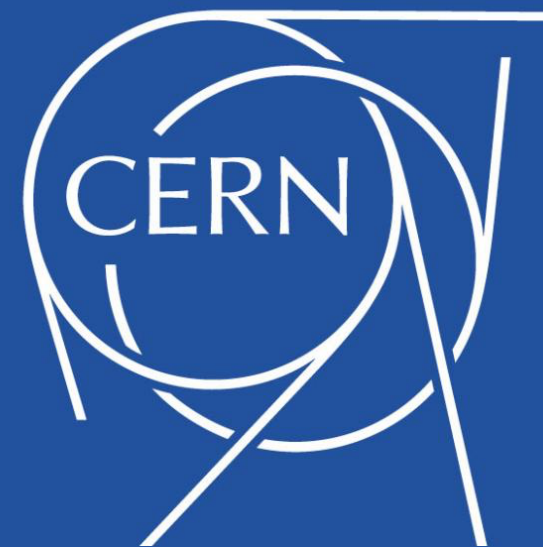


# Deep Learning

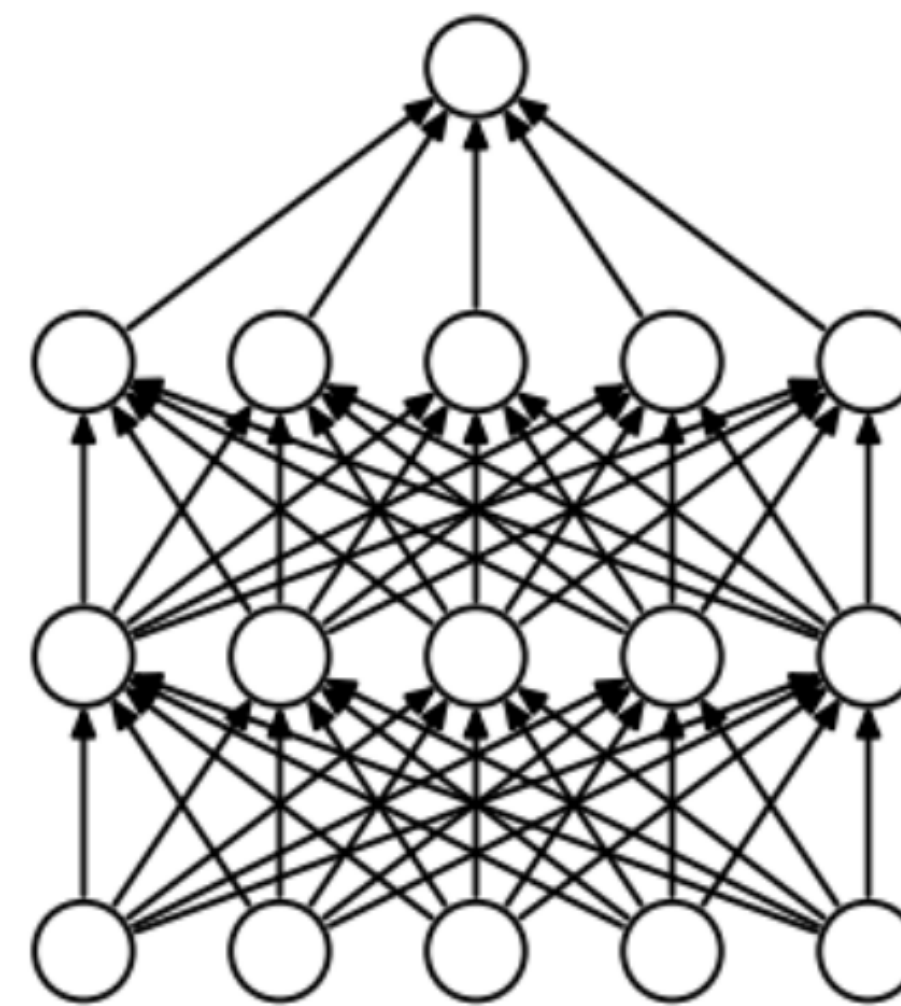
## Part I: Introduction

Maurizio Pierini

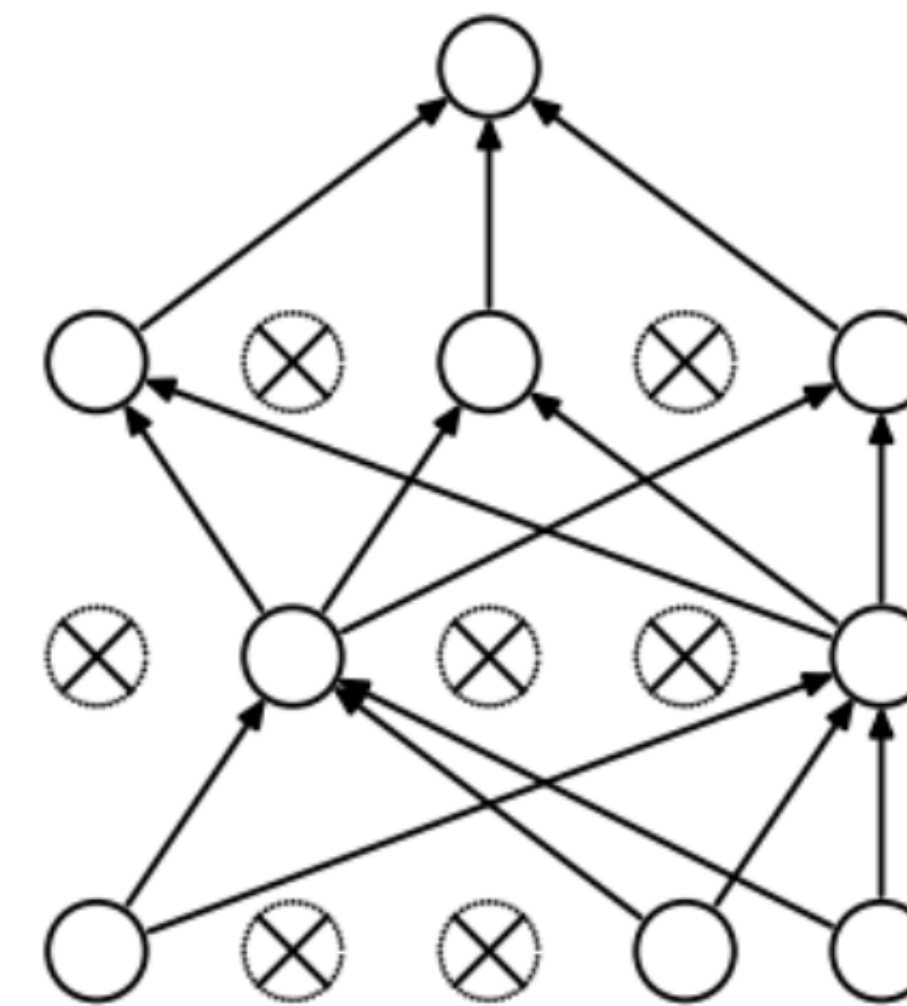


# Dropout Layer

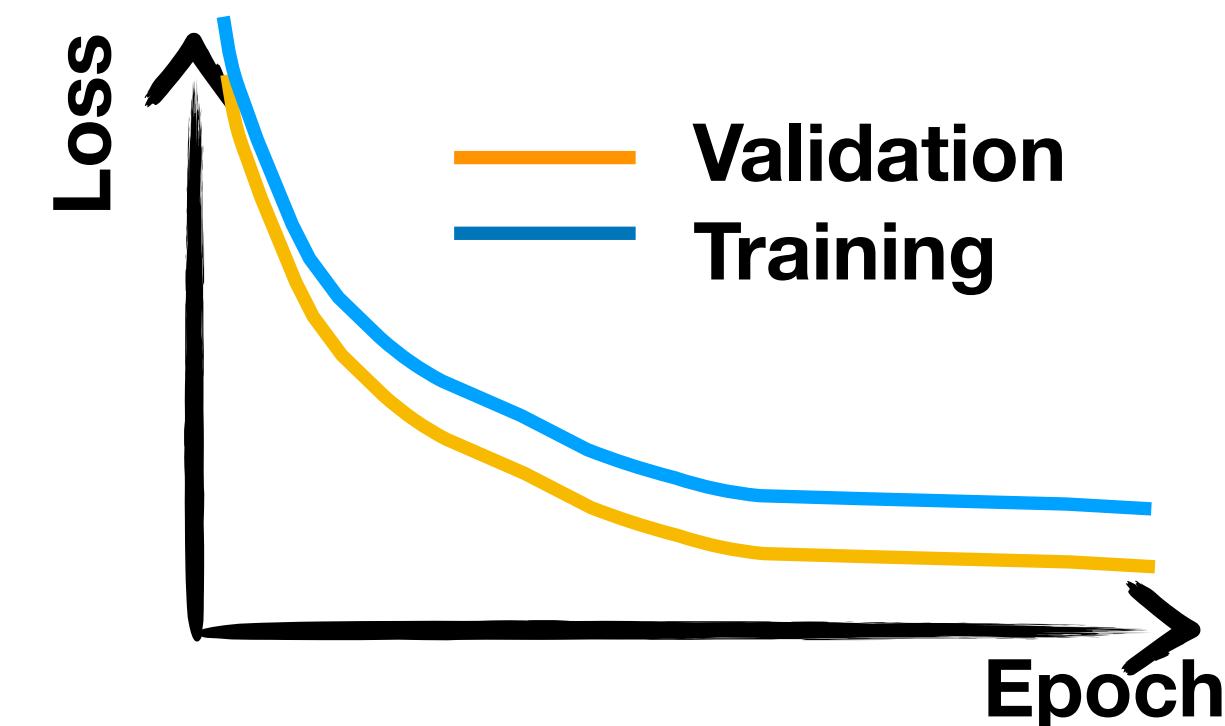
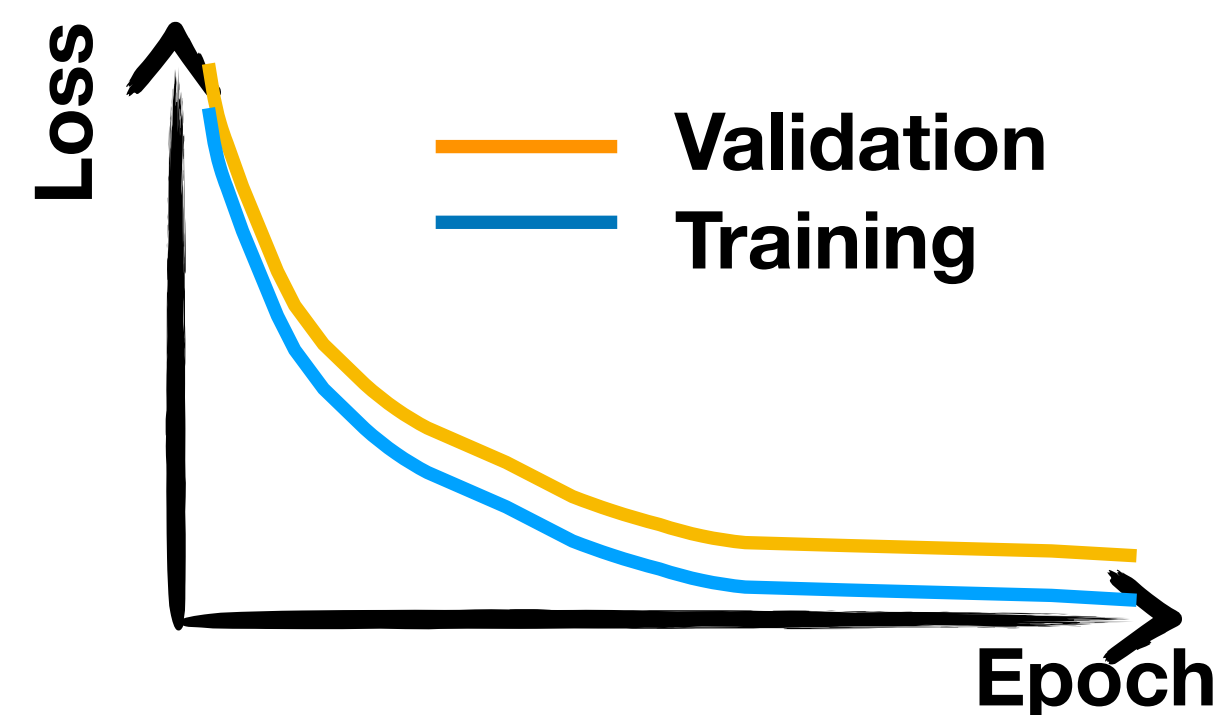
- A special kind of layer, introduced for regularisation purpose
- Randomly drop links between neurons, with probability  $p$
- The connections are re-established during the validation and inference steps
- Typical sign of it: invert hierarchy between training and validation loss



(a) Standard Neural Net

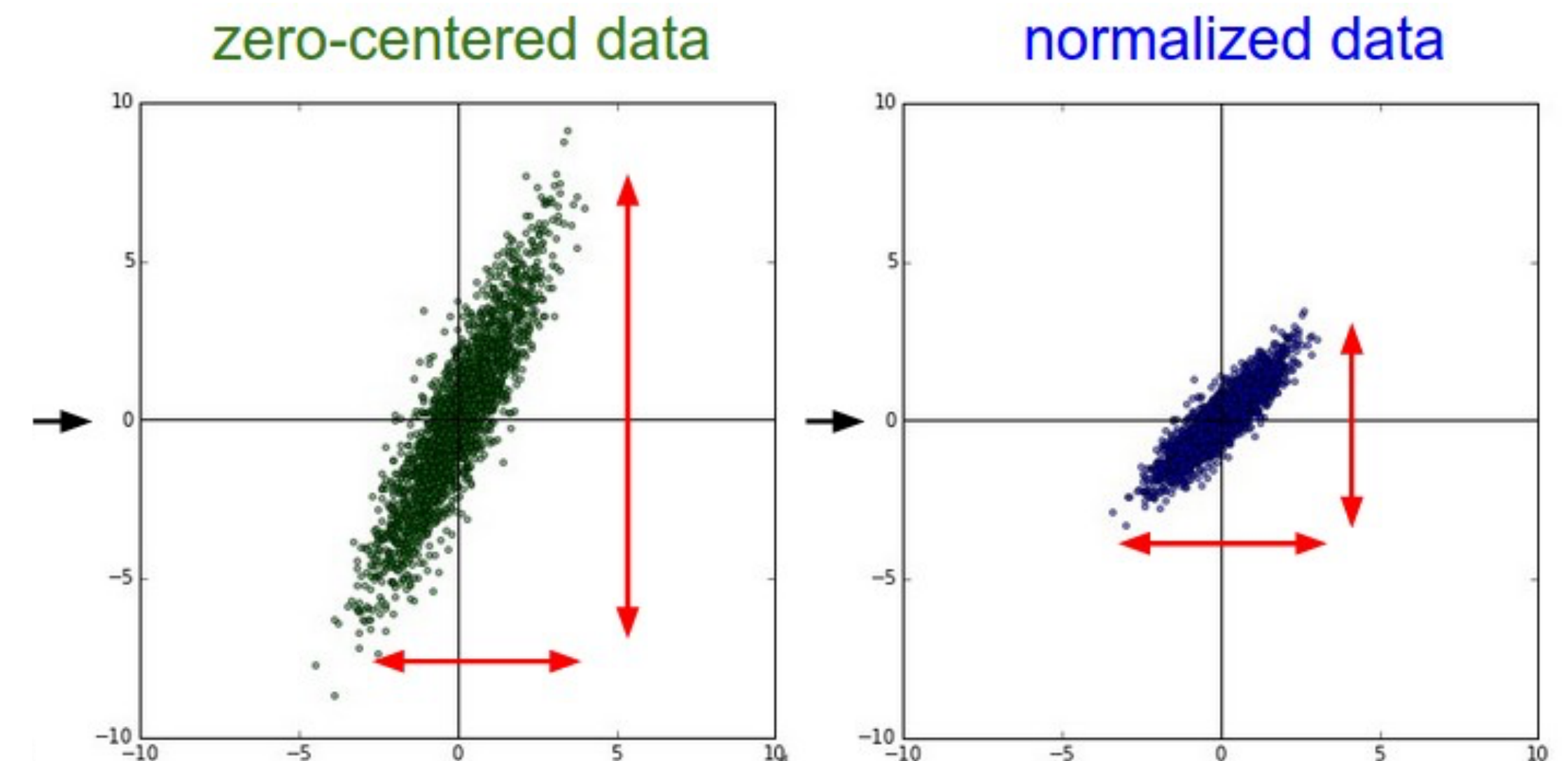
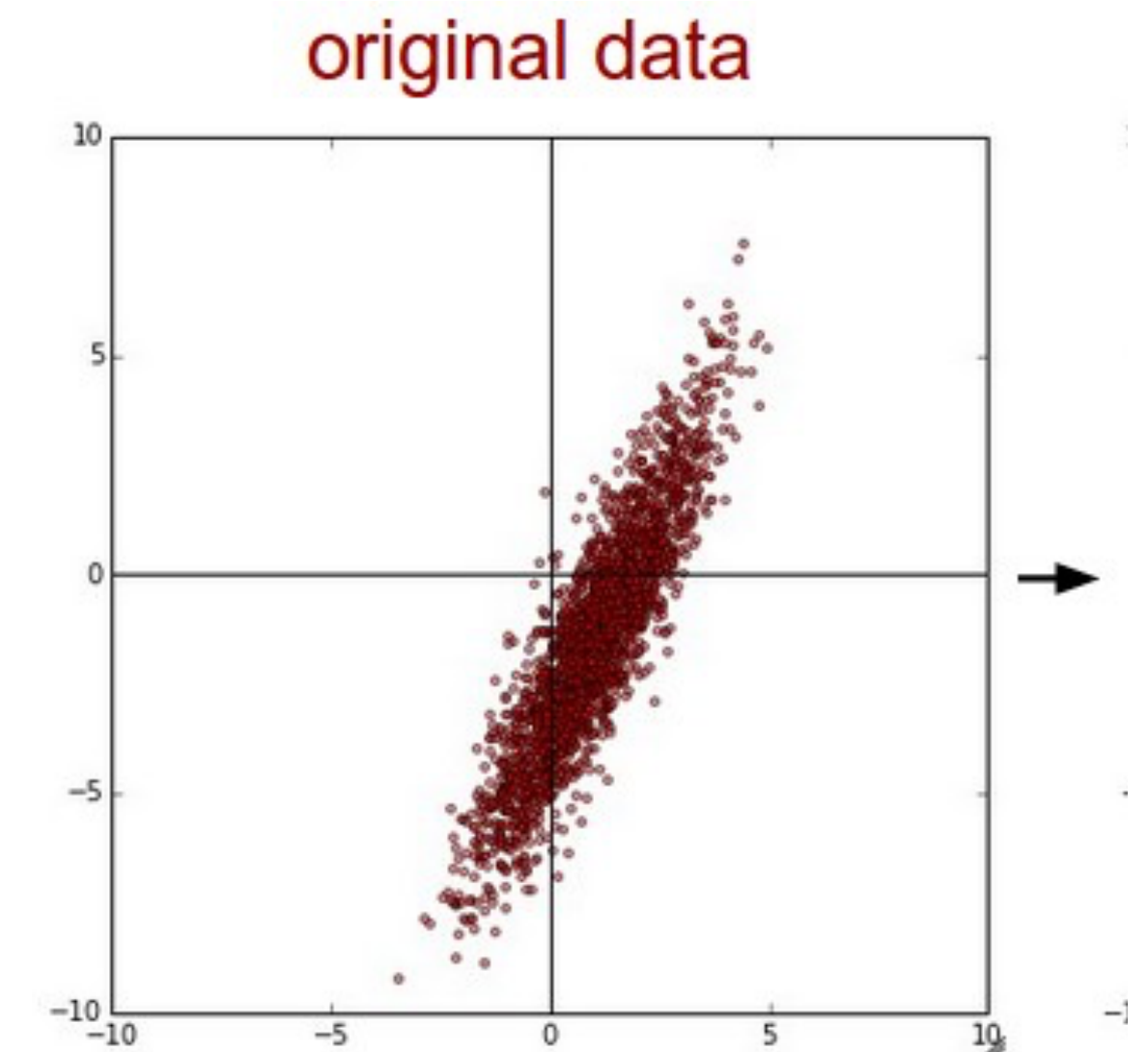


(b) After applying dropout.



# Batch Normalization Layer

- It is good practice to give normalized inputs to a layer
- With all inputs having the same order of magnitude, all weights are equal important in the gradient
- Prevents explosion of the loss function
- This can be done automatically with Batch Normalization
- non-learnable shift and scale parameters, adjusted batch by batch





# More complex structures

- ⦿ Dense NN architectures can be made more complex
  - ⦿ Multiple inputs
  - ⦿ Multiple outputs
  - ⦿ Different networks branches
- ⦿ This is possible thanks to layer-manipulation layers
  - ⦿ Add, Subtract, etc.
  - ⦿ Concatenation
  - ⦿ Flattening
- ⦿ All these operations are usually provided with NN training libraries

8 0 4 7 6 8 0    7 9 4 6 5 2 6    8 3 4 5 5 3 4

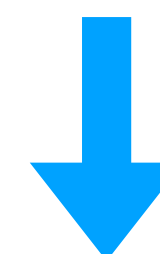


*Concatenation*

8 0 4 7 6 8 0 8 3 4 5 5 3 4 7 9 4 6 5 2 6

8	0	4	7	6	8	0
8	3	4	5	5	3	4
7	9	4	6	5	2	6

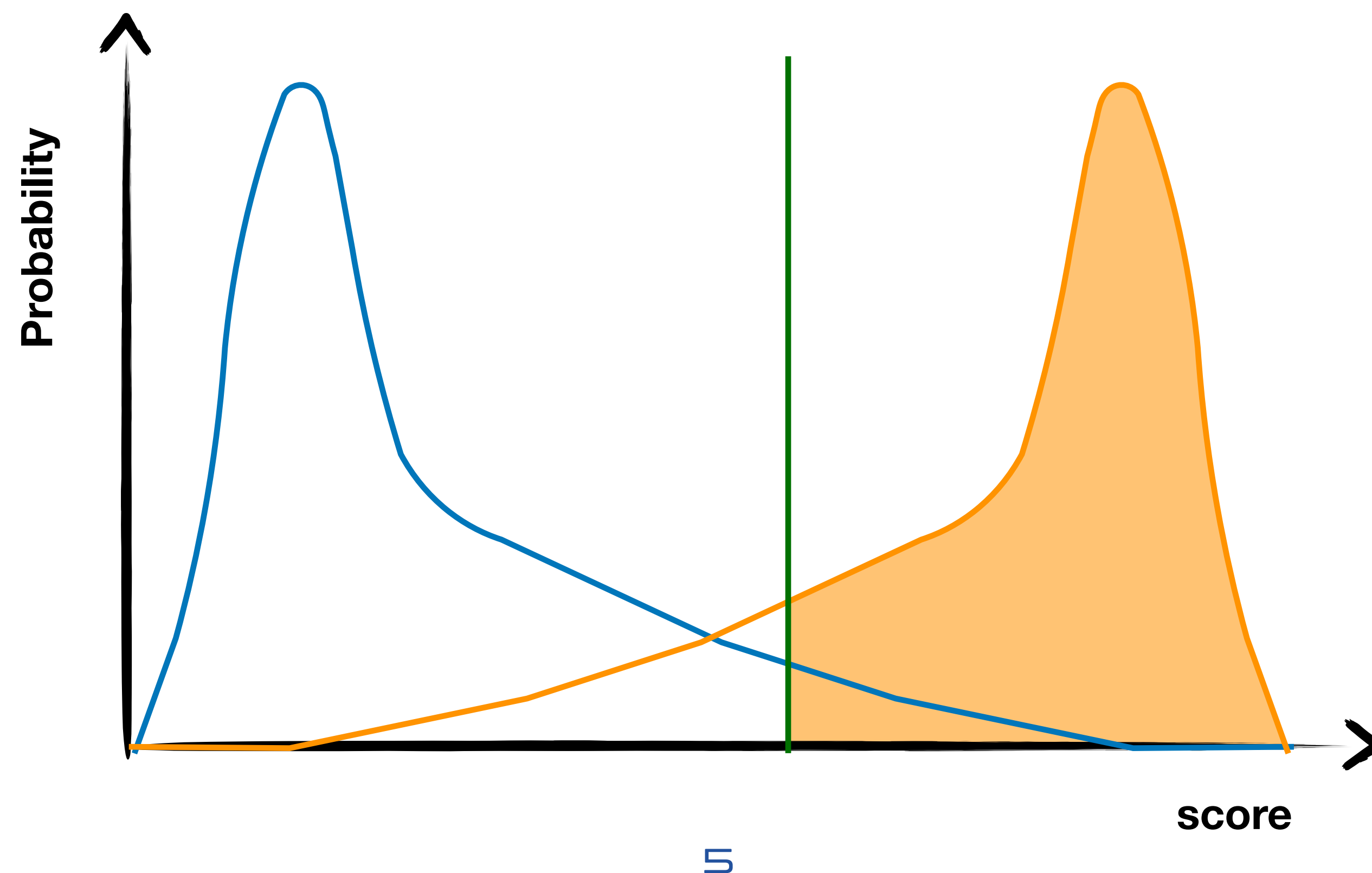
*Flattening*



8 0 4 7 6 8 0 8 3 4 5 5 3 4 7 9 4 6 5 2 6

# Classifier metrics

- A given threefold defines the following qualities
  - *True-positives: Class-1 events above the threshold*
  - *True-negatives: Class-0 events below the threshold*
  - *False-positives: Class-0 events above the threshold*
  - *False-negatives: Class-1 events below the threshold*



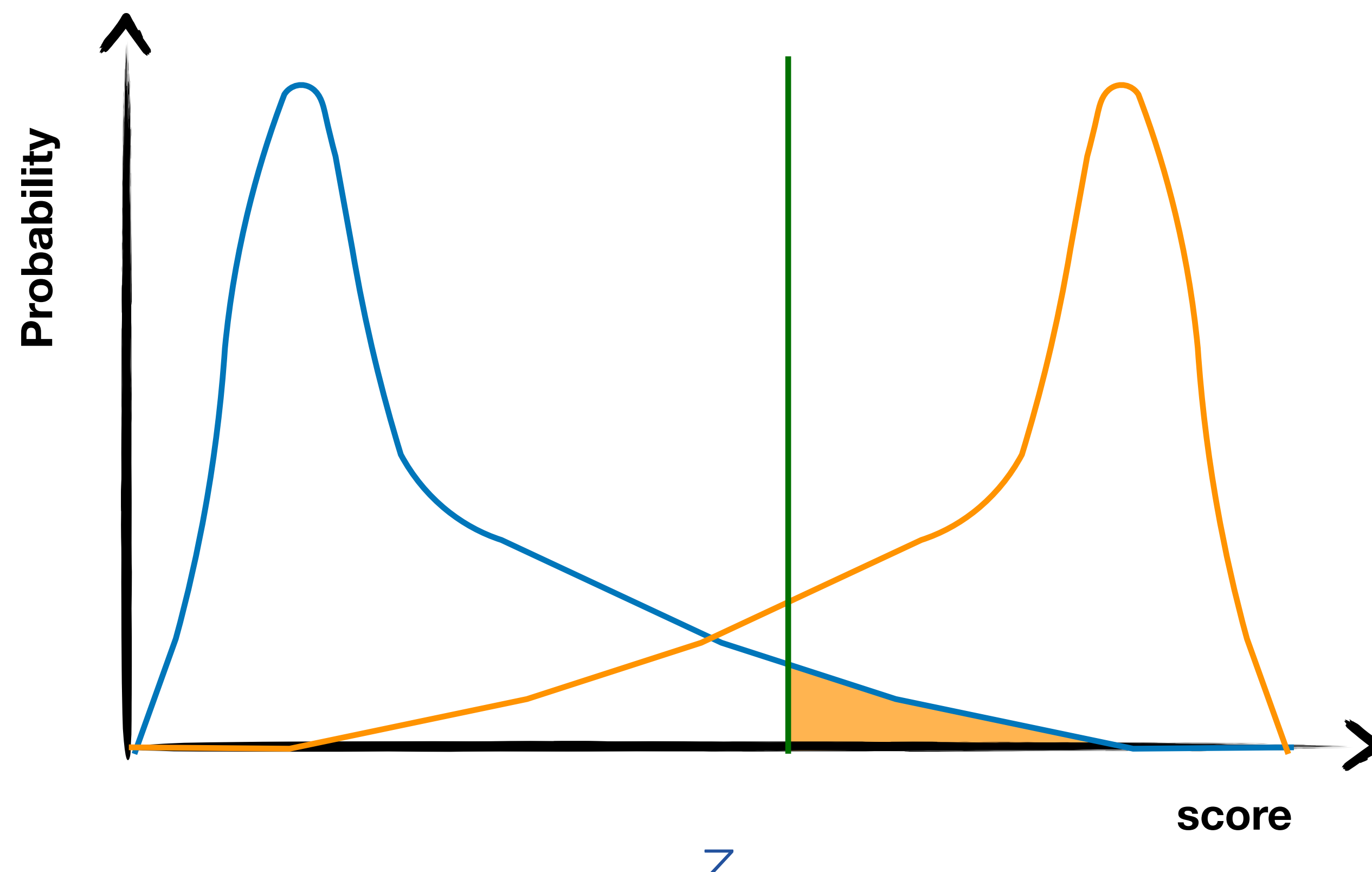
# Classifier metrics

- A given threefold defines the following qualities
  - True-positives: Class-1 events above the threshold
  - True-negatives: Class-0 events below the threshold
  - False-positives: Class-0 events above the threshold
  - False-negatives: Class-1 events below the threshold



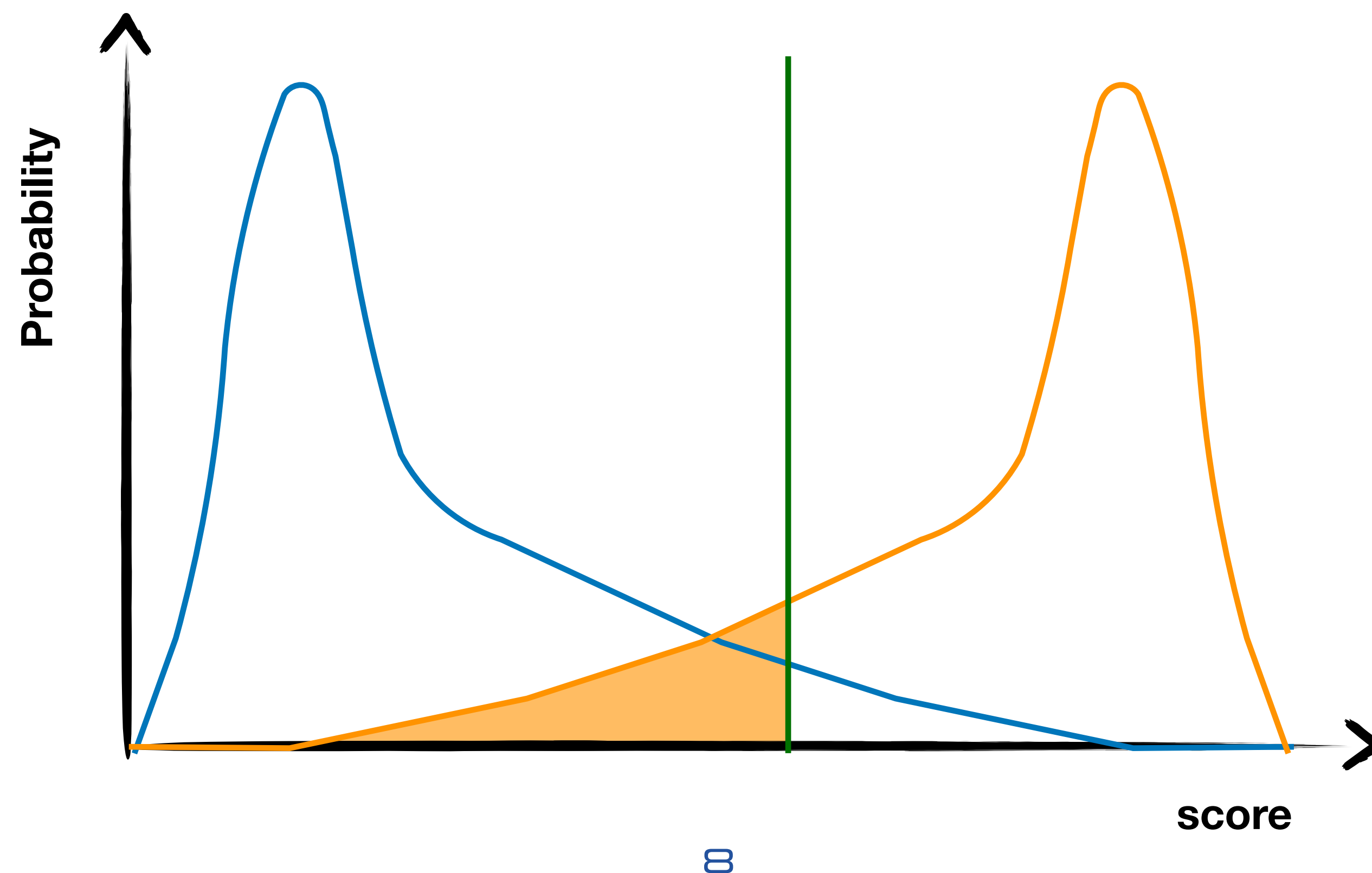
# Classifier metrics

- A given threefold defines the following qualities
  - True-positives: Class-1 events above the threshold
  - True-negatives: Class-0 events below the threshold
  - False-positives: Class-0 events above the threshold
  - False-negatives: Class-1 events below the threshold



# Classifier metrics

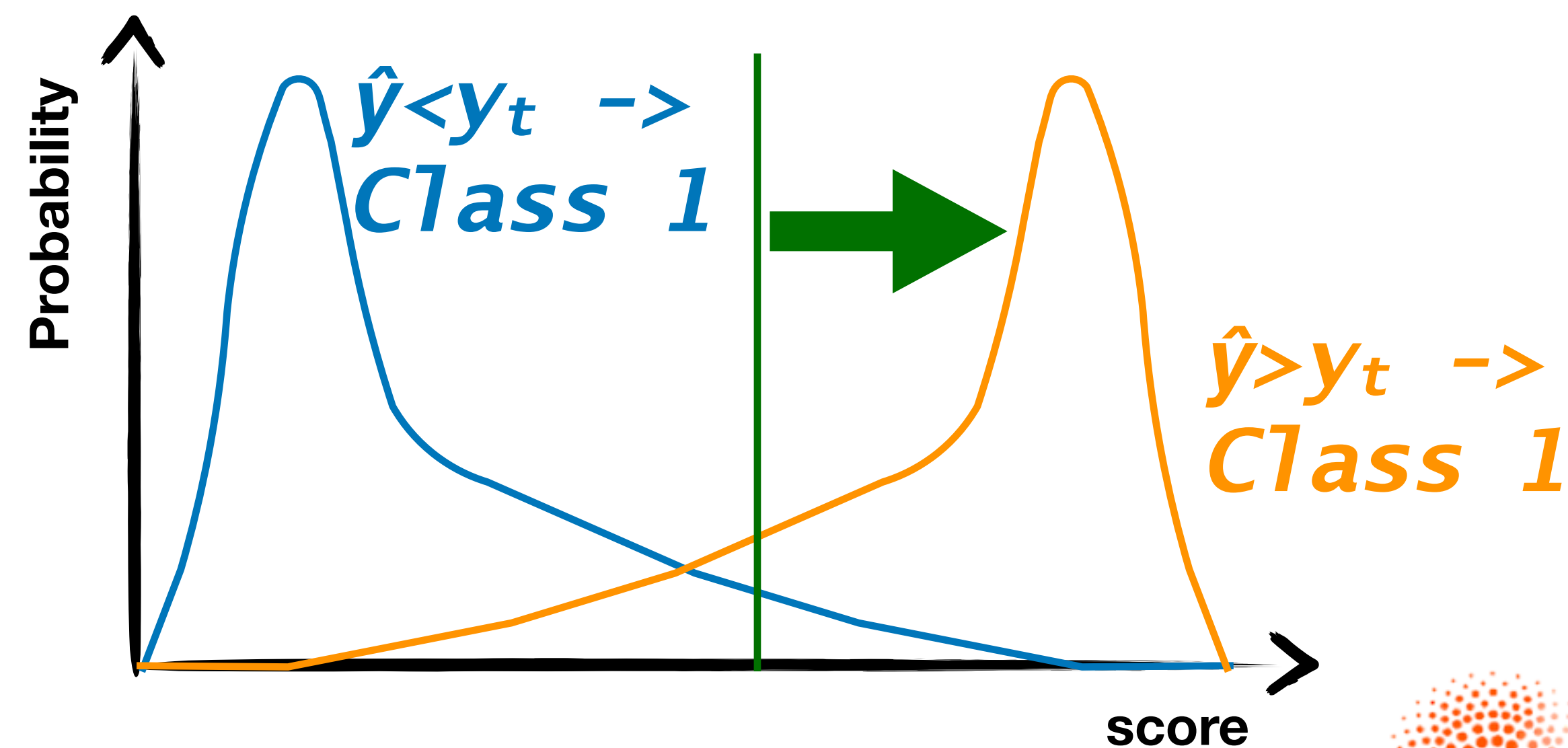
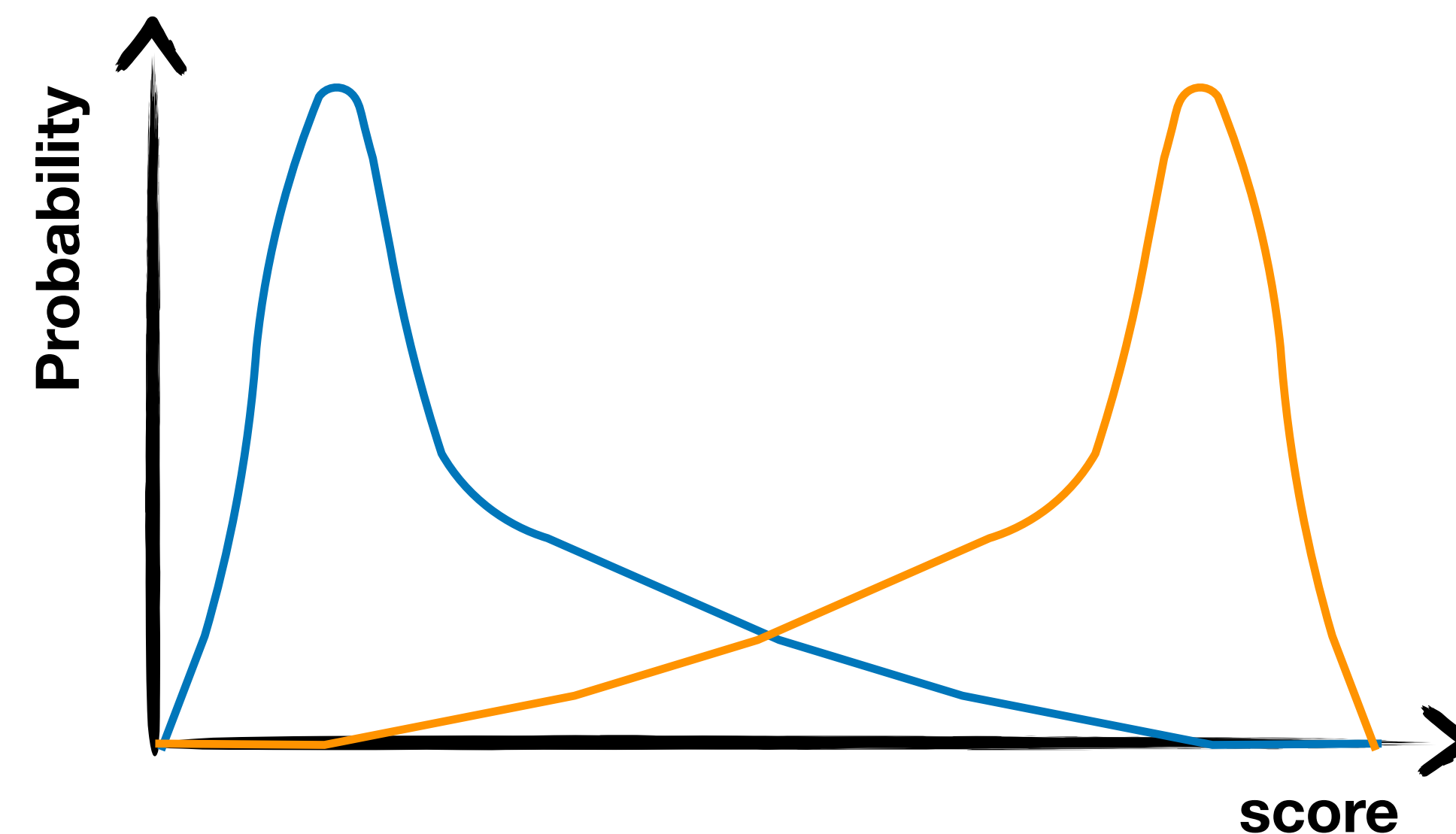
- A given threefold defines the following qualities
  - True-positives: Class-1 events above the threshold
  - True-negatives: Class-0 events below the threshold
  - False-positives: Class-0 events above the threshold
  - False-negatives: Class-1 events below the threshold





# Classifier metrics

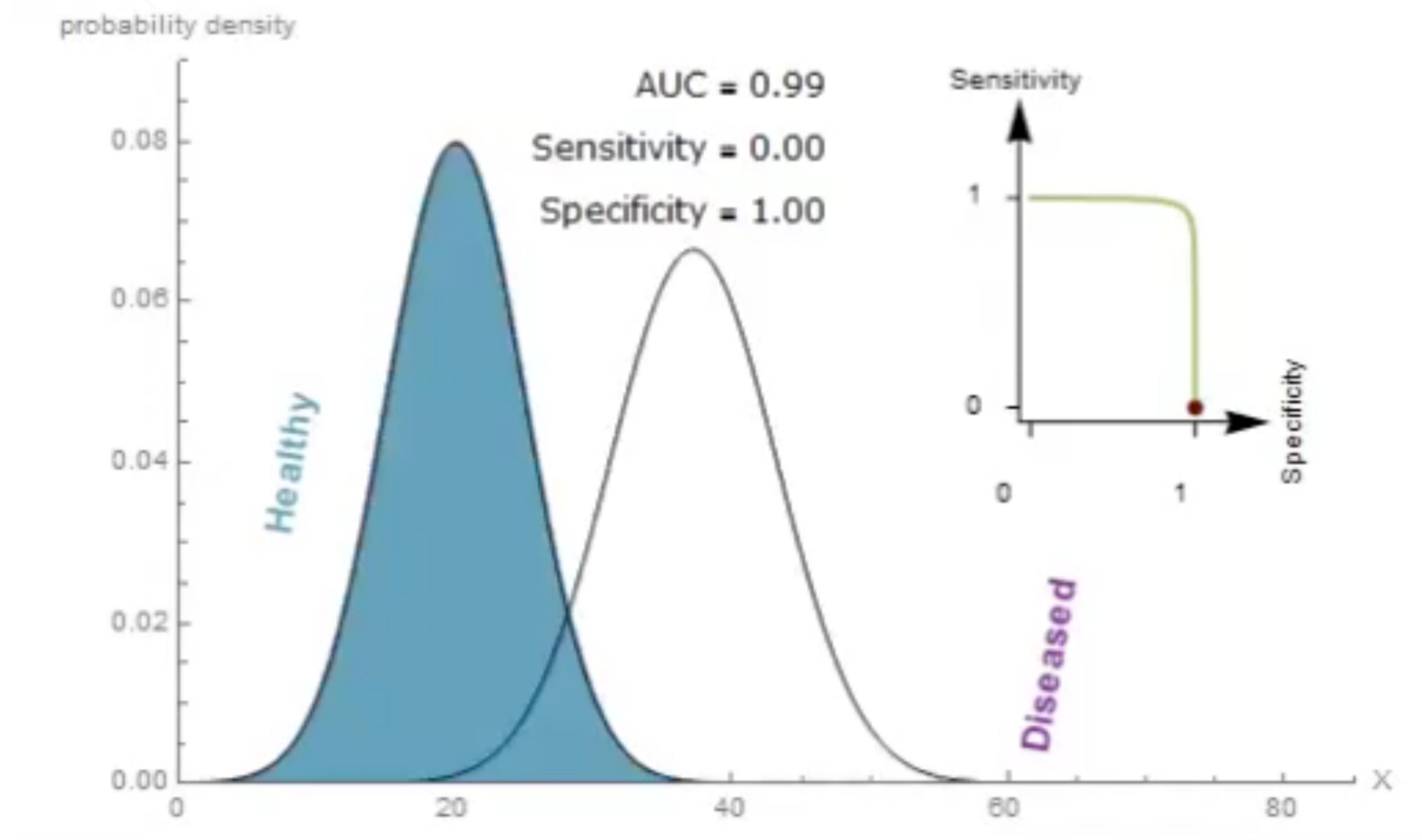
- Consider a binary classifier
- Its output  $\hat{y}$  is a number in  $[0,1]$
- If well trained, value should be close to 0 (1) for class-0 (class-1) examples
- One usually defines a threshold  $y_t$  such that:
  - $\hat{y} > y_t \rightarrow \text{Class 1}$
  - $\hat{y} < y_t \rightarrow \text{Class 0}$



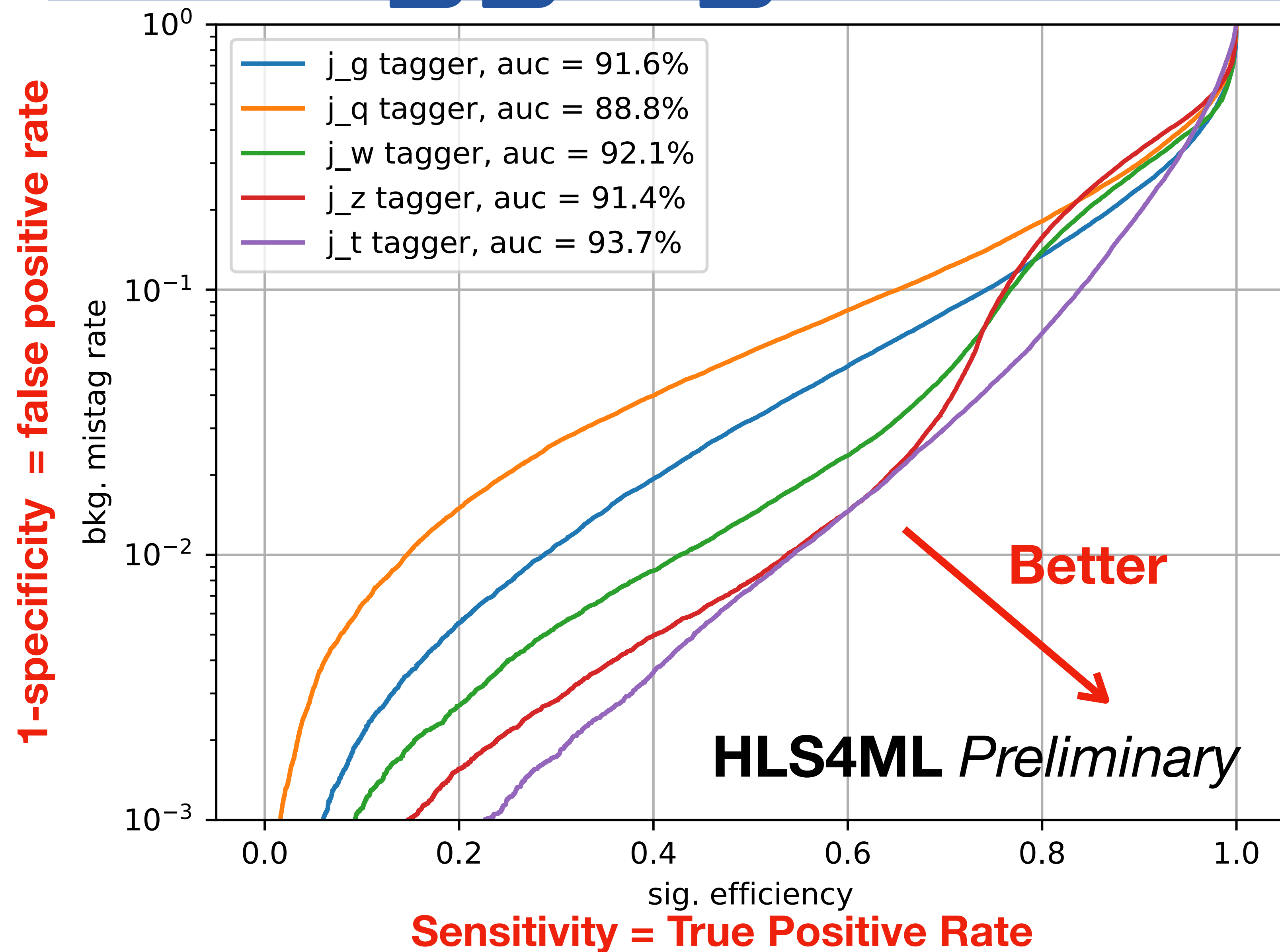
# Classifier metrics

- *Starting ingredients are true positive (TP) and true negative (TN) rates*
- *Accuracy:  $(TP+TN)/Total$* 
  - *The fraction of events correctly classified*
- *Sensitivity:  $TP/(Total\ positive)$* 
  - *AKA signal efficiency in HEP*
- *Specificity:  $TN/(Total\ negative)$* 
  - *AKA mistag rate in HEP*

# Receiver operating characteristic



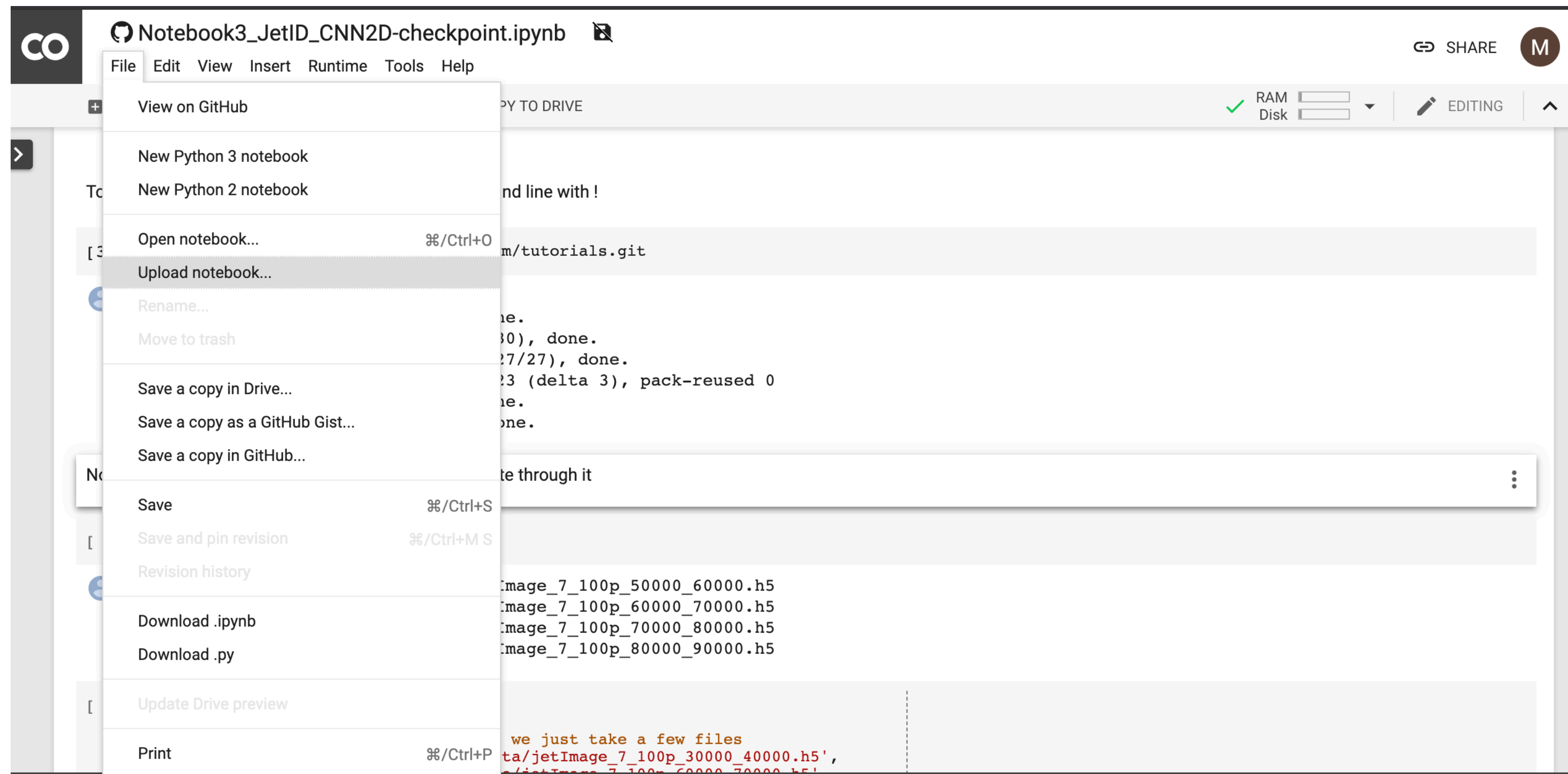
# Jet tagging ROC curve





# Step1: Open Notebook on Colab

● Go to <https://colab.research.google.com>



# Step2: import the Tutorial from gitlab

- Click on the GITHUB tab
- Specify the repository *pierinim/tutorials*
- Click on the notebook

Examples
Recent
Google Drive
GitHub
Upload

Enter a GitHub URL or search by organisation or user
☐ Include private repos

Repository:
Branch:

Path

GNN\_Pisa\_Nov2020/Notebook2\_JetID\_IN\_exercise.ipynb


GNN\_Pisa\_Nov2020/Notebook2\_JetID\_IN\_solution.ipynb

GNN\_Pisa\_Nov2021/GCN\_ShapeClassifier.ipynb

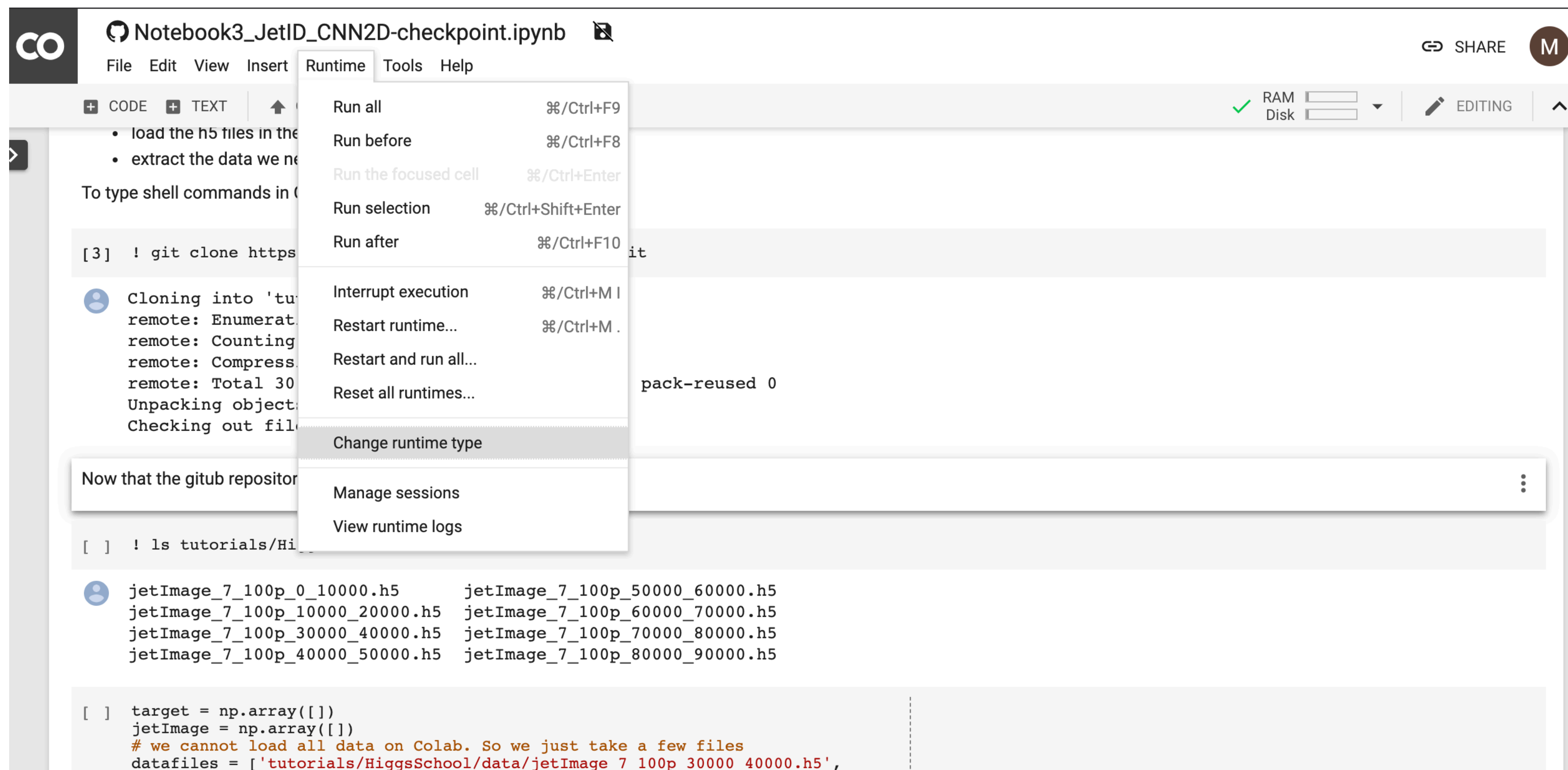
GNN\_Pisa\_Nov2021/GCN\_ShapeClassifier\_MakeData.ipynb

Cancel

14


European Research Council

# Set your resources to use GPUs



The screenshot shows a Jupyter Notebook titled 'Notebook3\_JetID\_CNN2D-checkpoint.ipynb'. The 'Runtime' menu is open, displaying various options. The 'Change runtime type' option is highlighted. The notebook content includes a list of files to load, a git clone command, and a list of HiggsSchool data files.

File Edit View Insert Runtime Tools Help

CODE TEXT

- load the h5 files in the
- extract the data we ne

To type shell commands in (

```
[3] ! git clone https
```

Cloning into 'tu  
remote: Enumerat  
remote: Counting  
remote: Compress  
remote: Total 30  
Unpacking object  
Checking out fil

Now that the gitub repositor

```
[ ] ! ls tutorials/Hi
```

```
jetImage_7_100p_0_10000.h5      jetImage_7_100p_50000_60000.h5
jetImage_7_100p_10000_20000.h5  jetImage_7_100p_60000_70000.h5
jetImage_7_100p_30000_40000.h5  jetImage_7_100p_70000_80000.h5
jetImage_7_100p_40000_50000.h5  jetImage_7_100p_80000_90000.h5
```

```
[ ] target = np.array([])
jetImage = np.array([])
# we cannot load all data on Colab. So we just take a few files
datafiles = ['tutorials/HiggsSchool/data/jetImage_7_100p_30000_40000.h5',
```

RAM Disk EDITING

pack-reused 0

# Set your resources to use GPUs

and line with !

im/tu

one.  
(30),  
27/2  
23 (  
one.  
one.

ate th

Image\_7\_100p\_50000\_60000.h5  
Image\_7\_100p\_60000\_70000.h5  
Image\_7\_100p\_70000\_80000.h5

## Notebook settings

Runtime type  
Python 3 ▼

Hardware accelerator  
GPU ▼ ⓘ

☐ Omit code cell output when saving this notebook

CANCEL SAVE