First Q4 cold mass engineering follow up meeting

16/03/2016

Q4 Status update

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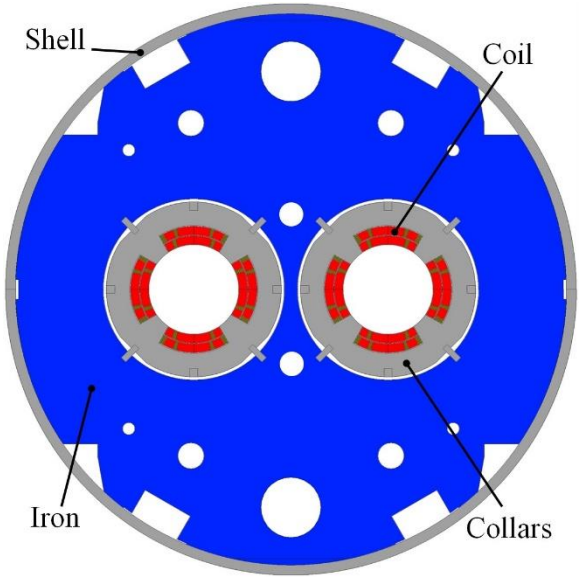
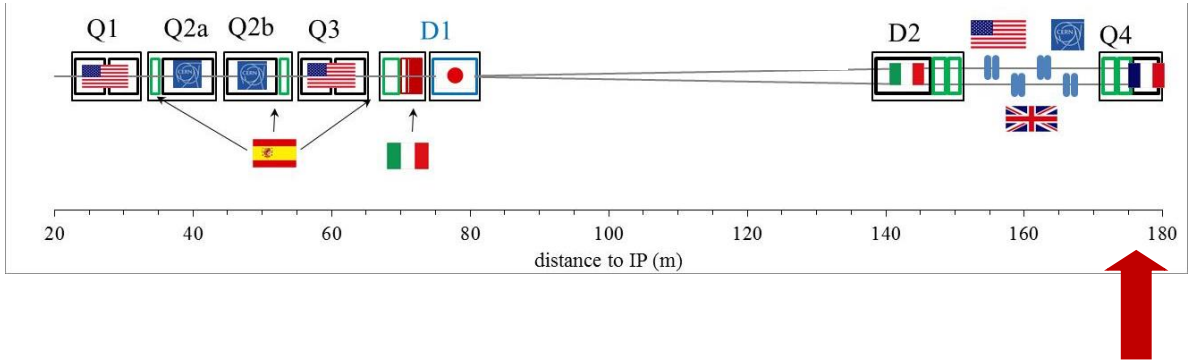
QUADRUPÔLE Q4 POUR LE LHC (HI-LUMI)





- Quadrupôle en cos2θ double couche
- Ouverture = 90 mm
- Integrated gradient = 440 T
- 1,9 K Magnetic length = 3.67 m
- Nominal gradient = 120 T/m
- Temperature = 1.9 K
- Nominal current = 4590 A
- Stored energy = 0.81 MJ

3 main axis:

- The single aperture short model MQYYM
- The full length prototypes
- The series magnets

Q4 Design Overview

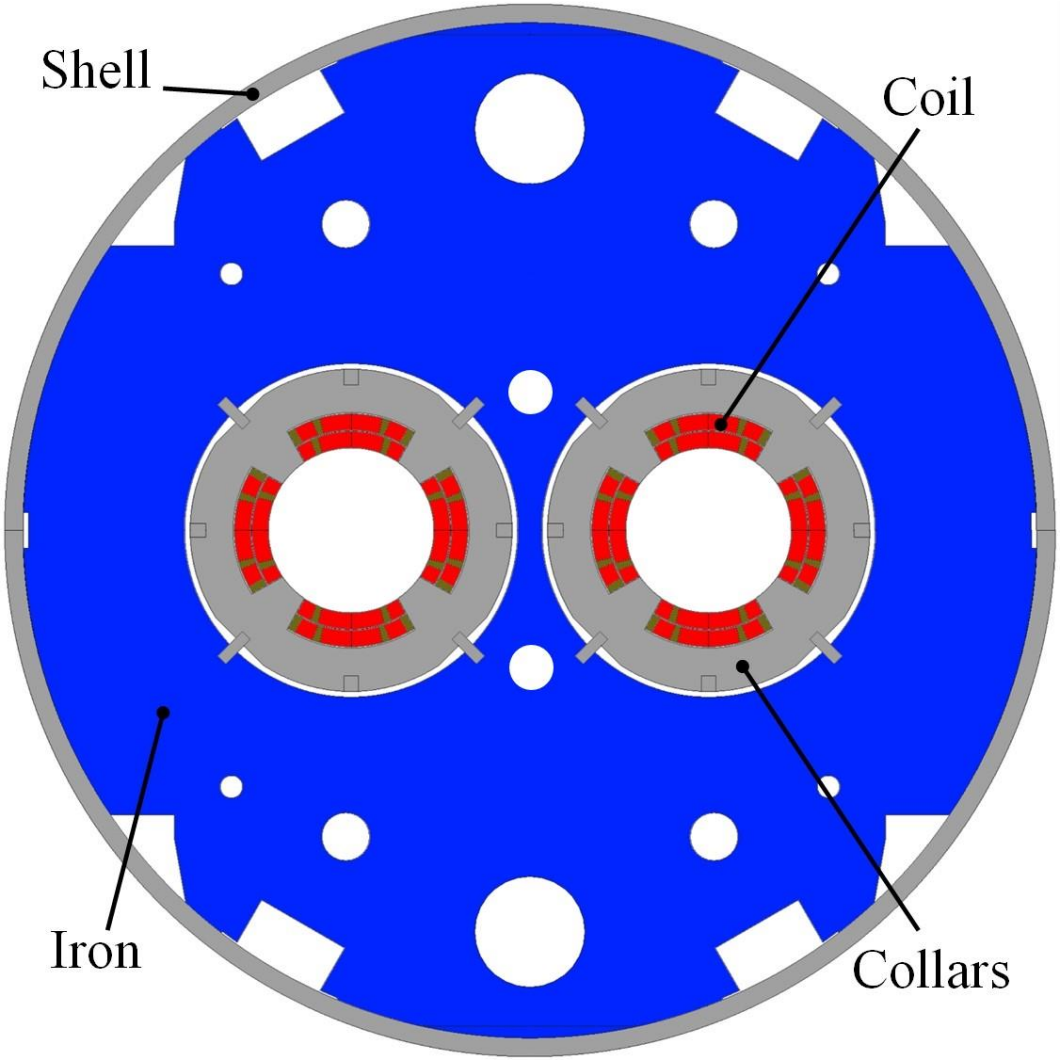
MAGNETIC DESIGN USING MQM CABLE

- 2 layers of MQM cable
- Inner blocks: 17 + 8 turns
- Outer blocks: 16 +10 turns

- **Aperture = 90 mm (as before)**

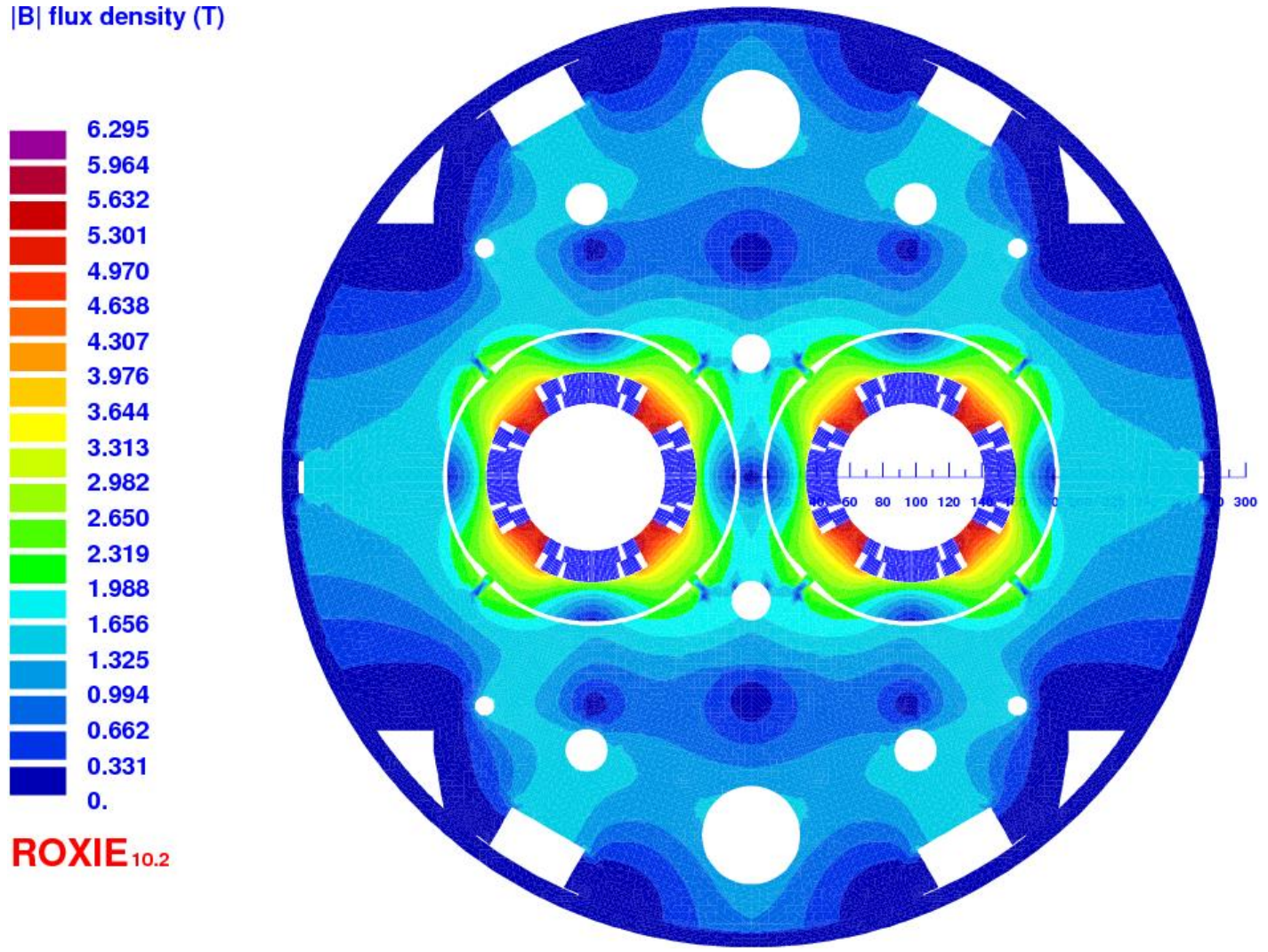
- Integrated gradient = 440 T
- Magnetic length = 3.67 m
- Nominal gradient = 120 T/m

- **Loadline margin = 20 %**
- Temperature = 1.9 K
- **Nominal current = 4590 A**
- Stored energy = 0.81 MJ
- **Differential inductance = 2 × 37.5 mH**



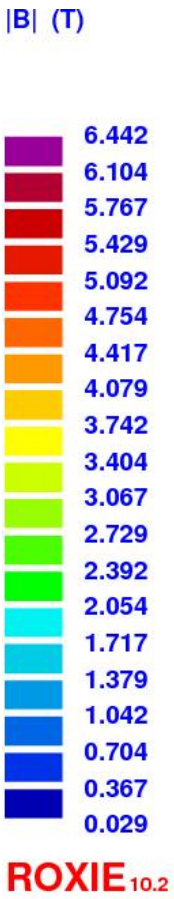
MAGNETIC DESIGN USING MQM CABLE

- Calculation with collars (assuming a relative permeability of 1.0025)
- Re-optimized cross-section to minimize impact of collars on b6

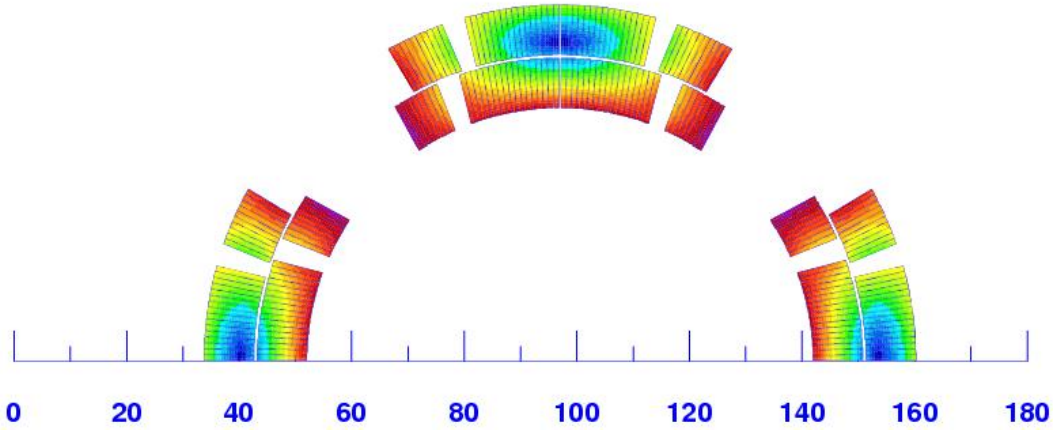


MAGNETIC DESIGN USING MQM CABLE

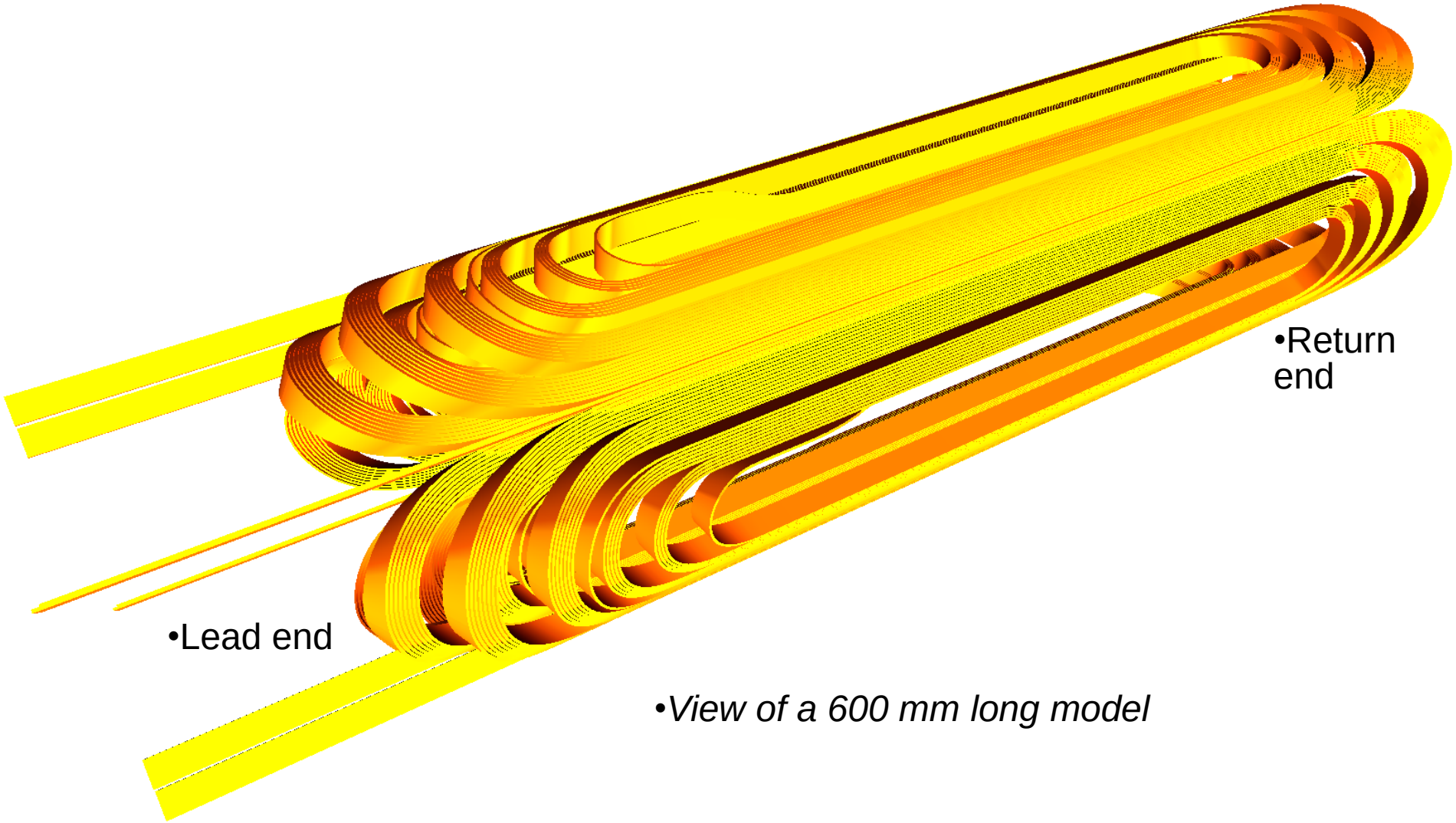
- Calculation with collars (assuming a relative permeability of 1.0025)
- At 4590 A, collars increase the peak field on conductor by about 0.12 T



- **Peak field = 6.4 T**

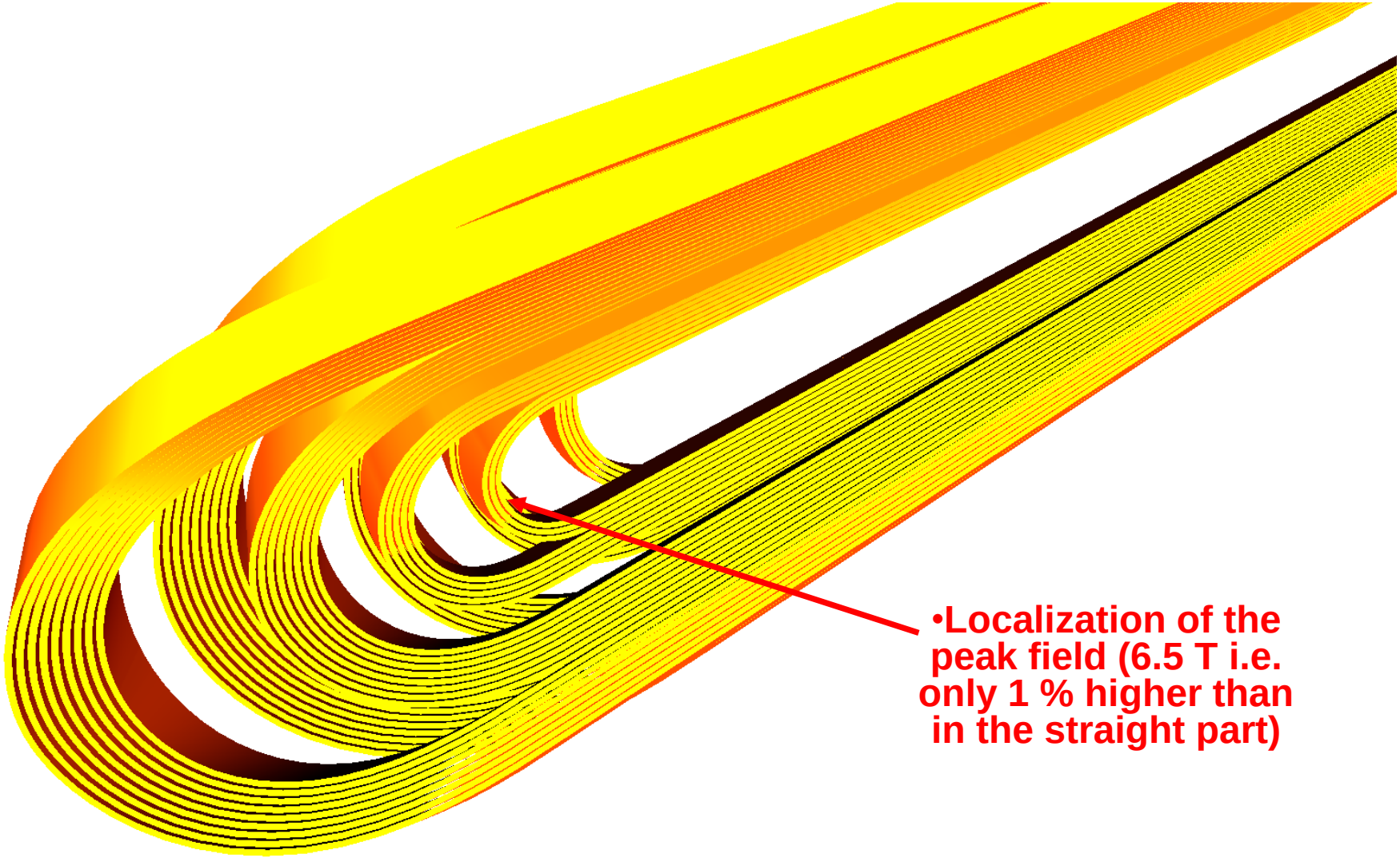


COIL ENDS



•*View of a 600 mm long model*

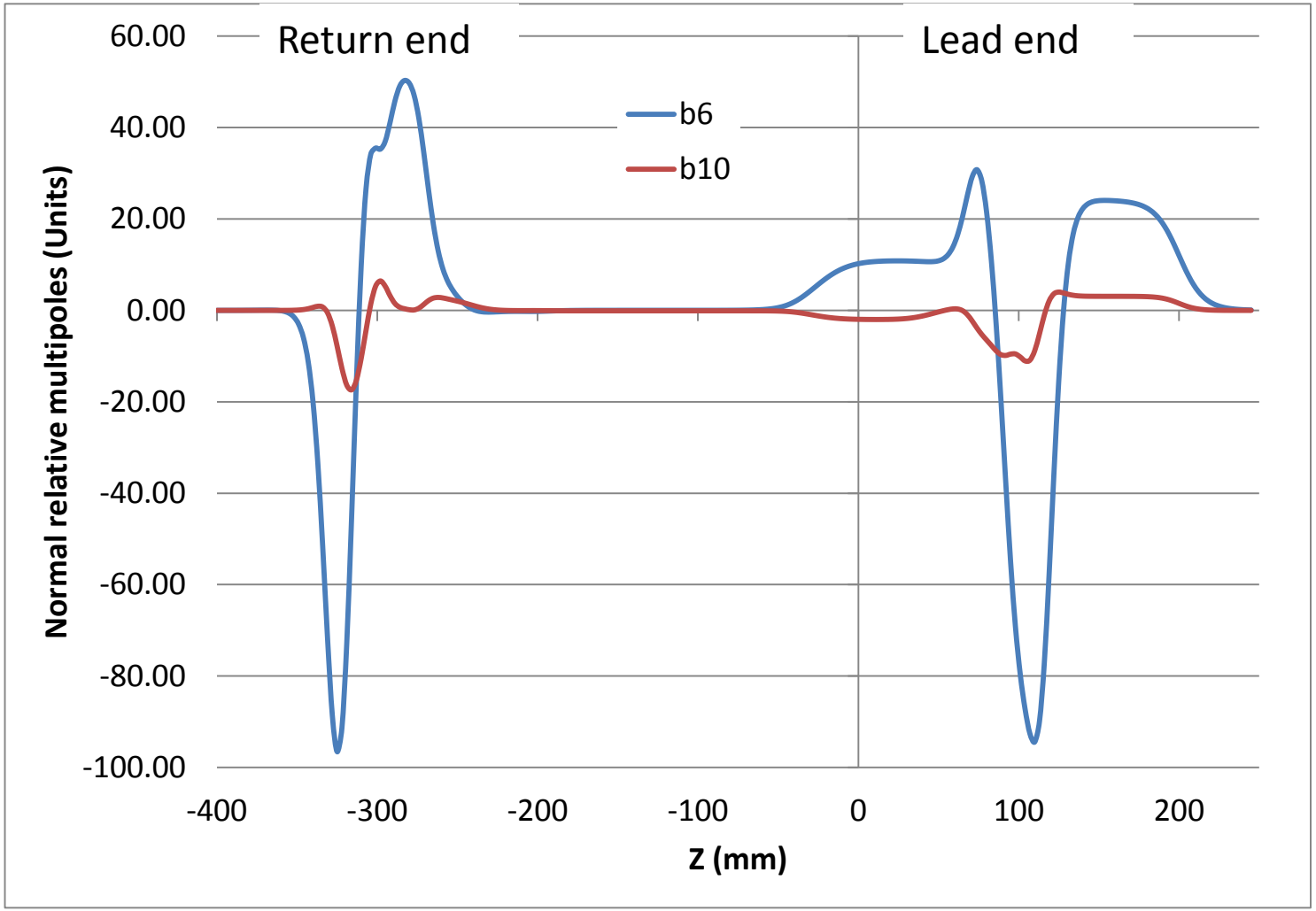
COIL ENDS



•Localization of the peak field (6.5 T i.e. only 1 % higher than in the straight part)

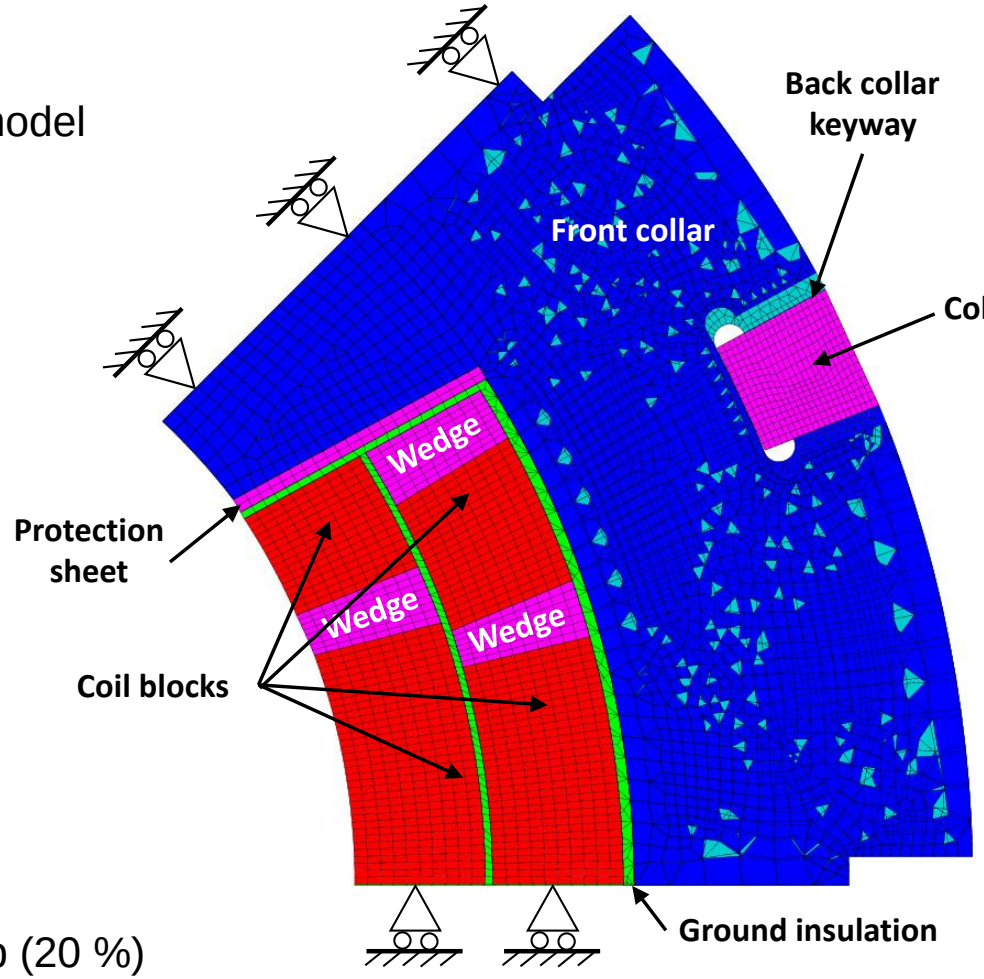
COIL ENDS

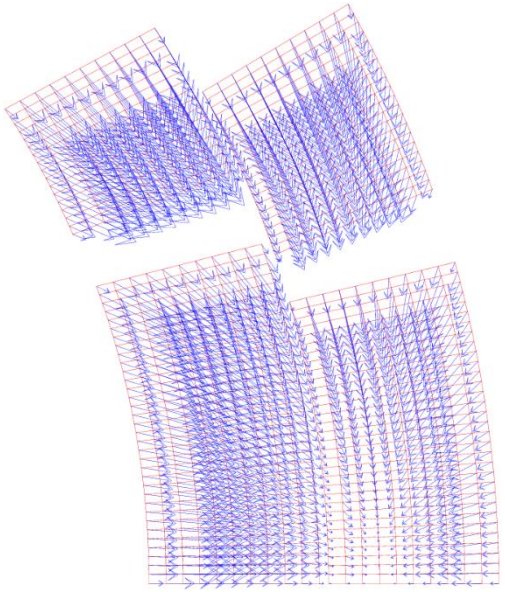
- Integrated b6 has been minimized



MECHANICAL STUDY

•Mechanical model
•CAST3M



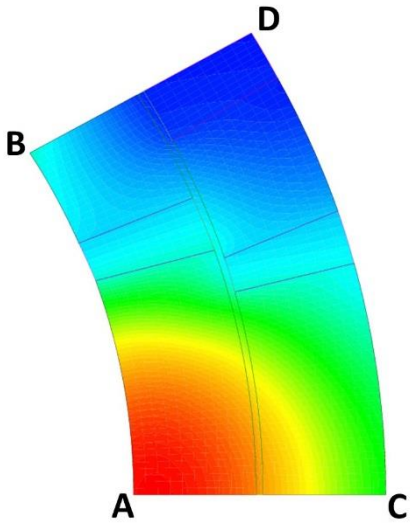


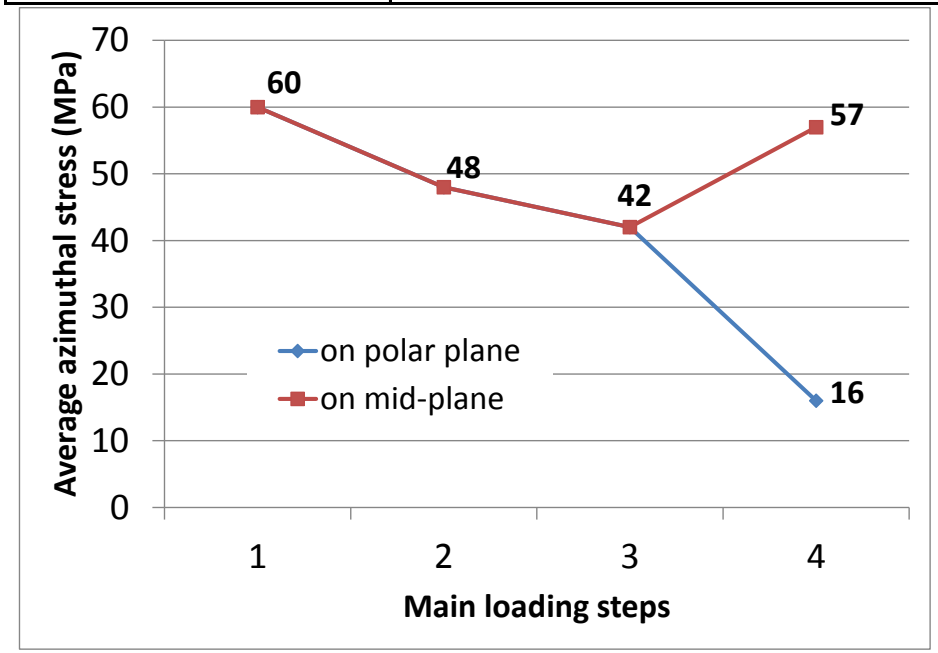
Fx = 0.47 MN/m
Fy = - 0.63 MN/m

•Simulation :
- Collaring (key)
- Insulation creep (20 %)
- Cooling
- Energisation at 110 % of I_{nom} → Magnetic forces are computed at each coil node

MECHANICAL STUDY

Q4 with MQM cable	Collaring	Creep (20%)	Cool down	Energization
Azimuthal stress in coil (MPa)				
Max	-94	-77	-52	-63
Average	-60	-48	-42	-43
Min on polar plan				**-10**
Average on polar plan				-16
Coil radial displacement due to Lorentz forces (µm)				
Point A				48
Point B				18
Point C				23
Point D				2





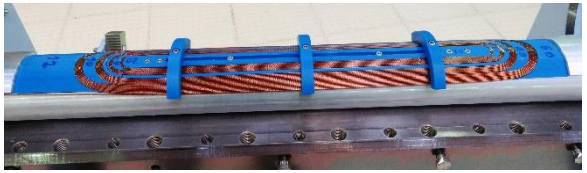
•The self-standing collar solution as mechanical structure is validated

Status of the Q4 development at CEA

SINGLE APERTURE SHORT MODEL MQYYM

Magnet key parameters

- Single aperture
- RT coil length = 1350 mm , RT Magnetic length = 1217 mm
- Self supporting austenitic collars
- non laminated yoke to speed up fabrication and lower cost



Time Frame

- Detailed design phase: ongoing
  - Drawings, Mock-ups
- Procurement of tooling and components: April to Dec 2016
- Coil fabrication should start in Fall 2016
- Collaring at CERN with CEA team in Spring 2017
  - Use of Vertical collaring press in 927
- Yoking in Spring 2017, location to be defined
- Test at Saclay => Summer 2017

CERN Contact persons:

- Ezio Todesco for coordination
- Juan Carlos Perez for specific activities: collaring, yoking and quench heaters
- Rosario Principe for material: steel and stainless steel

Open questions (in discussion or not yet discussed)

- Collar material availibility
- Details on the press
- Young modulus measuring machine modification
- Protection heater fabrication

PROTOTYPES MAGNETS

Magnet key parameters

- Double aperture
- RT/1,9K Magnetic length = 3681 / 3670 mm

SPECIAL CONTEXT: the Pre-commercialization procurement (PCP) QUACO

- EU finances 70% of the project but strong constraints on implementation
  - Activity divided in 3 phases: conceptual design, engineering design, first-of-a-kind fabrication
  - Firms in competition from one phase to the next: 4/3/2 firms in phases 1/2/3
- NOT A BUILT-TO-PRINT

Time Frame

- RFT in May 2016
- Start of the work in January 2017
- Prototypes delivered in Feb 2020

CERN Contact persons:

- Marcello Lossaso for QUACO coordination
- Ezio Todesco as WP3 leader
- Arnaud Foussat on support for integration?

SOME Open questions

- The choice of the mechanical solution for the support structure is open. If austenitic steel is used, the consortium commits to provide the material
- Some mock-ups can be produced during QUACO, for example a slice of structure: use of the press at CERN?

SERIES MAGNETS

Magnet key parameters
- Double aperture
- RT/1,9K Magnetic length = 3681 / 3670 mm

Open questions
- Transition between end of QUACO and start of the series, IP management…
- Type of technical solution (mechanical solution found in QUACO can be different from the MQYYM)
- Type of funding

Timeline:
- 4 magnets produced from 2021 to 2023

CERN Contact persons:
- Ezio Todesco as WP3 leader
- Arnaud Foussat on cold mass integration

PENDING DECISIONS AND TOPICS FOR DISCUSSION ON INTEGRATION

- Yoke outer diameter: working assumption since yesterday (discussion with Ezio) 614 mm
- Poisition of the cooling channel
- Bus bars

- Instrumentation: voltage taps, protection*
- CLIQ?

- Material availability for stainless steel collar: we would need some input

- …