



HO Corrector Magnets status octupole test review



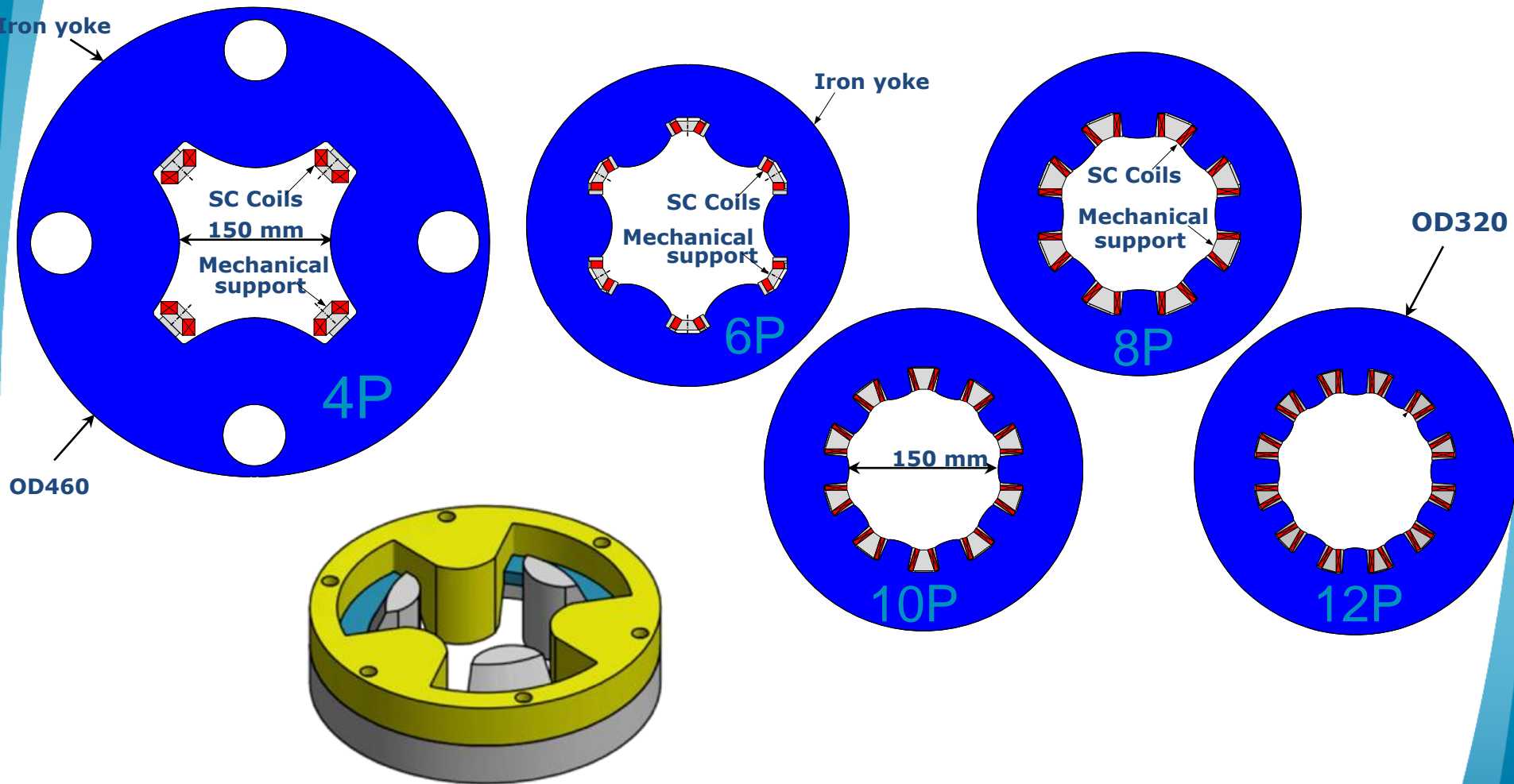
Marco Statera
on behalf of the LASA team
INFN Milano - LASA

CERN – 24 May 2017

OUTLINE

- the octupole: cold test review
- updates
 - decapole
 - MgB_2 round coil
 - dodecapole and quadrupole
- conclusions

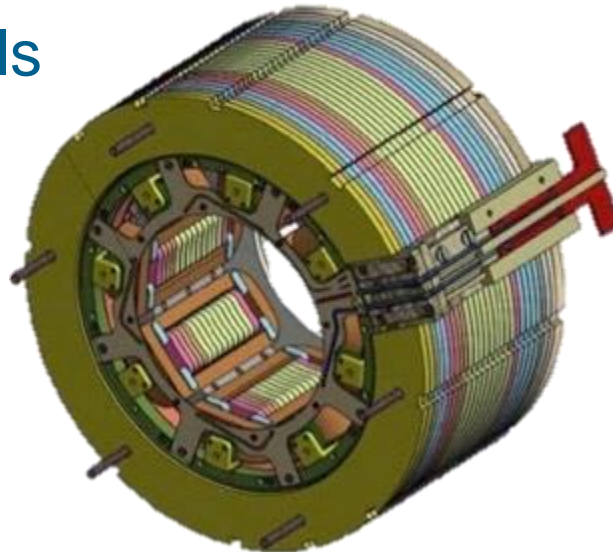
HO CORRECTOR MAGNETS ZOO



8POLE

	nominal	simulation
length	160 mm	183 mm
integrated field @ I_{op} @ r50 mm	46 Tmm	46 Tmm
magnetic length	87 mm	99 mm
energy @ I_{op}	1.4 kJ	1.07 kJ
harmonics		B12=11.6 B20=-3.0

- DURATRON coils
- electrical connections redesigned



M. Statera- CERN 2017/5/24

8POLE: assembly 1

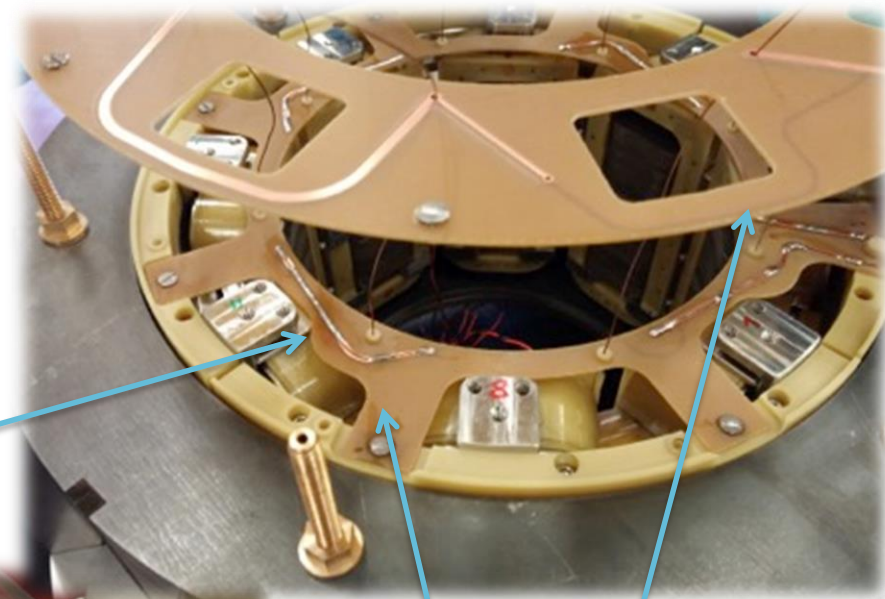
assembly procedure

- same as 6pole
- new electrical connections



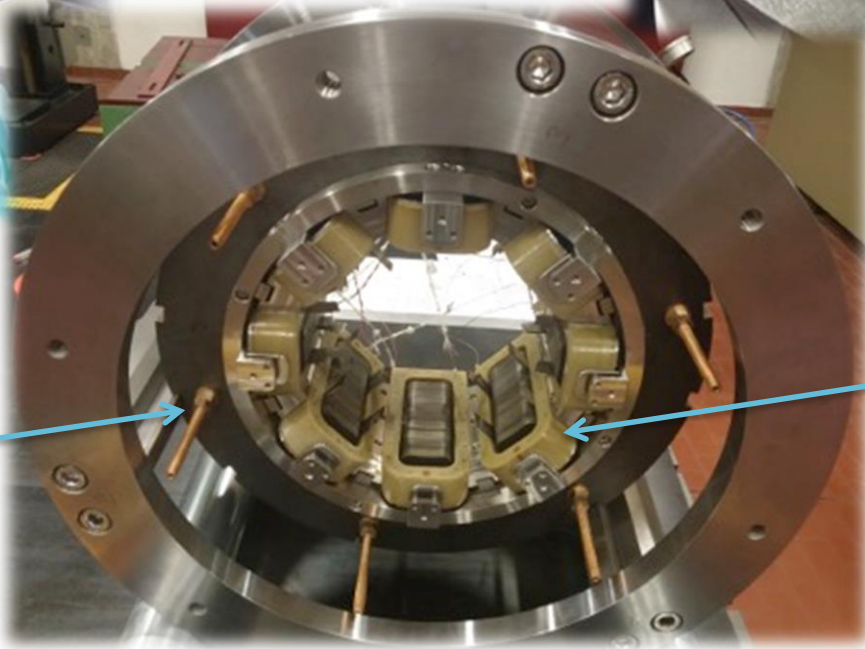
lamination

Copper 2 mm wide
0.035 mm thick



two printed circuit boards

- coils' connections
- signals

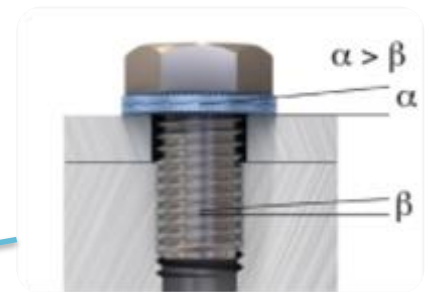
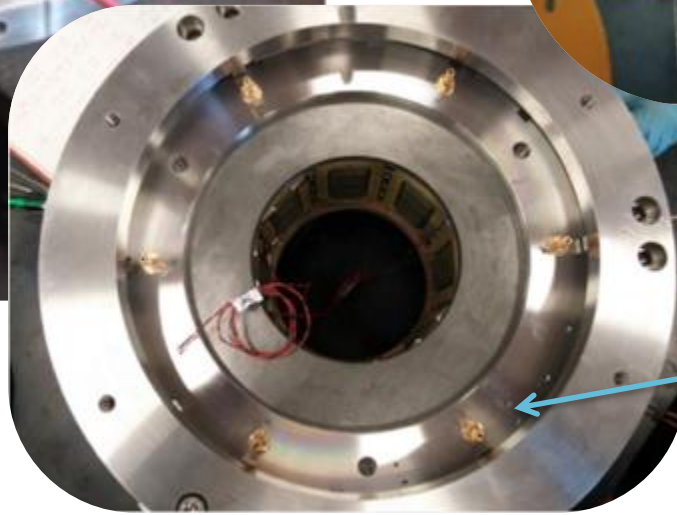
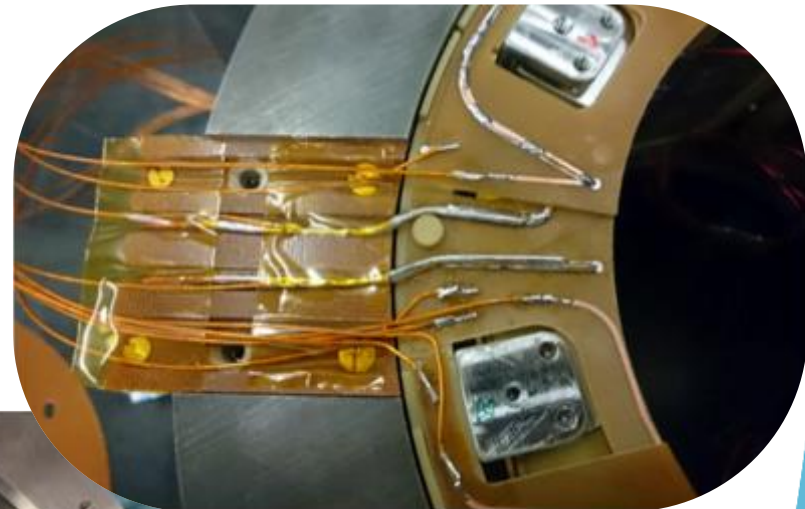
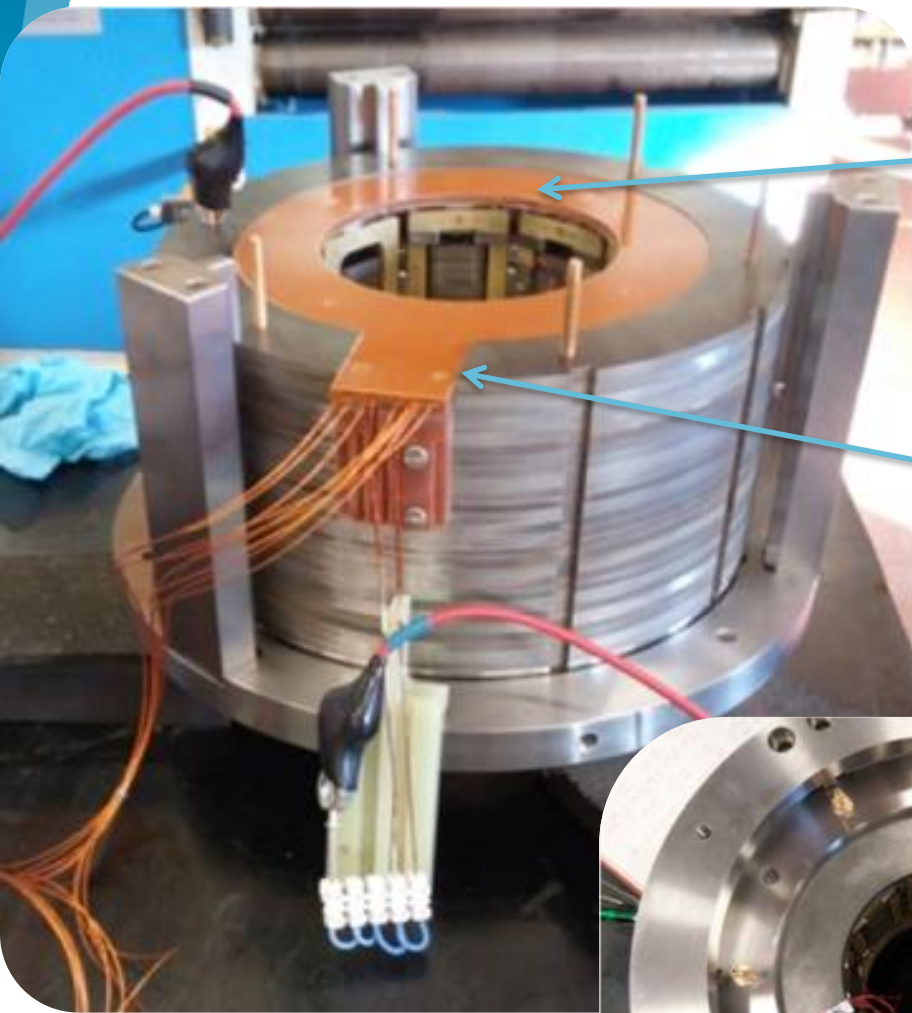


DURATRON
coils

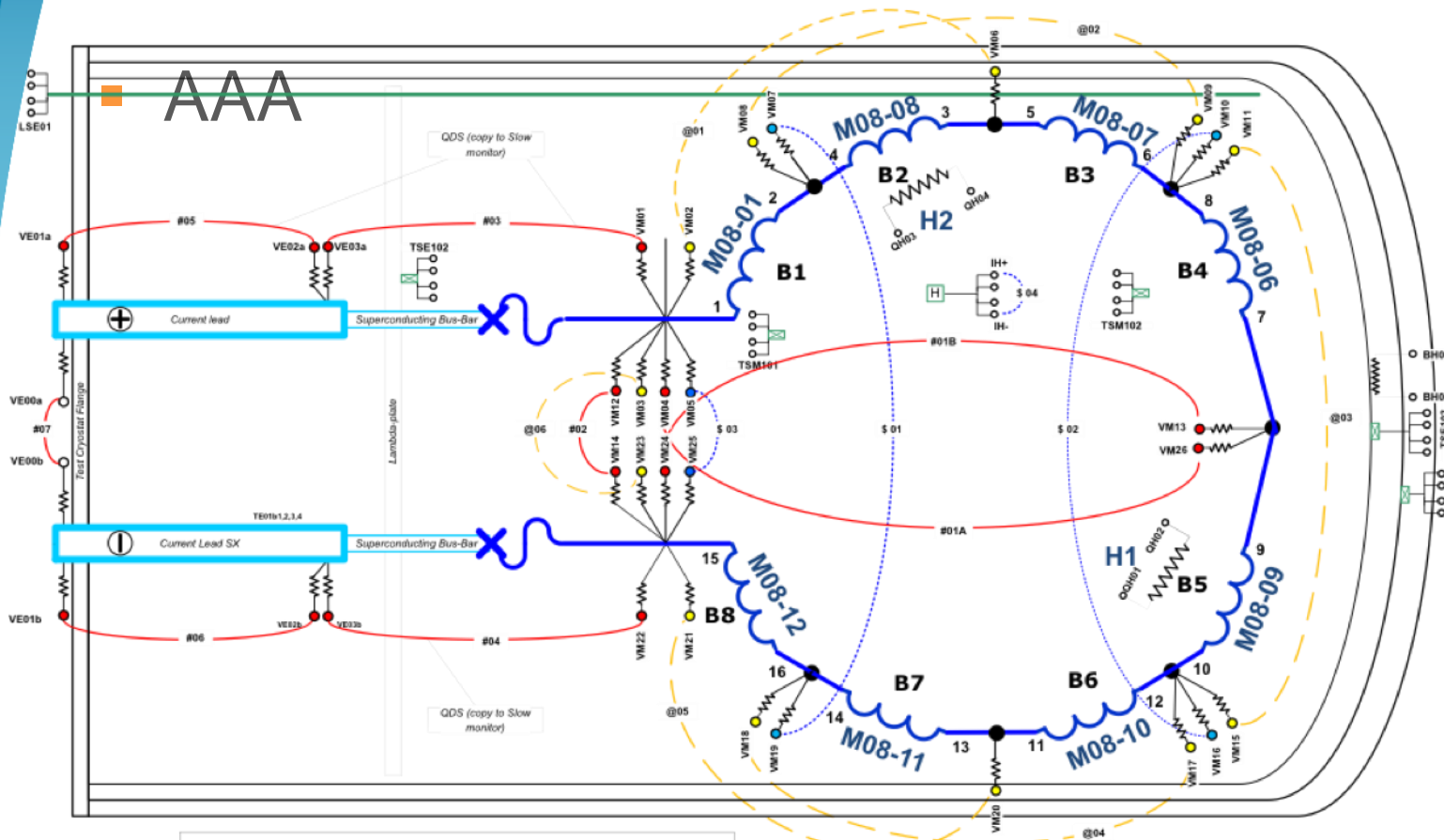
alignment frame

CuBe rods

8POLE: assembly 2



CONNECTIONS



B1	M08-01
B2	M08-08
B3	M08-07
B4	M08-06
B5	M08-09
B6	M08-10
B7	M08-11
B8	M08-12

PROTECTION ————
 @ FAST ACQ - - - - -
 \$ GP (VI) ······

The two wires form a twisted pair

● Voltage tap: protection
 ● Voltage tap: fast acquisition
 ● Voltage tap: general purpose (VI)

Temperature sensor (CGR, RTD) shown with its 4 leads

Protection resistance of magnet voltage taps TBD

Sensor code

TSM Magnet Temperature Sensor
 TSE System Temperature Sensor
 VM Magnet Voltage
 VE Connection system Voltage
 QH Quench heater

TSM, VM, and QH signals are on the cold mass
 TSE and VE signals are on the supporting system

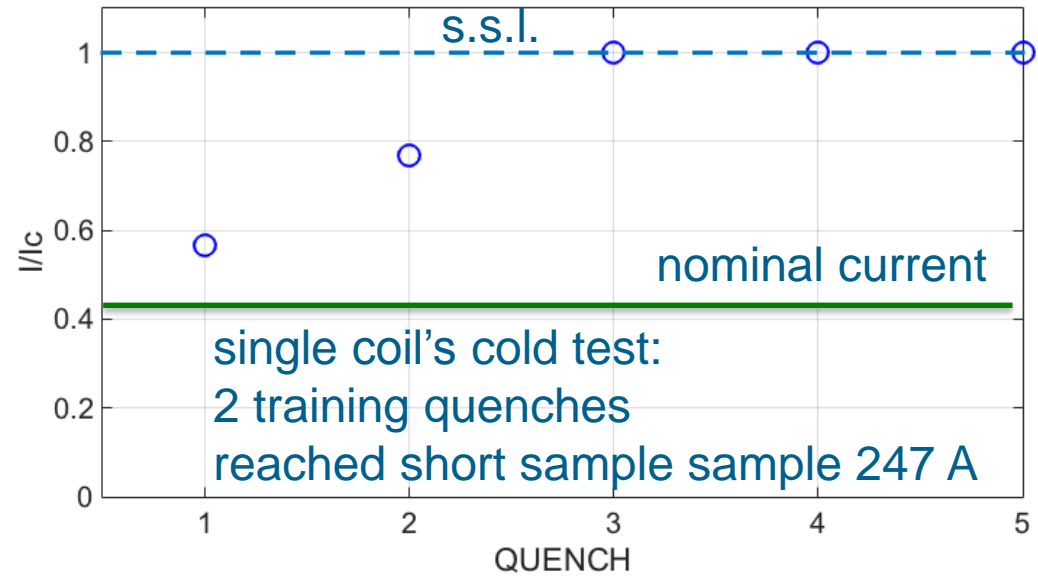
INFN Milano
 LASA lab
 Quadrio
 26/10/2016



8POLE: COILS

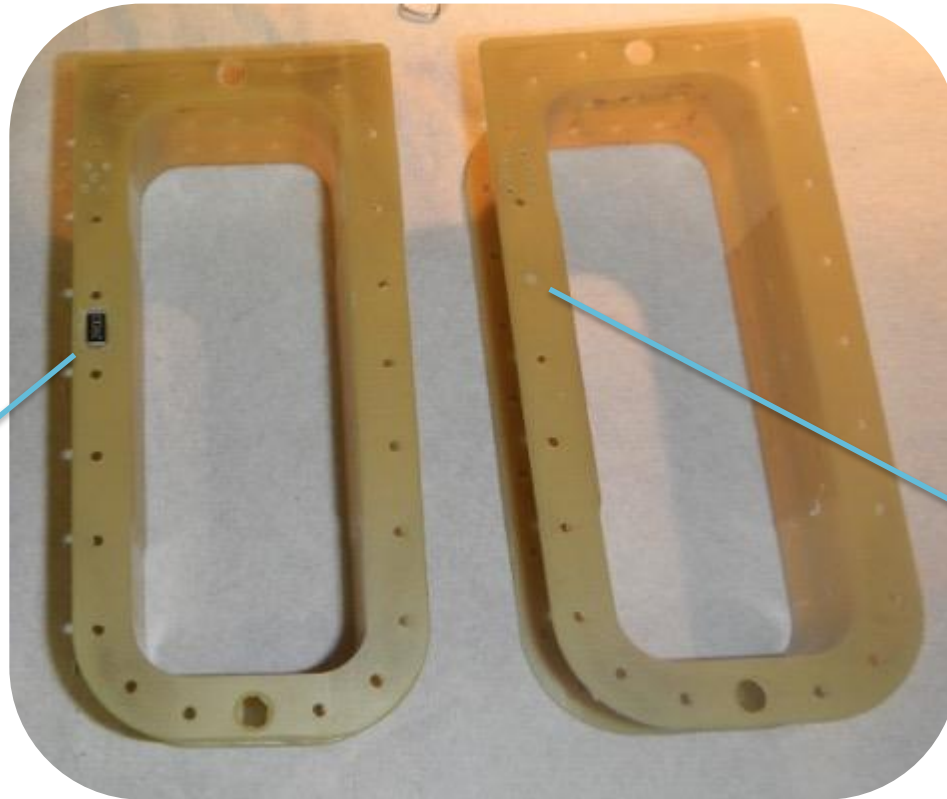
coils' assessment

- geometry
- resistance
- HV insulation



HEATERS

- two heaters are installed
- on coil B5 the duratron thickness was reduced by hand
- on coil B6 a Φ 2 mm AlN ceramic insert in the hole
- quench induced at 4.2 K, $I = 73$ A



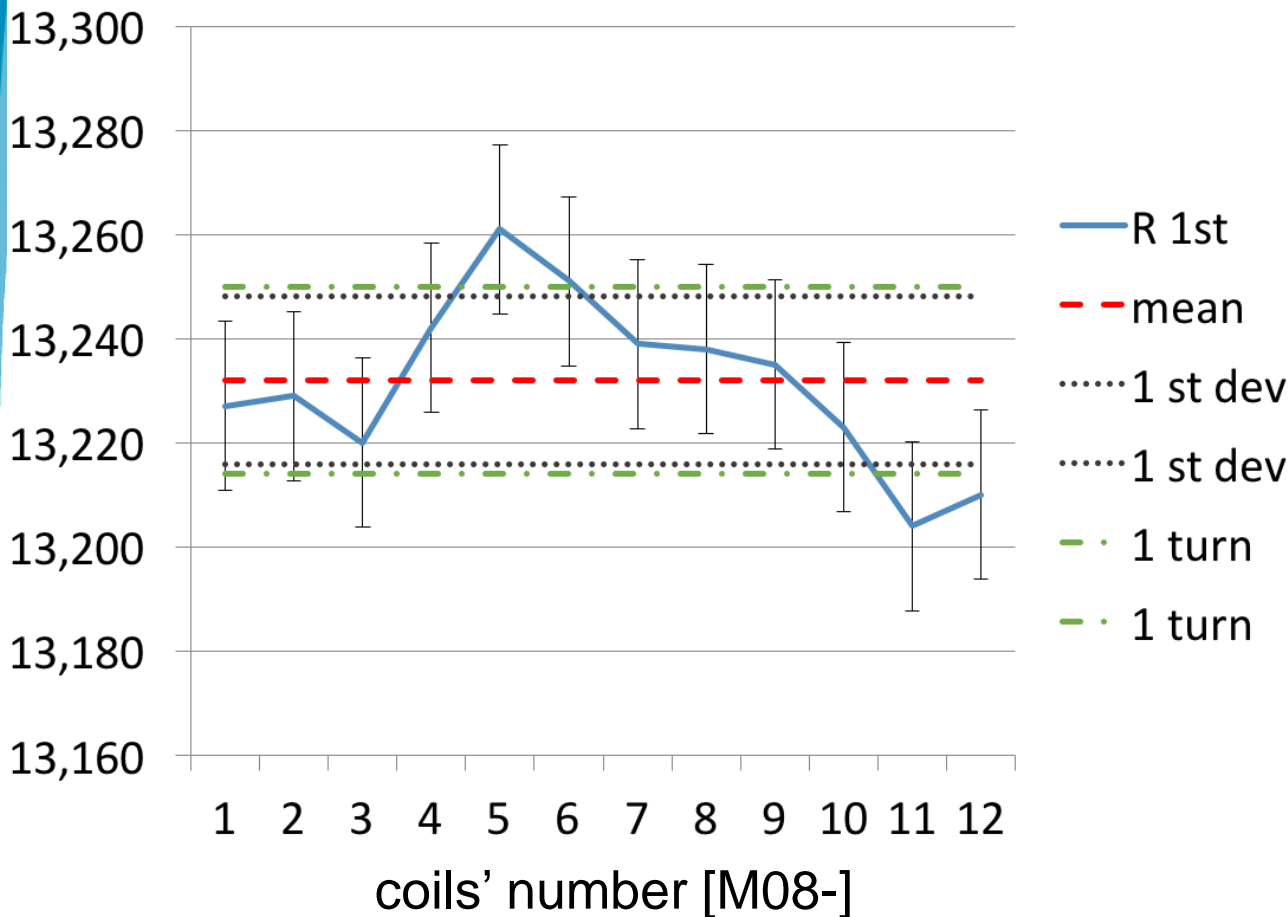
AlN
1 mm thick
By INTELLION S.a.r.l.

RESISTANCE - INSULATION

Ground insulation @5 kV [TΩ]



resistance [Ω]



B1	M08-01	1.86
6 parts	M08-02	>5.05
alt. cut	M08-03	>5.05
spare	M08-04	>5.05
spare	M08-05	>5.05
B4	M08-06	>5.05
B3	M08-07	>5.05
B2 Hr	M08-08	>5.05
B5 Hc	M08-09	>5.05
B6	M08-10	>5.05
B7	M08-11	>5.05
B8	M08-12	2.18

GEOMETRY

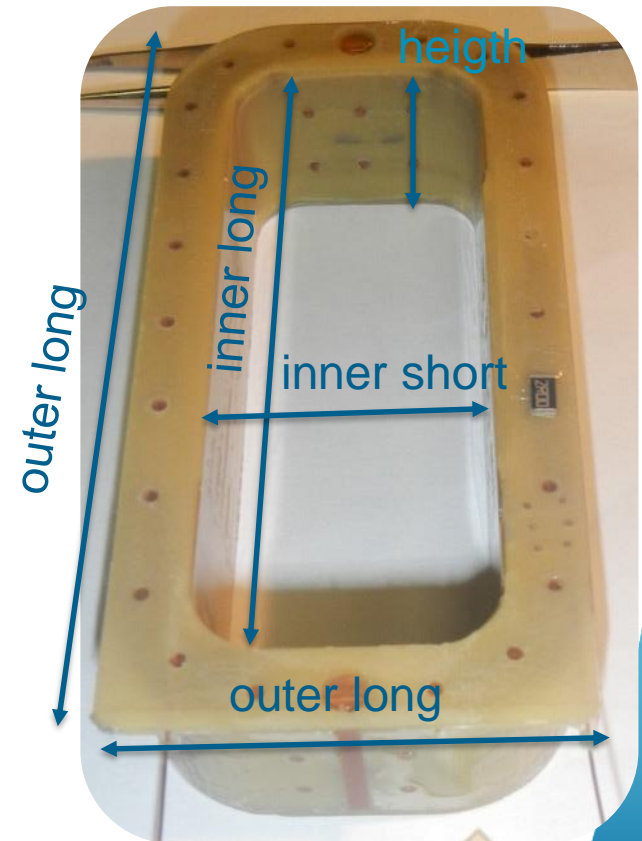
	nominal	mould	mean	std
height	25.7	A	26.65	0.04
		B	25.79	0.14
		C	25.66	0.09
inner long	99.2	A	99.53	0.10
		B	99.70	0.34
		C	99.54	0.21
outer long	119.6	A	119.20	0.07
		B	119.57	0.06
		C	119.33	0.22
inner short	35.8	A	36.35	0.13
		B	36.22	0.21
		C	36.22	0.14
outer short	56.2	A	55.79	0.02
		B	55.87	0.10
		C	55.80	0.16

all dimensions in mm

Good repeatability

6pole average σ 0.09 mm

8pole average σ 0.13 mm



8POLE TEST

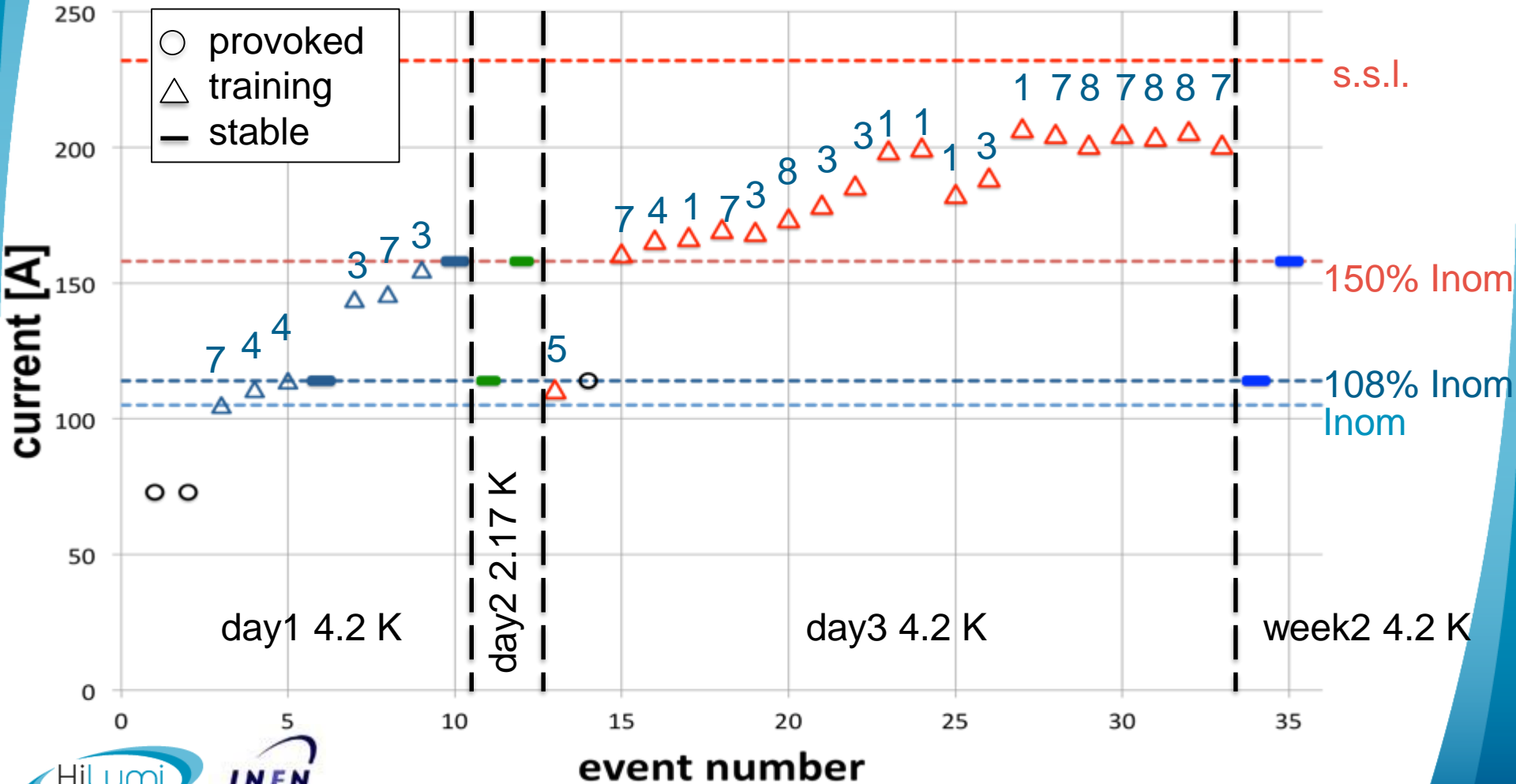
- qualification @ 4.2 K
- qualification 1h @ 108% @2.2 K
- training @4.2 K
- working condition test
w/o energy extraction
- thermal cycle
- qualification @ 4.2 K



IN MEMORY OF
GIOVANNI VOLPINI
1963 - 2016

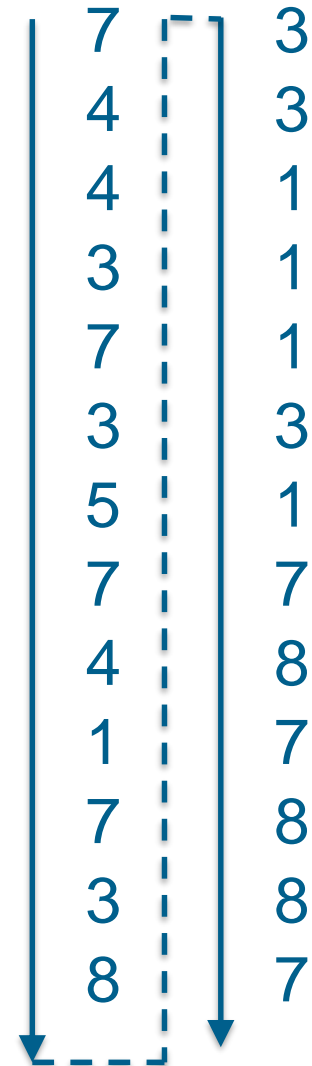
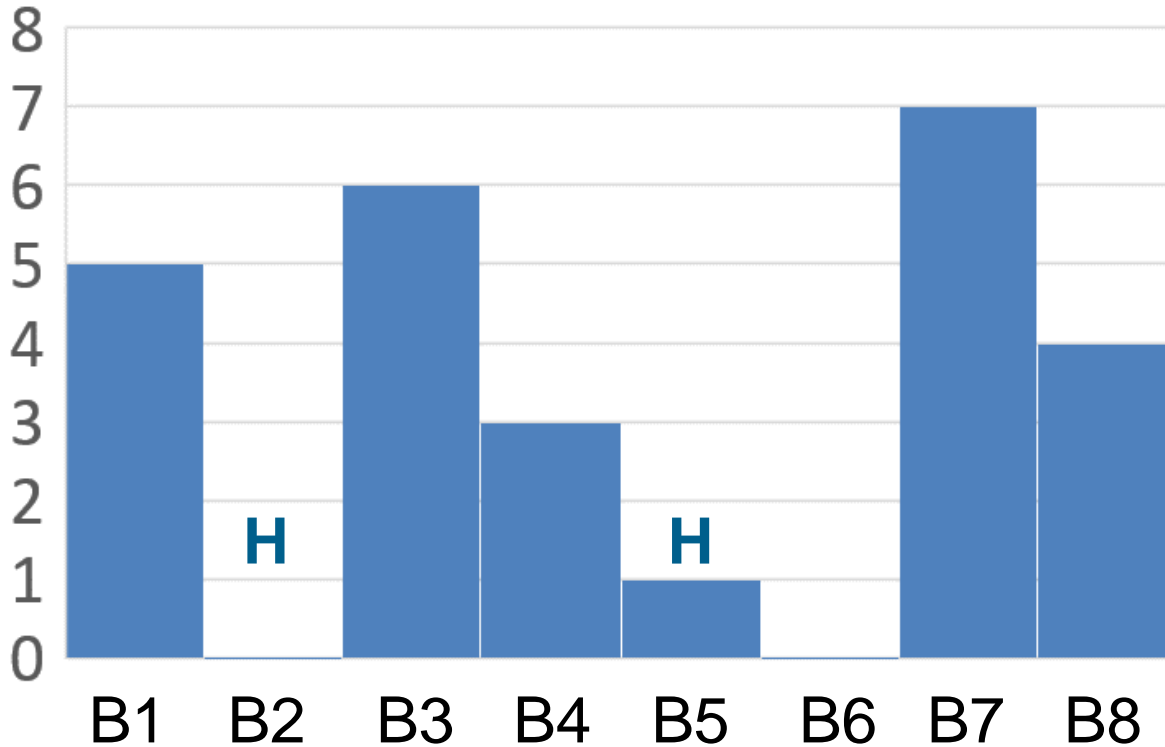
8POLE TRAINING

- stable at ultimate current (108% Inom) and at 150% Inom
- 26 quenches – $I_{ult} = 207$ A (89.2 % s.s.l.)



QUENCH SEQUENCE

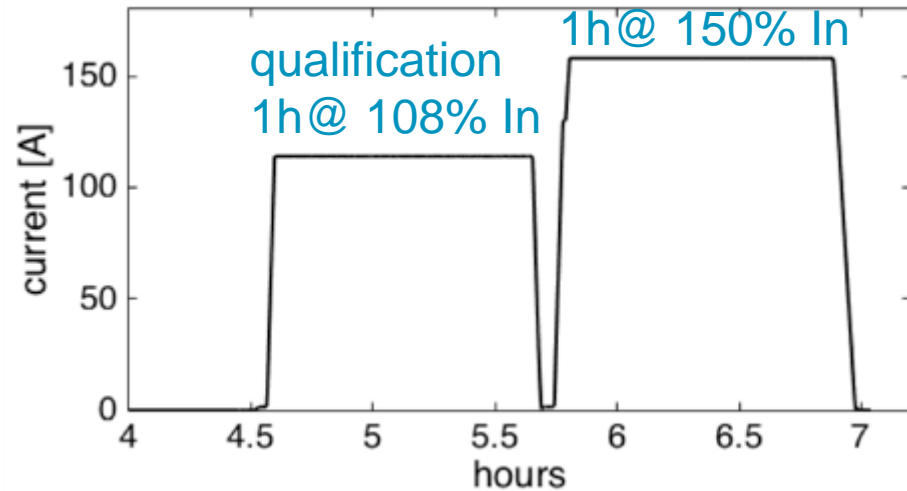
- not all coils have training
- single coil tested (B1) has training $I > 150\%$ I_{nom}
- no evidence of induced quench effect



8POLE COLD TEST RESULTS - 2

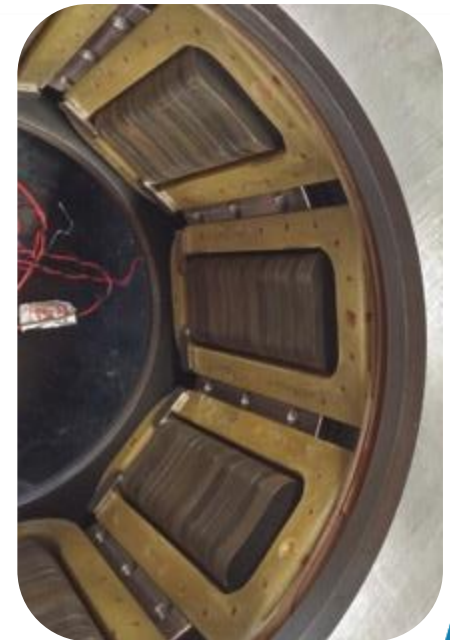
He II test: 2.17 K

- 1h @ 108% I_{nom} (114 A)
- 1h @ 150% I_{nom} (158 A)
- no quenches occurred

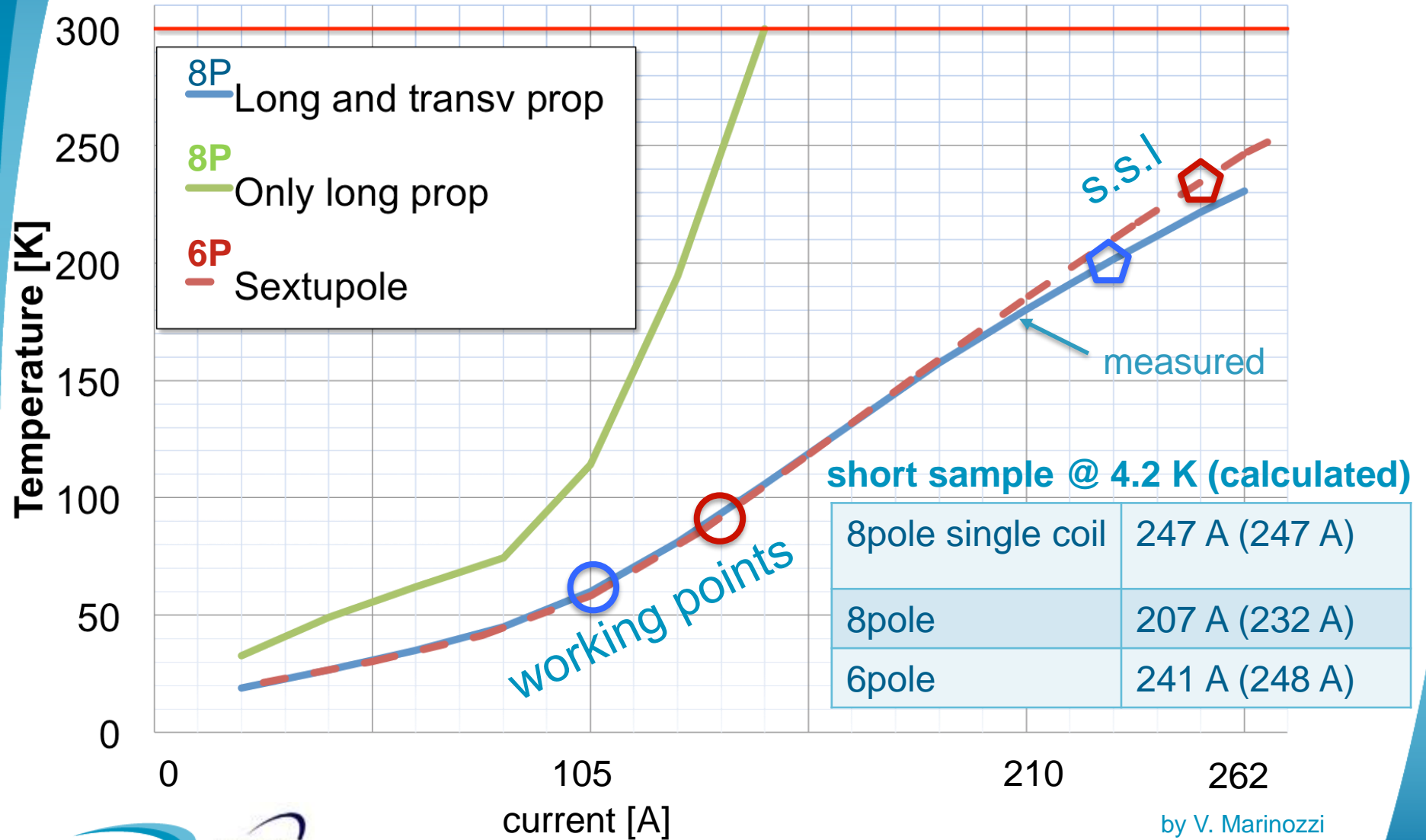


tests @ 4.2 K

- full training: I_{max} 90% of s.s.l.
- working condition test (w/o energy extraction)
- qualification @4.2 K after a thermal cycle
- preliminary single point field measurement: agreement with simulations, good repeatability
- field quality measurement @CERN



8POLE WORKING POINT

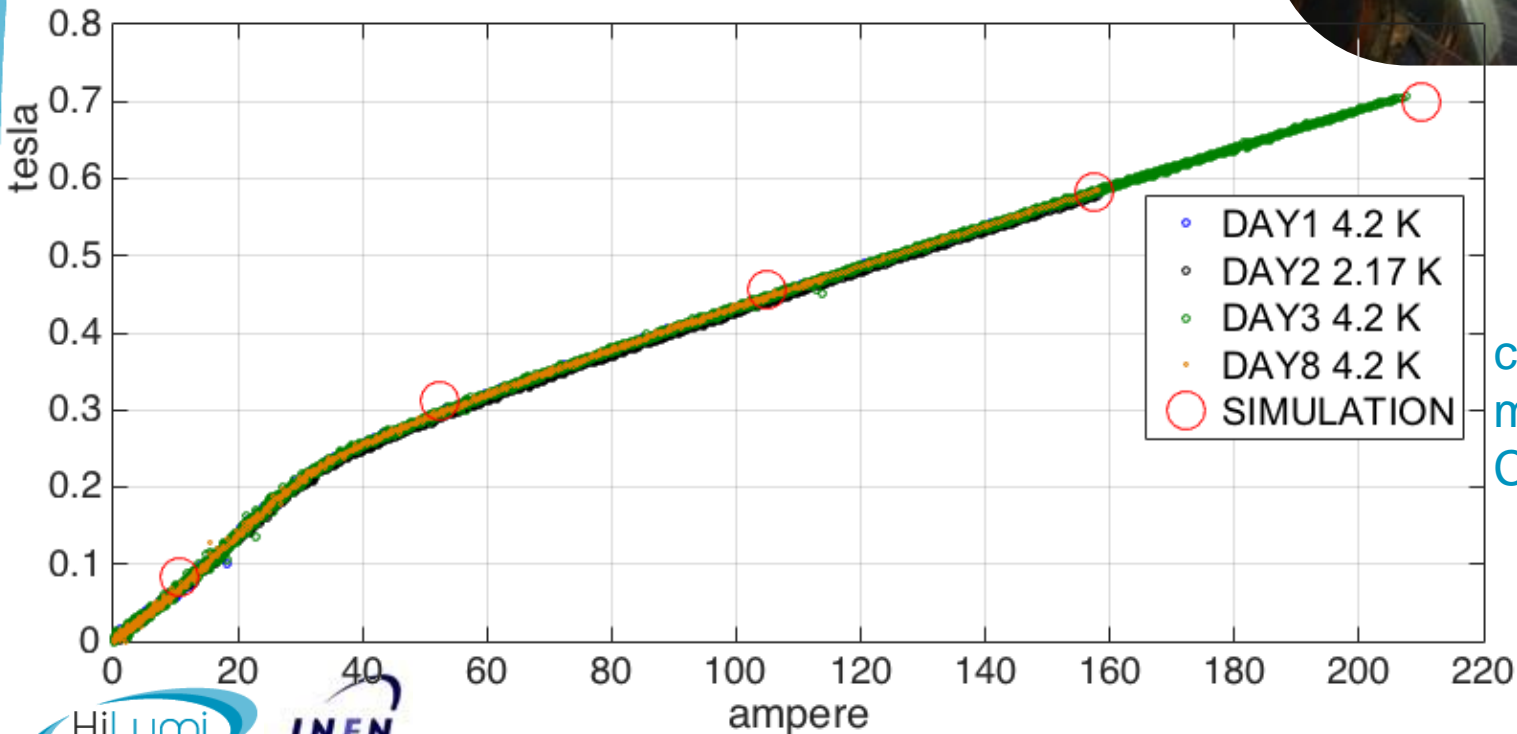


by V. Marinozzi

PRELIMINARY FIELD MEASUREMENT

preliminary measurement of the field

- single point
- in front of a pole
- radius of 50 ± 1 mm (correction applied)



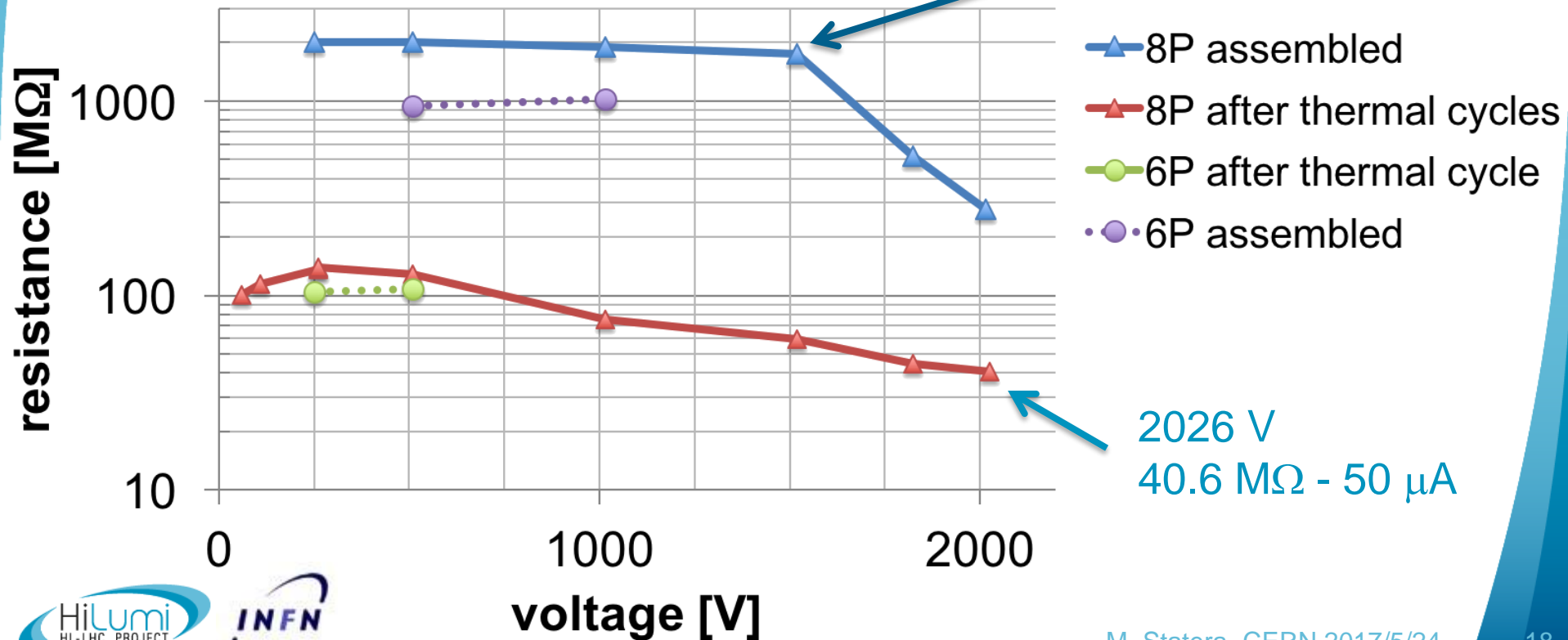
reproducible
5 mT
saturation 30 A

complete
measurement at
CERN is required

8POLE GROUND INSULATION

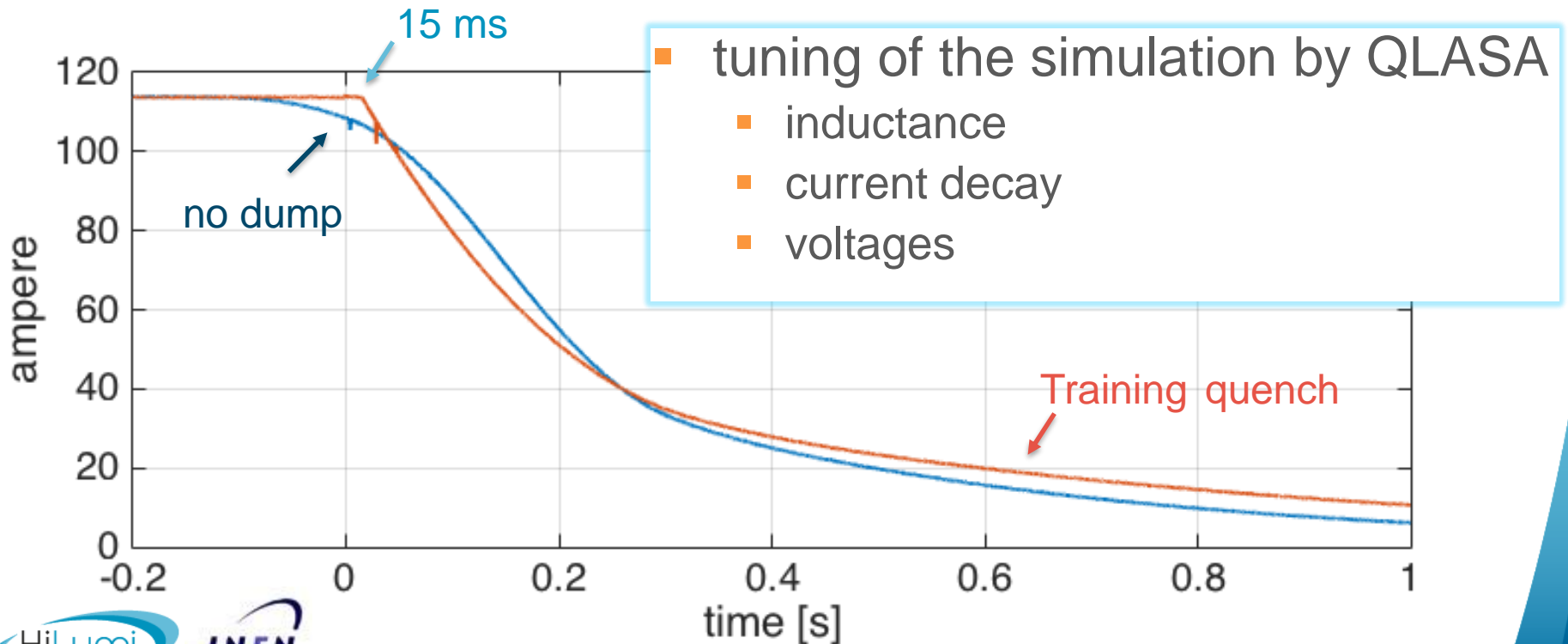
- same values during the assembly and at fully assembled magnet
 - coil vs iron yoke
 - circuits and connections vs return yoke
- improvement compared to the 6pole
- max voltage in working condition 50 V

drop @ 1.8 kV

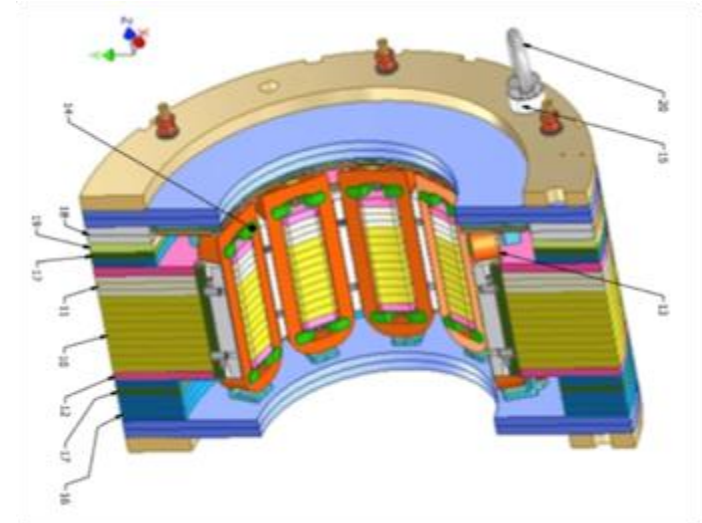
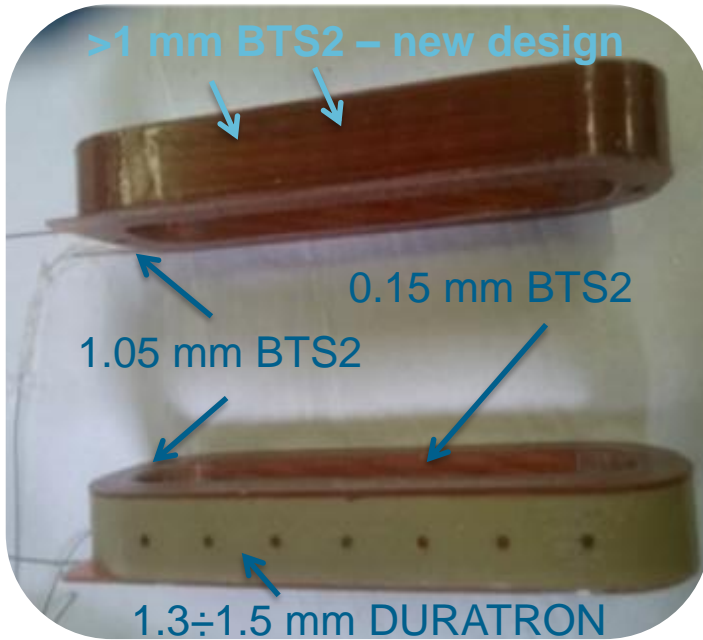


WORKING CONDITION TEST

- threshold up to 5.0 V (differential voltage)
- quench starts 130 ms before trigger (system dependent)
- total time before relay opening: 145 ms
(opening time in operation 60-180 ms)
- $\Delta I = 8 \text{ A @ } 145 \text{ ms PS dependent}$



10POLE



- mechanics procured
- coils updated parts procurement ongoing
- assembly and test: June



FIBER REINFORCED MATERIALS

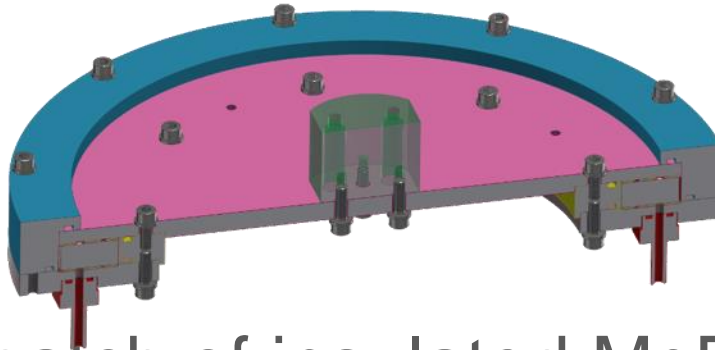
- COILS
 - hybrid BTS2/DURATRON construction tested
 - Full BTS2 construction v2 in preparation
thermal cycle test before decapole assembly
- Electrical connections
 - ARLON 85 printed boards tested

DURATRON and Arlon 85 are approved?

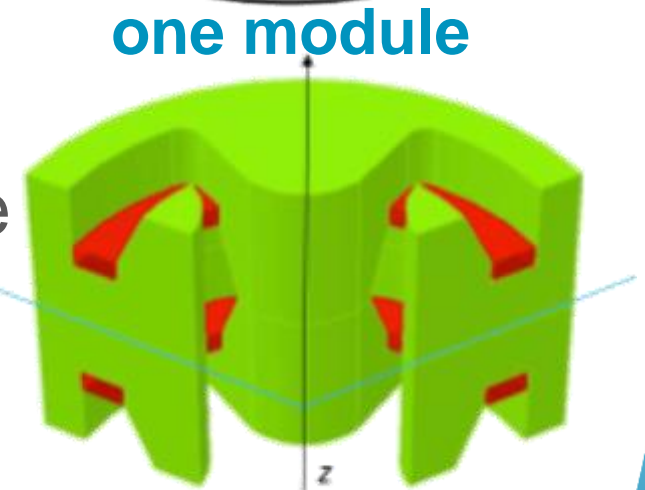
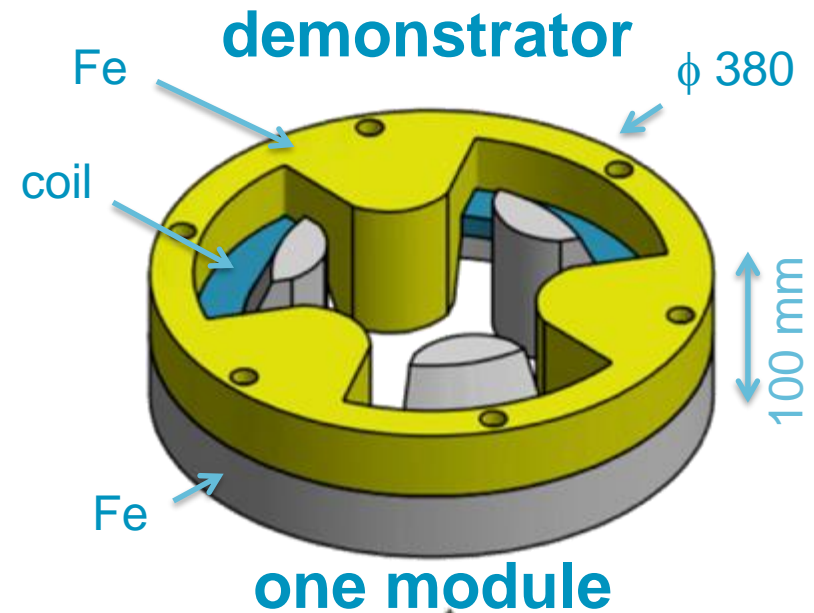
ROUND COIL MAGNET

demonstrator

- mechanics design ongoing
- mould designed



- first batch of insulated MgB_2 wire ready for delivery at LASA



G. Volpini et al. Electromagnetic Study of a Round Coil Superferric Magnet, IEEE Tr. App. Sup, 26, 4 (2016)

DODECAPOLE AND QUADRUPOLE

- tender approved by INFN
- tender launched
- companies are preparing the quotations
- unofficial (technical) award: June 2017
- end of the procedure: September 2017

CONCLUSIONS

- Octupole successfully tested
- decapole's modified coils production ongoing
- fiber reinforced material: approval pending
- first test MgB_2 coil for round coil: preparation is ongoing
- dodecapole and quadrupole tender launched

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THANK YOU

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GIOVANNI VOLPINI
1963 - 2016