Deep Learning with Keras I+II

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INFIERI19, Wuhan, 13 May 2019

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Introduction

About us

Universität Hamburg
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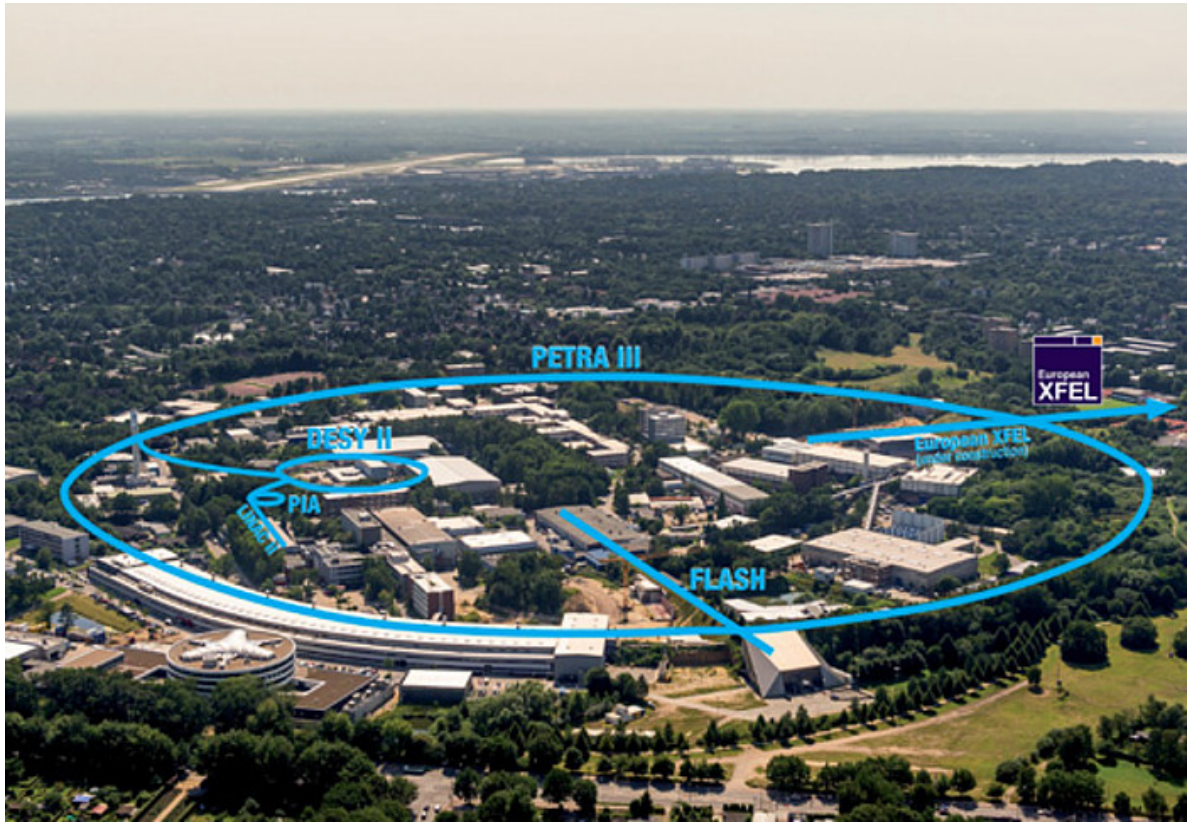


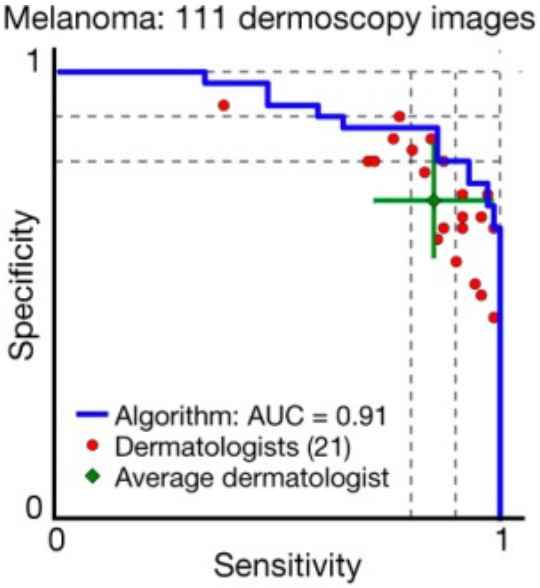
https://www.helmholtz.de/en/about_us/helmholtz_centers/centers_a_z/zentrum/detailansicht/deutsches-elektronen-synchrotron-desy-1/

- particle physicists from University of Hamburg and DESY (Hamburg), Germany
- members of CMS Collaboration

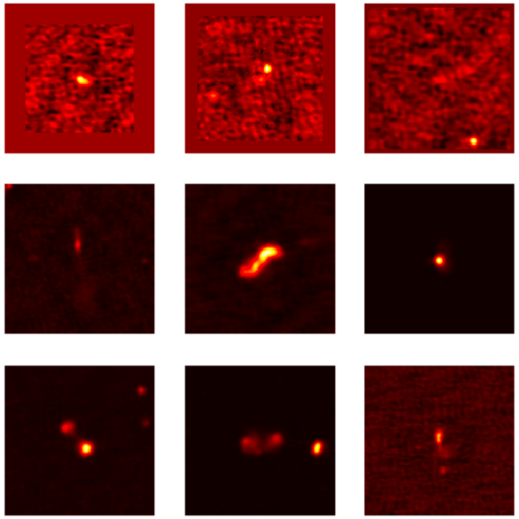
Machine Learning

Wide range of applications, huge progress in the last years

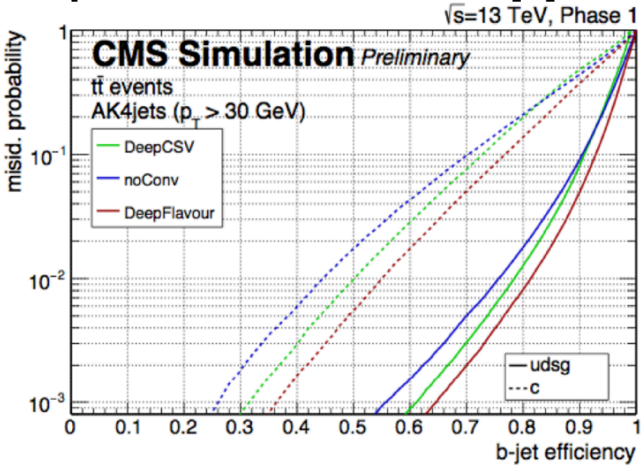
detection of diseases [1]



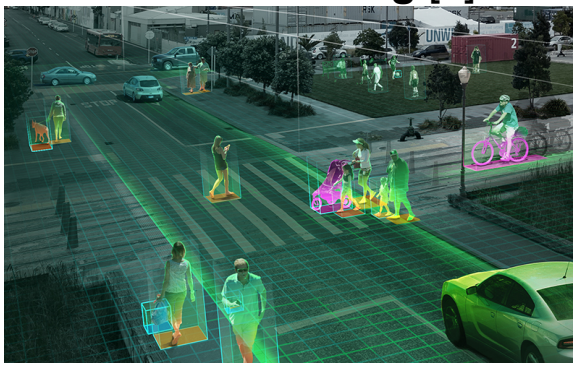
galaxy classification [2]



particle identification [3]

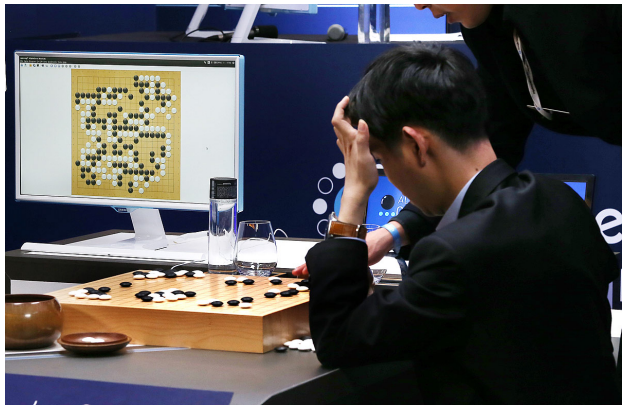


autonomous driving [4]



- and many more (speech recognition, social networks …)

Go [5]

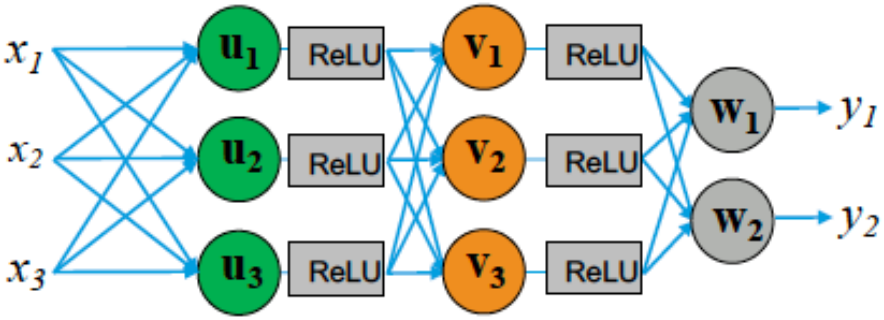


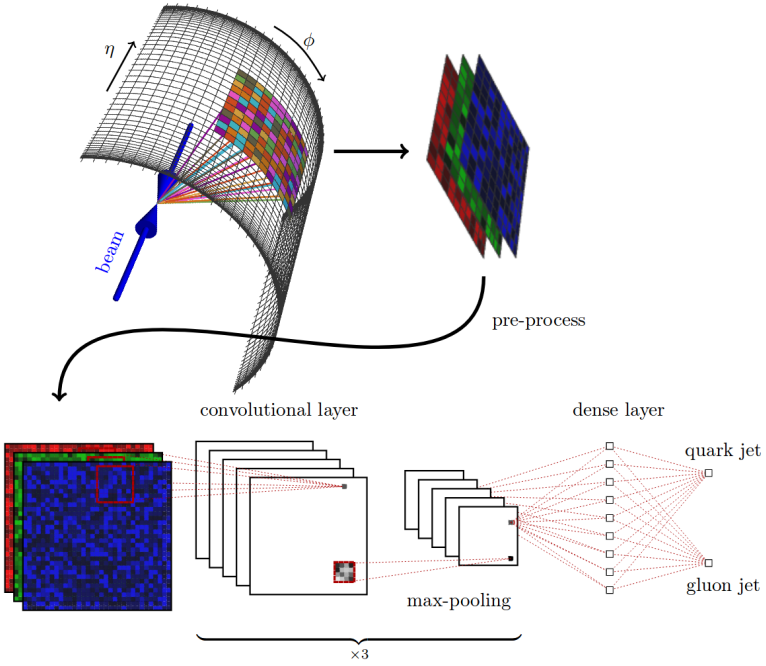
references for all images in back-up

Organization

Lab divided into two parts (alternating, schedule in back-up)

- **Deep Learning with Keras I**
  - starting from scratch
  - fully connected neural networks
  - supervised machine learning





Deep learning in color: towards automated quark/gluon jet discrimination, JHEP 01 (2017) 110, arXiv:1612.01551

- **Deep Learning with Keras II**
  - specific example from particle physics (**not restricted** to particle physicists)
  - we assume that you know the basics from our first part
  - convolutional neural networks
  - challenge

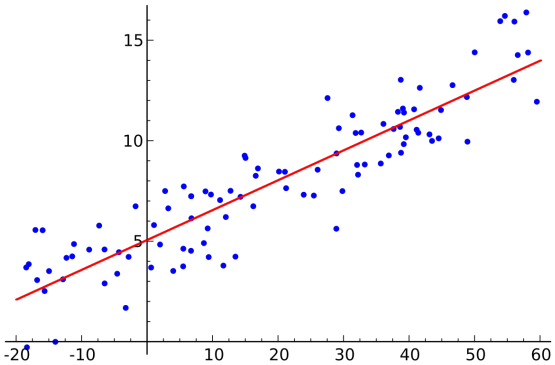
note: there is another advanced lab on Deep Learning by Lara Lloret Iglesias

Introduction to deep learning for beginners

Deep Learning with Keras I

- **learn basic concepts** of machine learning: loss function, activation function, optimizer, batch, epoch, training, validation & test dataset, overtraining

regression:



https://en.wikipedia.org/wiki/Regression_analysis

binary classification:

multi-class classification:

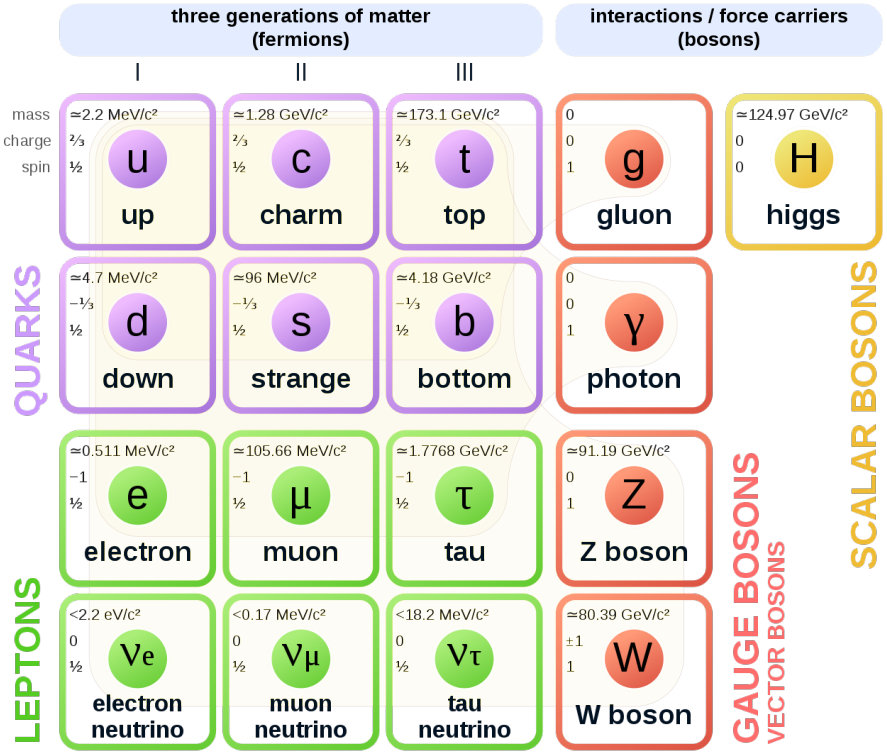
https://github.com/zalandoresearch/fashion-mnist

human accuracy is about 83.5%
Can you do better using ML?

Machine learning approaches to top-quark tagging

Deep Learning with Keras II

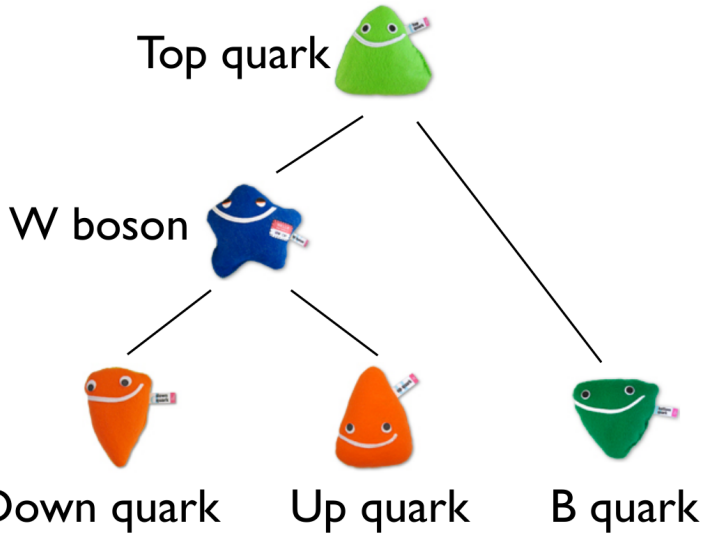
Standard Model of Elementary Particles



https://en.wikipedia.org/wiki/Standard_Model

top quark: key particle to search for new physics and for precision measurements

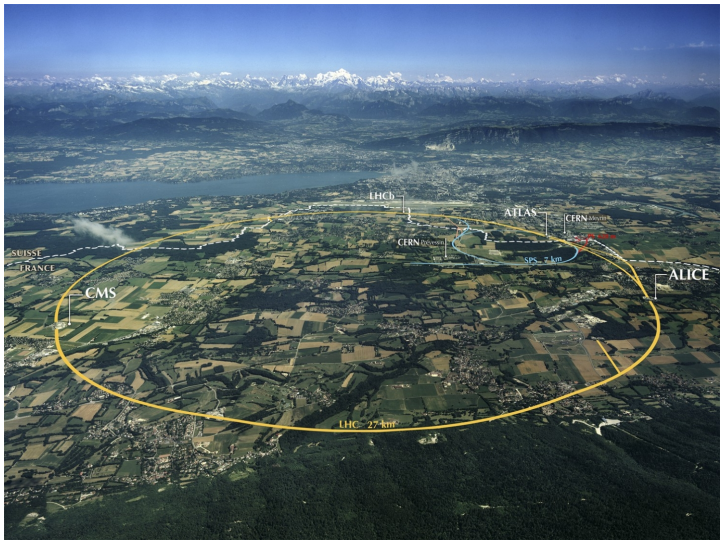
- heaviest known elementary particle ($m \approx 172.5$ GeV)
- very short lifetime (10^{-25} s)
  → only decay products detectable
- study hadronically decaying top quarks:



https://www.particlezoo.net

Machine learning approaches to top-quark tagging

Deep Learning with Keras II

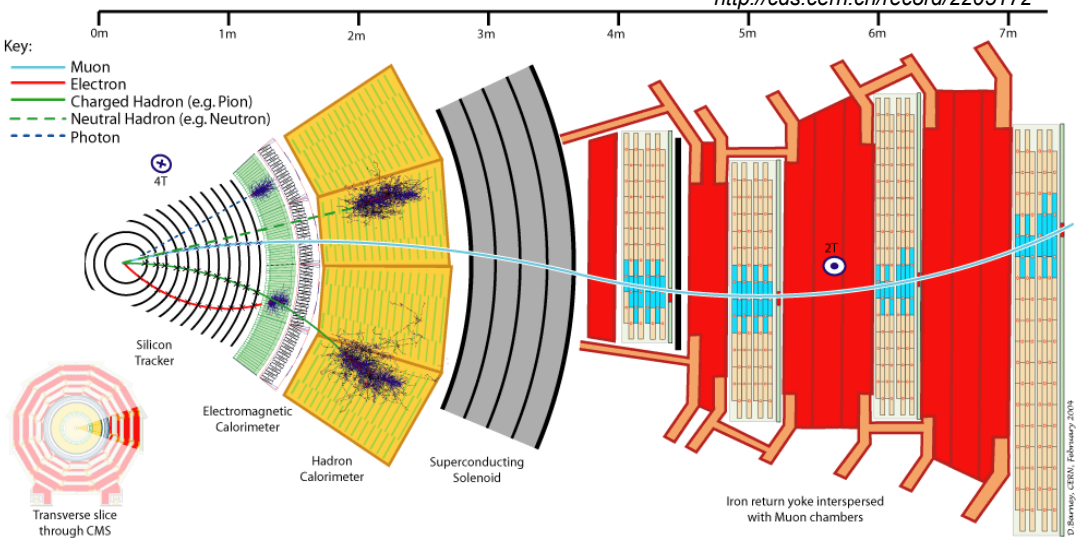


https://home.cern/news/news/cern/25-years-large-hadron-collider-experimental-programme

- **L**arge **H**adron **C**ollider (LHC)
- pp collider at CERN
- 27 km circumference
- centre-of-mass energy: 13 TeV

- **C**ompact **M**uon **S**olenoid (CMS)
- silicon tracker, ECAL, HCAL, solenoid, muon system
- reconstructs four-momenta of all visible final-state particles

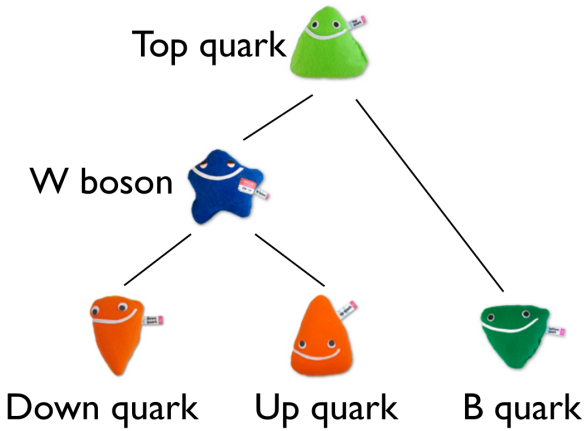
http://cds.cern.ch/record/2205172



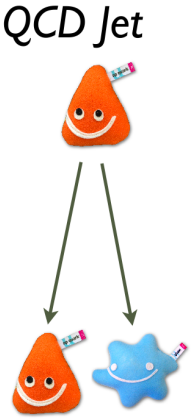
Machine learning approaches to top-quark tagging

Deep Learning with Keras II

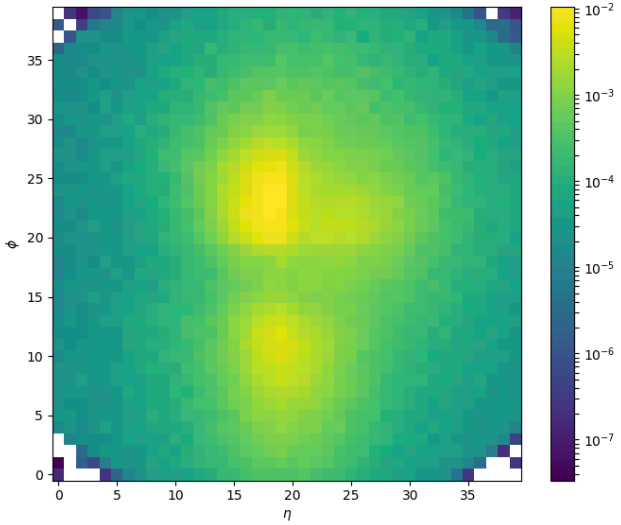
signal event (rare):

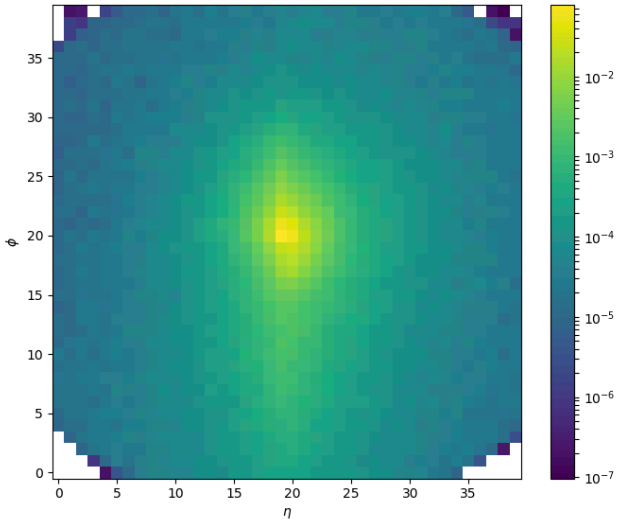


background event (frequent):



in the detector:
10000 image average



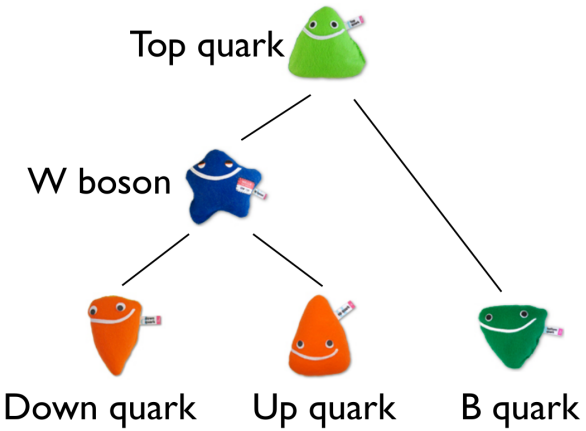


jet images from C. Daza

Machine learning approaches to top-quark tagging

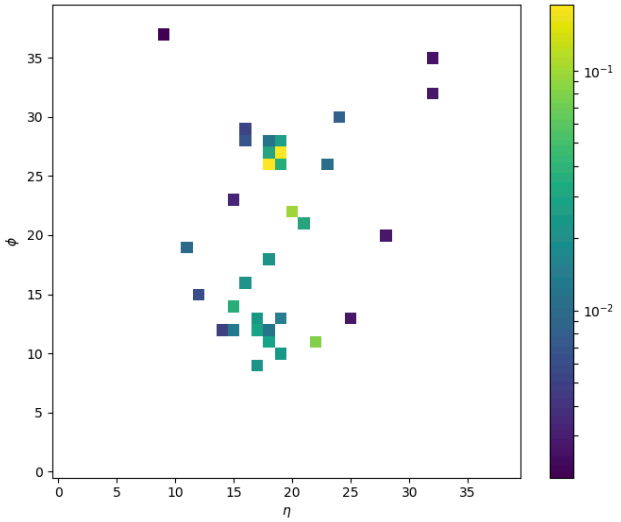
Deep Learning with Keras II

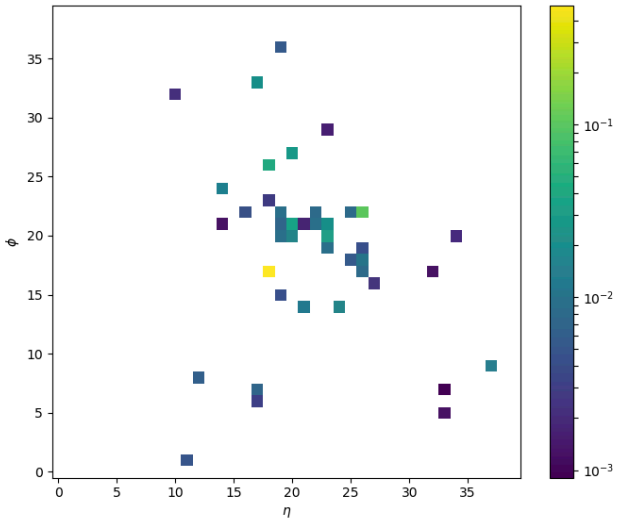
signal event (rare):



background event (frequent):

in the detector:
1 image





jet images from C. Daza

Use ML to distinguish signal from background events!

Machine learning approaches to top-quark tagging

Deep Learning with Keras II

signal event (rare): **background event (frequent):**

QCD Jet

Two different approaches will be tried in our lab

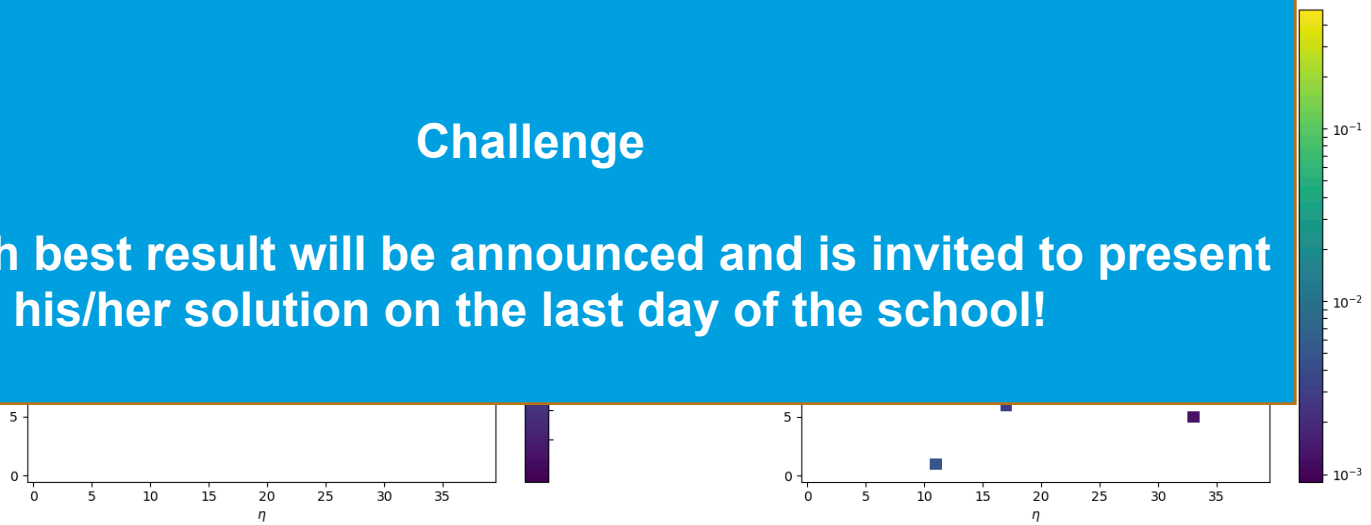
1. Fully Connected Neural Networks (jet constituents)

2. Convolutional Neural Networks (jet images)

Challenge

Team with best result will be announced and is invited to present his/her solution on the last day of the school!

in the d
1 image

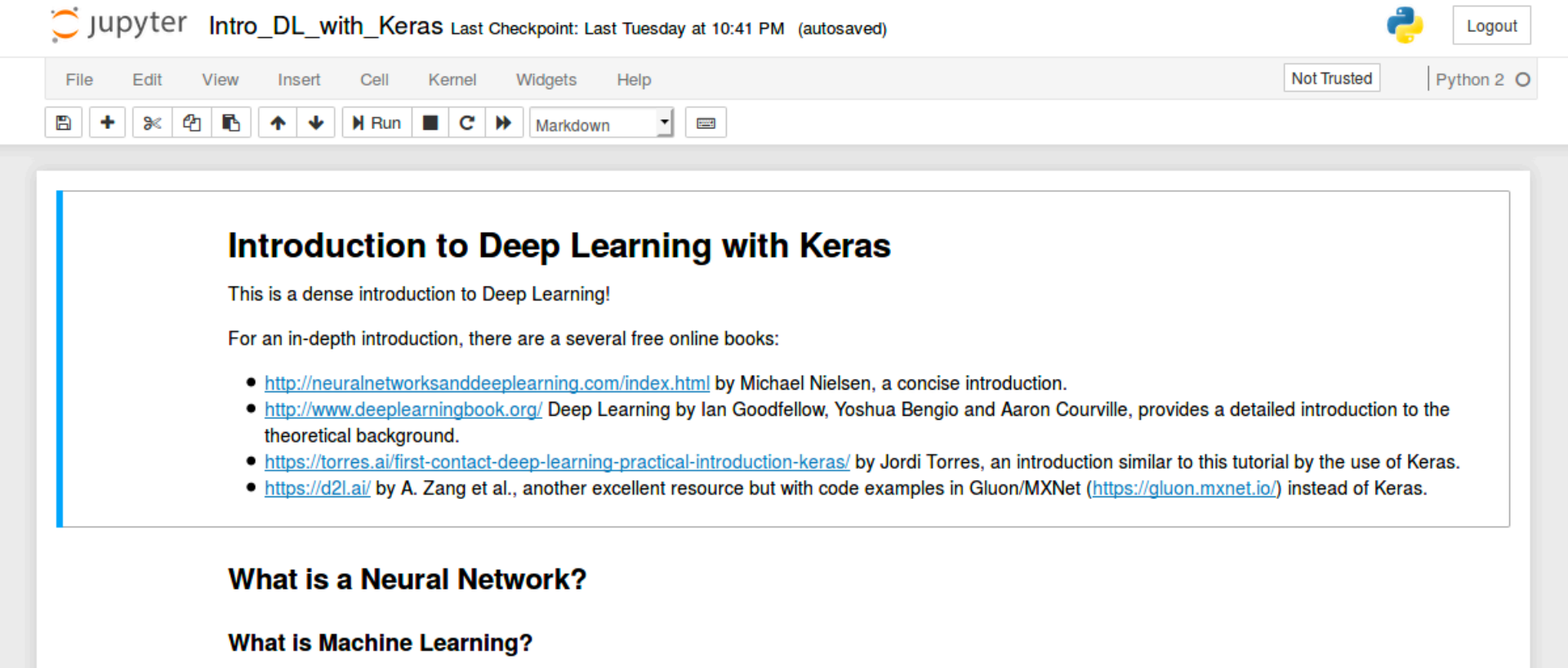


Use ML to distinguish signal from background events!

Prerequisites for our lab

if you use Windows: please come 10 mins before the start of the lab, we will help you to set up everything

- please bring your laptop
- we assume that you have some **basic programming knowledge**
- you will work with **Jupyter notebooks, NumPy, MatLib & Pandas**
  - basic **knowledge helpful, but not needed**
  - tutorials available



Thanks for your attention
&
see you in our lab!

Schedule

beginner (regression, classification) **and advanced** (top tagging) **courses on alternating days**

day	beginner course	advanced course
14. May (Tuesday)	✔	
15. May (Wednesday)		✔
16. May (Thursday)	✔	
17. May (Friday)		✔
18. May (Saturday)	✔	
19. May (Sunday)	no lab	
20. May (Monday)		✔
21. May (Tuesday)	✔	
22. May (Wednesday)		✔
23. May (Thursday)	✔	
24. May (Friday)		✔
25. May (Saturday)	announcement of challenge winners	

References for slide 1

- **particle identification:** “CMS Phase 1 heavy flavour identification performance and developments“, CMS Collaboration, CMS-DP-2017-013, https://cds.cern.ch/record/2263802/

- **galaxy classification:** “Morphological classification of radio galaxies: Capsule Networks versus Convolutional Neural Networks“, V. Lukic, M. Brueggen, B. Mingo, J. H. Croston, G. Kasieczka, Accepted for publication in MNRAS

- **skin cancer:** “Dermatologist-level classification of skin cancer with deep neural networks“, Andre Esteva, Brett Kuprel, Roberto A. Novoa, Justin Ko, Susan M. Swetter, Helen M. Blau & Sebastian Thrun, Nature volume 542, pages 115–118 (02 February 2017)

- **autonomous driving:** Nvidia, picture from https://www.car-it.com/das-auto-wird-zum-smart-device/id-0056444

- **Go:** https://www.technologyreview.com/s/604273/finding-solace-in-defeat-by-artificial-intelligence/ , D. Silver et al, Mastering the game of Go with deep neural networks and tree search, Nature 529, pp484–489 and D. Silver et al Mastering the game of Go without human knowledge, Nature 550, pp354–359