RFQ input-output beam parameters

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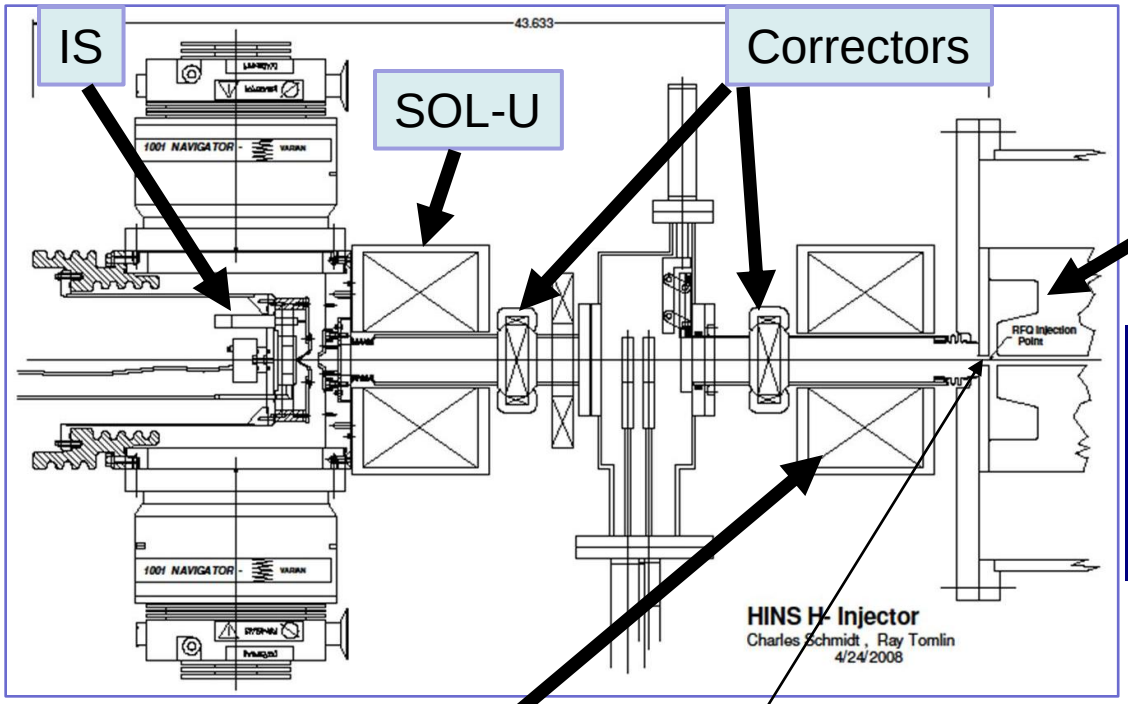
Outlook

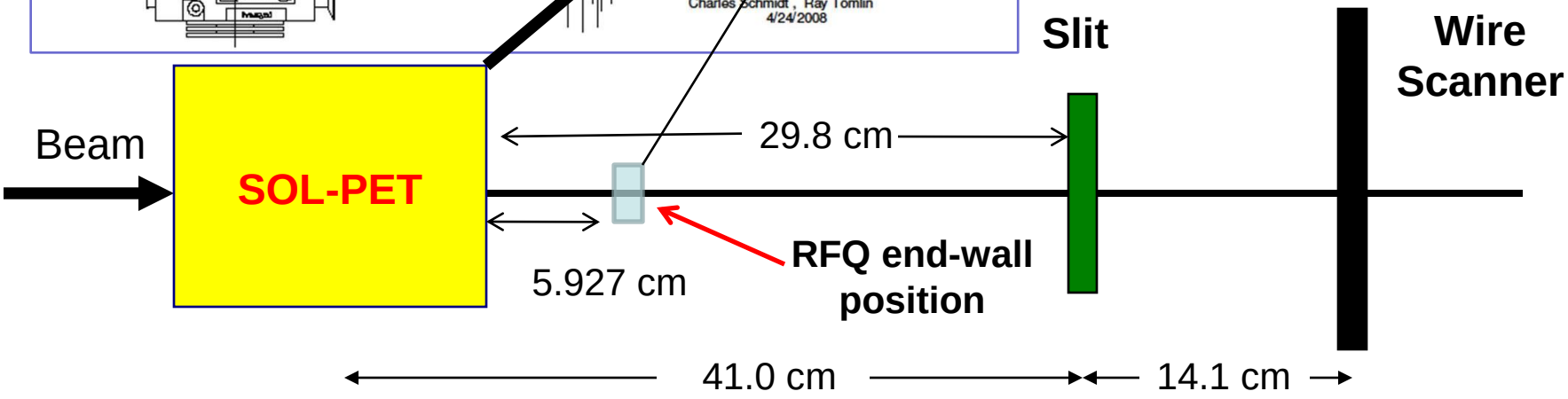
- Consideration of beam parameters before RFQ.
- Beam simulations in RFQ.
- Consideration of beam parameters after RFQ.

Beam measurements are done by Vic Scarpine, Salah Chaurize, Wai-Ming Tam, Bruce Hanna. Most of the data on IS is accumulated in Wai-Ming's thesis.

Slit – Wire Scanner Assembly

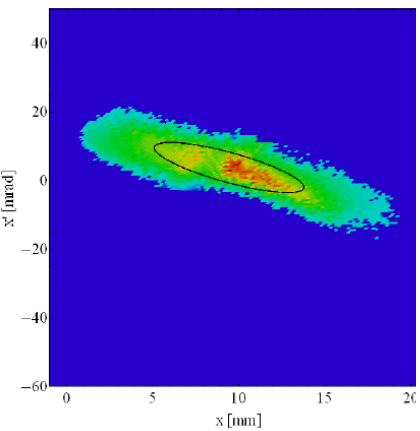


A slit assembly was installed for direct emittance measure-ments while RFQ was removed.

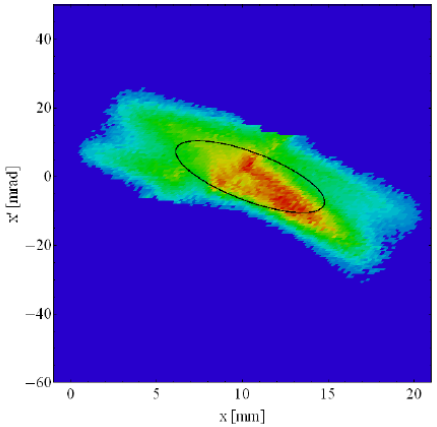


Phase space plots and rms ellipses in the slit scanner plane

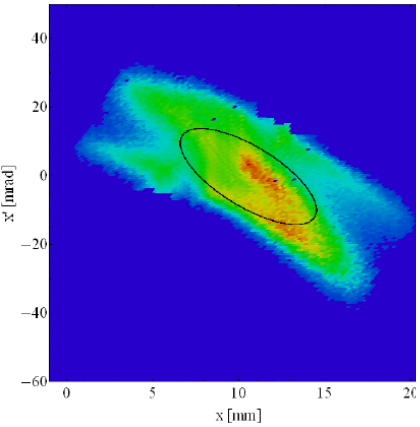
Horizontal



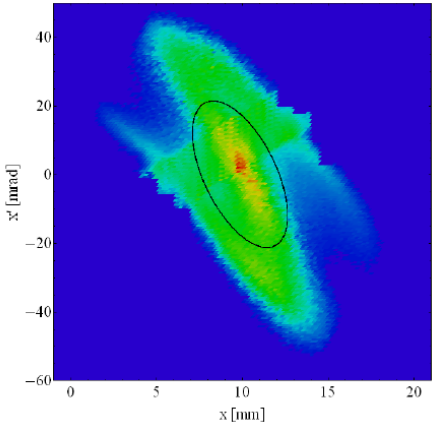
(a) A beam current of 4 mA.



(b) A beam current of 8 mA.

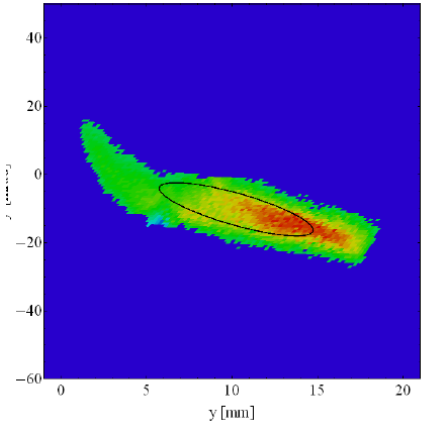


(c) A beam current of 12 mA.

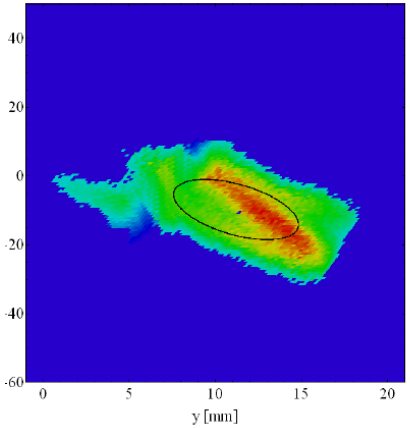


(d) A beam current of 16 mA.

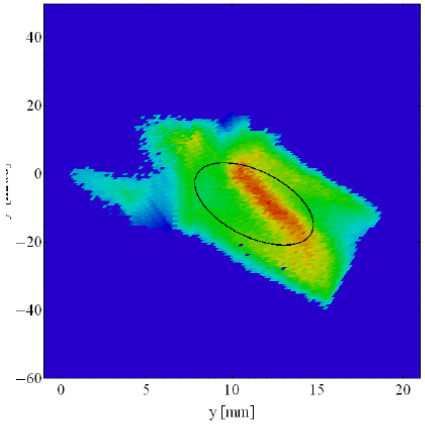
Vertical



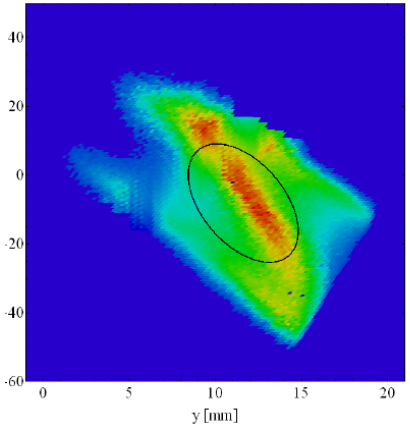
(a) A beam current of 4 mA.



(b) A beam current of 8 mA.



(c) A beam current of 12 mA.

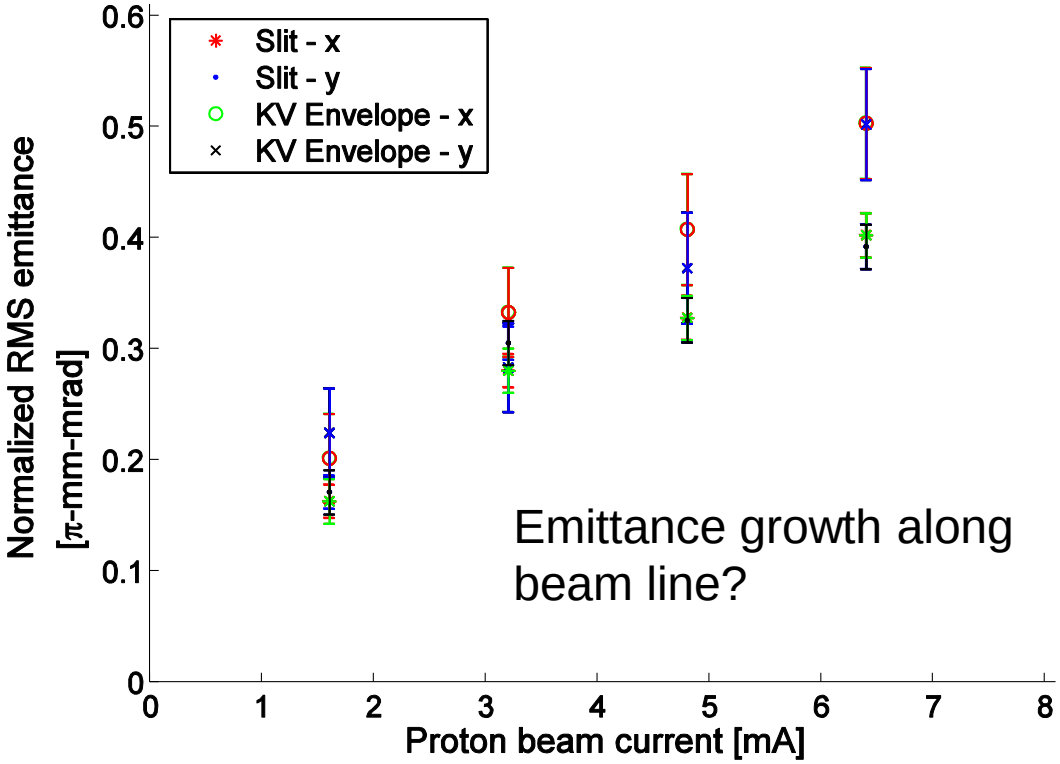


(d) A beam current of 16 mA.

Emittance versus Beam Current

Wai-Ming Tam

$I_{proton} \sim I_{total} \times 40\%$

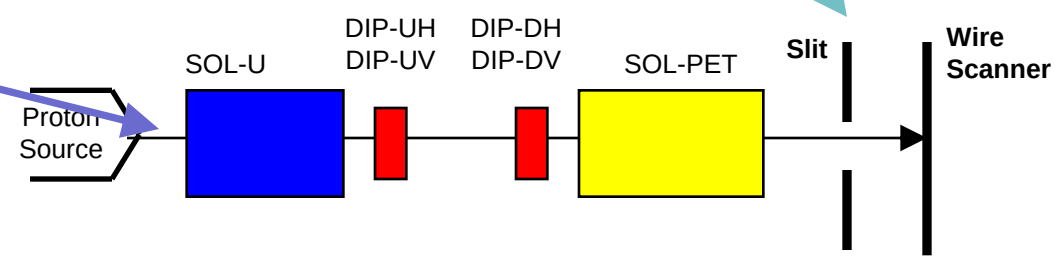


Emittance growth along beam line?

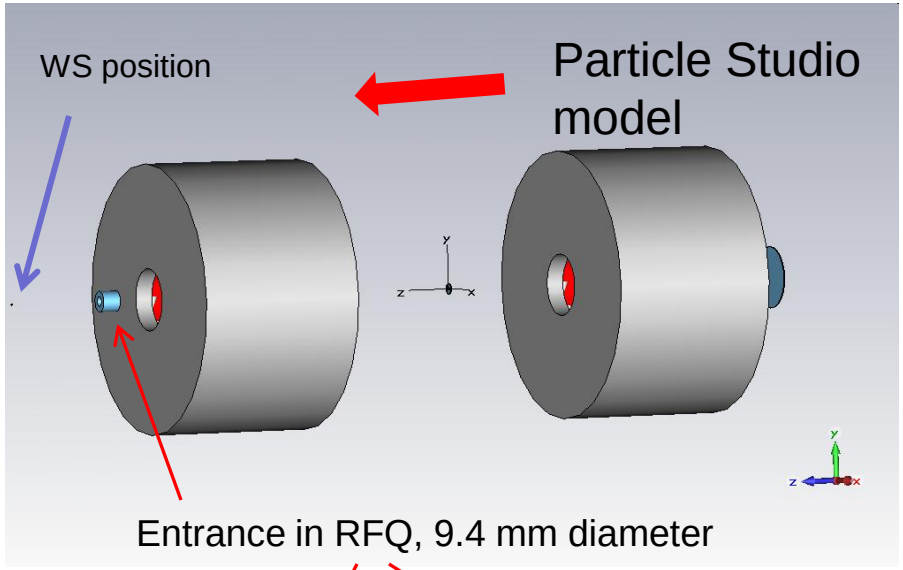
"Slit-WS" measurement defines emittance here

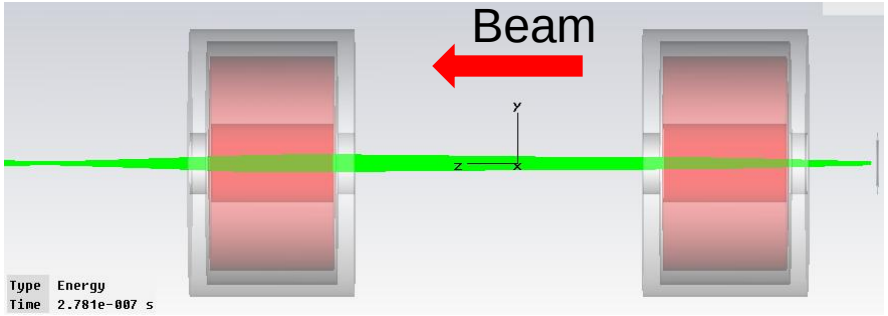
$$\epsilon_{x,rms} = \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle x x' \rangle^2}$$

"KV-WS" measurement defines emittance here

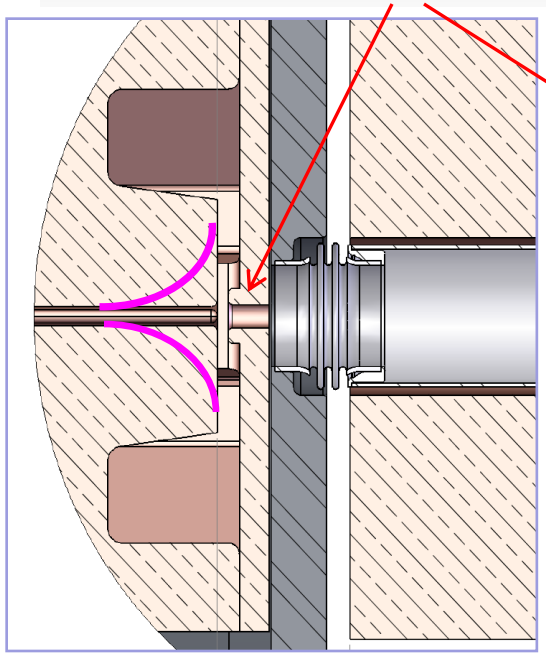


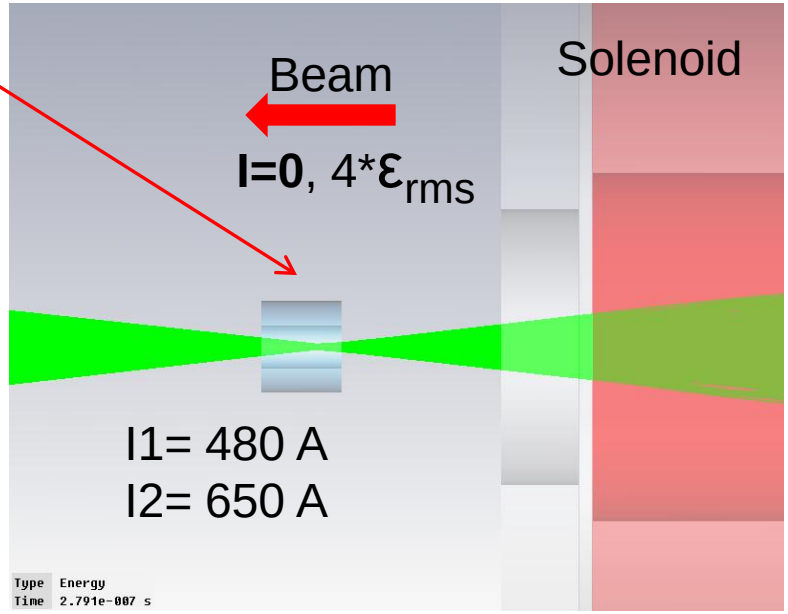
Entrance of RFQ





Normalized rms emittance 0.34 π mm mrad based on measurements from February 20, 2009





No more simulations since then.

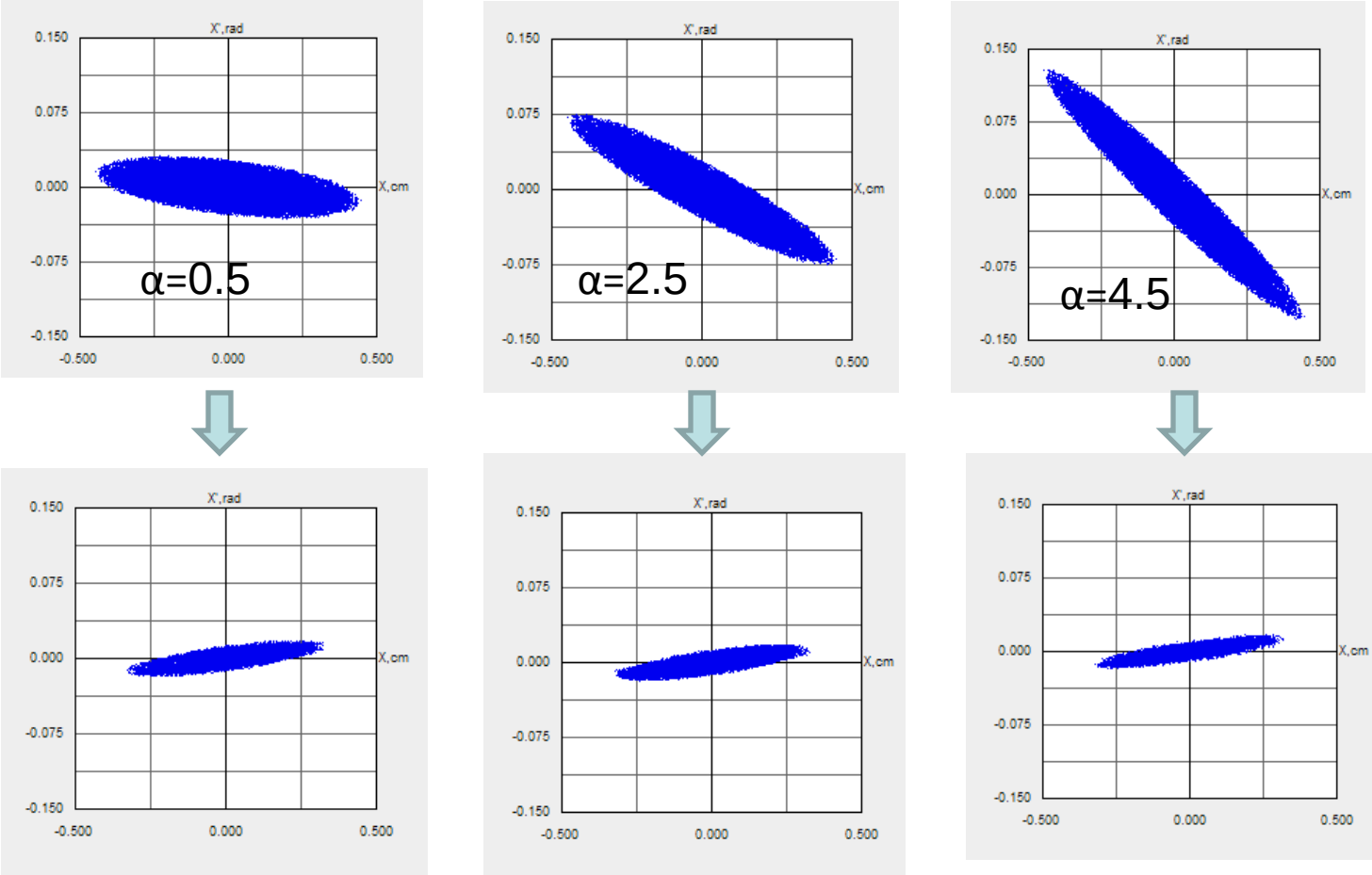
RFQ input beam parameters.

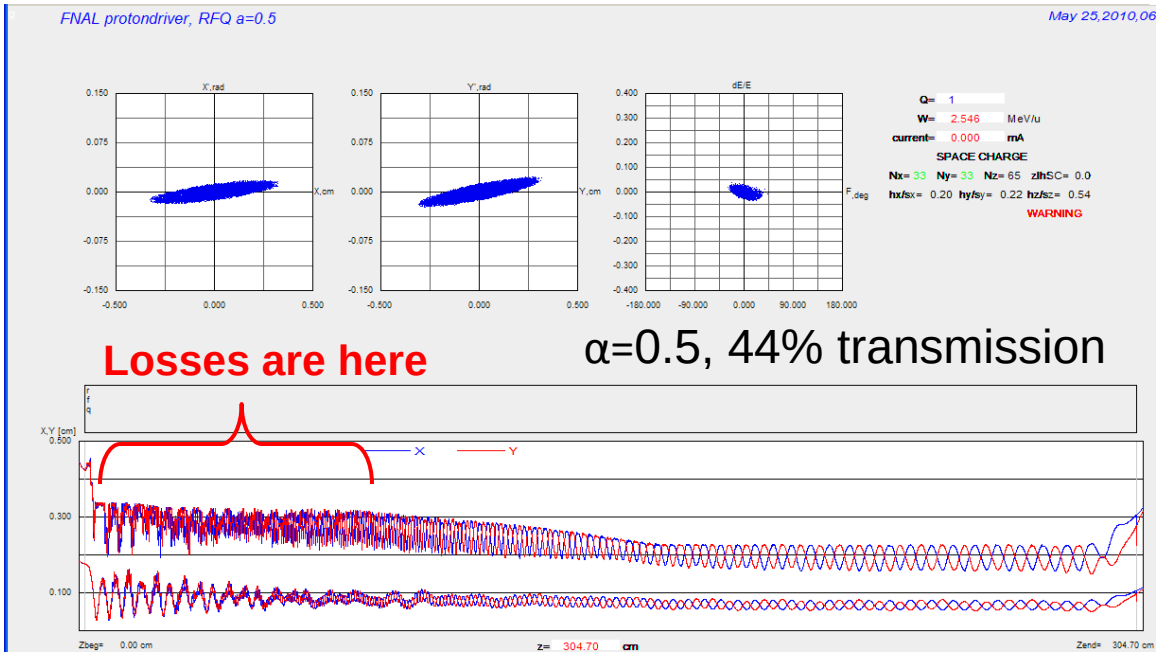
How do they affect RFQ output beam parameters?

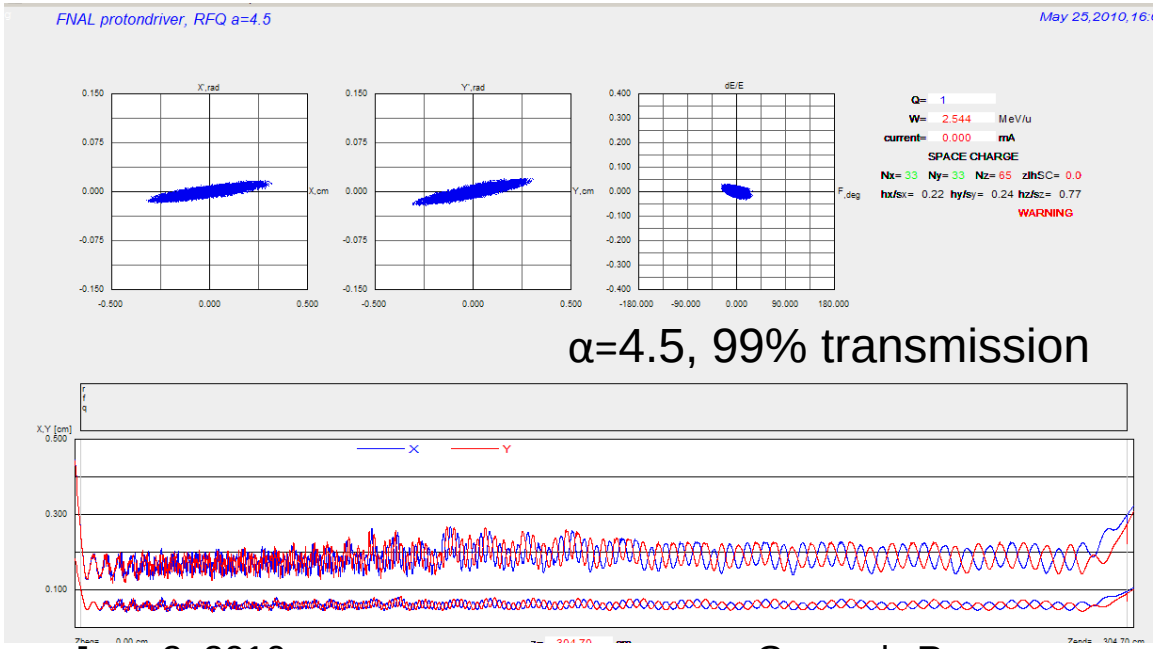
Input beam parameter assumption: at the entrance of RFQ beam diameter 8 mm to get through RFQ end wall without losses; $\varepsilon_{rms\ norm}$ = 0.34 mm·mrad; variable divergence - from almost parallel to strongly focused, current = 10 mA.

Input beam

Output beam

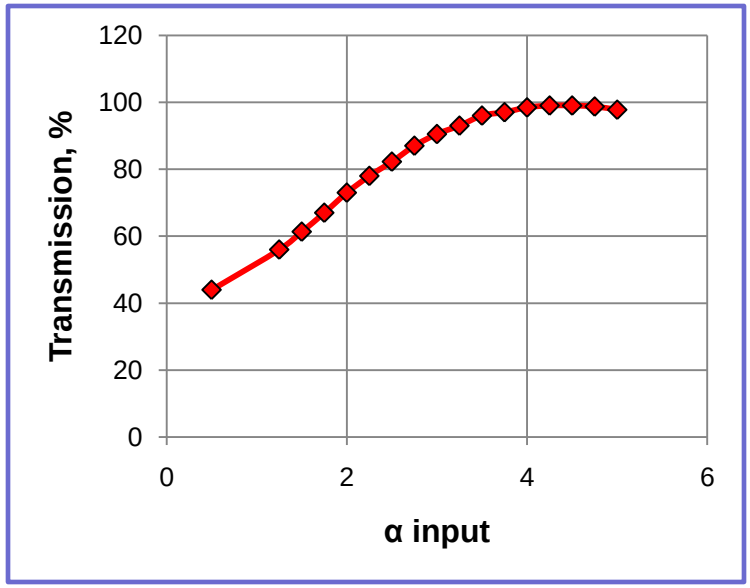


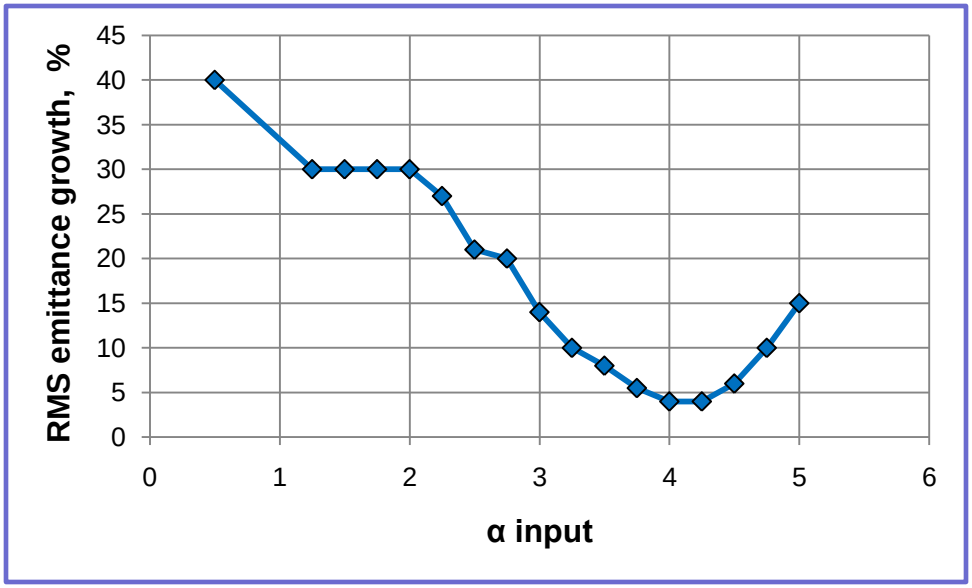


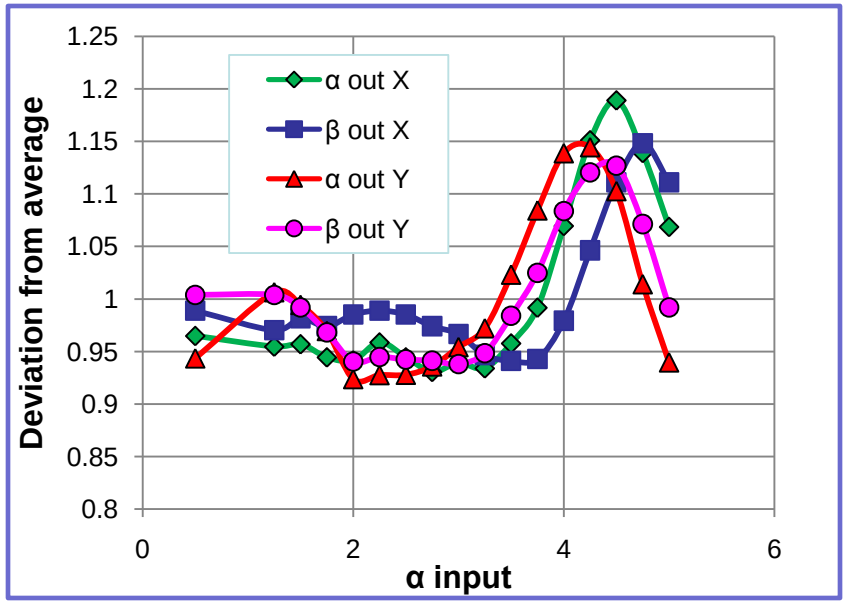


Beam matching affects transmission dramatically.

Transmision, emittance growth and Twiss parameters vs input α.



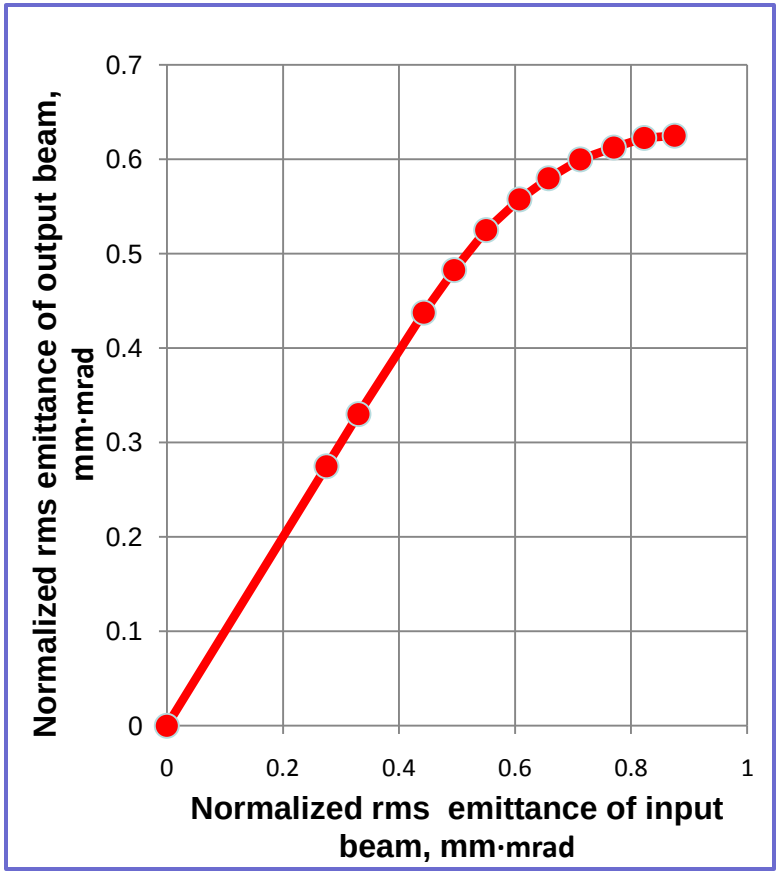


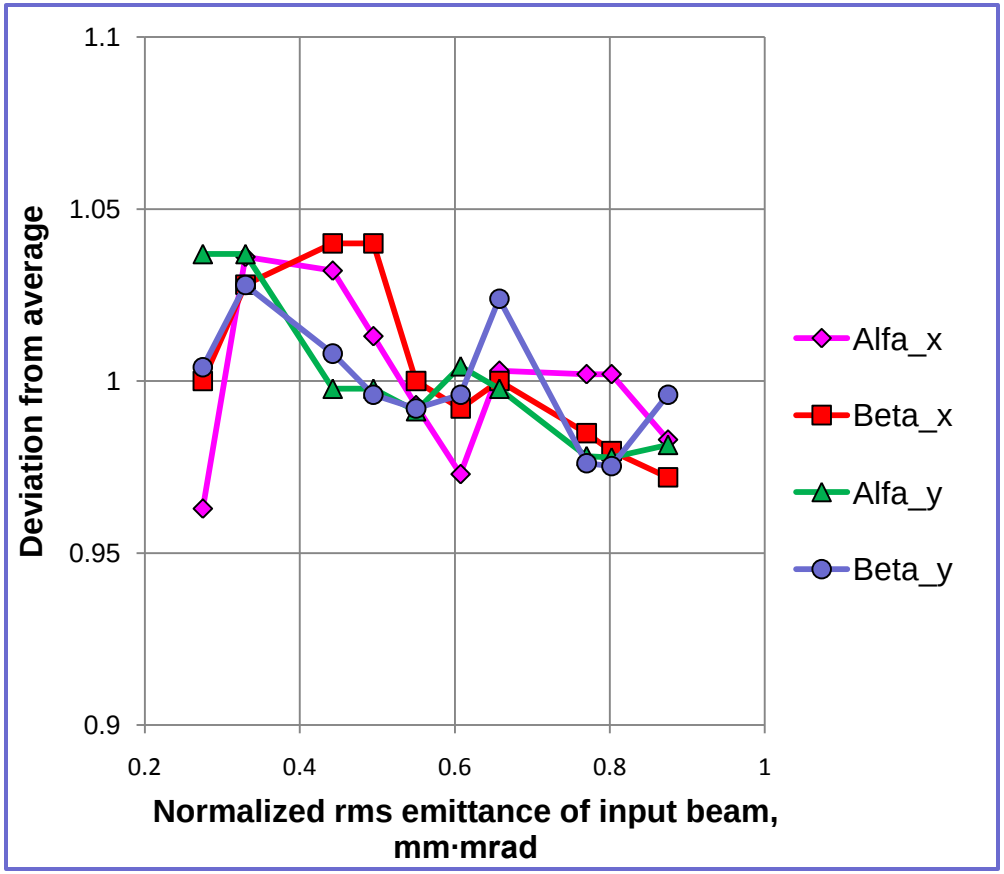


Here deviations of Twiss parameters from average are up to 20%, apparently due to Influence of losses.

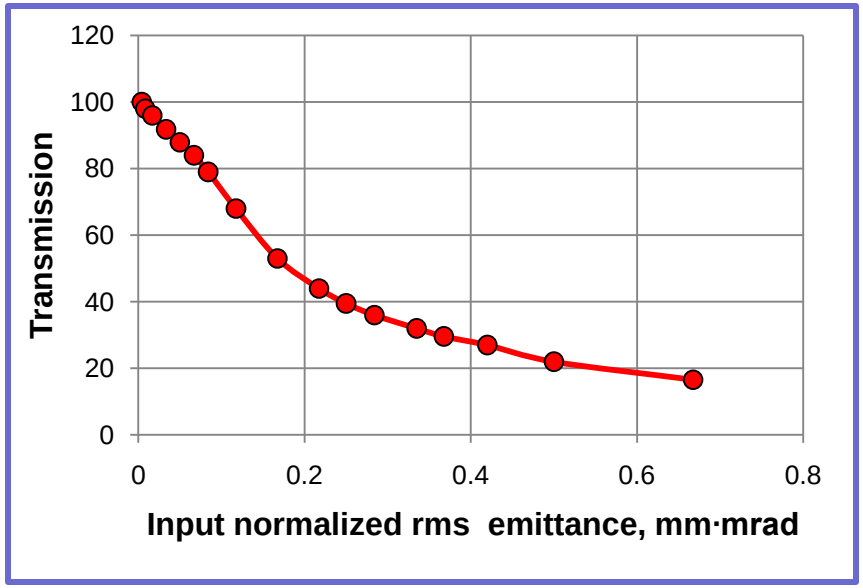
Output beam parameters vs input beam emittance.

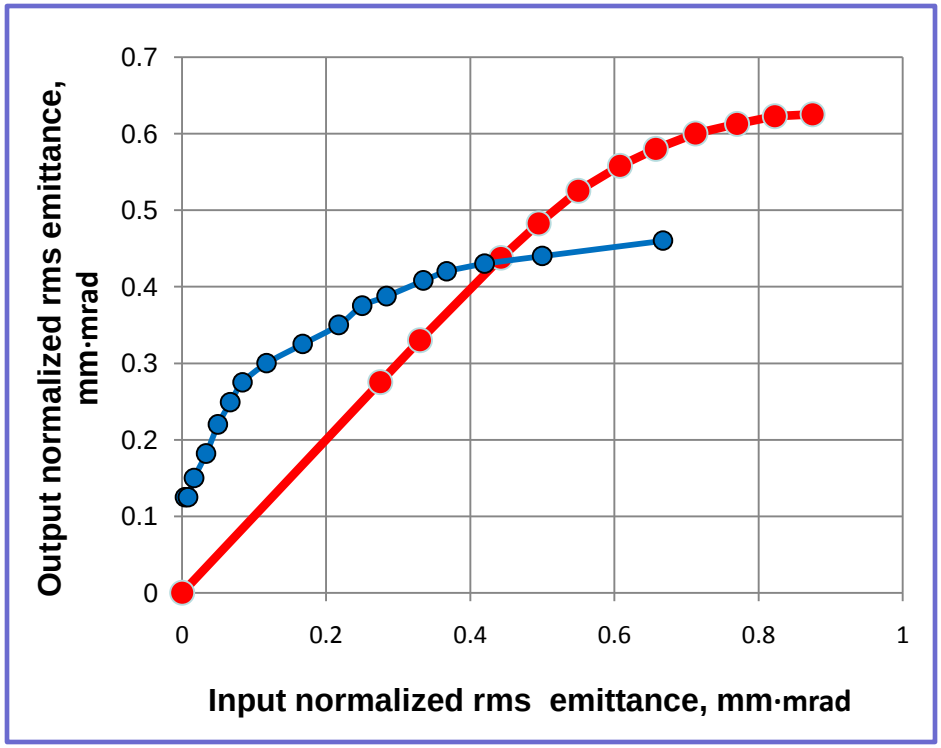
Input beam has matched Twiss parameters, but different emittances.

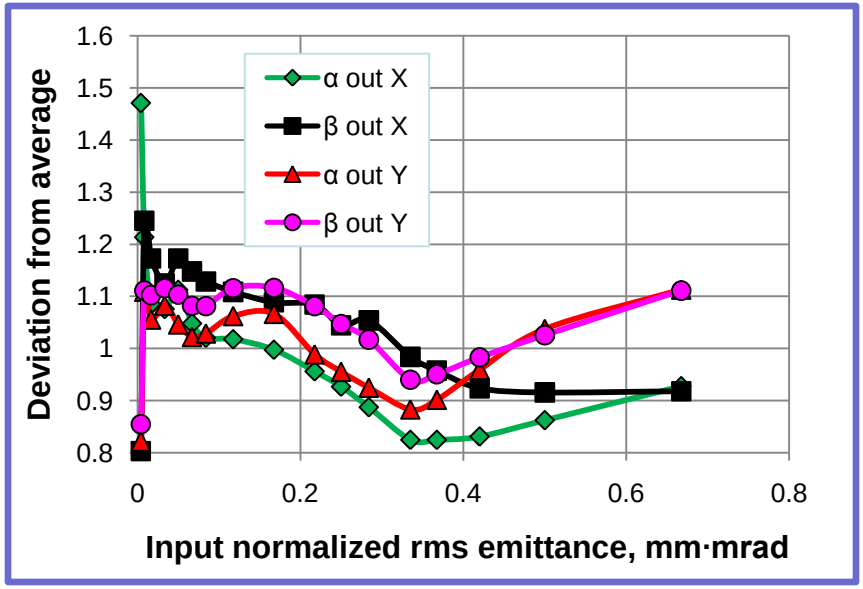


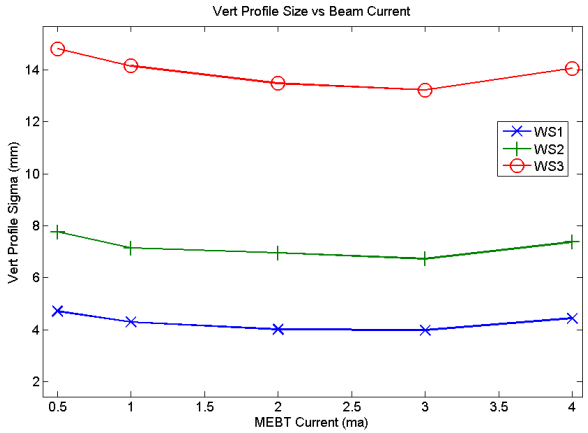


Output beam parameters with mismatched beam (α=0.5)

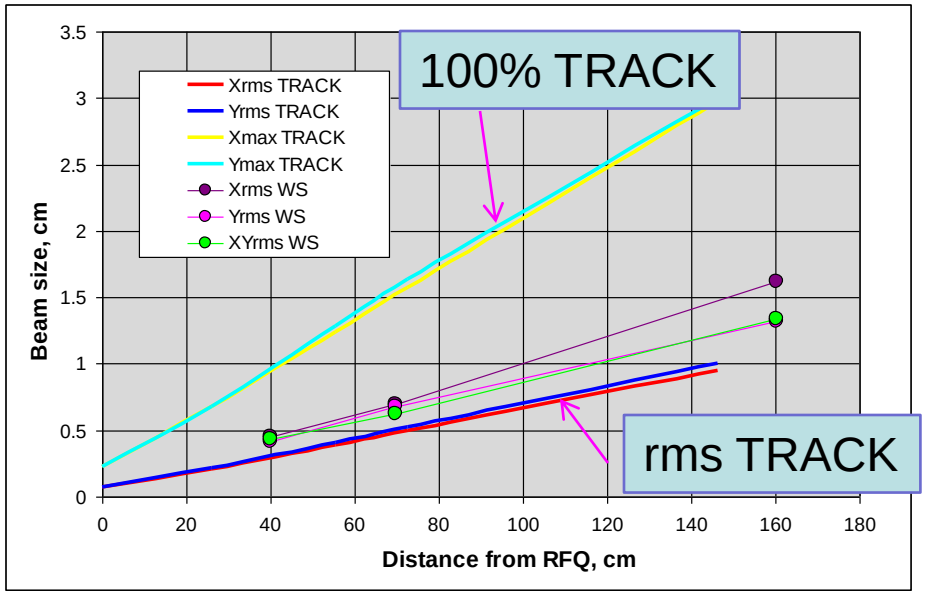






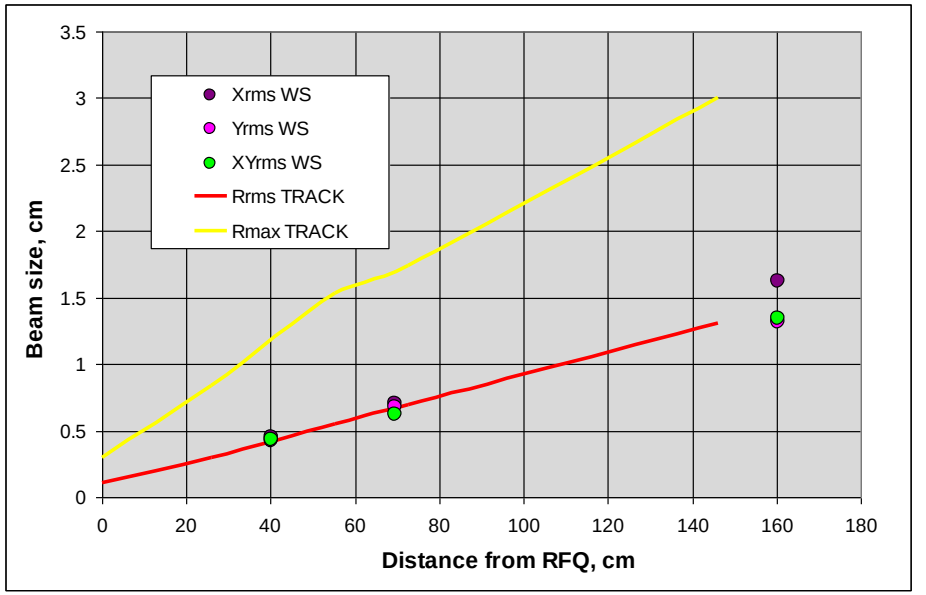


Back to WS measurements after RFQ.



Theoretically data from three WS at three positions define beam parameters in unique way. But the method is extremely inaccurate without waist (crossover) of a beam between WS.

TRACK simulation with beam normalized rms emitance from RFQ of **0.255** mm mrad (design value). Big dots – wire scanner positions and measurements.

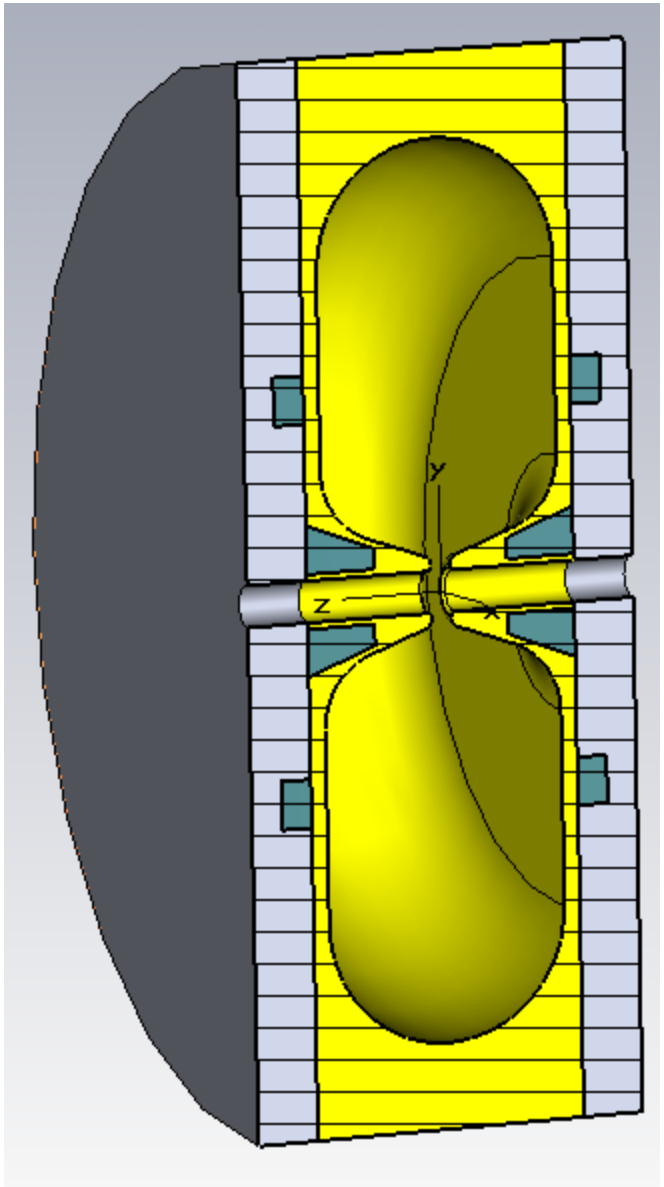


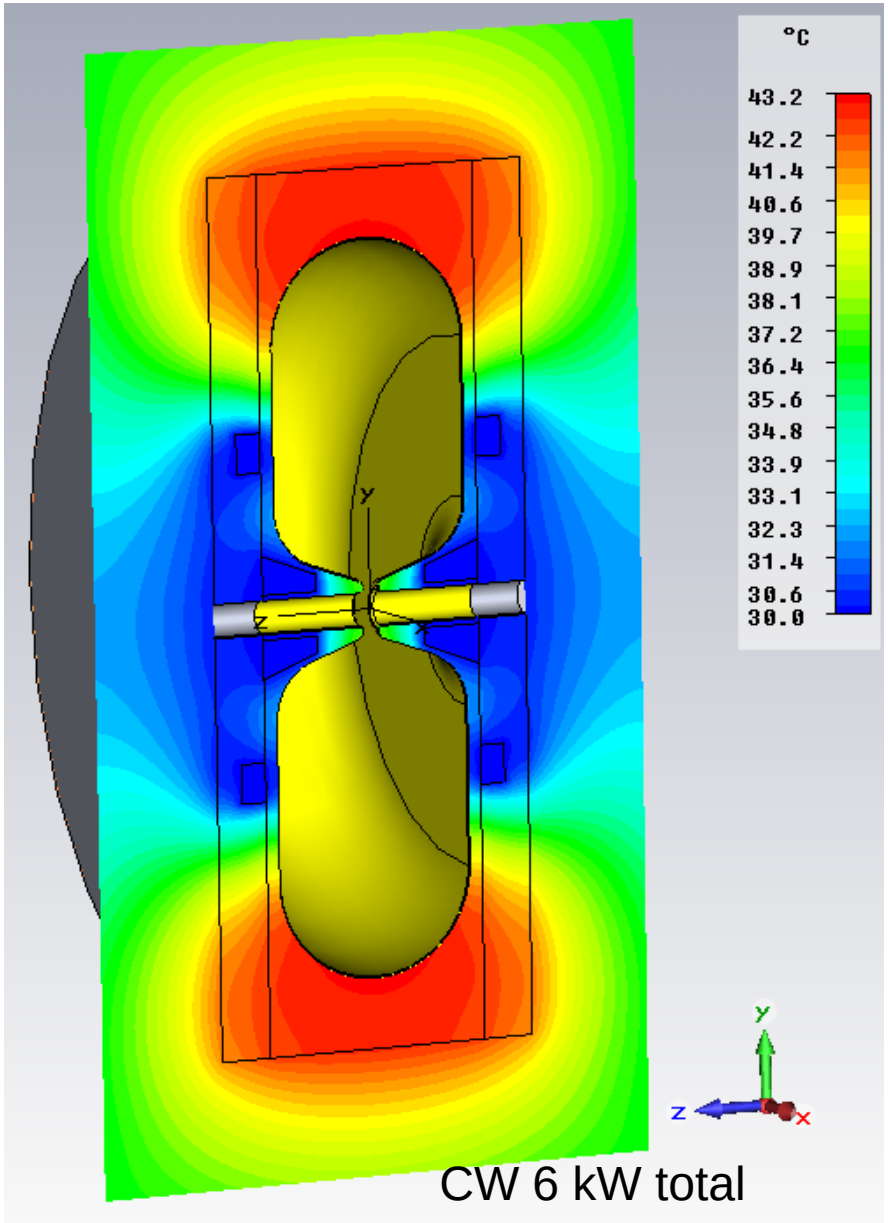
Simulation with normalized rms emittance increased up to **0.37** mm mrad. Beam phase ellipses orientation is nominal. There are 3% losses in the beam pipe of 1.74 mm radius.

Kinda conclusion.

- After RFQ we have bigger emittance then we would like to.
- Two factors can increase output emittance – bigger input emittance and mismatching (small beam current is assumed).
- Apparently we have a bigger emittance because of a combination of the two (and may be misalignment).
- Manipulations with input beam parameters don't change output Twiss parameters much, so they can be considered more or less fixed for given RFQ's operating mode.
- We can (and we should) make better matching. But if we want to work with higher current, we would still have a bigger emittance because of the IS.

Cooling_v_1, 5/25/2010





CW 6 kW total