LAMARR
INSTITUTE FOR MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

Deep Learning

Hands-On Session

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Grad School on Astro-Particle Physics (Jan 18th–23rd, 2026)

Partner institutions:

technische universität dortmund

Fraunhofer IAIS

UNIVERSITÄT BONN

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Hands-On Exercises

- Exercises provided in jupyter notebooks
- Part 1 (today), part 2 (Thursday) will be made available in due time
- Please let us know if you are not able to run the notebooks
- Feel encouraged to team up!
- Feel free to ask questions or to discuss your observations!

https://git.e5.physik.tu-dortmund.de/qfuehring/ml_intro_handson/

Hands-On Exercises: Part 1

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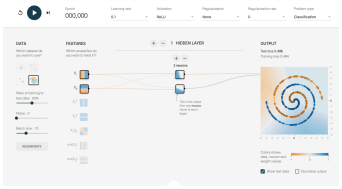
- A small playground to get a feeling of different aspects training a NN
- Tasks provided in a jupyter notebook:
  `https://git.e5.physik.tu-dortmund.de/qfuehring/ml_intro_handson/-/blob/main/part_1.ipynb`
- Leaderboard to compare your results with others in task 1.3:
  `https://keepthescore.com/board/tggjqlnyqrqre/`



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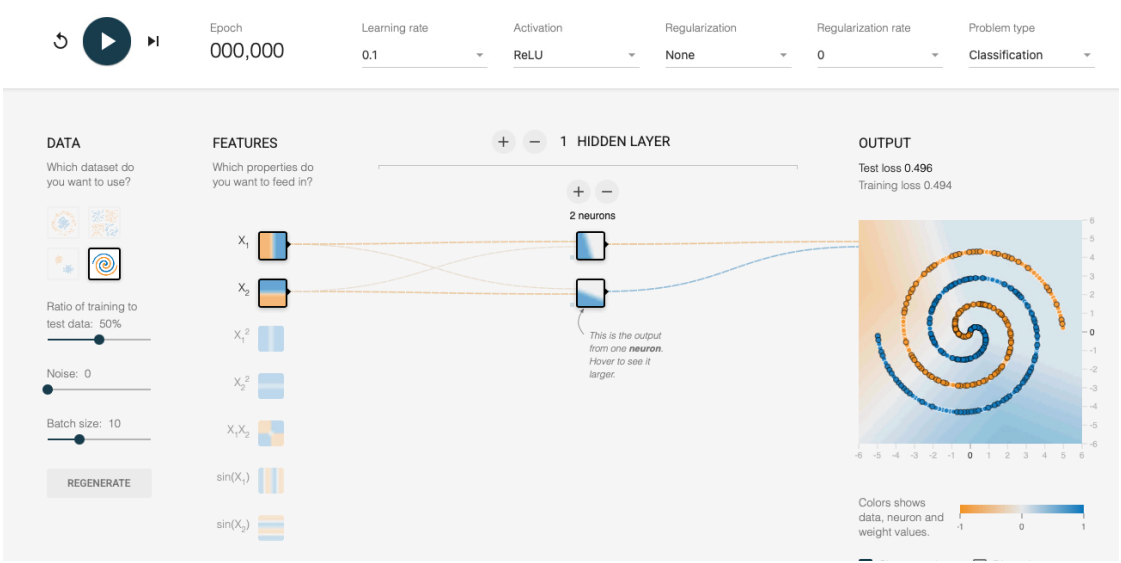

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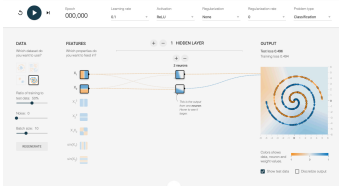

Hands-On Exercises: Part 2

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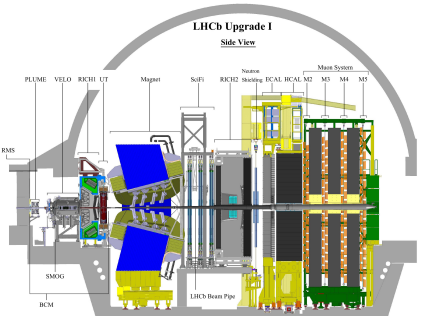
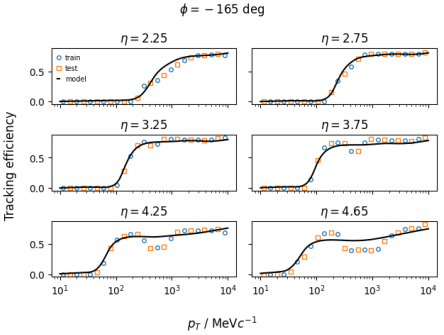
- **Task:** Use a neural network to predict the tracking efficiency of the LHCb detector
- **Context:** The LHCb experiment can be used to study hadron production rates (see Michael's lecture from Tuesday)
  - Proton-proton collisions with a center-of-mass energy of 13.6 TeV
  - SMOG: Fixed target collisions of protons and gas (e.g. He, O, etc)
  - Spectrometer with hadron PID in forward direction
  - Measured rates can be used to improve cosmic-ray air-shower simulations
  - Tracking efficiency crucial for production rate measurements



LHCb Upgrade 1 detector layout, E. Thomas, https://cds.cern.ch/record/2947697

https://git.e5.physik.tu-dortmund.de/qfuehring/ml_intro_handson/-/blob/main/part_2.ipynb

Hands-On Exercises: Part 2



- **Task:** Use a neural network to predict the tracking efficiency of the LHCb detector
  - Simulation usually computationally expensive
  - Use a fast NN-based surrogate model to predict the efficiency
  - Use kinematic properties of particles as input features
- **Data:** 3d histograms of generated and reconstructed particles, binned in
  - Pseudorapidity η (6 bins)
  - Transverse momentum p_T (25 bins)
  - Azimuthal angle ϕ (12 bins)

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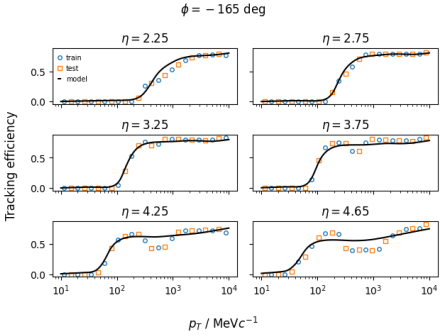
Hands-On Exercises: Part 2

- **Task:** Use a neural network to predict the tracking efficiency of the LHCb detector
- **Code:** JAX-based skeleton code provided
  - JAX: ML framework with NumPy-like API and automatic differentiation
    - → Familiar interface, still low-level access
  - Data loading, preprocessing, plotting baseline model, and training loop provided
  - Exercises focus on implementing and studying extensions to the baseline
- An **Example** will be made accessible after the session



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