CLIC module

ANALYSIS OF DYNAMIC RESPONSE

Team
Daskalaki Elena
Duquenne Mathieu
Rude Vivien
Vamvakas Alex
Zelios Athanasios

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Aim

Study the dynamic behaviour of the Accelerating Structures (AS) of the CLIC Two-Beam Module

CLIC two-beam module

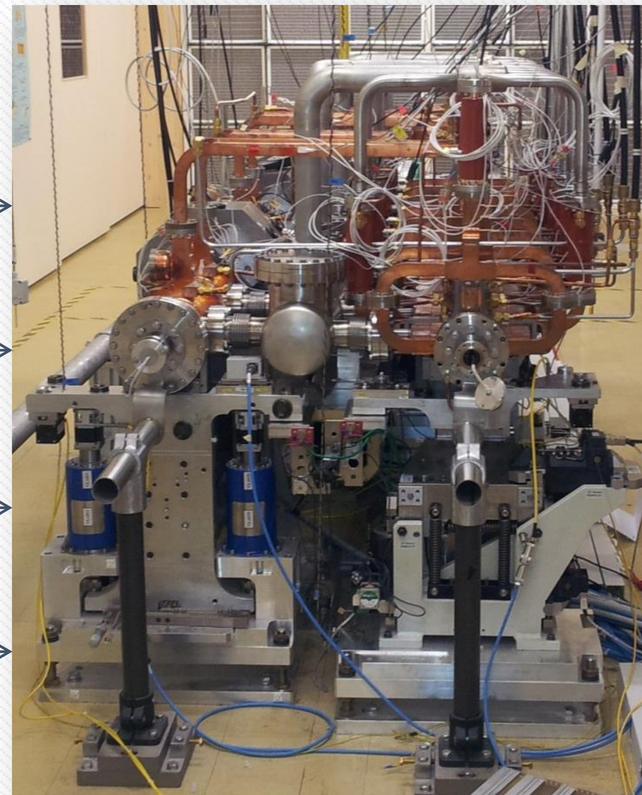
Mock-up of a real module where power dissipation is simulated by electrical heaters

Ambient temperature

Air velocity

Thermal power

Water flow



Temperature

Displacement

Procedure

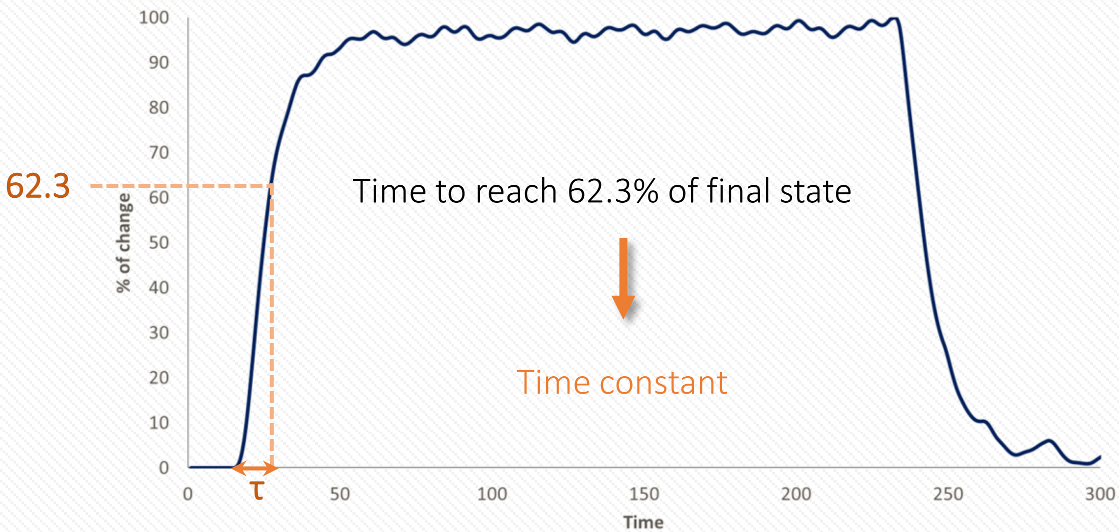
Phase 1: Temperature

Dynamic **thermal** response as a function of:

- Power applied
- Water flow
- Ambient conditions

Phase 2: Displacement

Dynamic **mechanical** response and its correspondence to the thermal dynamics



Procedure

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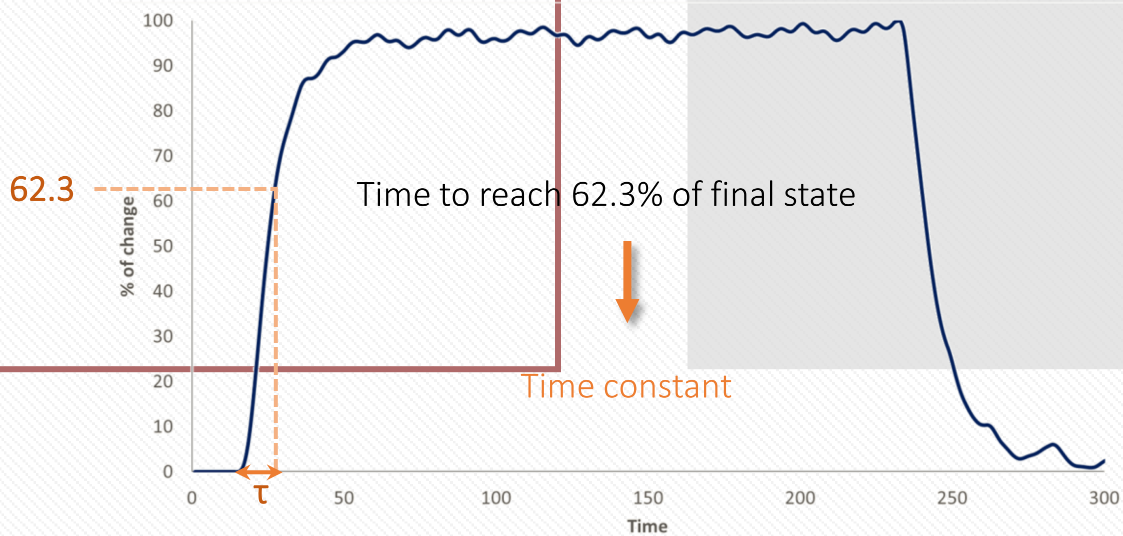


Theoretical analysis

$$P_h = P_{cu} + P_{water} + P_{air}$$

To copper → $P_{cu}(t) = m_{cu} c_{p,cu} \frac{dT_{cu}}{dt}$

To water → $P_{water}(t) = \dot{m}_w c_{p,w} [T_w(t) - T_w(0)]$

To air → $P_{air}(t) = hA_{cu} [T_{cu}(t) - T_\infty]$

$$T_{cu}(t) = \mathrm{T}_{\substack{steady \\ state}} - ce^{-t/\tau}$$

$$\tau = \frac{m_{cu} c_{p,cu}}{\dot{m}_w c_{p,w} + hA_{cu}}$$

geometry ($m_{cu} c_{p,cu}$, hA_{cu})

water flow ($\dot{m}_w$)

Tests plan

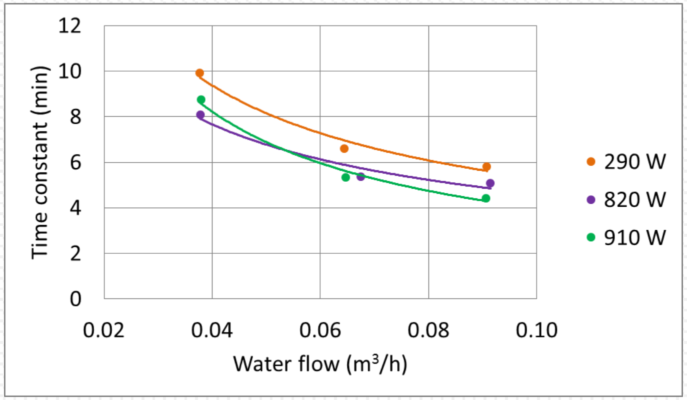
- Three cases of applied **power**, **water flow** and **ambient temperature** in all possible combinations

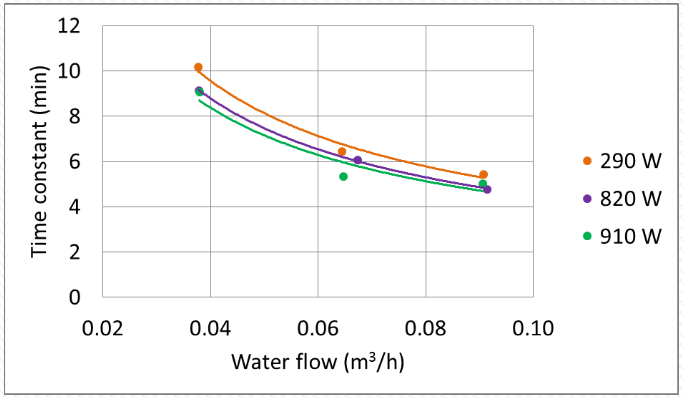
Power (W)	Water flow (m^3/h)	Ambient temperature (^oC)
290	0.040	20
820	0.068	30
910	0.090	40

Results

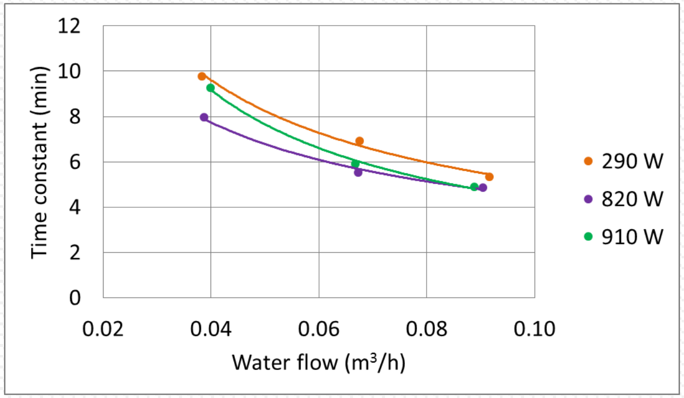
Temperature

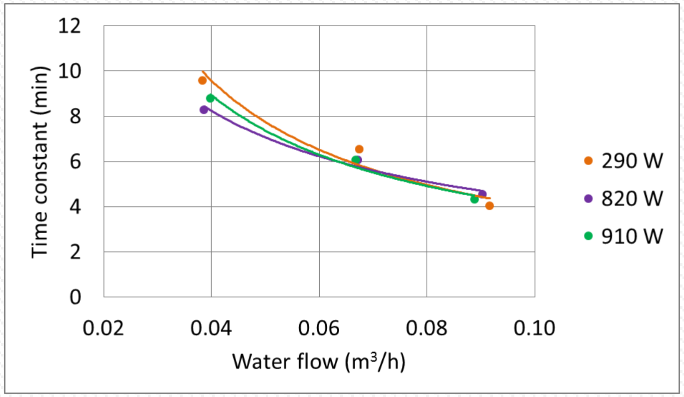
20 °C



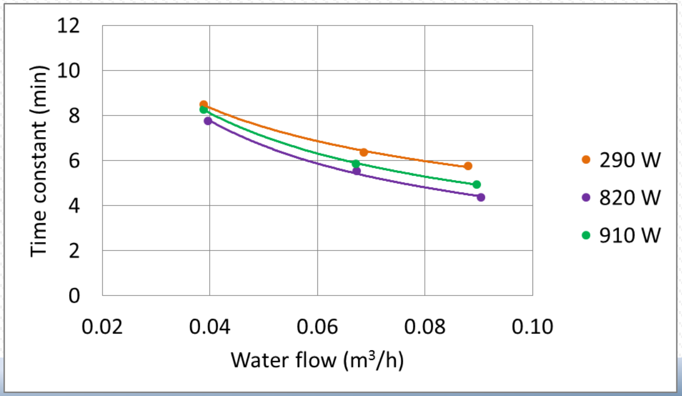


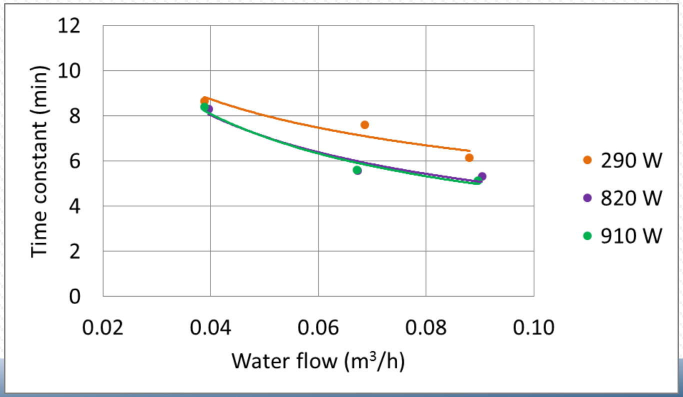
30 °C



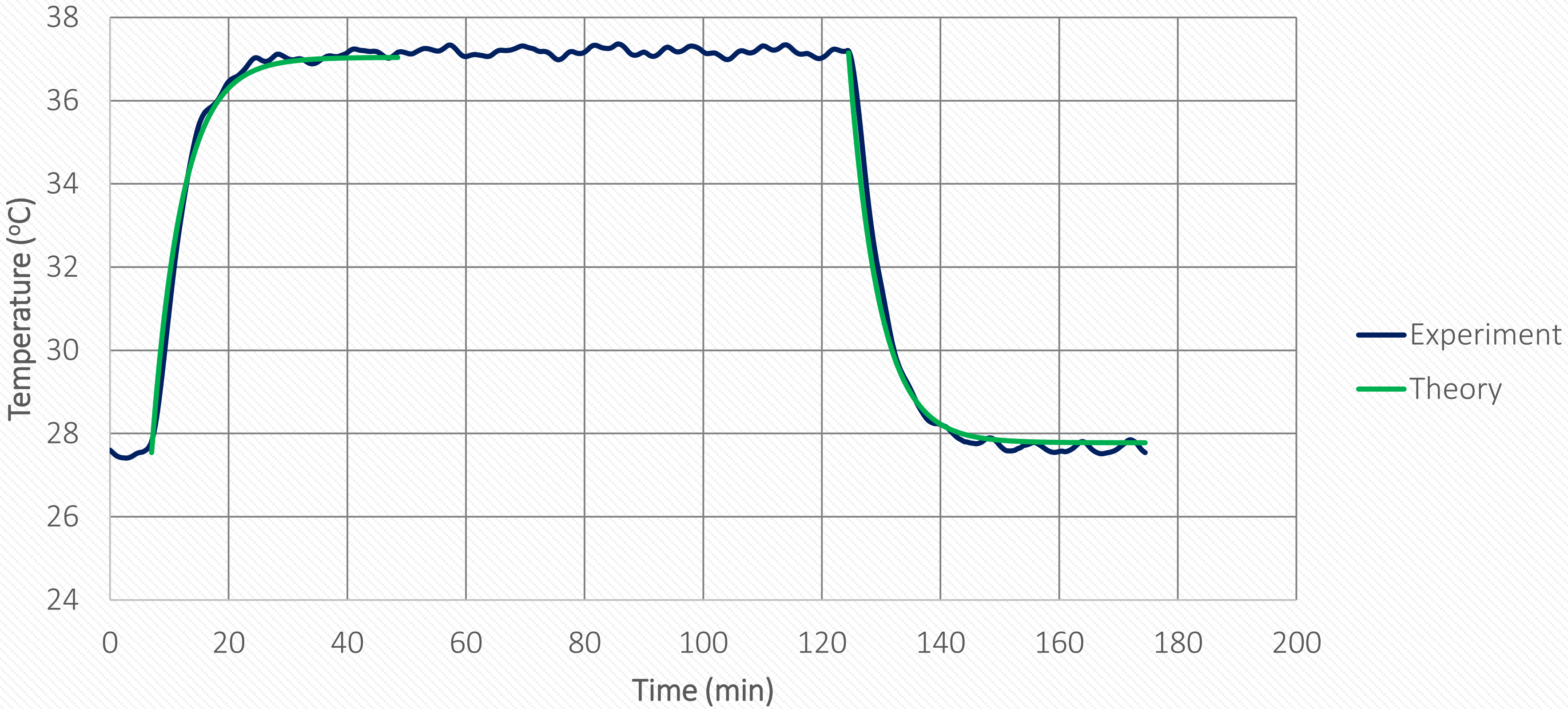


40 °C





Results



Comparison of SAS temperature profile: Experimental vs theoretical data

Procedure

Phase 1: Temperature

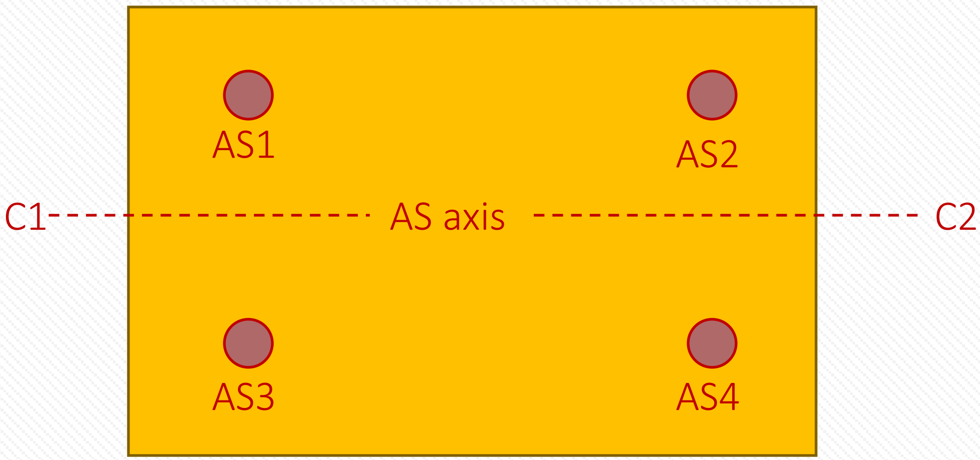
Dynamic **thermal** response as a function of:

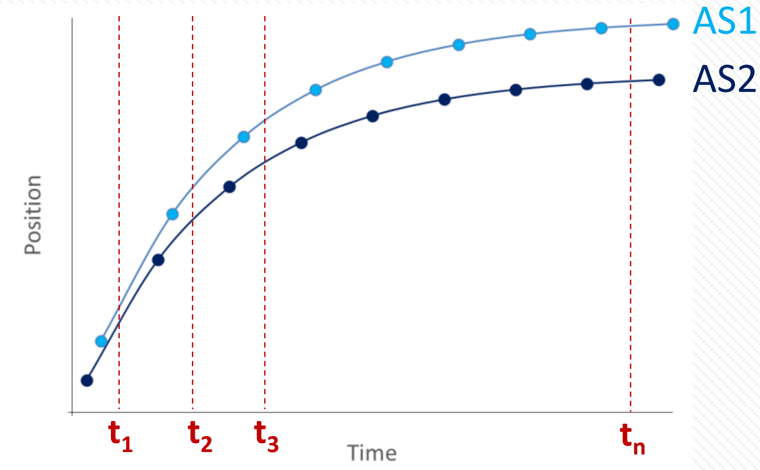
- Power applied
- Water flow
- Ambient conditions

Phase 2: Displacement

Dynamic **mechanical** response and its correspondence to the thermal dynamics

Measurement procedure





- Time to measure 1 AS point: 30 seconds
- Time to measure whole AS: 2 minutes

The four points are not measured exactly at the same time → Interpolate between measurements

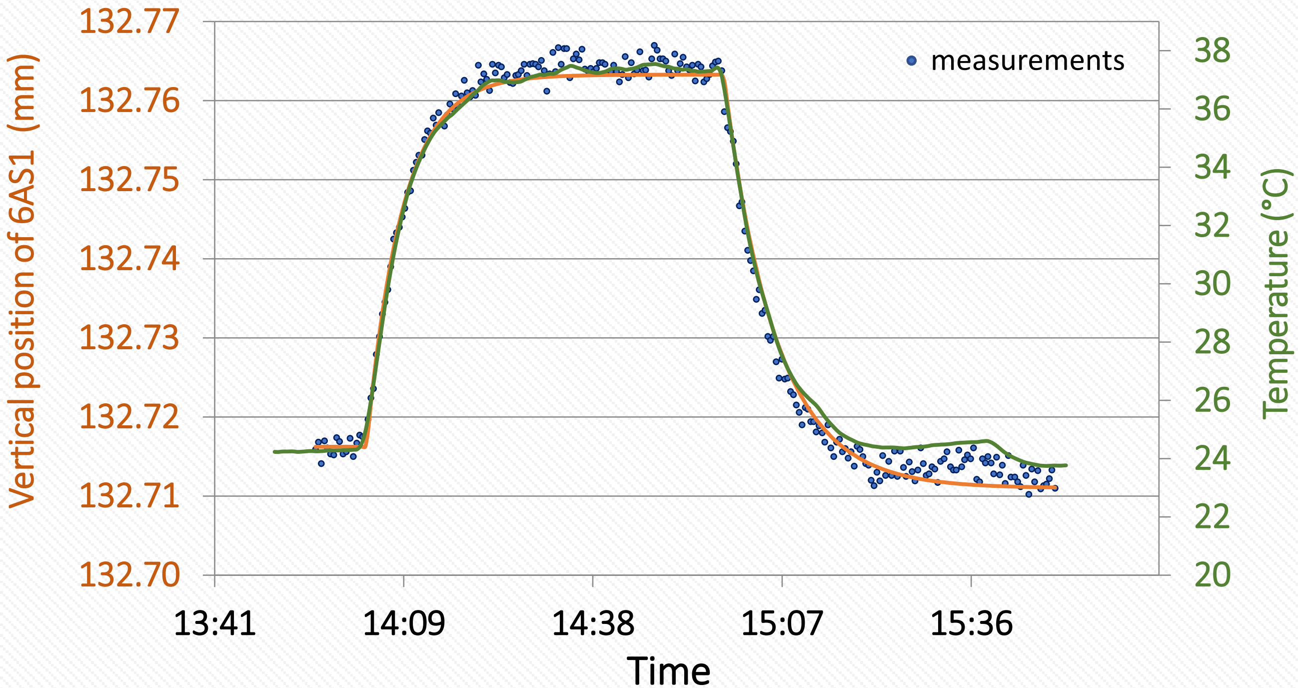
Tests plan

- **Case 1:** Follow one point of an AS
  - More frequent measurement of point's position
  - Investigate the dynamics of a single point accurately
  - Not adequate for the determination of AS axis movement
- **Case 2:** Follow one AS (4 points)
  - Determine the AS axis movement
  - Investigate axis dynamics based on point-to-point dynamics

Experiment conditions

- Power: 820 W
- Water flow: 0.04 m^3/h
- Ambient temperature: 20 °C

Results: One point of AS



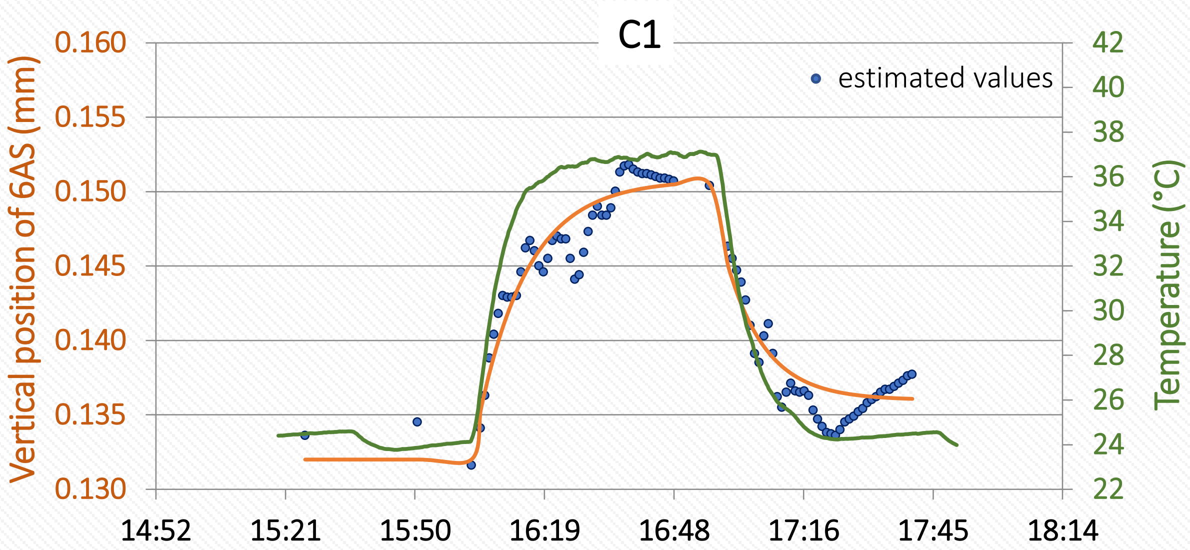
Time constants (min)

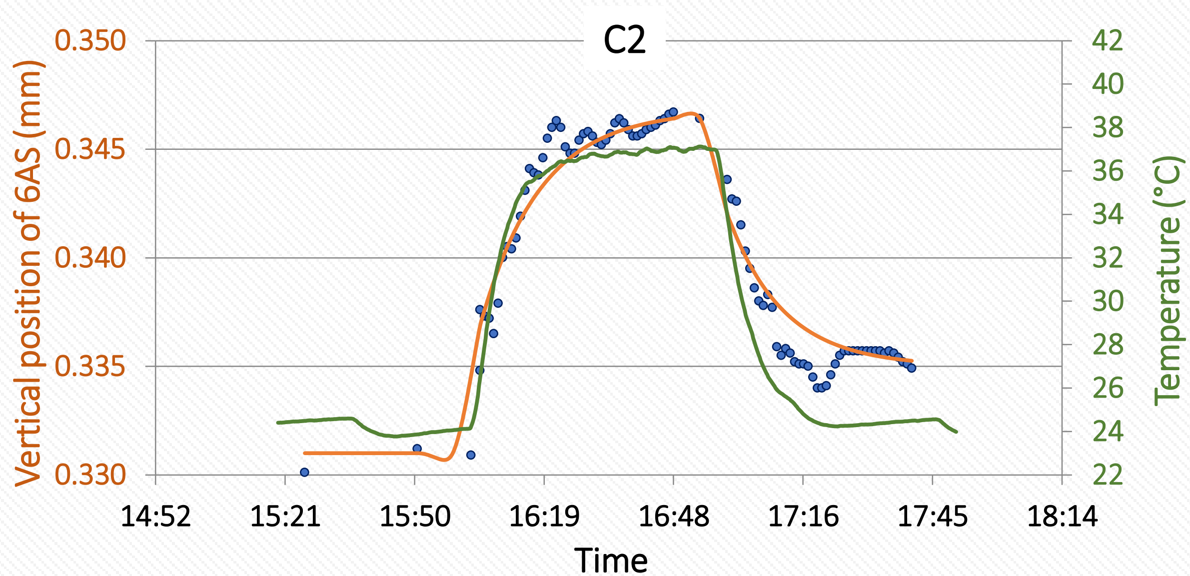
	Δx	ΔT
Rise	7.28	7.52
Fall	7.87	7.33

- Movement and temperature dynamics are the same
- Time constants can be calculated as in the case of temperature

Results: AS axis

Displacement





Time constants (min)

	ΔT	Δx C1	Δx C2
Rise	7.35	11.00	13.28
Fall	7.47	8.65	12.38

- *Vertical displacement of AS axis*
- *No radial displacement was detected*

Conclusions

Temperature

- Thermal time constant of SAS ranges between 4-11 minutes.
- Theoretical analysis matches very well with experimental data. This allows us to use a relatively simple model for the prediction of dynamic temperature response of SAS.

Displacement

- Displacement dynamics match well with the thermal ones.
- Temperature measurement (easy and fast process) could be used as an indicator of AS displacement (complex and time consuming process).

- The time constant of the components could be controlled as desired through the regulation of the water flow.

Thank you!