High average power couplers

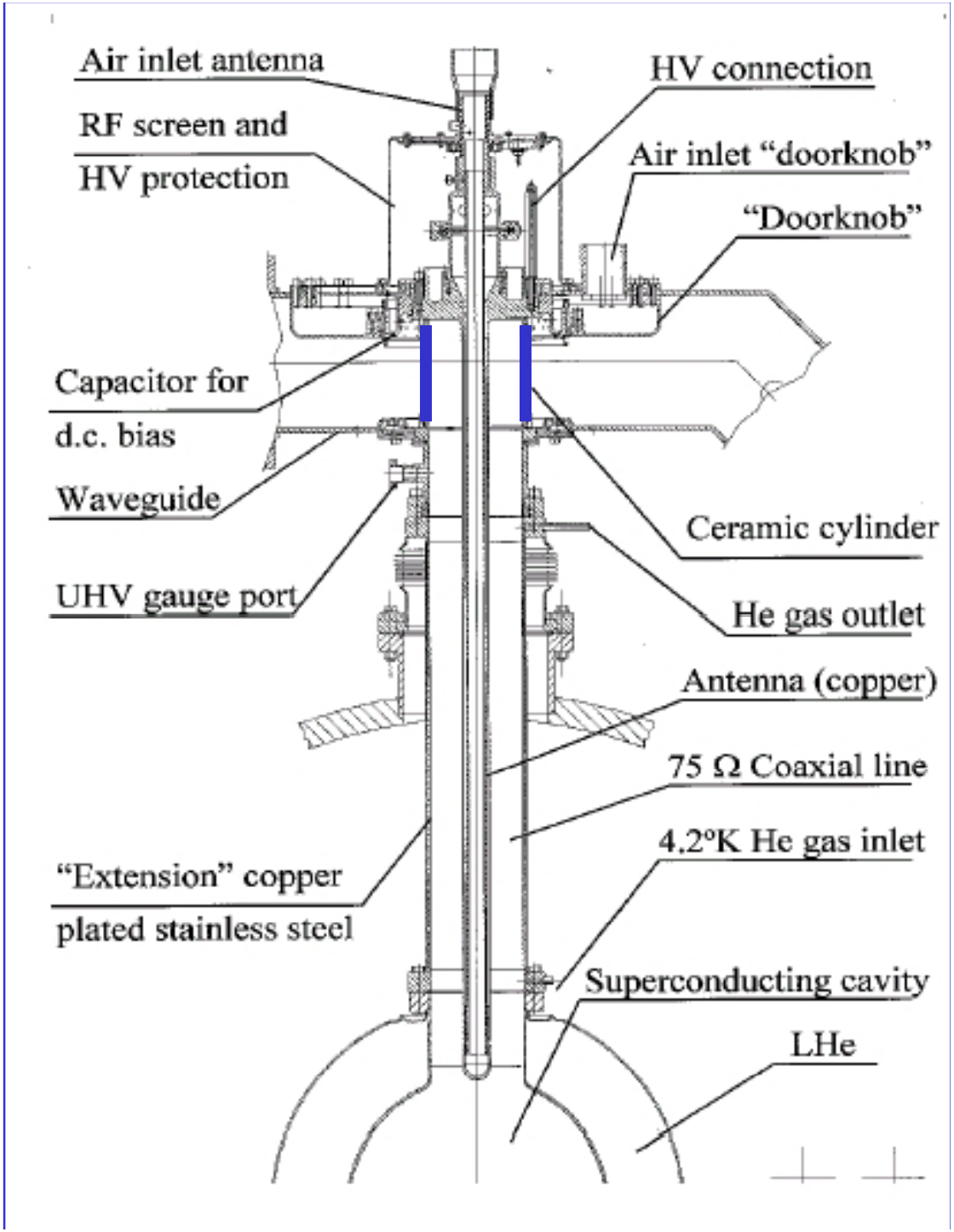
pulsed

	LEP	LHC	Cornell	KEKB	APT	SNS	SPL
Frequency (MHz)	352	400	500	508	700	805	704
Status	Op. on accel.	Test stand	Op. on accel.	Op. on accel.	Test stand	Op. on accel.	design
Number	288	2	4	4 + 4	8	93	[242]
Accelerator type	e- synch	p synch	e- synch	e- synch	p linac	p linac	p linac
Coupler type	coax	coax	WG	coax	coax	coax	coax
Mounting on cryostat	from top	from top	from bottom	from top	from side	from bottom	
Window type	cyl.	cyl.	WG	disk	2 disks	disk	
Biasing	yes	yes	no	yes	no	yes	
Cooling type	outer: cold He inner: air window: air	outer: 4,5 K He inner: forced air window: air	E-bend: LN2 WG transition: 4.5 K He Nb WG	outer: 4K He inner : water window: air	outer: 4,6 K He inner: 300 K He window: air	outer: 5K He inner: water	
Peak design power (kW)	140	120	325	270	210	550	1000
Average design power (kW)	140	120	325	270	210	48	100
Max. achieved power (kW) CW mode (TW)	565 on cavity	500 room temperature 300 kW on cavity	261 to beam	380 to beam 800 on stand not biased 450 on stand with bias	1011 room temperature 950 @70 K 950 with tunable	750 room temperature	

Note: Numerous CW RF windows for room temperature RF systems are under operation and provide relevant experience for high power couplers for SRF linacs

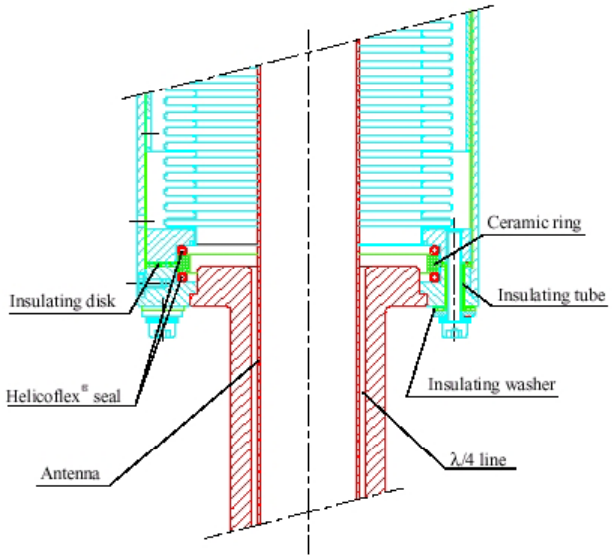
LEPII coupler

Main difficulties:
multipactor --> biasing



LHC coupler

Main difficulties: multipactor at 15 kW in 7Ω coax line --> additional biasing



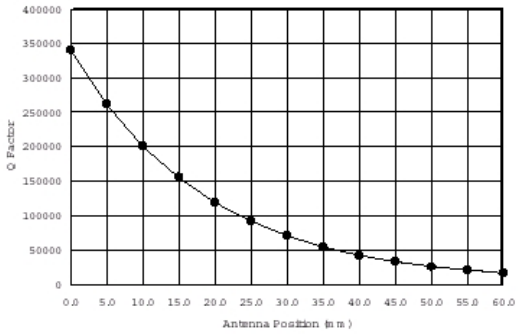
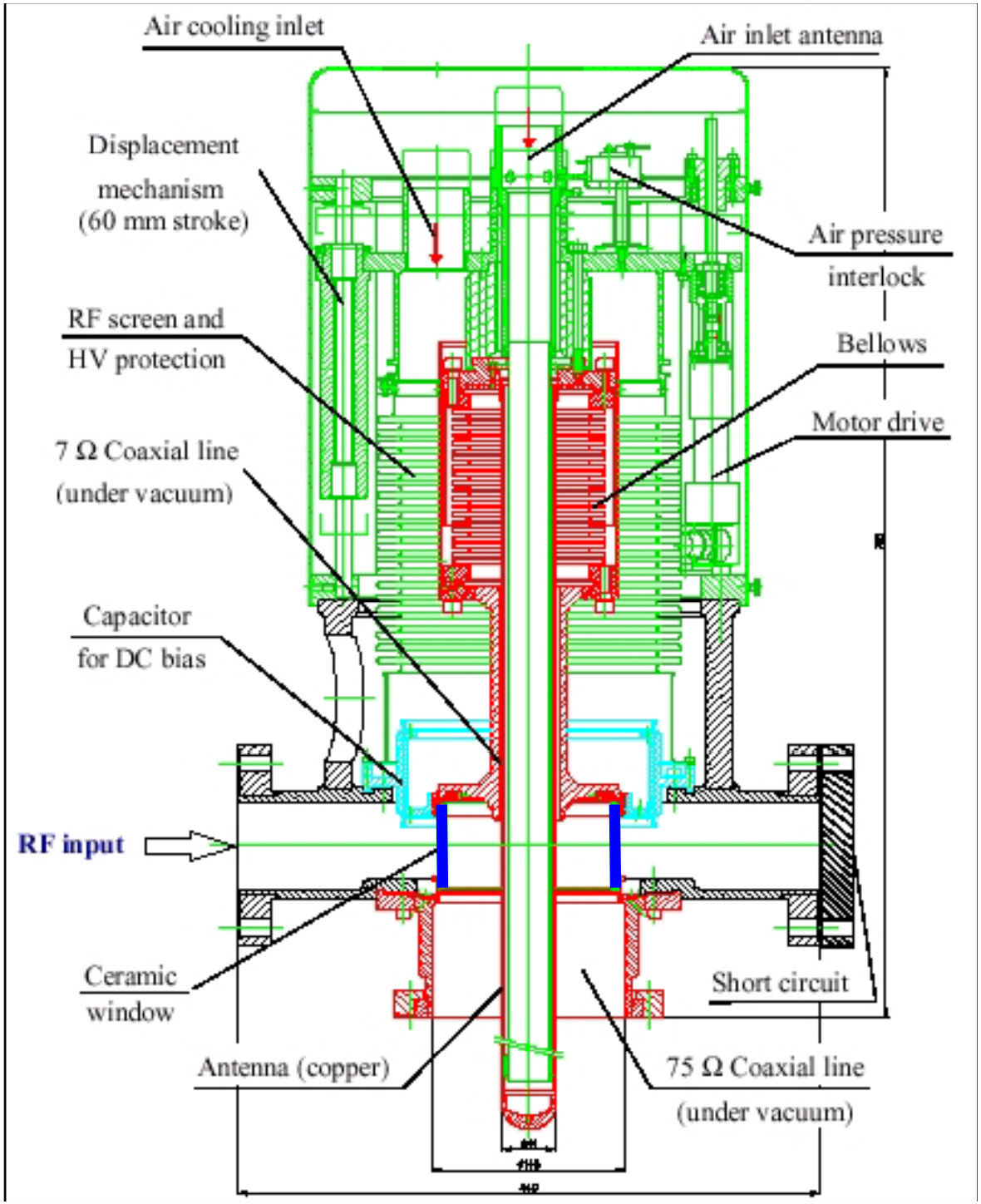
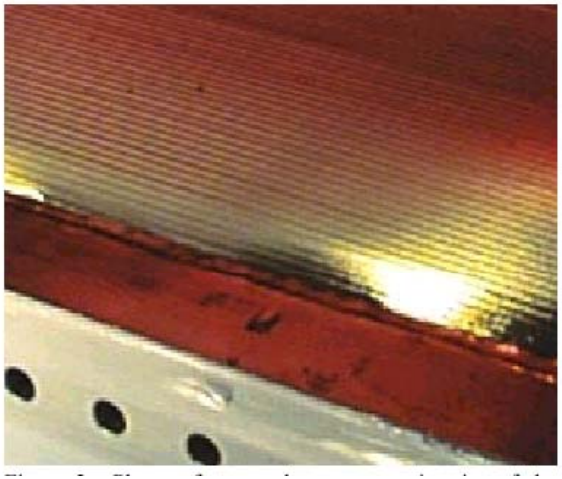


Figure 3: External Q as function of the antenna position.



Cornell coupler

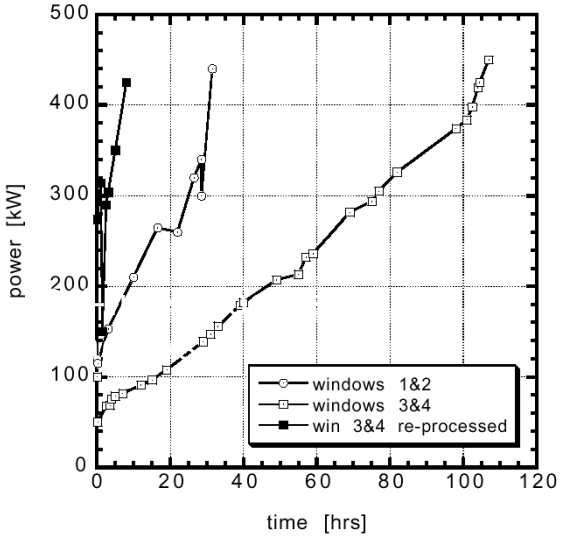


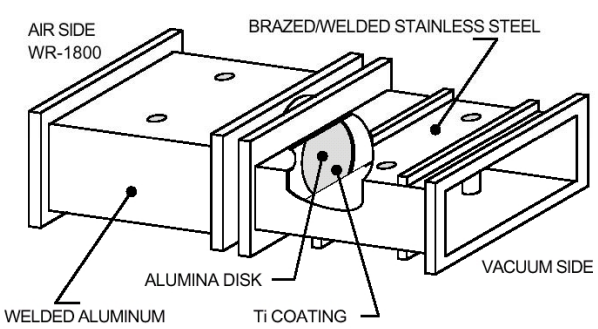
Main difficulties:

vacuum trips in double E-bend and/or Nb WG: multipactor on condensed-gas surfaces enhanced by corrugations

cures:

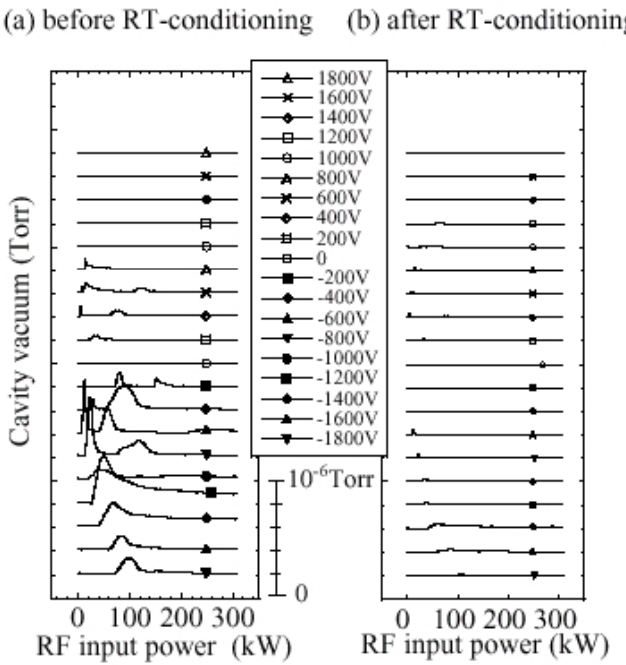
- baking
- improved pumping
- no corrugation
- new tapered waveguide geometry
- cut/e^- trap in WG mid-plane

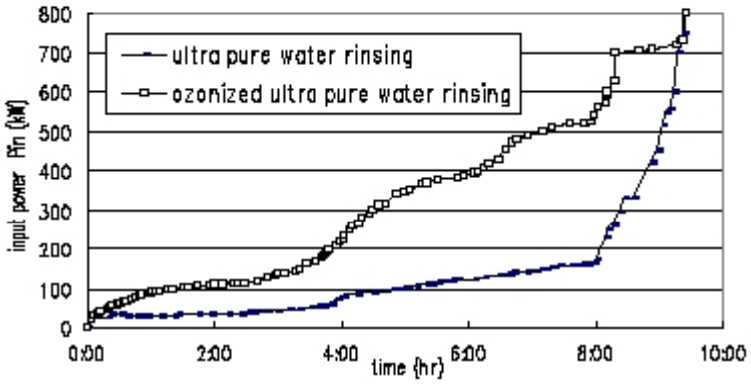


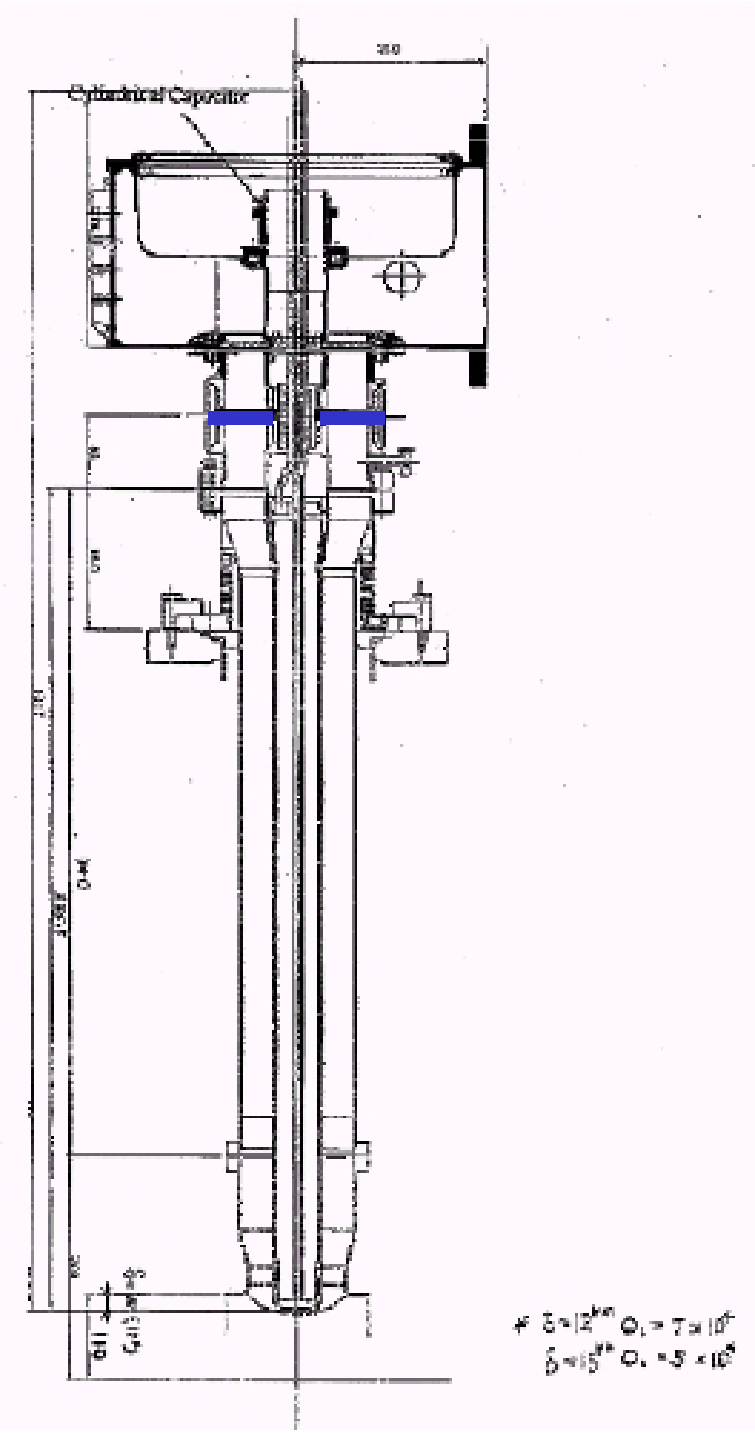


KEKB coupler

Main difficulties:
multipactor --> baking, conditioning with bias







JPARC coupler

Main difficulties:
N.A.

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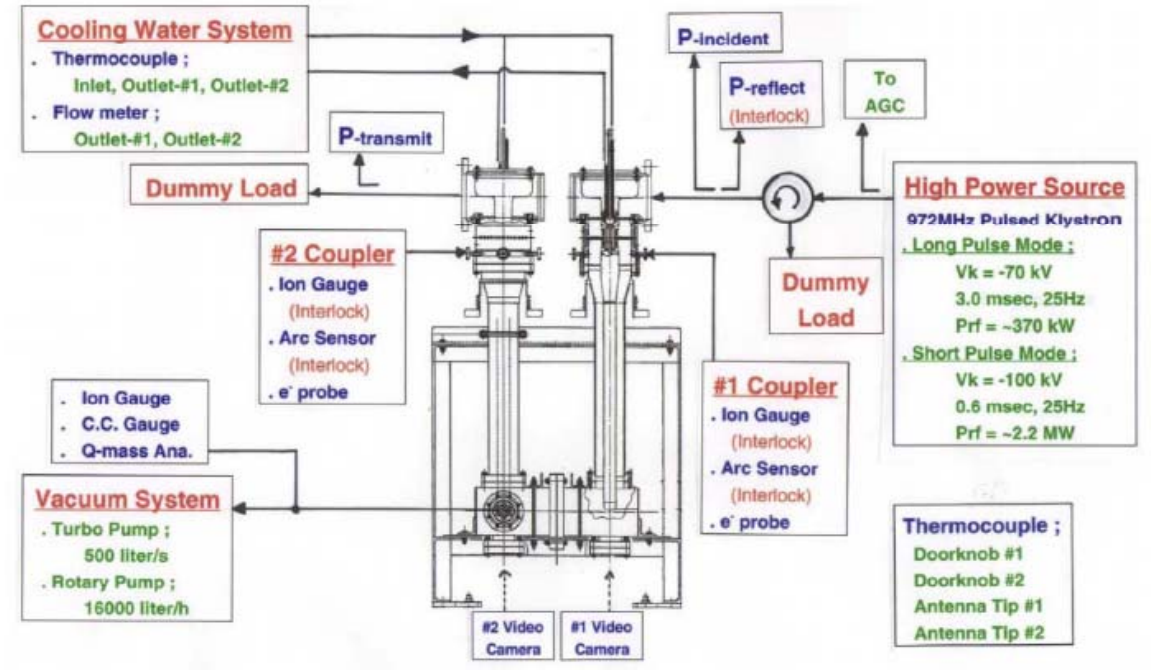


Test	Pulsed operation	Max. rf power
1.	Initial Tests:	
	0.1msec, 10Hz	300kW
	2.45msec, 25Hz	350kW
2.	Exposure to N_2 gas:	
	0.1msec, 10Hz	300kW
	2.45msec, 25Hz	350kW
	0.6msec, 25Hz	1100kW
3.	Kept for one month without pumping:	
	0.1msec, 25Hz	1700kW
	0.6msec, 25Hz	2200kW
	Standing Wave	650-800kW
4.	Exposure to air:	
	0.1msec, 25Hz	360kW
	3.0msec, 25Hz	370kW
	Standing Wave	370kW

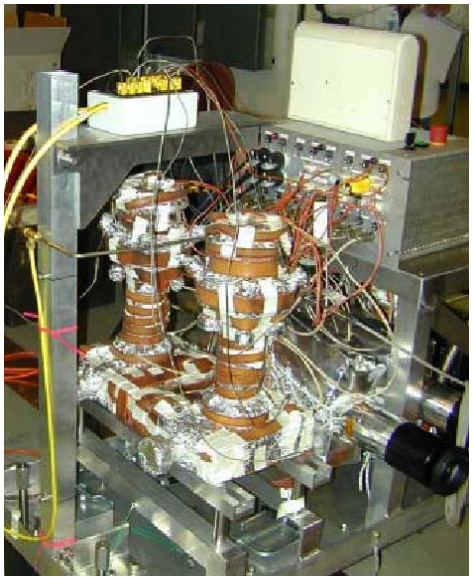
0.2% of power dissipated in inner conductor+window -> water cooling (without water, antenna tip increased by 100K)

Max average Power=33kW

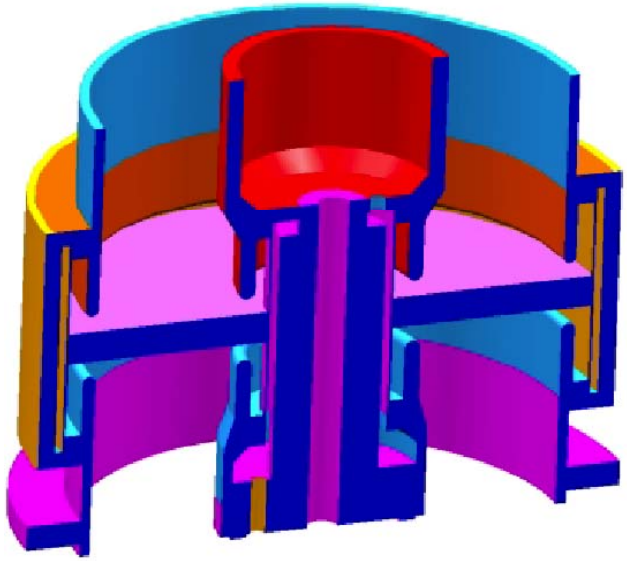
SNS coupler

Main difficulties:

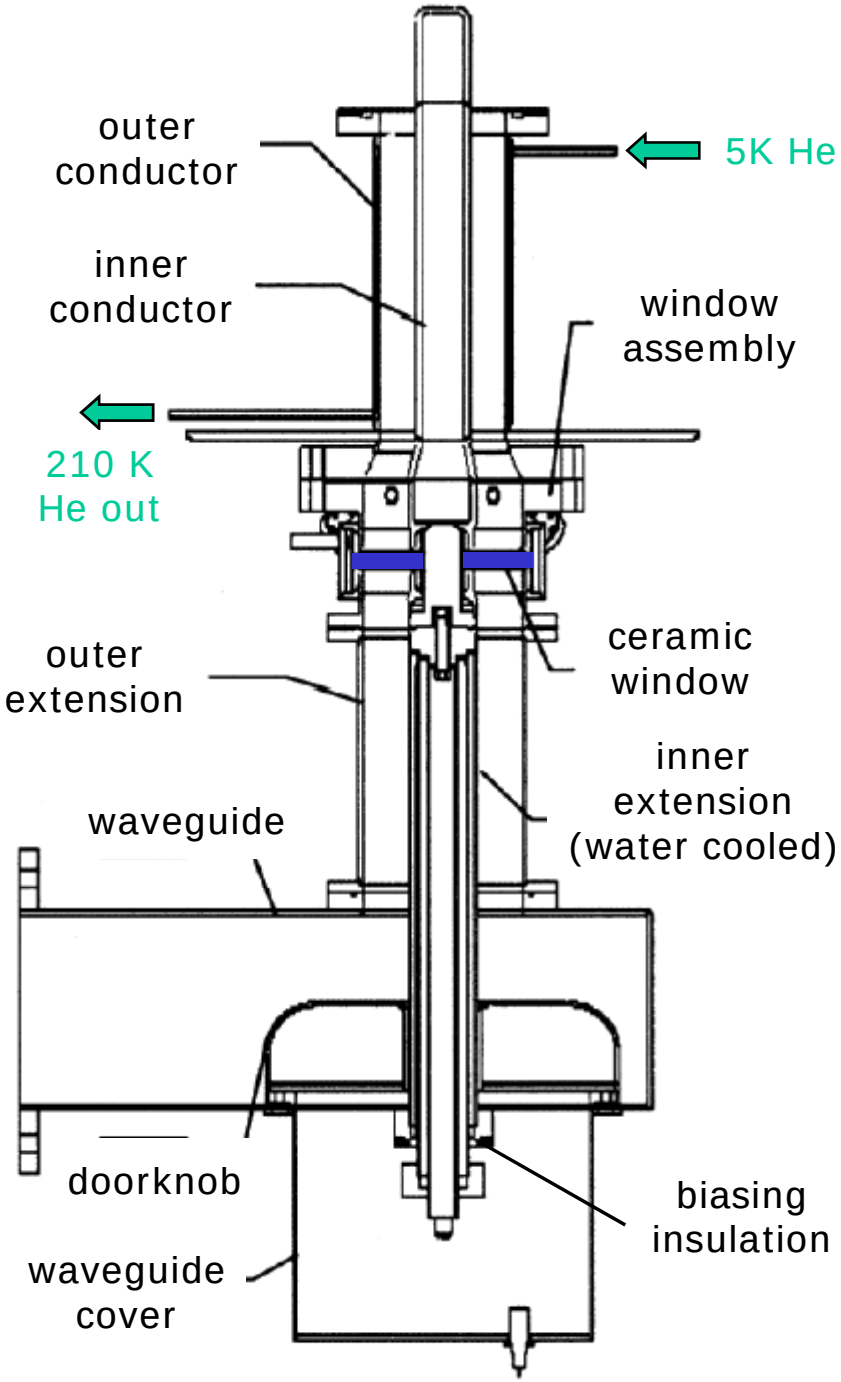
N. A.



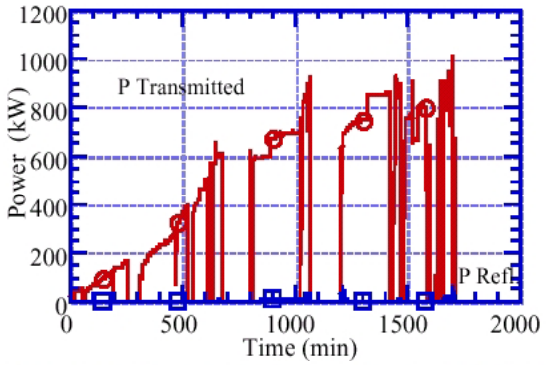
baking of vacuum part on test stand

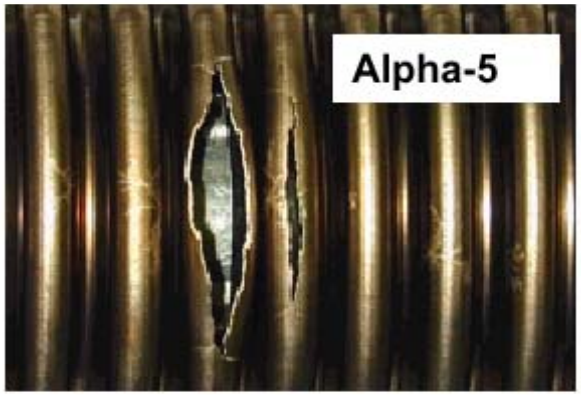


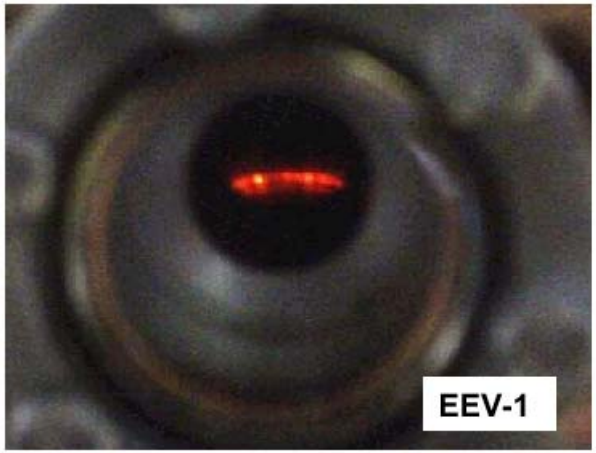
window geometry



APT coupler

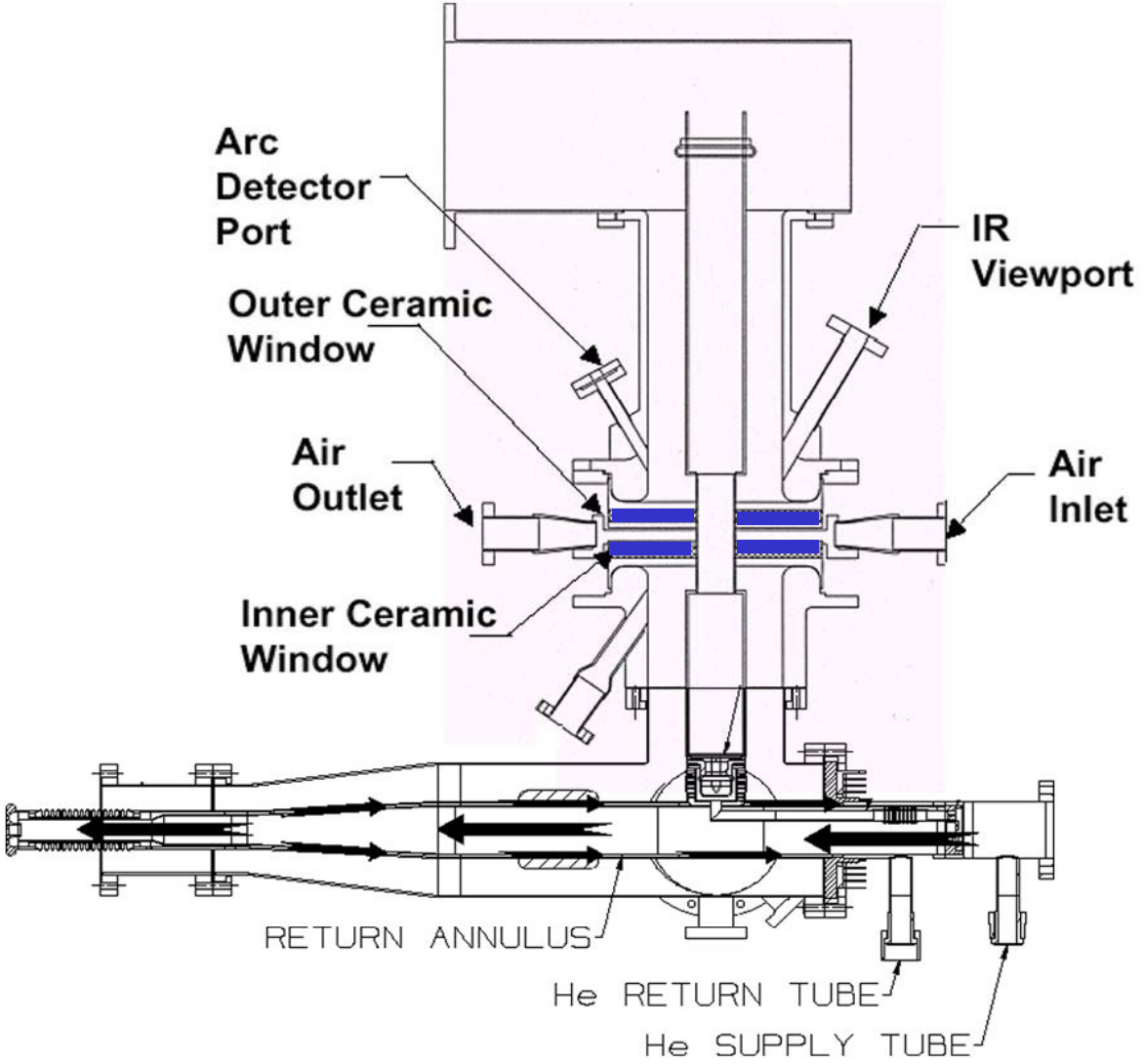






Main difficulties:

- **light multipactor at 190, 220, 290, 420 kW**
- **tip bellow failures -> change material, He cooling**
- **window glow @>400 kW ->grit-blasting**



Summary

- RF windows can reach:
  - 800 - 1000 kW (APT, KEK) for coax type
  - 500 kW (Cornell) for WG type
- couplers did reach 400 kW in operating conditions as of today
- multipactor remains an issue that can be alleviated by DC biasing (LHC, KEK), good pumping, surface conditioning, large diameter ($Z\ (fd)^4$ power law),...
- adjustability is troublesome at high power (bellows, enhanced complexity, ...) (LHC, APT)
- very few window manufacturers