Plasma Confinement Mode Classification Using a Sequence-to-Sequence Neural Network With Attention

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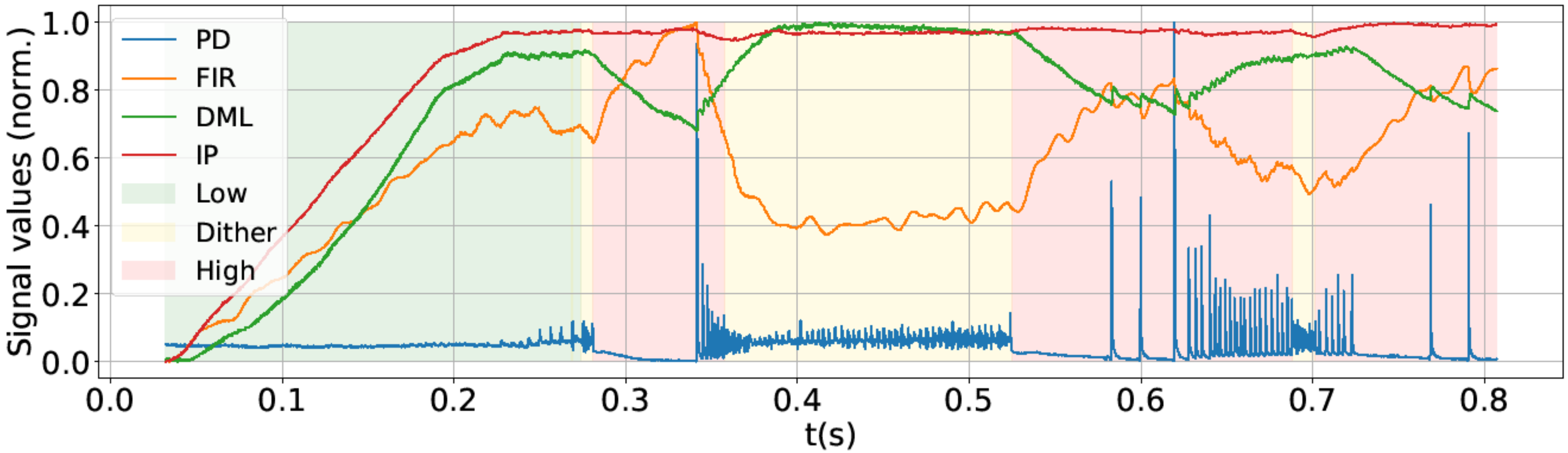
TU/e

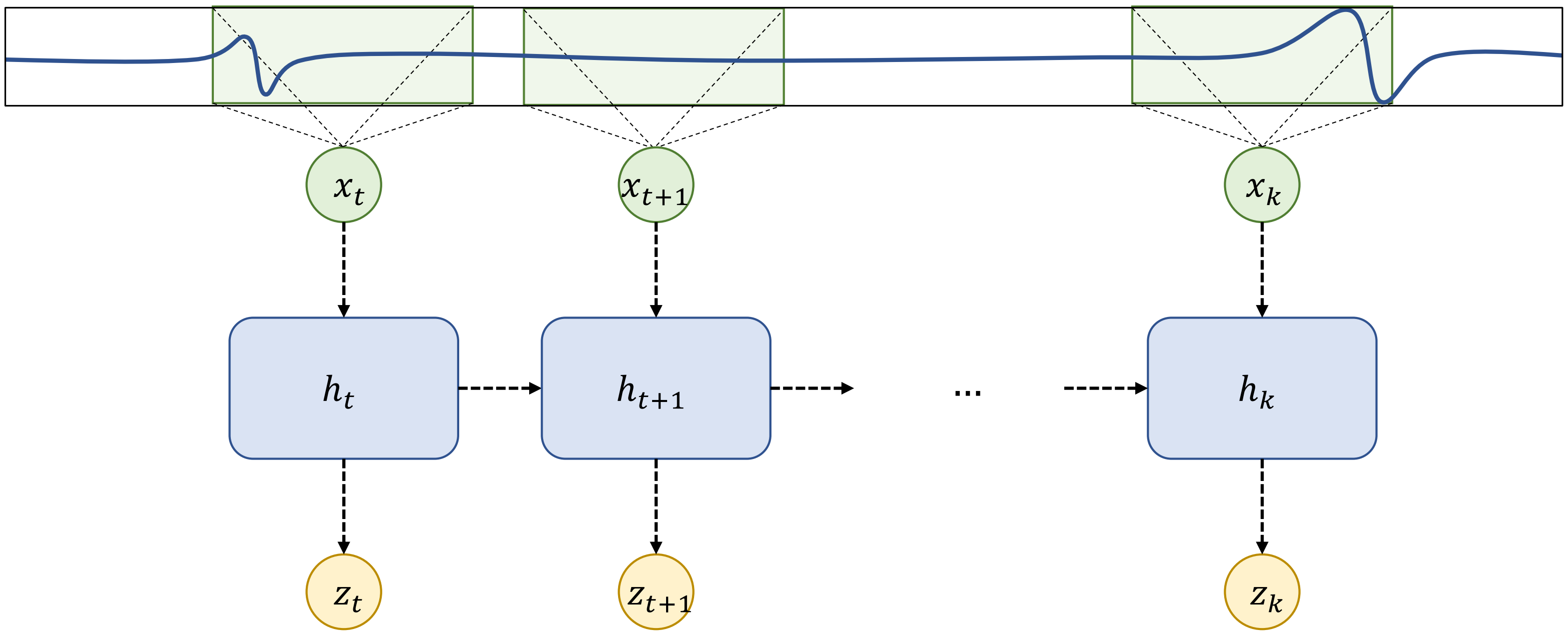
Dataset (signal data and timeseries)



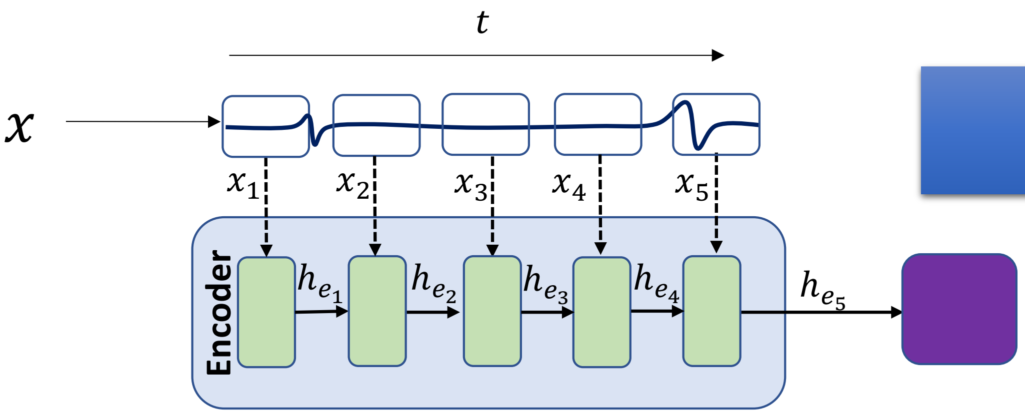
Modelling the problem – discriminative approach

- $\hat{\boldsymbol{z}}_{\mathbf{1}:N} = \boldsymbol{arg}\max_{\boldsymbol{z}_{\mathbf{1}:N}} \boldsymbol{p}(\boldsymbol{z}_{\mathbf{1}}, \boldsymbol{z}_{\mathbf{2}}, \dots, \ \boldsymbol{z}_{N} | \boldsymbol{x}_{\mathbf{0}:N})$
- **Use a discriminative model, based on convolutions and recurrent units**
- **Model is trained to find sample of high likelihood, probability of state *z* at time *t* depends only on past data**

Convolutional recurrent neural networks



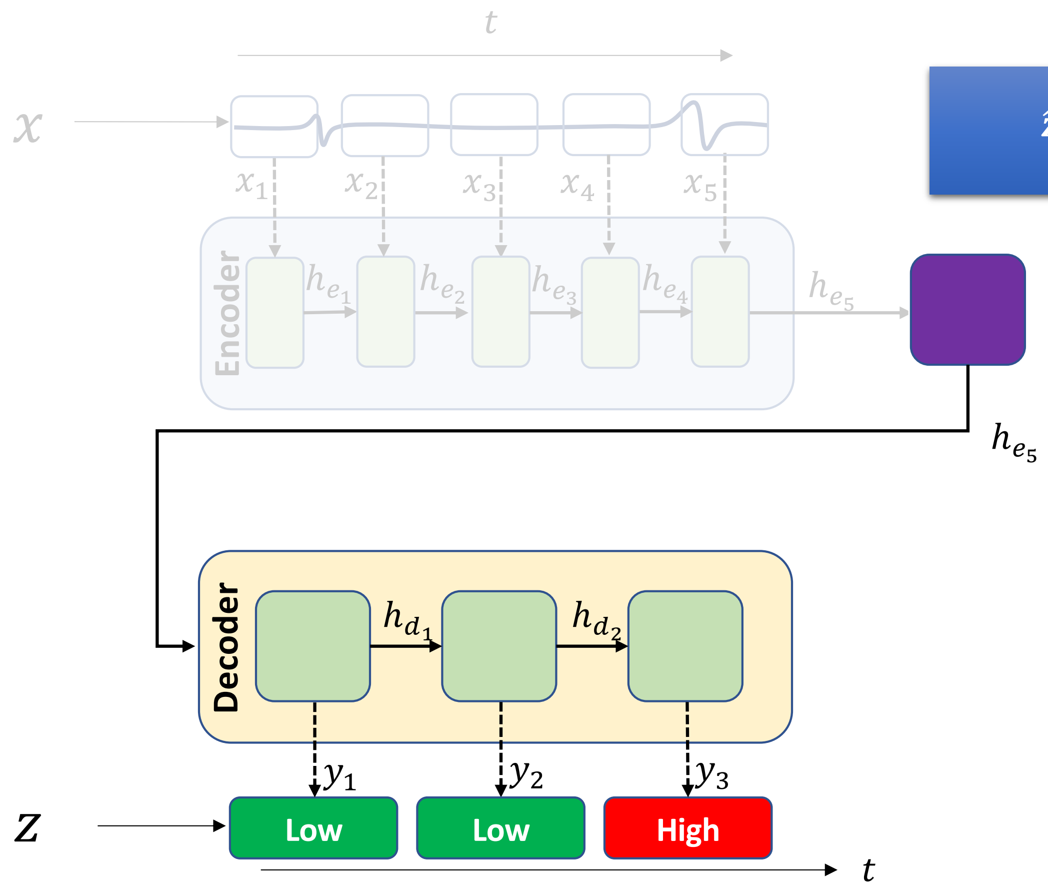
Sequence-to-sequence models



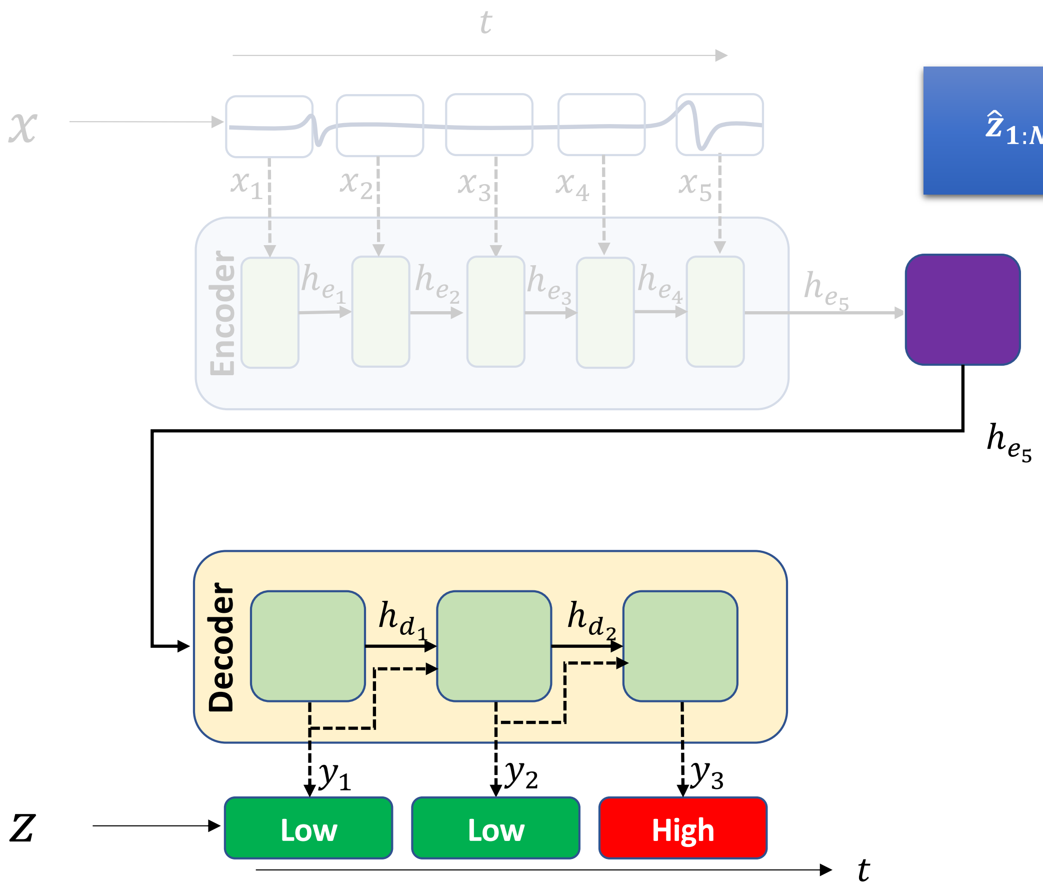
$$\hat{\boldsymbol{z}}_{\boldsymbol{1}:N} = \boldsymbol{arg}\max_{\boldsymbol{z}_{\boldsymbol{1}:N}} \prod_t \boldsymbol{P}(\boldsymbol{z}_t \,|\boldsymbol{x}_{\boldsymbol{0}:t})$$

Sequence-to-sequence models

$$\hat{z}_{1:N} = \underset{z_{1:N}}{arg\max} \prod_t P(z_t \mid x_{0:t})$$

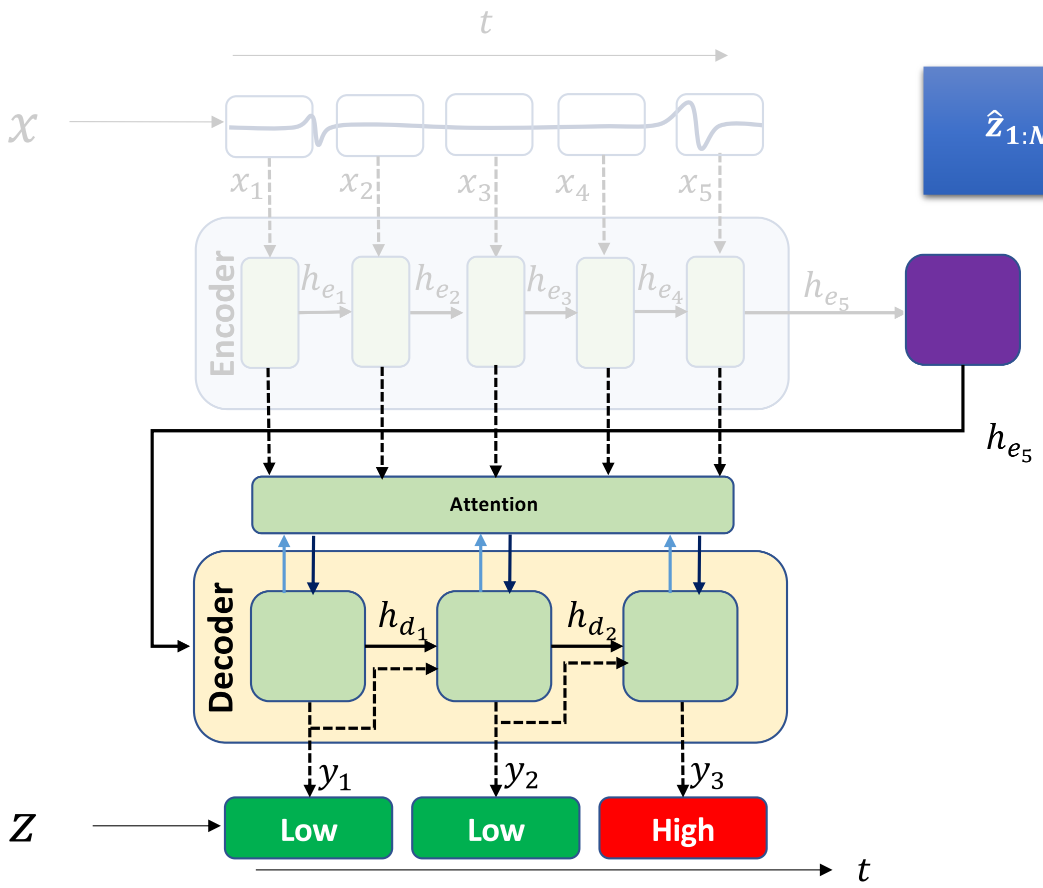


Autoregressive decoder



$$\hat{z}_{1:N} = \underset{z_{1:N}}{arg\max} \prod_{t} P(z_t \,|x_{0:t}, z_{0:t-1})$$

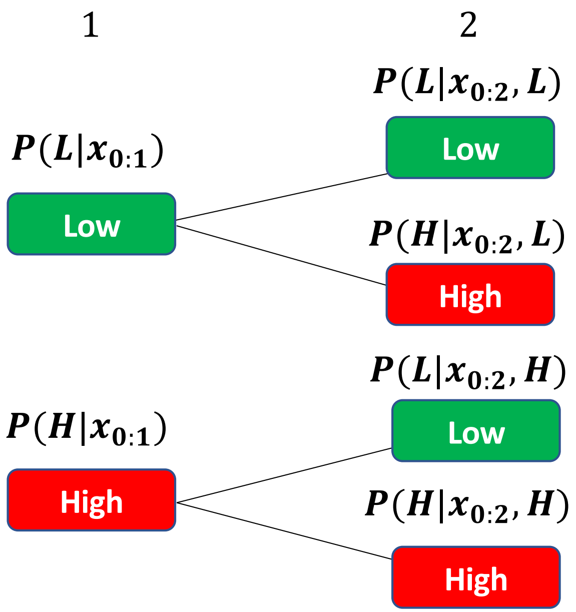
Attention mechanism



$$\hat{z}_{1:N} = \underset{z_{1:N}}{argmax} \prod_{t} P(z_t \mid x_{0:t}, z_{0:t-1})$$

Autoregressive decoder and beam search

Decoding timesteps



$$P(LL) = P(L|x_{0:1})P(L|x_{0:2}, L)$$

$$P(LH) = P(L|x_{0:1})P(H|x_{0:2}, L)$$

$$P(HL) = P(H|x_{0:1})P(L|x_{0:2}, H)$$

$$P(HH) = P(H|x_{0:1})P(H|x_{0:2}, H)$$

$$\hat{z}_{1:N} = \underset{z_{1:N}}{argmax} \log\left(\prod_t P(z_t \,|x_{0:t}, z_{0:t-1})\right)$$

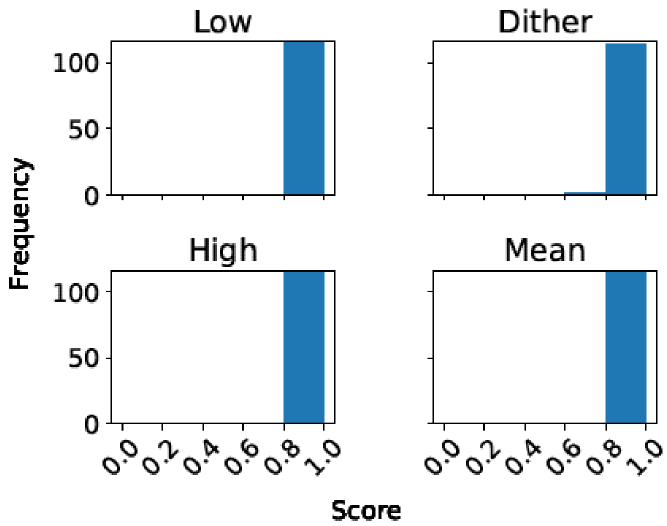
$$= \underset{z_{1:N}}{argmax} \sum_t \log\big(P(z_t \,|x_{0:t}, z_{0:t-1})\big)$$

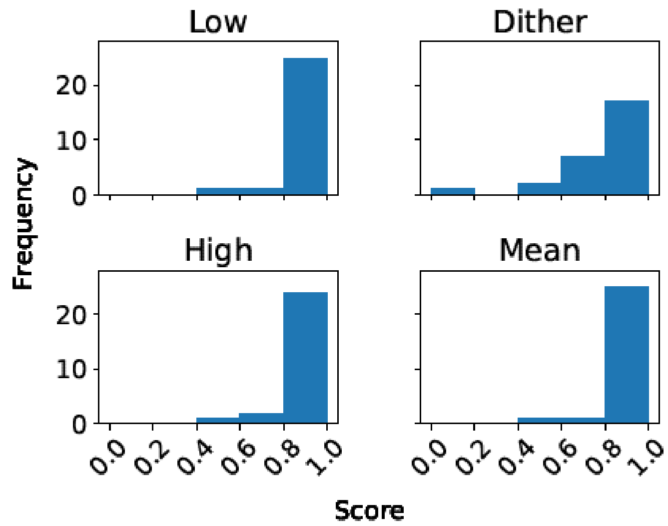
$$z_0 = \{'Low'\}$$

$$P(L_1, H_{2,}) = \log P(L_1|\, X) + \log P(H_2|X, L_1)$$

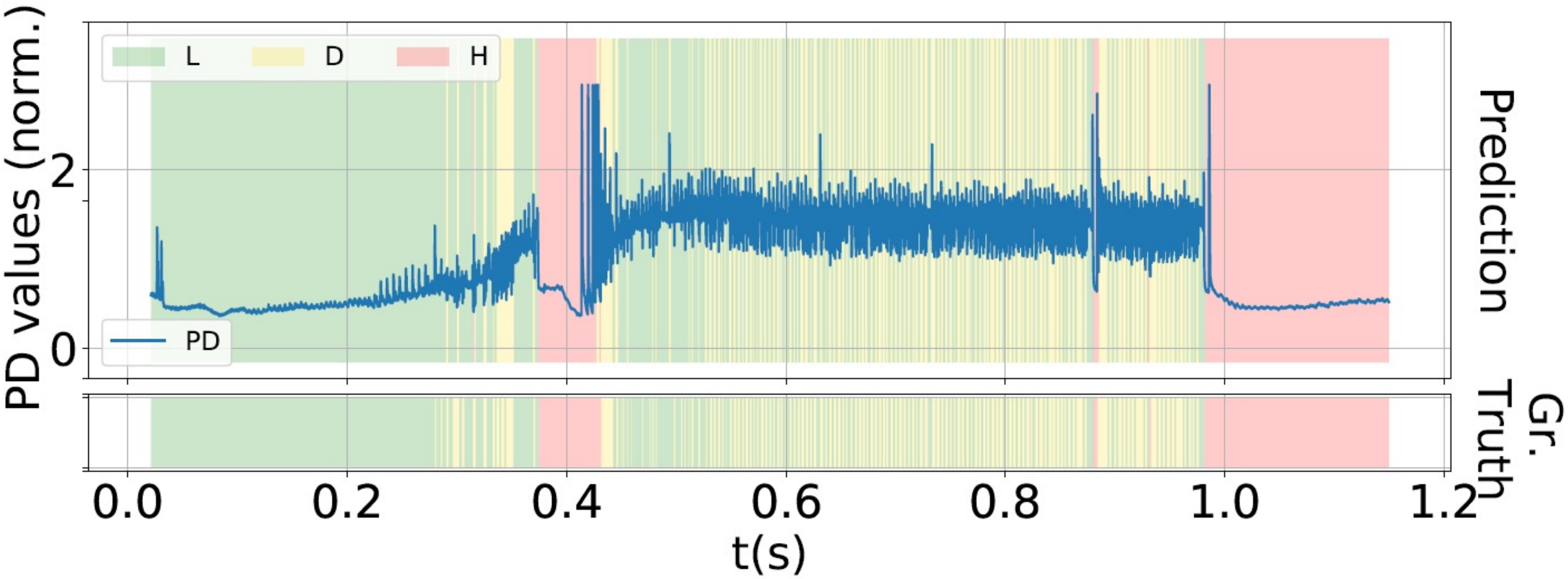
Results

		Score			
		L	D	H	Mean
k	Train	0.99	0.99	0.99	0.99
	Test	0.94	0.86	0.96	0.94

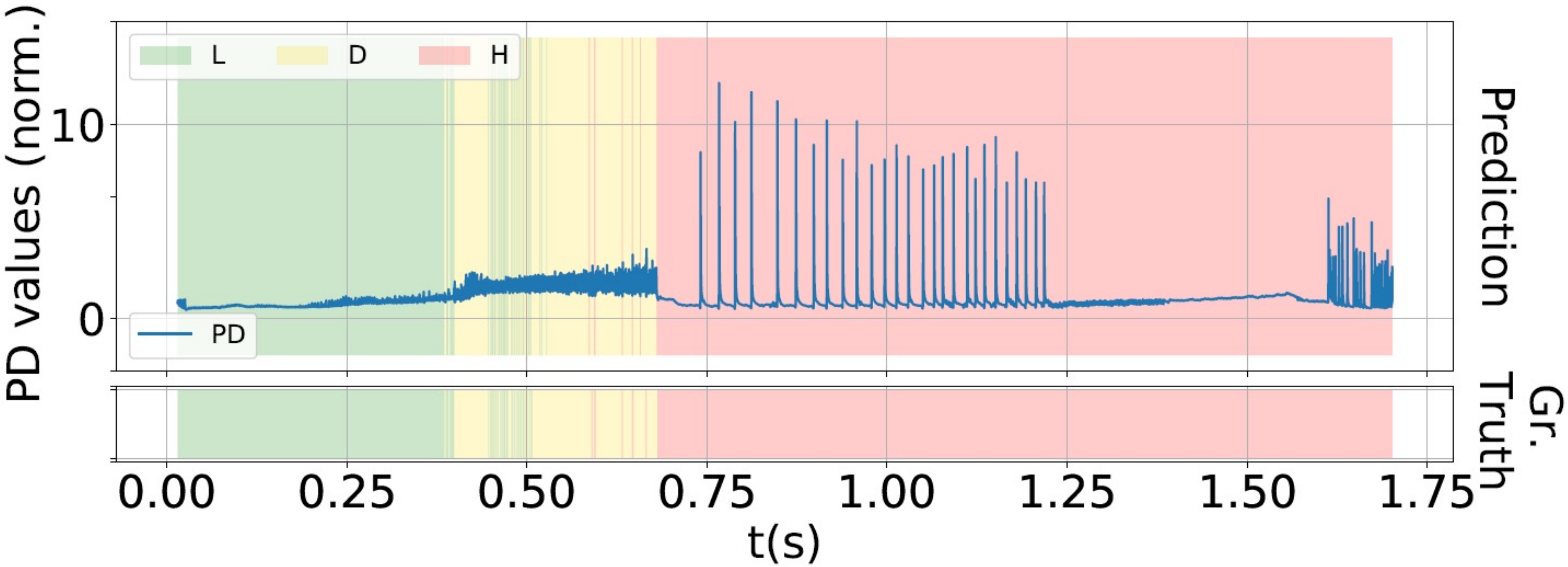




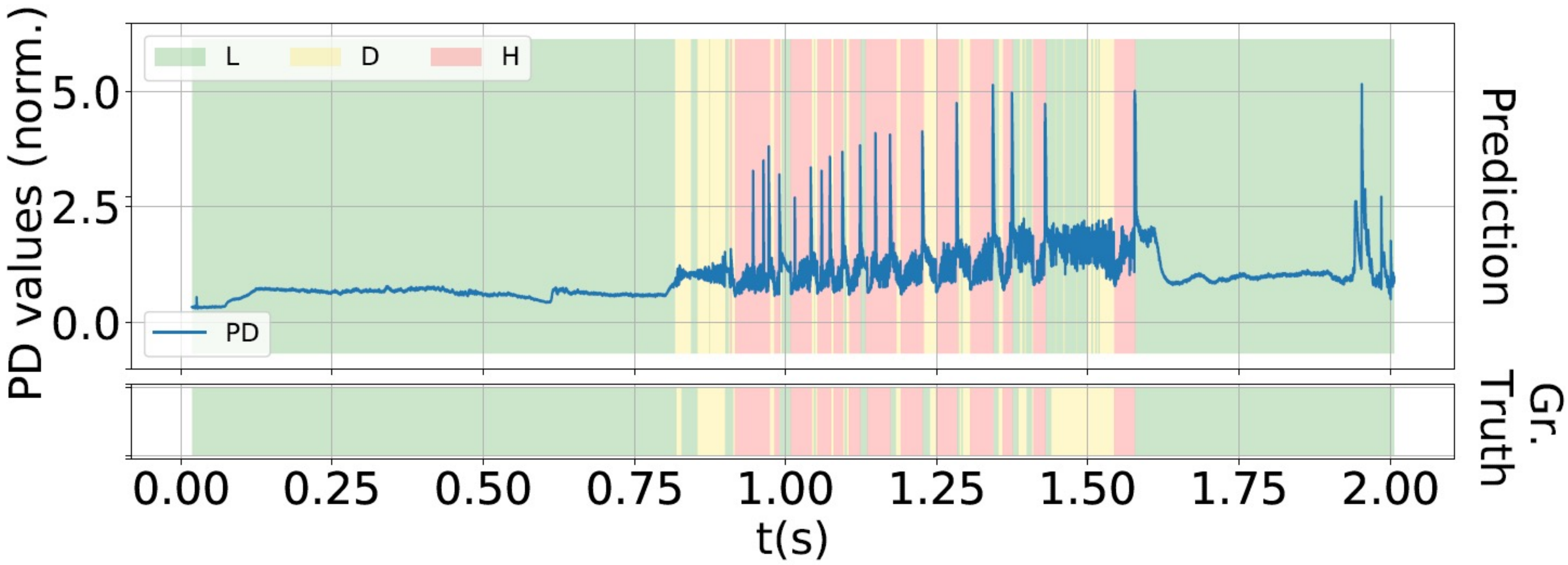
Sample results- #32911



Sample results- #62744



Sample results- #62744



Conclusions and next steps

- **Developed a sequence to sequence model to detect plasma confinement modes**
- **Generative unsupervised models (variational auto-encoders)?**
  - Study latent variables that might explain the variance in the data