Simulations with Gaussian 50MV/m Gun

Yauhen Kot

Summary for the S2E Meeting
25.11.2013

Meeting from 28.10.2013: Reduced Gun Simulations

Bunch Charge, [pC]	1nC	500pC	250pC	100pC
FT 2/20\2ps Gun MV/m vs Gun 50MV/m60	done	done	done	done
FT 2/20\ps Gun 60 MV/m vs Gauss 14ps Gun 50MV/m	done		done	done

Simulations were done for equal gradient in all cavities of the ACC1:

→ MaxE=34.42MV/m

Meeting 25.11.2013 added:

1. Gun Simulations for 50MV/m Gauss 10,12,14,16,18,20ps FWHM
   (nominal equal gradient in ACC1 cavities)

2. Scan of the peak booster field for Gun 50MV/m, Gauss 14ps FWHM

3. Nominal booster peak field of 34.42MV/m compared to 26.92MV/m and 21.92MV/m
   (evaluated for Gun 50MV/m, Gauss 14ps)

4. Gun 50MV/m:
   Gauss 14ps compared with 10ps and 20ps for optimized booster settings

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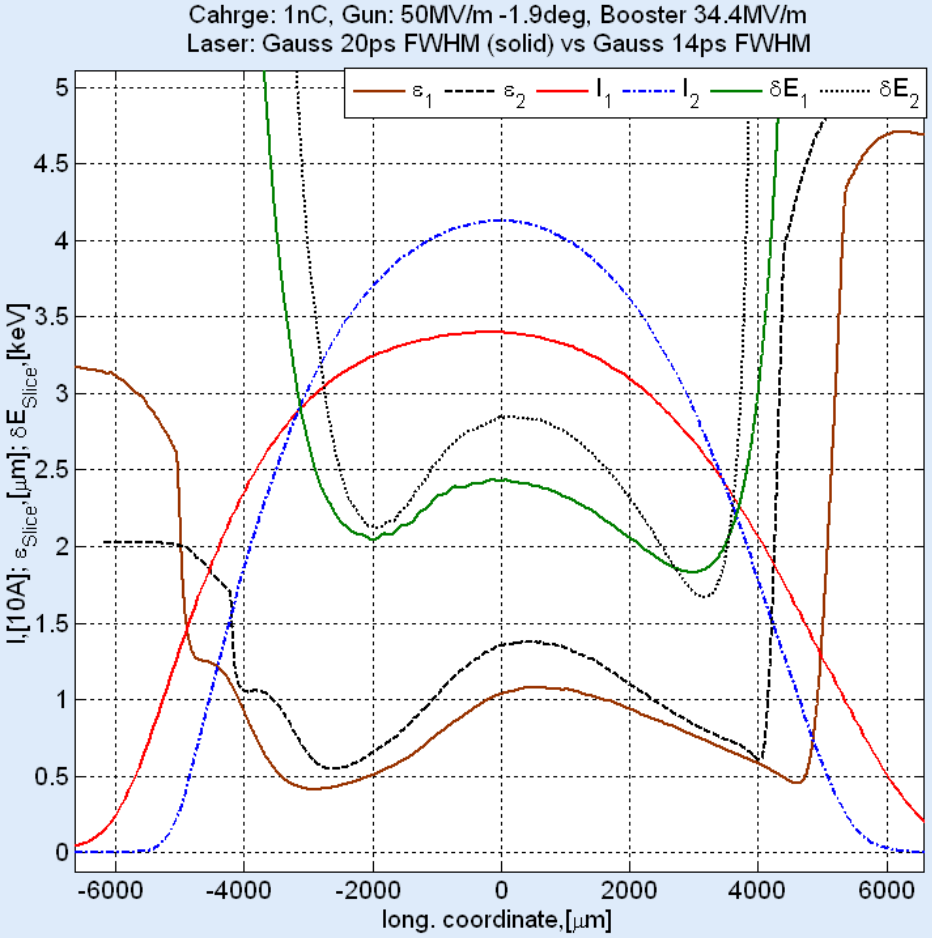
   Gauss 14ps compared with 10ps and 20ps for optimized booster settings

Sensitivity with Respect to the Laser Pulse Length

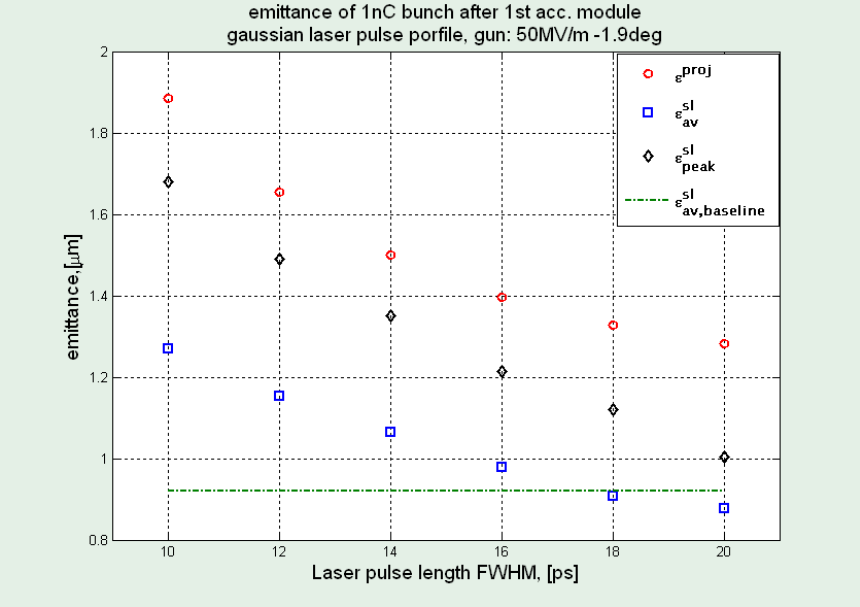


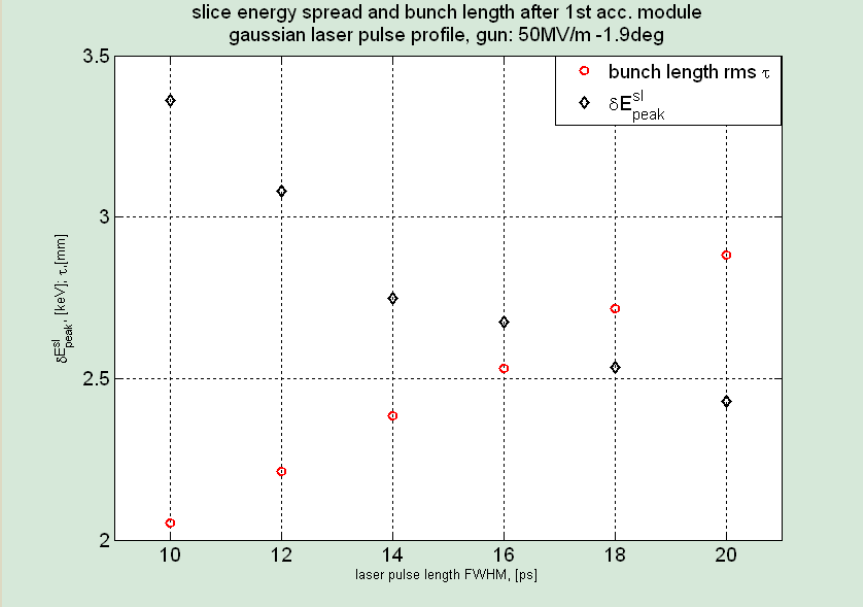
Extend laser pulse length from 14ps FWHM (nominal) to 20ps

- → -14.4% projected emittance growth
- → -25.7% growth of emittance at the current peak
- → -17.5% average slice emittance growth

Charge		**1nC**	
Gun peak electric field and phase		50MV/m, -1.9deg	
Laser form		Gauss 14ps FWHM	Gauss 20ps FWHM
Booster gradient		34.4 MV/m	
WP	MaxB,[T]	0.1889	0.1886
	XYrms,[mm]	0.460	0.410
$\varepsilon^{pr}_{s=14.44m}$, [mrad]		1.501	1.284
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]		1.352	1.005
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]		1.064	0.878
$\varepsilon^{sl,min}_{s=14.44m}$, [mrad]		0.546	0.413
$\varepsilon^{sl,max}_{s=14.44m}$, [mrad]		1.380	1.081
$\delta E^{sl,peak}$,rms [keV]		2.75	2.43
Ip, [A]		41.3	33.99
τ rms, [mm]		2.384	2.884
Beam optical functions after 1st accelerating module	β,[m]	19.64	20.17
	α	-2.419	-2.354
E_{ACC1},[MeV]		153.3	153.3

Scan vs Laser Pulse Length for a Gaussian Pulse and Gun Peak Field of 50MV/m (equal peak field of 34.42MV/m in all ACC1 cavities assumed)





→ *The goal of 0.920mm mrad could be hold only for long pulses*

Summary of the Scan of the Laser Pulse Length

Table: bunch parameters for different length of gaussian laser profile and Gun50								
FWHM, [ps]		10	12	14	16	18	20	Baseline
WP	MaxB,[T]	0.1891	0.1890	0.1889	0.1888	0.1887	0.1886	
	XY,[mm]	0.505	0.483	0.460	0.444	0.425	0.410	
ε^{proj},[μm]		1.887	1.656	1.501	1.398	1.328	1.284	
$\varepsilon^{sl,peak}$,[μm]		1.681	1.491	1.352	1.215	1.120	1.005	
$\varepsilon^{sl,av}$,[μm]		1.271	1.154	1.064	0.978	0.907	0.878	0.920
$\delta E^{sl,peak}$[keV]		3.360	3.081	2.750	2.676	2.534	2.430	450-2000
I_p,[A]		48.0	44.5	41.3	38.8	36.1	34.0	
τ_{rms},[mm]		2.054	2.213	2.384	2.530	2.716	2.884	0.076
Optics at s=14.44m	β,[m]	20.49	20.09	19.64	20.32	19.93	20.17	
	α	-2.535	-2.500	-2.419	-2.492	-2.376	-2.354	

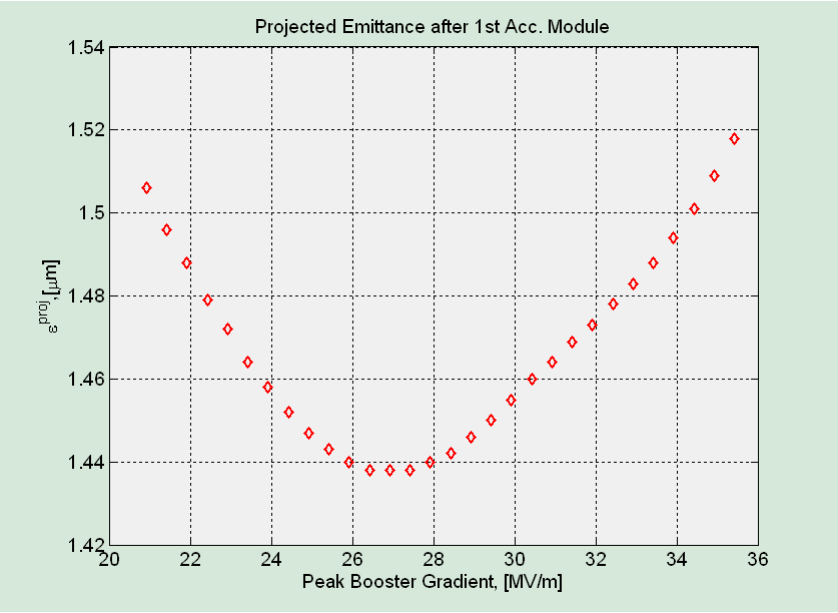
1. Gun Simulations for 50MV/m Gauss 10,12,14,16,18,20ps FWHM
   (nominal equal gradient in ACC1 cavities)

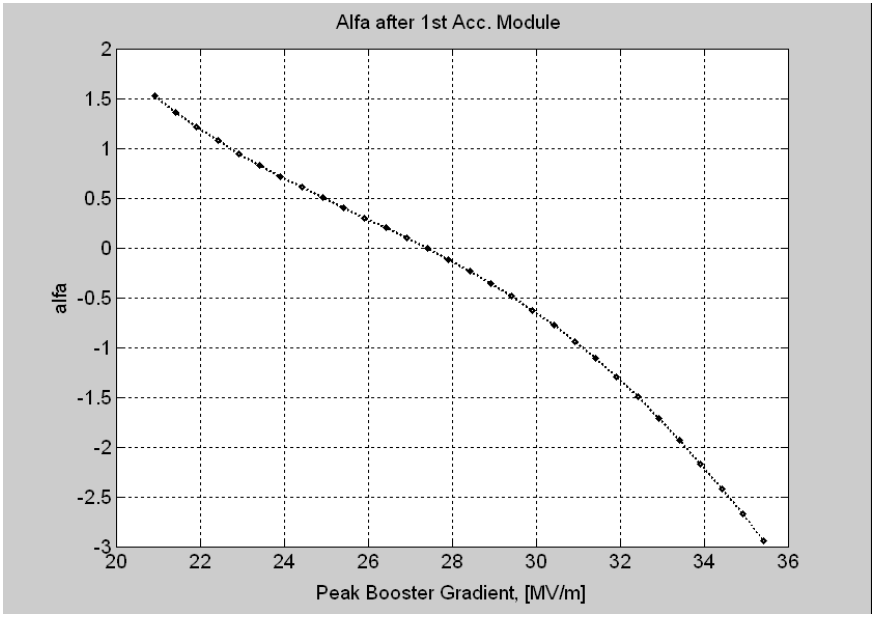
2. Scan of the peak booster field for Gun 50MV/m, Gauss 14ps FWHM

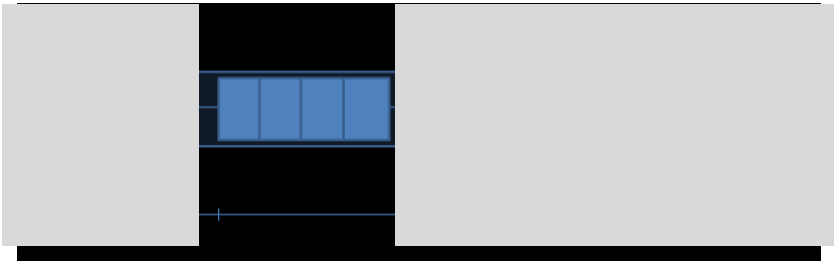
3. Nominal booster peak field of 34.42MV/m compared to 26.92MV/m and 21.92MV/m
   (evaluated for Gun 50MV/m, Gauss 14ps)

4. Gun 50MV/m:
   Gauss 14ps compared with 10ps and 20ps for optimized booster settings

Scan vs Booster Gradient. Gaussian Laser Profile, Gun=50MV/m, -1.9deg

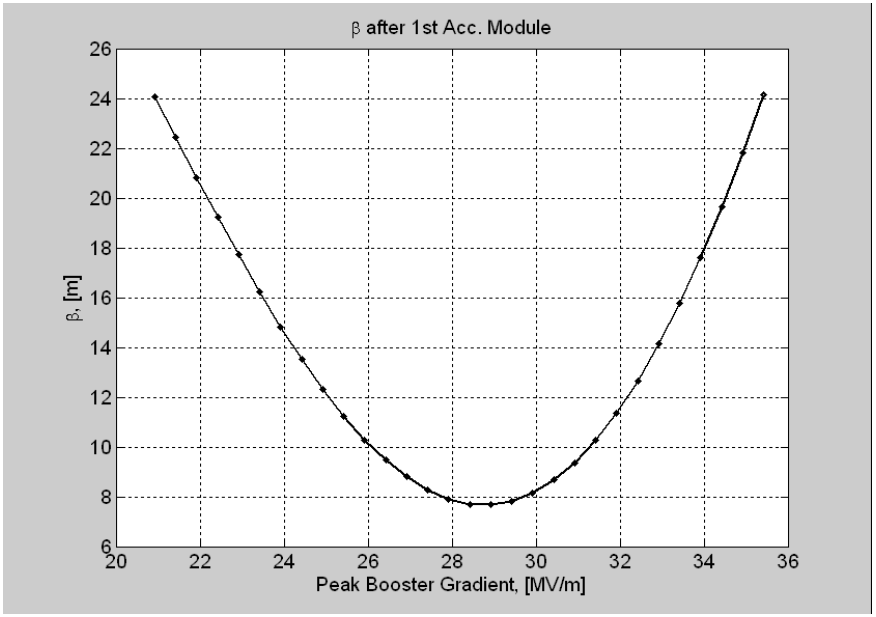




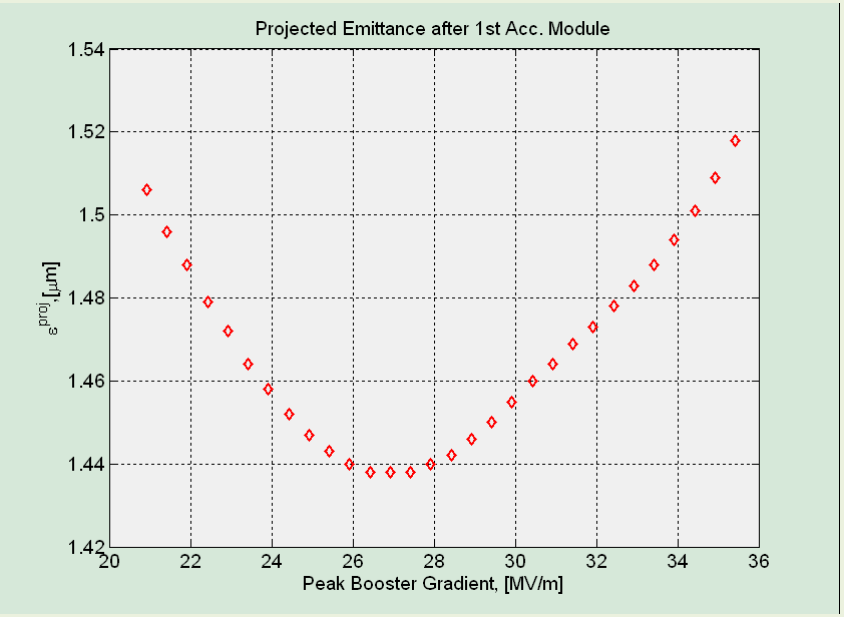


Booster: first 4 cavities of ACC1

Scan: over the peak booster gradient but keeping the energy after ACC1 constant by means of the cavities 5-8 of ACC1



Scan vs Booster Gradient. Gaussian Laser Profile, Gun=50MV/m, -1.9deg



Emittance minimum found for MaxE(2)=26.92MV/m
leading to ε_{pr}=1.438

That is an improvement of 4.38% compared to ε_{pr}=1.501
at the WP of MaxE(2)=34.42MV/m

Possible margins due to additional adjust of the working point (MaxB, XYrms) were not included!

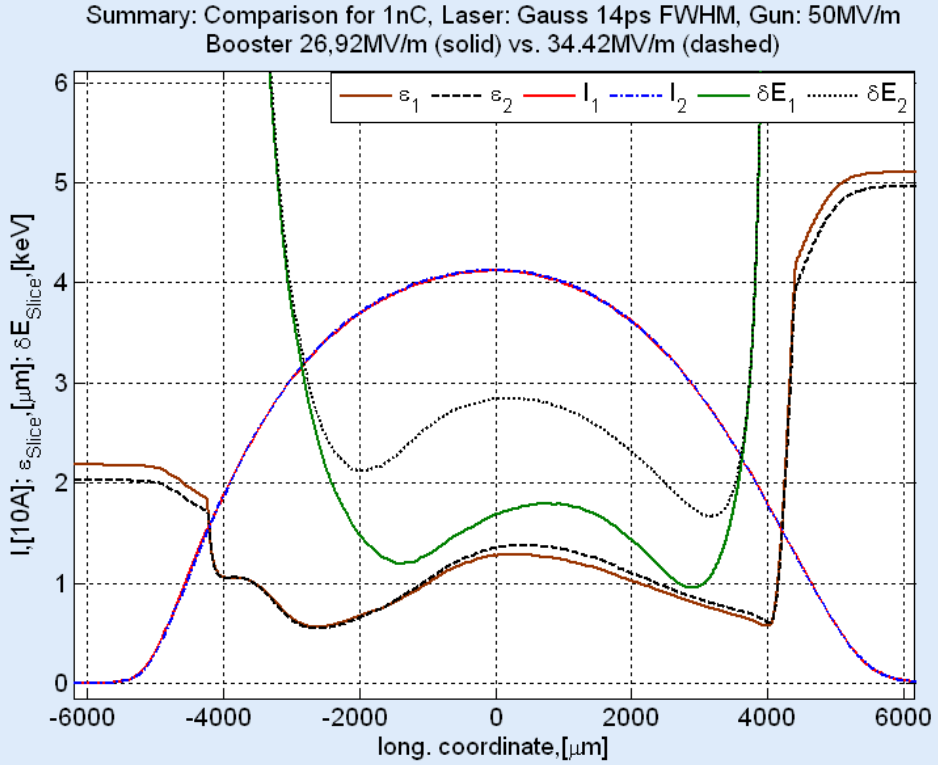
1. Gun Simulations for 50MV/m Gauss 10,12,14,16,18,20ps FWHM
   (nominal equal gradient in ACC1 cavities)

2. Scan of the peak booster field for Gun 50MV/m, Gauss 14ps FWHM

3. Nominal booster peak field of 34.42MV/m compared to 26.92MV/m and 21.92MV/m
   (evaluated for Gun 50MV/m, Gauss 14ps)

4. Gun 50MV/m:
   Gauss 14ps compared with 10ps and 20ps for optimized booster settings

Sensitivity of the Bunch Parameters with Respect to Peak Booster Gradient



Best for emittance: 26.9MV/m

Used in simulations: 34.4 MV/m

→ 4.2% projected emittance improvement

→ 4.5% improvement of emittance at the current peak

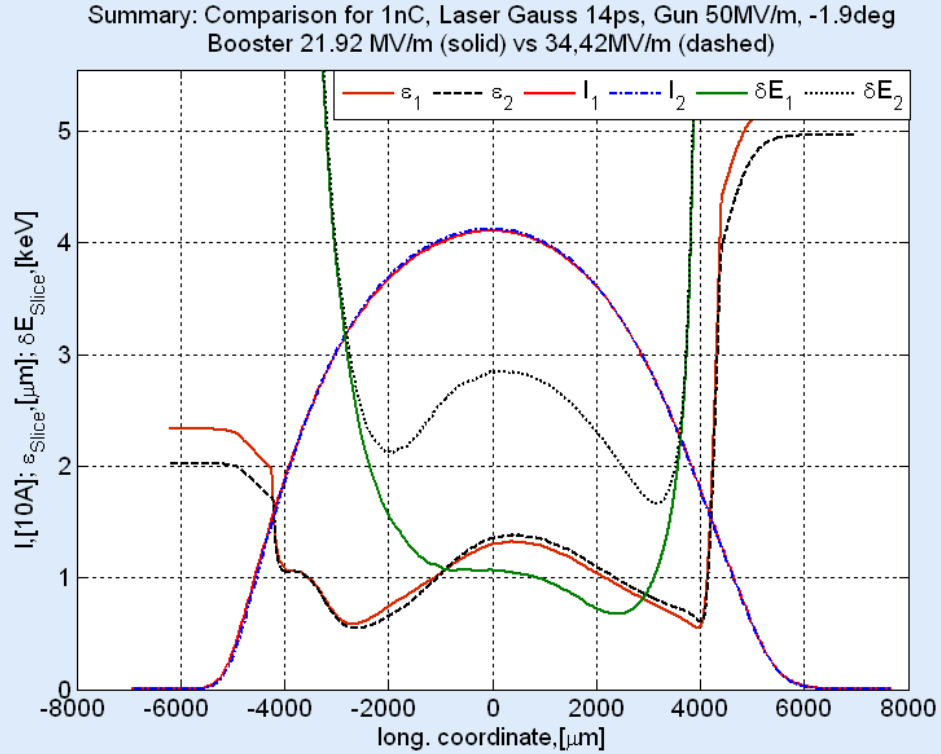
→ 3.9% improvement of average slice emittance

and

→ 40.5% improvement of slice energy spread at the current peak

Charge		**1nC**	
Gun peak electric field and phase		50MV/m, -1.9deg	
Laser form		Gauss 14ps FWHM	
Booster, [MV/m]		34.42	26.92
WP	MaxB,[T]	0.1889	
	XYrms,[mm]	0.460	
$\varepsilon^{pr}_{s=14.44m}$, [mrad]		1.501	1.438
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]		1.352	1.281
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]		1.064	1.023
$\varepsilon^{sl,min}_{s=14.44m}$, [mrad]		0.546	0.563
$\varepsilon^{sl,max}_{s=14.44m}$, [mrad]		1.380	1.288
$\delta E^{sl,peak}$,rms [keV]		2.842	1.691
Ip, [A]		41.3	41.2
τ rms, [mm]		2.384	2.389
Beam optical functions after 1st accelerating module	β,[m]	19.64	8.795
	α	-2.419	0.098
E_{ACC1},[MeV]		153.3	153.3

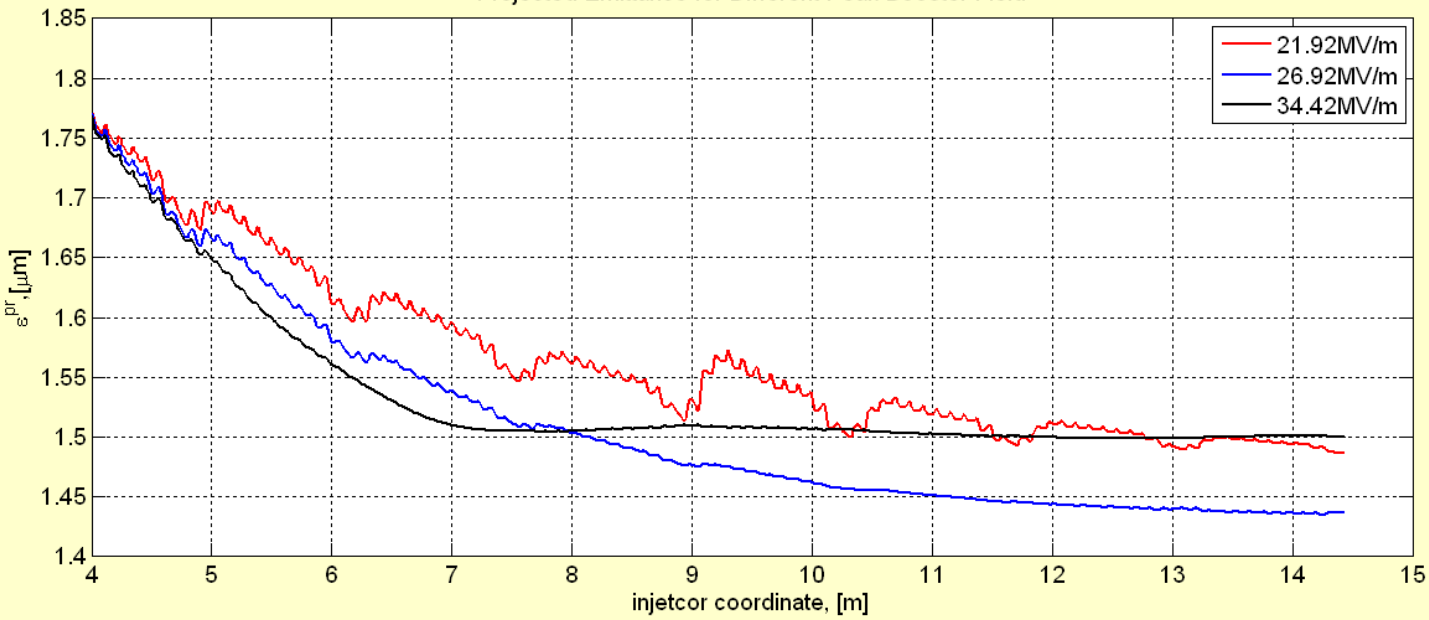
Sensitivity of the Bunch Parameters with Respect to Peak Booster Gradient



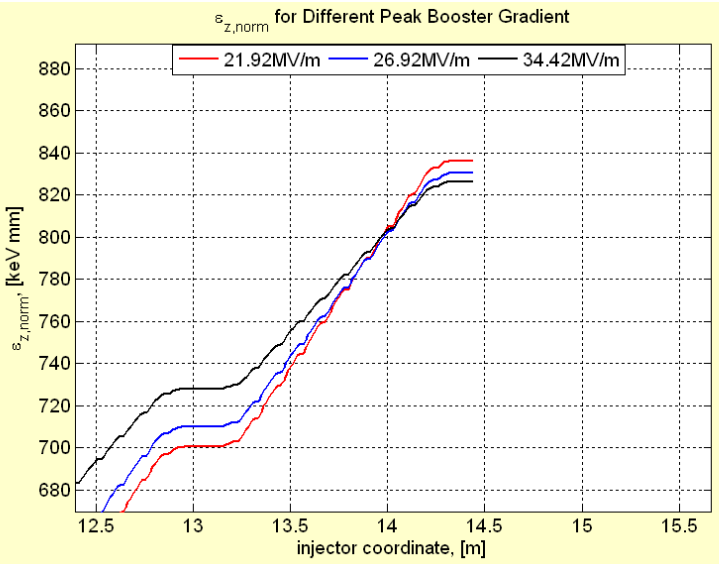
Charge		1nC	
Gun peak electric field and phase		50MV/m, -1.9deg	
Laser form		Gauss 14ps FWHM	
Booster, [MV/m]		34.42	21.92
WP	MaxB,[T]	0.1889	
	XYrms,[mm]	0.460	
$\varepsilon^{pr}_{s=14.44m}$, [mrad]		1.501	1.488
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]		1.352	1.307
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]		1.064	1.054
$\varepsilon^{sl,min}_{s=14.44m}$, [mrad]		0.546	0.553
$\varepsilon^{sl,max}_{s=14.44m}$, [mrad]		1.380	1.326
$\delta E^{sl,peak}$,rms [keV]		2.842	1.060
Ip, [A]		41.3	41.2
τ rms, [mm]		2.384	2.389
Beam optical functions after 1st accelerating module	β,[m]	19.64	20.83
	α	-2.419	1.211
E_{ACC1},[MeV]		153.3	153.3

→ Significant improvement of the slice energy spread by 62.7% while other parameters remain comparable

Sensitivity with Respect to Peak Booster Field
1nC Bunch Gauss 50MV/m 14ps FWHM; MaxB=0.1889, XYrms=0.460



$MaxE_{Boost}$,[MV/m]	21.92	26.92	34.42
$\varepsilon^{pr}_{s=14.44m}$, [mrad]	1.488	1.438	1.501
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]	1.307	1.281	1.352
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]	1.054	1.023	1.064
$\delta E^{sl,peak}$,rms [keV]	1.060	1.691	2.842
ΔErms[keV]	1141	1136	1134
$\varepsilon_{z,norm}$,[keV mm]	836.2	830.5	826.4



Possible margins due to additional adjust of the working point (MaxB, XYrms) are not included!

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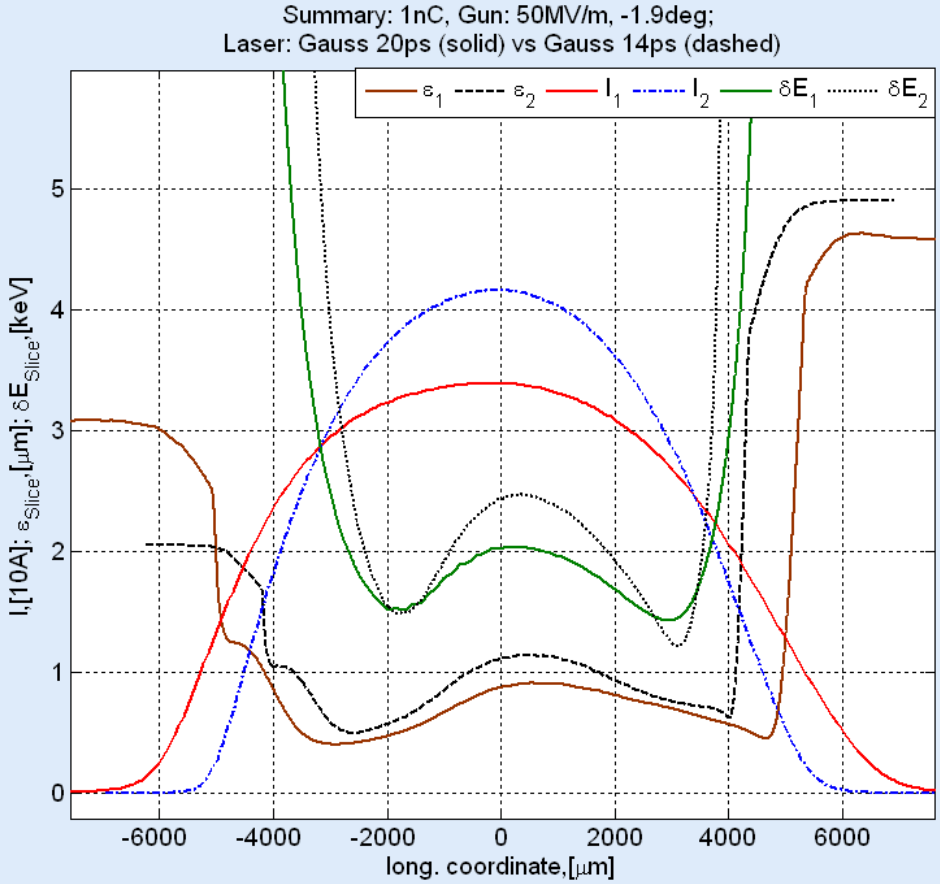
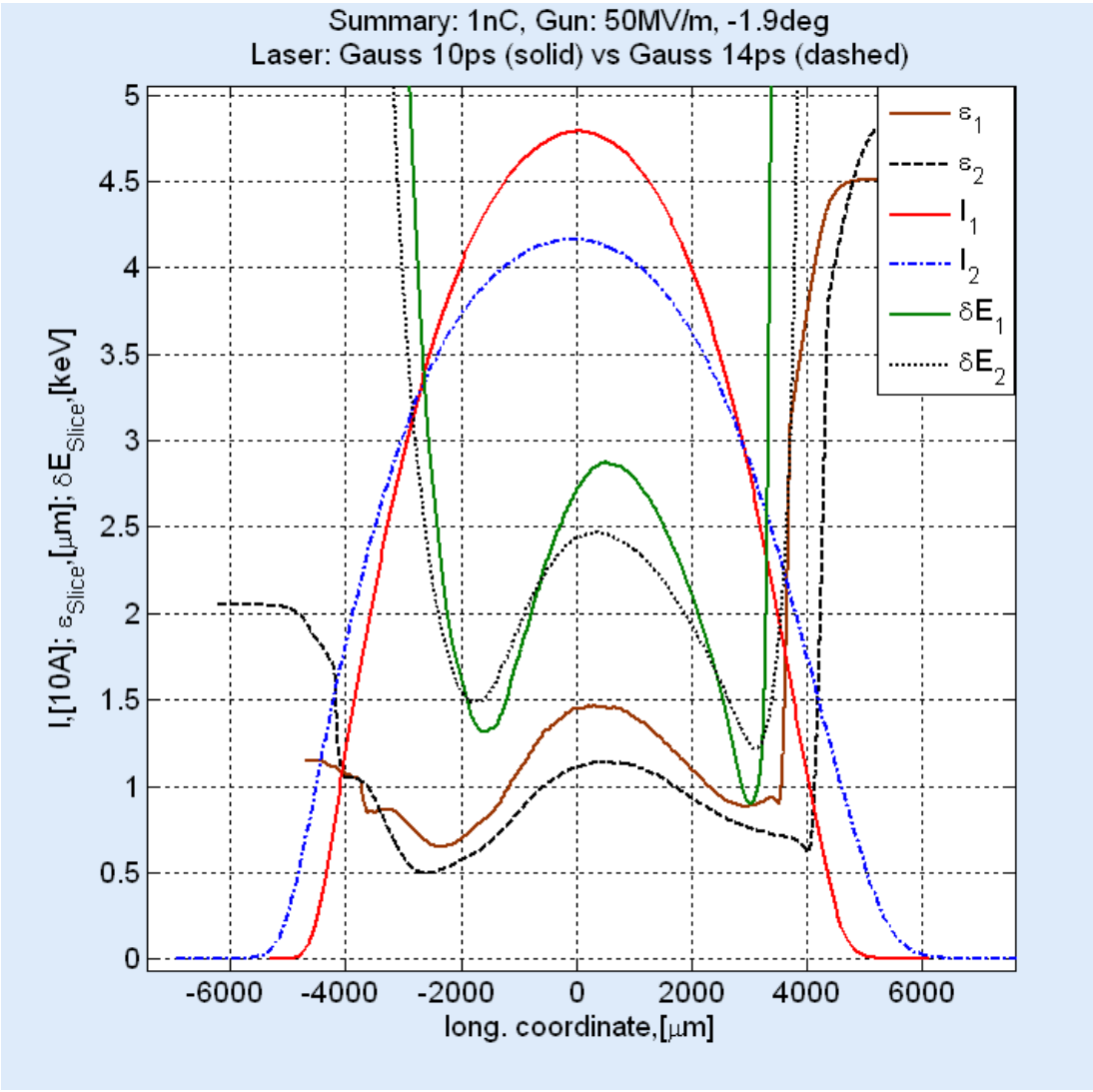
Sensitivity with Respect to Laser Pulse Length. Optimized Booster



WPs (MaxB, XYrms) are adjusted for new booster settings !

Charge		**1nC**	
Gun peak electric field and phase		50MV/m, -1.9deg	
Laser form		Gauss 14ps FWHM	Gauss 20ps FWHM
Booster gradient		26.92 MV/m	
WP	MaxB,[T]	0.1884	0.1882
	XYrms,[mm]	0.465	0.410
$\varepsilon^{pr}_{s=14.44m}$, [mrad]		1.386	1.187
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]		1.110	0.853
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]		0.922	0.786
$\varepsilon^{sl,min}_{s=14.44m}$, [mrad]		0.496	0.400
$\varepsilon^{sl,max}_{s=14.44m}$, [mrad]		1.144	0.910
$\delta E^{sl,peak}$,rms [keV]		2.75	2.43
Ip, [A]		41.7	33.9
τ rms, [mm]		2.365	2.888
Beam optical functions after 1st accelerating module	β,[m]	7.412	8.447
	α	-0.534	-0.460
E_{ACC1},[MeV]		153.3	153.3

Sensitivity with Respect to Laser Pulse Length. Optimized Booster



WPs (MaxB, XYrms) are adjusted for new booster setting !

Charge		**1nC**	
Gun peak electric field and phase		50MV/m, -1.9deg	
Laser form		Gauss 14ps FWHM	Gauss 10ps FWHM
Booster gradient		26.92 MV/m	
WP	MaxB,[T]	0.1884	0.1887
	XYrms,[mm]	0.465	0.505
$\varepsilon^{pr}_{s=14.44m}$, [mrad]		1.386	1.745
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]		1.110	1.455
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]		0.922	1.134
$\varepsilon^{sl,min}_{s=14.44m}$, [mrad]		0.496	0.646
$\varepsilon^{sl,max}_{s=14.44m}$, [mrad]		1.144	1.468
$\delta E^{sl,peak}$,rms [keV]		2.432	2.750
Ip, [A]		41.7	47.9
τ rms, [mm]		2.365	2.059
Beam optical functions after 1st accelerating module	β,[m]	7.412	7.136
	α	-0.534	-0.384
E_{ACC1},[MeV]		153.3	153.3

Summary

Final Comparison of the Calculated Cases

	FT 60	FT 50	Gau50/14	Gau50/10	Gau50/20	Baseline UND
$\varepsilon^{pr}_{s=14.44m}$, [mrad]	0.709	1.035	1.386	1.745	1.187	
$\varepsilon^{sl,peak}_{s=14.44m}$, [mrad]	0.629	0.955	1.110	1.455	0.853	
$\varepsilon^{sl,av}_{s=14.44m}$, [mrad]	0.634	0.905	0.922	1.134	0.786	0.920
$\delta E^{sl,peak}$,rms [keV]	1.100	2.555	2.432	2.750	2.430	
Ip, [A]	45.8	43.6	41.7	47.9	33.9	
β,[m]	8.729	22.18	7.412	7.136	8.447	
α	0.030	-3.99	-0.534	-0.384	-0.460	

→ *Not sure about the optimum for FT 50 case!*

→ *Booster optimized only for gaussian cases*