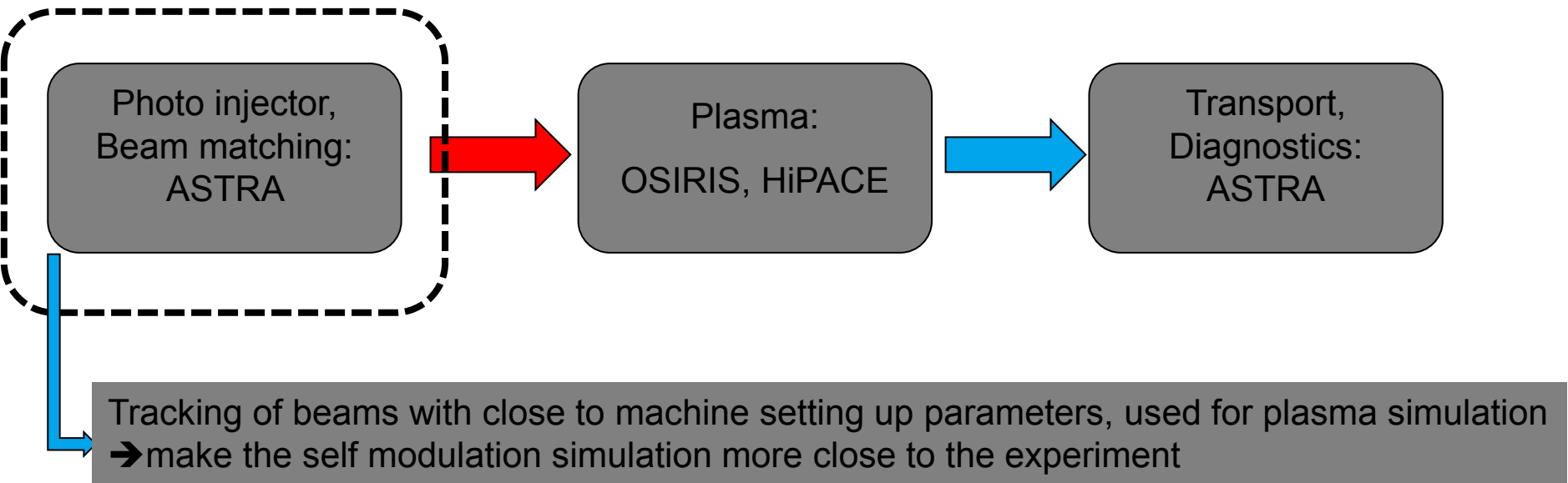# Electron beam for self modulation experiments with current machine settings

- **Motivation**

- **The difference between current and before simulation setting**

- **Simulation results**

- **Conclusions**

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PITZ PPS meeting
Zeuthen, 30.07.2015

HELMHOLTZ | ASSOCIATION

DESY

Motivation

➢ Start to end simulation of PITZ self modulation experiment

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┌─────────────────┐      ┌─────────────────┐      ┌─────────────────┐
│  Photo injector,│      │  Plasma:        │      │  Transport,     │
│  Beam matching: │ ───▶ │                 │ ───▶ │  Diagnostics:   │
│  ASTRA          │      │  OSIRIS, HiPACE │      │  ASTRA          │
└─────────────────┘      └─────────────────┘      └─────────────────┘
```

Tracking of beams with close to machine setting up parameters, used for plasma simulation
➔make the self modulation simulation more close to the experiment

➢ Requirements for an electron beam with 100pC charge:

> Smooth beam transverse focusing at the entrance of plasma (z = 6.2 m)
> Transverse beam rms size ~50 um

The difference between current and before simulation setting

parameters	E field Gun/ Booster	Laser profile
before	61/17.5	Flatten top, FWHM 22.5ps
Now(current machine setting)	54/17.2	Gaussian, FWHM 11.5 ps

- ➢ Transverse laser rms spot size on the cathode 0.3mm
- ➢ Solenoid scan for e-beam focus at Booster BPM2 (4.61m)

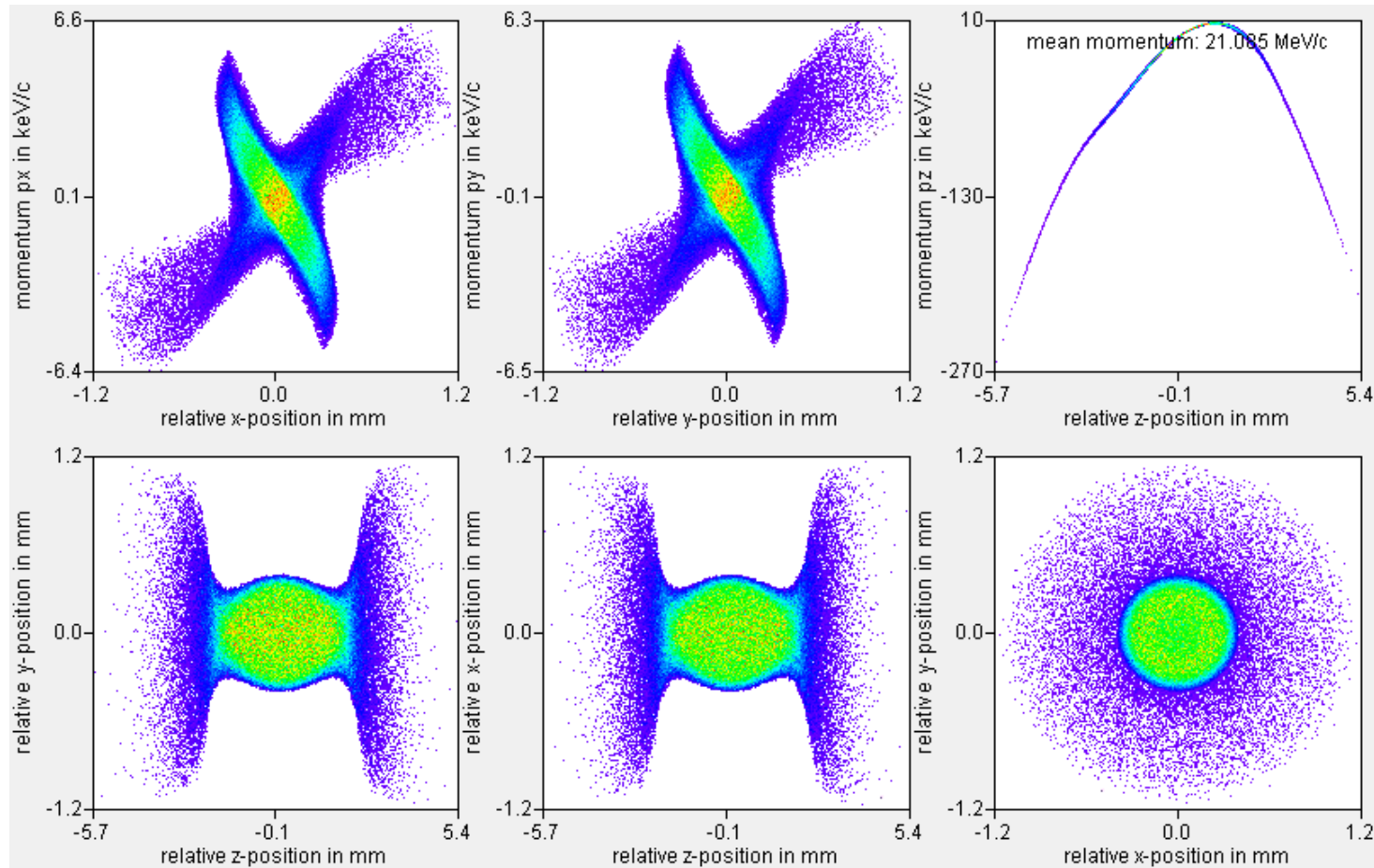Twiss parameters and emittance at booster BPM2 are different for above two cases:

parameters	Momentum (MeV/c)	Emittance (mm mrad)	ALF	BET	Bunch length (mm)
#before	22.01	1.678	-12.28	51.02	1.882
now	21.08	0.8	0.2434	2.557	1.348

from Yves simulation

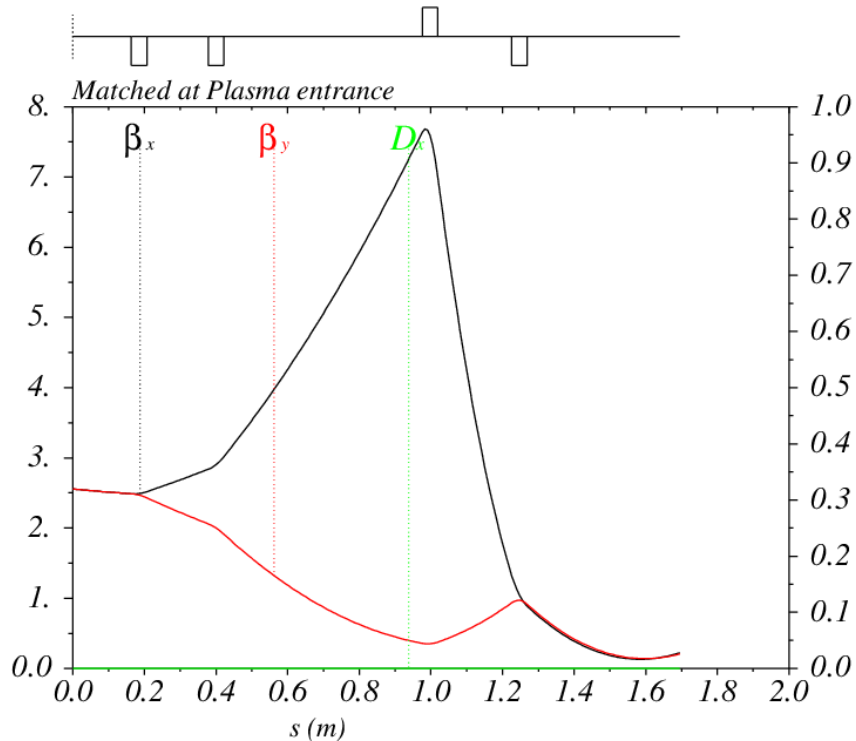# Beam focused at Booster BPM2 (4.61m) by solenoid with current machine setting

Z=4.61

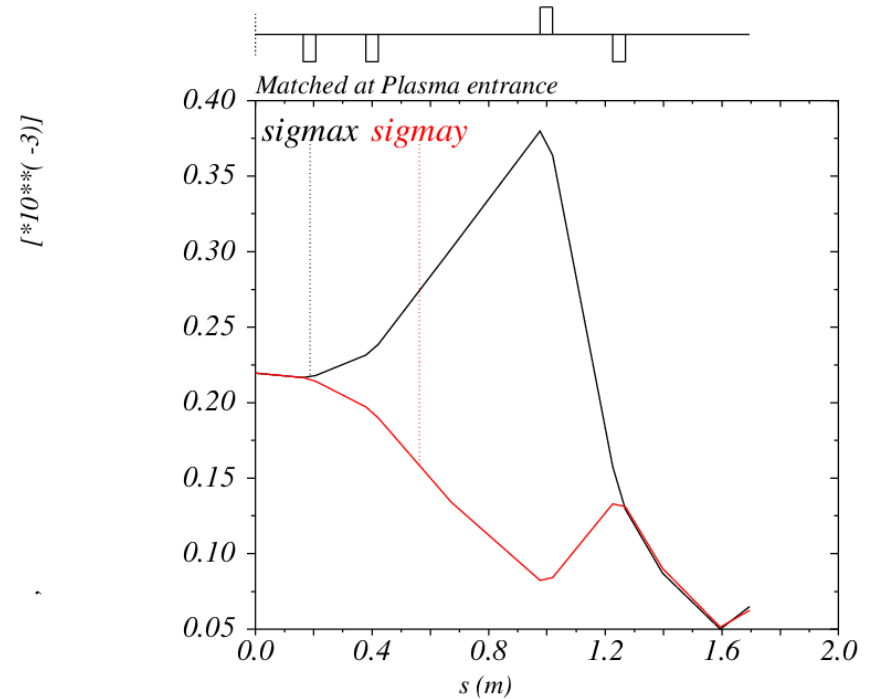| parameters	Sigm_x (um)	Sigm_y (um)	EMX (mm mrad)	EMY (mm mrad)	Bunch length (mm)
At Z=4.61	220	220	0.78	0.78	1.348

Matching to plasma entrance, at Z=6.2 m

50 um matching

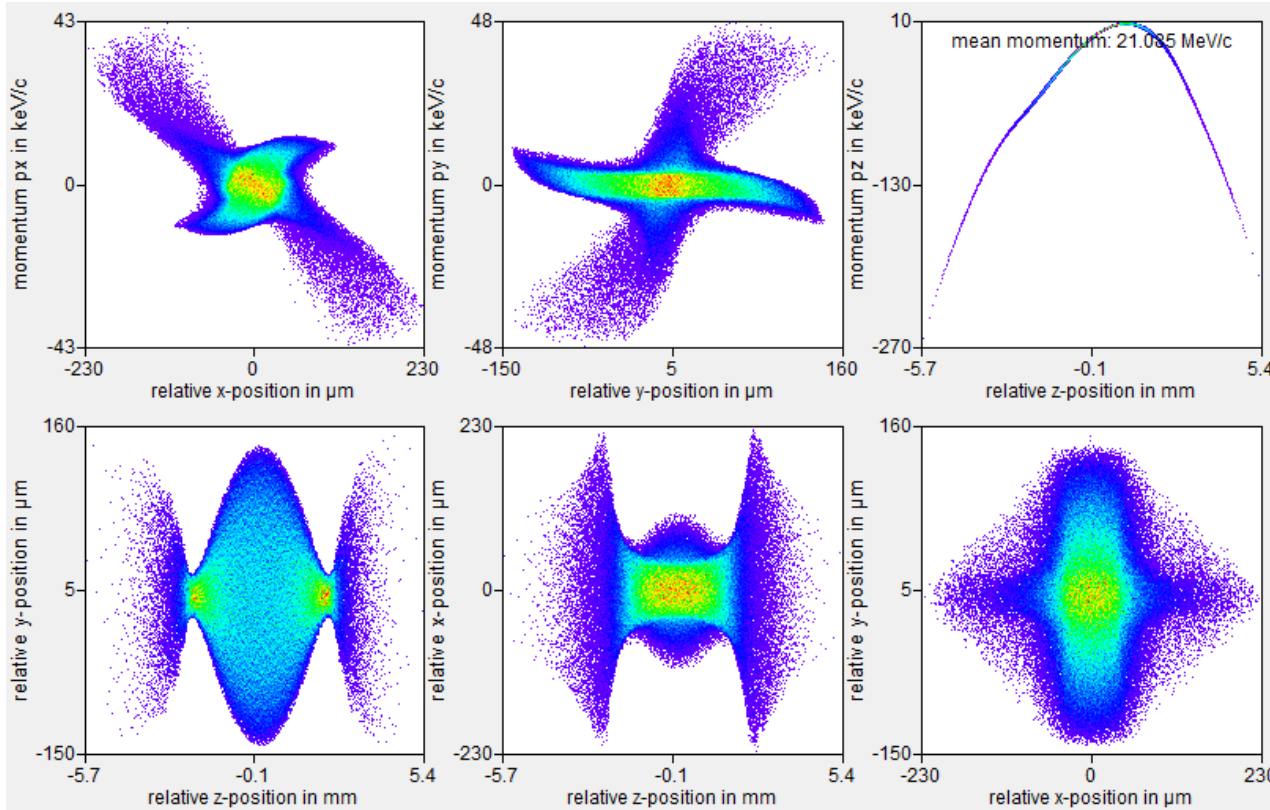Maximum quadrupole 10A➔ 7.5T/m

*Use MADX matching script from Yves

High1.Q1 ☐ position (middle) 4.790m
High1.Q2 ☐ position (middle) 5.005m
High1.Q3 ☐ position (middle) 5.6025m
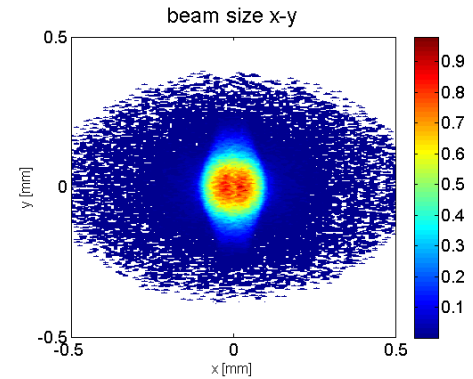High1.Q4 ☐ position (middle) 5.8525m

Beam focused at the plasma entrance without foil

Z=6.2, without foil

Simulation from start to end by Astra with matched Quads

kh1q1 = -9.562327889;
kh1q2 = -16.66899357;
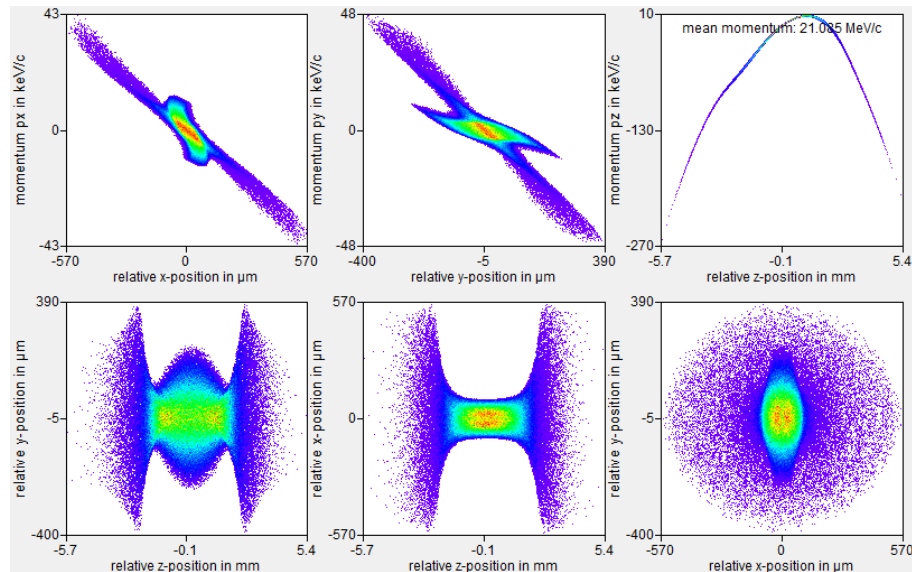kh1q3 = 77.54639616;
kh1q4 = -104.8256671;

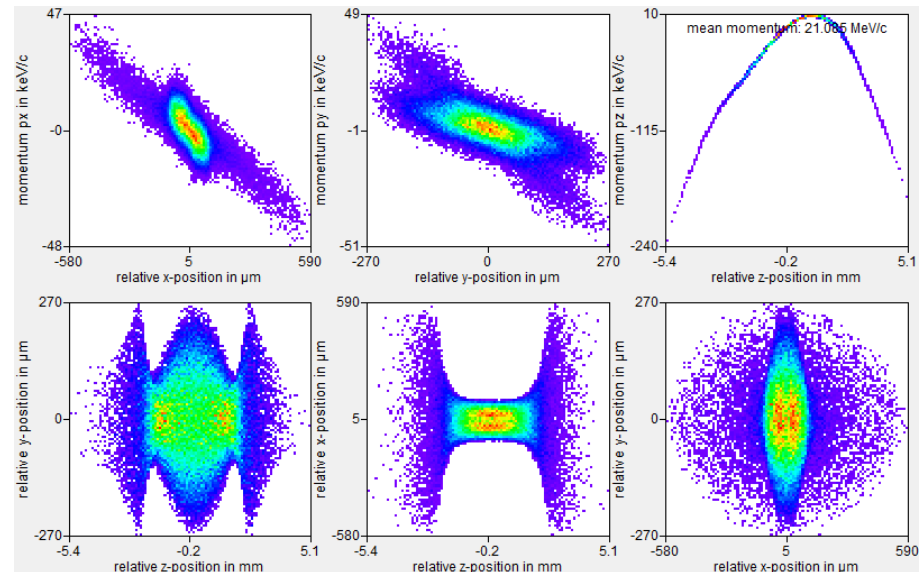| parameters	Sigm_x (um)	Sigm_y (um)	EMX (mm mrad)	EMY (mm mrad)	Bunch length (mm)
At Z=6.2	**44**	**51**	0.588	0.765	1.348

Add foil scattering to the beam

Z=6.0, without foil

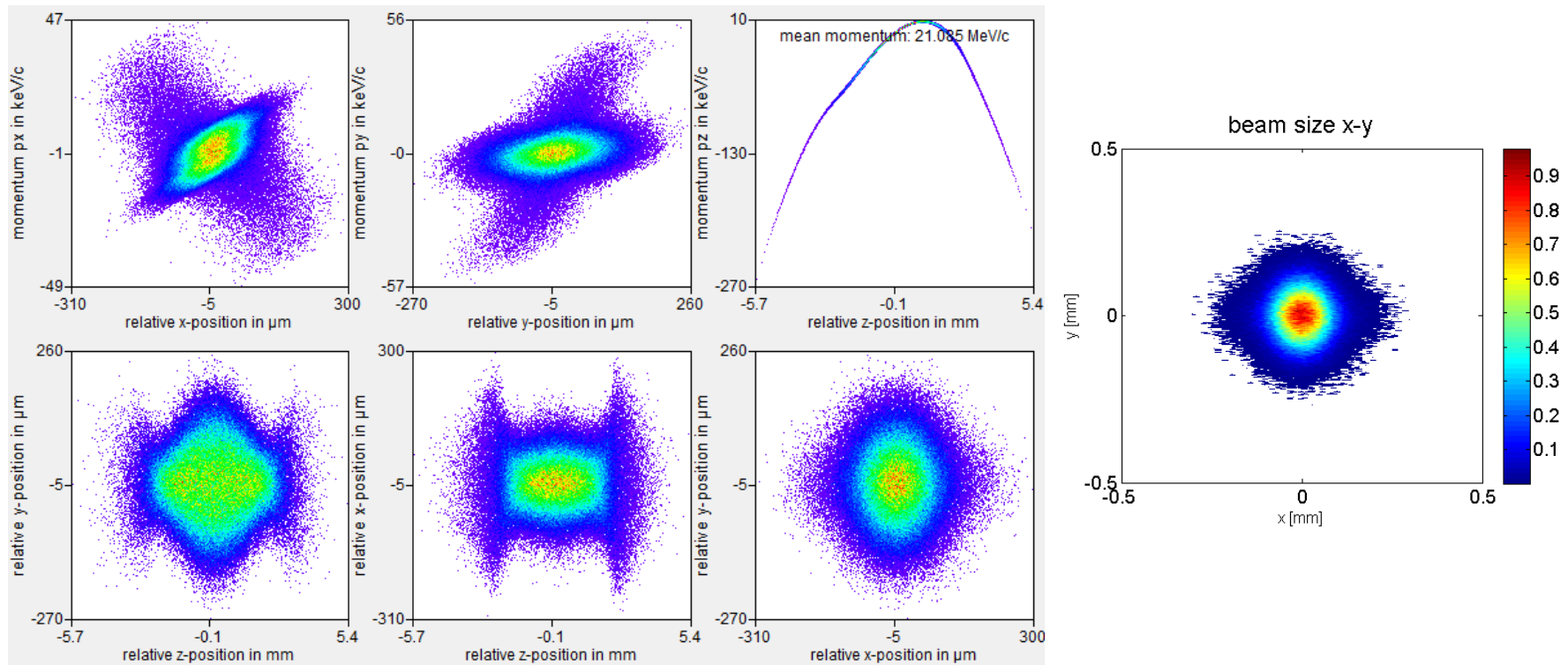Z=6.0, after foil, 0.2 mrad scattering
(script from Mikhail)

parameters	Sigm_x (um)	Sigm_y (um)	EMX(before/after foil) (mm mrad)	EMY(before/after foil) (mm mrad)	Bunch length (mm)
At Z=6.0	93	87	0.589/0.964	0.755/1.045	1.348

Track beam after foil to plasma entrance

Final beam distribution at plasma entrance

parameters	Sigm_x (um)	Sigm_y (um)	EMX (mm mrad)	EMY (mm mrad)	Bunch length (mm)
At Z=6.2	**59**	**65**	0.970	1.048	1.348

conclusions

> The simulation for beam rms size about 60 um at the plasma entrance is achieved including the foil scattering for current machine setting.

> The foil has a effect increasing the beam rms size about 15 um for 0.2 mrad scattering from simulation.

> From simulation, the beam sigm_x and sigm_y have several um difference.

> Quadrupoles matching for current machine setting has different solution compared with before simulation setting.

Matching solution

Sigm_match	K(Q1)	K(Q2)	K(Q3)	K(Q4)
30um	106.73	-81.26	101.78	-95.47
50um	-9.56	-16.67	77.54	-104.83
60um	10.88	-36.52	74.1	-88.09
80um	73.47	-74.48	98.03	-54.72
100um	69.96	-72.27	90.27	-38.01