

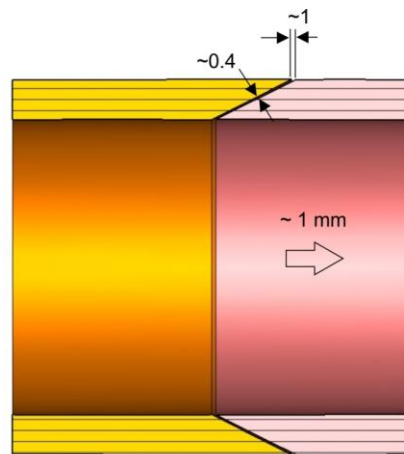
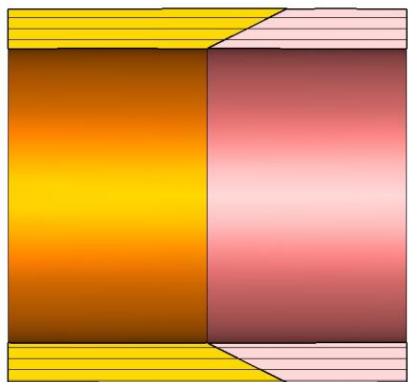
Coupler without copper coating

S. Kazakov

11/13/2013

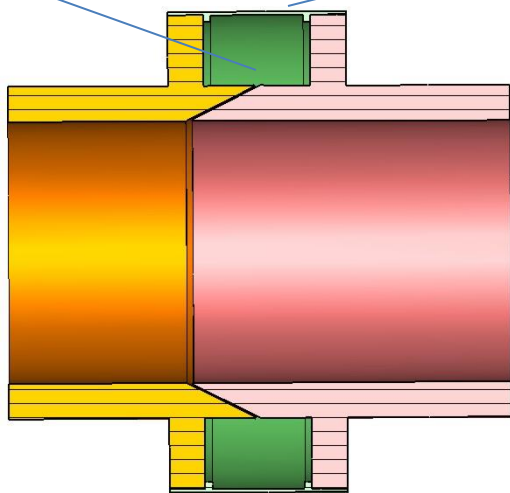
- ✓ **Coupler for SRF cavity has to provide low RF loss and low heat flow from room temperature to cryo-temperatures . These are contradictory requirements.**
- ✓ **Traditional solutions is thin SS coated with thin Cu.**
- ✓ **Problem with Cu coating still exists: difficult to get a durable coating , difficult to get a good reproducible RRR, copper coating increase thermo-conductivity (requires accurate control of copper layer.**
- ✓ **We would like to suggest new approach which solves this problem: without copper coating a coupler has RF loss as a pure copper and thermal conductivity as a pure SS.**

Idea:

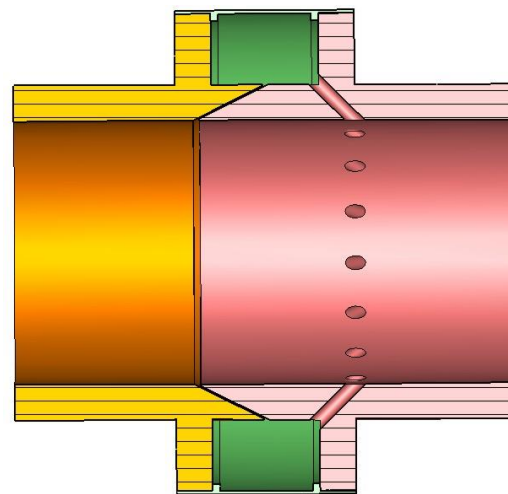


No thermal contact
between copper parts

Low fields chamber SS



Heat flows through SS only,
RF loss in SS < loss in Cu

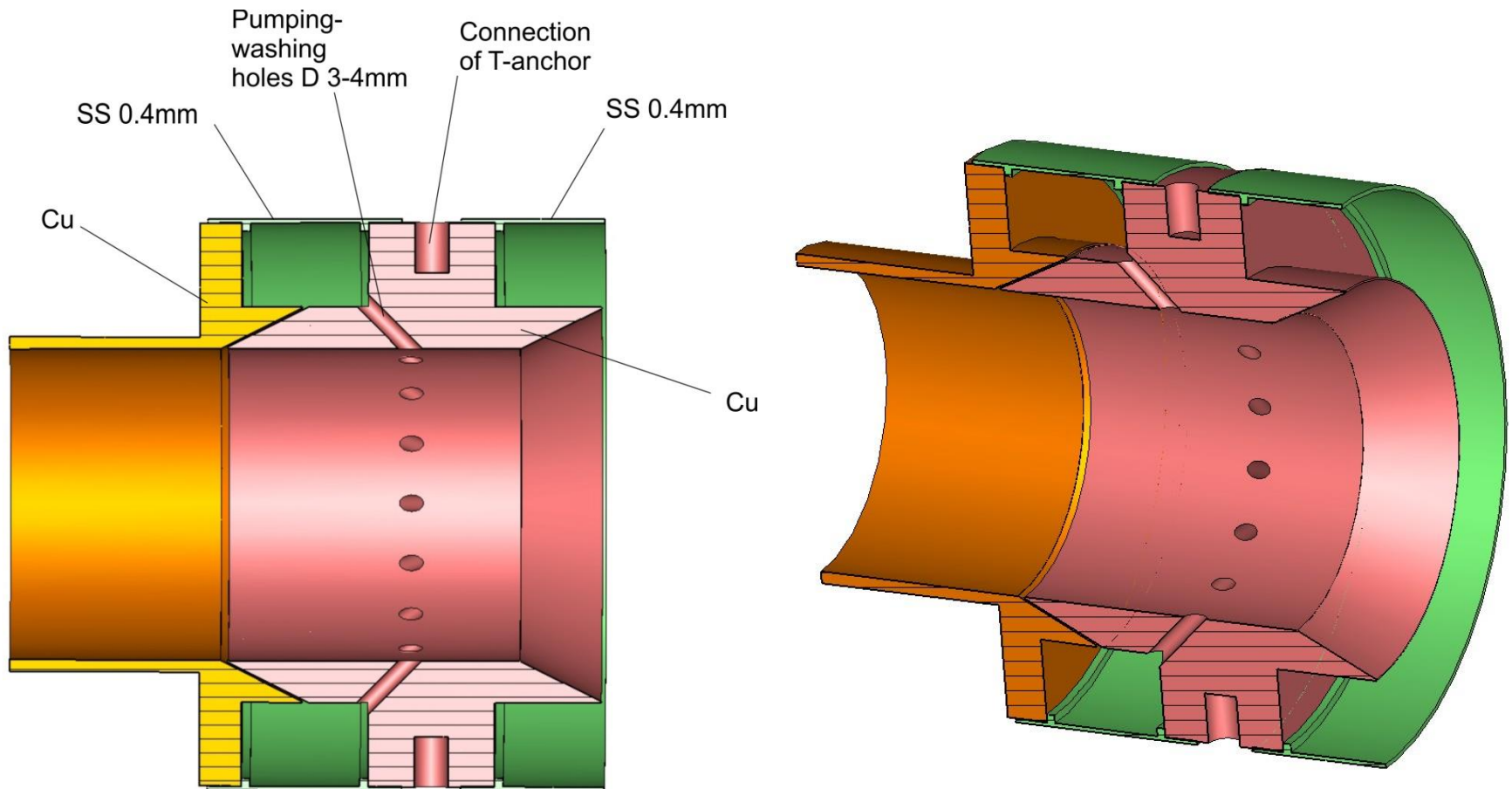


Holes for pumping and washing

One possible configuration:

With some combinations of dimensions of slot and chamber:

- 1) RF reflections < -35 dB
- 2) H-field at SS surface < 0.25 of H-field at Cu surface (losses at SS will be $<$ losses at Cu)



Requirements to slot, chamber dimensions:

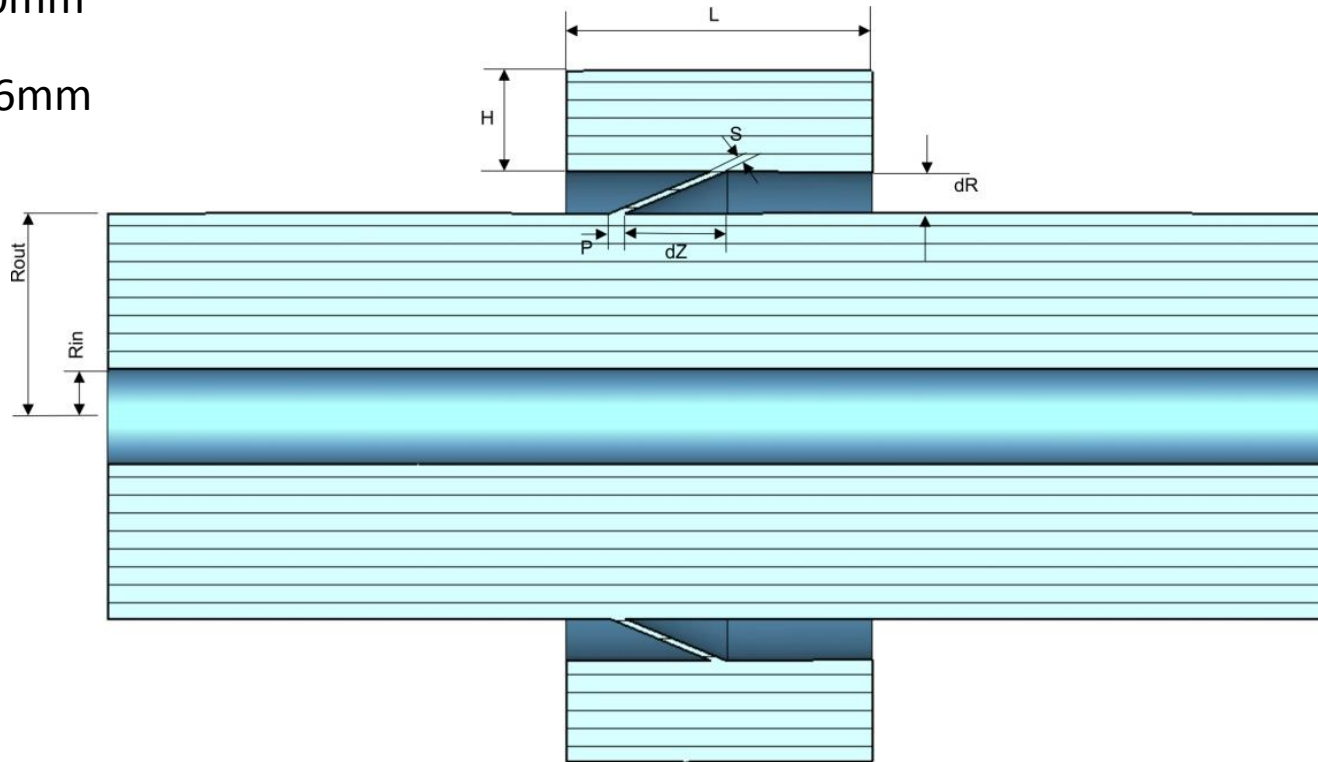
Requirements is not so strict:

Slot should be small and long enough, chamber should be big enough.

Examples:

$R_{out} = 20\text{mm}$

$R_{in} = 4.76\text{mm}$

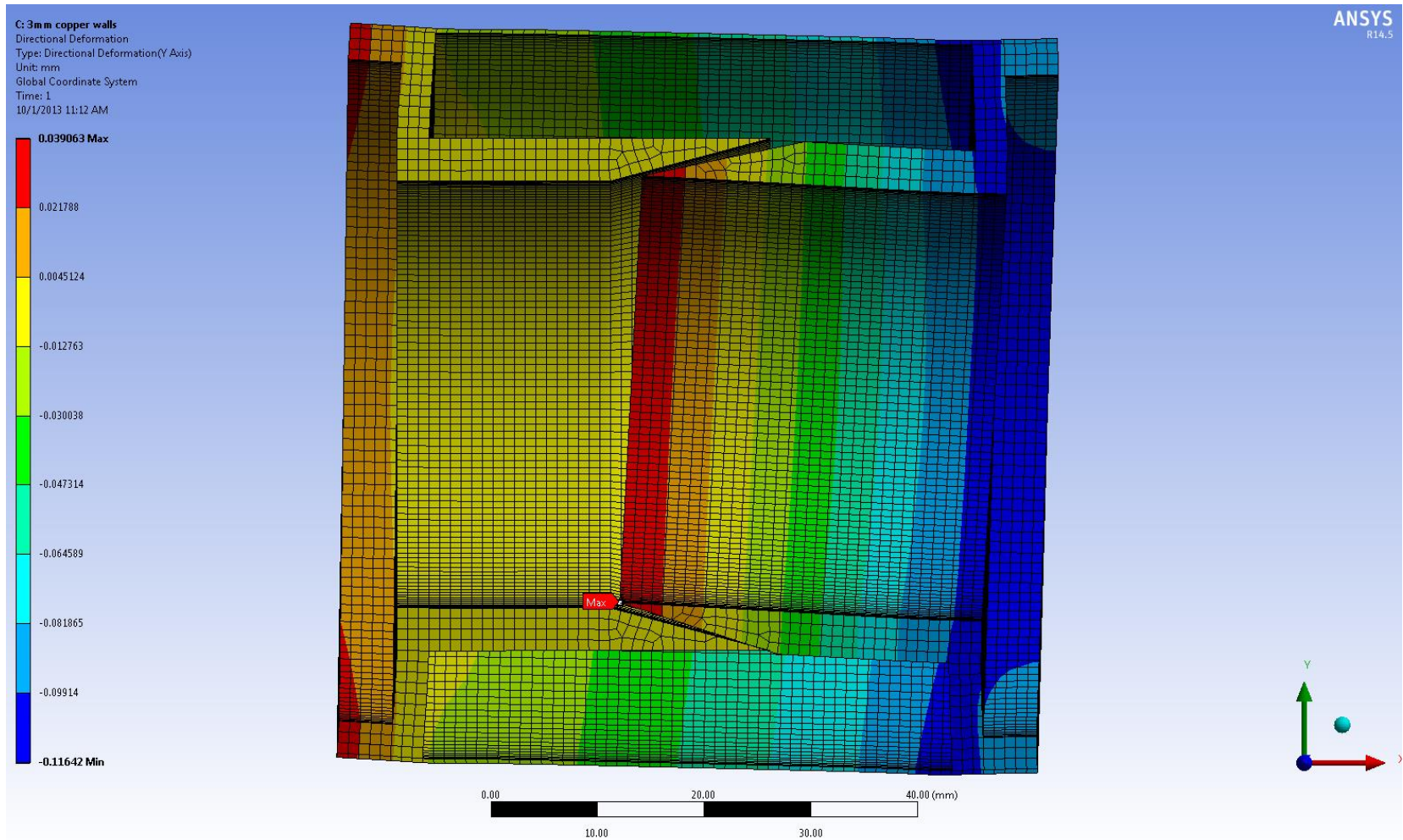


There is no multipactor for copper slot $< 0.5\text{ mm}$ for any fields (1.3 GHz)
There is no multipactor in chamber (low fields) in operating power range.

dR	dZ	P	S	Rb	H	L	Ref	H1	H2	H2/H1
4	10	1.5	0.557	0	10	30	-28.05	0.85	0.21	0.247
4	10	1.5	0.557	0	10	40	-29.0	0.854	0.143	0.167
4	10	1.5	0.557	0	10	50	-29.5	0.854	0.107	0.125
4	10	2.0	0.743	0	10	50	-26.4	0.853	0.153	0.179
4	15	2.0	0.515	0	10	50	-33.7	0.855	0.07	0.082
4	15	2.0	0.515	0	5	50	-32.7	0.856	0.165	0.196
4	15	2.0	0.515	0.5	5	50	-25.8	0.855	0.374	0.437
4	15	2.0	0.515	0.2	5	50	-30.6	0.855	0.210	0.246
4	15	1.5	0.386	0.2	5	50	-34.0	0.852	0.145	0.170
4	15	1.5	0.386	0.5	5	50	-29.7	0.853	0.240	0.281
5	15	1	0.316	0.2	5	50	-37.1	0.853	0.1	0.117
5	15	1	0.316	0.2	5	30	-35.8	0.853	0.192	0.225
5	15	1	0.316	0.2	8	30	-36.8	0.853	0.105	0.123
5	15	1	0.316	0.2	8	20	-35.8	0.853	0.172	0.202
5	15	1	0.316	0.2	10	20	-36.3	0.853	0.127	0.149
5	15	1	0.316	0.2	10	10	-33.7	0.853	0.333	0.390

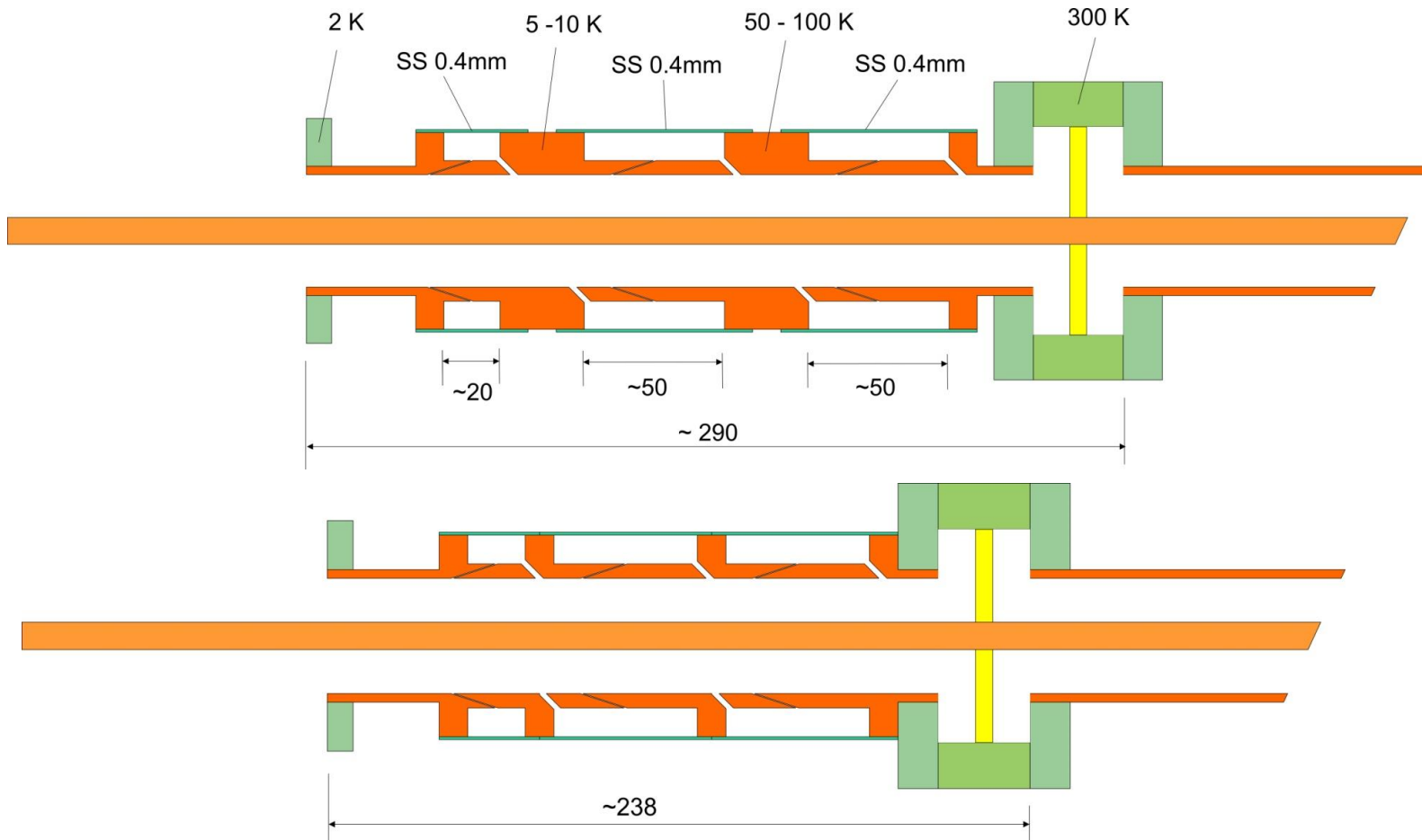
Loss in SS will be $\sim (0.2)^2 * 7 \sim 0.3$ of loss in copper

Preliminary mechanical analyses shows that this configuration is possible.



We cannot 'close' the slot by bending - plastic deformations start first.

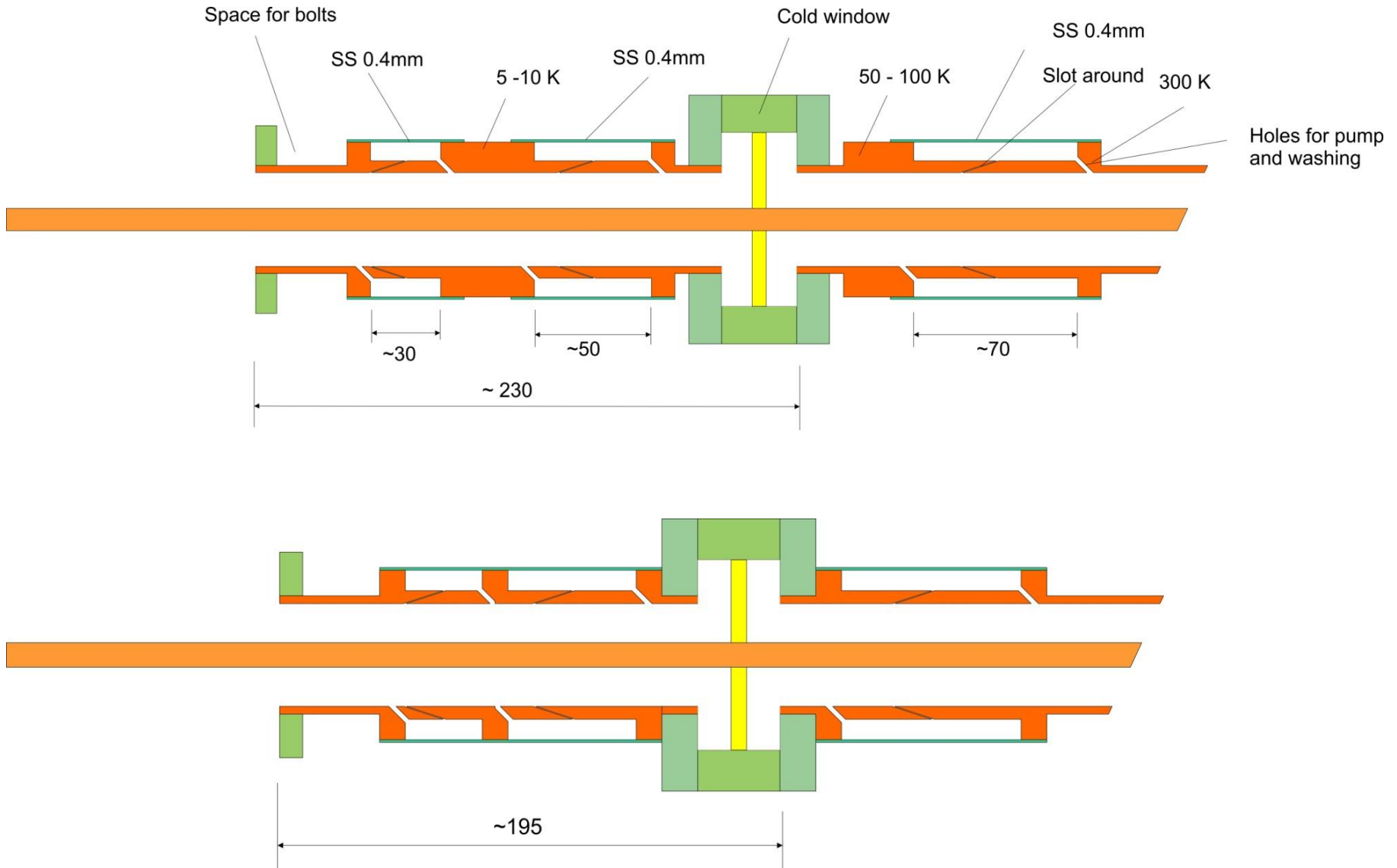
One-window 1.3 GHz coupler configuration



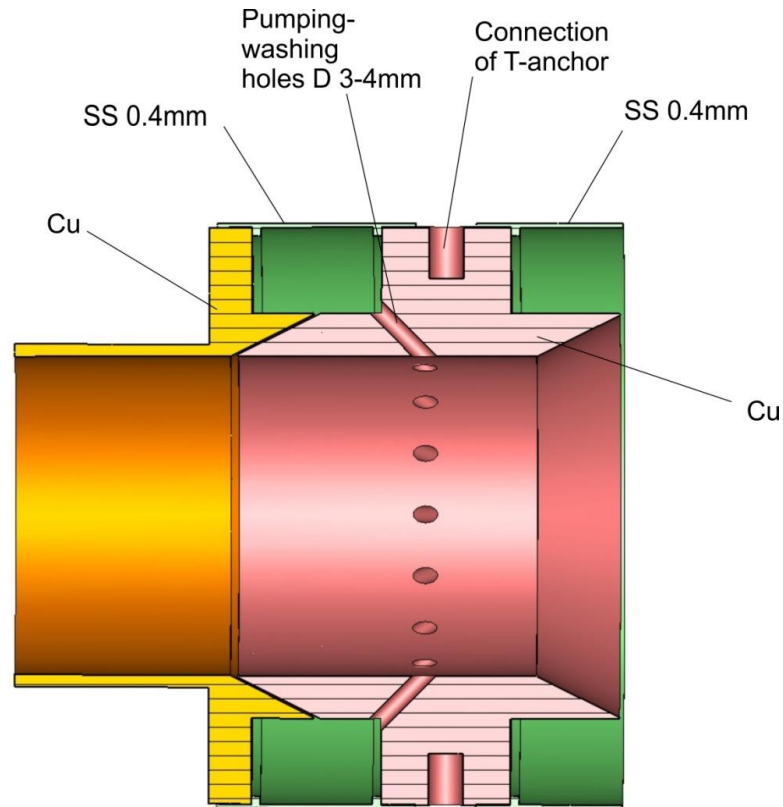
Cryo-loads, RRR = 10:

T	2 K	10 K	100 K
Static, W	0.017	0.90	3.2
Total (RF = 6kW, TW), W	0.12	1.05	3.5

1.3 GHz coupler configurations with cold window



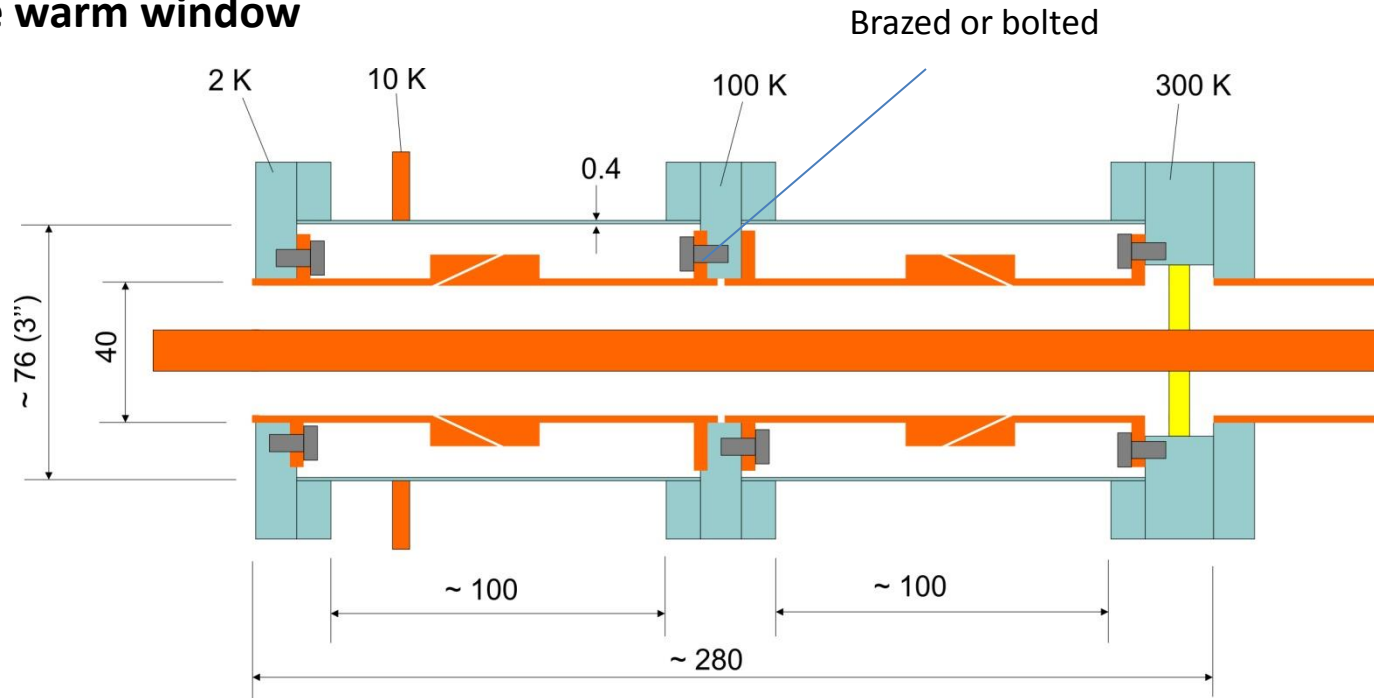
Main question: can we clean/wash this assembly?



**FNAL experts opinions: there is no problem to prepare initially clean assembly.
Problem is to re-clean the chamber after first test / conditionings.
May be it will be difficult to blow out particles from chamber.**

Demountable configuration allows to do a re-cleaning:

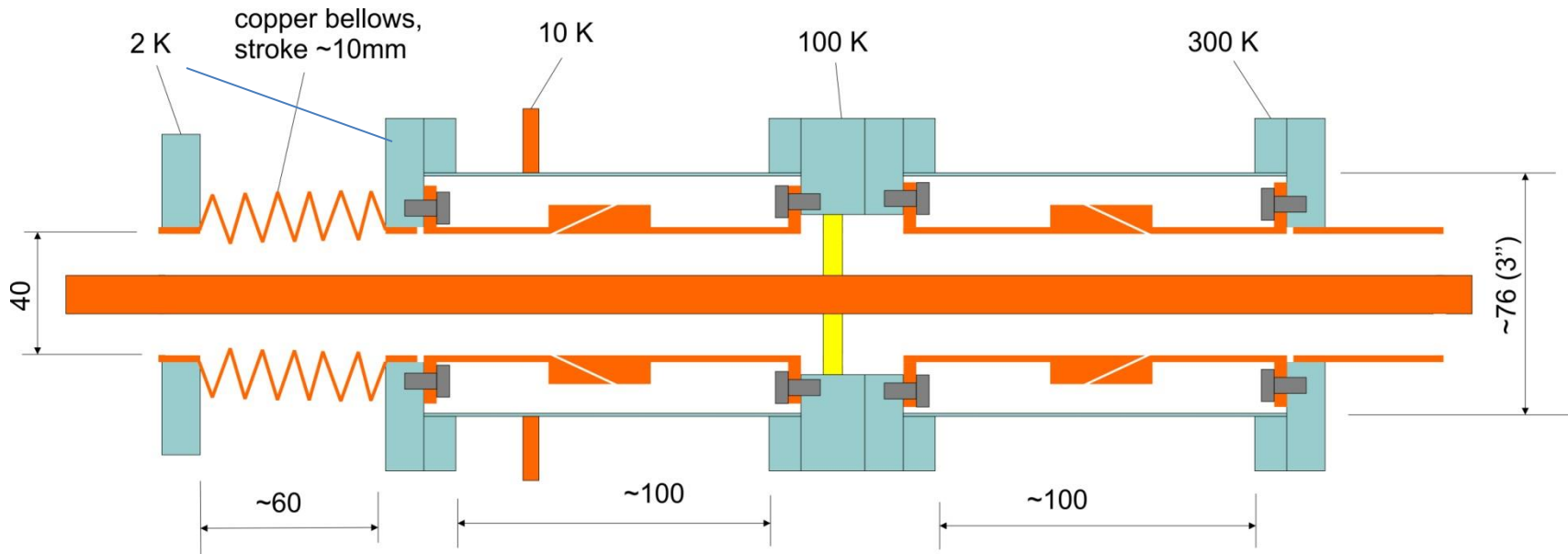
One warm window



Cryo-loads, RRR = 10:

Temperature, K	2 K	10 K	100 K
Static load, W	0.018	0.65	2.4
Total (RF=6 kW, TW)	0.134	0.66	3.0

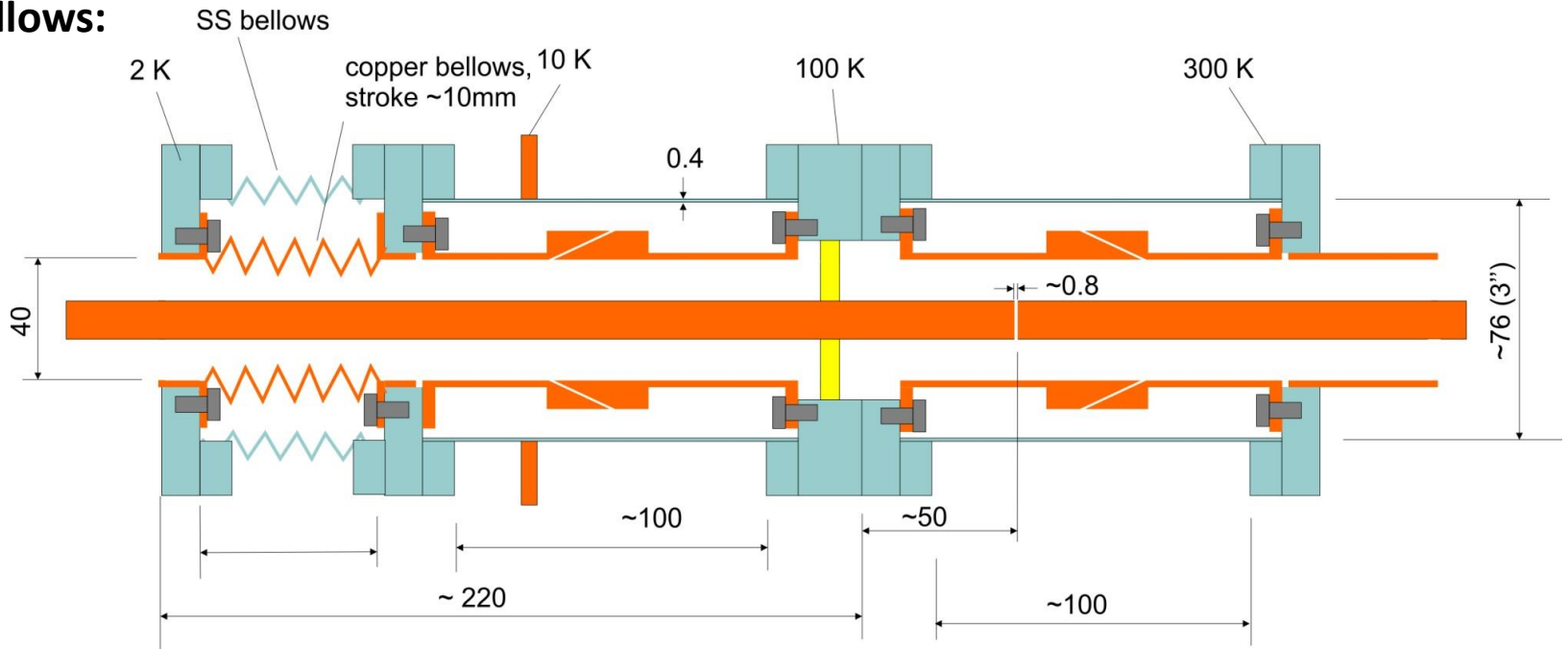
Cold window, adjustable coupling



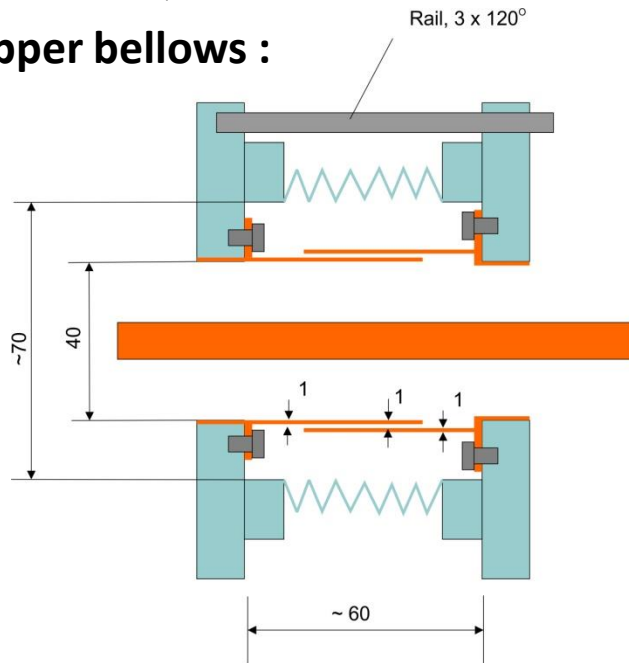
Cryo-loads, RRR = 10:

Temperature	2 K	10 K	100 K
Static load, W	0.018	0.65	2.4
Total (RF = 6 kW, TW)	0.57	0.66	8.8

Double bellows:



Or no copper bellows :



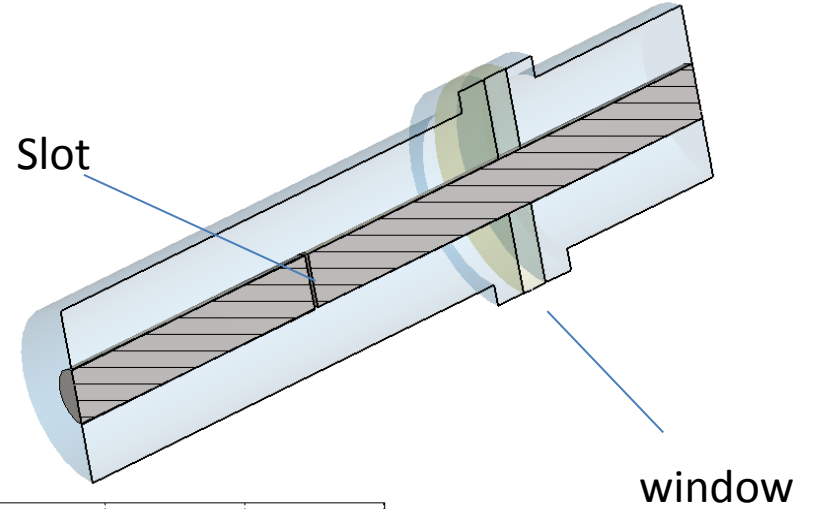
Problem – multipactor in slot.

**CST copper (max SE ~ 2.1), multipactor range
~ 10 kW - 2 MW, TW**

**'Clean' copper (max SE ~1.4), multipactor range
~ 25 kW – 800 kW, TW**

2 K load ~ 0.1 W for 6 kW RF

Slot matches the window and thermally decouples cold and warm parts of antenna.

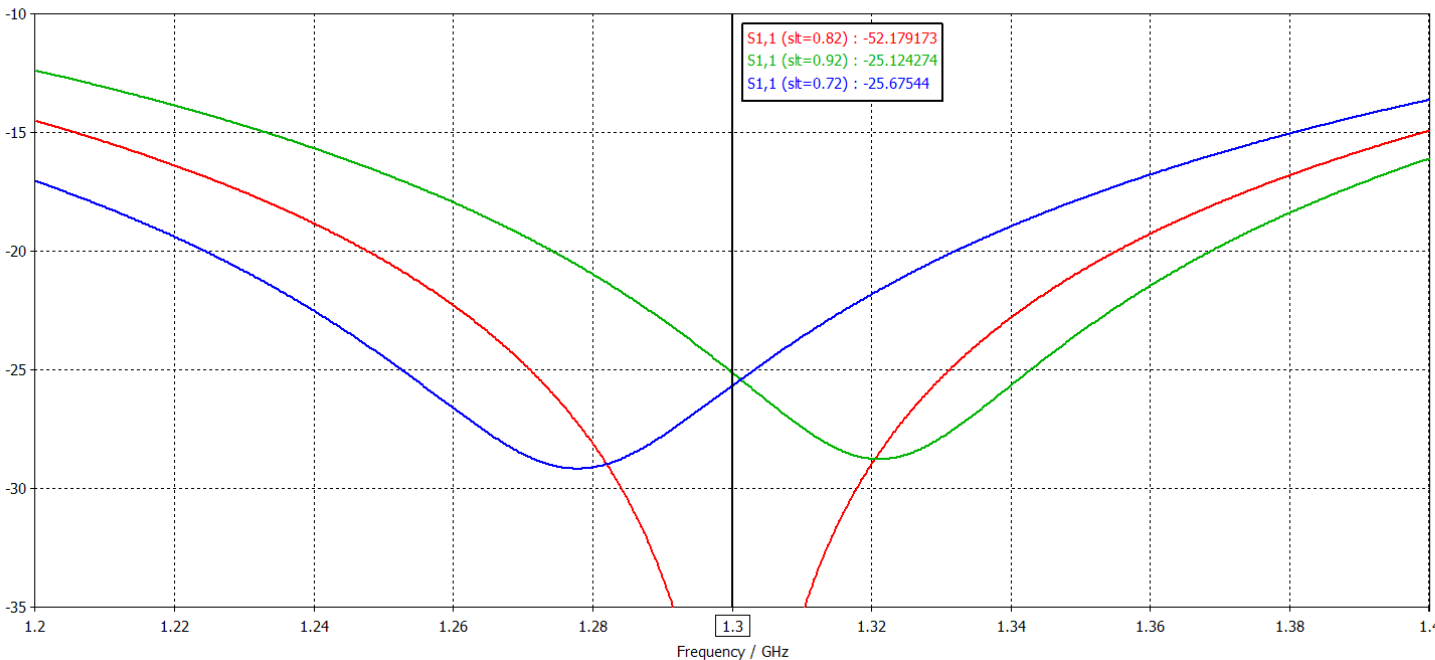


We can avoid SS bellows

Sensitivity to slot size:

Optimal size – 0.82mm. Simulated +/- 0.1mm

[Parametric Plot] [Magnitude in dB]



S1,1 (sk=0.82)
S1,1 (sk=0.92)
S1,1 (sk=0.72)

**E-field ~
0.18 kV/(cm*W^{0.5})**

400 kW -> 114 kV/cm

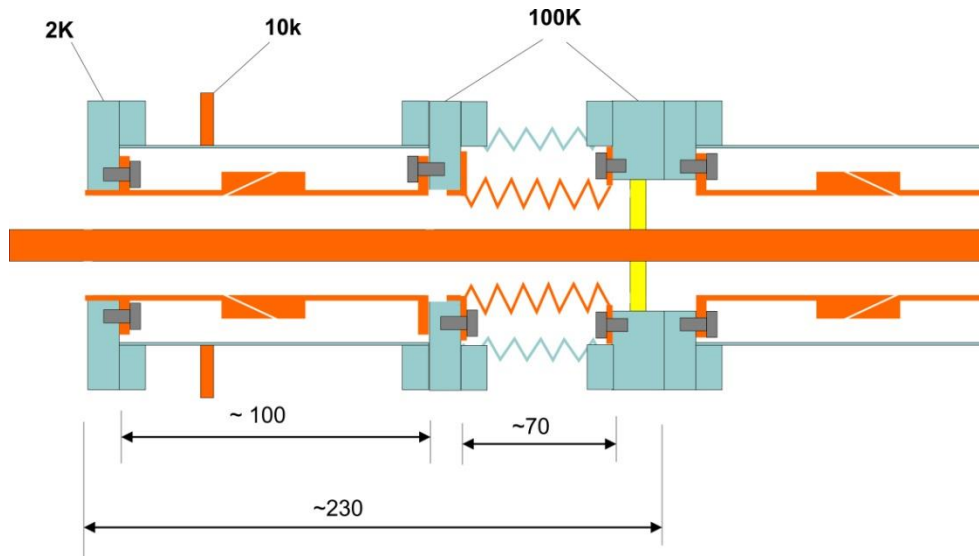
Multipactor in 0.82mm slot:

CST copper (max SE ~ 2.1), multipactor range ~ 20 W - 800 W, TW

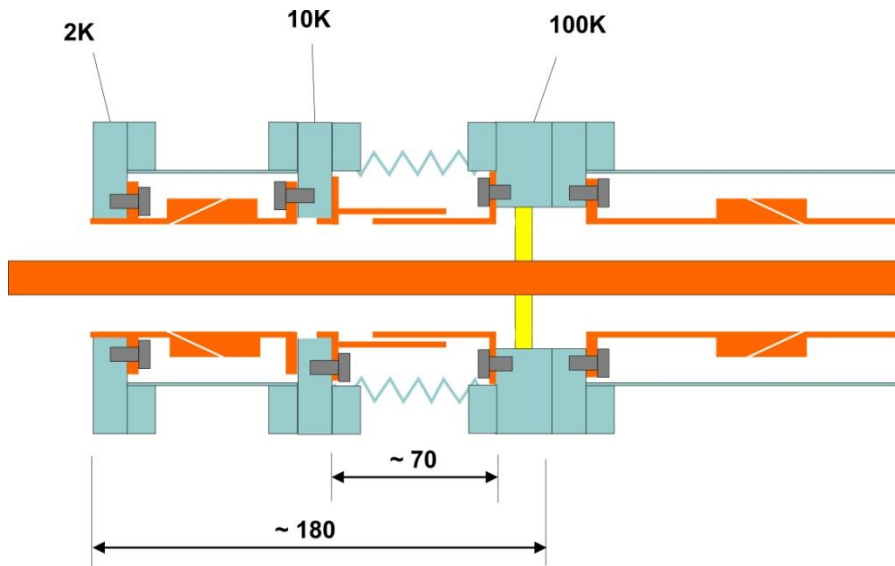
'Clean' copper (max SE ~1.4), multipatir range ~ 160 W – 250 W, TW

} **Out of operating range**

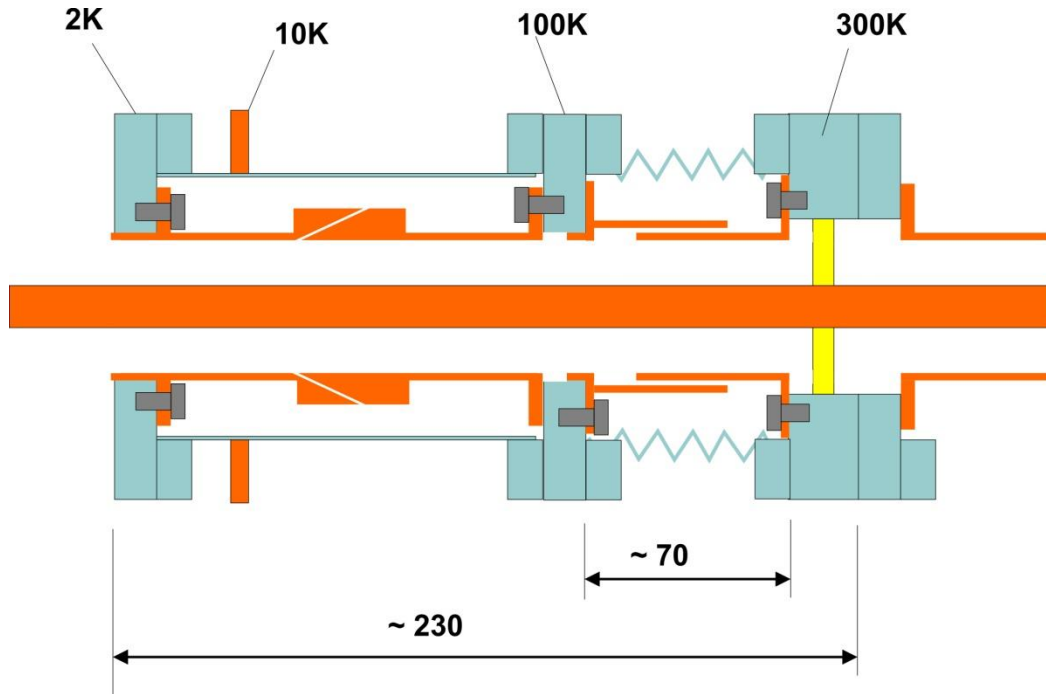
Adjustable coupler with cold window



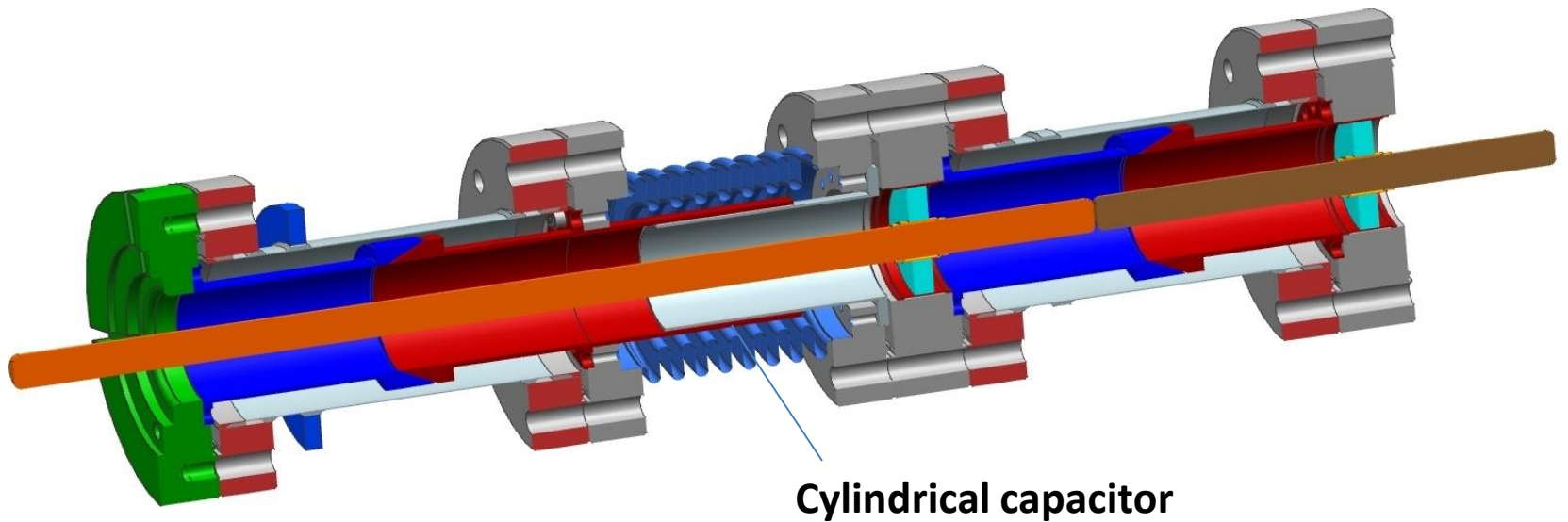
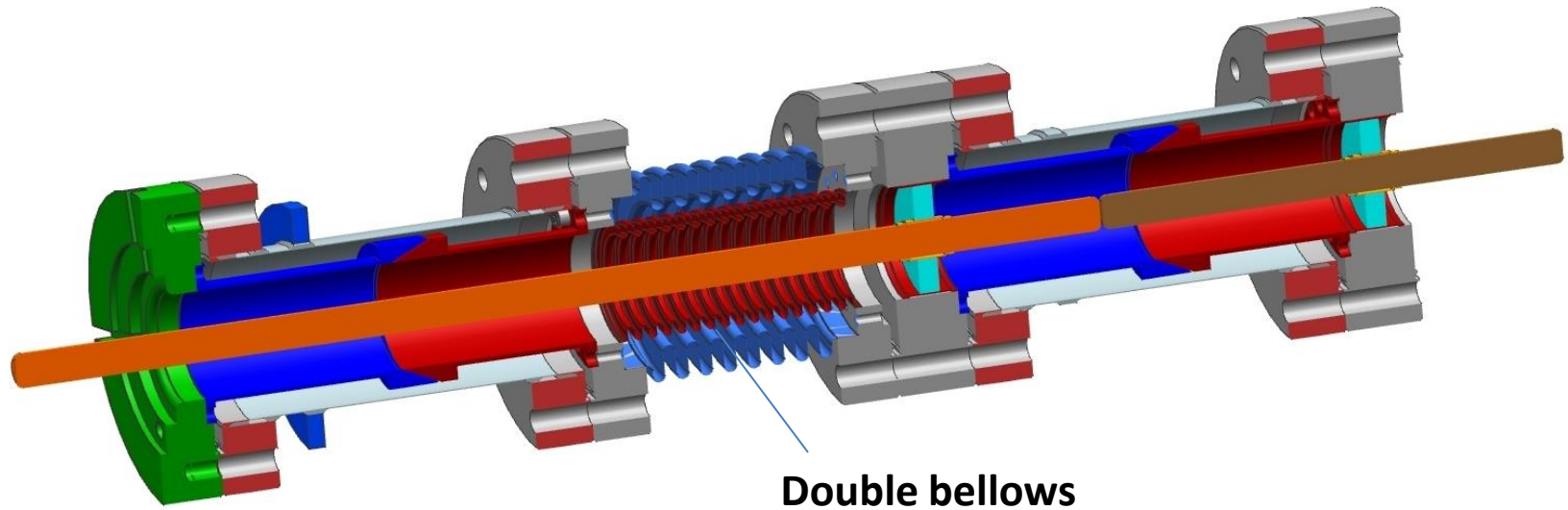
Compact adjustable coupler with cold window



Compact adjustable coupler with warm window(s)



“Realistic” conceptual designs (very preliminary)



Conclusions:

Pros: allow to avoid copper coating of SS. Reproducibility of RRR, low static and dynamic loss (high RRR).

Cons: requires high mechanical accuracy ($\sim \pm 0.2\text{mm}$ concentricity).
Cost?