THE CLIC MODULE FABRICATION

MEETING #1

Introduction and Selection of Criteria – 1 September 2020

OUTLINE

- Requirements for an effective Module integration;
- CLIC Module physical and conceptual interfaces;
- Choice of a Module type;
- Work organization and plan.

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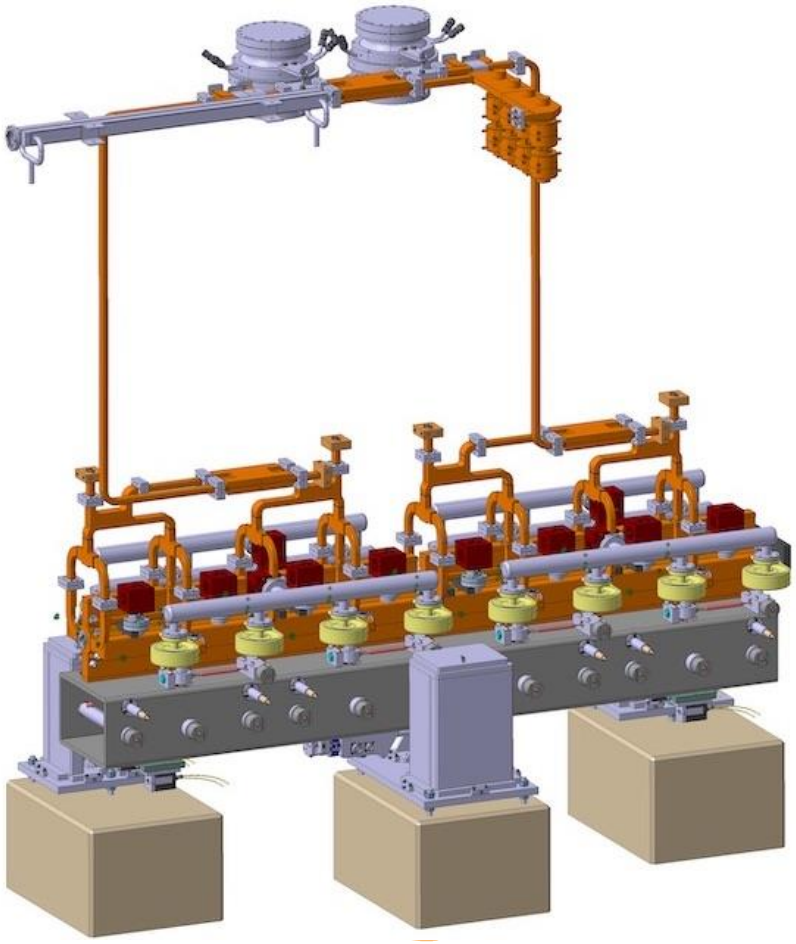
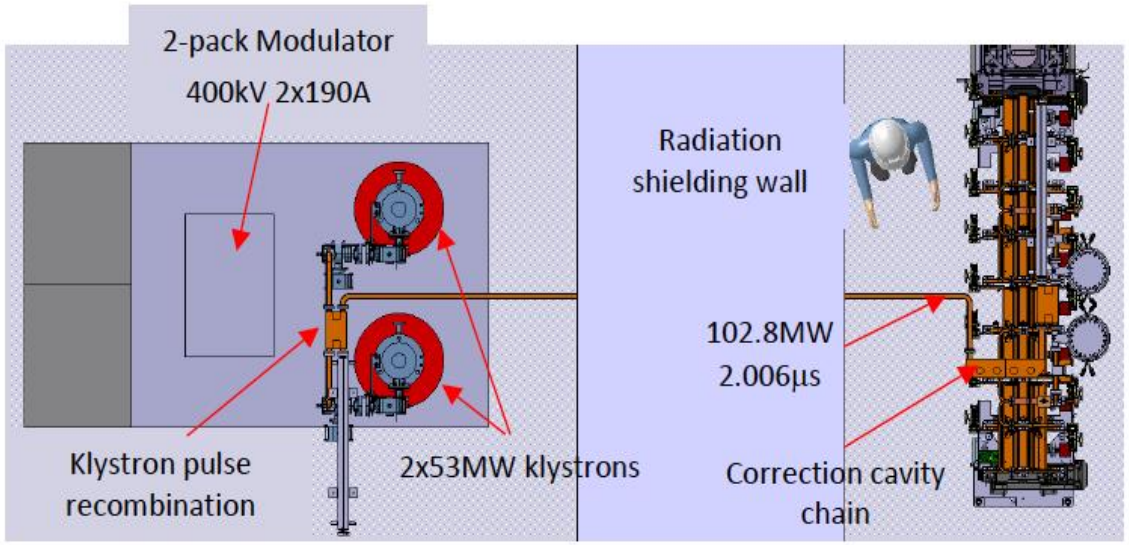
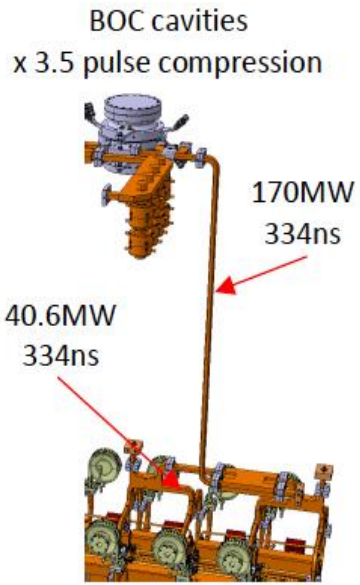
CLIC K-MODULE DESIGN







CLIC K-MODULE REQUIREMENTS (RF)

CLIC requirements
Design of RF coupling cell for damped structures
Design of RF power window
Design of damped structure interconnection (wakefield suppression)
Design of an integrated waveguide network around the Module
Demonstrate fabrication of damped SAS in one piece, with no need of tuning
Demonstrate RF conditioning of the Module
Demonstrate reliable operation at the nominal loaded gradient (75 MV/m)

CLIC requirements
Test RF power handling of the RF network
Develop high efficiency x-band klystrons
Double-klystron compact modular modulator
Pulse compression system with CLIC-K pameters: Large BOC with double height WG + correction cavity chain
Double height WG components
Develop a new or consolidate the old assembly technique of the manifolds for SiC damping loads

CLIC K-MODULE REQUIREMENTS (RF)

CLIC requirements	Xboxes	eSPS	FLASH	AWAKE
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Double-klystron compact modular modulator				
Pulse compression system with CLIC-K pameters: Large BOC with double height WG + correction cavity chain				
Double height WG components				
Develop a new or consolidate the old assembly technique of the manifolds for SiC damping loads				

CLIC K-MODULE REQUIREMENTS (MODULE)

	CLIC requirements	Xboxes	eSPS	FLASH	AWAKE
	Design of cooling circuit in damped structures				
	Design of vacuum circuit for damped structures				
	Design of support and alignment of accelerating structures				
	Design of support and alignment of the main girder.				

	CLIC requirements	Xboxes	eSPS	FLASH	AWAKE
	Design of the Module cooling and temperature stabilization system with the CLIC specs				
	Demonstrate ability to regularly achieve prealignment requirements				
	Test thermo-mechanics and stability of the Module in operation				
	Interfacing to magnets and general alignment system				

CLIC K-MODULE REQUIREMENTS (BEAM DYNAMICS & INST)

	CLIC requirements	Xboxes	eSPS	FLASH	AWAKE
	Nominal wakefield monitors				

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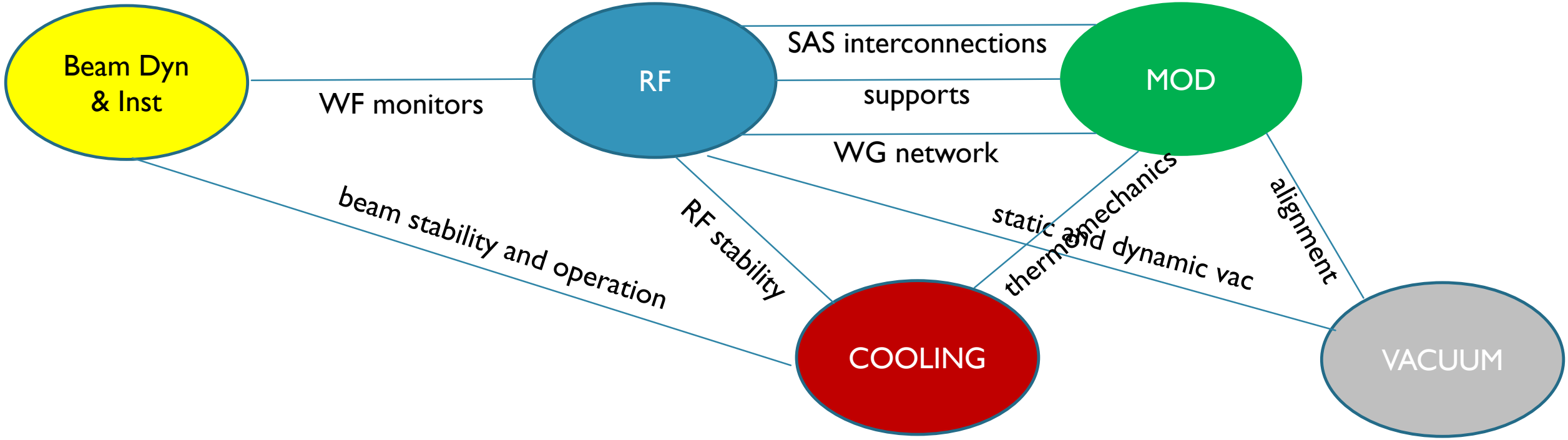
CLIC K-MODULE INTERFACES



PERSPECTIVES FOR MODULE INDUSTRIALIZATION

✓ Progress in defining a technical specification for the Module:

- Specify functions and interfaces;
- Study the assembly and alignment process;
- Define acceptance criteria;
- Identify benefits of industrial processes for the Module production.

CLIC K-MODULE INTERFACES

- A Functional specification document for the K-Module (10 – 15 pages)

1. DESCRIPTION OF THE WBS, MAIN PARAMETERS
1.1 SCOPE OF THE WORK PACKAGES
1.2 RESPONSIBILITIES
1.3 MAIN PARAMETERS
2. TECHNICAL DESCRIPTION
3. DELIVERABLES AND INTERFACES AMONG WORK PACKAGES
3.1 DELIVERABLES FOR THE WORK PACKAGES
3.2 INTERFACES AMONG WORK PACKAGES
5. ORGANISATION, PLANNING AND INTERMEDIATE MILESTONES
6. BUDGET ESTIMATE AND SPENDING PROFILE
7. MANPOWER NEEDS
8. POSSIBLE COLLABORATIONS AND IN-KIND CONTRIBUTIONS

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MAIN RF PARAMETERS

	CLIC K	XLS	eSPS	FLASH Confidential
Frequency [GHz]	**11.994**	**11.994**	**11.994**	**11.994**
RF pulse length (100Hz) [μs]	2.01	1.5	1.5	1.5
Average iris radius <a> [mm]	2.94	3.5	3.2	3.65
Iris radius a [mm]	3.62 - 2.25	4.3 - 2.7	3.7 - 2.7	3.65 const
Iris thickness t [mm]	2.08 - 1.12	2.0-2.24	1.37	1.5
Structure length L_s [m]	0.23	0.9	0.575	0.5
Q-factor Q_0	5619 - 5962		7090 - 7020	5750
Number of structures / module	8	4	4	4
Shunt impedance R [MΩ/m]	73 - 112	90 - 125	101 - 123	76.1875
Group velocity v_g/c [%]	2.362 - 0.682	4.7 - 0.9	3.6 - 1.34	3
Filling time [ns]	28.6+63.8	146	12+88	58
Average Loaded/Unloaded Gradient [MV/m]	75 / 94.9	65	60 / 60	35 / 47
Klystron power [MW]	2 x 51.6	40	43.5	45.3
Energy gain / Module [MeV]	156	234	137.5	75
Compressed RF pulse length [ns]	334.4		300	375
Compression power gain	3.5		3.2	2.8
Type of structure	Damped	Undamped	Undamped	Damped

ALIGNMENT TOLERANCES

Imperfection	CLIC	XLS	eSPS	FLASH
Quadrupole pitch [μrad]			100	
Quadrupole roll [μrad]	100			
Quadrupole offset [μm]	14	100	100	
BPM offset [μm]	14	100	100	
BPM resolution [μm]	0.1	5	10	
Cavity offset [μm]	14	100	100	100
Cavity pitch [μrad]	141		100	
Wake monitor Structure centre [μm]	3.5			

Only CLIC has so tight alignment requirements

CONSIDERATIONS ON POWER SOURCES

	CLIC K	XLS	eSPS	FLASH Confidential
Frequency [GHz]	**11.994**	**11.994**	**11.994**	**11.994**
RF pulse length (100Hz) [μs]	2.01	1.5	1.5	1.5
Repetition rate / max [Hz]	50 / 100	100 / 250	100	200 / 400 + burst mode
Average Loaded / Unloaded Gradient [MV/m]	75 / 94.9	65 / 65	60 / 60	35 / 47
Klystron power [MW]	2 x 51.6	40 (45)	43.5	45.3
RF Power / AS [MW]	40.6	(39.5)	30.5	29
Energy gain / Module [MeV]	156	234	137.5	75
Compressed RF pulse [ns]	334.4	(150)	300	375
Compression power gain	3.5	(4.0)	3.2	2.8

SYNERGIES WITH ON-GOING STUDIES

- In the difficult financial context, we should avoid duplicating studies and tests that are already planned by other laboratories (XLS);
- In spite of looser tolerances for all but CLIC modules, all modules would allow to check the mechanical alignment performance required by CLIC ;
- In terms of average power dissipation, eSPS is 60% of CLIC module and FLASH is 80% of CLIC module.
- With respect to peak RF power, no other project is adopting comparable gradients and power flows.

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GENERAL CONSIDERATIONS ABOUT RESOURCES

- An RF engineer working in the x-band team to design structures, components, also supporting thermo-mechanical simulations and experimental activity at Xbox;
- A mechanical engineer (M. Capstick + successor) to coordinate mechanical design and production, general integration and experimental activity ;
- A mechanical draftsman to develop 3D models and fabrication drawings, expert of the CATIA Smarteam environment. The activity can be outsourced, but less effective;
- Collaboration of the Survey, CV and VAC teams + general infrastructure.

- Consider using an existing test stand for testing and commissioning needs;
- In a longer term we may need support for development of LLRF, control and acquisition system.

COST SUMMARY (BASED ON PROTOTYPES)

Module Component	Prototype cost [kCHF]	Multiplicity	Partial cost [kCHF]	
X-band damped SAS (0.5 m)	150	4	600	
Waveguide delivery with BOC	350	1	350	
Module mechanics	150	1	150	
Vacuum system	100	1	100	
			1200	Total for Module Components
RF Source				
X-band Kystron (low eff)	800	2	1600	
Modulator two-pack	660	1	660	
X-band RF Driver + LLRF	130	2	260	
			2520	Total for RF Source
			3720	**Total cost**

WORK ORGANIZATION

- 4 – 5 meetings of the Module fabrication WG to converge on a module layout;
- Write a short (10 – 15 pages) Functional specification document by end 2020 – early 2021;
- Work packages are attributed to the respective areas;
- Technical coordination during design and fabrication is performed by a small committee with representatives of the areas involved; the TCC reports to CASC;
- Each area is responsible for its deliverables and budget.

ILLUSTRATIVE SCHEDULE

	2020		2021		2022		2023		2024		2025	
Activities	October	Q4	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Converge on Module layout and goals												
Complete functional specification												
Module design and fabricaton												
Infrastructure preparation												
Testing												
Final report												

LINES FOR THE DISCUSSION

- Agree on the CLIC requirements that we intend to address;
- Align development programs of the different areas:
  - Which goals look as achievable in the schedule / budget context ?
- Assess benefits for different levels of testing;
  - For example wrt RF power availability or infrastructure needs;
- Check which other projects can address the selected requirements and can provide the required performance.

SPARE SLIDES

GUIDELINES FOR THE CLIC MODULE ACTIVITY

- ✓ Complete the activities required for the mechanical design of the CLIC K-Module or similar: girder, adjustable supports, mechanical couplings (vacuum, RF network), installation and alignment strategy, general integration;
- ✓ Complete the studies on the thermo-mechanical behaviour of the CLIC K-Module or similar: FEA thermal model benchmarking, Module cooling circuit optimization;
- ✓ Experimental activity: Perform thermo-mechanical studies in collaboration with the Xbox team. Maintain and update the Module thermal exchange database.