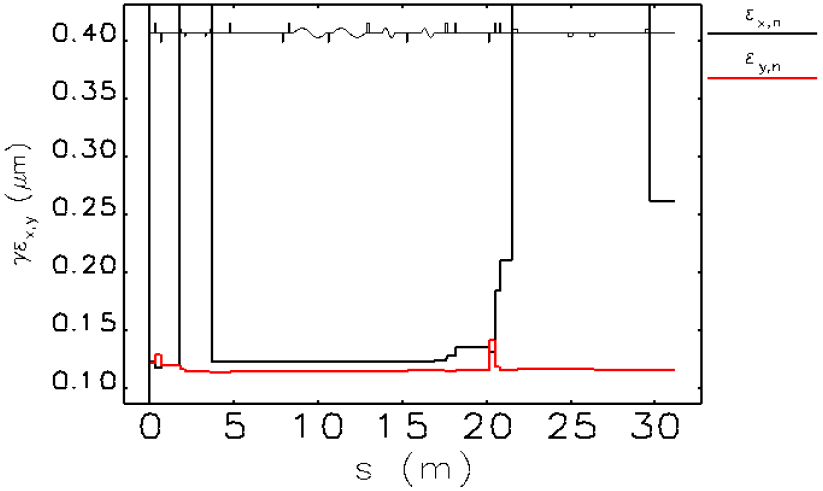
Projected horizontal emittance dilution with Elegant

(8.4 Mp 10Kbin on CSRCSBEND)

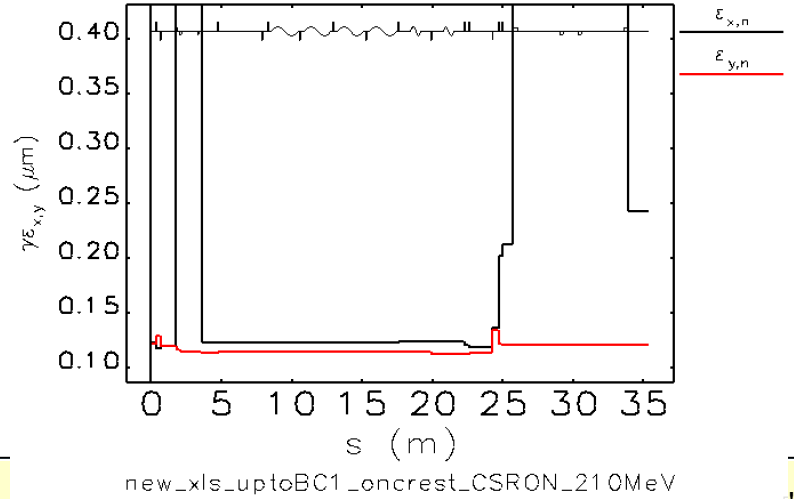
BC1 exit @ 165MeV NOCSR



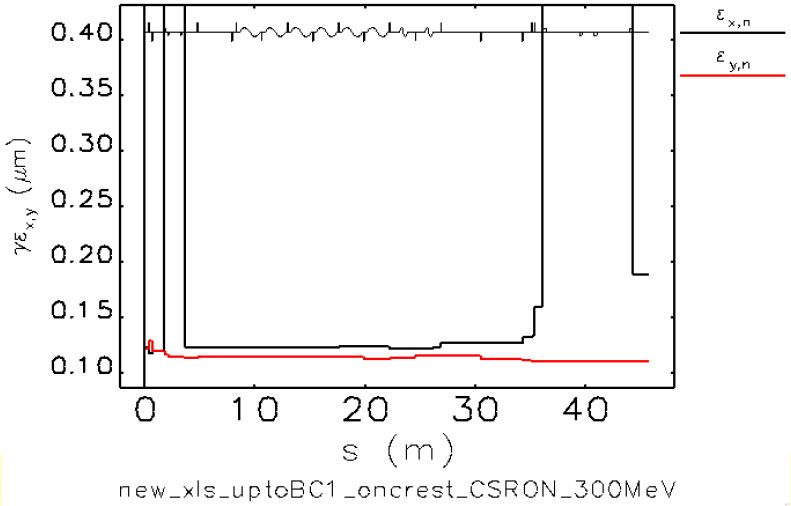
BC1 exit @ 165MeV



BC1 exit @ 220MeV

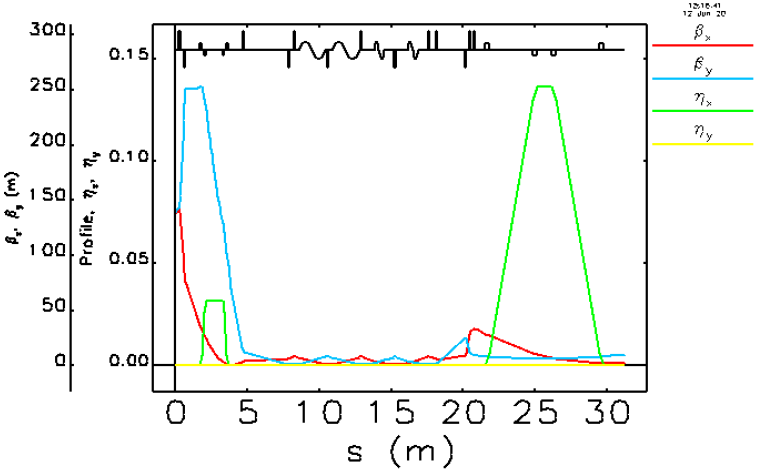


BC1 exit @ 280MeV

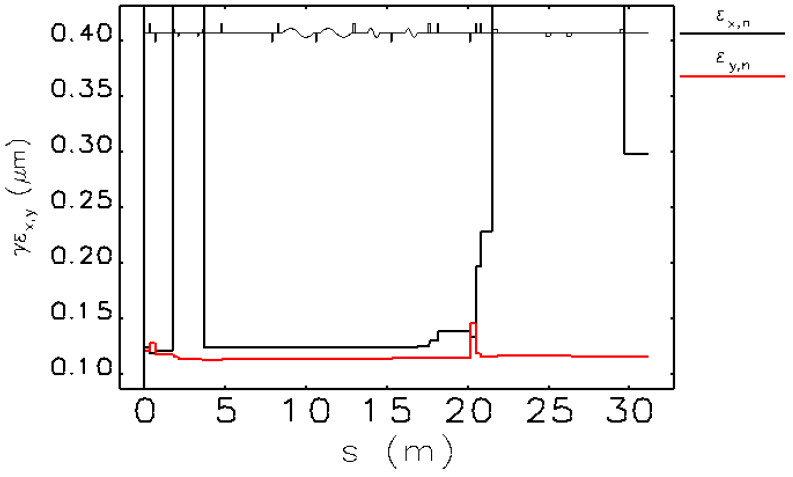


Slice horizontal emittance analys vs »lattice» in CSRCSBEND at 165 MeV

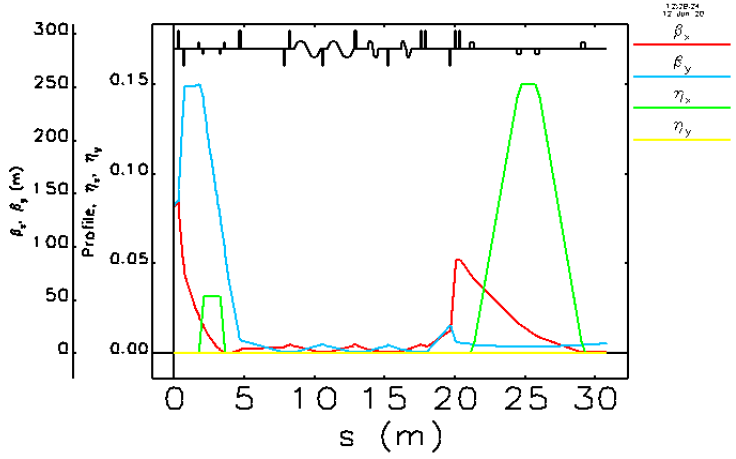
BC1 exit @ 165MeV CSROFF

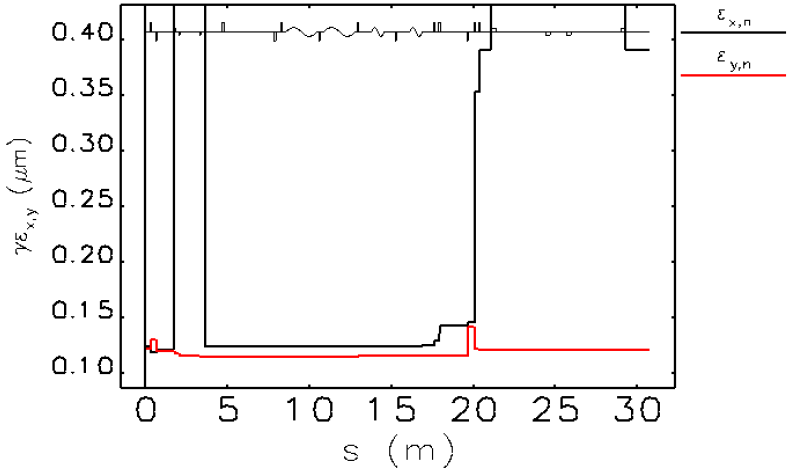


BC1 exit @ 165MeV CSR ON



Worse with low β_x at the end

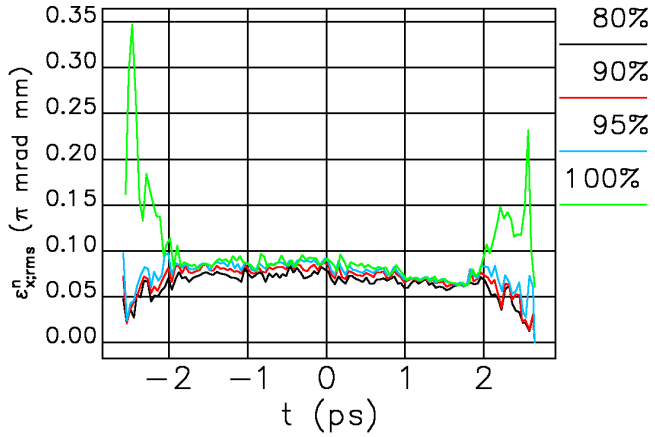




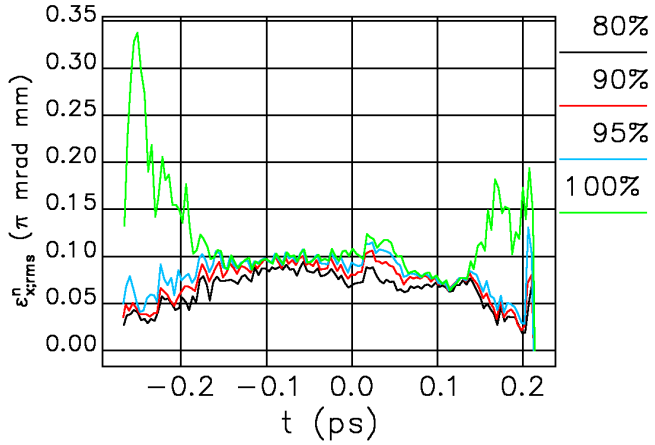
Slice analysis of Hor. Emittance vs energy entrance in BC1

(8.4 Mp 10Kbin on CSRCSBEND)

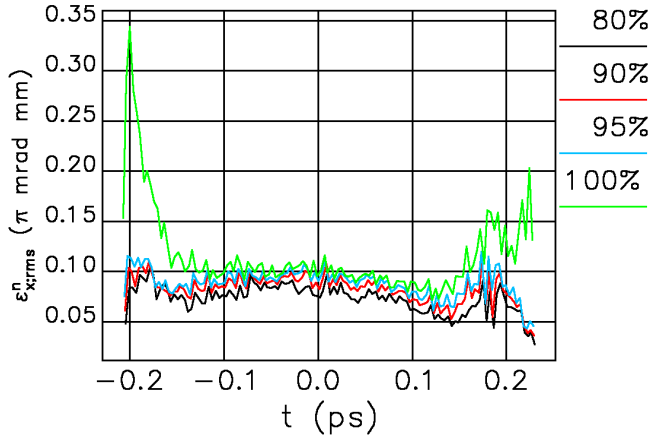
From PhInj



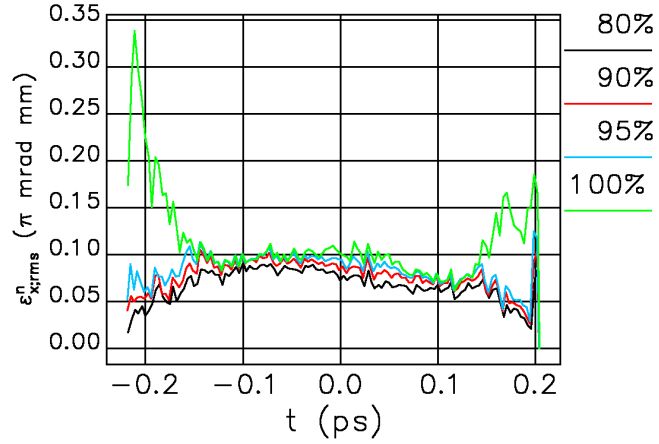
E_{in}= 160 MeV



E_{in}= 210 MeV



E_{in}= 280 MeV



Slice analysis of Hor. Emittance vs energy entrance in BC1

(8.4 Mp 10Kbin on CSRCSBEND)

From PhInj

%	Norm. emittance x (pi mm-mrad)	Norm. emittance y (pi mm-mrad)
80	0.08	0.08
90	0.09	0.09
95	0.10	0.10
100	0.12	0.12

E_{in}= 160 MeV

%	Norm. emittance x (pi mm-mrad)	Norm. emittance y (pi mm-mrad)
80	0.13	0.10
90	0.15	0.11
95	0.18	0.11
100	0.26	0.12

E_{in}= 210 MeV

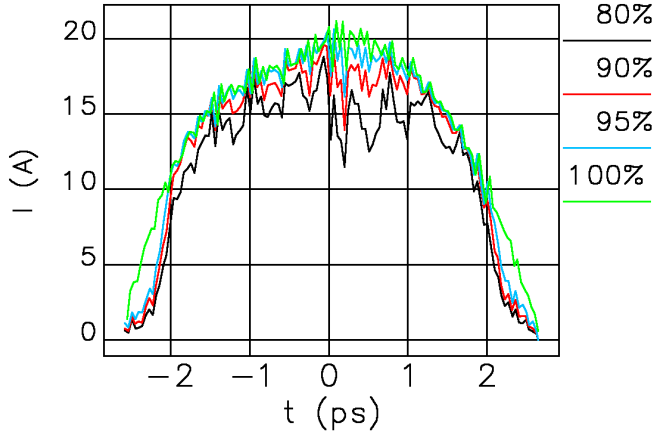
%	Norm. emittance x (pi mm-mrad)	Norm. emittance y (pi mm-mrad)
80	0.14	0.10
90	0.17	0.11
95	0.20	0.11
100	0.24	0.12

E_{in}= 280 MeV

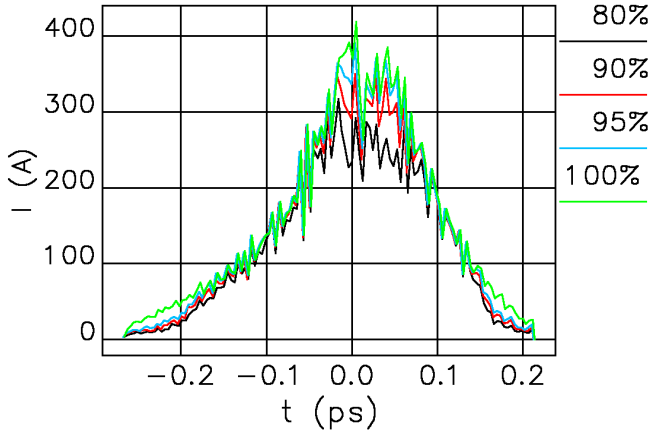
%	Norm. emittance x (pi mm-mrad)	Norm. emittance y (pi mm-mrad)
80	0.11	0.09
90	0.13	0.10
95	0.14	0.10
100	0.19	0.11

Current Distribution at BC1 exit

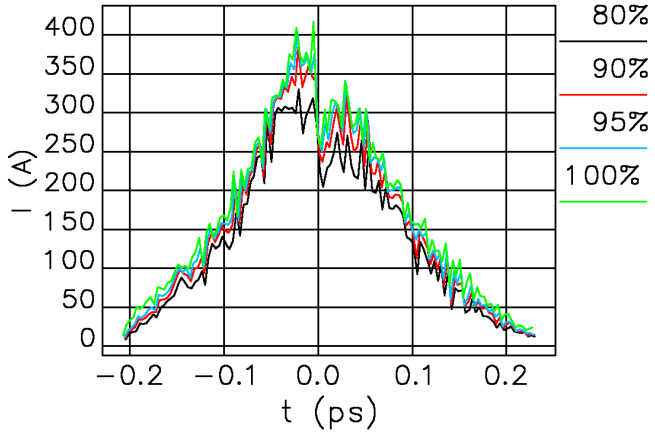
From PhInj



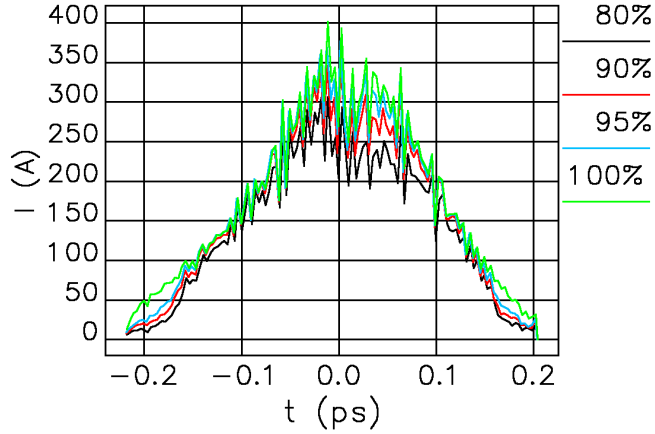
E_{in}= 160 MeV



E_{in}= 210 MeV



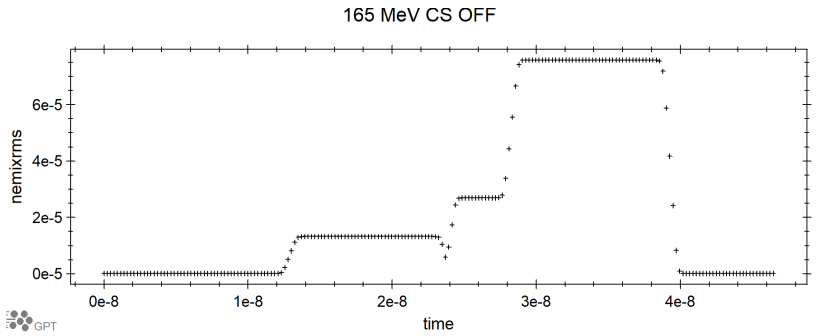
E_{in}= 280 MeV

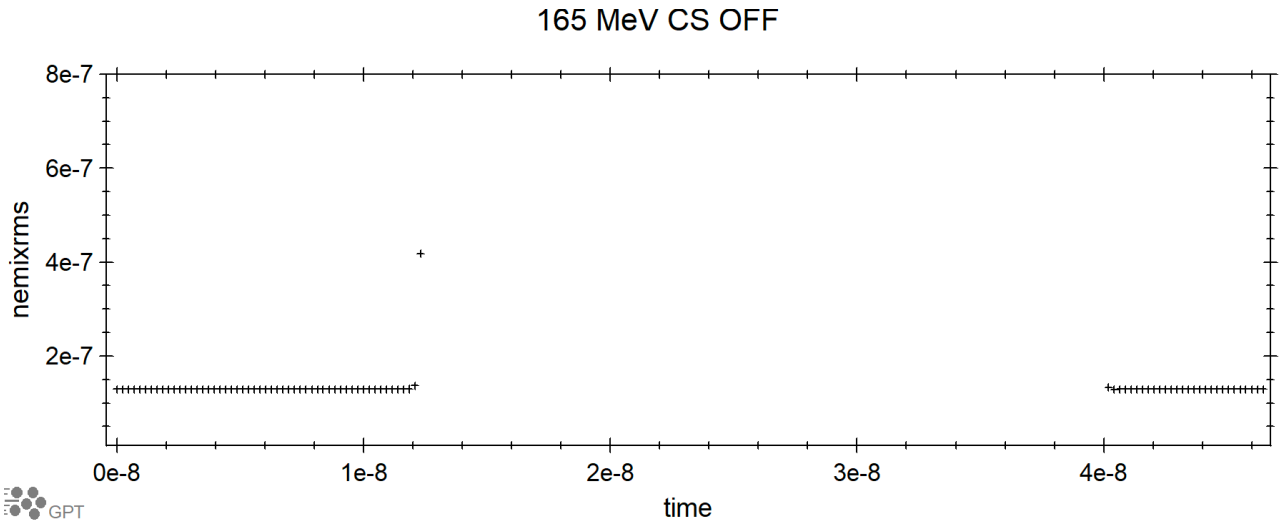


Proj. Hor. Emittance at BC1 exit with SC effect E_{in}=160MeV

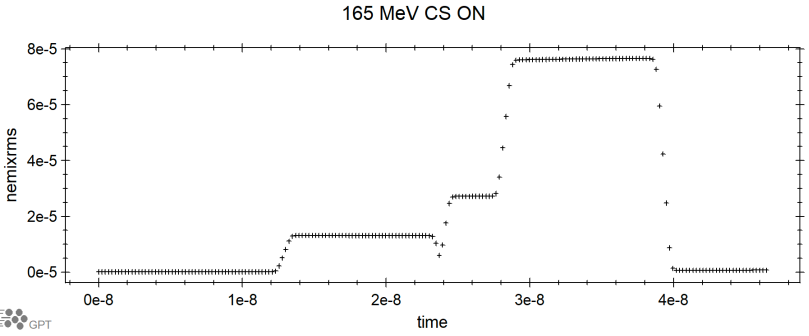
(GPT 110kp)

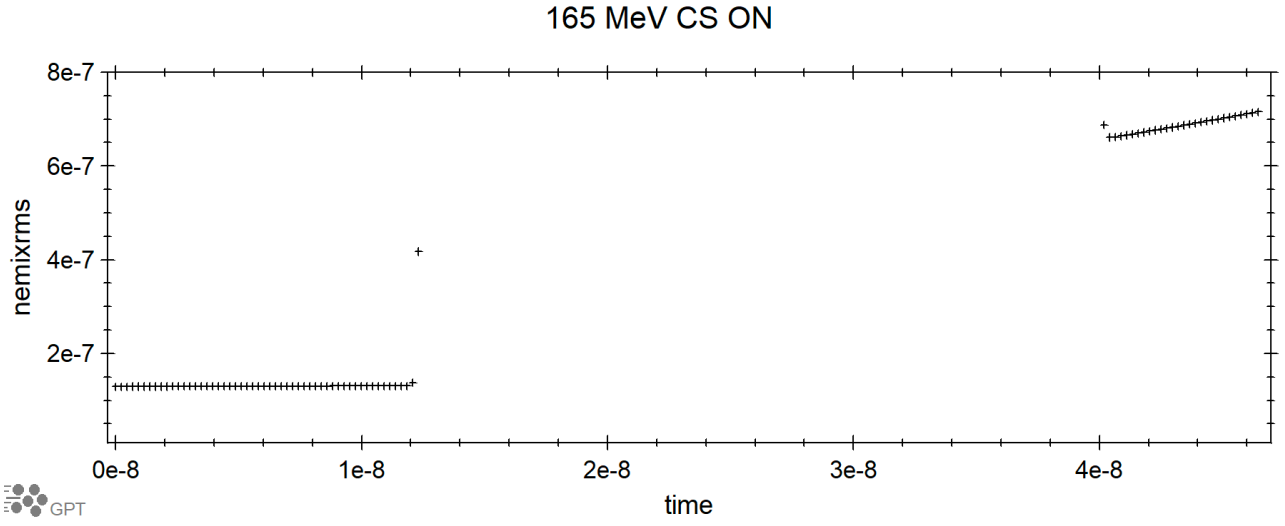
CS OFF





CS ON



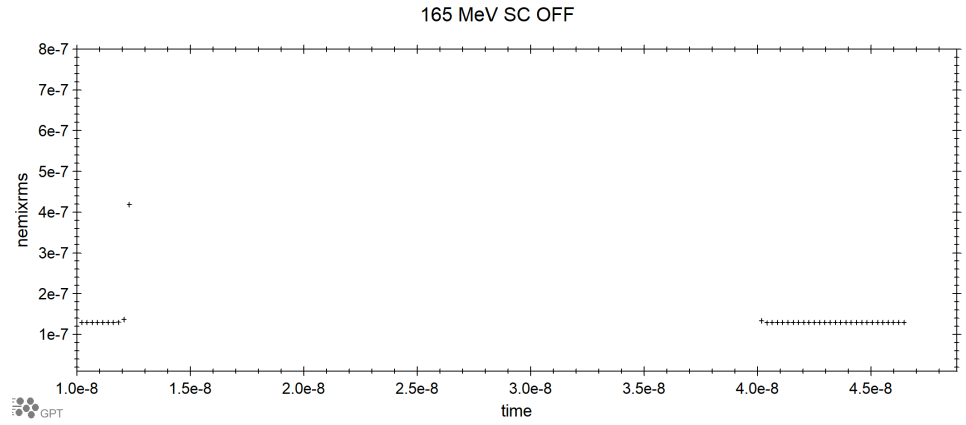


Funded by the
European Union

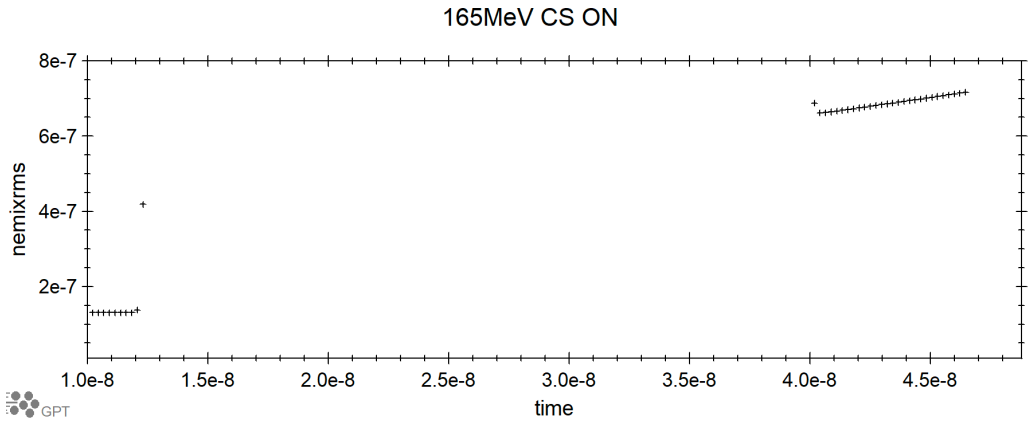
Slice analysis of Hor. Emittance vs energy entrance in BC1 with SC effect.

(GPT 110kp)

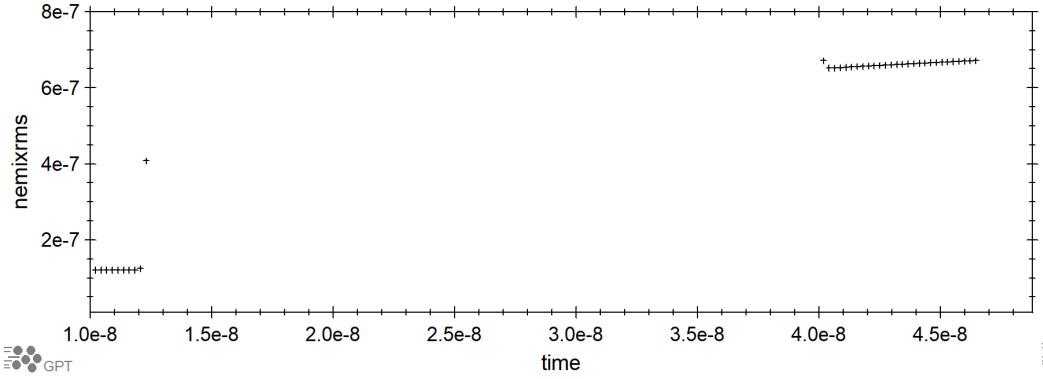
CS _OFF



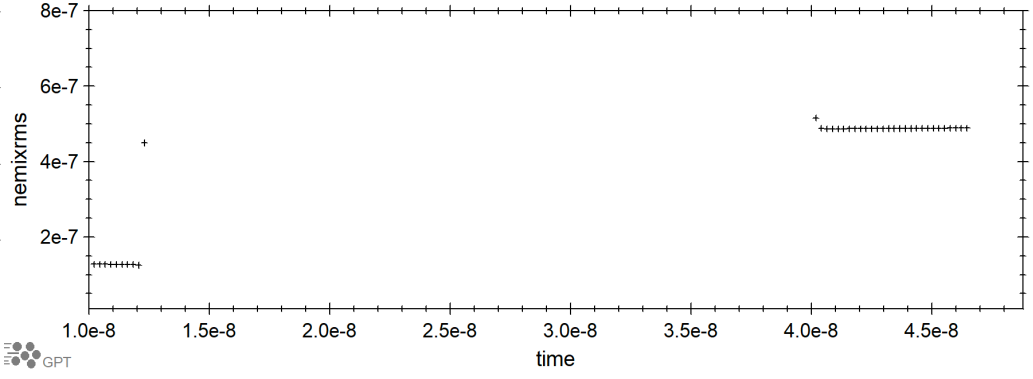
E_{in}= 160 MeV



E_{in}= 210 MeV



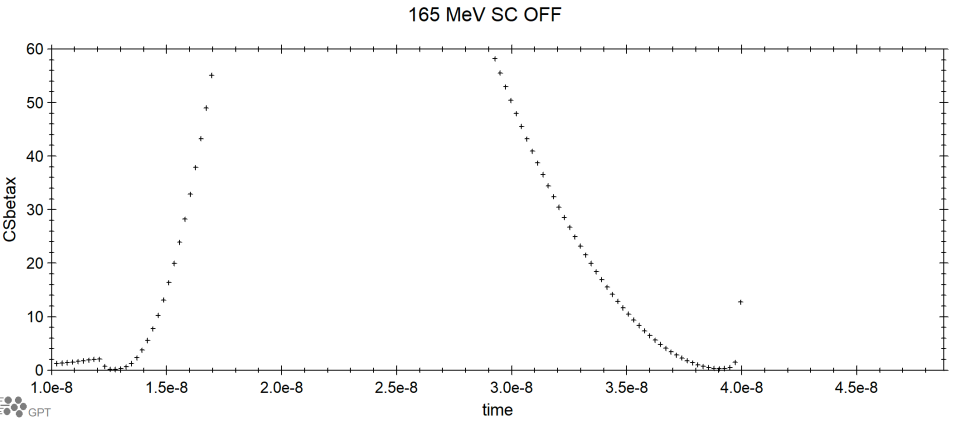
E_{in}= 280 MeV



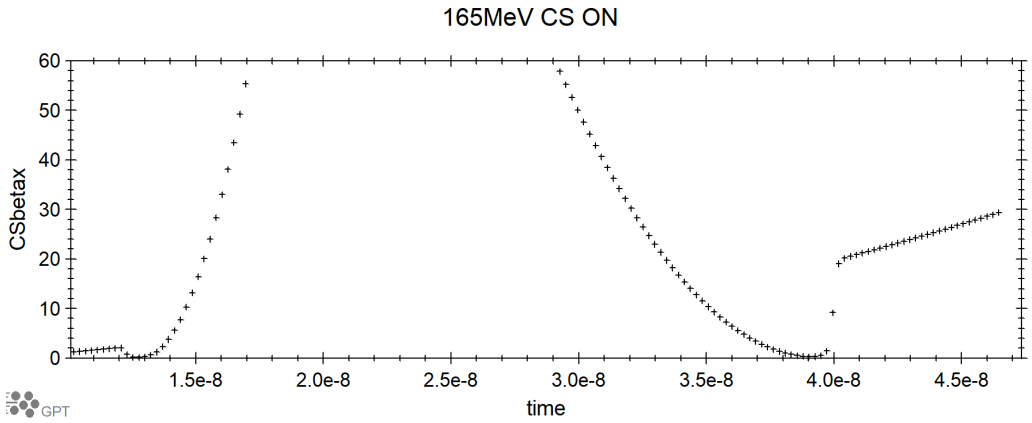
CSβ_x evolution with SC effect.

(GPT 110kp)

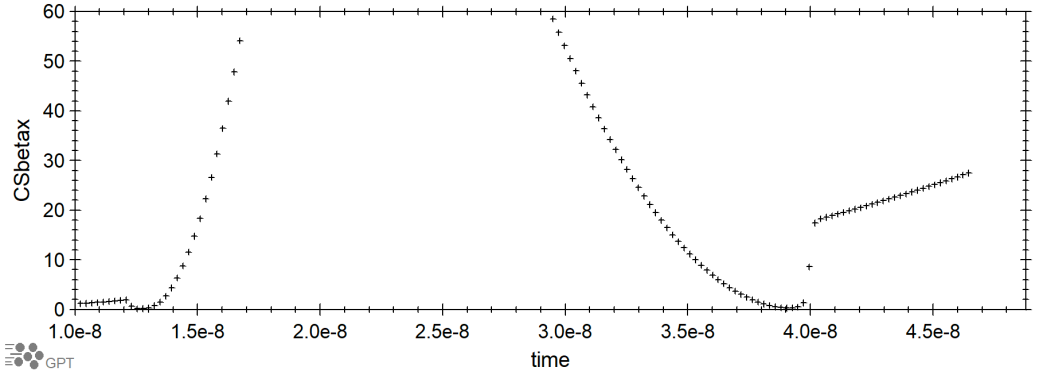
CS _OFF



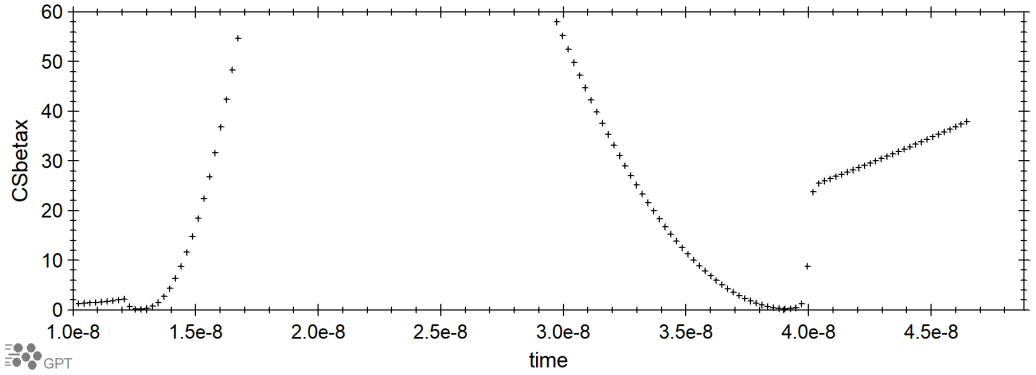
E_{in}= 160 MeV



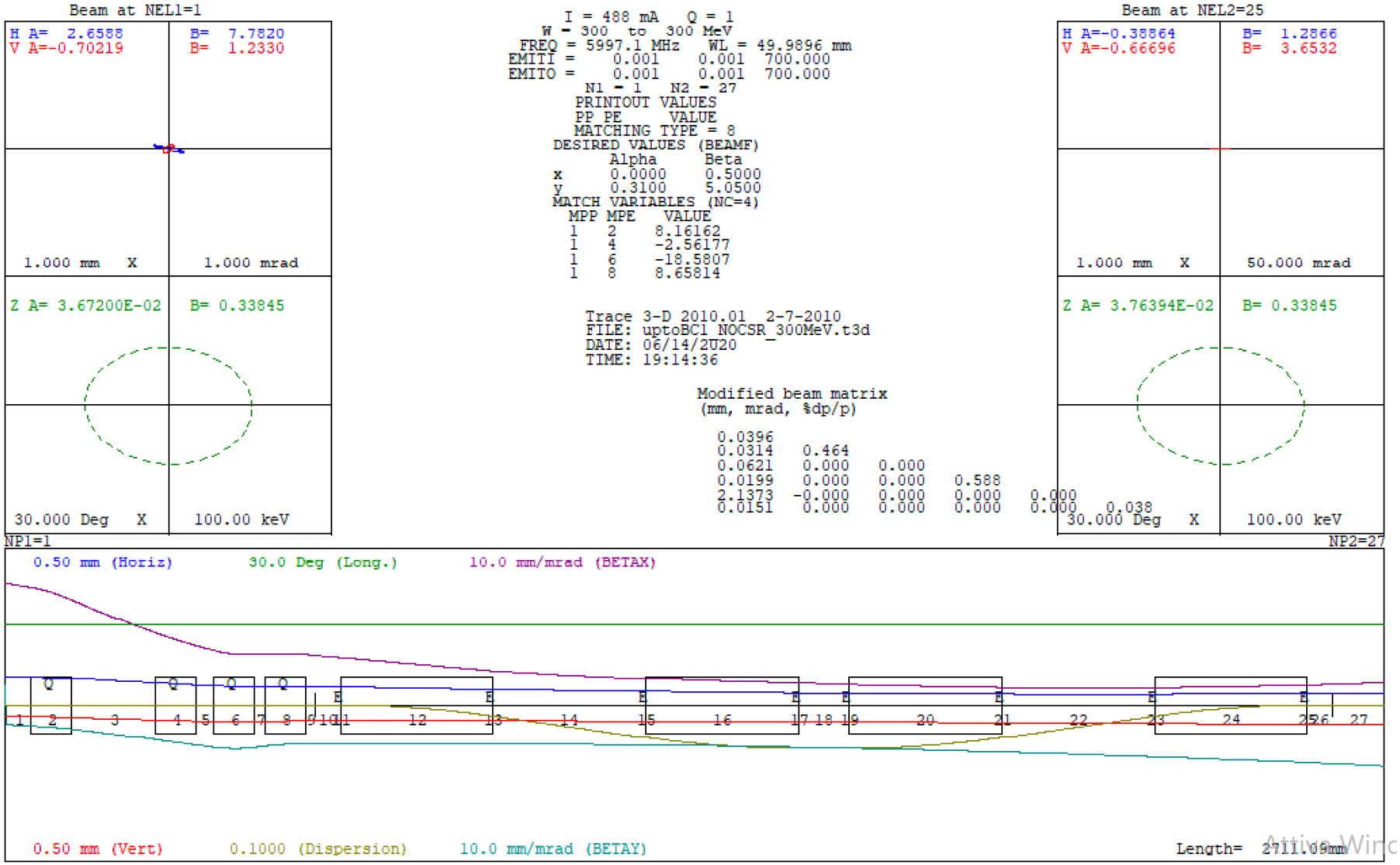
E_{in}= 210 MeV



E_{in}= 280 MeV



Matching example with TR3D



Conclusion

- At the lowest entrance energy for BC1:
  - The lower rigidity of the beam makes it more sensitive to the lattice matching,
  - The CSR dilution of the projected emittance is the highest, mainly reflecting the lenght of the «uniform» beam region
- The SC effect is less severe for the highest entrance energy, and the hor. transverse emittance stops to grow at the exit of BC1

Funded by the
European Union

Compact

Thank you!

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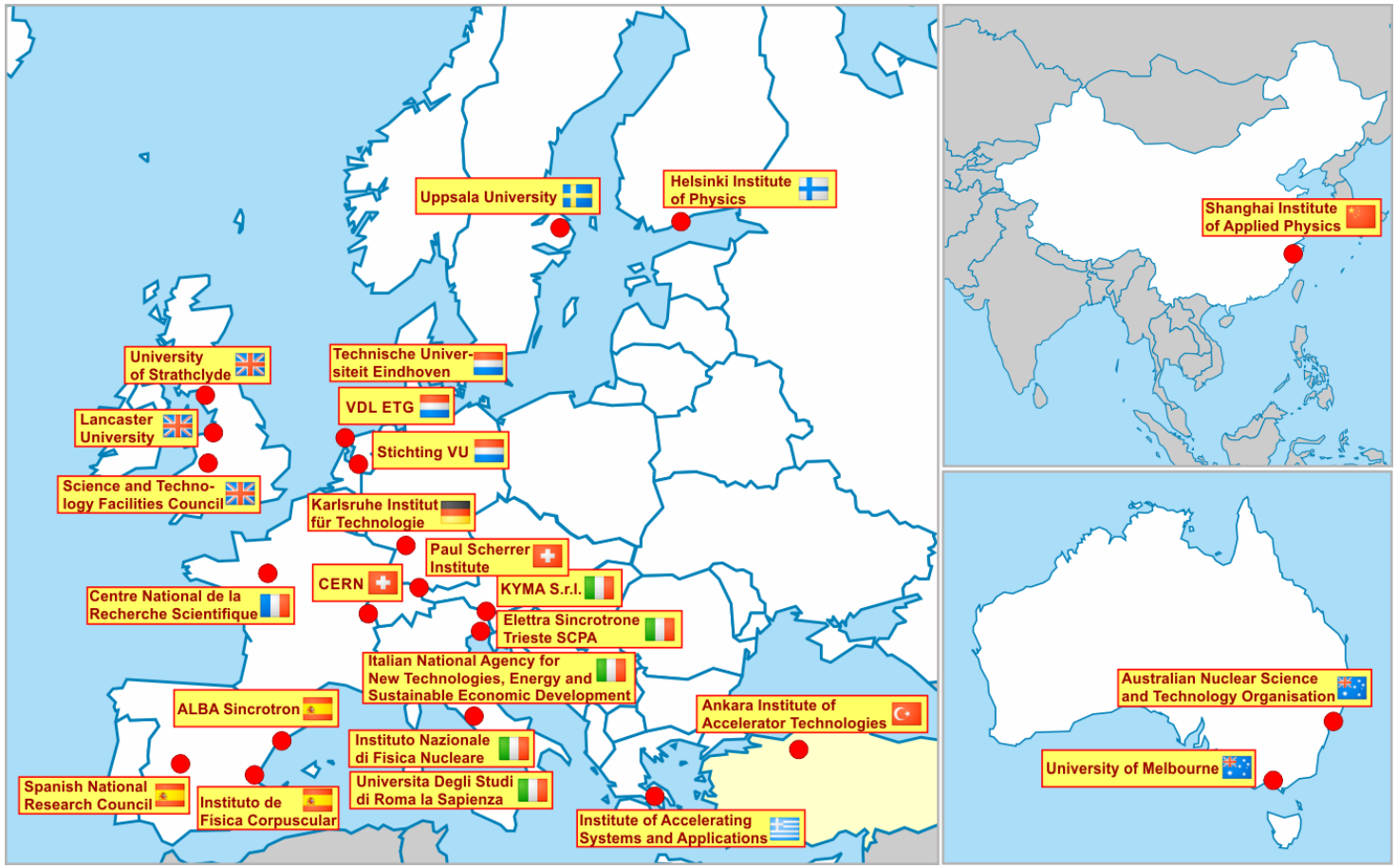

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