

LARP

Cold powering test requirements for HL LHC: MQXF

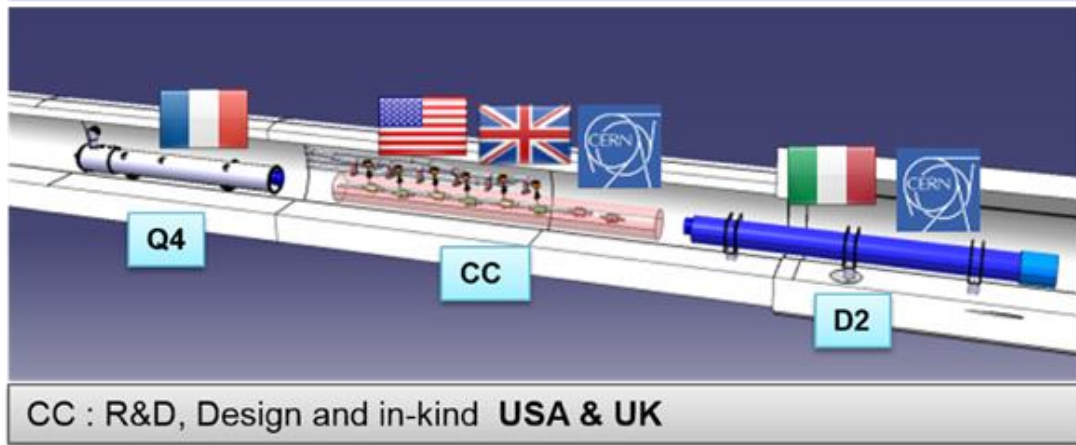
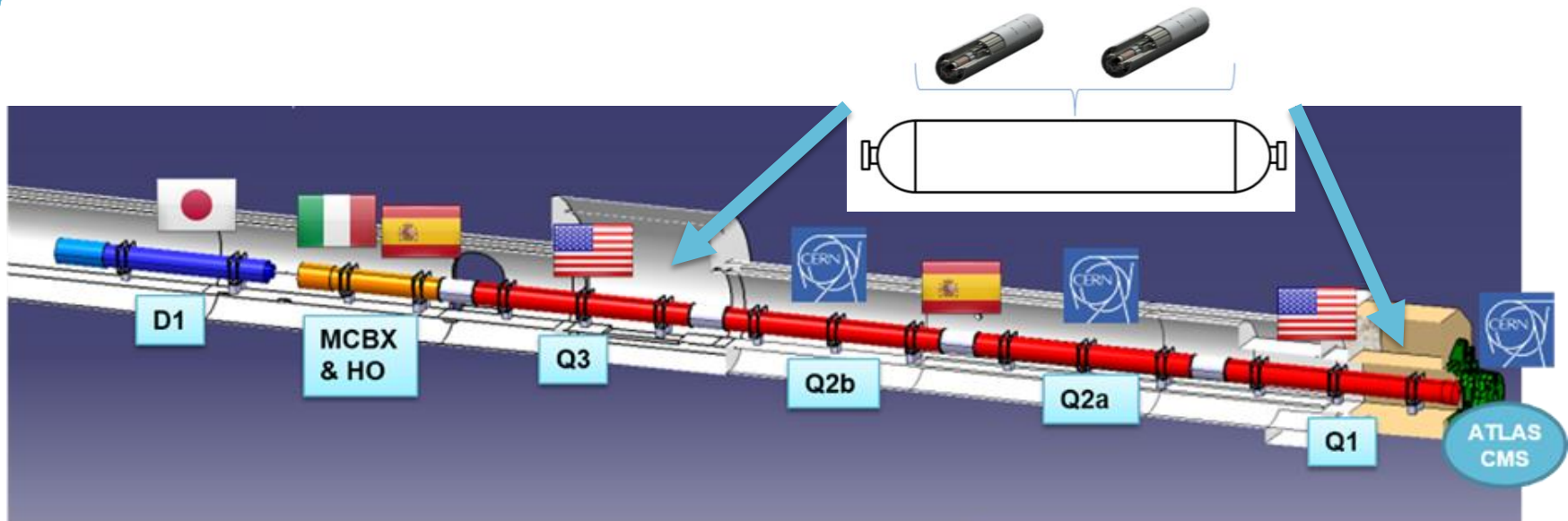
G. Ambrosio

1st International Workshop of SC Magnet Test Stands
CERN, June 13th – 14th, 2016

Outline

- MQXF Magnets
- MQXFA Functional Test Requirements
 - Test Objectives for Prototypes
 - Test Requirements

MQXFA/B: Magnets for LHC Inner Triplet Upgrade



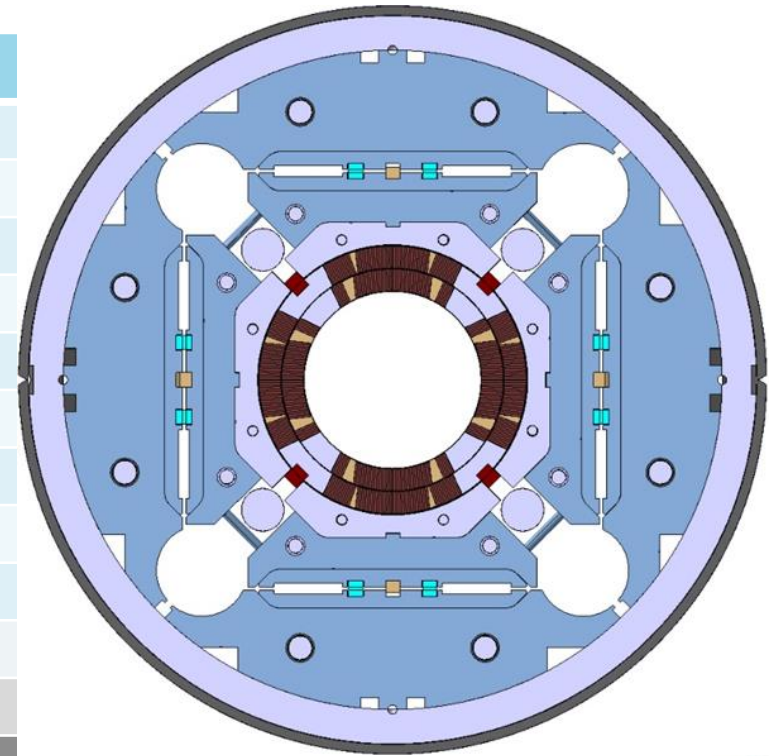
Q1-Q3 : R&D, Design, Prototypes and in-kind **USA**
 D1 : R&D, Design, Prototypes and in-kind **JP**
 MCBX : Design and Prototype **ES**
 HO Correctors: Design and Prototypes **IT**
 D2 Design **IT**
 Q4 : Design and Prototype **FR**

CC : R&D, Design and in-kind **USA & UK**

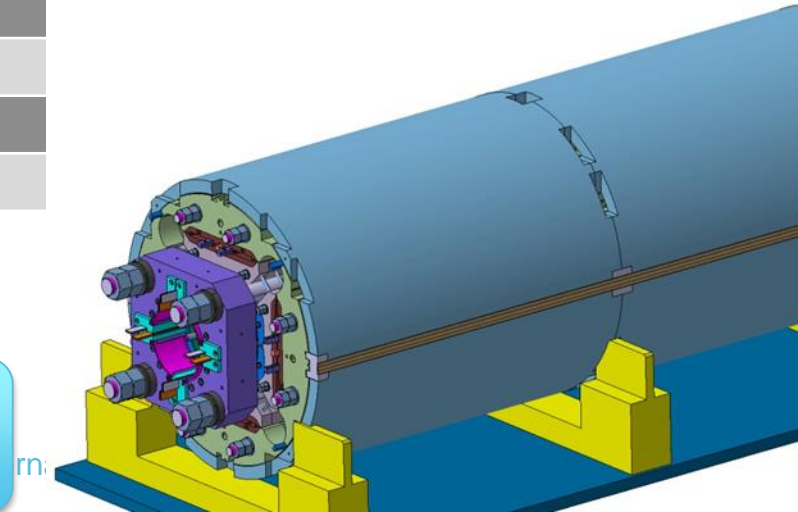
International collaborations: an opportunity and a challenge, also for testing!

MQXFA/B Magnets

PARAMETER	Unit	MQXFA/B
Coil aperture	mm	150
Magnetic length	m	4.2/7.15
N. of layers		2
N. of turns Inner-Outer layer		22-28
Operation temperature	K	1.9
Nominal gradient	T/m	132.6
Nominal current	kA	16.5
Peak field at nom. current	T	11.4
Stored energy at nom. curr.	MJ/m	1.17
Diff. inductance	mH/m	8.2
Strand diameter	mm	0.85
Strand number		40
Cable width	mm	18.15
Cable mid thickness	mm	1.525
Keystone angle		0.4





Design Report available on line at:
<http://larpdocs.fnal.gov//LARP-public/DocDB/ShowDocument?docid=1074>



Cold Test Requirements

- MQXFA (magnet) Functional Test Requirements
 - For Vertical Test
 - US-HiLumi DocDB # 7

	LARP MQXF Magnets Functional Test Requirements	US-HiLumi Doc #7 Rev. No. v7c Date: 4/22/15 Page 1 of 12
 LARP LARP MQXF MAGNETS FUNCTIONAL TEST REQUIREMENTS		
Prepared by: _____ Date: _____ Ruben Carrasco, LARP Project Engineer	Organization: FNAL Contact: rubem@fnal.gov (630) 840-3915	
Reviewed by: _____ Date: _____ Guram Chlachidze, LARP QXF Testing L3	Organization: FNAL Contact: guram@fnal.gov (630) 840-4622	
Reviewed by: _____ Date: _____ Giorgio Ambrosio, LARP QXF L2	Organization: FNAL Contact: giorgio@fnal.gov (630) 840-2297	
Approved by: _____ Date: _____ Giorgio Apollinari, LARP Director	Organization: FNAL Contact: apollinari@fnal.gov (630) 840-4641	

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MQXFA Magnet Parameters

	MQXFA
	Quadrupole
Aperture	150 mm
Overall Length	4961 mm
Max Support Structure OD without/with He vessel	614/630 mm
Magnet Weight	6800 Kg
Operating Temperature	1.9 K
Operating Current	16471 A
Operating Gradient	132.6 T/m
Peak Field at Operating Current	11.41 T
Magnetic Length	4200 mm
Stored Energy at Operating Current	4.91 MJ
Inductance at Operating Current	34.5 mH
Short Sample Gradient	168 T/m
Short Sample Current	21.2 A
Short Sample Peak Field	14.5 T
Maximum Coil MIITs	36

Test Objectives for Prototypes

- At room temperature:
 - HiPot Measurement
 - Magnetic Measurements
 - Rotating probe measurements
- Measurements during cooldown and warmup
 - RTD measurements
 - Strain Gauge measurements
 - Residual Resistivity Ratio (RRR) Measurements

Test Objectives for Prototypes

- Measurements at 1.9 K:
 - HiPot Measurement
 - Magnetic Measurements
 - Rotating probe measurements
 - Quench Training
 - Up to 120% operating current (19.7 kA)
 - Quench Characterization
 - Voltage taps measurements
 - Quench Antenna measurements
 - Quench Protection Studies
 - Quench Propagation Studies
 - Ramp Rate Dependence Measurements
 - Voltage Spikes Measurements
 - Energy Loss Measurements
 - Splice Measurements (at 1.9 or 4.5 K)

Test Objectives for Prototypes

- Measurements at 4.5 K:
 - Assess short sample limit percentage at 4.5 K after 1.9 K training
 - Ramp Rate Dependence at 4.5 K in case of issues at 1.9 K
- A thermal cycle will be included to verify that the magnet retains its training.

Requirements

- Cooldown and Warmup requirements:
 - Max temperature gradient btw magnet ends < 150 K
- Temperature measurement:
 - Accuracy ± 10 mK
 - Precision ± 20 mK
- HiPot requirement:
 - Coil-Ground and Heaters-Ground up to 3500 V
 - Heaters-Coil up to 2500 V
 - At room temperature in air, and at cold in LHe
 - Note: MQXF High Voltage requirements TDB

- Current requirements
 - For prototypes: up to 19.8 kA
 - For production magnets: up to 17.8 kA (108% I_{nom})
- Ramp Rate requirement:
 - Max test current ramp rate is 300 A/s
 - Ramp rate changeable during current ramp
- Magnetic measurements requirements:
 - Warm finger (anti-cryostat) for magn meas with rotating probe up to 100 mm diameter

- Quench Protection requirements:
 - Detection channels (minimal list): Whole coil, Whole coil – Idot, Half coil – Half coil;
 - with current-dependent thresholds
 - Quench heaters: 24 strips powered as pairs in series
 - HFU voltage up to 450 V per strip
 - Energy extraction: up to 50 mOhm dump
 - Variable dump delay: 0-1000ms
 - Power supply phase back with no delay after detection trigger
 - CLIQ: 2 leads for CLIQ units

- Quench Characterization:
 - Up to 80 voltage taps
 - Minimum sampling rate: 10 KHz
 - Minimum time window for logging data 4 sec

- Quench Antenna
 - Will be installed in the warm bore
 - Details TBD

- Voltage Spike measurements:
 - Minimum sampling rate: 100 kHz

Test Stand should be able to do these measurements:

- Energy loss measurements
- RRR measurements
- Splice measurements

Notes

- LARP & CERN have started testing short models,
 - MQXFS1 tested at FNAL in Spring 2016
 - MQXFS3 to be tested at CERN in August 2016
- In June/July BNL is going to commission the Vertical Test Facility, and to test a single 4m QXF coil in mirror structure

Thank you!