1.3 GHz TTF-3 Coupler Activities at SLAC

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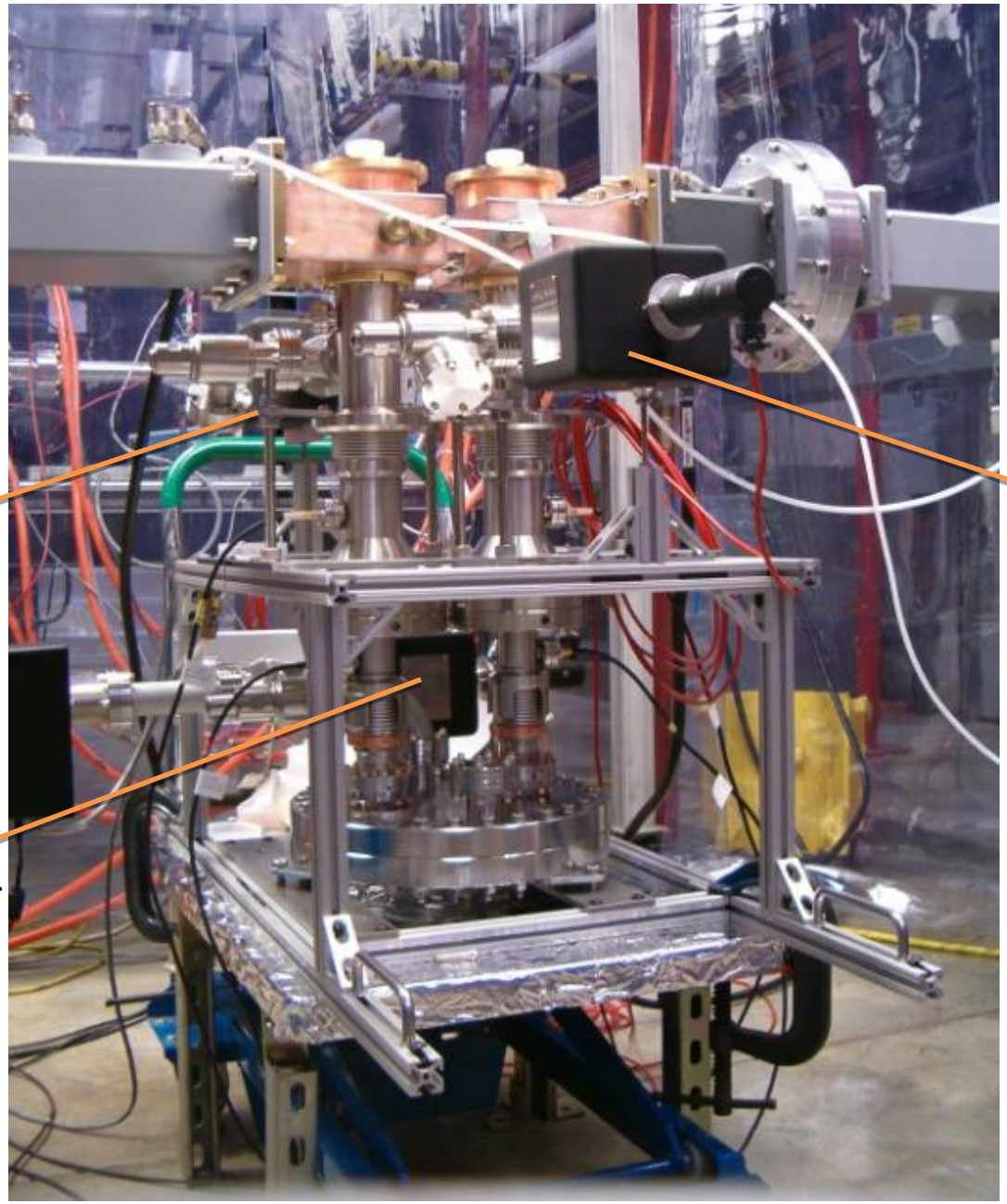
Outline

1. **RF processing results**
2. **Summary of coupler processing**
3. **TTF-3 Coupler RF Thermal Calculations with 15 kW Power**

Coupler Pair at RF Processing Facility



RF Out

Process with vacuum (100uA ~ 1.33e-6 mbar)

RF In

Pump for RF Out Section

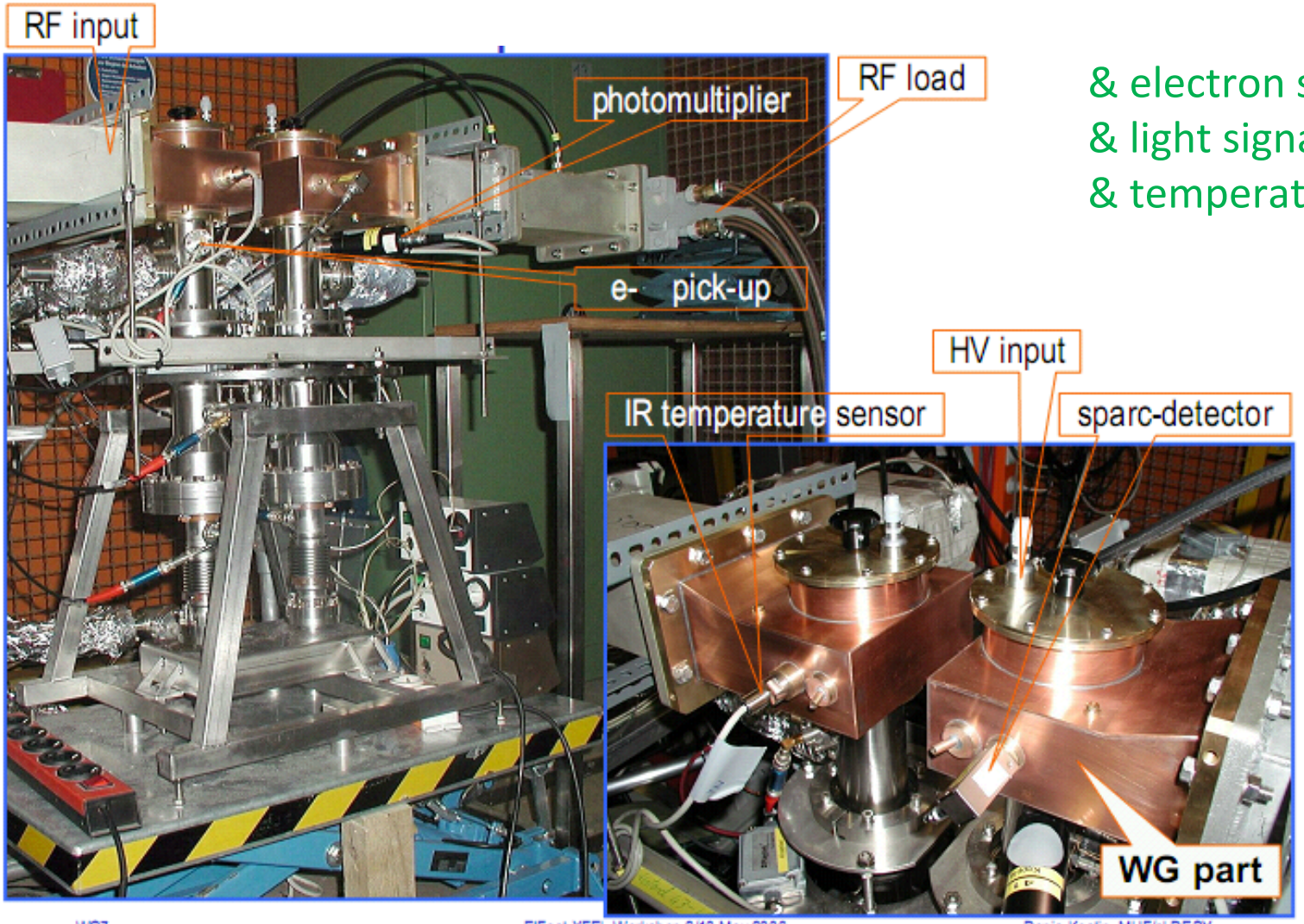
Pump for RF In Section

Pump for Coupler Process Cavity

& electron signal
& light signal
& temperature

DESY Coupler Test Stand

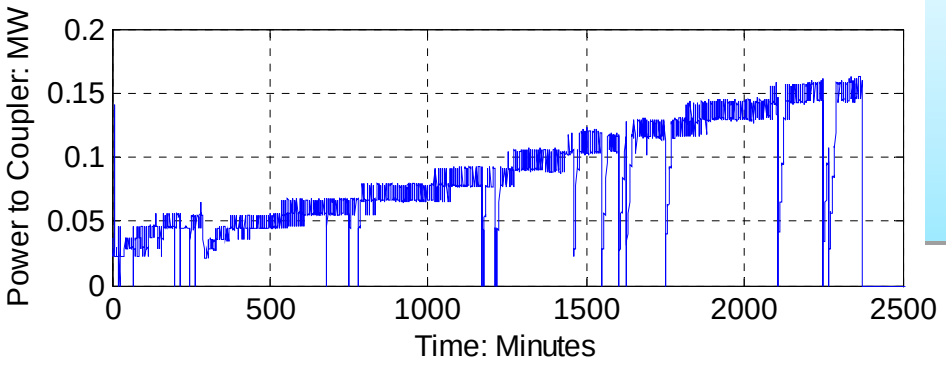
Process with vacuum (1e-6 mbar), electron signal (5mA), light

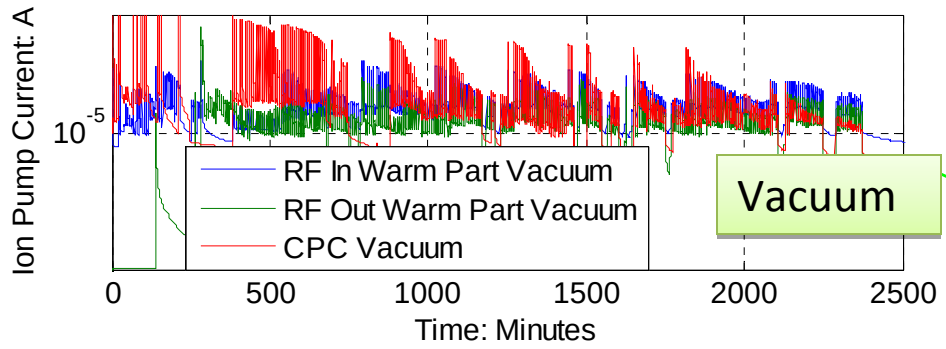


& electron signal
& light signal
& temperature

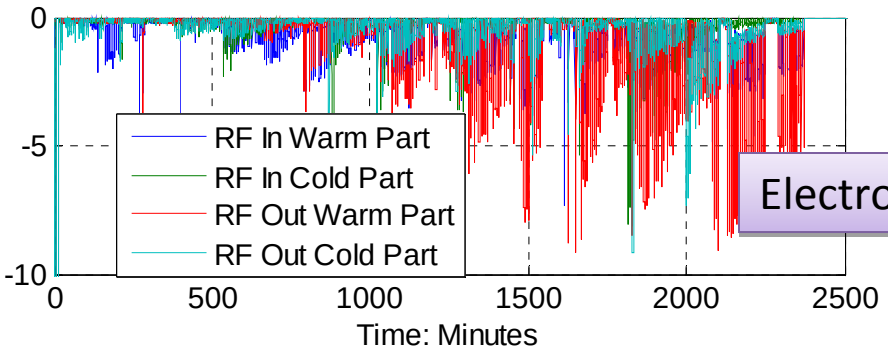
Test Coupler Pair Processing History

Without clean procedure and bake, the coupler power only got up to 200 kW @20 us with 5 Hz repetition freq after ~40 hrs.

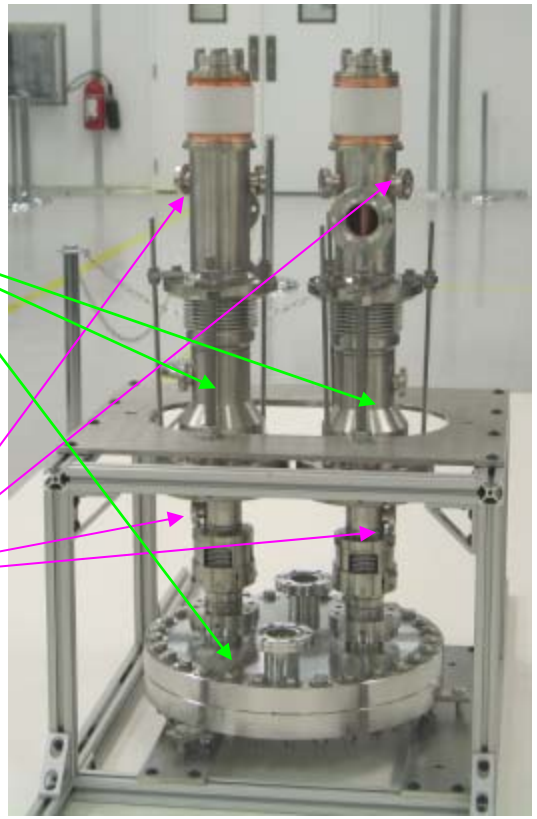




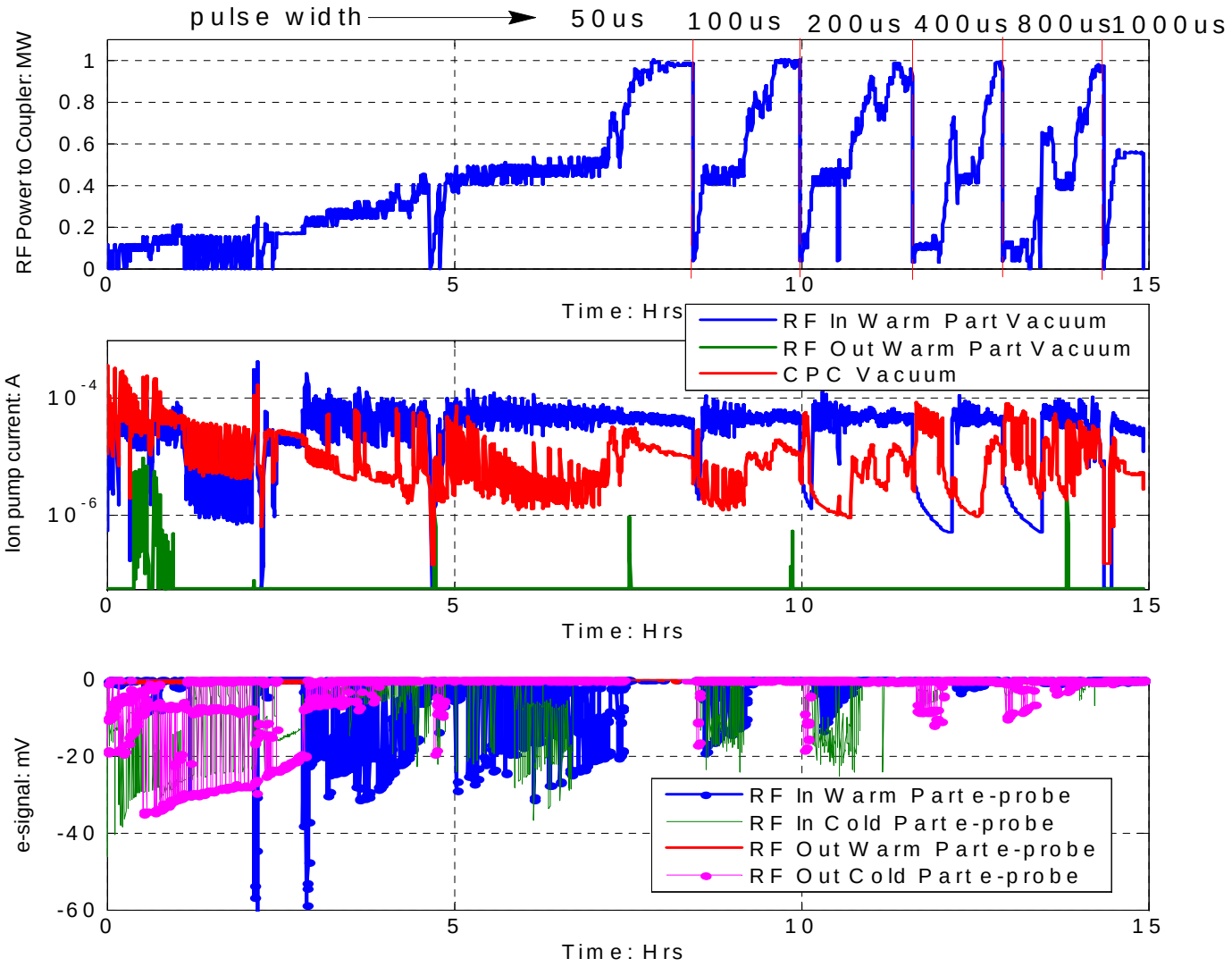
Vacuum



Electron

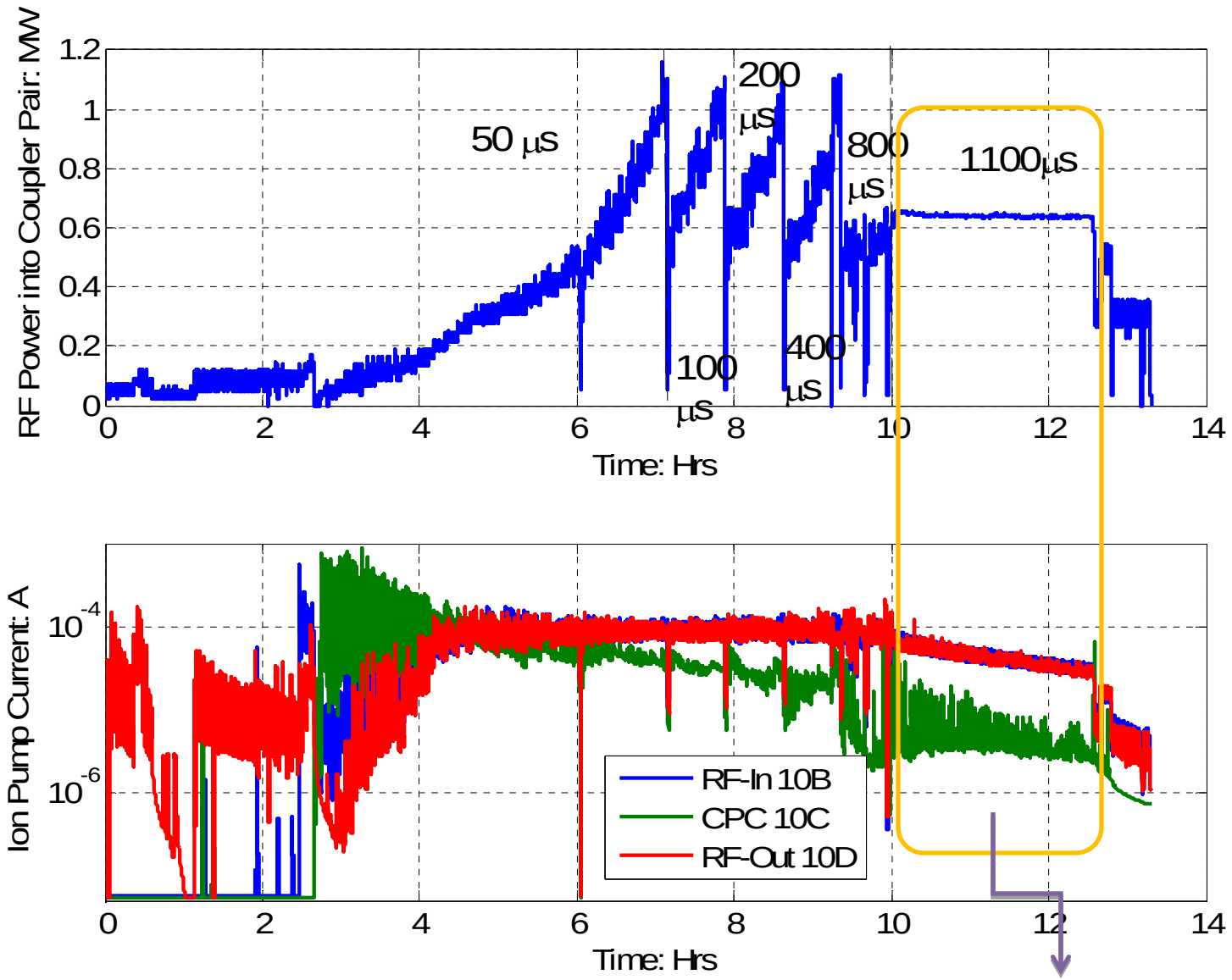


Test Coupler Pair Processing History After Baking



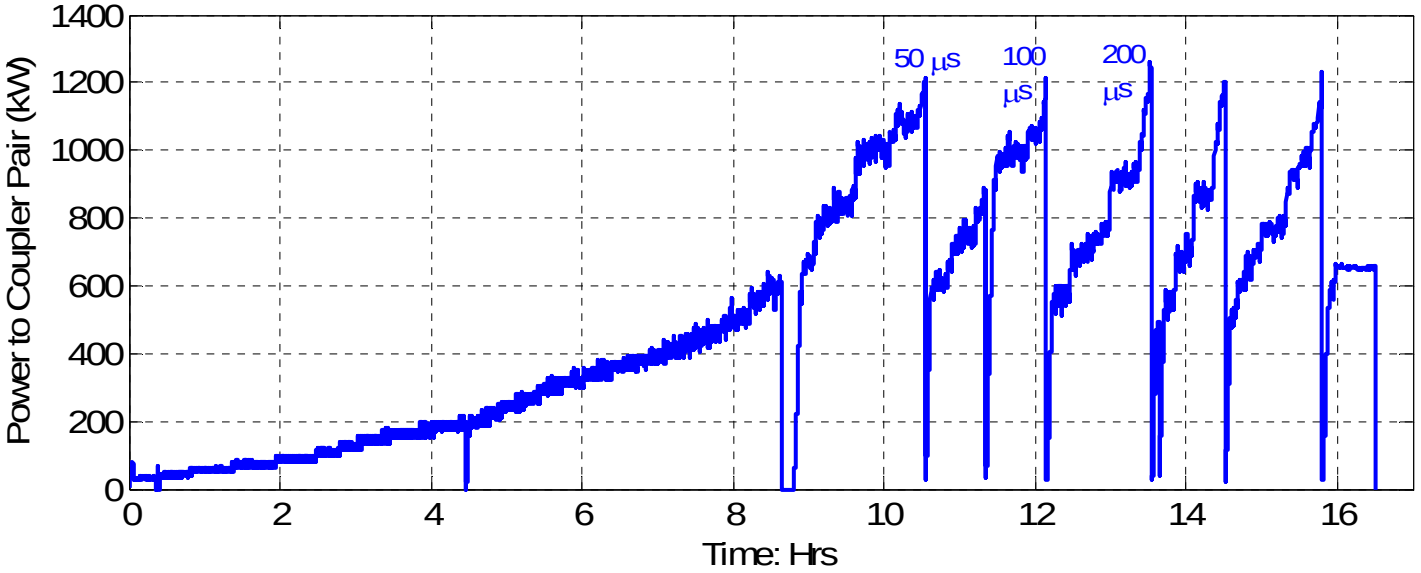
Processed much faster with just baking (assembled in clean area as Class 10 clean room was still under construction)

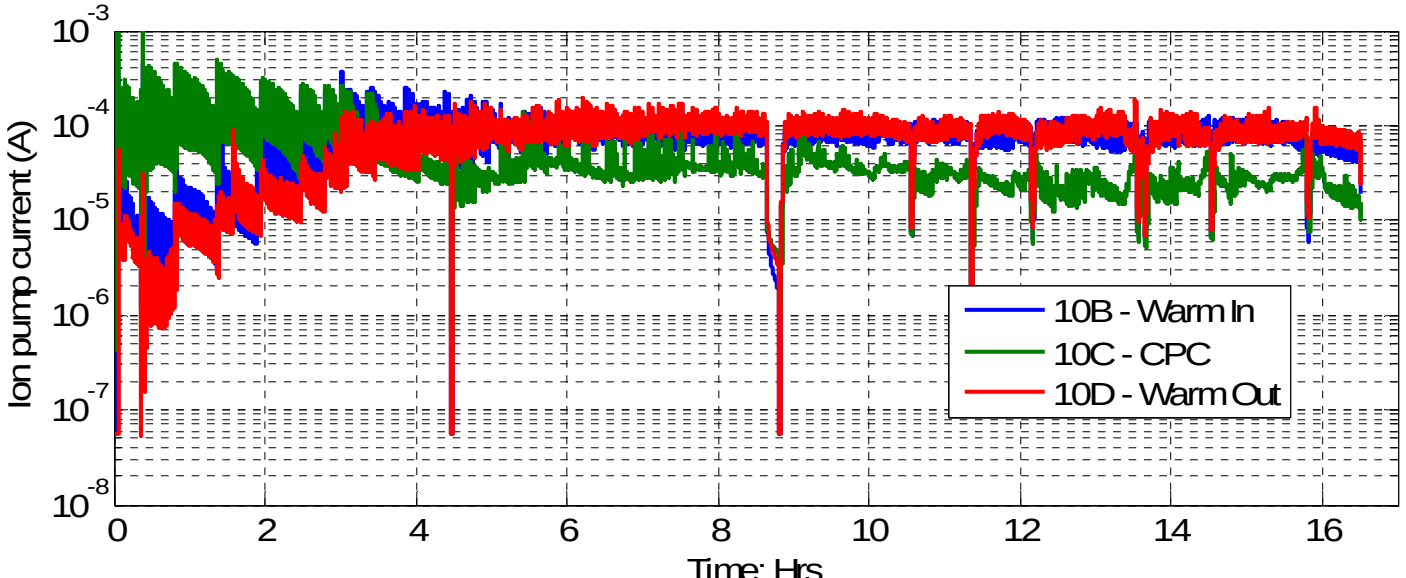
1st Coupler Pair Processing History after Clean and Bake



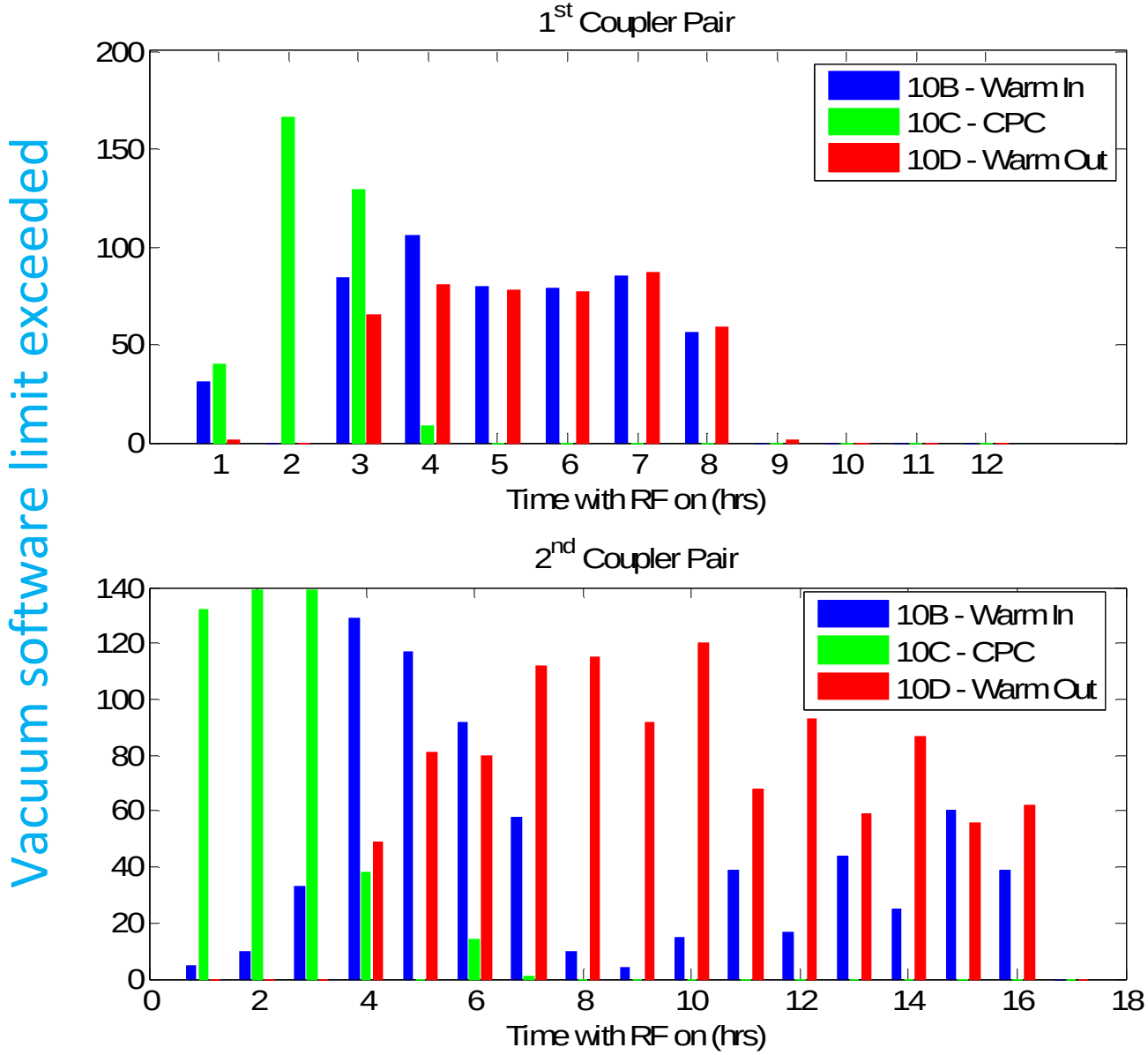
Extended test didn't help much

2nd Coupler Pair Processing History after Clean and Bake

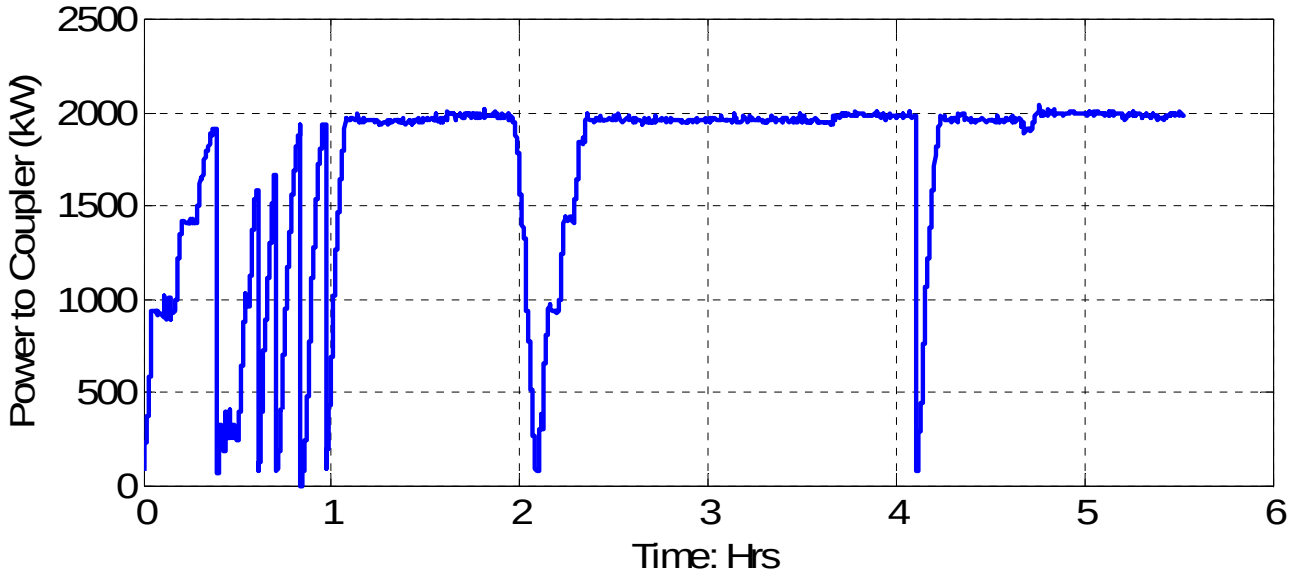


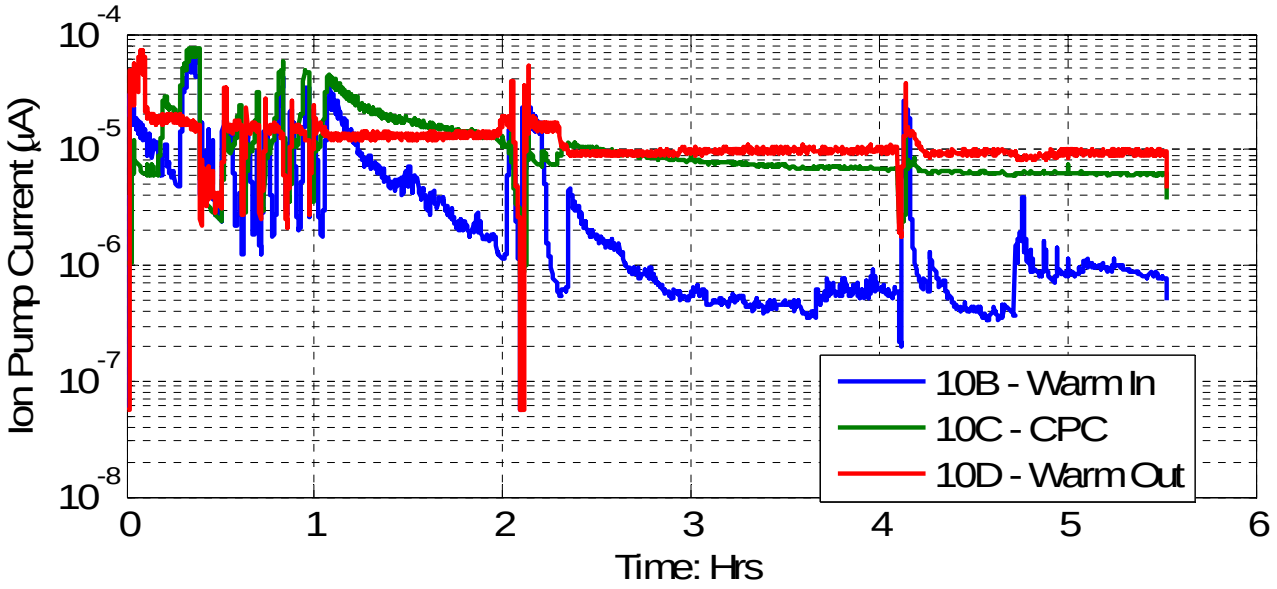


1st and 2nd Pair Vacuum Activity During Processing

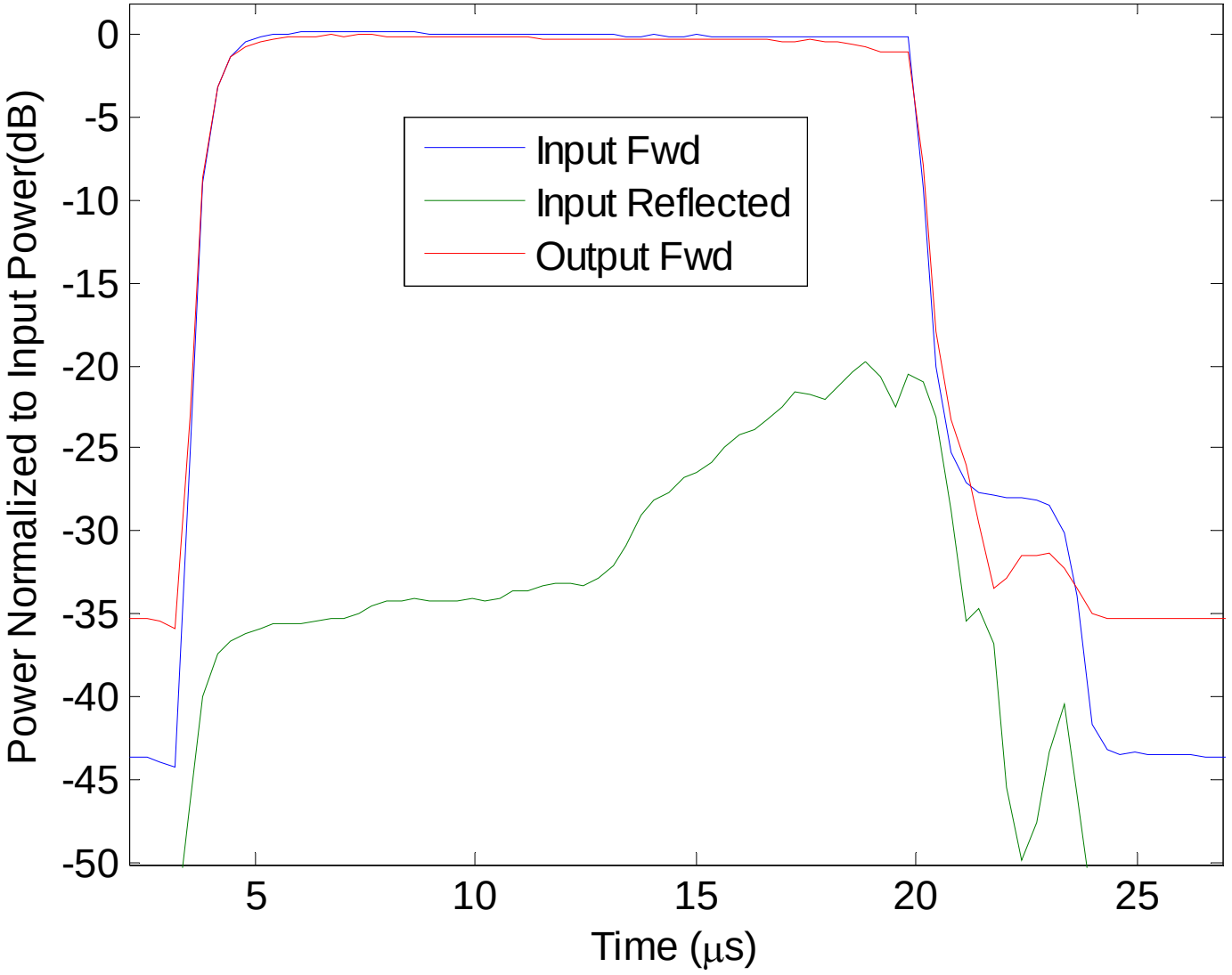


2nd Coupler Pair 2 MW@250 us Test for PX 20 mA Operation

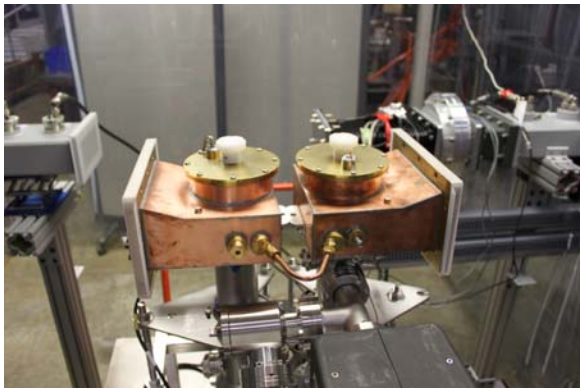


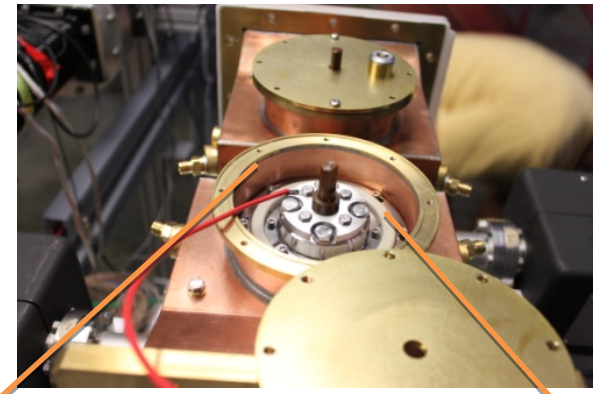


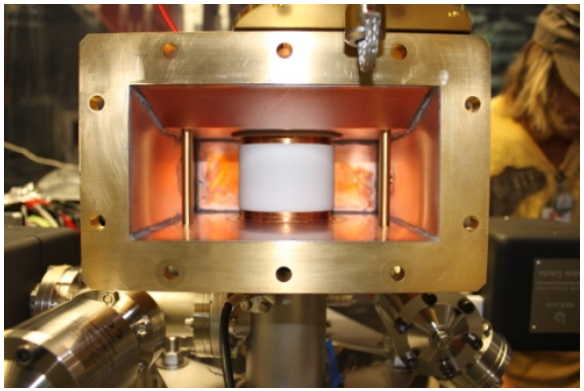
2nd Coupler Pair RF breakdown at 2 MW @ 250 us

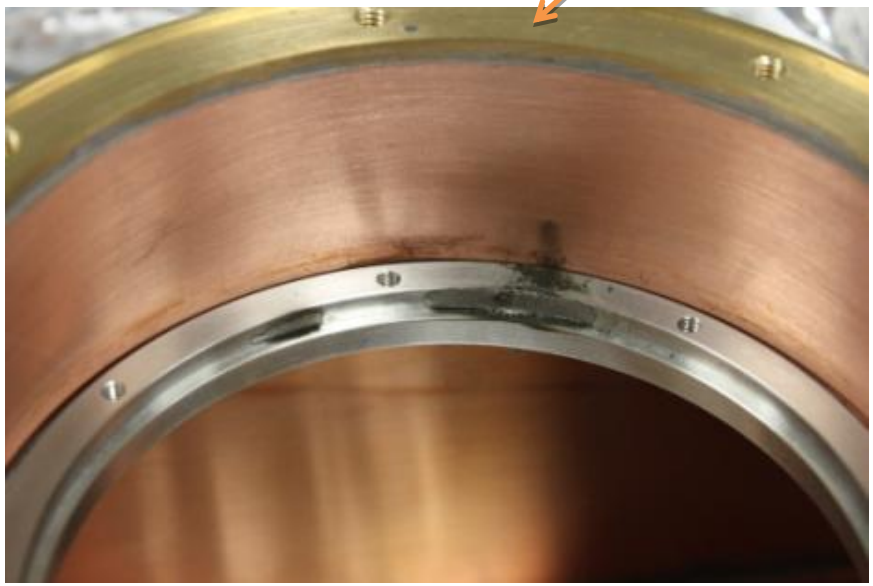


After tests, discovered that the waveguide ‘capacitor’ mating surface in one of warm section had arc’ed





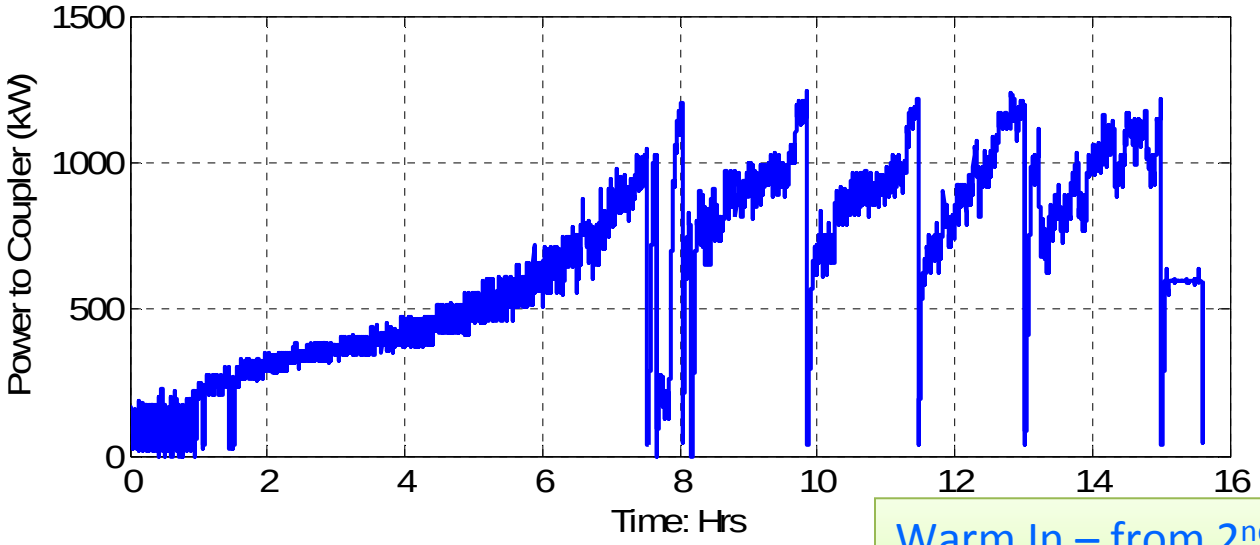




2rd Coupler Pair, Version 2

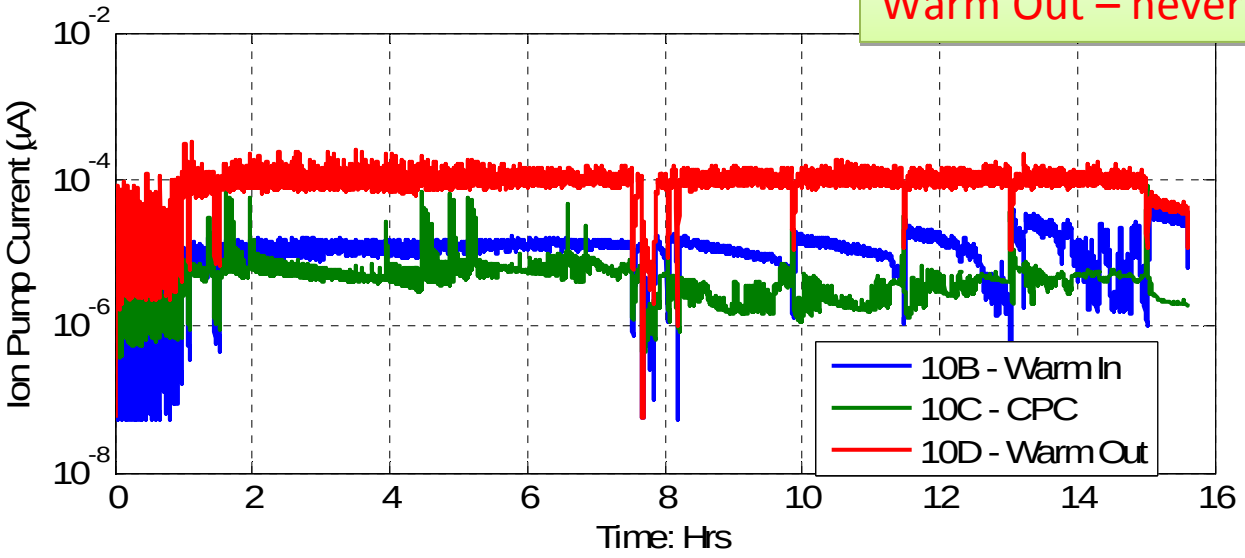
The damaged waveguide was replaced as was a warm section that had a galled bolt when being dissembled (changing to Nitronic bolts). During this period, the other warm section sat in the class 10 clean room exposed to air for a few days. The cold section remained under vacuum.

2rd Coupler Pair, Version 2: RF Processing History After System Re-baked

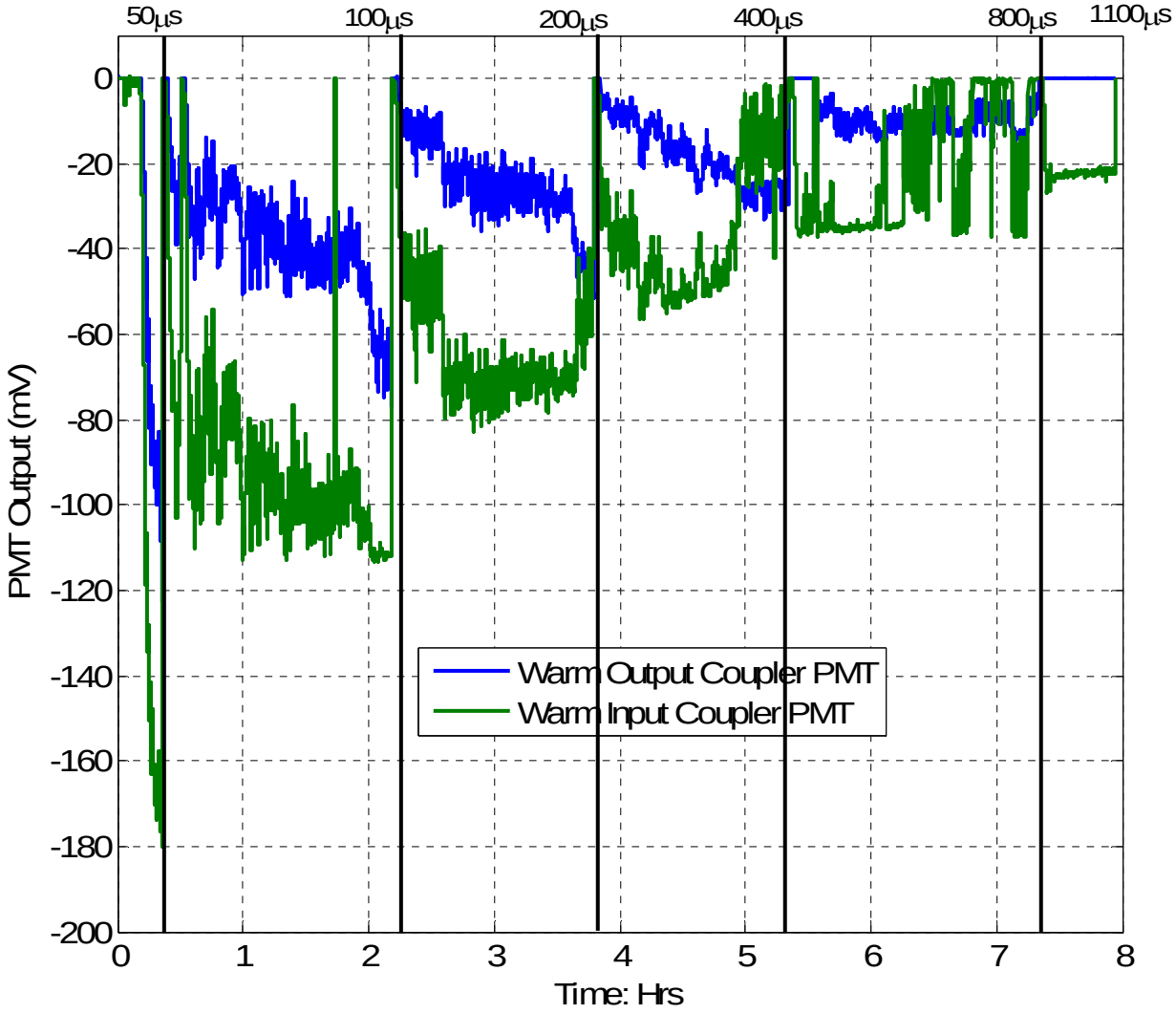


Warm In – from 2nd pair

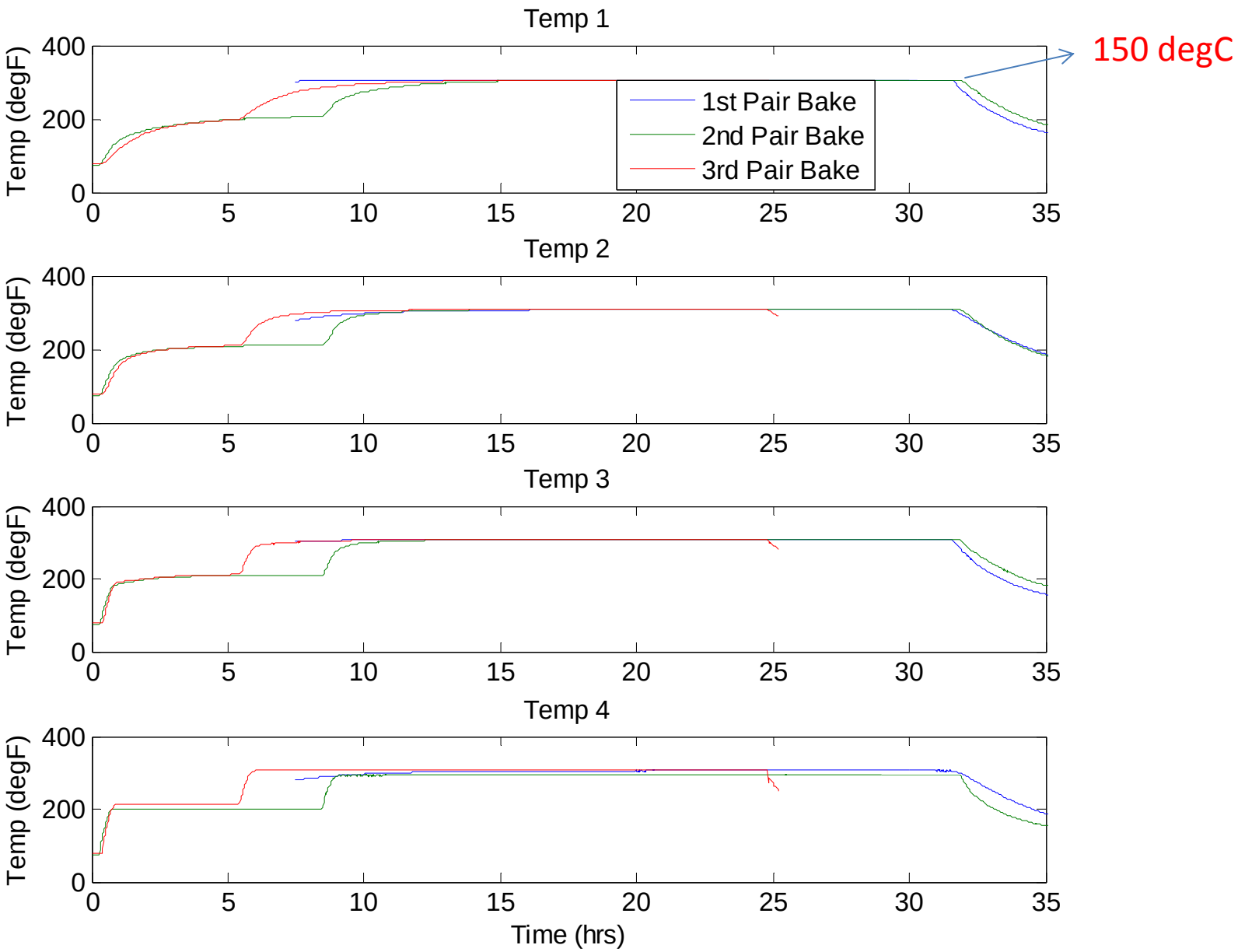
Warm Out – never tested



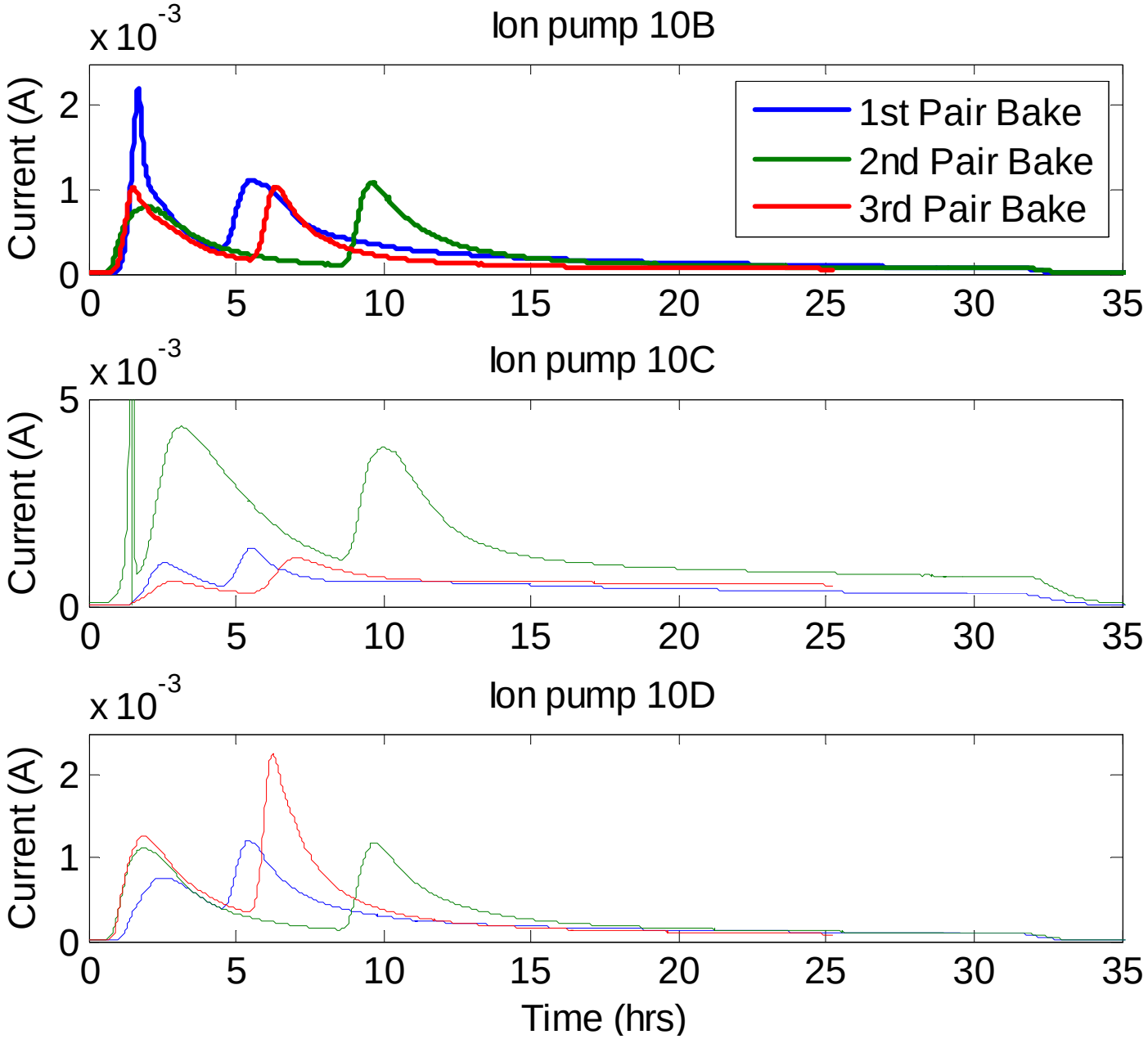
Added PMTs to Look for Arcs in Waveguides



Temperature History During Bakes



Pressure History During Bakes

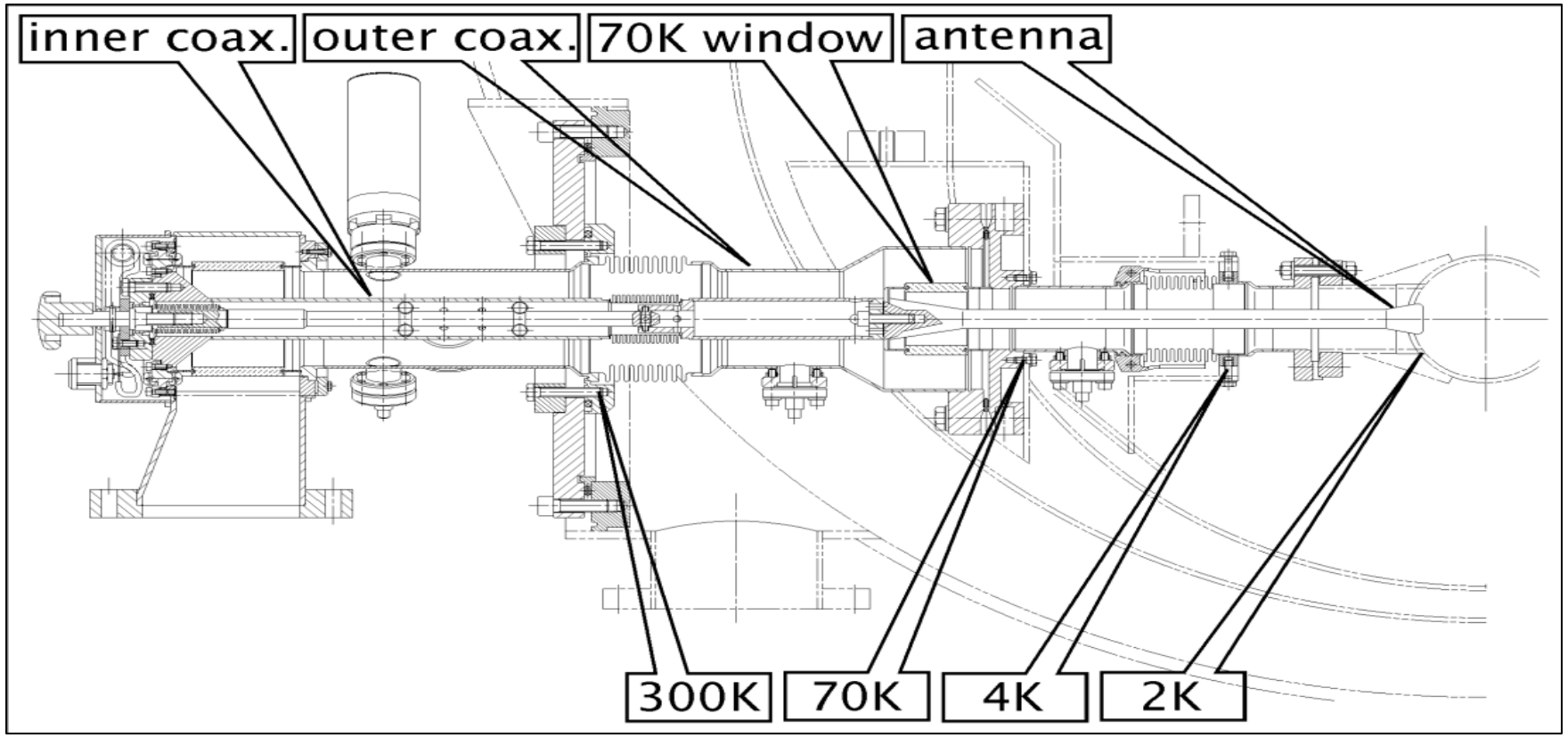


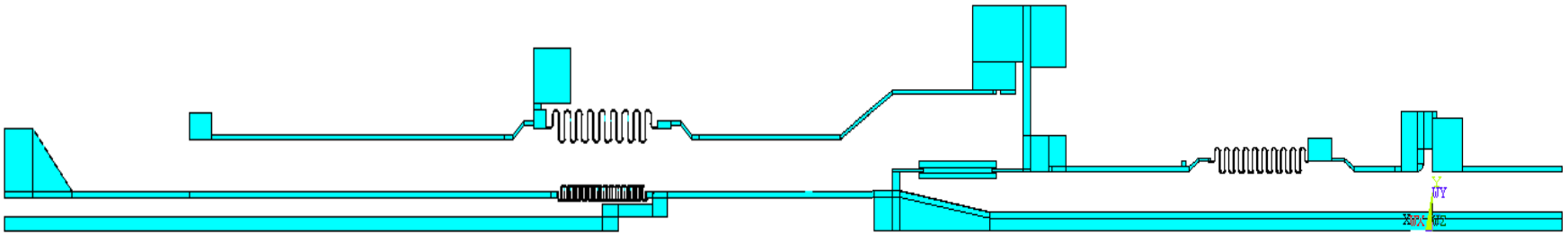
Processing Summary

- Coupler bake very important for fast processing.
- 2 couplers delivered to FNAL, 2 more next week.
- Only one waveguide capacitor had arcing problem (few % at DESY). Add PMTs to monitor for arcs in future tests.
- Warm section ‘remembers’ rf processing even after exposure to air – in-situ processing in cryomodules should go fast.
- Learning about coupler design problems (‘features’) and are making corrections – DESY/Orsay have been very helpful.

TTFIII Coupler Thermal Calculation at 15kW

by Shilun Pei



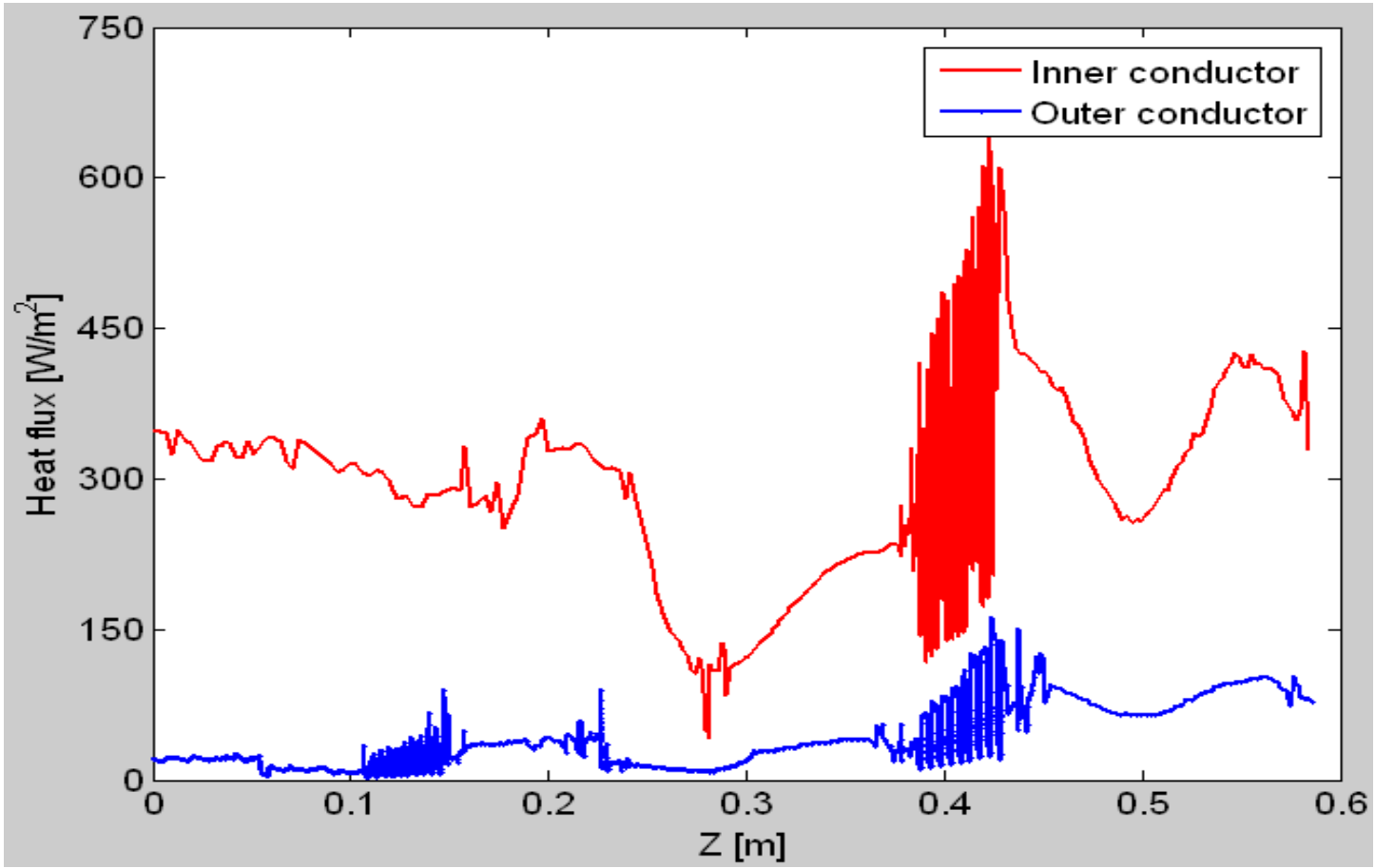


RF Heat Flux Distribution

100µm on inner and 10µm on outer with RRR=100

Dielectric Loss not included in this plot

$H_s^2 * R_s$

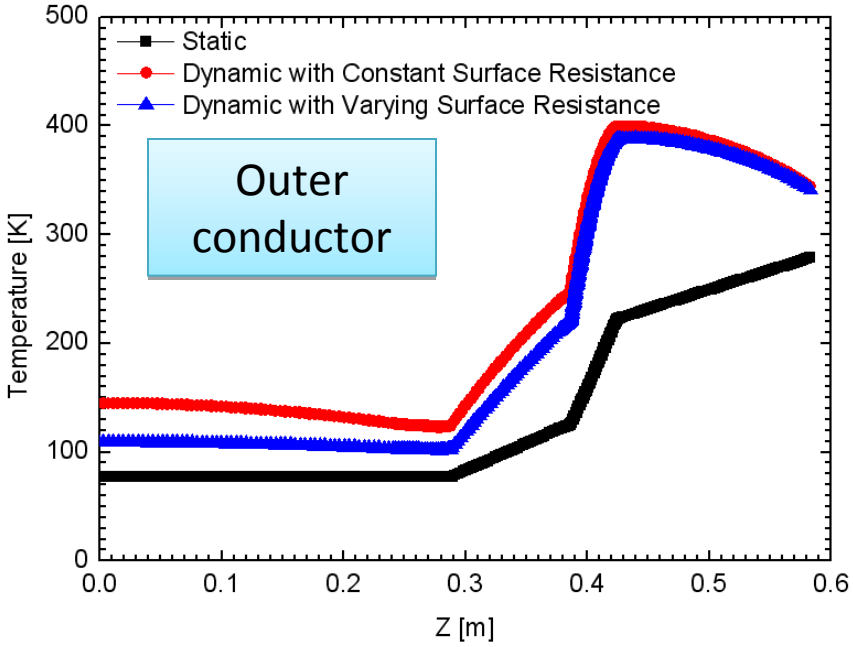


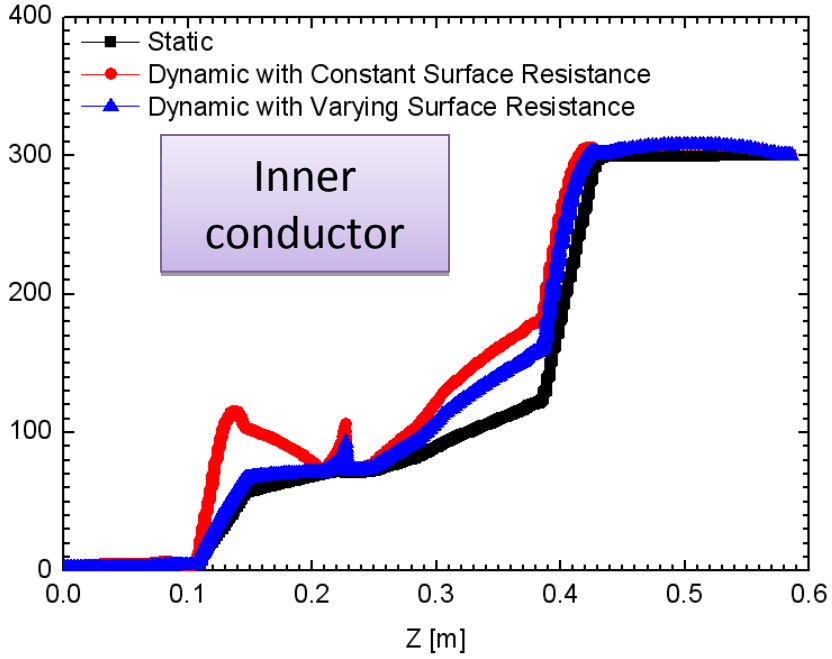
Cold

Warm

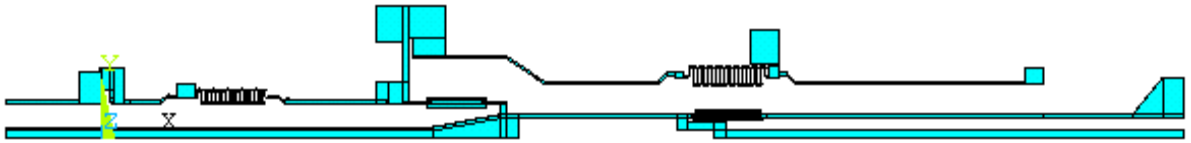
Temperature Distribution for Different RF Loss Calculation Method

100µm on inner and 10µm on outer with RRR=100





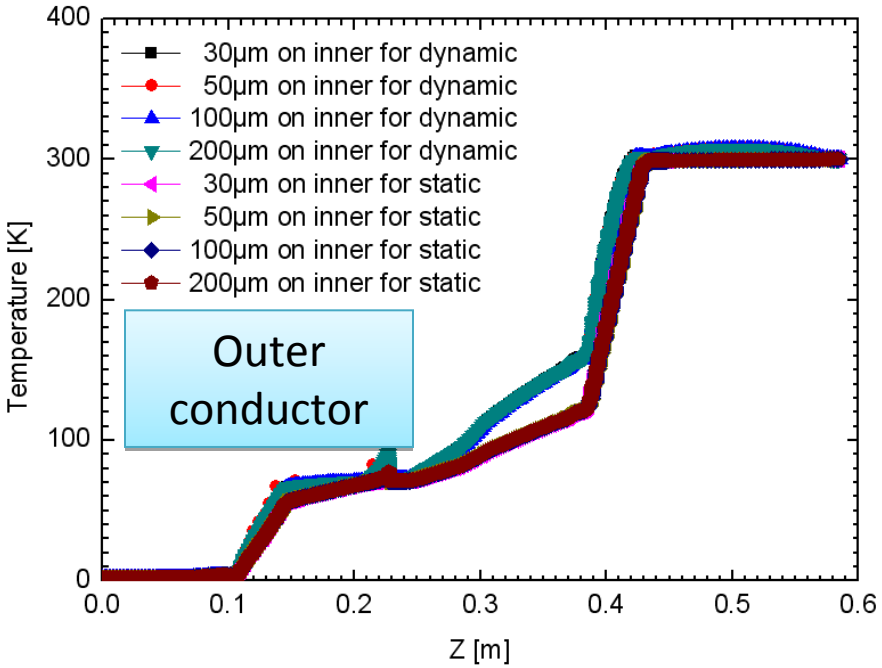
Cold

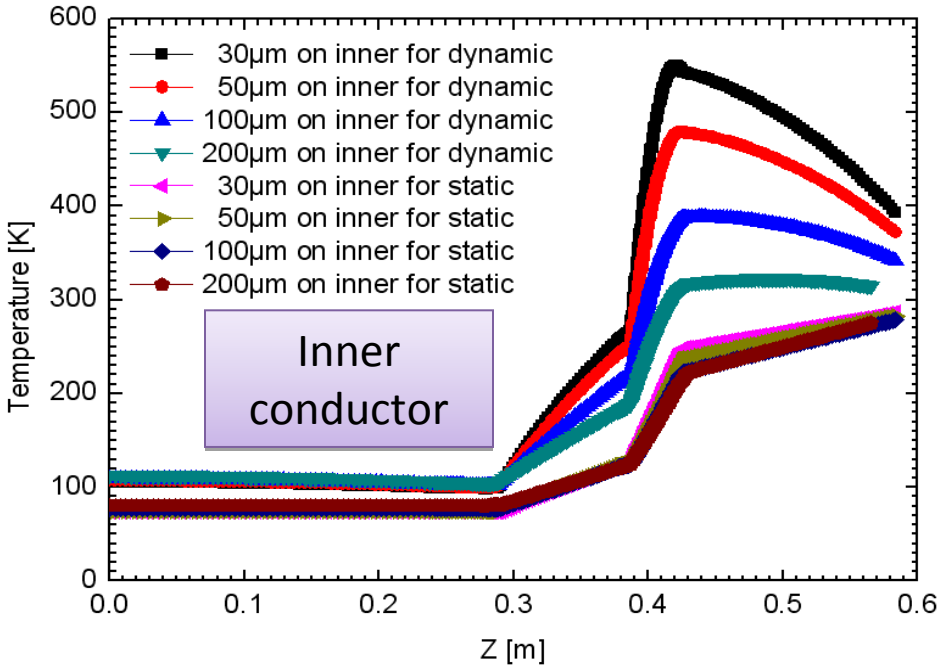


Warm

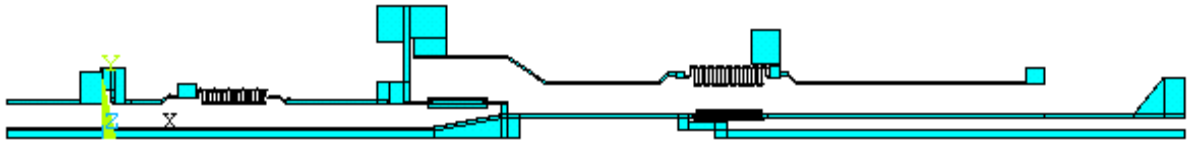
Temperature Distribution with Different Thickness of Copper Coating

resistance dependence on temperature considered





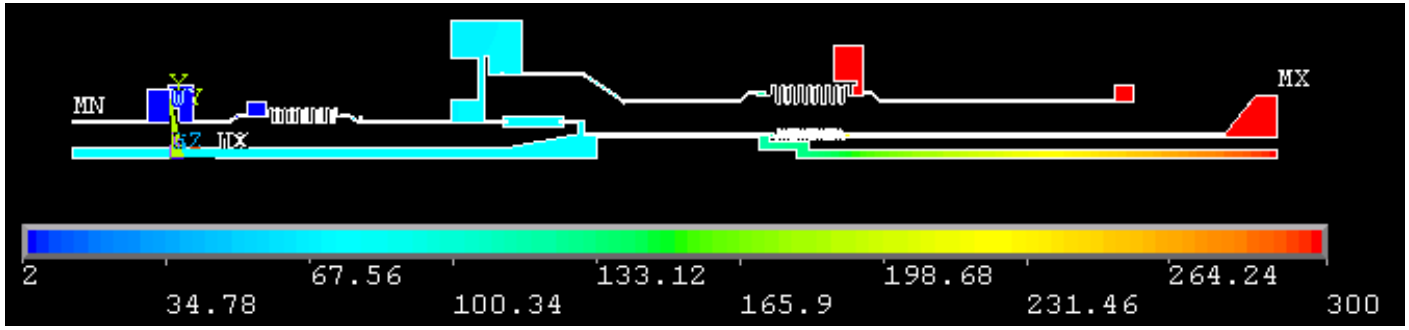
Cold



Warm

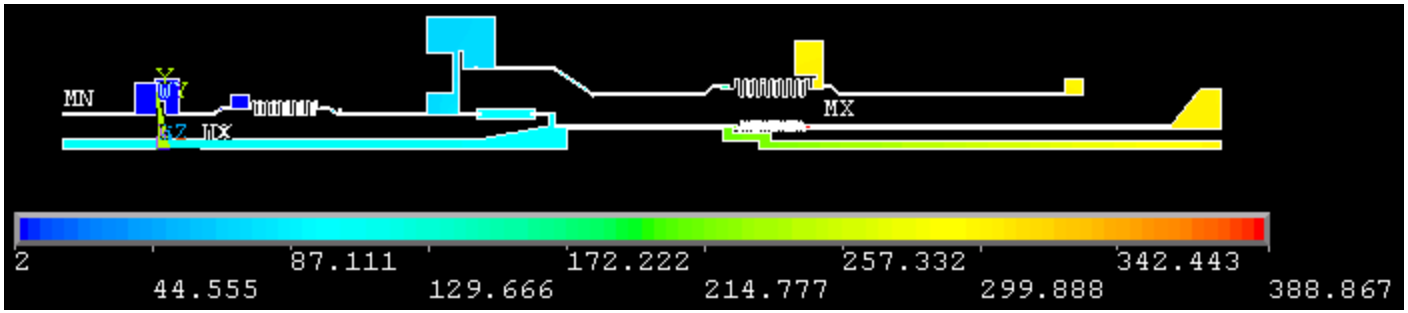
Temperature Distribution for 100µm on Inner and 10µm on Outer (RRR=100)

Static Case



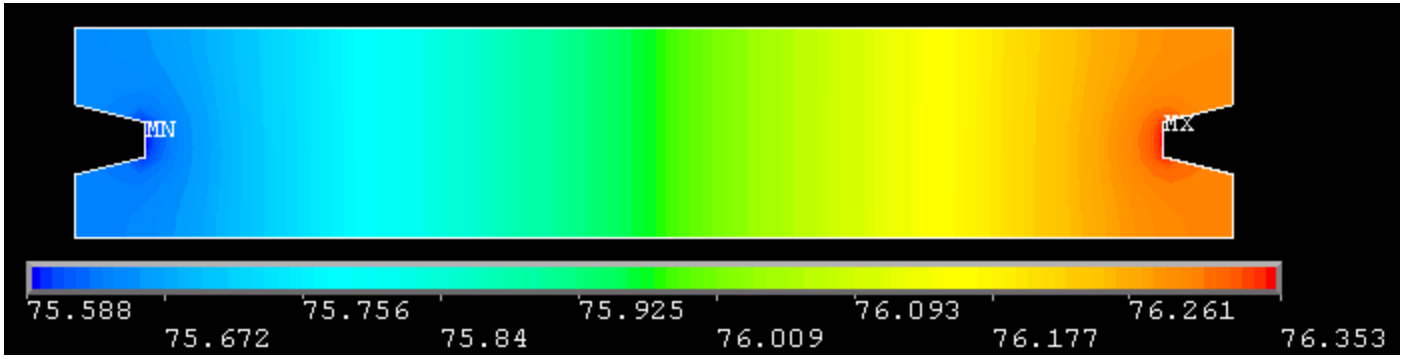
Dynamic case

Surface resistance dependence on temperature considered



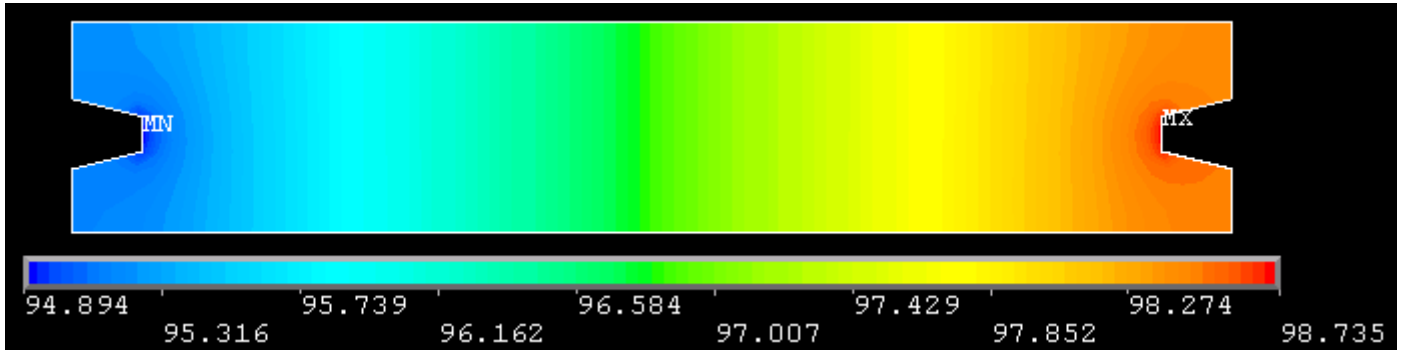
Window Temperature Distribution for 100µm on Inner and 10µm on Outer (RRR=100)

Static Case



Dynamic case

Surface resistance dependence on temperature considered



Power Losses for Copper Coating with Different Thickness and RRR=100

For dynamic case, surface resistance dependence on temperature was considered.

Copper Coating		Case	P	P	P_{in}	P_{out}	P_{win}	P_{total}	T_{max}, K
In	Out		2K	4K	70K				
30	10	ST	0.044	0.438	1.618	0.992	0	3.092	300
30		DYN	0.208	0.309	8.311	2.864	1.801	13.493	550
50		ST	0.044	0.438	2.016	0.993	0	3.491	300
50		DYN	0.208	0.309	8.494	2.851	1.799	13.661	479
100		ST	0.044	0.439	2.928	0.992	0	4.403	300
100		DYN	0.208	0.308	8.453	2.819	1.796	13.584	388
200		ST	0.044	0.439	4.506	0.991	0	5.980	300
200		DYN	0.209	0.312	8.059	2.834	1.808	13.202	323

Comparison with FNAL Simulations

- Maximum temperature is around 20K lower in our case than FNAL results (550K vs 570K, 479K vs 496K, 388K vs 415K, 323K vs 345K). In general, they are consistent.
- Static load is higher in our case (3.092W vs 2.205W, 3.491W vs 2.565W, 4.403W vs 3.375W, 5.980W vs 4.865W).
- Dynamic load is lower in our case (13.493W vs 21.058W, 13.661W vs 21.198W, 13.584W vs 21.488W, 13.201W vs 21.498W), ~2/3 of FNAL results. For FNAL results, what they mean for dynamics is also dynamic plus static (be careful).
- Strictly speaking, dynamic load is not always constant because of the complicate nonlinear temperature dependence of electric conductivity and thermal conductivity.
- In our results, only RRR=100 case was calculated. In addition, only few points (~10-12) from the material property curve were used, results may have some error. The power reflection is relatively big.
- Need better material property table and reduce the power reflection by modifying dimensions.