INSTITUTO TECNOLÓGICO DE ARAGÓN

EMC studies for CMS tracker upgrade
Status & Plans

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OUTLINE

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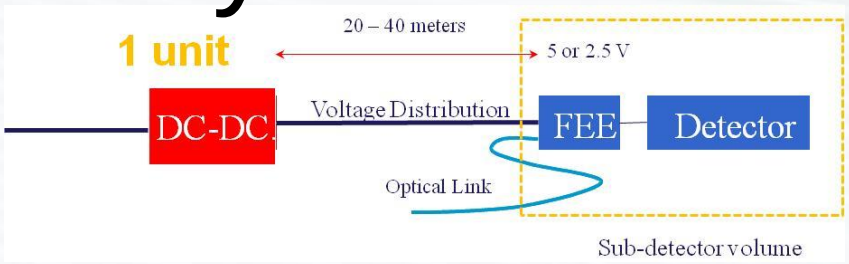
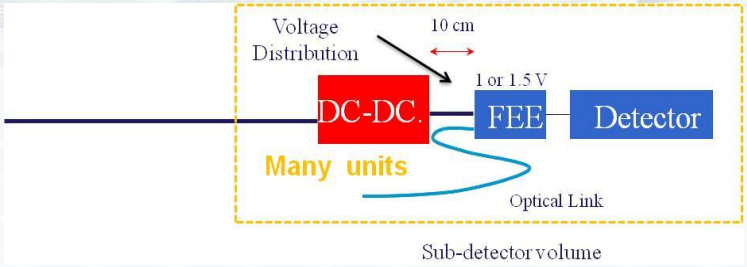
1. Introduction - Motivation

Today



Upgrade



- New FEE requirements forces to install DC-DC converters close to FEE (inside sub-detector modules).
  - The high current demanded by each power channel
- However DC-DC converters are a very noise source
  - It is necessary minimize the noise coupling between FEE – DC-DC units
  - It is necessary to minimize the total noise inside sub-detector volume
- A large R&D effort is planned and taking place to develop a DC-DC switching converter to operate under high magnetic field with low noise emissions inside tracker volume
  - GREAT effort form CERN & Aachen

2. EMC project for tracker upgrade

- **EMC immunity studies for CMS tracker upgrade - 9.04**
  - **IFCA & ITA – Approved by CMS MB on November 2009**
    - Long & detailed review process (Tracker & CMS upgrade MB)
    - Proposal was welcomed because cover critical integration issues for the detector
- First stage of the EMC strategy – long term strategy for CMS
- The main goal of the project is:
  - To define preliminary rules to ensure the integration of main components (Detector, FEE, Power network and DC-DC)
  - To define design strategies that allow increasing the immunity of the Detector-FEE unit.
- It is divided in two parts:
  - **Noise coupling mechanism at system level**
    - Impedance & Power Network effects on noise emissions
  - **New high immunity systems to EM noise**

2. EMC project for tracker upgrade

- This proposal has been included in a bigger project as part of the Spanish contribution for future colliders.
  - Title: **R&D on detectors for future colliders**
- It has been submitted to Spanish research program for founding
  - Project members:
    - Centro Nacional de Microelectrónica Barcelona (CSIC)
    - Instituto de Física de Cantabria (CSIC-UC)
    - Instituto Tecnológico de Aragón (G. Aragón)
- The project covers several aspects of the R&D for future colliders
  - Sensors
  - **EMC studies at system level**
  - **Optical fiber sensors to increase EMC immunity**

2. EMC project for tracker upgrade

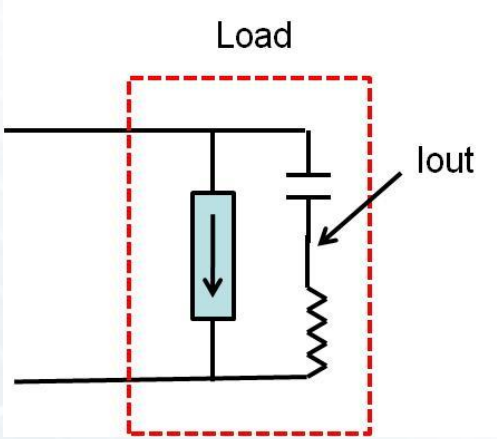
- This proposal has been **approved -** July 2010
- It is a 3 years project
- **Founding for the EMC tracker upgrade project (300 K€)**
  - EMC studies: 140 K€
  - FOS studies: 160 K€
- **Teams involved in the project**
  - IFCA – 8 members (Physisics & Engineers)
    - Dr. Fernandez García (100%) , RyC contract@IFCA; Broad instrumental expertise;.
    - Dr. R. Jaramillo Echeverria (100%) , Electronic engineer@IFCA
    - Dr. C. Martínez Rivero (50%) CSIC Tenured researcher@IFCA,
    - Prof. A. Ruiz Jimeno (50%) , U. Cantabria full professor@IFCA,
    - Dra. A. Lopez Virto (50%), U. Cantabria tenured researcher@IFCA,
    - Dr. I. Vila Álvarez (100%) CSIC Tenured researcher CSIC@IFCA
    - F.J. Muñoz Sanchez (100%) CSIC FPI FPA2007student@IFCA.
    - D. Moya Martín (100%) CSIC Engineer; Mechanical design, carbon composites, ILD.
  - ITA – 4 members (Engineers)
    - Dr. Fernando Arteche (100%) Electrical Engineer @ITA;
    - M. Cristina Esteban Lallana (50%) Electrical Engineer @ITA
    - Iván Echeverria Ciaurri (50%) Electrical Engineer @ITA;
    - Fco Javier Piedrafita Orduna (50%) Electrical Engineer @ ITA

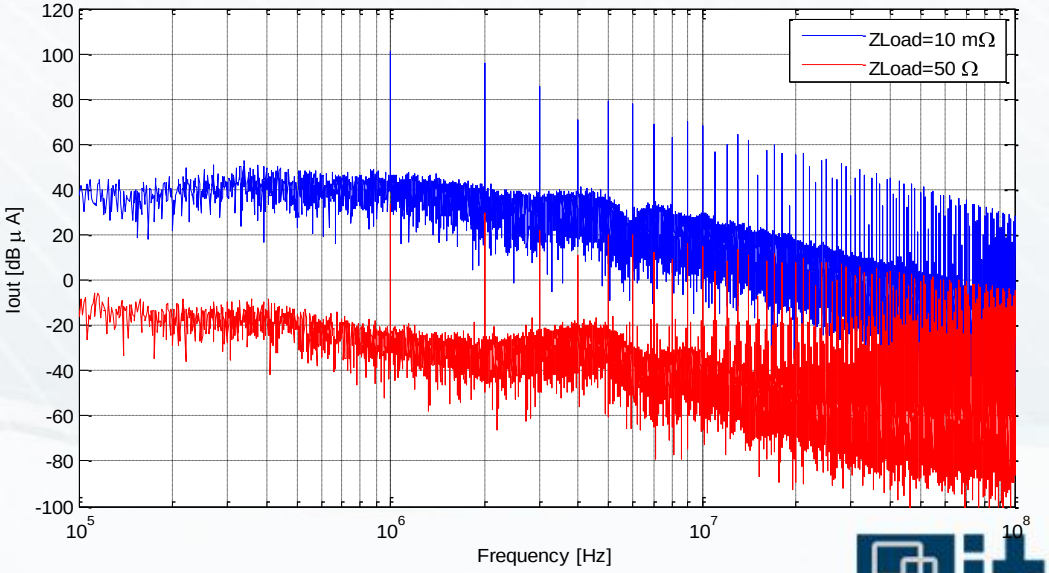
3. Working packages – Status & Plans

- The project has started in 2010
- It is divided in four working packages
  - WP 1: Power network impedance characterization
  - WP 2: Noise propagation effects in power network
  - WP 3: Noise immunity test in FEE prototypes
  - WP 4: Validation of EM immune OFS for temperature, magnetic field and strain: Effect on overall EM noise
- Strong collaborations with other groups is planned
  - FERMILAB – M. Johnson
  - Aachen – L. Feld & K. Klein
  - CERN – F. Faccio & G. Blanchot
  - Others collaborations are welcome

3. Working packages – Status & Plans

- ***WP 1: Power network impedance characterization***
  - *The aim of WP1 is to define and characterize the impedances connected to the DC-DC power converter*
    - *It defines the noise (conducted and radiated) levels emitted by the DC-DC power converters **AT SYSTEM LEVEL***
    - *Characterization of the electromagnetic environment*
      - *Impedances (FEE & Power Bus)*
      - *Multiple units*





3. Working packages – Status & Plans

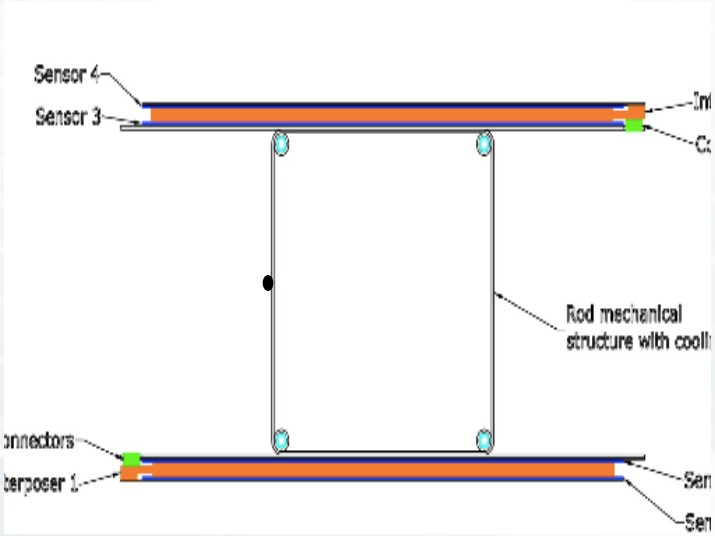
- ***WP 1: Power network impedance characterization***
  - *Preliminary results (More details during poster session)*
    - *Strong dependence of DM noise emissions respect*
      - *Input & output Impedance*
      - *Granularity*
    - *Strong dependence of CM noise emissions respect*
      - *Stray capacitance Impedance*
      - *Input voltage*
  - *These conclusions have to be confirmed with a special test set – up for noise emissions at system level*
    - *Set-up preparation has already started.*
      - *First results - October 2010*
      - *Final results – December 2010*
  - *We are open to test CERN & Aachen group´s DC-DC converters with the system test set-up at ITA*
    - *Still to discuss*

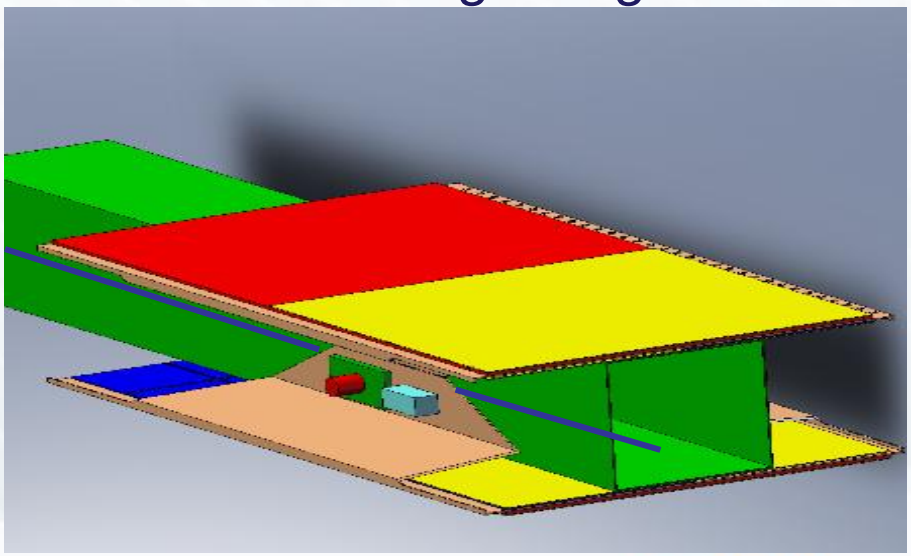
3. Working packages – Status & Plans

- ***WP 2: Noise propagation effects in power network***
  - *The aim of WP2 is to define the key points that allow designing the power network to minimize the effects of noise currents generated by DC-DC converter.*
    - *PCB or twisted pair cables – Ability to radiate*
    - *Slots in the CF frame - Cable inside carbon fibre structure*
    - *DC-DC layout effects (conducted and radiated)*
  - *This WP is carrying out in two stages:*
    - *Simulations models*
      - *Transmission line models - MATLAB code*
      - *FEM –EMA3D or COMSOL - Antenna models*
        - » *Long experience at ITA in EMC simulation*
    - *Real conducted and radiated test (Anechoic chambers)*
      - *Radiated noise from power network*
      - *Noise distribution on power networks*

3. Working packages – Status & Plans

- ***WP 2: Noise propagation effects in power network***
  - *This WP will be focused on double stack layout*
    - *Strong collaboration with FERMILAB*
      - *It was discussed with Marvin Johnson on July*
  - *Simulation phase has been already started*
    - *First results second part of 2011*
  - *Real test phase is planned for end 2011 or beginning 2012*





3. Working packages – Status & Plans

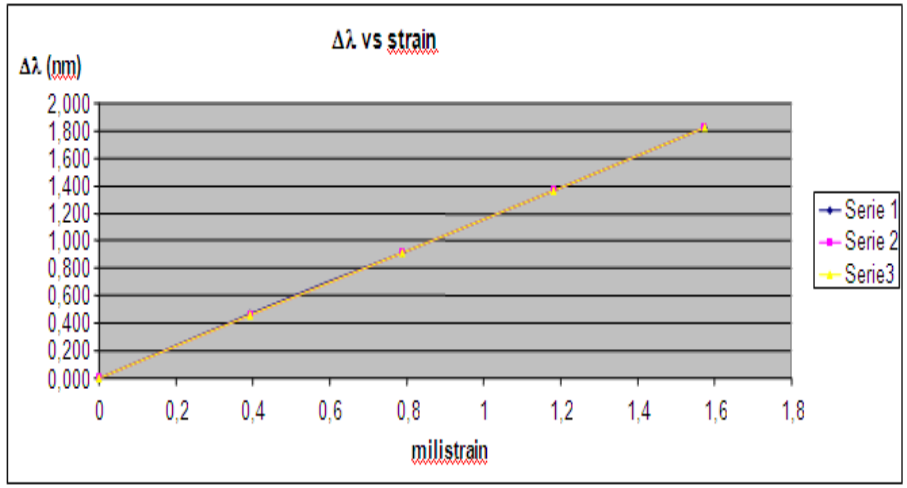
- ***WP 3: <u>Noise immunity test in FEE prototypes</u>***
  - *The aim WP3 is to define the FEE immunity on prototypes:*
    - *Impact of integration strategies in the overall design.*
      - *Conducted immunity test*
      - *Radiated immunity test (ITA facilities).*
  - *Some preliminary work has been done during 2009*
    - *Analysis of coupling mechanism in old tracker*
      - *Already presented in TWEPP 2009 & Tracker upgrade meetings (H field at pitch adapter)*
  - *Future plans – two options*
    - *Test FEE prototypes of new Tracker system*
    - *Test old FEE in new topologies*
  - *These tests are planned for 2012*
  - *We expect to collaborate with other groups*

3. Working packages – Status & Plans

- ***WP 4: Validation of EM immune OFS for temperature, magnetic field and strain: Effect on overall EM noise***
  - *The purpose of WP4 seeks out the implementation of OFS to substitutes previous measuring systems based on cooper cables.*
    - *Different methods for attaching the fibres to carbon composites supports*
    - *Architectures for sensor distribution network*
    - *EMC factor measurement (Copper Vs FOS)*
  - *Main FOS activities*
    - *Complete the market survey.*
    - *Proposal of fiber routing for CMS upgraded tracker*
    - *Testing of standalone fibers (irradiation).*
    - *CF test structures with bonded or embedded fibers.*
    - *Mechanical expansion and compression test under several thermal and humidity conditions.*
    - *Experimental validation of OFS vs. electrical expansion gauges.*
    - *Comparison with FEA simulations*

3. Working packages – Status & Plans

- ***WP 4: Validation of EM immune OFS for temperature, magnetic field and strain: Effect on overall EM noise***
  - First activities (During 2010)
    - Host material impact
      - Fiber embedded in hosting material (CF laminate)
    - Irradiation effects
      - First test on going Irradiation campaign at CNA (Sevilla)
        - » Synchrotron 18Mev (October 2010)
    - Collaboration with INTA – Madrid & CNM-Barcelona
      - Some prototypes & test



4. Conclusions

- ITA & IFCA have started this year a new project focused on integration issues at system level
- This project is supported by Spanish R&D program
  - Some founding has been received
  - Collaboration with CNM-Barcelona
- R& D project divided in 4 WP
- WP1 , WP2 & WP4 has started
  - WP1 focused on impedance effects on noise emission is finishing
  - WP2 focused on power network issues has recently started
  - WP4 focused on development of high immunity systems is on going