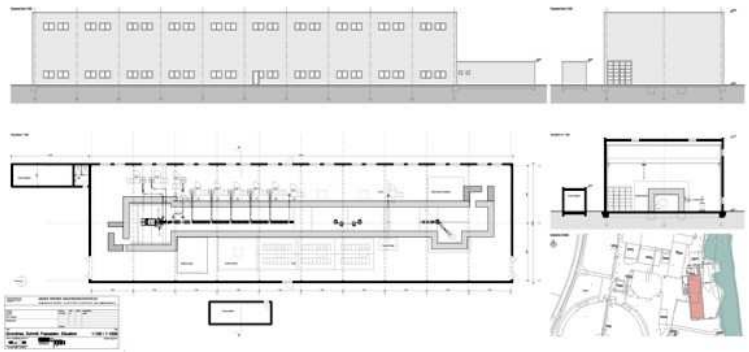
PAUL SCHERRER INSTITUT

PSI

L FEL G



Experimental Measurements Based

Back Tracking Simulations for Recent OBLA Operations

Yujong Kim

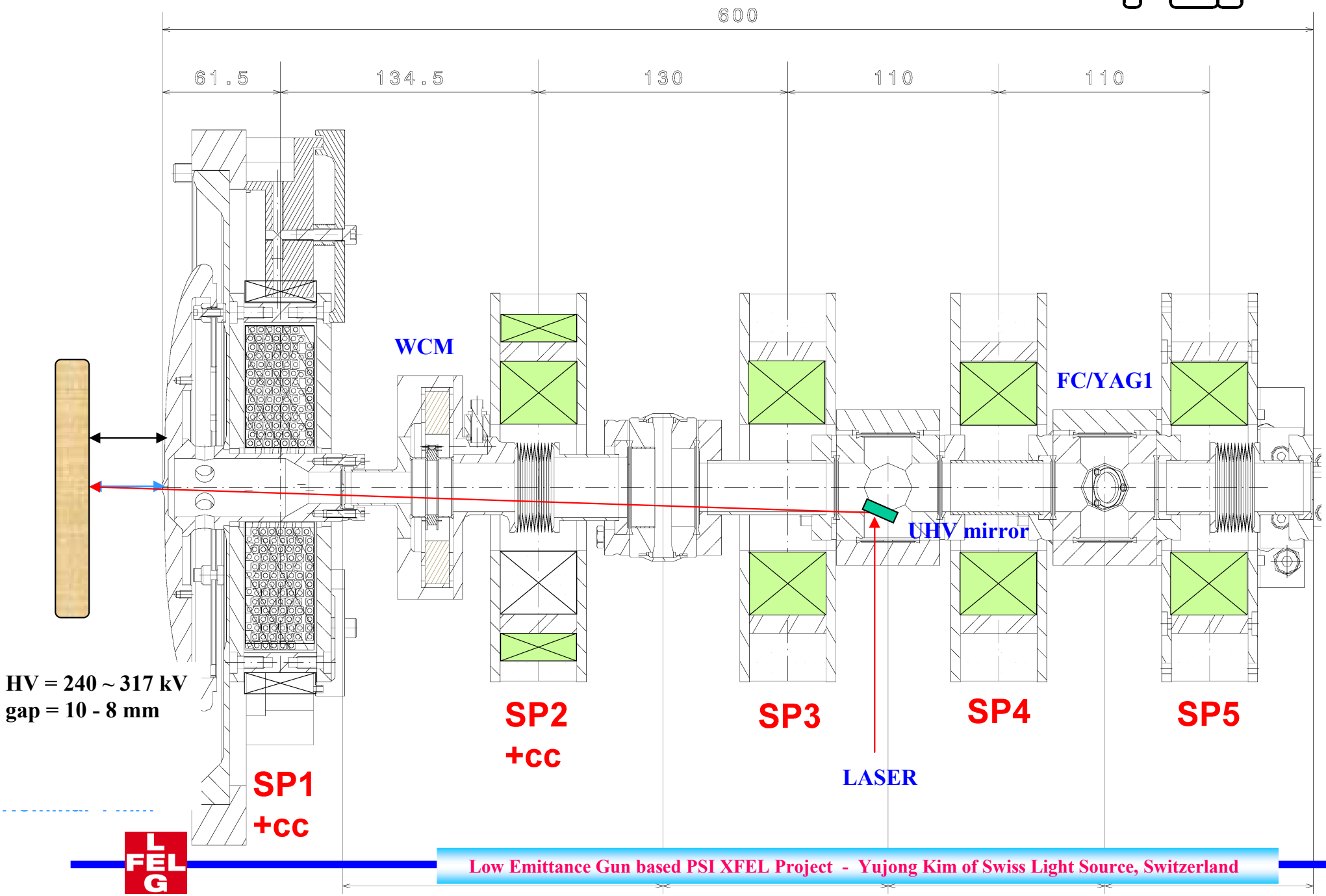
PSI, CH-5232 Villigen PSI, Switzerland

yujong.kim@PSI.ch, http://www.PSI.ch/~kim_y, http://FEL.WEB.PSI.ch

PSI XFEL-2008-02

Contents

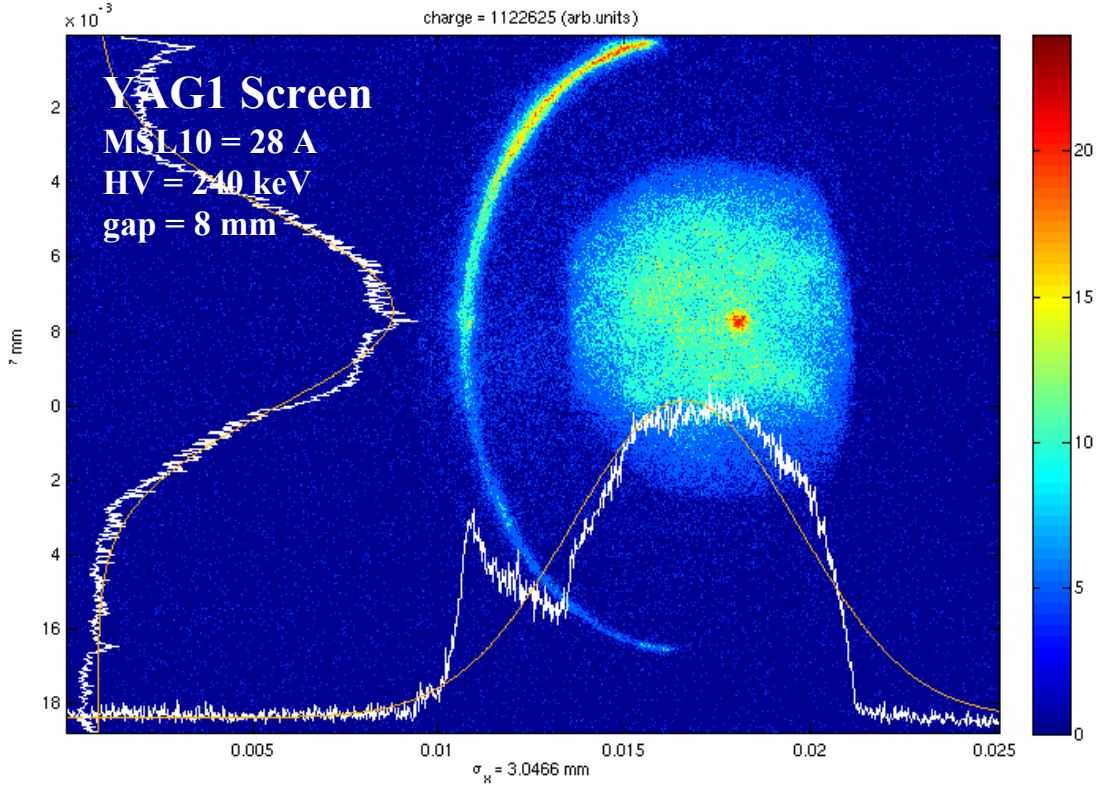
Layout of OBLA

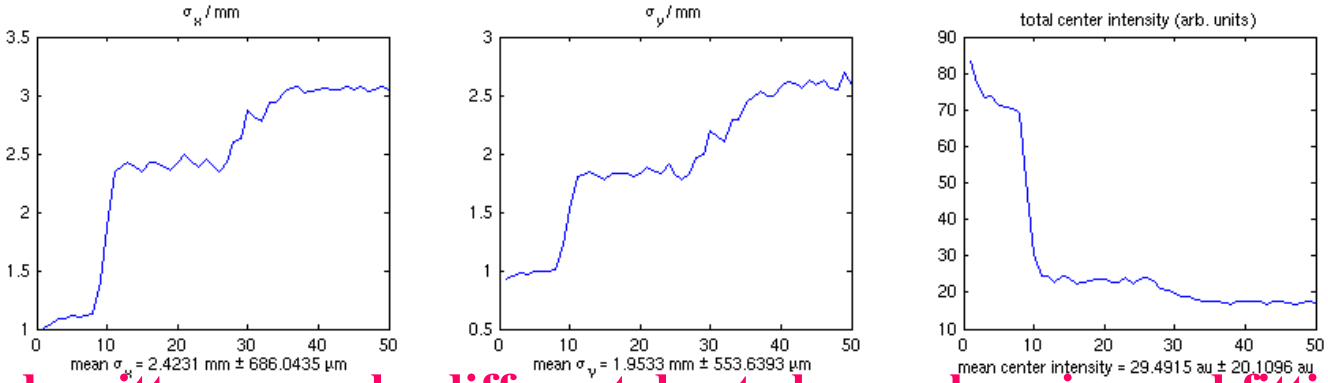


Chopped Beam and Fitting Error

PAUL SCHERRER INSTITUT

HV = 280 ~ 317 kV
gap = 8 ~ 10 mm
MSL10 ~ 28 - 37 A





our measured emittance can be different due to beam chopping and fitting error !!!

Charge Difference Between FC & WCM

PAUL SCHERRER INSTITUT

gap voltage = 280 kV (low beam energy, we can not apply strong focusing)
gap = 10 mm
MSL10 = from 27 A to 36 A with 1 A step.
all other magnets = 0 A

MSL10 current	Charge at FC		Charge at WCM
36 A	13.7 pC	over focusing	
35 A	15.5 pC		
34 A	15.6 pC		
33 A	15.8 pC		~ 16 pC
32 A	15.5 pC		
31 A	15.26 pC		
30 A	14.18 pC		
29 A	11.44 pC		
28 A	9.1 pC		
27 A	7.22 pC	weak focusing	

Measured on Feb. 20th, 2008

Back Tracking Simulation Method

PAUL SCHERRER INSTITUT

For realistic simulations, we used all measured data for Back Tracking:

Measured gap voltage
Measured solenoid fields
Measured charge from Faraday cup
Measured laser pulse length & profile (assumed uniformed Gaussian)
Measured laser profile (assumed uniform Gaussian)
Measured beam size on YAG1 screen to estimate laser beam size on cathode (Back Tracking)

Measured RMS Beam Size

PAUL SCHERRER INSTITUT

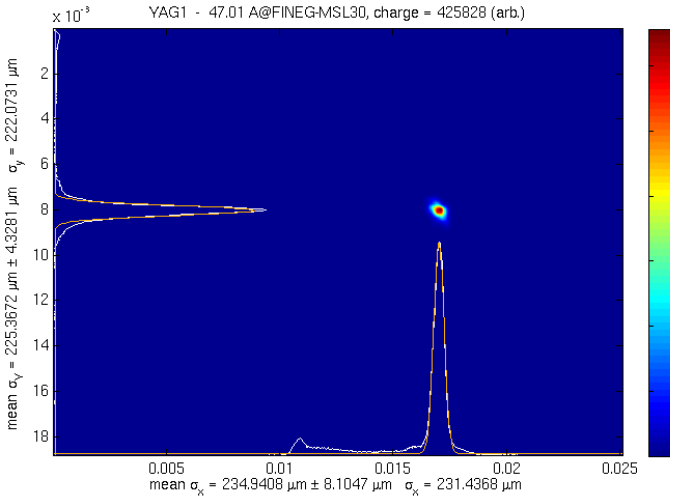
For realistic simulations, we used all measured data for Back Tracking

Operation conditions on Feb 22nd, 2008

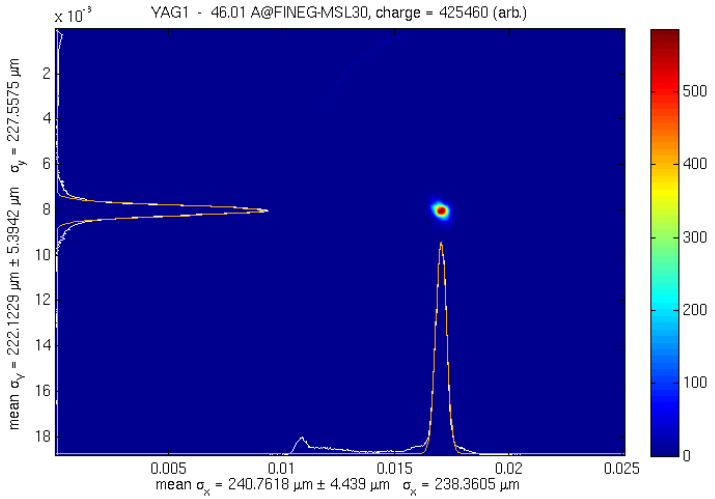
Beam kinetic energy = 240 keV	**Gap size = 8 mm**	**Charge = 12 pC**
MSL10 = 29 A	**MSL30 = 46 - 48 A**	**Used screen = YAG1**
Laser long profile = Gaussian	**Laser rms length = 6.5 ps**	**Laser trans. profile = Gaussian**

Estimated laser rms size ~ 53.75 μm from back tracking and measured one.

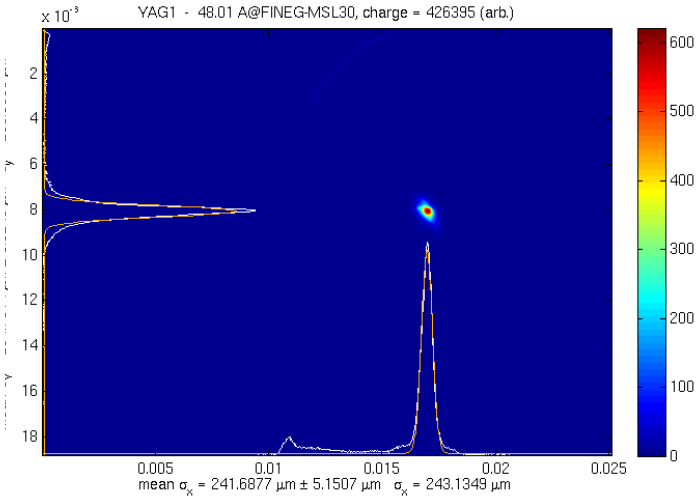
MSL30 = 46 A



MSL30 = 47 A



MSL30 = 48 A



measured beam size on YAG1 = 230 ~ 240 μm

ASTRA Back Tracking on RMS Laser Size

PAUL SCHERRER INSTITUT

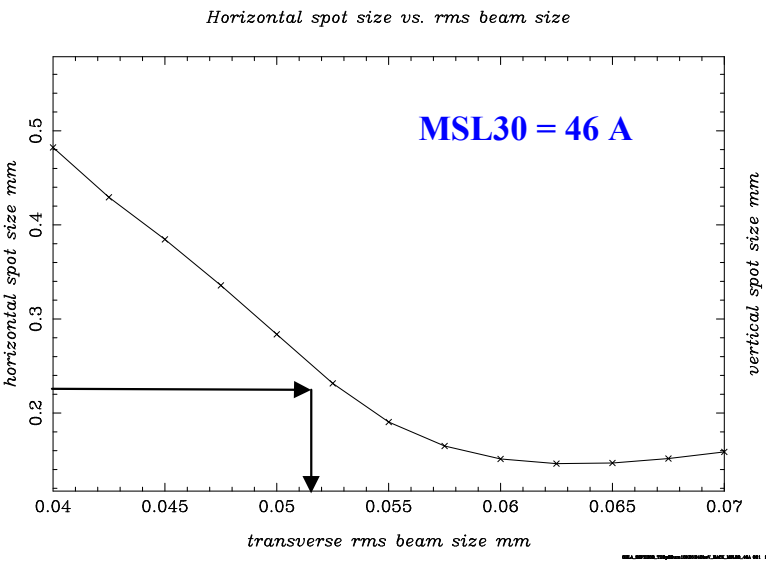
For realistic simulations, we used all measured data for Back Tracking

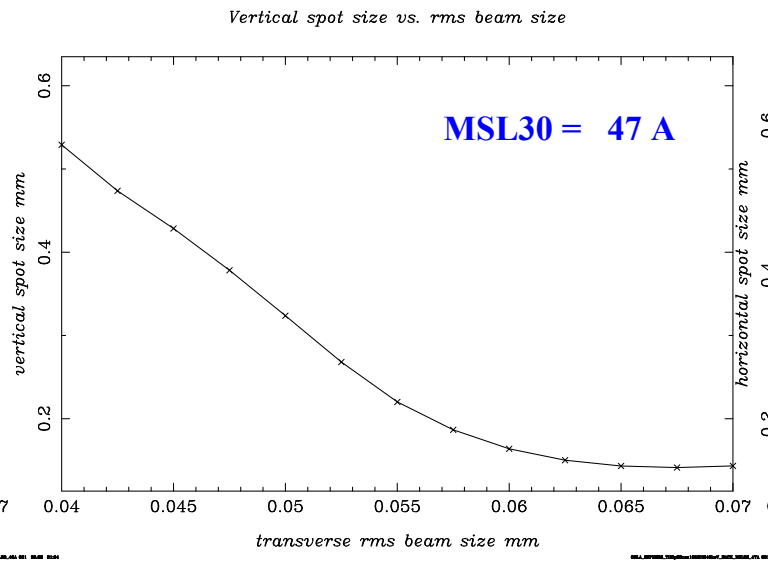
Operation conditions on Feb 22nd, 2008

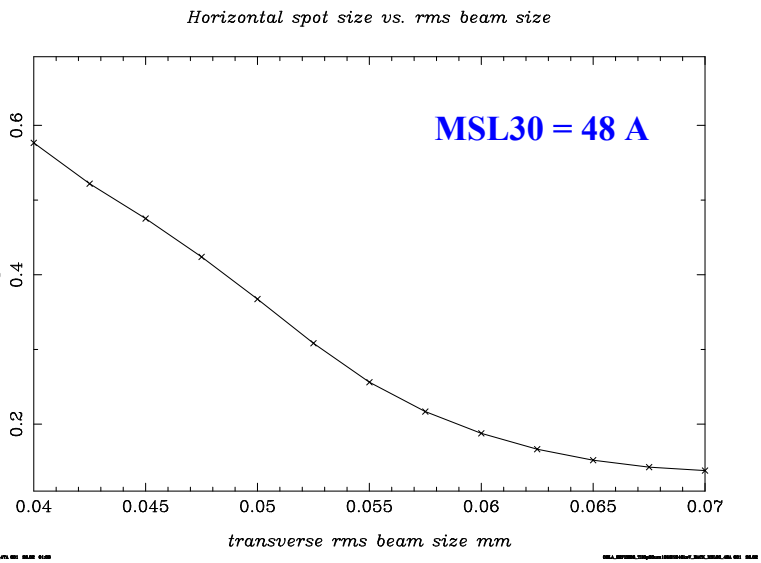
Beam kinetic energy = 240 keV	**Gap size = 8 mm**	**Charge = 12 pC**
MSL10 = 29 A	**MSL30 = 46 - 48 A**	**Used screen = YAG1**
Laser long profile = Gaussian	**Laser rms length = 6.5 ps**	**Laser trans. profile = Gaussian**

Estimated laser rms size ~ 53.75 μm from back tracking and measured one.

ASTRA Back Tracking Simulation on rms laser size Vs. MSL30 current







estimated laser beam size on cathode = 53.75 μm

Measured Laser Profile on Virtual Cathode

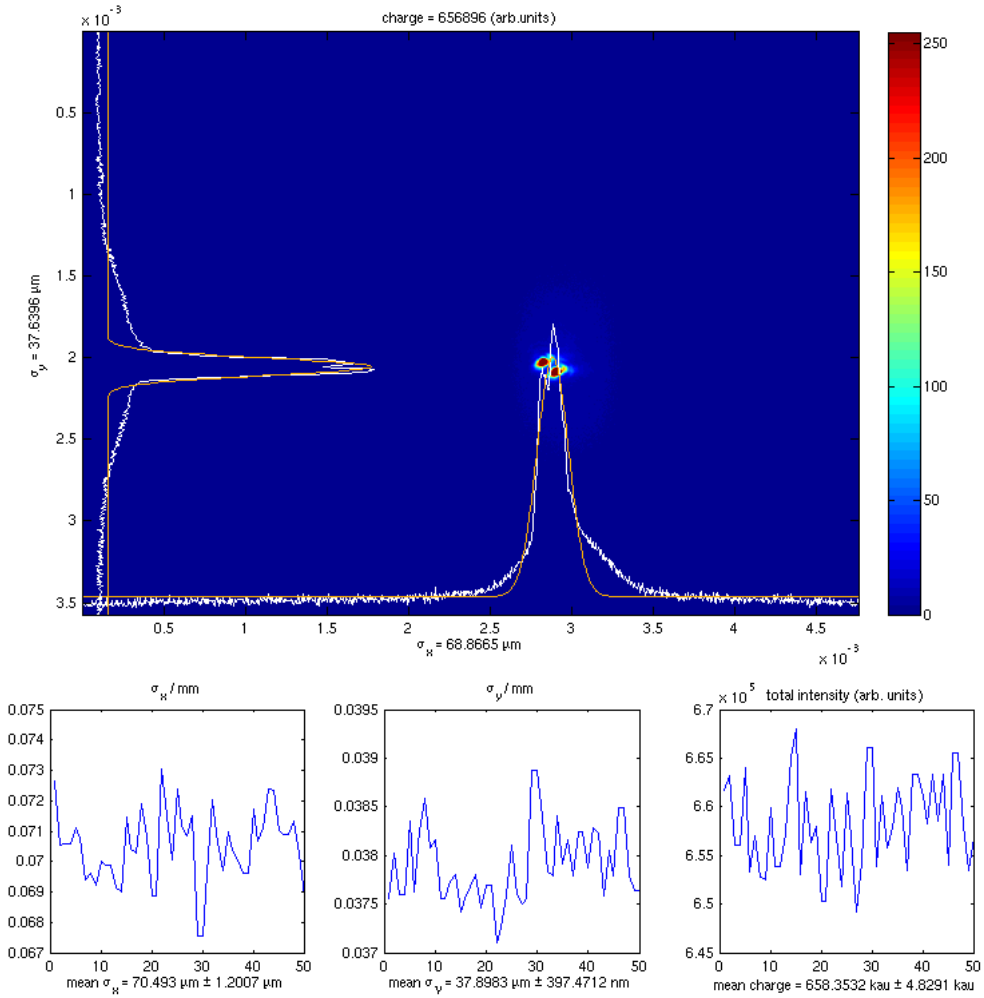
PAUL SCHERRER INSTITUT

Well agreed with Simulation & Measurements !!!

From e-logbook on Feb. 21, 2008

Note that we have to multiply a missing factor sqrt(2) in this measured value

We fixed this bug in Matlab ShowImage tool from Feb. 22th, 2008.



horizontal for two some overlapping spikes
~ 68.9 µm * sqrt(2) ~ 97 µm
If we divide with 2, it is about 48.69 µm.

vertical for almost one spike
~ 37.6 µm * sqrt(2) ~ 52.3 µm

Measured Laser Profile on Virtual Cathode

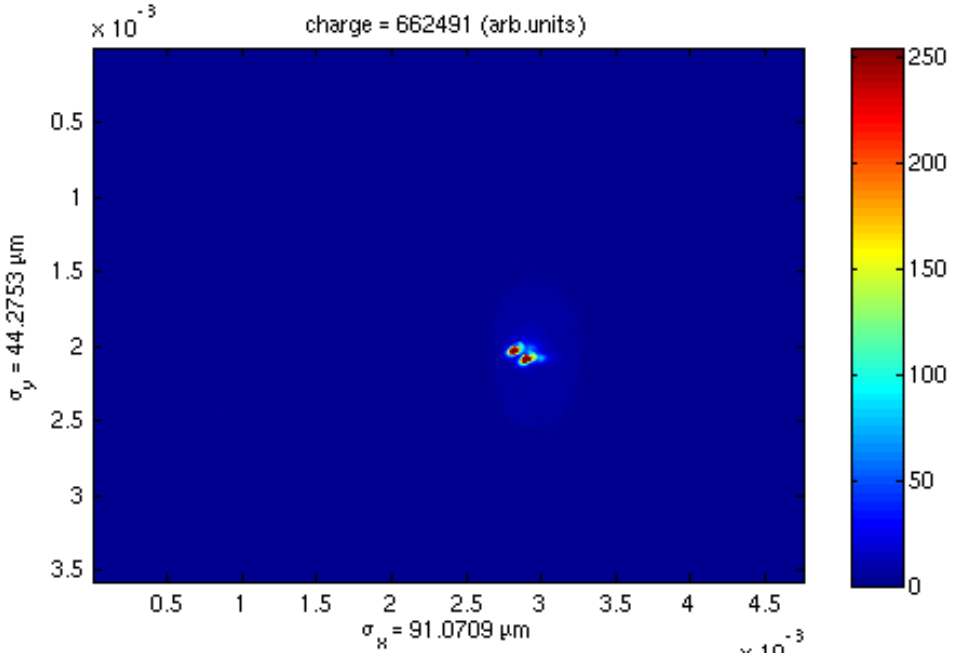
PAUL SCHERRER INSTITUT

Well agreed with Simulation & Measurements !!!

From e-logbook on Feb. 21, 2008

Note that we have to multiply a missing factor sqrt(2) in this measured value

We fixed this bug in Matlab ShowImage tool from Feb. 22th, 2008.



horizontal for two some overlapping spikes
~ 91.1 μm * sqrt(2) ~ 129 μm
If we divide with 2, it is about 64 μm.

vertical for almost one spike
~ 44.2 μm * sqrt(2) ~ 62.6 μm

When we used a different Matlab tool for the same laser profile, measured laser beam size was slightly larger than that at previous page. Therefore, if we apply average for two cases, it is close to 56 μm for horizontal and it is close to 57.6 μm for vertical.
These sizes are very close to our estimated value with the backing tracking simulation.

ASTRA Simulations on Recent Operations

PAUL SCHERRER INSTITUT

For realistic simulations, we used all measured data for Back Tracking

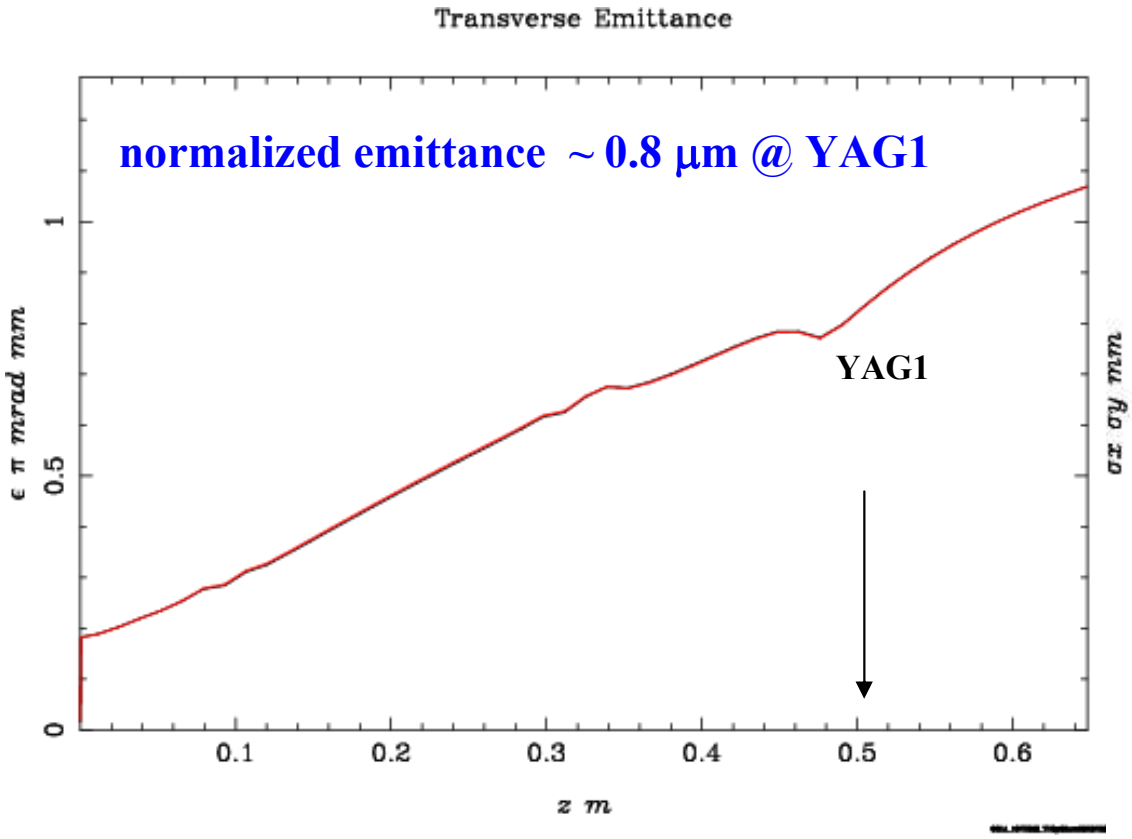
Operation conditions on Feb 19th, 2008

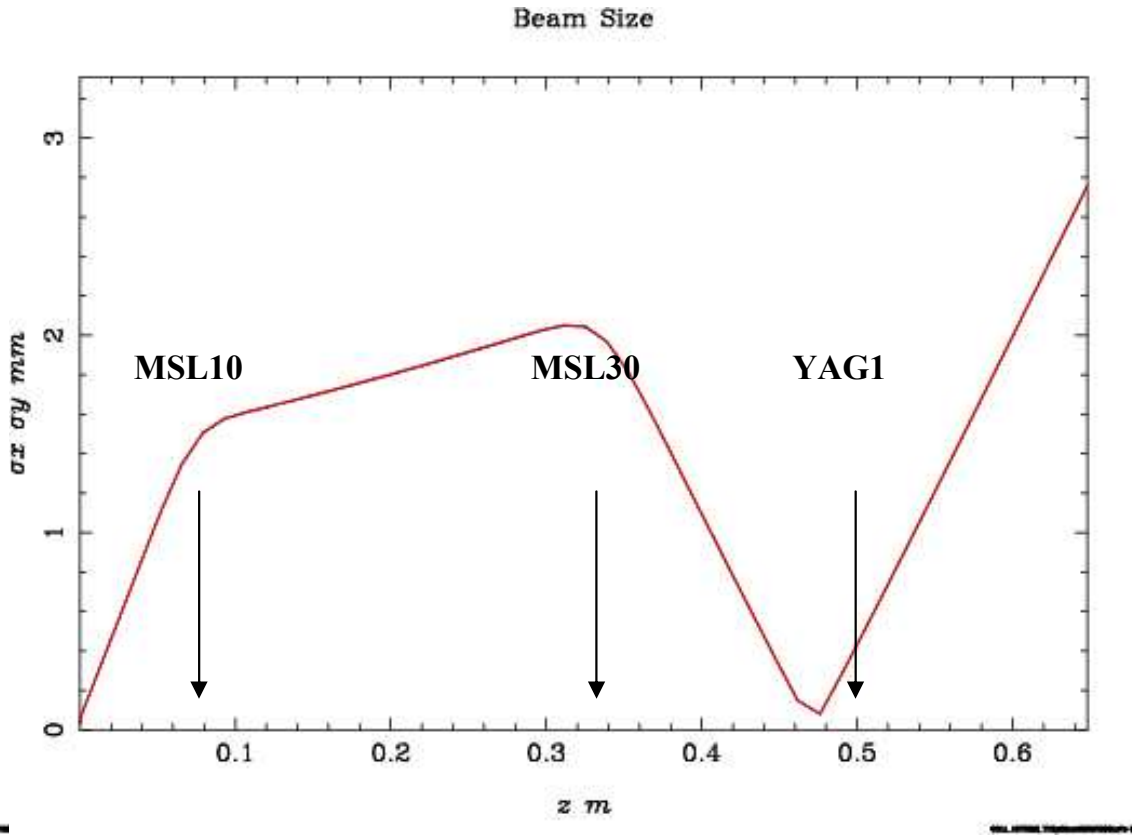
Beam kinetic energy = 292 keV
Gap size = 10 mm
Charge = 12 pC
MSL10 = 28 A
MSL30 = 58 A
Used screen = YAG1
Laser long profile = Gaussian
Laser rms length = 6.5 ps
Laser trans. profile = Gaussian
Laser rms size ~ 54 μm
(comes from back tracking and measured one).

ASTRA Back Tracking Results

PAUL SCHERRER INSTITUT

Cathode = 0.0 m
MSL30 = 0.336 m from cathode
YAG1 = 0.501 m from cathode
MSL10 = 0.0715 m from cathode
MSL40 = 0.446 m from cathode
MSL50 = 0.556 m from cathode

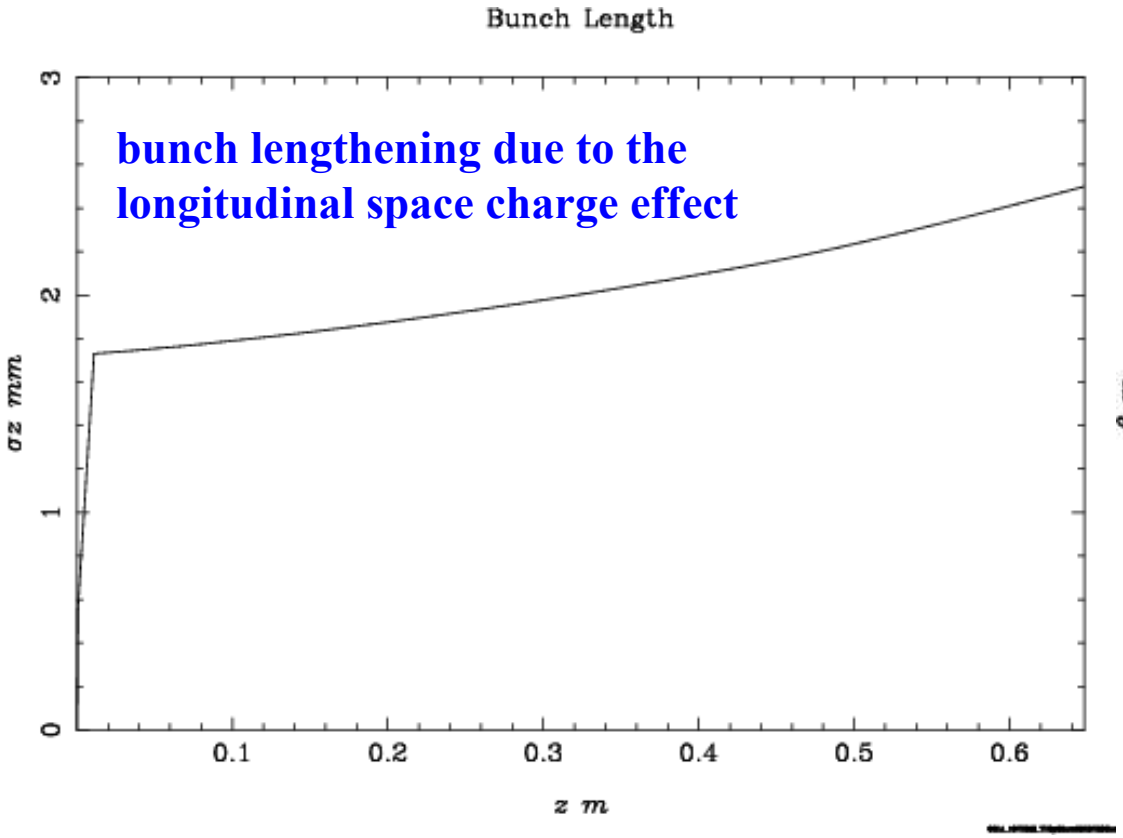


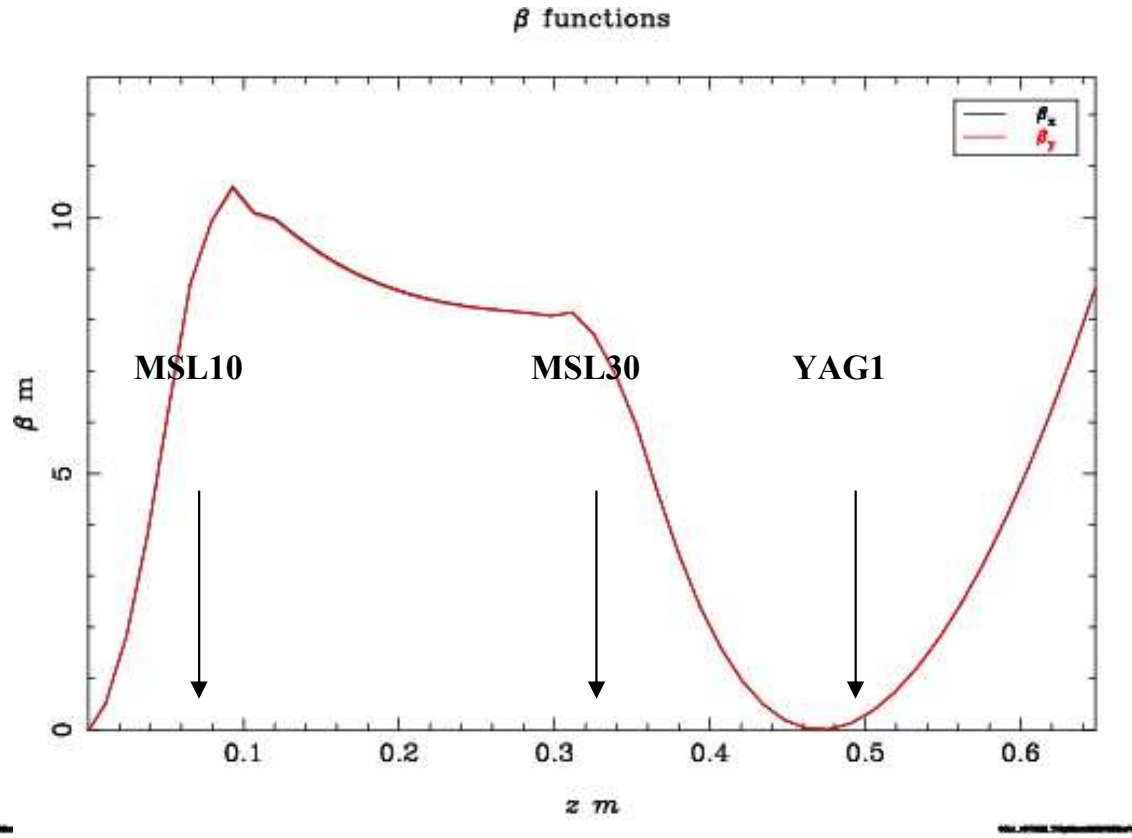


ASTRA Back Tracking Results

PAUL SCHERRER INSTITUT

Cathode = 0.0 m
MSL30 = 0.336 m from cathode
YAG1 = 0.501 m from cathode
MSL10 = 0.0715 m from cathode
MSL40 = 0.446 m from cathode
MSL50 = 0.556 m from cathode

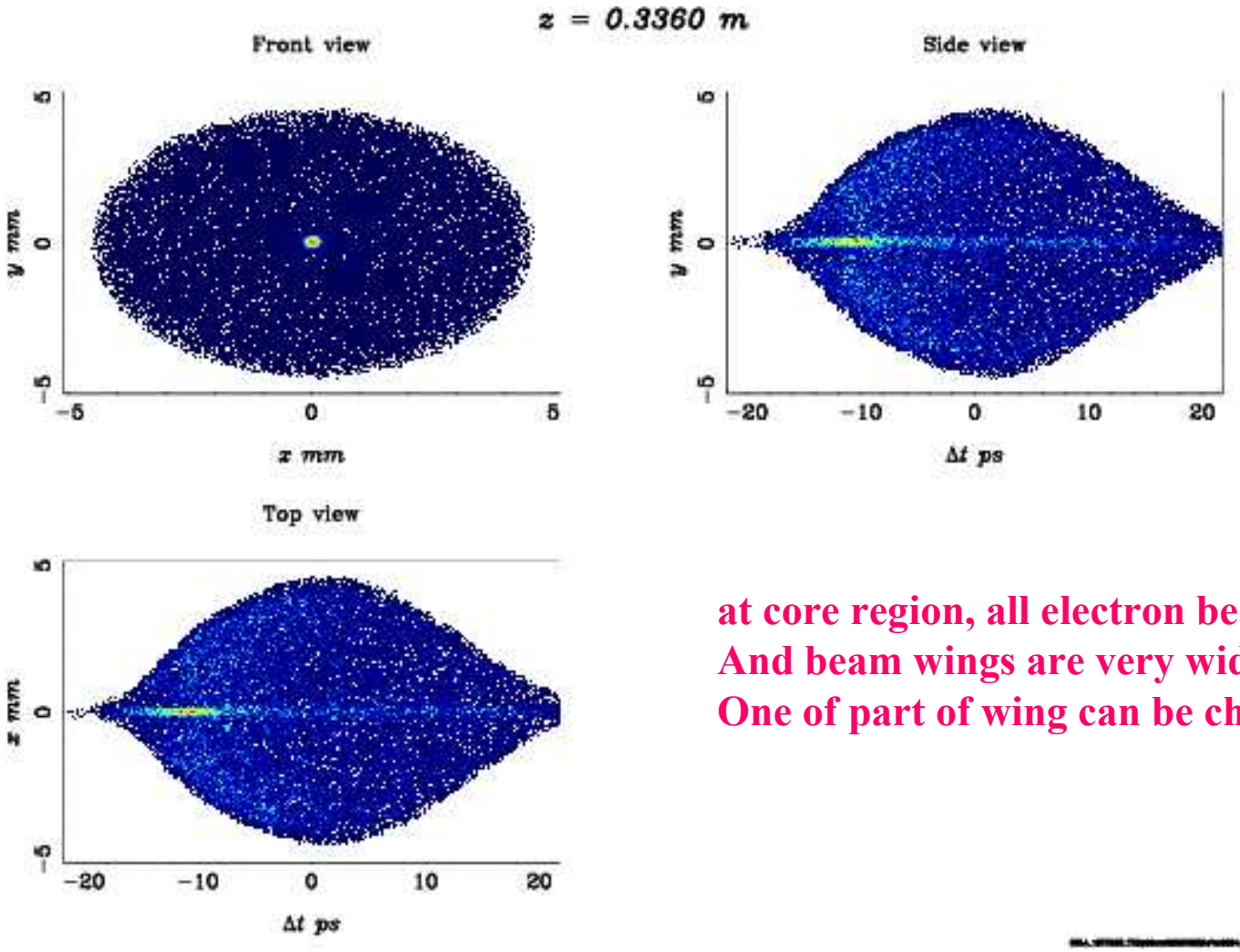




ASTRA Back Tracking Results

PAUL SCHERRER INSTITUT

Cathode = 0.0 m
MSL30 = 0.336 m from cathode
YAG1 = 0.501 m from cathode
MSL10 = 0.0715 m from cathode
MSL40 = 0.446 m from cathode
MSL50 = 0.556 m from cathode



Beam @ MSL30
Before UHV mirror

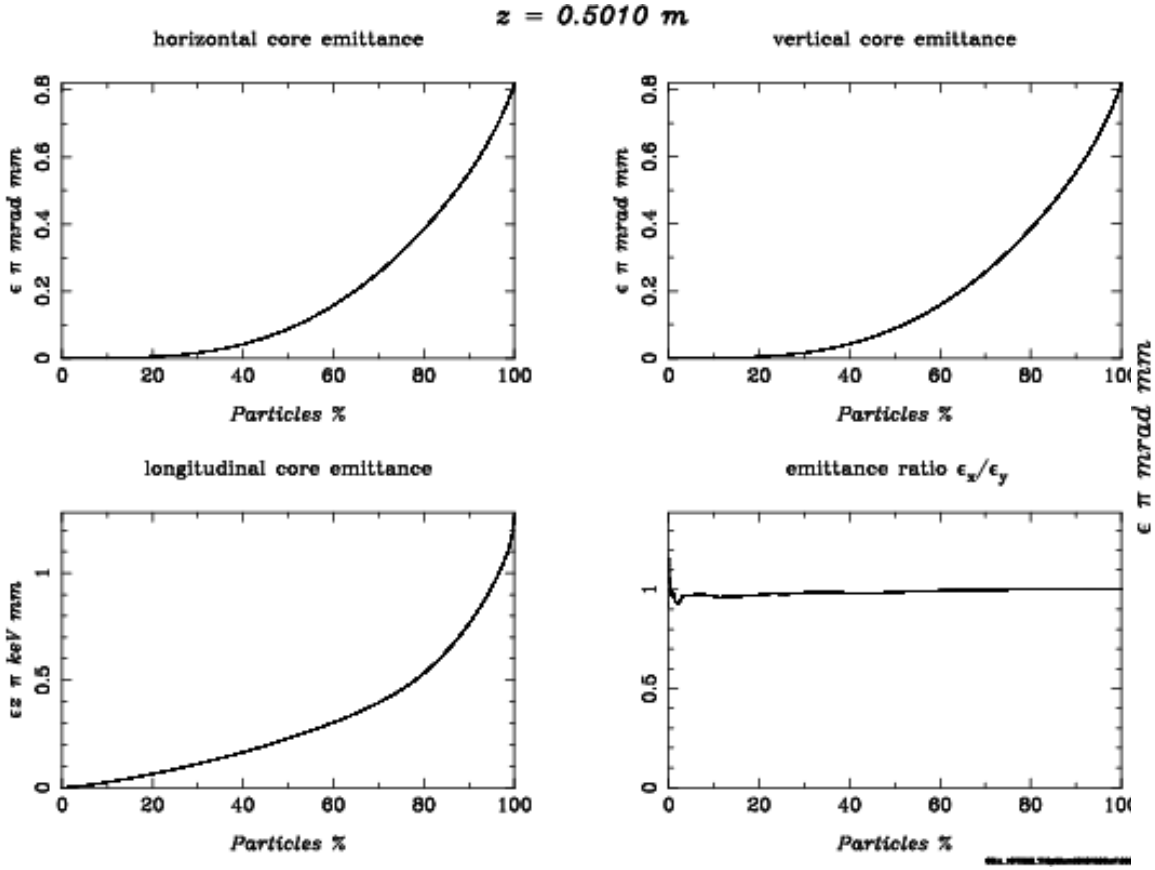
at core region, all electron beams are concentrated !!!
And beam wings are very wide ~ 5 mm !!!
One of part of wing can be chopped by the UHV mirror.

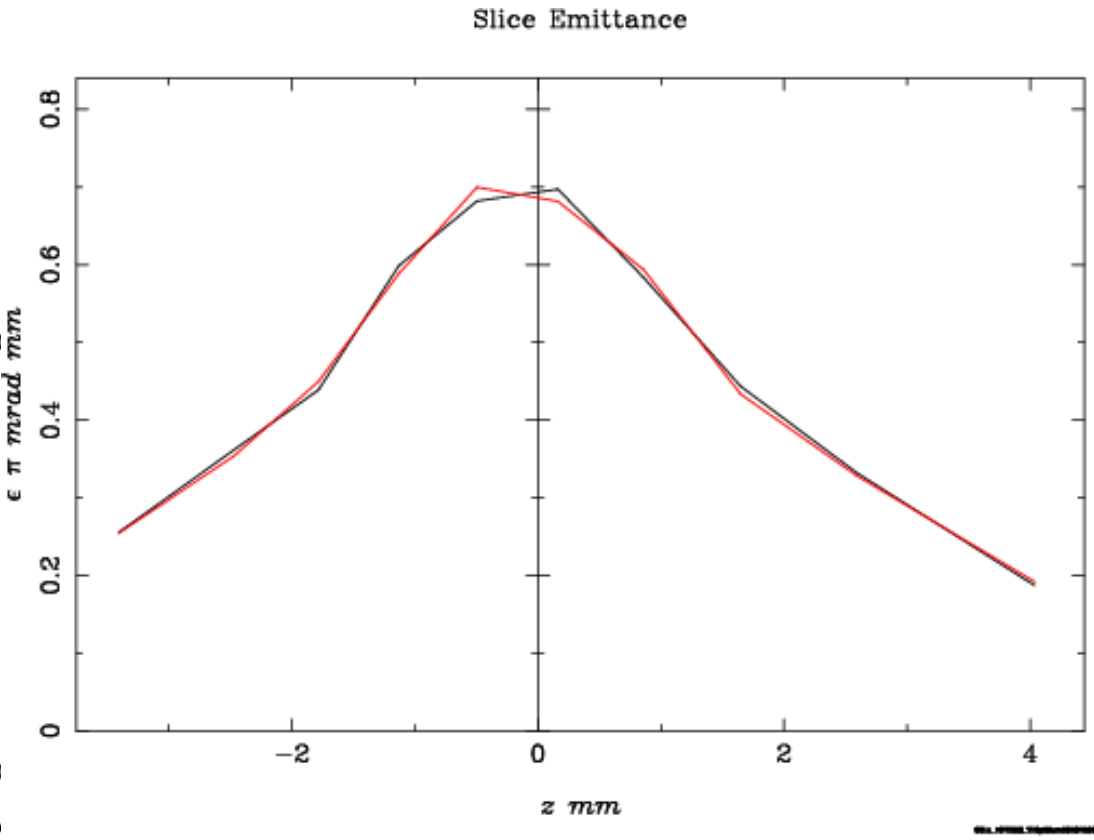
ASTRA Back Tracking Results

PAUL SCHERRER INSTITUT

Cathode = 0.0 m
MSL30 = 0.336 m from cathode
YAG1 = 0.501 m from cathode
MSL10 = 0.0715 m from cathode
MSL40 = 0.446 m from cathode
MSL50 = 0.556 m from cathode

At YAG1 screen



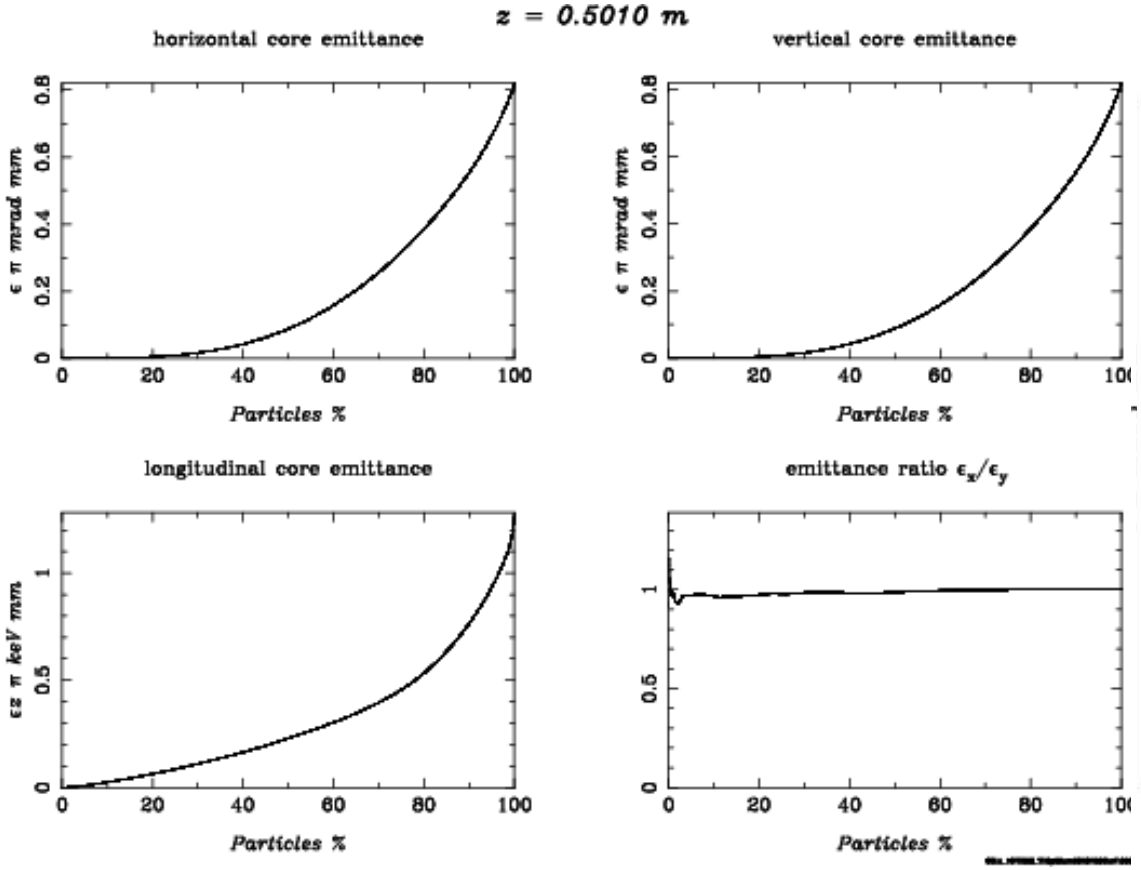


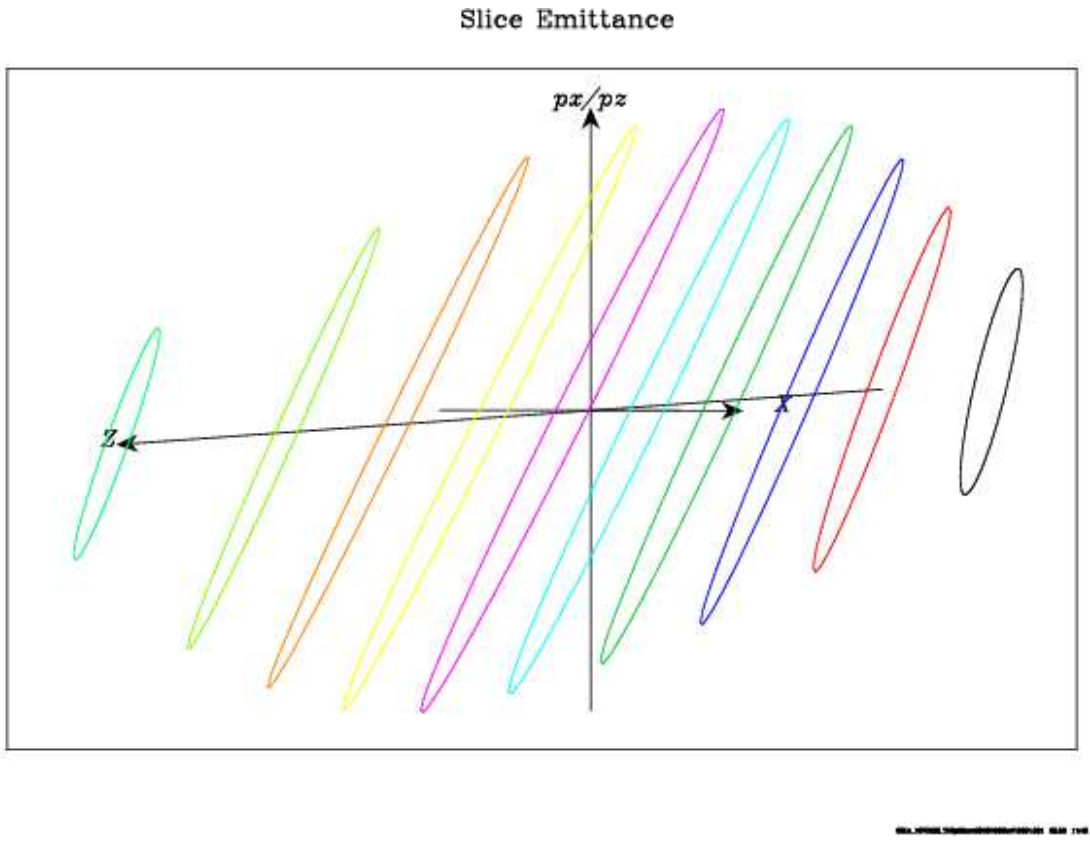
ASTRA Back Tracking Results

PAUL SCHERRER INSTITUT

Cathode = 0.0 m
MSL30 = 0.336 m from cathode
YAG1 = 0.501 m from cathode
MSL10 = 0.0715 m from cathode
MSL40 = 0.446 m from cathode
MSL50 = 0.556 m from cathode

At YAG1 screen

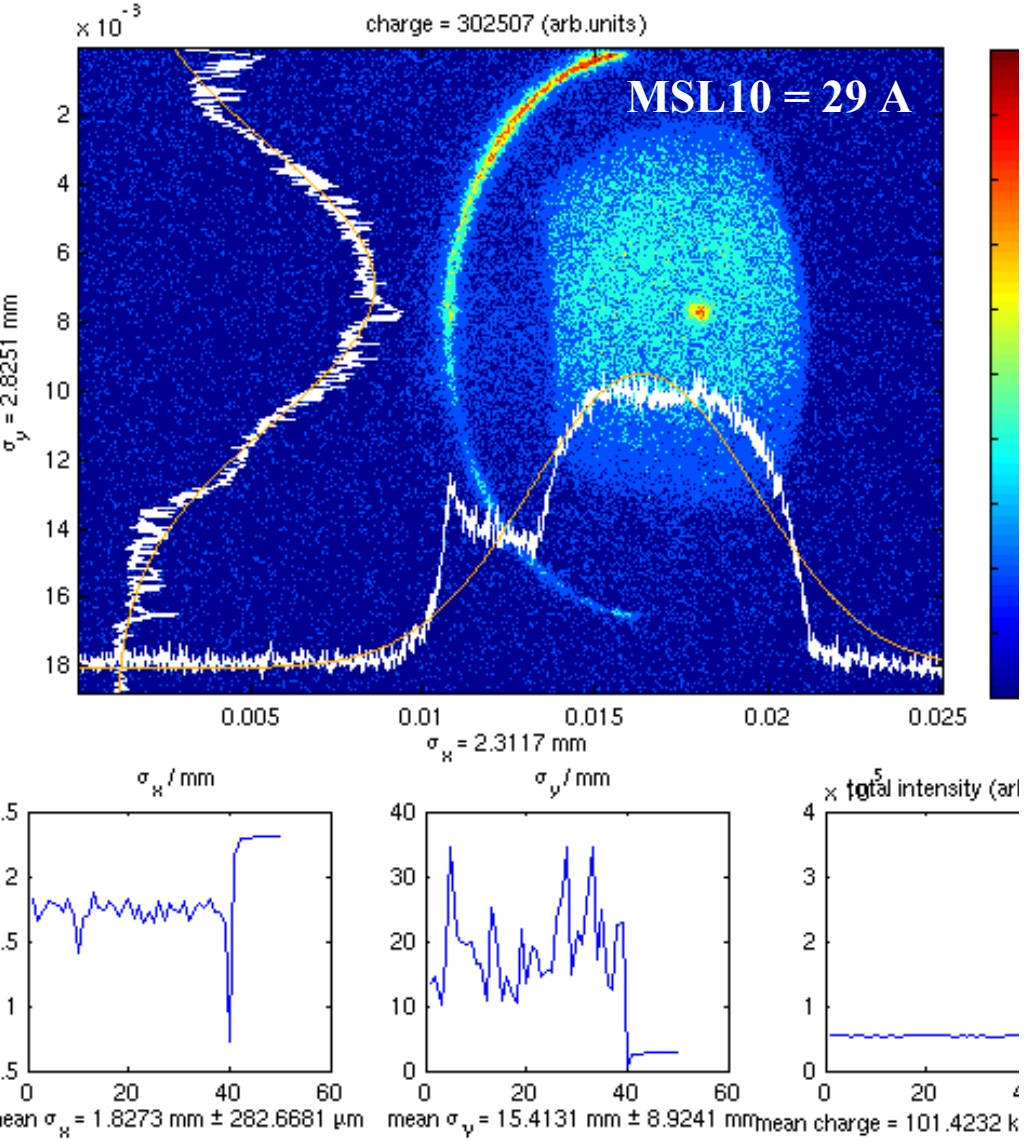


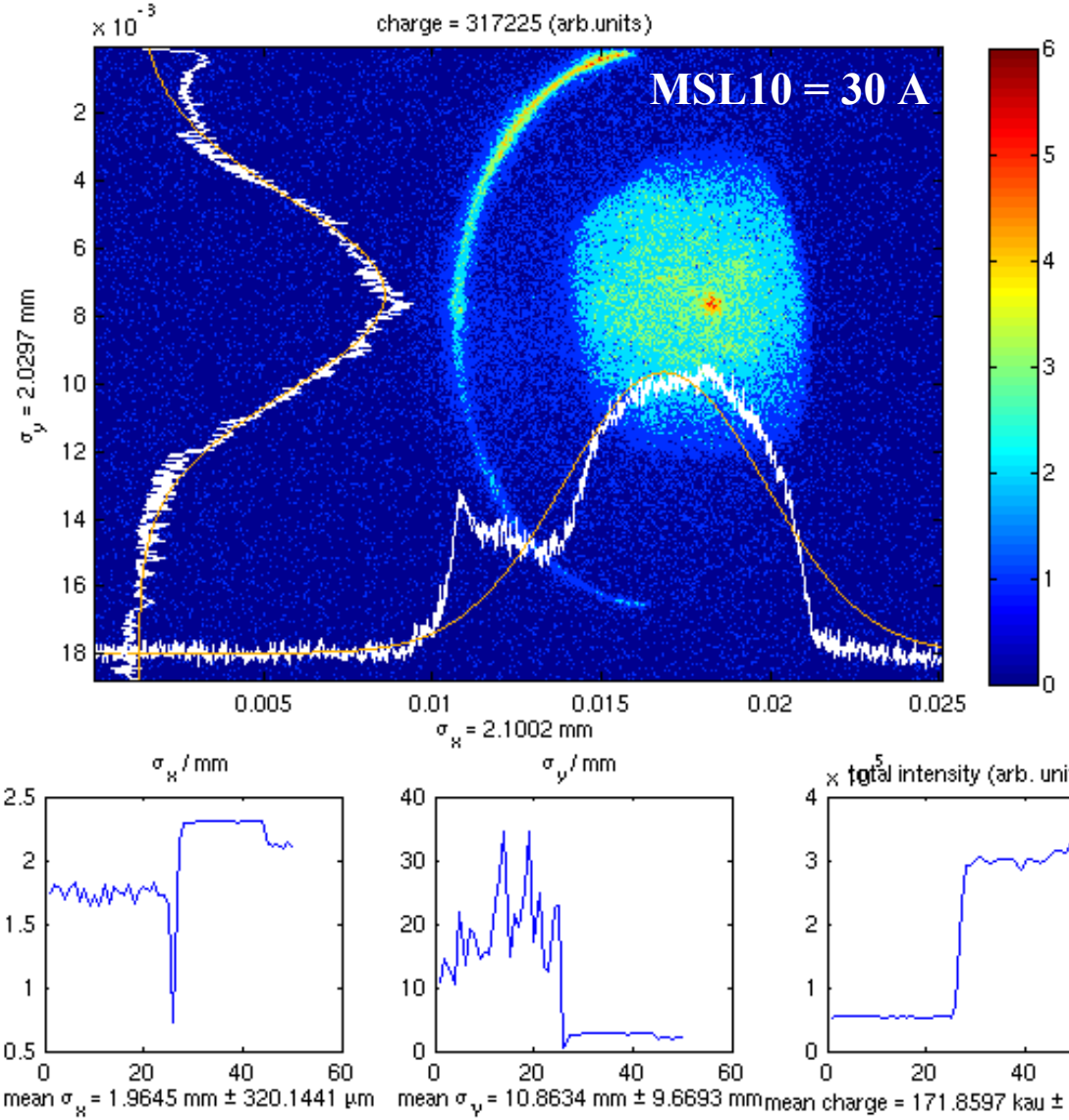


Beam Chopping Checking at 280 keV

PAUL SCHERRER INSTITUT

gap voltage = 280 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A

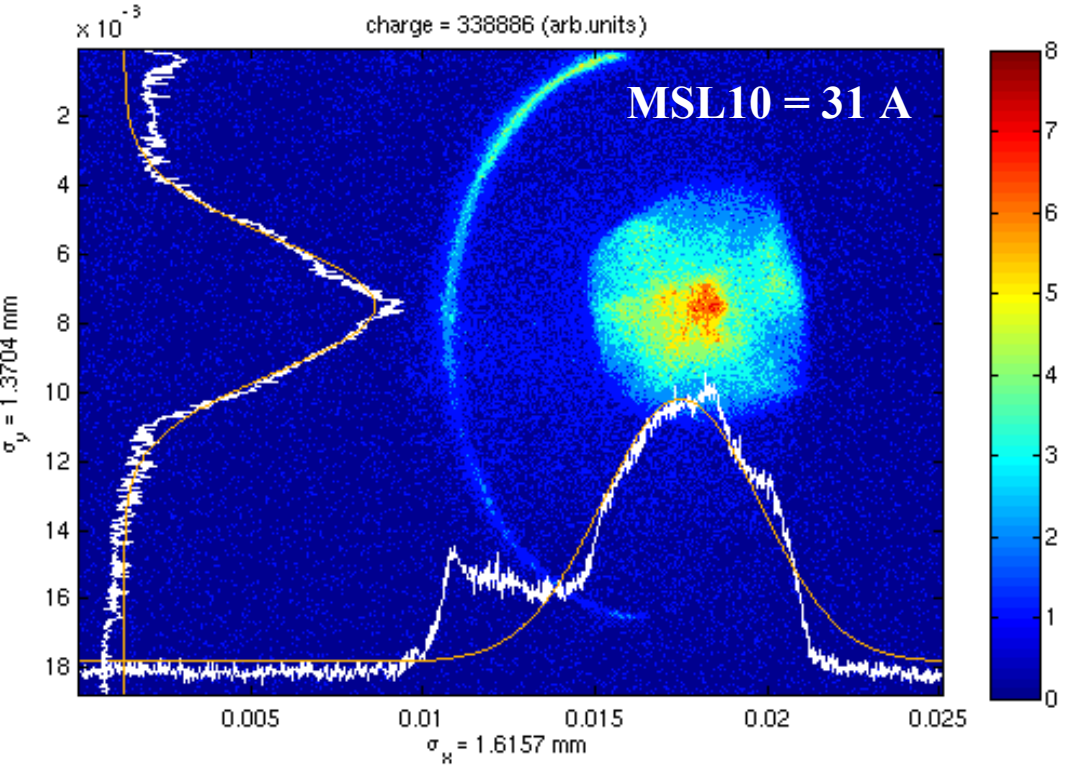


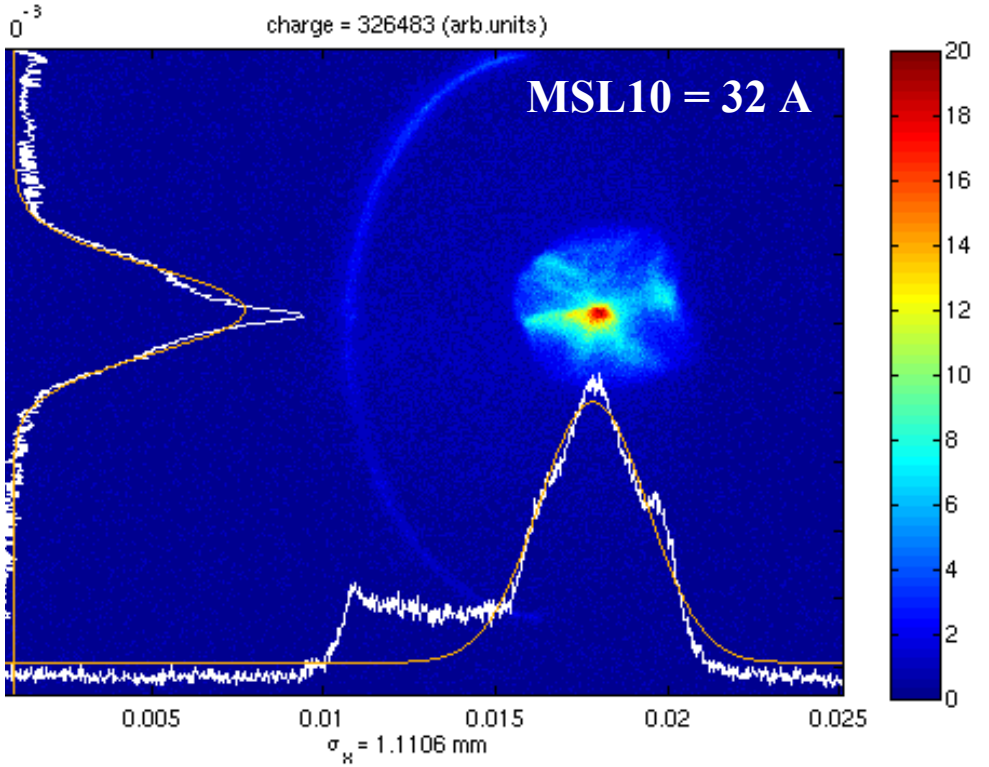


Beam Chopping Checking at 280 keV

PAUL SCHERRER INSTITUT

gap voltage = 280 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A

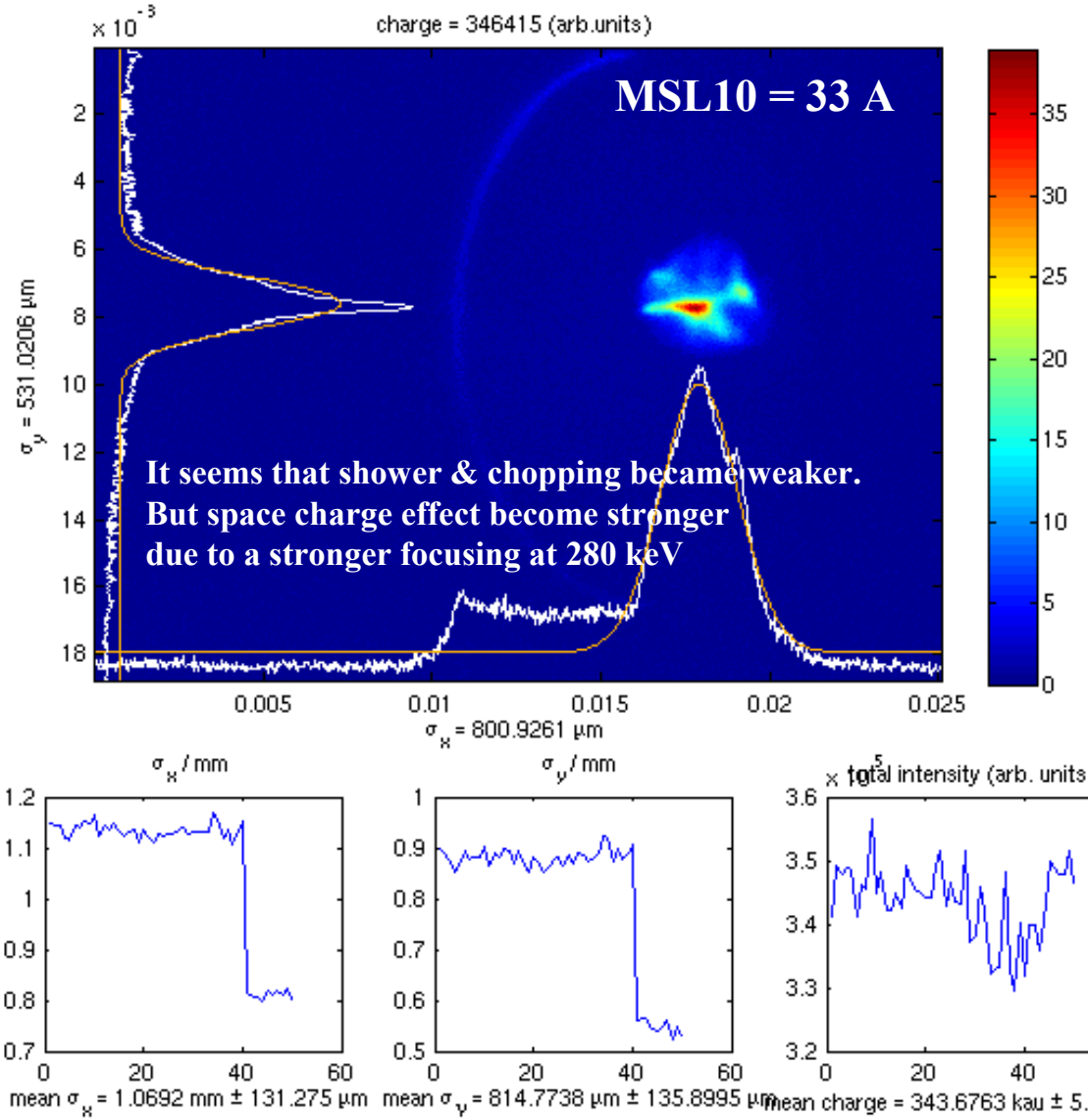


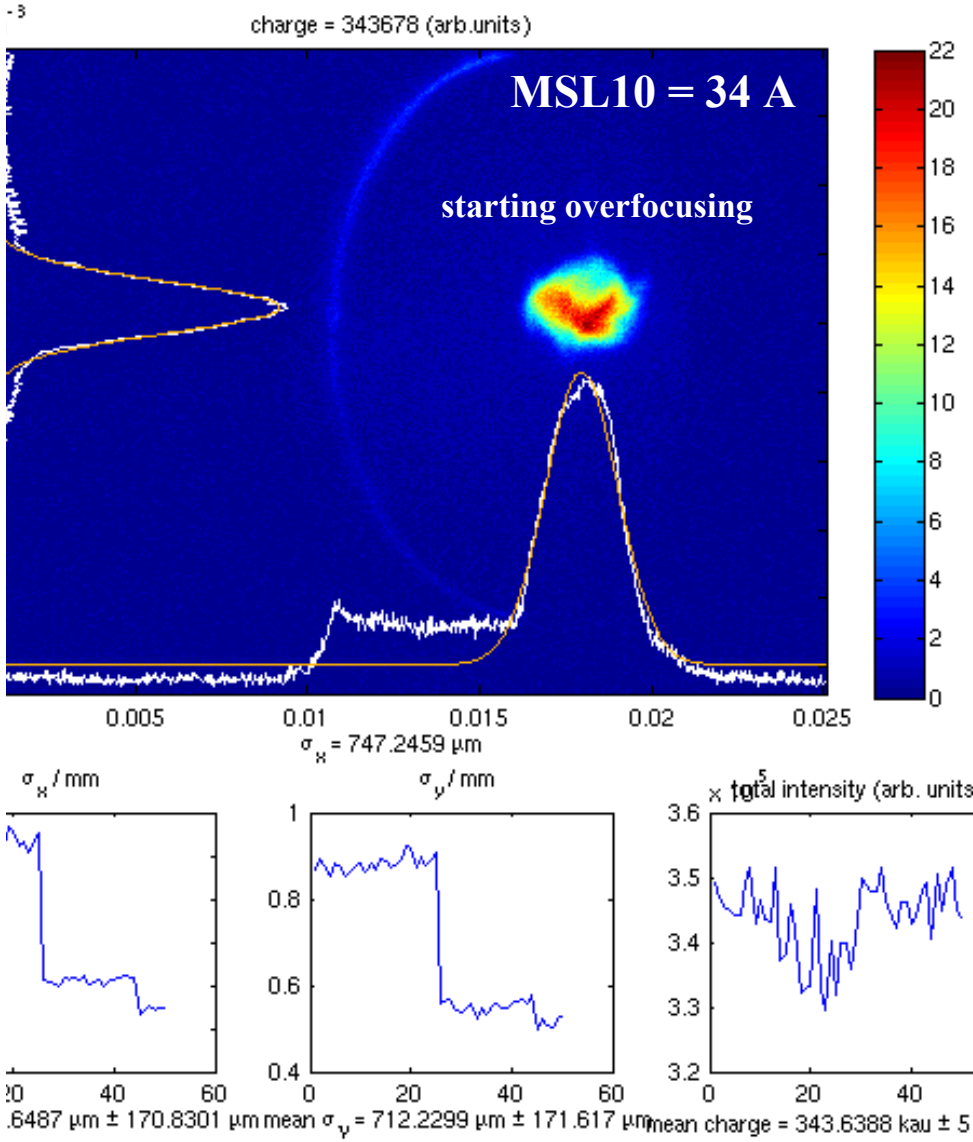


Beam Chopping Checking at 280 keV

PAUL SCHERRER INSTITUT

gap voltage = 280 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A

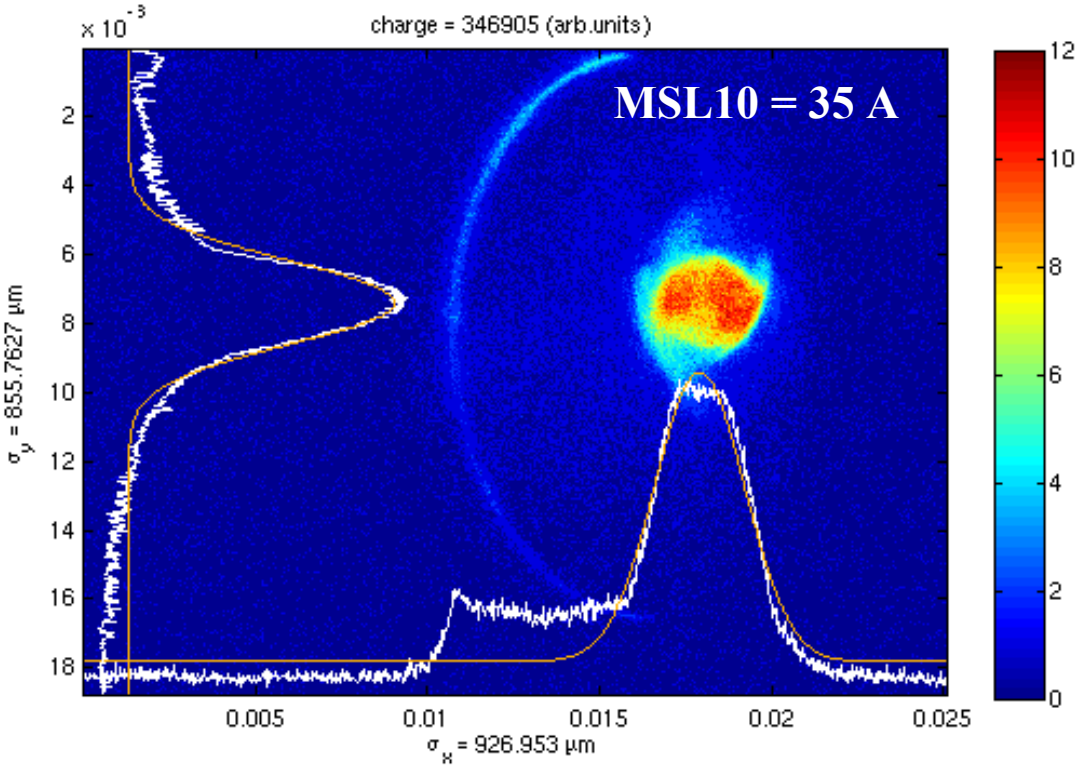


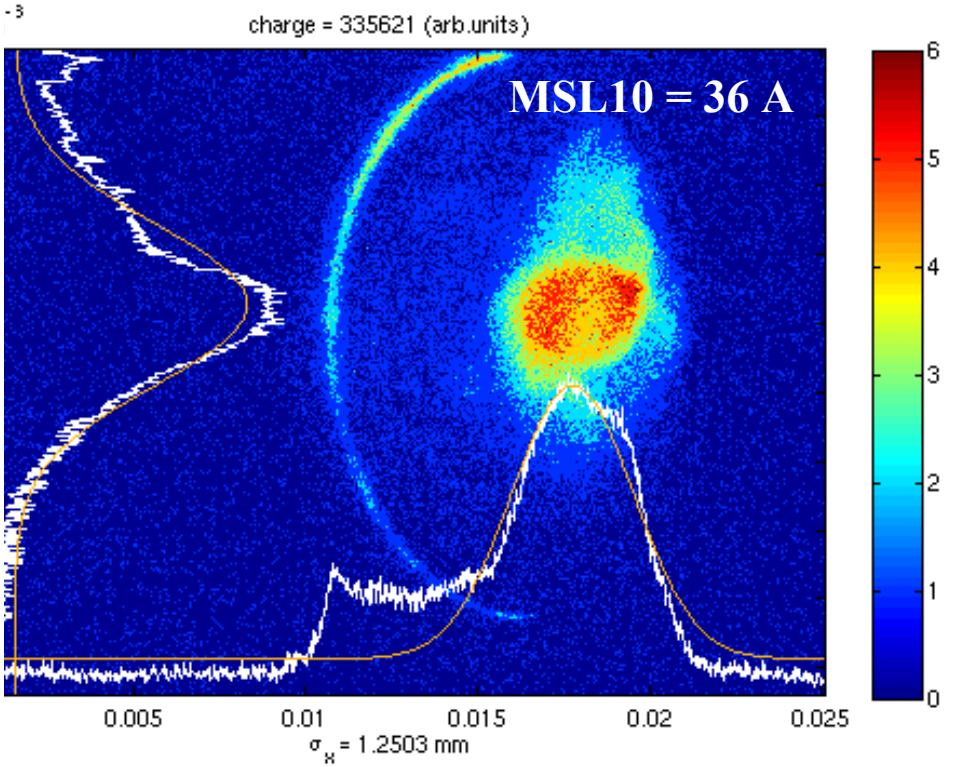


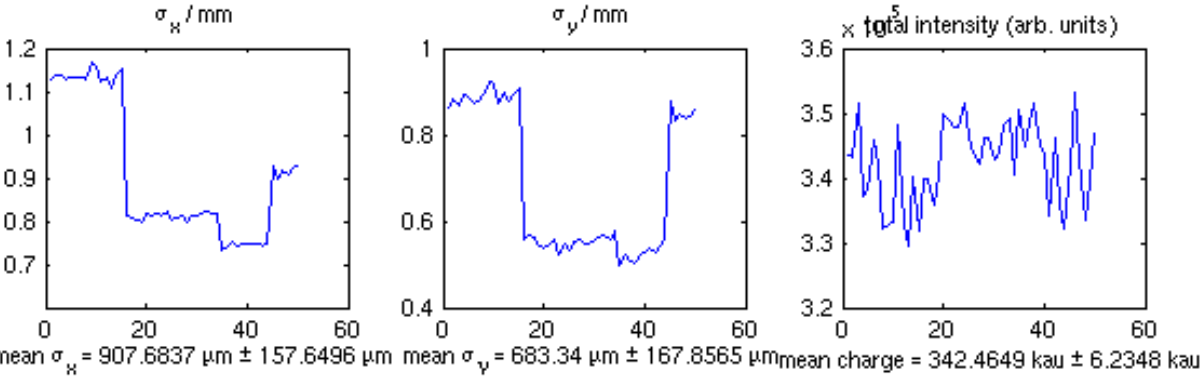
Beam Chopping Checking at 280 keV

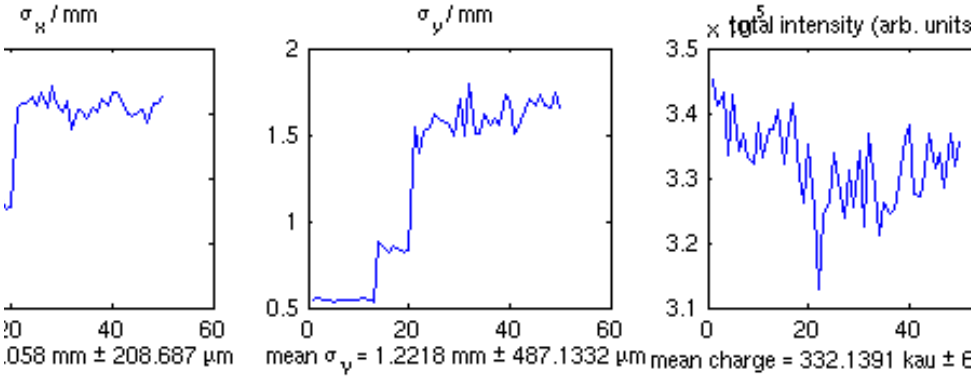
PAUL SCHERRER INSTITUT

gap voltage = 280 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A





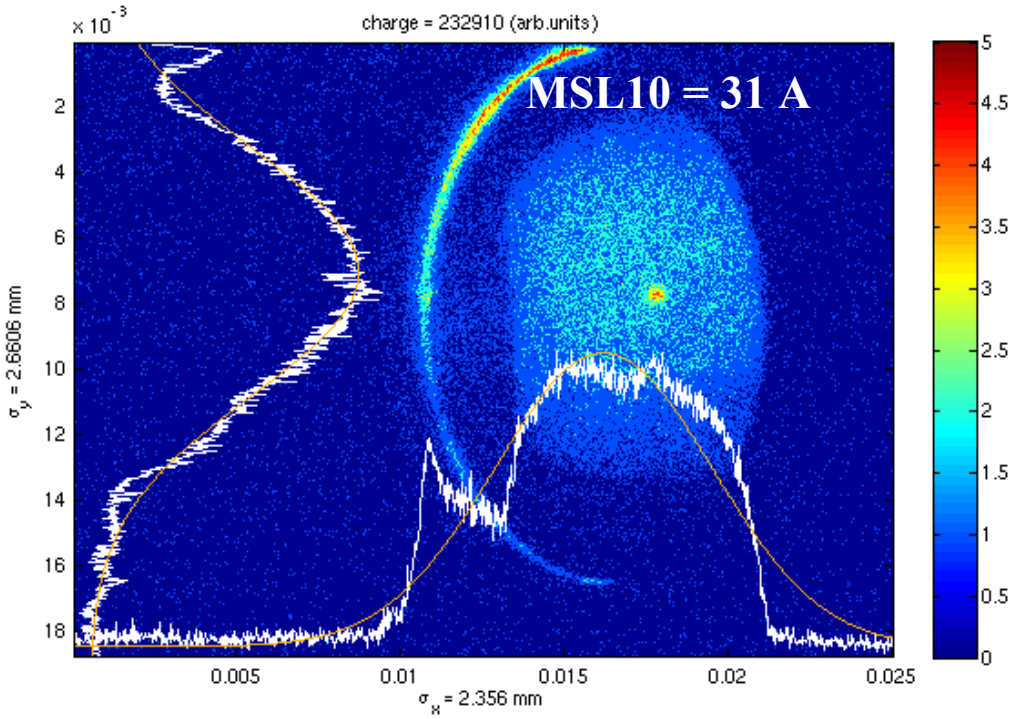


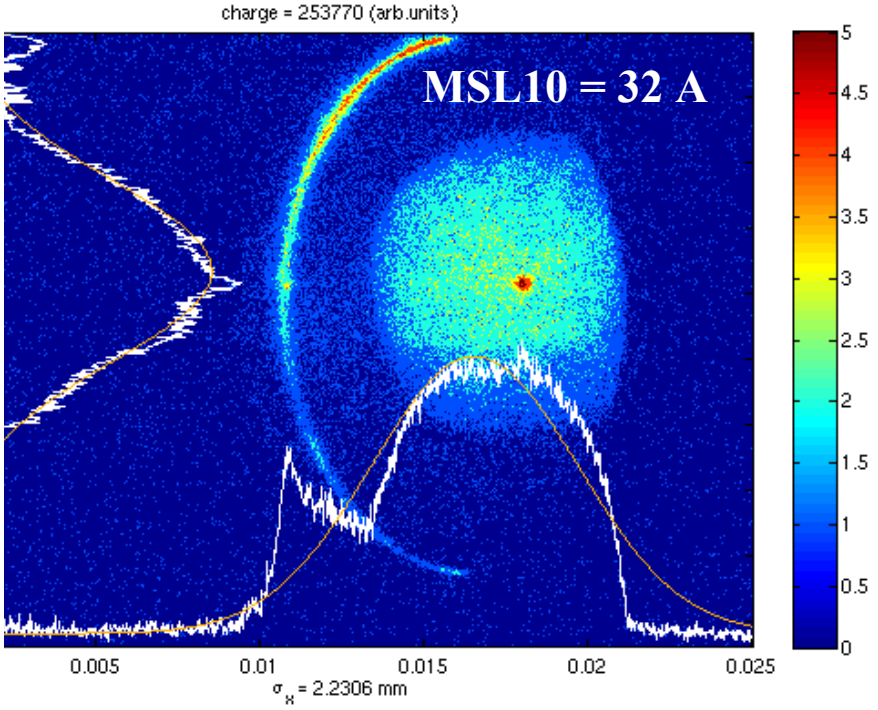


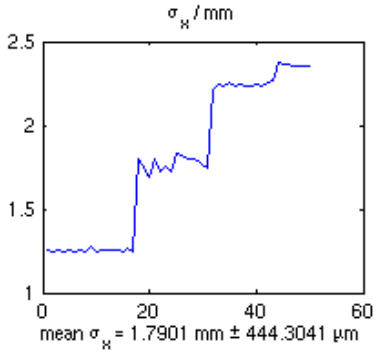
Beam Chopping Checking at 317 keV

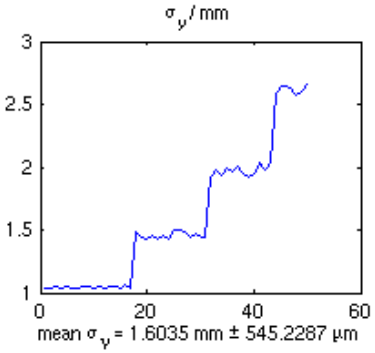
PAUL SCHERRER INSTITUT

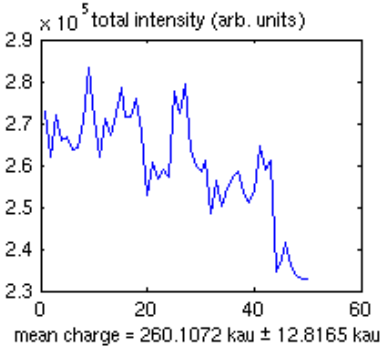
gap voltage = 317 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A

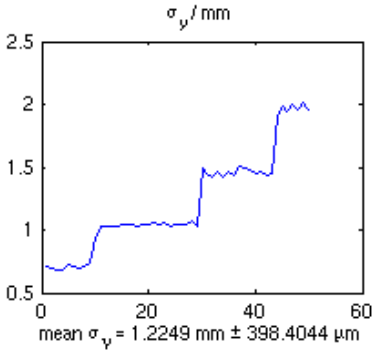


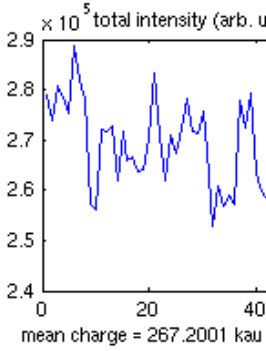








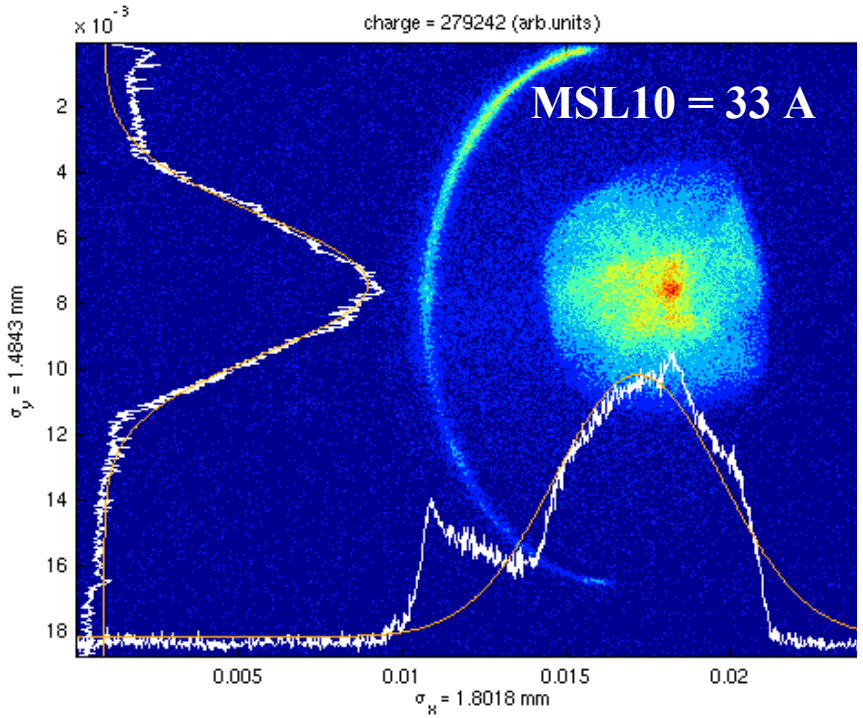


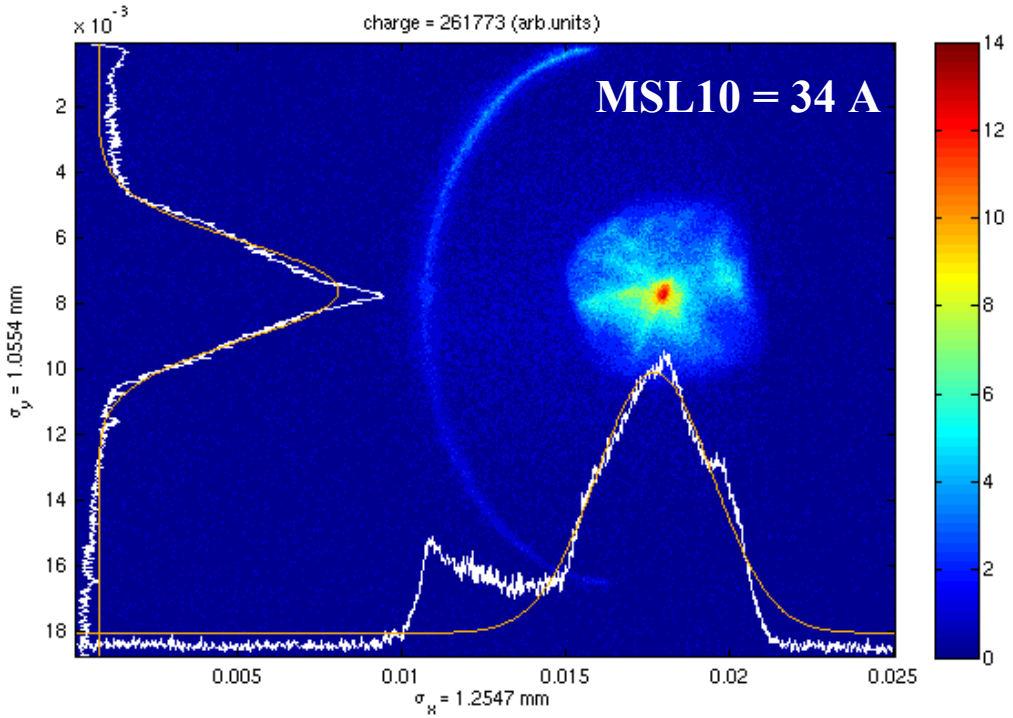


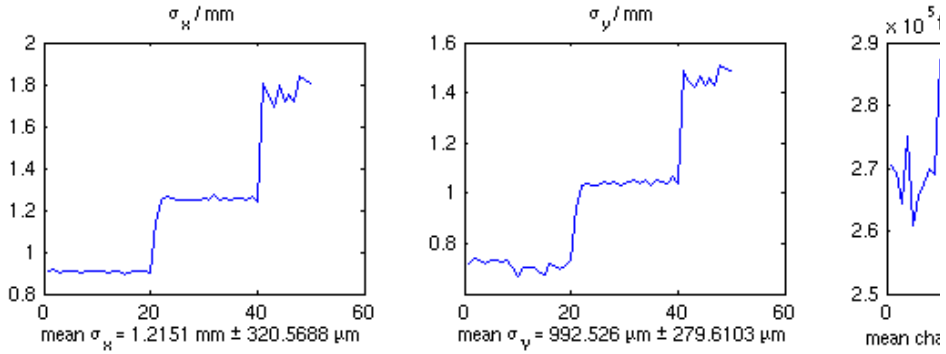
Beam Chopping Checking at 317 keV

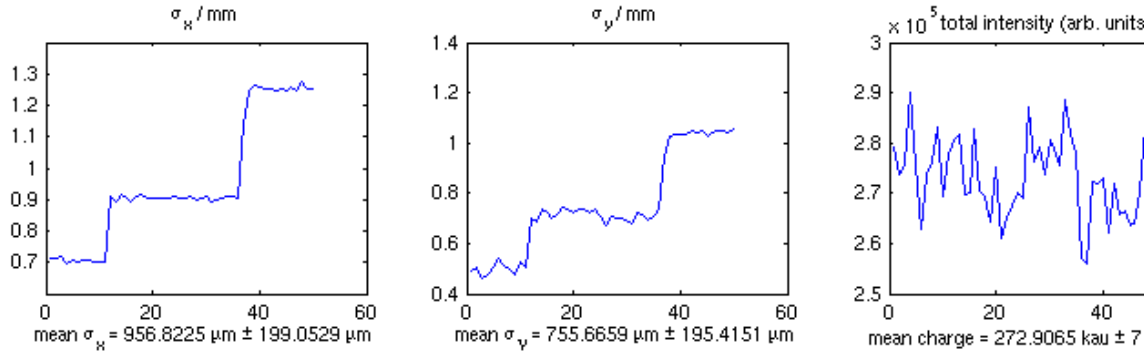
PAUL SCHERRER INSTITUT

gap voltage = 317 kV, gap = 10 mm, MSL10 = from 27 A to 36 A with 1 A step, all others = 0 A









Simulation for Operation on Feb. 20th

PAUL SCHERRER INSTITUT

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 = 35 ~ 70 A

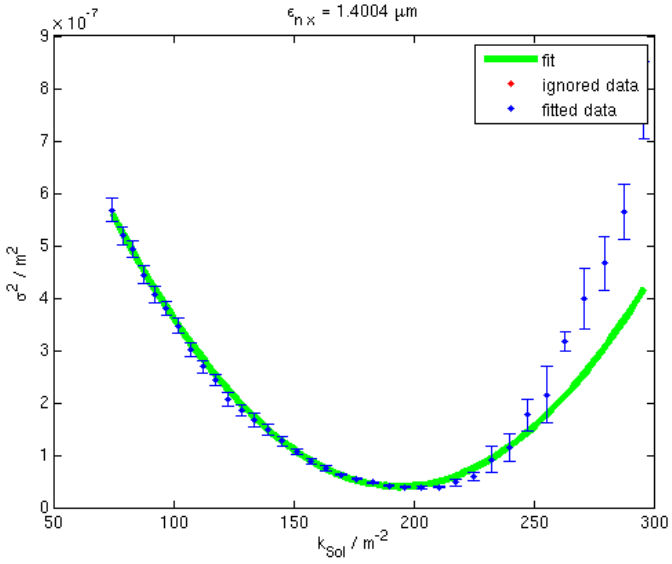
H steerer = 0.32 A

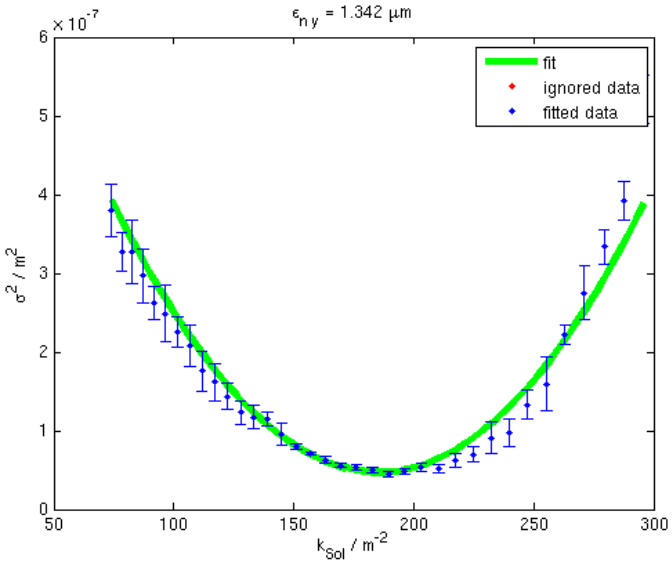
V steerrer = 0.35 A

Used screen = YAG1

YAG1 gain setting = 250

YAG exposure setting = 1





Simulation for Operation on Feb. 20th

MSL10 = 0.0715 m **MSL30 = 0.336 m** **YAG1 = 0.501 m**

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 = 35 ~ 70 A

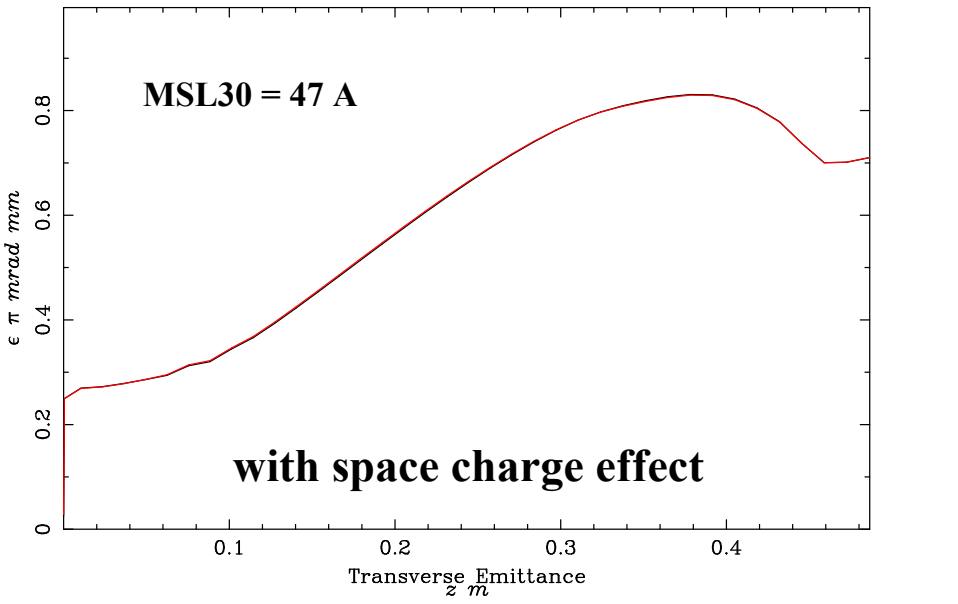
H steerer = 0.32 A

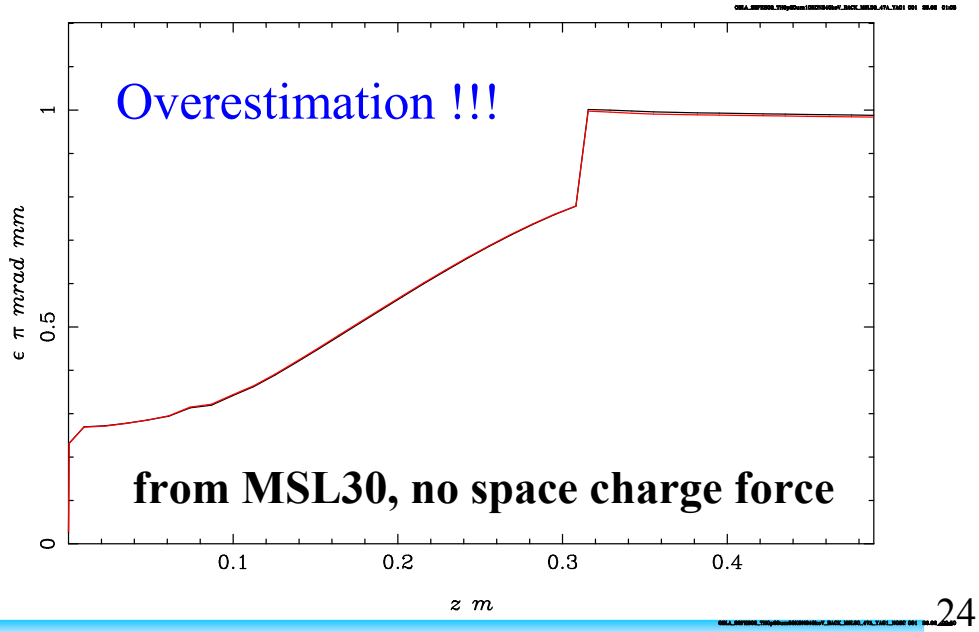
V steerrer = 0.35 A

Used screen = YAG1

YAG1 gain setting = 250

YAG exposure setting = 1





Simulation for Operation on Feb. 20th

PAUL SCHERRER INSTITUT

MSL10 = 0.0715 m **MSL30 = 0.336 m** **YAG1 = 0.501 m**

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 = 35 ~ 70 A

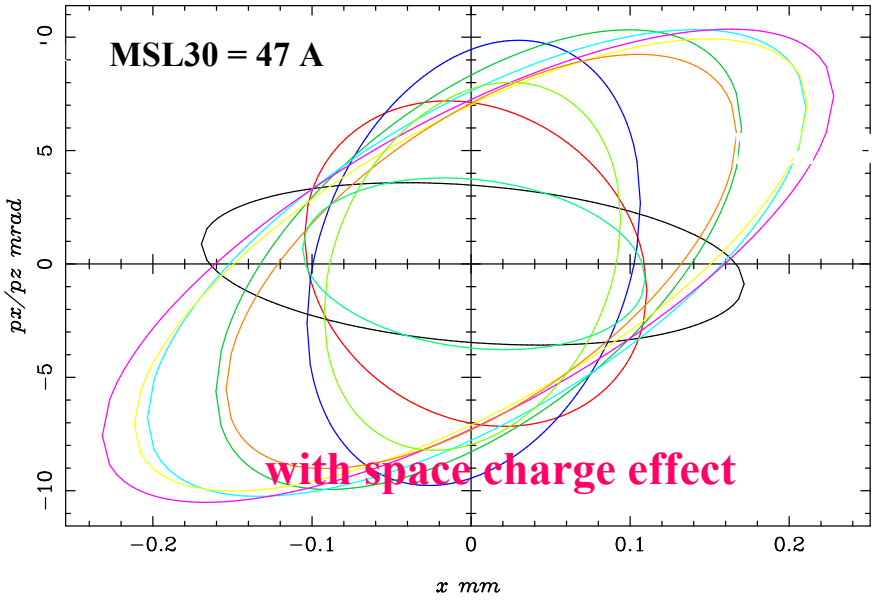
H steerer = 0.32 A

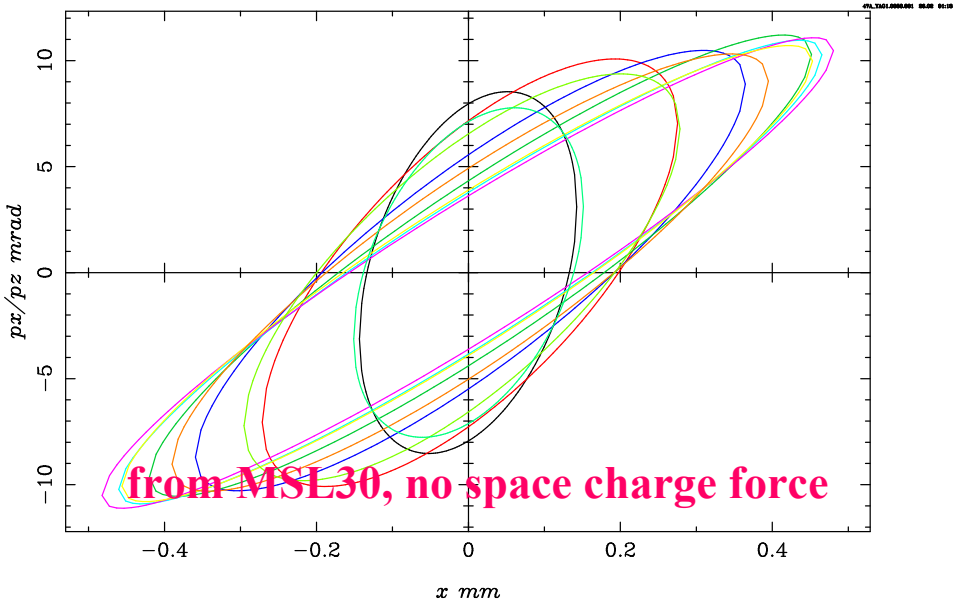
V steerrer = 0.35 A

Used screen = YAG1

YAG1 gain setting = 250

YAG exposure setting = 1





Optimization on Feb. 20th Operation

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 ~ 31.8 A

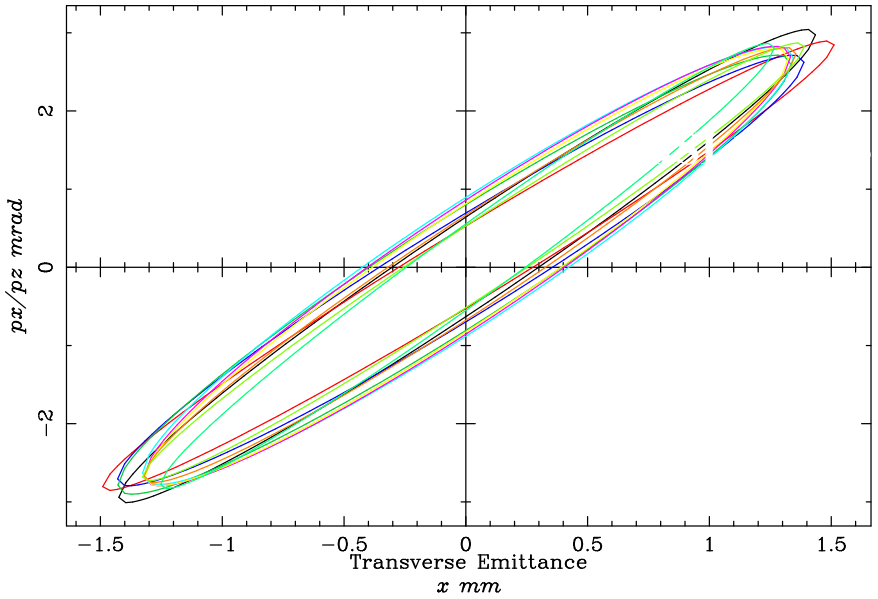
H steerer = 0.32 A

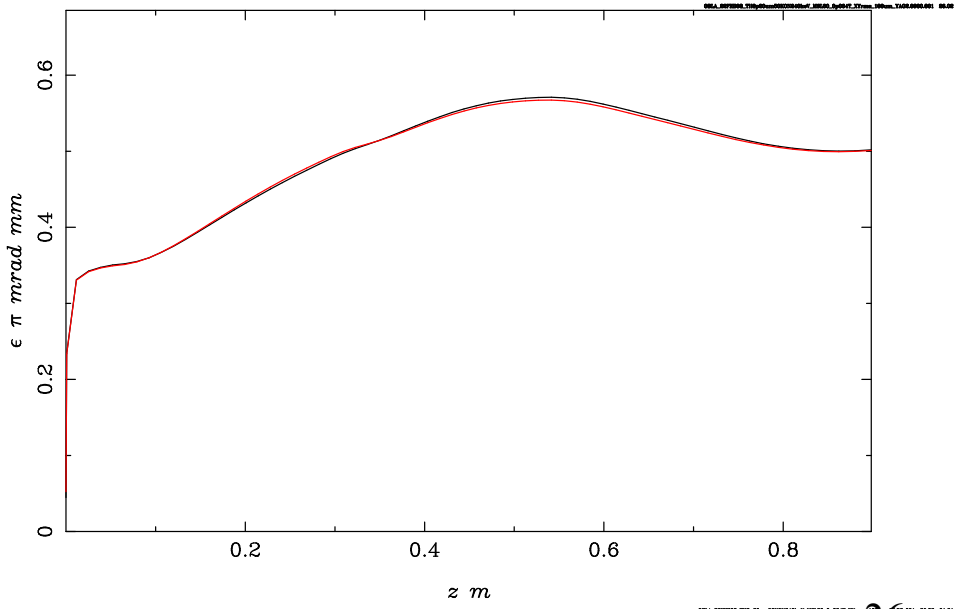
V steerrer = 0.35 A

Used screen = YAG2 @ 0.9 m

Laser transverse rms size = 100 μm

Laser length = 6.5 ps





Optimization on Feb. 20th Operation

PAUL SCHERRER INSTITUT

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 ~ 31.8 A

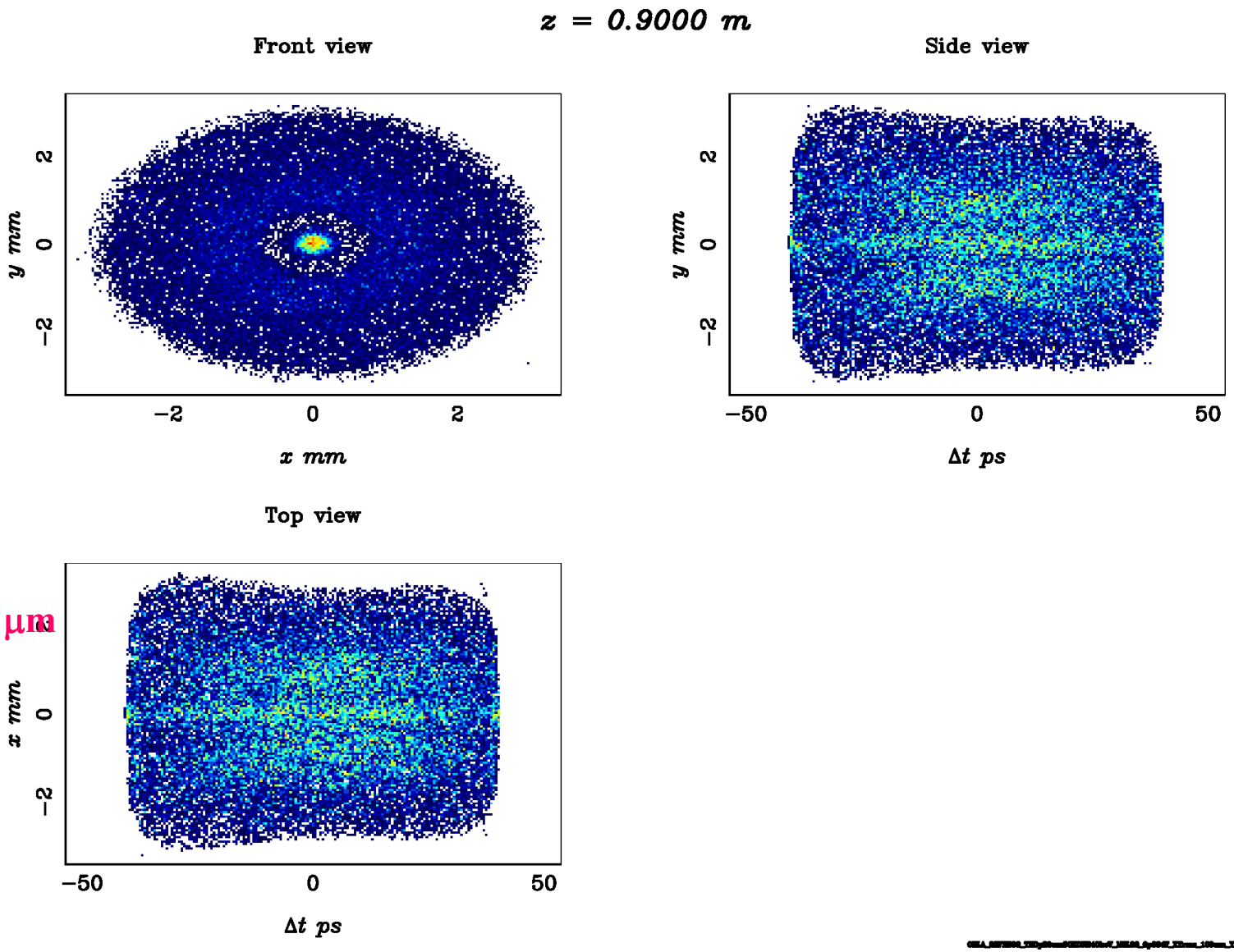
H steerer = 0.32 A

V steerrer = 0.35 A

Used screen = YAG2 @ 0.9 m

Laser transverse rms size = 100 μm

Laser length = 6.5 ps



Optimization on Feb. 20th Operation

PAUL SCHERRER INSTITUT

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 ~ 31.8 A

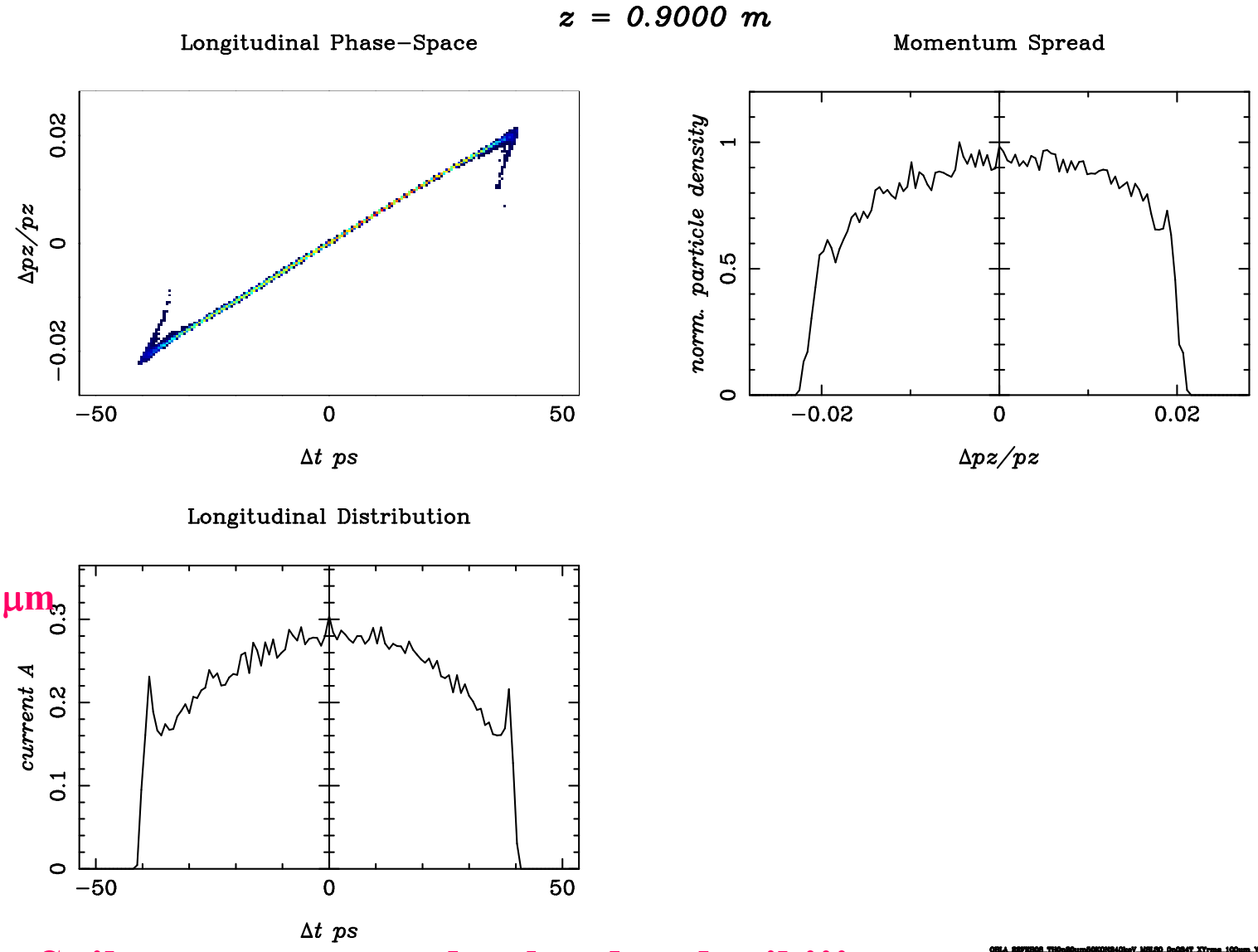
H steerer = 0.32 A

V steerrer = 0.35 A

Used screen = YAG2 @ 0.9 m

Laser transverse rms size = 100 μm

Laser length = 6.5 ps



Spikes are generated at head and tail !!!

Optimization on Feb. 20th Operation

gap volatge ~ 317 kV

Q ~ 17.6 pC

gap = 10 mm

MSL10 = 34.81 A

MSL30 ~ 31.8 A

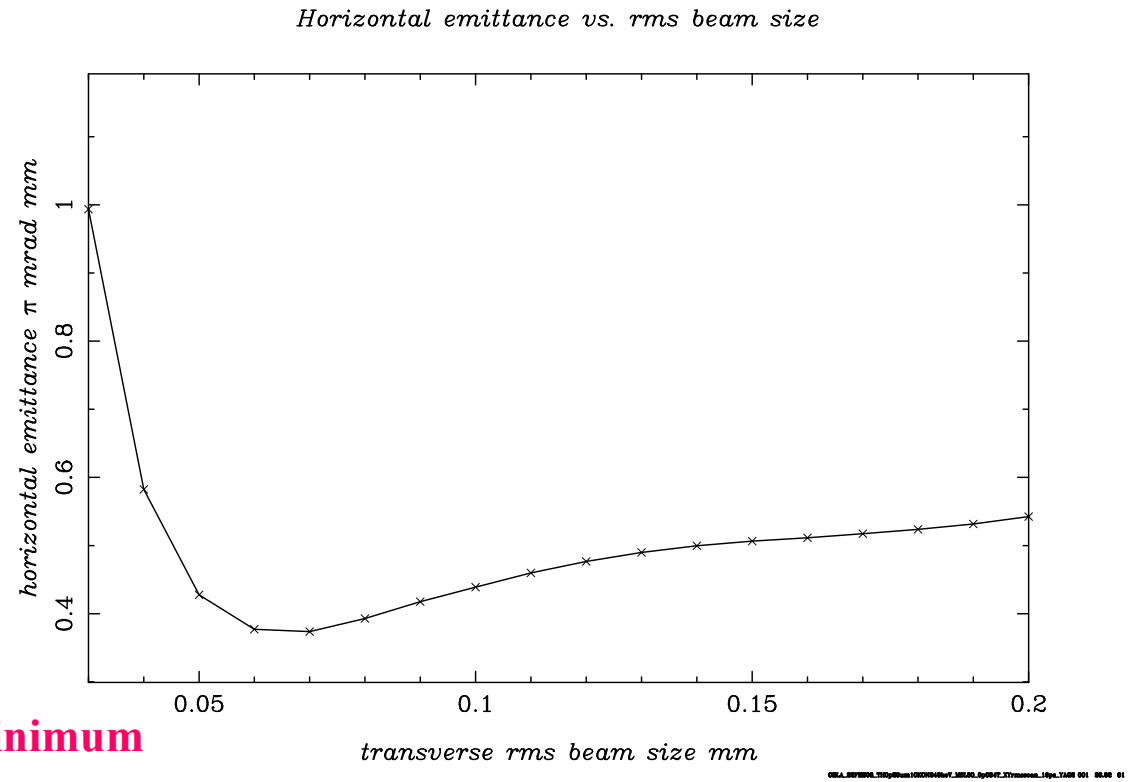
H steerer = 0.32 A

V steerrer = 0.35 A

Used screen = YAG2 @ 0.9 m

Laser transverse rms size = 70 μm gives minimum

Laser length = 16 ps



a laser with a longer length of 16 ps & a bigger spotsize of around 70 μm gives a better emittance at the moment (at 300 keV range) !!!

Summary & Acknowledgments

PAUL SCHERRER INSTITUT

It seems that there are beam chopping by the UHV mirror. But we can not apply too strong focusing due to a lower beam energy (hence stronger space charge force).

When a big chopping is generated, there is a shower and background on YAG1 screen. Due to the background, we met a fitting error in estimating beam size. Therefore, our measured emittance can be different.

We have to optimize laser spotsize and length to reduce space charge force at a lower beam energy.

At the moment, it seems that a round chopping at the right side of YAG1 screen is generated due to misalignment of screen.

Y. Kim sincerely thank Dr. Andreas Adelmann, Dr. Andreas Streun, and Dr. Marco Pedrozzi for their encouragement for OBLA study.