AI/ML in the context of QCD theory

Machine learning is a class of tools for optimising the parameters of complex models

- **Given data:** describe/model/approximate data, identify correlations/features, …
- **Without data:** approximate known or unknown functions, reinforcement-based optimisation…

Machine learning is not a black box or model-independent approach to any problem

Advances to be made at every level of complexity: **diverse requirements**

Level of development required: Existing tools → Custom approaches
Computational requirements: Laptop → Exascale hardware

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Applications of AI/ML target almost **all facets of QCD theory** and are in a phase of **rapid development**

- **First-principles theory**
  i.e., Lattice QCD, perturbative QCD, EFT, nuclear many-body, …
- **Data analysis**
  i.e., global fits, classification, interpretation, …

Strong overlap with approaches and challenges on experimental side, but also **unique demands and opportunities**

Many applications are in an early stage of development: **developmental work is required** to achieve potential

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Capitalising on **great potential** for transformative impact on QCD theory **requires targeted action**

- Full exploitation requires true "ground-up" ML/AI for physics problems
  - Requires support (people+hardware) for exploratory and developmental research at *both* universities and labs
  - Must train and retain talent at physics/AI intersection
    Collaborations with AI/ML "experts" external to physics community are necessary but not sufficient
- Computational workflow of AI/ML problems can be different to other algorithmic problems
  - Demands supporting AI/ML workflows in hardware purchasing and computing allocation policies

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Discussion questions:

- How should AI/ML for EIC fit into the EIC planning process?
- Are we positioned to exploit AI/ML for EIC theory?
- Similarities/differences between computational and human needs for AI/ML+physics vs other computational approaches vs theory?
- What are/will be the roles of industry, universities, labs?
- How can we retain talent at this intersection?
- …