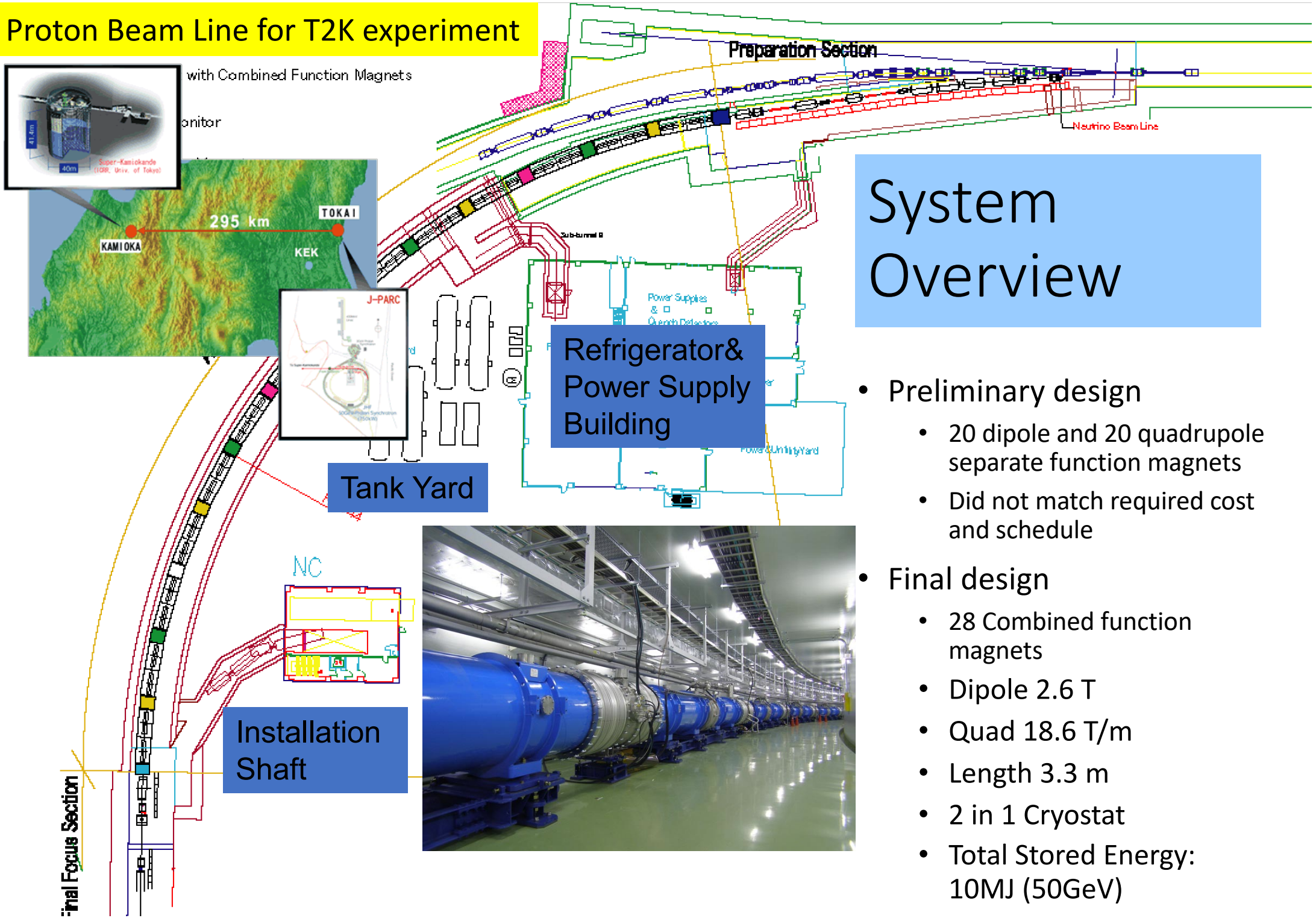
Combined Function Magnet Option

Experience from the development of J-PARC Neutrino Beam Line Magnet

Toru Ogitsu, KEK

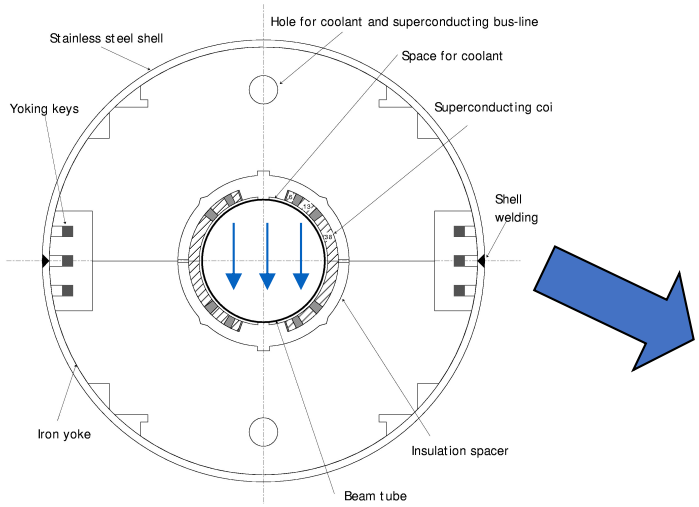
Proton Beam Line for T2K experiment



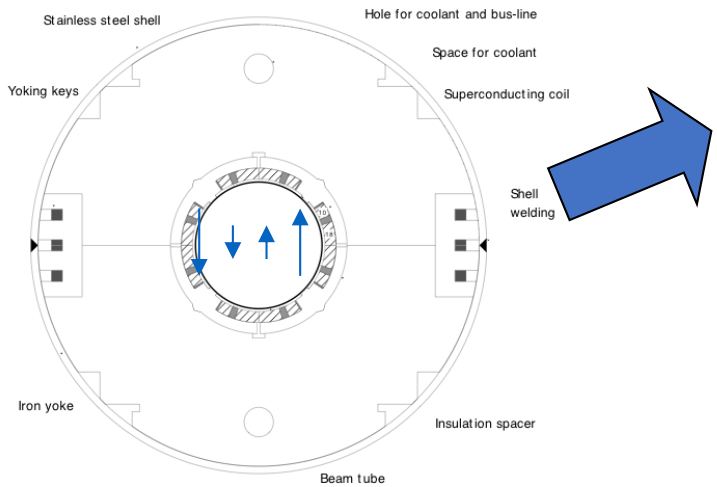
System Overview

- Preliminary design
  - 20 dipole and 20 quadrupole separate function magnets
  - Did not match required cost and schedule
- Final design
  - 28 Combined function magnets
  - Dipole 2.6 T
  - Quad 18.6 T/m
  - Length 3.3 m
  - 2 in 1 Cryostat
  - Total Stored Energy: 10MJ (50GeV)

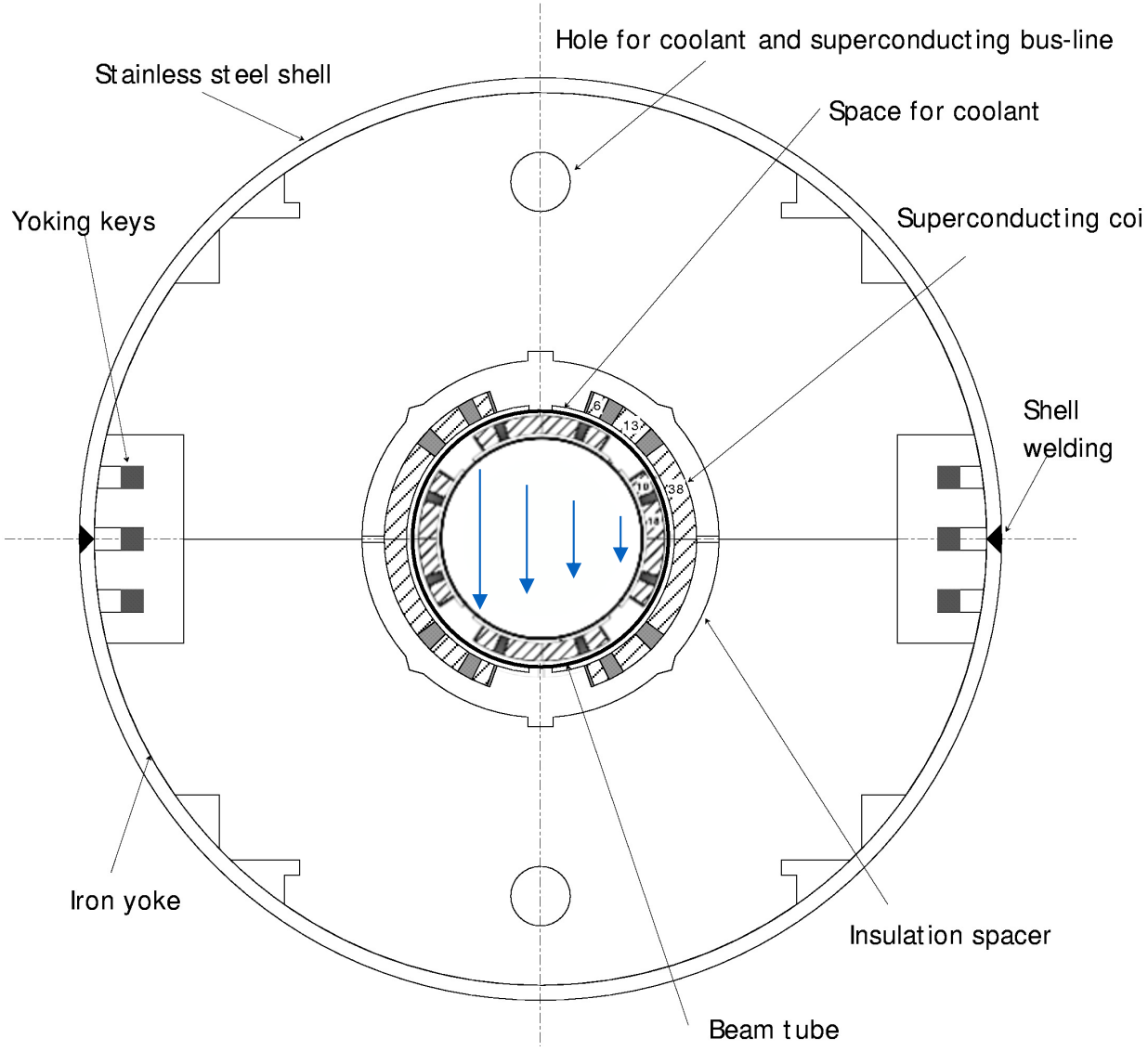
SC Combined Function Magnet: Nested



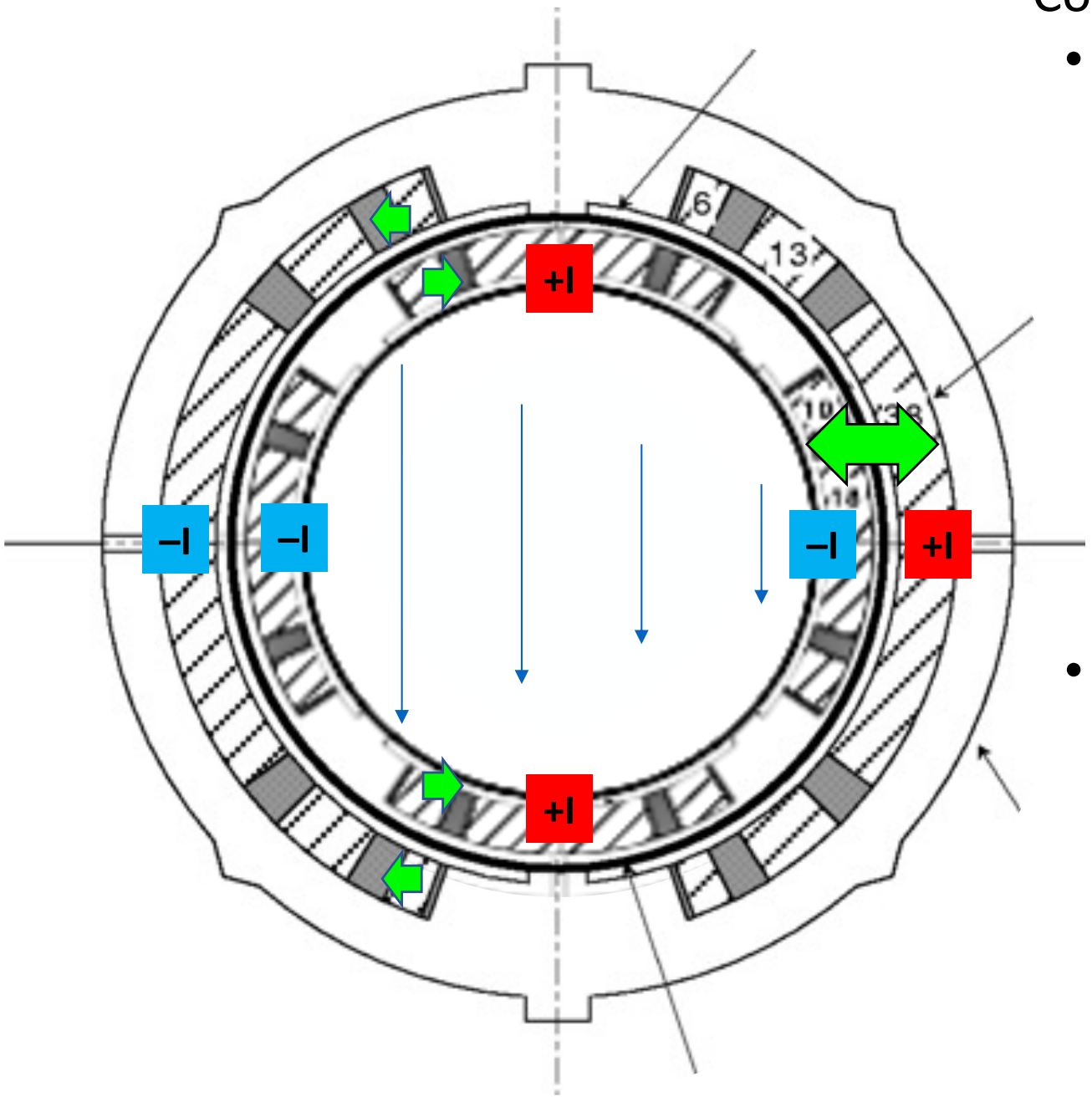
Dipole (Bending)



Quadrupole (Focusing)

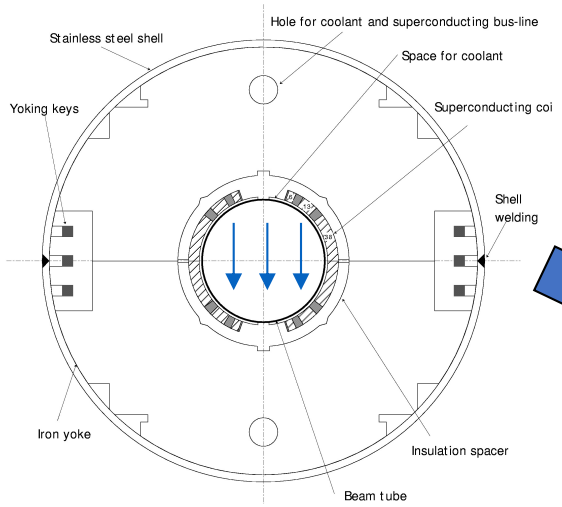


Dipole/Quadrupole Combined
Bending + Focusing

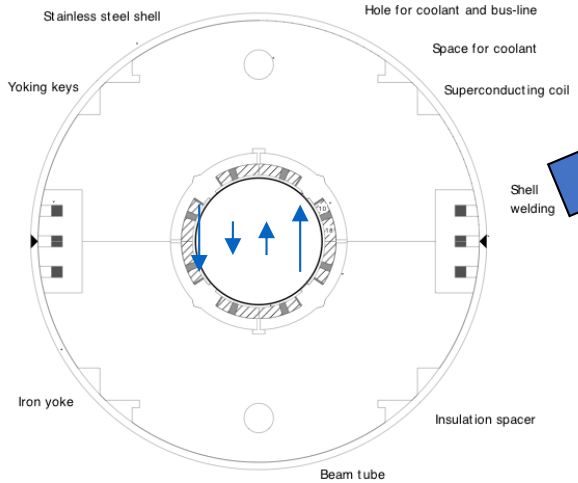


- Concern with nested coil
  - Structure:
    - Opposite current
      - Large repulsive or sharing force
        - Risk on stress management
      - Alignment of Quadrupole coils
- Cost and Schedule
  - 2 kinds of coils
  - 6 coils per magnet
  - Did not have considerable merit against ordinally separate function

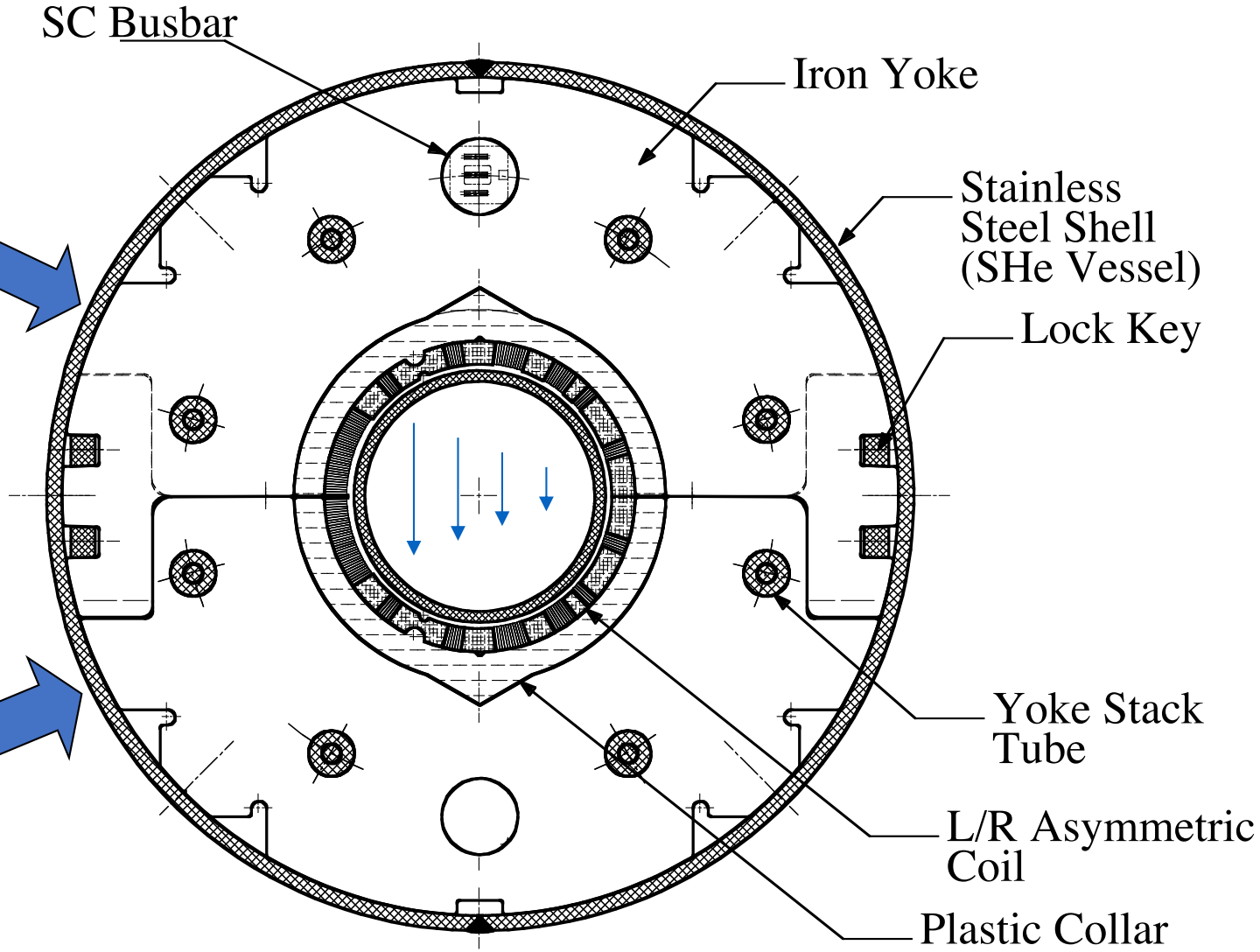
SC Combined Function Magnet: L/R Asymmetry



Dipole (Bending)

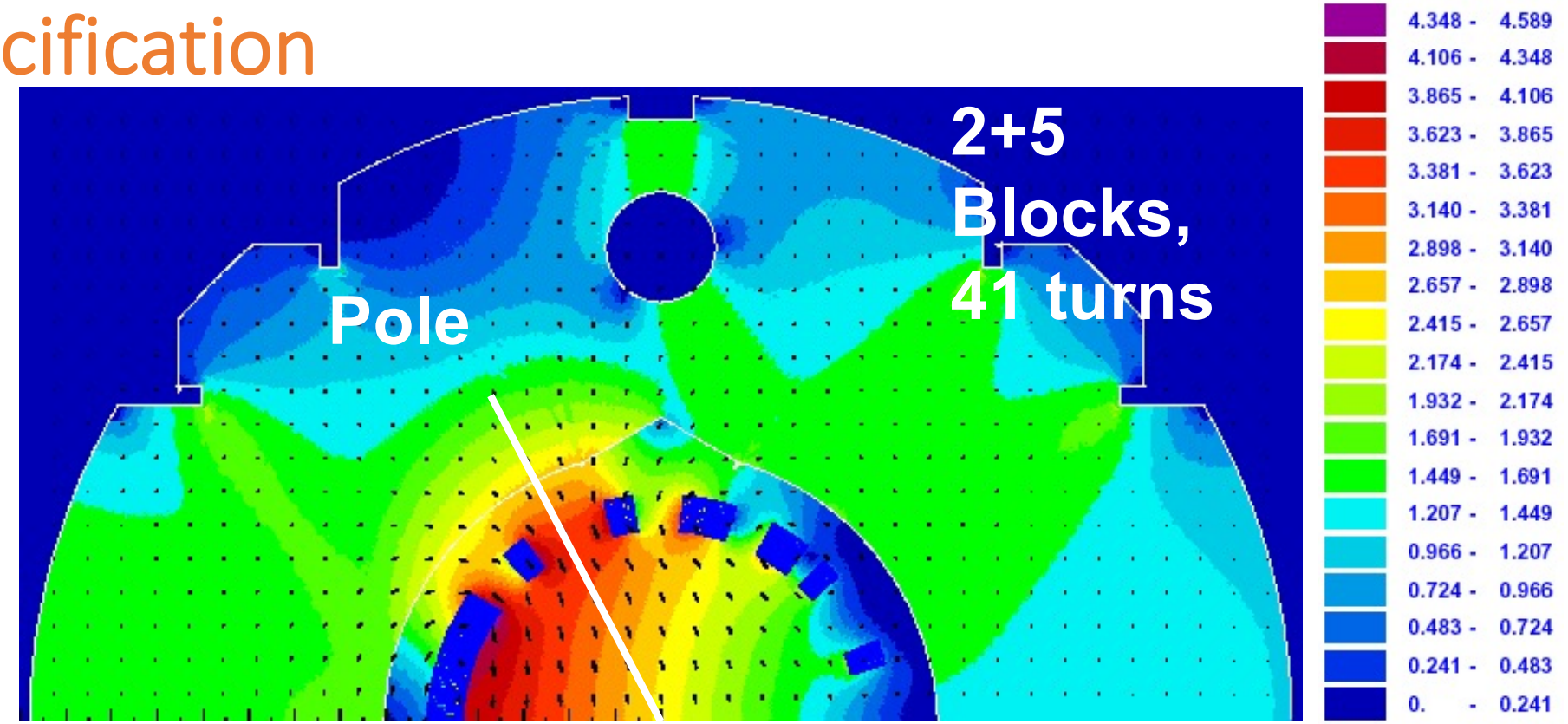


Quadrupole (Focusing)



Dipole/Quadrupole Combined Bending + Focusing

Specification



Coil ID.: 173.4mm

Mag. Length: 3300 mm

Mech. Length: 3630 mm @RT

Tmax: < 5.0K

(Supercritical Helium)

Dipole Field: 2.59 T

Quad. Field: 18.6 T/m

Field Error: < 10^-3

Op. Current: 7345 A

Op. Margin: 72%

Inductance: 14.3 mH

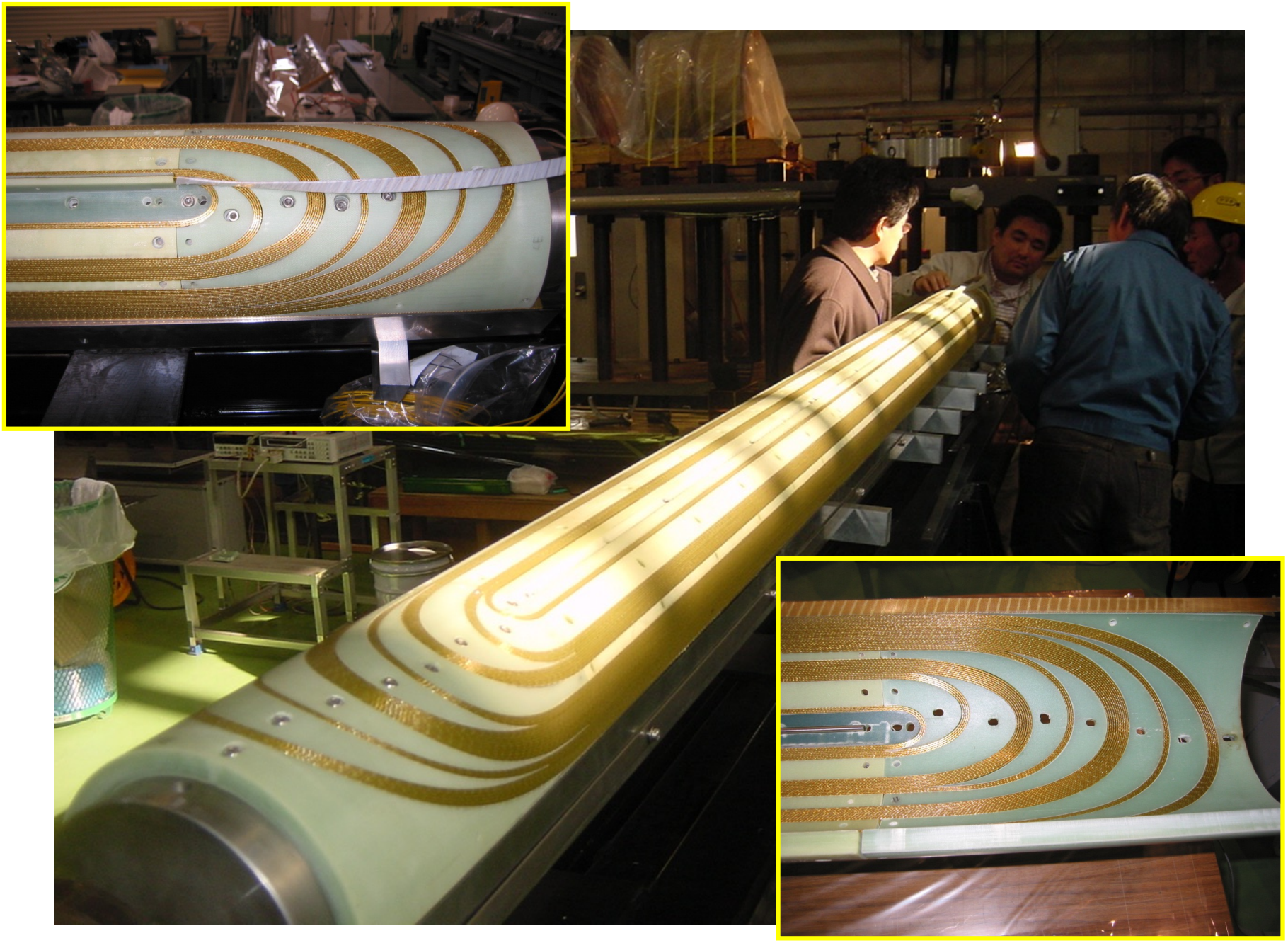
Stored Energy: 386 kJ

# of Magnet: 28

SC Cable: NbTi/Cu for LHC

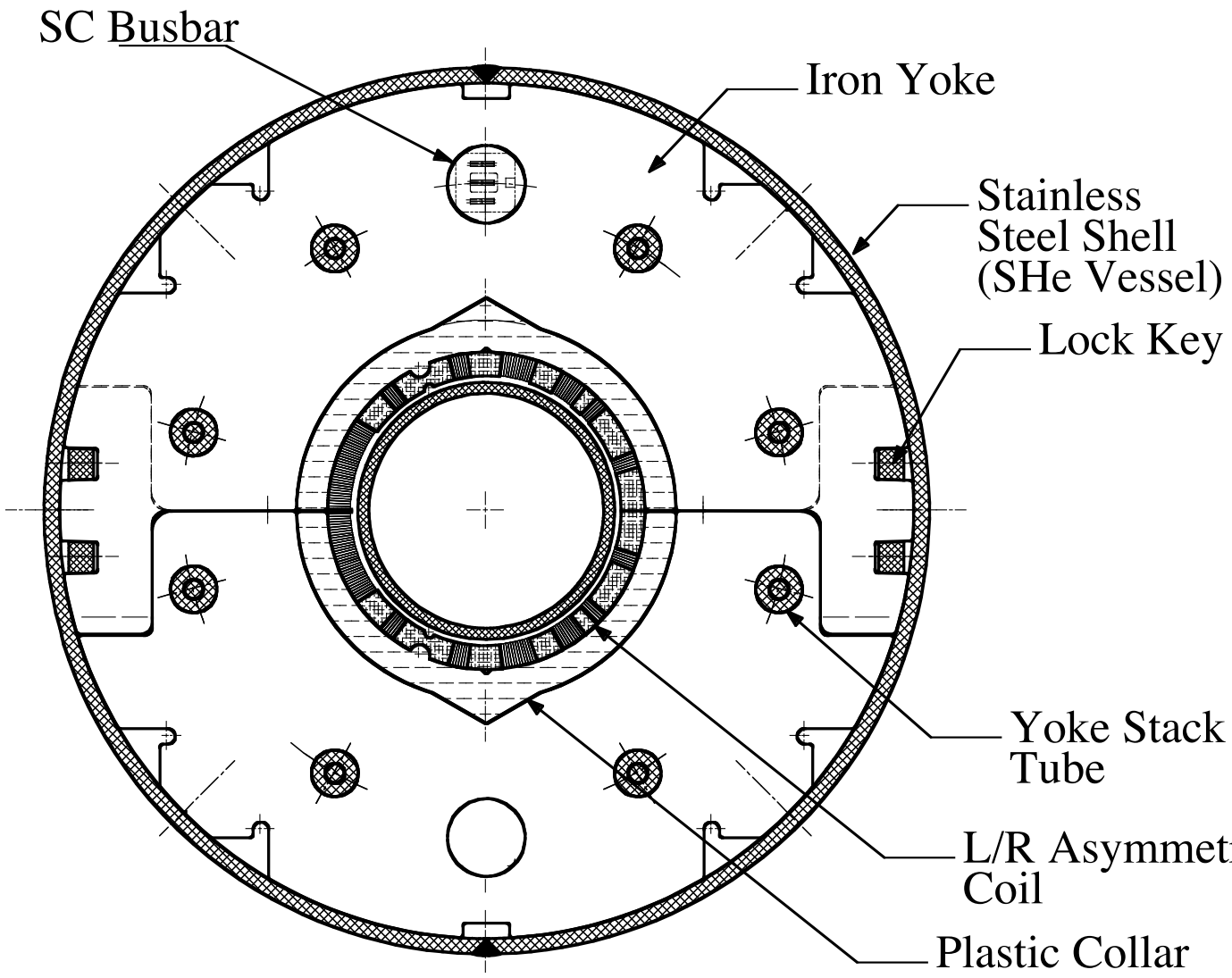
Dipole Outer-L

The Asymetric Coil



High Field Version: 1.8K Operation

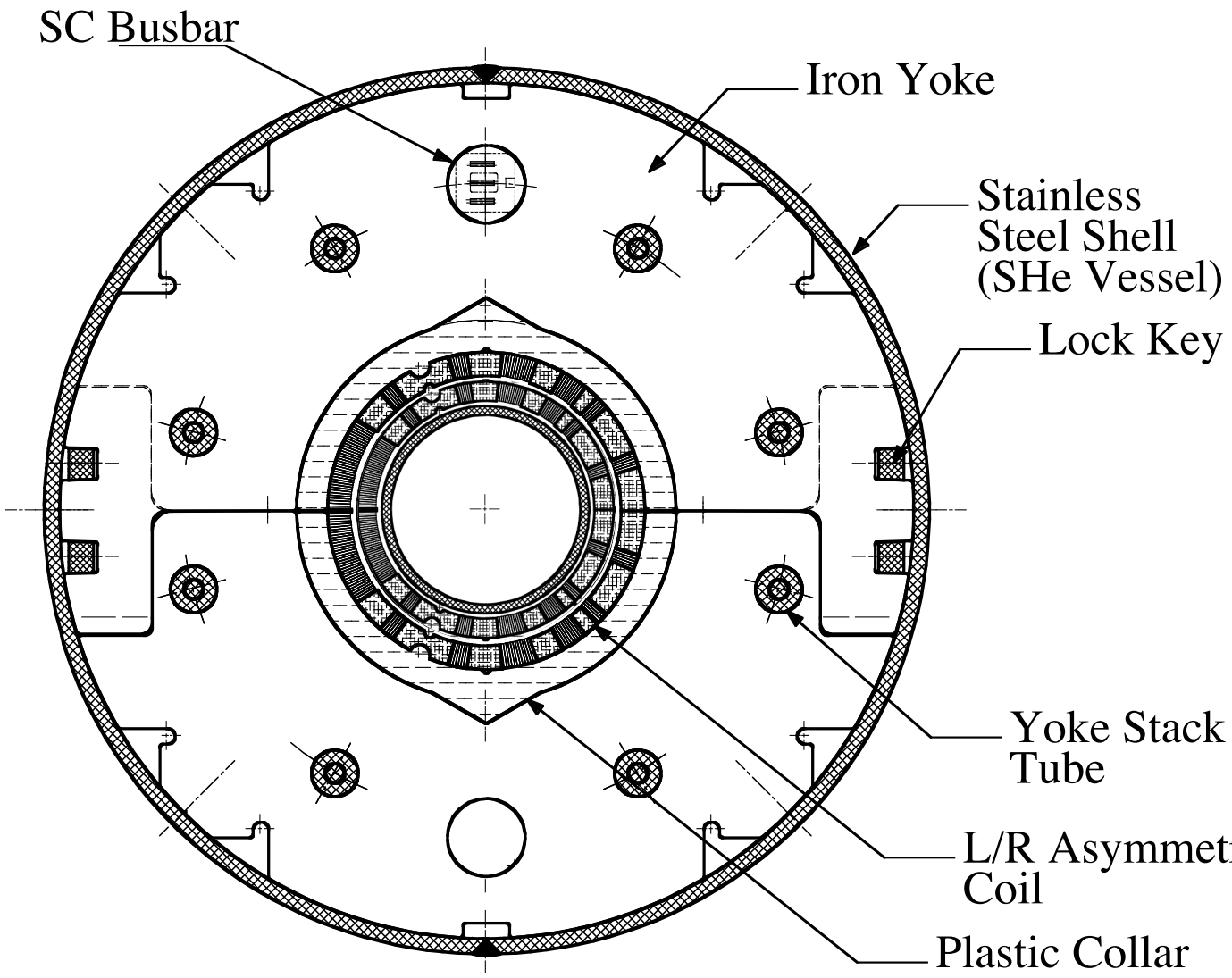
structure needed to be optimized



- Temperature: 1.8 K
- Conductor: LHC arc outer
- Coil: 1 layer L/R asy.
- Coil ID: ~ 173 mm
- Operation Current: ~1200 A
- Dipole: ~ 4.25 T
- Quad: ~ 31 T/m
- Peak Field: ~ 7.35 T

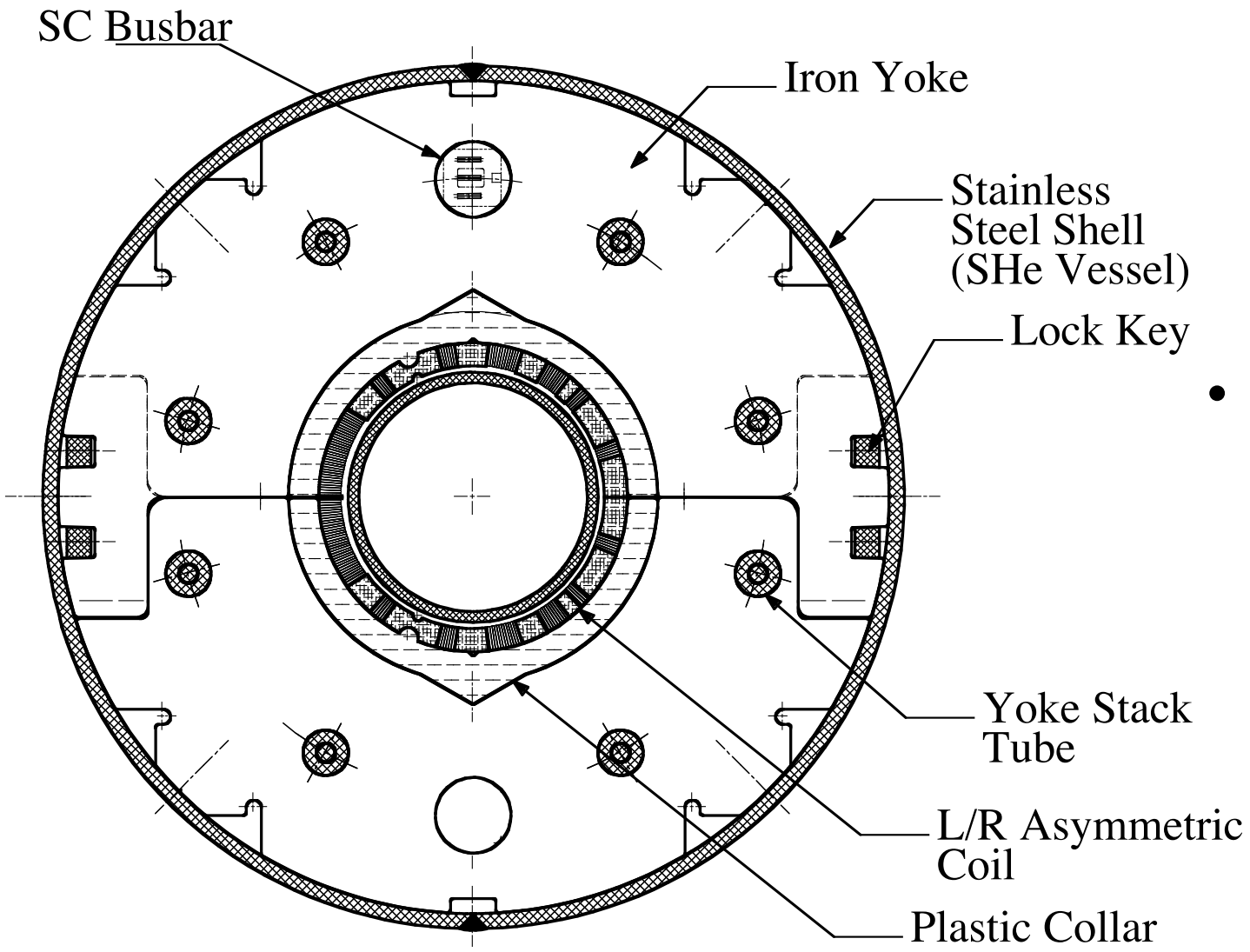
High Field Version: 2 layer, Nb_3Sn

structure needed to be optimized



- Conductor: LHC arc outer like Nb_3Sn?
- Coil: 2 layer L/R asy.
- Coil ID: ~ 140 mm
- Operation Current: ~1100 A
- Dipole: ~ 7.5 T
- Quad: ~ 68 T/m
- Peak Field: ~ 12 T

Combined Function Magnet: L/R Asymmetry



- Pros
  - 2 L/R symmetric dipole like coil
  - Stress on the coil is dipole like (manageable)
  - Only one kind of dipole like coil tooling (with a little modification to accommodate mirror symmetry)
- Cons
  - Dipole and Quadruple ratio is fixed
  - Quadrupole strength ratio is limited (maximum strength ratio is about 10 T/m per 1 T dipole with 150 mm aperture)