KEK-Experiment Granular target temperature measurement during channeling experiment

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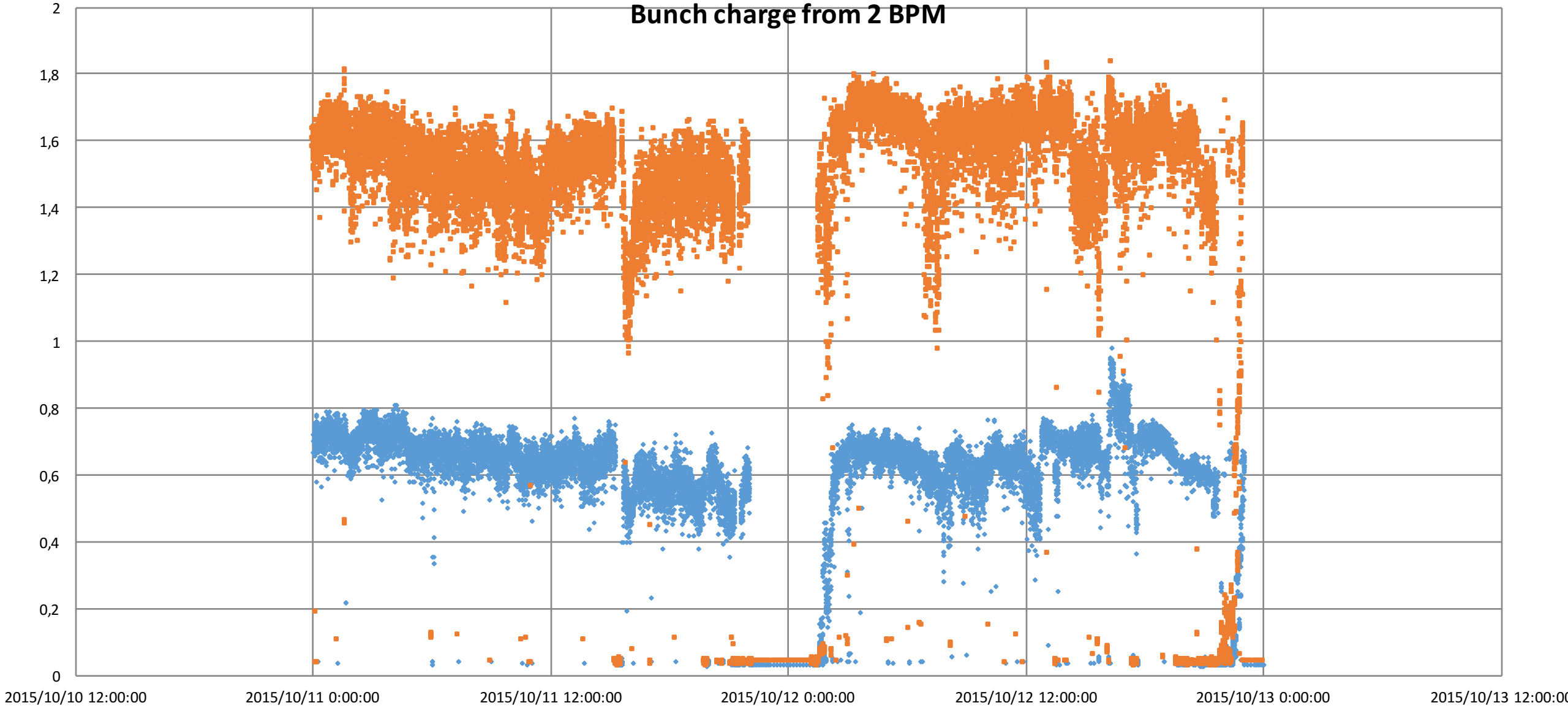
Presented by H. GULER (LAL)

Outline

- Data taking timeline
- Experimental setup
- Filtering the data
- Measurements
  - 25 Hz Pattern beam
  - 1 Hz beam
  - 25Hz continuous beam
- Evaluate the time constants

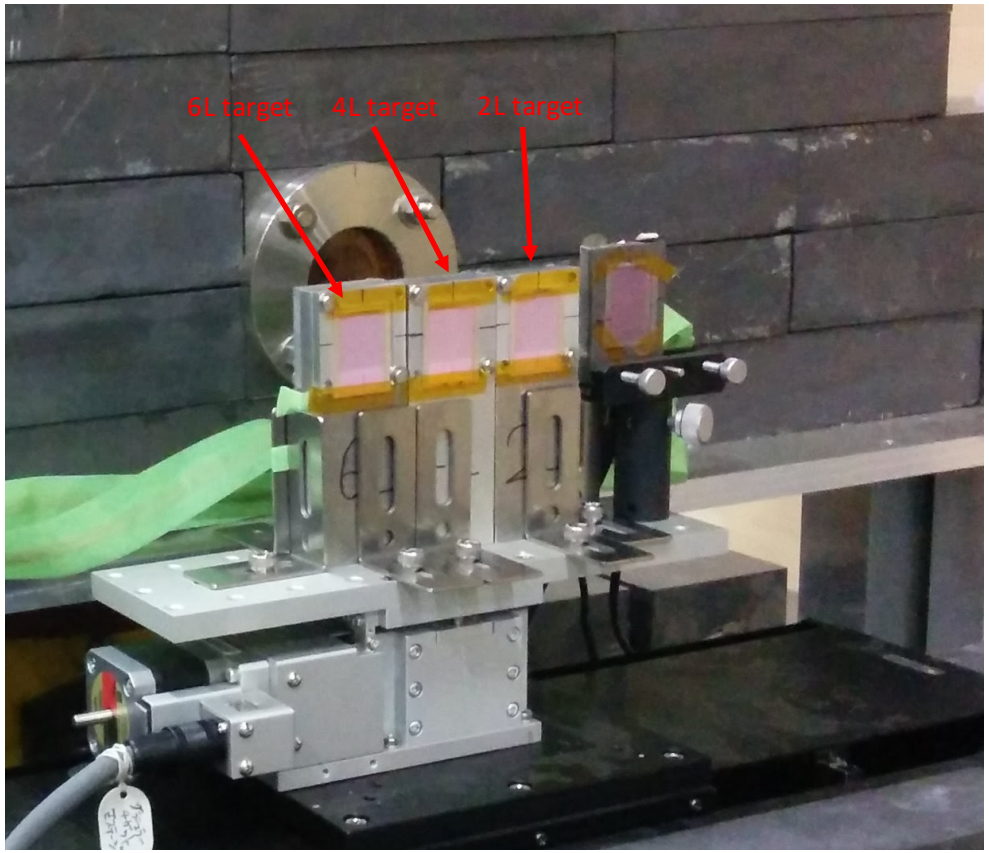
Data taking timeline

- Different beam repetition rates and beam pattern:
  - 1Hz
  - 25Hz continuous
  - 25Hz pattern : [1s **ON** , 5s **OFF**]

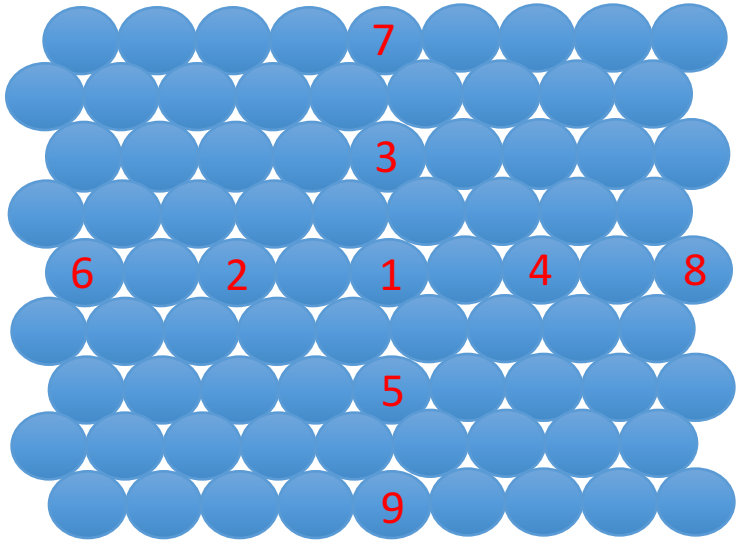

Bunch charge from 2 BPM
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
2015/10/10 12:00:00
2015/10/11 0:00:00
2015/10/11 12:00:00
2015/10/12 0:00:00
2015/10/12 12:00:00
2015/10/13 0:00:00
2015/10/13 12:00:00
SP_61_A3 charge (nC)
SP_61_A1 charge (nC)

Experimental setup

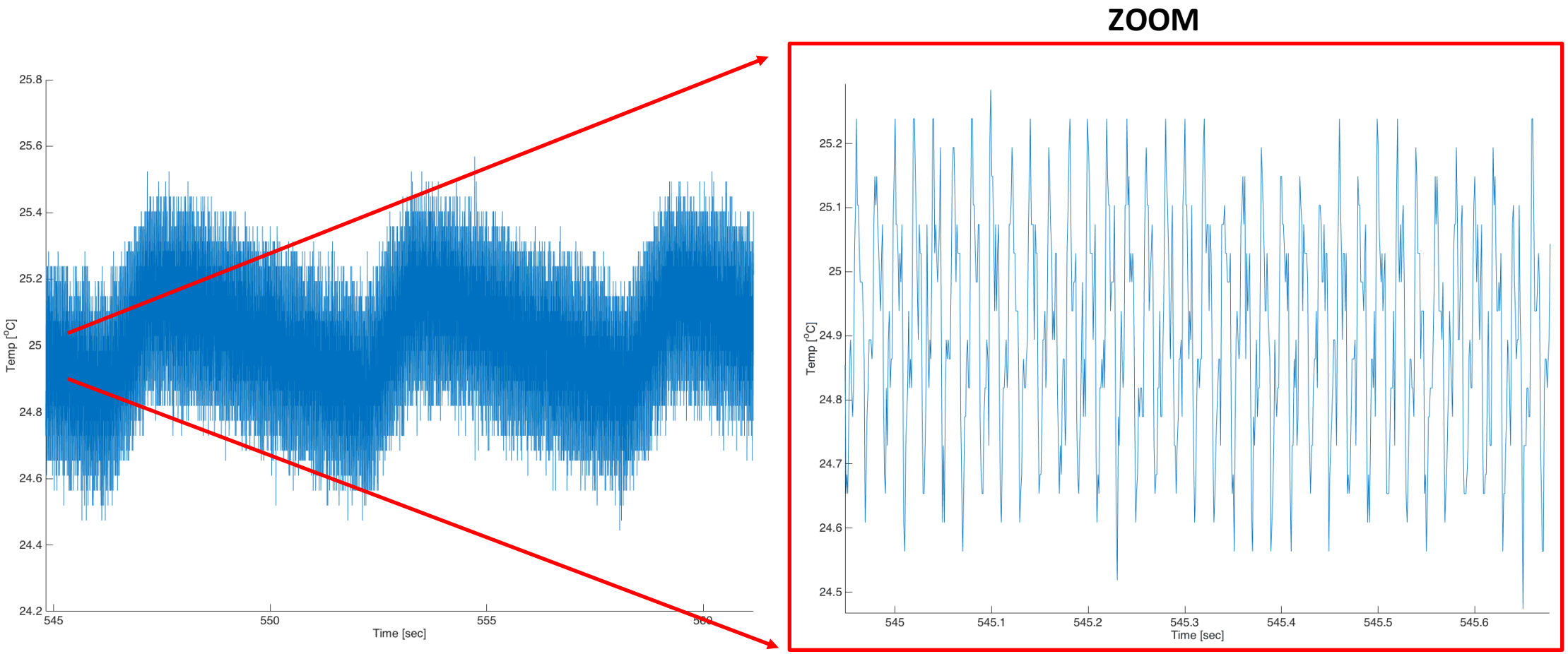
- Automatically switch between different targets
  - Without stopping the beam and have an access
  - Different thickness (2,4,6 or 8) Layers



- Thermocouple disposition
  - 9 placed on **the back surface** of each granular target
  - 1 placed on the table to measure **ambient temperature**



Data structure : 50H noise

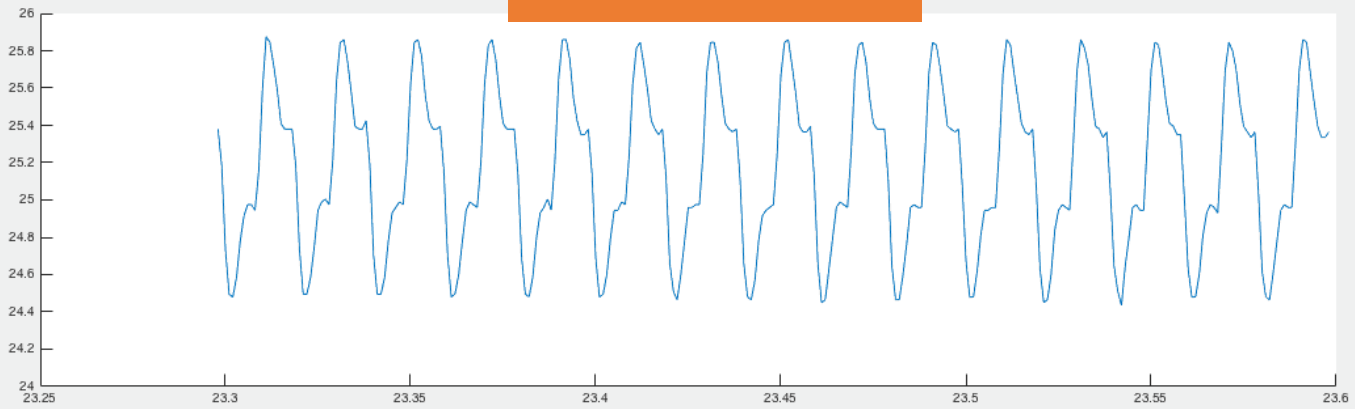


Method to cleanup (filter) the data

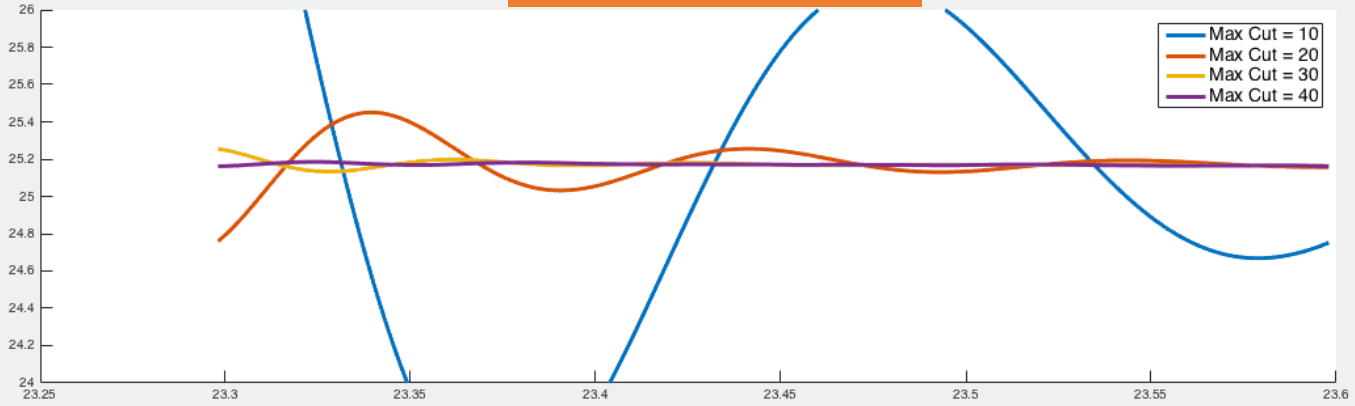
- 50Hz noise in the data is visible
- Temperature signal mostly at low frequency (<10Hz)
- Try to perform a **low pass filter** to eliminate the high frequency noise
  - See how the filtering is depending on the upper frequency cut

Filtering upper cut study

Raw data



After filtering



Best filtering upper frequency cut : 30 to 40 Hz

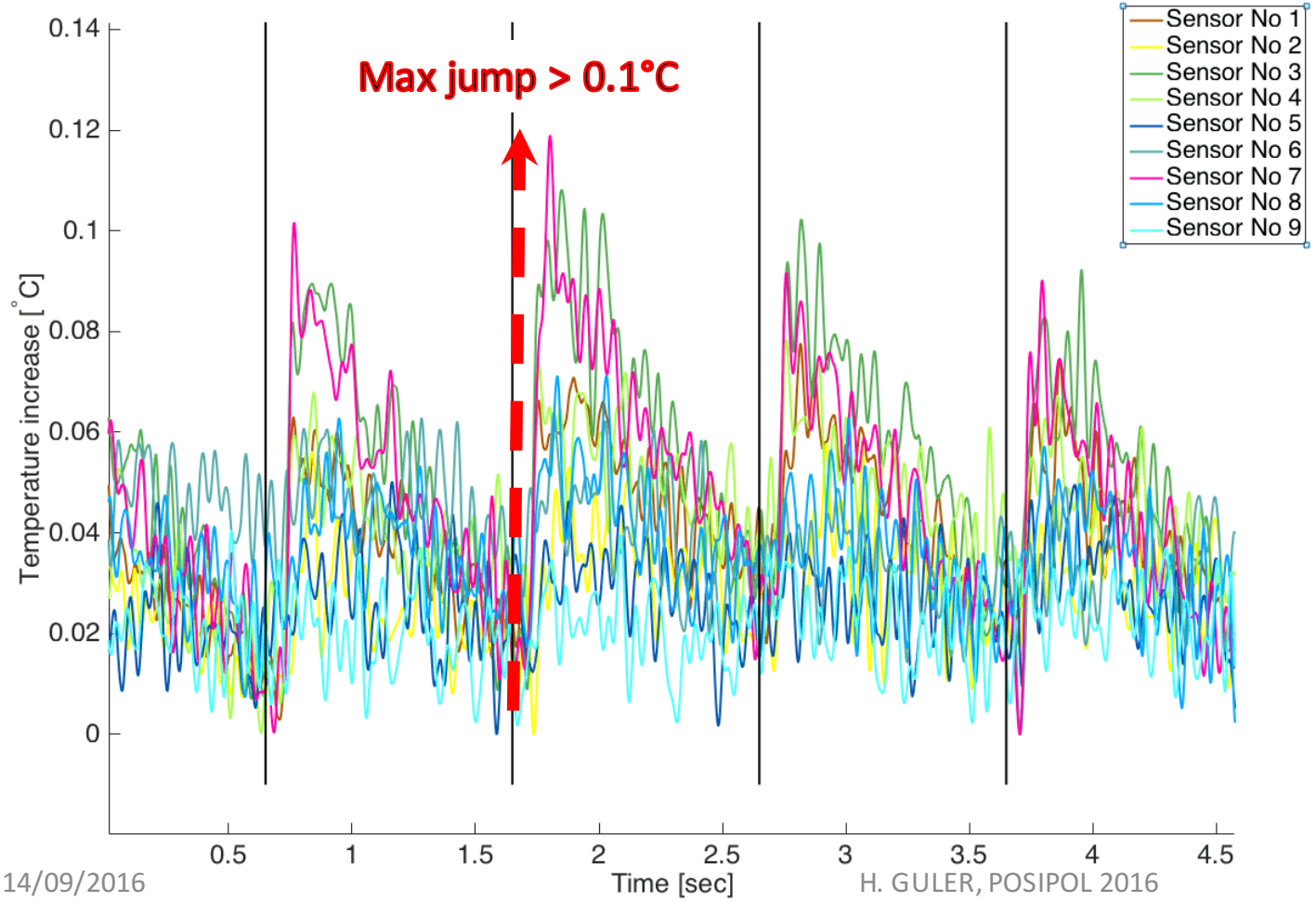
20<Upper cut<50 should be a reasonable value

Measurements

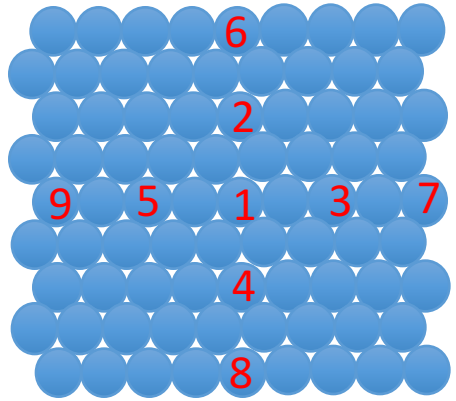
1Hz data :

Need filtering to see temperature jump

1Hz data : raw temperature jump

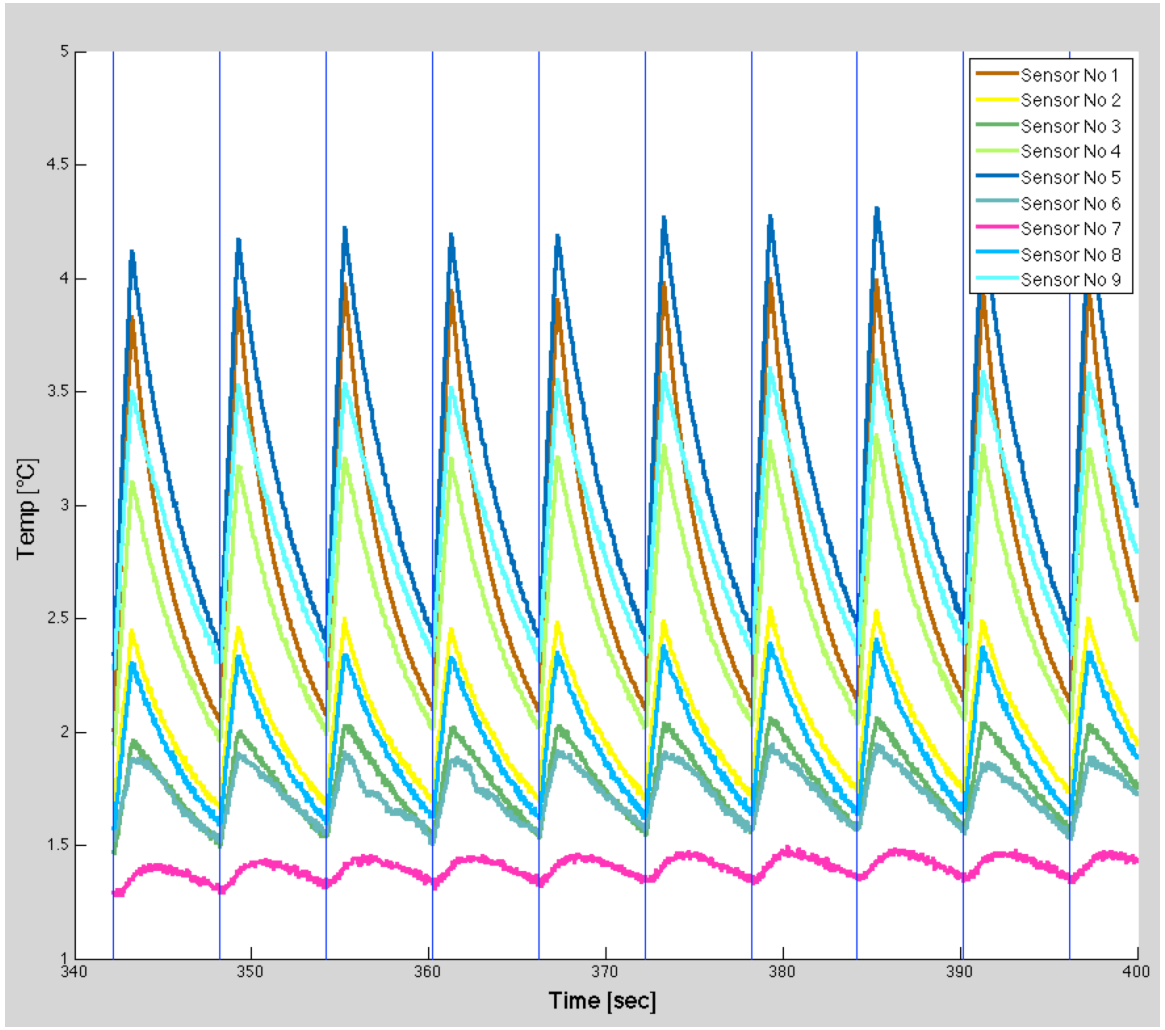


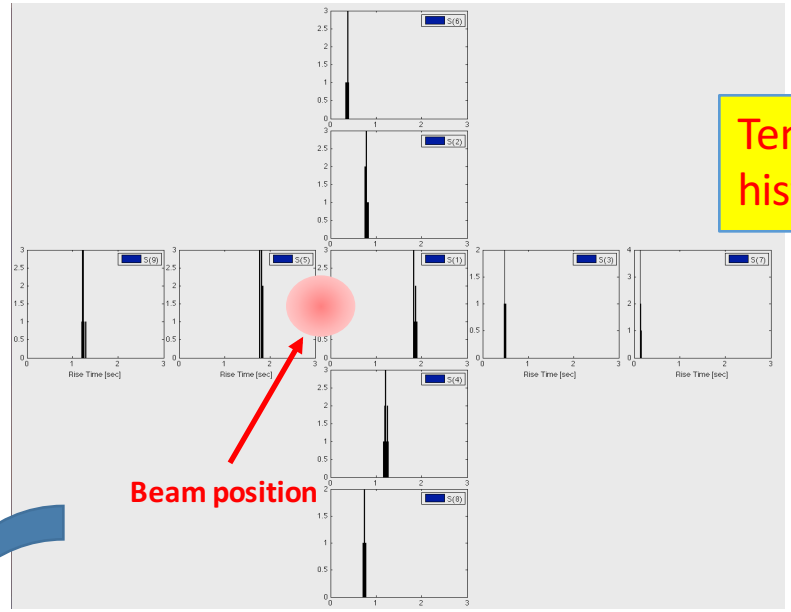
The maximum temperature jump around 0.1°C for the sensors 3 and 7.
Rise time around 0.15s



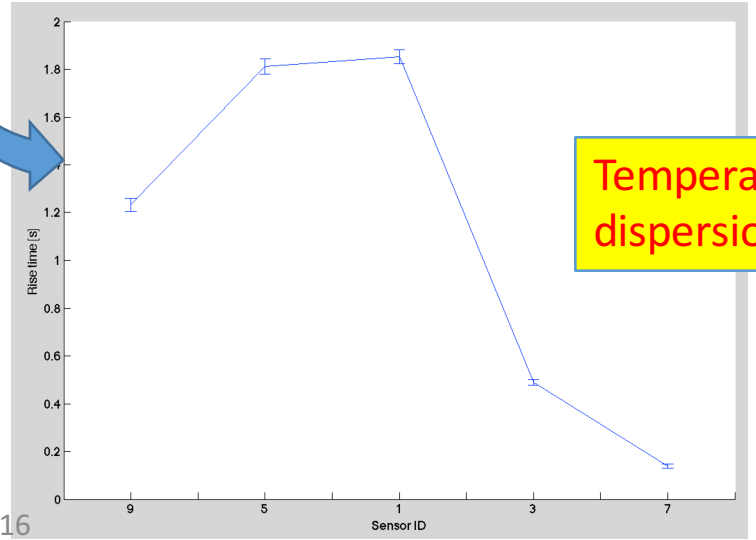
25Hz pattern beam :

25 Hz beam pattern [1s ON, 5s OFF] data





Temperatures histograms

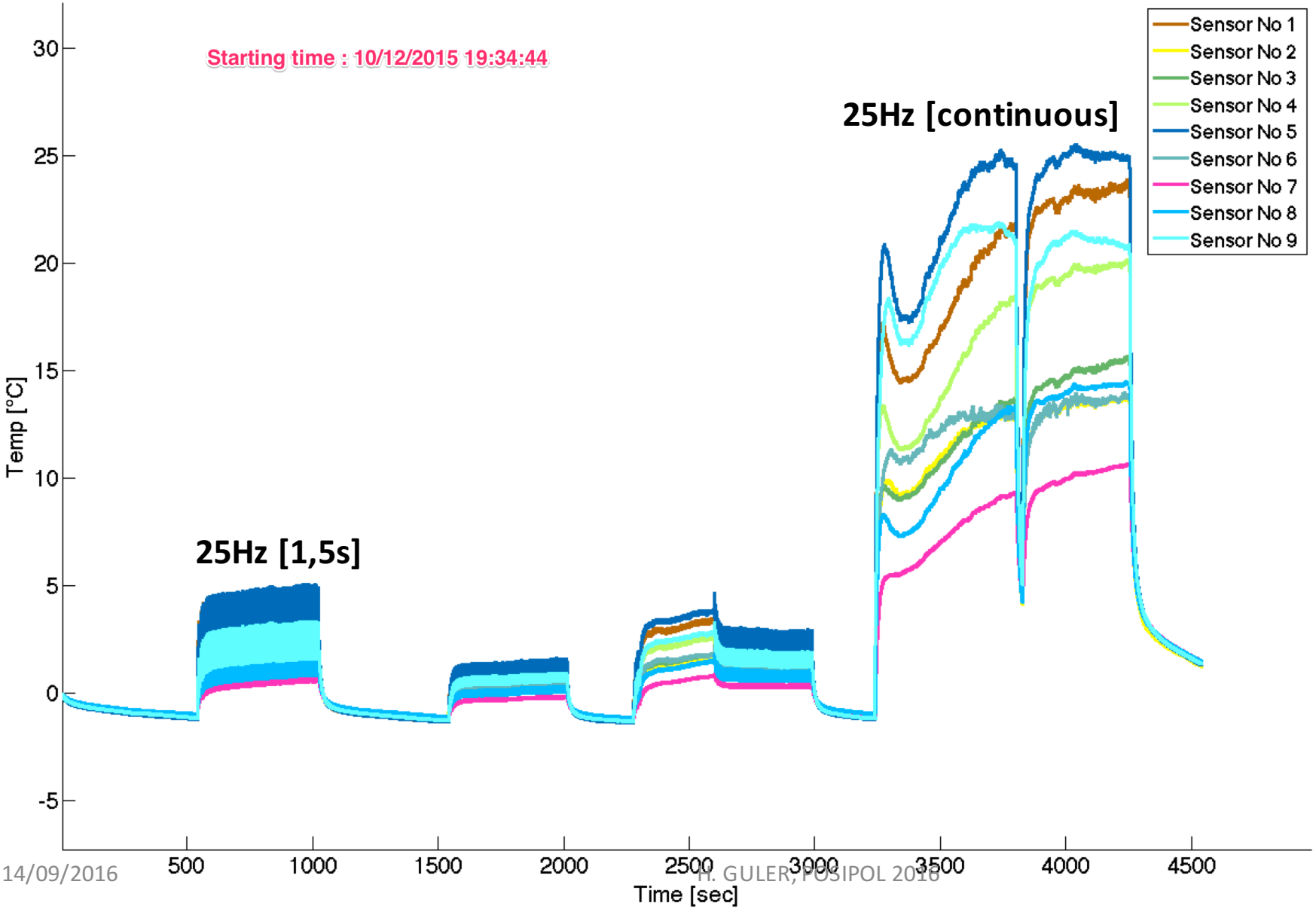


Temperature horizontal dispersion

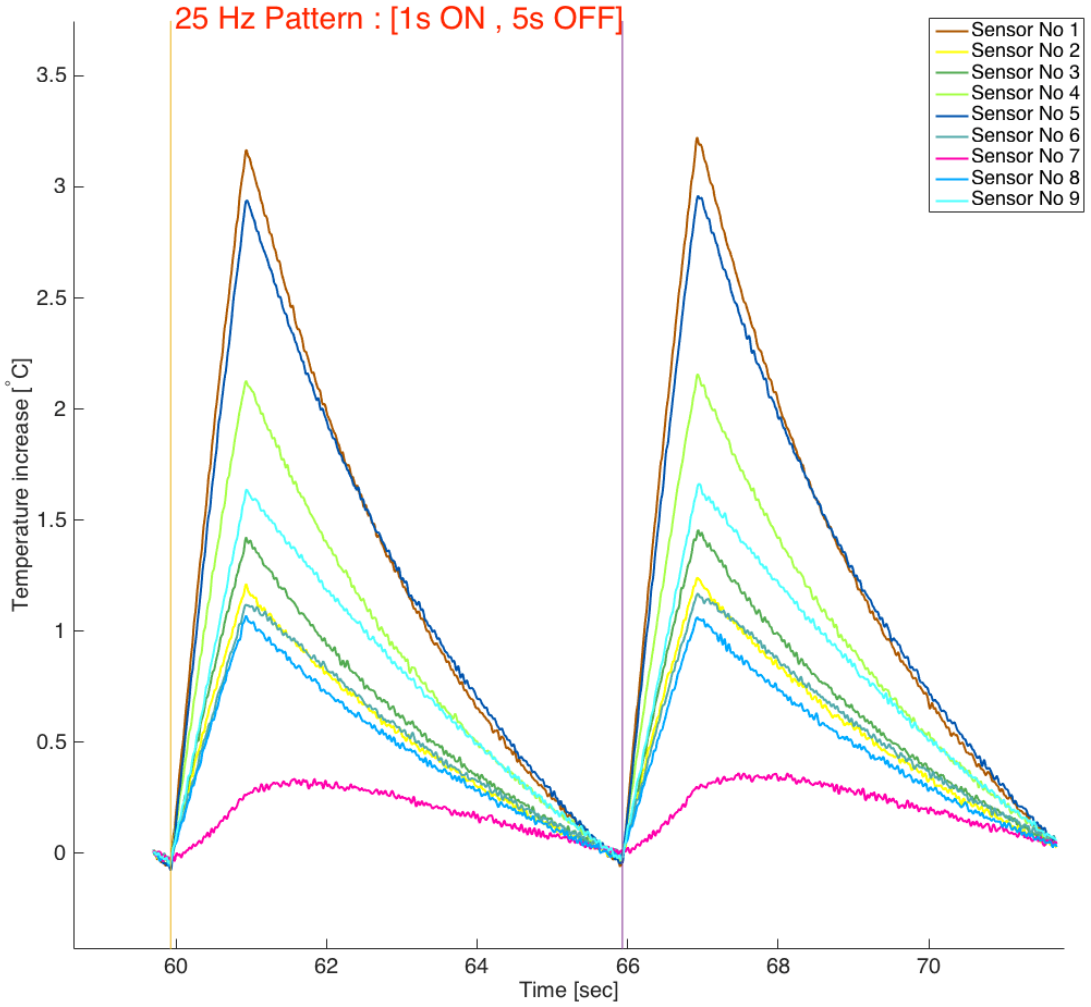
Data Fitting :

1Hz data → Compare with the last article
25H Pattern fitting
25 continuous data fitting

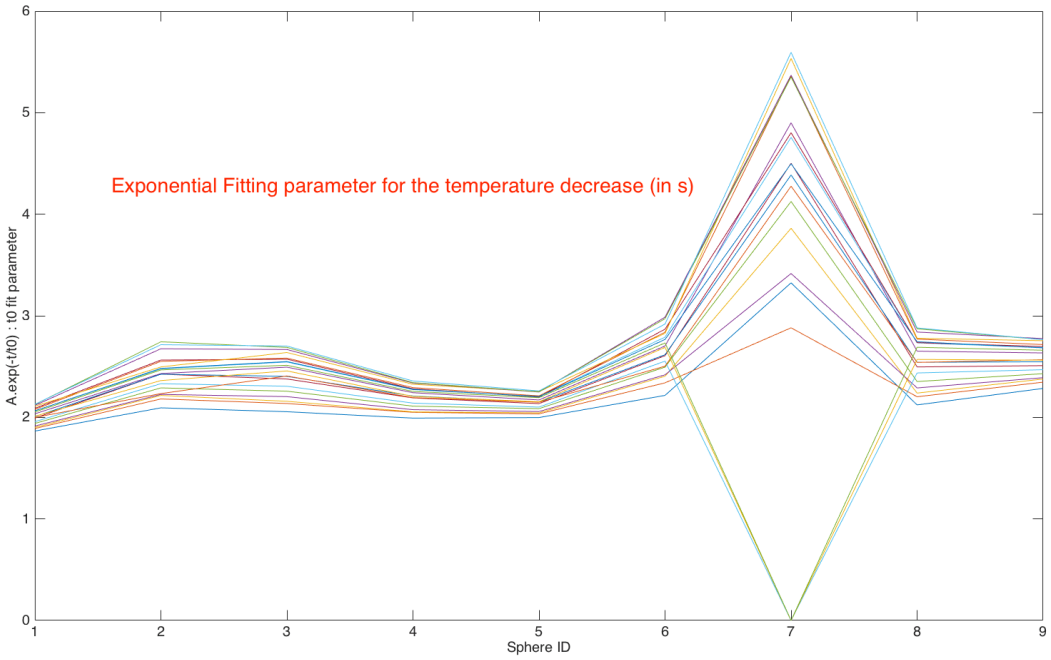
Long term data taking (10/12/2015 from 19h34)



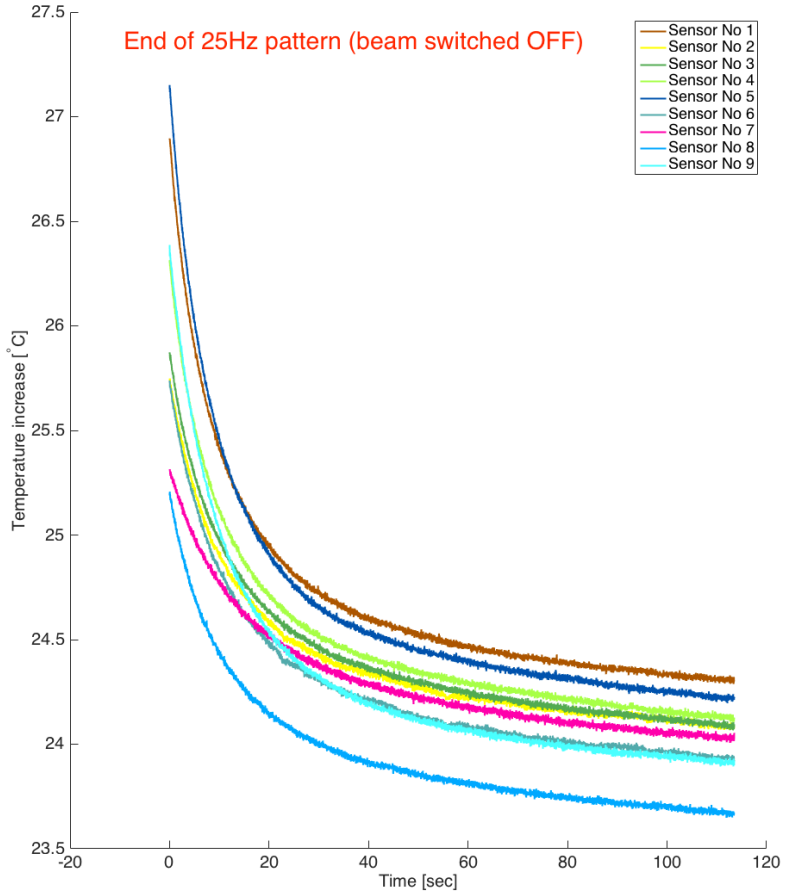
25 Hz pattern analysis → fitting shape

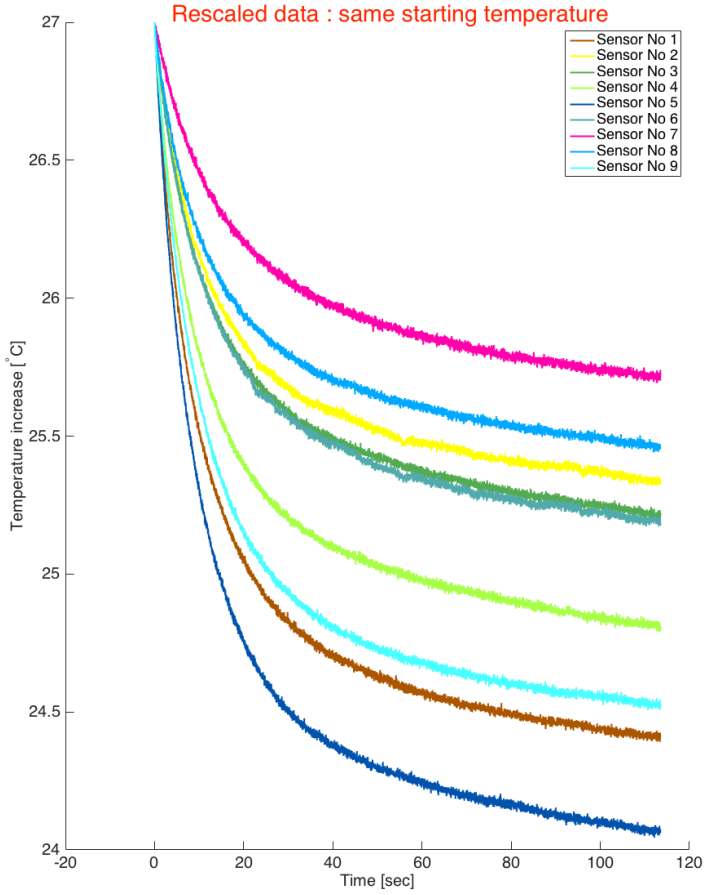


- Decrease shape compatible with **exponential law** with constant time on plot below.
- Increase shape in compatible with **linear function**.
  - Rise time for 1Hz ~ 0.15s
  - @25 Hz beam, temperature has no time to decrease, so rise keep linear until saturation.



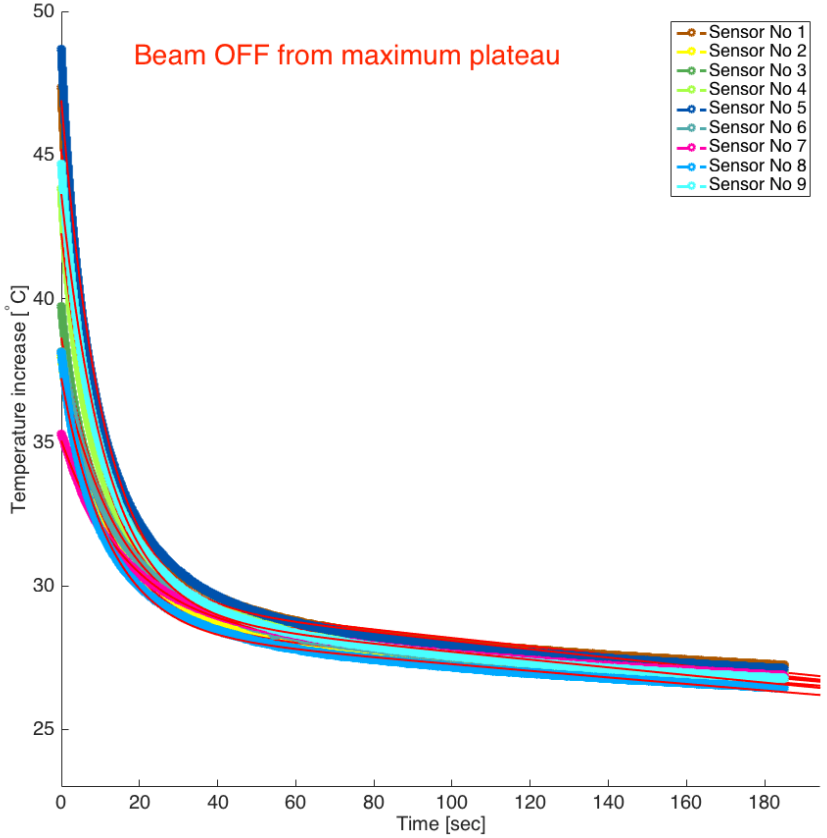
End of 25 Hz region : Beam switched OFF

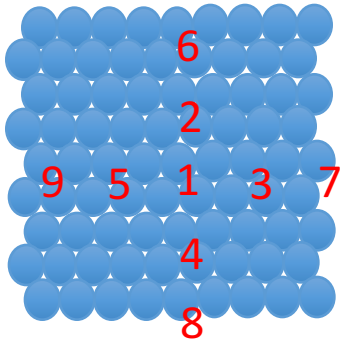




Temperature decrease depends on the sphere position. It seems to decrease faster for central sphere. But also from a sphere with higher initial temperature.

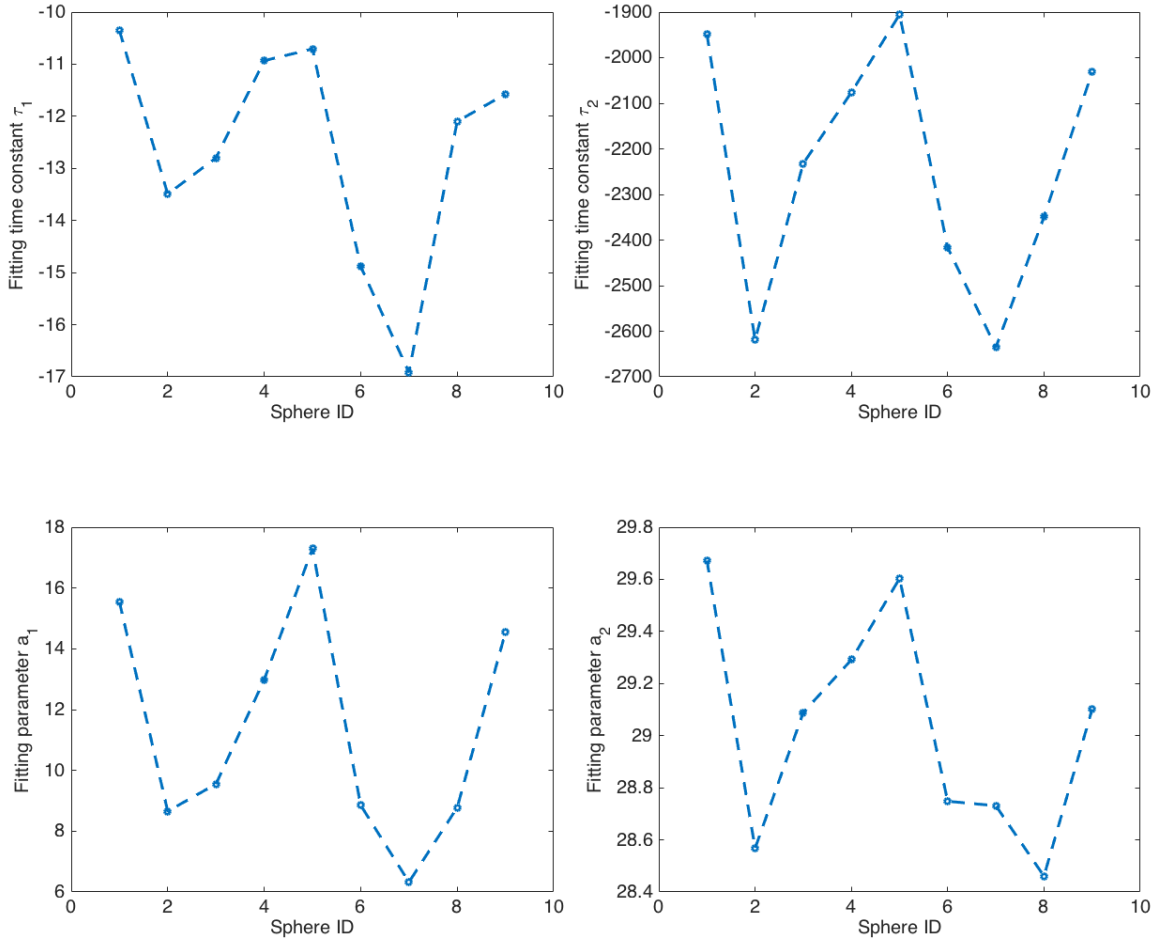
25 Hz continuous data taking – Decrease part → FITS





Fitting with sum of 2 exponentials:

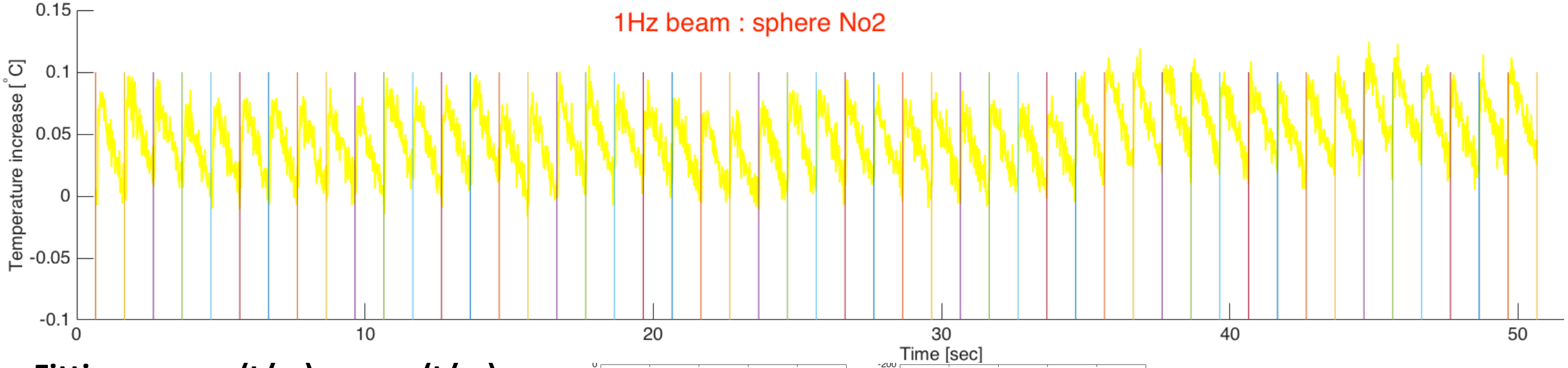
$a_1.\exp(t/\tau_1)+a_2.\exp(t/\tau_2)$



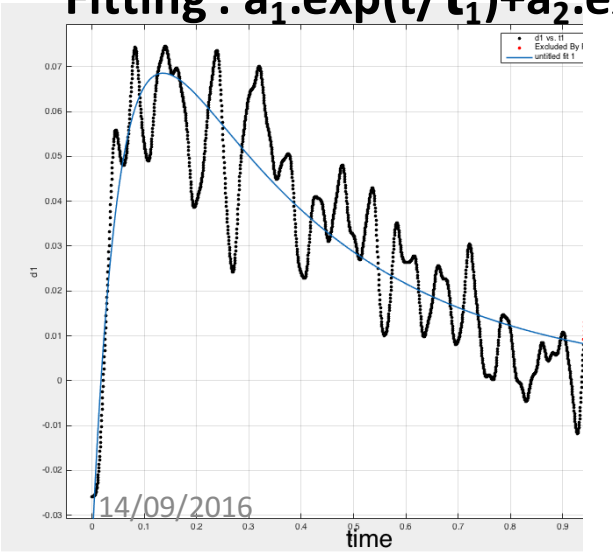
Fitting with sum of 2 exponentials:

2 cool down constant time are seen : around 10s and around 2000s… any reason for that ?

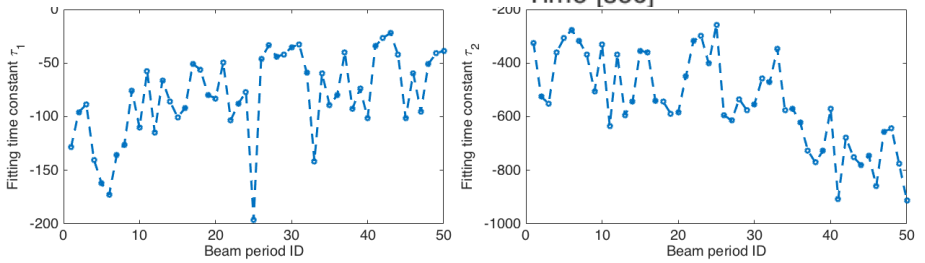
1Hz Data : 10/11/2015 : 14h11

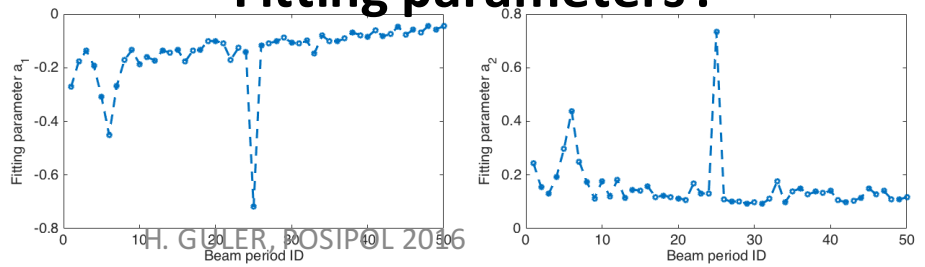


Fitting : $a_1.\exp(t/\tau_1)+a_2.\exp(t/\tau_2)$

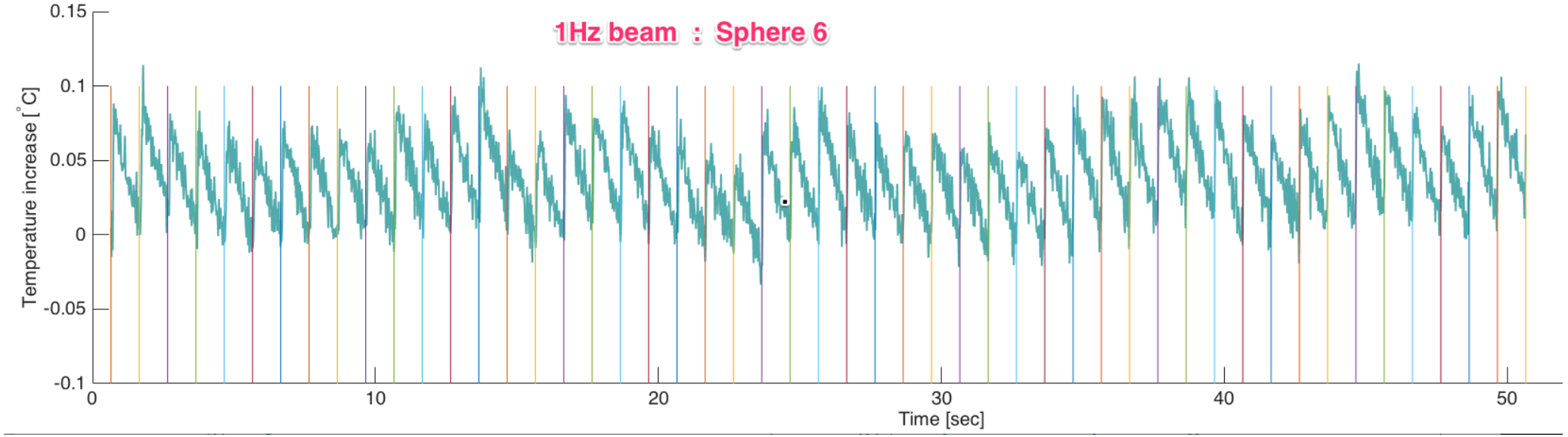


Fitting parameters :



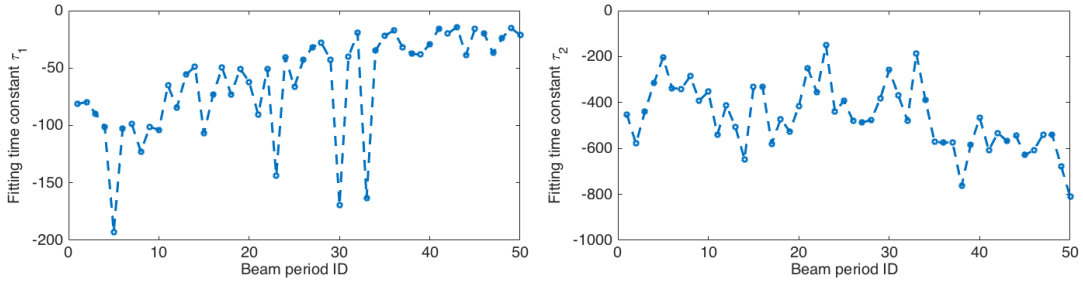


1Hz Data : 10/11/2015 : 14h11

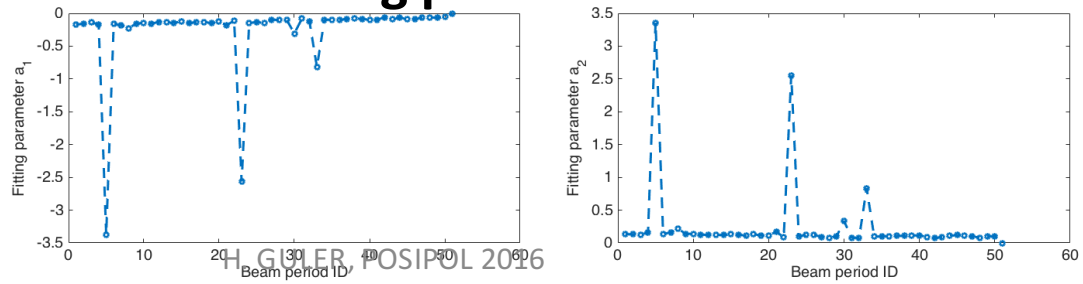


Fitting : $a_1.\exp(t/\tau_1)+a_2.\exp(t/\tau_2)$

- Rise time between **50 and 100 ms**
- Decay time between **250 and 500 ms**
- All varying during the data taking



Fitting parameters :



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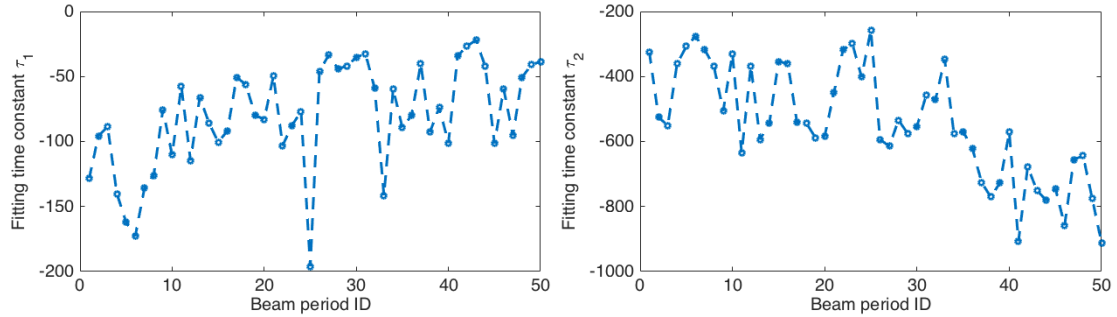
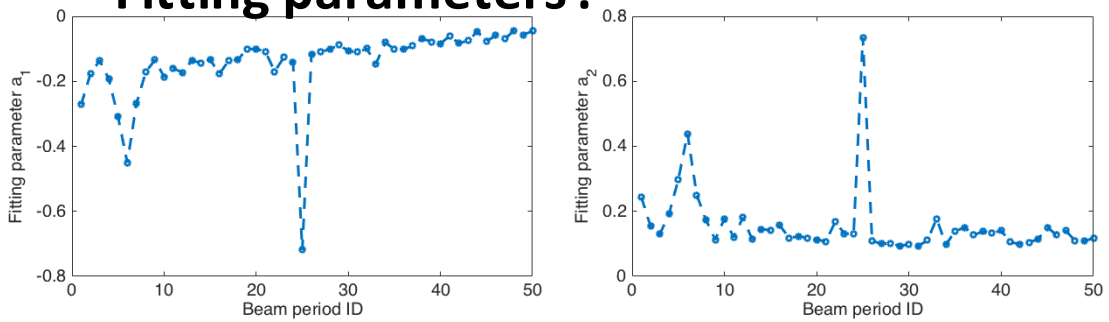
Fitting : $a_1.\exp(t/\tau_1)+a_2.\exp(t/\tau_2)$



Fitting parameters :



Compact vs Granular

- ✓ Temperature jump is **3 times less** for the granular target (hottest sphere) than for the compact (8mm) target.
- ✓ Temperature rise time is much longer for granular target than for the compact one
- ✓ Temperature decay take also more time for the granular target

Results of the temperature rise measurement. Each property corresponds to a parameter in the fitting function.

Target scheme	Thickness (mm)	a: Temperature rise (°C)	τ_1: Decay time (ms)	τ_2: Rise time (ms)
Conventional	18	1.071 ± 0.003	332 ± 3	8 ± 1
	8	0.373 ± 0.003	116 ± 1	3 ± 1
Hybrid axis on	18	0.419 ± 0.002	537 ± 1	10 ± 1
	8	0.300 ± 0.002	178 ± 2	2 ± 1
Hybrid axis off	18	0.197 ± 0.004	542 ± 3	7 ± 1
	8	0.095 ± 0.001	144 ± 4	3 ± 1

Article data

Conclusions and ideas for the next experiment

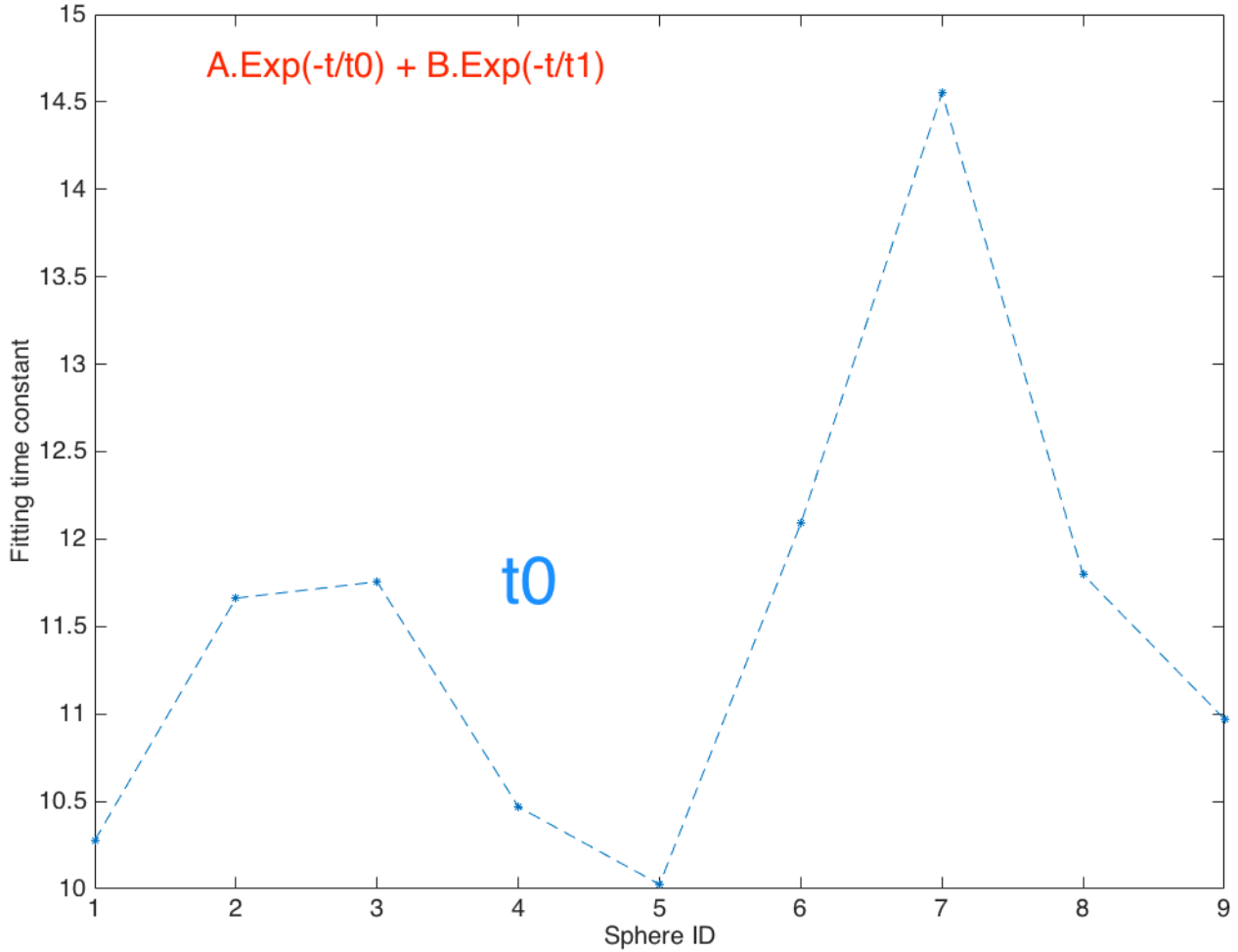
- Temperature measurements on granular target during channeling experiment
  - different beam modes have been tried (1Hz, 25Hz continuous, 25Hz pattern)
  - 😞 only **the 4 layer target** was useful (thermocouple cabled)
  - 😀 but the 4 layer data were extracted and compared to previous measurement with compact target
- Next measurements should include :
  - All the different target (4 granular target) and also compact (reference)target
    - To get the data in the same conditions
  - Think about the origin of the 50Hz noise / Or perform an online noise reduction to better see the data changing with the beam conditions
- Simulation side :
  - GEANT4 → Deposited energy into spheres (quite well understood)
  - ANSYS simulations are still needed to simulate the temperature behavior and have a comprehensive picture of the heat transfers.

Thank you ----------

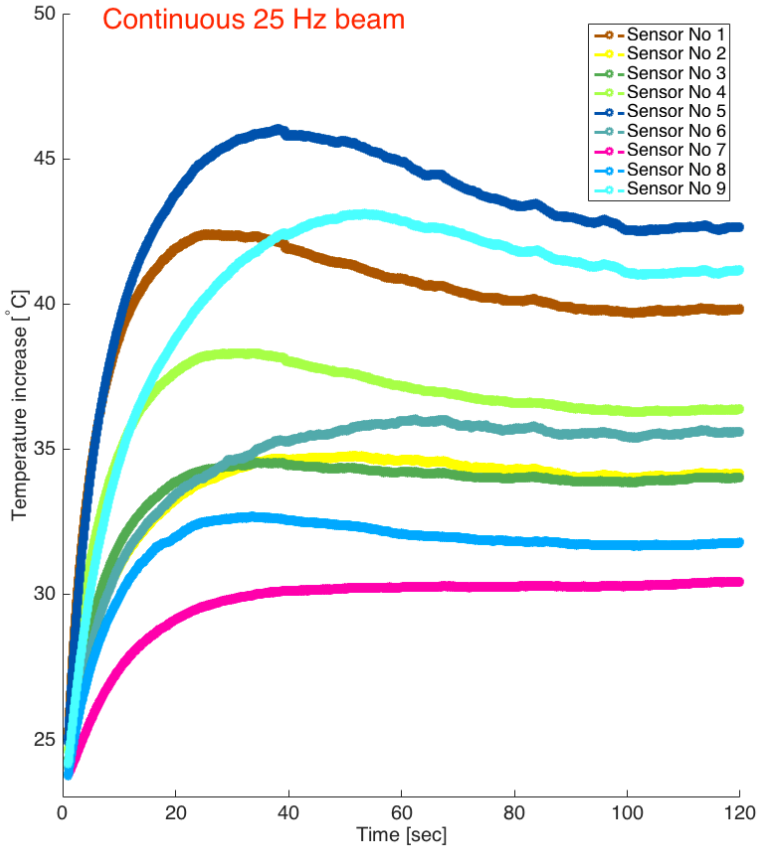
Backup slides

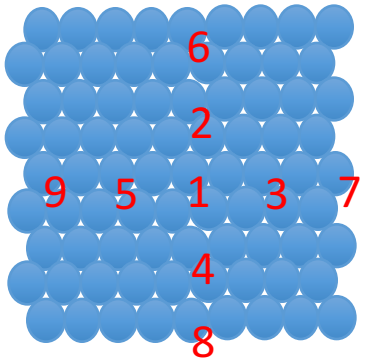
End of 25 Hz pattern region : Beam switched OFF
Fitting the shape.

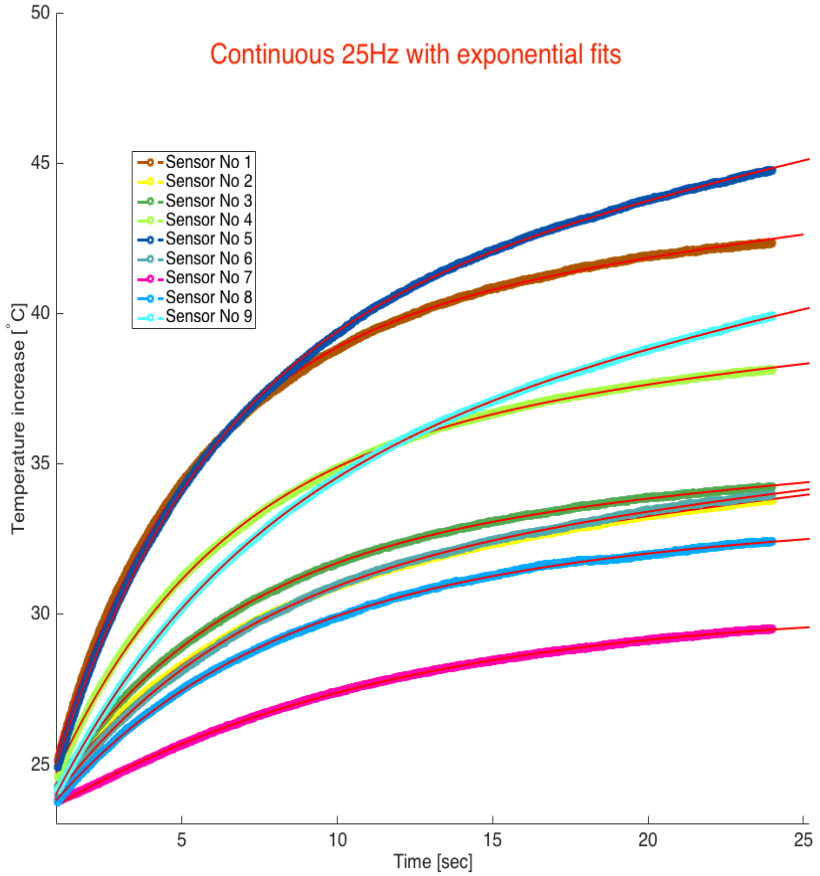
- We expect an exponential drop or 2 additional exponential corresponding to different regimes in the temperature drop.
- In our case the beam OFF appear around 23s in our graph (little discontinuity in the curve).
- Fitting parameter :
  - Time constant for the exp is consistent with the data shape.
  - Single exponential was not sufficient.
    - Addition of second exponential shaped used for the fit but has not physical meaning (parameters are negative for B and t1 …)



25 Hz continuous data taking – Increase part

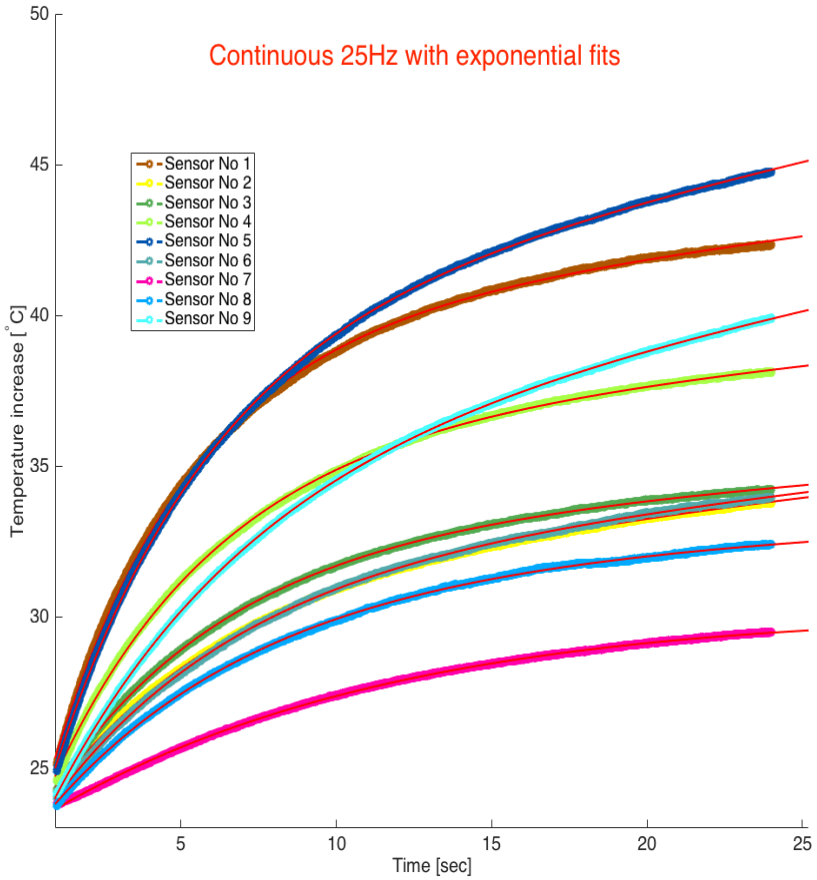


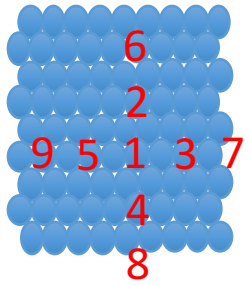




- 25 Hz continuous :
  - Plateau (equilibrium) appear at different time (25 to 60 and more) depending on the sphere position.
  - Increase part compatible with exponential fit (sum of 2 exponentials)

25 Hz continuous data taking – Increase part → FITS





Fitting with sum of 2 exponentials:

$a_1.\exp(t/\tau_1)+a_2.\exp(t/\tau_2)$