

Results of high power test of 325 MHz couplers

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08/26/2014

Outline:

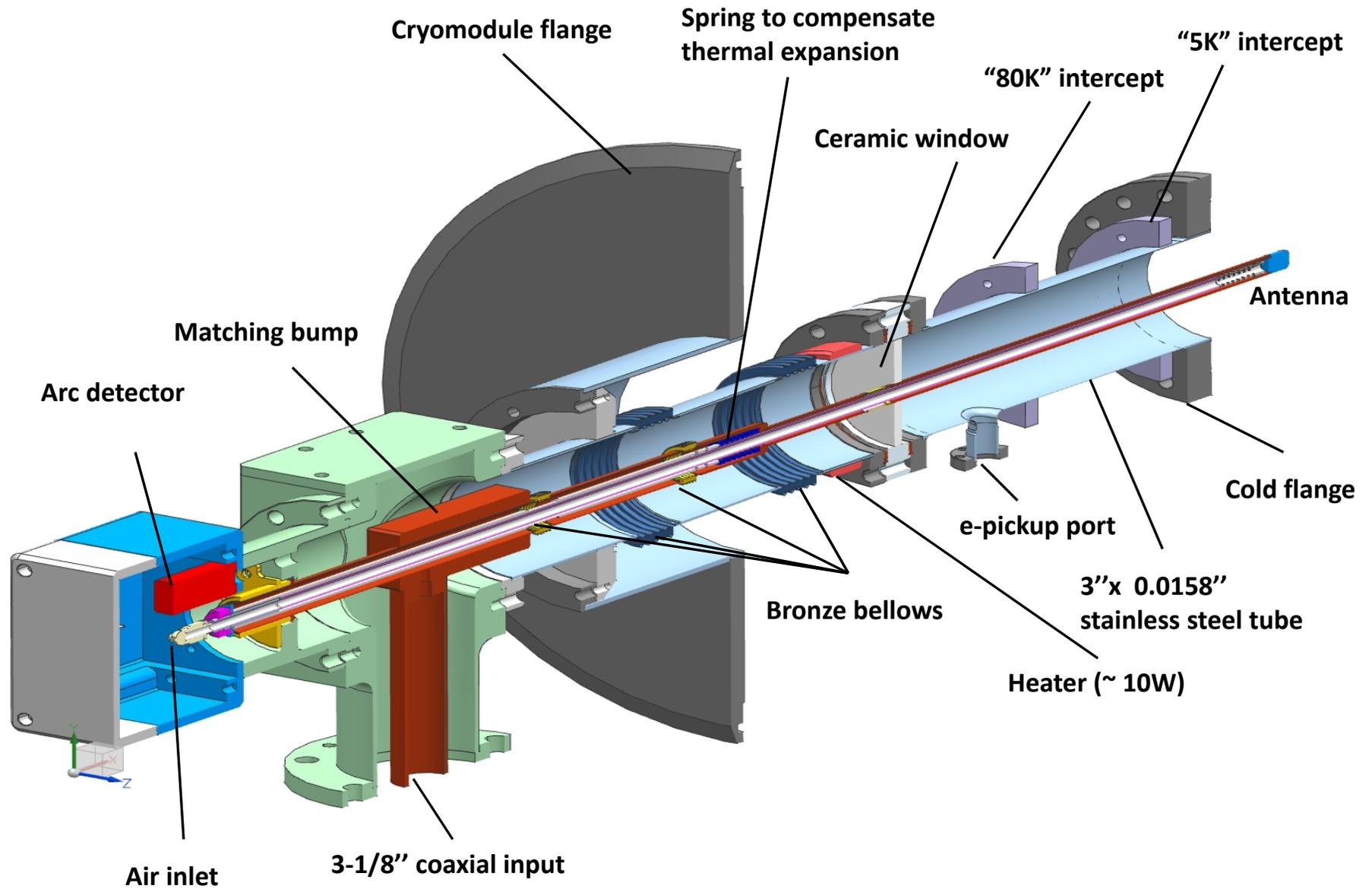
- **325MHz coupler structure**
- **Coupler tuning**
- **Test stand structure and tuning**
- **DC blocks**
- **Movable short**
- **High power test**
- **Conclusions and future works**

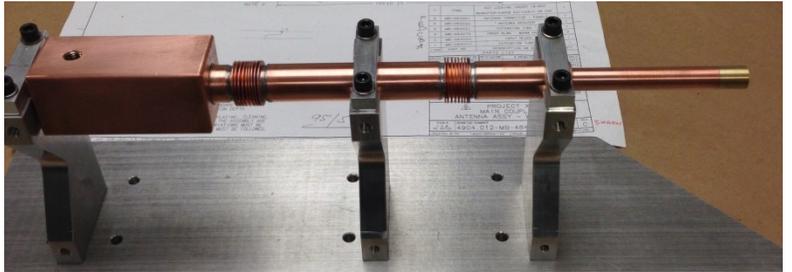
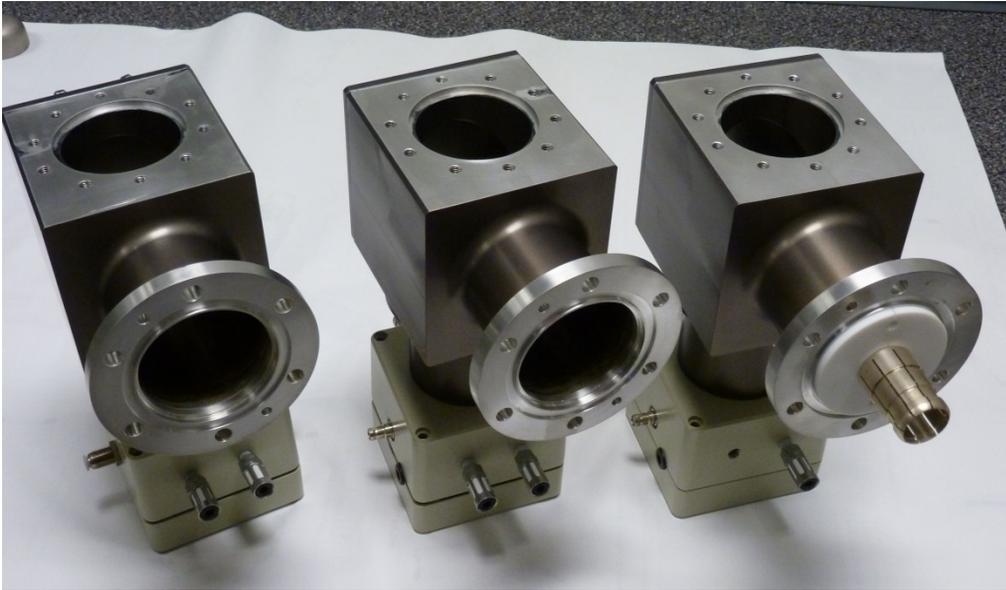
325 MHz Coupler FRS:

Parameter	Value
Frequency	325 MHz
Pass band ($S_{11} < 0.1$)	> 1 MHz
Operating power (CW, any reflection)	25 kW
HV bias	~ 2 kV

Parameter	Value
Input	3-1/8" , 50 Ohm coaxial
Output	3-1/8" coaxial, SSR1/SSR2 flange
RF window	Single, room temperature
Cold flange relative displacement	+3 mm
Vibration and shock	Up to 3 g in any direction

325 MHz coupler anatomy

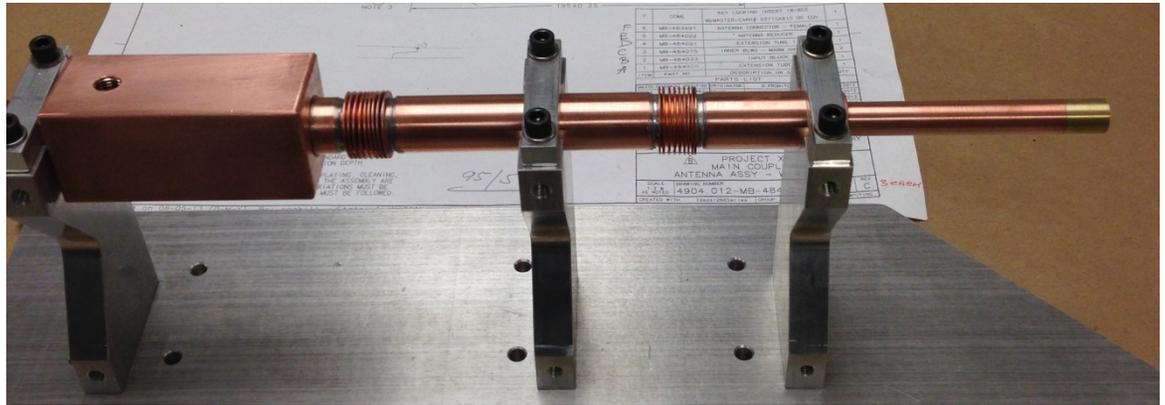




Problems:

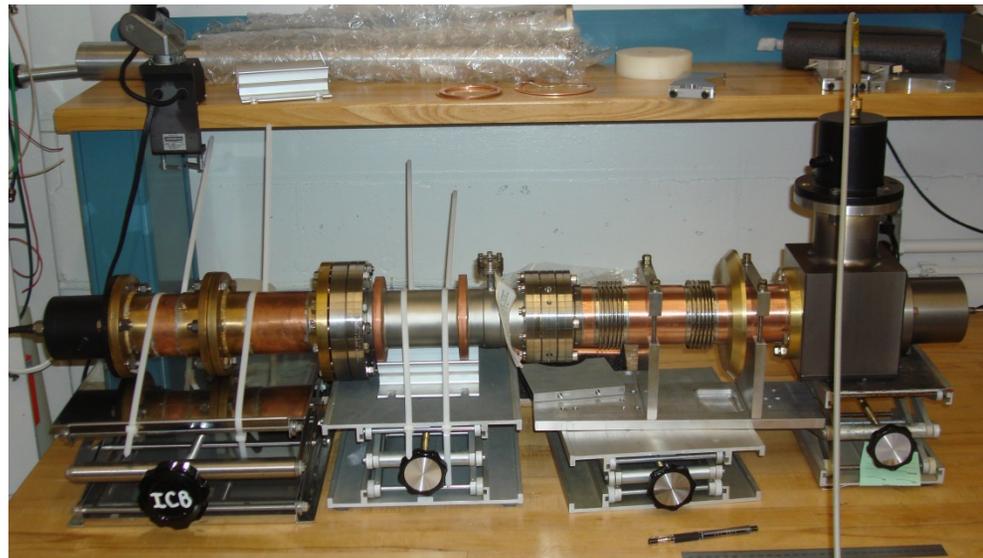


Windows are vacuum tight,
but bracing is not perfect: the are
hollows in ceramic – metal joints



Bellows are too soft.

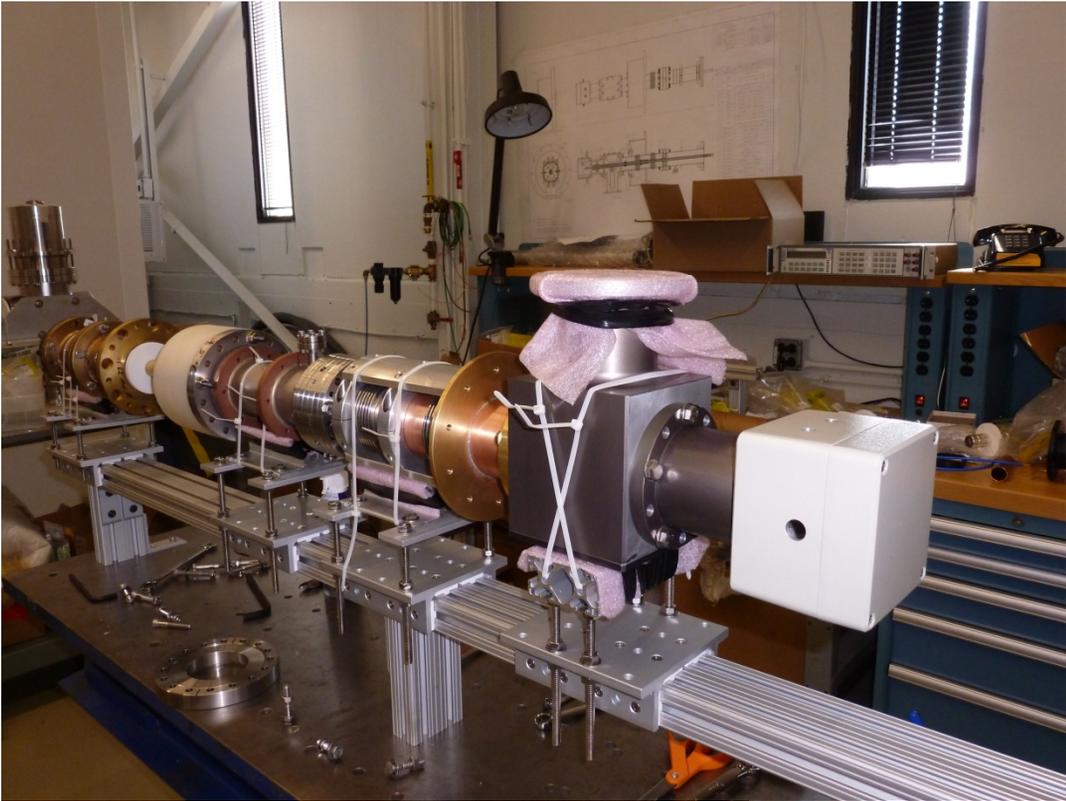
First coupler is assembled :



Three couplers were fabricated, assembled in FNAL and tuned.



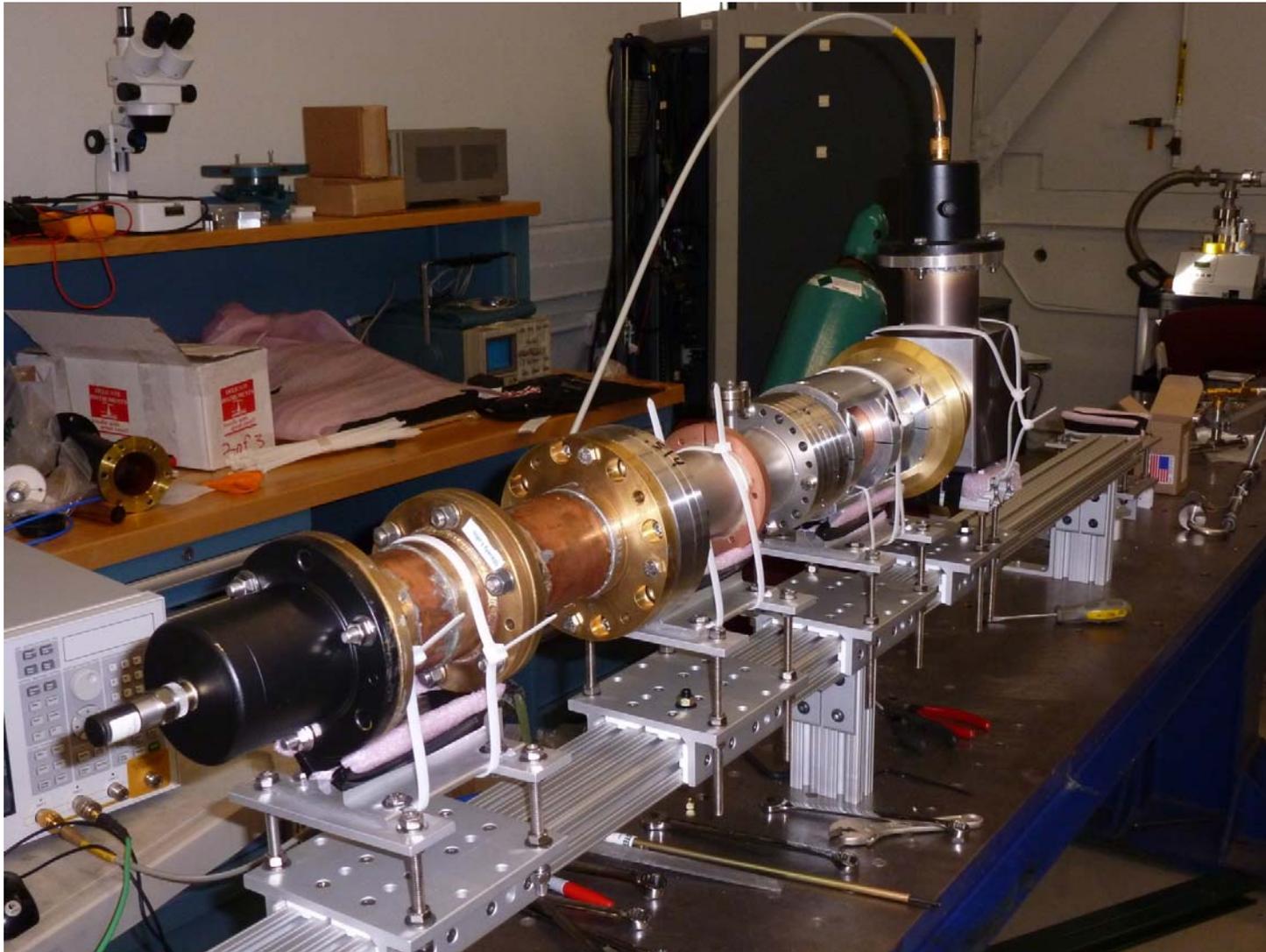
Coupler #1 at test bench.



Coupler #2

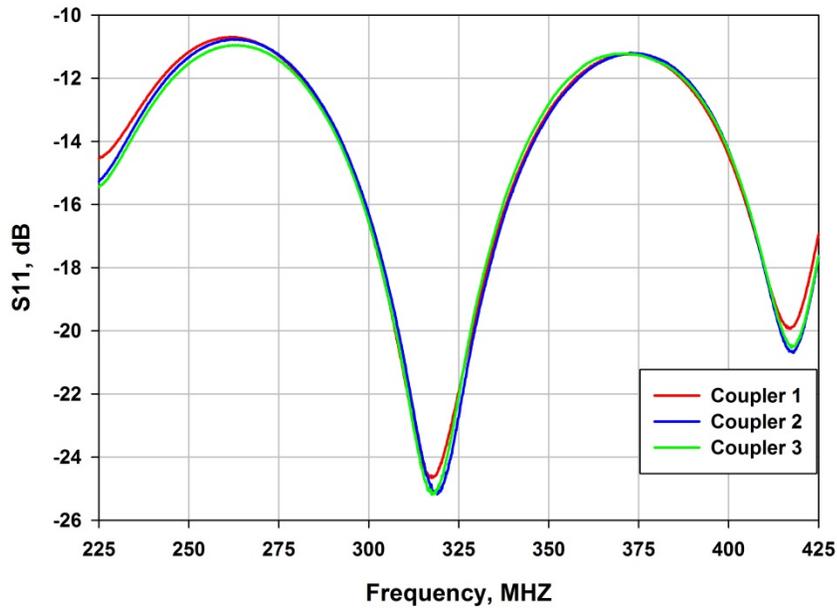


Coupler #3



**Couplers before tuning.
All couplers are identical:**

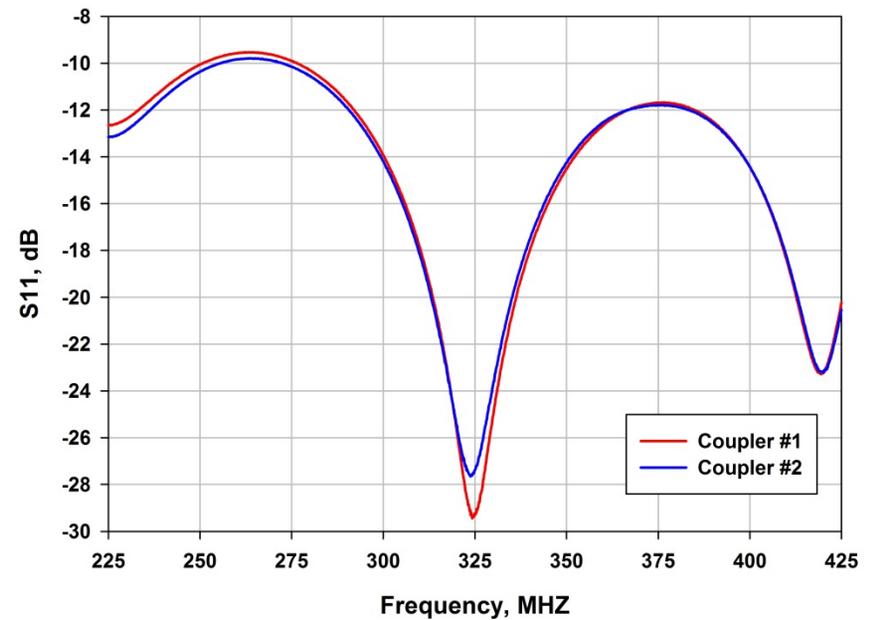
All couplers, S11



Passband (-20dB) ~ 20 MHz

Couplers after tuning:

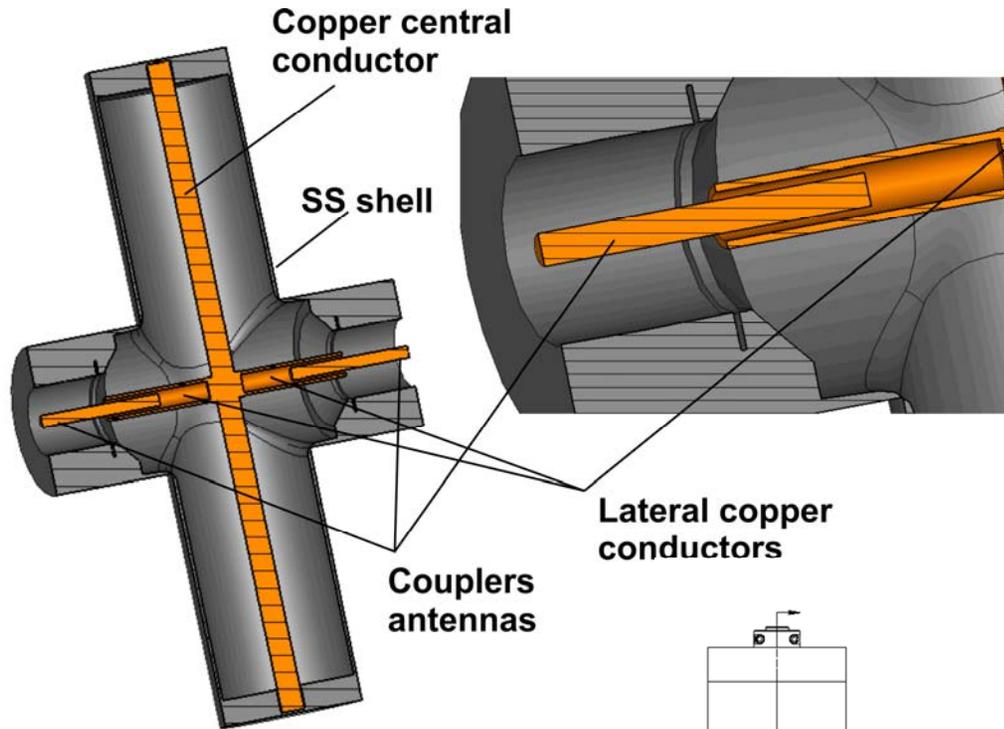
325 MHz couplers after tuning



Test cavity

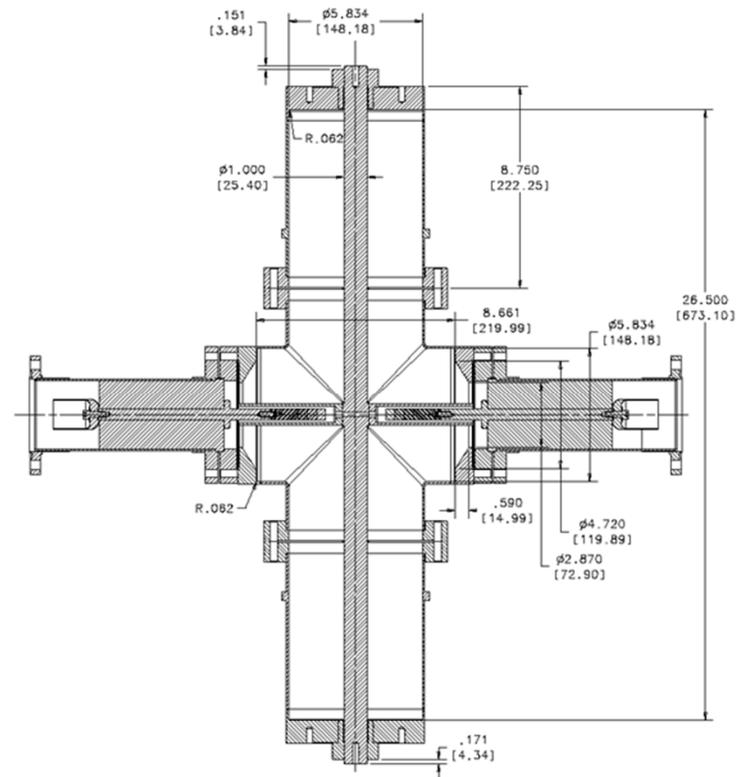
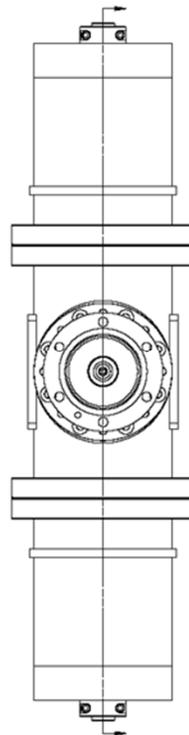
Calculated $Q_0 = 3.3e+3$

Calculated losses = 0.23%

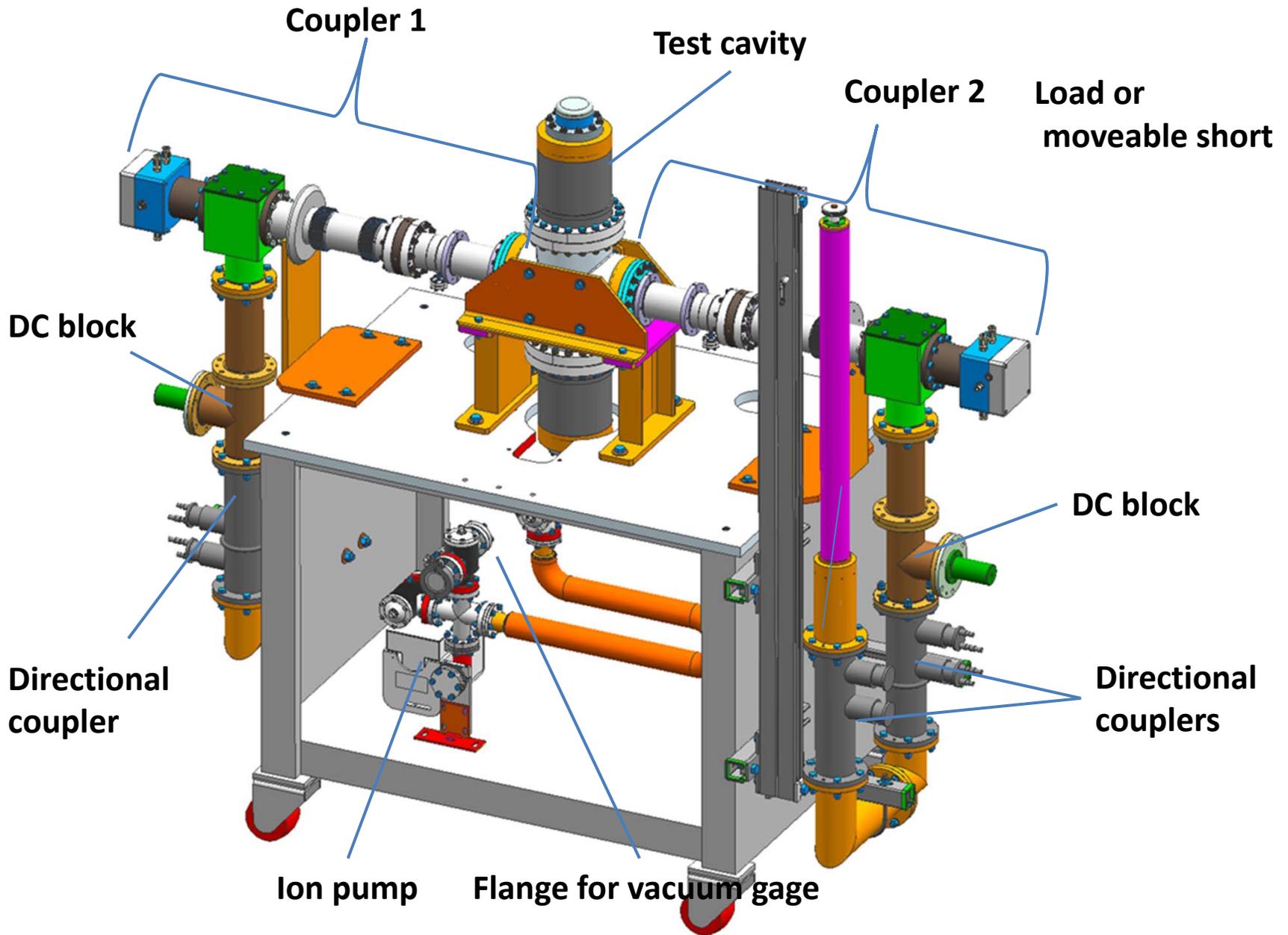


Coupling through lateral conductors makes it wide-banded.

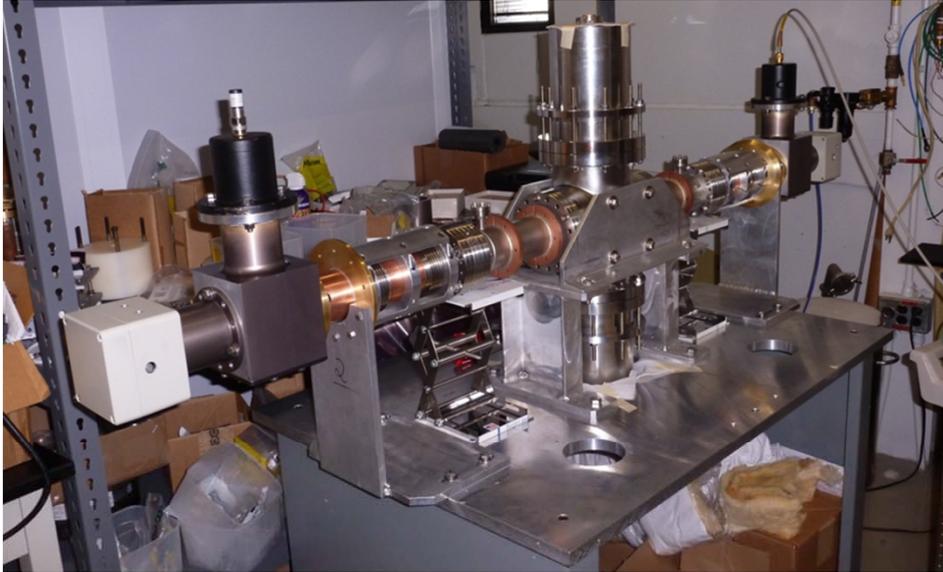
Size of test cavity was chosen to avoid multipactor .



325 MHz Test Stand

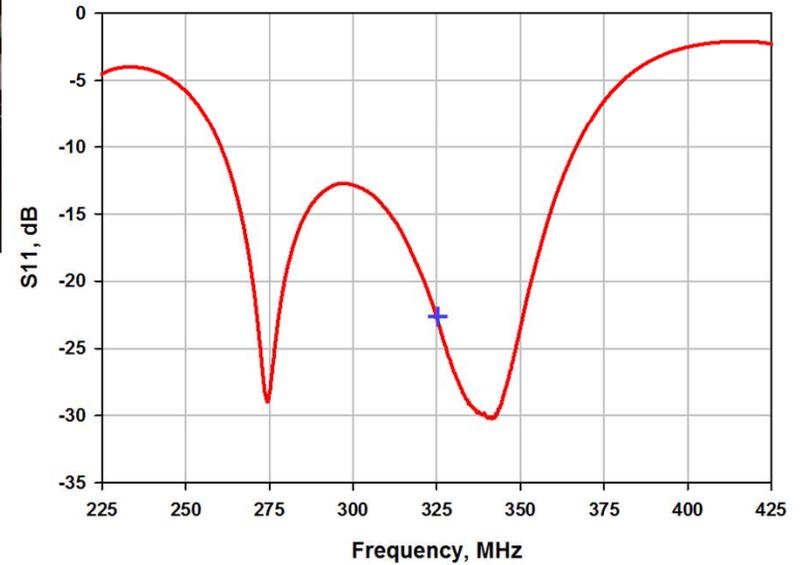


Couplers with test cavity assembled for tuning



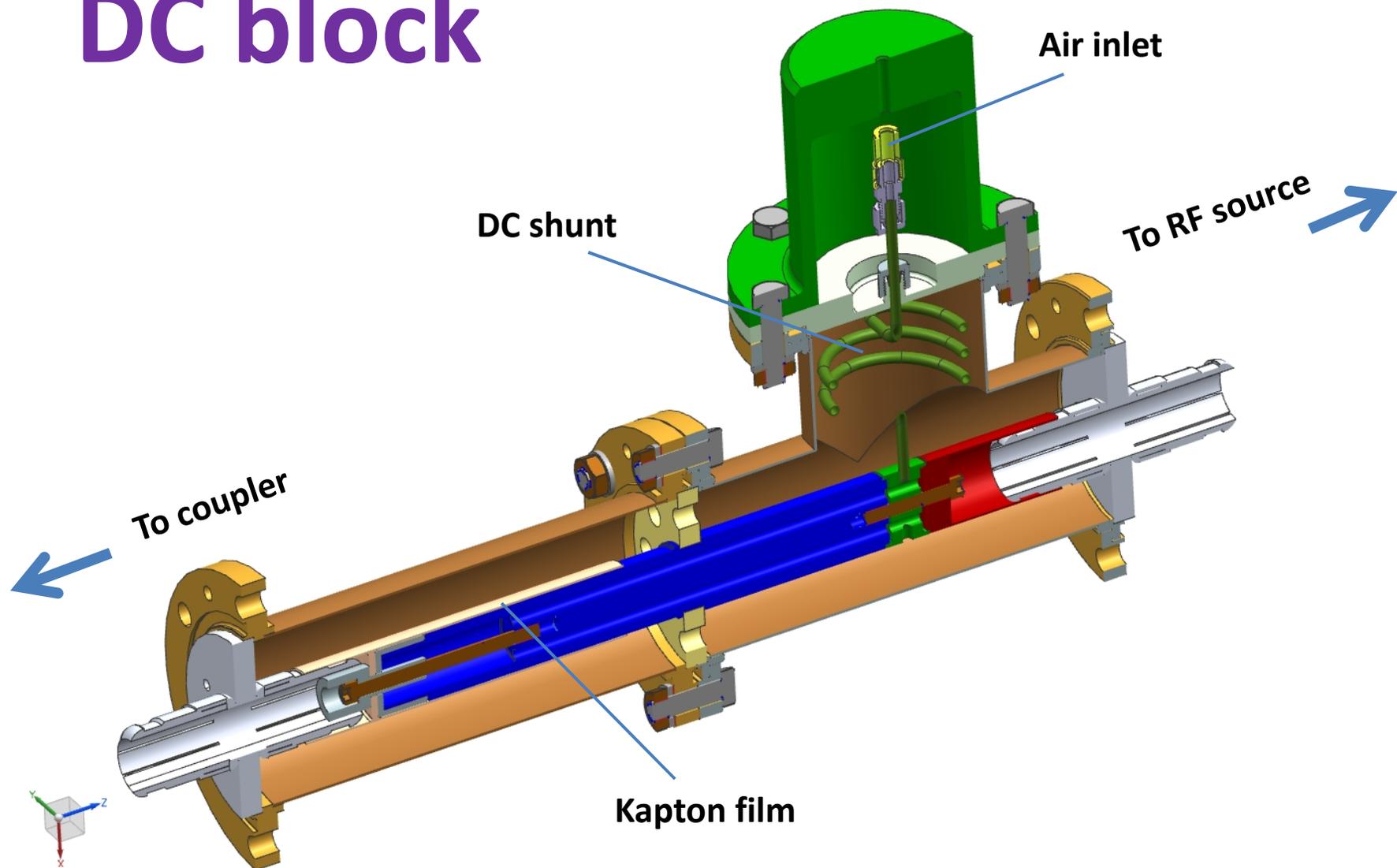
After tuning:

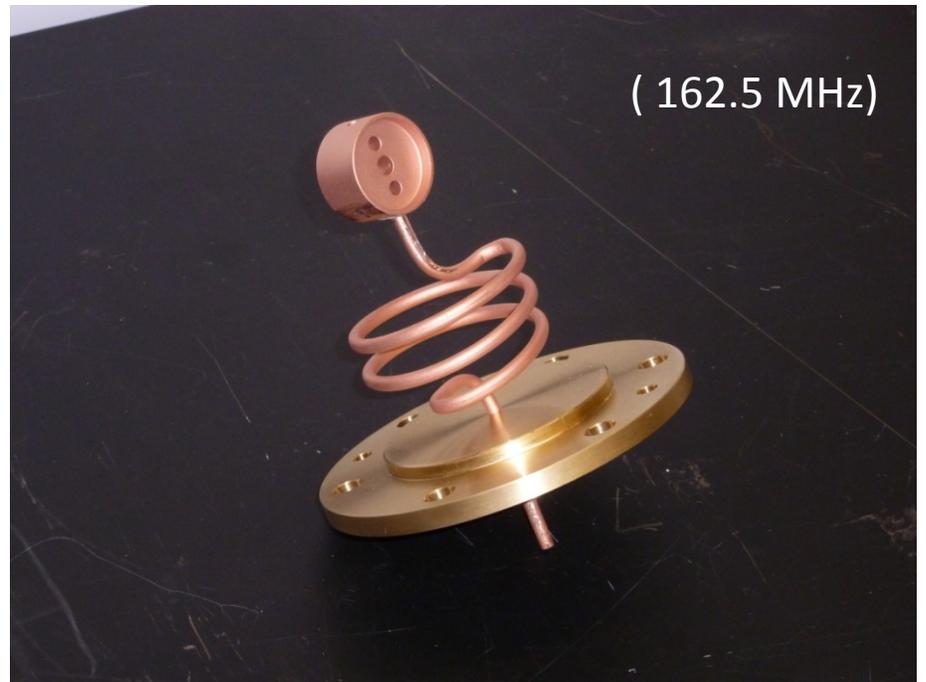
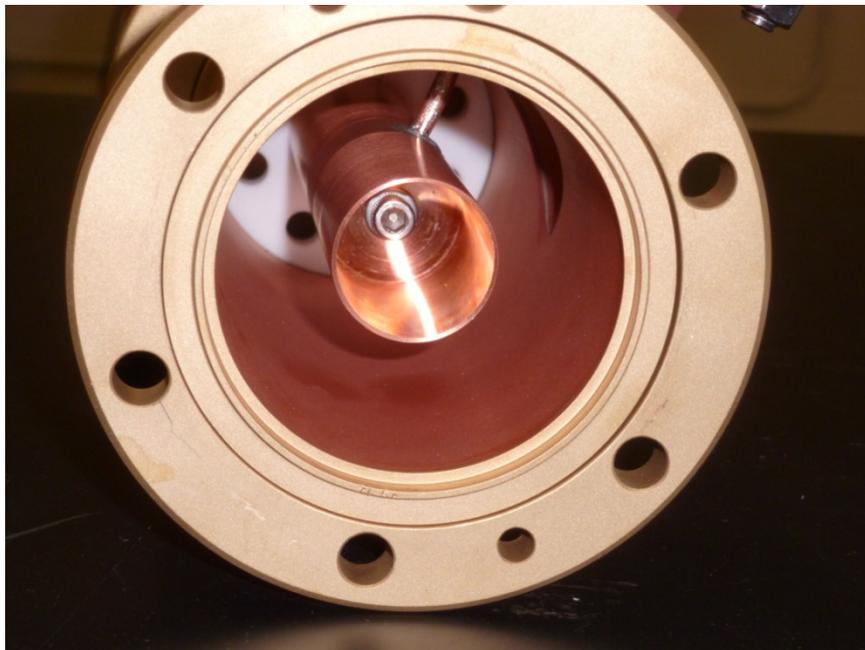
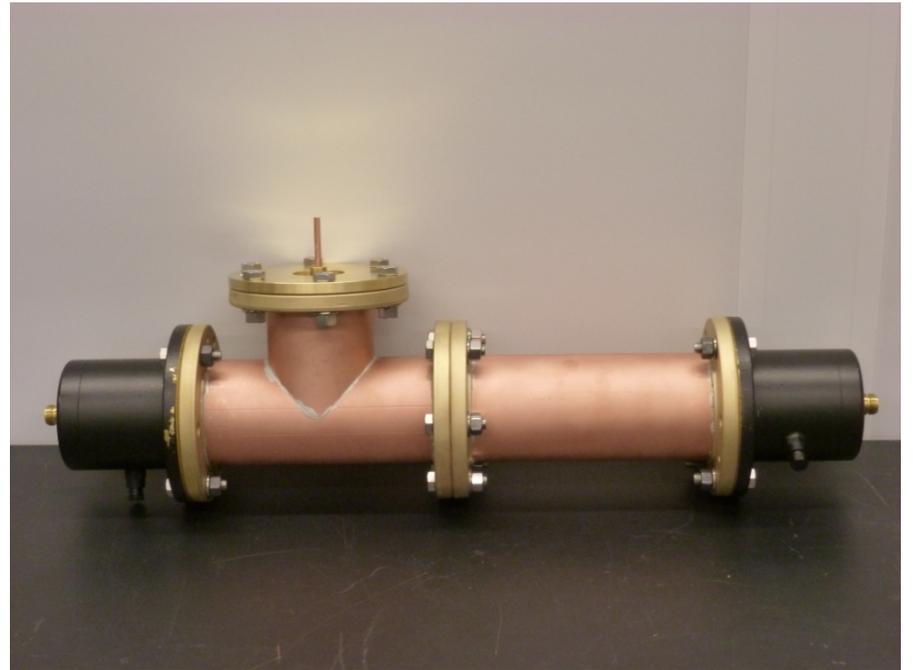
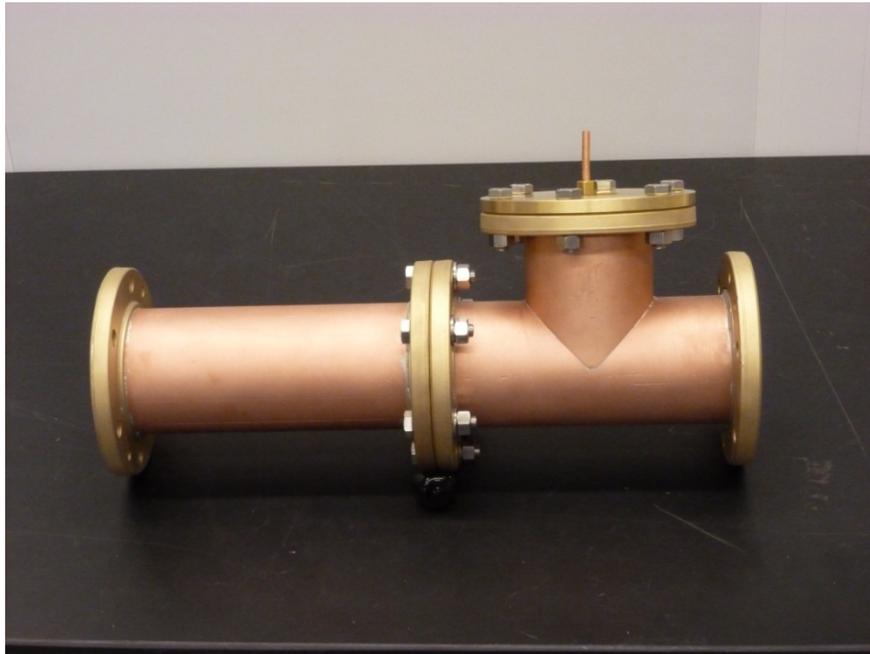
Test cavity with couplers after welding



Test cavity with window parts of couplers is under vacuum in Meson building

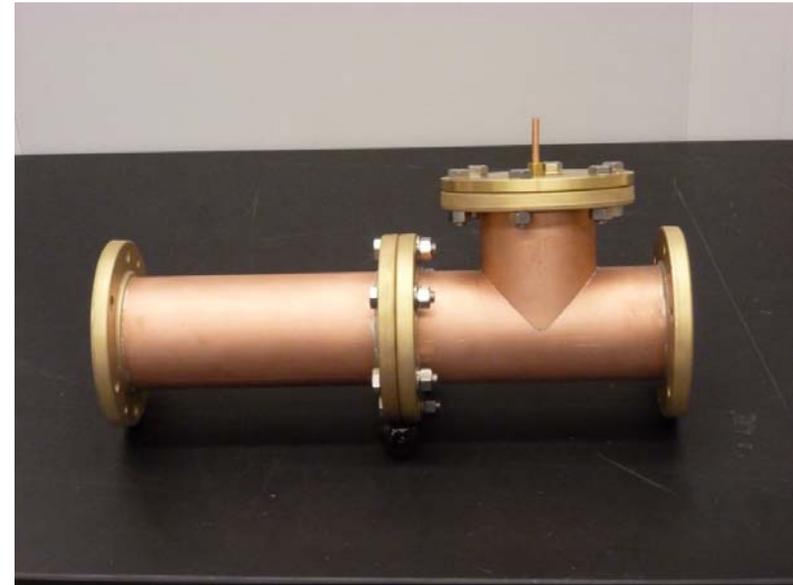
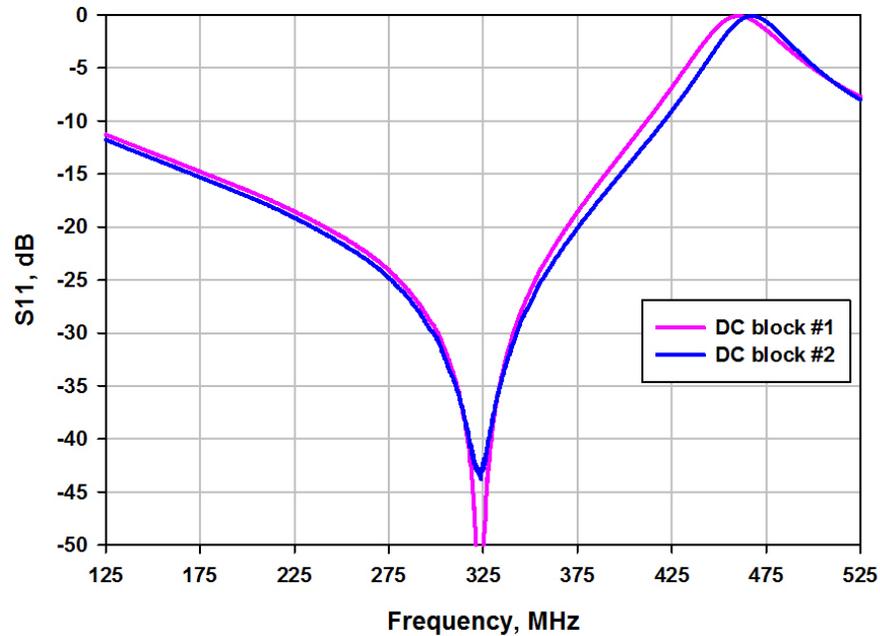
DC block





325 MHz DC blocks

325 MHz DC blocks, S11
final assemblies (after HV test)

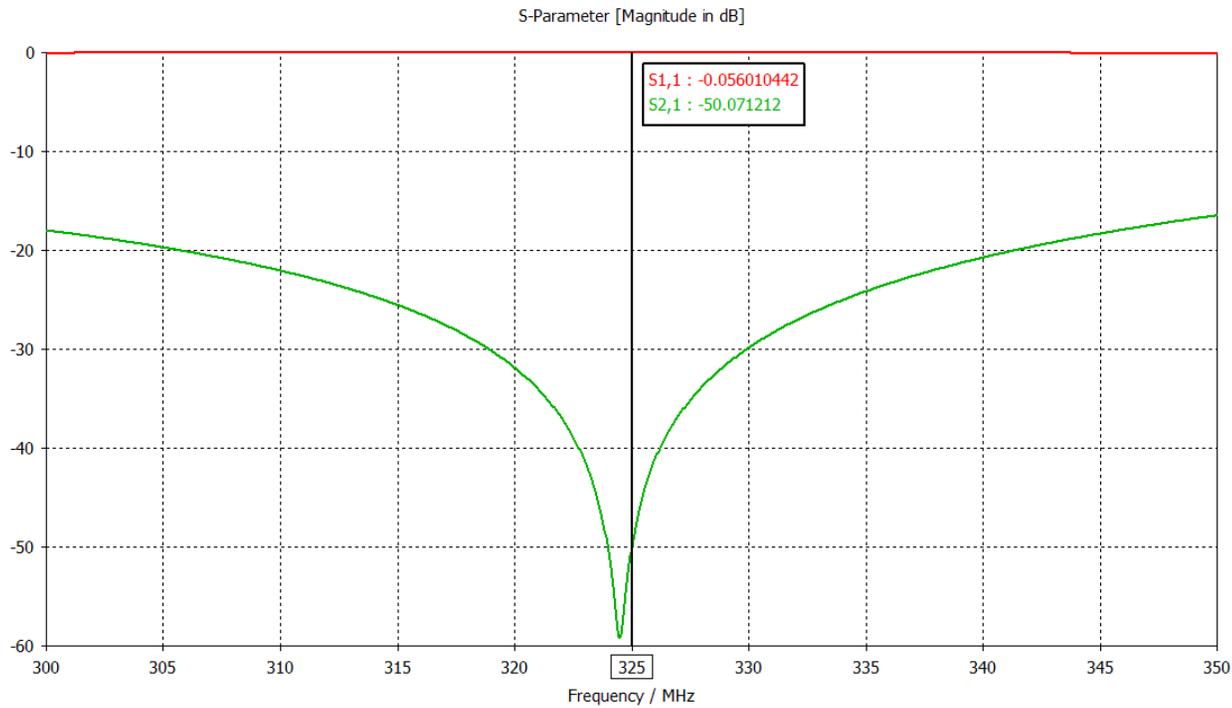
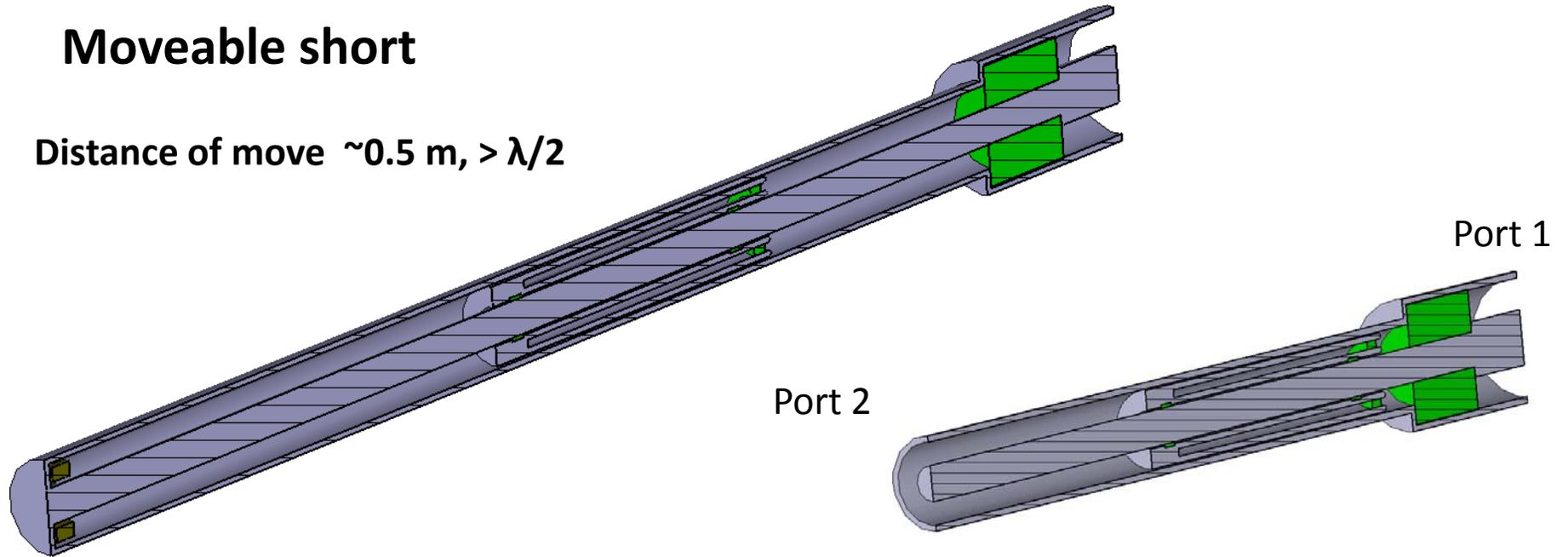


Passband (-20dB) > 100 MHz

DC blocks and couplers have been tested up to 5.5 kV of DC voltage.
(Operating voltage at 325MHz ~ 2 kV, at 162.5 MHz ~ 4 kV)

Moveable short

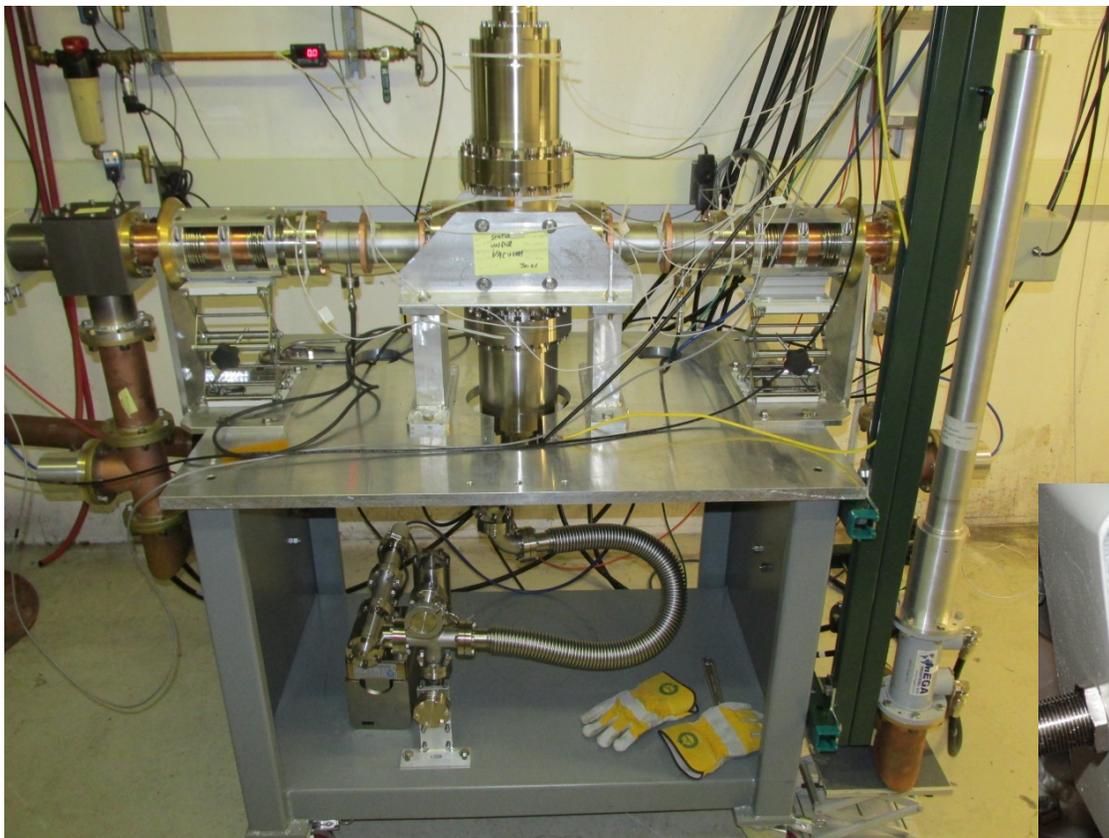
Distance of move $\sim 0.5 \text{ m}, > \lambda/2$



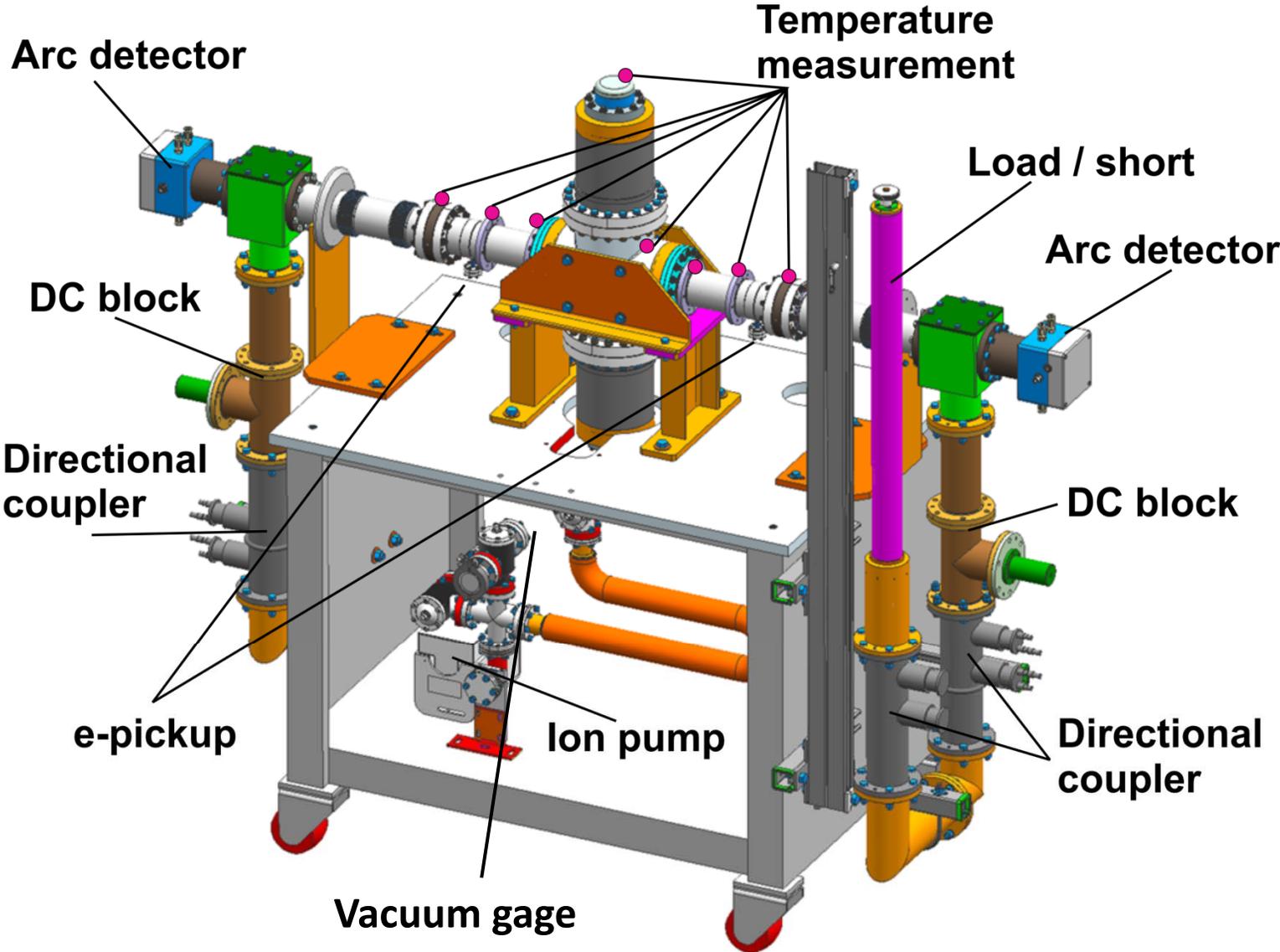
Measured reflection
 $\sim -0.073 \div -0.1 \text{ dB}$

Loss $\leq 2.3 \%$

325 MHz coupler test assembly in Meson building



Points of monitoring



Results of testing

Work with matching load (TW mode). No HV bias.

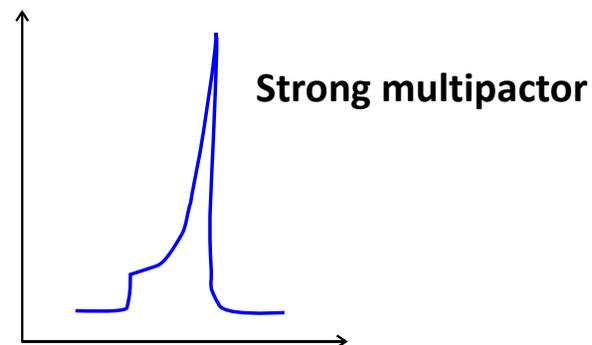
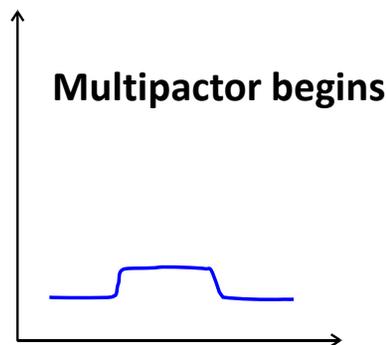
- Multipactor at power $\sim 300\text{W}$.

Place – between antenna and lateral conductor of test cavity. No signal from e-pickups, only vacuum activity. (It is not real coupler multipactor).

Multipactor disappears at power $\geq 1\text{ kW}$.

- Next multipactor zone appeared at power at power $\geq 4.5\text{ kW}$. Multipactor place – coupler coaxials. There were signal from e-pickups and vacuum activity. Multipactor was successfully conditioned during one day till maximum power $\sim 7.5\text{ kW}$.

Signals for e-pickups:



- Next day coupler was tested at **CW** mode at maximum power $\sim 7.8\text{ kW}$ for **7 hours**. **There was no trips caused by coupler** (was one trip – RF amplifier was overdriven). No signals from e-pickups, no vacuum activity. Temperature rise was small enough $\sim 5\text{C}$.

Matching load was replaced by moveable short (SW mode). No HV bias.

- Multipactor started at $\sim 3.5\text{kW}$ and it was more significant. We managed to condition up to maximum power at 5 positions (step – 5 cm) of moveable short at CW mode. Vacuum activity was presented till the end, but vacuum was better than $1\text{e-}6$ Torr. It means weak multipactor existed. Rise of temperature was moderate $\sim 10\text{C}$. Then cable between RF amplifier and couplers was burned.
- There was no signal from photomultiplier (may be we do not need PM in serial couplers).

Work with HV bias.

- Cable was repaired. We continued work in configuration with HV bias. Because of cable limitation it was pulse mode with pulse duration 0.5s and 1pps.
- Bias works well. Multipactor was suppressed by +1.5 kV (“+” at the antenna) up to maximum power ($\sim 7.5\text{kW}$) at any position of moveable short without any vacuum activity and without signals from e-pickups. Negative bias voltage suppresses works worse. It requires about – 3kV to suppress multipactor.

Conclusions:

- 325 MHz couplers work well up to 7.8 kW CW at TW mode.
- With high probability they work well up to 7.5 kW CW mode at any reflection (because of cable failure this mode was checked only for 0-20cm short positions. To be completely sure we need to test with shift 0-50cm).
- Bias suppress multifactor well. +1.5 kV is enough to suppress multipactor up to 7.5 kW.

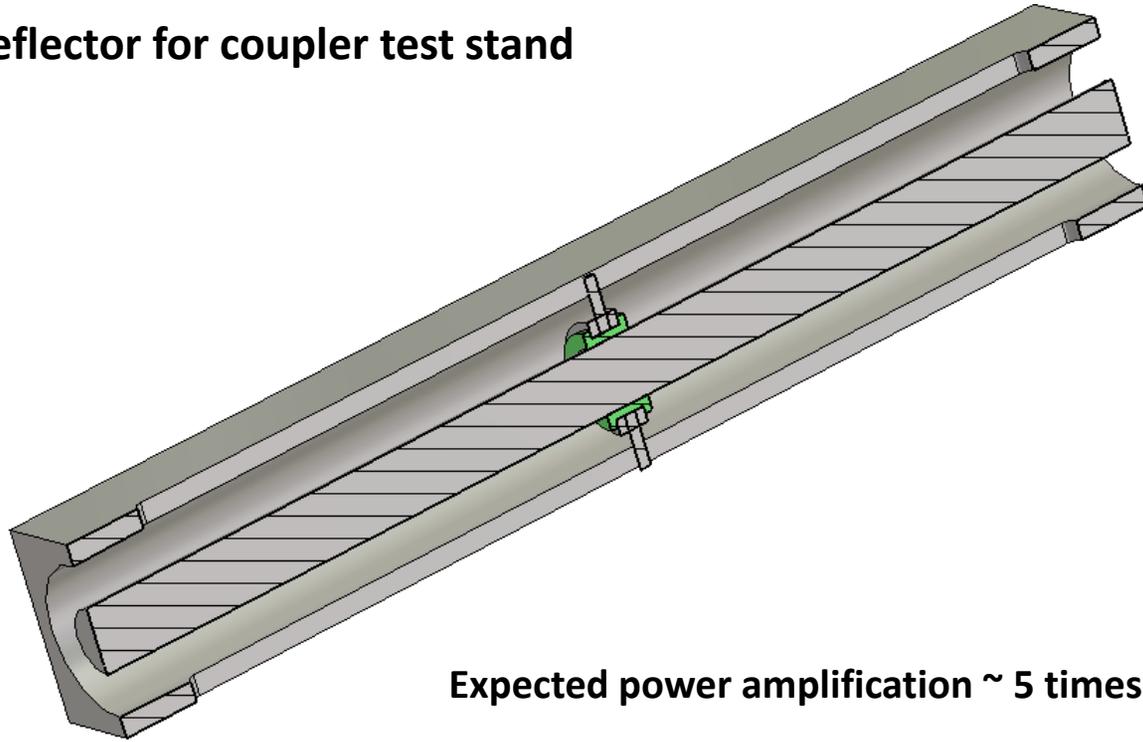
Future plans:

Cable will be changed to more powerful one (max. power 28 kW)

We are preparing a moveable reflector. It will allow to organize a resonance and increase power about 5 times (in couplers, not in the cable). It will allow to test couplers at 25 kW (FRS requirement) and more.

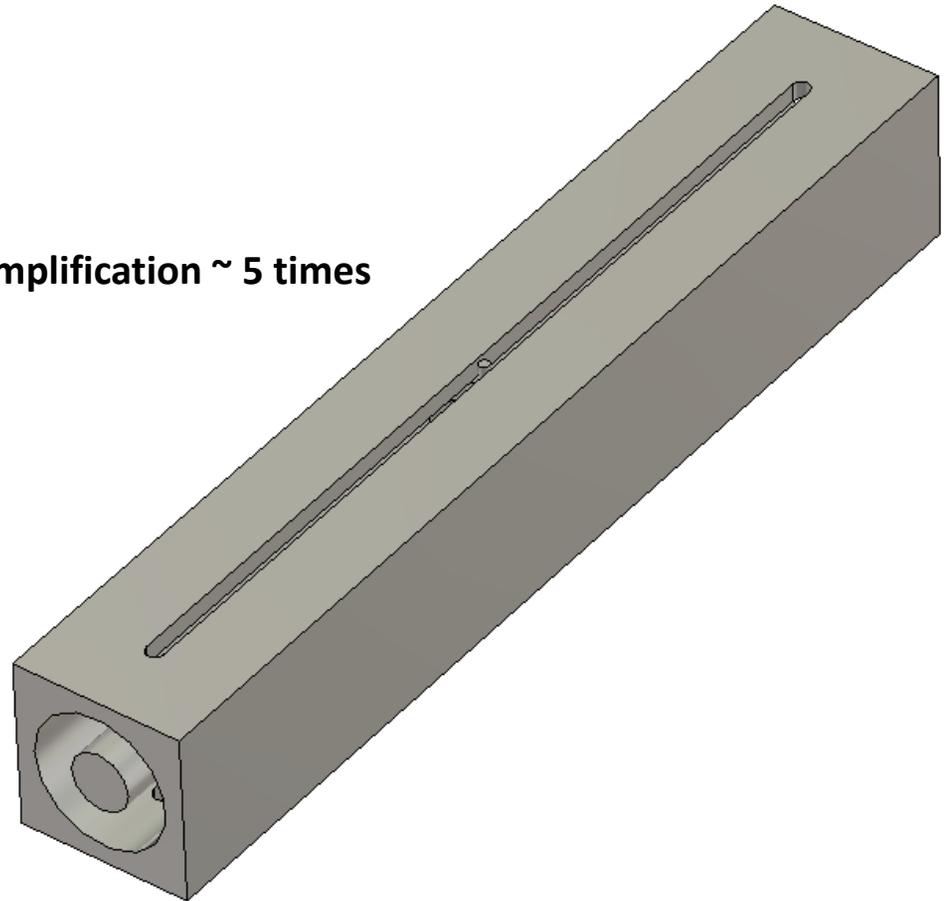
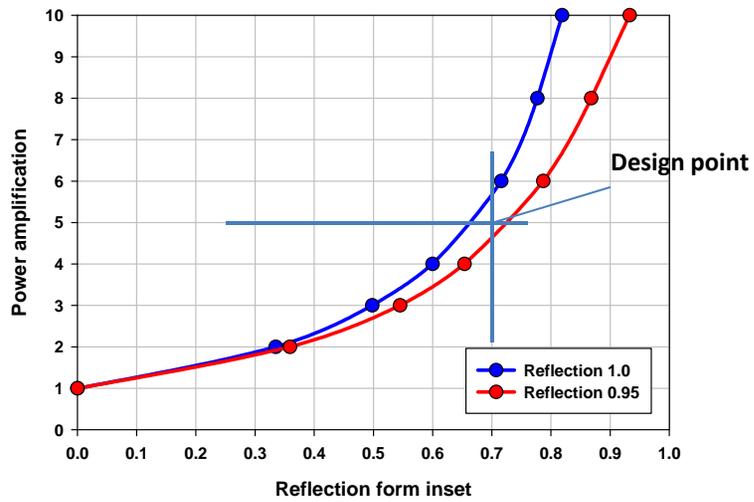
We are preparing documents for 8-10 coupler and DC blocks production. Small modifications / improvements will be made.

Reflector for coupler test stand

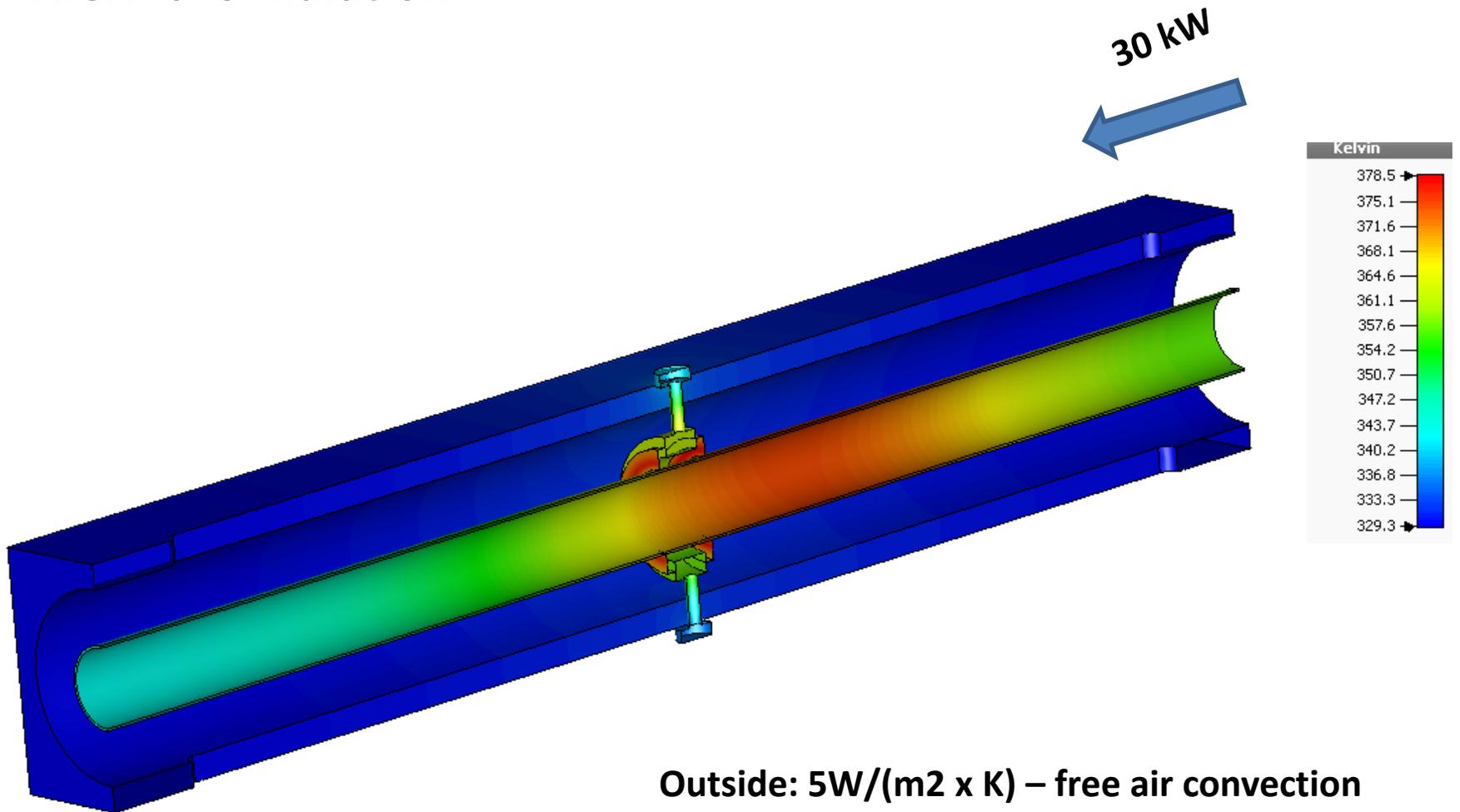


Expected power amplification ~ 5 times

Power amplification vs. inset reflection



Thermal simulation



Outside: $5\text{W}/(\text{m}^2 \times \text{K})$ – free air convection

Inside: $15\text{W}/(\text{m}^2 \times \text{K})$ – air cooling ($\sim 2\text{g/s}$)

Mechanical design of reflector

