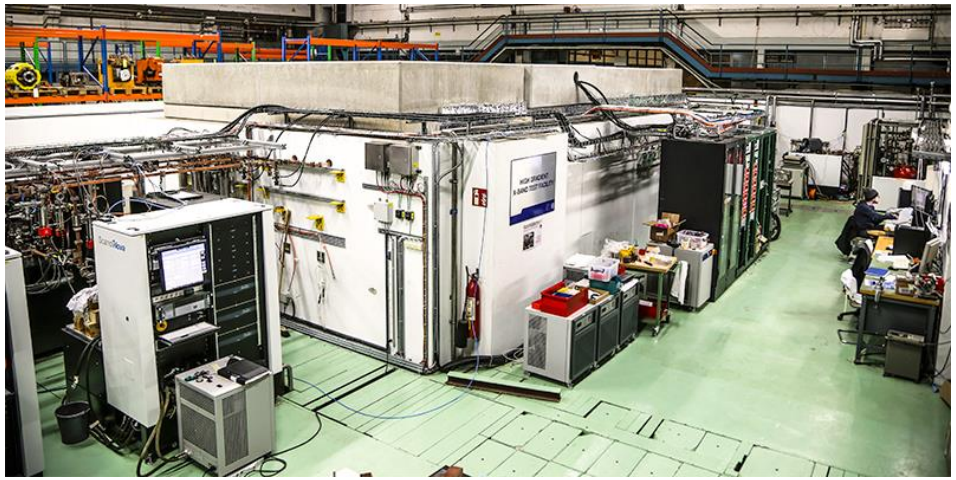
Study of Power losses on the XBox3 test stand

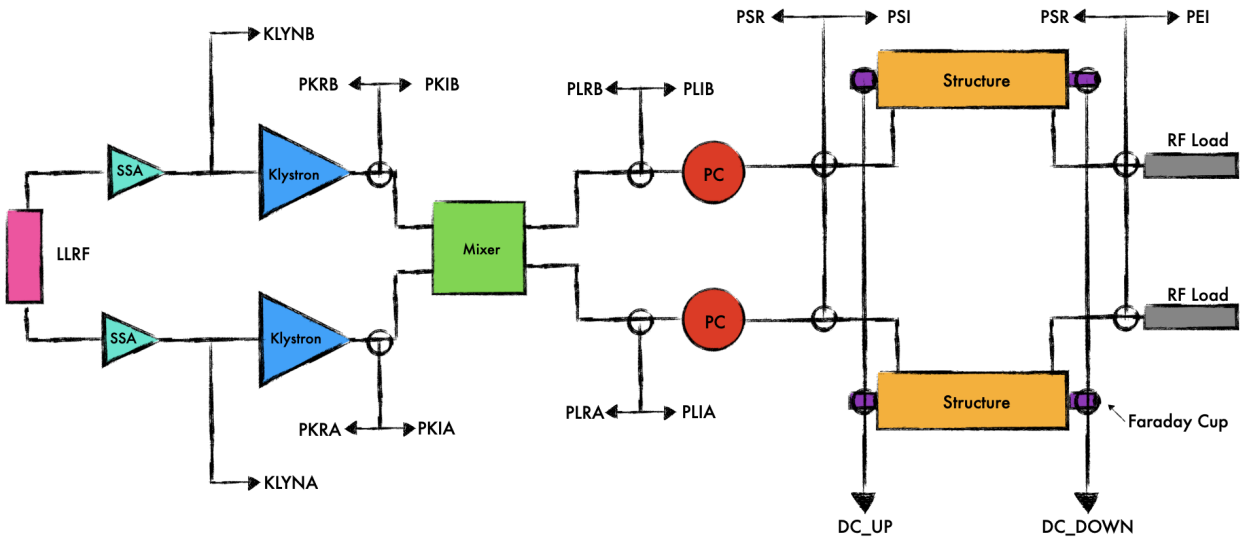
Summer Students Programme 2022

Karolina Klimek

Supervisors: Marçà Boronat, Nuria Catalan Lasheras

Introduction

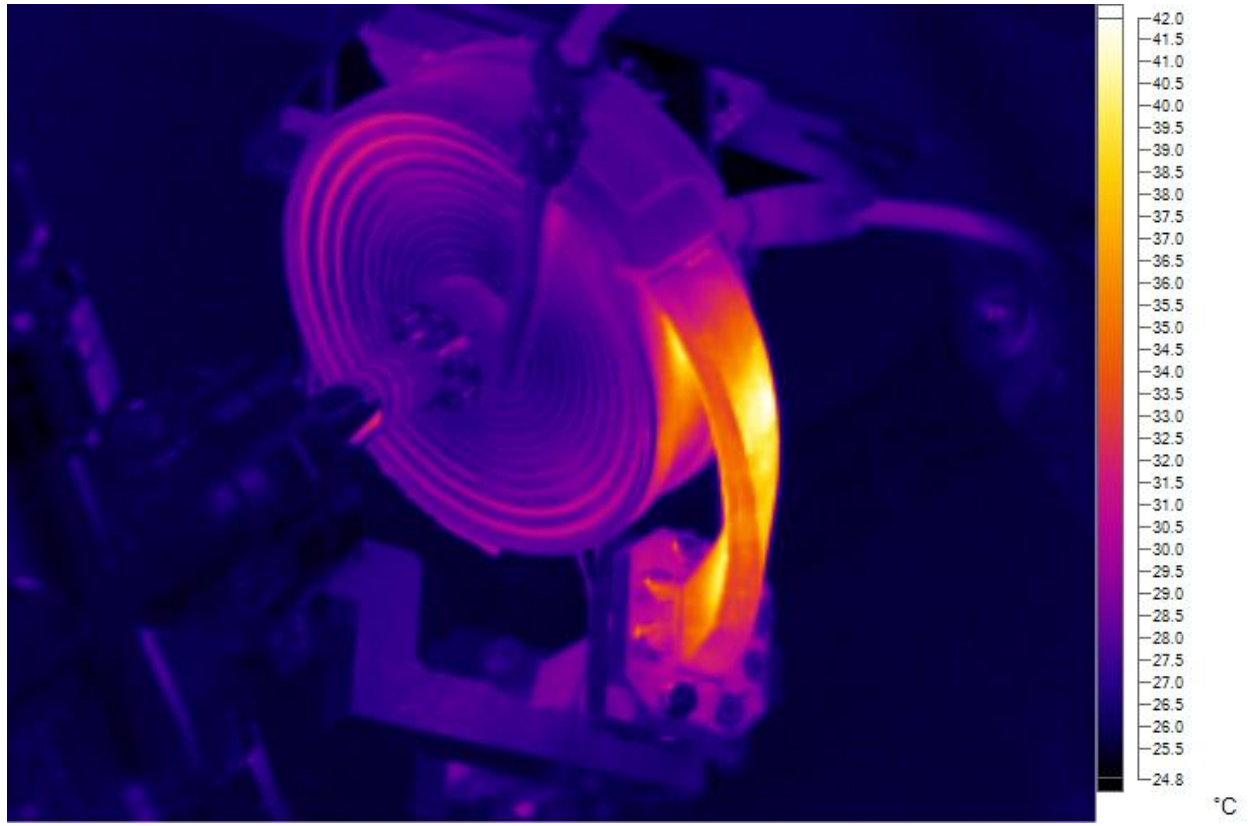




The aim of the project was to calculate the efficiency of the system

1. Estimate the (transmission) efficiency before the pulse compressor and before the structure
2. How efficiency depends on the ratio between PSI pulse lenght and PKI pulse lenght
3. Correlations between the efficiency and the temperature

Data



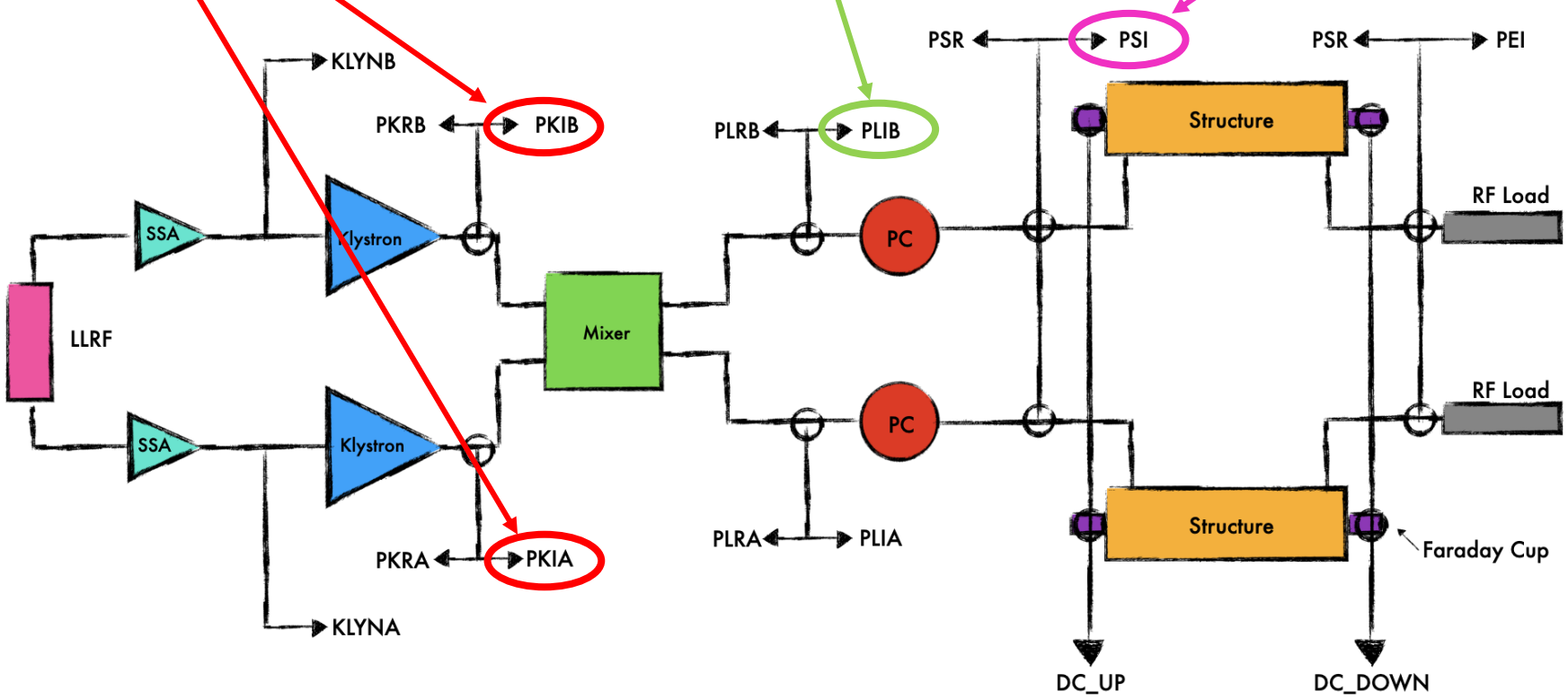
- Data from spiral load 45 degrees 17.05.2022-15.07.2022

1. Calculation the efficiency before pulse compressor and before the structure

1. How much power is generated by the klystrons

2. How much power reaches the pulse compressor

3. How much power reaches the structure

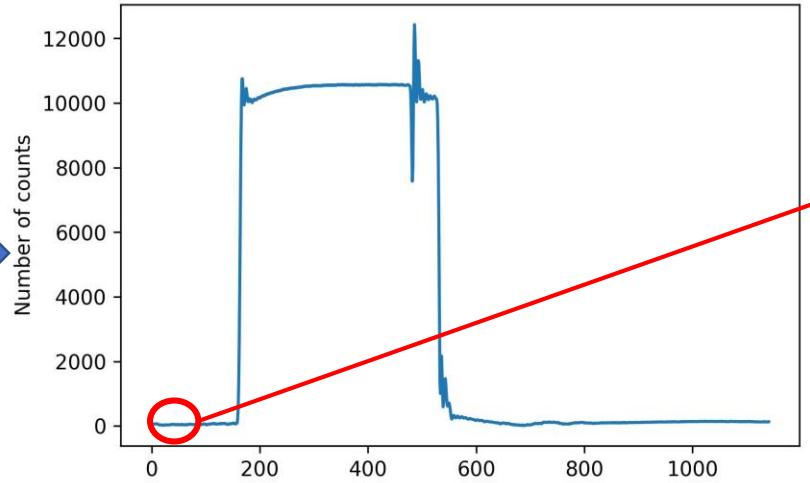


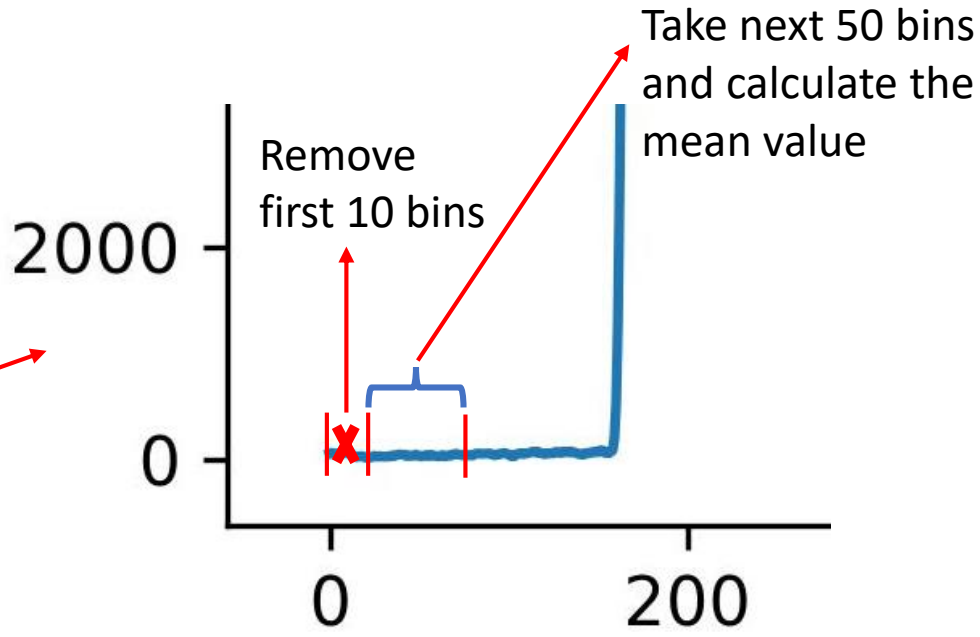
Data preprocessing

Data from tdms file:

- take only pulses without breakdowns
- take only pulse with PSImax – PSImin > 0.3MW

PKIA pulse

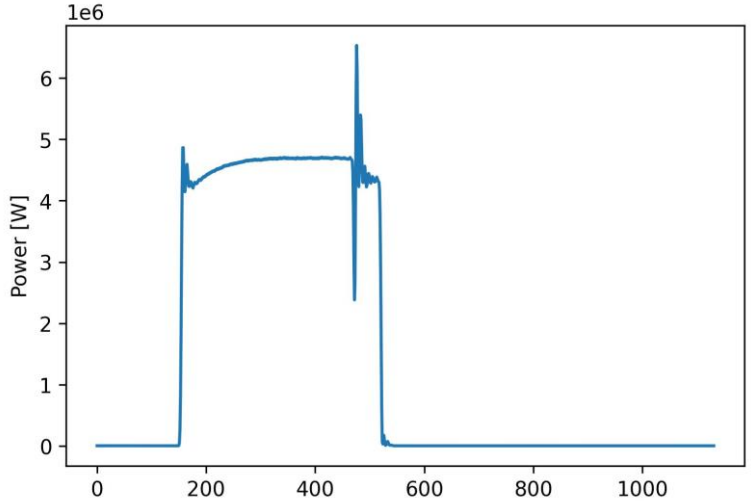




Subtract the mean value from all data to center the noise to zero

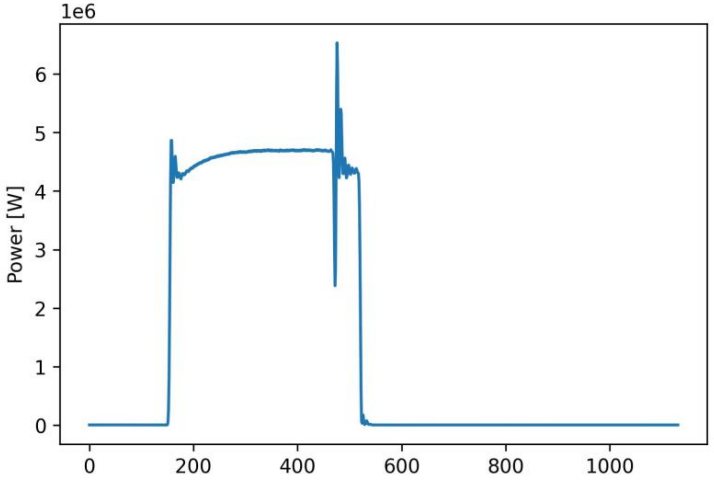
Calibrate the data from counts to power in W using the coefficients from data

$$P = C_2 y^2 + C_1 y^1 + C_0$$

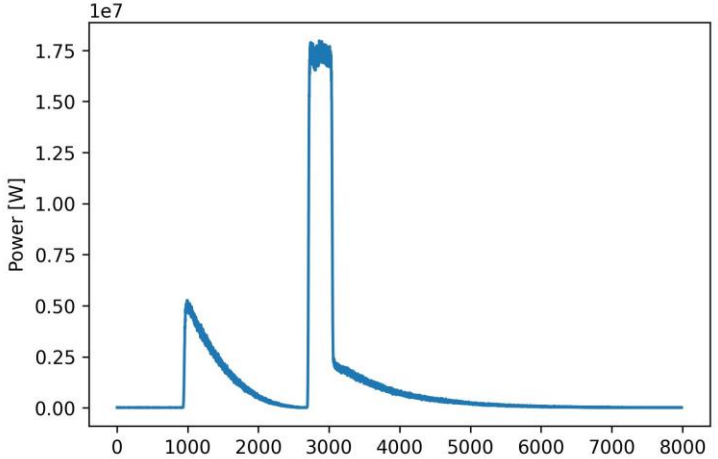


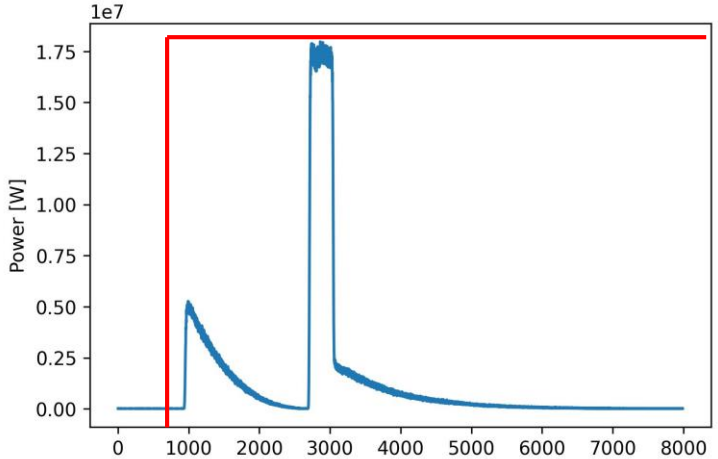
How was the procedure to calculate the average power?- compressed pulse

In general PKIA/PKIB/PLIA/PLIB pulses should be rectangular pulses



PSI pulses can be rectangular or can have a different shape because of compression

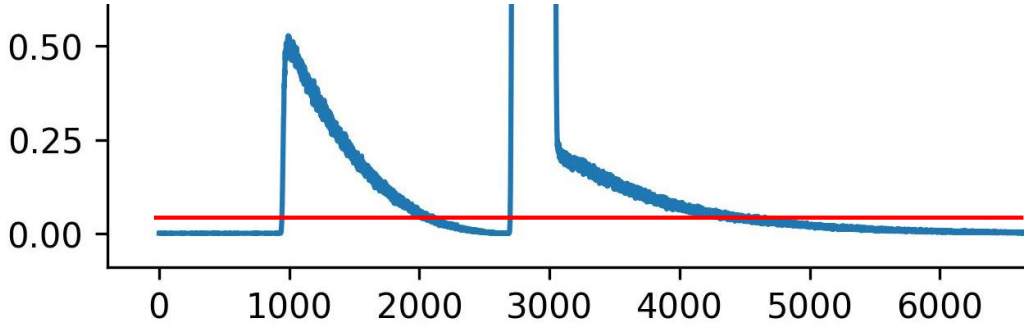




Definition of integration region

In both cases I calculate the max value from first 50 bins (”noise_max”)

Compressed pulse- define that pulse will start when the power is bigger than 5 times ”noise_max”

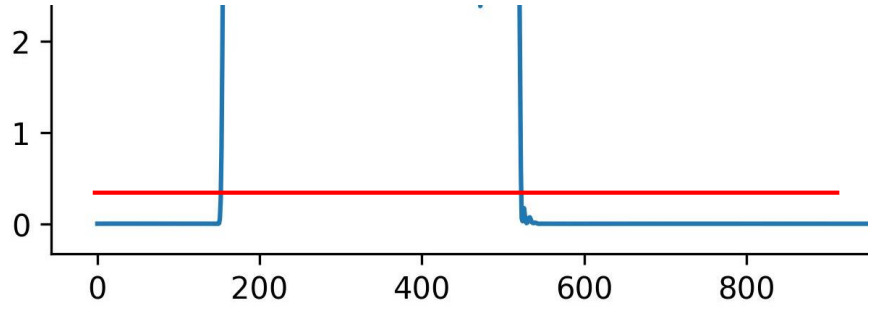


Take 50 bins before that place

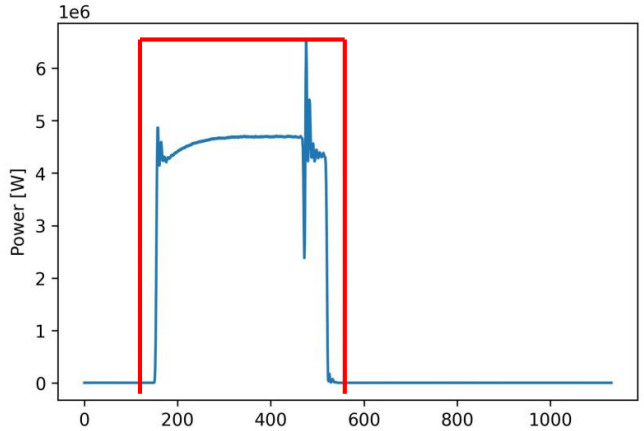
Calculate the area: integrate the power from that point to the end

How was the procedure to calculate the average power?- rectangular pulse

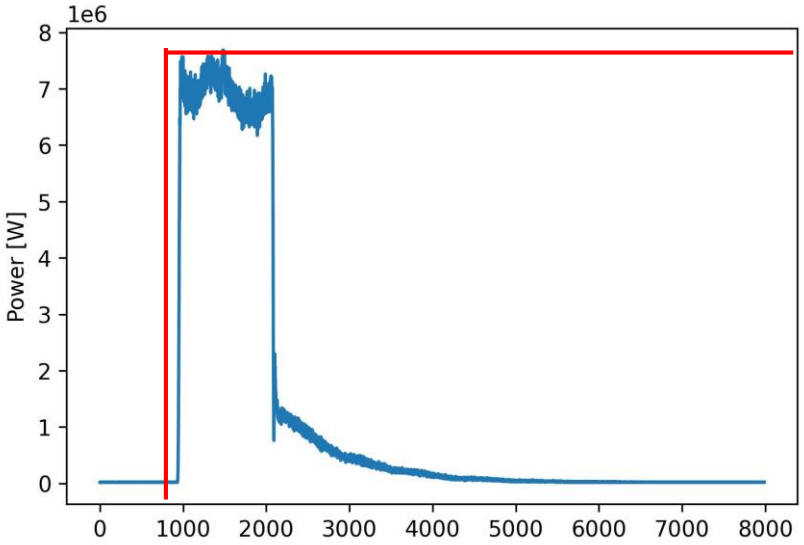
- Rectangular pulse: define that pulse will be in the area where the power will be bigger than 5 times ”noise_max”



- Take some bins before and after this region- the number of the bins before and after should correspond to the same time as 50 bins in PSI



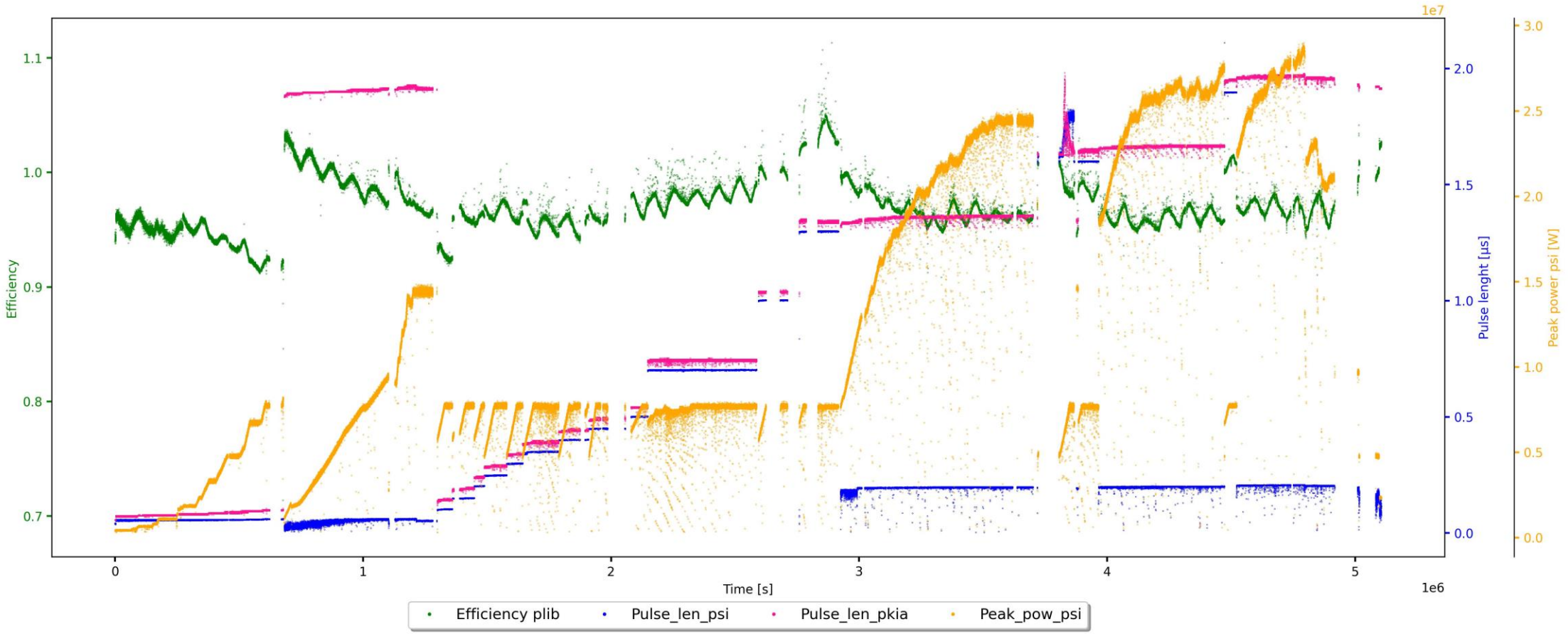
- Calculate the area: integrate the power



!

Sometimes when PSI pulse is not compressed and is long, it can be not perfectly rectangular: I defined that if the PSI pulse length is bigger than 500ns- I am taking 50 bins before and then integrating the whole signal

Efficiency plib. Before pulse compression



- Efficiency plib is approximately flat and is around 96%
- Oscilations in the plib efficiency are produced by changes on the ambient temperature during day and night

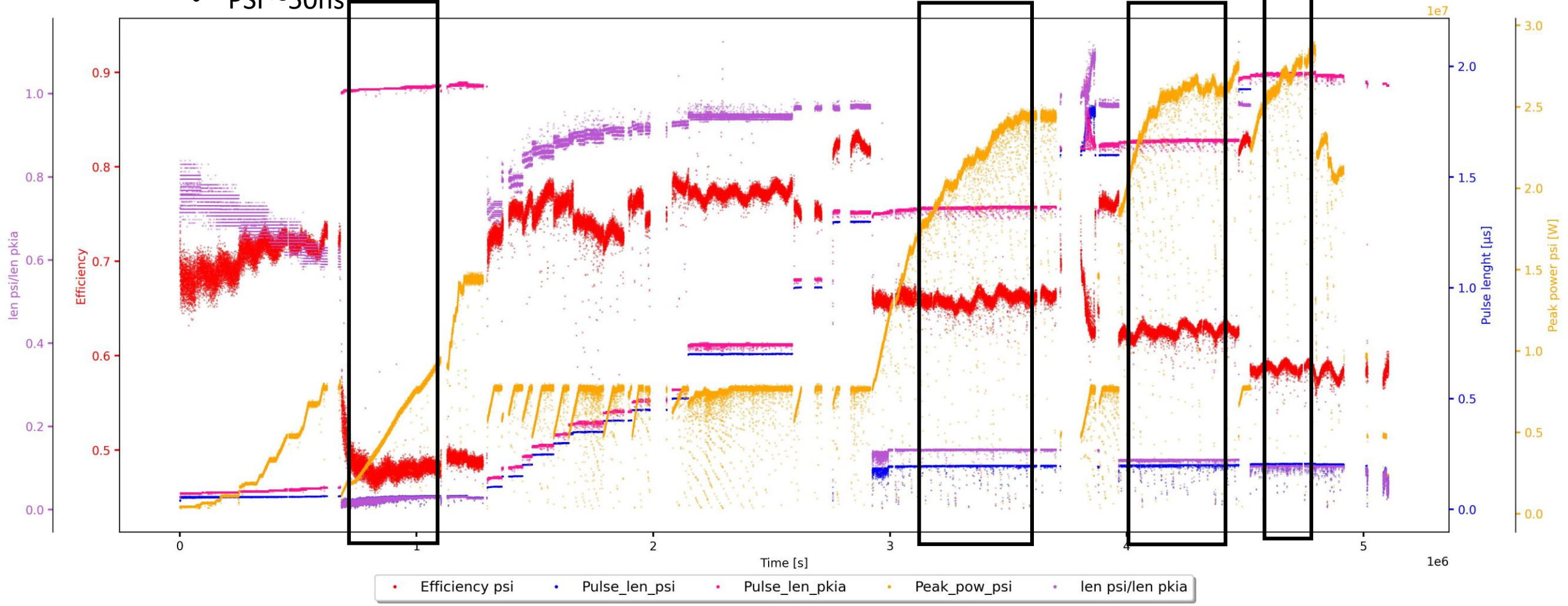
Efficiency psi. After pulse compression

Region 1
- PKIA ~1.9µs
- PSI ~50ns

Region 2
- PKIA ~1.3µs
- PSI ~200ns

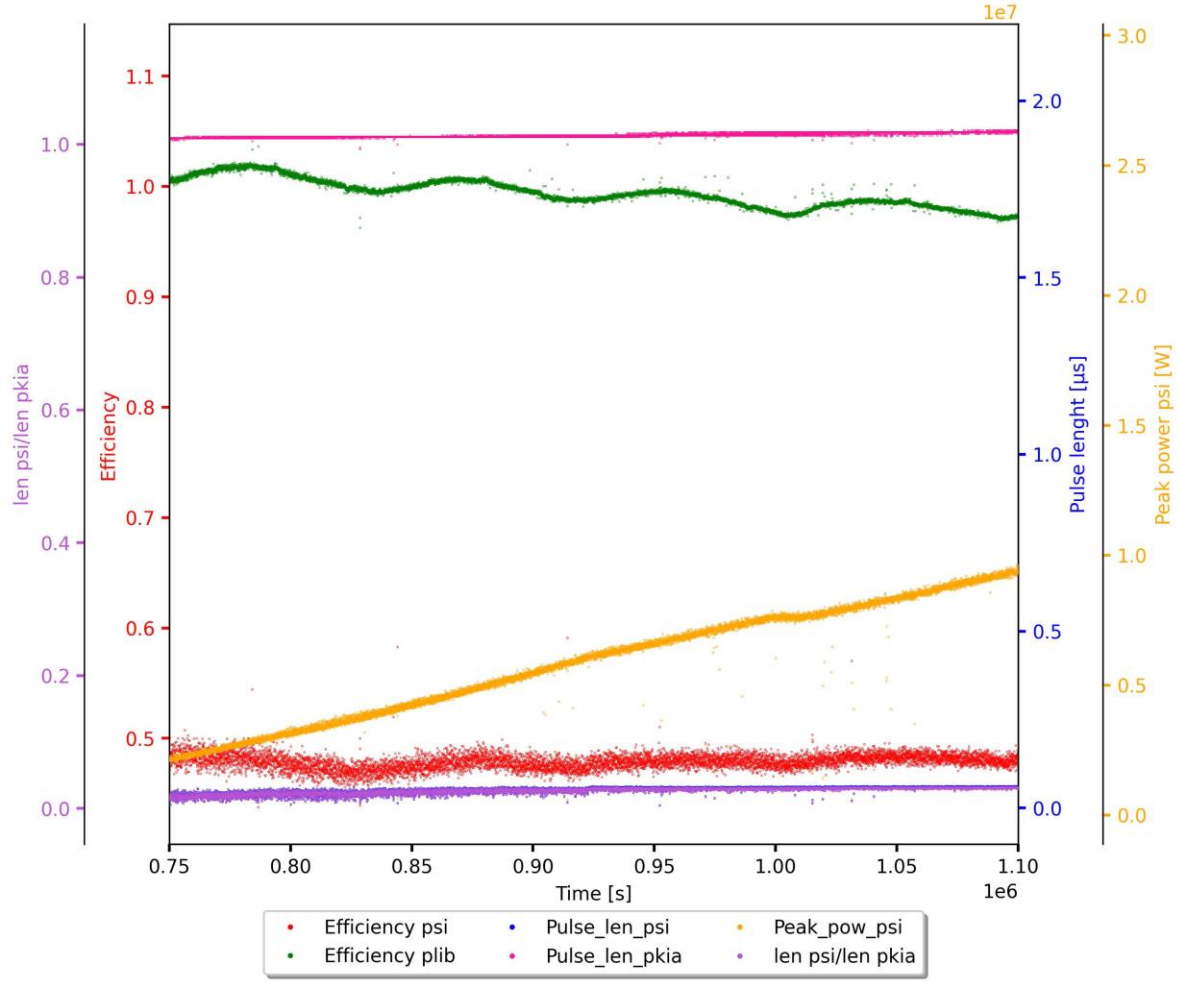
Region 3
- PKIA ~1.6µs
- PSI ~200ns

Region 4
- PKIA ~1.9µs
- PSI ~200ns

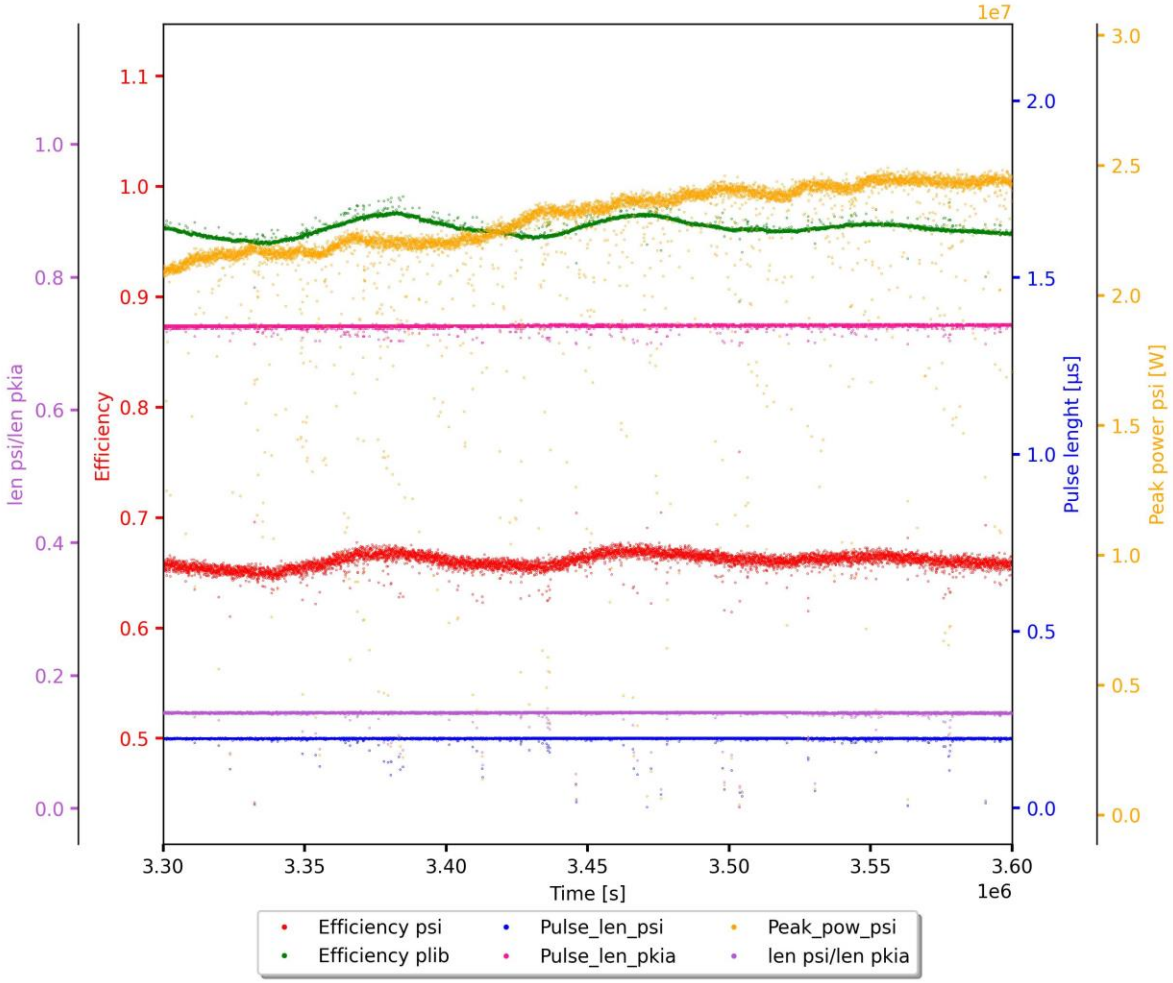


Zoom on the region 1 and 2

Region 1

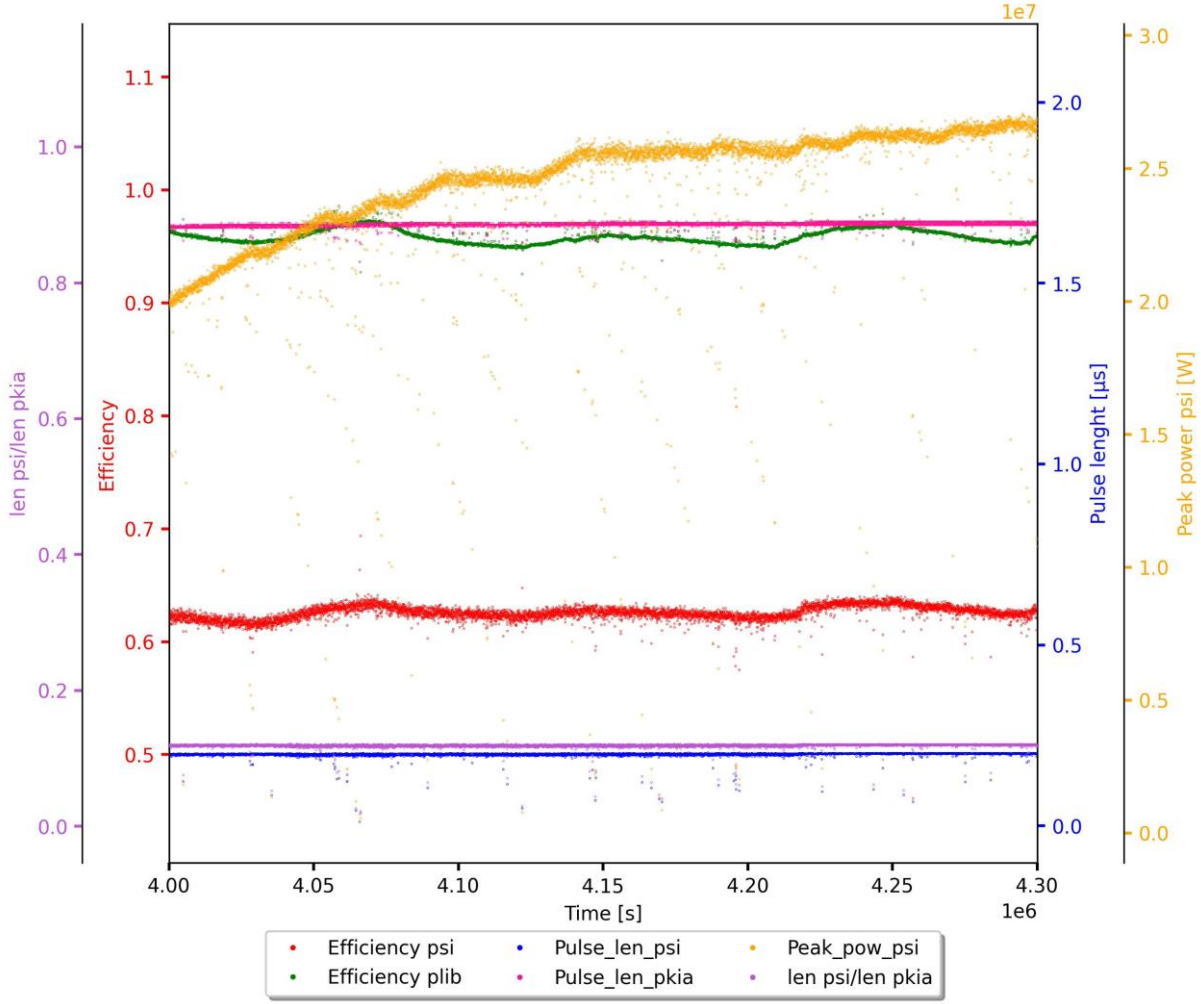


Region 2

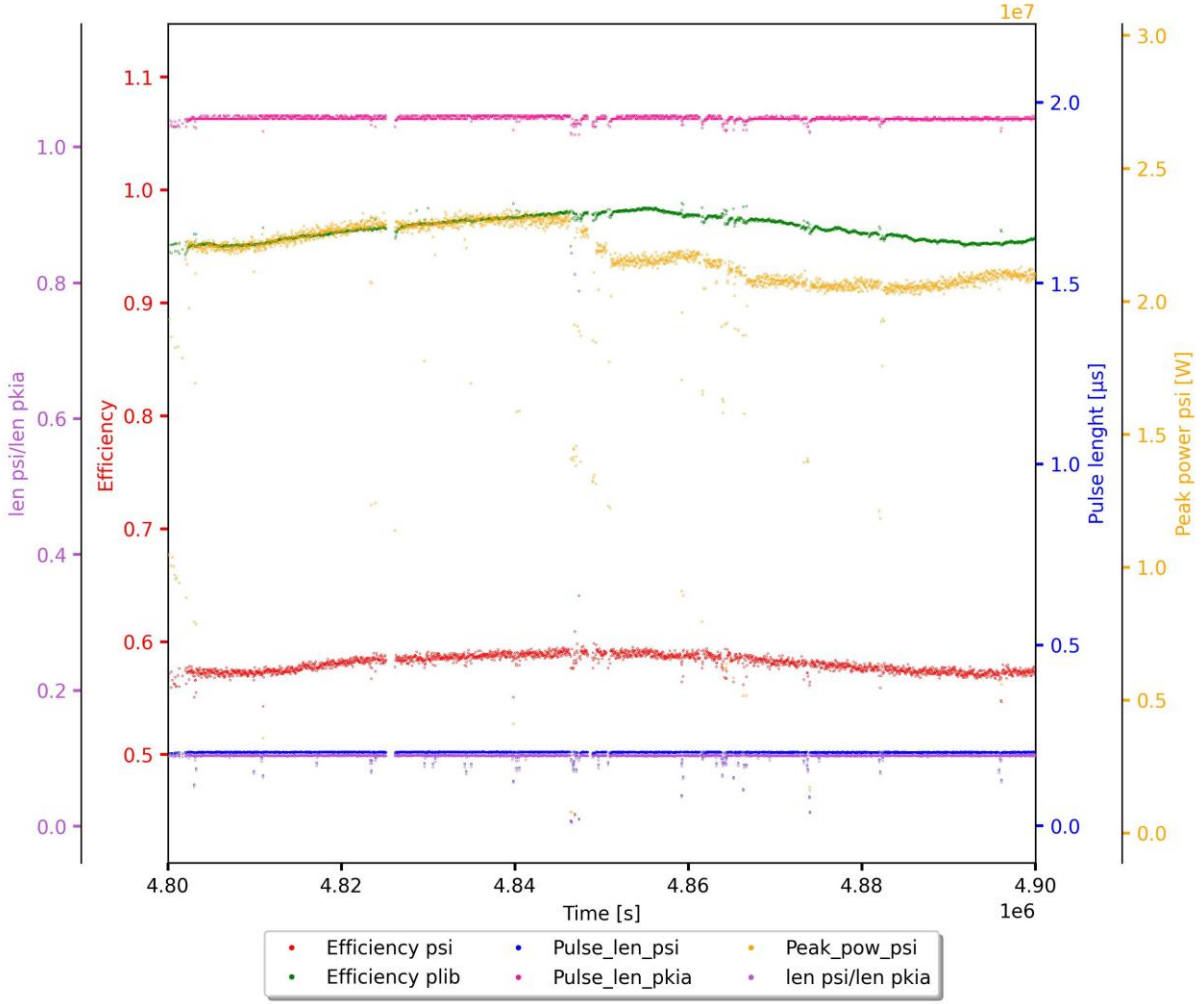


Zoom on the region 3 and 4

Region 3

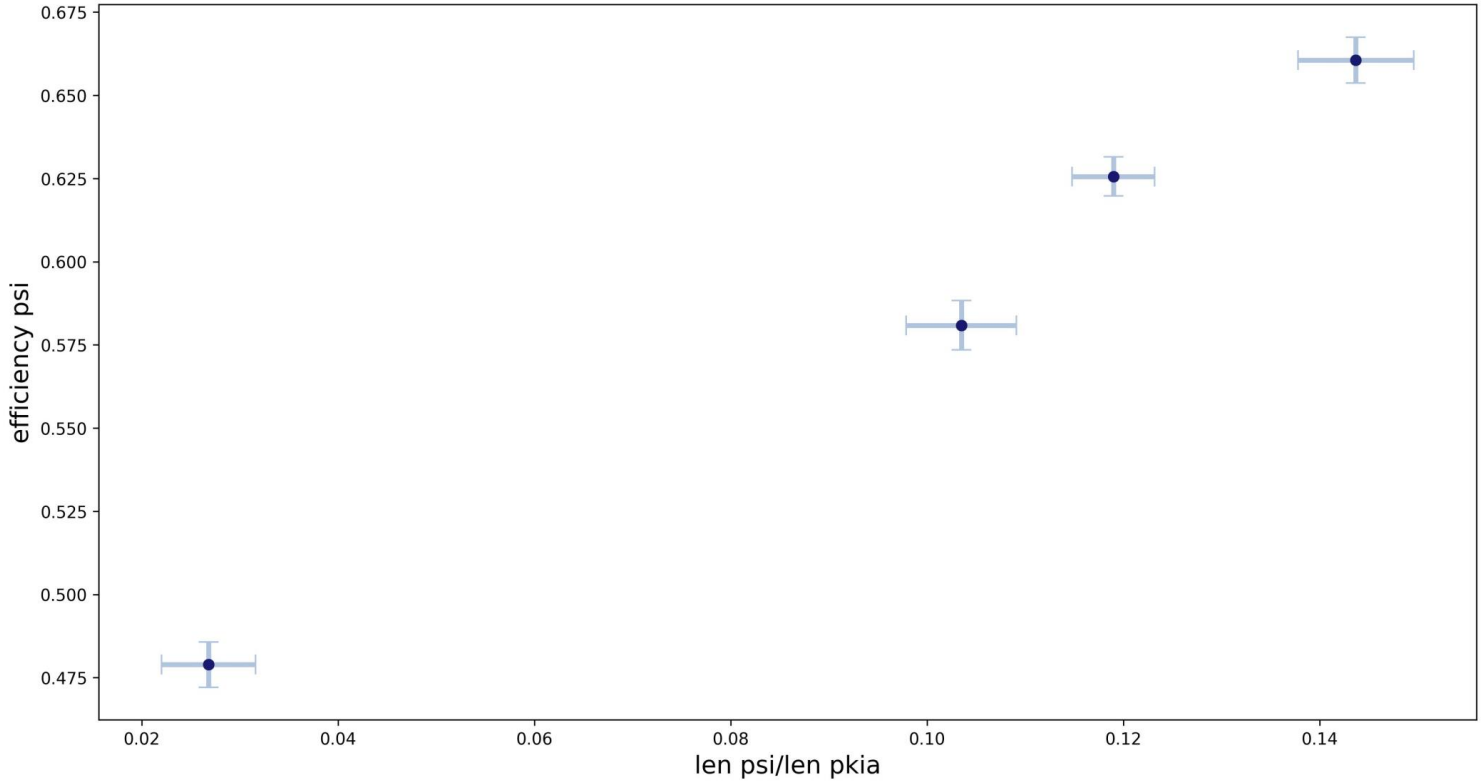


Region 4



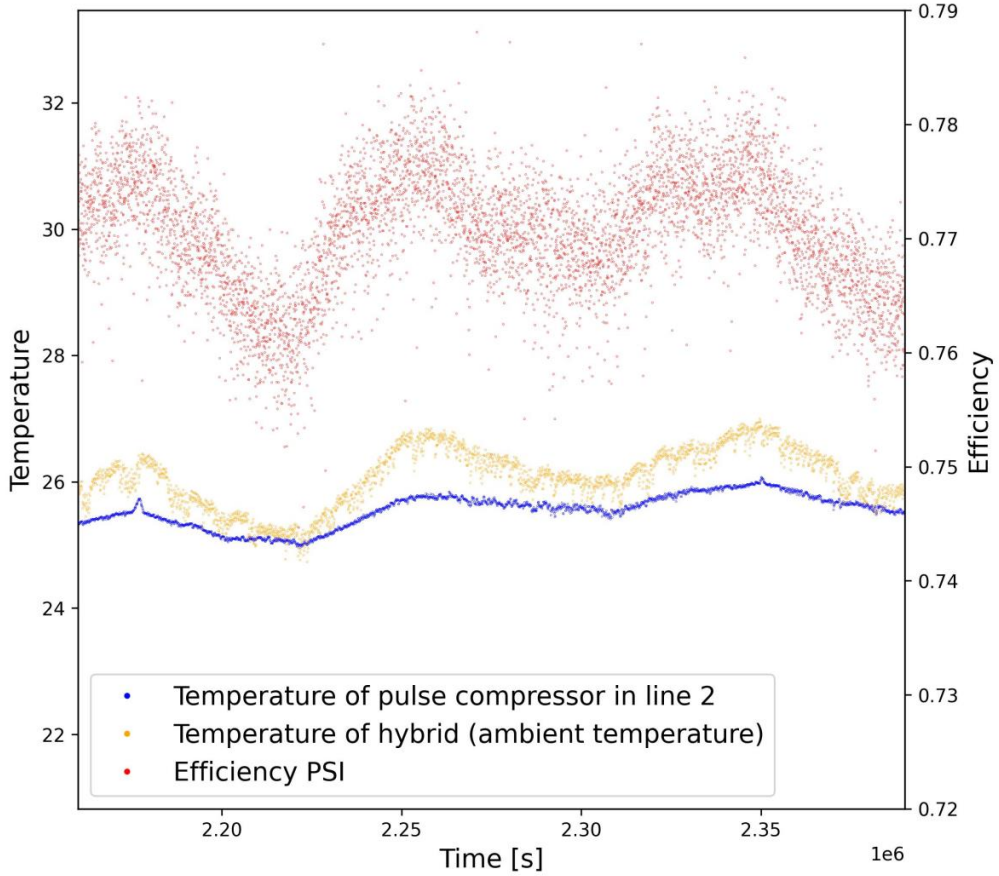
2. How efficiency depends on the ratio between PSI pulse lenght and PKI pulse lenght

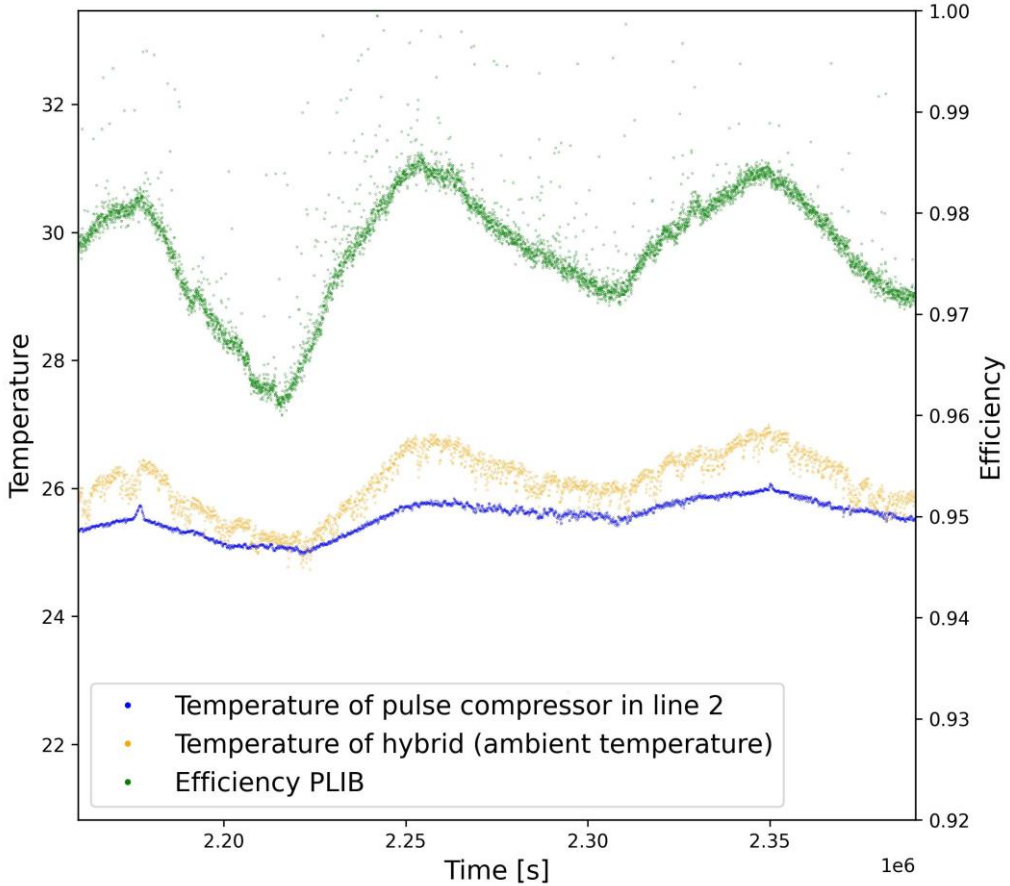
Region	mean efficiency psi	std efficiency psi	mean len psi/len pkia	std len psi/len pkia
(0.75-1.1)E6 s	0.4789	0.0068	0.0268	0.0048
(3.3-3.6)E6 s	0.6606	0.0069	0.1437	0.0059
(4.0-4.3)E6 s	0.6256	0.0059	0.1190	0.0042
(4.8-4.9)E6 s	0.5809	0.0074	0.1035	0.0056



3. Correlations between the efficiency and the temperature

WITHOUT compression

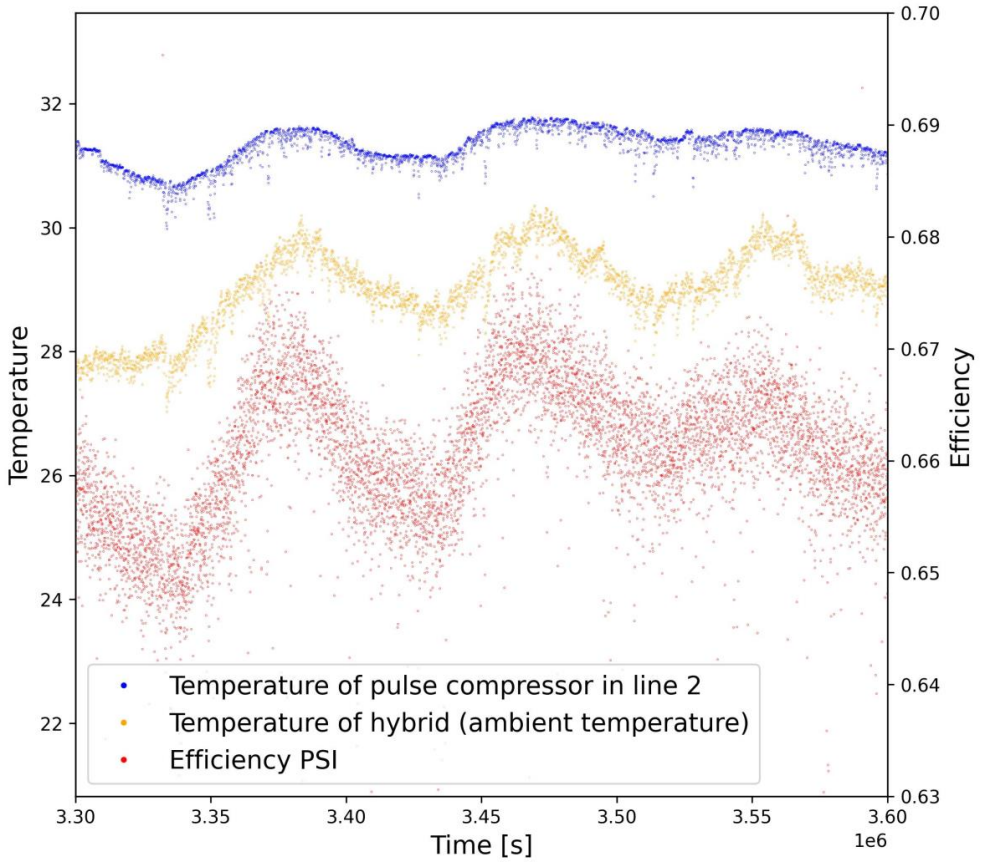


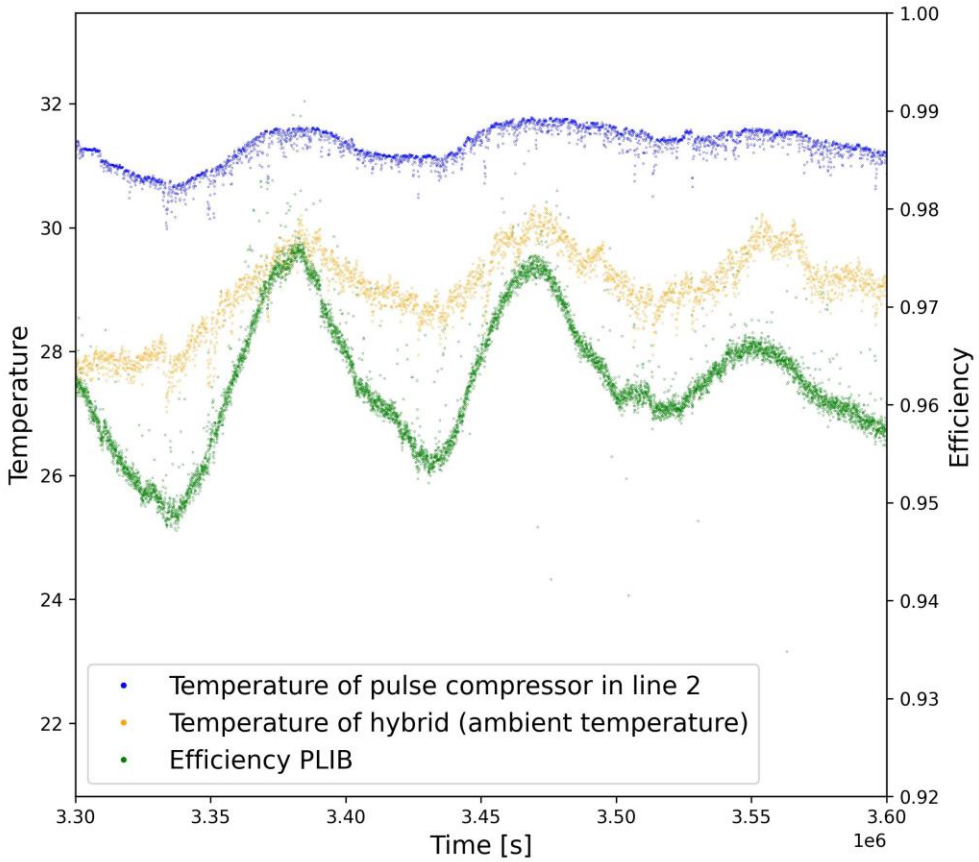


- Both efficiency PSI and efficiency PLIB have oscilations: oscilations in efficiency are paralel to the oscilations of the ambient temperature
- In the temperature of pulse compressor the oscilations are also visible but they are smaller

3. Correlations between the efficiency and the temperature

WITH compression

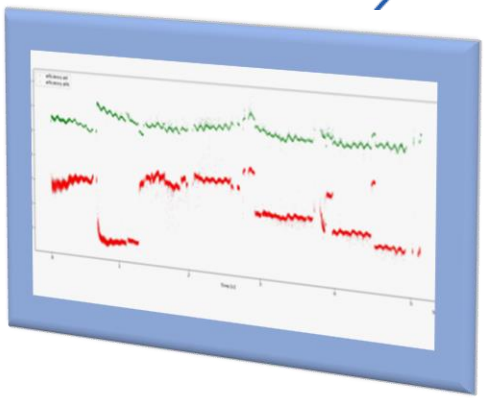


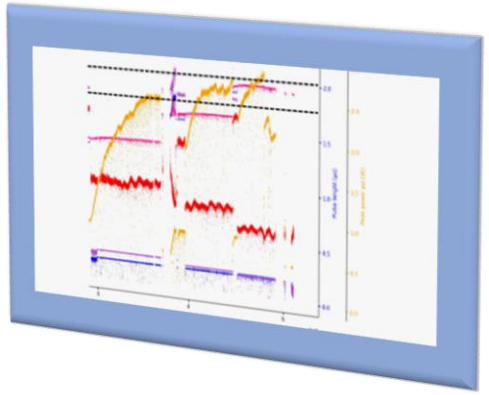


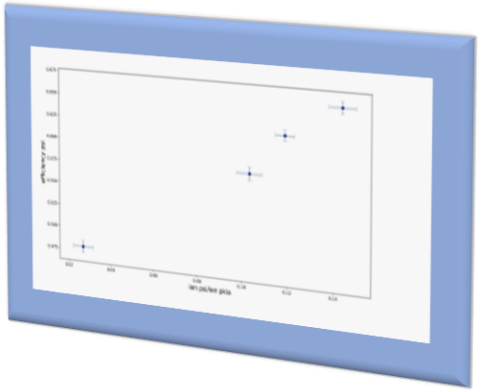
- Without compression the temperature of pulse compressor was around 25.5 ^{o}C, but with compression the temperature of pulse compressor is much higher around 31 ^{o}C

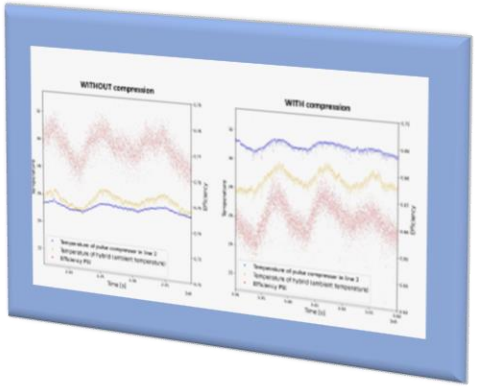
Summary and conclusions

1. Most losses of power comes from pulse compressor
2. Oscilations in efficiency are caused by the changes of ambient temperature during day and night
3. If we want to get a specific peak power - we can be more efficient when we use a shorter input pulse and compress it
4. The more we compress the pulse, the less efficient we are
5. When we are compressing the pulse: the pulse compressor heats up

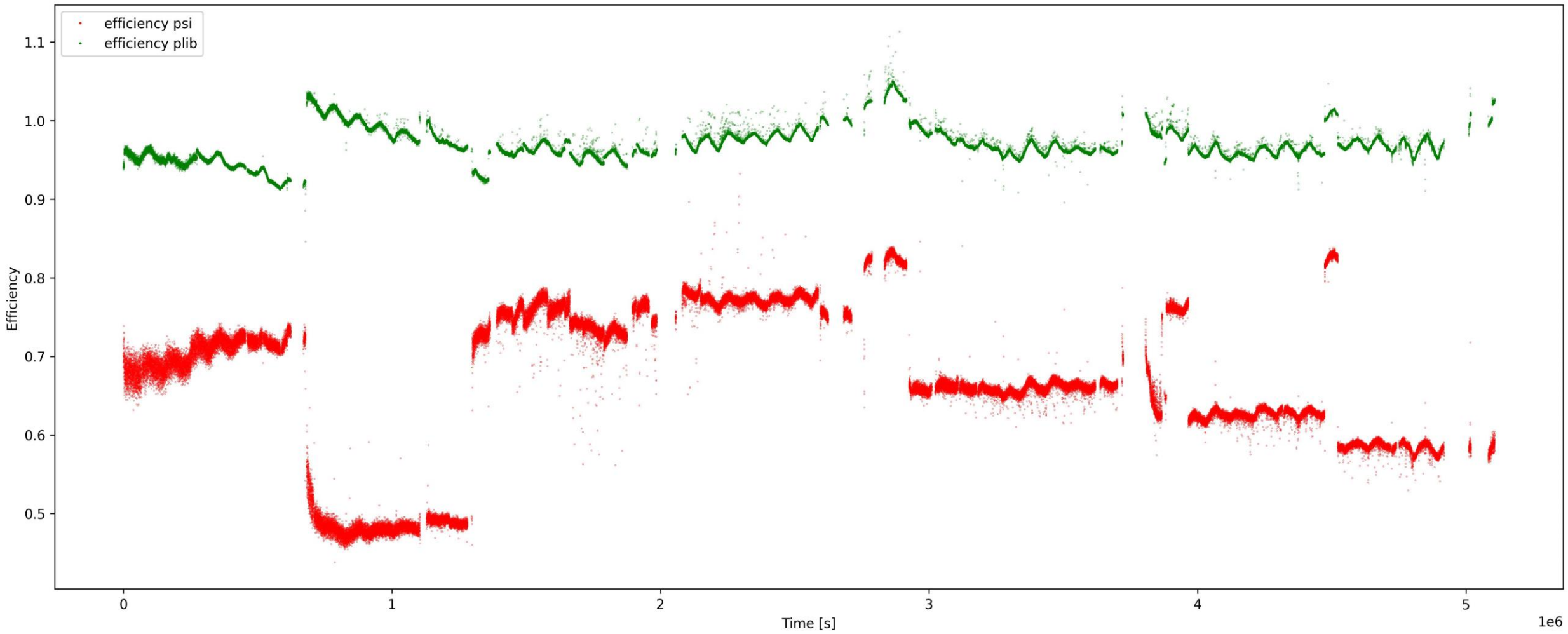


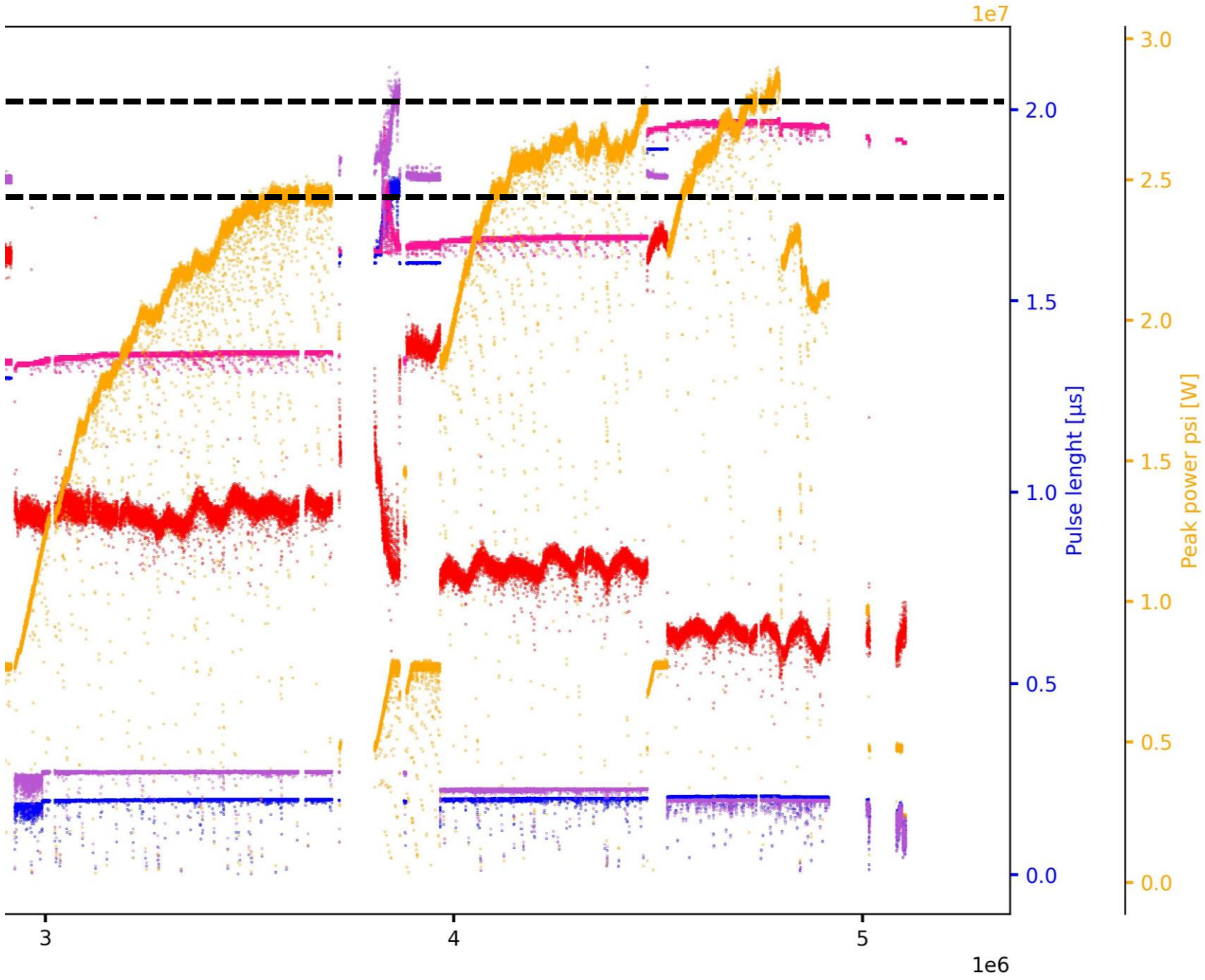


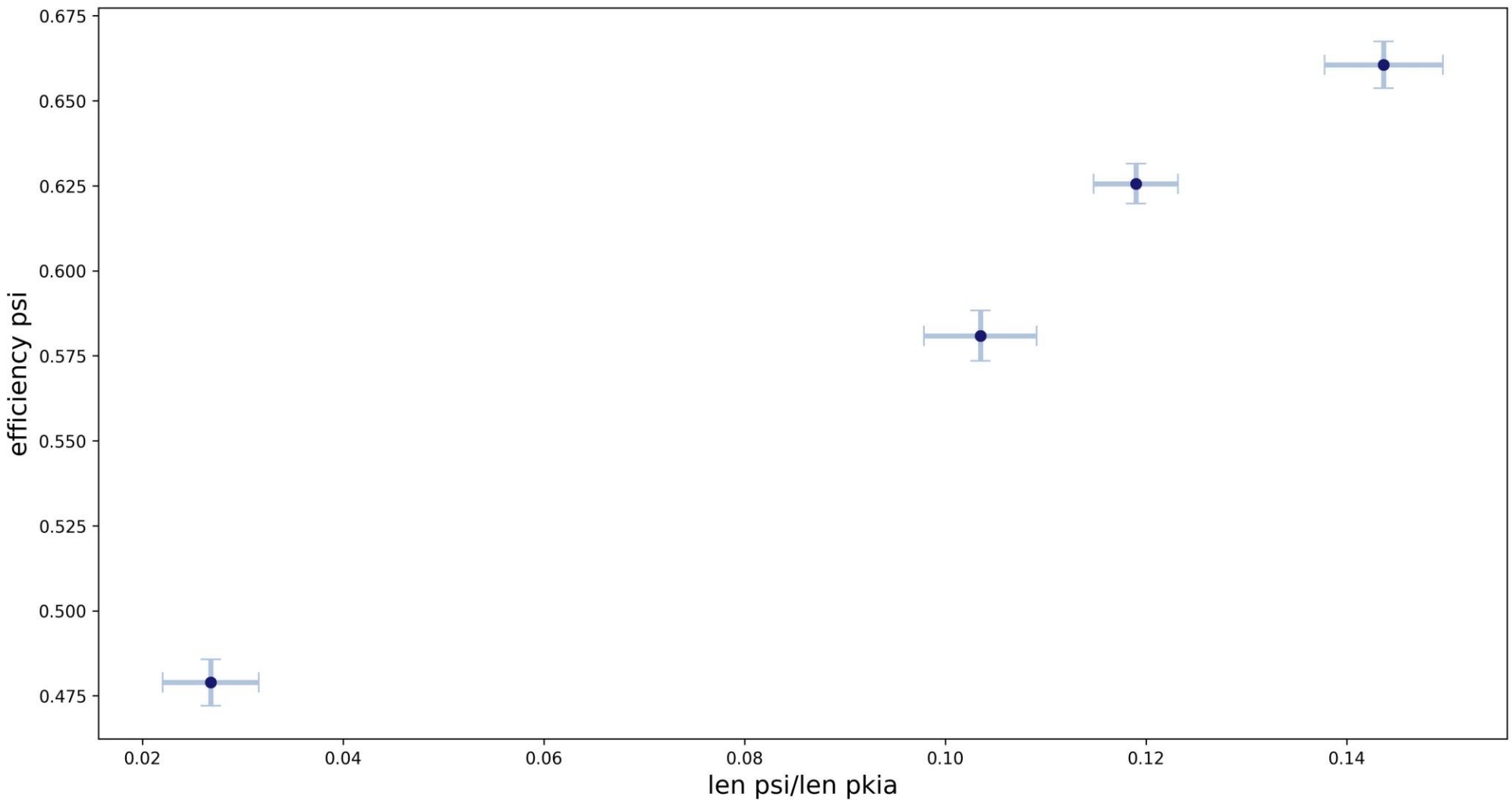




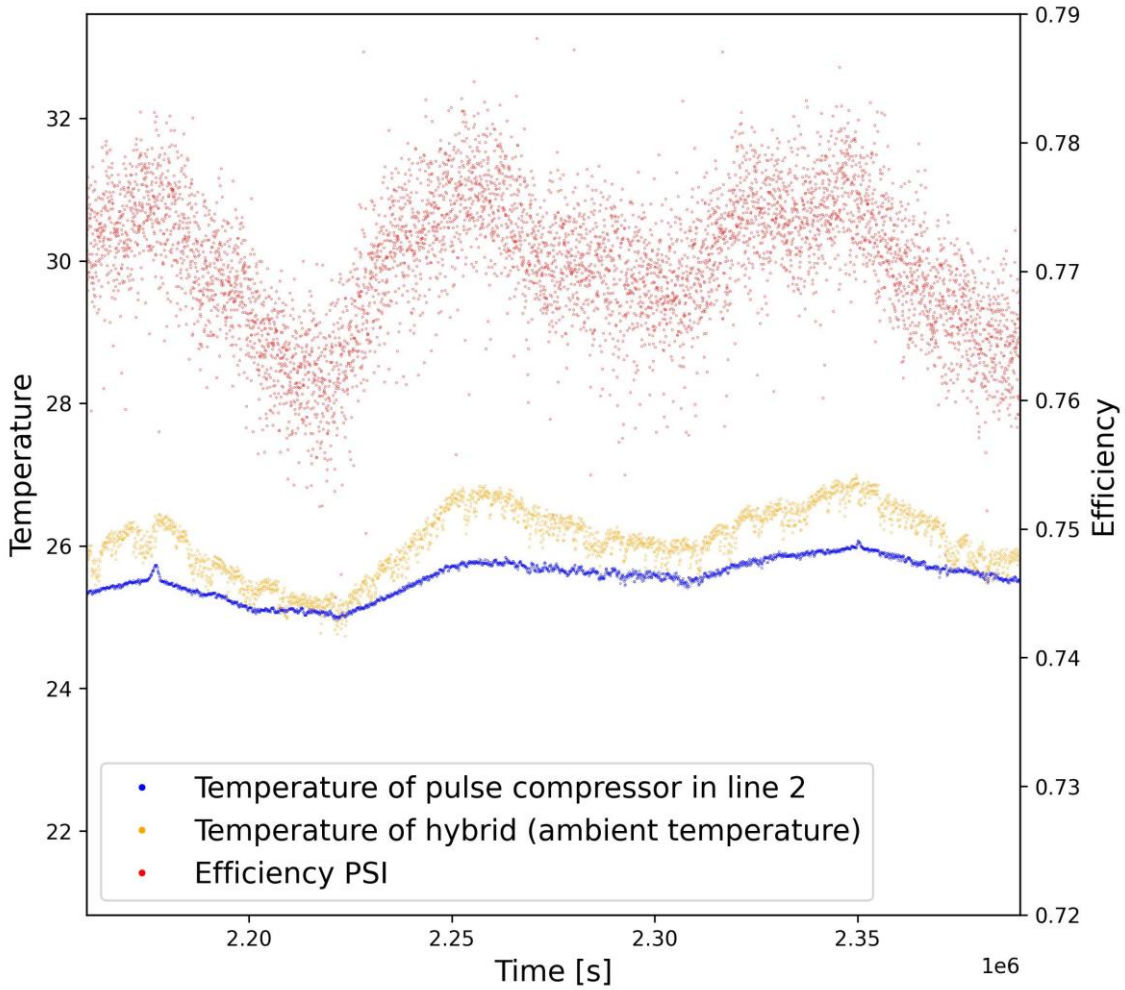
Thank you for your attention!


efficiency psi
efficiency plib
Efficiency
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0
1
2
3
4
5
Time [s]
1e6


1e7
2.0
1.5
1.0
0.5
0.0
Pulse lenght [µs]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Peak power psi [W]
3
4
5
1e6


0.675
0.650
0.625
0.600
0.575
0.550
0.525
0.500
0.475
efficiency psi
0.02
0.04
0.06
0.08
0.10
0.12
0.14
len psi/len pkia

WITHOUT compression



WITH compression