Maps for Electron Cloud in LHC Dipoles

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The Map Formalism

Building the map for an LHC Dipole

Application to bunch patterns

Conclusions and Outlook

Maps for Electron Clouds

U.Iriso, S.Peggs, Phys. Rev. ST-AB8, 024403 (2005)

•For a given beam pipe characteristics (SEY, Chamber dimensions, etc.) the evolution of the electron density is only driven by the bunch passing by, and the existing electron density before the bunch passed by.

$$\rho_{m+1} = F(\rho_m)$$

• Simplify the Electron Cloud problem into a small number of mathematical parameters.

•For typical RHIC parameters the bunch-to-bunch evolution of the electron density can be represented by a cubic map:

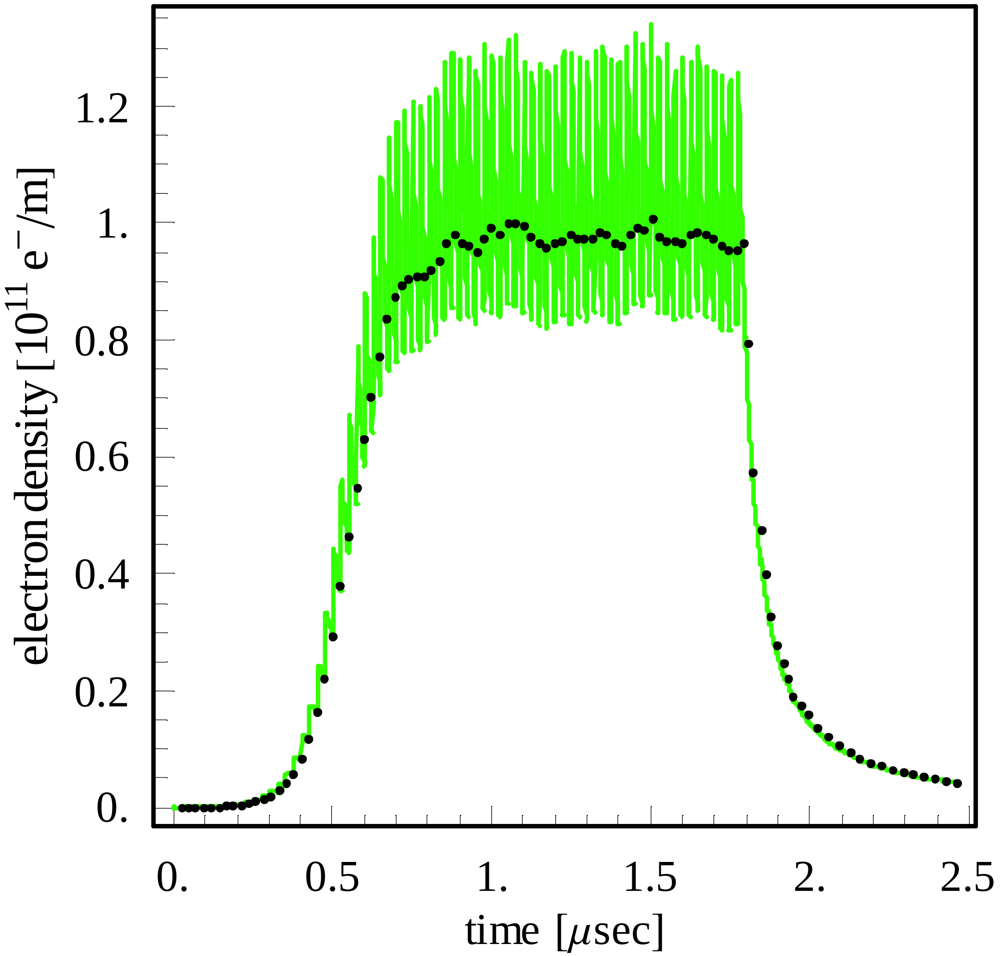
$$\rho_{m+1} = a\,\rho_m + b\,\rho_m^{\,2} + c\,\rho_m^{\,3}$$

Where ρ_m is the bunch-to-bunch average of the electron line density

Table 1: Input parameters for ECLOUD simulations.

parameter	unit	value
beam particle energy	GeV	7000
bunch spacing	ns	25
bunch length	m	0.075
number of bunches N_b	–	72
number of particles per bunch N	10^{11}	0.8 to 1.6
bending field B	T	8.4
length of bending magnet	m	14.2
vacuum screen half height	m	0.018
vacuum screen half width	m	0.022
circumference	m	27000
primary photo-emission yield	-	$7.98 \cdot 10^{-4}$
maximum SEY δ_{max}	-	1.3 to 1.7
energy for max. SEY E_{max}	eV	237.125
energy width for secondary e^-	eV	1.8

Maps for Electron Clouds: Application to LHC



δ_{max}=1.7; N=1.2 $\cdot 10^{11}$

72 Bunches

28 “Empty” Bunches

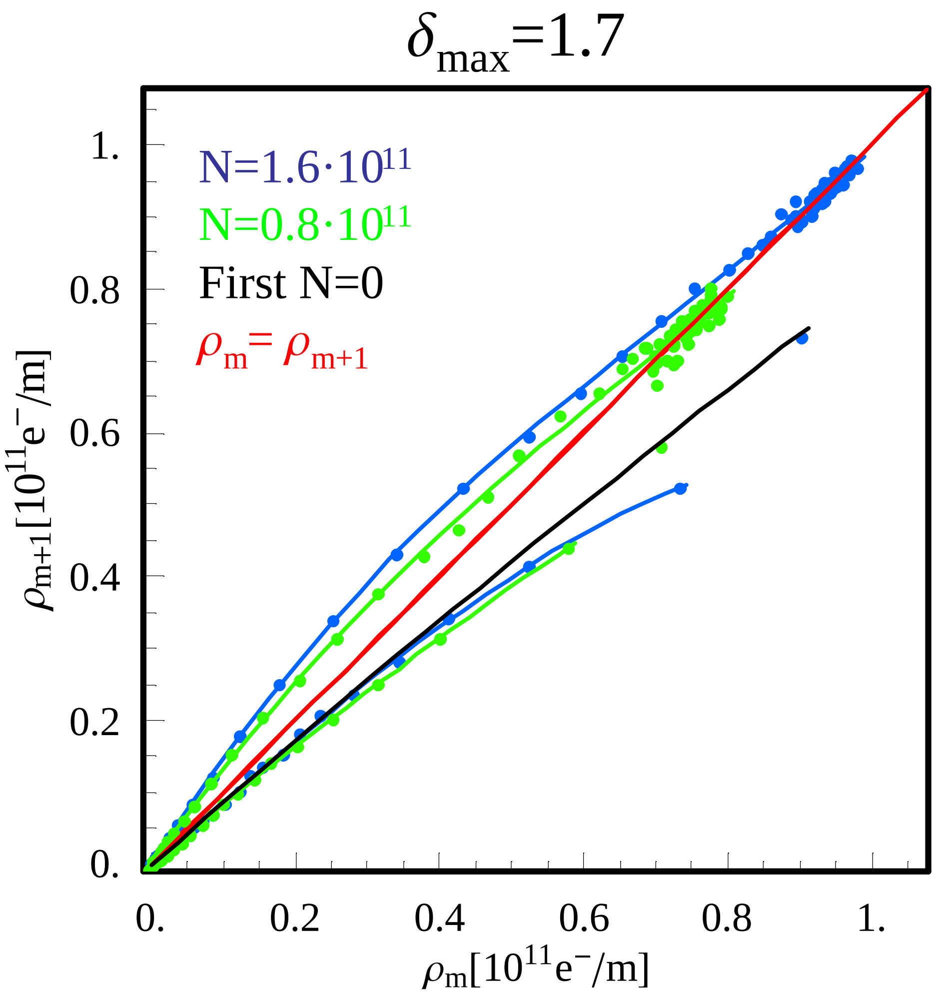
Bunch Spacing 25 ns

ECLOUD output

bunch-to-bunch avg.

Typical simulation time 12 h

Building the Cubic Map for LHC



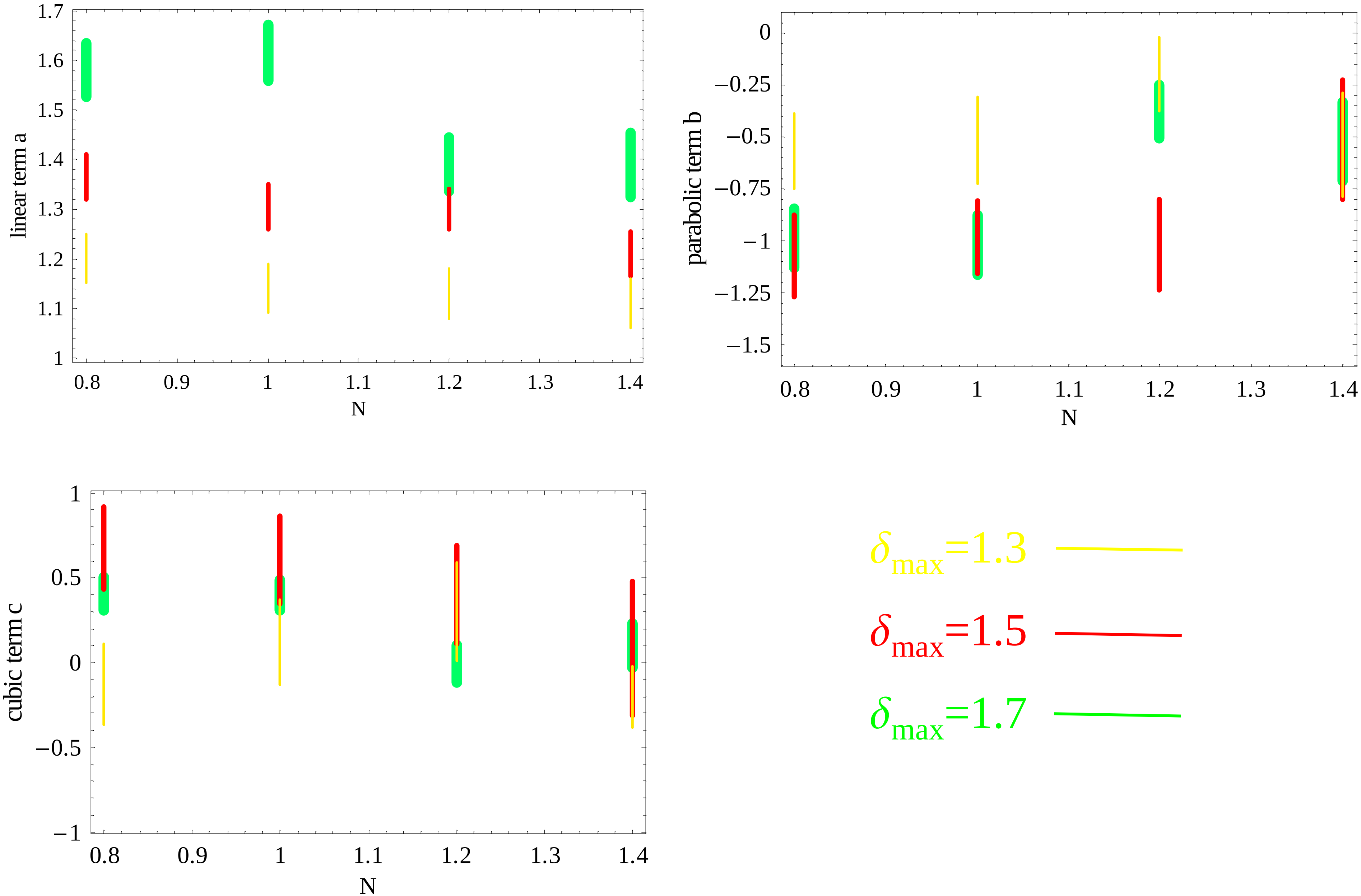
Lines corresponds to cubic fit of the form:

$$\rho_{m+1} = a\,\rho_m + b\,\rho_m^{\,2} + c\,\rho_m^{\,3}$$

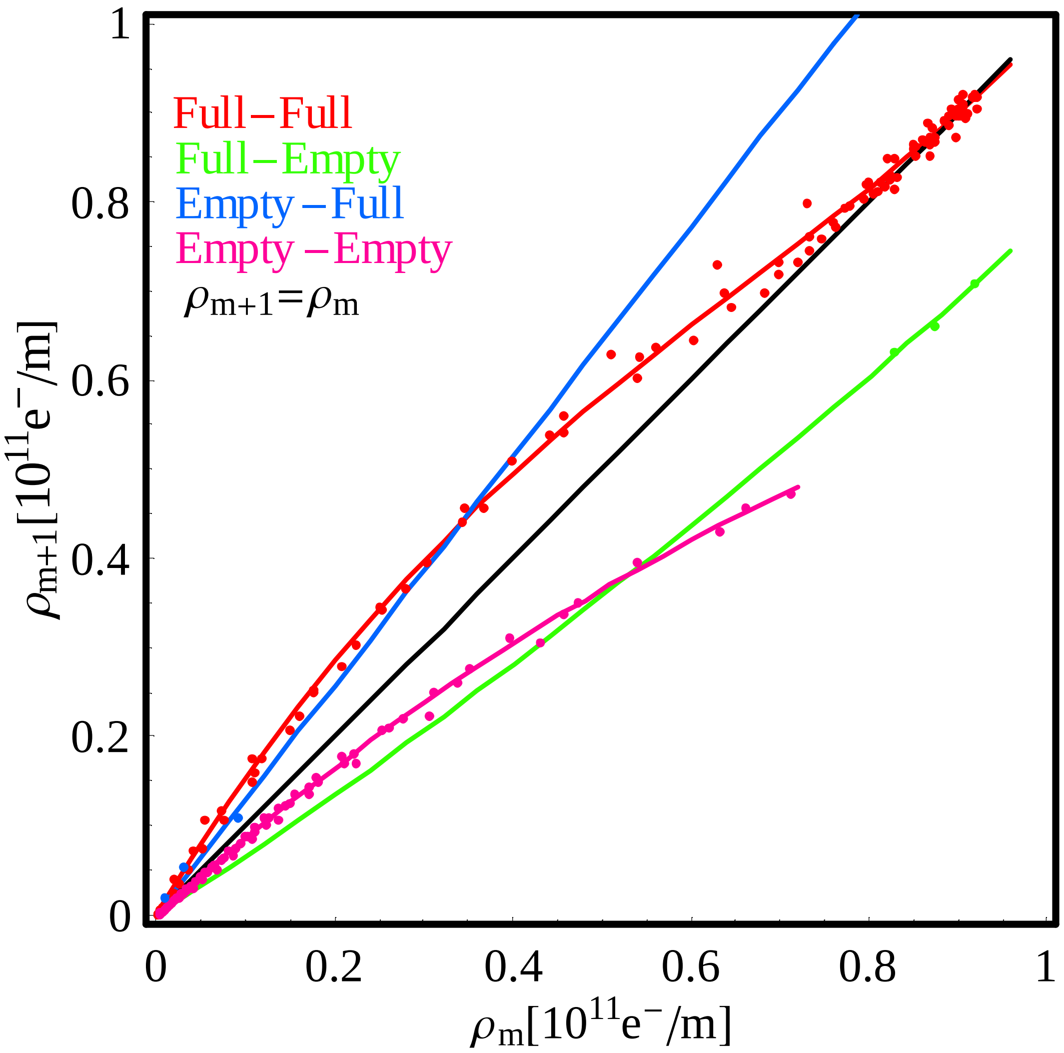
Three sets of map coefficients are needed to describe electron density evolution.

Qualitative agreement with previous results (Iriso and Pegg)

Evolution of Map Coefficients



Bunch Patterns



4 Trains of 72 Bunches

Bunch Pattern (24f,12e,36f)

8 Buches gap

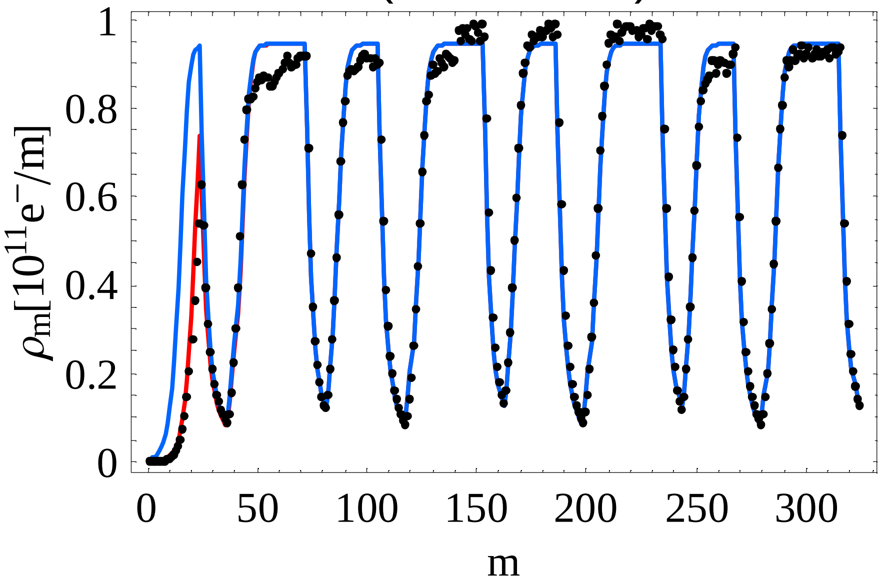
δ_{max}=1.7; N=1.2 $\cdot 10^{11}$

Four different sets of map coefficients are needed to describe the electron density evolution

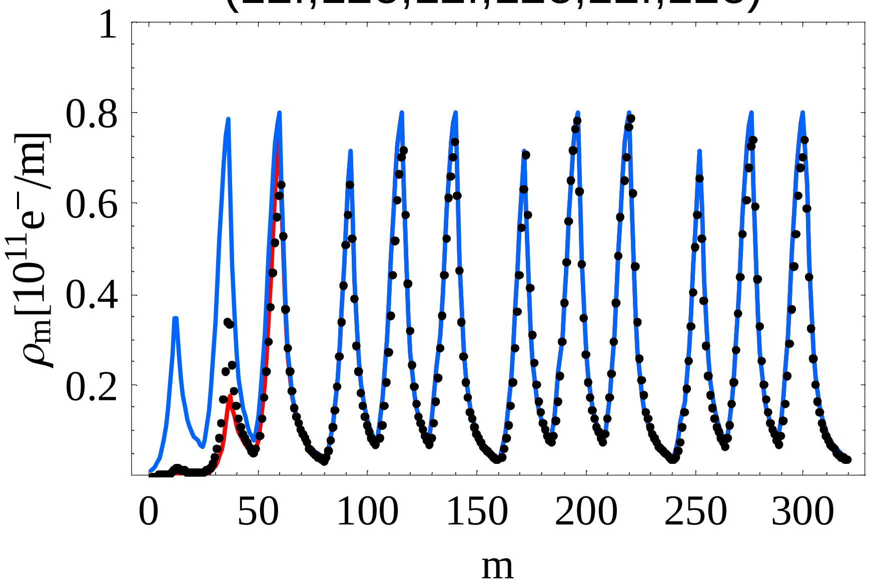
Bunch Patterns cont.

$\rho_0 = 10^{-2}[10^{11}e\text{-}/m]$, $\rho_0 = 10^{-4}[10^{11}e\text{-}/m]$

(24f,12e,36f)



(12f,12e,12f,12e,12f,12e)



Map results do not depend on the initial electron density ρ_0

Relative error under 20%

For a given set of the physical parameters (Bunch Intensity, SEY, etc.), diffrenet Bunch Patterns can be described using the same Map coefficients

Conclusions and Outlook

- The electron cloud build-up in an LHC dipole can be described using a cubic map.
- The coefficients of this map are functions of the pipe and beam parameters. This dependence can be extrapolated from simulation codes.
- The map coefficients are independent of the fill pattern,and they can be used to simulate the bunch to bunch evolution of electron cloud for different bunch filling patterns, obtaining a reduction by orders of magnitude in the simulation time.
- Deeper insight of the map formalism would be gained if a model of the dependence of the map coefficients on the physical parameters influencing the electron cloud were available.