# Anomalous Resonance Identification with Autoencoders

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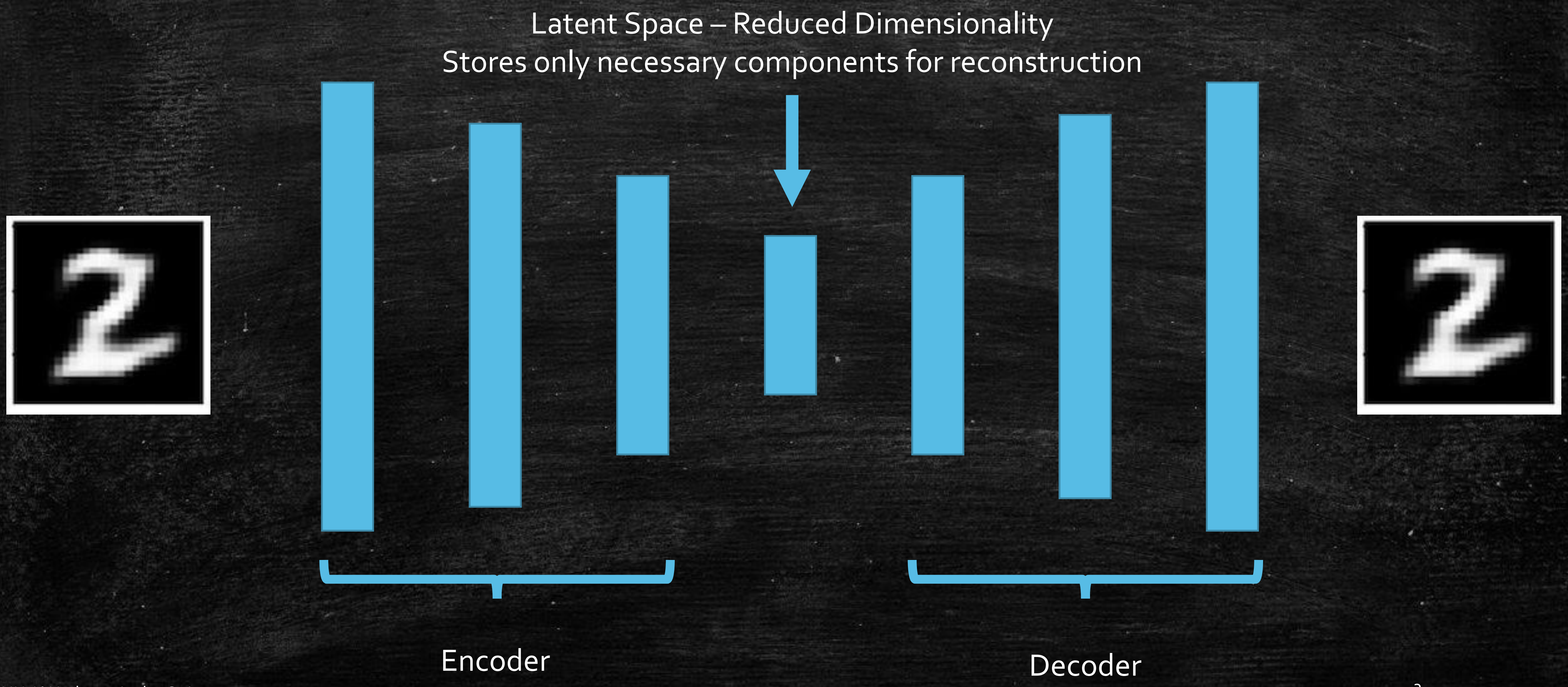
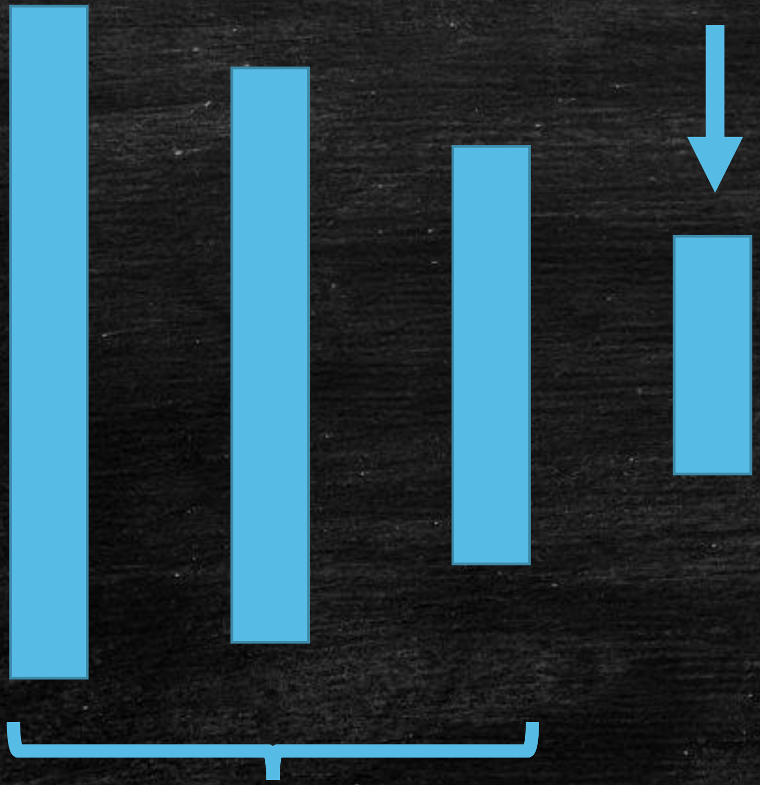
# What is an Autoencoder?



# What is an Autoencoder?

Latent Space – Reduced Dimensionality
Stores only necessary components for reconstruction



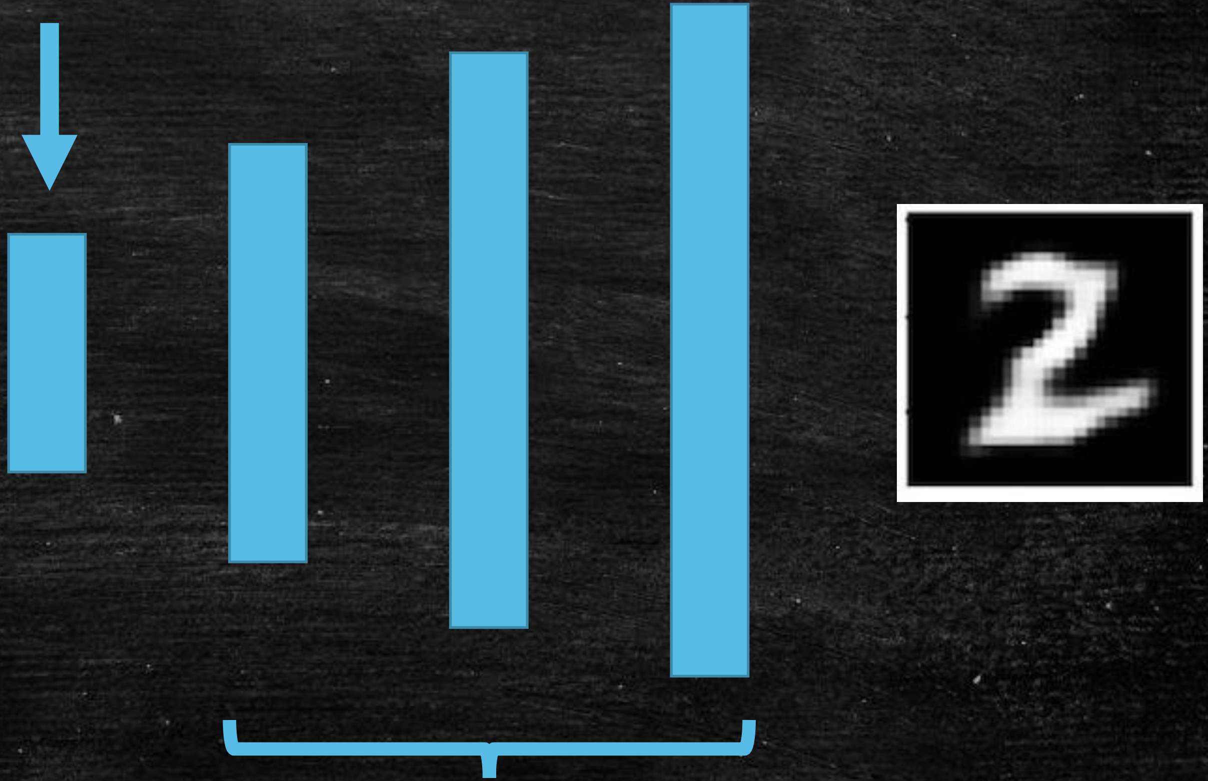
Encoder

The Encoder's job is to reduce the dimensionality of the feature space.

# What is an Autoencoder?

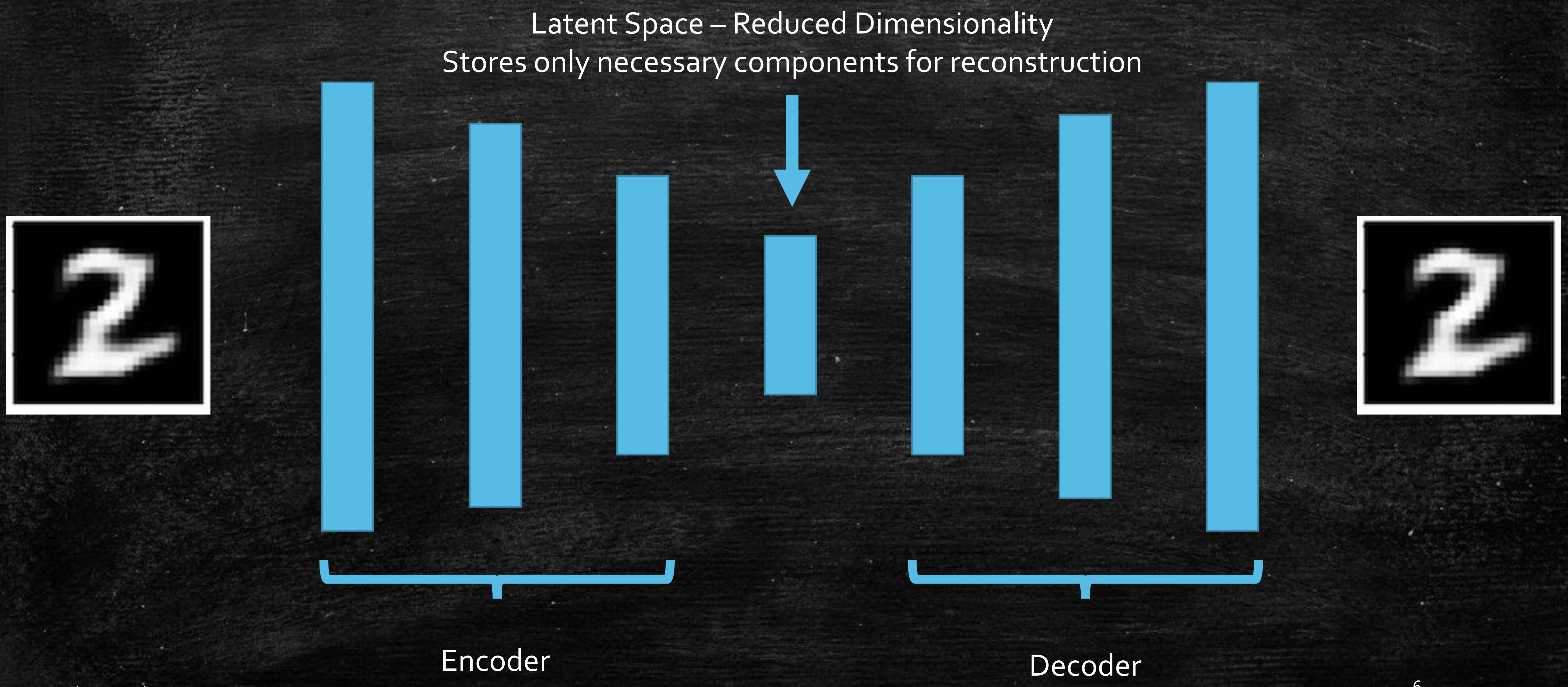
Latent Space – Reduced Dimensionality
Stores only necessary components for reconstruction

The Decoder's job is to take this encoded latent representation and reconstruct the original feature space.

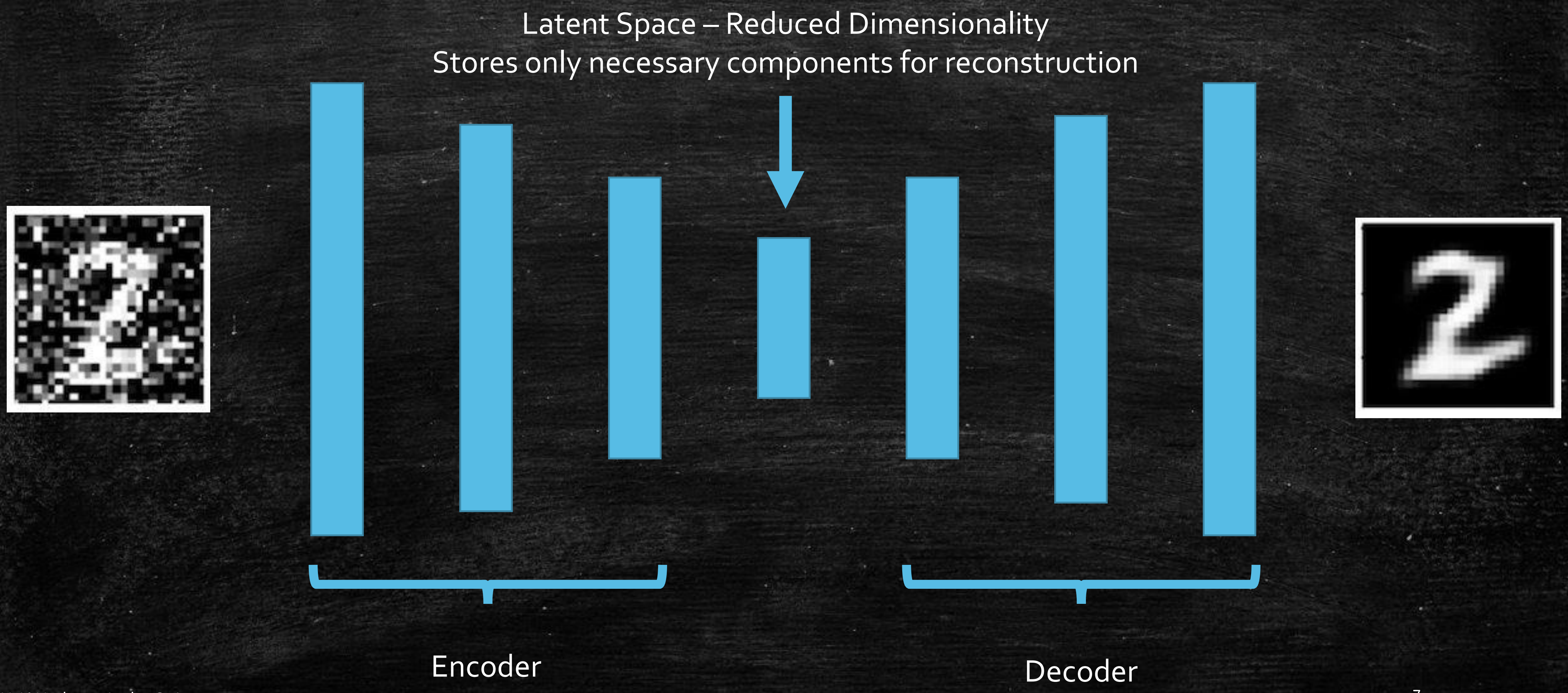


Decoder

# What is an Autoencoder?



# What is an Autoencoder?



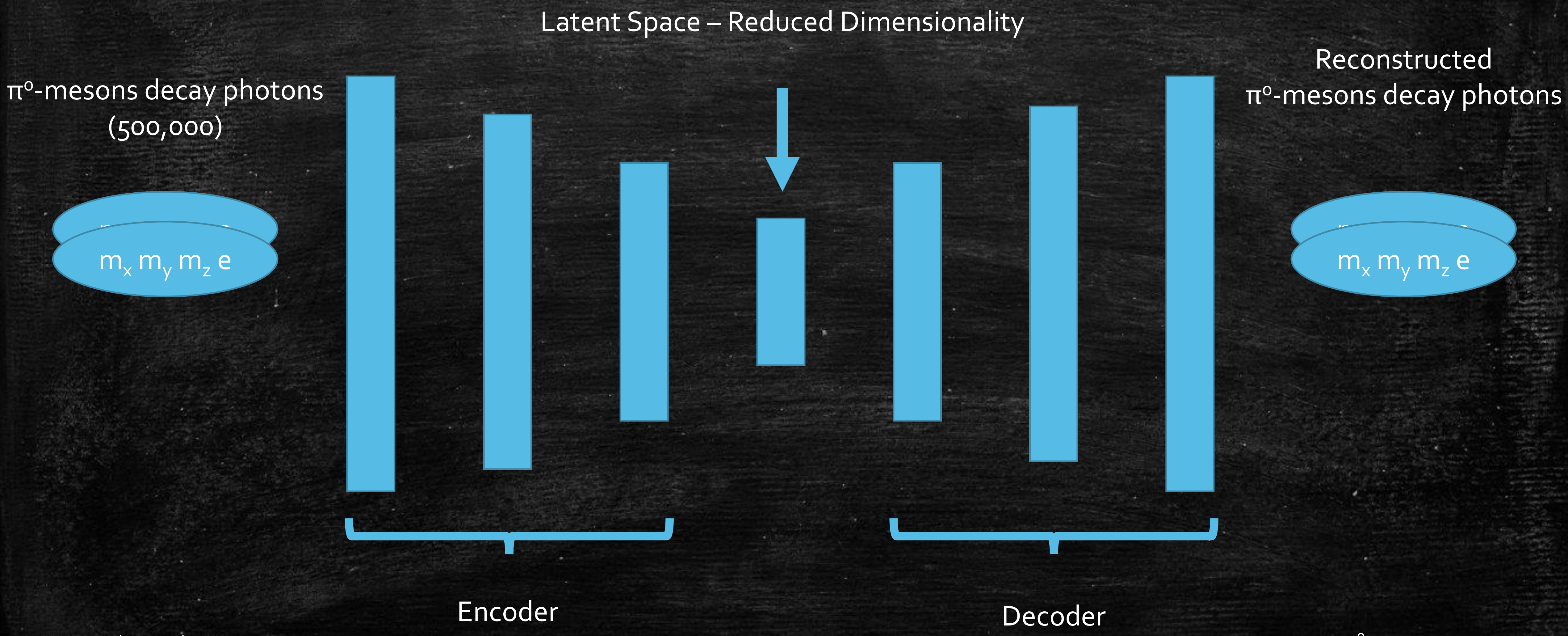
# Anomalous Resonance Identification?

- The goal is to Identify several resonances with only one known resonance.
- I will be using exclusively the decaying photons to allow the autoencoder more freedom and flexibility to encode the resonance.
- In this method we <u>intentionally overtrain</u> a specific known resonance, such as $\pi^0$, during training.
- By doing this, the latent representation of resonances will only make sense for our <u>overtrained resonance</u>.

$\pi^0$-mesons decay photons

Reconstructed $\pi^0$-mesons decay photons

# Training Data



# Theory

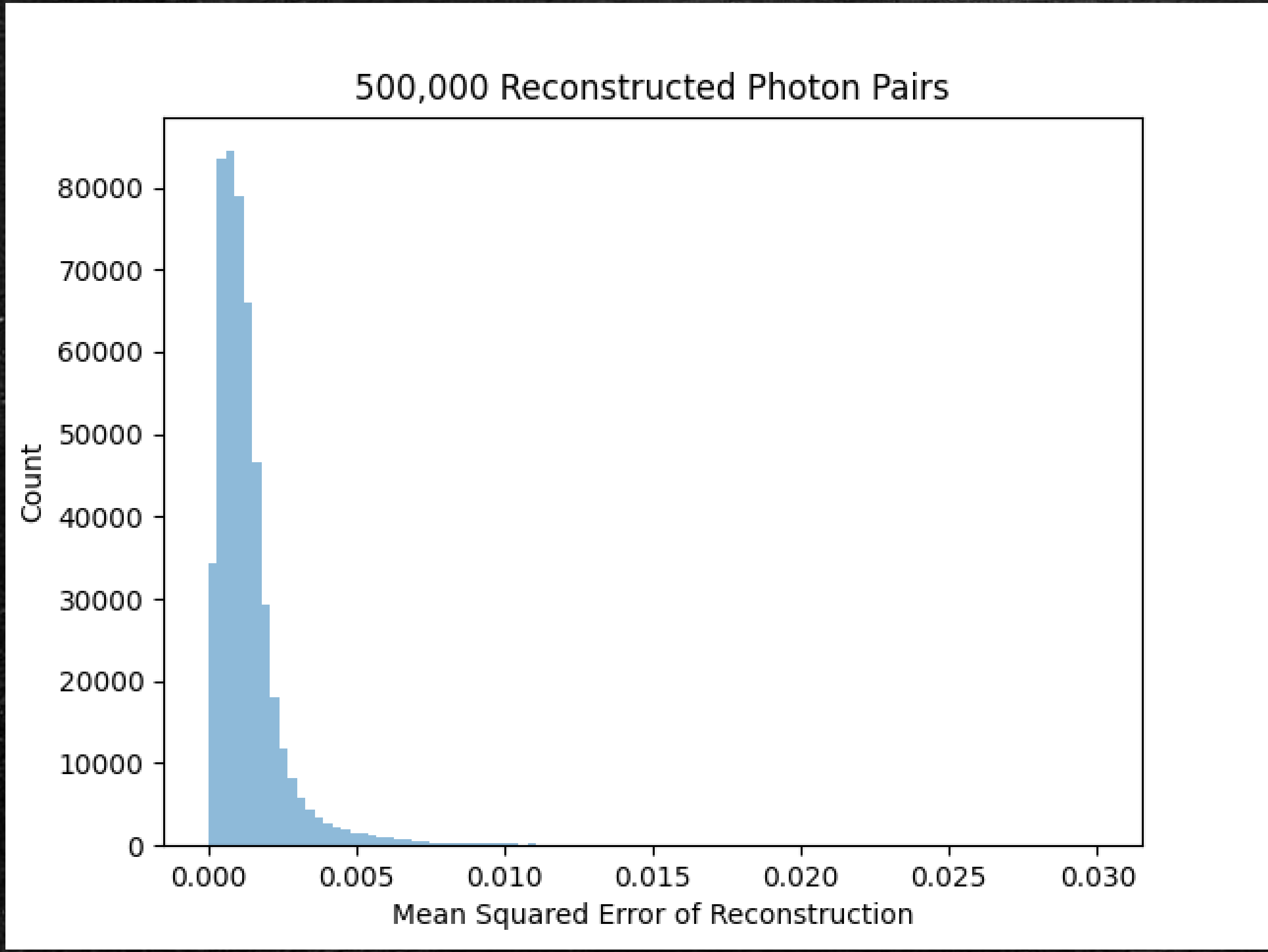
$\pi^0$-meson decay photons

A well reconstructed $\pi^0$-meson decay photons

$\eta$-mesons decay photons

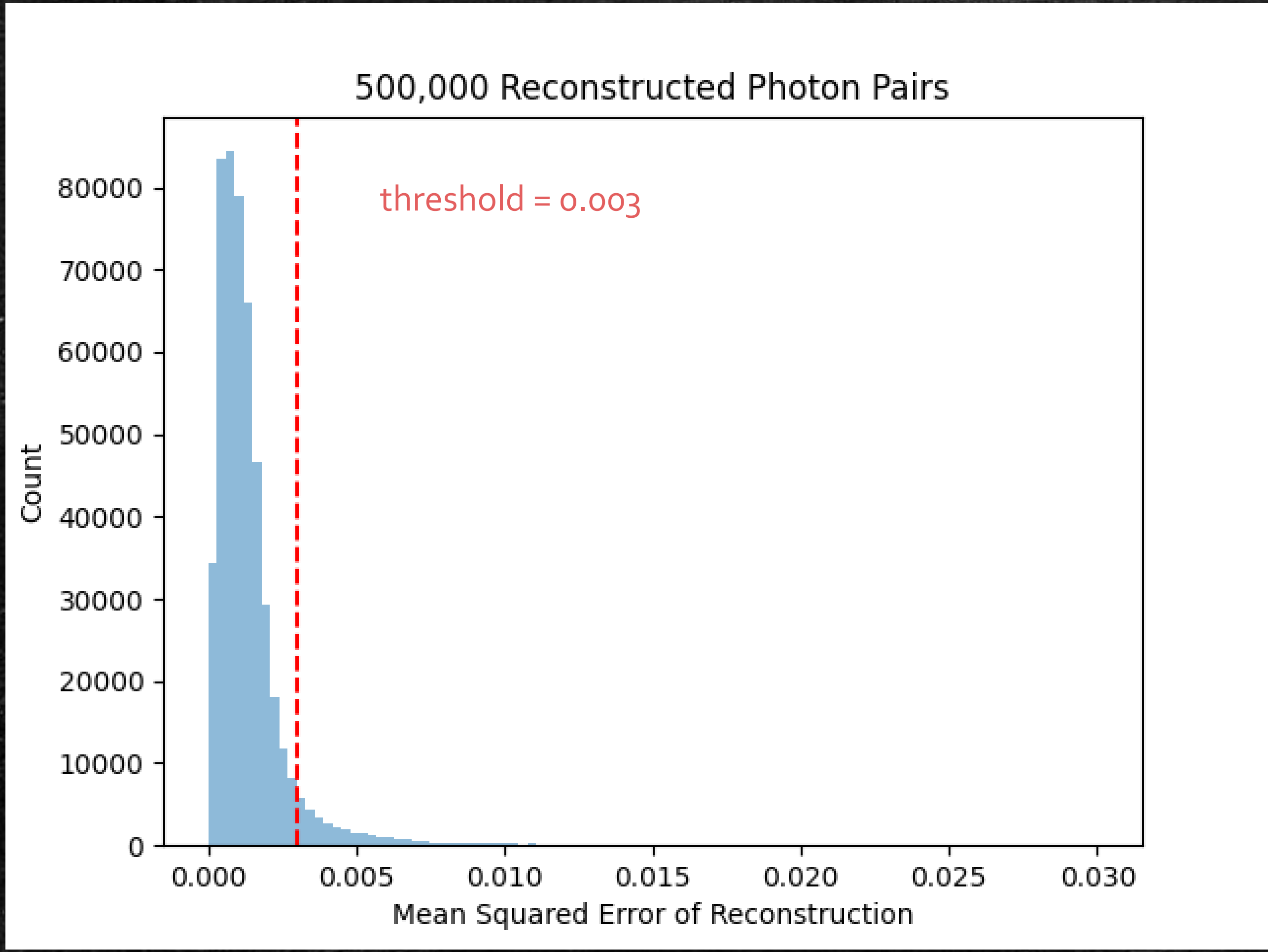
? Jumbled mess
(Anomaly!)

# Results




- After Training, we can plot a histogram of the photon pair's reconstruction loss.
- Now let's eyeball a threshold to justify an "Anomaly".

# Results




- After Training, we can plot a histogram of the photon pair's reconstruction loss.
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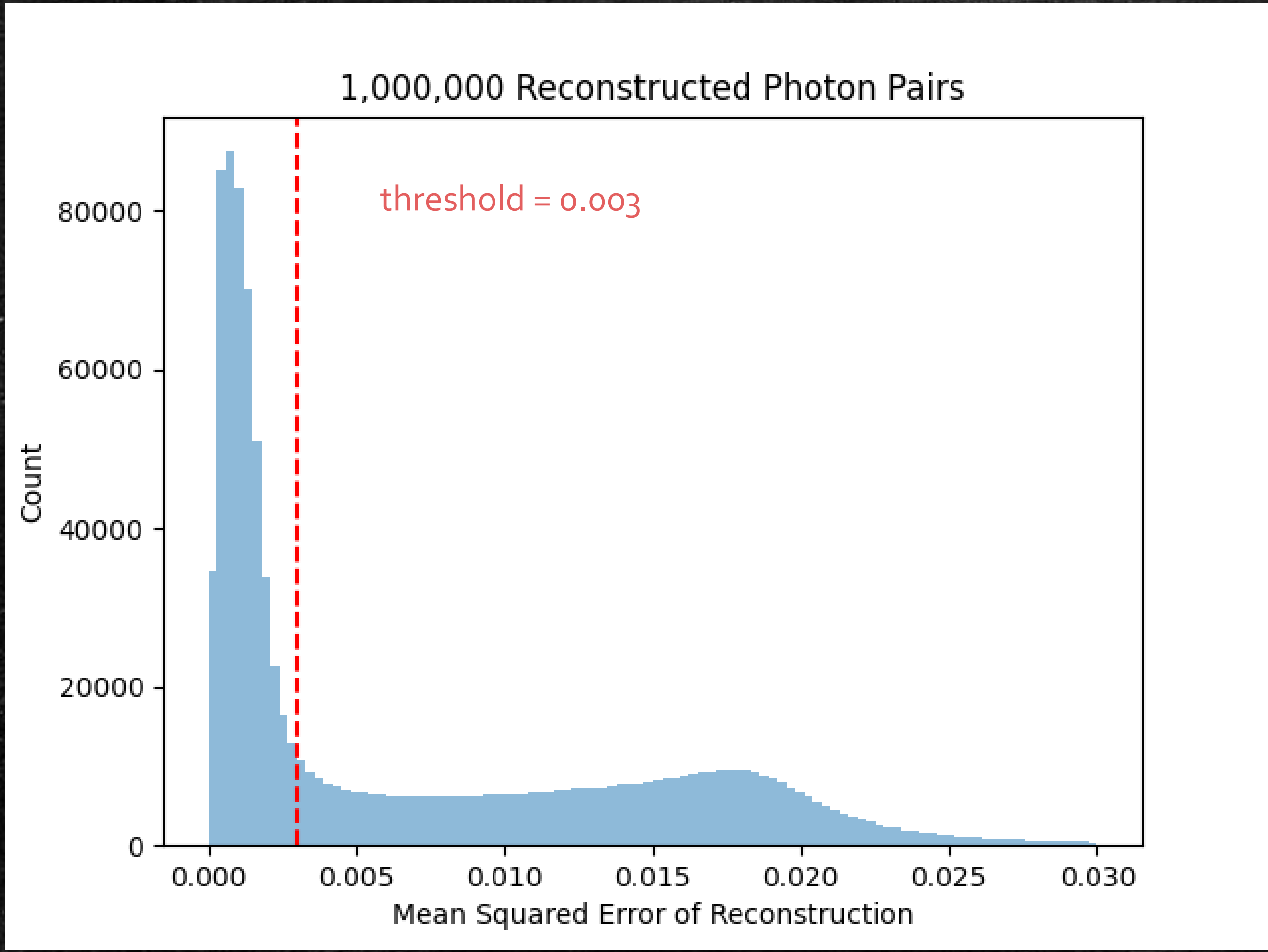
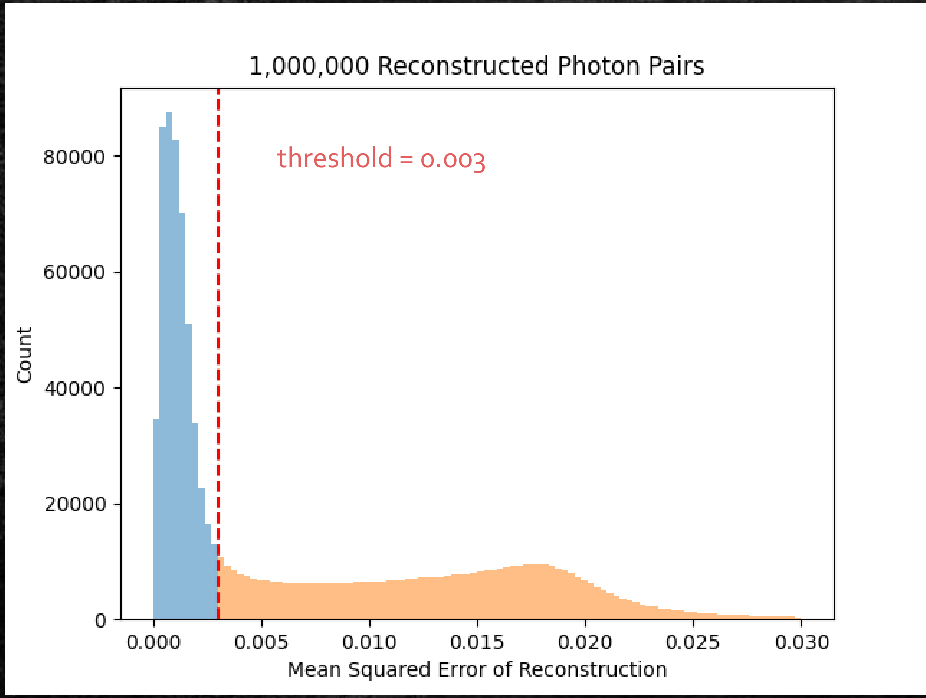
# Results

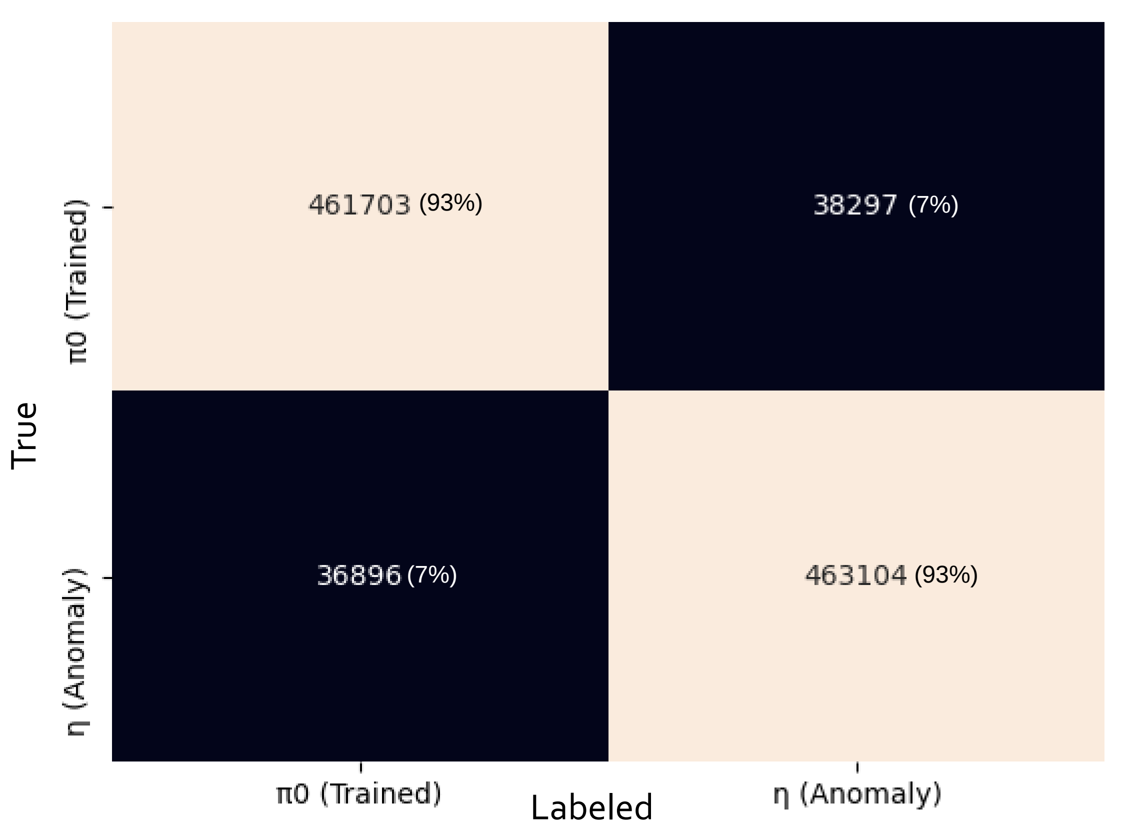



- After Training, we can plot a histogram of the events and their reconstruction loss.
- Now let's eyeball a threshold to justify an "Anomaly".
- Adding in some new data: η-mesons

# Results

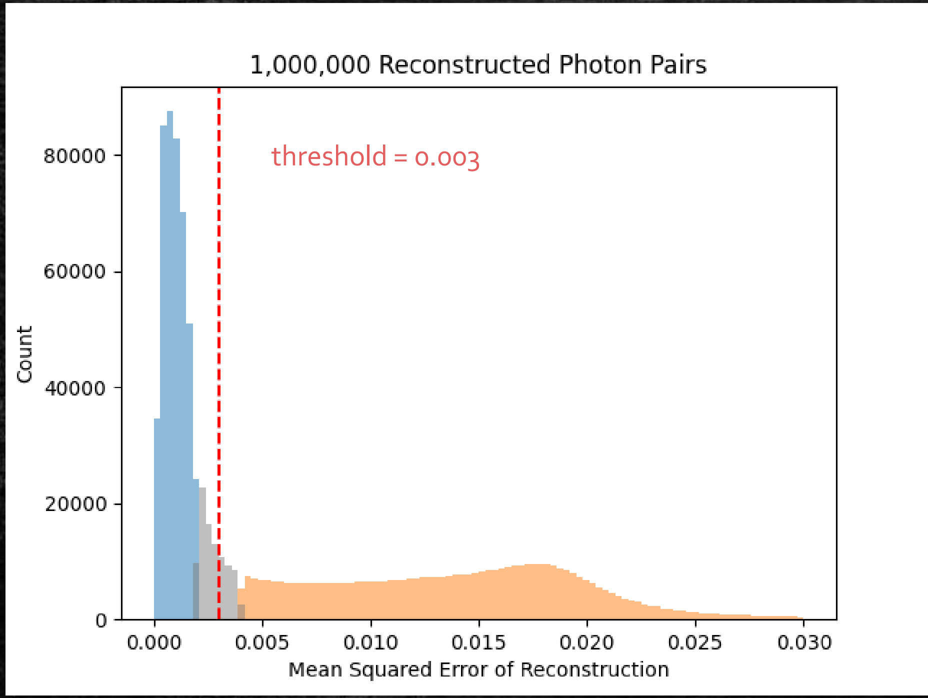
We can very crudely classify using this threshold.
By doing so we get the following results:

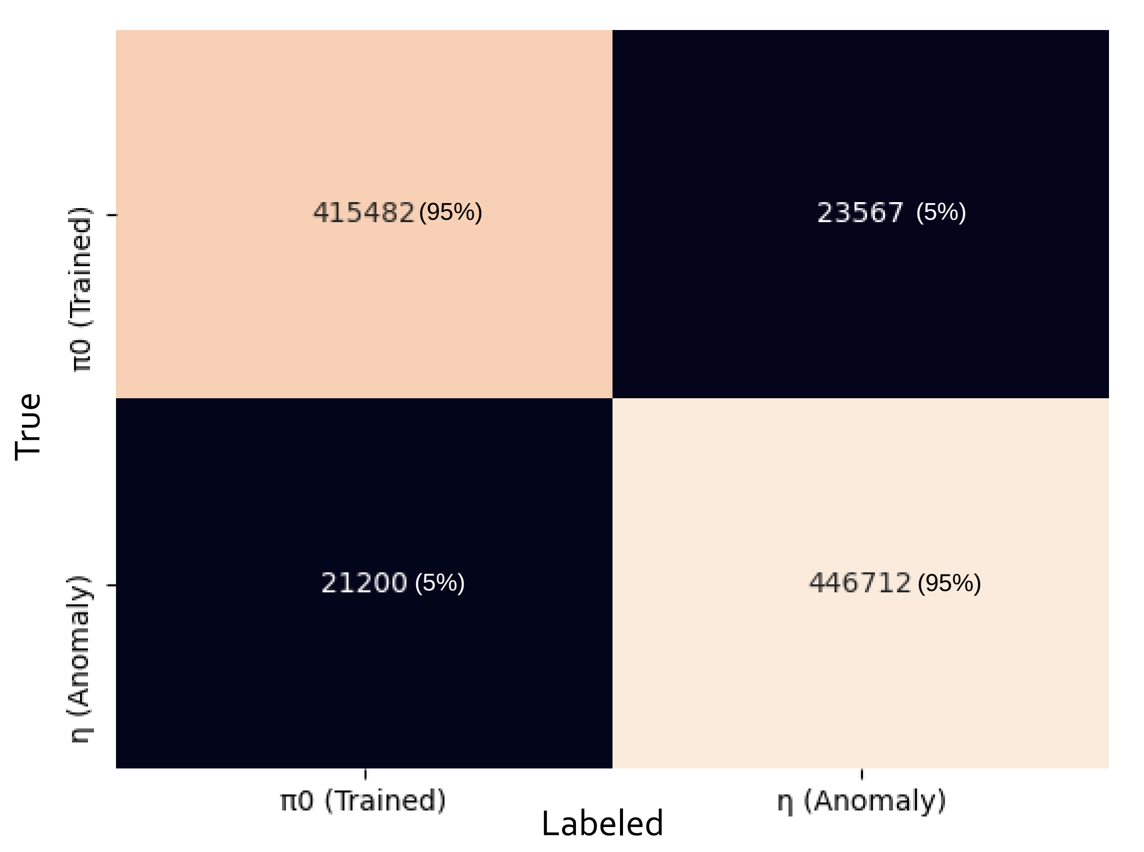


# Results

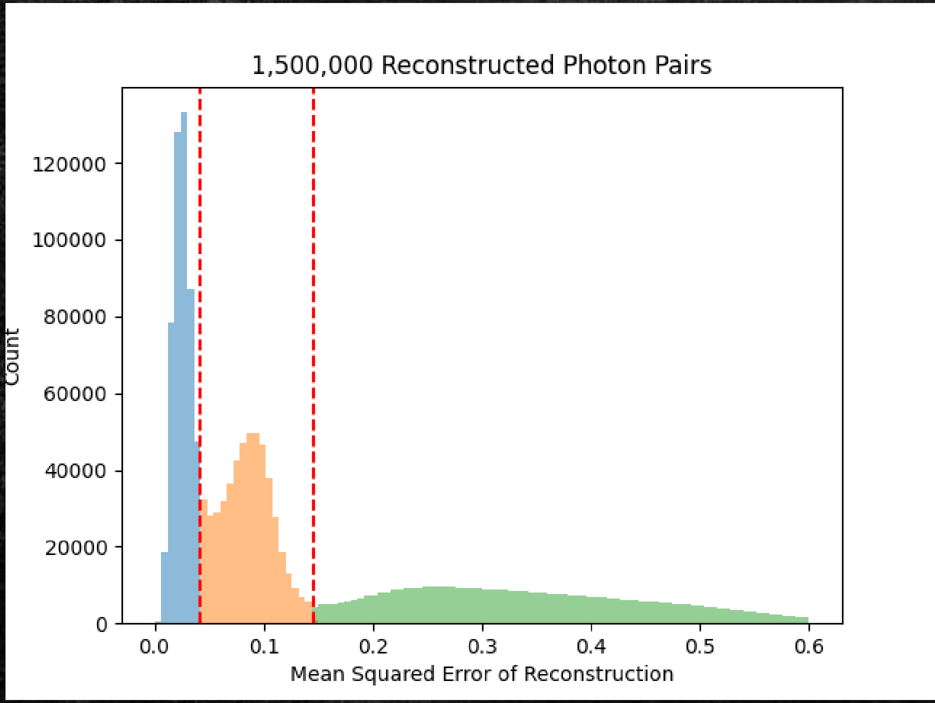
We can also take out a portion of the loss space for 'uncertainty':

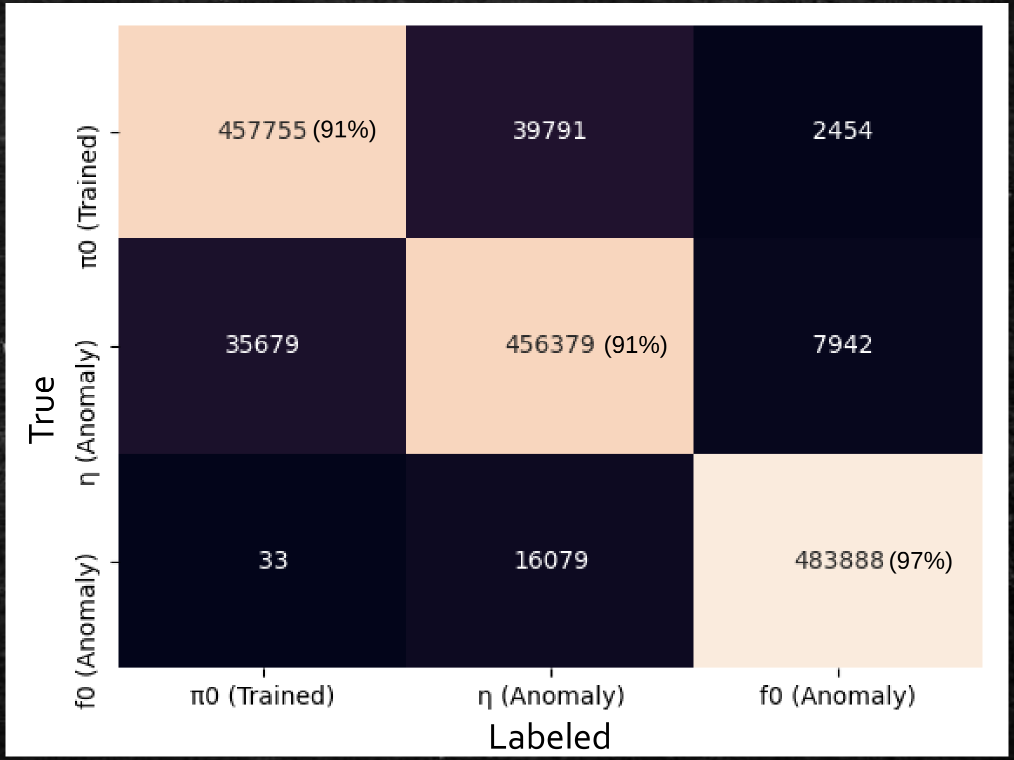


# Does this expand beyond 2 Resonances?

Let's see what happens when we add another Resonance:



# Summary

- Unsupervised classification of decays with only being trained on one resonance
  - With multiple categories!
- What can we do with this?
  - Would it be possible to use as a way of selecting signal?
  - Is it possible to find evidence of new resonances using this technique?
- Preliminary work with promising results!