Summary of Projected Emittance Measurements for PITZ 1.8 Setup

PITZ 1.8 setup

Emittance vs.:

- rms laser spot size on the cathode
- Booster gradient
- Gun phase

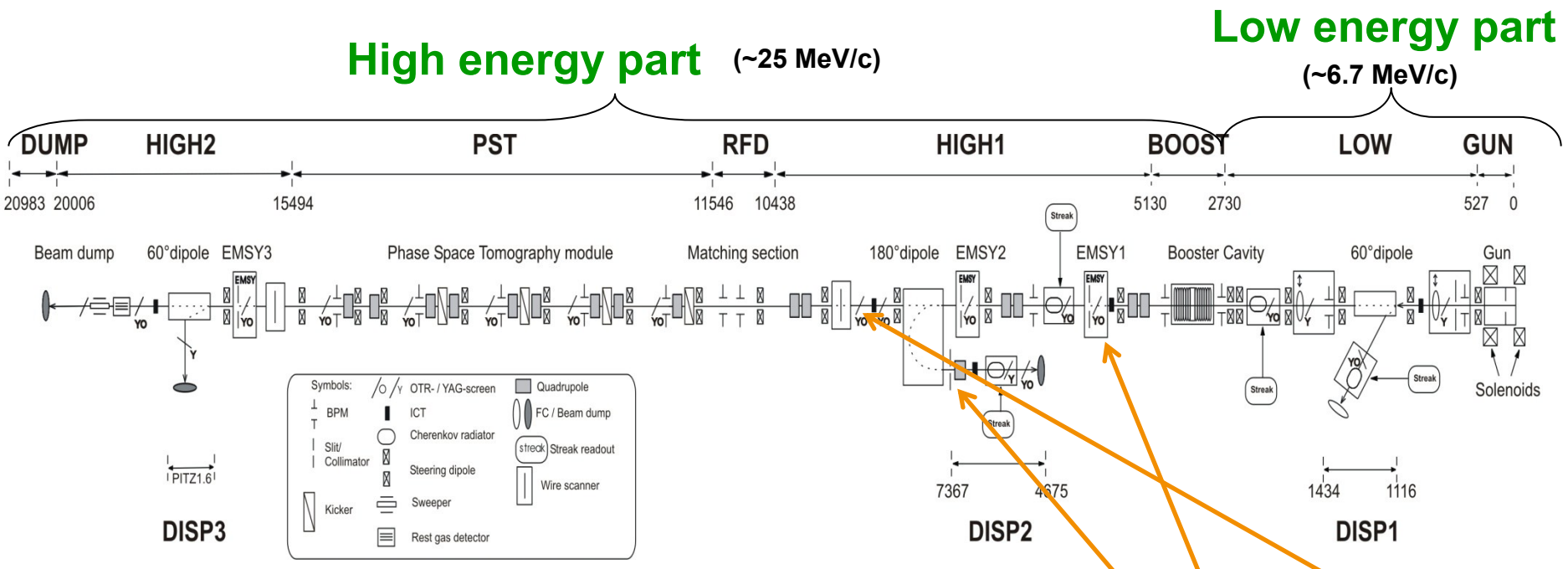
Emittance for the long Gaussian laser temporal profile

Summary

HELMHOLTZ GEMEINSCHAFT

DESY

PITZ setup

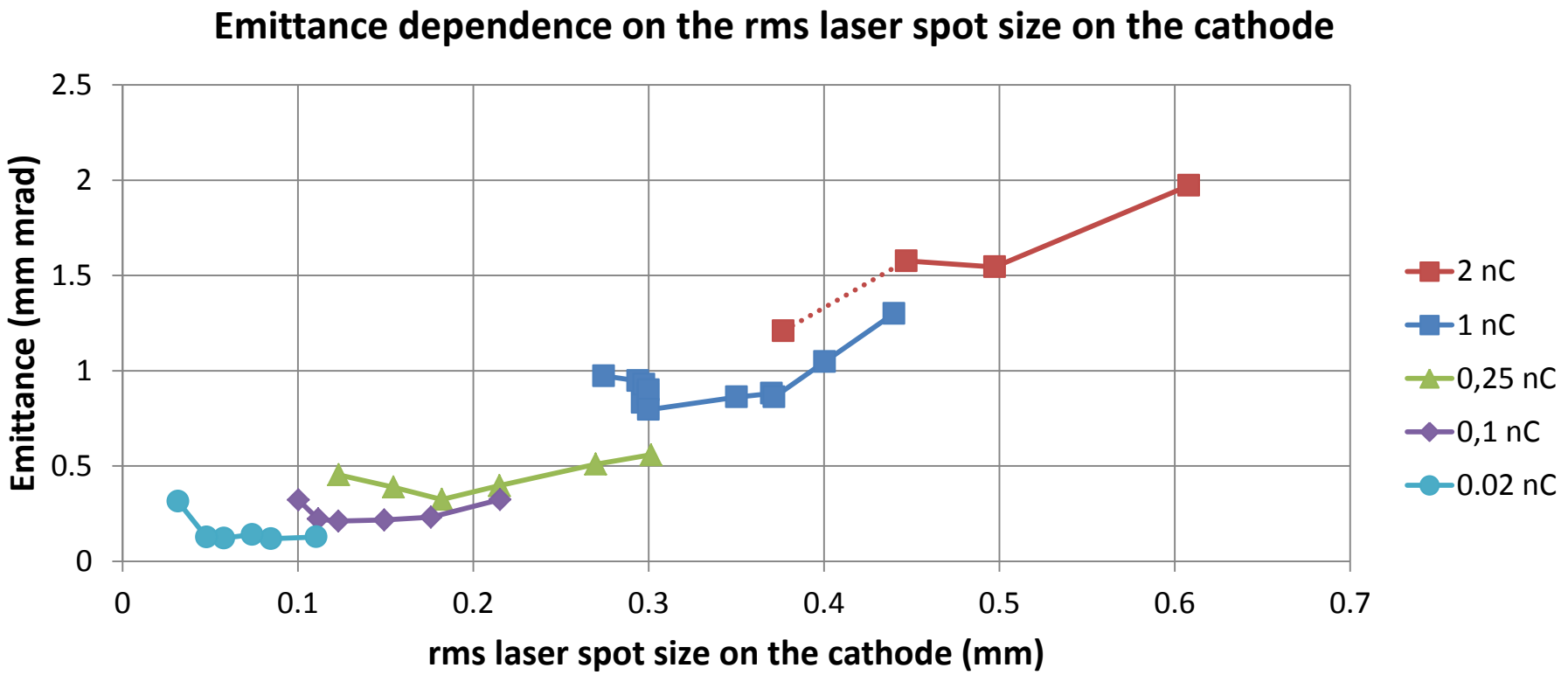


$$\varepsilon_x = \beta\gamma \frac{\sigma_x}{\sqrt{\langle x^2 \rangle}} \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle x x' \rangle^2}$$

$$\varepsilon = \sqrt{\varepsilon_x \varepsilon_y}$$

Emittance measured at position EMSY1
Beam momentum measured at HEDA1
Beamlets profiles after propagation in the drift space collected at position High1.Scr4

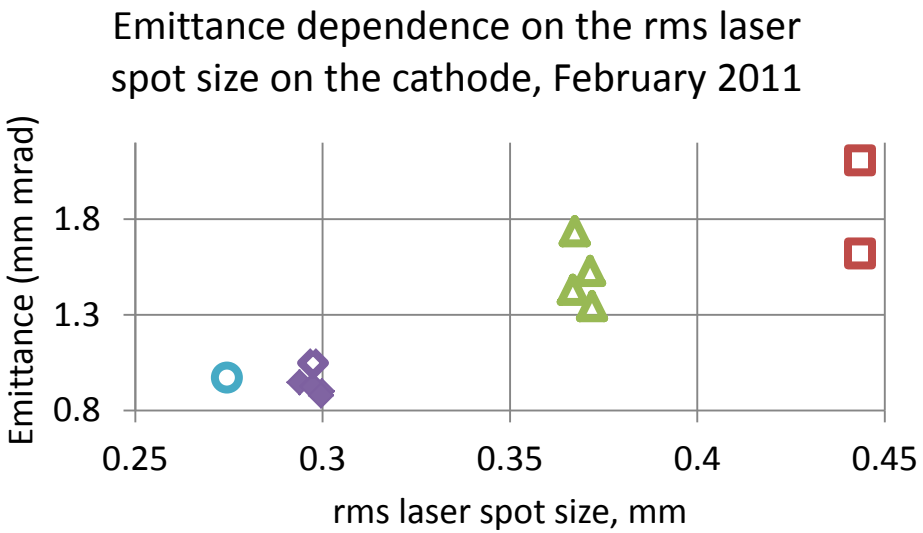
Emittance dependence on rms laser spot size on the cathode for different charges

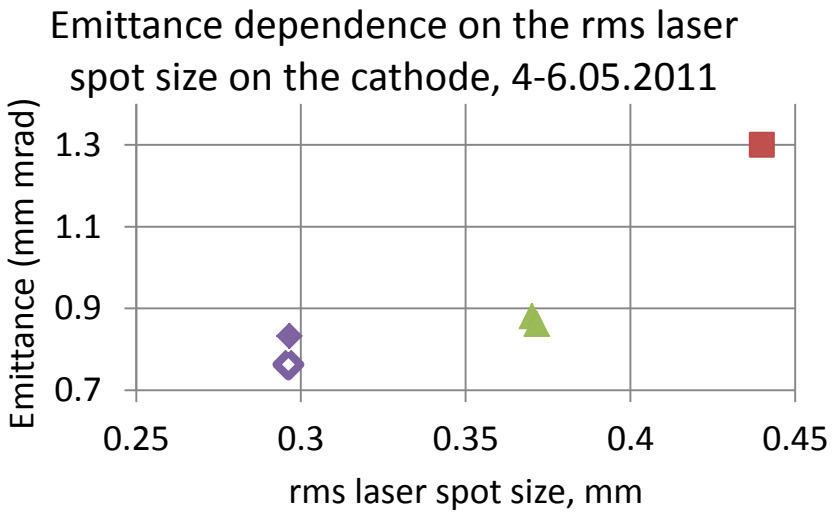


Flattop laser temporal profile with FWHM ~ 22 ps, 2 ps rise/fall time
Gun at maximum peak power => ~6.7 MeV/c electron beam momentum, MMMG phase
Booster at maximum peak power => 24.9 MeV/c electron beam momentum, MMMG phase (0.02 nC => not maximum peak power => 23.5 MeV/c electron beam momentum)

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

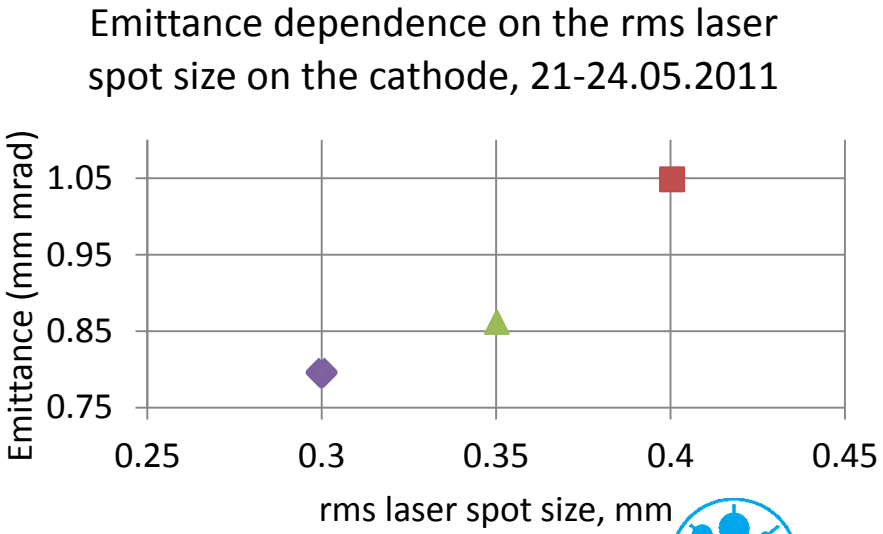
Emittance dependence on rms laser spot size on the cathode for 1 nC



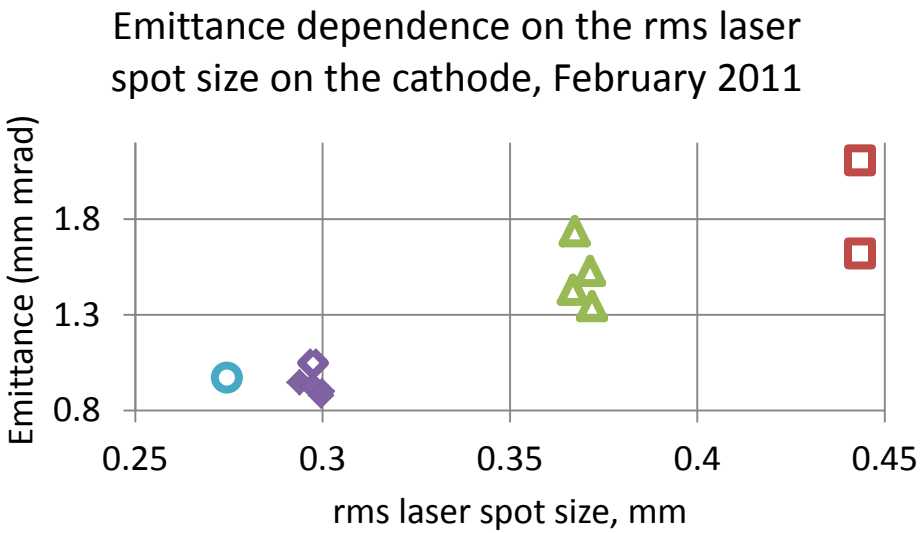


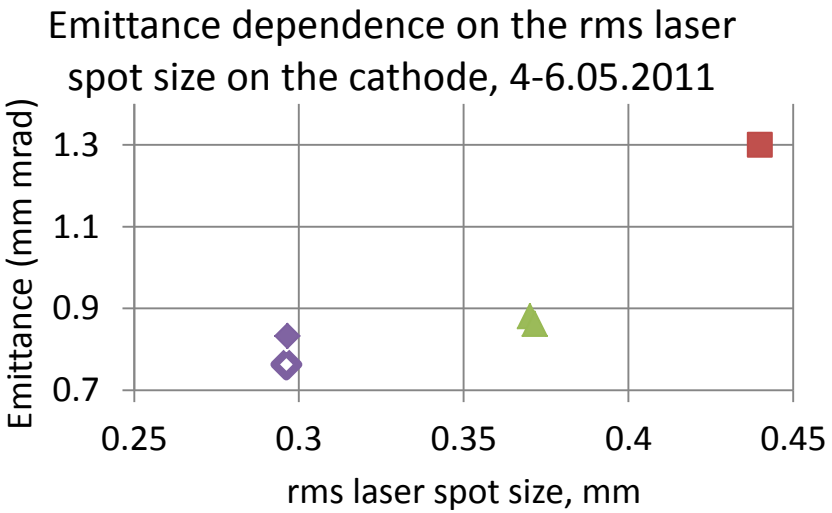
Empty markers – values from solenoid scan, no statistics

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 maximum power => 24.9 MeV/c electron beam momentum, MMMG phase
Best emittance value => about 0,8 mm mrad at rms laser spot size on the cathode 0.3 mm



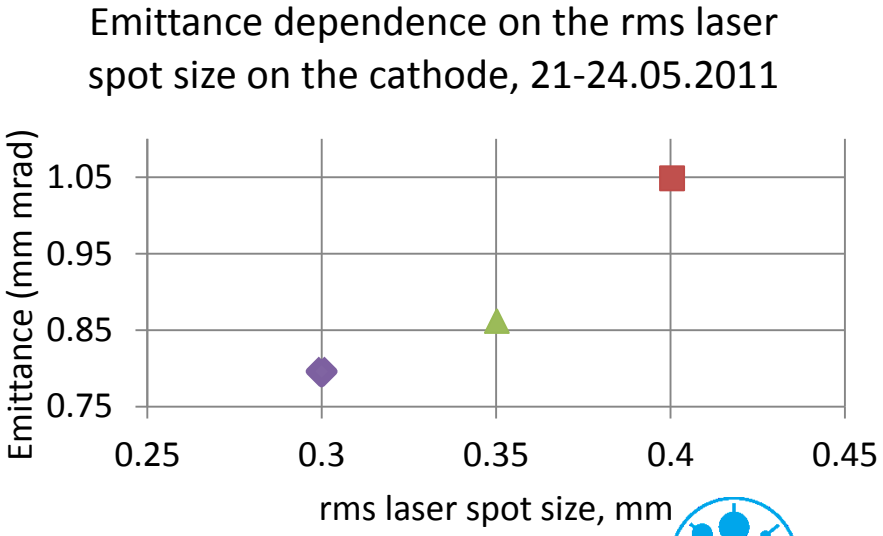
Emittance dependence on rms laser spot size on the cathode for 1 nC



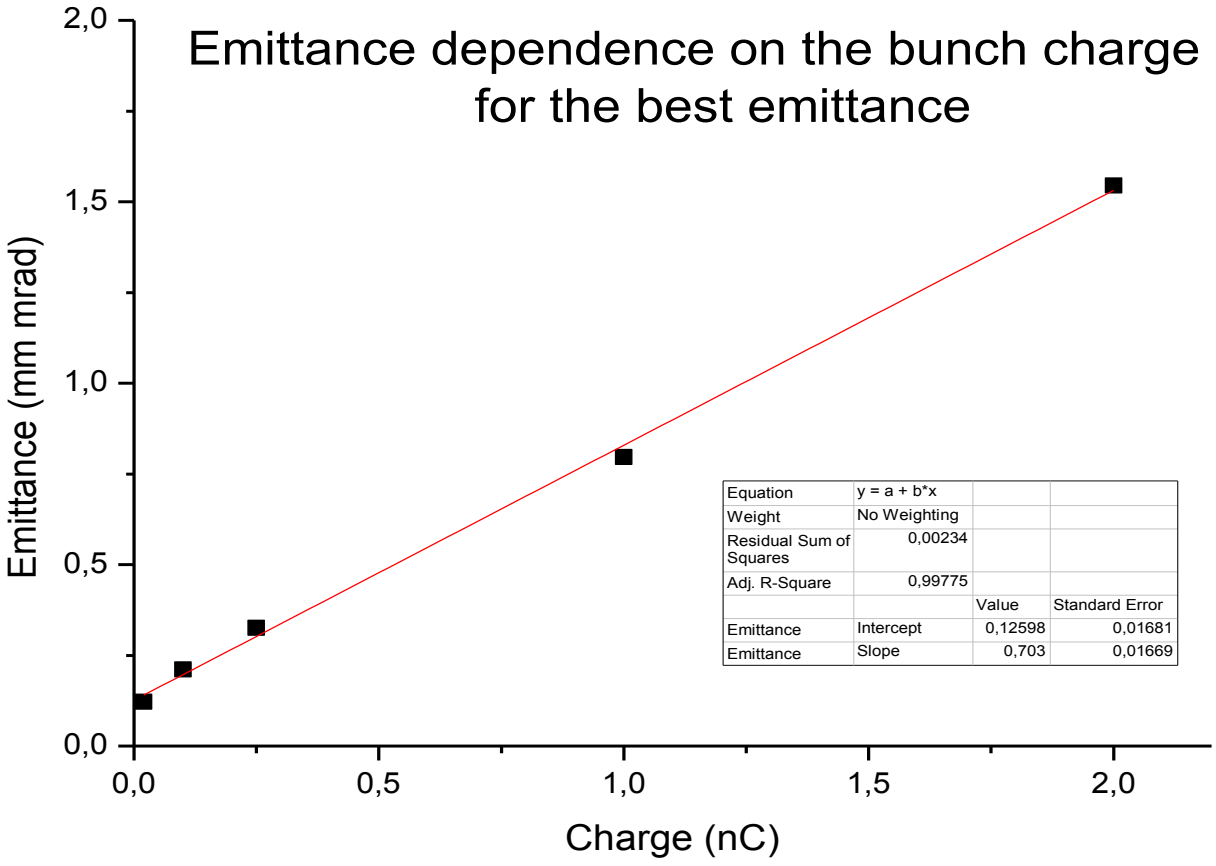


Summary data

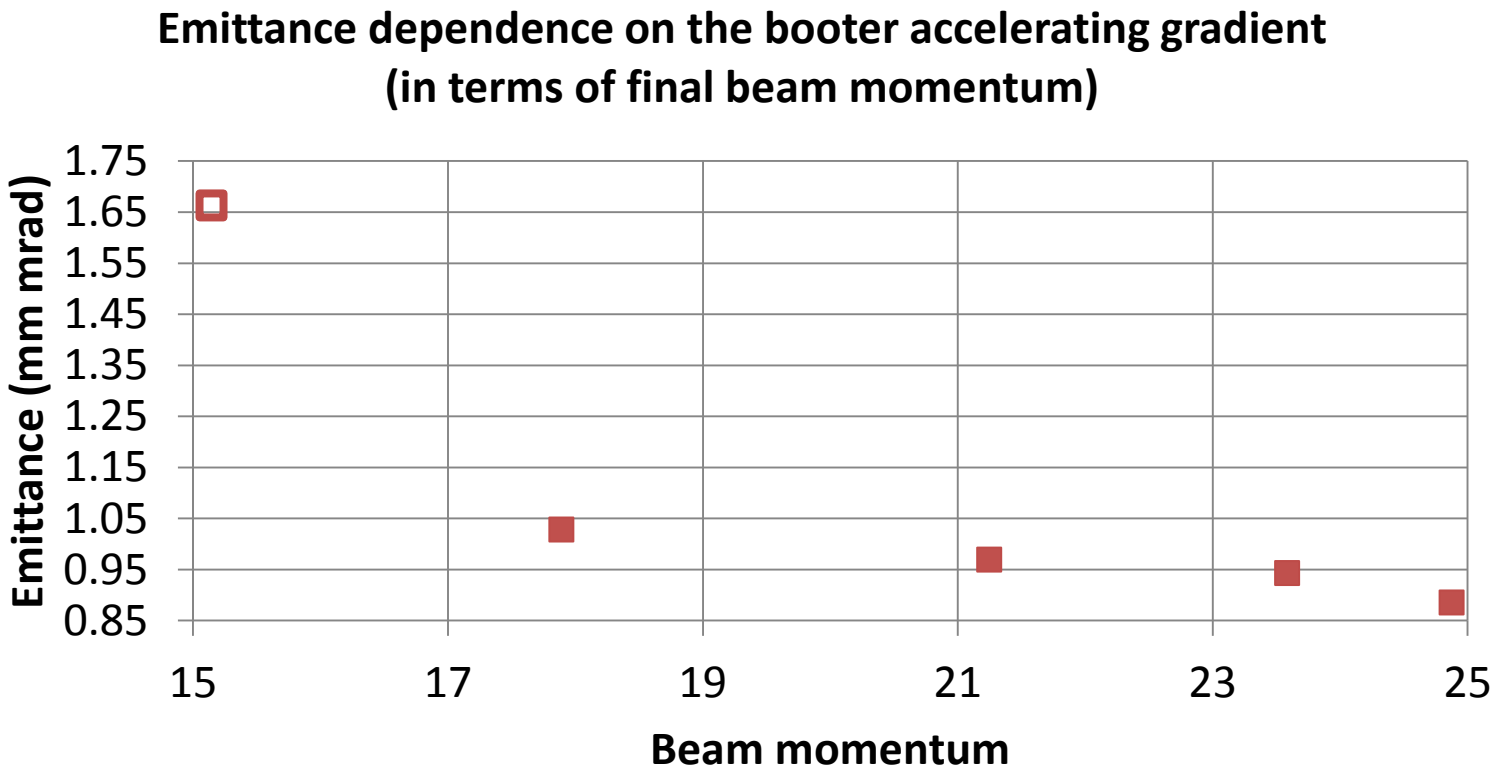
Charge	σ_{xy}	ε_{xy}	$\Delta\varepsilon_{xy}$
2 nC	0,497	1,545	0,02
1 nC	0,3	0,796	0,007
0.25 nC	0,182	0,325	0,002
0.1 nC	0,123	0,211	0,002
0.02 nC	0,058	0,122	0,003



Emittance dependence on charge and Solenoid currents distribution

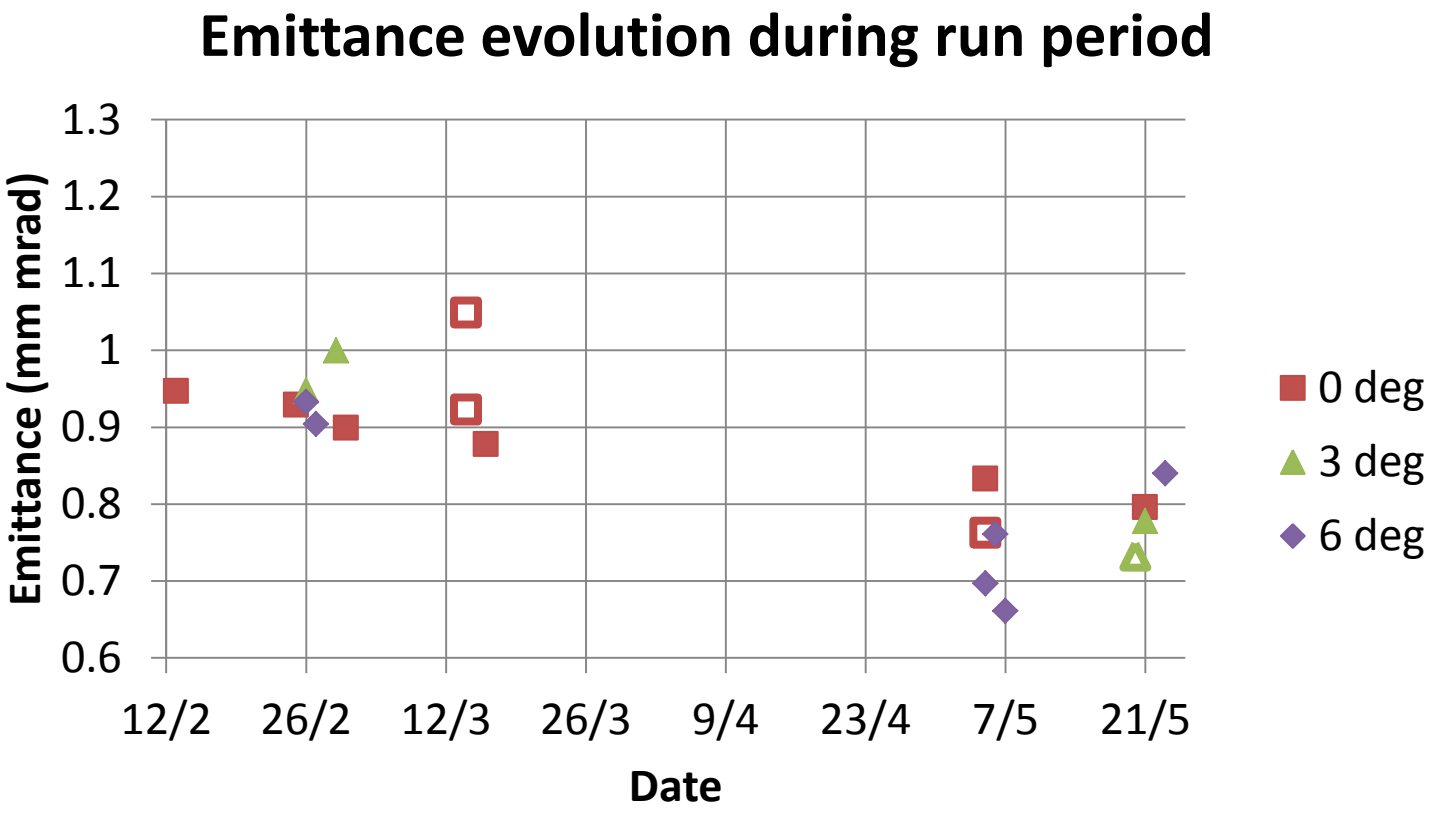


Emittance dependence on the booster accelerating gradient.



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

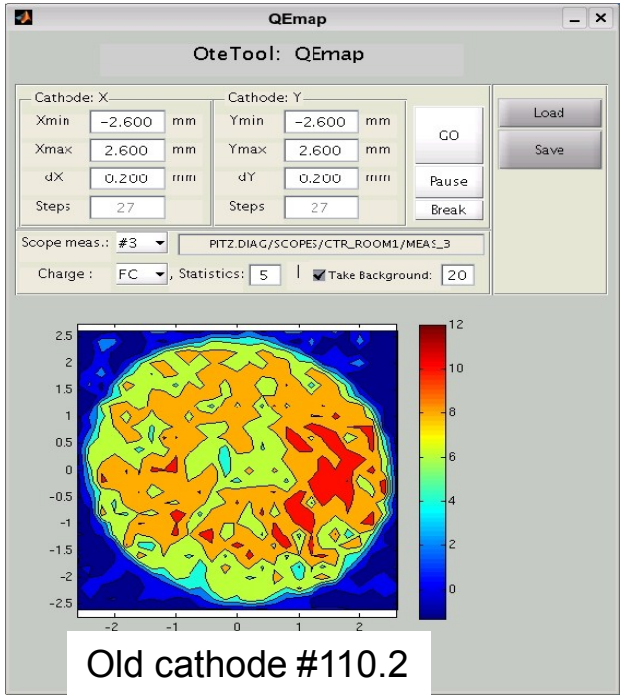
Emittance evolution for 1 nC bunch charge and BSA 1.2 mm.



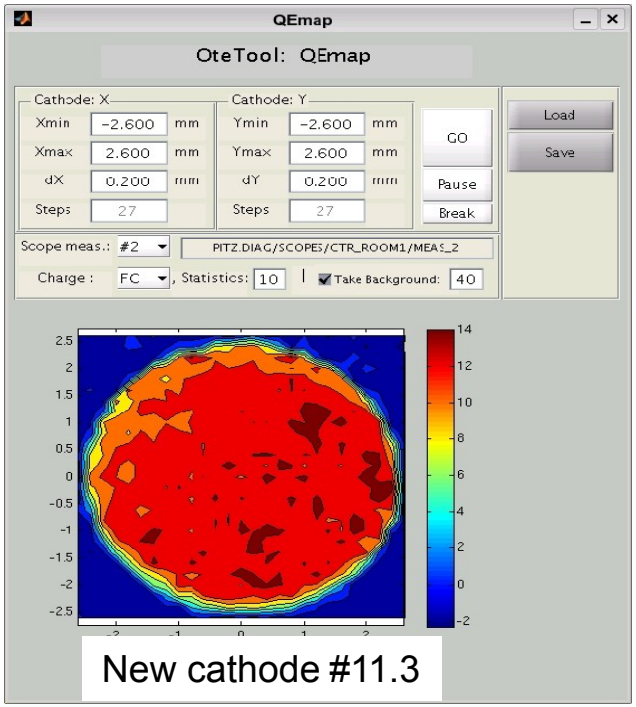
On these plot data from the previously shown plot are distributed over the date. Emittance values for gun phases -3 and -6 are removed, as they always significantly higher then for other phases.

“New Cathode Effect” studies 07.05.2011

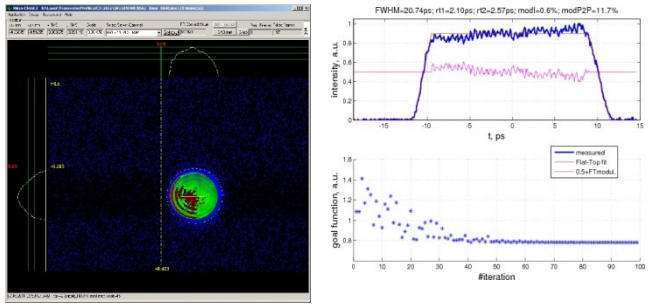
- 07.05.2011M – “Old” cathode (#110.2) → best 1nC machine setup (+cathode measurements: dark current, QE maps)
- 07.05.2011N – “New” (fresh) cathode (#11.3) → best 1nC machine setup (+cathode measurements : dark current, QE maps)

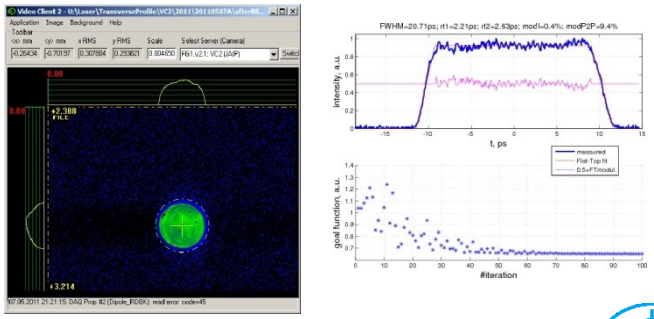


Old cathode #110.2



New cathode #11.3

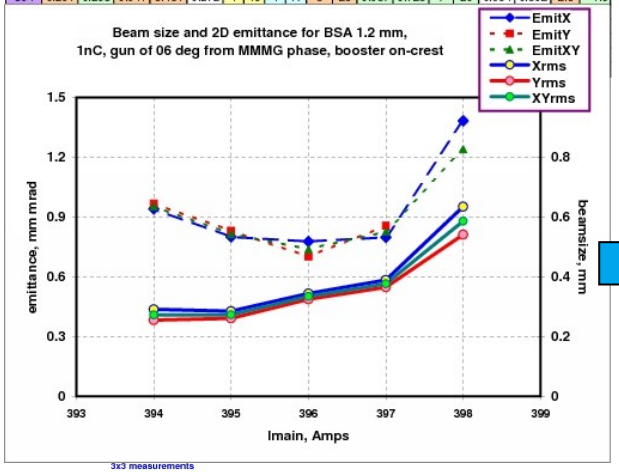




“New Cathode Effect” studies 07.05.2011

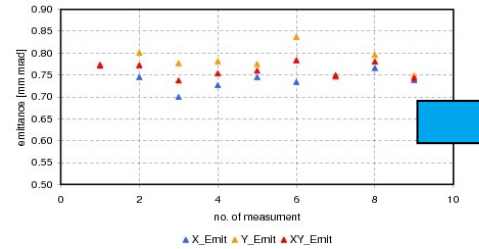
Old cathode #110.2

I_main (A)	Xrms, mm	Yrms, mm	EmitX_2D, mm mrad	EmitX_2D, nonscaled	XYrms, mm	EMSY1 NoP	EMSY1 Gain	MOI NoP	MOI, Gain	XBL NoP	XBL gain	EmitY_2D, mm mrad	EmitY_2D, nonscaled	YBL NoP	YBL gain	EmitXY_2D, mm.mrad	EmitXY_2D, nonscaled	X-scale factor	Y-scale factor
For all measurements f250 lenses and 2x2 binning were used																			
398	0.635	0.541	1.383	0.905	0.586	3	20	2	20	26	20	1.113	1.049	25	20	1.241	0.974	1.5	1.3
397	0.389	0.365	0.798	0.632	0.377	1	24	1	23	14	20	0.856	0.798	13	20	0.826	0.710	1.3	1.2
396	0.344	0.325	0.778	0.514	0.334	1	21	1	21	7	20	0.701	0.606	8	20	0.738	0.558	1.5	1.3
395	0.285	0.261	0.800	0.477	0.273	1	17	1	18	5	20	0.831	0.732	7	20	0.815	0.591	1.7	1.4
394	0.291	0.255	0.941	0.481	0.272	1	15	1	17	5	20	0.967	0.728	7	20	0.954	0.592	2.0	1.6



3x3 measurements

meas	beam size @ EMSY			X-emittance		Y-emittance		XYemit, scaled	XYemit, nonscaled
	X	Y	XY	scaled	nonscaled	scaled	nonscaled		
1	8.318	8.322	8.320	0.771	0.492	8.774	0.691	8.772	0.583
2	8.318	8.322	8.320	0.745	0.474	8.801	0.700	8.772	0.576
3	8.318	8.322	8.320	0.708	0.471	8.777	0.669	8.737	0.551
4	8.316	8.314	8.315	0.727	0.497	8.781	0.730	8.754	0.602
5	8.316	8.314	8.315	0.745	0.486	8.775	0.763	8.760	0.616
6	8.316	8.314	8.315	0.734	0.516	8.837	0.770	8.784	0.630
7	8.309	8.313	8.311	0.758	0.513	8.746	0.666	8.748	0.585
8	8.309	8.313	8.311	0.765	0.531	8.796	0.709	8.781	0.614
9	8.309	8.313	8.311	0.735	0.580	8.749	0.691	8.743	0.588
Mean	8.314	8.318	8.315	0.742	0.499	8.782	0.710	8.761	0.595
Std	0.004	0.004	0.004	0.021	0.019	0.028	0.037	0.017	0.022



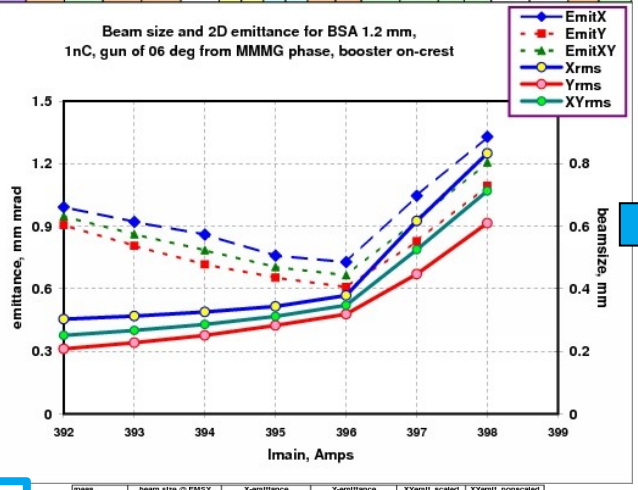
07.05.2011M
from sol.scan:
X-emit=0.778
Y-emit=0.701
XY-emit=0.738

07.05.2011M
3x3 stat:
X-emit=0.742
Y-emit=0.782
XY-emit=0.761

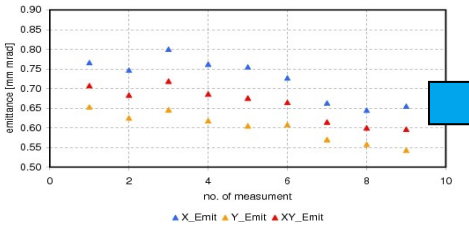
13%

New cathode #11.3

I_main (A)	Xrms, mm	Yrms, mm	EmitX_2D, mm mrad	EmitX_2D, nonscaled	XYrms, mm	EMSY1 NoP	EMSY1 Gain	MOI NoP	MOI, Gain	XBL NoP	XBL gain	EmitY_2D, mm mrad	EmitY_2D, nonscaled	YBL NoP	YBL gain	EmitXY_2D, mm.mrad	EmitXY_2D, nonscaled	X-scale factor	Y-scale factor
For all measurements f250 lenses and 2x2 binning were used																			
398	0.833	0.610	1.329	0.532	0.713	3	23	2	23	7	25	1.094	0.652	10	25	1.206	0.589	2.5	2.0
397	0.617	0.447	1.048	0.558	0.525	2	20	1	25	10	24	0.828	0.645	13	24	0.931	0.600	1.9	1.8
396	**0.379**	**0.319**	**0.728**	**0.482**	**0.348**	**1**	**24**	**1**	**22**	**6**	**24**	**0.608**	**0.558**	**8**	**24**	**0.665**	**0.519**	**1.5**	**1.3**
395	0.344	0.283	0.759	0.378	0.312	1	20	1	19	4	24	0.654	0.550	6	25	0.705	0.456	2.0	1.5
394	0.326	0.251	0.860	0.382	0.286	1	16	1	17	3	24	0.717	0.554	5	24	0.785	0.460	2.3	1.7
393	0.313	0.228	0.921	0.378	0.267	1	14	1	16	3	24	0.806	0.585	5	24	0.862	0.470	2.4	1.8
392	0.303	0.208	0.992	0.329	0.251	1	13	1	15	3	25	0.906	0.620	6	24	0.948	0.452	3.0	2.1



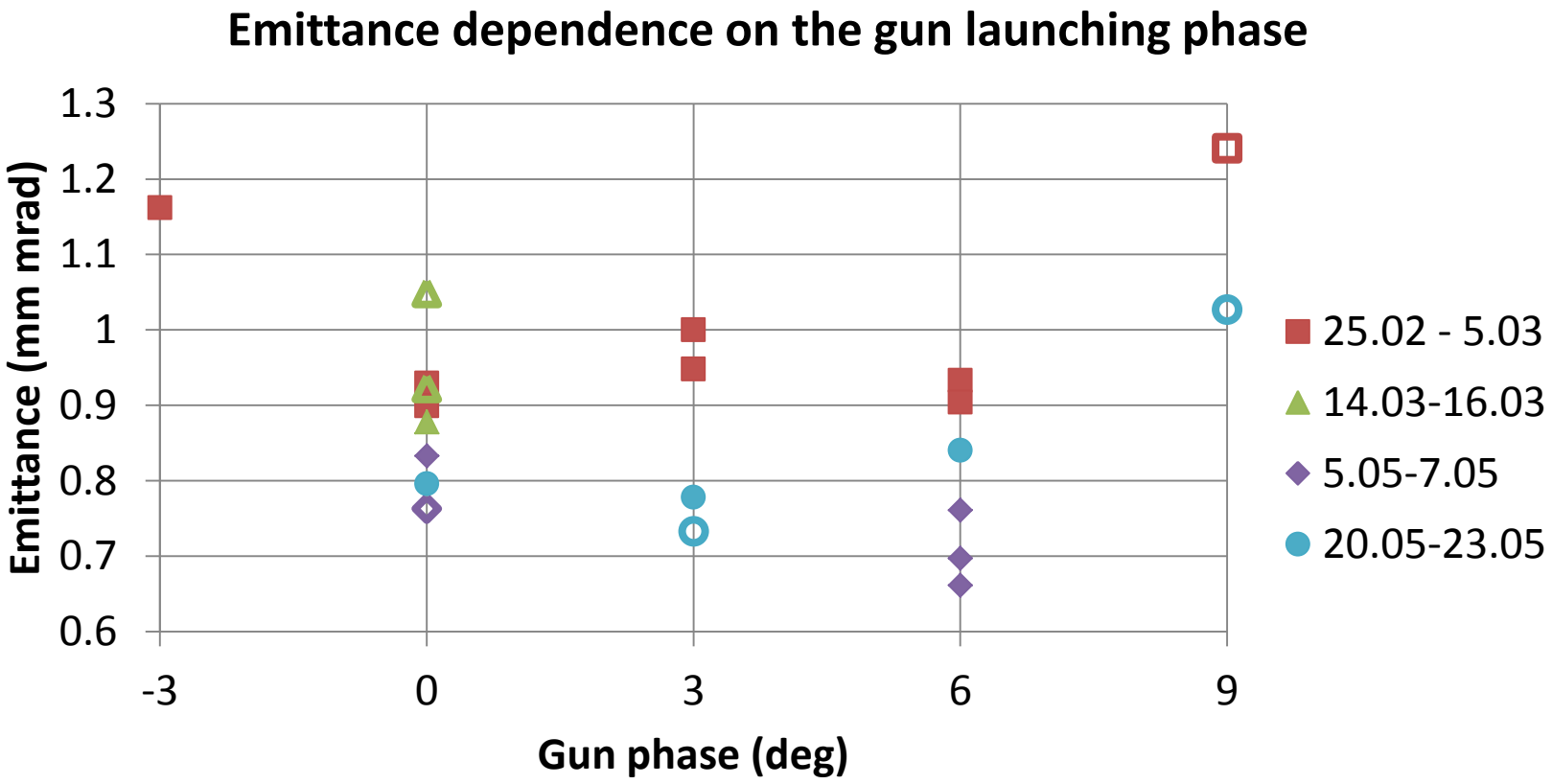
meas	beam size @ EMSY			X-emittance		Y-emittance		XYemit, scaled	XYemit, nonscaled
	X	Y	XY	scaled	nonscaled	scaled	nonscaled		
1	0.399	0.328	0.362	0.755	0.468	0.653	0.586	0.707	0.524
2	0.399	0.328	0.362	0.747	0.474	0.625	0.550	0.683	0.511
3	0.399	0.328	0.362	0.600	0.496	0.646	0.550	0.719	0.522
4	0.387	0.316	0.350	0.762	0.512	0.618	0.562	0.685	0.536
5	0.387	0.316	0.350	0.755	0.483	0.605	0.559	0.675	0.520
6	0.387	0.316	0.350	0.755	0.456	0.608	0.559	0.665	0.509
7	0.335	0.292	0.313	0.653	0.522	0.576	0.570	0.615	0.537
8	0.335	0.292	0.313	0.645	0.485	0.592	0.573	0.600	0.518
9	0.335	0.292	0.313	0.655	0.473	0.543	0.552	0.599	0.511
Mean	0.374	0.312	0.342	0.724	0.484	0.603	0.560	0.661	0.520
Std	0.029	0.016	0.022	0.056	0.018	0.038	0.012	0.046	0.011



07.05.2011N
from sol.scan:
X-emit=0.728
Y-emit=0.608
XY-emit=0.665

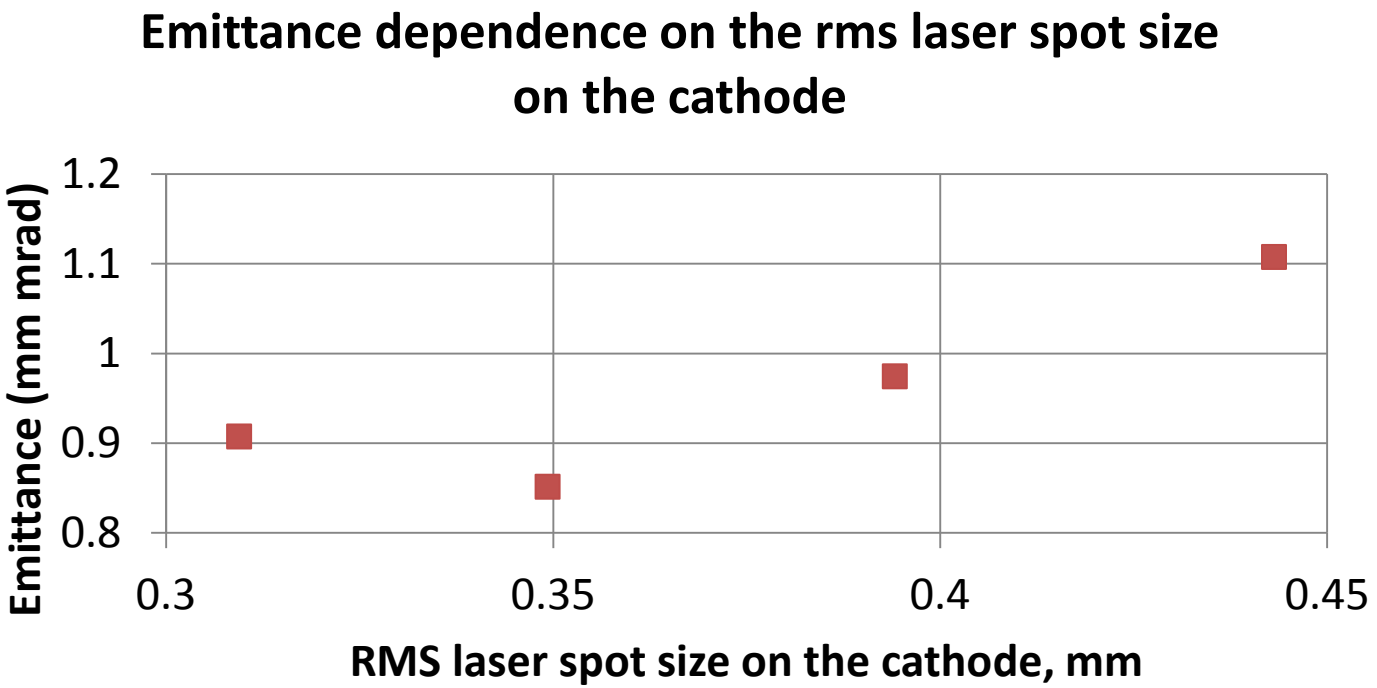
07.05.2011N:
3x3 stat:
Xemit=0.724
Y-emit=0.603
XY-emit=0.661

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

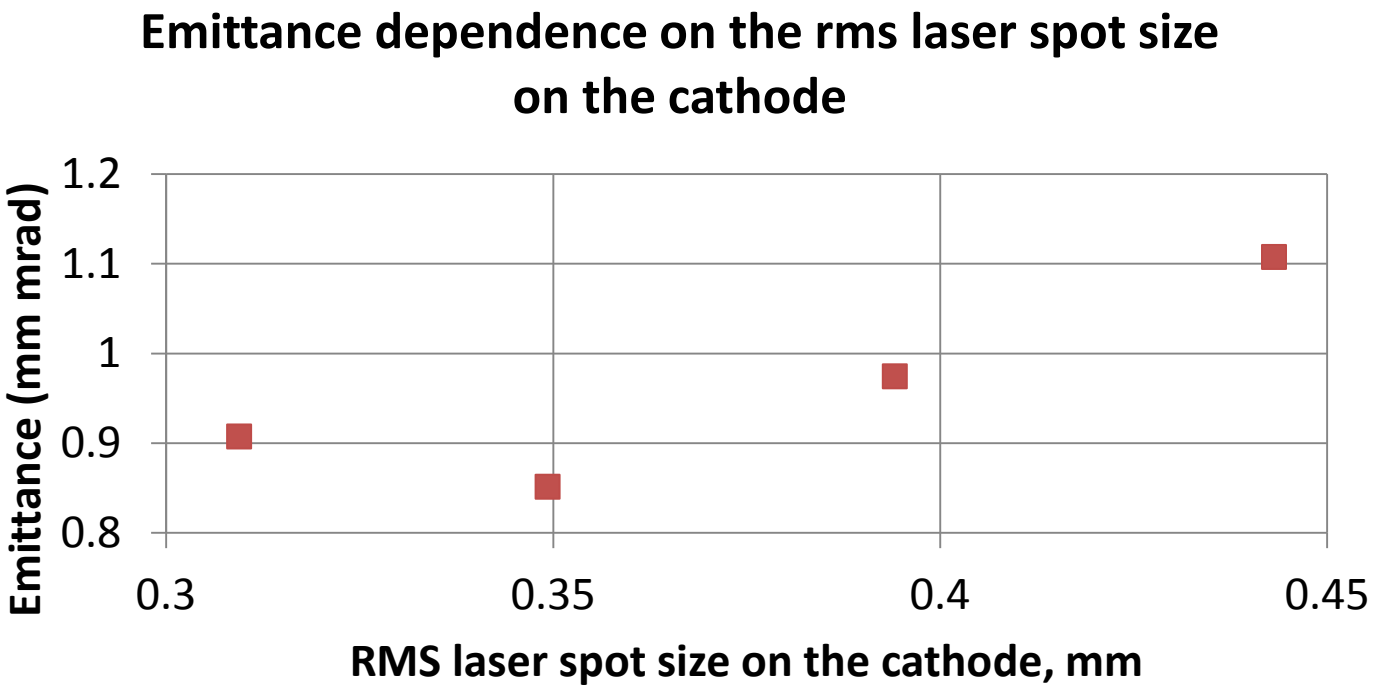


Gaussian laser temporal profile with FWHM ~ 12 ps
Gun at maximum power => ~6.6 MeV/c electron beam momentum, MMMG phase
Booster at maximum power => 24.6 MeV/c electron beam momentum, MMMG phase

Xyrms, mm	Emittance, mm mrad	Stdev, mm mrad
0,443	1,107	0,008
0,394	0,974	0,014
0,349	0,851	0,007
0,309	0,907	0,09

Gauss 30.05-31.05

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



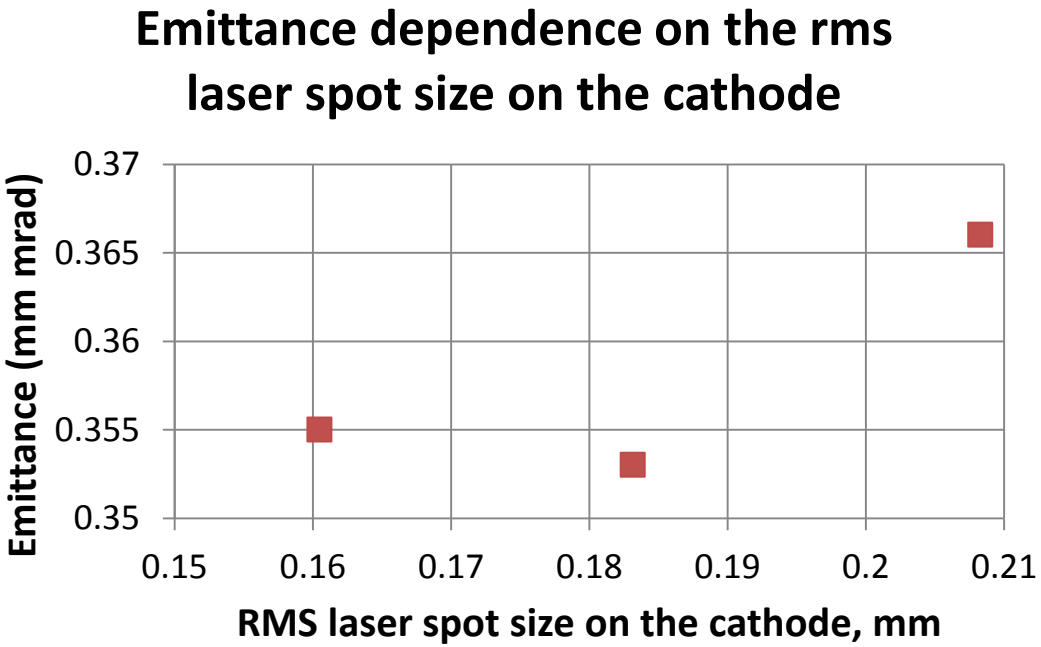
Gaussian laser temporal profile with FWHM ~ 12 ps
Gun at maximum power => ~6.6 MeV/c electron beam momentum, MMMG phase
Booster at maximum power => 24.6 MeV/c electron beam momentum, MMMG phase

Xyrms, mm	Emittance, mm mrad	Stdev, mm mrad	Difference, %
0,3	0,807	0,09	5
0,349	0,851	0,007	
0,309	0,907	0,09	

Flattop 21.05

1.05

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

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
- 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.
- 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 about 8-9 % higher emittance values for 1 nC and 250 pC charges than in Flattop case.

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