MQXF Cold-mass Assembly and Cryostating

H. Prin, D. Duarte Ramos, P. Ferracin, P. Fessia

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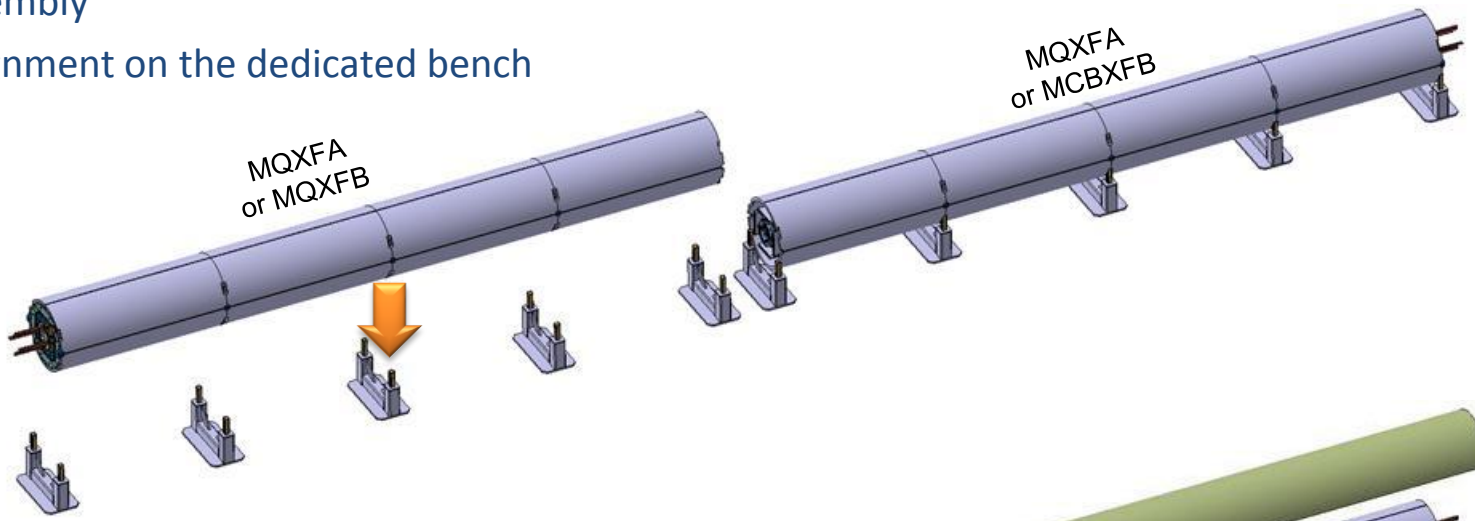
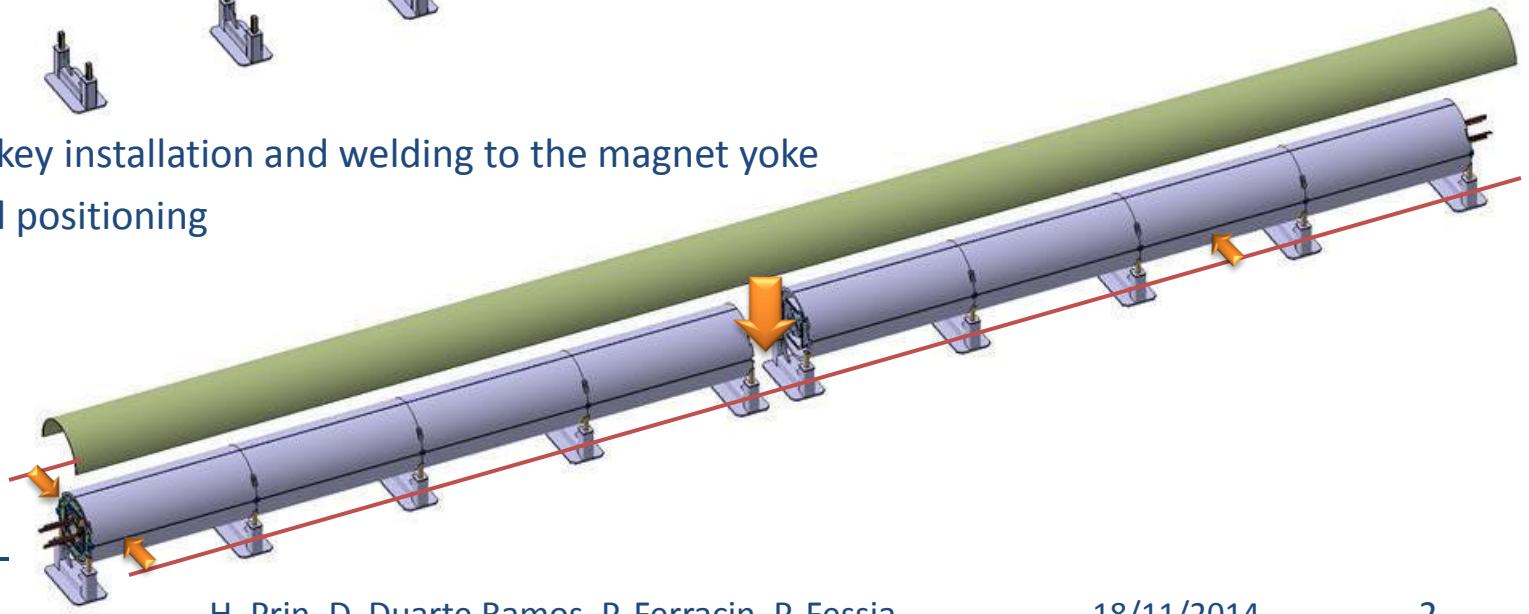
Cold mass assembly steps

- Magnets reception (visual inspection, mechanical and electrical measurement…)
- Cold mass assembly

1. Magnets alignment on the dedicated bench

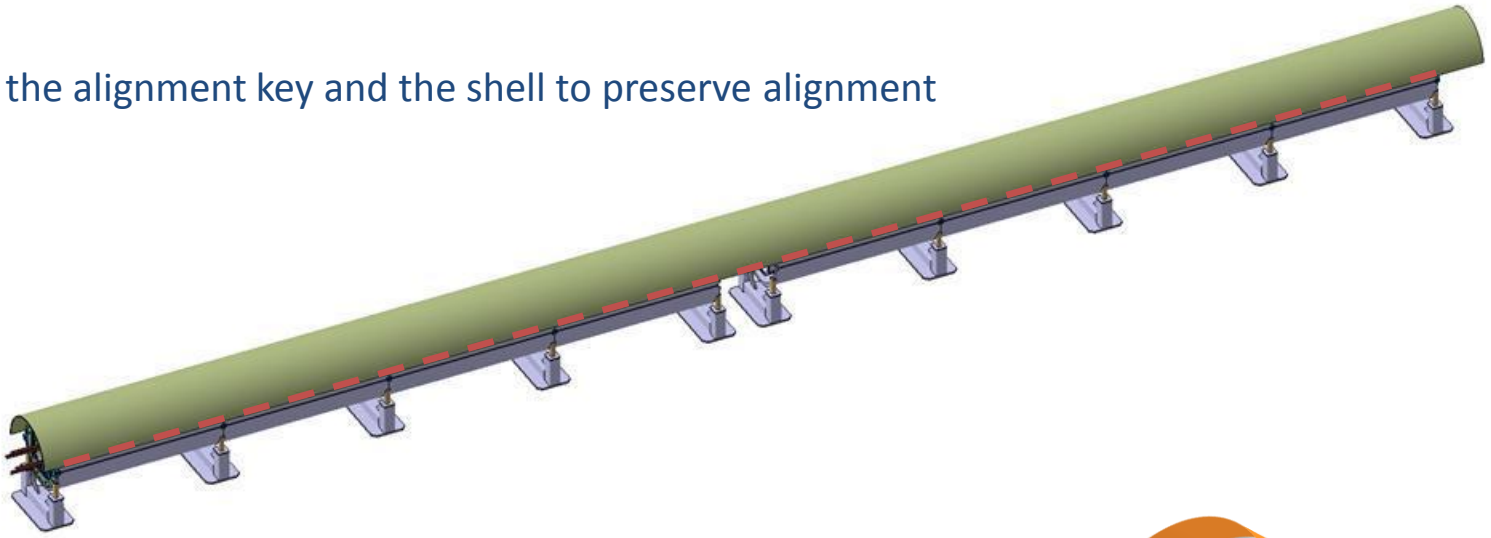


2. Alignment key installation and welding to the magnet yoke
3. Upper shell positioning

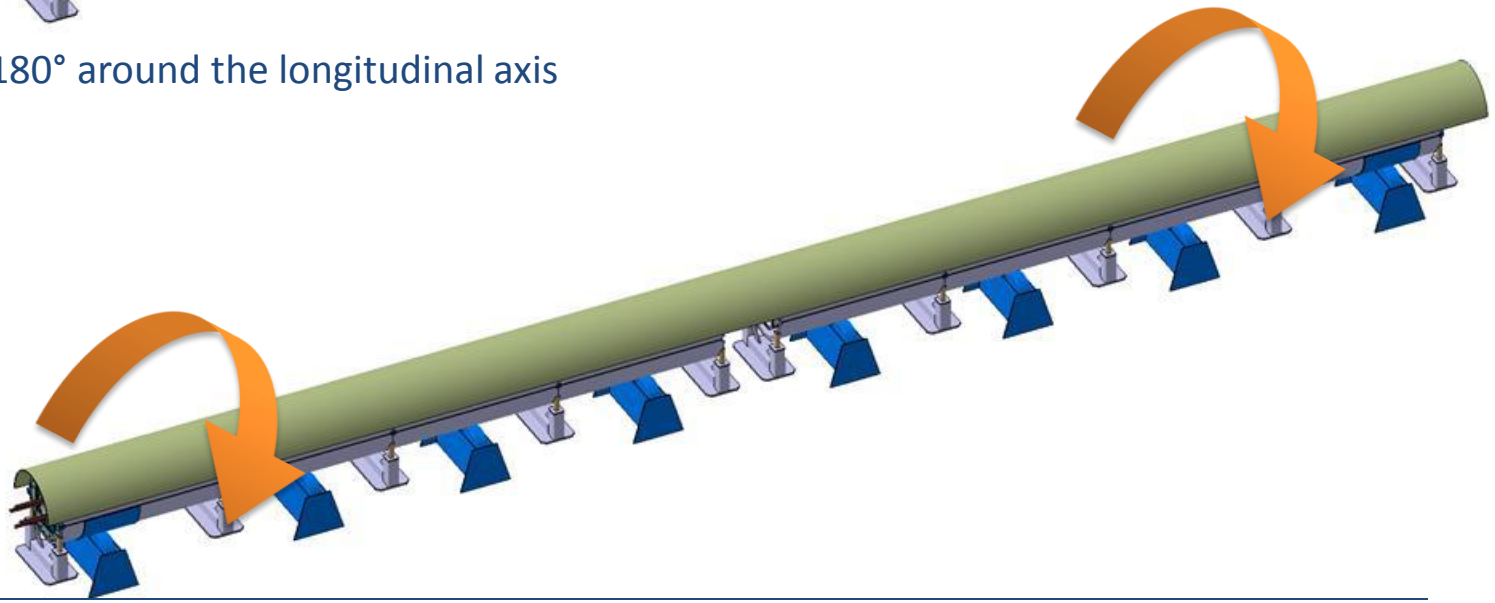


Cold mass assembly steps

4. Tack welding the alignment key and the shell to preserve alignment

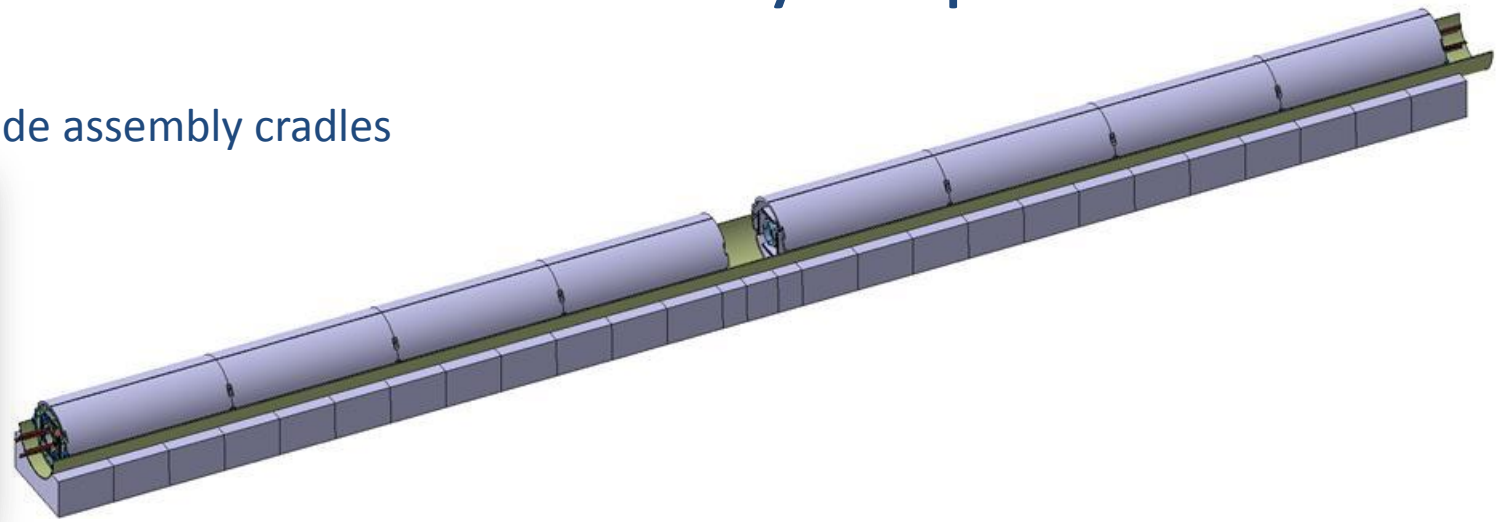


5. Rotation by 180° around the longitudinal axis

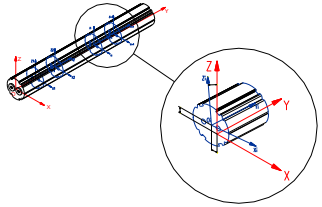


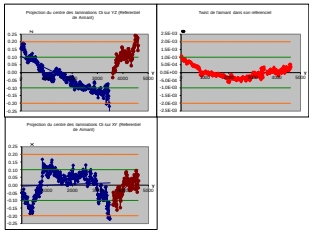
Cold mass assembly steps

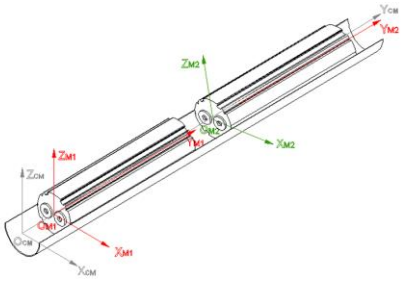
6. Transfer inside assembly cradles

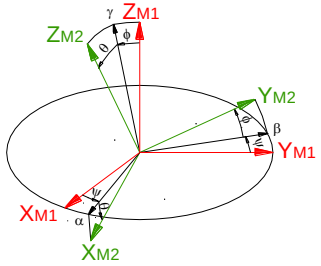


7. Magnets alignment measurement (at the yoke level)







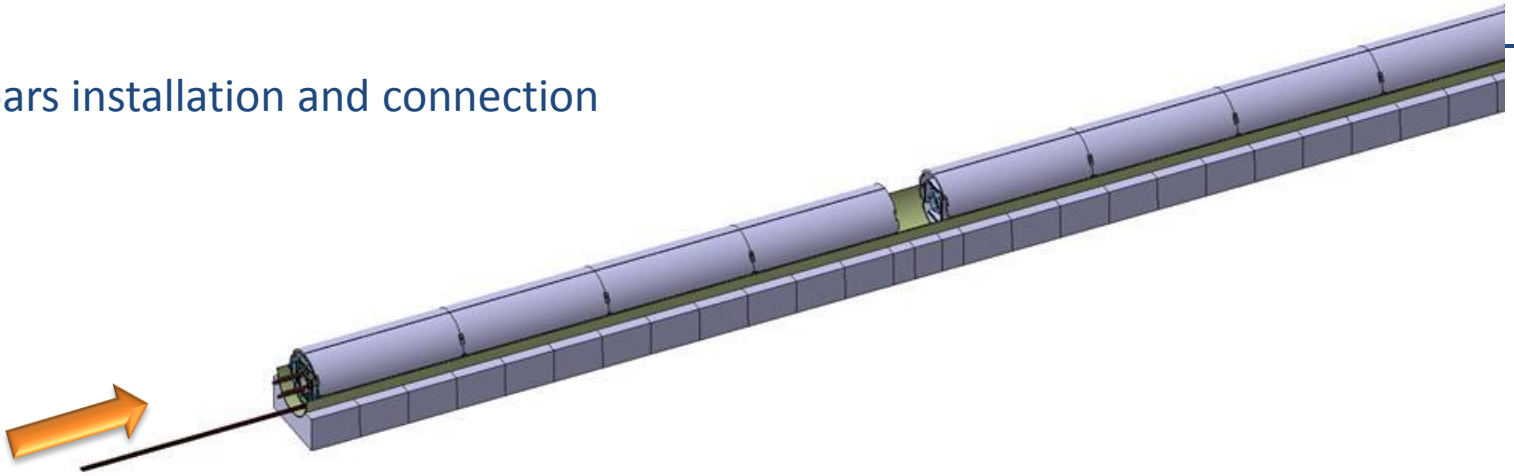


1. Individual geometrical measurements of straightness in horizontal and vertical planes, twist over full length

2. Pitch, yaw and roll angle between magnets

Cold mass assembly steps

8. Bus bars installation and connection



9. Instrumentation wires connection (V-Taps, Quench heaters, cryogenic instrumentation…)

Wires preparation

Wires routing

Wires connection

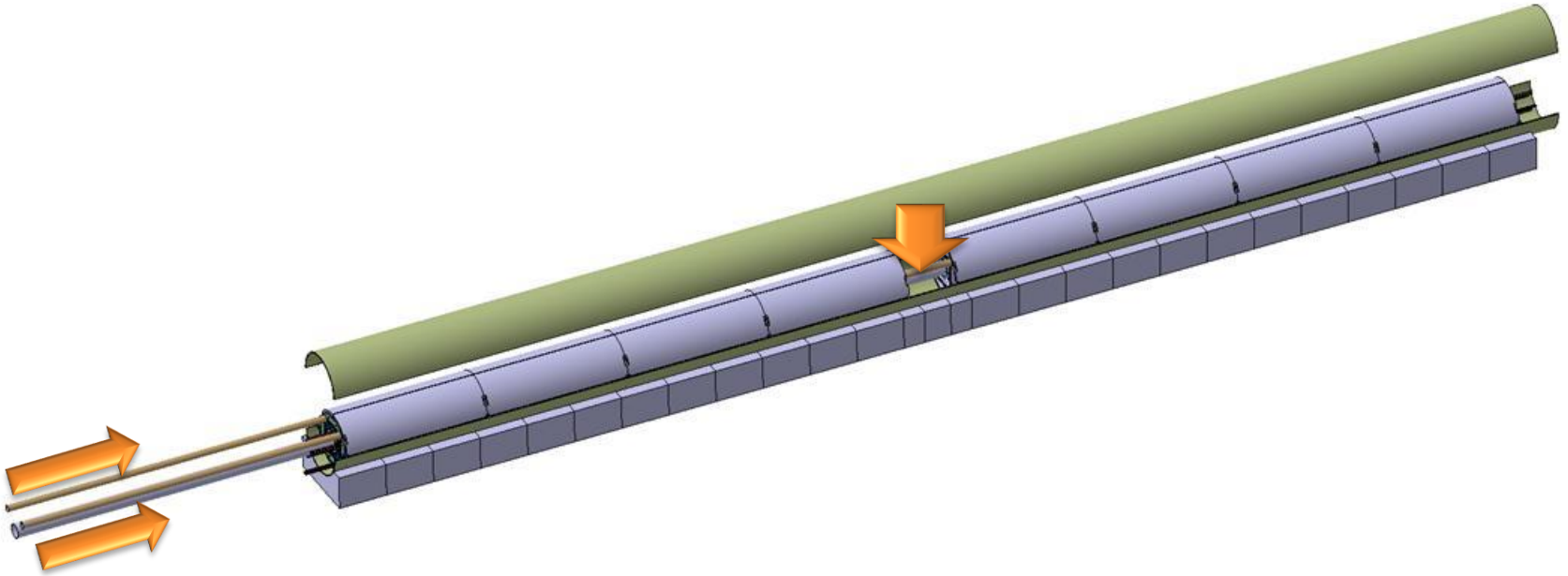
Resistive heater

Cryo Thermometer

10. Electrical tests (check instrumentation and general wiring)

Cold mass assembly steps

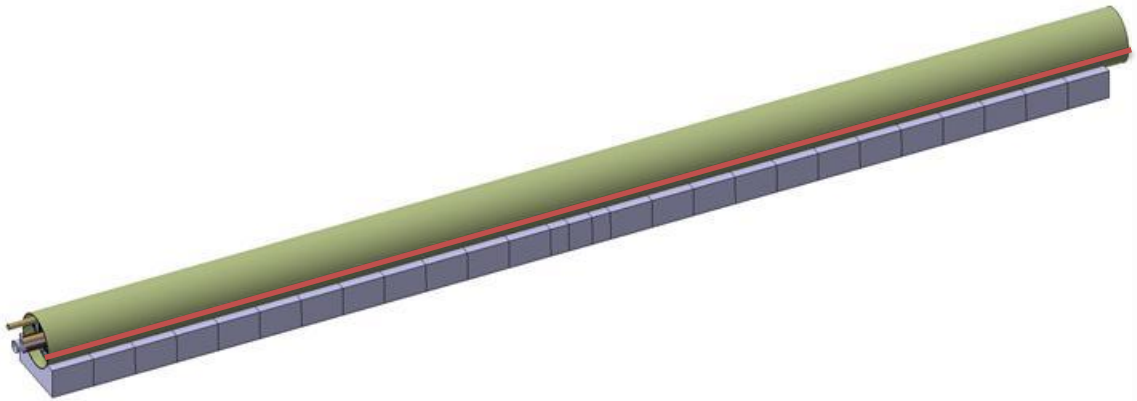
11. Cold bore tube installation
12. Heat exchanger tubes insertion
13. Upper shell installation

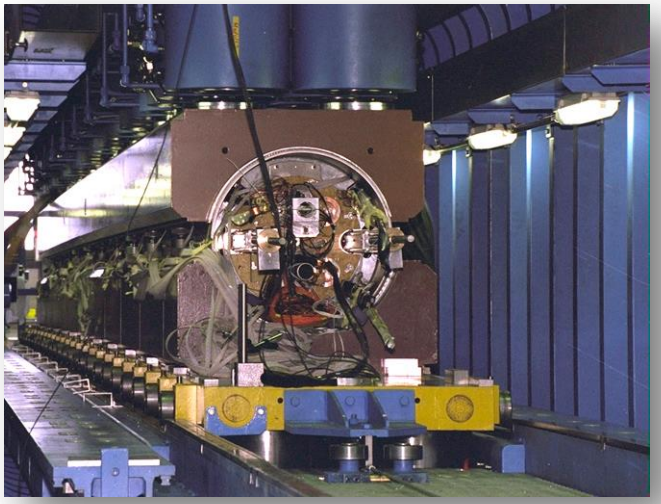


14. Electrical tests (final check before welding, very important!)

Cold mass assembly steps

15. Transfer in the welding press





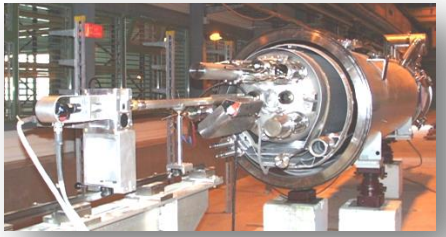
16. Longitudinal welding

Cold mass assembly steps

17. Removal from the welding press
18. Welds examination (Visual + X rays)
19. Electrical tests
20. Transfer to finishing bench
21. Geo-magnetic measurements to determine the cold mass main axis

Cold mass transfer to the finishing bench

Tracker in position during measurements



Existing QIMM and DIMM magnetic measurement rotating coil systems

Cold mass assembly steps

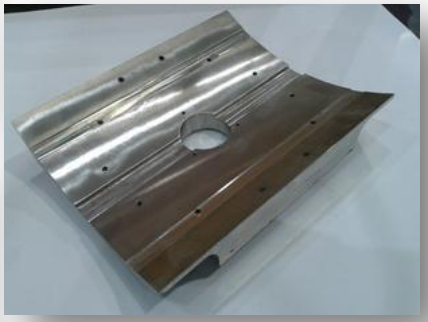
21. Welded cylinder cutting extremities and machining

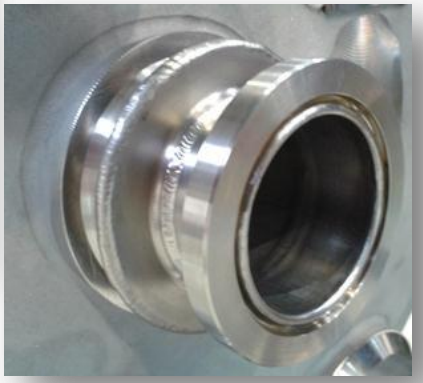
22. Support bases alignment and welding

23. Equipped end covers (flanges and bellows) alignment and welding

24. Cold bore and heat exchangers alignment and welding to the end covers

25. (Pick-up support alignment and welding if any)





Cold mass assembly steps

26. Cold mass geometry measurement

Cold mass finishing benches

Geometric measurement mole

Laser tracker

27. Electrical tests
28. Warm magnetic measurements and polarity checks (if different from step 21.)

Cold mass assembly steps

29. Cold mass preparation for pressure/leak and cold tests: weld caps on covers apertures

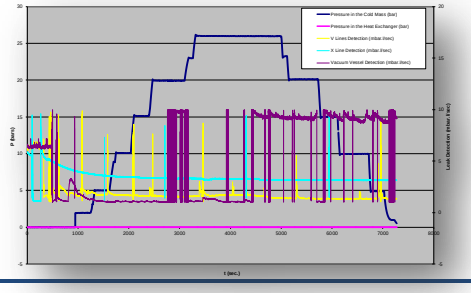
30. Weld examination (Visual + X rays)

Preparation for leak/pressure and cold tests

31. Transfer and connect the cold mass into the pressure test tank

Insertion in the pressure/leak test tank

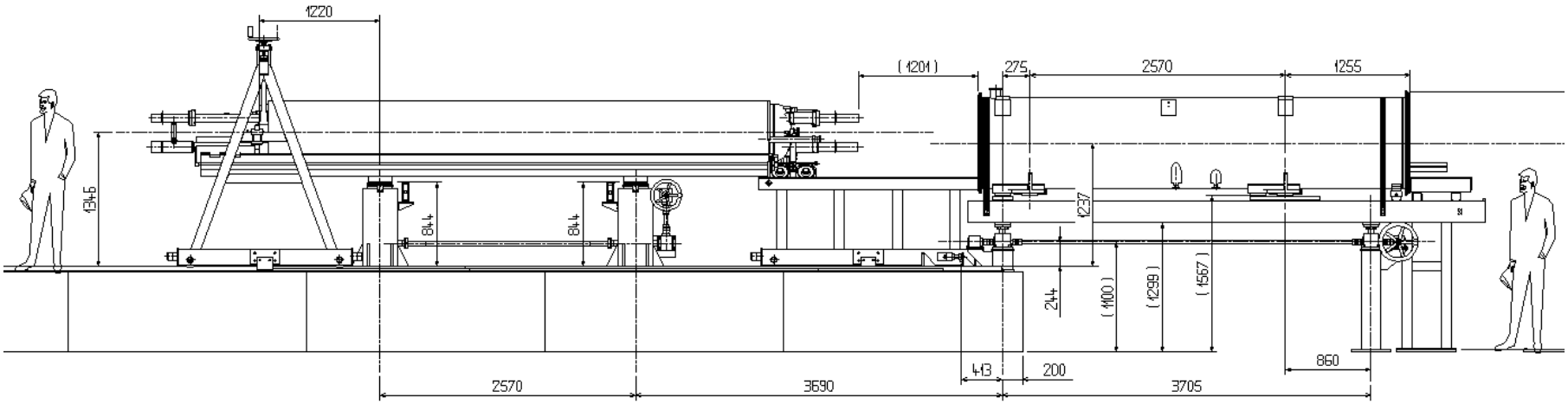
32. Perform pressure and leak tests



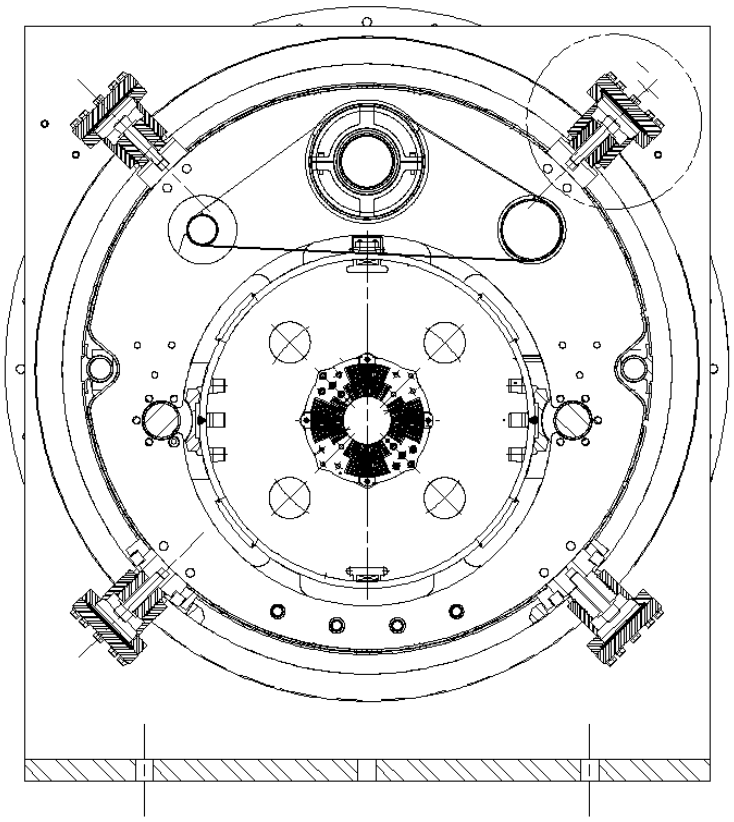
33. QA documentation

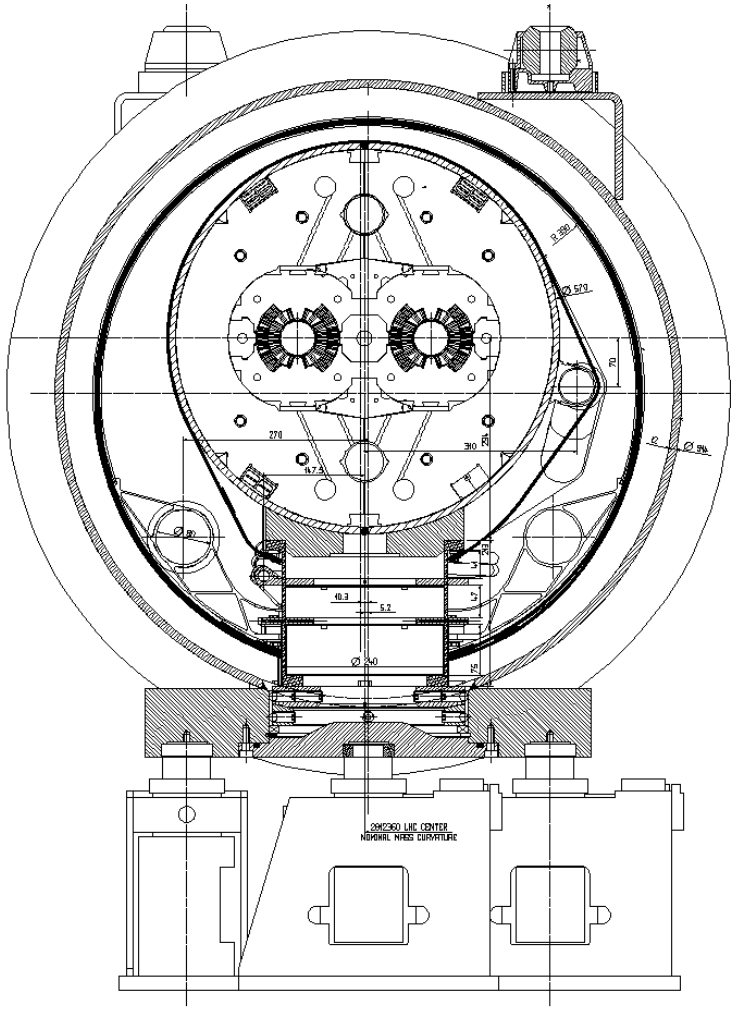
Cryostating steps

- Only the main steps are listed
- The list is for the most complex cryostat variant, i.e. with jumper and phase separator, thus including a so-called service module
- Intermediate leak checks and electrical tests will be done at critical steps (to be defined)
- A pressure test may be required at the end, before shipping to the cold test facility
- Assuming an LHC type cryostat with support posts and a bottom tray supported shield. The sequence may end up quite different if we need to implement an alternative cryostat design.



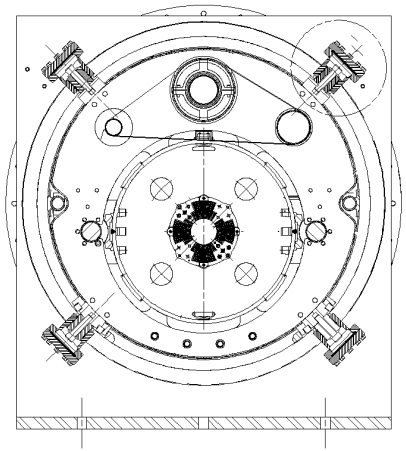
The examples of the IR quad and LHC main dipole

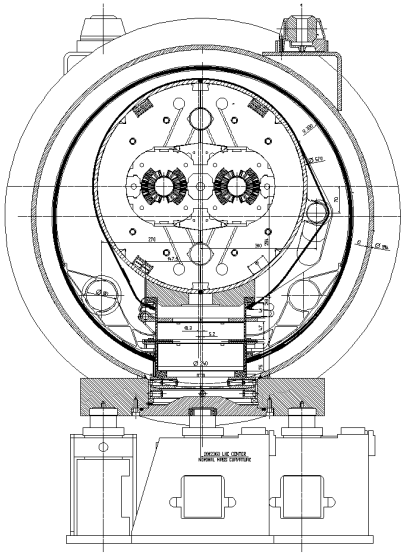


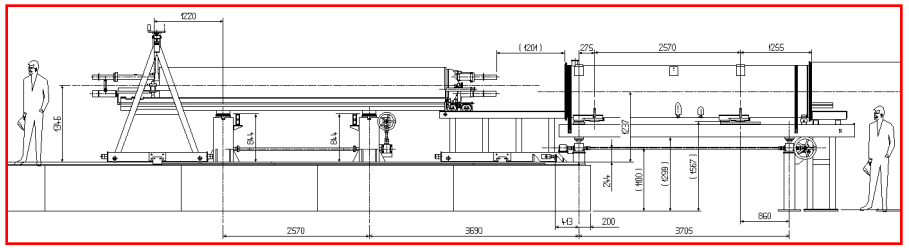


Cryostating steps (I)

1. Assembly of 1.9 K auxiliary lines, outside the cold mass
    1. pumping line, aux. bus-bar lines, quench line, etc.
2. Preparation of instrumentation cables
    1. present LHC choice is to connect all of them to instrumentation feed-box on top of the cryostat
3. Assembly the cold mass onto the bottom tray and cold supports subassembly
4. Wrapping multi-layer insulation (MLI) around the cold mass
5. Assembly of the thermal shield shells and auxiliary 70K lines, if any
6. Wrapping MLI around the thermal shields
7. Insertion into the vacuum vessel
    1. in this phase only 2 lifting points at the extremities
8. Fastening the cold supports

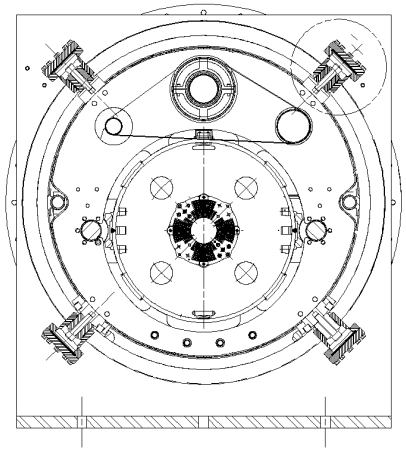


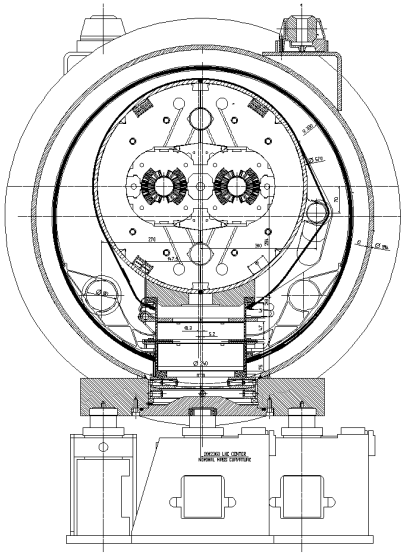


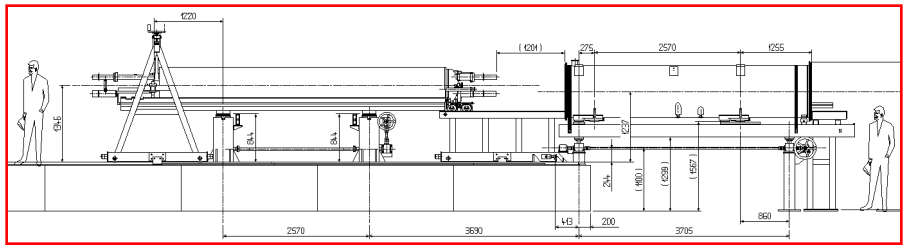


Cryostating steps (II)

9. Welding of cryogenic piping and phase separators
10. Assembly of the instrumentation feed-through (IFS)
11. Splice brazing and welding of bus-bars bypass and temporary cryo circuits for cold testing (those that may not be done during cold mass assembly)
12. Closing of the service module thermal shield and vacuum vessel
13. Assembly of the jumper to the QRL and the IFS box
14. Final tests and preparation for transport to SM18 for cold testing
15. Cold test
16. Stripping
17. Interfaces preparation for tunnel installation
18. **Shielding/beam screen insertion**







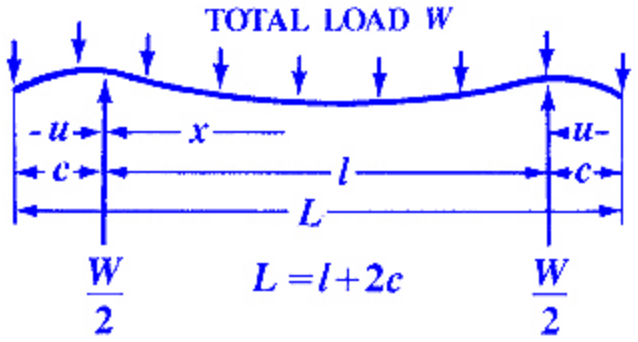
Appendix

Computation of deflection

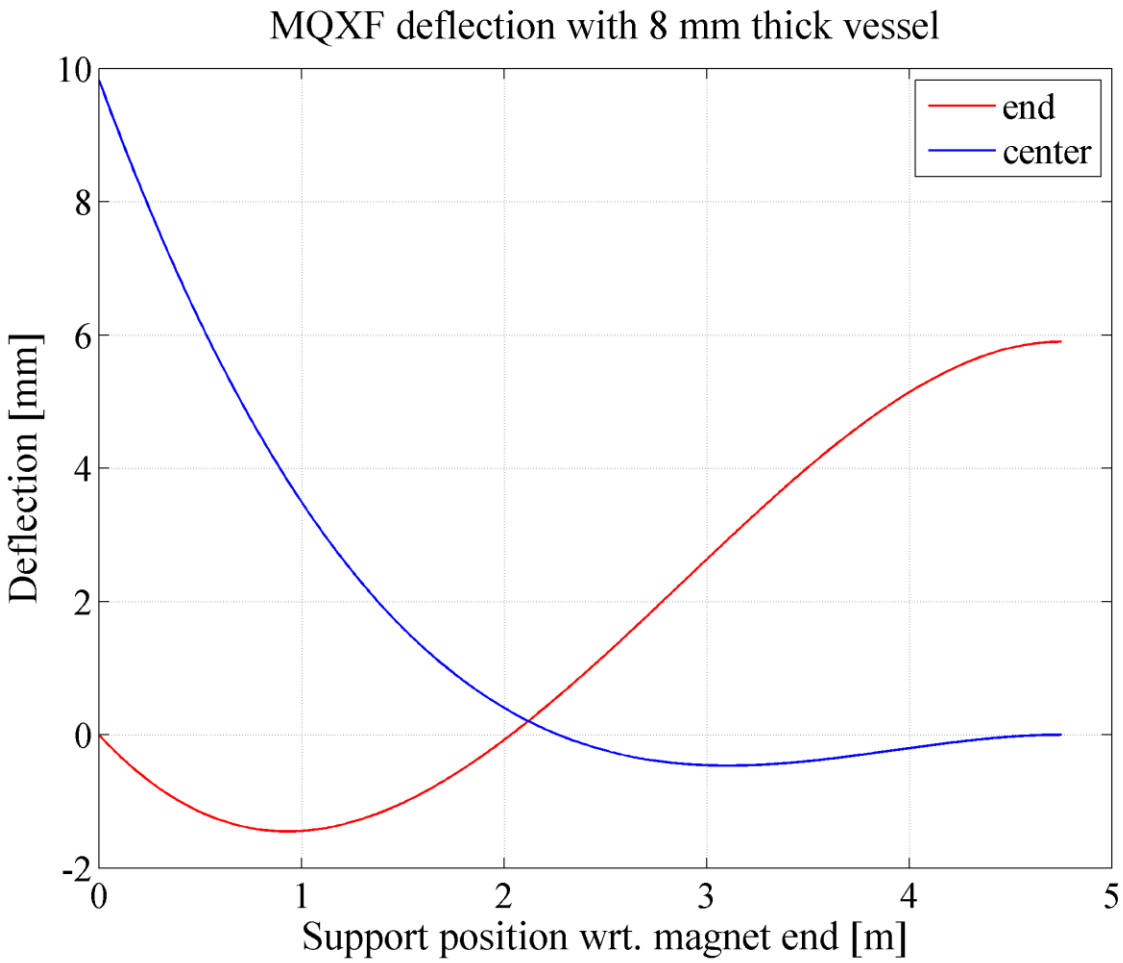
- Assumptions
  - Total length: 9.5 m
  - Mass/m: 1500 kg/m
  - OD: 630 mm
  - Vessel thickness:
    - 8, 10 and 12 mm
  - Only the moment of inertia of the vessel is considered

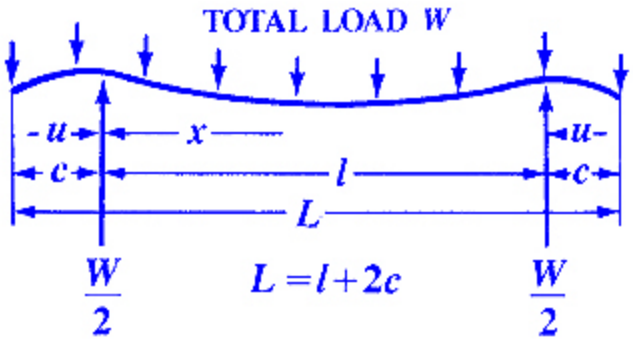
- Minimum deflection
  - C = 2.12 m
- Maximum deflection
  - C = 0 m

TH	8 mm	10 mm	12 mm
Y min	0.20 mm	0.16 mm	0.14 mm
Y max	9.83 mm	7.94 mm	6.68 mm



Computation of deflection





Cold mass and cryostat
Open issues

- Welding on backing strip on aluminum shells
- Thickness of stainless steel shell (8 or 10 mm)
- Supports of the cold-mass
  - Considered scenario
    - 2 (not at the extremities) or 3 supports while inserting the magnet (LHC main dipole scenario)
    - 3 support of the cold-mass inside the cryostat
    - 2 supports for the cryostat