ETH zürich

SuperFGD box thermal tests and review

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SFGD mechanics group meeting

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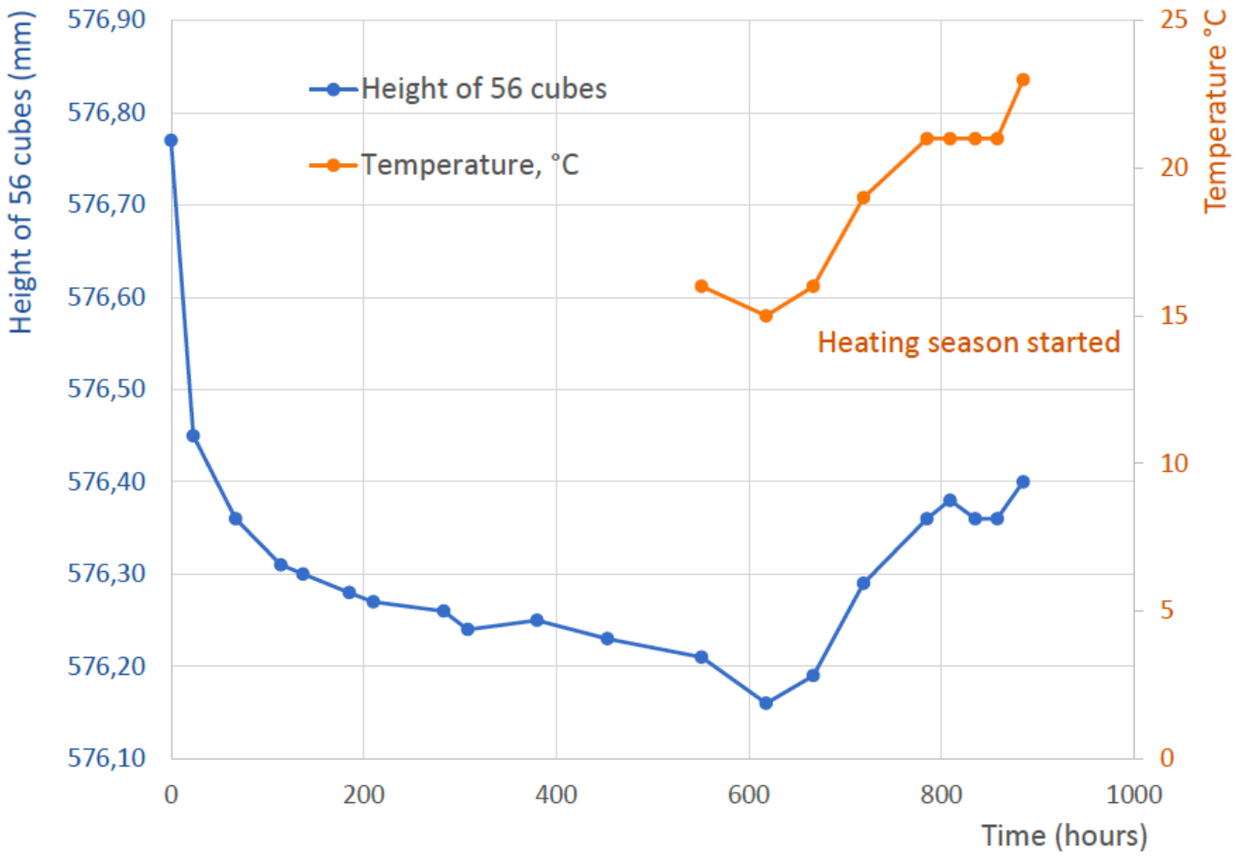
Introduction

- Thermal tests performed verify the stability of the CF-based sandwich under different temperatures

- Different materials with different thermal expansion coefficients
    - ✦ Very hard to simulate and to rely on the results
    - ✦ Need experiments to see the sandwich behaviour
- Used the thermal chamber at the University of Geneva
    - ✦ Relatively large chamber that can fit up to ~1.9m

Temperature expansion of cubes

56 layers height: temperature effect on the 3rd set of cubes



Initial drop is caused by compressing of cube array. Then ambient temperature effect changes the height.

The coefficient of vertical expansion was estimated to be 52 µm/(m · °C).

Polystyrene thermal expansion is specified as ~70 µm/(m · °C).

From O.Mineev

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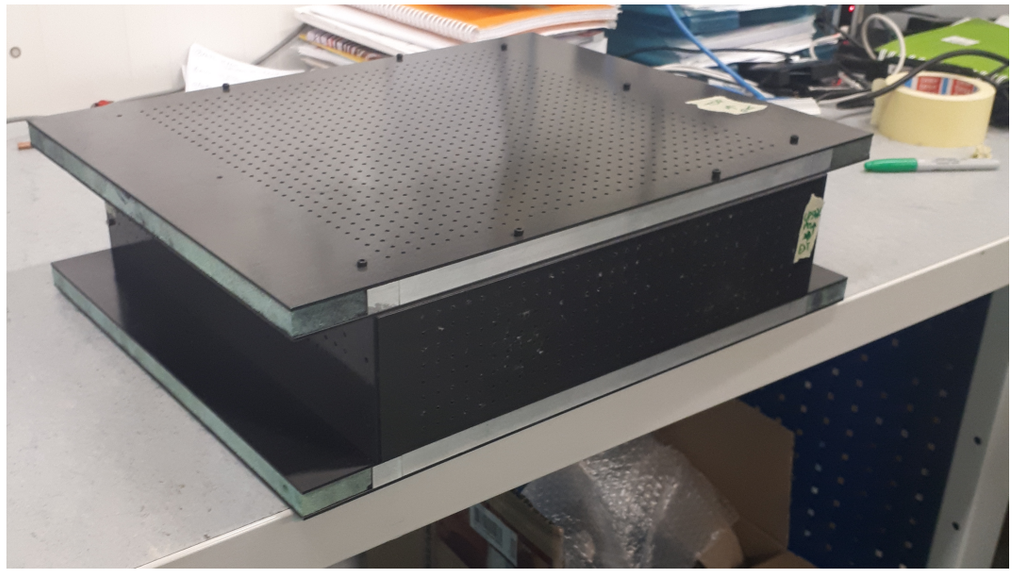
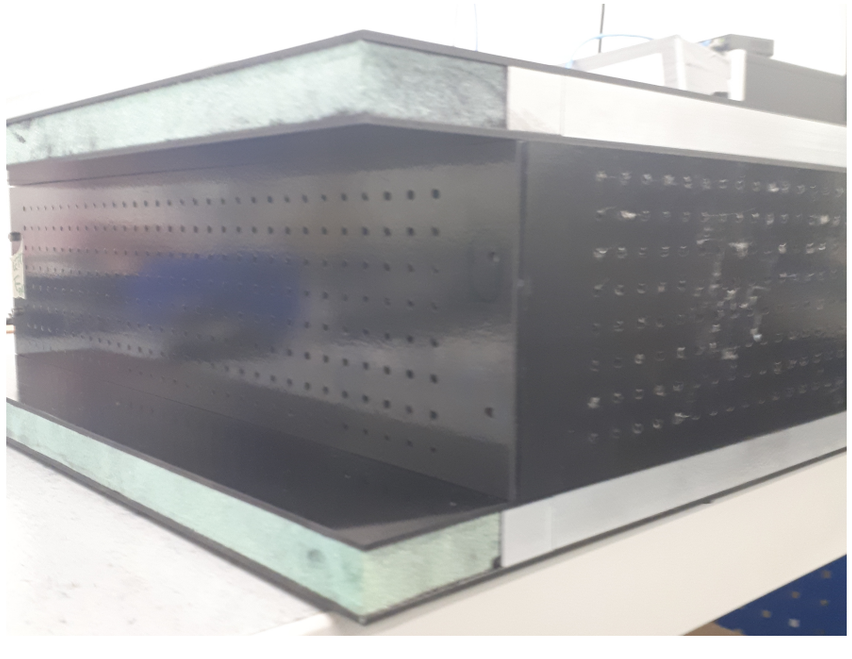
Not an issue because not connected with the sFGD box. WLS fiber holes in sFGD box are made conical to absorb potential tolerances due to thermal expansion

Test #1

- Tested small prototype (CF-Foam-CF) with aluminum frame to close the 6 plates of the box

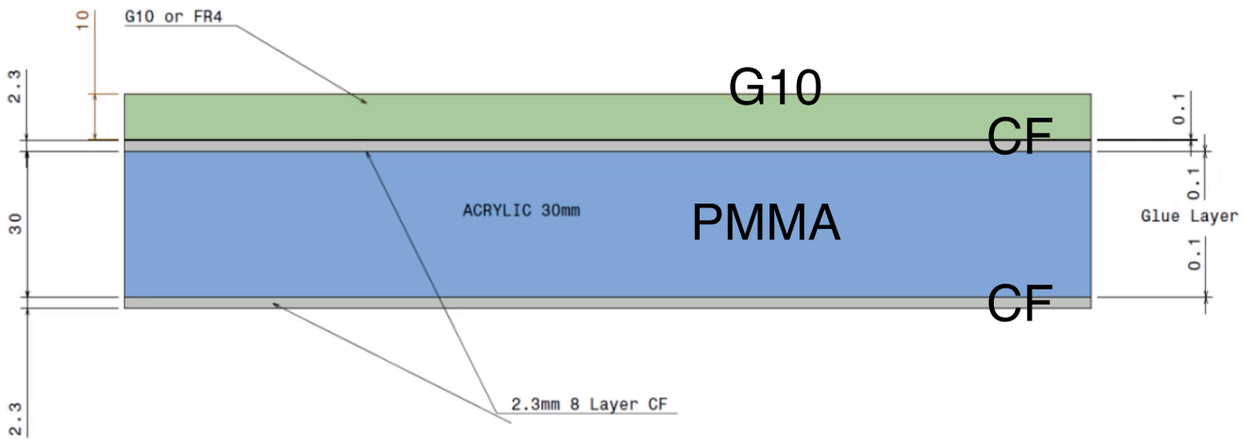




- Tested up to 40°C —> no visible problems

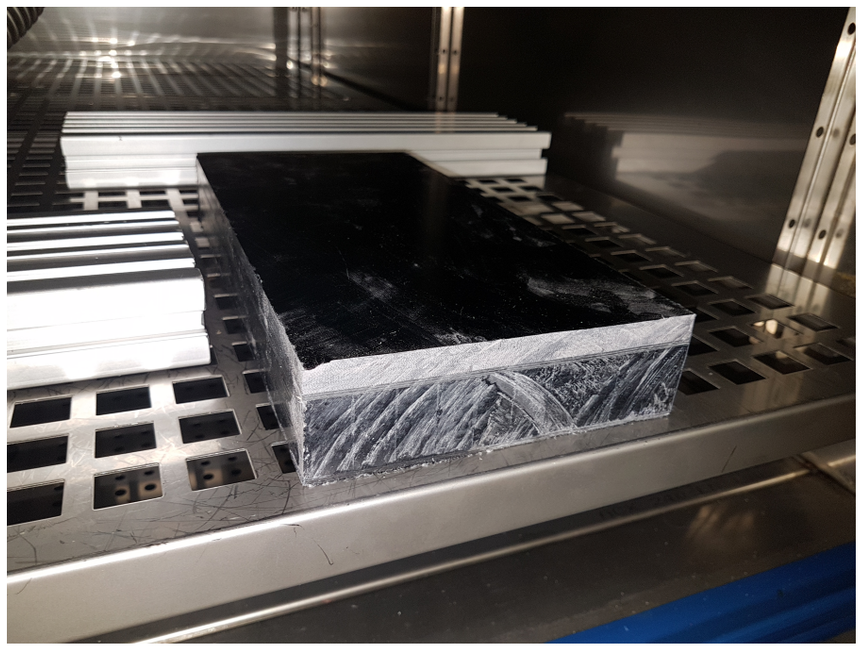
Test #2

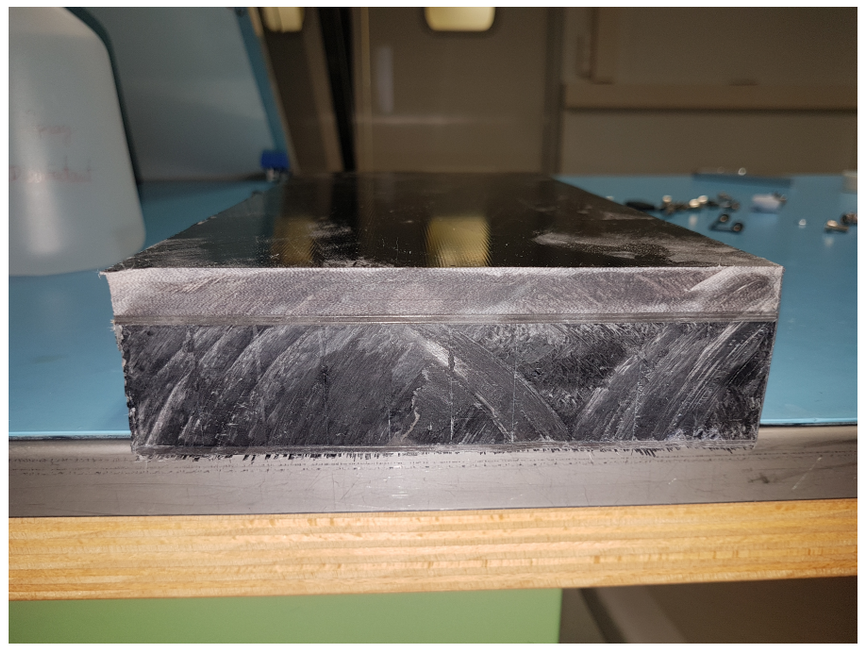
- Purchased a 2.3m sandwich G10-CF-PMMA-CF
- Cut 1.9m sandwich to fit the thermal chamber
- The core is made of PMMA bars of 15 x 30 mm2 cross section



Thermal Expansion Coefficients

- Acrylic: $\sim 7.5 \times 10^{-5}$
- Polystyrene: $\sim 7 \times 10^{-5}$
- Stainless steel: $\sim 1.7 \times 10^{-5}$
- Aluminum: 2.3×10^{-5}
- G10/Fr4: 1.5×10^{-5}
- CF - longitudinal: $\sim -4.7 \times 10^{-7}$
  - transverse: $\sim 3 \times 10^{-5}$
- Dyvynicell H250: $\sim 4.5 \times 10^{-5}$

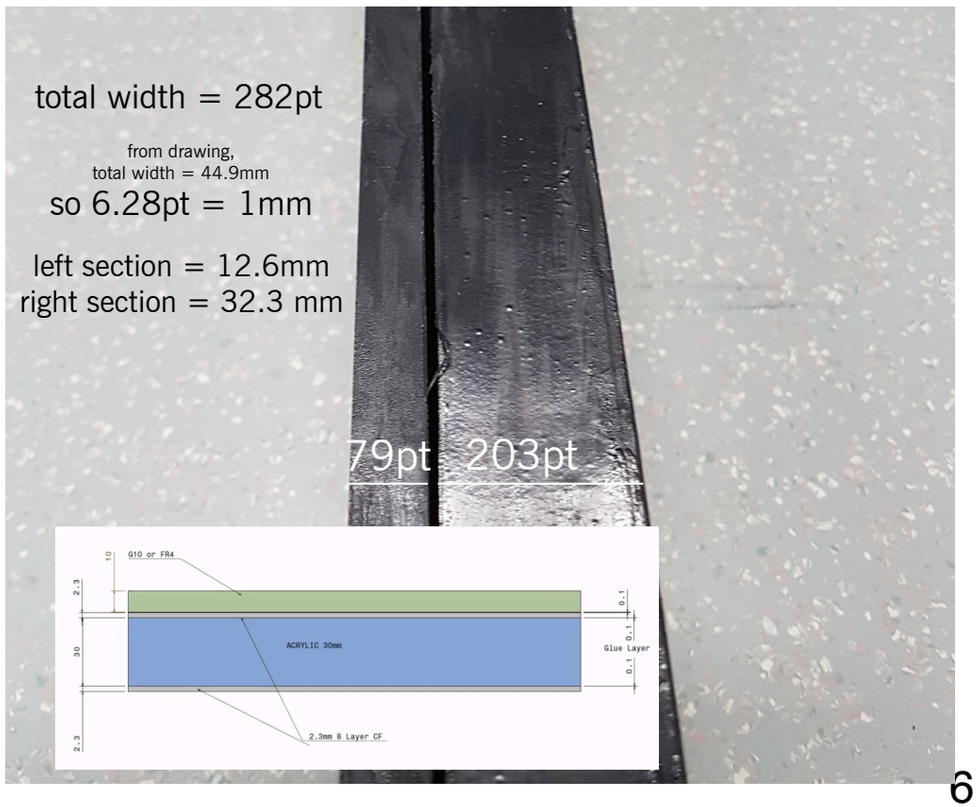




Test #2

- Quite extreme test were performed
- From room T to $40°C$ —> no visible problems were found
- From room $40°C$ to $50°C$ and then down to $-10°C$
  - ✦ Apparent failure of glue joint between likely CF and PMMA on the G10 side
  - ✦ Visible crack in the upper part of the plate but it seems on the glue coating, not through the PMMA. We will examine this crack in more detail, but it may not be a problem

✦ Permanent deformation of all the materials on one extreme of the panel



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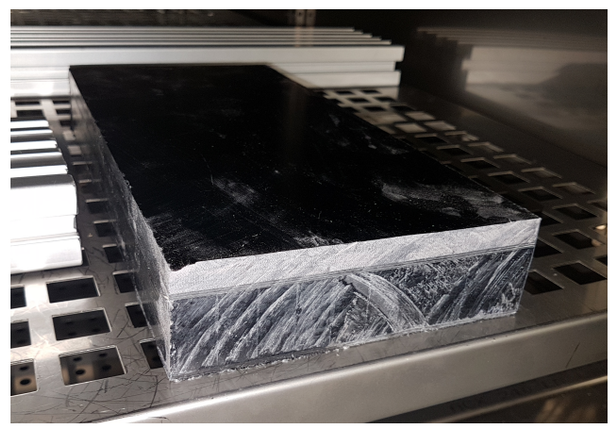
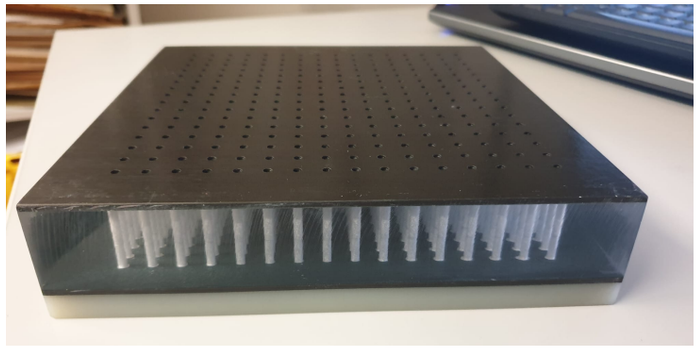
- Is the problem PMMA, G10 or both ?
  - ✦ PMMA stable until ~65° C (to check)
- Did the problem happen at $> 40^\circ$ C or $< -10^\circ$ C ?
- The panel will be cut and checked in its inner part at different heights
- Hard to say whether providing specs on max T range is sufficient because of lacking of informations

Next steps

- Thermal tests with
  1. 40 cm long plate of CF-PMMA-CF-G10 plate (cut from sample in previous slide to fit the thermal chamber)
     - ✦ Cross-check results, measure allowed T range for a safety transport, storage and installation
  2. ~2m long plate of CF-Foam-CF-G10
     - ✦ Verify if the problem is on PMMA or G10



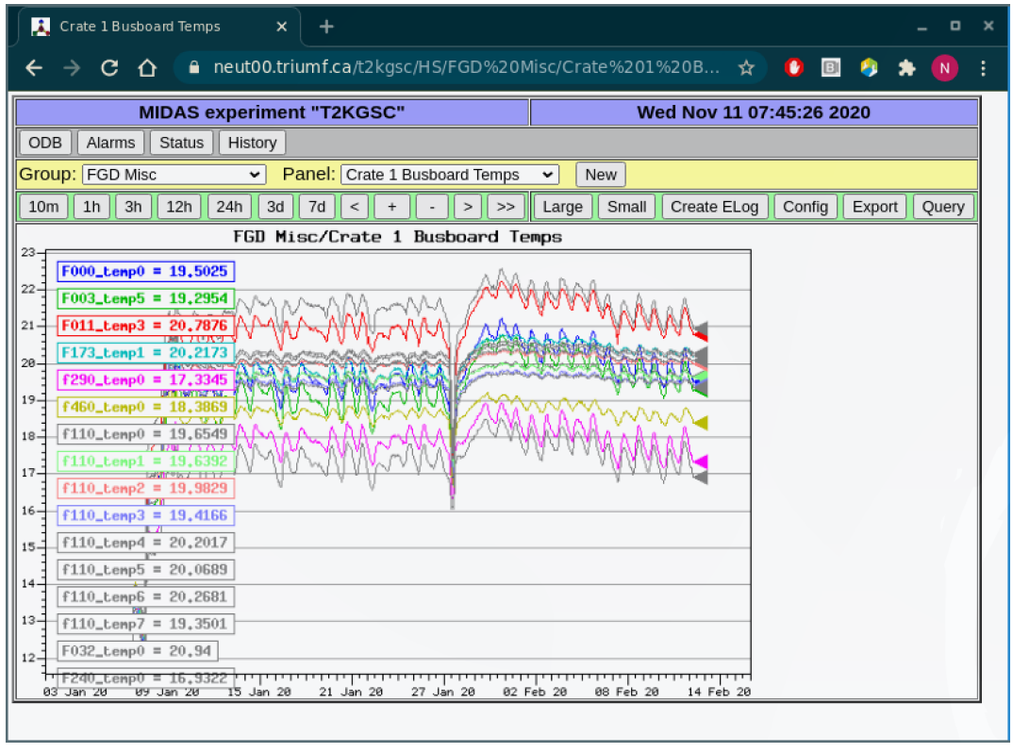
  3. 30x30 cm^2 CF-PMMA-CF-G10 prototype
     - ✦ Transparent PMMA makes easier understanding what is going on

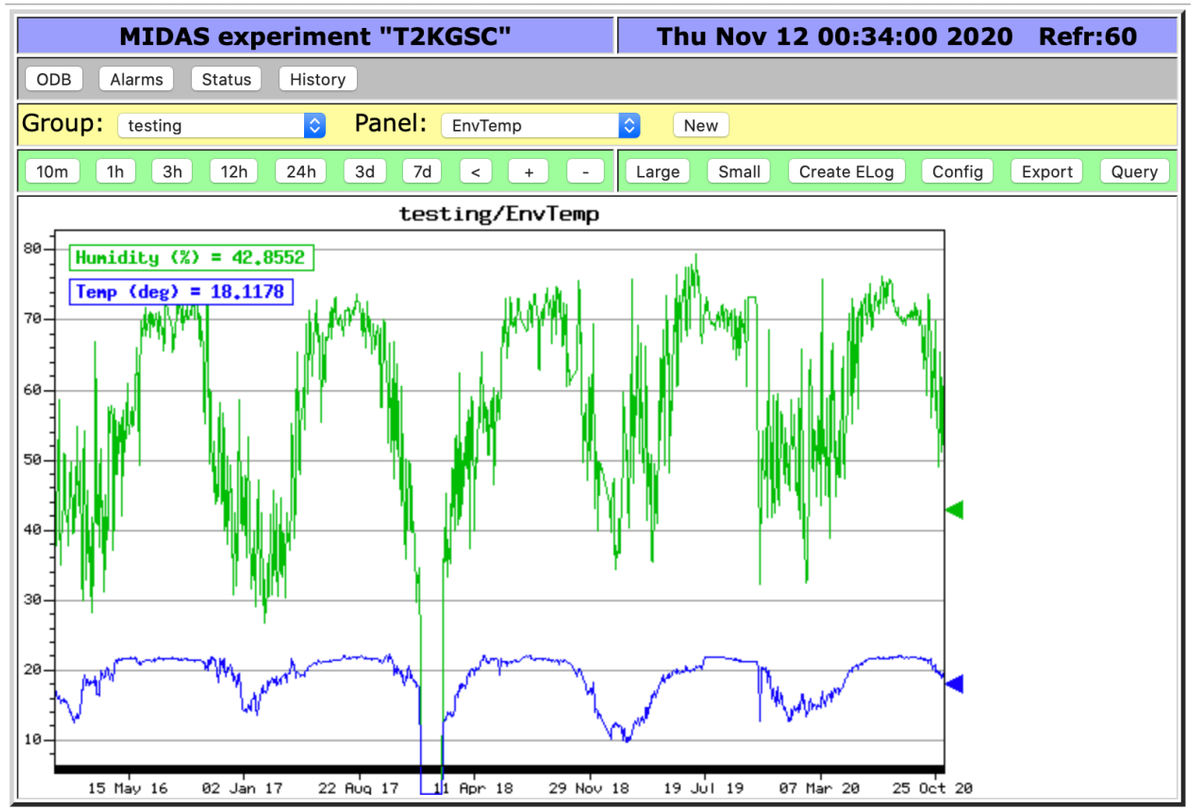


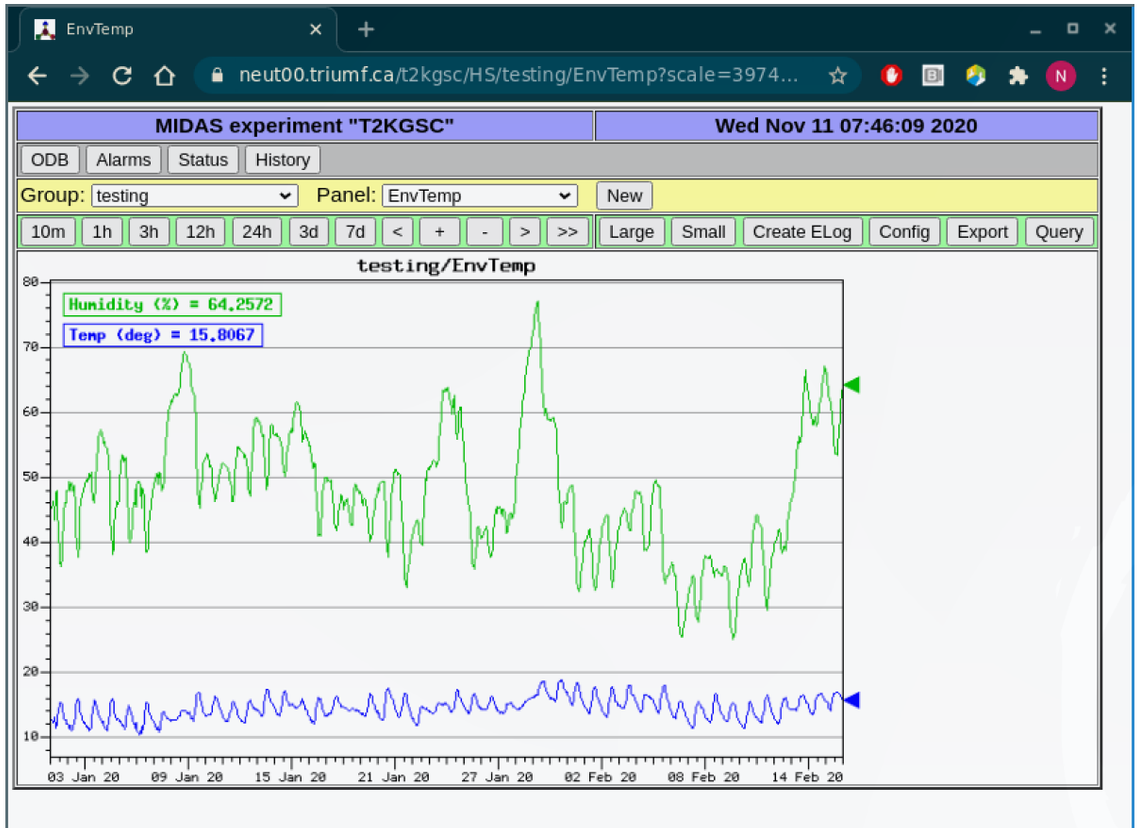
- Discussions with the company producer about the issues
- Also thinking of producing more prototypes for more tests

Temperatures at ND280

- Largest temperature variation seem to be $< 10^{\circ}$ C from a sensor in the ND280 pit
- Not clear where it is exactly but it should be indicative of the temperature range in ND280 also when the detectors are off, i.e. no detector cooling

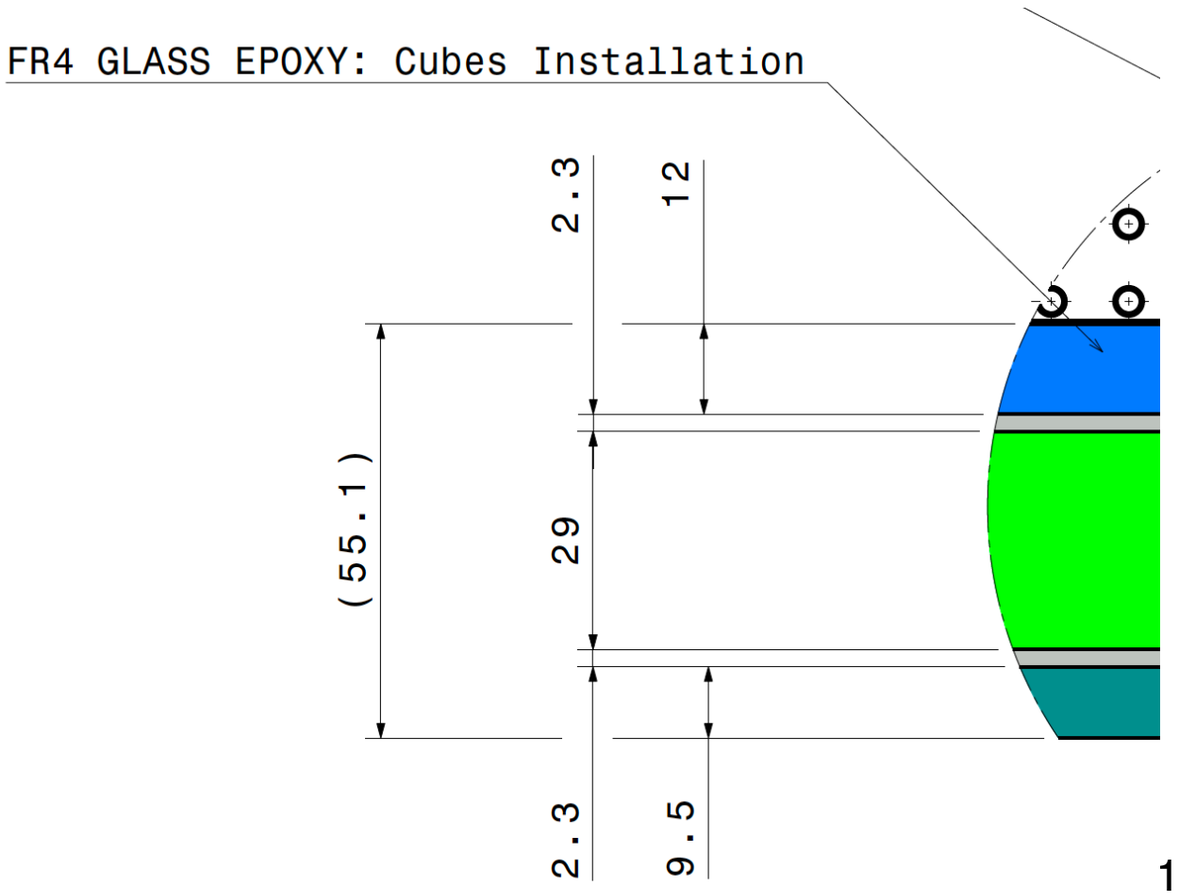






Status of Review

- We met with Lluis (CERN engineer) to explain the unexpected situation
- We all agreed to wait for more data to have the full picture of the thermal behaviour of all the sFGD box sandwiches, both with PMMA and Dyvynicell cores
- A possible issues is due to the G10, that make the sandwich asymmetric, and the PMMA, that has quite a higher thermal expansion coefficient
    - ✦ Some bending seen in the G10-CF-Foam-CF plate before the tests. Probable stress from G10
    - ✦ PMMA is stable until $\sim 70°C$ without stresses. But here there may be non negligible stresses that created permanent deformations
    - ✦ Bottom panel is more symmetric that the one we tested: there is G10 on both sides, although of slightly different thickness



Status of Review

- Understand at which temperature the problems arise
  - ✦ maybe issue only for transport and storage (possible to control and not expensive, it was checked)
  - ✦ On the other hand SuperFGD power is ~4.5 kW. To check impact on overall ND280 temperature (e.g. convection, etc.)
- Priority is now to collect more data with the other samples to understand
  - ✦ Behaviour of PMMA core (only bottom plate)
  - ✦ Behaviour of rigid foam (other 5 plates)
  - ✦ Asymmetry introduced by G10 (in 3 out of 6 plates, but not on the bottom one)
- The strategy will be defined upon we have a clear picture from new data. Key points for deciding the future strategy are:
  - ✦ Rigidity of the panel
  - ✦ Potential delamination from extreme temperature conditions
- New prototypes:
  - ✦ Replica of the bottom panel (G10-CF-PMMA-CF-G10, important is length)
  - ✦ Other prototypes upon results from ongoing thermal tests

Conclusions

- All the questions for review were addressed
  - ✦ Found company to produce single panel of PMMA of (~2000x2000x30 mm^3)
  - ✦ FEA studies confirm low stresses in the aluminum frame between holes (documentation in preparation)
- We were ready to move forward
- The issues found in the thermal tests require time for more investigations
- Collecting more data. Once all the tests are performed, a clear strategy will be defined and proposed
- In contact with companies to produce a new PMMA prototype
- We met with Lluis and we will meet again in the end of this week / beginning of next week, once we have collected the new data

BACKUP