MBHSP106
DC-loss measurements

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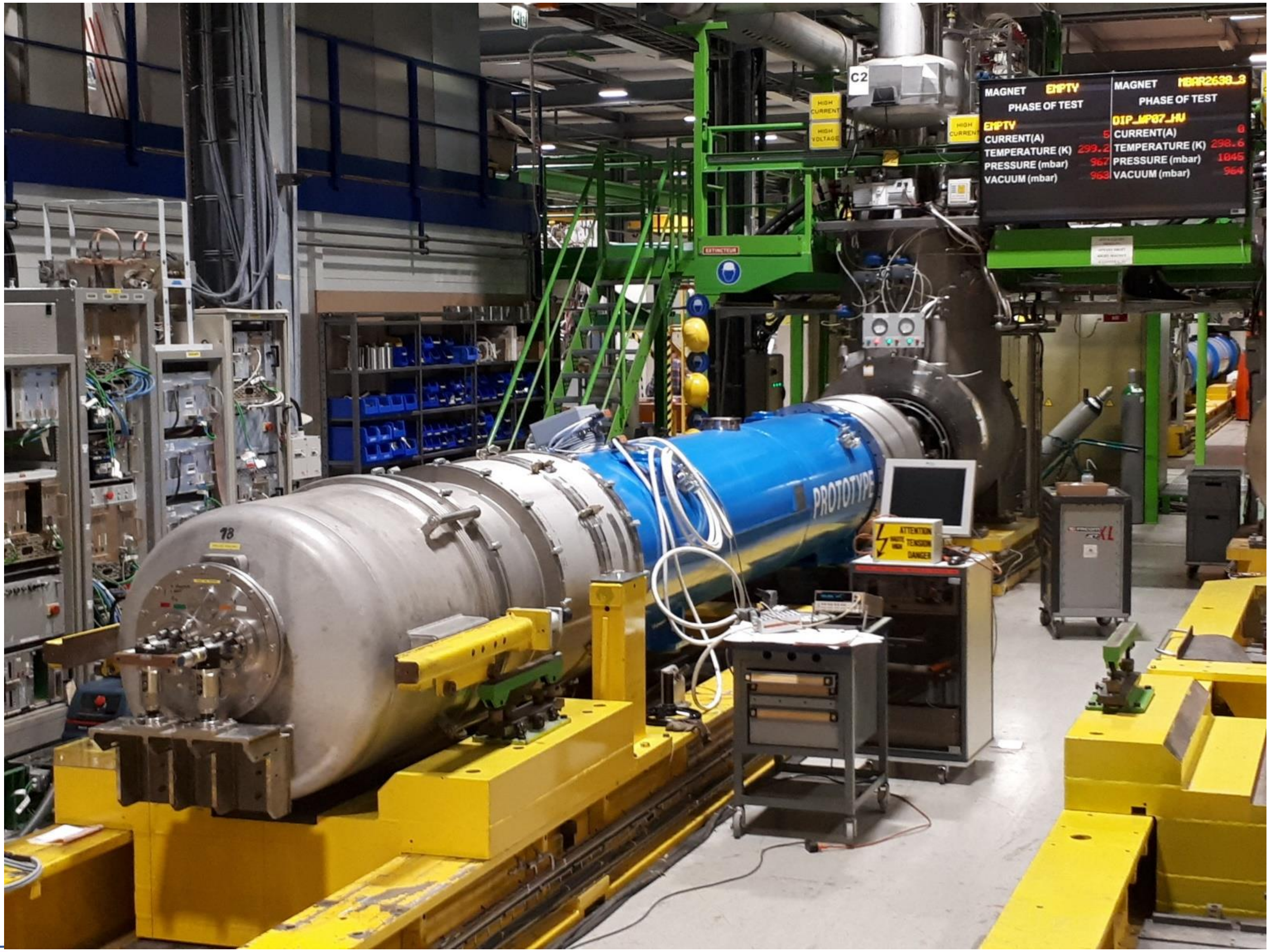
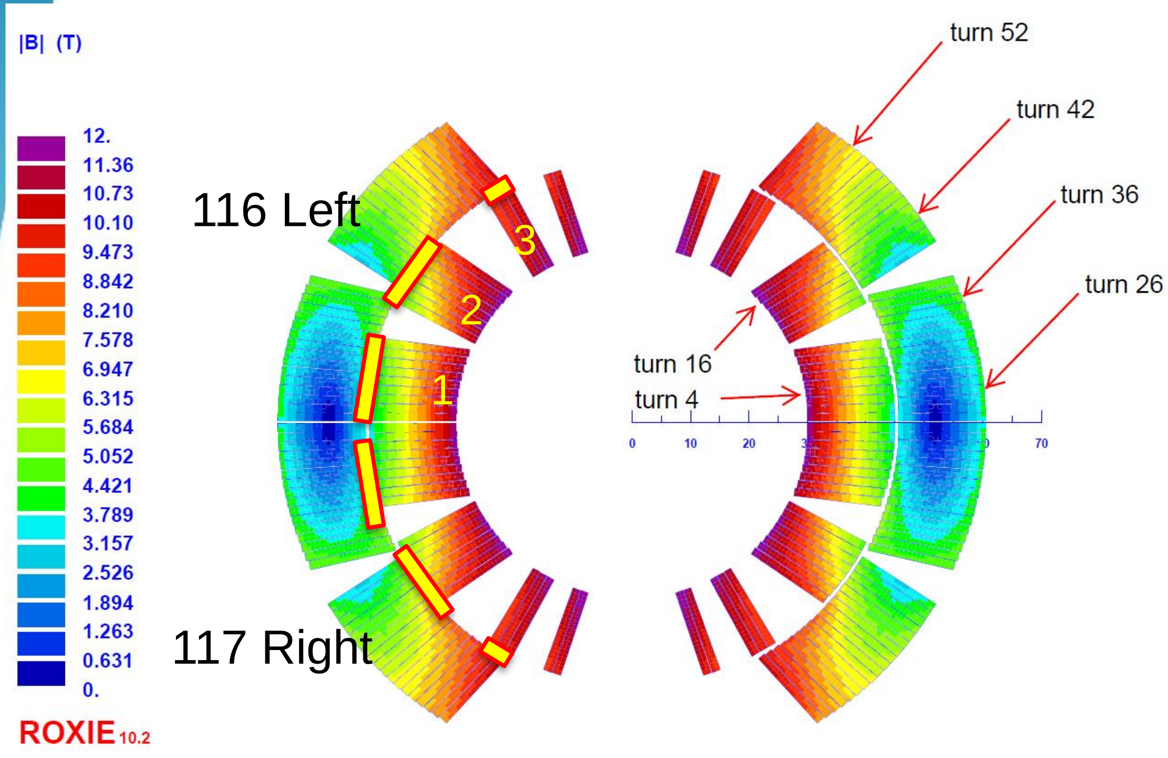
DCloss MBHSP106 - 06-05-2018

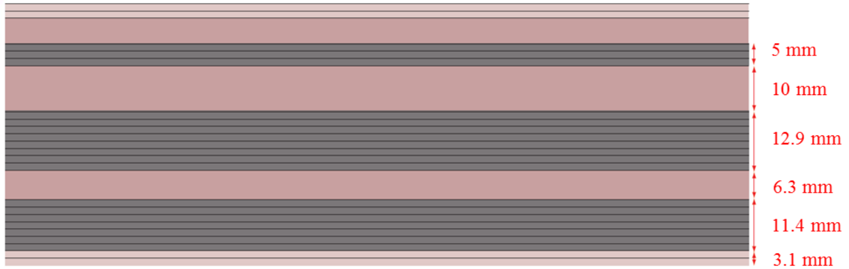
MBHB prototype on test bench

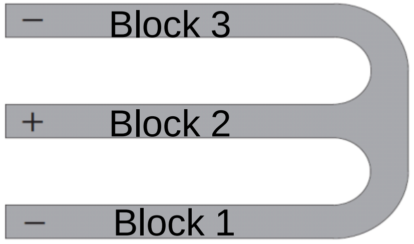


DC-loss measurements on MBHSP106



2 Interlayer heater circuits fully intact
116 Left quadrant and 117 Right quadrant (on the left seen in the image)



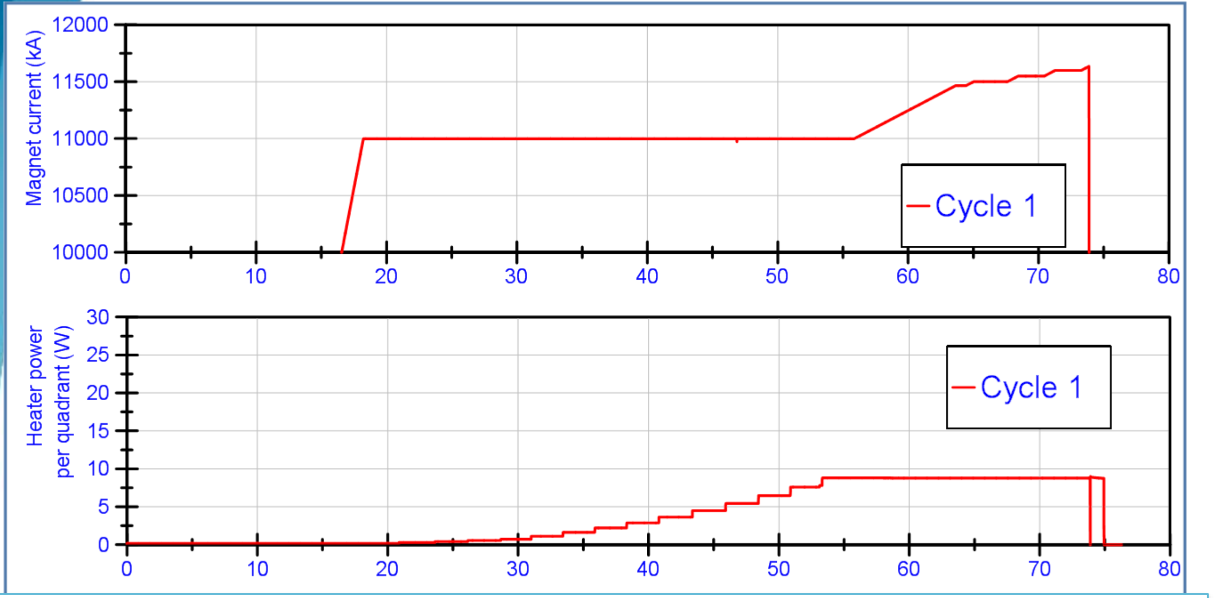


QH fully stainless steel, 1.7 meter long for 1.7 meter long coil.
Heating distribution:
Block 1 = 27.7 %
Block 2 = 44.7 %
Block 3 = 27.7 %

Heating of 5.9 W/m for 1 quadrant of the magnet:
Block 1 = 0.016 W/cm^2 (or 5.3 mW/cm^3 using 2 time 15 mm cable width)
Block 2 = 0.026 W/cm^2 (or 8.5 mW/cm^3 using 2 time 15 mm cable width)
Block 3 = 0.016 W/cm^2 (or 5.3 mW/cm^3 using 2 time 15 mm cable width)

Production and Roxie data by Susana

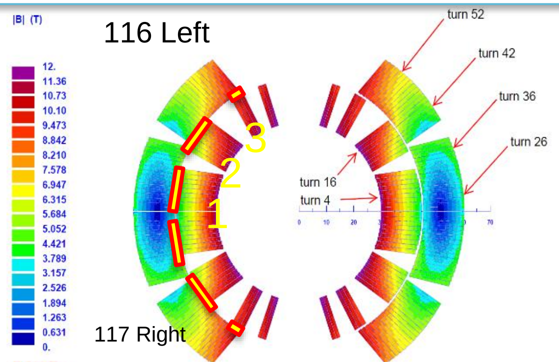
MBHSP106 - DC cycle 1 at 4.5 K



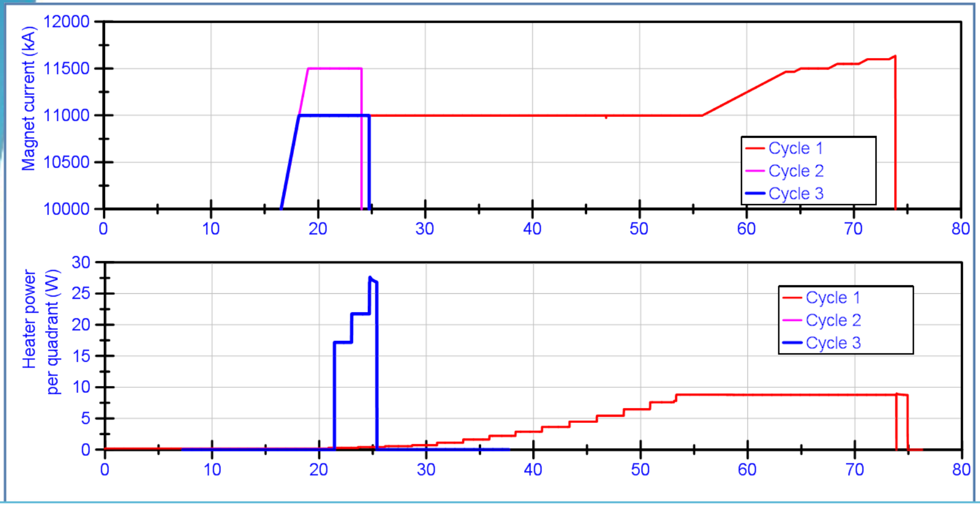
Cycle 1:

- **116 left quadrant and 117 right quadrant powered simultaneously**
- At 11 kA we increased heater current stepwise to **5.9 W/m per quadrant** (1.4 A): no quench.
- Then we kept **5.9 W/m per quadrant** (1.4 A) and increased magnet current to 11.5 kA at 1 A/s, followed by stepwise increase of 50 A with 2 minute plateaus.
- Quench while ramping **to 11.644** kA in center of block 3: coil 116 I7-I8 and QA segment 4 (segment that also quenches at 10 A/s **at 11.648** kA and that showed a SC-normal transition).

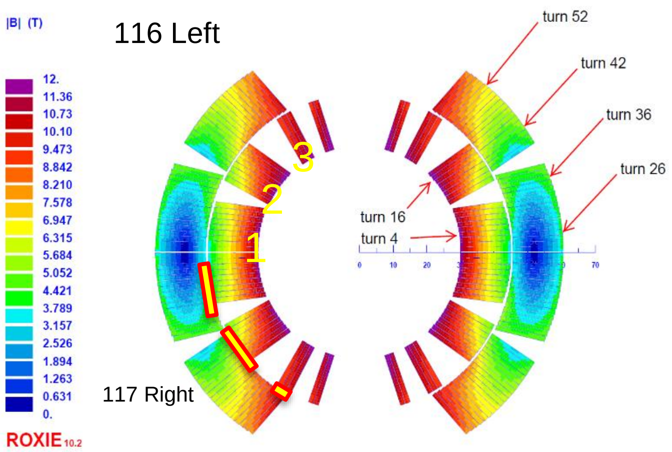
4.5 K
5.9 W/m per quadrant
11.8 W/m in a half-aperture
11.64 kA (same as without heating)



MBHSP106 - DC cycle 2 and 3 at 4.5 K



Cycle 2
4.5 K
9.7 W/m in 1 quadrant
11.5 kA



Cycle 2:

- **Only 117 right quadrant powered**
- **11.5 kA** in the magnet
- 7.7 W/m (1.6 A) for 2 minutes, followed by 9.7 W/m (1.8 A) for few seconds -> Quench
- Quench location:
  - Quench antenna segment 3
  - Block 1, midplane turn

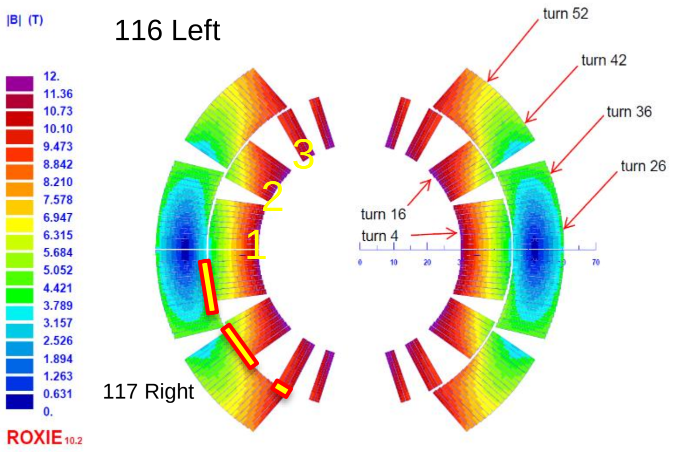
Cycle 3:

- **Only 117 right quadrant powered**
- **11 kA** in the magnet
- 7.7 W/m (1.6 A) for 2 minutes, followed by 9.7 W/m (1.8 A) for 2 minutes, followed by **12 W/m (2 A)** for seconds -> Quench
- Quench location:
  - Quench antenna segment 3
  - Block 1, midplane turn

Cycle 3
4.5 K
12.0 W/m in 1 quadrant
11 kA

MBHSP106 - DC cycle 4 at 1.9 K

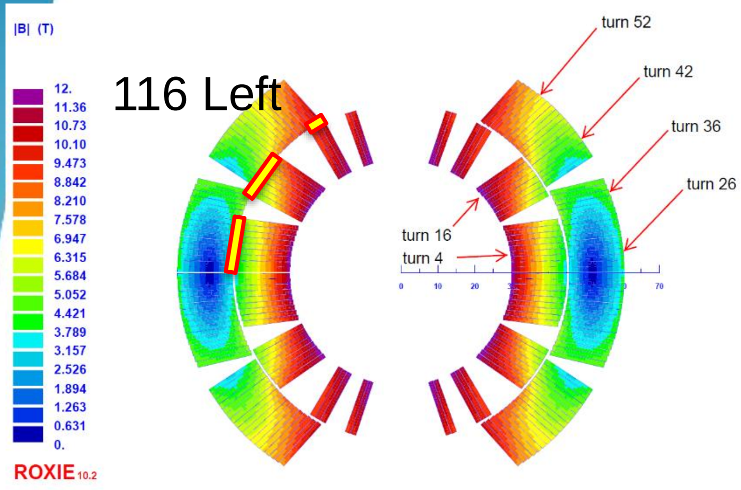
Cycle 4
1.9 K
7.7 W/m in 1 quadrant coil 117
12.85 kA



Cycle 4:

- Only 117 right quadrant heater powered
- Magnet ramp up at 10 A/s with 5.9 W/m of DC heater powering
- **12.85 kA** in the magnet
- Step to **7.7 W/m (1.6 A)** -> quench within seconds
- Quench location:
  - 117 I3-I4 (midplane turn)
  - 117 I2-I3 (miplane at head)

MBHSP106 - DC cycle 5 at 1.9 K

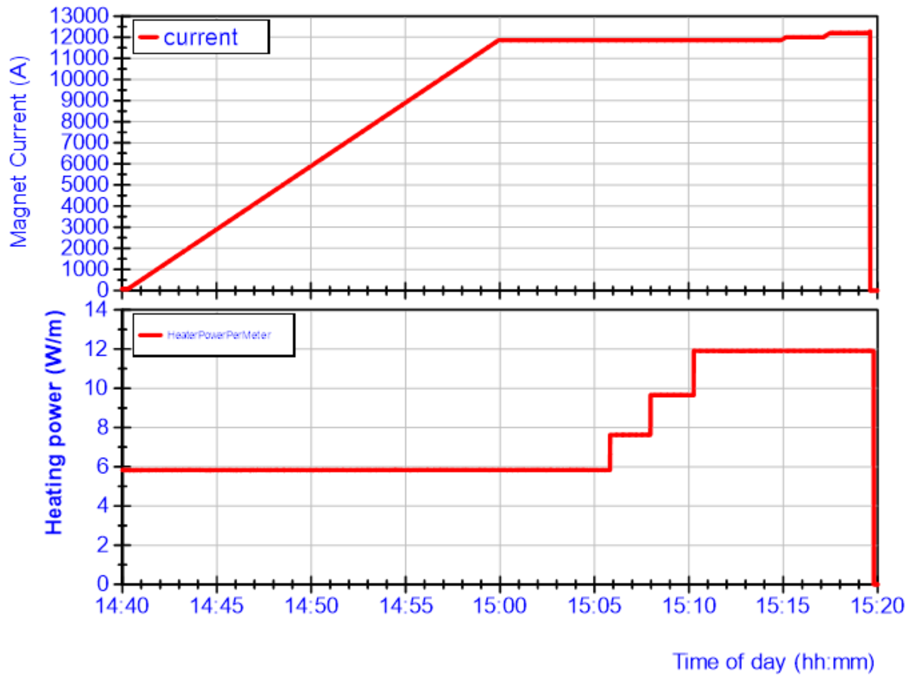


Cycle 5:

- **Only 116 left quadrant powered**
- **5.9 W/m during ramp up to nominal current 11.85 kA**
- **Stepwise increase to 12 W/m (2A)**
- Stepwise rampup of current to quench at 12.27 kA

Quench location:

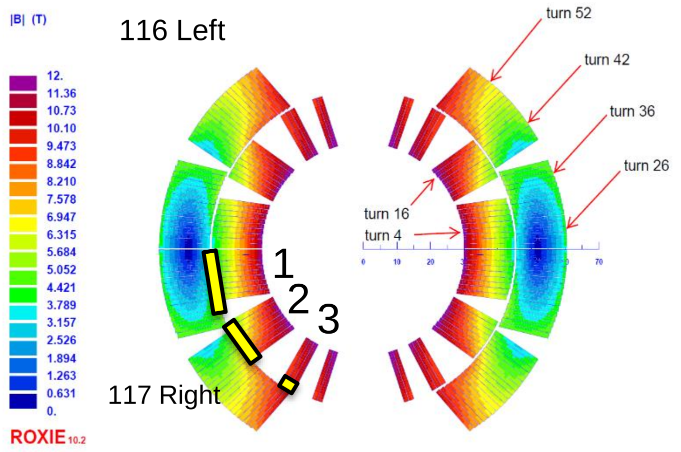
- Coil 116 block 3 (block with known conductor degradation)



Cycle 5
1.9 K
12 W/m in 1 quadrant coil 116
12.27 kA

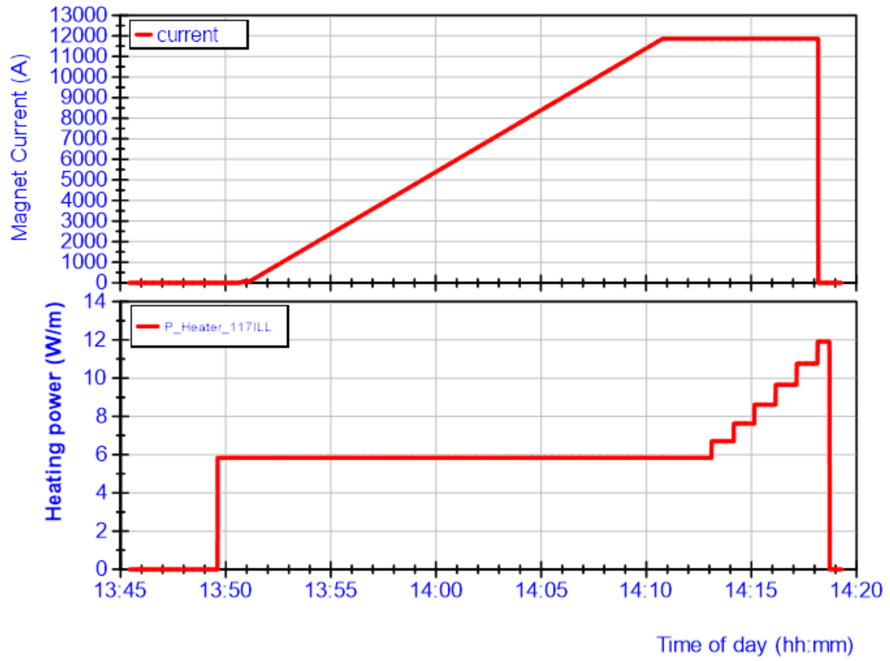
MBHSP106 - DC cycle 4 at 1.9 K

Cycle 6
1.9 K
11.9 W/m in 1 quadrant coil 117
11.85 kA

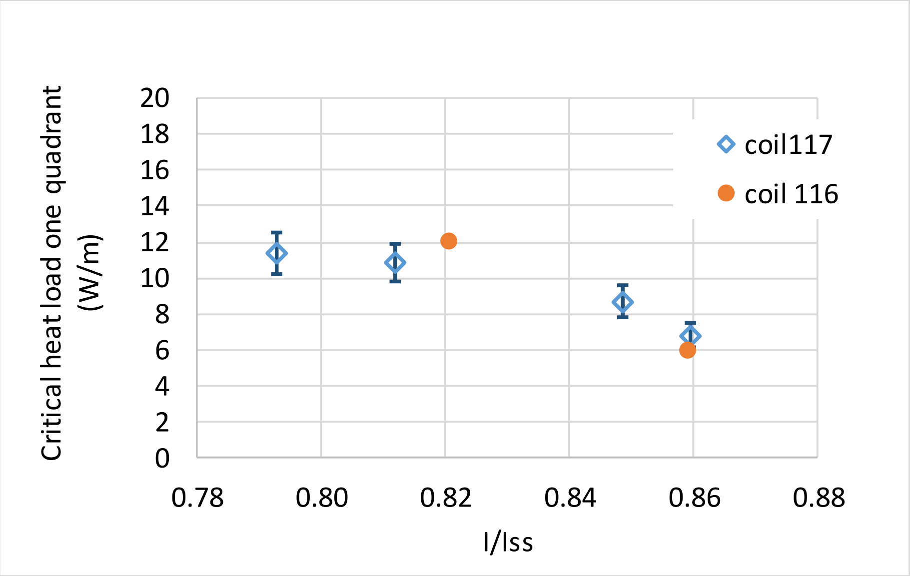


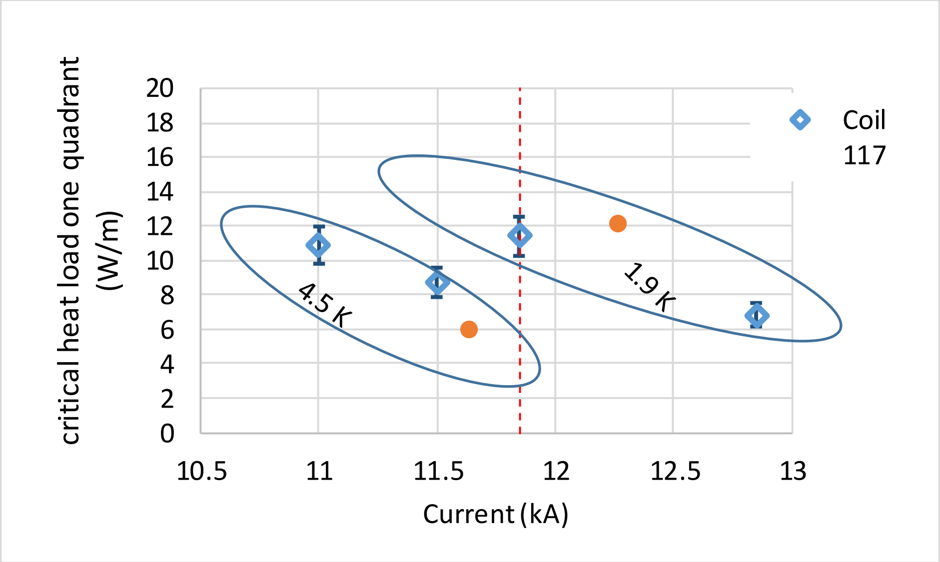
Cycle 7:

- Only 117 right quadrant heater powered
- Magnet ramp up at 10 A/s with 5.9 W/m (1.4 A) of DC heater powering
- **11.85 kA** in the magnet
- Increase of heater current by steps of 0.1 A every 1 minute
- 10.8 W/m stable for 1 minute
- Step to **11.9 W/m (2 A)** -> quench in 2 seconds
- Quench location:
  - 117 I3-I4 (midplane turn)
  - 117 I2-I3 (miplane at head)



Overview of critical heat loads (per quadrant)





			power per quadrant					
cycle	coil	Tempera ture	Power-stable	Power-Quench	Power-average	Iquench	Iss	Iquench/ Iss
#	#	K	W/m	W/m	W/m	kA	kA	-
1	116	4.5	5.9	5.9	**5.9**	11.644	13.55	0.86
2	117	4.5	7.7	9.7	**8.7**	11.5	13.55	0.85
3	117	4.5	9.7	12	**10.9**	11	13.55	0.81
4	117	1.9	5.9	7.7	**6.8**	12.85	14.95	0.86
5	116	1.9	12	12	**12**	12.27	14.95	0.82
6	117	1.9	10.9	11.9	**11.4**	11.85	14.95	0.79

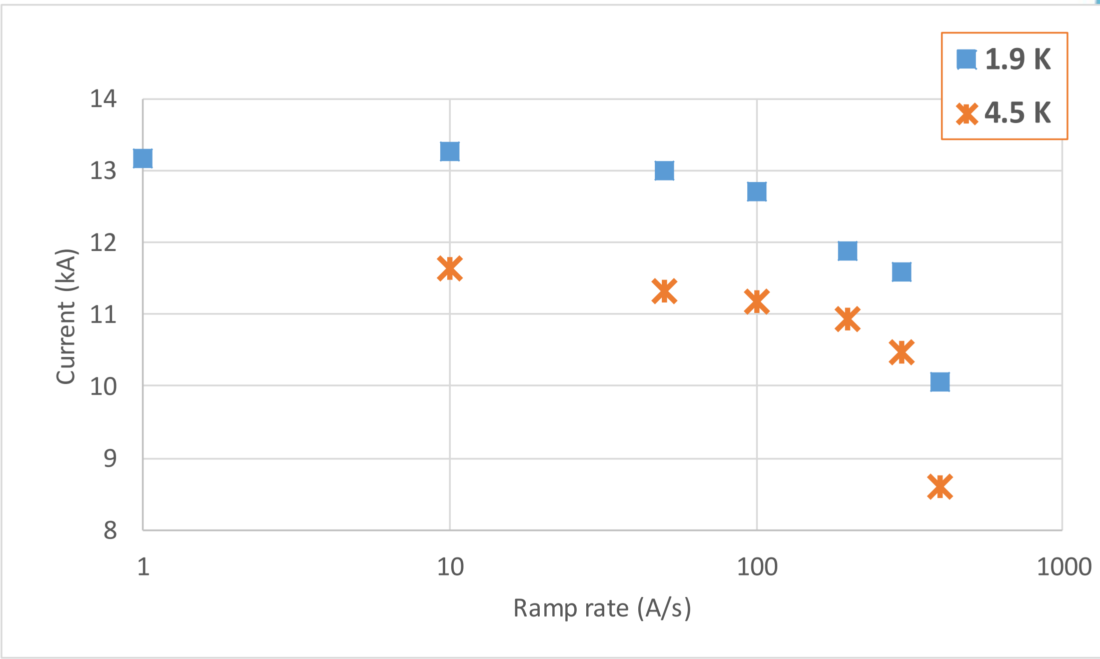
Disclaimer:

- This data is measured on a single magnet: no statistics
- Some cables may have seen degradation (measurable with coil 116, not measurable in coil 117).
- A heat load in the LHC due to beam loss, synchrotron radiation or due to AC-losses in the conductor will have a different distribution
- In the vertical test station the total helium volume is more than an order of magnitude larger than in the LHC.
- Data should mainly

Ramp rate studies and AC losses

AC loss measurements/calculations and ramp rate studies combined may also give a good indication of quench levels as function of losses.

MBHSP106 reaches ultimate current at 100 A/s and nominal current at > 200 A/s.



Outlook

Some DC measurements are done in particular conditions: they can validate calculations that can be used to do a good prediction of the critical heat loads

AC loss data is measured averaged over the coil (electrically)

Ramp rate studies may give a good indication on quench levels too.