

PS e-Cloud Simulations

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e-cloud simulation meeting

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Motivation for Simulations

- An experiment is proposed in the PS to characterize e-cloud effects on the **LHC-type** beam and beam in **Double harmonic rf buckets** by varying
 - $V(80\text{MHz})/V(40\text{MHz})=0.2-0.6$, BLM & BSM



- LHC25 and LHC50 type of beam
- Bunch intensities: Nominal to ultimate and beyond

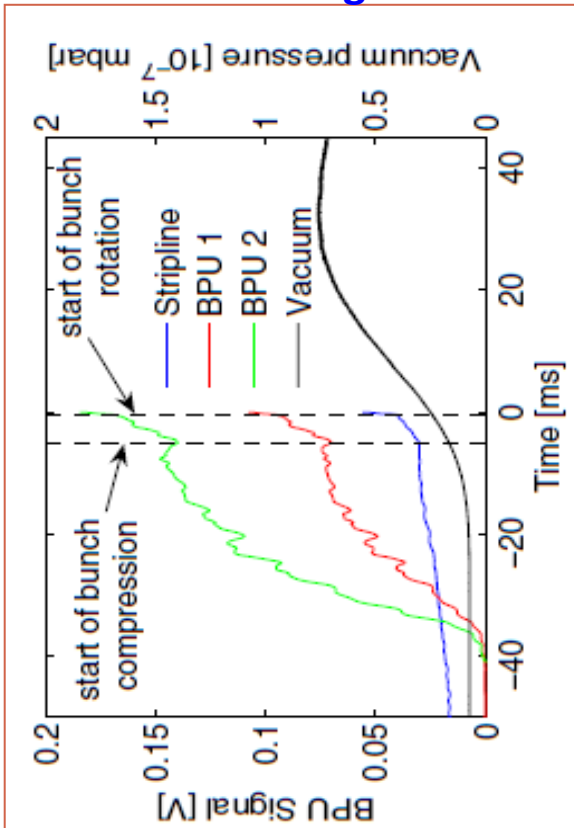
(Collaborators: C. Bhat, H. Damerau, S. Hancock, E. Mahner, F. Caspers, F. Zimmermann and H. Maury Cuna)

Simulate/bench-mark the observed e-cloud effects in the PS & extend the findings to the LHC/SLHC scenarios

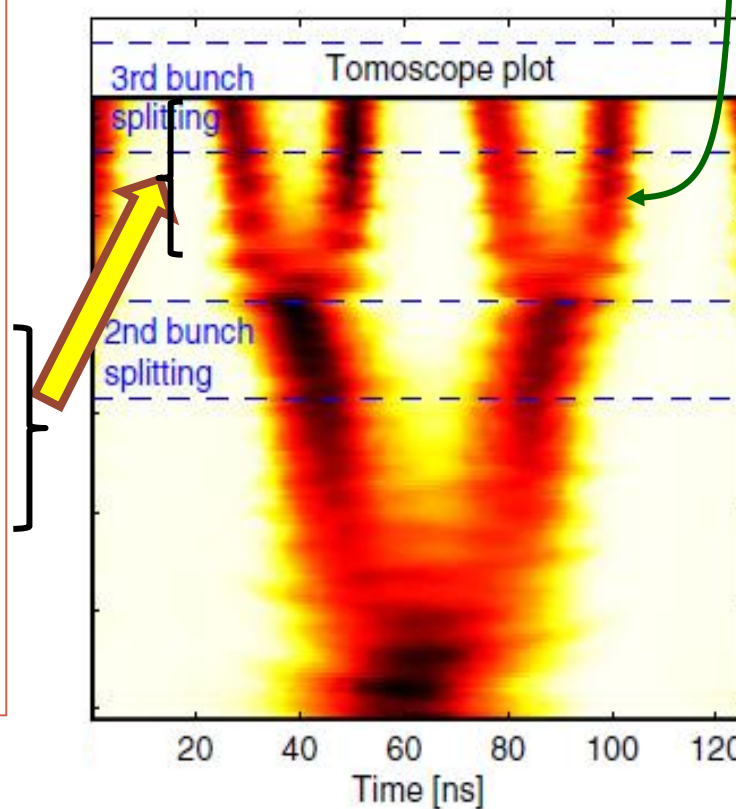
During 2007 PS MD e-cloud is observed after the quadrupole splitting

E. Mahner et.al,
PRSTAB Vol. 11, 094401(2008)

e-Cloud Signals



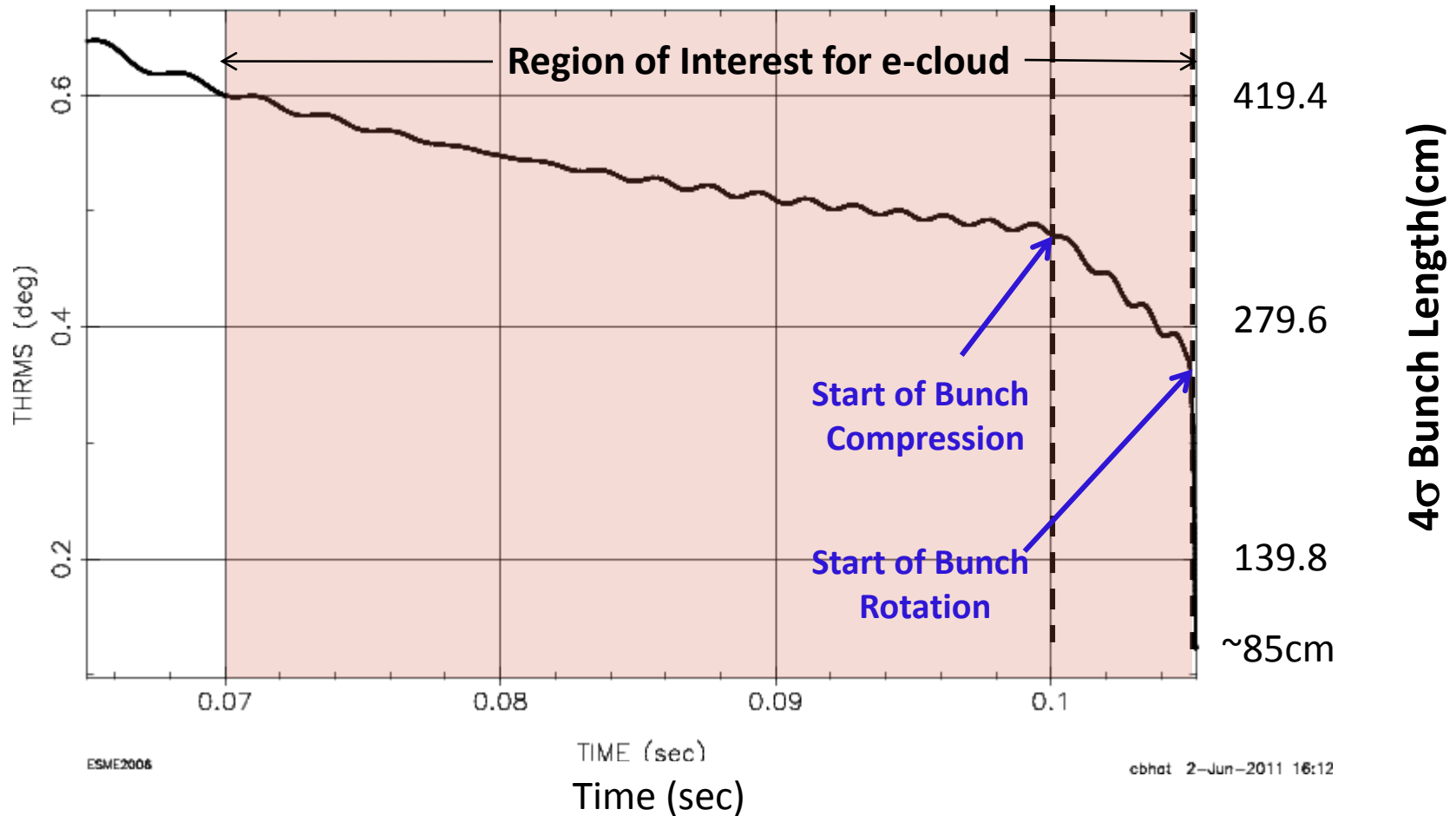
Changing bunch length and shape



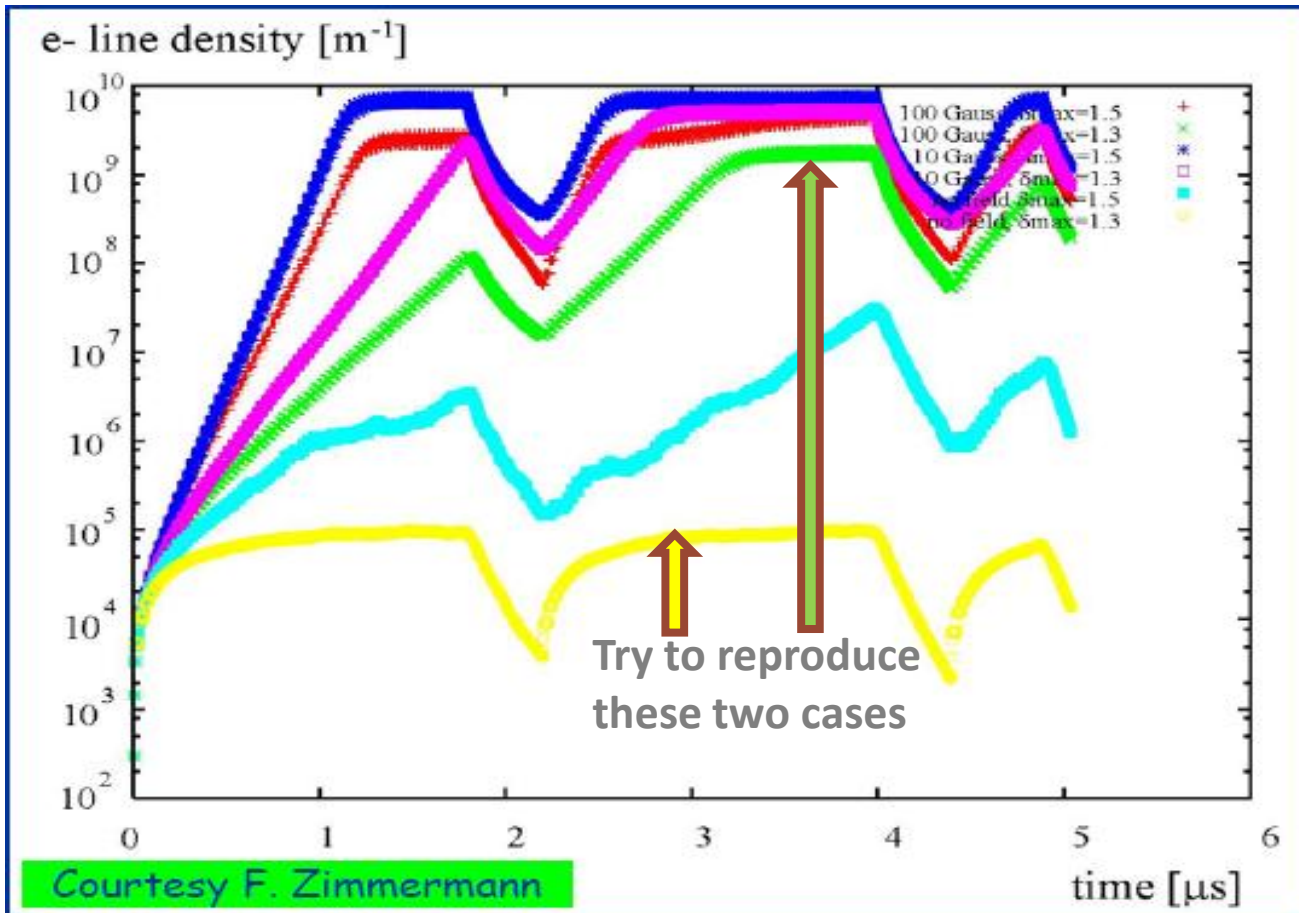
PS RF Systems

- ← 40MHz(+80MHz)
- ← 40MHz
- ← 40MHz+ 20MHz
- ← 20MHz
- ← 20MHz+ 10MHz
- ← 10MHz

Variation of Bunch Length in the PS 40 msec before extraction from ESME simulations



Attempts to Reproduce Frank's Simulations of 2007 (ref. APC – 6th July 2007)



E. Mahner, T. Kroyer, F. Caspers, CERN

APC 6. July 2007

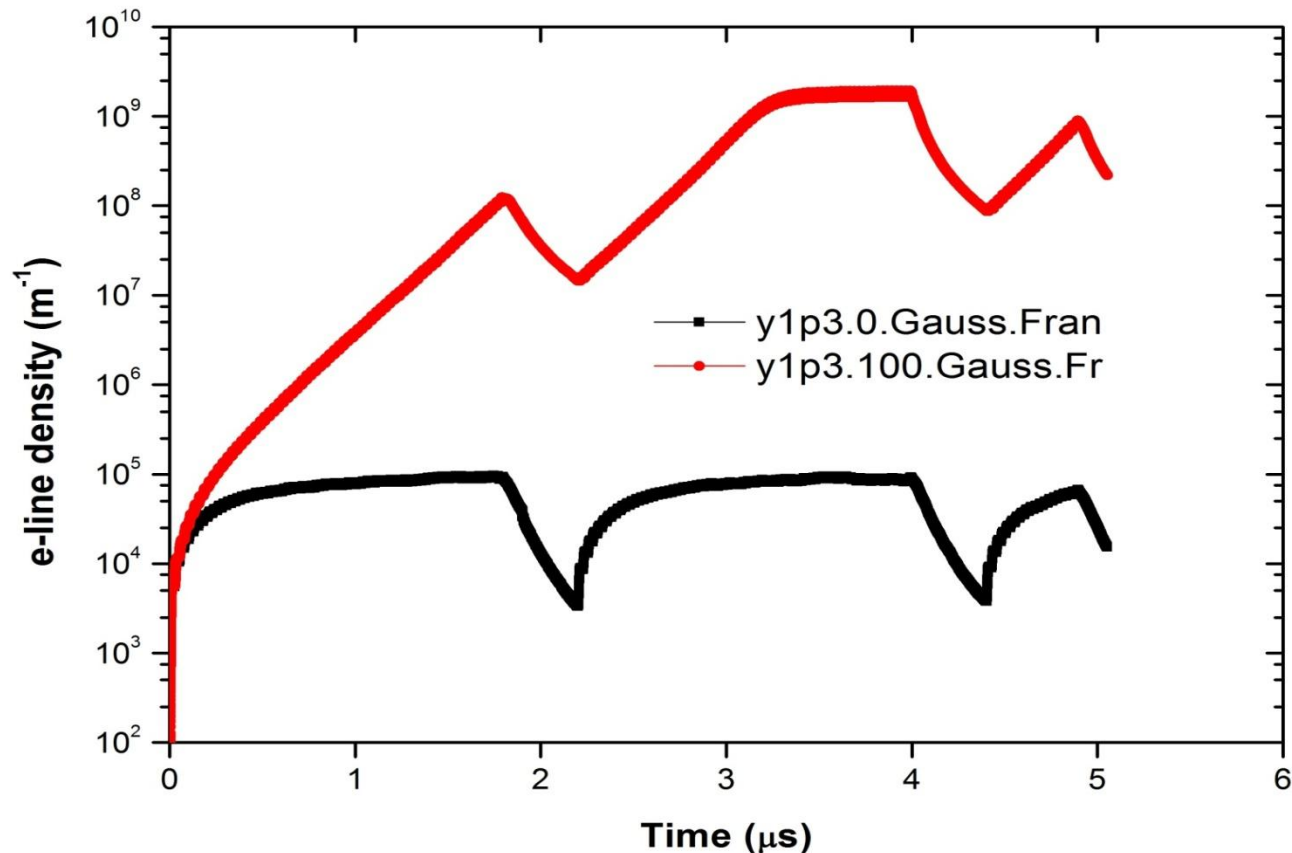
- Parameters for the PS after third bunch splitting.
- Secondary electron yield (SEY) chosen with $\delta_{max} = 1.3 - 1.5$.
- Simulations for $B = 0, 10, 100 G$.

Parameter	Value
proton momentum [GeV/c]	26
number of bunches	72
protons per bunch	$1.15 \cdot 10^{11}$
bunch spacing [ns]	25
gap length [μs]	0.4
rms bunch length [m]	0.75
rms momentum spread	$2.30 \cdot 10^{-4}$
rms trans. norm. emittance [μm]	3.00
σ_x [mm]	1.58
σ_y [mm]	0.42
β_x [m]	20
β_y [m]	12
horizontal dispersion D_x [m]	2.5
chamber half width [mm]	73
chamber half height [mm]	35
maximum SEY yield δ_{max}	1.5
electron energy at δ_{max} [eV]	239.5
pressure [nTorr]	10

Missing input parameters in this list:

1. Ionization cross section, σ ←
2. Reflectivity
3. Filling pattern

PS e-Cloud: Repeating Frank's 2007 simulations for
25 nsec LHC type 1.15E11ppb beam (500 macro particles)
Version **3.3(b), 3 September 2009**



Were able to reproduce the results with the e-cloud input data given by Frank
**Conclusions: Very little difference in the results from the ECLLOUD code used then (?)
and now**

Ionization Cross Section σ

(Review/revisit)

$\sigma = 2$ Mbarn is used in SPS simulations at 26 GeV

$$\sigma = (1.874 \times 10^{-20} \text{ cm}^2) C \left[\frac{M^2 \ln \left\{ \frac{\beta^2}{1-\beta^2} \right\}}{C} + \frac{1}{\beta^2} \right] \text{ Bethe's formula}$$

	M**2	C	σ (Mbarn)	
N2	3.74	34.84	1.05	} 1.08 Mbarn
O2	4.2	38.84	1.17	
CO2	5.75	55.92	1.66	
Ar	3.69	38.14	1.11	

PRA Vol 51 (1995) 4631

PRA Vol 6 (1972) 1501

PRA Vol23(1981)95

(Thanks to Sergio Calatroni)

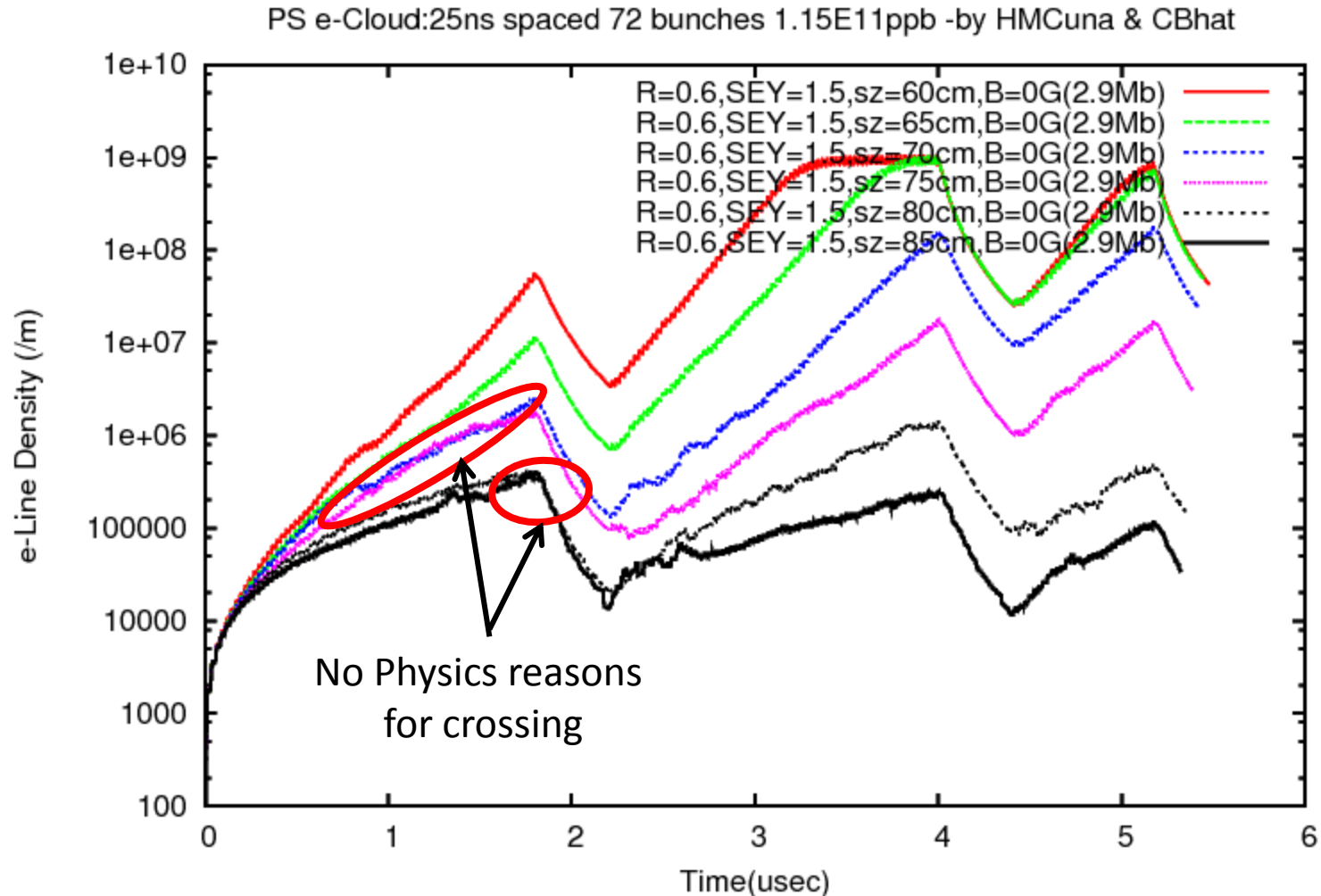
$$\sigma = 0.78\sigma(\text{N}_2) + 0.21\sigma(\text{O}_2) + 0.01\sigma(\text{CO}_2)$$

for air

A factor of two large σ values is used?

Work in Progress:

PS e-Cloud: $\sigma_{ion}=2.9$ MBarn, SEY=1.5, R=0.6, BF=0G, sz=60-85cm, Gaussian bunch(500 macro particles)

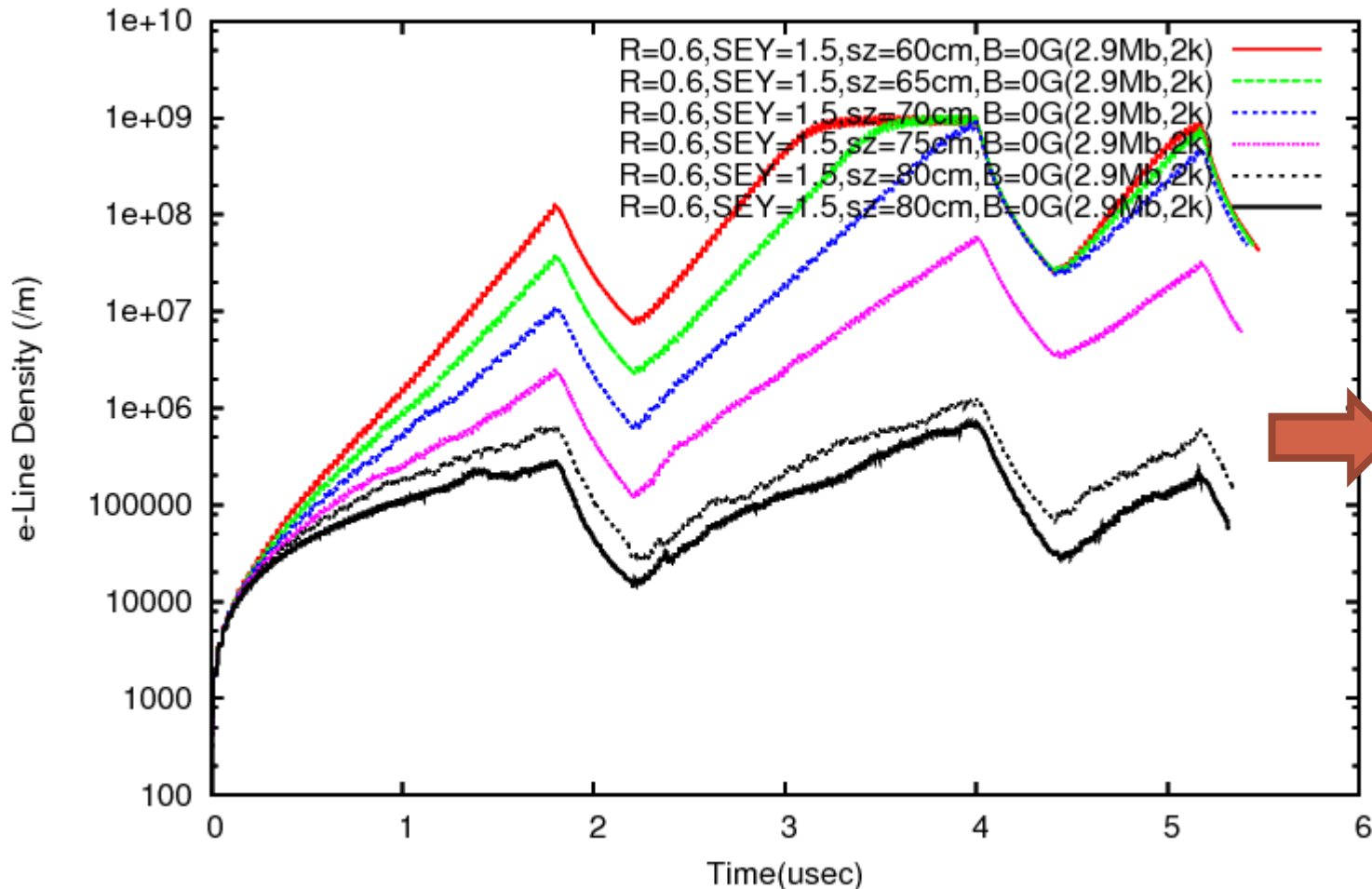


Mon May 30 11:02:17 2011

Work in Progress:

PS e-Cloud: $\sigma_{ion} = 2.9$ MBarn, SEY=1.5, R=0.6, BF=0G, sz=60-85cm, Gaussian bunch(2000 macro particles)

PS e-Cloud: 25ns spaced 72 bunches $1.15E11$ ppb -by HMCuna & CBhat



No crossing;
The previous simulations did **not** have enough statistics

→ One may have to revisit previous simulations done for the LHC e-cloud- make sure that there were not statistical effect.

Thu Jun 02 14:04:11 2011

5/31/2011

C. M. Bhat, H. Maury Cuna, F. Zimmermann

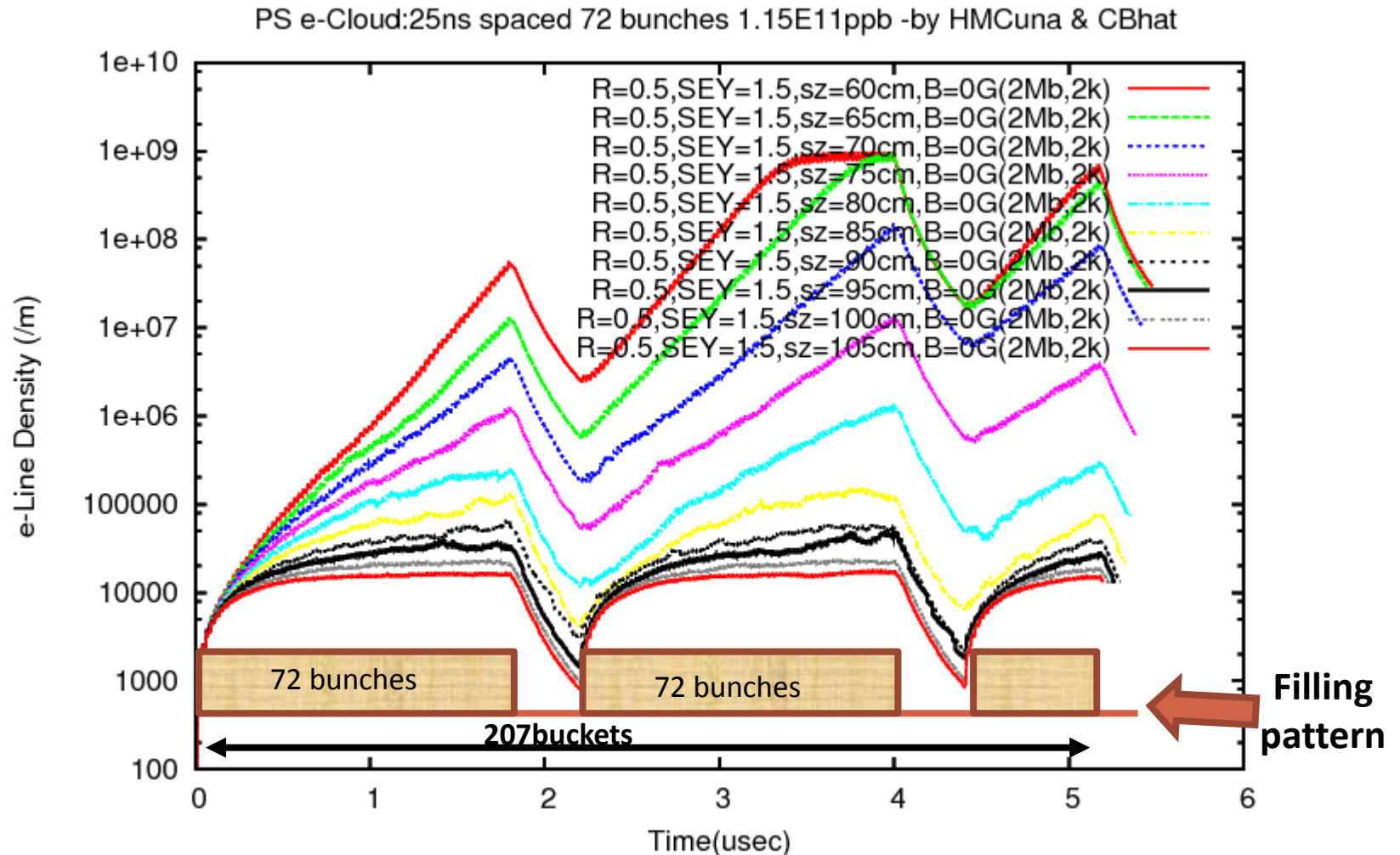
Work in Progress

PS- e-Cloud Simulation

- We have studied
 - Seed dependence ← no strong dependence is seen
 - # of macro-particles ← strong dependence is seen, suggests **>2000** macro-particles in our case
 - σ_{Ion} : 2.9, **2.0**, 1.0 Mbarn
 - SEY=1.0 to 1.6 (**1.5**) and R=0.3-1.0 (**0.6**)
 - Bunch Length (1σ)=60cm-175cm

Work in Progress:

PS e-Cloud: $\sigma_{ion}=2$ MBarn, SEY=1.5, R=0.5, BF=0G, sz=60-105cm, Gaussian bunch(2000 macro-particles)



Tue Jun 07 08:49:53 2011

Summary/Conclusions

- An experiment is proposed/being conducted in the PS to study the e-cloud effects to study the e-cloud density as a function of
 - Bunch profile, Bunch spacing and Bunch intensityFor the LHC type beam
- ELOUD Simulations are being conducted to reproduce the observed e-cloud buildup in the PS
- Systematic approach is adopted to establish
 - Minimized statistical effects
 - Good set of physical parameters for the simulation

Work in Progress

PS- e-Cloud Experiment

- We have taken
 - Baseline data → on MD6 LHC25nsec with a special rf voltage configuration which includes
 - Tomo-scope data (Longitudinal profiles)
 - Transverse emittance, Beam Int.
 - e-cloud data from PS e-cloud monitors
- (June 1-6, 2011)