Application of Machine Learning to ATLAS Physics Analysis

BDP(Bachelor's degree project) case of study

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Overview

What is about Machine Learning and models?

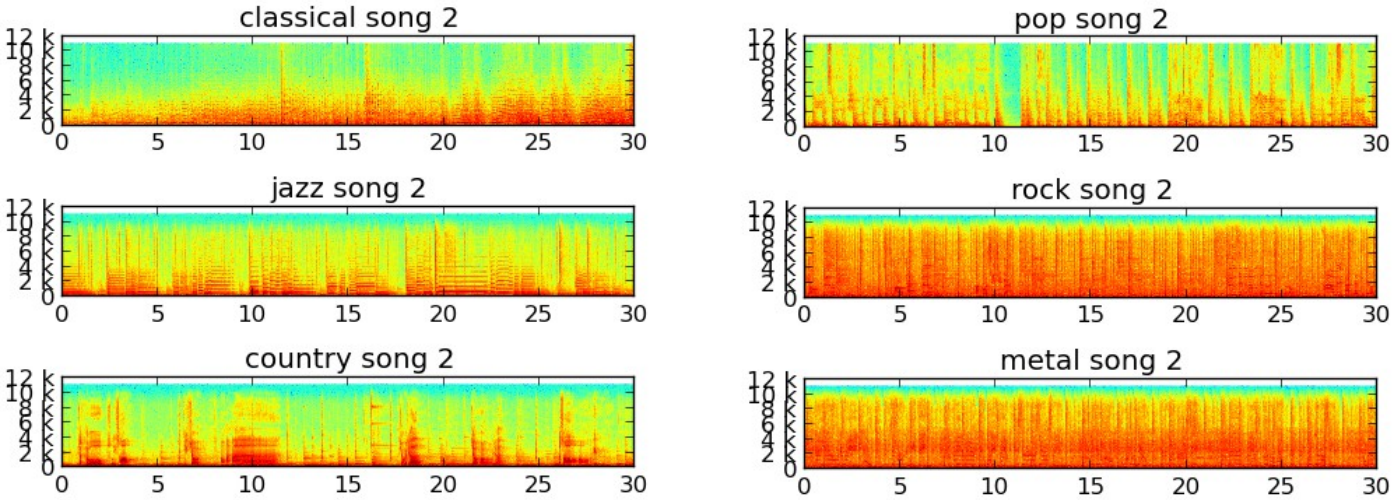
How is related data and model for choosing wisely?

Which are the Machine Learning analysis options?

Machine Learning?

To start:

- **Recognise complex patterns**



- **Ask to data and wait for an understandable answer**

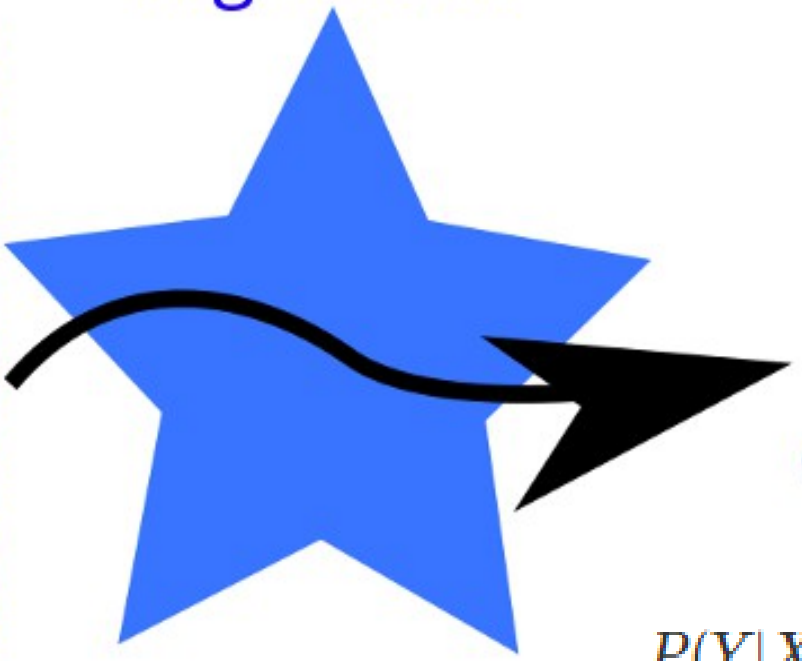
What is a model?

LEARNING

Data

Algorithm

Model

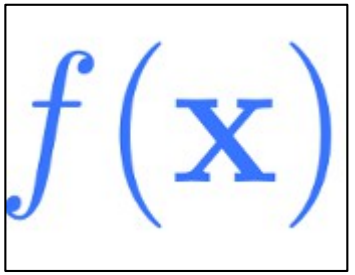


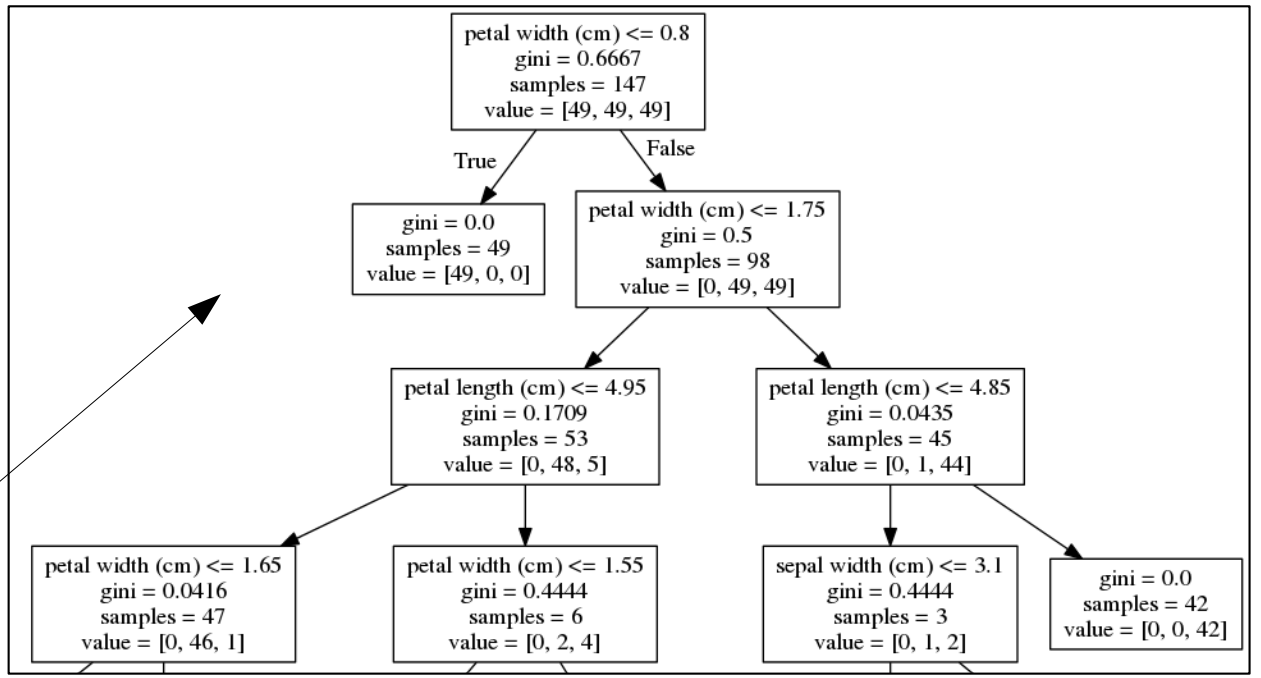
$f(\mathbf{x})$

$$P(Y|X) = \theta_1 x_1 + \theta_2 x_2 + \ldots$$

What makes a model?

ANALYSIS





Which model should I choose?

Depends on:

- Which **data type** you have

- What **information** you want to extract

Data types

Label Data

sepal length(cm)	sepal width(cm)	petal length(cm)	petal width (cm)	type
5,0	3,3	1,4	0,2	Iris-setosa
7,0	3,2	4,7	1,4	Iris-versicolor
5,9	3,0	5,1	1,8	Iris-virginica

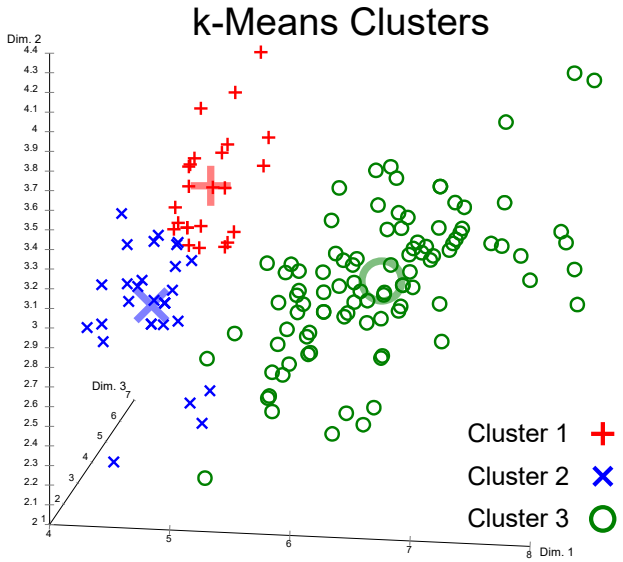
Unlabel Data

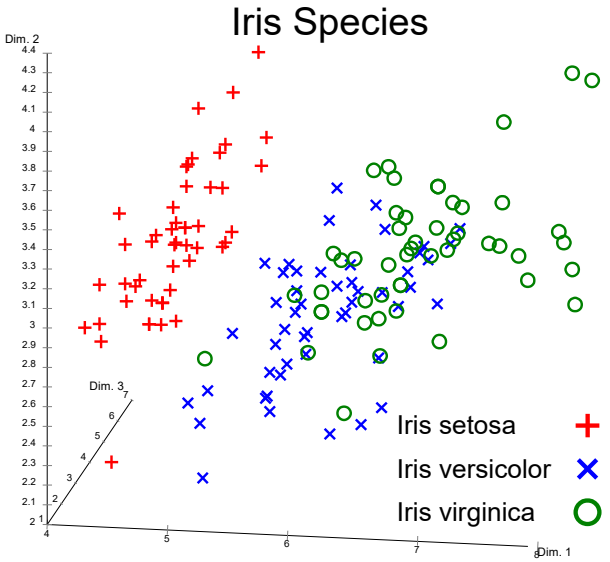
Height (cm)	Weight (kg)	Age (years)	Buys (€)
172	80	14	20
150	43	50	400
162	46	34	1000
160	65	89	10

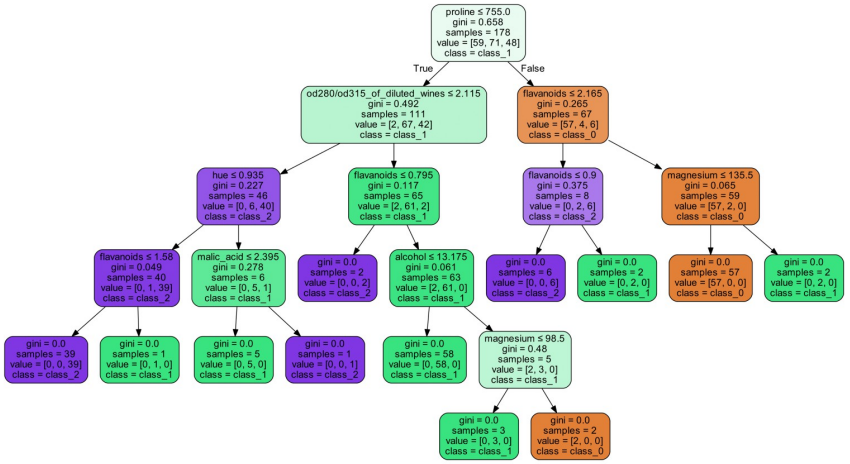
Data types – Learning model type

Label data ⟶ Supervised learning

Unlabel data ⟶ Unsupervised learning



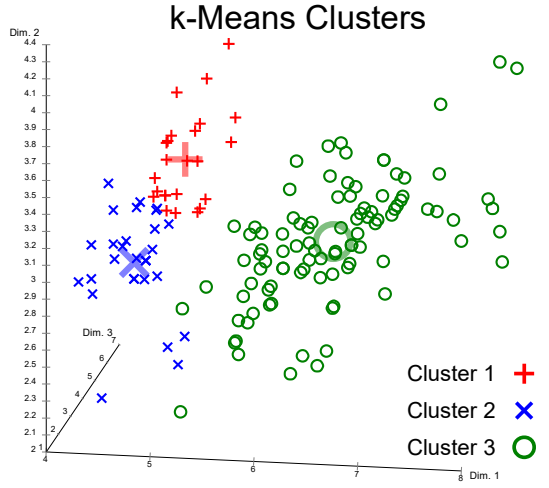


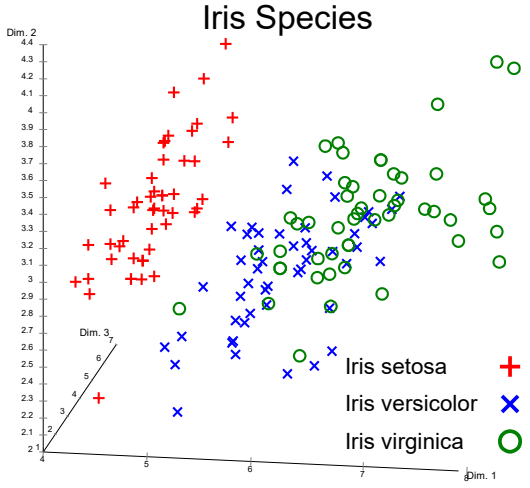


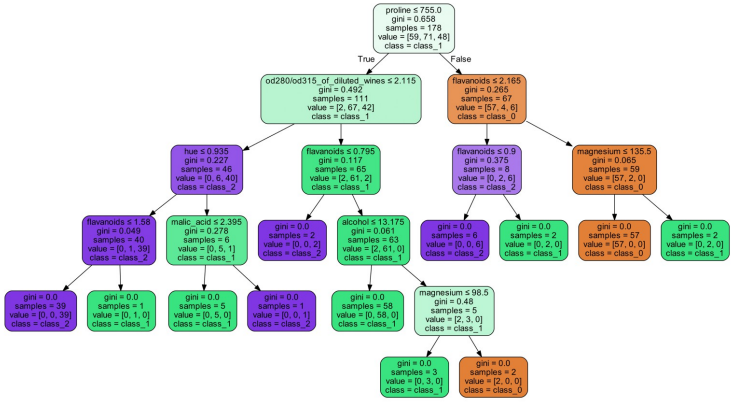
Unsupervised and Supervised Learning

Unsupervised: *interpreting and processing models*
Supervised: *predictive and descriptive models*

	Unsupervised Learning	Supervised Learning
CONCLUSION	-	+
TEST	-	+
FEATURES ANALYSIS	+	-
PROCESS DATA	+	-
CONTROL	-	+

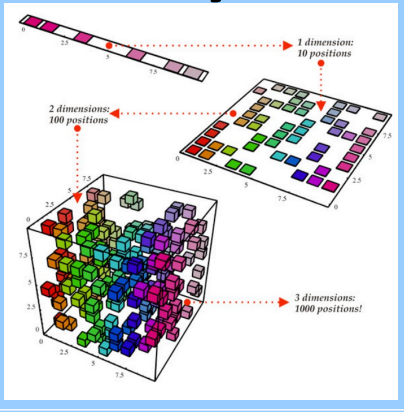




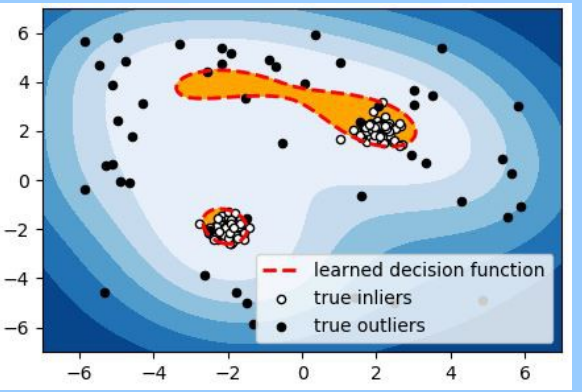


Information from data by ML

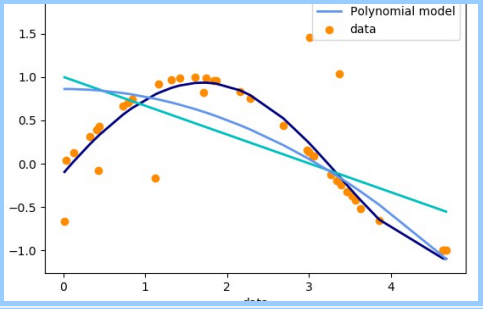
Dimensionality Reduction



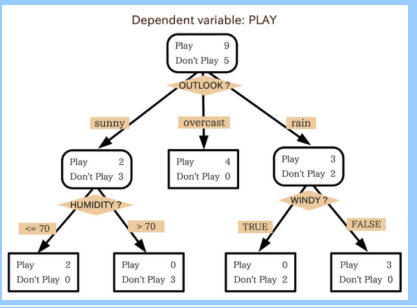
Anomaly detection



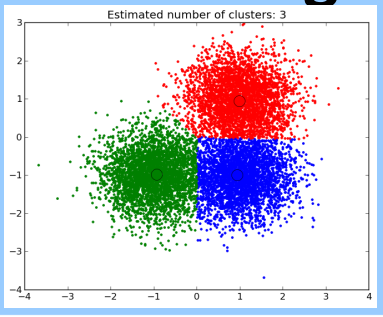
Regression



Classification



Clustering

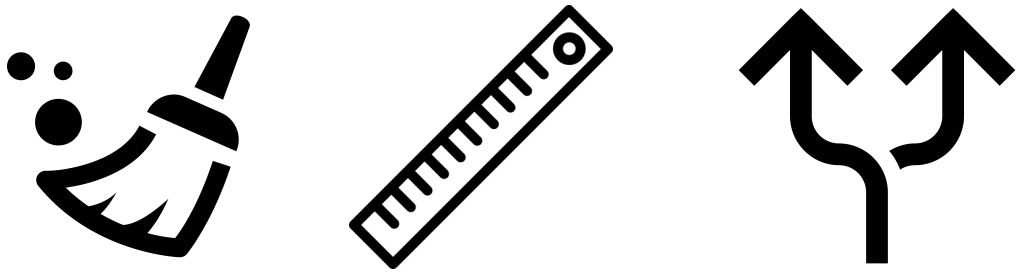


Generation

Machine Learning Workflow

Gather Data > Prepare Data > Choose Model (Train > Evaluate > Hyperparameter Tuning) > Prediction

Prepare Data: *Clean, scale and train/test split*



Choose Model: *Train, evaluate and maximize accuracy*

Our case of study

Pseudorapidity	Missing Momentum	Angle	Invariant mass	Model
2,1245	1,5123	-2,7362	1500	1
0,5787	0,1913	-2,4253	500	1
-1,4872	0,1008	2,9731	750	0
-0,4587	-2,0445	2,8722	1000	1
1,0124	-0,6498	-2,5371	1250	0
0,7652	-1,0118	2,2763	1000	1
-0,1241	1,6875	2,7352	1000	1

Models we have used:

Classification: *Neural Network, Decision Tree, Logistic Regression, etc.*

Models we are going to use:

Clustering: *K-means*

Generation: Generative Neural Network

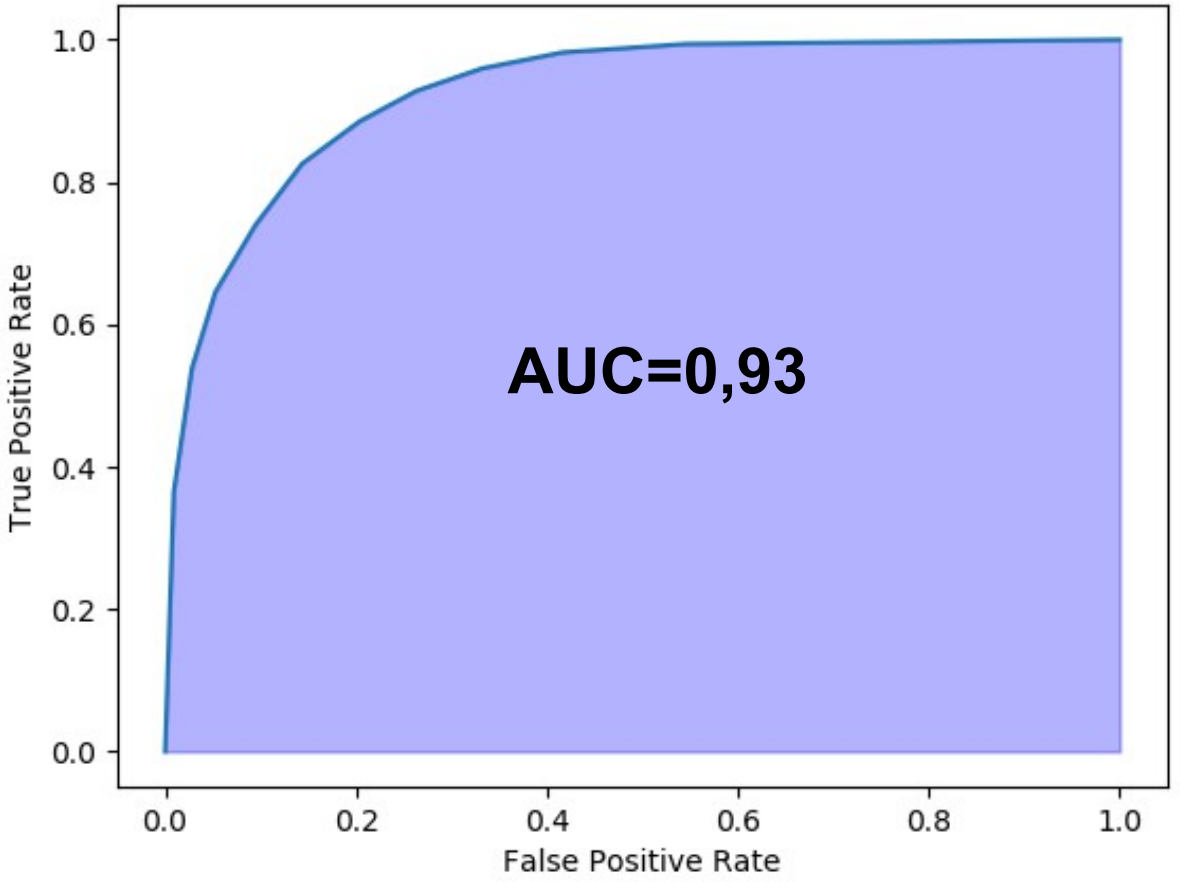
Showcase of Machine Learning

- 28 features to analyse with.

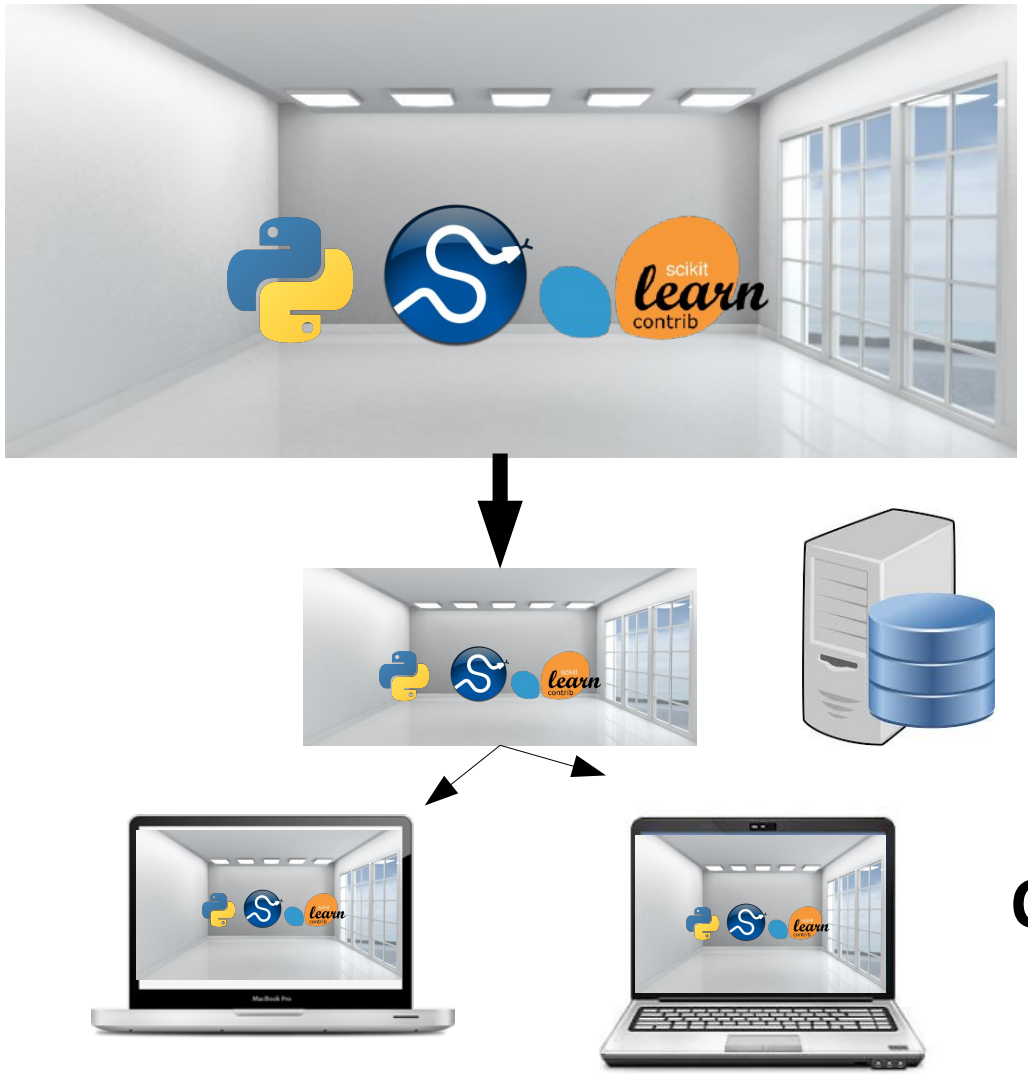
- More than 7,000,000 events.

- 2 Labels.

Classification for 2 labels among 196,000,000 non-integer numbers



Code Laboratories: Enviroments and Dockers



Local computer

Shared enviroment

Companion local computer

Code Laboratories

Anaconda 

Enviroments which can be copied and shared, but you **need some installation**.

Easiest and more common

Docker 

Containers that can be copied and shared, and you have **NO need of installing** nothing at all.

Lightest and more powerful

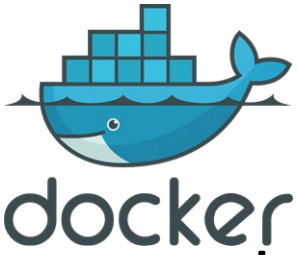
Open Fronts

Nowadays our project has these open fronts:

- Make real use of **SWAN** on our study

- Put together ML models trained in **Python and ROOT**

- Implement **Docker** as a common tool on our development



- Improve our analysis on **Neural Network using GPU's**

To sum up:

Machine Learning is used for **pattern analysis** and **prediction**

Docker and **Anaconda** are really good friends for **Science research** using Machine Learning

References to learn more...

Machine Learning explanations and examples:
https://machinelearningmastery.com/
http://scikit-learn.org
https://stackoverflow.com/

Datasets to practise:
https://archive.ics.uci.edu/ml/index.php
https://www.kaggle.com/datasets

Thanks for your attention!