Update of 100 pC charge simulation for phase space tomography diagnostics

- **Simulation results of laser spot size of 150 µm**
- **Simulation results of laser spot size of 180 µm**
- **Conclusions and future works**

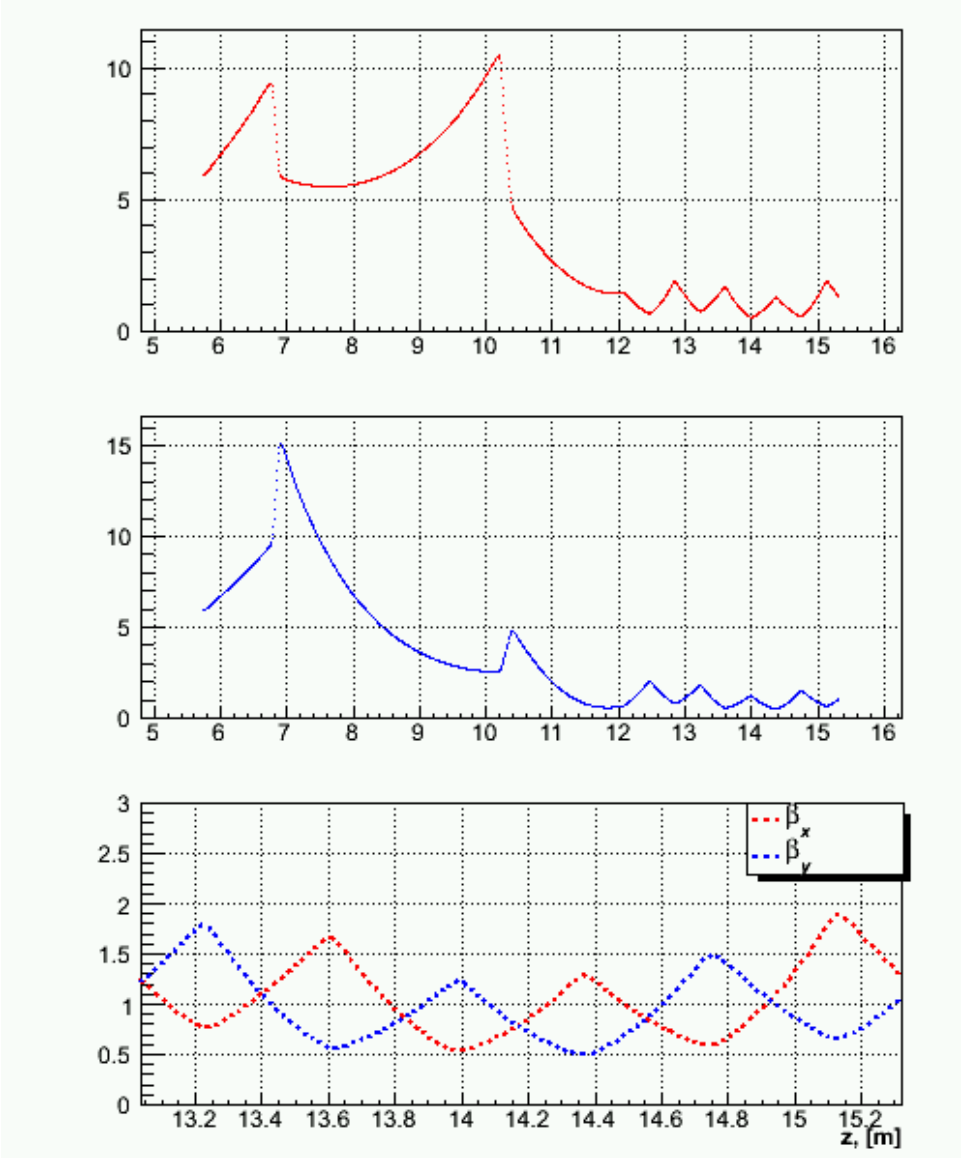
Jatuporn Saisut
PPS meeting
Zeuthen, October 26, 2010

HELMHOLTZ ASSOCIATION

DESY

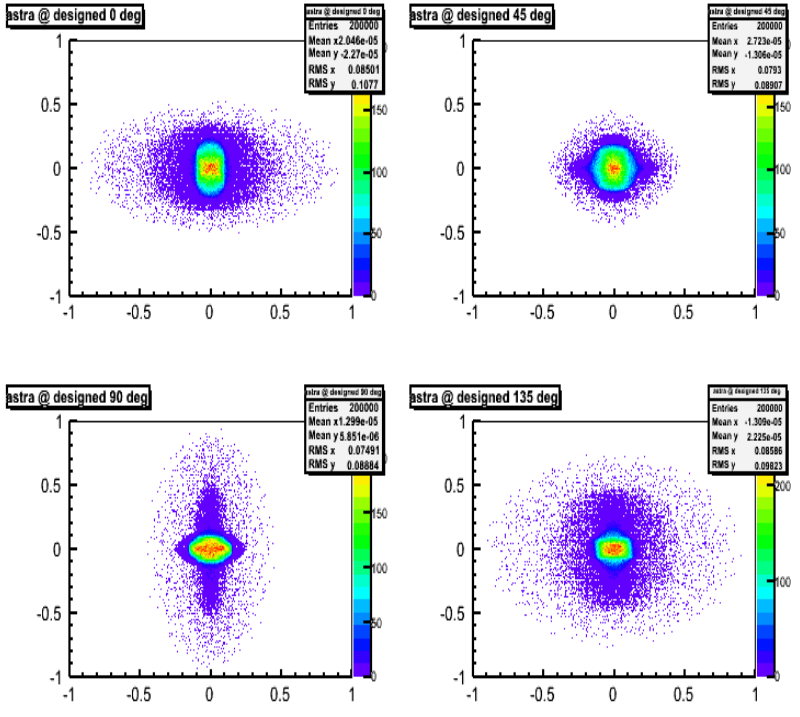
Simulation results (laser spot size of 150 μm)

I. Booster gradient = 14 MV/m



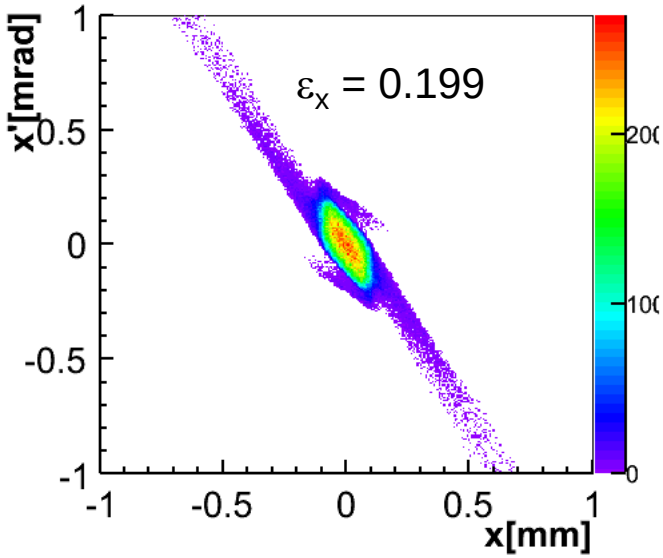
- Gun gradient = 60 MV/m
- Gun phase = 1.8 deg.
- Booster gradient = 14 MV/m
- Booster phase = 0.0 deg
- Ek = 18.34 MeV
- Bz = -0.2238 T
- ε_{xy} @ EMSY I = 0.1779 mm mmrad

$\Delta\beta_{xmax}$ ≈ 33.3 % , $\Delta\beta_{ymax}$ ≈ 26.2 %

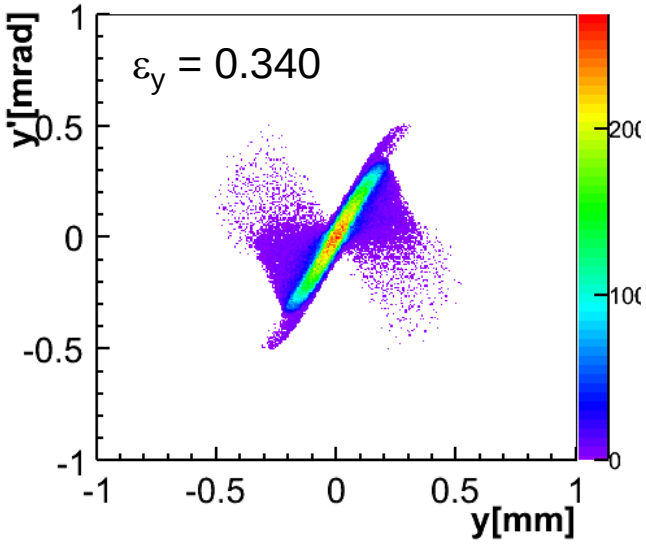


ASTRA : 3D space charge , include quadrupole field

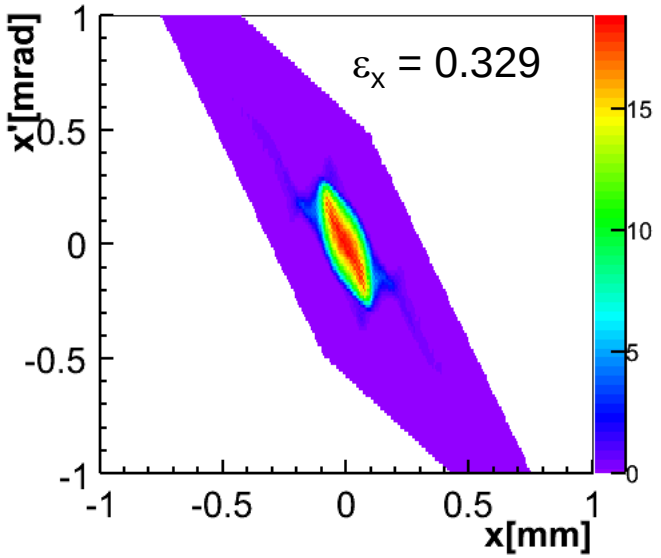
Phase space reconstruction (laser spot size of 150 µm)



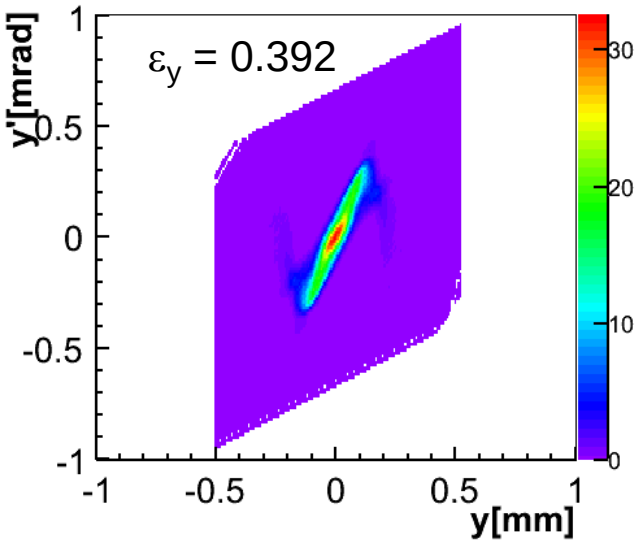
phase space at first screen(ASTRA)



MENT, Reconstructed



phase space reconstruction



I. Booster gradient
= 14 MV/m
Ek = 18.34 MeV

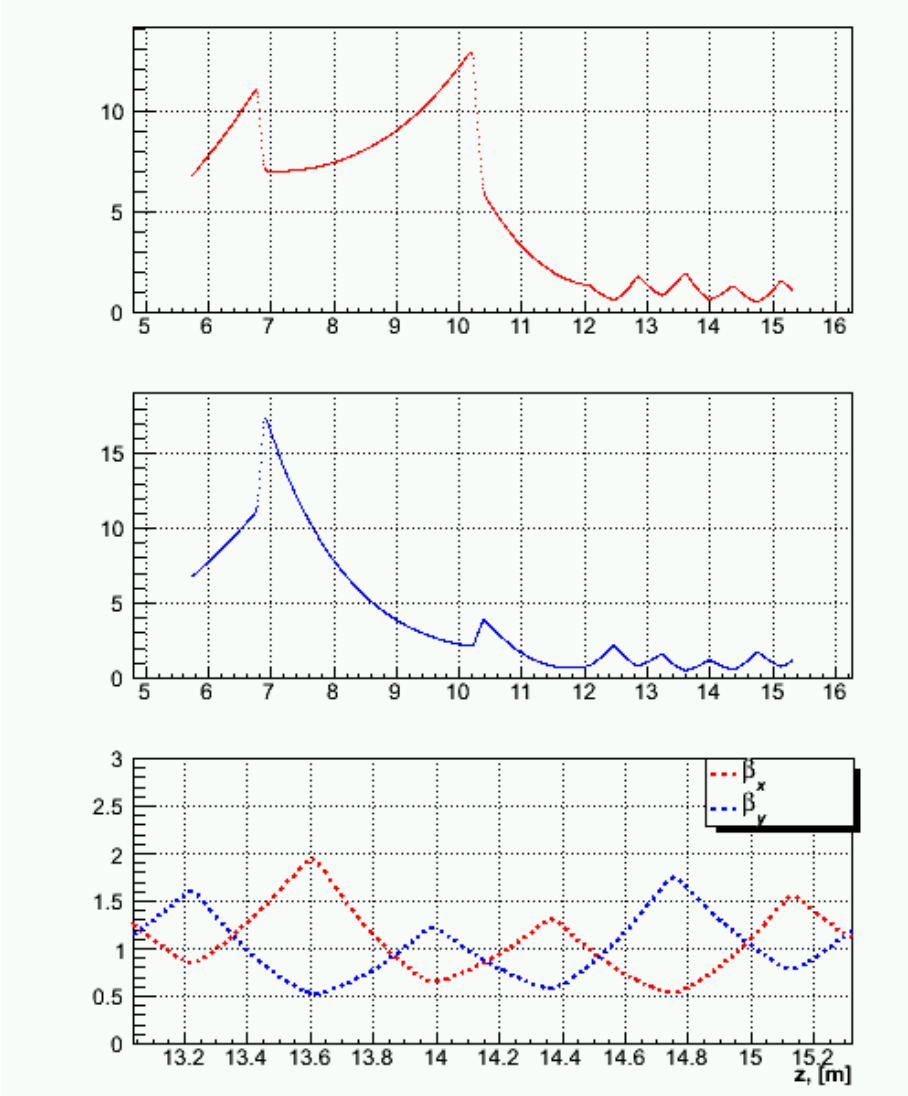
$\Delta\beta_{xmax} \approx$ **33.3 %**
$\Delta\beta_{ymax} \approx$ **26.2 %**

$\Delta\ \varepsilon_x$ = 65.3 %

$\Delta\ \varepsilon_y$ = 15.5 %

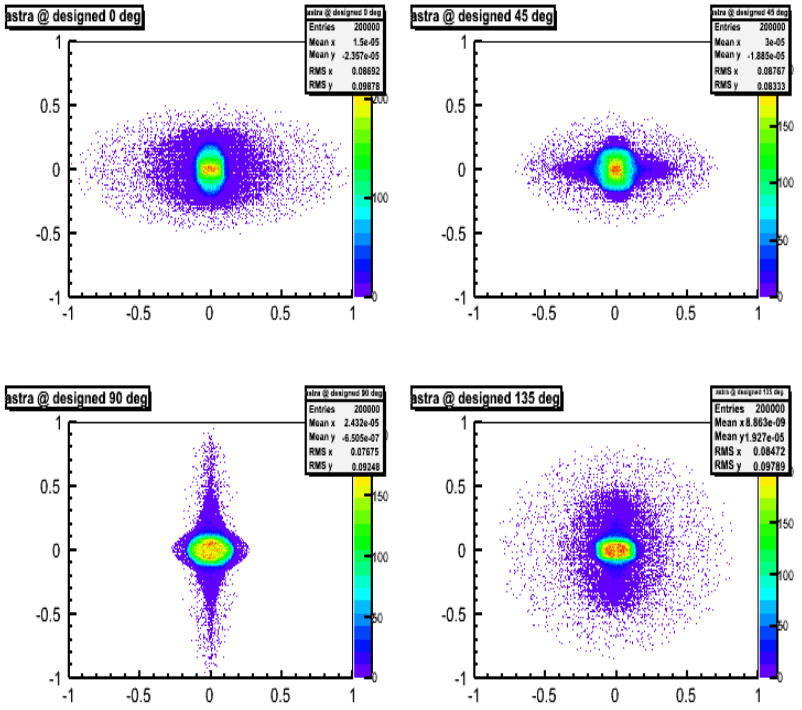
Simulation results (laser spot size of 150 μm)

II. Booster gradient = 15 MV/m



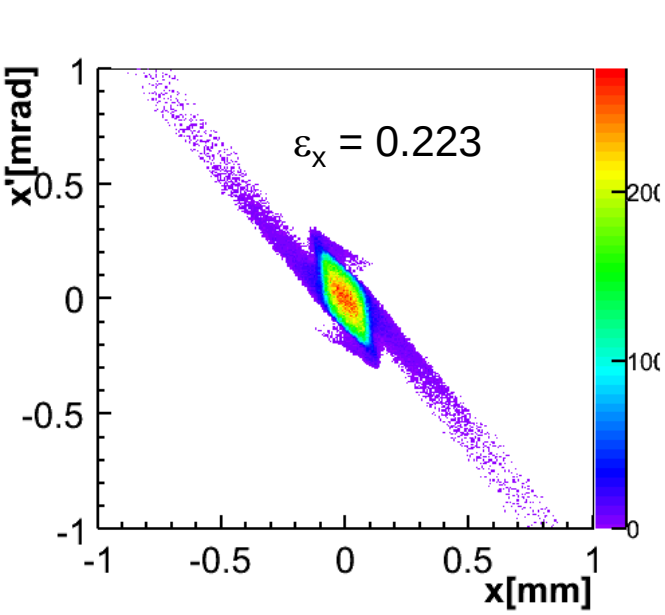
- Gun gradient = 60 MV/m
- Gun phase = 1.7 deg.
- Booster gradient = 15 MV/m
- Booster phase = 0.0 deg
- Ek = 19.21 MeV
- Bz = -0.2240 T
- ε_{xy} @ EMSY I = 0.1808 mm mmrad

$\Delta\beta_{xmax}$ ≈ 29.1 % , $\Delta\beta_{ymax}$ ≈ 21.3 %

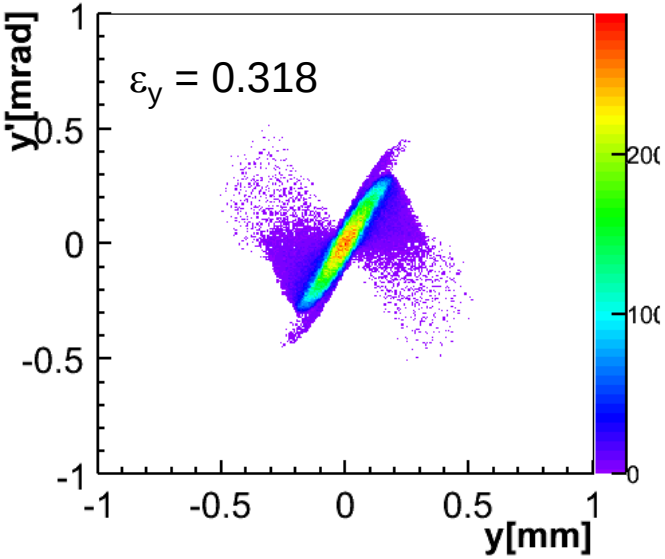


ASTRA : 3D space charge , include quadrupole field

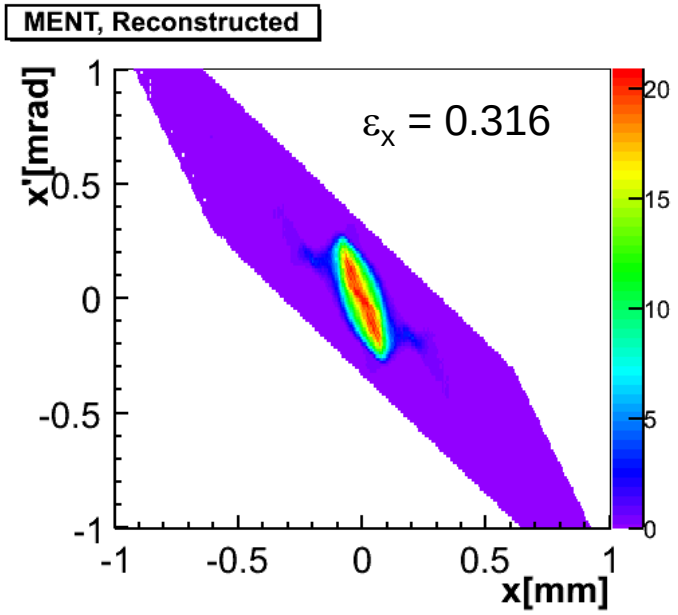
Phase space reconstruction (laser spot size of 150 µm)



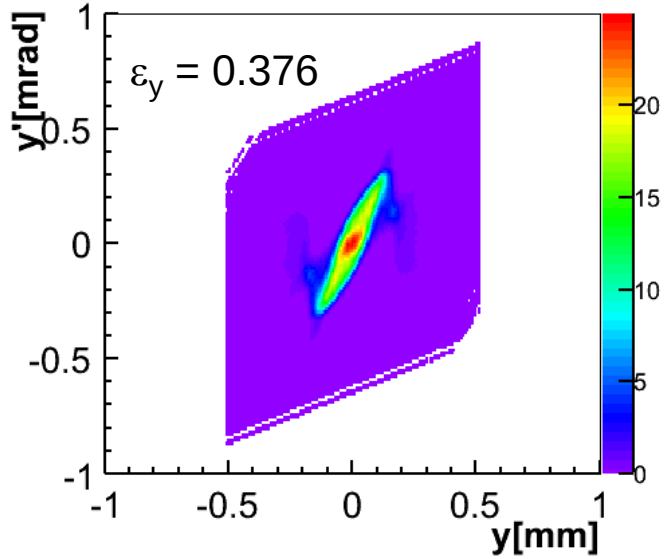
phase space at first screen(ASTRA)



MENT, Reconstructed



phase space reconstruction



I. Booster gradient
= 15 MV/m
Ek = 19.21 MeV

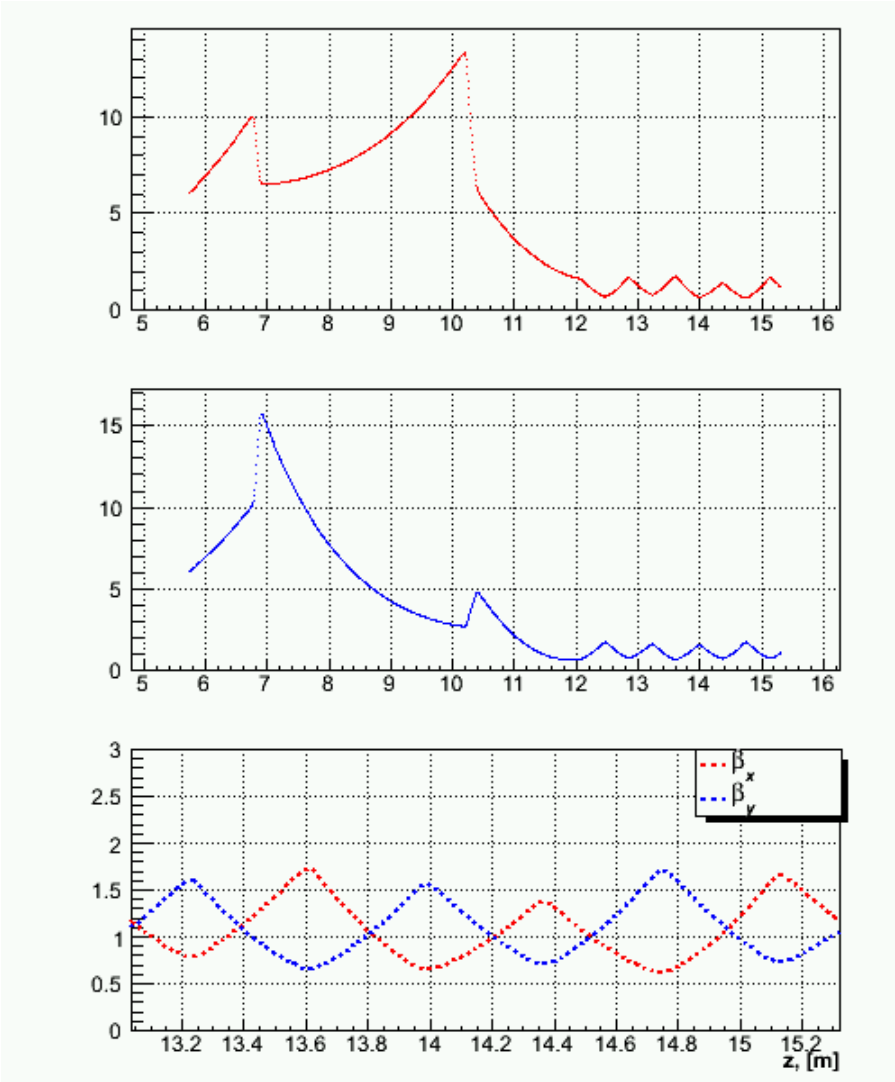
$\Delta\beta_{xmax}$ **≈ 29.1 %**
$\Delta\beta_{ymax}$ **≈ 21.3 %**

$\Delta\ \varepsilon_x$ = 41.8 %

$\Delta\ \varepsilon_y$ = 18.1 %

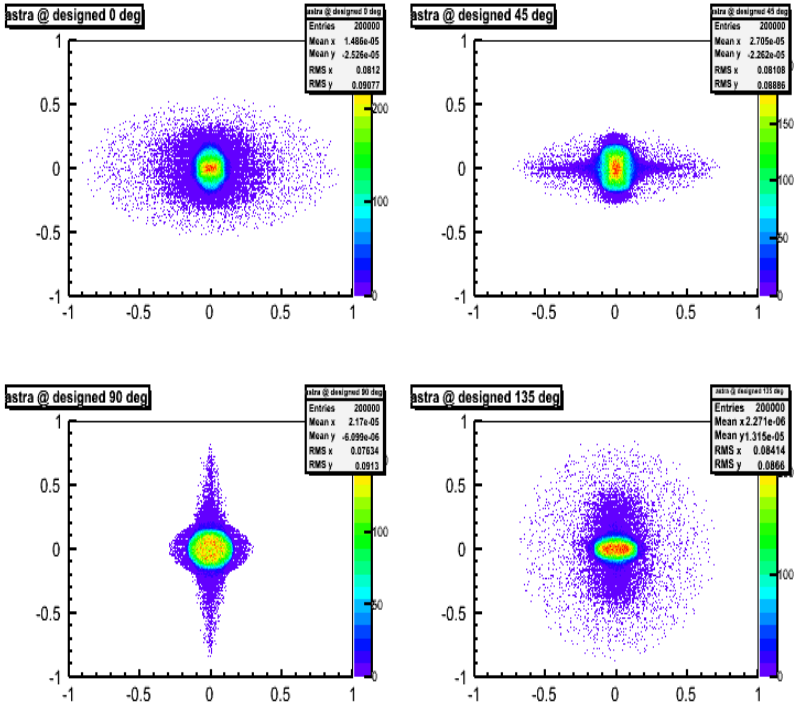
Simulation results (laser spot size of 150 μm)

III. Booster gradient = 16 MV/m



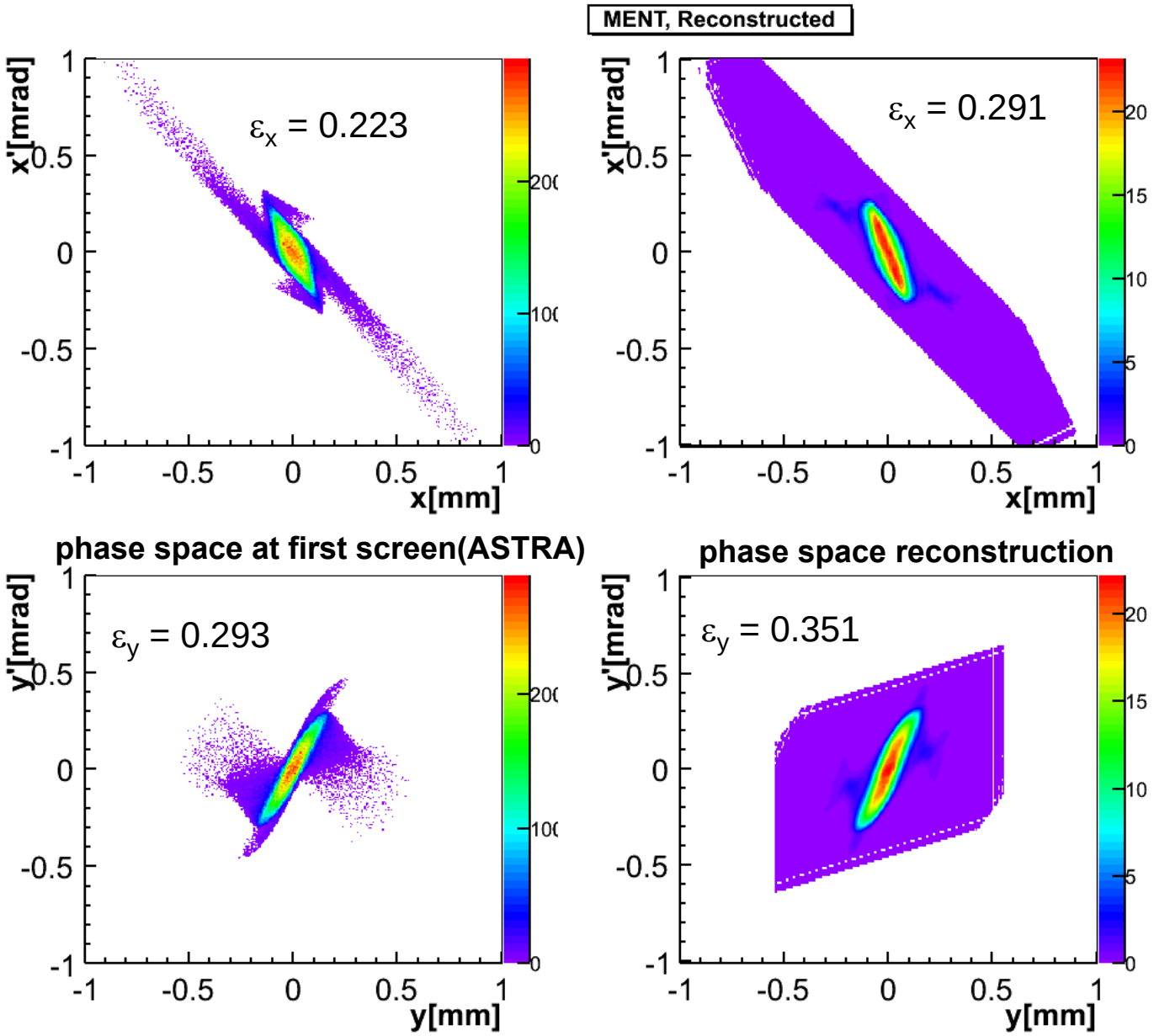
- Gun gradient = 60 MV/m
- Gun phase = 1.6 deg.
- Booster gradient = 16 MV/m
- Booster phase = 0.0 deg
- Ek = 20.09 MeV
- Bz = -0.2242 T
- ε_{xy} @ EMSY I = 0.1826 mm mmrad

$\Delta\beta_{xmax}$ ≈ 21.0 % , $\Delta\beta_{ymax}$ ≈ 14.0 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 150 µm)



I. Booster gradient
= 16 MV/m
Ek = 20.09 MeV

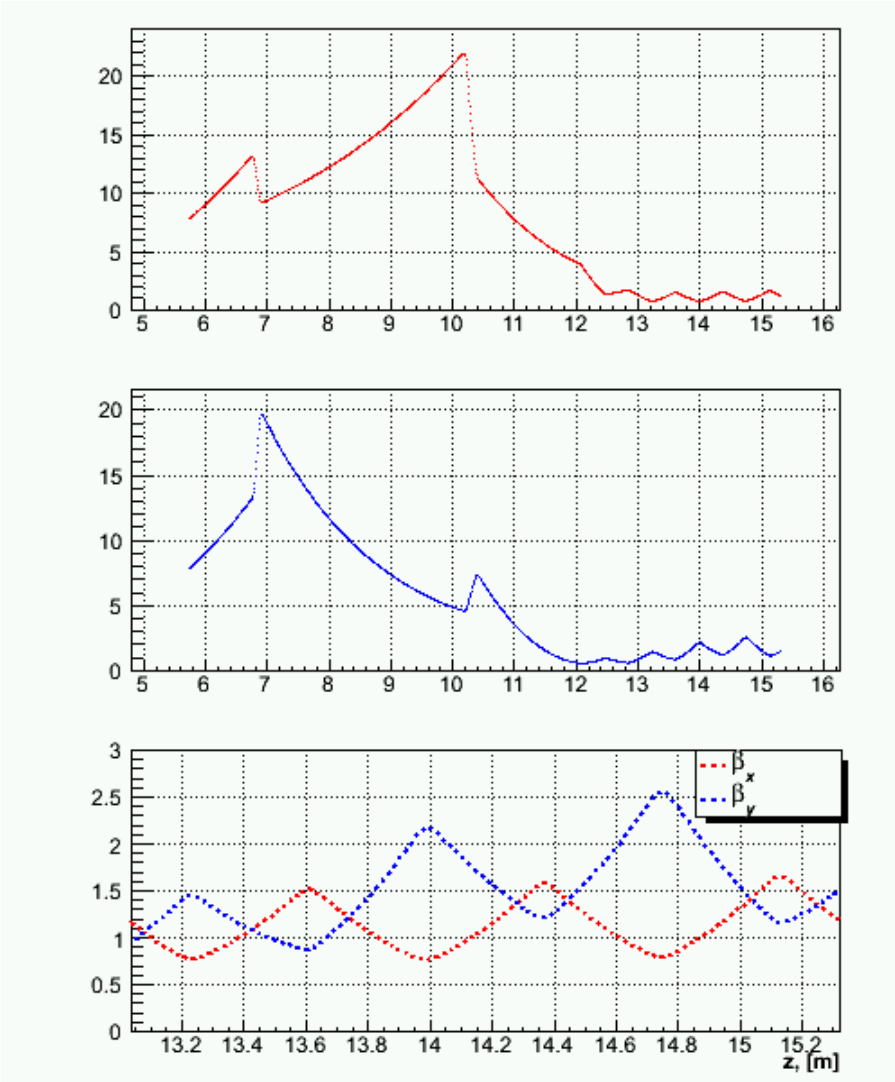
$\Delta\beta_{xmax}$ **≈ 21.0 %**
$\Delta\beta_{ymax}$ **≈ 14.0 %**

$\Delta\ \varepsilon_x$ = 30.0 %

$\Delta\ \varepsilon_y$ = 20.0 %

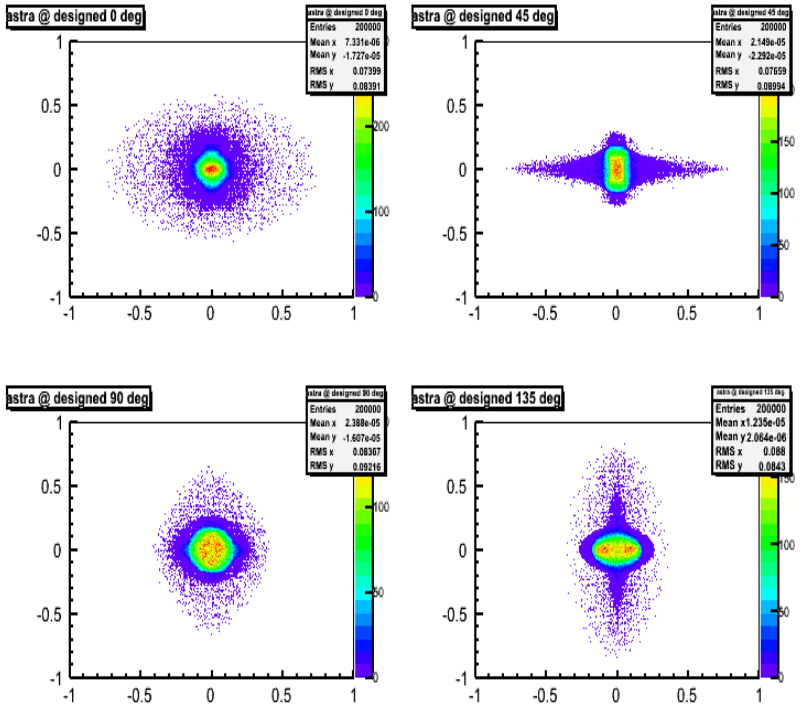
Simulation results (laser spot size of 150 μm)

IV. Booster gradient = 18 MV/m



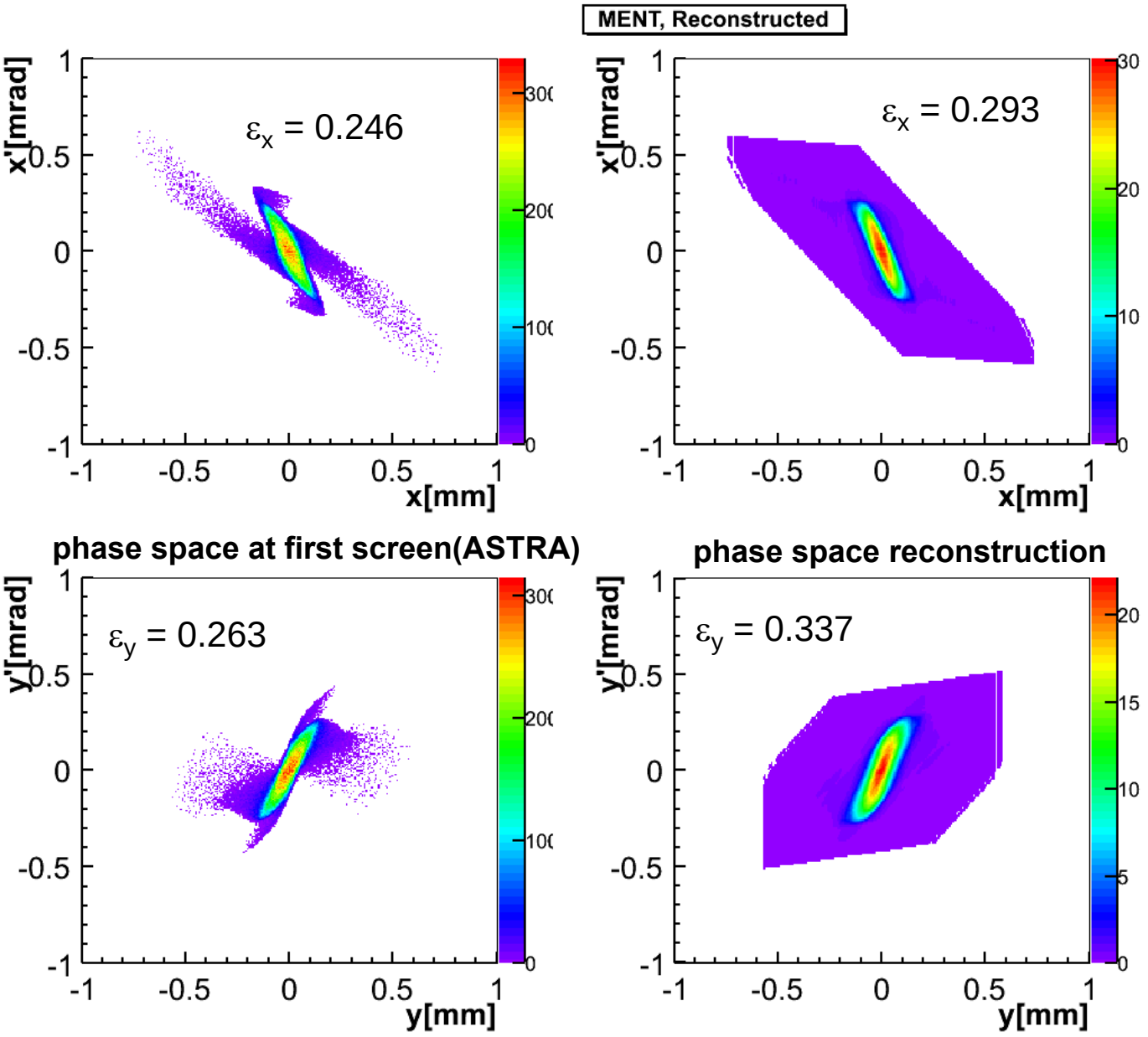
- Gun gradient = 60 MV/m
- Gun phase = 1.6 deg.
- Booster gradient = 18 MV/m
- Booster phase = 0.0 deg
- Ek = 21.83 MeV
- Bz = -0.2244 T
- ε_{xy} @ EMSY I = 0.1840 mm mmrad

$\Delta\beta_{xmax}$ ≈ 29.4 % , $\Delta\beta_{ymax}$ ≈ 31.2 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 150 µm)



I. Booster gradient
= 18 MV/m
Ek = 21.83 MeV

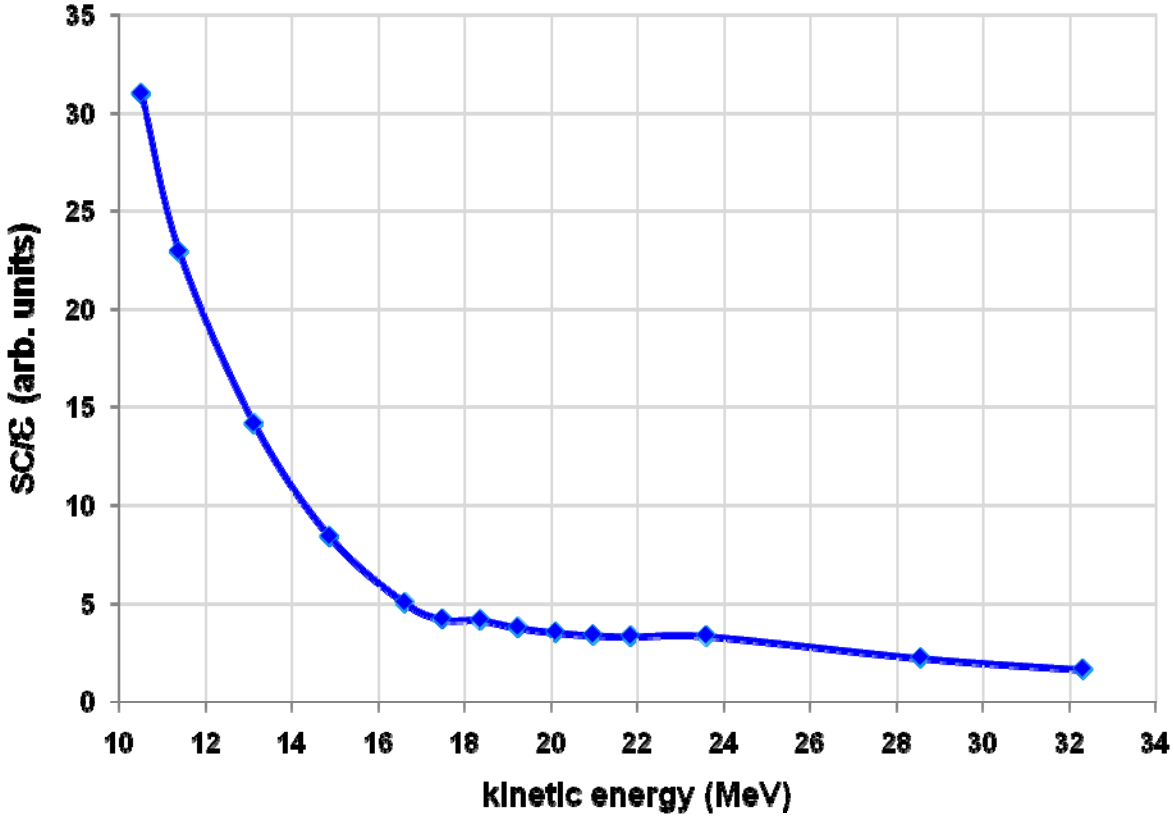
$\Delta\beta_{xmax}$ **≈ 29.4 %**
$\Delta\beta_{ymax}$ **≈ 31.2 %**

$\Delta\ \varepsilon_x$ = 19.0 %

$\Delta\ \varepsilon_y$ = 27.9 %

Difficulty (laser spot size of 150 µm)

Phase charge over emittance (at EMSY 1)



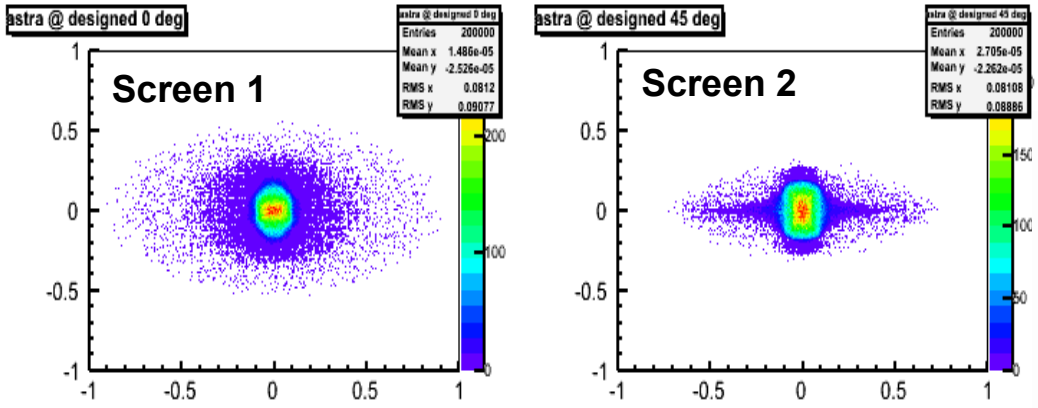
$$\rho = \frac{I\sigma^3}{2\beta\gamma I_0 \varepsilon_N^2}$$

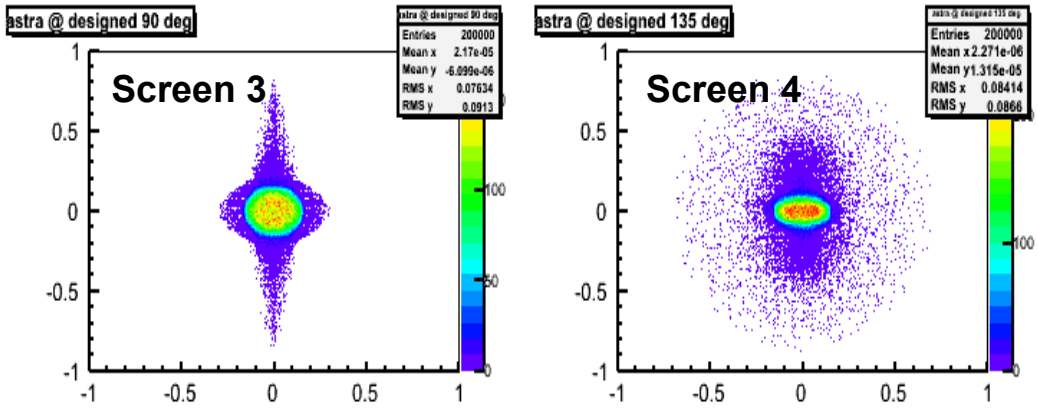
> 1

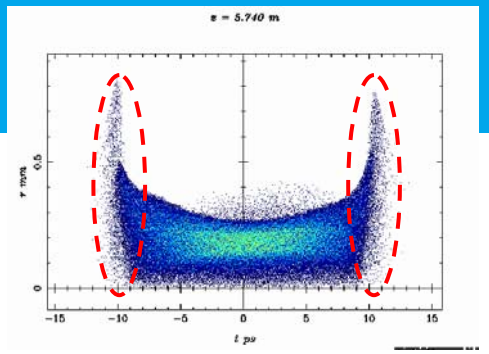
Difficulty (laser spot size of 150 μm)

Particles in the head and tail ???

Ex: Booster gradient = 16 MV/m (Ek = 20.09 MeV)

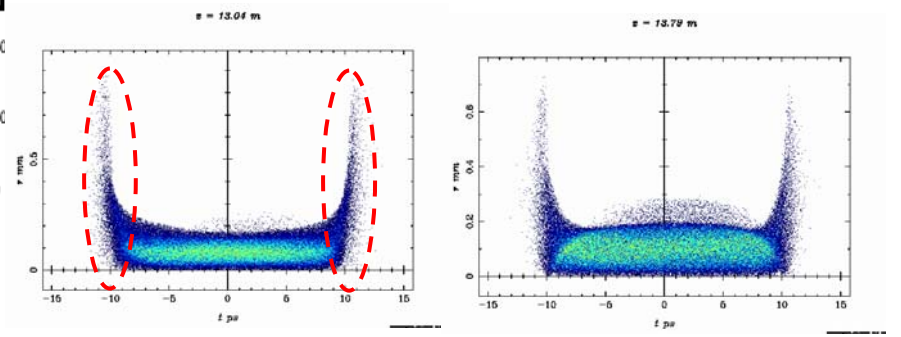




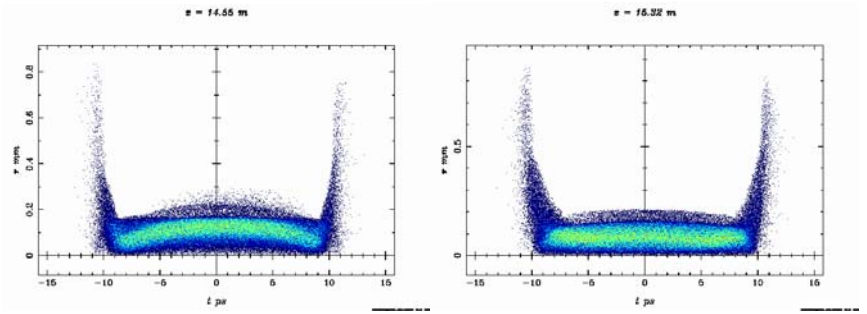


EMSY 1

Screen 1 Screen 2

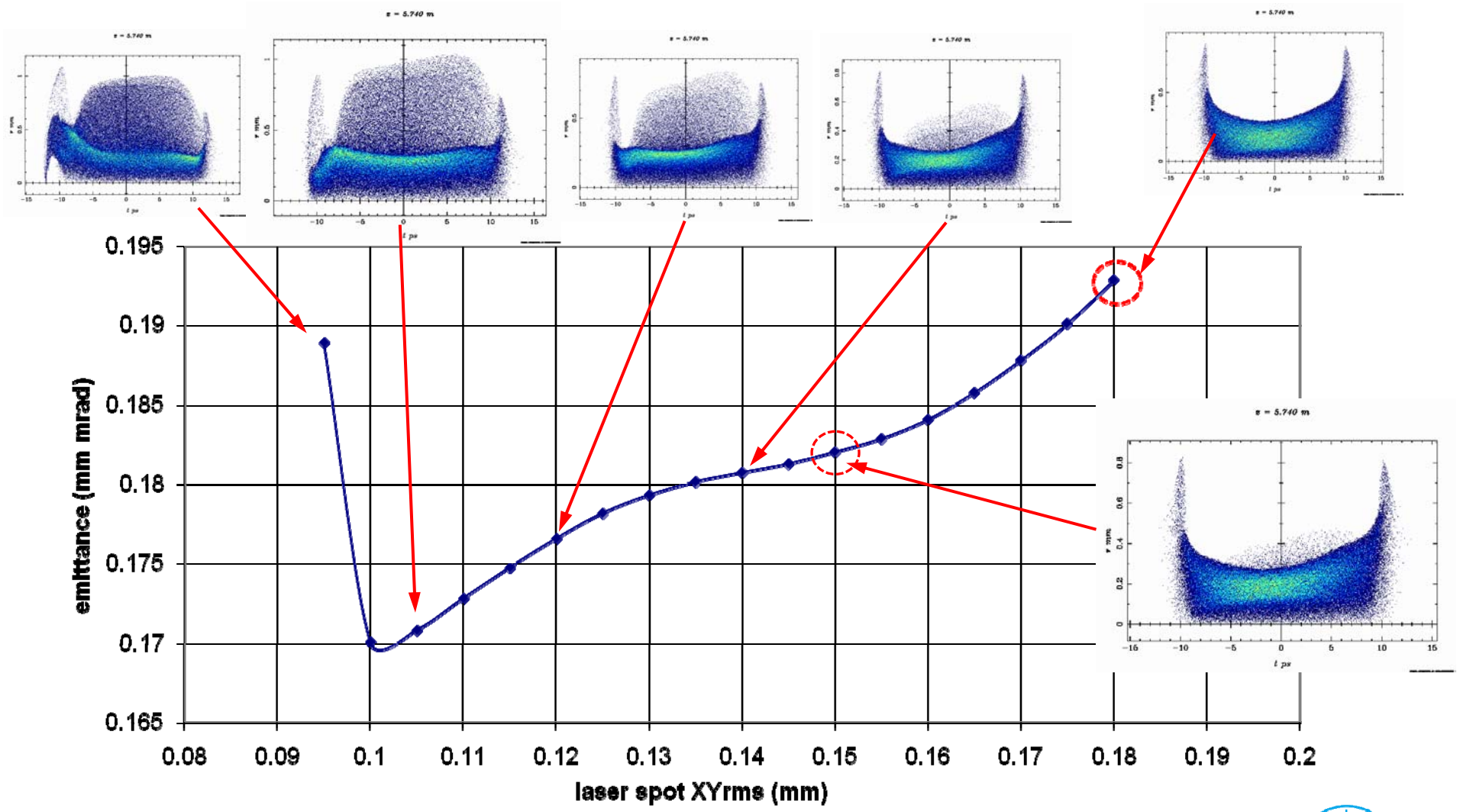


Screen 3 Screen 4



Emittance optimization

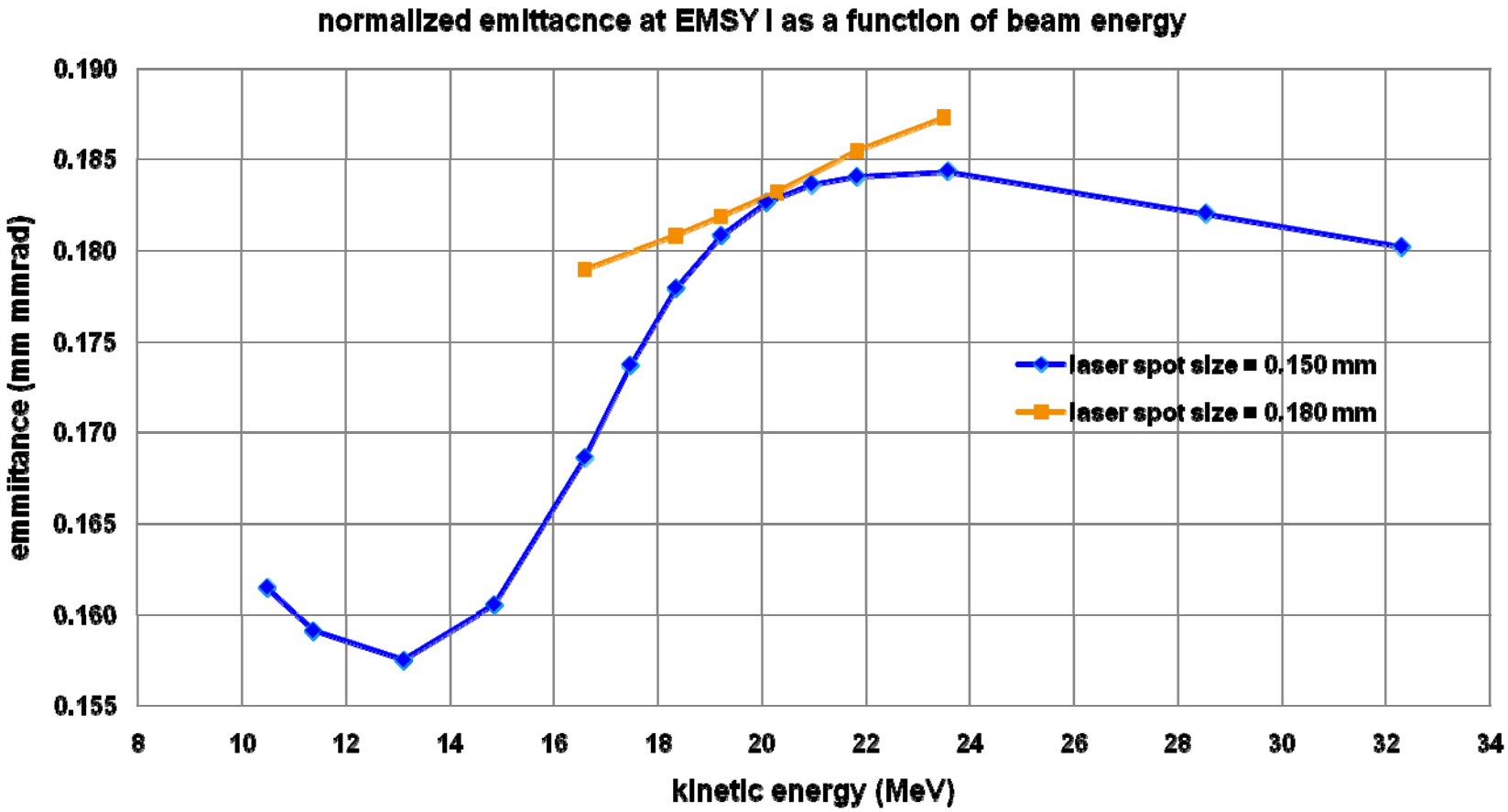
Laser spot size VS emittance (gun phase = 0 deg., Ek = 28.54 MeV)



* *Scan solenoid for each laser spot size

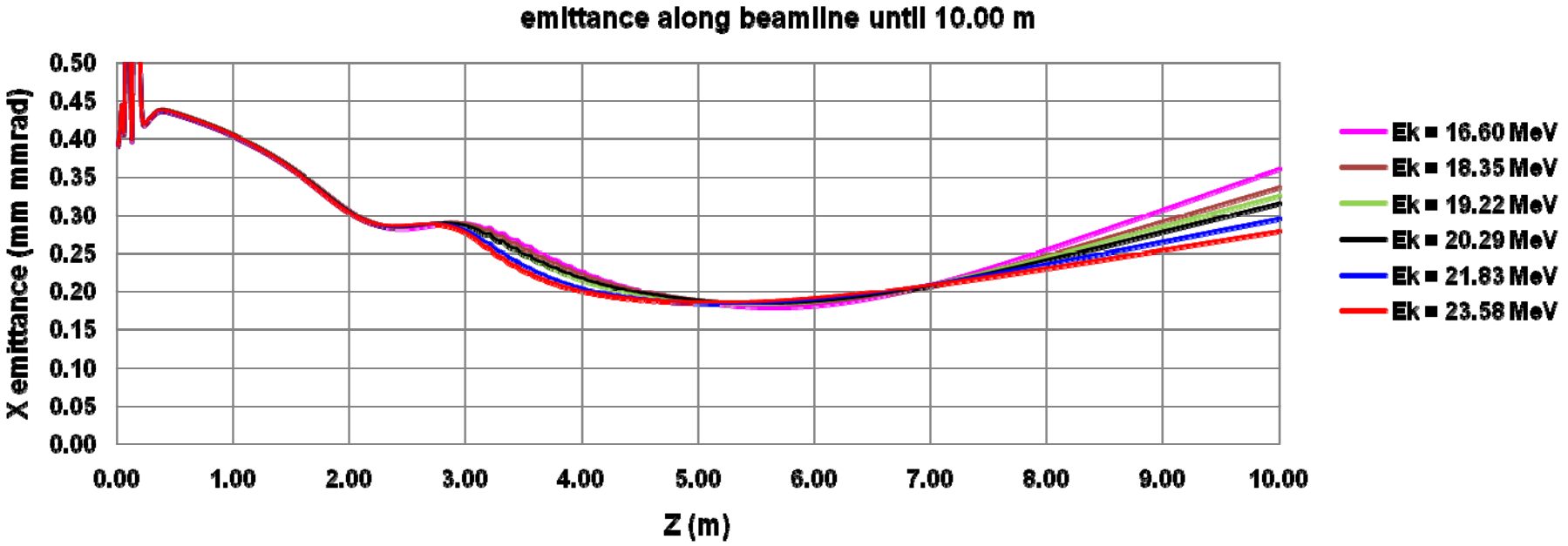
Emittance VS Booster gradient

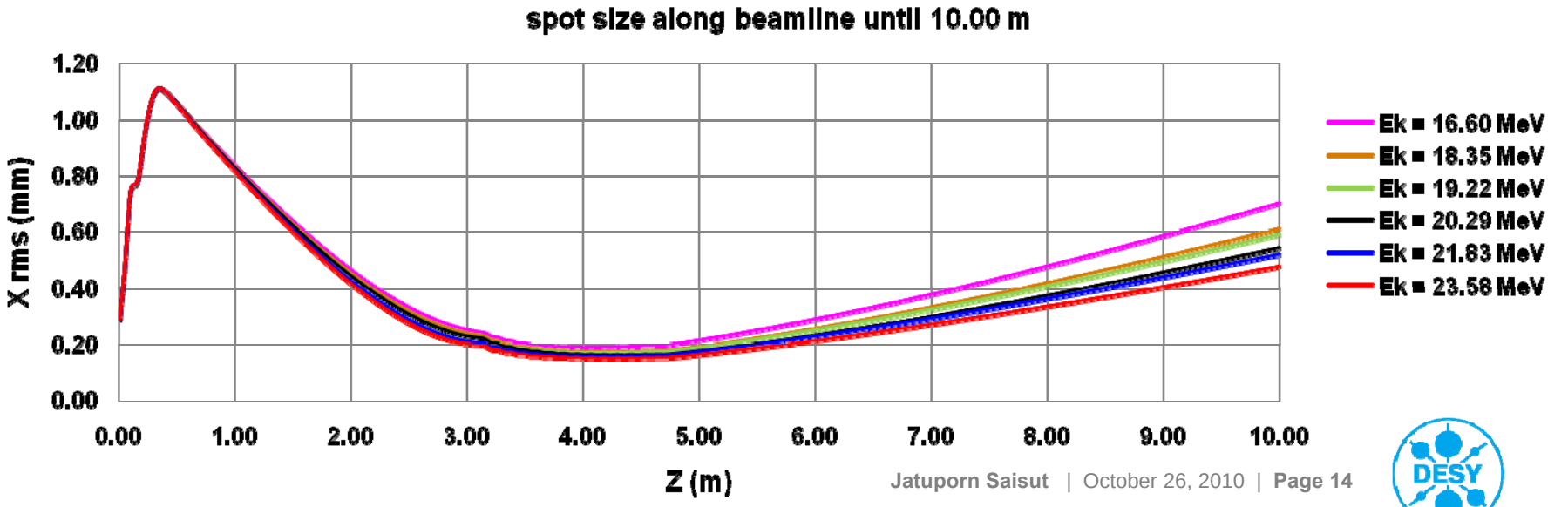
Laser XY rms spot = 0.180 mm



* *Scan solenoid for each booster gradient

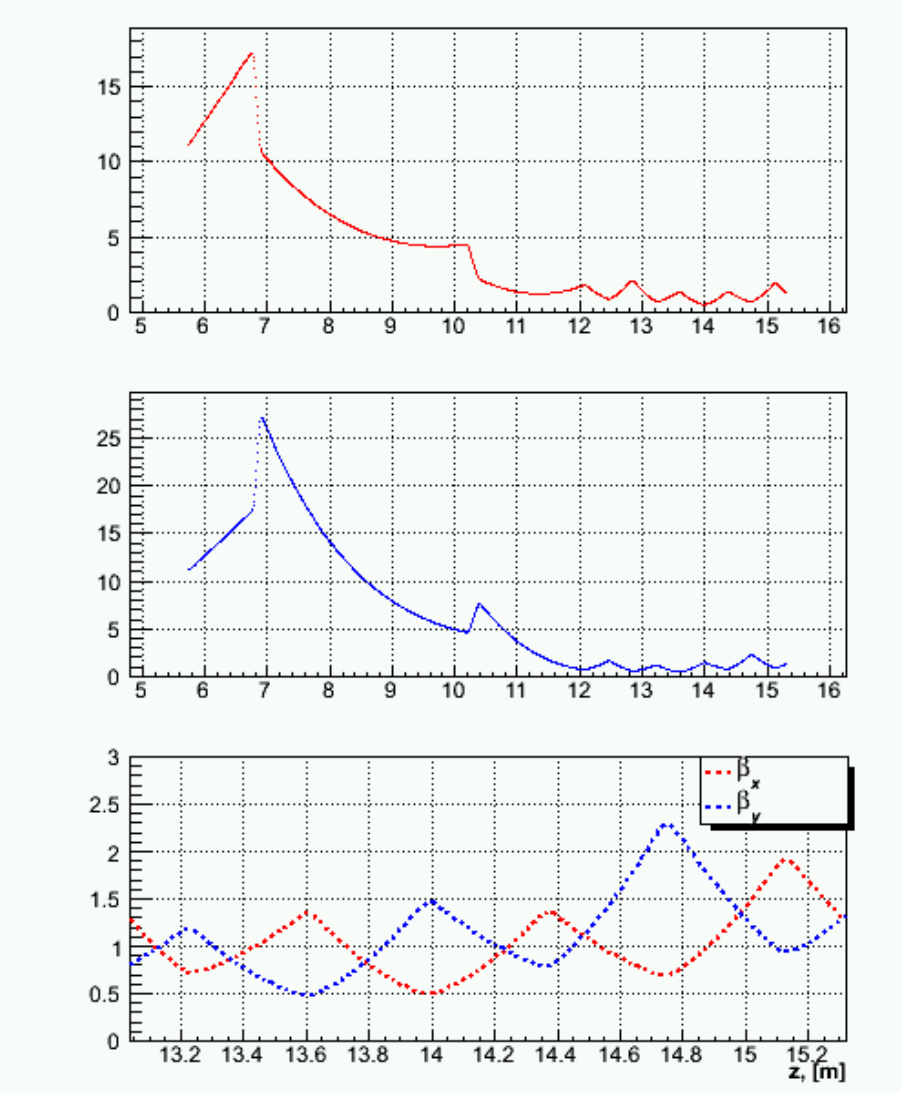
Laser XY rms spot = 0.180 mm





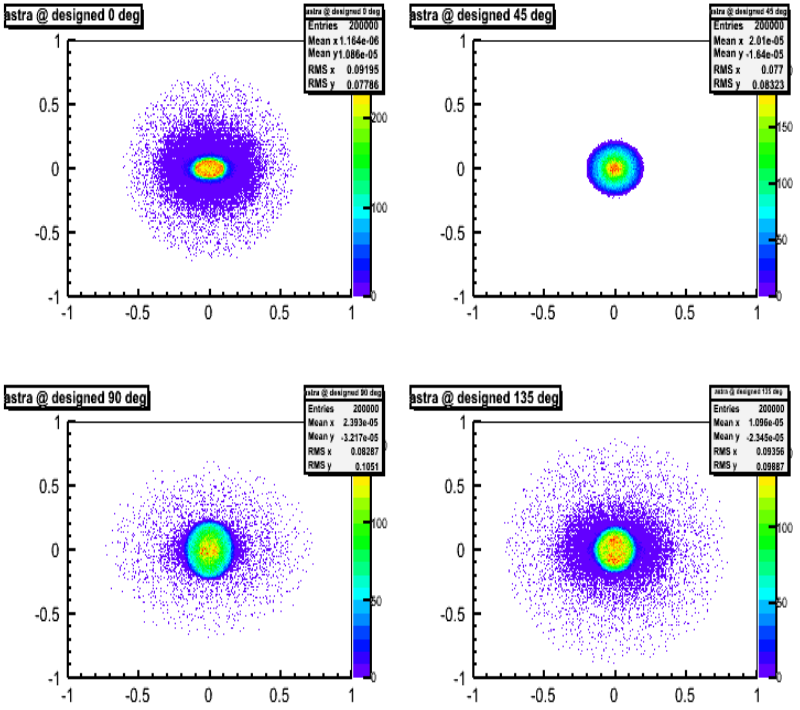
Simulation results (laser spot size of 180 μm)

I. Booster gradient = 15 MV/m



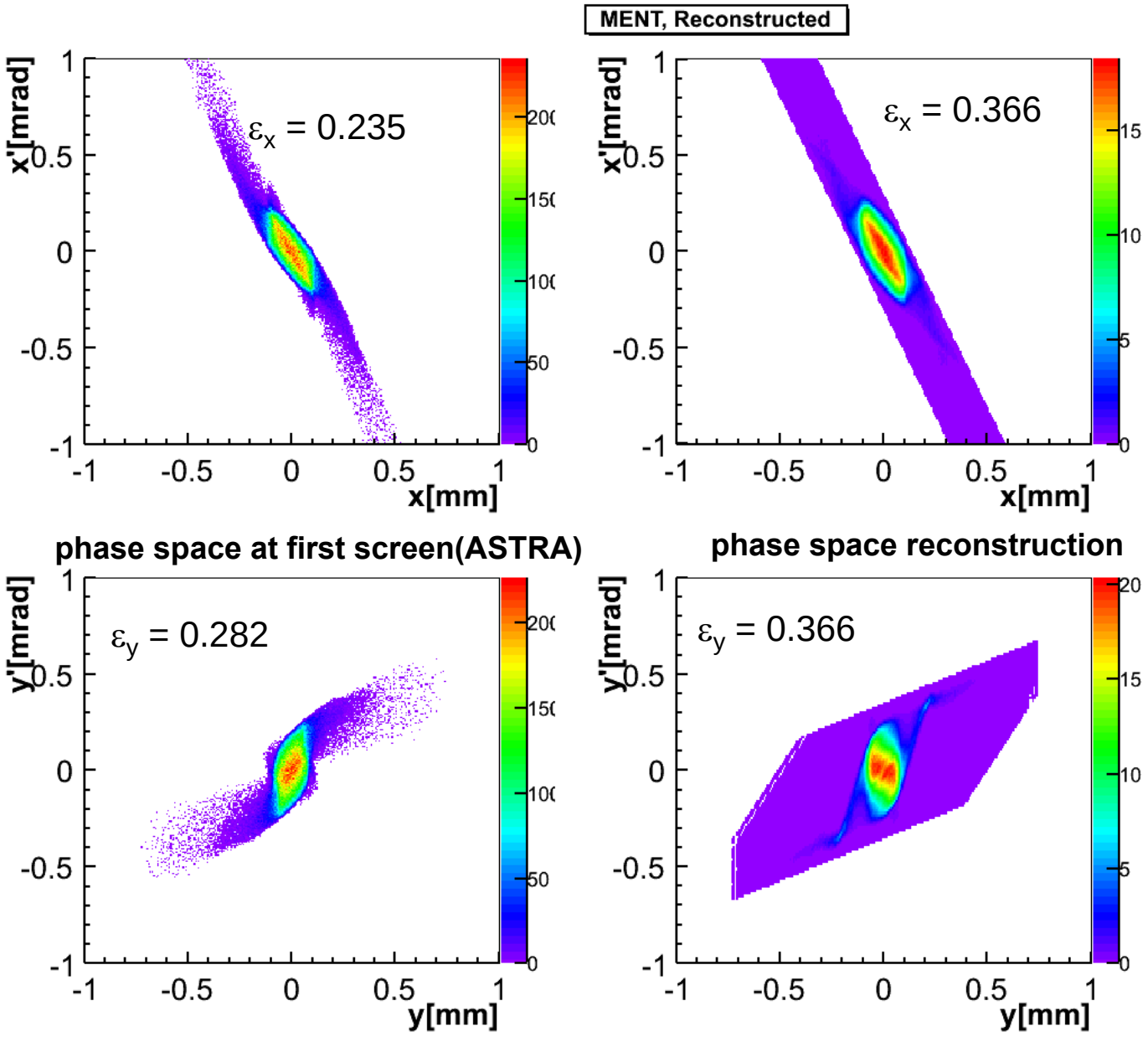
- Gun gradient = 60 MV/m
- Gun phase = 1.5 deg.
- Booster gradient = 15 MV/m
- Booster phase = 0.0 deg
- Ek = 19.22 MeV
- Bz = -0.2236 T
- ε_{xy} @ EMSY I = 0.1819 mm mmrad

$\Delta\beta_{xmax}$ ≈ 31.7 % , $\Delta\beta_{ymax}$ ≈ 41.8 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 180 µm)



I. Booster gradient
= 15 MV/m
Ek = 19.22 MeV

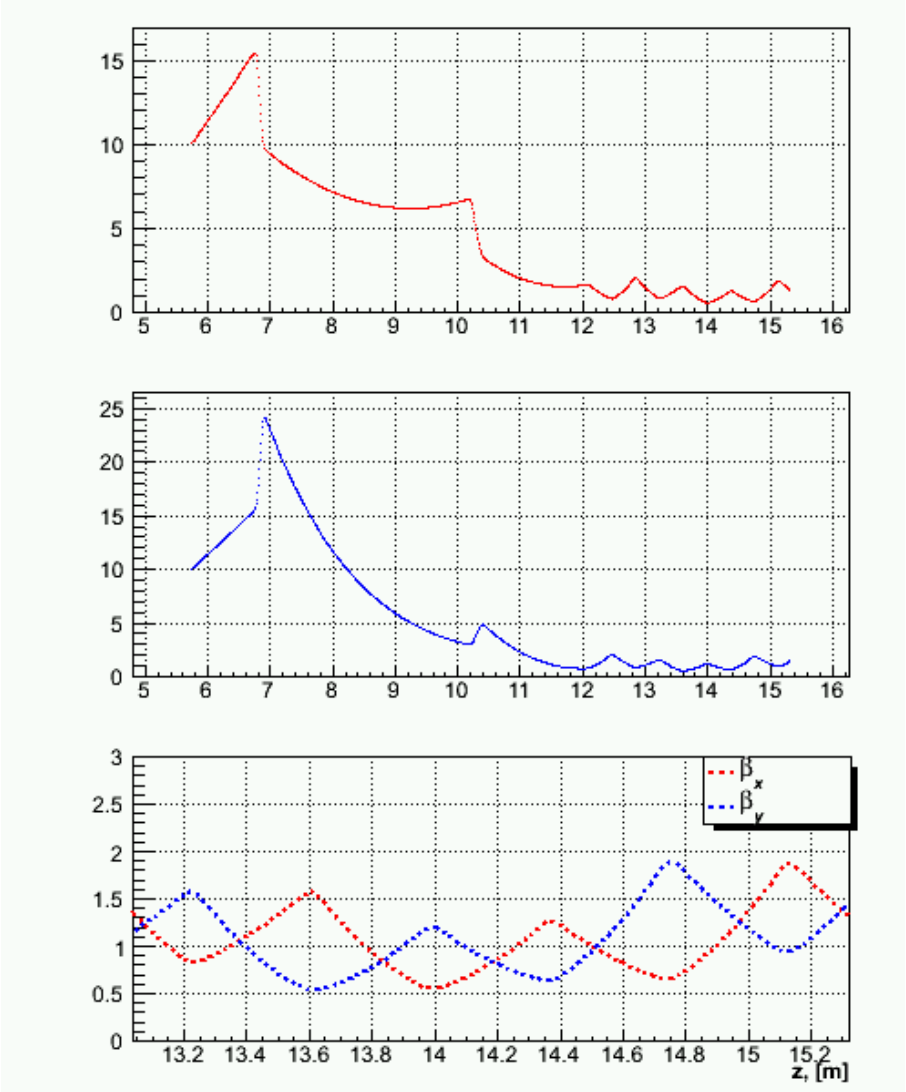
$\Delta\beta_{xmax}$ **≈ 31.7 %**
$\Delta\beta_{ymax}$ **≈ 41.8 %**

$\Delta\ \varepsilon_x$ = 55.6 %

$\Delta\ \varepsilon_y$ = 30.4 %

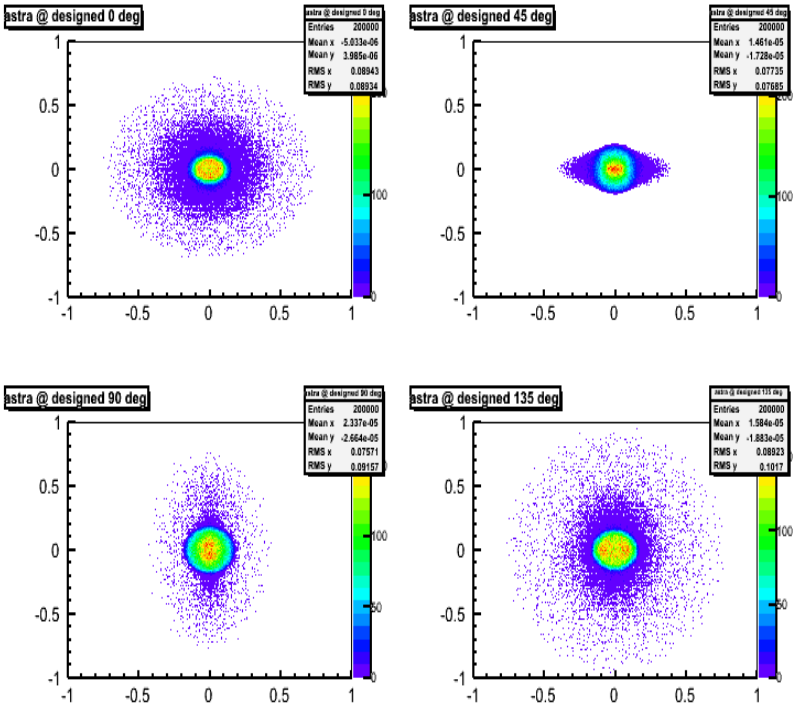
Simulation results (laser spot size of 180 μm)

II. Booster gradient = 16 MV/m



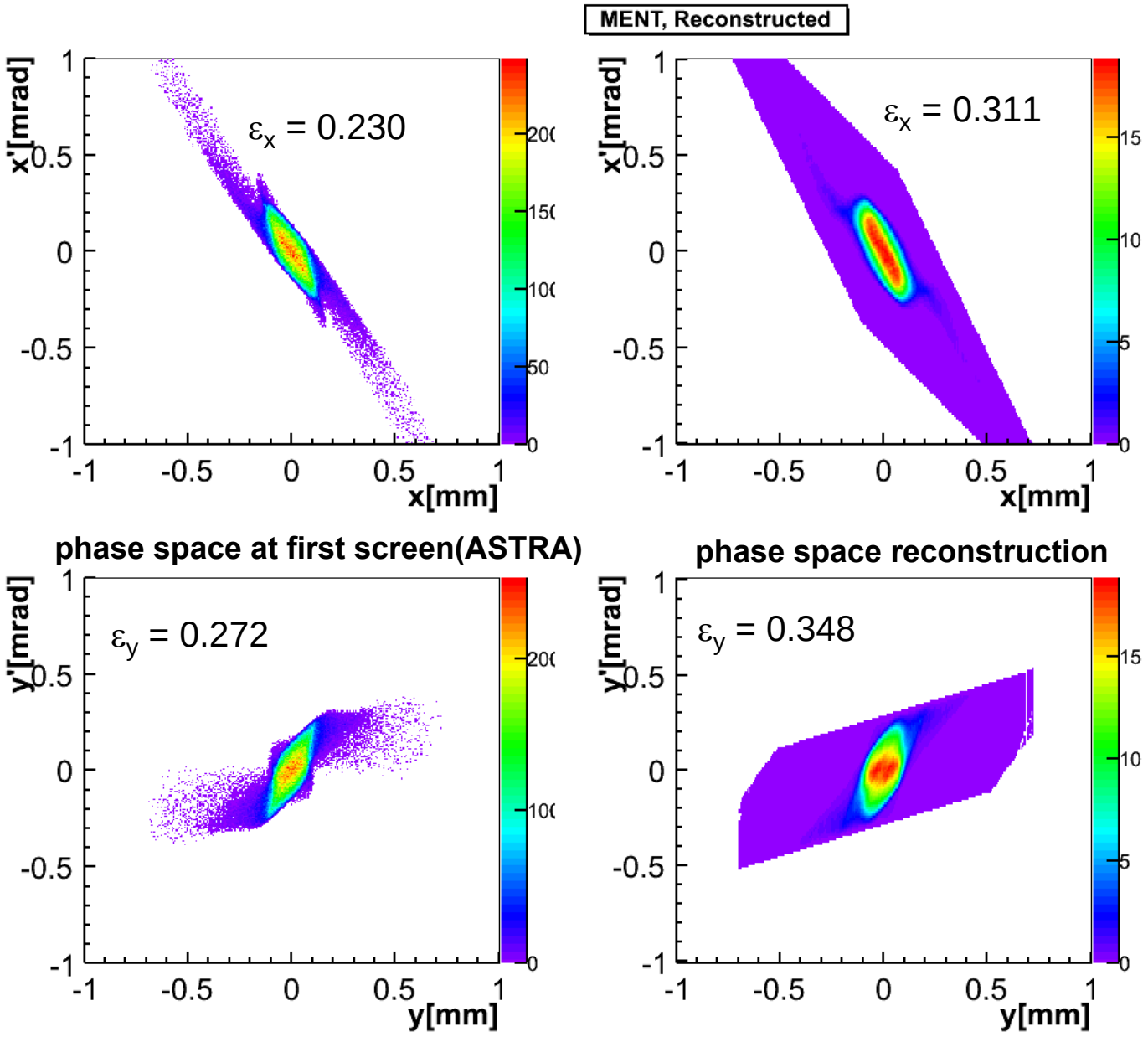
- Gun gradient = 60 MV/m
- Gun phase = 1.5 deg.
- Booster gradient = 16 MV/m
- Booster phase = 0.0 deg
- Ek = 20.09 MeV
- Bz = -0.2236 T
- ε_{xy} @ EMSY I = 0.1832 mm mmrad

$\Delta\beta_{xmax}$ ≈ 38.1 % , $\Delta\beta_{ymax}$ ≈ 49.1 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 180 µm)



I. Booster gradient
= 16 MV/m
Ek = 20.09 MeV

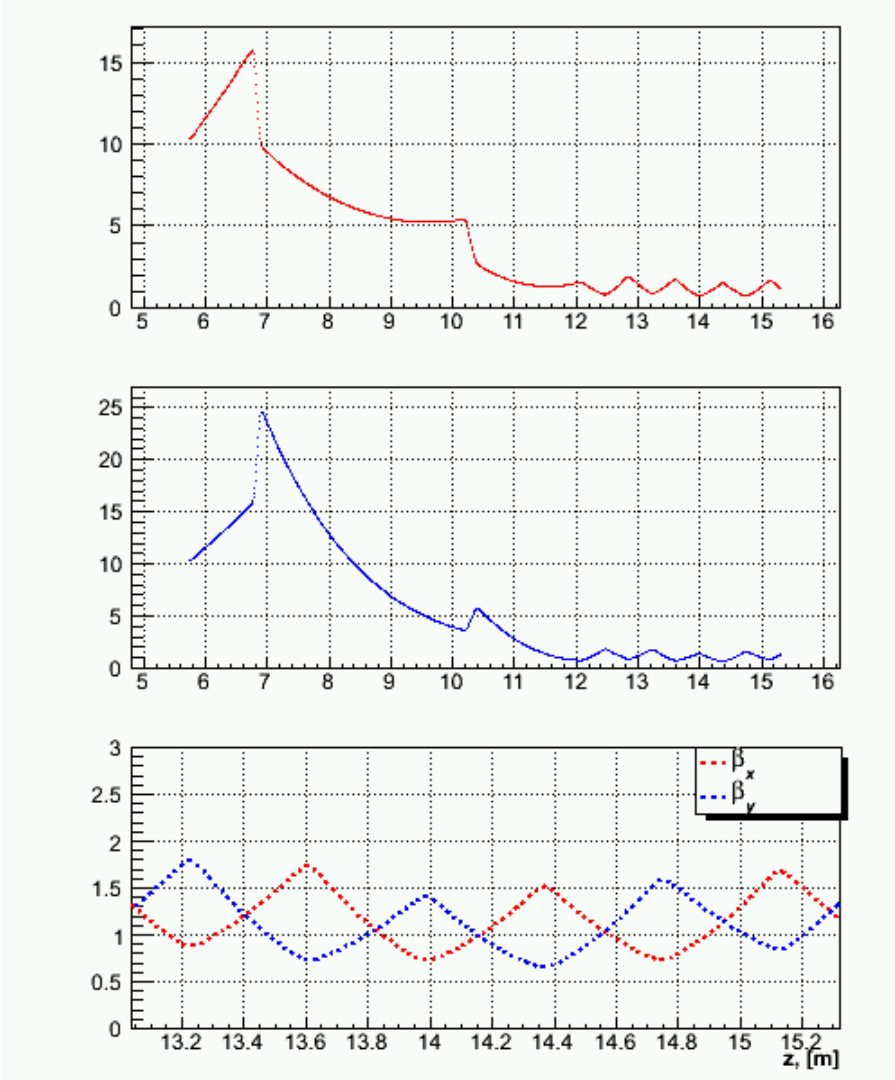
$\Delta\beta_{xmax}$ **≈ 38.1 %**
$\Delta\beta_{ymax}$ **≈ 49.1 %**

$\Delta\ \varepsilon_x$ = 35.0%

$\Delta\ \varepsilon_y$ = 28.1 %

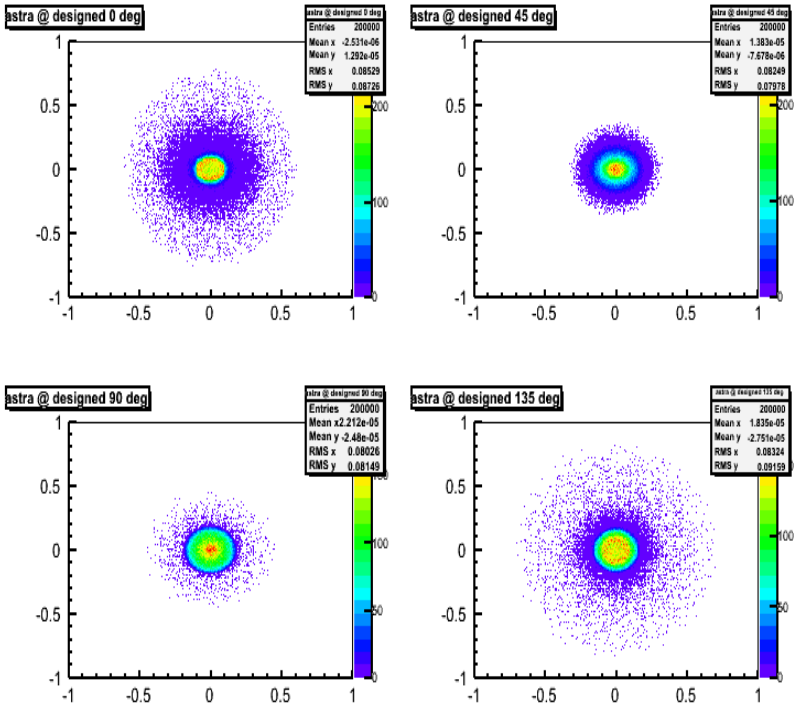
Simulation results (laser spot size of 180 μm)

III. Booster gradient = 18 MV/m



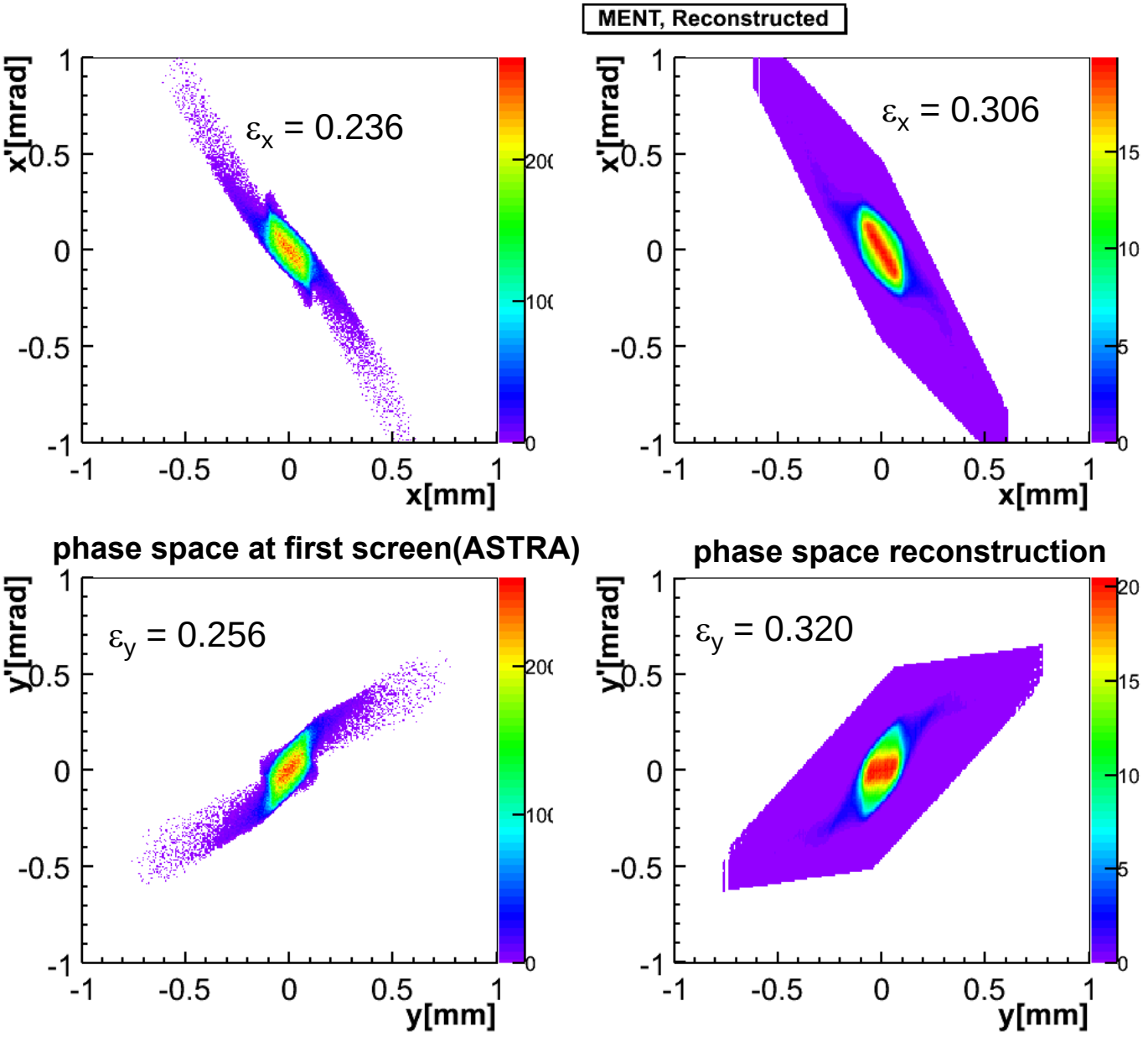
- Gun gradient = 60 MV/m
- Gun phase = 1.3 deg.
- Booster gradient = 18 MV/m
- Booster phase = 0.0 deg
- Ek = 21.83 MeV
- Bz = -0.2240 T
- ε_{xy} @ EMSY I = 0.1855 mm mmrad

$\Delta\beta_{xmax}$ ≈ 34.9 % , $\Delta\beta_{ymax}$ ≈ 36.9 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 180 µm)



I. Booster gradient
= 18 MV/m
Ek = 21.83 MeV

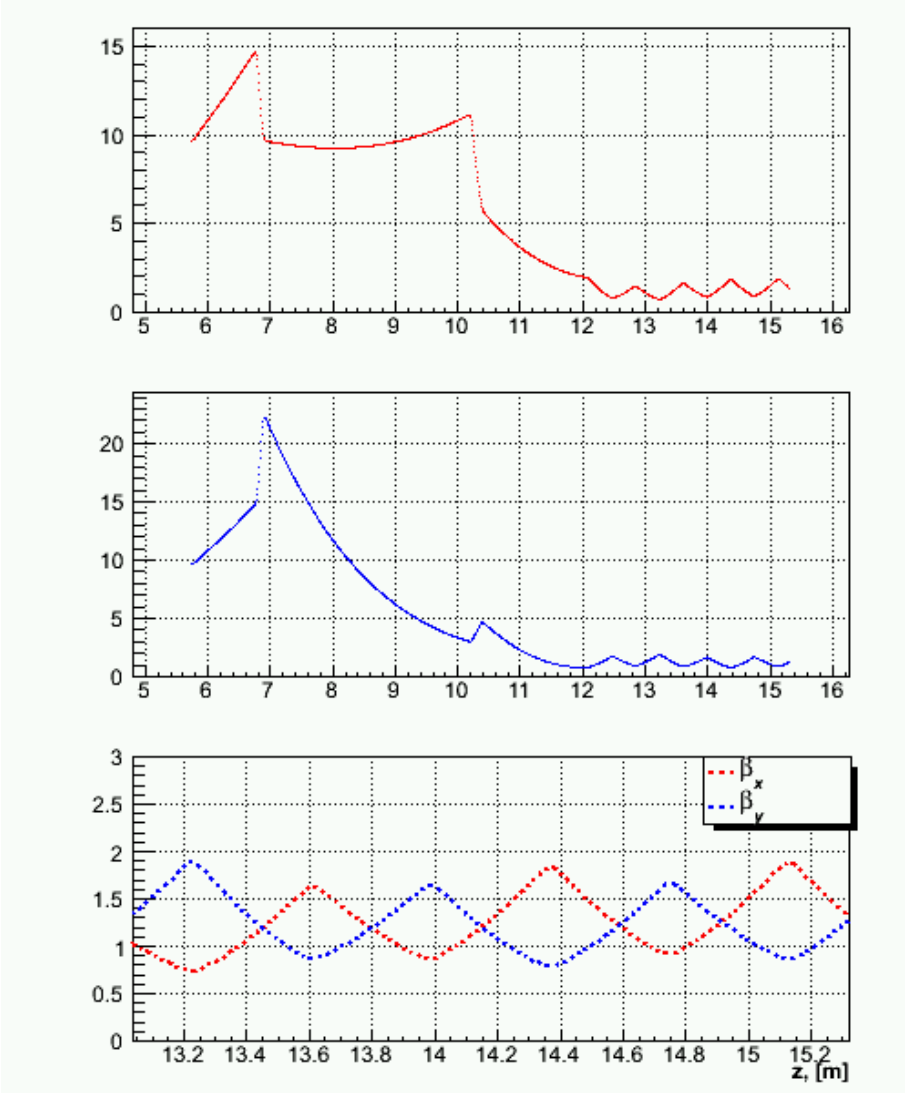
$\Delta\beta_{xmax}$ **≈ 34.9 %**
$\Delta\beta_{ymax}$ **≈ 36.9 %**

$\Delta\ \varepsilon_x$ = 29.0 %

$\Delta\ \varepsilon_y$ = 25.2 %

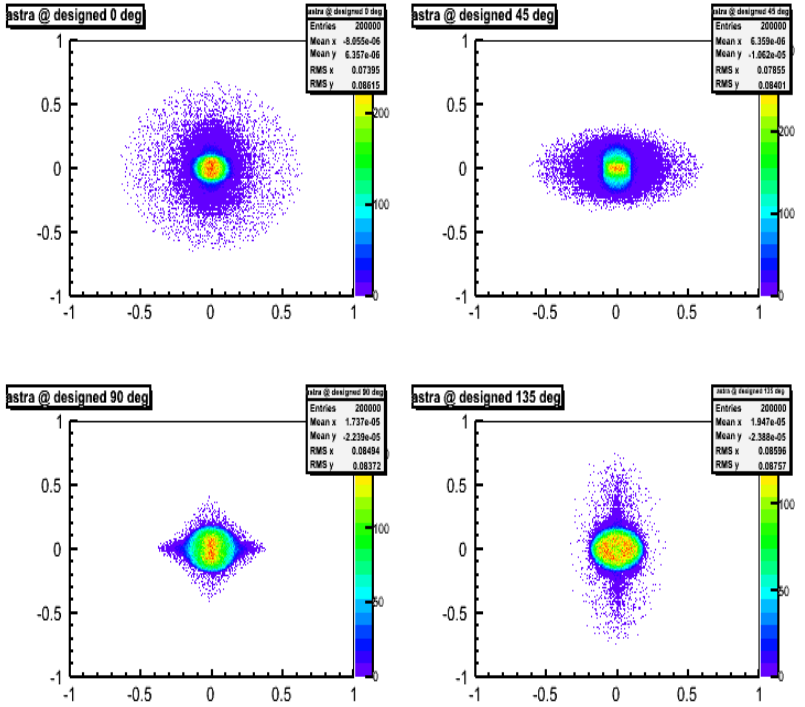
Simulation results (laser spot size of 180 μm)

IV. Booster gradient = 20 MV/m



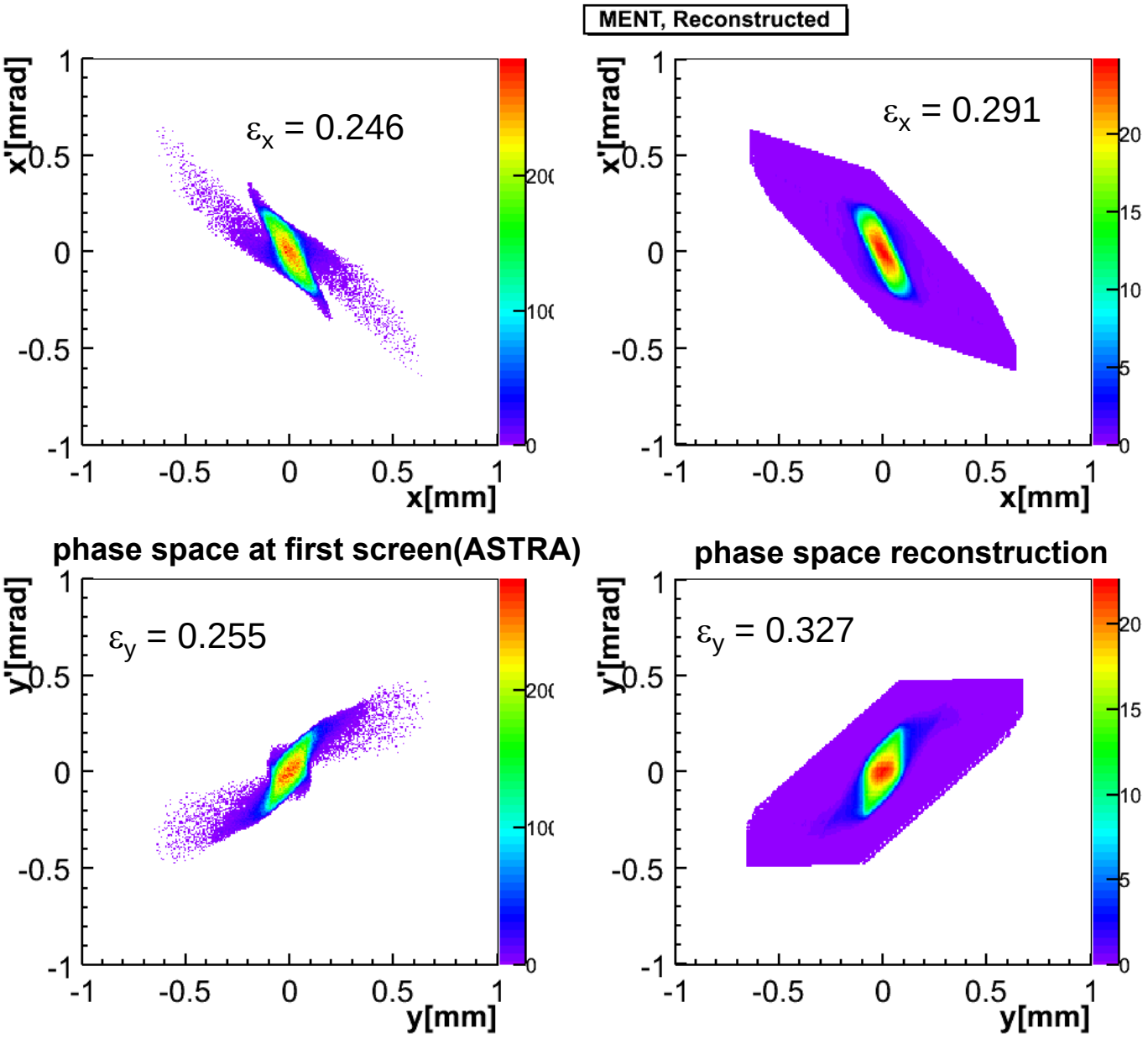
- Gun gradient = 60 MV/m
- Gun phase = 1.4 deg.
- Booster gradient = 20 MV/m
- Booster phase = 0.0 deg
- Ek = 23.58 MeV
- Bz = -0.2242 T
- ε_{xy} @ EMSY I = 0.1873 mm mmrad

$\Delta\beta_{xmax}$ ≈ 34.5 % , $\Delta\beta_{ymax}$ ≈ 37.6 %



ASTRA : 3D space charge , include quadrupole field

Phase space reconstruction (laser spot size of 180 µm)



I. Booster gradient
= 20 MV/m
Ek = 23.58 MeV

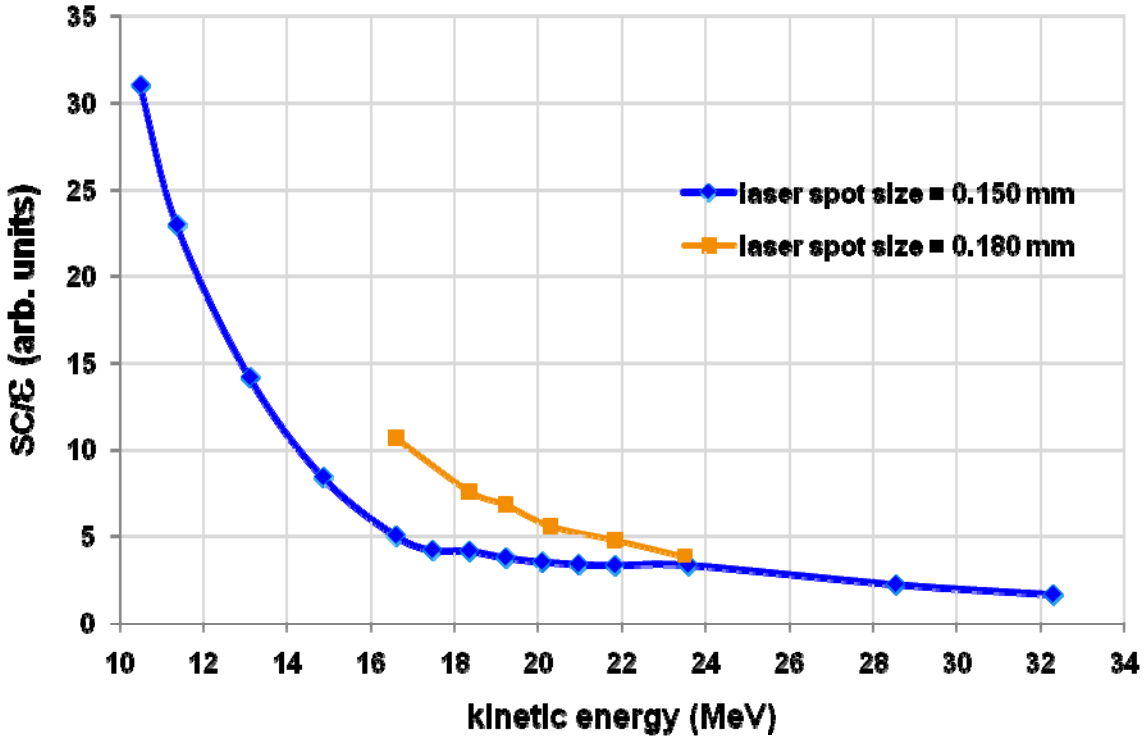
$\Delta\beta_{xmax}$ **≈ 34.5 %**
$\Delta\beta_{ymax}$ **≈ 37.6 %**

$\Delta\ \varepsilon_x$ = 18.4 %

$\Delta\ \varepsilon_y$ = 28.2 %

Difficulty (laser spot size of 180 µm)

- **Phase charge over emittance (at EMSY 1)**



$$\rho = \frac{I\sigma^3}{2\beta\gamma I_0 \varepsilon_N^2}$$

> 1

- **Particles in the head and tail ???**

Conclusions and future works

Conclusions

- Minimum emittance at EMSY 1 for laser spot size of 150 μm and 180 μm is still in space charge dominate regime
- Particles in the head and the tail of the bunch might cause difficulty in matching process (need to be investigated)
- Big halo in electron bunch on tomo screen contribute higher error in reconstructed phase space

In progress

- Adjust Q gradient systematically to find the best solution for laser spot size of 150 μm and 180 μm cases

Future works

- try new matching configulations
- Influence of particles in the head and the tail of the bunch in matching process
- Match solution for minimum spot size case
- Different charge simulation
- Phase space reconstruction @ EMSY I if we have good solutions

Special thank

F. Stephan, M. Krasilnikov, G. Asova and S. Rimjaem

&

All colleagues in PITZ

&

Thank you for your attention !

Difficulty

Emittance change in matching section and tomography module