CAN WE INCREASE THE HIGH ORDER CORRECTORS INTEGRATED GRADIENTS?

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INFN Milano - LASA

CERN, 21 February 2017

OUTLINE

- Introduction
- Scenarios
- Are they effective?
- What is required?
- Conclusions

INTRODUCTION

MAIN PARAMETERS

- Integrated field
- Harmonics

CONSTRAINTS

- Current

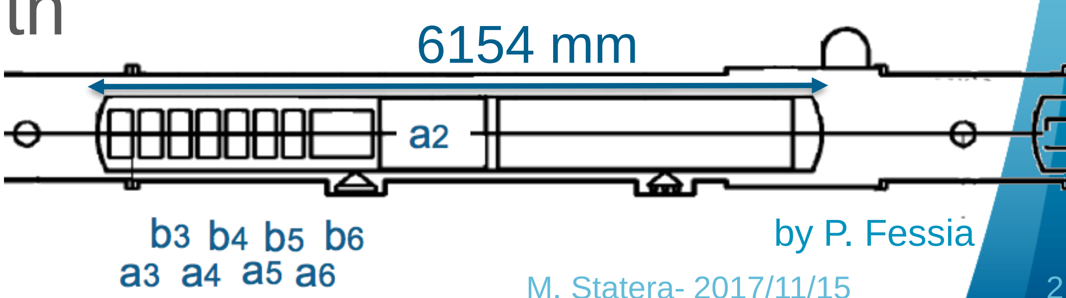
  I_{op}=105 A / 182 A
- Self protected (but 4P)
- Flange to flange length
- Radiation (15 MGy)

TABLE I
MAIN ELECTRO MAGNETIC PARAMETERS OF THE CORRECTOR MAGNETS

Magnet	Type	Integr. field at r=50 mm	Magnetic Length	Coil Peak Field	Magnetic stored energy	Operating Current	Turn per coils
		T·m	m	T	kJ	A	-
Quadrupole	S	1.016	0.671	3.53	36	182	754
Sextupole	N,S	0.064	0.140	2.14	1.2	132*	216*
Octupole	N,S	0.046	0.099	2.06	1.1	105	372
Decapole	N,S	0.026	0.097	1.73	0.5	105	372
Dodecapole	N	0.086	0.471	1.44	7.8	105	432
Dodecapole	S	0.017	0.089	1.44	~0.9	105	432

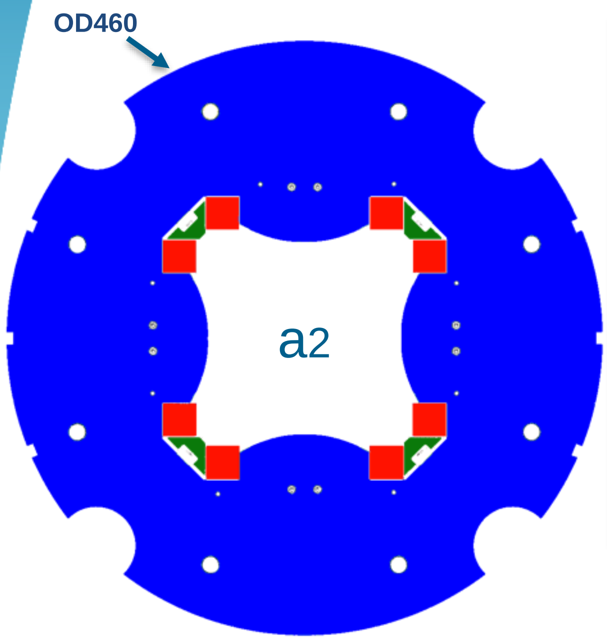
* Value of the prototype, to be scaled for the series production.

M. Sorbi et al. MT25, M. Statera et al. EUCAS 2017

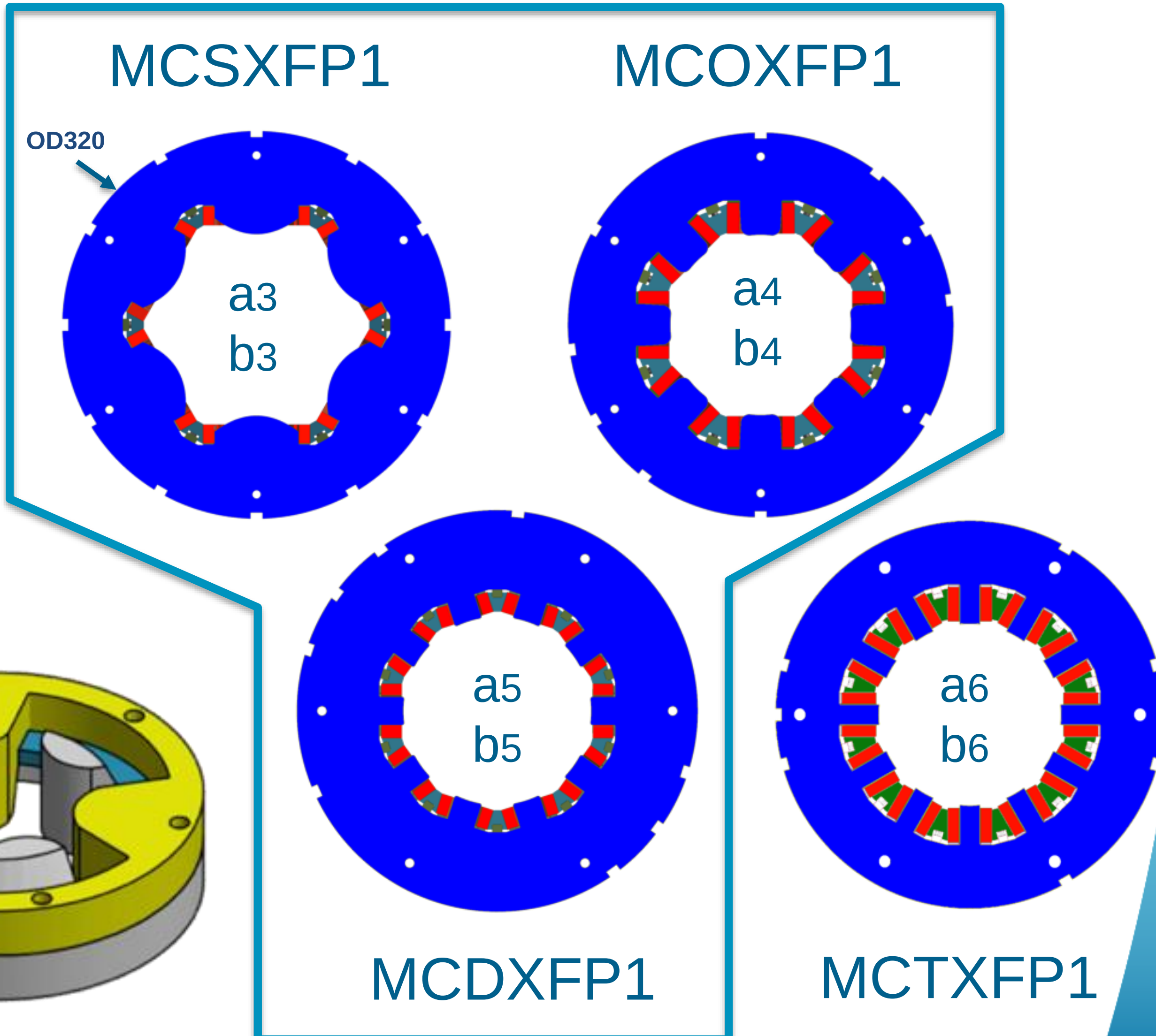


by P. Fessia

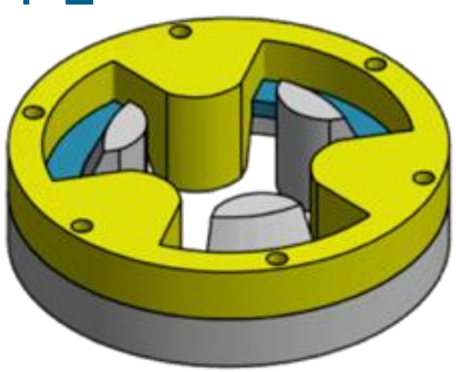
HO CORRECTOR MAGNETS ZOO



MQSXFP1



MgB_2
round coil



CAN WE INCREASE THE GRADIENTS?

- Strength increasing 25/30% or 50%
- Two approaches: increasing → **LENGTH** / → **CURRENT**

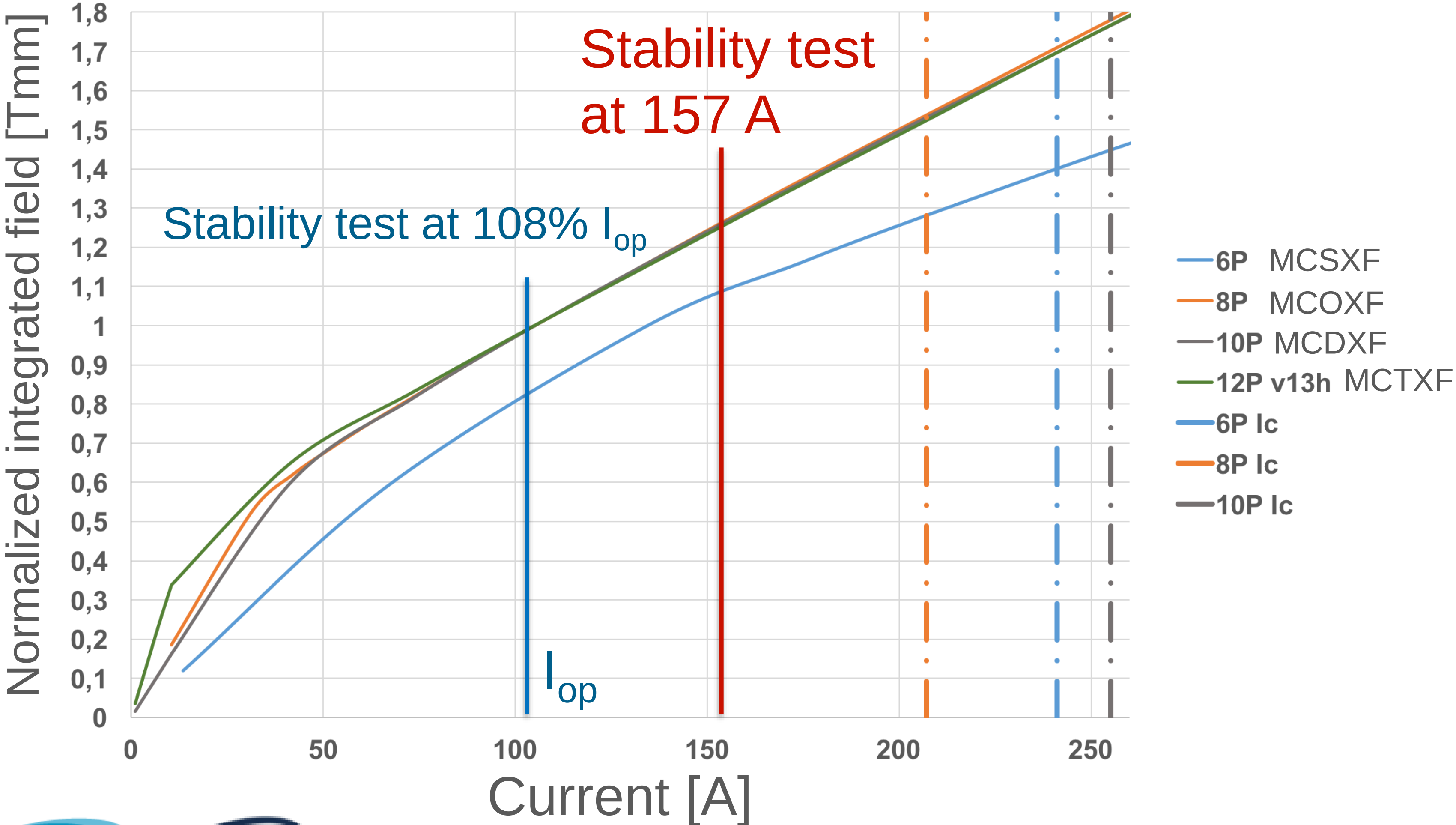
Increasing **current**	Increasing **length**
• PS/feedthrough to be updated? • Do we have (enough) margin? • No geometry changes	• Same operational current (105 A) • How much longitudinal space? (cold mass and cryostat)

- Energy extraction required?
- Maximum voltage?

INCREASING CURRENT

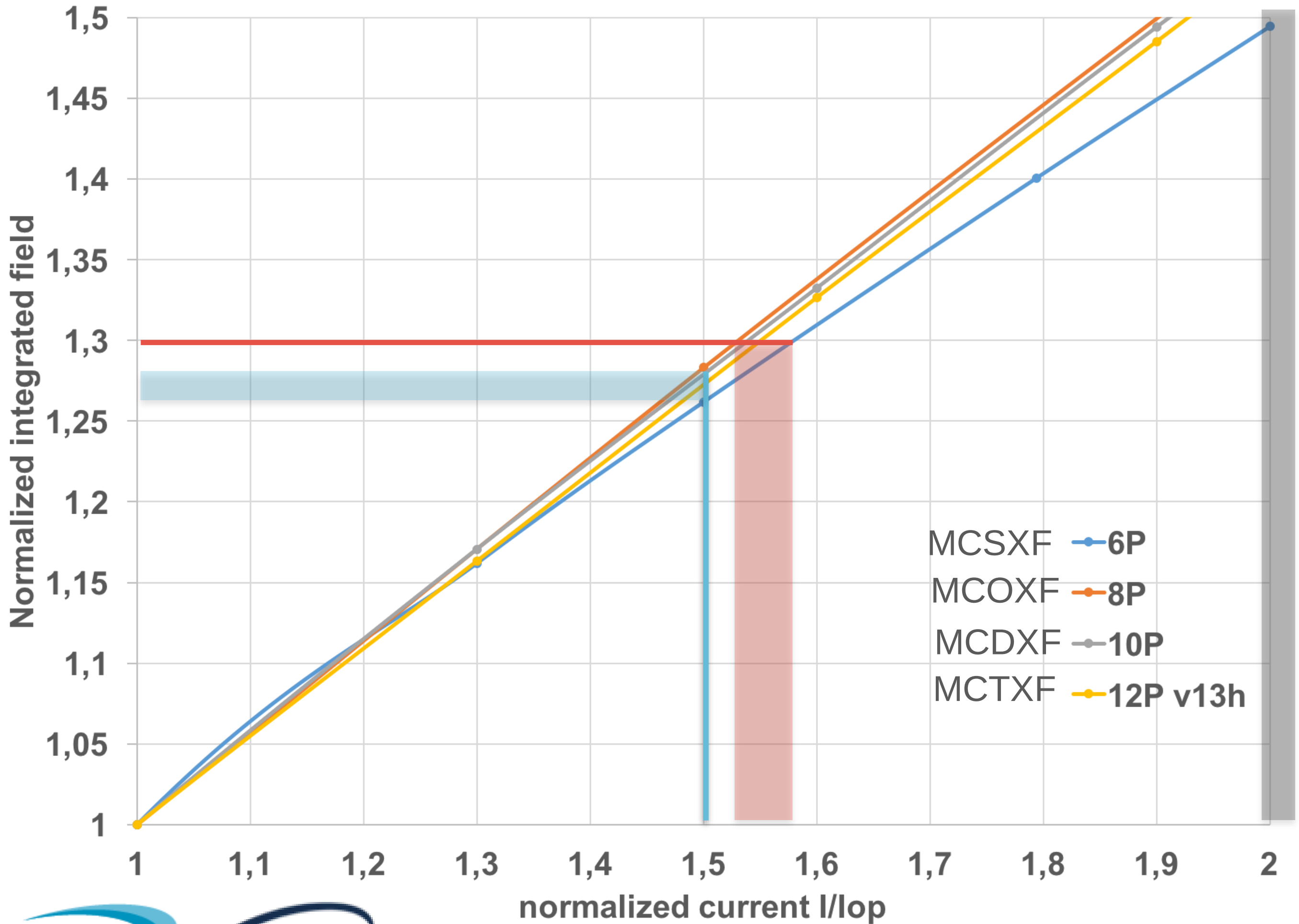
- Very same geometry

Measured critical currents **above 200 A**



HOW MUCH CAN WE REALLY INCREASE?

- How much can we really increase?



critical zone
But 6P

+25% tested
margin >24%

+30%
Margin >20%
but 6P

INCREASING LENGTHS

- ‘short’ HO correctors are fringe field dominated
- A length increase is effective

Flange to flange length and increase required for a 50% increase in integrated field

magnet	MCSXF	MCOXF	MCDXF
actual length [mm]	185	183	183
Increase [mm]	60	50	50

FIELD QUALITY

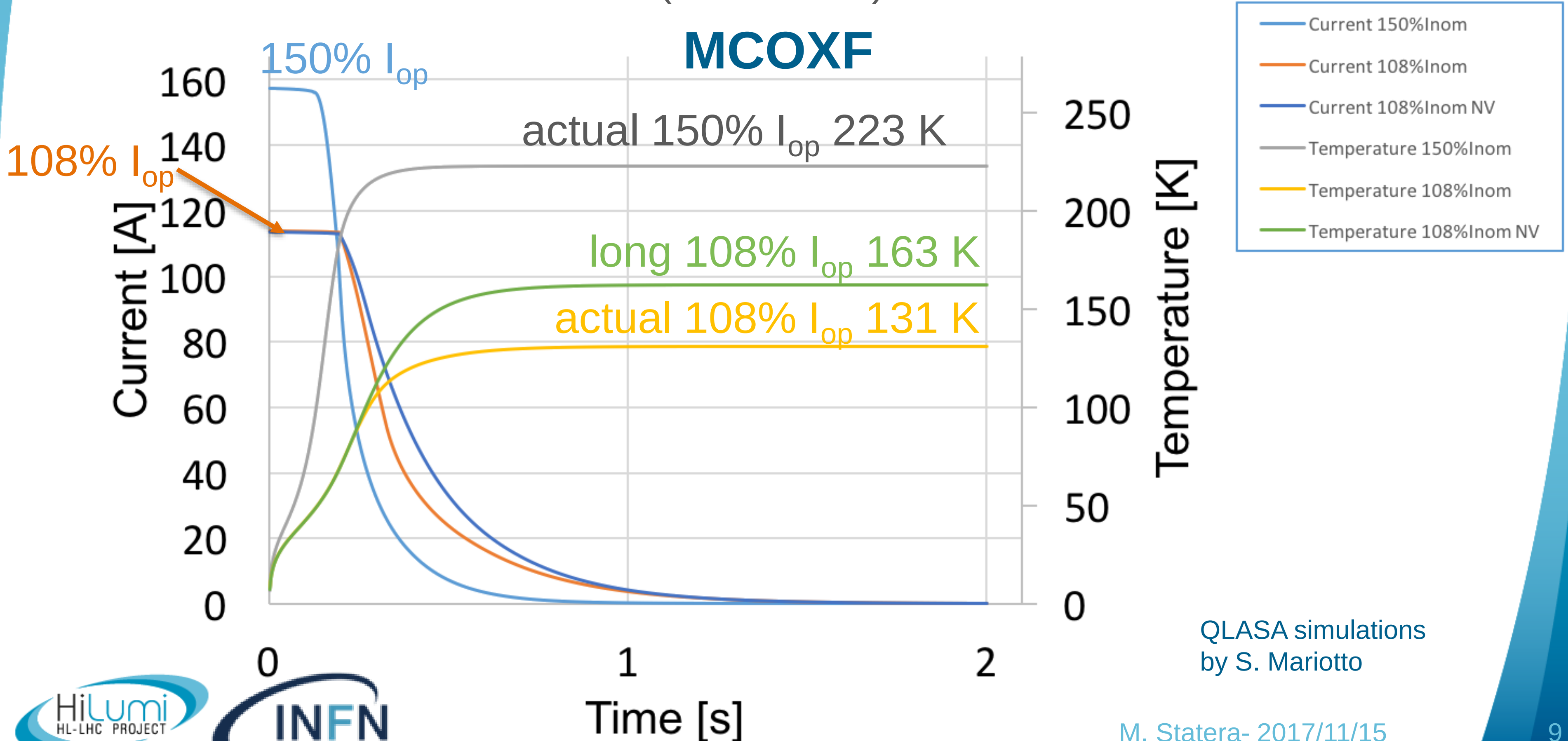
- **MCOXF**: full analysis performed
- Other short correctors: analysis ongoing

	MCOXF I_{op}	MCOXF 150% I_{op}	MCOXF +50 mm - I_{op}
Fist harmonic A12	11.8	15.3	11.8
Second harmonic A20	-2.9	-2.4	-2.9
Total	<15	<20	<15

Both scenarios within specs

QUENCH PROTECTION

- CERN protection scheme
  - No energy extraction
  - PS maximum voltage 10 V
  - Quench detection by current decay
  - Detection time 180 ms (worst case)



QLASA simulations
by S. Mariotto

QUENCH PROTECTION II - VOLTAGE

No dump	MCSXF I_{nom}=134 A	MCOXF I_{op} (150% I_{op})	MCOXF +50 mm - I_{op}	MCDXF I_{op}	MCTXF I_{op}
Peak voltage to ground	135 V	70 V (282 V)	117 V	36 V	251 V
Hot spot temperature	164 K	131 K (223 K)	163 K	122 K	147 K
HV test at RT	1.5 kV	1.5 kV (2.2 kV)	1.5 kV	1.5 kV	2.0 kV

Designed for 2kV
Possible solution: energy extraction

QLASA simulations by V. Marinozzi and S. Mariotto

Room Temperature test
V_{test}=(2 x V_{mx} + 500) x2

HO correctors tested
V_{test} 1.5 kV at RT
But 4P and 12P
Note: 6p to be reviewed

EFFECTIVE?

- Increasing current
  - +25% strength
  - Self protected (no energy extraction)
  - Redesign for HV insulation or introduce energy extraction
  - New power supplies **required**
- Increasing length
  - +50% strength
  - Self protected (no energy extraction)
  - Same PS (120 A)
  - Total length increase about 320 mm (cold mass)
  - Updated prototypes may be **required**

- Redesign required for **MCSXF**

CONCLUSIONS AND NEXT STEPS

- Two effective scenarios to increase strength of short HO correctors
- Increasing current
  - +25%
  - Ground insulation to be managed (or **energy extraction**)
- Increasing length
  - +50%
  - Cold mass 320 mm longer
  - Small changes, **updated prototypes** may be required
- Next steps
  - Detailed analysis of one scenario
  - Decision before tender for series production
  (see M. Sorbi talk)

THANK YOU

LASA team

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