Investigation threads on fabrication technologies for the CLIC X-band Accelerating Structures

C. Rossi on behalf of the CLIC X-band Activity

Thanks for contributions and discussions to S. Calatroni, N. Catalan Lasheras, R. Corsini, A. Grudiev, D. Gudkov, R. Montonen, A. Perez, N. Shipman, A. Solodko, I. Syratchev, A. Xydou, W. Wuensch, H. Zha, W. Zhou, E. Zisopoulou.

9th October 2014

Areas of Possible Development

Push the investigation on the integration of the different elements of the accelerator to a higher level of detail, in the perspective of assembling modules and the complete accelerator, in the end. Clarify issues at the interfaces.

Clarify some technological aspects of the AS fabrication process that were inherited from other labs and from the work of different study groups and consolidate them in the form of validated procedures.

Start building a consolidated baseline for the project. This will not prevent further developments, on the contrary it will allow a better tracking of changes.

↓

Adopt a

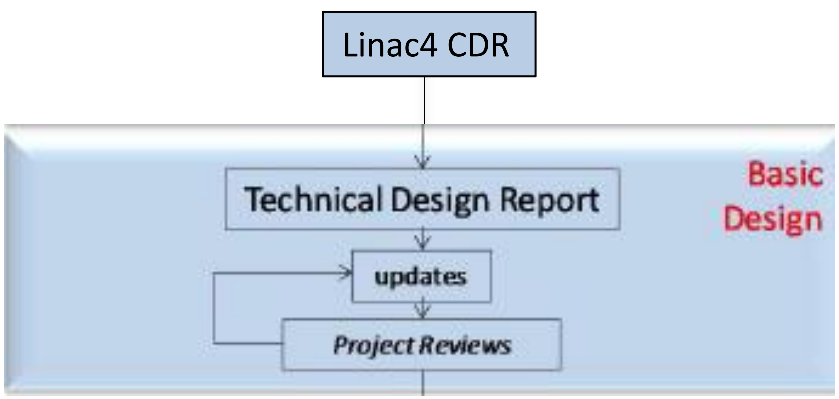
Quality Assurance Policy ?

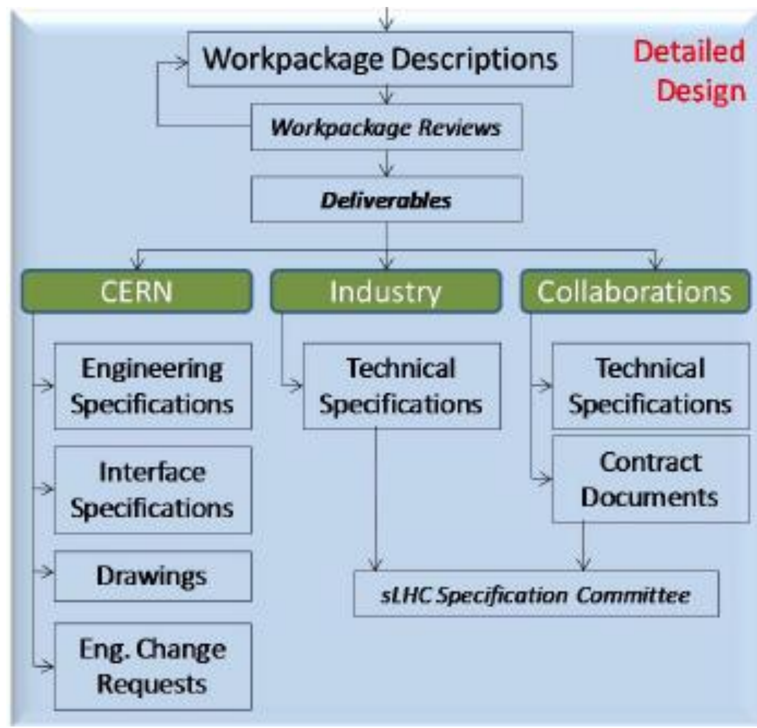
Quality Assurance Policy

A Quality Assurance Policy would contribute to progressively consolidate the project baseline by means of an agreed published procedure, which stakeholders can trust.

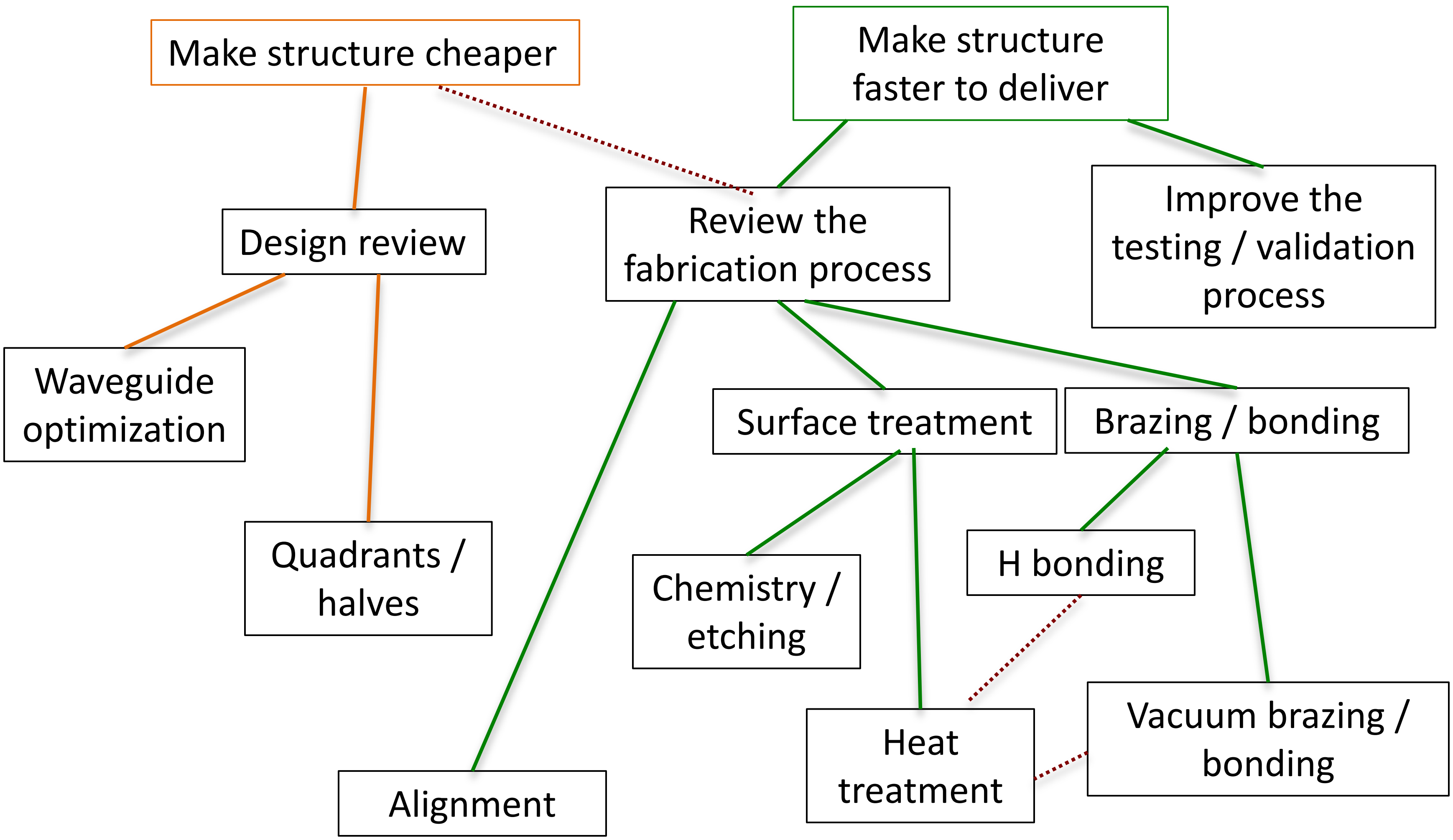
The QAP will create the conditions for an effective control of changes within the project baseline and their follow-up.

To provide an example … (Linac4)





Motivation for a review of the technical / technological aspects of the AS fabrication



Outline

A primary goal for the CLIC X-band Study Group is to establish reliable and ready to be industrialized procedures for the fabrication of X-band accelerating structures and modules. This may require:

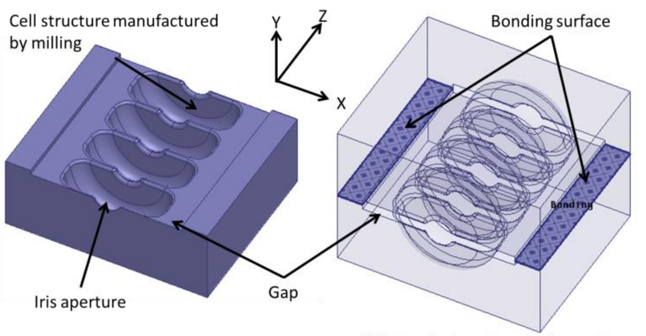
- Reviewing some aspects of the design.
- Optimizing the fabrication process:
  - machining and assembly tolerances;
  - etching;
  - disk alignment;
  - assembly technologies and bake-out.
- Enlarging the park of investigation tools beyond AS RF tests
  - DC breakdown
  - Fixed gap system (field emission and breakdown)
- Extending the testing capability:
  - X-box 1 and dog-leg is in production;
  - X-box 2 soon in-line;
  - X-box 3 in preparation, expected in 2015.

See presentations from: W. Wuensch, I Syratchev and A. Solodko.

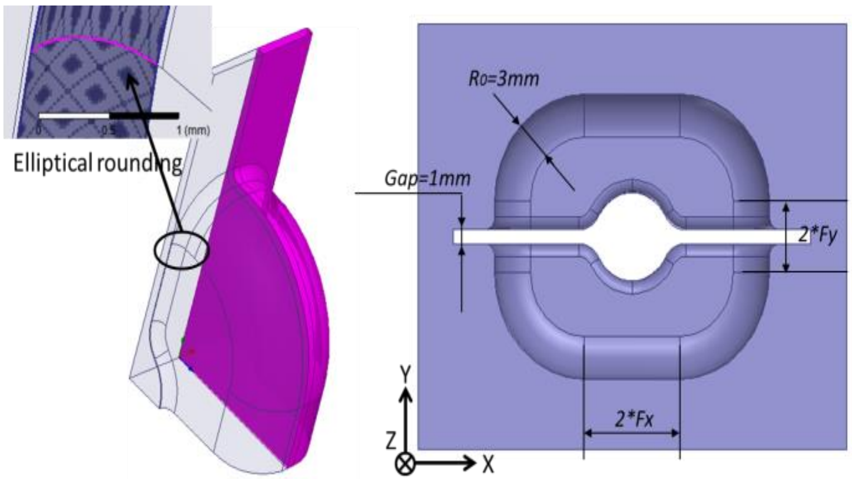
- Consolidating the baseline: Quality Assurance Policy.

New structure concepts (A. Grudiev and H. Zha)

CLIC structures optimized for milling with a potential for reducing the fabrication cost. Based on CLIC-G design.

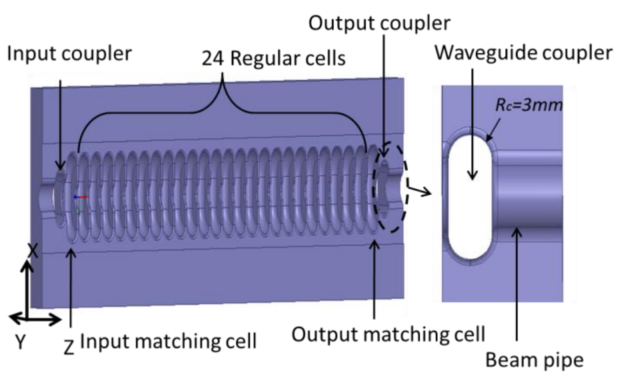


(a) One half of the copper plate (b) Two halves bonded together



(a) A quarter cell model (b) Geometry Parameters

Loaded gradient* [MV/m]	100
Input/output radii [mm]	3.15/2.35
Group velocity [%c]	1.99/1.06
Shunt impendence [MΩ/m]	107/137
Peak input power [MW]	60.9
Filling time [ns]	49.5
Maximum E-field [MV/m]	313
Maximum modified Poynting vector[MW/mm^2]	7.09
Maximum pulse heating temperature rise [K]	35



(a) full structure on one half (b) Waveguide coupler

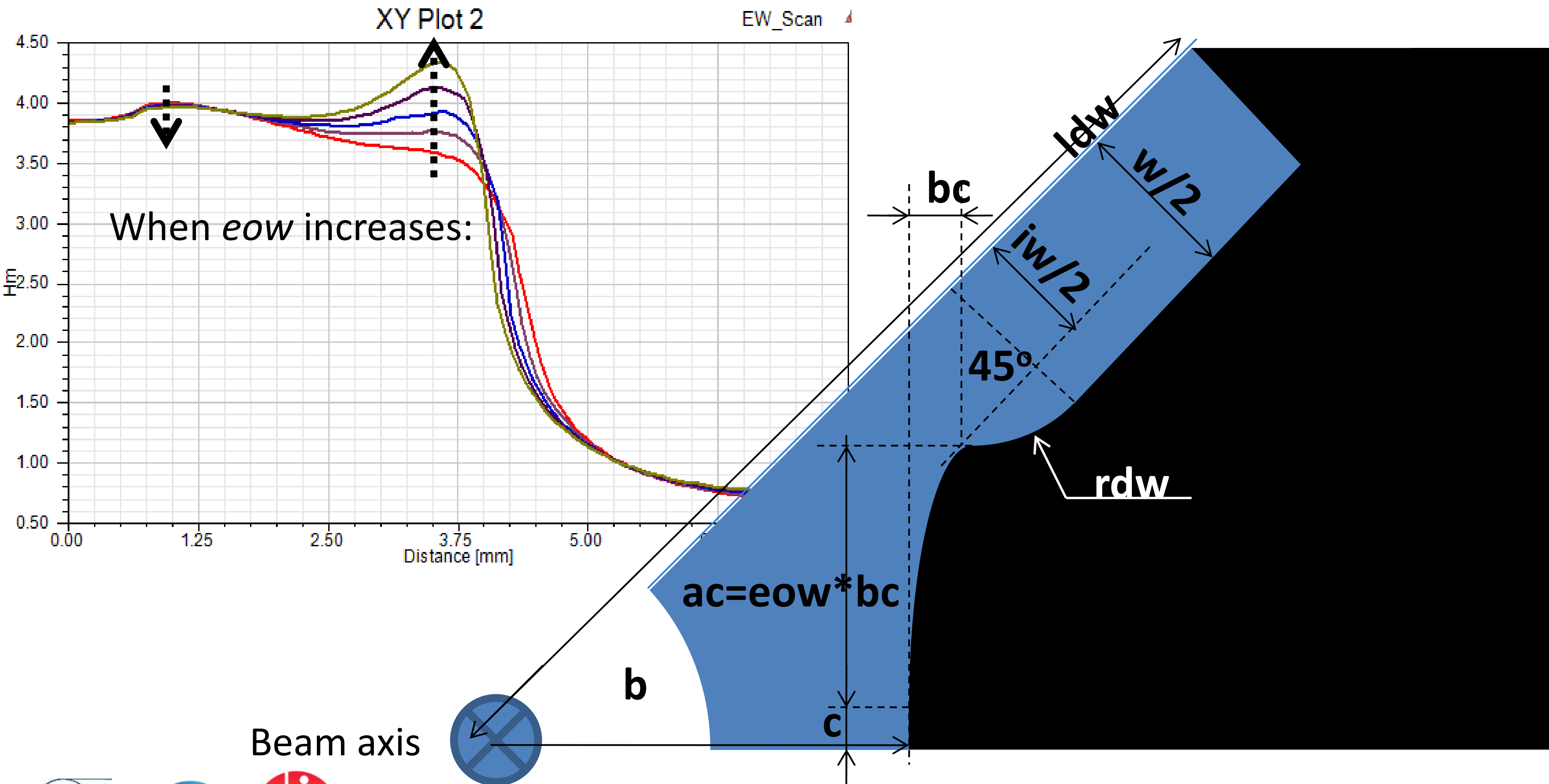
Optimization of waveguide geometry (A. Grudiev and H. Zha)

Independed parameters:
- -- *c*
- -- *eow* = ac/bc

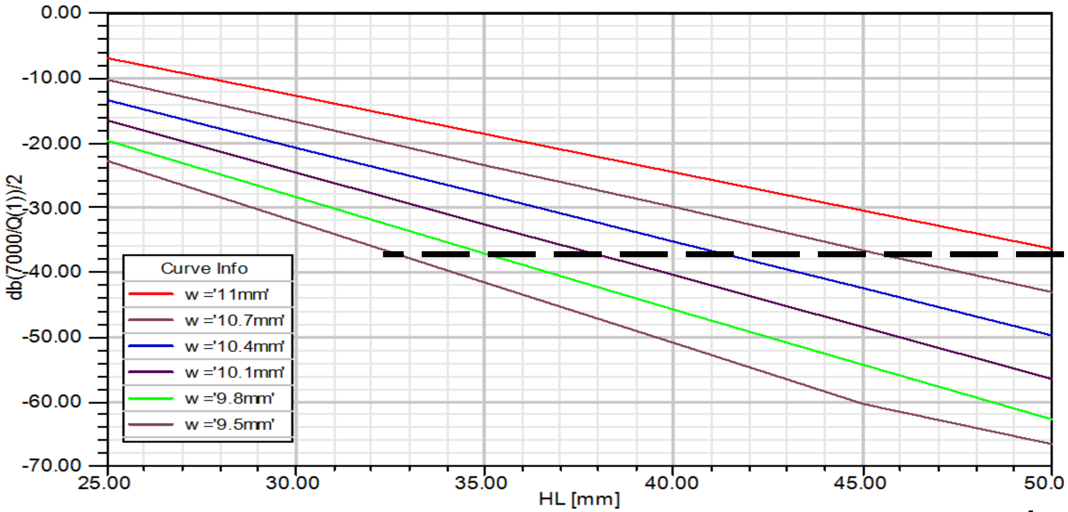
} Optimized for magnetic field

- -- ***iw*: waveguide opening**
- -- ***w*: wavegude width**

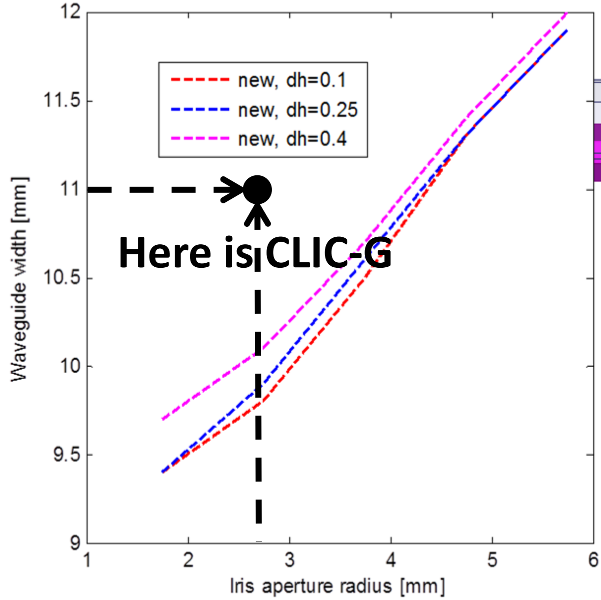
} Optimized for wakefield damping

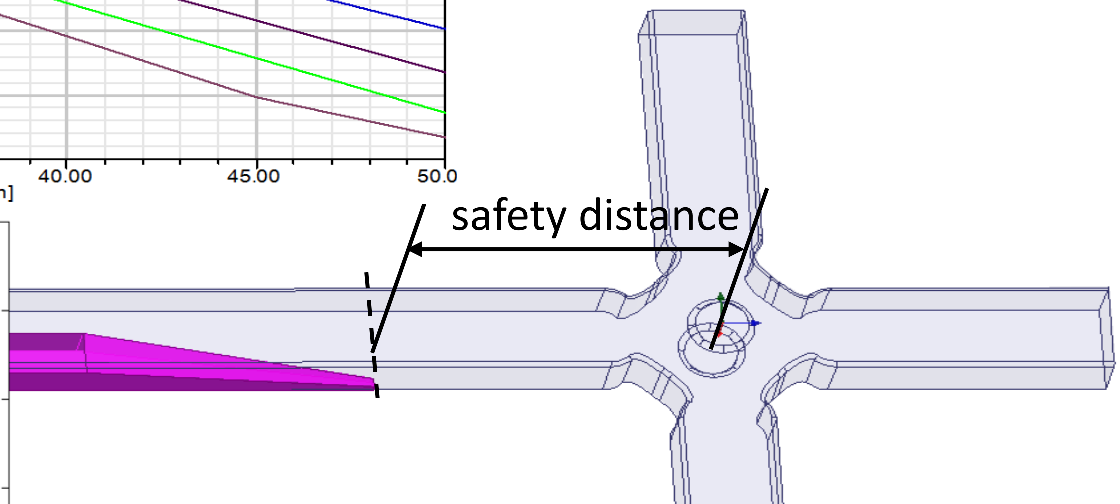


Optimization of waveguide geometry (A. Grudiev and H. Zha)



A considerable reduction of the disk diameter can be expected by this change with a beneficial impact on the Linac cost.

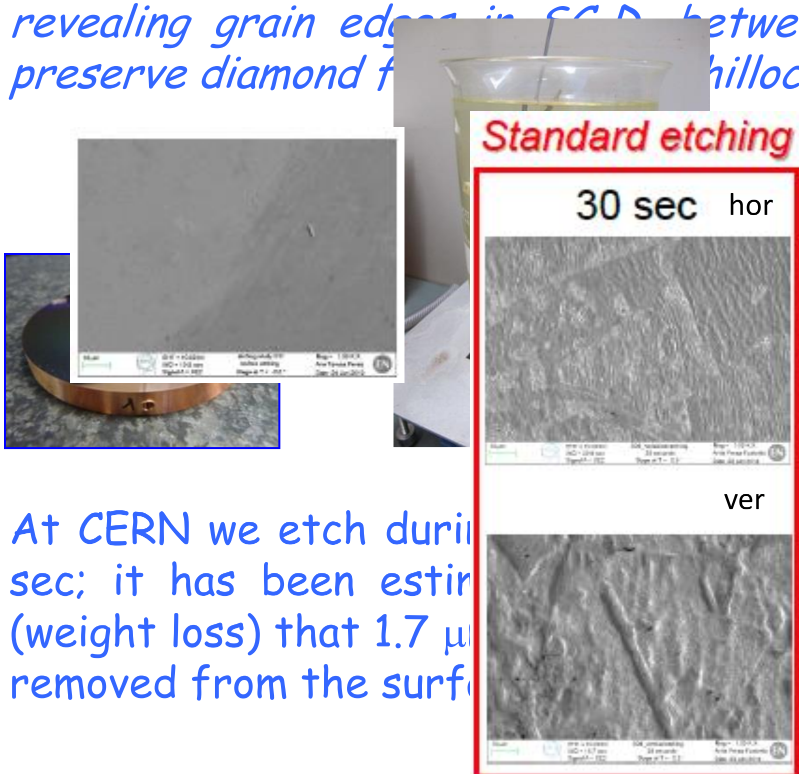




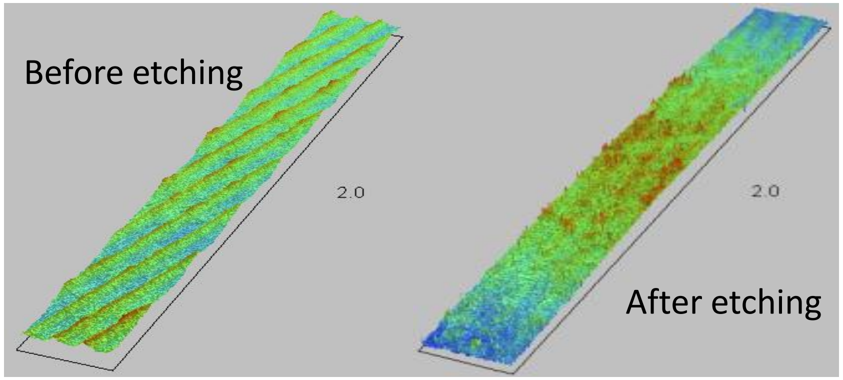
Cells	Optimized width		Optimized width & opening	
	width	Opening	Width	opening
First	10.3mm	8mm	9.9mm	7.98mm
Middle	10.0mm	8mm	9.8mm	7.94mm
Last	9.7mm	8mm	9.7mm	7.90mm

Etching (A. Xydou and W. Zhou)

According to SLAC studies, during the NLCTA program: 30 s etching starts revealing grain ed… between 5 and 10 s is the correct duration to preserve diamond f… hillocks by limiting furnace time.



At CERN we etch duri… sec; it has been esti… (weight loss) that 1.7 μ… removed from the surf…



Copper surface morphology before and after etching (EDMS 1277865)

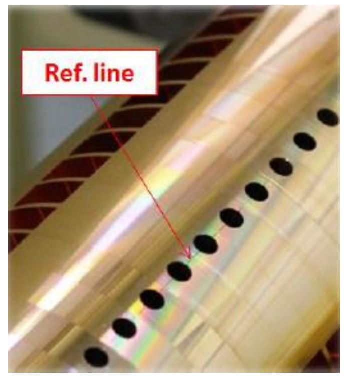
Surface roughness is required by RF to be better than 0.3 μm; it is 0.02 μm after machining.

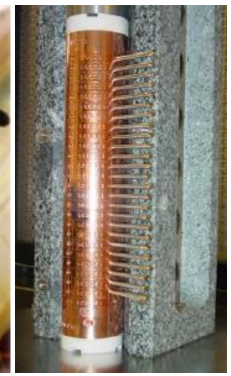
Possible purposes of etching:

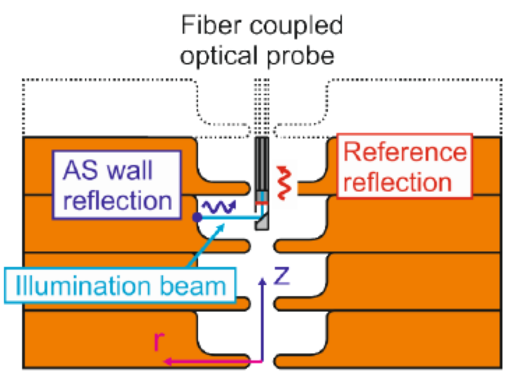
- To remove the stress layer at the copper surface caused by machining, and obtain a homogenous copper surface;
- To enhance RF behaviour (breakdown threshold and breakdown rate);
- To remove oxide layer (CuO, Cu2O) for bonding, burrs and other possible surface defects.

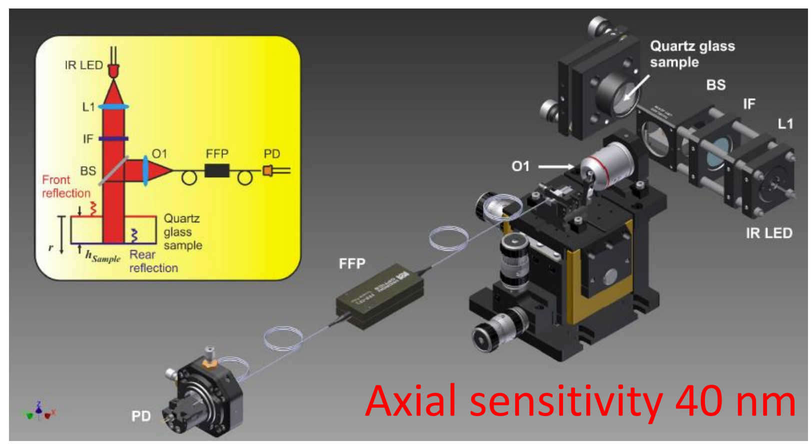
Disk Alignment (E. Zisopoulou and R. Montonen)

Current alignment strategy of CERN structures (26 cells) based on V-block. Achieved accuracy is ± 5 μm.





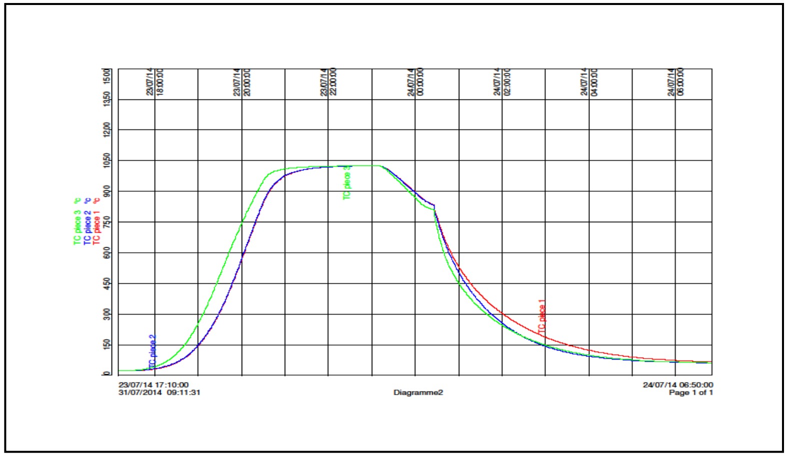


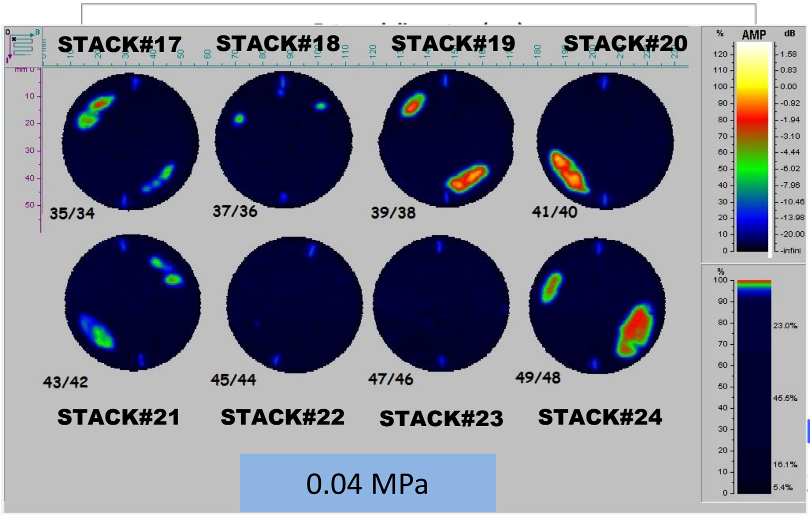


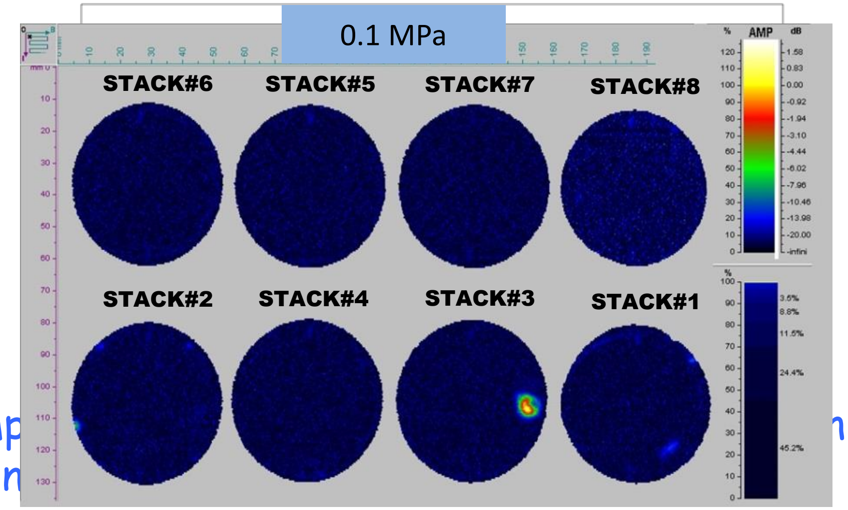
Development ongoing by collaborators at HIP (Helsinki Institute of Physics) on an interferometry-based technique to measure inside assembled structures.

Structure Assembly (A. Xydou)

Diffusion bonding in hydrogen atmosphere is the current technology for the X-band AS assembly at CERN.

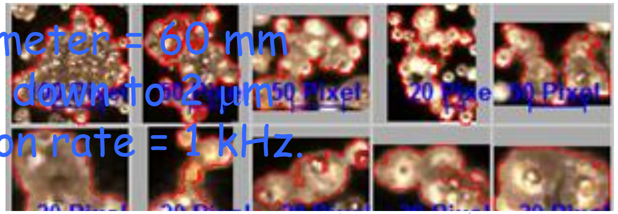


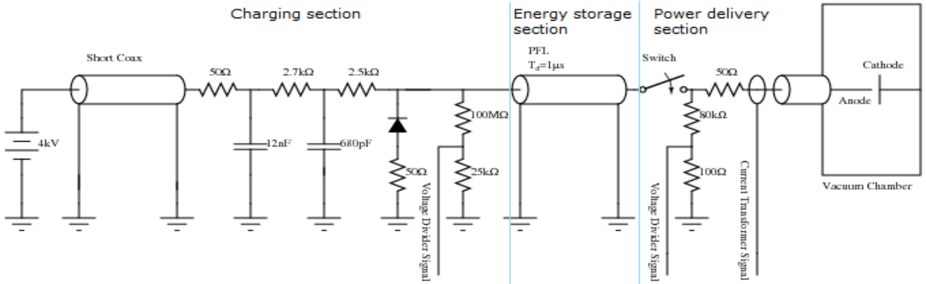


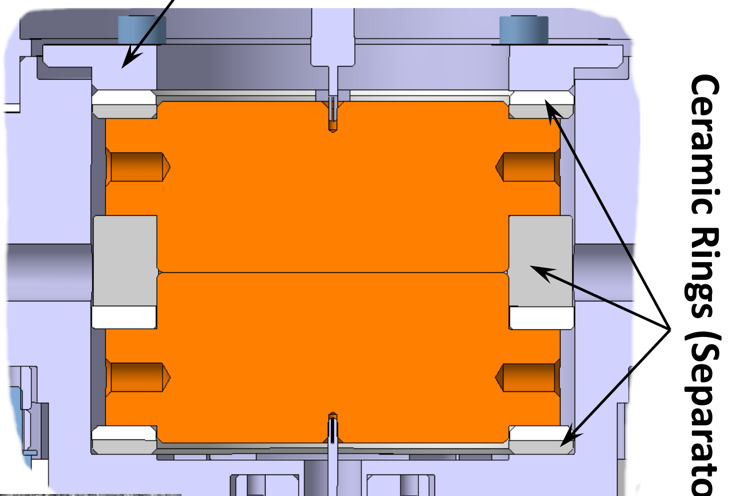


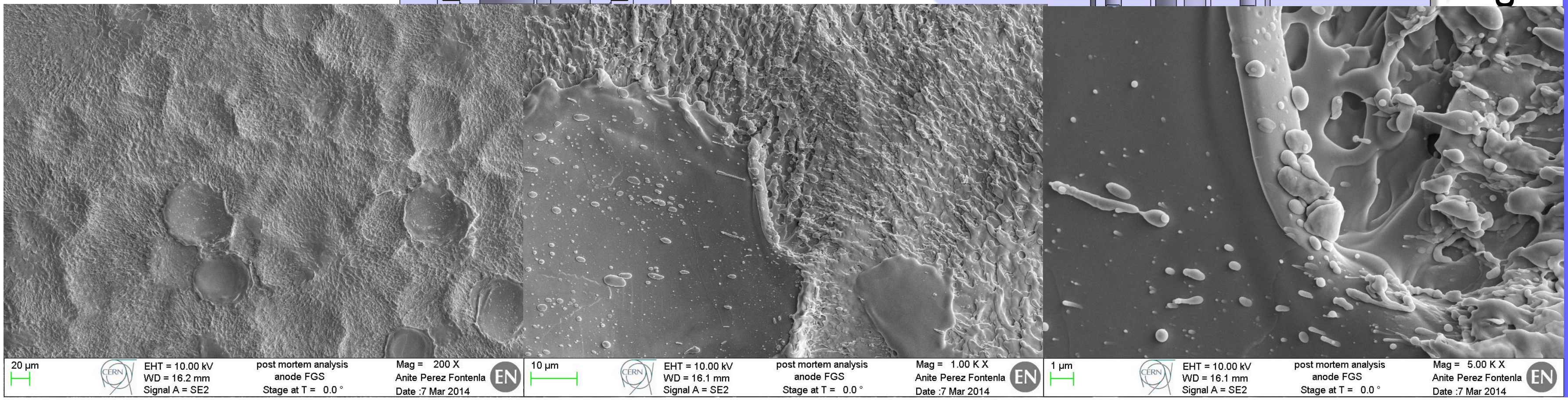
Fixed Gap System (S. Calatroni, A. Perez, N. Shipman)

Disk diameter = 60 mm
Disk gap down to 2 µm
Repetition rate = 1 kHz.









Fixed Gap System – preliminary test (S. Calatroni, A. Perez, N. Shipman)

Summary of observations		
Specimen	Fabrication & surface state	The electrodes were diamond machined by VDL and degreased at CERN before use;
BD's	Counting	• The counting of BD's was optimized by replacing the manual counting for an automatic particle analysis performed with "Axio Vision SE64" ZEISS software; • Proximity between BD's and their overlapping, results on a conservative estimate of the total number. Despite this, the estimated BD's number by the software (≈ 3.500) is bigger than the number estimated by the user (≈2.500);
	Distribution	The distribution of BD's is the same in the anode and cathode;
Features	Anode vs. cathode	• The spots have identical size in both electrodes (Ø≈200 um); • The melt material has been spread from the center outwards; • Smaller is the damage → more similar they are; • Greater damages reveal that craters in the anode are round and smoother than in the cathode;
	FGS vs. RF	• Electrodes didn't follow the standard treatment used for RF cavities (SLAC etching + heating on H_2); • The way in which the material has splashed around is different; • Also B-field arc sites??


06 - 10 OCTOBER '14
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Thank you