

Beam dynamics simulation compared with the 100 pC emittance measurement

- **Simulation set up with experiment parameters**
- **Simulation results and compared with the experiment results**
- **conclusions**

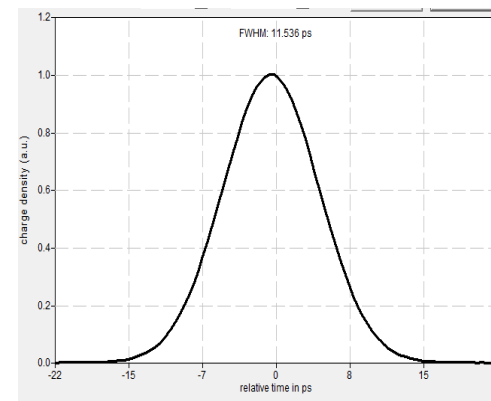
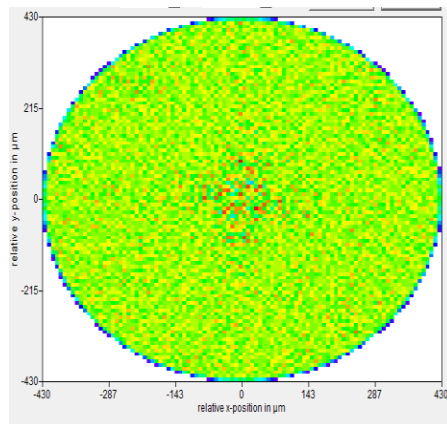
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PITZ physics Seminar

Zeuthen, 23.04.2015

Simulation setup: according to experiment parameters (31.03_A)

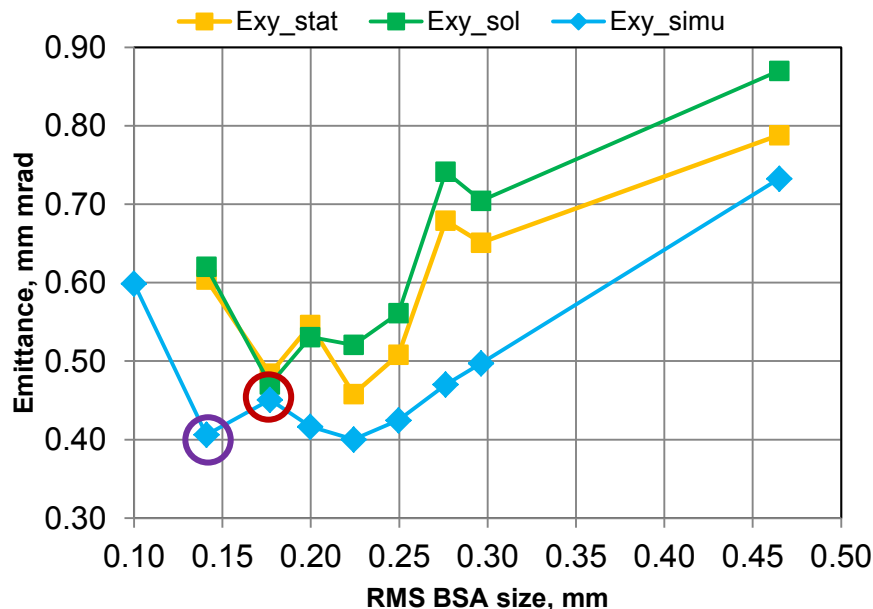
- Laser pulse : Gaussian pulse, with FWHM= 11.5 ps
- Charge: 100 pC
- Momentum: LEDA = 6.116 MeV/c, HEDA1 = 21.117 MeV/c
- Gun: MMMG phase, with field gradient = 54.25 MV/m (LEDA: 6.12 MeV/c)
- Booster: MMMG phase, with field gradient = 17.2 MV/m (HEDA1: 21.13 MeV/c)
- Experiment: booster position, Z = 2.675 m, EMSY1 position, Z = 5.277 m.
- *according to PITZ2.5 coordination



Simulation results compared with emittance measurement results for different BSA size

> At each laser beam size, take the solenoid scan for minimum emittance

BSA	Xrms	Yrms	Xyrms	Ex_sol	Ey_sol	Exy_sol	Shift	Ex_stat	Ey_stat	Exy_stat	Exy_simu
			0.100								0.598
0.6	0.137	0.145	0.141	0.836	0.460	0.620	30.03_A	0.709	0.514	0.604	0.406
0.7	0.172	0.182	0.177	0.613	0.361	0.470	31.03_M	0.595	0.395	0.484	0.450
0.8	0.190	0.210	0.200	0.568	0.496	0.531	31.03_A	0.516	0.579	0.546	0.416
0.9	0.214	0.235	0.224	0.549	0.494	0.521	31.03_A	0.46	0.458	0.458	0.4002
1	0.236	0.264	0.250	0.595	0.529	0.561	02.04_A	0.547	0.471	0.508	0.424
1.1	0.265	0.288	0.276	0.824	0.667	0.741	03.04_M	0.675	0.683	0.679	0.470
1.2	0.288	0.305	0.296	0.743	0.668	0.705	03.04_A	0.665	0.638	0.651	0.497
1.4	0.465	0.465	0.465	0.821	0.922	0.870	04.04_M	0.828	0.750	0.788	0.732



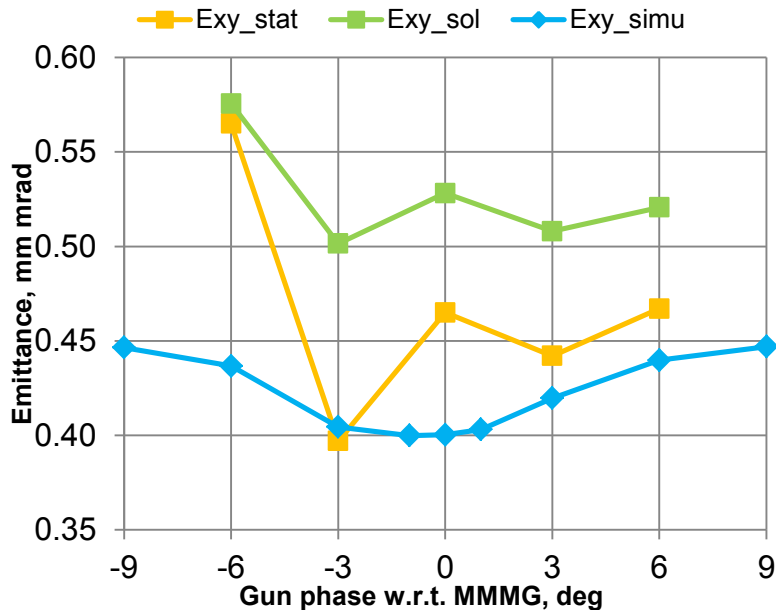
- > For BSA ≥ 0.8 mm, the minimum emittance effected by laser beam size from simulation are consistent with measurement, for BSA = 0.6mm, 0.7mm, simulation result is quite different from measurement. (?)
- > One more point for Xyrms = 0.1 mm was simulated, the emittance becomes large.
- > The minimum emittance from simulation occurred at $I_{\text{main}} = 353\text{A}$ (0.2072 T/m), a little different with measurement $I_{\text{main}} = 356$ (0.2082 T/m)



Solenoid scan for BSA = 0.9 mm at different gun phase

- For BSA = 0.9 mm, take the solenoid scan for minimum emittance by change the gun phase w.r.t MMMG phase.

Gphase; deg (relative to MMMG)	Ex_sol	Ey_sol	Exy_sol	Ex_stat	Ey_stat	Exy_stat	Exy_simulation
-6	0.696	0.476	0.576	0.687	0.465	0.565	0.4397
-3	0.548	0.459	0.502	0.474	0.332	0.397	0.4197
0	0.580	0.481	0.528	0.515	0.419	0.465	0.4002
3	0.581	0.444	0.508	0.502	0.381	0.442	0.404
6	0.560	0.484	0.521	0.515	0.424	0.467	0.4366

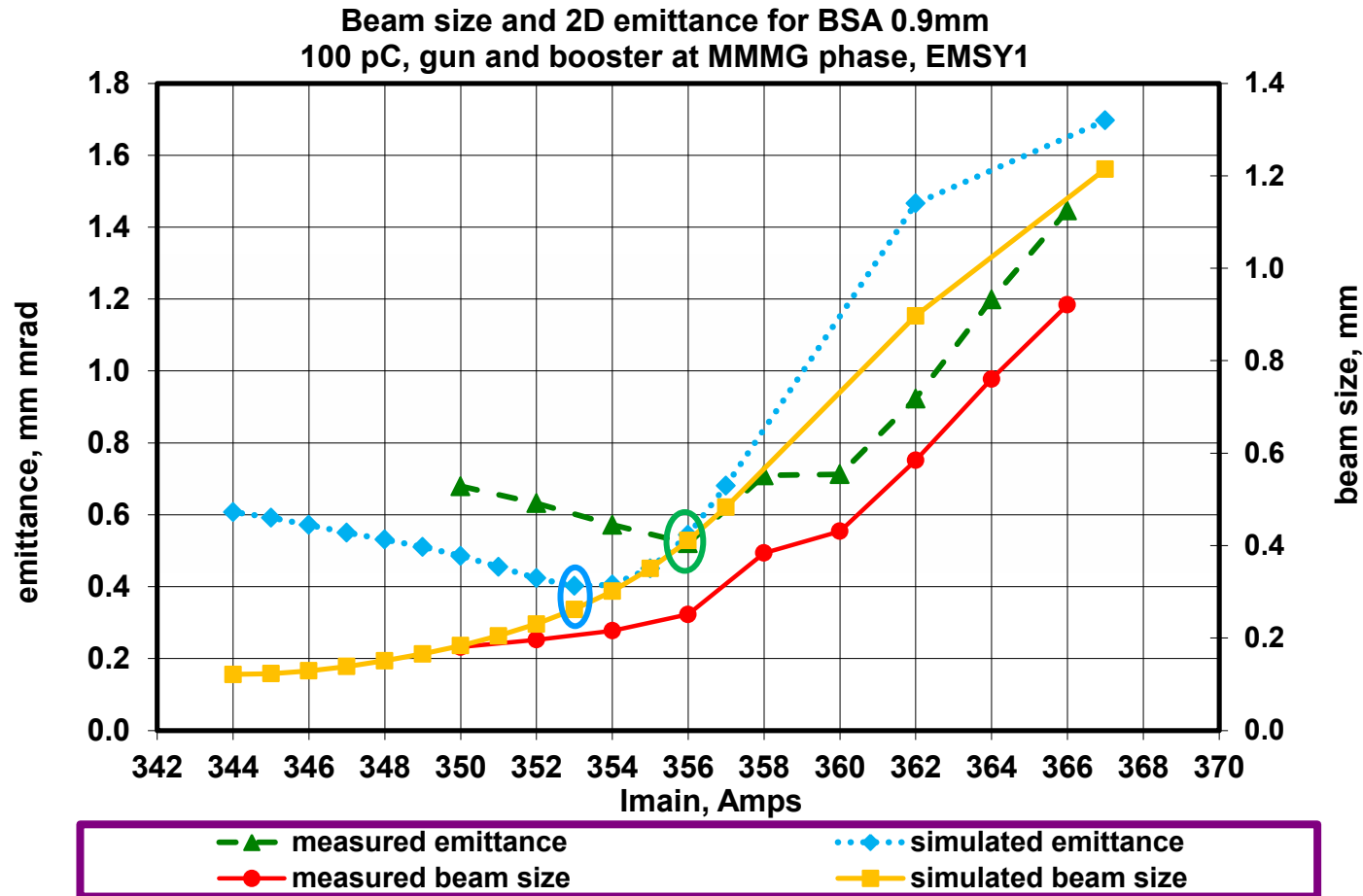


- From simulation, the minimum emittance occurred at phase (MMMG-1), not consistent with the measurement (MMMG -3).
- The dependence of the emittance value on gun rf phase is rather weak in simulation, but stronger in experiment.



Solenoid scan for BSA = 0.9 mm compared with measurement and simulation

- Gun and booster work at MMMG phase, laser beam size $X_{rms} = 0.224\text{mm}$



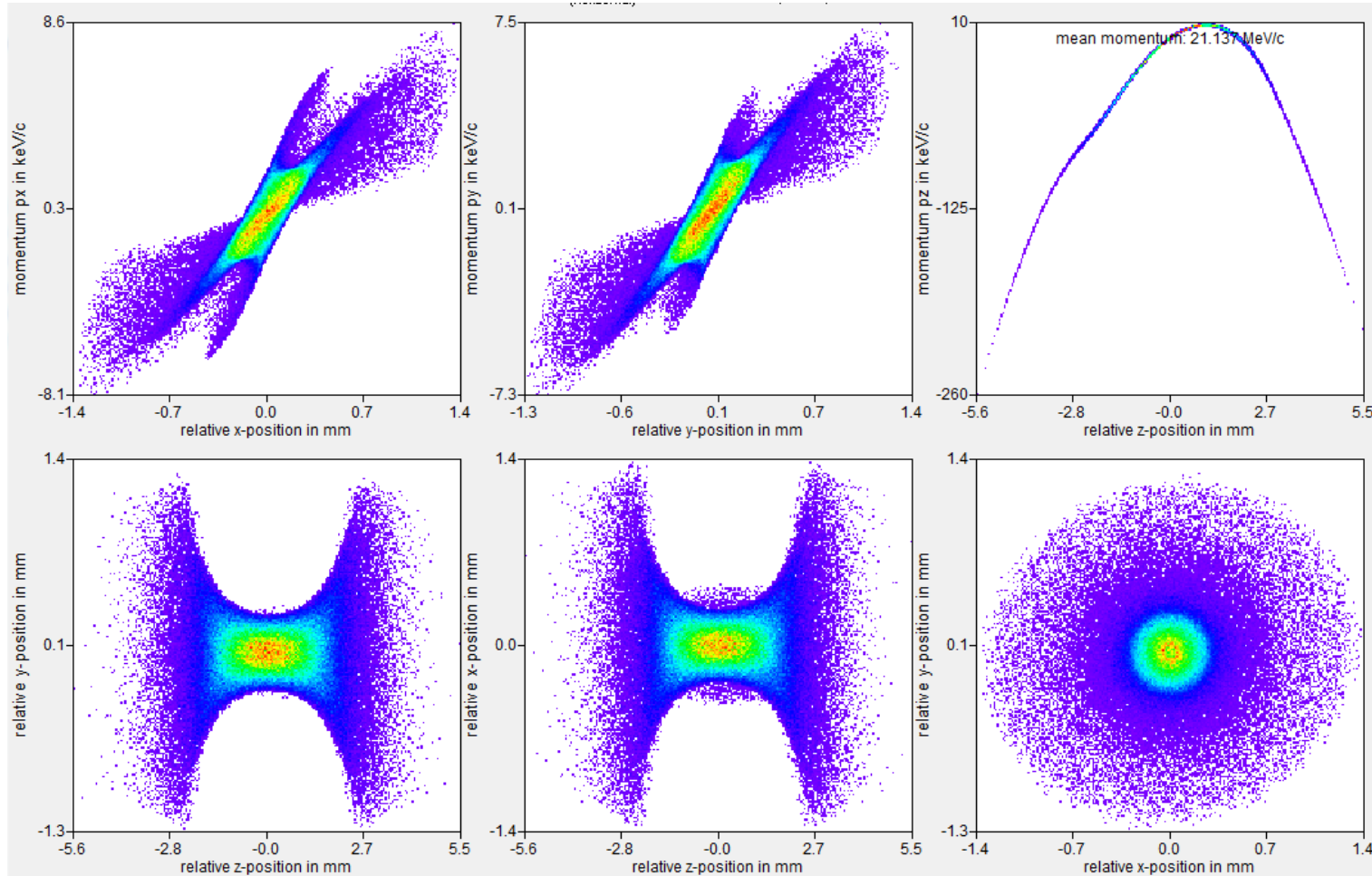
- The solenoid scan for the emittance and beam size at MMMG phase from simulation are consistent with measurement, with a little different of I_{main}.



Simulation results with experiment parameters setting except I_{main} (BSA = 0.9 mm)

➤ solenoid scan for minimum emittance. $I_{\text{main}} = 353$ A

Bfield= 0.2072 T/m



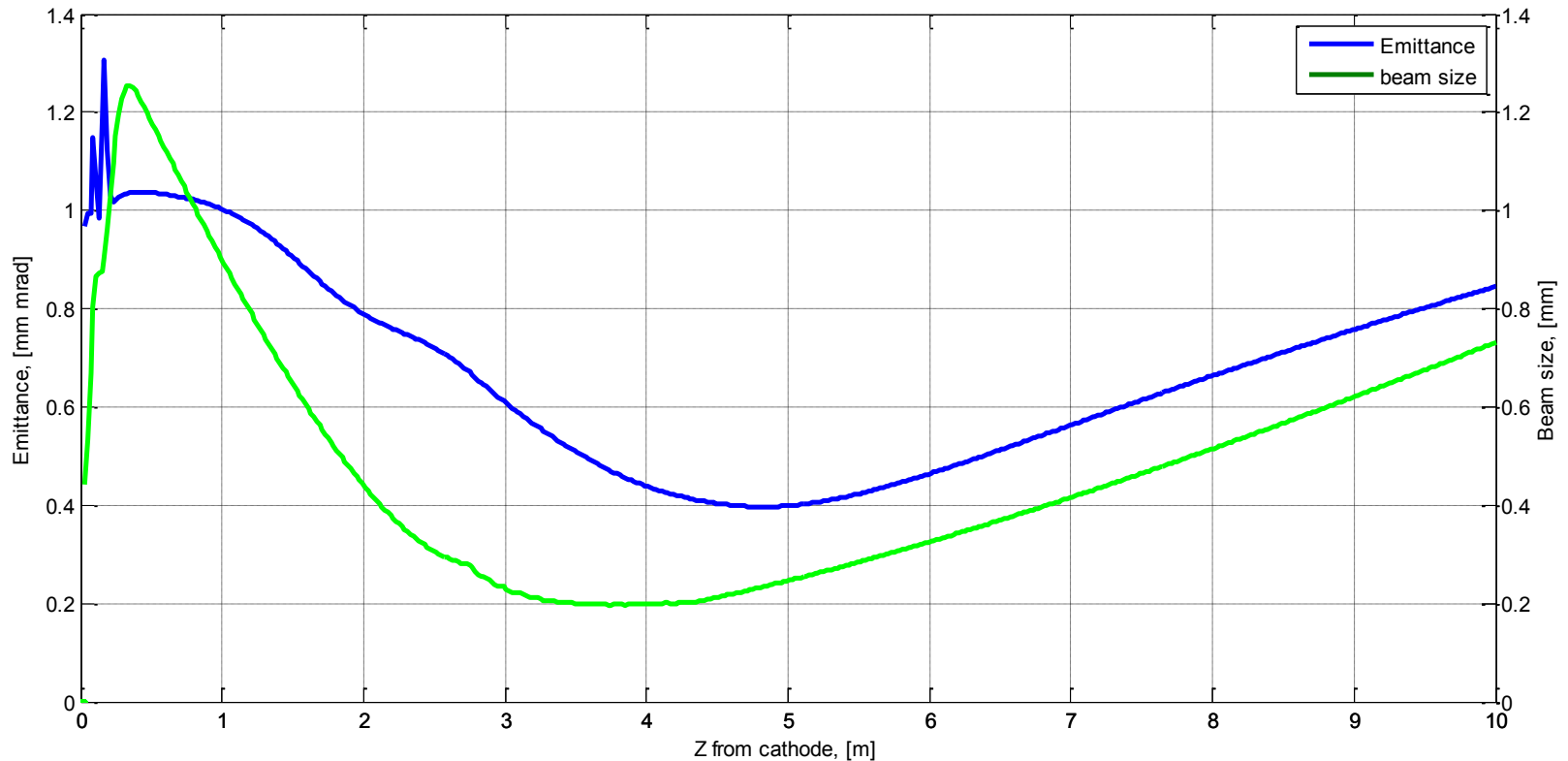
Phase spaces and beam distributions , Emittance_{xy} = 0.4002 mm mrad



Simulation results with experiment parameters setting except $I_{\text{main}} = 0.9 \text{ mm}$ (2)

> solenoid scan for minimum emittance. $I_{\text{main}} = 353 \text{ A}$

$B_{\text{field}} = 0.2072 \text{ T/m}$



Emittance and beam size along the beam line

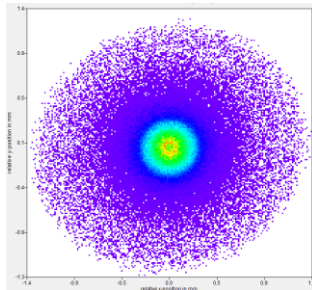
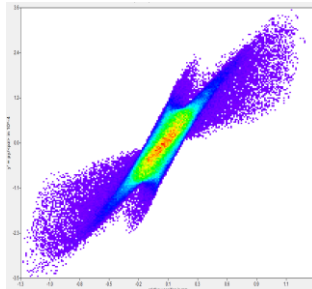
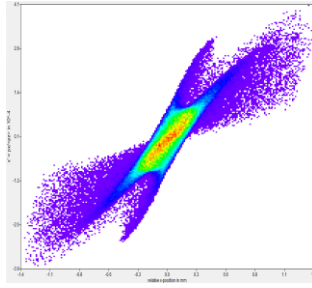


Simulation phase space and beam size compared with measurement at minimum emittance

simulated phase space at EMSY1

$I_{\text{main}} = 353 \text{ A}$

Simulation: $E_{xy_sim} = 0.402 \text{ mm mrad}$



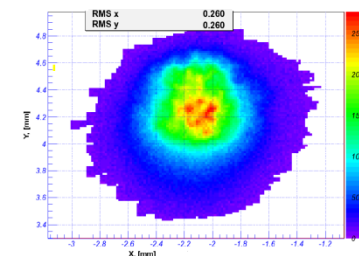
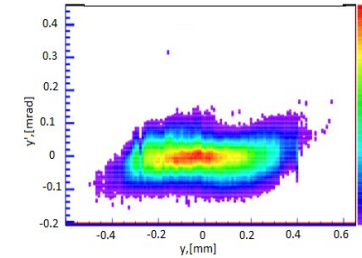
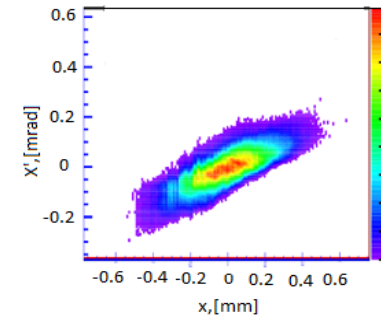
beam size at EMSY1

$X_{rms} = 0.269 \text{ mm}$, $y_{rms} = 0.259 \text{ mm}$

Measured phase space at EMSY1

$I_{\text{main}} = 356 \text{ A}$

Measurement: $E_{xy_sta} = 0.458 \text{ mm mrad}$



Measurement beam size at EMSY1

$X_{rms} = y_{rms} = 0.26 \text{ mm}$

conclusions

- For $BSA \geq 0.8$ mm, the minimum emittance effected by laser beam size from simulation are consistent with measurement, for $BSA = 0.6$ mm, 0.7 mm, simulation result is quite different from measurement. (?)
- The dependence of the emittance value on gun RF phase is rather weak in simulation, but stronger in experiment. The minimum emittance from simulation occurred at phase (MMMG-1), not consistent with the measurement (MMMG phase – 3).
- The phase space and beam size from simulation at minimum emittance setting parameters is consistent with the measurement except the symmetry between x and y.
- In general, for 100 pC, the simulation by Astra with experiment machine parameters setting can produce the very close results to experiment measurement.

