LHC electron cloud studies - some curves

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Proposed studies

1. Energies: $[0.45, 4, 7]$ TeV
2. Reproduce Elena's studies for 0.45 TeV:
   - Scan over ecloud density:
     $[3, 4, 5, 6, 7, 8, 10, 15, 30] \cdot 10^{11}$ m^{-3}
   - Scan over intensity:
     $[0.40, 0.55, 0.70, 0.85, 1.00, 1.15, 1.30] \cdot 10^{11}$
   - Scan over chromaticities:
     $[2, 4, 10, 13, 15, 20, 25, 30]$
   - Fast instabilities threshold and rise times
   - Tune footprint analysis $\rightarrow$ coherent and incoherent tune shift
3. Repeat for other energies/settings

Simulation parameters

Simulation parameters

Number of macroparticles (electrons)	$1 \cdot 10^5$
Number of macroparticles (protons)	$3 \cdot 10^5$
Number of slices (protons)	70
Number of kick sections	100
Number of turns	1024
Synchrotron motion	linear

Simulation parameters

Simulation parameters

α	$3.22 \cdot 10^{-4}$
β_x [m]	103
β_y [m]	106
ξ'_x	2
ξ'_y	2
Q_x	64.28
Q_y	59.31
Harmonic number	35'640

Simulation parameters

Reference case beam parameters

Average electron density [m^{-3}]	$6 \cdot 10^{11}$
Protons per bunch	$1.1 \cdot 10^{11}$
Transverse emittance [μm]	2.5

450 GeV

Machine and beam parameters

V [MV/m]	8
σ_z [m]	0.1
δp	$4.22 \cdot 10^{-4}$
ε_z [eVs]	0.8
Q_s	0.0058

450 GeV
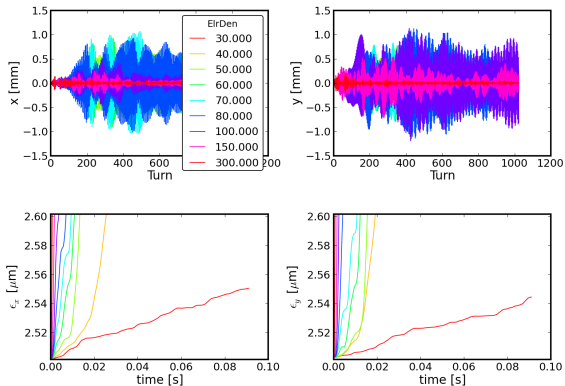
Figure: "ElrDen" in units 10^{10} m^{-3}. Bunch intensity at $1.1 \cdot 10^{11}$. Density threshold at $3 \cdot 10^{11}$ m^{-3}.

450 GeV
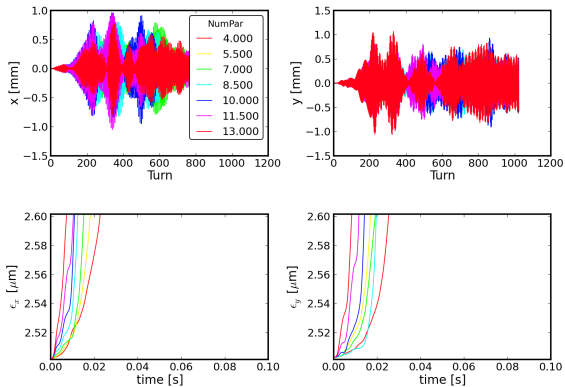
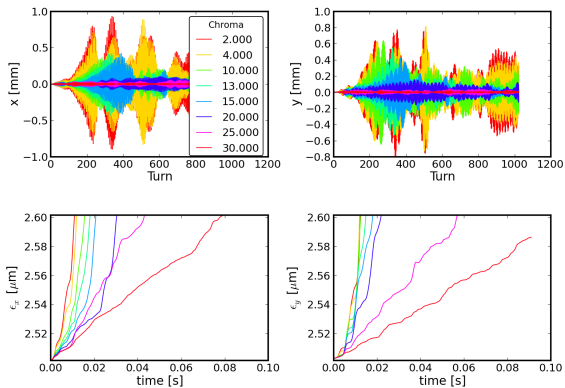Figure: "NumPar" in units 10^{10} ppb. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.

450 GeV

Figure: Non-normalised chromaticities. Bunch intensity at $1.1 \cdot 10^{11}$. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.

Beam parameter extrapolation for changed energies

RF bucket matching

$$\frac{c}{4\pi m\gamma c^2\beta}\,\frac{\varepsilon_z}{\delta p} = \sigma_z$$

$$\frac{R\eta}{Q_s}\,\frac{\delta p}{\sigma_z} = 1$$
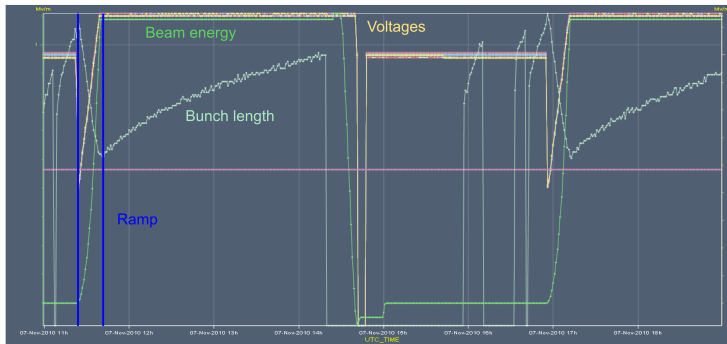
Beam parameter extrapolation for changed energies

Figure: Chart obtained from timber for a 3.5 TeV beam on November 7, 2010 (~~before~~ ion runs).
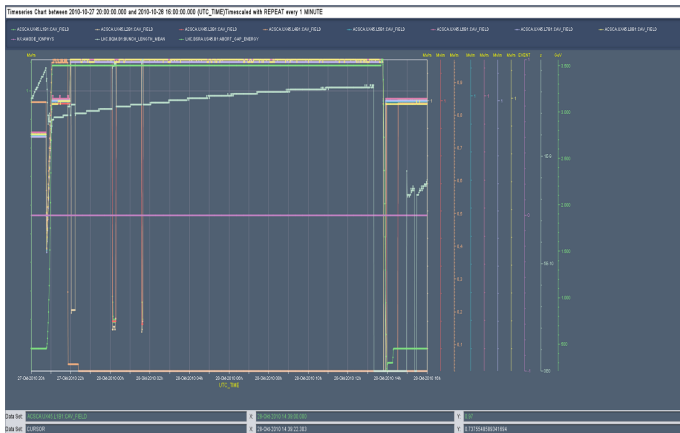
Beam parameter extrapolation for changed energies

Figure: Chart obtained from timber for a 3.5 TeV beam on October 27, 2010 (sample parameters).
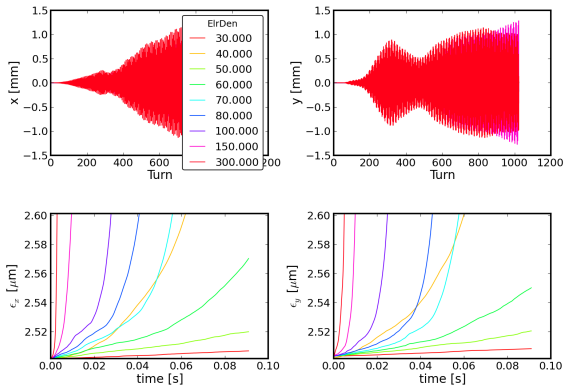
4 TeV - 0c77 ns

Machine and beam parameters

V [MV/m]	7.94
σ_z [m]	0.0577
δp	$8.048 \cdot 10^{-5}$
ε_z [eVs]	0.779
Q_s	$1.903 \cdot 10^{-3}$

4 TeV - 0c77 ns - field free

ρ_{max} [m^{-3}]	$\sim 3 \cdot 10^{11}$
I_{max}	$< 4 \cdot 10^{11}$
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	10

Figure: "ElrDen" in units 10^{10} m^{-3}. Bunch intensity at $1.1 \cdot 10^{11}$.
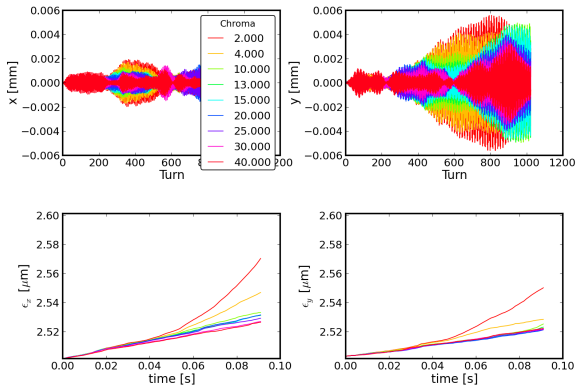
4 TeV - 0c77 ns - field free
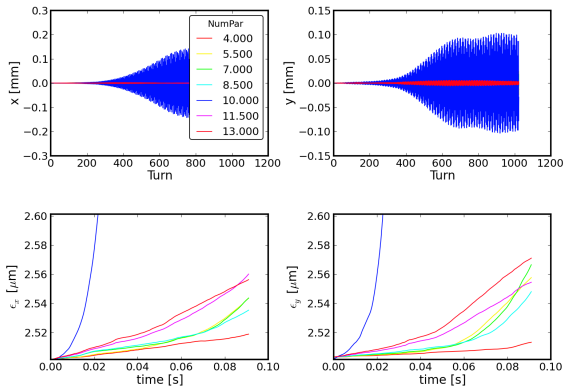
$\rho_{\max}$ [m^{-3}]	$\sim 3 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	10

Figure: "NumPar" in units 10^{10} ppb. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.

4 TeV - 0c77 ns - field free

$\rho_{\max}$ [m^{-3}]	$\sim 3 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	10

Figure: Non-normalised chromaticities. Bunch intensity at $1.1 \cdot 10^{11}$. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.
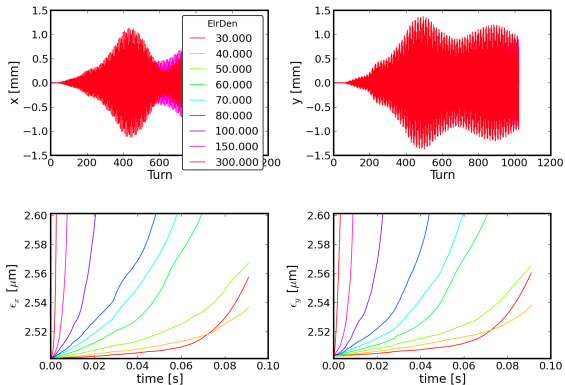
4 TeV - 1c20 ns

Machine and beam parameters

V [MV/m]	7.94
σ_z [m]	0.0899
δp	$1.25 \cdot 10^{-4}$
ε_z [eVs]	1.89
Q_s	$1.903 \cdot 10^{-3}$

4 TeV - 1c20 ns - field free

Figure: "ElrDen" in units 10^{10} m^{-3}. Bunch intensity at $1.1 \cdot 10^{11}$.

4 TeV - 1c20 ns - field free

$\rho_{\max}$ [m^{-3}]	$< 3 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$
ξ'_{recovery} $\left[\frac{dt'}{dp/p}\right]$	4

Figure: "NumPar" in units 10^{10} ppb. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.
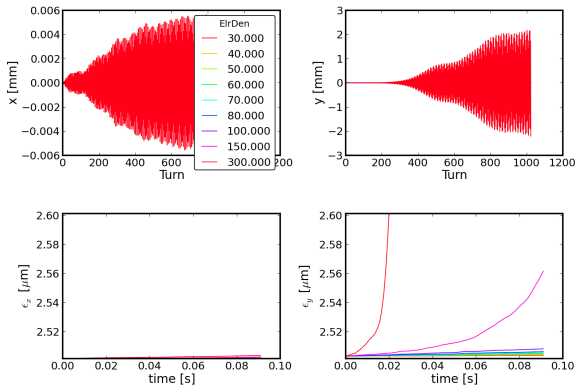
4 TeV - 1c20 ns - field free
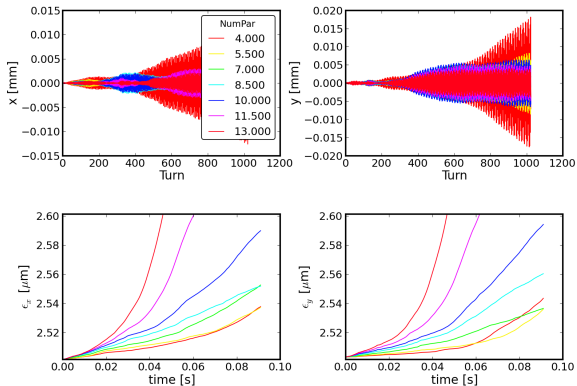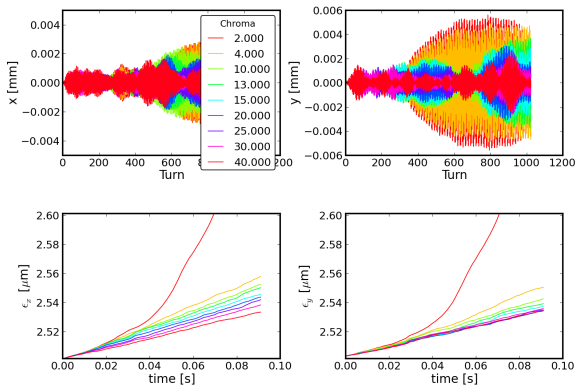
$\rho_{\max}$ [m^{-3}]	$< 3 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	4

Figure: Non-normalised chromaticities. Bunch intensity at $1.1 \cdot 10^{11}$. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.
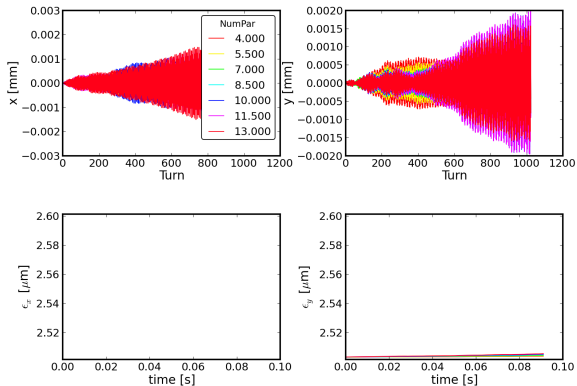
4 TeV - 1c20 ns - dipole

ρ_{max} [m^{-3}]	$\sim 8 \cdot 10^{11}$
I_{max}	stable
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	stable

Figure: "ElrDen" in units 10^{10} m^{-3}. Bunch intensity at $1.1 \cdot 10^{11}$.
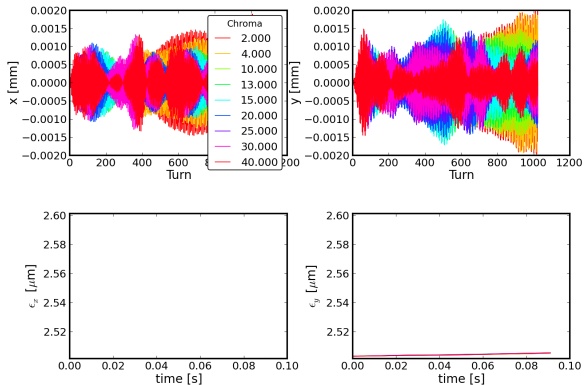
4 TeV - 1c20 ns - dipole

$\rho_{\max}$ [m^{-3}]	$\sim 8 \cdot 10^{11}$
$I_{\max}$	stable
$\xi^{l}_{\text{recovery}} \ [\frac{dtl}{dp/p}]$	stable

Figure: "NumPar" in units 10^{10} ppb. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.
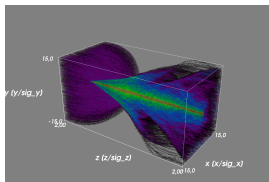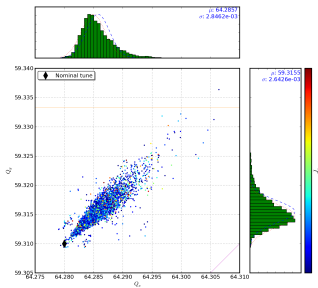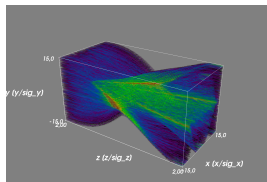
4 TeV - 1c20 ns - dipole

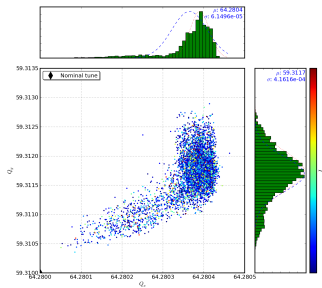|	
$\rho_{\max}$ [m^{-3}]	$\sim 8 \cdot 10^{11}$
$I_{\max}$	stable
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	stable

Figure: Non-normalised chromaticities. Bunch intensity at $1.1 \cdot 10^{11}$. Electron cloud density at $6 \cdot 10^{11}$ m^{-3}.

4 TeV - 1c20 ns - reference case footprint and pinch

Summary

450 GeV

σ_t [ns]	1.33 free
$\rho_{\max}$ [m^{-3}]	$\sim 3 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	30

4 TeV

σ_t [ns]	0.77 free	1.20 free	1.20 dipole
$\rho_{\max}$ [m^{-3}]	$\sim 3 \cdot 10^{11}$	$< 3 \cdot 10^{11}$	$\sim 8 \cdot 10^{11}$
$I_{\max}$	$< 4 \cdot 10^{11}$	$< 4 \cdot 10^{11}$	stable
ξ'_{recovery} [$\frac{dQ}{dp/p}$]	10	4	stable

End

Thank you!