



# Magnets and Power Converters

**PRESENTED BY EMMANOUIL TRACHANAS-ACCELERATOR ENGINEER-LINAC GROUP  
DANA MACKENZIE- ELECTROMECHANICAL TECHNICIAN-POWER CONVERTERS GROUP**

**2025-02-04**

# Scope for SAR4

For each system, present:

Brief Scope description and status ✓

Brief status of system(s) ✓

Status of documentation (could refer to CIDL here)-**Documentation & CIDLs Released** ✓

Known issues deemed OK to proceed -**No Issues Detected.**

Are there any NCRs related to system(s)? -**No NCRs.**

Does the system have any SSCI2S (rad safety) function? -**All Magnets-Applicable to SAR4 and BoD** ✓

Applicable codes and compliance (e.g required periodic inspections) ✓

Describe briefly any tests needed with beam (and point to plan) -**No specific Tests\***

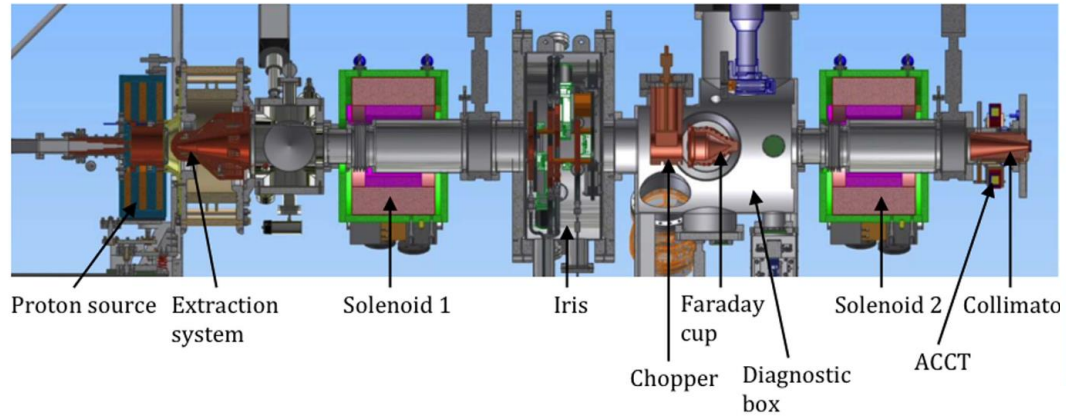
Have start up checklist been performed? Any issues found? -**In Progress**

Have all recommendations from previous reviews (not just TRR) been addressed? -**Completed.**

# Magnet Systems-NCL



ISRC-LEBT- 3x Solenoids, 2x Solenoids with Embedded Steerers

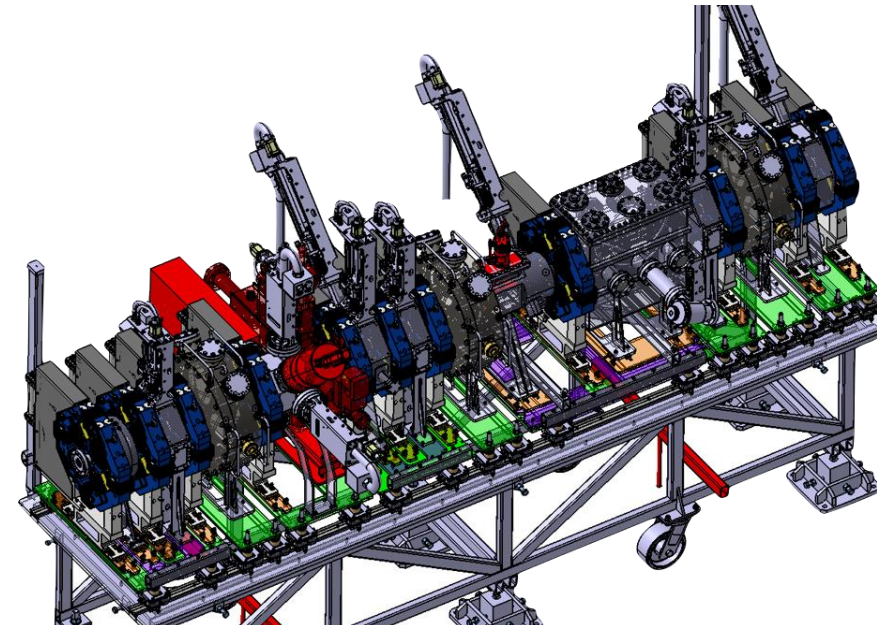
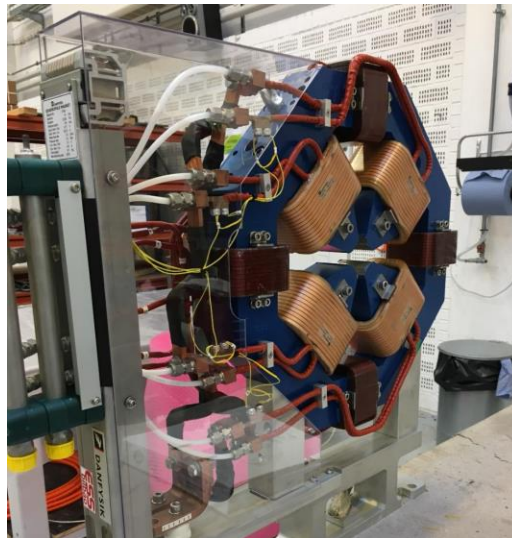
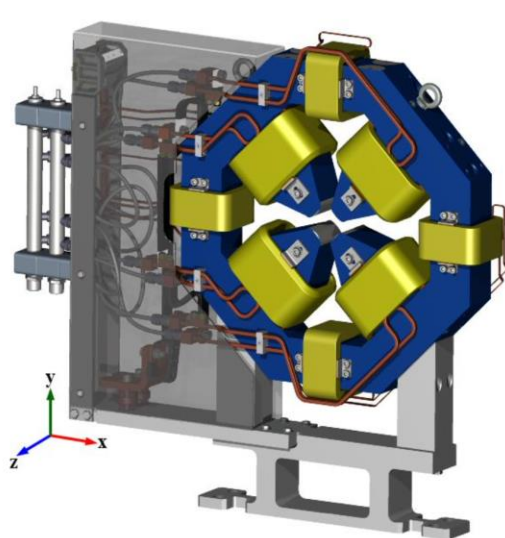


DTL- 89 PMQs and 30 Steerers



Tank	PMQs	Steerers
1	31	12
2	18	6
3	15	4
4	13	4
5	12	4

MEBT- 11 Quadrupoles with Embedded Steerers



Parameter	Value	Unit
Aperture diameter	41	mm
Total length (coil to coil)	90	mm
Yoke length	59	mm
Quadrupole coil current	250	A
Dipole coil current	8.5	A
Good field radius	15	mm
Quadrupole gradient	34.25	T / m
Integrated gradient	2.74	T
Dipole strength	20	G · m
Water temperature rise	11	°C
Pressure drop	2.4	bar

# Magnet Systems-SCL

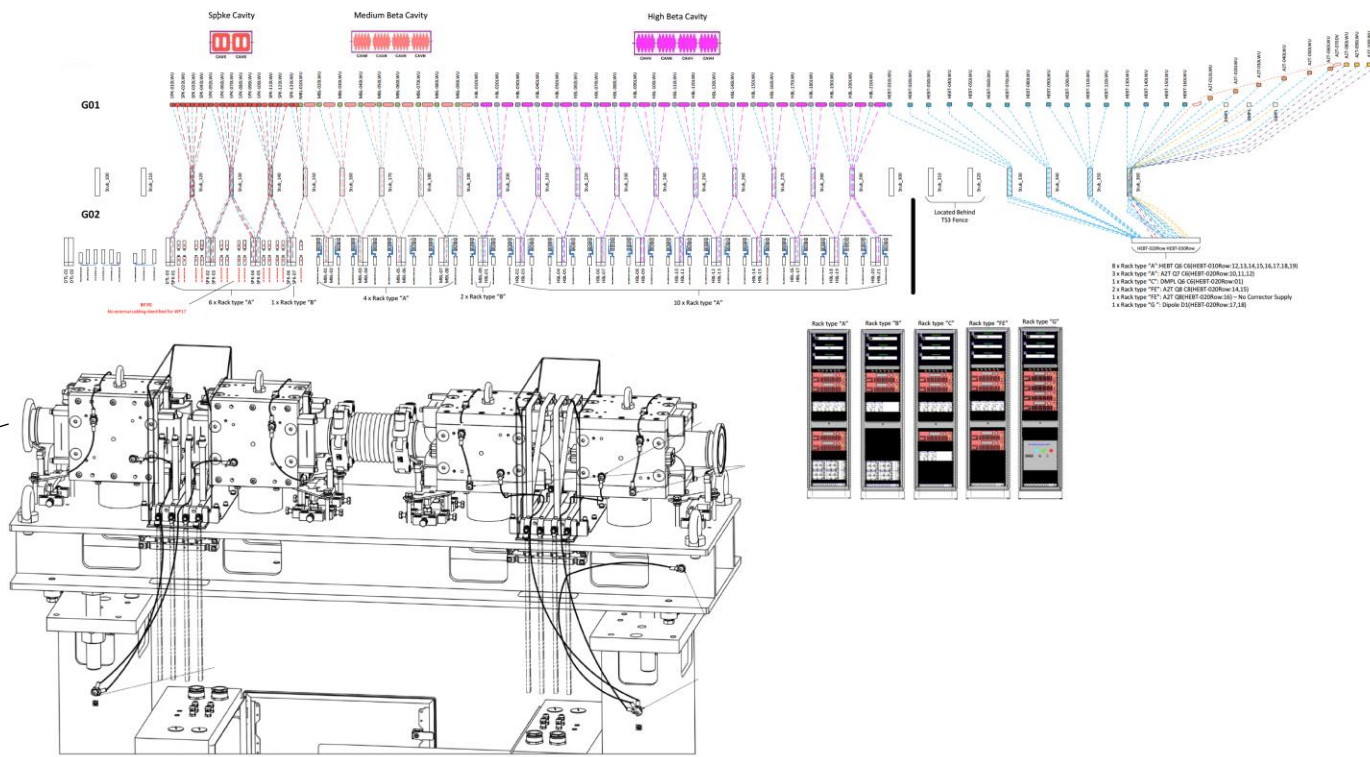
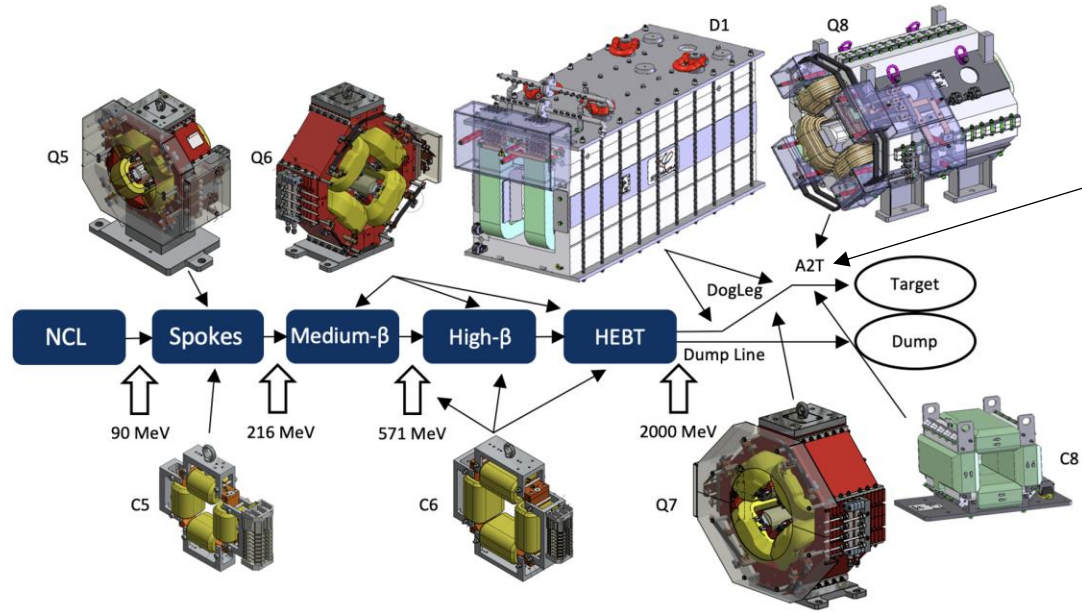
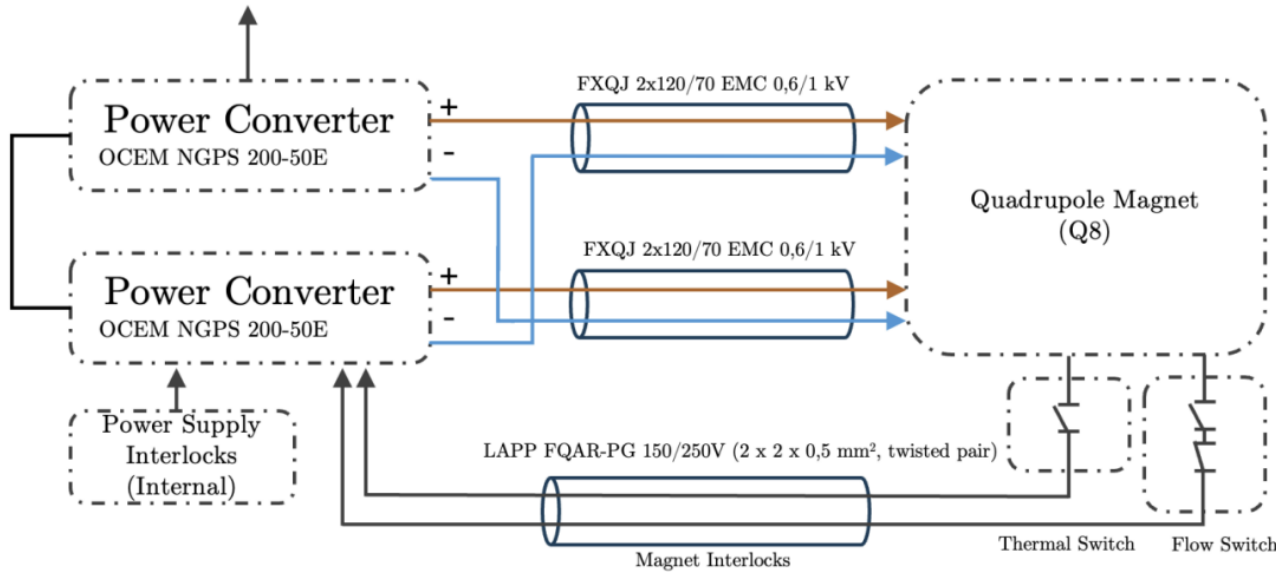
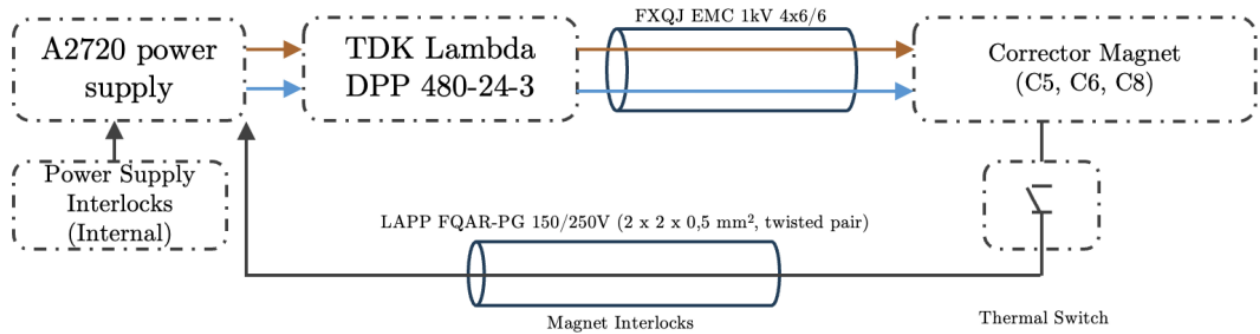


Table 1: Different Types of ESS Magnets, Quantities and Main Design Requirements

Parameter	Q5	Q6	Q7	Q8	C5	C6	C8	D1
Quantity	26	95	12	6	13	55	4	2
Aperture radius (mm)	34	56	56	137	68	112	127	N/A
Nominal Current (A)	148	173	179	400	16	16	17.3	400
Magnetic Length (mm)	200	277	337	800	146	221	466.3	1800
Good Field Region radius $r_0$ (mm)	22	22	35	45	22	35	42	H,V $\pm 35$
Maximum Integrated Gradient (T)	2.21	2.47	3.01	8.91	-	-	-	-
Nominal Integrated field (Tm)	-	-	-	-	$1.67 \times 10^{-3}$	$3.15 \times 10^{-3}$	$8.4 \times 10^{-3}$	0.648



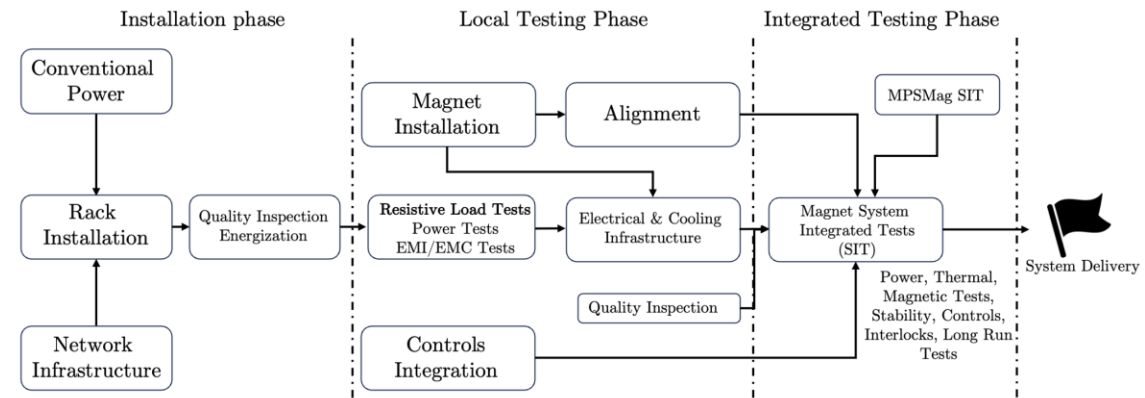
# System Architecture



**CAENels**  
Gear For Science



Product Overview



# Scope-NCL & Correctors & Raster Magnets

## SPK

Spk-010LWU:BMD-CX-010	=ESS.ACC.A03.A02.W02.MB01
Spk-020LWU:BMD-CX-010	=ESS.ACC.A03.A03.W02.MB01
Spk-030LWU:BMD-CX-010	=ESS.ACC.A03.A04.W02.MB01
Spk-040LWU:BMD-CX-010	=ESS.ACC.A03.A05.W02.MB01
Spk-050LWU:BMD-CX-010	=ESS.ACC.A03.A06.W02.MB01
Spk-060LWU:BMD-CX-010	=ESS.ACC.A03.A07.W02.MB01
Spk-070LWU:BMD-CX-010	=ESS.ACC.A03.A08.W02.MB01
Spk-080LWU:BMD-CX-010	=ESS.ACC.A03.A09.W02.MB01
Spk-090LWU:BMD-CX-010	=ESS.ACC.A03.A10.W02.MB01
Spk-100LWU:BMD-CX-010	=ESS.ACC.A03.A11.W02.MB01
Spk-110LWU:BMD-CX-010	=ESS.ACC.A03.A12.W02.MB01
Spk-120LWU:BMD-CX-010	=ESS.ACC.A03.A13.W02.MB01
Spk-130LWU:BMD-CX-010	=ESS.ACC.A03.A14.W02.MB01

## MBL

MBL-010LWU:BMD-CX-010	=ESS.ACC.A04.A02.W02.MB01
MBL-020LWU:BMD-CX-010	=ESS.ACC.A04.A03.W02.MB01
MBL-030LWU:BMD-CX-010	=ESS.ACC.A04.A04.W02.MB01
MBL-040LWU:BMD-CX-010	=ESS.ACC.A04.A05.W02.MB01
MBL-050LWU:BMD-CX-010	=ESS.ACC.A04.A06.W02.MB01
MBL-060LWU:BMD-CX-010	=ESS.ACC.A04.A07.W02.MB01
MBL-070LWU:BMD-CX-010	=ESS.ACC.A04.A08.W02.MB01
MBL-080LWU:BMD-CX-010	=ESS.ACC.A04.A09.W02.MB01
MBL-090LWU:BMD-CX-010	=ESS.ACC.A04.A10.W02.MB01

## HBL

HBL-010LWU:BMD-CX-010	=ESS.ACC.A05.A02.W02.MB01
HBL-020LWU:BMD-CX-010	=ESS.ACC.A05.A03.W02.MB01
HBL-030LWU:BMD-CX-010	=ESS.ACC.A05.A04.W02.MB01
HBL-040LWU:BMD-CX-010	=ESS.ACC.A05.A05.W02.MB01
HBL-050LWU:BMD-CX-010	=ESS.ACC.A05.A06.W02.MB01
HBL-060LWU:BMD-CX-010	=ESS.ACC.A05.A07.W02.MB01
HBL-070LWU:BMD-CX-010	=ESS.ACC.A05.A08.W02.MB01
HBL-080LWU:BMD-CX-010	=ESS.ACC.A05.A09.W02.MB01
HBL-090LWU:BMD-CX-010	=ESS.ACC.A05.A10.W02.MB01
HBL-100LWU:BMD-CX-010	=ESS.ACC.A05.A11.W02.MB01
HBL-110LWU:BMD-CX-010	=ESS.ACC.A05.A12.W02.MB01
HBL-120LWU:BMD-CX-010	=ESS.ACC.A05.A13.W02.MB01
HBL-130LWU:BMD-CX-010	=ESS.ACC.A05.A14.W02.MB01
HBL-140LWU:BMD-CX-010	=ESS.ACC.A05.A15.W02.MB01
HBL-150LWU:BMD-CX-010	=ESS.ACC.A05.A16.W02.MB01
HBL-160LWU:BMD-CX-010	=ESS.ACC.A05.A17.W02.MB01
HBL-170LWU:BMD-CX-010	=ESS.ACC.A05.A18.W02.MB01
HBL-180LWU:BMD-CX-010	=ESS.ACC.A05.A19.W02.MB01
HBL-190LWU:BMD-CX-010	=ESS.ACC.A05.A20.W02.MB01
HBL-200LWU:BMD-CX-010	=ESS.ACC.A05.A21.W02.MB01
HBL-210LWU:BMD-CX-010	=ESS.ACC.A05.A22.W02.MB01

## HEBT

HEBT-010LWU:BMD-CX-010	=ESS.ACC.W03.W02.W02.MB01
HEBT-020LWU:BMD-CX-010	=ESS.ACC.W03.W03.W02.MB01
HEBT-030LWU:BMD-CX-010	=ESS.ACC.W03.W04.W02.MB01
HEBT-040LWU:BMD-CX-010	=ESS.ACC.W03.W05.W02.MB01
HEBT-050LWU:BMD-CX-010	=ESS.ACC.W03.W06.W02.MB01
HEBT-060LWU:BMD-CX-010	=ESS.ACC.W03.W07.W02.MB01
HEBT-070LWU:BMD-CX-010	=ESS.ACC.W03.W08.W02.MB01
HEBT-080LWU:BMD-CX-010	=ESS.ACC.W03.W09.W02.MB01
HEBT-090LWU:BMD-CX-010	=ESS.ACC.W03.W10.W02.MB01
HEBT-100LWU:BMD-CX-010	=ESS.ACC.W03.W11.W02.MB01
HEBT-110LWU:BMD-CX-010	=ESS.ACC.W03.W12.W02.MB01
HEBT-120LWU:BMD-CX-010	=ESS.ACC.W03.W13.W02.MB01
HEBT-130LWU:BMD-CX-010	=ESS.ACC.W03.W14.W02.MB01
HEBT-140LWU:BMD-CX-010	=ESS.ACC.W03.W15.W02.MB01
HEBT-150LWU:BMD-CX-010	=ESS.ACC.W03.W16.W02.MB01
HEBT-160LWU:BMD-CX-010	=ESS.ACC.W03.W17.W02.MB01

## A2T/DumpLine/DogLeg

A2T-010LWU:BMD-CX-010	=ESS.ACC.W05.W02.W02.MB01
A2T-020LWU:BMD-CX-010	=ESS.ACC.W05.W03.W02.MB01
A2T-030LWU:BMD-CX-010	=ESS.ACC.W05.W04.W02.MB01
A2T-040LWU:BMD-CX-010	=ESS.ACC.W05.W05.W02.MB01
A2T-050LWU:BMD-CX-010	=ESS.ACC.W05.W06.W02.MB01
A2T-060LWU:BMD-CX-010	=ESS.ACC.W05.W07.W02.MB01
A2T-080DrfBMD-CX-010	=ESS.ACC.W05.W09.W02.MB01
A2T-100DrfBMD-CX-010	=ESS.ACC.W05.W11.W01.MB01
A2T-120DrfBMD-CX-010	=ESS.ACC.W05.W13.W01.MB01
A2T-130DrfBMD-CX-010	=ESS.ACC.W05.W14.W02.MB01
DmpL-010QC:BMD-CX-010	=ESS.ACC.W04.W02.MB01
DmpL-020QC:BMD-CX-010	=ESS.ACC.W04.W03.MB01
DmpL-030QC:BMD-CX-010	=ESS.ACC.W04.W04.MB01

## ISRC & LEBT

ISrc-CS:PwrC-PSCoil-01	=ESS.ACC.E01.E02.R01.TA01
ISrc-CS:PwrC-PSCoil-02	=ESS.ACC.E01.E02.R01.TA02
ISrc-CS:PwrC-PSCoil-03	=ESS.ACC.E01.E02.R01.TA03
LEBT-CS:BMD-Sol-01	=ESS.ACC.W01.W02.MB01
LEBT-CS:BMD-Sol-02	=ESS.ACC.W01.W02.MB02

## Raster Magnets

A2T-100RSM	=ESS.ACC.W05.R01.R01
A2T-110RSM	=ESS.ACC.W05.R01.R02

## MEBT

MEBT-010:BMD-QV-001	=ESS.ACC.W02.W01.R03.MB01
MEBT-010:BMD-CH-001	=ESS.ACC.W02.W01.R03.MB02
MEBT-010:BMD-CV-001	=ESS.ACC.W02.W01.R03.MB03
MEBT-010:BMD-QH-002	=ESS.ACC.W02.W01.R04.MB01
MEBT-010:BMD-CH-002	=ESS.ACC.W02.W01.R04.MB02
MEBT-010:BMD-CV-002	=ESS.ACC.W02.W01.R04.MB03
MEBT-010:BMD-QV-003	=ESS.ACC.W02.W01.R05.MB01
MEBT-010:BMD-CH-003	=ESS.ACC.W02.W01.R05.MB02
MEBT-010:BMD-CV-003	=ESS.ACC.W02.W01.R05.MB03
MEBT-010:BMD-QH-004	=ESS.ACC.W02.W01.R06.MB01
MEBT-010:BMD-CH-004	=ESS.ACC.W02.W01.R06.MB02
MEBT-010:BMD-CV-004	=ESS.ACC.W02.W01.R06.MB03
MEBT-010:BMD-QH-005	=ESS.ACC.W02.W01.R07.MB01
MEBT-010:BMD-CH-005	=ESS.ACC.W02.W01.R07.MB02
MEBT-010:BMD-CV-005	=ESS.ACC.W02.W01.R07.MB03
MEBT-010:BMD-QV-006	=ESS.ACC.W02.W01.R08.MB01
MEBT-010:BMD-CH-006	=ESS.ACC.W02.W01.R08.MB02
MEBT-010:BMD-CV-006	=ESS.ACC.W02.W01.R08.MB03
MEBT-010:BMD-QH-007	=ESS.ACC.W02.W01.R09.MB01
MEBT-010:BMD-CH-007	=ESS.ACC.W02.W01.R09.MB02
MEBT-010:BMD-CV-007	=ESS.ACC.W02.W01.R09.MB03
MEBT-010:BMD-QV-008	=ESS.ACC.W02.W01.R10.MB01
MEBT-010:BMD-CH-008	=ESS.ACC.W02.W01.R10.MB02
MEBT-010:BMD-CV-008	=ESS.ACC.W02.W01.R10.MB03
MEBT-010:BMD-QH-009	=ESS.ACC.W02.W01.R11.MB01
MEBT-010:BMD-CH-009	=ESS.ACC.W02.W01.R11.MB02
MEBT-010:BMD-CV-009	=ESS.ACC.W02.W01.R11.MB03
MEBT-010:BMD-QV-010	=ESS.ACC.W02.W01.R12.MB01
MEBT-010:BMD-CH-010	=ESS.ACC.W02.W01.R12.MB02
MEBT-010:BMD-CV-010	=ESS.ACC.W02.W01.R12.MB03
MEBT-010:BMD-QH-011	=ESS.ACC.W02.W01.R13.MB01
MEBT-010:BMD-CH-011	=ESS.ACC.W02.W01.R13.MB02
MEBT-010:BMD-CV-011	=ESS.ACC.W02.W01.R13.MB03

## DTL

Tank DTL-010	=ESS.ACC.A02.A01.R01
Tank DTL-020	=ESS.ACC.A02.A02.R01
Tank DTL-030	=ESS.ACC.A02.A03.R01
Tank DTL-040	=ESS.ACC.A02.A04.R01
Tank DTL-050	=ESS.ACC.A02.A04.R01



# System Status



- Integrated Tests Completed- **Full BoD/BoT Scope.**
- MPS Interface Tests Completed.
- Magnets Long Run Tests for 400 Hours.





# Requirements Documentation -Released



1. ESS-0036939-Magnet Functional Requirements for Types C5, C6, C8, Q5, Q6, Q7, Q8 and D1
2. ESS-0036940- Magnet Interface Requirements for Types C5, C6, C8, Q5, Q6, Q7, Q8 and D1

## Design Documentation -Released

1. C5 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.35584.50656>
2. C6 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.38656.59795>
3. C8 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.33280.23352>
4. Q5 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.64256.40621>
5. Q6 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.18944.21202>
6. Q7 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.10240.48462>
7. Q8 System Design, 3D Model, FAT Reports, Magnetic Measurements: <https://chess.esss.lu.se/enovia/link/21308.51166.33280.56467>
8. Raster Magnets Design Documentation- <https://chess.esss.lu.se/enovia/link/21308.51166.28673.2150>
9. MEBT Magnets Design Documentation-<https://chess.esss.lu.se/enovia/link/21308.51166.61184.36273>
10. ISRC & LEBT Magnets Design Documentation- <https://chess.esss.lu.se/enovia/link/21308.51166.9472.7818>
11. MEBT Magnets PC SAT: <https://chess.esss.lu.se/enovia/link/21308.51166.59648.36741>
12. DTL Steerers:<https://chess.esss.lu.se/enovia/link/21308.51166.21504.51905>
13. DTL PMQs: <https://chess.esss.lu.se/enovia/link/21308.51166.11776.22108>

# SAT & Installation & Energisation Documentation (2/2)-SCL



## **LWU Vacuum Acceptance Documentation (Vacuum Group):**

Vacuum acceptance tests folder: <https://chess.esss.lu.se/enovia/link/21308.51166.10752.15785>

ESS-2069339- Guideline for Acceptance Tests of the Particle Free Linac Warm Units

Confluence page: <https://confluence.esss.lu.se/pages/viewpage.action?pageId=64914873>

## **Magnet Systems Acceptance & Installation Documentation (Linac Group)**

ESS-4239660-Receiving Inspection Report LWU Magnets- **Released**

ESS-3062528-Electrical inspection LWU magnets- Delivery inspection of LWU magnets at RATS and Tunnel- **Released**

ESS-5446025-SPK Magnets Electrical Quality Inspection-Final inspection before integrated testing. - **Released**

ESS-5510171- Electrical inspection MBL LWU magnets in G01. - **Released**

ESS-5402205-Electrical inspection Magnets HBL - **Released**

ESS-4970029- Inspection of magnets HEBT-030-LWU and HEBT-040-LWU. - **Released**

ESS-5064501- Electrical installation inspection of HEBT LWU magnets in G01 prior to energization for testing. - **Released**

ESS-5165562- Electrical inspection of Magnets in Dumpline and A2T - **Released**

Electrical interface Schematics: <https://chess.esss.lu.se/enovia/link/21308.51166.64512.28648>- **Released**

## **Power Converters Group Documentation:**

Energisation Requests: <https://chess.esss.lu.se/enovia/link/21308.51166.56064.25116> - **Released**

Rack circuit diagrams: <https://chess.esss.lu.se/enovia/link/21308.51166.7936.43208> -**Released**- Rack Types

Connection diagrams: <https://chess.esss.lu.se/enovia/link/21308.51166.6144.23552> -**Released**

SAT Acceptance reports: <https://chess.esss.lu.se/enovia/link/21308.51166.65025.928>-**Released**

Rack Self Inspection: <https://chess.esss.lu.se/enovia/link/21308.51166.30464.60533> - **Released**

# Test Plans & Maintenance Manuals

## NCL:

ESS-1093283-ESS-Bilbao - Operation and service manual ESS MEBT Quadrupoles – Released

ESS-3069799-MEBT Magnets Testing plan and Report – Released

ESS-3077645-MEBT Verification and Validation Plan – Released

ESS-4867732-DTL Verification and Validation (V&V) plan – Released

ESS-3148851-Sorensen SGA 30X501D-2GAA LEBT Solenoid Test Procedure– Released

ESS-3148850-Ion Source Solenoid Coils Test Procedure and Report– Released

ESS-3148853-FAST PS 20-20-400 LEBT Steerer Test Procedure– Released

## Local Testing Phase (SCL):

ESS-4164904-MPC Routine Test Template – Released

Test Reports: <https://chess.esss.lu.se/enovia/link/21308.51166.13312.34632>

ESS-4818003-Rack Type Test protocol– Released

Test Reports: <https://chess.esss.lu.se/enovia/link/21308.51166.13312.34632>

## Integrated Testing Phase (SCL)

ESS-4585532-Raster Magnets Test Plan and Report– Released\*

ESS-5507926-SPK LWUs Magnet Systems (Q5,C5) Test Report– Released

ESS-5507961-MBL LWUs Magnet Systems (Q6,C6) Test Report– Released

ESS-5507962-HBL LWUs Magnet Systems (Q6,C6) Test Report– Released

ESS-5507958-HEBT LWUs Magnet Systems (Q6,C6) Test Report– Released

ESS-5507966-DumpLine DogLeg A2T- LWUs Magnet Systems Test Report– Released

ESS-5584247-Dipole Magnet Systems (D1) Test Report– Released

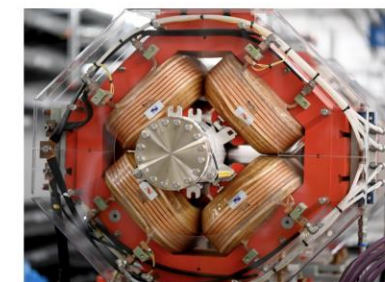
ESS-5421600-Quadrupole, Corrector and Dipole Magnets Operation & Maintenance Manual– Released

ESS-XXXXXX-Raster Magnet Maintenance Manual-In Progress



Document Type: Manual  
 Document Number: ESS-5421600  
 Date: Dec 19, 2024  
 Revision: 1  
 State: Released  
 Confidentiality Level: Internal  
 Page: 1 (17)

Quadrupole, Corrector and Dipole Magnets  
 Operation & Maintenance Manual



Document Type: Test Plan  
 Document Number: ESS-4818003  
 Date: Apr 28, 2023  
 Revision: 1  
 State: Released  
 Confidentiality Level: Internal  
 Page: 1 (12)

MAGNET SYSTEMS TEST PLAN AND REPORT

Q5, Q6, Q7, Q8 Quadrupole Magnets

C5, C6, C8 Corrector Magnets

D1 Dipole Magnets \* (Will be added in rev. 2.0)

	Name	Role/Title
Owner	Emmanouil Trachanas	Accelerator Engineer FEM Section
Reviewers	Dana McKenzie	Electromechanical Technician, Power Converters Group
Approvers	Bryan Jones	Section Leader FEM Section

	Name	Role/Title
Owner	Emmanouil Trachanas	Accelerator Engineer – Linac Group
Reviewer	Dana McKenzie	Electromechanical Technician
Approver	Håkan Danared	Linac Group Leader



Thank you !