D2 requirements

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www.cern.ch/hilumi/wp3

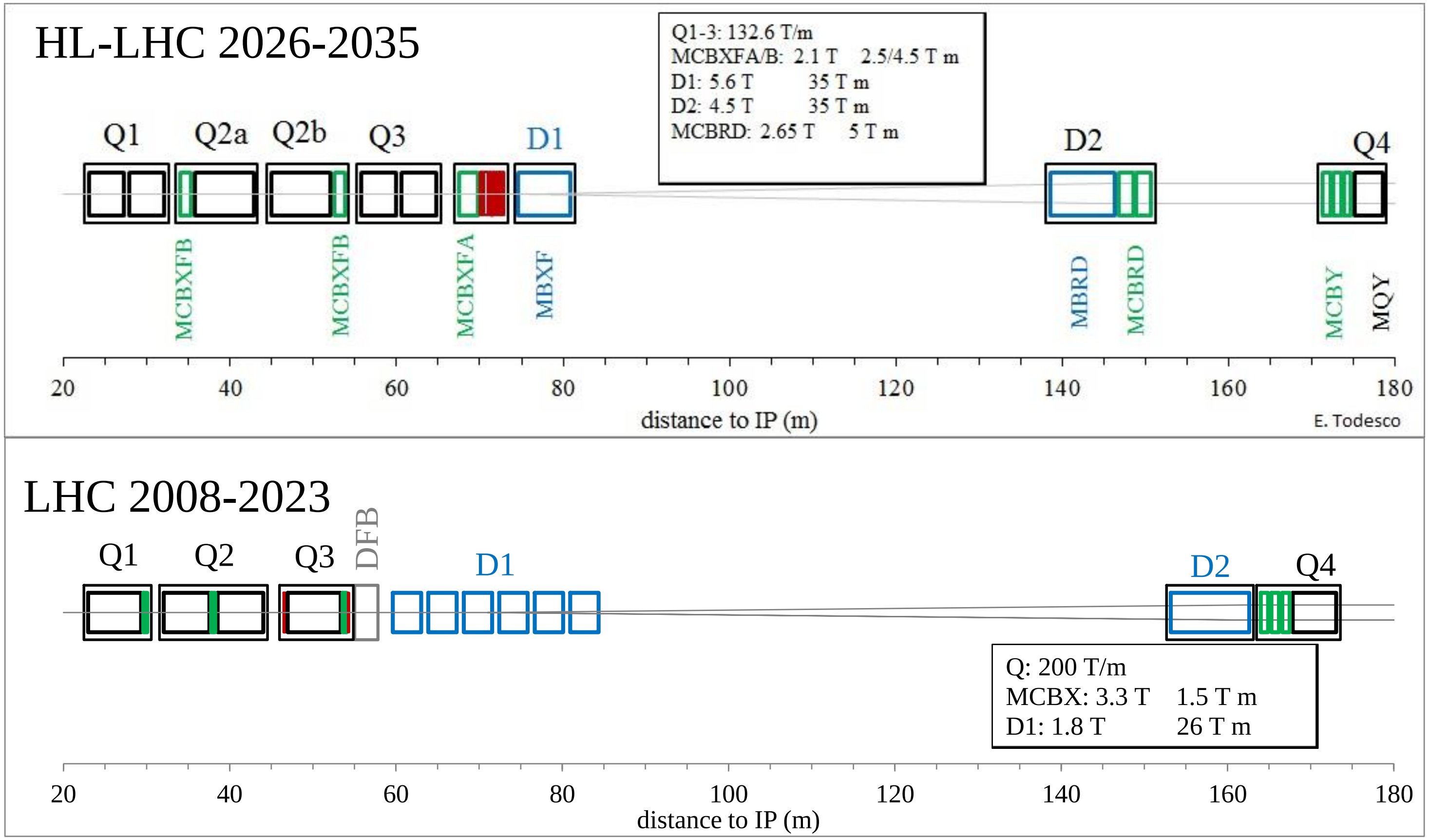
11 March 2019 – D1 and D2 review

SUMMARY

- Lay out and function
- Requirements
- Selection of design
- Structure

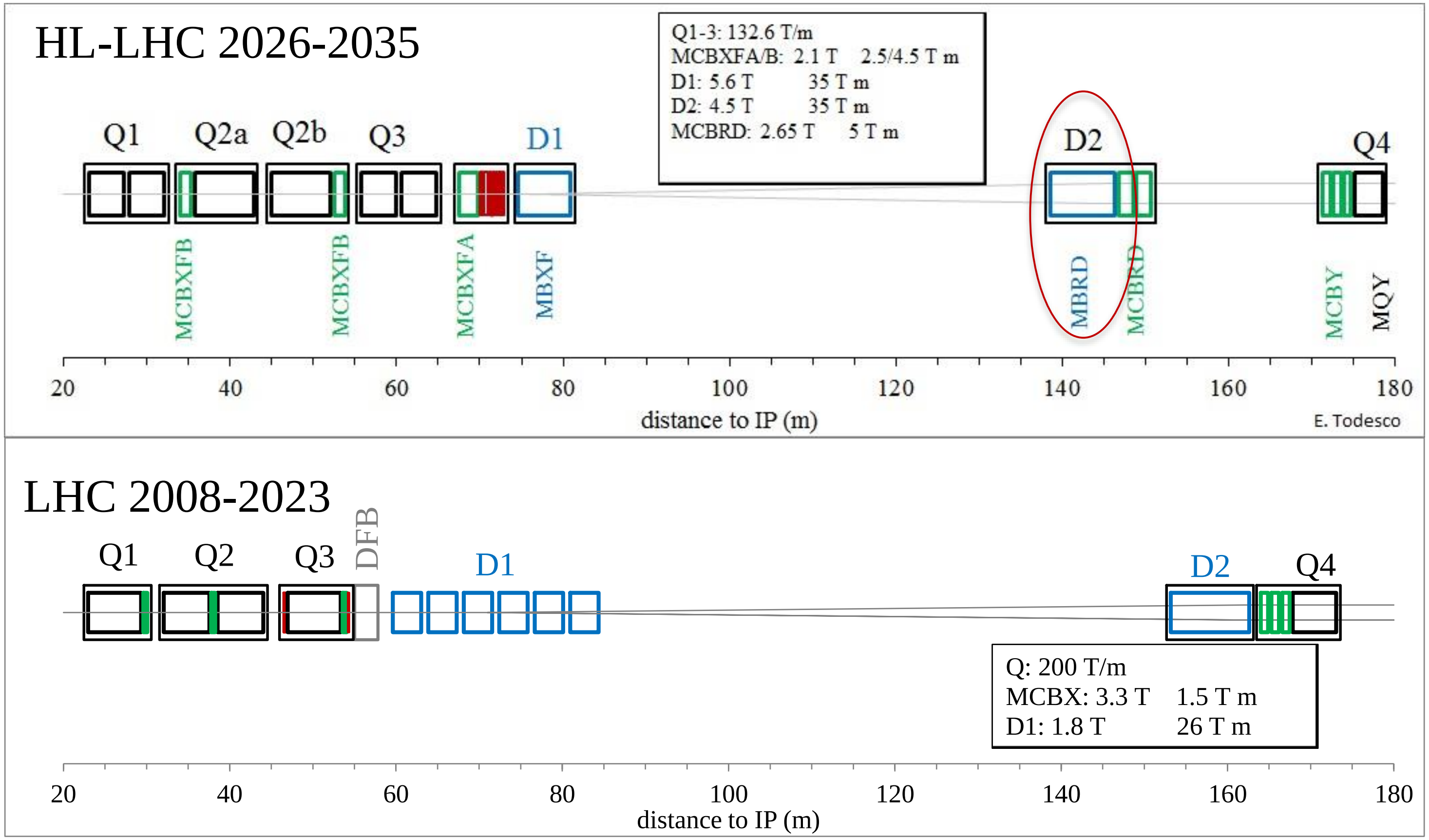
HL-LHC LAYOUT

- Replacement of Q1-Q3, D1 and D2 plus correctors in IP1 and IP5 with larger aperture magnets (from 70 mm to 150 mm)



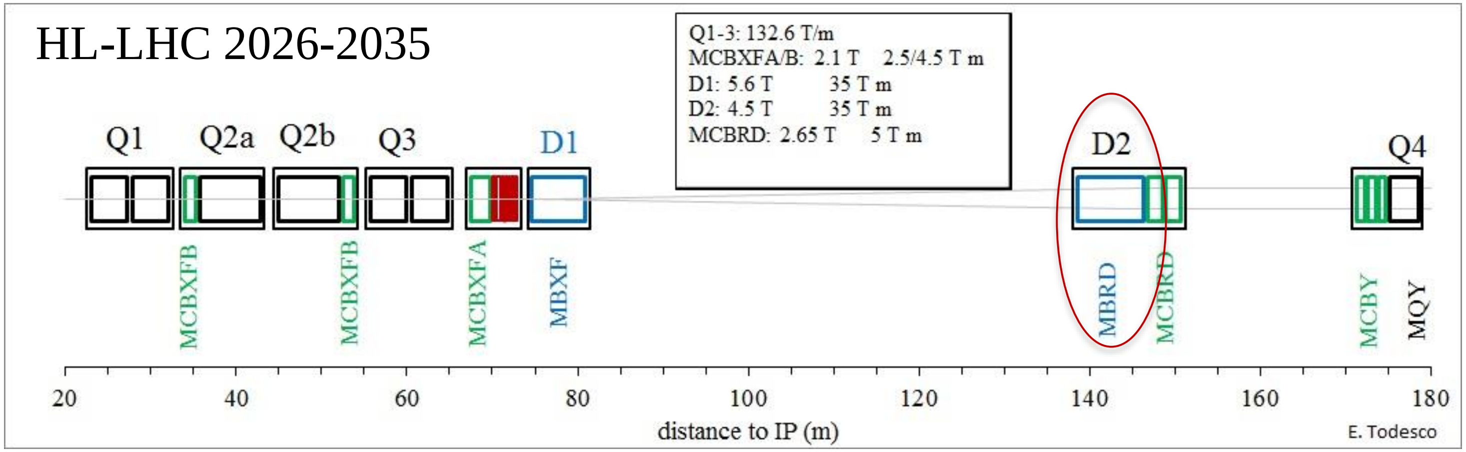
D2 LAYOUT

- Here we talk about the D2 (aka MBRD)



D2 LAYOUT AND FUNCTION

- Detail of the layout: one magnet per IP side, 8 m long, in the cold mass including also two orbit correctors (MCBRD) (A. Foussat talk)



- Which magnet and why?
  - Horizontal dipole, same field direction in both apertures, apertures in series
  - 35 T m integrated field at 7 TeV
    - Used to bring beams to collision
  - 37.5 T m integrated field at 7.5 TeV (ultimate field)

SUMMARY OF MAIN REQUIREMENTS

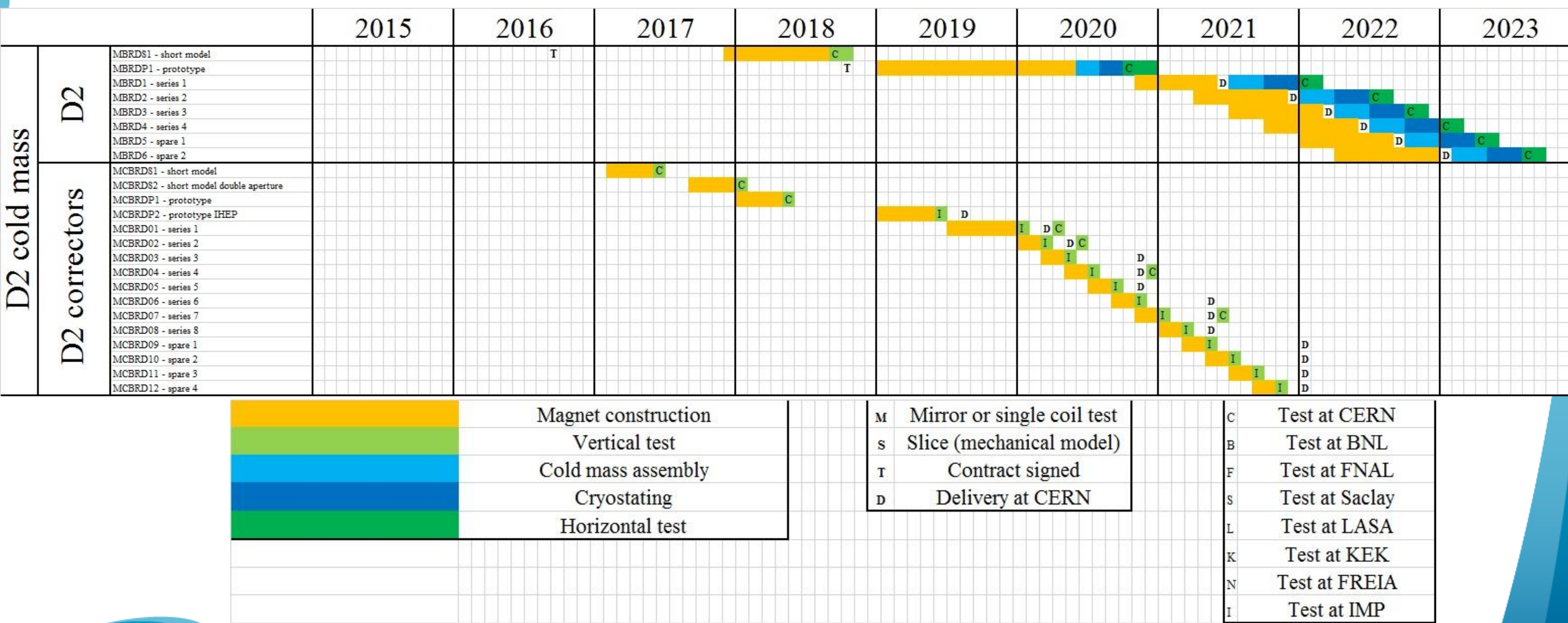
- Ultimate field of 37.5 T m has to be reached
  - Apertures in series
  - Virgin training: no requirement
  - Training after thermal cycle: 1 quench to nominal
- Size:
  - Magnet length has to fit within the 8.3 m (D2 cold mass)
  - Magnet diameter has to fit within the 614 mm diameter (D2 cold mass)
- Field quality
  - Low order systematic field harmonics have to be smaller than 3 units at R_{ref}=35 mm at nominal field in any aperture, the others smaller than 1 unit – requirement only at 7 TeV
  - Saturation pattern should be limited to avoid a major change of field quality in the range 6.5-7.5 TeV
- Cooling: heat exchanger on one side of the cold mass, not going through the 8 m length
  - Free X-sectional area of 225 cm^2 and stacking factor lower than 98.5%

REQUIREMENTS: QUANTITIES

- 6 series magnets
  - We have 1 magnet per IP side, 4 needed
  - Plus two spare IP sides, 2 needed (both assembled in D2 cold masses)
- Plus one prototype for the prototype D2 cold mass
  - Note: The D2 prototype cold mass could be an additional spare if everything goes for the best (i.e. no major iterations needed in design and requirements, no major non conformities) (P. Fabbricatore talk)

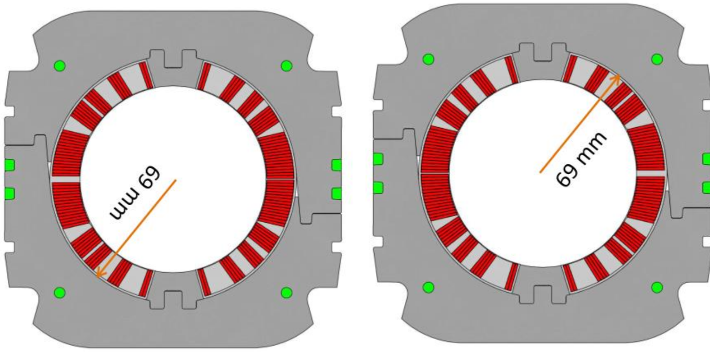
REQUIREMENTS: SCHEDULE

- Prototype tested before the end of 2020
  - No requirements from string
- Fourth magnet of the series should be tested by July 2023
  - 6 months contingency in the present schedule



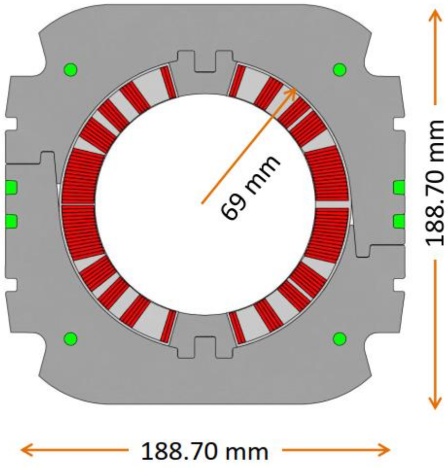
SELECTION OF THE DESIGN - 1

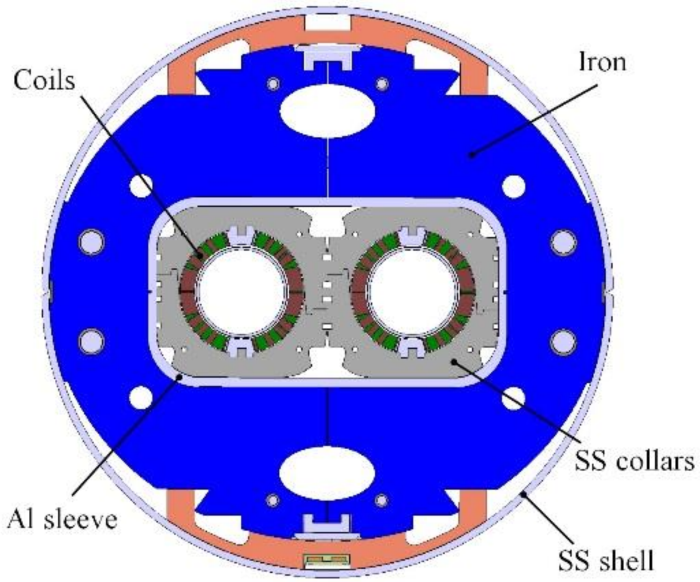
- Initial decision to reuse the LHC dipole cable, outer layer
  - To reduce time related to development of new cable, and cost (reusing LHC spare)
- Decision to place the loadline fraction below 70%
  - Loadline fraction = current at nominal field/short sample current
- Main constraint is the field quality: cross talk between apertures
  - Aperture is 105 mm, beam separation is 188 mm, little space to place iron to magnetically separate the apertures
  - This limits field at 4.5 T, length of 7.8 m
- Decision to have an asymmetric coil to compensate the cross talk, and not to have iron between the apertures
  - Single coil has b_2 and b_3 of order of 200 units – compensation required within 98% (S. Farinon talk)



SELECTION OF THE DESIGN - 2

- Decision to have self supporting collars
  - Decouple the iron from the mechanical part
- Decision to have separate collars
  - More flexibility in a short production
  - Smaller collaring press
- Decision to have no energy extraction
  - Cost reduction, use standard LHC quench heaters
- New feature of the Al sleeve (see S. Farinon talk)

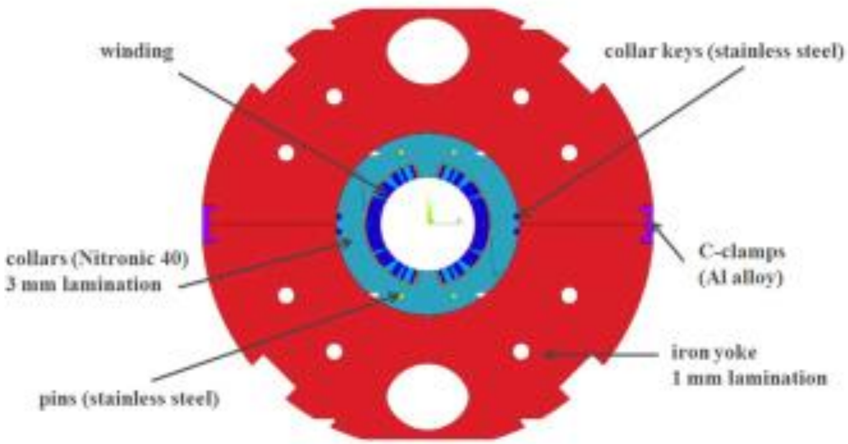


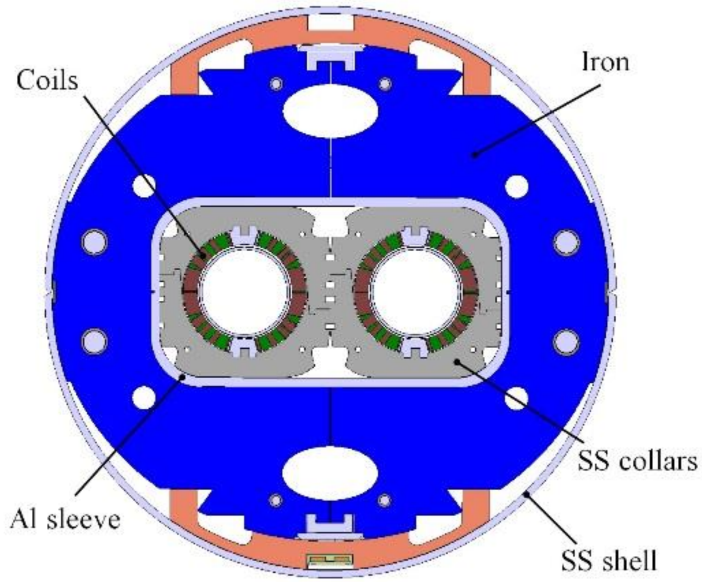


D2 cross-section (P. Fabbricatore, S. Farinon)

SELECTION OF THE DESIGN - 3

- D2 also relies on the experience of SIS 300
  - INFN-Ge built in ASG, in 2014-a full length prototype magnet for GSI (SIS 300) whose parameters are quite smilar
    - Same cable size and number of strands
    - Same one layer, five block coil
    - Same operational field 4.5 T
    - Similar aperture (100 mm versus 105 mm)
    - Same collared structure

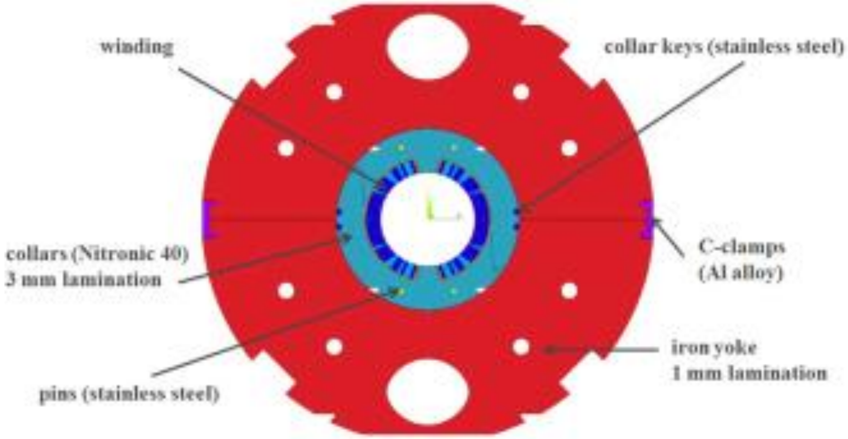


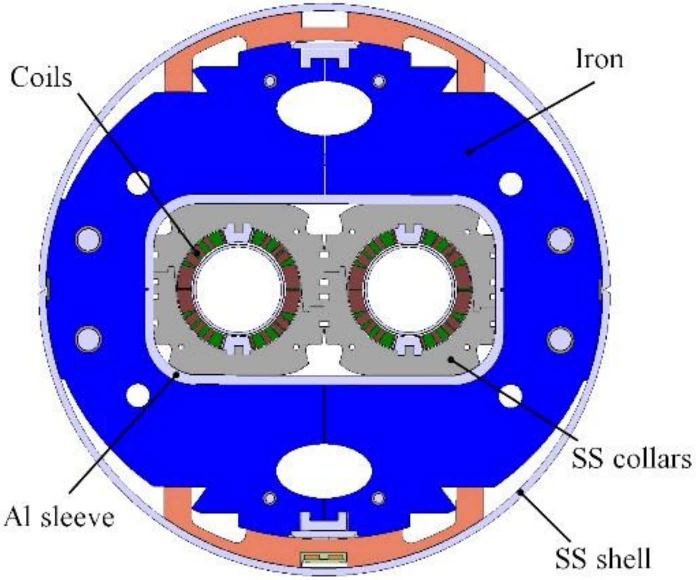


SIS 300 magnet (P. Fabbricatore, S. Farinon, et al. IEEE TAS 24 (2014))

SELECTION OF THE DESIGN - 3

- Additional complexities for SIS 300
  - Curved magnet
  - Fast ramping (smaller filament, cored cable, much attention devoted to reduce losses)
- Additional complexities of MBRD
  - Double aperture
  - Asymmetric coil





STRUCTURE

- HL-LHC project leader: L. Rossi (CERN)
  - WP3 leader: E. Todesco (CERN)
    - D2 magnet: P. Fabbricatore (INFN), A. Foussat (CERN project engineer)
    - D2 cold mass: A. Foussat (CERN)
    - D2 cryostat: D. Duarte Ramos (CERN)

- INFN deliverable
  - Magnet
  - No SS shell, no end covers, no cold bore, no test

STRUCTURE: COLLABORATION WITH INFN-Ge

- First engineering design starts in INFN in April 2014
  - Collaboration agreement 2291, with engineering design as deliverable
  - Completed in advance (mid 2016)
- Construction of the short model steered by INFN starts in 2017
  - Second collaboration agreement 3084
  - Initial target of short model test: March 2018 – tested in February 2019
- Construction of the prototype steered by INFN to start in 2019
  - This is also included in the second collaboration agreement 3084
  - Initial date for the prototype test October 2019, shifted to October 2020
  - Call for tender has been completed in January 2019
- Construction of the series steered by INFN to start in 2020
  - Collaboration agreement XXXX
  - Series included as an option in the call for tender of the prototype

STRUCTURE OF REVIEW

- General framework and requirements (E. Todesco)
- Design and results of the model program (S. Farinon)
- Plans for the prototype and series (P. Fabbricatore)
- Integration in the cold mass (A. Foussat)
- Documentation and QA/QC (A. Foussat)
- Integration in the cryostat (A. Vande Craen)

APPENDIX

- Acceptance criteria draft: EDMS 2051868