PANDA Fw Endcap EMC, status prototype

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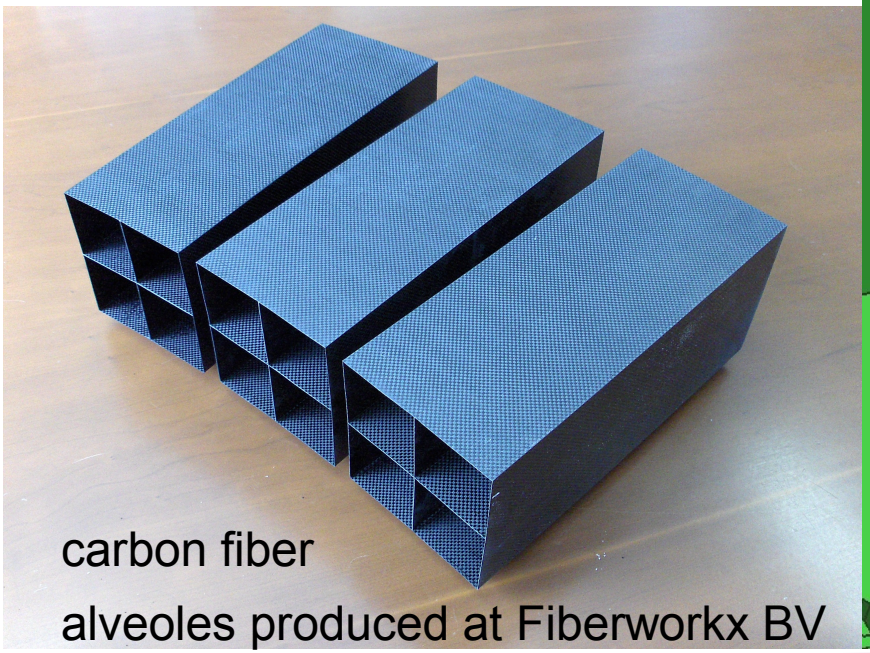
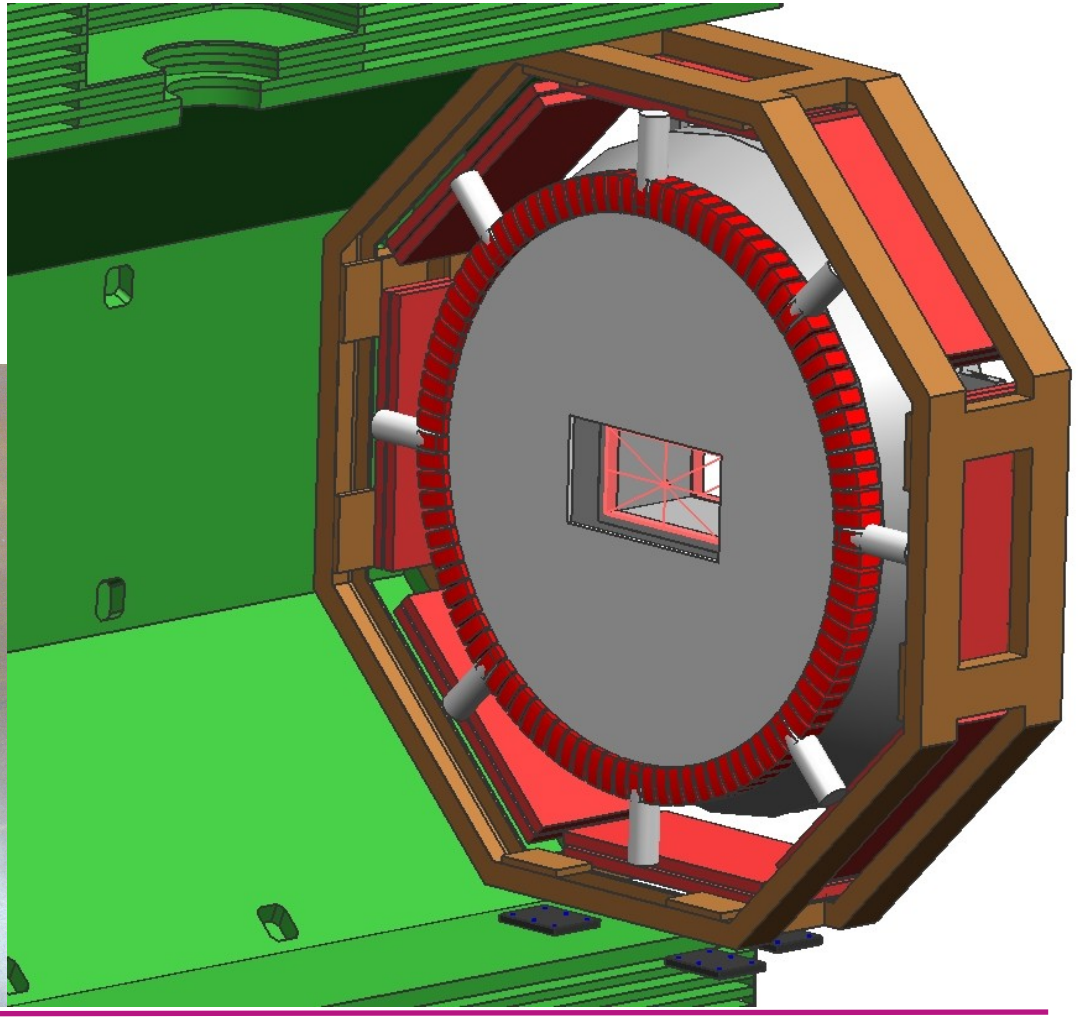
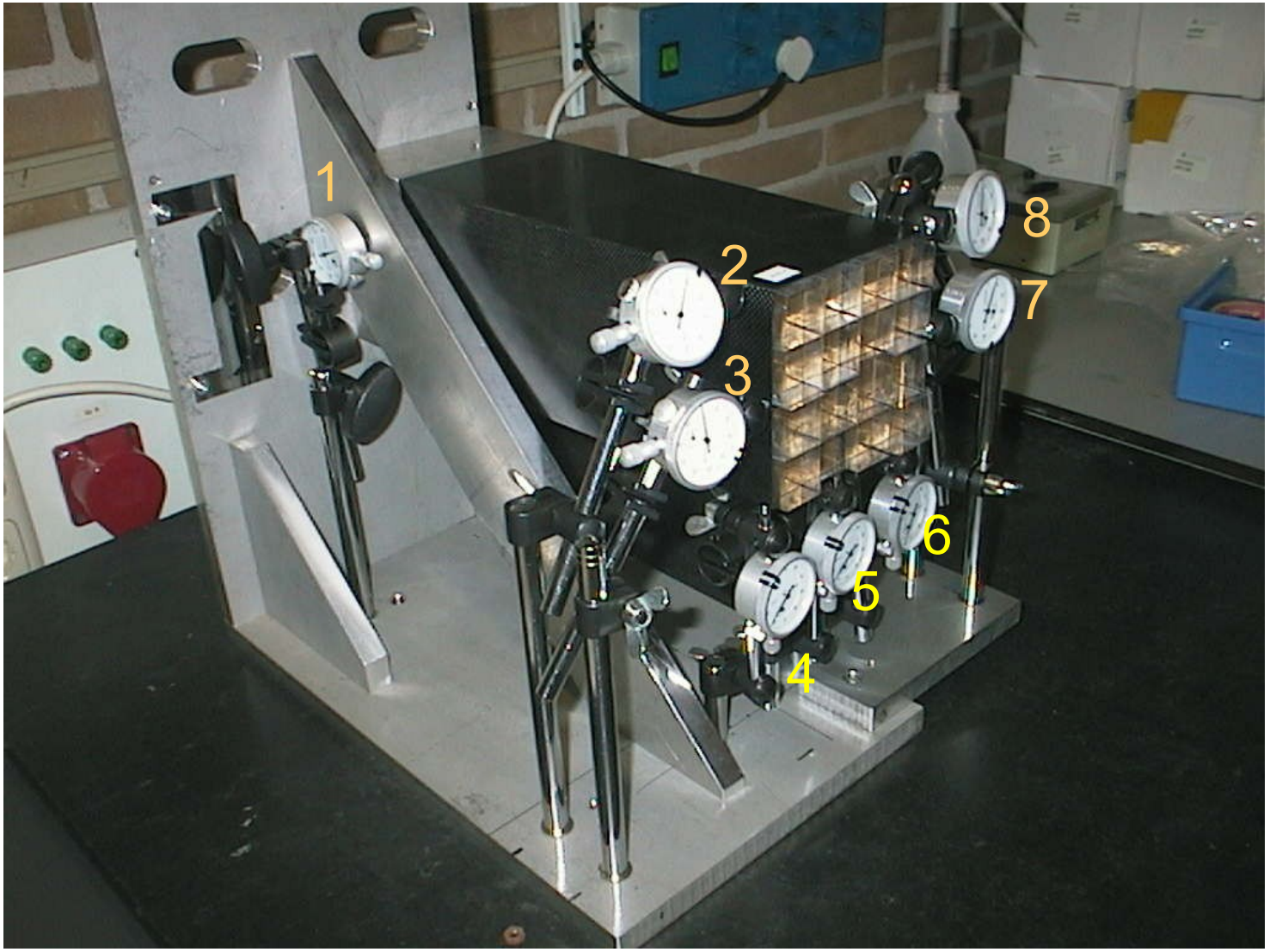


carbon fiber

alveoles produced at Fiberworkx BV

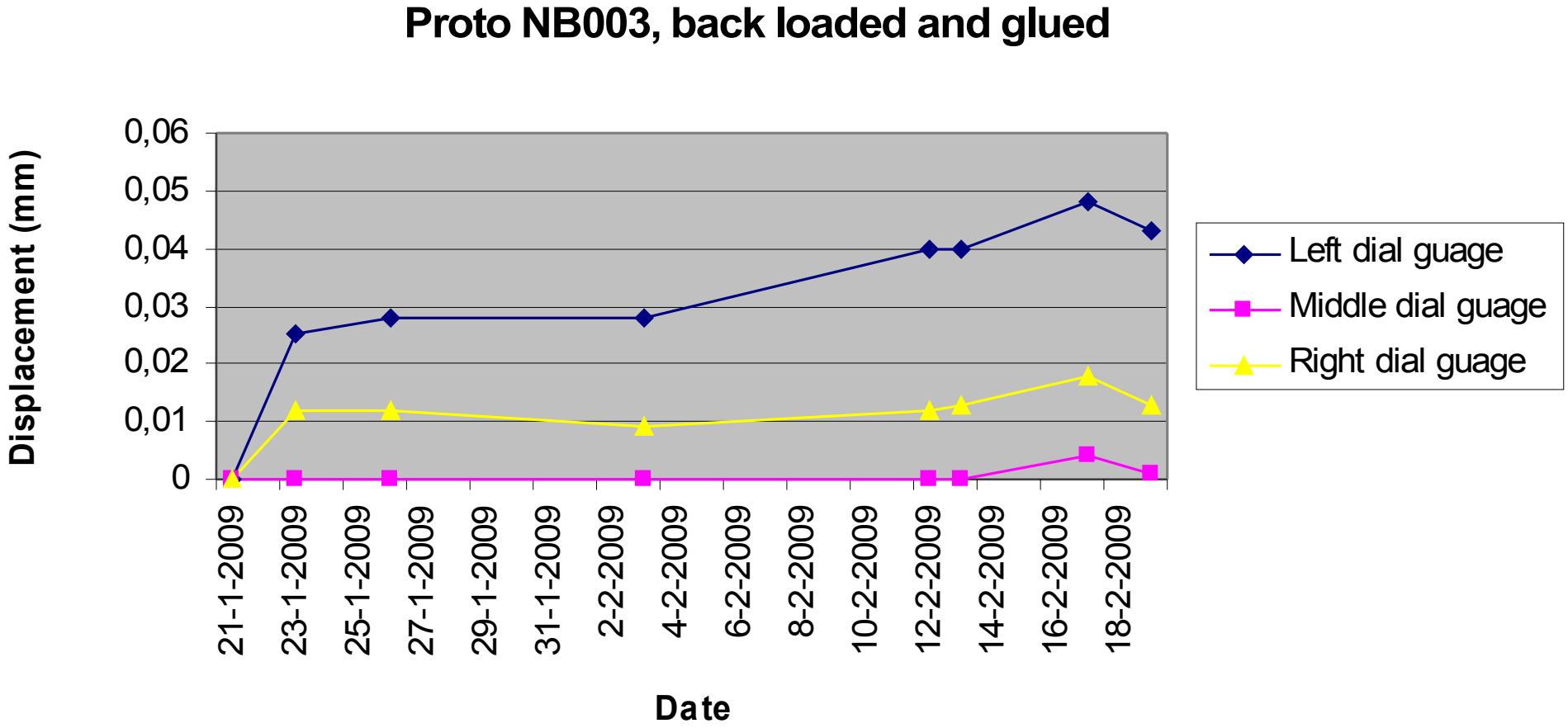


identification of position gauges



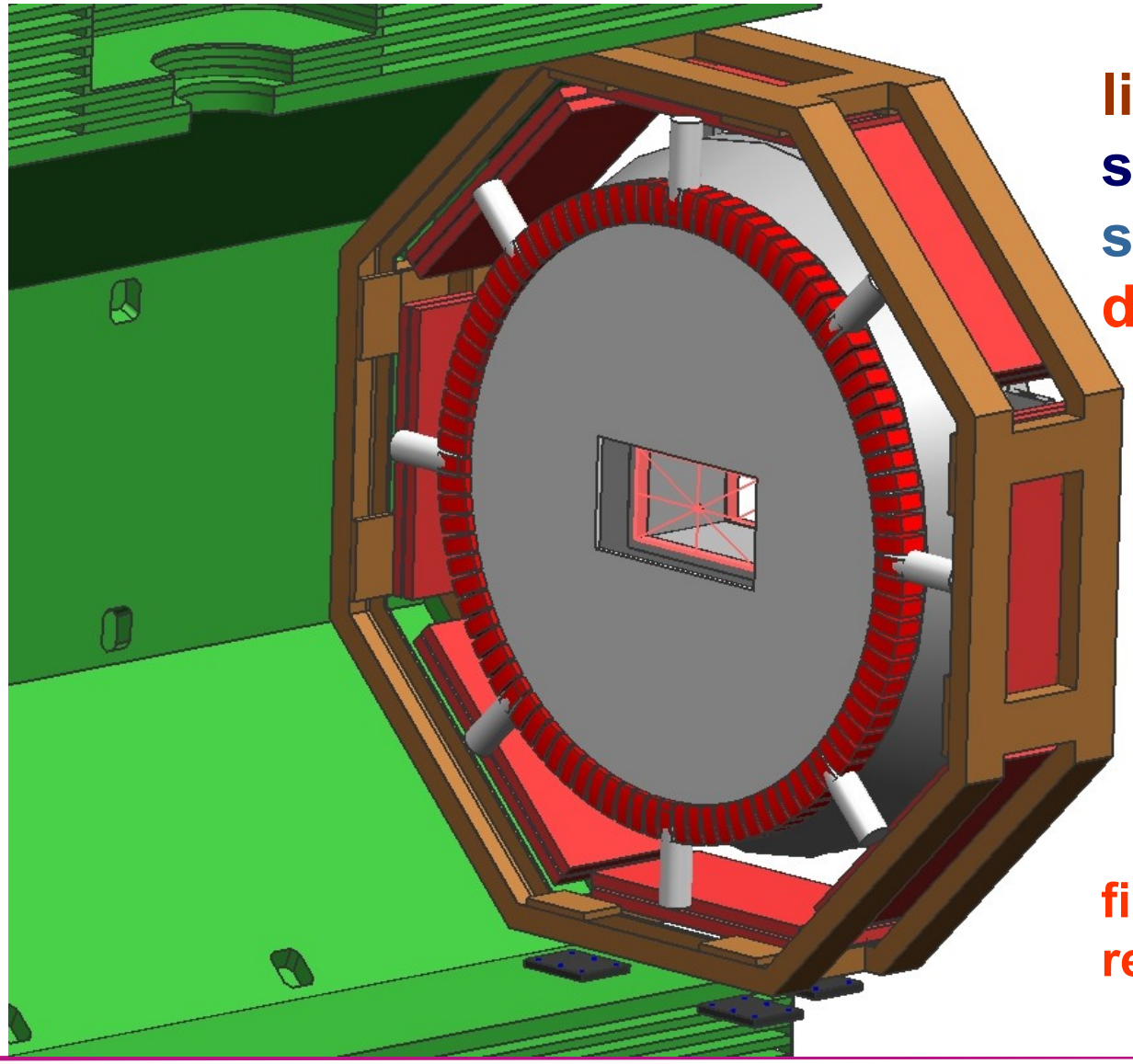
reading
accuracy
0.005 mm

alveole # NB003 sag progression after loading “crystals” from the back side



displacement < 0.05 mm during 30 days

integration DIRC and FwEndcapEMC

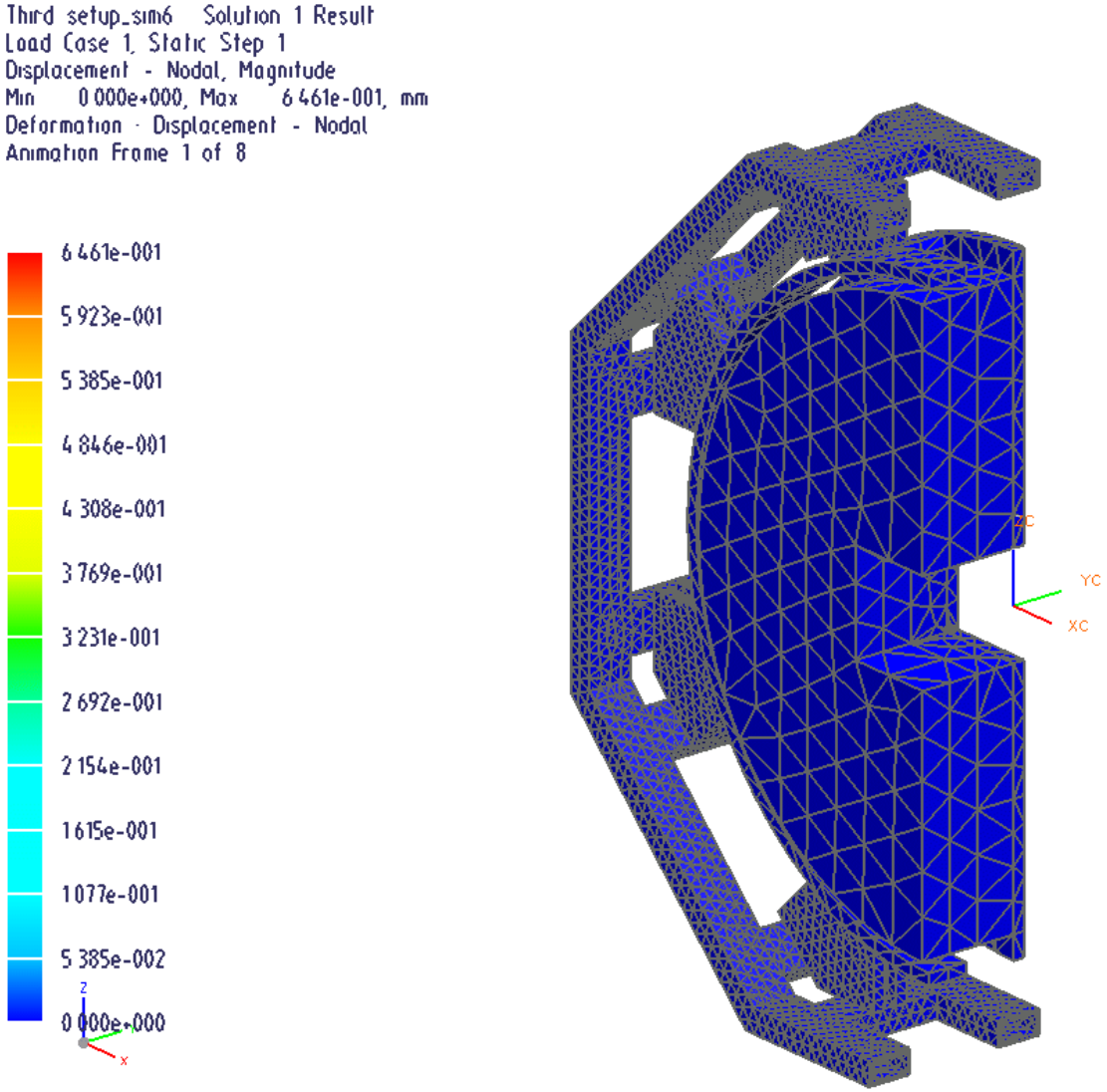


light Al frame (540 kg)
supported by solenoid,
space for
digitizing electronics:
16 times
0.4 m^2 = in total 6.5 m^2

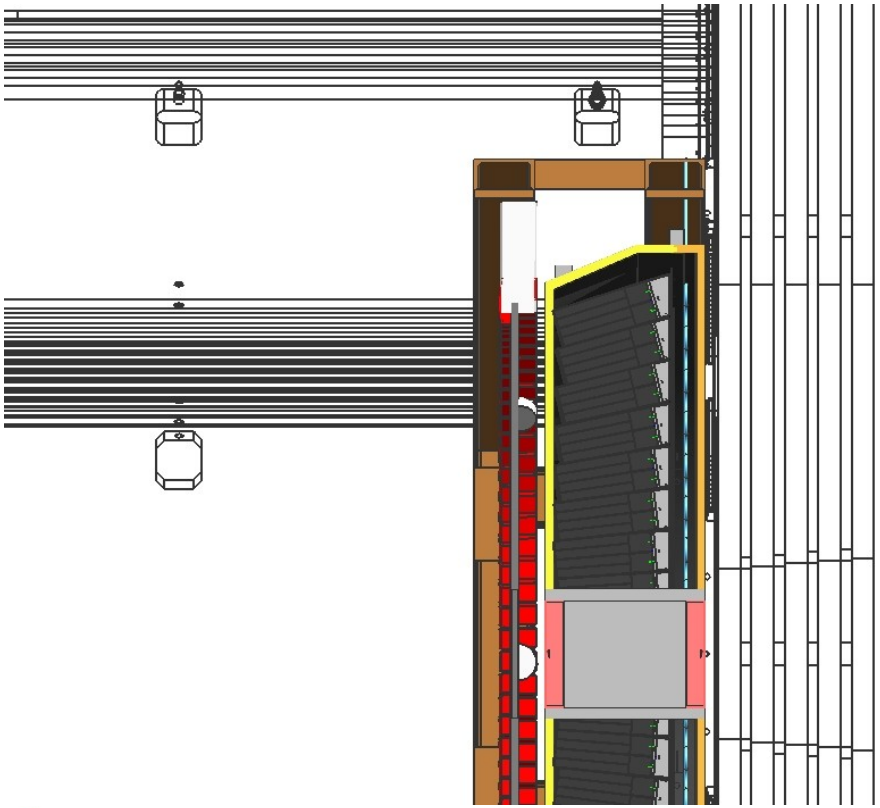
inserts with
alignment crosses
foreseen in central hole

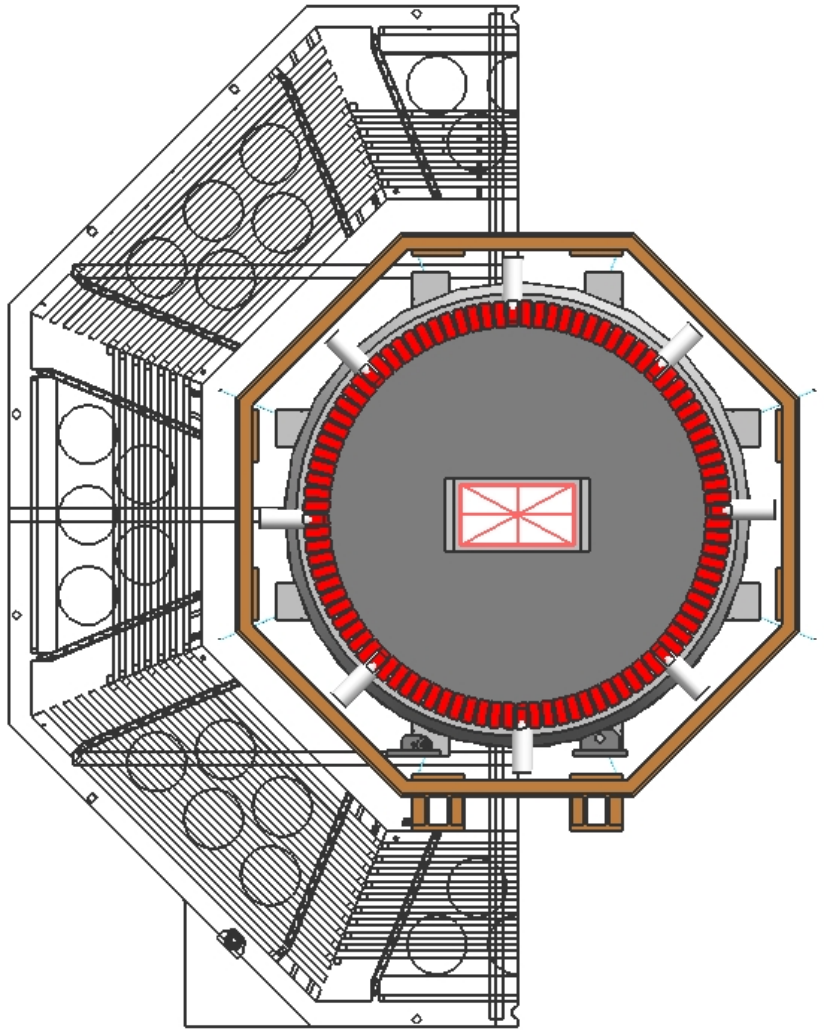
final decision needed:
rectangular / elliptic hole?

simulation:
displacement max. 0.64 mm

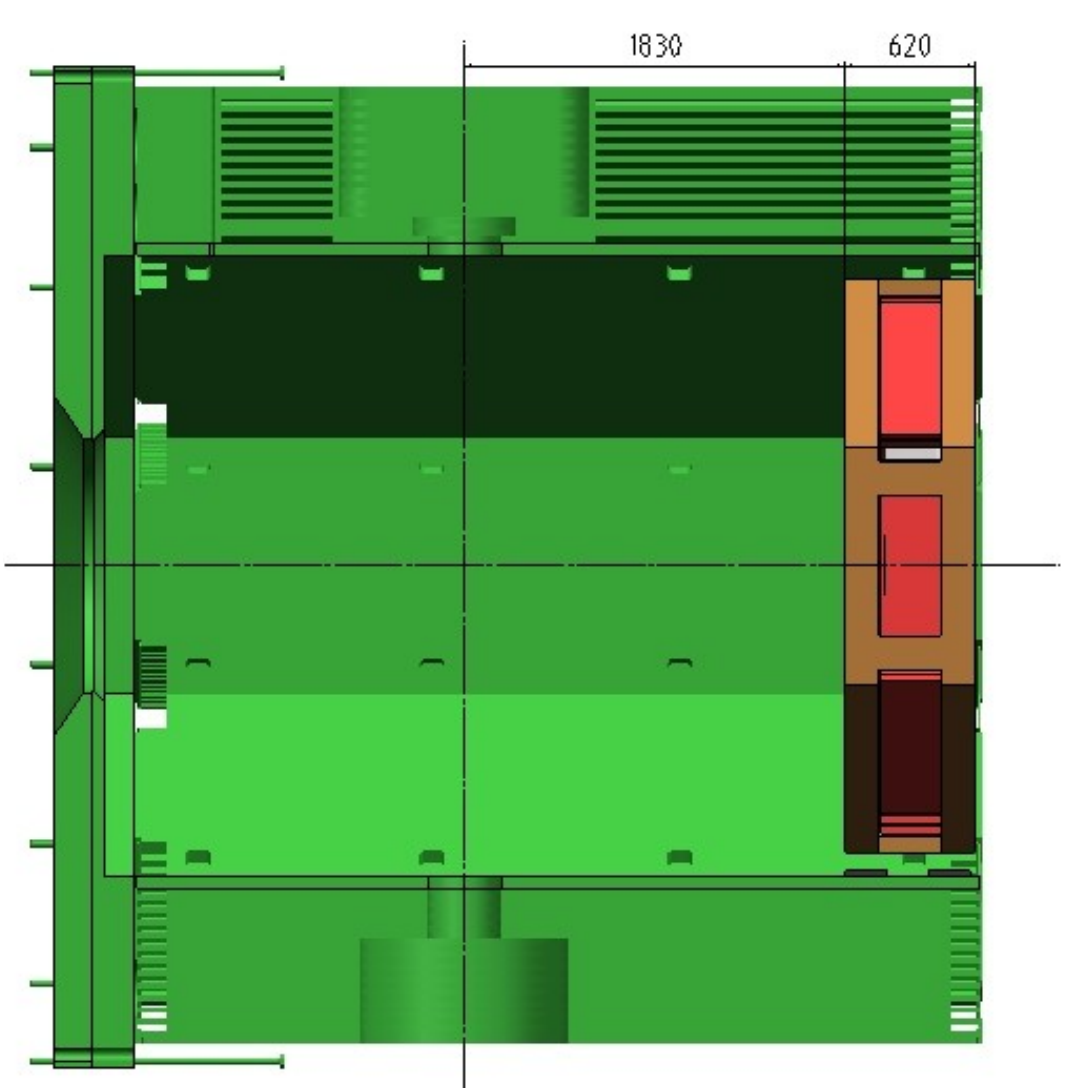


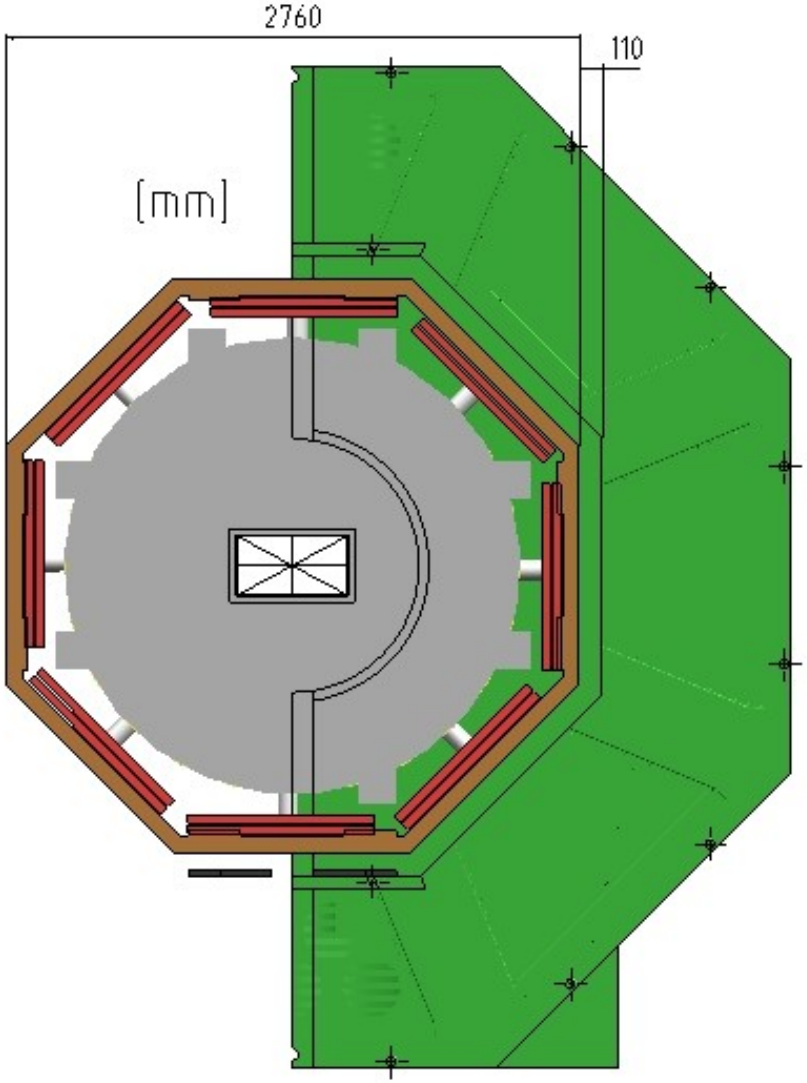
Assembly with alignment crosses





space for cables and supplies





stress and temperature sensors

Fiber Bragg Gratings (FBG)

C. Doyle, Smart Fibres Ltd. 2003

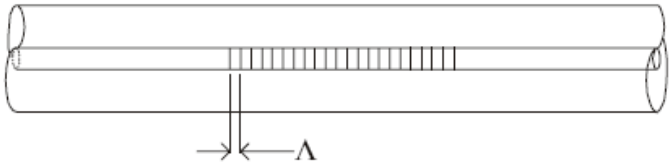
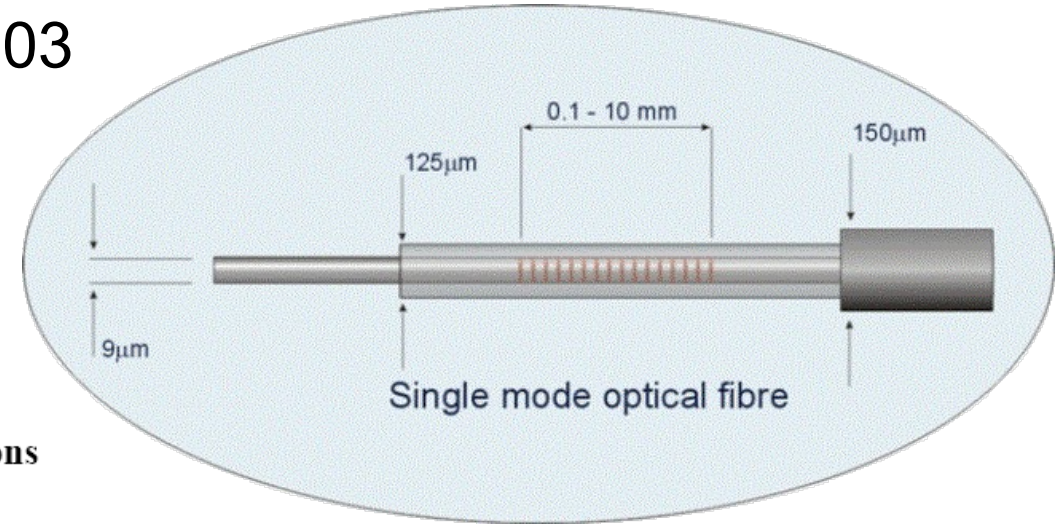


Figure 1. FBG, indicating core refractive index variations



maximum reflectivity occurs at Bragg wavelength λ_B with

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

where n_{eff} = effective refractive index of mode of propagation in fiber,
and Λ = FBG period

FBG interrogation techniques

time-division multiplexing: TDM

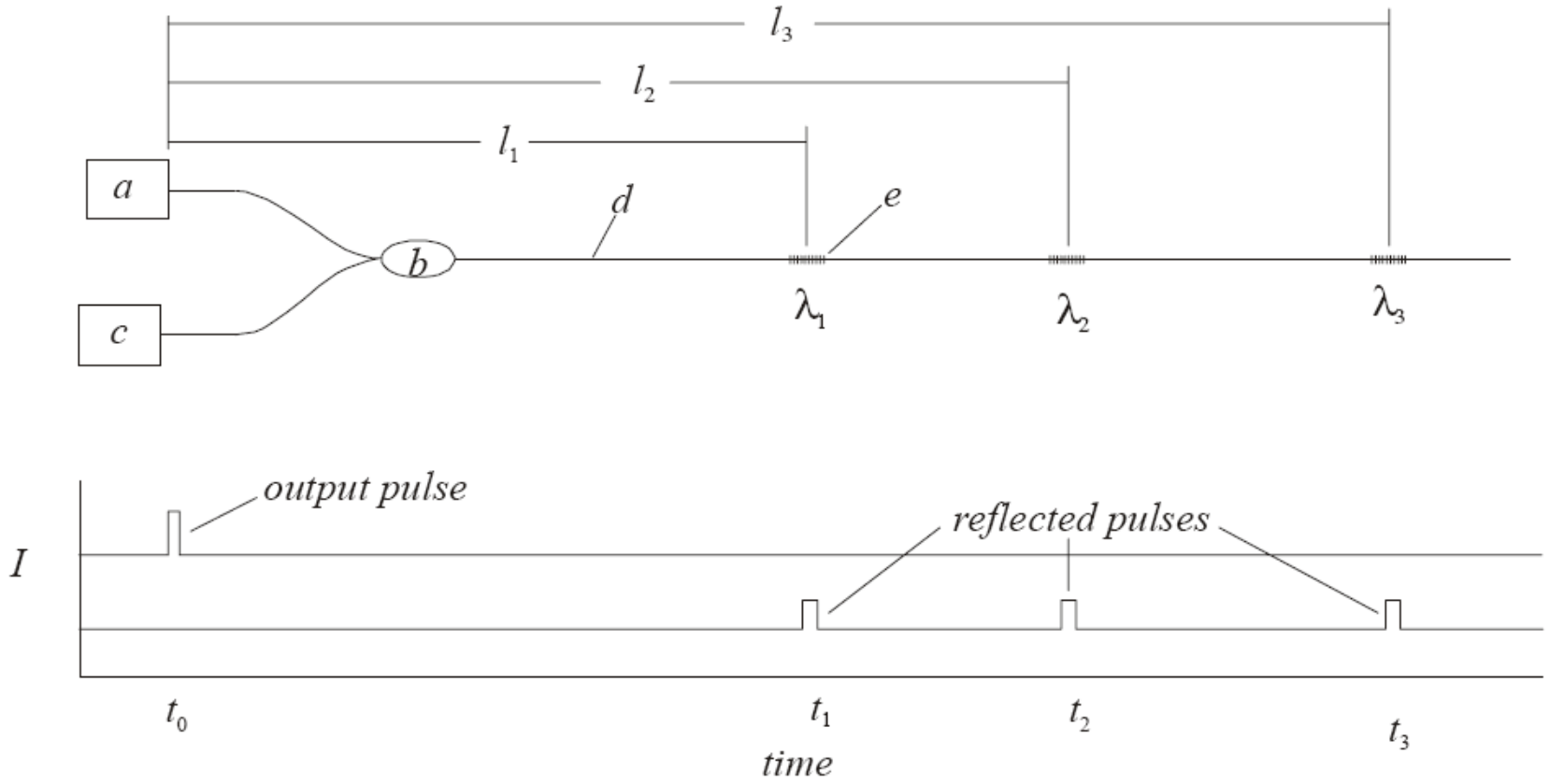


Figure 4. TDM system. Top: Pulses from light source (a) pass through coupler (b) , which is also connected to detector (c), to fibre (d) containing FBG (e). Bottom: pulses emanating from source at time t_0 are reflected from FBG at l_1, l_2 and l_3, and return at t_1, t_2 and t_3.

FBG measurement results

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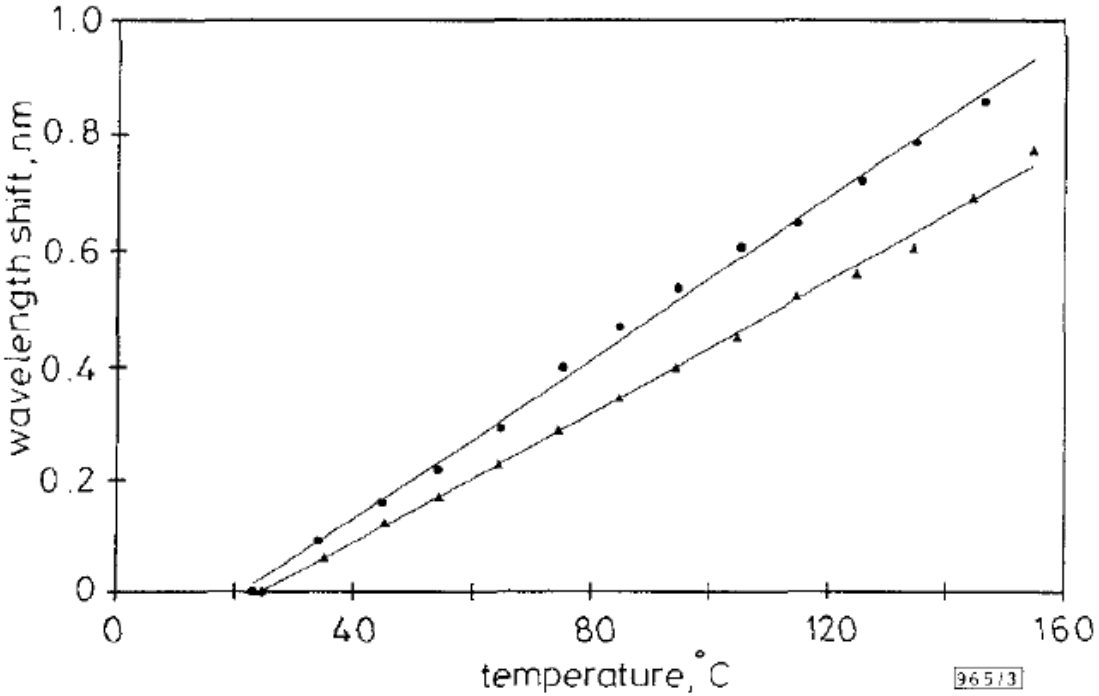
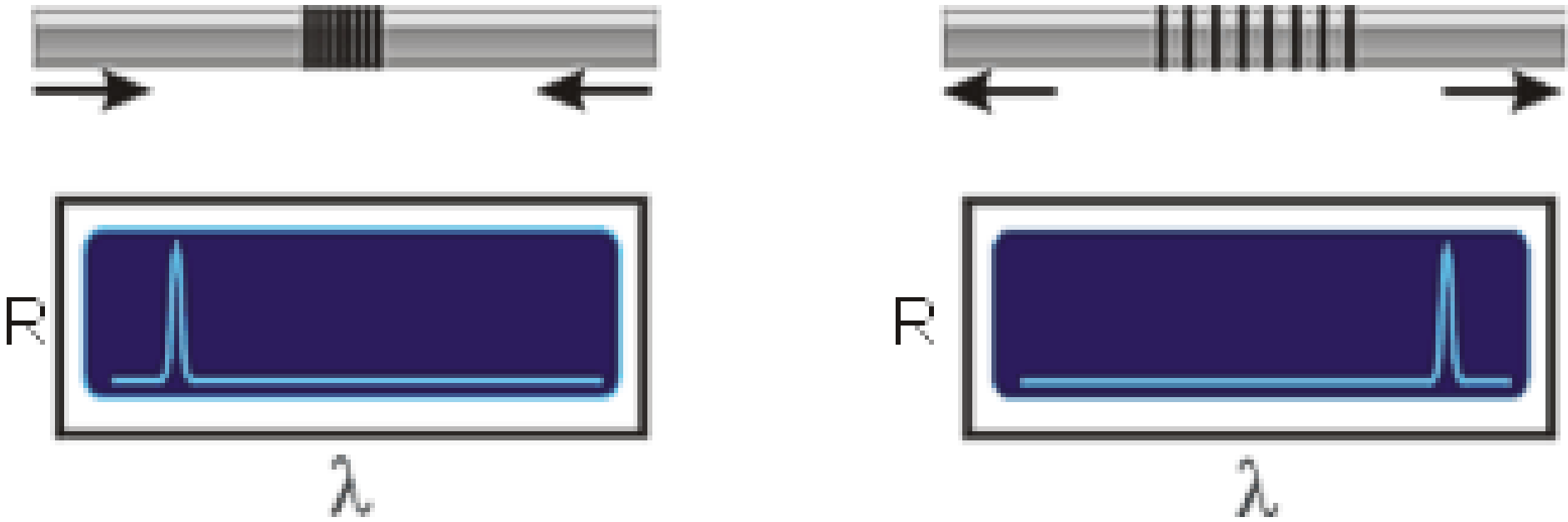


Fig. 3 *Temperature responses of grating pair*

Applications of
Fibre Bragg Grating Sensors

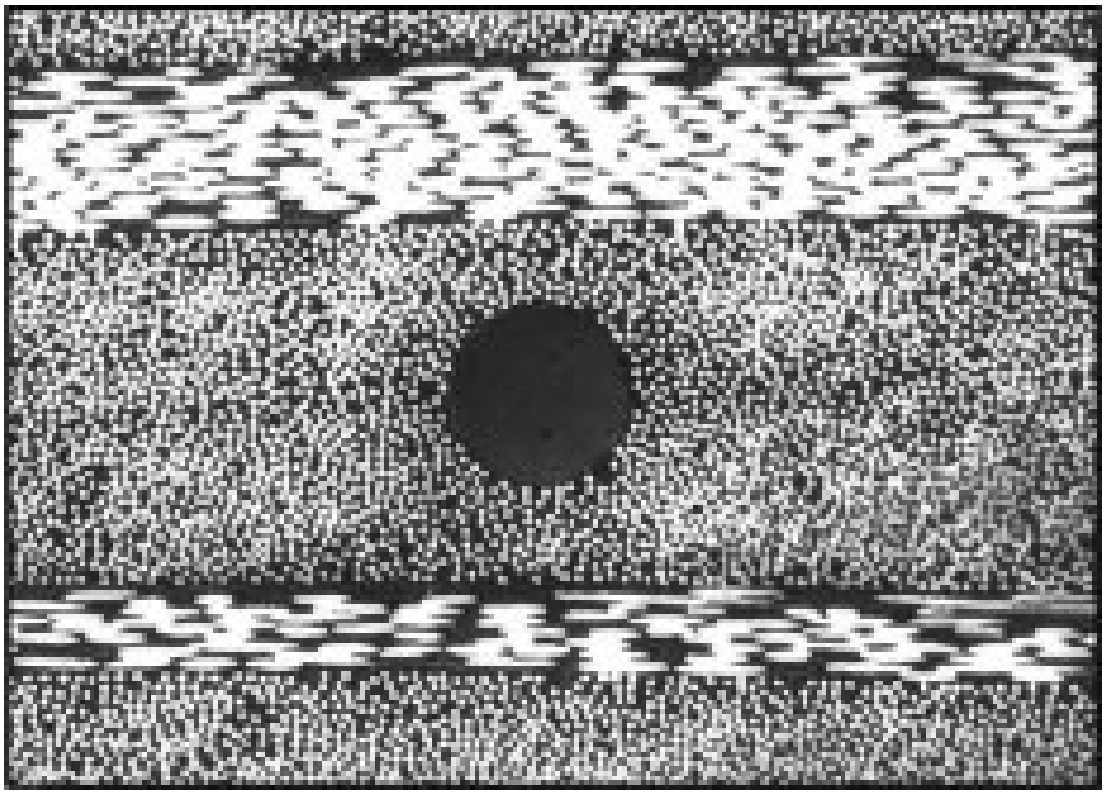
Wolfgang Ecke
Institute of Photonic Technology - IPHT Jena

temperature and strain sensitivity



temperature / strain applied to a Bragg Grating alters the wavelength of reflected light

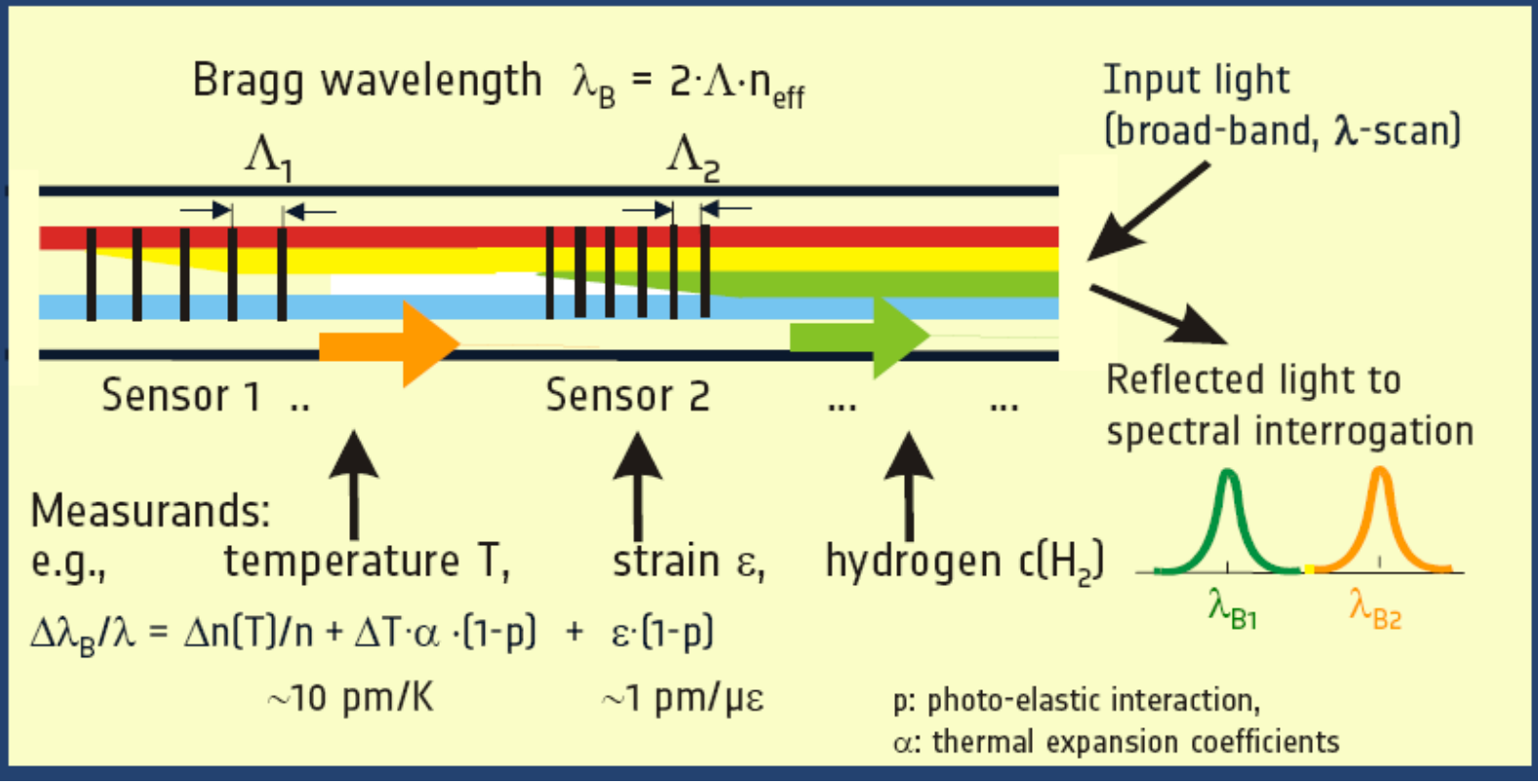
fiber embedded in C-fiber composite



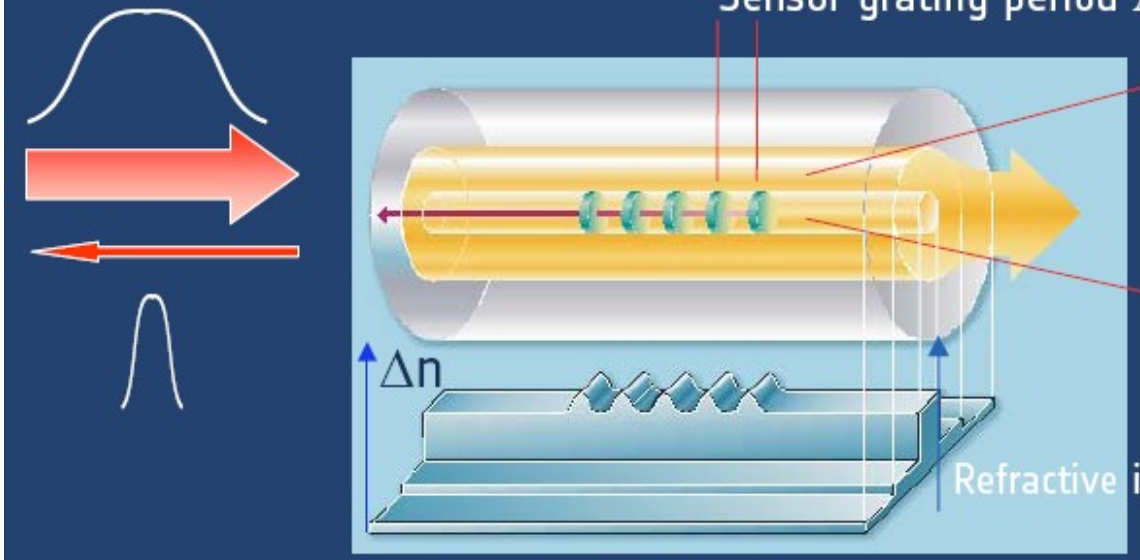
Magnified cross section of a laminated carbon fiber panel containing an embedded optical fiber sensor (125 µm diameter):
option to embed fiber in alveole composite:
avoid strain sensitivity?

Fibre Bragg Grating Sensor and Multiplexing Principle

- FBG sensor systems: distributions of strain, temperature, refractive index, ..
- Wavelength Division Multiplexing (WDM)



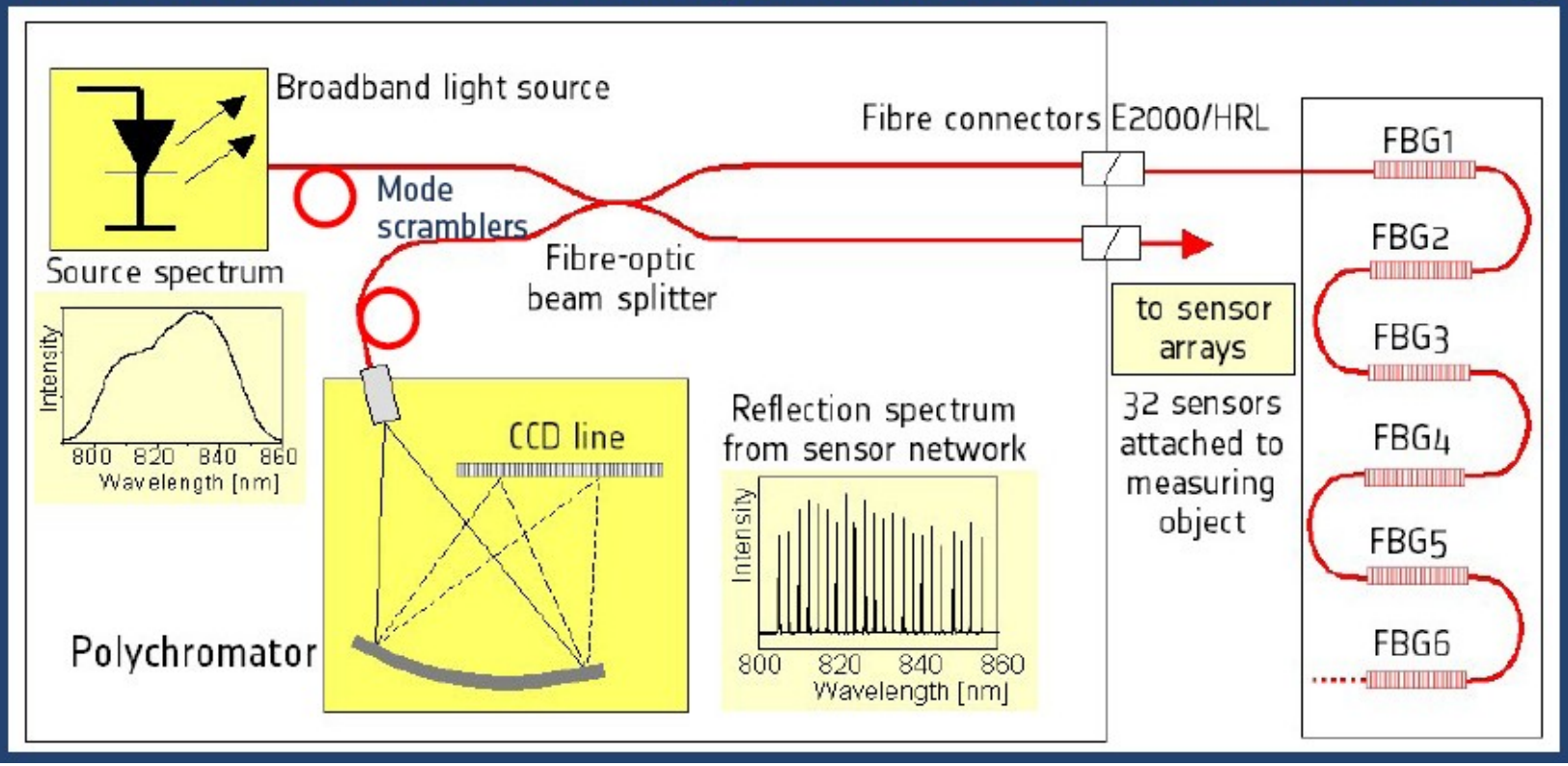
Structure of Fibre Bragg Gratings



- Excimer laser illumination inscribes a refractive index modulation in the core of optical fibre (periodic fringe pattern of refractive index = Bragg grating)
  - Bragg reflection at specific wavelength: $\lambda_B = 2\, n_{eff}\, \Lambda$
  - Sensor for temperature, strain, chemicals: $\lambda_B \sim T, \varepsilon, n_A, ..$
  - FBG = optical equivalent to resistive strain gauge

Polychromator FBG Interrogator: Fibre Optics/Optoelectronics

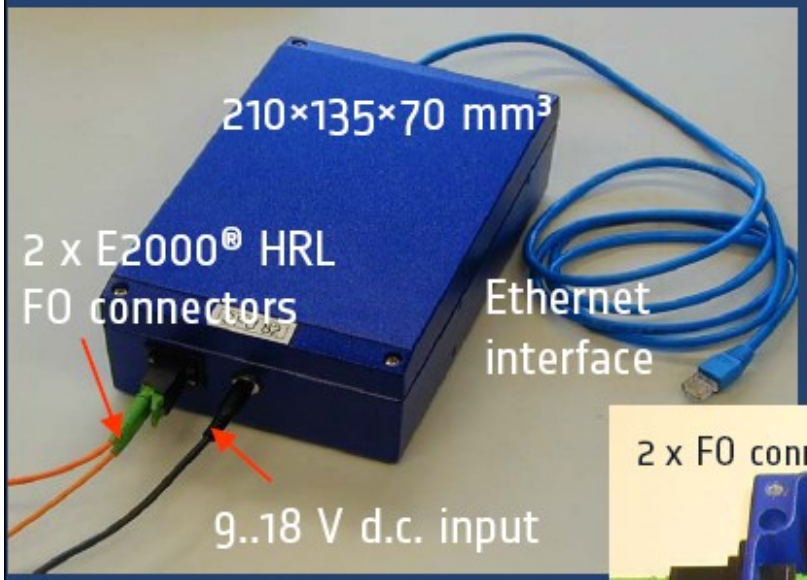
- SLD broadband light source 800 .. 860 nm: higher WDM capacity than @ 1550 nm
- Low-cost polychromator: imaging diffractive grating (polymer replicated) & CCD detector
- Simultaneous measurement of all sensors; no interference of scan rate/distance/wavelength!



Technical Parameters of Polychromator Based FBG Sensor System

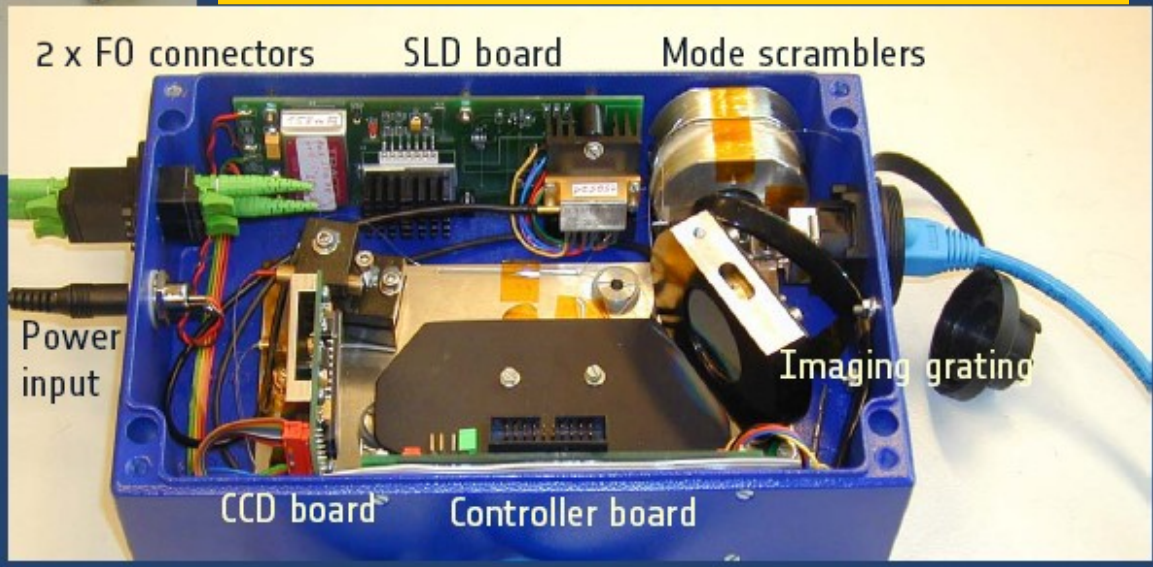
- Broadband source wavelength range: 805 .. 870 nm (= 10% strain)
- 32 sensors, measurement exactly simultaneously
- Measuring speed: 1000.00 measurements/s; Ethernet data to PC
- SPU operational temperature range: -40 .. +70 °C
- Sensor reflectivity: 2 .. 90 %
- 1σ rms noise at spectrometer full scale: 0.4 pm (= 0.6 με, 0.05 K)
- Noise reduction: Gaussian correlation, averaging, Kalman filter
- Sensor temperature operation range: -270 °C .. +300 °C (.. +900 °C)
- Sensor strain range: ±0.5 % (standard FBG), ±5 % (draw tower FBG)
- Bragg wavelength accuracy: 25 pm
- Max. length of fibre-optic transmission cable: ~ 1 km

Examples of Technical Realisation – "BlueBox", External and Internal Views



Compact, robust, fast:

- 32 sensors, 1000 measurements/s
- All sensors are measured exactly simultaneously
- FBG peak fit by Gaussian phase correlation
- Repeatability 0.6 με (strain), 0.05 K (temperature)
- Spectrometer temperature compensation
- Accuracy better 15 pm (= 1.9 K absolute temp.)



however ...

equipment available from IPHT Jena:

readout unit for 32 sensors at 400 Hz: 14 k€

cost of fiber: per sensor ca. 40 €

will investigate with other companies
if cheaper test system can be acquired