

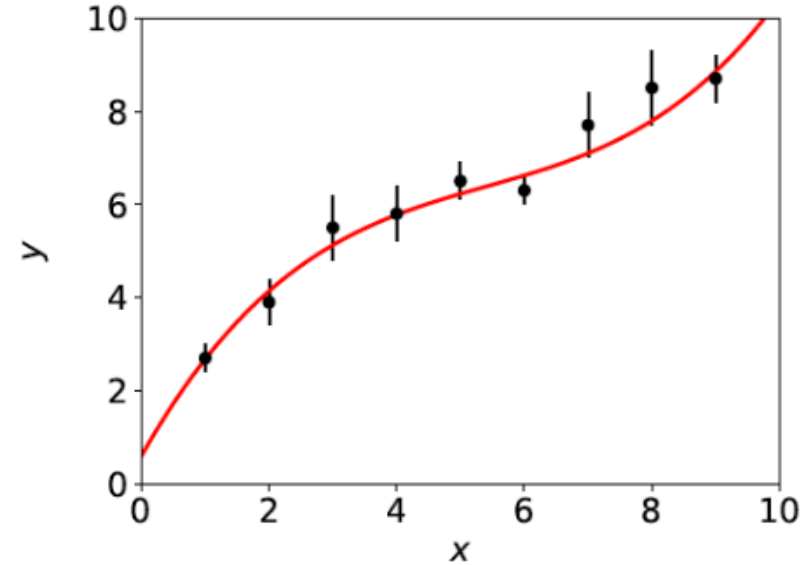


MIDDLE EAST TECHNICAL UNIVERSITY

# Particle Data Analysis in High Energy Physics

## Lecture 1 Introduction

**Ahmet Bingül**  
**METU, Physics**  
**Feb 2026**



# Introduction

*The aim of these notes is to present the most important concepts and methods of statistical data analysis in High Energy Physics*

**Statistics** is the study of the collection, organization, analysis, interpretation, and presentation of data. We will deal with analysis of the sampled data.

Statistics and physics are similar; each starts from sets of basic principles.

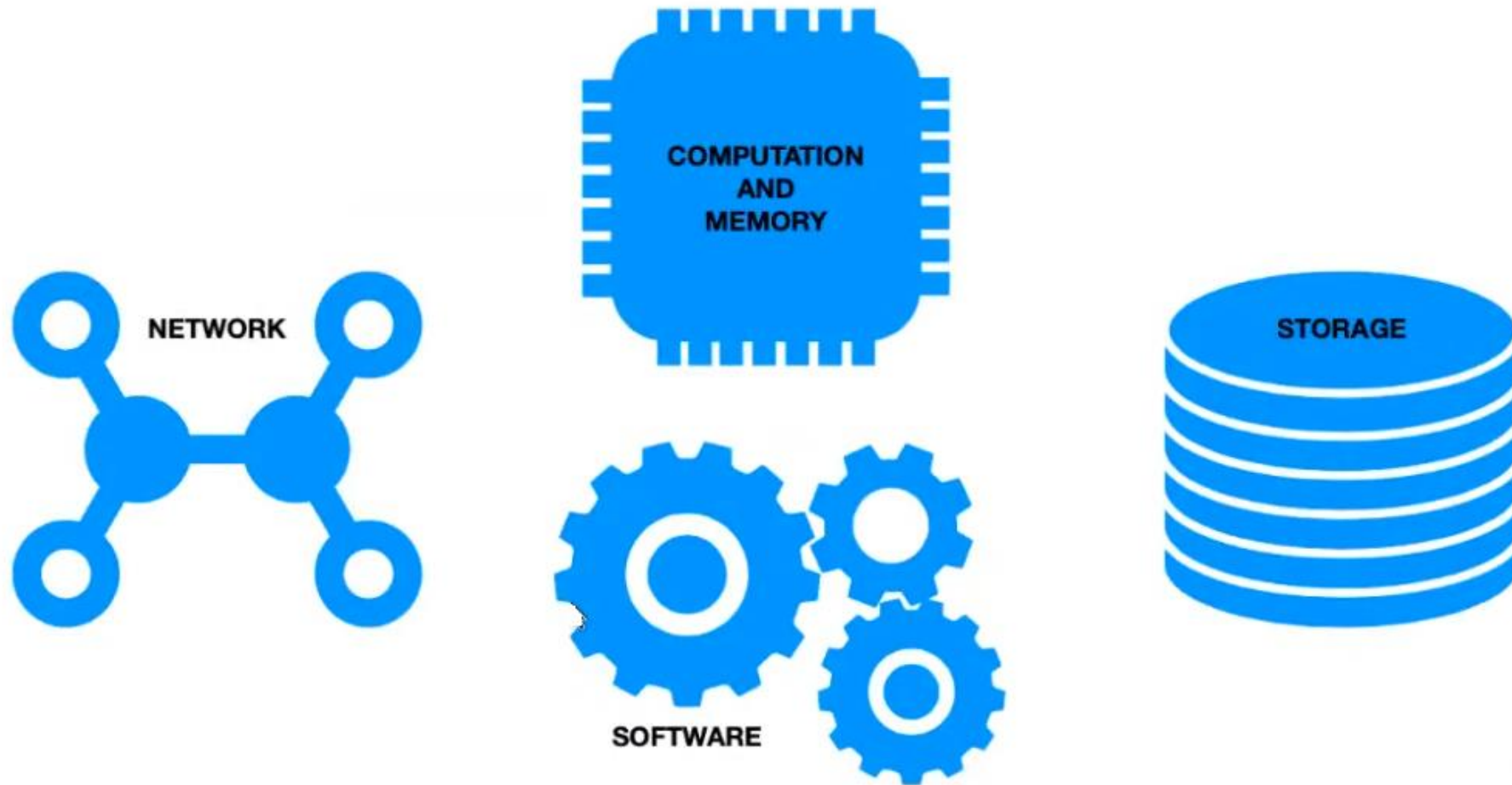
**Data Analysis** is a very broad subject covering many techniques and types of data.

Today, computing, statistical methods, and other parts of data science have become invaluable tools in

- physics
- engineering
- climate science
- finance
- epidemiology
- . . .

# Technology

To analyse data collected, We need to understand the software and computing behind Particle Physics.



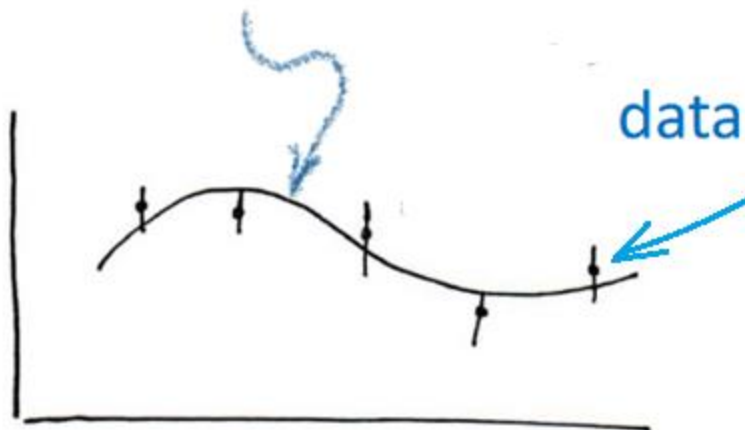
# Theory - Statistics - Experiment

Theory (model, hypothesis):

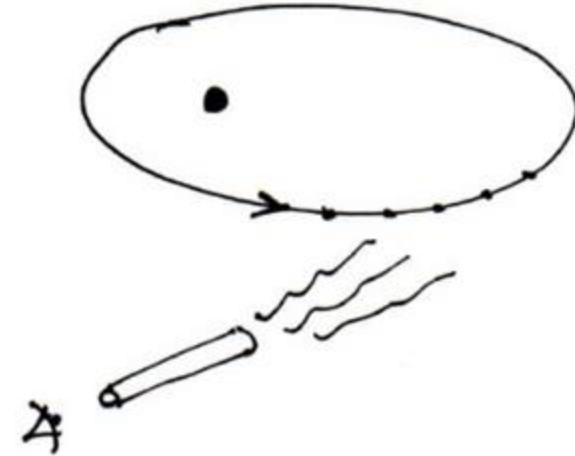
$$F = -G \frac{m_1 m_2}{r^2}, \dots$$

+ response of measurement apparatus

= model prediction



Experiment (observation):

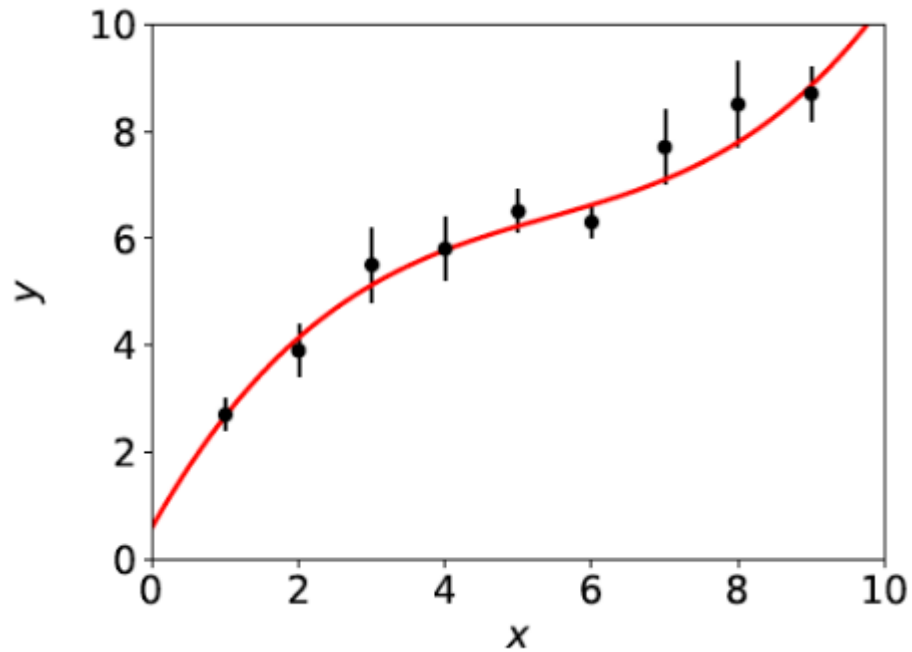


Measure / estimate / fit parameters ( $m_1, m_2, G, \dots$ ) and quantify uncertainties.

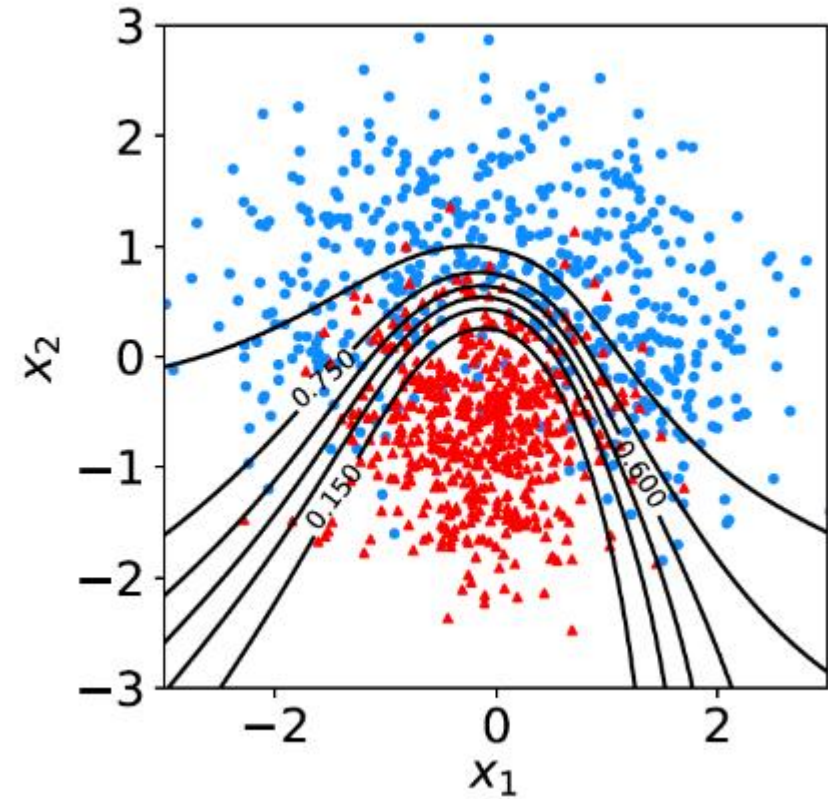
Test model / hypothesis.

# Some Tasks of Statistics

## Curve Fitting

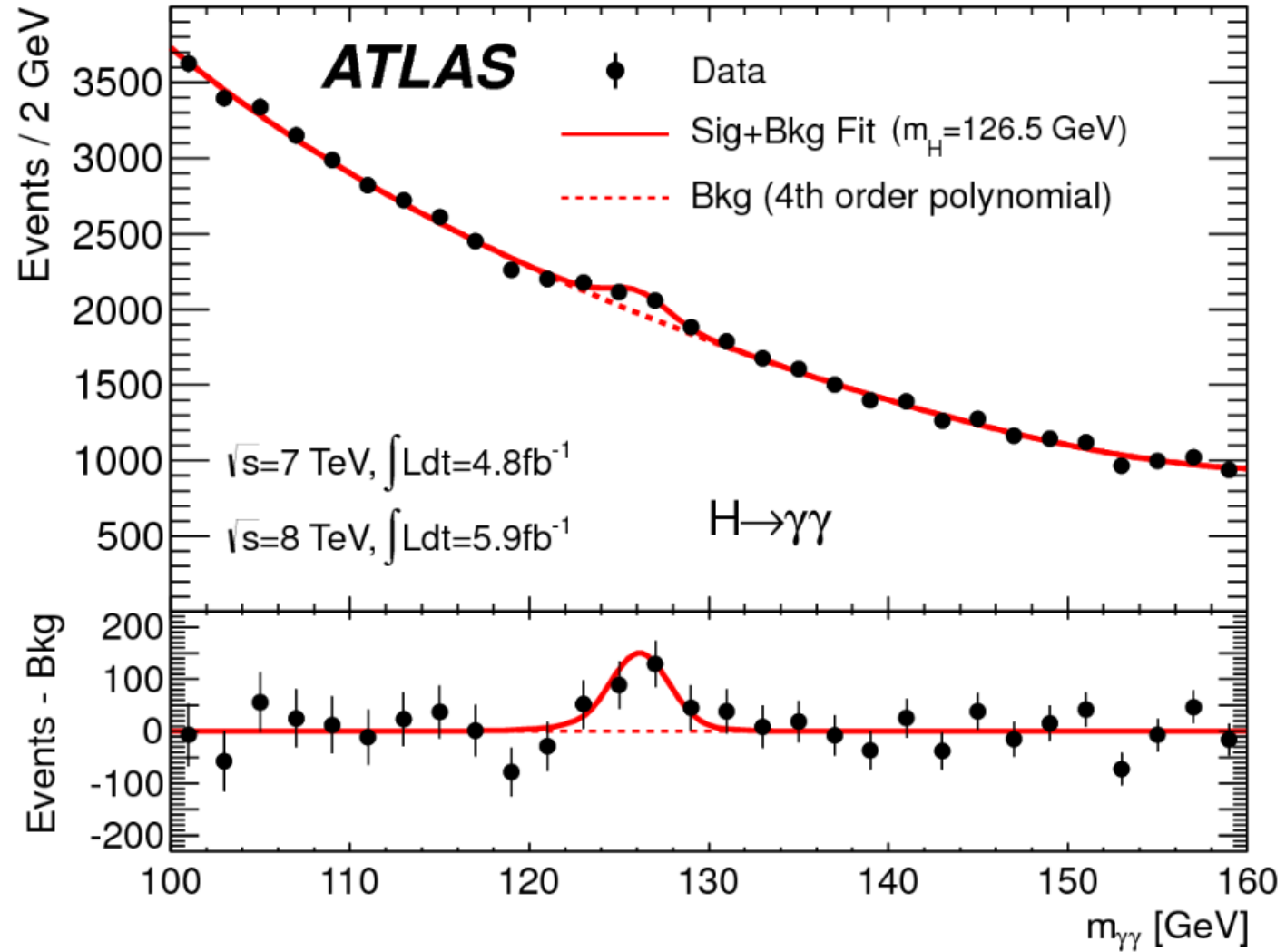


## Classify Objects



# Discovery of Higgs Boson

ATLAS Collab., Phys. Lett. B 716 (2012) 1-29

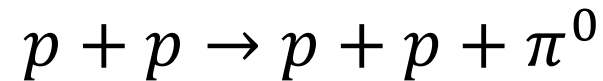


# Particle Physics

- **Particle Physics = High Energy Physics (HEP)**

is a branch of physics that studies the elementary constituents of matter and radiation, and the interactions between them.

- **High Energy means ~ 300 MeV or above (the threshold for the pion production)**

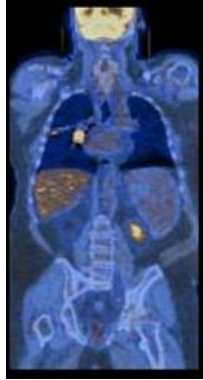


- **HEP pioneered 'big science'**

- experiments are performed at accelerators increasing energy
- collaboration of many physicists from many institutes

- **Research methodology is based on 'Statistical Data Analysis'**

# Some Particle Physics Applications



Medicine



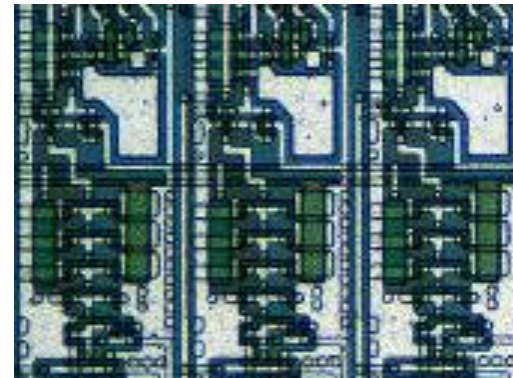
Research



Education



Computer Science



Technology

# The Course Resources

- Course web page for lecture materials & exam result  
<https://users.metu.edu.tr/abingul/phys715>
- We will follow several parts of the following books:
  - Statistical Data Analysis, Glen Cowan, Oxford
  - Techniques for Nuclear and Particle Physics Experiments, William R. Leo, Lausanne
- Other Books (if you want to be an expert)
  - Statistical Methods for Data Analysis in Particle Physics, Luca Lista, Napoli
  - Statistical Methods in Experimental Physics, Frederick James, CERN

# Syllabus

## Part I: Physics (~ 3-4 weeks)

**Overview of Particle Physics**

**Relativistic Kinematics**

**Experimental Concepts**

**Particle Interaction with Matter**

**Accelerators and Detectors**

**Cosmic Rays**

## Part II: Statistical Analysis (~ 4 weeks)

**ROOT** (Object Oriented Analysis Framework)

**Probability**

**Statistics**

**Curve Fitting**

**Monte Carlo Methods**

## Part III: Applications (~ 4-5 weeks)

**Analysis of CERN LHC Open Data**

**Analysis of CERN LEP Data**

**Machine Learning Tools**

**Pythia8, MadGraph, Delphes, Geant4 [Optional]**

# Teaching

- **Mondays**

- 13:40-17:00 - at Smart Class

- **Computing**

- We'll use Python and C++

- We'll need basic Linux or Mac OS

- **Exams**

- **Mid-term**            **30%**    **Written (30 March 2026)**

- **Quiz (max 8)**    **30%**    **Written / Software**

- **Final**                **40%**    **Project Presentation**