LARP

Tests Results of Nb_3Sn Quadrupole Magnets Using a Shell-based Support Structure

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LBNL

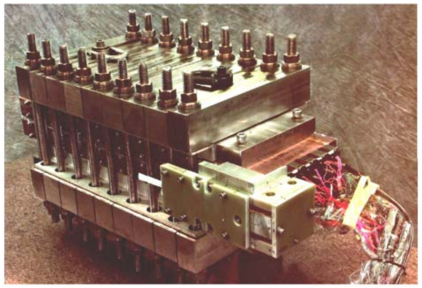
WAMSDO 2008
CERN, May 19-23, 2008

Outline

The need for a new structure approach in high field magnets

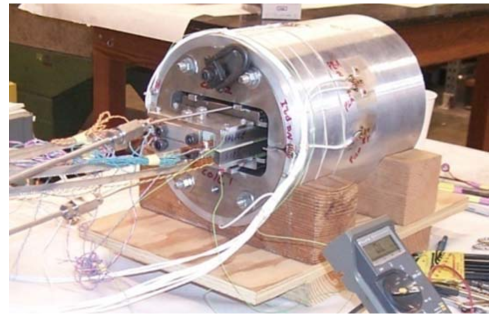
Test results of LARP TQ quadrupoles using a shell structure approach

The road to shell structures at LBNL



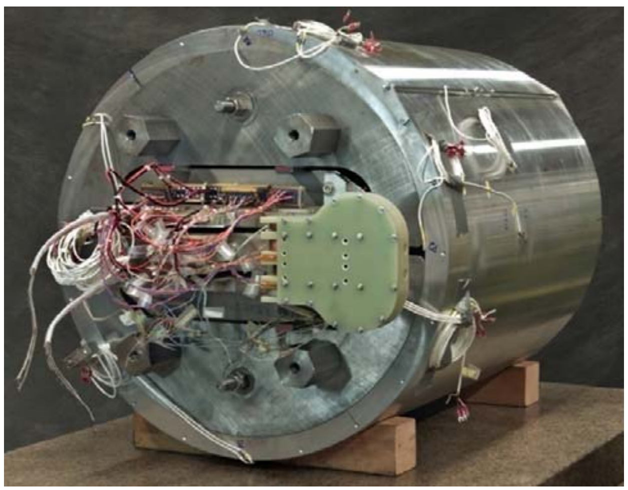
RD2 - 6 Tesla

RT1 - 12 Tesla

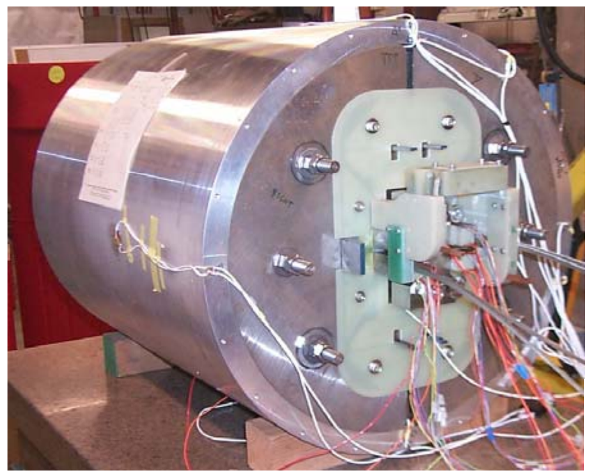


SM-01 - 12 Tesla

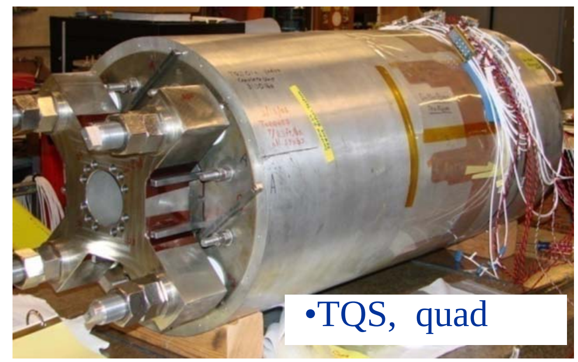
•SQ01 short quad



RD3-b - 14.5 Tesla



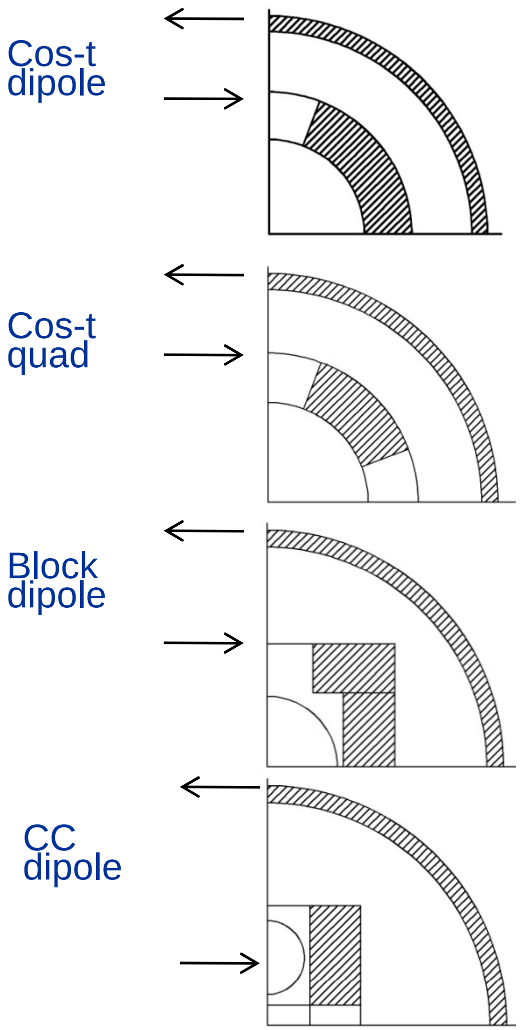
HD1 - 16 Tesla

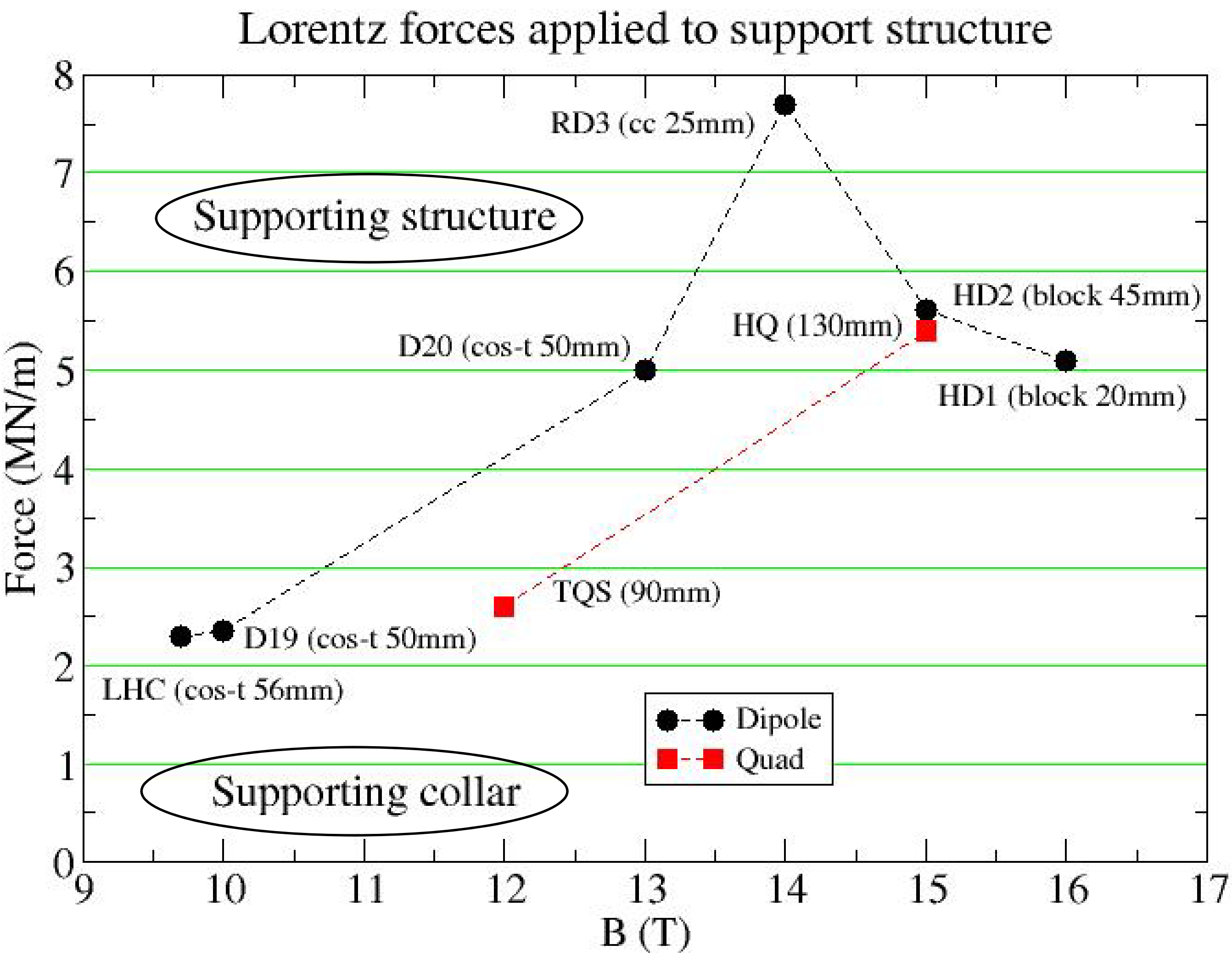


•TQS, quad

LR01 3.6 m long cc, 11.5 T, (2007)

Supporting Collars and Shells





TQS Quadrupole

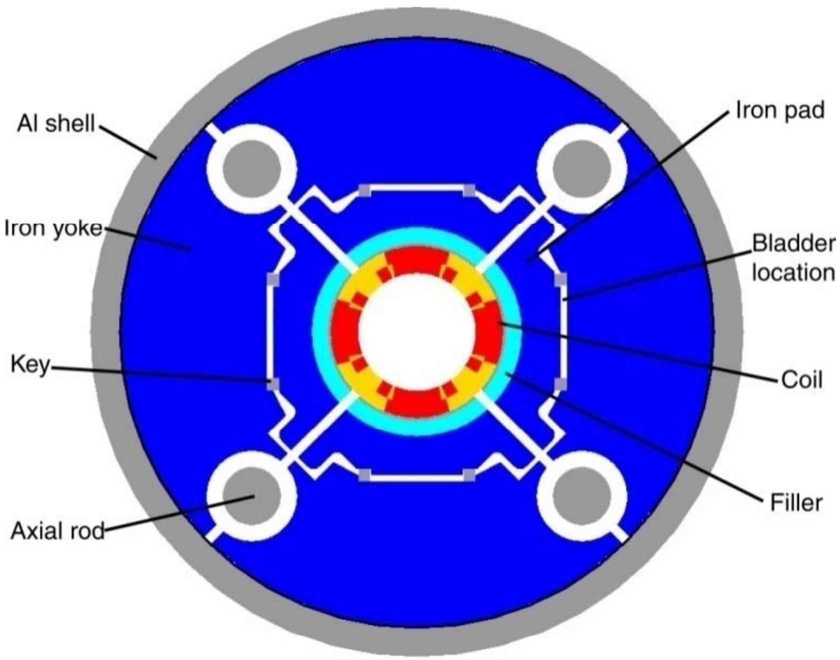
- Demonstrate Nb_3Sn technology as an option for an LHC luminosity upgrade
- High gradient (> 200 T/m) in 90 mm aperture
- Azimuthal Stress ~ 150 MPa
- Axial Lorentz Force ~ 350 kN

•1 m long magnet models

TQS

- Aluminum shell over iron yoke
- Assembly with bladders and keys

1. Low pre-stress during assembly
2. High pre-stress with cool-down
3. Reusable structural components

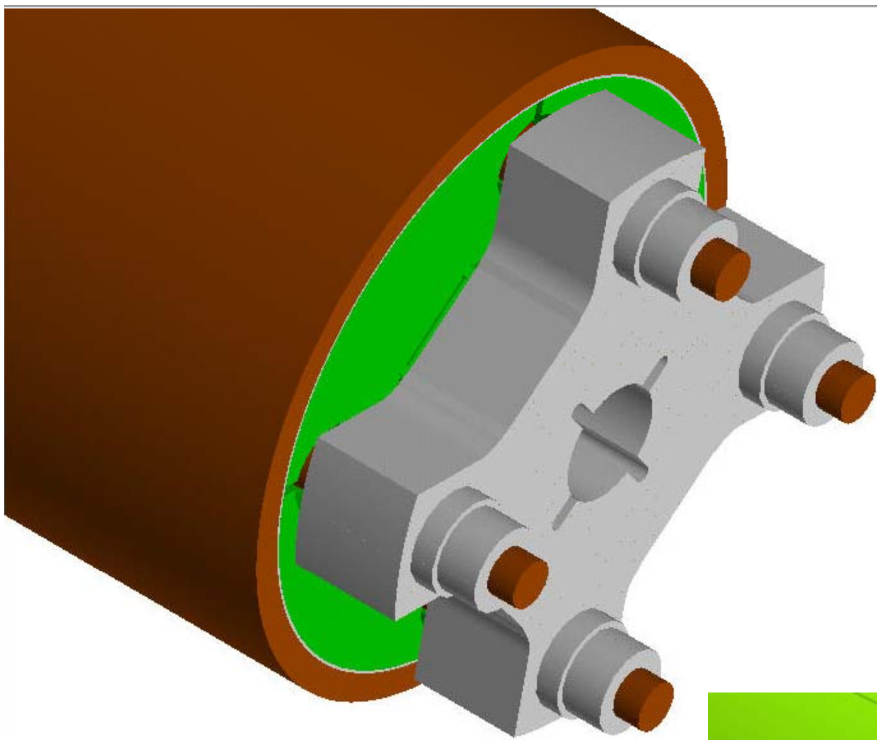


TQS Status

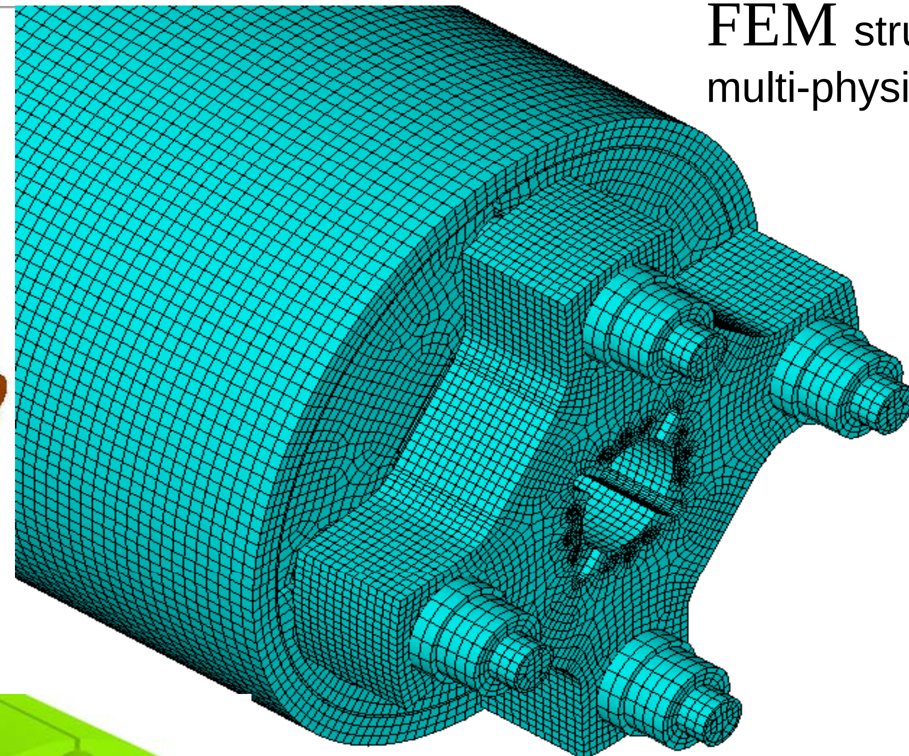
- 6 assemblies, 5 tests
- Efficient and reliable
- Technology transfer

- Met the LARP 200 T/m target – reached > 220 T/m
- Short-sample plateau at 4.4K of 80-90%
- Short-sample plateau at 1.9K of 77-84%

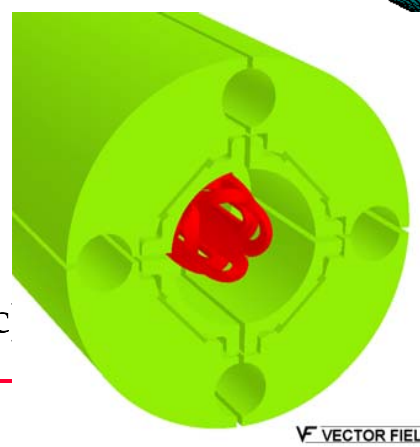
Design and analysis



CAD
(engineering)



FEM structure
multi-physics



FEM
(magnetic

1. **Axial pre-load**
2. **Azimuthal pre-load**
3. **Cool-down**
4. **Excitation**

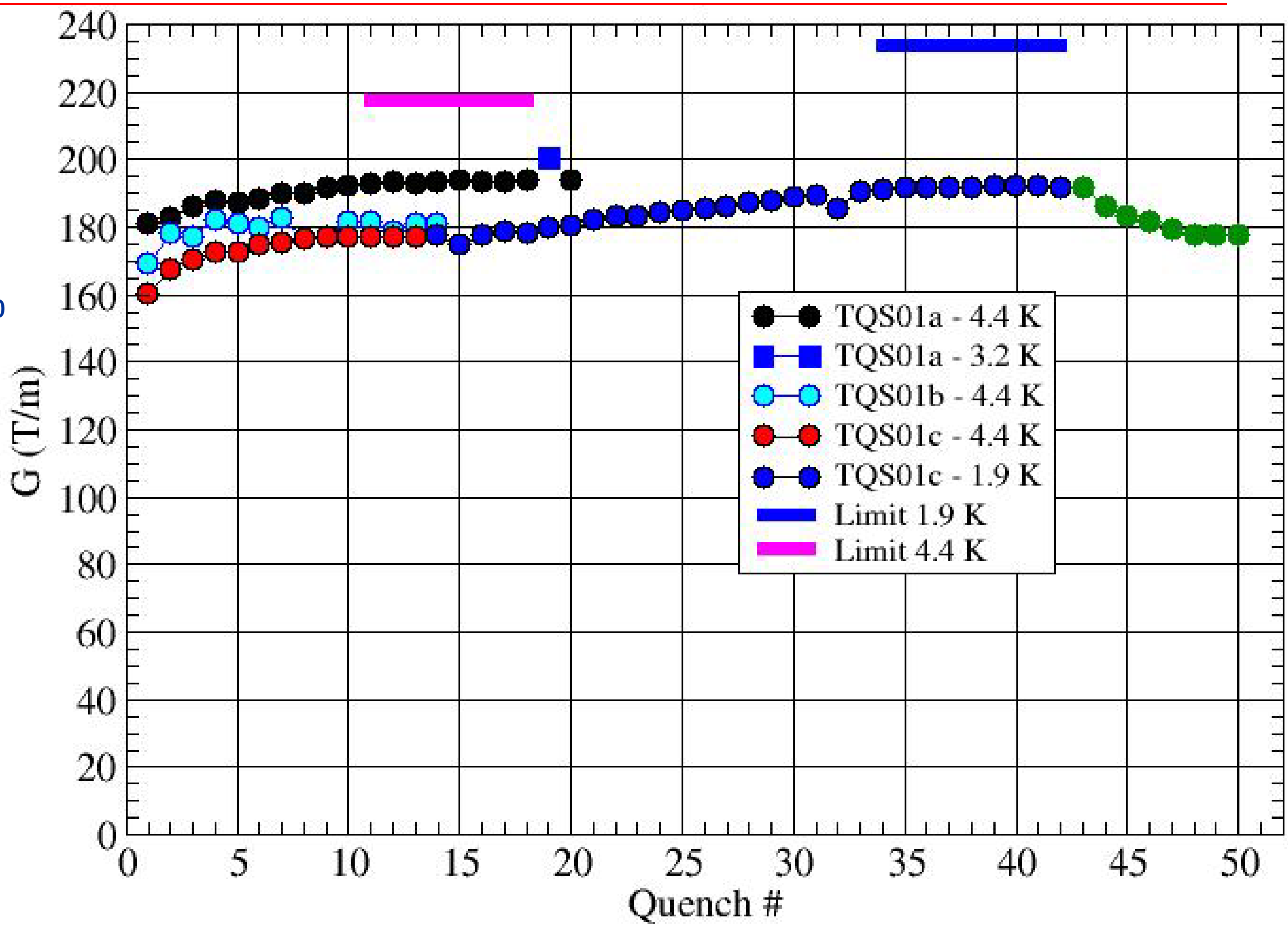
Magnet Tests

Magnet	Conductor	Coils	Island	Temperature	Test
TQS01a	MJR	**5, 6, 7, 8**	Bronze	4.4 K	April 2006 LBNL
TQS01b	MJR	**14, 15,** 7, 8	Bronze	4.4 K	Nov, 2006 LBNL
TQS01c	MJR	5, 15, 7, 8	Bronze	4.4 K & 1.9 K	March 2007 FNAL
TQS02a	RRP	**20, 21, 22, 23**	Titanium	4.4 K & 1.9 K	June 2007 FNAL
TQS02b	RRP	22, 23,**28,29**	Titanium	4.4 K & 1.9 K	March 2008 CERN
TQS02c	RRP	22, 23,28,20	Titanium	4.4 K & 1.9 K	June 2008 CERN

•Virgin coils are listed in bold

TQS01 Training

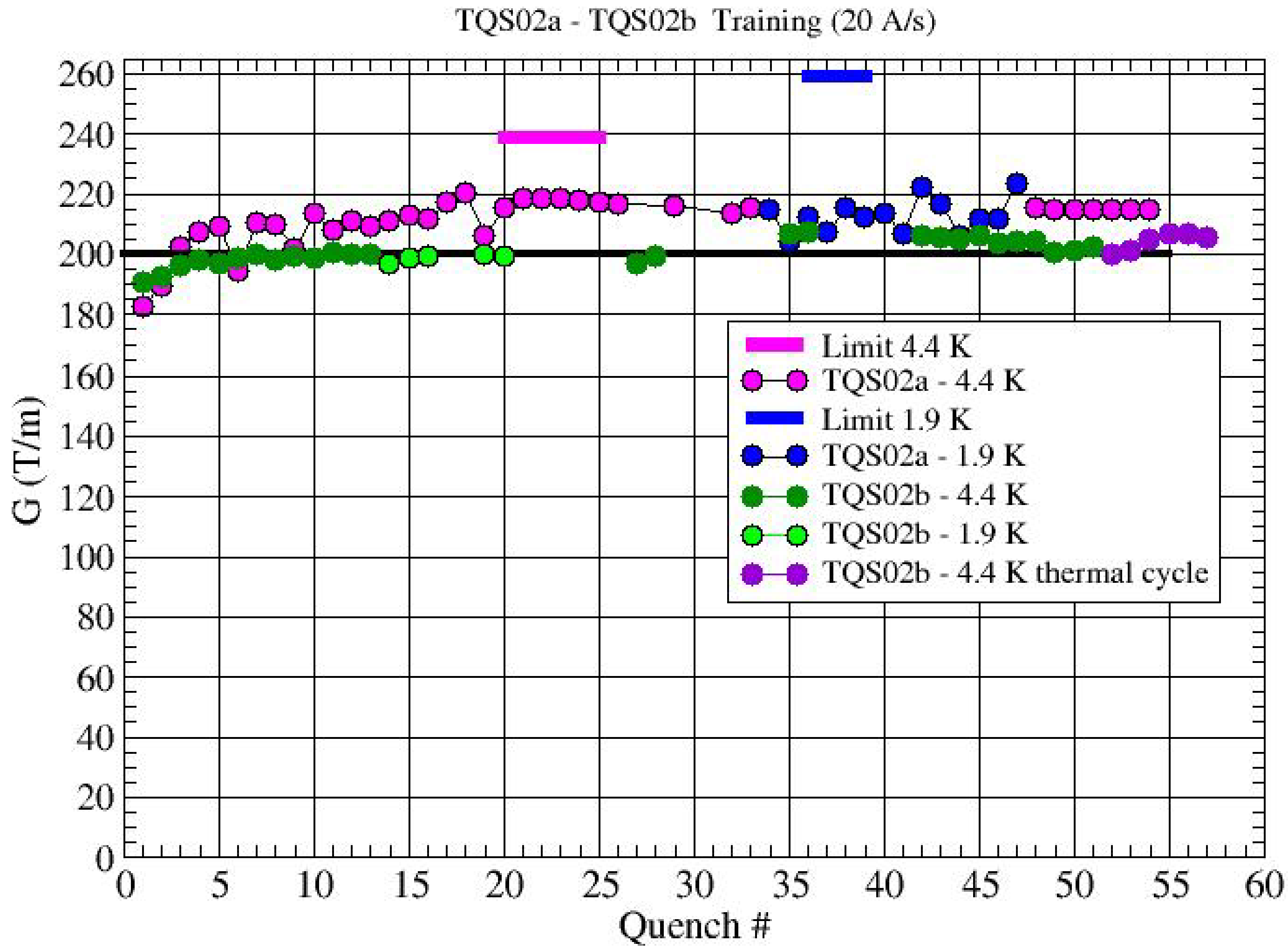
- 4.4K training
  - ~10% gain
- 1.9K training
  - ~additional 10%



TQS02 Training

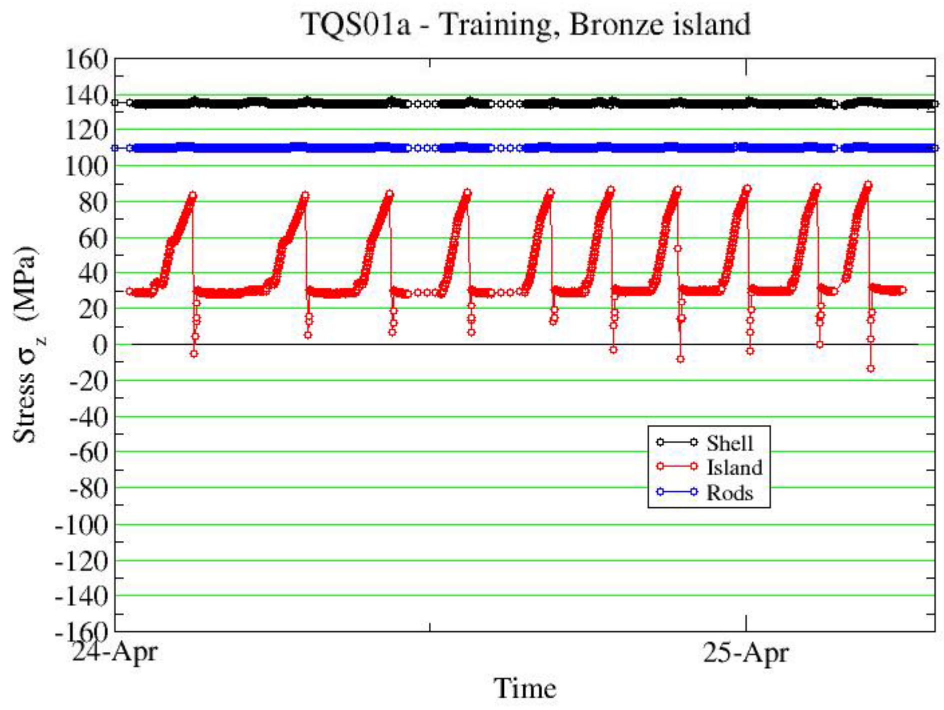
LARP

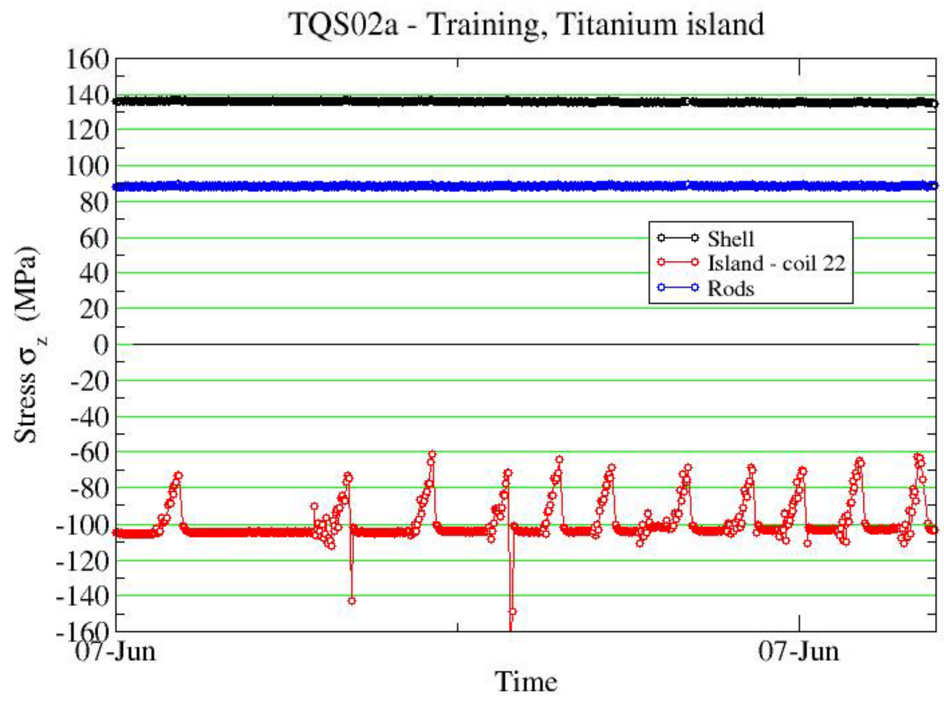
- 4.4K training
  - ~10-20% gain
- 1.9K training
  - ~no gain



Training - 2 types of islands

TQS01a -Axial Stress Bronze islands	TQS02a -Axial Stress Titanium islands

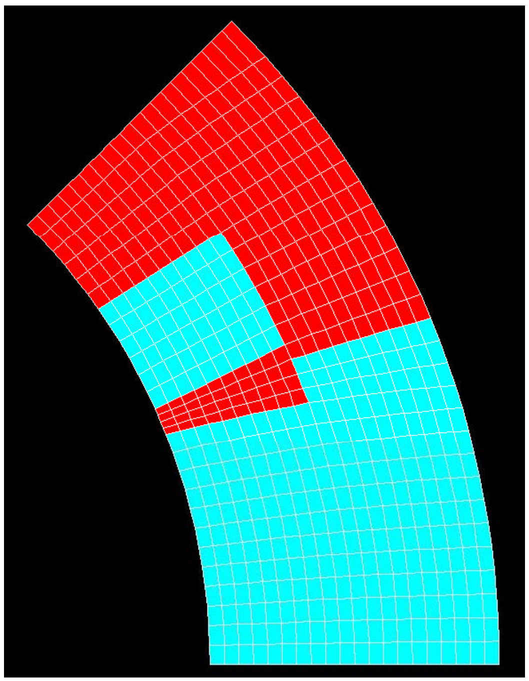


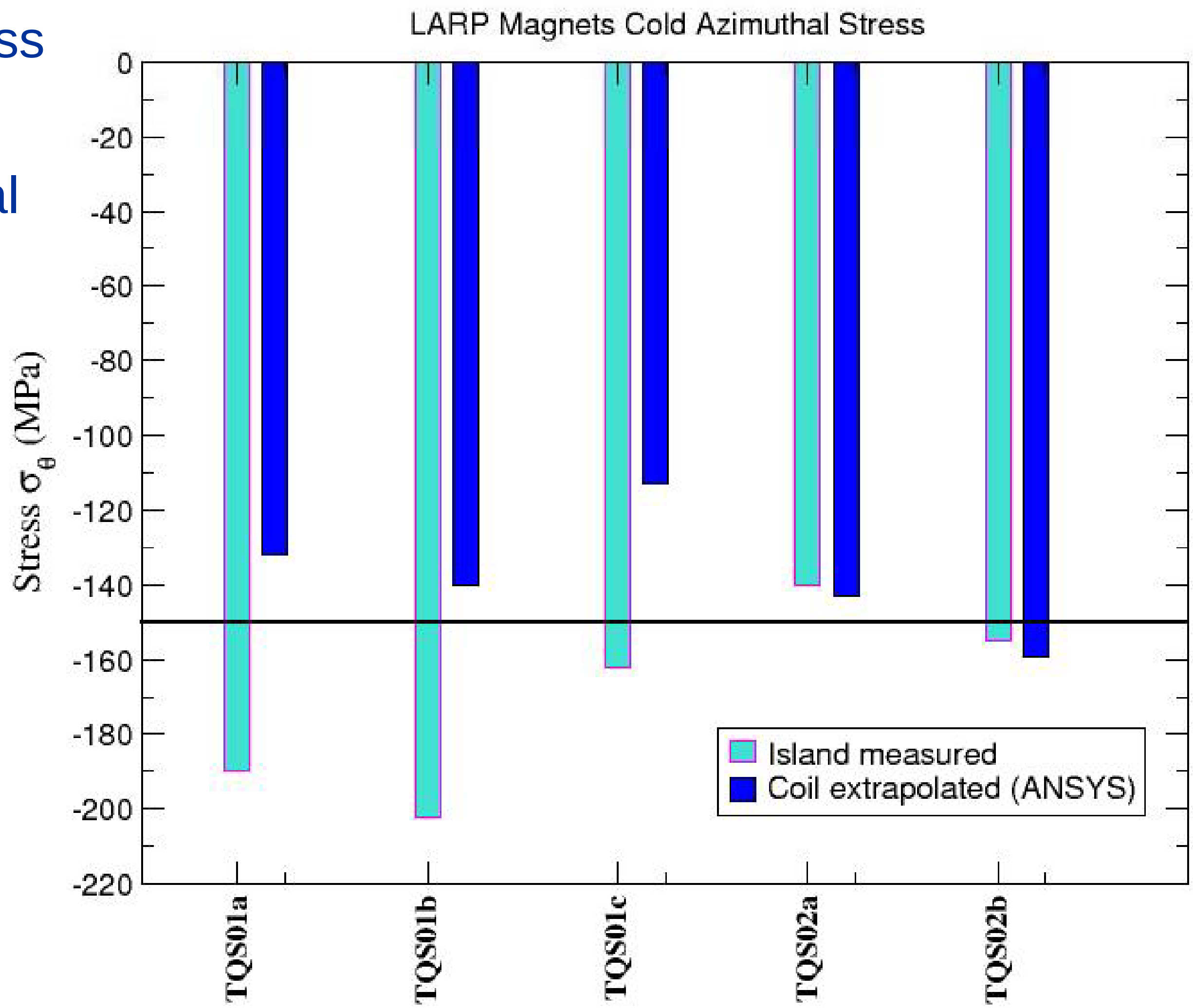


Average Stress Layer 1- Coil & Island

Difference in azimuthal stress between island and coil

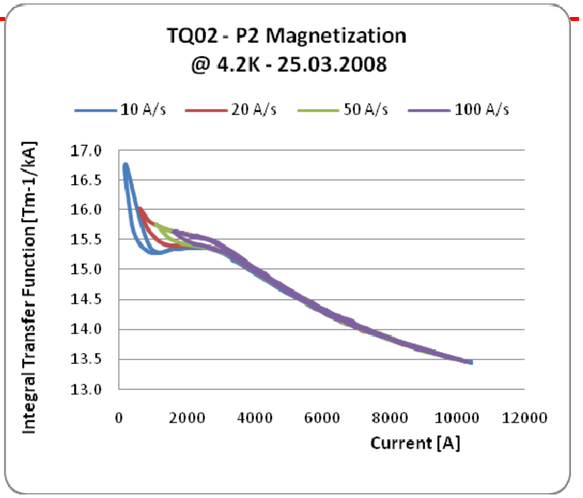
Axial tension of Bronze Axial compression in Titanium

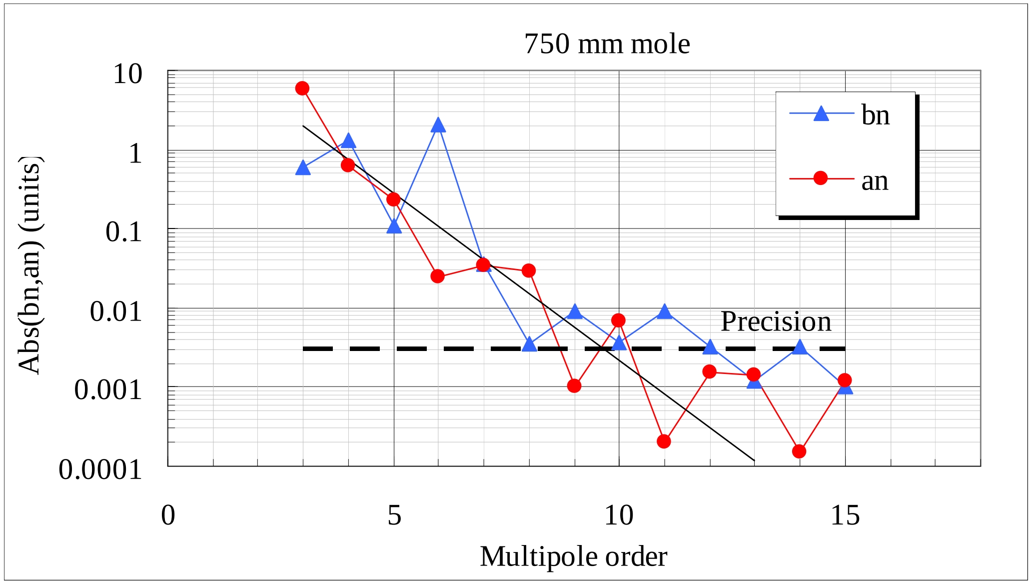


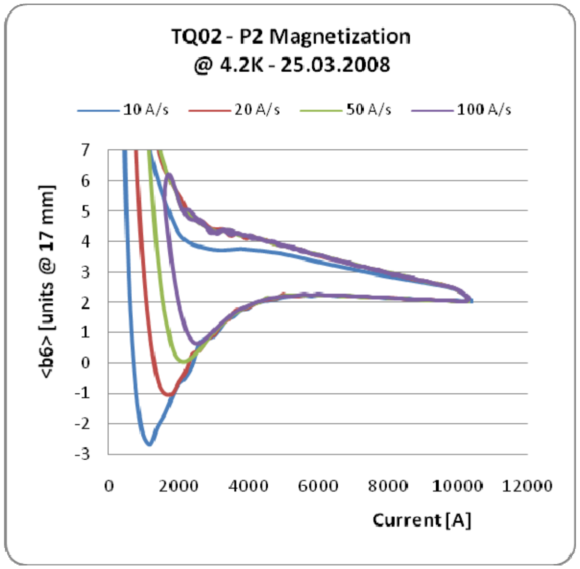


magnetic measurements

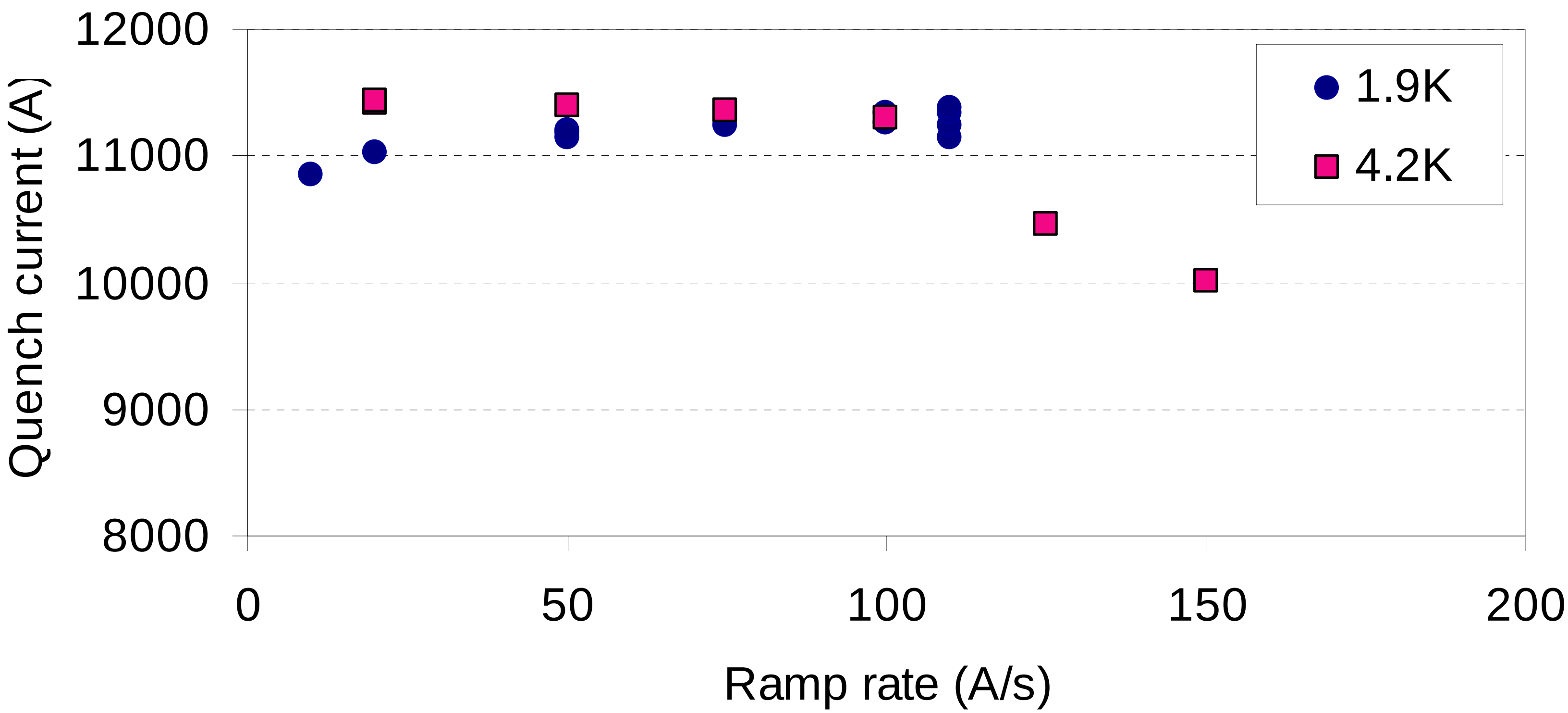
- Warm and cold magnetic measurements
- Magnetization
- Decay & snapback







TQS02b - Ramp rate dependence



Inverted ramp rate dependence at 1.9K

LARP

Summary

- The TQS magnet met the 200 T/m goal.
- 6 assemblies 5 tests:
  - Maximum gradients at 4.4K - 180-222 T/m
  - Plateau reached after 4-20 quenches with 80-90% of short-sample
  - Maximum gradients at 1.9-3.2K - 192-225 T/m
  - Plateau reached after 20 quenches with 77-84% of short-sample
- Titanium islands replacing Bronze
- TQS01 quenches in inner layer straight section (near island gaps)
- TQS02a dominated by outer layer quenches
- Technology transfer to CERN - TQS02b, c

Next test – TQS02c

•Magnet TQS02b was disassembled last week at CERN

- Coil 29 was replaced with coil 20
- Magnet TQS02c was reassembled and pre-stressed
- TQS02c ready for test end of May
    - Demonstrate 220 T/m and show reproducibility
    - Continue with more test with variations of pre-stress

The disassembly of TQS02b and the reassembly of TQS02c at CERN – a 3 days operation

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Juan Carlos Perez CERN