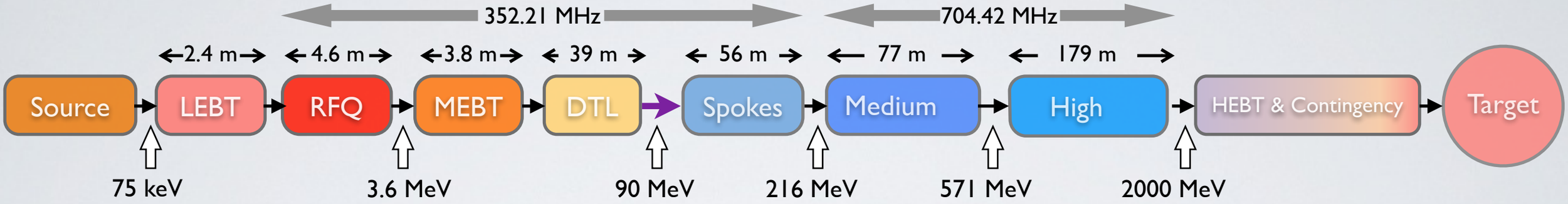
THE ESS LINAC

Mamad Eshraqi
for the Accelerator physics work package

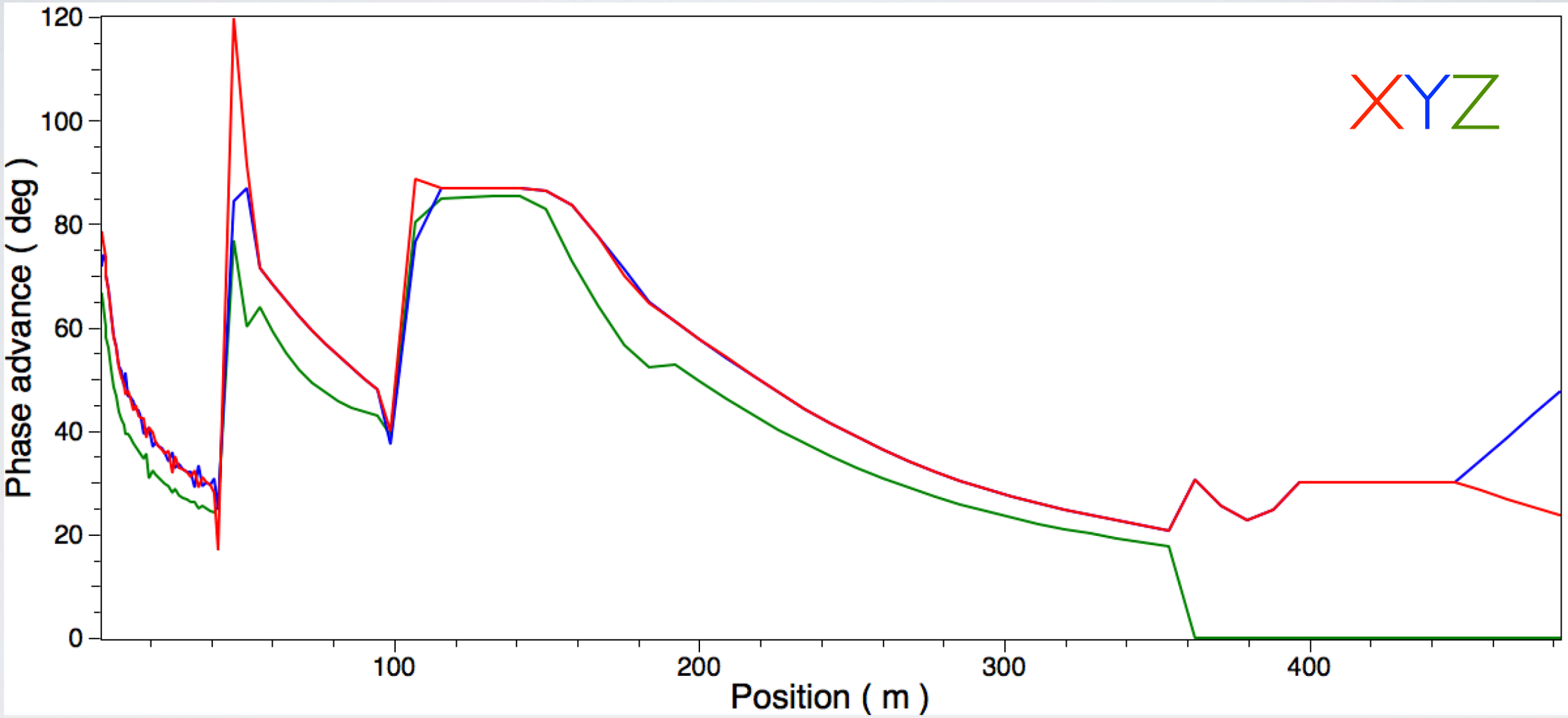
2014 May 13, Lund

THE ESS LINAC

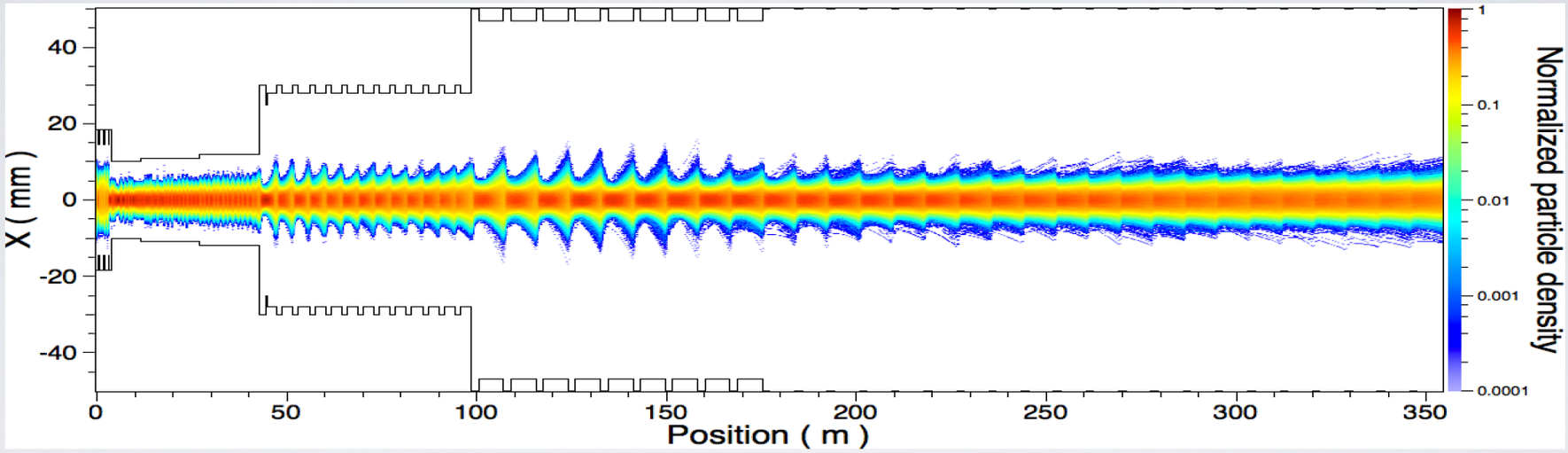


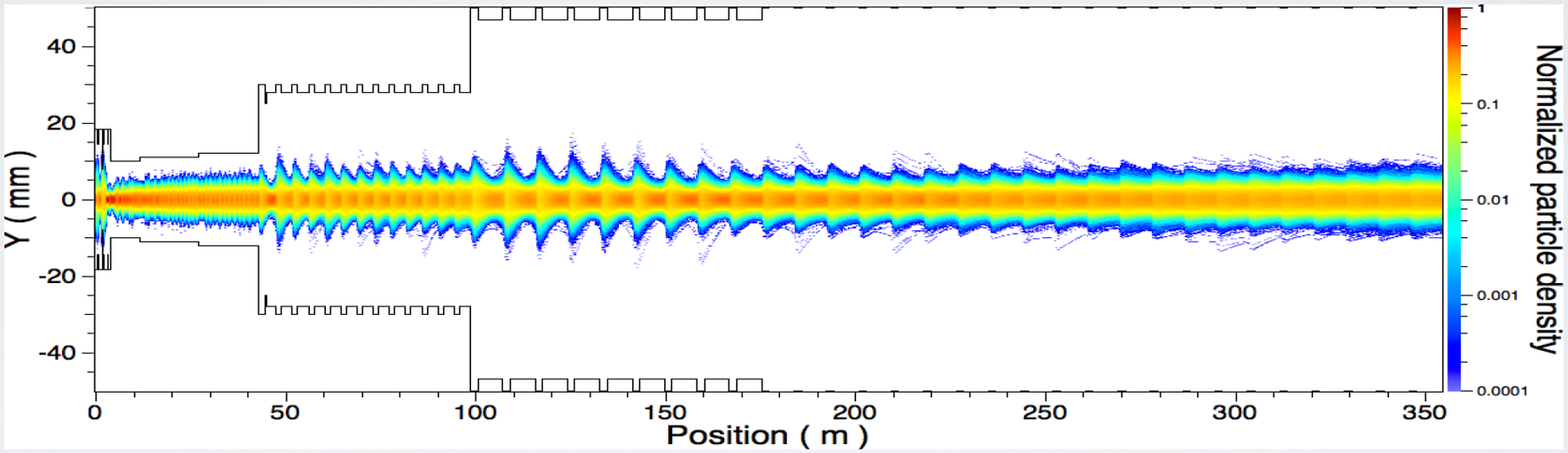
	Length (m)	W_in (MeV)	F (MHz)	β Geometric	No. Sections	T (K)
LEBT	2.38	0.075	--	--	1	~300
RFQ	4.6	0.075	352.21	--	1	~300
MEBT	3.81	3.62	352.21	--	1	~300
DTL	38.9	3.62	352.21	--	5	~300
LEDP + Spoke	55.9	89.8	352.21	0.50	13	~2
Medium Beta	76.7	216.3	704.42	0.67	9	~2
High Beta	178.9	571.5	704.42	0.86	21	~2
Contingency	119.3	2000	704.42	(0.86)	14	~300 / ~2
~~Upgrade~~	~~59.6~~	~~2000~~	~~704.42~~	~~(0.86)~~	~~7~~	~~~300 / ~2~~

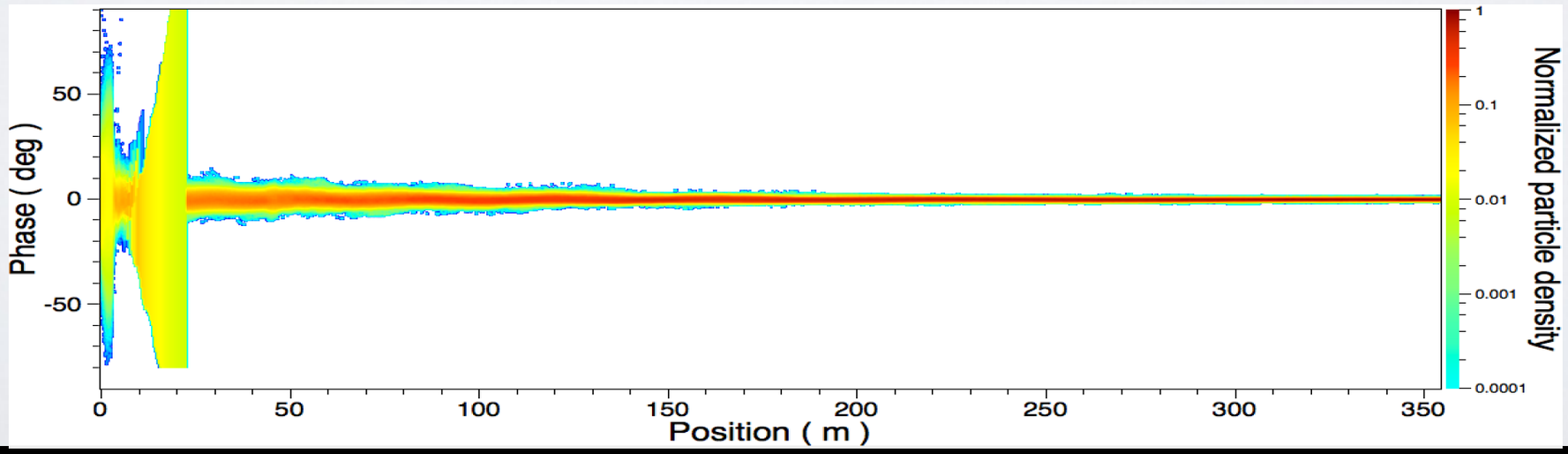
PHASE ADVANCE @ RIGHT ENERGY



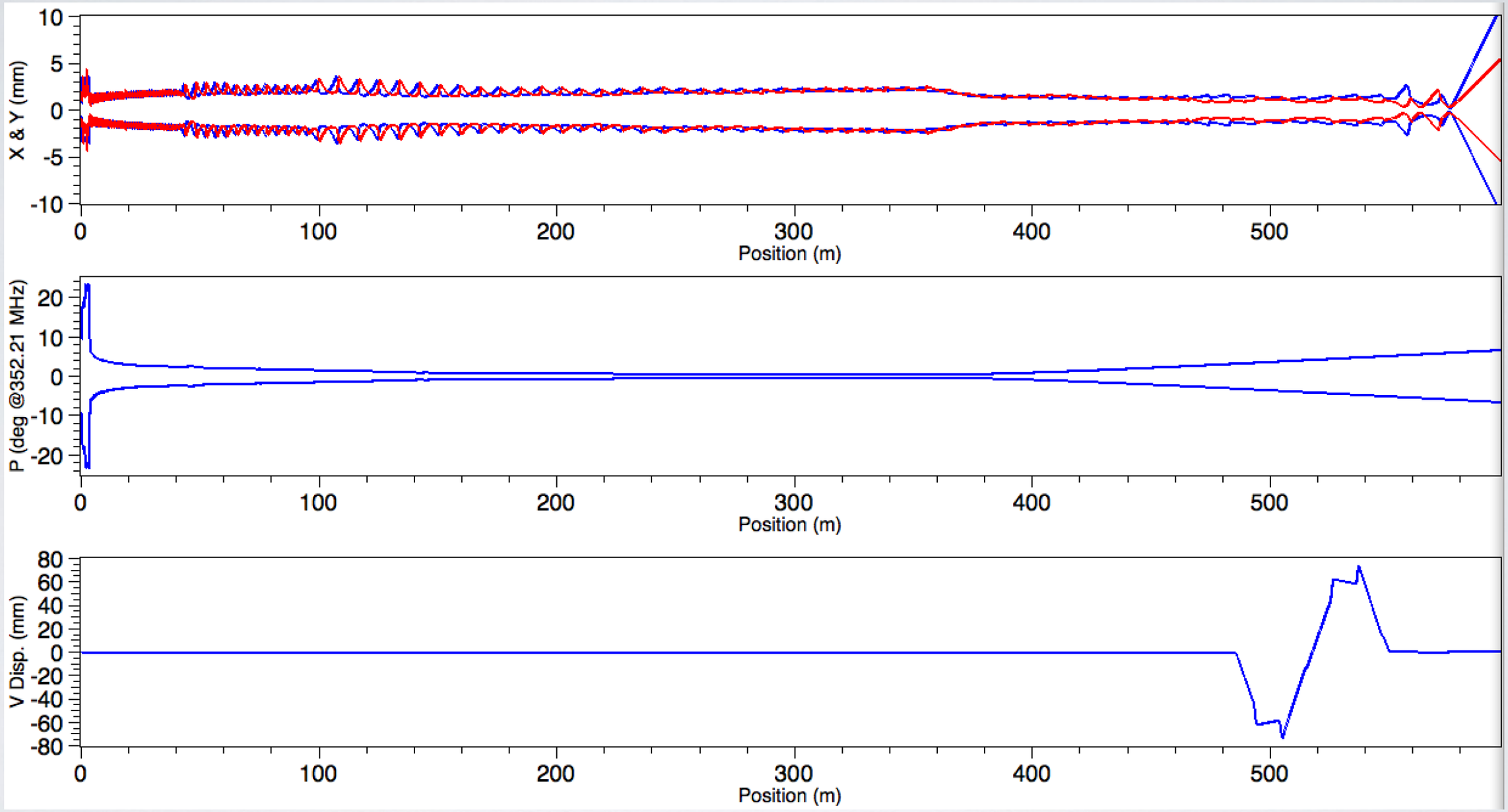
NO ERRORS


X (mm)
Position (m)
Normalized particle density


Y (mm)
Position (m)
Normalized particle density


Phase (deg)
Position (m)
Normalized particle density

ENVELOPES


X & Y (mm)
10
5
0
-5
-10
0
100
200
300
400
500
Position (m)
P (deg @352.21 MHz)
20
10
0
-10
-20
0
100
200
300
400
500
Position (m)
V Disp. (mm)
80
60
40
20
0
-20
-40
-60
-80
0
100
200
300
400
500
Position (m)

APPLIED ERRORS I

- RFQ:
  - Input beam
    - Input beam position and angle
    - Input beam mismatch (alpha and beta)
  - Machining
    - Longitudinal profile of the vane
    - Transverse profile of the vane
  - Alignment and Voltage errors
    - Parallel and perpendicular vane shift
    - Parallel and perpendicular vane tilt
    - Section shift
    - Section tilt
    - Voltage jitter

APPLIED ERRORS II

- MEBT:
  - Input beam
    - Position and angle
    - Emittances
    - Mismatch (alpha and beta)
    - Energy
    - Current

APPLIED ERRORS III

- MEBT:
  - Quadrupoles
    - Alignment
    - Rotation around the beam axis
    - Gradient
  - Cavities
    - Alignment
    - Tilt perpendicular to beam axis
    - Field and phase set point
    - Field and phase jitter

APPLIED ERRORS IV

- DTL:
  - PMQ
    - Alignment
    - Rotation around the beam axis
    - Gradient
  - RF
    - Field and phase error on each cell
    - Tank field and phase set point
    - Tank field and phase jitter

APPLIED ERRORS V

- Spoke/MB/HB:
  - Quad
    - Alignment
    - Rotation around the beam axis
    - Gradient
  - Cavity
    - Alignment
    - Tilt perpendicular to beam axis
    - Field and phase set point error
    - Field and phase jitter

APPLIED ERRORS VI

- HEBT/DogLeg/A2T
  - Quad
    - Alignment
    - Rotation around the beam axis
    - Gradient
  - Dipole
    - Alignment
    - Tilt perpendicular to beam axis
    - Field error

ERROR STRATEGY

- 10% emittance growth per plane on top of nominal per section
- Effect of dynamic errors smaller than the rms energy/phase spread within the beam
- Optimizing the positions of steerers
- Minimizing the number of active BPMs
- Defining the transverse tolerances after setting (and using) the steering strategy

TOLERANCES (RFQ)

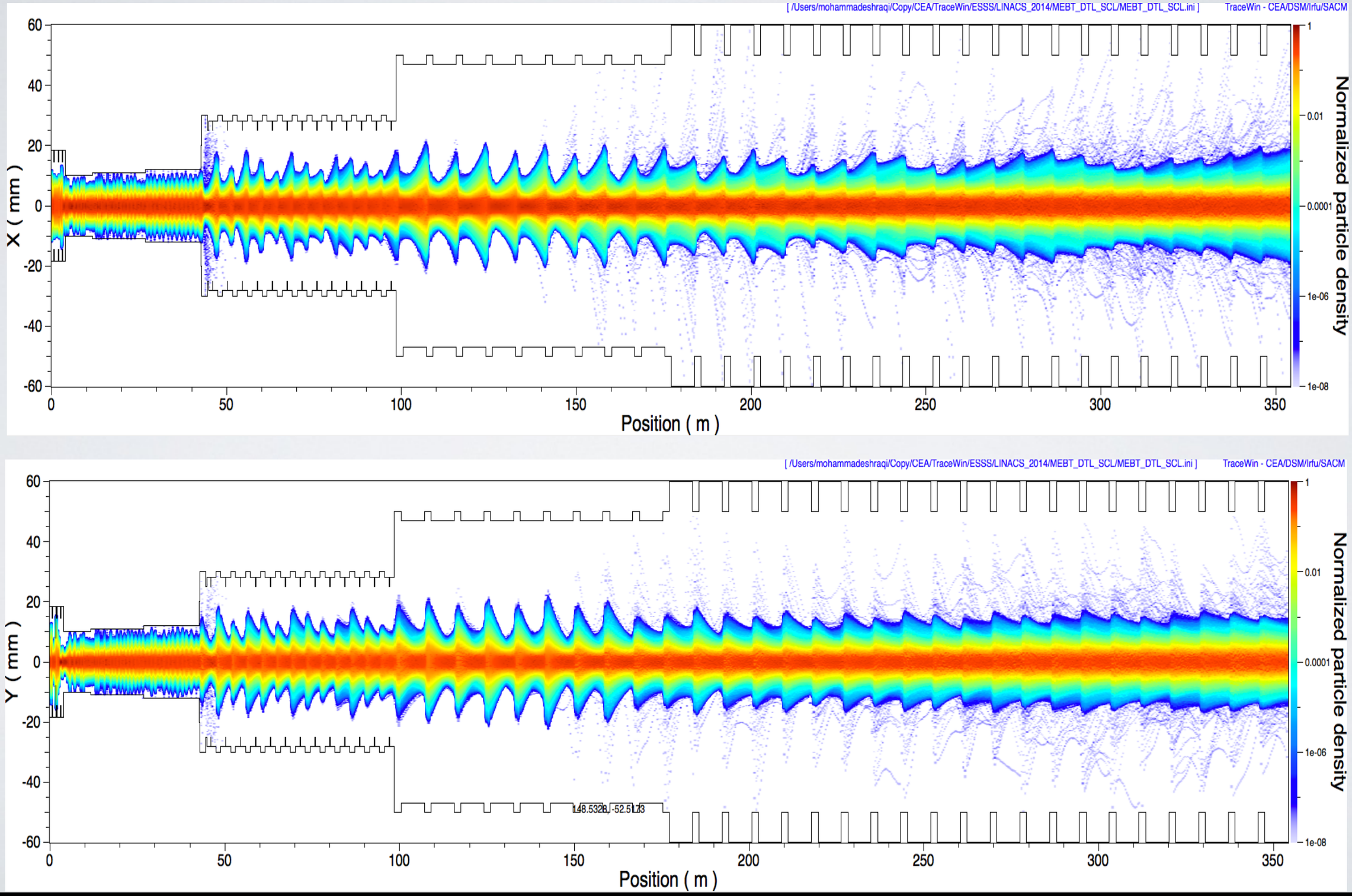
Input beam error	**Alignment position**	0.2	mm
	Alignment angle	2	mrad
	Twiss mismatch (	10	%
	Twiss mismatch (	5	%
Machining errors	**Longitudinal vane profile**	0.02	mm
	Transverse vane curvature	0.02	mm
Alignment error	**Parallel and perpendicular vane shift**	0.03	mm
	Parallel and perpendicular vane tilt	0.03	mrad
	Horizontal and vertical segment shift	0.03	mm
	Segment tilt around X and Y axis	0.03	mrad
Voltage error	**Vane voltage jitter**	0.5	%

TOLERANCES

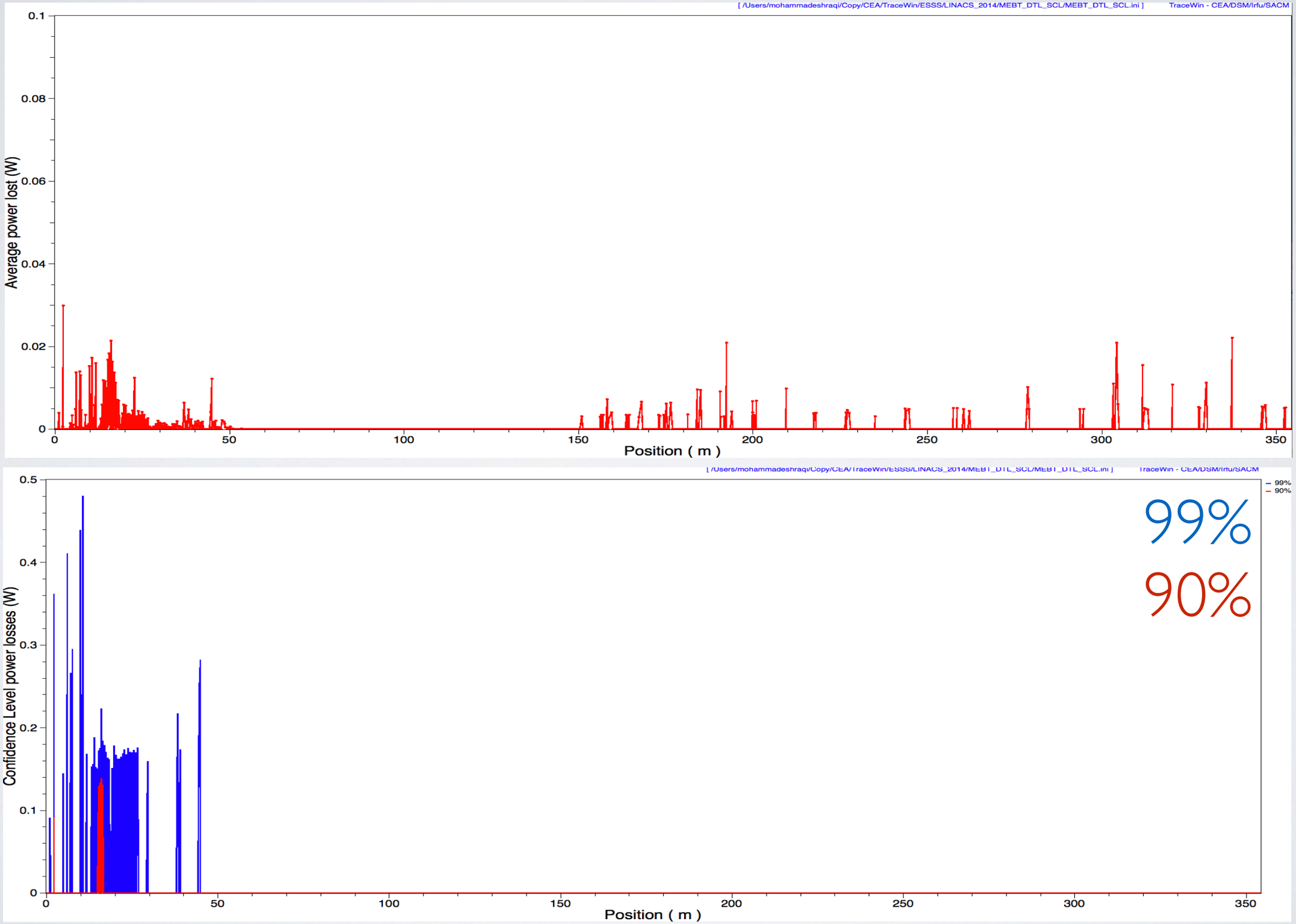
	dx (mm)	dy (mm)	dϕ(º)	dx'(mrad)	dy'(mrad)	dE (%)	dEx (%)	dEy (%)	dEz (%)	mx	my	mz	dI (mA)
Beam	0.3	0.3	0	1	1	0.01	5	5	5	5	5	5	0.625

			dx (mm)	dy (mm)	ϕx (º)	ϕy (º)	ϕz (º)	dG	dϕ	dE
MEBT	**Static**	**QUAD**	0.2	0.2	0	0	0.06	0.5	—	—
	Static	**Cavity**	0.5	0.5	0.115	0.115	—	—	1	1
	Dynamic	**Cavity**	0	0	0	0	—	—	0.1	0.1
DTL	**Static**	**QUAD**	0.15	0.15	0.5	0.5	0.24	0.9	—	—
	Static	**Cav_CL**	0	0	0	0	—	—	2	2
	Static	**Cav_TK**	0	0	0	0	—	—	1	1
	Dyanmic	**Cav_TK**	0	0	0	0	—	—	0.1	0.1
Spoke MB HB	**Static**	**Quad**	0.2	0.2	0	0	0.06	0.5	—	—
	Static	**Cavity**	1.5	1.5	0.129	0.129	—	—	1	1
	Dynamic	**Cavity**	0	0	0	0	0	0	0.1	0.1
HEBT	**Static**	**Quad**	0.2	0.2	0	0	0.06	0.5	—	—
	Static	**Dipole**	0.2	0.2	0	0	0.06	0.05	—	—

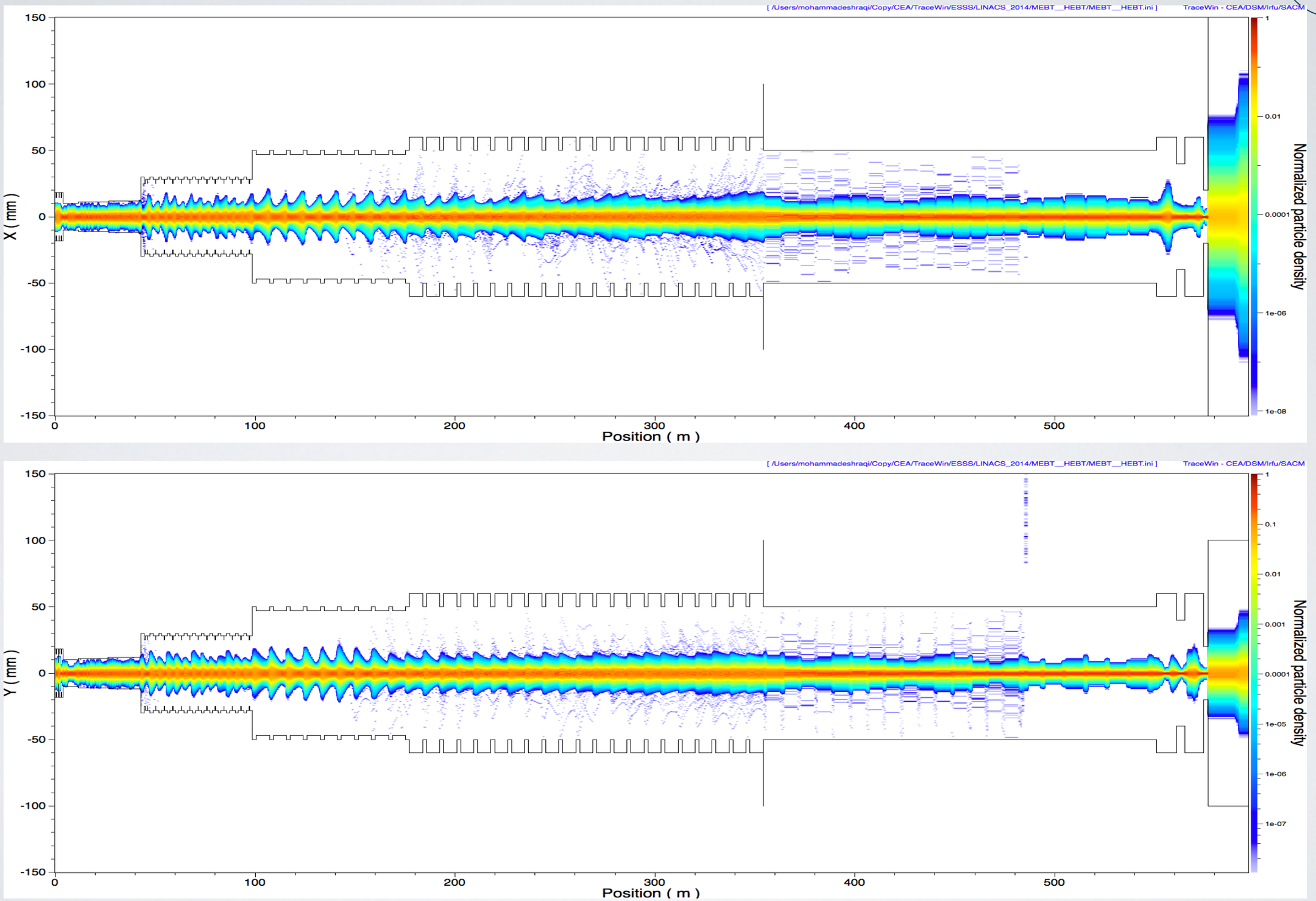
RFQ TO HB ERROR RESULTS



RFQ TO HB ERROR LOSS MAPS

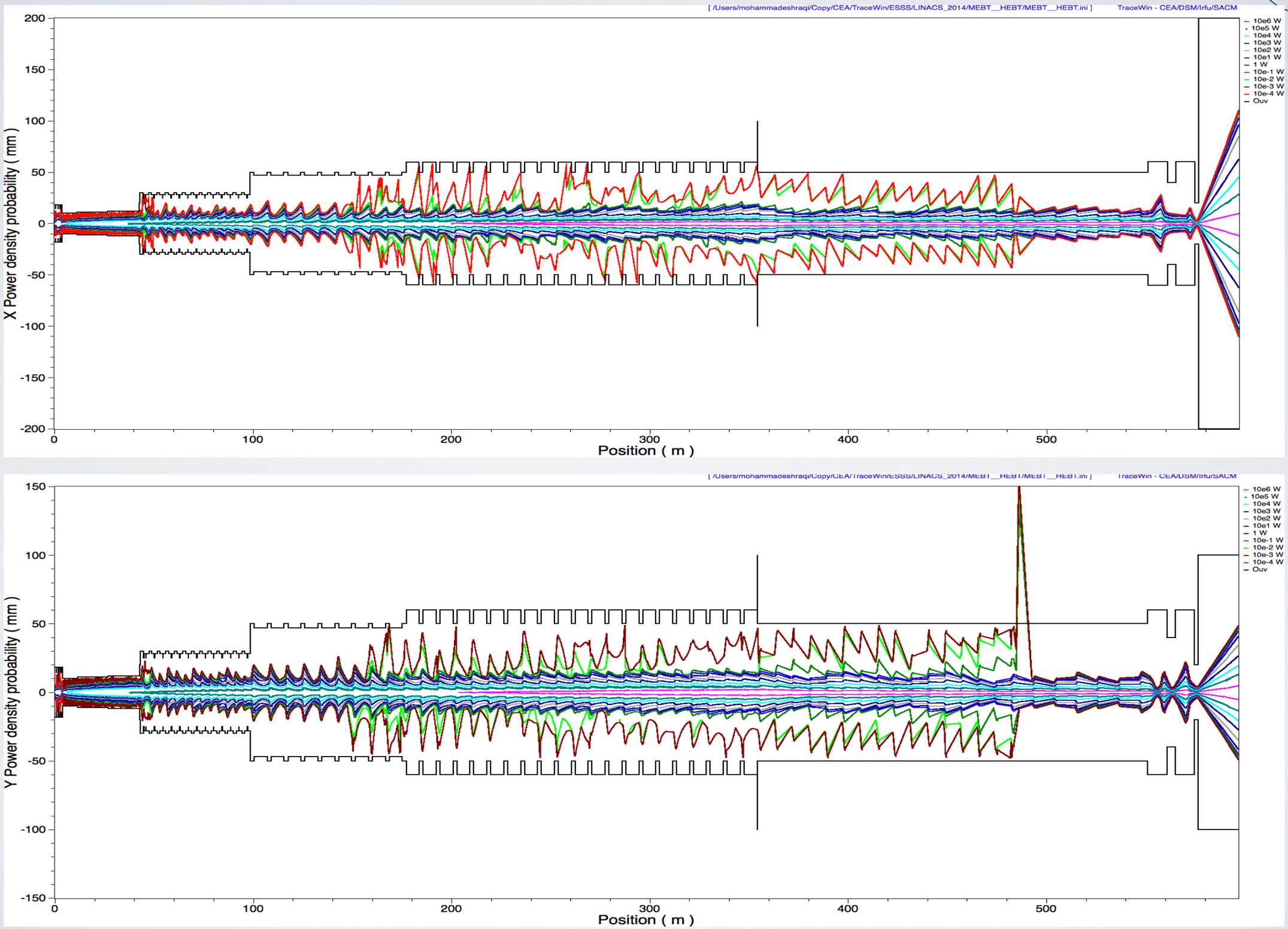


RFQ TO END ERROR RESULTS I

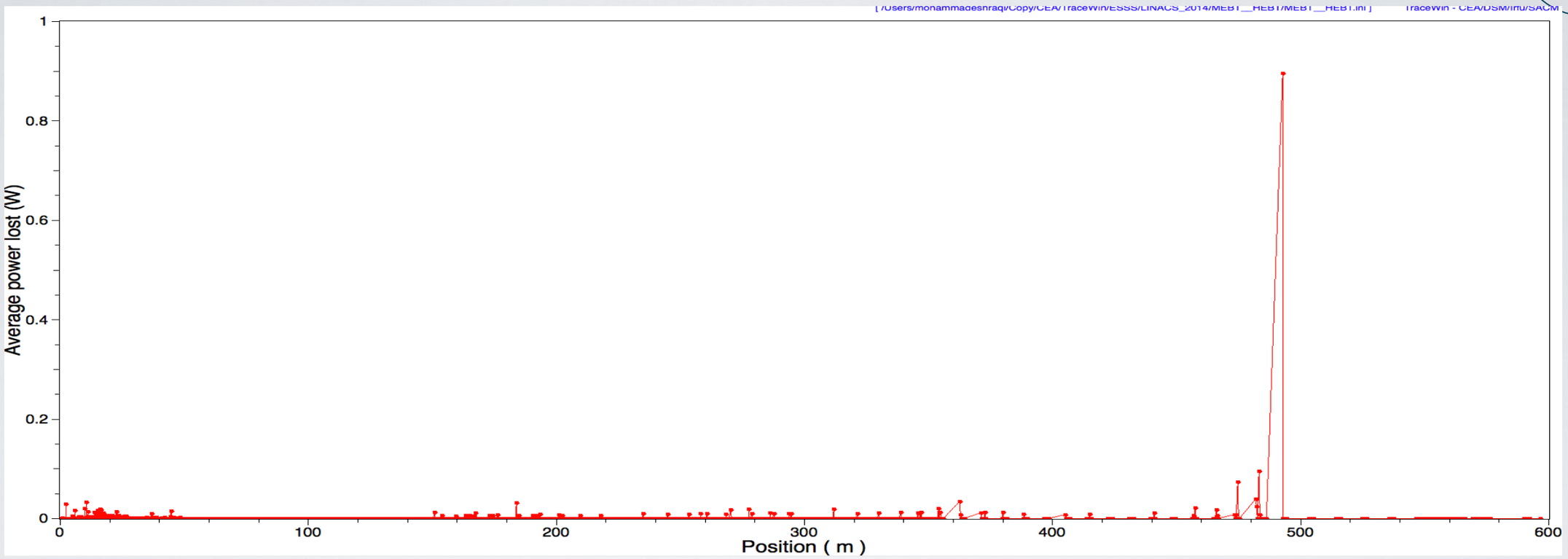


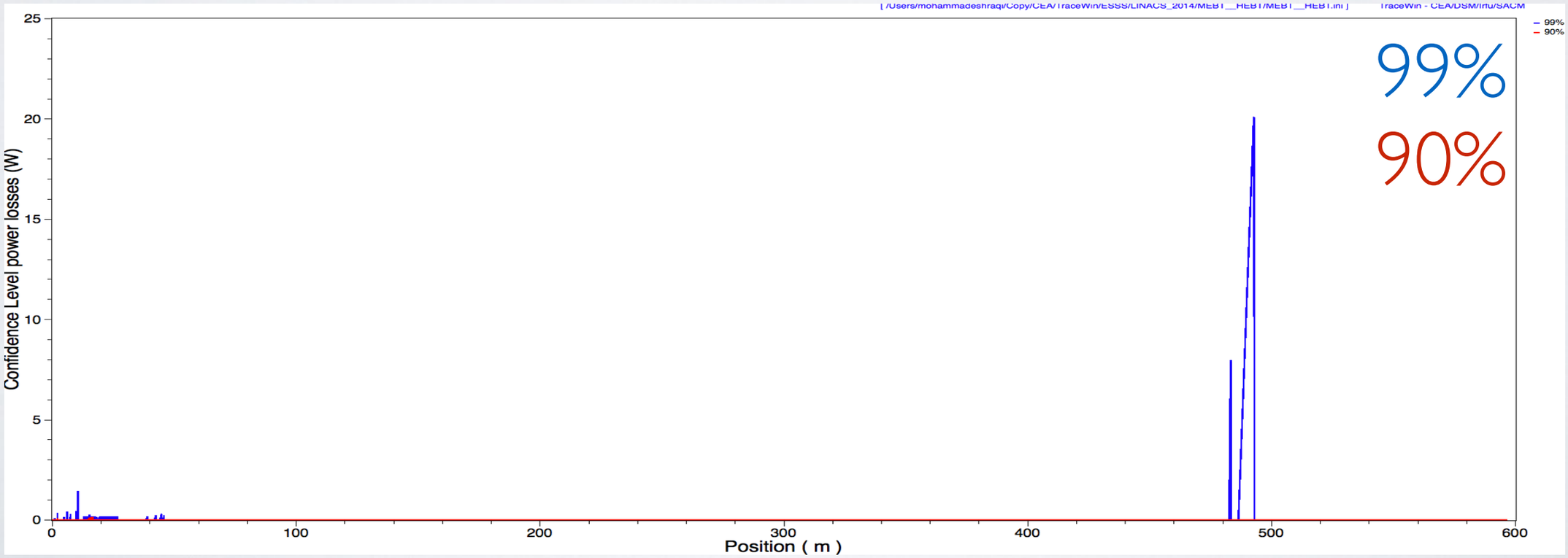
Thanks to Heine Dølrath Thomsen for early delivery of HEBT lattice

RFQ TO END ERROR RESULTS II



RFQ TO END ERROR LOSS MAPS





SUMMARY

- The end to end runs have been performed using a gaussian beam truncated at 4 sigma, generated at the RFQ input.
- The same beam is used for end to end error studies.
- Individual error studies on all sections of the linac is finished and the tolerances are set.
- The end to end error studies show that the average losses is ~0.1 W/m
- 99% of the simulated linacs show a loss level less than ~1W in each meter, with a single hot spot in the dogleg area
- The "right" position for collimators is a function of energy and depends on the shape of tails

THANK YOU FOR YOUR ATTENTION AND COMMENTS