Machine Learning in ALICE and cross-experiment initiatives at CERN

Dr Lee Barnby

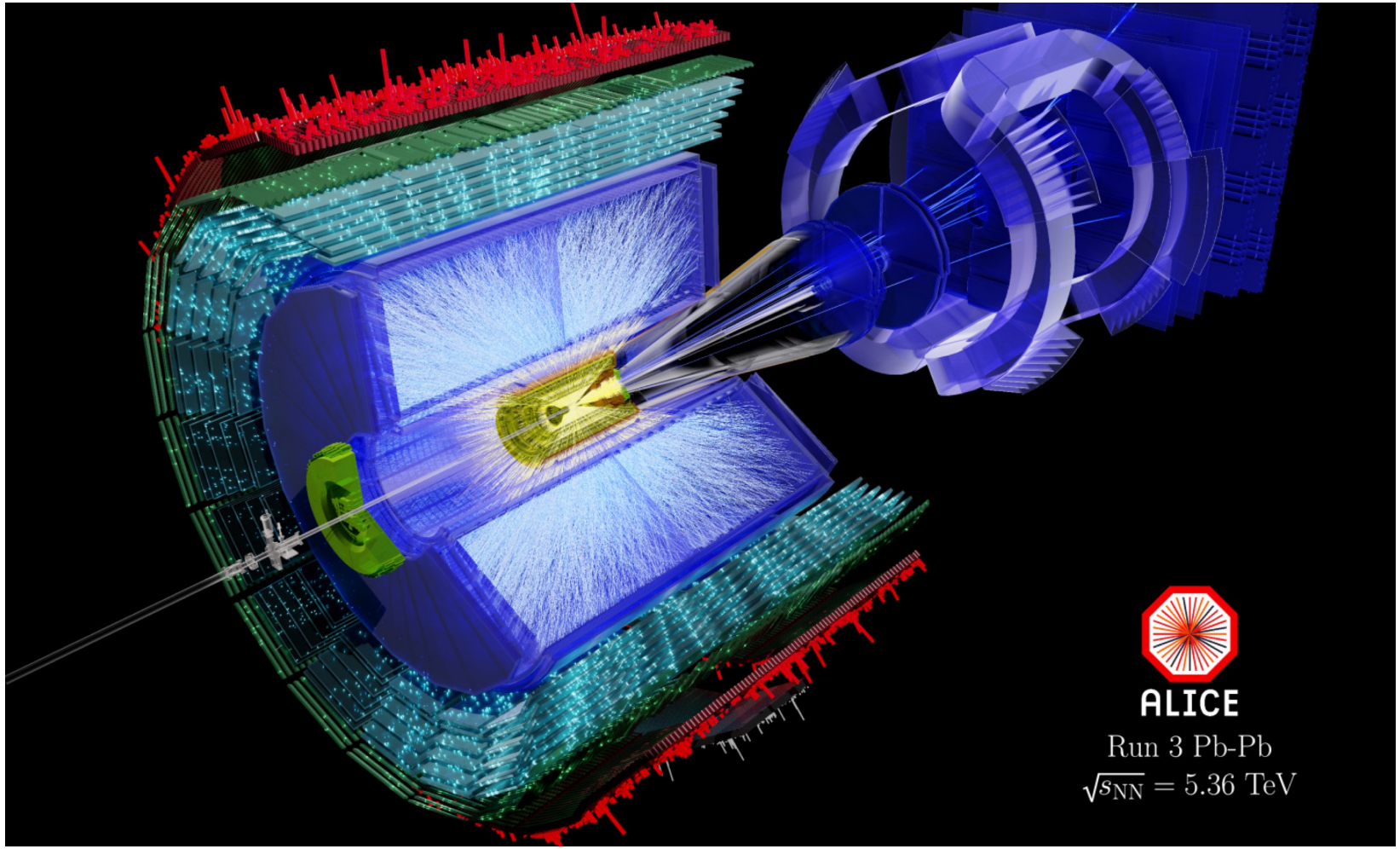
University of Derby

Outline

- Brief introduction to ALICE
- Machine learning use cases
- HEP landscape
- Inter-Experimental LHC Machine Learning Working Group
- CERN Data Science Seminar Series
- Other initiatives
- Open issues and questions

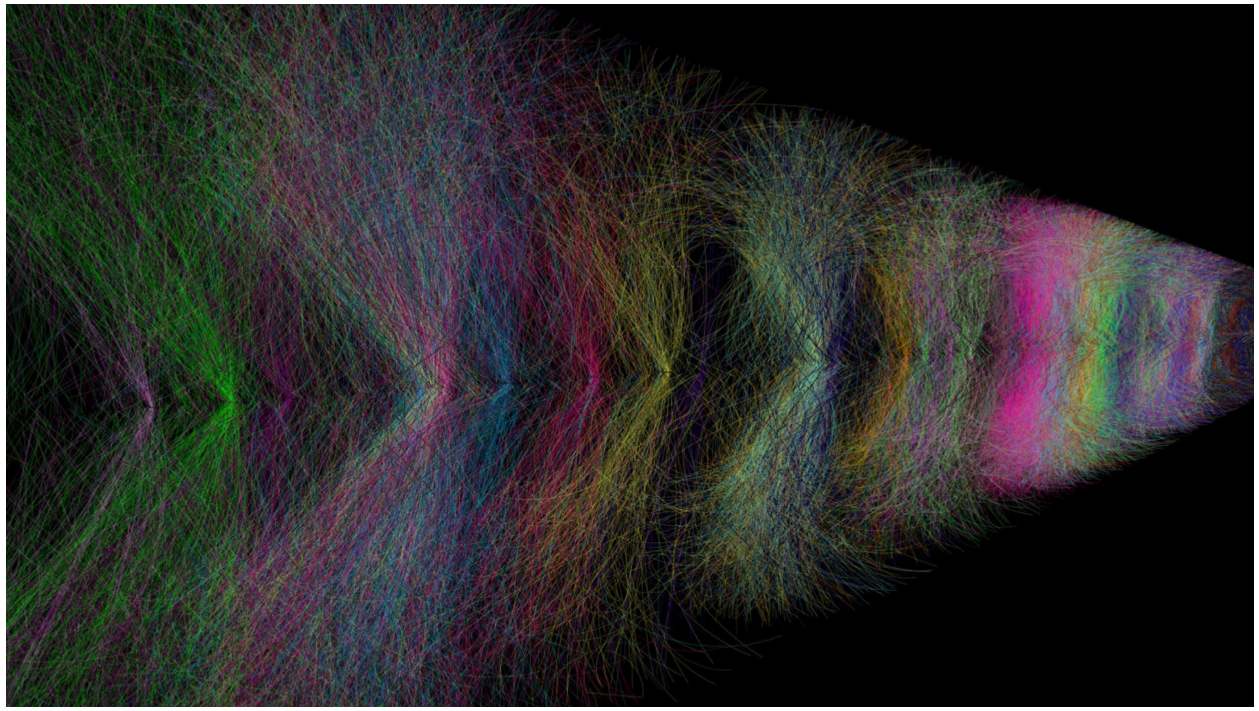
A Large Ion Collider Experiment

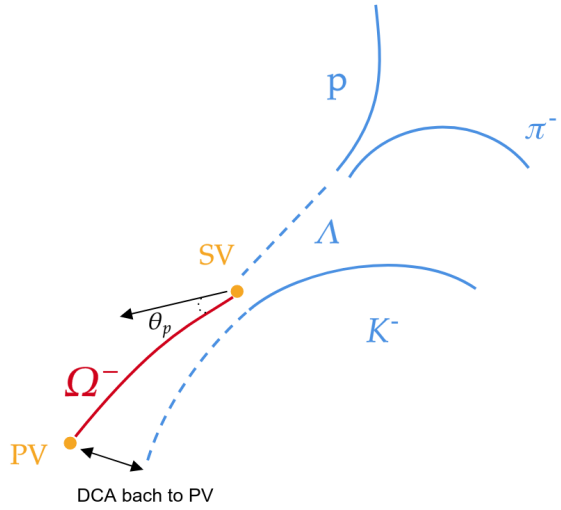
- High energy nuclear physics experiment at LHC



ALICE ML use cases

- Typical example
- Optimising the identification of decaying particles
  - something we know how to do but want to be more efficient
  - Using BDT or CNN
- Also, dE/dx and calorimeter particle ID





High Energy Physics Landscape

- Machine Learning in High Energy Physics Community White Paper
  - Kim Albertsson *et al* 2018 *J. Phys.: Conf. Ser.* **1085** 022008 doi:10.1088/1742-6596/1085/2/022008 also arXiv:1807.02876
  - 20 pages – it is not a review but sets out challenges as seen in 2017 (for next 5-10 years)
  - Context is large data rates (TB/s), huge data samples (100s PB), distributed/grid computing (WLCG) and large user communities (100s active people analyzing data)
- Living Review (thanks to Nicodemos Andreou)
  - Large set of categorized resources curated by community members

Inter-Experimental LHC Machine Learning Working Group

- Mandate
  - facilitates the advancement and application of ML methods for the LHC experiments
  - identifies areas of common interest and importance to the LHC community (… etc.)

IML WG Events

- ‘Regular’ meetings (next is 9 April 2024 but last was Jul’23!)
  - Agenda are public. Sometimes there is a special topic
    - e.g. LLMs for HEP can be quite esoteric
  - Others are open and have more understandable topics like:
    - *A Deep Learning Approach to Proton Background Rejection for Positron Analysis with the AMS Electromagnetic Calorimeter*
    - But also looking at new model developments e.g. *Versatile Energy-Based Models for High Energy Physics*
- Annual Workshops
  - 5 Days including plenary and parallel talks, some tutorial sessions + posters
  - Already held this year in January, see indico page

CERN Seminars

- Principally from the Data Science series
  - Margarita Osadchy, "Model/dataset compression for optimizing the efficiency of deep networks"
  - Eric Wulff, "Hyperparameter Optimization for Deep Learning Models Using High Performance Computing"
- Sometimes sneaking into other places
  - CERN **Detector** Seminar series
    Sioni Summers, "Fast Machine Learning at the Edge for HEP Experiments"
- Good resources for students and broadening knowledge, open and usually recorded

Nuclear Physics Initiative

- Artificial Intelligence for Accelerating Nuclear Applications, Science and Technology INTERNATIONAL ATOMIC ENERGY AGENCY, Non-serial Publications , IAEA, Vienna (2022)
  - Thanks to Tzany Kokalova Wheldon for pointing this out
  - Very comprehensive (80 pages), also interesting list of references
  - Much broader than just nuclear science
  - *"Key drivers for AI applications in nuclear physics are uncertainty quantification and real-time systems."*

Open issues and questions

- Uncertainty quantification
  - What is progress in being able to report a result analogous to traditional statistical and systematic uncertainty (including systemics of model choice)
- Resources
  - Are specialized resources needed and available, such as parallel processing or GPU-enabled clusters. NP groups are smaller and not as well-resourced as HEP (shared facilities)
- Expertise
  - Adapting not re-inventing…
  - … but our data are not structed like images nor free-text and we often know physically-motivated things about the structure