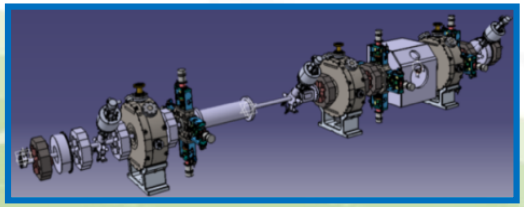
Advances in the development of the ESS-Bilbao proton injector

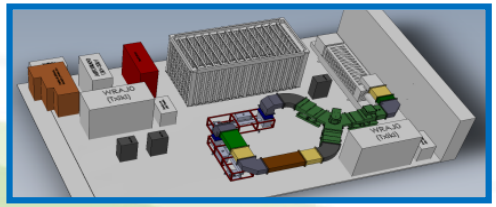
Z. Izaola, I. Bustinduy, et. al.
ESS-Bilbao
July 5, 2016

What is ESS-Bilbao?

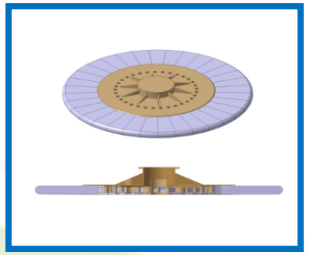
1. MEBT

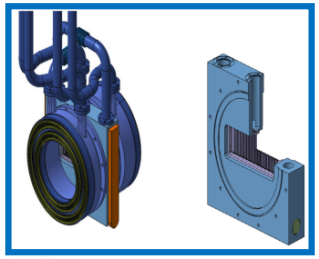


2. RF Chain



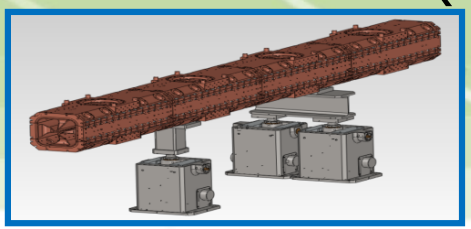
3. Target



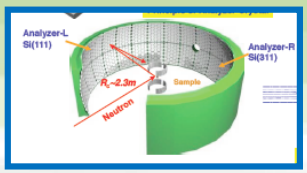


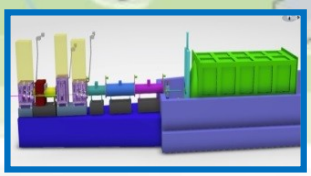
EUROPEAN SPALLATION SOURCE

ESS-Bilbao's RFQ

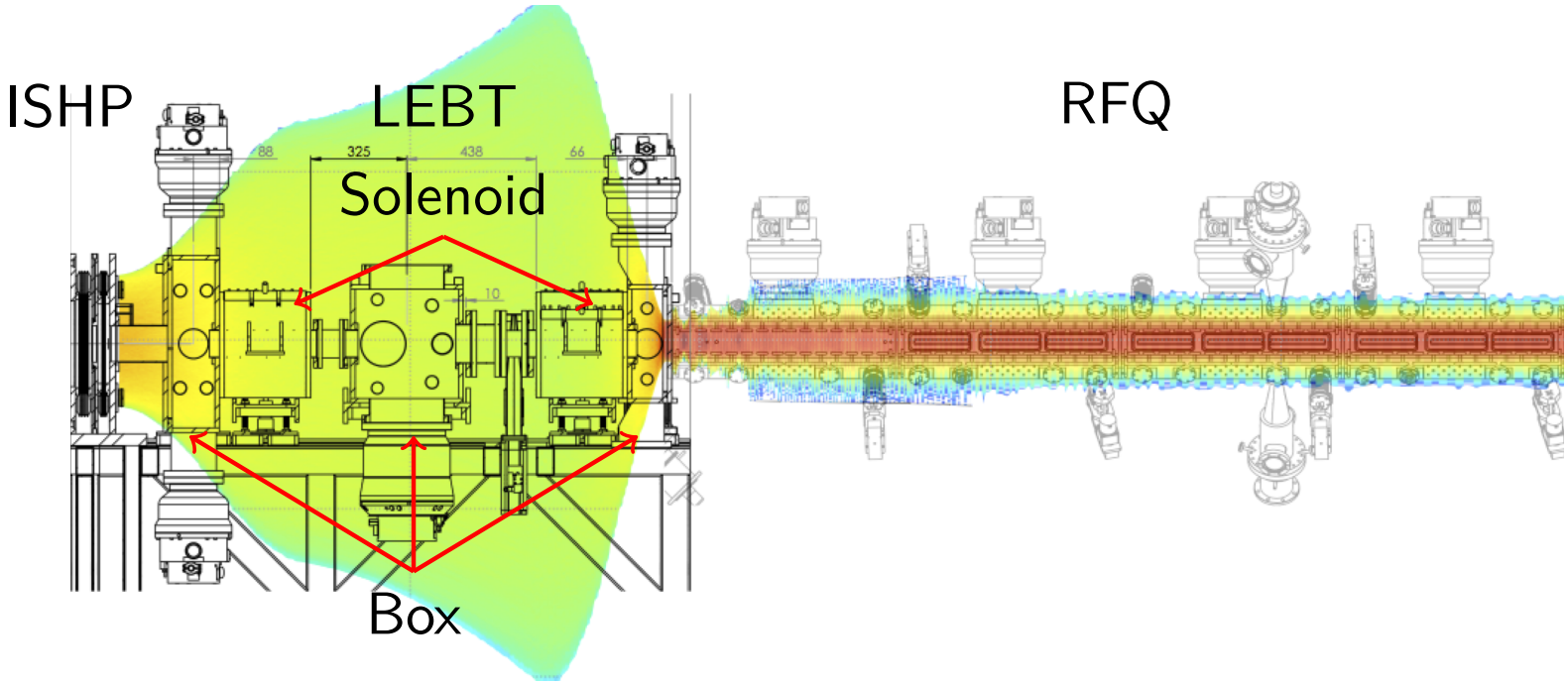


4. Neutron Instruments

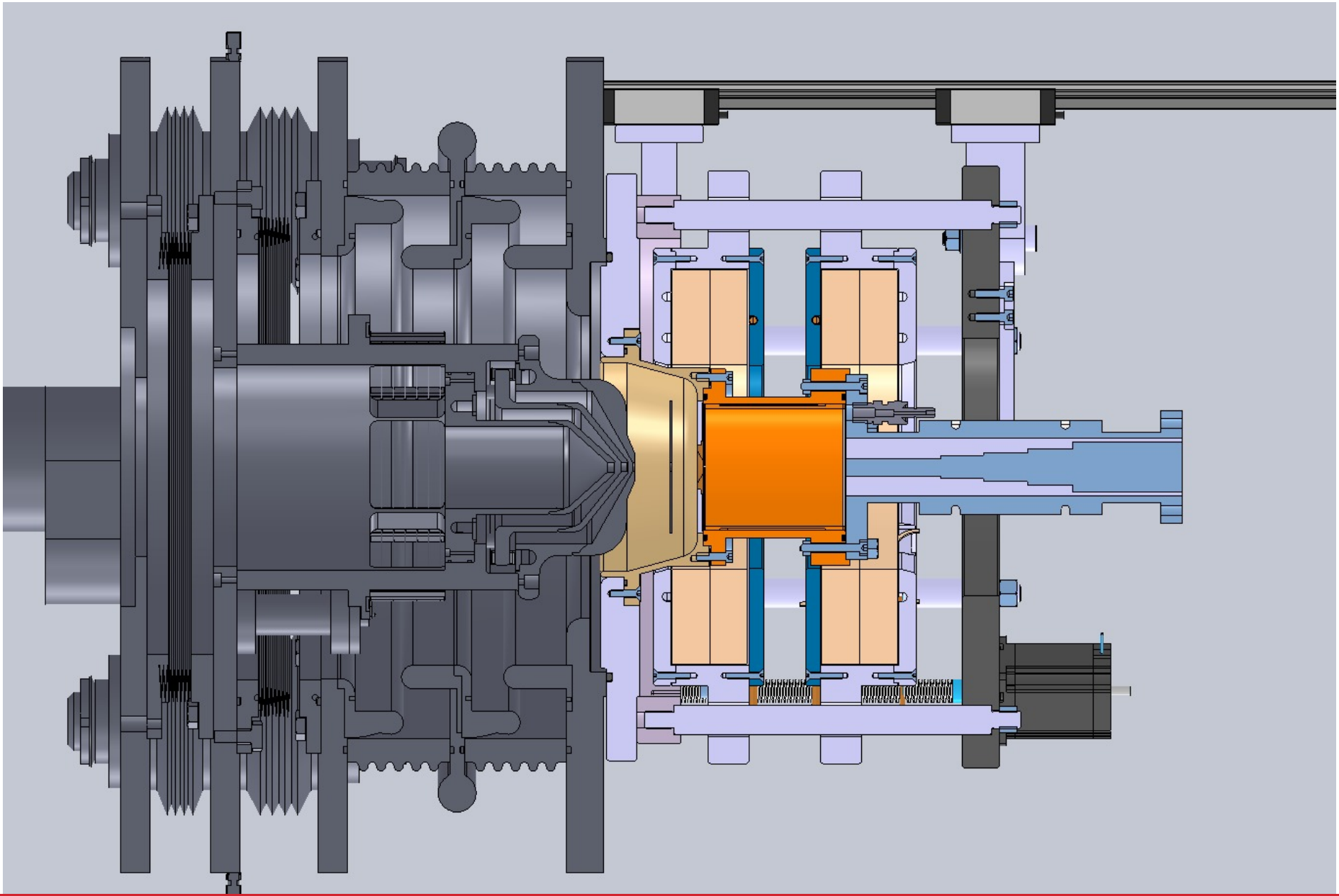




The ESS-Bilbao Injector



The ISHP H^+ ECR Ion Source



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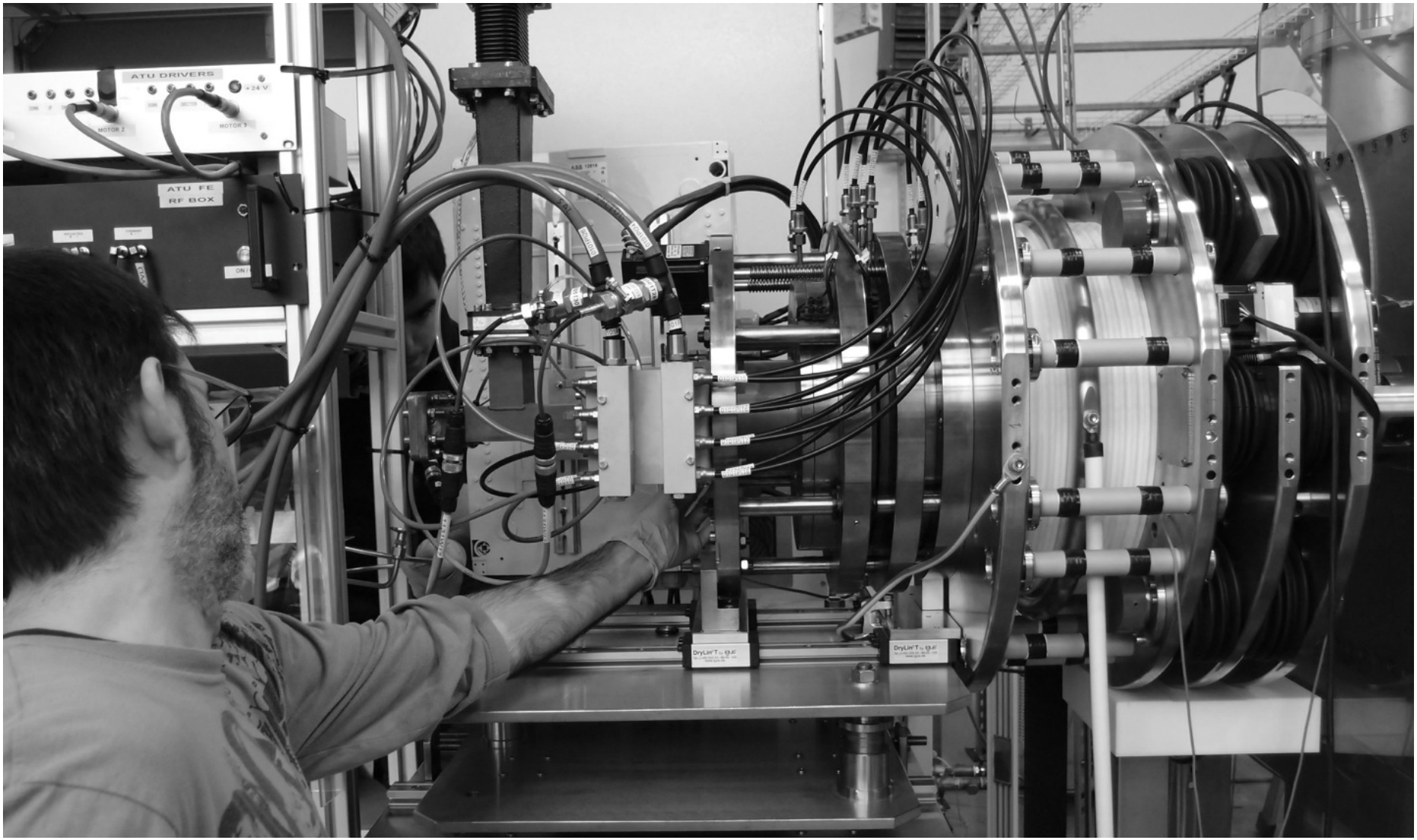

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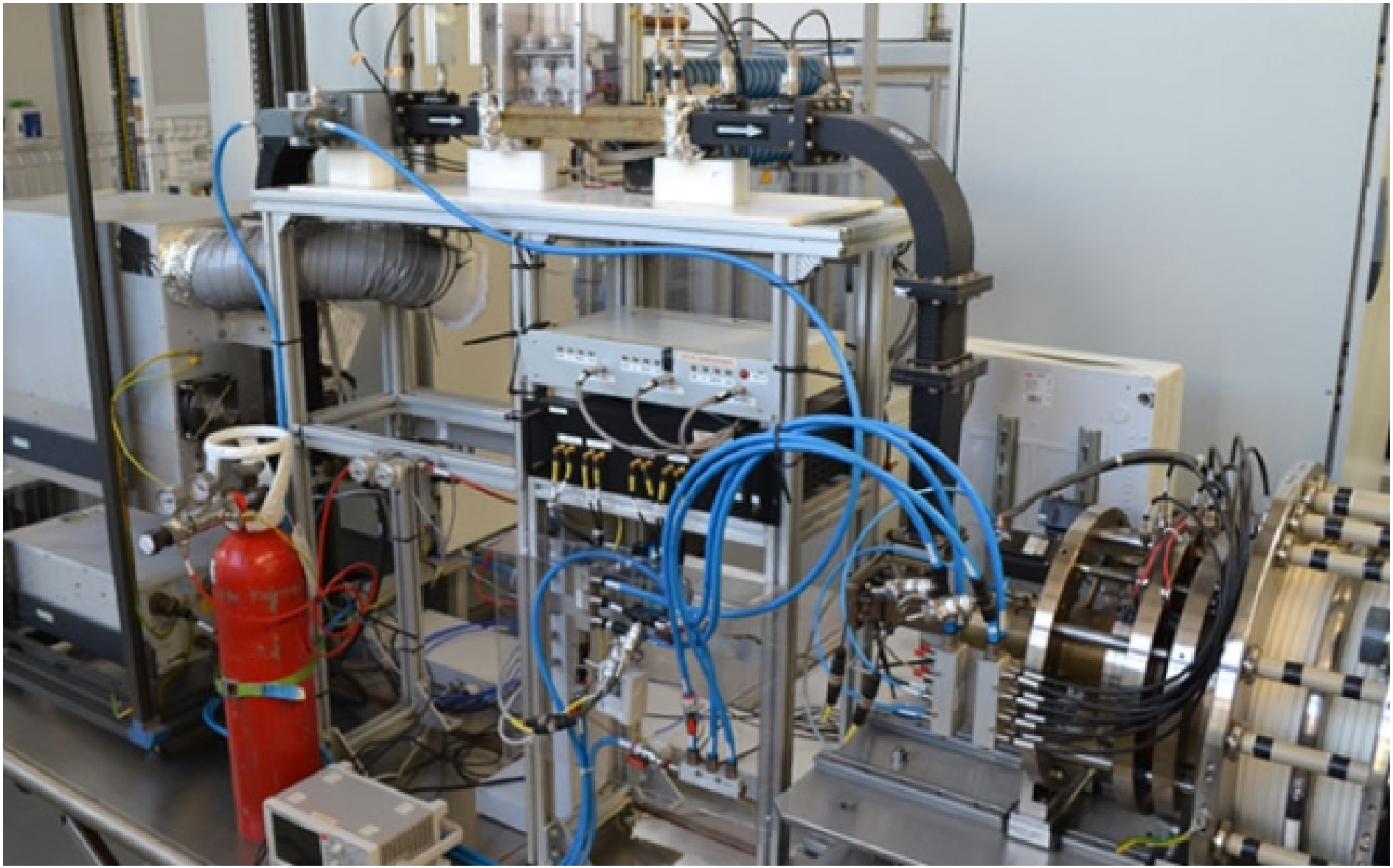
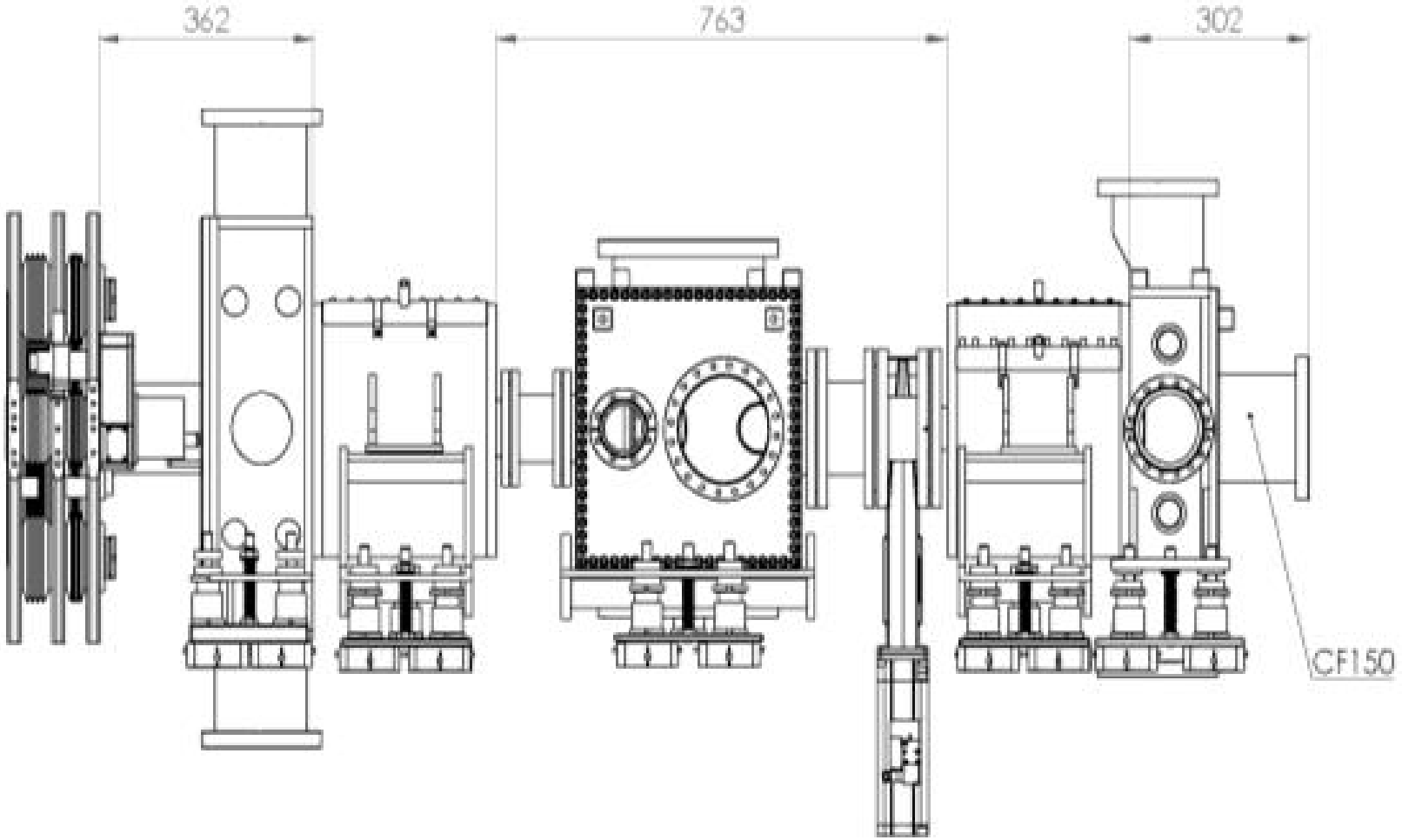
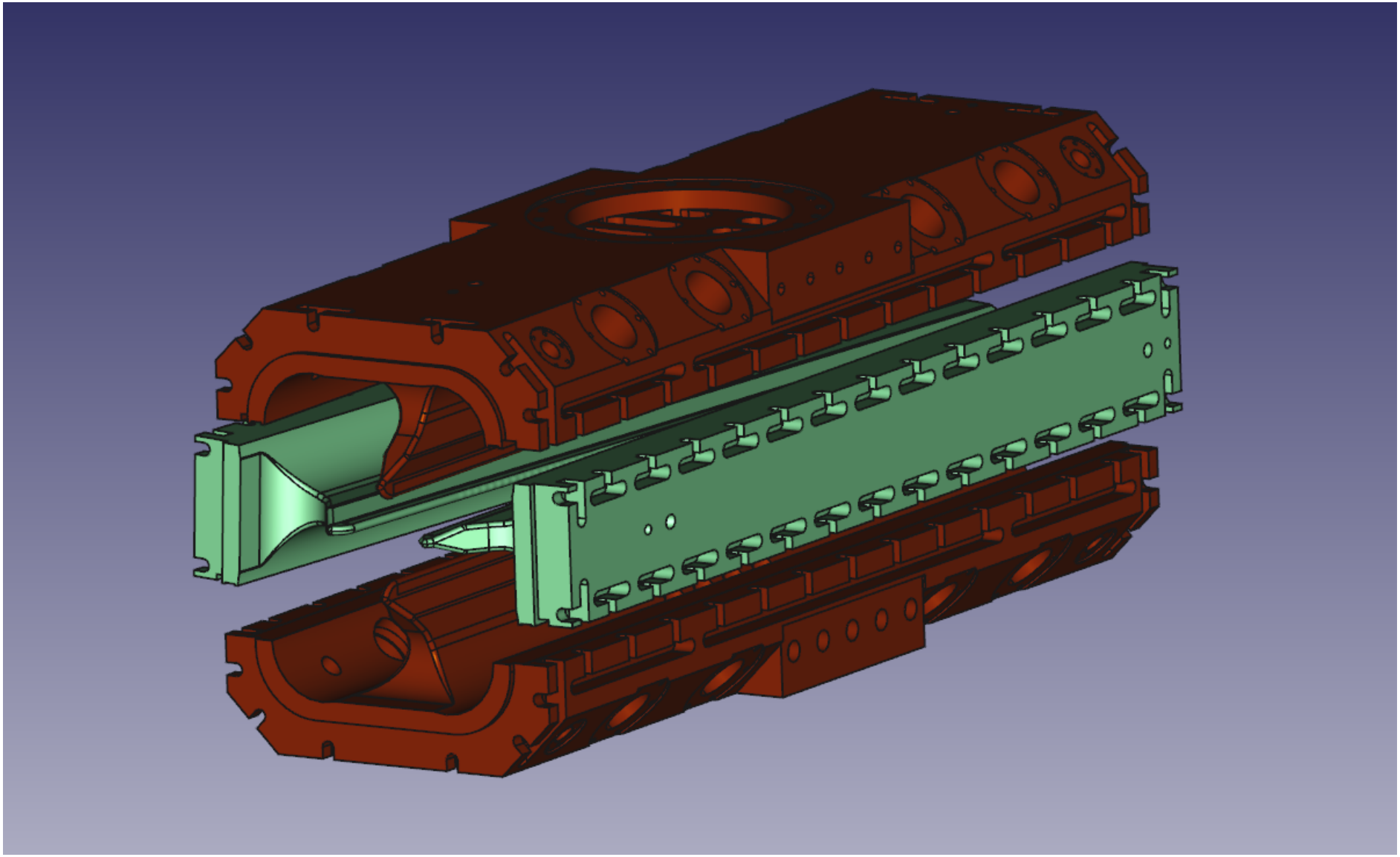


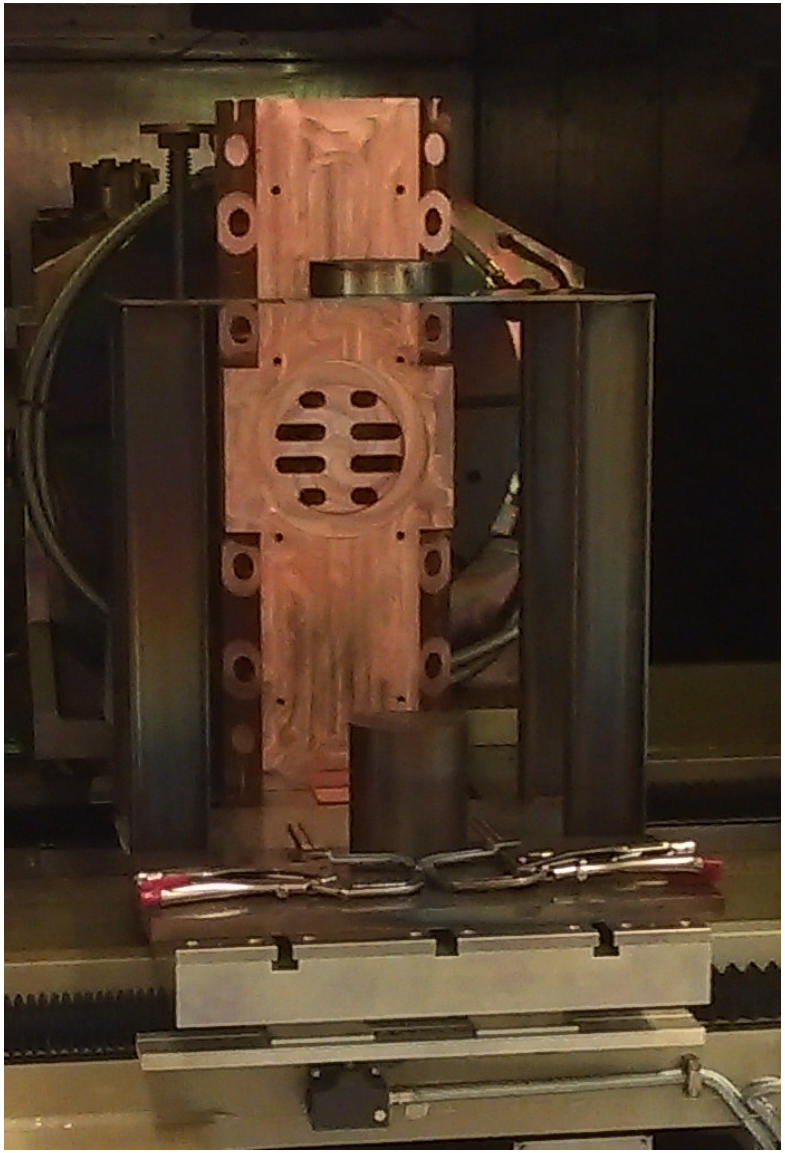
The LEBT, complete with 2 solenoids and 3 boxes



The design of the RFQ was finished July 2015



The first section of the RFQ is in production (July 2016)



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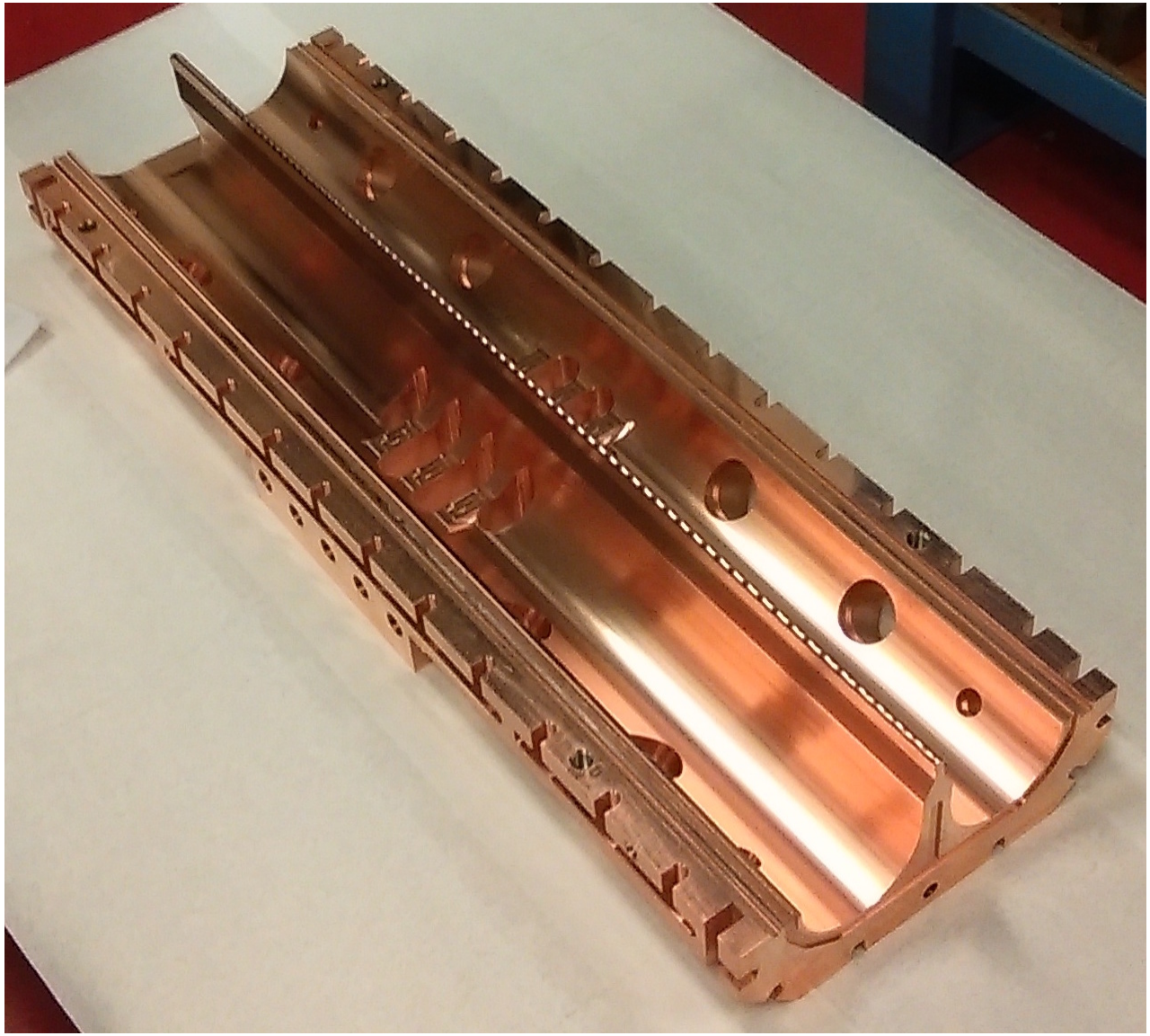
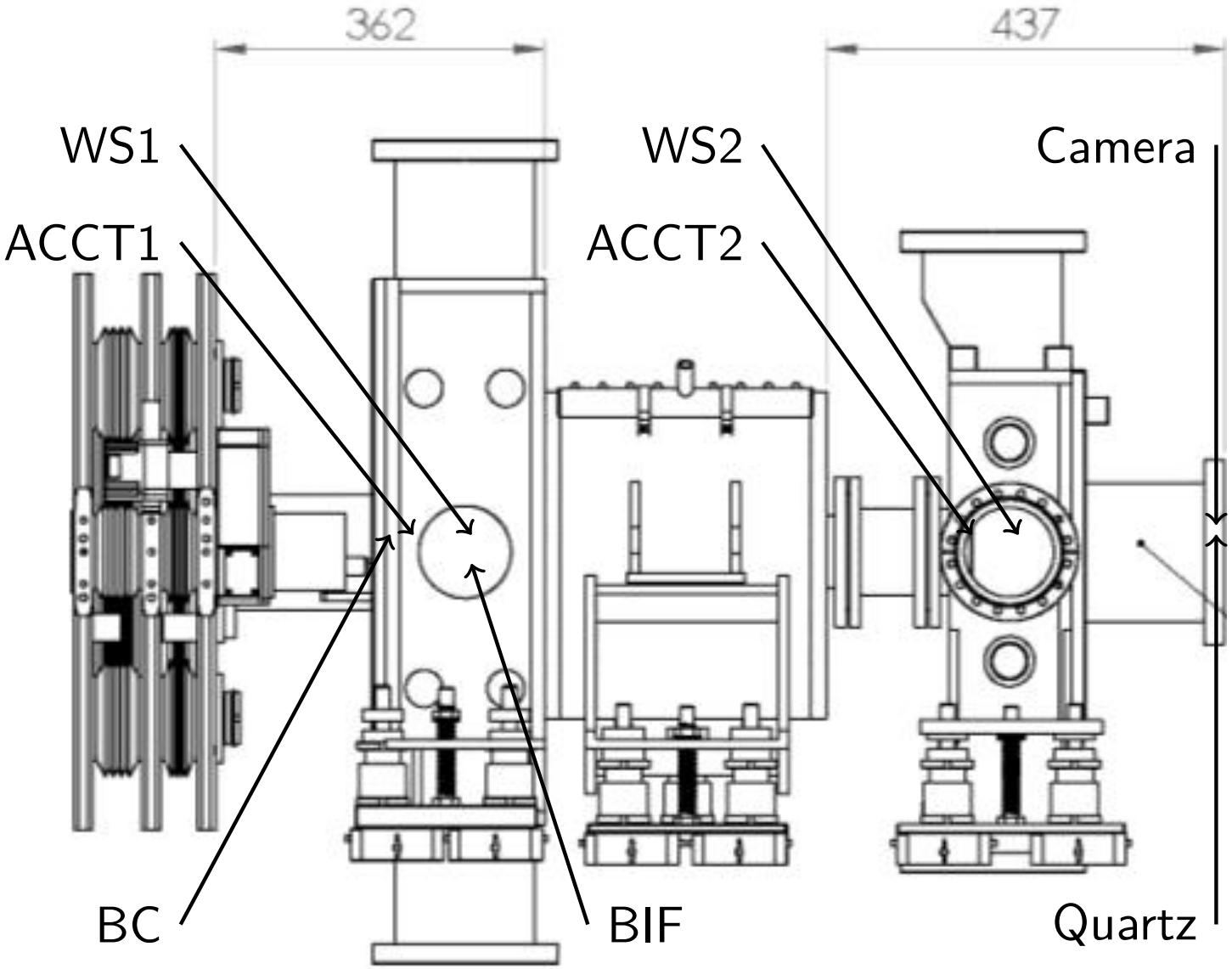


The RFQ should be built for late 2017

- From 45 keV to 3 MeV
- Total length of 3.12 m (4 segments)
- Uniform 85 kV inter-vane voltage
- First segment in fabrication
- Planned for late 2017

The LEBT: Comissionng stage #1 with one solenoid



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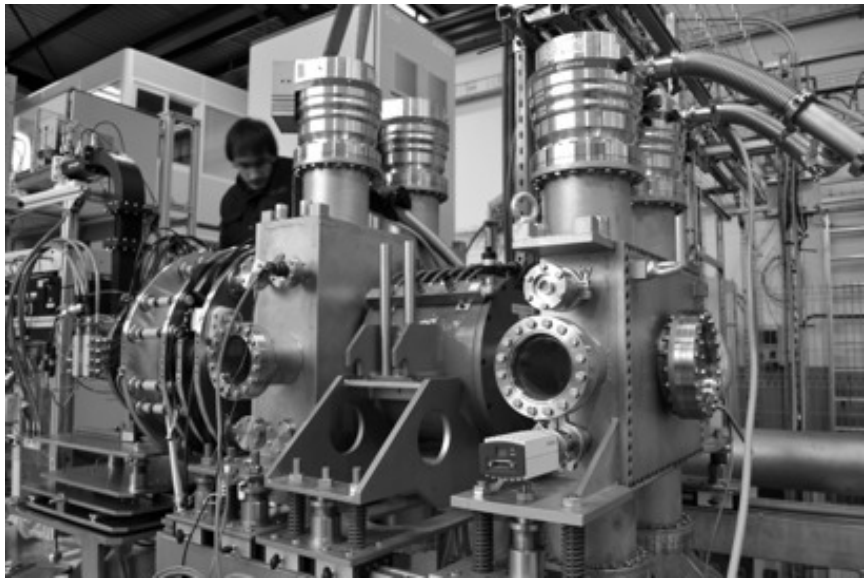
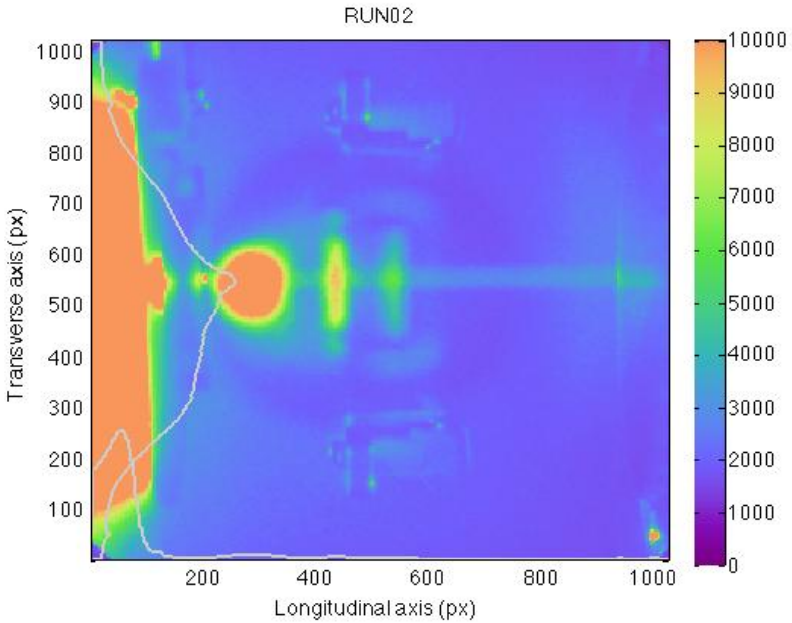
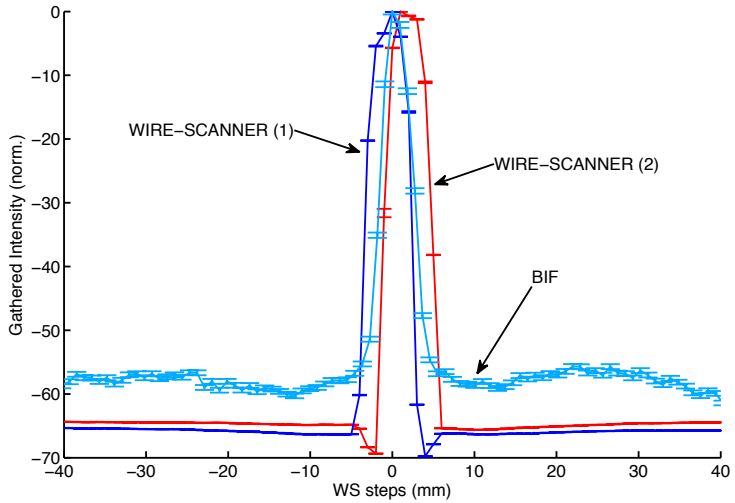
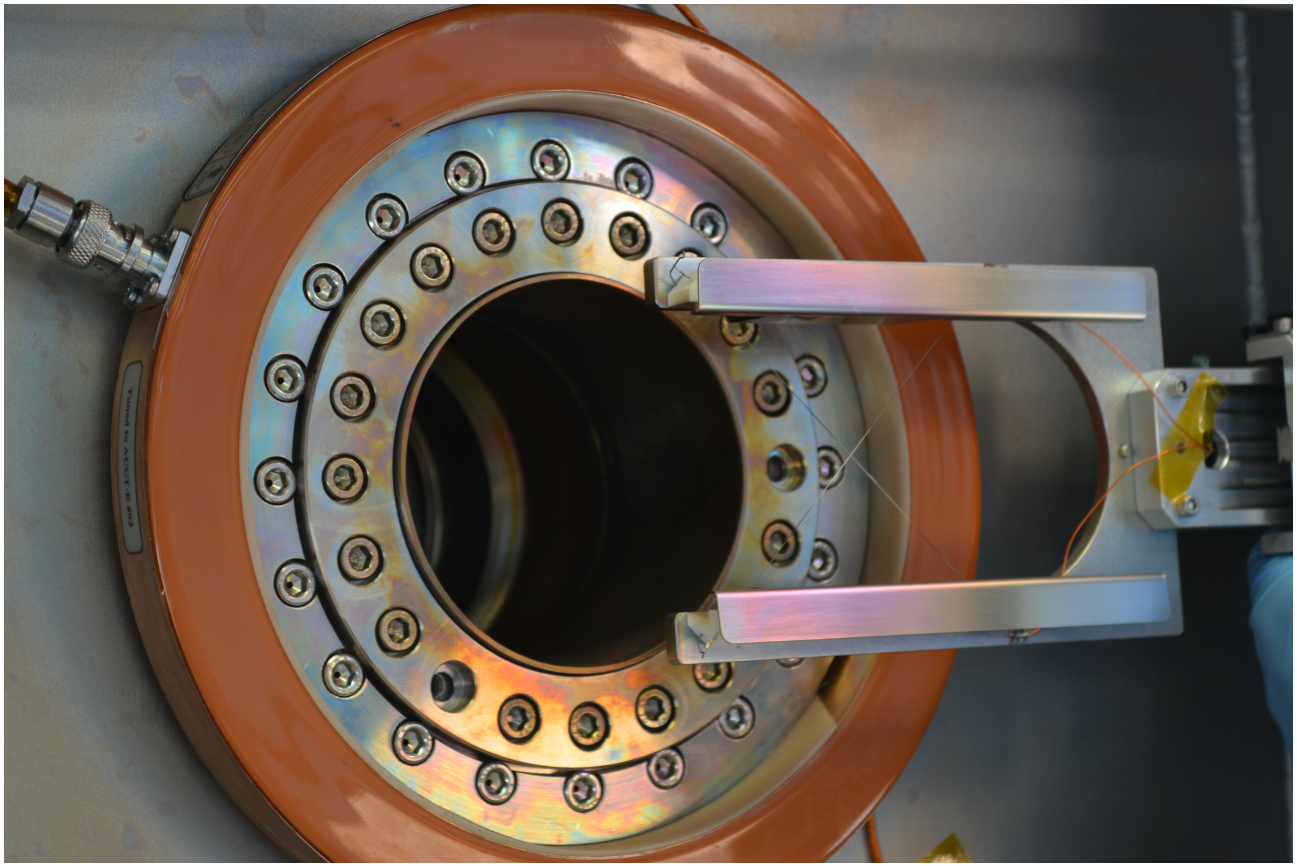


Beam Induced Fluorescence beam width is similar to WS

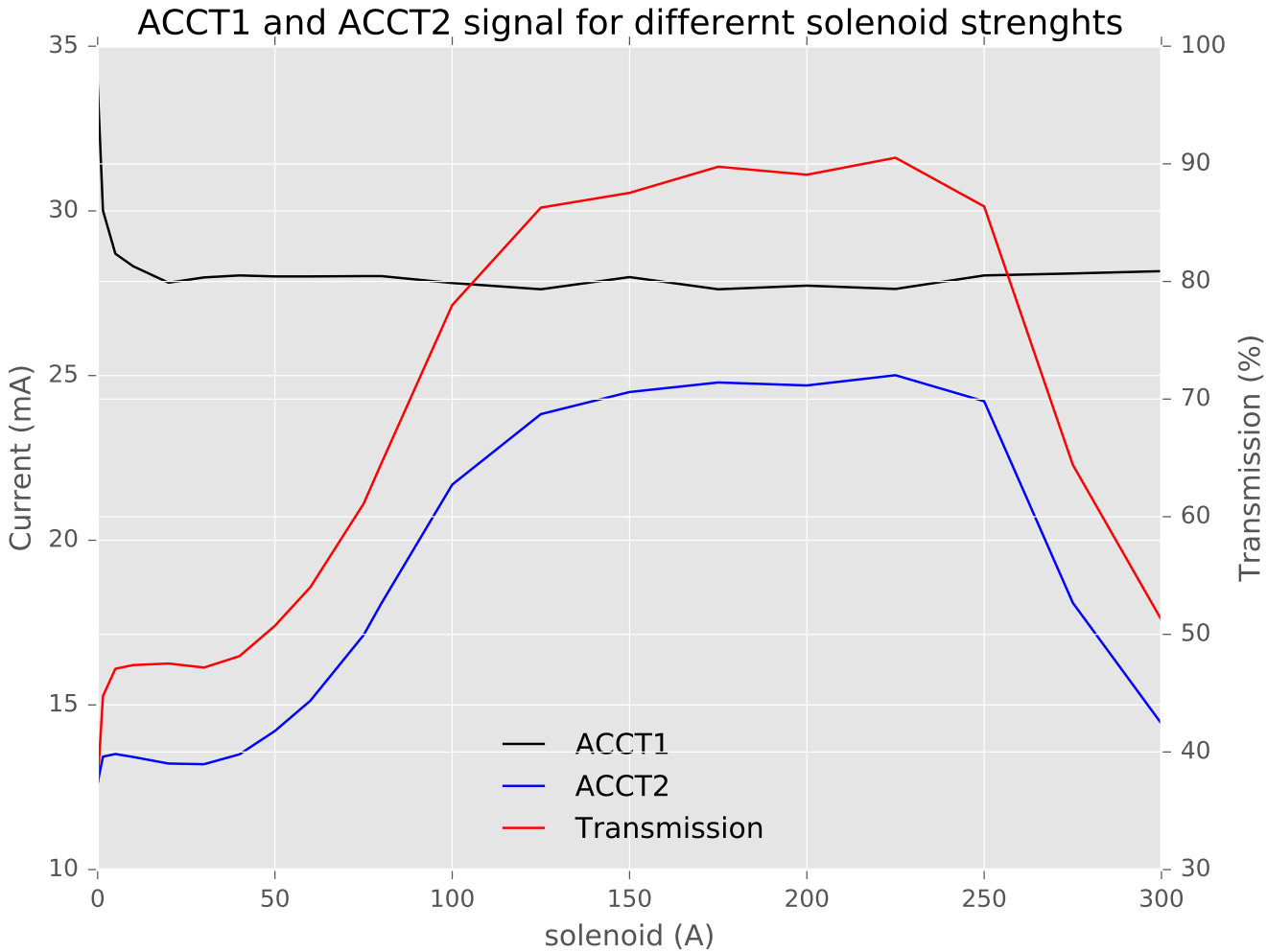




WS measures in 45°!



Solenoid raises transmission above 85 %

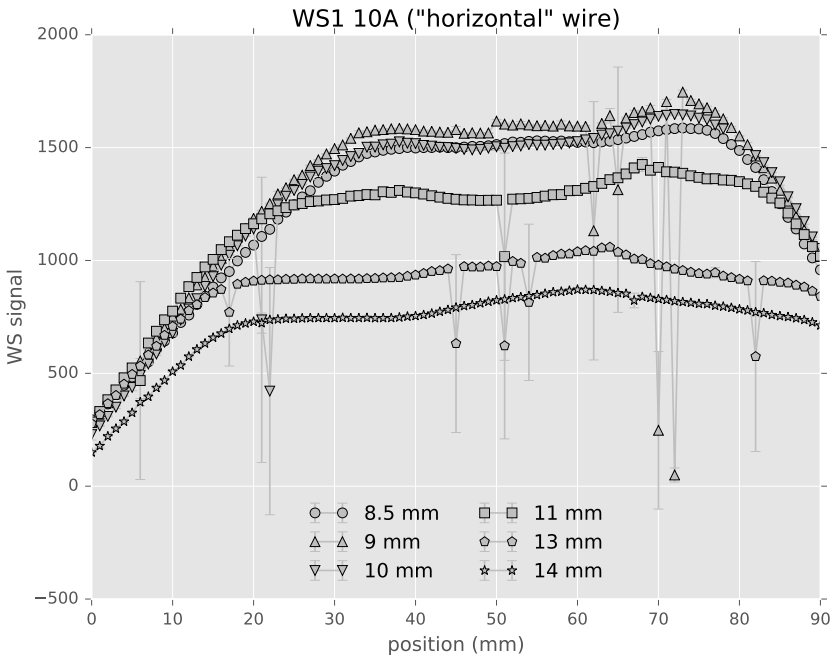


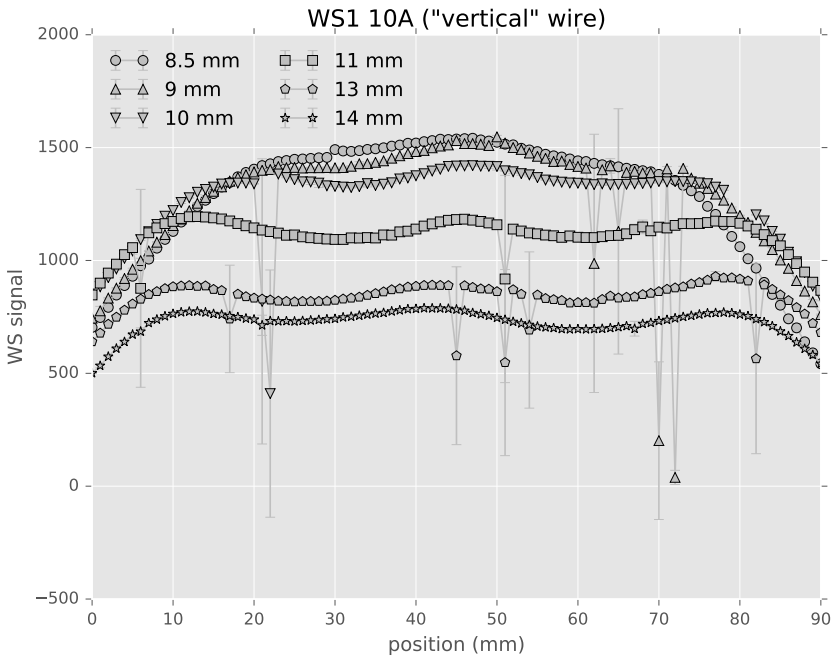
$$B(\mathrm{T}) = 0.0013 \times I(\mathrm{A})$$

We measure more than 100 profiles

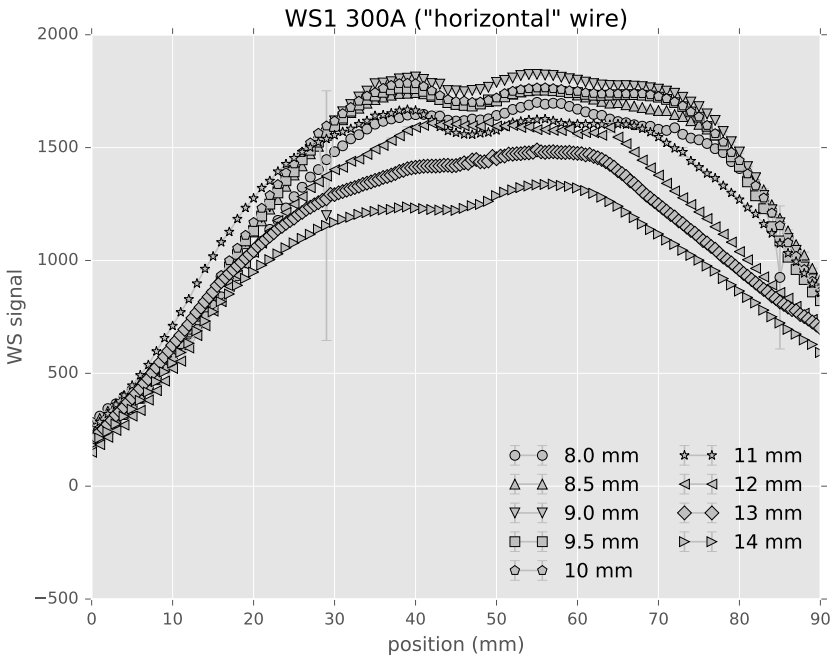
Solenoid [A]	Gap [mm]								
	14	13	12	11	10	9.5	9.0	8.5	8.0
0	● 002	● 021							
	○ 003	○ 022							
10	○ 009	● 018	● 028	○ 040	○ 050	● 108	○ 058	● 099	● 102
		○ 019	○ 030	○ 041	○ 051	○ 107	○ 059	○ 095	○ 101
				● 078	● 086	○ 109	○ 067	○ 098	○ 103
				○ 077	○ 085		● 068		
				○ 079	● 087				
100	○ 010	○ 023	○ 034	○ 042	○ 052		○ 060		
150	○ 012	○ 024	○ 035[1]						
175		● 026	● 036	○ 043	○ 053	○ 110	○ 061	○ 092	○ 100
	○ 013	○ 025	○ 031		● 081				○ 104
				● 074	○ 080		○ 069		
				○ 073	● 089		● 070		
					○ 088				
200	○ 014		○ 037	○ 044	○ 054		○ 062		
				○ 075					

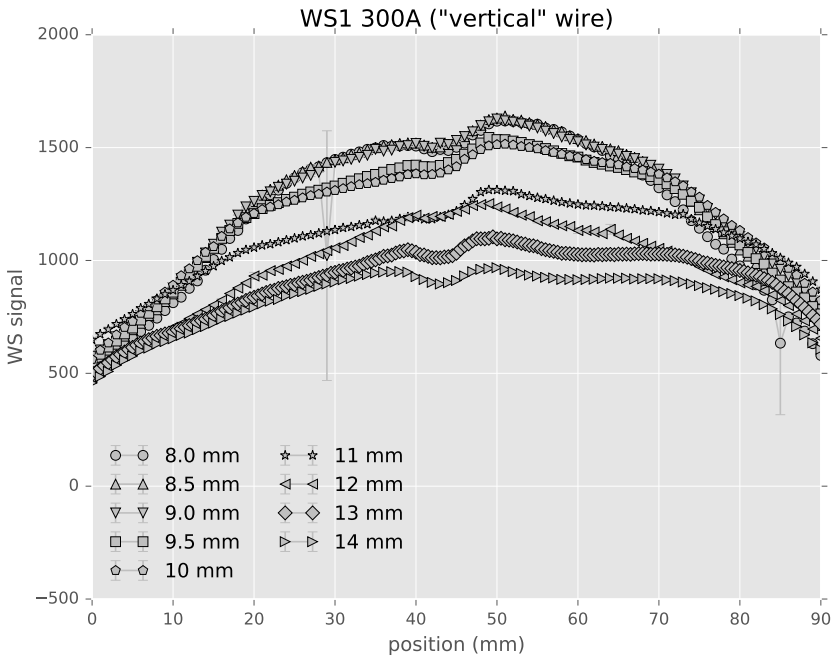
Beam profiles at WS1 not Gaussian



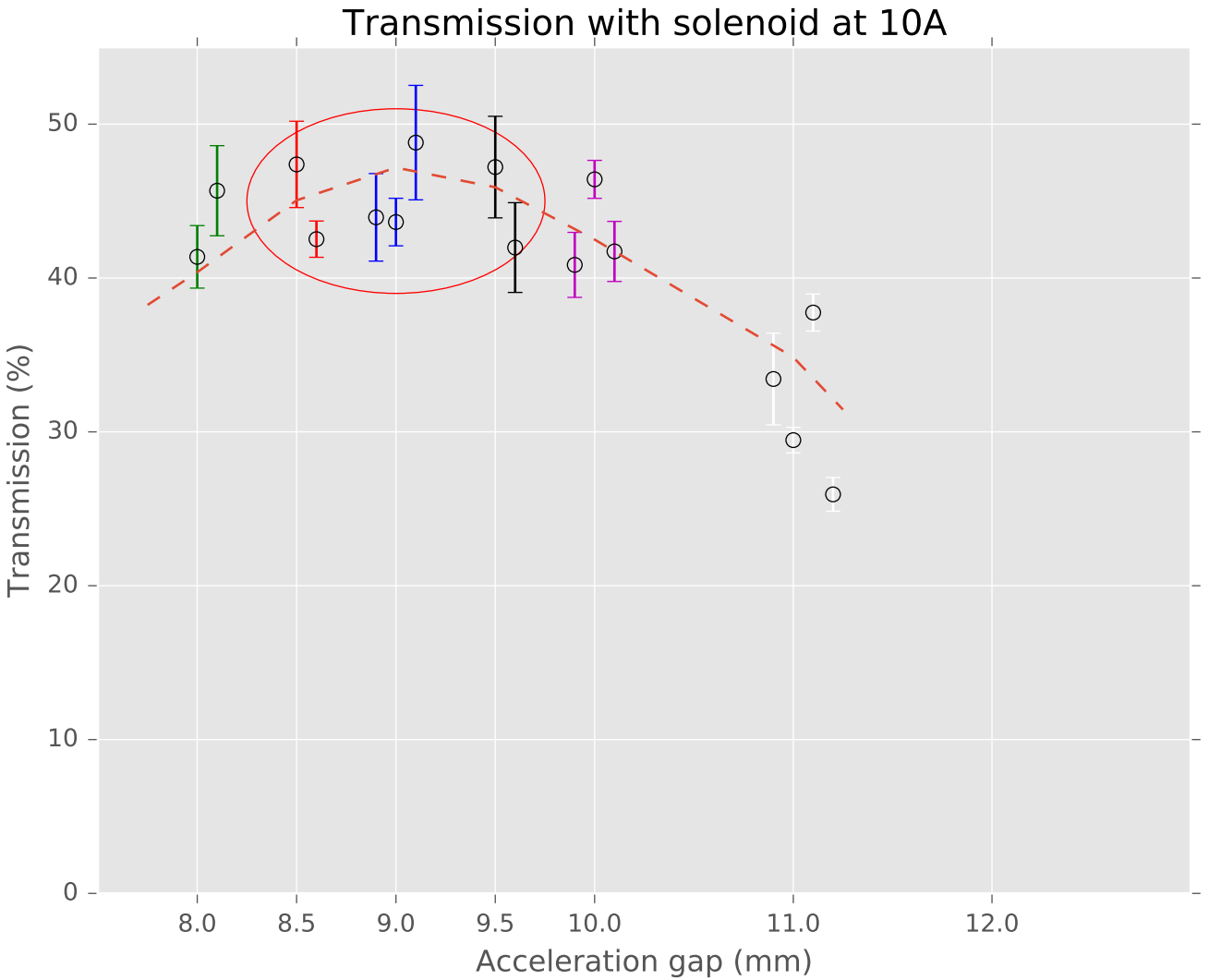


Fringe field has more effect in “horizontal” wire

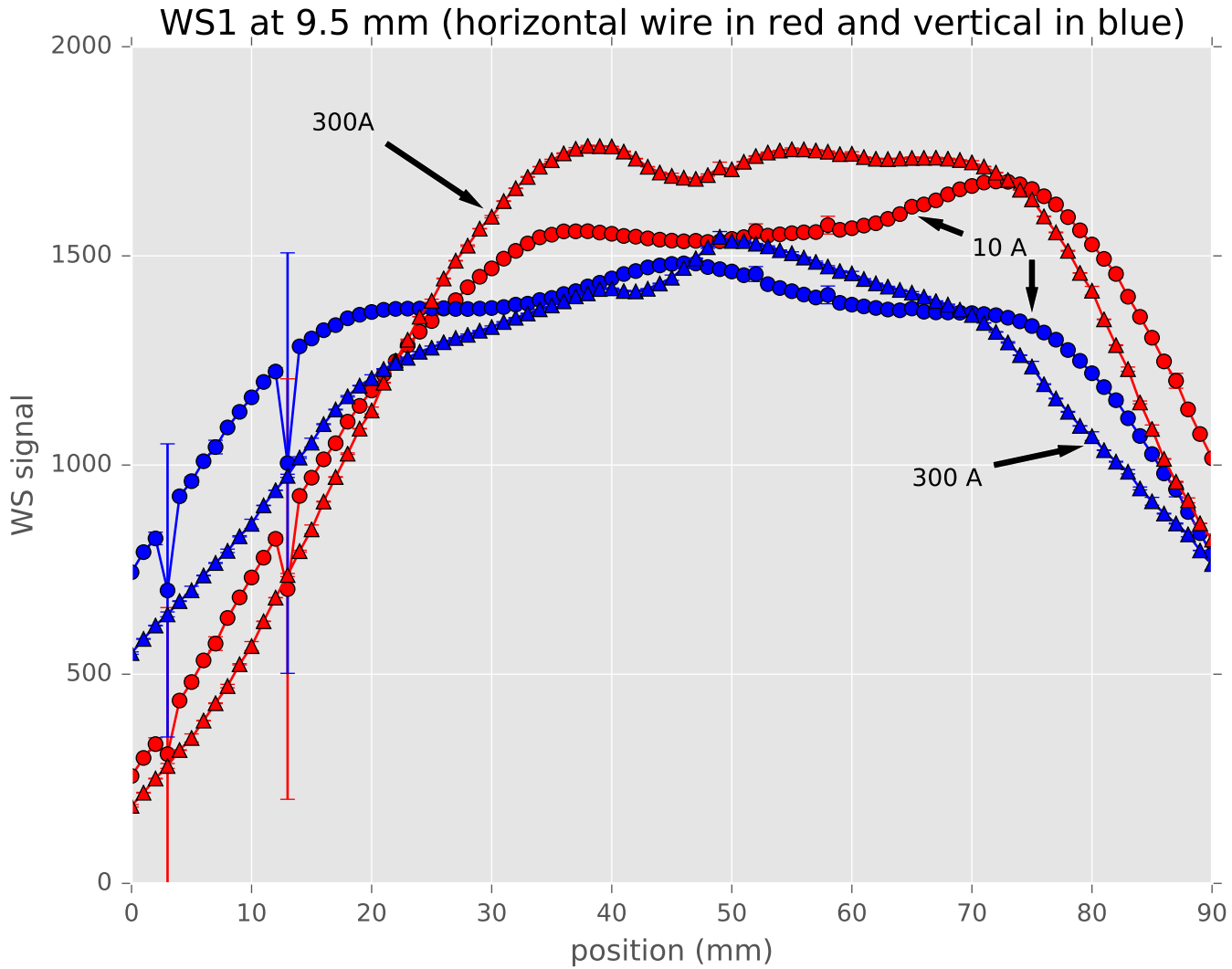




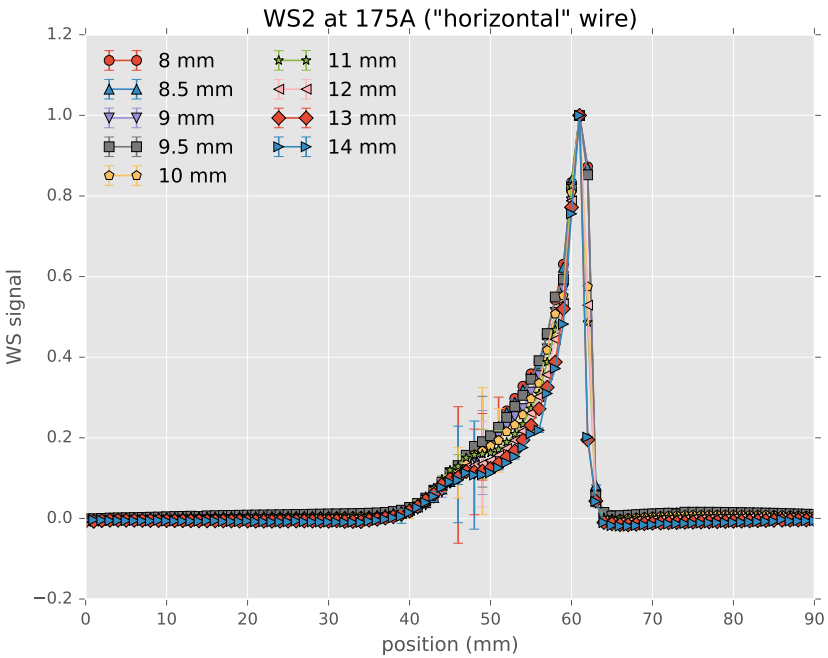
Best transmission is between 8.5 mm and 9.5 mm gap

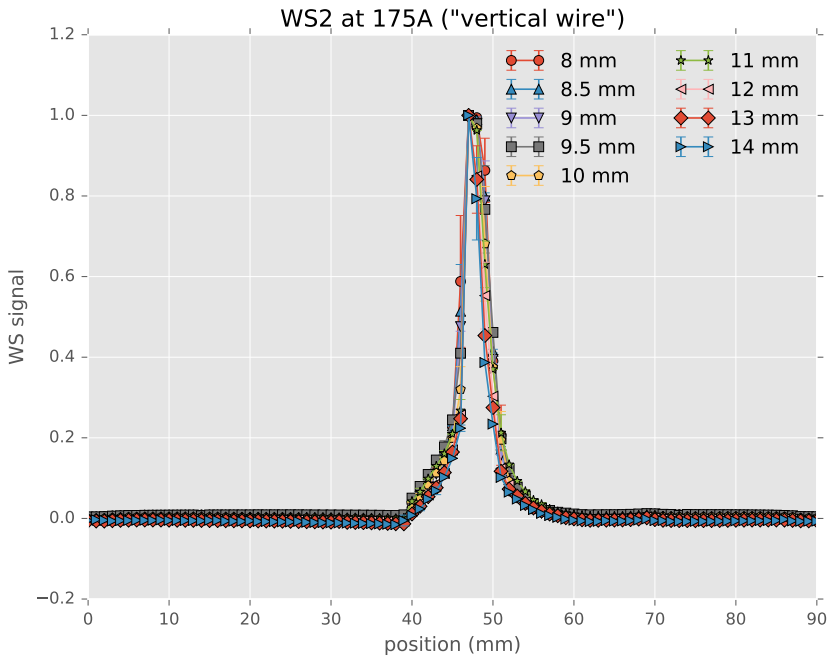


Fridge field focus beam, reduces background

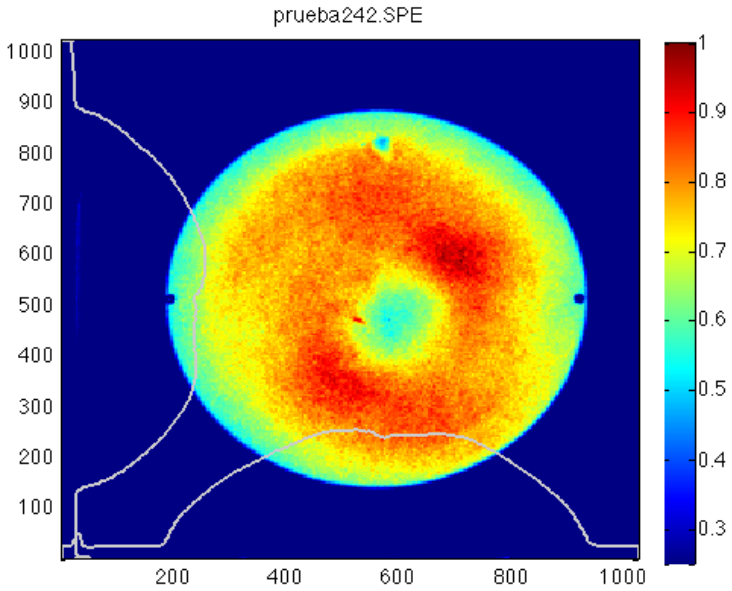


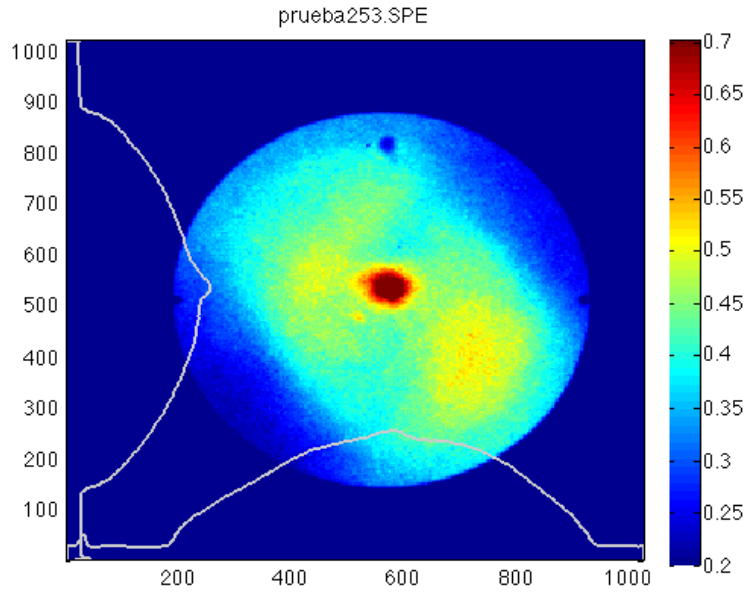
Beam profiles WS2 at 175 A show more than a peak





Measure 2D profiles for different plasma parameters

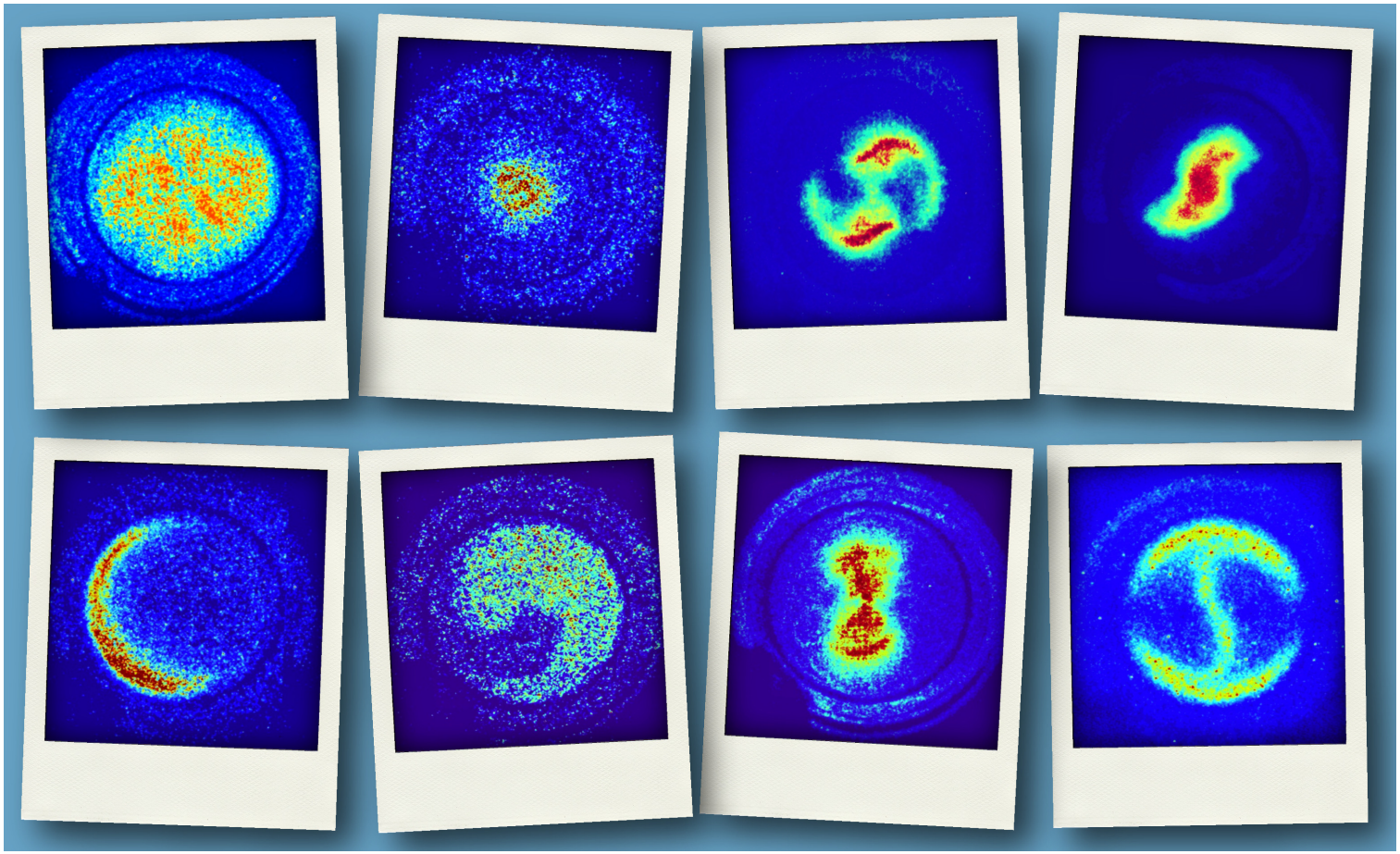




We find different "families"

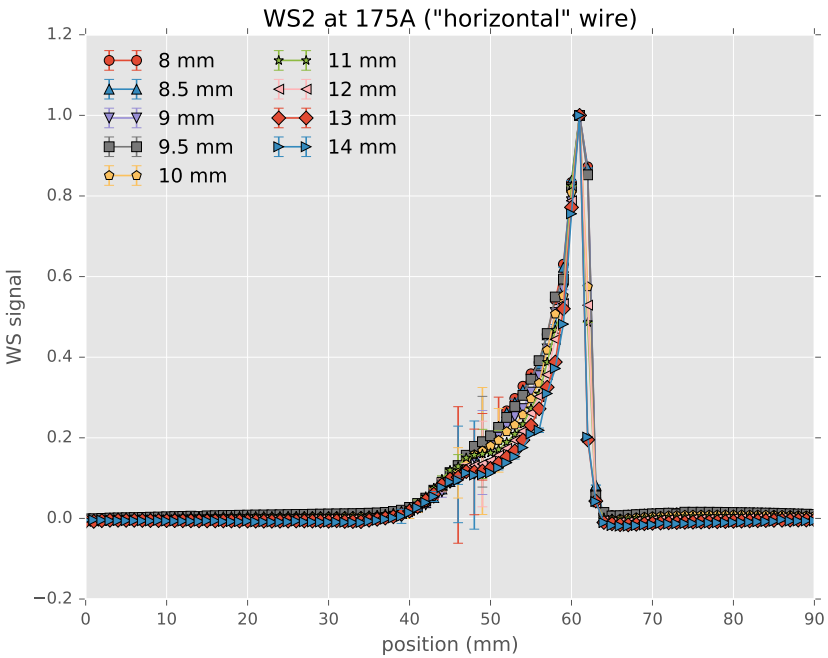
Family	3	4	5	7	10
H_2 (%) flow	42	42	42	23	44
Coil#1 (A)	2	2	2	2	2
Coil#2 (A)	5.1	2	3.5	3.9	7.1
Coil#3 (A)	10	10	10	10	7.5
Coil#4 (A)	3.5	5.8	4.5	3.5	4.4

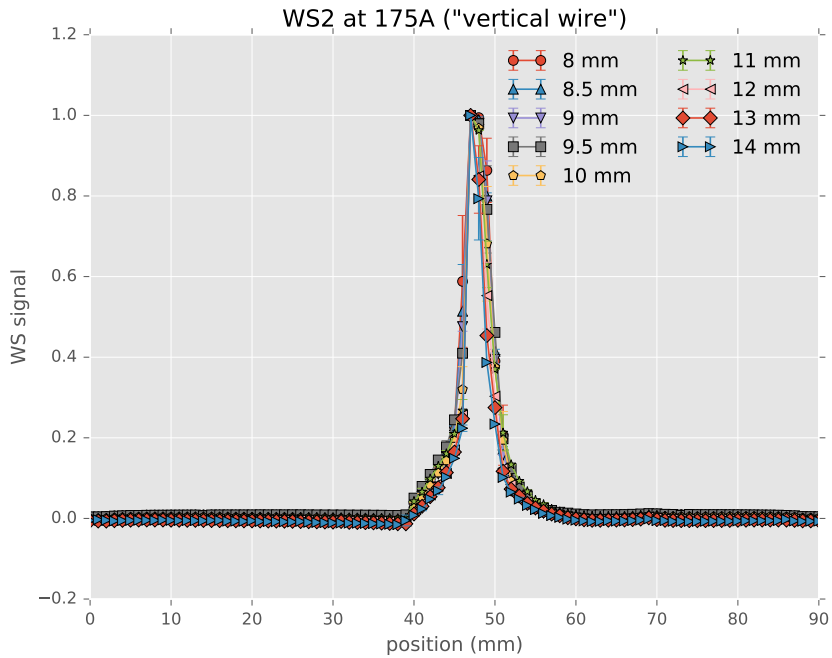
Photos similar to plasma distribution found in similar IS



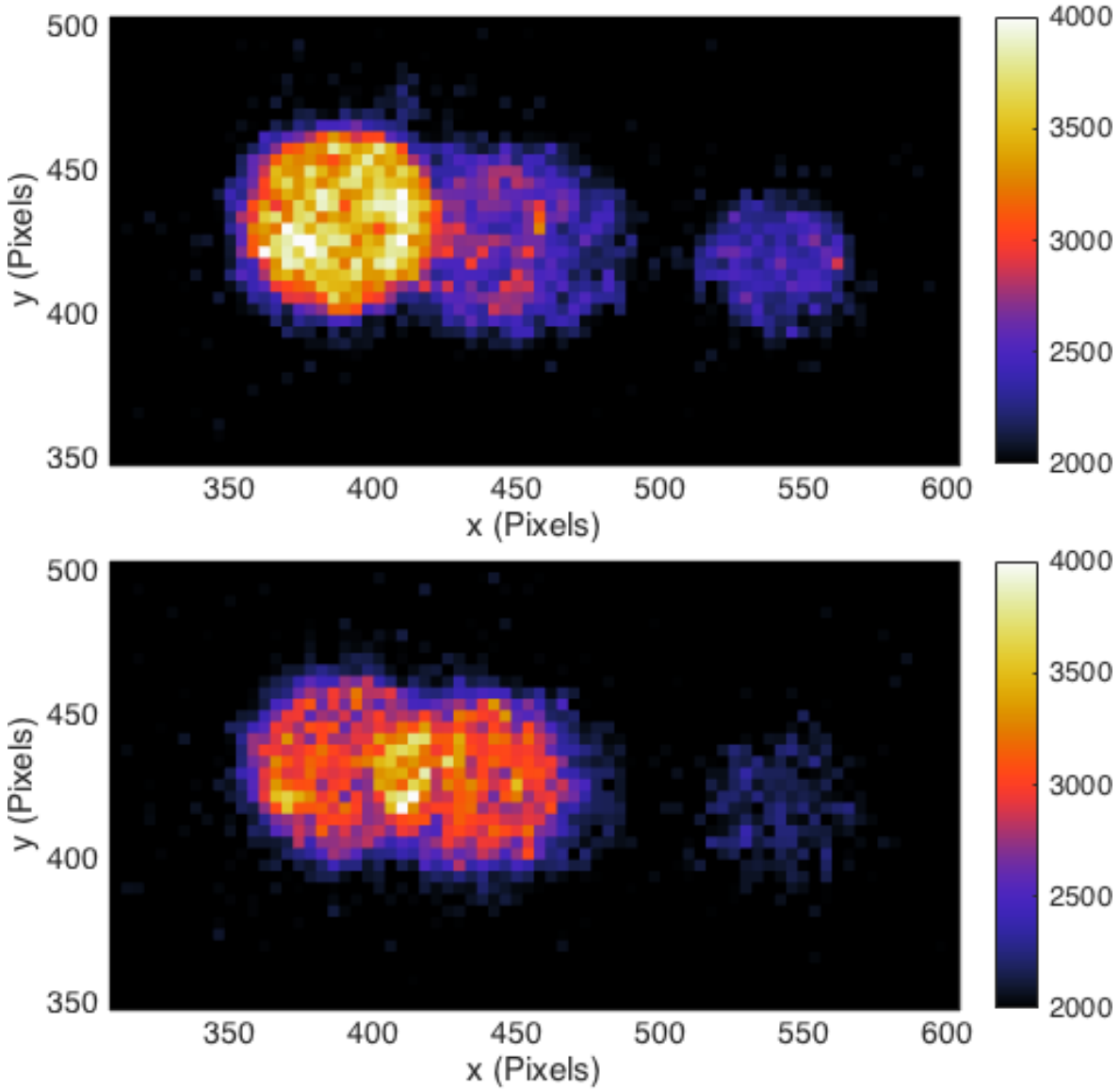
Contributions to ECR Plasma Source Dynamics:
Diagnostics Development and Experimental Results.
Ana María Megía Macías. PhD. Thesis 2014

Beam profiles WS2 at 175 A show more than a peak

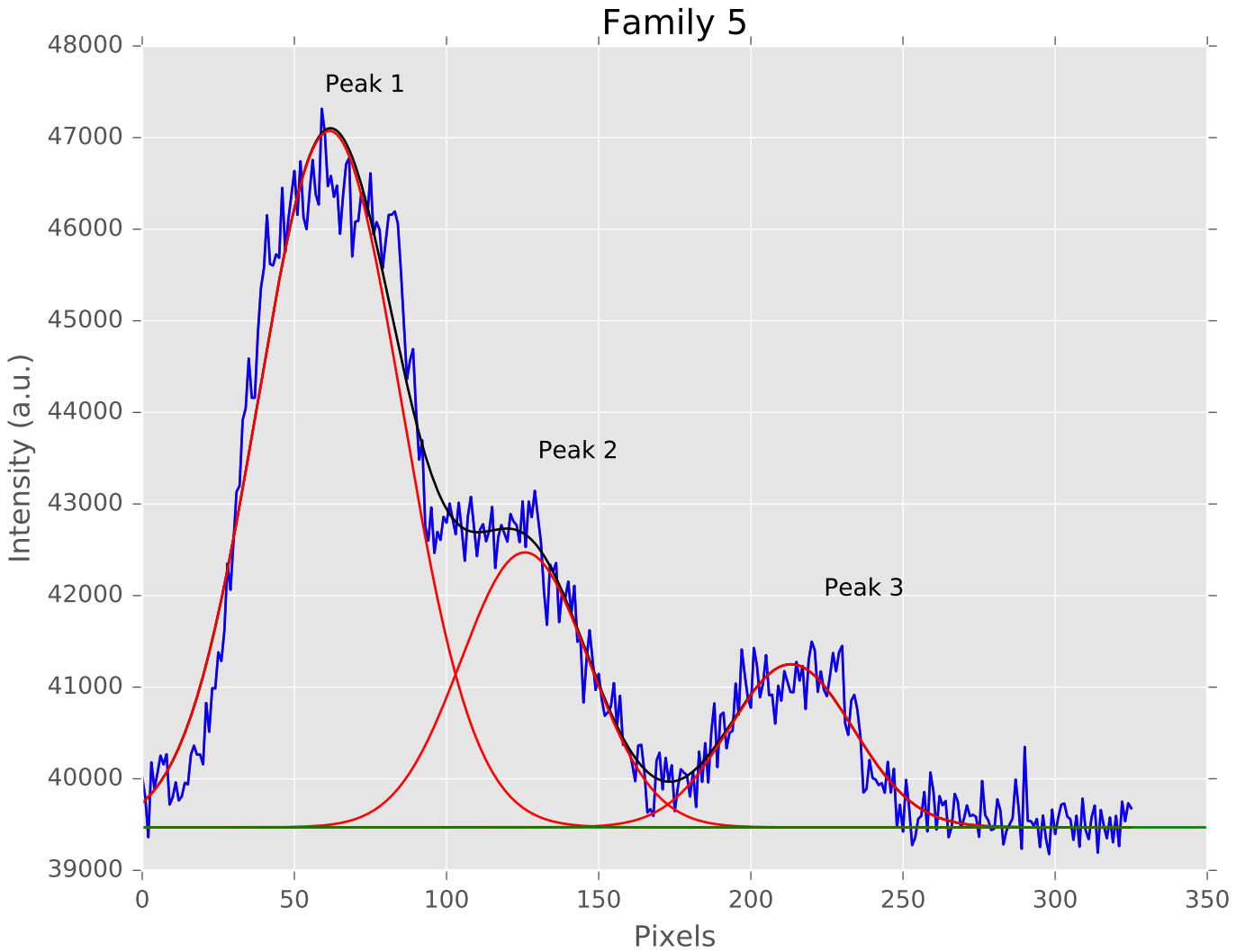




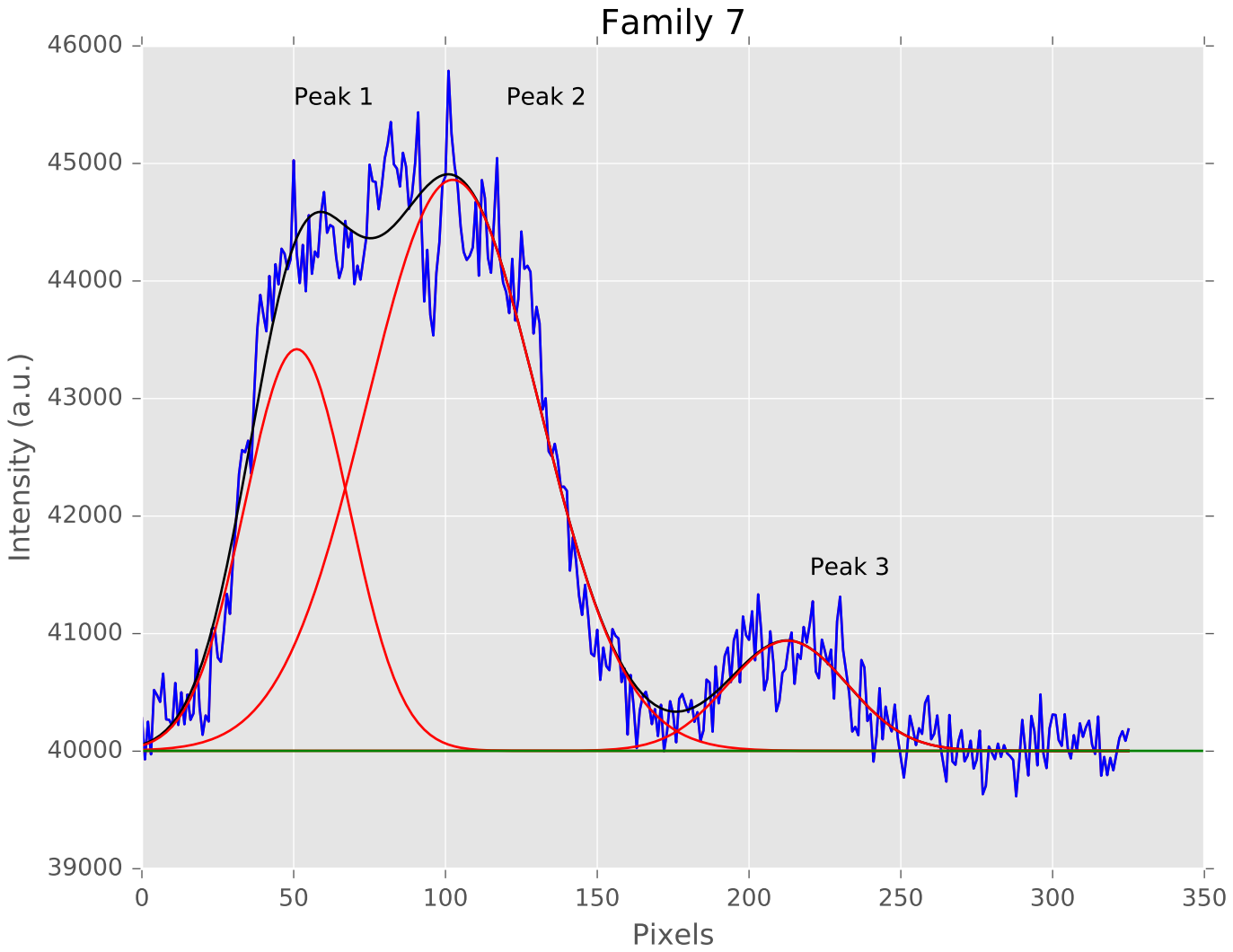
Different ion specimens present in the beam



Integrated profiles allow calculate peak position



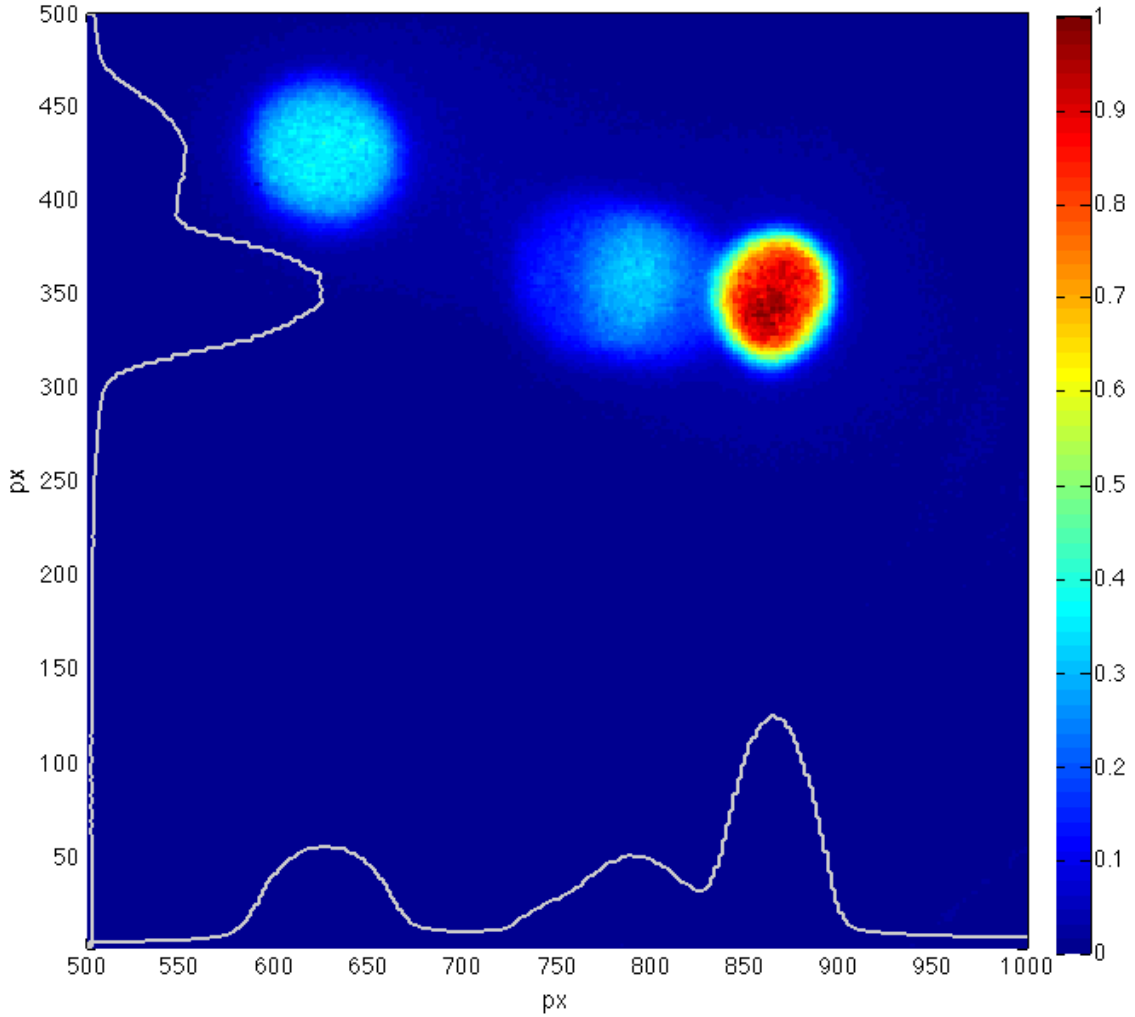
Different peak position and composition appear



Simulation allow to identify some peaks

Peak	Position [mm]			Composition (%)		
	#1 H^+	#2 H_2^+	#3 H_3^+(?)	#1 H^+	#2 H_2^+	#3 H_3^+(?)
Family5	30.2	18.1	1.4	64	23	13
Family7	32.1	22.4	1.3	24	67	9
Simulation	30.9	21.4	17.1			

Peak #2 mix of H^+ and H_2^+ and peak #3 contamination?



Conclusions

- The effect of the plasma parameters on the extracted beam profiles is greater than we expected, if compared to the effect of the acceleration gap in these profile.
- Different ion source configurations show unlike profiles, not only in the plasma but also in the extracted beam, that are far from being "ideal Gaussian beam."

Future Work

- Improve H^+ proportion

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- Improve H^+ proportion
- Measure emittance

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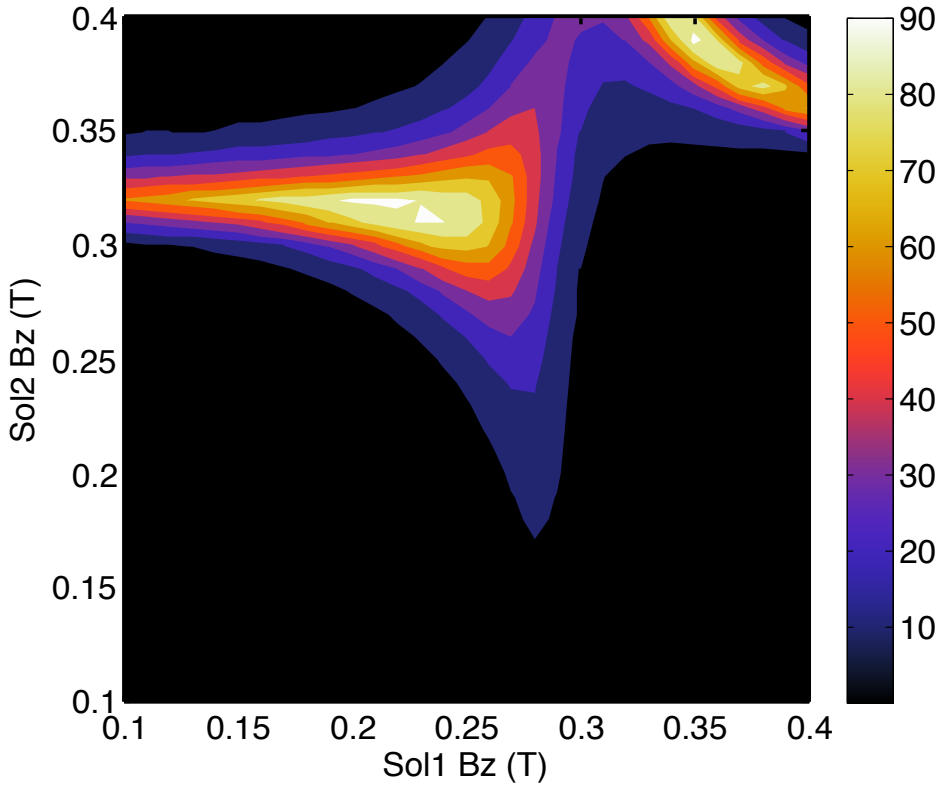
- Improve H^+ proportion
- Measure emittance
- "Map" of emittance at RFQ entrance for solenoid configurations



Acknowledgement

Thanks to:

- I. Bustinduy
- J. Corres
- D. de Cos
- C. de la Cruz
- G. Harper
- R. Miracoli
- J. L. Muñoz
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- A. Zugazaga

To all the staff at ESS-Bilbao that works in the design, building and running of the injector.