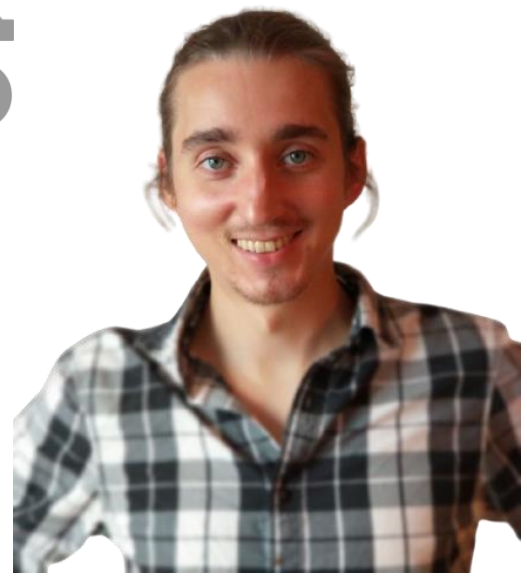


Fault Detection in Solar Thermal Systems using

Probabilistic Reconstructions

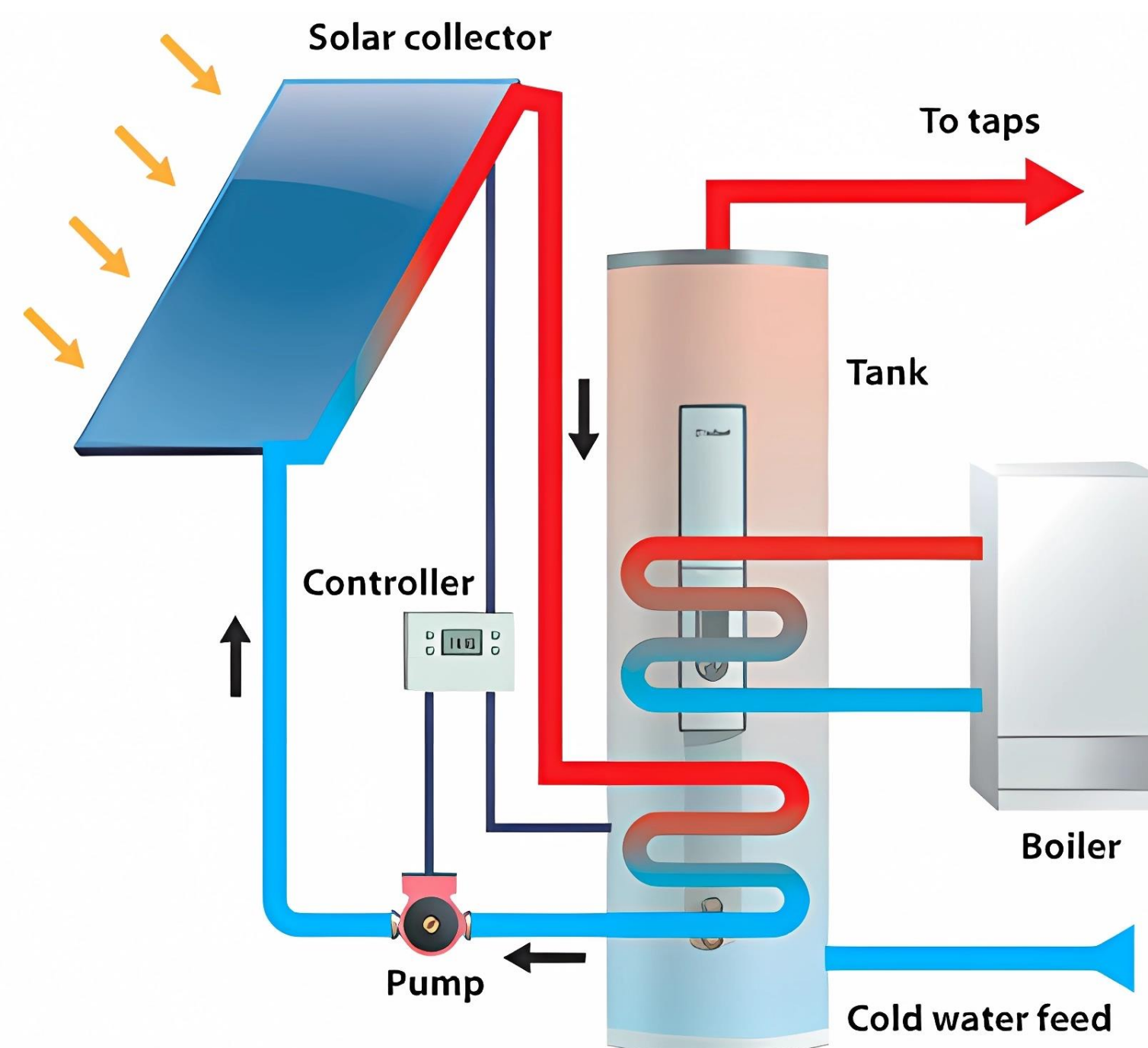


Motivation

- Solar Thermal Systems provide renewable heat with excellent efficiency.
- Fault detection and monitoring by experts is prohibitively costly for domestic systems.

Approach

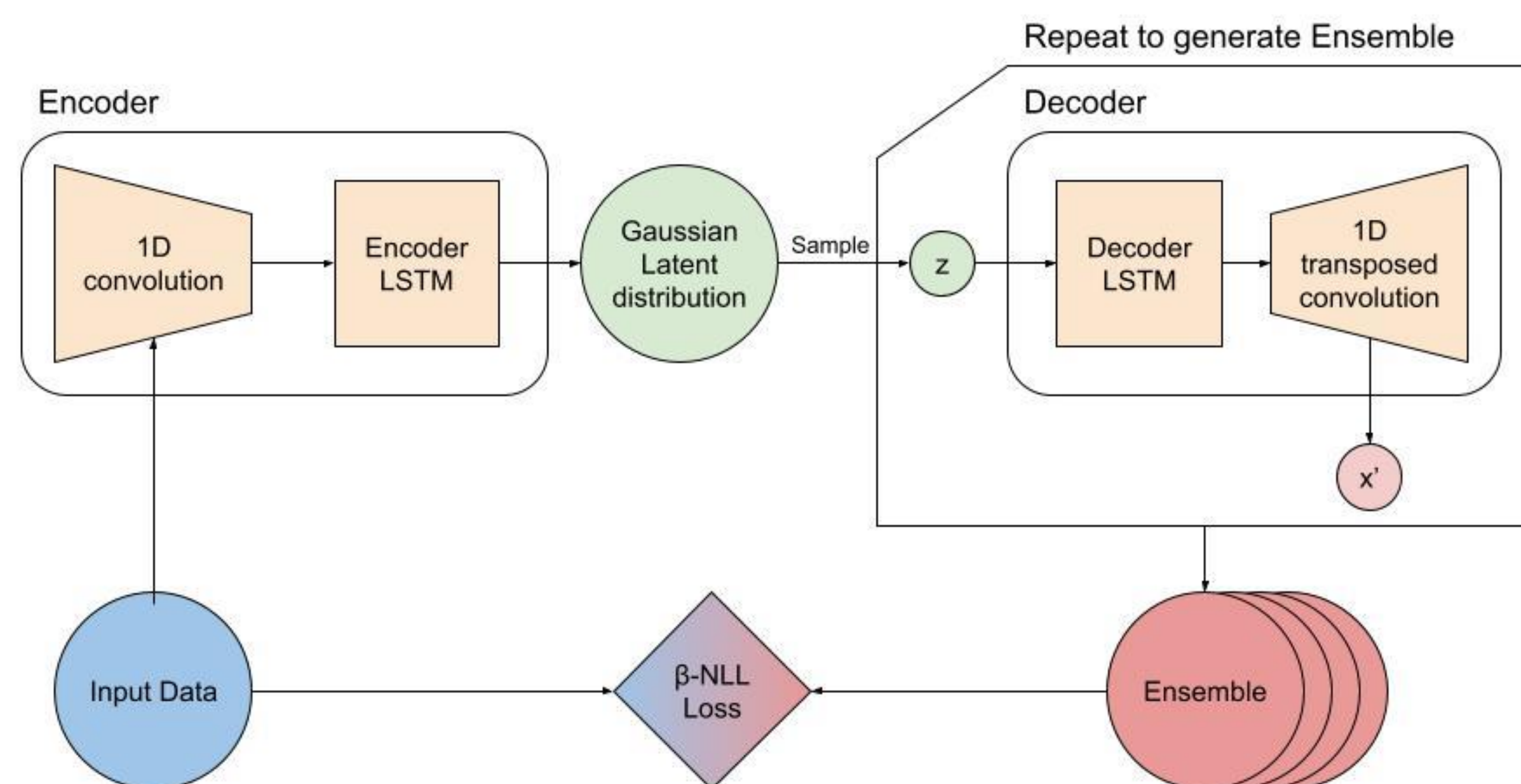
- Transfer learning
- Unsupervised training
- Uncertainty estimation
- LSTM-based Variational Autoencoder [1].



Data

- Created dataset with Ritter Energie
- 72 total systems with 38 294 days of operational data.
- Input: Sensor data, Control signals, Status data.
- Train model on nominal systems.
- Reconstruct only temperature time series.
- Reconstruct full days

Model

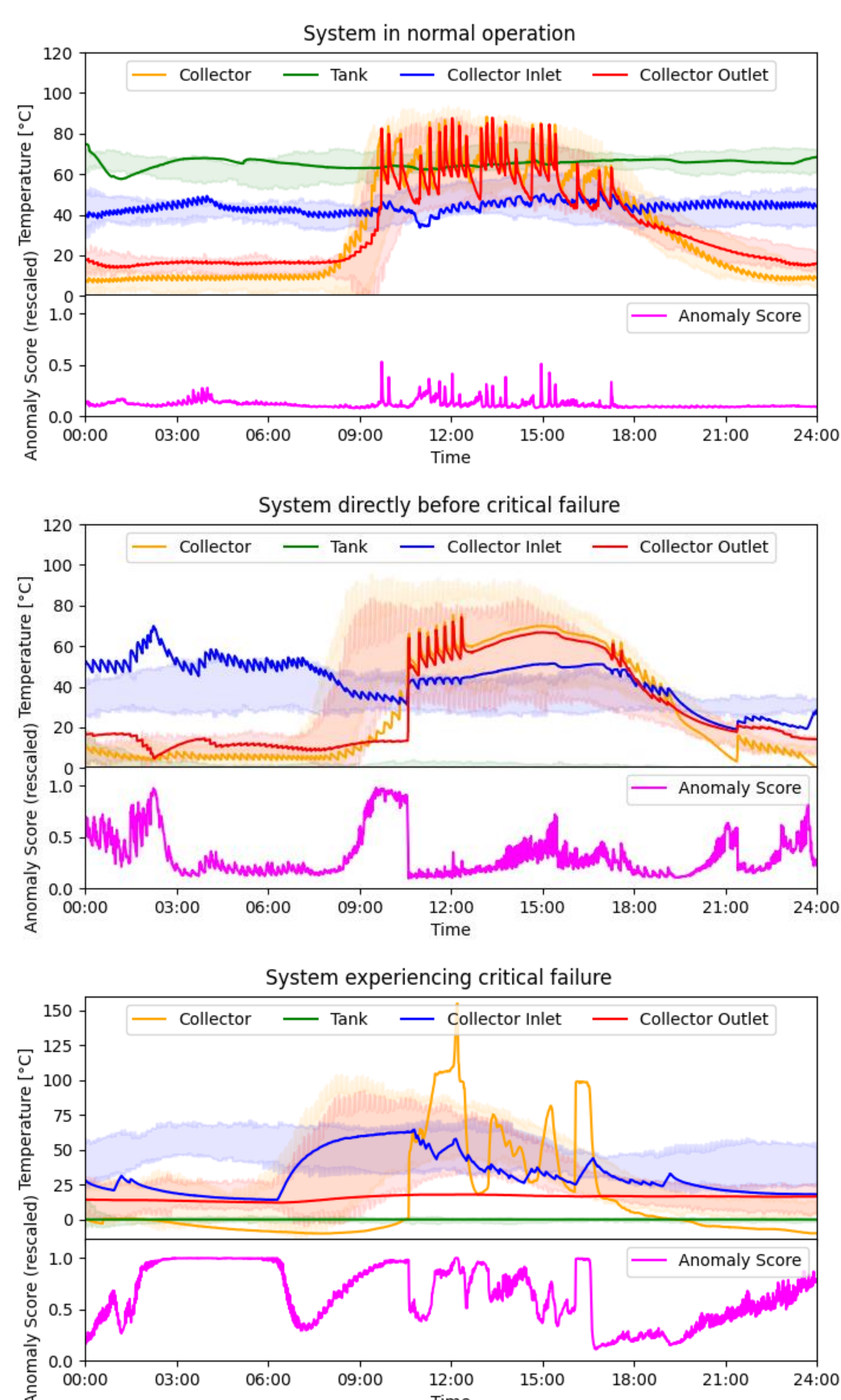


- Ensemble for uncertainty estimation.
- Sample multiple times to generate ensemble.
- Probabilistic Loss: Beta-NLL [2]

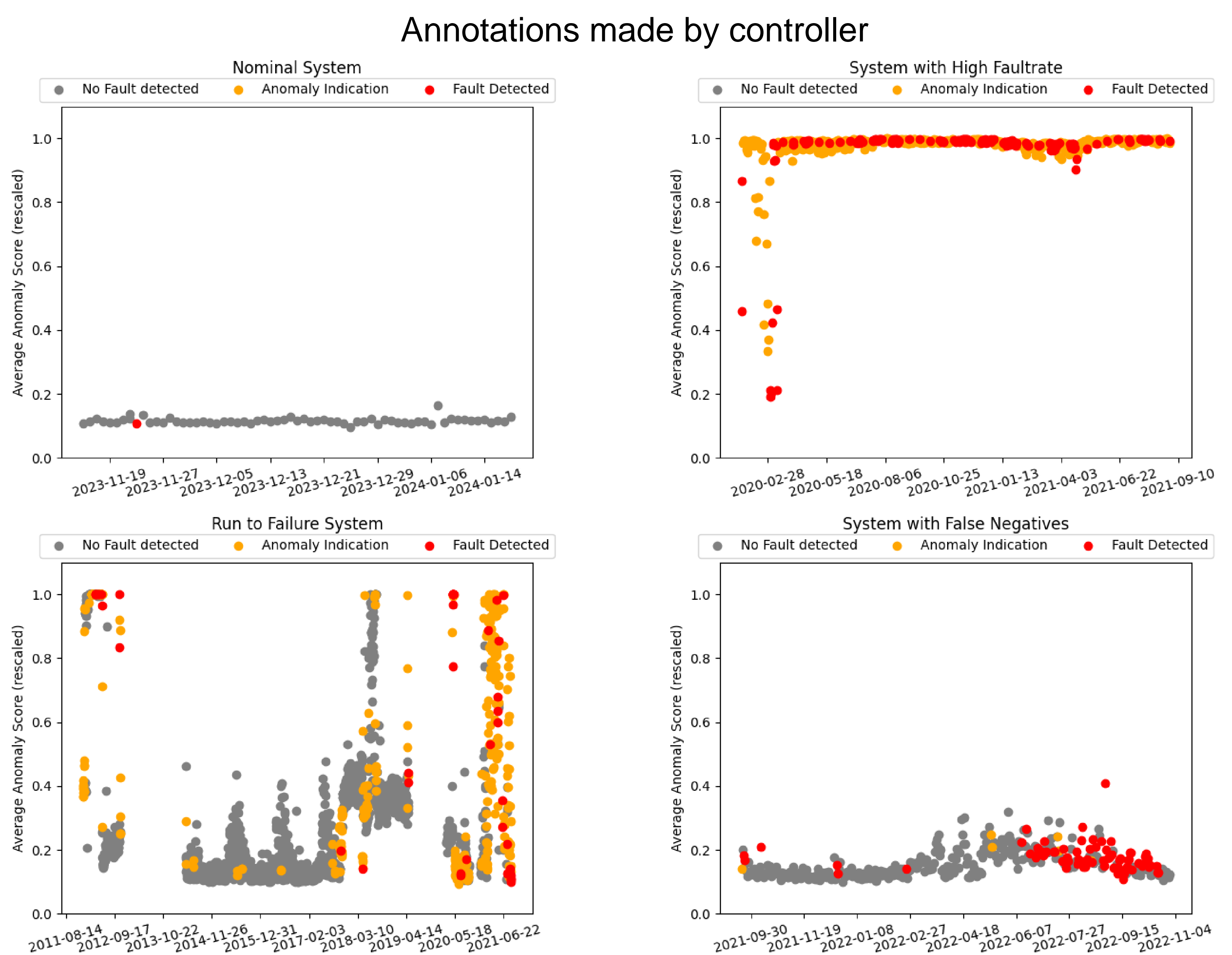
Fault Detection

- Use probabilistic loss as anomaly score.
- Aggregate loss over features and time.
- Compare to rules-based fault detection in system.
- Annotations might be several days **after** anomaly was present in the system.

Reconstructions



System Analysis



Summary / Discussion

- Correct reconstructions for nominal behavior.
- Critical faults clearly detected.
- Anomaly score based on probabilistic reconstruction is informative about the state of the system.
- Some faults are hard to detect by aggregated losses.

References

- [1] Park, D., Hoshi, Y., & Kemp, C. C. (2018). A multimodal anomaly detector for robot-assisted feeding using an lstm-based variational autoencoder. *IEEE Robotics and Automation Letters*, 3(3), 1544-1551.
 [2] Seitzer, M., Tavakoli, A., Antic, D., & Martius, G. (2022). On the pitfalls of heteroscedastic uncertainty estimation with probabilistic neural networks. *arXiv preprint arXiv:2203.09168*.

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