RFQ PERFORMANCE DURING RF CONDITIONING AND BEAM COMMISSIONING AT ESS

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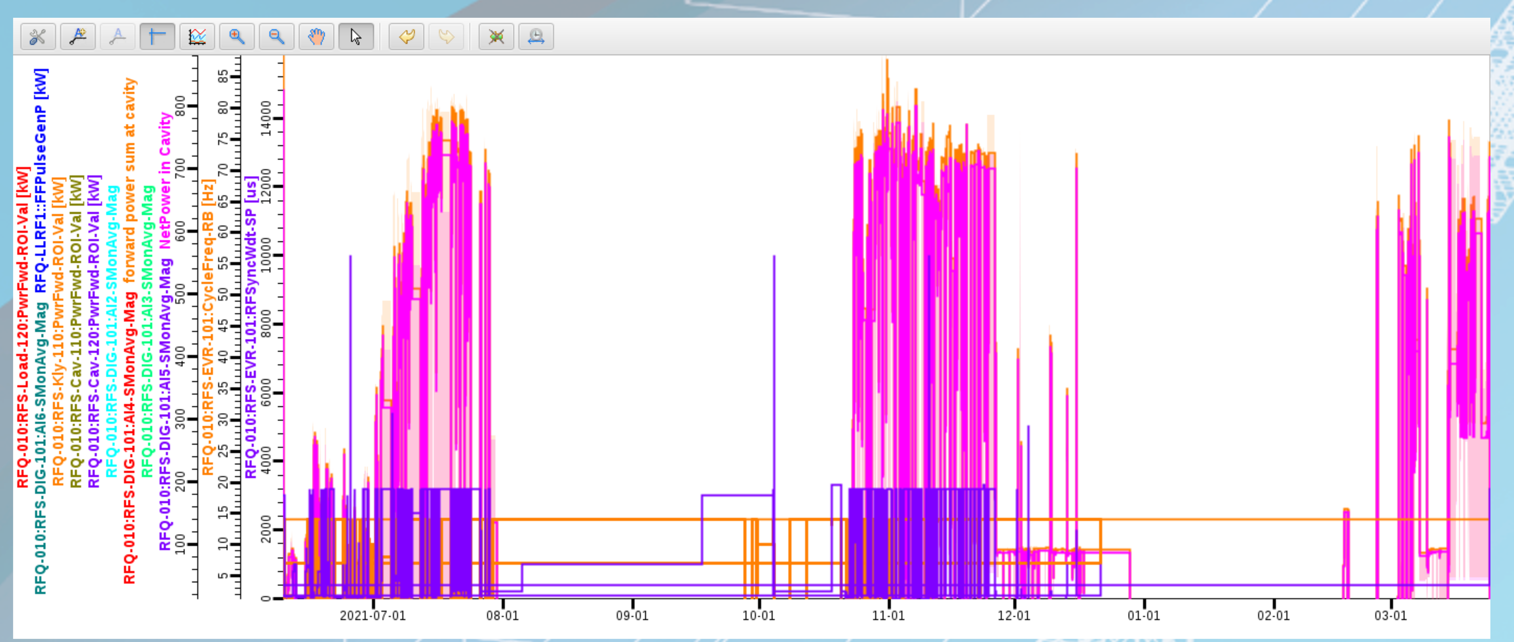
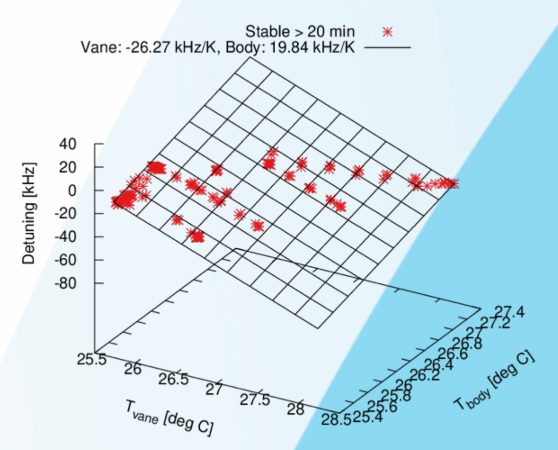
- RFQ conditioning(2021 Jul ~ 2021 June):
  - **6 weeks to 800kW** forward power, 14Hz, 3200us
- RFQ re-conditioning I (2021 Oct, after LEBT open):
  - **1.5 days to 800kW** forward power, 14Hz, 3200us
- RFQ re-conditioning II & III(2022 Feb, after LEBT open):
  - **2 days to 120kW** forward power, 3.5Hz, 3200us and 800kW, 25us, 1Hz. (more days to nominal field @ full duty cycle)
- Low Duty Cycle Beam Commissioning (2021 Oct-Dec, 2022 Apr-Jul): RF: 1Hz 100us, beam: 1Hz/14Hz, 5~62.5mA, 5~20us

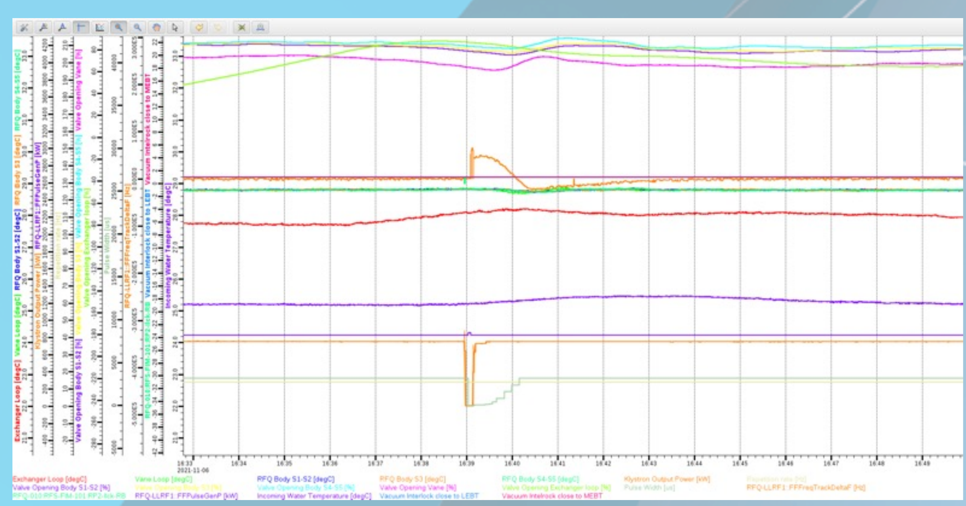
RFQ	Design	Measured	Unit
Frequency	352.21		MHz
Beam Duty Cycle	4% (14Hz, 3200us)		
Pcu	713~1375	713	kW
Pbeam	241 (67.5mA)	200 (58mA)	kW
Vane Voltage	80~120	118 (pickup read)	kV
Max E field	1.9		Kilpatrick
Power Coupler	2		
Coupling factor (beta)	1.337~1.175	1.321	
Phisync	-43.4	-43	deg
Q0	4055~7821	7436	
W_in	0.075		MeV
W_out	3.62	3.60	MeV
3dB bandwidth	±52.4	±55.0	kHz
Cooling skid stability at full duty cycle	±0.1 @30° (Vane) ±0.1 @30° (Body)	±0.04 @28.81° (Vane) ±0.06 @28.80° (Body)	deg



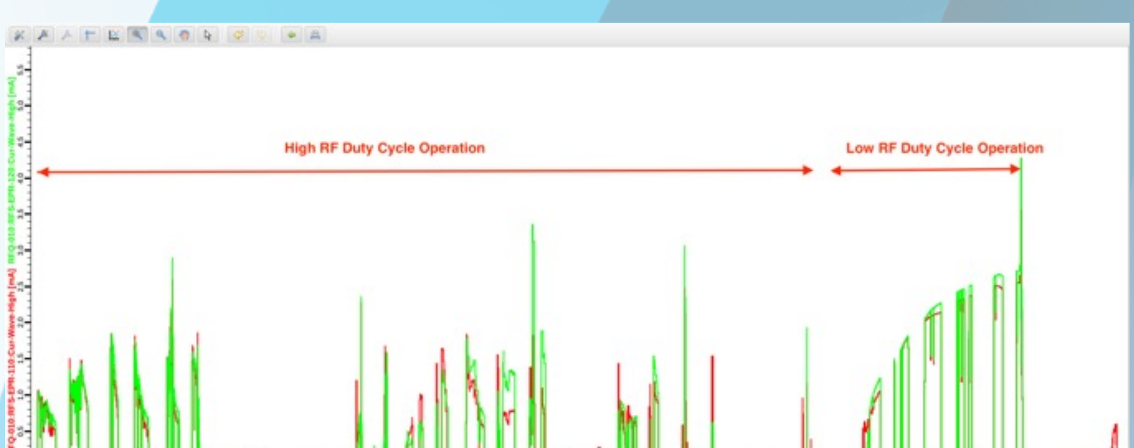
Interaction between RF and Cavity

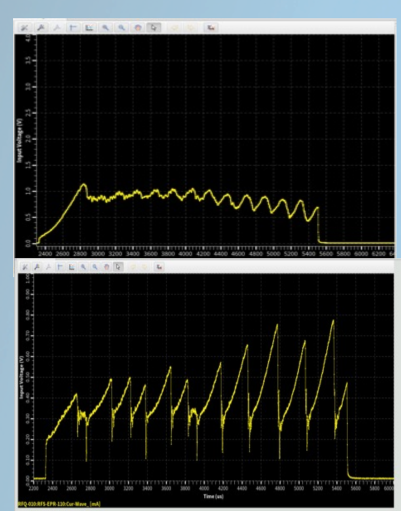
Transient Thermal Effect



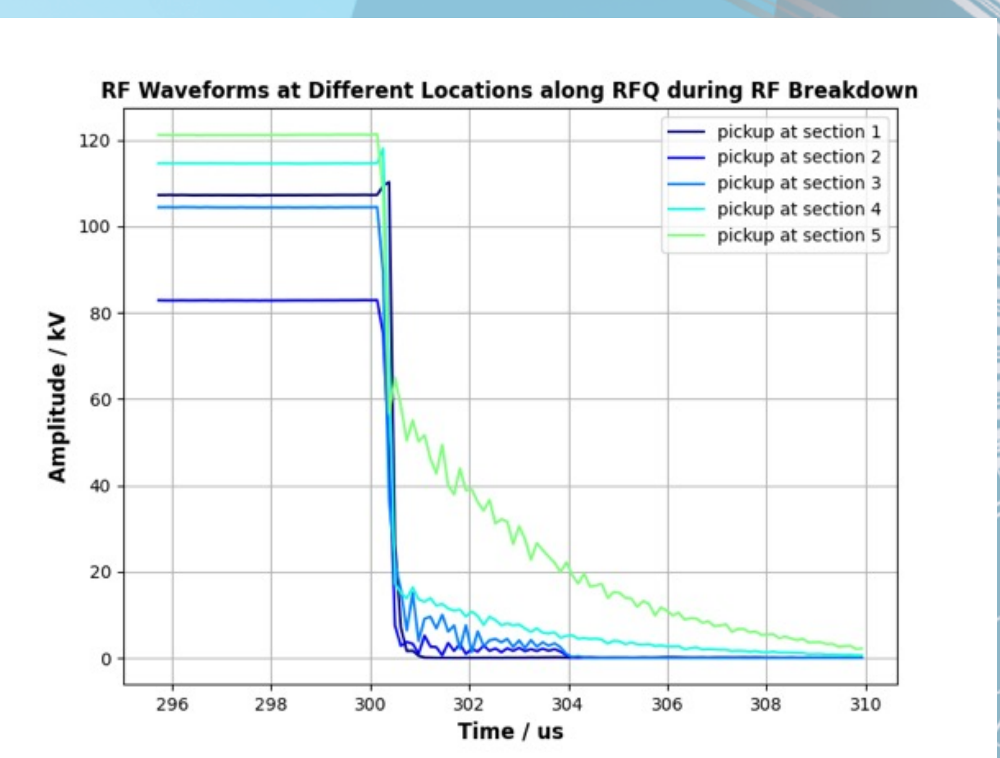


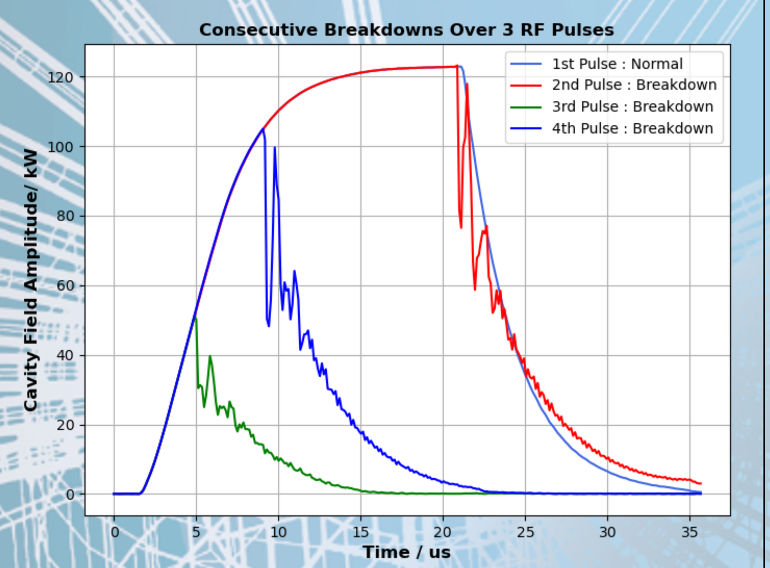
Multipacting

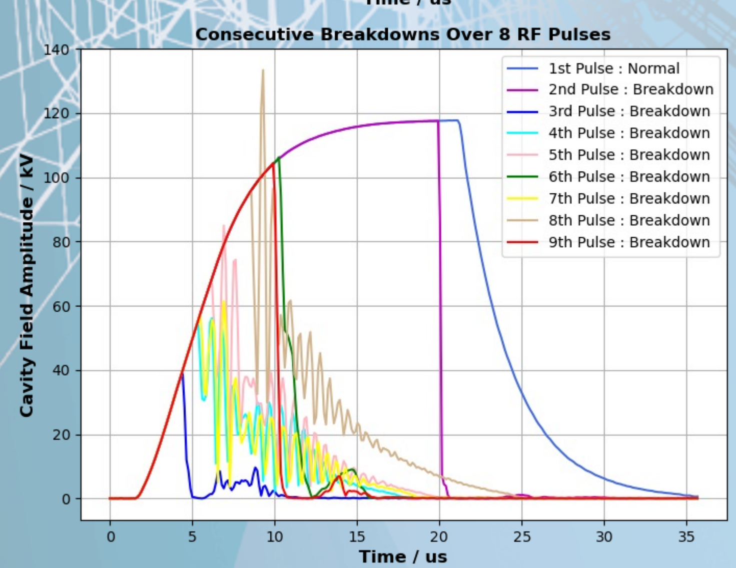




Breakdown

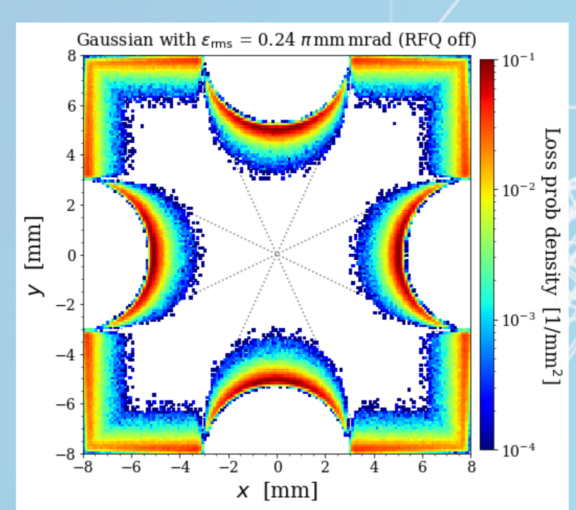


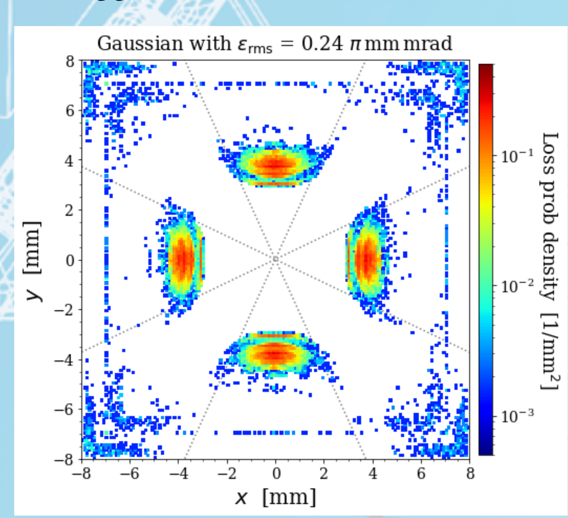




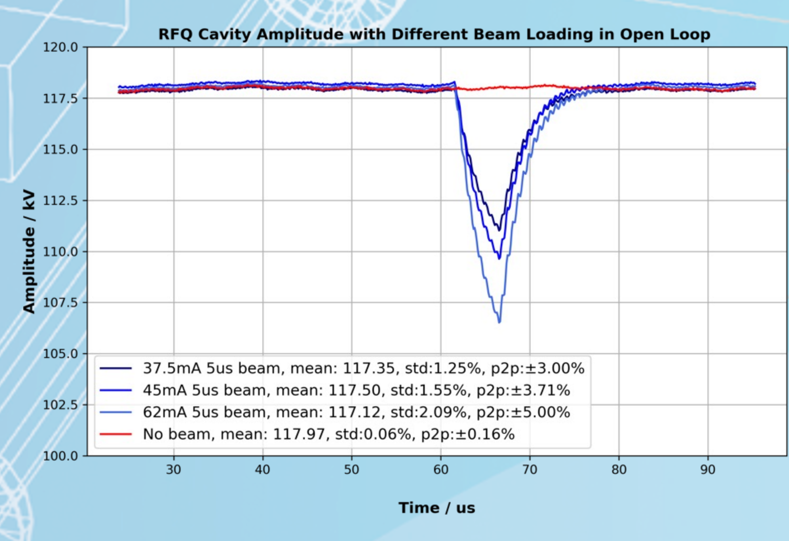
Interaction between Beam and Cavity

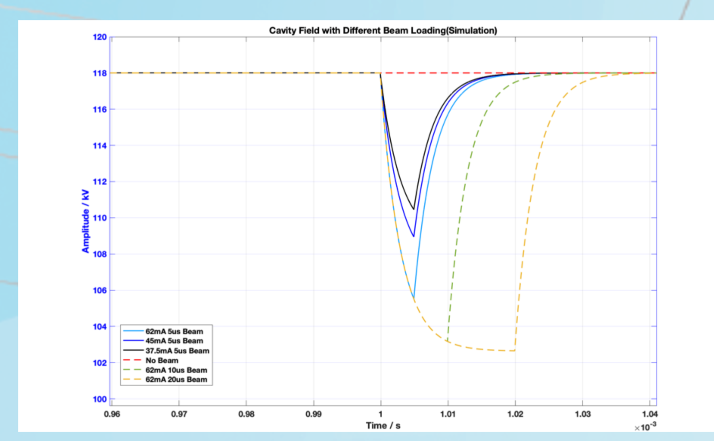
Beam loss in RFQ when RF off and RF on



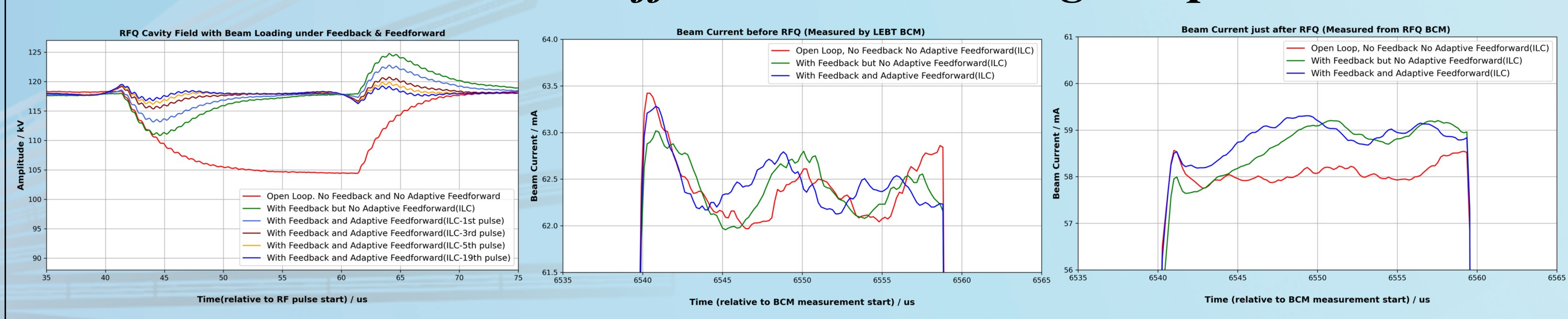


Beam Loading: Meaurement and Simulation

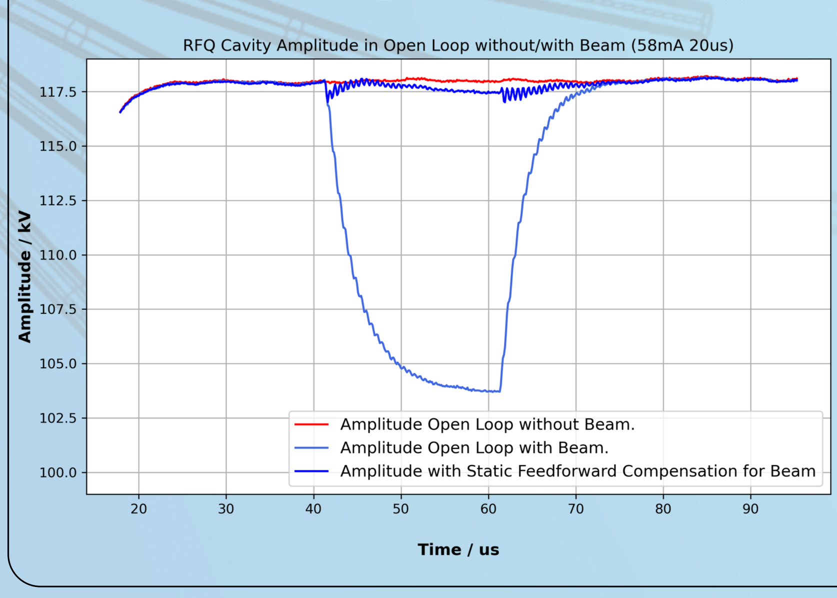


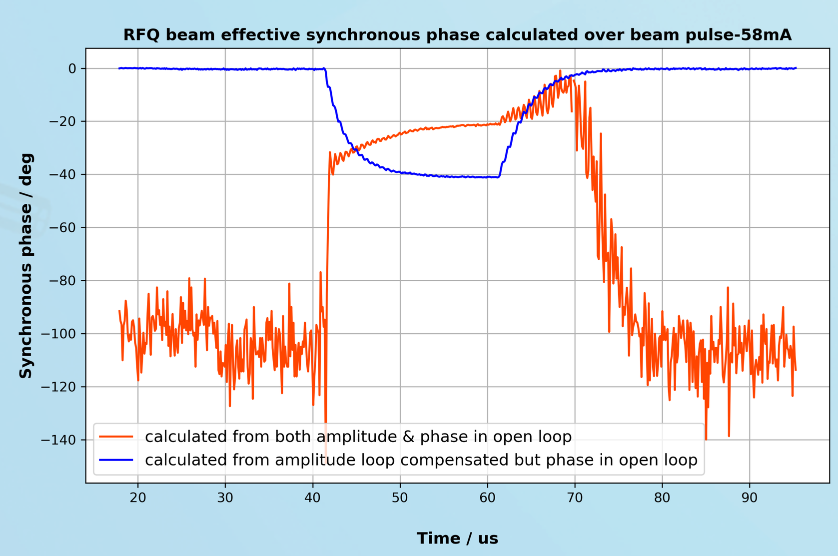


Beam transmission under different beam loading compensation



Effective beam phase under different beam loading compensation





RFQ at ESS and its supporting system such as cooling, vacuum, diagnostics and software applications have been demonstrating stable performance over conditioning, re-conditionings and low duty cycle beam commissioning. Stable operation of RFQ systems enables systematic and deep observation of dynamics and interactions between cavity, RF and beam, which in turn allow us to gain insight into system limits and find way to operate RFQ at its full capacity

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