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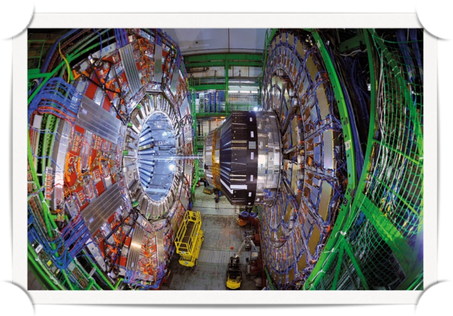
XXIX Cycle - II year presentation

Fibre optic sensors for high energy physics

Use of fibre grating sensors for monitoring and mapping environmental, mechanical and dosimetric parameters in harsh environments with high level of ionizing radiation (CERN facilities, Nuclear power plants, …)



Key feutures

- High sensitivity
- Immunity to electromagnetic interference
- Lightweight
- Versatility
- Absence of electronic circuitry in the measurement area
- Multiplexing capability
- Reduction of cabling complexity

CMS iPipe project

The CMS beam pipe is part of the Large Hadron Collider (LHC) and it is the place where the high energy proton-proton collisions take place. It is made of a beryllium tube section, 3m long with a central diameter of 45mm and 0.8mm thickness wall, sealed on the two extremities with two conical aluminum sections, each 1.5m long. Our monitoring system consists of four “naked” glass 28SMF fibers placed along the cardinal longitudinal positions on beam pipe cross section. On each fiber, 16 FBGs have been manufactured: 7 are glued on the BP to measure the local strain and the remaining 9 are left unglued but in contact with the BP in order to work as local thermometers and as temperature compensators for the adjacent strain sensors. This innovative FBGs SHM system will be a milestone for any future beam pipe monitoring in High Energy Physics domain.

A Fiber Bragg Grating is made by periodical changes of the Refractive Index (RI) in the glass core of a single-mode optical fiber

$$\lambda_B = 2n_{eff}\Lambda$$

By measuring the changes in λ_B is possible to use the FBG sensors as strain-gages and as thermometers:

$$\frac{\Delta\lambda_B}{\lambda_B} = (1-p_e)\epsilon + \left(\alpha_\Lambda + \frac{1}{n}\frac{\delta n}{\delta T}\right)\Delta T$$

Direct Strain [Λ] Elasto-optic [nₑff] — Thermal expansion [Λ] Thermo-optic [nₑff]

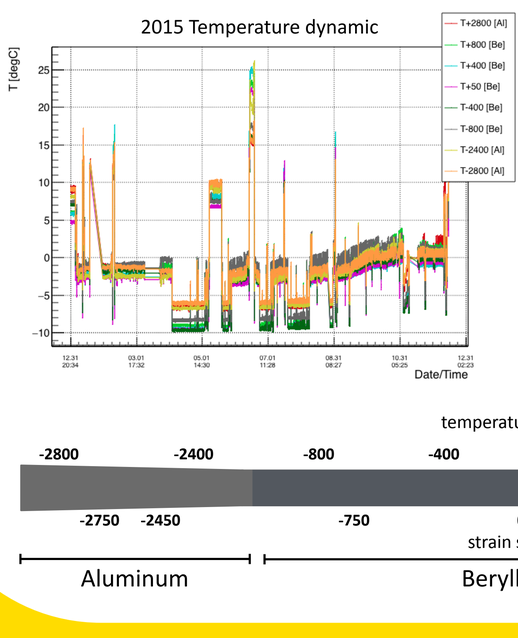
Calibration parameters optimization

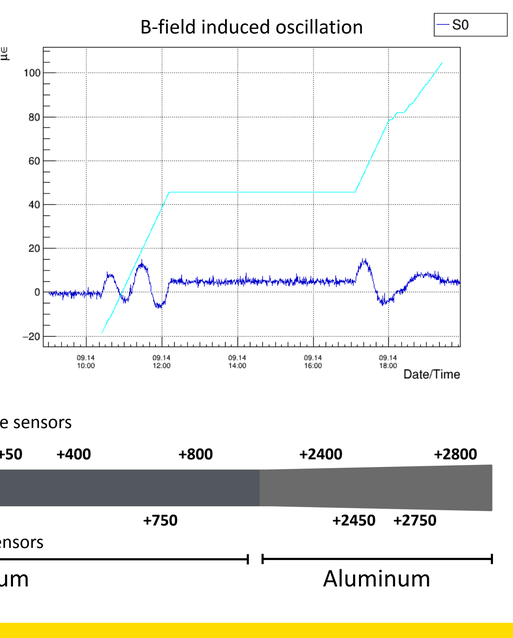
Temperature measurements validation

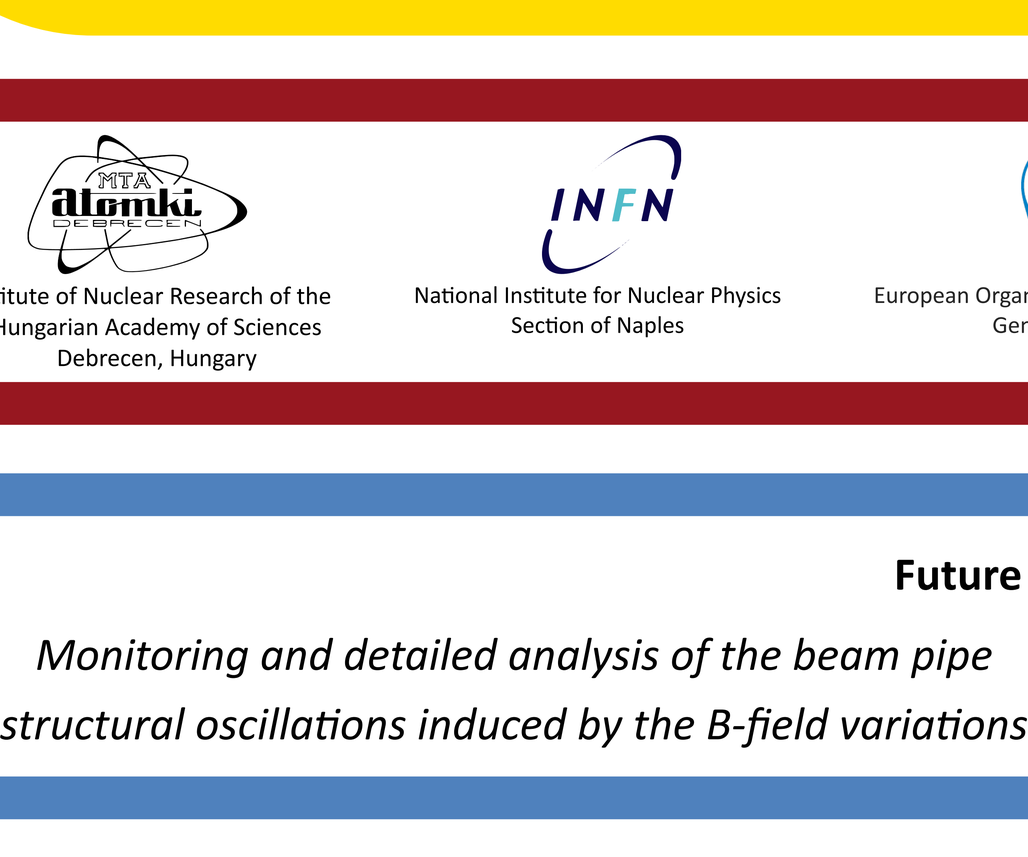
Long-term temperature and strain monitoring

Definition of the strain calculation method

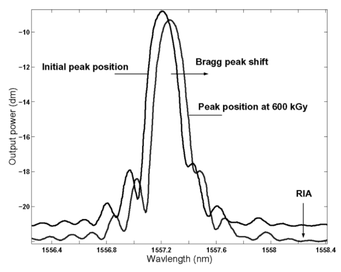
B-field (3.8T) induced oscillation analysis







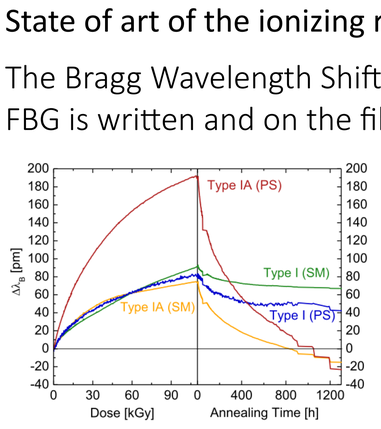
Fibre grating sensors radiation hardness

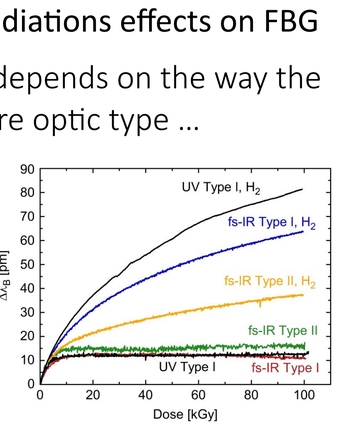


State of art of the ionizing radiations effects on FBG

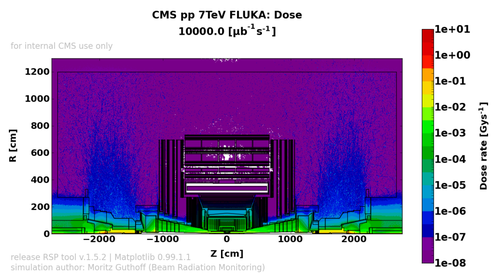
The Bragg Wavelength Shift depends on the way the FBG is written and on the fibre optic type …

$$\frac{\Delta\lambda_B}{\lambda_B} = \frac{\Delta n_{rad}}{n_{eff}} + \frac{\Delta\Lambda}{\Lambda}$$





Definition of new tests aimed to quantify experimentally the effect of the effective ionizing radiation dose absorbed by the sensors during a typical LHC run, with the real dose rate.



Fibre gratings dosimeter

Developing a new, fibre grating based, dosimeter for low dose, up to the kGy

Fibre gratings refractive index sensors:

LPG, etched FBG, tilted FBG

+

Chemical solution sensitive to ionizing radiation:

Fricke, or ferrous sulphate, dosimeter

+

Additional, rad hard, temperature sensor:

femtosecond IR fibre Bragg grating

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Geneva, Switzerland

Physics Department
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Optoelectronic Division Engineering Department, University of Sannio, Benevento

Future developments

Monitoring and detailed analysis of the beam pipe structural oscillations induced by the B-field variations

Radiation effects tests on LPG and FBG at CERN

Fibre grating dosimeter R&D