HEPDipo

Manufacturing considerations, including experience from FRESCA2

J-C. Perez

EuCARD: European Coordination for Accelerator Research & Development

EuCARD is a common venture of 37 European Accelerator Laboratories, Institutes, Universities and Industrial Partners involved in accelerator sciences and technologies. The project, initiated by ESGARD, is an Integrating Activity co-funded by the European Commission under Framework Programme 7 for a duration of four years, starting April 1st, 2009.

Its main goal is to upgrade the large European research accelerators by R&D on innovative concepts and techniques, thereby offering researchers the best facilities. This common venture will strengthen durable collaboration among the partners and will contribute to the development of world-class infrastructures, one of the main features of the European Research Area.

EuCARD dipole “specification”

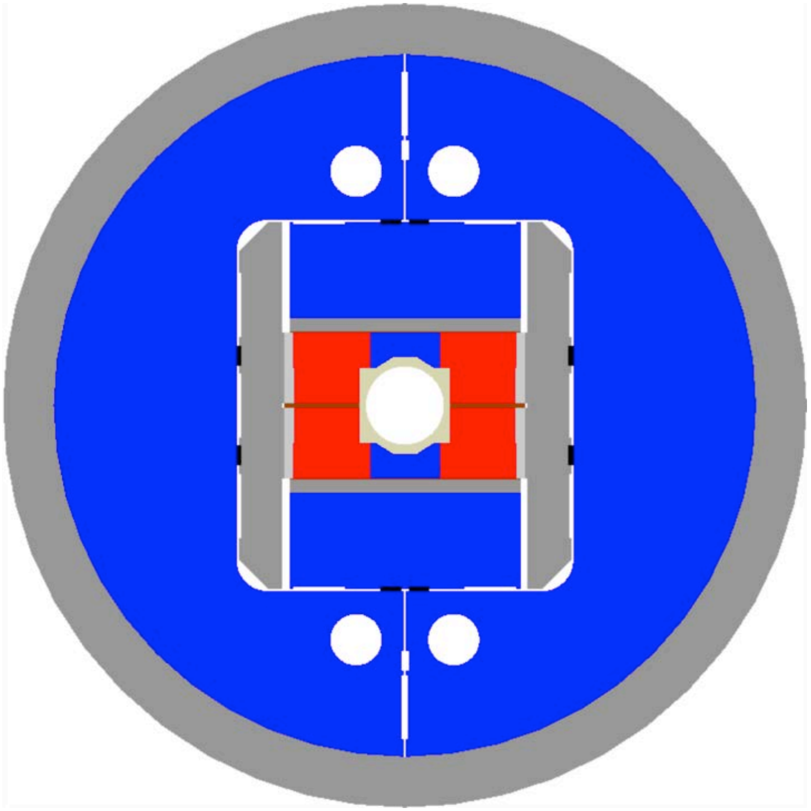
The technologies to be used for Nb_3Sn magnets, which are residing with the partners (e.g. high current density conductors, Nb_3Sn wind-and-react coil fabrication, insulation) are to be brought together and tested in short models. Several of these technologies (superconducting cable, insulation, coil design, support structures) were partly developed during the FP6-CARE-NED project.

The proposed dipole model will test these technologies for large accelerator magnets and the model will afterwards be used to upgrade the superconducting cable test facility FReSCa at CERN from 10 T to 13 T. The issues are to reach high fields in large apertures with good temperature margins in the coil, beyond the possibilities of Nb-Ti conductors.

As a test bed for high field accelerator magnets a 1.5 m long dipole model will be build with an aperture of 100 mm and a design field of 13 T. For this dipole model, CEA-DSM and CERN will design together the magnet. CERN will do the conductor characterization. PWR will do the thermal design and thermal component tests. CEA-DSM will fabricate the coils and CERN will build the mechanical support structure. Combined teams will integrate the coils into the support structure. The cryogenic test of the model will be done in the CERN test station.

Overview of magnet design

- Target: 13 T in 100 mm clear bore built as a EU-FP7 collaboration
  - Coil fabrication at CEA-Saclay
  - Heat treatment, impregnation & assembly at CERN
- Goal: test bed (new test station) and technology step towards fields in excess of 15 T
- OD: 1.030 m; length: 2.255 m
- Al shell, 65 mm thick, 1.6 m long
- Bladder and key pre-load
- Iron yoke
  - Holes for axial rods (60 mm ∅)
- Horizontal stainless steel pad
  - 3 bladders per side, 75 mm wide
  - 2 load keys
- Vertical iron pad
  - 2 bladders per side, 60 mm wide
  - 2 load keys
- Four double-layer coils with flared ends
- Iron and Ti alloy central posts



22 March 2013:

Complete magnet in 2014, test in 2015, installed as cable test station by 2016

Magnet design & construction

- FRESCA2 was designed and constructed in close collaboration with CEA-Saclay
  - The magnetic design was leaded by CERN (several fellows involved)
  - Mechanical structure design in collaboration with CEA engineering team
  - Magnet protection studies shared between CERN & CEA
  - Regular video meetings for magnet and tooling design activities follow-up
  - Regular technical visits to exchange information
  - CEA designer was fully dedicated to the project supervised by an engineer
  - CEA had the responsibility of the 3D model
  - Core team of CERN engineers and technicians involved
- CEA was in charge to place the orders throw CERN’s purchasing office and of the fabrication follow-up of most of the magnet components
- 8 years were needed to get the first magnet tested at CERN

Construction activities

- Cable production at CERN
  - Cable insulation (braiding) subcontracted to a French company
  - Insulation thickness measurements at CERN before cable delivery
- Coil winding operation at CEA
  - 2 copper coils to validate winding techniques and tooling
  - 7 coils using RRP or PIT conductor
- Heat treatment at CERN
- Instrumentation and coil impregnation at CERN
- Magnet assembly and cold powering tests at CERN

R&D activities

- At CEA
  - Winding trials (optimised radius for hard way bend)
  - Cable dilatation tests during heat treatment (definition of moulds cavities size)
  - Segmented mould for heat-treatment (test at CERN)
- At CERN
  - Mechanical structure validation using Al dummy coils
  - Flexible printed circuit for QH & Vtaps
  - Coating of coil components using AL_2O_3
  - Tailored shim fabrication
  - Mock-up to validate coils interconnection

Main discussion topics during FRESCA2 design

- Tooling concepts
- Segmented base plate of the reaction mould
- Support of longitudinal forces
- How to support the vertical forces at coil extremities
- Geometry and position of the spacer to support the inner coils
- Final coil geometry and lateral shimming. Need identical coil dimension for loading

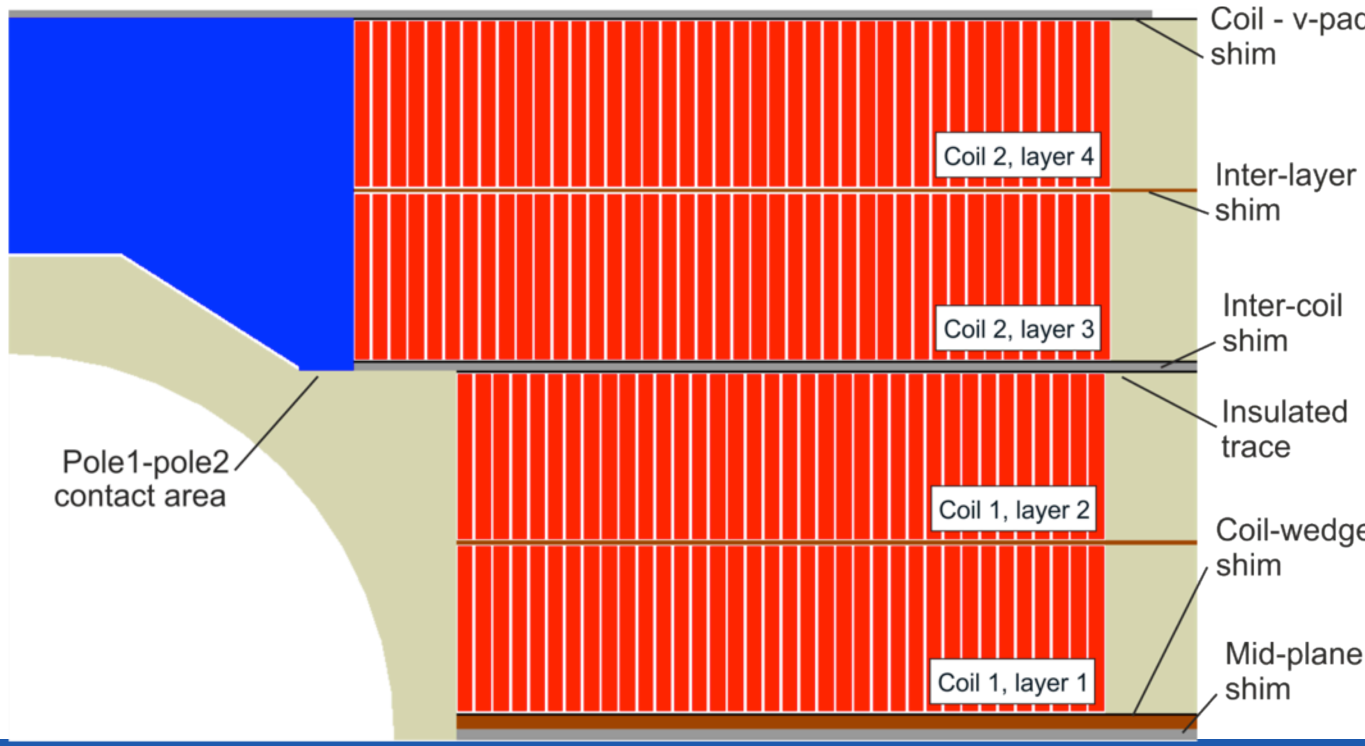
- To be considered during HEPDipo design
  - Mechanical structure validation using instrumented dummy coils
  - Bladders dimension
  - Segmented pole allowing thermal expansion during heat treatment
  - Magnet protection: impregnated traces?
  - Impregnation mould design for pressure impregnation up to 3 bars
  - External geometrical references for alignment

Back-up slides

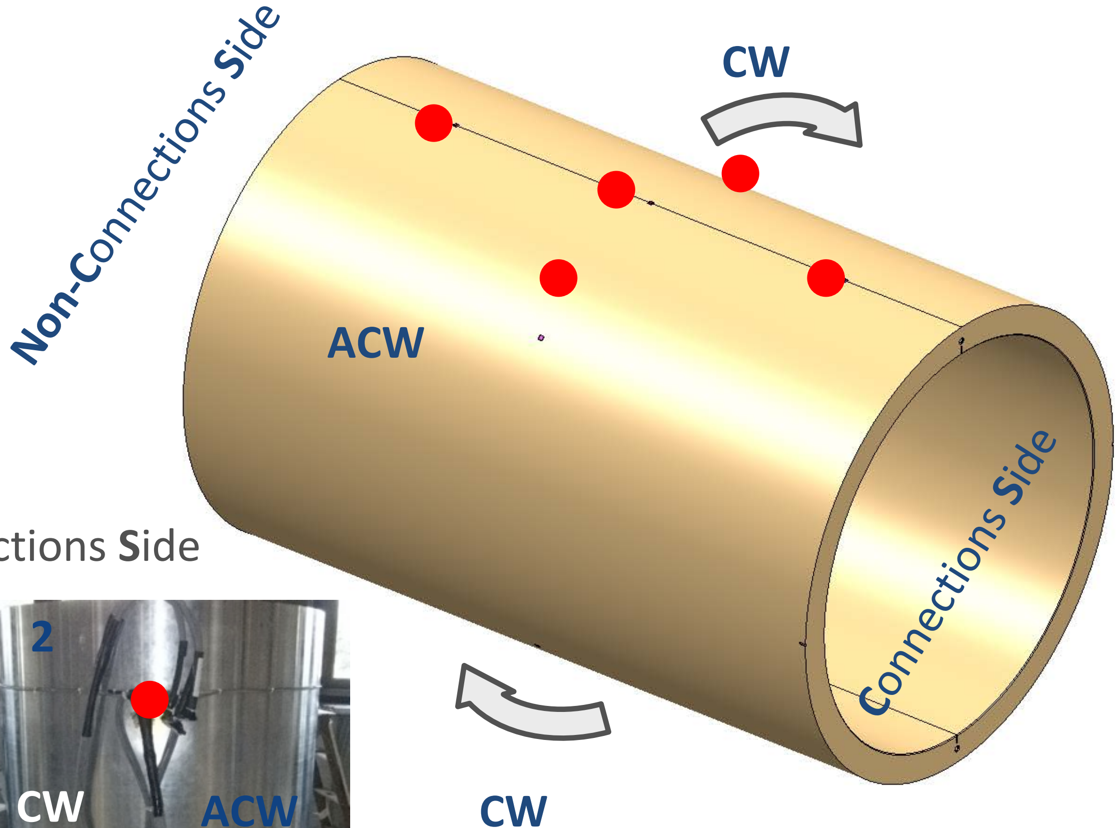
Coil cross-section

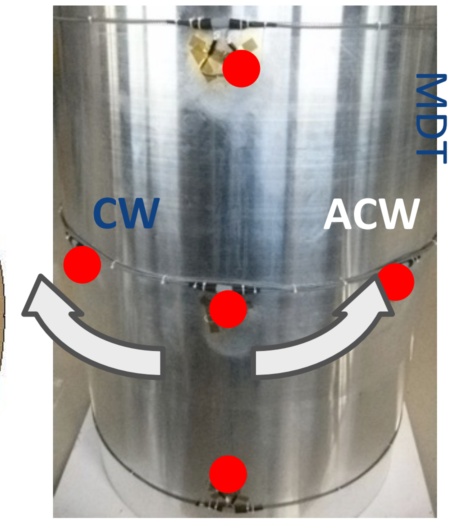
- Two double-layers with 36 and 42 turns
- Bore aperture 100 mm

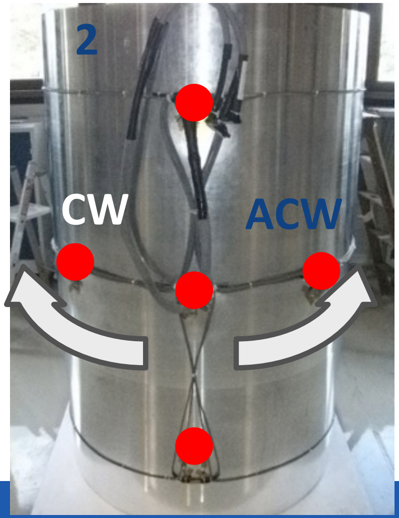
- Ti poles
- Inter-coil gap and mid-plane "tailored" shim



Shell Instrumentation

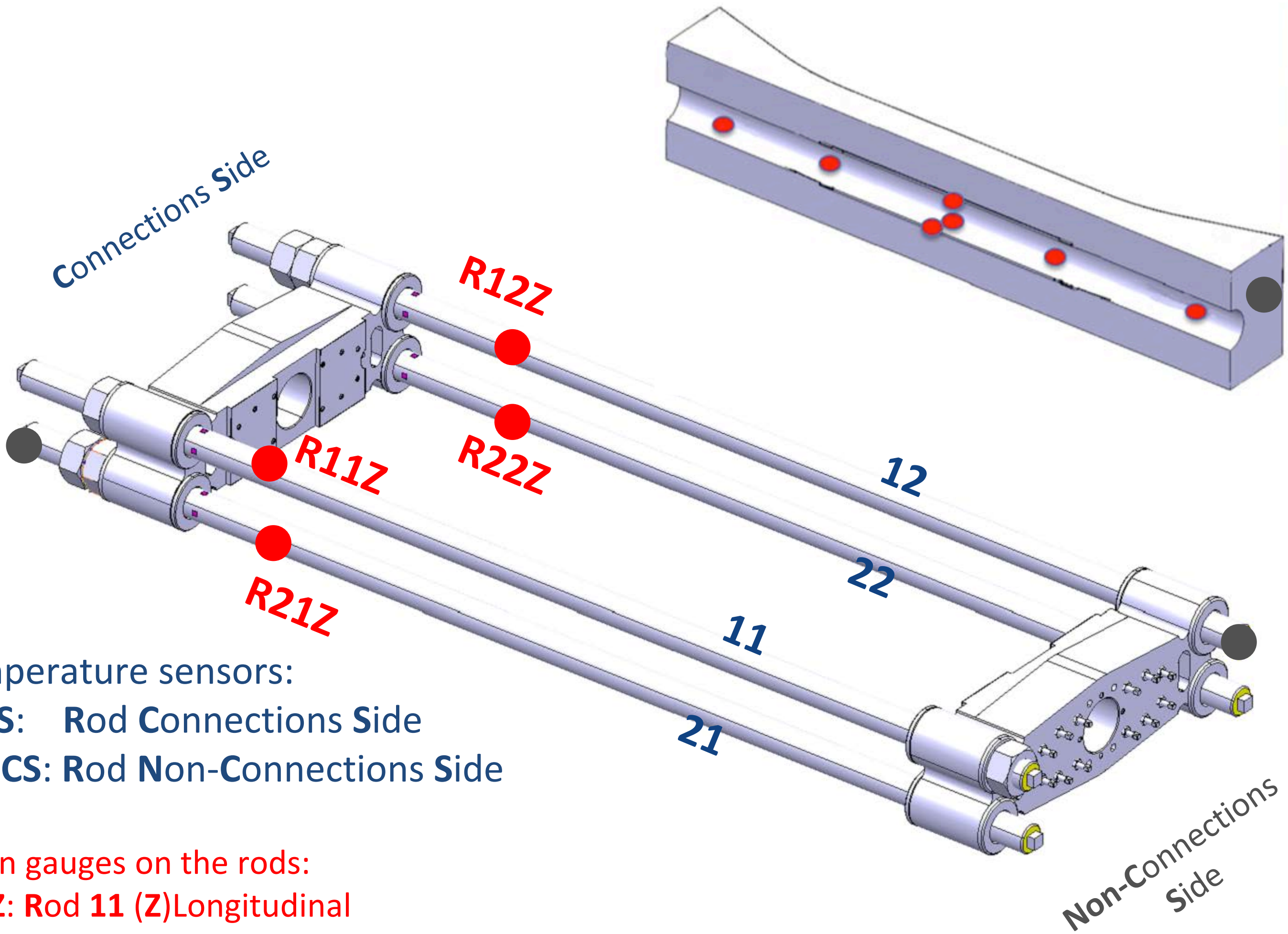






The aluminum shell has been instrumented with 10 measuring stations

Rods and dummy coil Instrumentation



Temperature sensors:
TRCS: **R**od **C**onnections **S**ide
TRNCS: **R**od **N**on-**C**onnections **S**ide

Strain gauges on the rods:
R11Z: **R**od **11** (**Z**)Longitudinal
R21Z: **R**od **21** (**Z**)Longitudinal
R12Z: **R**od **12** (**Z**)Longitudinal
R22Z: **R**od **22** (**Z**)Longitudinal