News from the KEK Test Facility

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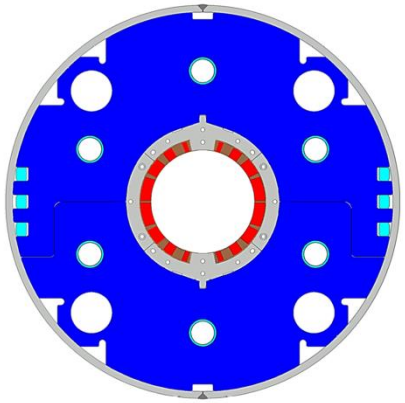
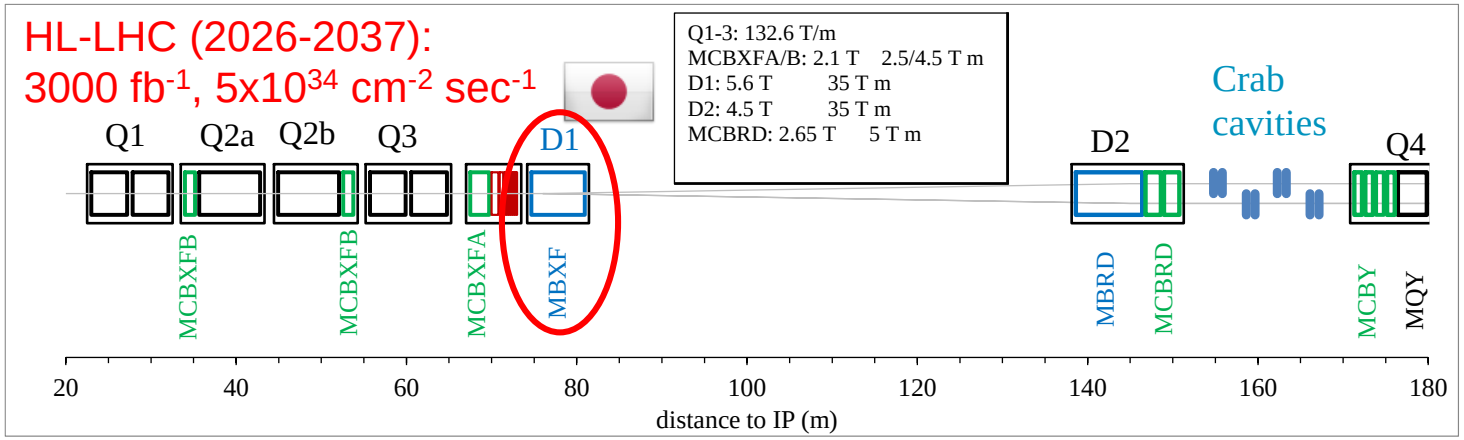
On behalf of CERN-KEK Collaboration for HL-LHC D1 Development

2nd International Magnet Test Stand Workshop, BNL, May 8-9, 2018

D1 to be built by KEK for HL-LHC

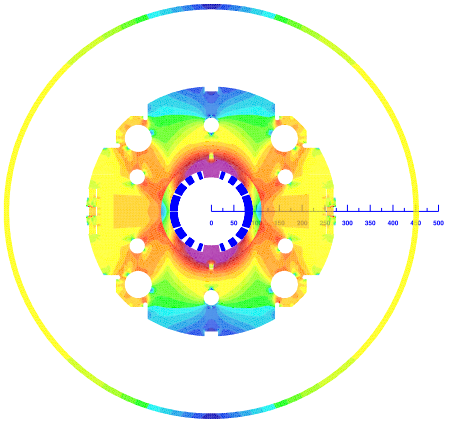


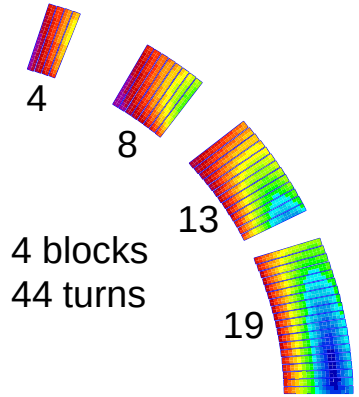


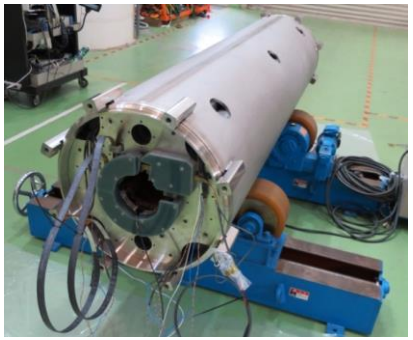
- **Beam separation dipole (D1) by KEK**
  - **Design study of D1 for HL-LHC within the framework of the CERN-KEK collaboration since 2011.**
  - **150 mm single aperture, 35 Tm (5.6 T x 6.3 m), Nb-Ti technology.**
  - **3 units of 2-m long model magnet (MBXFS1-3)**
- **Final deliverables (present baseline):**
  - **1 full-scale prototype cold mass (MBXFP)**
  - **6 series cold masses (MBXF1-6)** **3 short models, 7 full-scale magnets**
  - **Cryostats and horizontal tests by CERN**

Overview of D1

	Production	2 m model
Coil aperture	150 mm	
Field integral	35 T·m	9.4 T·m
Nominal field	5.57 T	
Peak field	6.45 T (SS), 6.58 T (coil end)	
Operating current	12.05 kA	
Operating temperature	1.9 K	
Field quality	<10^{-4} w.r.t B_1 (R_{ref}=50 mm)	
Load line ratio	75.6%（SS）, 76.7%(coil end）at 1.9 K	
Differential inductance	4.0 mH/m	
Conductor	Nb-Ti MB outer cable	
Stored energy	340 kJ/m	
Magnetic length	6.26 m	1.68 m
Coil mech. length	6.58 m	2.00 m
Magnet mech. length	6.73 m	2.15 m
Heat load	135 W (Magnet total) 2 mW/cm^3 (Coil peak)	
Radiation dose	> 25 MGy	







Cold tests of 2m models

- **MBXFS1: April to June 2016.**
- **MBXFS1b: Feb. to April 2017. Reassembled with coil pre-stress increase.**
- **MBXFS2: Under assembly. To be tested in July 2018. New Cross section.**
- **MBXFS3: Identical to MBXFS2. Check of reproducibility.**

Vertical Cold Test Stand at KEK (1/2)

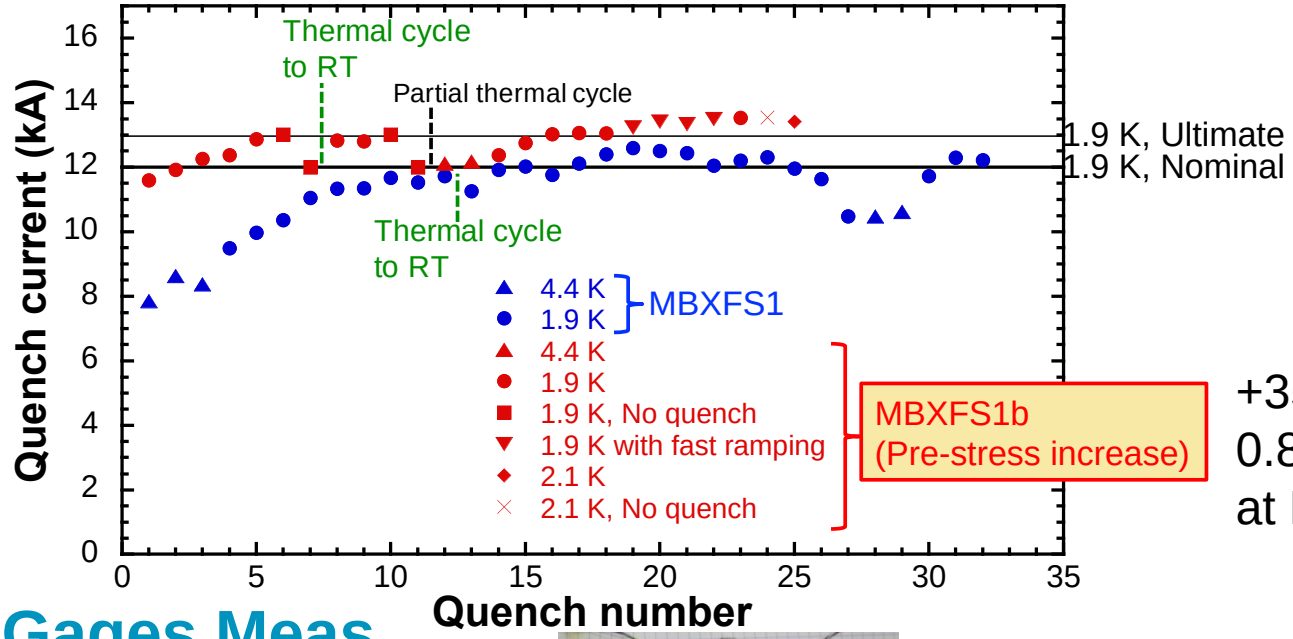
- **Previous report can be found in https://indico.cern.ch/event/507584/contributions/2027926/**
- **Operating Temp.: 4.4 K to 1.9 K by Hell Sub-cooler (55 W for MQXA)**
- **Capacity of 1.9 K bath: 7524 mm deep, 700 mm in a diameter.**
- **New header for the D1 (MBXF) in 2014**
  - **Anti-cryostat for field measurement: O.D. 141.3 mm**
    - **Quench antennas: 11 arrays for 7 m long magnet**
  - **15 kA Current Leads**
  - **HVWL: 1.5 kV (but present limit 0.5 kV.)**

Vertical Cold Test Stand at KEK (2/2)

- **Power Converter (1993): 15 kA – 15 V P/C**
  - **Thyristor switch for prompt shutoff.**
  - **Dump resistor of 50 mΩ for D1.**
    - **Full scale magnets need quench heaters.**
  - **External 15 kA DCCT (Zero-Flux Current Transformer)**
    - **First DCCT in 2014, but performance degradation was found.**
    - **Another new DCCT was recently installed (March 2018).**
  - **Contact failures found in relays due to aged deterioration were …**
    - **Overhaul was completed in 2016.**

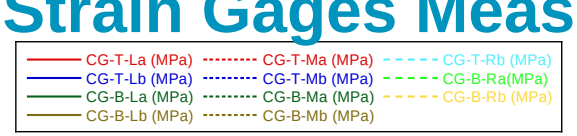
- **Quench detectors**
  - **2 x Balanced Voltage (Main): 0.1 V, 10msec for validation**
  - **2 x Total Voltage**

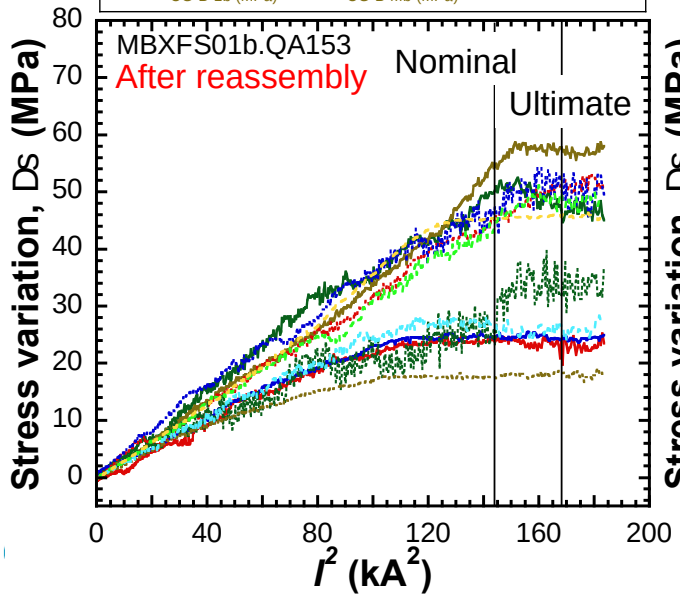
Test Results: Training Quenches

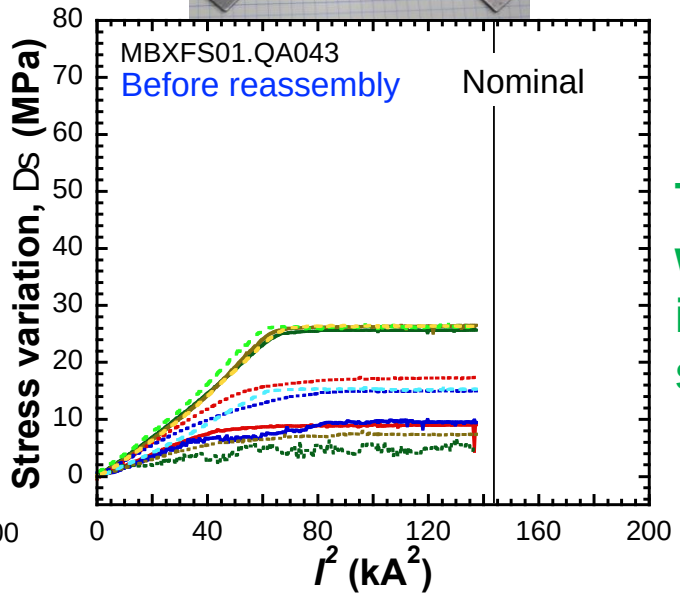


+35 MPa by 0.8 mm shim at MP.

Strain Gages Meas.



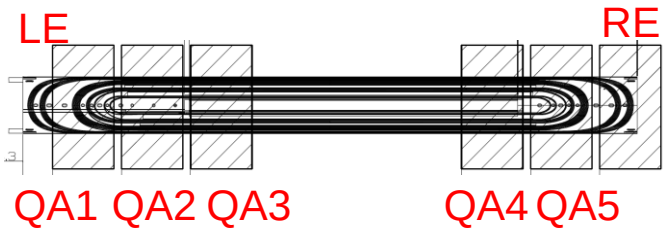




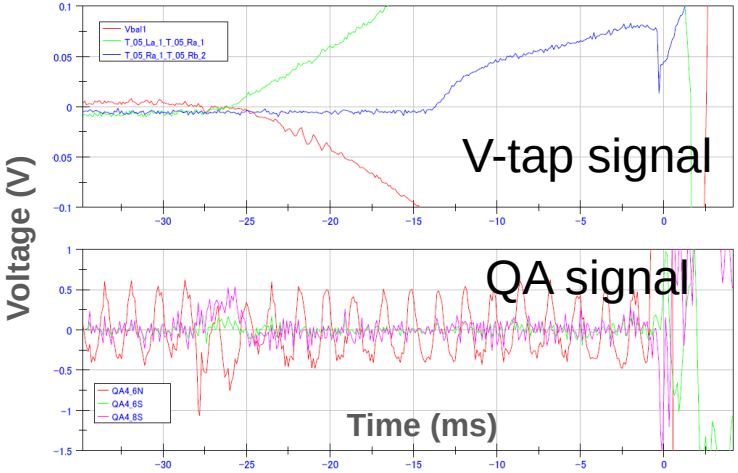
Training performance was significantly improved by pre-stress increase.

Test Results: Quench Locations of MBXFS1b

Run	Quench start location		
	Coil	CB No.	Turn No.
1st cycle			
01b.QA008	T	3	5th
01b.QA009	T	1	26-27th
01b.QA010	T	3	5th
01b.QA011	Failure in data acquisition		
01b.QA013	B	3	5th
2nd cycle-1			
01b.QA032	B	2, 3	12-13th
01b.QA033	B	3	5th
2nd cycle -2			
01b.QA138	B	3	5th
01b.QA139	T	3	5th
01b.QA140	B	1	26-27th
01b.QA141	T	1	26-27th
01b.QA142	T	1	26-27th
01b.QA145	T	3	5th
01b.QA146	B	1	26-27th
01b.QA147	B	3	5th
01b.QA148	T	3	5th
01b.QA149	B	2	13th
01b.QA150	T	1	26-27th
01b.QA151	B	3	5th
01b.QA154	T	1	26-27th



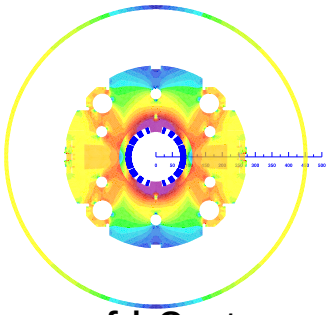
Axial position of quench antennas



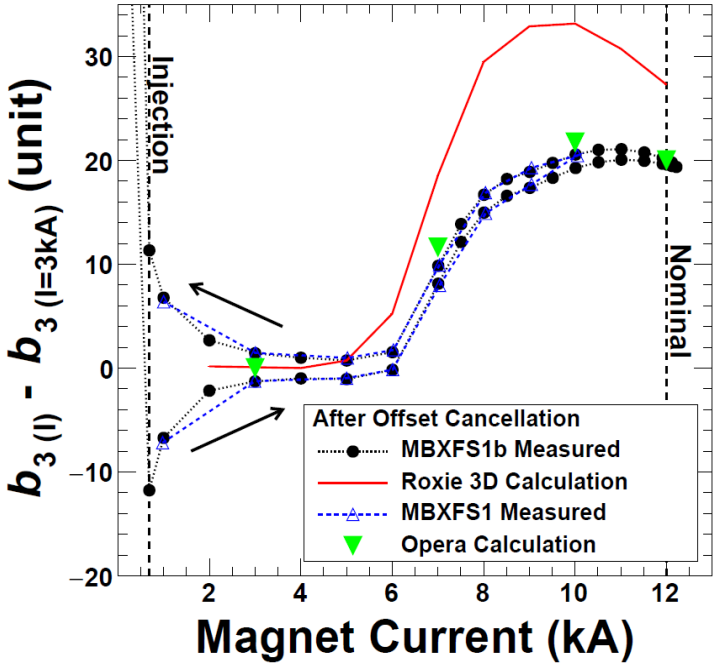
88ch x NI PXI 1643 (16bit, 250 kS/s/ch) & Labview

- Quench start location was identified from voltage tap.
  - Small signals from quench antennas.
    >> Efforts for noise reduction.
- 50% at the 5th turn (peak field)
- The rest of quenches initiated at the innermost turn of CB1B and CB2.

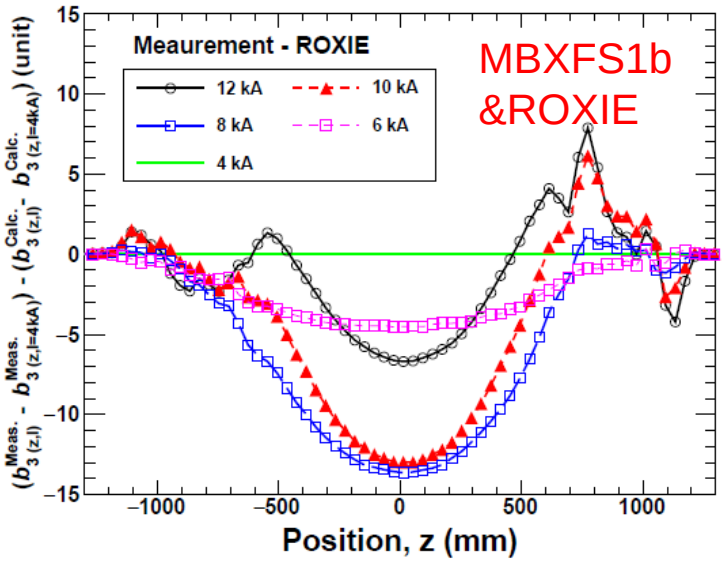
Test Results: MFM

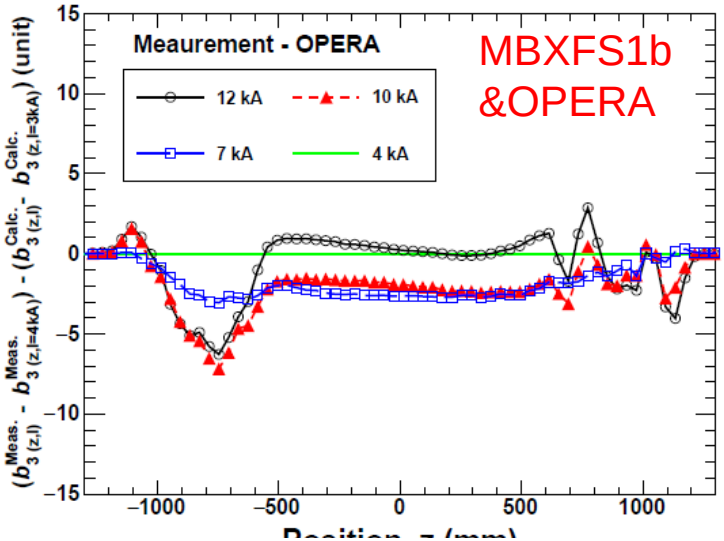


DC loop of b3 at magnet center (offset cancelled)



b3 (offset cancelled)
Measurement-ROXIE-OPERA





- **Significant saturation (and stray field) effects on b3.**
- **Iron pit around the vertical cryostat (SUS) needs to be considered in the simulation model.**
- **z-scan measurement to validate the longitudinal saturation effects.**

For Full-Scale Magnets

- Only up to vertical cold tests for magnets
  - Cryostatting and horizontal cold test at CERN
- Warm MFM before cold test
  - Most likely right after assembly in industry
  - Measurement system will be supported by CERN. The detail will be discussed soon.
- Vertical cold test at KEK
  - Quench performance tests
    - Stored energy (2MJ) same as MQXA
    - P/C, QPH PS, DAQ: ready for full scale magnets
      - Modification maybe needed for quench antennas.
  - MFM using anti-cryostat
    - New “long” rotating coils will be built.
    - Discussions on cold bore tube insertion >> New anti-cryostat??