

# **Installation to commissioning of a turn-key LINAC** and transition to user operation

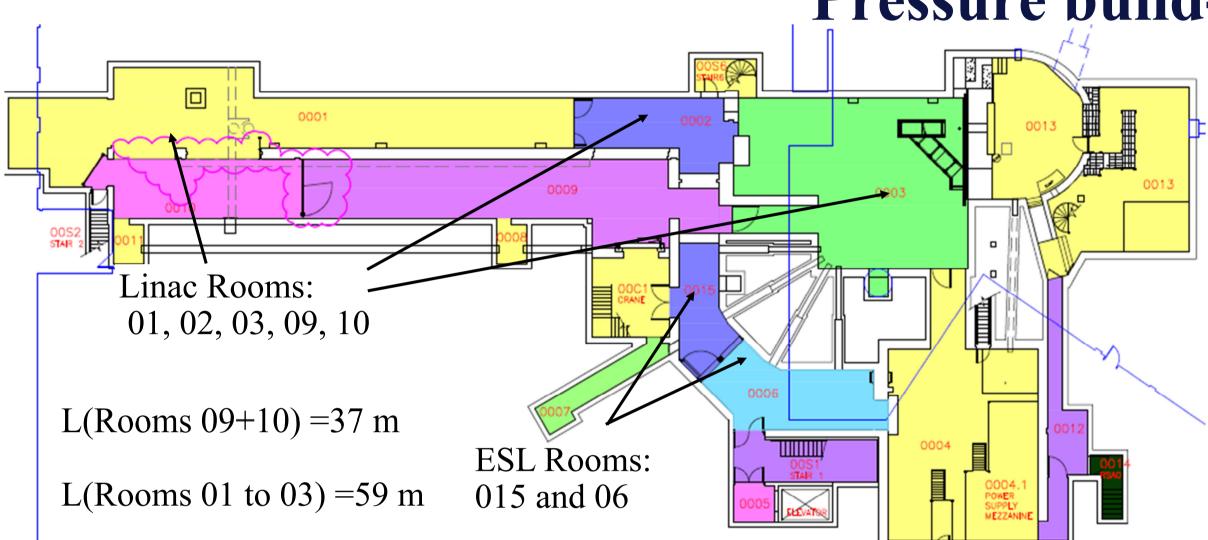
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### **Summary**

CLS will soon - Mid-April 2024 - install a "turn-key" 250 MeV injector, based on a normal conducting S-band (3000.24 MHz) linac fed from a thermionic gun. The machine will be shorter than the existing 2856 MHz linac thanks to the addition of SLED system that saves on RF power stations. One of the challenge for the supplier is to handle the knowledge and rebuttal of experts, hence the supplier cannot quite deliver a turn-key system. After the installation, the commissioning starts. First without beam when components are tested for operation. Some of the steps will require the host institutes to provide the adequate green light in terms of safety (i.e live work). This requires understanding and lining up of the supplier to the host institutes policies and the adequate explanation and support from the institute to the supplier, the misunderstanding can impact the entire "ready to operate" schedule. Beyond, the installation a complete ecosystem is perturbated. Science needs to take advantage of the downtime to ameliorate its services to the users. New techniques, new BL set-up, BL scientists publications, tackling issue discovered during runs (require Accelerator physicist time competition). A major downtime for an upgrade has to provide better performance - The machine alone is not enough and this require investment.

### **Location - Overall schedule - Planning and Staffing Requirements Pressure build-up / failure is not an option**

~4.5 Weeks



~6.5 Weeks

Phase	Start	Finish
Dismantling/CLS Service		
Installs	April 10, 2024	May 26, 2024
RI Installation and		
Testing	May 27, 2024	July 10, 2024
*Commissioning,		
Conditioning, and SAT	June 28, 2024	September 17, 2024
**Finalization and		
LINAC Handing Over	September 17, 2024	October 21, 2024
CLS Development Shifts		
Startup for Operations		
Shifts	October 21, 2024	November 5, 2024

~2.5 Weeks



Installat	tion	5 Comm	issioning
		5.1	Ontrol system commissioning and test
4.1	W Linac mechanical installation	5,1,1	Test control of each component
4.1.1	Waveguide holder installation (According to P167183)	5.1.2	Temperature tuning
4.1.2	Waveguide installation (According to P157099)	5.2	🕼 继 Component commissioning
4.1.3	Linac mechanical installation	5,2,1	Environmental conditions
		5.2.2	ACIS protection system
4.1.4	✤ Final alignment of the LINAC	5.2.3	Person safety
4.1.5	ull leak testing of the assembled Linac and the WG	5,2,4	Machine protection system
4,1,6	Itart pumping-down	5.2.5	🕼 Vacuum system
4.2	Ø Modulator system mechanical installation	5.2.6	Water system
		5.2.7	Magnets
4.2.1	Placement of the modulators	5.2.8	Timing system
4.2.2	Installation of the klystron	5.2.9	IF cables, directional couplers, and pickup
4.2.3	Oil filling     8	5.2.10	0 /
		5.2.11	
4.3	🕼 🦑 Water and pressurized air9	5.2.12	
4.3.1	₩Installation between CLS water header and components / manifolds	5,2,13	
4.3.2	Installation between RI-Manifold and Linac component, Lauda chiller circuit 9	5.2.14	
		5.3	High power RF operation
4.3.3	Sonnection to the CLS pressurized air system	5.3.1	RF conditioning (non-SLED mode)
4.4	🕼 🦑 Electrical installation	5,3,2	IF conditioning (SLED mode)
4.4.1	After the second	5.3.3	Igh power RF test
		5.3.4	Test of the tuning loop
	Second Se	5.4	Beam commissioning
4.4.3	American Section 4. Se	5.4.1	Repetition rate (MBM)

#### Bullet point Plan vs Procedural Plan

- We know what to do but not necessarily how it will be executed.
- Supplier responsible but work force is local problem handling & Interfaces
- (Nothing New Drawing on other experiences)

			Integration		*Commissioning, Conditioning	**Finalization and LINAC Handing		
Division	Resource Type	Dismantling	(CLS Service Installs)	RI Installation	and SAT	Over	Startup For Operations	
		April 10, 2024	to May 26, 2024	May 27, 2024 to July 10, 2024	June 28, 2024 to Sept. 17, 2024	Sept. 18, 2024 to Oct.21, 2024	Oct.21, 2024 to Nov. 5, 2024	
OTS	MTECH ETECH	*4 max hours OT/day/person	•4 max hours OT/day/person	•10 hours/day/person •Additional overtime as needed •Max 48 hours/week/person			•8 hours/day/person •On-call as needed	
		•4 max hours OT/day/person	•4 max hours OT/day/person	•10 hours/day/person •Additional overtime as needed •Max 48 hours/week/person			•8 hours/day/person •On-call as needed	

~11 Weeks

~6.5-10.5 Weeks

Engineering	EENG						
	MCAD	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person
	ECAD	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person
	HSE RAD	shifts flex start time *After hour coverage shift change	(short notice will need overtime for	•8 hours/day/person •After hour coverage shift change (short notice will need overtime for in scope)	•8 hours/day/person •After hour coverage shift change (short notice will need overtime for in scope)		•8 hours/day/person •After hour coverage shift change (short notice will need overtime for in scope)
) <sup>HSE</sup>	HSE OHS	•8 hours/day/person •After hour coverage shift change (short notice will need overtime for in scope)	tafter hour coverage Optrall or shift	•8 hours/day/person •After hour coverage On-call or shift change (short notice will need overtime for in scope)	•After hour coverage On-call or shift change	•8 hours/day/person •After hour coverage On-call or shift change (short notice will need overtime for in scope)	•8 hours/day/person •After hour coverage On-call or shift change (short notice will need overtime for in scope)
	HSE General	•On Call as needed	•On Call as needed	•On Call as needed	•On Call as needed	•On Call as needed	•On Call as needed
CID	Control Analyst	•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed		•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed
			•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed	-Shift coverage minimum 16 hours/day for 6	<ul> <li>Normal operations shift schedule</li> <li>Shift coverage minimum 16 hours/day for 6 days/wk</li> </ul>	-Normal operations shift schedule
AOD			•8 hours/day/person •Flex start time as needed	•8 hours/day/person •Flex start time as needed	<ul> <li>Normal operations shift schedule</li> </ul>	•Normal operations •Shift coverage 24/7	-Normal operations -Shift coverage 24/7
		<ul> <li>After hour coverage On-call or shift change</li> </ul>	shift change	•8 hours/day/person •After hour coverage On-call or shift change	•After hour coverage On-call or shift change	•After hour coverage On-call or shift change	•8 hours/day/person •After hour coverage On-call or shift change
	RF HV		•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed	•8 hours/day/person •On-call as needed
finance	BUYERS		•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person
Finance		•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person	•8 hours/day/person
CLS ACIS V&V	initiates Commissioning Ph fer accounted for in schedu			~			

• Efficiency gain - Start testing before end of installation Flexibility of Staffing (obvious but company culture)

Task Mode	Compl	Vorgangsname	Lead	Resource Names	Support	Start	Duration	Finis	n AD	x '24	May '24	Jun '24	Jul '24	Aug '24	Sep '24	Oct 24	Nov '24	Dec '2/
	0					00.07.00	(77.4.4.4	07.00	0108	15222	9061320	270310172	Jul '24 401 08 15 22	29 05 12 19 2	0209 16 23	30 07 14 21 2	804 11 18 25	020916
-4	53%	Design, Procurement, Manufacturing				08.07.22	477 dys?	07.06	24			Deeig	n, Procurem	ent, Manurak	xunng			
-4	4004	Transat				00 40 00	100.000	21.00										
-4	_	Transport				26.10.23	166 dys			_			Transport					L
	0%	Installation phase				15.04.24	143 dys										Installatio	n pnase
*	0%	Dismanting	CLS			15.04.24			24 5.04	-		Plamantling						
-3	0%	Installation (10h / day)				15.04.24			241.04	-				lation (10h	cay)			1
-3	0%	CLS water system (in dismantling phase)	CLS			15.04.24		26.04					lismantling p					1
-3	0%	Waveguide holder installation (in dismantiing phase)	CLS			15.04.24		26.04					allation (in di					
-3	<u>a</u> 0%	Linac mechanical and vacuum	RI	PBI	CLS 3 persons	27.05.24		14.06			27.05		ac mechanica		m			
-4	0%	Vacuum leak test (Linac)	CLS		PBI	17.06.24		21.06					acuum leak					1
-	L 0%	Linac water system, connection and pressure test	RI, CLS	PBI	CLS 2 persons (water experts)	24.06.24		28.06				24.06	Linac wate	-		1		1
-	å 0%	Waveguide system incl. water cooling, pressure test	RI	PBI	CLS 2 persons (incl. water expert)	03.06.24		28.06			03.0	C				ling, pressur	e test	1
-	0%	Leak test (Waveguide)	CLS		PBI	01.07.24		03.07	_			01.05	Leak test	Wavegulde	2			
-	0%	Laser tracker alignment	CLS		PBI	04.07.24		10.07	_			04.0	1 Laser	tracker align	ment			
-	0%	Mechanical Installation complete				10.07.24		10.07					Mech		ation comp	ete		
	0%	Cable tray installation (in dismantling phase)	CLS			15.04.24		26.04					(in dismantiir					1
-	L 0%	Modulator Installation Incl. klystron and oil	RI	FWI	CLS 2 persons	27.05.24	2 wks	07.06	24		27.05		ator Installati					
-	🊨 0%	Placement of cabinets (maybe in end of dismanting)	RI	FWI	CLS 2 persons	27.05.24		31.05			27.05	Placemer	nt of cabinets	(maybe in e	nd of dism	antling)		
-	0%	Electrical tests (conformance)	RI	FWI	CLS 1 person (electrician)	10.06.24	1 WK	14.06	24		1	DC Elec	ctrical tests (	onformance	•)			1
	0%	Mains connections	CLS		FWI	17.06.24	1 wk	21.06	24			17.0	Aains connec	tions				
	0%	Release of electrical installation (by local authority)	CLS		FWI	24.06.24	2 dys	25.06	24			24.06	Release of e	ectrical Inst	allation (by	local author	ty)	
	0%	Cabling between cabinets and Linac	CLS		FWI	03.06.24	4 wks	28.06	24		03.0	b <b></b>	Cabling be	ween cabin	ets and Lina	ac		1
	0%	Signal cable testing	RI	FWI	CLS 2 persons (electrician)	01.07.24	2 wks	12.07	24			01.05	Signa	cable testi	g			1
	0%	Control system standalone test	RI	MGR;TPF,DKR	CLS 1 person (IT expert)	08.07.24	0.67 wks	11.07	24			08	07) Contro	l system st	indalone te			
	0%	Component and control system comm. (1.5 shifts)			CLS 1 expert (further on demand)	15.07.24	19 dys	08.08	24			1	15.0 <b>1)</b>	Comp	onent and c	ontrol system	n comm. (1.	5 shifts)
	0%	Start vacuum pumps	RI	PBI	CLS 1 person (vacuum expert)	15.07.24	1 dy	15.07	24				15.07 -Star					
	0%	ACIS V+V (partially no Linac access)	CLS		MGR	16.07.24	8 dys	25.07	24				16.07	CIS V+V (p	artially no L	Inac access)		1
	2 0%	Test MPS	RI	FWI;DKR;TPF;MGF		26.07.24	4 dys	31.07	24				26.0	Test MPS				1
	L 0%	Test control of each component	RI	FWI;DKR;TPF;MGF		01.08.24	3 dys	05.08	24				01.08	-Test con	trol of each	component		
	0%	Electron source commissioning	RI	GBL		06.08.24	3 dys	08.08	24				06.0	Electro	n source co	mmissionin	9	1
	0%	LLRF system test	RI	MGR		15.07.24	4 dys	18.07	24				15.07 🔛 🖓	F system te	et			
	0%	Kystron test	RI	MGR;JHO;BKE		19.07.24	3 dys	23.07	24				19.07 K	ystron test				
	2 0%	Calibrations	RI	MGR;JHO;BKE	CLS 1 person (RF engineer)	26.07.24	3 dys	30.07	24					Calibration	8			
	. 0%	Low power SLED pulse	RI	MGR;JHO;BKE		31.07.24	5 dys	06.08	24				31.01	Low po	ver SLED p	ulse		
	0%	RF conditioning (2 shifts, better 24h/7d)				09.08.24	15 dys									tioning (2 shi	its, better 24	h/7d)
	0%	Week 1	RI	MGR;JHO;BKE	CLS 1 person (expert) / shift	09.08.24		15.08						eeW-00 80				
<b>-</b> +	0%	Week 2	RI	MGR	CLS 1 person (expert) / shift	16.08.24	1 wk	22.08	24					16.08900 W				
6+	0%	Week 3	RI	MGR	CLS 1 person (expert) / shift	23.08.24	1 wk	29.08	24					23.08	Week 3			
6+	0%	Beam commissioning (1.5 shifts)	RI	MGR;KDU	CLS 1 expert (further on demand)	30.08.24	3 wks	19.09	24					30.08		am commis	sioning (1.5	shifts)
6+	0%	SAT	RI	KDU	CLS project lead	20.09.24	1 wk	26.09	24						20.09	SAT		
<b>C</b> +	0%	Finalization of user documentation	RI			27.09.24		03.10								Finalizati	on of user d	ocument
2-	0%	Installation buller	-			04.10.24	19 dys											
2-	0%	Linac handing over				30.10.24		30.10	_								Linac han	
<b>C</b> +			-						-									
- ÷	0%	Agreed Milestones (Incl 6 weeks delay, agreed 2023-11)				01.03.24	177 dys										- Annora	Mileston

### **Ensuring User Operation**

#### **Competitive needs: Machine**

- Injector can pass the SAT, but it is not an absolute guarantee that beam goes to the rest of the chain
- Need time to pass beam from Injector to SR • Accelerator complex needs Maintenance. How to take advantage of 6 months downtime to enhance the overall facility - Manpower and \$
- **Competitive needs: Science** Ensuring return of the users
- Beam Lines need upgrade 6 month downtime competition for Manpower and \$
- BL scientists time for own Science write up publications - Career development

**Questions before & after:** 

• Risks well evaluated & appropriate mitigation plans in place? Holding Schedule

(Up-time, Beam Quality)?

• User operation: Will we

show improvements

• Training of Operators

Care of not losing their Qualifications during downtime

• Tackling the Photon Beam Quality issues Resources needed from Accelerator and from BL scientists

Acknowledgement: The author would like to thank his AOD colleagues that are part of the journey and provided along the way their criticisms.



## Particle Accelerator Upgrade - Removal and Installation, Trieste, Italy 2024