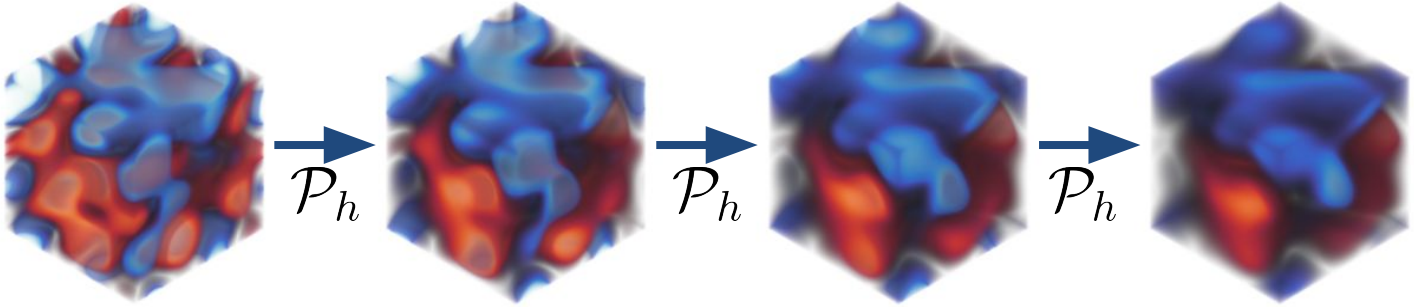


APEBench

Benchmark for Autoregressive Neural Emulators of PDEs

Felix Koehler, Simon Niedermayr, Rüdiger Westermann, Nils Thuerey

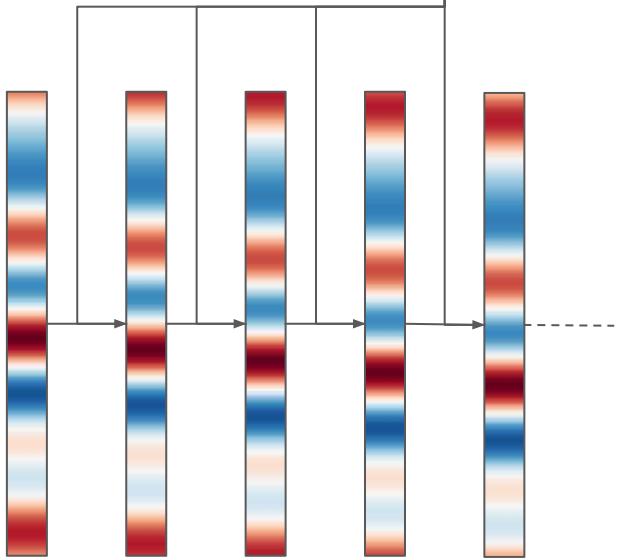
NEURAL INFORMATION PROCESSING SYSTEMS

Munich Center for Machine Learning

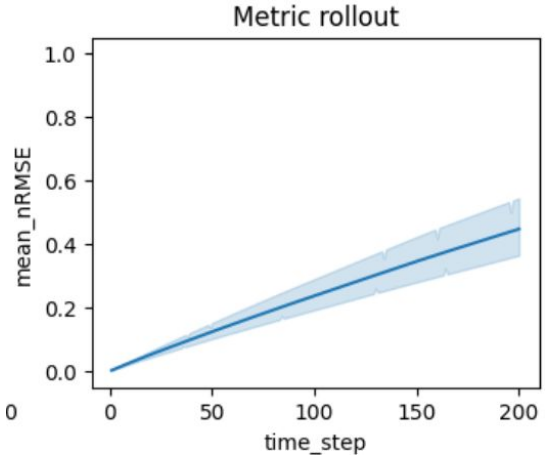
Technical University of Munich

Autoregressive Simulation & Emulation

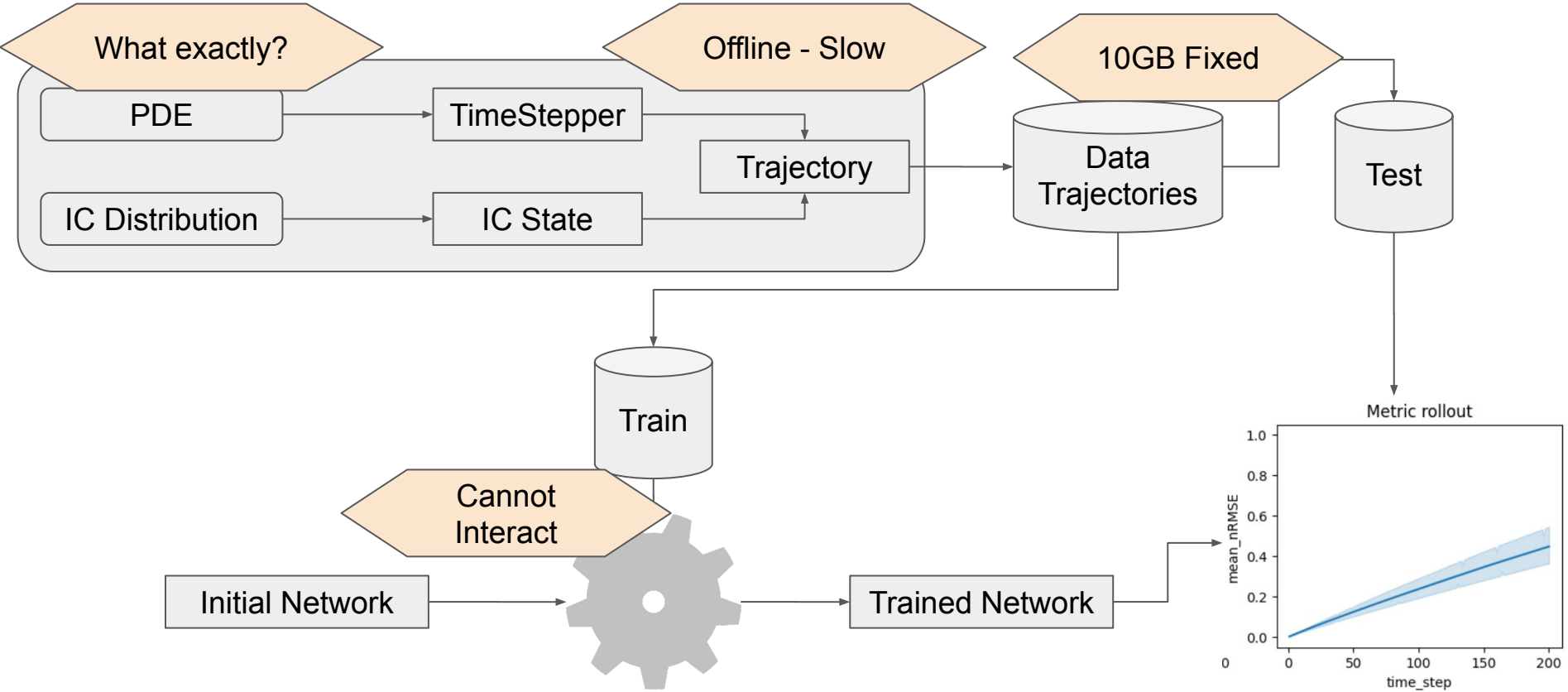
$$\frac{\partial u}{\partial t} = -c\frac{\partial u}{\partial x} \rightarrow \mathcal{P}_h$$



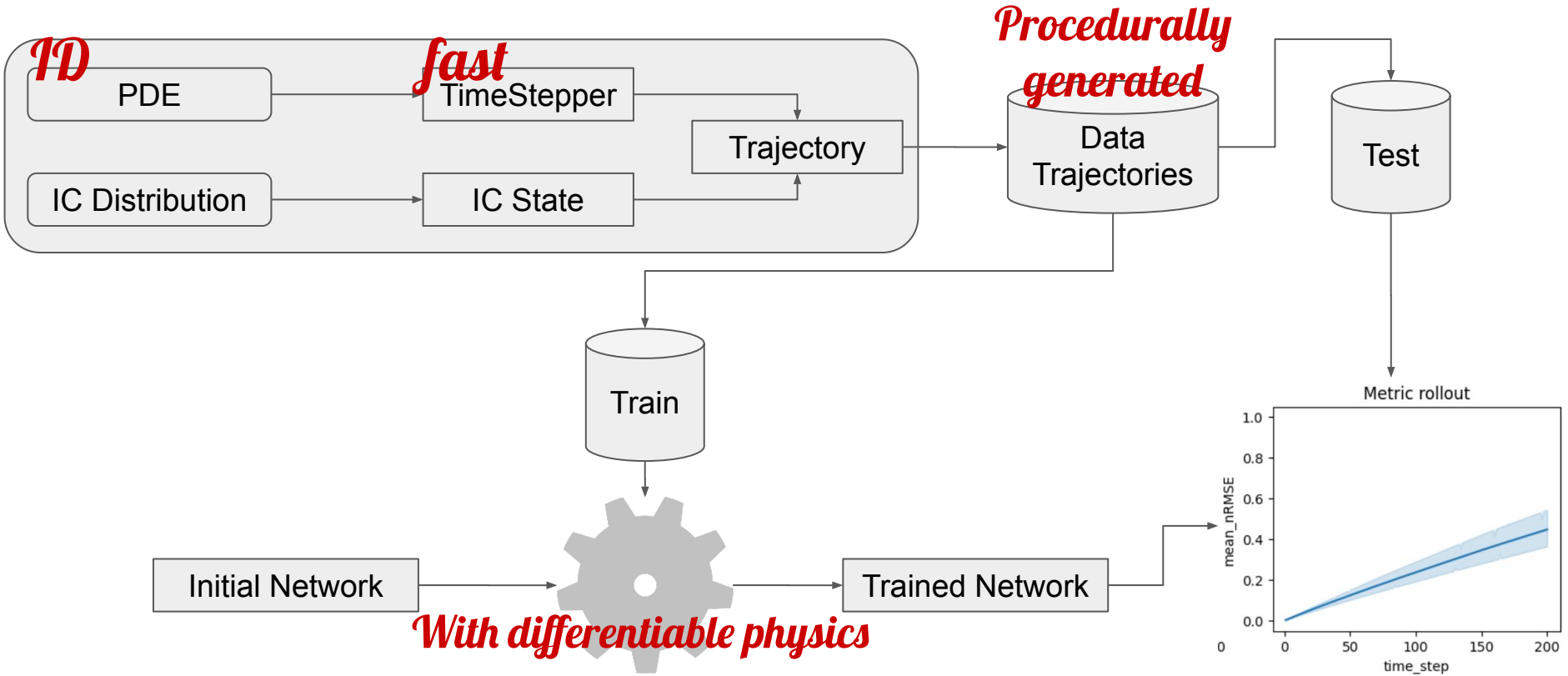
$$f_\theta \approx \mathcal{P}_h$$



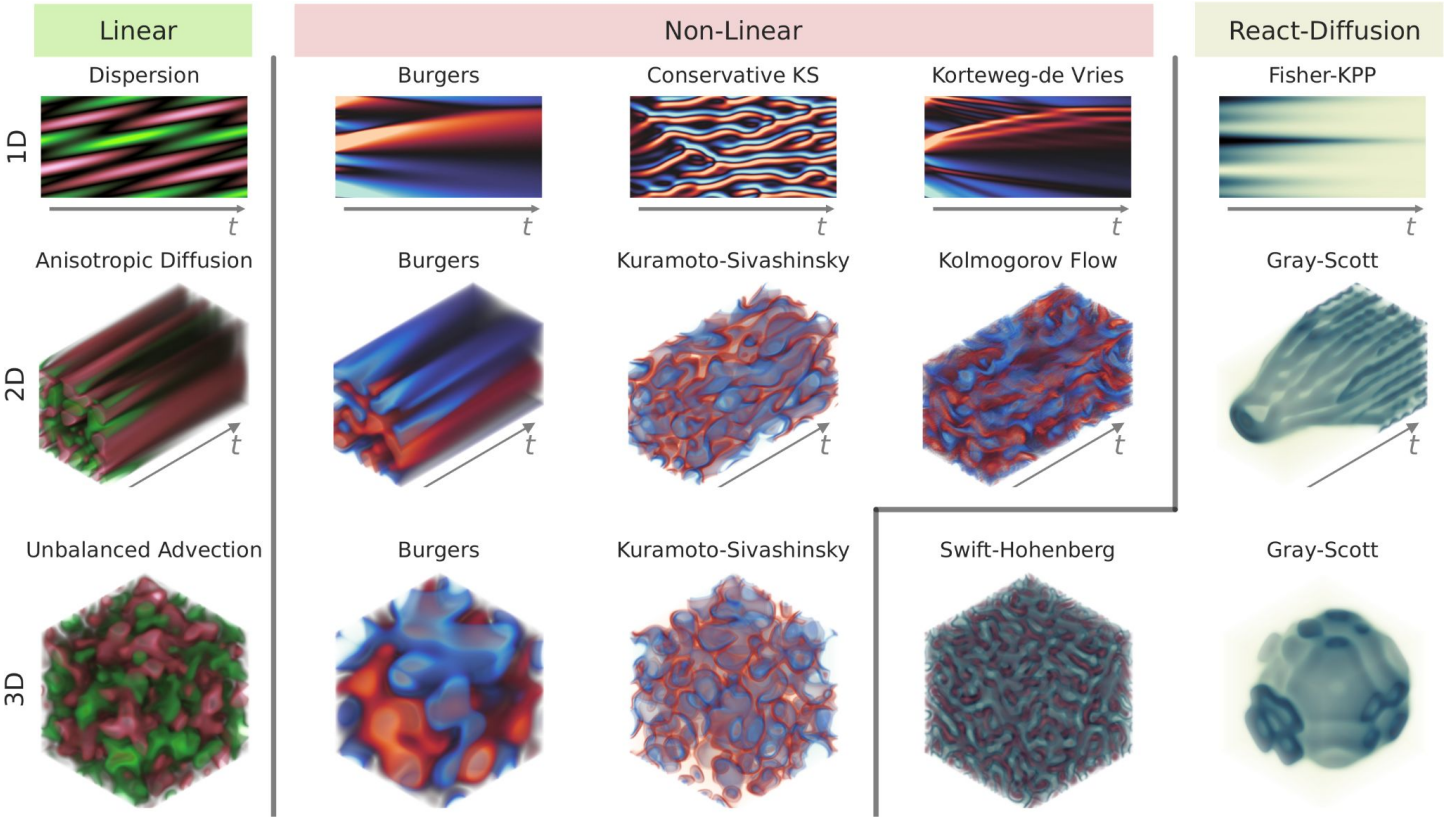
Training Autoregressive Emulators



Training Autoregressive Emulators in APEBench



46 PDEs across 1D, 2D, and 3D



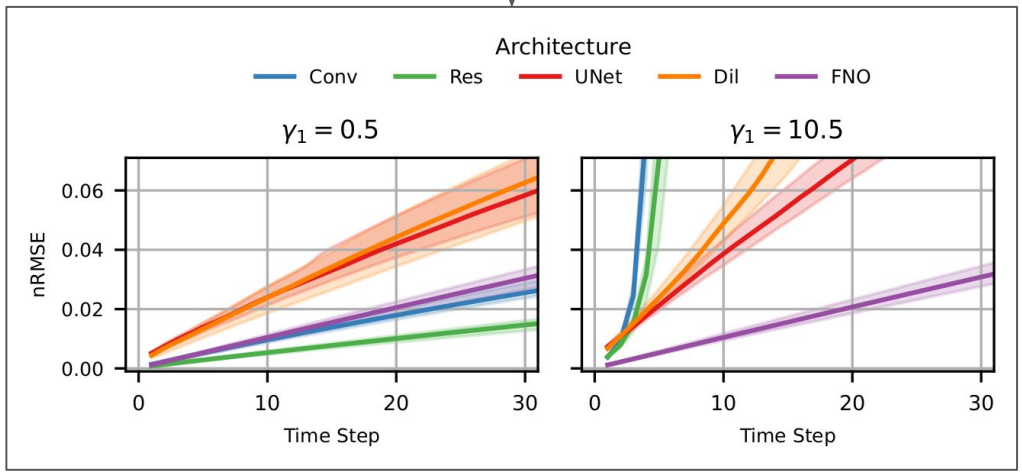
A Pipeline for Experiments

```
pip install apebench
```

```
CONFIGS = [
    {
        "scenario": "diff_adv",
        "task": "predict",
        "net": net,
        "train": "one",
        "start_seed": s,
        "num_seeds": 10,
        "advection_gamma": advection_gamma,
    }
    for s in [0, 10, 20, 30, 40]
    for net in [
        *[f"Conv;34;{depth};relu" for depth in [0, 1, 2, 10]],
        "UNet;12;2;relu",  # 27'193 params, 29 receptive field per direction
        "Res;26;8;relu",  # 32'943 params, 16 receptive field per direction
        "FNO;12;18;4;gelu",  # 32'527 params, inf receptive field per direction
        "Dil;2;32;2;relu",  # 31'777 params, 20 receptive field per direction
    ]
    for advection_gamma in [
        0.5,
        2.5,
        10.5,
    ]
]
```

Unique ID

pandas



APEBench in a nutshell

- JAX-based
- Fast reference simulator based on spectral methods:
  - Procedural data generation in seconds!
  - Differentiable Physics
- 46 PDEs in 1D, 2D, and 3D with unique identifiers
- Big selection of modern Emulator Architectures in JAX
- Built-in unrolled training with differentiable physics
- Built-in neural hybrid emulation
- An integrated volume renderer for 2D & 3D
- Understand neural emulators and draw analogies with classical numerical methods

APEBench: A Benchmark for Autoregressive Neural Emulators of PDEs

Felix Koehler
Technical University of Munich
Munich Center for Machine Learning
f.koehler@tum.de

Simon Niedermayr
Technical University of Munich
simon.niedermayr@tum.de

Rüdiger Westermann
Technical University of Munich
westermann@tum.de

Nils Thuerey
Technical University of Munich
nils.thuerey@tum.de

```
pip install apebench
```

tum-pbs.github.io/apebench