PARMELA Modeling for AO facility

Shaoheng Wang

Femtosource Advisory Committee Meeting

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PARMELA Modeling for A0 facility

1. Why modeling A0
2. A0 setup
3. Solenoid
4. Photocathode RF gun
5. 9-cell TESLA cavity
6. Beam dynamics in RF gun
7. Beam parameters choosing
8. Flat beam production
9. Future work

Why modeling AO

- In our facility, the "crabbed" beam technique requires a beam with small emittance in the tilted plane --- "*Flat-beam*"

- AO facility --- first experimentally realize Flat-Beam production with quadruples adaptor

- Acquire knowledge of beam dynamics in the RF gun:
  space charge effect, RF acceleration,
  emittance compensation, ……

. In one word, it is a good starting point to acquaint a code and gain confidence for it's output

A0 setup

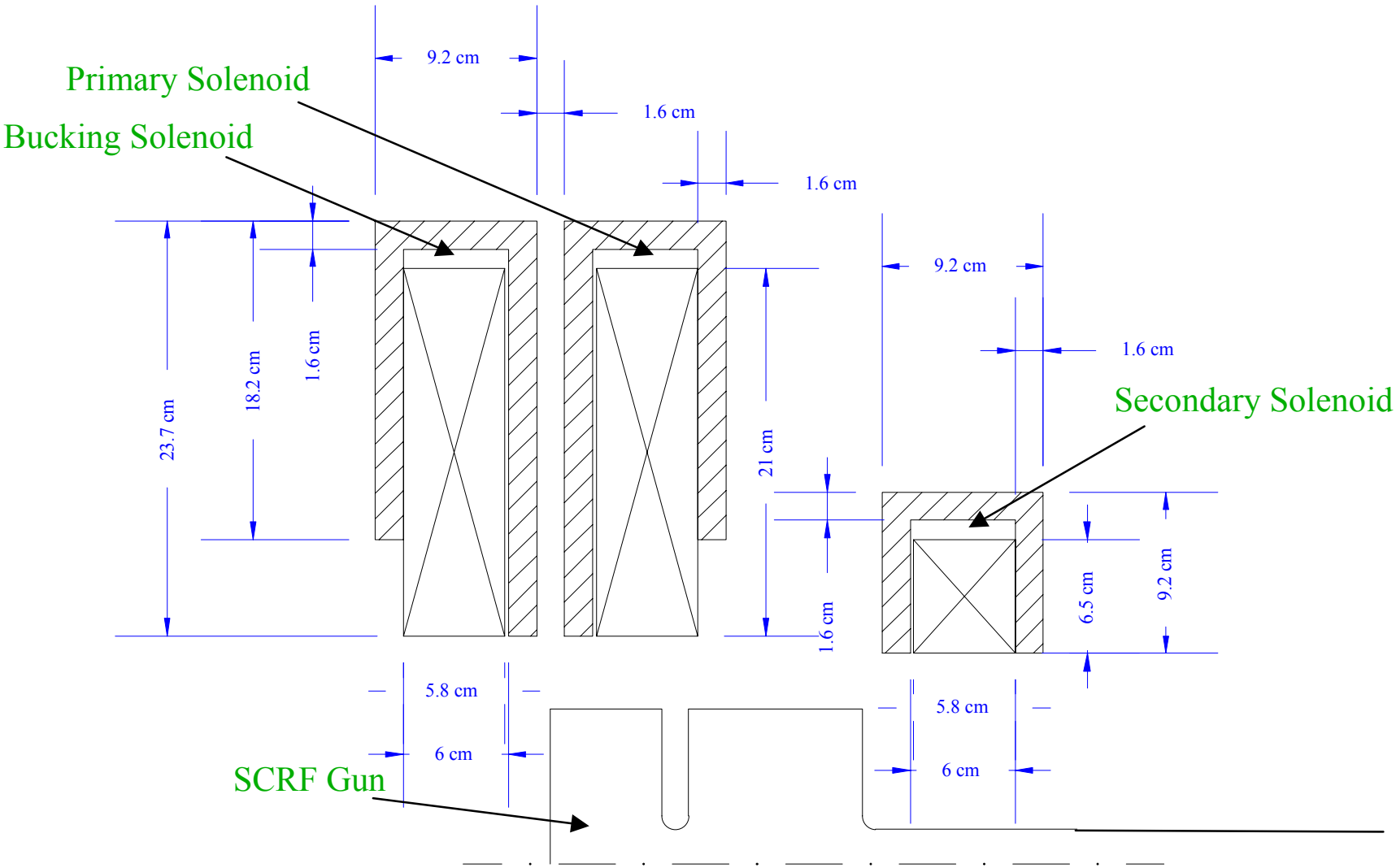
One and half cell RF gun plus solenoids → TESLA 9-cell SC cavity → skew quads adaptor and measurements

$E_{cathode}$: 35MV/m
Energy gain:
about 4MeV
Frequency: 1.3GHz
Emittance:
about 20mm-mr
Bunch charge:
1-8nC

$E_{average}$: 12MV/m
Energy gain:
about 13-14MeV

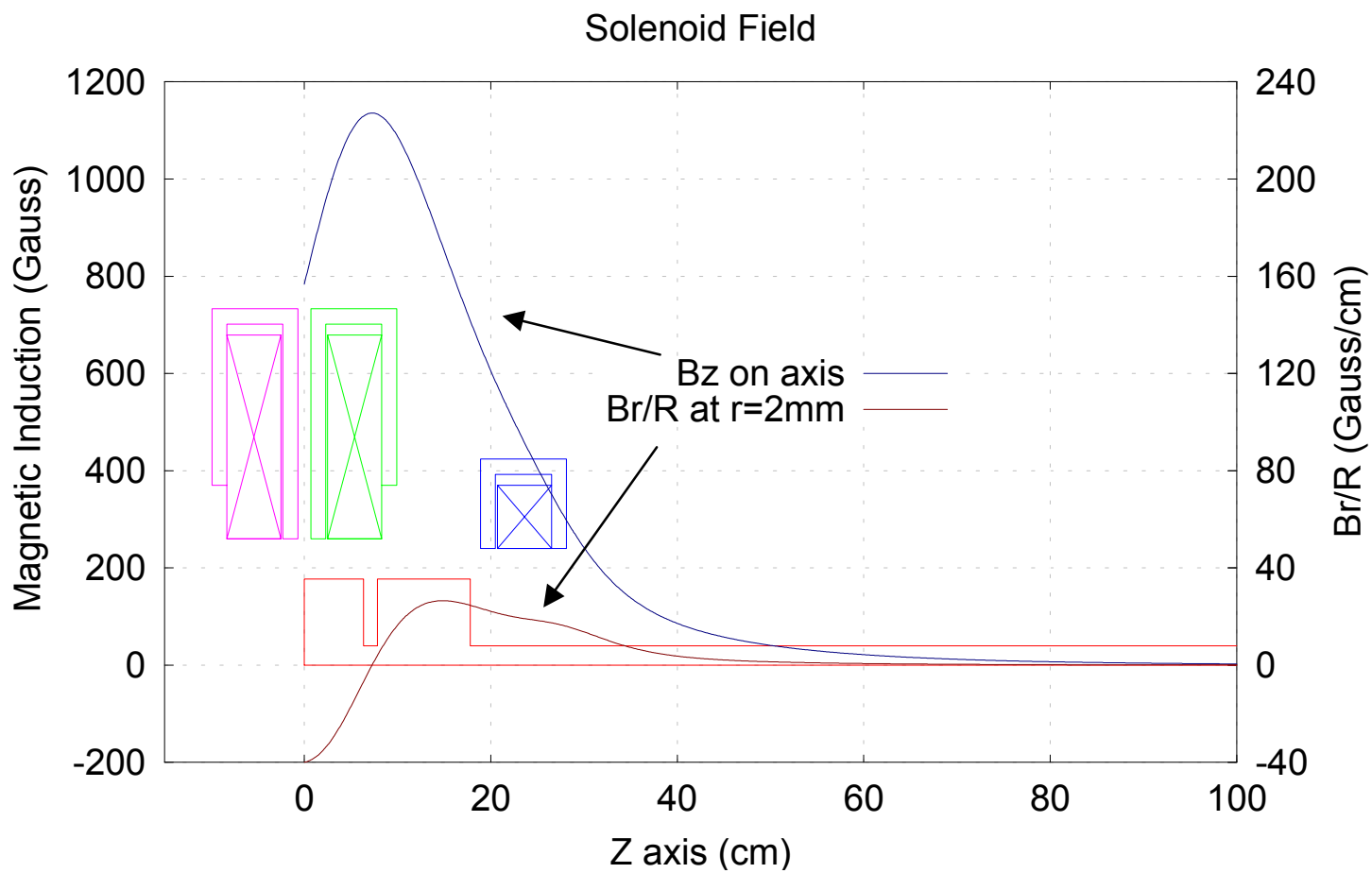
Emittance x 46mm-mr
Emittance y 0.9mm-mr

Solenoid


Primary Solenoid
Bucking Solenoid
9.2 cm
1.6 cm
1.6 cm
23.7 cm
18.2 cm
1.6 cm
21 cm
9.2 cm
1.6 cm
Secondary Solenoid
1.6 cm
6.5 cm
9.2 cm
5.8 cm
6 cm
5.8 cm
6 cm
SCRF Gun

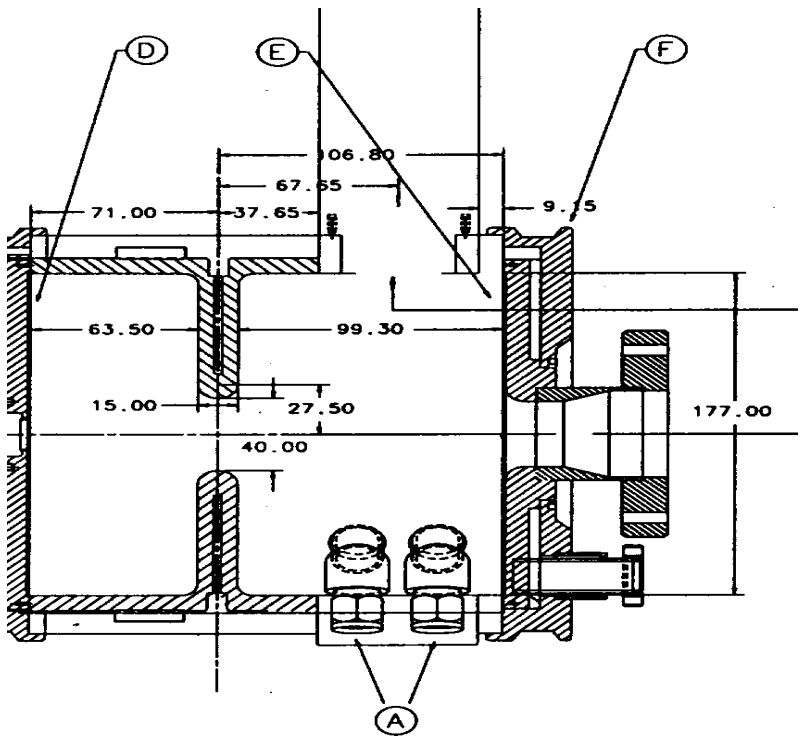
Solenoid

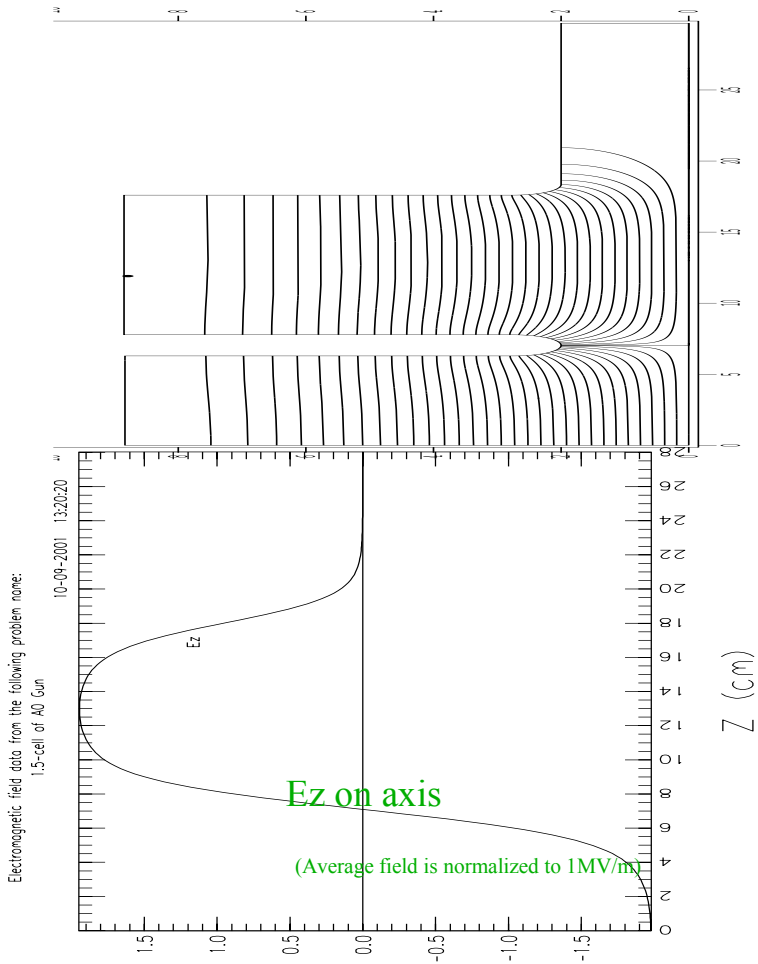
For flat beam production, certain finite Bz at cathode plane is required, in A0 experiments, bucking solenoid is turned off . Below is Poisson output



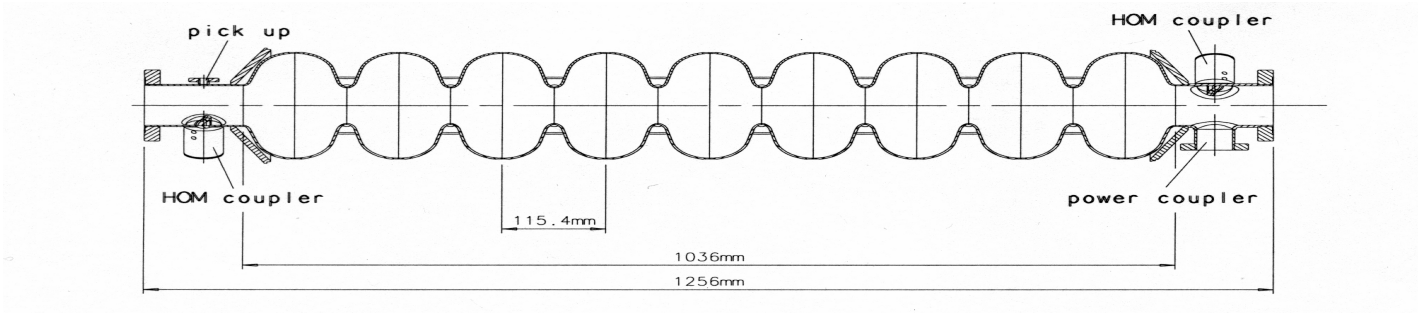
Photocathode RF gun

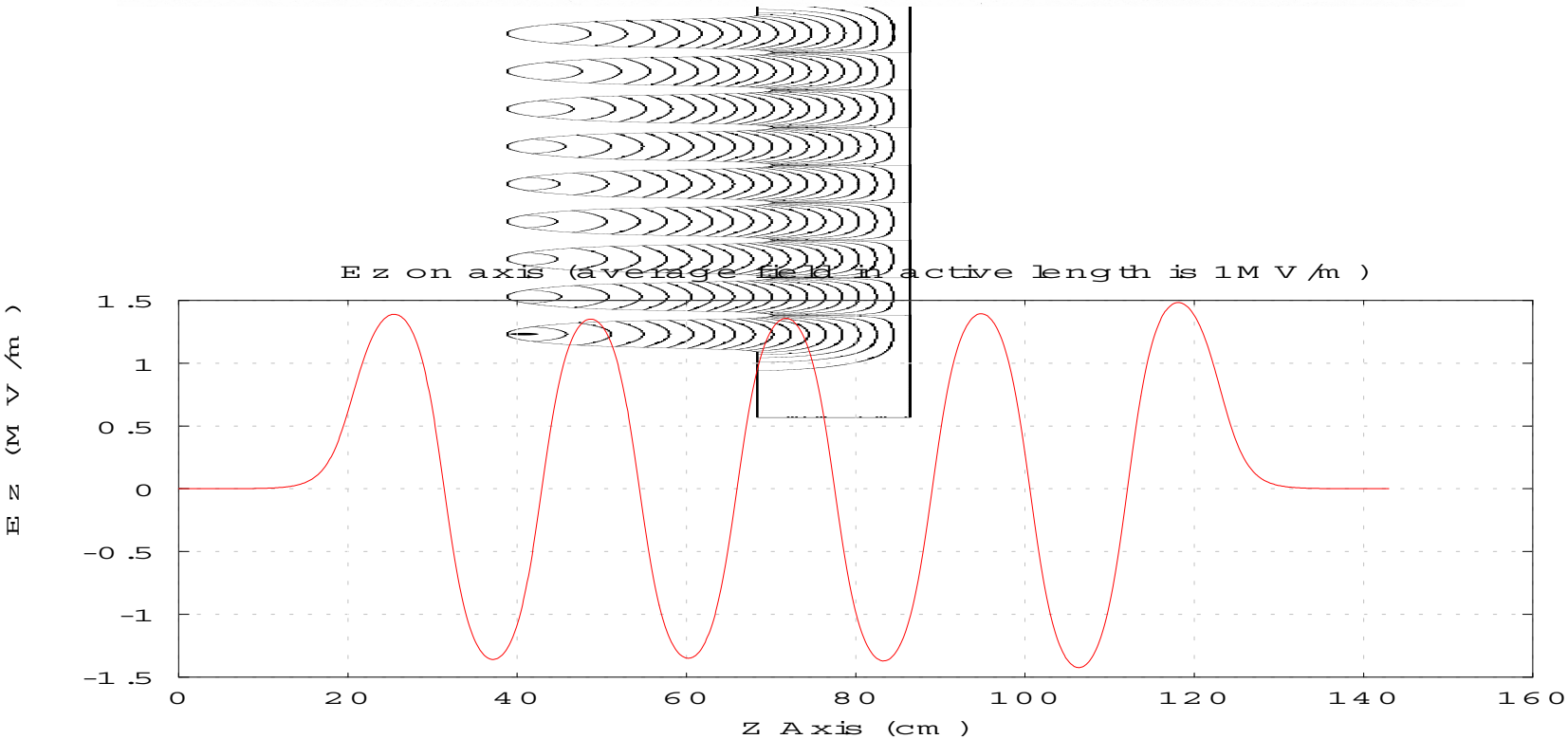
Geometry and Superfish results





9-cell TESLA cavity





Superfish Result

Beam dynamics in RF gun

Calculation Condition:

1. Mesh size:

   i. RF field : near cathode region: 0.1mm x 0.1mm

   other region: 0.3mm x 0.3 mm

   ii. Solenoid field: 1mm x 1mm

2. Time step:

   i. Launching period: 0.01degree (one part in 234 of the bunch length)

   ii. Acceleration period: 0.1degree

3. Bunch:

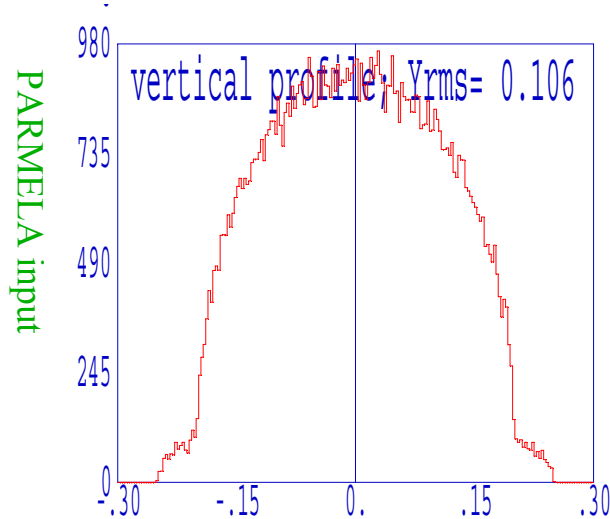
   1nC, 5pS, uniform-distributed longitudinally,

   transverse distribution use that from experiment

   initial energy 0.55eV, without transverse velocity,

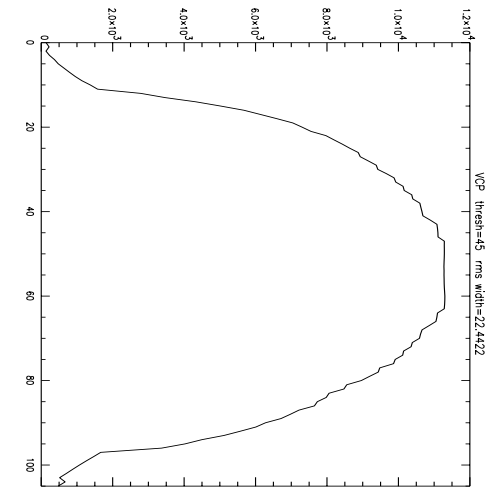
   lunched behind the cathode with 20 degree w.r.t. 0 crossing

   macro particle number 100,000



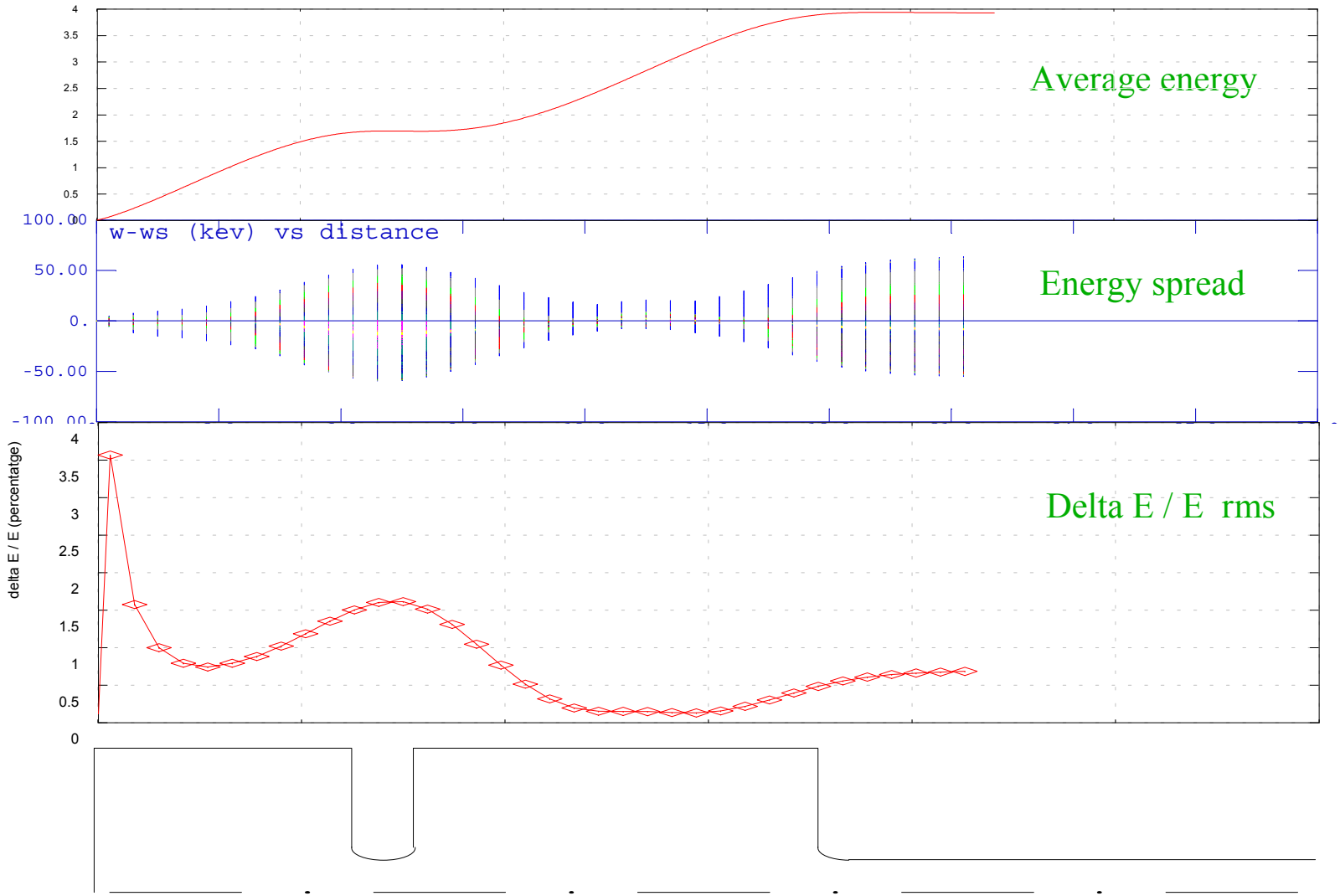
PARMELA input

Transverse distribution

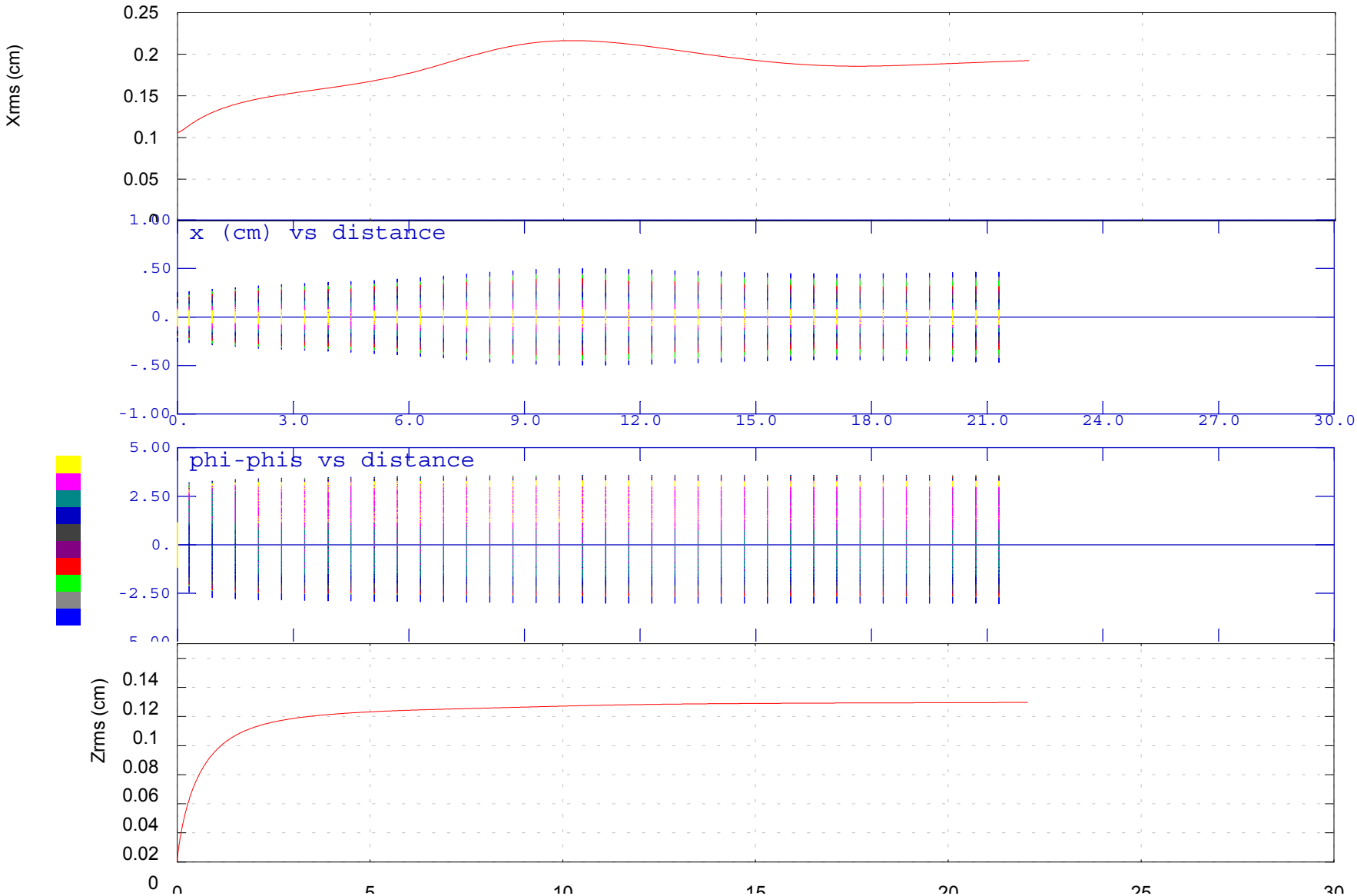


Experiment measurement

Beam dynamics in RF gun: energy



Beam dynamics in RF gun: bunch size



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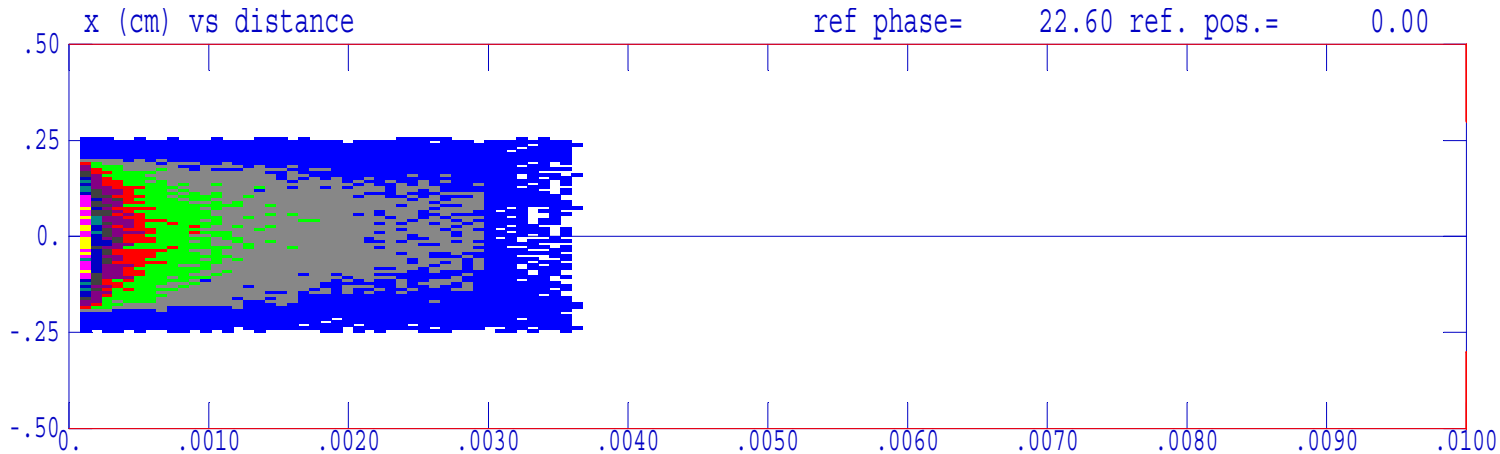
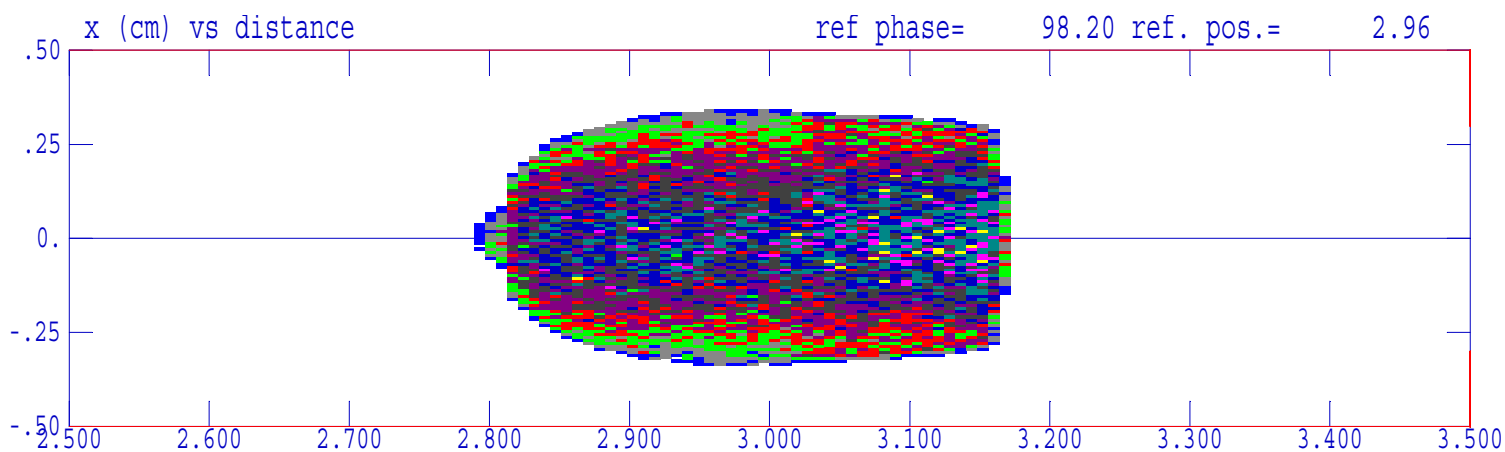
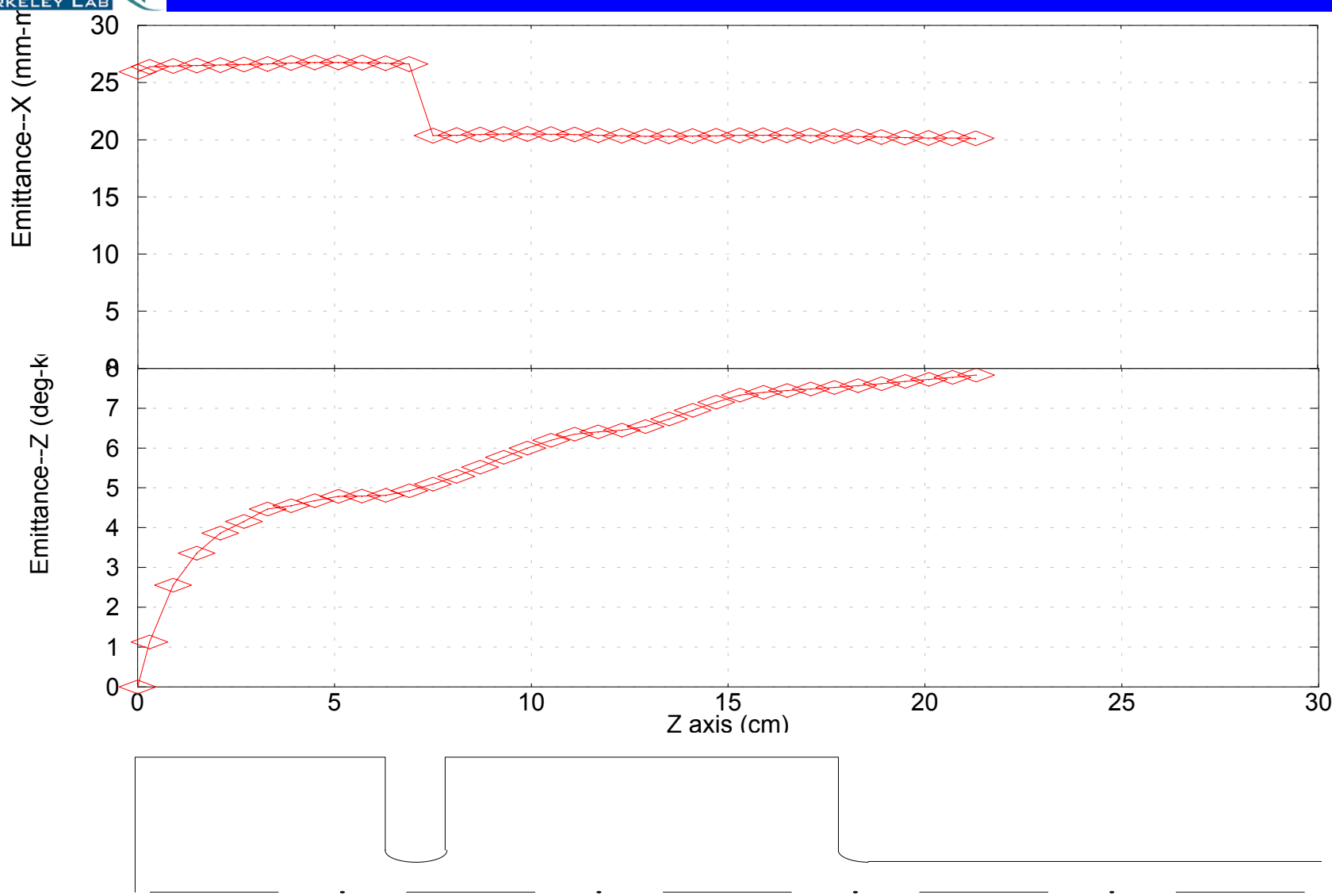
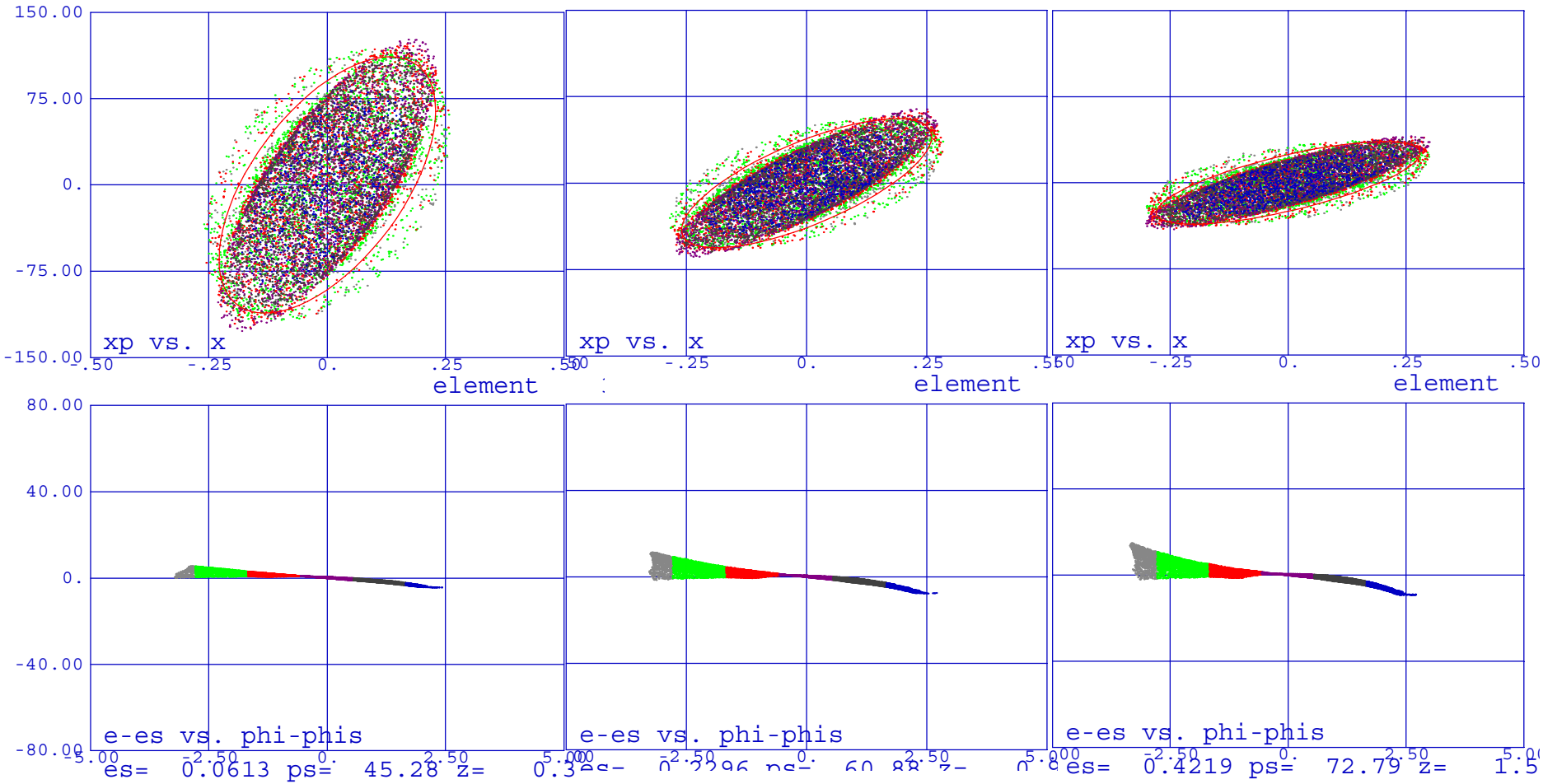




Beam dynamics in RF gun: emittance



Beam dynamics in RF gun: distribution in phase space



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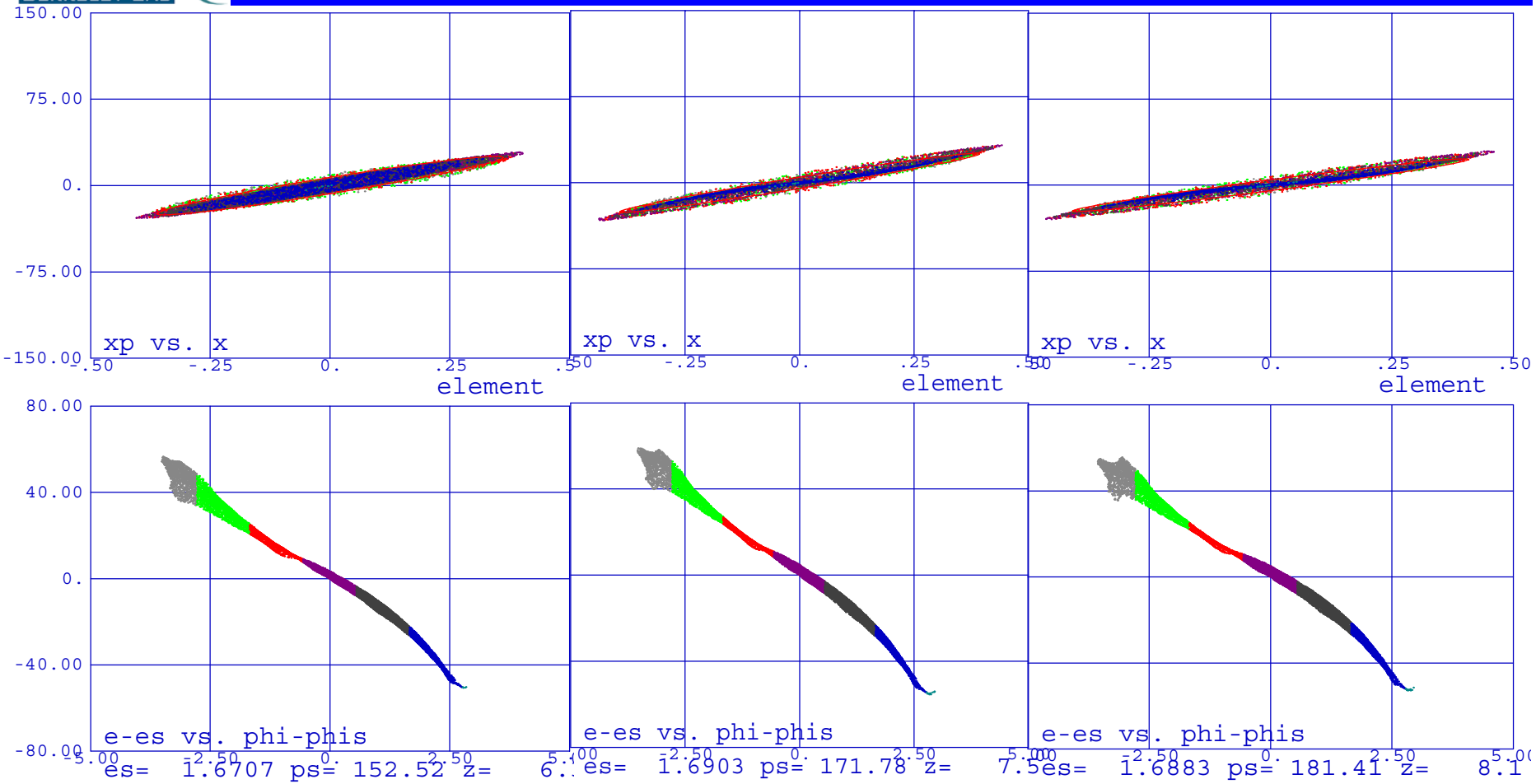

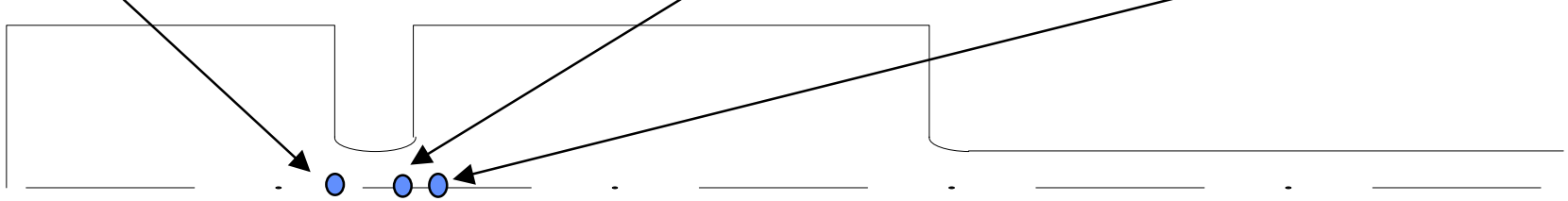

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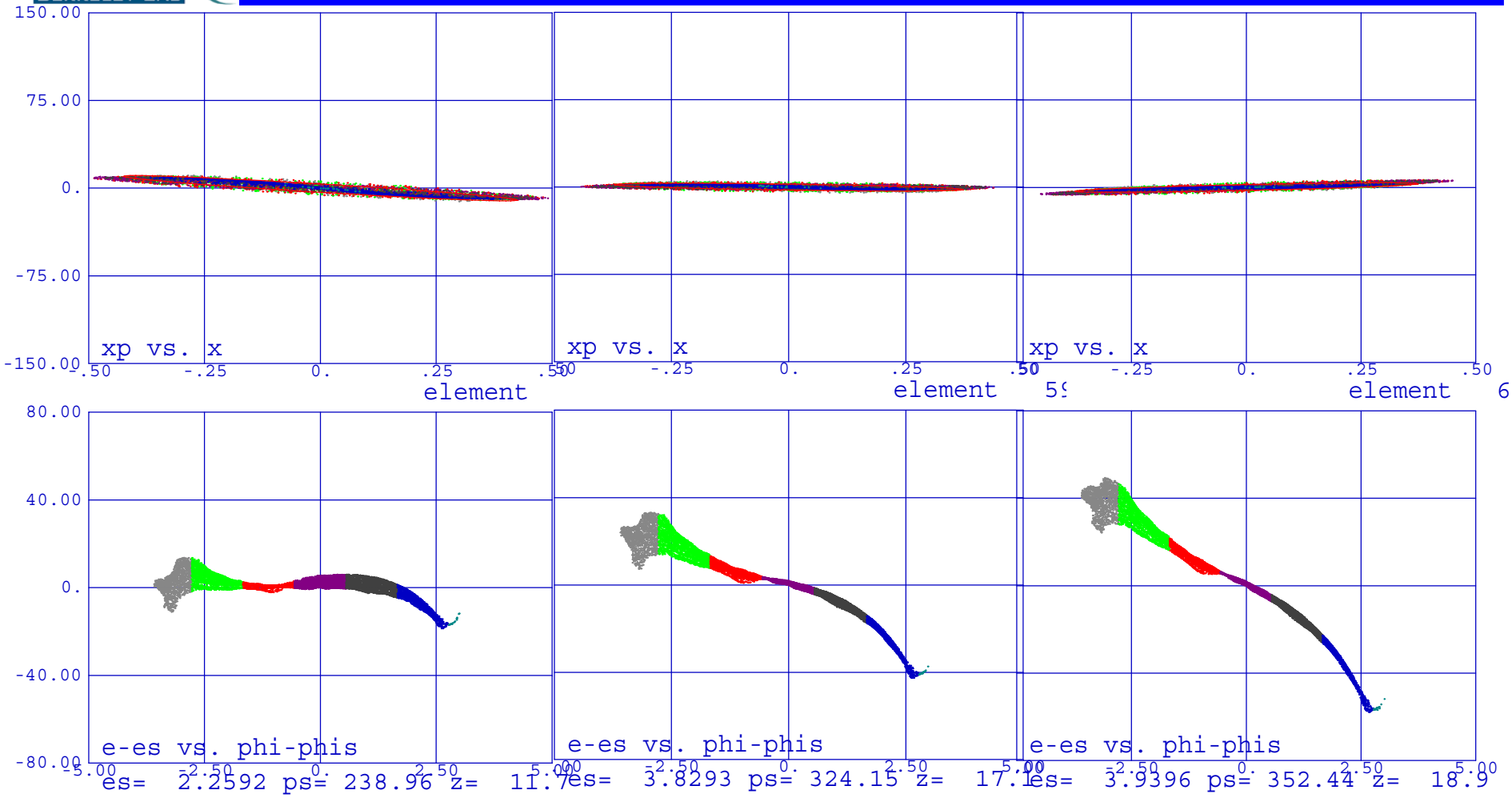
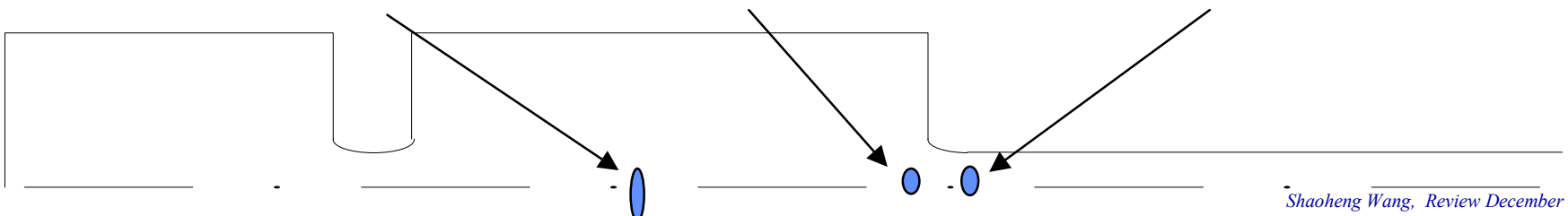
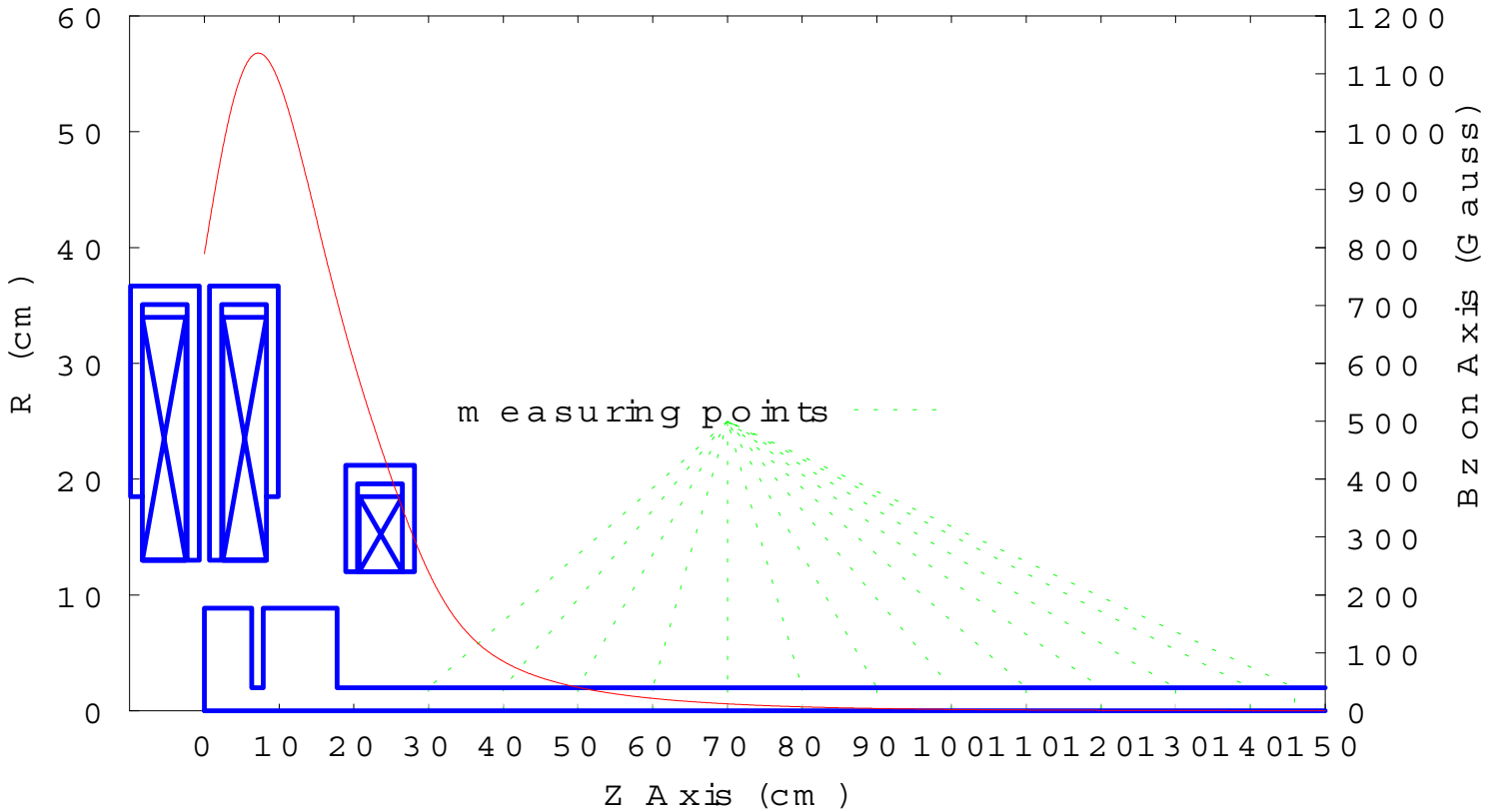


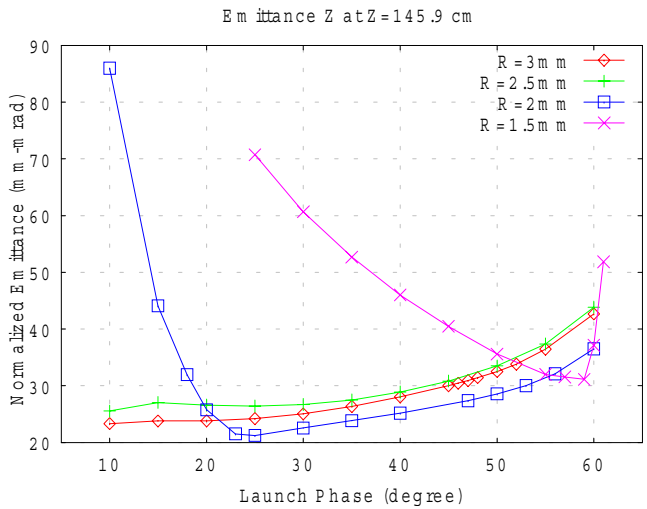


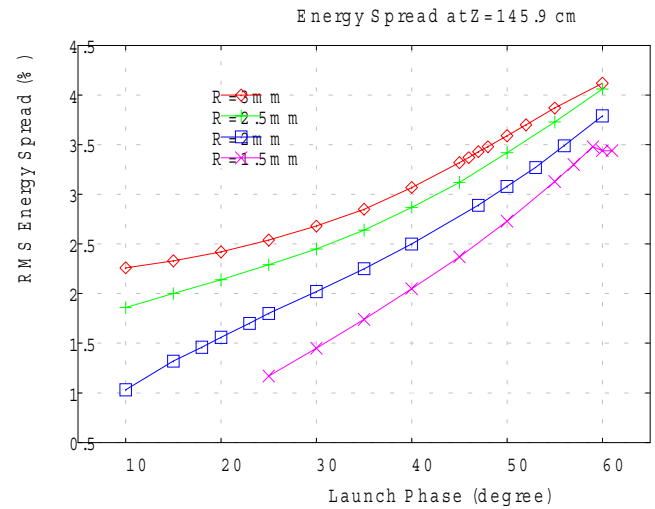
Beam parameters choosing

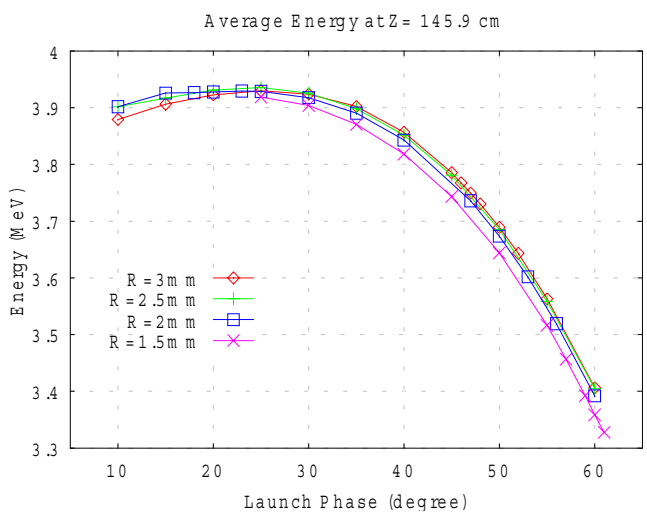
Measured at z=145.9cm, bunch has
got out of magnetic field region
and before get into the cavity

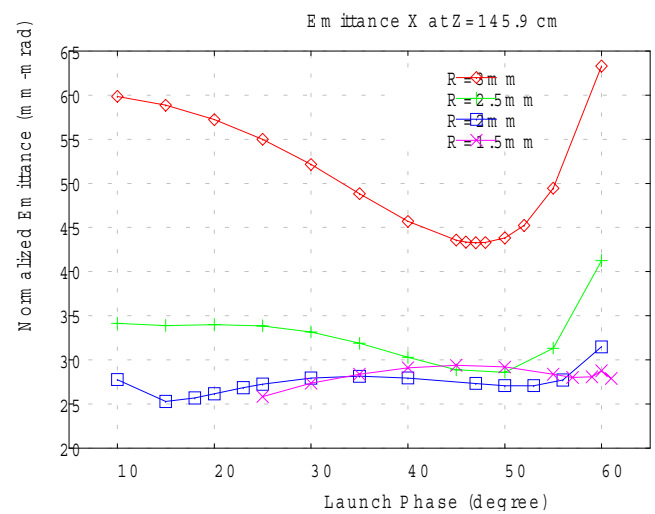


Beam parameters choosing

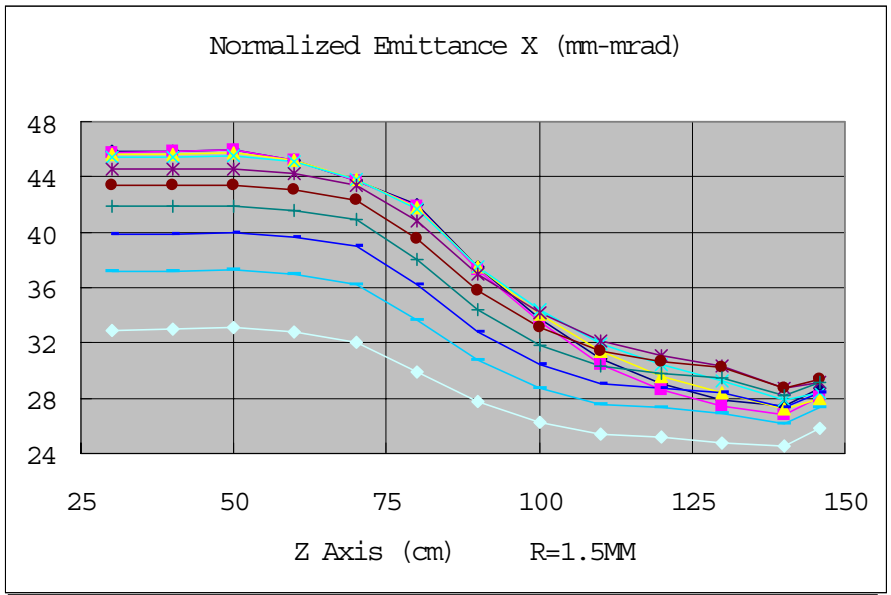


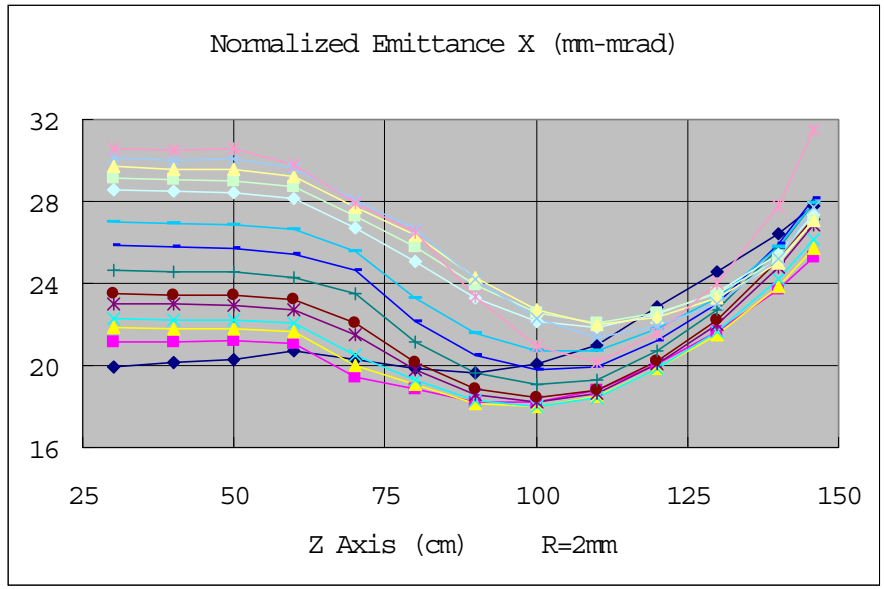


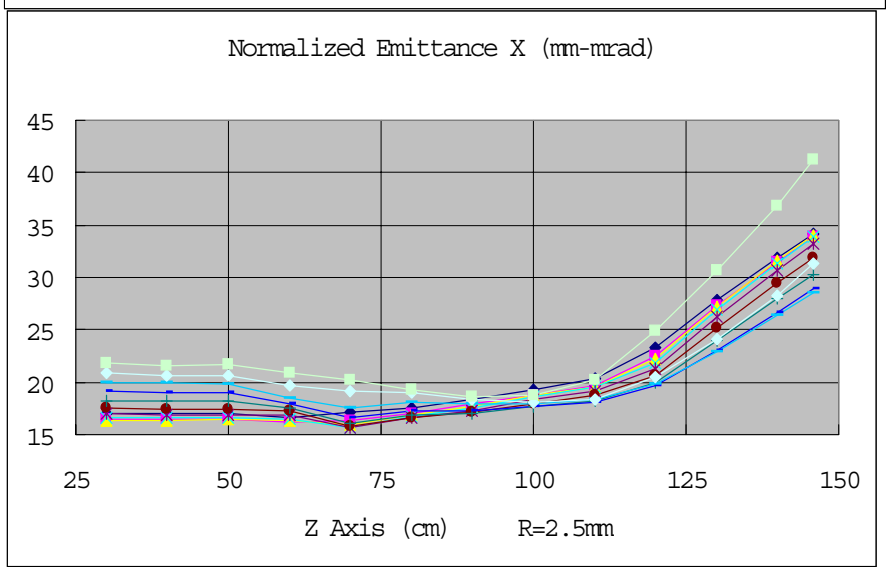


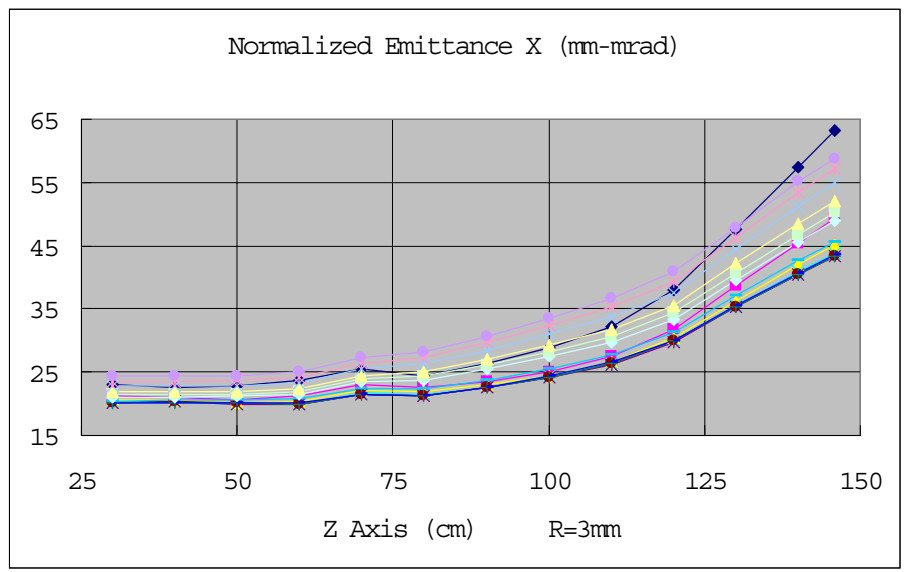


Beam parameters choosing









Flat beam production example

A very simple example of flat beam transformation

no space charge effect is considered

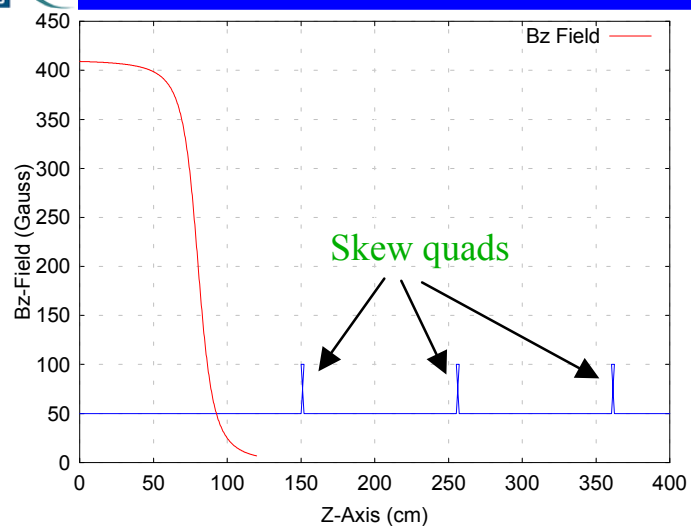
A 10ps bunch

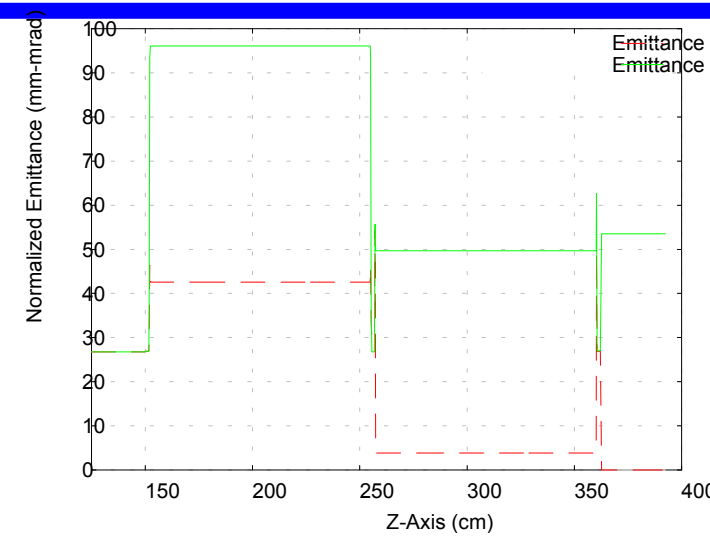
- uniformly distributed longitudinally and transversly
- spot size 3mm
- uniform energy 17.5MeV
- energy spread 0

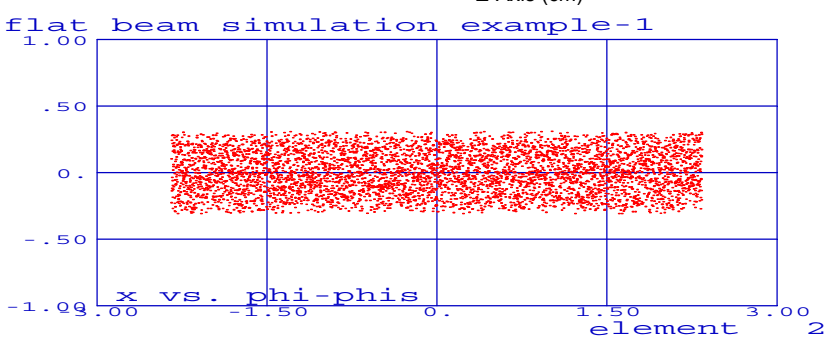
is put in a uniform Bz field (400Gauss), downstreams outside of the Bz field is a set of symmetric skew quads triplet. Before entering the skew quad, it is 150cm drift space

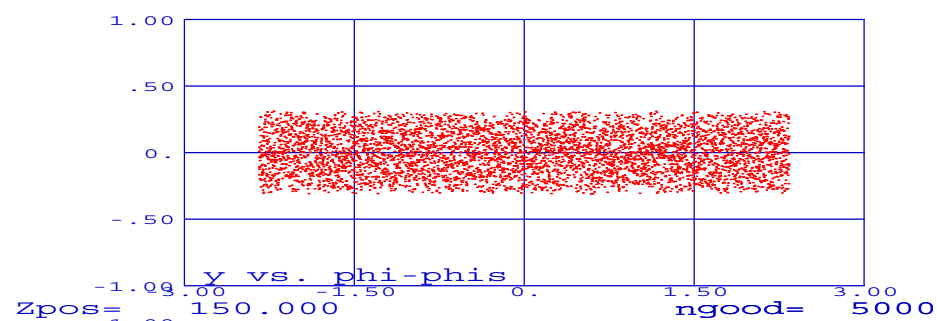
Resulting emittance ratio: 21062

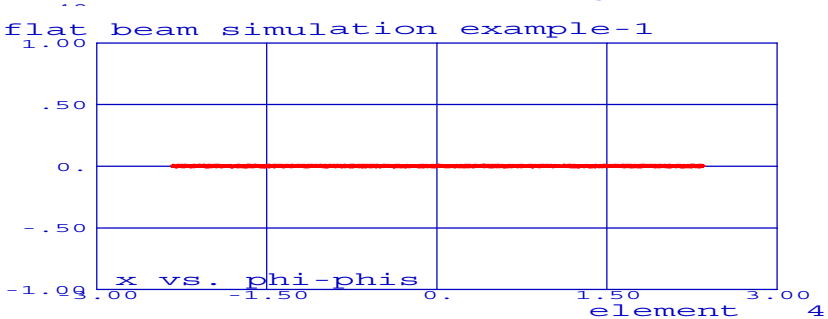
Flat beam production example

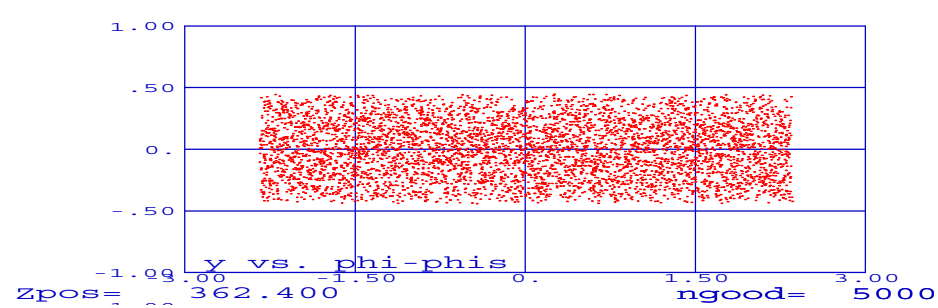












Future work

- Investigate the emittance compensation in flat beam production beam line setup.
- 9-cell cavity investigation
- Get detail knowledge about flat beam production and the aspect ratio limit.
- Compare results with other codes.