OBLA-500 and OBLA-4 Simulations with OPAL

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FELSI Meeting - Dec 9th, 2008

Topics

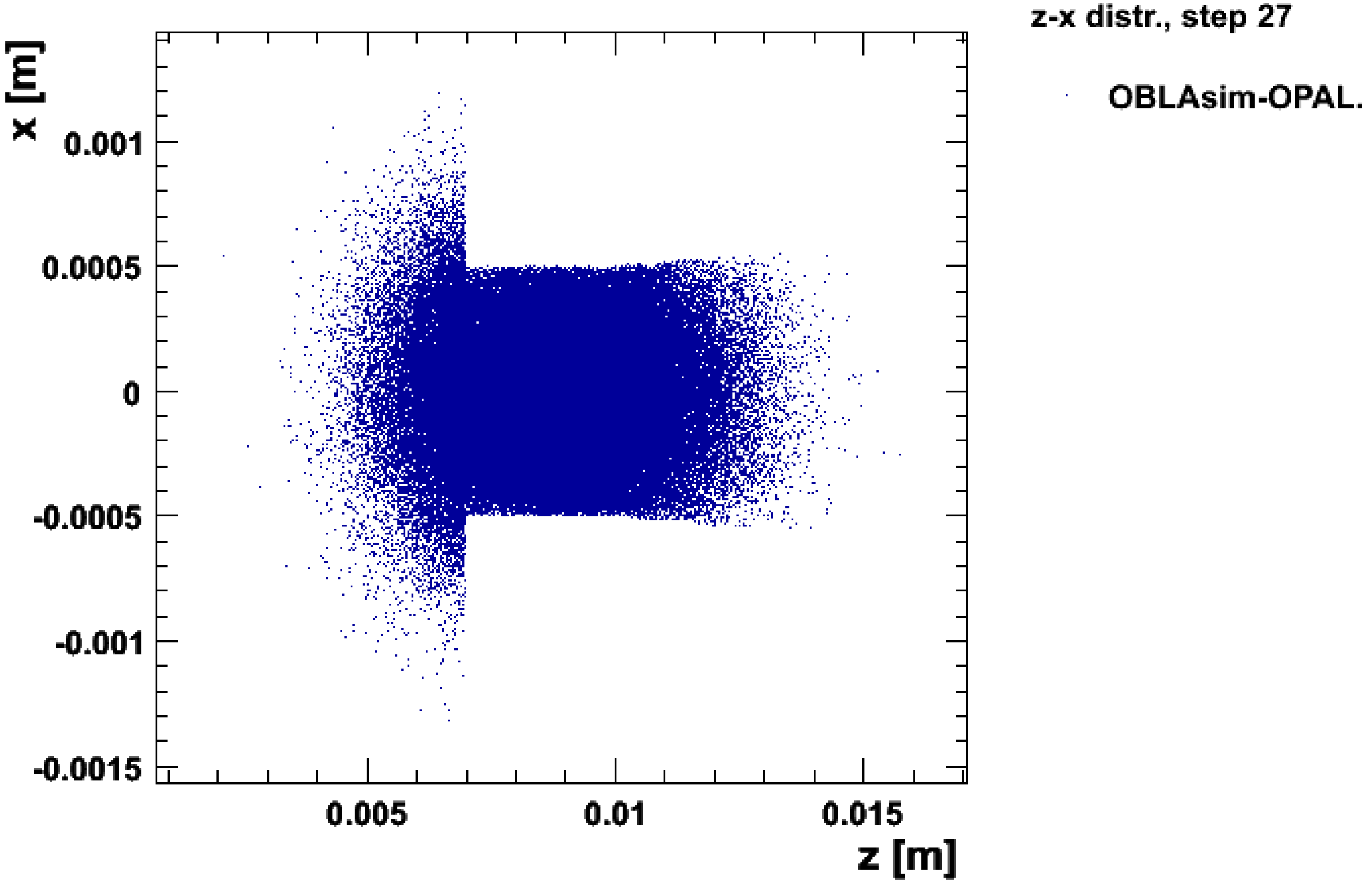
- OBLA-500 keV
  - the OPAL collimator module
  - the OPAL pepperpot module
  - Beamlet tail effect
  - Cross-check of the XanaROOT emittance computation method
- OBLA-4MeV
  - Focusing with the pulsed solenoid
  - Beam focusing for different cavity power level

OBLA-500 keV Simulations

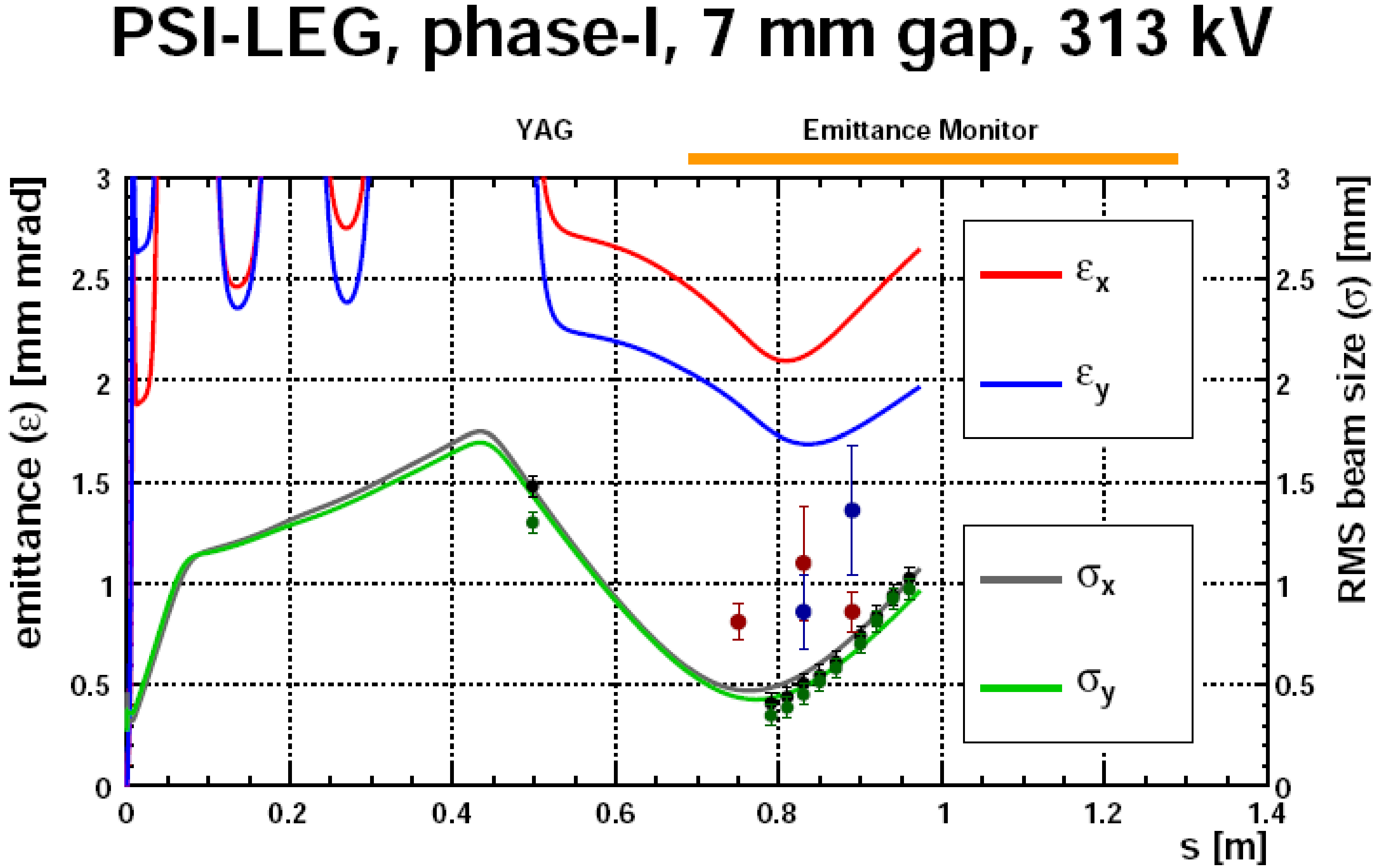
OPAL Collimator module

- the collimator module is the equivalent of the anode iris
- simulations without collimator have a false halo around the beam
  - not seen in any picture from OBLA
  - small impact on the RMS beam-size
  - big impact on the emittance of the simulated bunch

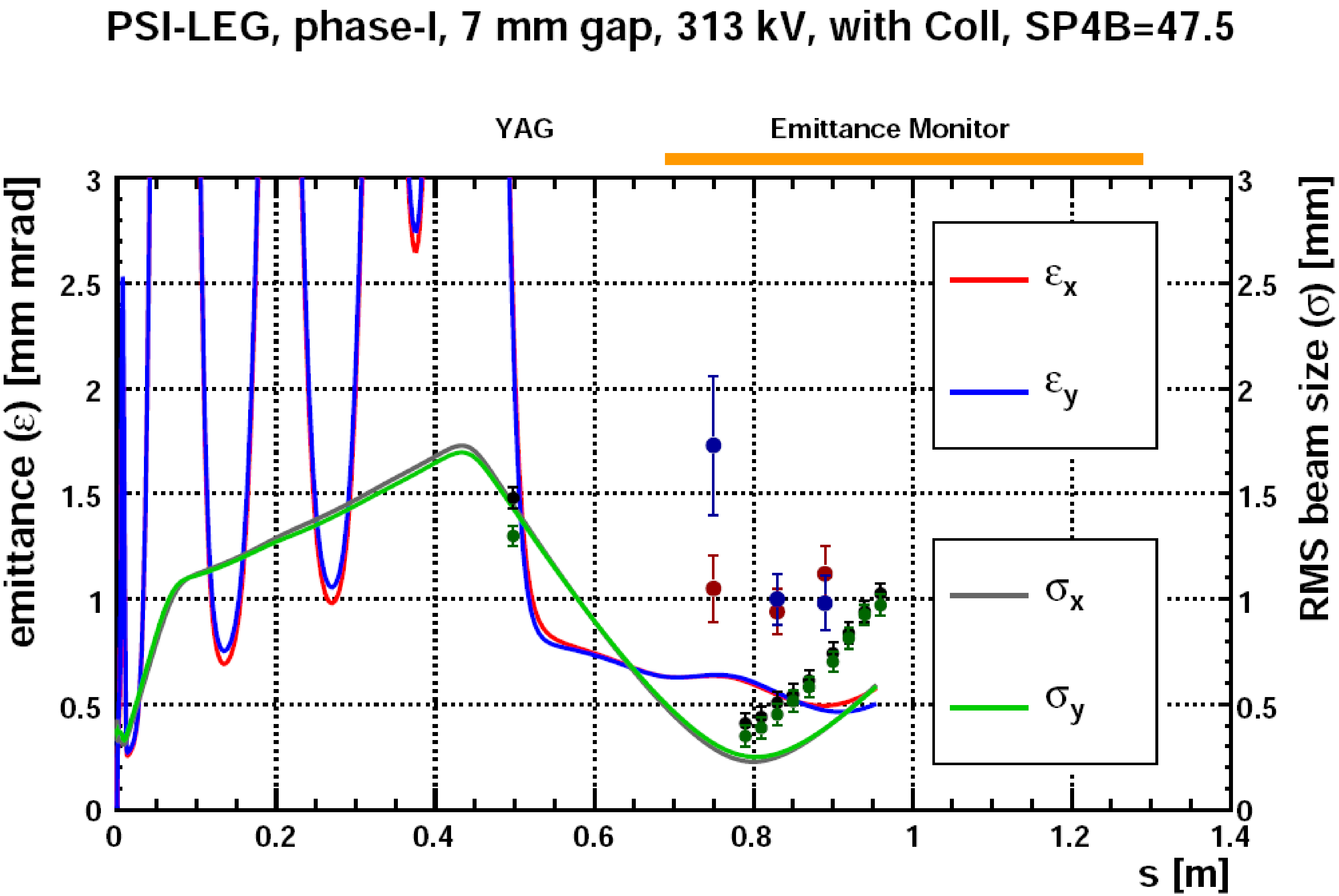
OPAL Collimator module



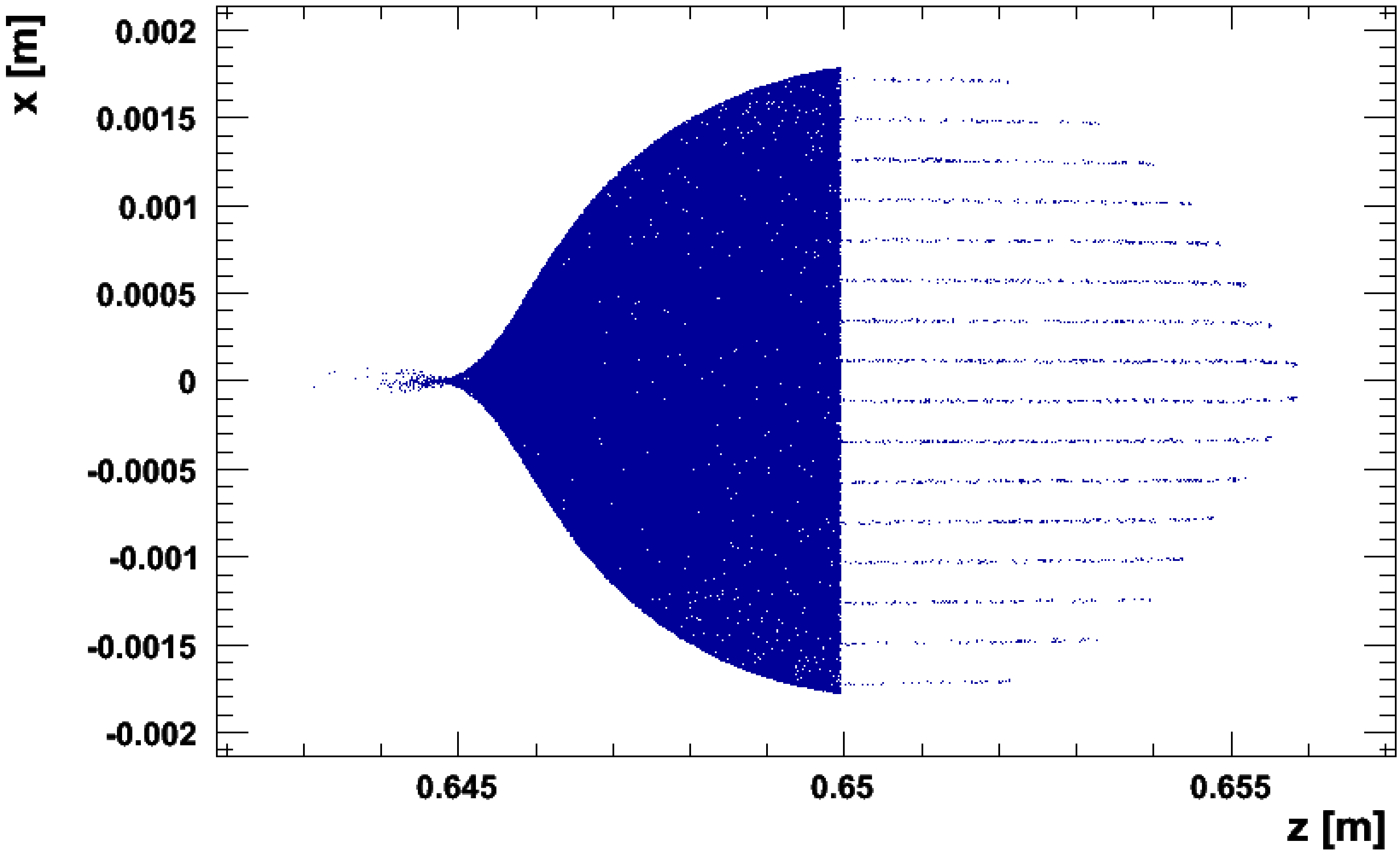
Simulated experiment



Same simulation with collimator

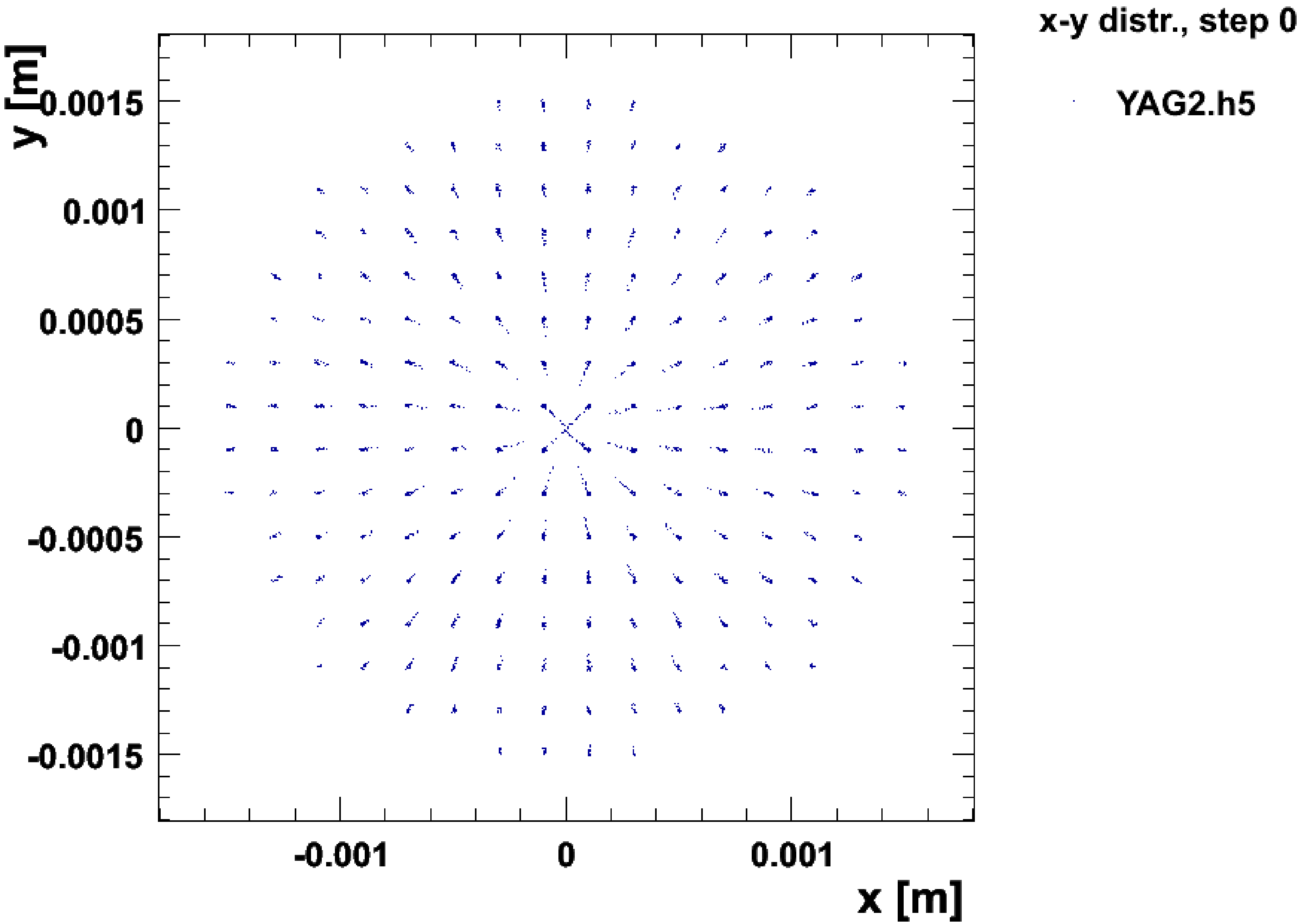


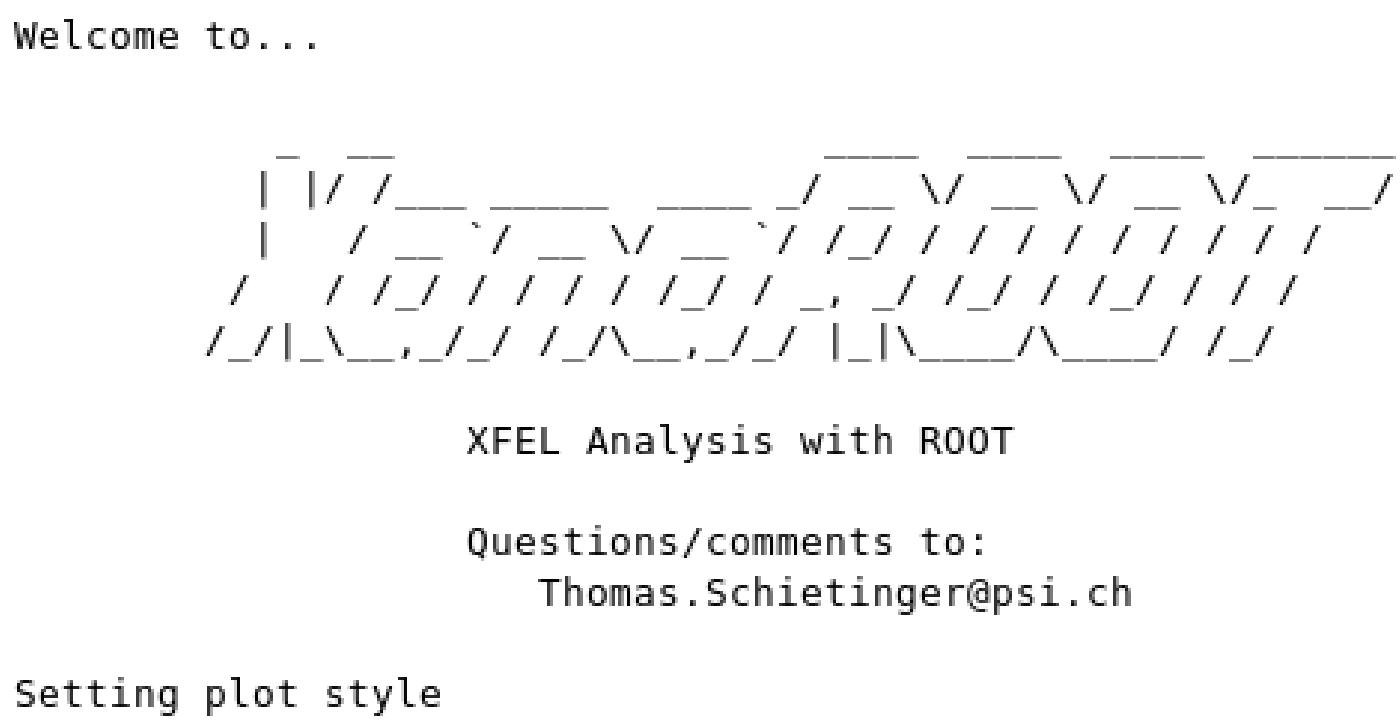
OPAL Pepperpot module



- OBLA-500 setup; 313 kV; 7 mm gap
- 675k particles → 3.8k particles, ~0.5%

Virtual Pepperpot Image



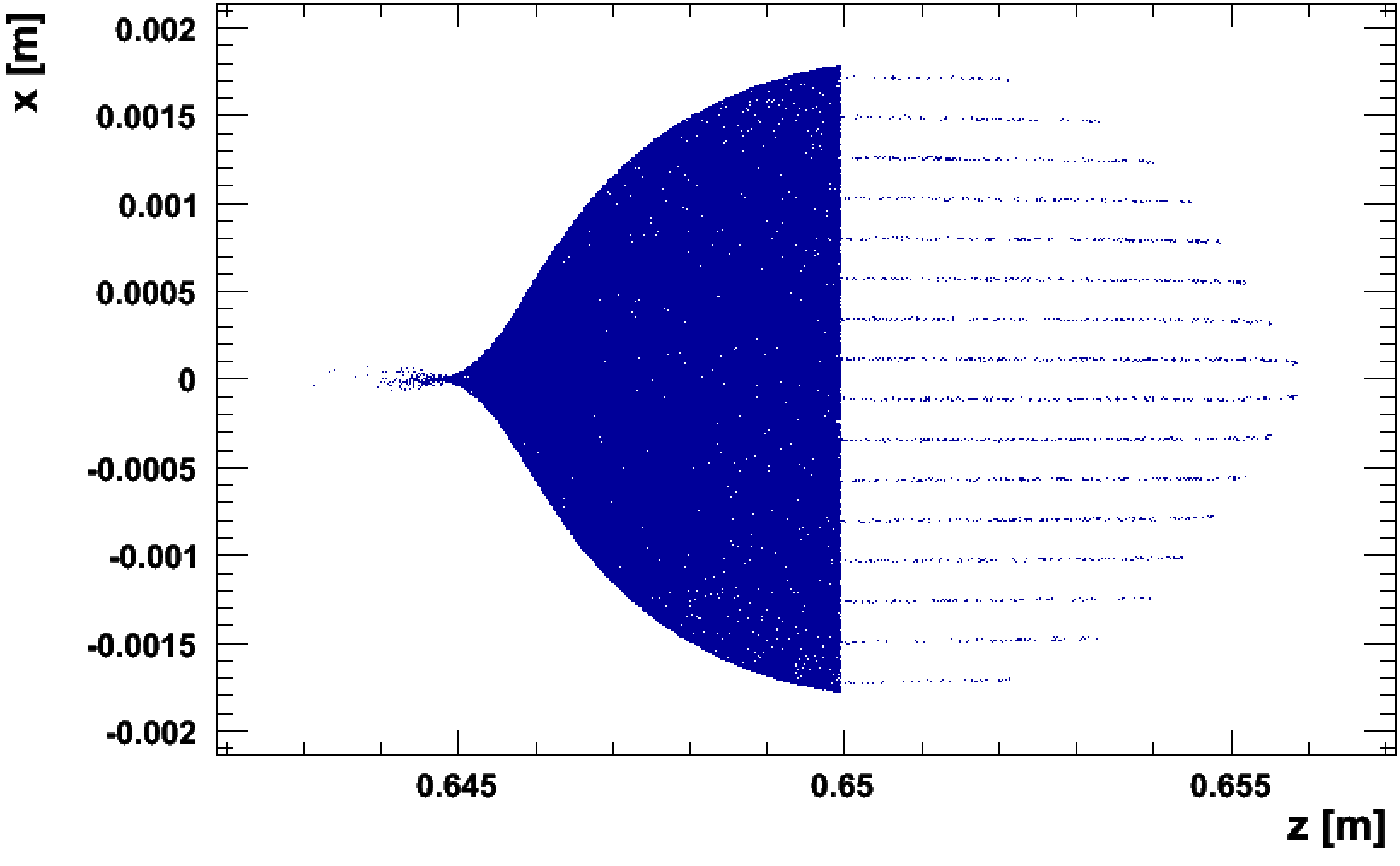


- The implementation of the Pepperpot module in OPAL made it possible to cross-check the emittance computation of XanaROOT

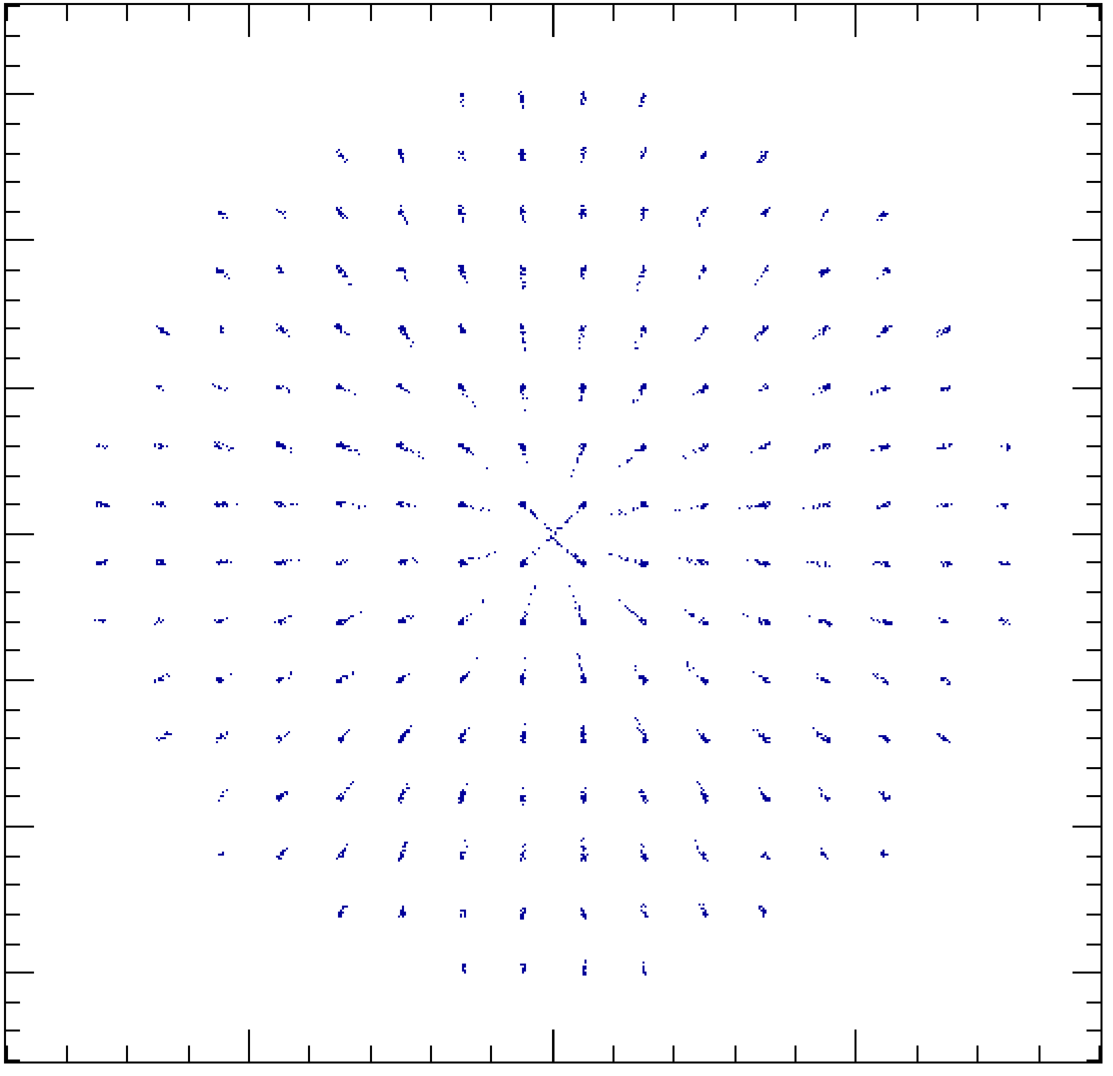
OBLA-500 layout in the OPAL input file

```
// L:        physical element length (real)
// KS:       field scaling factor (real)
// FMAPFN:   field file name (string)
// ELEMEDGE: physical start of the element on the floor (real)

Col: ECollimator, L=3.0E-3, ELEMEDGE=7.0E-3, XSIZE=5.0E-4, YSIZE=5.0E-4,
       OUTFN="Coll.h5";
SP1: Solenoid, L=1.20, ELEMEDGE=-0.5315, FMAPFN="1T2.T7", KS=8.246e-05;
SP2: Solenoid, L=1.20, ELEMEDGE=-0.397, FMAPFN="1T3.T7", KS=1.615e-05;
SP3: Solenoid, L=1.20, ELEMEDGE=-0.267, FMAPFN="1T3.T7", KS=1.016e-05;
SP4: Solenoid, L=1.20, ELEMEDGE=-0.157, FMAPFN="1T3.T7", KS=4.75e-05;
SP5: Solenoid, L=1.20, ELEMEDGE=-0.047, FMAPFN="1T3.T7", KS=0.0;
Ppo: PepperPot, L=200E-6, ELEMEDGE=650.0E-3, R=10.0E-6, PITCH=230.0E-6,
       NHOLX=20, NHOLY=20, XSIZE=5.0E-3, YSIZE=5.0E-3, OUTFN="Ppo.h5";
Mon: Monitor, ELEMEDGE=660.0E-3, OUTFN="Mon.h5";
YAG2: Monitor, ELEMEDGE=680.0E-3, OUTFN="YAG2.h5";

gun: RFCavity, L=0.013, VOLT=-47.51437343, FMAPFN="1T1.T7", ELEMEDGE=0.00,
       TYPE="STANDING", FREQ=1.0e-6;

end: Solenoid, L=1.20, ELEMEDGE=1.0e4, FMAPFN="1T3.T7", KS=1.0e-10;
```

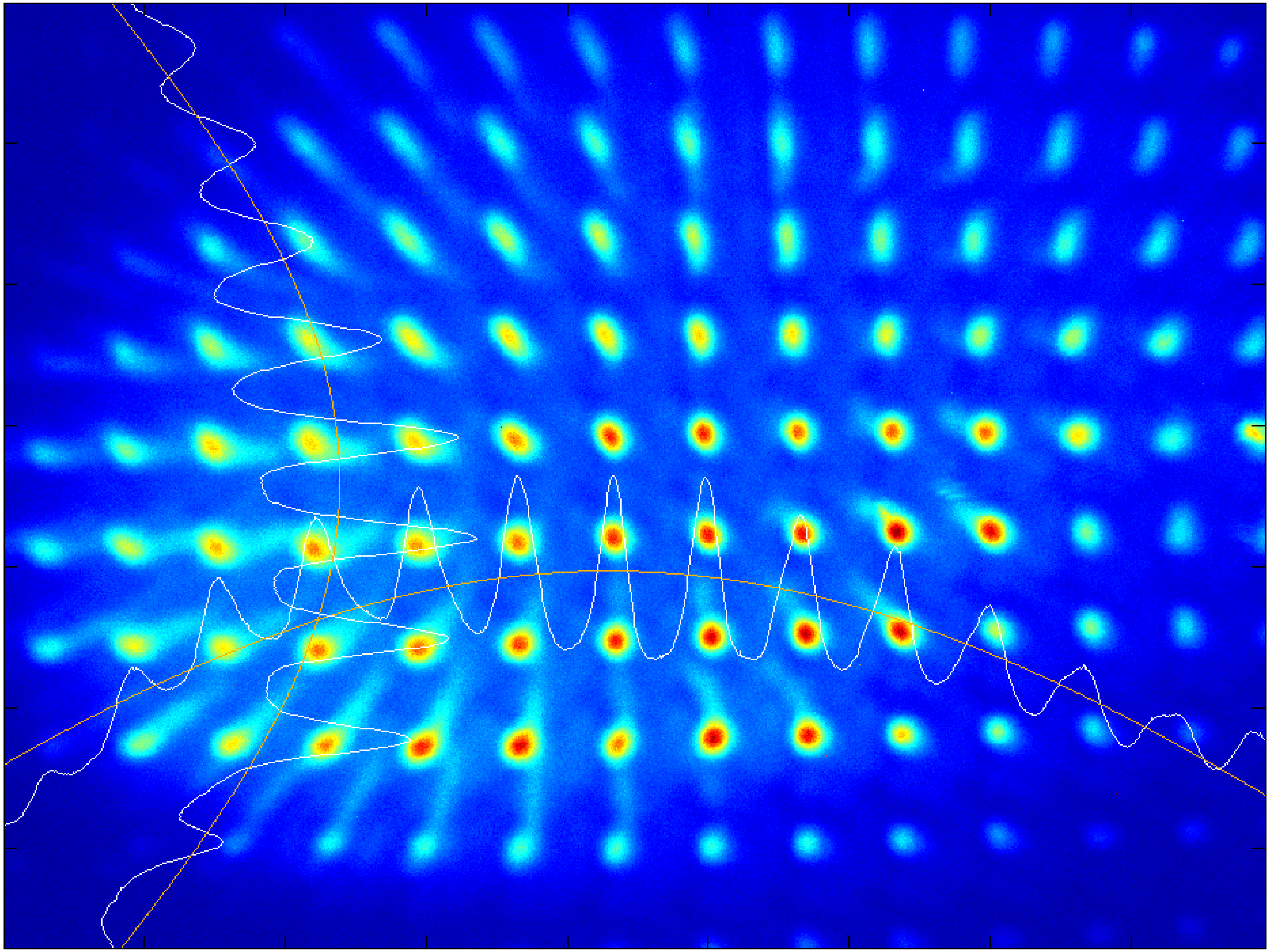
Electron bunch in the pepperpot x-z projection



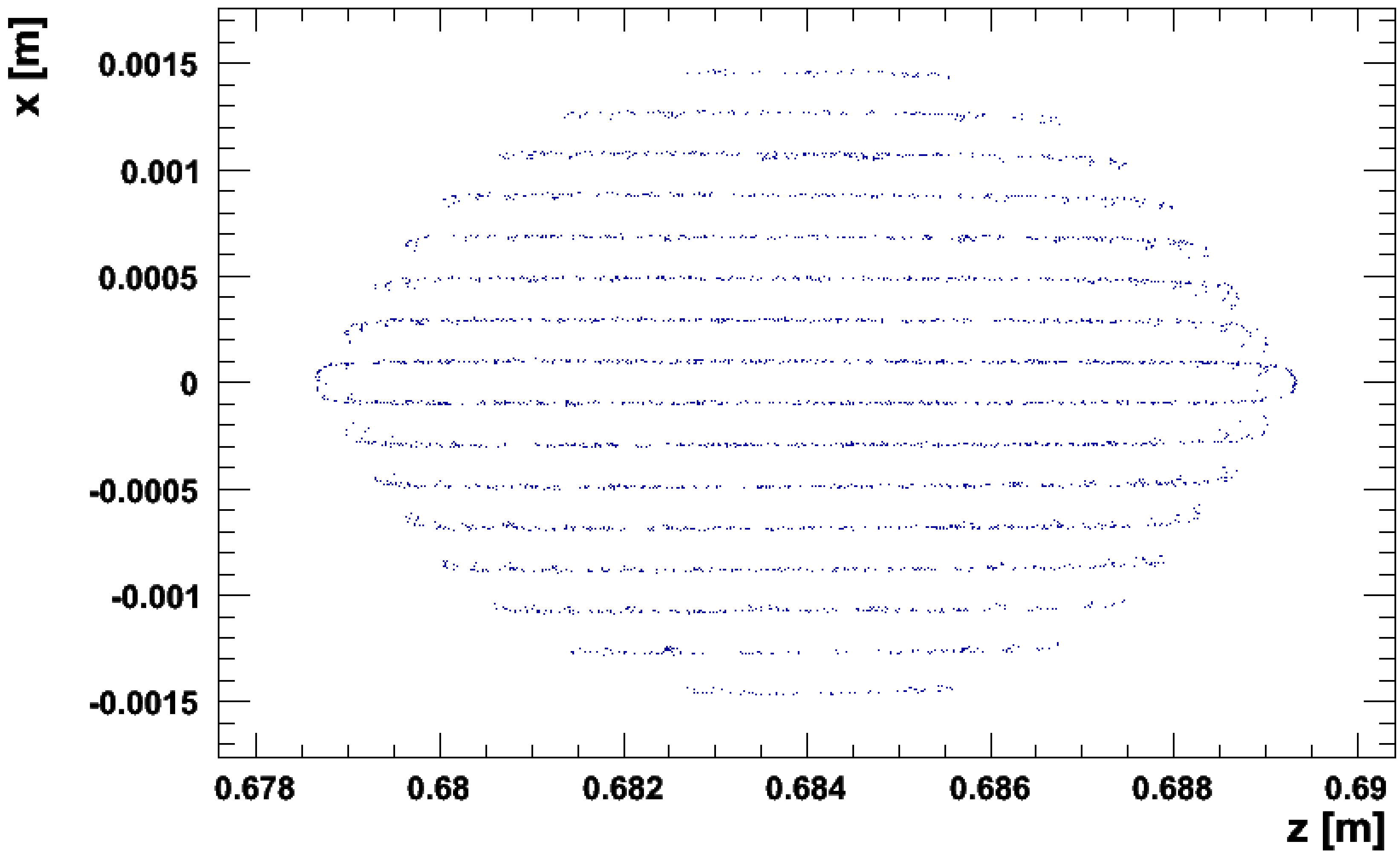
Virutal pepperpot picture



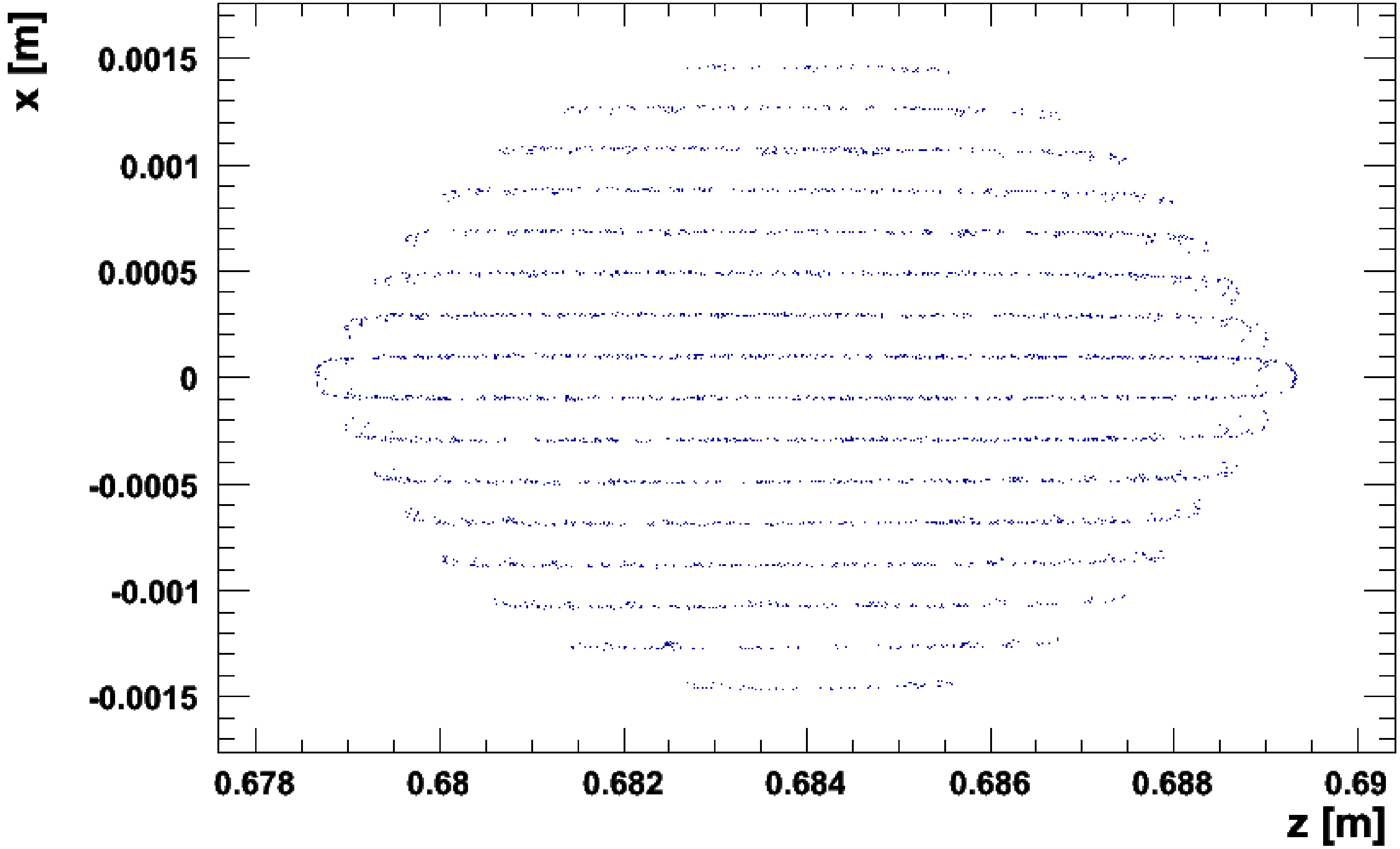
Beamlet tail effect



Beamlet tail effect

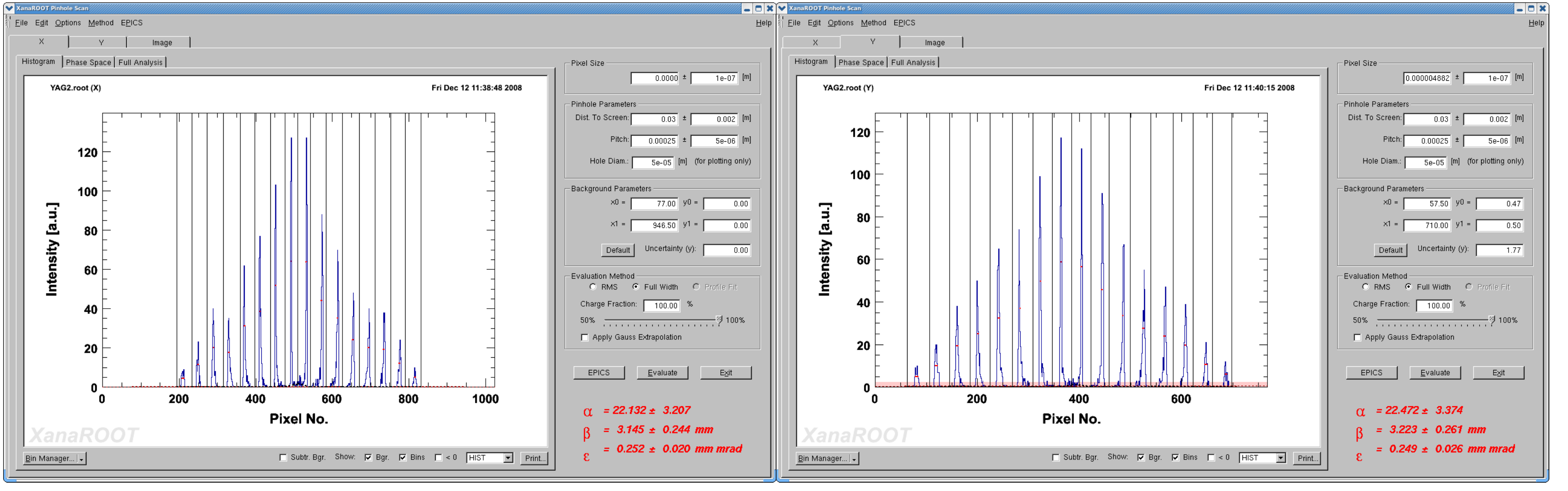


Beamlet tail effect



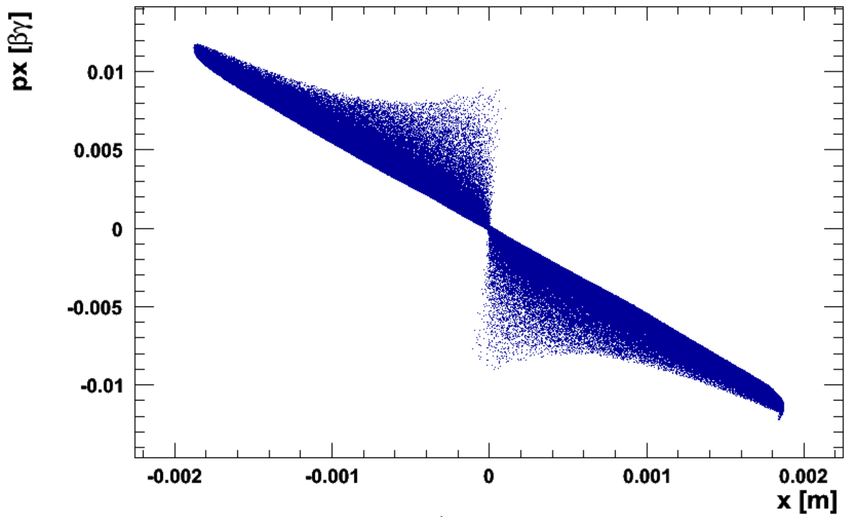
- not caused by space charge or fields

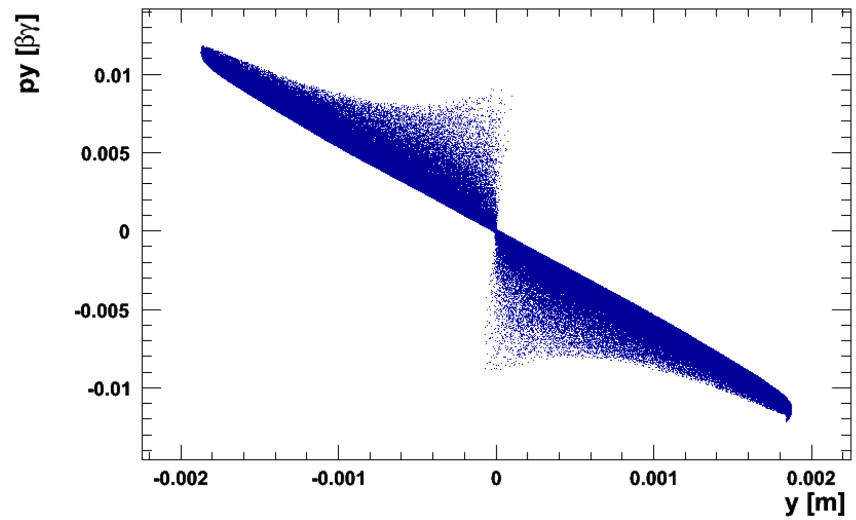
XanaROOT emittance computation



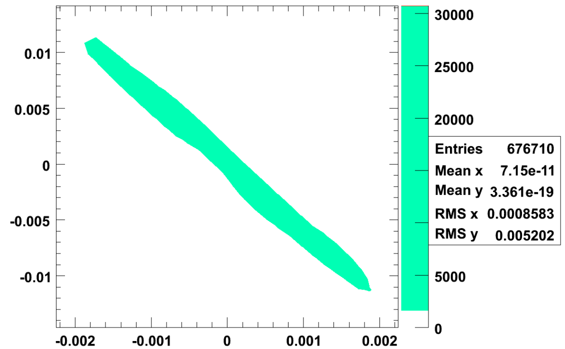
- After normalization:
  - $\varepsilon_x = 0.319 \pm 0.025$ mm mrad
  - $\varepsilon_y = 0.315 \pm 0.033$ mm mrad

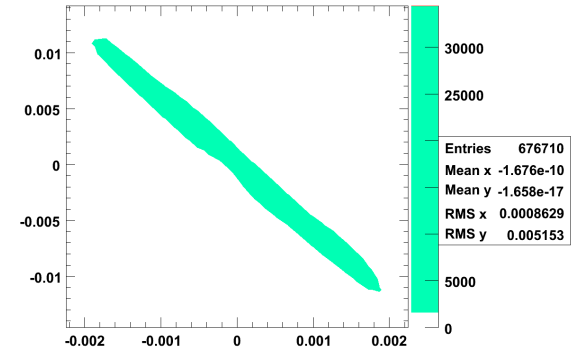
Noise reduction – equivalent to that of XanaROOT





Clipping of the outer 4% of the particles
in the x-px and y-py phase spaces





Emittance comparison

- OPAL emittance:

  $\varepsilon_x = 0.330$ mm mrad

  $\varepsilon_y = 0.318$ mm mrad

- XanaROOT emittance:

  $\varepsilon_x = 0.319$ mm mrad

  $\pm\ 0.025$ mm mrad

  $\varepsilon_y = 0.315$ mm mrad

  $\pm\ 0.033$ mm mrad

OBLA-4MeV Simulations

Goal

- focus the beam on the emittance monitor at 2 - 2.5 m

Parameters

- beam emission:
  - Pulser at 500 kV, emits 200 pC
  - Jaguar Laser
  - Transverse laser profile: rectangular, radius = 0.4 mm
  - Temporal laser profile: gaussian
  - Gap = 6mm
- cavity at 1.5 GHz, maximum field 35.5 MV/m
- cavity phase: 66.0°
- all element positions are taken from the OBLA layout

Studied cavity power levels

- 35.5 MV/m – full power (Thomas)
- 17.75 MV/m – half power
- 0 MV/m – cavity turned off
- 5 MV/m – low power (14%)
- 8.9 MV/m – quarter power

- PSL field is set to 162.5 mT (best focusing for all lower cavity power levels)

Full cavity power

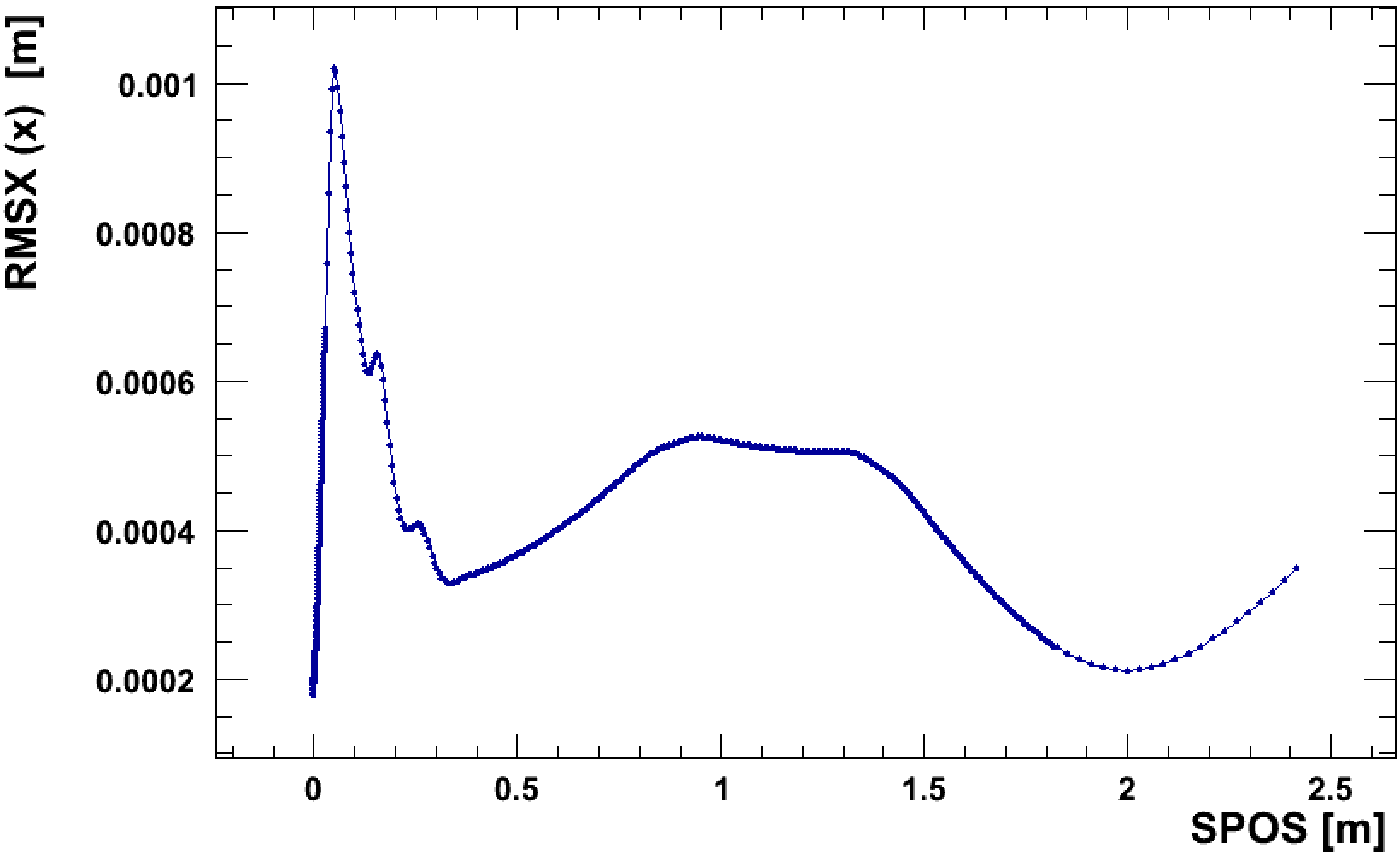
- setup by Thomas Schietinger:
  - pulsed solenoid (in this talk PSL):

    170 mT
  - first double solenoid (in this talk SL10B):

    +100 mT / -100 mT
  - second double solenoid (in this talk SL20B):

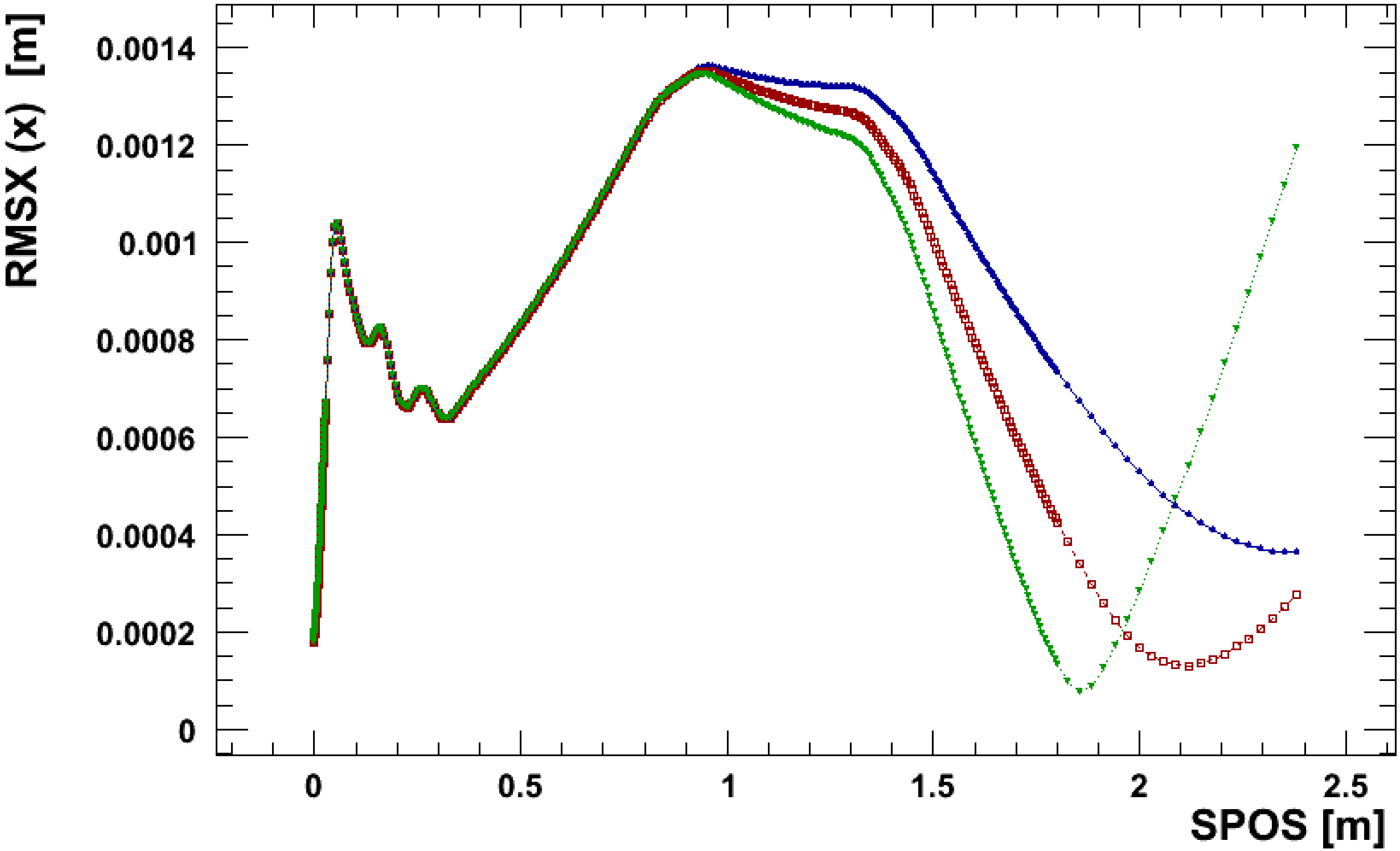
    +110 mT / -110 mT

Full cavity power



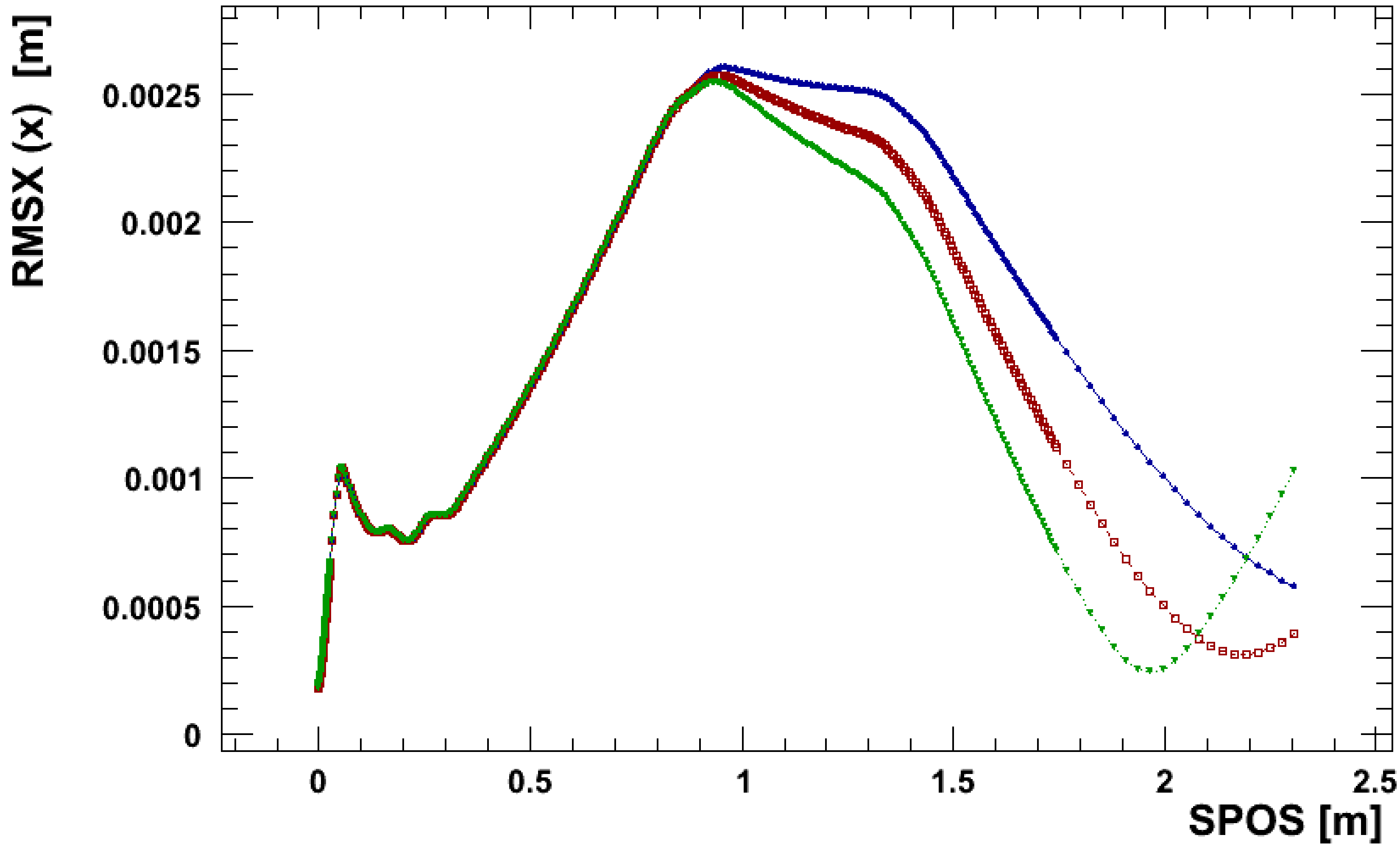
- PSL: 170 mT; SL10B: 100 mT; SL20B= 110 mT
- Waist: 0.2 mm

Half cavity power



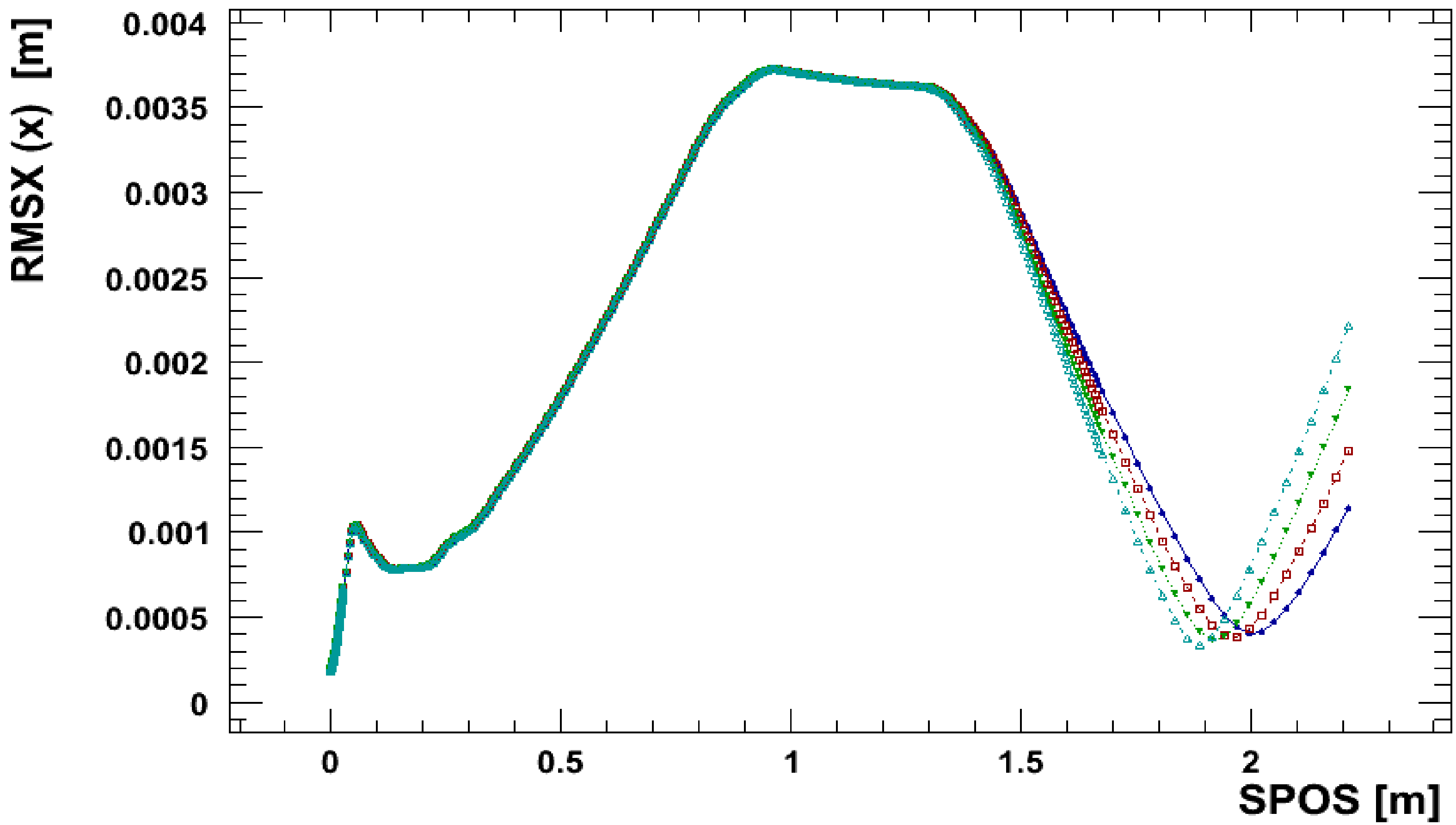
- SL10B = 58 mT; SL20B = 55 mT
- SL10B = 60 mT; SL20B = 65 mT
- SL10B = 62 mT; SL20B = 75 mT
- Waist: 0.2 mm

One quarter cavity power



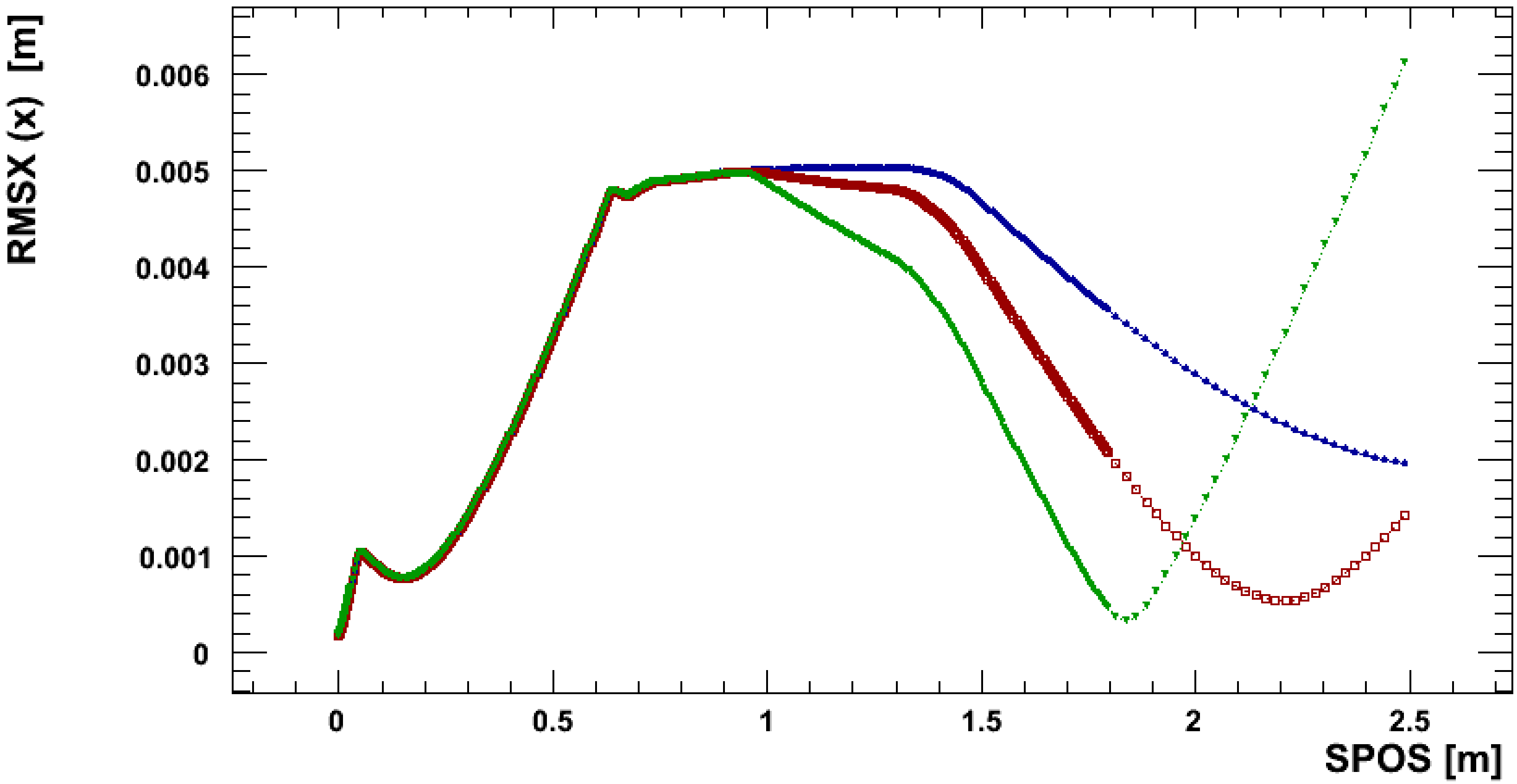
- SL10B = 38 mT; SL20B = 32 mT
- SL10B = 40 mT; SL20B = 35 mT
- SL10B = 42 mT; SL20B = 38 mT
- Waist : 0.5 mm

Low cavity power



- SL10B = 28 mT; SL20B = 29 mT
- SL10B = 28 mT; SL20B = 30 mT
- SL10B = 28 mT; SL20B = 31 mT
- SL10B = 28 mT; SL20B = 31 mT
- Waist : 0.5 mm

Cavity off



- SL10B = 15 mT; SL20B = 13 mT
- SL10B = 17 mT; SL20B = 15 mT
- SL10B = 19 mT; SL20B = 17 mT
- Waist : 1 mm
- at most 45% of the e^- pass the cavity

Settings Table

Cavity field	MV/m	35.5	17.75	8.9
PSL	mT	170	162.5	162.5
SL10B	mT	100	60	38
SL20B	mT	110	65	32

Cavity field	MV/m		5	0 *
PSL	mT		162.5	162.5
SL10B	mT		28	17
SL20B	mT		29	15

* at most 45% of the beam reaches the monitor