Detailed analysis of the measured transverse projected emittance for run period 2011

PITZ 1.8 setup

Emittance vs.:

- **Rms laser spot size on the cathode**
- **Booster gradient**
- **Gun phase**

Emittance for the Gaussian laser temporal profile

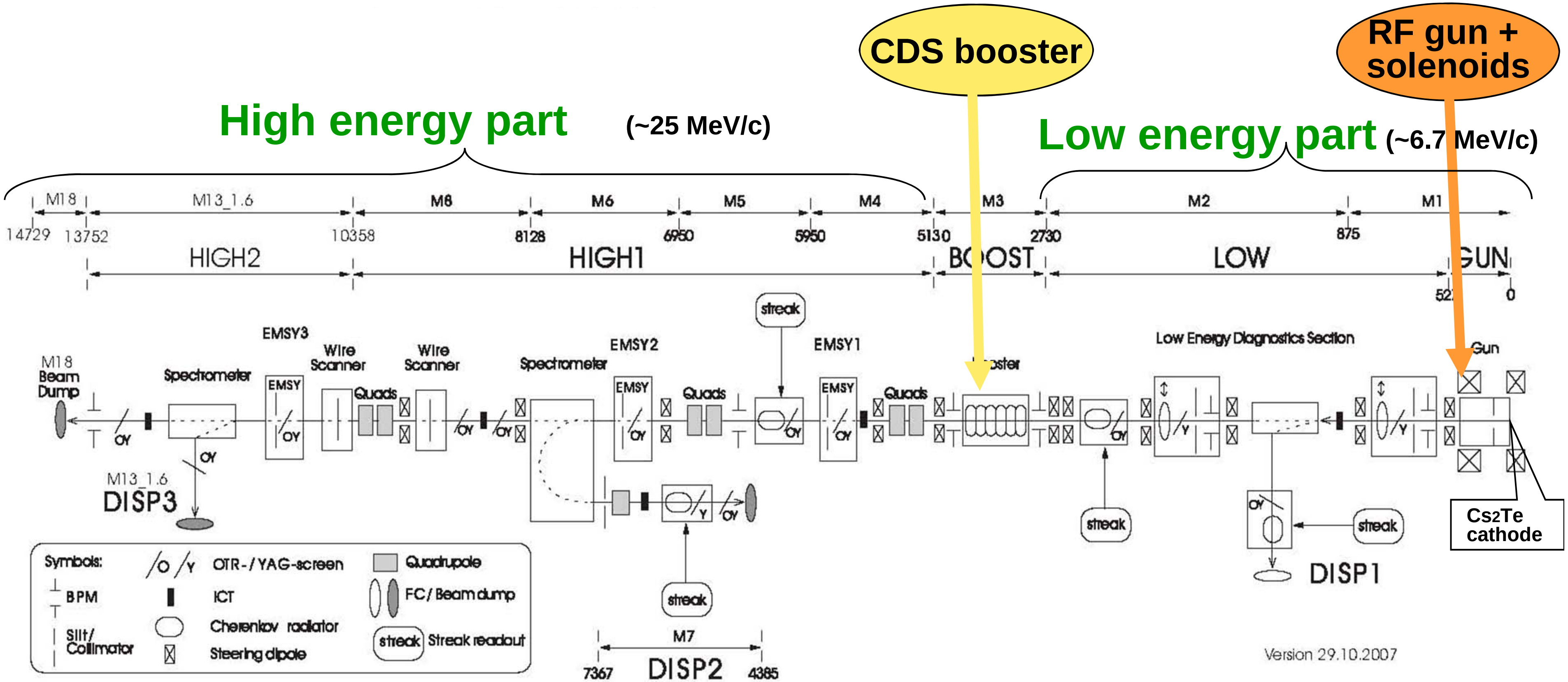
Summary

Grygorii Vashchenko
PITZ collaboration meeting
Zeuthen, 27-28.10.2011

HELMHOLTZ
GEMEINSCHAFT

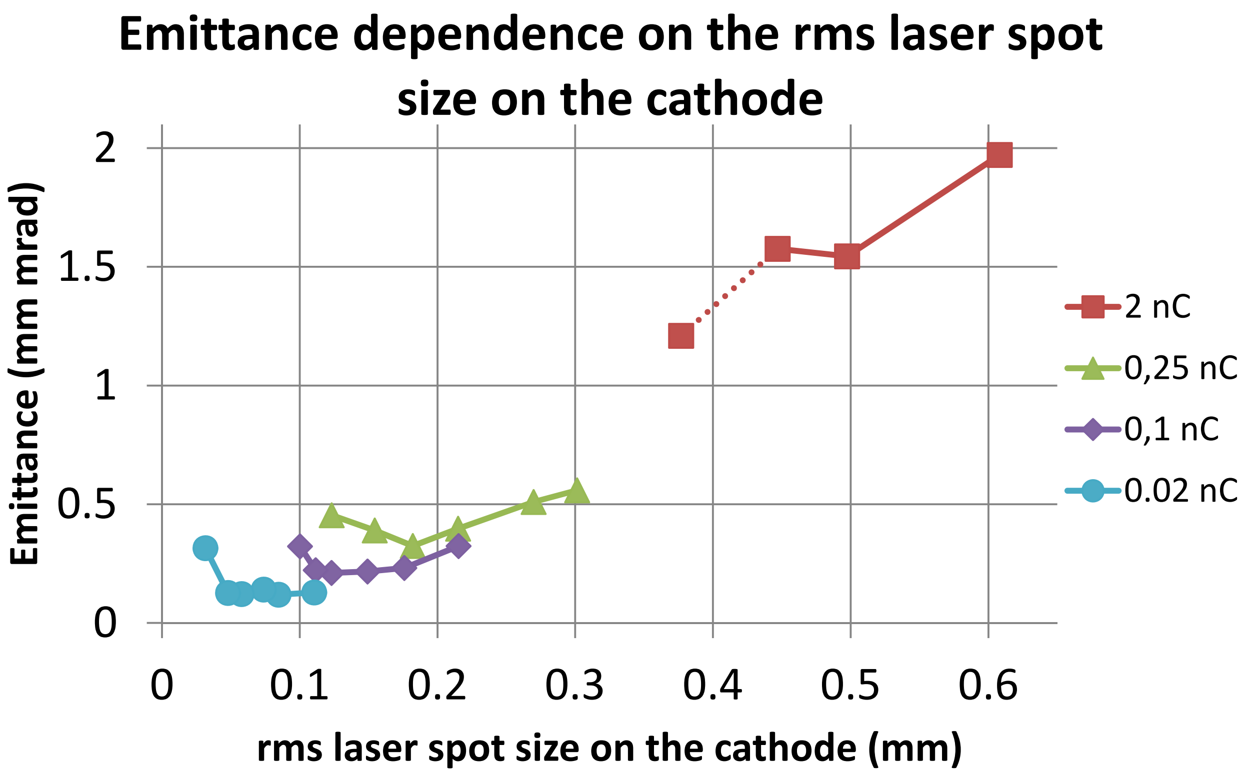
DESY

PITZ setup

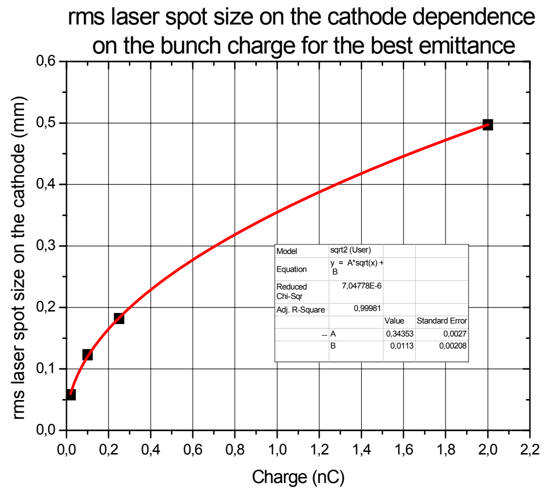


> New gun 4.1 was installed in January 2010
> New 10 MW in-vacuum directional coupler have to provide better RF stability
> LLRF feedback loop implemented
> Tesla booster replaced by CDS booster

Emittance dependence on rms laser spot size on the cathode for different charges (1 nC on the next slide)

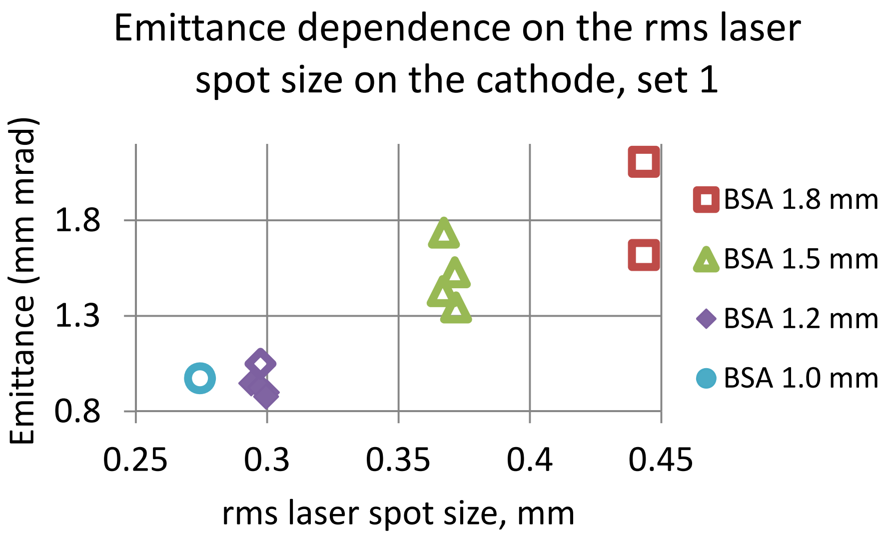


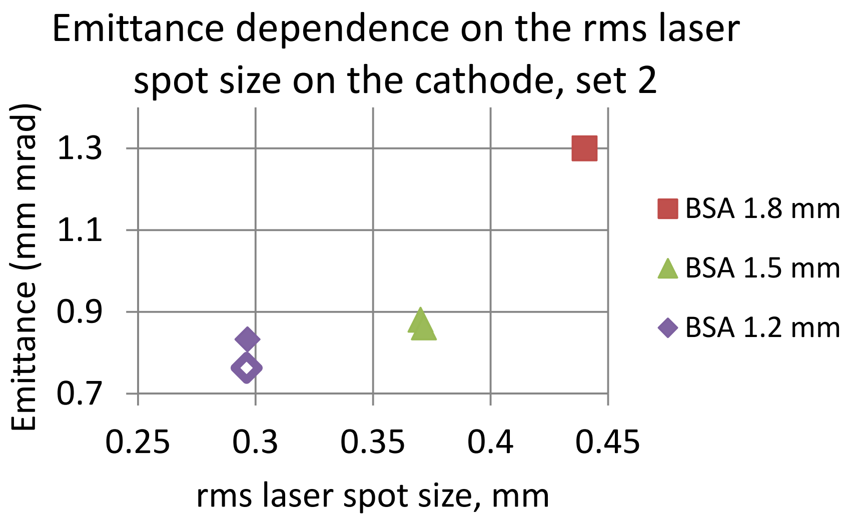
Summary data			
Charge	σ_{xy}	ε_{xy}	$\delta\varepsilon_{xy}$
2 nC	0,497	1,545	0,020
0.25 nC	0,182	0,325	0,002
0.1 nC	0,123	0,211	0,002
0.02 nC	0,058	0,122	0,003



Charges: 2, 0.25, 0.1, 0.02 nC
Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at maximum peak power => ~6.7 MeV/c electron beam momentum, MMMG phase
Booster at maximum peak power => 24.9 MeV/c electron beam momentum, MMMG phase (0.02 nC => not maximum peak power => 23.5 MeV/c electron beam momentum)

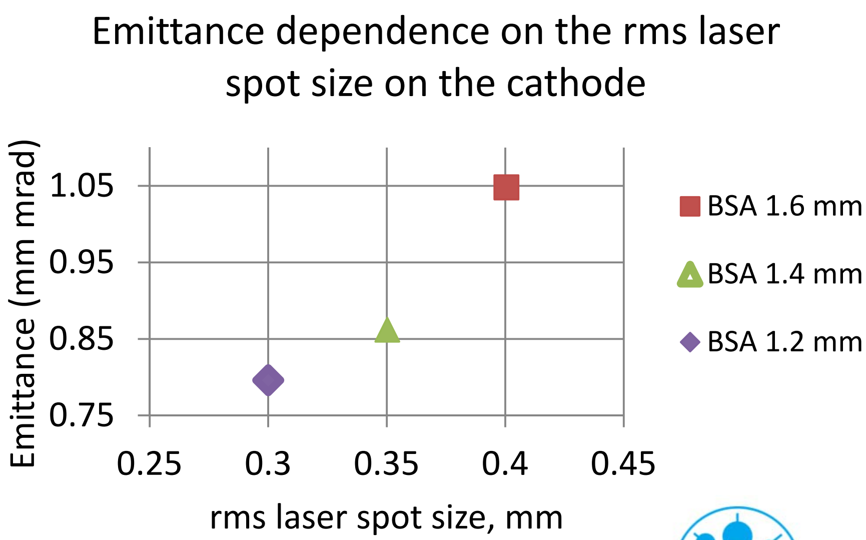
Emittance dependence on rms laser spot size on the cathode for 1 nC



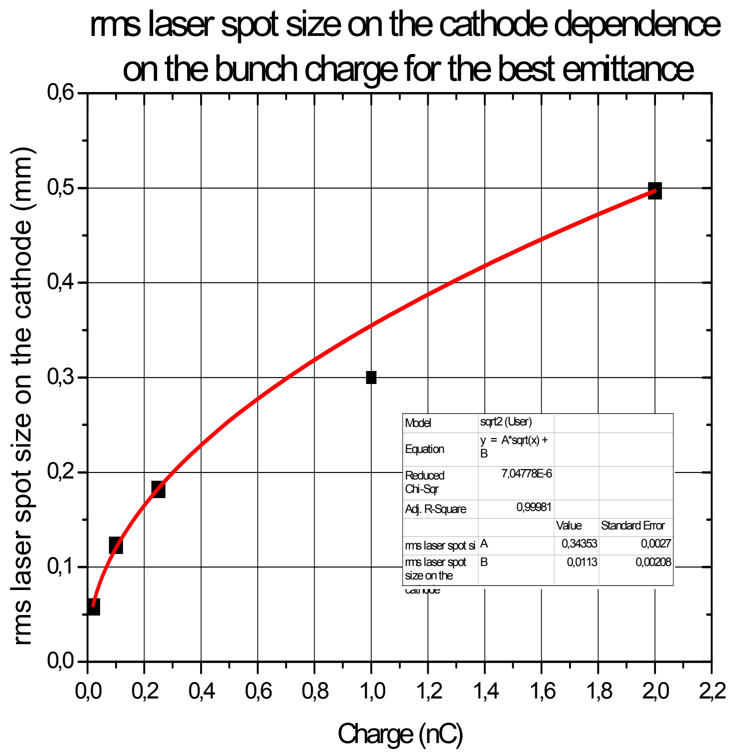


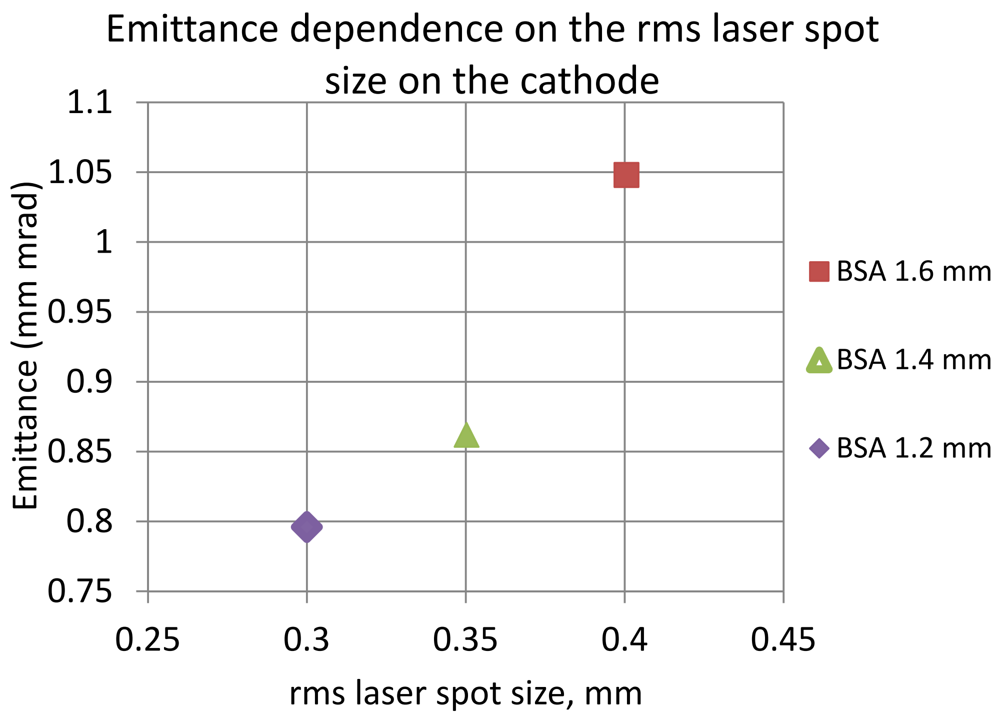
Summary data

Charge	σ_{xy}	ε_{xy}	$\Delta\varepsilon_{xy}$
2 nC	0,497	1,545	0,02
1 nC	0,3	0,796	0,007
0.25 nC	0,182	0,325	0,002
0.1 nC	0,123	0,211	0,002
0.02 nC	0,058	0,122	0,003



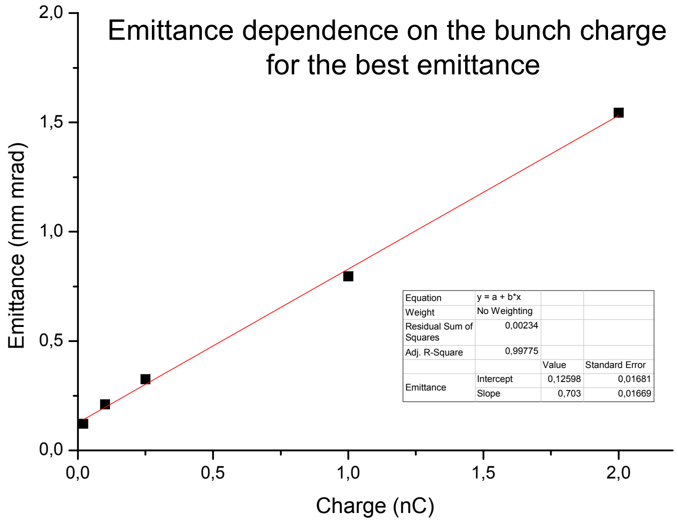
Rms laser spot size dependence on charge for the minimum emittance values

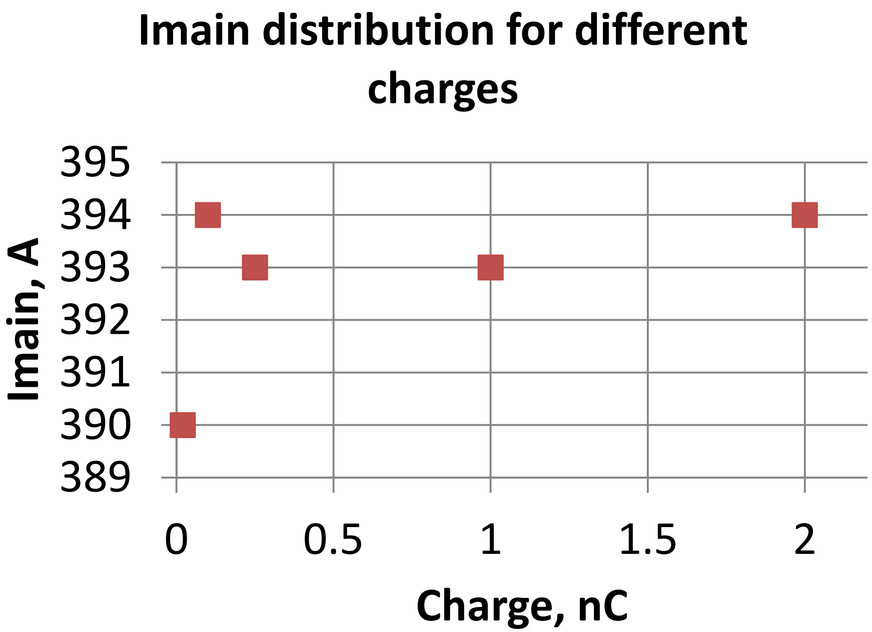




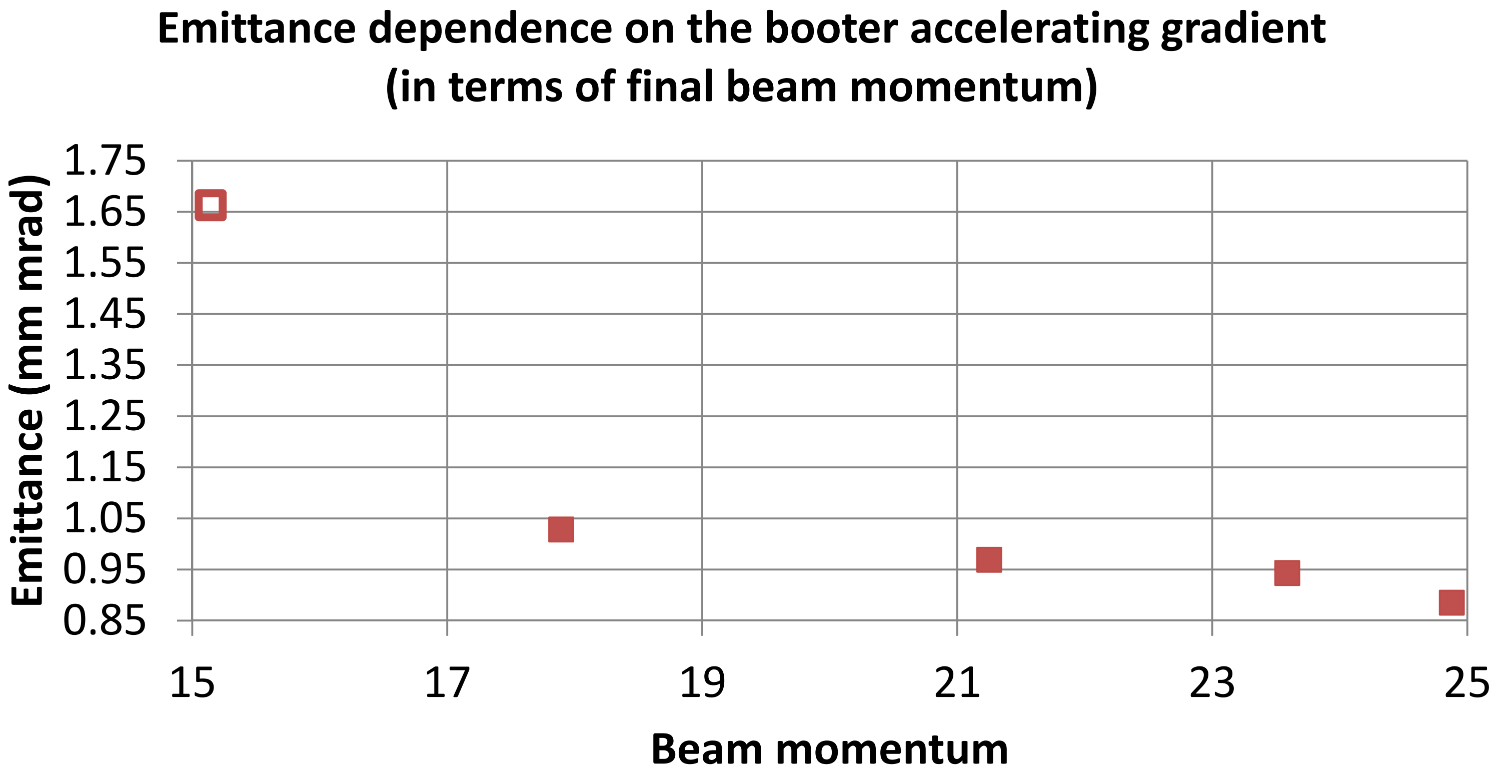
1 nC measurement far from the fitting curve => 0.35 mm can gives better value? Has to be measured next run period.

Emittance dependence on charge and Solenoid currents distribution



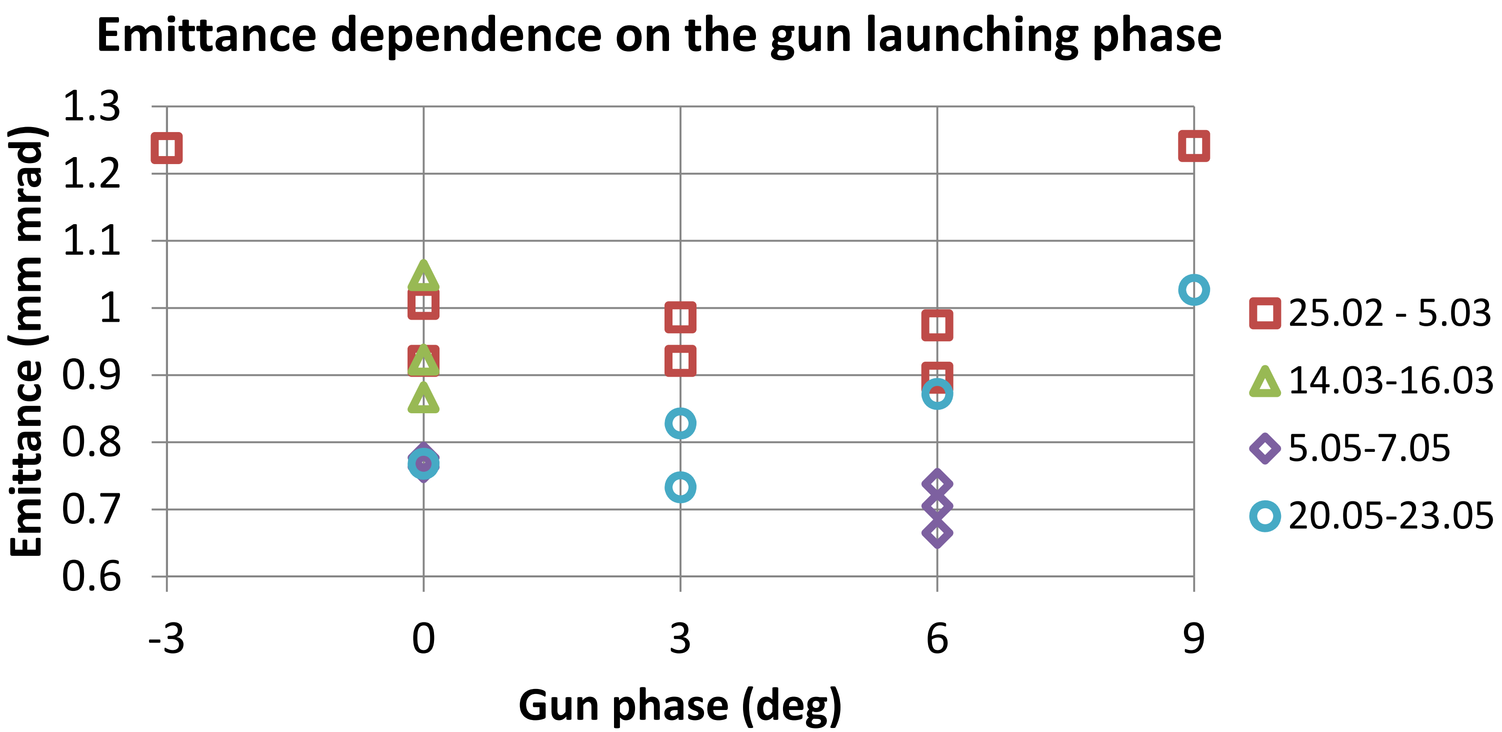


Emittance dependence on the booster accelerating gradient.



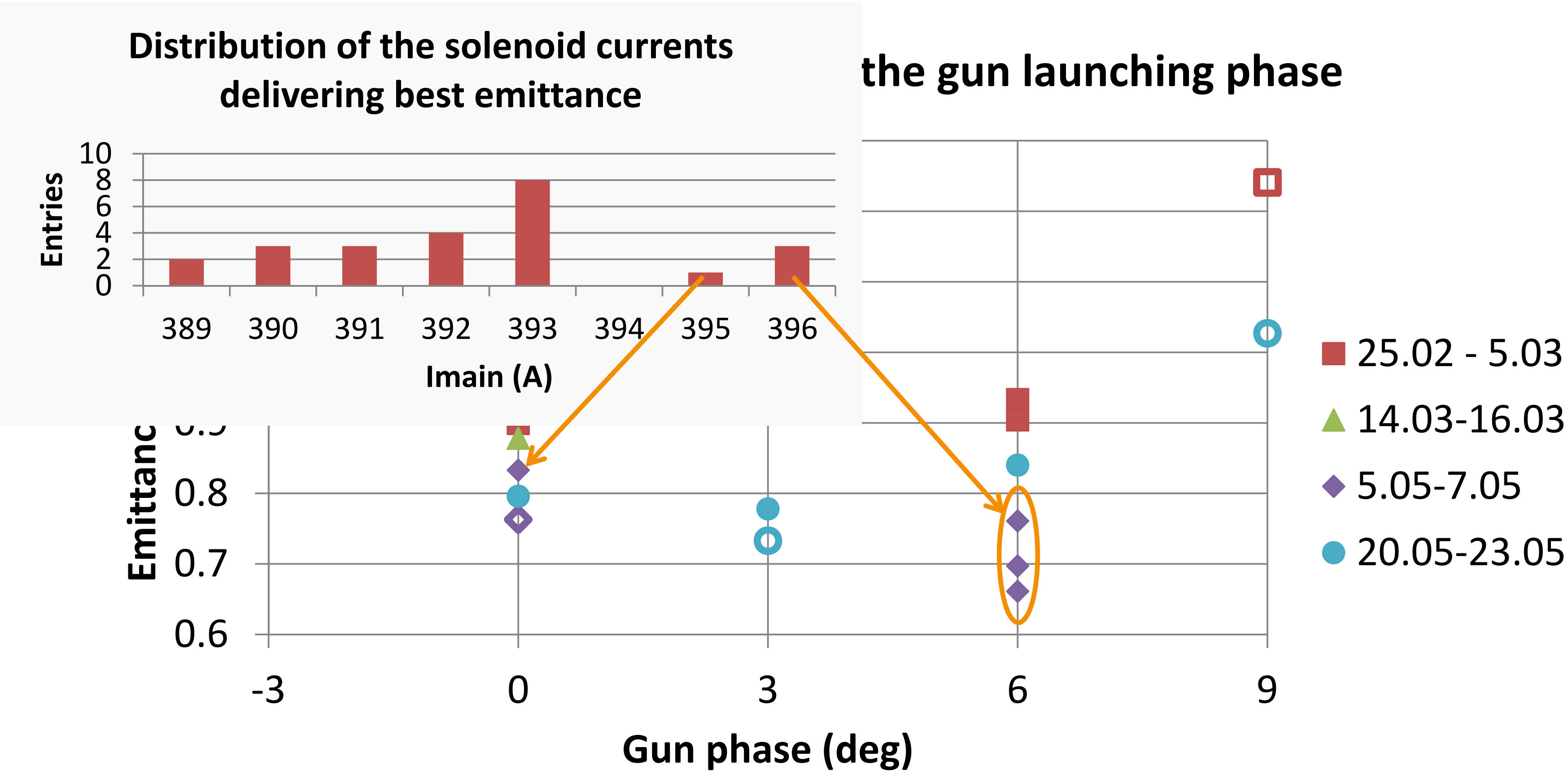
Rms laser spot size at the cathode ~ 0.3 mm
Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at maximum power => ~6.7 MeV/c electron beam momentum, MMMG phase
Booster at MMMG phase

Emittance dependence on the gun phase for BSA 1.2 mm



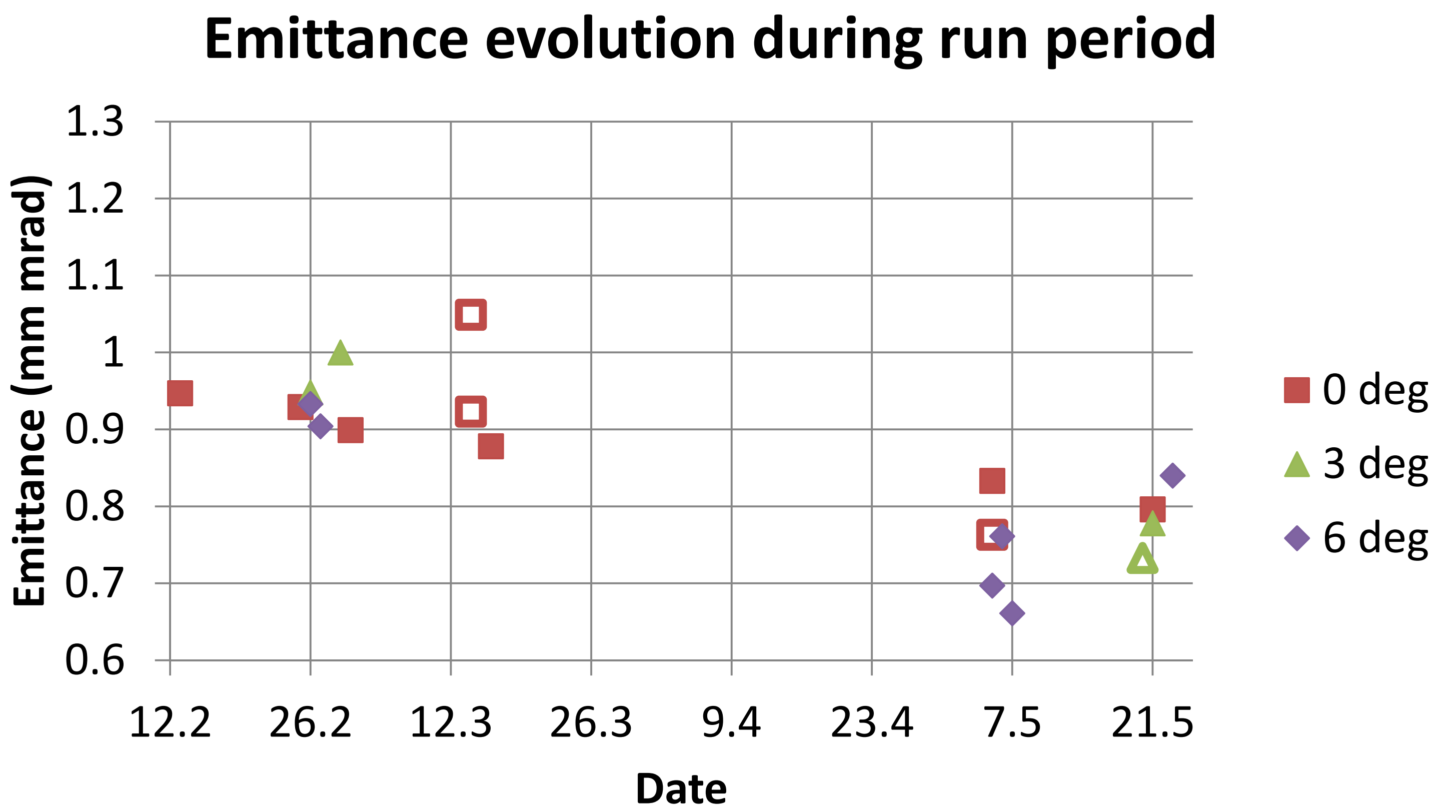
Rms laser spot size at the cathode ~ 0.3 mm
Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at maximum power => ~6.7 MeV/c electron beam momentum
Booster at maximum power => 24.9 MeV/c electron beam momentum, MMMG phase

Emittance dependence on the gun phase for BSA 1.2 mm



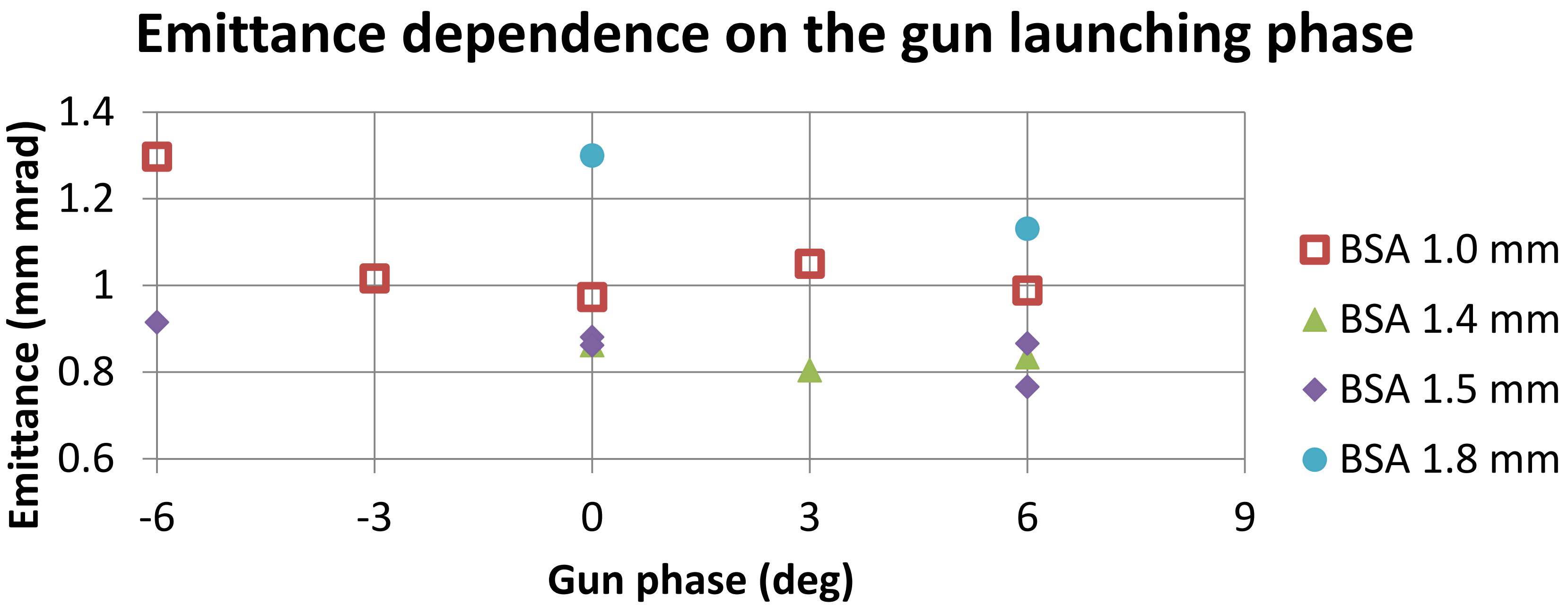
Data from the same measurements as on the previous slide, but from statistical measurements for the solenoid current which gives minimum emittance. Empty markers – values from solenoid scan as no statistics were taken.

Emittance evolution for 1 nC bunch charge and BSA 1.2 mm.



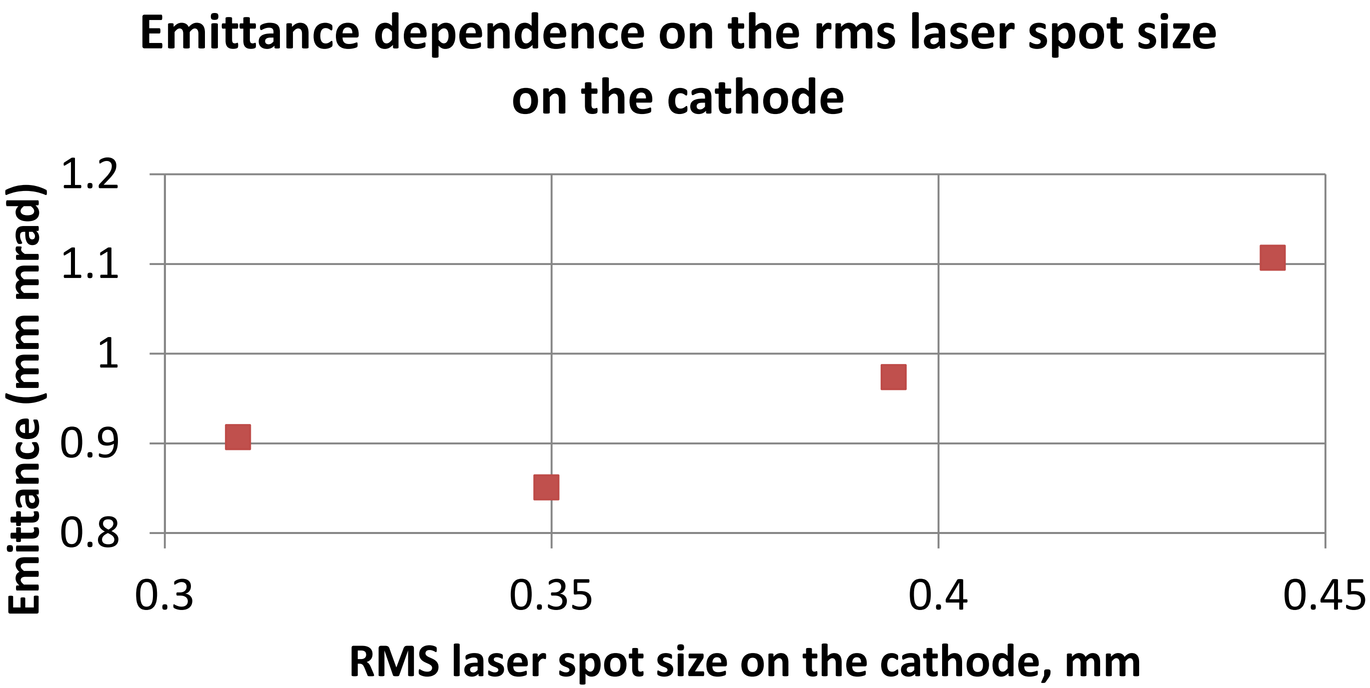
On these plot data from the previously shown plot are distributed over the date. Emittance values for gun phases -3 and -6 are removed, as they always significantly higher then for other phases.

Emittance dependence on the gun phase for other BSAs



Rms laser spot size at the cathode ~ 0.3 mm
Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at maximum power => ~6.7 MeV/c electron beam momentum
Booster at maximum power => 24.9 MeV/c electron beam momentum, MMMG phase

Emittance measured for long Gaussian laser temporal profile and 1 nC bunch charge

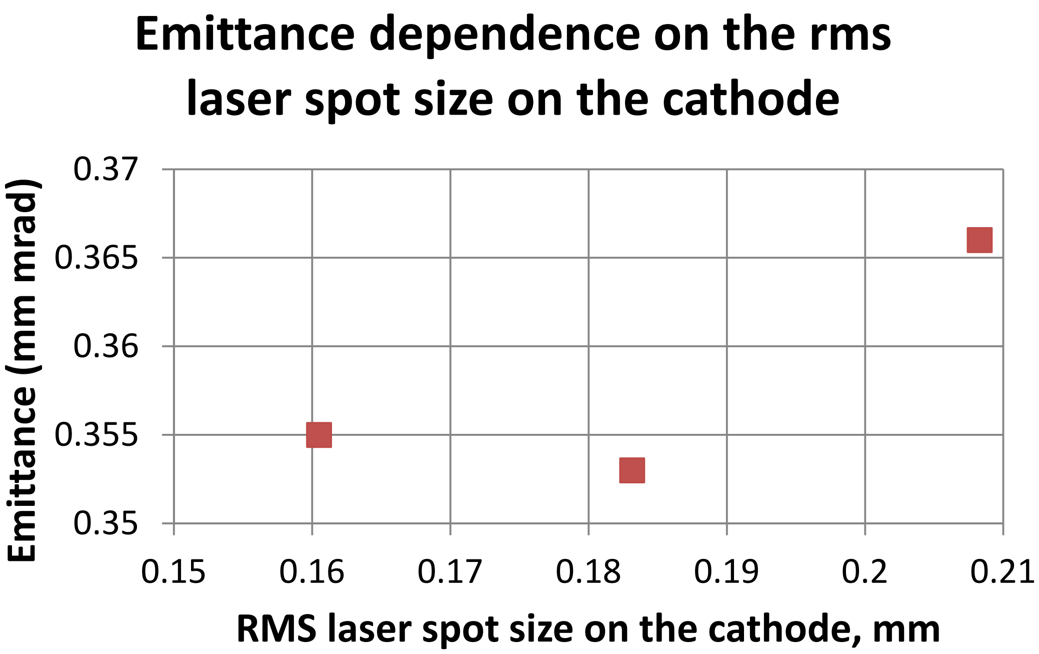


Gaussian laser temporal profile with FWHM ~ 12 ps
Gun at maximum power => ~6.6 MeV/c electron beam momentum, MMMG phase
Booster at maximum power => 24.6 MeV/c electron beam momentum, MMMG phase

Flattop 21.05

Xyrms, mm	Emittance, mm mrad	Stdev, mm mrad	Phase, deg	Difference, %
0,302	0,775	0,011	3	5
0,3	0,807	0,09	0	9
0,349	0,851	0,007		
0,309	0,907	0,09		

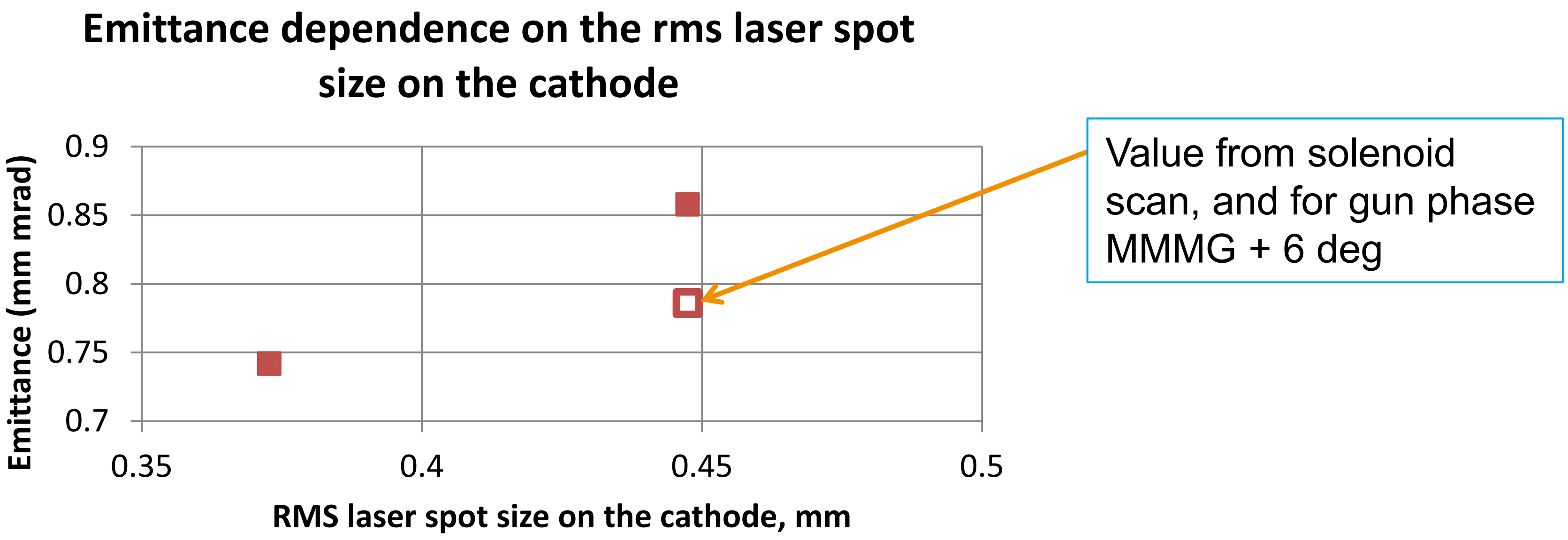
Emittance measured for long Gaussian laser temporal profile and 250 pC bunch charge



Summary data			
Profile	σ_{xy}	ε_{xy}	$\Delta\varepsilon_{xy}$
Flattop	0,182	0,325	0,002
Gauss	0,183	0,353	0,003

8% difference

Emittance measurements for reduced gun gradient (45 MV/m)



Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at reduced gradient ~45 MeV/m => ~5.2 MeV/c electron beam momentum, MMMG phase
Booster at maximum power => 24.9 MeV/c electron beam momentum, MMMG phase

Summary

- Emittance for different charges measured, results presented in the table. For 1 nC case emittance values less than 0.9 mm mrad measured with good reproducibility
- Minimum emittance values for all charges, except 1 nC, obtained at the same transverse space charge density. 1 nC case needs more detailed studies.
- Emittance measurements for different booster gradients in 1 nC case show that the minimum emittance lies around maximum booster gradient available at the moment. It will be nice to get more power for the booster to get more points on the right side, we still can increase it on about 3 MW.
- Emittance dependence on the gun launching phase studied, minimum emittance values found for gun phases [3; 6 deg]. More measurements are needed.
- Emittance measurements for long Gaussian profile gave from 5 to 9 % higher emittance values than in Flattop case.
- Emittance measurement for reduced gun gradient showed emittance value even less than for maximum gun gradient -> strong contradiction with theory. But only one measurement was done -> more investigations necessary.

Summary data

Charge	σ_{xy}	ε_{xy}	$\Delta\varepsilon_{xy}$
2 nC	0,497	1,545	0,02
1 nC	0,3	0,796	0,007
0.25 nC	0,182	0,325	0,002
0.1 nC	0,123	0,211	0,002
0.02 nC	0,058	0,122	0,003