PHYSICS DATASET 1: TOP TAGGING

University of Washington, Seattle

Spring 2022

OUTLINE

Dataset Background

About the Dataset

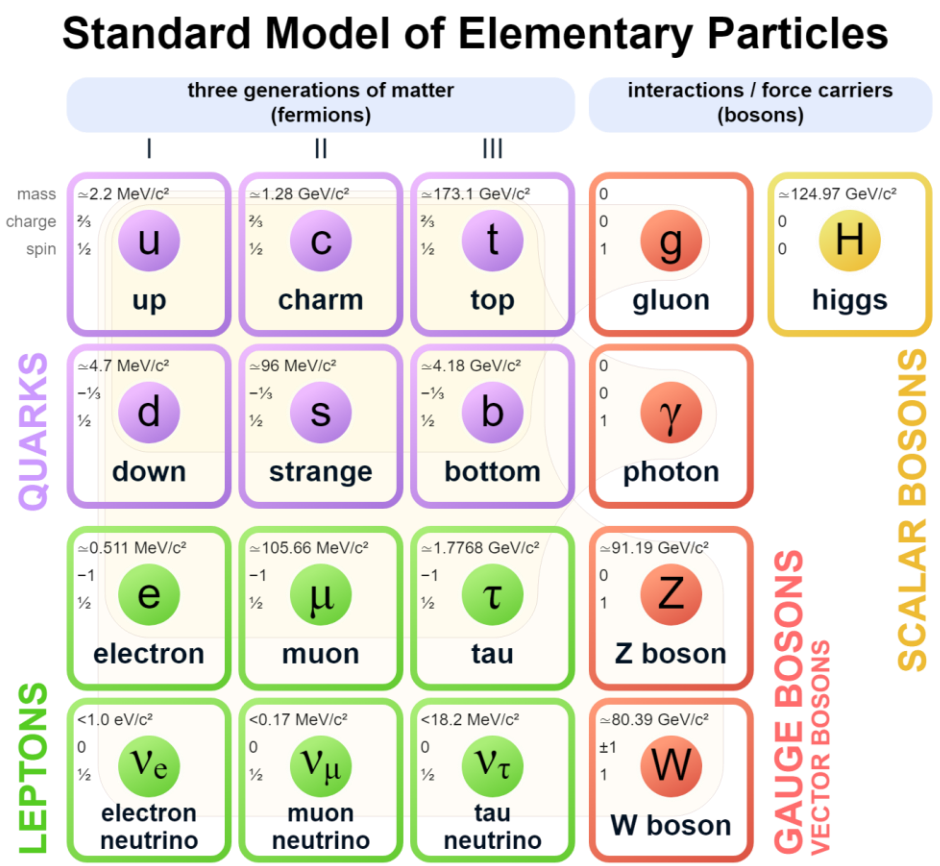
Problem Description

Dataset Background

- Standard Model
- Proton-Proton Collision
- Large Hadron Collider (LHC)
- ATLAS Detector
- Physics Event

Standard Model of Particle Physics

- Describes three of the four fundamental forces (electromagnetic, weak, strong, ~~gravity~~)
- One of the most successful theories in physics
  - Predicted (before discovery) the existence of top quarks, charm quarks, tau neutrinos, Higgs bosons, etc. as well as many of their properties
- Many unexplained phenomena
  - Gravity*
  - Dark matter/energy
  - Matter-antimatter asymmetry
  - Neutrino masses

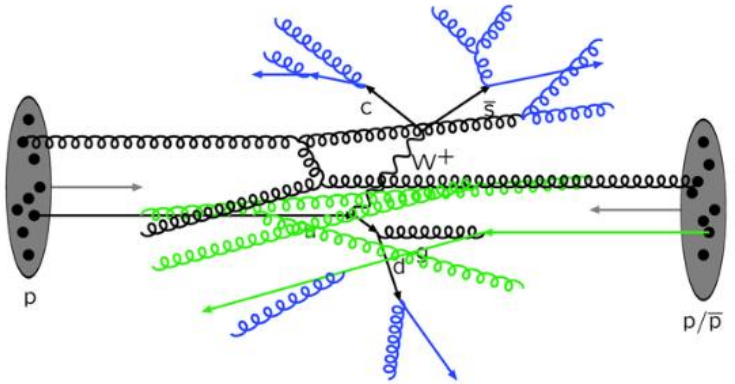


*explained by General Relativity, but needs to be unified into a single theory

Proton-Proton Collision

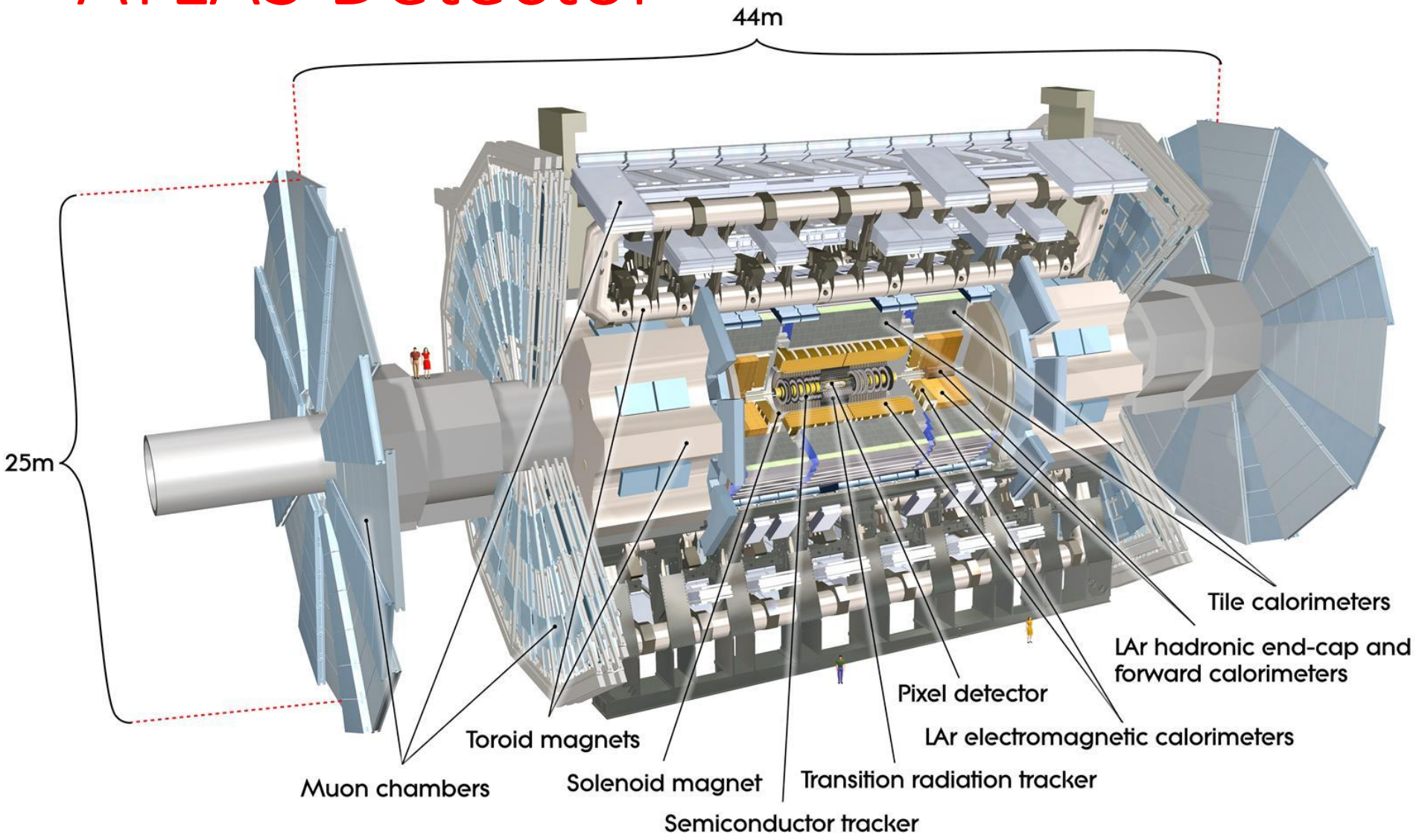
- The standard model predicts that collisions of protons at sufficiently high energy can lead to the creation of other particles. (see right)

- By analyzing these particles (‘final state’ particles), we can learn about the standard model and potential new physics (e.g., dark matter).



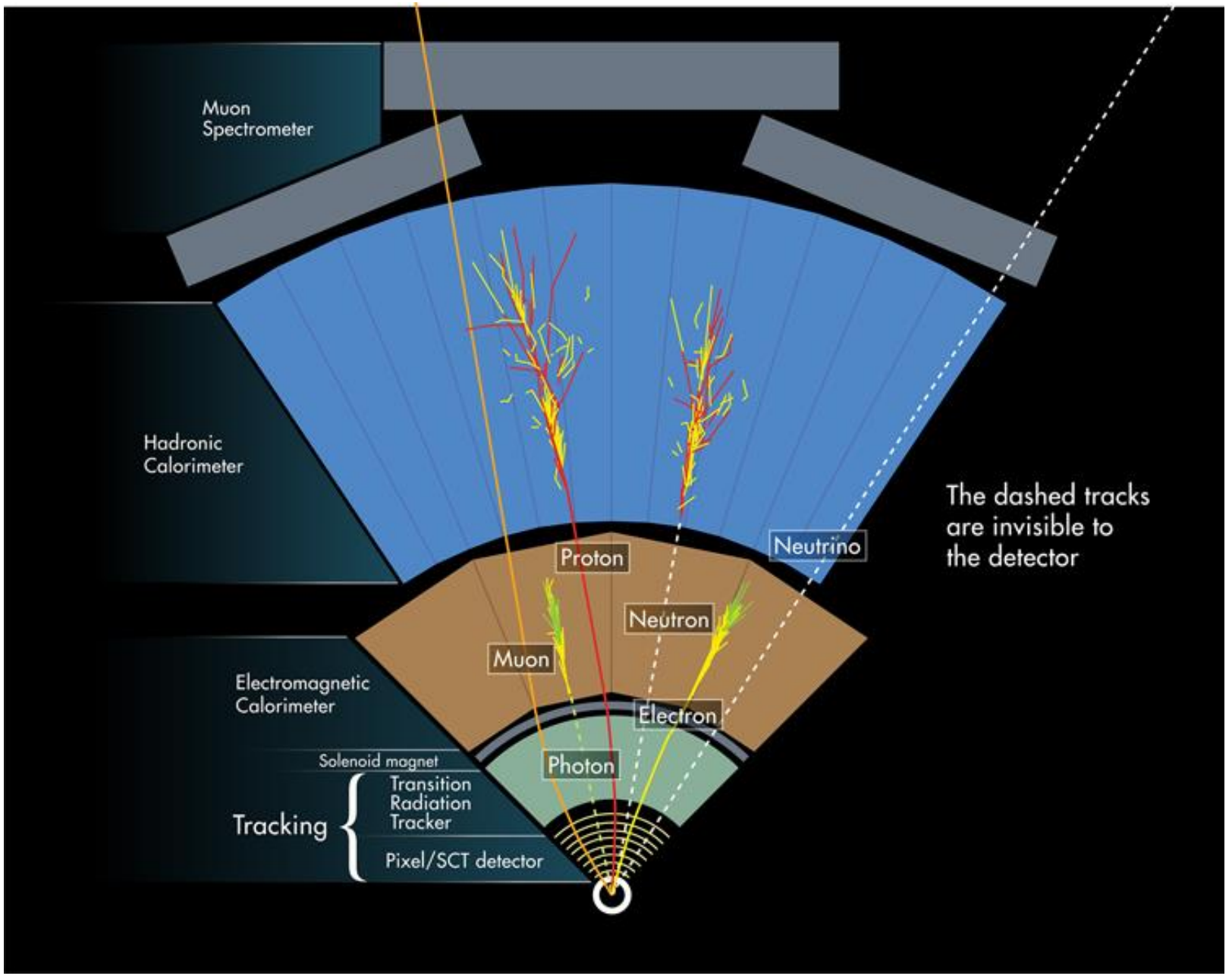

LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
ALICE
CMS
LHC 27 km

ATLAS Detector

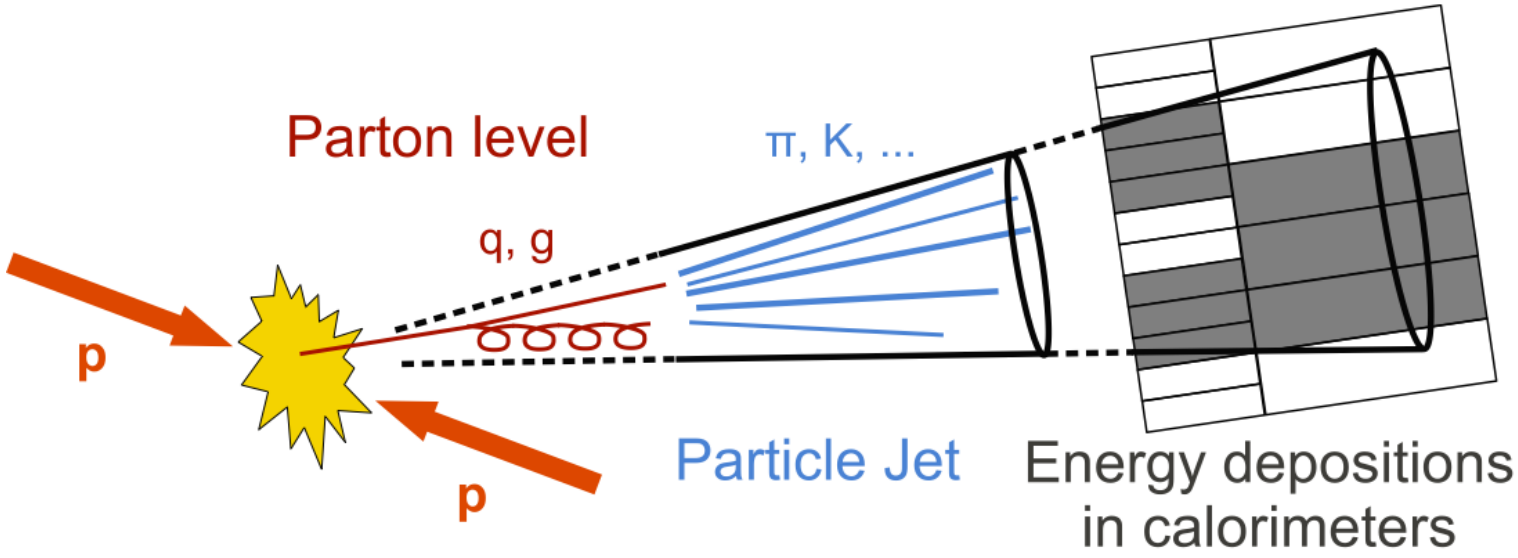


Physics Event

- Goal: record properties of the ‘final state’ particles produced in a collision for analysis:
  - Type (Proton, Electron, Photon, etc.)
  - Energy
  - Momenta
  - Path through the detector (incl. origin: ‘vertex’)



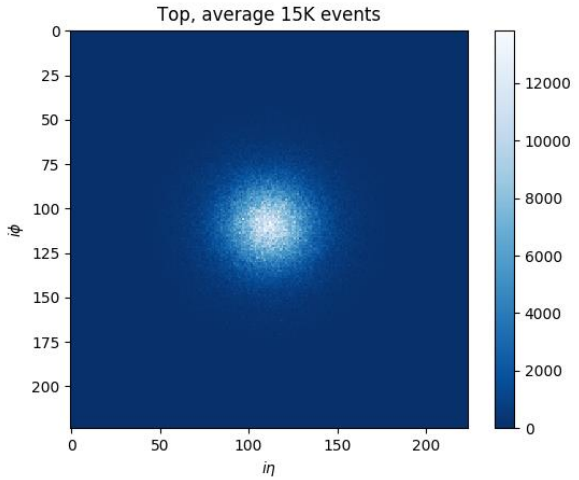
Particle Jets

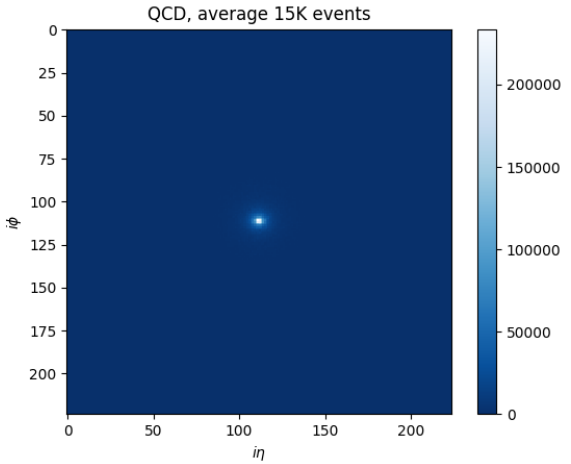


- Some particles such as quarks **cannot exist on their own** (“color confinement”). Instead, they **hadronize** into a **collection of particles** known as a **jet**.
- One task in event reconstruction is to determine the **type of particle** that created a jet (“tagging”), given the particles that make up the jet.

About the Dataset

- ~1M jets
- Per jet, variable number of constituents with **5 features** (see Glossary · GitBook (atlas.cern) for details):
  - p_T – transverse momentum, fraction of jet total
  - η (eta) & ϕ (phi) – angular coordinates, relative to jet center
  - E – energy from constituent
  - $\Delta R \equiv \sqrt{\eta^2 + \phi^2}$
- Per jet, single classification:
  - Gluon
  - Light quark
  - W boson
  - Z boson
  - Top quark



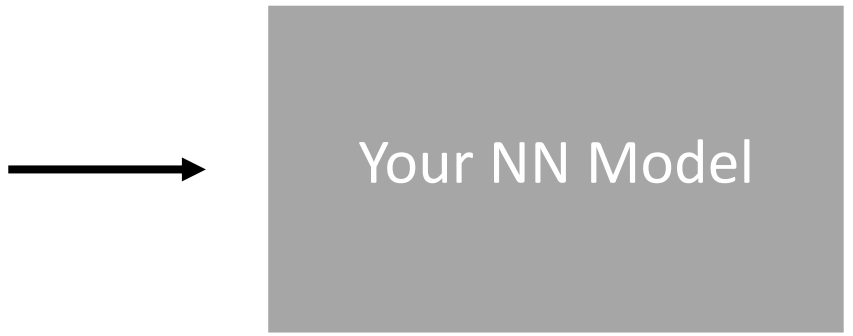


Problem Description

$$\begin{bmatrix} p_{T,1} & \eta_1 & \phi_1 & E_1 & \Delta R_1 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ p_{T,n} & \eta_n & \phi_n & E_n & \Delta R_n \end{bmatrix}$$

n x 5 array of jet constituents, where n can vary

Input



Tag

Gluon

Light quark

W boson

Z boson

Top quark

Output