



US LHC Accelerator Research Program
bnl - fnal- lbnl - slac

TQ2a Progress and Plans

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LARP Collaboration Meeting
April 6-8, 2005

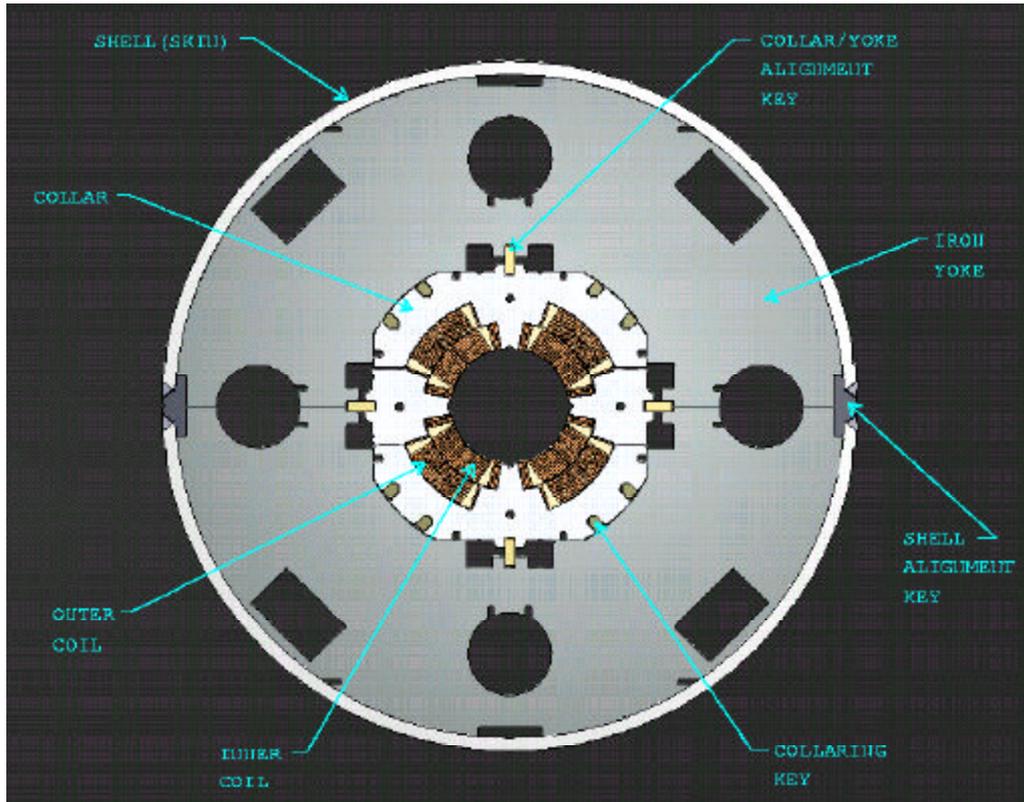


TQ2a objectives

- TQ2 are the technological quadrupole models based on *90-mm shell-type coils* and *collar-yoke-skin mechanical structure*
- Design goals
 - Achieve $G_{\max} > 210$ T/m.
 - Fabricate, test and evaluate *2-layer shell-type coil design without internal interlayer splices*
 - Fabricate, test and evaluate *mechanical structures based on collar-yoke-skin support*
 - Develop and evaluate *coil fabrication and magnet assembly technologies*
- Performance study:
 - *magnet quench performance*: training, re-training, SSL
 - *field quality*: geometrical harmonics, coil magnetization, iron saturation, alignment, field quality correction
 - *quench protection*: conductor parameters, quench heaters
 - *operation margin*: thermal model with mid-plane heaters
- Compare TQ1a and TQ2a designs, technology and performance parameters



TQ2 design approach



MQXB cross-section.

TQ2a design is based on the MQXB mechanical structure (collar, yoke, skin, end plate, etc.).

Two stages

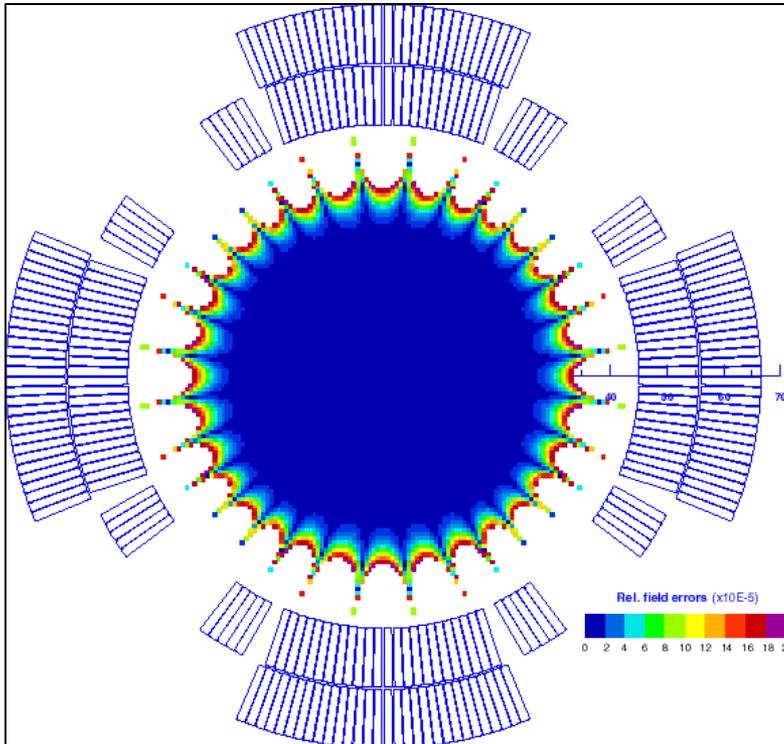
- TQ2a – 2-layer coil with thick collar
- TQ2b – 3-layer coil with thin collar

TQ2a uses available coil winding and curing tooling (winding tables, mandrels, presses, etc.).

Mechanical structure, tooling and infrastructure exist for 1-2 m long and up to 6 m long magnets.



TQ2a coil



Coil:

- 2-layer shell-type
- Inner-layer wedges
- Inner-layer pole glued into the coil

Cable:

- Strand – Nb₃Sn, MJR, 0.7 mm
- Number of strands – 27
- Keystone angle – 1 deg
- Width – 10.05 mm
- Thickness – 1.26 mm

Insulation: 0.125 mm S2-glass sleeve

Coil fabrication technology and tooling will be tested using 2 practice coils



End Parts



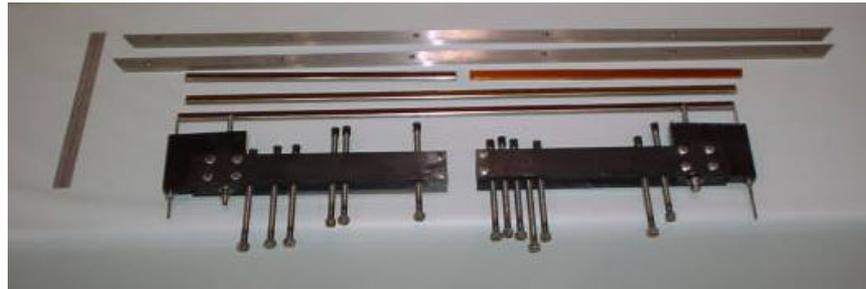
Lead End Parts



Non-lead End Parts



Tooling

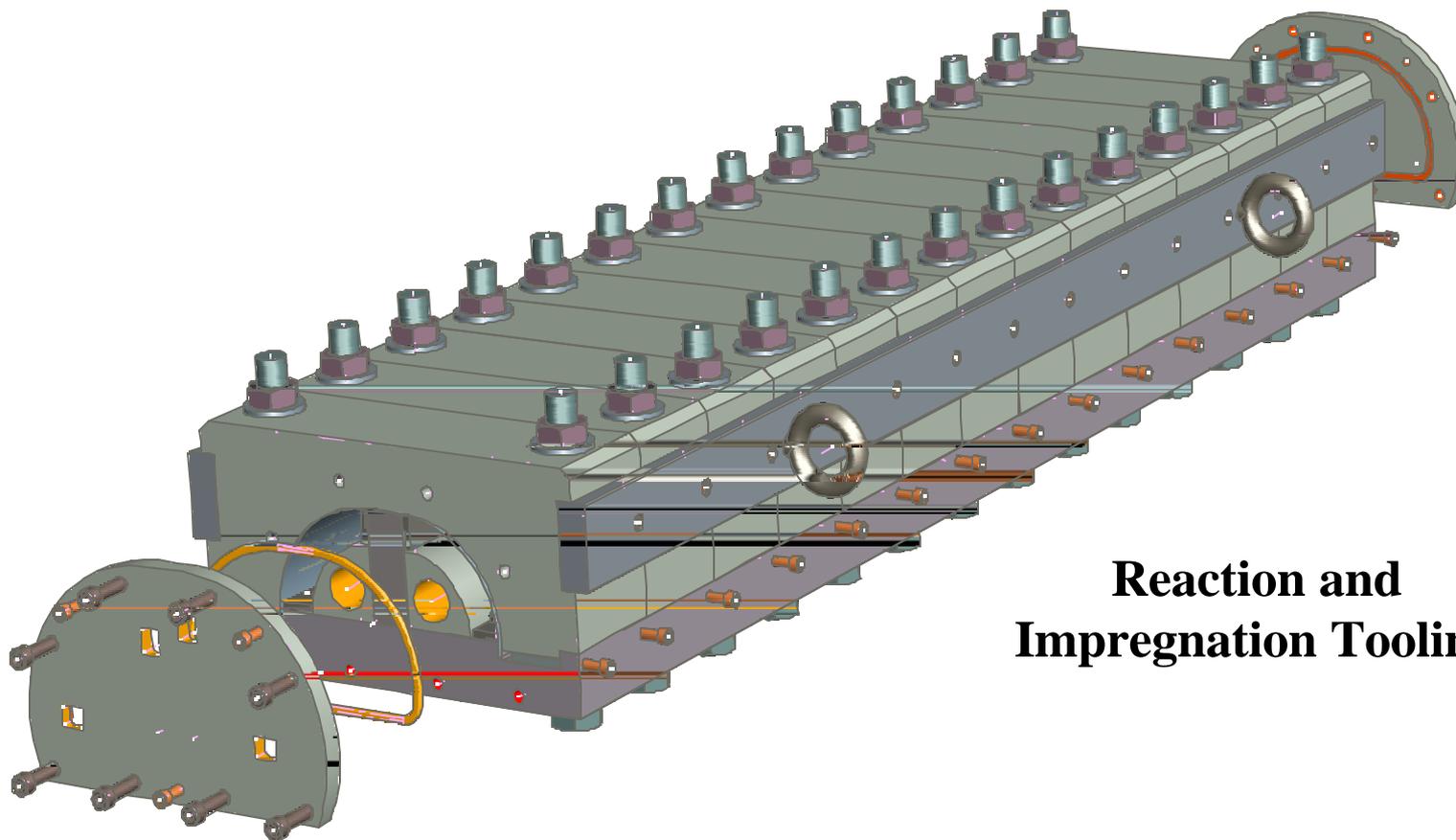


Winding and Curing Tooling





Tooling



**Reaction and
Impregnation Tooling**



Current Status

Cable for practice coils being fabricated and insulated at LBNL.

All coil components (wedges, pole pieces, end parts) have been ordered.

All winding, curing, reaction, impregnation and splice tooling has been ordered

All tooling is expected to arrive at Fermilab by April 15th.

Priority of parts delivery has been arranged so that coil winding can proceed as quickly as possible. Schedule for parts:

- Inner pole straight sections and keys. Arrive April 20th.
- Balance of inner coil parts. Arrive May 2nd.
- Outer coil parts and parts needed for impregnation. Arrive May 9th.



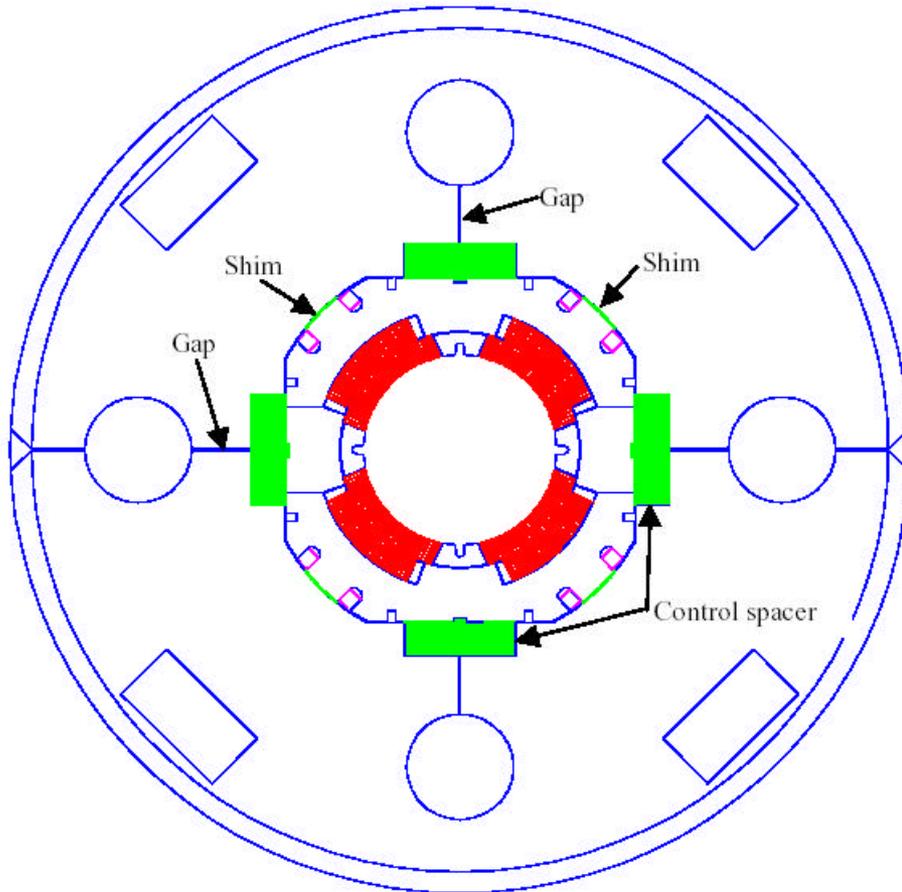
Current Status

Short-term schedule for winding TQ coils

- April 16th – Set up and assemble winding and reaction tooling
- April 21st – Begin winding first inner coil
- May 2nd - Wind 2nd current block of inner coil
- May 9th – Begin winding first outer coil
- May 16th – Begin winding second inner coil
- May 23rd – Begin winding second outer coil
- June 1st – Begin reaction of two practice coils.
- June 10th – Perform splices on practice coils
- June 14th – Begin impregnation of practice coils.
- June 27th - Begin winding first TQ1a coil



TQ2a mechanical structure



TQ2a cross-section

Modified MQXB collar blocks with outer-layer poles for coil alignment. Inner-layer poles are glued into the coil.

Radial yoke cut per lamination to provide symmetrical load.

Control spacers for collared coil alignment and yoke motion control.

Four shims in the midplanes to control coil-yoke interference.

10 mm thick stainless steel skin.

Coil pre-stress remains below 70MPa (100 MPa before the spring back) through all stages of magnet production and operation.

Mechanical structure and coil pre-stress will be studied and optimized using short (~30 cm) mechanical model.



TQ2a parameters

Parameter	Unit	Value
N of layers		2
N of turns		136
Coil area (Cu + nonCu)	cm ²	29.33
Assumed non-Cu J _c @ 12 T & 4.5 K	A/mm ²	2000
Quench gradient @ 1.9 K	T/m	233
Quench current @ 1.9 K	kA	14.07
Peak field in the coil at quench	T	12.1



TQ2a milestones

FY05

- | | | |
|---|-----------|-------------|
| - Design of cable, coil, and tooling: | FNAL+LBNL | 02/28/2005 |
| - Fabricate insulated cable: | LBNL | 04/01/2005 |
| - Procure coil fabrication tooling/parts: | FNAL | 04/15/2005* |
| - Fabricate practice coil: | FNAL+LBNL | 06/25/2005 |
| - Procure collars (modified from MQXB): | FNAL | 06/15/2005 |
| - Assemble and test mechanical model: | FNAL | 08/15/2005 |
| - Wind and cure coils: | FNAL | 10/25/2005 |

*1-2 week delay is possible (can be accommodated w/o significant impact on project schedule)

FY06

- | | | |
|-------------------------------|----------|------------|
| - React and impregnate coils: | FNAL | 12/25/2005 |
| - Assemble magnet: | FNAL | 02/15/2006 |
| - Test magnet: | BNL+FNAL | 03/31/2006 |



TQ1a/2a schedule FY2005-FY2006

ID	Task Name	Start	2004 Finish	2005												2006											
				S	O	N	D	J	F	M	A	M	J	J	A	S	S	O	N	D	J	F	M	A	M	J	
1	Shared TQ1a/2a Tasks	Fri 10/1/04	Fri 12/30/05	[Gantt bar from Oct 2004 to Dec 2005]																							
2	Establish Cross Section	Mon 1/3/05	Mon 1/3/05	[Gantt bar from Jan 2005 to Jan 2005]																							
3	TQ1a/2a Coil Tooling	Fri 10/1/04	Fri 4/15/05	[Gantt bar from Oct 2004 to Apr 2005]																							
6	TQ1a/2a Coil Parts	Mon 1/3/05	Mon 5/16/05	[Gantt bar from Jan 2005 to May 2005]																							
9	TQ1a/2a coil fabrication	Wed 4/20/05	Fri 12/30/05	[Gantt bar from Apr 2005 to Dec 2005, highlighted in red]																							
16																											
17	TQ Mech Model Assy	Mon 6/27/05	Fri 8/19/05	[Gantt bar from Jun 2005 to Aug 2005, highlighted in red]																							
20																											
21	TQ2a Magnet Assembly	Mon 1/3/05	Mon 3/13/06	[Gantt bar from Jan 2005 to Mar 2006]																							
22	TQ2a Magnet Assy Tooling	Mon 1/3/05	Tue 8/2/05	[Gantt bar from Jan 2005 to Aug 2005]																							
25	TQ2a Magnet Assy Parts	Mon 1/3/05	Fri 8/26/05	[Gantt bar from Jan 2005 to Aug 2005]																							
28	TQ2a Magnet Assy Fabricati	Tue 1/3/06	Mon 3/13/06	[Gantt bar from Jan 2006 to Mar 2006, highlighted in red]																							



TQ1a/2a Cost

	FY04	FY05	FY06
TQ1a/2a			
TQ1a/2a coils			
Analysis		\$18,000	
Tooling	\$62,199	\$101,049	
Parts		\$138,528	
Fabrication		\$214,800	
TQ2a Magnet			
Analysis		\$39,363	
Tooling			
Parts		\$24,639	\$102,882
Fabrication		\$83,238	\$240,900
Yearly FNAL Totals	\$62,199	\$619,617	\$343,782
FNAL base Program Contribution		\$289,952	