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Memo

DATE: *March 9, 2007*

TO: RHIC E-Coolers

FROM: *Ady Hershcovitch*

SUBJECT: **Minutes of the March 9, 2007 Meeting**

Present: Ilan Ben-Zvi, Rama Calaga, Xiangyun Chang, Alexei Fedotov, Wolfram Fischer, Harald Hahn, Lee Hammons, Ady Hershcovitch, Dmitry Kayran, Jorg Kewisch, Derek Lowenstein, William Mackay, Thomas Roser, Gang Wang.

Topic discussed: Simulations and Computations, Diamond Cathode

Simulations and Computations: Most of the meeting consisted of a presentation by Jorg Kewisch (which can be found below) on preinjection simulation comparison among three codes: PARMELA, ASTRA, and ImpactT. The first two are 2D codes, while the later is a 3D code. Simulations were performed for both beer can and tear drop bunch shapes. Without taking space charge into consideration, there was good agreement among the codes. With space charge effects, PARMELA and ASTRA showed better agreement with each other than either with ImpactT. Jorg was able to trace the reason for the discrepancy to the way space charge, and hence electric field is computed by ImpactT. After making some adjustments agreement within 25% is reached. Since worst case is given by PARMELA, which nevertheless yields good results, our cooler concept is very promising.

Next, system optimization was described. For optimization Jorg used the CONDOR program, which was originally developed to optimize jet engine rotors. Jorg also develop his own optimizer, which communicated with PARMELA. Optimization objective is to reach a low emittance at the end of the LINAC. After performing numerous optimizations that entailed drift-space adjustments of up to ± 5 cm, a number of configurations, which meet the RHIC e-cooler requirements, are revealed. Those configurations can accelerate either 5 nC beer can shaped bunches of electrons (readily available technology), or 10 nC tear drop shaped electron bunches (requiring some laser R&D). Ilan pointed out that "it's good to have multiple choices." With the best laser distribution the emittance at the end of the linac was about 1 micron (normalized rms) for a charge of 5 nC.

Diamond Cathode: Ilan gave a brief report on success with the first photo-cathode diamond capsule. Student Jacob Grimes (SBU) has performed most of that work for his MS thesis. The capsule consists of a copper cathode that serves as a primary current emitter whose current is subsequently amplified by a low quality (for cost saving at this stage) diamond and accelerated by a mesh. A 20-microsecond pulse from a flash lamp is used to initiate primary

current emission. Current gain was observed, but it is low at this point (due to low diamond quality).

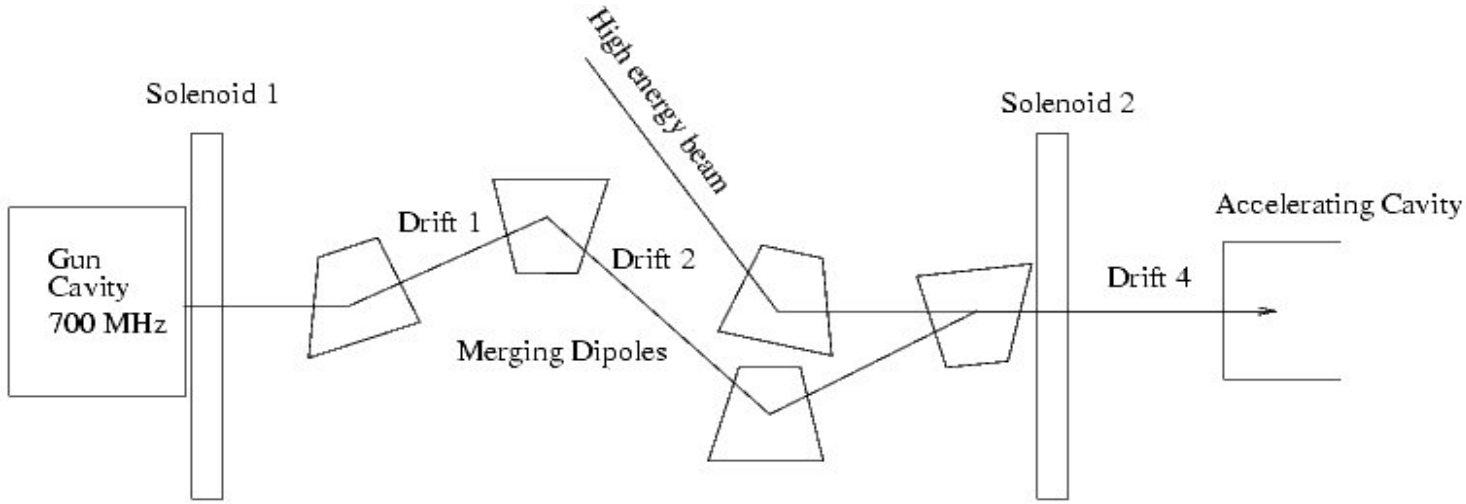
An important effect was observed: gain increased with increasing light intensity. This is due to light induced de-trapping of trapped electrons near the hydrogenated face of the diamond. This capsule represents yet another advance towards a complete diamond amplified photocathode.

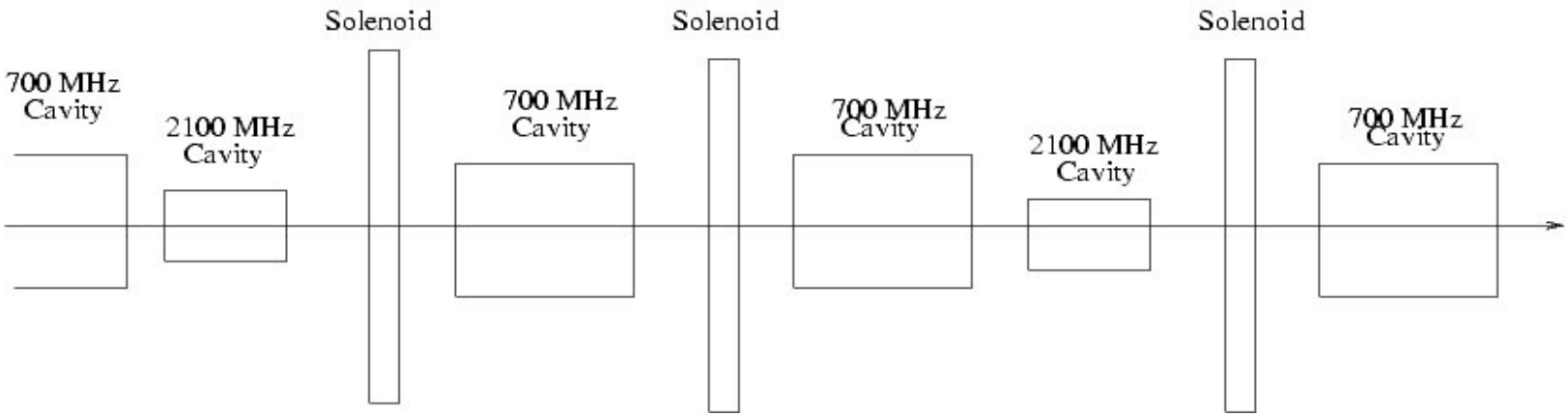
Code Comparison and Optimization of the RHIC Electron Cooler Injector

Jörg Kewisch

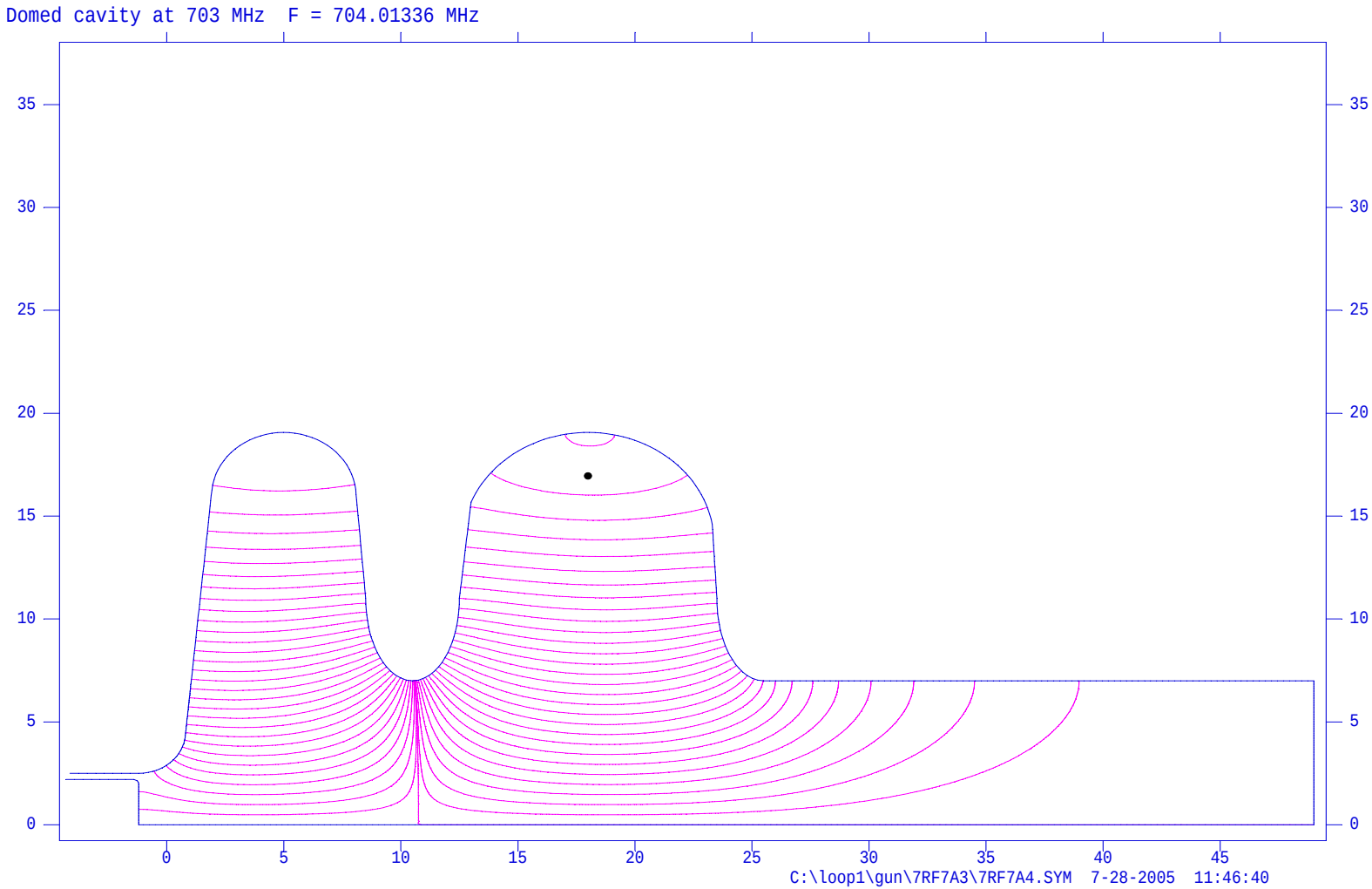
- Comparison
  - No space charge
  - Investigate integration parameters
  - With space charge
- Optimization strategy
- Results

Layout

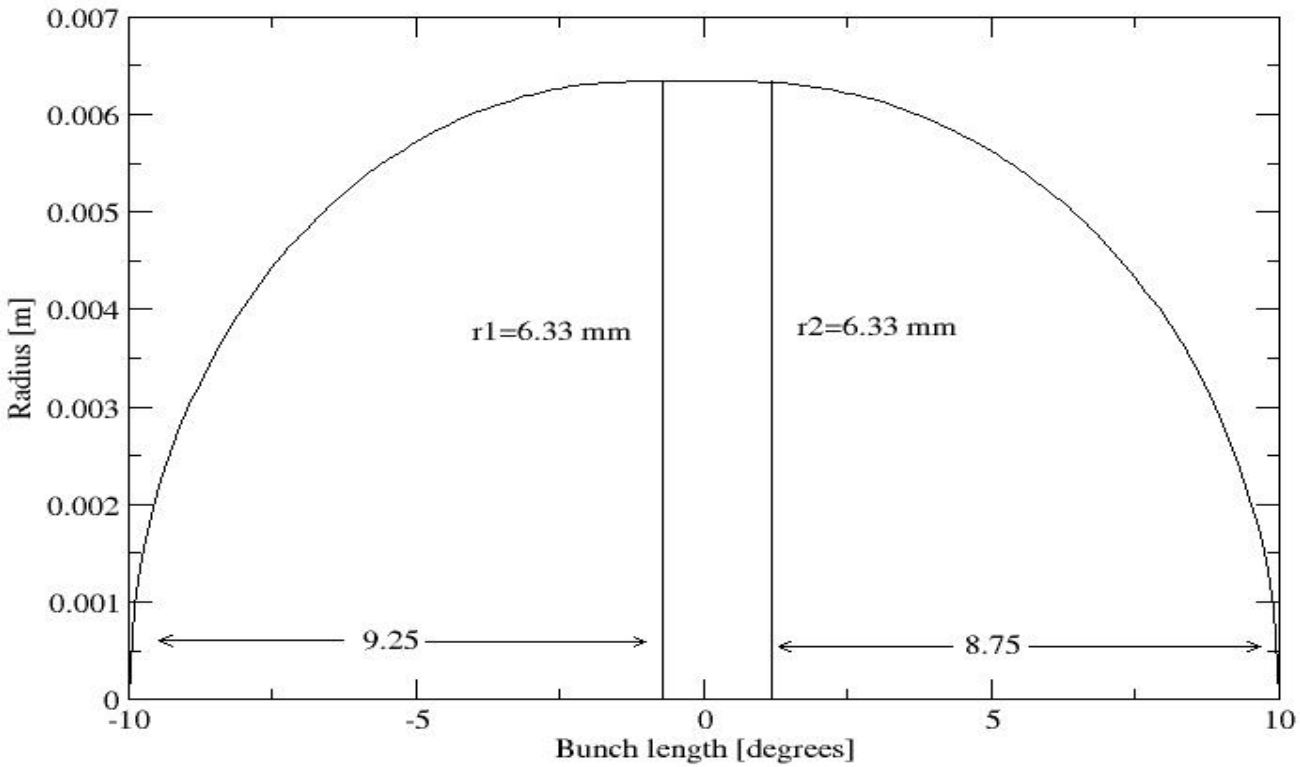

Solenoid 1
High energy beam
Solenoid 2
Accelerating Cavity
Drift 1
Drift 2
Drift 4
Gun
Cavity
700 MHz
Merging Dipoles


Solenoid
Solenoid
Solenoid
700 MHz
Cavity
2100 MHz
Cavity
700 MHz
Cavity
700 MHz
Cavity
2100 MHz
Cavity
700 MHz
Cavity

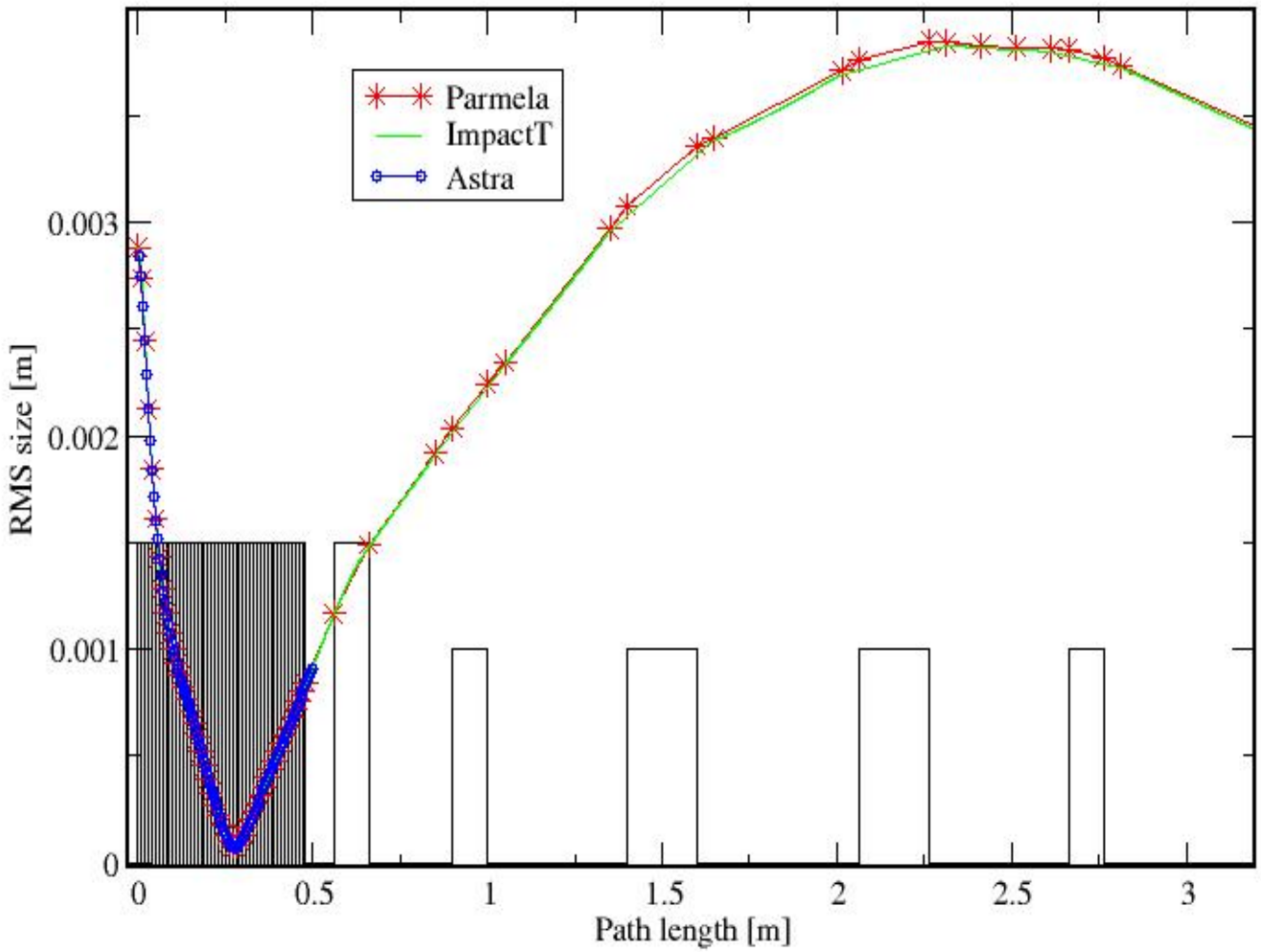
1½ cell gun


Domed cavity at 703 MHz F = 704.01336 MHz
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
C:\loop1\gun\7RF7A3\7RF7A4.SYM 7-28-2005 11:46:40

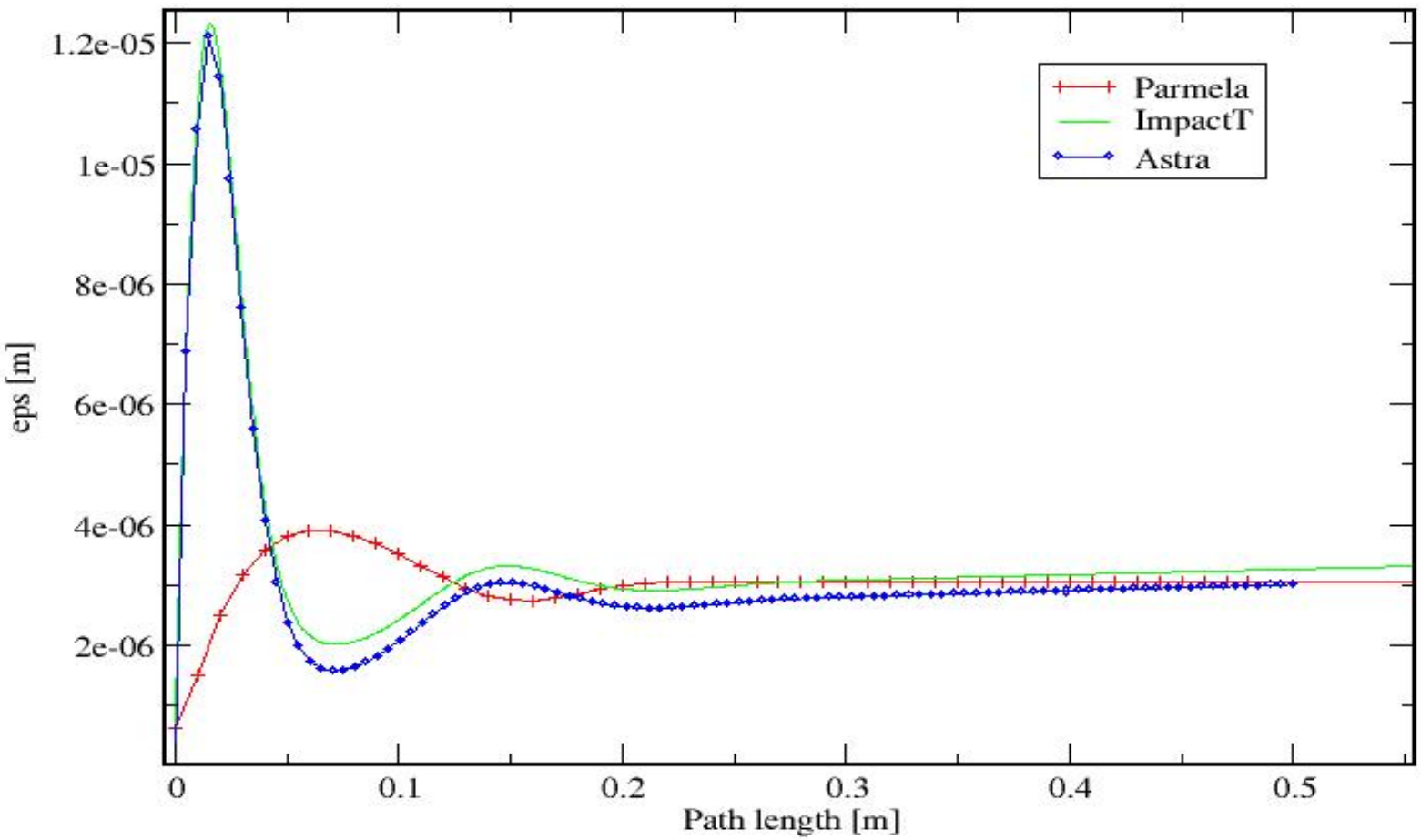
Bunch shape


0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Radius [m]
r1=6.33 mm
r2=6.33 mm
9.25
8.75
-10
-5
0
5
10
Bunch length [degrees]

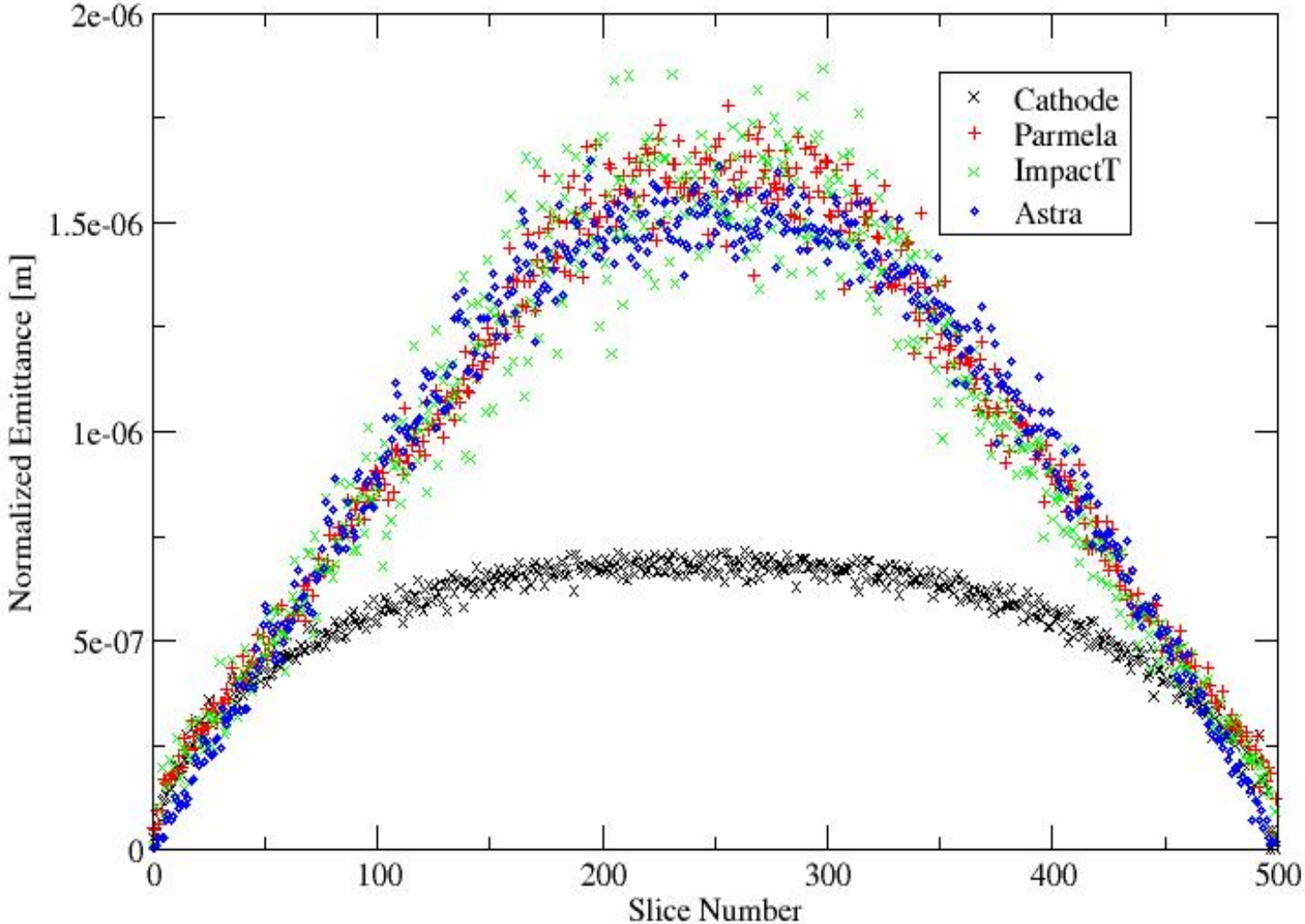
Without Space charge



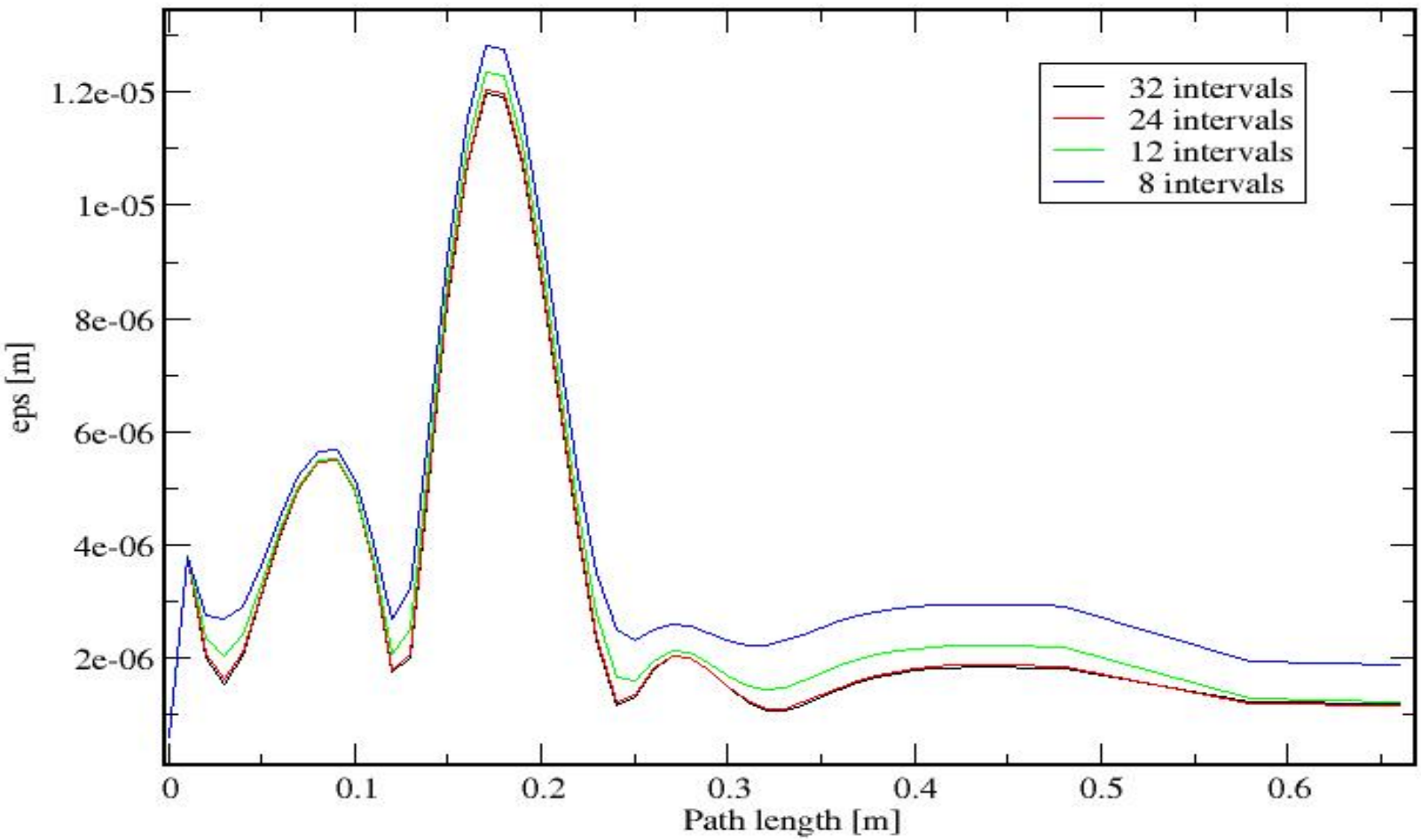
Without space charge



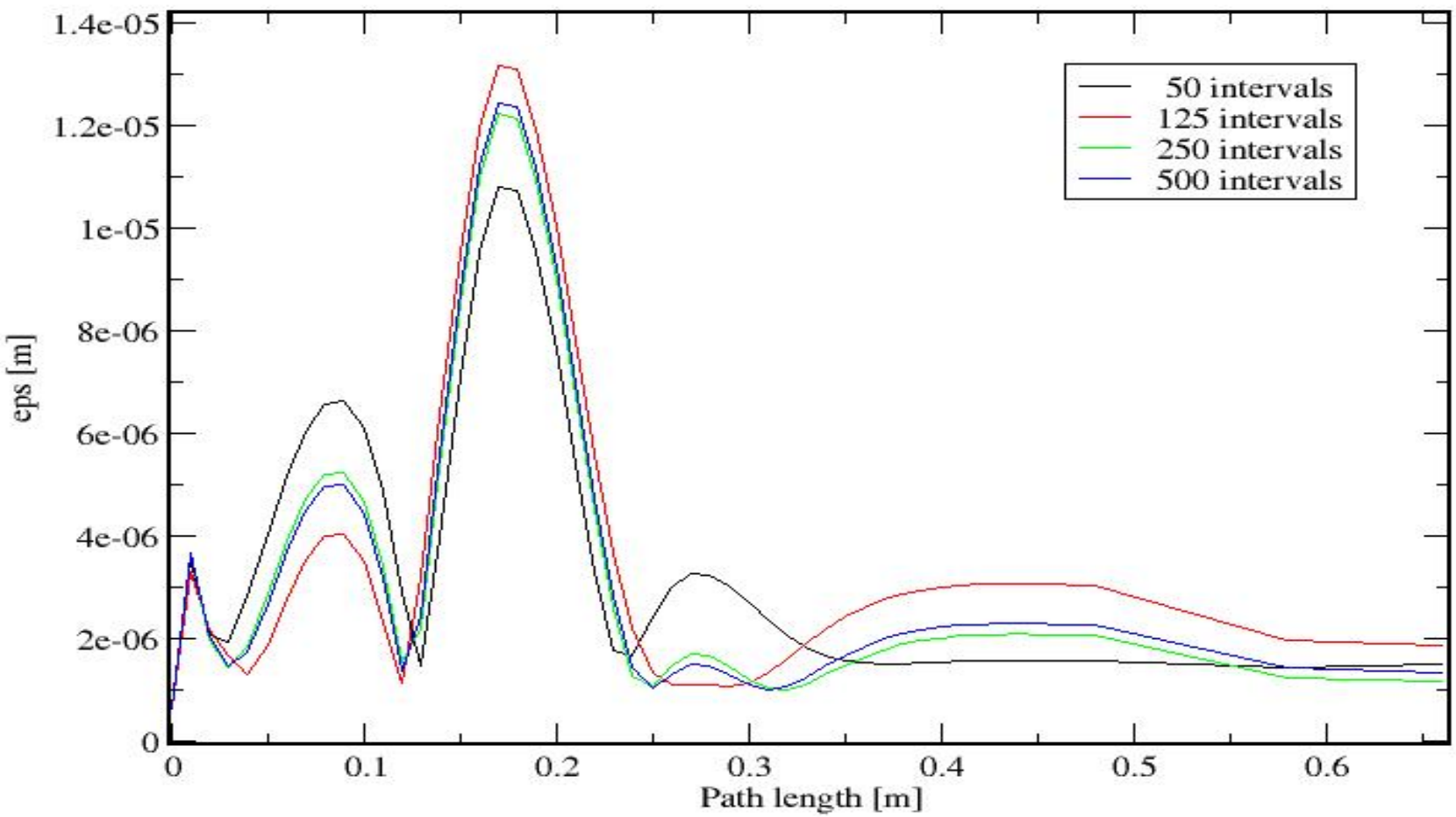
Without space charge



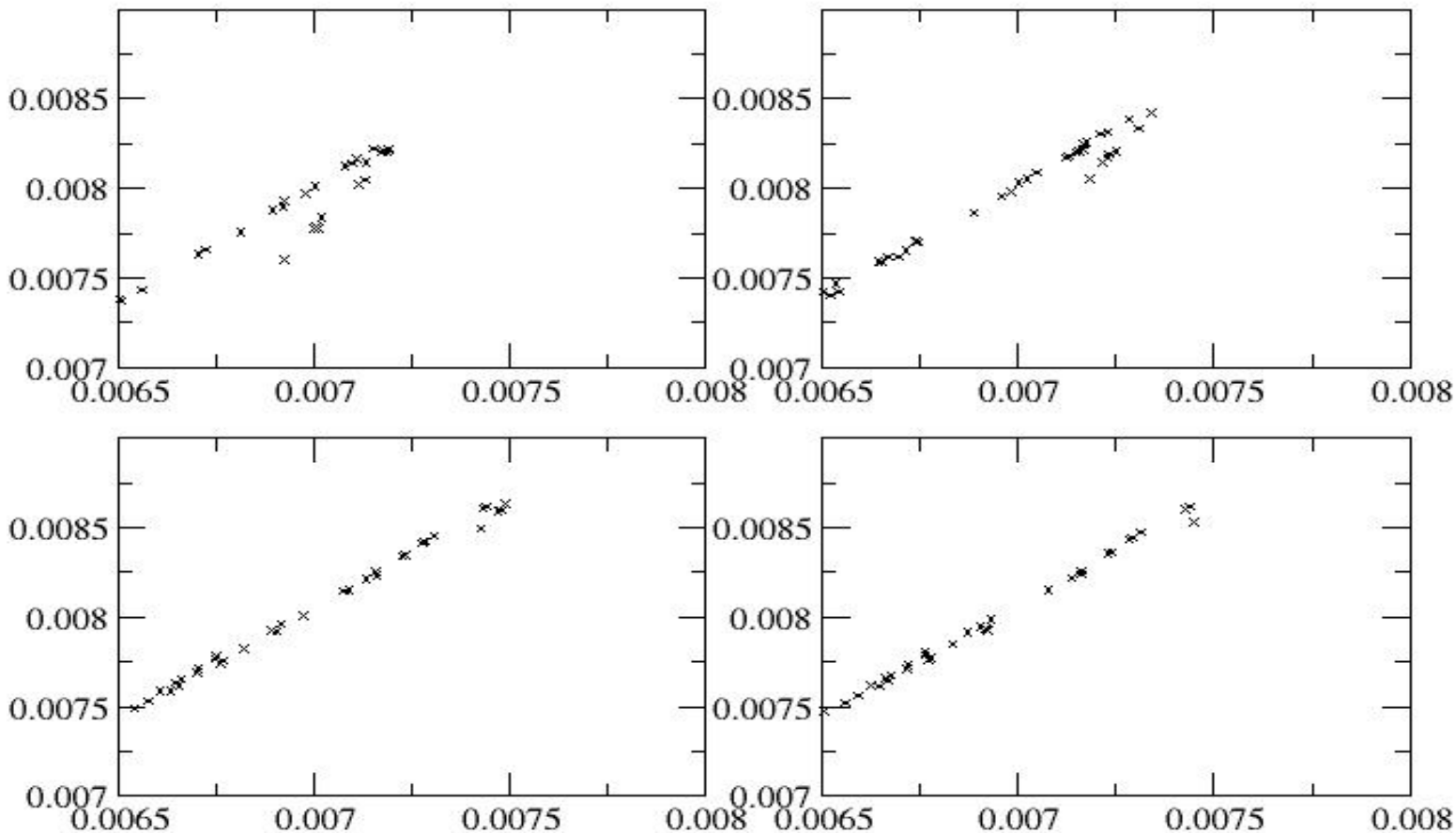
Number of transverse bins



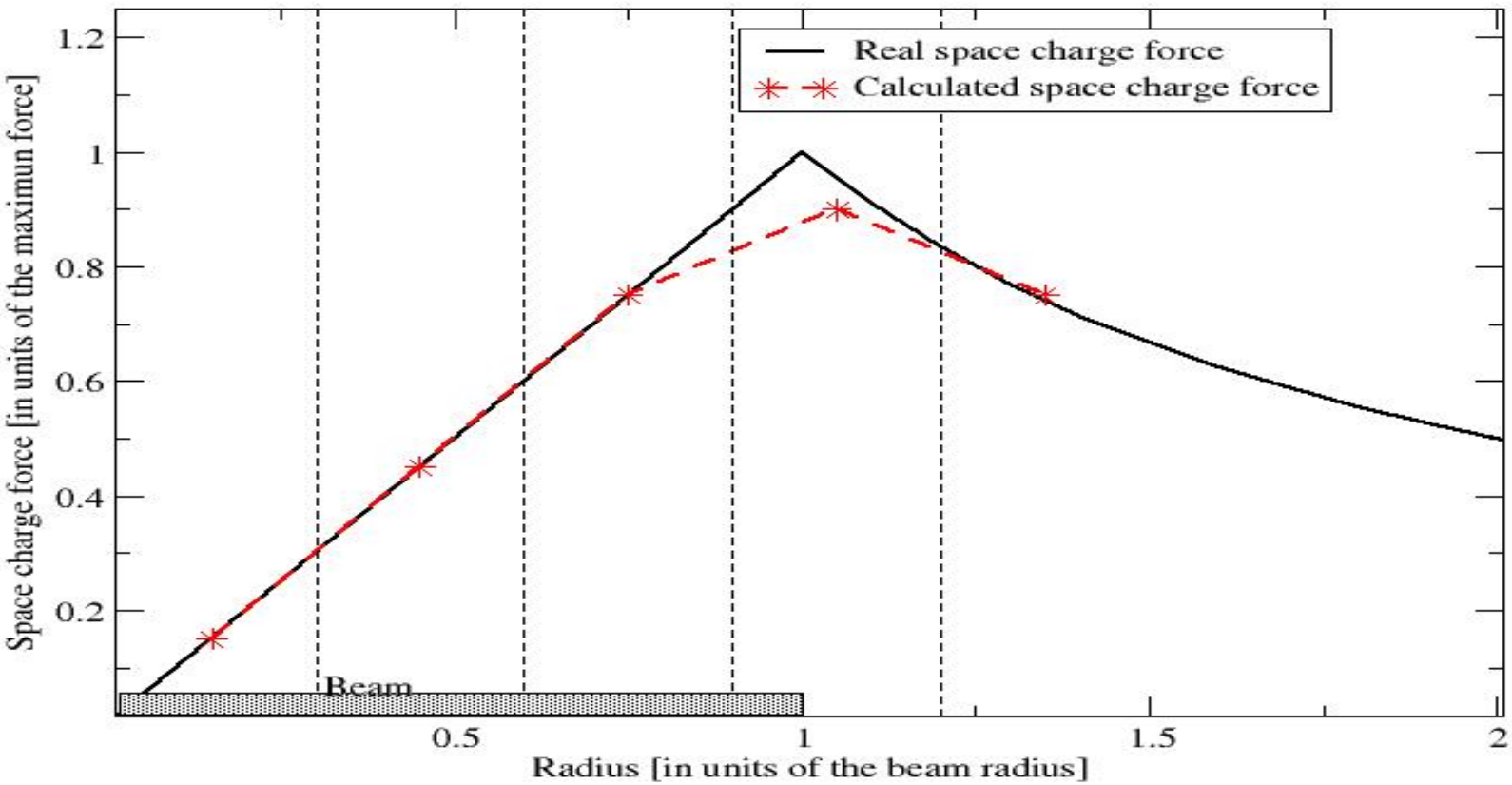
Number of longitudinal bins



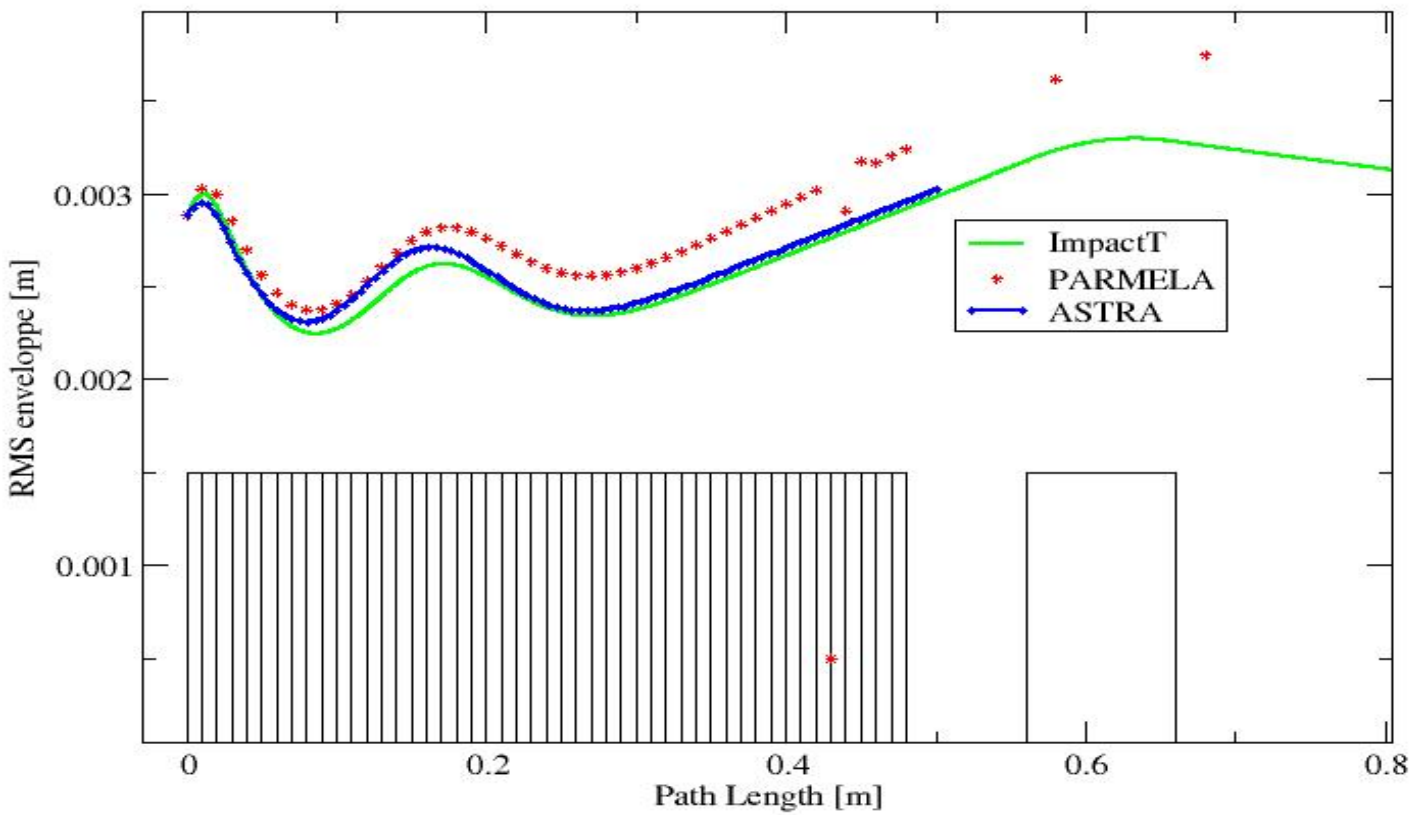
Number of transverse bins



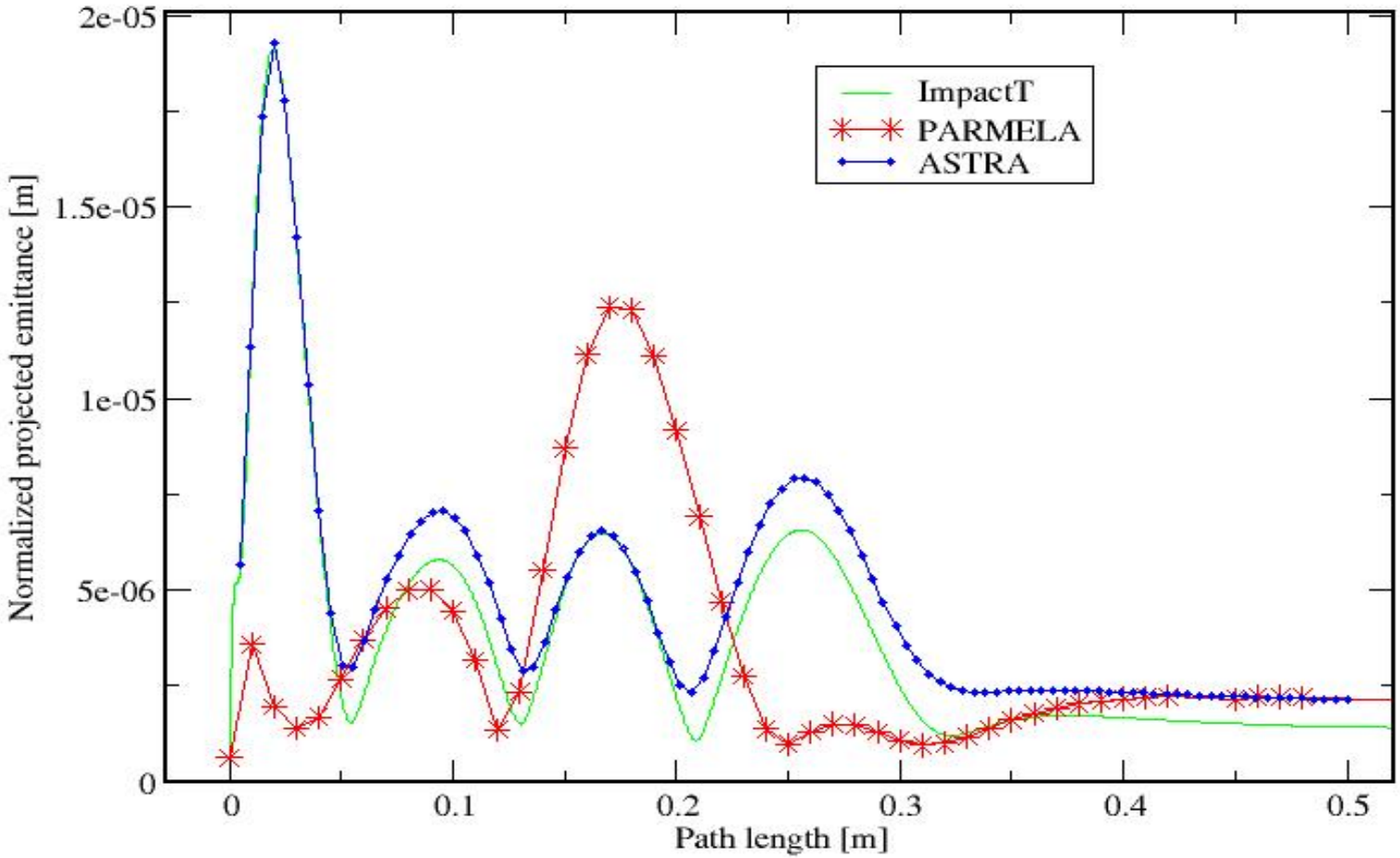
Effect of transverse bins



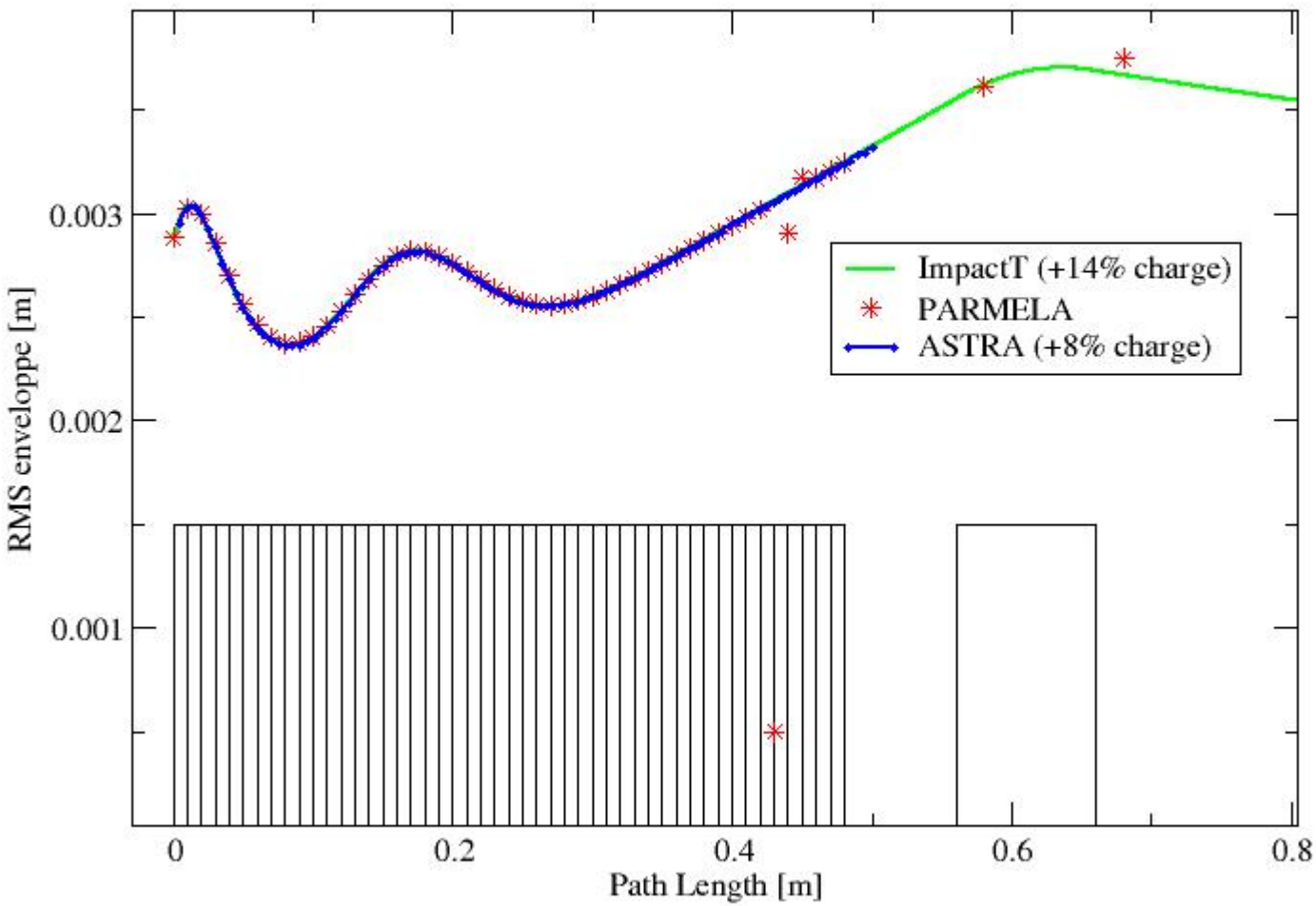
Enveloppe with space charge



Emittance with SC



Adjusted bunch charge

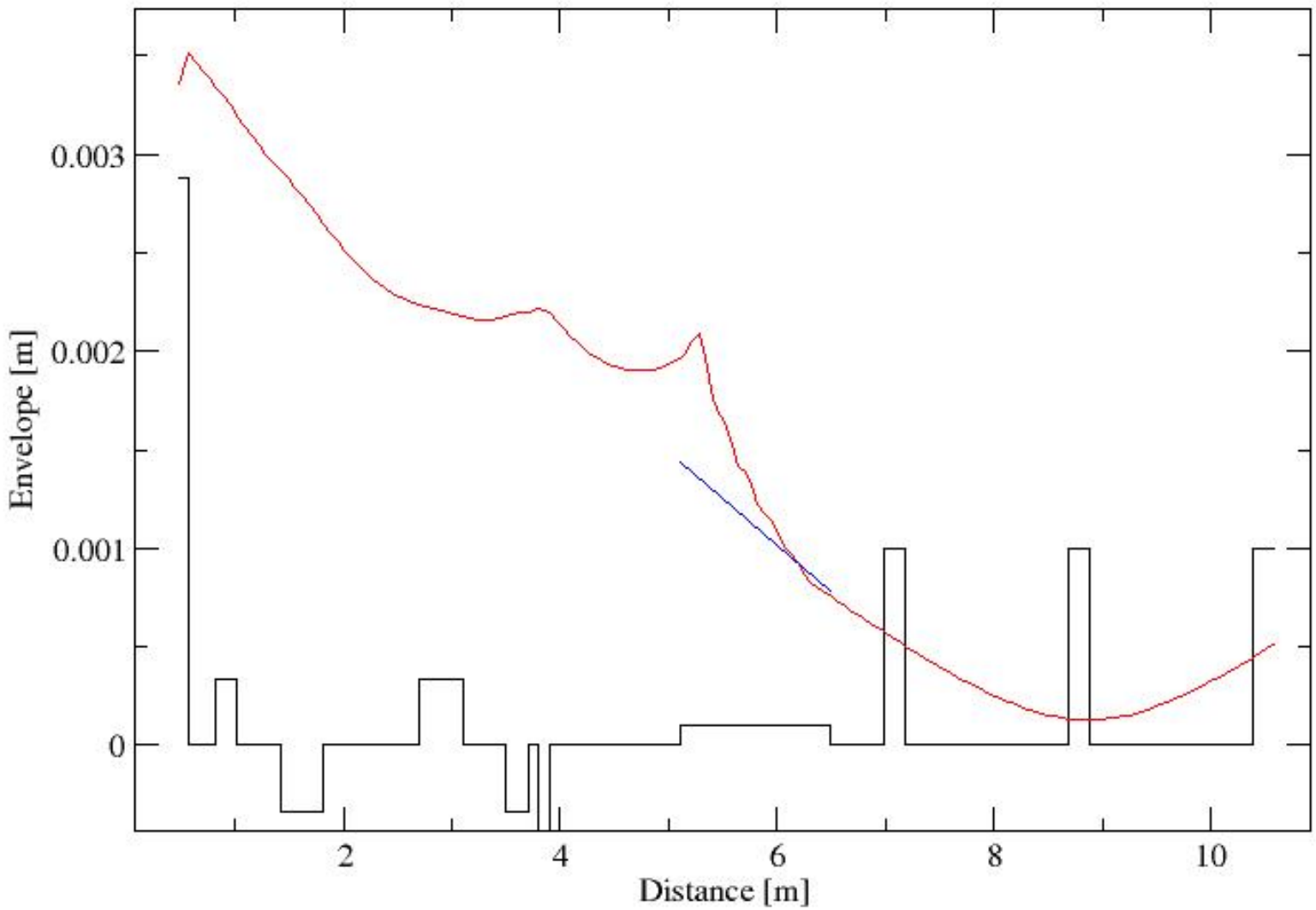


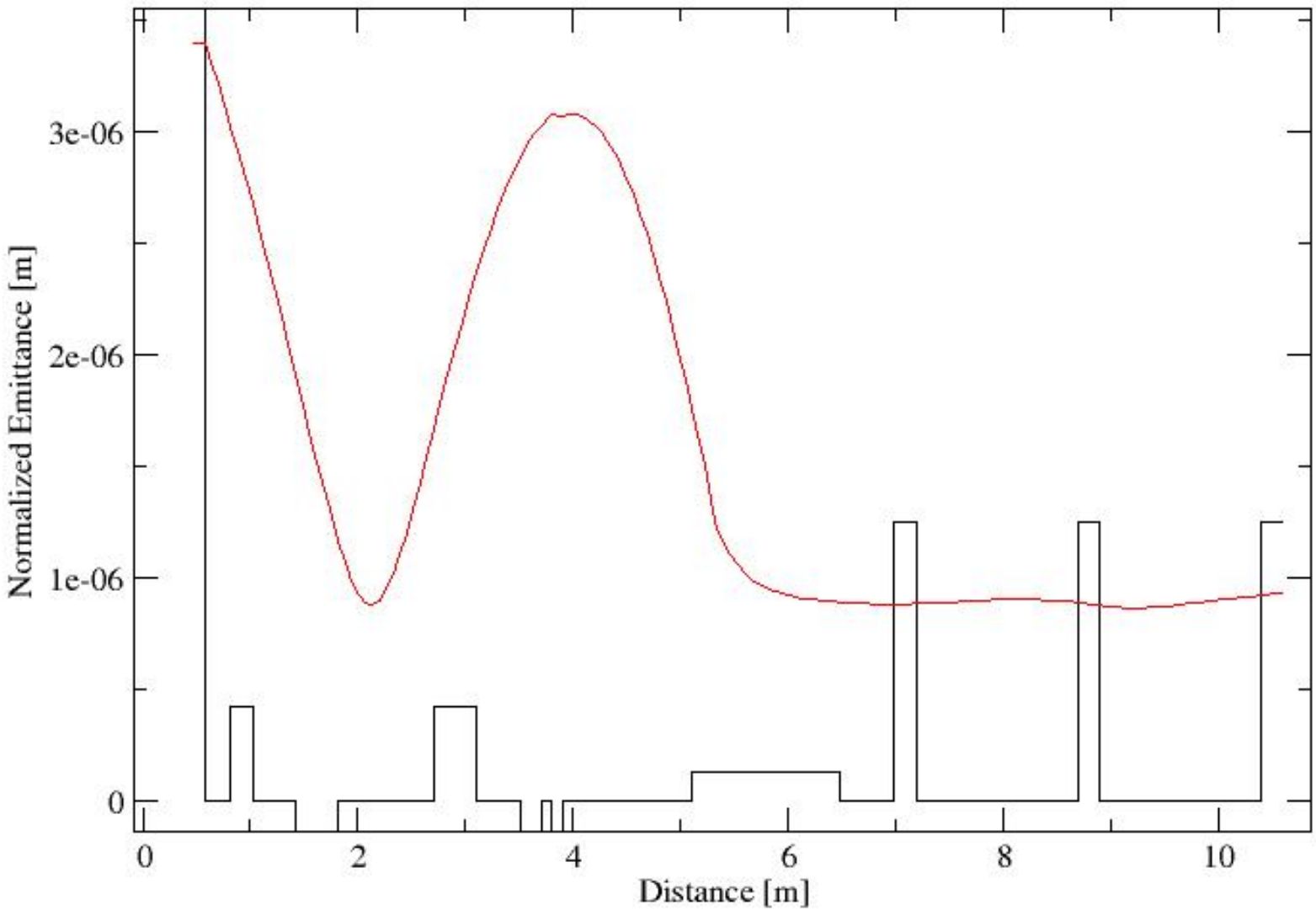
Optimization procedure

	Parameters	Figure of merrit
Gun	**Start Phase, radius, gun voltage**	**Slice emittance, energy spread**
Injector with SLENV	**2 Solenoids, drift**	
Gun and Injector	**Radius, 2 Solenoids, drift, 2 merger drifts**	**Emittance (x,y)**
Linac	**Cavity phases**	**Energy spread**
Injector and linac	**2 Solenoids, drift**	**Emittnace**

SLENV

- Calculate with Parmela to the exit of the gun
- Cut bunch into 500 slices
- Calculate radius, slope, energy, emittance and angular momentum for each slice
- Smooth data and select 9 slices
- Optimize (1 second per step):
  - Track slice envelopes (Runge-Kutta)
  - Calculate projected emittance


0.003
0.002
0.001
0
Envelope [m]
2
4
6
8
10
Distance [m]


Normalized Emittance [m]
3e-06
2e-06
1e-06
0
0
2
4
6
8
10
Distance [m]

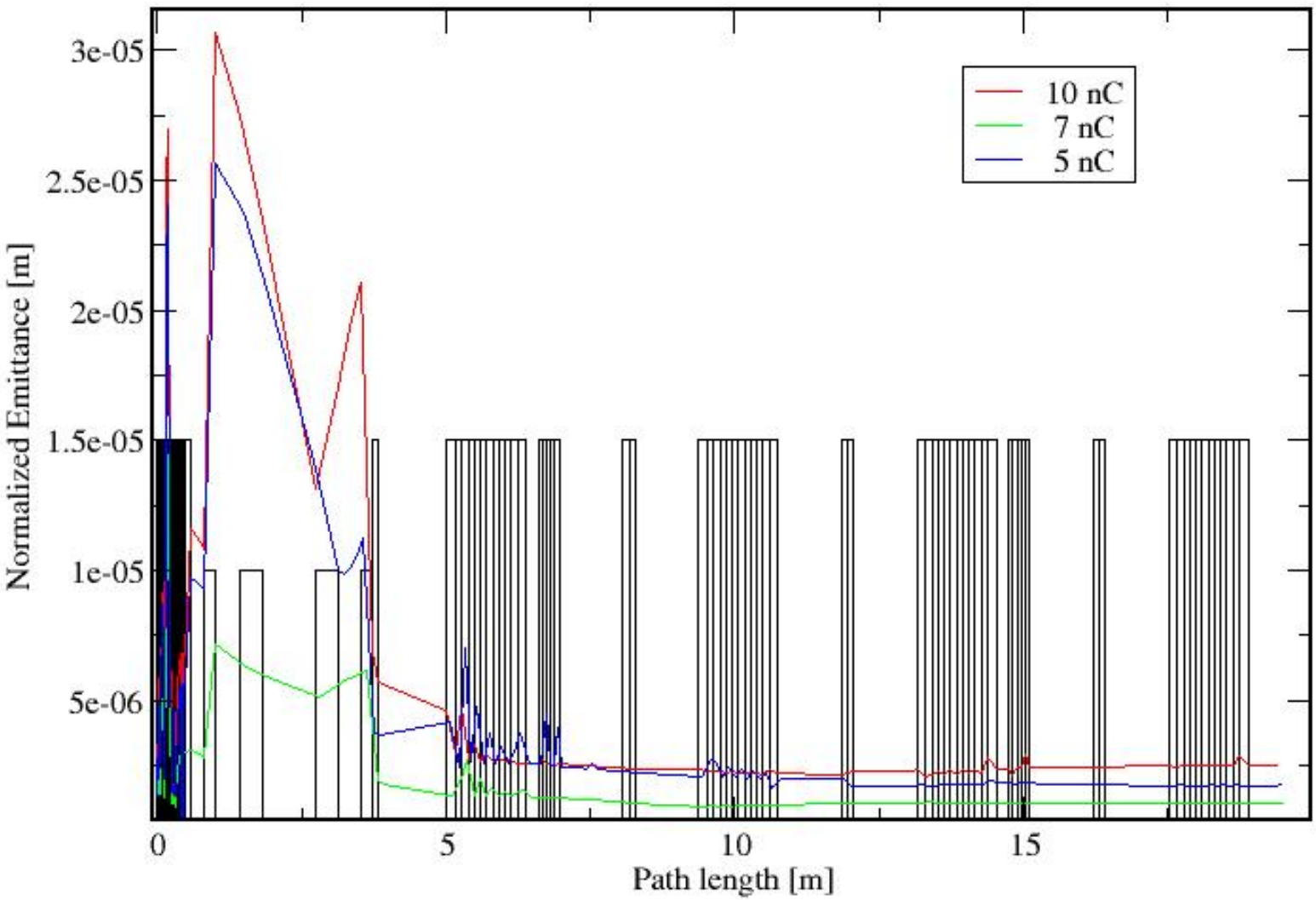
Results

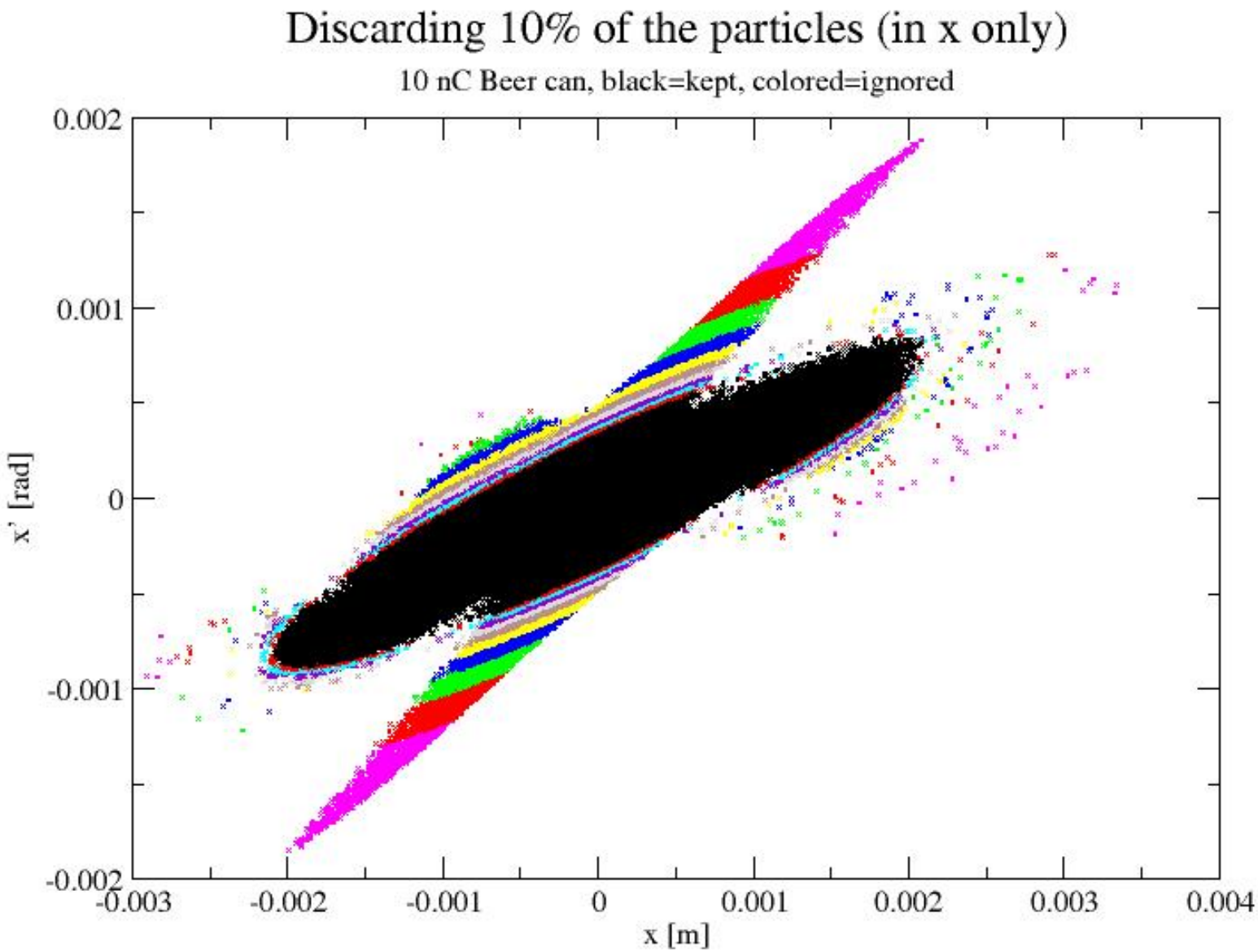
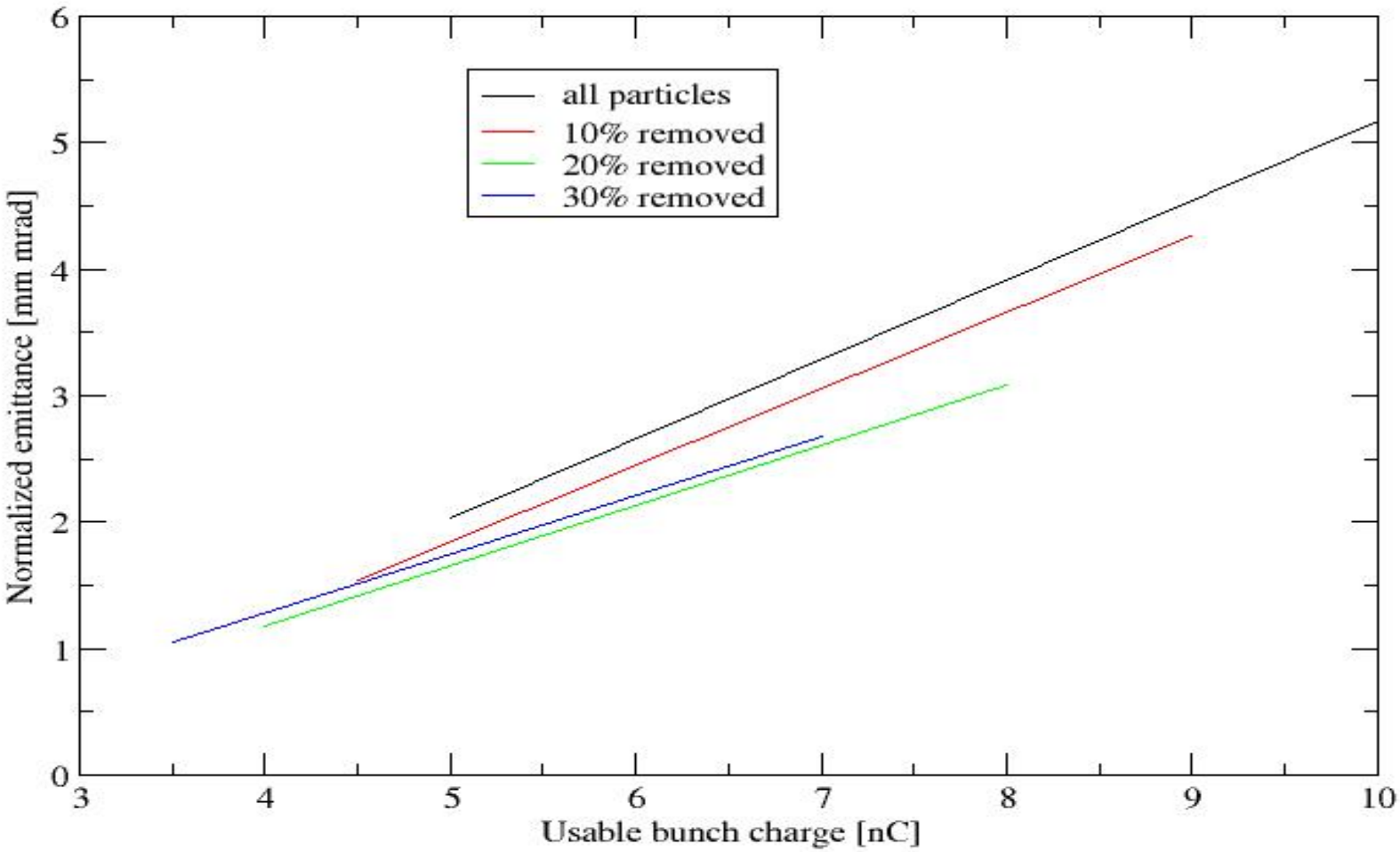
Bunch shape	Bunch charge	Emittance horizontal	Emittance vertical	Energy Spread
Beer Can	5 nC	1.99 μ	2.07 μ	3.04e-4
	7 nC	3.45 μ	3.96 μ	3.11e-4
	10 nC	5.07 μ	5.14 μ	3.07e-4
Tear Drop	5 nC	1.03 μ	1.00 μ	2.48e-4
	7 nC	1.62 μ	1.73 μ	2.55e-4
	10 nC	2.29 μ	2.75 μ	2.72e-4

Old Results

Bunch shape	Transverse Temperature	Bunch charge	Emittance	Thermal Emittance	Energy Spread
Beer Can	0.1 eV	3 nC			
		5 nC	2.99 μ	0.50 μ	3.04e-4
		7 nC			
		10 nC			
	0.3 eV	5 nC	3.24 μ	1.24 μ	2.96e-04
		7 nC	4.04 μ	1.53 μ	2.51e-04
		10 nC	4.68 μ	1.83 μ	2.55e-04
Tear Drop	0.1 eV	3 nC	1.27 μ	0.45 μ	0.61e-04
		5 nC	1.50 μ	0.62 μ	1.48e-04
		7 nC	1.85 μ	0.71 μ	
		10 nC	2.31 μ	0.79 μ	
	0.3 eV	3 nC	1.48 μ	1.17 μ	0.90e-04
		5 nC	2.15 μ	1.39 μ	2.10e-04
		7 nC	2.35 μ	1.65 μ	1.91e-04
		10 nC	3.25 μ	2.08 μ	3.00e-04

	Solenoid [kG]	D1 [cm]	D2 [cm]	D4 [cm]	Start phase	Gun Voltage factor	Beam radius [mm]
Beer Can							
0.1 eV, 5nC	**1.2750**	**10.11**	**3.616**	**54.67**	**24.96**	**12.50**	**4.58**
0.3 eV, 5nC	**1.2874**	**5.67**	**39.57**	**56.03**	**21.35**	**12.52**	**4.56**
7nC	**1.2849**	**6.68**	**39.60**	**54.98**	**21.58**	**12.48**	**5.03**
10nC	**1.2899**	**6.26**				**12.53**	**5.94**
Tear Drop							
0.1 eV, 3 nC	**1.3088**	**9.58**	**40.04**	**24.00**	**21.11**	**12.48**	**4.57**
5 nC	**1.2167**	**10.04**	**33.66**	**55.06**	**20.00**	**12.50**	**6.34**
7nC	**1.2262**	**13.58**	**27.55**	**49.29**	**19.73**	**12.52**	**7.26**
10nC	**1.2276**	**10.04**	**33.66**	**58.75**	**18.66**	**12.53**	**7.98**
0.3 eV, 3 nC	**1.2163**	**0.57**	**35.35**	**91.61**	**22.59**	**12.44**	**4.51**
5 nC	**1.2274**	**0.35**	**35.16**	**83.88**	**22.59**	**12.43**	**5.14**
7 nC	**1.2368**	**0.55**	**29.45**	**69.19**	**20.06**	**12.47**	**6.40**
10 nC	**1.2457**	**10.03**	**33.66**	**58.75**	**18.65**	**12.52**	**7.48**


10 nC
7 nC
5 nC
Normalized Emittance [m]
3e-05
2.5e-05
2e-05
1.5e-05
1e-05
5e-06
0
5
10
15
Path length [m]


Discarding 10% of the particles (in x only)
10 nC Beer can, black=kept, colored=ignored
0.002
0.001
0
-0.001
-0.002
x' [rad]
-0.003
-0.002
-0.001
0
0.001
0.002
0.003
0.004
x [m]

Removed Halo