INTERACTION REGION MAGNETS

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OUTLOOK

- We started the protection work favoring the energy extraction option
  - Having seen the overhaed for operation and the risk/faults associated to quench heaters
- After cost and schedule review we decided to remove the energy extraction for the high current (>10 kA) system because of their cost (millions)
- Panorama of protection systems in LHC given by B. Auchmann in WP3 meetings
  - Many different solutions according to the zoo
- For the intermediate current (single aperture orbit correctors, at 2 kA) designers would prefer avoid quench heaters
- For the high order correctors we explore the options of self protection (power converter crowbar, with a 50 V max)

OUTLOOK

- General feature: HL LHC has independently powered magnets with few exceptions
- For the intermediate current (single aperture orbit correctors, at 2 kA) designers would prefer avoid quench heaters
  - Preliminary simulations in CIEMAT
- For the high order correctors we explore the options of self protection (power converter crowbar, with a 50 V max)
  - Ongoing work in LASA
- For the D2 Q4 correctors we just decided to change from Rutherford cable 2 kA to a ribbon cable with 500 A, so we have not yet estimates
  - We have to wait for final design of ribbon to know inductance, etc and see how to protect

Main magnets

- D1, D2, Q4
  - No dump resistor to save money on the switches
  - Energy density on the coil between 0.040 and 0.070 J/mm^3, values similar to typical Nb-Ti magnets
- Quench heaters on the outer layer
  - D1, D2 are single layer so even more efffective than in the LHC dipoles
  - Q4 has double layer but heaters will work as well
    - If switches are available consider extraction ?
- CLIQ a viable option
  - Cost to be estimated
  - D1 and D2 in series to be considered

Orbit correctors

- Two lengths, and two circuits (V and H) so four cases
- Protection with energy extraction and 500 V looks easy
- Possibility of relying on the power converter: resistor can tolerate at max 80 V
  - This solution seems beyond our target
  - This is a first estimate, iteration with PC needed
  - Simulations including quench propagation needed, work to be ddone in CIEMAT and CERN

	I (kA)	L (mH)	V (V)	Dump (mΩ)	τ (s)	MIITs	Cable MIITs
MCBXFB V	1.60	56	80	50	1.13	1.44	1.0
MCBXFB H	1.47	119	74	50	2.38	2.57	1.0
MCBXFA V	1.60	103	80	50	2.07	2.65	1.0
MCBXFA H	1.47	218	74	50	4.36	4.71	1.0

Nonlinear Correctors

- With 50 V, protection possible for short magnets
  - Sextupole octupole decapole, skew dodecapole
- For normal dodecapole and skew quadrupole larger stored energy and inductance
  - Estimates ongoing

	I (kA)	L (mH)	V (V)	Dump (mΩ)	τ (s)	MIITs	Strand MIITs	time left
sextupole	0.13	118	52	400	0.30	0.002	0.0036	0.066
dodecapole	0.17	229	50	300	0.76	0.011	0.0036	
quadrupole	0.18	1247	55	300	4.16	0.069	0.0138	

CONCLUSIONS

- D1, D2, Q4
  - Quench heaters is the baseline
  - CLIQ option to be studied and estimated
    - If cost and risks are not larger then heaters, I would go for it
- Orbit correctors
  - Protection on the PC looks difficult, more simulations needed
- High Order correctors
  - Protection on the PC looks viable for sex, oct, dec, and skew dod
    - Lowering the current to match the 120 A PC must be assessed
  - Skew quadrupole is a big beast and may need extraction
  - Probably also normal dodecapole should follow the same strategy