IBS and luminosity evolution with higher harmonic RF

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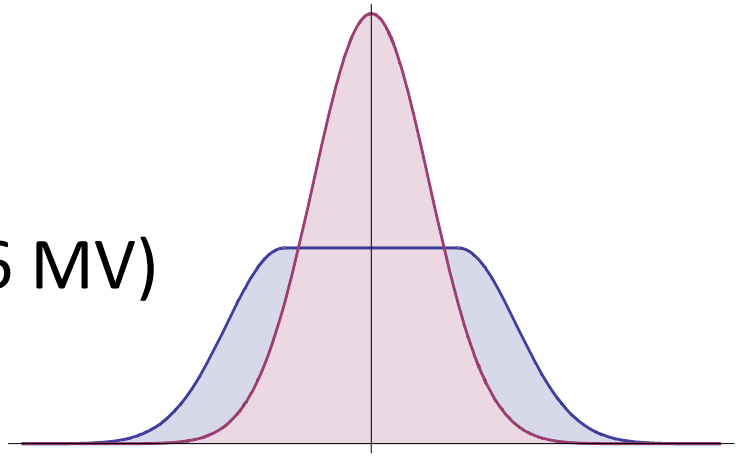
Outline

- Introduction
- Simulation Program
- Evolution of a Gaussian distribution in the double RF system
- Protons : 450 GeV , 3.5 TeV and 7 TeV in collision
- Ions : 450 Z GeV , 3.5 Z TeV and 7 Z TeV in collision
- Side note : Luminosity and debunching vs initial longitudinal emittance
- Conclusions

Introduction

- Problems with heating in beam screens of the LHC -> add secondary RF system to modify longitudinal bunch profile (C.M. Bhat. Bunch shaping in the lhc a quick look, June 2010 LMC Meeting 97 on 22/06/2011)
- How does such a double RF system affects emittance growth, debunching and integrated luminosity for protons and ions.
- Double RF system:
  - 800 MHz
  - ½ RF Voltage of Primary RF (6 MV)

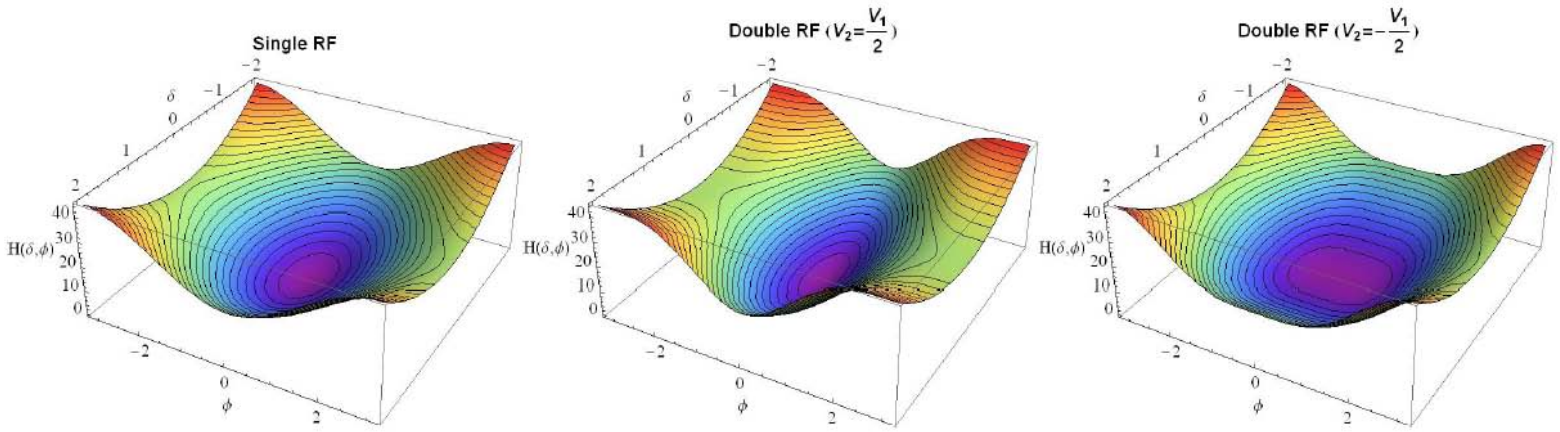


Simulation program

- Particle Tracking code written in FORTRAN developed by R. Bruce and M. Blaskiewicz
- Physics processes taken into account:
  - Injection :
    - Betatron motion
    - Synchrotron motion
    - Radiation Damping
    - IBS
  - 3.5 (Z) TeV and 7 (Z) TeV
    - Same as injection
    - Collisions
- Different IBS models implemented -> used Nagaitsev (successfully applied for ions 2010) with the Coulomblog put to 20.

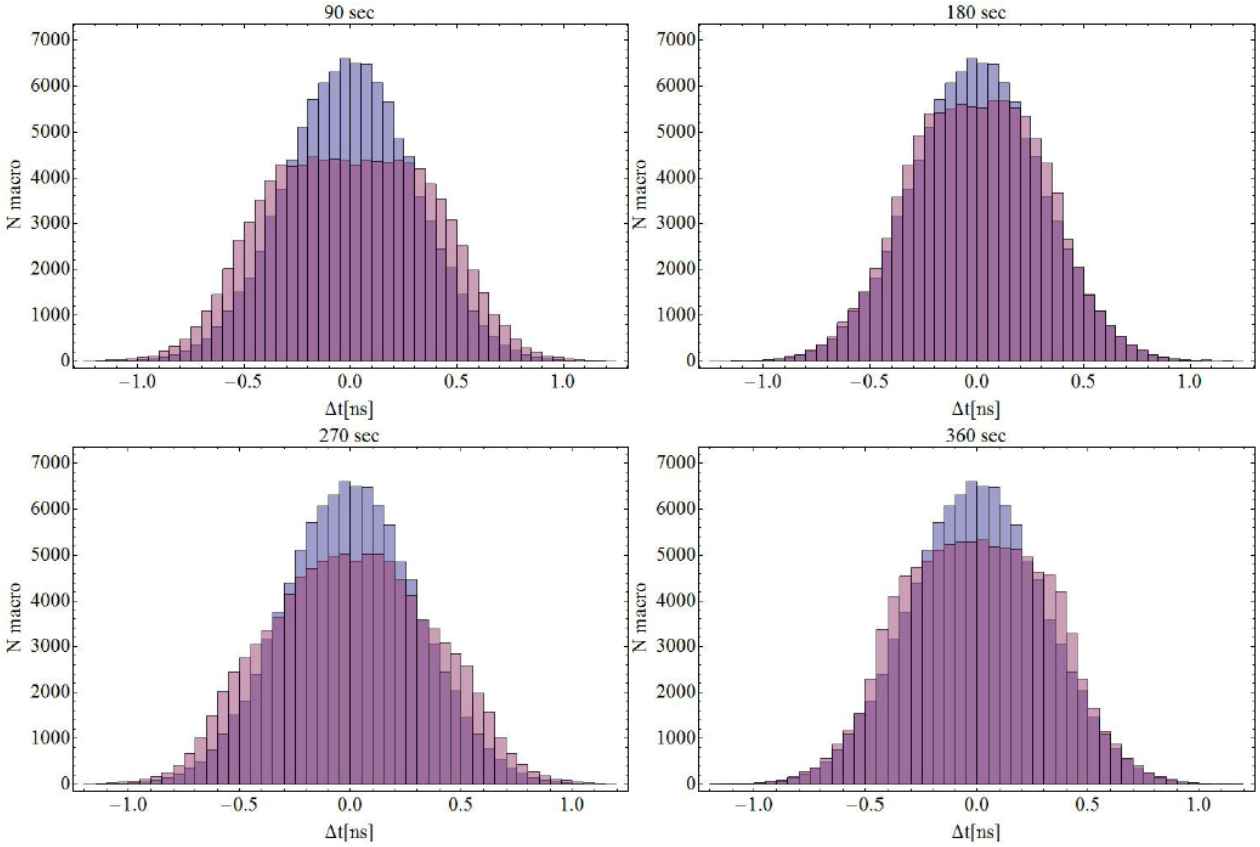
Evolution of a Gaussian distribution in the double RF system

- Relative Hamiltonians



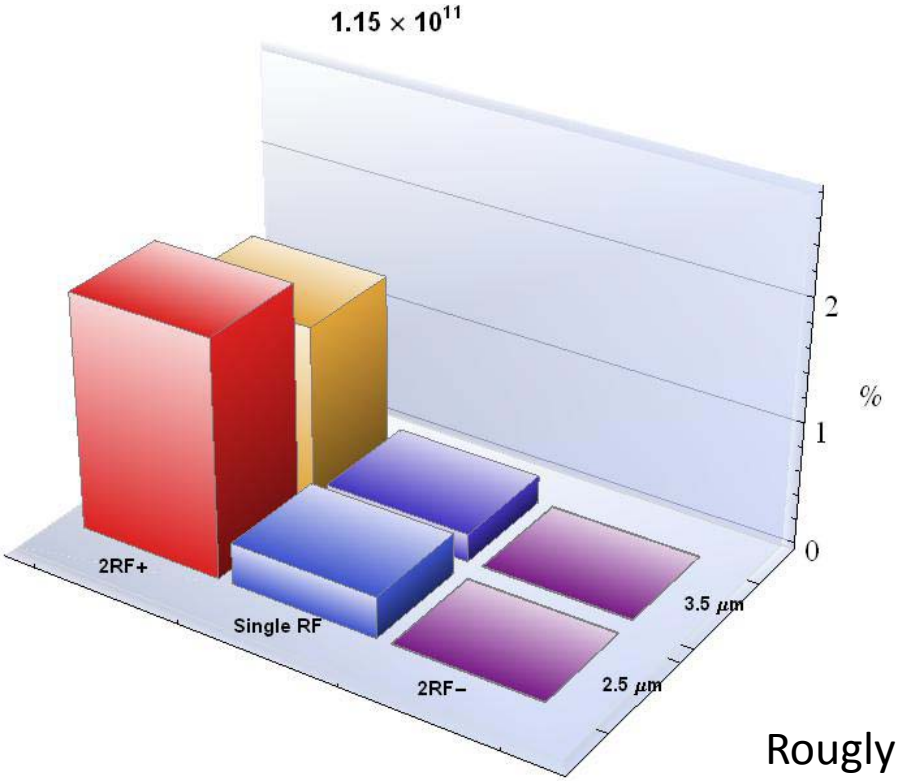
Evolution of a Gaussian distribution in the double RF system

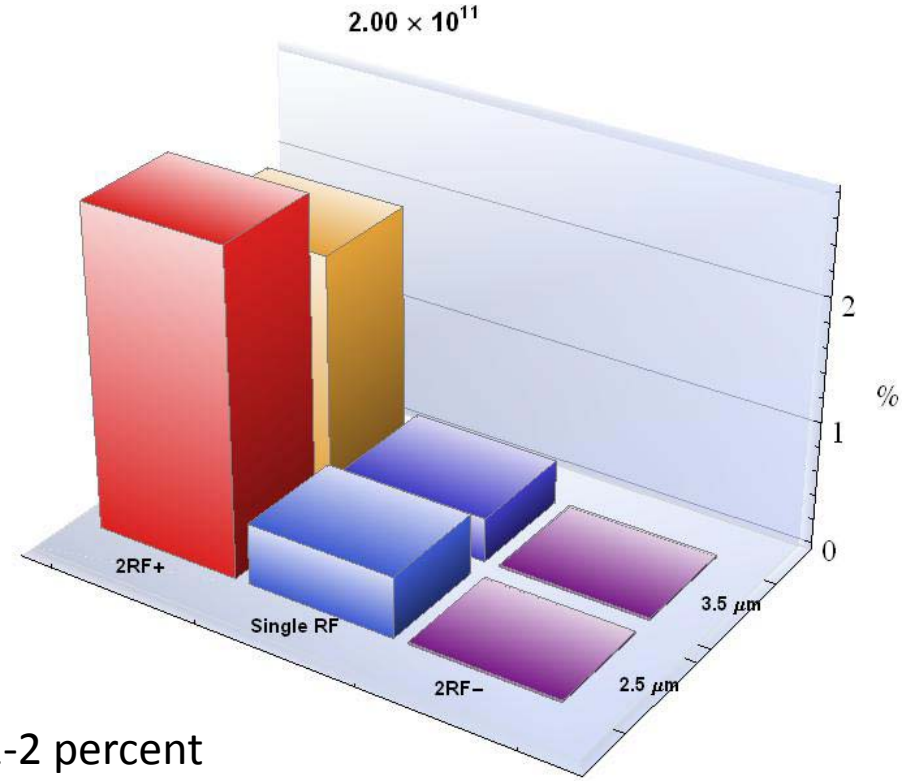
- Starting with a Gaussian bunch matched to the single RF system we turn on the secondary RF. Plots below show the evolution of the longitudinal profile. Blue histogram is original Gaussian bunch, pink histogram is the profile with the secondary RF system turned on.



Protons 450 GeV

Debunching Losses (in % of initial beam) after 1 hour

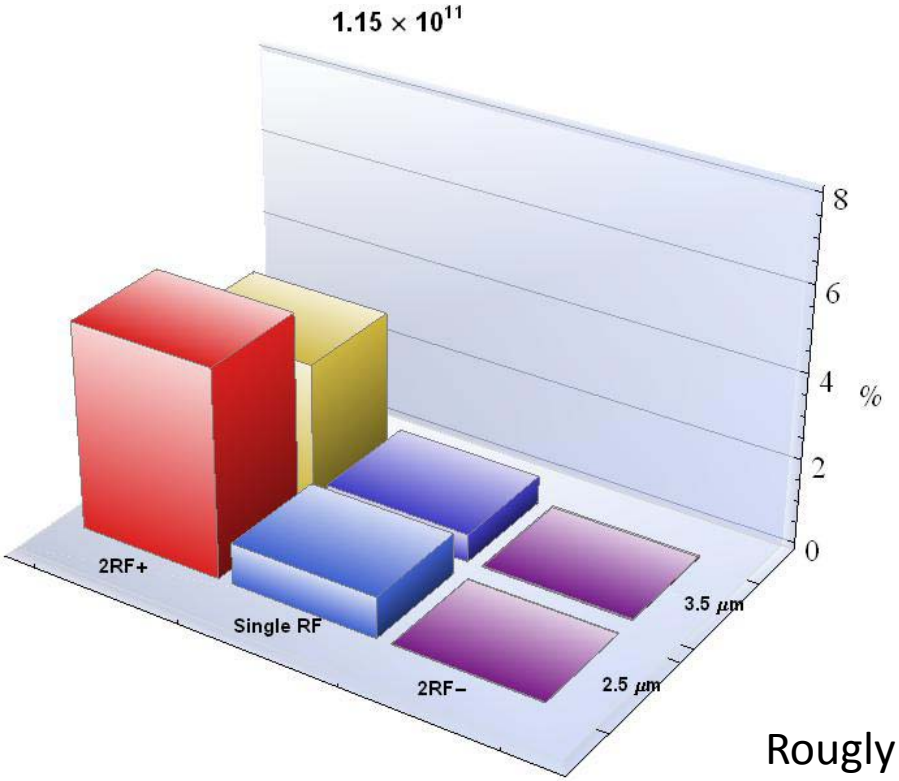


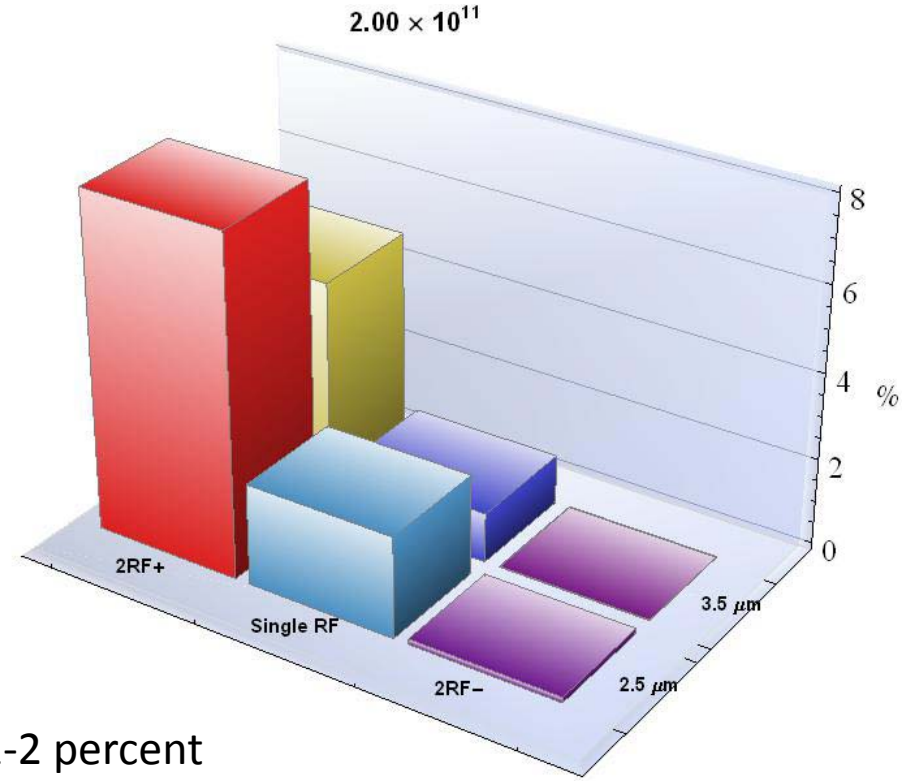


Rougly 1-2 percent improvement of debunching losses.

Protons 3.5 TeV

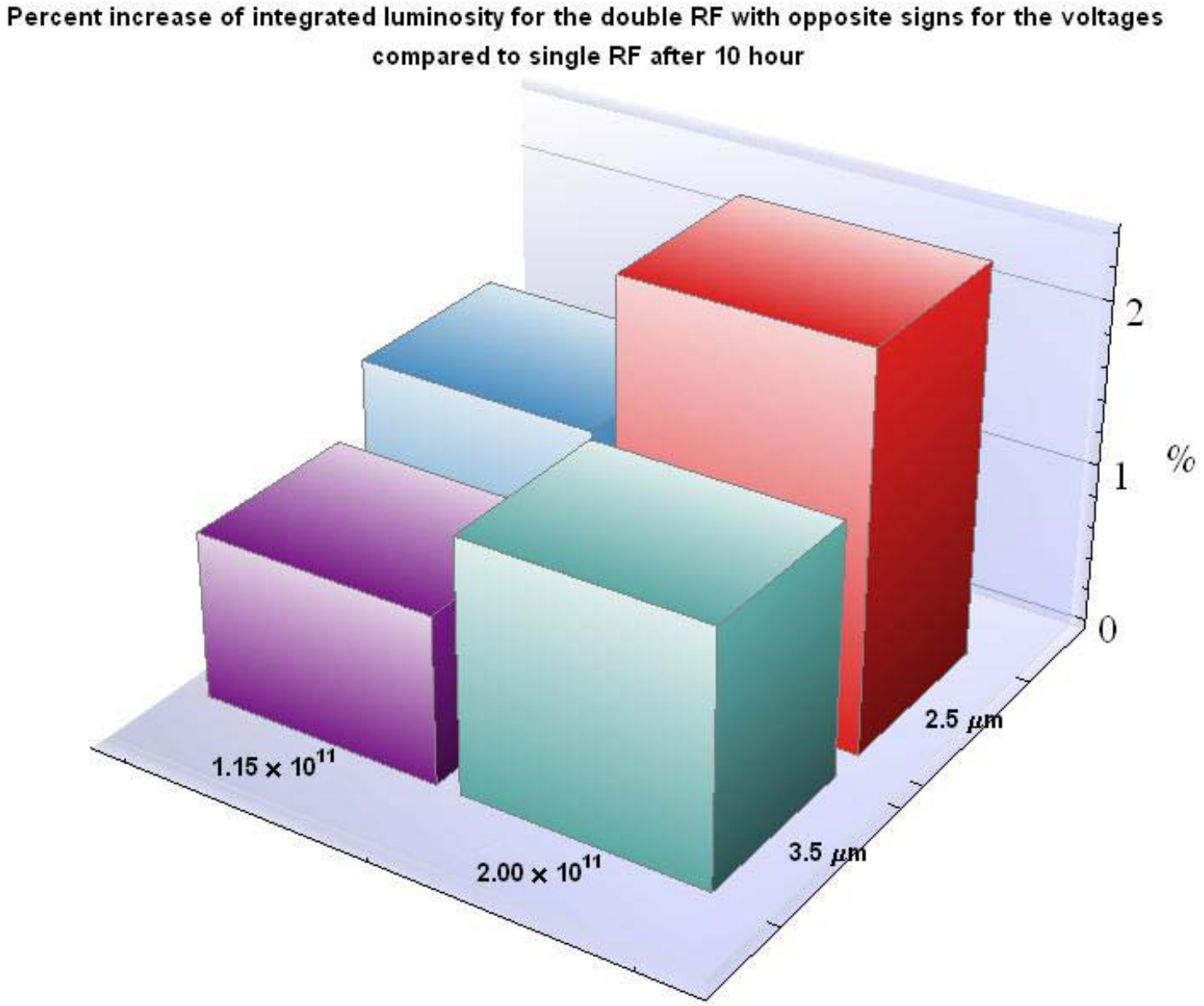
Debunching Losses (in % of initial beam) after 10 hour





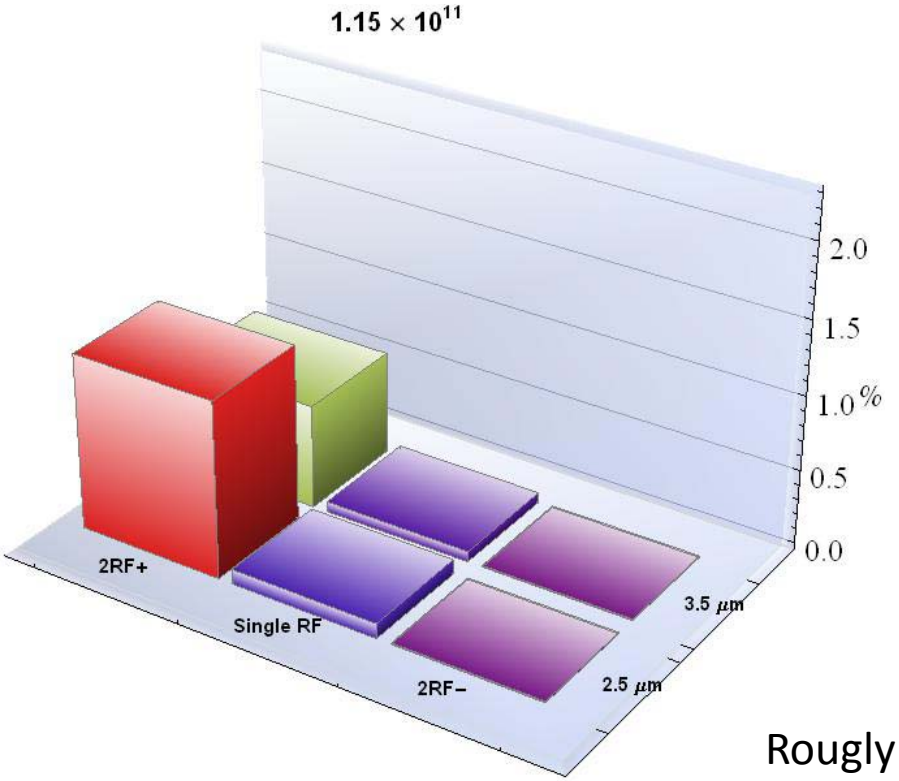
Rougly 1-2 percent improvement of debunching losses.

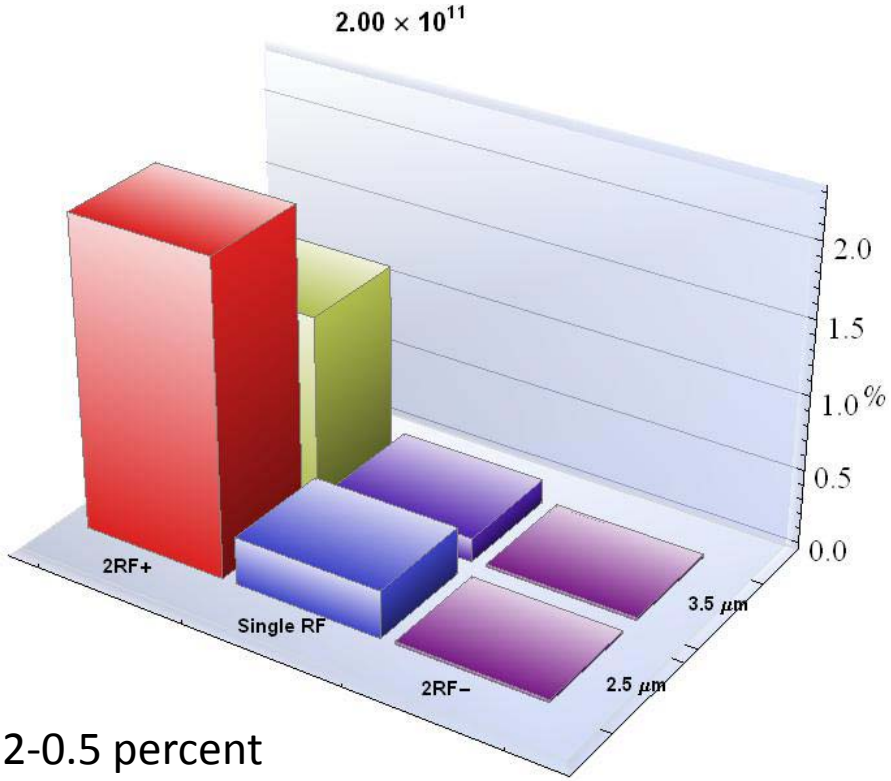
Protons 3.5 TeV



Protons 7 TeV

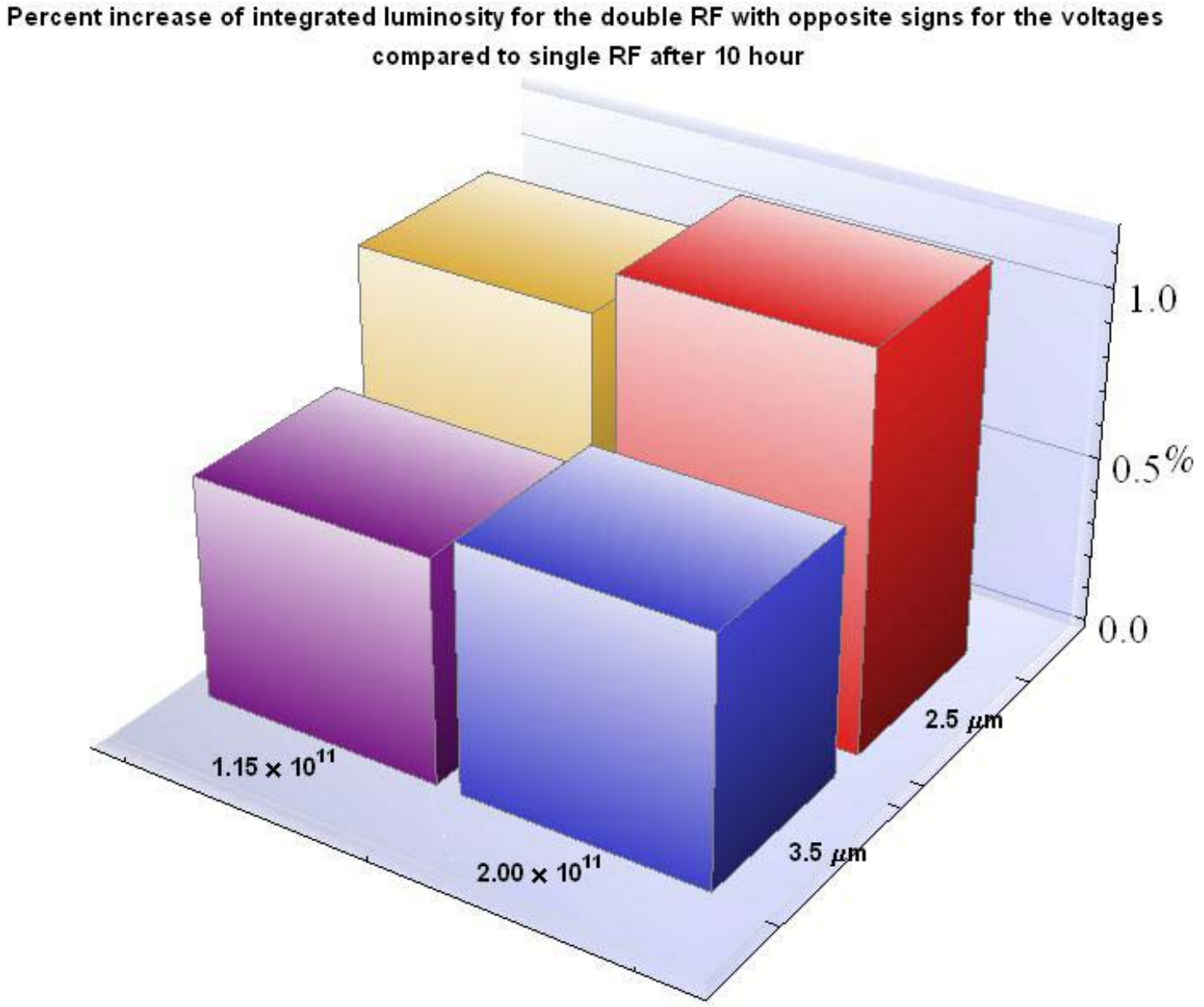
Debunching Losses (in % of initial beam) after 10 hour





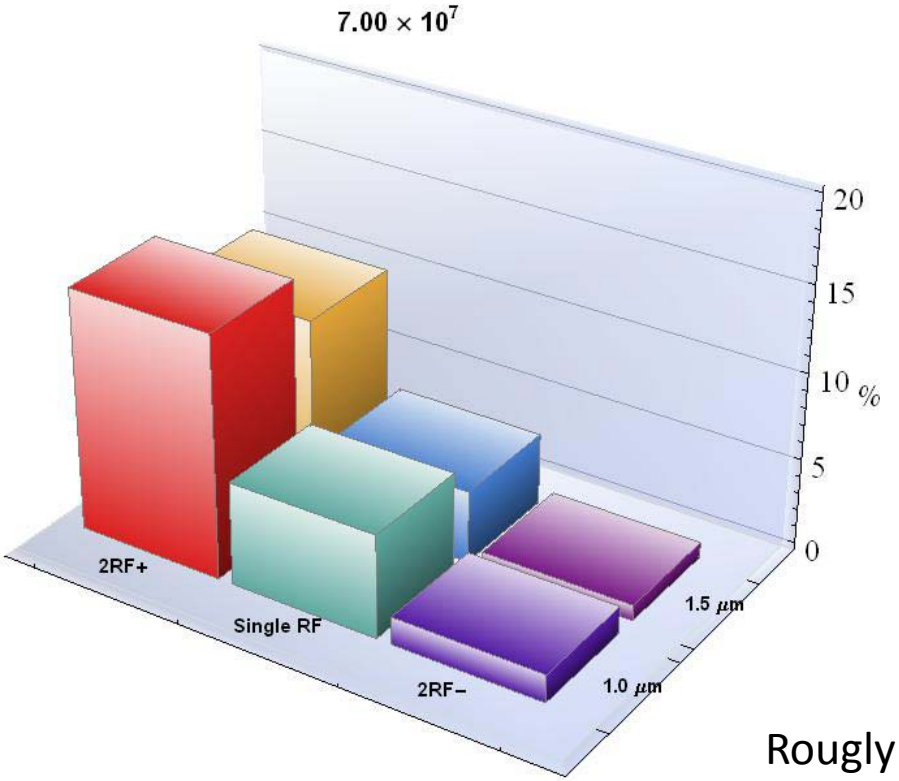
Rougly 0.2-0.5 percent improvement of debunching losses.

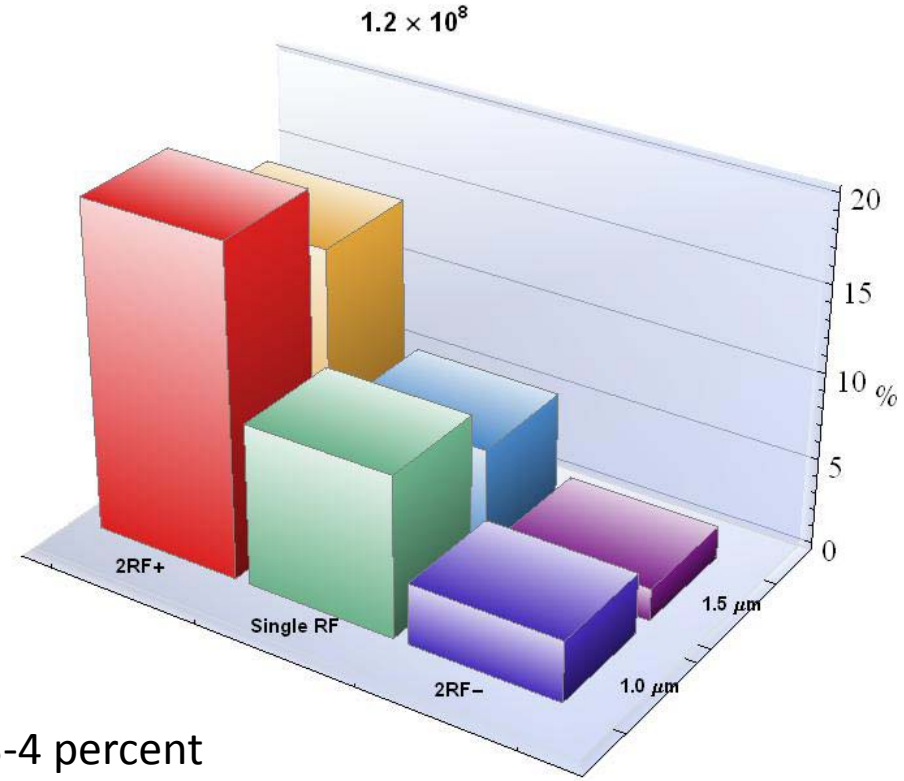
Protons 7 TeV



Ions 450 Z GeV

Debunching Losses (in % of initial beam) after 1 hour

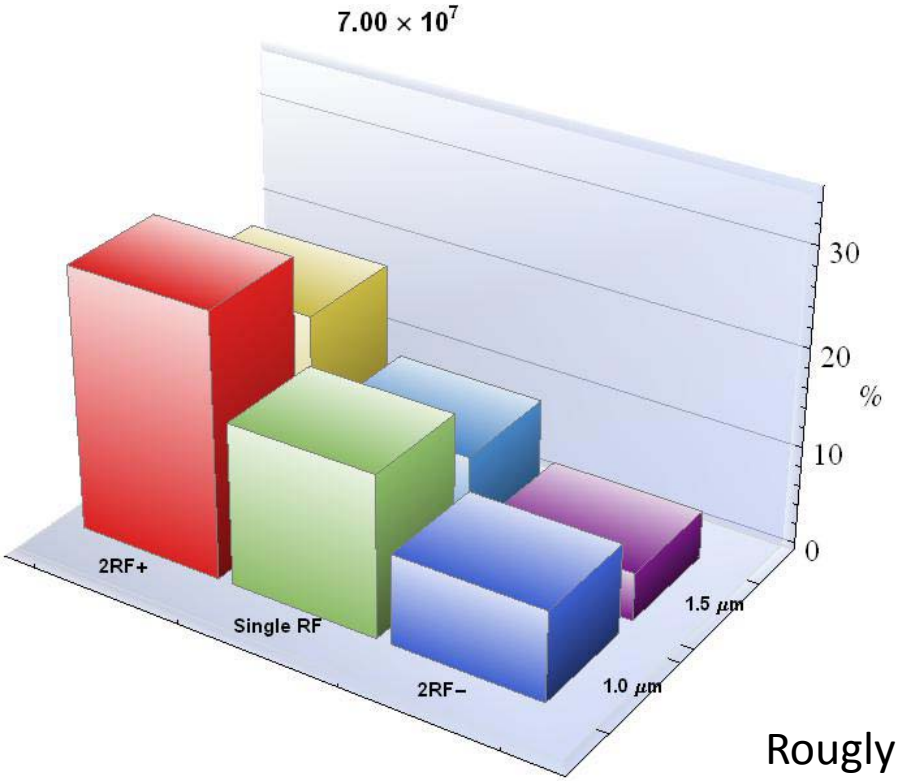


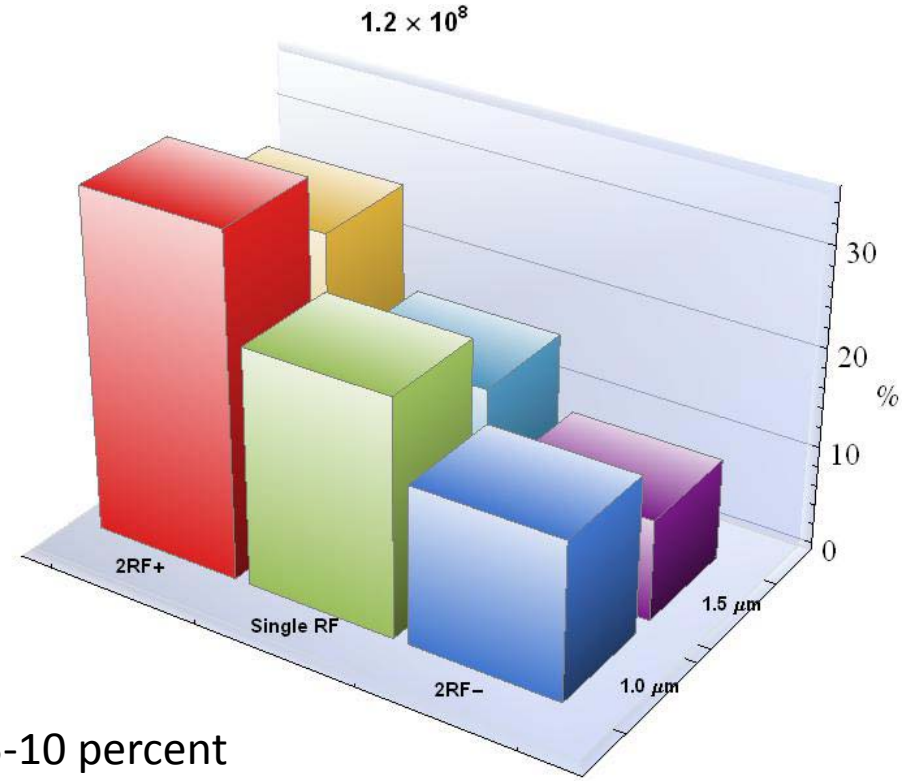


Rougly 3-4 percent improvement of debunching losses.

Ions 3.5 Z TeV

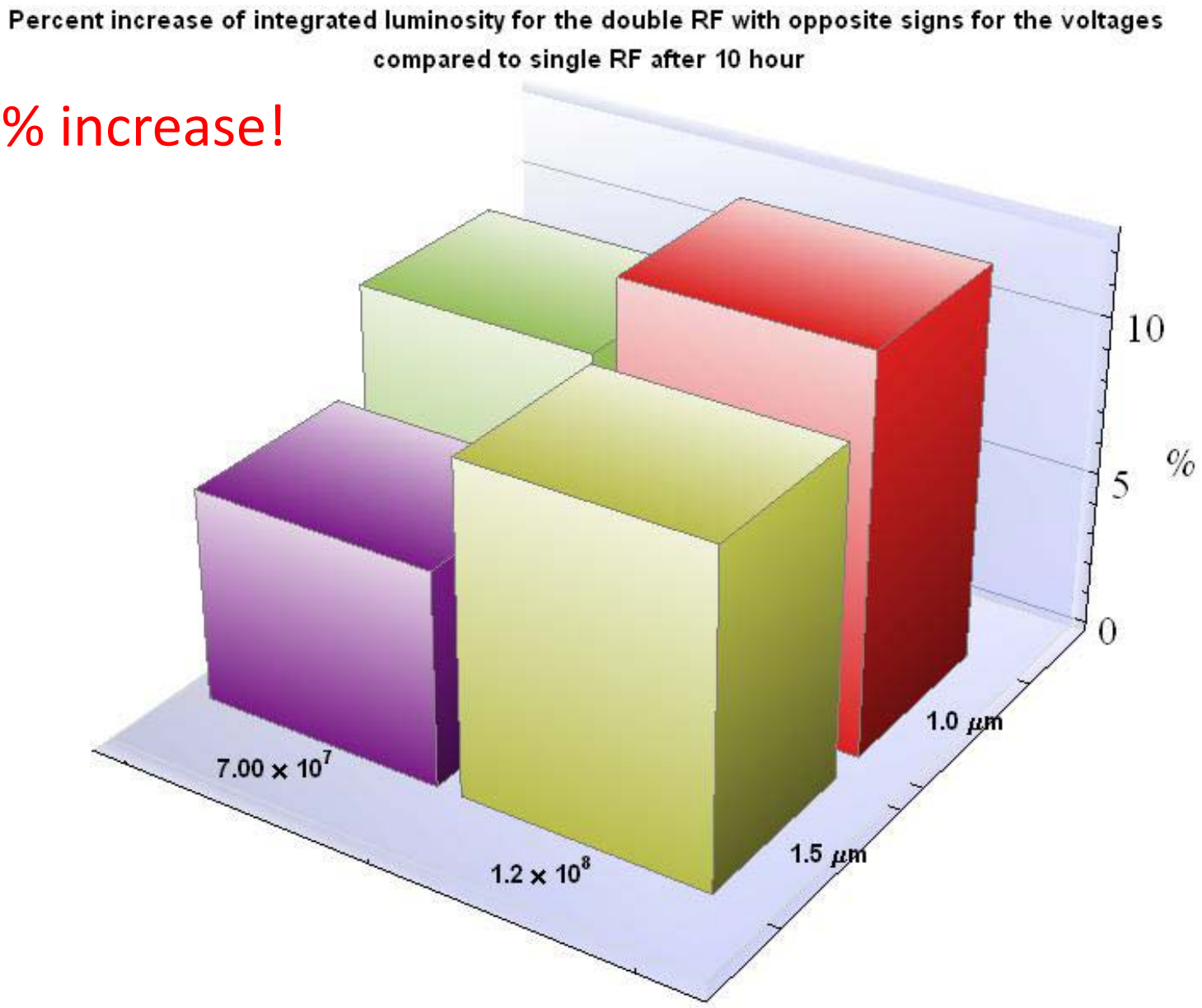
Debunching Losses (in % of initial beam) after 10 hour





Rougly 5-10 percent improvement of debunching losses.

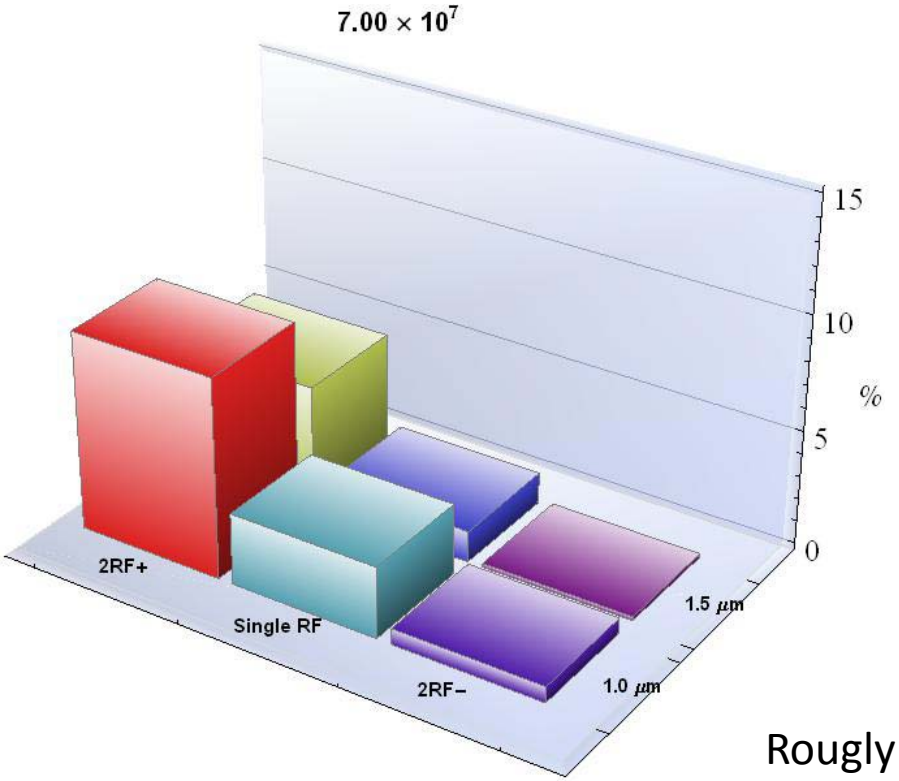
Ions 3.5 Z TeV

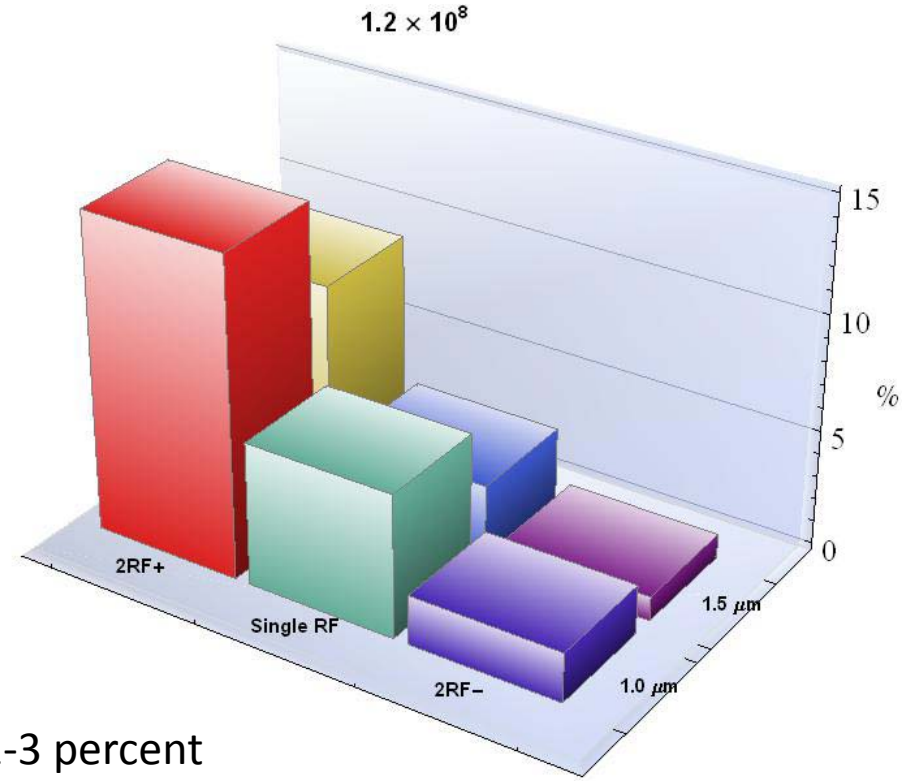


5-10 % increase!

Ions 7 Z TeV

Debunching Losses (in % of initial beam) after 10 hour

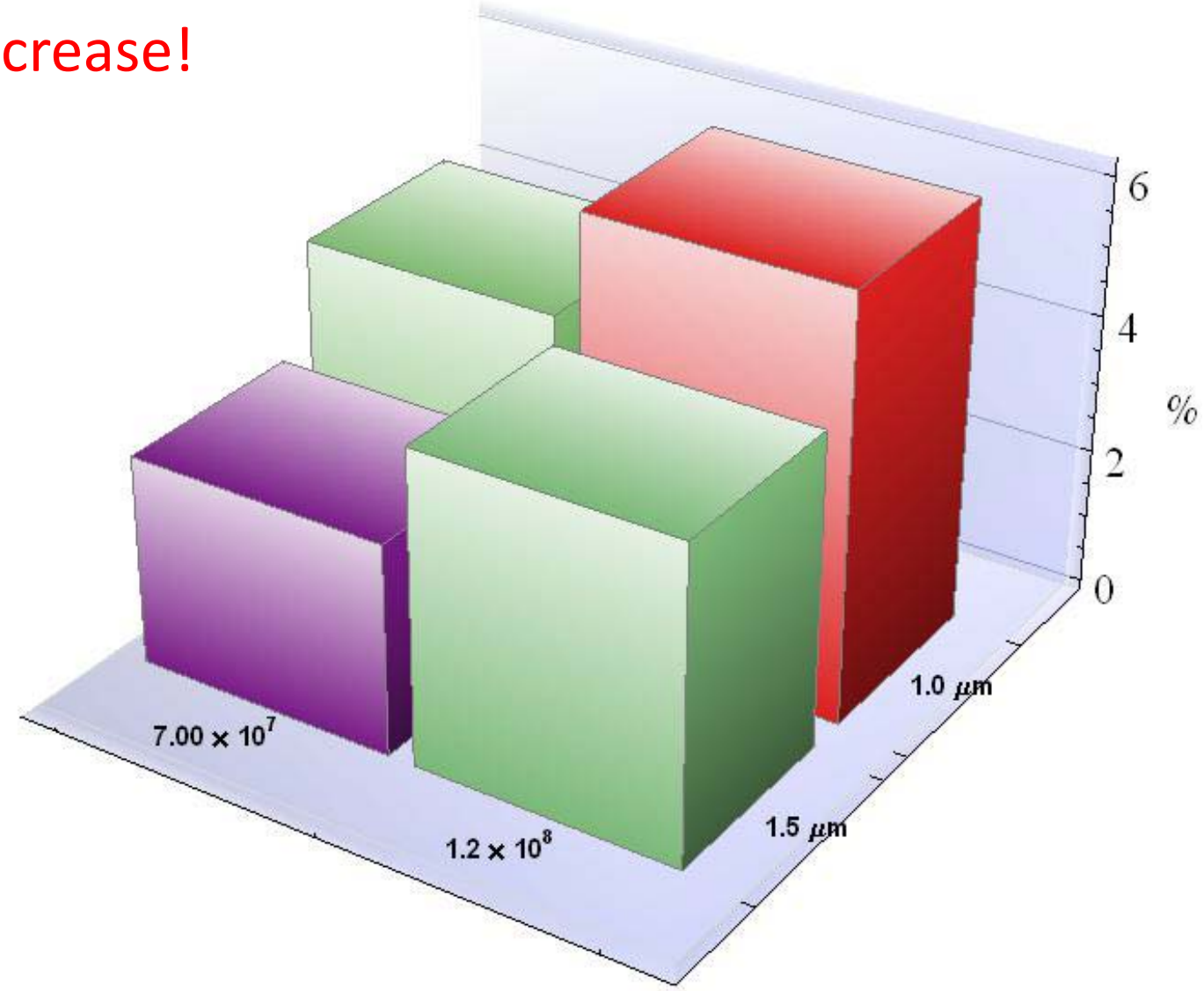




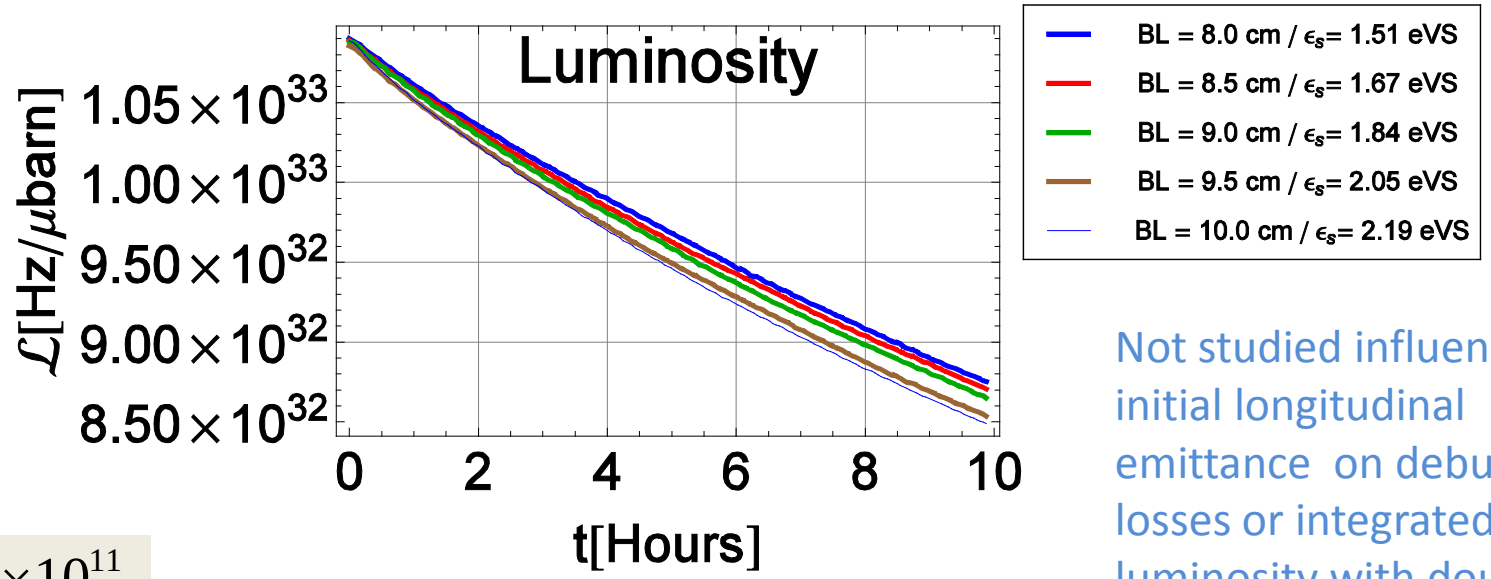
Rougly 1-3 percent improvement of debunching losses.

Ions 7 Z TeV

2-6 % increase!



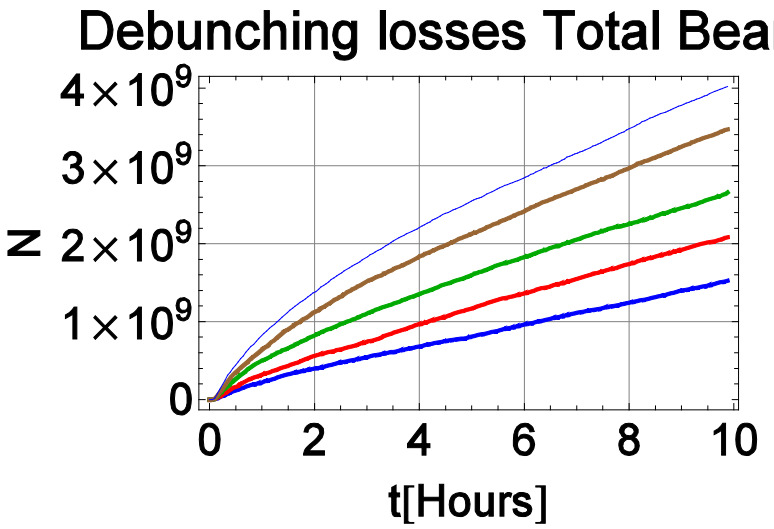
Side note: (Integrated) Luminosity/ debunching losses vs initial longitudinal emittance (protons) in single RF

- 

$I = 1.15 \times 10^{11}$

$\varepsilon_{N,x,y} = 2.7\,\mu m$

$V_{RF} = 12 MV$



Not studied influence of initial longitudinal emittance on debunching losses or integrated luminosity with double RF.

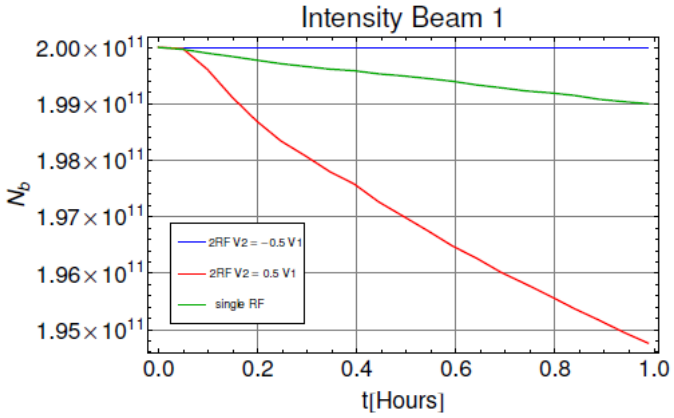
Conclusions

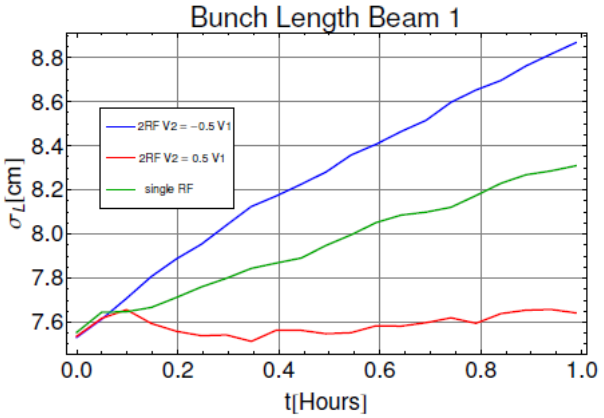
	Protons		Ions	
E [TeV]	Case	Integrated Lumi increase (10 h)[%]	Case	Integrated Lumi increase (10 h)[%]
3.5	NP1.15_EM2.5	1.4	NP7_EM1.0	10.0
3.5	NP1.15_EM3.5	1.0	NP7_EM1.5	6.8
3.5	NP2.0_EM2.5	2.4	NP1.2_EM1.0	12.55
3.5	NP2.0_EM3.5	1.5	NP1.2_EM1.5	10.45
7	NP1.15_EM2.5	1.0	NP7_EM1.0	4.58
7	NP1.15_EM3.5	0.6	NP7_EM1.5	3.06
7	NP2.0_EM2.5	1.14	NP1.2_EM1.0	6.14
7	NP2.0_EM3.5	0.7	NP1.2_EM1.5	4.54

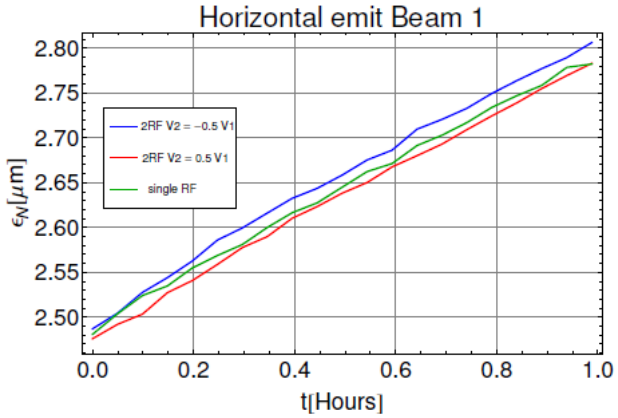
- Decrease in debunching (stronger effects for ions)
- Increase of integrated luminosity (significant for ions)

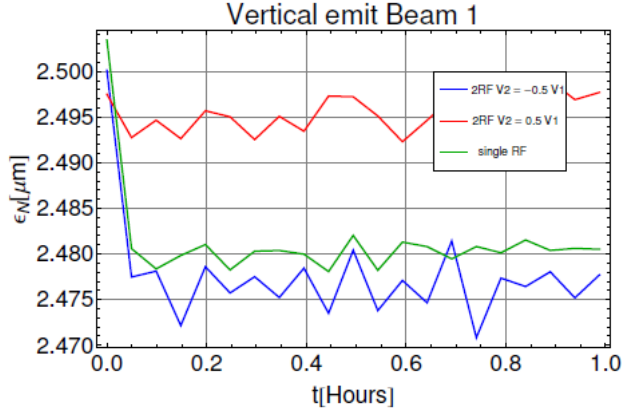
Backup slides

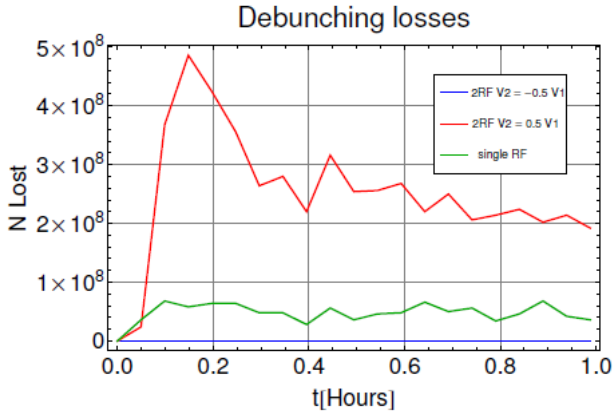
Evolution of intensity, bunch lengths, debunching and luminosity.



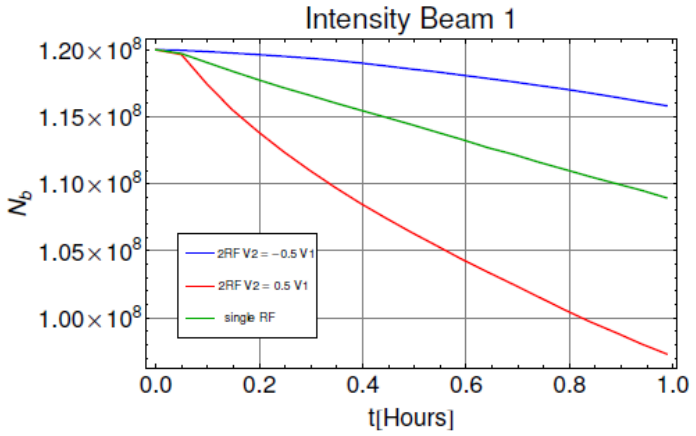


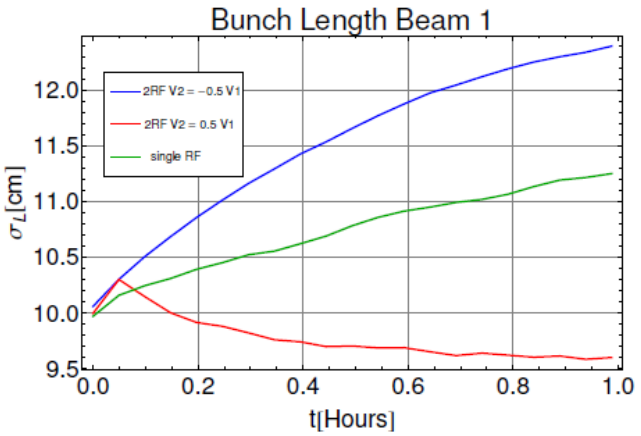


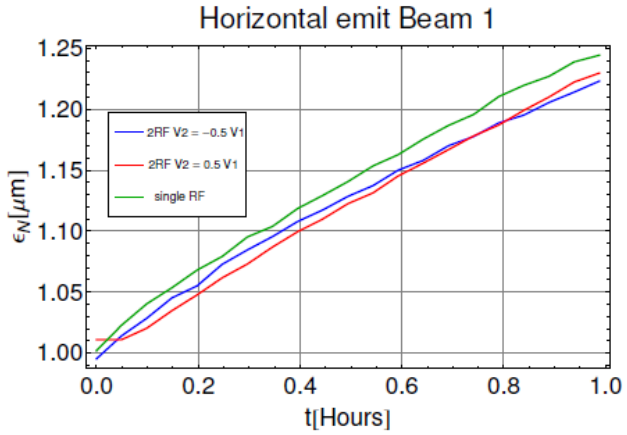


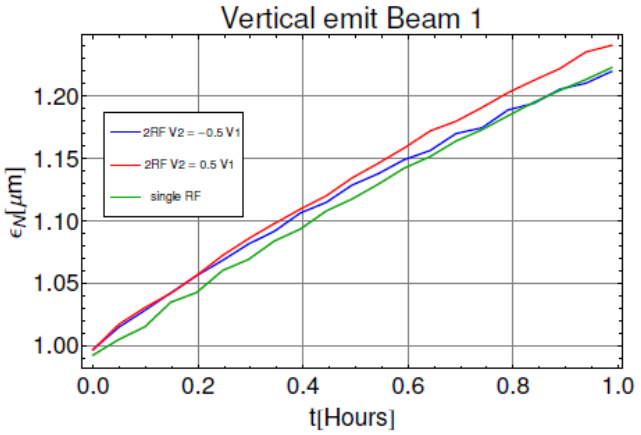


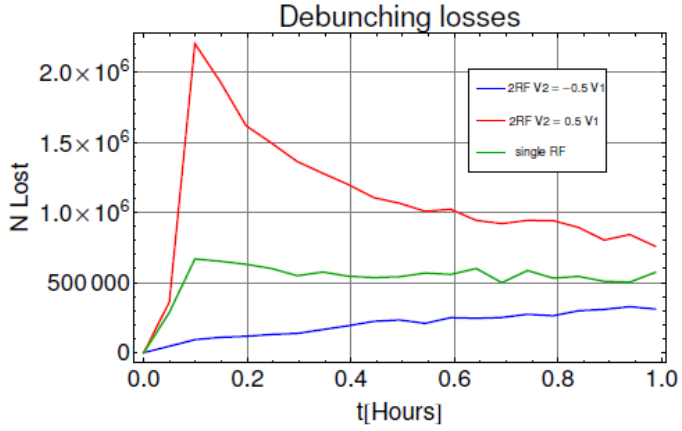
Protons at 450 GeV





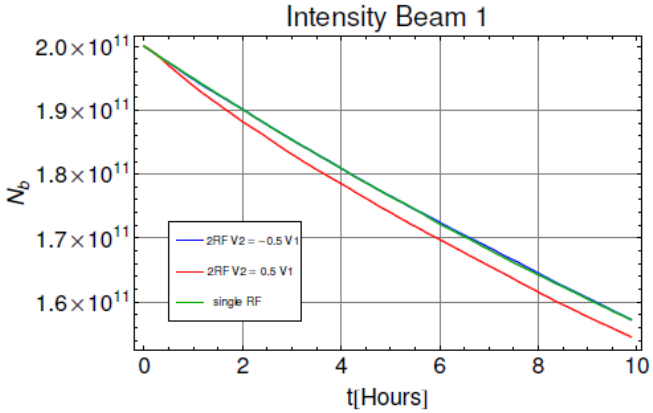


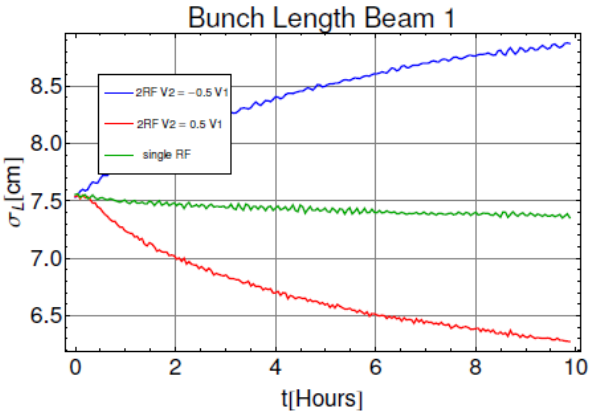


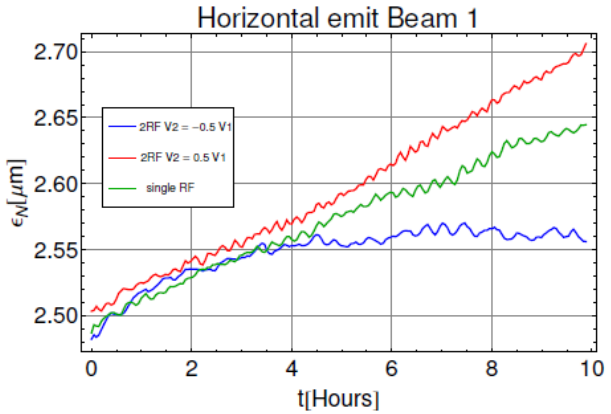


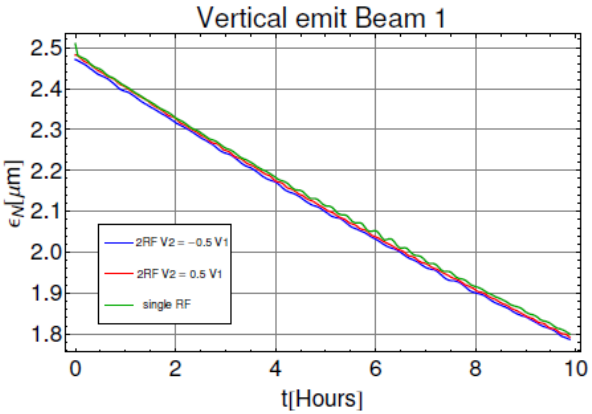
Ions at 450 Z GeV

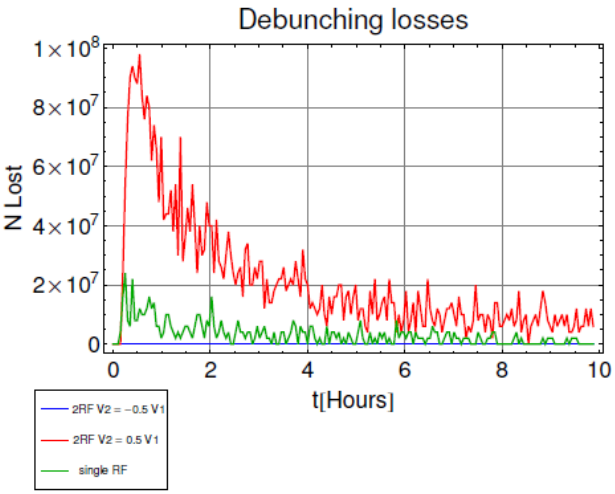
Protons at 7 TeV

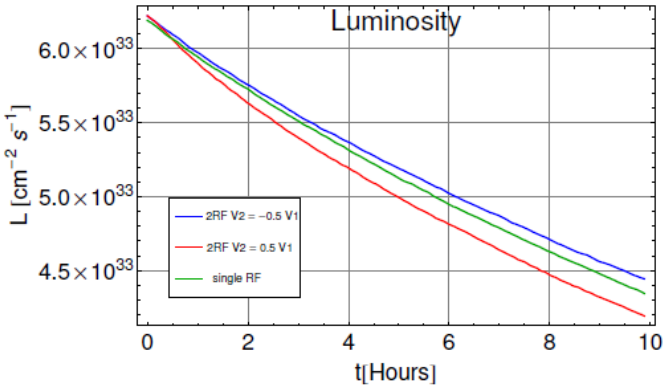


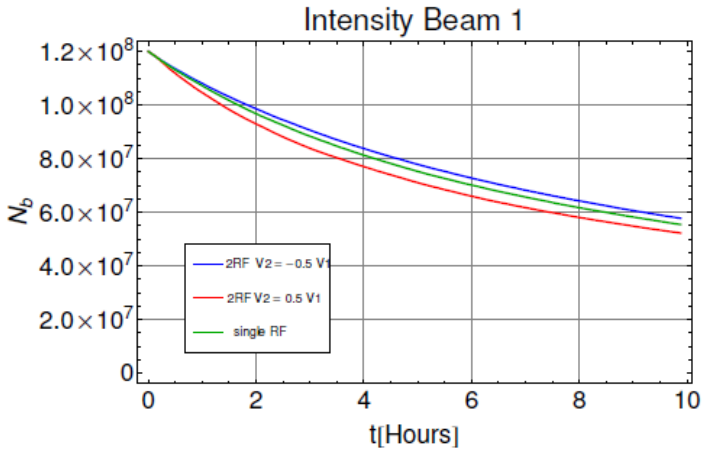


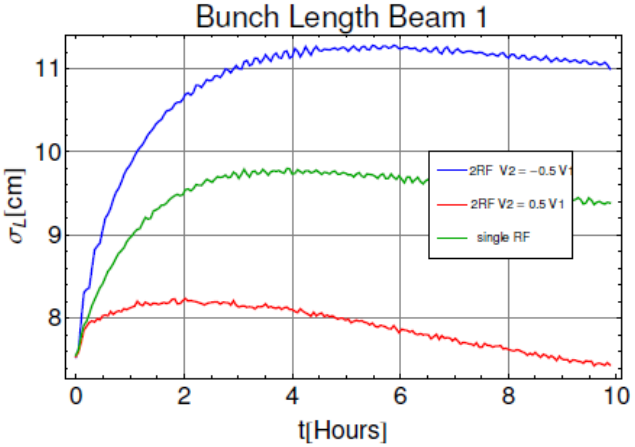












Ions at 7 Z TeV