Simulations for low charge beams at PITZ

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PITZ Physics Seminar

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Content

- PITZ1.7 setup:
- Simulations for 10pC bunch charge@long flat-top
- Measurement results and simulations for low bunch charge@short Gaussian

Description of the 'optimization' process

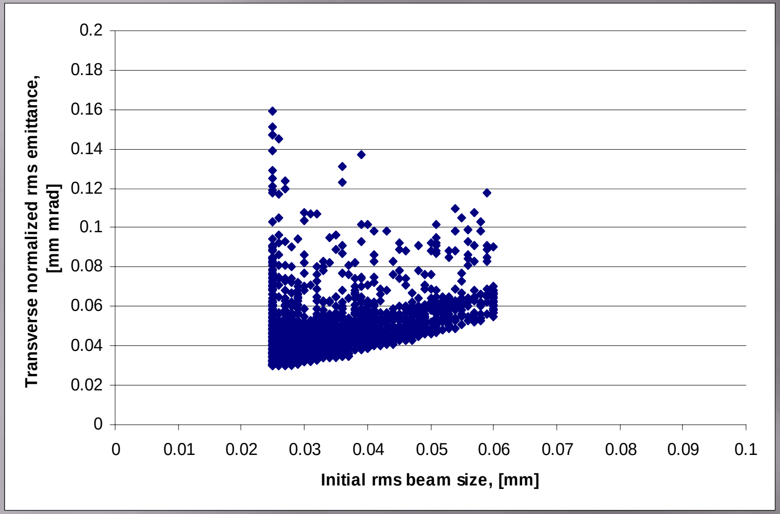
During the optimization process the following parameters were constant:

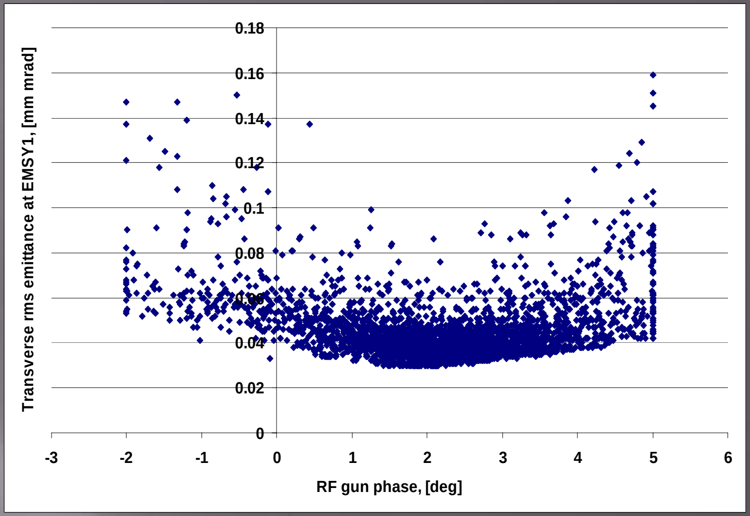
- bunch charge (10pC),
- temporal laser flat-top distribution (20ps FWHM) and rise/fall time (2ps),
- thermal kinetic energy in the cathode (0.55eV),
- gun gradient (60MV/m).
- the reference screen is EMSY1 (5.74m downstream from the cathode).
- Solenoid calibration: B(T)=B1*I(A)+B2, where B1=0.00058838, B2=0.000004084

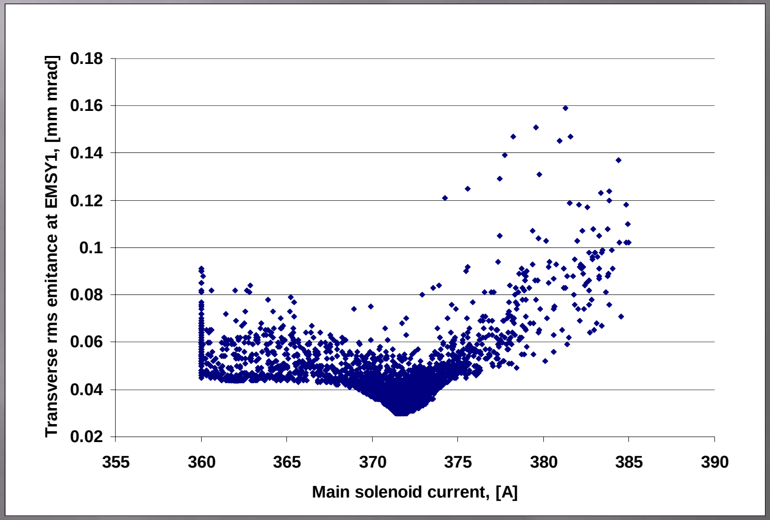
Five parameters were variable:

- RF gun ([-2:5]deg) and booster ([-2:2]deg) phases,
- booster gradient ([2:10]MV/m),
- Initial rms beam size ([0.025:0.06]mm) and main solenoid current ([360:385]A) .

Optimization was done with 50kp







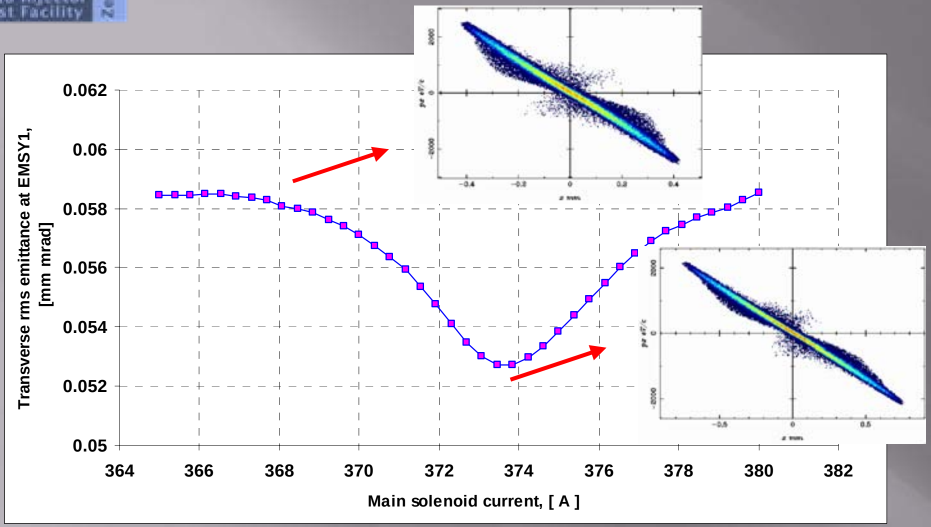
1. For 10pC charge one should go To a smaller BSA's about 0.1mm **but** current min available BSA is 0.2mm

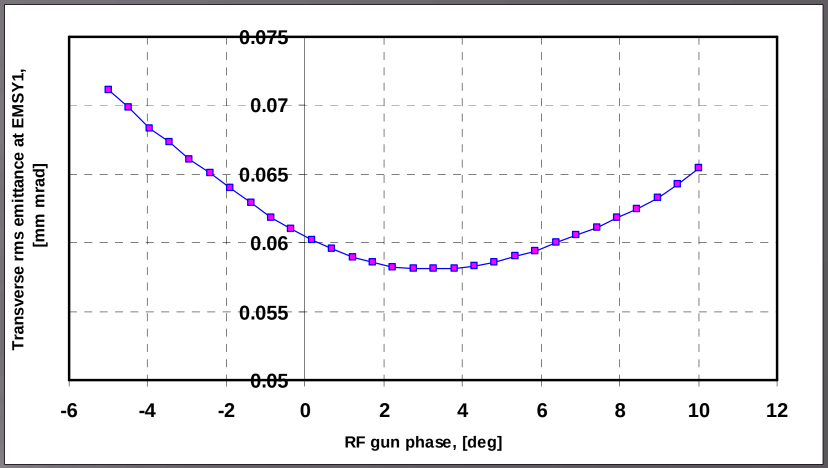
2. Min emittance at about [1-3]deg gun phase

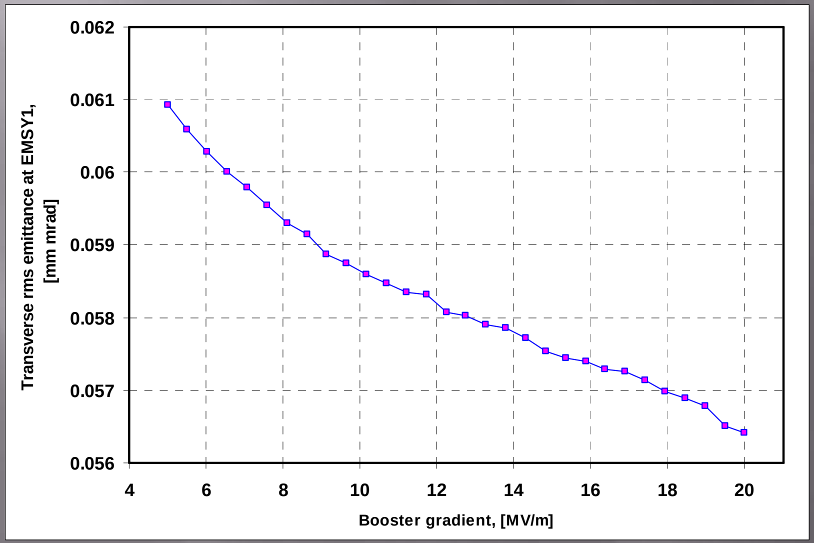
3. Small emittance values at Imain-[368-374]A

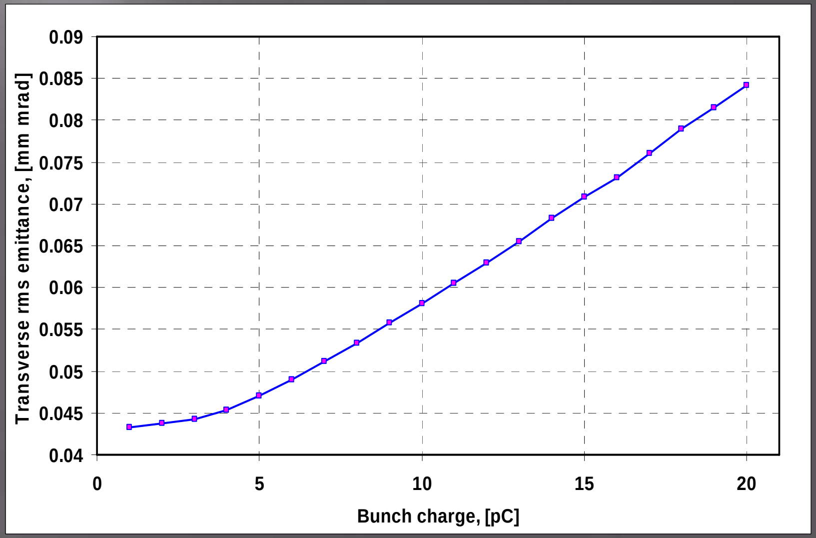
Bunch charge, temporal laser flat-top distribution: FWHM, rise/fall time Thermal kinetic energy	RF gun phase (from max mom. gain) [deg]	Booster phase (from max mom. gain) [deg]	Main solenoid current [A]	Initial rms beam size [mm]	Booster gradient [MV/m]
10pC 20ps, 2ps 0.55eV	3.008	-0.096	368.263	0.05	10
Trans. rms emitttance, [mm mrad] EMSY1	**Transverse rms beam size, [mm] EMSY1**	**Rms energy spread, [keV] EMSY1**	**Average kinetic energy, [MeV] EMSY1**	**Long. beam size, [mm] EMSY1**	**Long. emittance, [pi keV mm] EMSY1**
0.056994	0.1042	14.47	11.77 Pz~12MeV/c	1.379	16.66

Emittance as a function of different machine parameters



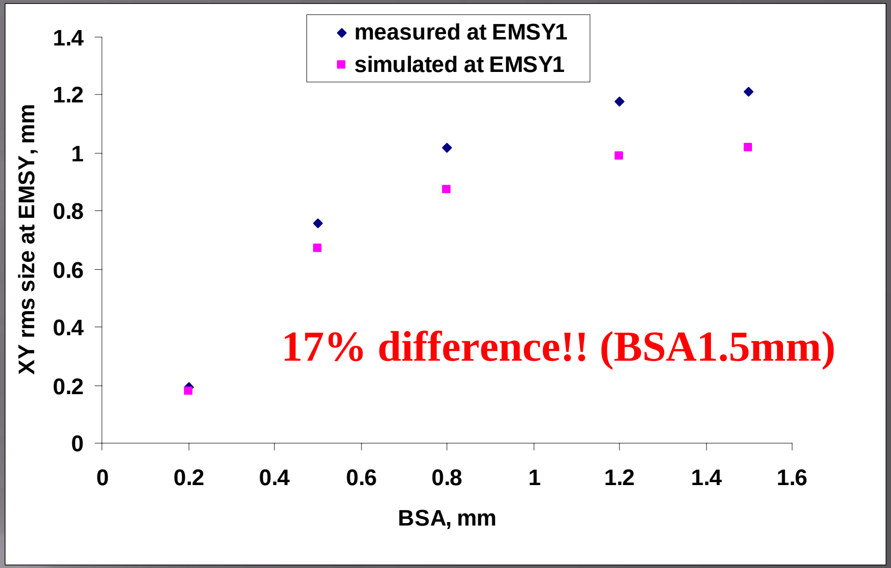


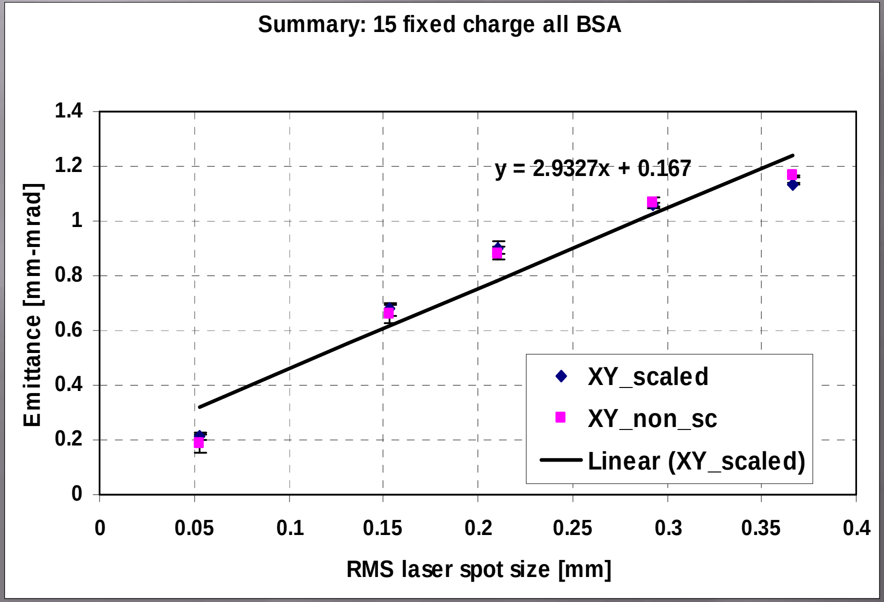


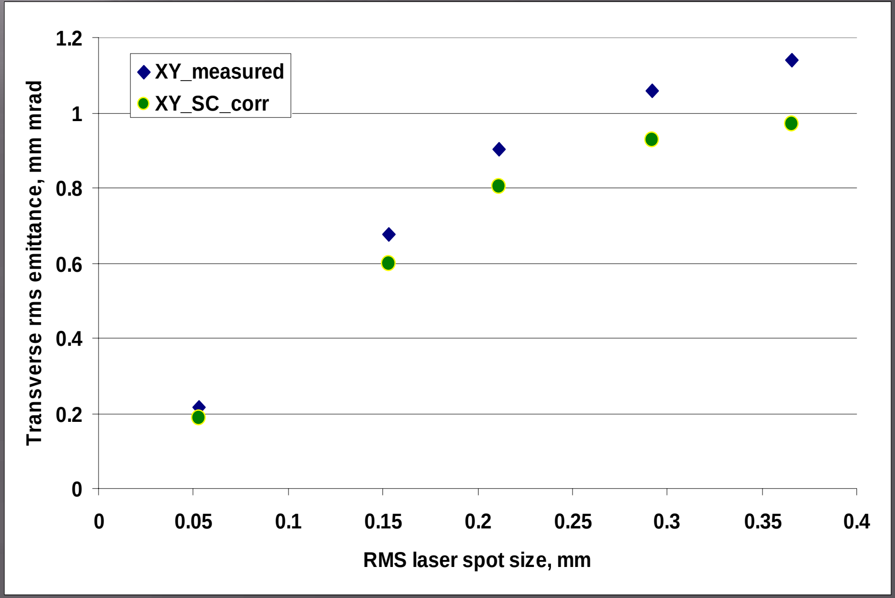


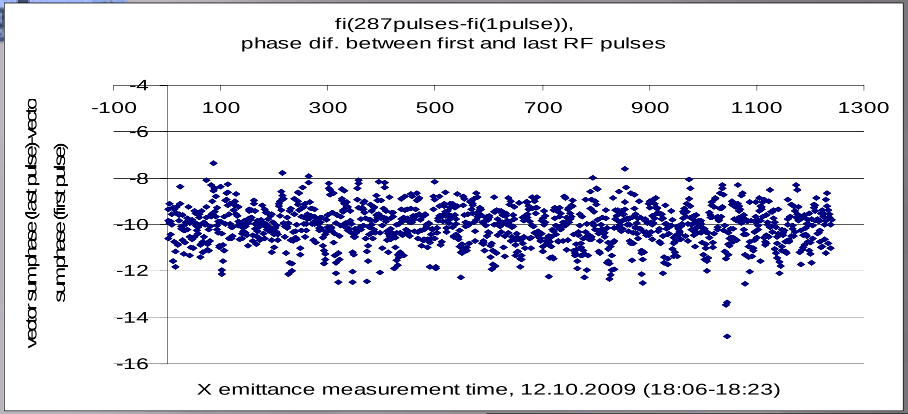
Measurement and simulation results for 15 pC bunch charge and different BSA's

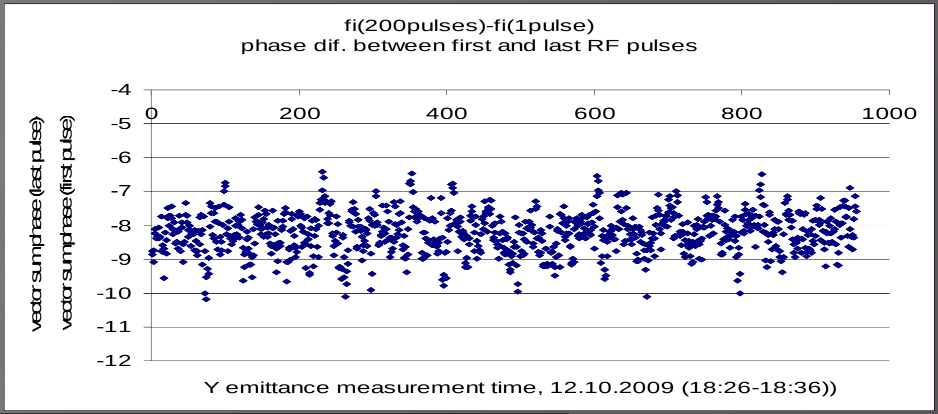
BSA,mm	Number of pulses used for hor. emittance measurements	Number of pulses used for vert. emittance measurements
0.2 (10pC)	7	7
0.5	75	87
0.8	125	155
1.2	175	200
1.5	287	200

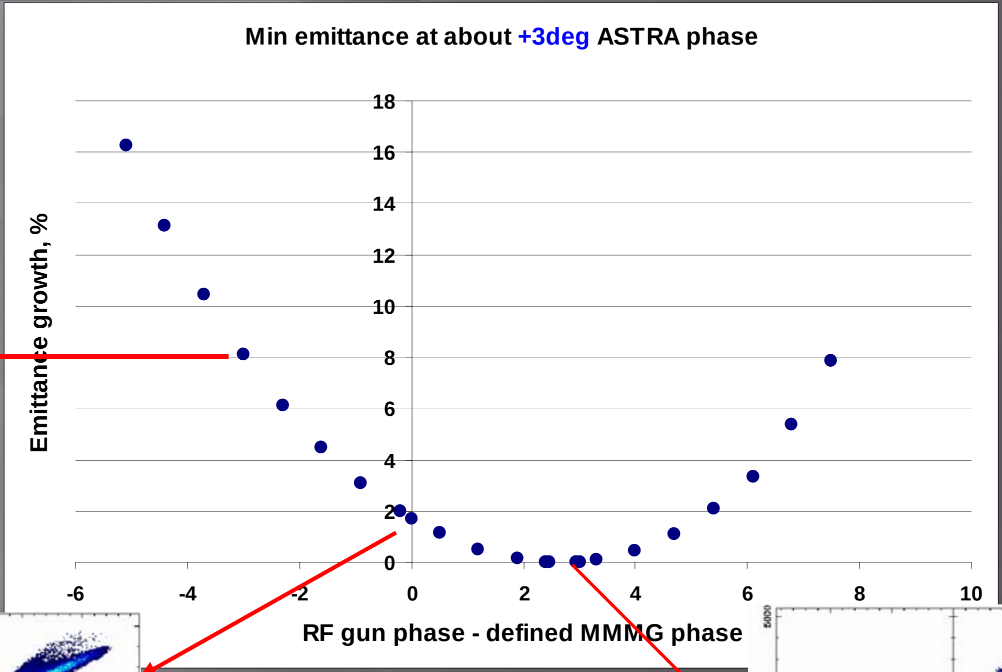


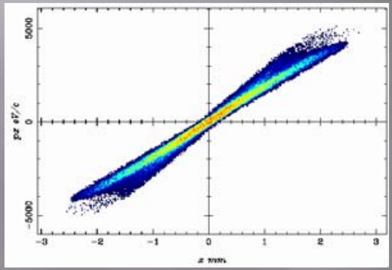


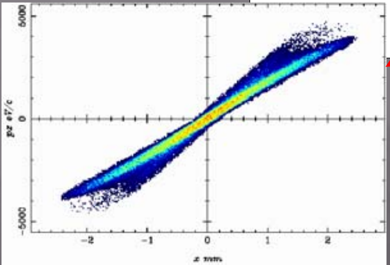


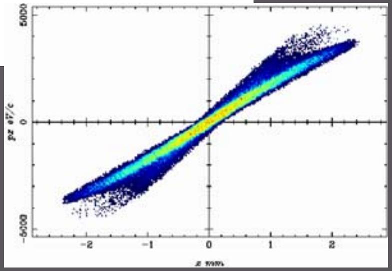

fi(287pulses-fi(1pulse)),
phase dif. between first and last RF pulses
vector sumphase (last pulse)-vector sumphase (first pulse)
-4
-6
-8
-10
-12
-14
-16
-100
100
300
500
700
900
1100
1300
X emittance measurement time, 12.10.2009 (18:06-18:23)


fi(200pulses)-fi(1pulse)
phase dif. between first and last RF pulses
vector sumphase (last pulse)
vector sumphase (first pulse)
-4
-5
-6
-7
-8
-9
-10
-11
-12
0
200
400
600
800
1000
Y emittance measurement time, 12.10.2009 (18:26-18:36))


Min emittance at about +3deg ASTRA phase
Emittance growth, %
18
16
14
12
10
8
6
4
2
0
-6
-4
-2
0
2
4
6
8
10
RF gun phase - defined MMMG phase



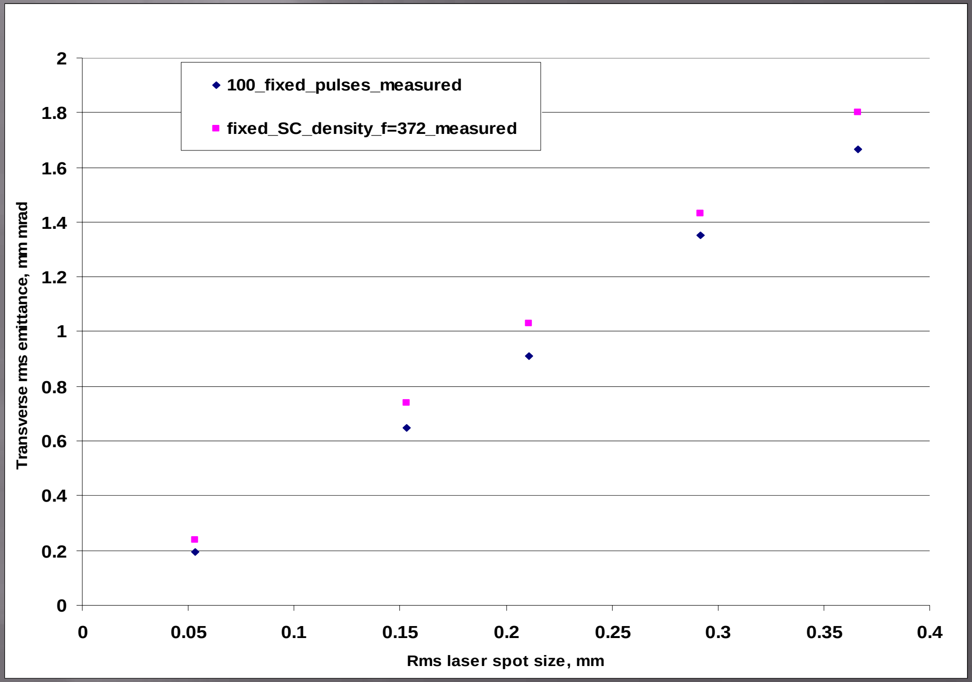




$$f_{SC} = \frac{Q(pC)}{FWHM \cdot (XY_{laser})^2} = \frac{1000}{20 \cdot (0.366)^2} \sim 373$$

Charge density at cathode, pC/mm^2	BSA1.5 mm Q, pC	BSA1.2 mm Q, pC	BSA0.8 mm Q, pC	BSA0.5mm Q, pC	BSA0.2mm Q, pC
372	50	32	17	9.7	1.05
Number of RF pulses used for the measurement X/Y	100/110	125/150	125/155	110/115	51/78

BSA, mm	Bunch charge, pC Fixed 100 pulses (f~222)
0.2	1.4
0.5	11.8
0.8	20
1.2	36
1.5	47



} ⇒ 13%

} ⇒ 8.2%

} ⇒ 11.8%

} ⇒ 9.12%

} ⇒ 4.6%

Summary and outlook

- It seems that for low charge (~10pC) optimal ASTRA phase is +3 deg for the injector optimized at 1nC charge (+6 deg in that case) but one has to go to detailed investigations (bigger BSA's, RF studies ...)
- For the case of short Gaussian (more pronounced space charge…) profile the charge density factor has to be carefully set for low charge measurements

- Continue RF investigations…
- Do 'optimization' for PITZ1.8 setup (CDS booster)

Thank you for your attention!