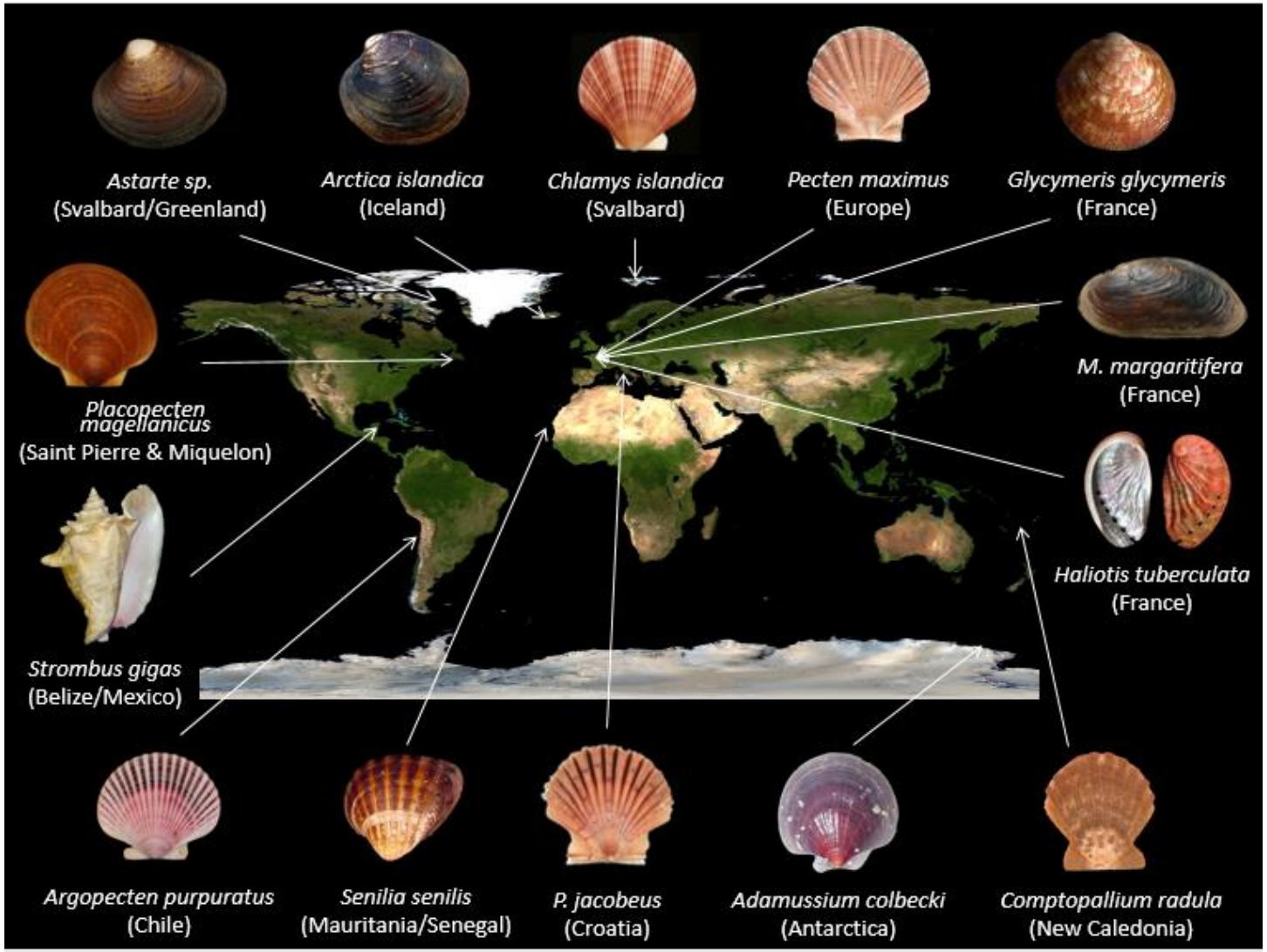
Signal Processing and Valvometry: from instrumentation to description of a biological state

- S. Reynaud[1.4], A. Chauvaud[2], E. Retailleau[2], D. Mathias[2], J. Paysan[1], L. Chauvaud[3], S. Chauvaud[4], J. Mars[1].
- [1] GIPSA-Lab, [2] SOMME, [3] LEMAR – BeBEST, [4] TBM Environnement,

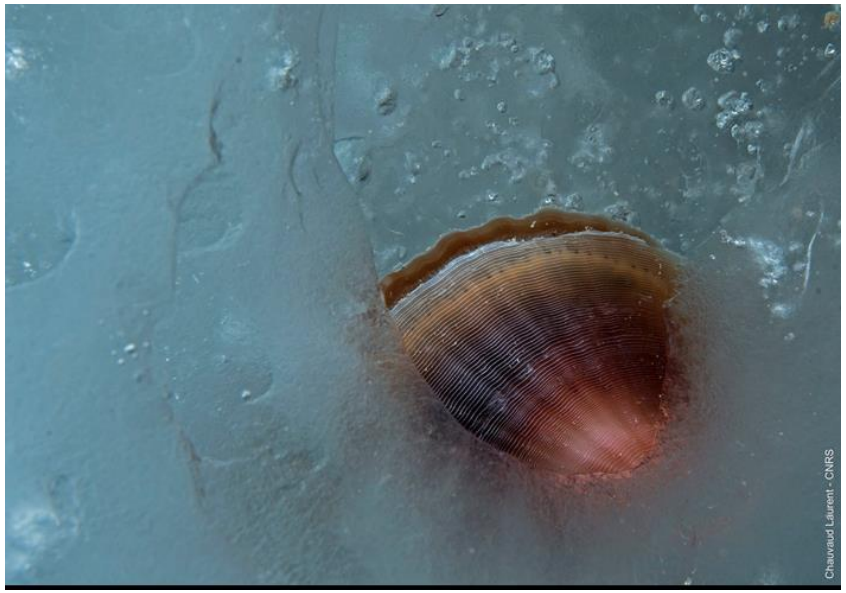
Advantages of working on scallops.

A wonderful sentinel for environmental studies.



Spatial :

Worldwide exposition…
even in the ice.



Advantages of working on scallops.

A wonderful animal / Behavior under stress.

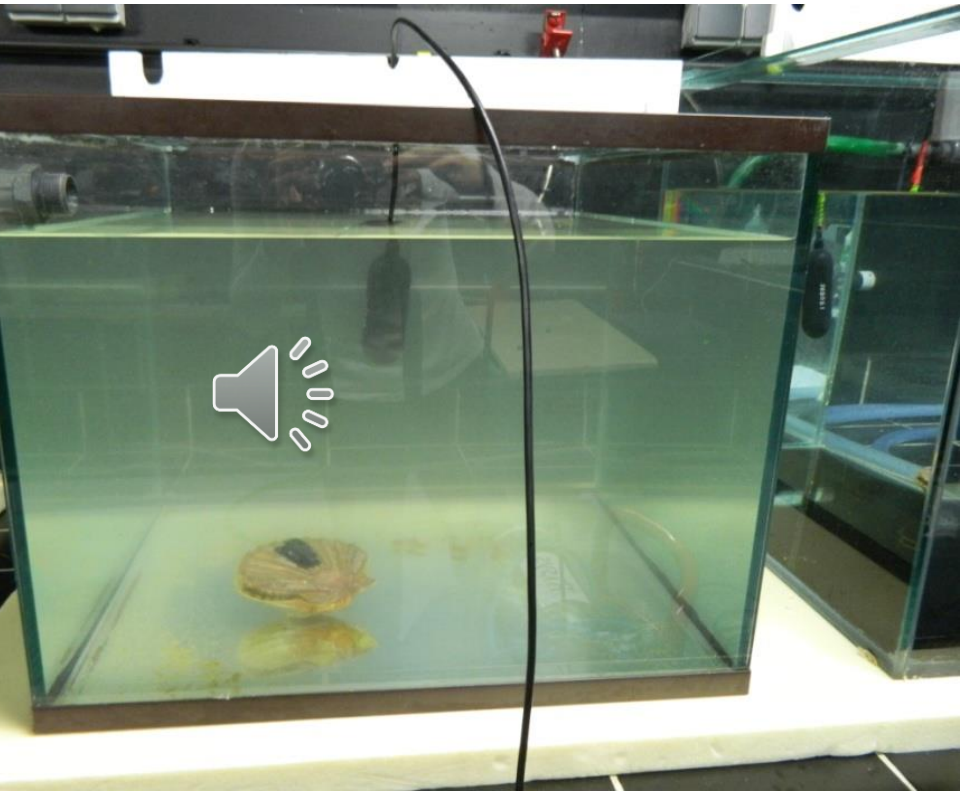
Not a fixed animal
it is calm……

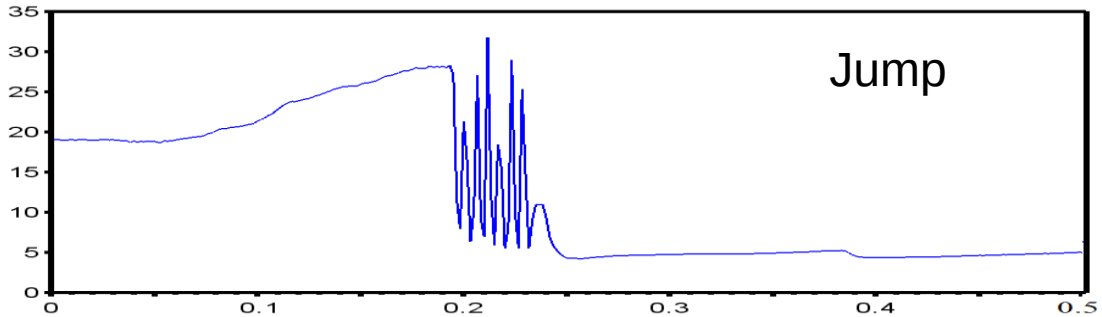
Under STRESS….can move

- Chemical pollutions
- Biological stress (green algae, predators…
- Humain Stress sound///

Commercial : big interest..
Food… it is really tasty with creams.

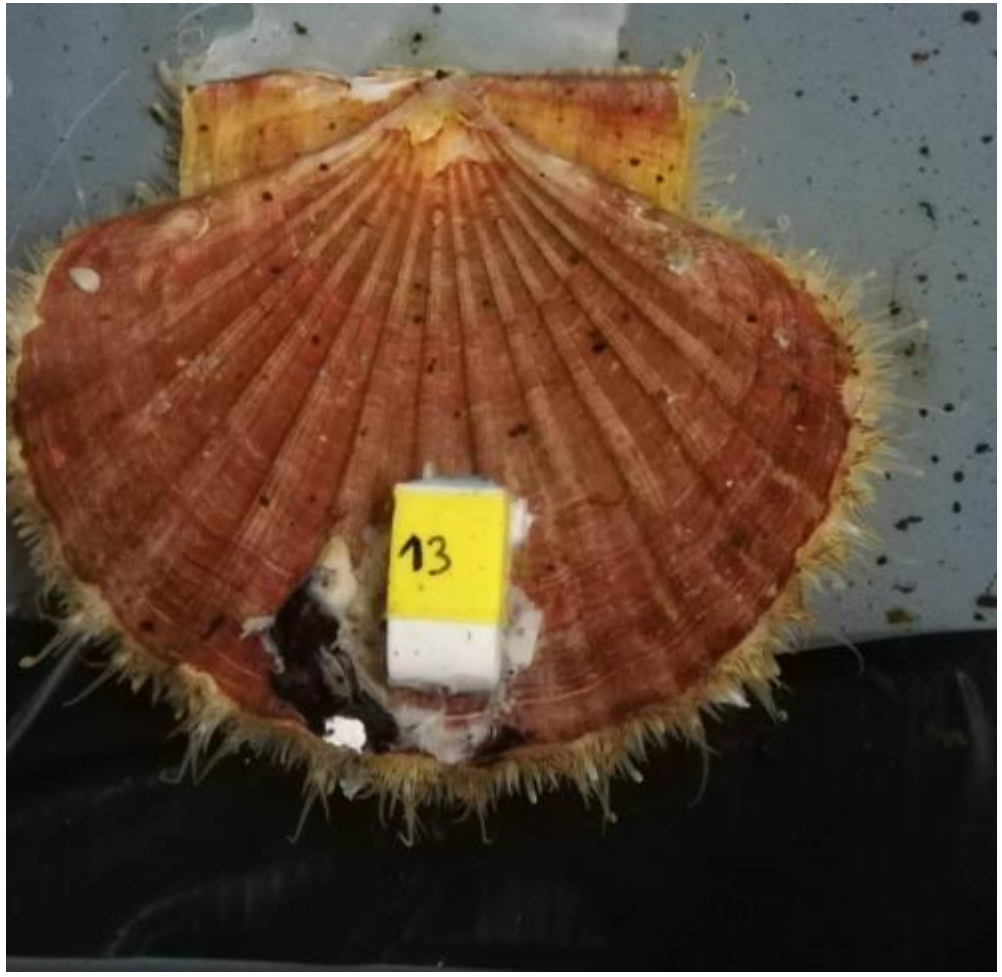
Acoustic against Movement / Valvometry.





Sensor + Shell
Old fashion :

New sensor.



Since 2020..
New Sensor by TechnoSmart : **3 axial accelerometer datalogger + Magnetometer**.(2 modalities)

Accelerometer : Sensor measuring the acceleration of a body in its own frame. F= 25Hz.

The magnetometer (valvometer) based Hall effect and collect information about orientation, movement direction.
F = 2Hz

Capacity record: at least 15 days.
Easy to manage ; fixed by glue on shell
Easy to collect data.
No disturbance for the shell. Less than 1g in water.

Valvometry signals → determine different behaviours

- Partial closing
- Faeces expulsion
- Rotation
- Jump/Flip
- Swimming
- Total closing
- Burying (?)

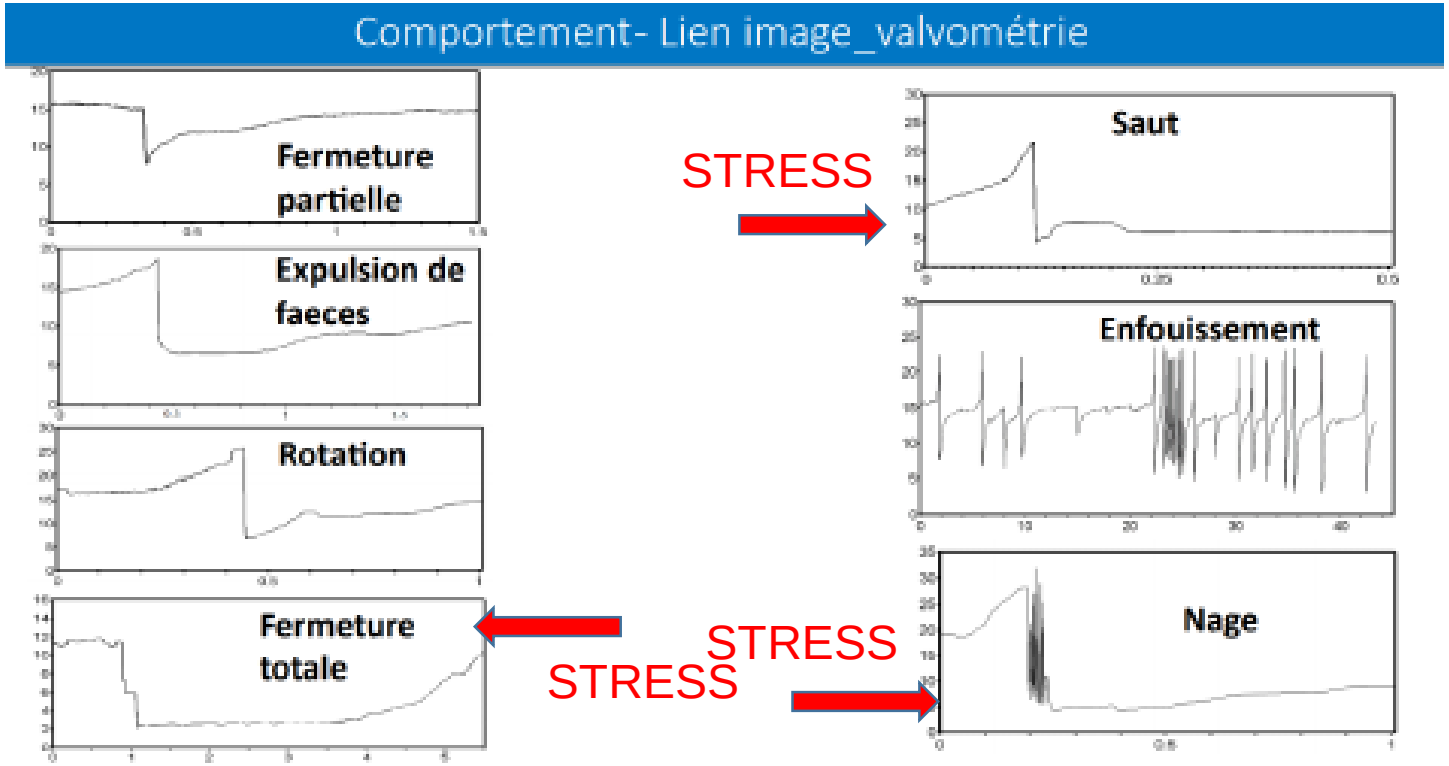


Image : A. Chauvaud, Caractérisation de l'effet des sons anthropiques sur le comportement de Pecten maximus

We need automatisation

Manipulation-Data acquisition

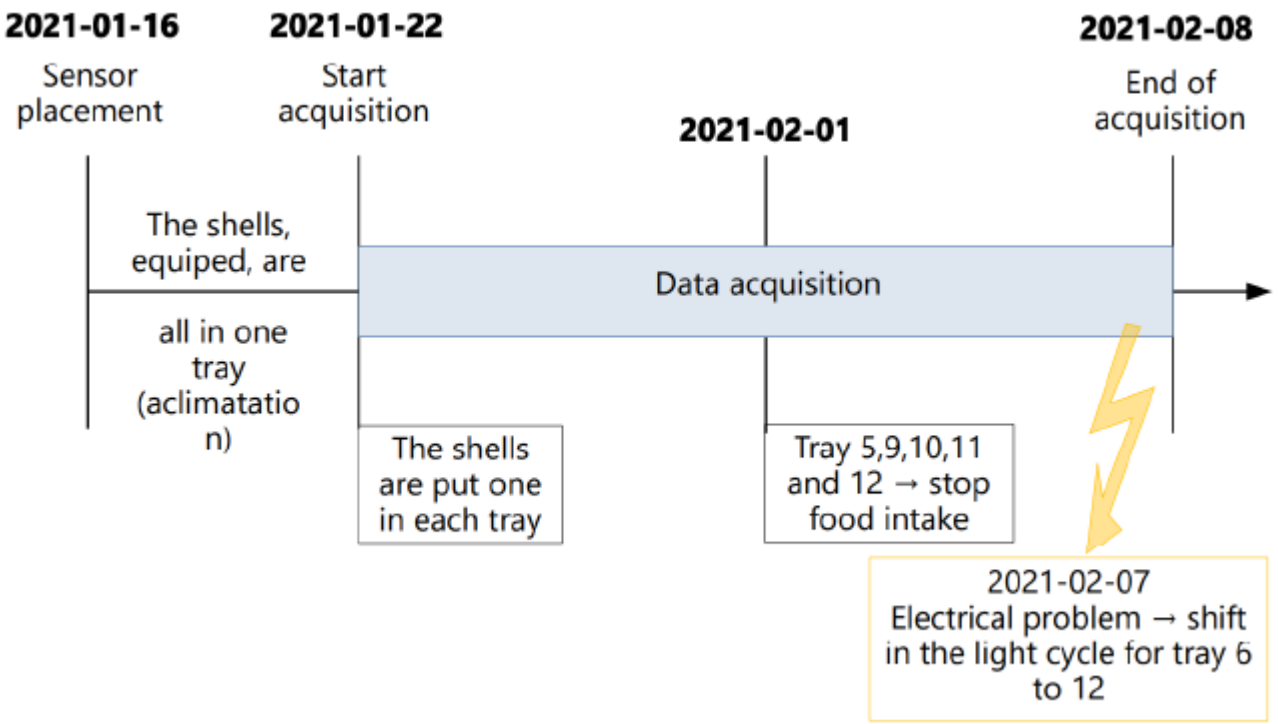
10 shells equipped with AXY sensor (*TechnoSmart* company) → record accelerometry (movement) and valvometry (valve position) signals.

16 days of recording in a **controlled environment** → characterize unstressed behaviour of the scallop

Controlled environment =

Temperature, food intake, light cycle, salinity measured and controlled

Shells are **separated** (avoid group effect) : one tray/ one shell



Shell and tray during the manipulation : each shell is alone in its tray

Tinduff hatchery (29470)

From 2021-01-22 to 2021-02-08

Hatchery @ Tinduff is the unique place in France for scallops growing.
30km from Brest.

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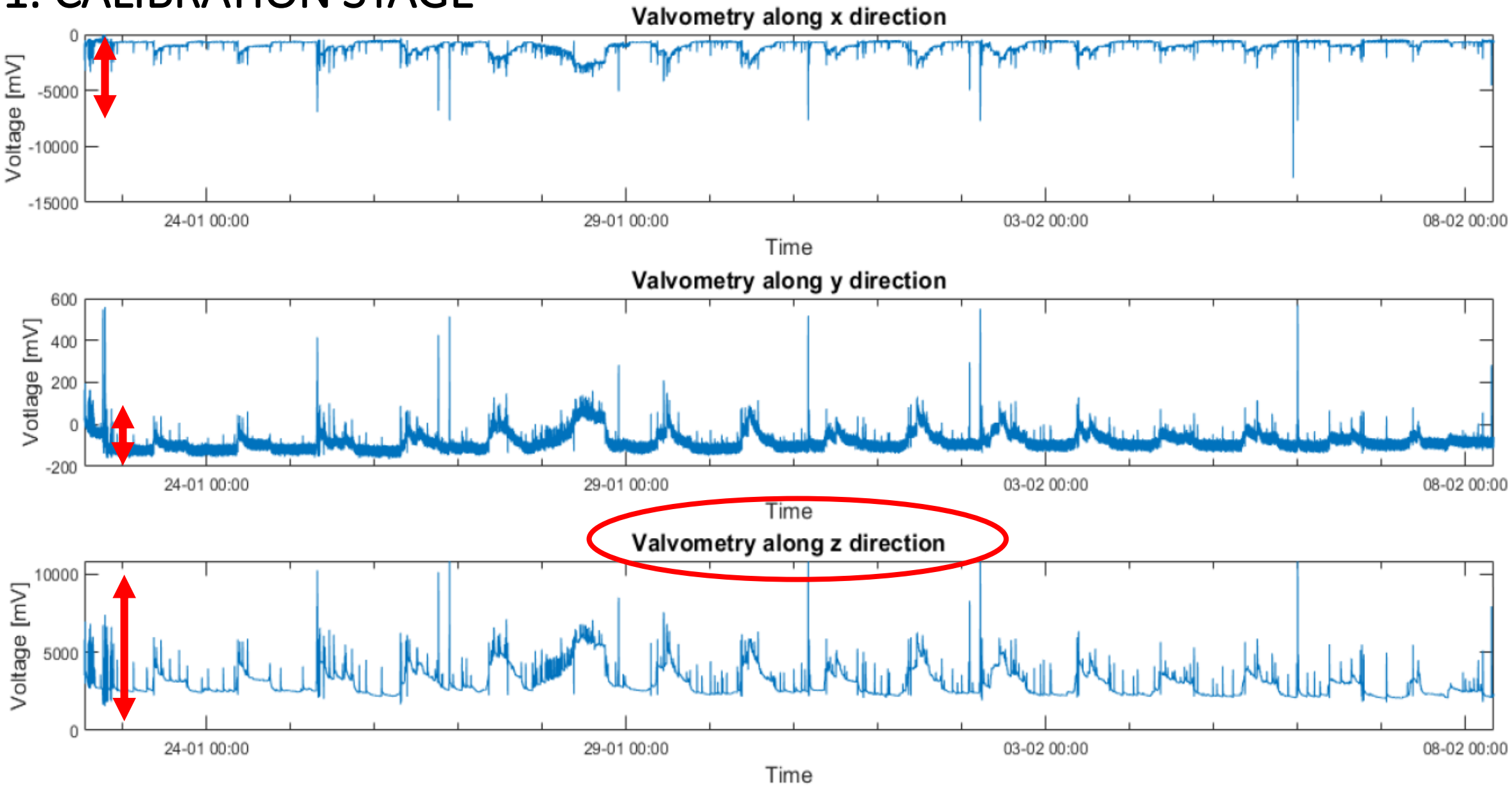
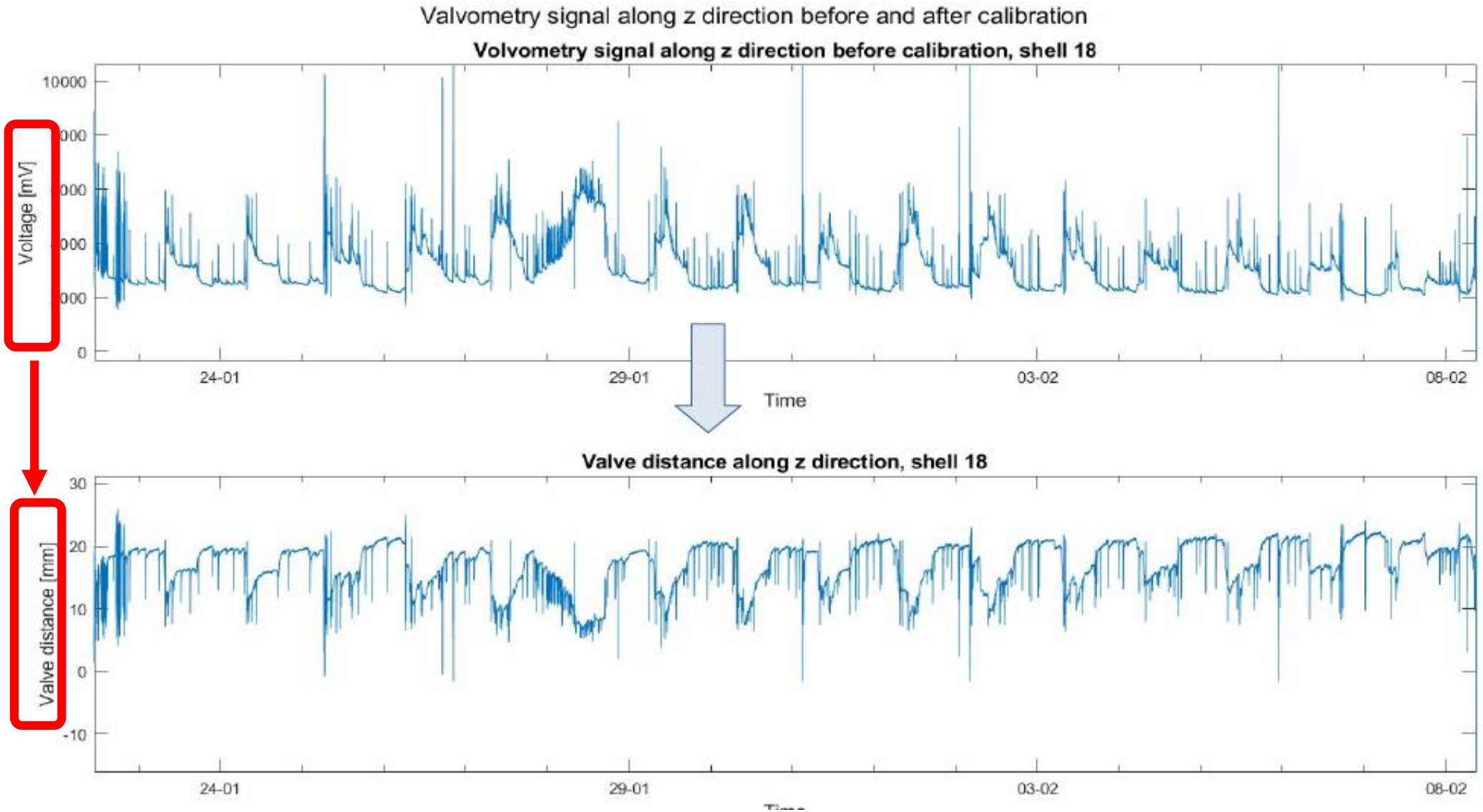
1. CALIBRATION STAGE

voltage has no biological direct meaning :



1. CALIBRATION STAGE Distance measurement for shell 18 on 16 days



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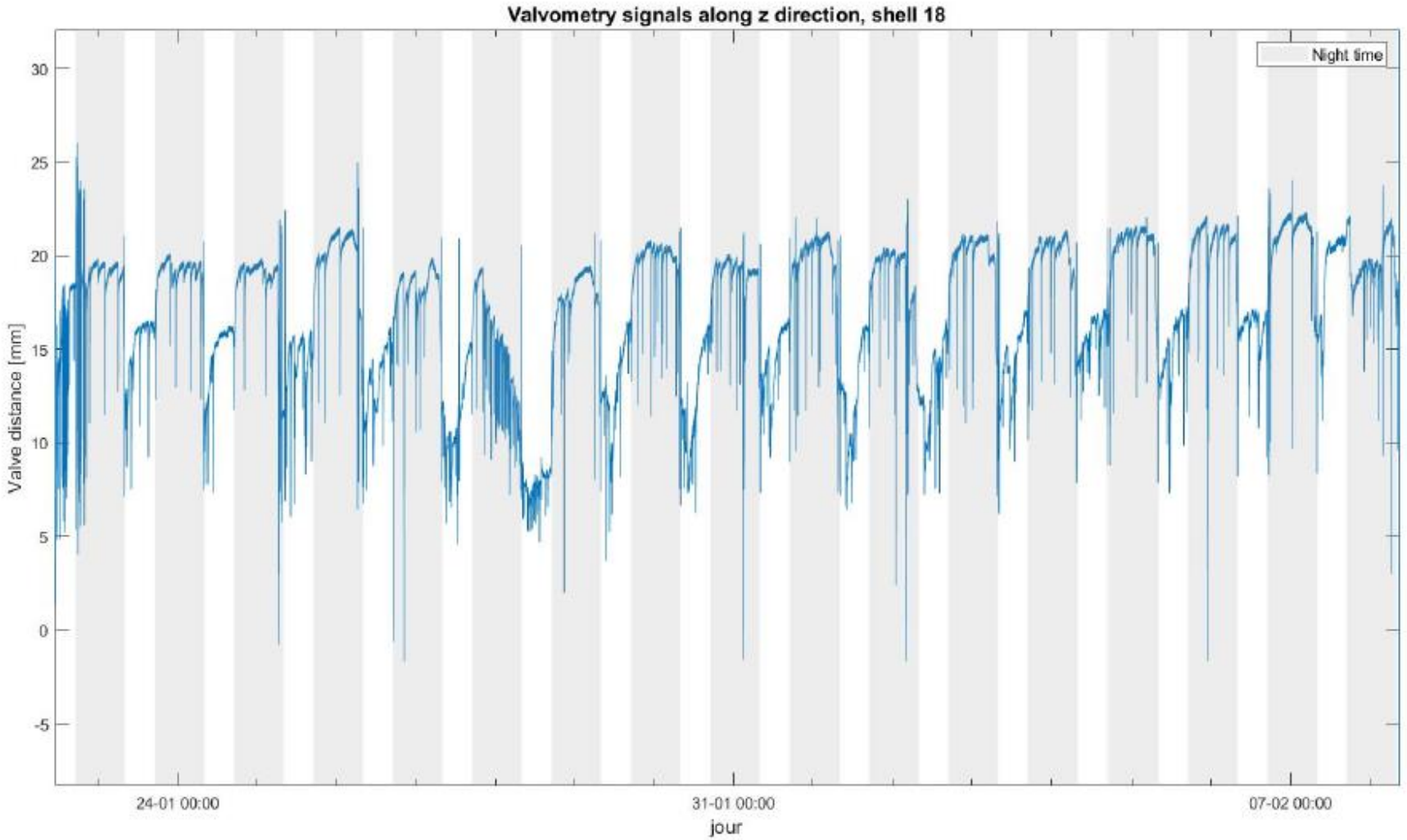
Long time analysis

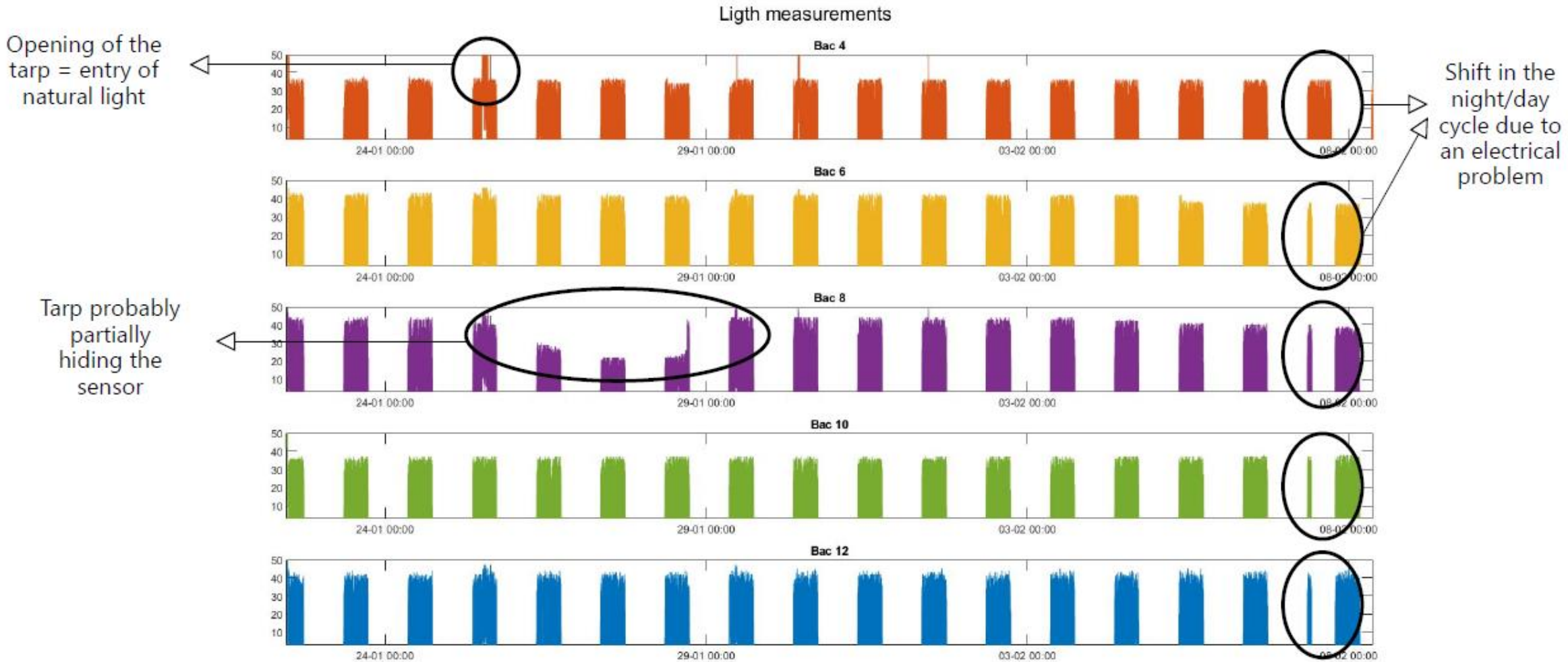


Sunrise	Sun	Night fall	Night
8:30 am	9:00 am	5:30 pm	6:00 pm

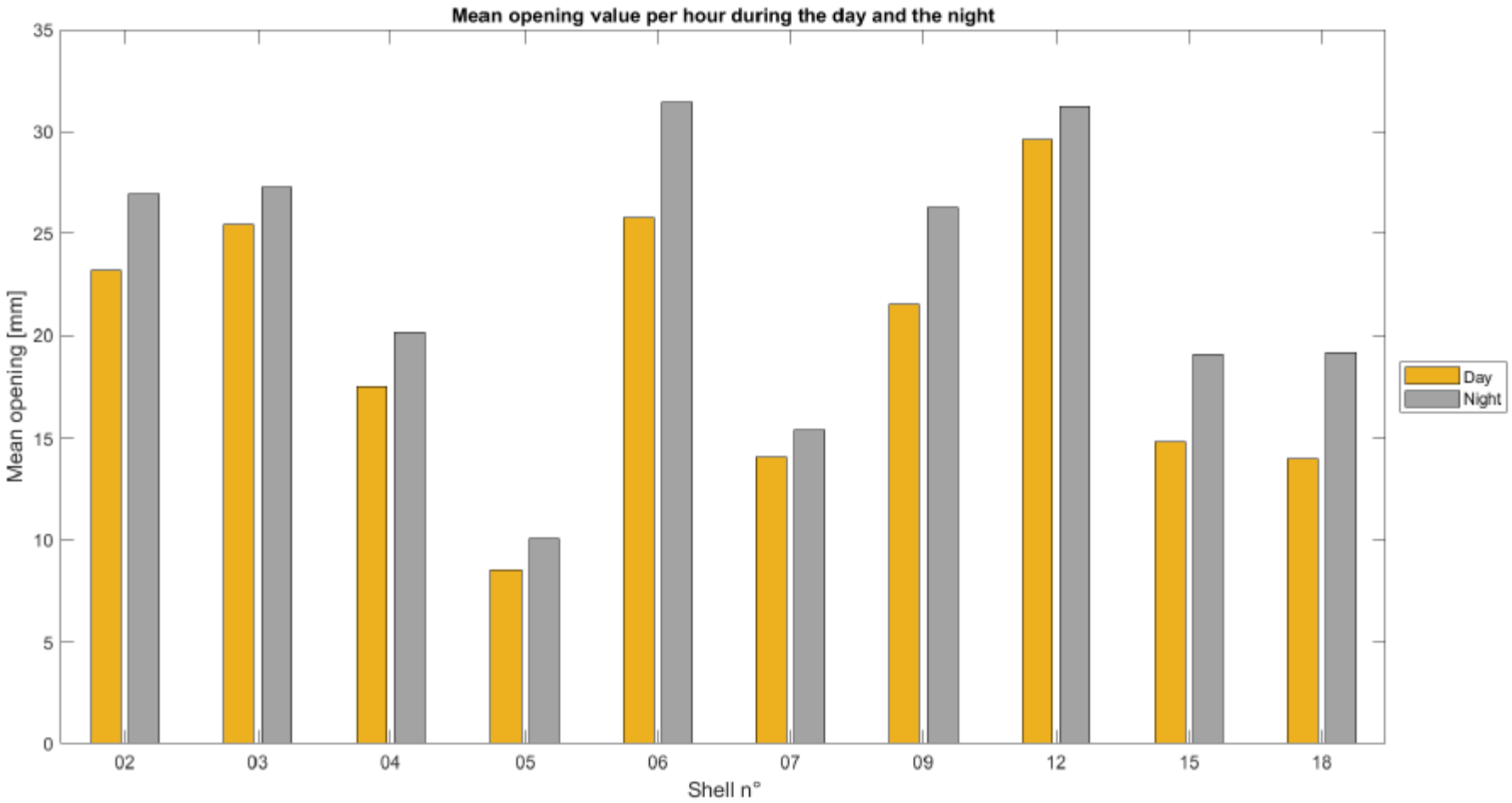
Full night duration: 14h30 ;
Full day duration : 08h30

Visible cycles → shell more open during the night than during the day
→ do they appear in the analysis ?

Light measurements

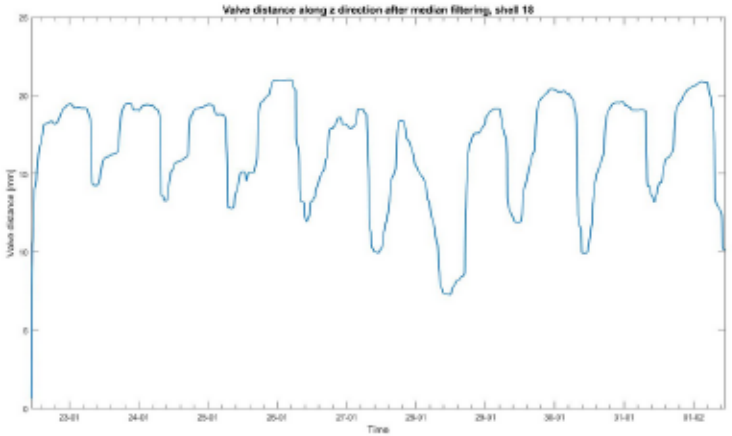


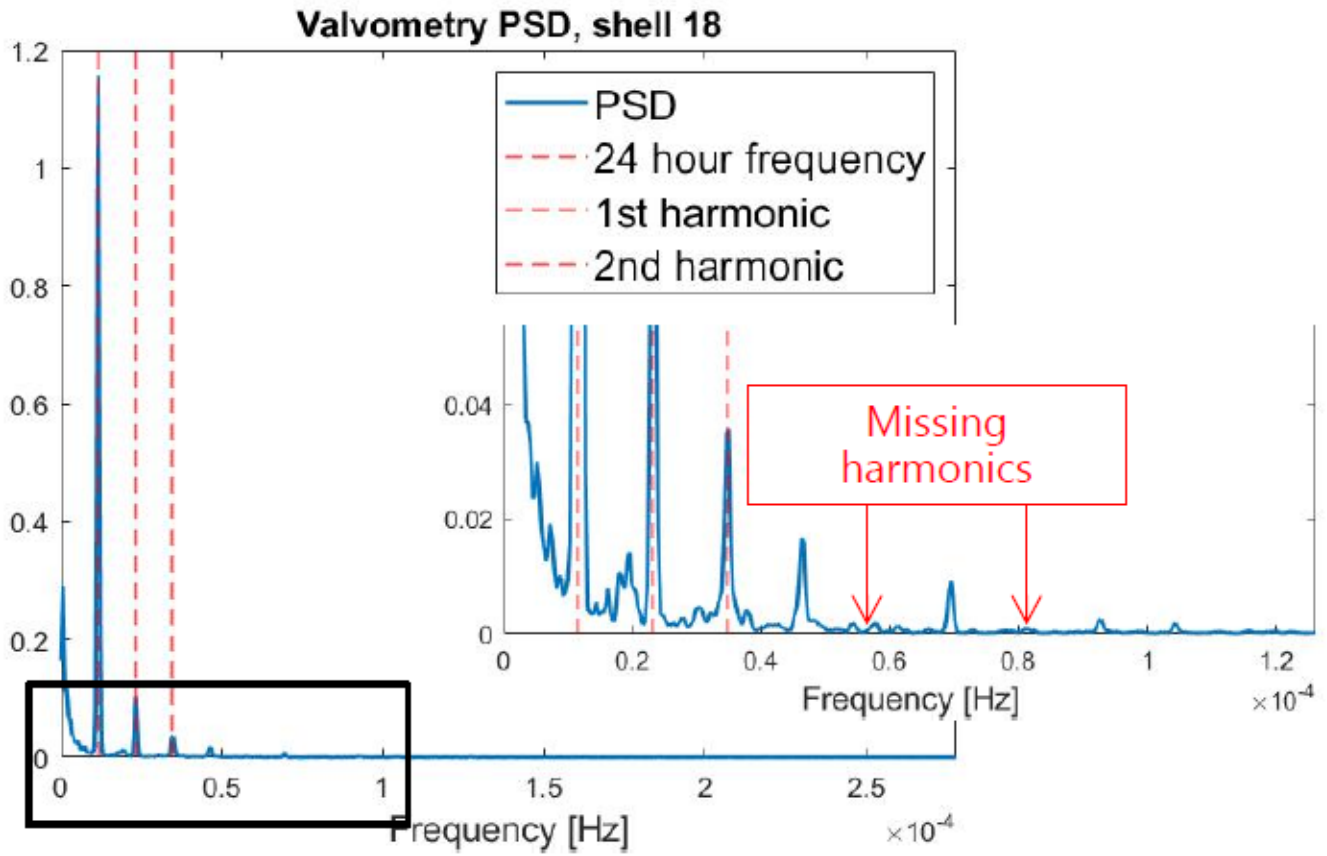
Light measurements



Mean base opening during the day and during the night periods, for all individuals.

Long time analysis : Power Spectral Density (PSD)

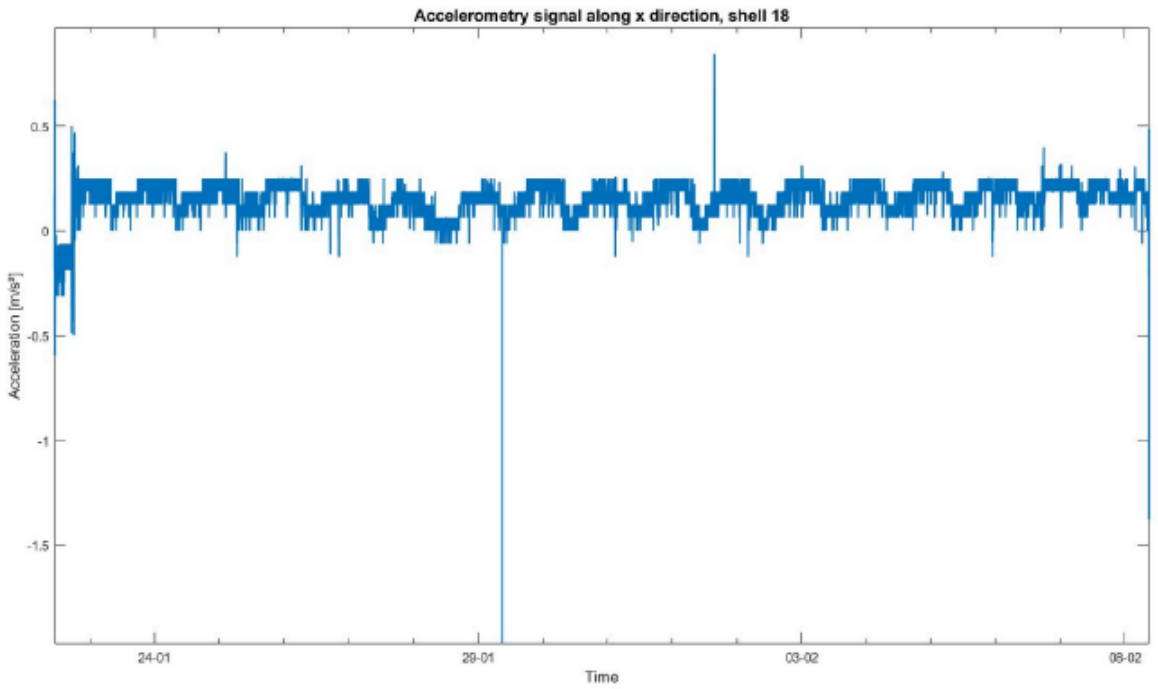




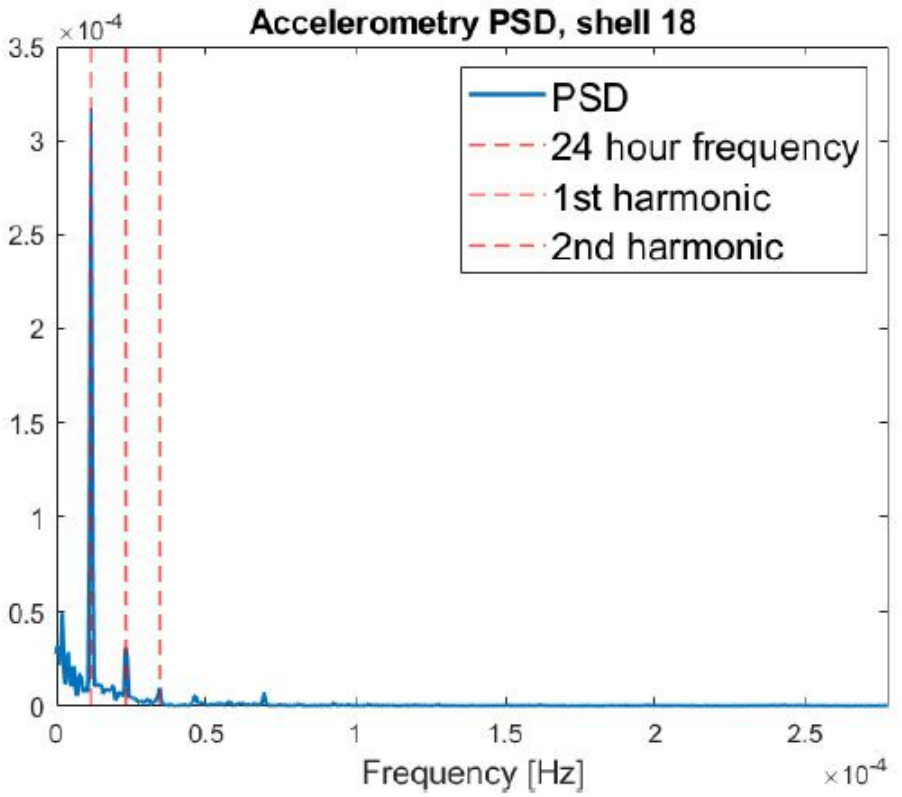
Peak in very small frequency → not perfectly zero mean signal

Peak of highest amplitude for a 24h frequency (fundamental)
Harmonics every 24h
5th and 7th harmonics are cut → cycle between 14h and 14h30 duration (cf theory)

Long time analysis : accelerometry signal along x direction



Visible cycles → more activity/movement during the night ; shell more open



Same comments than the valvometry signal and valvometry PSD :

- Fundamental at 24h frequency
- Harmonics and 5th and 7th missing → cycle of a duration between 14h and 14h30 (i.e about night duration)

→ Again, 2 time/cycle influence

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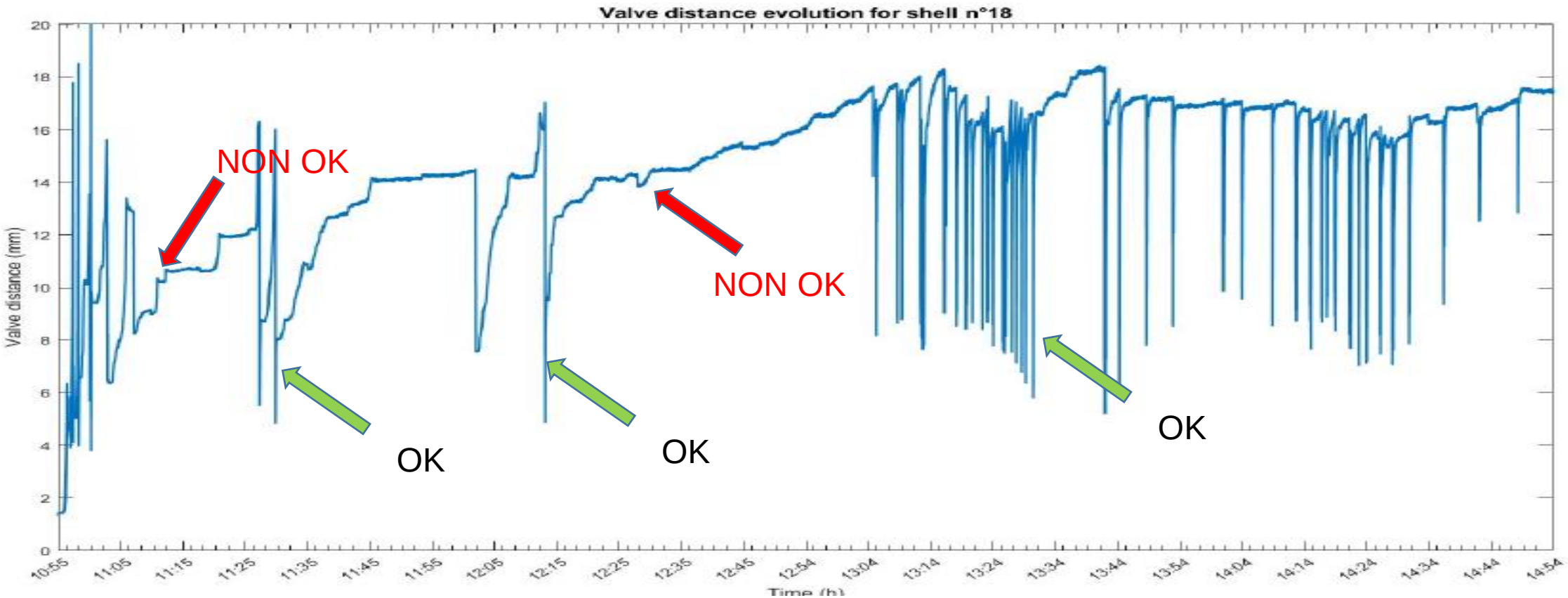
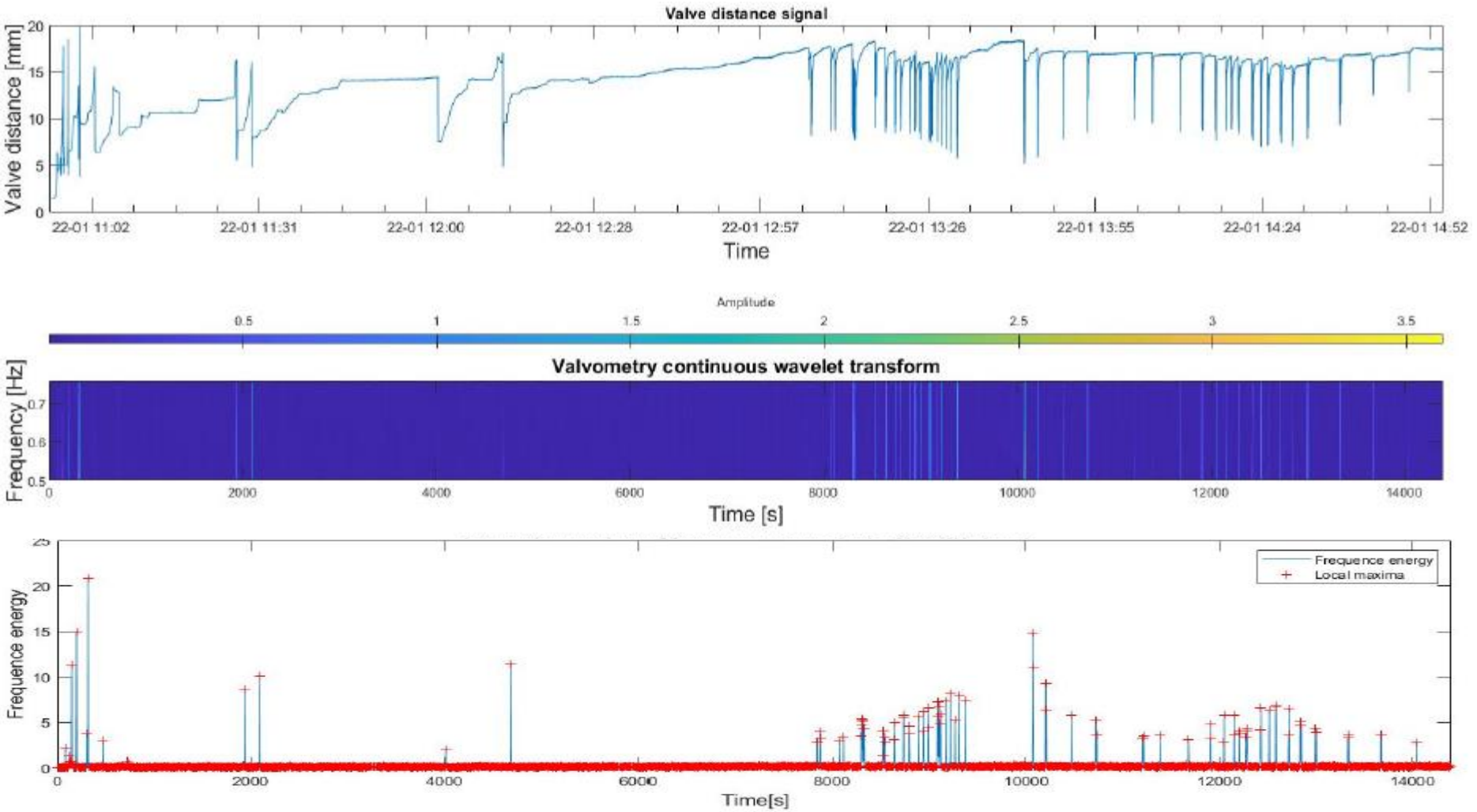
3. MOVEMENT DETECTION



4 hours of the valve distance signal
Slow and fast variation of valve opening : base line variation and movement (closings mainly)

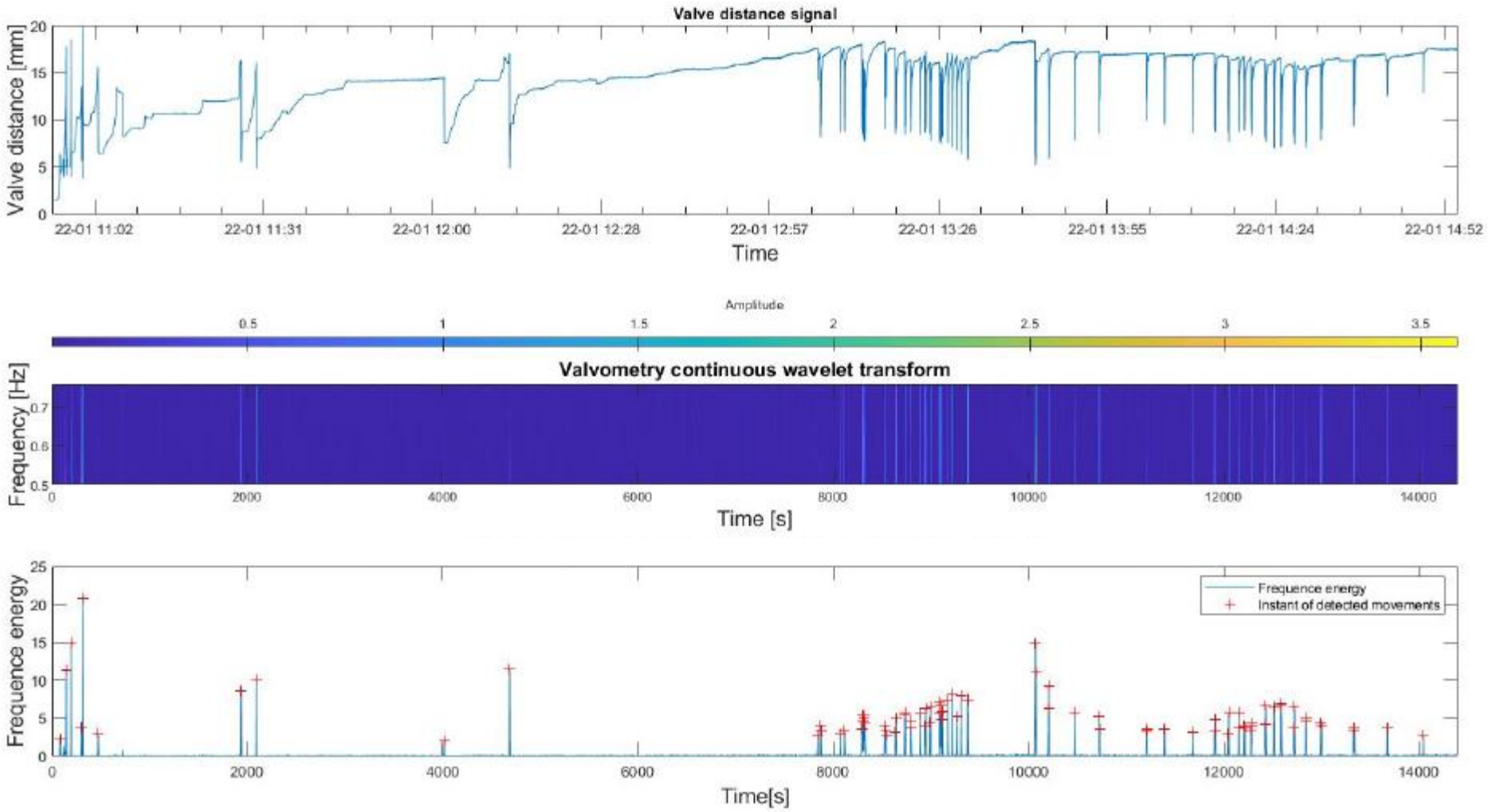
Goal : - detect, localize and count the movements, characterize their amplitude.
- then apply this “real time”

3. MOVEMENT DETECTION



Detection on all peaks after WT

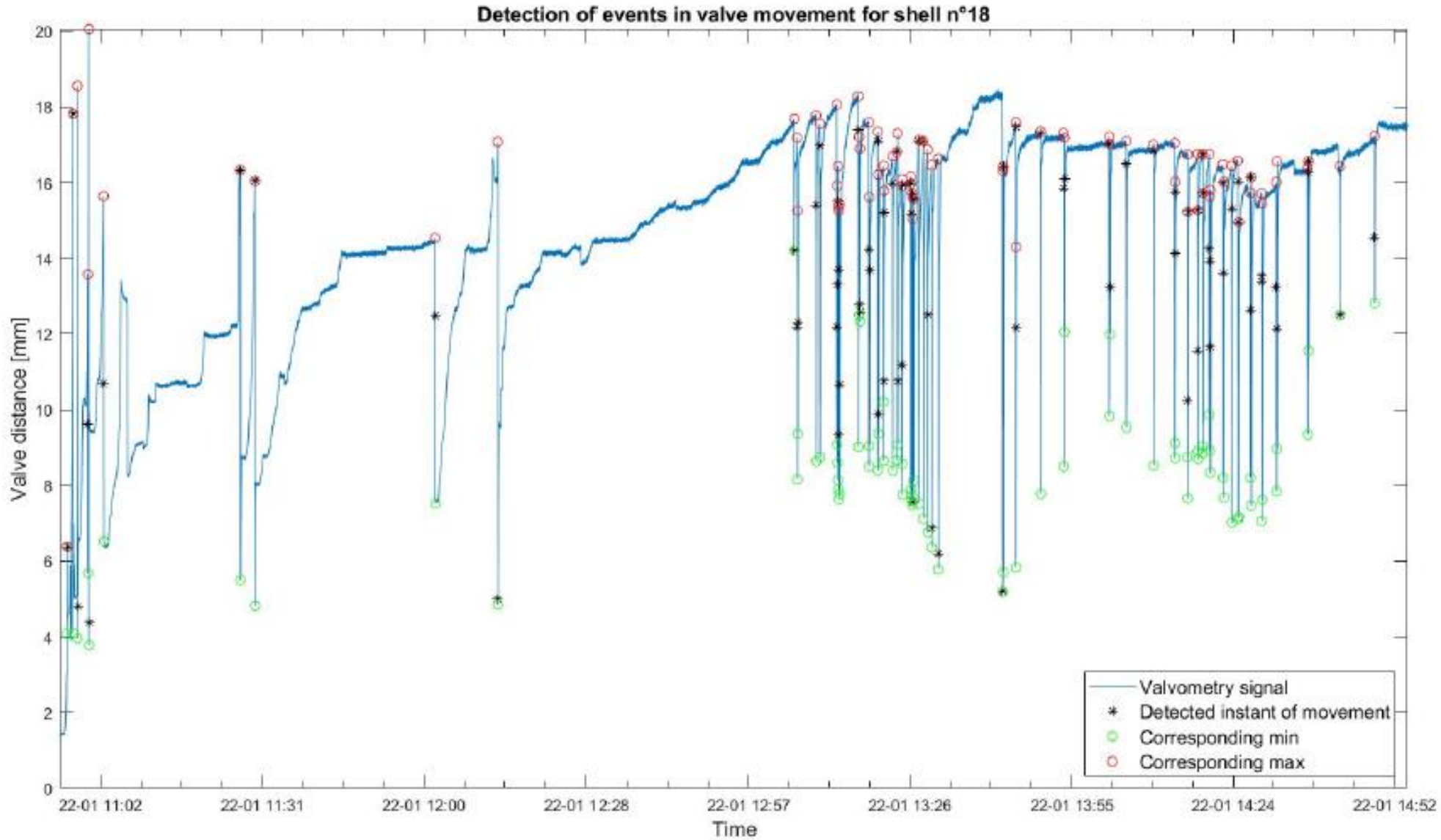
3. MOVEMENT DETECTION



→ smallest peaks are removed

What amplitude remaining movement corresponds to?

3. MOVEMENT DETECTION



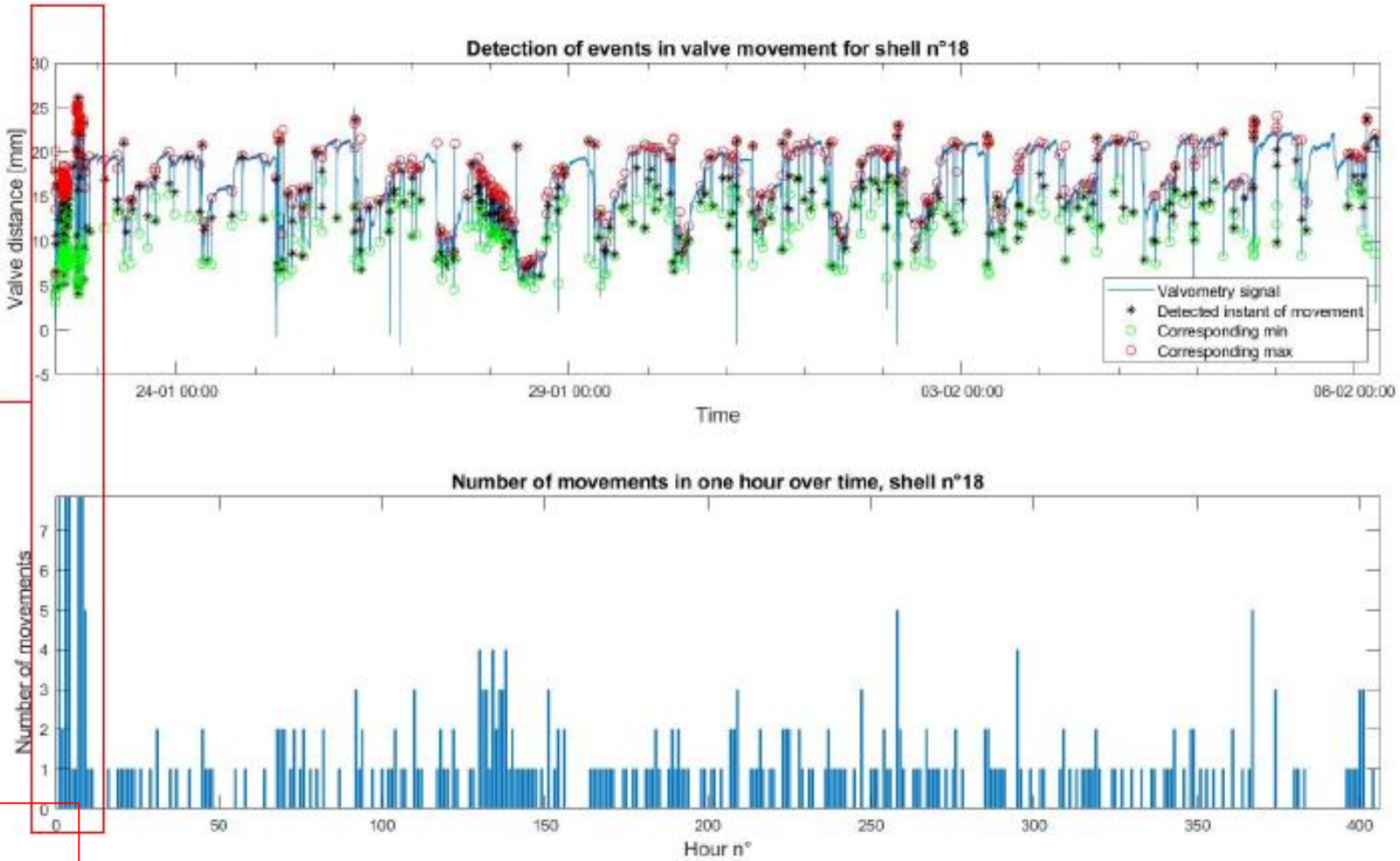
Quasi real-time implementation on 16 days

Minimum and maximum values linked with a detected movements

- **number of movements per hour**
- distribution of movements' amplitude

On time signal : many movements (burying)

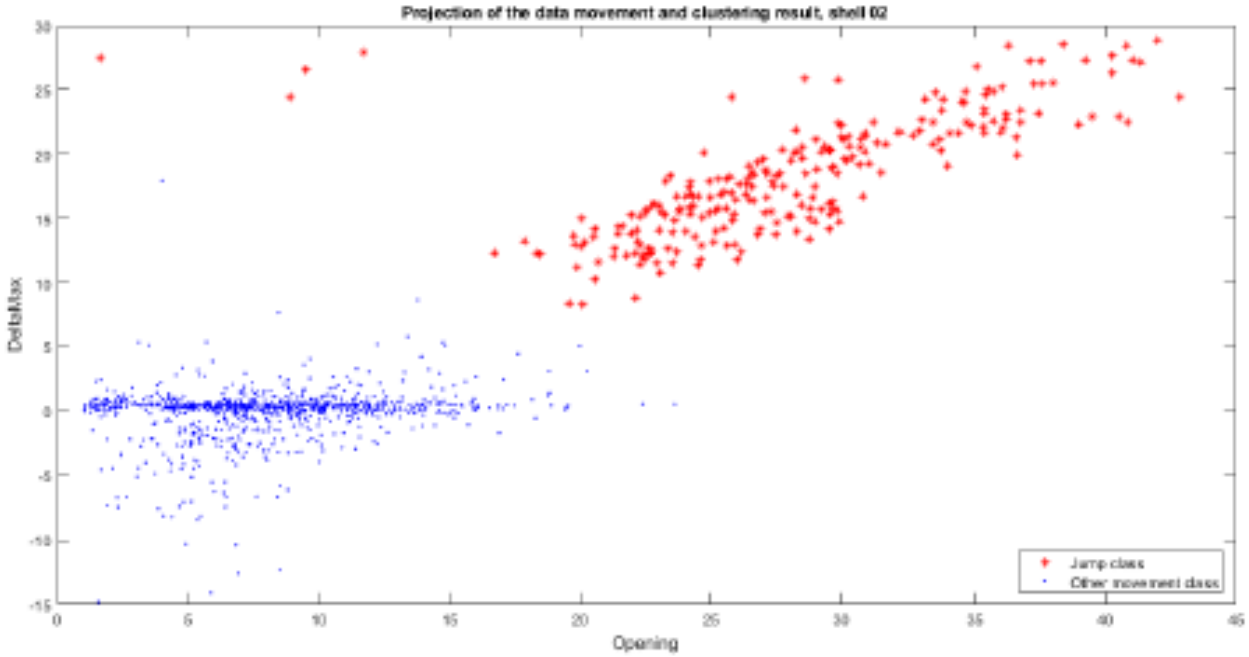
→ peaks of number of movements



After control :
>90% movements detected

About the same number of movement on 'normal' days

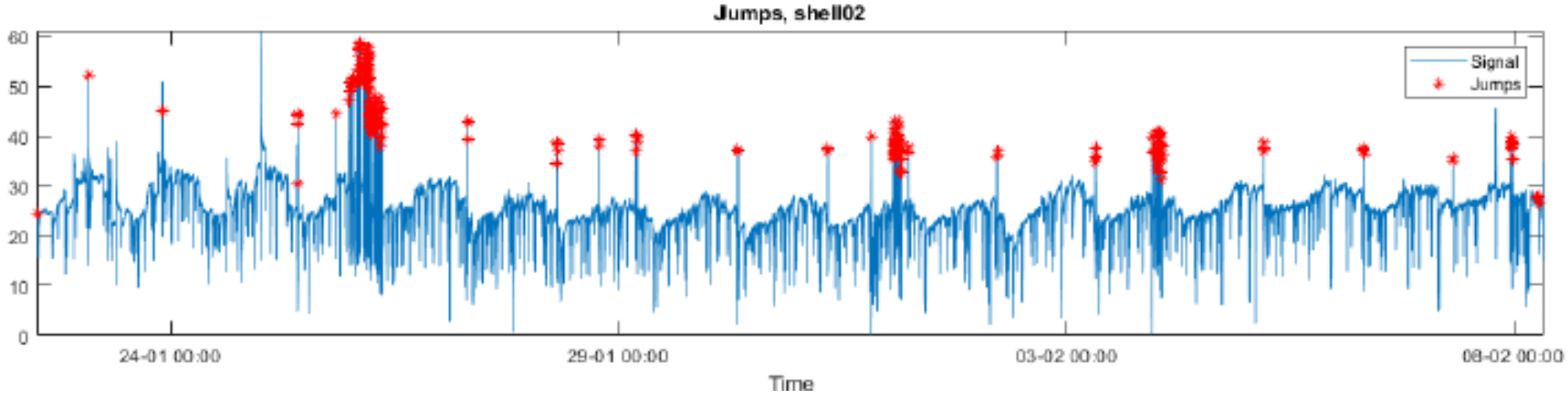
3. JUMP DETECTION



2 classes :
- Movements (blue)
- Jumps (red)

For each detected movement find different features to describe the movement (scalar value)
Put them all in a matrix and perform PCA (1 movement = 1 individual; 1 feature = 1 variable)

Results on the time signal



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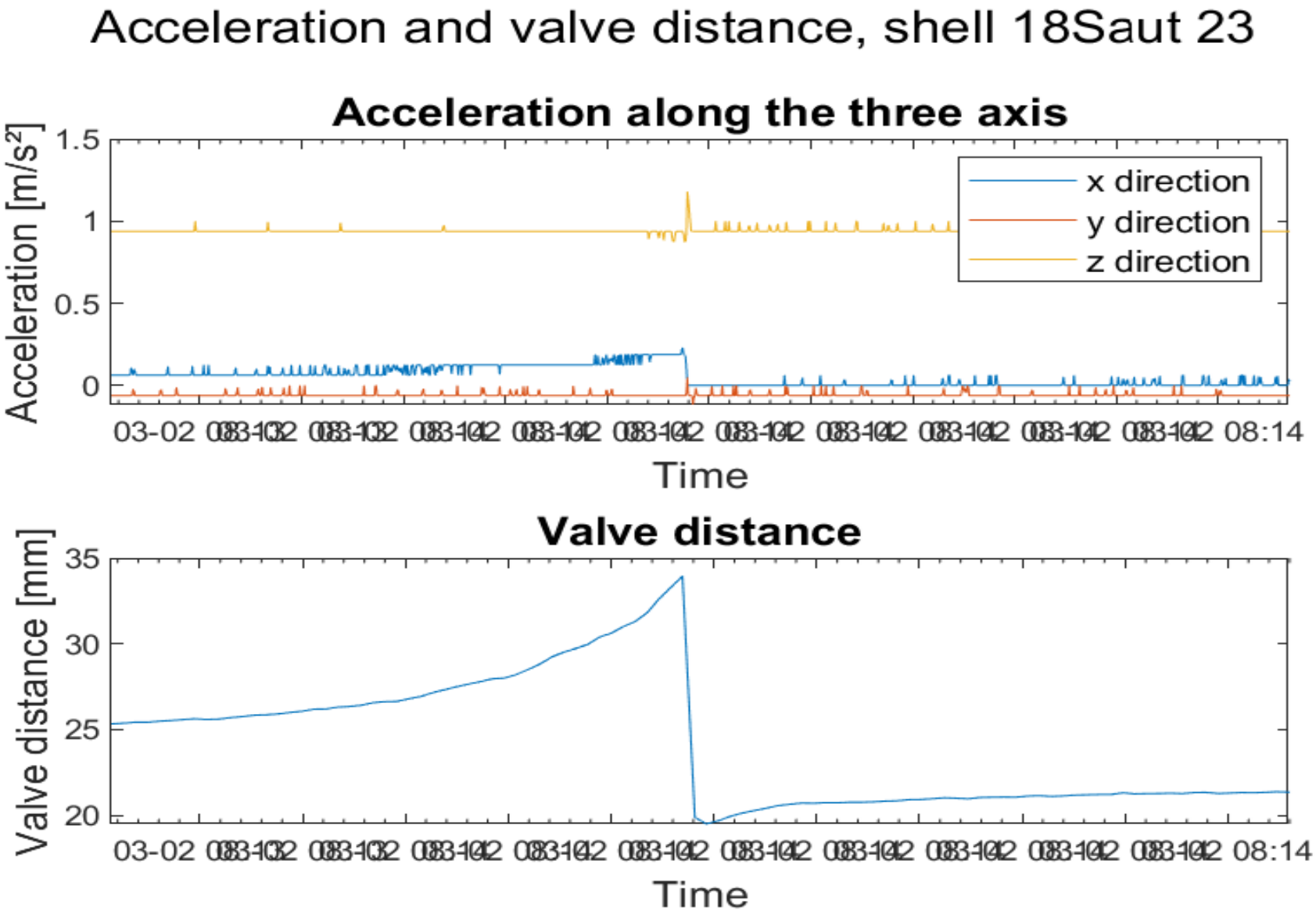
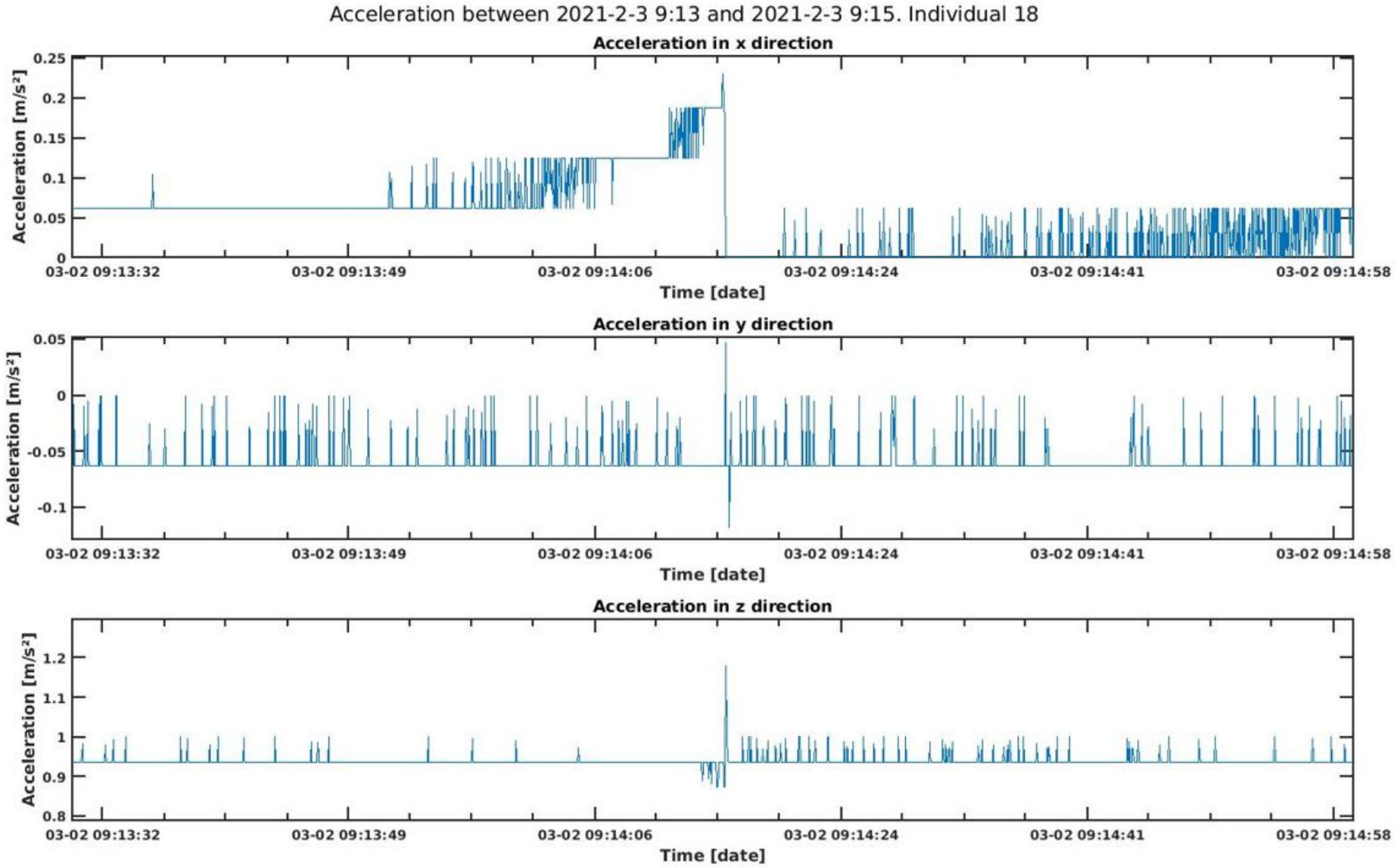
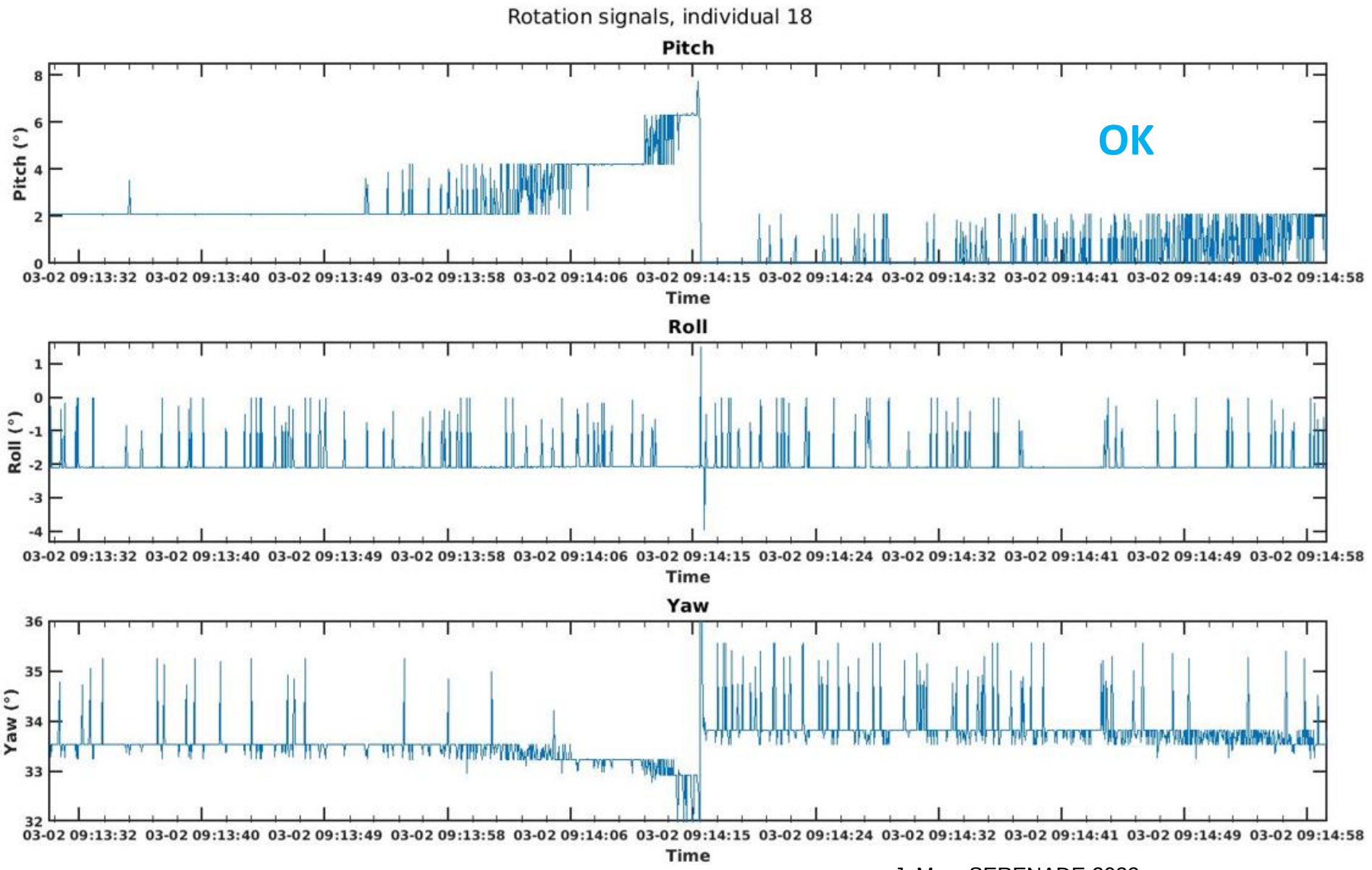
4. ACCELERATION / VALVOMETRY



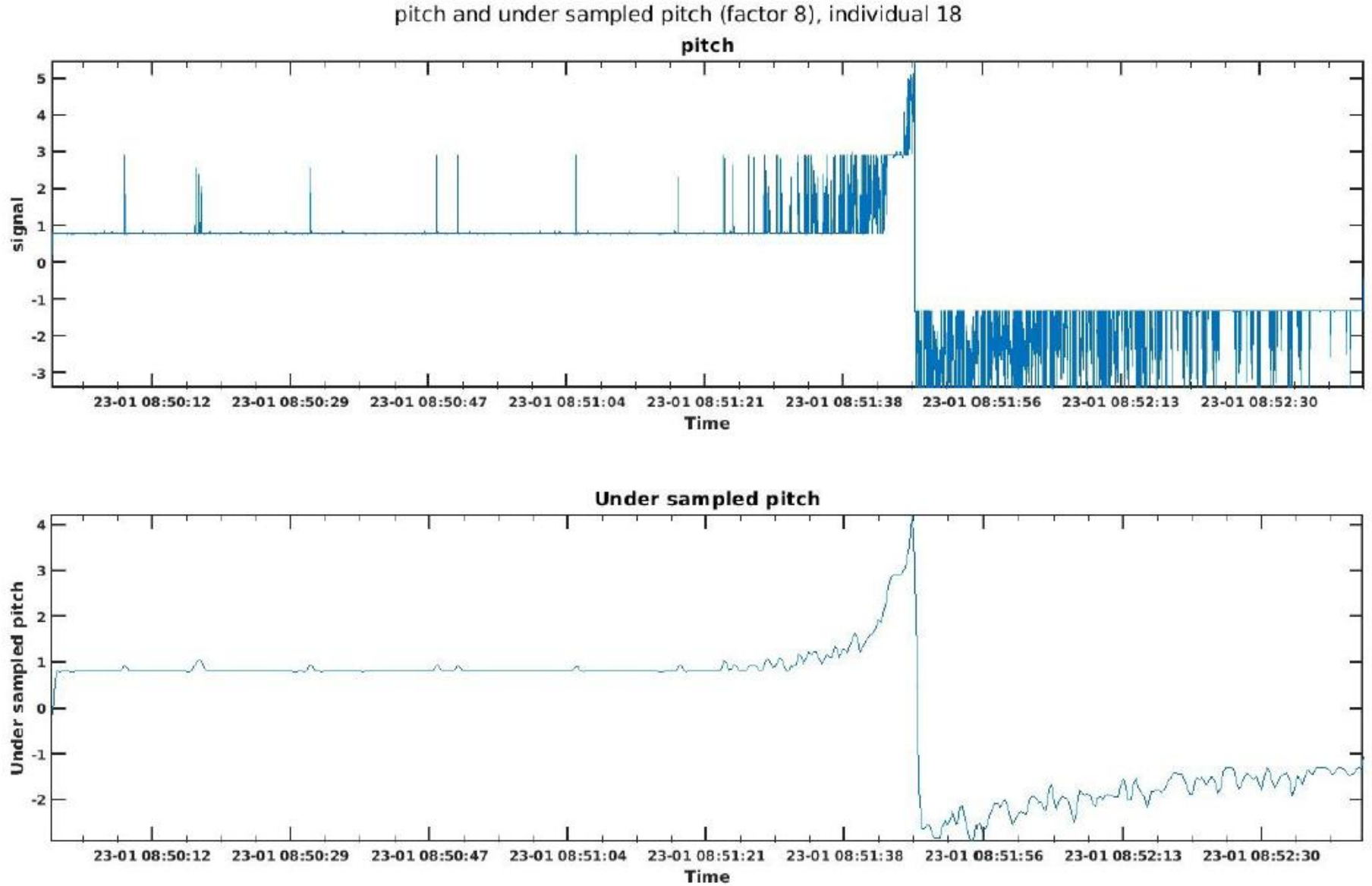
4. ACCELERATION / VALVOMETRY (Raw data)



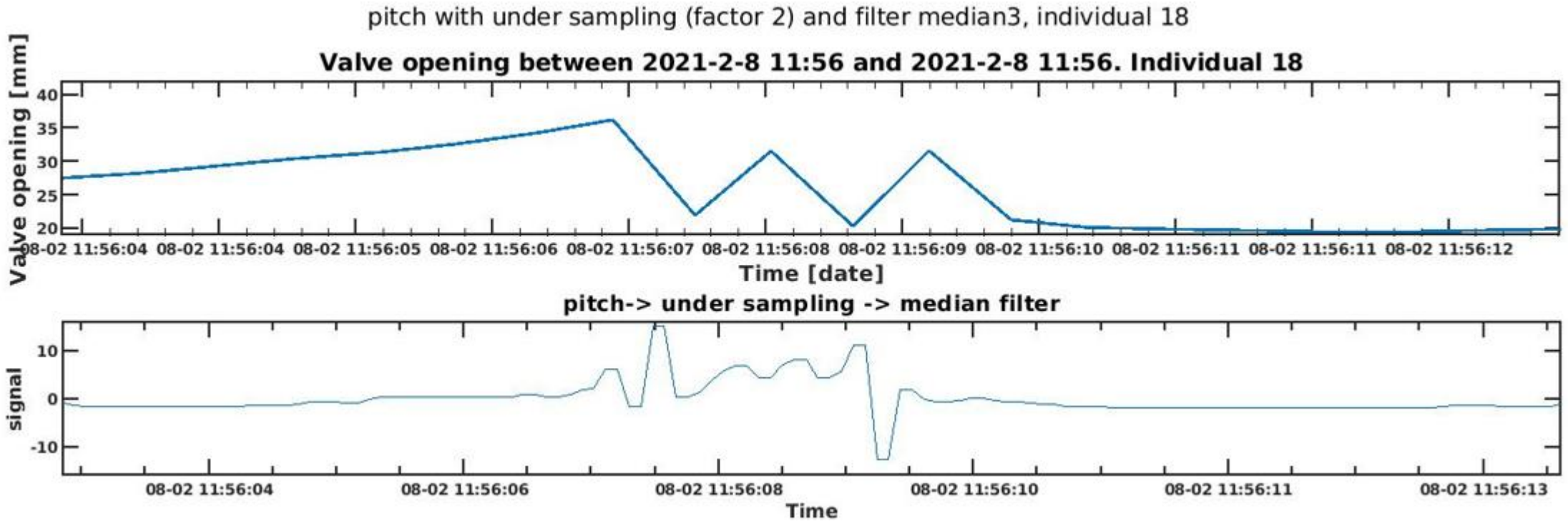
4. ACCELERATION / VALVOMETRY (physical data)



4. ACCELERATION / VALVOMETRY (Undersampling)

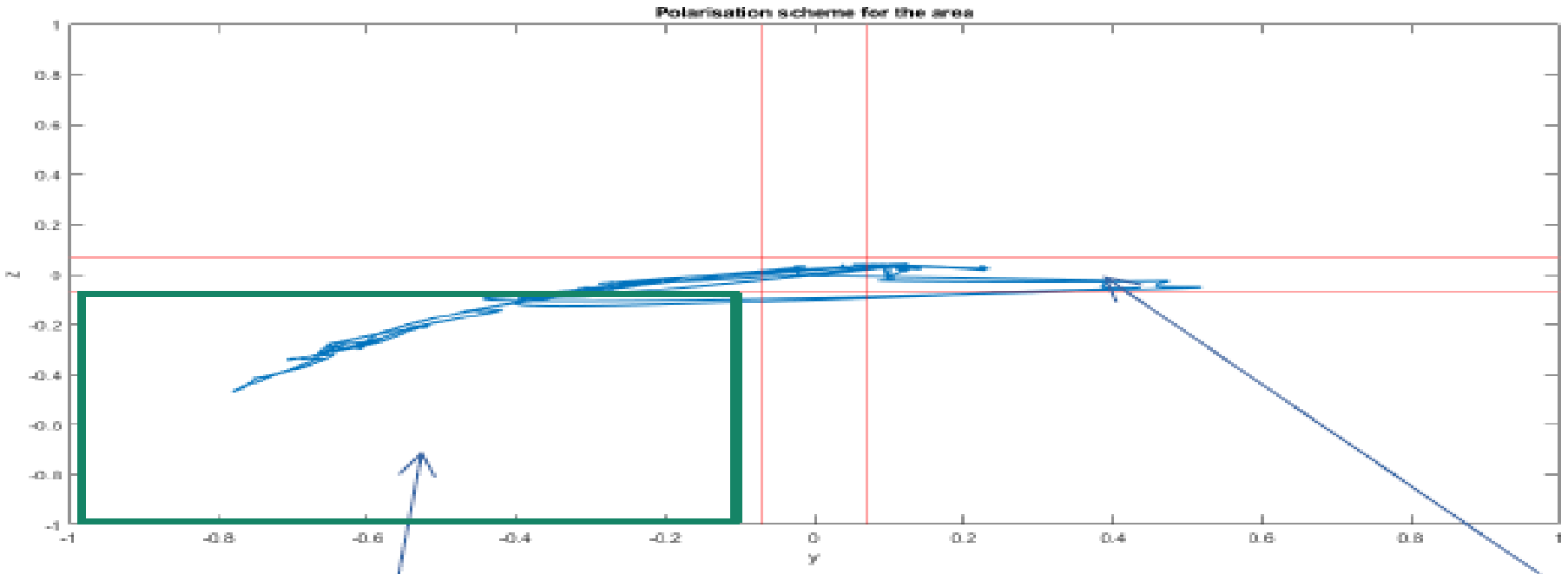


4. ACCELERATION / VALVOMETRY (Swim movement)



4. Example : BURYING Detection by accelerometer signal.

"Polarisation" figure : z(y), on the filtered accelerometry signals



Points due to burying ie variations of y and z simultaneously → lower left corner = are a of interest

Noise or small variations in the red cross

CONCLUSION & PERSPECTIVES

What's new..

Data collected under controlled environment.

Understand the raw data.

Valvemeter : We control the data (calibration – processing)

Processing for detection (different behavior)

- Number of movements / day & Night / by hours on several shells.
- Processing for Jump (stress) and Burying Detection (stress)

Light effect is also new.

NEXT/

Go outside (leave the lab)… in a real site (SPM and Brest, others places (arctic..etc..)…

Merge accelerometer and valvometer

Continue on Classification and detection