



CLIC MiniWeek

Pedro Morales Sanchez – CERN

12/12/2023

Contents

- CompactLight + iFAST
- iFAST prototype on going
 - Design
 - Mock-Up
 - Prototype
- Conclusion

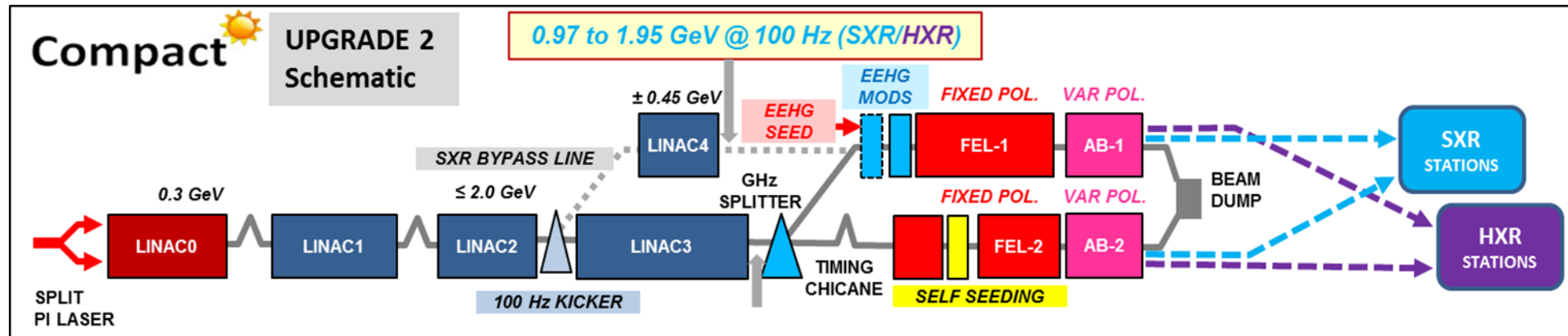


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CompactLight + iFAST

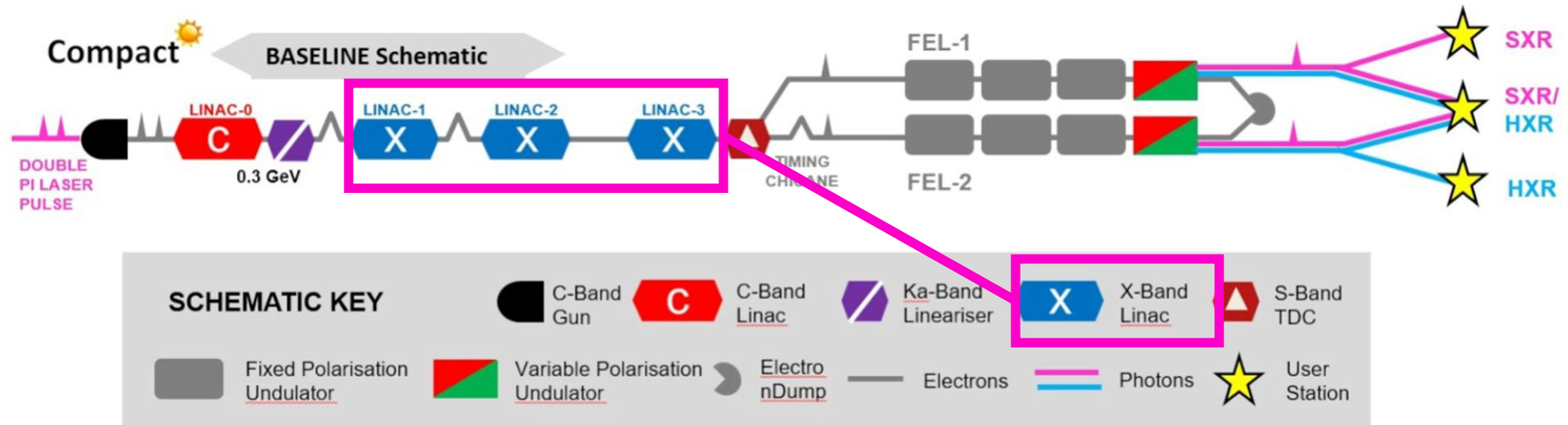


Objective of CompactLight: “The project aims at making X-ray FELs small and inexpensive enough to be within national and even university scale, yet with uncompromised scientific potential”.

Focus on Cost, Power consumption and Footprint.

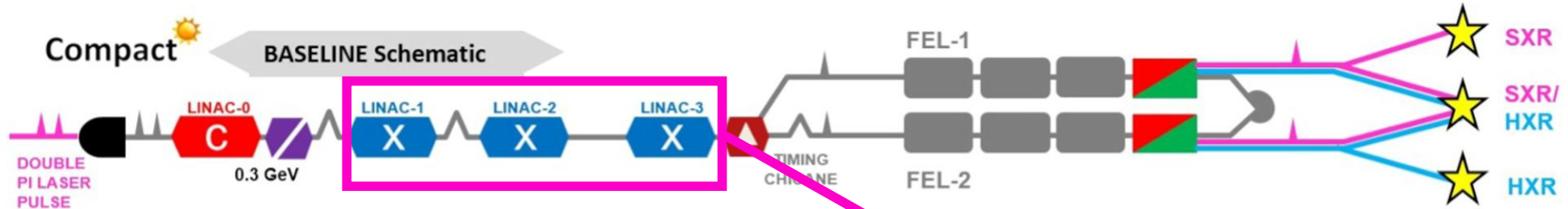
EU Founded H2020 collaboration among 26 institutions

CompactLight + iFAST

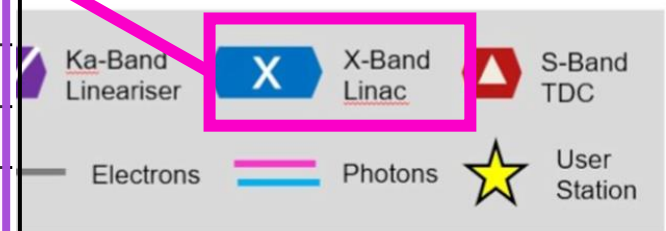


10 MW, 1.5 μ s, @1 KHz
50 MW, 1.5 μ s, @100 Hz

CompactLight + iFAST



Parameter	Unit	Dual mode		Dual source	
Operating Mode		B		U1, U2	
Repetition rate	kHz	0.1	0.25	0.1	1
Linac active length	m		94		
Number of structures			104		
Number of modules			26		
Number of klystrons		26		26 + 26	
Peak acc. gradient	MV/m	65	32	65	30.4
Energy gain per module	MeV	234	115	234	109
Max. energy gain	MeV	6084	2990	6084	2834



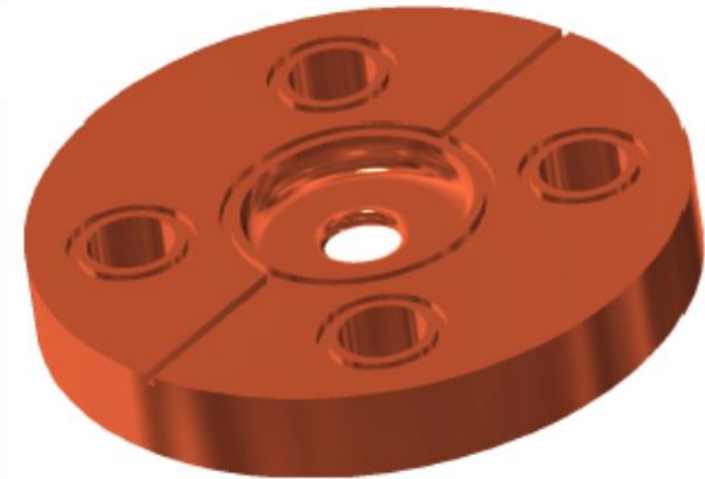
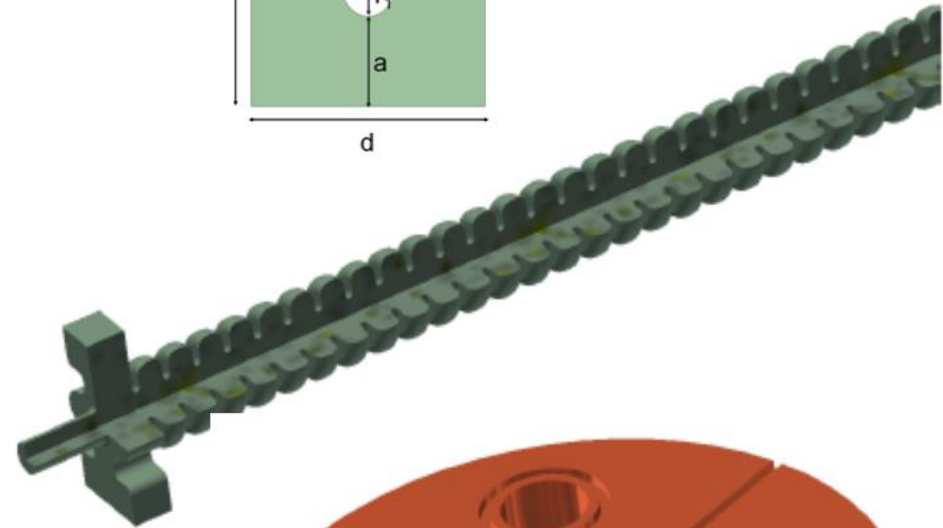
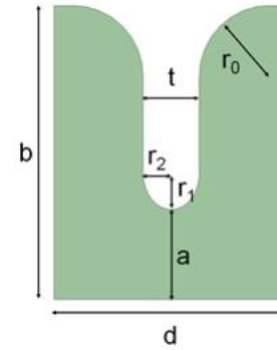
10 MW, 1.5 μ s, @1 KHz

50 MW, 1.5 μ s, @100 Hz



CompactLight + iFAST

Parameter	Units	Value		
Frequency	GHz	11.994		
Peak klystron power (100 - 250 Hz)	MW	50		
Peak klystron power (1000 Hz)	MW	10		
RF pulse length (250 Hz)	μ s	1.5 (0.15)		
Waveguide power attenuation	%	≈ 10		
Average iris radius a	mm	3.5		
Iris radius a	mm	4.3-2.7		
Iris thickness t	mm	2.0-2.24		
Structure length L_s	m	0.9		
Unloaded SLED Q-factor Q_0		180000		
External SLED Q-factor Q_E		23300		
Shunt impedance R	M Ω /m	85-111		
Peak modified Poynting vector	W/ μ m ²	3.4		
Group velocity v_g/c	%	4.7-0.9		
Filling time t_f	ns	146		
Repetition rate	Hz	100	250	1000
SLED		ON	OFF	ON
Required klystron power	MW	44	44	9
Average accelerating gradient	MV/m	65	30	30



Courtesy M. Diomede

CompactLight + iFAST

Objectives: “i.FAST aims to enhance innovation in the particle accelerator community,[...]These include, among others, new accelerator designs and concepts, advanced superconducting technologies for magnets and cavities, techniques to increase brightness of synchrotron light sources, strategies and technology to improve energy efficiency, and new societal applications of accelerators”.

Quick links

WP1: Management
WP2: Communication
WP3: Industry engagement
WP4: Innovation, materials
WP5: R&D strategies
WP6: Novel concepts
WP7: Light sources
WP8: Magnets
WP9: Cavities
WP10: Technologies
WP11: Sustainability
WP12: Applications
WP13: Technology infrastructure
WP14: Ethics requirements

WP7: High brightness accelerators for light sources

Objectives

- Organise workshops on the technology enabling the design and construction of future ultra-low emittance rings
- Specify and design magnetically and mechanically a longitudinal variable field dipole magnet with transverse gradient, adapted to the ELETTRA storage ring upgrade, for reducing further the horizontal emittance
- Design of two different C-band (5.712 GHz) RF electron guns operating at very high gradient cathode peak field
- Build and test, at low and high RF power, two prototypes at different TRL of the X-band (12 GHz) accelerating structure designed for the CompactLight (XLS) project

Tasks

Task	Name	Task Leader
7.1	Coordination and communication	R. Bartolini (DESY)
7.2	Enabling technologies for ultra-low emittance rings	A. Mochihashi (KIT)
7.3	Variable Dipole for the upgrade of the ELETTRA storage ring	Y. Papaphilippou (CERN)
7.4	Very high gradient RF Guns operating in the C-band RF technology	D. Alesini (INFN)
7.5	CompactLight Prototype Accelerating Structures	G. D'Auria (Elettra)

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Task 7.5: CompactLight accelerating structure prototype

Objective: Build and test, at low and high RF power, two prototypes of the X-band (12 GHz) accelerating structure designed for the CompactLight project.

Two deliverables:

- **D7.5: Construction of the XLS accelerating structure pre-prototype.**







Development of production process and RF tests of the pre-prototype (@TRL 6/7)_Feb24

- **D7.6: Construction of the XLS accelerating structure full prototype.**

Production process analysis and validation, RF tests of the full prototype (@TRL 7)_Apr25

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Task 7.5 Partners

ELETTRA-ST	CERN	INFN	VDL-ETG	COMEB	TMD
 Elettra Sincrotrone Trieste		 Istituto Nazionale di Fisica Nucleare			
<ul style="list-style-type: none">- General coordination	<ul style="list-style-type: none">- Consultancy- Metrology verification<ul style="list-style-type: none">- RF measurements at low and high power	<ul style="list-style-type: none">- Electro-magnetic design of the structure<ul style="list-style-type: none">- RF measurements at low and high power	<ul style="list-style-type: none">- Fabrication of cells and couplers	<ul style="list-style-type: none">- Fabrication of cells and couplers	<ul style="list-style-type: none">- Brazing

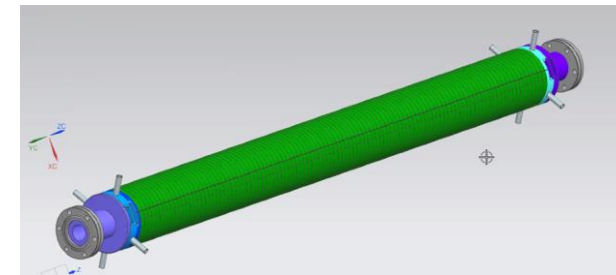
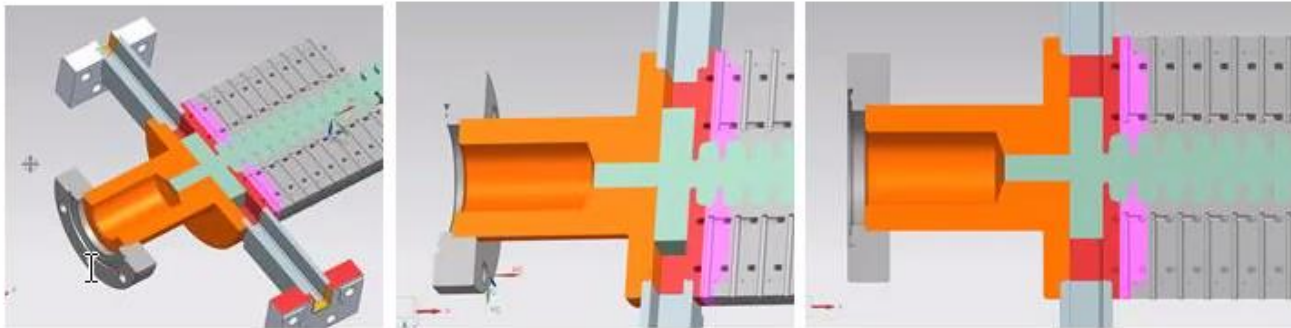
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iFAST prototype on going - Design



RF accelerating structure

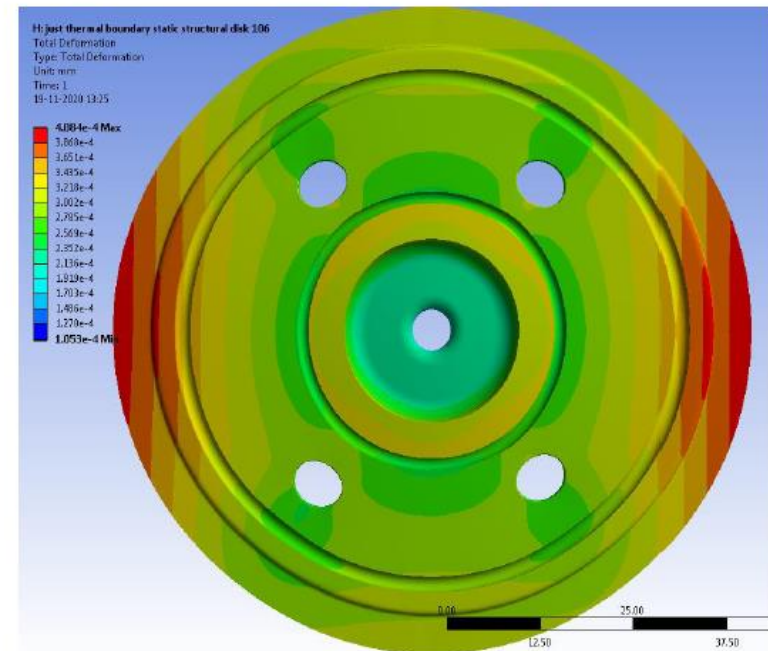


RF Structure
Input – Output RF couplers

iFAST prototype on going - Design

Thermo-mechanical simulations

- Optimization of the cooling geometry
- Iteration with RF on the deformation
- Choice for 4 cooling channels with a diameter of 6 mm (similar to CLIC)
- Cooling channels slightly asymmetrical to match the RF couplers

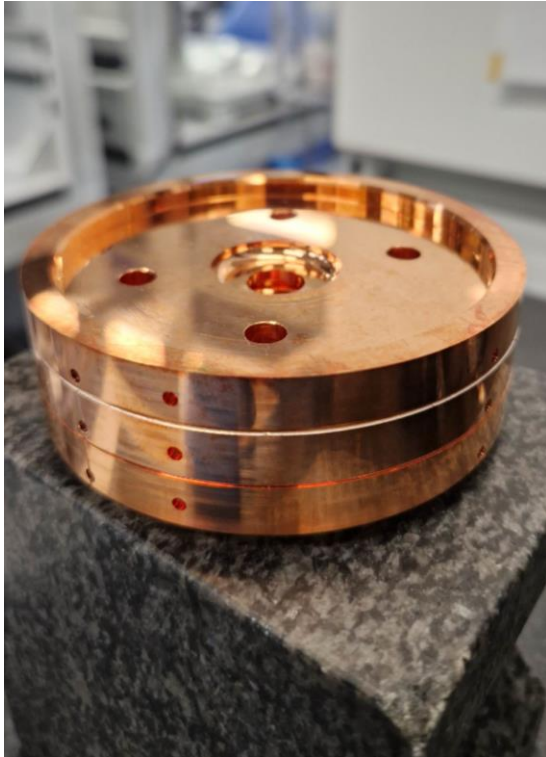


Courtesy M. van den Berg

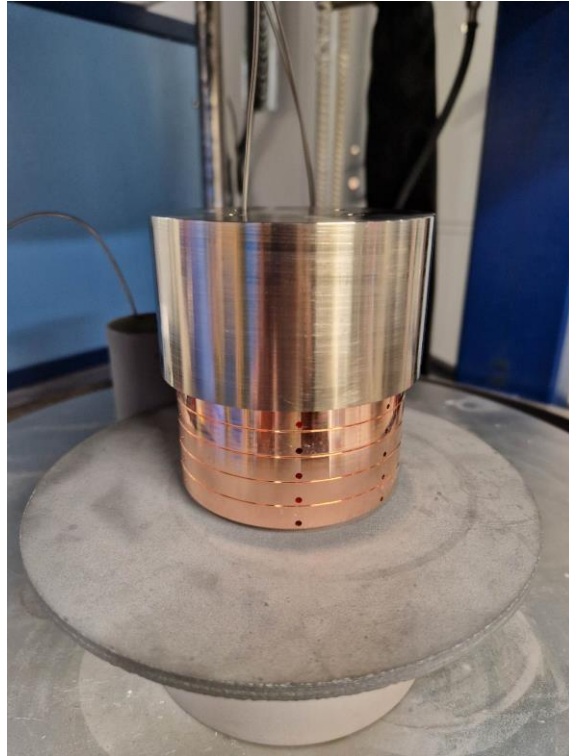
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iFAST prototype on going – Mock-up



1st



2nd



3rd

3 trials have been carried out with different conditions:

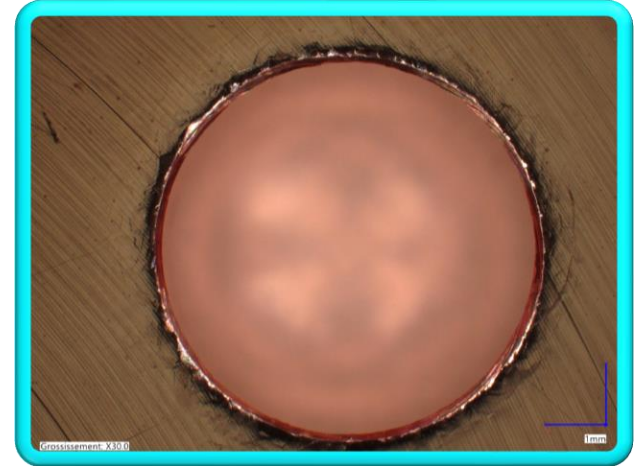
Machinability
Interlocking alignment
Brazing material
Leak tightness
Weight

iFAST prototype on going – Mock-up

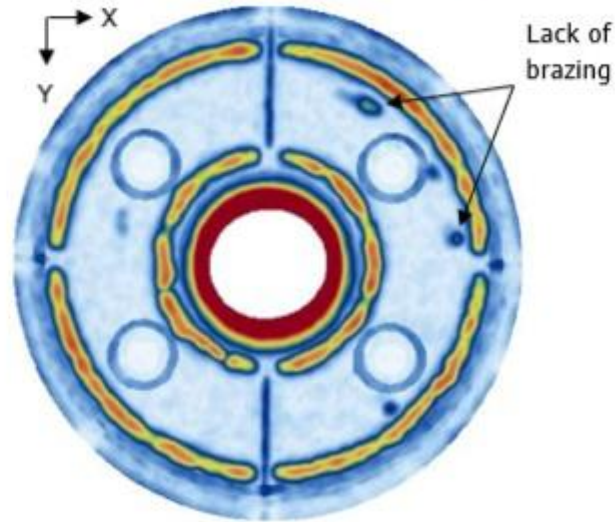


Courtesy COMEB

- 35um

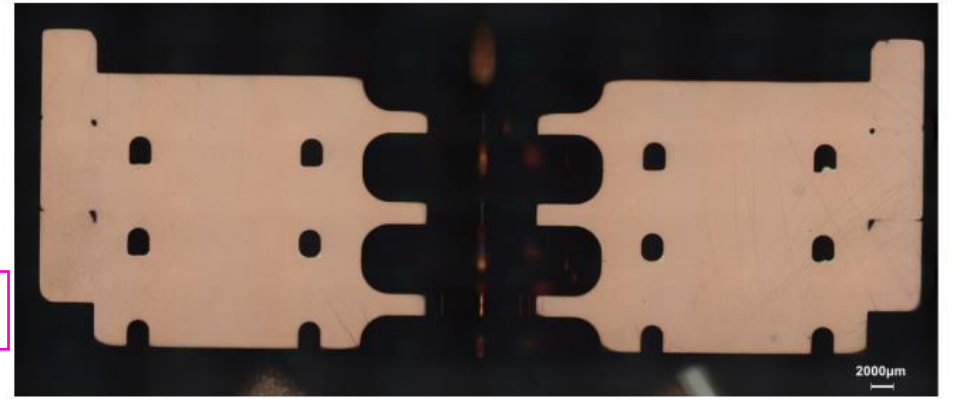


iFAST prototype on going – Mock-up



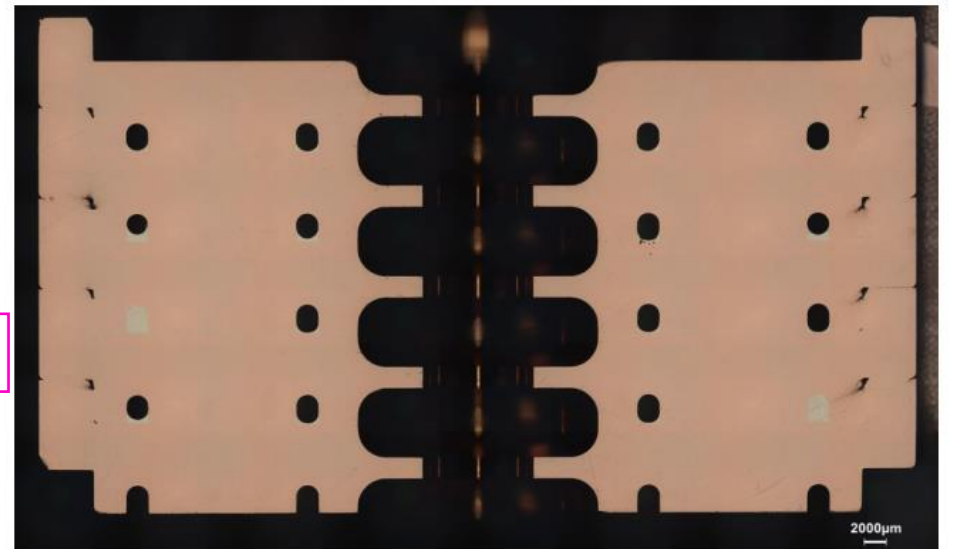
X3

1st



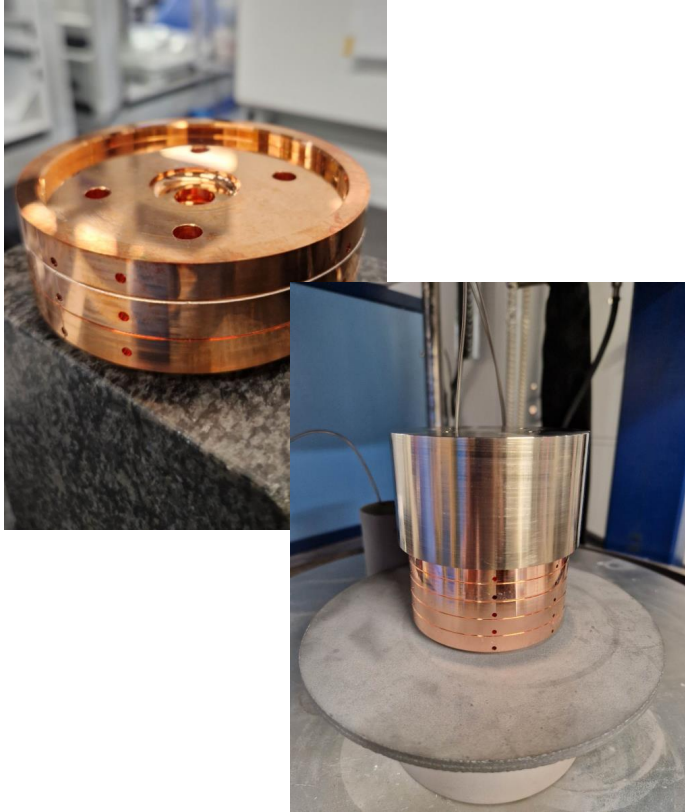
X5

2nd

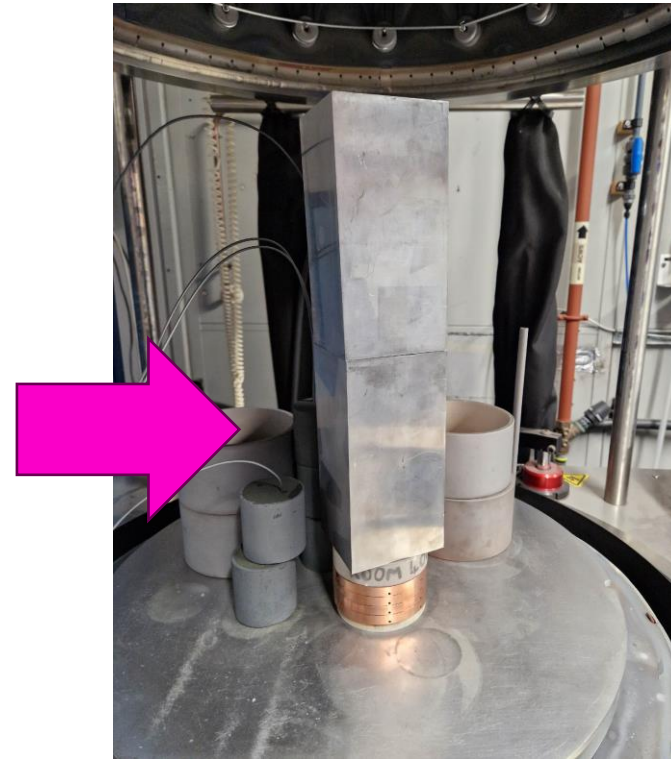


Performed UT analysis and microscopy afterward. BFM inspection

iFAST prototype on going – Mock-up



The alignment and flatness of the structure were kept as expected after the cycle with the 40kg on top. The BFM was not showing itself on the external surface and it was successfully tested under vacuum.



3rd

Contents

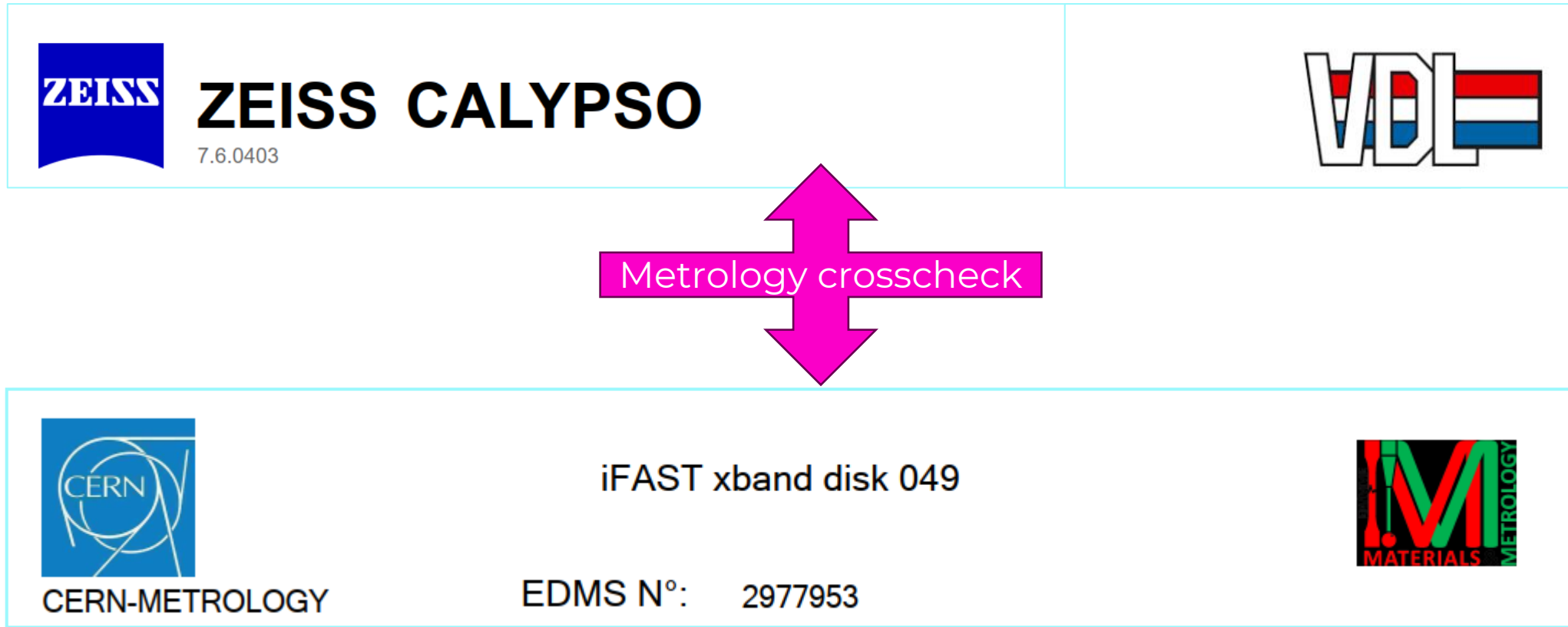
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iFAST prototype on going – Prototype

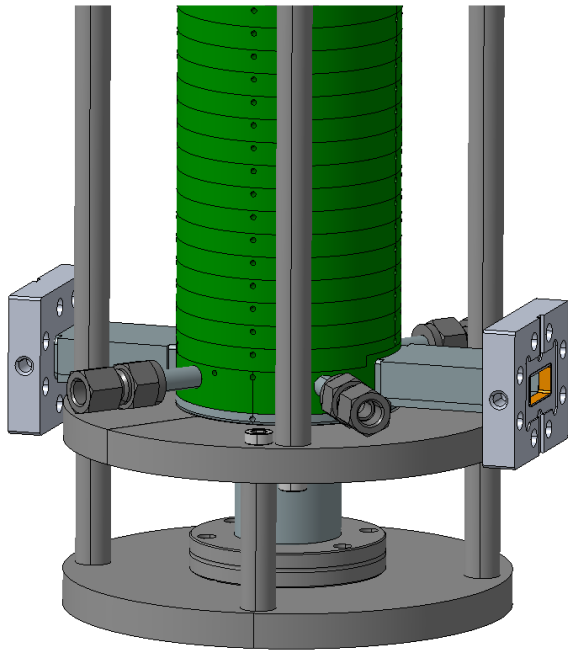


Machining done at VDL

iFAST prototype on going – Prototype



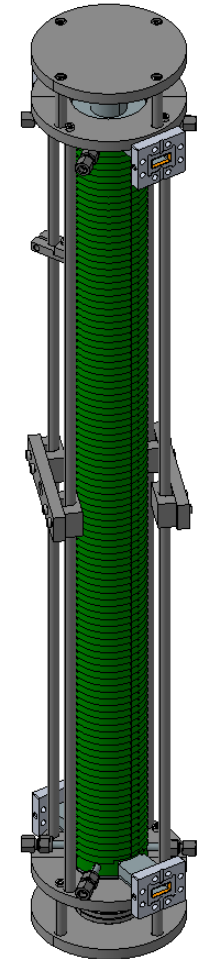
iFAST prototype on going – Prototype



Tooling fabrication is ongoing at TMD

The shipment is on its way from CERN to the UK

Assembly forecasted by January 2024



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Conclusions

- The work from CompactLight to develop cost-efficient and versatile X-Band linac has been a success story. We have been able to benefit from this in iFAST project.
- We have validated the assembly method at least in the mock-up phase and we are confident to have similar results in the final assembly.
- On track to deliver the first structure early next year and test it around February 2024.

iFAST

Thank you for your attention

References:

<http://www.compactlight.eu/Main/Publications>
[Home | IFAST \(ifast-project.eu\)](http://www.compactlight.eu/Main/Publications)

Thanks, Gerardo, for the opportunity giving and building this presentation



This project has received funding from the European Union's Horizon 2020
Research and Innovation programme under GA No 101004730.