Event Generation and Simulation

A.I. for Nuclear Physics in a nutshell

Supervised

- **Accelerating detector simulation** using GANs, etc.
- **Anomaly detections** using RNN (GRU & LSTM), etc.
- **Reconstruction: Track finding** using U-Net, etc.
- **Analysis: Event classification**

Unsupervised

- **Analysis: Event clustering techniques**
- **Data reduction**

Reinforcement Learning and Bayesian optimization

- **Control: Accelerator elements or trigger**
- **Design: New systems**

Other

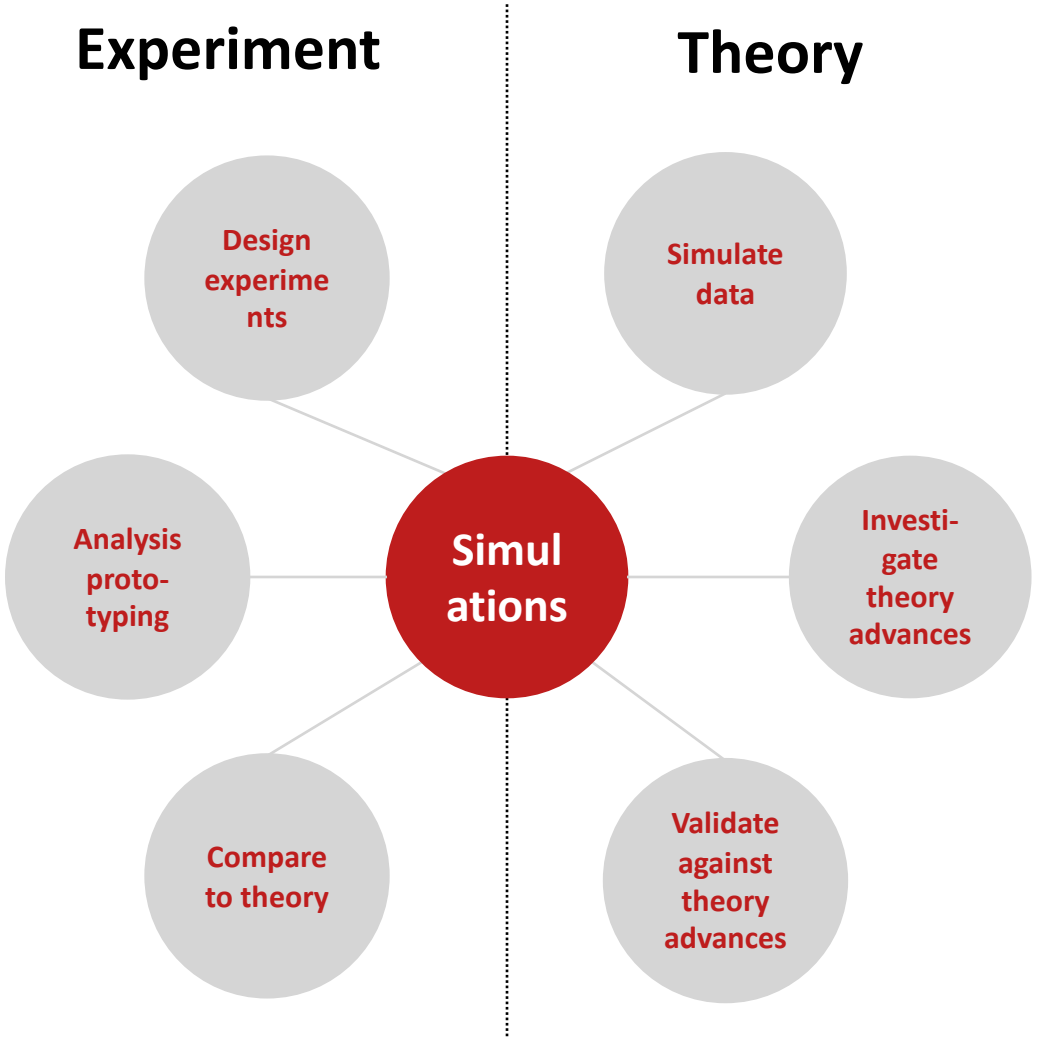
Glossary

GAN Generative adversarial network
LSTM Long short-term memory

- **RNN** Recurrent neural network
- **GRU** Gated recurrent unit

U-Net convolutional neural network variant

Simulations in Experiment and Theory



The role of A.I. in simulations

Lesson learned High-precision QCD measurements require high-precision simulations

Statistical accuracy for precise hypothesis testing

- up to trillion of simulated events required (HL-LHC)
- often computationally intensive, in particular calorimeter simulations

Common alternatives

- fast simulations with computationally efficient approximations, e.g., parameterizations or look-up tables
- **still** insufficient accuracy for high-precision measurements

Promising alternatives

- fast generative models, e.g., GANs or VAEs
- A.I. driven design, e.g., Bayesian optimization

Your contributions

Please summarize your project for data scientists:

- What problem are you working on?
- What is the scientific significance?
- What motivated you to undertake this problem using A.I./ML?

Please summarize technical details of your project:

- What is your data source?
- What techniques/approaches are you using and why?
- How do you validate your results?

Please summarize the status of your project:

- Is your project at the start or the end or the middle?
- Do you have collaborators? If so, please describe.
- What challenges have you faced or are you facing?
- If you have plots you would like to share, please add them to the slides.

Confirmed contributions

Yaohang Li (ODU) **ETHER**

Cristiano Fanelli (MIT) **AI-optimized Detector Design**

Nicholas Polys (VT) **Advances In Human-Centered AI**

Noëlie Cherrier (CEA) **Event classification with ML at CLAS12**

Veronique Ziegler (JLAB) **CLAS12 Tracking with ML**

Abdullah Farhat (ODU) **ML to reconstruct DIS kinematics**

Google document for discussions