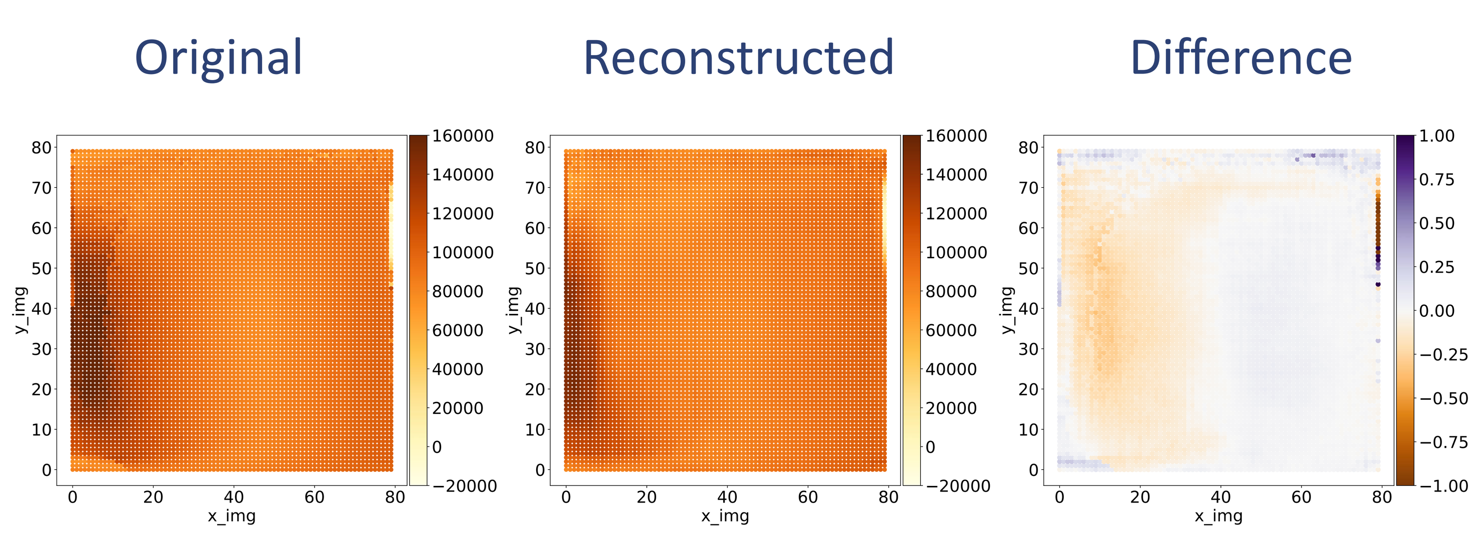
# Physics-informed Neural Networks based Processing of CFD Data for Predictions of Propeller Blade Pressure Distributions

## 11th GACM Colloquium on Computational Mechanics for Young Scientists

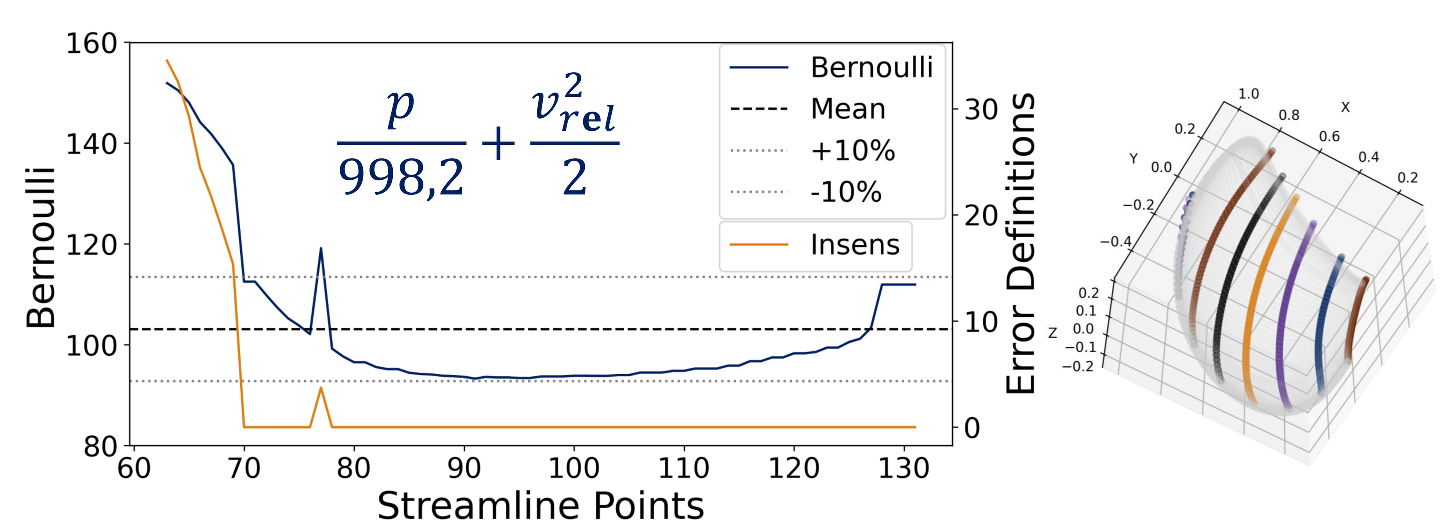
### Motivation & Current Status

- The idea is using existing amounts of hydrodynamic data to predict the behavior of new designs and reduce the number of CFD computations
- In existing research, thrust and moment coefficient of propeller designs are the output by ANNs for new geometries
- In combinations with machine learning, a genetic algorithm evaluates cavitation behavior, and noise and vibration can be predicted from design variables using ANNs
- A new combination of machine learning and physical information to output the pressure and shear distributions on the blades is presented

### Difference of Output - MSE



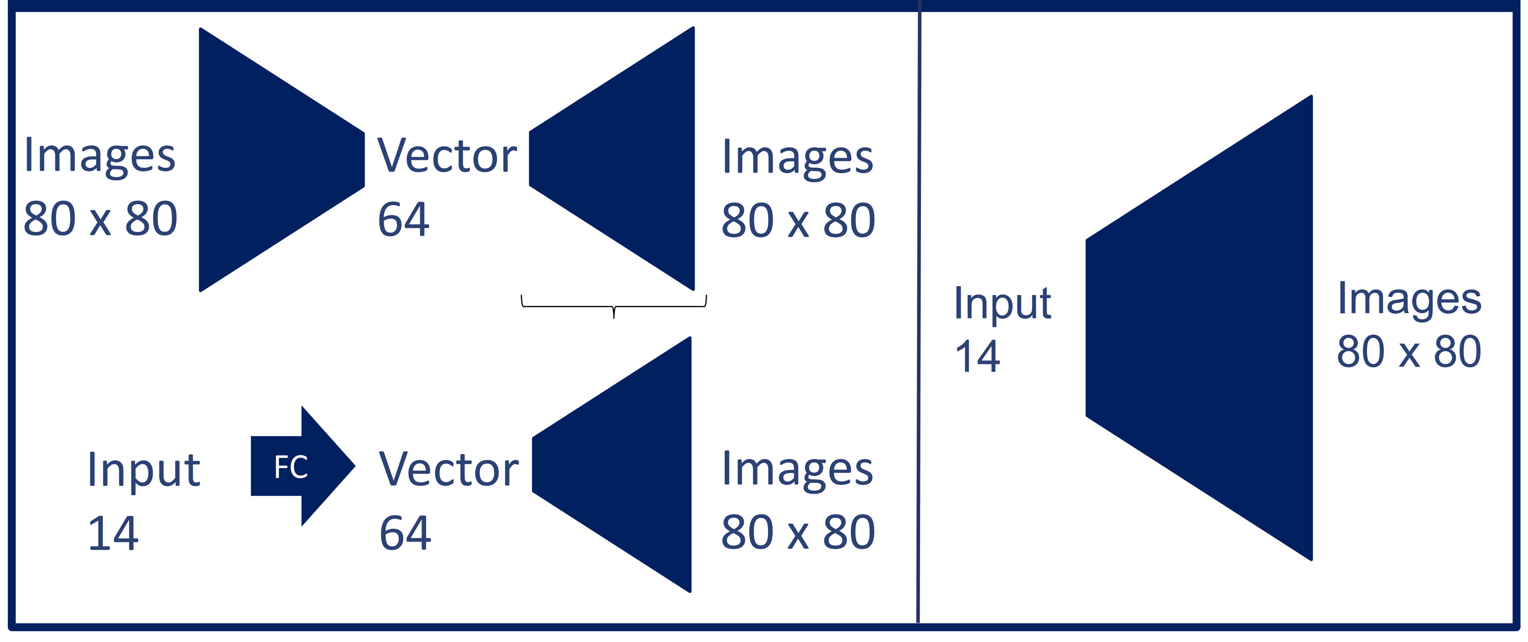

### Physical Equation



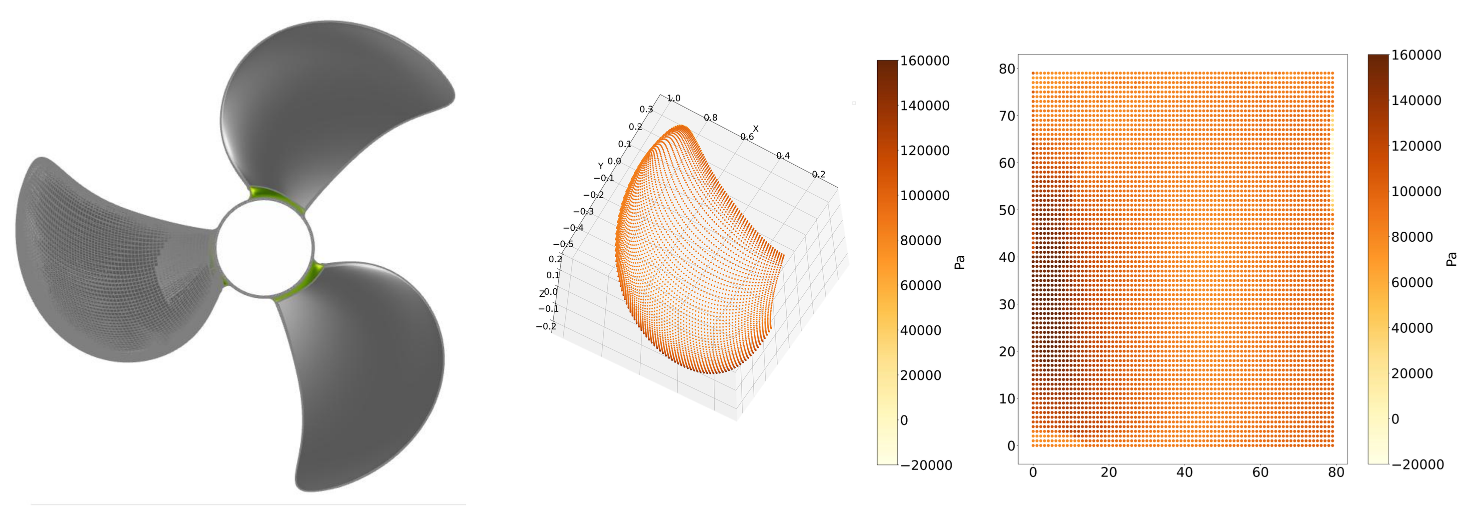

### Results & Conclusion

- With a higher amount of training data, the MSE decreases
- At 20 geometries there is an optimum of MSE on unknown data, so 20 geometries is a sufficient amount of training data before potential overfitting occurs
- Train times for training with formula are much longer
- Train results for limited amounts of data have a lower MSE using the physical formula
- Using specific networks for each propeller blade side improves the MSE
- The viscous terms regarding the physical formula have not been considered, this will be a further improvement

### Autoencoder and FC-Layer | Decoder



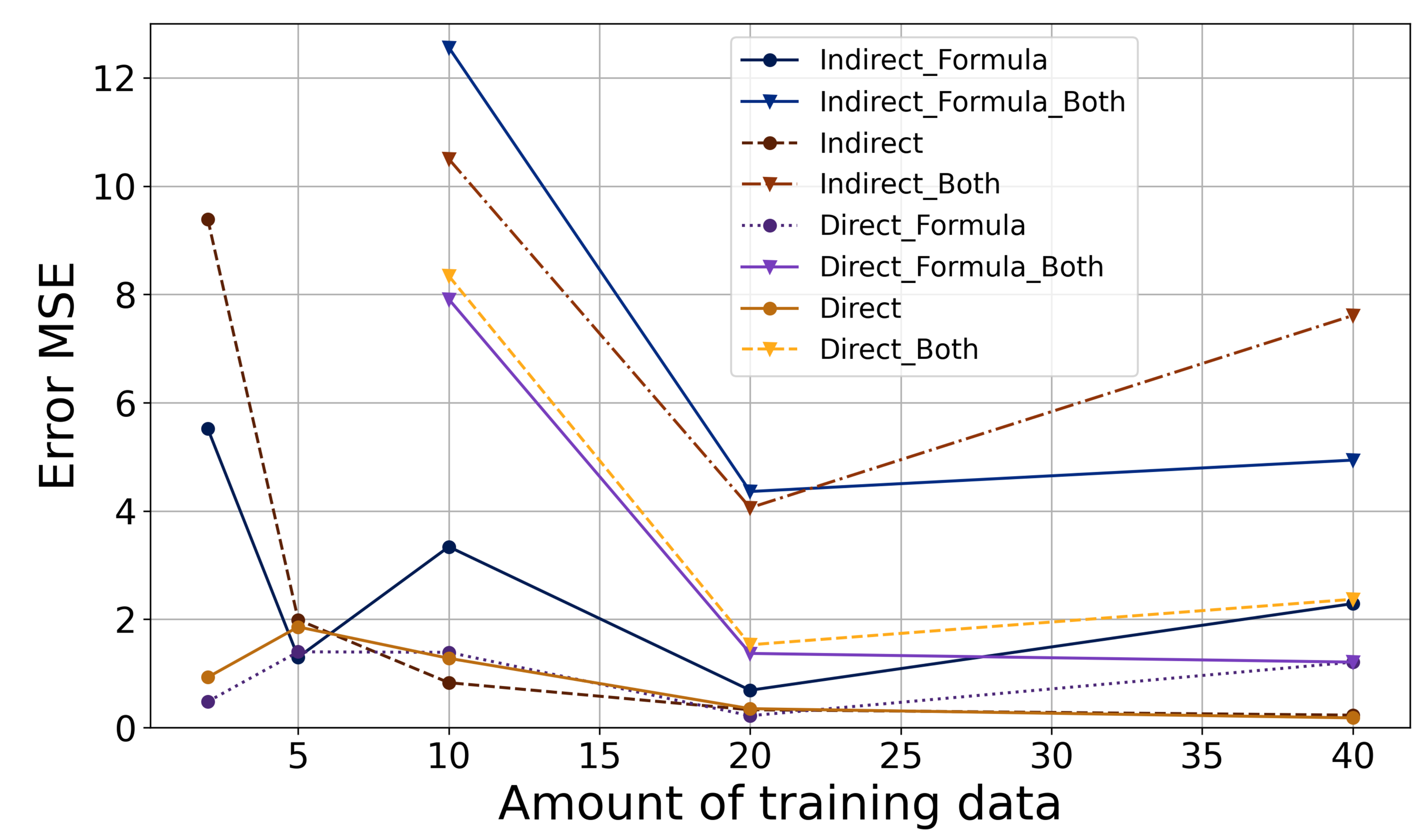

### Geometry and Pressure and Shear Distributions



### Set-Up

- Propeller geometries are varied with 14 parameters and their pressure and shear distributions are calculated with STAR-CCM+
- Two different NN-architectures are set up (shown at the top)
- One physical formula (on the left) is integrated in the loss function and compared to the performance without formula
- As a formula the Bernoulli equation is evaluated along streamlines across the blade surface
- For fixed architecture parameters the networks are trained with varying amounts of data and compared regarding MSE on unknown datasets

### Error over Amount of Training Data





**References**

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