



Wrap up Xband accelerating structures review 24-25.11.2014

N. Catalan Lasheras

<https://indico.cern.ch/event/346988/>





Background

- A number of the collaborators have participated in the assembly of X-band structures
 - KEK/SLAC, CEA, Tsinghua University have successfully manufactured/assembled structures
 - PSI, CIEMAT, SINAP, Lancaster university are joining the effort
- Ultimately, the whole manufacturing and assembly process should be accomplished by a commercial company
 - To have a real estimate of the CLIC structure costs
 - Needs an effort towards cost-driven design
- Document all manufacturing procedures currently used for putting together CLIC AS
 - With references, scientific or historical background
 - Defining a quality assurance program in parallel
- Extract procedures for off-site manufacturing
 - Which steps can be let to the different establishments?
 - What measurement will ensure a uniform quality?
- Write specifications for an industry built structure

- Describe/put together existing manufacturing steps
 - Conditions, procedures, tests, etc.
- Verify and agree on the procedures
- Bring short term modifications
 - To be implemented already in 2015
- Propose longer term modifications, studies or R&D efforts
 - There will not be time for discussing all in detail but it will be most useful to have a list of potential directions to explore
 - In coordination with other CLIC-RF work packages

31 participants including outside laboratories

D. Schulte, **CERN/ABP**

PH. Lebrun, S. Stapnes, **CERN/DG**

S. Atieh, A. Cherif, G. Favre, M. Garlache, A. Perez Fontenla, **CERN/MME**

M. Aicheler, O. Brunner, N. Catalan Lasheras, M. Filippova, A. Grudjev, D. Gudkov, S. Lebet, A. Olyudnin, C. Rossi, A. Solodko, I. Syratchev, J. Vainola, A. Xydou, B. Woolley,

W. Wuensch, **CERN/RF**

M. Taborelli, M. Thiebert, **CERN/VSC**

F. Toral, L. Sanchez. **Ciemat, Spain**

T. Higo, T. Abe, **KEK, Japan**

M. Franzi, J. Weng, **SLAC, USA**

23 talks plus discussions

2 long days



Program of the review

Introduction to the review. N. Catalan Lasheras

Manufacturing workflow and status of the procedures. A. Solodko

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Tolerances coming from alignment. D. Schulte

Tolerances coming from RF. A. Grudjev

Manufacturing for High-Gradient. W. Wuensch

Ultra precision machining and built to cost disk optimization. S. Atieh

How do we measure/accept the disks, shape. Roughness. A. Cherif

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Review of SLAC and KEK etching procedures. J. Wang

Current cleaning and etching procedures followed at CERN. M. Taborelli

Heat treatment study results, burrs and roughness. A. Perez Fontenla

Role of oxidation in bonding . M. Taborelli

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Assembly and alignment procedure. M. Aicheler

Cell to cell alignment on GLC structures. T. Higo

Brazing/bonding sequence. S. Lebet, A. Solodko

Bonding dependence from weight and roughness. A. Xydou

H2 diffusion bonding against vacuum brazing. T. Higo

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TD26CC plans from CIEMAT. L. Sanchez

MTF. M. Filippova

RF measurements and tuning. R. Wolf, B. Wooley

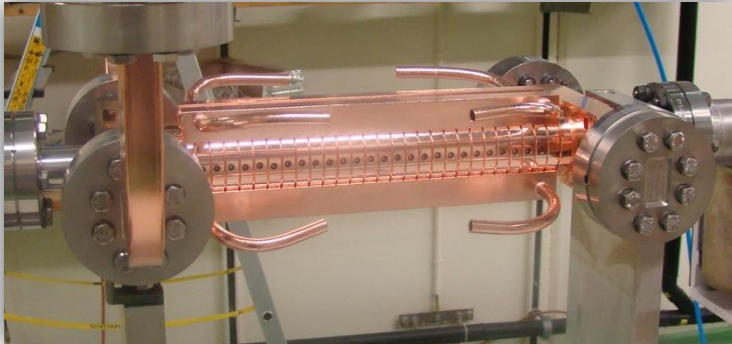
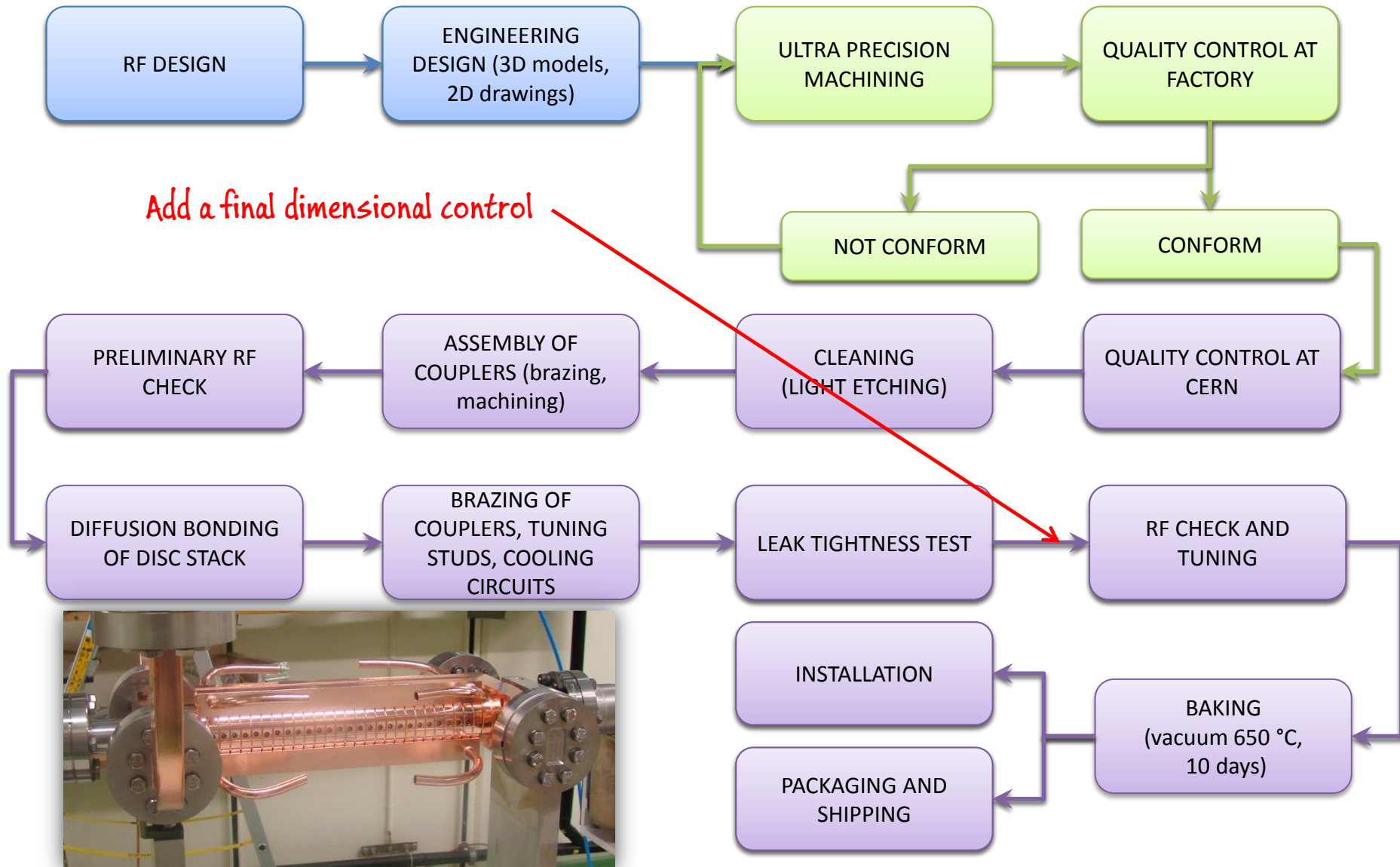
Baking requirements. M. Taborelli

Systematic analysis done on existing samples. A. Perez Fontenla

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Manifolds assembly. D. Gudkov

SiC to copper brazing. A. Solodko



- Some metrology needs to be done for all pieces including reference outside surface and shape.
 - Included in the acceptance tests besides visual inspection and made if necessary in b.169 lab. *Action: Nuria, Anastasiya, Andrej, Ahmed*
- Sharp edge. Machining sequence to be stated in the technical specs to chose the orientation of burrs. *Action: Said.*
- Can we accept a larger roughness in the wall? *Action: Alexej*
- Burrs, scratches, contamination and indents to be accepted if not visually detected 10-100um? *Action: Andrej.*
- Need to define acceptable burrs, scratches, contamination and indents
 - accepted if not visually detected 10-100um? *Action: Andrej*
 - Bonding tests on scratched disks. *Action Serge*
- Flatness should be not relaxed but measurements checked.
 - Measurements with the vacuum chuck to be compared with the “free state” *Action Ahmed*
- Changing R05 to 1.0 or 2.5 to be studied *Action: Alexej*
- Shall we tight the tolerance for OD to +/-1um? And the shape?

- Surface roughness after etching

AFM Average Roughness Values

Coupon #	143	144	145	146
Bare machining (nm)	128.73	100.63	123.95	130
After ETCH (nm)	105.12 (5'')	40.42 (30'')	44.41 (60'')	90.48 (120'')
Heat treatment (nm)	67.15	35.63	31.32	53.06

Poly-diamond Machined

Coupon #	137	138	139	140
Bare machining (nm)	4.73	6.27	8.67	3.35
After ETCH (nm)	4.74 (0'')	6.32 (5'')	12.46 (30'')	21.33 (60'')
Heat treatment (nm)	/	8.00	19.83	20.60

SC-diamond Machined

*Etching for removing slight contamination and fluids
Not justified for diamond-turned pieces*

- No etching should be done on disks anymore.
 - Only solvent cleaning.
 - Thus no dimples should be allowed in the RF part larger than $\sim 1\mu\text{m}$
 - Burrs and machining steps need to be under control
- Test on oxide to be prepared. XPS measurements of oxide layer growth.
 - Bonding cycle on oxidised samples to assess the bonding quality and the “deoxidising” capacity of the heating cycle. *Action: Mauro, Serge.*
- Handling from the reception of the disks needs to be reviewed. *Action Nuria*
 - Beware of Carbon contamination
- Stress relieve temperature much lower than in SLAC, KEK and CIEMAT. Is this a concern? *Action Said*



Discussion on assembly

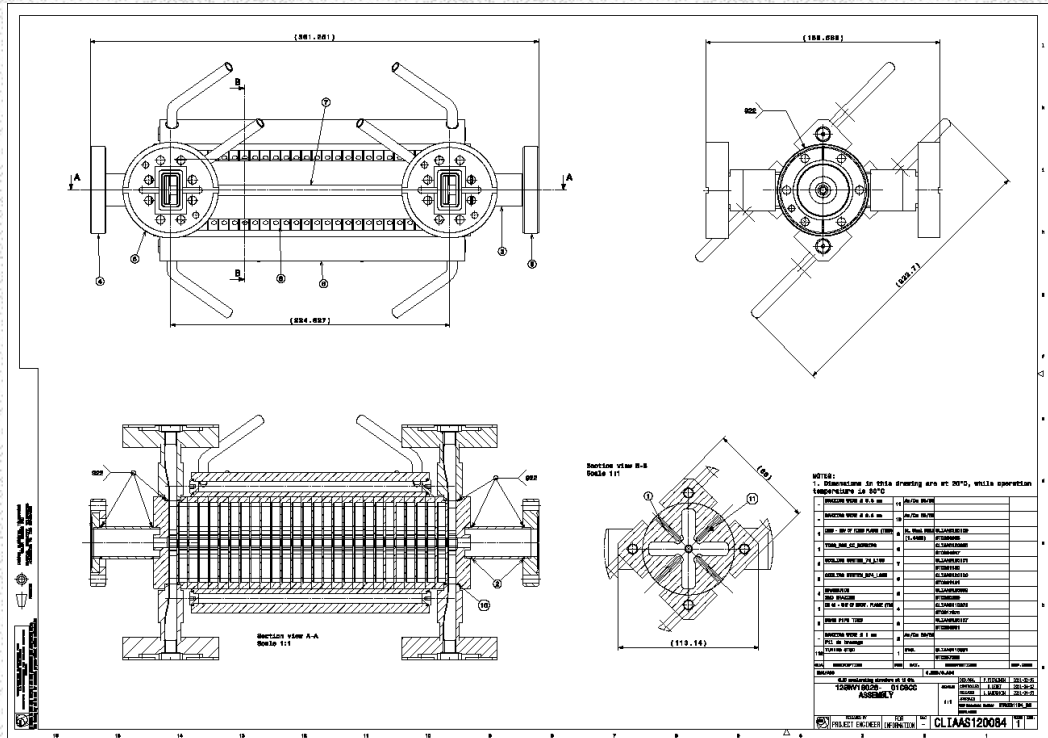
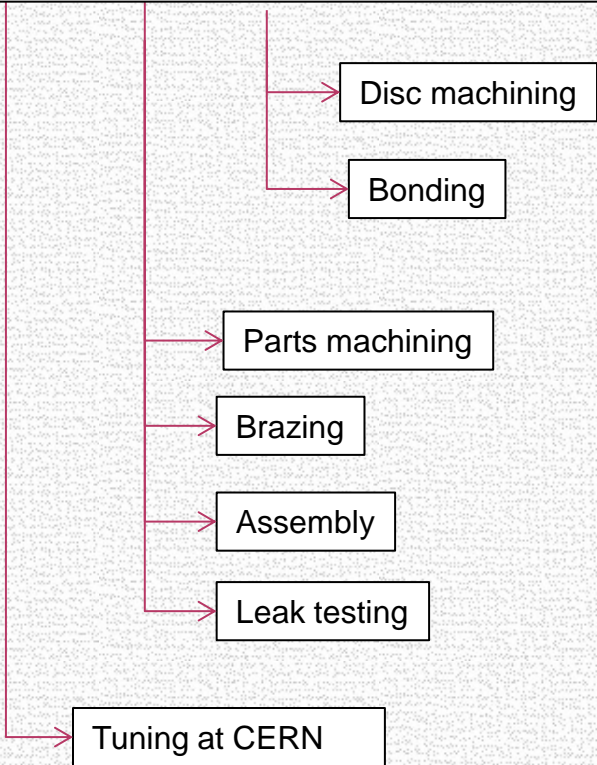
- Manual stacking applied both at CERN and KEK
 - Scattered measurements at CERN within $\pm 10\mu\text{m}$ but no disk-to disk data
 - Smooth disk to disk alignment in KEK ($\pm 1\mu\text{m}$) with a larger bow
 - Control OD of all disks upon arrival. *Action Ahmed*
 - Review geometry measurements after bonding, more points. Action Serge
 - Analyse all data taken during assembly. *Action Serge*
- Bonding movements seem to be under control
- Review procedure in the near future. *Action Nuria*

- Avoid using graphite pads in contact with diamond-machined parts
- Bonding dependence on weight studies
 - Better understanding of the measurements is required
 - not conclusive for real disks. Investigating flatness. *Action Anastassia*
- Vacuum brazing used at lower frequency. Single cell study In KEK. Waiting for the results
- No big changes in the procedure in the short term
 - Could be worth to study different atmosphere in electrodes
- New smaller tooling to avoid leaving the cleanroom. *Action Serge*

Plans for CLIC structures: TD26CC

Scope of the collaboration

CIEMAT will manufacture a TD26CC structure according CERN procedures



Nº	AS Workflow Steps	Applicable Standard	Result file	Manufacturing step catalogue data
1	Discs and coupler manufacturing at factory	Technical Specification for UP parts	yes	
2	Discs and coupler inspection at factory	EDMS #1207881	yes	
3	Discs and couplers acceptance	EDMS #1207881	yes	
4	Sample discs dimensional control	EDMS #823316	yes	CMM used
5	Sample discs SEM	EDMS #887717	yes	
6	Assembly of couplers	EDMS #1421001	yes	
7	RF check before diffusion bonding	EDMS # 1257643	yes	
8	Discs and couplers surface treatment	EDMS# 1440603 (disc-etching -->EDMS #1242352 couplers, manifolds, waveguides - degreasing-->EDMS #1072247)	yes	
9	Alignment control before diffusion bonding	EDMS #1237642	yes	
10	Diffusion bonding of disc stacks	EDMS #1237642	yes	oven, atmosphere, pressure
11	Alignment control after diffusion bonding	EDMS #1237642	yes	
12	Brazing of disc stack with couplers and tuning studs	EDMS #1421002	yes	oven, atmosphere
13	Brazing of manifolds	EDMS #1421004	yes	oven, atmosphere
14	Brazing of cooling circuits	EDMS #1421006	yes	oven, atmosphere
15	Leak tightness test	EDMS #1278313	yes	
16	RF check and tuning	EDMS #1257643	yes	
17	Vacuum Baking	EDMS #1421007	yes	oven
18	Installation	EDMS #1421009	no	facility name
19	Power test	EDMS #1421012	yes	test bench, max. archived gradient, breakdown

Dimensional control

Manufacturing Step Main Catalogue Data:

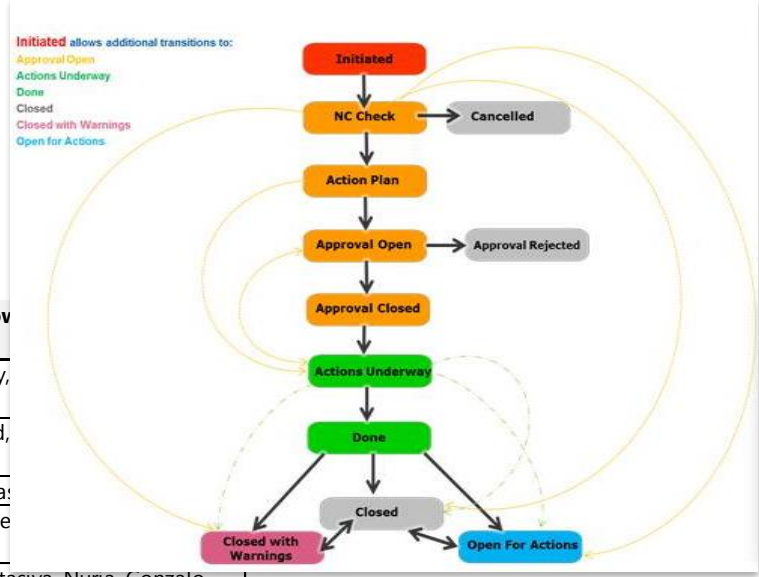
- **Applicable Standard** → EDMS document Nº where the corresponding step procedure is attached
- **Results** → EDMS document Nº of the corresponding result report

Some step data fields to be implemented individually for some steps according to **table 3**, column “Manufacturing step catalogue data”.



Responsibilities

Define manufacturing sequence
 Approve procedures
 Coordinate between steps
 Discuss and decide on NC actions



No	Description	and workflow	step	People allow the step
1	Discs and coupler manufacturing at factory	Said ATIEH		Said, Andrey, Maria
2	Discs and coupler inspection at factory	Said ATIEH, Andrey OLYUNIN		Andrey, Said, Maria
3	Discs and couplers acceptance	Andrey OLYUNIN		Andrey, Ana
4	Sample discs dimensional control	Ahmed CHE		Didier, Ahme, Maria
5	Sample discs SEM	Ana Teresa Z FONTENLA		Anitè, Anastasiya, Nuria, Gonzato, Maria
6	Assembly of couplers	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Serge, Nuria, Maria
7	RF check before diffusion bonding	Rolf WEGNER		Rolf, Andrey, Anastasiya, Nuria, Maria
8	Discs and couplers surface treatment	Marc THIEBERT		Marc, Anastasiya, Nuria, Maria
9	Alignment control before diffusion bonding	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Nuria, Serge, Maria
10	Diffusion bonding of disc stacks	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Nuria, Serge, Maria
11	Alignment control after diffusion bonding	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Serge, Nuria, Maria
12	Brazing of disc stack with couplers and tuning studs	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Serge, Nuria, Maria
13	Brazing of manifolds	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Serge, Nuria, Maria
14	Brazing of cooling circuits	Anastasiya SOLODKO, Serge LEBET		Anastasiya, Serge, Nuria, Maria
15	Leak tightness test	Cedric GARION, Esa Antero PAJU		Anastasiya, Nuria, Maria
16	RF check and tuning	Rolf WEGNER		Rolf, Andrey, Alexej, Anastasiya, Nuria, Maria
17	Vacuum Baking	Anastasiya SOLODKO, Serge LEBET		Serge, Anastasiya, Nuria, Marko, Mauro, Cedric, Maria
18	Installation	Nuria CATALAN LASHERAS		Serge, Andrey, Philipp de S., Philipp G., Anastasiya, Nuria, Maria
19	Power test	Nuria CATALAN LASHERAS		Anastasiya, Nuria, Maria

Write procedure
 After each manufacturing step:
 Close the MTF step
 Attach result file
 Open Non conformity in not ok

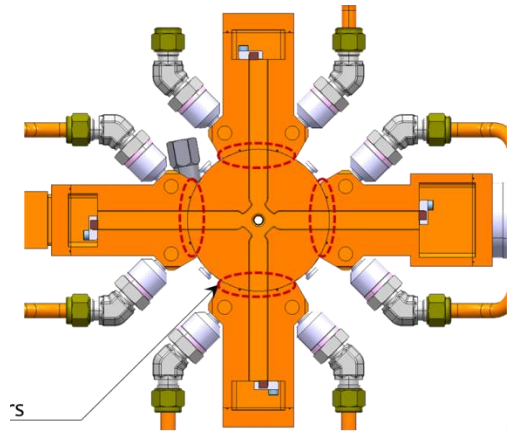
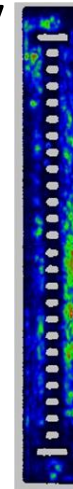
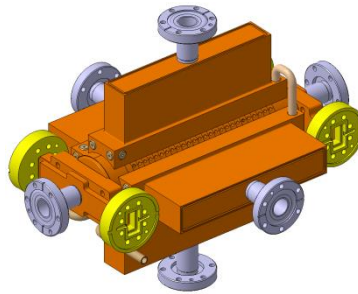
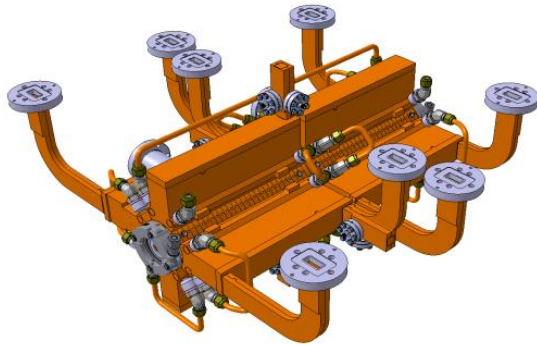


Discussion on RF measurements

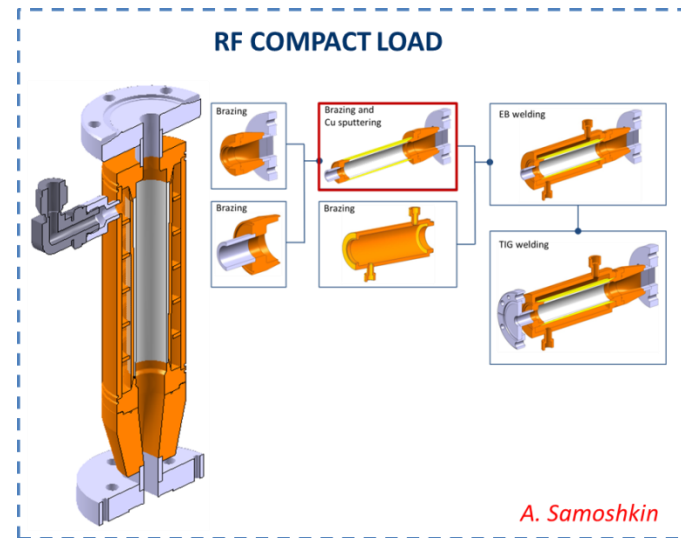
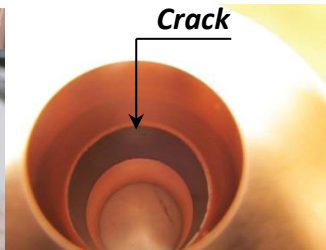
- Use the same pins for all structures.
- Verify that tuning is preserved after baking
 - Next structure TD26_CC to be re-measured after baking
- Need statistical study of tuning for all structures up to know
 - To validate the CLIC baseline (no tuning)
 - To evaluate the assembly quality,
- No correlation found between tuning records and disks/cells geometry errors.
 - Possibly most errors are produced by assembly
 - TBC. Only one structure has been done.

- According to simulations work 10 hours would be sufficient to eliminate H₂ in the copper bulk.
 - Sample is thin (1cm) and may not be representative?
- Data from PSI structure seems to indicate that degassing is not that fast.
 - Significant reduction after 12 hours
- Refurbished degassing oven in building 101 has been equipped with gas analyser. *Action Ivo*
 - Data to be taken on the next cycles. TD26CC on January
 - With and without structure

- Manifolds assembly. D. Gudkov



- Brazing of SiC on Cu. A. Solodko



- Procedures are fully known and justified. Ongoing with the authors.
 - Need to make the point in January
- Very long discussions on almost every subject.
- Wrap-up of the workshop with all glory details tomorrow
 - Immediate changes, some need a verification in the followin weeks
 - Long term studies on manifolds, brazing, etc
 - Lots of changes in the way we measure and analysis
- Industry-ready specs need to define a clear QA
- Changes that may impact bonding quality will be tested in simple disks in the oven.
- Changes that may impact high gradient will be first tested on electrodes



Thanks to all speakers!

Great feedback and positive criticism!