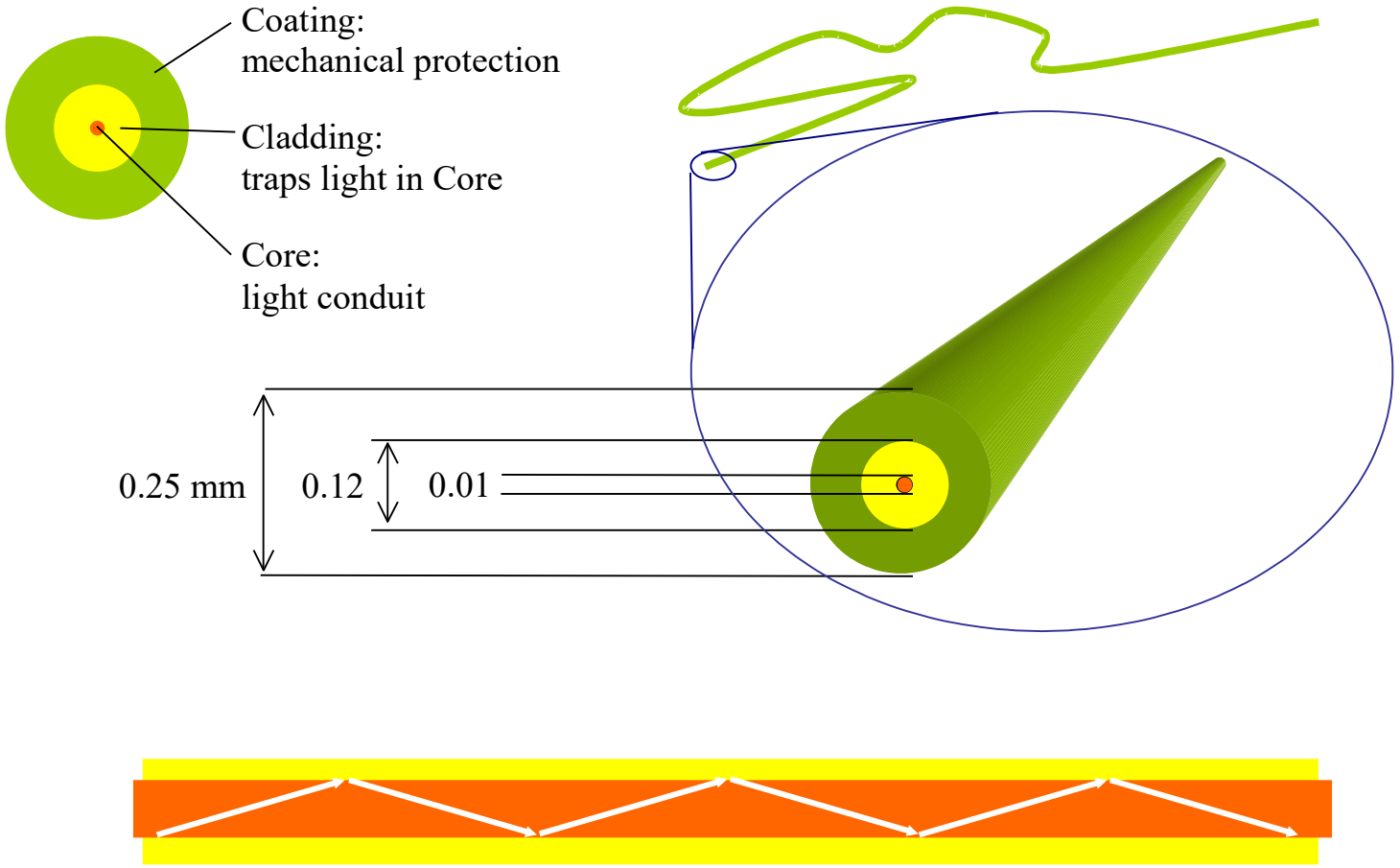
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Optical sensors based on Fiber Bragg Grating technology

ENEA/CRF & INFN/LNF expertise in developing monitoring systems for HEP experiments

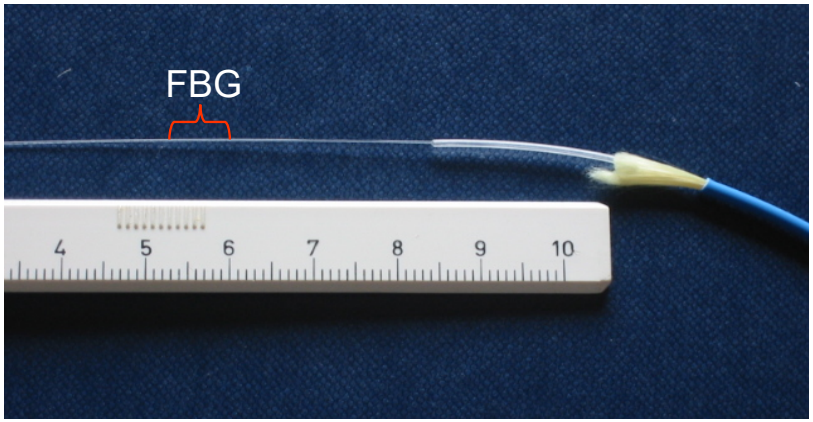
M. A. Caponero ENEA and INFN
on behalf of CYGNO/Frascati

Optical fibre: thin and flexible light delivery 'pipe'.



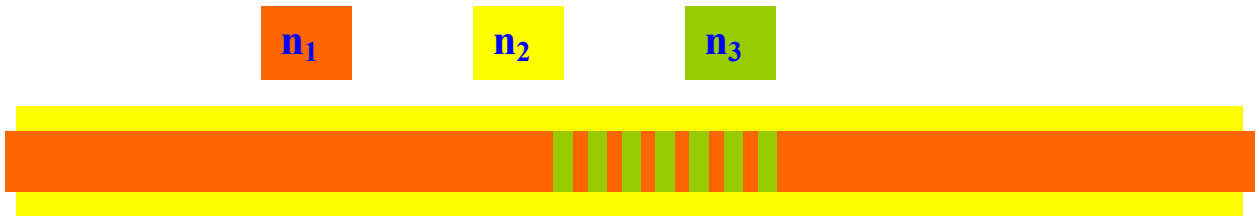
Fibre Bragg Grating (FBG) sensor: diffraction grating along the fibre axis.

Diffraction grating is produced by modulation of the Core refractive index.



Optical fibre before FBG production

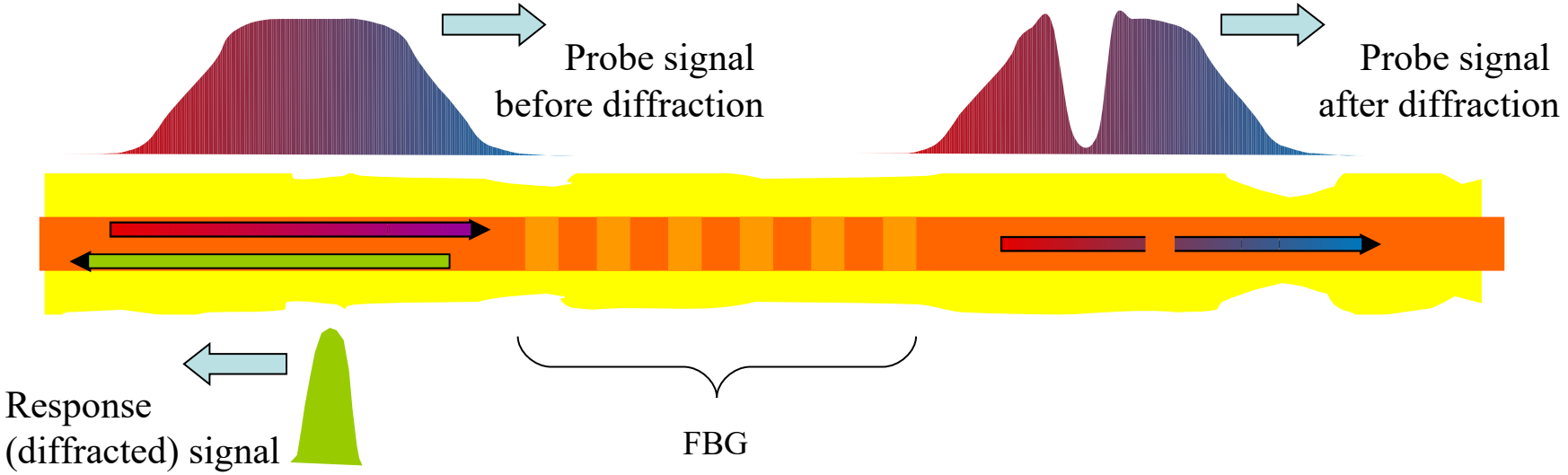
Core: constant refractive index (n_1)
Cladding: constant refractive index (n_2)



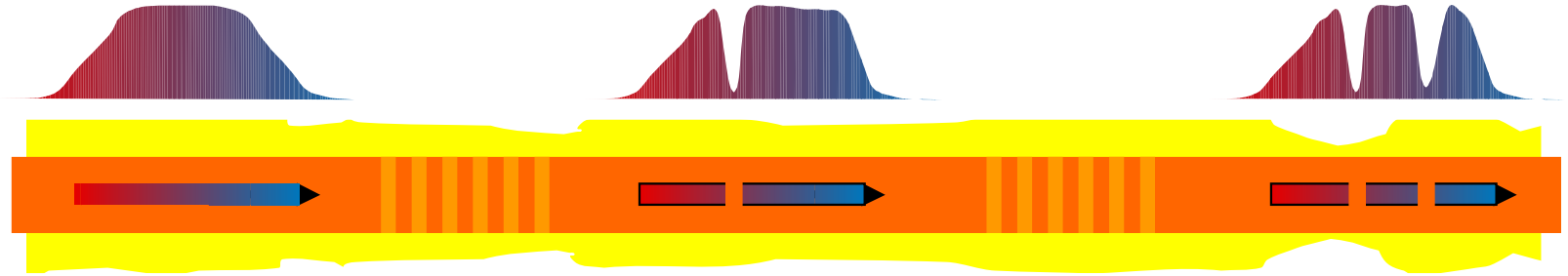
Optical fibre after FBG production

Core: local modulation of refractive index (n_1 & n_3)
Cladding: constant refractive index (n_2)

Light propagating along the optical fibre is diffracted (back-reflected) by FBG



Many FBGs at different λ_{BRAGG} can be arranged along one optical fibre



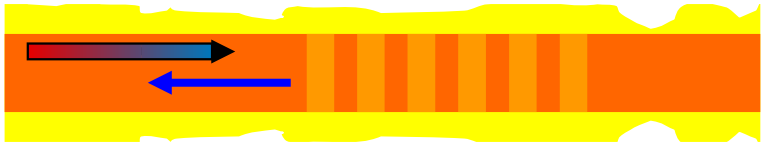
Diffracted wavelength depends on FBG geometry, that is affected by Temperature and Strain.

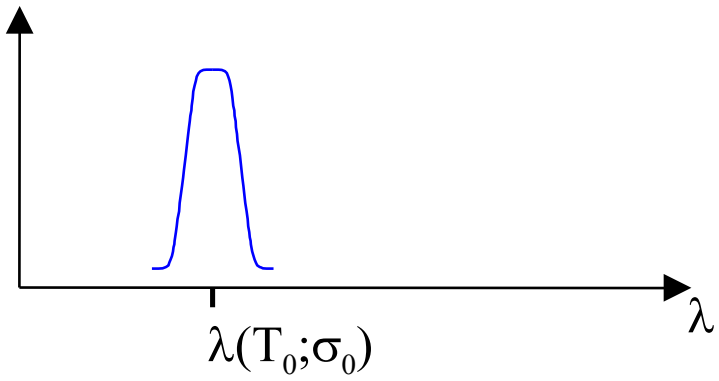
Typical values:

$\Delta\sigma = 1 \quad \mu\varepsilon \quad \Rightarrow \quad \Delta\lambda = 1$ pm

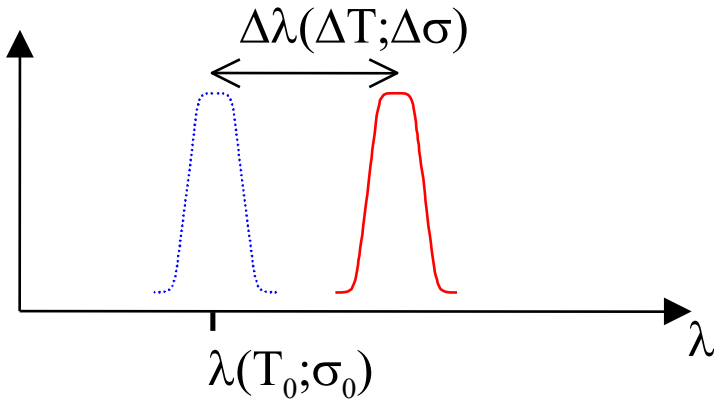
$\Delta T = 0.1 \quad °K \Rightarrow \quad \Delta\lambda = 1$ pm

Fibre 'at rest' $(T_0;\sigma_0)$



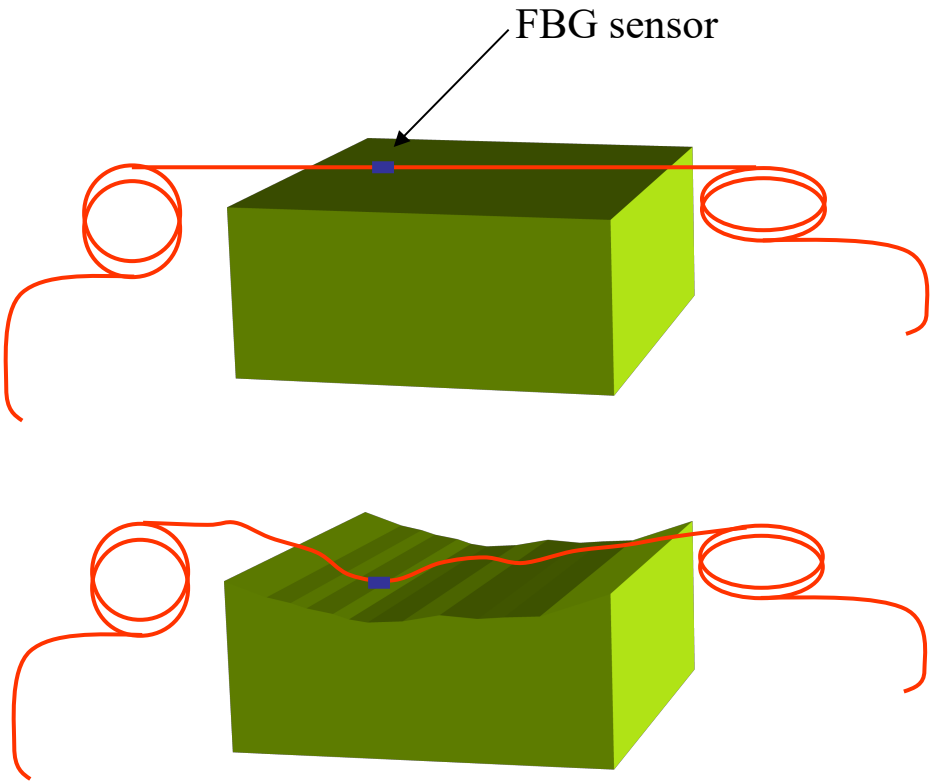


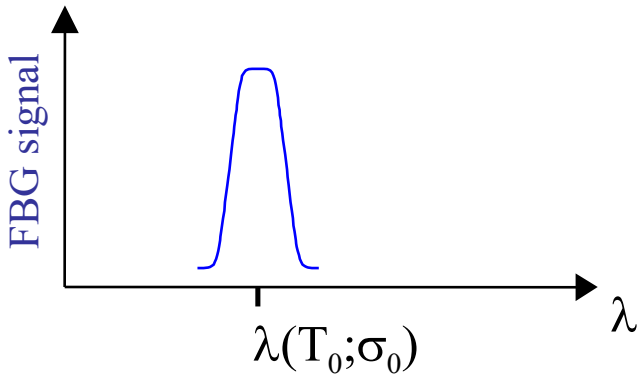
Fibre stressed $(T_0+\Delta T;\sigma_0+\Delta\sigma)$

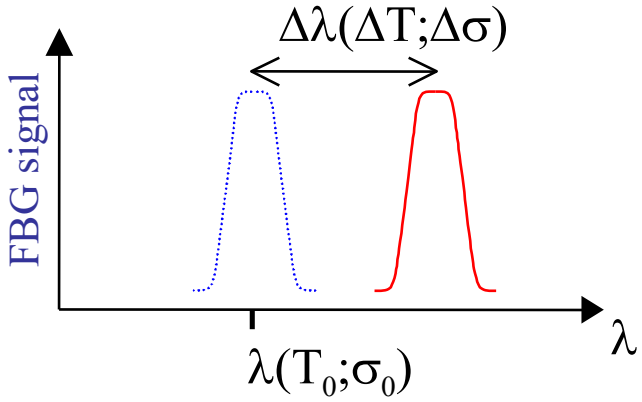


FBG

Deformation and temperature of a structure can be monitored by stuck/embedded FBGs.







FBG main features

- high dynamic range (>>KHz)
- long term stability
- insensible to e.m. disturbances
- rad-hard
- large operating temperature range (400°C ÷ cryo)
- reduced cabling by WDM

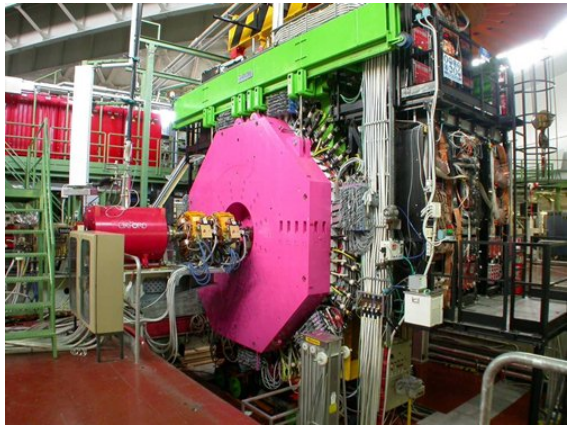
Various measurands

(resolution depends on measurement range and operating conditions)

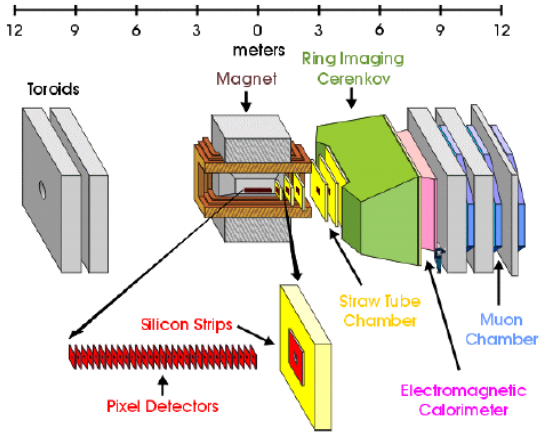
- Temperature and Strain
- Humidity
- Displacement
- Static Magnetic Field

EXPERTSE IN MONITORING EXPERIMENTS OF HIGH ENERGY PHYSICS

FINUDA
DAΦNE - Frascati



BTeV
TEVATRON - Fermilab



CMS
LHC - CERN

SOME PAST WORKS - USE OF FBGs FOR MONITORING VARIOUS PARAMETERS

deformation of structures

E.Basile et al physics/0512255

(re-)positioning

L.Benussi et al Nucl Phys Proc Suppl 172(2007)263-265

GEM foil tension

D.Abbaneo et al NIM A824(2016)493

L.Benussi et al arXiv:1512.08629

temperature

L.Benussi et al Phys. Procedia 37(2012)483

RH

M.Caponero et al JINST 8 (2013) T03003

G.Saviano et al 10.1109/ICSensT.2011.6136946

contaminants in gas mixture

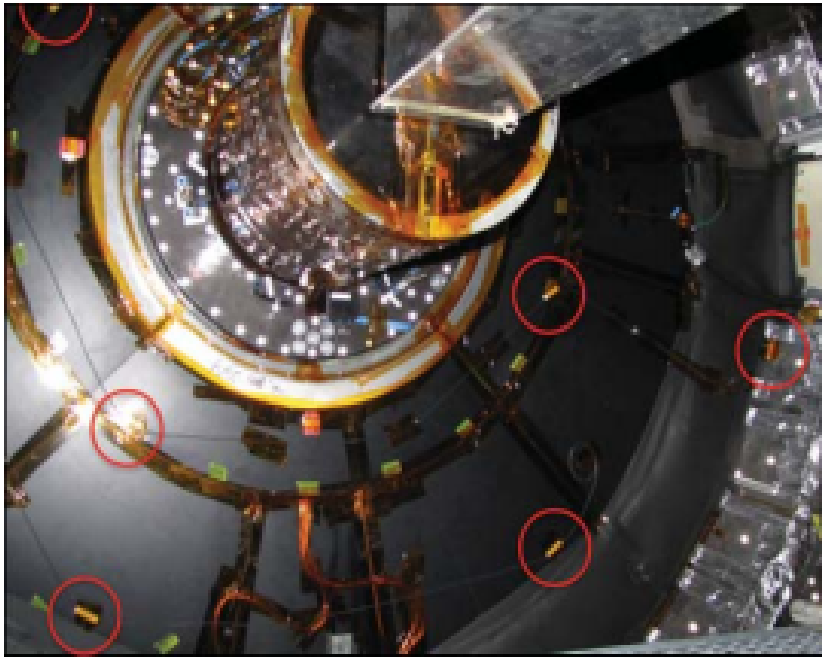
S.Grassini et al 2012 JINST 7 P12006

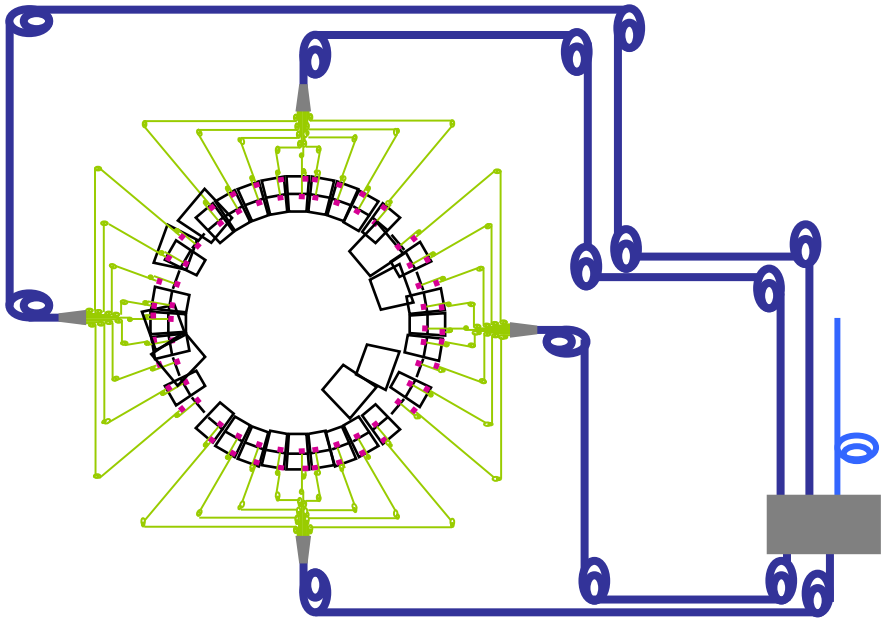
G.Saviano et al Zeosensors ®

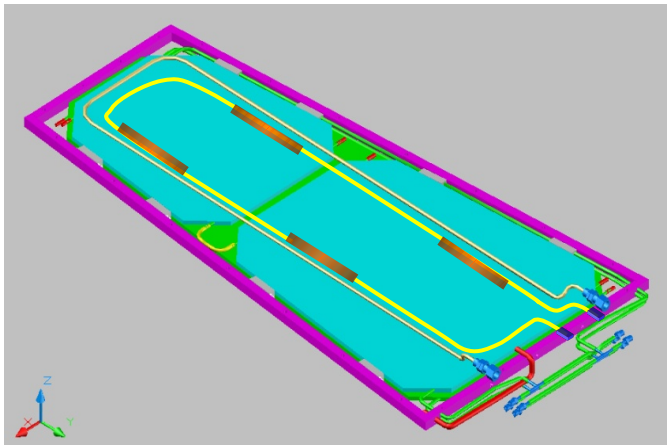
CMS Experiment

Development of custom FBG sensors for RPC chambers

Design and testing of the engineered sensing system



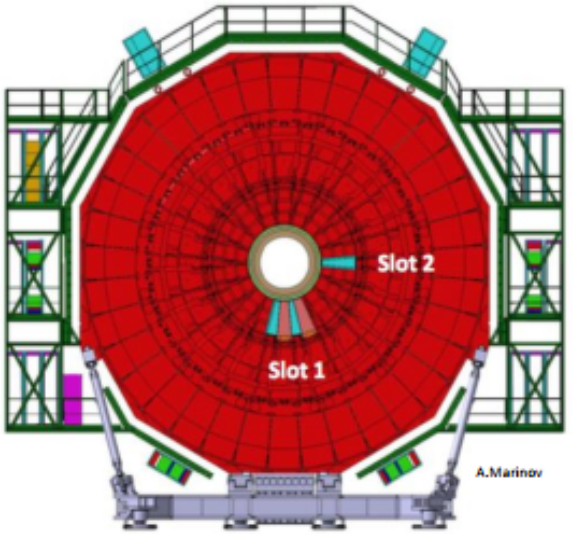


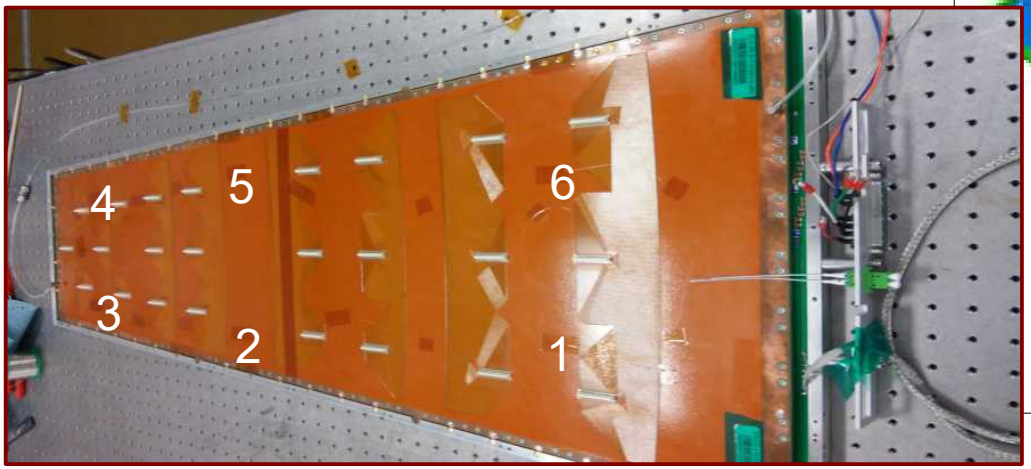


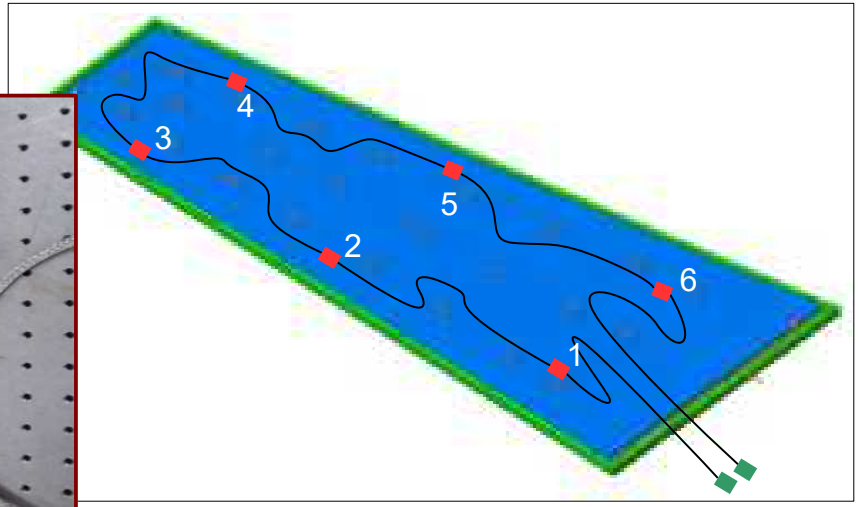
CMS Experiment

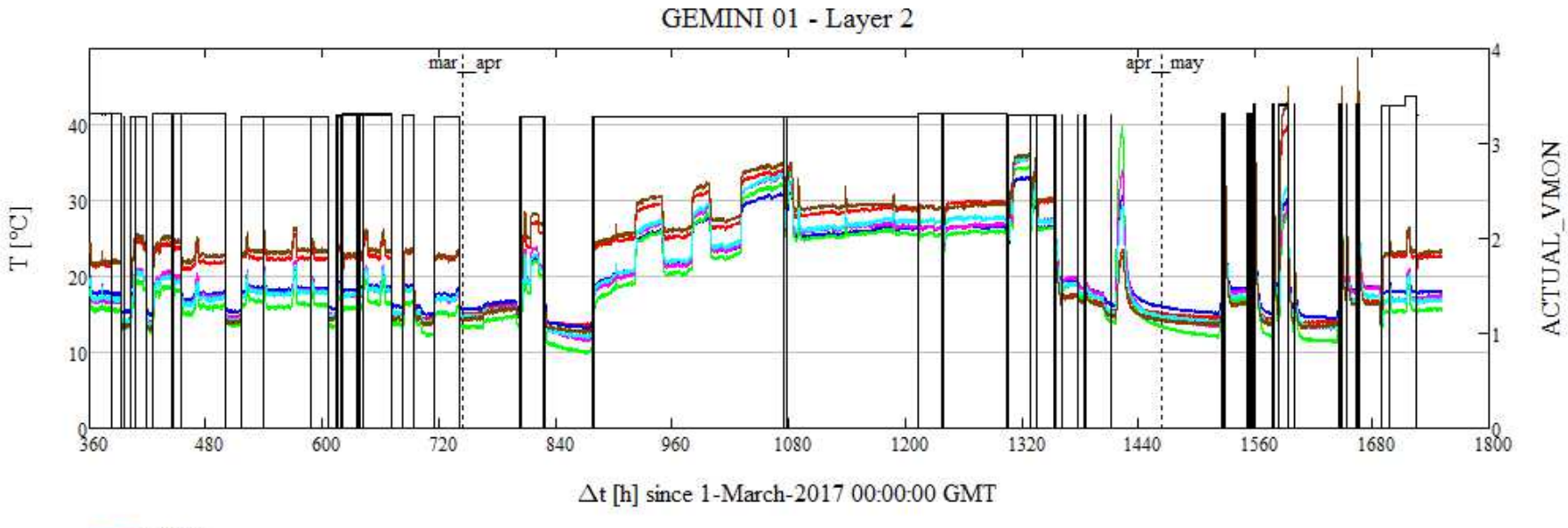
FBG Temperature sensor to be installed on GEM chambers during 2013 Long Shut-Down

Preliminary test on few prototypes during 2017 run ("Slice Test")



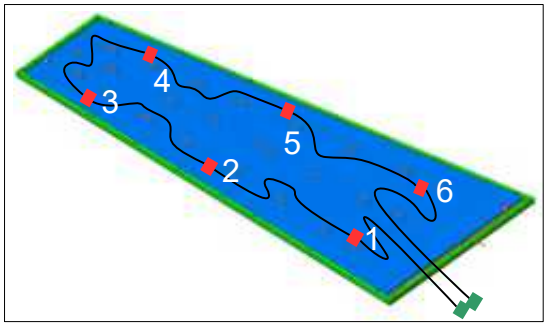




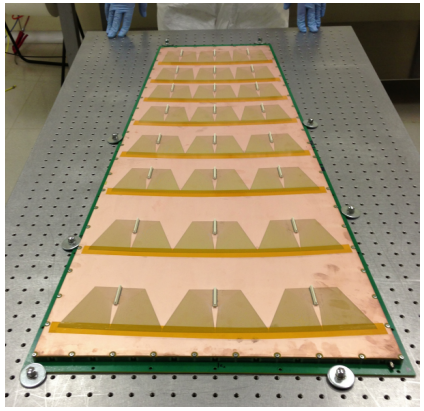


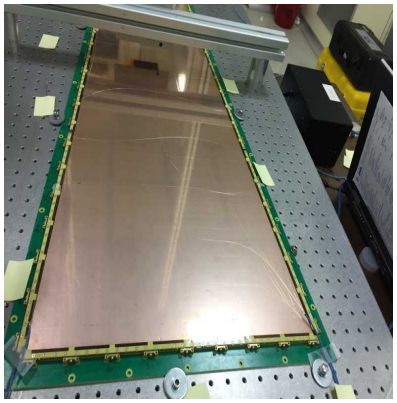
CMS Experiment - "Slice Test"

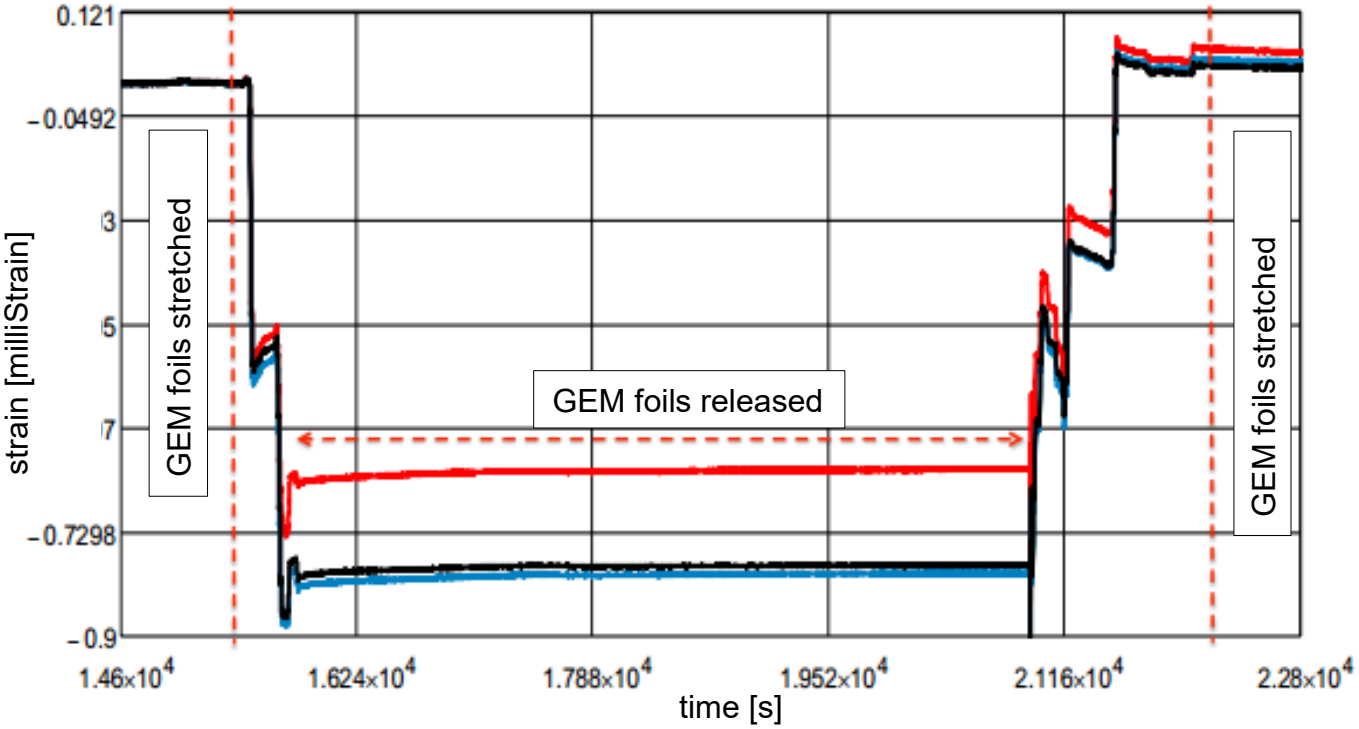
Time History:
temperature (Y-left)
on-board optohybrid on/off (Y-right)



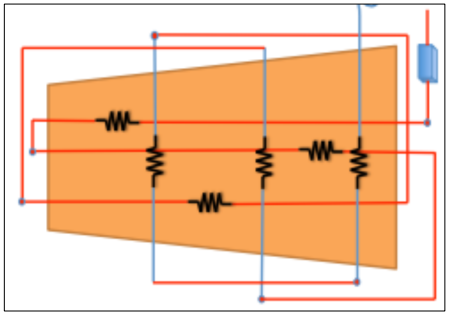
MONITORING TENSIONINING OF GEM FOILS







Test of the mechanical "scres & clamps" stretching system



Position of FBGs

Application	Necessary R&D
deformation of structures	Low
(re)-positioning	Medium
tension of GEM foils	Low
temperature	Low
humidity	Medium
contaminants in gas mixture	High

Can FBGs and our expertise be of interest for CYGNO / INITIUM ?