HEC WHEEL ASSEMBLY AND INSTALLATION
CABLING AND ELECTRICAL TESTS

Action	Position	Means	Team	Time
Loop 1: Preparation of individual modules				
Work outside cleanroom:				1 d total
Module N moved from LOST to SHUN	LOST /SHUN	Crane	Hall T	inclusive
Visual inspection of box **If box is damaged, move module to be repaired.** **Take next equivalent module.**	SHUN		HEC MT	inclusive
Open box	SHUN		HEC MT	inclusive
Visual inspection of module covers (plastic) **If cover is damaged, move module to be repaired.** **Take next equivalent module.**	SHUN		HEC MT	inclusive
Remove outer cover	SHUN		HEC MT	inclusive
Mechanical work inside single module cleanroom:				0.5 d
Move module into SMCA, place onto stones, backside accessible	SHUN / SMCA	Crane	Hall T	inclusive
Remove inner plastic cover	SMCA		HEC MT	inclusive
Visual inspection of module **If module is damaged, move module to be repaired.** **Take next equivalent module.**	SMCA		HEC MT	inclusive
Fasten tie rods with proper torque	SMCA		HEC MT	inclusive
Place HV shortening boards on module flat side	SMCA		HEC ET	0.5 d
HV Test 1.5 kV **If HV test fails, move module to be repaired.** **Take next equivalent module.**	SMCA	HV test system	HEC ET	inclusive
Install PSB boards on module outer side	SMCA		HEC ET	0.5 d

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Action	**Position**	**Means**	**Team**	**Time**
Connect signal cables to PSB output connectors, place rolled cables on backside of module	SMCA		HEC ET	inclusive
Connect LV cables to PSB LV connectors	SMCA		HEC ET	inclusive
Place rolled cables on backside of module	SMCA		HEC ET	inclusive
Fix LV connectors near outside of module	SMCA		HEC ET	inclusive
Mount fixation cover over signal and LV cables on backside of module N	SMCA		HEC ET	inclusive
Connect calibration test cables to calibration distribution board.	SMCA			1 d
Signal read-out test with calib.pulsing **If test fails, remove module for repair.** **Take next equivalent module.**	SMCA	Signal test system	HEC ET	inclusive
Mount fixation cover over signal and LV cables on backside of module N	SMCA		HEC ET	inclusive
Mount PSB protection cover (not modules close to rails)	SMCA		HEC ET	inclusive
If N is module with difficult access, connect HV test cable to HV distribution board	SMCA			inclusive
Declare module N ready for assembly			HEC ET Chief	Milestone
Move module N from SMCA to WHAS	SMCA / WHAS		HEC MT	?
If module N not.last, continue Loop 1				

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Action	Position	Means	Team	Time
Loop 2: Wheel assembly				
Mount module N in wheel	WHAS		HEC MT	?
Connect LV to module N-1	WHAS		HEC ET	0.25 d
Connect HV to HV distribution board of module N-1	WHAS		HEC ET	inclusive
HV Test 1.5 kV **If HV test fails, remove module for repair.**	WHAS	HV Test system	HEC ET	inclusive
Declare wheel ready to accept next module	WHAS		HEC ET Chief	Milestone
If module.N not.last, continue Loop 2	WHAS			
Finalize wheel assembly	WHAS		HEC MT	?
Remove PSB protection covers	WHAS		HEC ET	0.5 d
Declare wheel ready for installation	WHAS		HEC MT Chief	Milestone
Move wheel with shipping frames and assembly frame to rotator	WHAS / ROTA	Rotator	HEC MT	?
Loosen centering dowels and screws between shipping frames and modules	ROTA	Rotator	HEC MT	?
Rotate wheel to vertical position	ROTA	Rotator	HEC MT	?
Move T6 to rotator	T6	Air cushion	LARG IT	?
Position wheel on T6	T6	T6	LARG IT	?
Mount scaffolding for access to backside of wheel on T6	T6	Scaffolding	LARG IT	1 d

Action	Position	Means	Team	Time
Wheel HEC1				
Loop 3: HEC1 HV test of vertical wheel				5 d total
Connect LV test cables to LV connectors of module N	T6		HEC ET	inclusive
Connect HV test cables to HV distribution board of module N	T6		HEC ET	inclusive
HV Test 1.5 kV **If HV test fails, check accessible HV connections.**	T6	HV test system	HEC ET	inclusive
If module.group N not last, continue Loop 3				
Declare wheel electrically ready for insertion into cryostat			HEC ET Chief	Milestone
Finalize wheel for insertion into cryostat	T6		HEC MT	?
Declare wheel ready for insertion into cryostat			HEC MT Chief	Milestone
Remove scaffolding for access to backside of wheel	T6	Scaffolding	LARG IT	1 d
Insert wheel HEC1 into cryostat	T6 / CRH1		LARG IT	?
Mount scaffolding for access to backside of wheel HEC1 inside cryostat	CRH1		LARG IT	1 d
Mount scaffolding for access to HEC1 quad cables	CRYB		LARG IT	1 d

Action	Position	Means	Team	Time
Loop 4: HEC1 Quadrant cabling				10 d total
Route **signal** cables from module N to quad position	CRH1		HEC ET	inclusive
Route cables through cable tray	CRH1 / CRH2		HEC ET	inclusive
Fix cables temporarily at front of cryostat	CRH2		HEC ET	inclusive
Route **LV** cables from module to quad position	CRH1		HEC ET	inclusive
Route cables through cable tray	CRH1 / CRH2		HEC ET	inclusive
Fix cables temporarily at front of cryostat	CRH2		HEC ET	inclusive
Connect **calibration** quad cables to calibration distribution board on backside of module N	CRH1		HEC ET	inclusive
Route **calibration** quad cables from module to quad position	CRH1		HEC ET	inclusive
Route cables through cable tray	CRH1 / CRH2		HEC ET	inclusive
Fix cables temporarily at front of cryostat	CRH2		HEC ET	inclusive
Connect **HV** quad cables to HV distribution board on backside of module N	CRH1		HEC ET	inclusive
Route **HV** cables from module to HV cable tray position	CRH1		HEC ET	inclusive
Route cables through HV cable tray	CRH1 / CRH2		HEC ET	inclusive
Fix cables temporarily at front of cryostat	CRH2		HEC ET	inclusive
If module N not last, continue Loop 4				

Action	Position	Means	Team	Time
Loop 5: HEC1 Wheel acceptance tests				5 d total
Connect LV, calibration and signal read-out system to HEC1 quadrant cables		Signal test system		inclusive
Signal read-out test with calibration pulsing **If test fails, check quadrant cabling.**	CRYB		HEC ET	inclusive
Connect HV test system for module group N	CRYB		HEC ET	inclusive
HV Test 1.5 kV **If HV test fails, check accessible HV connections.**	CRYB	HV test system	HEC ET	inclusive
If module group N is not last, continue Loop 5				
Mount protecting cover over backside of HEC1	CRH1		HEC ET	1 d
Mount covers of cable trays	CRH1 / CRYB		HEC ET	inclusive
Declare HEC1 ready for insertion of HEC2			HEC ET Chief	Milestone
Remove scaffolding for access to HEC1 quad cables	CRYB		LARG IT	1 d
Remove cryostat scaffolding for access to backside of wheel	CRH1		LARG IT	1 d

Action	Position	Means	Team	Time
Wheel HEC2				
Loop 6: HEC2 Quadrant cabling				10 d total
Remove cable protection on backside of modules N and N+1	T6		HEC ET	inclusive
Route **signal** cables of modules N and N+1 to azimuthal position on flat side of modules	T6		HEC ET	inclusive
Route **LV** cables of modules N and N+1 to azimuthal position on flat side of modules	T6		HEC ET	inclusive
Connect **calibration** quad cables to calibration distribution board on modules N and N+1	T6		HEC ET	inclusive
Route **calibration** quad cables from calibration distribution boards to azimuthal position on flat side of modules	T6		HEC ET	inclusive
Connect **HV** quad cables to HV distribution boards of modules N and N+1	T6		HEC ET	inclusive
Route **HV** quad cables from HV distribution boards to azimuthal position on flat side of modules	T6		HEC ET	inclusive
Mount protecting covers over backsides of modules N and N+1	T6		HEC ET	inclusive
Mount patch panel support structure of modules N and N+1	T6		HEC ET	inclusive
Mount **signal** patch panels on support structure	T6		HEC ET	inclusive
Mount **LV** patch panels on support structure	T6		HEC ET	inclusive
Mount **calibration** patch panels on support structure	T6		HEC ET	inclusive
Route **signal** cables and connect to signal PPs	T6		HEC ET	inclusive

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Action	**Position**	**Means**	**Team**	**Time**
Route **LV** cables and connect to LV PPs	T6		HEC ET	inclusive
Route **calibration** cables and connect to calibration PPs	T6		HEC ET	inclusive
Mount **HV**patch panels on tie rods	T6		HEC ET	inclusive
Route **HV** cables and connect to HV PPs	T6		HEC ET	inclusive
If module N+1 not last, continue loop 6				
Loop 7: HEC2 Wheel acceptance tests				5 d total
Connect LV, calibration and signal read-out system to HEC1 quadrant cables		Signal test system		inclusive
Signal read-out test with calibration pulsing **If test fails, check quadrant cabling.**	CRYB		HEC ET	inclusive
Connect HV test system for module group N	CRYB		HEC ET	inclusive
HV Test 1.5 kV **If HV test fails, check accessible HV connections.**	CRYB	HV test system	HEC ET	inclusive
If module group N is not last, continue Loop 7				
Declare HEC2 electrically ready for insertion into cryostat			HEC ET Chief	Milestone
Finalize HEC2 for insertion into cryostat	T6		HEC MT	?
Declare HEC2 ready for insertion into cryostat			HEC MT Chief	Milestone
Remove scaffolding for access to backside of wheel	T6		LARG IT	1 d
Insert wheel HEC2 into cryostat	T6 / CRH2		LARG IT	?

Action	Position	Means	Team	Time
Mount scaffolding for access to backside of wheel HEC2 inside cryostat	CRH2		LARG IT	1 d
Loop 8: HEC1 Quadrant cabling, finalization				5 d total
Route **signal** cables of quad N from signal cable trays to signal patch panels	CRH2		HEC ET	inclusive
Route **LV** cables of quad N from signal cable trays to LV patch panels	CRH2		HEC ET	inclusive
Route **calibration** cables of quad N from cable tray to calibration patch panels	CRH2		HEC ET	inclusive
Route **HV** cables from HV cable tray to HV patch panels of quadrant N	CRH2		HEC ET	inclusive
If quadrant N is not last, continue Loop 8				
Loop 9: Combined acceptance test HEC1 and HEC2				5 d total
Connect LV, calibration and signal read-out system to HEC1 quadrant cables of module group N	CRH2	Signal test system	HEC ET	inclusive
Signal read-out test with calibration pulsing **If test fails, check quadrant cabling.**	CRH2		HEC ET	inclusive
Connect HV test system for module group N	CRH2		HEC ET	inclusive
HV Test 1.5 kV **If HV test fails, check accessible HV connections.**	CRH2	HV test system	HEC ET	inclusive
If module group N is not last, continue Loop 9				

Action	Position	Means	Team	Time
Loop 10: Pigtail connection				5 d total
Route **signal** pigtails of signal feedthrough N and connect to signal patch panels of quadrant N	CRYB / CRH2		HEC ET	inclusive
Route **LV**pigtails of signal feedthrough N and connect to LV patch panels of quadrant N	CRYB / CRH2		HEC ET	inclusive
Route **calibration** pigtails of signal feedthrough N and connect to calibration patch panels of quadrant N	CRYB / CRH2		HEC ET	inclusive
Route **HV** pigtails of HV feedthrough and connect to HV patch panels of quadrant N	CRYB / CRH2		HEC ET	inclusive
If quadrant N is not last, continue Loop 10				
Mount protecting cover over patch panels on HEC2 and over pigtails	CRH2		HEC ET	1 d
Declare HEC1 and HEC2 ready for combined electronics and HV test through feedthroughs			HEC ET Chief	Milestone
Overall read-out test through feedthroughs and pedestals	Cryostat circumference	?????	?????	?????
Overall HV test through HV feedthrough	Cryostat circumference	?????	?????	?????

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Abbreviations used:

Teams

HEC ET	HEC Electrical team (Chief + three, typically each task is done by two people)
HEC MT	HEC Mechanics team (Chief + three)
LARG IT	LARG Integration team
HALL T	Hall team (crane drivers etc)

Positions

LOST	Area for ong term storage of modules
SHUN	Area for short term storage and unpacking of modules. Just outside of HEC cleanrooms in B180
SMCA	Single module check area, cleanroom
WHAS	Wheel assembly area
ROTA	Rotator
T6	Insertion cradle in front of cryostat
CRH1	Position of wheel HEC1 in cryostat
CRH2	Position of wheel HEC2 in cryostat
CRYB	Position at cryostat circumference near feedthroughs