US LARP

US LHC Accelerator Research Program

BROOKHAVEN NATIONAL LABORATORY

Superconducting Magnet Division

bnl - fnal- lbnl - slac

Support Structure Considerations

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(work by J. Schmalzle, J. Cozzolino, P. Kovach)

Goals

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

“Guidance” on cooling, from

“LHC Project Report 1163
Conceptual Design of the
LHC Interaction Region Upgrade – Phase-I”

Figure 6: Normalised transfer functions of the present low-β quadrupoles (MQXA and MQXB) and of three possible designs of MQXC (aperture 110, 120 and 130mm) with four 110 mm holes, one of which is used for the heat exchanger.

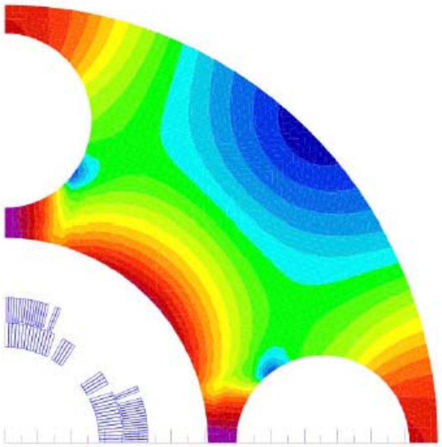


Figure 7: Conceptual design of the 120 mm MQXC quadrupole with a 110 mm opening for the heat exchanger.

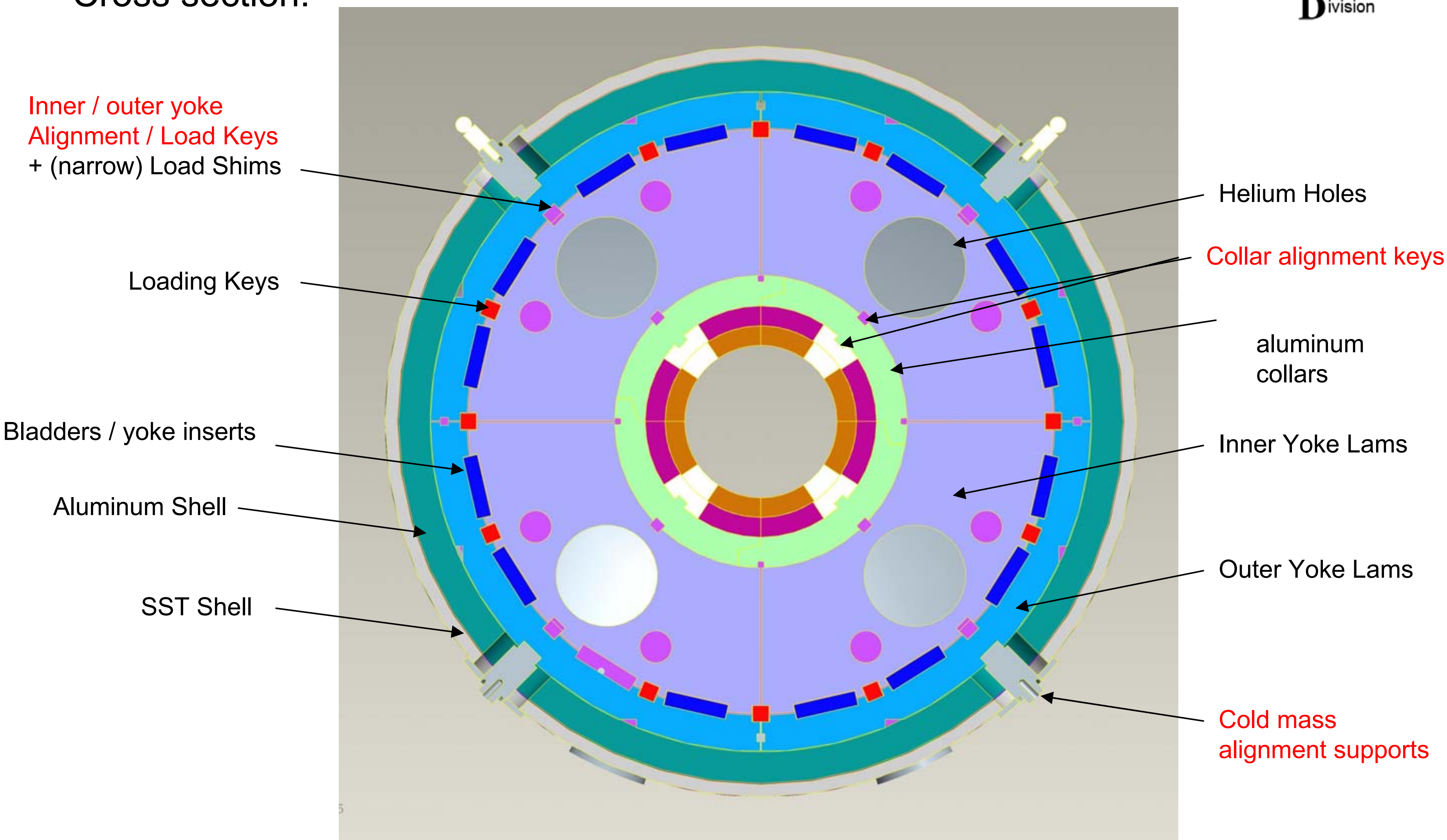
So, use 2x 80mm holes for 2 heat exchangers

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

Support Structure

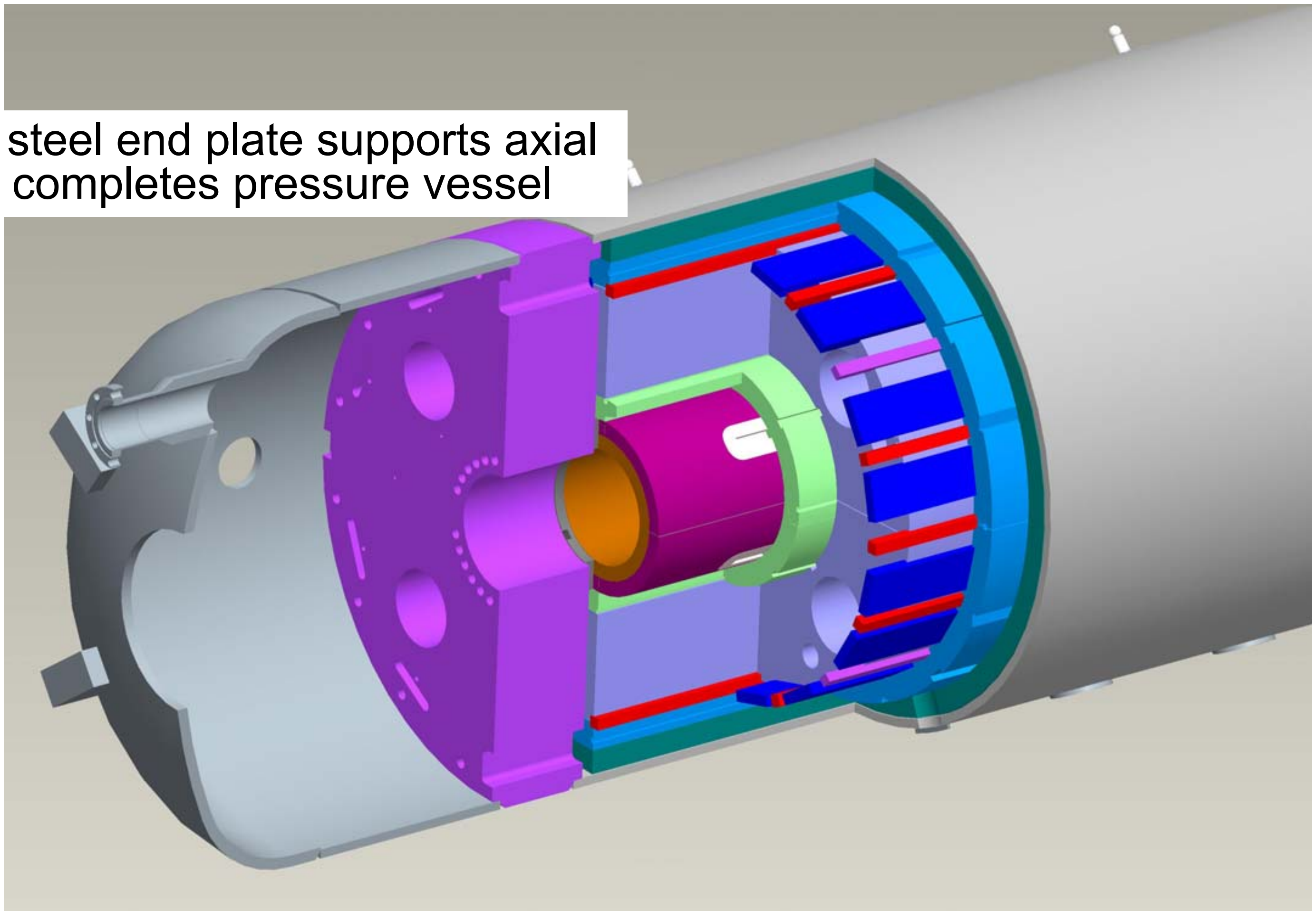
- Cross section:



Support Structure

- Cut away view

Stainless steel end plate supports axial loads, completes pressure vessel



Proposed Collaring Concept

“Bladder-technology” based:

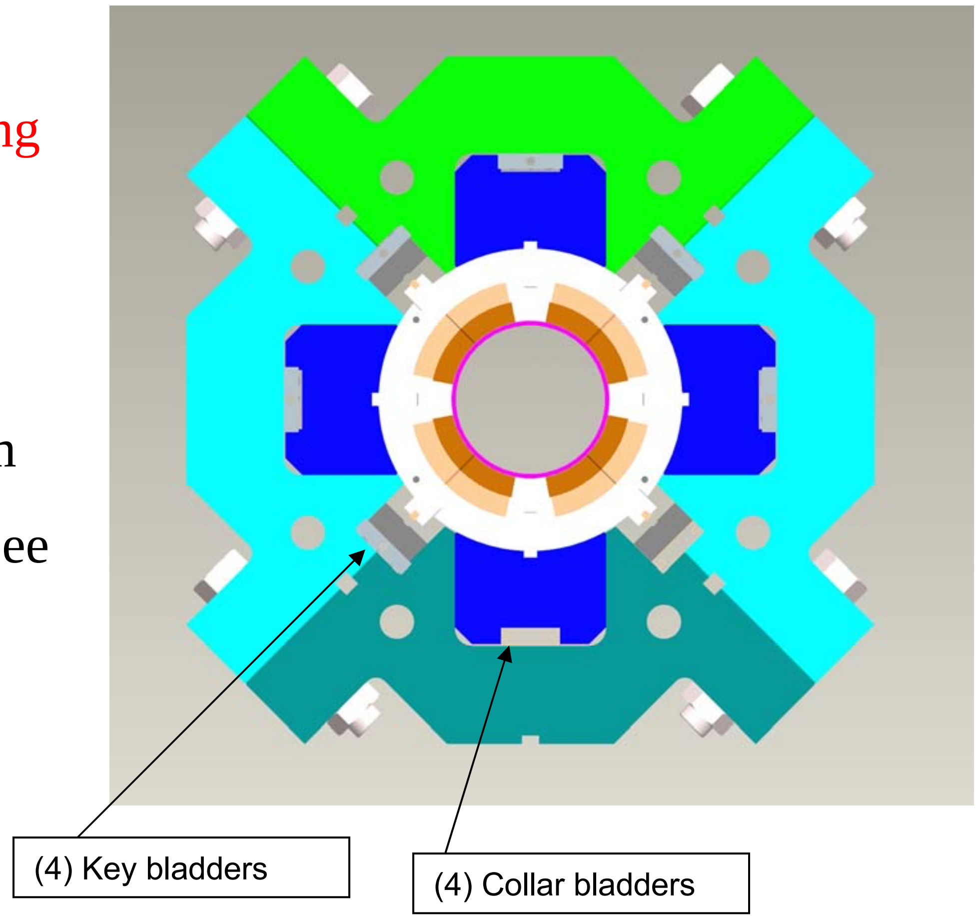
•Quad symmetry assembly

•Provide precise alignment during assembly

•Lower capital cost, easily incorporated into R&D budget

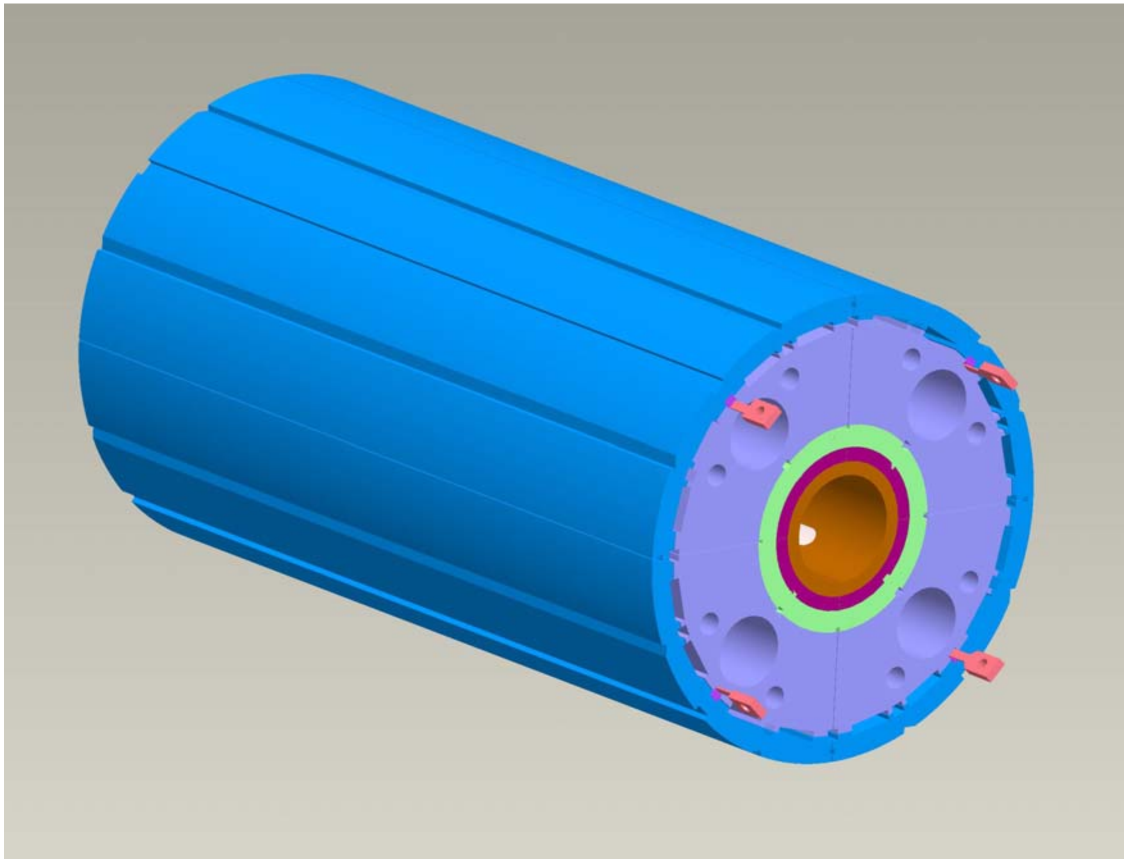
•Easily expanded from 1m to 6m

•Assembly process developed (see back-up sheets)



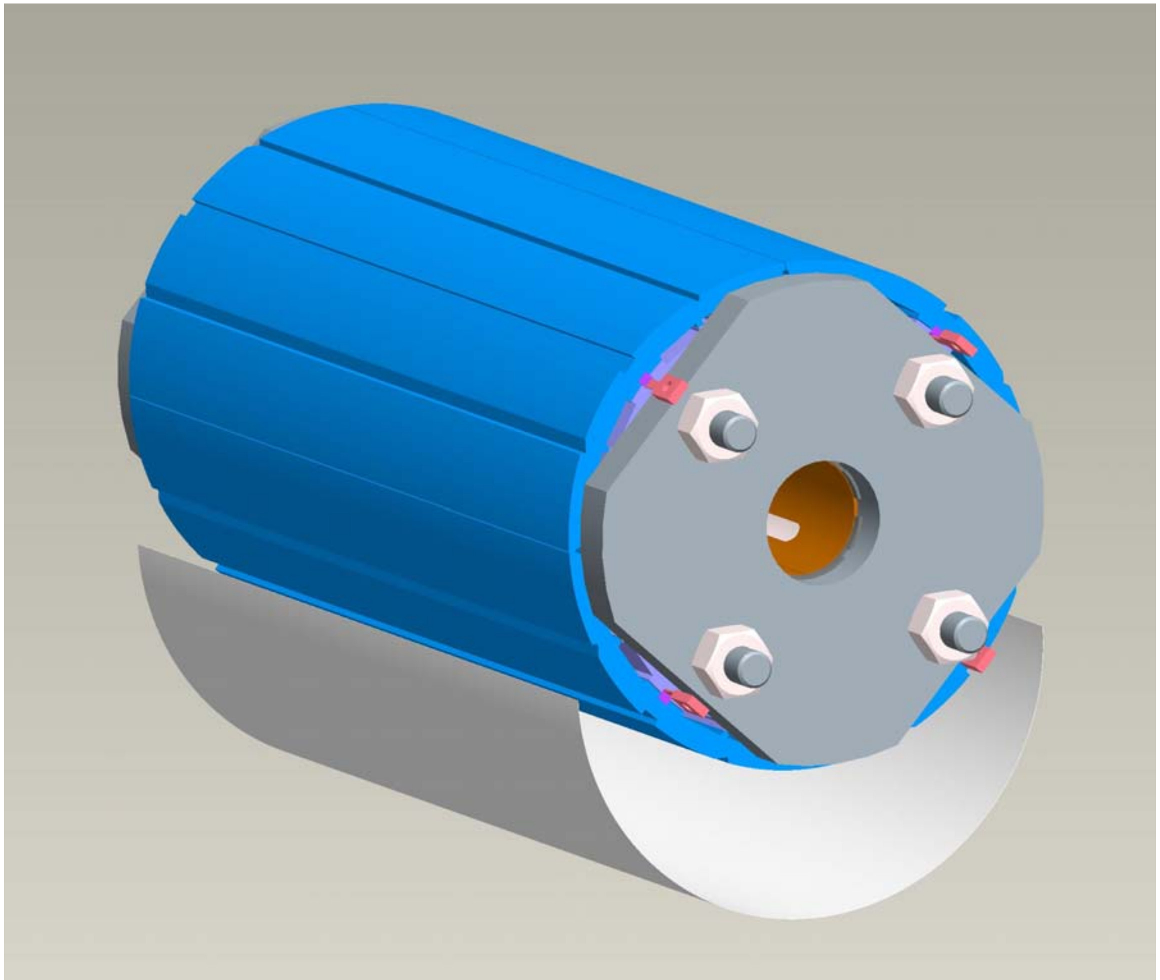
Assembly process

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



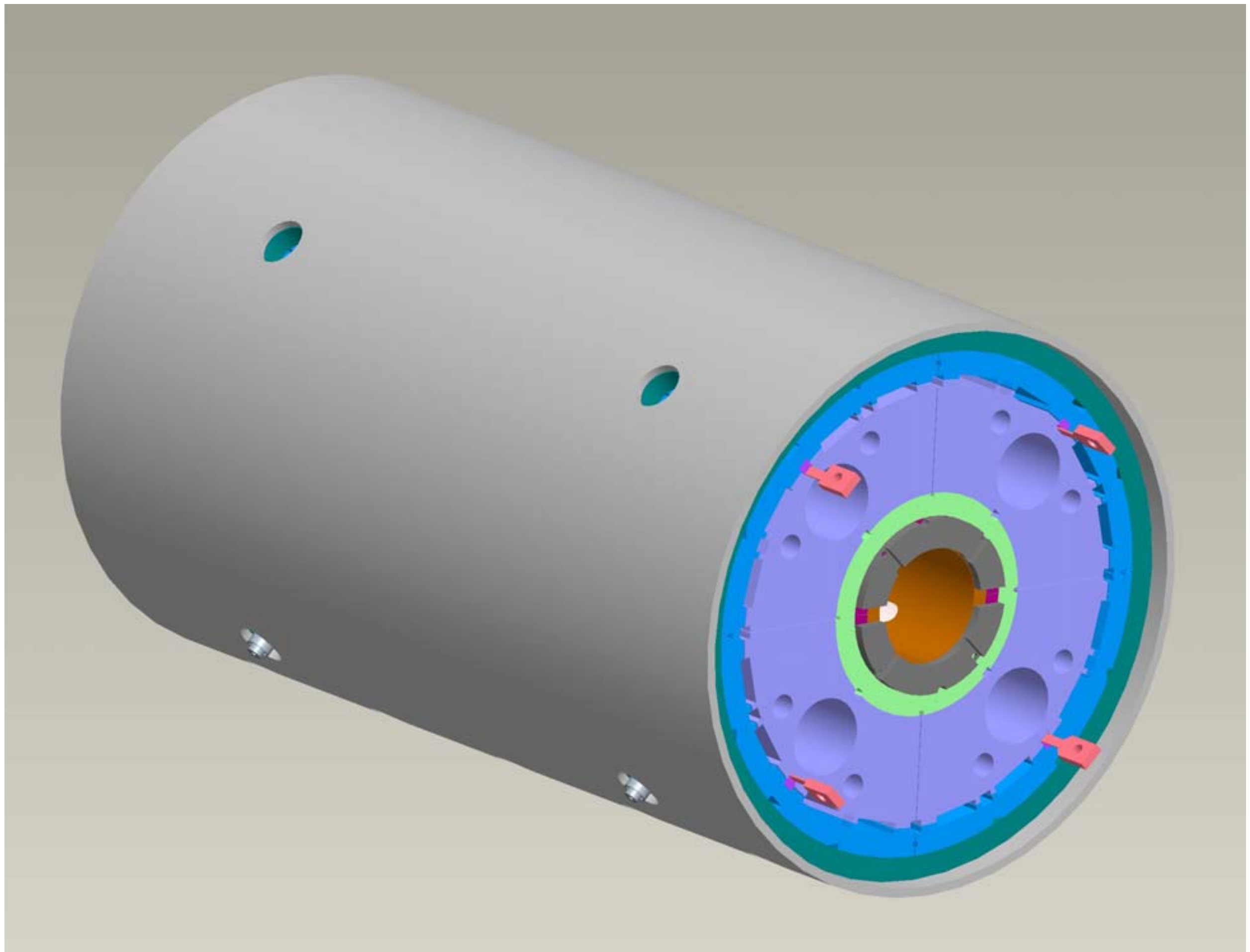
Assembly process

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



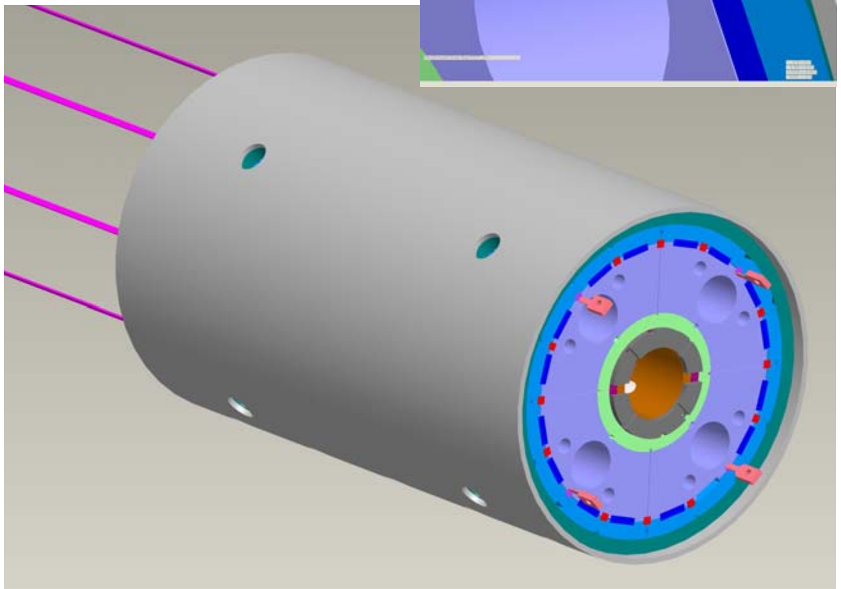
Assembly process

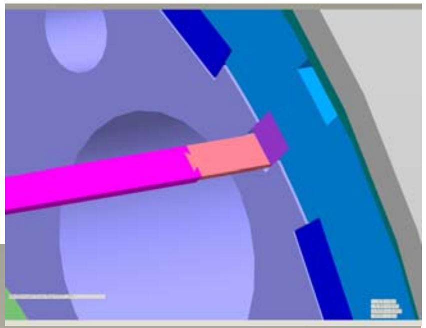
- Pull assembly into shell. Clearance because outer yoke is clamped to inner yoke.

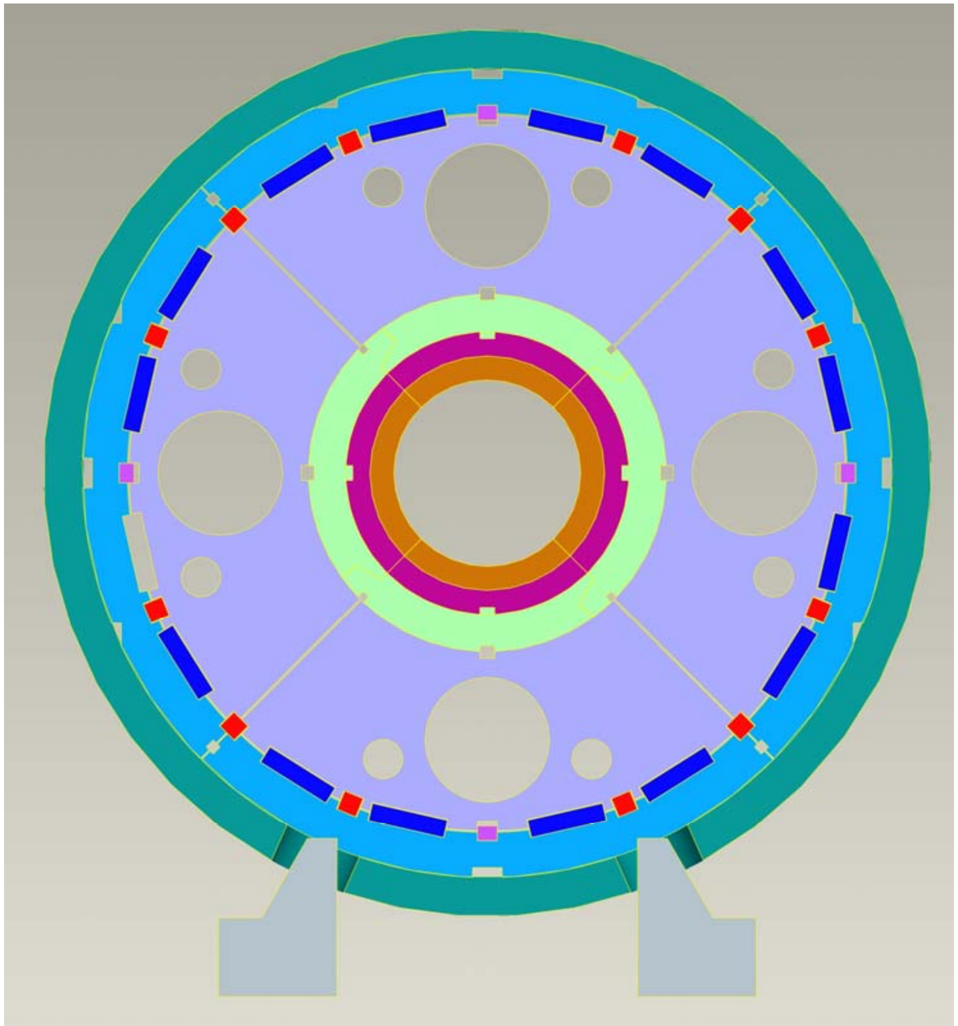


Assembly process

- 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.

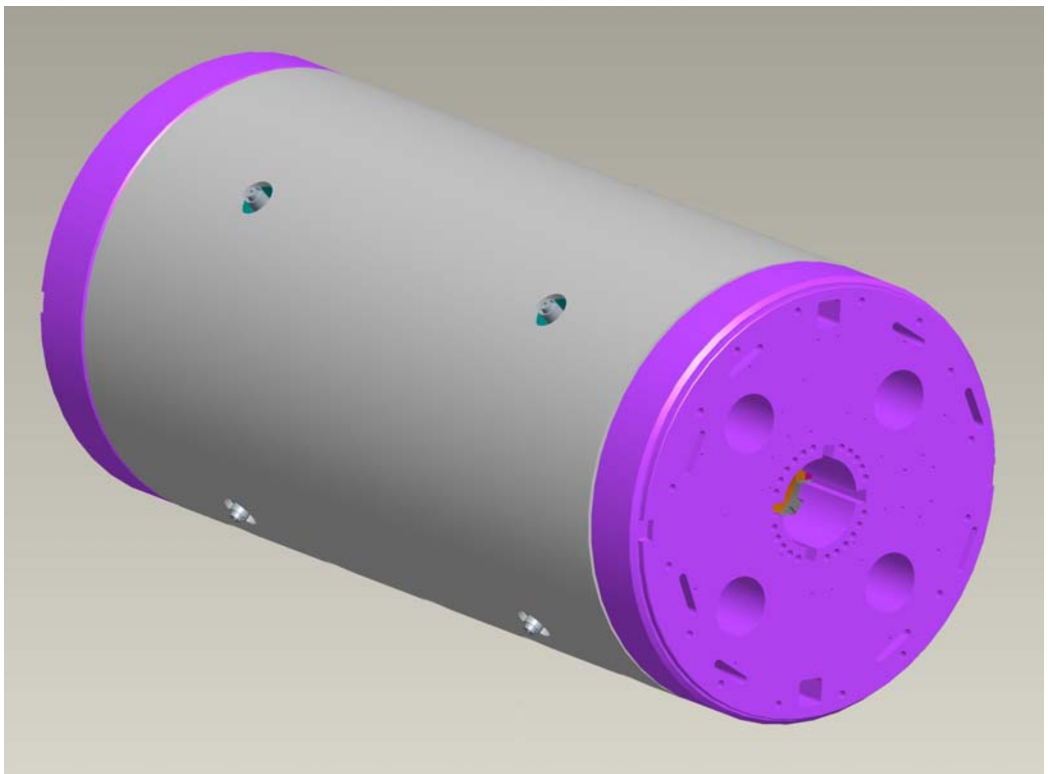


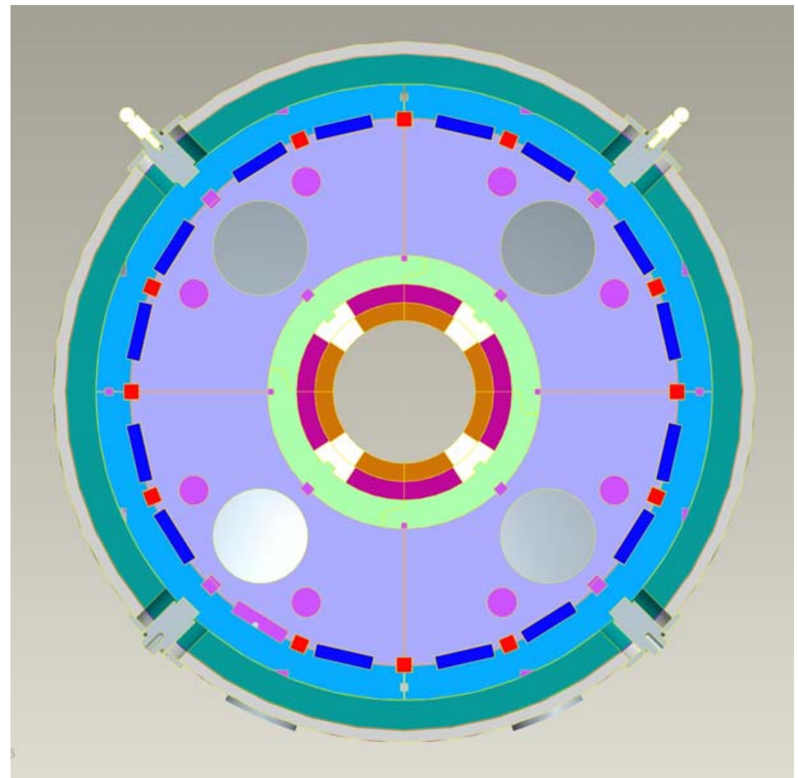




Assembly process

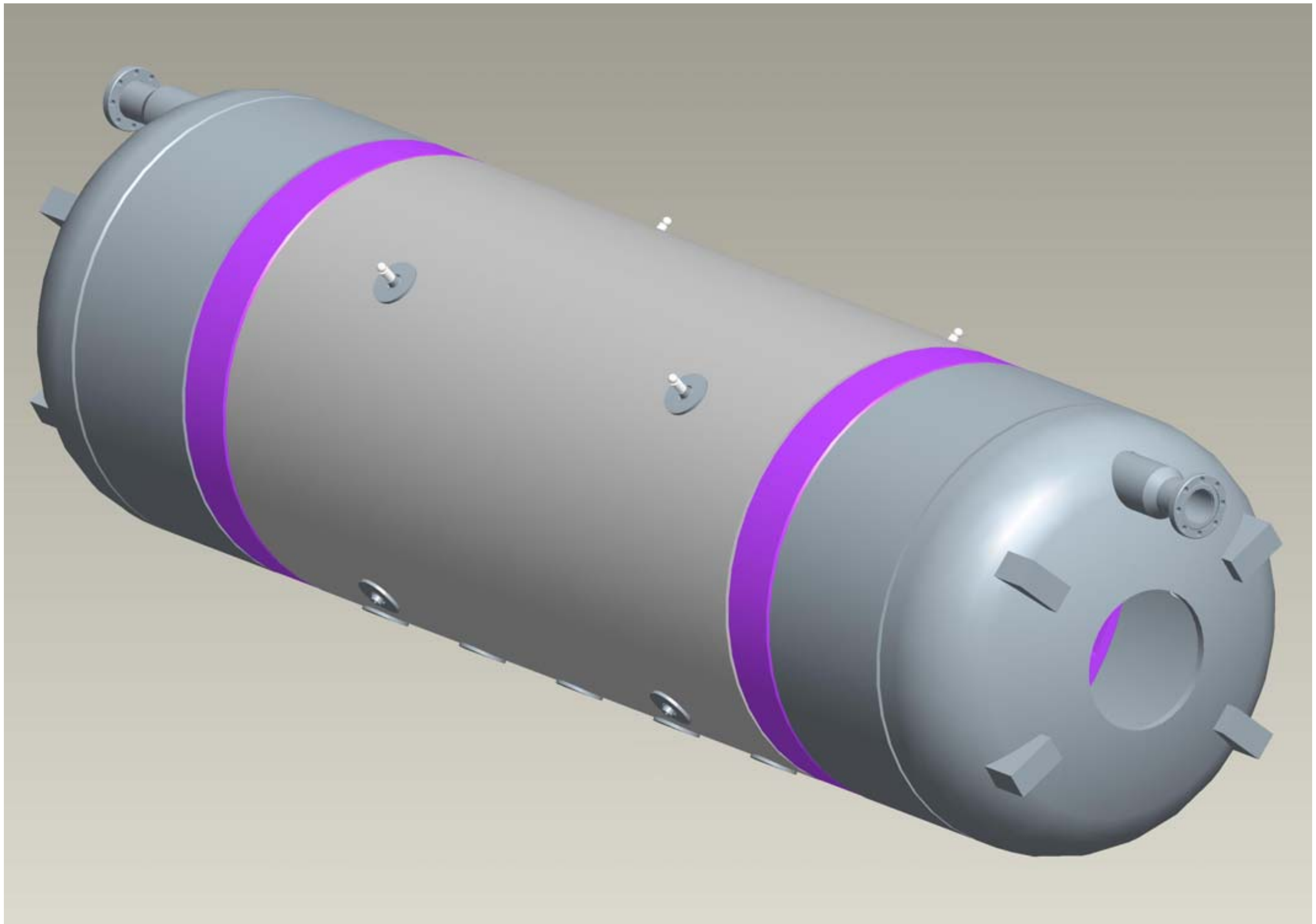
- Install into helium vessel (loose clearance fit)
- Install cold mass supports / alignment fiducials on yoke thru access holes.
- Install end plates – set screws to load coil ends.
- Install cover patches onto vessel





Support Structure

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



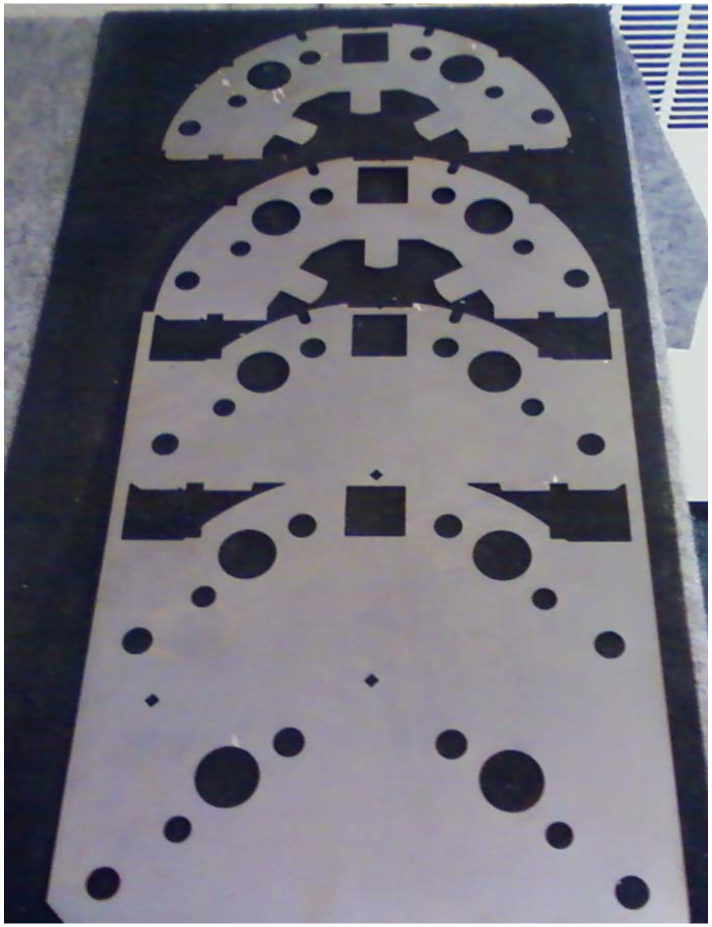
How can this fit into the existing LARP program?

- Consider this part of the "essential ancillary R&D"
- Optimize design and plan with help from key people at LBNL, FNAL, BNL
- Incorporate in an "HQ rebuild", i.e. use coils from 1 or 2 successful HQ cold masses
- plan for future work based on results above

Back-up slides

- Picture of laminations from progressive die
- Collaring process

Laminations from a progressive die



Collaring Process

Superconducting Magnet Division