

Conditioning of 120 KW CW 1.3 GHz High Power Couplers for the bERLinPro Energy Recovery Linac

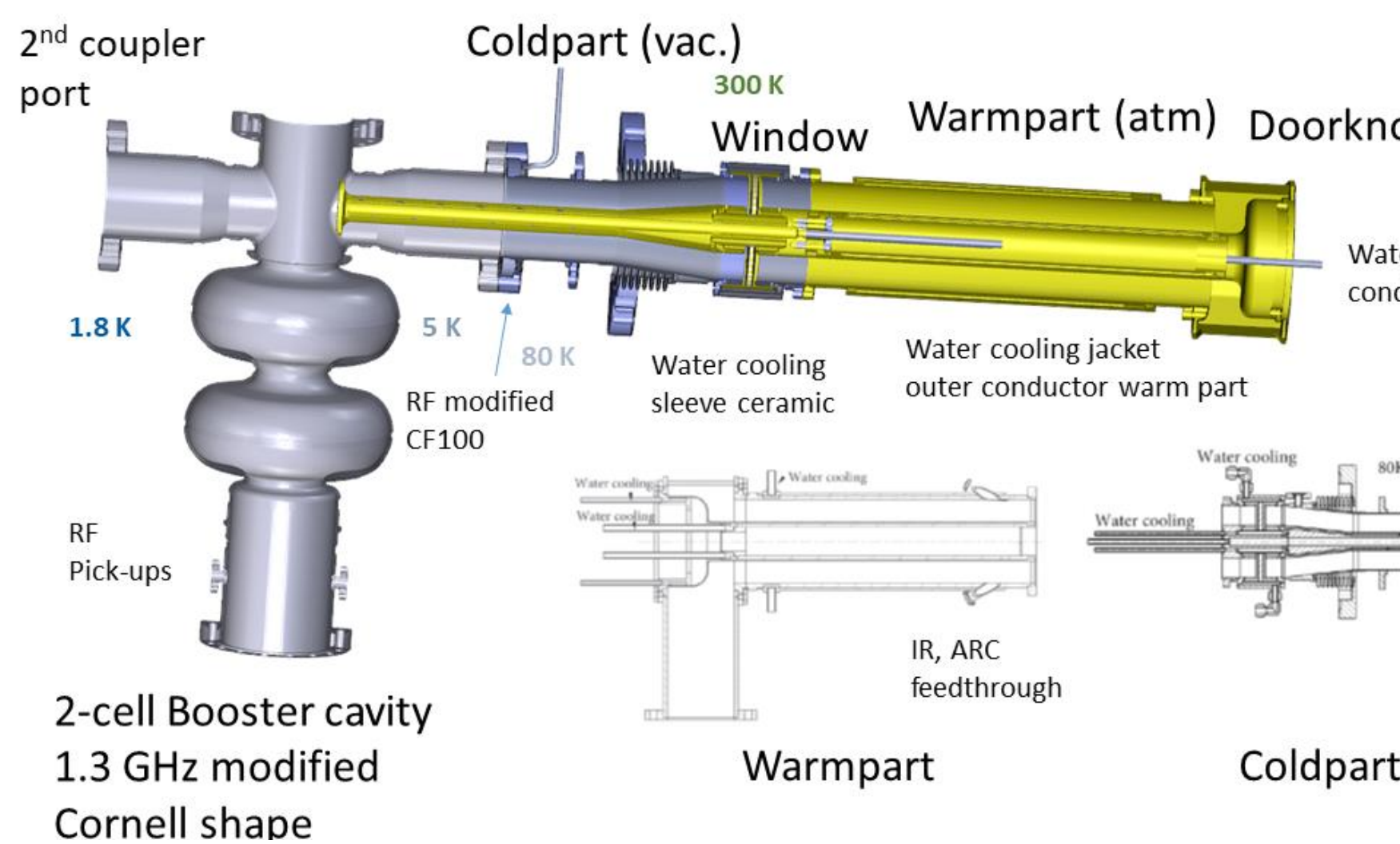
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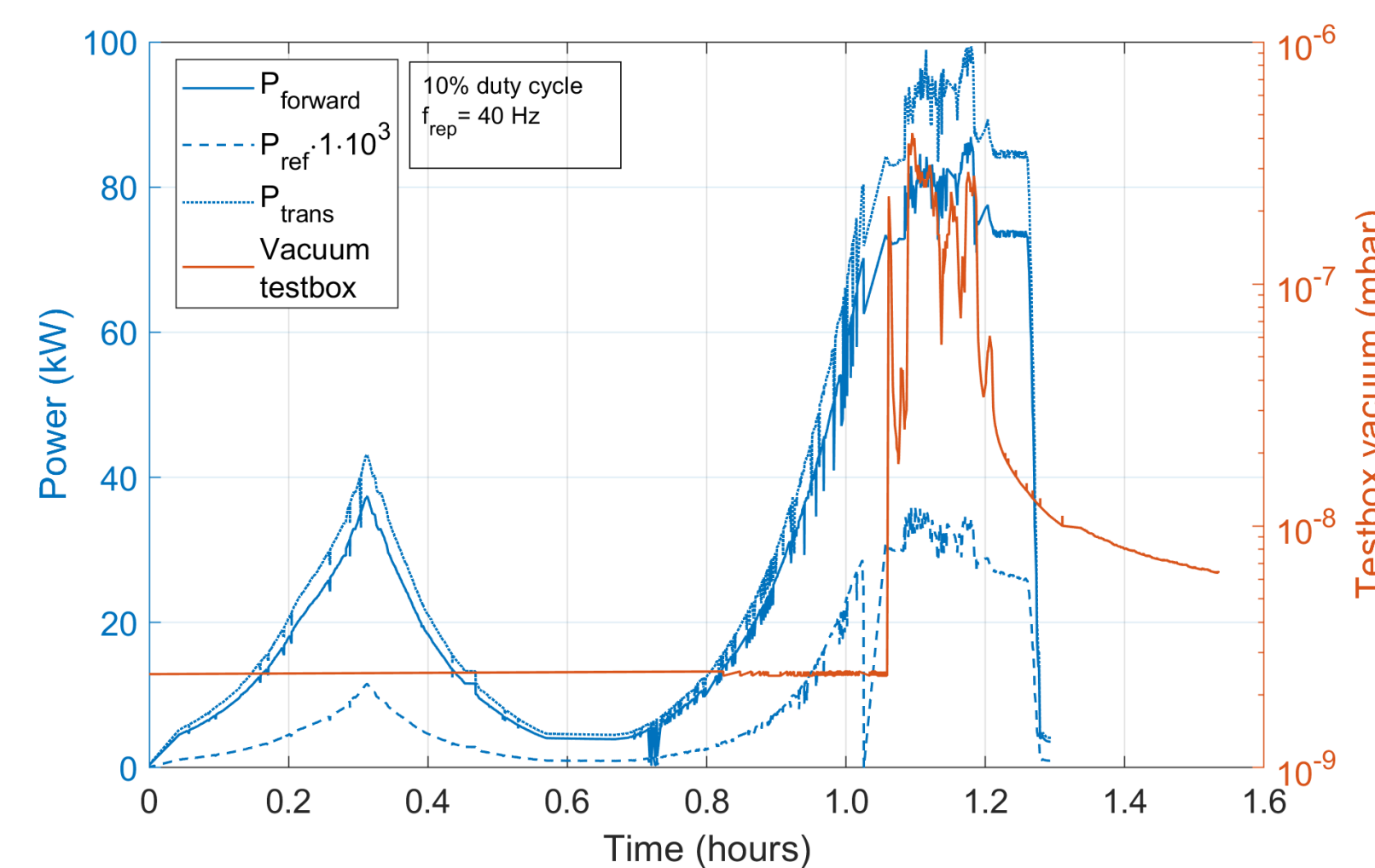
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Coupler design: A modification of KEK's C-ERL design with a new type of antenna tip for increased coupling with flush at beam tube to minimize coupler kicks and emittance dilution: Fixed coupling, single window, no inner RF exposed bellow



| Parameter | at 100 mA | at 6 mA |
|-------------------|--------------------|---------------------|
| Loaded Q | $1.05 \cdot 10^5$ | $1.74 \cdot 10^6$ |
| $f_{1/2}$ | 6.2 kHz | 374 Hz |
| V_{acc} | 0.56, 2.1 MV | 0.56, 2.1 MV |
| E_0 (MV/m) | 4.833, 19 | 4.833, 19 |
| Φ_{acc} | -90, 0 deg | -90, 0 deg |
| Penetration depth | 2 mm | -18 mm |
| $P_{forward}$ TW | 3.4, 220 kW | 0.2, 13.8 kW |
| $P_{forward}$ SW | 3.4, 54 kW | 0.2, 3.45 kW |

Booster operation: For the first stage with SRF Gun 1, delivering 6 mA max. at design energy and 10 mA at 2 MeV, the couplers will be operated at higher Q_L by installing a distance ring. Still, the couplers will be conditioned to 120 kW TW CW at later stage, when a high power 100 mA Gun is available.

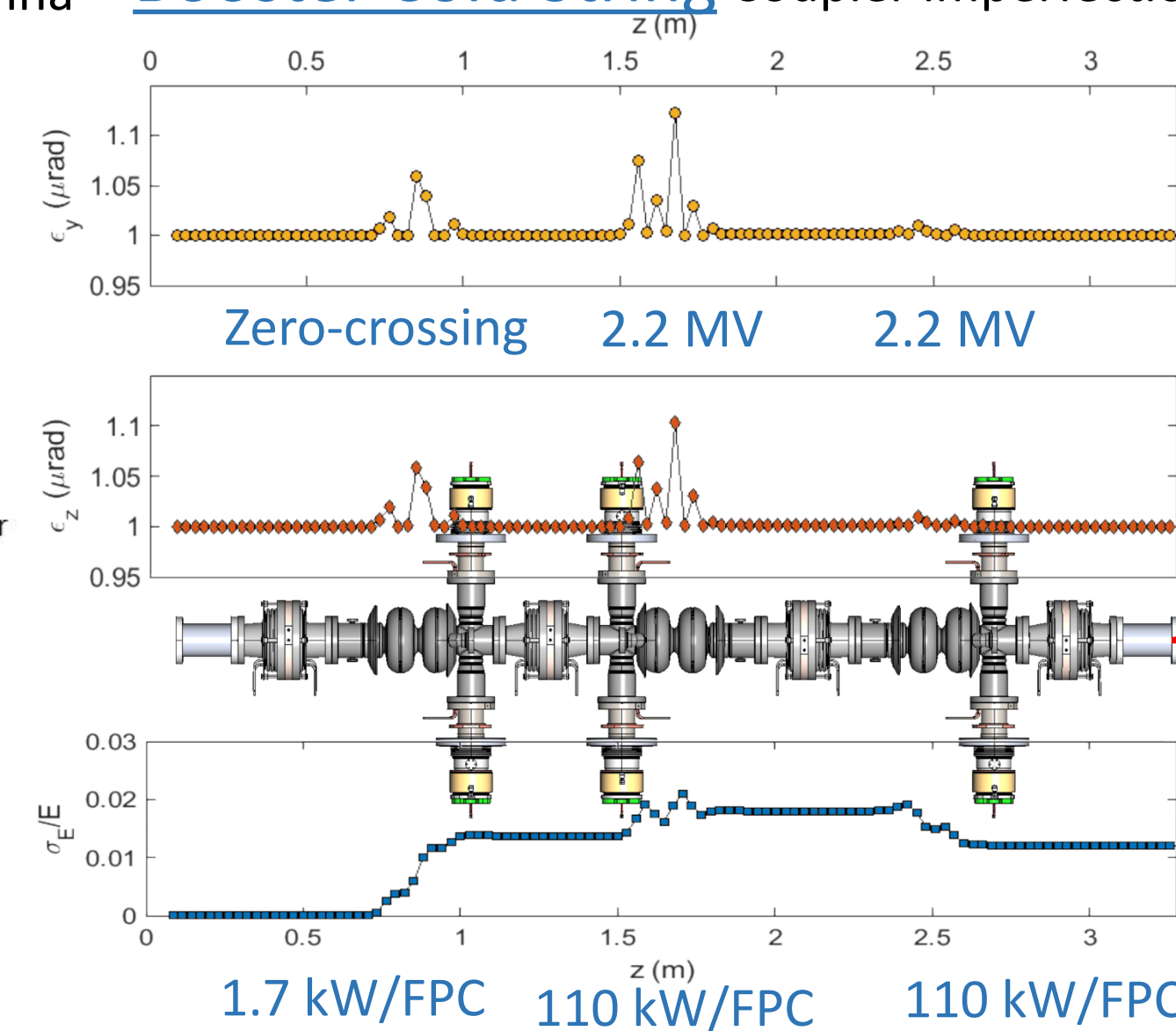


Results 1st pair (pre-series coupler)

After some pre-conditioning during teststand assembly, conditioning went smooth reaching 90-95 kW in TW mode at 10% duty cycle and in the following 40 kW in CW TW and 17 kW CW in SW condition. More was in reach, but the first coupler pairs are conditioned for stage 1 operation. Multipacting did not occur during the whole test series.

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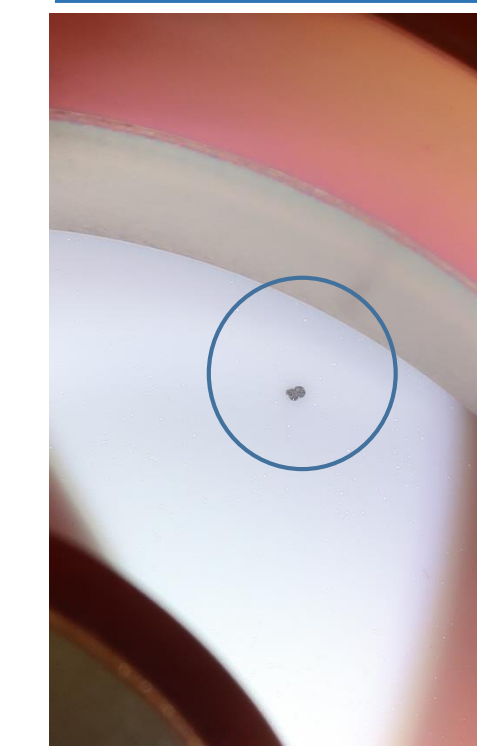
Booster Cold String Coupler imperfection's influence on emittance increase due to coupler kick fields below 1% simulating with data received by CMM measurements of the Booster cavity Coupler ports and expected variations from the couplers themselves (FAT reports).



Status of the project/facility:

- This year, the commissioning of the 50 MeV, 100mA bERLinPro Energy Recovery Linac test facility will resume.
- These days, the Gun module is being prepared for reassembly, after both available cavities underwent an extensive refurbishment program (see : talk WEOCAV07 by Y. Tamashevich)
- Currently, the high power couplers are being conditioned, to be prepared for injector Booster cold string assembly
- After conditioning, the couplers are stored in dedicated N2 containers to preserve the conditioning
- In total eight couplers have been fabricated by Canon Electron Tubes and devices (cold part) and FMB Berlin (warm part)
- Assuming no major failure, those couplers will be tested in four pairs. An assignment, which coupler will go to what cavity in the module will be based on cavity performance and geometry variation of coupler port, coupler performance and its own geometry variation

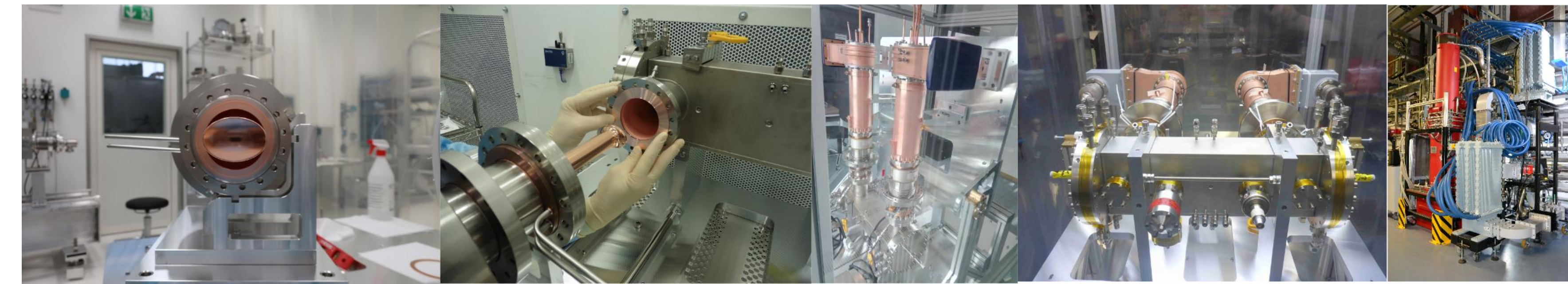
Problems found



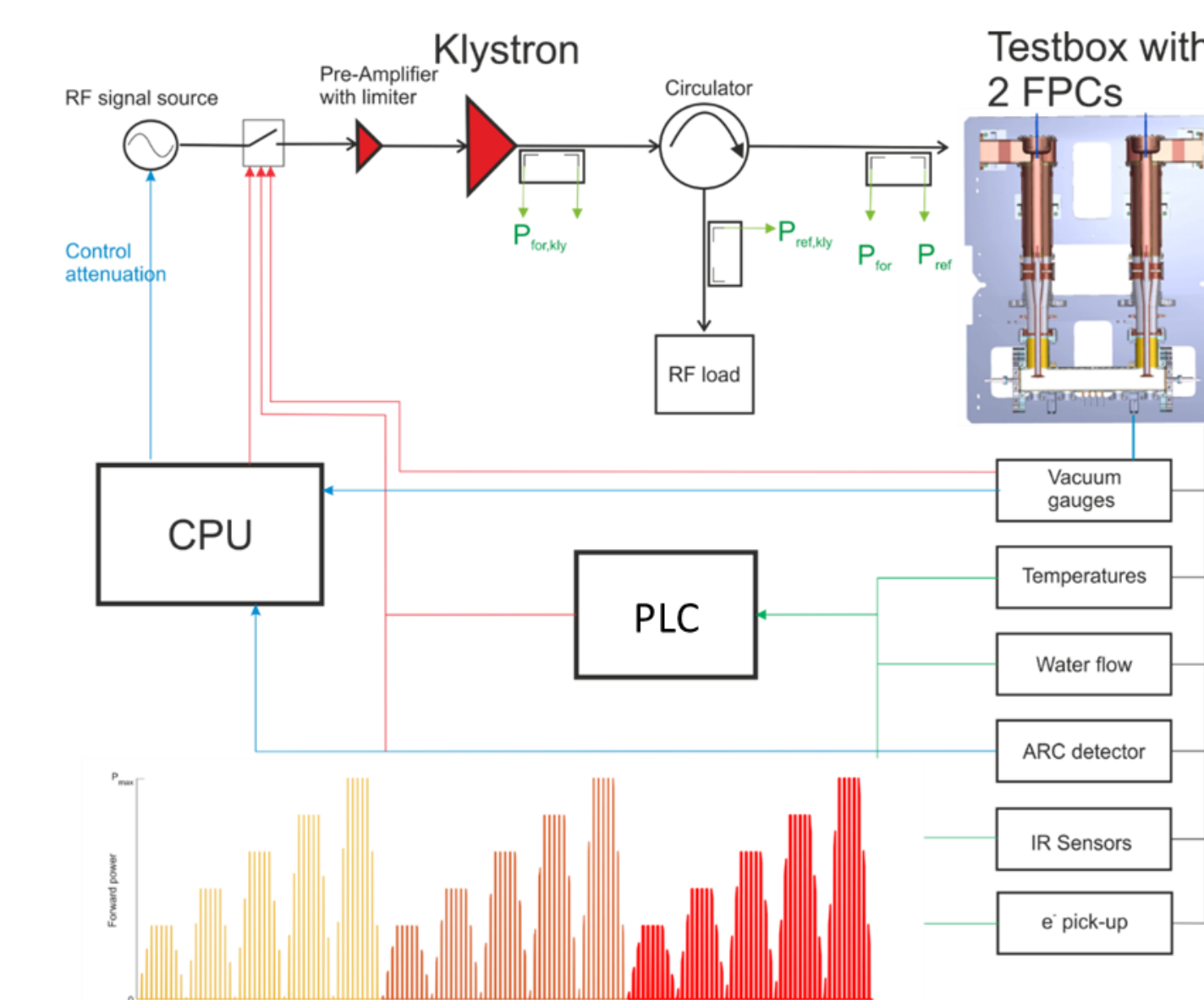
2nd pair upstream
Coupler airside
Window!

2nd pair result: Here, some strong vacuum and ARC event occurred after a calm start. Since then increased vacuum activity above 13 kW and always a higher ceramic heating at the downstream coupler was observed. Above this level, heating became exponential with power (field emission?), no multipacting was observed.

Paper copy: Preliminary version

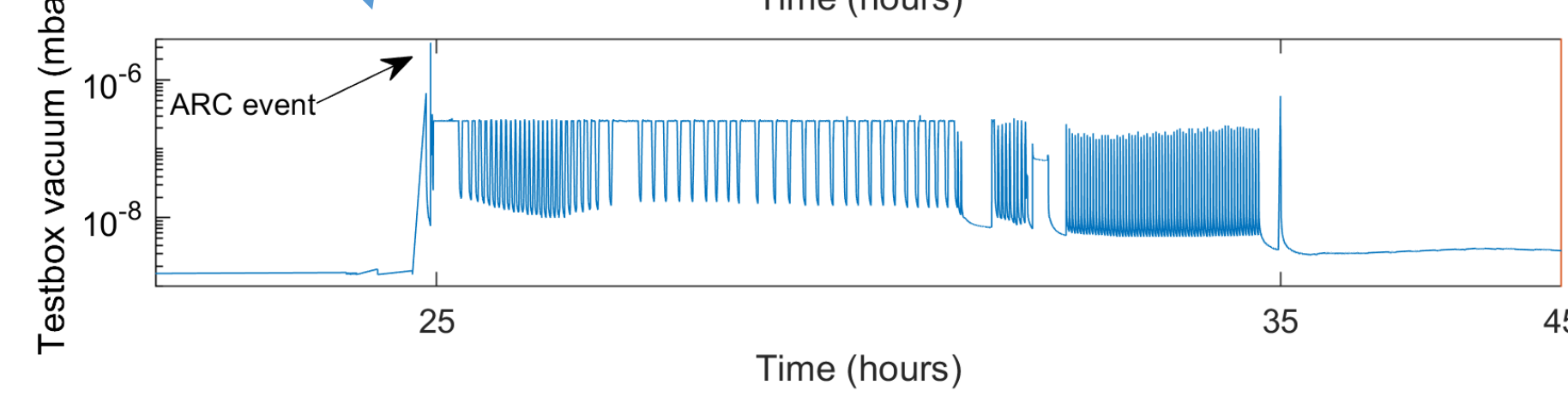
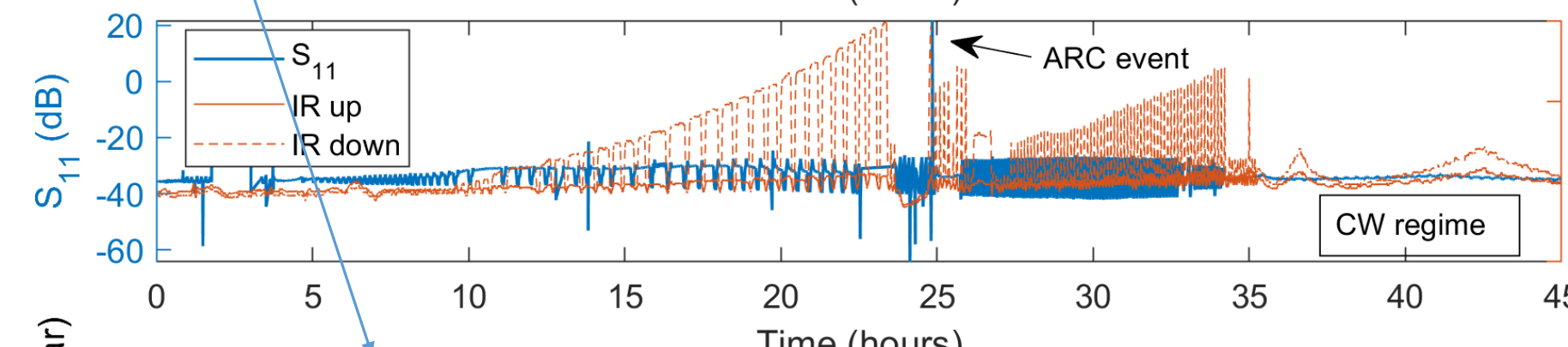
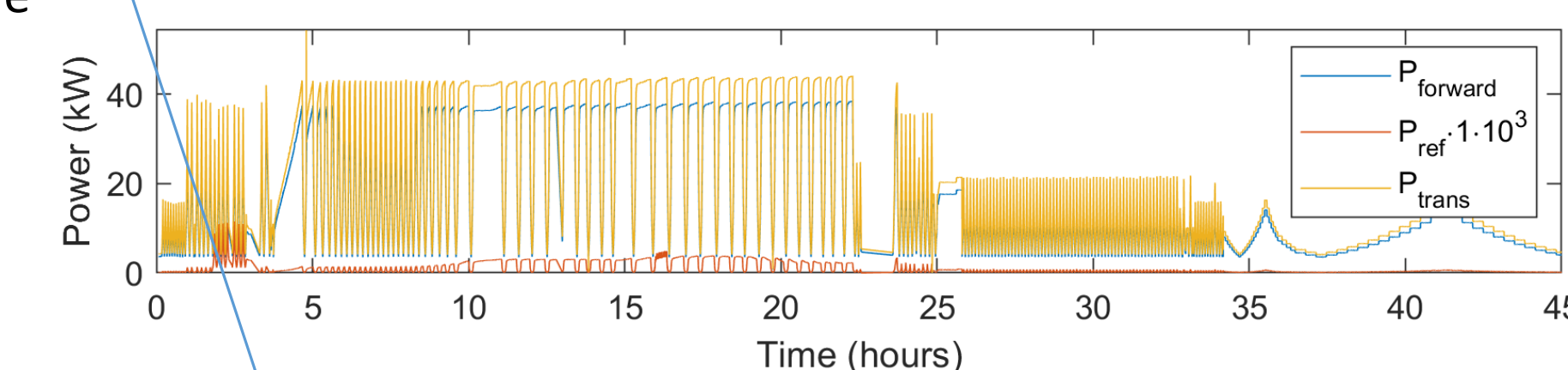


Assembly procedure for conditioning: 1. Cleaning in cleanroom, 2. Assembly in ISO 4-5 cleanroom, 3. Leak check, 4. Transport in special sealed cart in vertical setup, 5. 120°C baking in horizontal position, 6. Warm part assembly, cooling water and diagnostics, 7. Low power RF test with VNA, 8. RF assembly, low power Klystron test, 9. Start conditioning



Conditioning procedure scheme used

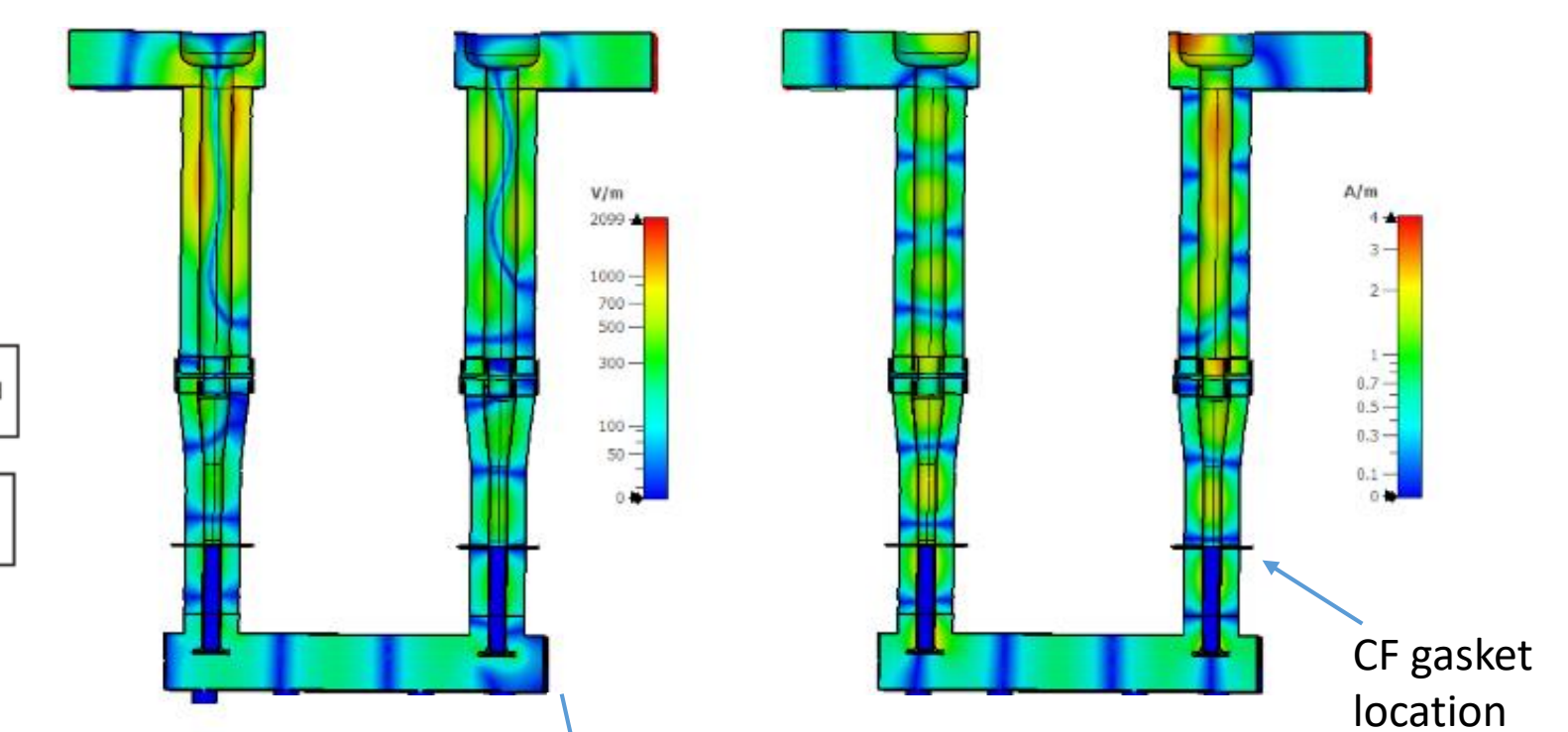
Color code denotes pulse length or duty cycle.



Intermediate Results after 2 pairs:

Operation at 6 mA or even 10 mA is possible w/o restrictions with all couplers conditioned so far. Beside the heating issue of the coupler of the 2nd pair, the temperature to power gradients are within the expectations by simulation and 120 kW are within reach. The particulate found on the airside window will be analyzed.

| Parameter | at 100 mA | at 6 mA | 1 st pair | 2 nd pair |
|-----------------------|-------------|--------------|-----------------------|--------------------------------------|
| $P_{forward}$ TW | 3.4, 220 kW | 0.2, 13.8 kW | 40 kW, 95 kW (10 %DC) | 13 kW, 45 kW (29 %DC) |
| $P_{forward}$ SW | 3.4, 54 kW | 0.2, 3.45 kW | 17 kW | na |
| CW TW ceramic heating | - | - | 0.14, 0.28 K/kW | 0.18, 0.20 (0.35 ¹) K/kW |
| CW SW ceramic heating | - | - | 0.35, 0.89 K/kW | na |



RF properties: Simulated (CST FD Solver) traveling wave field distribution (0.5 W_{rms}) and measured S11 parameter at teststand with VNA for normal CF gasket and optimized RF sealed CF gaskets, blue denote the latter with Klystron as power source.

