D1 requirements

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www.cern.ch/hilumi/wp3

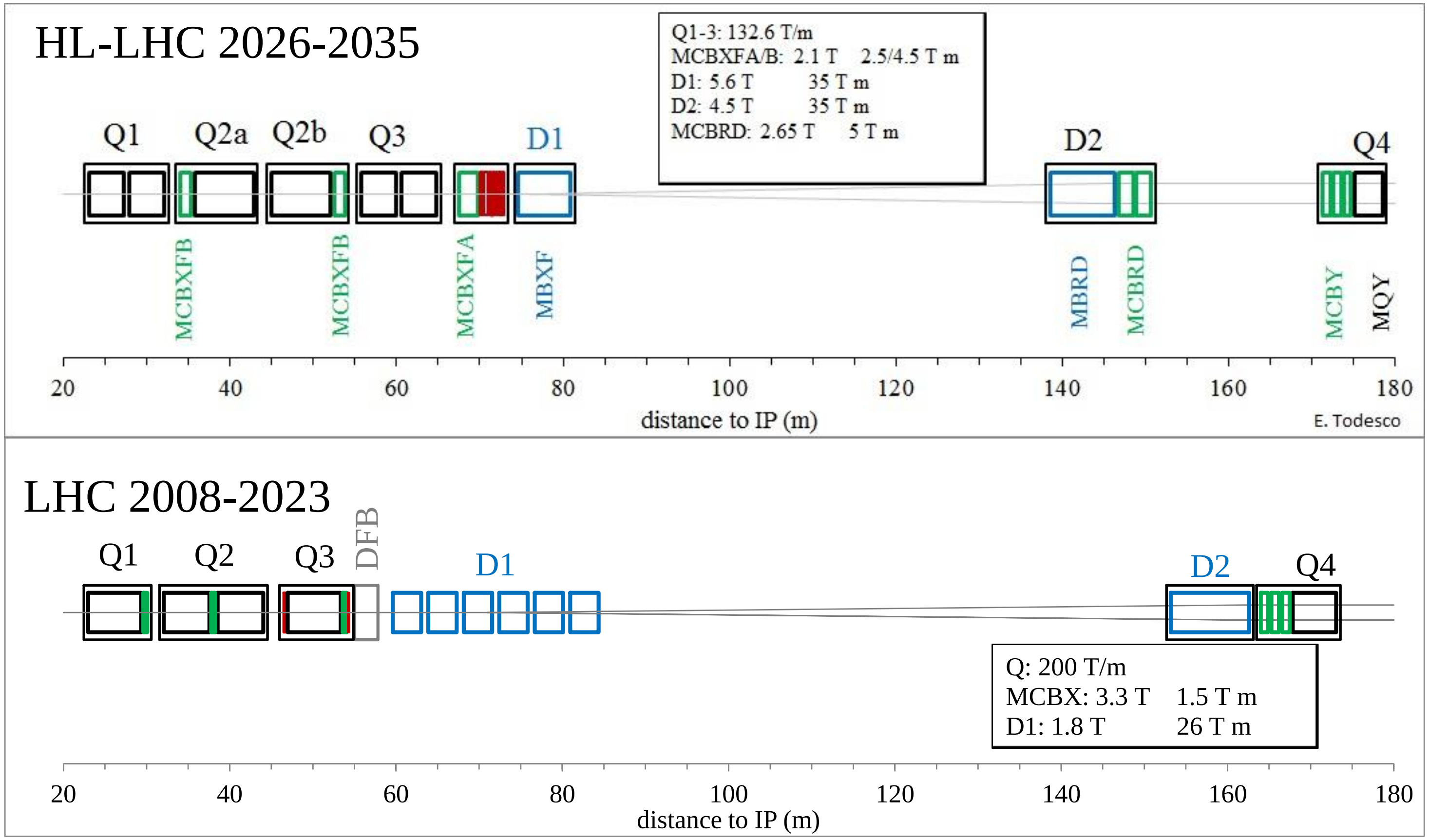
11 March 2019 – D1 and D2 review

SUMMARY

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

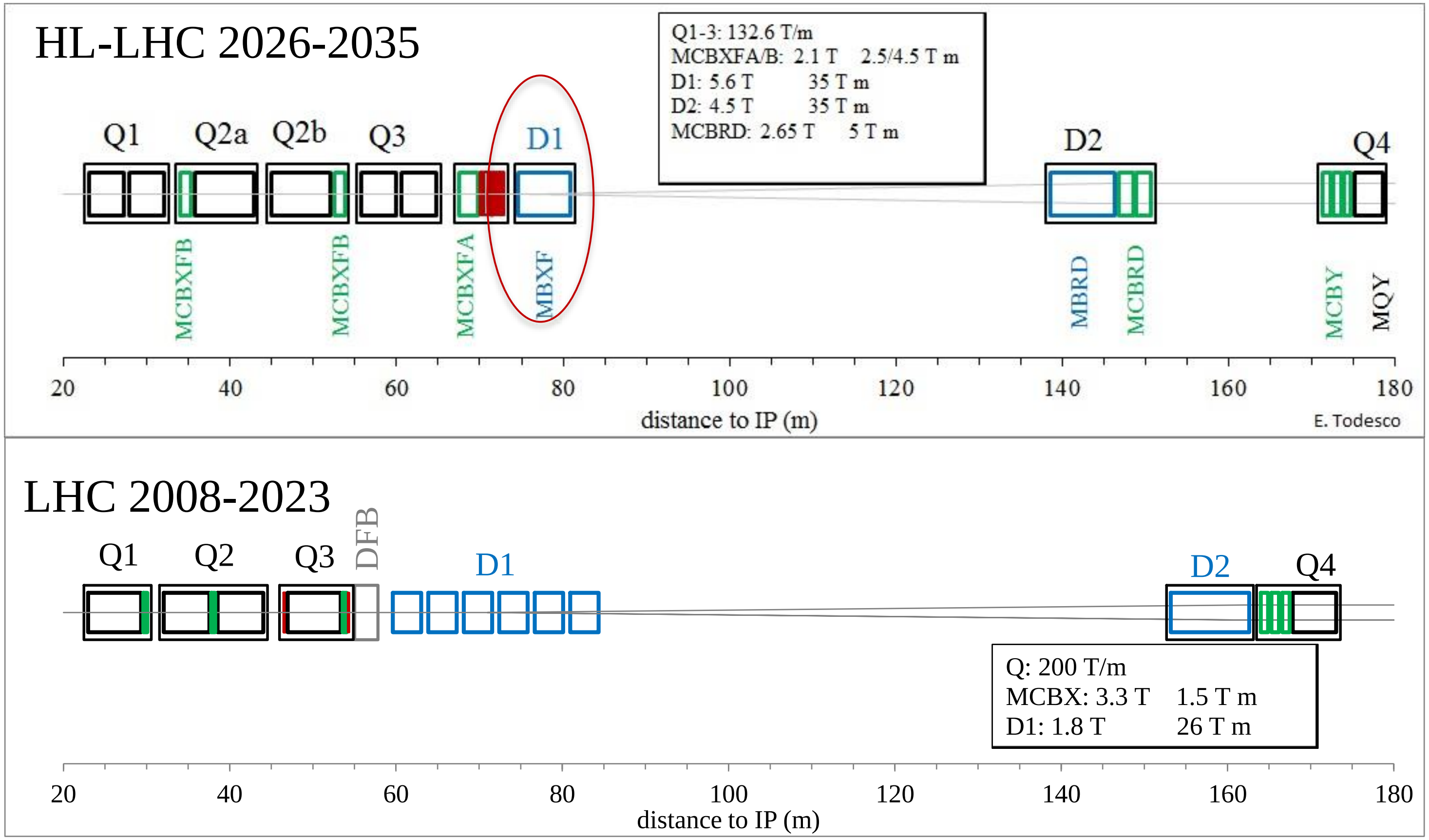
HL-LHC LAYOUT

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



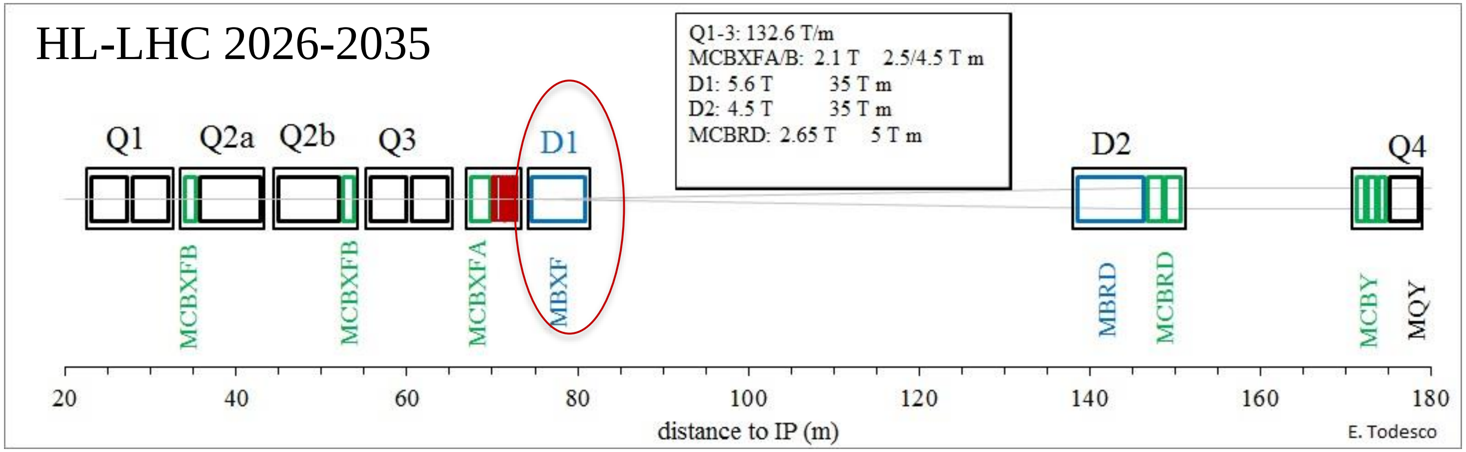
D1 LAYOUT

- Here we talk about the D1 (aka MBXF)



D1 LAYOUT AND FUNCTION

- Detail of the layout: one magnet per IP side, 7 m long, all alone in its cold mass



- Which magnet and why?
  - Vertical dipole, one aperture
  - 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

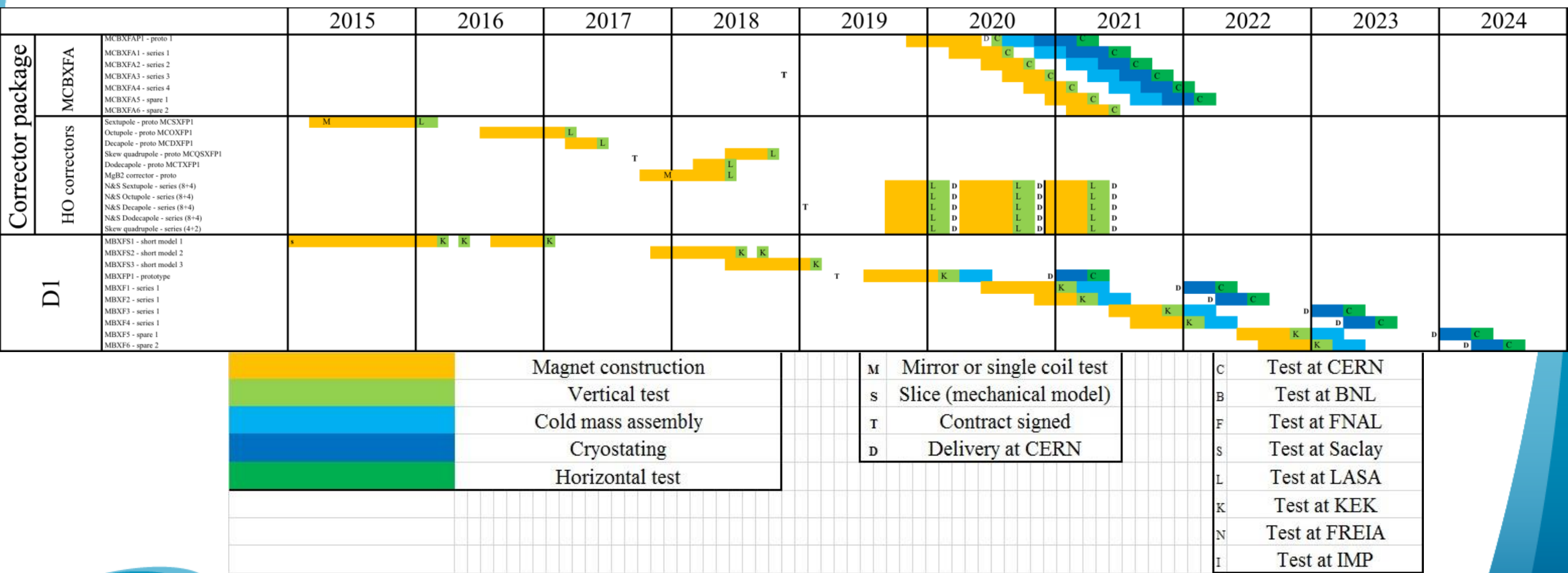
- Ultimate field of 37.5 T m has to be reached
  - Virgin training: no requirement
  - Training after thermal cycle: 1 quench to nominal
- Size:
  - Magnet length has to fit within the 7 m (D1 cold mass)
  - Magnet diameter has to fit within the 570 mm diameter (D1 cold mass)
  - Smaller size than D2 and triplet: 614 mm not needed and 570 fits the steel sheets available in KEK
- 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: two heat exchangers, same size of LHC
  - Gap between cold bore and magnet of 1.5 mm

REQUIREMENTS: QUANTITIES

- 6 series magnets
  - We have 1 magnet per IP side, 4 needed
  - Plus two spare IP sides, 2 needed (both assembled in D1 cold masses)
- Plus one prototype for the prototype D1 cold mass
  - Note: The D1 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) (T. Nakamoto talk)

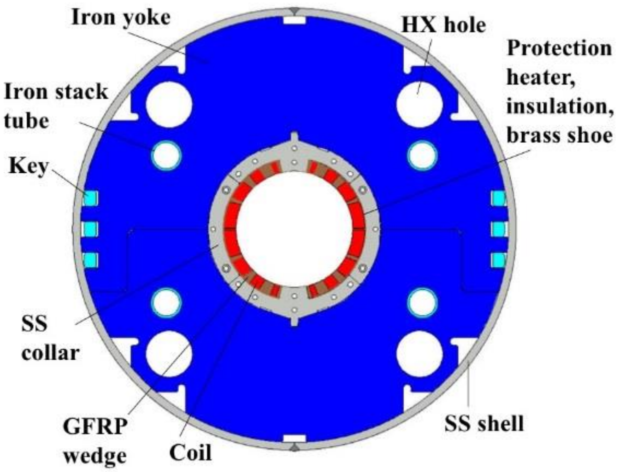
REQUIREMENTS: SCHEDULE

- Prototype tested before the end of 2020
  - Requirement from the string installation: looks critical, no contingency
- Fourth magnet of the series should be tested by June 2023
  - 3 months contingency in the present schedule, plus the large gap between vertical test and shipping
- Schedule is built around the budget constraints from KEK



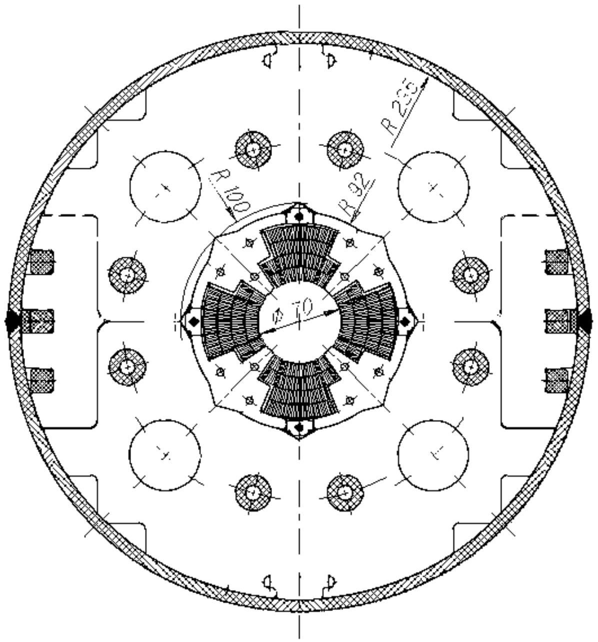
SELECTION OF THE DESIGN

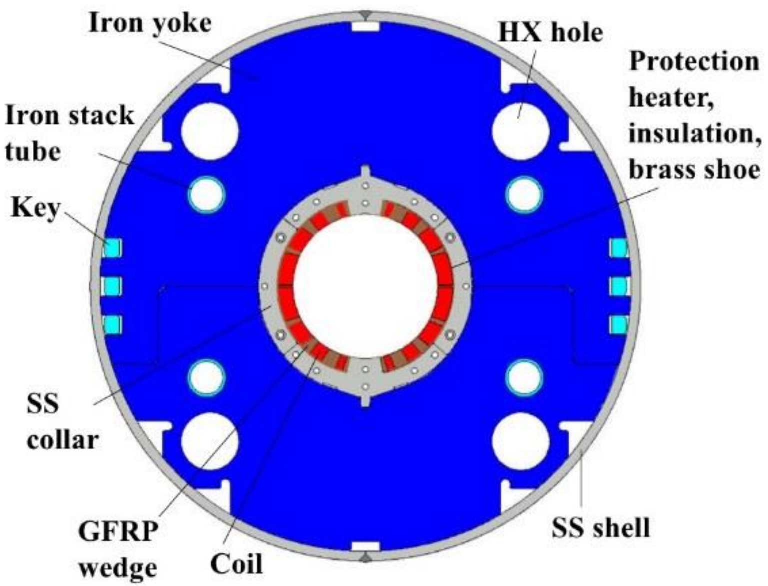
- Initial decision to reuse the LHC dipole cable, outer layer
  - To reduce time related to development of new cable, and cost (reusing LHC spare)
- Decision to place the loadline fraction below 80%
  - Loadline fraction = current at nominal field/short sample current
- Additional constraint from vertical test station: magnet not longer than 7 m
  - Iteration in the main field/lenght to fit the test station – field at 5.6 T, loadline fraction at 77%
- Decision to exploit as much as possible the iron to increase the field
  - Thin collars without mechanical function
  - Drawback: larger saturation
  - Iron gives the preload
- Decision to have no energy extraction
  - Cost reduction, use standard LHC quench he



SELECTION OF THE DESIGN

- The mechanical structure is based on the same concept adopted for the MQXFA





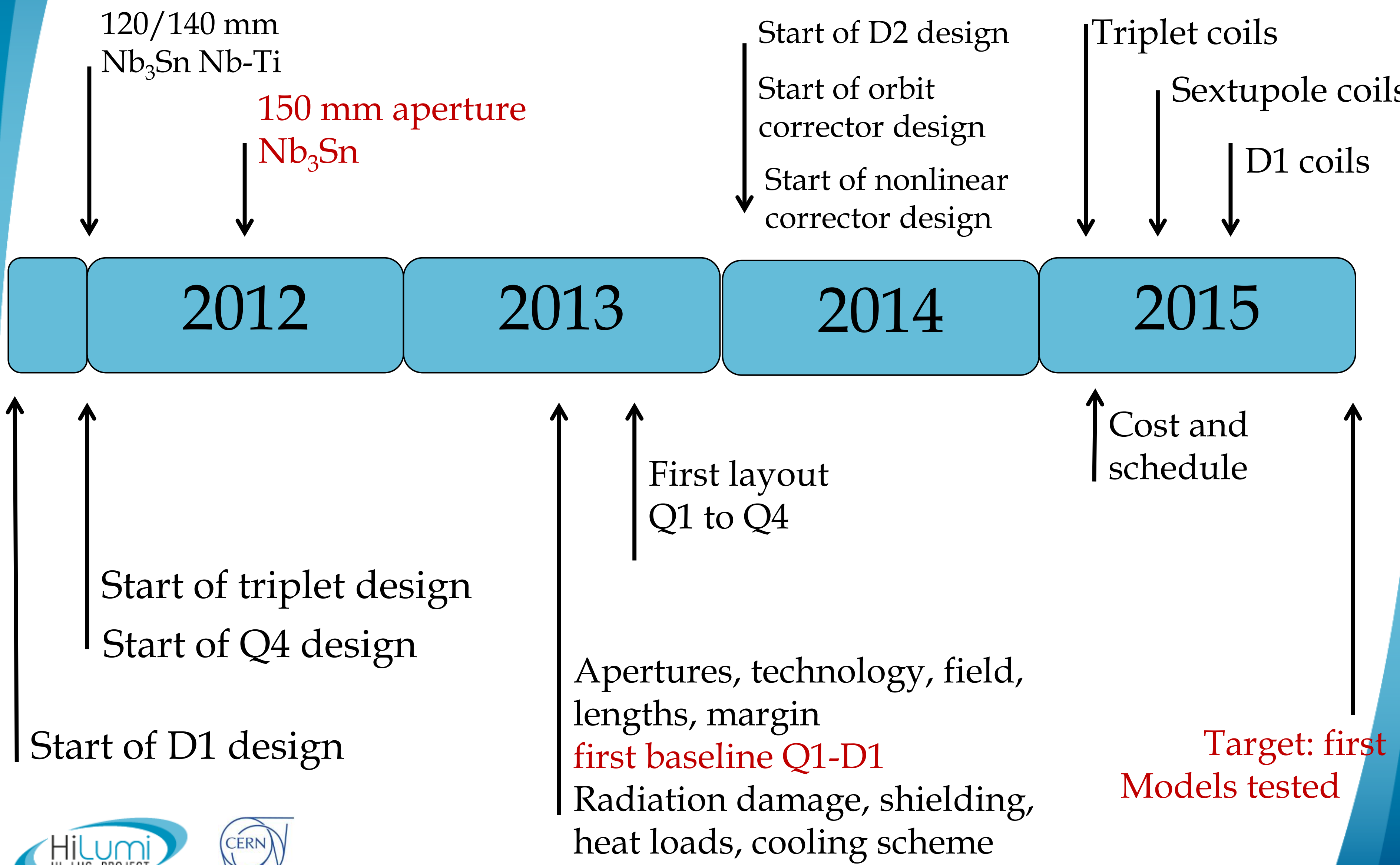
STRUCTURE

- HL-LHC project leader: L. Rossi (CERN)
  - WP3 leader: E. Todesco (CERN)
    - D1 magnet: T. Nakamoto (KEK), A. Musso (CERN project engineer)
    - D2 cold mass: T. Nakamoto (CERN)
    - D2 cryostat: D. Duarte Ramos (CERN)

- KEK deliverable
  - Cold mass, He tight, including cold bore heat exchangers, end covers, SS shell
  - Vertical test of the magnet at 1.9 K in KEK

Slide shown in annual meeting Fall 2015 https://indico.cern.ch/event/400665

THE BEGINNING OF THE PROJECT



STRUCTURE: COLLABORATION WITH KEK

- First conceptual design starts in KEK in Fall 2011
  - With the contribution of Q. Xu, now leading the IHEP magnet group
- 150 mm aperture fixed in July 2012
  - Baseline of 2 short models, one prototype
  - First coil winding in January 2015
  - Iteration on collar shape
  - Test of first short model January 2016
  - Insufficient performance, prestress increase
  - Second test of the first short model January 2017 - success
  - Second short model construction starts in fall 2017– sussesfull test in June 2018
- Decision to build a third model
  - Bridge the gap with the prototype
  - Check reproducibilty of field quality
- Tender for prototype and series ongoing

STRUCTURE OF REVIEW

- General framework and requirements (E. Todesco)
- Design and results of the short model program (M. Sugano)
- Plans for the prototype series (T. Nakamoto)
- D1 integration in the cryostat (D. Duarte Ramos)
- Documentation and QA/QC (A. Musso)

APPENDIX

- Acceptance criteria draft: EDMS 2045899
  - Alignment part still in progess, rest of the document is pretty solid
- Design report draft: EDMS 2082579