



Informed Sampling of the Plasma Hyperspace for Digital Twinning

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Motivation



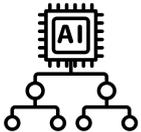
Real-time Prediction



Low Latency



Fast and Creative Experimentation at minimal risk and cost



Precursor to building advanced automated control feedback loops.

Thomson Scattering Digital Twin



8 time instances of Control Signals

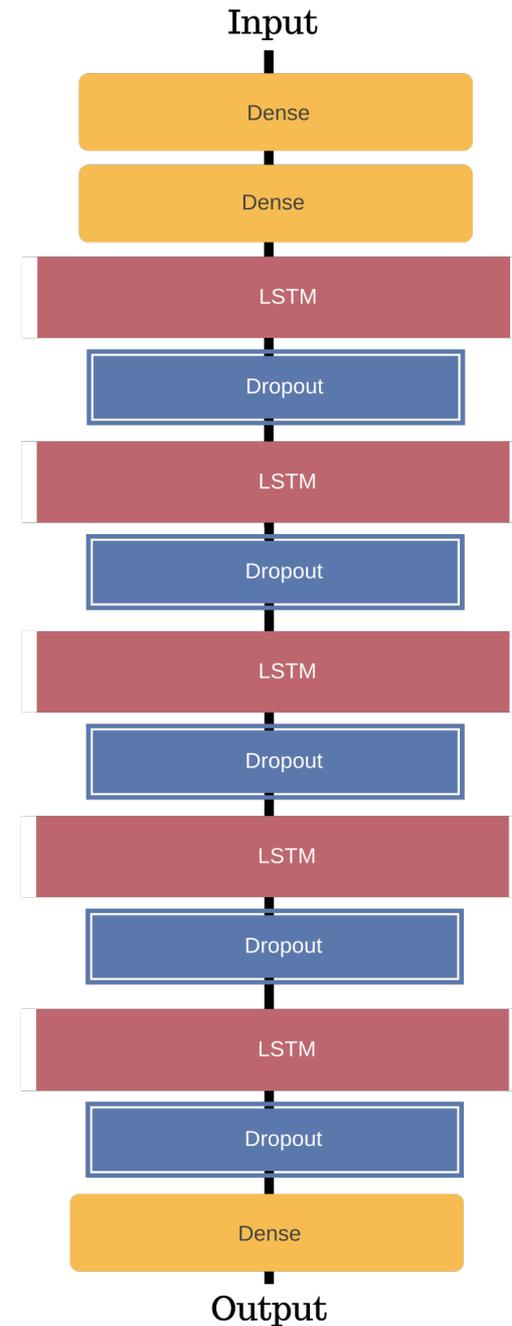
Next 4 time instances of Diagnostic Output

Model Architecture

Dense – Fully Connected Layer:
Extract Dependencies across Signals

LSTM – Long Short Term Memory:
Extract Temporal Dependencies for each signal

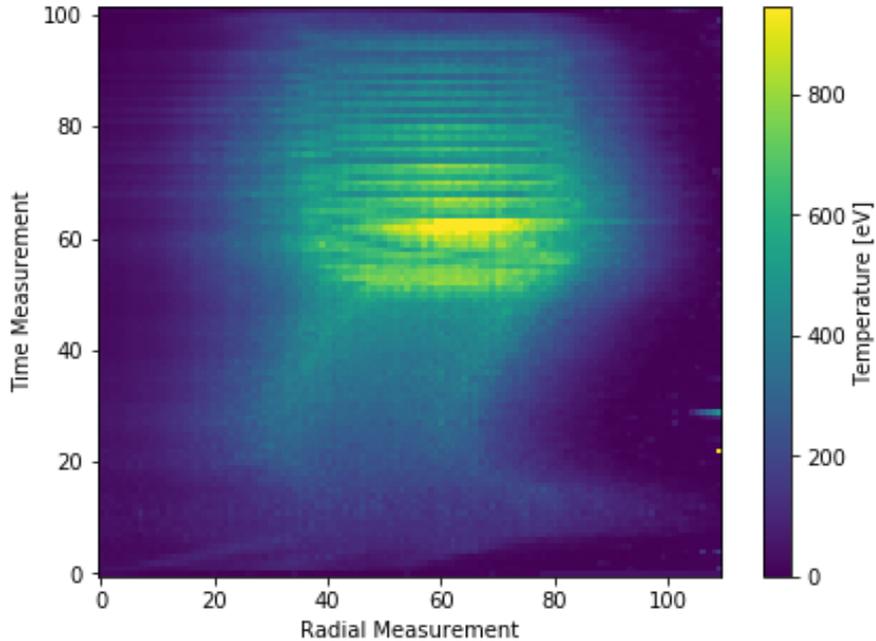
Dropout: Allows for regularisation



Prediction Comparison

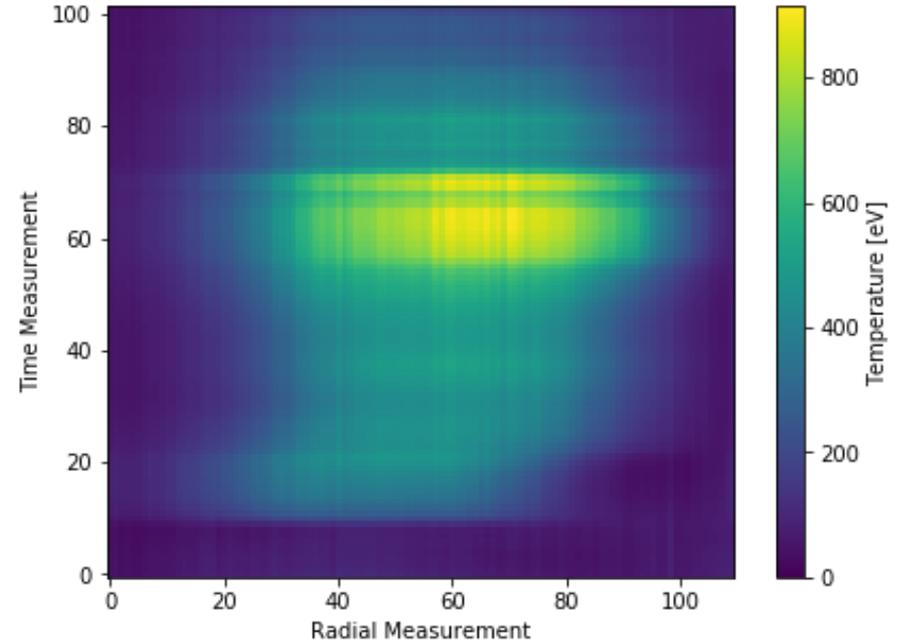
Actual

Shot 24863



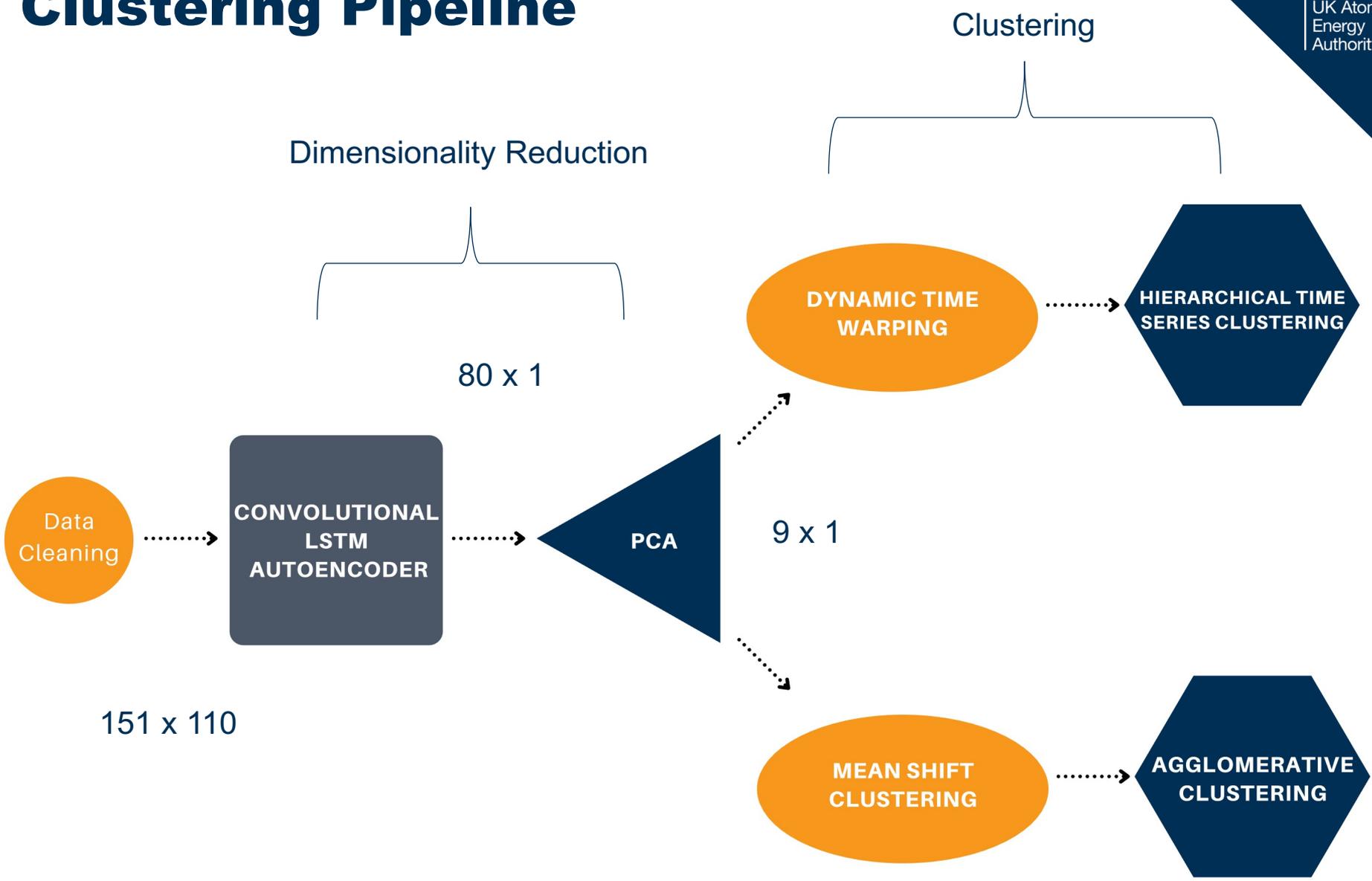
Prediction

Predicted Shot 24863

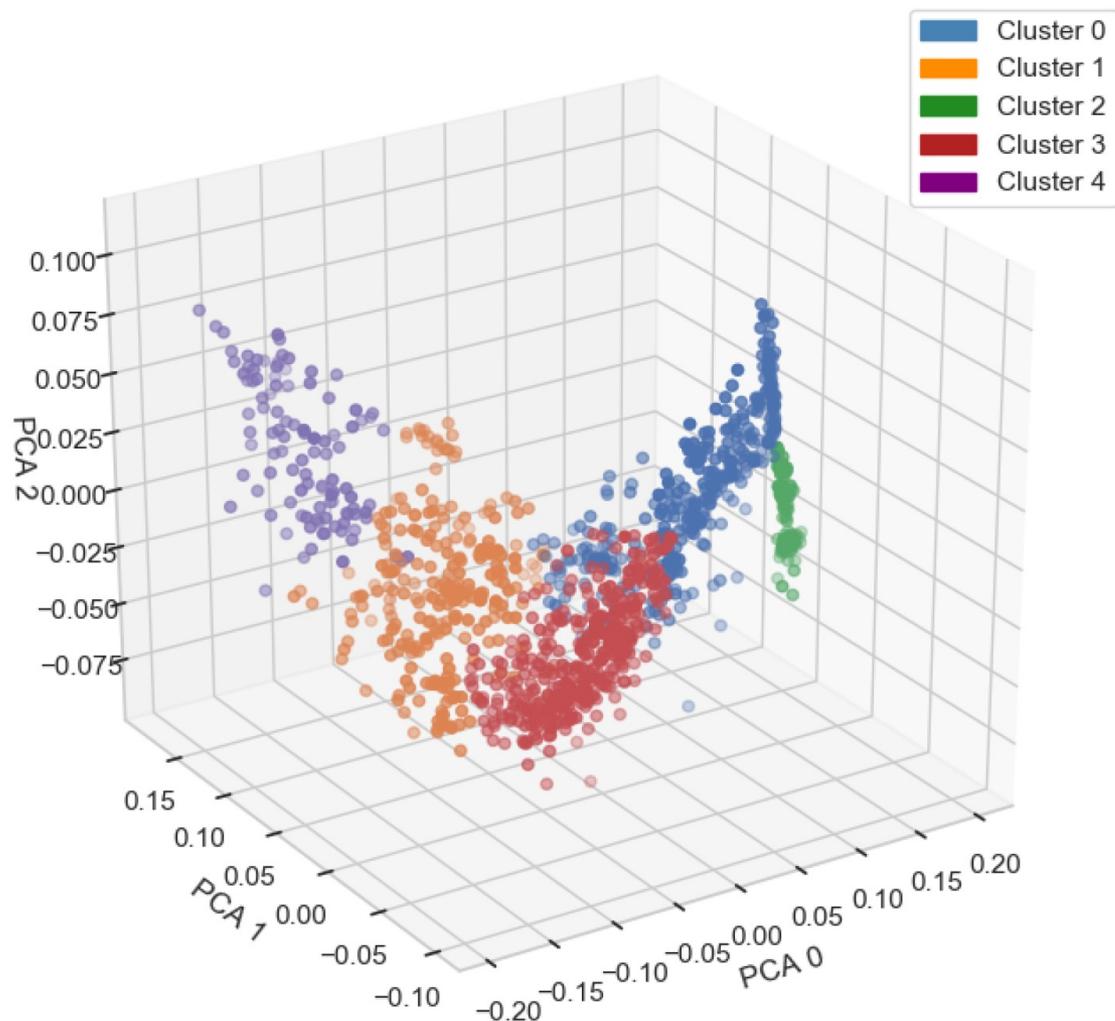


Prediction Error : 0.0285
Includes a total of 1366 shots

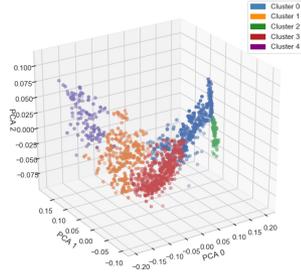
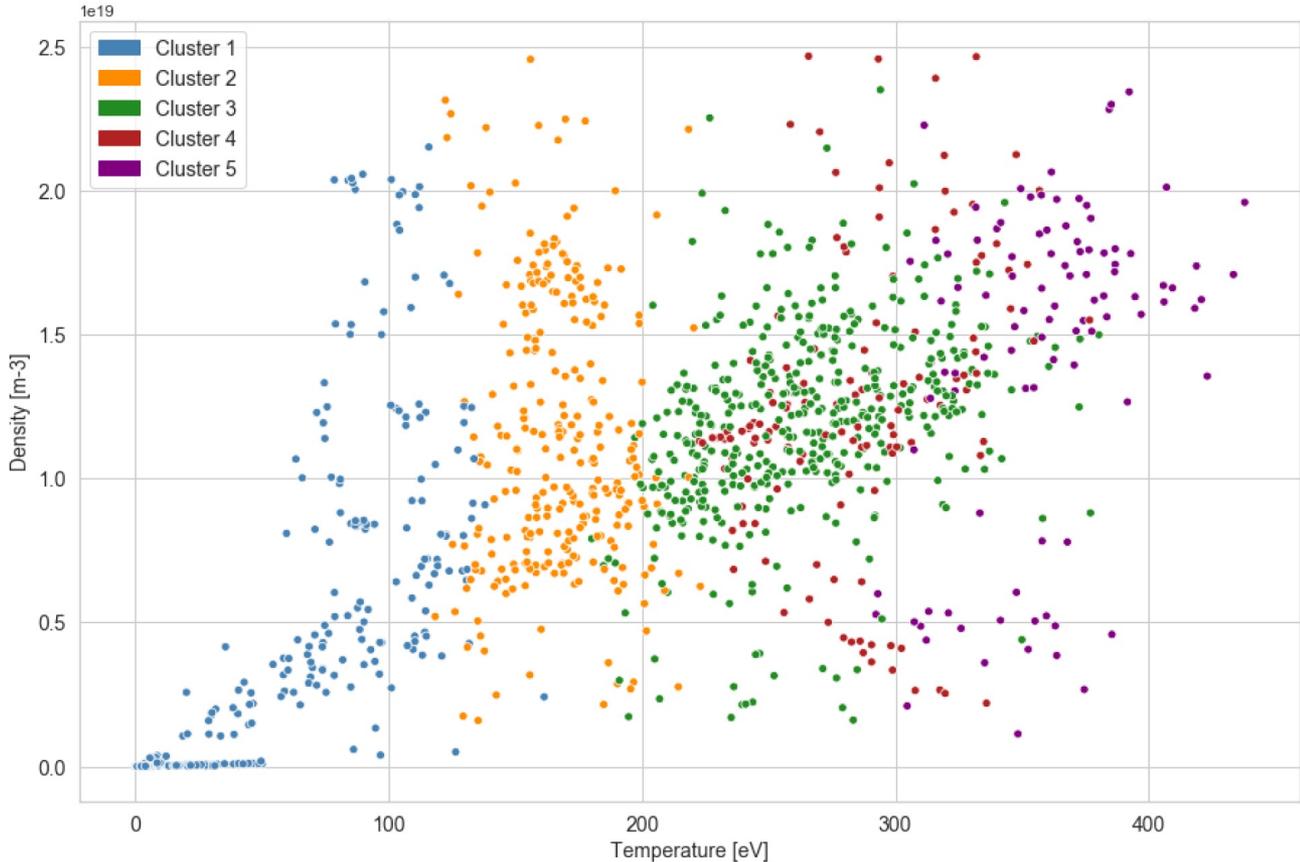
Clustering Pipeline

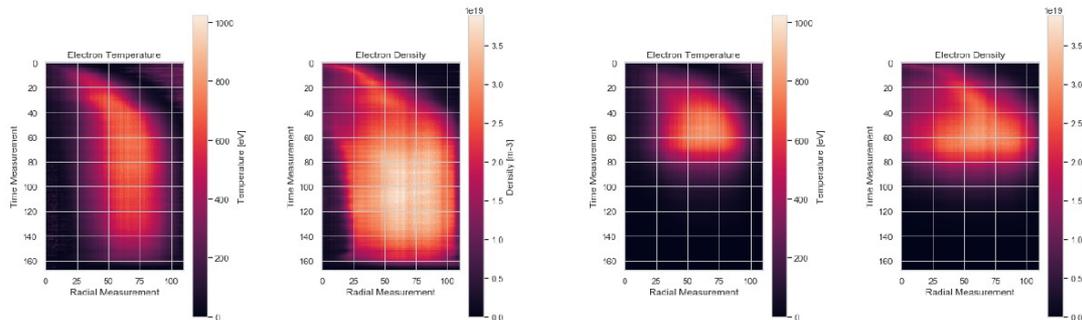


Mapping the Hyperspace of Plasma shots



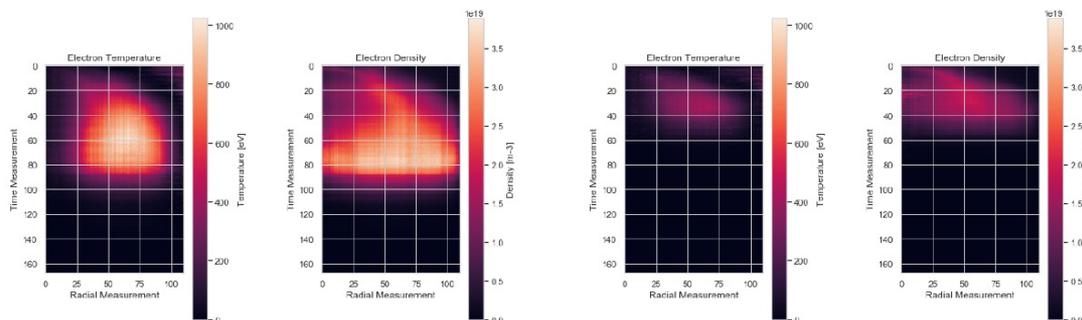
Mapping the Hyperspace





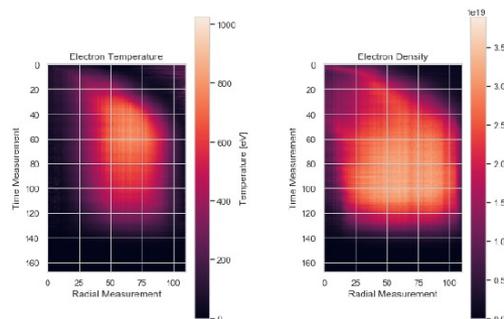
(a) Cluster 0: 204 shots

(b) Cluster 1: 394 shots



(c) Cluster 2: 205 shots

(d) Cluster 3: 130 shots



(e) Cluster 4: 184 shots

Plots of average density and average temperature taken across shots within a cluster.

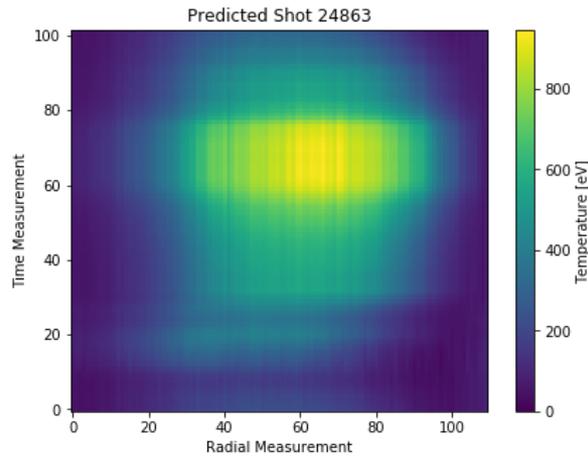
Cluster based sampling for building surrogate dataset – M7 and M9

Campaign	Percentage Data	MSE
M7	100	0.0285
M7 (Sampling Technique)	10	0.0293
M9	100	0.0265
M9 (Sampling Technique)	10	0.0302
M7 + M9	100	0.0279
M7 + M9 (Sampling Technique)	10	0.0282

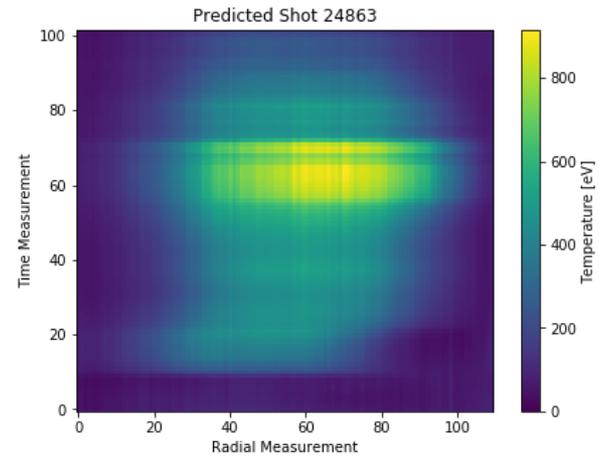
M7 – 1366 Shots

M9 – 1117 Shots

Prediction Comparison



10% Data



100% Data

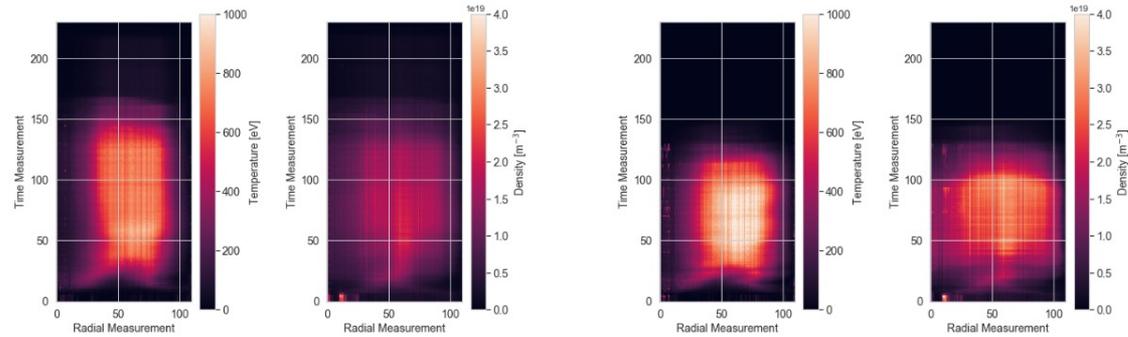
Prediction Error (100%) : 0.0285

Prediction Error (10%) : 0.0293

Cluster based sampling for building surrogate dataset – M8 and MU

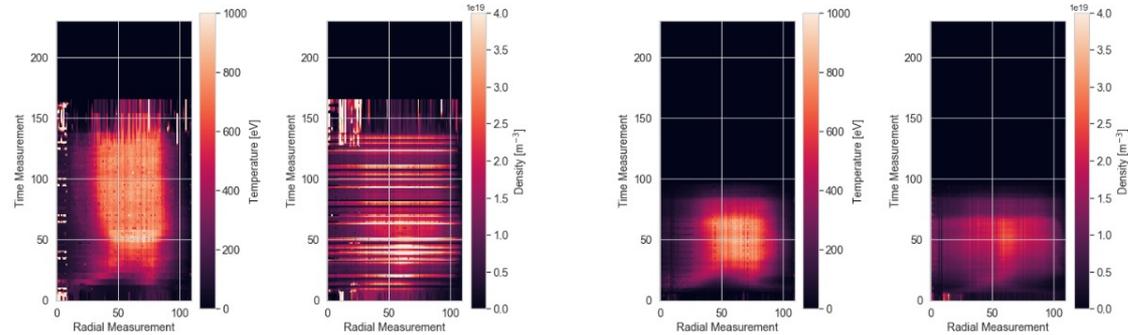
Campaign	Percentage Data	MSE
M8	100	0.0209
M8 (Cosine Sampling)	10	0.0237
MU	100	0.0434
MU (Cosine Sampling)	10	0.0532
M8 + MU	100	0.0321
M8 + MU (Cosine Technique)	10	0.0323

Mast-U Clusters



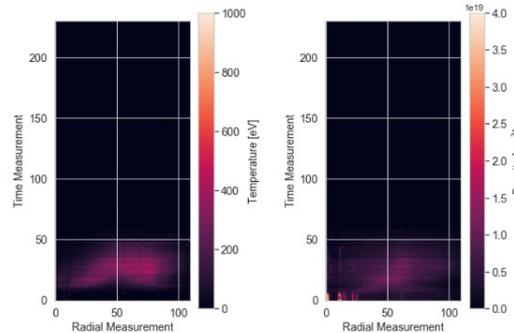
(a) Cluster 0: 44 shots

(b) Cluster 1: 34 shots



(c) Cluster 2: 4 shots

(d) Cluster 3: 20 shots



(e) Cluster 4: 14 shots