US LHC Accelerator Research Program

bnl - fnal- lbnl - slac

Accelerator Integration

M. Anerella, BNL

4/27/10

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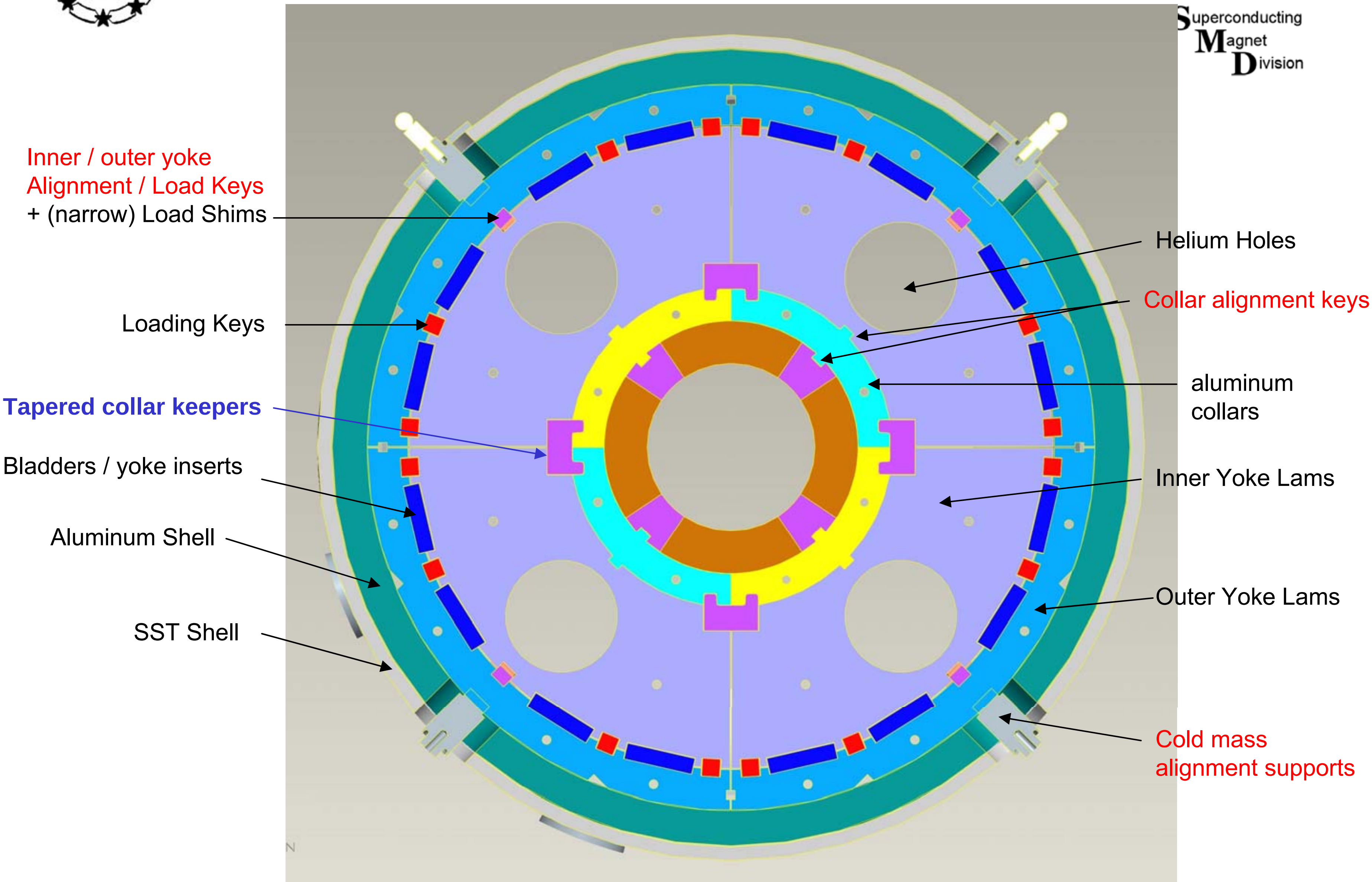
Outline

- Brief Review from CM13
- Collar progress since then
- Collaring tooling progress since then
- Work to go

Goals (from CM13)

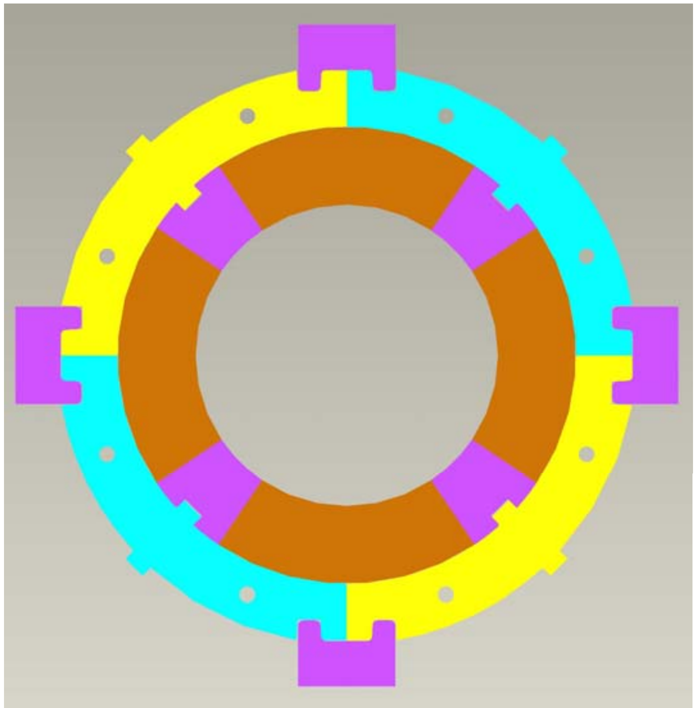
- Employ all of the benefits of the existing LQ/HQ shell structures
- Add provisions for 2K helium cooling – 80mm heat exchanger holes
- Improve alignment features – provide keys from coils to helium vessel
- Complete cold mass – helium vessel
- Enhance reliability, manufacturability (reduce cost)
- Develop a design which is accepted for use in LHC by CERN

Updated Support Structure



Alternate Collar Investigation

- Keys replaced by "keepers"
  - Allows for 2x the collar key bearing area, therefore ½ x the collar stress for a given load
  - Potential for higher coil loading at 300K
  - Results in cheaper collars (single part style, no welding or pinning needed)



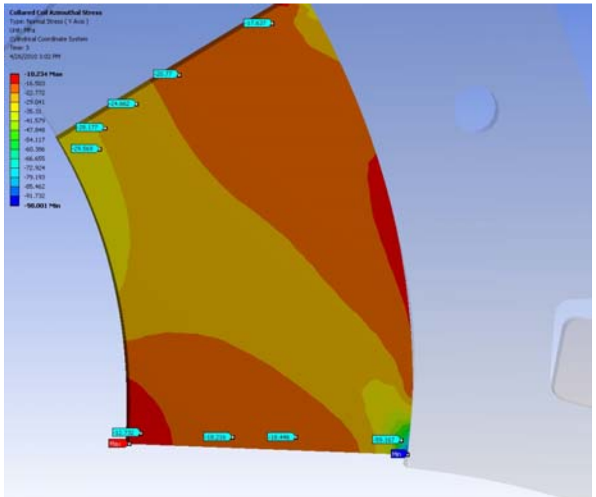
→ decision to be based on technical performance + cost

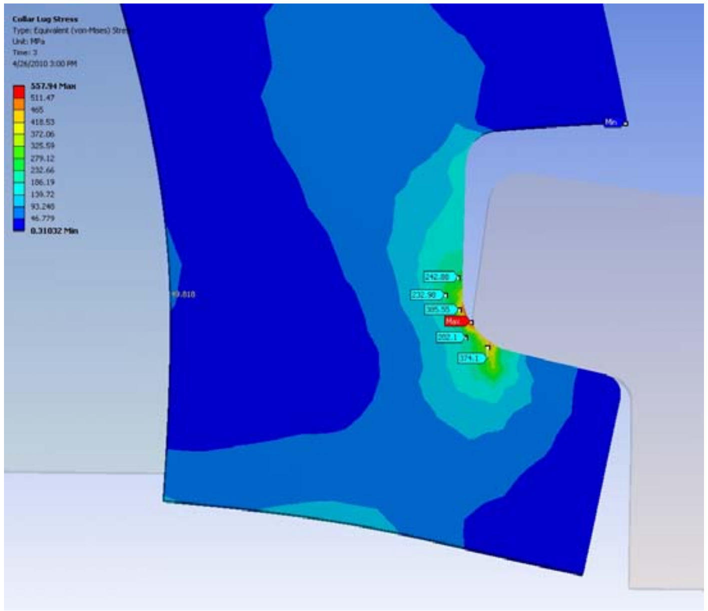
Alternate Collar FEA

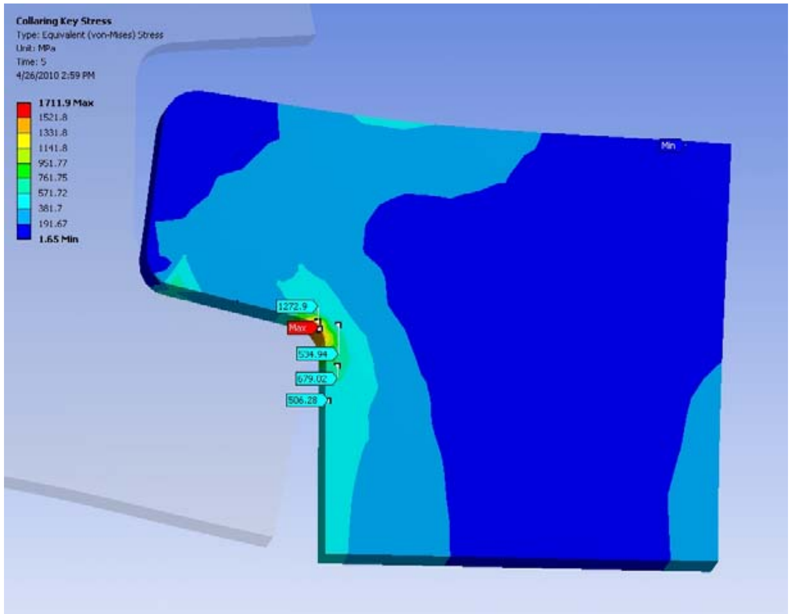
Work is presently underway:

•Collar loading now

•Cool down, Lorentz forces next







Updated Collaring Concept

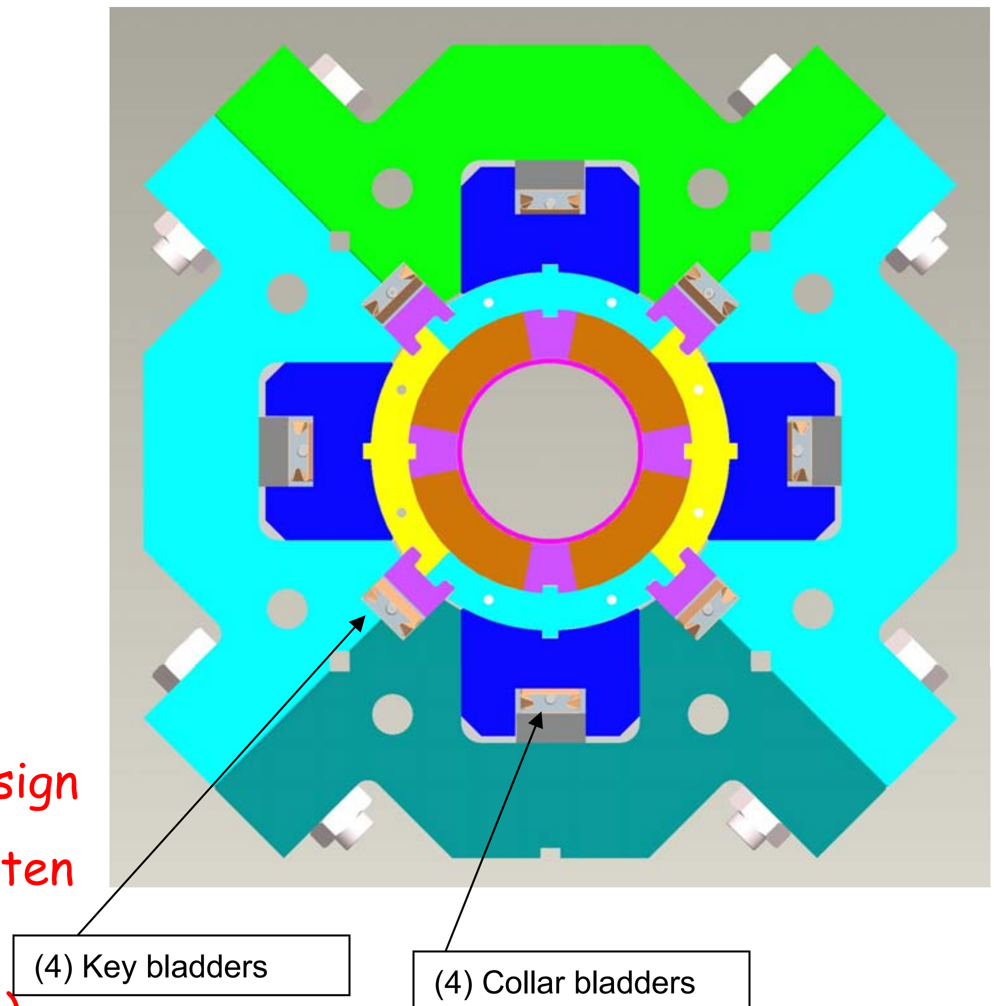
Review:

"Bladder-technology" based:

- Quad symmetry assembly
- Provide precise alignment during assembly
- Lower capital cost, easily incorporated into R&D budget
- Easily expanded from 1m to 8m
- Assembly process developed (see back-up sheets)

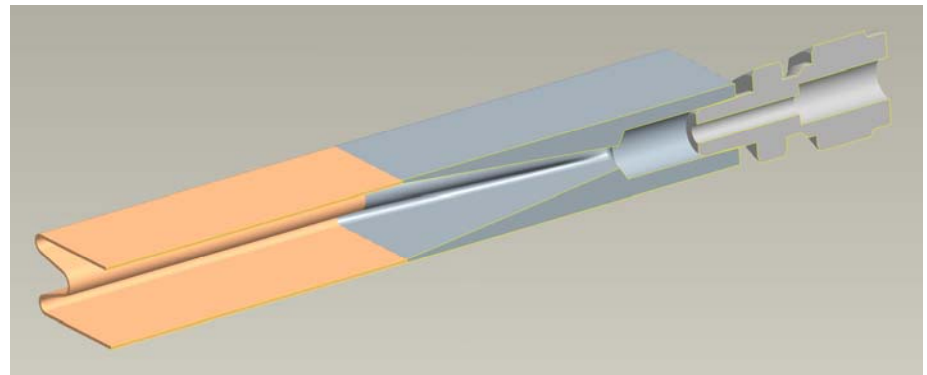
Updates:

- Revised for updated collar design
- Minor corrections to keys, platen travel, etc.
- Bladder development (next slide)



Bladder Development

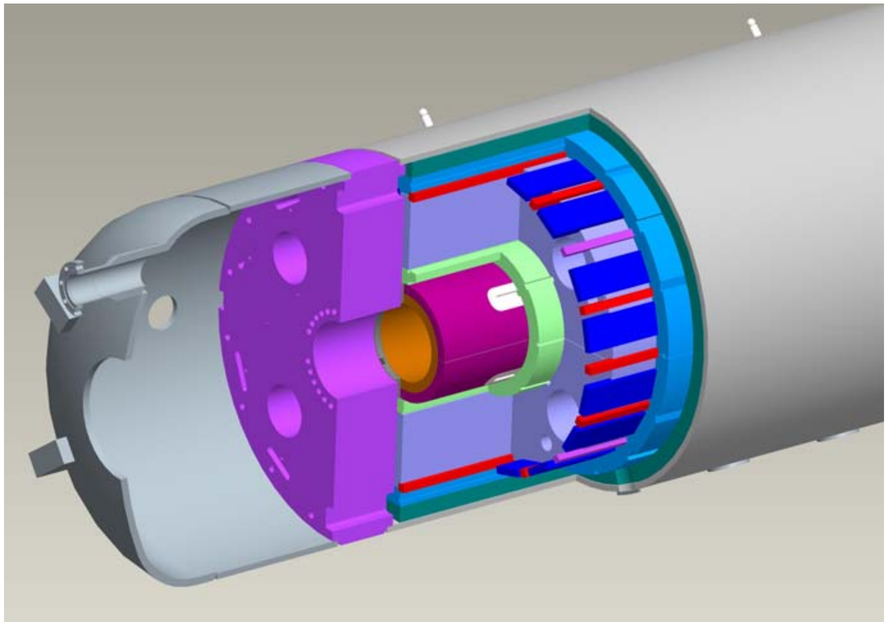
- Designed for ~ 6mm stroke
- Stainless steel extrusion, welded only at ends
  - Sample ordered, delivery ~ now
- End fittings transition from extension to fixed pressure fitting
  - Prototypes to be ordered 4/10



→ single bladder assembly (~ 6" to 12" long) to be tested before tool fabrication begins

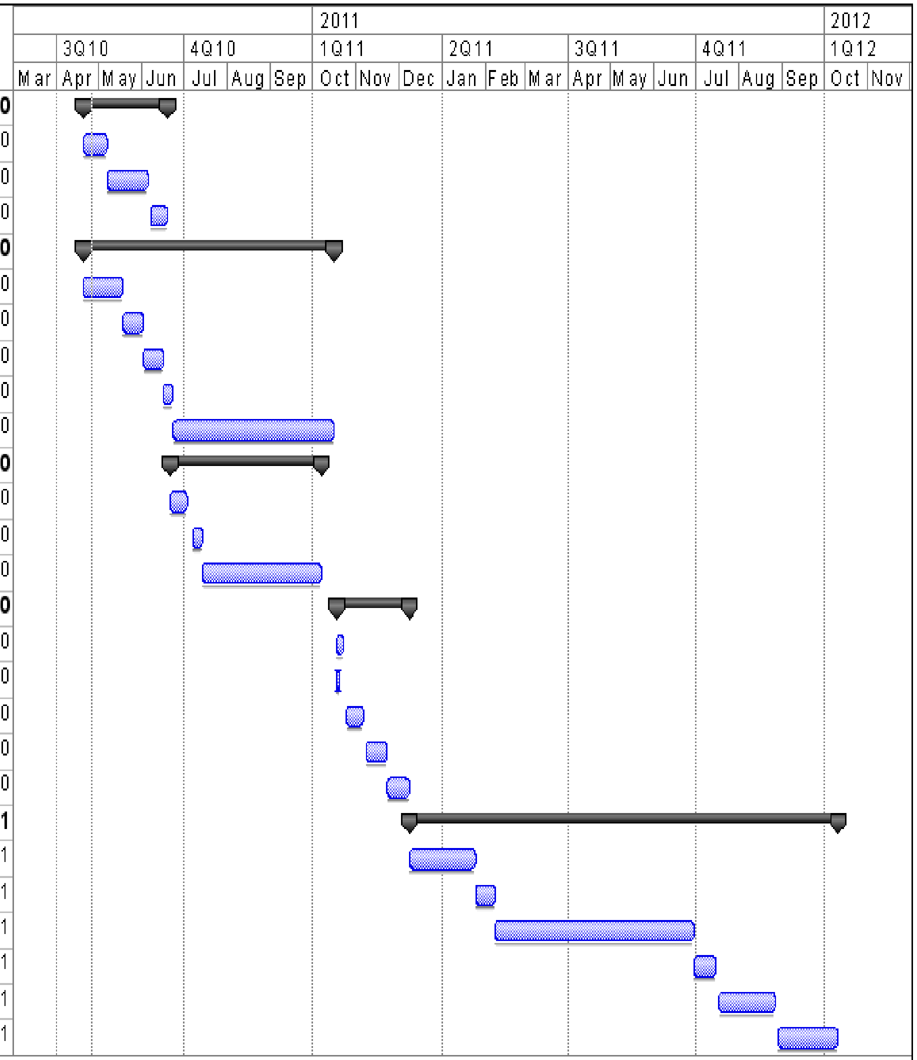
Next task – Axial Loading FEA

- Stainless steel end plate, set screws support axial loads
- Also serves as an element of pressure vessel



Schedule – work to go

ID	Task Name	Duration	Start	Finish
1	**Bladder R&D**	**43 days**	**4/20/10**	**6/18/10**
2	finish end housing design	13 days	4/20/10	5/6/10
3	make parts	20 days	5/7/10	6/4/10
4	perform single bladder test	10 days	6/7/10	6/18/10
5	**6" model assembly**	**125 days**	**4/20/10**	**10/15/10**
6	finish collar analysis	20 days	4/20/10	5/17/10
7	detailed collar design	10 days	5/18/10	6/1/10
8	cold mass analysis / design	10 days	6/2/10	6/15/10
9	order parts	5 days	6/16/10	6/22/10
10	fabricate parts	80 days	6/23/10	10/15/10
11	**6" model tooling**	**75 days**	**6/21/10**	**10/6/10**
12	detailed tooling design	10 days	6/21/10	7/2/10
13	order parts	5 days	7/7/10	7/13/10
14	fabricate parts	60 days	7/14/10	10/6/10
15	**6" model test**	**35 days**	**10/18/10**	**12/8/10**
16	calibrate strain gauges	5 days	10/18/10	10/22/10
17	cut, assemble coil sections	2 days	10/18/10	10/19/10
18	collar coils	10 days	10/25/10	11/5/10
19	assemble model	10 days	11/8/10	11/22/10
20	test	10 days	11/23/10	12/8/10
21	**1m magnet test**	**210 days**	**12/9/10**	**10/10/11**
22	final detailed design	30 days	12/9/10	1/24/11
23	order parts	10 days	1/25/11	2/7/11
24	fabricate parts, tooling	100 days	2/8/11	6/29/11
25	assemble parts, tooling	10 days	6/30/11	7/15/11
26	assemble magnet	30 days	7/18/11	8/26/11
27	vertical cold test	30 days	8/29/11	10/10/11



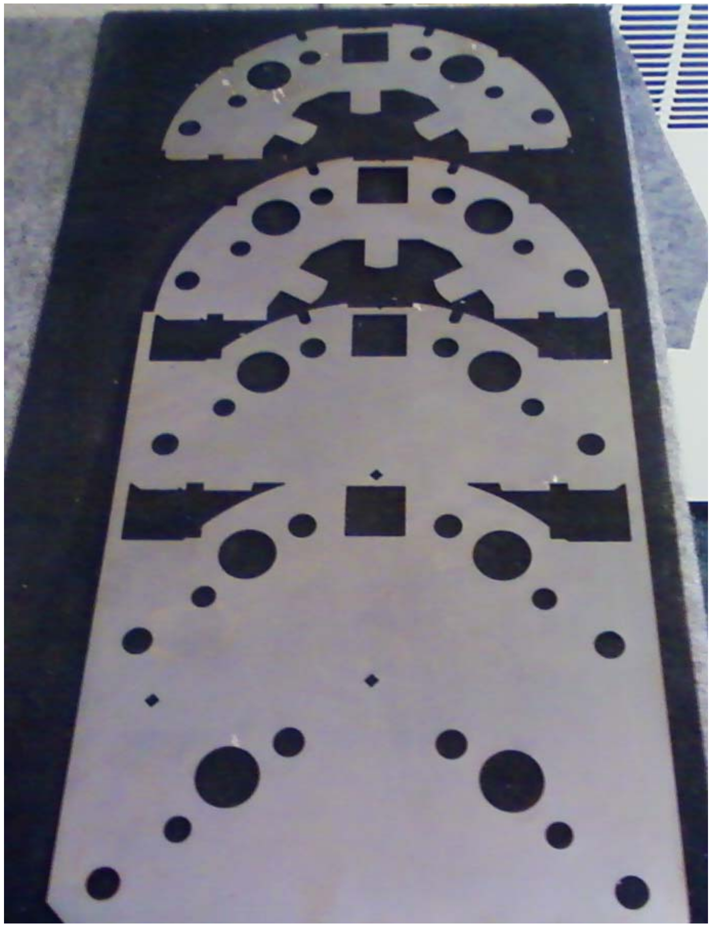
Back-up (CM13) slides

- Goals
- Design philosophy
- Picture of laminations from progressive die
- Collaring process
- Assembly steps

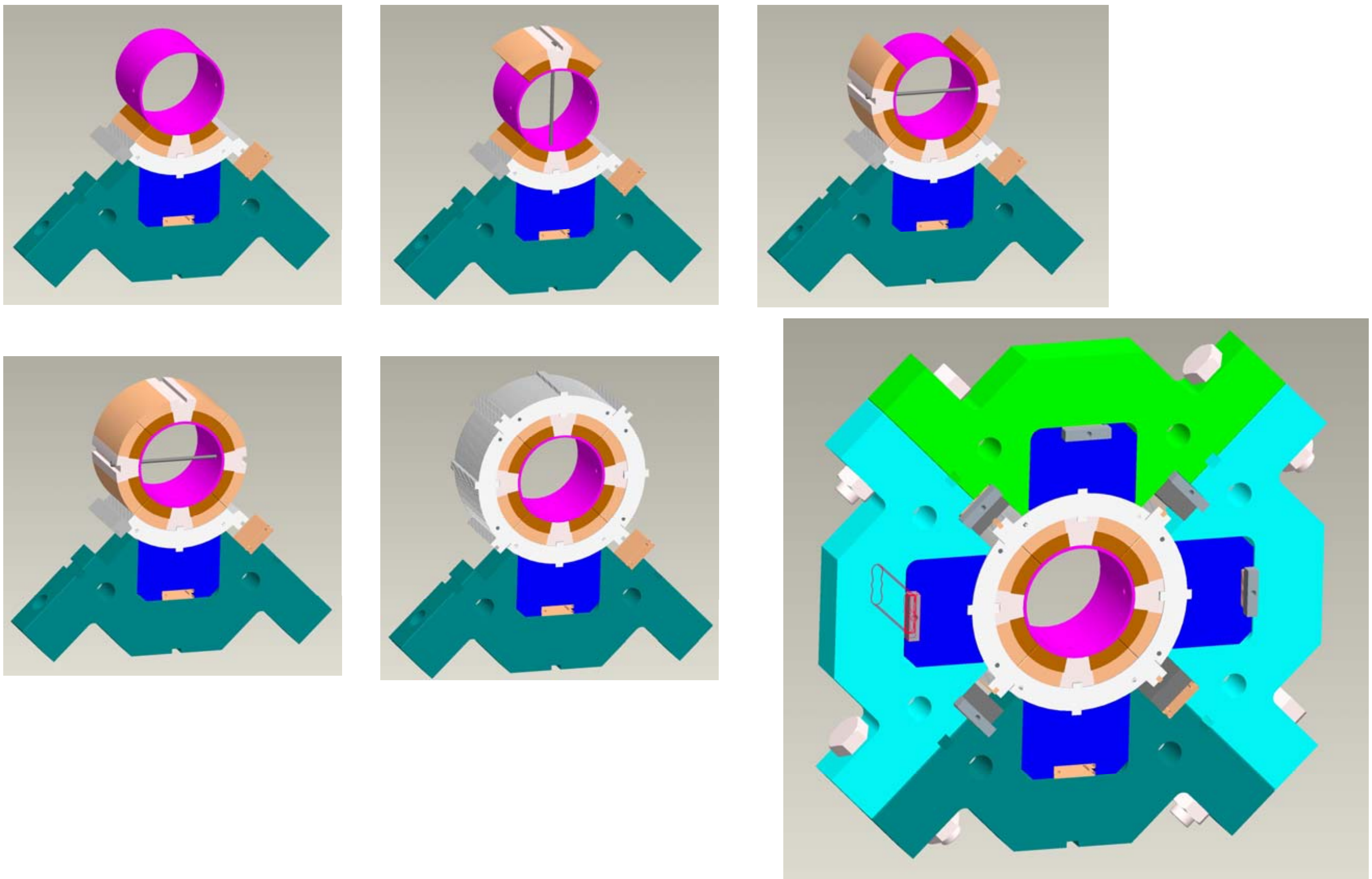
Design Philosophy

- Traditional aluminum collars
  - apply low initial prestress to coils
  - Guarantee alignment from coil pole to collar o.d. (no sliding/mating of alignment features during assembly)
  - Provide reliable geometry
  - Prohibit over-compression of coils by means of mechanical stop
- Circular contact between collar and inner yoke
  - Greater contact provides full support - geometric repeatability, lower contact stresses
- Shift inner-outer yoke boundary outward radially
  - Enables incorporation of helium heat exchanger holes
  - Enhances flux return
  - Allows for greater surface area of bladders, loading keys → lower pressure
- Shift yoke parting planes to midplane
  - Allows for continuous alignment from coil to exterior of helium vessel
  - Coil deflections under full excitation are acceptable
- Utilize fewer, cheaper parts
  - Inner and outer yokes made from common lamination in a progressive die
    - Guaranteed alignment of critical features
    - Cheapest method of manufacture
  - Simple keys, shims inserted easily through procedural changes
- Support axial forces through sst shell – allows greater helium, flux space

Laminations from a progressive die

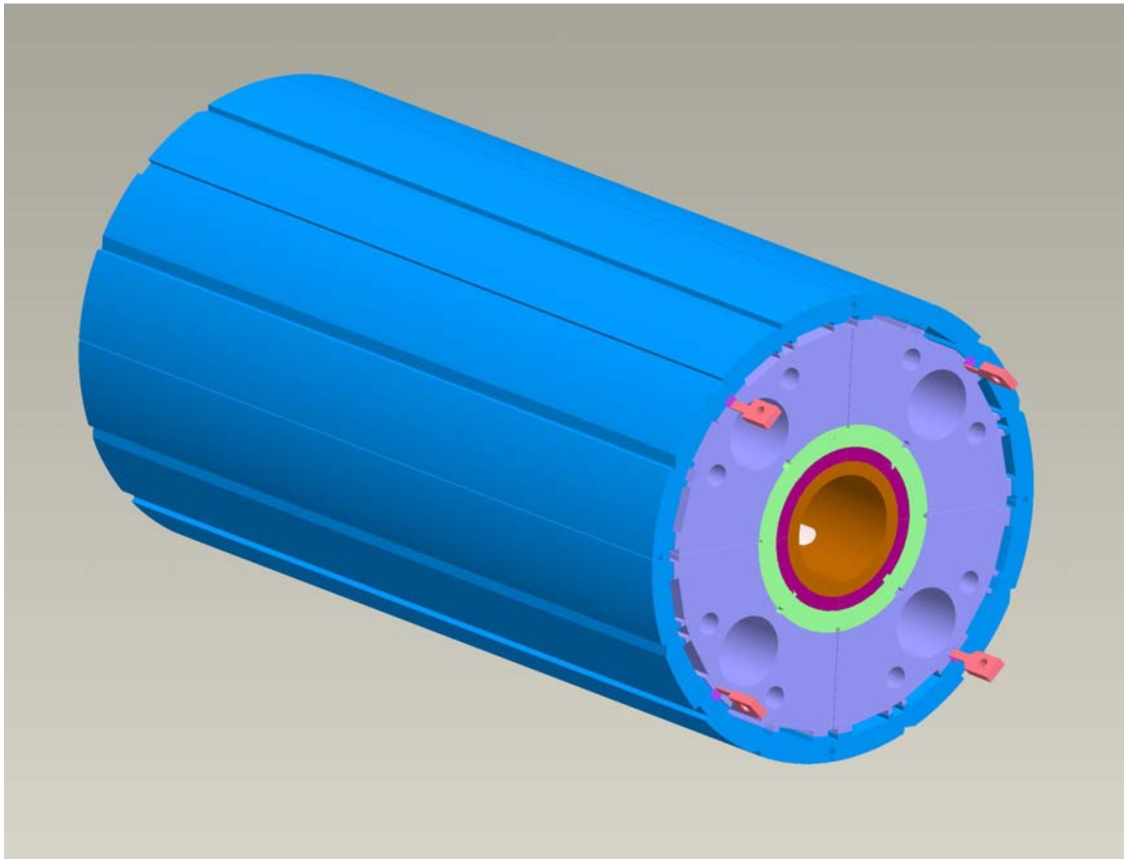


Collaring Process



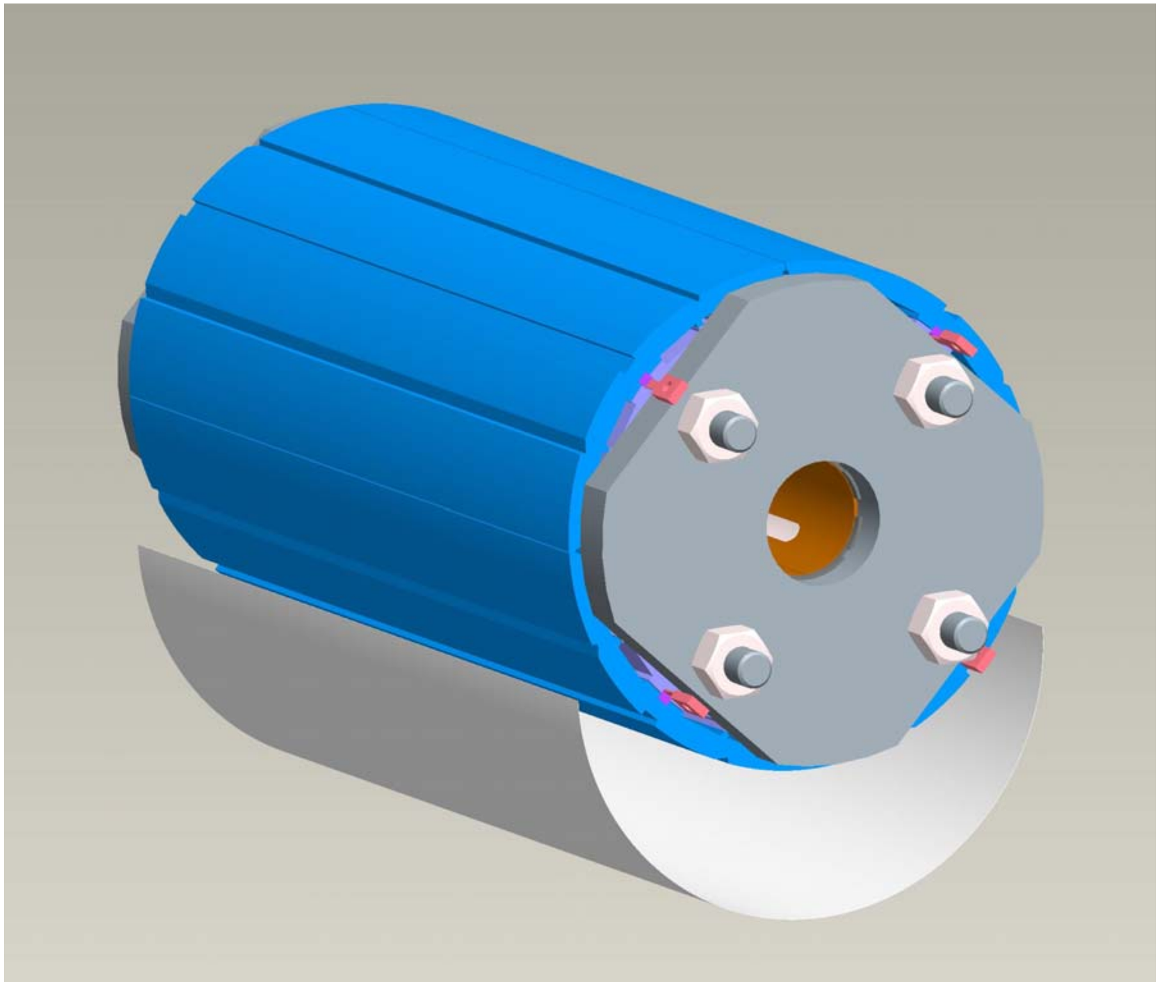
Assembly process

- Collar coils to fairly low load.
- Assemble into yoke. Under size keys maintain alignment , allow outer yoke to be closed against inner yoke.



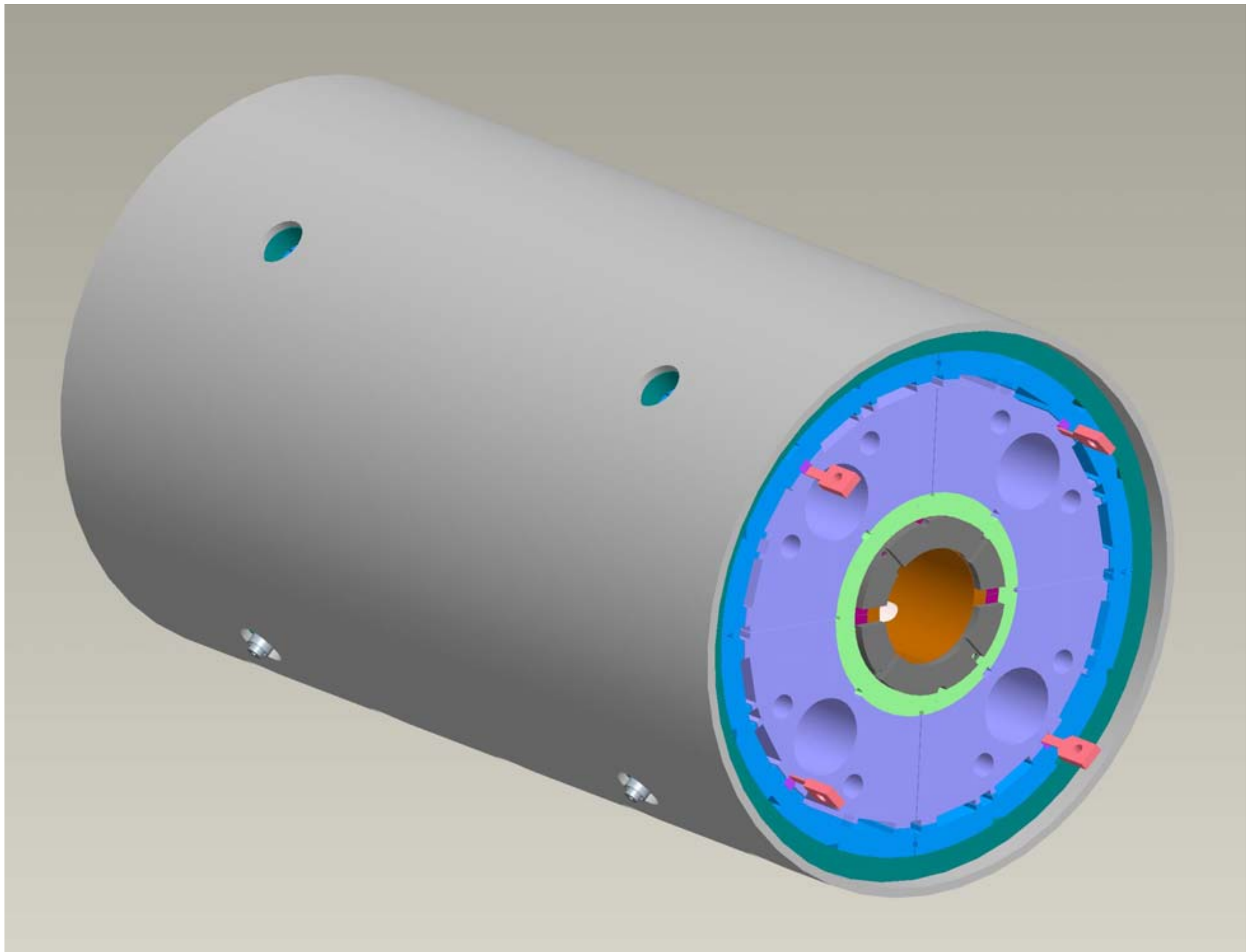
Assembly process

- Place yoke assembly onto thin liner / sled.
- Temporary end plates and tie rods hold yoke together.



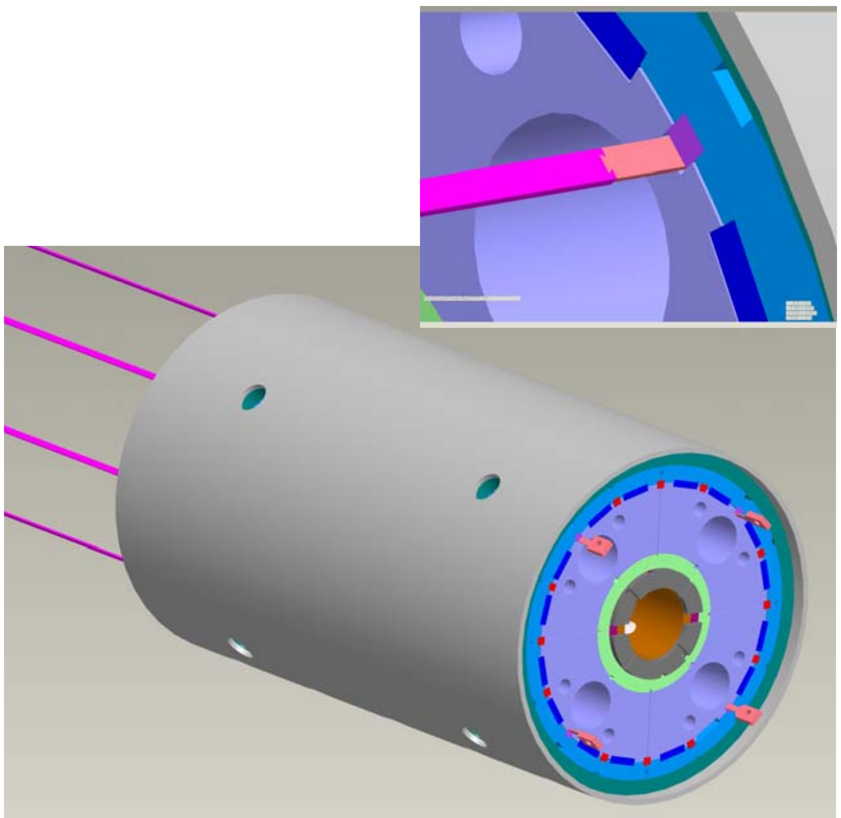
Assembly process

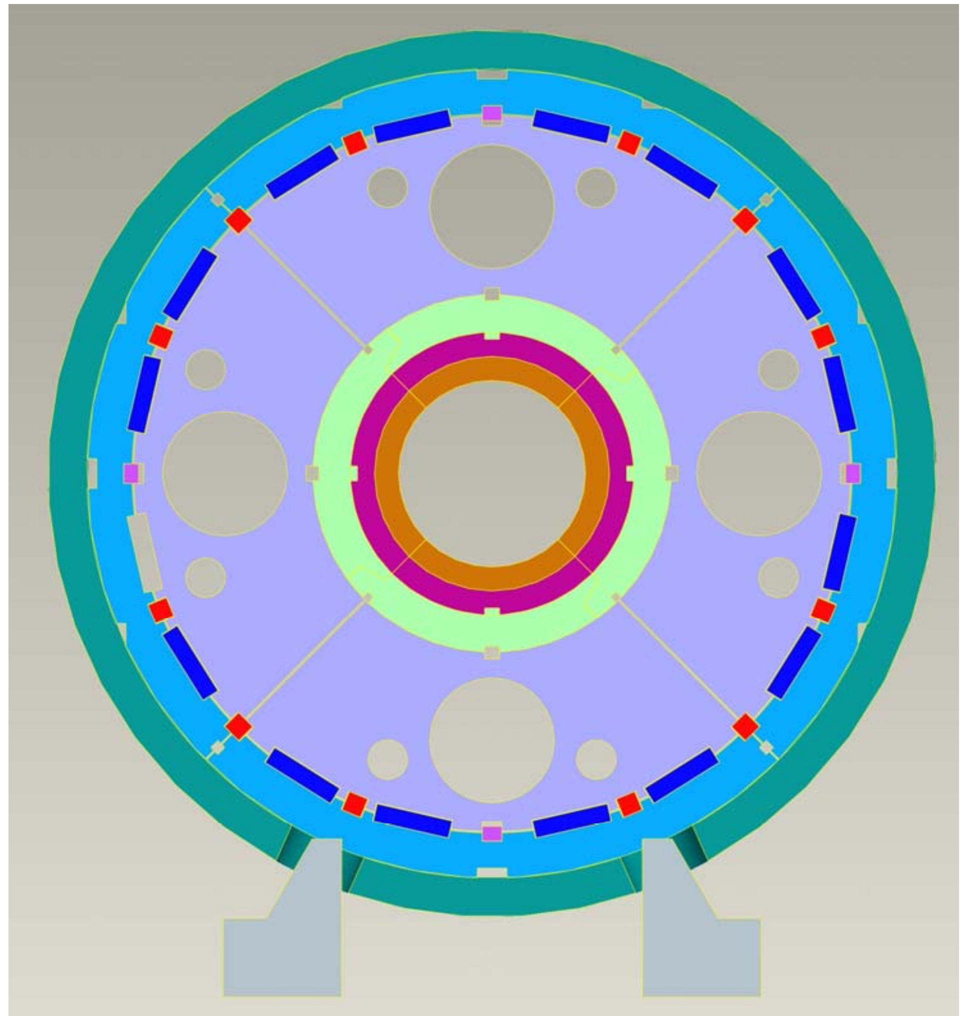
- Pull assembly into shell. Clearance because outer yoke is clamped to inner yoke.



Assembly process

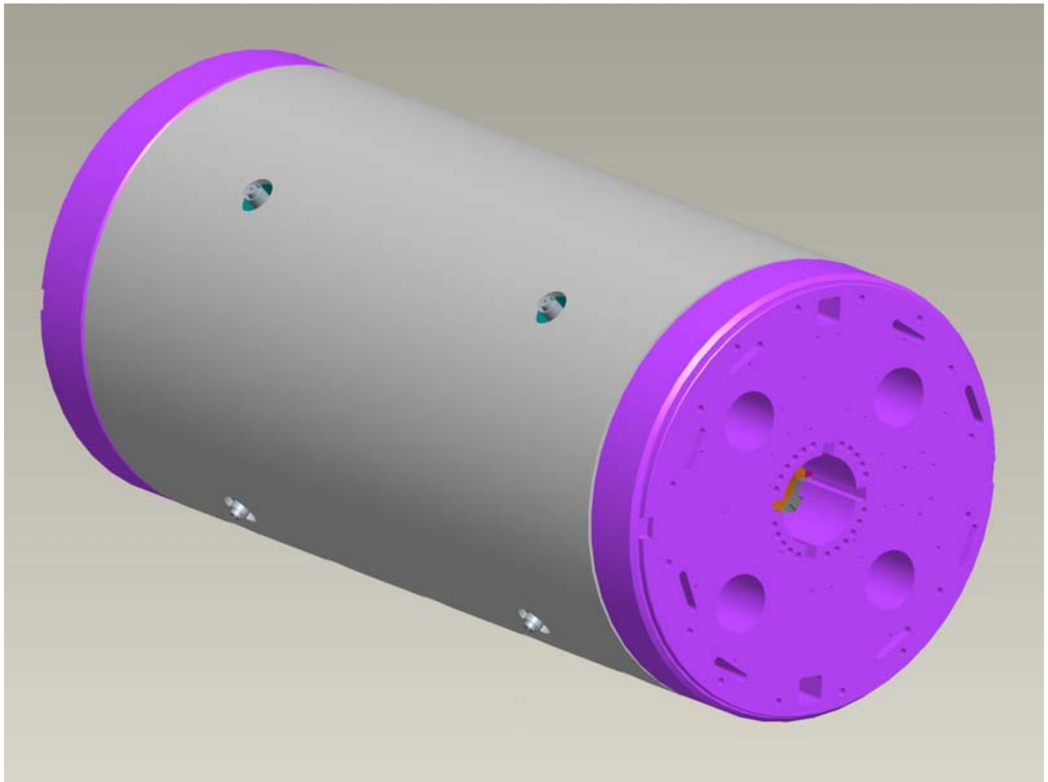
- Place onto precision supports, providing alignment of yoke during assembly
- Use bladders to load coils / shell.
  - 1 or 2 quadrants at a time (as now)
  - Rotate 90° and repeat
- Install support keys / shims.

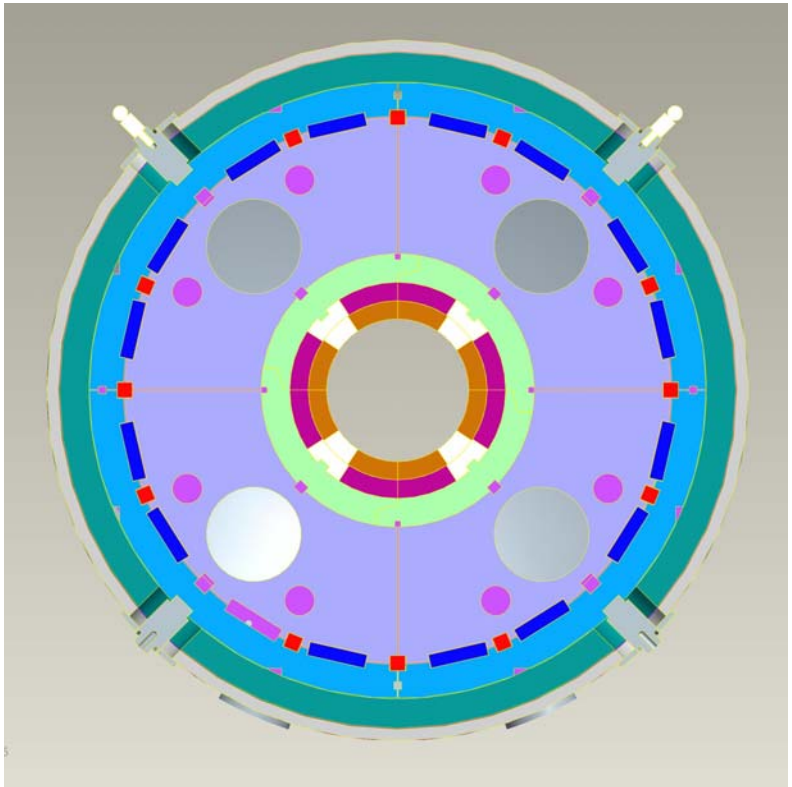




Assembly process

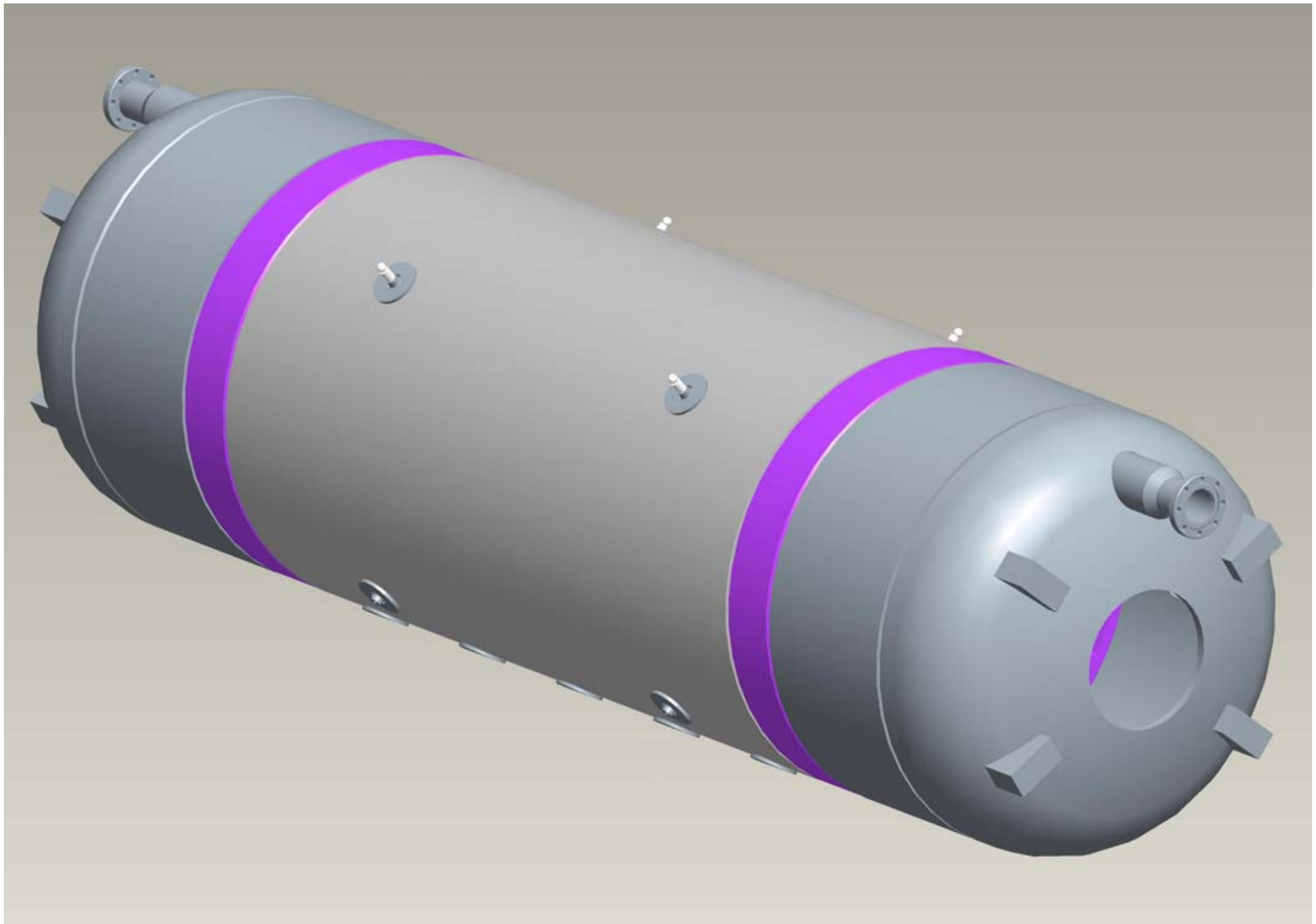
- Install into helium vessel (loose clearance fit)
- Install cold mass supports / alignment fiducials on yoke through access holes.
- Install end plates – set screws to load coil ends.
- Install cover patches onto vessel





Support Structure

- Complete electro-mechanical assembly
- Install end domes, cradles aligned to cold mass supports / fiducials to complete helium vessel.



Support Structure

- Cut away view