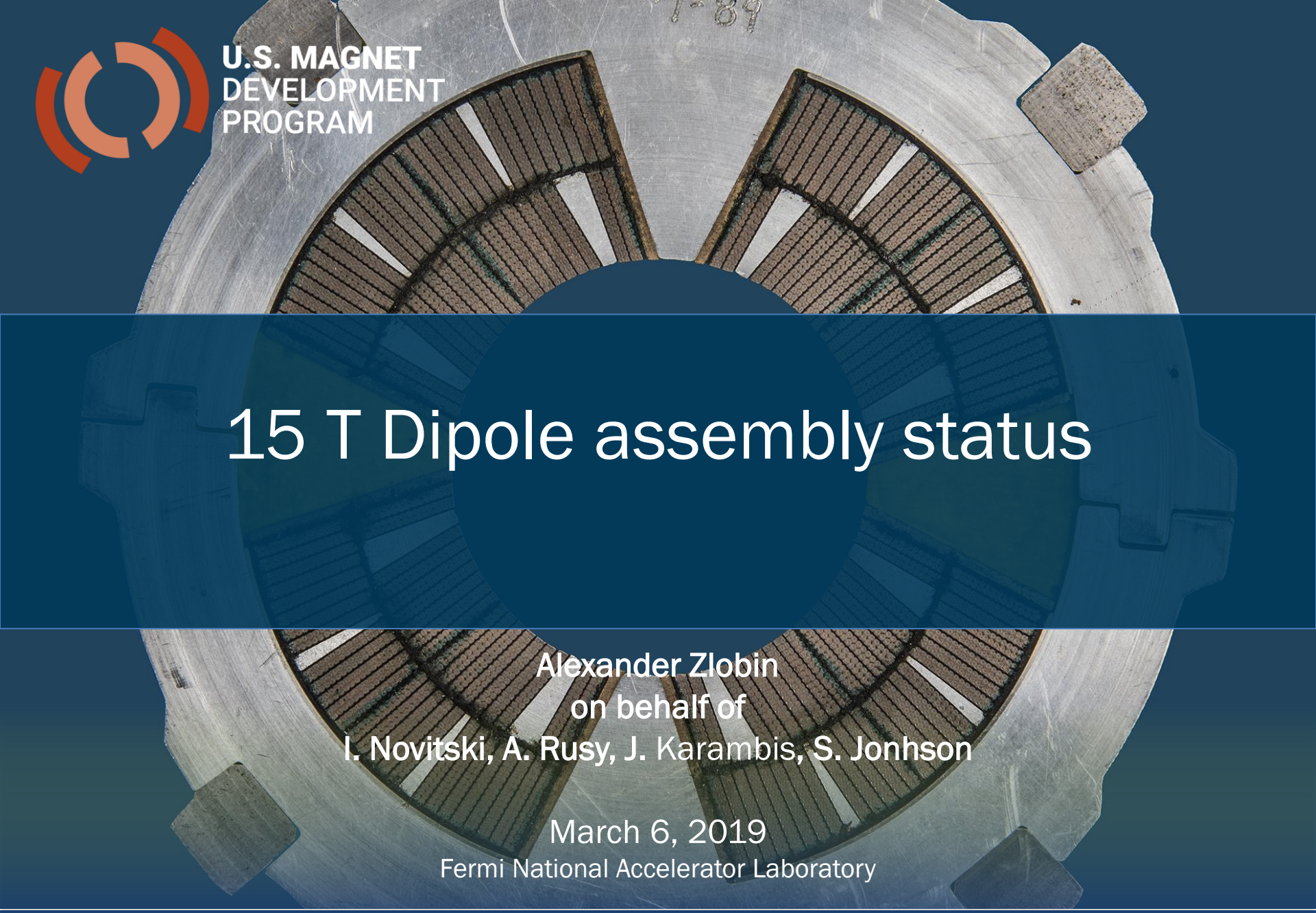


U.S. MAGNET DEVELOPMENT PROGRAM

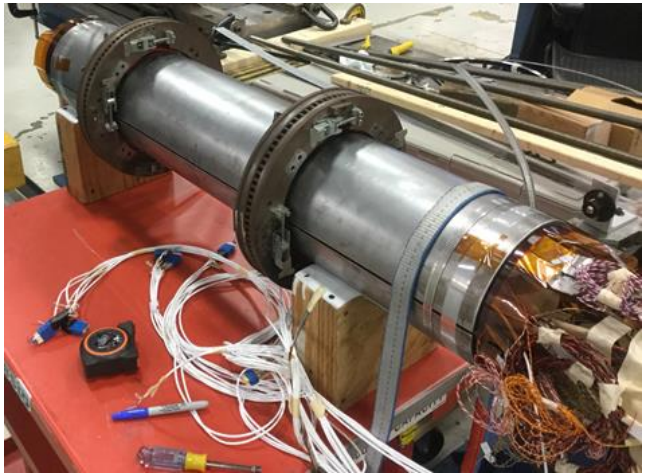
15 T Dipole assembly status

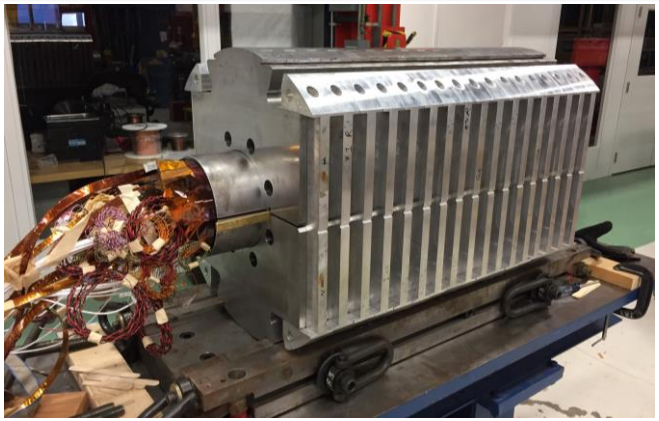
Alexander Zlobin
on behalf of
I. Novitski, A. Rusy, J. Karambis, S. Jonhson

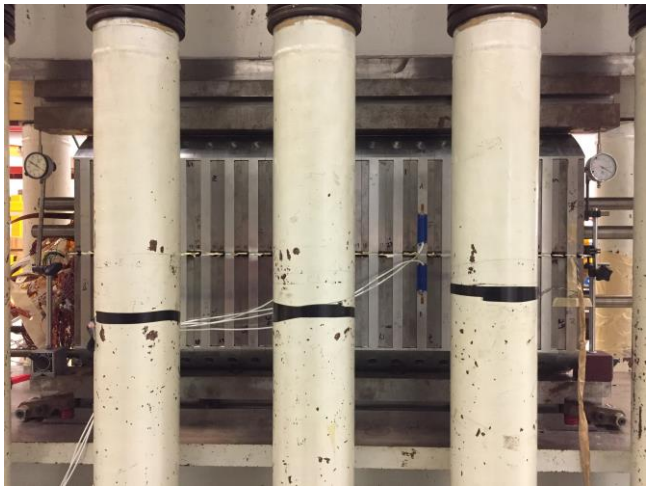
March 6, 2019
Fermi National Accelerator Laboratory

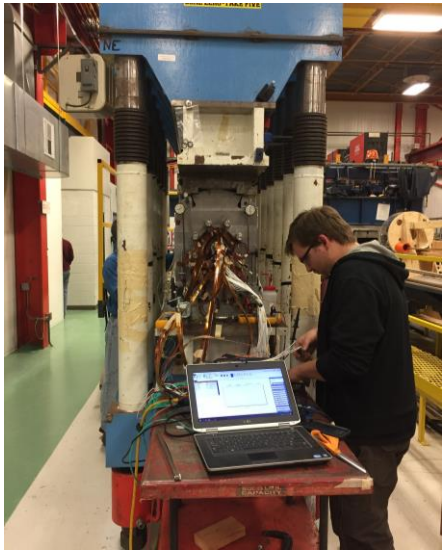
U.S. MAGNET DEVELOPMENT PROGRAM

Magnet assembly status (CM3, 30 January 2019)





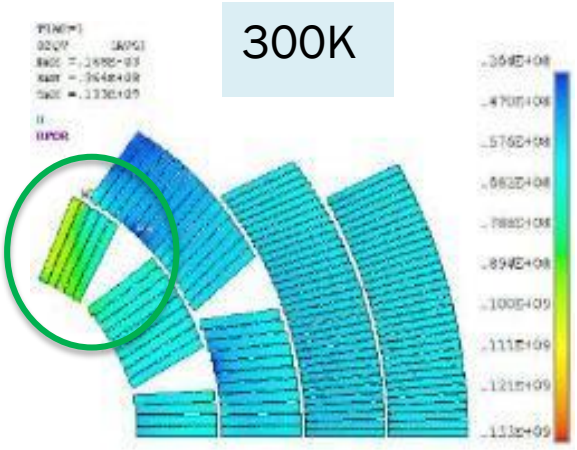




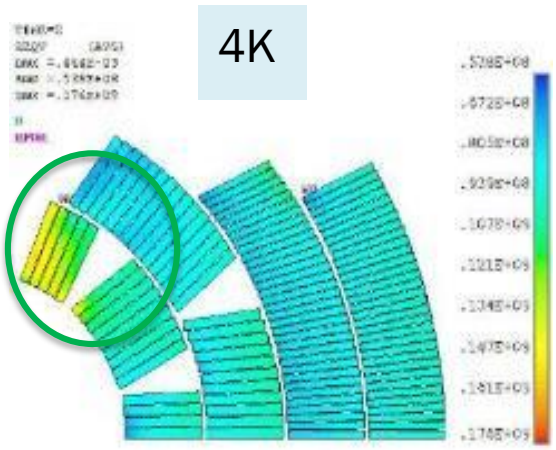
- Coil matching and shimming
- Coil-yoke assembly
- Coil massaging in press
- Coil assembly shimming
- Yoke clamping
- Skin welding
- End pre-load
- Instrument. connectors
- Final tests
- Test readiness review – end of February

Design and Conservative coil pre-stress

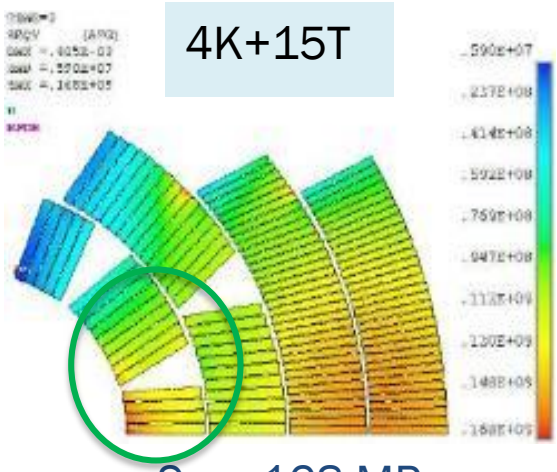
Design coil pre-stress



S_{eqv}=133 MPa
Limit 150 MPa



S_{eqv}=176 MPa
Limit 200 MPa

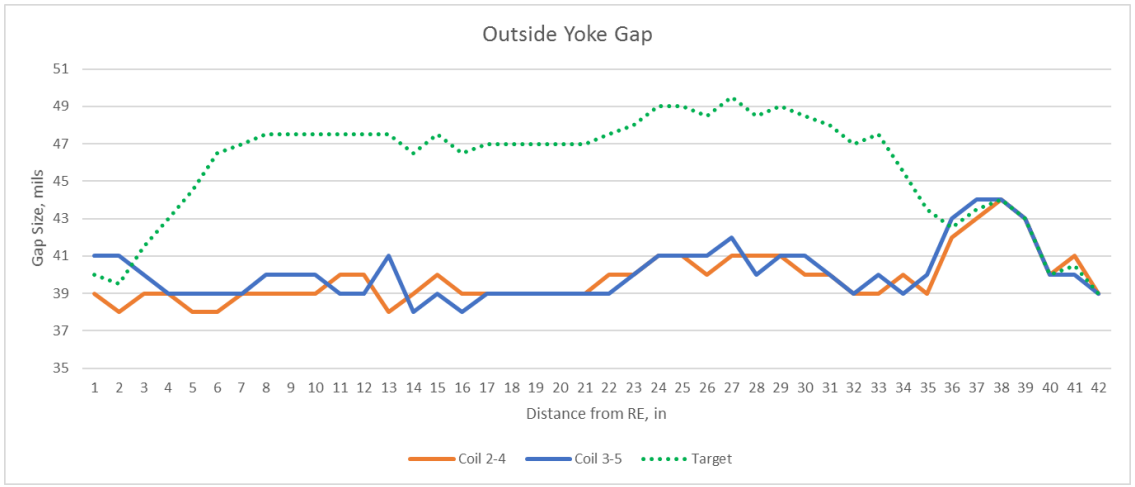


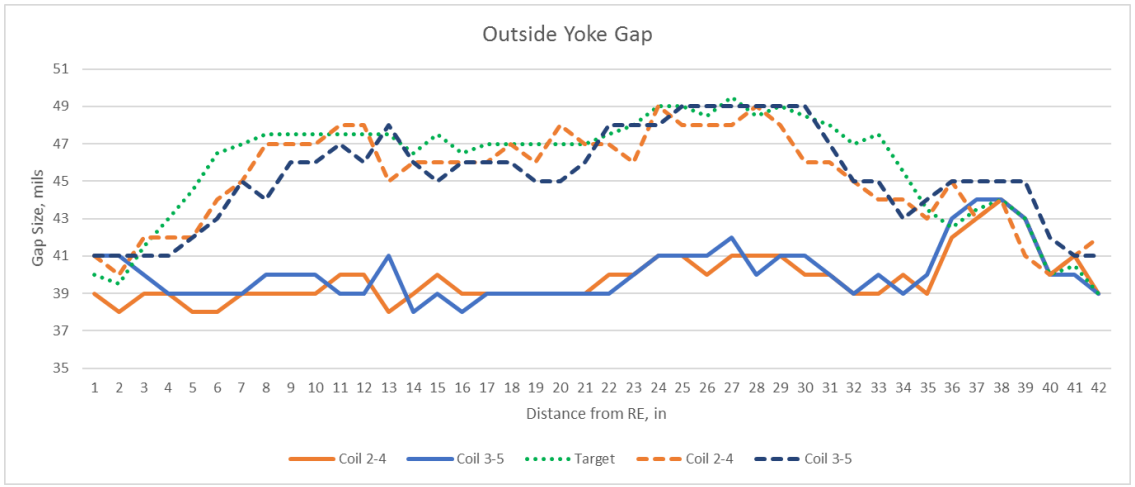
S_{eqv}=168 MPa
Limit 200 MPa

Conservative pre-stress: S_{max} at all steps <150 MPa

Location	Yoking-clamping	Skin welding	Cooling-down	B_{max} = 14 T
IL Pole	60	113	150	~5
IL MP	~15	~40	~75	143

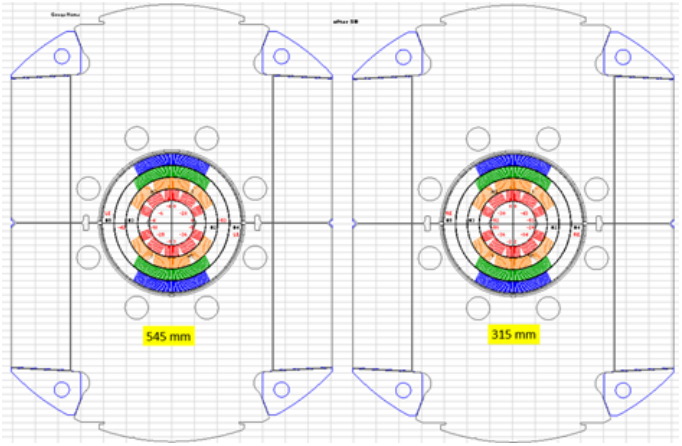
Radial shimming of coil assembly, 2nd assembly with old clamps, gap measurement

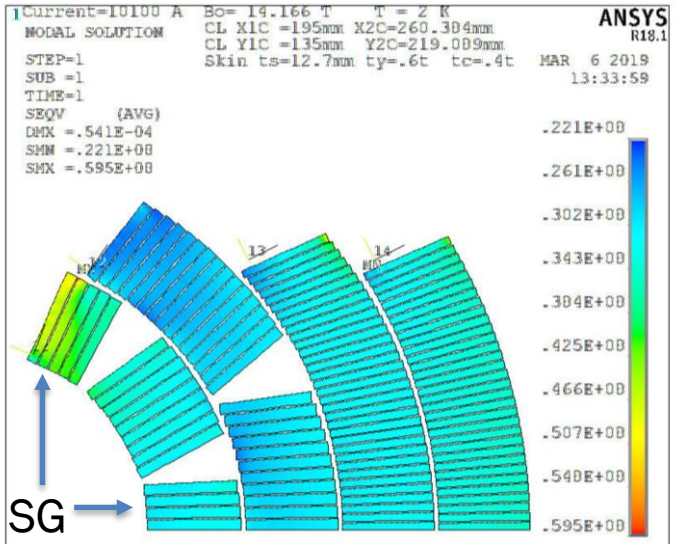




- 0.1 mm radial Kapton shim, tapered towards coil ends to protect coil leads
- Old aluminum clamps

Stress measurements (old clamps)

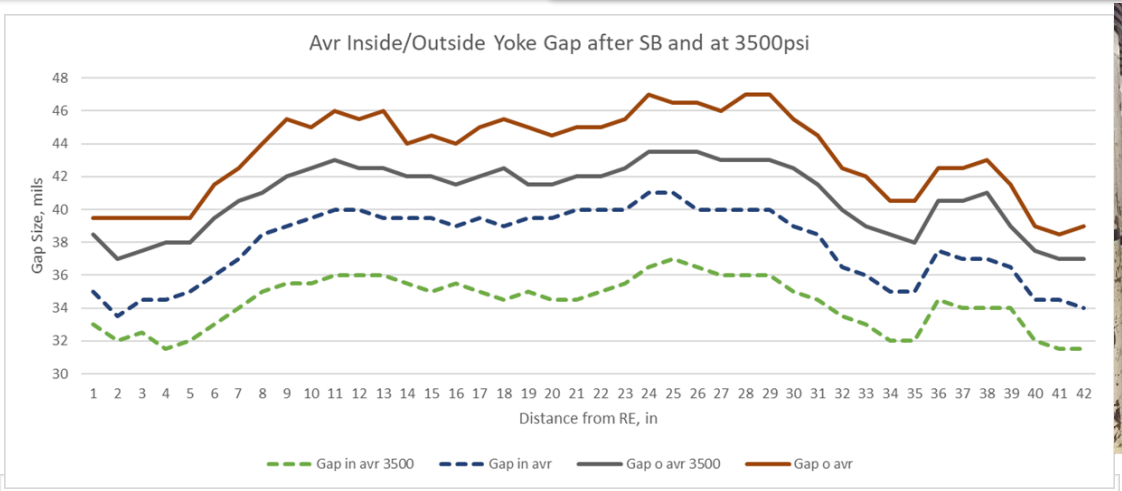


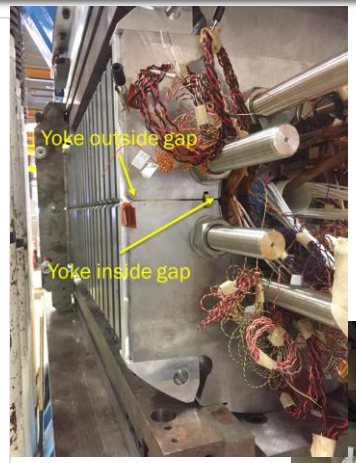


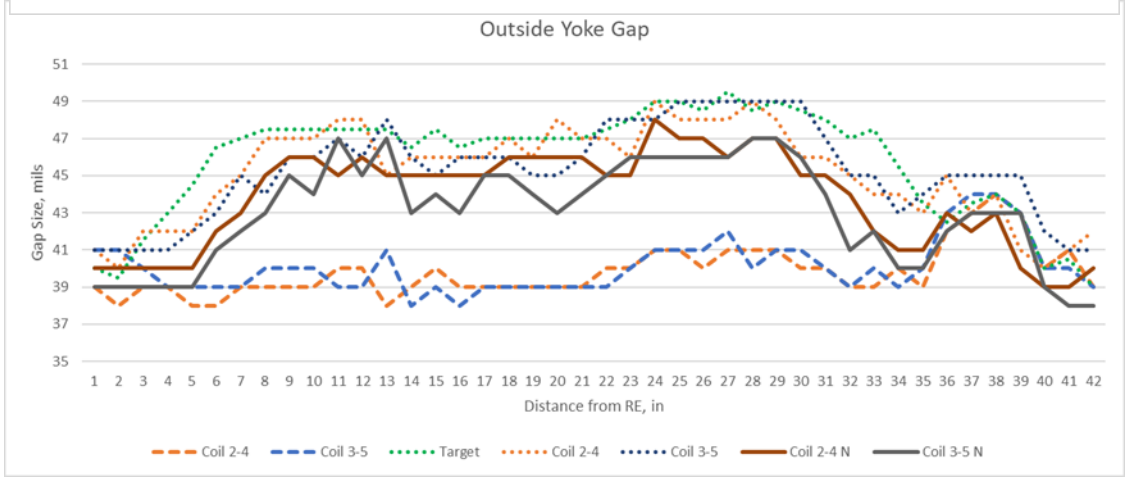
Old Clamp. New "0"	At 3000psi Main Pressure		After Spring Back	
	LE MPa	RE MPa	LE MPa	RE MPa
Coil-MP	-19	-13	-23	-16
Coil-Pole	-29	-52	-14	-36
Pole	-40	-75	-8	-33

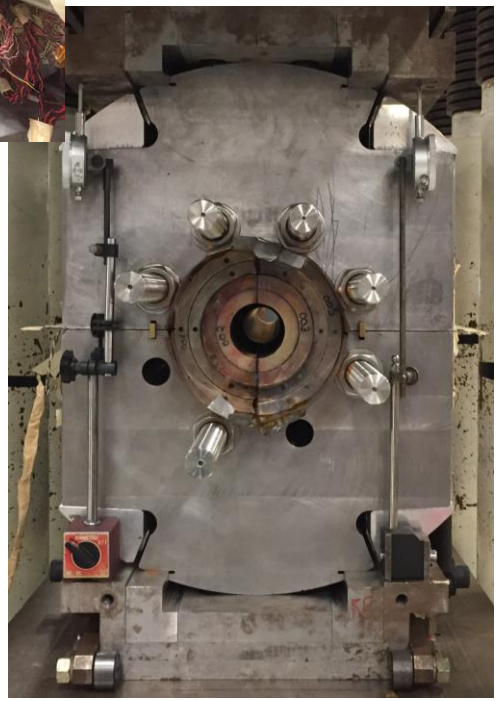
- Average coil pre-stress after clamping
  - Pole: ~25 MPa
  - MP: ~20 MPa

Clamp replacement in press, gap measurements



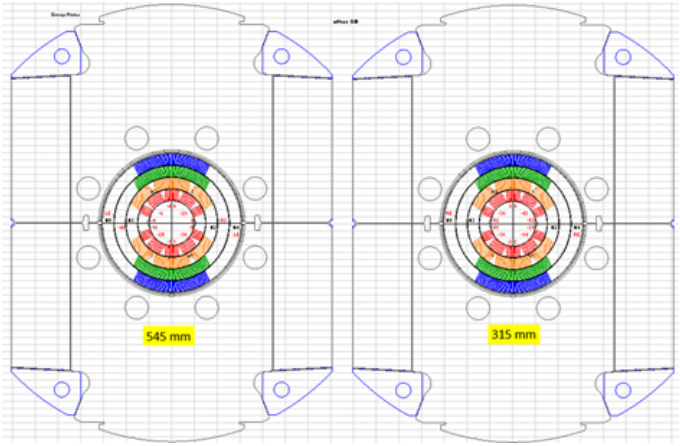


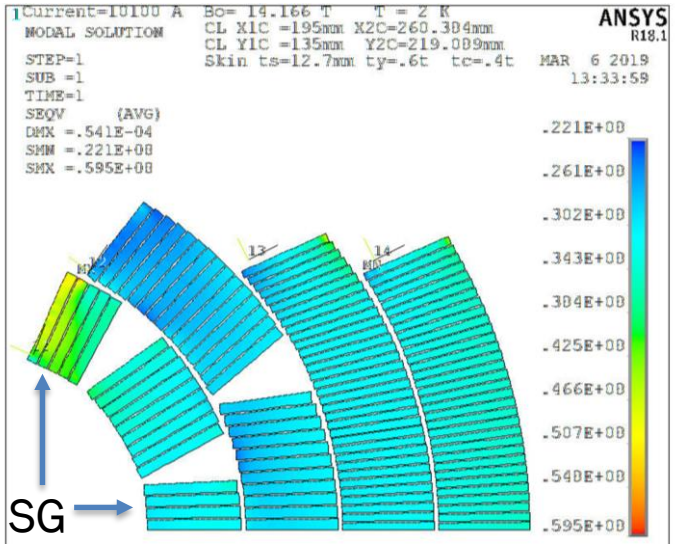




- Gaps slightly reduced due to smaller size of the new clamps

Stress measurements

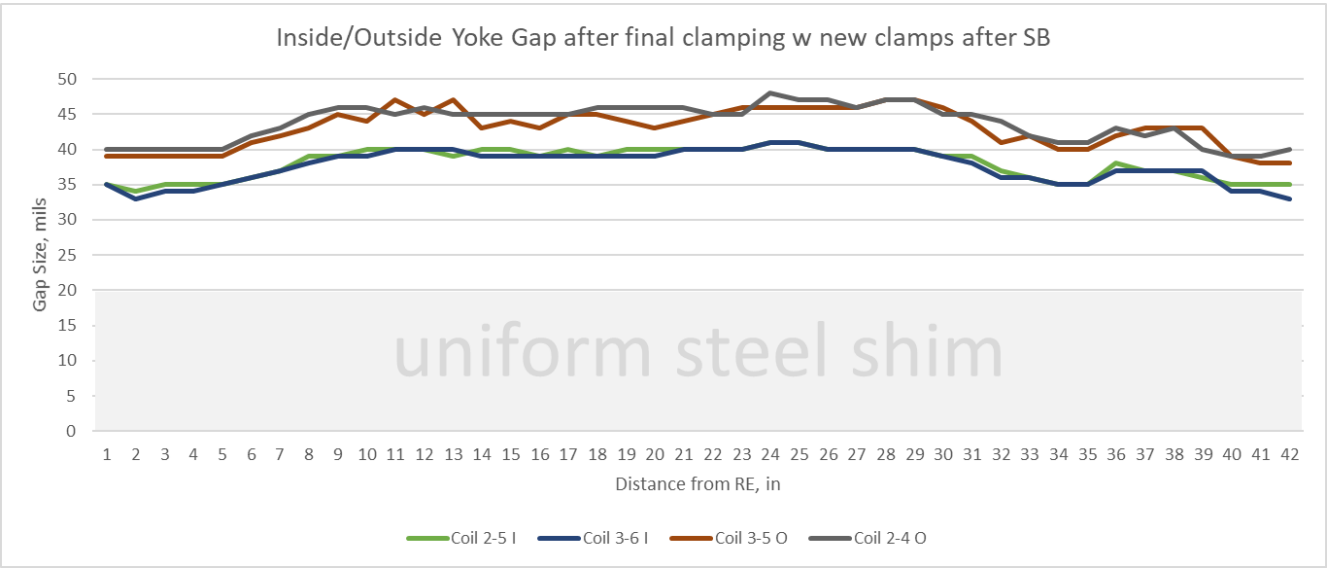


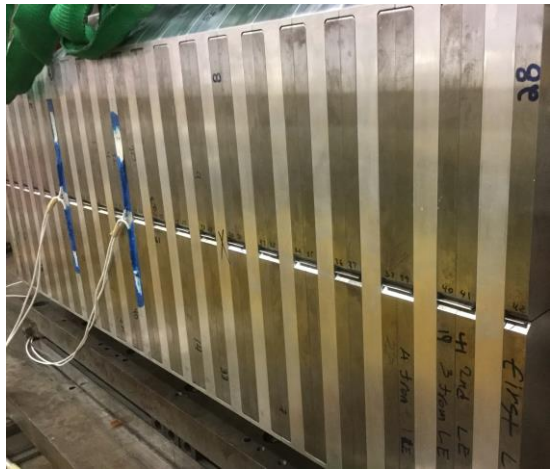


New Clamp. New "0"	At 3000psi Main Pressure		After Spring Back	
	LE MPa	RE MPa	LE MPa	RE MPa
Coil-MP	-20	-10	-25	-17
Coil-Pole	-36	-51	-22	-44
Pole	-53	-65	-15	-44

- **Average coil pre-stress after clamping**
  - **Pole: ~33 MPa**
  - **MP: ~21 MPa**

Gap shimming

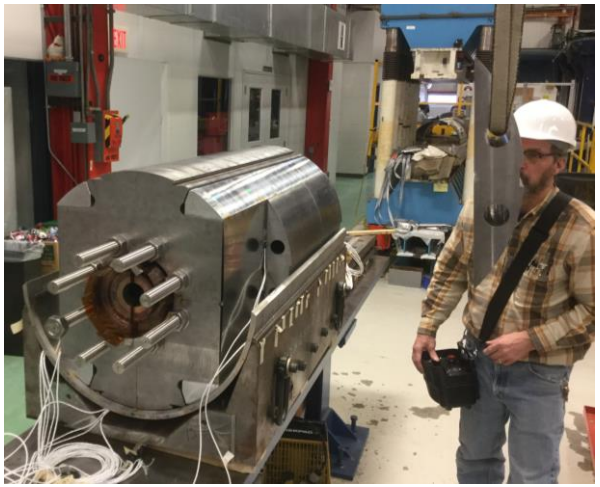




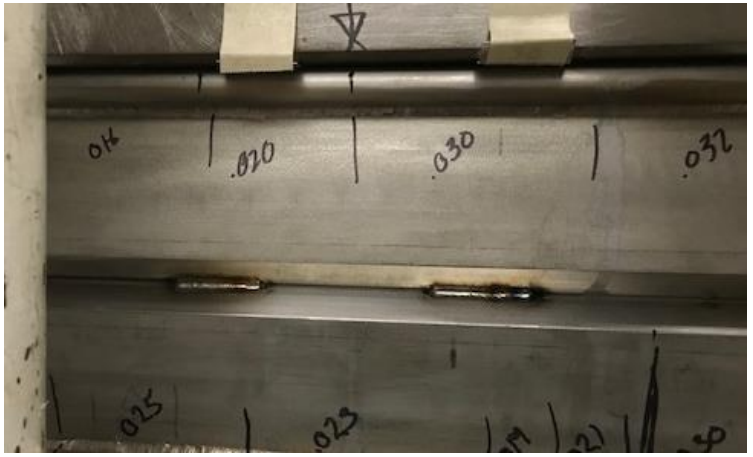
Shim size selection:

- After welding the gap will reduce by 0.125 mm adding up to 50 MPa to the coil pre-stress
- The gap of 0.375 mm will limit the coil pre-stress increase after cooling-down by ~40 MPa

Cold mass assembly inside the welding tooling, electrical test, installation in press

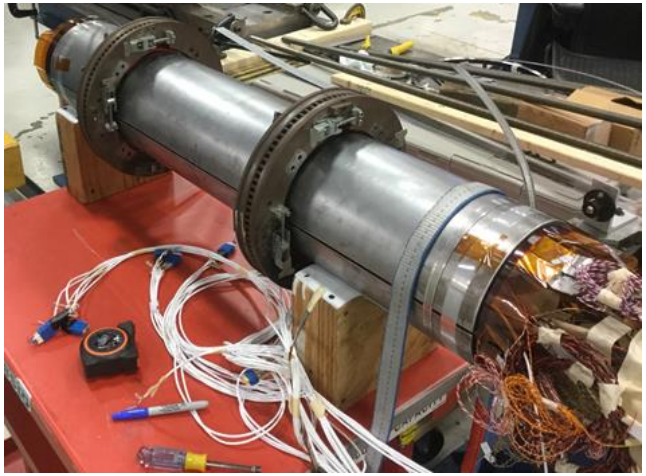


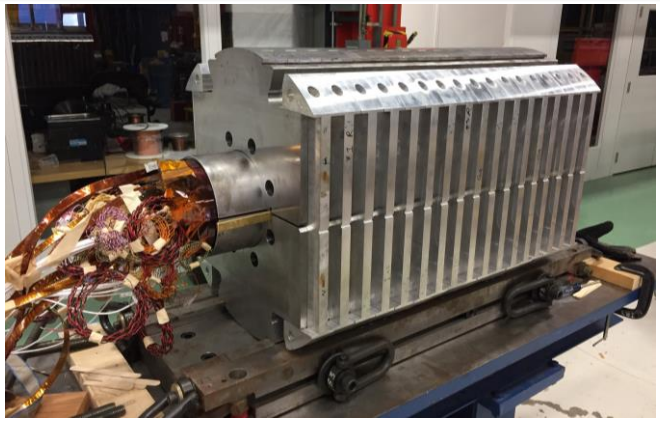
Skin welding

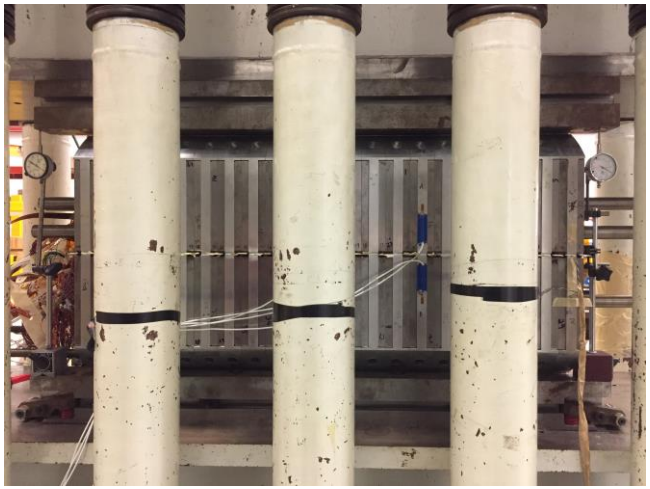


- Skin welding has started with first skip welds inside press
- Welding procedure will be completed outside press
- End rings to be welded to the skin

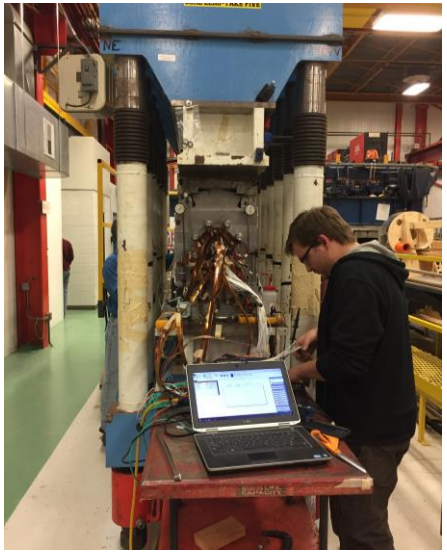
Next steps







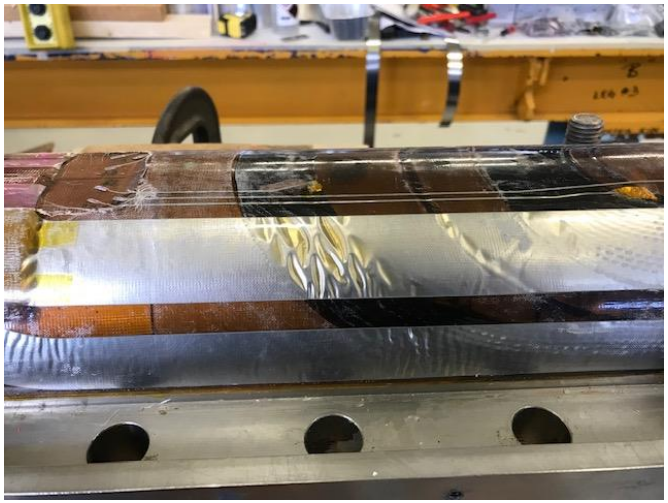
- Coil matching and shimming
- Coil-yoke assembly
- Coil massaging in press
- Coil assembly shimming
- Yoke clamping (3 iterations)
- Skin welding
- End pre-load
- Instrumentation connectors
- Final electrical tests
- Test readiness review and cold test – April



Summary

- To reduce the risk of coil damage during assembly the maximum target pre-stress was limited by 150 MPa. It limit the target field during the first test by ~14 T.
  - Regarding the cos-theta prototype, the TAC strongly supports and encourages a gradual approach to a target field ~ 14 T.
  - Special care must be paid to mechanical stress management and quench protection, in order not to damage the magnet during pre-stress assembly and to enable extending the effort for realizing higher field.
- Target coil pre-stress is defined for each assembly step including yoking, clamping, skin welding and cooling-down.
- 15 T dipole coil clamping is complete
  - three clamping steps (with old and new clamps)
  - Final IL coil pre-stress after clamping is ~33(pole)/21(MP) MPa (target ~37/30 MPa)
- Skin welding has started
  - skin welding will add up to ~ 50 MPa to the coil pre-stress after clamping
  - expected IL pole pre-stress up to ~80 MPa (target ~85 MPa)
- The level of coil pre-stress after cooling-down will be controlled by the gap shims selected based on the gap measurements after clamping

L1-L2 spare coil status



- L1-L2 spare coil has been impregnated
  - placing QP heaters on traces does not look as a good idea
- Next: coil size measurement and instrumentation