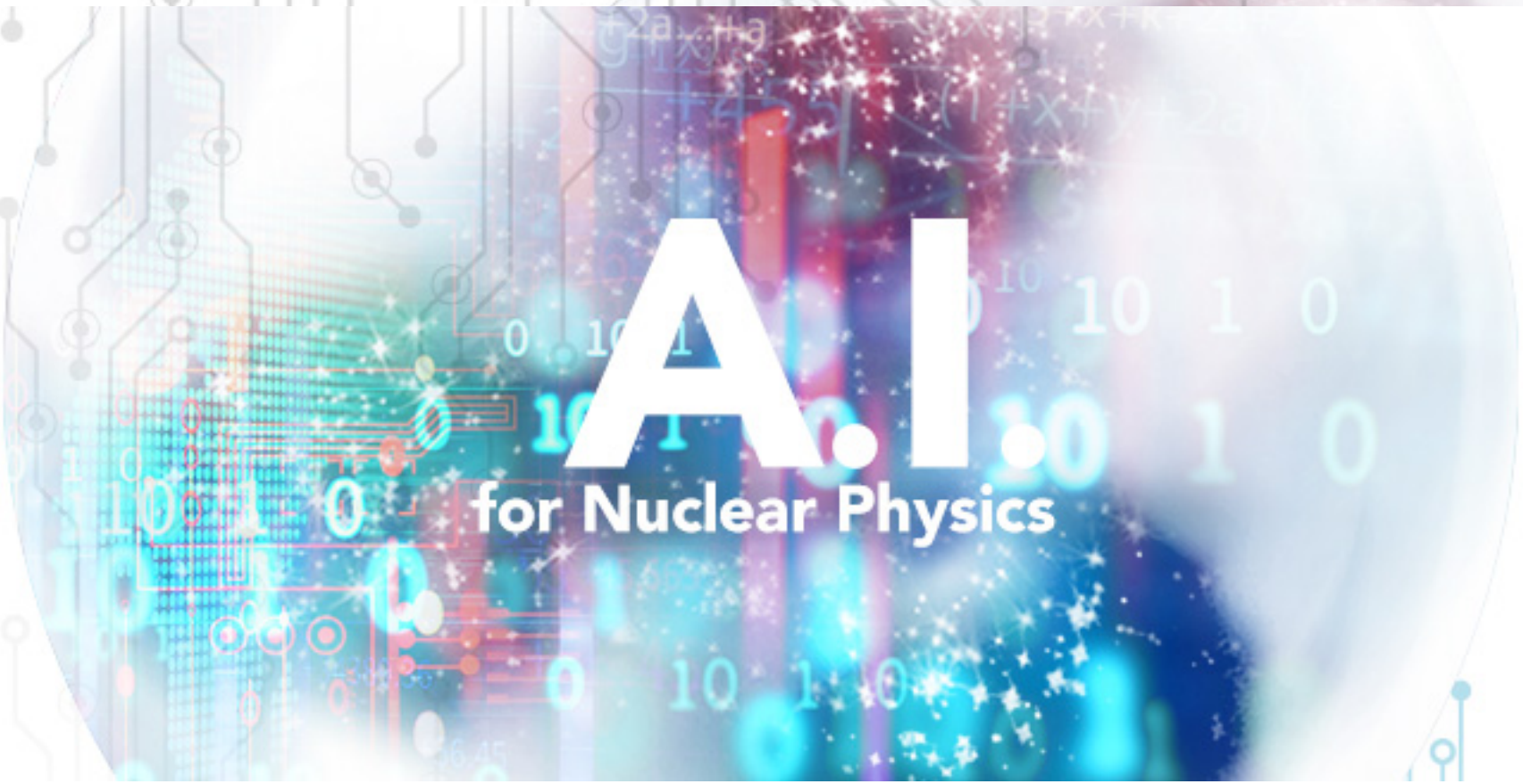


Accelerator Science and Operations

Recap of the week's sessions

- **~40-50 participants!**

- **Wednesday**
  - **Accelerator science that uses and can benefit from AI support**
- **Thursday**
  - **Accelerator operations that can be improved from AI methodologies**

Applications - Accelerator Science

- **Optics and lattice design**
  - "Experiments on Improving Cooling Results in the LEReC system using Machine Learning Techniques", Y. Gao **Bayes Reinforcement Learning (RL)**
  - ML techniques applied to 6D phase space evolution and equilibria (higher dimensional frequency maps, beam-beam effects in EIC). Identify working points. **Unsupervised learning**
- **Beam instrumentation design and optimization**
  - "EM structure optimization", B. Mustapha **Surrogate Models**
  - Interpolation of high dimensional beam phase space data – virtual diagnostics
- **Reinforcement Learning for Controls**

Applications - Accelerator Operations

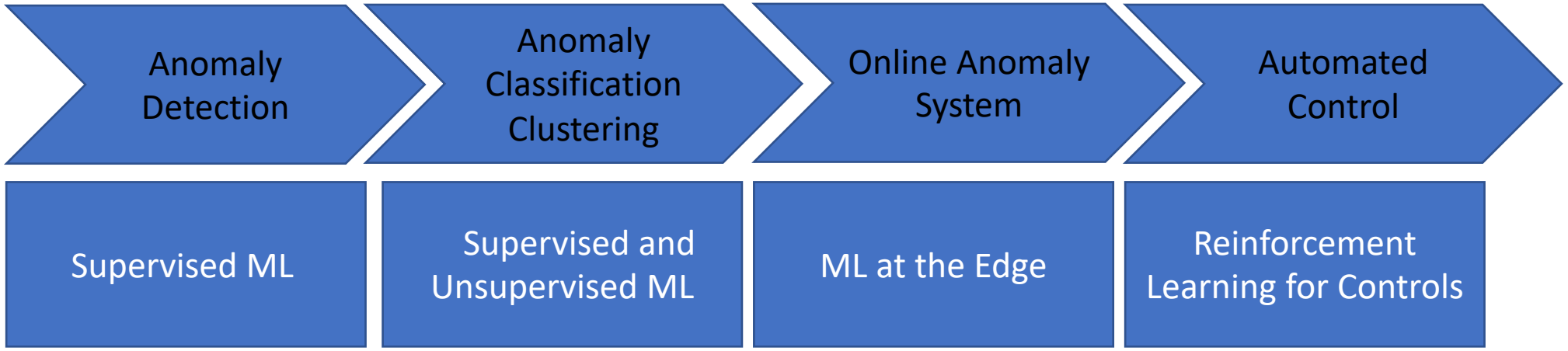
- **Optics and lattice optimization**
  - “Bayes analysis of beamline optimization” Y. Hao **Bayesian GP**
  - "Online Optimization Strategies at the Argonne Wakefield Accelerator", Ryan Roussel **GP Surrogate+NN RL**
  - “Autonomous On-line Beam Optimization”, Matt Amthor **Particle swarm**
- **Target, charge stripper, collimation systems**
  - ML/HPC to investigate high power target damage, material properties
- **Anomaly detection and mitigation**
  - LLRF trip events, beam loss monitoring **Random Forest DL PCA**
- **Other operational aspects**
  - Cryoplant operations, component maintenance prediction

Synergies with many accelerator labs

- **NP**
  - RHIC, EIC
  - 88” cyclotron, VENUS source
  - ATLAS, TAMU
- **HEP/BES and Others**
  - SNS, ESS, GSI
  - LCLS, Argonne Wakefield Accelerator
  - Swiss FEL, EU-XFEL
  - FNAL

Data Science Uses and Needs

- Gaussian processes, optimization
- Supervised, unsupervised learning
- Reinforcement learning, design of agents
- Centralized and distributed computing
  - Network, hardware, and software architecture for data
- Example workflow:



Challenges and Opportunities

- **Optimized design of linacs, synchrotrons, transport lines**
  - Development and validation of virtual diagnostics (eg. long. phase space)
  - Design and simulation of novel accelerators; advanced engineered materials
  - Optimized diagnostic deployment
- **Improving facility performance and user experience**
  - Data-driven beam generation, transport, delivery optimization
    - Automated learning for operator support
    - Hardware acceleration of ML in distributed control systems
  - Anomaly detection and mitigation (eg. LLRF, beam diagnostics)
  - System health monitoring (eg. targets, cryoplant); data driven system maintenance
- **Create/deploy data standards for integration to ML workflows (big, small)**
  - Aggregated and distributed computing resources
- **Benchmark techniques on standard models; dedicated accelerator studies**
  - Dedicated studies on machines and diagnostic support?
  - AI Cookbook of techniques, Data Science training (for humans)

Thank you to all of the session speakers and participants
and to
Jlab and DOE/NP for organizing the workshop