



# EMC studies for CMS tracker upgrade Status & Plans

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IFCA



# OUTLINE

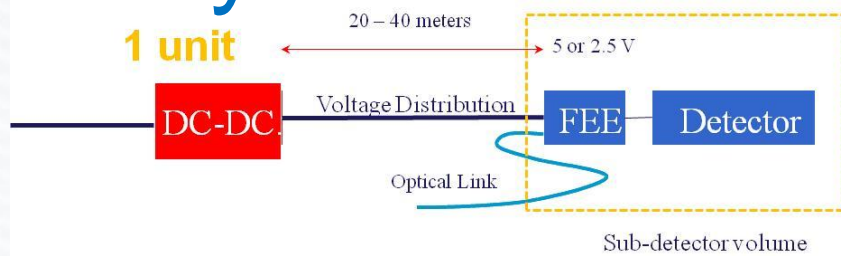


1. Introduction – Motivation
2. EMC project for tracker upgrade.
3. Working Packages
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4. Conclusions

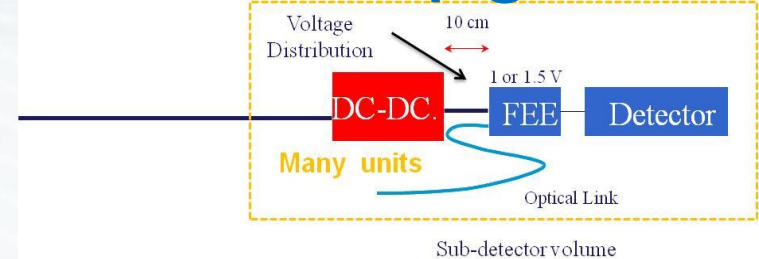


# 1. Introduction - Motivation

## 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 to 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-upgrade

- EMC immunity studies for CMS tracker upgrade - 9.04
  - IFCA & ITA – Approved by CMS MB on November 2009
    - First stage of the EMC strategy – long term strategy for CMS
- The project is founded by Spanish agencies and ITA
  - 3 year project
  - Project members:
    - Instituto de Física de Cantabria (CSIC-UC)
    - Instituto Tecnológico de Aragón (G. Aragón)
    - Centro Nacional de Microelectrónica Barcelona (CSIC)
- 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 – Robust FEE designs to EMI phenomena



# 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- B. Copper
  - Aachen –K. Klein
  - CERN-F. Faccio



# 3. Working packages – Status & Plans



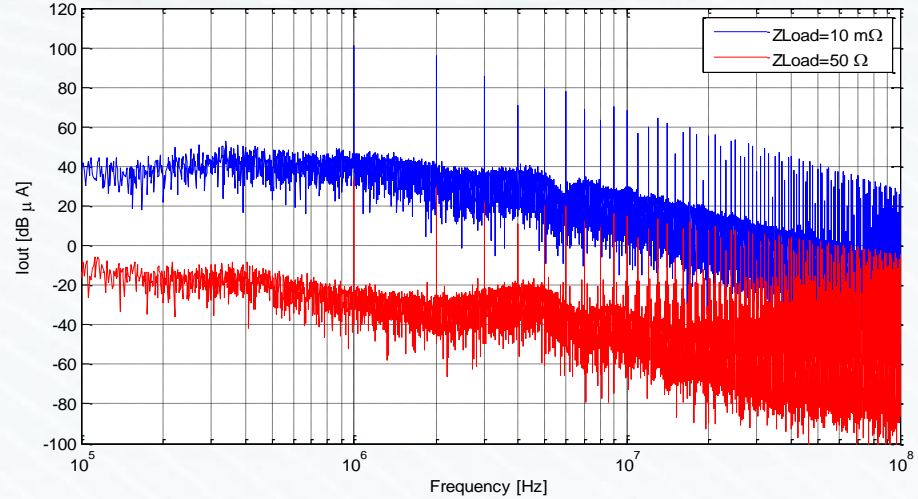
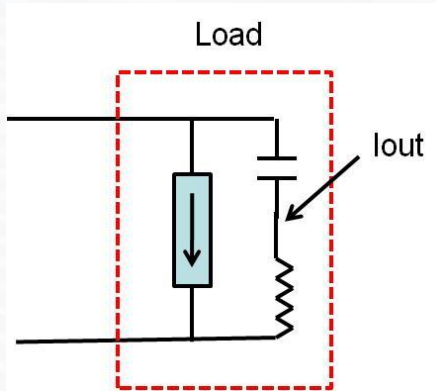
- **WP 1: Power network impedance characterization**
  - The aim of WP1 is to define and characterize the impedances connected to the DC-DC power converter
    - It defines the noise (conducted and radiated) levels emitted by the DC-DC power converters **AT SYSTEM LEVEL**
    - Characterization of the electromagnetic environment
      - Impedances ( FEE & Power Bus)
      - Multiple units
  - Simulation of effect to impedances connected to the DC-DC power converter-TWEPP 2010
  - First measurement on ITA facilities with a ITA DC-DC power converter prototype – May 2011



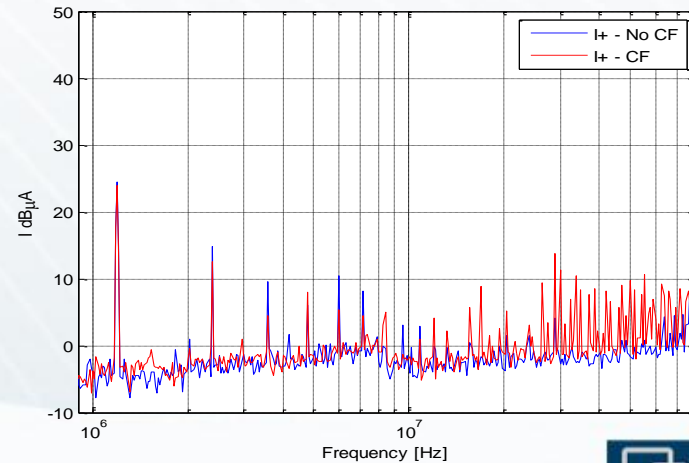
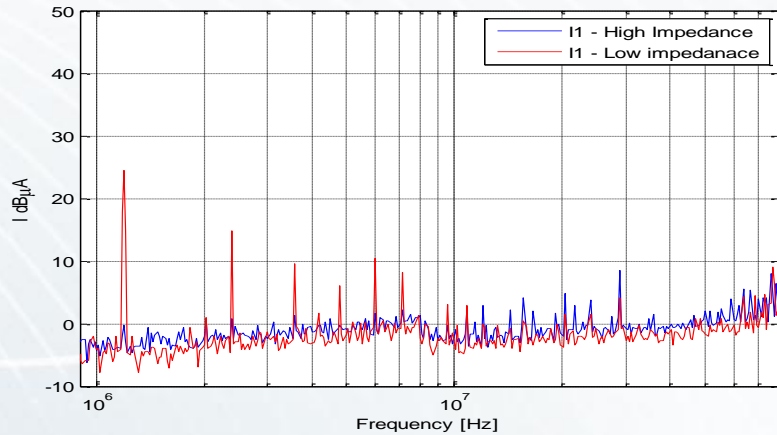
# 3. Working packages – Status & Plans



- *Simulations*



- *Measurements*



# 3. Working packages – Status & Plans

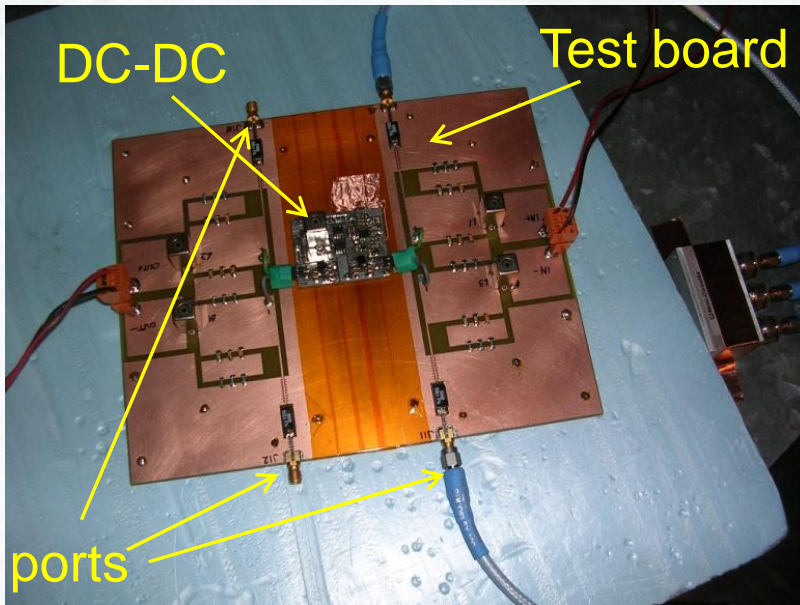


- *Preliminary results*
  - *Strong dependence of DM noise emissions respect*
    - *Input & output Impedance*
    - *Granularity*
  - *Strong dependence of CM noise emissions respect*
    - *Stray capacitance Impedance*
    - *Input voltage*
- *A test set up has been developed to estimate noise emissions in real scenario – System Level*
  - *Previous studies have shown that the impedance connected to the DC-DC has strong impact in noise emission*
  - *It represents the low impedances connected to the DC-DC*
  - *It has to be prepared to work between up to 100 MHz .*

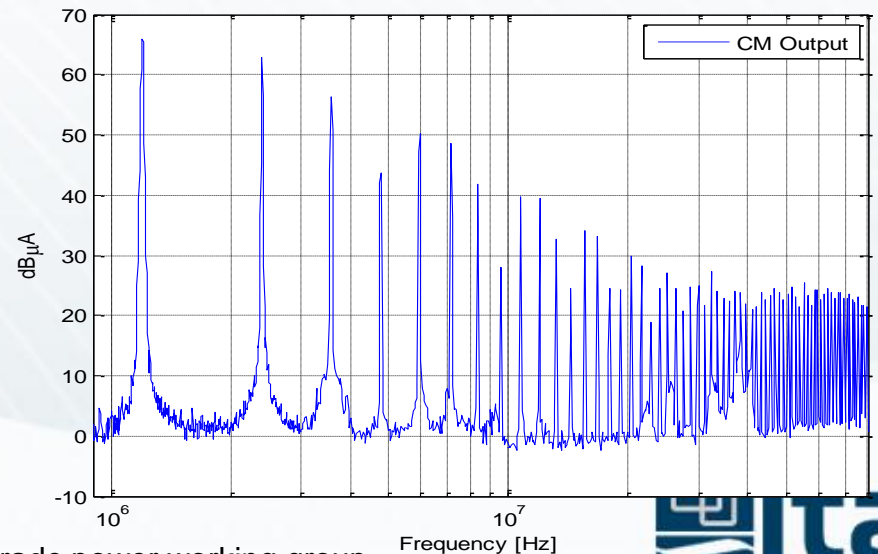
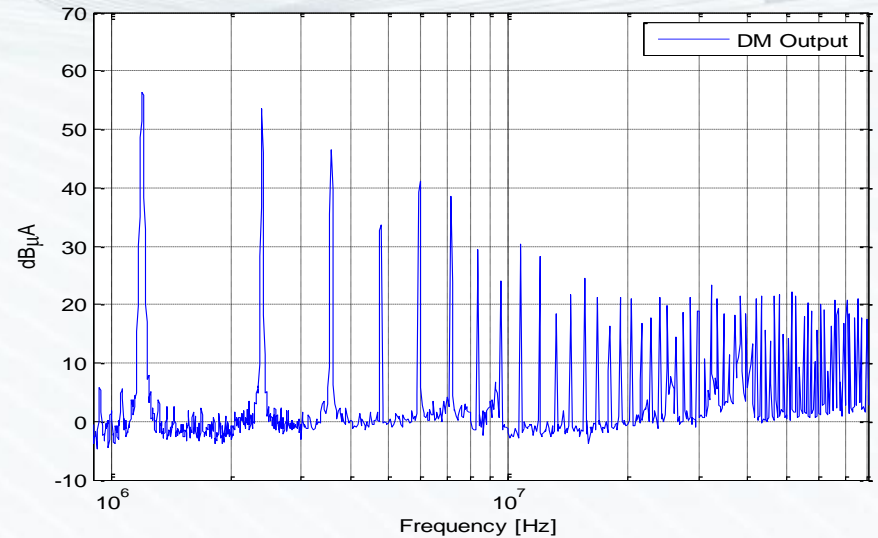




# 3. Working packages – Status & Plans



- *The impedance effect have more or less impact depending on DC-DC layout & size*
  - *It is planned to repeat these tests with Aachen's converter*



# 3. Working packages – Status & Plans

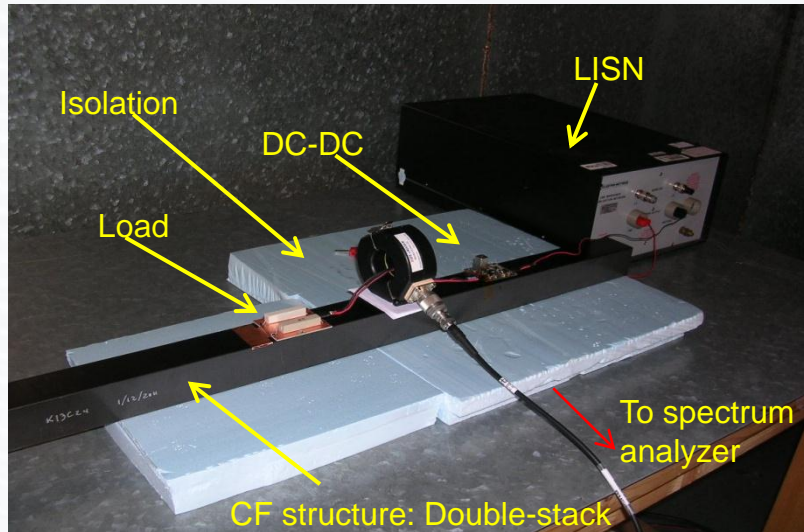


- **WP 2: Noise propagation effects in power network**
  - *The aim of WP2 is to define the key points that allow designing the power network to minimize the effects of noise currents generated by DC-DC converter.*
    - *Effects of noise emission of carbon fiber*
    - *Shielding effectiveness to carbon fiber*
    - *DC-DC layout effects (conducted and radiated)*
    - *Cables – Ability to radiate*
  - *This WP is carrying out in two stages:*
    - *Simulations models*
      - *Transmission line models - MATLAB code (finished)*
    - *Real conducted and radiated test (Anechoic chambers)*
      - *Radiated noise from DC-DC prototype*
      - *Noise distribution on DC-DC prototype*

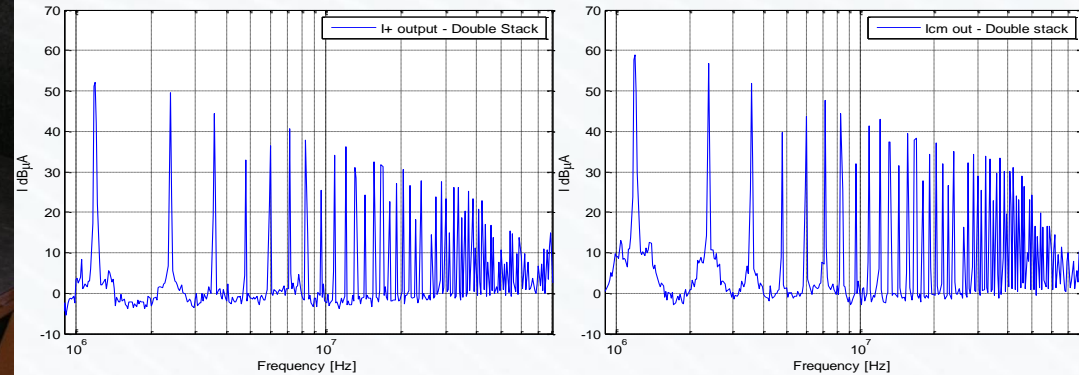


# 3. Working packages – Status & Plans

- WP 2: Effects of noise emission of carbon fiber**



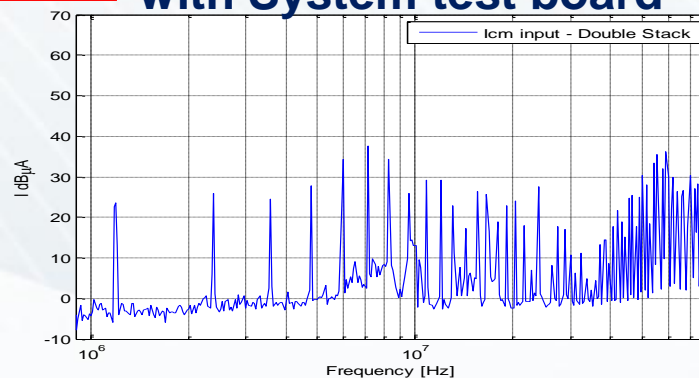
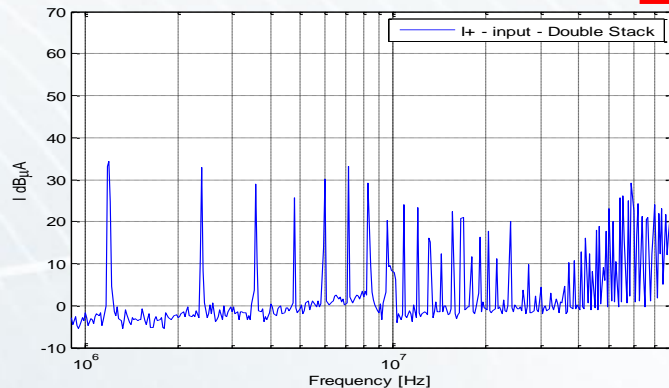
## OUTPUT



## Results for ITA prototype

They are similar to the ones measured with System test board

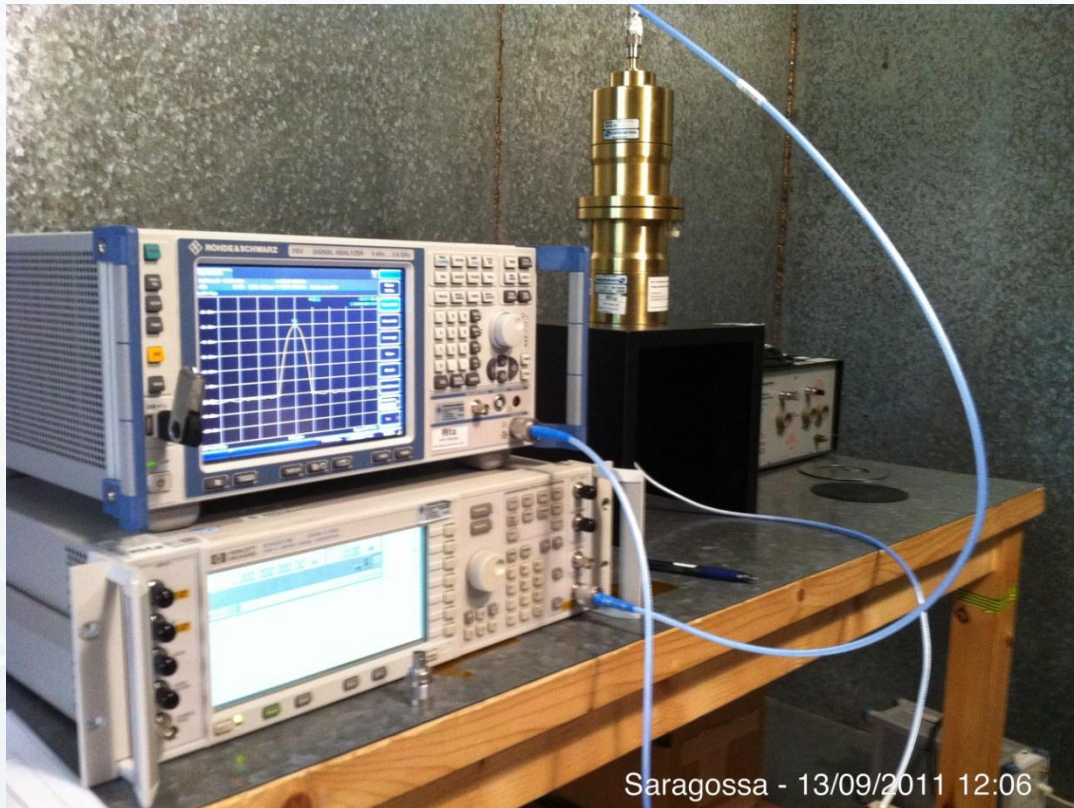
## INPUT



# 3. Working packages – Status & Plans

## WP2. Shielding effectiveness test of carbon fiber

- The carbon fiber is used in the development of double-stack structure.

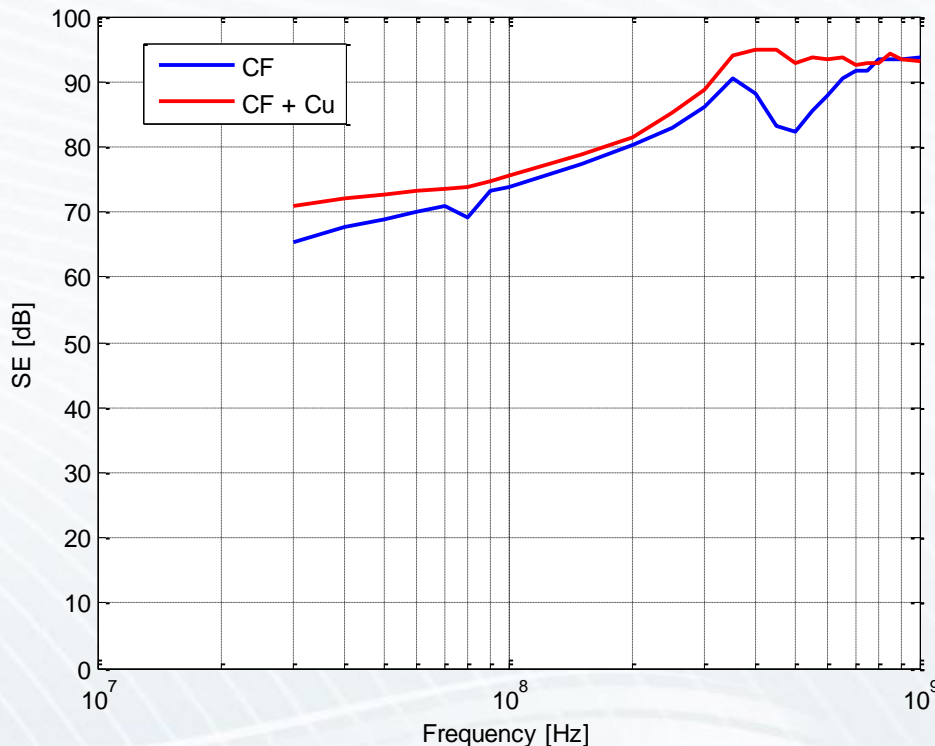


# 3. Working packages – Status & Plans

## Shielding effectiveness test to carbon fiber



- Sample 1: Carbon fiber
- Sample 2: copper insertion on carbon fiber



SHIELDING EFFECTIVENES	SE dB	ATEN.	%
POOR	20	10:1	90%
	40	100:1	99%
	60	1000:1	99,90%
	80	10000:1	99,99%
EXCELENT	100	100000:1	100,00 %

- They may be use as DC-DC converter shield
- More studies are required – Copper ground



# 3. Working packages – Status & Plans



- **WP 3: Noise immunity test in FEE prototypes**
  - *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 – Future works-

## Long & detailed tests campaign planned for next months

### 1.- Conducted emission test to DC-DC Aachen converter

### 2.- Radiated emission test (ITA and Aachen)

- Magnetic emission test to DC-DC converter.
- Electric emission test to DC-DC converter.
- Magnetic and electric emission test to DC-DC converter on double-stack carbon fiber developed by FERMILAB:
  - On double-stack carbon fiber
  - Inner double-stack carbon fiber
  - On double-stack structure not grounded, grounded one side, grounded two sides, grounded at the middle of the structure

### 3.- Multiple DC-DC converter test

- It is planned to install 4 or 5 DC-DC converters on the CF structure. Radiated and conducted emission test.





# 3. Working packages – Future works



## 4.- Radiated emission test

- Radiated emission test will be performed inside of the semi-anechoic chamber.
- Near and far field will be measured.
- The electromagnetic field will be measured using electric antenna (30 MHz to 1 GHz) and magnetic antenna (9kHz to 30 MHz) for near and far field.
- Radiated emissions test to different components to power system distribution, they will carry out with current probe and antenna:
  - Unshielding twisted cables
  - Shielding twisted cables
  - Radiated emissions on power distribution board



# 4. Conclusions

- EMC Tracker upgrade project is on going.
- This project is well founded by Spanish R&D program and ITA
- The project is divided in 4 WP
- WP1, WP2 & WP4 has started
  - WP1 focused on impedance effects on noise emission is finished
  - WP2 focused on power network issues- on going
  - WP3 is planned
  - WP4 focused on development of high immunity systems is on going

