The ESS LINAC

Design and Beam Dynamics

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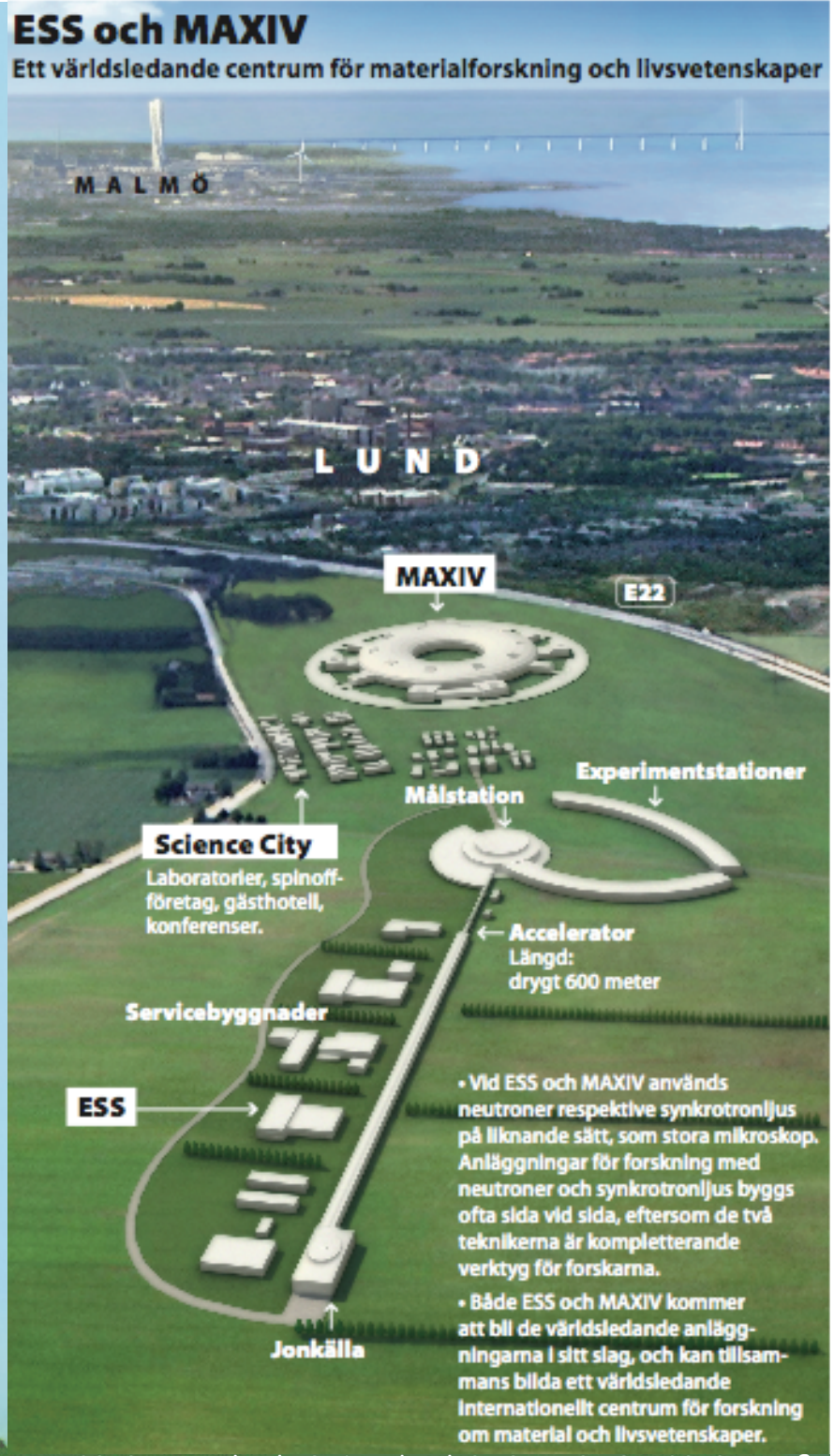
HB2010 28 September 2010

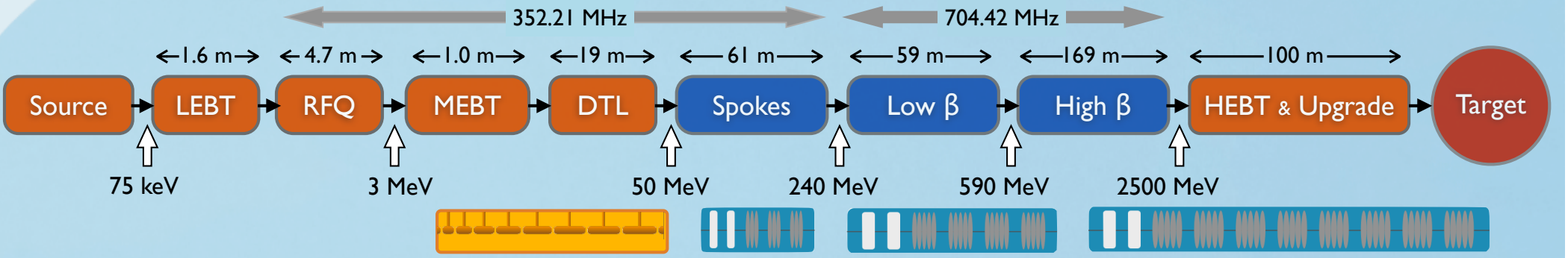
Intro.

* The European Spallation Source, ESS, uses a high current proton LINAC to provide 5 MW (7.5 MW) of power to the target at 2.5 GeV with a 50 mA beam of protons.

50 (75) mA of p^+
Pulse length ⩽ 2 msec
Rep Rate ⩽ 20 Hz
Reliability > 95%

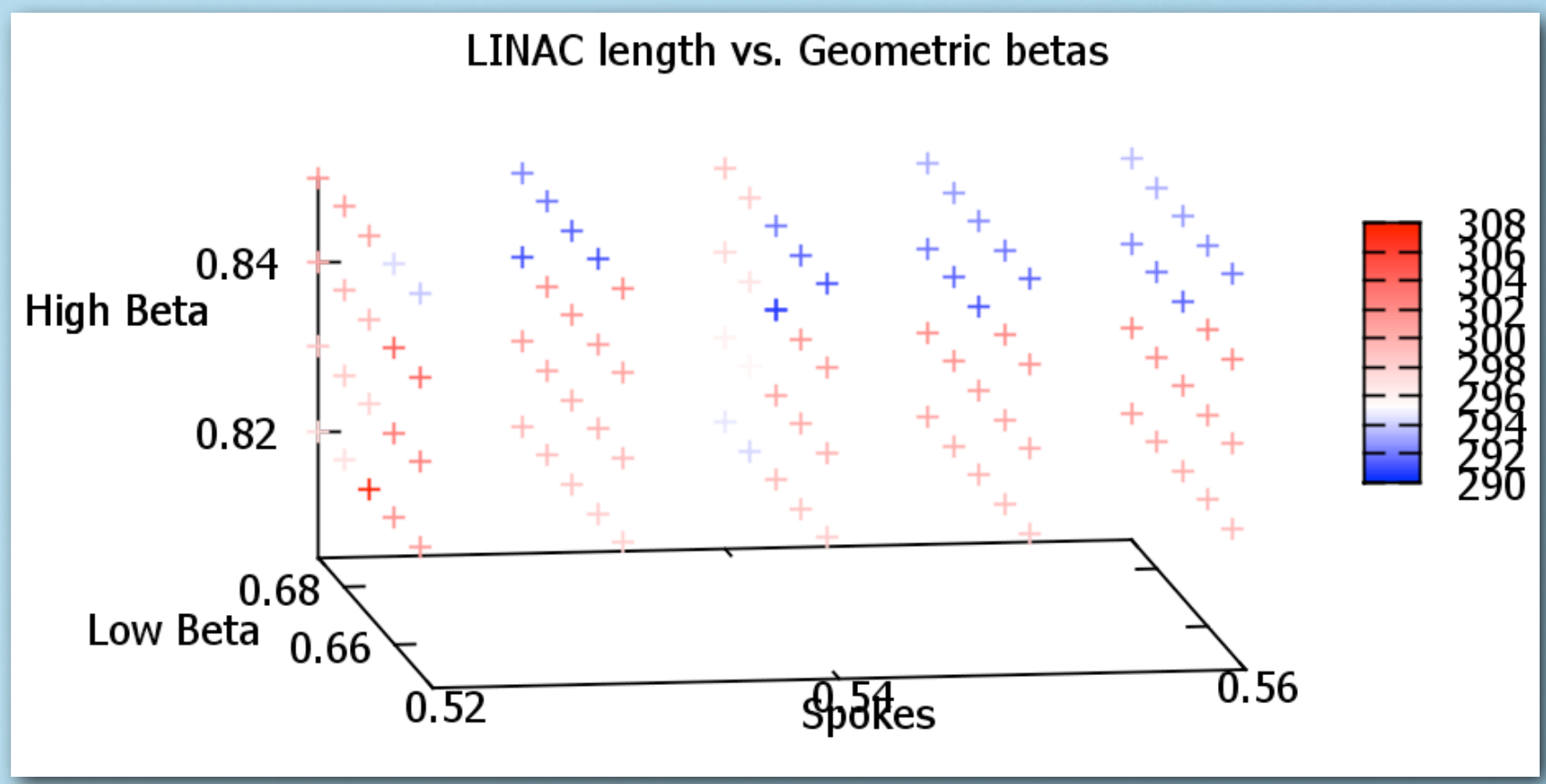


LINAC layout



	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric β	# of Sections	Temp (K)
LEBT	1.6	75×10^{-3}	--	--	--	≈ 300
RFQ	4	75×10^{-3}	352.21	--	1	≈ 300
MEBT	1	3	352.21	--	--	≈ 300
DTL	19	3	352.21	--	3	≈ 300
Spoke	61	50	352.21	0.54	15	≈ 2 (4?)
Low Beta	59	240	704.42	0.67	10	≈ 2
High Beta	169	590	704.42	0.84	14	≈ 2
HEBT	100	2500	--	--	--	--

Optimization



The same optimization has been done on all the other parameters of the LINAC.

Beam dynamics

- In the design of the LINAC special care has been taken to avoid emittance increase, halo production and loss of particles, by respecting the key criteria:

1: When the space charge is not negligible, i.e. $\sigma/\sigma_0 < 1$, zero current phase advance per period, σ_0, should be smaller than 90^o. This limit is as low as 60 degrees to avoid sextupule envelope resonance

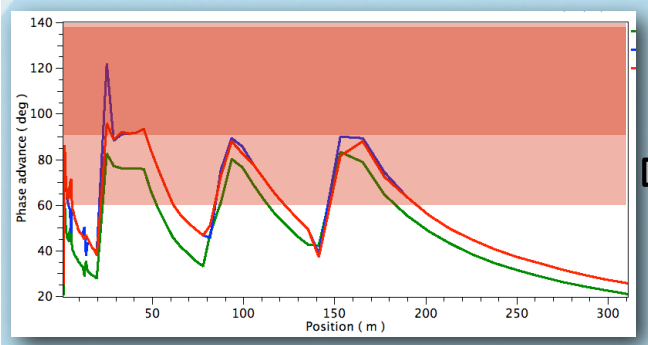
2: Special care has to be taken to avoid the space charge resonances.

3: The average external force on the beam, $(\sigma_0/L_p)^2$, has to be smooth and continuous.

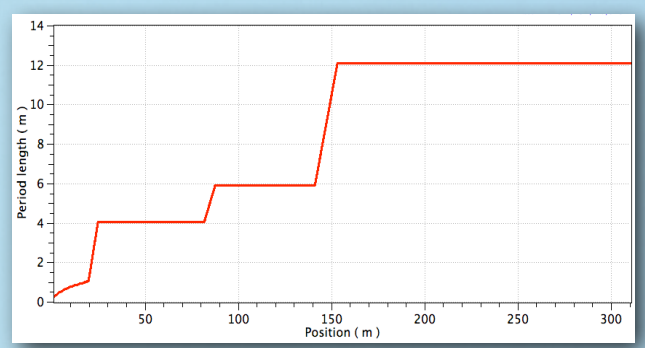
Implementation!

... of these criteria

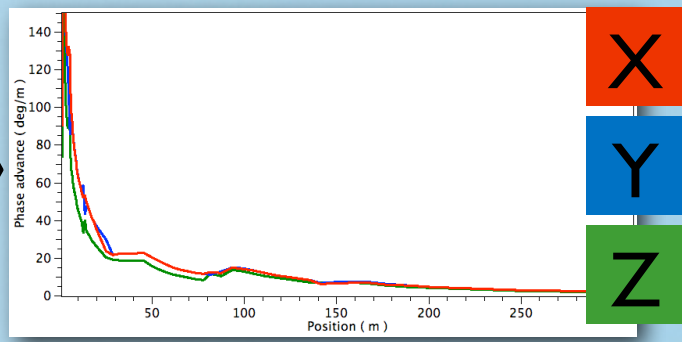
Phase Adv. (Deg)

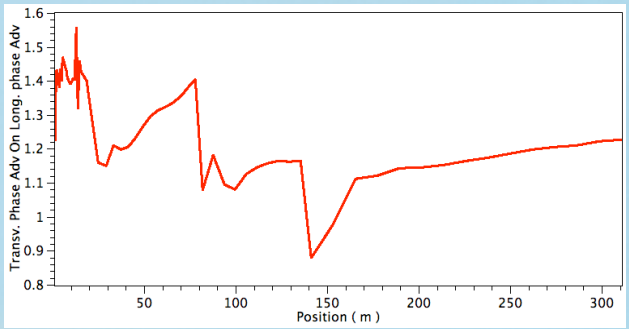


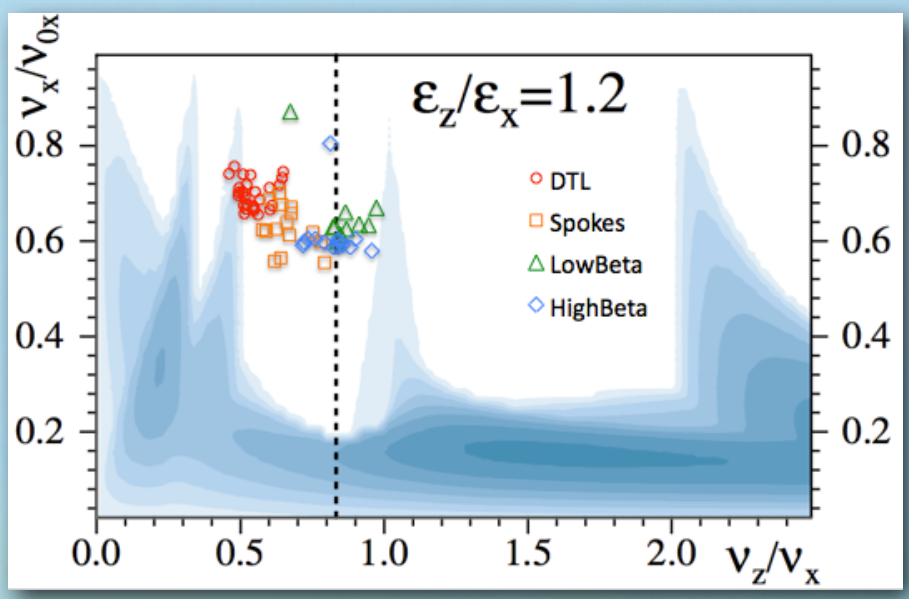
L. period (m)



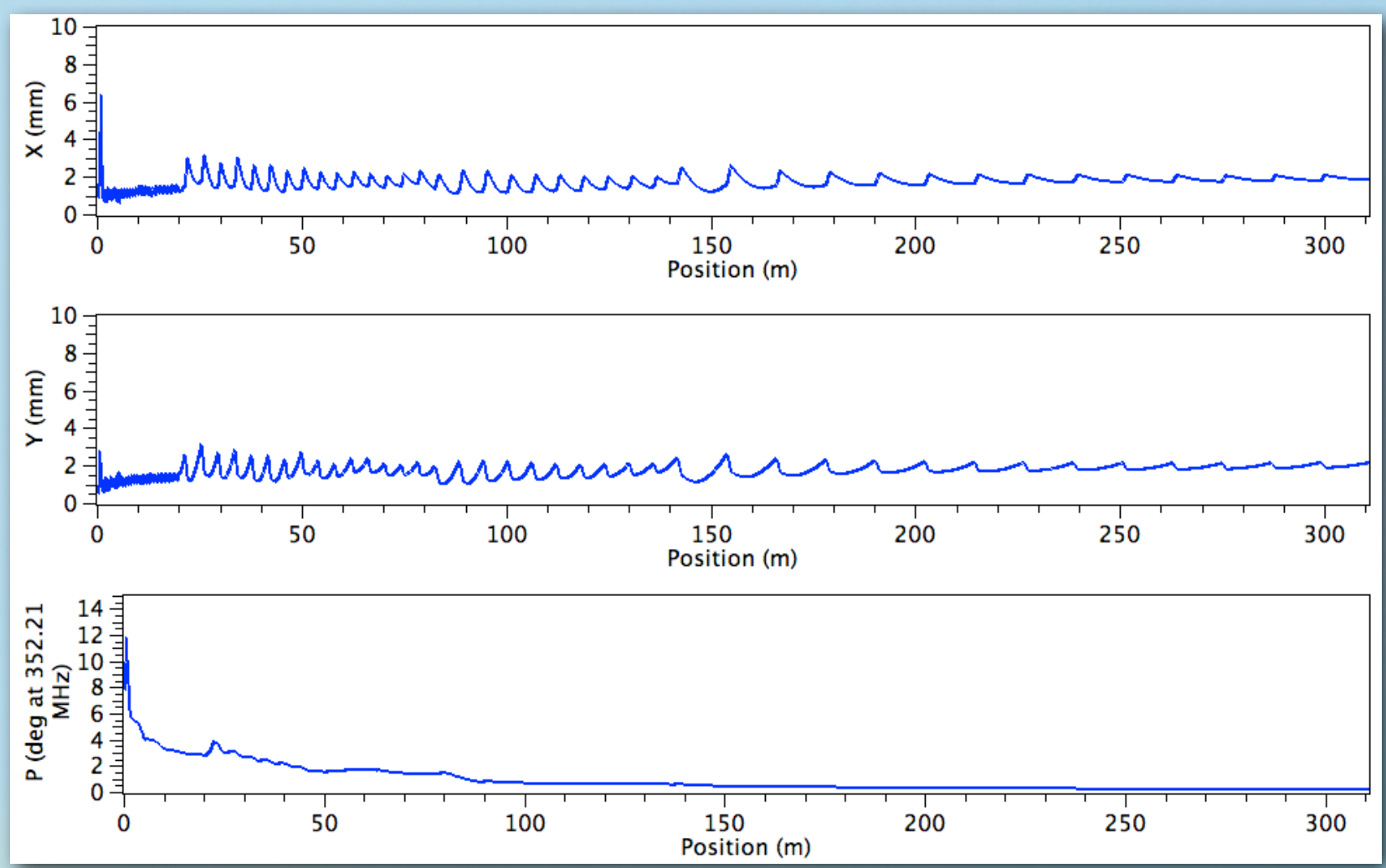
Phase Adv/m (deg/m)



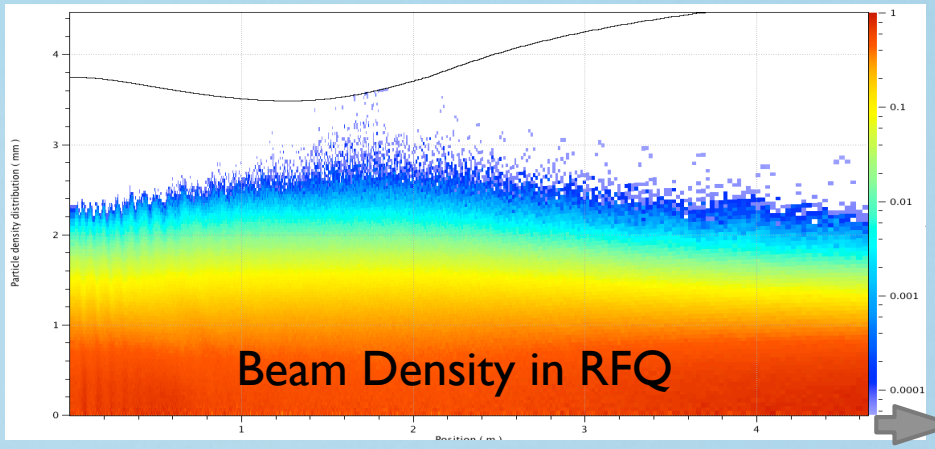




Envelopes



Density



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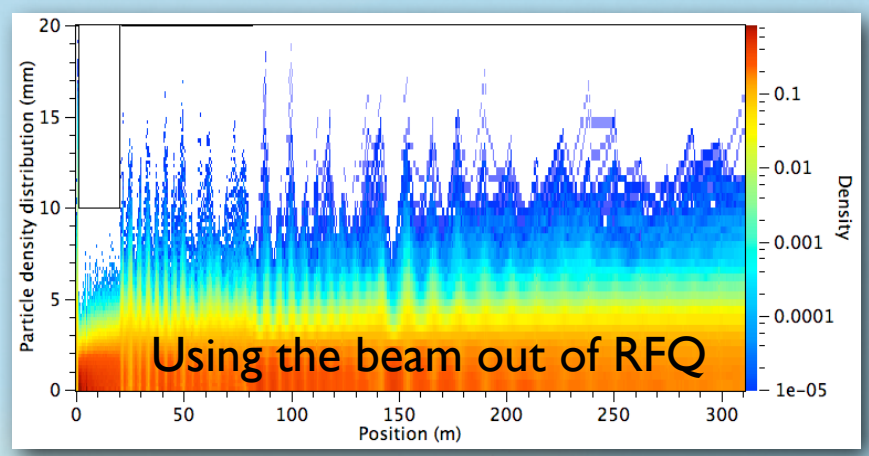
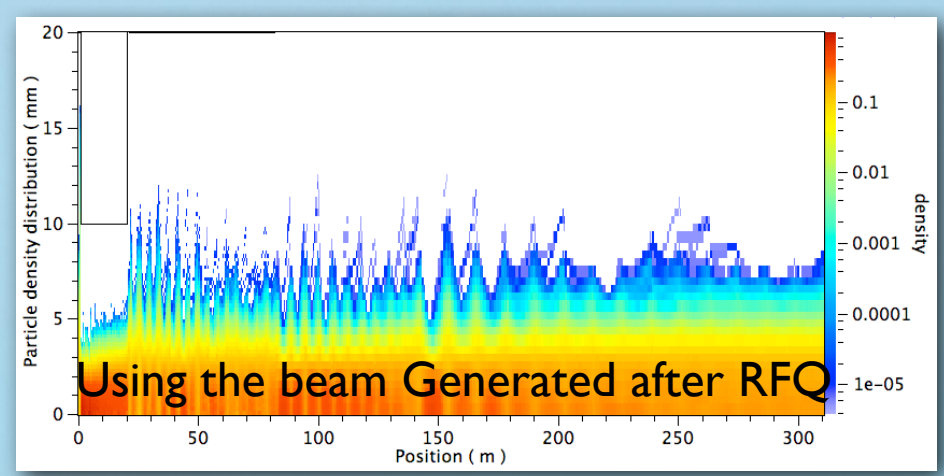
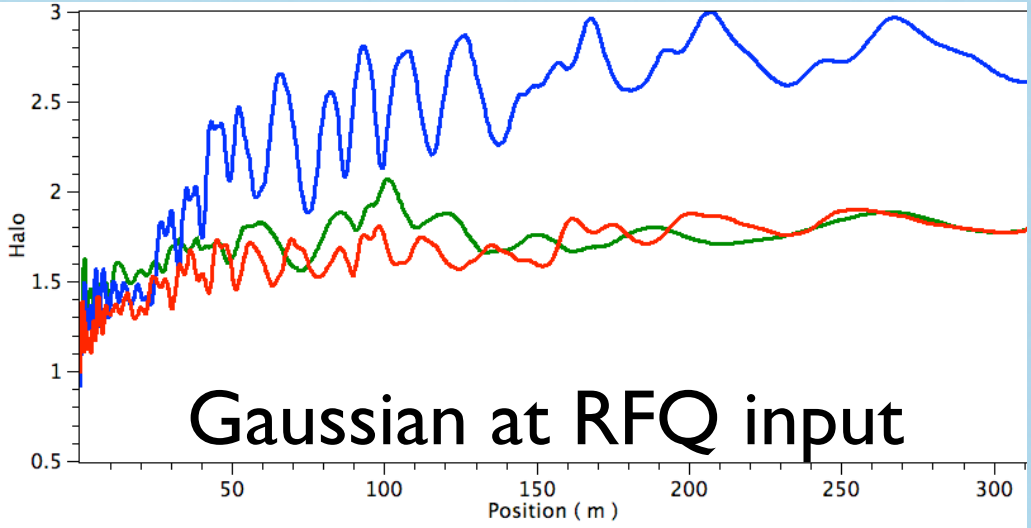
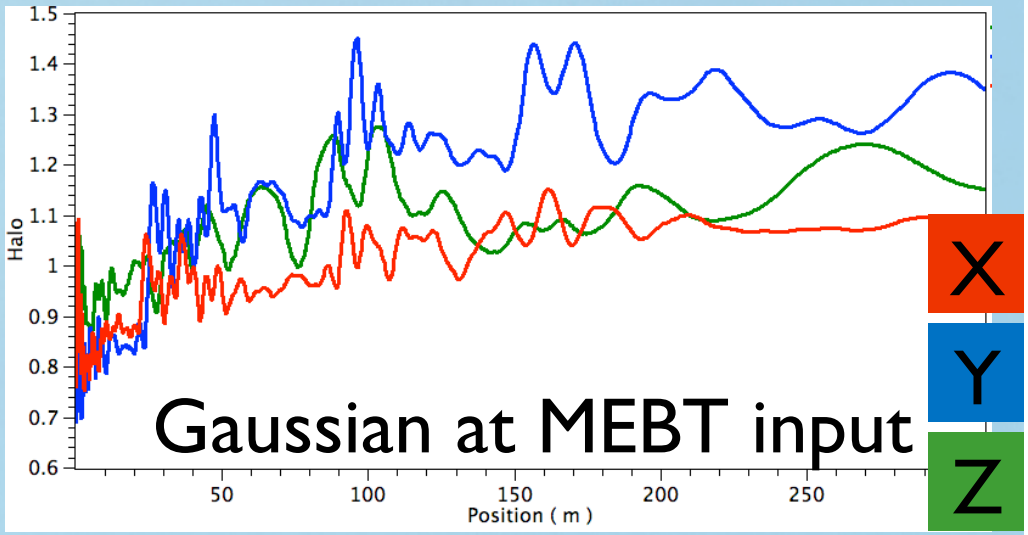




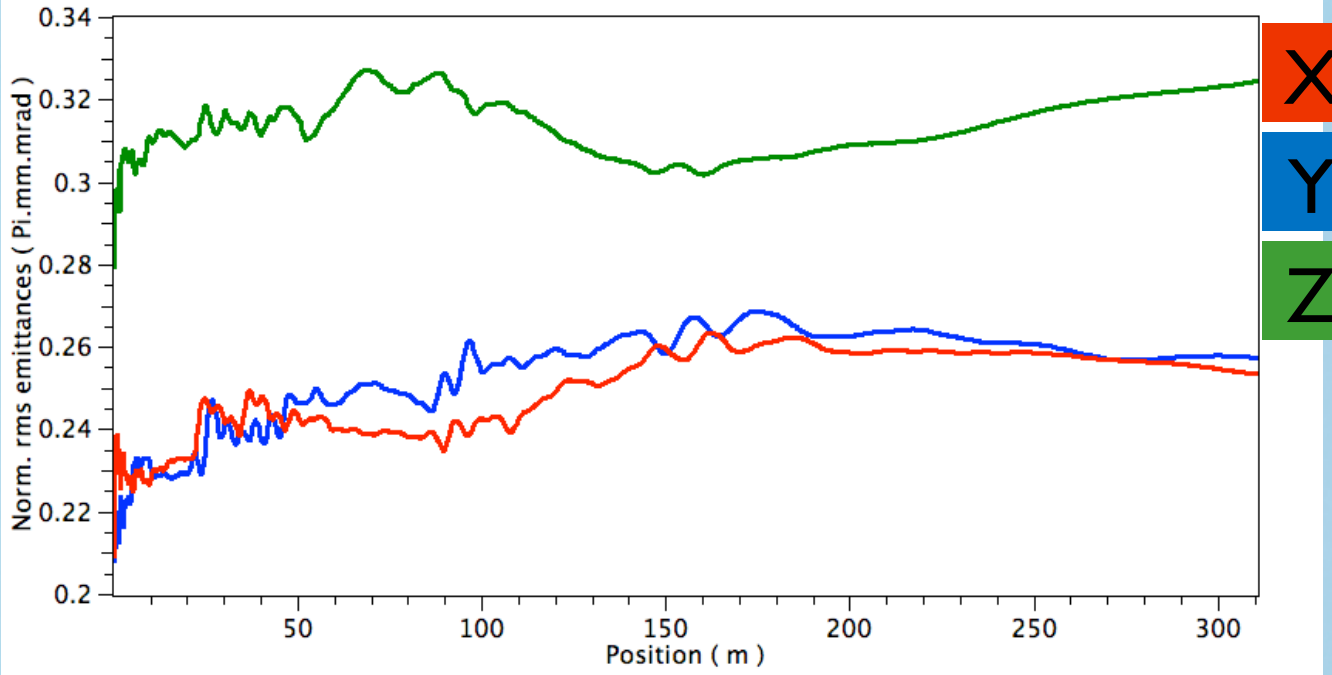
Halo Parameter





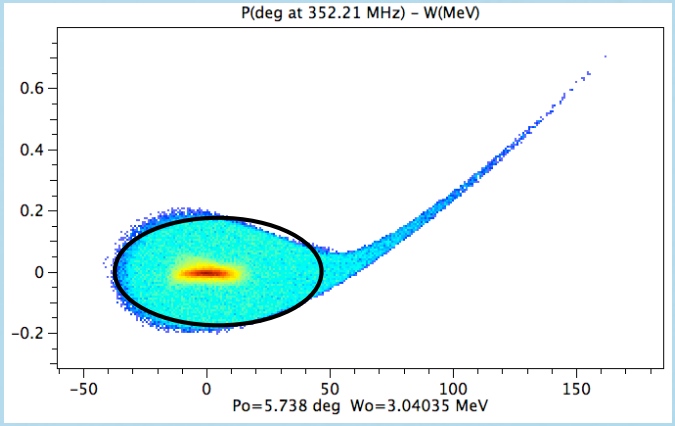
Note the different scale

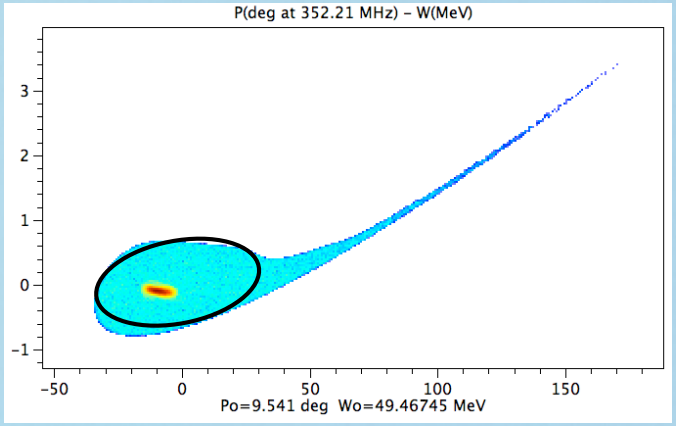
Emittances

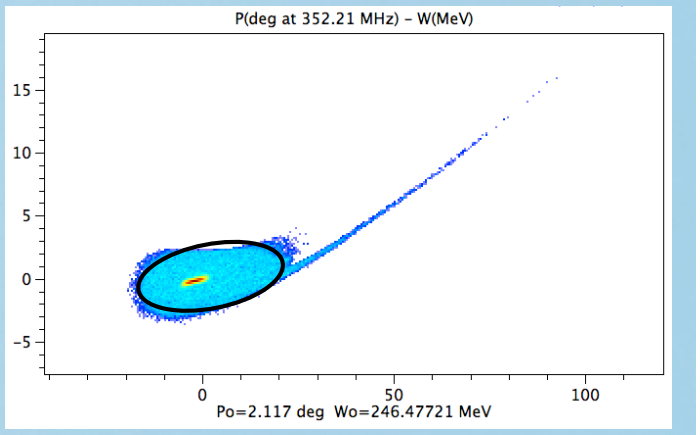


	$\Delta\varepsilon_x$ %	$\Delta\varepsilon_y$ %	$\Delta\varepsilon_z$ %	ε_x π mm.mrad	ε_y π mm.mrad	ε_z π mm.mrad
RFQ	3.1	2.3	--	0.206	0.205	0.274
MEBT	18.5	5.2	0.3	0.243	0.215	0.275
DTL	-1.7	7.3	14.3	0.240	0.230	0.314
Spokes	2.3	12.3	5.7	0.244	0.254	0.330
Low β	7.7	8.9	-8.4	0.260	0.272	0.307
High β	-1.2	-2.1	7.5	0.257	0.268	0.328
Total	28.7	33.9	19.4	--	--	--

Acceptance Longitudinal







Note the different scale

	DTL			Superconductors			Ellipticals		
	A π.mm.mrad	ε π.mm.mrad	Ratio	A π.mm.mrad	ε π.mm.mrad	Ratio	A π.mm.mrad	ε π.mm.mrad	Ratio
RMS	6.4203	0.1116	57.52957	20.1484	0.1215	165.8305	42.53	0.1308	325.1529
TOT	6.4203	0.4095	15.67839	20.1484	0.4292	46.94408	42.53	0.4577	92.92113

Summary

* The ESS LINAC accelerates 50 mA of protons to 2.5 GeV in a sequence of normal conducting and superconducting structures.

* The LINAC is designed and optimized for the best performance, as well as the shortest possible.

* Beam dynamics simulations show no degradation of beam quality.

Thank you for your attention!