

Pre-ictal Seizure Detection

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What is a seizure's pre-ictal stage?

Seizure:

- Sudden abnormal electrical activity in the brain
- Can affect movement, awareness, or behavior
- Typically lasts less than two minutes

Pre-ictal State:

- Time period before a seizure
- Brain activity begins to change from its normal patterns
- Changes can often be detected in EEG signals

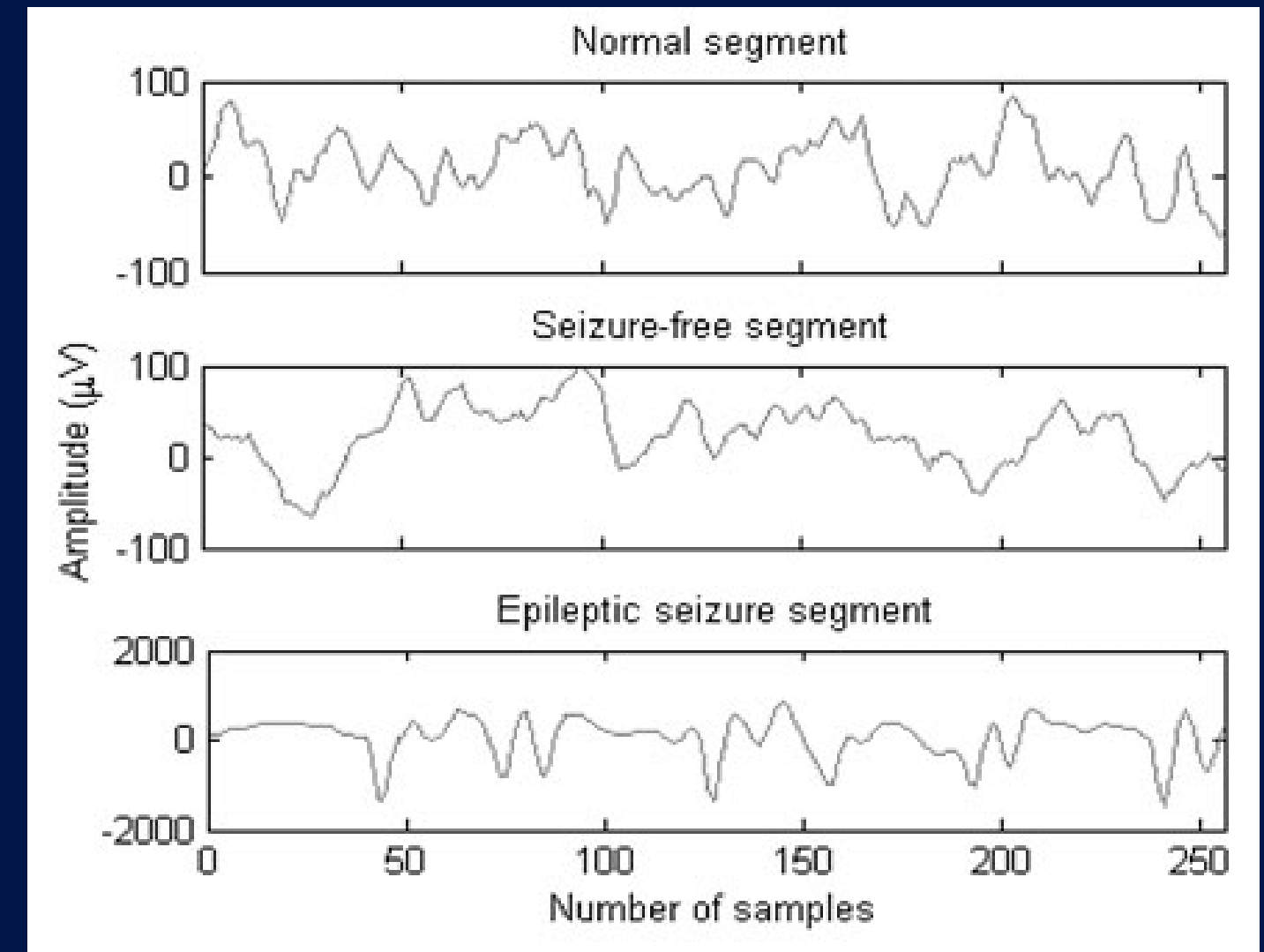
What is EEG?

Electroencephalography (EEG)

- A non-invasive method to measure neuronal electrical activity

How It Works:

- Electrodes placed on the scalp
- Records electrical signals from post-synaptic currents
- Signals appear as brain wave patterns



Current Problems:

1. Epileptic seizures are sudden and unpredictable
2. ~30% of epilepsy patients don't respond to medication
(Tao, 2022)
3. No current guaranteed method to predict the onset of seizures

Previous Literature:

- Previous research involving machine learning has only explored seizure detection, not seizure warnings
- Many studies focus on adults or smaller homogenous populations, creating an imbalance in our understanding of seizures as a whole

CHB-MIT Scalp EEG Database

Overview

- Public dataset for epileptic seizure research

Source

- Boston Children's Hospital & MIT

Dataset

- EEG recordings from 23 pediatric uncontrolled epilepsy patients
- Multi-channel scalp EEG signals
- Includes labeled seizure (1) and non-seizure data (0)

Goal

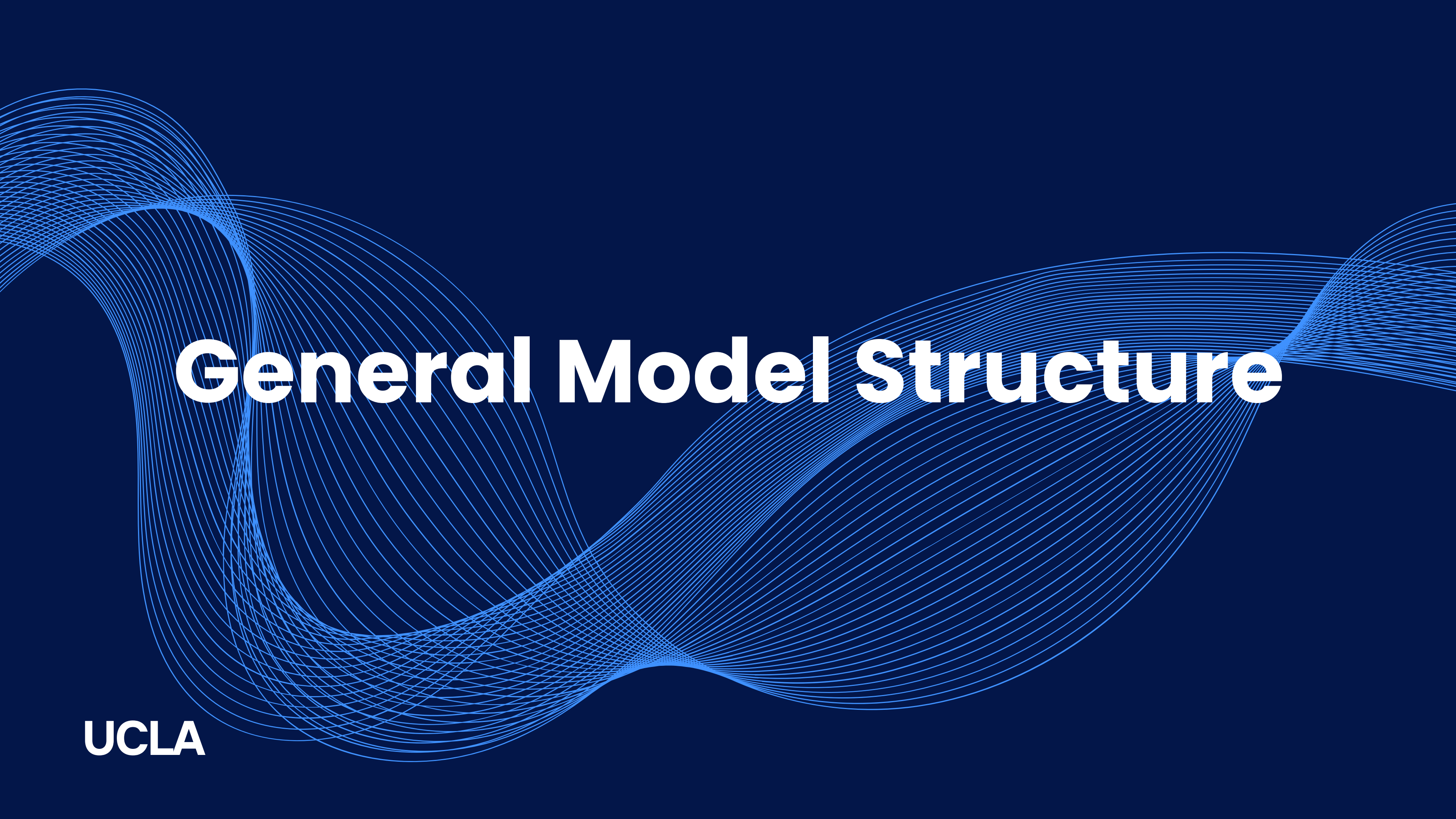
Alert patients that pre-ictal changes were detected to allow them to maximize their ability to take preventative and mitigative measures before a seizure occurs

Hypothesis

Seizure detection does vary between patients and the pre-ictal state is the earliest we can detect changes to brain activity

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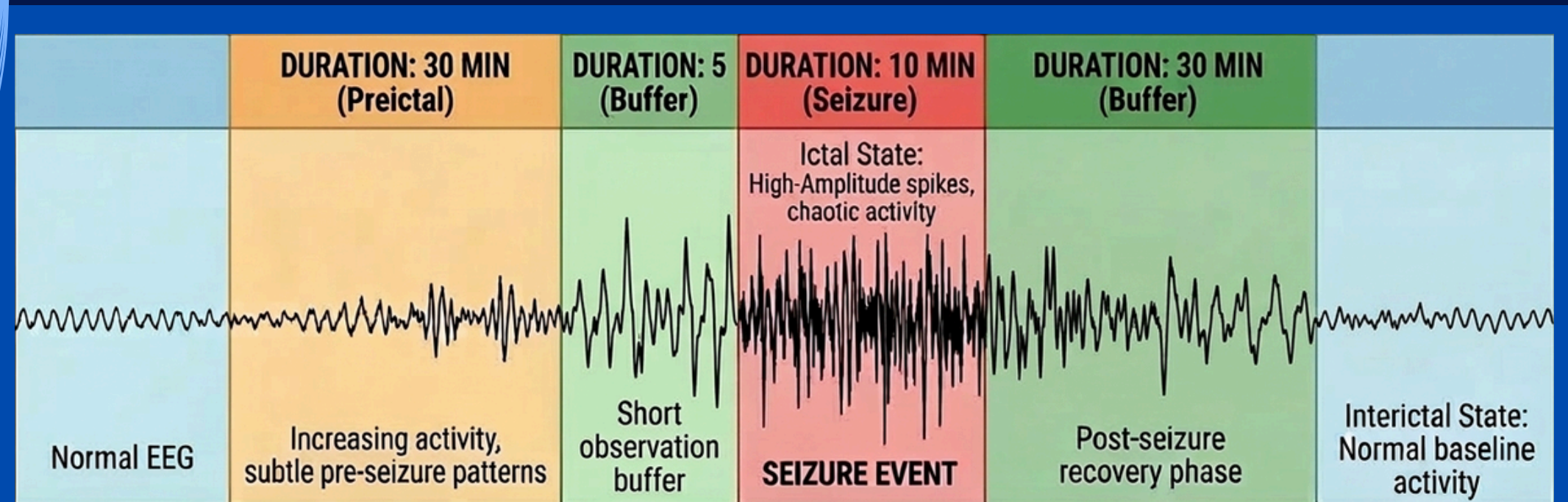


The background of the slide is a solid dark blue. Overlaid on this are several sets of thin, light blue lines that form a complex, wavy, and somewhat chaotic pattern. These lines are arranged in a way that suggests movement and flow, with some areas being more densely packed than others, creating a sense of depth and texture.

General Model Structure

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Defining the Labels



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Pre-ictal Zone

- 5–30 minutes before seizure onset
- Positive Case

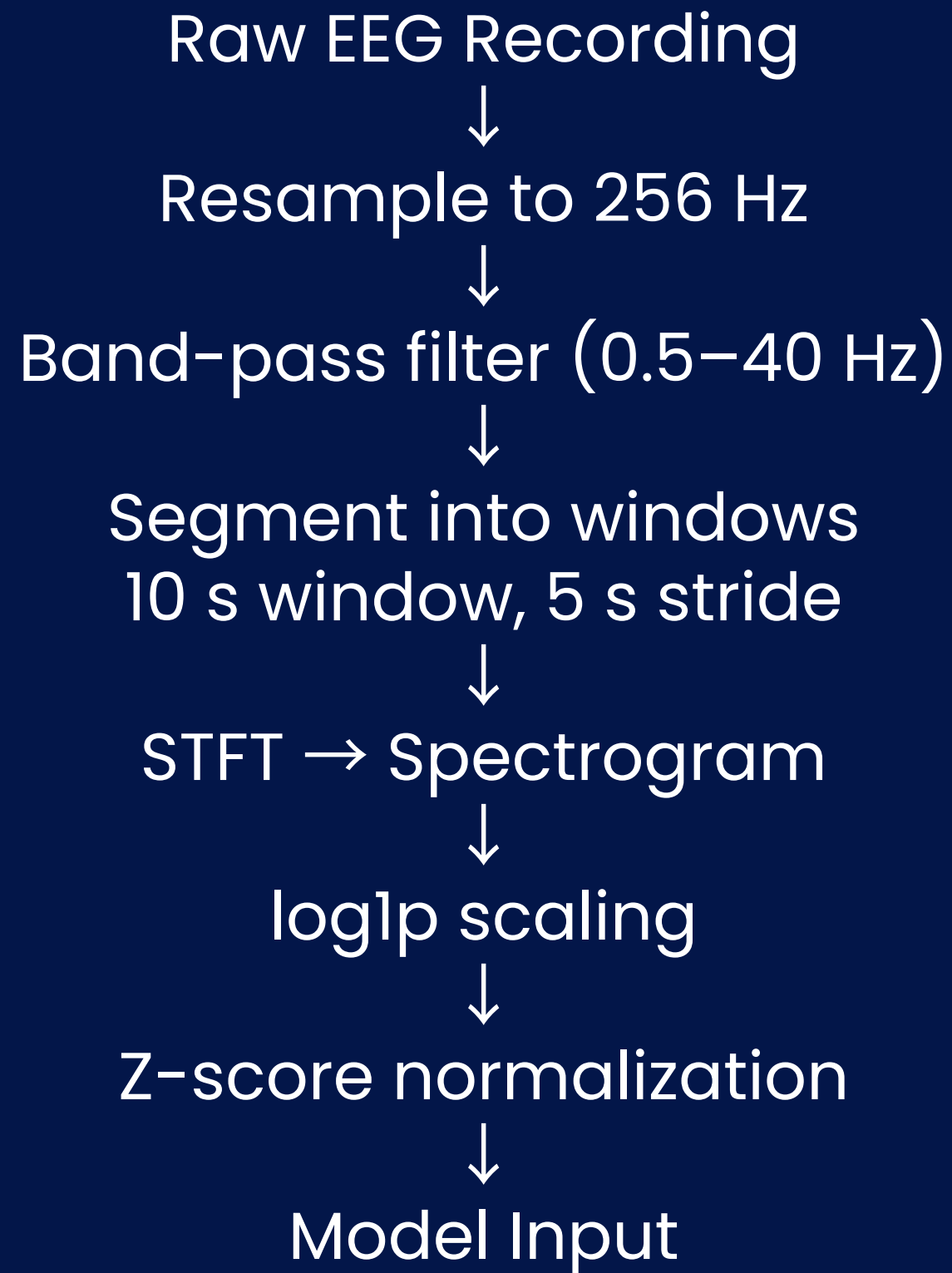
Buffer zone

- 5 min before seizure
- 30 min after seizure
- Excluded from our sampling
- Too close to seizure

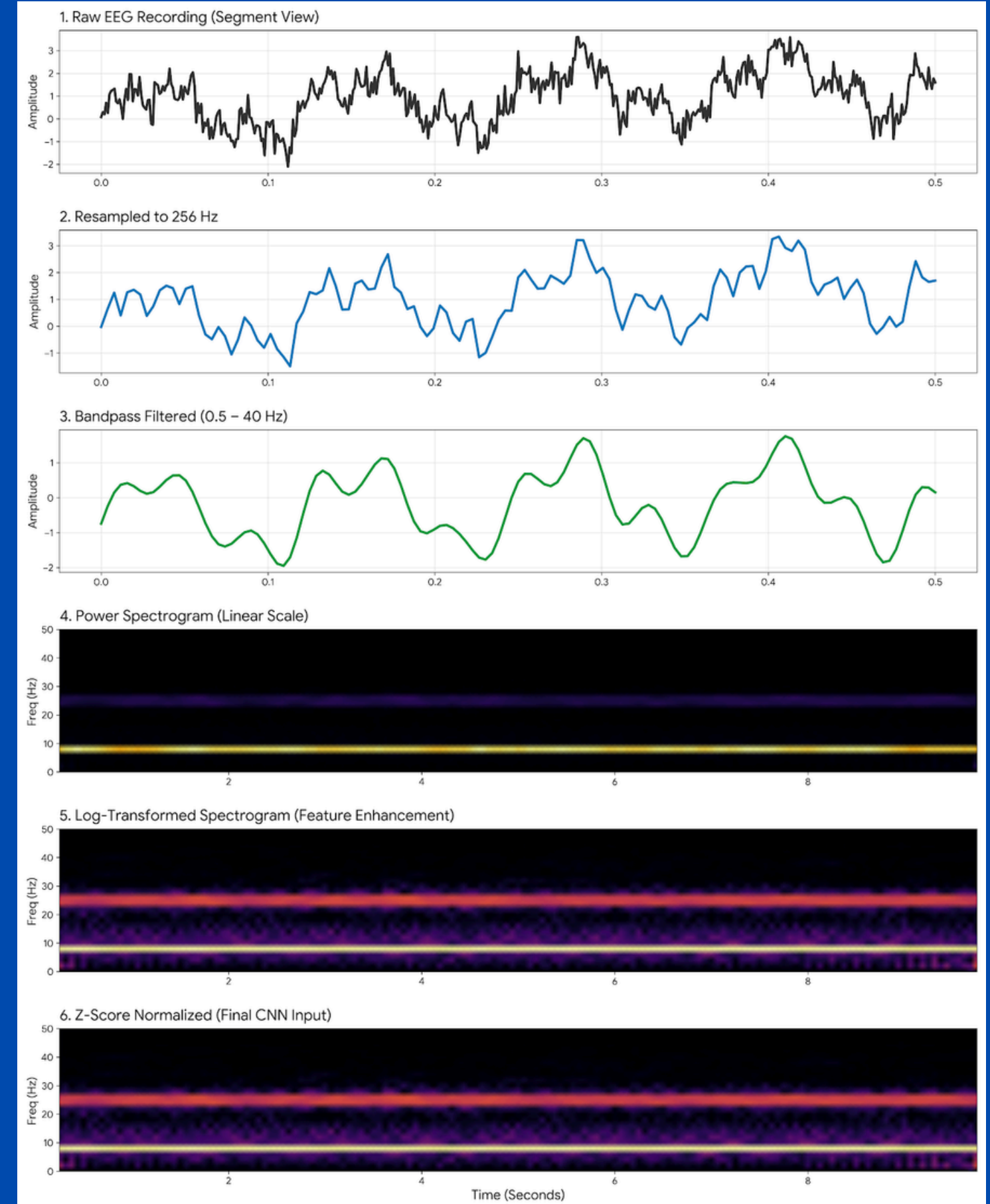
Inter – ictal ("normal") Zone

- all other brain activity, far from any seizure
- Negative / Control Case

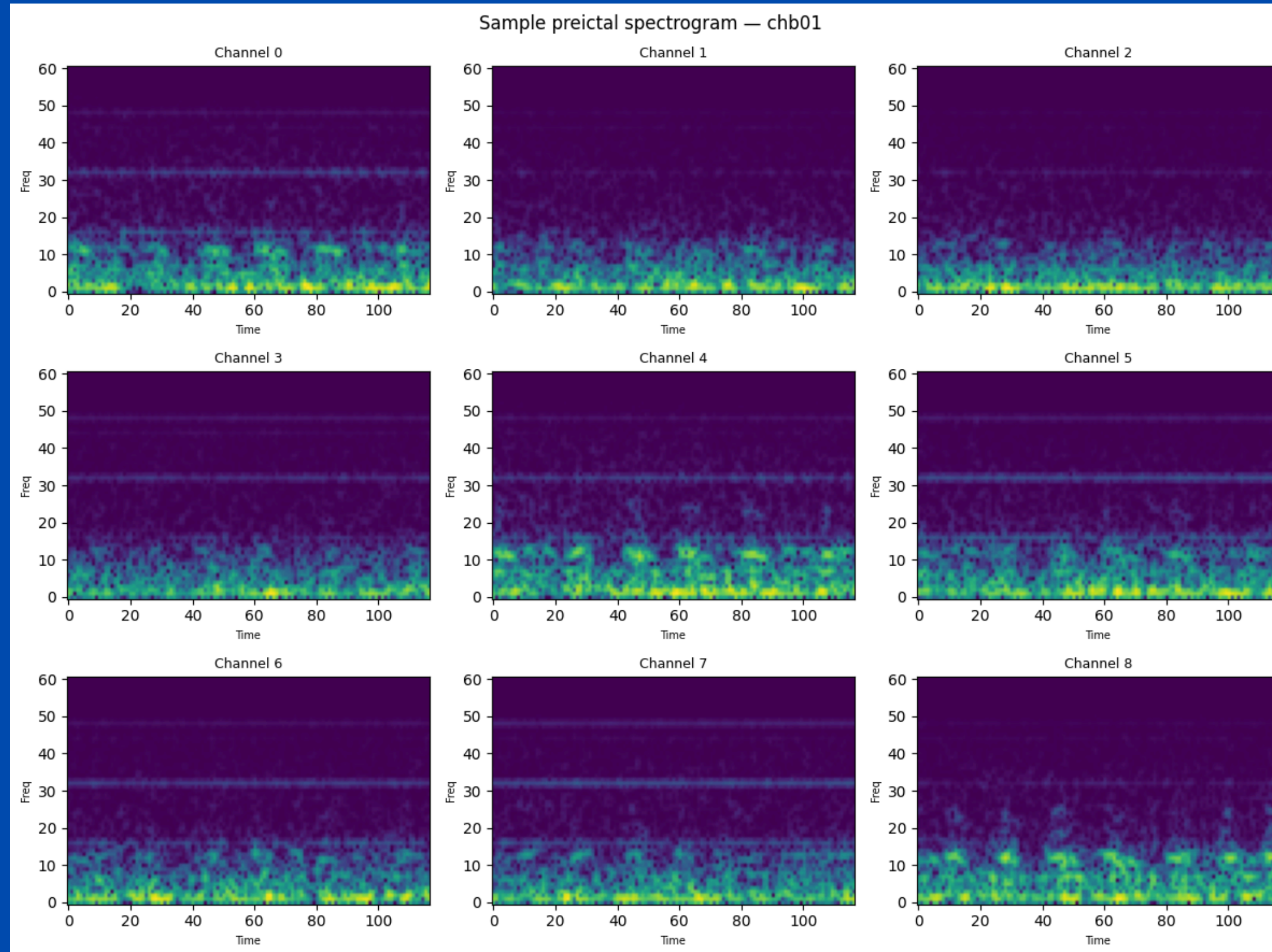
Signal Preprocessing



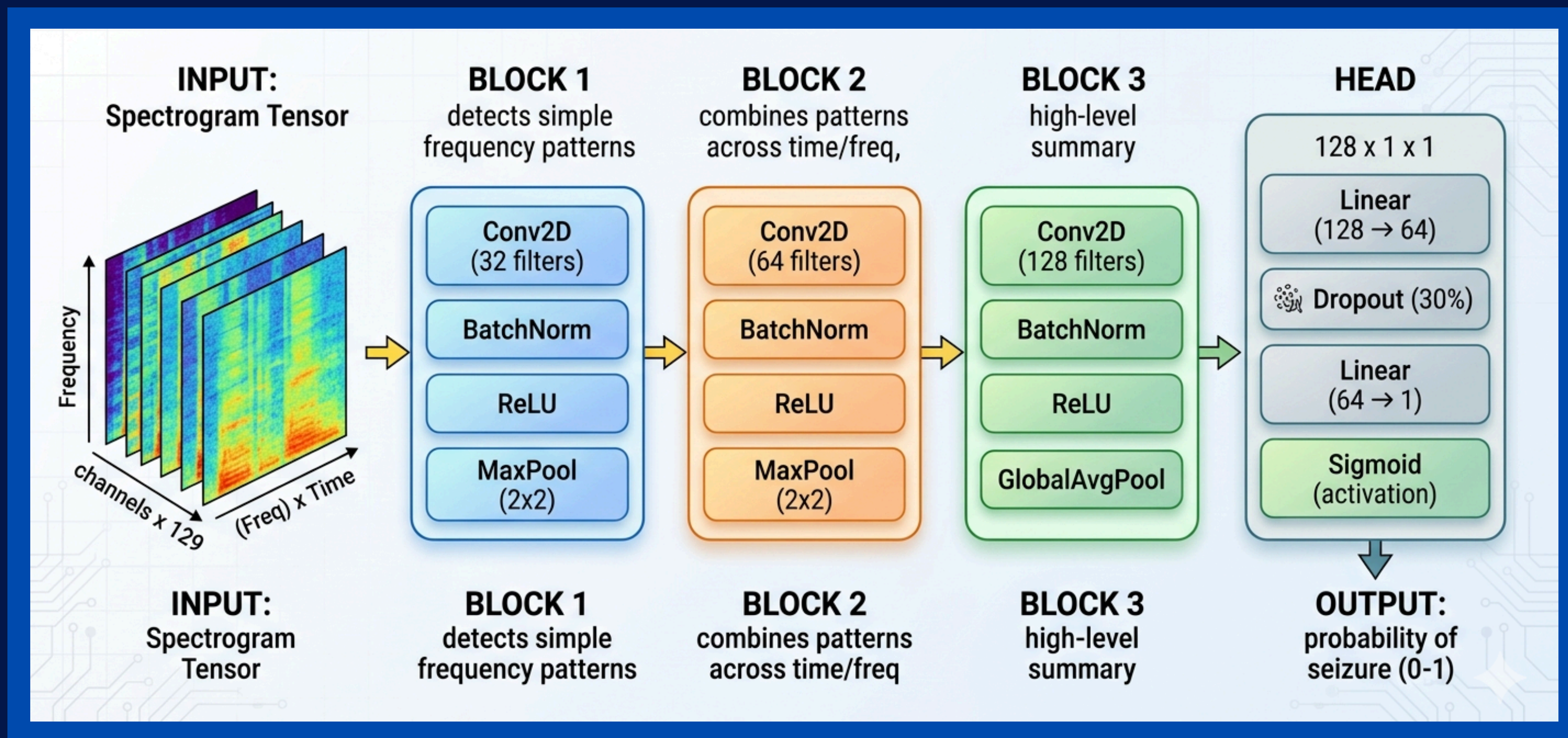
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Signal Preprocessing



The CNN Architecture



Training

Loss function: Binary Cross-Entropy

- penalizes confident wrong predictions

Optimizer: AdamW

- adapts learning rate per parameter
- weight decay prevents overfitting

Each run:

15 epochs, batch size 16, learning rate 0.001

- After each epoch: evaluated on validation set

Best model by validation AUPRC is saved and restored at the end

Evaluation Metrics

AUROC (Area Under ROC Curve)

- how well the model ranks pre-ictal above inter-ictal
- 0.5 = random, 1.0 = perfect

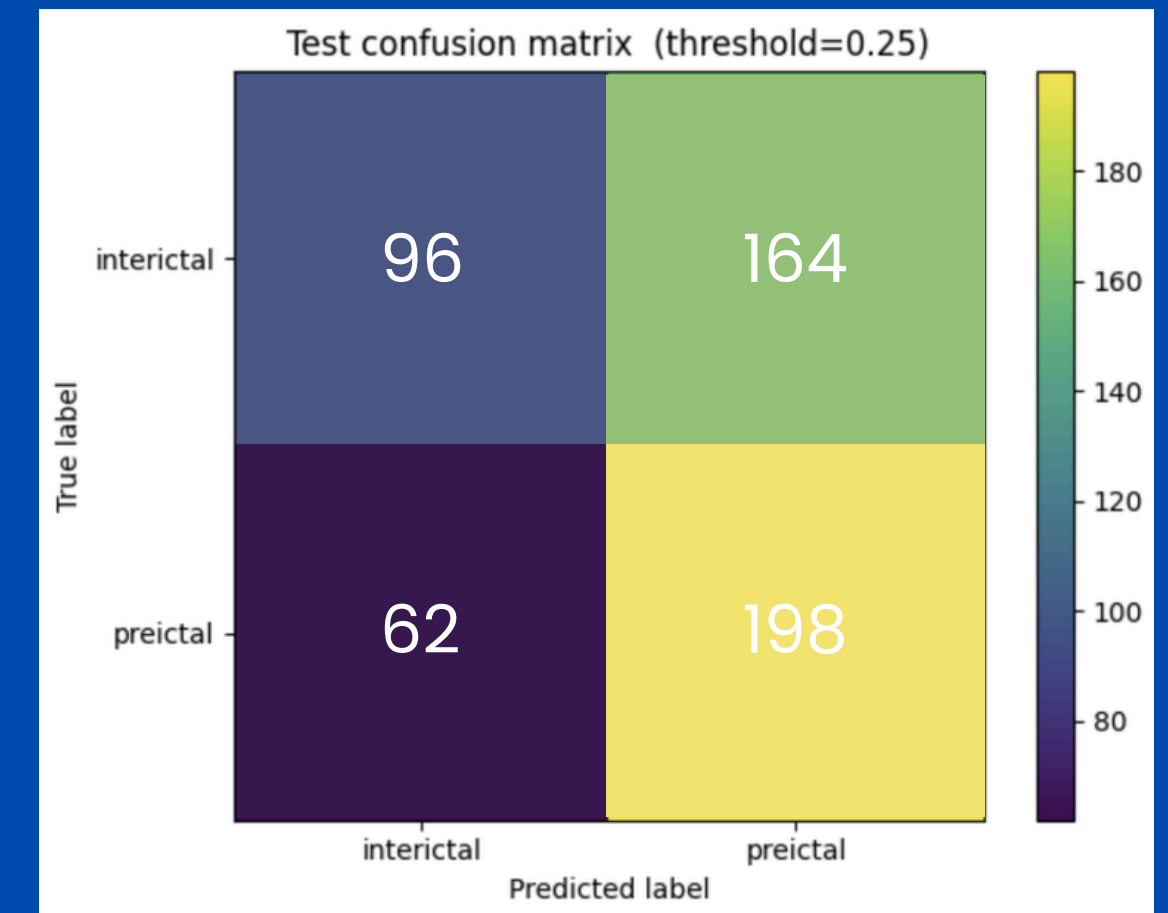
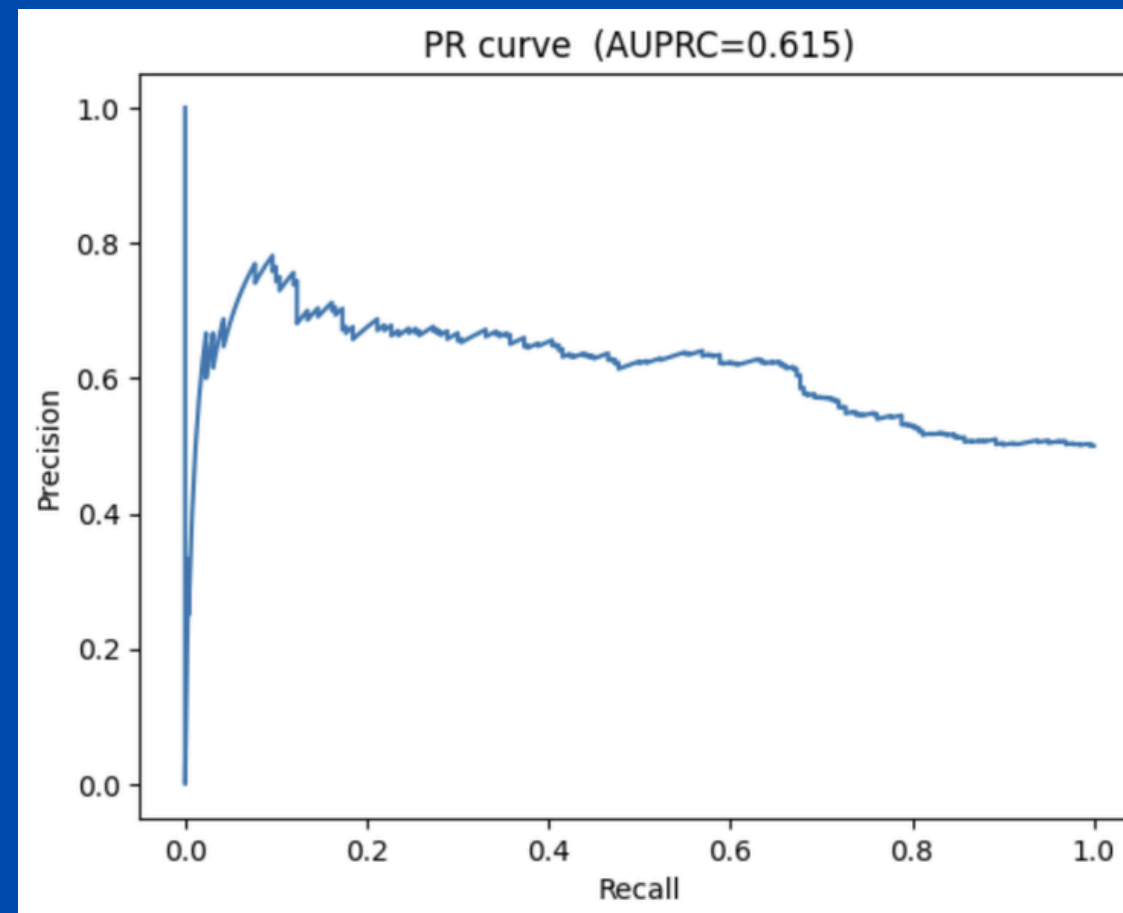
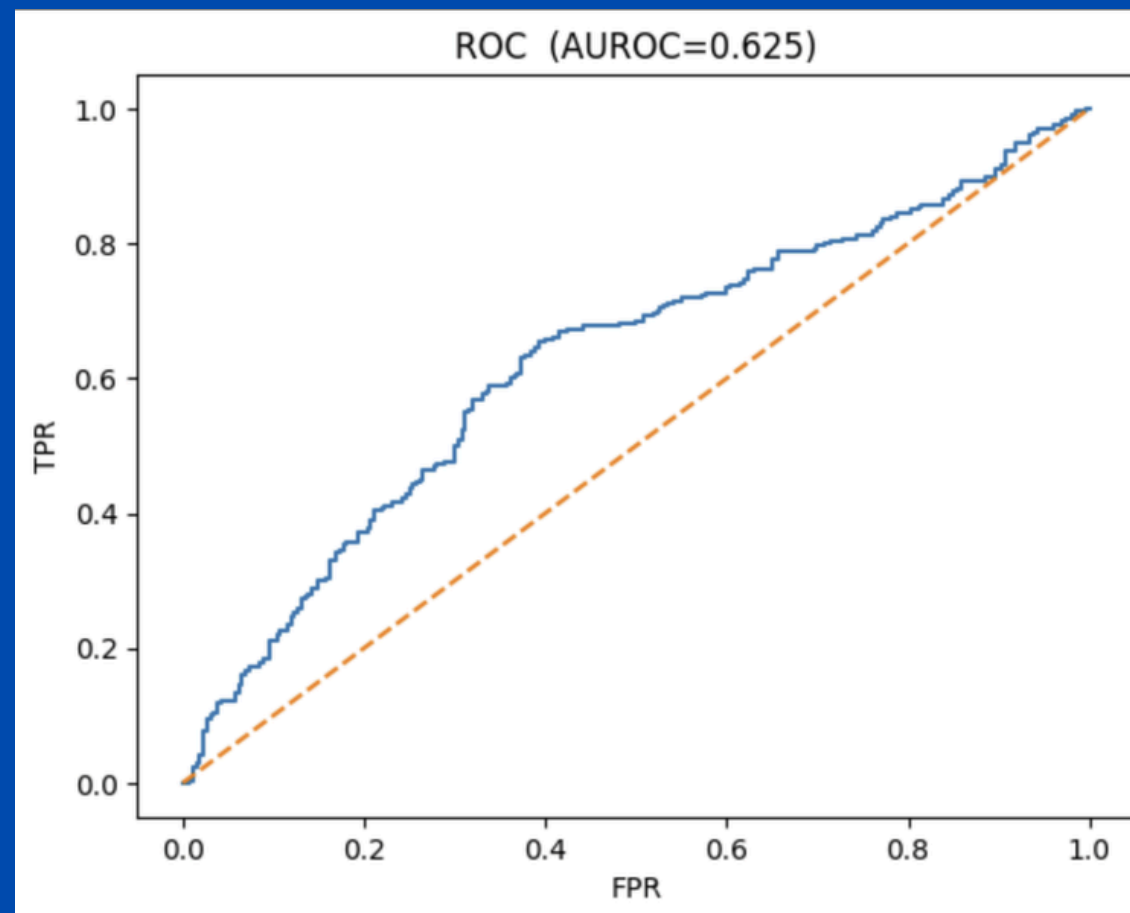
AUPRC (Area Under Precision-Recall Curve)

- better metric for imbalanced classes
- punishes false alarms

Confusion matrix

- at threshold 0.25
- counts of true positives, false positives, true negatives, false negatives

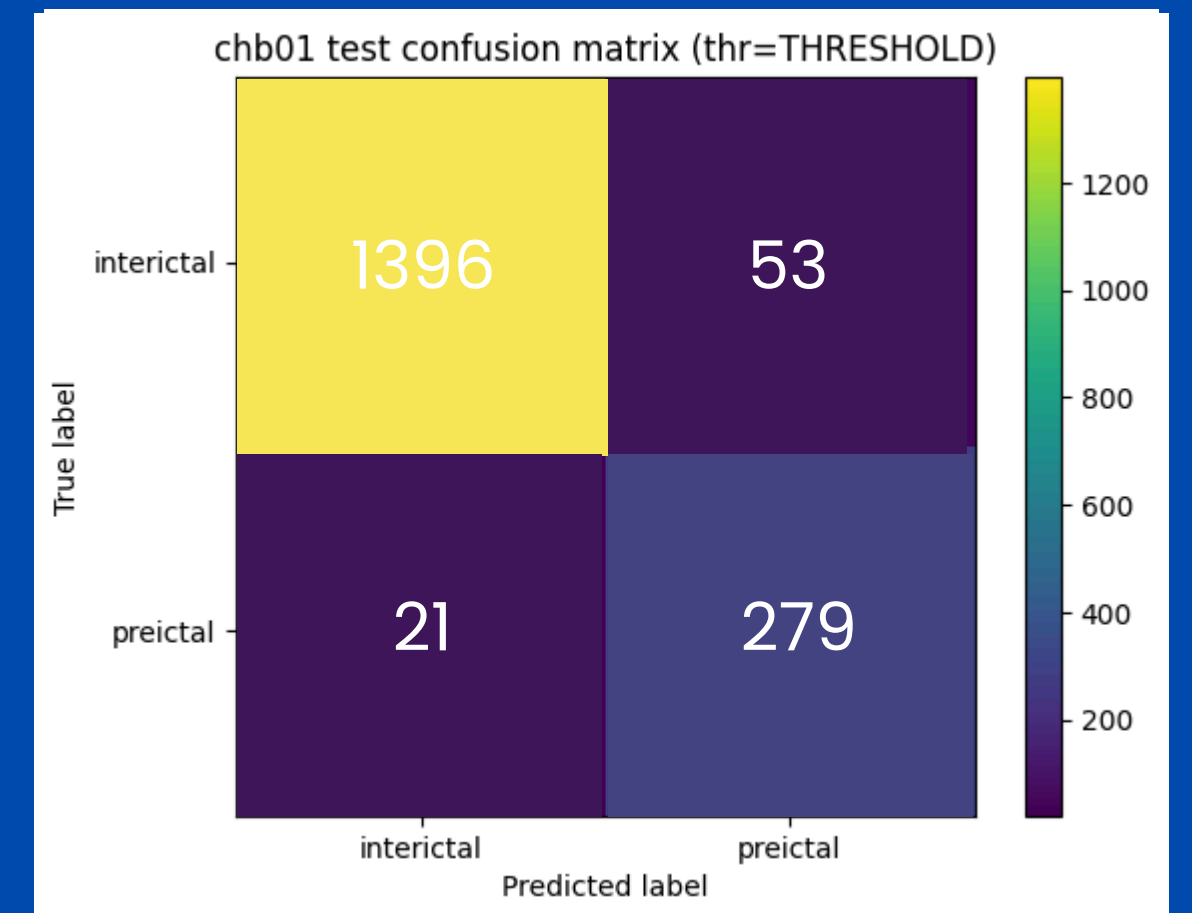
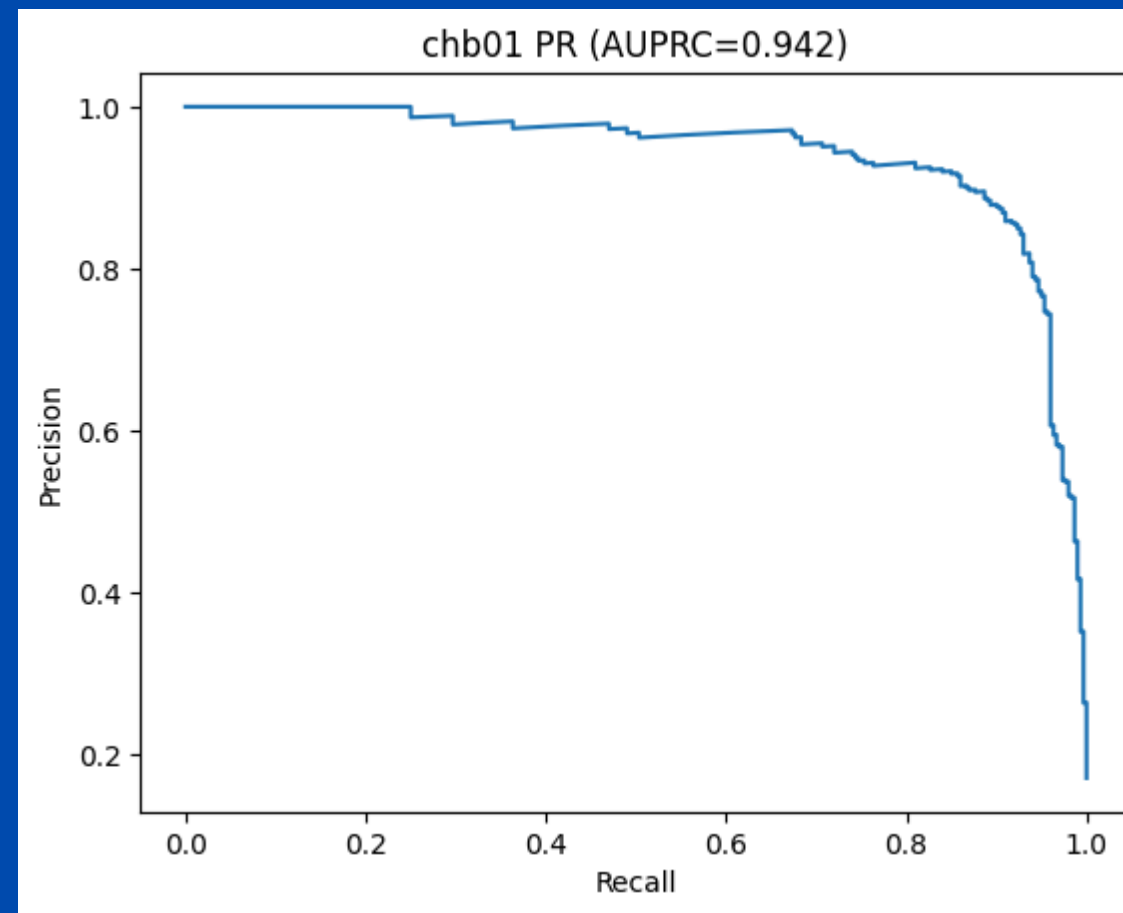
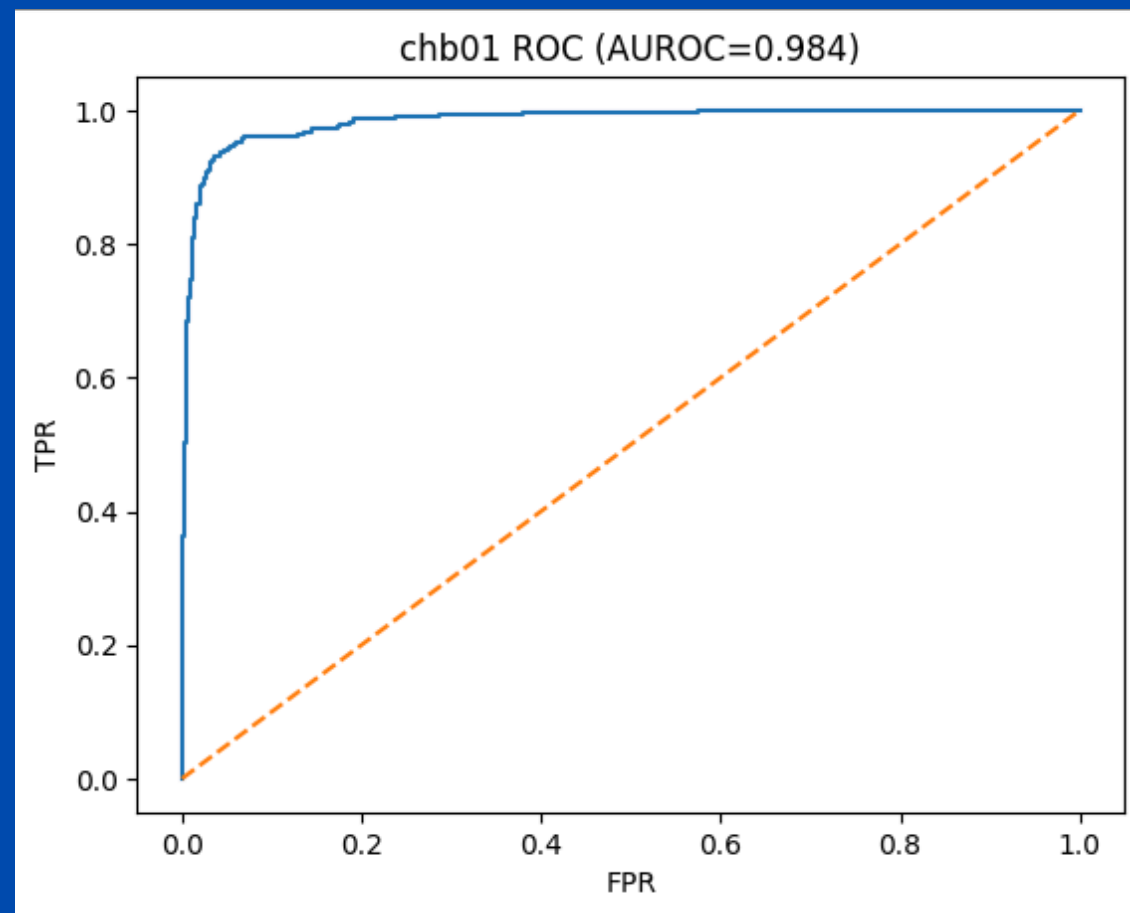
Results: All Subjects Model



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Pre-ictal: 76% correct
Inter-ictal: 36% correct

Results: Personalized Model



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Pre-ictal: 93% correct
Inter-ictal: 96% correct

Use case for each model

All Subjects Model:

- Patients who have no prior EEG data recorded
- Patients who are currently recording their data to later get a personalized model

Personalized Subject Model:

- Patients who have recorded their EEG data and seizure activity (fairly common for people with epilepsy and chronic seizures)
- Patients who want a higher accuracy predictor

Overall, we would recommend a personalized model, but we understand there are limitations to collecting personalized data.

Limitations

- Computationally expensive to process a lot of data
- Requires positive seizure examples to train the model
- Difficult to collect EEG recordings of seizure activity

Conclusion

- We would recommend a personalized model, but understand there are limitations to collecting and processing personalized data
- Seizure detection does vary between patients
- We are able to detect potential seizure activity in the pre-ictal state



Thank you!

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