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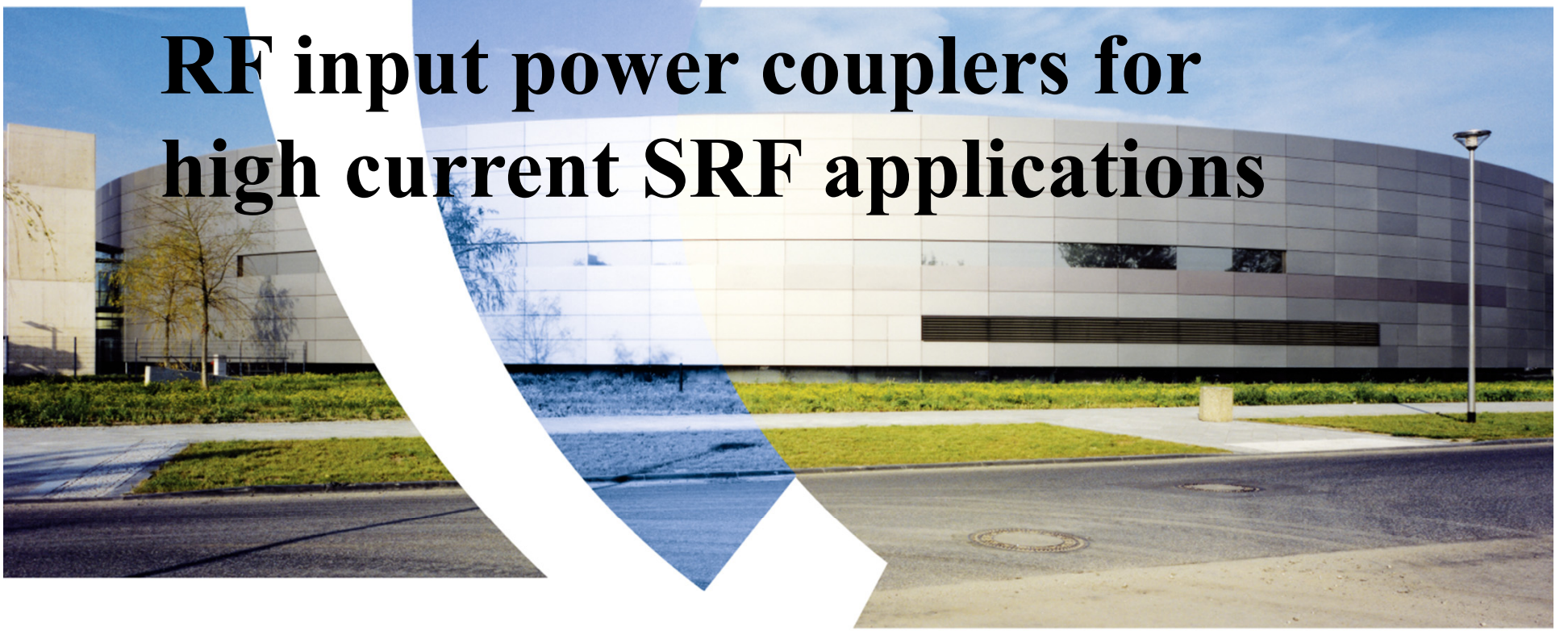
RF input power couplers for high current SRF applications



Vasim Khan for bERLinPro team

02/09/2014

b*ERL*inPro layout

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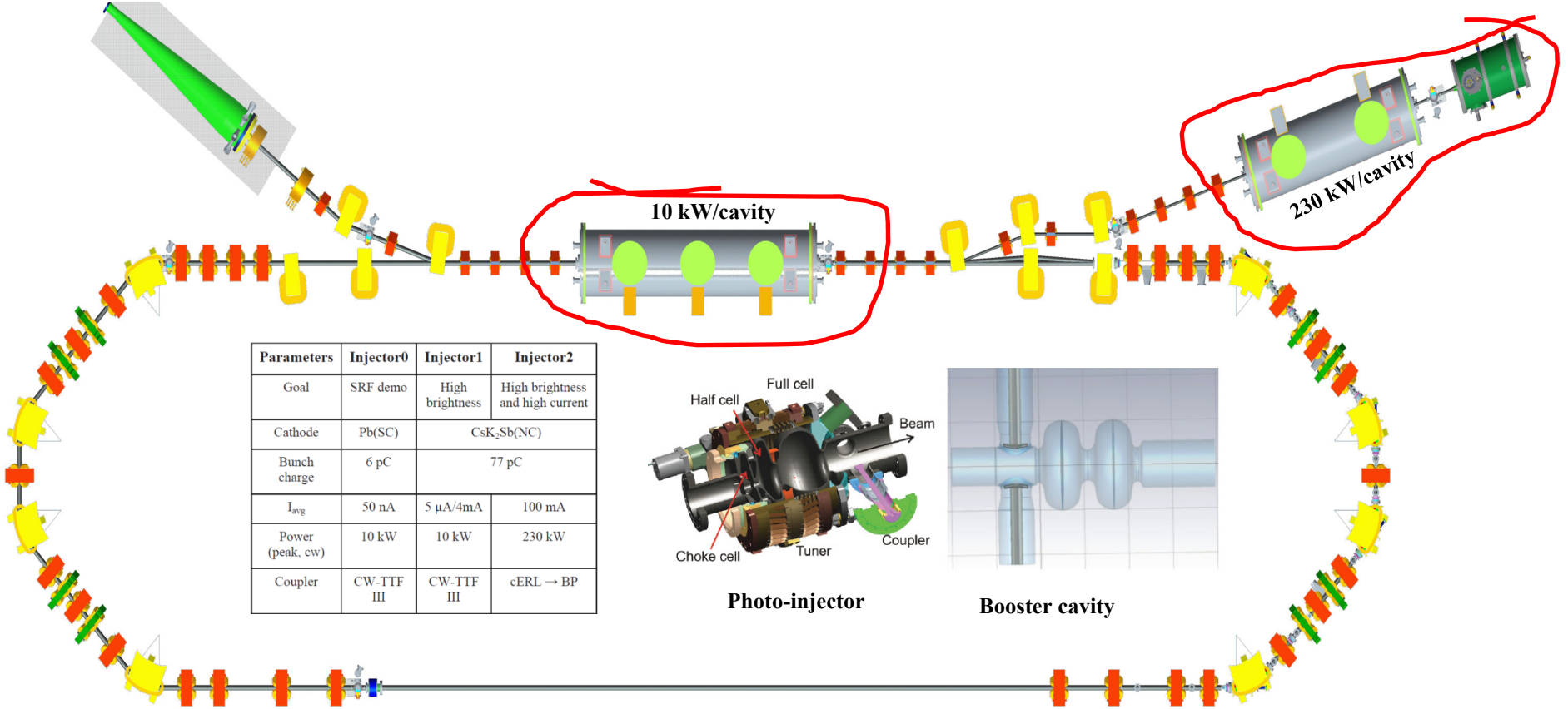
SRF ERL @ 1.3 GHz: 100 mA beam circulating at 50 MeV



Parameters	Injector0	Injector1	Injector2
Goal	SRF demo	High brightness	High brightness and high current
Cathode	Pb(SC)	CsK_2Sb(NC)	
Bunch charge	6 pC	77 pC	
I_{avg}	50 nA	5 μA/4mA	100 mA
Power (peak, cw)	10 kW	10 kW	230 kW
Coupler	CW-TTF III	CW-TTF III	cERL → BP

Photo-injector

Booster cavity

Recirculator
1st arc, 50 MeV

2nd arc, 50 MeV

Main linacs (10 kW): Modified TTF III coupler
Initial stage Photo-injector (10 kW): Modified TTF III coupler
Final stage Photo-injector (230 kW): bERLinPro (BP) coupler
Booster cavity (230 kW): BP coupler

cERL-KEK high power couplers

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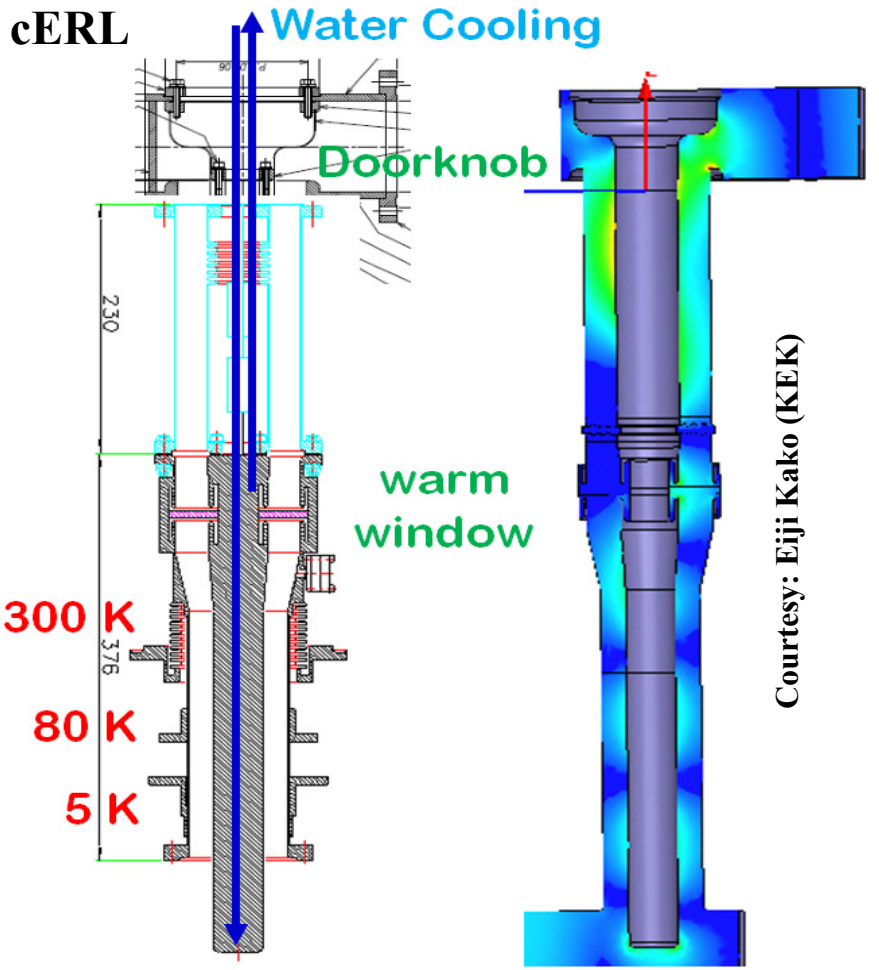
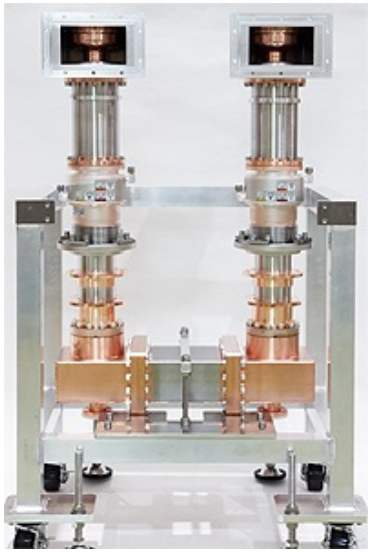
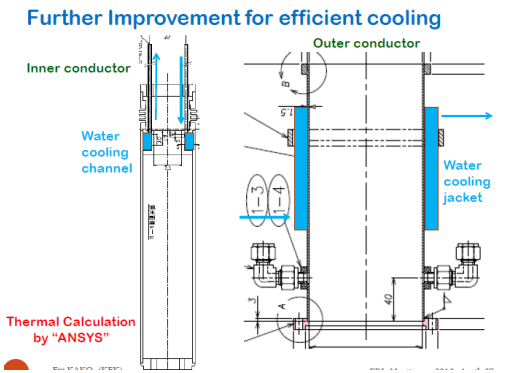


Courtesy: E. Kako, KEK.





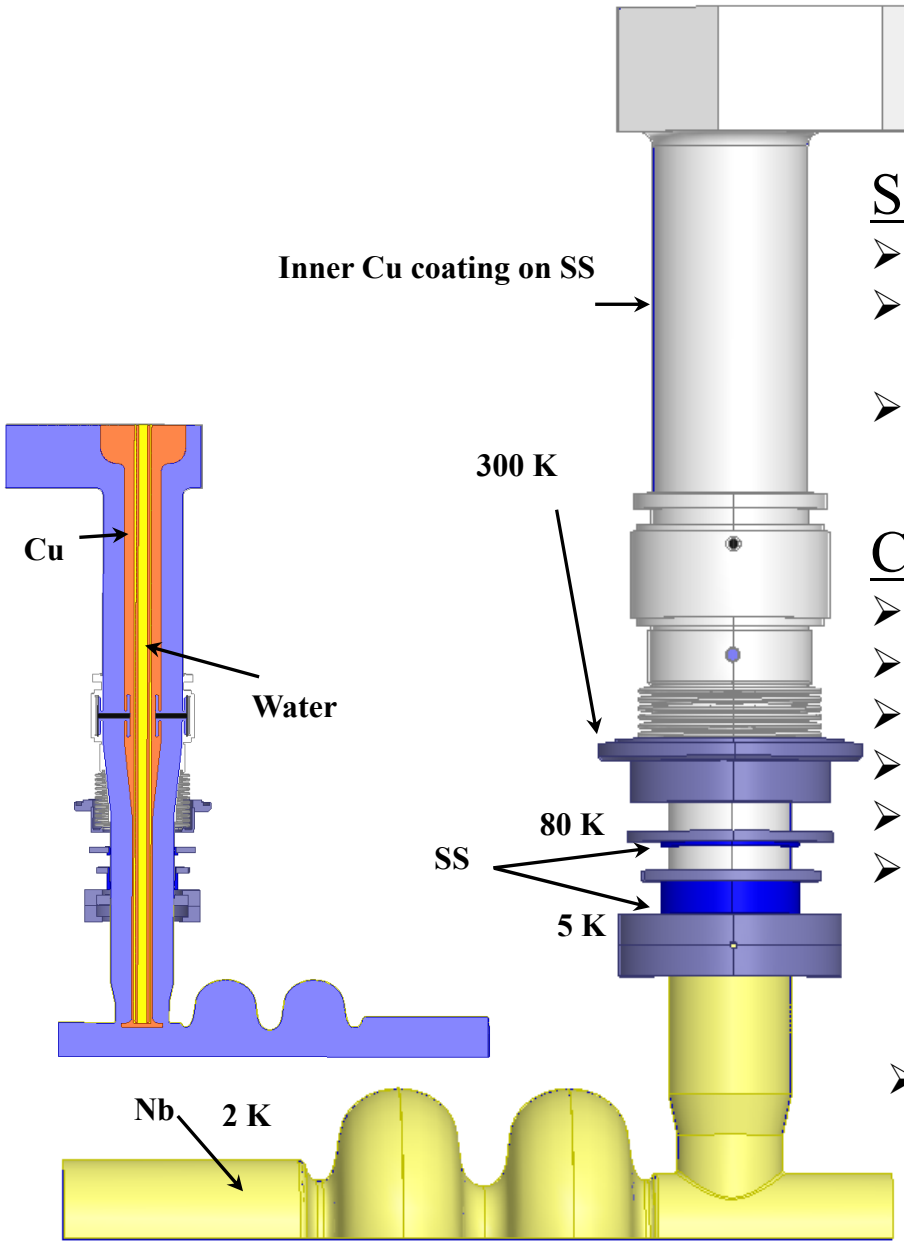
cERL (~100 kW):

High power coupler
Qext ~ 10^5 - 10^6

bERLinPro couplers

BP: cERL + modified antenna tip
Qext ~ 10^5
To be used for: Gun2 and booster

BP coupler model



Similarities with the baseline cERL design

- High power capability (115 kW)
- Baseline geometry: Window, choke, bellows –outer conductor
- Temperature intercepts: 5K and 80 K

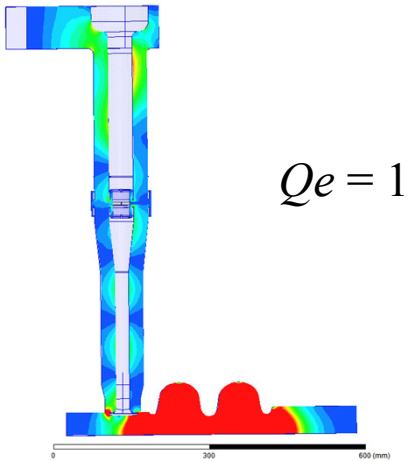
Changes to meet bERLinPro requirements

- Golf T-shape: Minimised penetration
- Door knob geometry
- Smoother inner conductor surface
- No bellows in the inner conductor (warm part)
- Improved water cooling for the inner and outer conductor
- Additional water cooling in the WR650 doorknob section

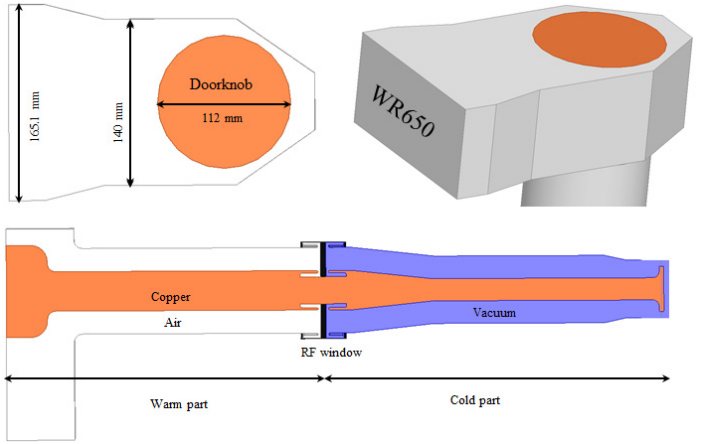
Issues(s)

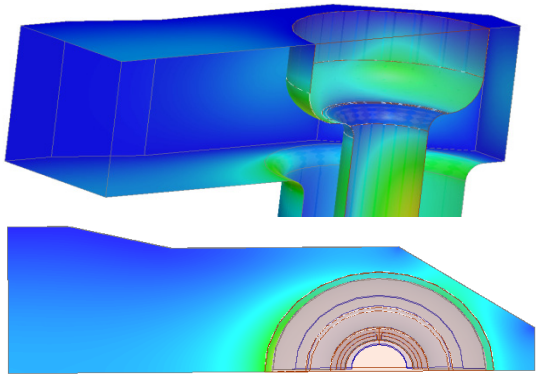
- Small space between 5 K and 80 K intercepts

BP coupler design: The RF part

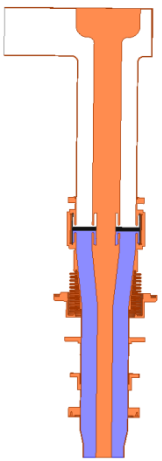


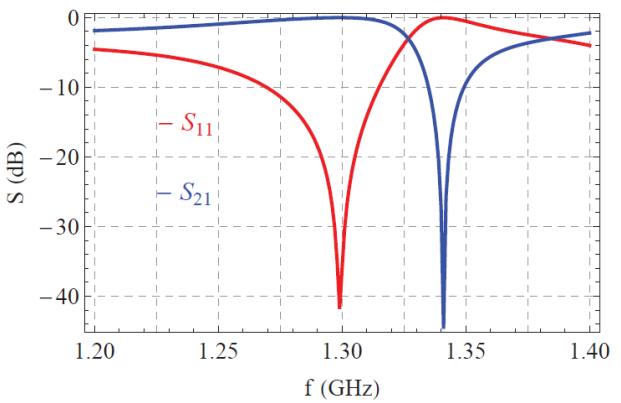
$Qe = 10^5$

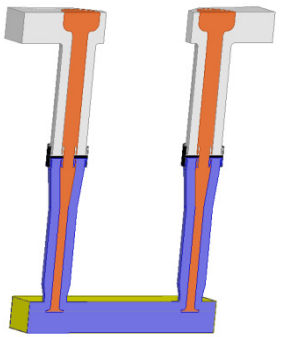


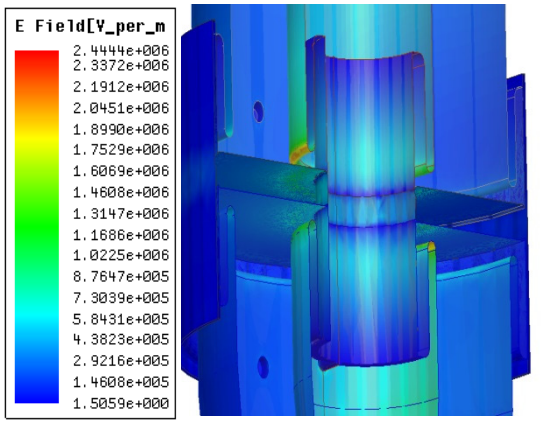


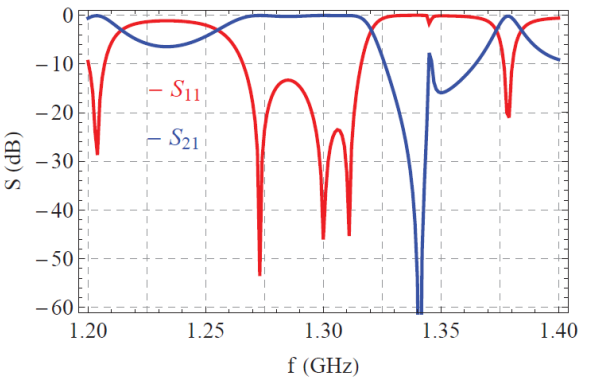
Test stand











Thermal simulations

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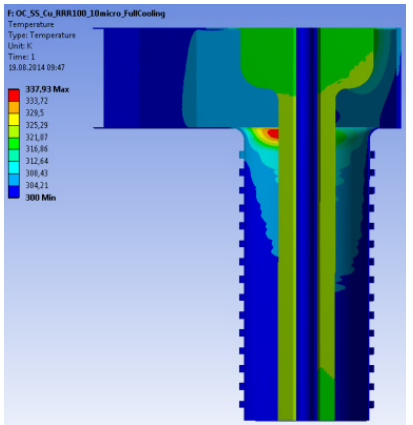
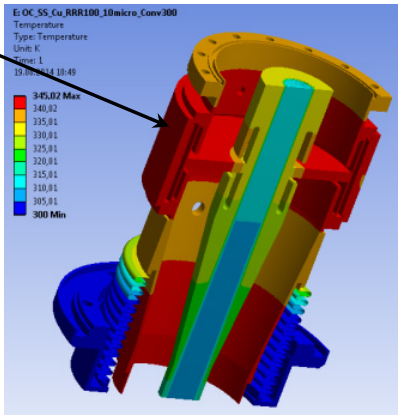
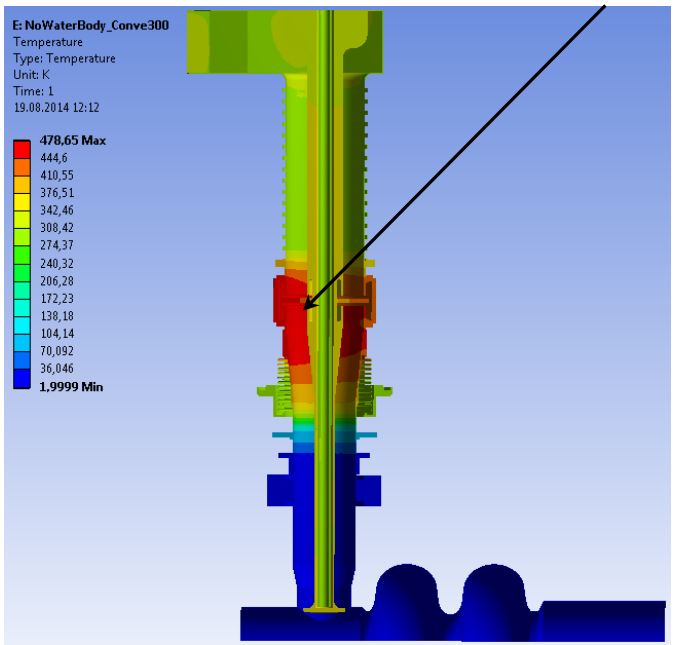
P_{in} = 115 kW, Beam on (S_{11}=20 dB) 45K temp rise

Convection: 300 W/m^2/K for inner & outer conductor cooling





P_{in} = 115 kW, Beam off (S_{11}=0) 180 K temp rise



Input Power 115 kW, S_{11}=0, No beam i.e. full reflection		
Surface loss (W)		
1	Inner conductor (Cu)	430.4
2	Outer conductor (SS-Cu)	260.4
3	Cavity (Nb)	8.1
Volume loss (W)		
4	RF window	61.9

Courtesy: Gary Cheng, Jefferson Laboratory

	Temp. intercepts	No heat Load	Heat load	Total
	T (K)	Q (W)	Q (W)	Q (W)
1	2	0.044	0.442	0.486
2	5	2.03	0.863	2,893
3	80	3.29	12.512	15.802

Thermal simulations

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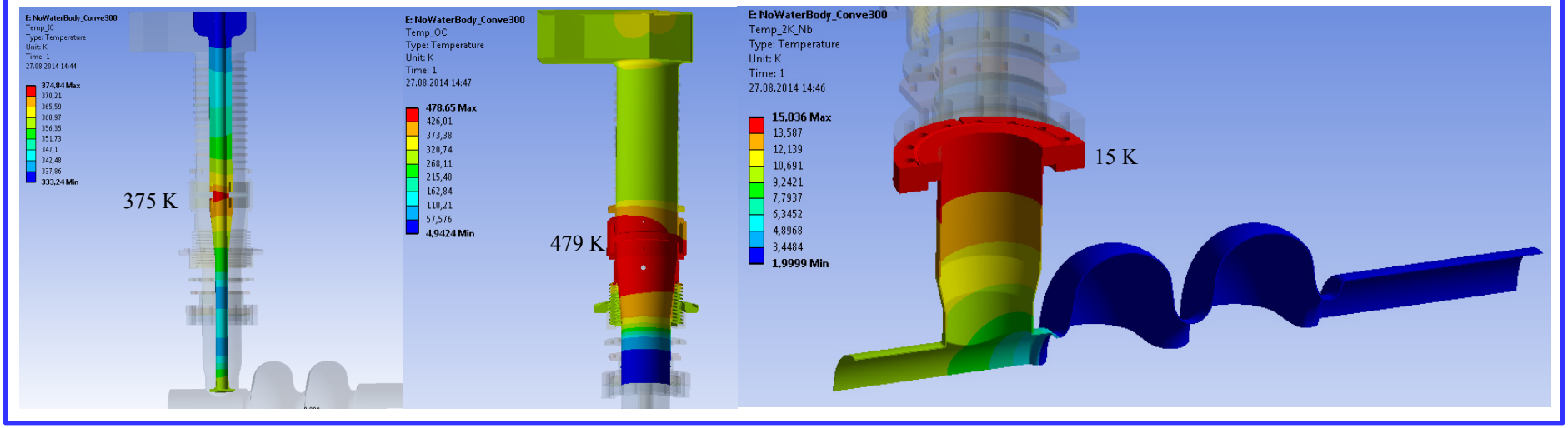
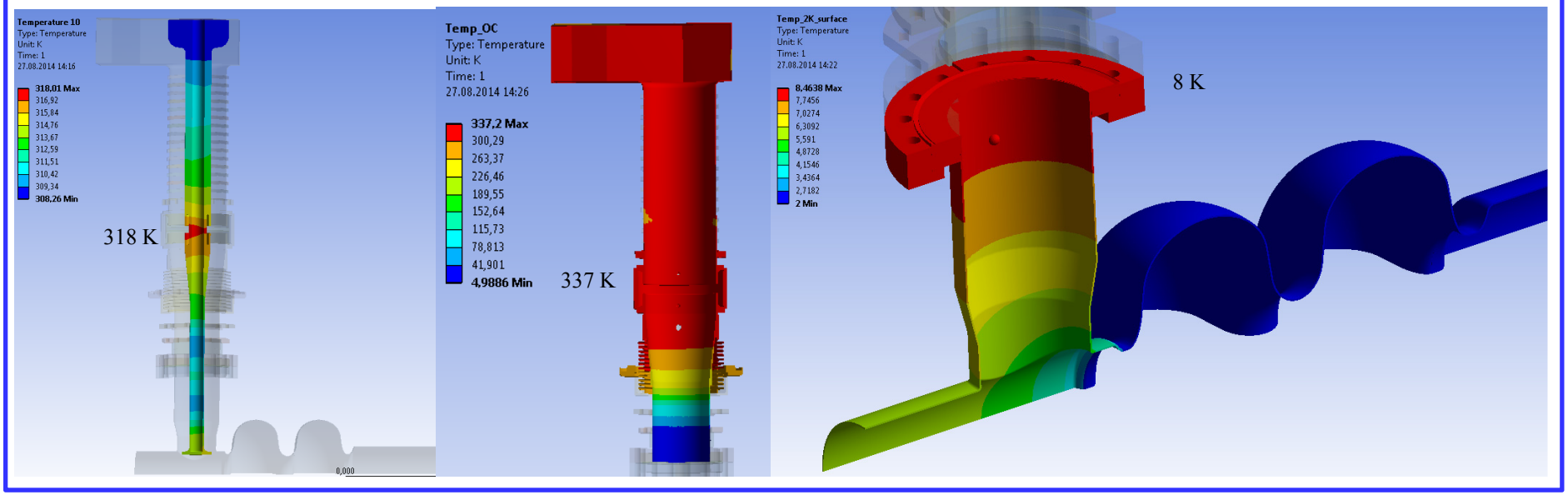
P = 115 kW : No beam, full dynamic loads



P = 115 kW : No beam, Quarter dynamic loads



Summary

- RF design is completed
- Cu thickness on the inner conductor should be minimum 10 µm
- Outer conductor should be cooled completely
- Thermal simulations are preliminary (averaging SS and Cu thermal conductivities)
- Detailed thermal analysis is underway in collaboration with JLab by considering a layer of Cu inside SS
- Outer conductor cooling channel design is ongoing

Acknowledgements

On behalf of bERLinPro team, thanks to our collaborators from
KEK : E. Kako
Thomas Jefferson Laboratory : H. Wang and G. Cheng
Also many thanks to K. Papke and R. Bonomi from CERN for helping with thermal calculations.

For more details please visit: TUPP065

Thank you