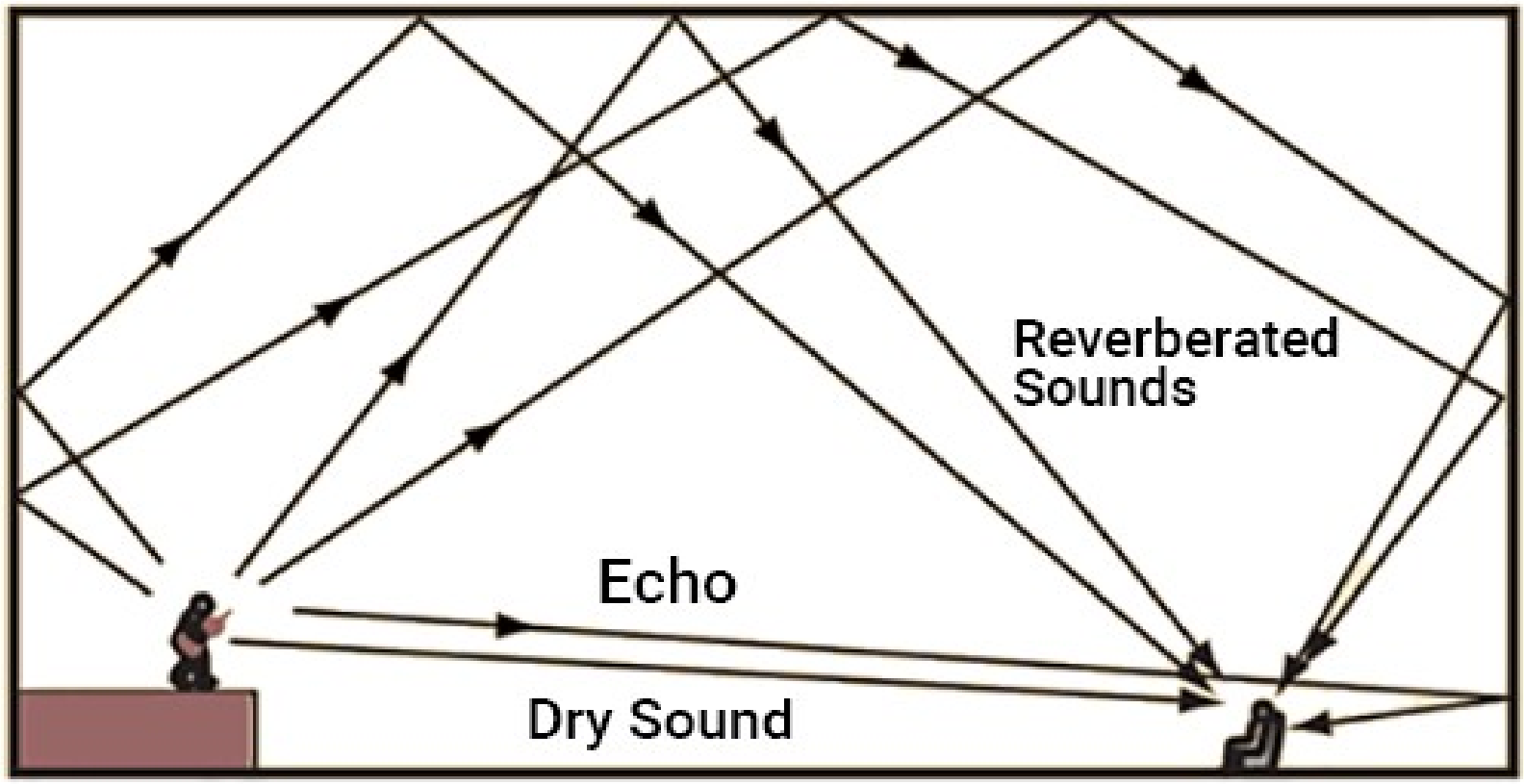
Remove reverb from sound

Reverb = echo from walls



- source: https://www.softdb.com/what-is-reverberation-in-acoustical-analysis/

Use cases

1) professional music production
   - real time
   - high quality of sound required
2) home recordings
   - post production of recordings for e.g. youtubers
   - not real time
3) speech transfer
   - zoom, phone calls
   - real time
   - lower quality is sufficient

Generate sound with reverb

- anechoic sound + convolution with IR = sound with reverb

$$\int_0^t f(t-y)g(y)dy = h(t)$$

- IR: Impulse Response characterizes the room acoustics
- can be computed with FFT
- IR depends on:
  - room size and shape
  - position of source and receiver
  - shape and size of objects in the room

Strategies for dereverberation

- IR is **known:**
  - deconvolve signal with IR

- IR is **unknown:**
  - known as blind dereverberation/deconvolution

1) classify IR with neural network and deconvolve with a known IR
2) predict dereverberated signal directly with autoencoder

Deconvolution

- deconvolution requires a **known** IR
- can be done by FFT
- numerically unstable: strong amplification of even small noise
- better, but not perfect: Wiener deconvolution
- many problems, e.g.
  - deconvolved sound with length of 10s
  - same sound, same deconvolution, but length of 11s

Blind dereverberation by classification

- train
  1) sufficiently sample space of relevant IRs
  2) generate sound with reverb
  3) train a neural network for IR classification
- deploy
  1) classify IR with a neural network
  2) deconvolve with closest IR or a linear combination of IRs
- classification of 20 different IRs works well with a network similar as for speech MNIST

Possible strategies

- Work with MEL spectrograms
  - AE and WaveGlow

    (too slow for RT execution)
  - AE and WaveGAN

    (rather slow but possible)
- Work with audio signal
  - LSTM (bad quality)
  - Use WaveNet AE (slow convergence, no results, bad for reverb)
  - Train WaveGAN to omit reverb in translation (transfer learning)
- Work with STFT and complex numbers
  - Unknown territory! (potential to be fast)

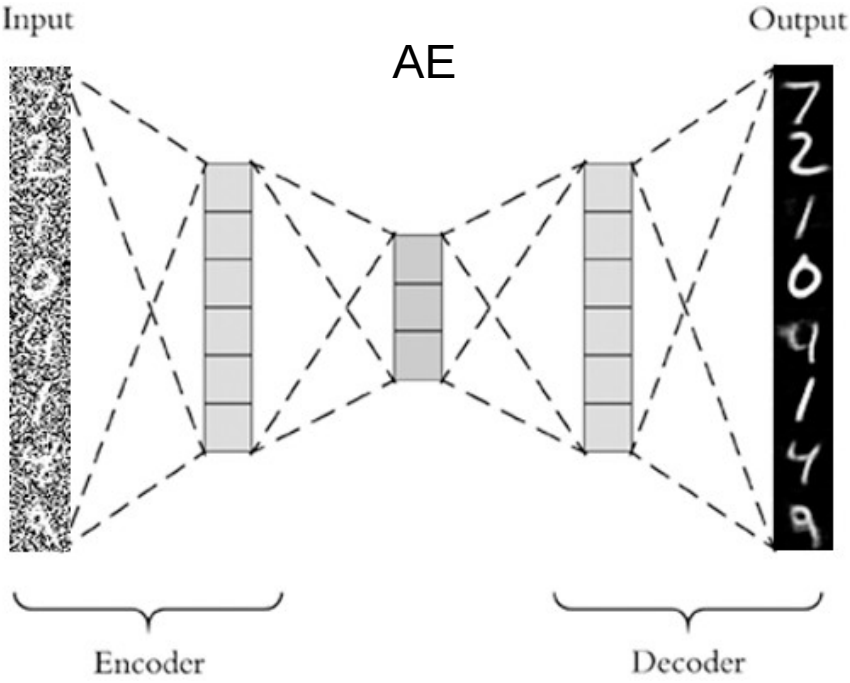
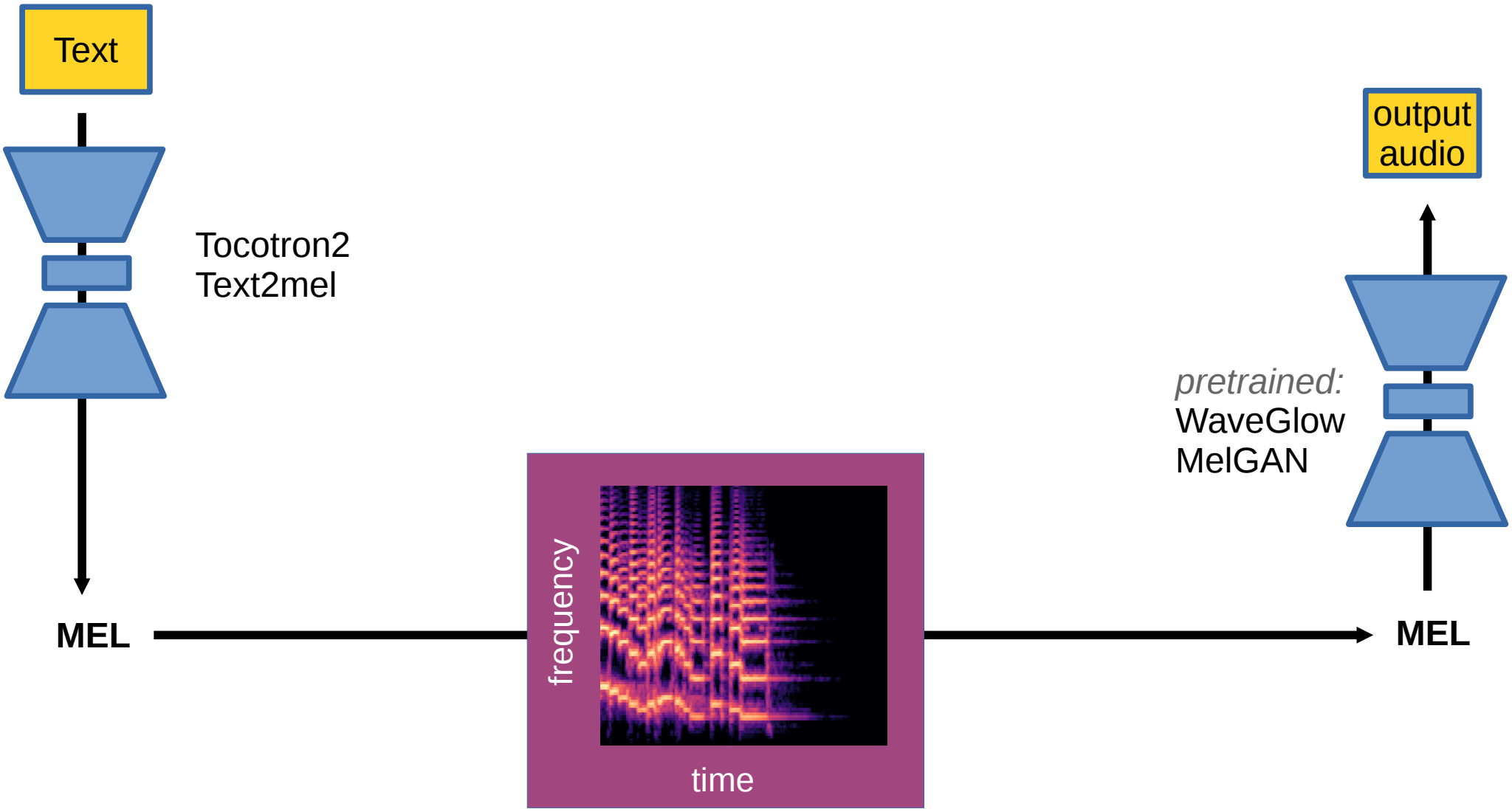
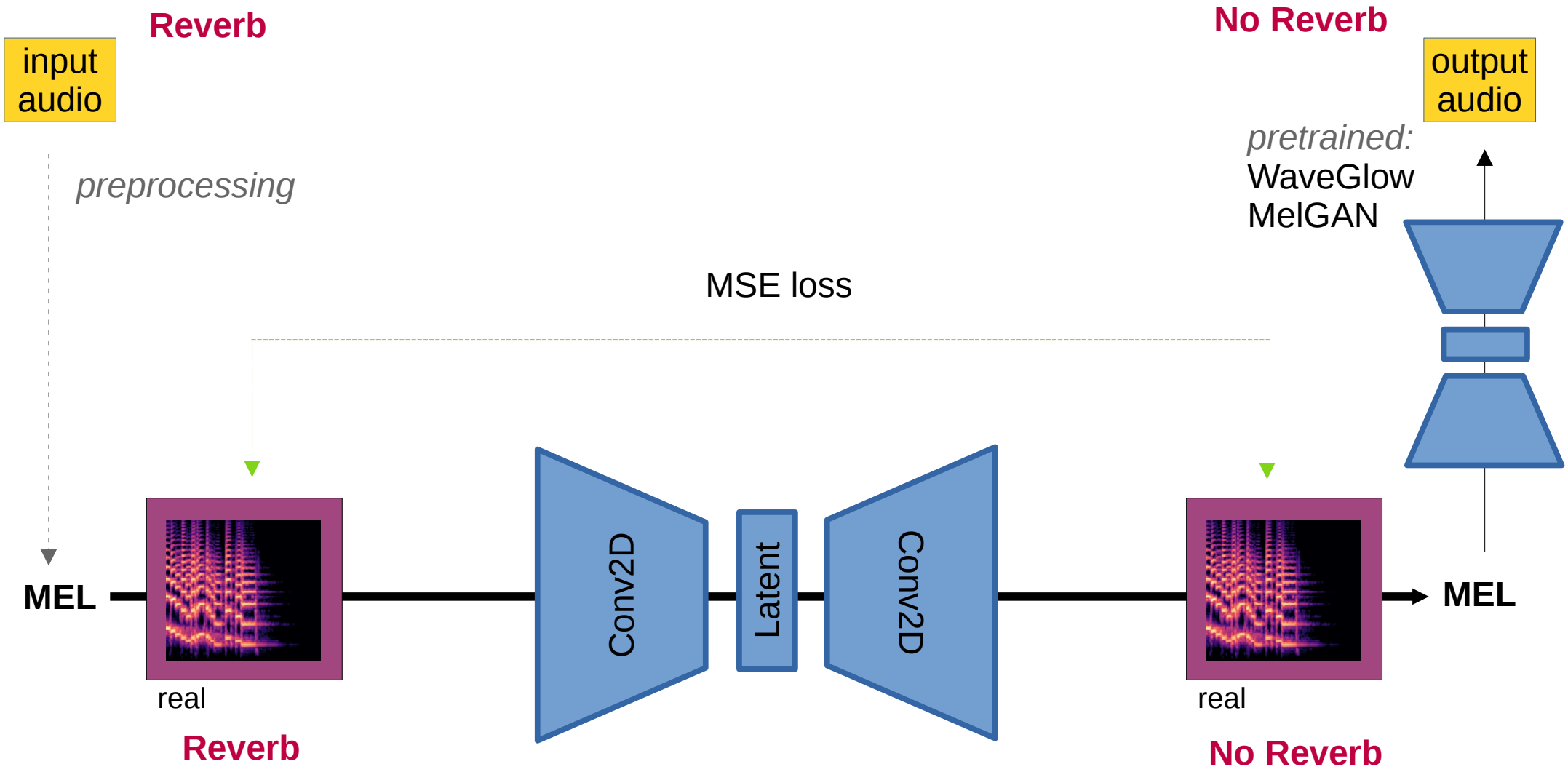


Image source:
pyimagesearch.com/wp-content/uploads/2020/02/keras_denoising_autoencoder_header.png

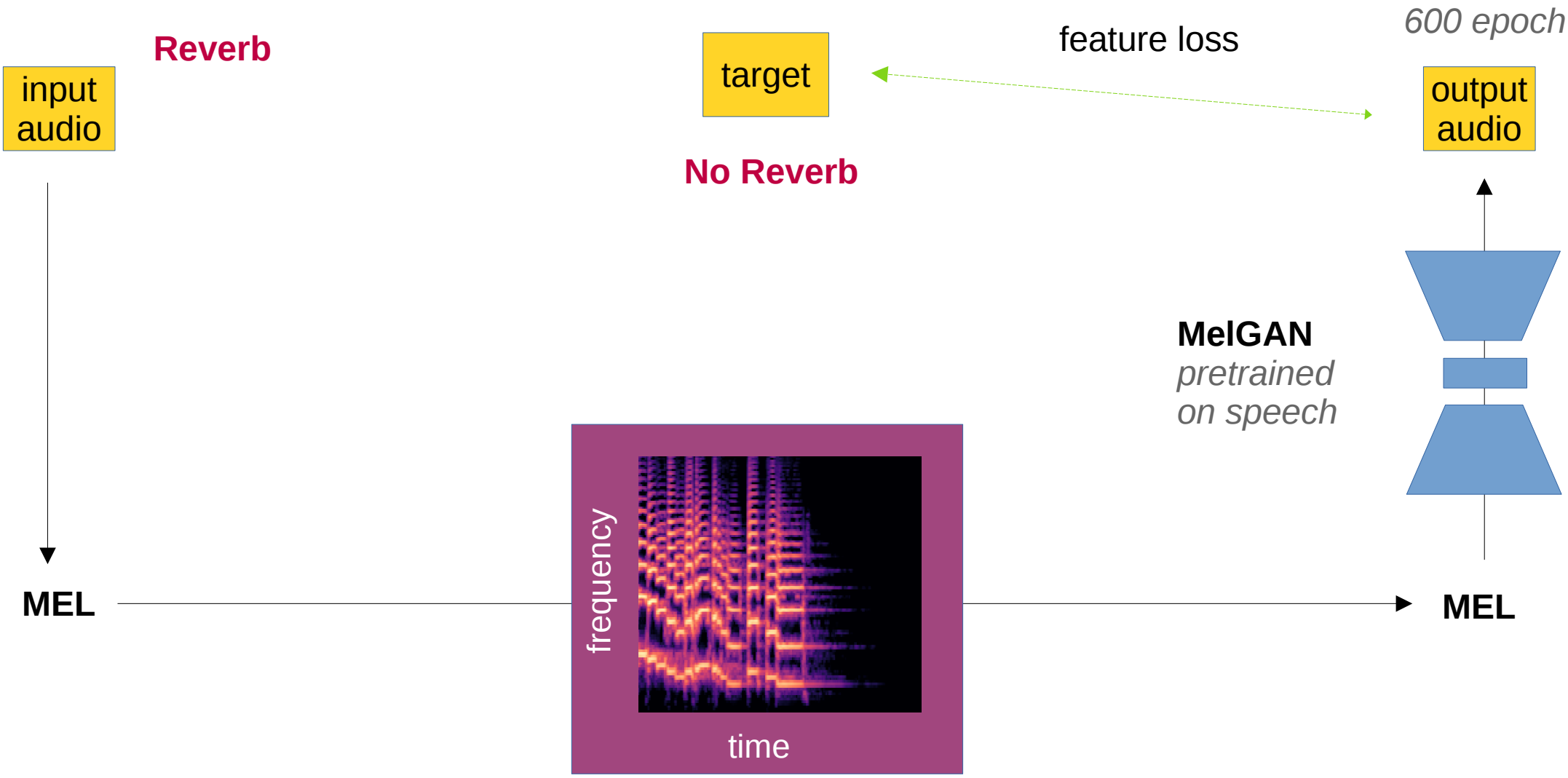
MEL (Text-to-Speech SOTA)



MEL SOTA *Slow!*



MelGAN - transfer learning

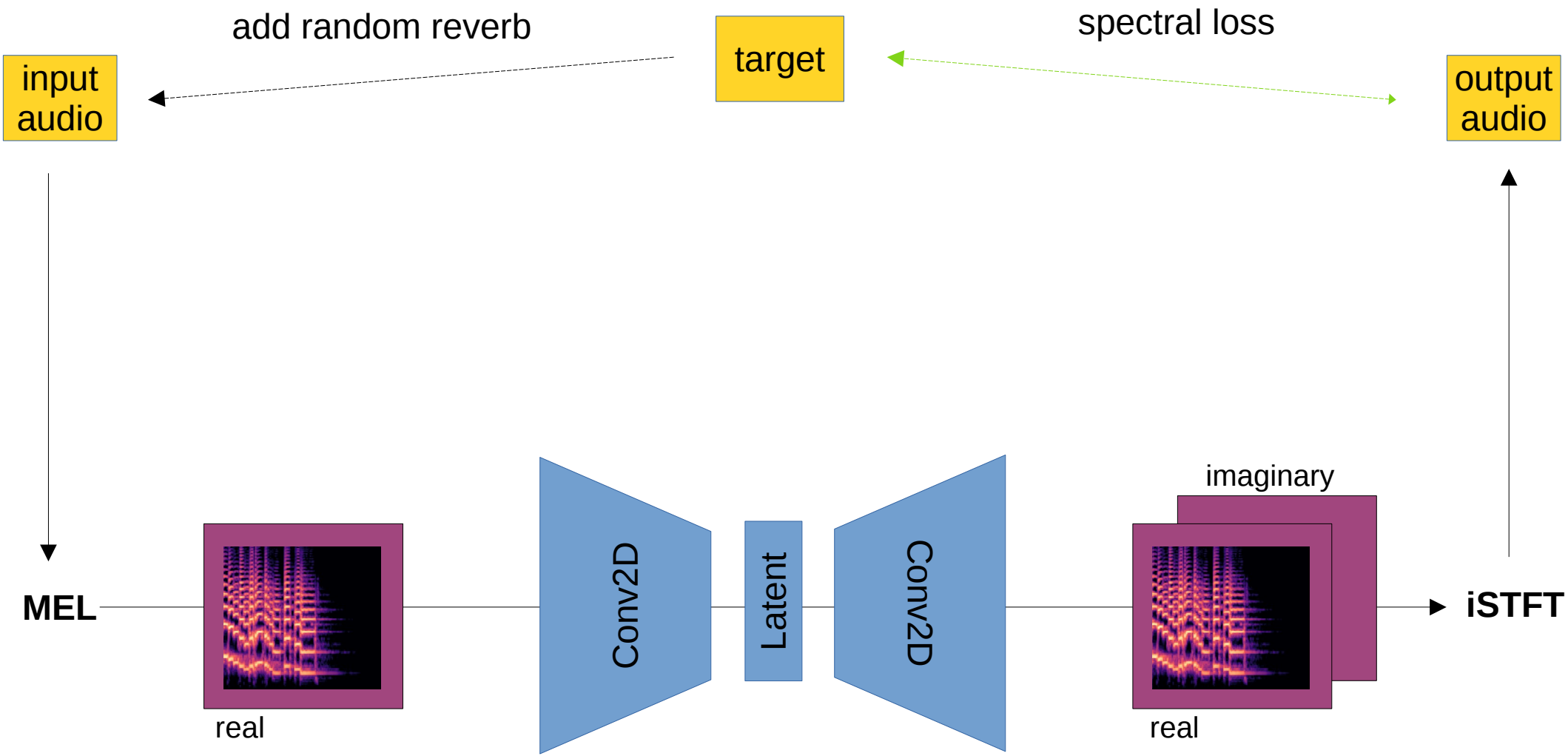


Unseen speaker

MelGAN trained on speech

1600 epoch

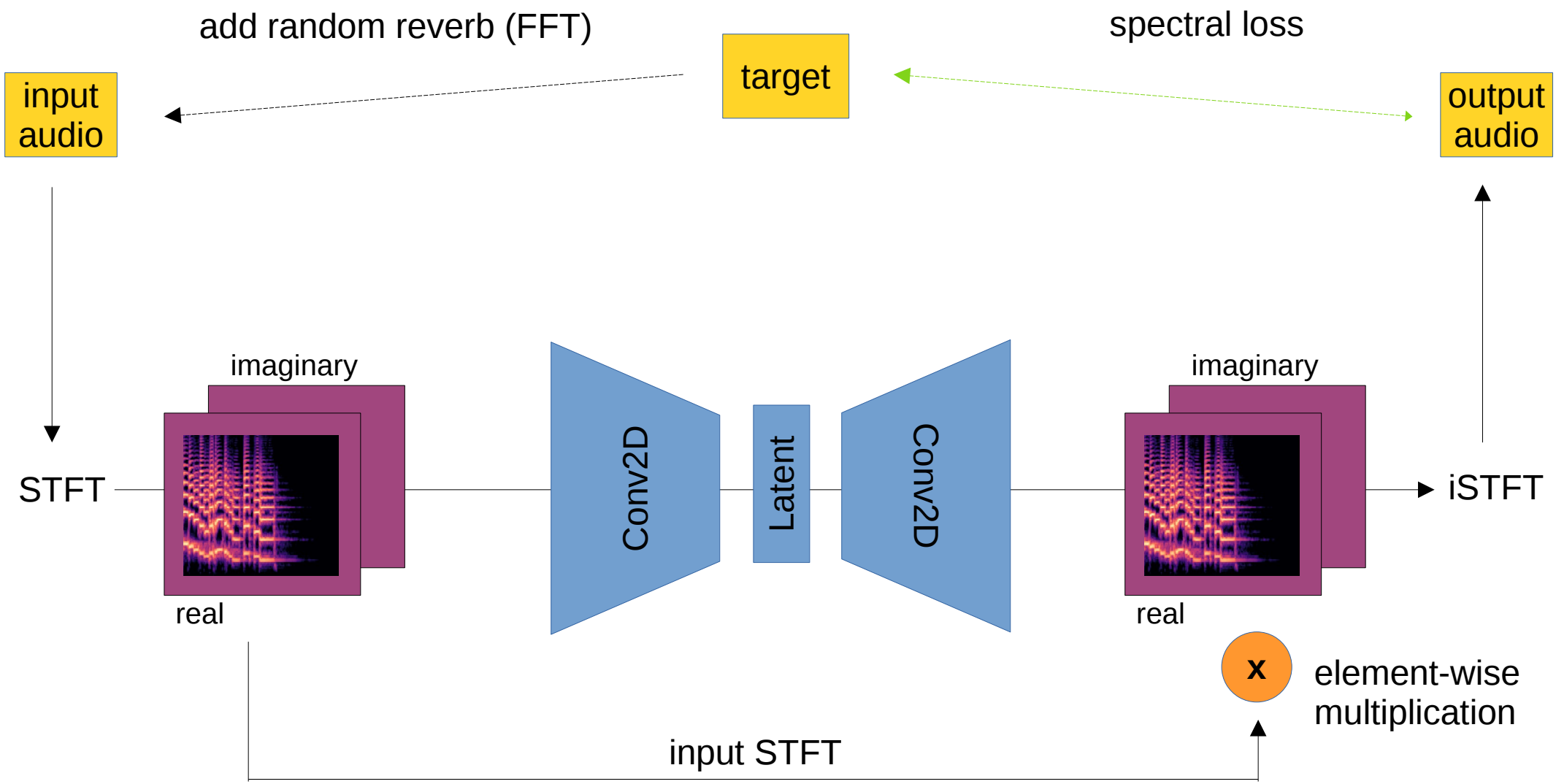
MEL-to-STFT



Unseen speaker

Mel-to-STFT test

STFT



real data | test | add room reverb | or a big reverb

Conclusions

- high sound quality requires sufficient sampling of IRs → requires a lot of resources
- NNs can work with complex numbers (STFT) when the right architecture is used
- combination of architecures and/or postprocessing with e.g. noise filters might yield better results