MBH
Quench and degradation locations.

Gerard Willering and Ruben Keijzer
TE-MSC-TF

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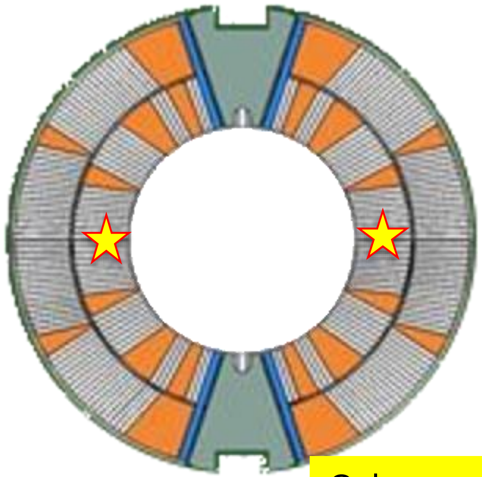
Degradation issues MBH models, proto and series

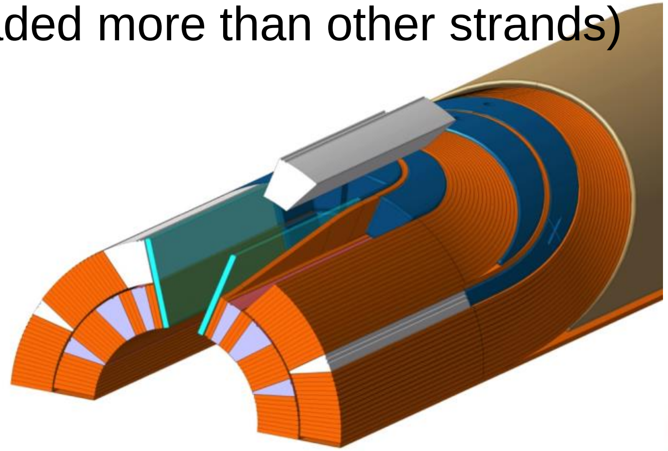
Midplane, straigth segment issues
- Problem for many model magnets
- Inner layer Midplane
- Straight part
- "Homogeneous" cable degradation
- Solved !?!?!?
- 2D problem?? Only cross-section??



Only seen in model magnet (but hybrid at 4.5 K confirmed that the upper limit at 12.7 kA was in the midplane I/I_{ss} = 94 %).

Head/pole turn issues
- 2 times in model magnets, 5 times in long magnets
- Head or transition region of the magnet, possibly pole turns inner layer.
- In 3 cases after thermal cycle connection side
- "non-Homogeneous" cable degradation (one or more strands degraded more than other strands)

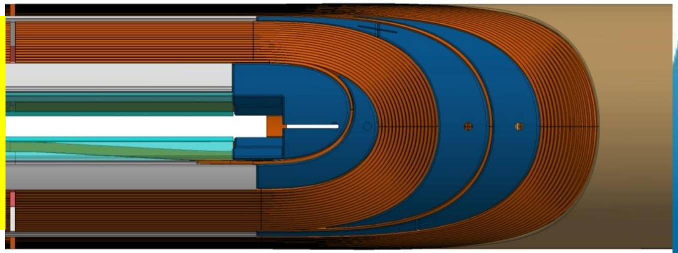
- Un-solved
- 3D problem.



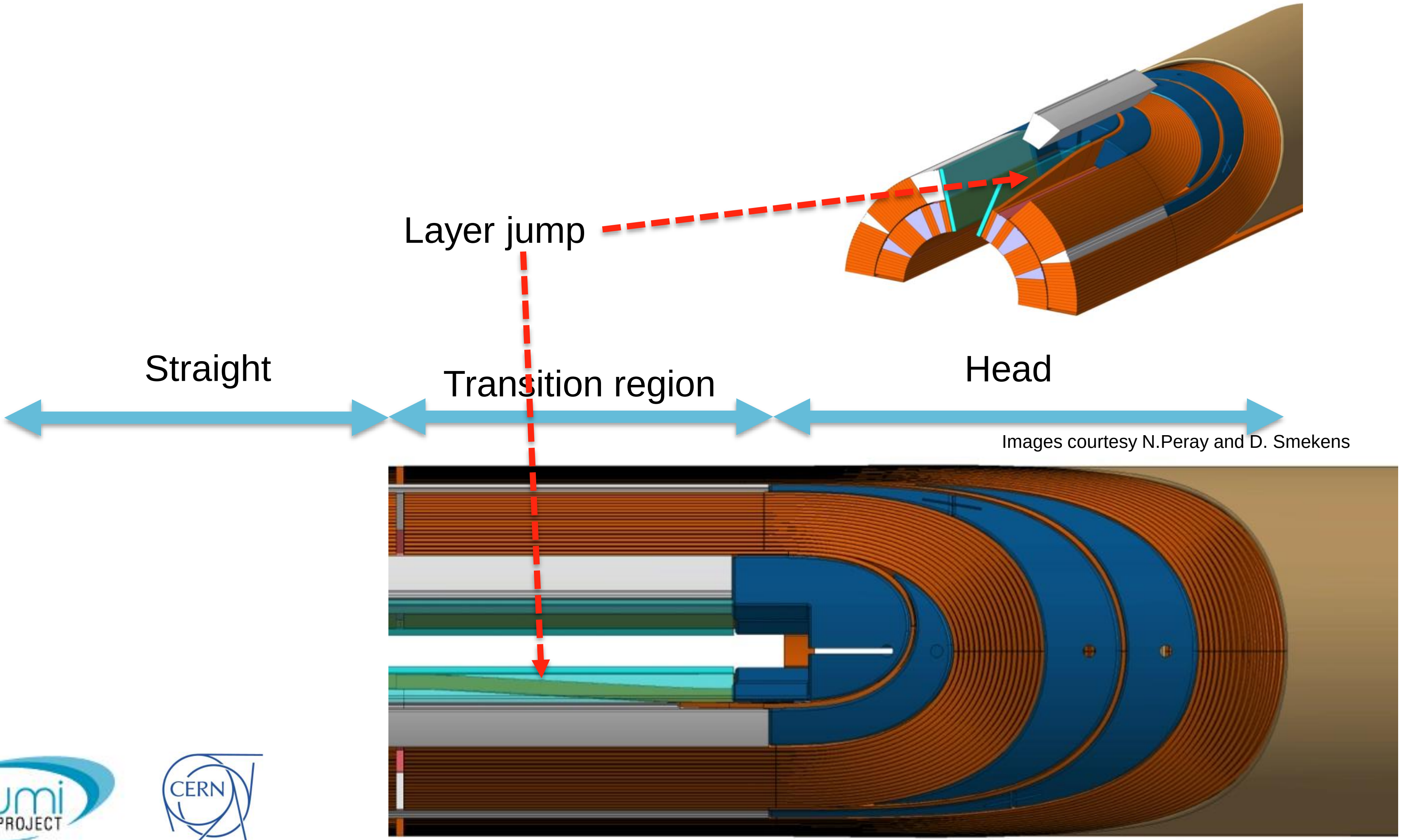
Images courtesy N.Peray and D. Smekens

In two model coils there was also a pole turn/layer jump issue.

In these slide I do not look at the mid-plane issues.

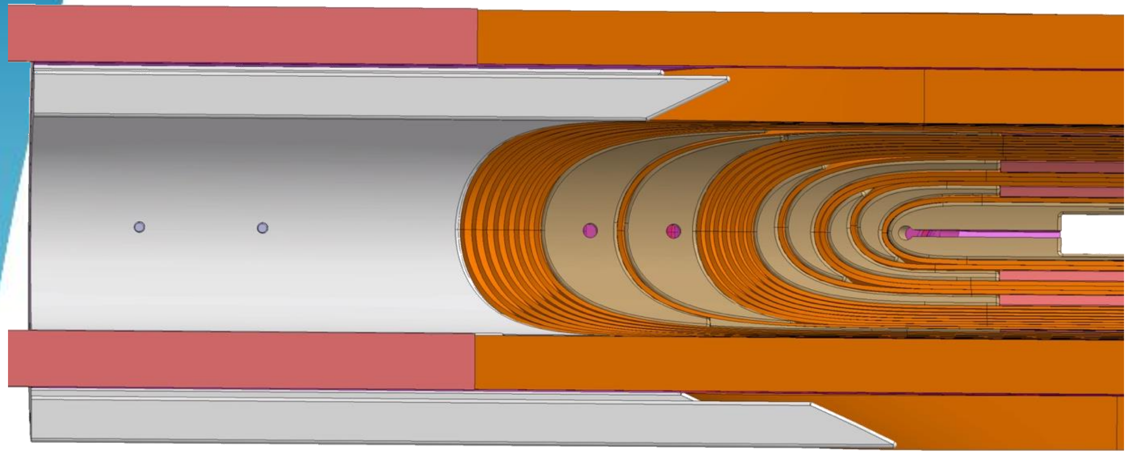


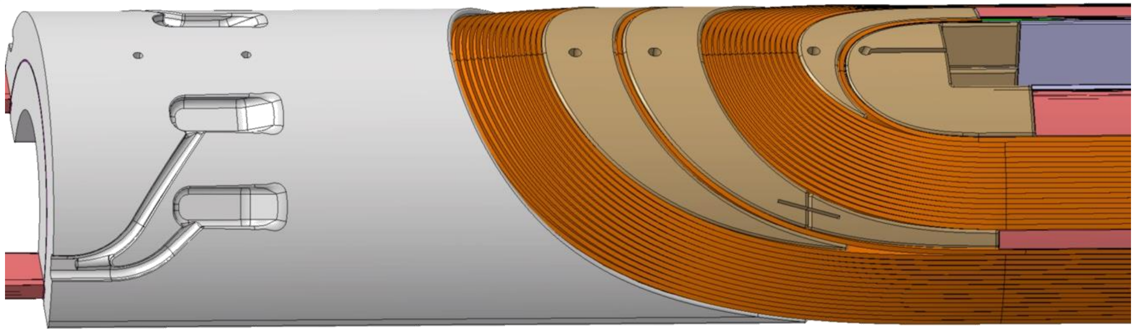
Nomenclature

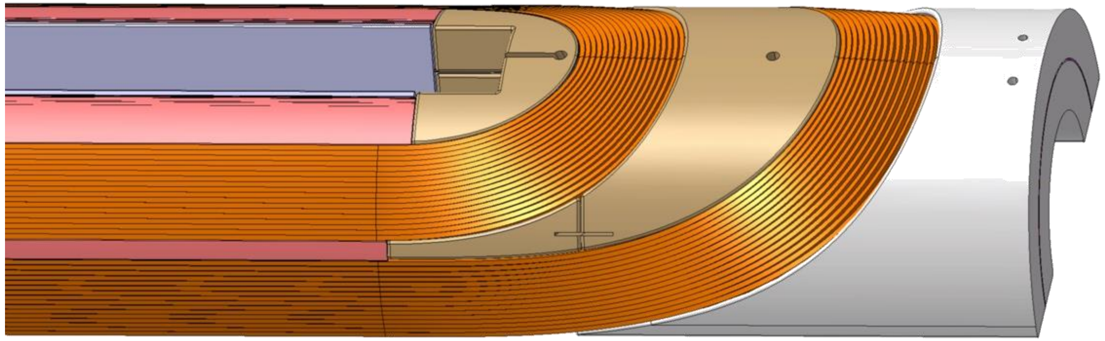


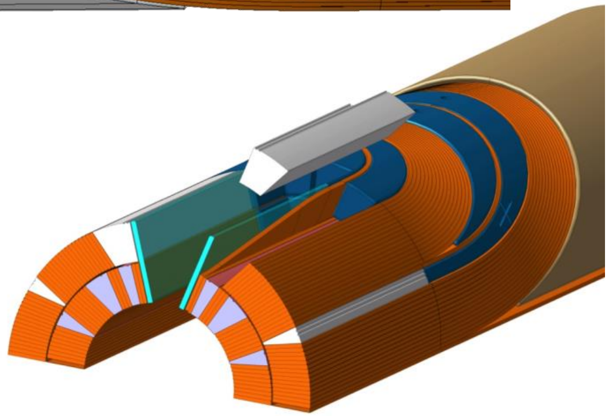
Images courtesy N.Peray and D. Smekens

Images



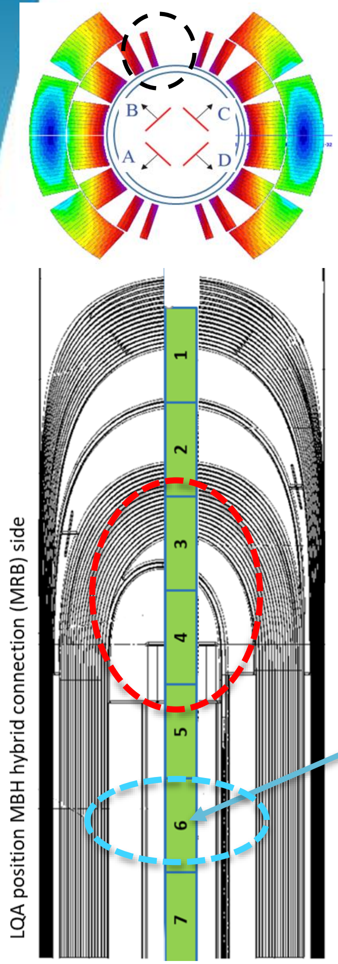


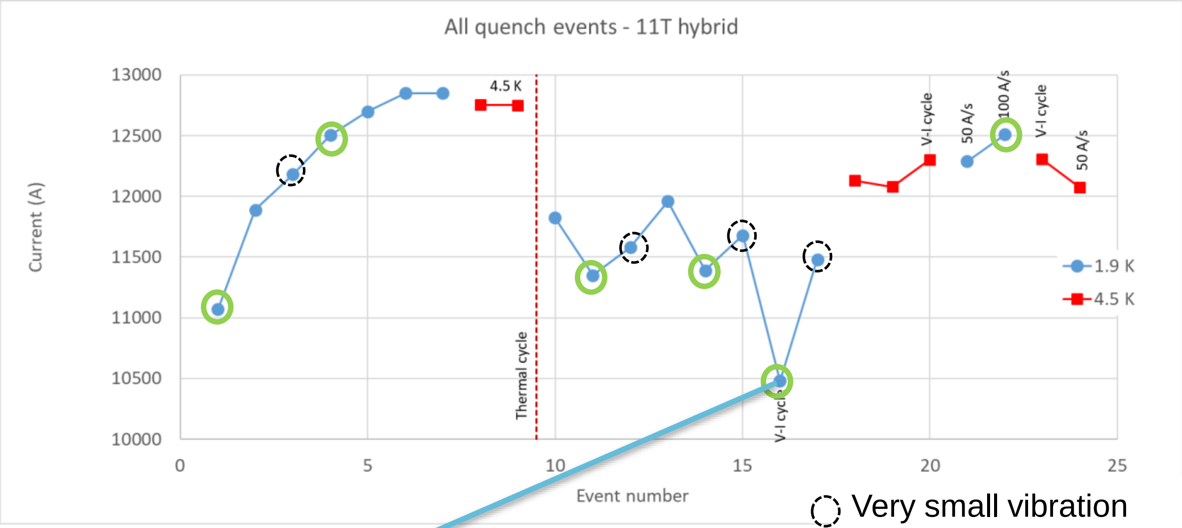




There is no absolute certainty from the data if a quench occurs in the outer layer or inner layer for a series magnet.
In the ext slides an image of the outer layer is used: this could be misleading.

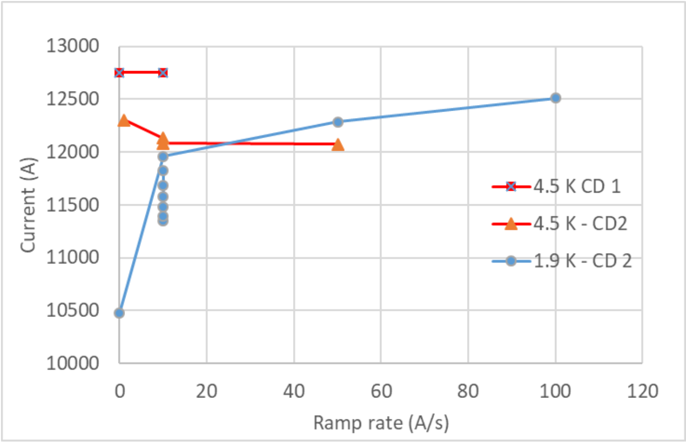
MBH-hybrid D1U



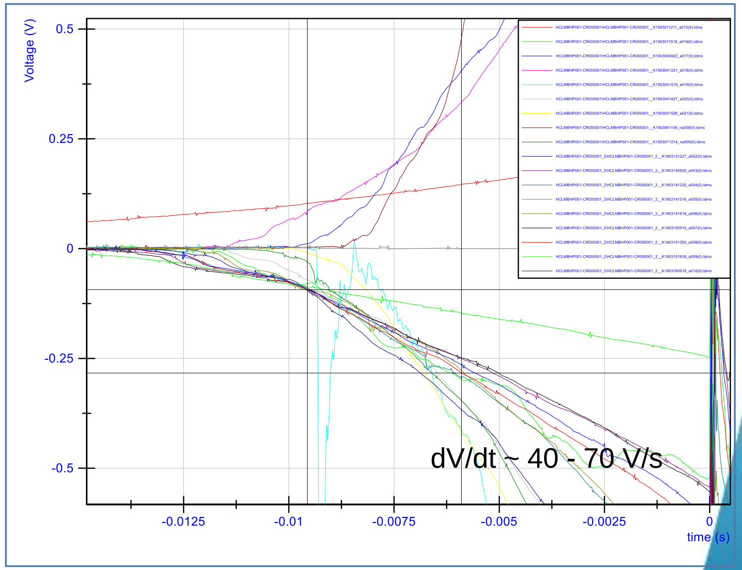


Very small vibration

Larger vibration



- No quenches in CD 1
- All quenches, but 1, starting in segment 3-4, some with and some without precursor.
- 1 quench (lowest current, V-I cycle) started around segment 6.



Quench Location vs Defect Location

Is the quench location identical to the defect location??

- Some quenches start with external energy source (precursor), other quenches start without (measurable) precursor.
- Some quenches (particularly at 1.9 K) may be caused by instabilities.
- Some quenches (particularly at 4.5 K) may be caused by reaching the critical surface (B, T, J)

Non-homogeneous defects (affecting one or a few strands)

Modeling done on defects in one or a few strands (Ruben Keijzer, Giovanni Succi):

- The strand with defect will cary almost 0 current. This strand may be very difficult to quench!!!
- Neighbouring strands will cary most current, not only around the defect, but also throughout most of the coil!! These strands may be easily quenched, since they are pushed towards carrying their critical current and possibly closer to instability limits.

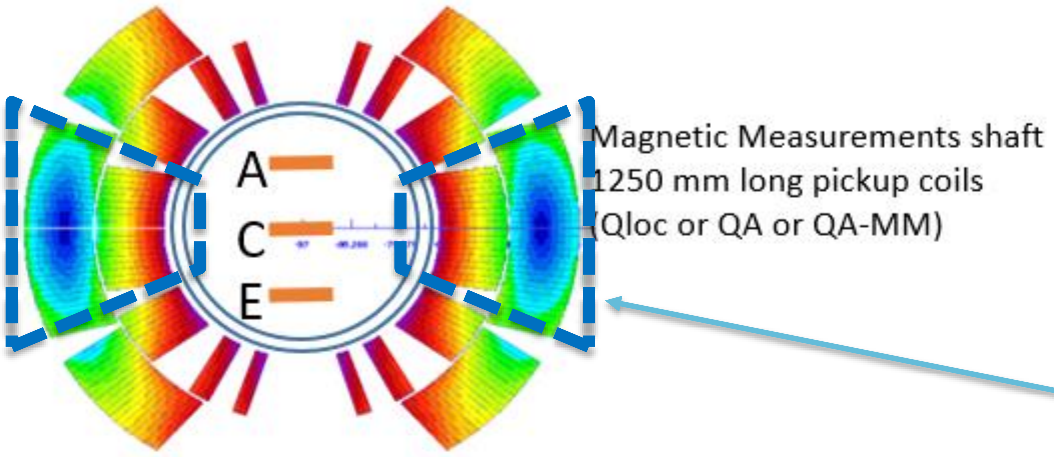
Some ‘weak’ consensus of phenomenology:

Fast ramps: Current pushed more through the defect, main redistribution directly around defect (could still be meters)

Slow ramps/plateaus: Time to redistribute over long lenghts, up to the splices.

Time constant for redistribution strongly varies over the distribution length (seconds to minutes)

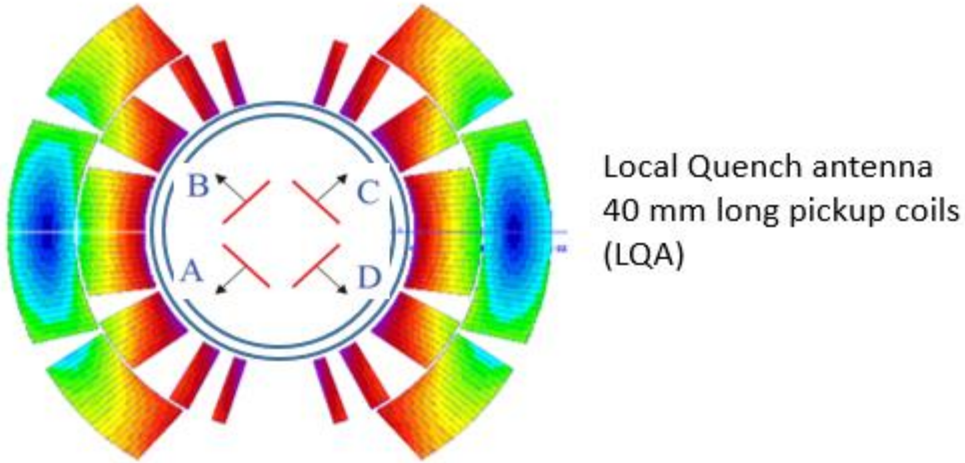
Exclusion midplane blocks



Two Quench Localisation shafts:

The data from the first shaft (long pickup coils) show that in all quenches there is only a signal in either A or E.

This means we can effectively **exclude the midplane blocks** from the investigation.

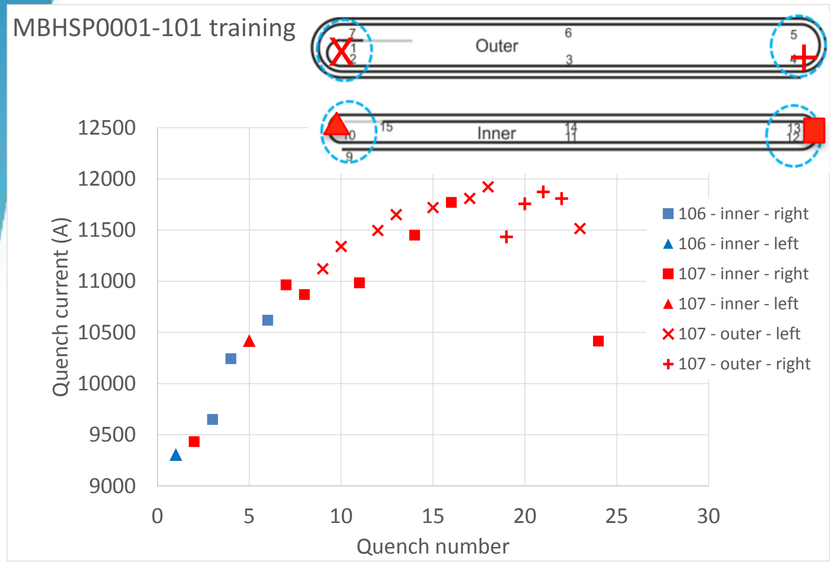


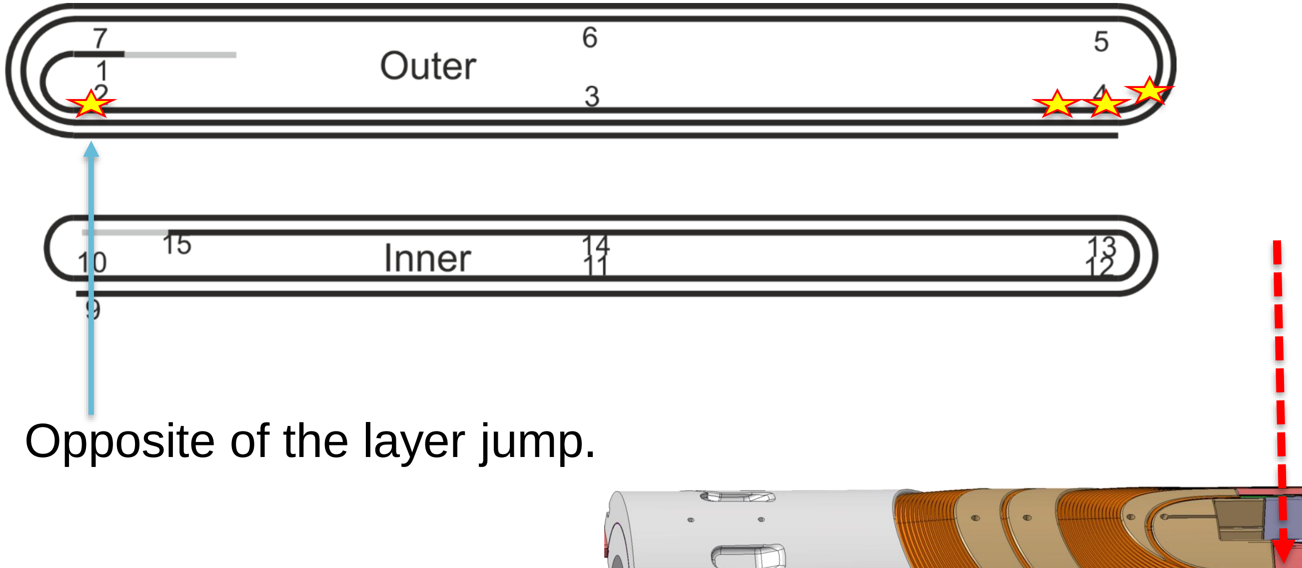
The data from the second shaft (short pickup coils, 4 cm long) gives the longitudinal position very precisely.
We still debate how precise we can find the azimuta quench start location.

Overview table of degradation issues in coils

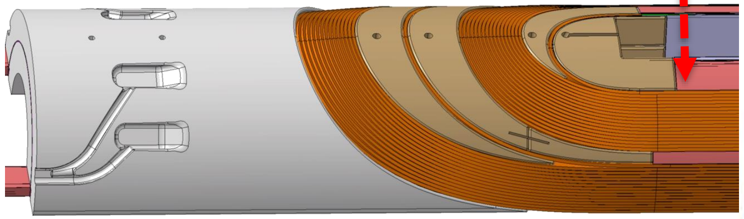
Magnet	Cryo process	Degradation
MBHSP101 (coil 107)	Long test station	CD 1: Coil 107, outer layer quenches
MBHSP104 (coil 113)	Long test station	CD 1: Coil 113, slow training, layer jump quenches.
MBH-Prototype	No delta T specifications (fast cool down)	CD 1: D2U, head, connection side and non-connection side
MBH-hybrid (1 aperture)	No delta T specifications (fast cool down and warm up)	CD 1: OK up to 12.85 kA at 1.9 K, 12.6 kA at 4.5 K CD 2: D1U, head connection side
MBHB-002	Delta T = 30 K for range 90 K – 300 K	CD 1: - CD 2: -
MBHA-001	Delta T = 30 K for range 90 K – 300 K	CD 1: no data above 9 kA CD 2: no degradation up to 11.95 kA at 1.9 and 4.5 K. CD 3: D2L, head, connection side. small degradation D1L, head connection side noticable. CD 4: D2L, head, connection side (same as CD 3) D1L, head connection side strongly degraded.
MBHA-002	Delta T = 30 K for range 90 K – 300 K	CD 1: D1U, Head, Non-connection side.

First short model: MBHSP101 – coil 107





Opposite of the layer jump.

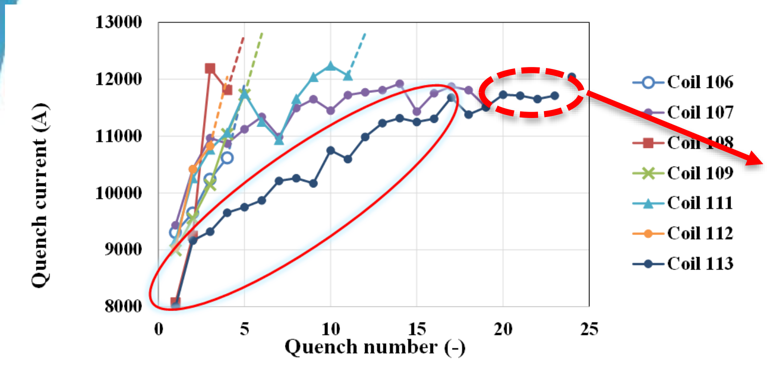


Quenches in both Connection side and non-connection side in the head of coil 117.
Mainly in the outer layer!!

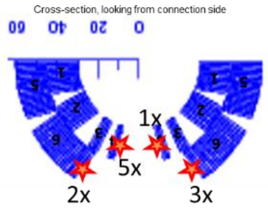
No quench antenna data.

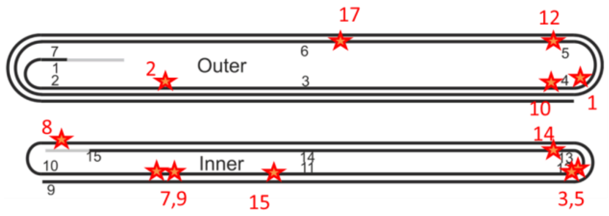
Characteristics
Outer layer quenches, pole turn.
Around voltage tap location and transition region.

MBHSP104 – coil 113

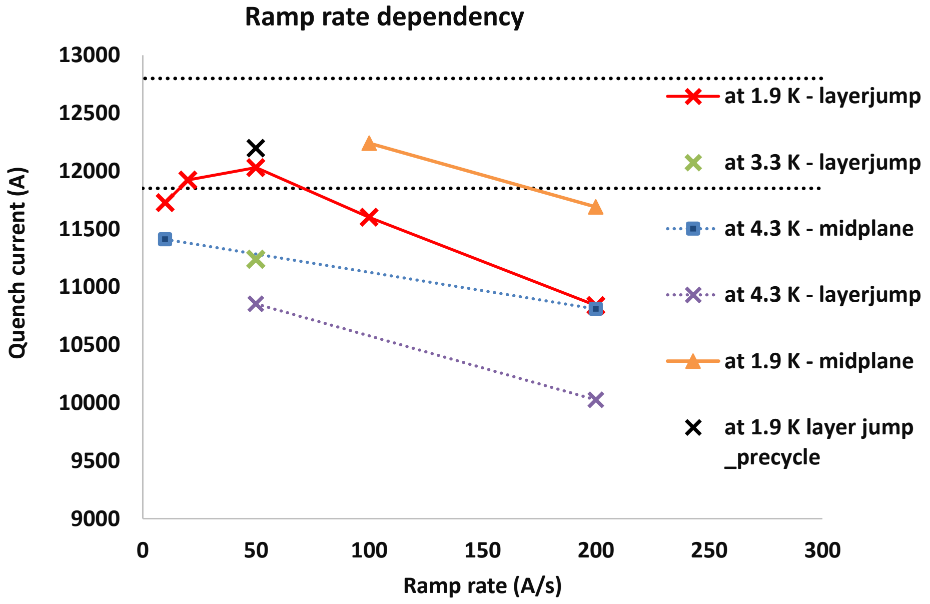


“Plateau quenches” in the layer jump.





Very slow training throughout pole turn inner and outer layer.



For some temperature/ramp rate, the limit is in the layer jump, others are in the midplane.

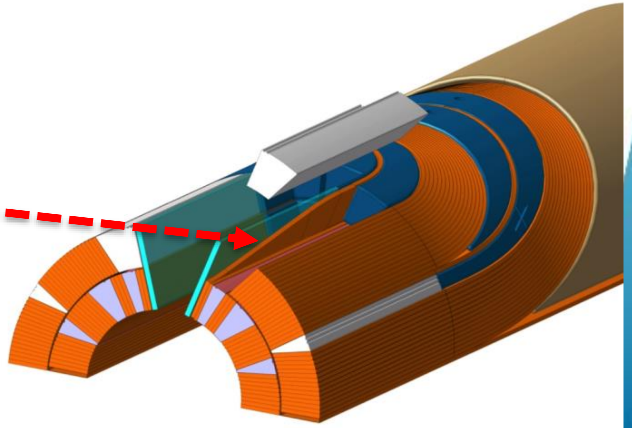
Characteristics

Very slow training thoughout pole turns.

Limiting quenches in the layer jump.

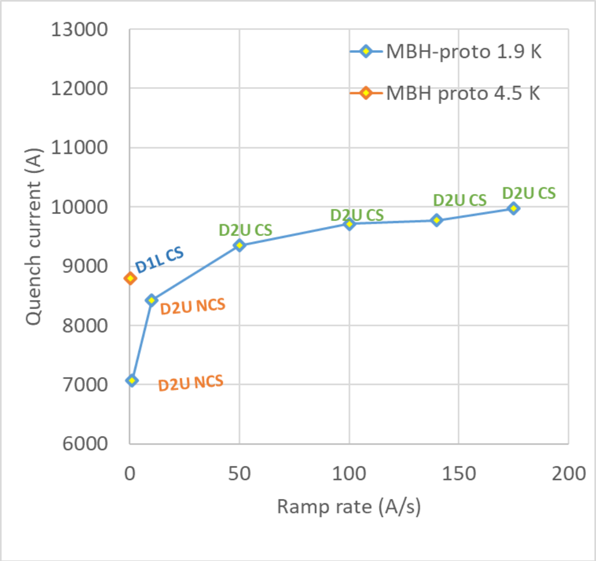
Very fast quench propagation

Strange temperature characteristics.



Clear case of non-homogeneous conductor degradation.

MBH-proto D2U



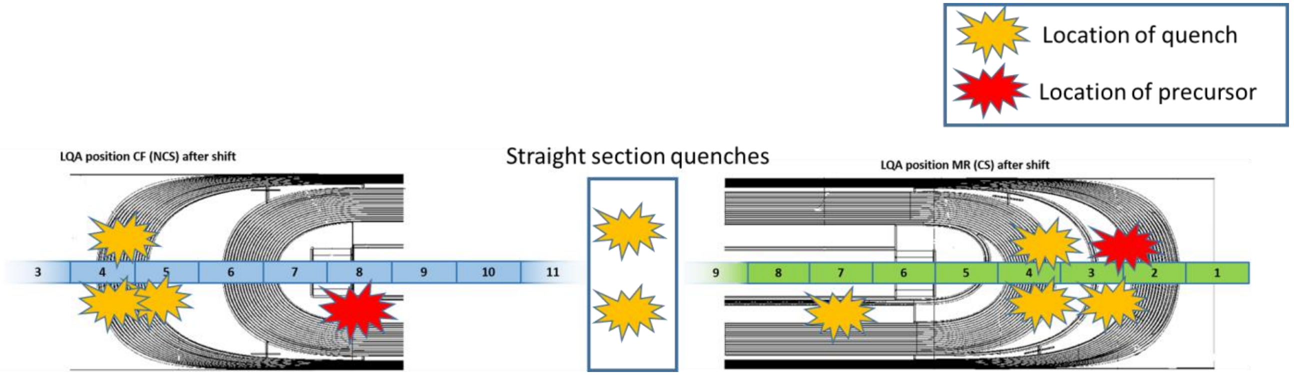
Characteristics

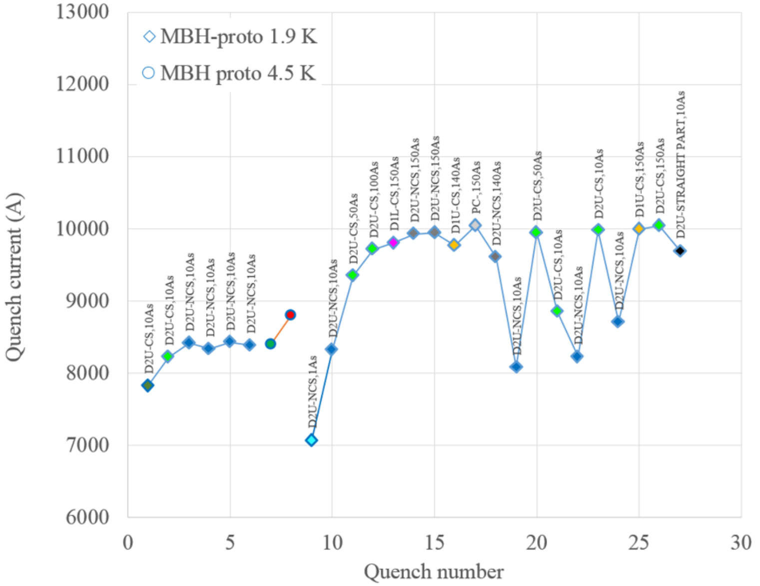
Very strong degradation, high voltage measured in V-I measurements.
Very fast quench propagation
Abnormal temperature characteristics.

Difficulty:

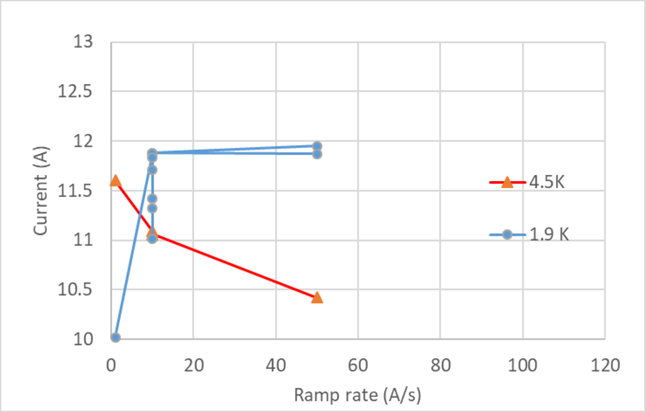
Depending on ramp rate quenches occur in both heads:

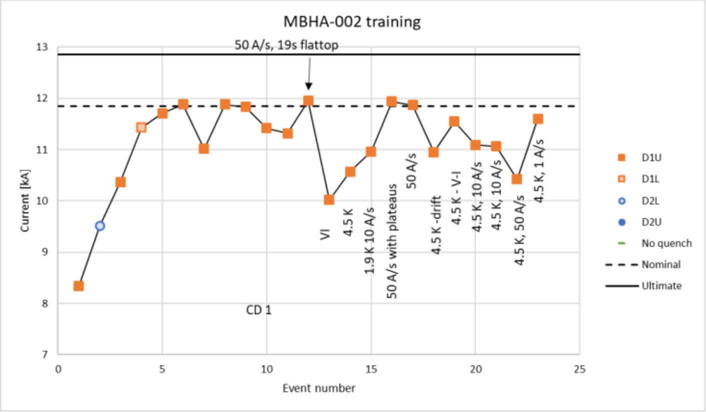
- Or 2 seperate defects, or is there one defect that causes current redistribution over long lengths to render the coil instable in both heads?





MBHA-002 – D1U

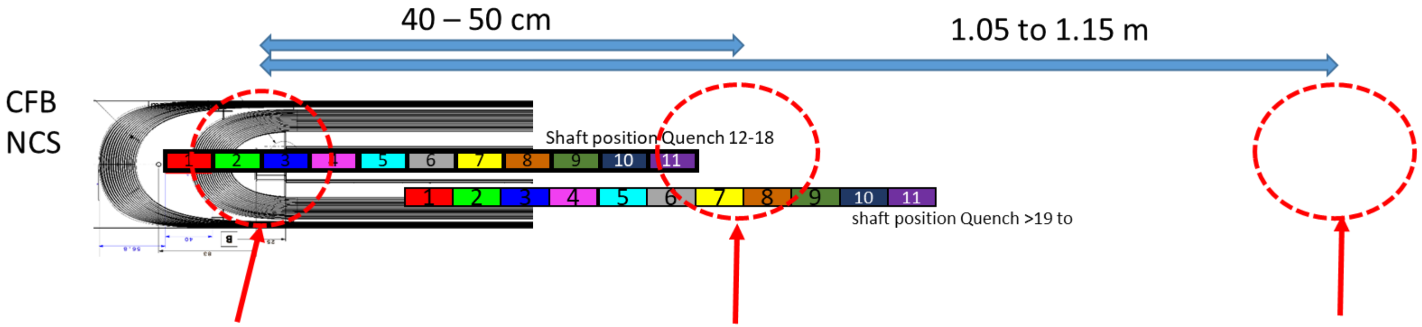




Characteristics
Abnormal ramp rate dependency
Clear decay in V-I measurements
Connectoin si

Difficulty:
3 quench locations, depending on the temperature and ramp rate.

Consensus:
- The most likely to quench at the defect location is when: at 4.5 K and ramping fast. In this case that would be in the head, non-connection side.

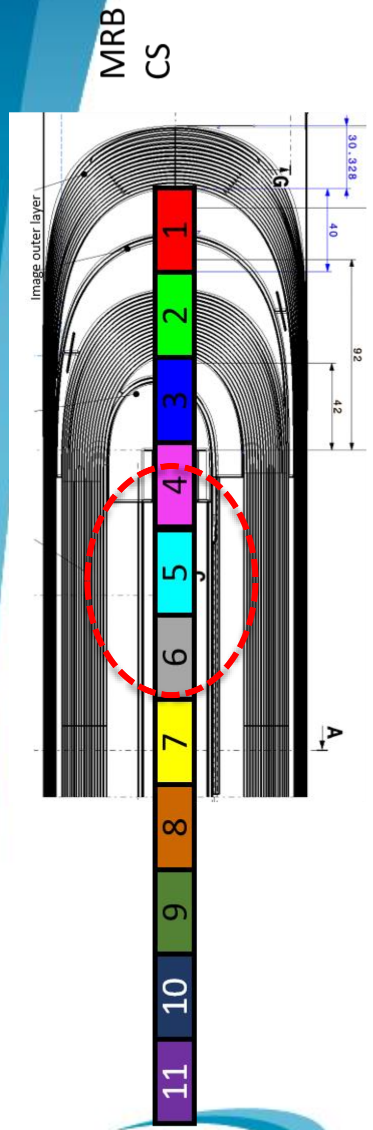


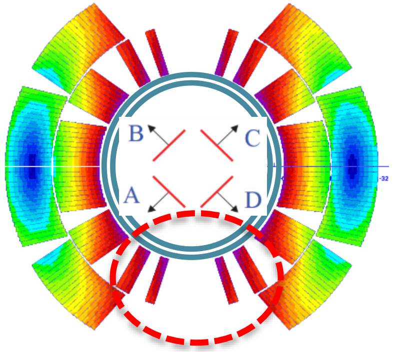
1.9 K, 10 A/s – all quenches
1.9 K, 50 A/s+ 19seconds plateau
1.9 K V-I cycle
4.5 K, 10 A/s – 2 quenches
4.5 K, 50 A/s

1.9 K, 50 A/s
4.5 K after drift from 1.9 k (2 times)

4.5 K V-I cycle
4.5 K 1A/s ramp (special cycle)

MBHA-001, D2L





Characteristics

Only appearant degradation in Cool Down 3

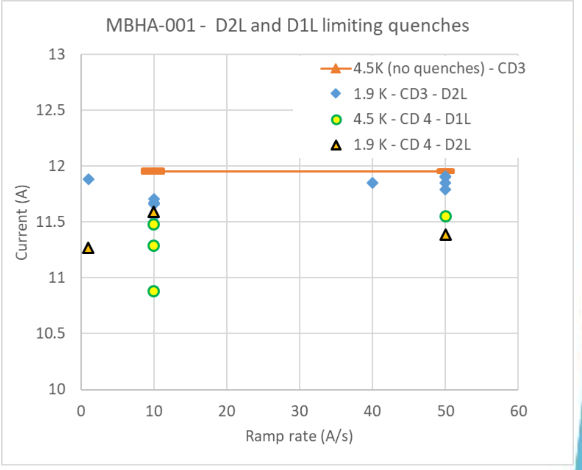
Clear decay in V-I measurements

Abnormal temperature and ramp rate dependency.

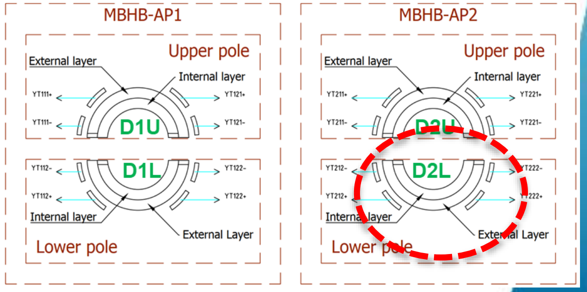
Quench location

Connection side

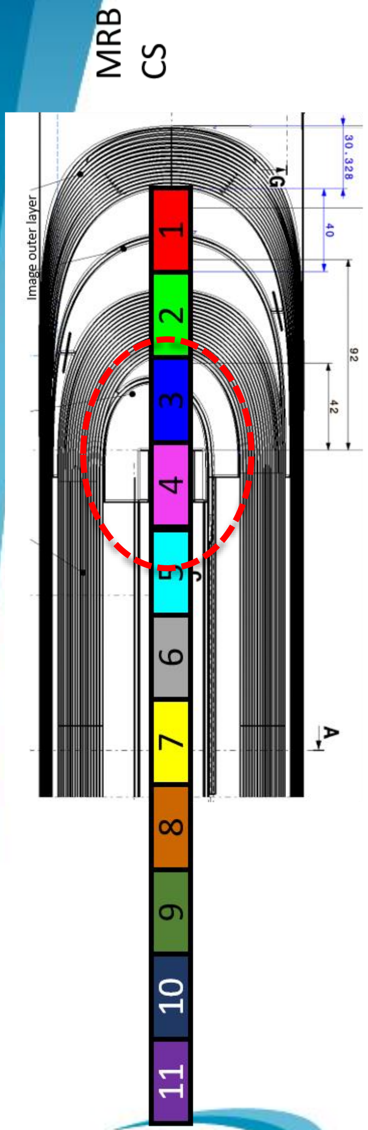
Transition region. Could be layer jump.

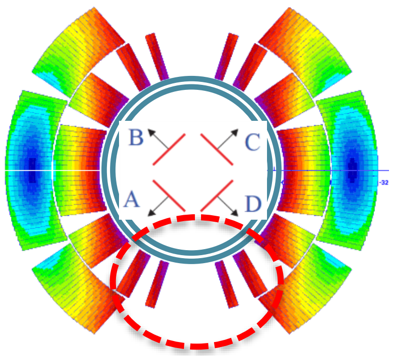


dV/dt ~ 50 V/s



MBHA-001 - D1L





Characteristics

Main degradation in Cool Down 4

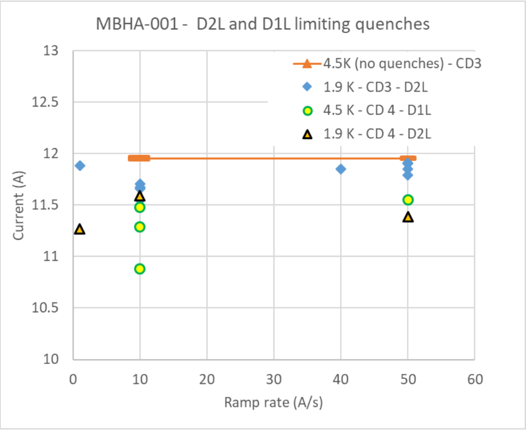
Clear decay in V-I measurements

Abnormal temperature and ramp rate dependency.

Quench location

Connection side

Head, possibly towards transition region.



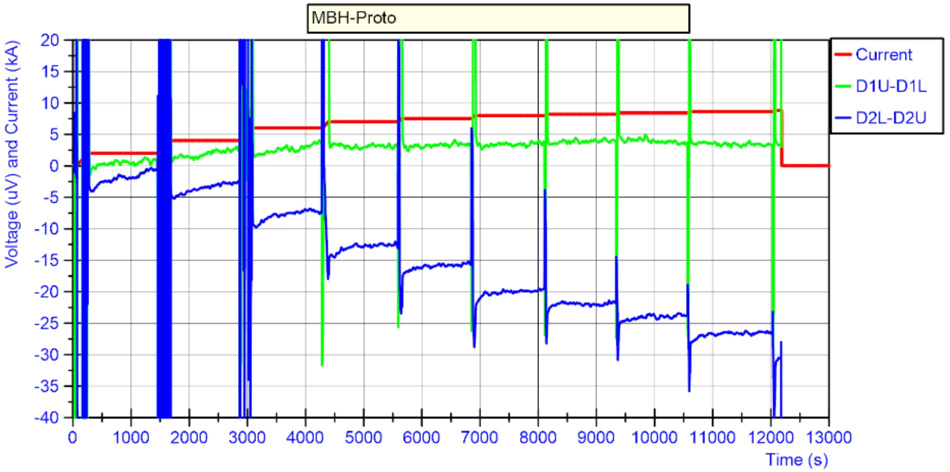
Characteristics of quenches

Magnet	$I_{c\ 1.9}/I_{c\ 4.5}$ (1 A/s)*	Quench location	dV/dt [V/s]	Feature in early quench voltage (< 5 ms)	Ramp rate dependency	Suspected damage type	
MBHSP101 (coil 107)		Heads/outer layer					
MBHSP104 (coil 113)	1.03	Heads/straight section	150-300		Reversed** below 50 A/s @1.9 K	Local	
MBH-prototype	0.87	head	40	yes	Reversed @1.9 K		
MBH-hybrid	0.85	head	40-70	yes	Reversed @1.9 K	Local	
MBHA-002	0.86	Head/straight section	100	yes	Reversed @1.9 K	Local	
MBHA-001	0.95 (CD3/CD4)	Head	50-100	Yes (D1L)	Reversed @1.9/4.5 K	Local (progressive)	

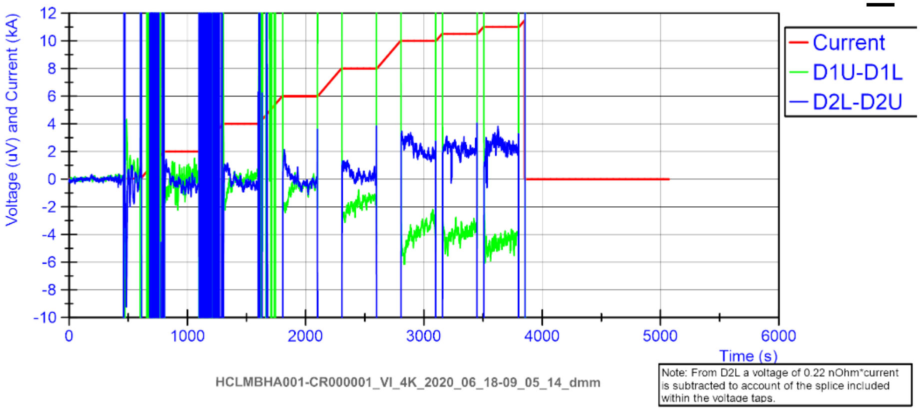
DRAFT table, to be expanded and made more precise

V-I curves

MBH-Prototype_CD4_4.5 K

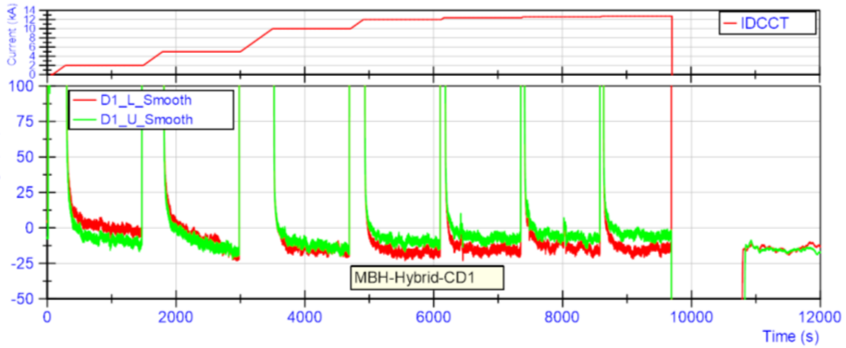


MBHA-001_CD4_4.5 K

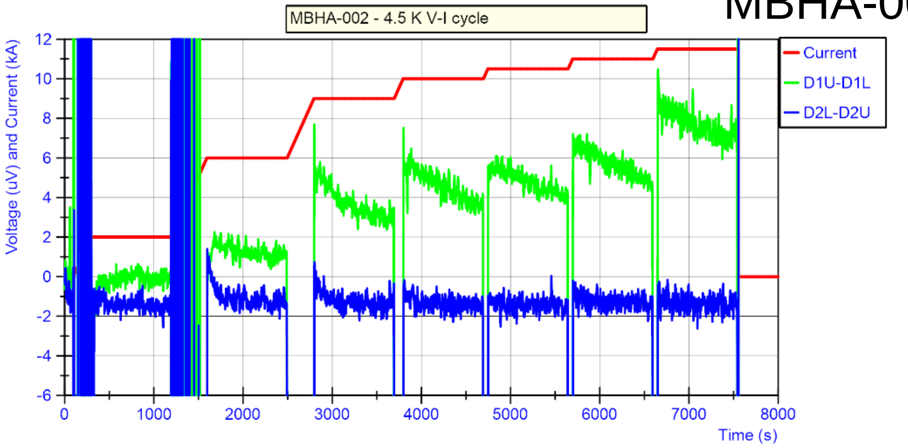


MBH-hybrid data

(slightly different measurement settings)



MBHA-002_4.5 K



Overview table of degradation issues in coils

	Head/straigth	**Upper/lower coil**	**Aperture 1/2**	**Connection/non-connection side**	**First notification of degradation**	**CD/WU process**
MBHSP101	Head	Coil 107		CS and NCS	CD1	Long test station (Lhe)
MBHSP104	Head	Coil 113		CS	CD1	Long test station (Lhe)
MBH-proto	Head	Upper	2	CS and NCS	CD 1	Fast
MBH-hybrid	Head	Upper	1	CS	CD 2	Fast
MBHA-001 defect 1	Head	Lower	2	CS	CD 3	ΔT = 30 K (90 K – 300 K) ΔT = 80 K (4 K – 90 K)
MBHA-001 defect 2	Head	Lower	1	CS	CD 4	ΔT = 30 K (90 K – 300 K) ΔT = 80 K (4 K – 90 K)
MBHB-002	Head	Upper	1	NCS	CD 1	ΔT = 30 K (90 K – 300 K) ΔT = 80 K (4 K – 90 K)