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RFQ Status and Commissioning Plan

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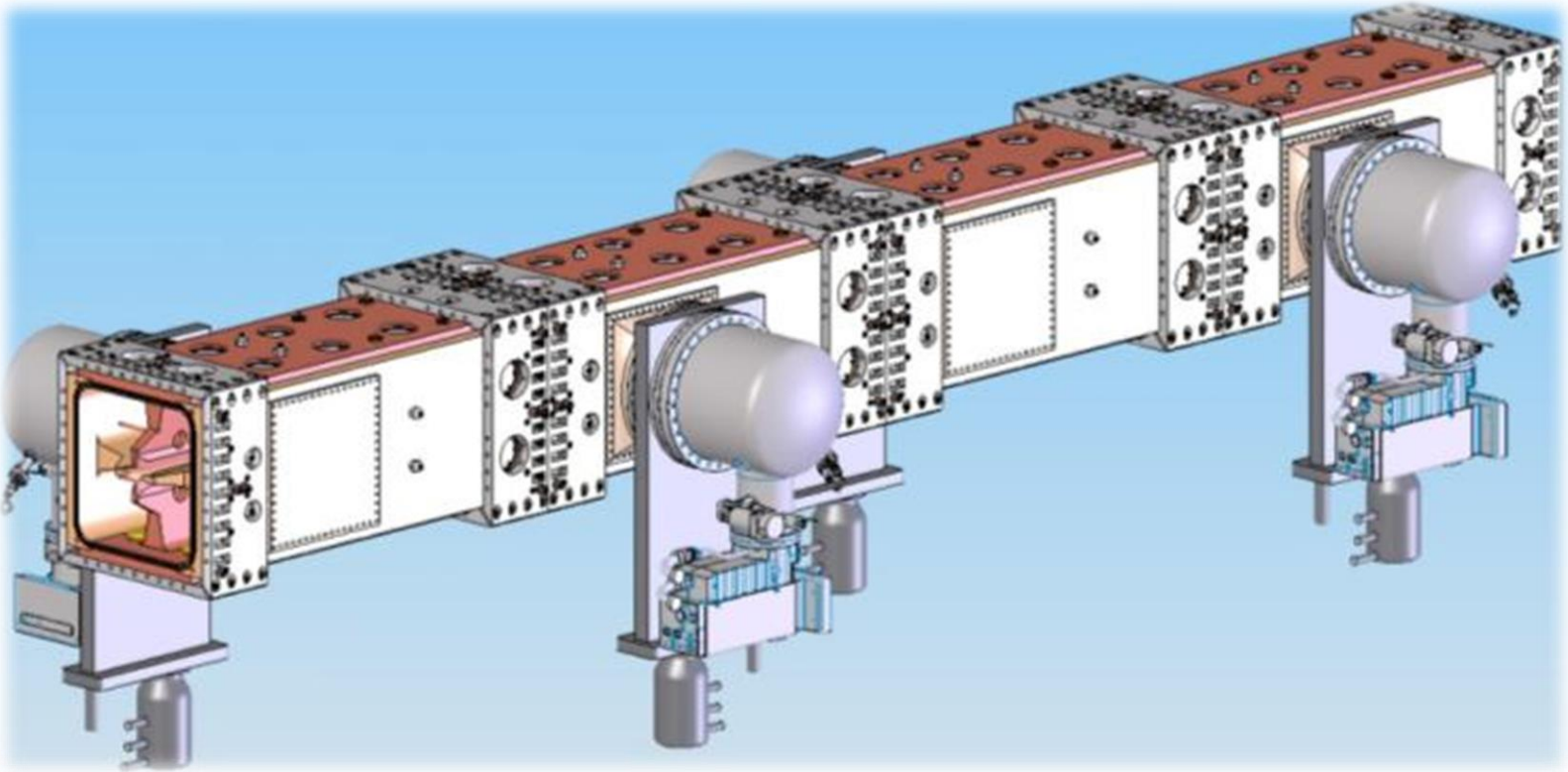
PIP-II Machine Advisory Committee

9-11 March 2015

PXIE RFQ Solid Model

D. Li (LBNL) RFQ Design Review 4-12-12



Picture showing solid model of 4-vane x 4-module PXIE RFQ. Design consists of 2 RF power inputs, 8 vacuum pumping ports, and 32 Pi-mode stabilization rods.

Beam Dynamics Requirements

D. Li (LBNL) PXIE RFQ Fabrication Readiness Review 6-26-13

Parameters	PXIE	Unit
Ion Type	H-	
Output Energy	2.1	MeV
Duty factor	100	%
Frequency	162.5	MHz
Beam current	5 (nominal); 1-10	mA
Transverse Emittance	< 0.25 (norm. rms)	πmm-mrad
Longitudinal Emittance	0.8-1.0	keV-nsec
Input energy	30	kV
Emittance Growth	< 10	%
Transmission	> 95	%
TWISS Parameter αs	Less than 0.2	

Design Simulation Results

D. Li (LBNL) PXIE RFQ Fabrication Readiness Review 6-26-13

Simulated beam parameters

Parameters	Value	Unit
Vane Tip Voltage	60	kV
RFQ Length	4.45	m
Transmission	99.8	%
Transverse Emittance	0.15	πmm-mrad
Longitudinal Emittance	0.70	keV-nsec
TWISS Parameters α_x, α_y	0.187 -0.088	

Simulated RF and thermal properties

Parameters	PXIE-T	Units
Frequency	162.493	MHz
Frequency of dipole mode	181.99	MHz
Q factor	14660	
Q factor drop due to everything	-14.7	%
Power loss per cut-back (In/Out)	336/392	watts
Max power loss density at cut-back	7.9	W/cm^2
Total power loss	**74.6**	kW
H (1/2 of the inner width of the RFQ)	172.73	mm

RFQ Resonant Frequency Tuning

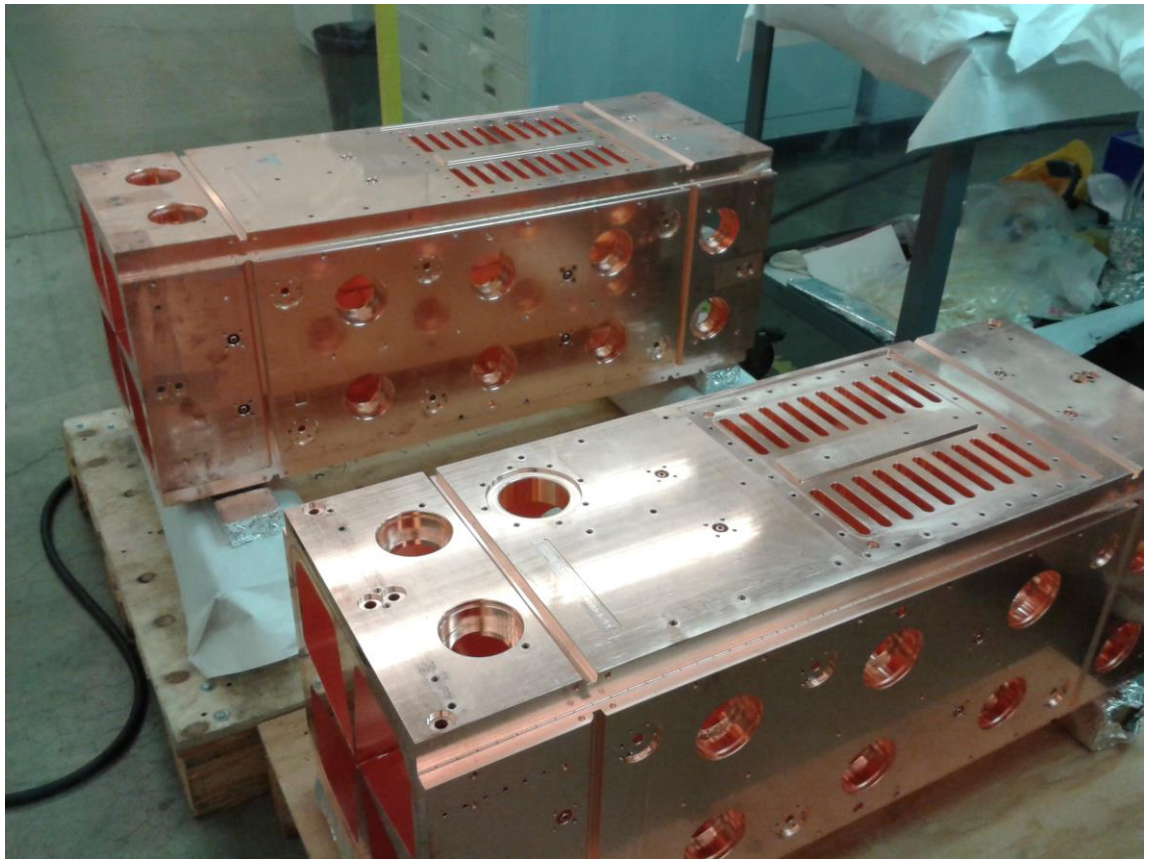
- There are no adjustable, mechanical tuners in RFQ design.
- Resonant frequency tuning controlled by water temperature during CW operation.
- Engineering team looking at optimizing water system design for temperature stability and fast, power interruption recovery.
- We may use RF pulse width variation as virtual water heater during pulsed beam operations.

Resonant Frequency Shift Thermal Response
A. Lambert (LBNL) RFQ Design Review 4-12-12

Frequency Shift (2D)	Average
Overall (kHz/°C)	-2.80
Vane (kHz/°C)	-16.70
Wall (kHz/°C)	13.90
Sum of Vane & Wall (kHz/°C)	-2.80
Theoretical (kHz/°C)	-2.91
% Error	3.8%

RFQ Module Construction Status

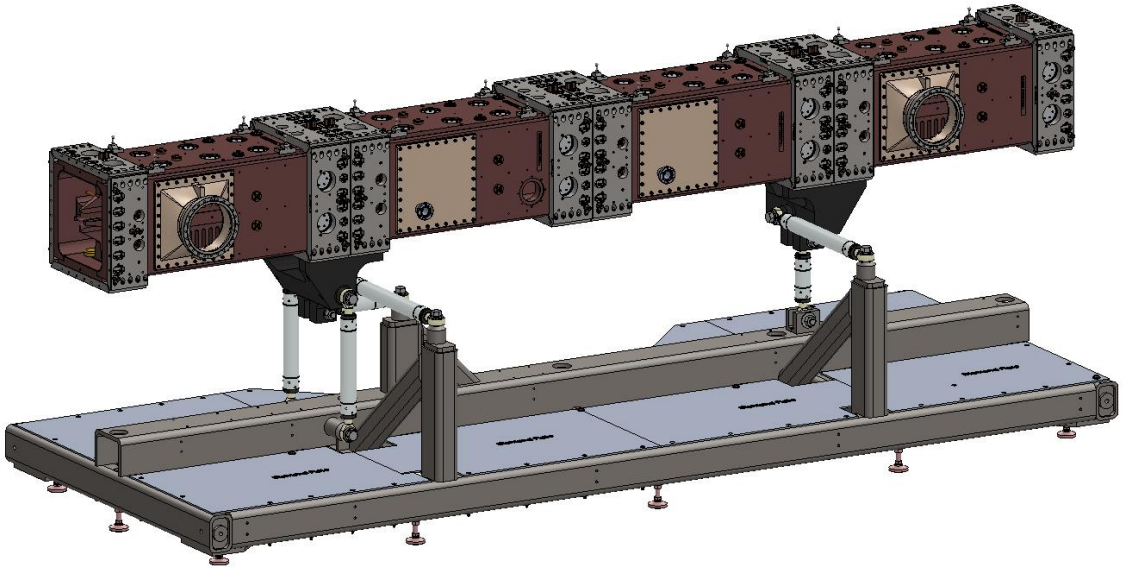
- Two modules brazed and leak tight.
- One module needs final, leak sealing braze.
- One module final braze complete and awaiting leak test results.
- Only final end machining remains (o-ring grooves, RF seal grooves, and final length).



RFQ Support Stand

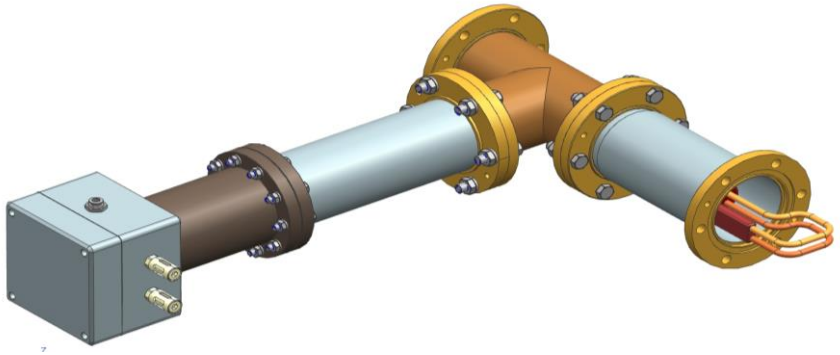
- Final design review completed early last month.
- Design includes operational stand and shipping configuration.
- All material is on hand and the shop is cutting the material.
- Estimate 7-10 weeks for completion.
- Bead-pull tuning will begin after modules are mounted on the stand.

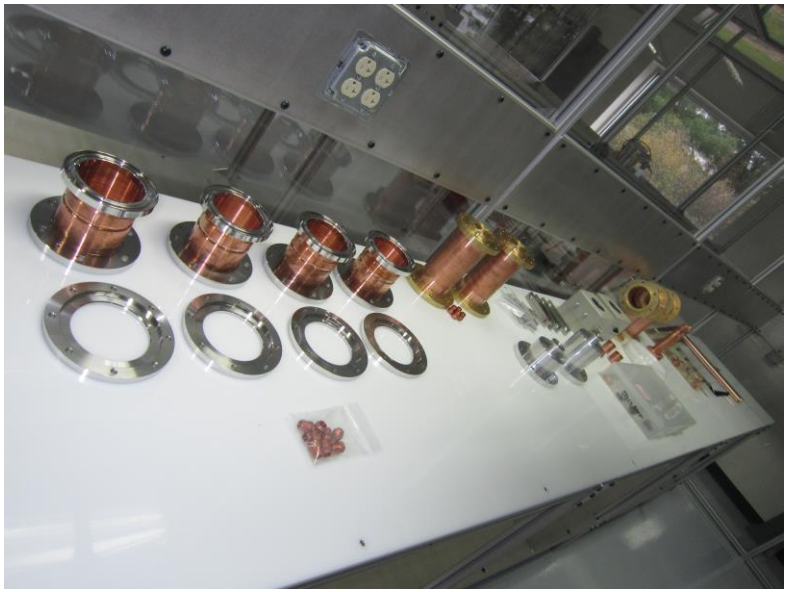
M. Hoff (LBNL) RFQ Support Stand Design Review 2-5-15



Input Coupler Fabrication

- Input coupler design complete and being manufactured by vendor, Mega Inc.
- All components have been procured and machined.
- Ceramic window braze complete. Now need to work on brazing coupling loop.
- Expect delivery in June.





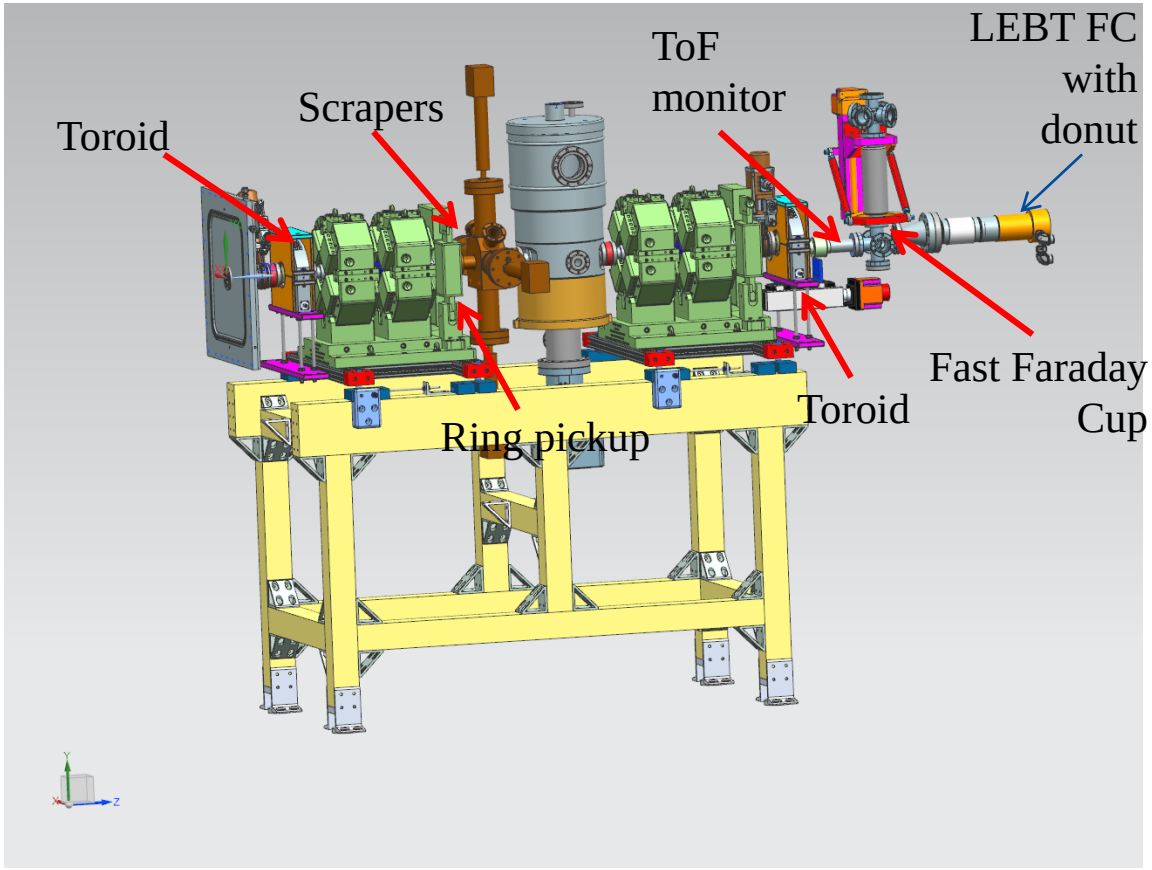
RF Distribution Status

- Both 75kW power amplifiers are commissioned to spec and operational.
- Circulators are not capable of CW operation into a short, but they will be good enough to protect amplifiers from RFQ filling time and sparks.
- Amplifiers are self-protected from highly reactive loads.
- RF interlock system for RFQ operation is based on HINS system.

RFQ Beam Commissioning Line - Short MEBT 1_1 (Fall 2015)

- Plan to start RFQ beam commissioning with front MEBT section fully assembled, including prototype magnets and cavity
- Pulsed mode only (<1 ms, <60 Hz)
- Measurement of beam energy, RFQ transmission, bunch length
- Commission prototype buncher cavity.

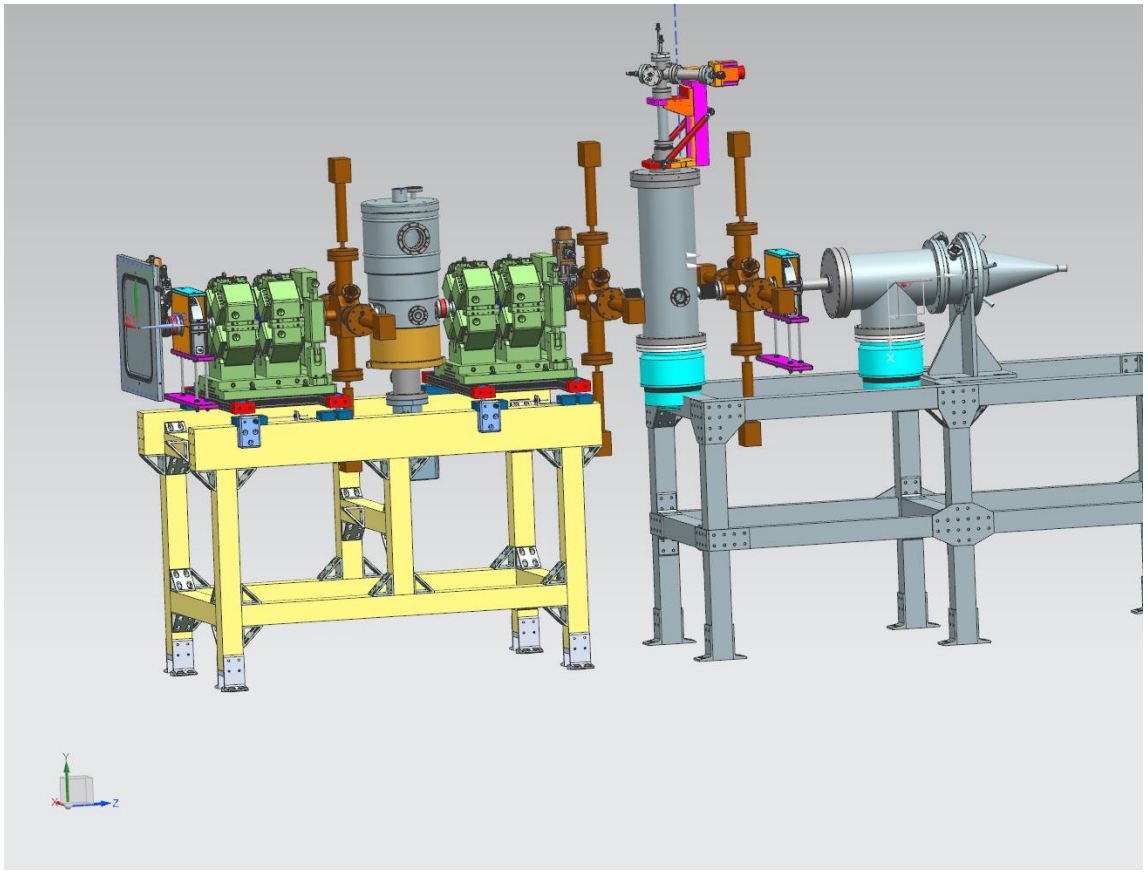
3D model of MEBT 1_1, C. Baffes, S. Oplt.



RFQ Beam Commissioning Line - Short MEBT 1_2 (End of 2015)

- First measurements of beam emittance, Twiss functions
- May try using the LEBT emittance scanner to compare with measurements by slits/scrapers
- First high – power tests
- Use HINS beam dump (from SNS)

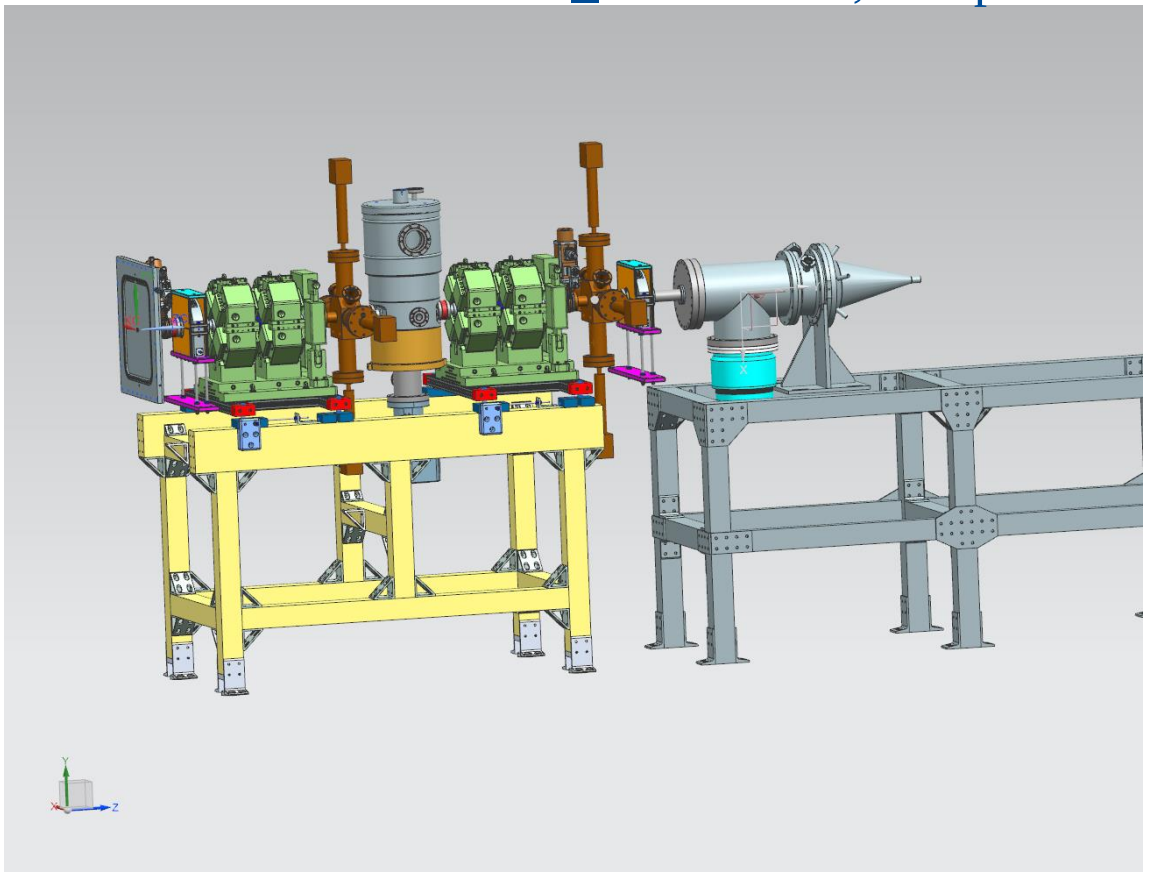
3D model of MEBT 1_2. C. Baffes, S. Oplt.



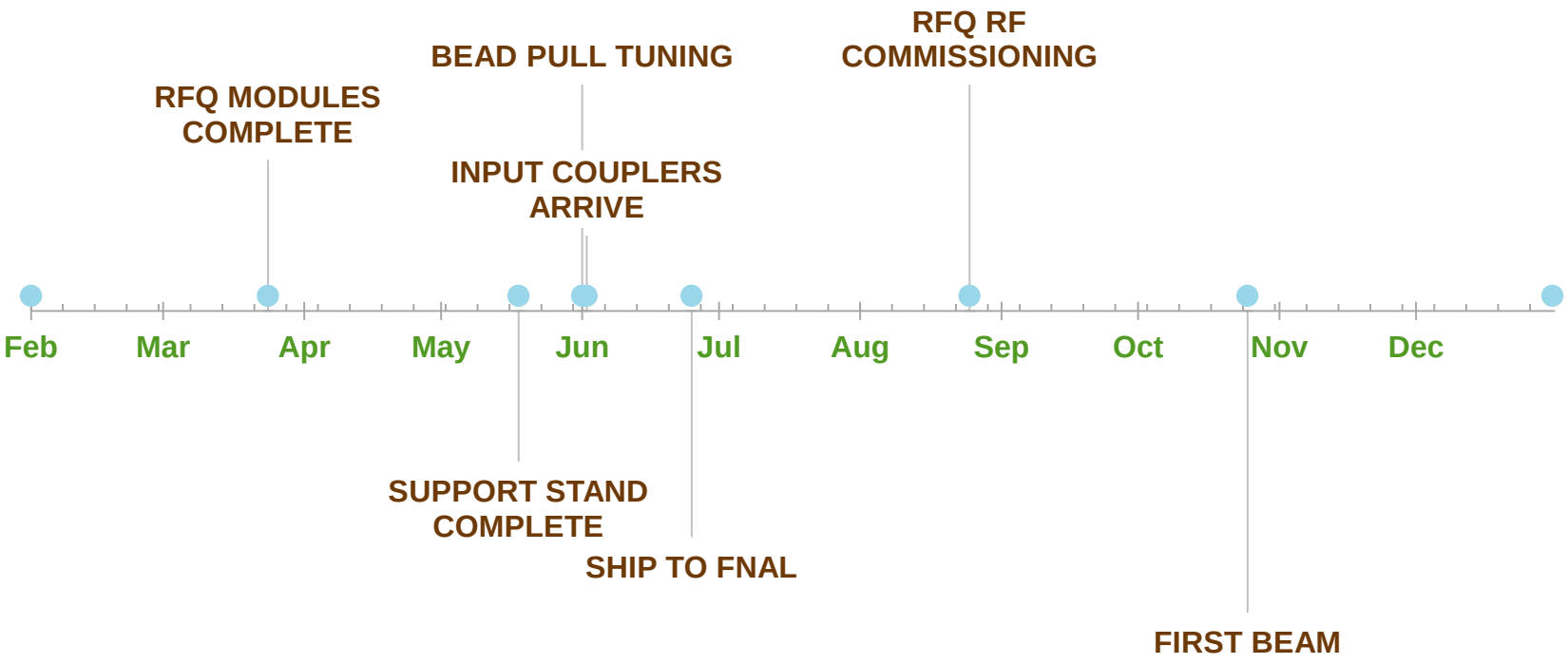
RFQ Beam Commissioning Line - Short MEBT 1_3 (2016)

- 16 kW power with removed “diagnostics section”, to provide larger beam at the dump.

3D model of MEBT 1_3. C. Baffes, S. Oplt.



RFQ Commissioning Schedule (2015)

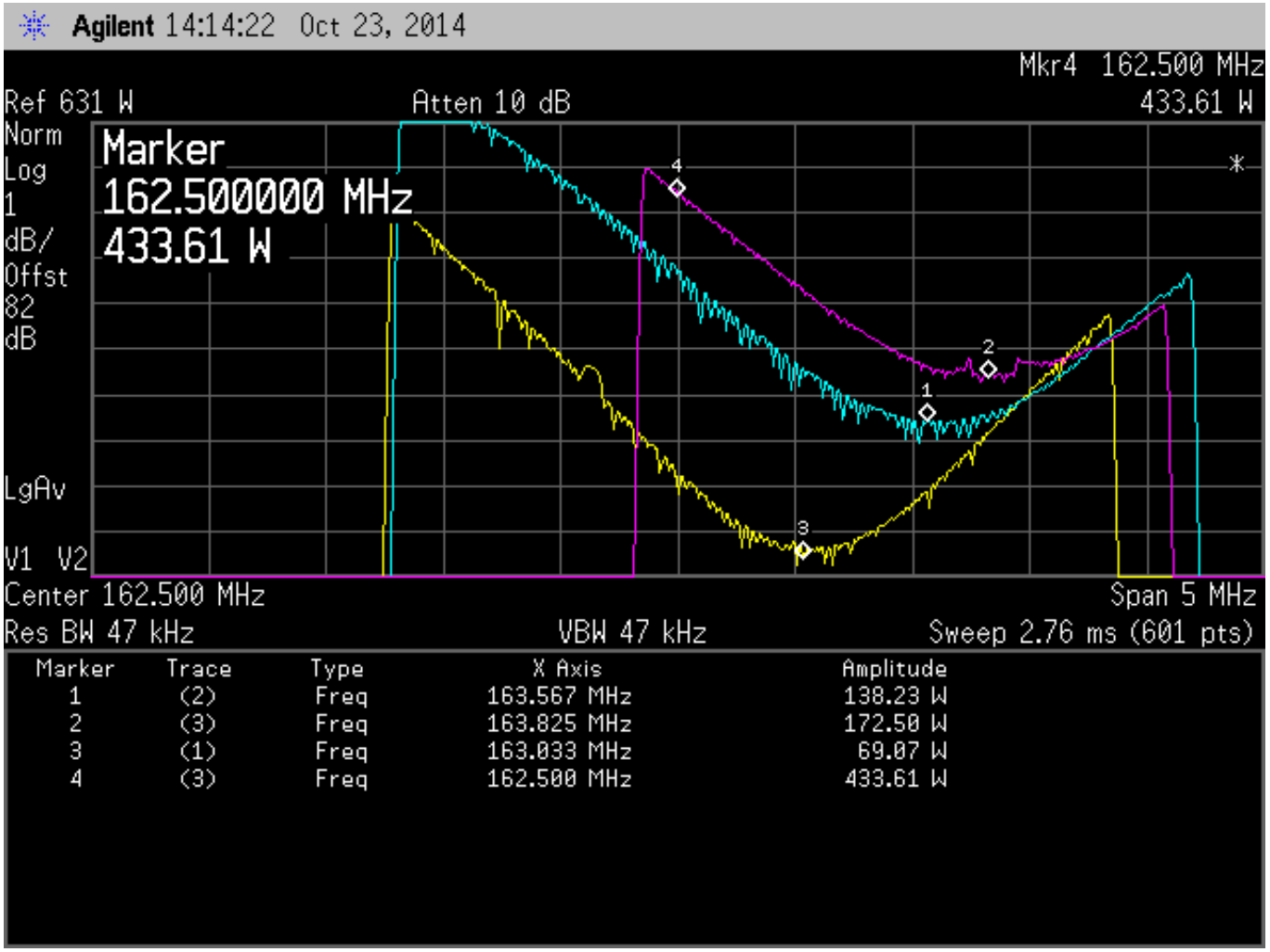


Here is the estimated completion time of major milestones in the RFQ commissioning process.

Extra Slides

Module 1 arriving and being set-up for the repair braze at Bodycote. The braze was run February 26.

Input Water Temperature = 85 F, yellow 60 kW, blue 70 kW, magenta 75 kW amp reflected power into a ***50 ohm load***. (note color scheme different from previous plots due to operator, i.e.me)



Input Water Temperature = 85 F, ***short circuit*** on port 2, amplifier reflected power vs freq. Blue 10 kW, Magenta 20 kW, Yellow 30 kW, markers indicate minimal power and freq. Note there does not appear to be a sharp power minimum.