WG8 on Detector Magnets

Generic R&D studies

16 March 2018

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CERN/EP

Introduction

The generic R&D studies identified by WG8 cover 3 main domains :

A. Magnet studies,
B. Powering and control systems,
C. Instrumentation.

The list of proposed R&D activities is described in the following slides.

See Herman' talk for the specific R&D studies.

A- Magnet generic studies

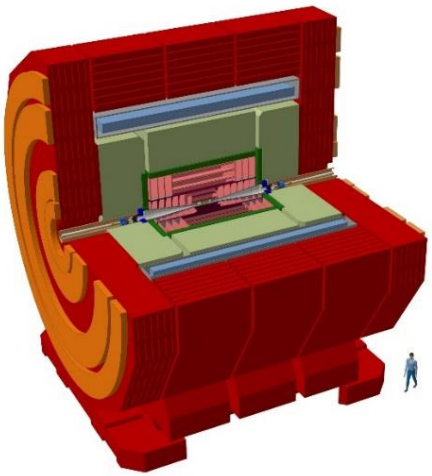
WG8 – Magnet generic studies

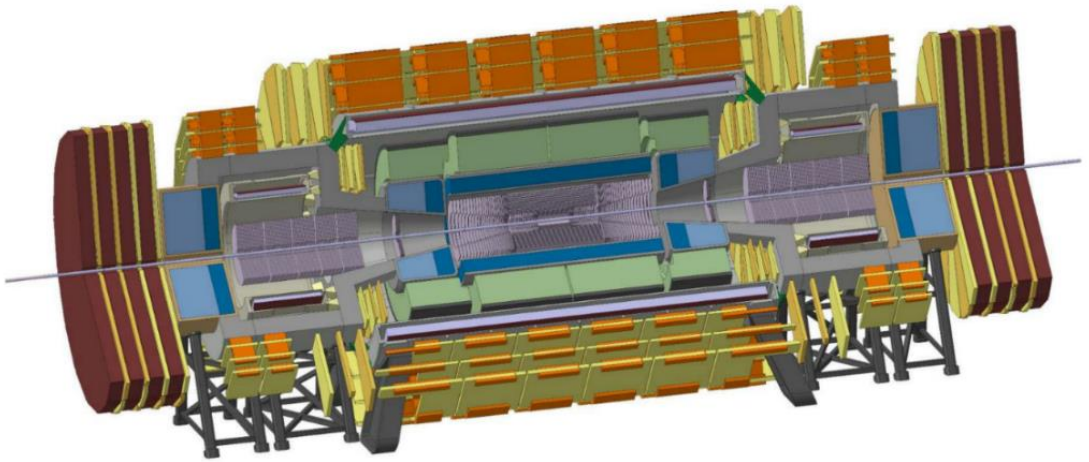
1. Magnet design and Finite Element Analysis activities

Conceptual studies (e.g. CLIC, FCC-hh)

Computation of :

- Magnetic field,
- Forces (on magnet, thermal shields, steel structures, …),
- Stress distribution in the coil due to cooldown and powering.





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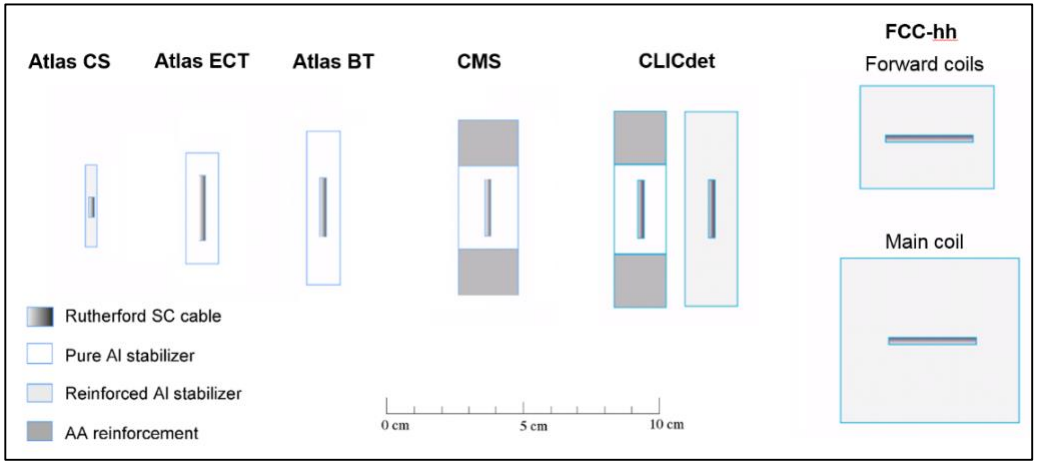
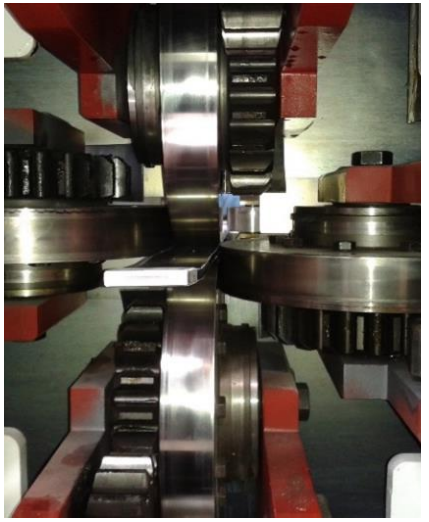
2. Activities on superconductor

- Studies on performance of conductor with reinforced stabilizer (continuation of R&D started by CLICdp).
- Fabrication of a prototype.
- Development of the associated fabrication tooling.
- Investigation on the feasibility of new HTS conductors.

Conductor proposed designs



Characterization of Al0.1wt%Ni coextruded and coldworked conductor



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3. Superconducting splice design and testing

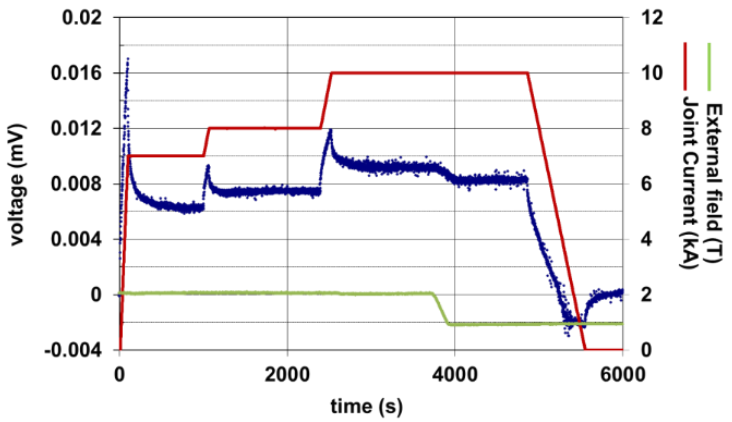
Splices are necessary for large SC coils for **module-to-module** and **layer-to-layer** connections

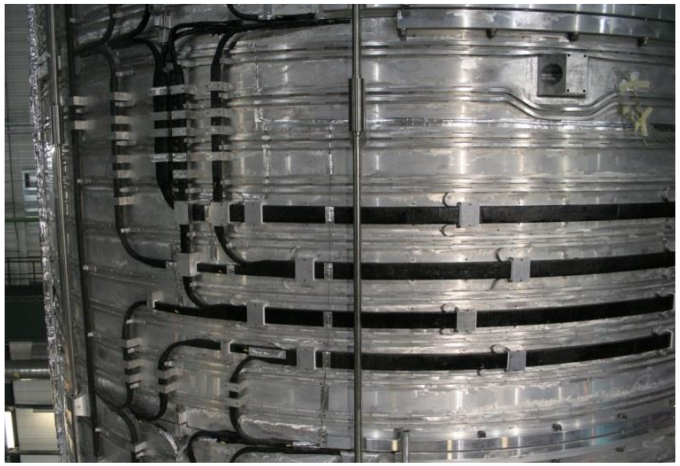
- Splice designs have to be investigated, aiming at lowest resistance.

Example :

Splice R&D done for the CMS magnet, resistance < 1 nano-ohm/m.

CMS R&D with CERN, CEA-Saclay and INFN-Genova.





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4. Conduction cooling at 4K

- Study of indirect conduction cooling,
- Thermal conductivity measurements on samples,
- Performance tests with experimental setup at laboratory scale.

5. Design of cryogenics and flexible transfer line

- Comparison of configuration with a refrigerator either underground or at surface level.
- Design of cryo ancillaries.

6. Superconducting busbars and current leads

- Study of the implementation of MgB_2 or High Temperature Superconductor for SC busbars and leads.
- Fault case scenario and protection studies.

An R&D is led by TE-MSC for the HL-LHC superconducting lines on these HTS.

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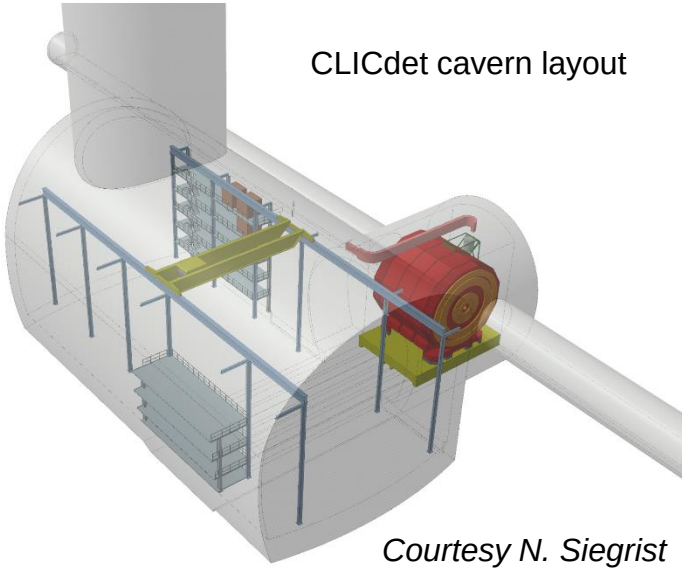
7. Cryostat Integration studies

- Design of vacuum tank structure and supports,
- Design of cold mass suspension system.



CLICdet cavern layout

Courtesy N. Siegrist

8. Studies of in-cavern magnet system integration and infrastructure layout

- Design of opening and support systems (air pads, rollers, rails, jack systems)
- Study of infrastructure layout (power, cryo, vac, etc.)

Example:

Long telescopic jack for CMS end cap opening (on going development, for LS2).

Courtesy Hubert Gerwig

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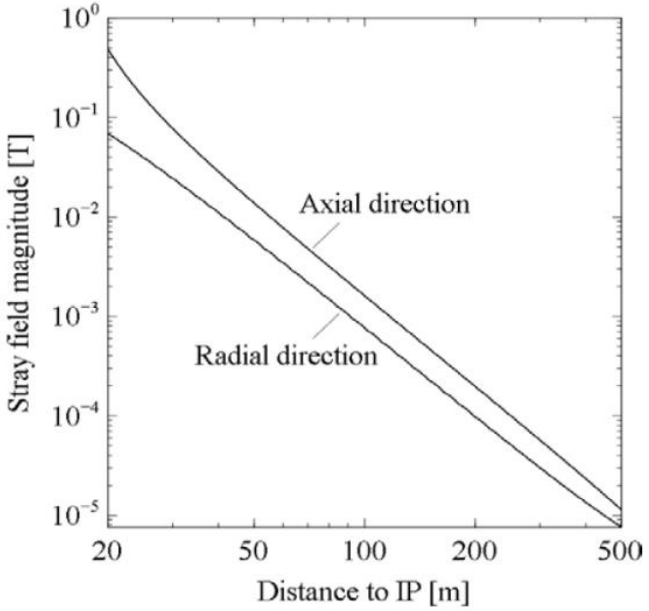
9. Global and local magnetic field shielding studies

- Characterization campaign of the magnetic stray field effect on equipment.
- Studies of magnetic field shielding with computations and tests.

Several magnet (resistive and SC) available within EP.

FCC-hh stray field



~ two orders of magnitude higher wrt CMS

B - Magnet powering and control systems

WG8 - Magnet powering and control systems

1. R&D for magnet control system

Existing magnet control system on the LHC detector magnets will be obsolete for the next magnet generation.

- Need for upgrades to run the existing system until 2035.
- R&D is needed on new control systems to get improved capacity (hardware & software).

- ➢ Prototype (hardware and software) shall be built.
- ➢ Could be first deployed as test bench on existing magnet.

2. Development of the interface with the future power converter control system

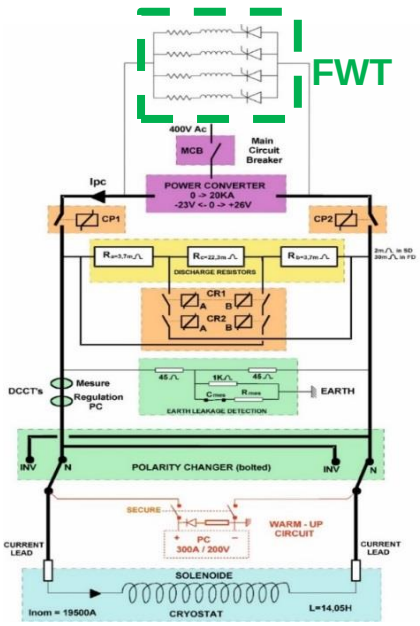
- Requirements shall first be defined at an early stage.

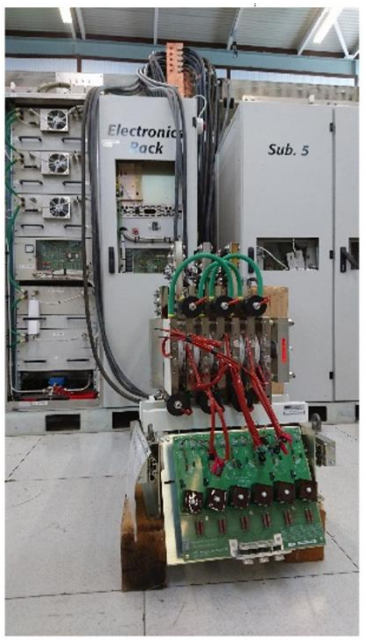
WG8 - Magnet powering and control systems

3. Feasibility study of free wheel systems

Large gain on magnet availability against power cut during operation (avoid discharge & ramp up time, typically 8-12 hours).

Reduction of mechanical cycling with field on-off cycles.





- Development of resistive free wheel thyristors system,

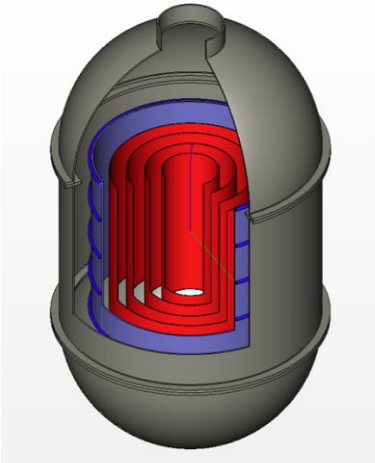
Example:

Development specific to CMS magnet with EP-CMX and TE-EPC (on-going, LS2).

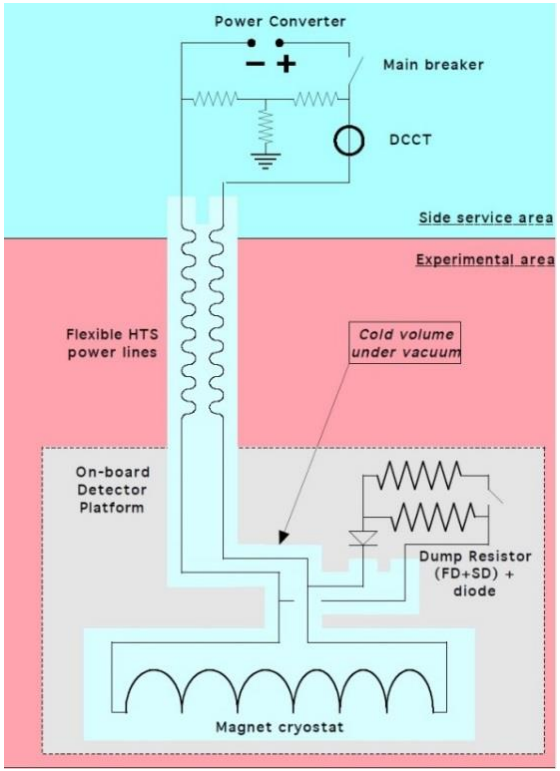
- Study of persistent current switch applied to future detector magnets:
  - Check compatibility with field stability.
  - Study switch protection and compatibility with magnet protection.

4. Powering and energy extraction systems for quench protection

- Study of magnet electrical circuit and powering configurations.
- Study of discharge, quench propagation, fault case scenario.
- Design of protection scheme :
  - Energy extraction: quench back or heaters.
  - Dump circuit (passive or active cooling).



Water cooled resistor study (CLICdet magnet)



C - Magnet instrumentation

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1. Magnetic measurements

Topics of interest for R&D :

- Magnetoresistive (MR) Sensors
  - Performance
  - Sensitivity in high fields
  - Radiation hardness
  - Investigation of other MR flavors
- Motion actuation in high magnetic fields for scanning tables
  - Piezoelectric motors
- Interfaces
  - Updates to CAN (possibly CAN FD - Flexible Data-rate)

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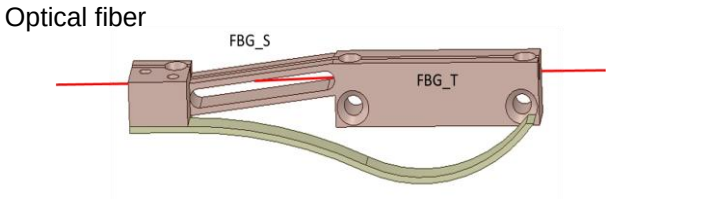
2. Low temperature sensors

- Assessment of Fibre Bragg Grating (FBG) sensor application at temperatures down to 4K, for temperature and strain monitoring of SC coils, SC busbars, current leads.
- Investigation of contactless positioning sensors for coil position monitoring within the cryostat.

3. Positioning sensors

- Development of fibre optical sensors (FOS) for strain/displacement monitoring.

Example: Sensor used on CMS GE1/1 demonstrator



Courtesy Z. Szillasi, N. Beni

4. Other studies and sensor developments

- Capacitive sensors for small displacements.
- Capacitance measurements for vacuum impregnation quality assessment (study lead by TE/MSC for accelerator magnets).
- Superconducting quench detectors (SQD).

With assessment of radiation hardness, magnetic field tolerance.

Conclusions

- A proposal of WG8 is to study and build a new magnet :
  - which integrates as much detector magnet R&D as described,
  - with free bore large enough to be used for future detector prototype tests and B-sensors calibration,
  - both CLICdp and FCC intends to use 4-T central field, but no 4-T facility at CERN available for tests,
  - a 4-T test magnet is proposed at this stage,
  - Installed on a test beam ?

- CERN Technical sectors shall also be involved.

Conclusions

- Several studies are closely linked to a specific magnet design, but the work can be transposed to other magnet projects.
- R&D shall be based on experience within EP and CERN teams.
- Prioritization of R&D activities to be defined & agreed with stakeholders.