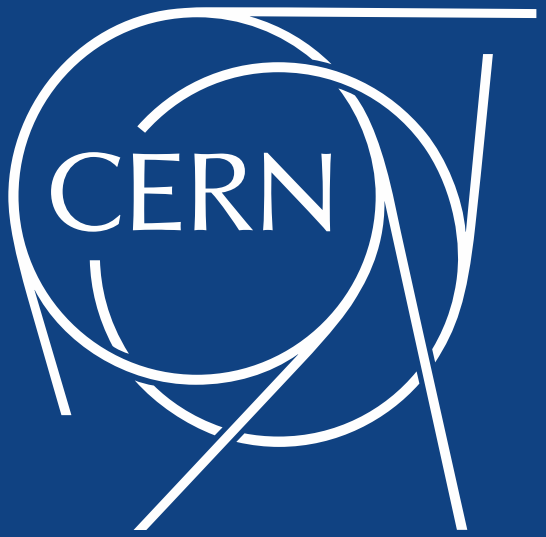

CERN

MQXFS Assembly Procedure

J.C Perez

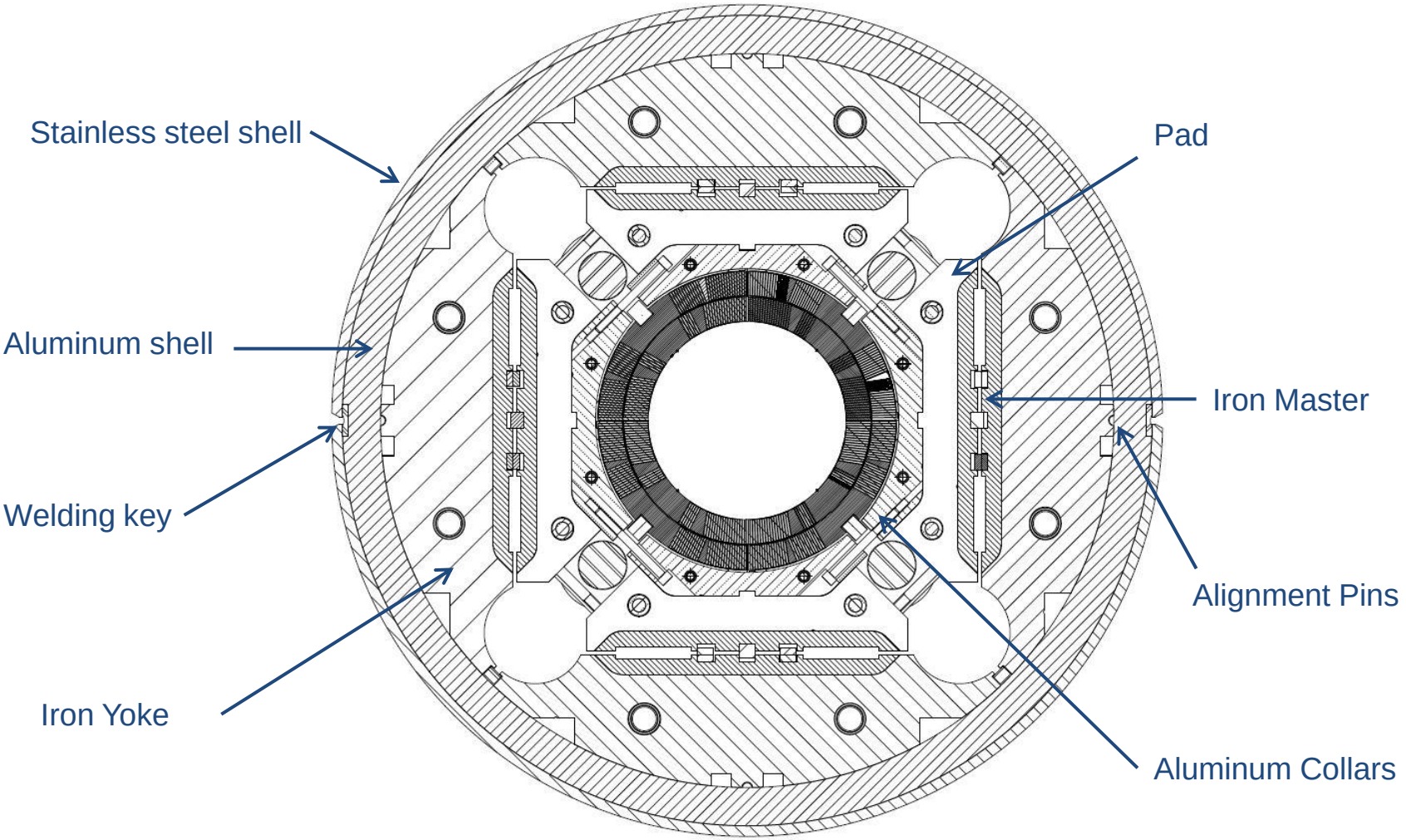
4th Joint HiLumi LHC-LARP Annual Meeting
November 17-21, 2014
KEK, Tsukuba

N. Bourcey, D. Cheng, B. Favrat, H. Felice, P. Ferracin, Ph. Grosclaude, R. Hafalia, M. Juchno, L. Lambert, P. Moyret, J. Parrilla Leal, N. Peray, T. Sahner, A. Temporal

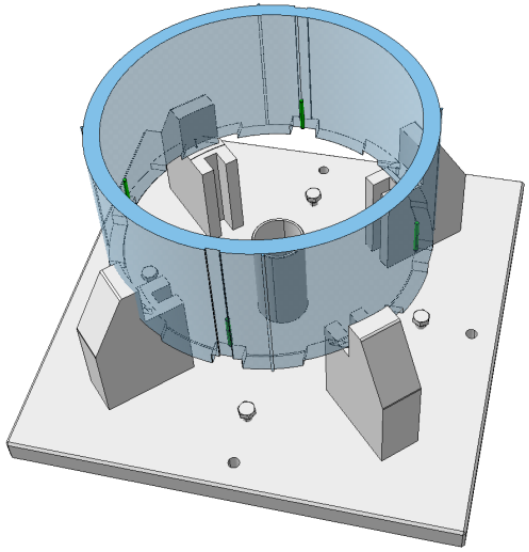
OUTLINE

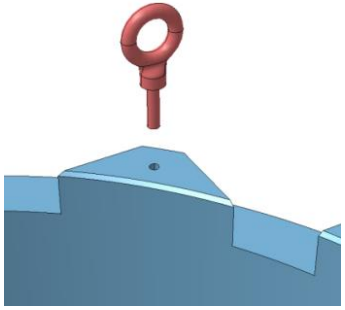
- MQXFS magnet
  - ✓ Main assembly steps and status of components and tooling
  - ✓ External aluminium shell configuration
- 150 mm mechanical model
  - ✓ Assembly and Cool-down to 77K
- Conclusions

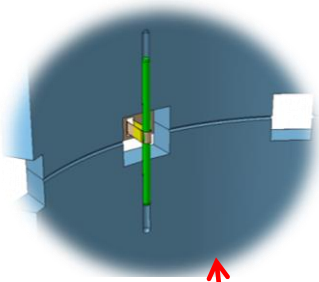
MQXFS cross section

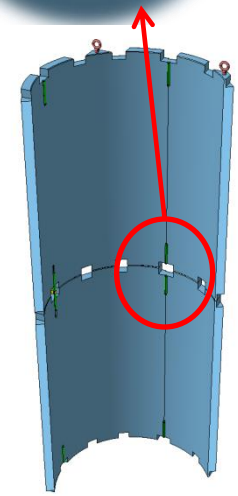


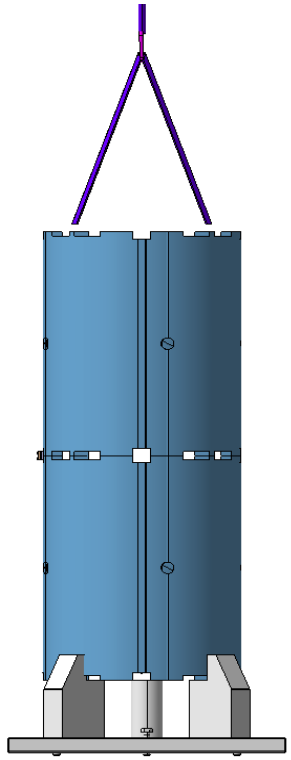
Shells preparation for vertical assembly



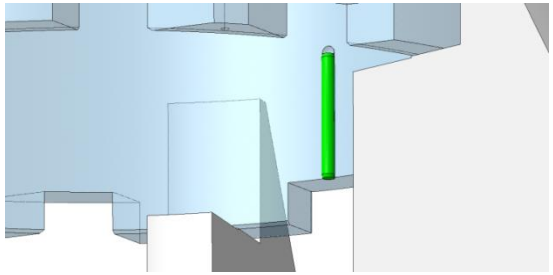








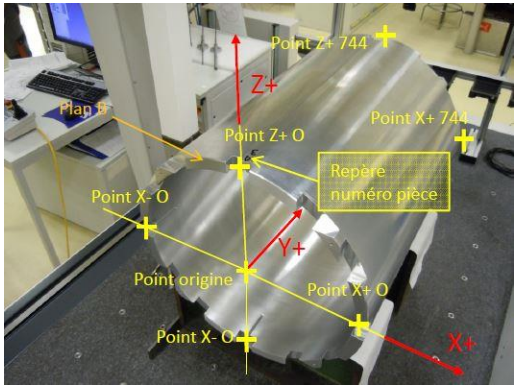
The shells are manipulated using a 4 sling lifting tool and adjustable bolted lifting eyes.



- The base plate will be leveled and bolted to the floor

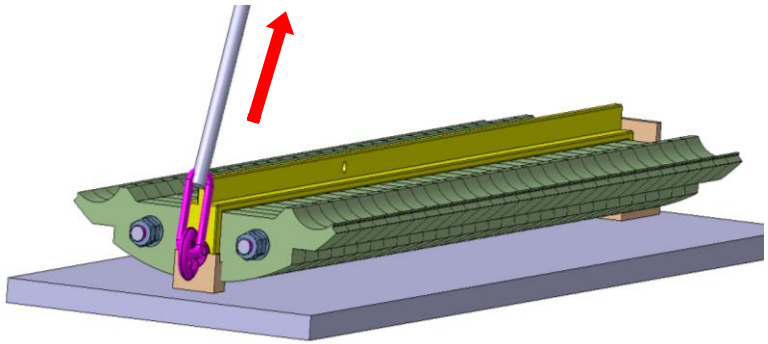
- The shells are instrumented with the strain gauges before starting the assembly sequence
- 4 short alignment pins are inserted and glued in the lower inner shell slots of the first shell to be installed on top of the assembly base plate
- The relative angular alignment between the 2 shells is guaranteed by the use of the 2 long pins

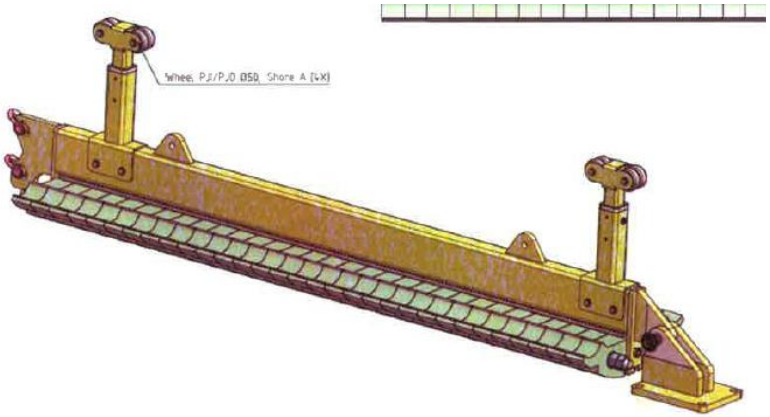
First batch of aluminium Shell

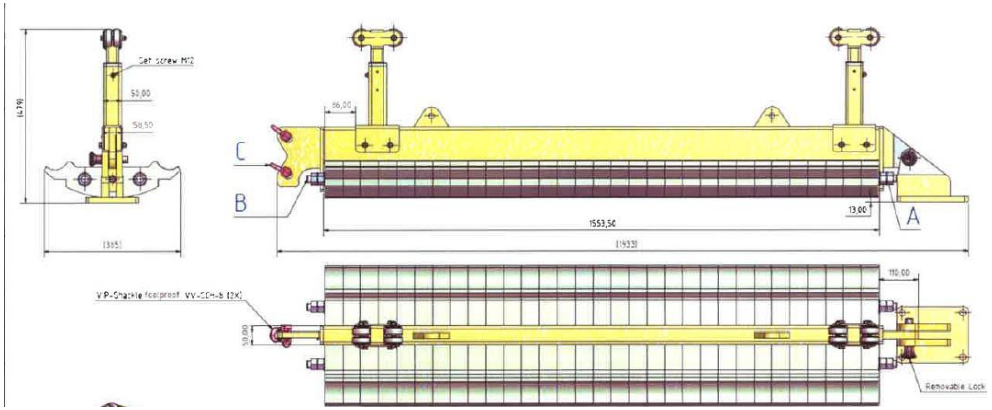


- 4 shells have been ordered and CMM controlled at CERN and LBNL (pins slots position out of tolerance)
- 1 pair of shell has been delivered to LBNL
- The CERN and LBNL pairs of shells have been instrumented and are ready for assembly

¼ yoke lifting and preparation for insertion

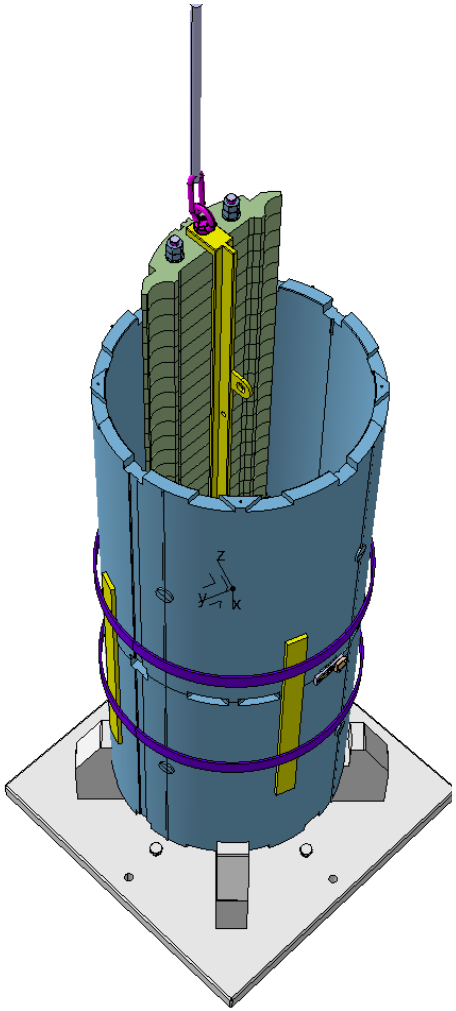


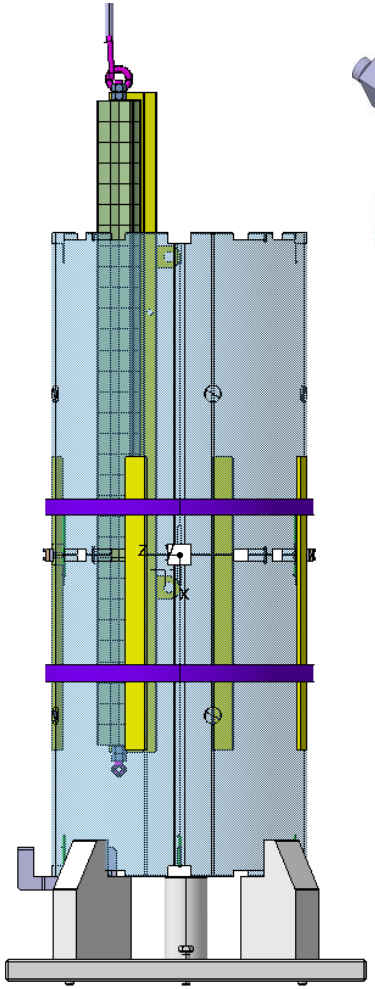


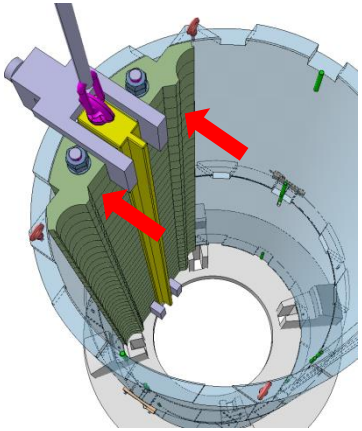


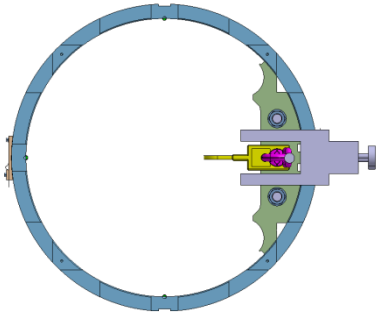
- The ¼ yokes are manipulated with a dedicated lifting and pivoting tool.
- The yokes will be inserted on the shells in vertical position
- Two lifting tools CE certified have been delivered end of October (1 will be shipped to LBNL by end of November 2014)

¼ yoke insertion



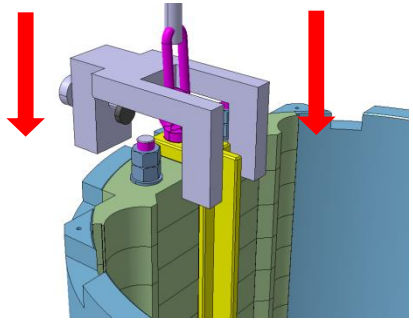




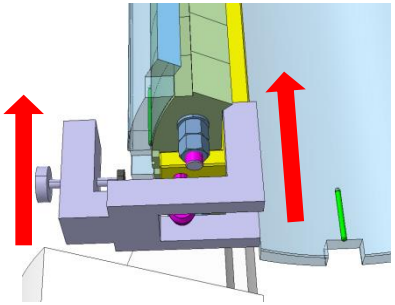


The angular alignment of the first ¼ yoke is defined by 1 long middle pin and 2 small pins located at the shell extremities

Upper radial clamp

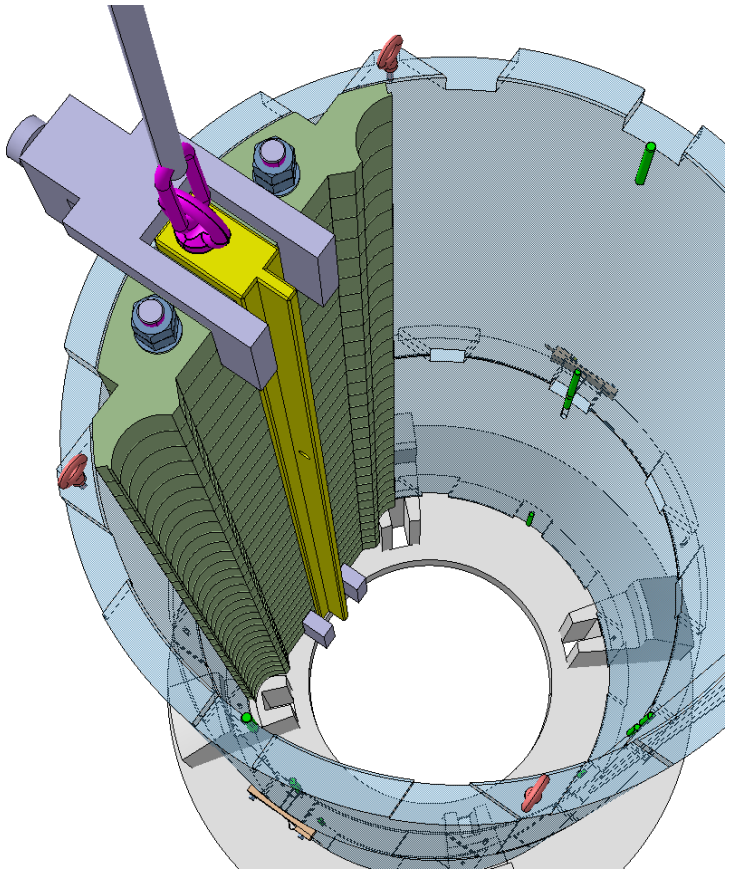


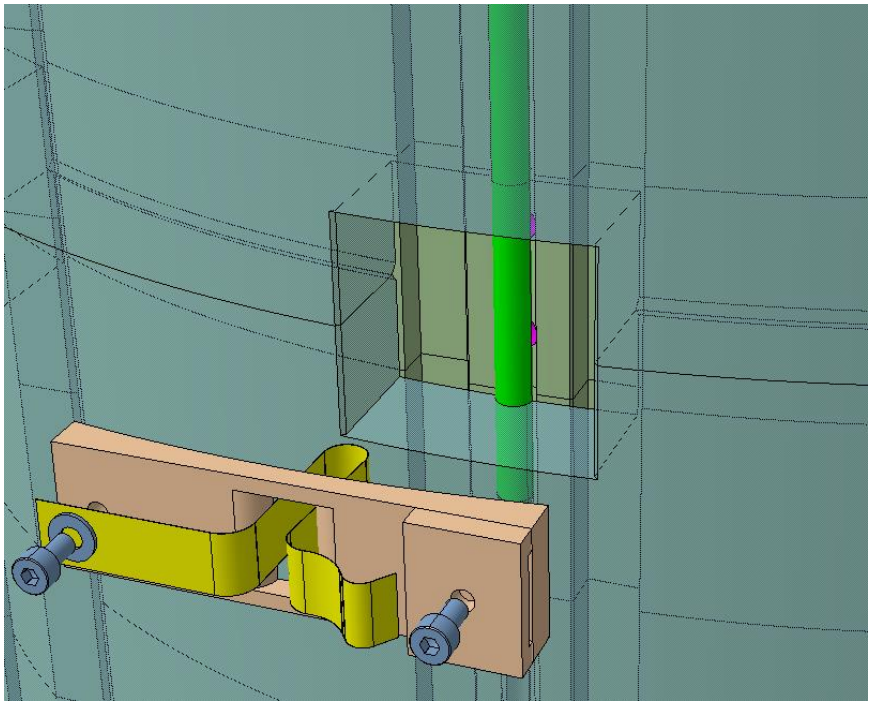
Lower radial clamp



Dedicated clamping tools will be used to radially clamp the ¼ yoke in the shells

Removing central pin holding tool



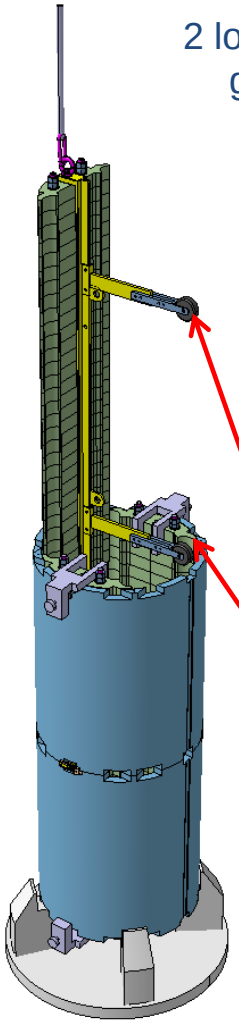


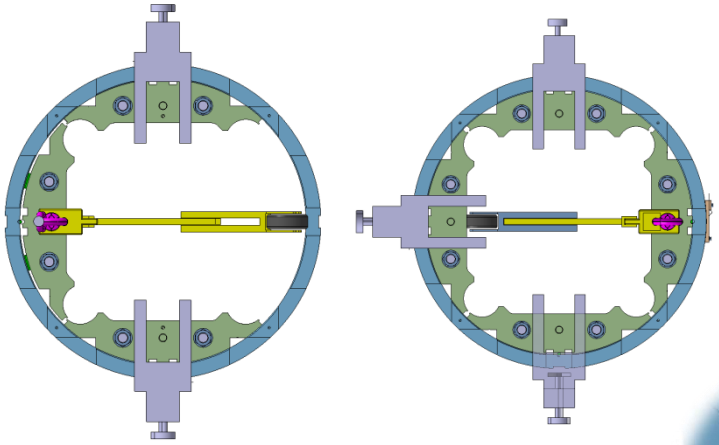
The holding tooling of the middle pin is removed before clamping the yoke at its final radial position (required gap between yoke and shell to allow pin removal ± 0.3 mm)

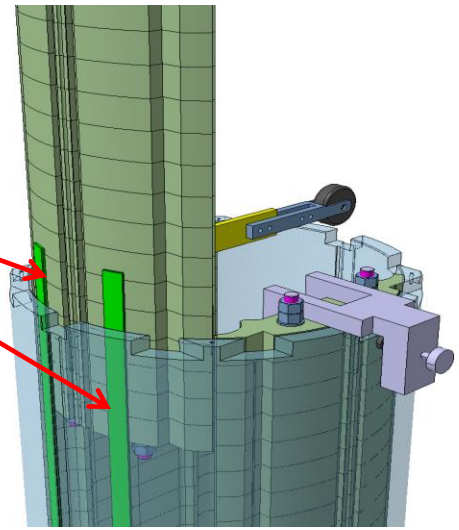
Two sets of iron yokes have been delivered. One set is going to be shipped to LBNL

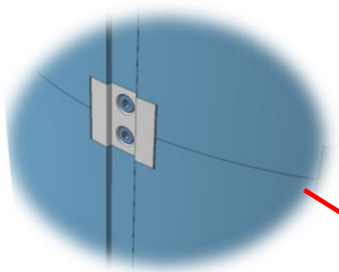
3rd and 4th ¼ insertion

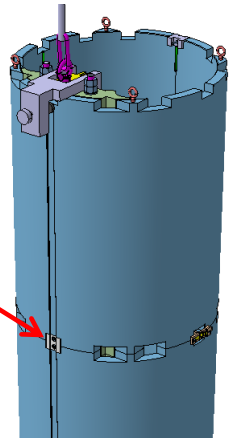
2 longitudinal plastic spacers will be used to guarantee a constant gap between yoke and shell preventing interference with the already inserted yokes







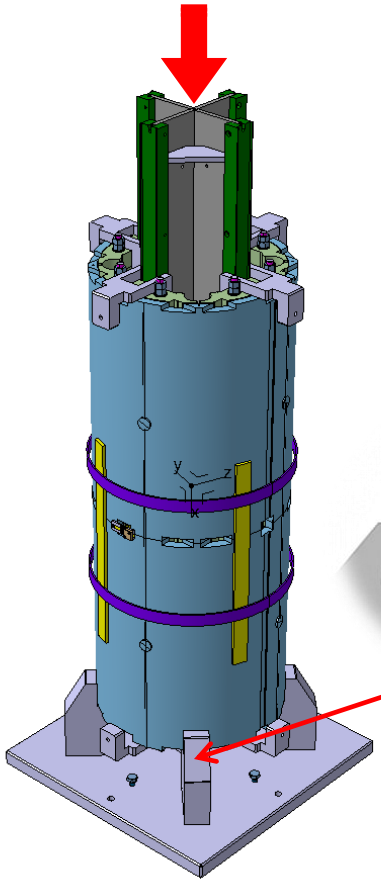


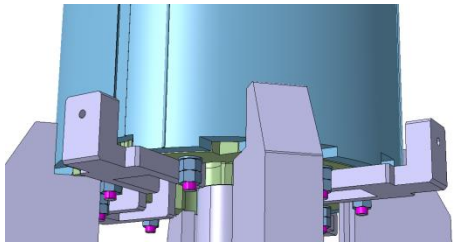


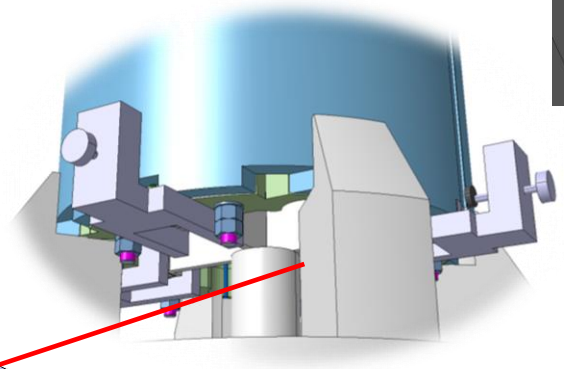
The Yoke lifting tool is equipped with 2 guiding wheels forcing the yoke against the plastic spacers

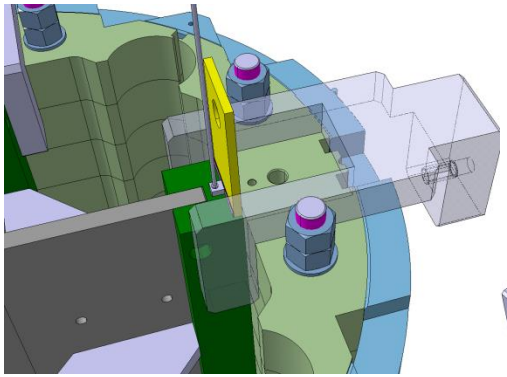
2 stainless steel blocks for welding key alignment and tack welding will be bolted to the yokes

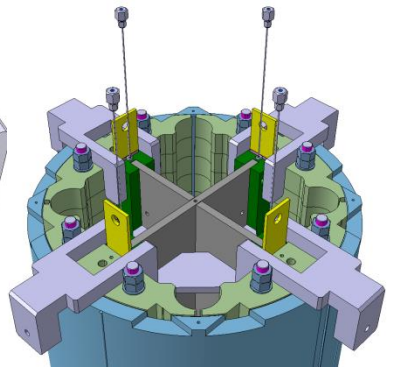
Bladders support structure for shell loading





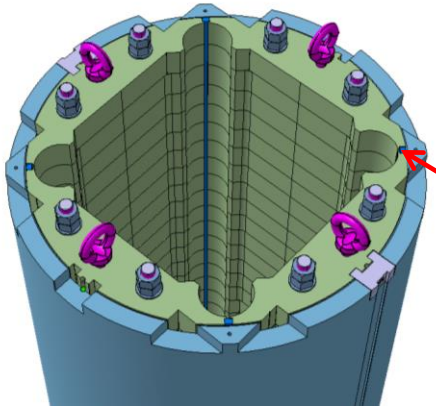






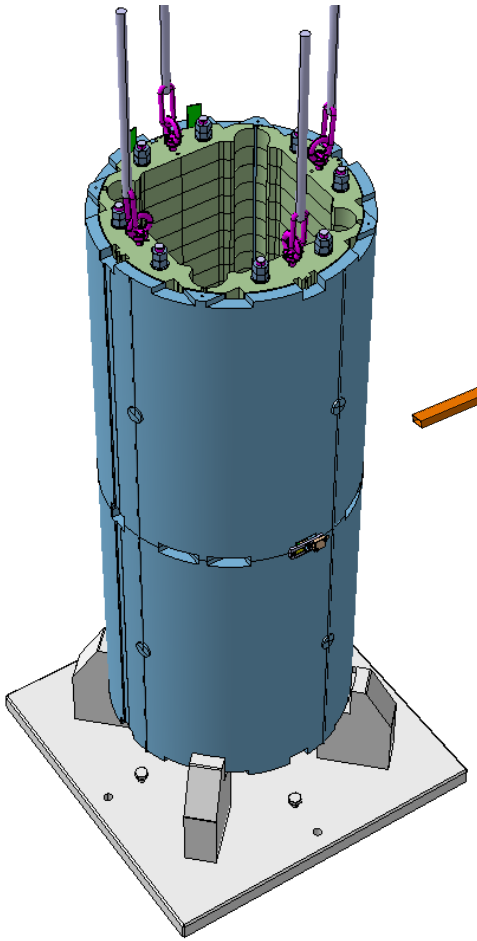
4 bladders 1549 mm * 57 mm will be used for shell pre-loading operation.

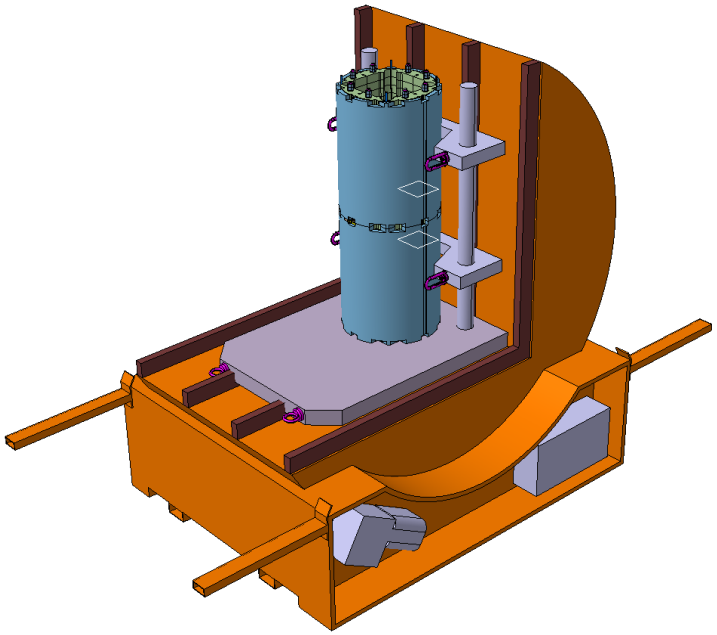
A cross-shape support inserted in the structure is used to support the bladders for shell pre-loading operation

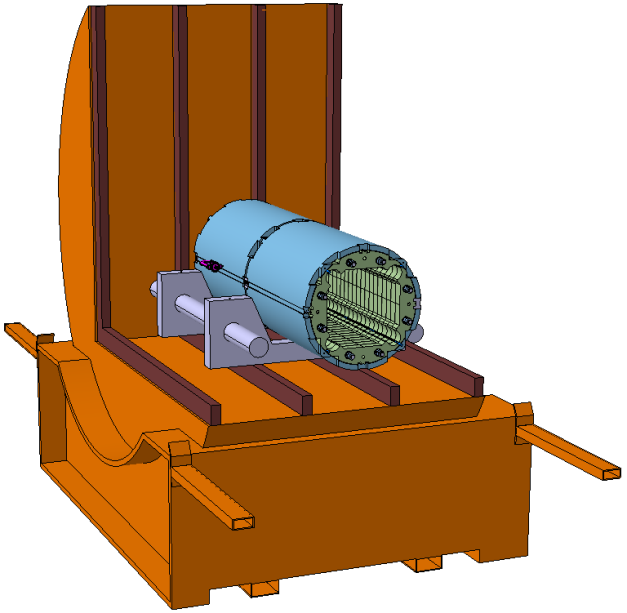


Temporary yoke keys will be inserted in the yoke gaps

Lifting and rotating Yoke and Shell assembly CERN concept



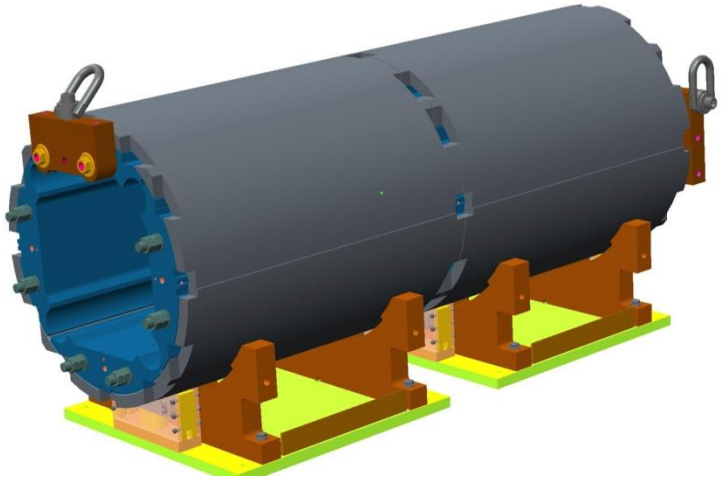




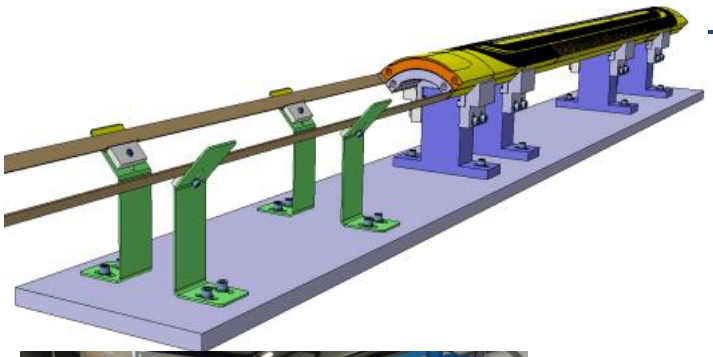
The yoke and shell assembly will be transported, using a 4 sling lifting tool and adjustable lifting eyes bolted on the yoke, to an existing rotated device. The yoke and shell assembly will be flipped from vertical to horizontal position.

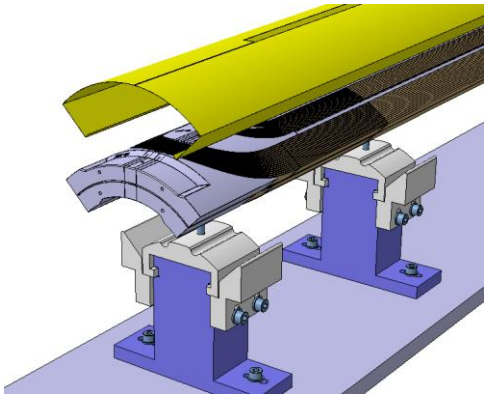
Lifting and rotating Yoke and Shell assembly LARP concept

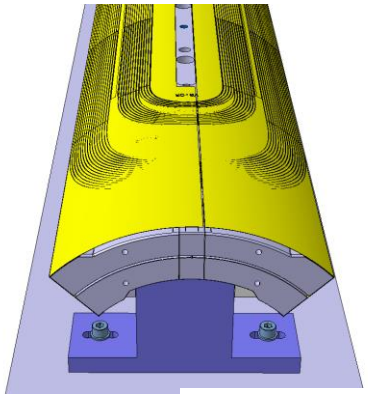
The vertical yoke and shell assembly will be lifted by two offset lifting eyes from “ears” that are attached to the yoke tie rods. A chain fall is connected to a third lifting eye at the bottom, which allows the rotation of the assembly to horizontal. The horizontal assembly is placed on modified LQ cradles.

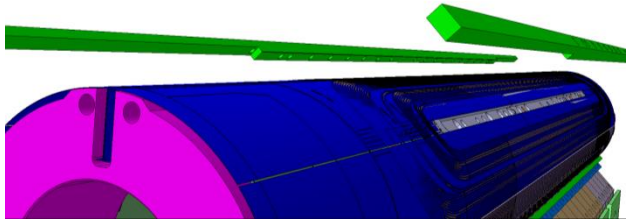


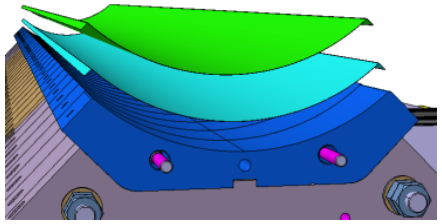
Coils and collars preparation





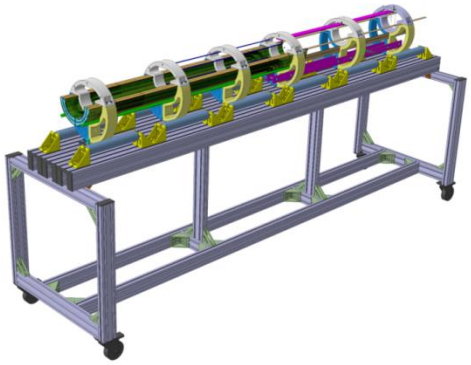




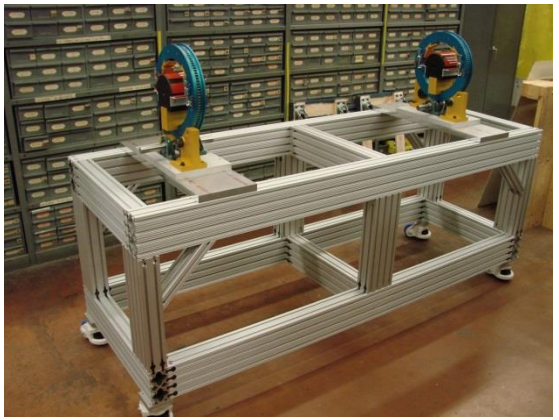


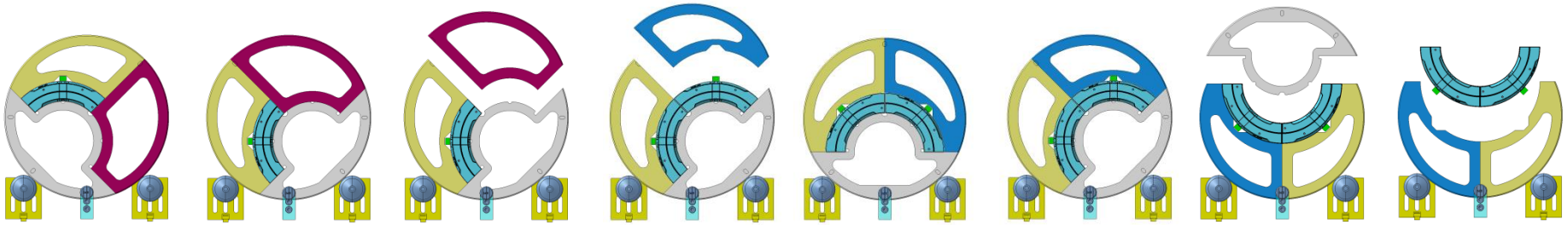
- The coils are equipped with 2 layers of Kapton for ground insulation.
- The fiber glass keys are inserted in the longitudinal pole slot.
- Two ground insulation layers are glued to the aluminum collars.
- Assembly table delivered and will be tested during mechanical model assembly
- The aluminum dummy coils are being instrumented with strain gauges (will be ready by end of November at CERN and LBNL)

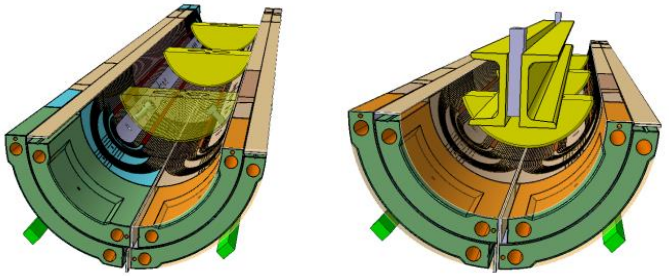
Coils rotation

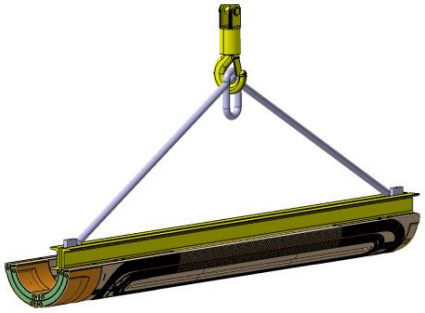


CERN: adaptation of an existing 11 T dipole rotating device for MQXFS. Delivery expected by end of November
LBNL: adaptation of a LARP rotating device for MQXFS. Assembled.



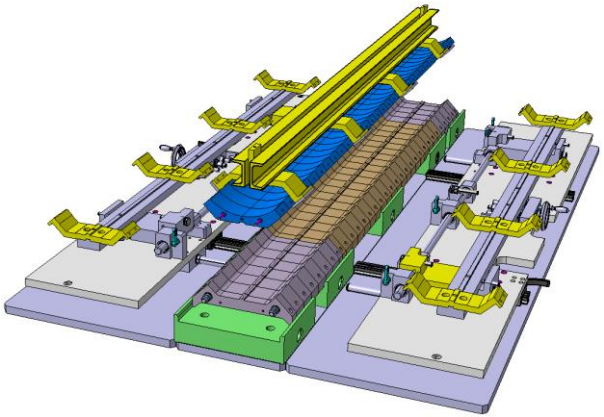


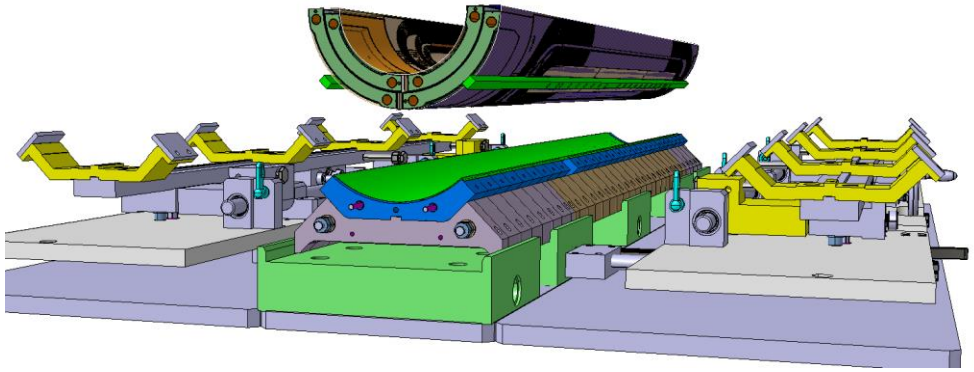


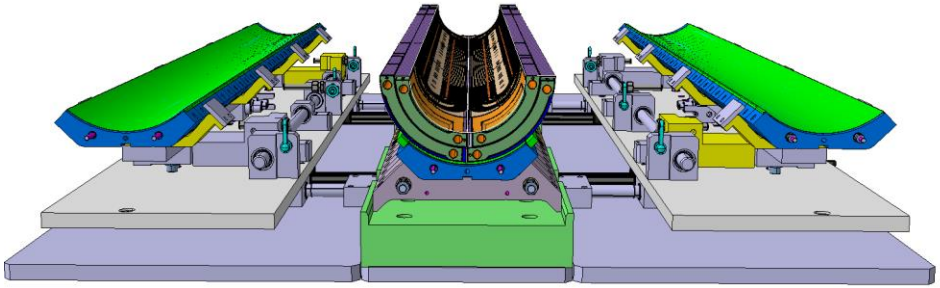


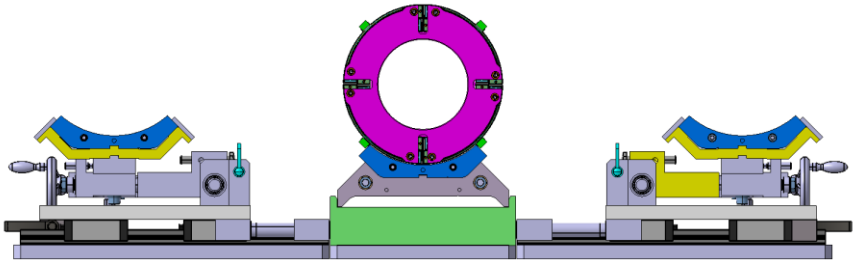
CERN: The first pair of coils to be assembled will be rotated up-side down and lifted from their inner face. The coil handling tooling is designed to manipulate the coils from inner and outer radius.
LBNL: coil lifting tooling designed based on LARP experience

Coil pack assembly: mounting the coils



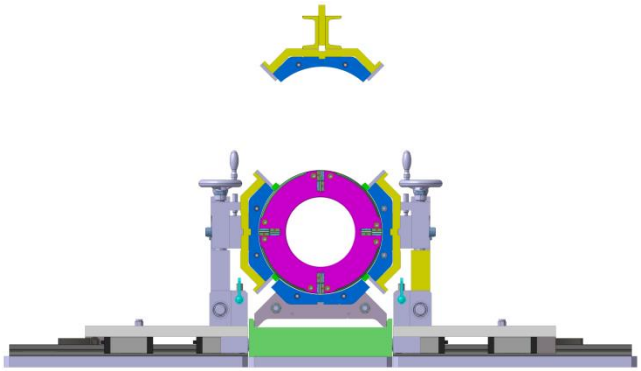


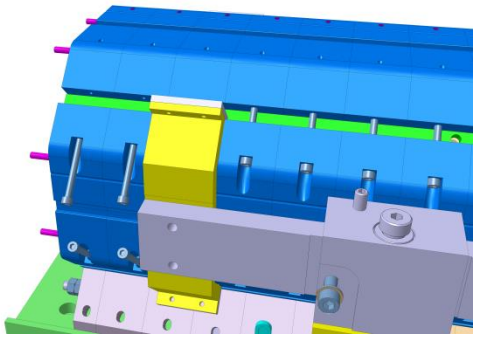


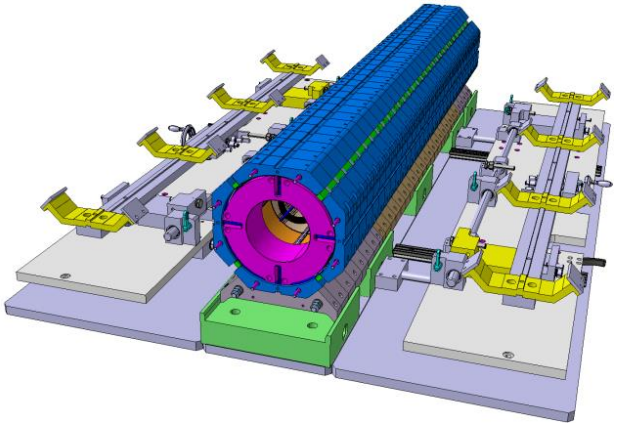


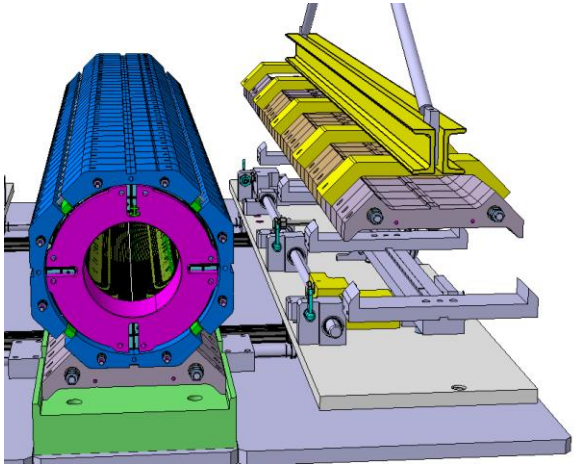
- The fabrication drawings of the coil pack assembly tooling parts are ready at CERN and design ongoing at LBNL
- The assembly bench delivery is foreseen in February 2015 at CERN
- The first mechanical assembly using aluminum dummy coils will not be performed with this tooling

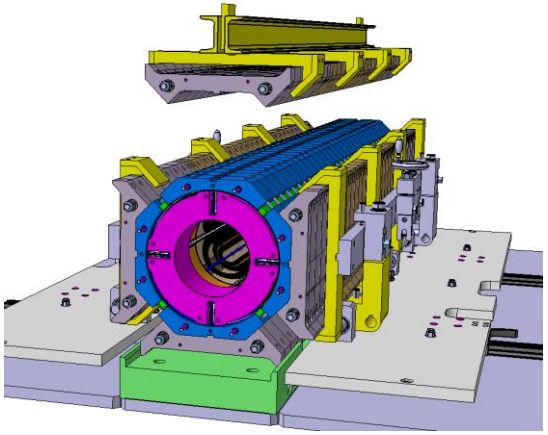
Collars and pads assembly

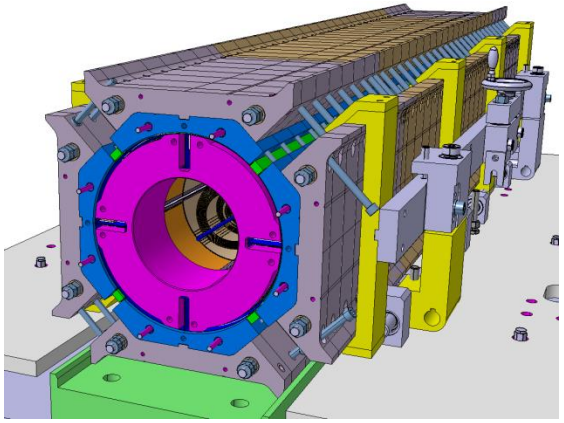




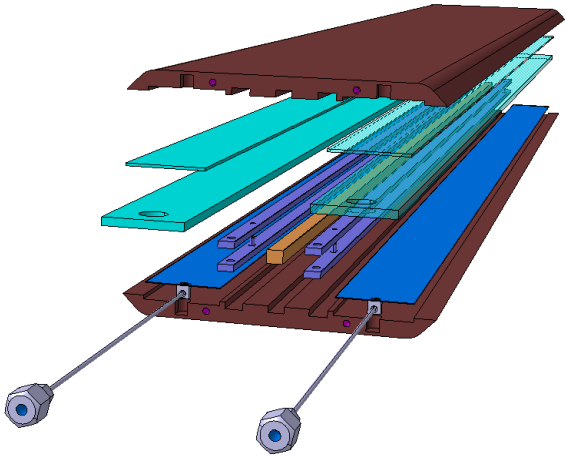


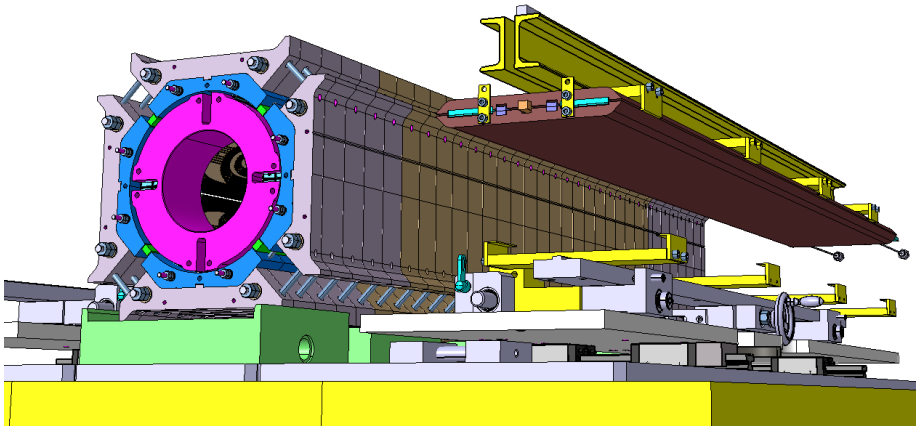


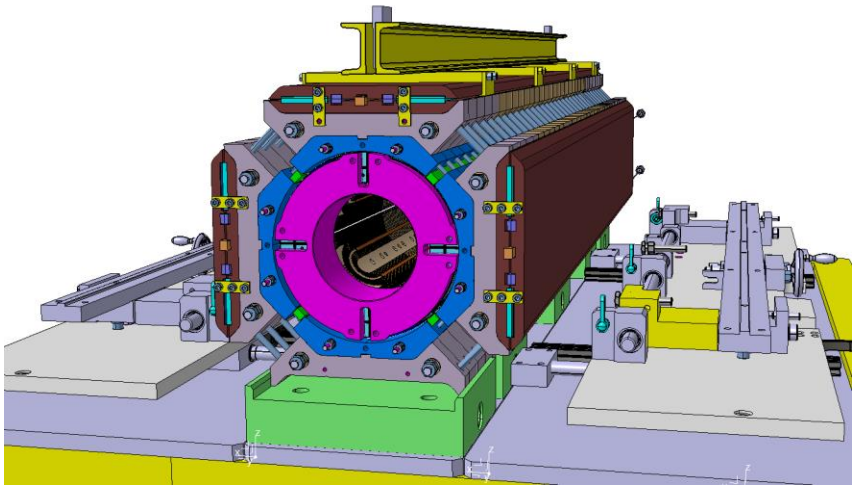


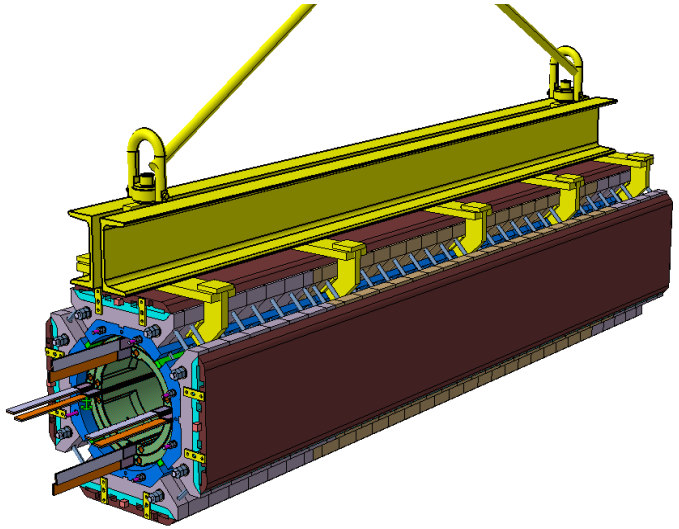


Masters and coil pack preparation

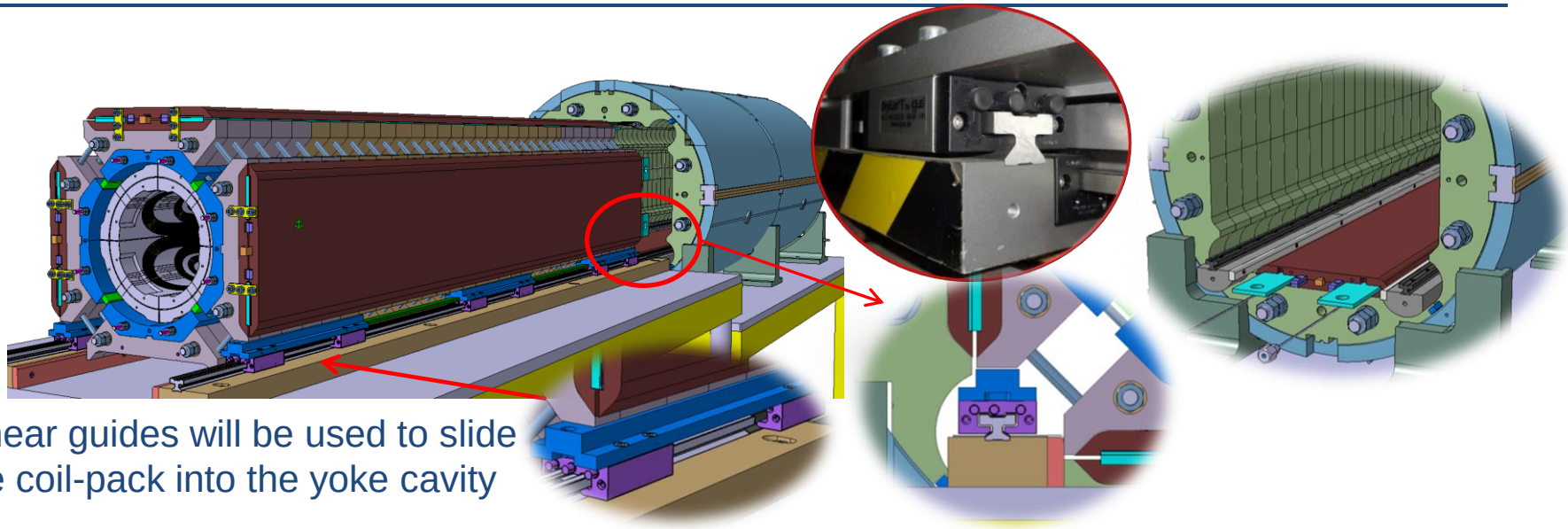




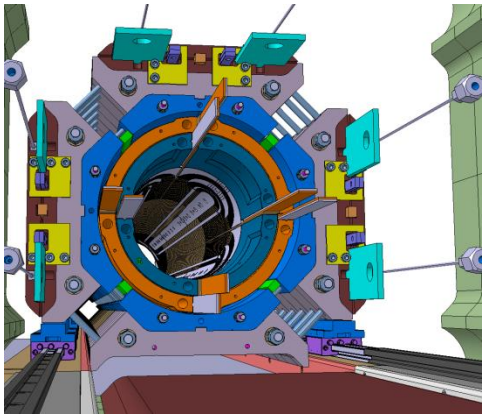


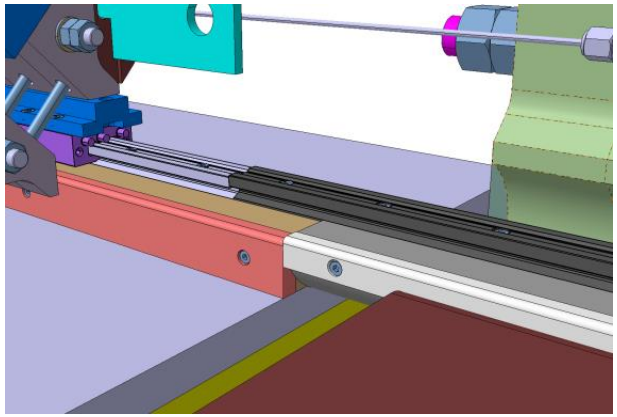


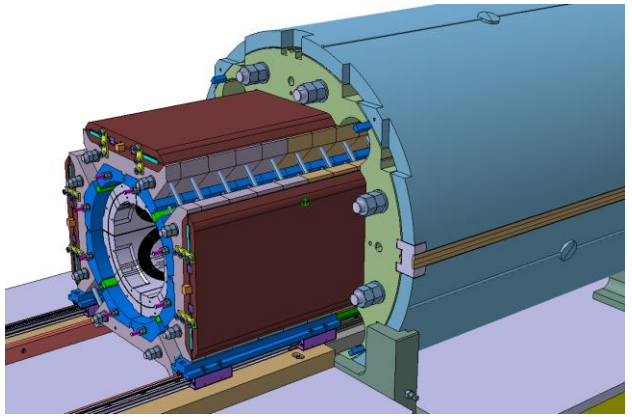
Coil-pack insertion
CERN concept



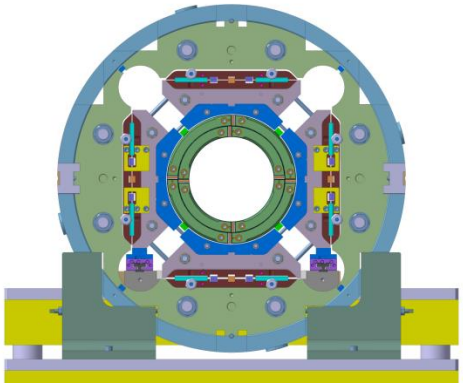
Linear guides will be used to slide the coil-pack into the yoke cavity



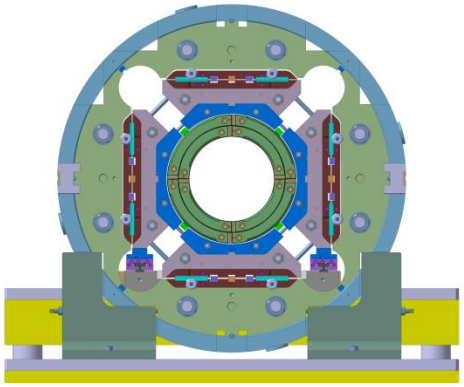




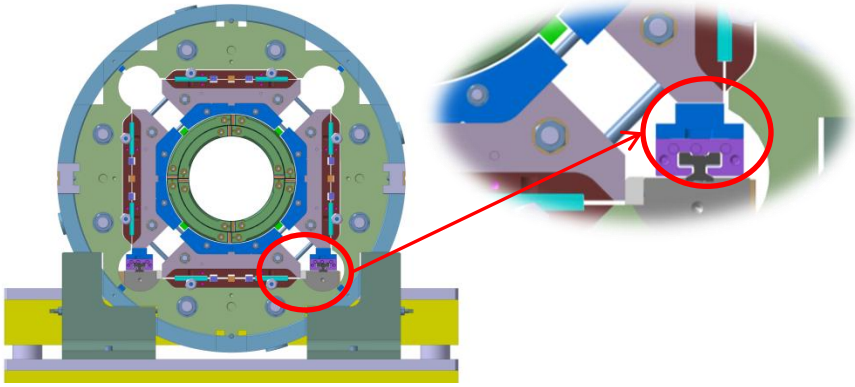
Bladders operation
CERN concept



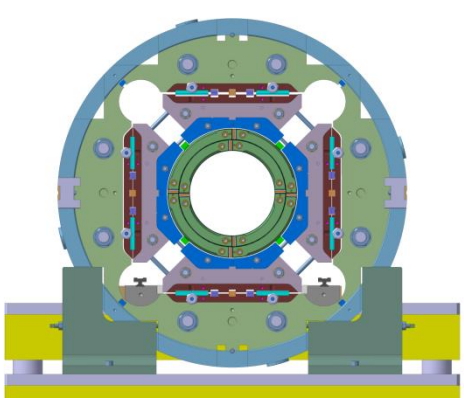
Coil pack inserted in the yoke

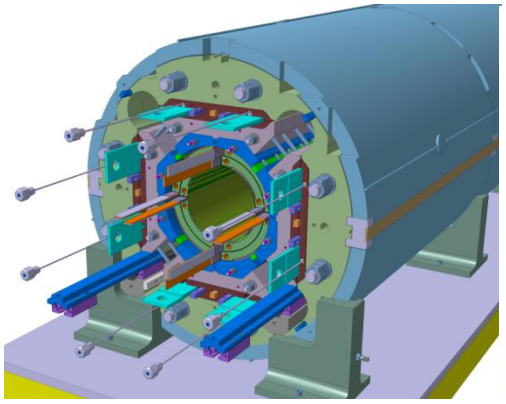


Master clamps are removed

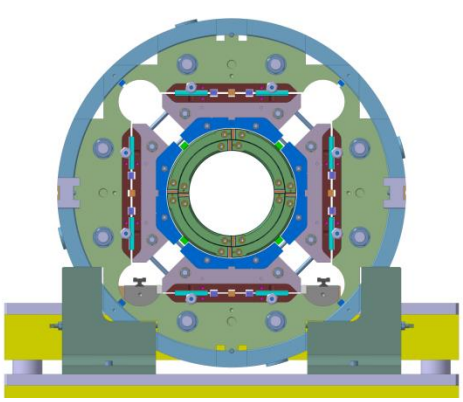


Lower bladder is pressurized and top nominal key inserted

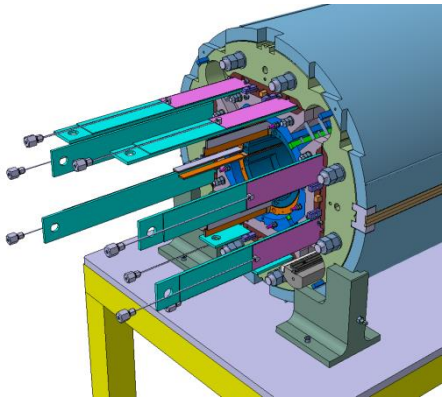




Insertion guides are removed and lower nominal keys inserted



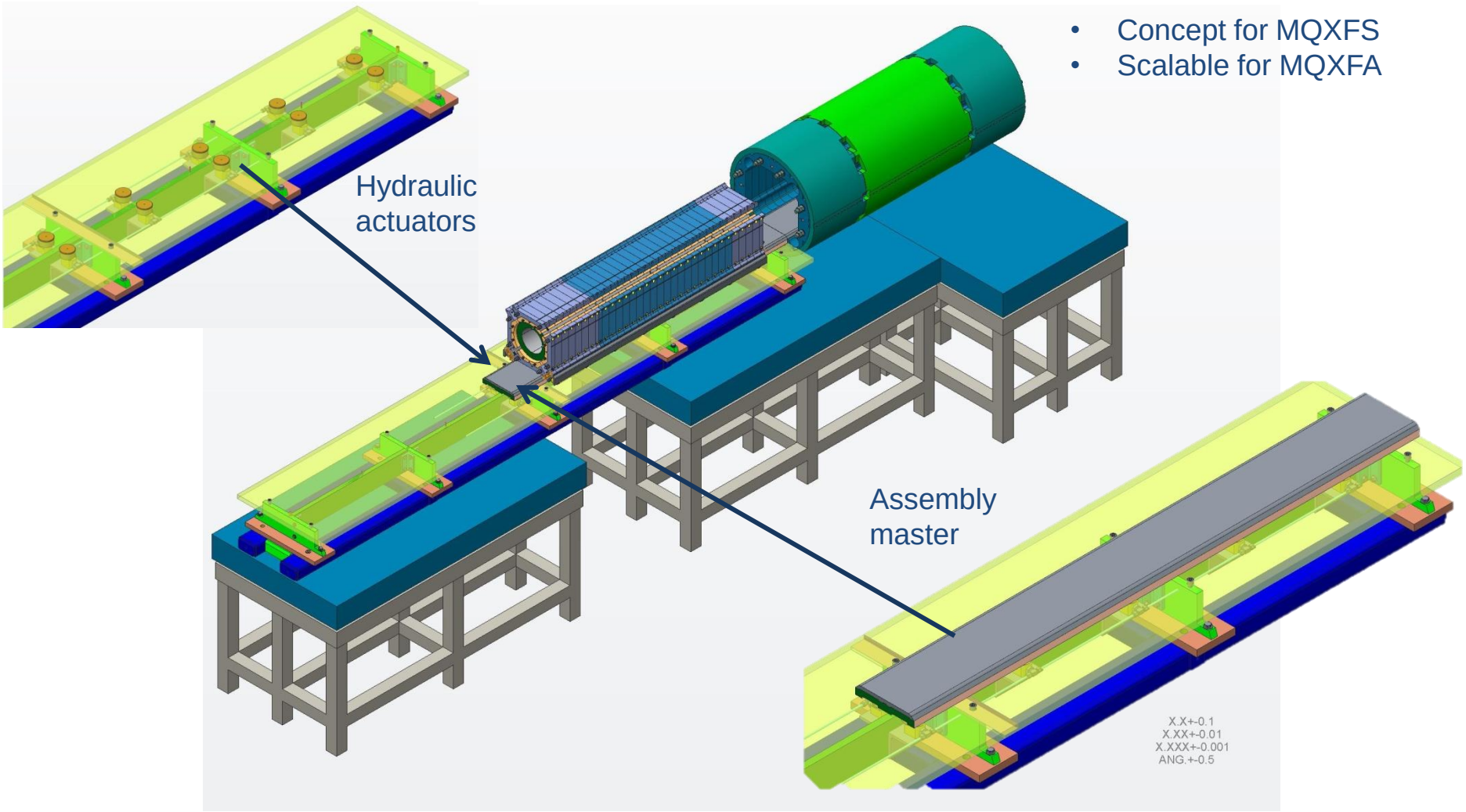
Bladders operation



Bladders and slip shims are removed after full loading operation

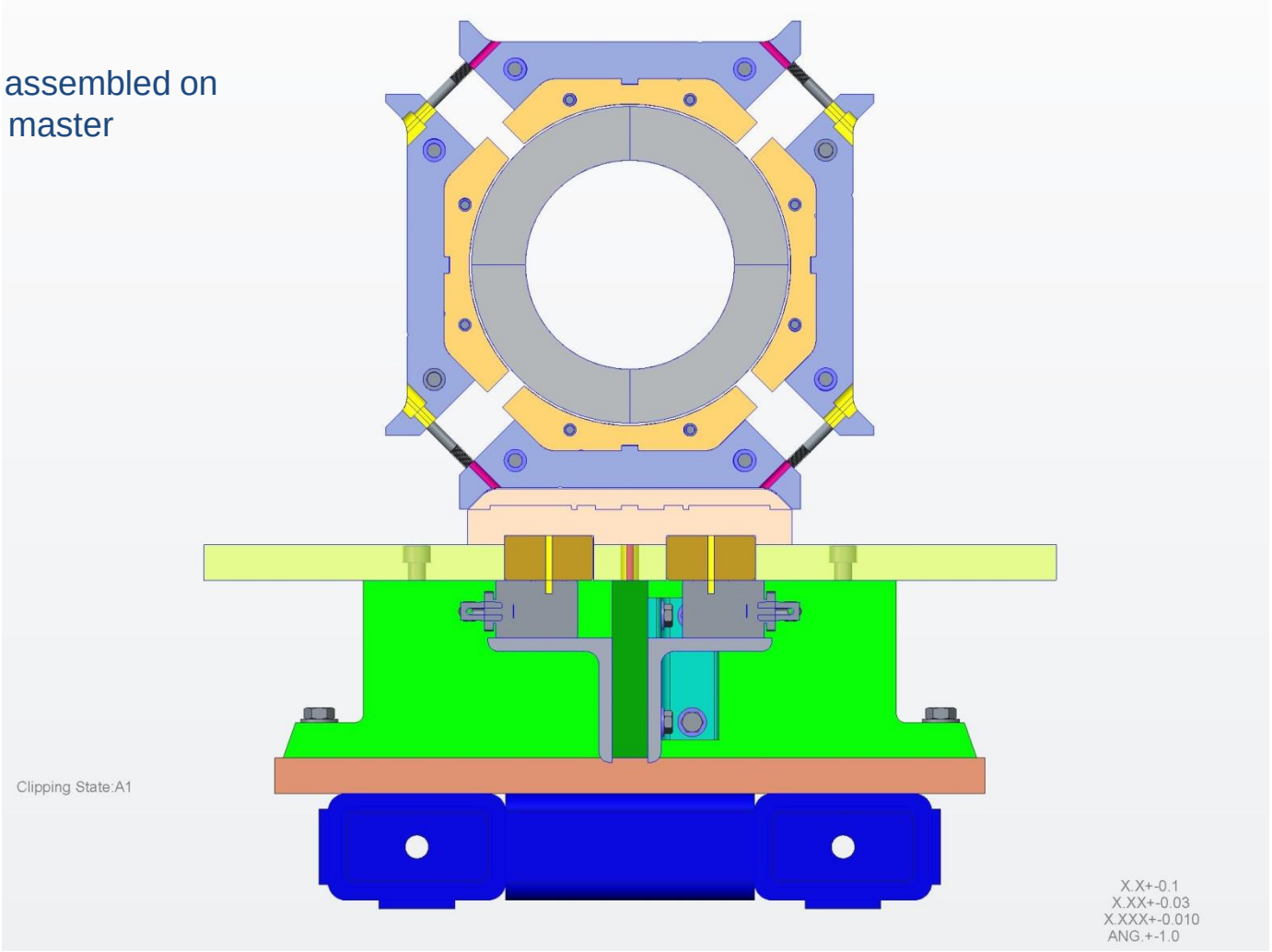
Coil-pack insertion
LARP concept

- Concept for MQXFS
- Scalable for MQXFA



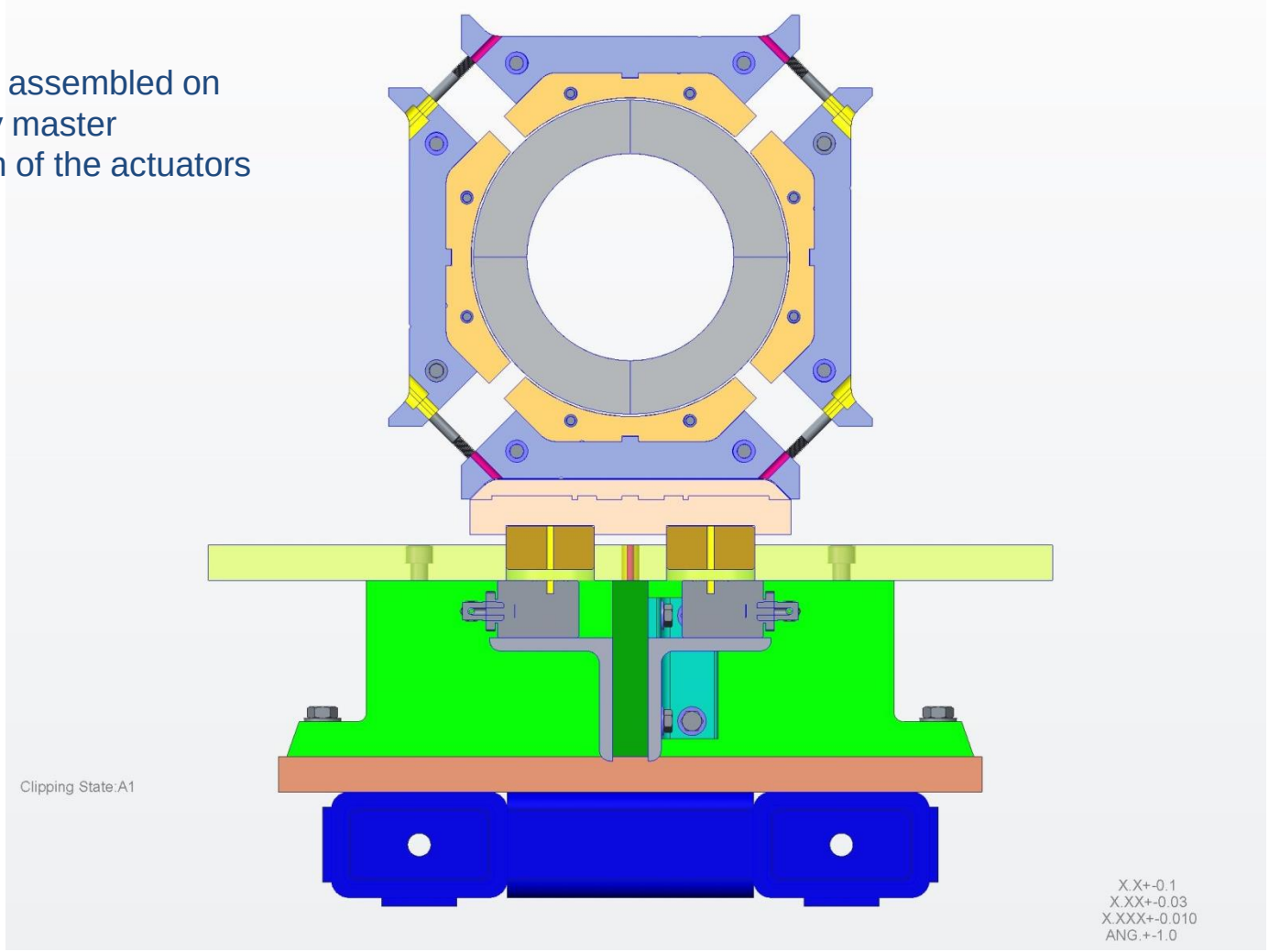
Coil-pack insertion
LARP concept

- Coil pack assembled on assembly master



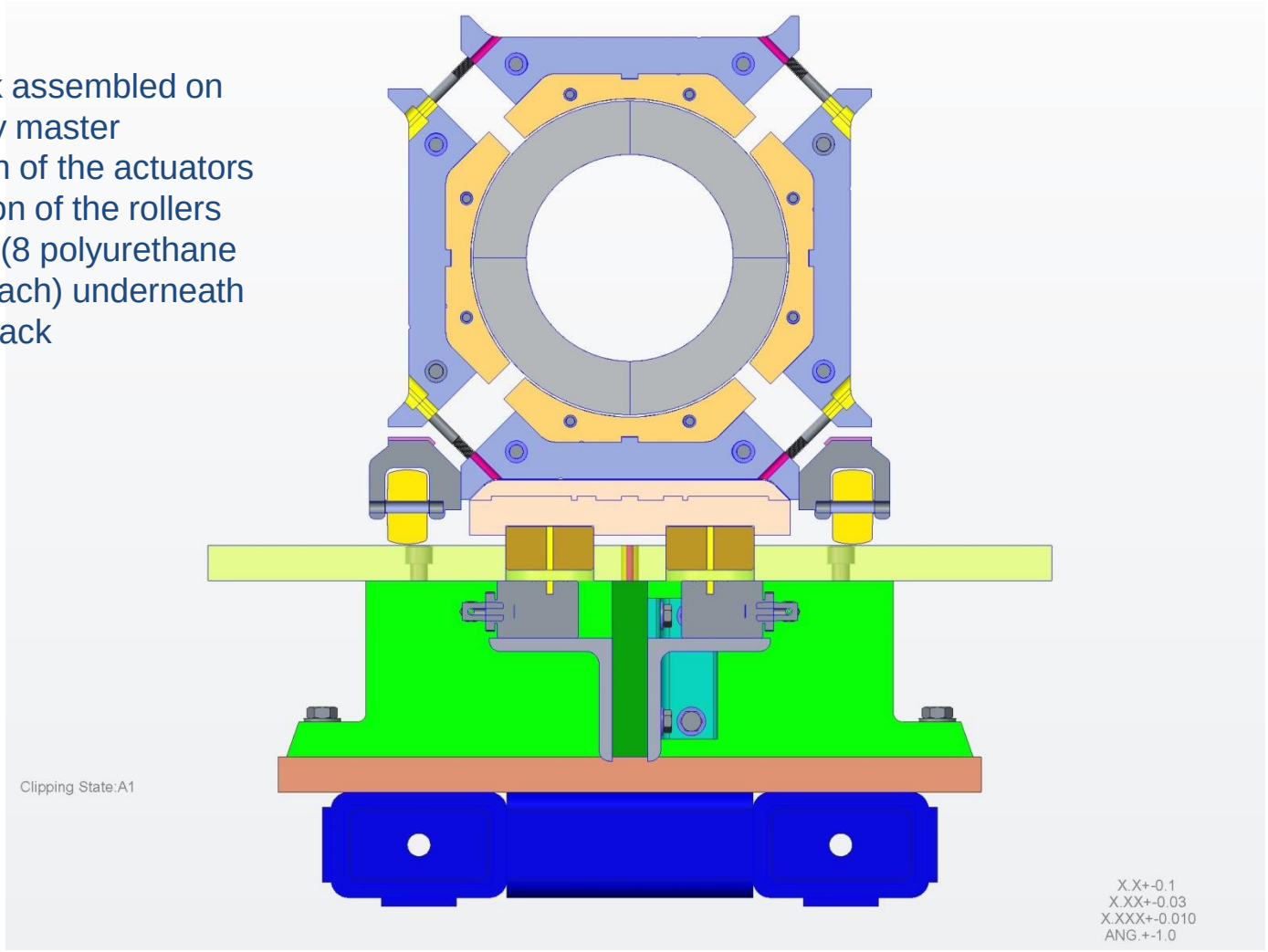
Coil-pack insertion
LARP concept

- Coil pack assembled on assembly master
- Activation of the actuators



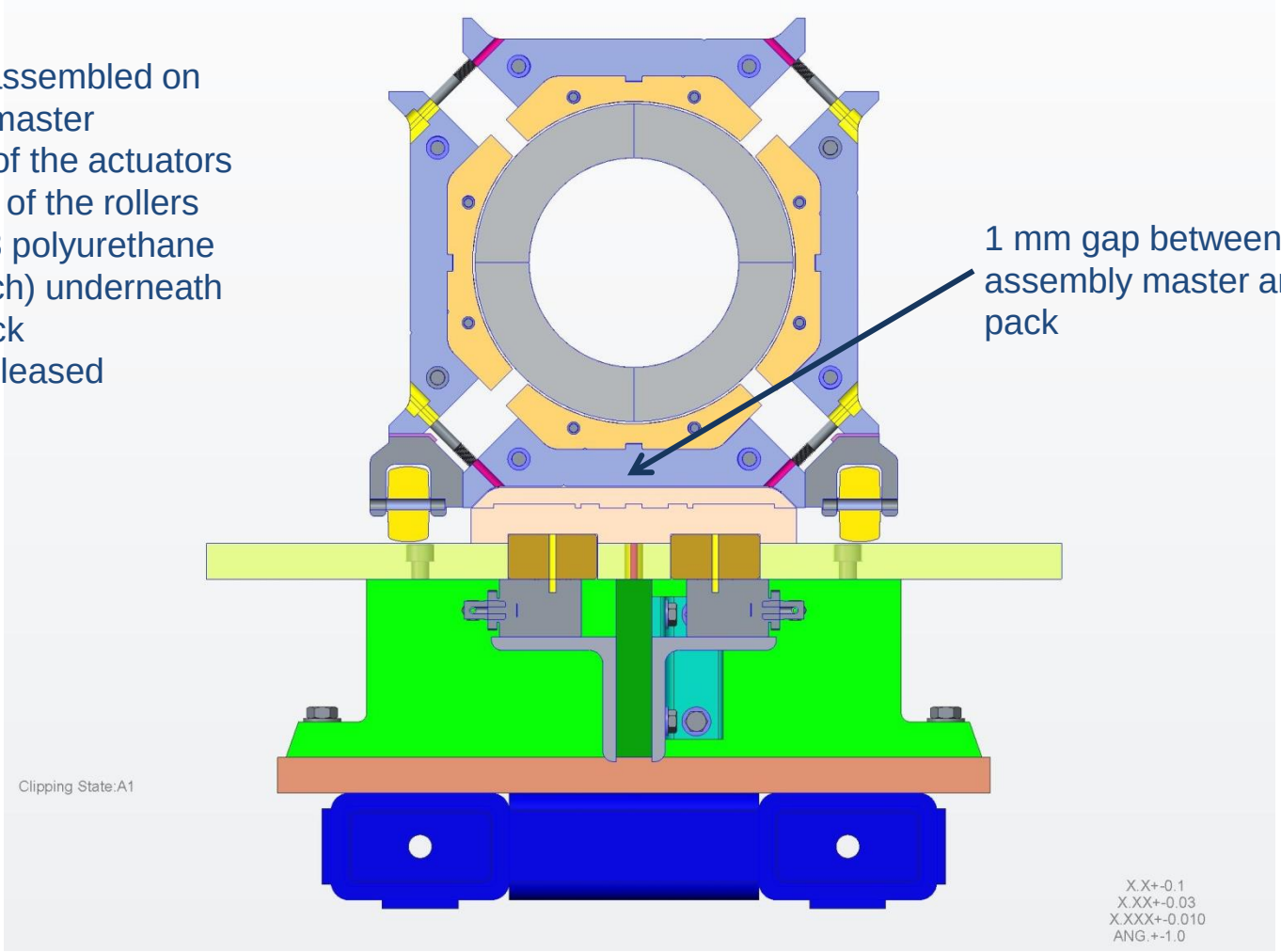
Coil-pack insertion
LARP concept

- Coil pack assembled on assembly master
- Activation of the actuators
- Installation of the rollers modules (8 polyurethane wheels each) underneath the coil pack



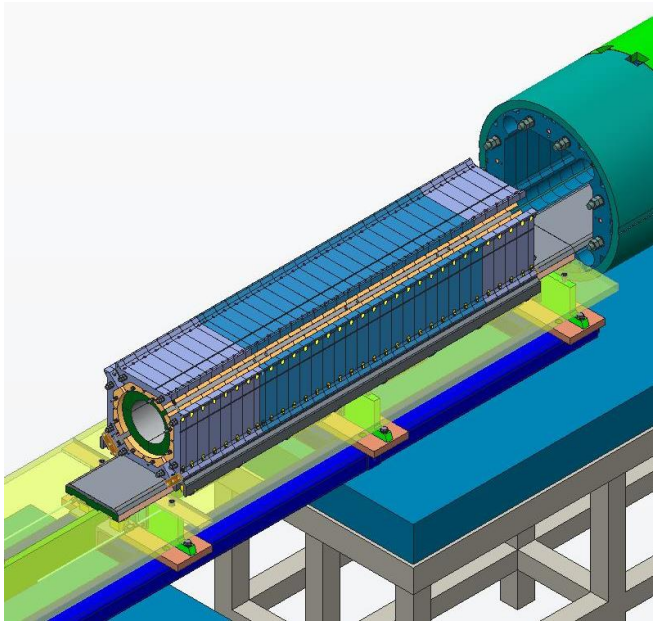
Coil-pack insertion
LARP concept

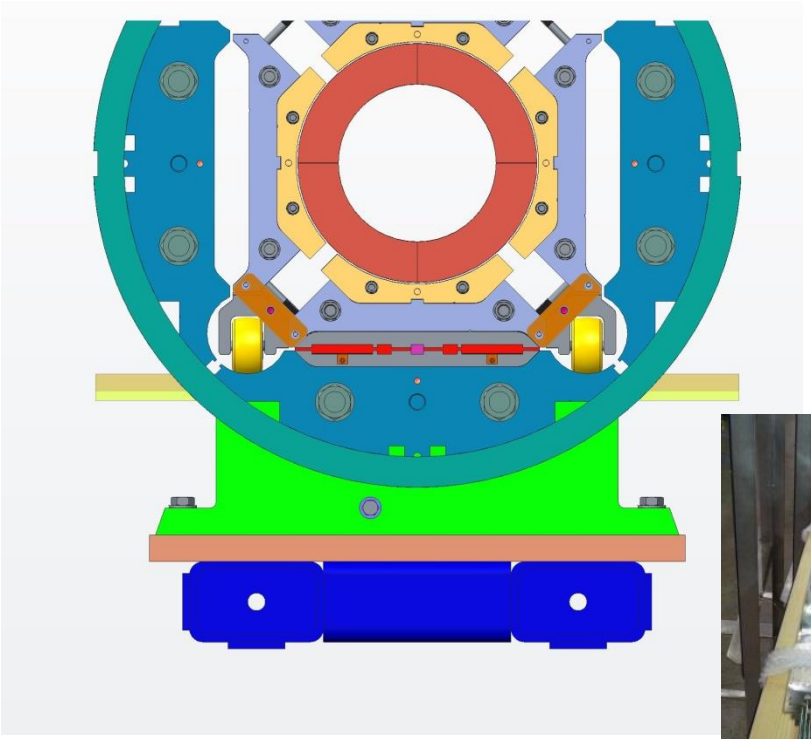
- Coil pack assembled on assembly master
- Activation of the actuators
- Installation of the rollers modules (8 polyurethane wheels each) underneath the coil pack
- Actuator released



Coil-pack insertion
LARP Concept

- "Rolling" of the coil-pack into structure using a winch
- Wheels roll in the cooling channels
- Wheel rack removal during bladder operation
- Bladders delivered at LBNL

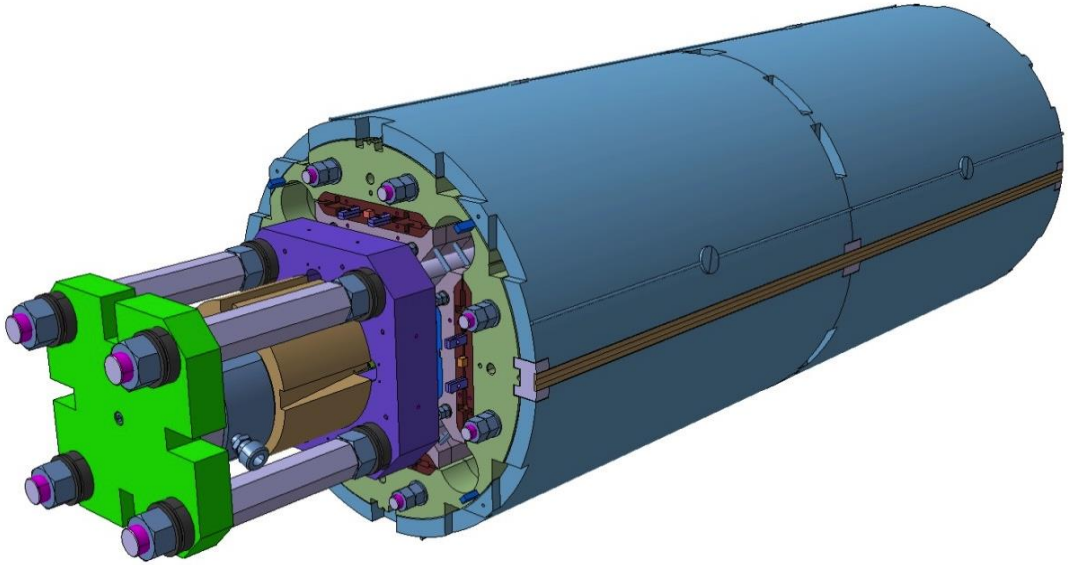


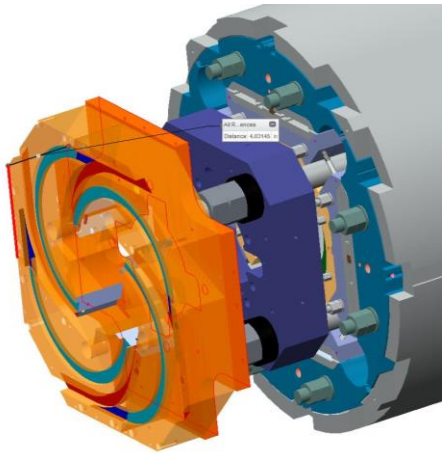


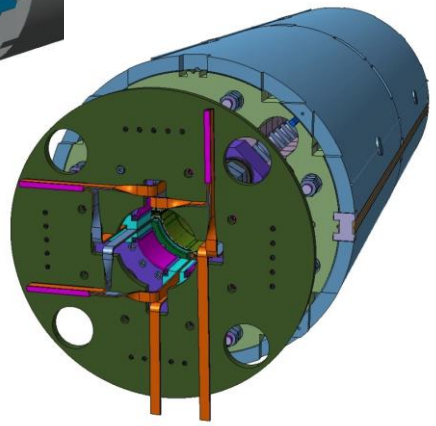
Longitudinal loading and splicing

Magnet equipped with the longitudinal pre-loading system

- 2 sets of tooling ready



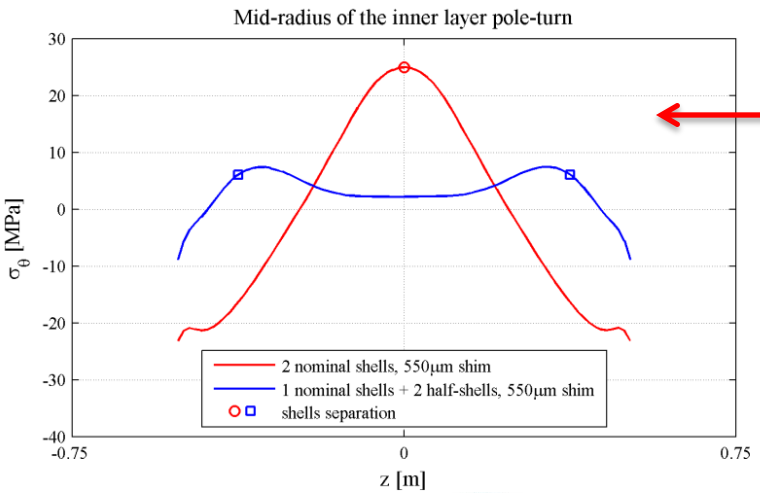




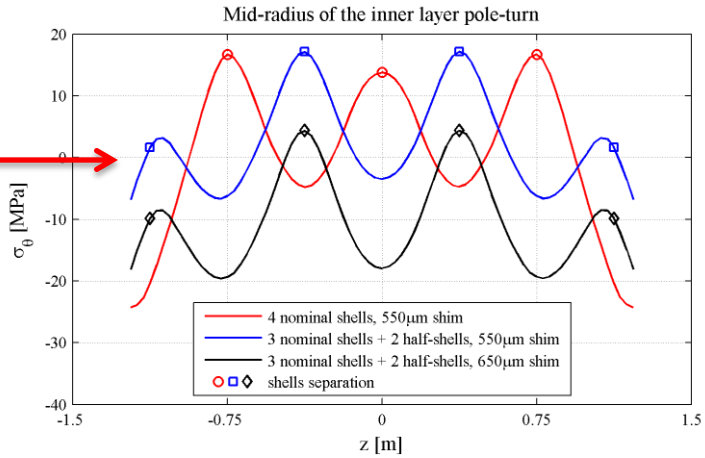
Splice box design: work in progress

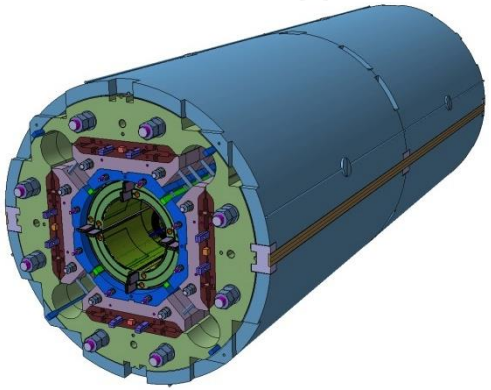
Nitronic 50 end-plates, aluminum rods and the pre-loading tooling will be shipped to LBNL beginning of December

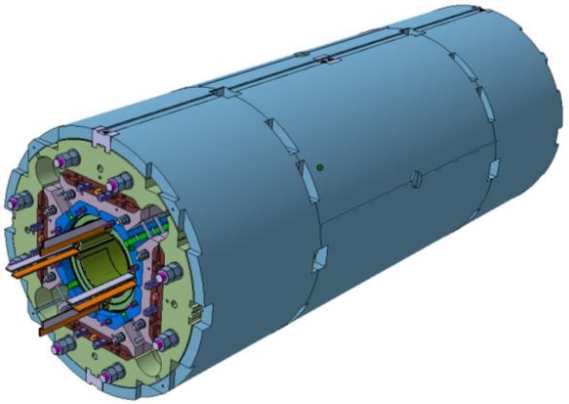
New outer aluminium shell configuration



Impact of shell segmentation on MQXFS MQXFA/B

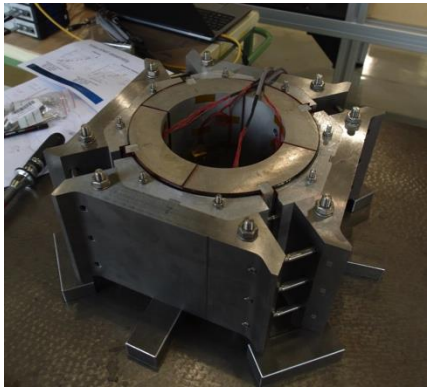


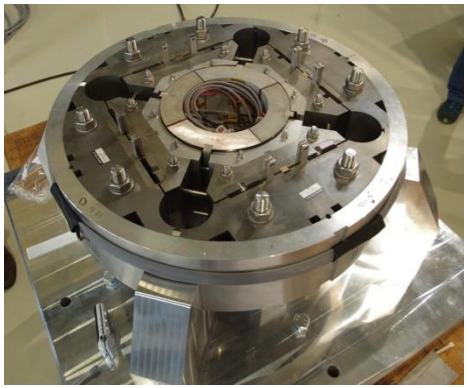


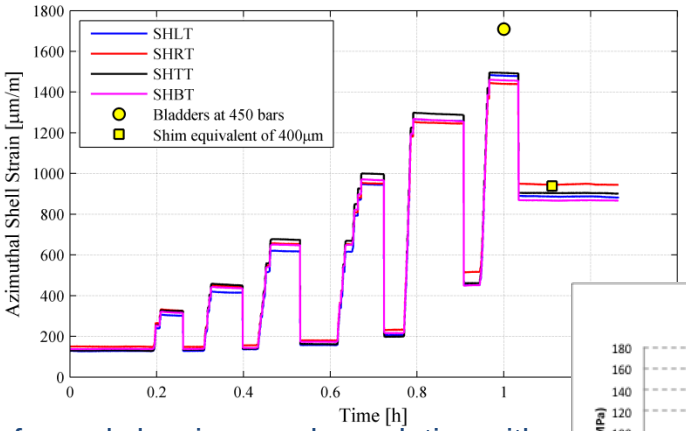


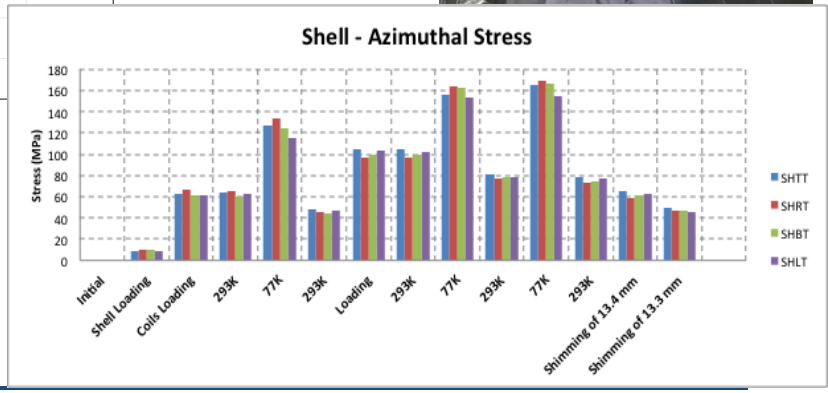
- 4 new shells are being machined and foreseen to replace the existing batch
- The possibility to use 1 shell (774 mm long) and two half shells (387 mm long) for MQXFS is being considered
- 2 weeks turnaround at LBNL to split one existing shell
- Using 3 shells instead of 2 for the 1.5 m model will not significantly impact the assembly procedure nor the schedule

Mechanical 150 mm mock-up









- 3 cool-down to 77K have been performed showing good correlation with FEM models
- Data analysis is in progress
- The force intercepted at cold by the G11 coil keys will be quantified with a dedicated test
- Low-grade coil #101 will be cut and used for further assembly trials

Conclusions

- MQXFS assembly procedure has been defined and partially tested during the assembly of the 150 mm mock-up
- Tooling design and assembly procedures are scalable for longer magnets
- 2 sets of Yoke and shell assembly tooling are operational (CERN & LBNL)
- Shells, collars, masters and dummy aluminium coils have been delivered to LBNL
- Pads, yokes and yoke lifting tool will be delivered to LBNL by end of November 2014
- All CERN missing assembly tooling (except coil pack assembly table) will be delivered in November
- CERN and LBNL will be ready to start the mechanical assembly with instrumented aluminium dummy coils beginning of December/January
- After Xmas brake, 3 cool-down to 77K,with different pre-stress applied to the dummy coils, are foreseen in CERN SM18 LN_2 test station and 1 cool-down at LBNL
- A decision for the final aluminium shell configuration on MQXFS is required within 2 weeks
- The 150 mm mock-up equipped with segments of coil #101 will be used to better understand the structure behaviour and define the shimming values

ご清聴ありがとうございました

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