

PIP-II 2nd Technical Workshop
Fermilab
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ppSSR2 Coupler Production
Experience and Lessons
Learned - IJCLab

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1. Public procurement procedure
2. Technical discussions prior MRR
3. Changes in design and expected assembly processes
4. Production status
5. Subcontractor : mishaps, strength and weakness
6. Perspective - conclusion

2 candidates :

- PMB : Cie specialized in brazing, especially metal-ceramic brazing ; experience in coupleurs production
- Thales : wide filed of expertise, experience in couplers production... but much more expensive than PMB

-> Chosen subcontractor : PMB

Delicate matter for PMB

- Bellows : find a supplier regarding specifications (fatigue, cycles) and dimensions
- Copper outer sleeve on ceramic : thin and flexible part
- Antenna manufacturing : brazing joint stops ; risk of antenna scratch when positioning washer
- Inner cond. : 1 bellow solution preferred over 2 bellows solution
- Assembly process : brazing forbidden after TiN
- Optimization of assembly processes : avoid brazing furnace “queue” ; chose process more suitable for serial production

Answers... next slide

# Modification	Asked by	Modified part or assy	Modification
1	PMB	antenna	collet [shoulder] added to help - part machine from rod
2	PMB	outer cond. - vacuum side	collets [shoulders] added as intercept interface - part machine from thick tube
3	PMB	outer cond. - air & vacuum sides	groove on collets (see above) to set intercept angular position (for thermal straps at right location)
4	PMB/IJCLab	outer cond. - air & vacuum sides	copper plating stopped 3 mm before knife instead of filet
5	PMB	outer sleeve	collet [shoulder] added (modification added to Fermilab's latest set of drawing)
6	PMB		EB welding instead of brazing
7	PMB	inner and outer bellows	AISI 316 Ti instead of 316 L
8	FNAL / IJCLab / PMB	inner bellow	one inner bellow solution ; new thickness ; lighten specs, esp. # of cycles [10000 - > 2000]) - finally supplier met the original requirements (# of cycles)
9	PMB	outer bellow	axial position moved by 4 mm to give room for welding
10	FNAL / IJCLab / PMB !		lighten specs, esp. # of cycles [10000 - > 2000] - finally supplier met the original requirements (# of cycles)
11	PMB		interface dia. increased (supplier constraint) ; interface - ring - part added
12	PMB	air parts (inner and outer cond.)	laser welding instead of brazing
13	PMB	connector (for air supply)	collet added for "butt" welding
14	PMB	support cap (for vacuum side assy)	cap in 2 parts + kapton sheet (ESS solution)
15	IJCLab		extended length by 5 mm
16	IJCLab	cover (for vacuum side assy)	thickness 2 -> 5 mm

1. **PMB working much more slowly than expected (almost one extra year)**
 - New project manager with no experience in couplers
 - Fermilab's design changes raised at PMB MRR- Change of project manager during projet at that time
 - New project manager with no experience in couplers
 - Use of many subcontractors (1 for TiN, CT scan (cancelled), laser welding, EB welding, 2 for cu plating (one dedicated one parts with bellow), several for machining including dimensional checks)
 - Many non conformity from PMB subcontractors : bad part clamping for antenna, individual 3D check reports provided without parts identification (so impossible to determine the non conform part), grooves too thigh for brazing rings...
2. **Tools for low level RF measurements by IJCLab** : exp. delivery end of June

3. **Tests and qualification** : done expect inner cond. Cu plating
-> Cu plating, laser and EB welding, Cu samples tests (bend, liq. N2 shock, peeling... but IJCLab Cu RRR measurements not done yet (nor SEY on TiN, not a blocking point)

4. **Antenna**

- 1st production piece brazed
- other pieces to be brazed, starting 30 June (after furnace repair)

5. **Ceramic window (metal-ceramic brazing and TiN)**

- Quite straightforward for PMB
- Done with no shot peening after brazing that PMB uses to do (ESS couplers)
- Dye penetrant test revealed several ceramics not suitable for brazing (damages on the edge)

6. **Ceramic window flange**

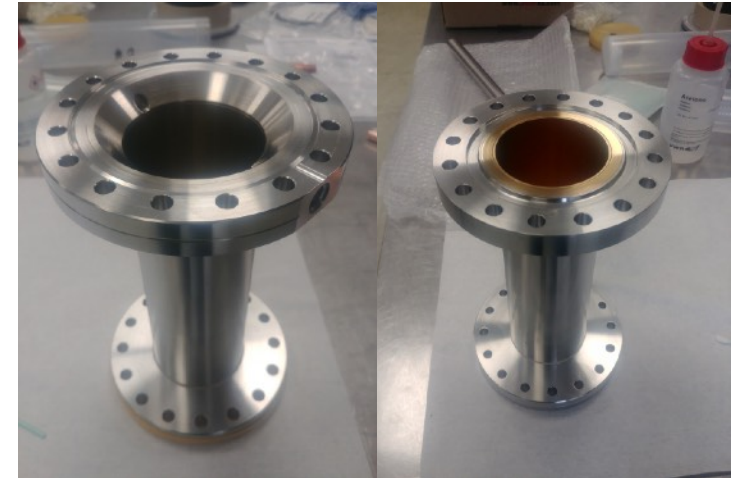
- Final machining of Cu insert before EB welding ceramic to flange

7. Vacuum side outer cond.

- 2 pieces shipped for Cu plating
- 3 other waiting for IJCLab Cu RRR measurement (Aug.)
- Two 2K flanges with slightly tight groove for Al diamond seal (investigation in progress)

8. Inner cond.

- 3 test parts done
- Production parts ready for Cu plating (waiting test parts qualification)
- Some mishaps on test parts :
 - bubbles under the Cu coating during 400 °C stabilisation baking (due to laser welding, PMB did not perform usual baking for brazed parts)
 - Corrosion attack after bathing (leads : corrosion sensitivity of titanium [310 Ti] ; shared bath)



Vacuum side outer cond. test parts
Nickel wood coating (L) / Cu coating (R)



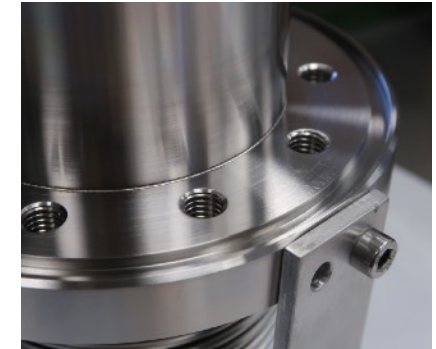
Bubbles under Cu coating
(no bubbles where penetrant compound applied)



Corrosion attack

9. Air side outer cond.

- 3 test parts done - in a row with no intermediate analysis ; laser welding issue solved (deformation after 1st welding) ; production parts would have an improved design to reduced the number of welding operations to 3 to 2 and deformation
- Production parts ready for welding (waiting results of welding trail with alternative solution 2 [light machining on “cryomodule flange”] on 1st production parts)



10. Other misc. parts : All delivered, expect for the T-junction

11. Clean room cleaning and RGA :

Un-expected change of subcontractor (a “yes” became a late “no” due to fear of Cu plating)... and extra delivery time (4 to 6 wk for 2 pieces processed)

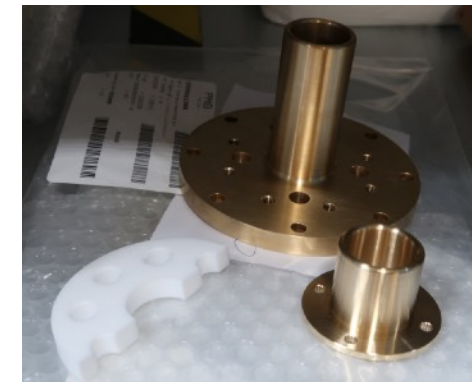
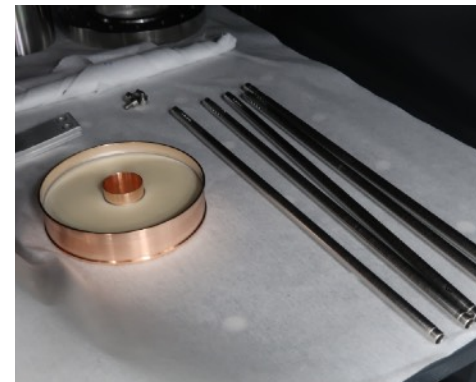


All pics : air side outer cond. test piece and parts

Production status - bottom line

- All machined parts delivered (except T-junction parts)
- Vacuum side outer cond. and inner cond. waiting for Cu plating (2 vacuum sides plated and heat treated)
- Air side outer cond. to be welded
- All components (air fitting, screws...) delivered

PMB unable to follow the schedule, nor to establish a reliable schedule due to the chain of subcontractor



- Skilled Cie struggling with its subcontractor (the ones called during prototype phase) ; processing pace could be higher during serial production (+ PMB plan to buy laser welding machine).
- New project manager learning how to pull the strings in its Cie and with its satellite subcontractors ; could be up to date / at the page for serial production.
- Expected 2 first couplers delivery : end of Aug.
- Expected 2 last couplers delivery : mid or end of Sept. (after IJCLab Cu RRR meas., beg. of Aug.)