Machine Learning for Physics

Report of Contributions

https://indico.lip.pt/e/2130

Contribution ID: **1** Type: **not specified**

Introduction to Machine Learning for Physics (lecture)

Thursday 12 March 2026 09:00 (1 hour)

This lecture will introduce the broad concept of Machine Learning, its connection to Artificial Intelligence, and will broadly review the use of ML in High Energy Physics.

Presenter: Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **2** Type: **not specified**

Automatic Differentiation and Supervised Learning (lecture)

Thursday 12 March 2026 10:30 (1h 30m)

This lecture will focus on supervised learning, a setting where the training data set is "labelled" , that is the target quantity of learning is known. Automatic Differentiation, the technique that powers up modern machine learning frameworks will then be explained in detail, together with its connection to differentiable programming.

Presenter: Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **3** Type: **not specified**

Exercise 2: Classification and anomaly detection in S-top searches

Thursday 12 March 2026 16:00 (2 hours)

Classification is a category of supervised learning where the goal is to classify the data into different categories. For the CMS search of the supersymmetric partner of the top quark in the compressed mass scenario a Boosted Decision Tree (BDT) algorithm was used to distinguish between signal-like and background-like events. In this exercise, a neural network will be implemented to achieve this task and performance will be compared with the BDT approach. If time allows, a further attempt will be made with an autoencoder neural network, where only background simulated events are used for training, the performance of this approach will also be compared to the previous two approaches. For comparison of the approaches a simplified limit setting via the pyhf library will be used.

Presenter: SILVA, Cristóvão (LIP)

Contribution ID: **4** Type: **not specified**

Exercise 1: Network structure and inductive bias in Higgs physics (ttH)

Thursday 12 March 2026 13:30 (2 hours)

Inductive bias refers to the process of encoding into the learning process some properties of the data known a priori: this can happen by manipulating the training data (augmentation), by modifying the structure of the algorithm (e.g. dense vs convolutional networks), or by modifying the learning target (loss function). The exercise will consist in comparing the performance of generic algorithms with that of algorithms targeted to specific structures (e.g. convolutional networks).

Presenter: Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **5** Type: **not specified**

Into the belly of Transformers: mathematical formalism and inner workings (lecture)

Friday 13 March 2026 09:00 (30 minutes)

Transformers are an architecture that powers up most Large Language Models in the market nowadays. This lecture will explain the inner structure of a transformer.

Presenter: Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **6** Type: **not specified**

Exercise 3: Flavour tagging with Transformers

Friday 13 March 2026 09:30 (1 hour)

Flavour tagging allows us to identify jets that originate from b- and c-quarks, and is a crucial tool for the physics programme of LHC experiments. The jet flavour can be predicted based on the characteristics of the charged particle tracks associated with it. This set of variable number and unordered tracks lends itself to a graph representation, which can be exploited by transformers. In this exercise, we train and evaluate a transformer for identifying b-jets.

Presenter: OCHOA, Inês (LIP)

Contribution ID: **7** Type: **not specified**

Wrap-up, Awards, and Group Photo

Friday 13 March 2026 18:00 (30 minutes)

Contribution ID: **8** Type: **not specified**

Unsupervised learning (lecture)

Friday 13 March 2026 11:00 (1 hour)

When the data set is unlabelled, that is when the target quantity for learning is not known, traditional supervised learning techniques cannot be used. This lecture will explain the corresponding techniques to obtain learning algorithms without an explicitly known target, such as reinforcement learning.

Presenter: Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **9** Type: **not specified**

Exercise 4: probing the substructure of boosted jets with unsupervised learning

Friday 13 March 2026 13:30 (2 hours)

Presenter: OCHOA, Inês (LIP)

Contribution ID: **10** Type: **not specified**

Data challenge‼!

Friday 13 March 2026 16:00 (1h 40m)

The data challenge will consist in solving a machine learning problem on a given data set.

The participants will be provided access to the data set, and skeleton code to set up the study.

Participants will have to submit a series of predictions for an evaluation data set, as well as the code and an explanation of the logic behind it.

The models faring the best in the evaluation dataset will be declared winner: the first three models will be presented by their developers (1st: 5 minutes, 2nd and 3rd: 2 minutes) during the awards ceremony.

Certificates for the first three classified will be provided.

Presenters: SILVA, Cristóvão (LIP); OCHOA, Inês (LIP); Prof. VISCHIA, Pietro (Universidad de Oviedo and Instituto de Ciencias y Tecnologías Espaciales de Asturias (ICTEA))

Contribution ID: **11** Type: **not specified**

Introduction to the course and welcome

Thursday 12 March 2026 08:55 (5 minutes)

Presenter: GALLINARO, Michele (LIP)