



# ELectrical Quality Assurance (ELQA) for the HL-LHC IT String

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ELQA team*

## **ELQA related presentations:**

- [ELQA scope of work and electrical design criteria](#) (Tuesday PM - WP3/WP7)
- [ELQA tests for the HL-LHC IT String](#) (Thursday AM - IT String - WP16/WP1/WP3/WP6A/WP7/WP9)
- [ELQA scope of work for SC links](#) (Thursday PM - WP6A/WP7)

# Outline

- ELQA in the IT String - objective
- Qualification „building blocks”
- Program for the IT String
- Manpower
- Summary

# ELQA in the IT String - objective

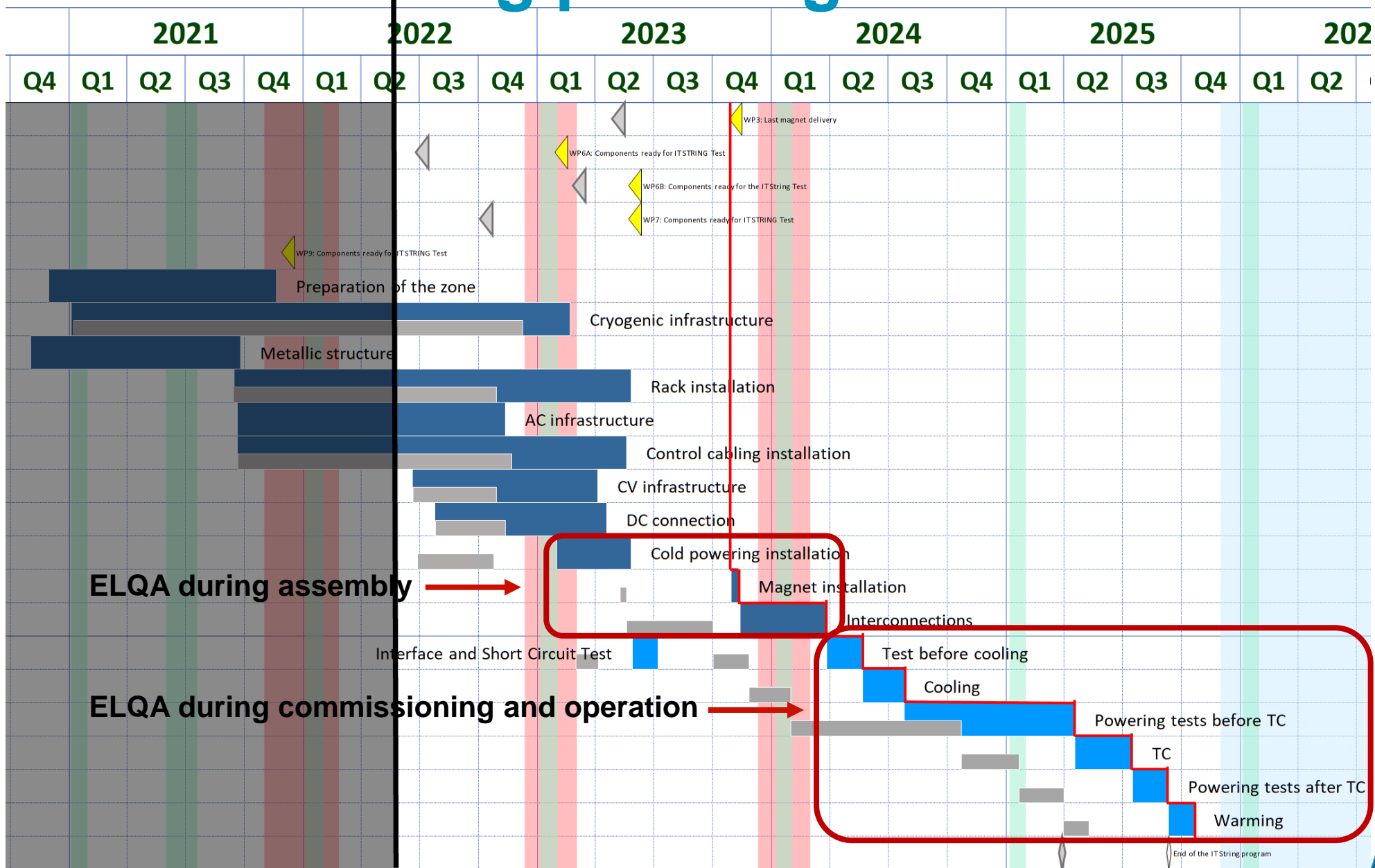
- Validate the superconducting circuits for cool-down and powering
- Acquire working experience on HL-LHC circuits
- Acquire reference values for complete HL-LHC circuits
- Validate ELQA test procedures, ELQA test equipment and software
- Ensure that the qualification is as tight as possible and that there is no negative impact on HL circuits
- The ELQA in the IT String should be as similar to the final ELQA in the tunnel as possible

# ELQA „building blocks”

- HVQ – High Voltage Qualification
- TFM – Transfer Function Measurement
- IRC – Instrumentation Resistance Check
- ICC – Instrumentation Configuration Check
- TDR – Time Domain Reflectometry
- COC – Continuity of Conductor check
- QHR – Quench Heater Resistance measurement
- DVC – Diode opening Voltage Check
- TSQ – Temperature Sensor Qualification

„Building block” tests are described in details in the document  
**[EDMS 2746933](#)**

# IT String planning



# ELQA during the IT String assembly

	SLC	MIC-W	IT-PAQ	ITIV	ITIC
HVQ	✓	✓	✓	✓	✓
TFM	✓	✓		✓	
IRC	✓	✓		✓	
ICC	✓	✓	✓	✓	
TDR	✓	✓			✓
COC	✓			✓	✓
QHR		✓			
DVC		✓			
TSQ	✓	✓			

HVQ – High Voltage Qualification

TFM – Transfer Function Measurement

IRC – Instrumentation Resistance Check

ICC – Instrumentation Configuration Check

TDR – Time Domain Reflectometry

COC – Continuity of Conductor check

QHR – Quench Heater Resistance measurement

DVC – Diode opening Voltage Check

TSQ – Temperature Sensor Qualification

SLC – Superconducting Link Check

MIC-W – Magnet Instrumentation Check

IT-PAQ – Inner Triplet Partial Assembly Qualification

ITIV – Inner Triplet Interconnection Verification

ITIC – Inner Triplet Instrumentation Check

# ELQA during the IT String commissioning

	TP4-A	MIC-W	TP4-B	TP4-C	TP4-D +MIC-D	MIC-C	TP4-E
	At warm	At warm	After flushing	During cool-down/ warm-up	At 80 K	At cold	At cold
HVQ		✓	✓	✓	optional	✓	✓
TFM	✓	✓			optional	✓	✓
IRC	✓	✓			optional	✓	✓
ICC	✓	✓			optional	✓	✓
TDR		✓			optional	✓	
QHR		✓			optional	✓	
DVC		✓				✓	
TSQ	✓	✓			optional	✓	✓

TP4-A – Test Procedure 4 type A

MIC-W – Magnet Instrumentation Check at warm

TP4-B – Test Procedure 4 type B

TP4-C – Test Procedure 4 type C

TP4-D – Test Procedure 4 type D

MIC-D – Magnet Instrumentation Check at 80 K

MIC-C – Magnet Instrumentation Check at cold

TP4-E – Test Procedure 4 type E

HVQ – High Voltage Qualification

TFM – Transfer Function Measurement

IRC – Instrumentation Resistance Check

ICC – Instrumentation Configuration Check

TDR – Time Domain Reflectometry

QHR – Quench Heater Resistance measurement

DVC – Diode opening Voltage Check

TSQ – Temperature Sensor Qualification



# ELQA during the IT String commissioning and operation

Qualification set	At warm	At warm after flushing	Cool-down 300 K to 80 K	At 80 K	Cool-down 80 K to 1.9 (4.5) K	At cold	At cold after powering	Warm-up	At warm	Cool-down	At cold	At cold after powering	Warm-up	At 80 K	Warm-up 80 K to 300 K	At warm
TP4-A	>								>							>
MIC-W		>							>							>
TP4-B		>							>							>
TP4-C			>		>			>		>			>		>	
TP4-D				>										>		
MIC-D				>										>		
MIC-C						>	>				>	>				
TP4-E						>	>				>	>				

# Manpower

- Particular attention to be put on verification of ELQA methods, procedures, hardware and software
- Manpower will be provided by TE-MPE-PE
- Support of ELQA experts from HNINP in key IT String time slots
  - Good experience from the collaboration from the past
  - Experts from HNINP have a detailed know-how of ELQA and superconducting magnet systems
  - Dedicated Addendum to existing Collaboration Agreement is being finalised



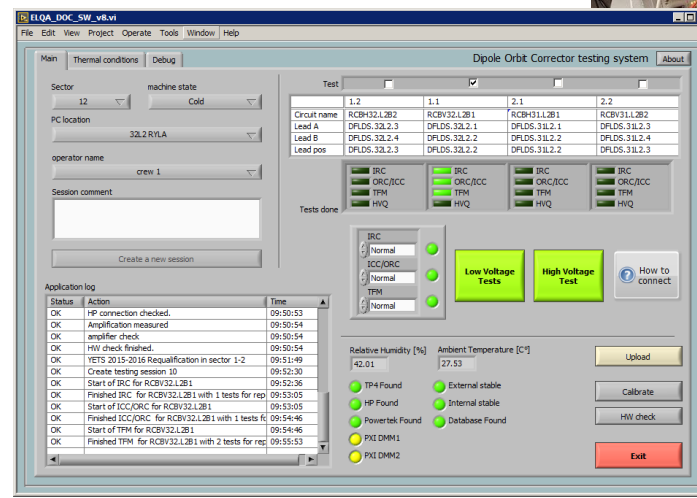
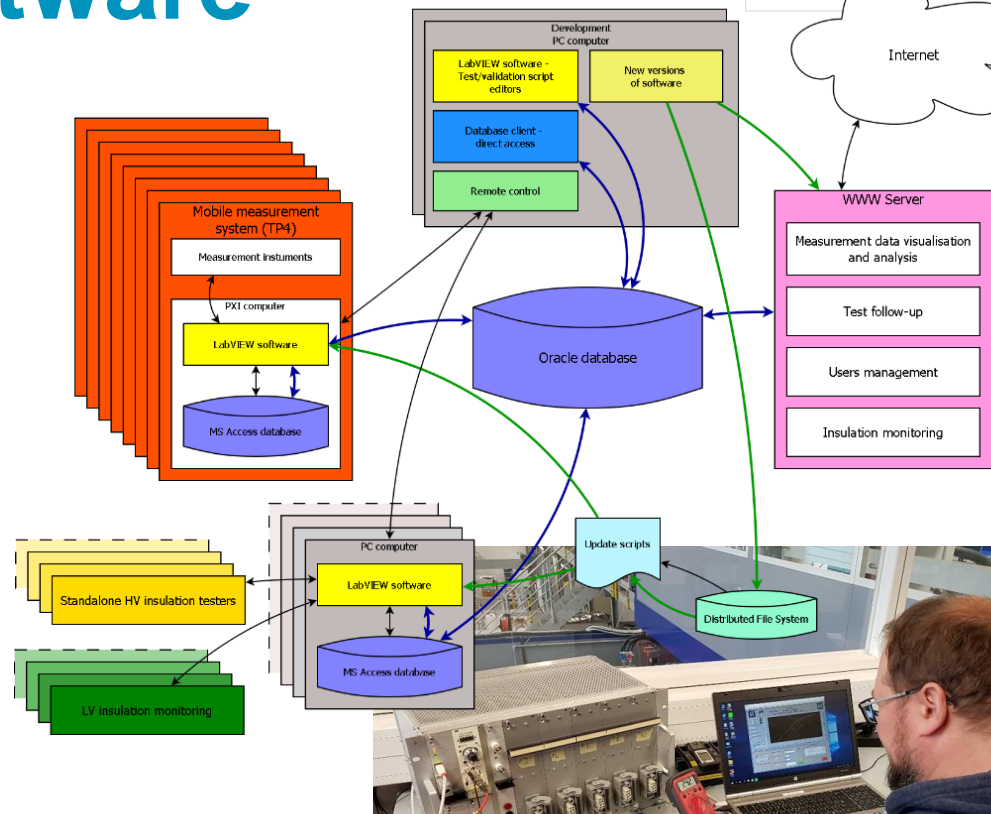
# Definition of HV test levels for ELQA during IT String assembly

- Discussions are ongoing on test levels of various components
- The annex table summarises the **approved** and **proposed** test levels for ELQA
- Magnet test levels are defined in the EDC

Equipment / component	SLC@warm, IT-PAQ, ITIV, ITIC		
	Test voltage at warm	Ramp rate	Duration
	V	V/s	s
MQXF	368	50	180
MBXF (D1)	260	50	180
MQSXF	200	50	180
MC(S,O,D,T)(S)XF	150	50	180
MCBXF	200	50	180
MBRD (D2) <i>(not in IT String)</i>	420	50	180
MCBRD <i>(not in IT String)</i>	330	50	180
18 kA return bus-bars	368	100	60
CP: 18 kA pass-through bus-bars	1000	100	60
Line N1/N2 2 kA bus-bars	1000	100	60
Line N1/N2 18 kA bus-bars	1000	100	60
DCM: 18 kA bus-bars	1000	100	60
DCM: 2 kA bus-bars	1000	100	60
SC link: 18 kA bus-bars	2300	100	60
SC link: 2 kA bus-bars	2300	100	60
Cold instrumentation wires	2300	100	60
Warm instrumentation wires	2000	100	60
Cryo heaters	500	100	30

# Hardware and software

- The ELQA hardware and software covers all needs for tests of regular LHC circuits and magnets
- Dedicated hardware for qualification of HL-LHC (and IT String) components is being developed
  - New configurations need to be tested
  - New tests will be added
  - Development started
  - Type tests performed
  - Collaboration with HNINP, addendum is being finalised





# Summary

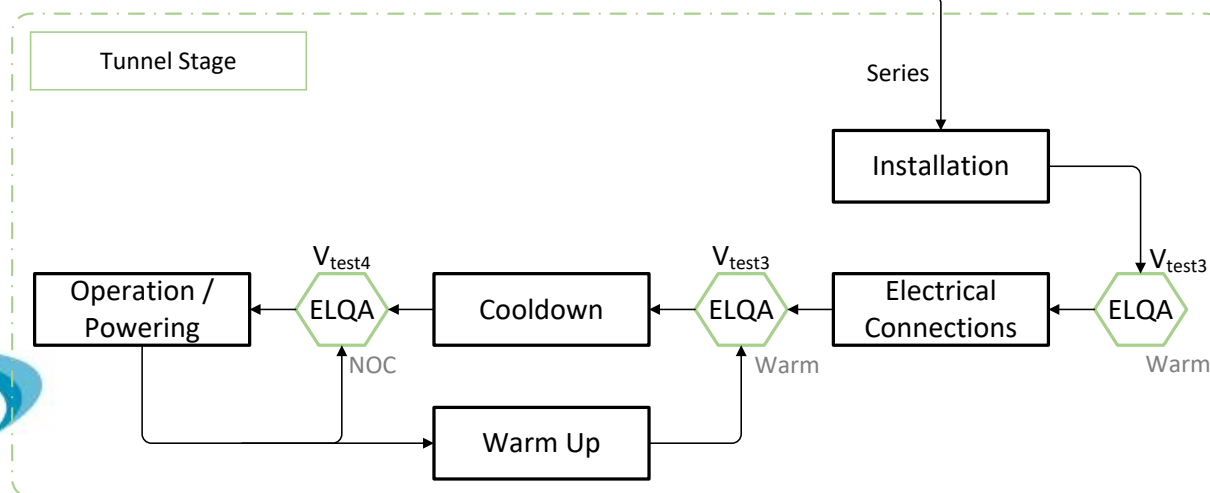
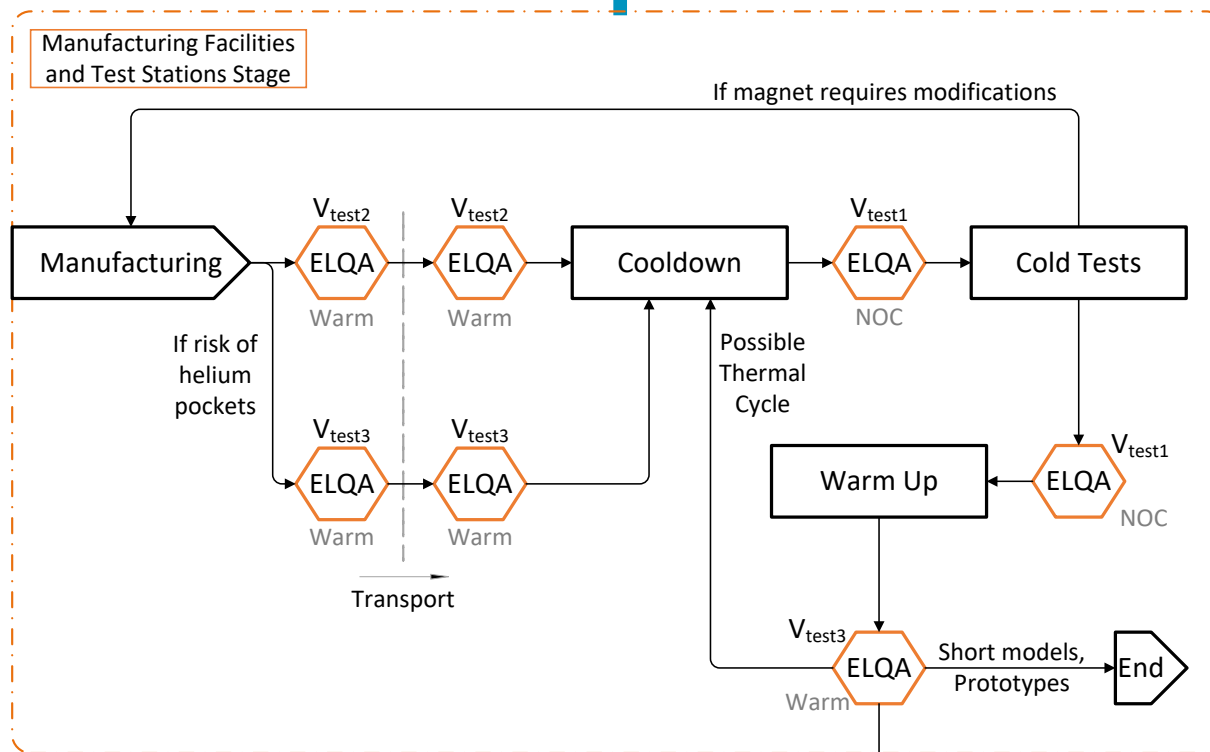
- ELQA on HL-LHC installations (including the IT string test) will be performed by the ELQA team (TE-MPE-PE)
  - Additional support of ELQA experts from HNINP in key time slots (agreement is being finalised)
- ELQA test program on the IT String is being finalised
  - Draft version is available: [EDMS 2746933](#)
  - Details of test voltages for certain components need to be finalised
- Detailed procedures for each qualification set and each component are being drafted
- Dedicated hardware for qualification of HL-LHC components in the IT String is being developed



Thank you for  
your attention!

# Annex slides

# Components' lifecycle



Following the Electrical Design Criteria documents the ELQA tests at an adapted level of voltage need to be performed at multiple stages of a component lifecycle

NOC – Nominal Operating Conditions