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

IFAST WP7_Task 7.5: CompactLight Prototype Accelerating Structure

I.FAST Steering Committee, 15-16 November, 2021

Gerardo D'Auria, Elettra - Sincrotrone Trieste

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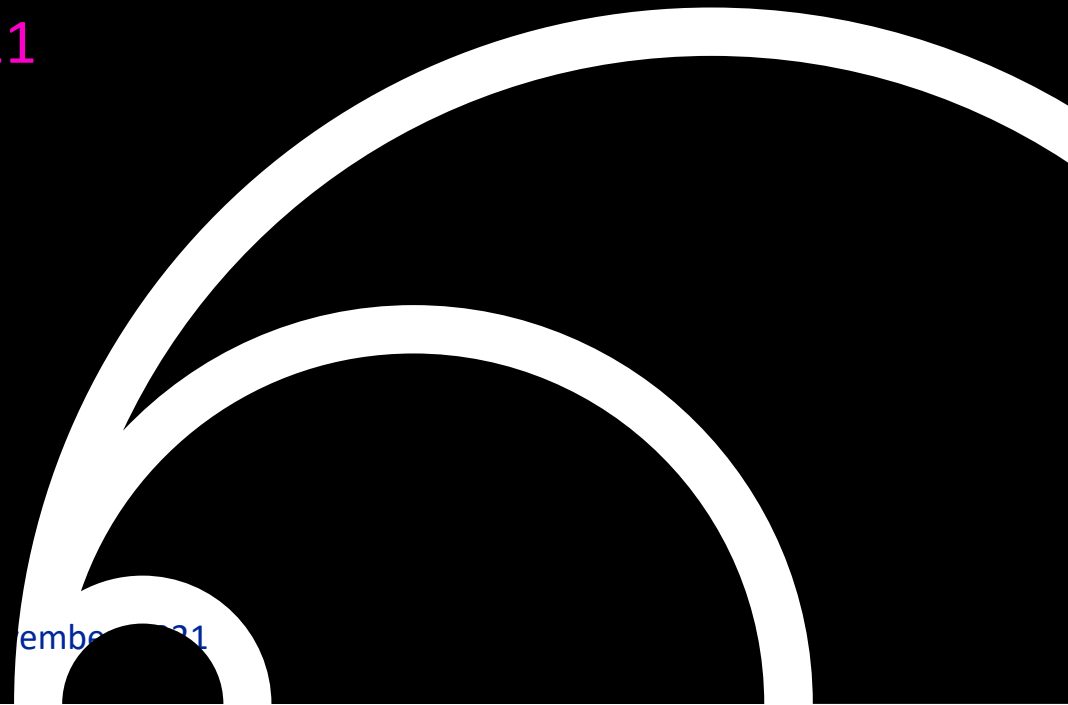


Task 7.5: CompactLight Prototype Accelerating Structures

Objective:

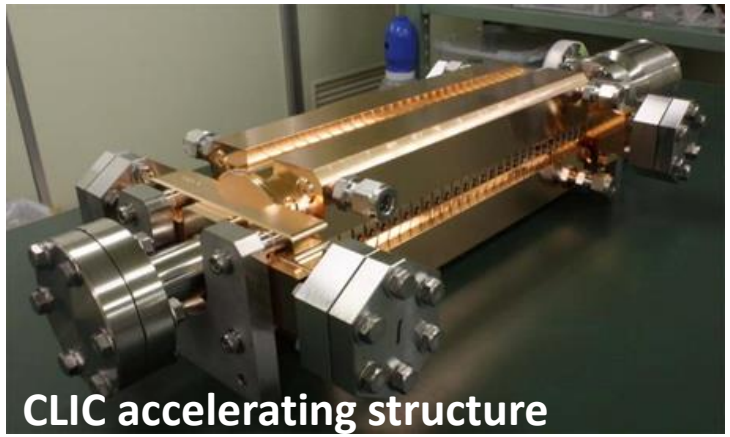
Build and test, at low and high RF power, two prototypes of the X-band (12 GHz) accelerating structure designed for the CompactLight (XLS) project, a new class of linac-driven FEL facilities, based on a Horizon 2020 Design Study.

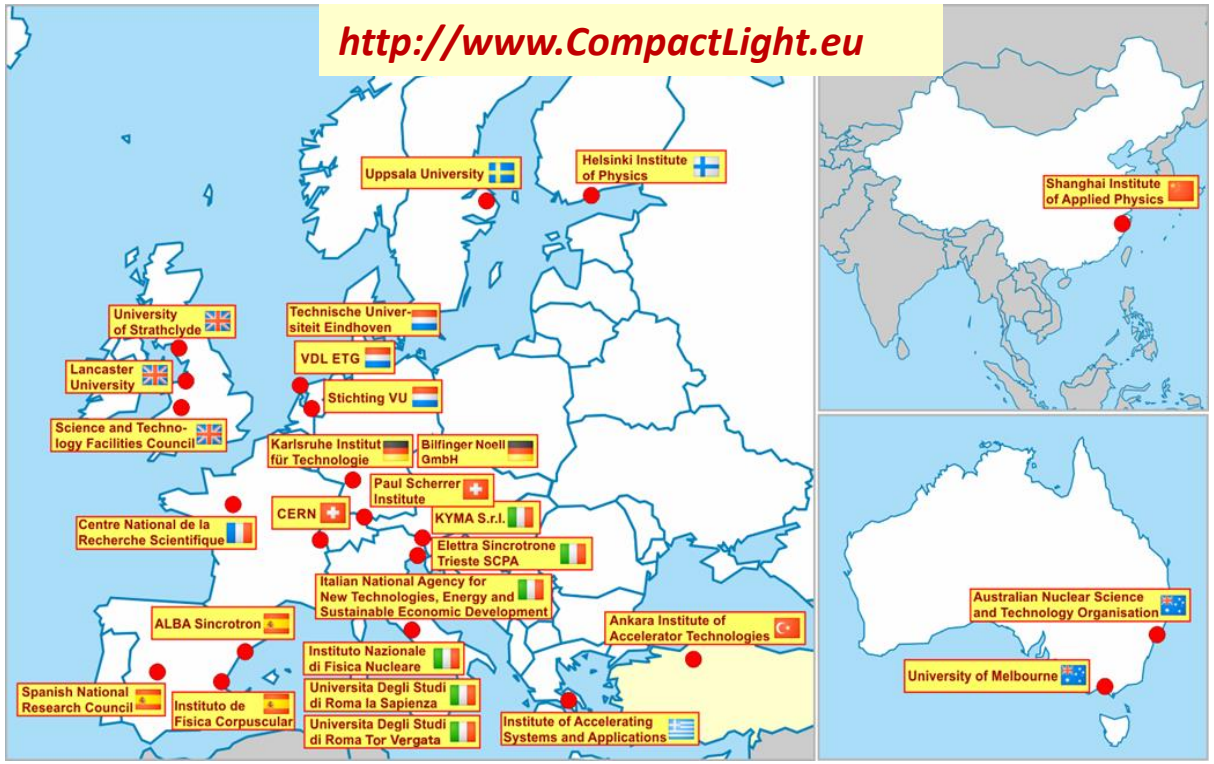
Task 7.5 Partners:

ELETTRA-ST, CERN, INFN, VDL-ETG, COMEB, TMD

The CompactLight (XLS) design study

- The CompactLight Project (XLS) is an EU funded design study aimed at promoting the construction of the next generation FEL based photon sources with innovative accelerator technologies.
- The objective is the design of a 5.5 GeV X-band linac, based on the CLIC technology, to drive a FEL facility with soft and hard X-ray options.





26 Partners:

- 23 International Laboratories and Universities
- 3 Private Industries.

Activities and Deliverables

The two prototypes will be used to get a full validation of the XLS accelerating structure at two RF operating regimes:

a) high gradient/low pulse repetition rate (60 MV/m @100Hz);

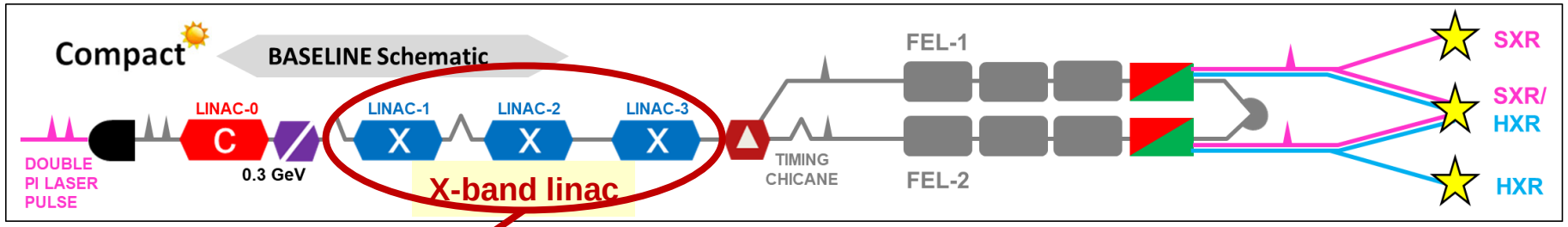
b) low gradient/high pulse repetition rate (30 MV/m up to 1KHz).

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)_M24

D7.6: Construction of the XLS accelerating structure full prototype.
Production process analysis and validation, RF tests of the full prototype (@TRL 7/8)_M36

CompactLight Linac layout



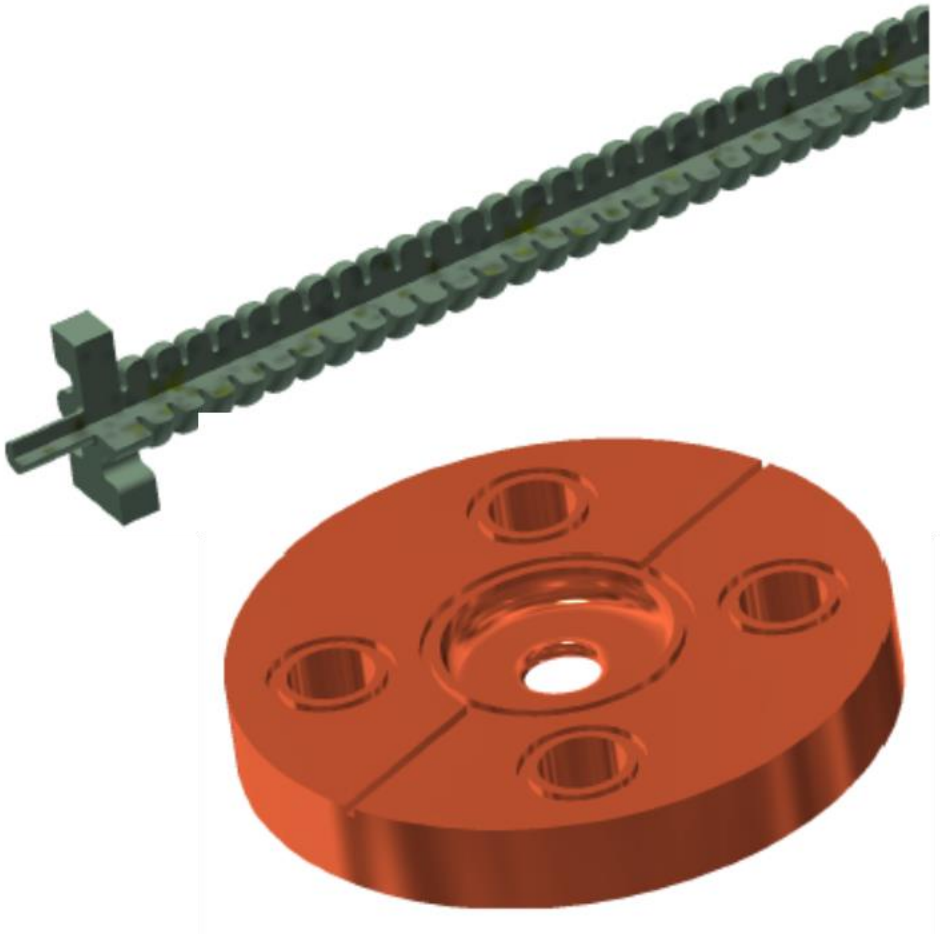
10 MW, 1.5 μs, @1 KHz

50 MW, 1.5 μs, @100 Hz

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

Accelerating structure RF operating parameters

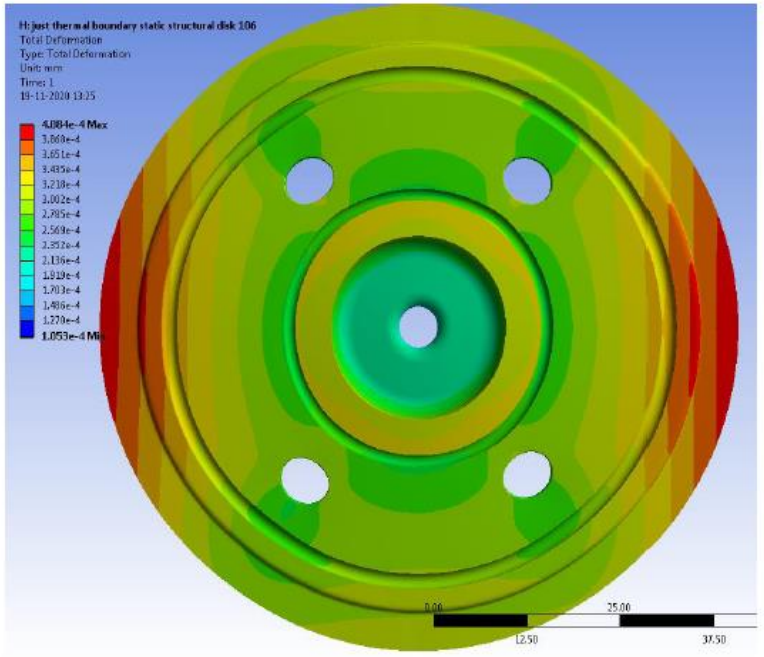
Parameter	Units	Value		
Frequency	GHz	11.994		
Peak klystron power (100 - 250 Hz)	MW	50		
Peak klystron power (1000 Hz)	MW	10		
RF pulse length (250 Hz)	μs	1.5 (0.15)		
Waveguide power attenuation	%	≈ 10		
Average iris radius a	mm	3.5		
Iris radius a	mm	4.3-2.7		
Iris thickness t	mm	2.0-2.24		
Structure length L_s	m	0.9		
Unloaded SLED Q-factor Q_0		180000		
External SLED Q-factor Q_E		23300		
Shunt impedance R	MΩ/m	85-111		
Peak modified Poynting vector	$W/\mu m^2$	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

Thermo-mechanical design

- 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

Time plan

Preparatory phase for structure fabrication

#	Activity	2021								2022												2023												2024			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
		M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
1	Technical drawings for prototype production																																				
2	Thermo-mechanical analysis and temperature stabilization at different operating regimes																																				
3	Structure thermal simulations (INFN)																																				
4	Brazing tests (three disks) at TMD																																				
5	Brazing procedure																																				
6	Production process analysis and optimization																																				
7	First prototype fabrication																																				
8	RF characterization																																				
9	High power RF tests and validation																																				
10	Post-mortem characterization																																				
11	Review of metrology data and test results																																				
12	Second prototype fabrication																																				
13	RF characterization																																				
14	High power RF tests and validation																																				
15	Post-mortem characterization																																				

Unexpected problems

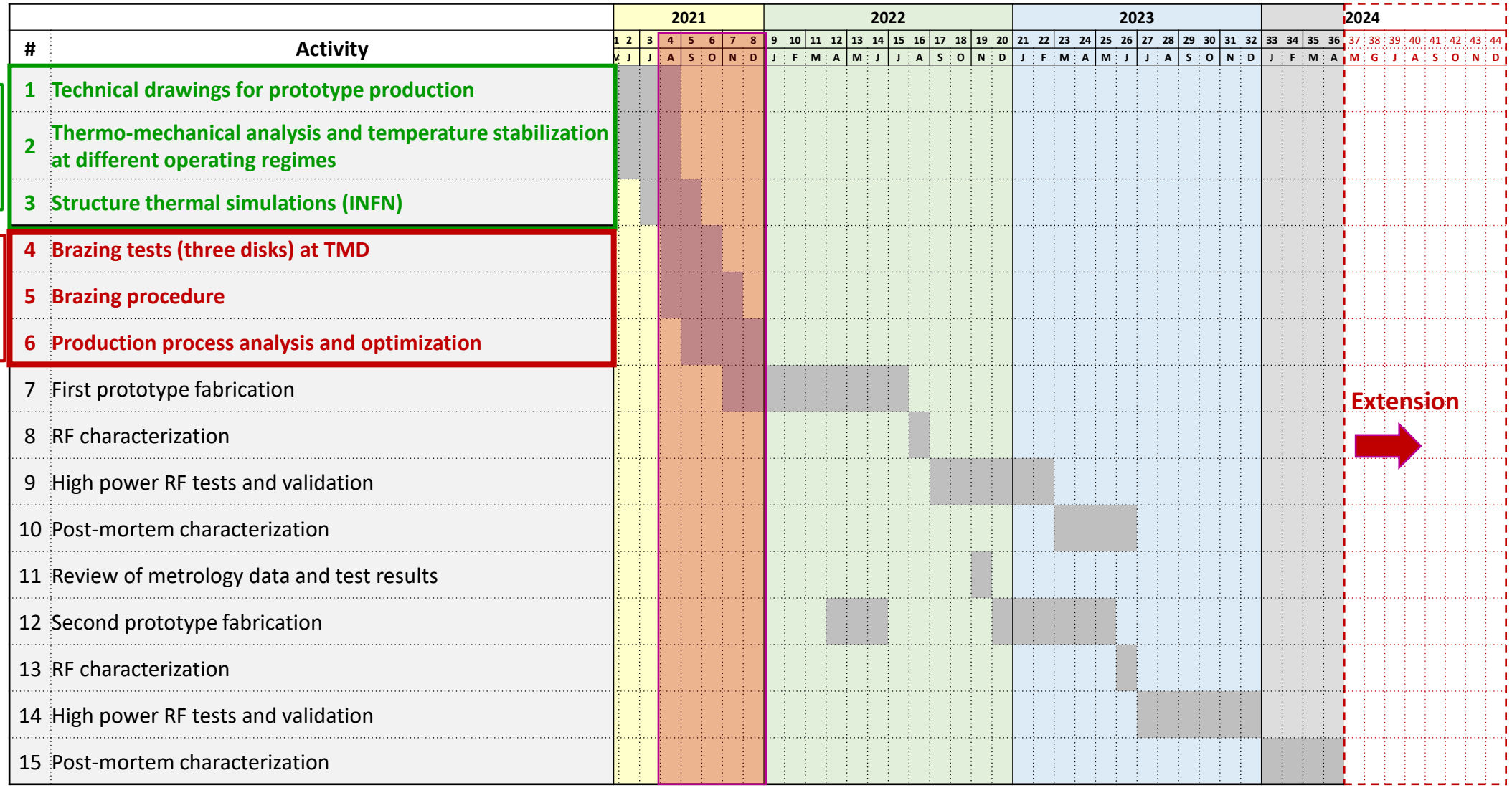
Unfortunately, in mid-August, we were informed that our colleague, Mathieu Breukers, one of the founding fathers of the ultra precision machining activities at VDL-ETG, responsible for the XLS structure manufacturing, passed away.

For this reason, all the activities to prepare the disks manufacturing, the structure brazing, etc. have been stopped to allow VDL to review their work plans and to determine the way forward without the expertise and experience of Mathieu.

Modified schedule

Activities started in May and carried out up to mid of July

Activities that need to be continued as soon as possible



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Thank you!

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