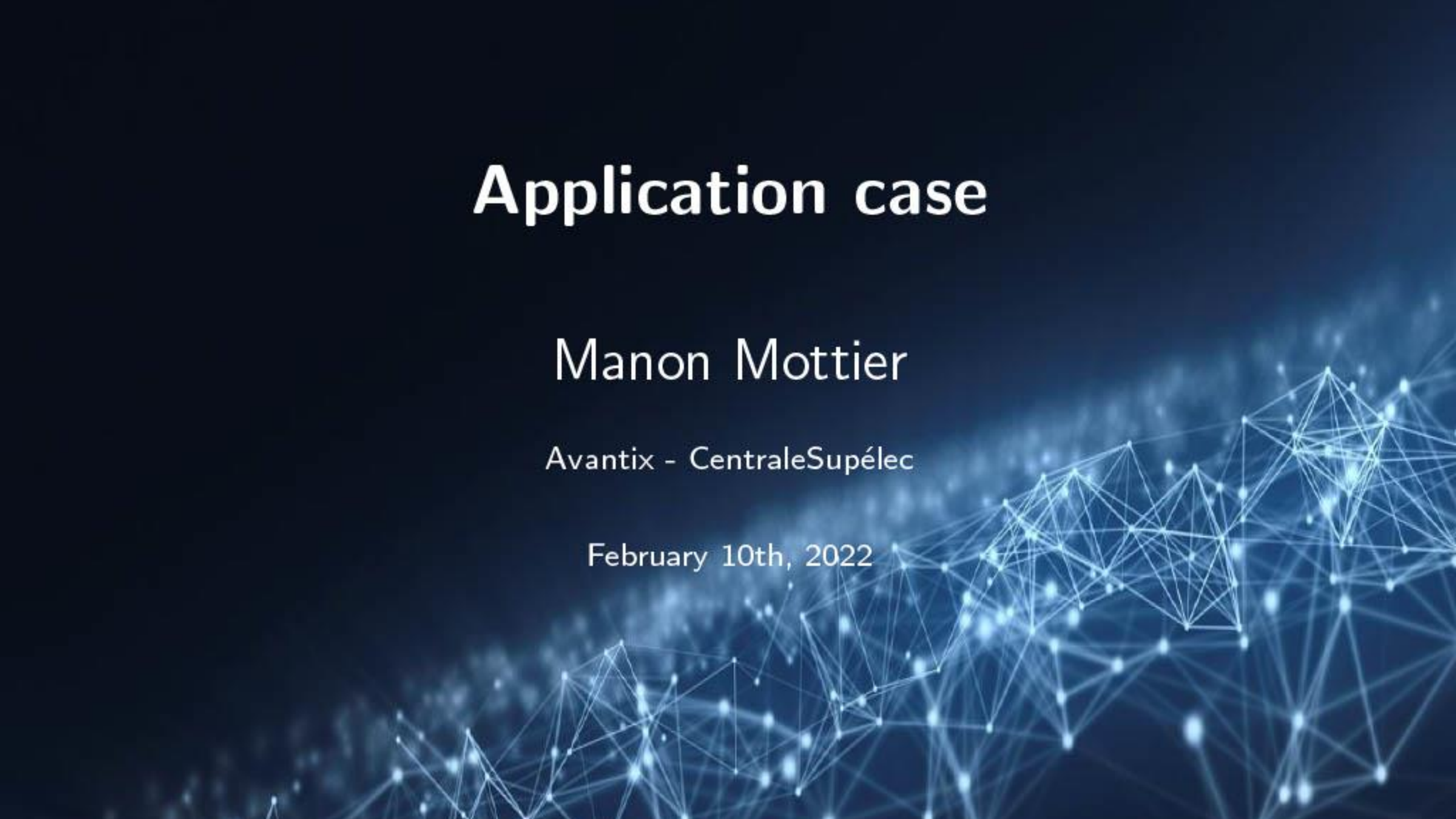


Application case

Manon Mottier

Avantix - CentraleSupélec

February 10th, 2022



Content

1. Waveform overview
2. Dataset 1
3. Dataset 2
4. Dataset 3
5. Global results

Content

1. Waveform overview

2. Dataset 1

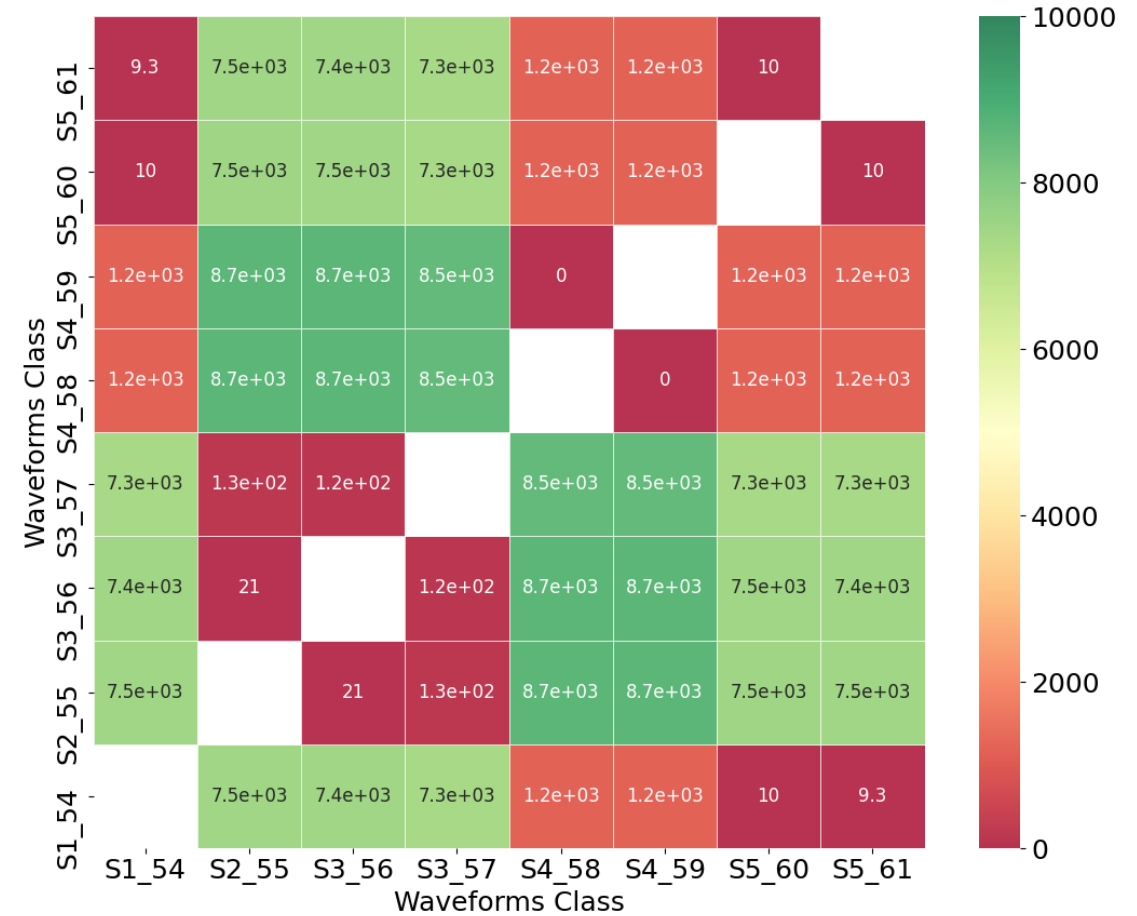
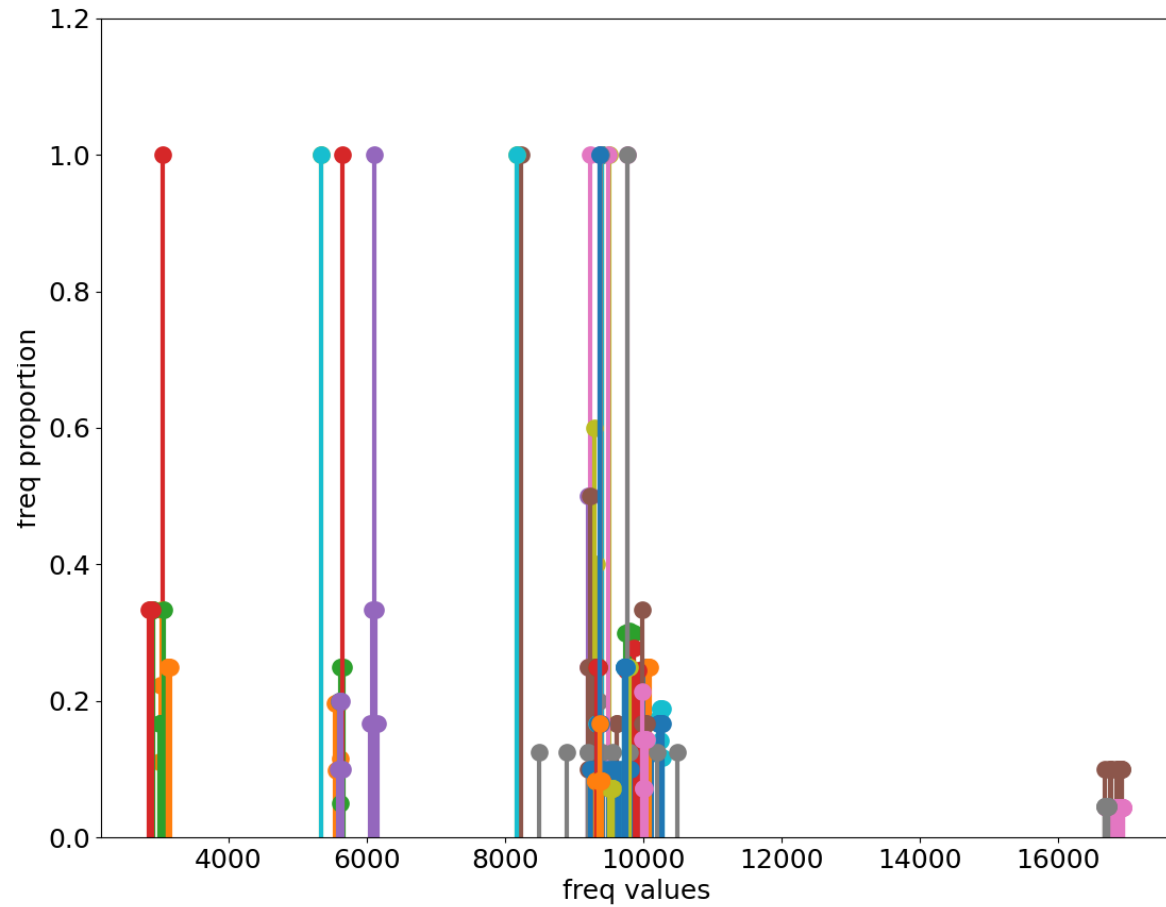
3. Dataset 2

4. Dataset 3

5. Global results

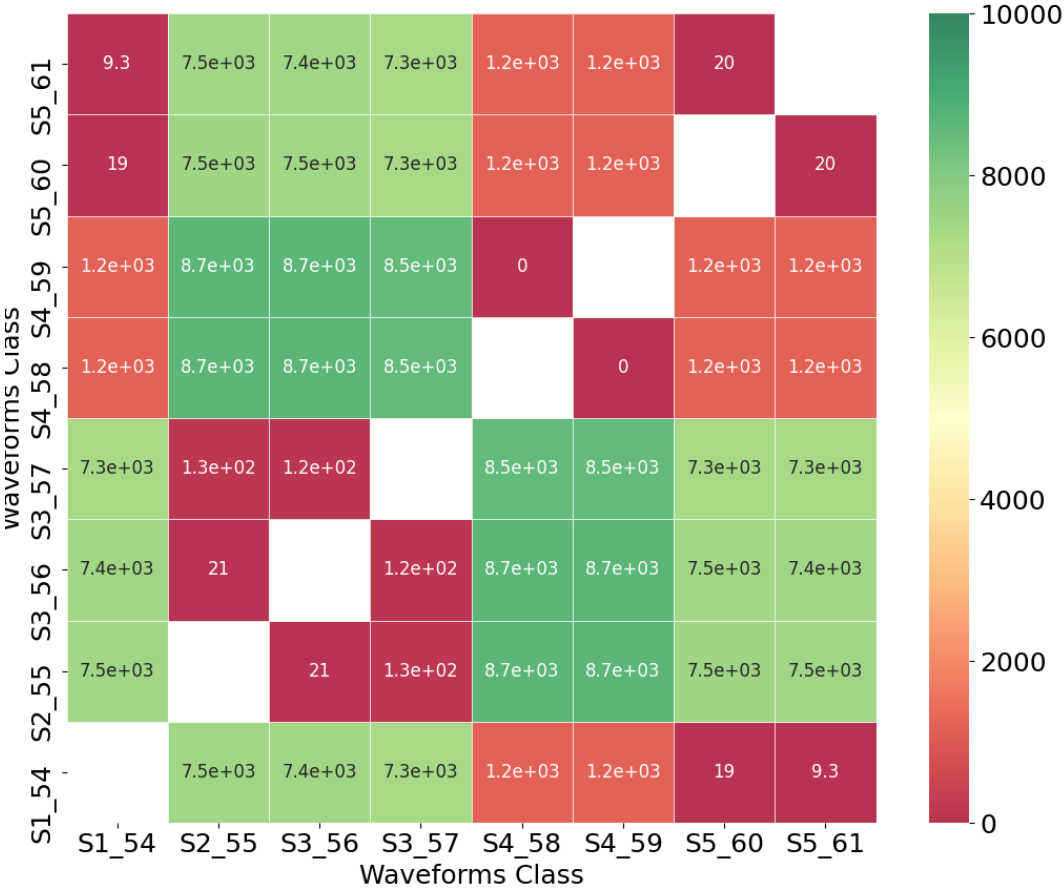
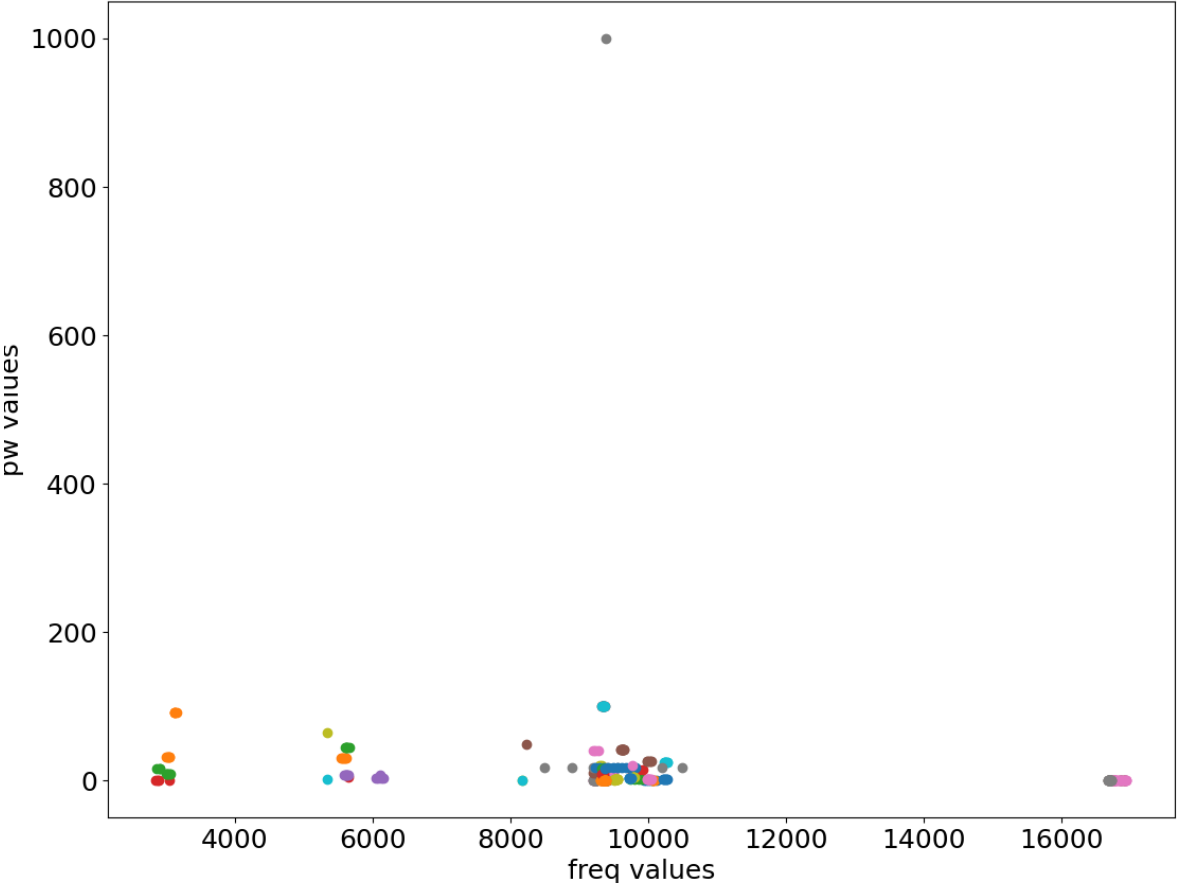
Waveform overview

Representation – 1D (Frequency)



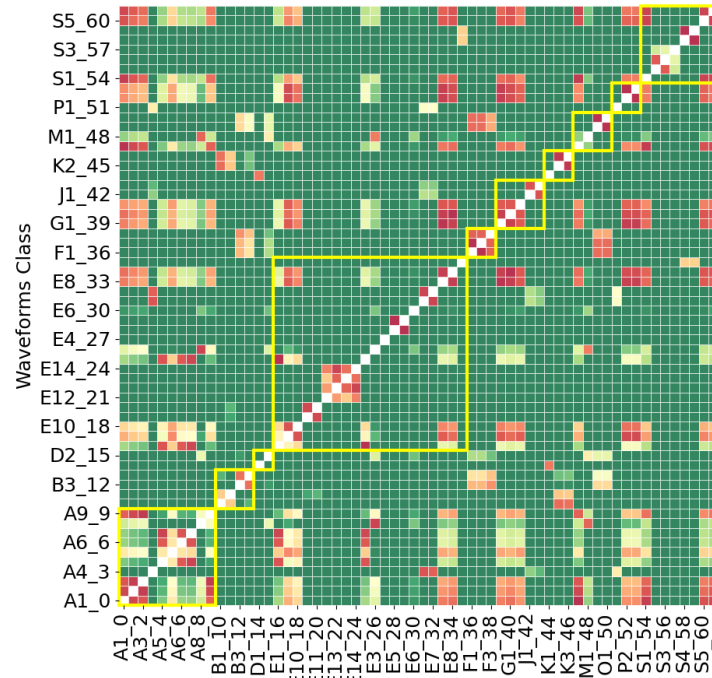
Waveform overview

Representation – 2D (Frequency x Pulse Width)

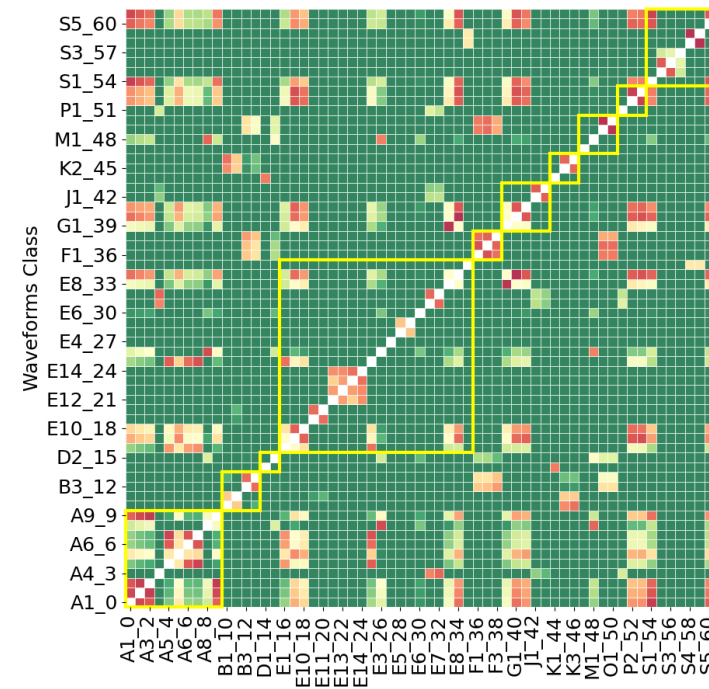


Waveform overview

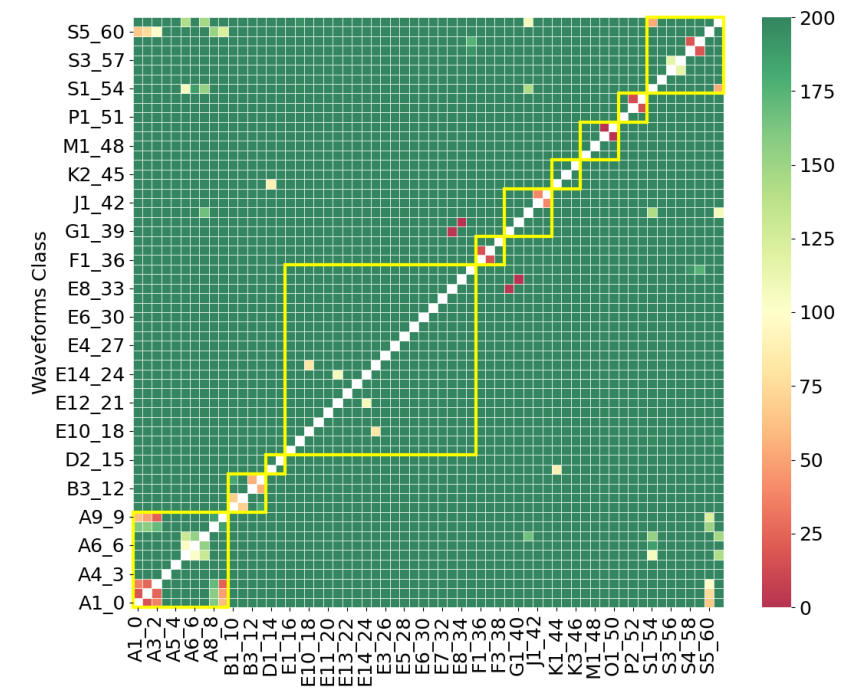
Cost matrix



Freq



Freq - Pw



PRI - Freq - Pw

Content

1. Waveform overview

2. Dataset 1

3. Dataset 2

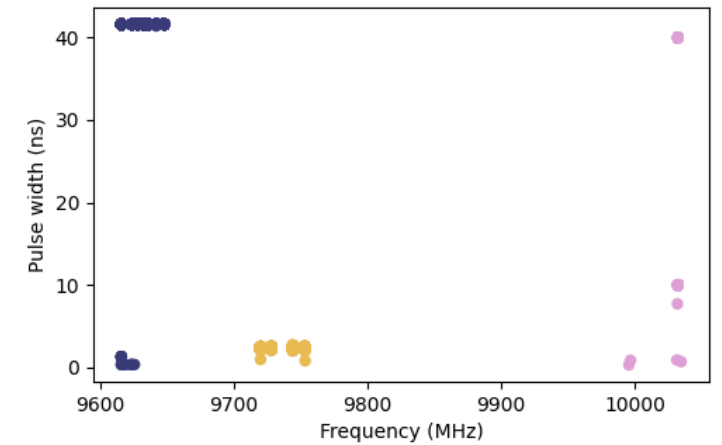
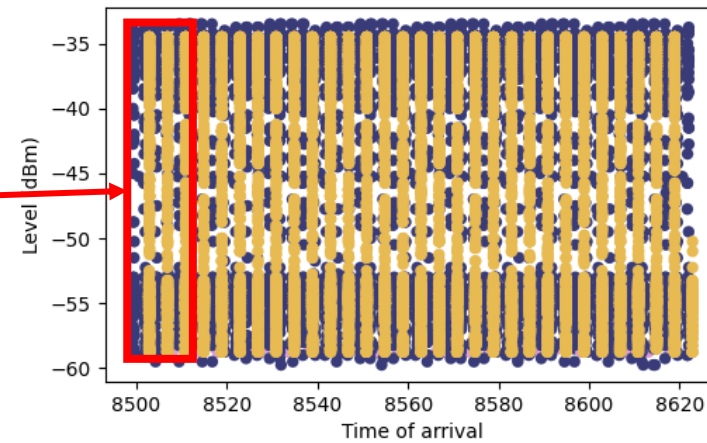
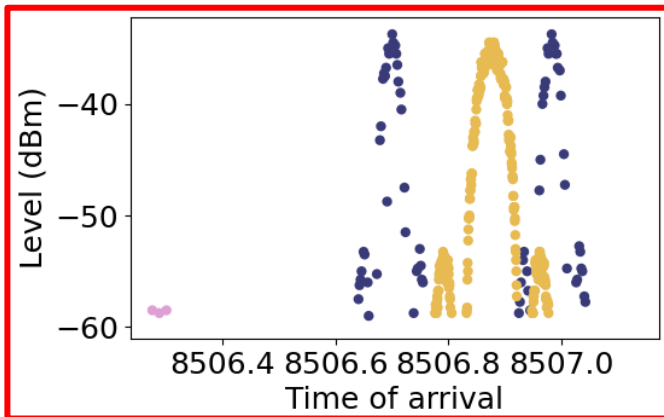
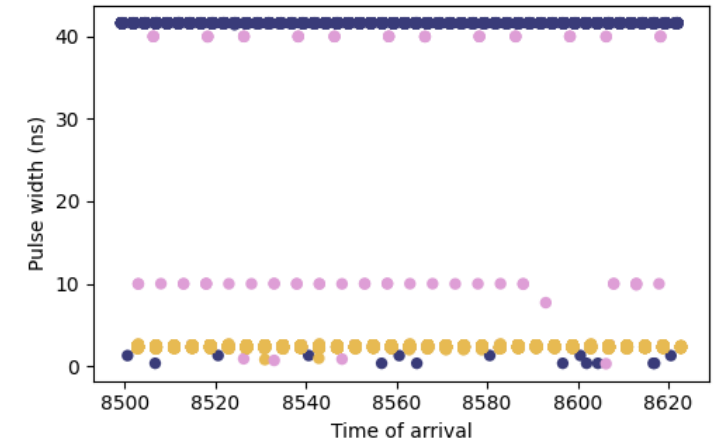
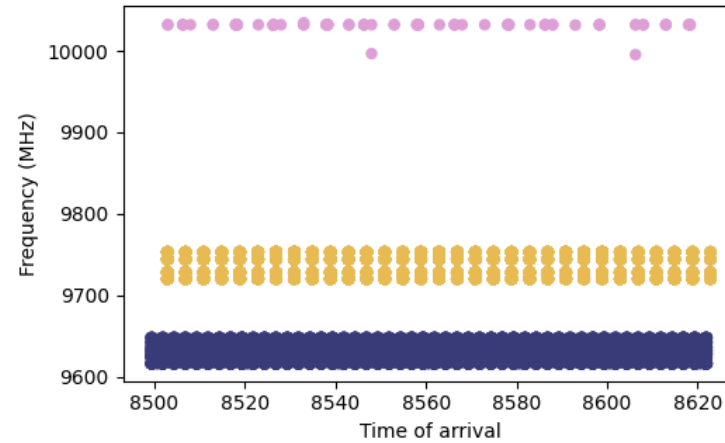
4. Dataset 3

5. Global results

Deinterleaving RADAR pulses

True Label

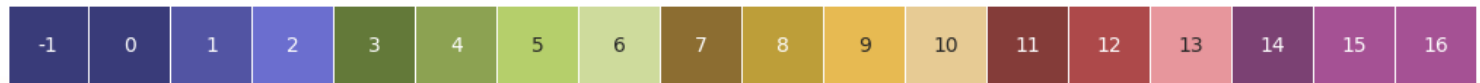
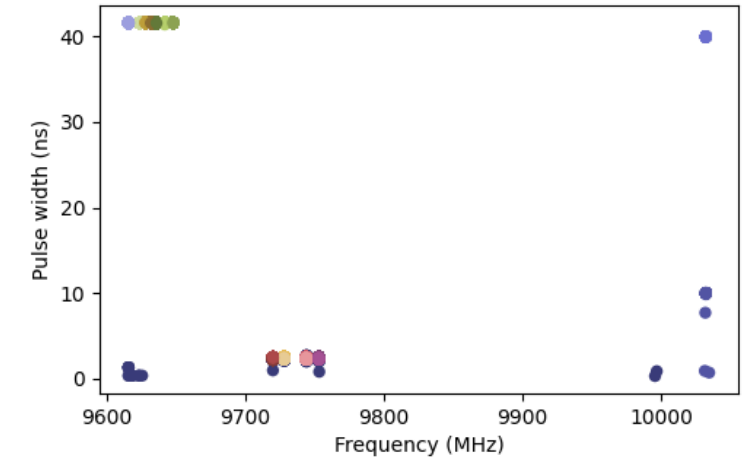
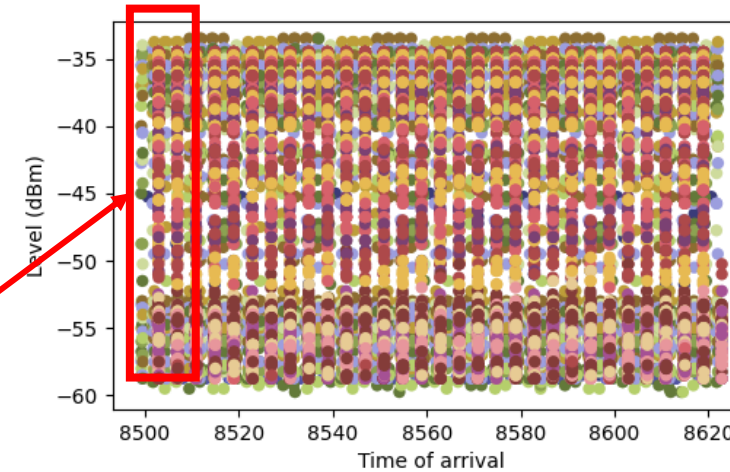
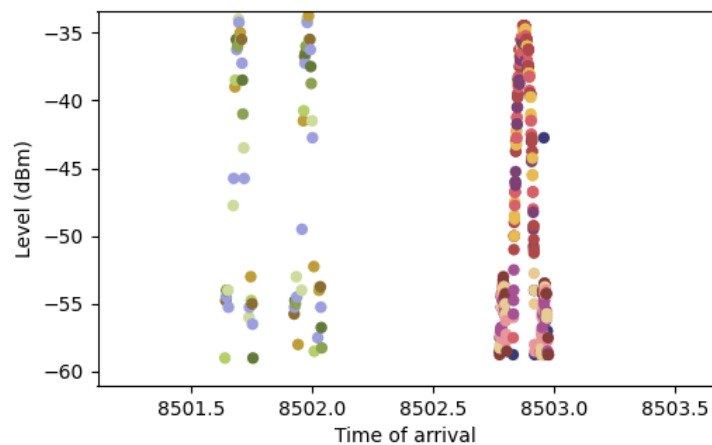
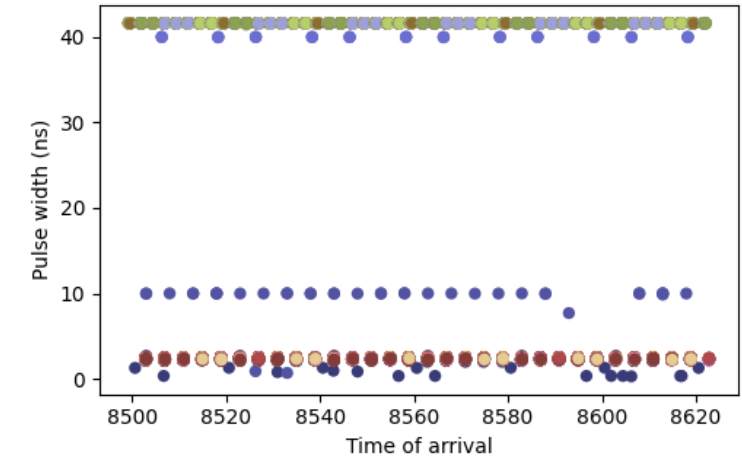
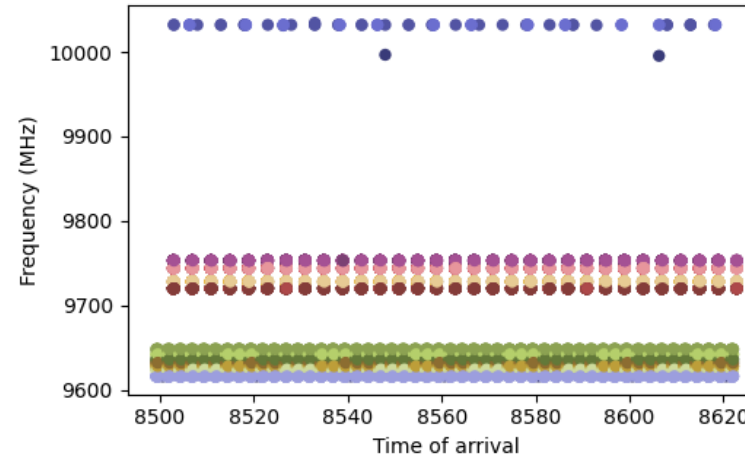
Group	RADAR Label
0	D2
1	N1
2	Unknown



Deinterleaving RADAR pulses

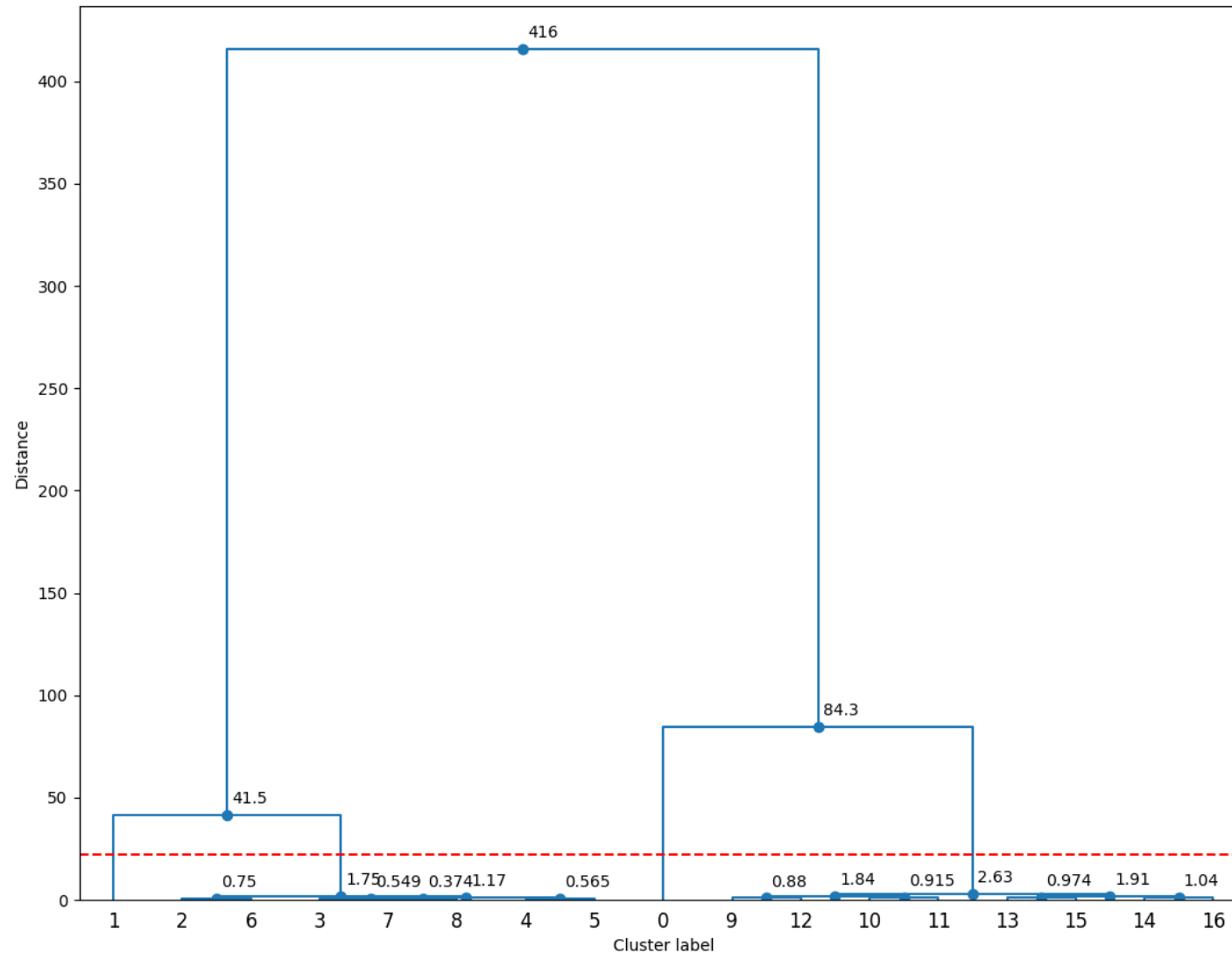
Clustering Pulses in 2D (Frequency x Pulse Width)

Group	Pulses	%	Group	Pulses	%
-1	333	2,6%	8	428	3,3%
0	37	0,3%	9	1 367	10,5%
1	35	0,3%	10	888	6,8%
2	868	6,7%	11	983	7,6%
3	441	3,4%	12	1 375	10,6%
4	410	3,2%	13	1 322	10,2%
5	446	3,4%	14	997	7,7%
6	407	3,1%	15	1 304	10,0%
7	446	3,4%	16	913	7,0%



Deinterleaving RADAR pulses

Dendrogram

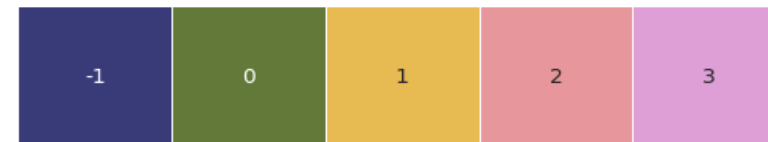
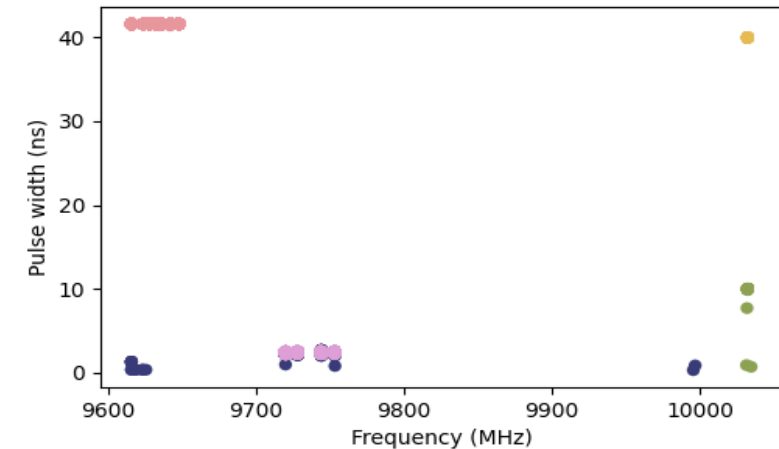
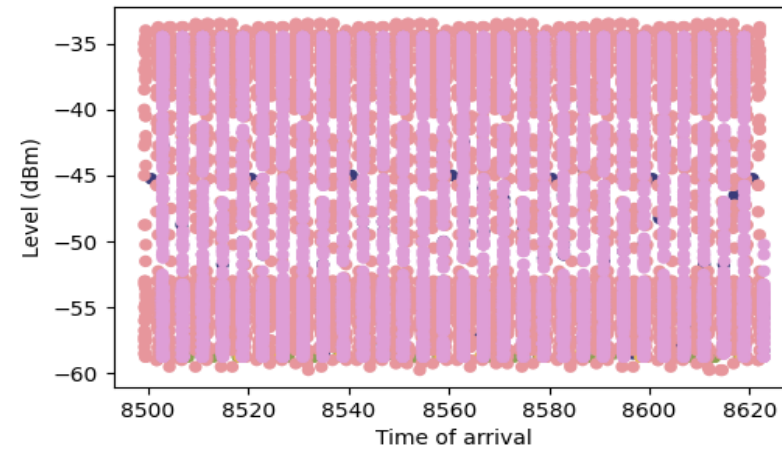
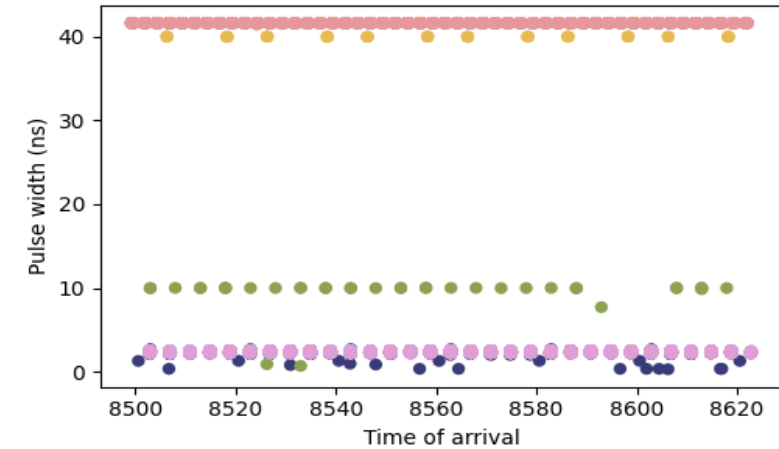
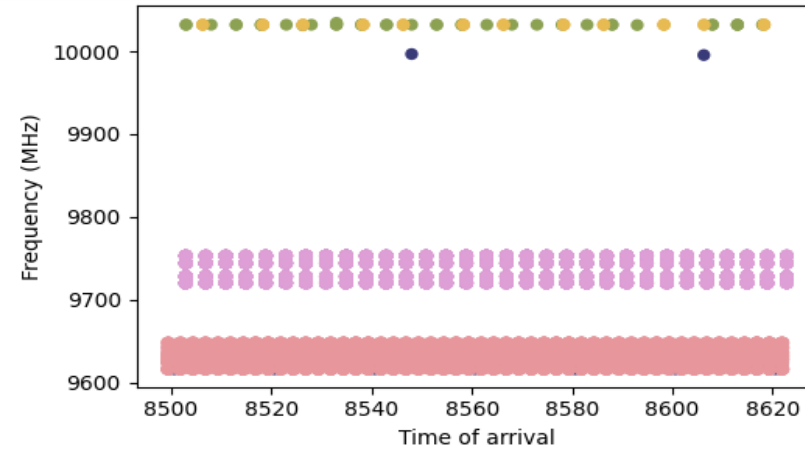


Deinterleaving RADAR pulses

Grouping Pulses

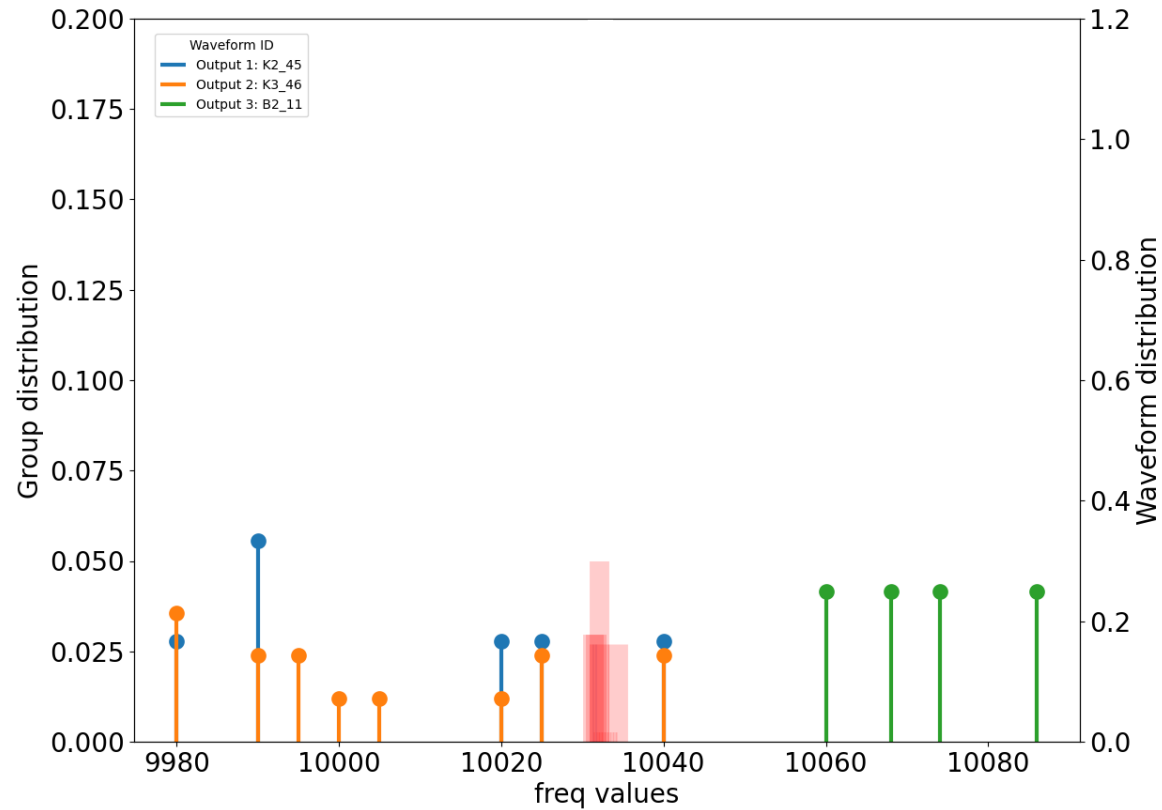
Statistic	Value
Pulses	13 000
Completeness	0,99
Homogeneity	1
Outliers	2,5%

Group	Pulses	RADAR Label
-1	333	/
0	37	Unknown
1	35	Unknown
2	3 446	D2
3	9 149	N1

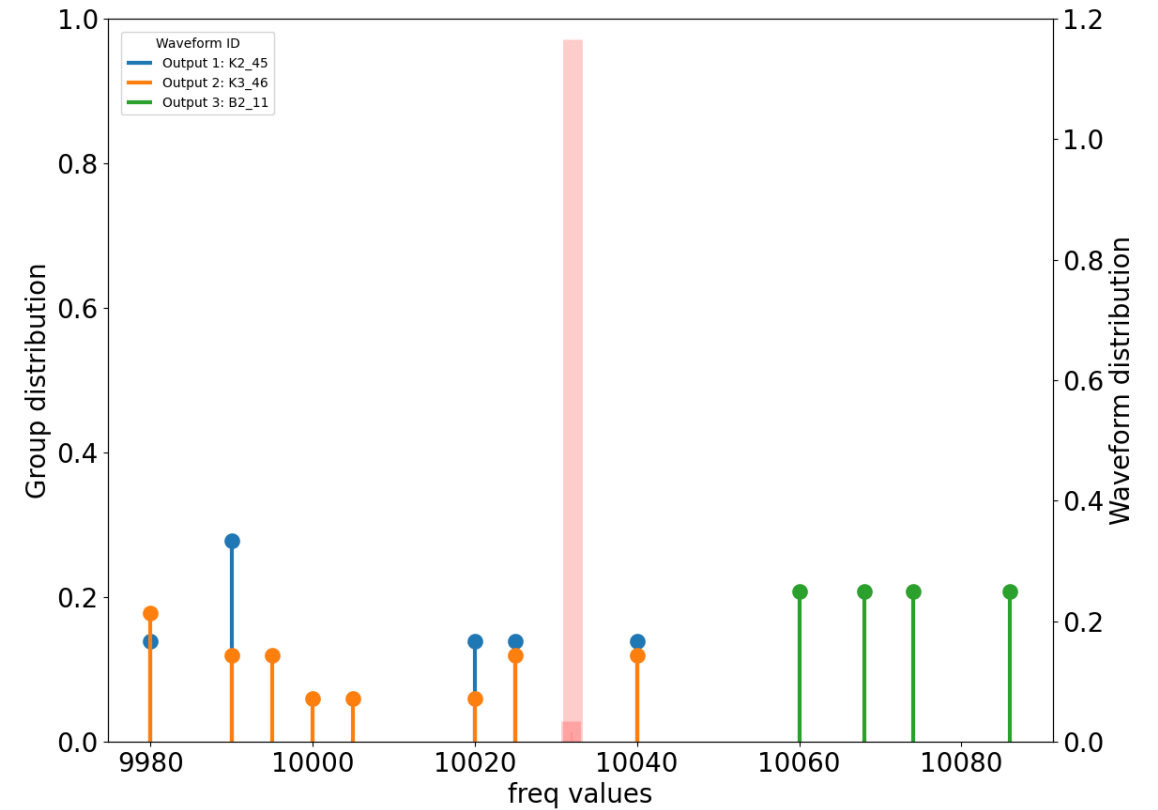


RADAR Classification

Classification output in 1D – Group 0 & 1



Group 0: Frequency

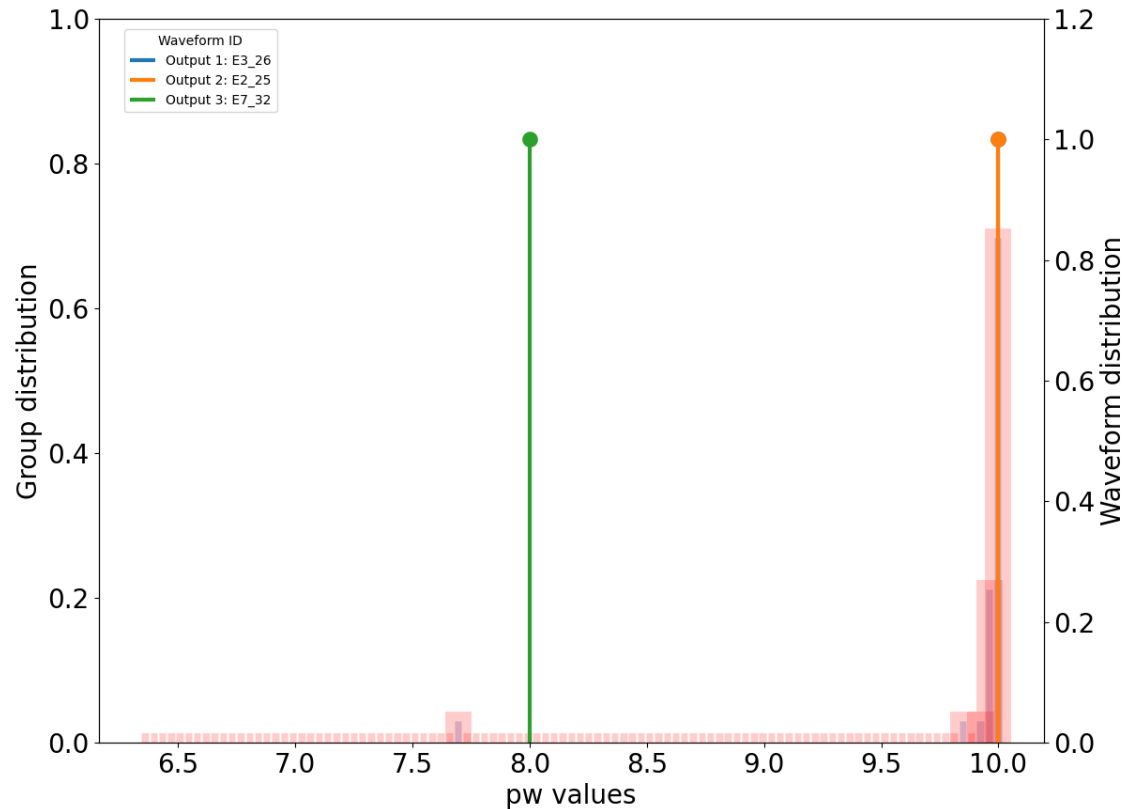


Group 1: Frequency

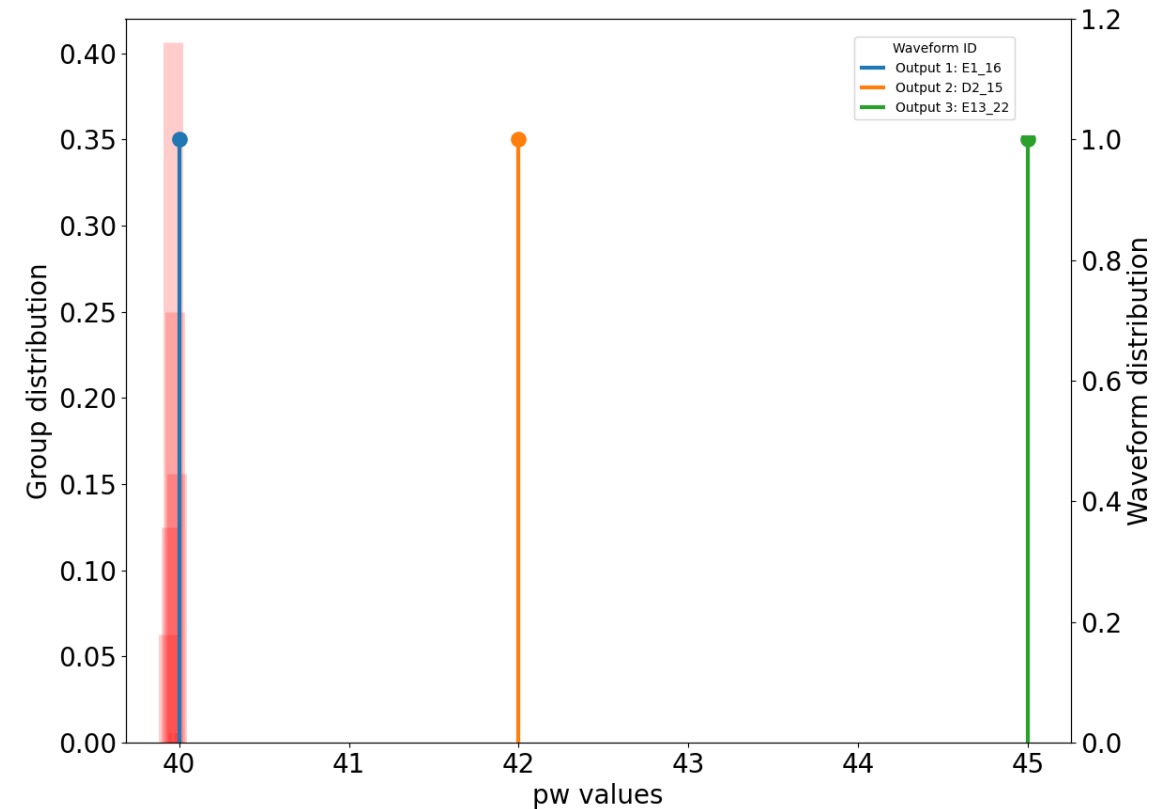
RADAR Classification

Classification output in 1D – Group 0 & 1

Group 0: Pulse Width



Group 1: Pulse Width

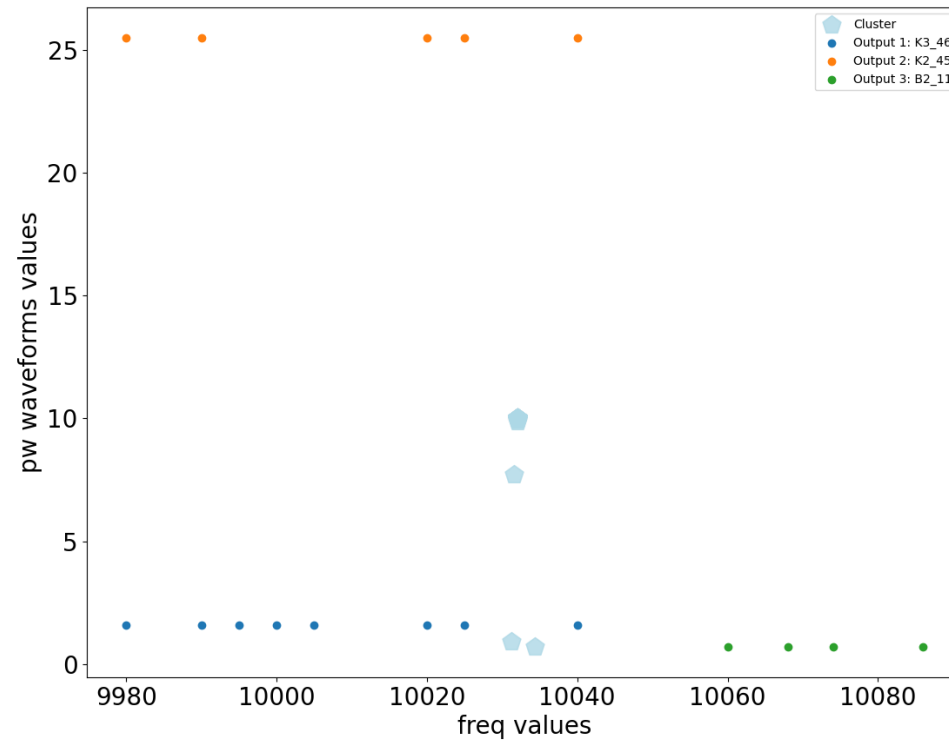


- E3 and E2 have the same Pulse width value, and the waveforms have their distributions overlapped.

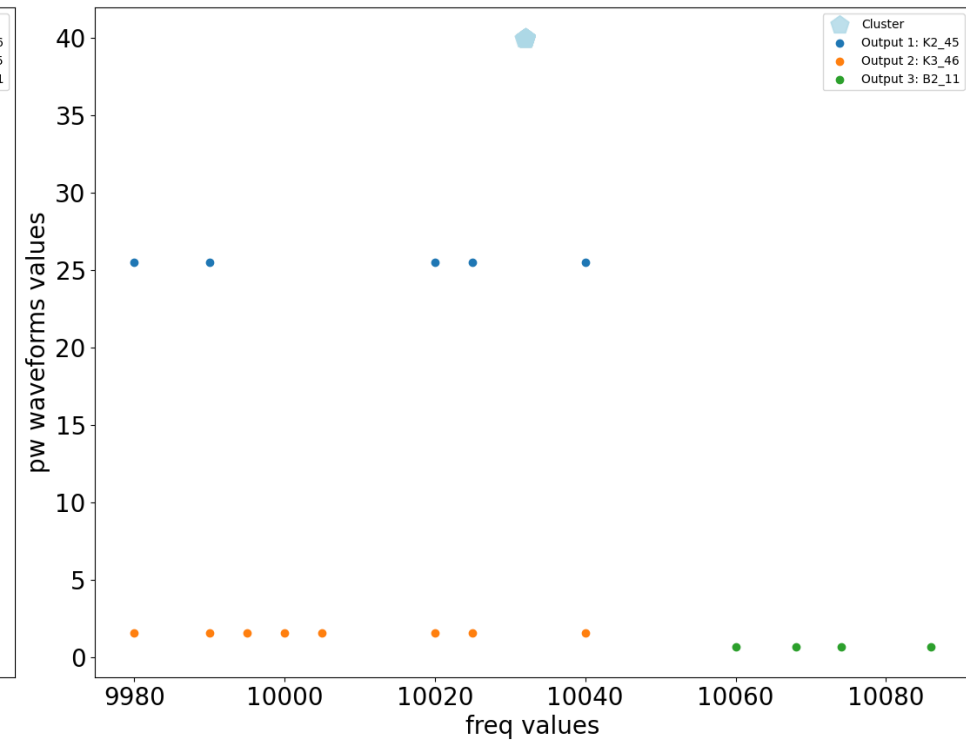
RADAR Classification

Classification output in 2D – Group 0 & 1

- Few pulses
- Uncertain results
- We should identify E1 and E2
- It is a subsample of a more extended signal.



Group 0: Frequency - Pulse Width

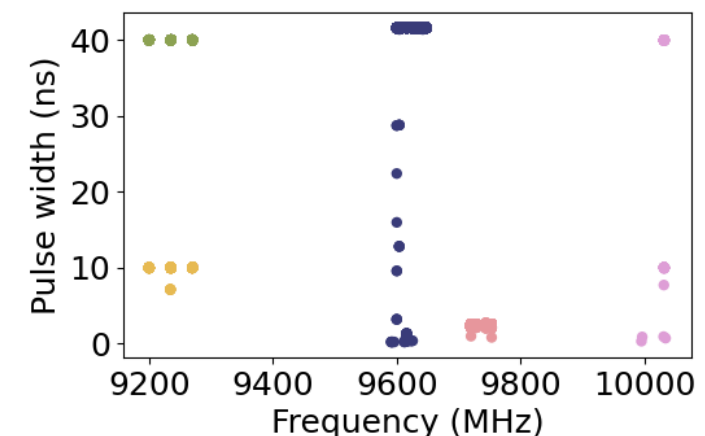
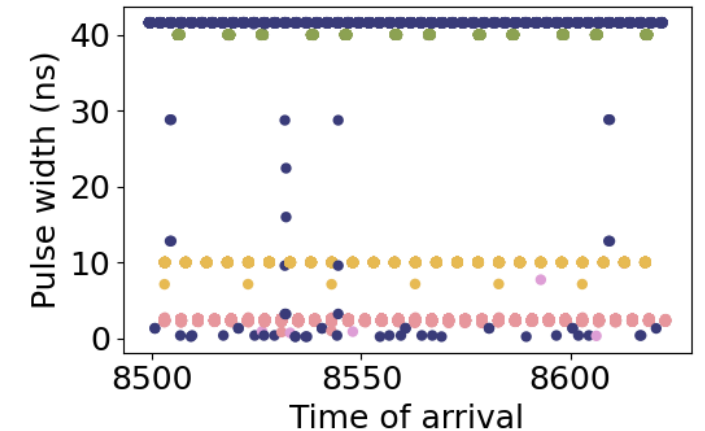
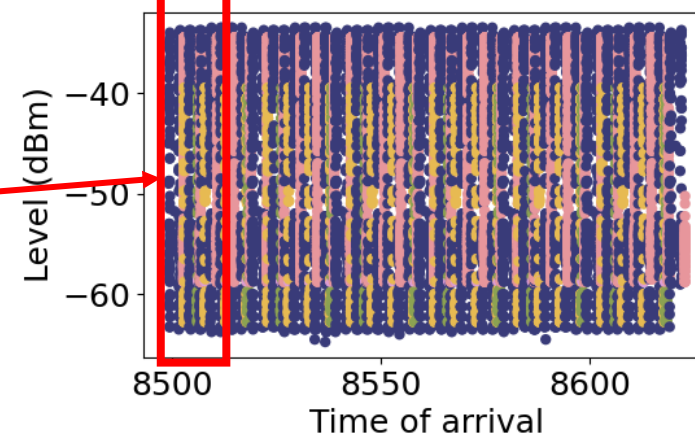
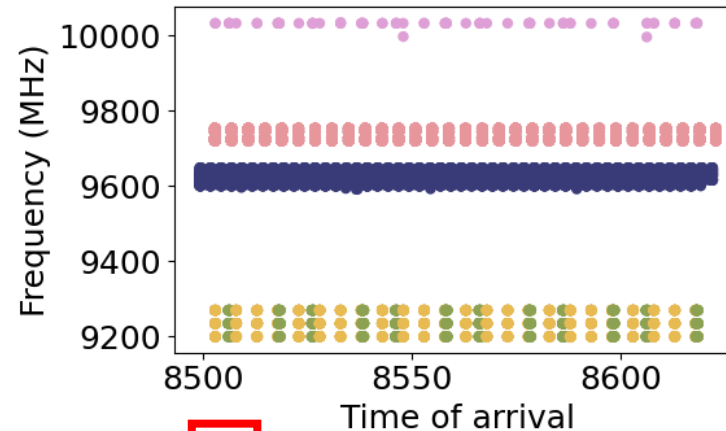
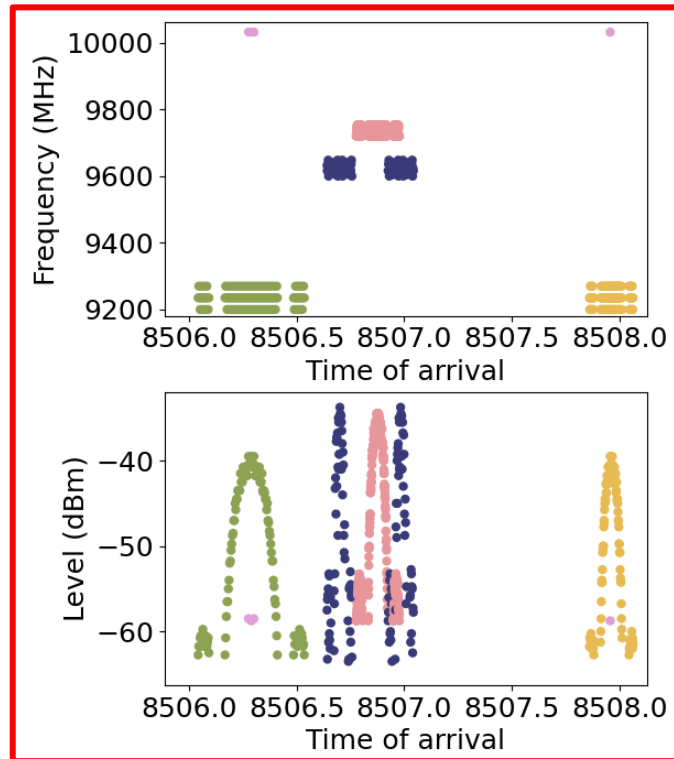


Group 1: Frequency - Pulse Width

Deinterleaving RADAR pulses

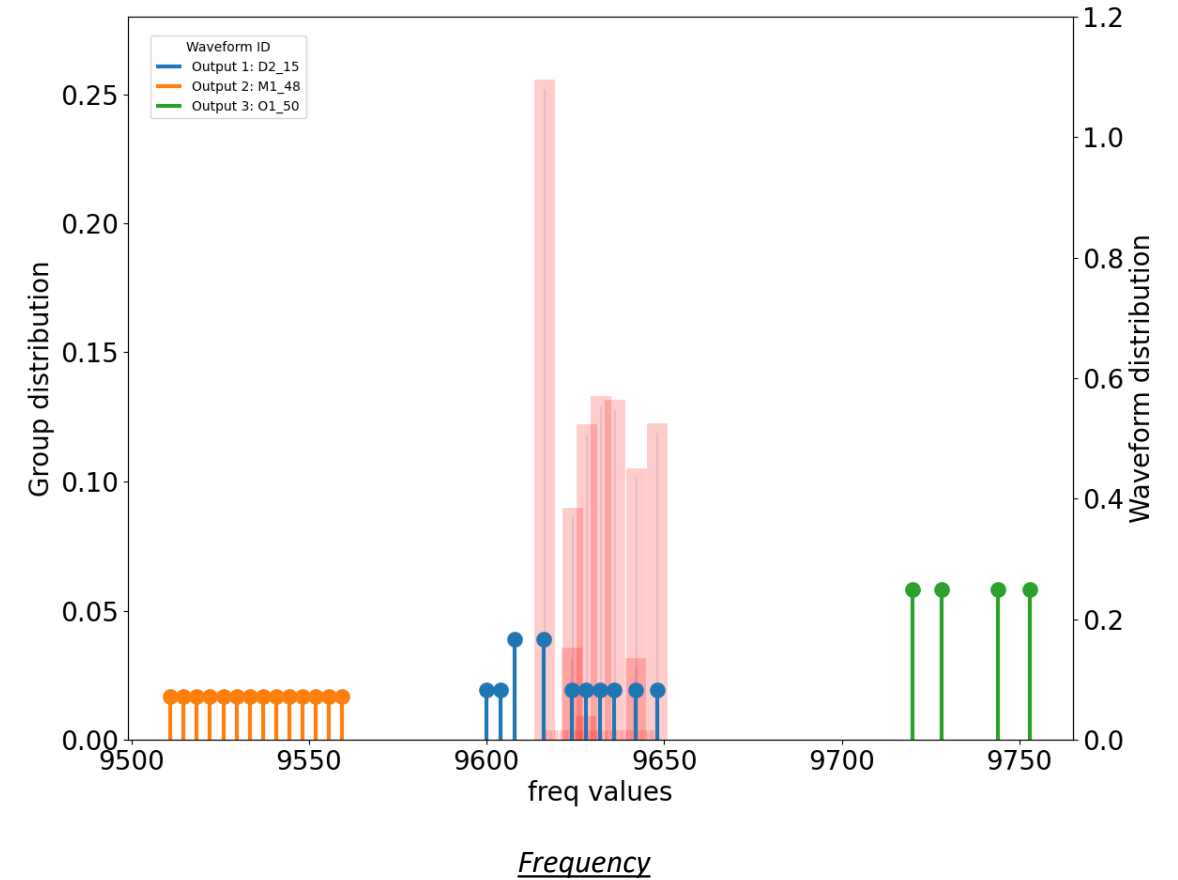
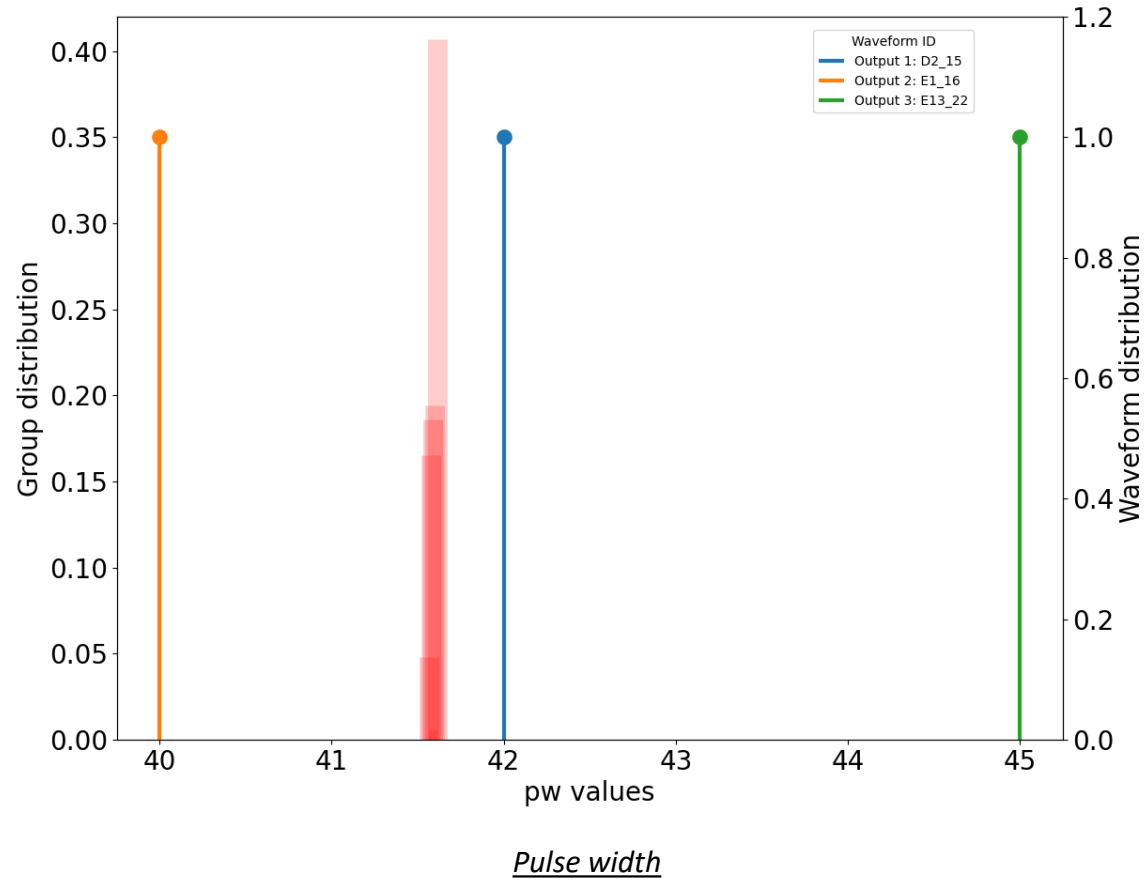
More extended signal

- There is a frequency error on group 4 due to the change of scan band (> 100 MHz on the frequency)



RADAR Classification

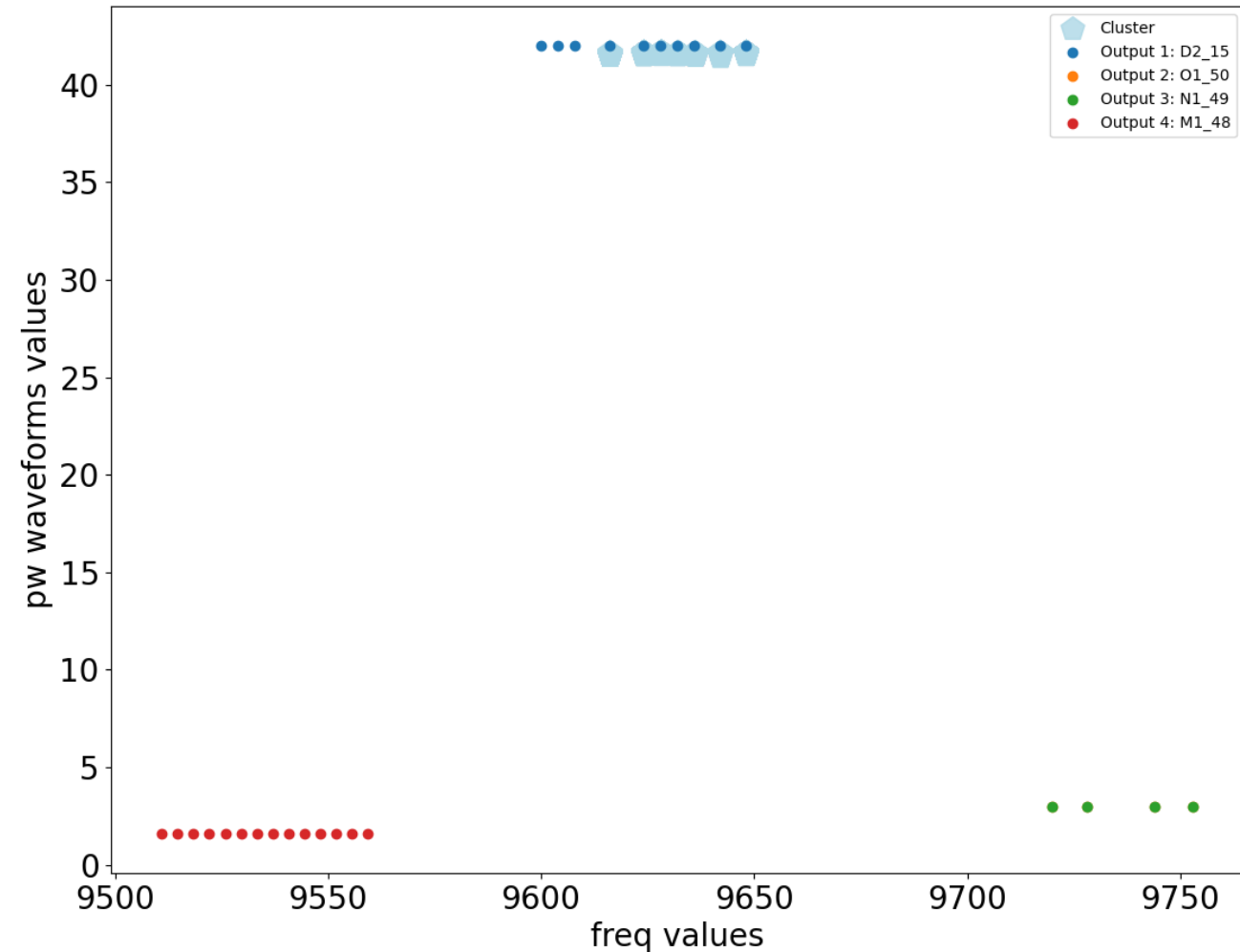
Classification output in 1D – Group 2



RADAR Classification

Classification output in 2D – Group 2

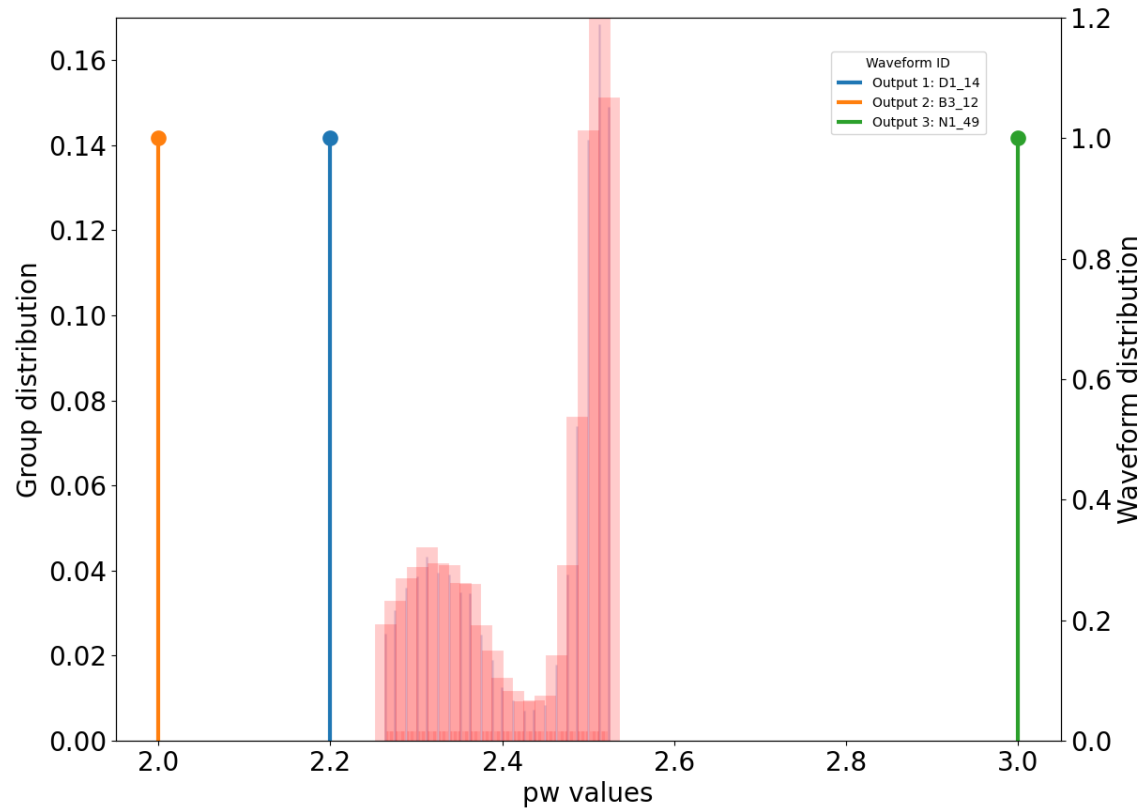
- Correct identification
- The transmitter O1 and N1 are indissociable because they have an identical Frequency and Pulse Width, so the waveforms have their distribution overlapped.



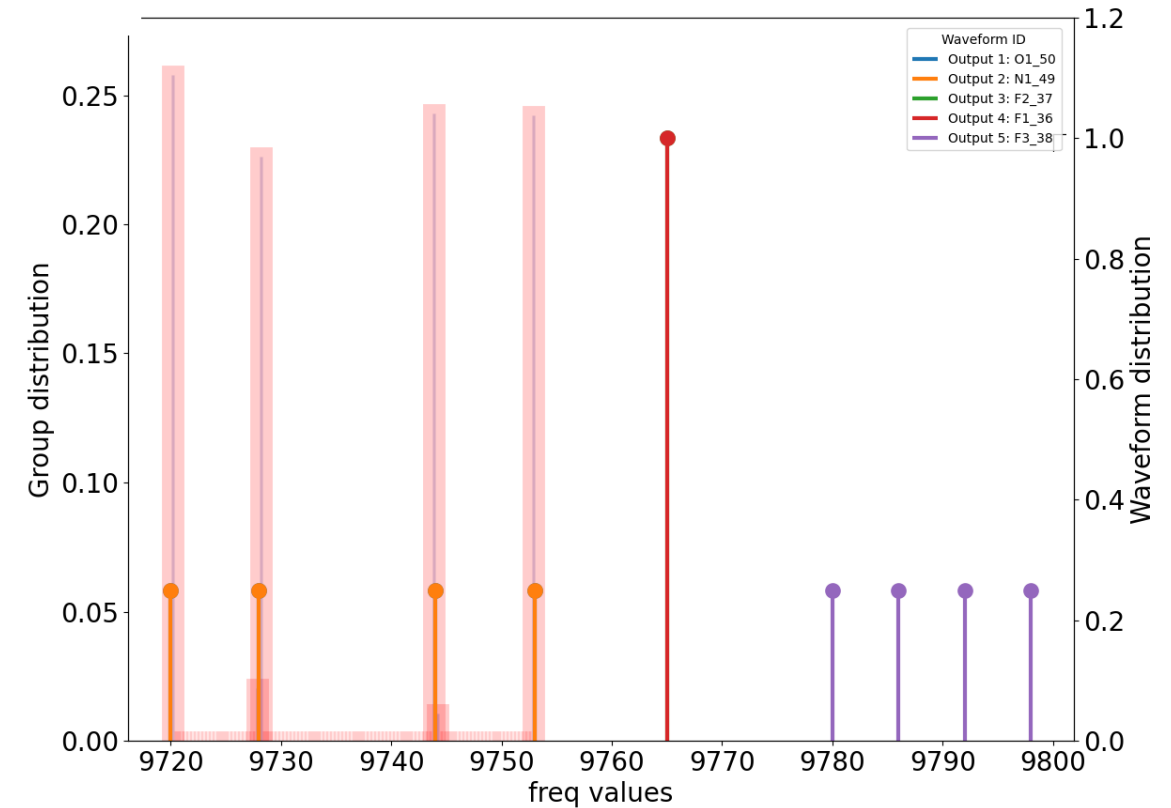
RADAR Classification

Classification output in 1D – Group 3

Pulse width



Frequency

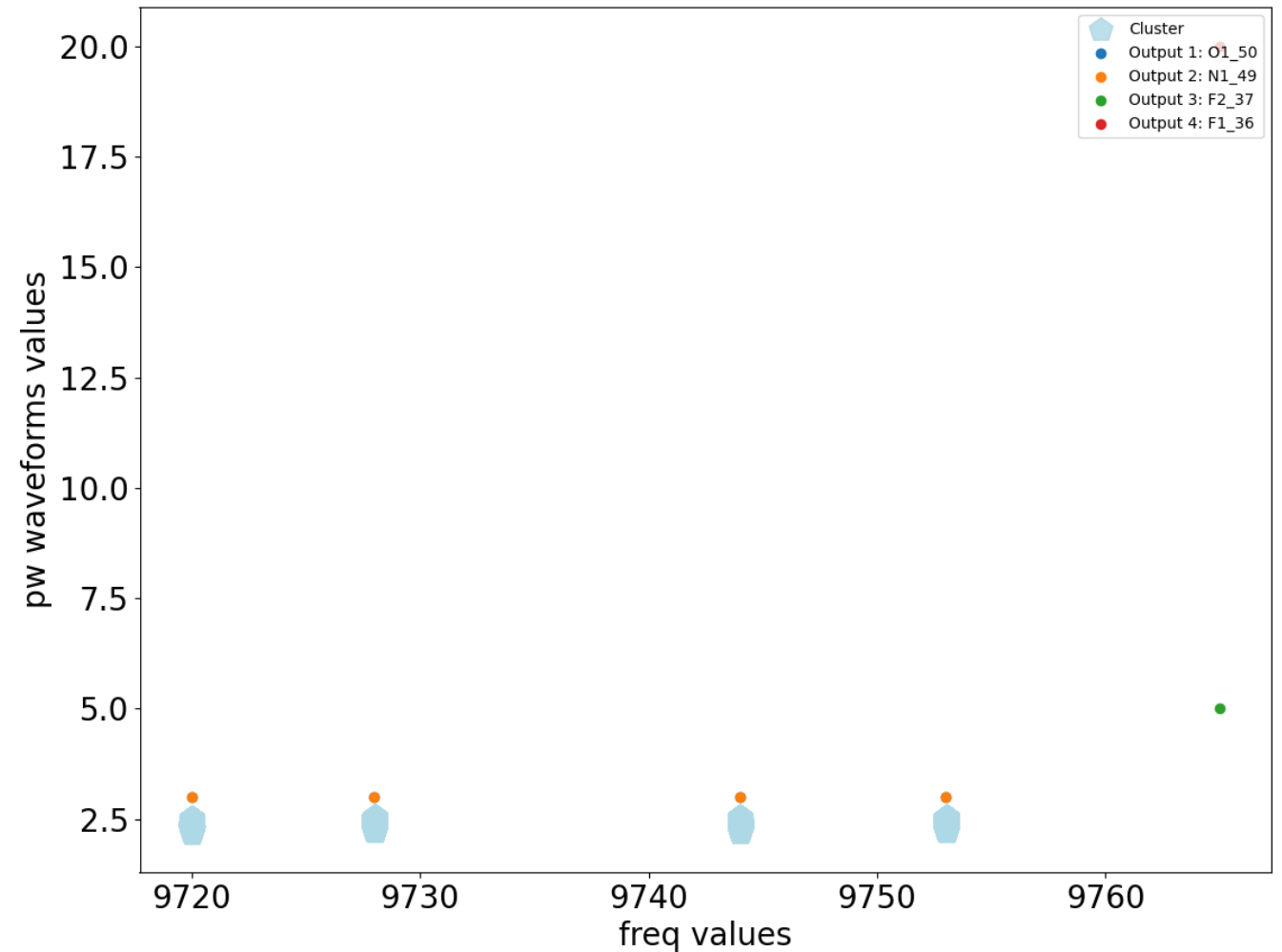


- O1 and N1 have same frequency bands so the waveforms have their distribution overlapped.

RADAR Classification

Classification output in 2D – Group 3

- Correct result but impossibility to dissociate some transmitters because they have same characteristics:
 - O1 and N1



Content

1. Waveform overview

2. Dataset 1

3. Dataset 2

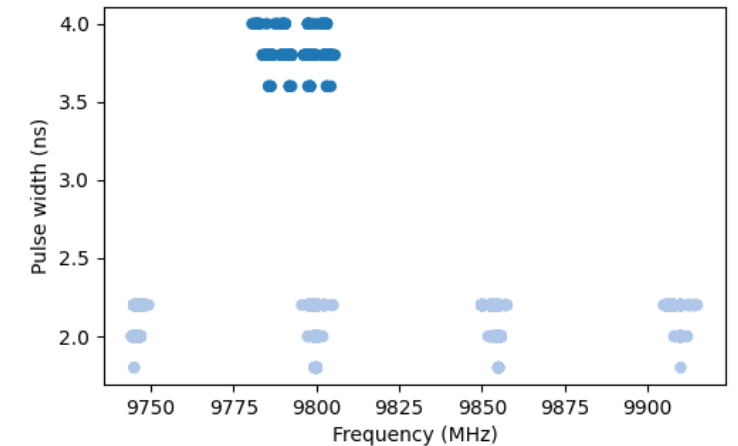
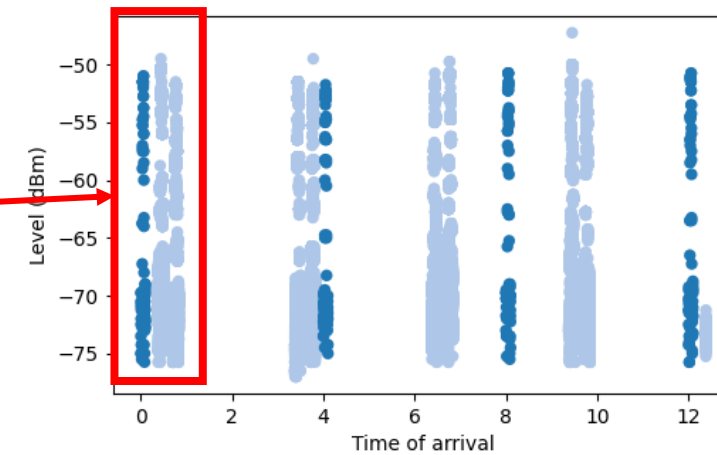
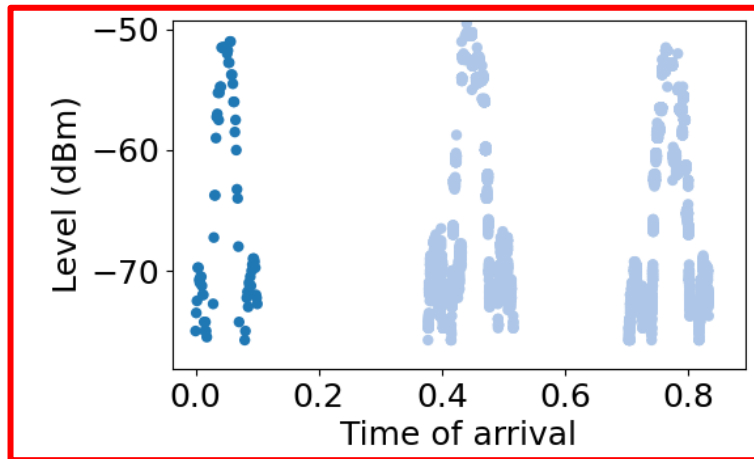
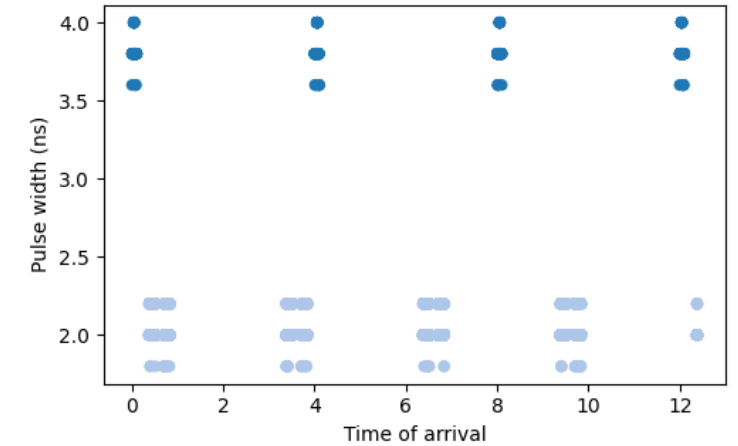
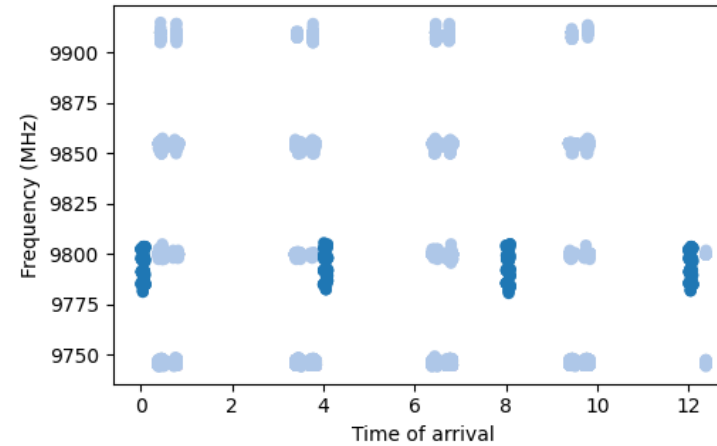
4. Dataset 3

5. Global results

Deinterleaving RADAR pulses

True Label

Group	RADAR Label
0	B3
1	F3



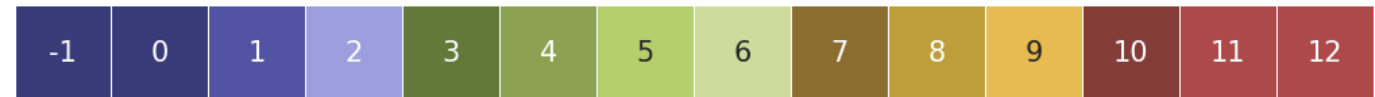
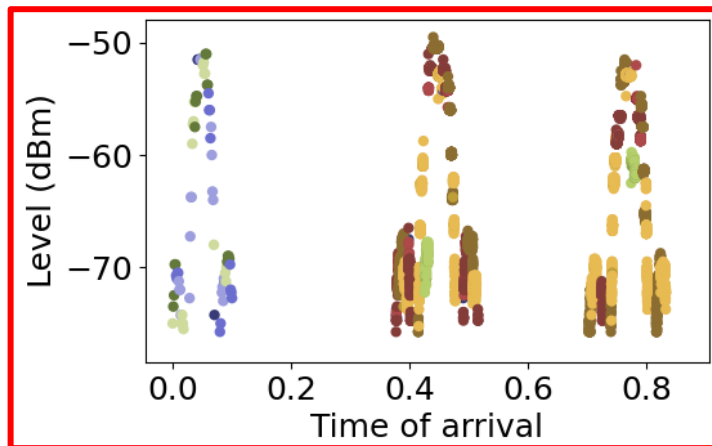
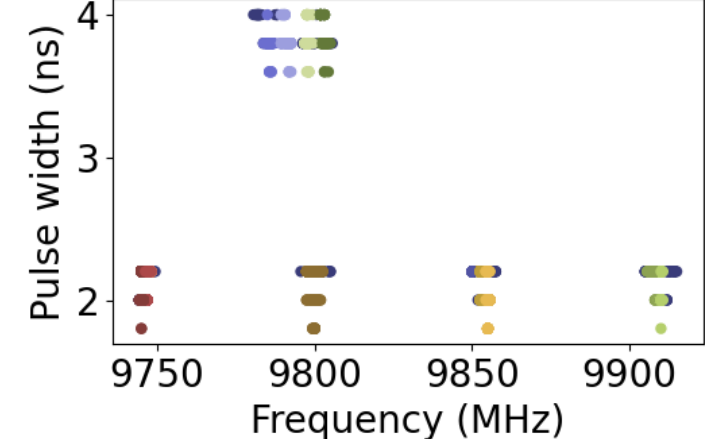
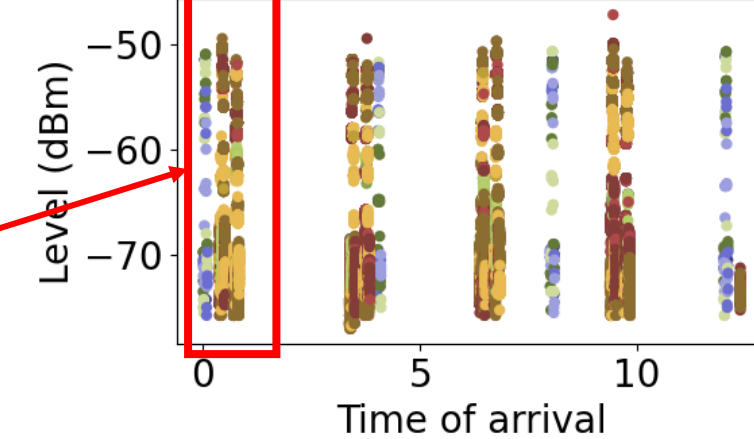
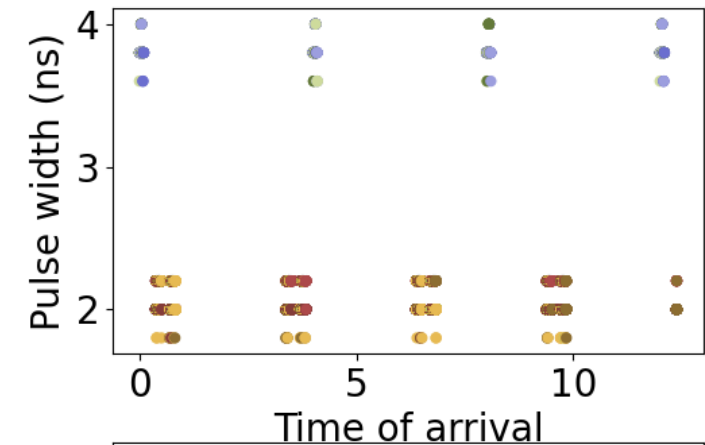
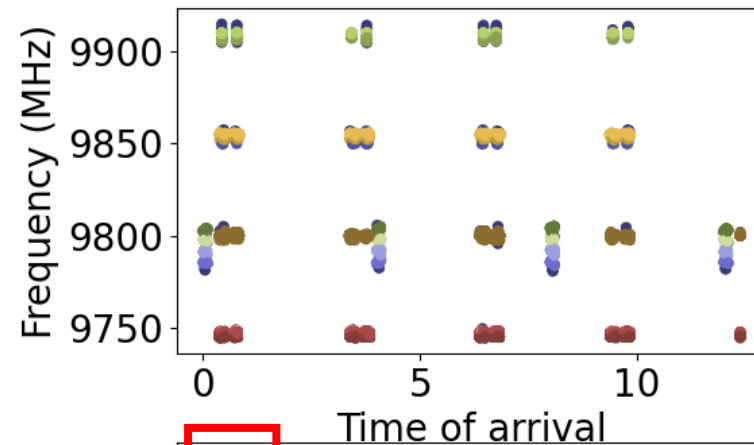
0

1

Deinterleaving RADAR pulses

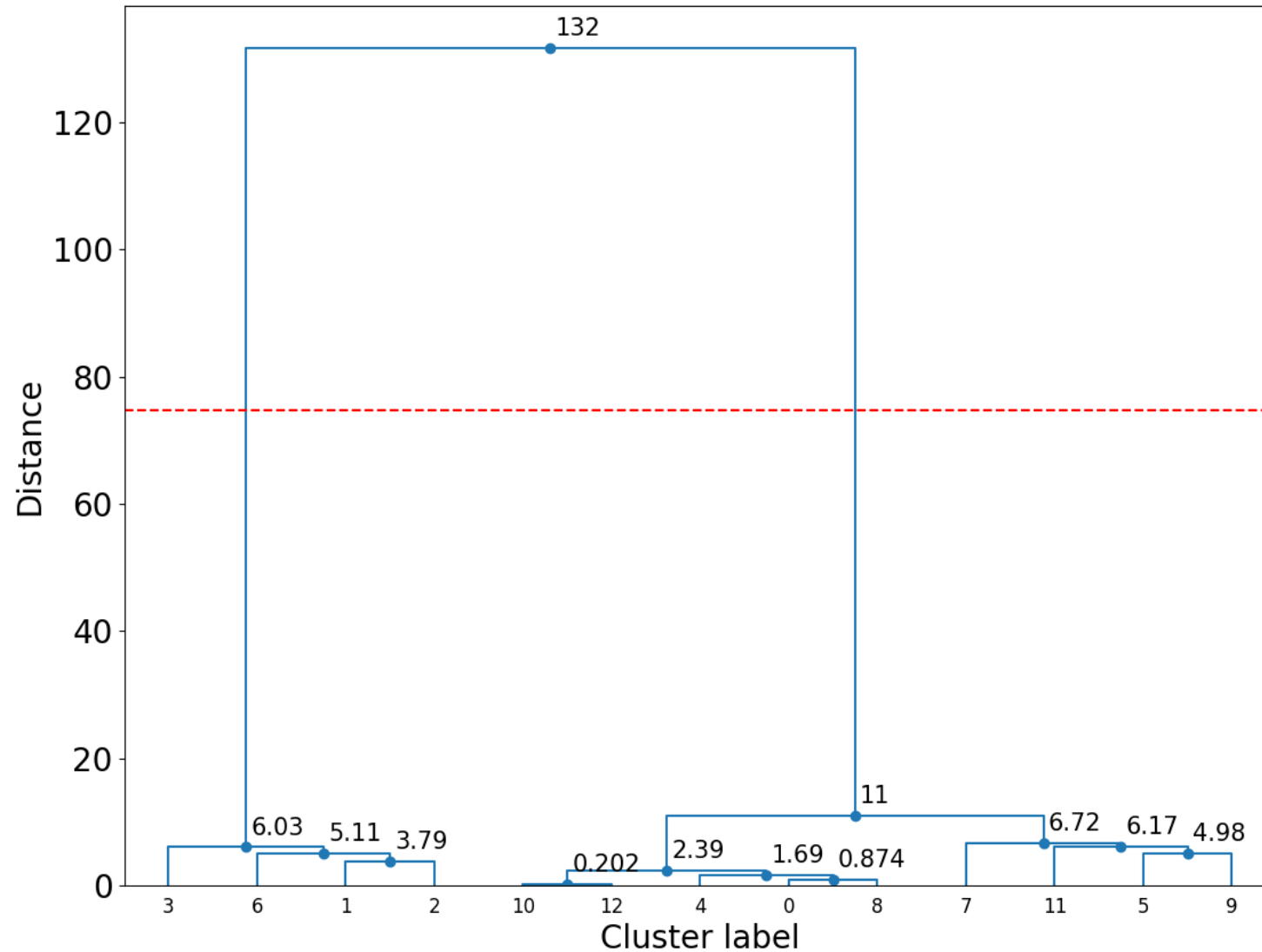
Clustering Pulses in 2D (Frequency x Pulse Width)

Group	Pulses	%	Group	Pulses	%
-1	315	1,6%	7	6135	30,7%
0	26	0,1%	8	179	0,9%
1	51	0,3%	9	6024	30,1%
2	72	0,4%	10	22	0,1%
3	66	0,3%	11	4620	23,1%
4	236	1,2%	12	1508	7,5%
5	682	3,4%	Total	19 999	
6	63	0,3%			



Deinterleaving RADAR pulses

Dendrogram

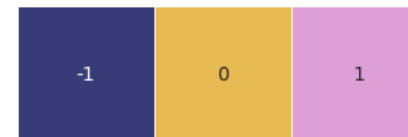
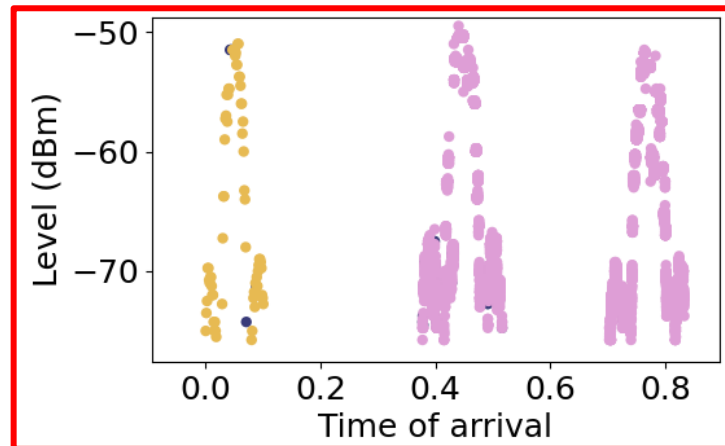
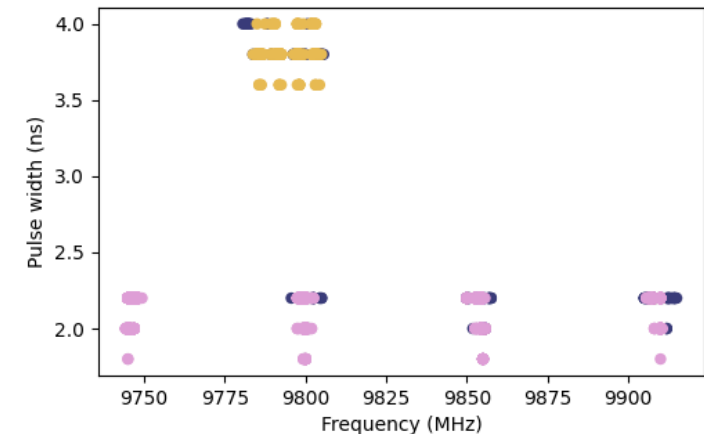
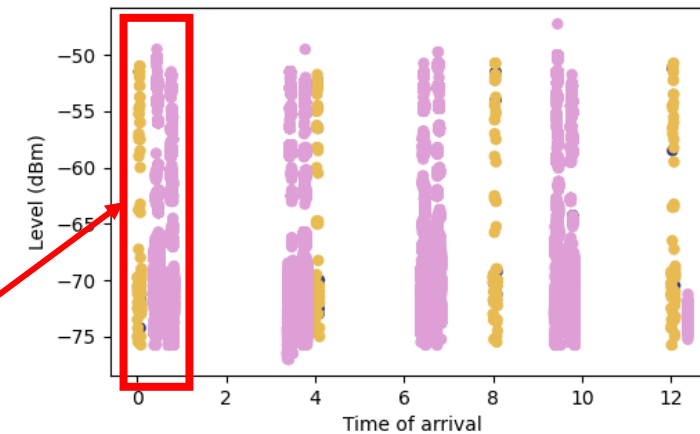
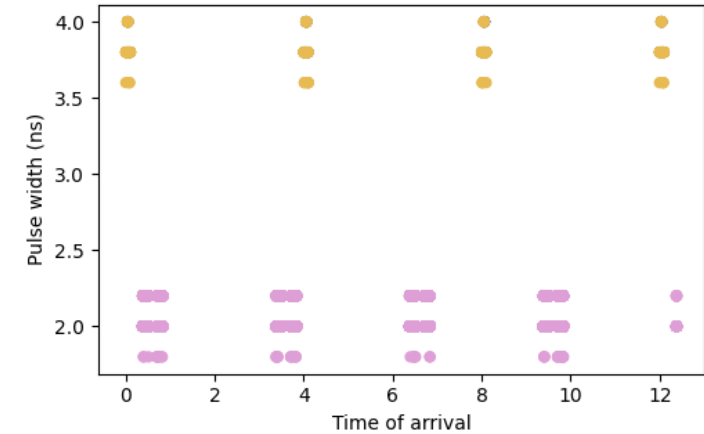
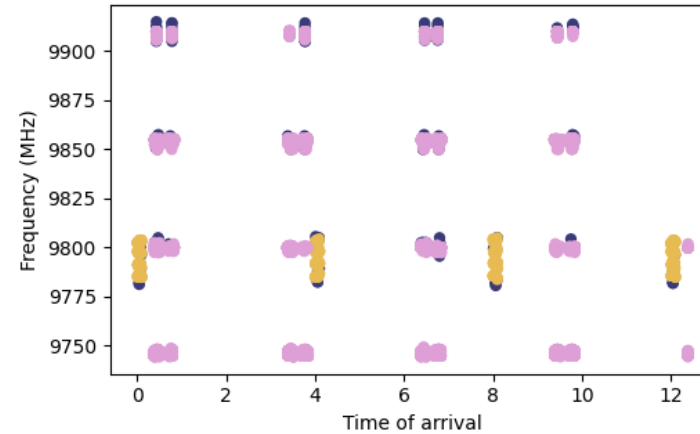


Deinterleaving RADAR pulses

Grouping Pulses in 2D

Statistic	Value
Pulses	19 999
Completeness	1
Homogeneity	1
Outliers	1,6%

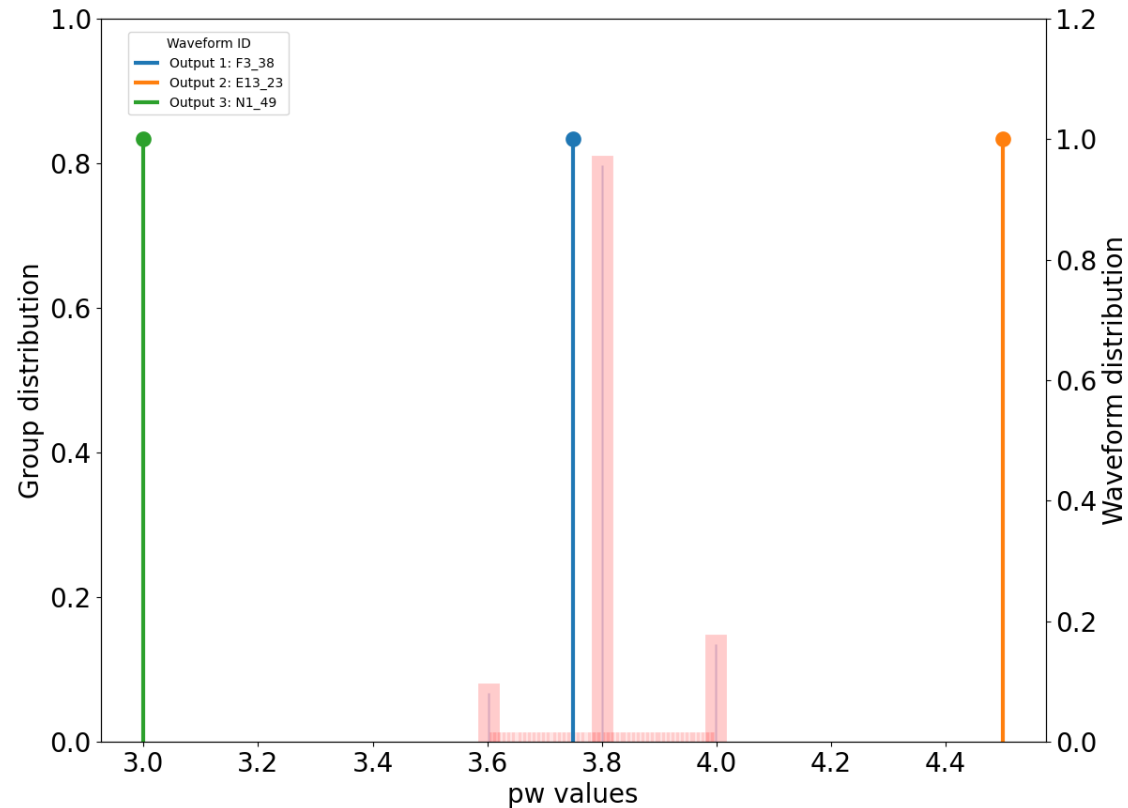
Group	Pulses
-1	315
0	252
1	19 432



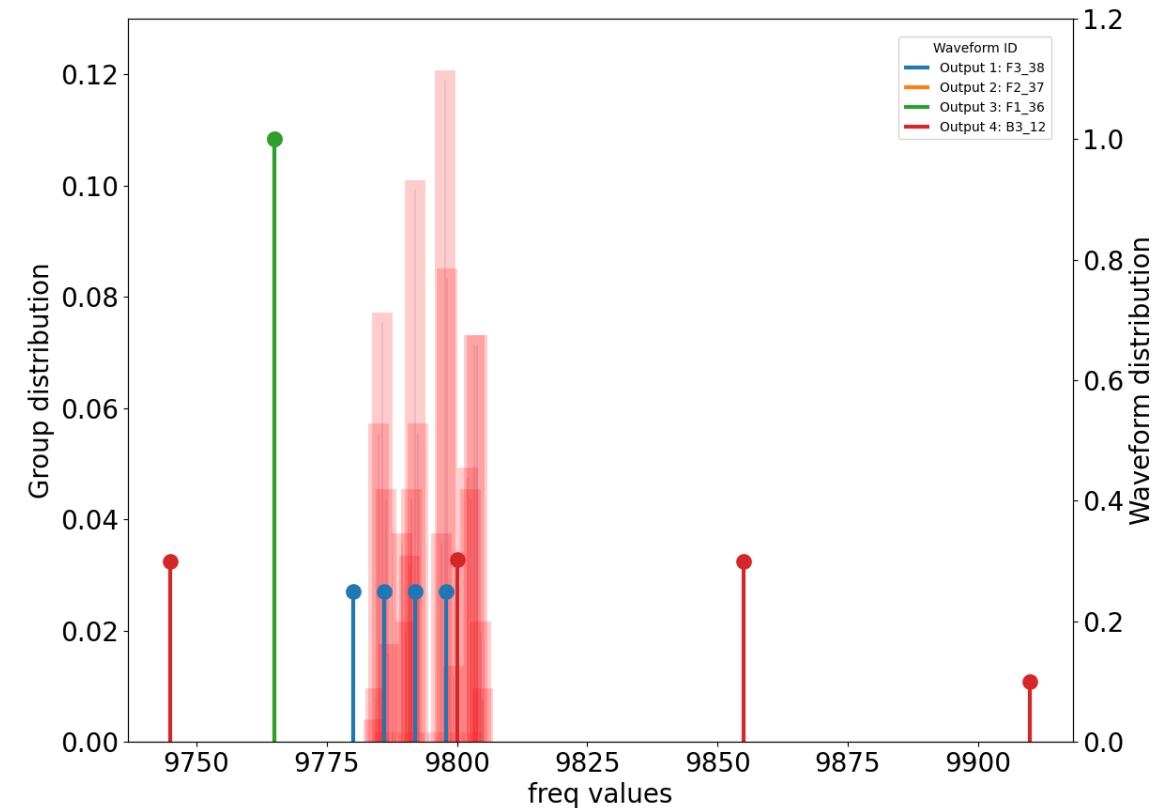
RADAR Classification

Classification output in 1D – Group 0

Pulse width



Frequency

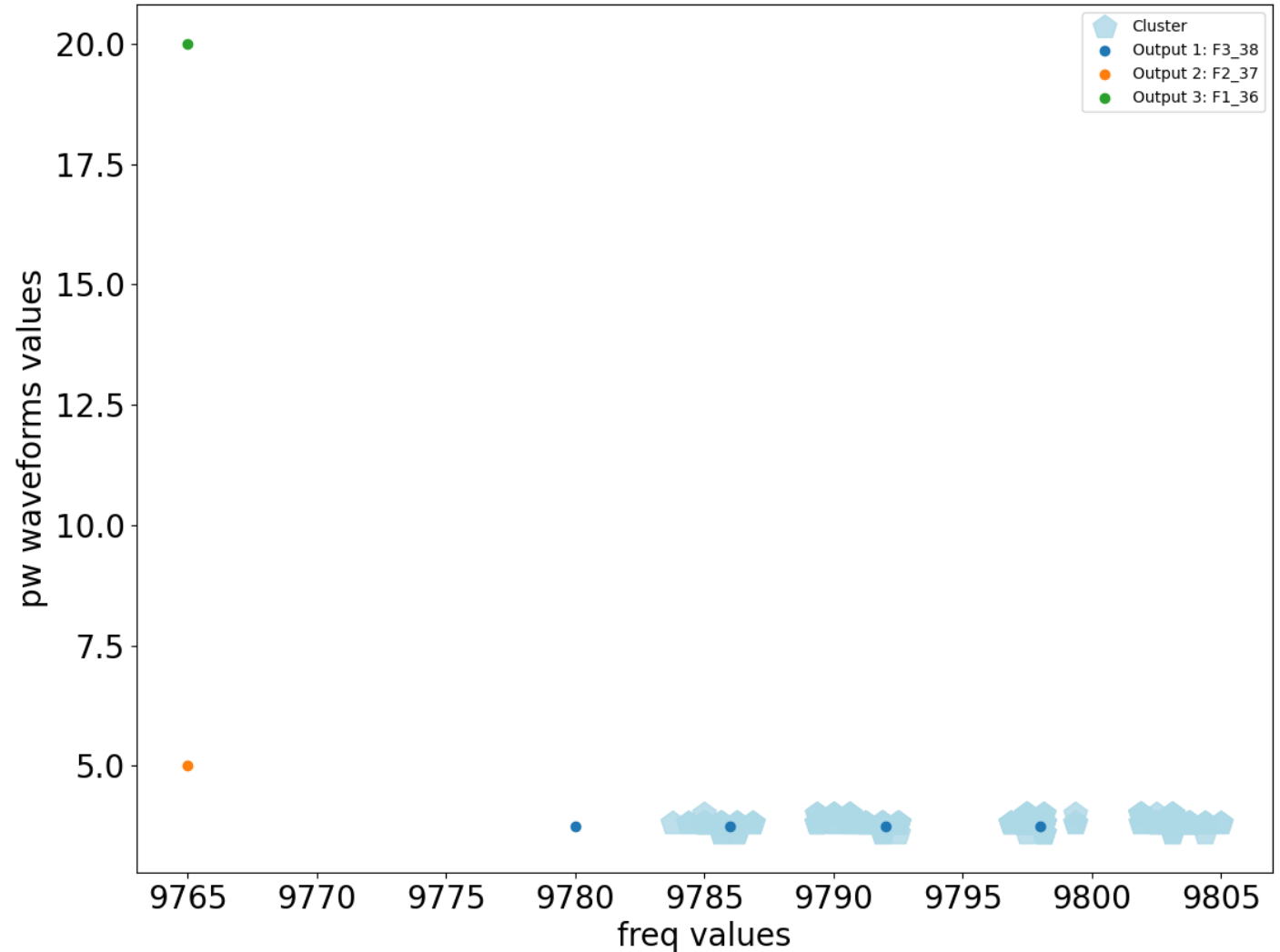


- F1 and F2 have same frequency bands so they have their distribution overlapped.

RADAR Classification

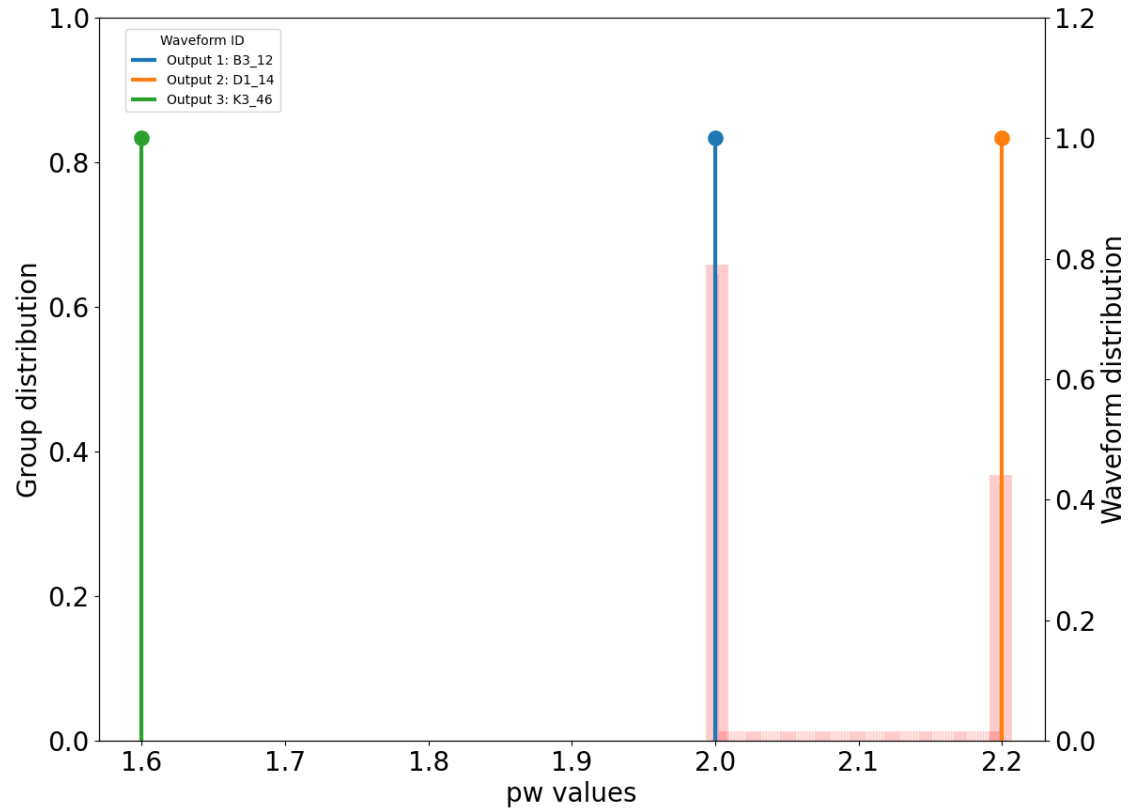
Classification output in 2D – Group 0

- Frequency - Pulse Width representation
- Frequency shift
 - Error in the classification database? Wrong description ?
 - Measurement error ?
- Result correct

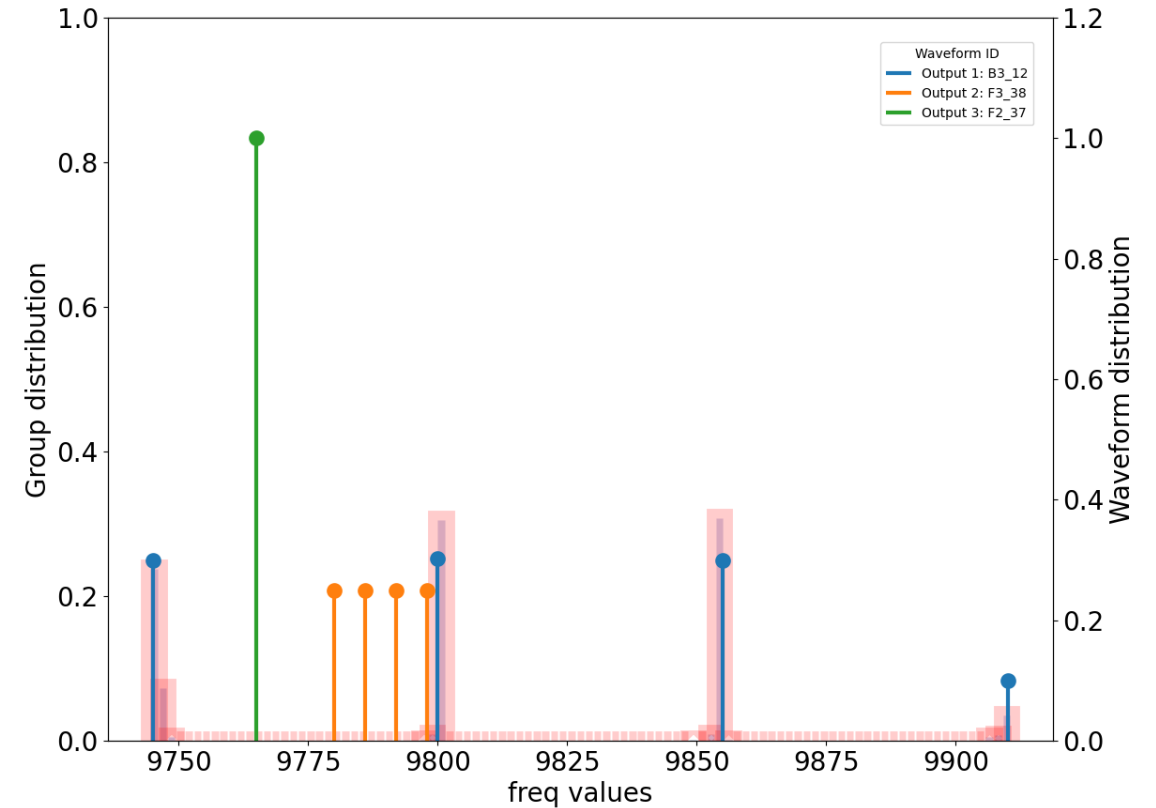


RADAR Classification

Classification output in 1D – Group 1



Pulse width

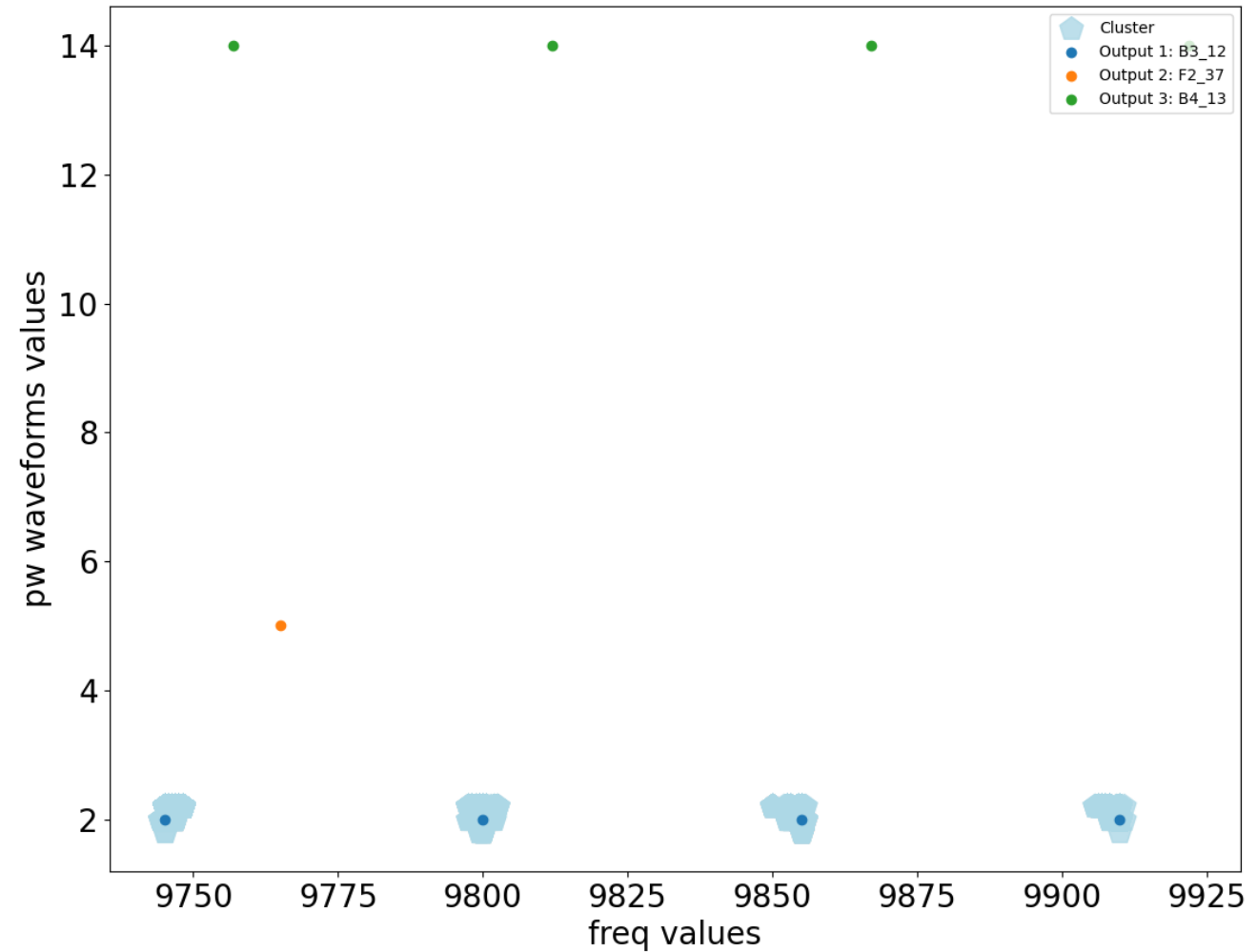


Frequency

RADAR Classification

Classification output in 2D – Group 1

- Frequency - Pulse Width representation
- Result correct

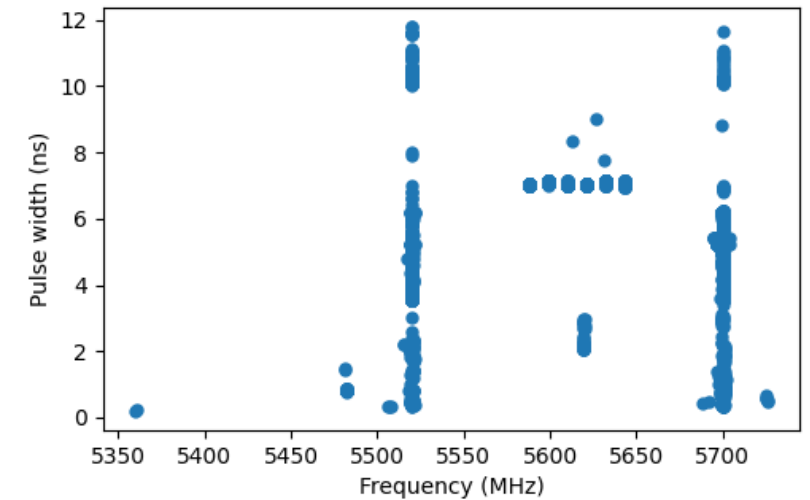
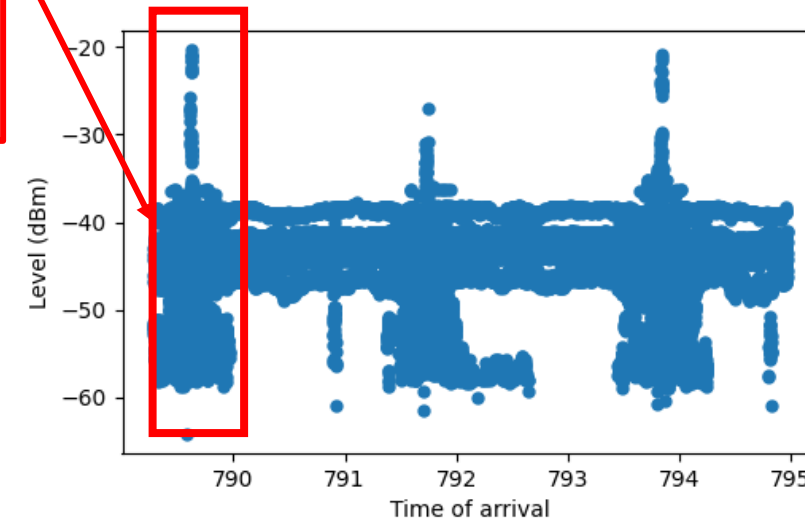
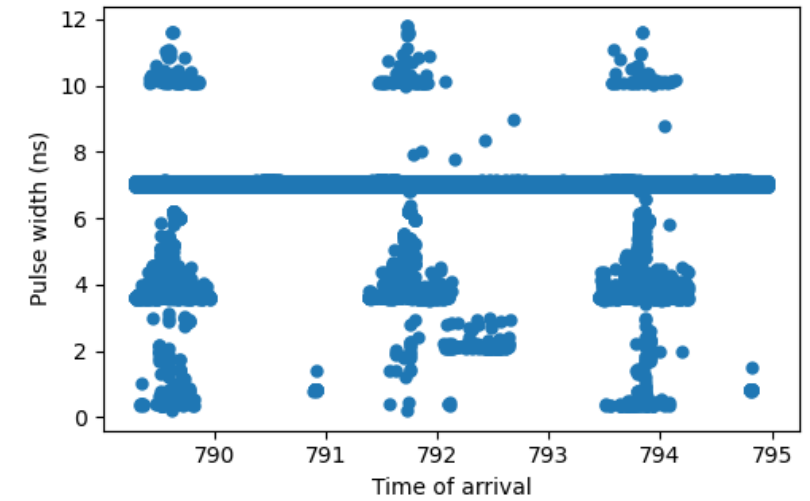
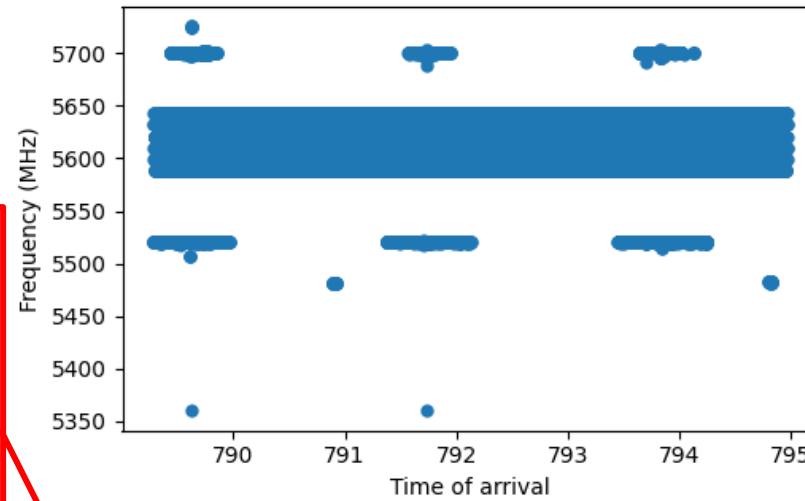
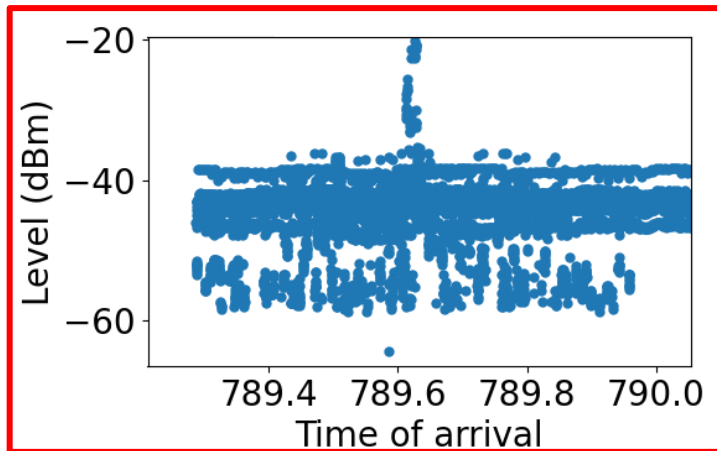


Content

1. Waveform overview
2. Dataset 1
3. Dataset 2
4. **Dataset 3**
5. Global results

Deinterleaving RADAR pulses

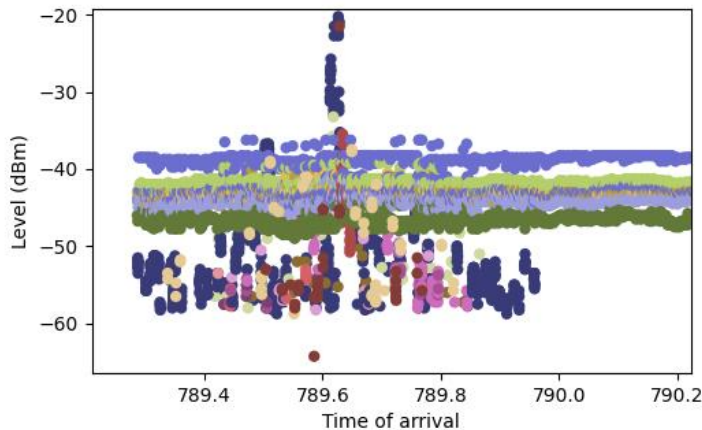
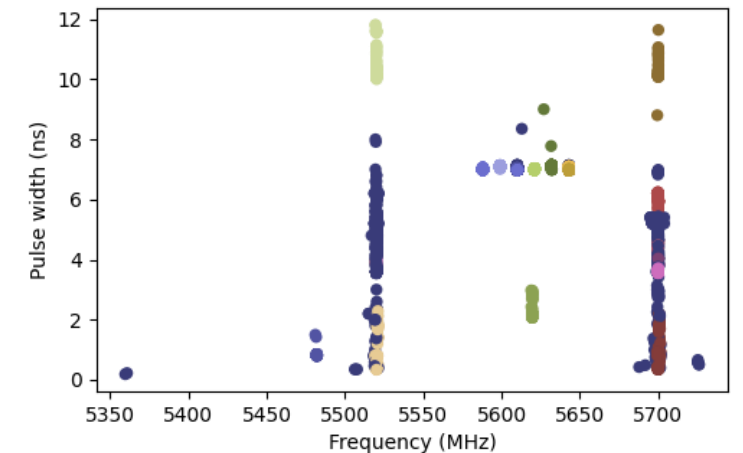
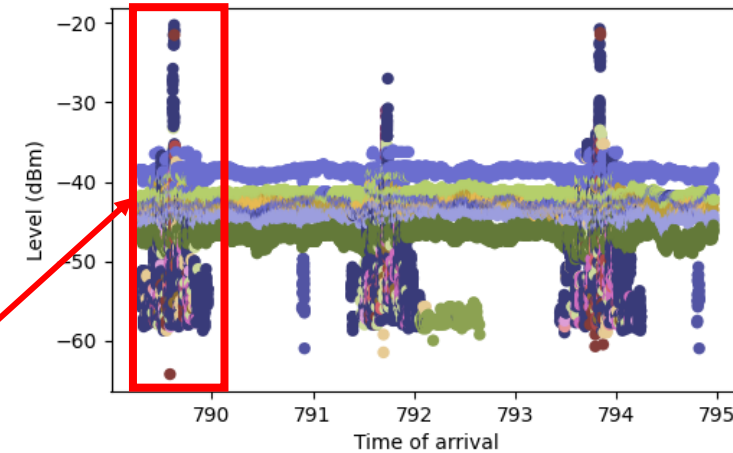
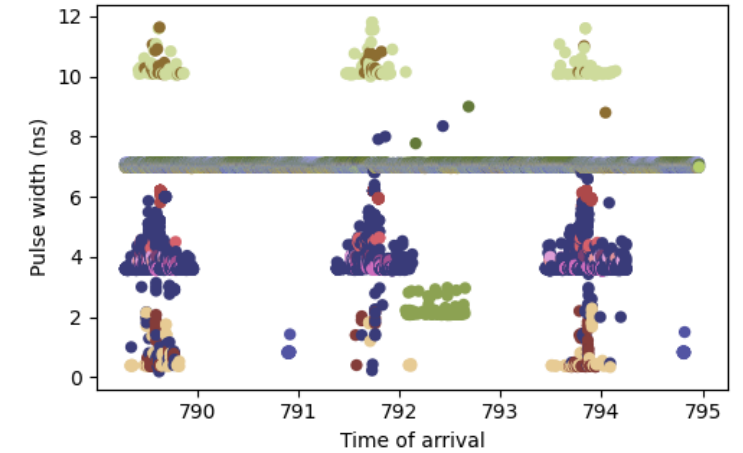
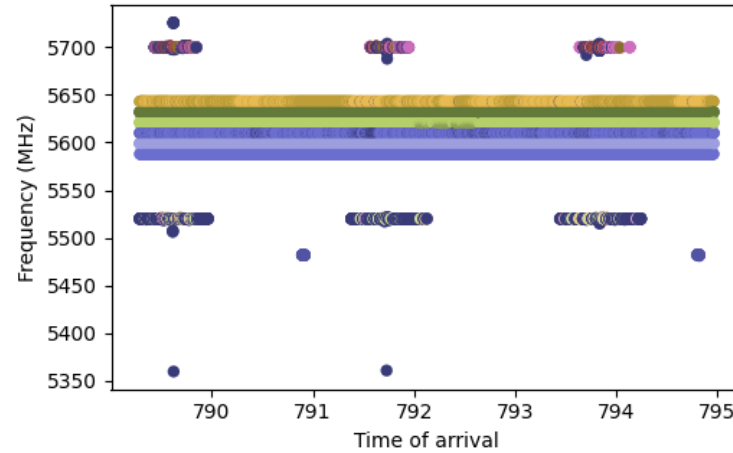
Unlabeled pulses



Deinterleaving RADAR pulses

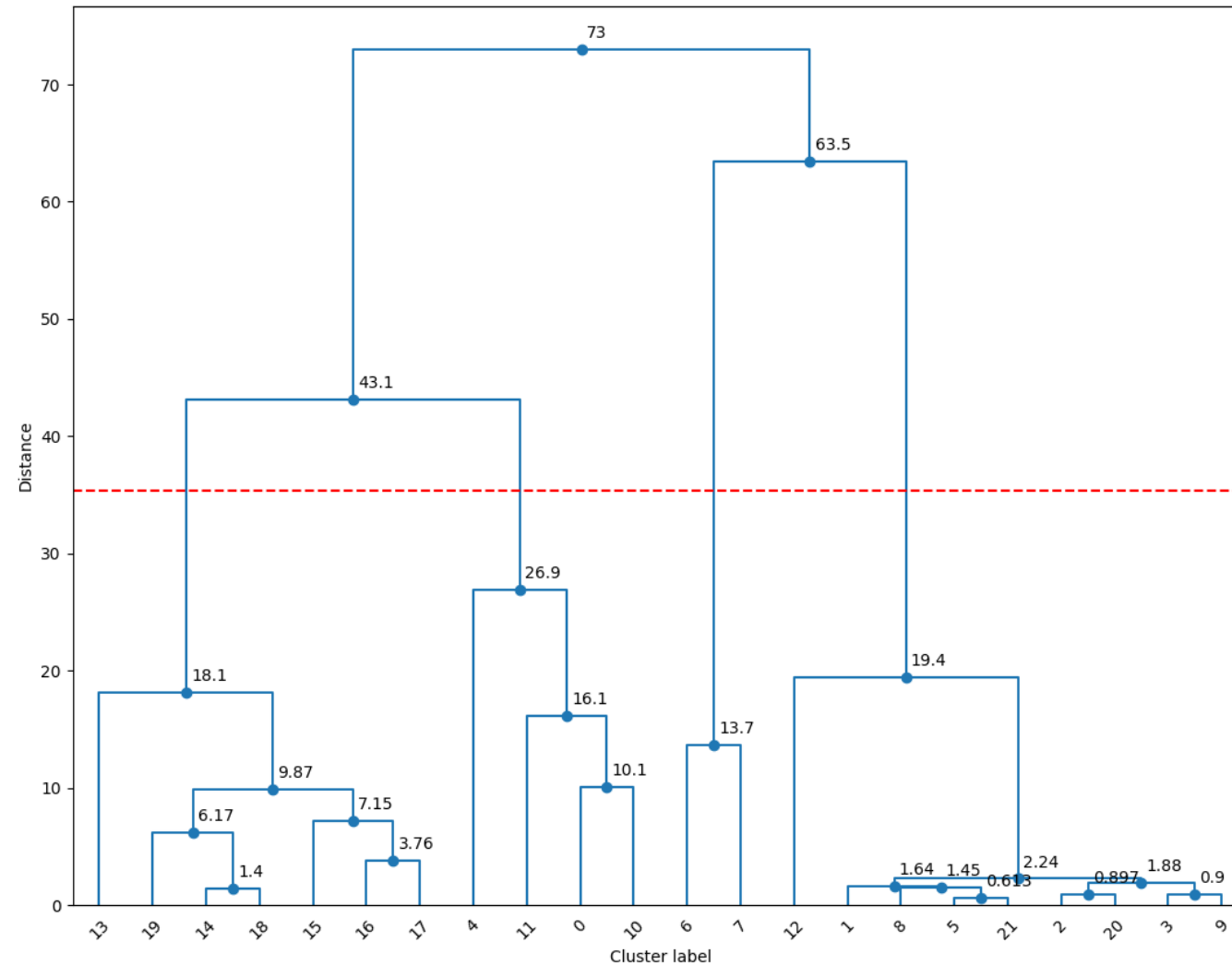
Clustering Pulses in 2D (Frequency x Pulse Width)

Group	Pulses	%		Group	Pulses	%
-1	1 196	5,0%		11	74	0,3%
0	57	0,2%		12	89	0,4%
1	2 027	8,5%		13	49	0,2%
2	4 055	17,0%		14	21	0,1%
3	4 055	17,0%		15	33	0,1%
4	200	0,8%		16	44	0,2%
5	4 055	17,0%		17	298	1,2%
6	135	0,6%		18	66	0,3%
7	36	0,2%		19	1 613	6,8%
8	940	3,9%		20	64	0,3%
9	1 073	4,5%		21	3 554	14,9%
10	109	0,5%		Total	23 843	



Deinterleaving RADAR pulses

Dendrogram

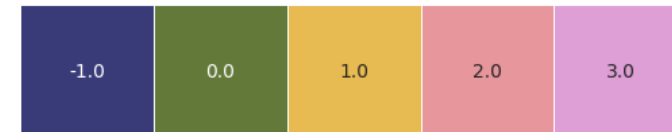
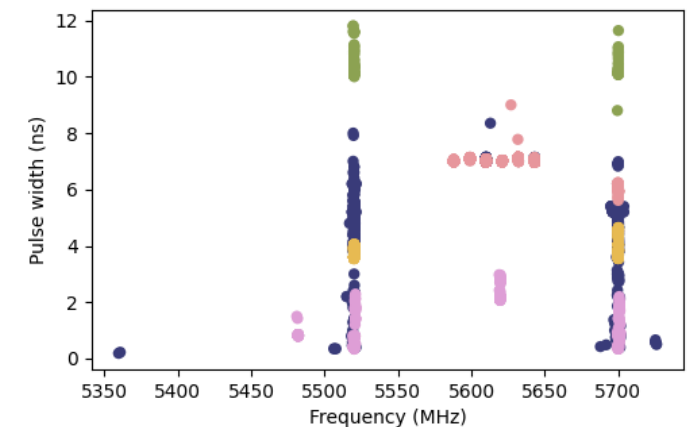
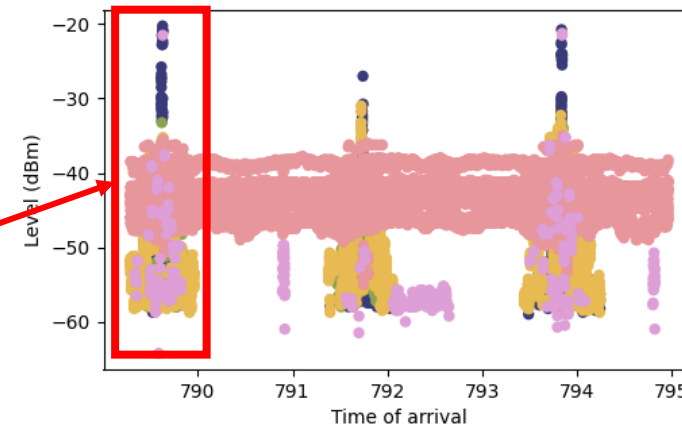
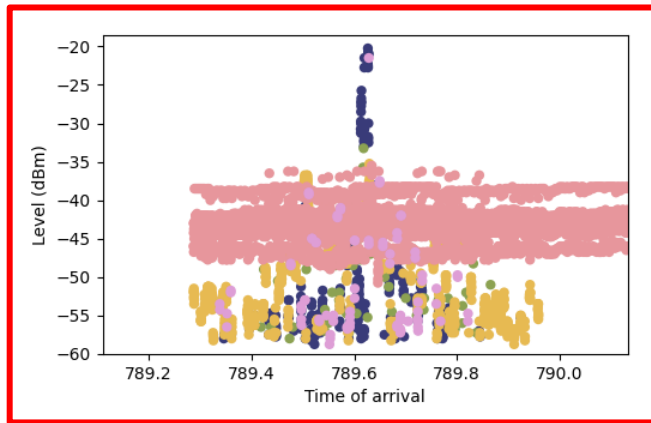
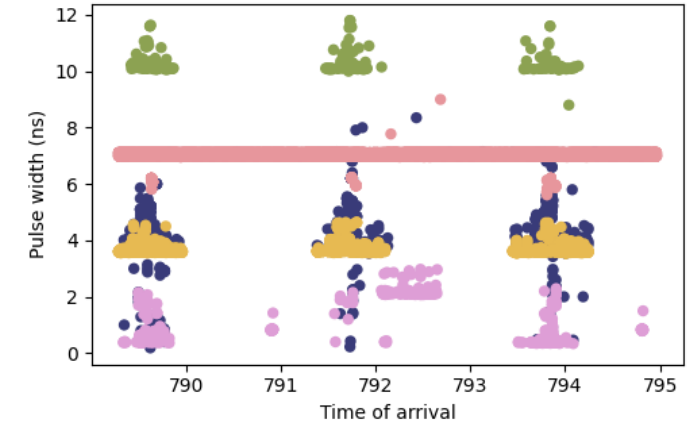
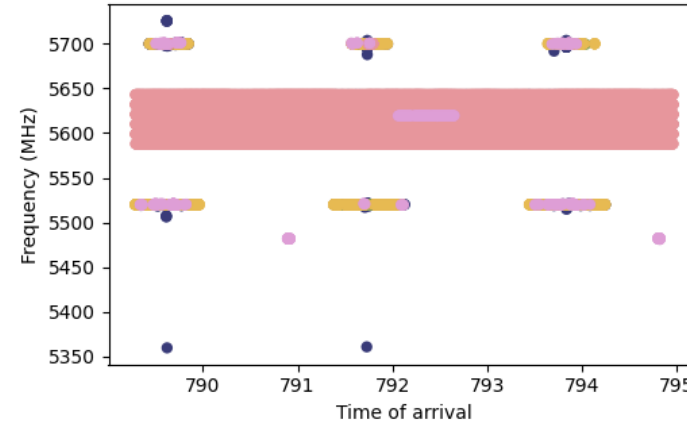


Deinterleaving RADAR pulses

Grouping Pulses in 2D

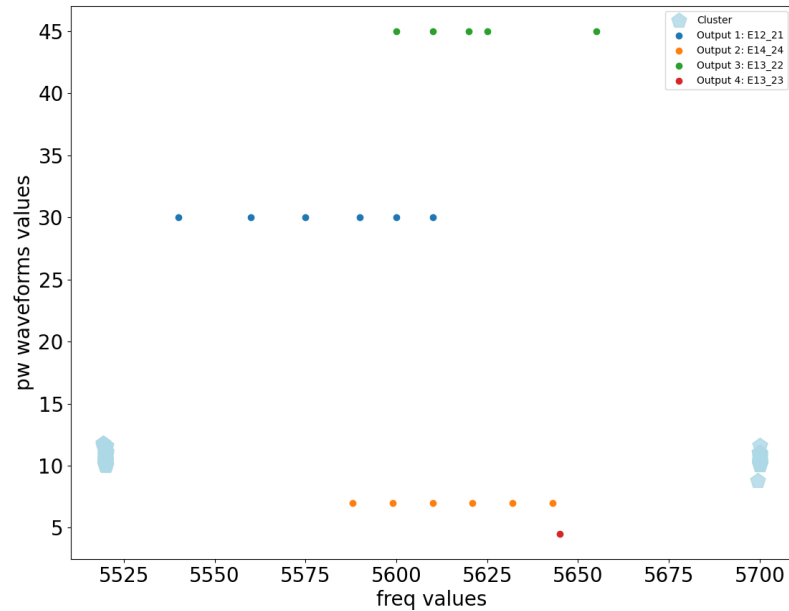
- Groups 0, 1, and 3 seem to belong to the same transmitter
- Wrong Pulse width?

Group	Pulses
-1	1 196
0	171
1	2 124
2	19 912
3	440

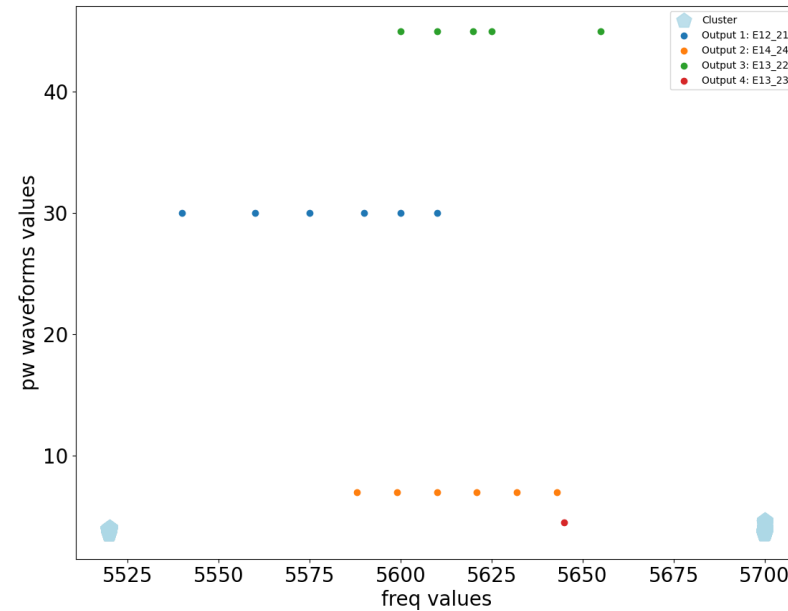


RADAR Classification

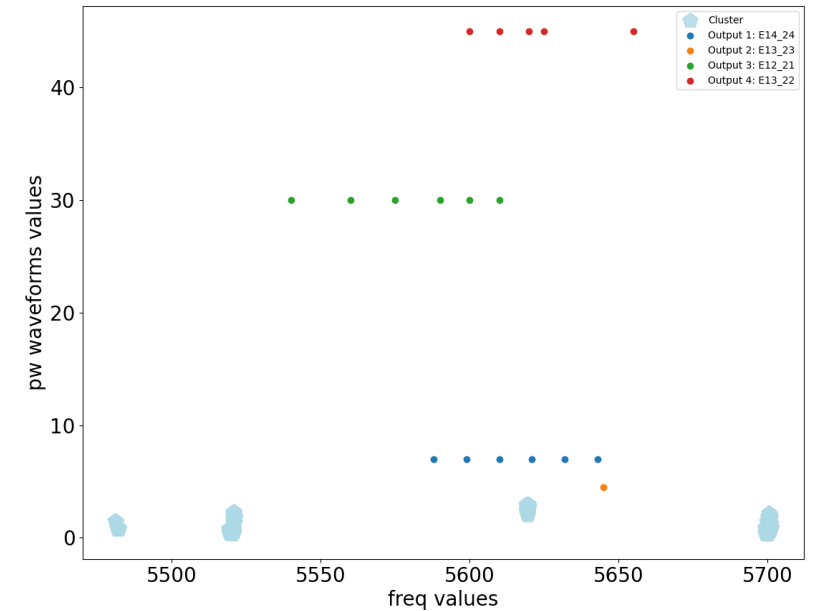
Classification output in 2D – Group 0, 1, 3



Group 0



Group 1



Group 3

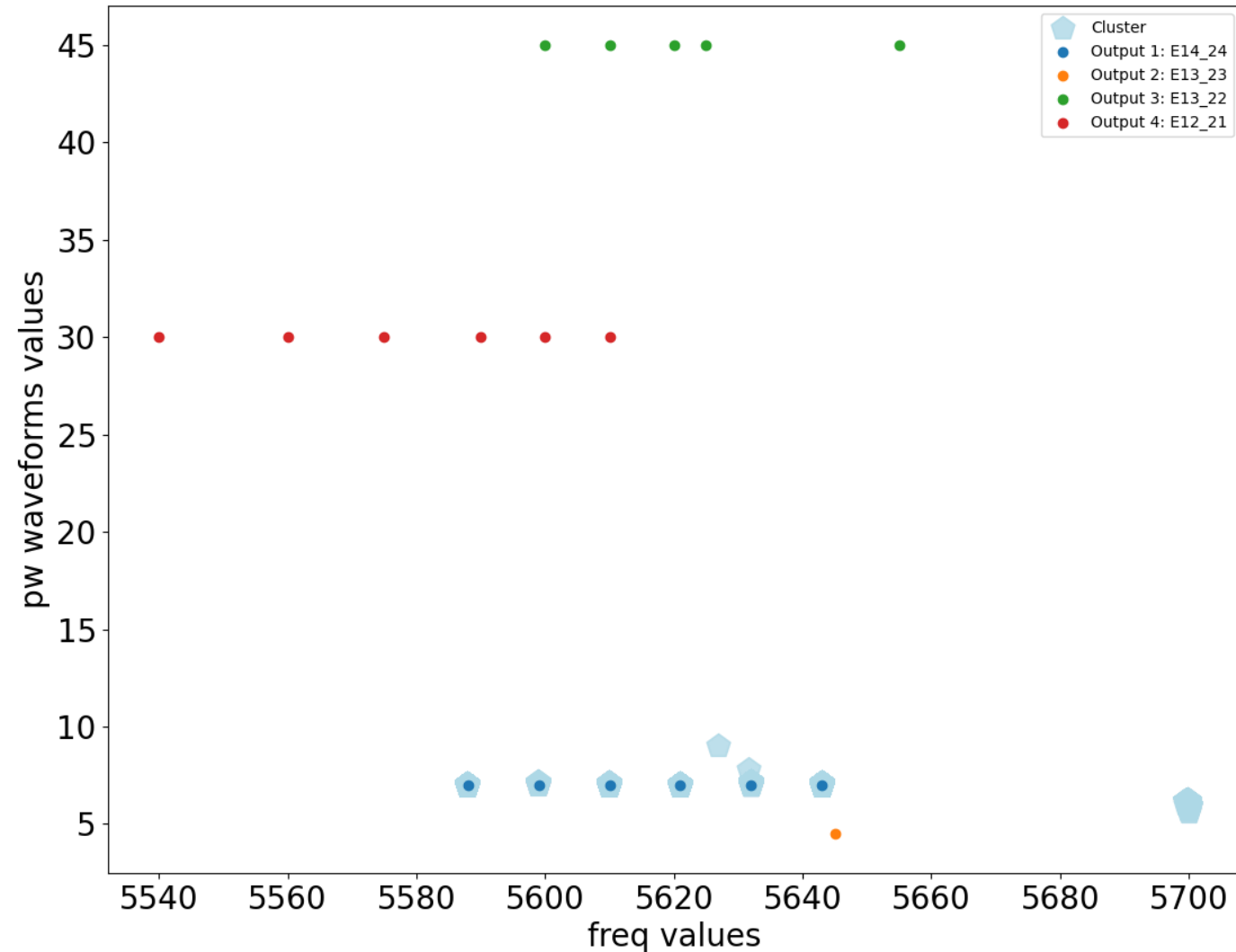
➤ The results are not very robust.

➤ New emitter ?

RADAR Classification

Classification output in 2D – Group 2

- There seems to be a mixture of pulses around 5700 MHz



Content

1. Waveform overview

2. Dataset 1

3. Dataset 2

4. Dataset 3

5. **Global results**

RADAR Classification

Global results on real transmitter

Classification position	Number of transmitters tested	%
First	74	70,5
Second	17	16,2
Three	4	3,8
More	10	9,5
Total	105	