Fiber Bragg Grating (FBG) Sensors For Micromegas

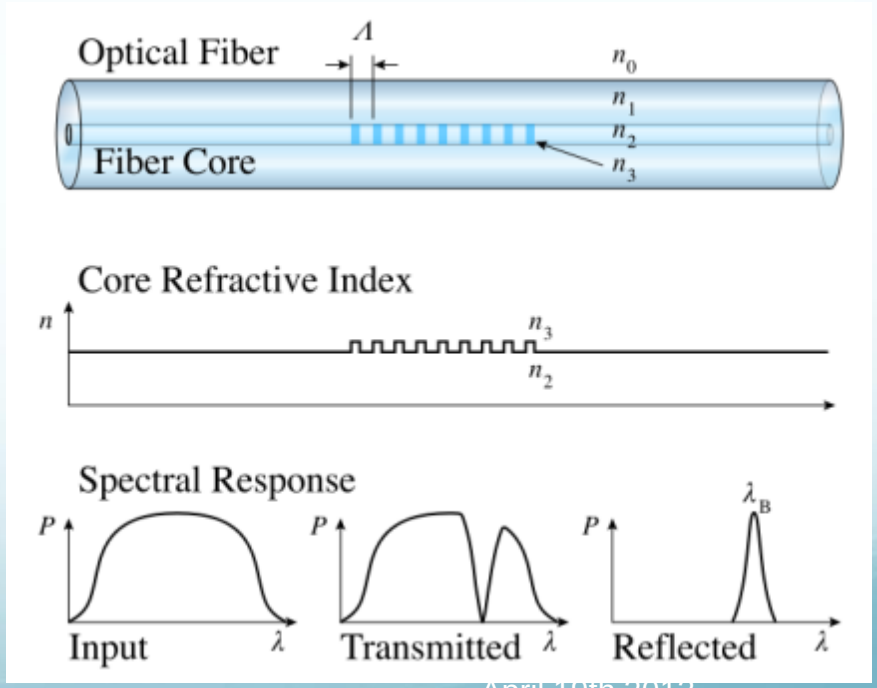
S. Campopiano, A. Iadicicco
(University of Naples "Parthenope")
M. Della Pietra
(University of Naples "Parthenope" and INFN sez Naples)
V. Canale, P. Iengo
(INFN sez. Naples and University of Naples "Federico II")

Outline

- FBG sensors
- Previous experience in HEP
- Experimental setup
- Preliminary results
- Plan for next measurements

FBG sensors

- A sensor based on Fiber Bragg Grating is an optical fibre where the refractive index in the fibre's core has an induced period variation, in such a way to produce a “grating” on which the light undergoes the Bragg diffraction.
  - In this way the reflected spectrum has a peak centred on a wavelength λ_B that is a function of Λ, the period of the refraction index changing



FBG sensors

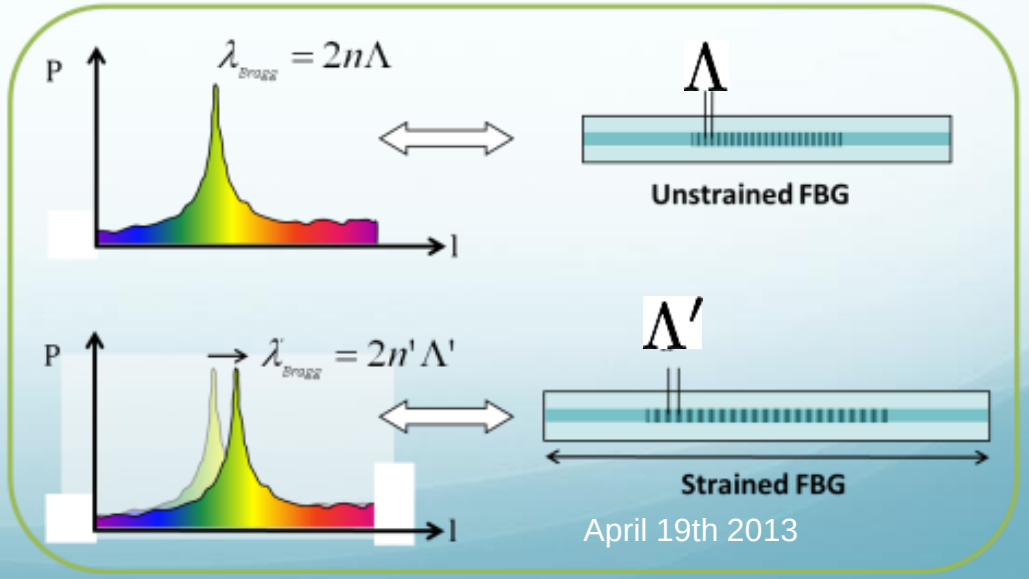
- With more details, if the period of refraction changes due to an external strain ε and/or a temperature variation ΔT, the Bragg wavelength changes according to the law:

$$\Delta\lambda_B = k_\epsilon\,\epsilon + k_T \Delta T$$

$$k_\epsilon \simeq 1.2\ \mathrm{pm}/\mu\epsilon$$

$$k_T \simeq 10\ \mathrm{pm}/K^\circ$$

$$\epsilon = \frac{\Delta L}{L}$$



FBG sensors

- Clearly the strain ε could be due both to an external mechanical stress and to a temperature change.
- Two sensors (one mechanically coupled and the other not) are usually used to disentangle the two effects

$$\Delta\lambda_B = k_\epsilon\ \epsilon + k_T \Delta T$$

$$k_\epsilon \simeq 1.2\ \mathrm{pm}/\mu\epsilon$$

$$k_T \simeq 10\ \mathrm{pm}/K^\circ$$

FBG sensor in HEP

- These sensors have a wide use in many fields, such as industry, space technology, healthcare, civil nuclear industry
- Their performance are similar to strain gauge with the advantage that:
  - many FBG sensors can be installed on the same fiber and can be read out at once;
  - FBG sensors are insensitive to environmental electromagnetic fields.
  - FBG sensors can be distributed over a long range system (up to few tens of kilometres)

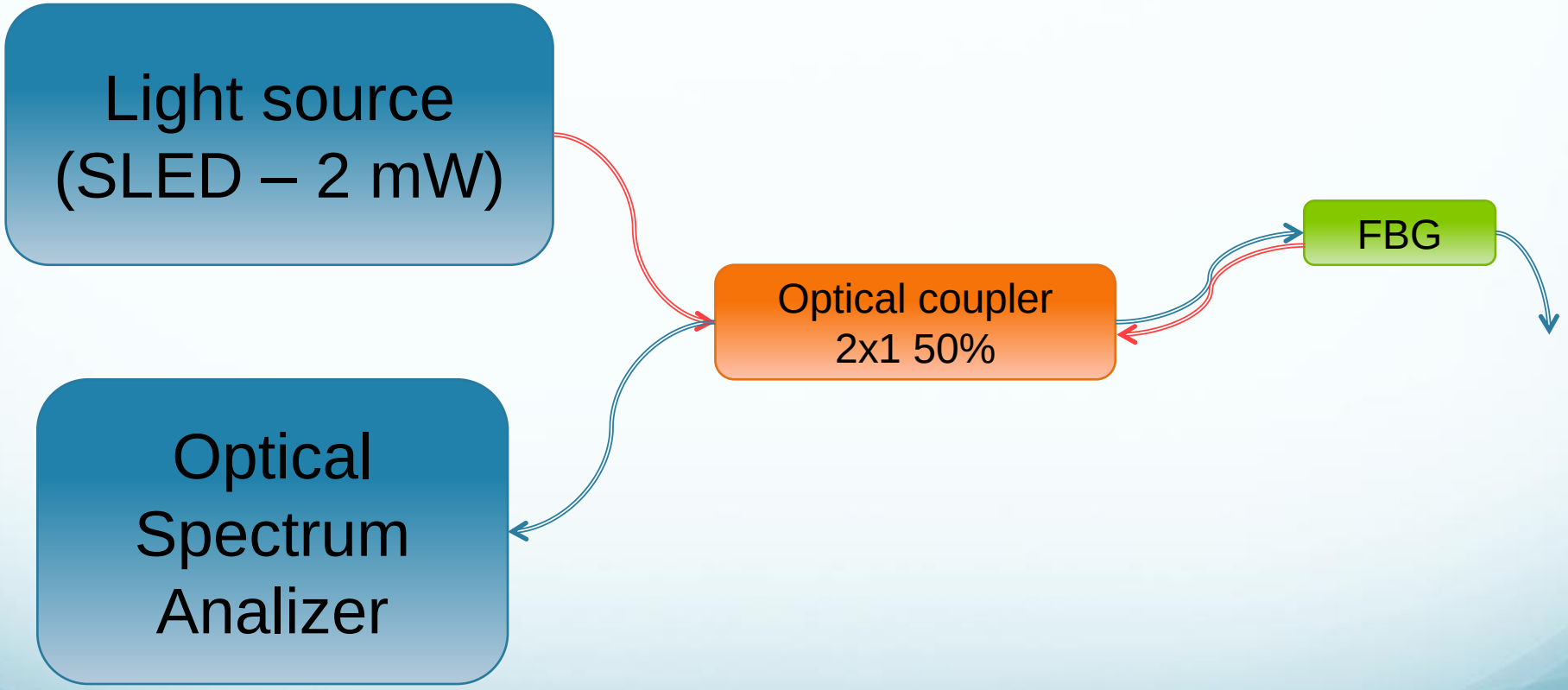
FBG sensor in HEP

- Since few years there is big interest in these optical fiber sensors in the High Energy Physics community for several reasons:
  - Well know radiation hardness behaviour of the fibers
  - No sensitivity to external electromagnetic fields
  - Tiny dimension of the sensors (few hundreds of microns)
  - Many sensors can be implemented on the same fiber and can be readout simultaneously in an easy way
- Strain and temperature sensors have been installed in CMS since 2010
  - Temperature monitoring for the Tracker
  - Strain monitoring for the very forward calorimeter detector
- A lot of R&D is ongoing to develop humidity, chemical radical and B-Field sensors with the same technique

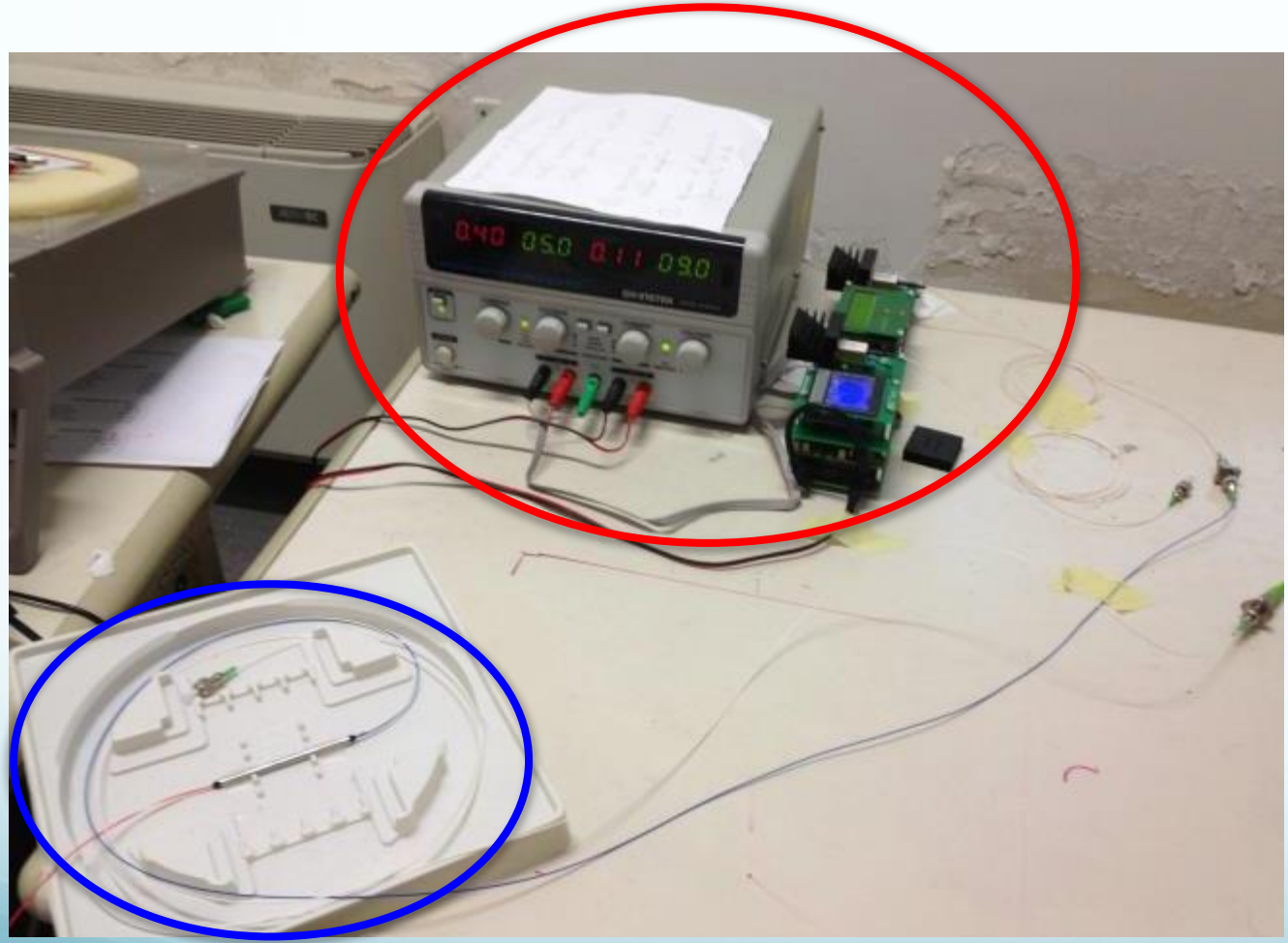
FBG on micromegas

- Try to understand if we can use these sensor as a monitor of the deformation of the detector.
- This technique is complementary to the alignment system.
- Very preliminary work done using FBG on the MM support panel (2nd gluing trial in Rome 1 lab)
- FGBs used both as strain and temperature sensor
- Deformation on the panel induced by bending it under pressure of a known weight.

Experimental setup



Experimental setup



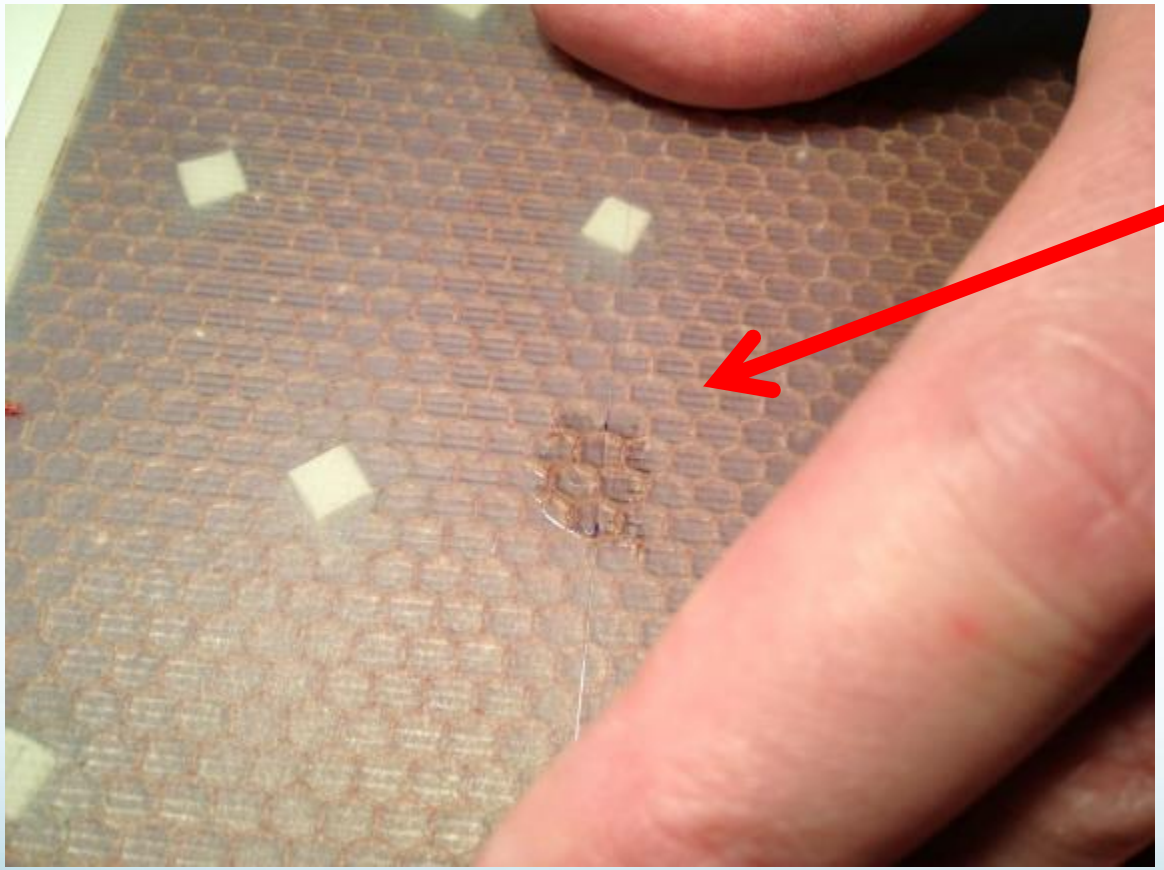
SLED Source

Optical coupler

Experimental setup

OSA with a single point resolution of 20 pm

Experimental setup

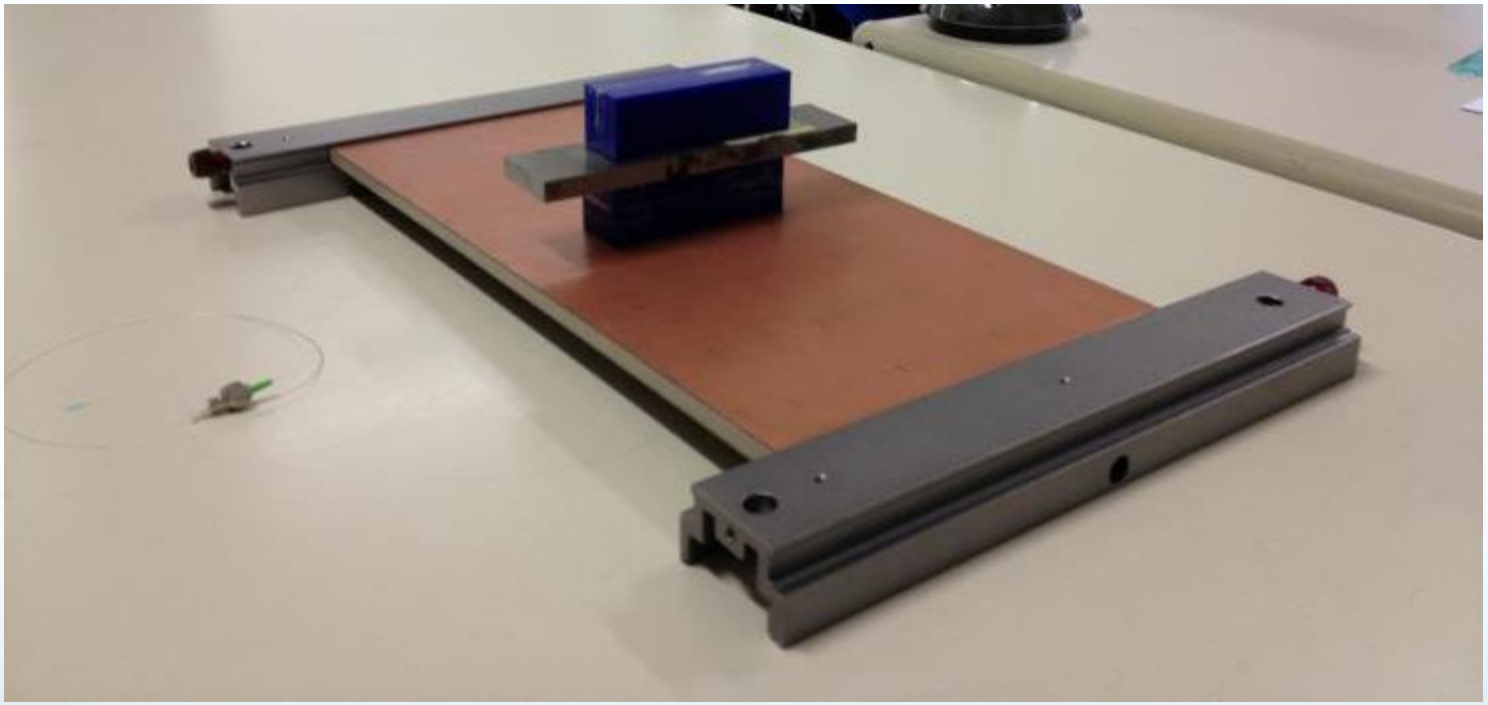


FBG sensor glued on the support plane

Glue is the commercial loctite

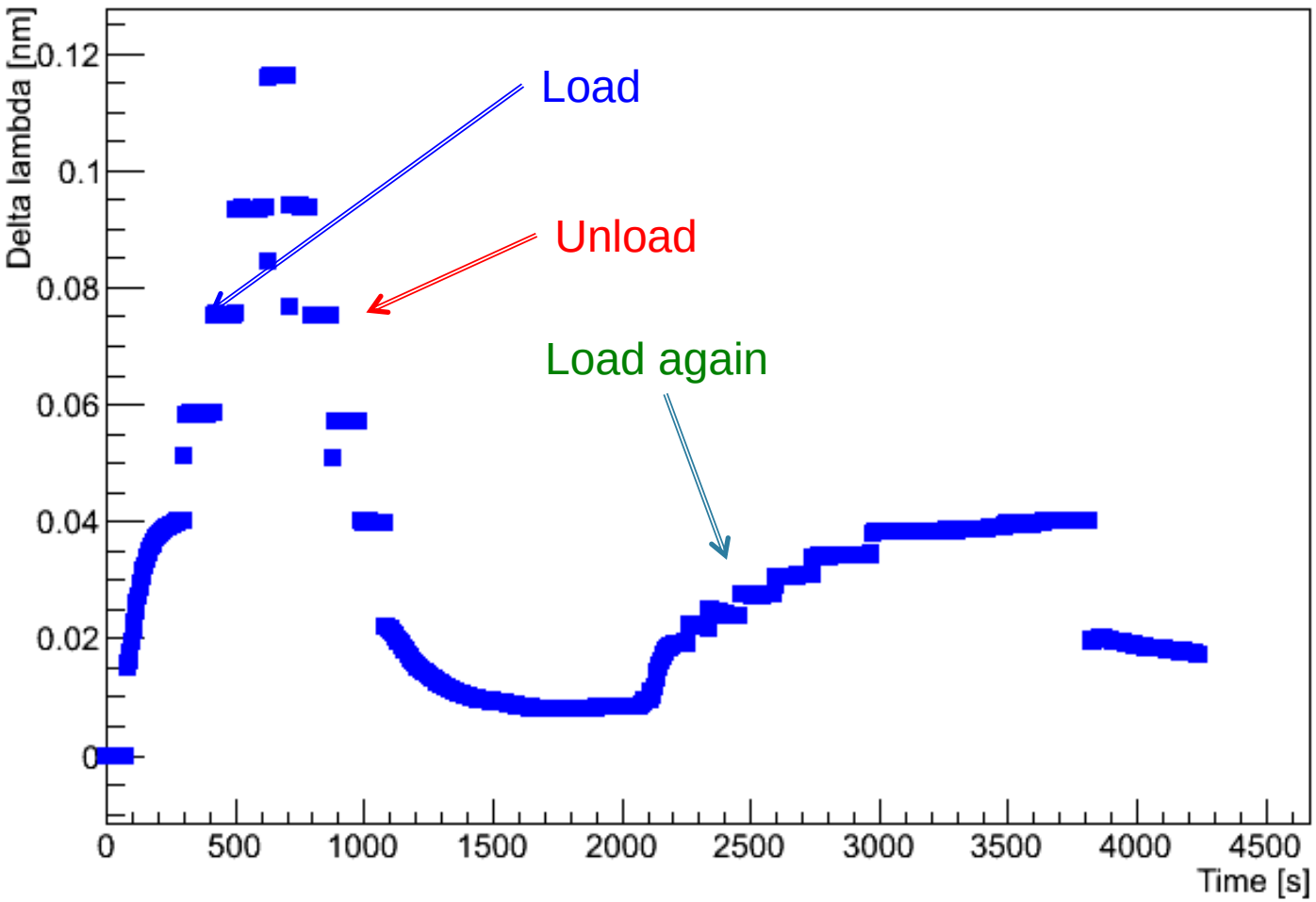
Fiber dimension is 125 micron

Experimental setup

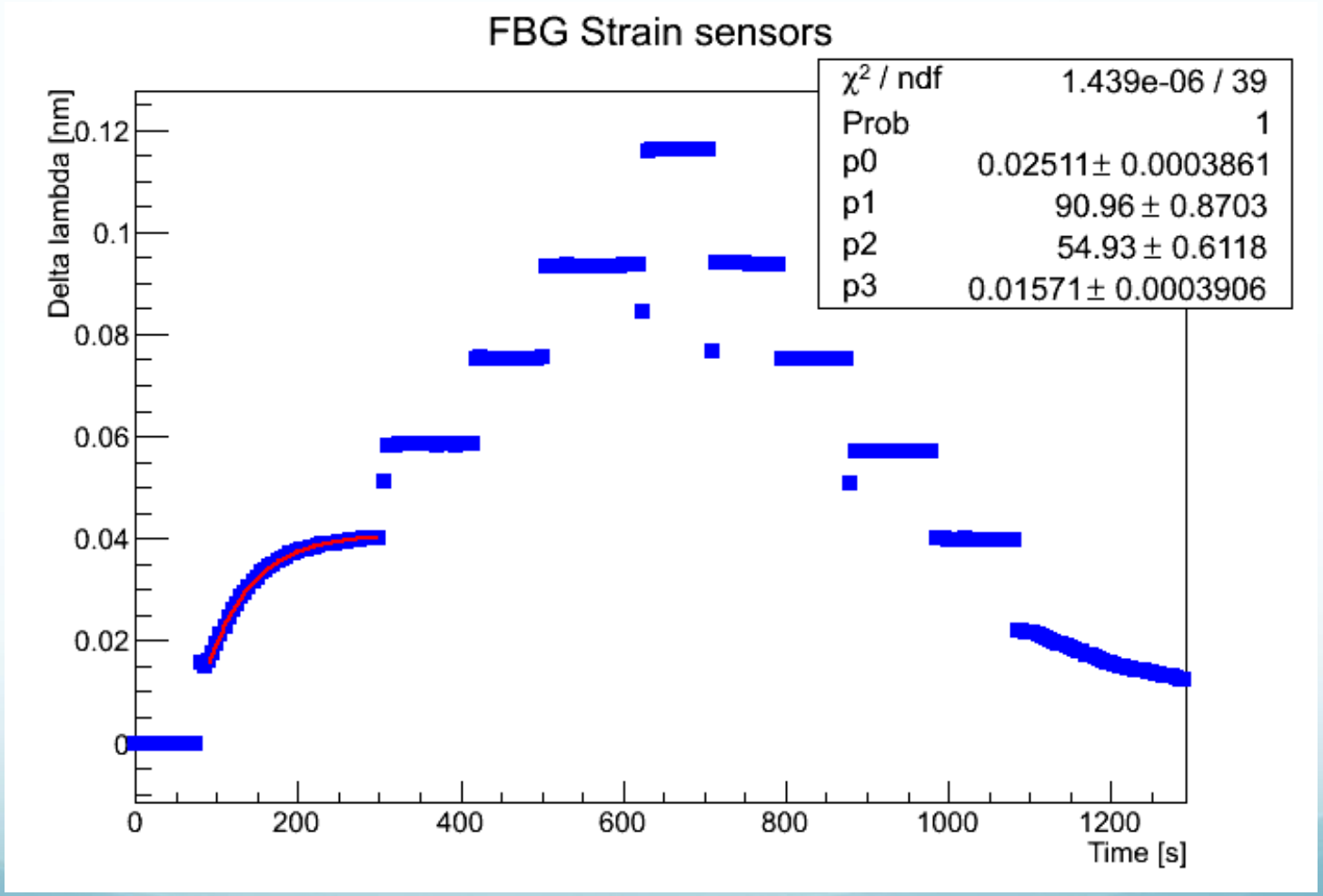


FBG sensor is glued on the bottom surface
Load is applied on the top one

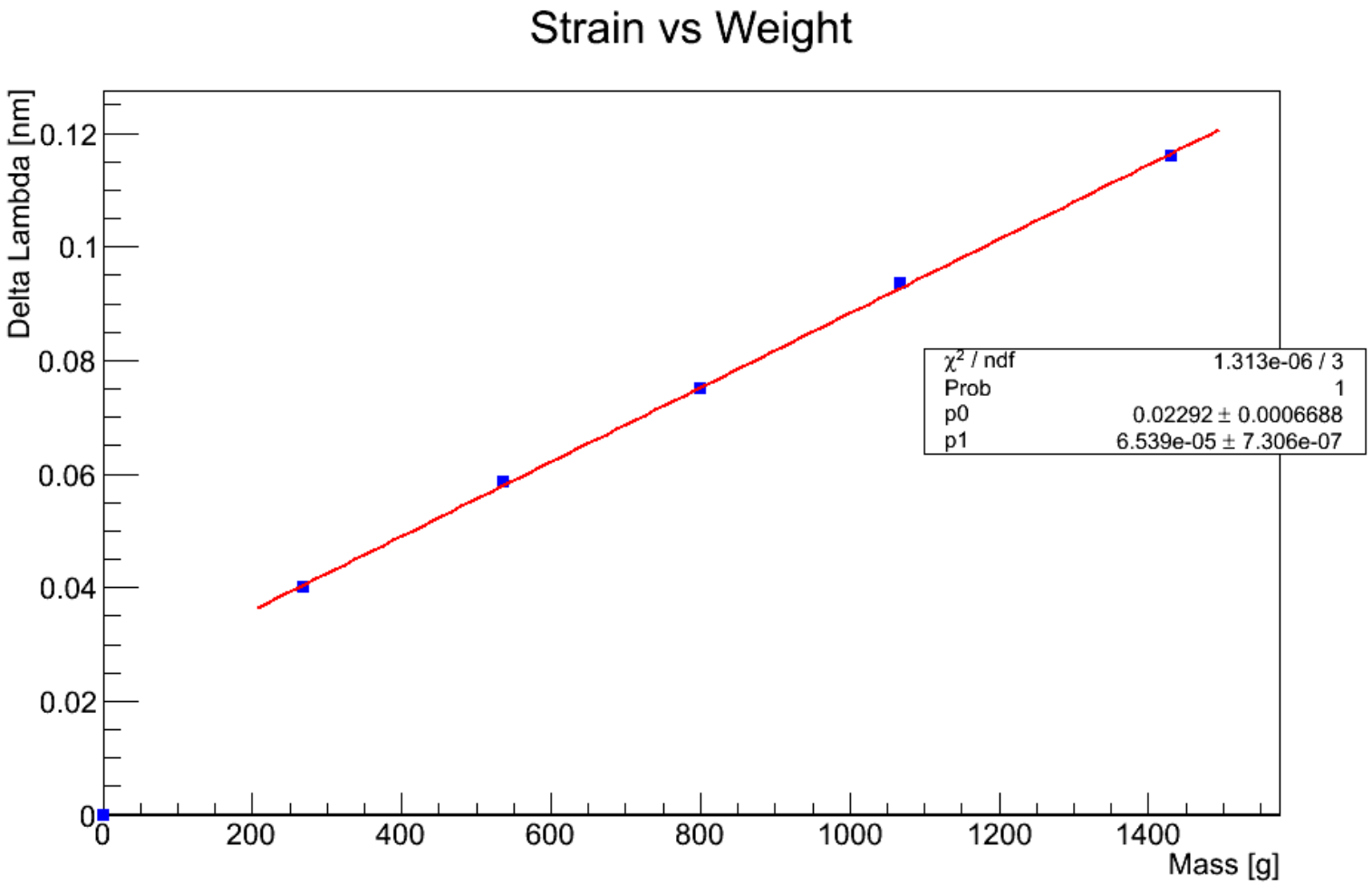
Preliminary results



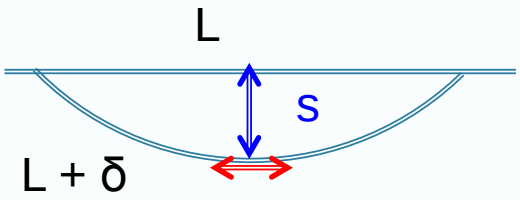
Preliminary results



Preliminary results



Preliminary results



FBG sensor

$$s \simeq 3 \sqrt{\frac{\epsilon\,(1-\epsilon)}{24}}\; L$$

$$L = 40 \text{ cm}$$

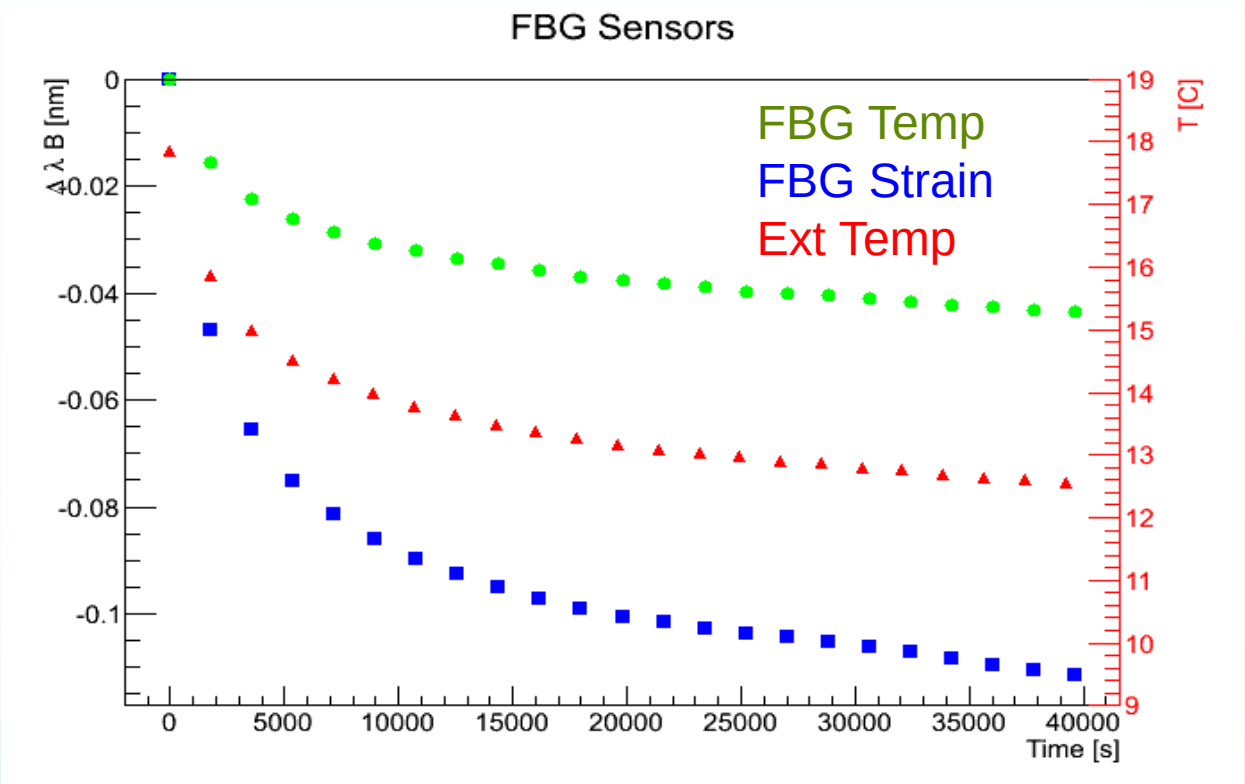
$$\epsilon = \frac{L+\delta}{L} = 10^{-4}$$

$$s \simeq 2.5 \text{ mm}$$

Good agreement with a simple model:

1. **Panel is bent as an arc**
2. **Strain is uniform over the surface**

Preliminary results



All night long data taking with no load on the panel:

- Strain (blue curve) is only due to thermal expansion
- 120 pm of shift corresponds to about 5 degrees in T

Work in progress

- More data taking in different condition;
  - Measurement of strain in both coordinates;
  - Measurement of planar deformation by the difference of strains measured on both sides of the panel;
- Correction of thermal strain by temperature variations
- Try to glue the fiber with the correct glue
- Need a mechanical simulation to understand the right number of sensors and their position on the detector.