

# Instrumentation, Data analysis and Machine Learning

Master in Astrophysics, Particle  
Physics and Cosmology

P. Bordas, X. Luri, C. Marin



Institute of Cosmos  
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EXCELENCIA  
MARIA  
DE MAEZTU



UNIVERSITAT DE  
BARCELONA

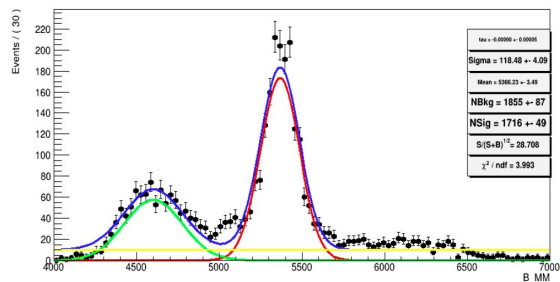
# Content

Instrumentation



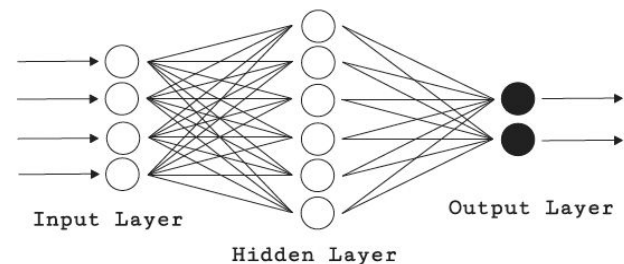
Joan Oro telescope (CAM)

Data analysis



Credit: A. Santander

Machine learning



Hidden Layer

Credit: V. Costa

# General information

- Optional subject (2nd semester), joint astro & particle & cosmology
  - 6 credits = 150h
  - Lectures: 12h (first weeks)
  - Practical sessions: 20h
  - Workshops and field trips: 20h
  - Supervised project: 50h
  - Independent learning: 48h
  
- Professors
  - Astrophysics: P. Bordas and X. Luri
  - Particle physics: C. Marin



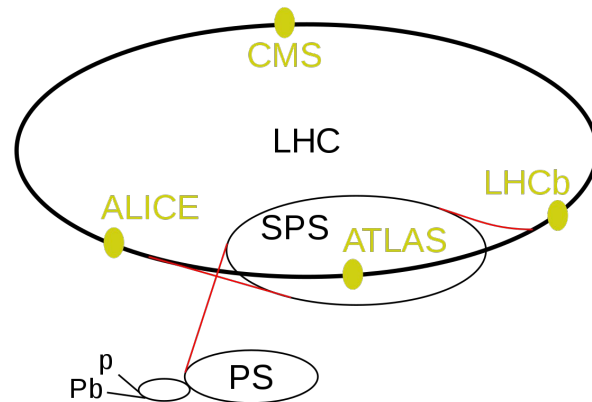
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Dpt. Física Quàntica  
i Astrofísica

# Lectures

First weeks (12h):

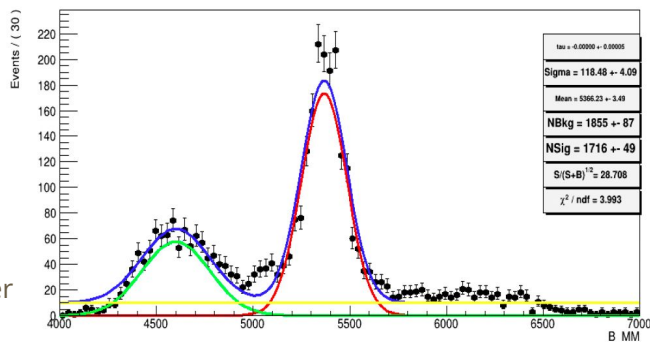
1. Requirements of particle physics experiments
2. Requirements of astrophysical observations
3. Particle accelerators
4. Detection techniques
5. Design of high energy physics experiments
6. Data acquisition and processing
7. Astrophysical instrumentation
8. Astrophysical observation techniques



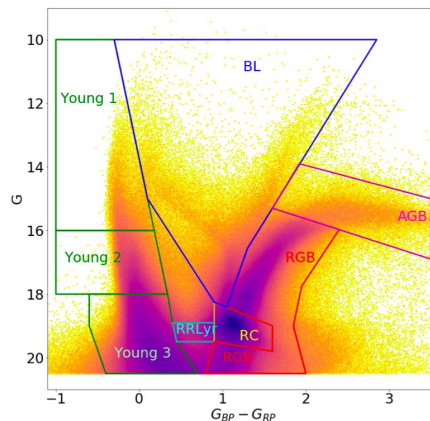
# Practical sessions

During all the course (20h):

- Machine learning and fitting techniques using LHCb data
- Cloud computing using Gaia data
- X-rays using Chandra and XMM-Newton data
- High-Energy gamma rays using Fermi-LAT data
- Very high-energy gamma rays using CTA data



Credit: A. Santander



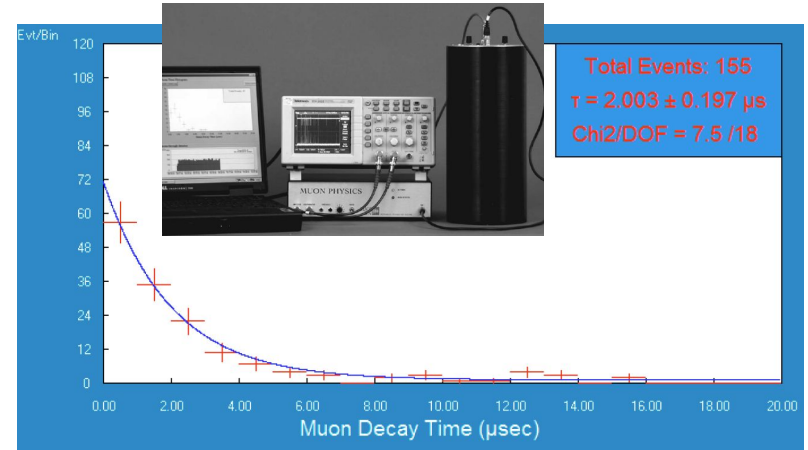
# Workshops and field trips (1)

During all the course (20h):

## ALBA synchrotron beam emittance



## Muon lifetime



Credit: J. R. Stocchetti

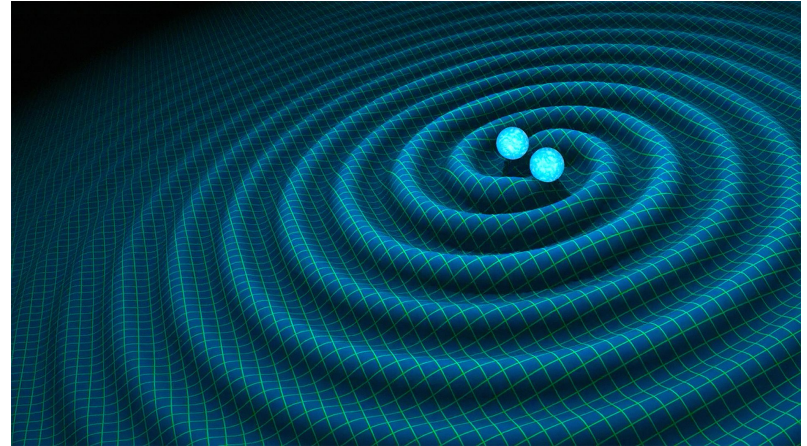




# New this year: Gravitational waves (optional)

- Topic already covered in astrophysical instrumentation lecture
- Dedicated Scientific Seminar (1h) this course
- Topics will be proposed for final supervised project using LIGO-Virgo data

by T. Andrade and O. Bulashenko





# Supervised project (50h)

To be submitted at the end of the course (start early!)

Related to a topic of the subject or to your TFM project (extension)

Topic examples:

- Related to site testing, instrument characterisation or telescope setting up
- Calibration or time alignment of detectors
- LHCb, Fermi satellite, MAGIC telescope, Gaia or LIGO-Virgo data analysis
- Radio interferometric observations

Examples from last course:

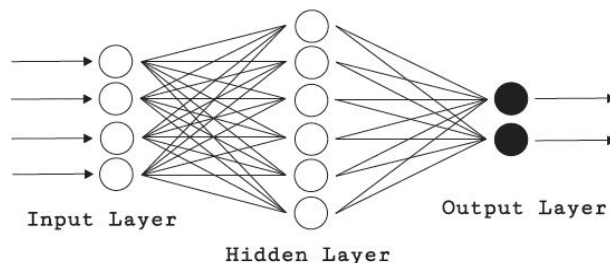
- *Processing and stacking astrophotography images using python and DSS*
- *Boosted Decision Tree implementation in Lepton Universality studies in  $B_s \rightarrow D_s^{**} l \nu$*

# Summary

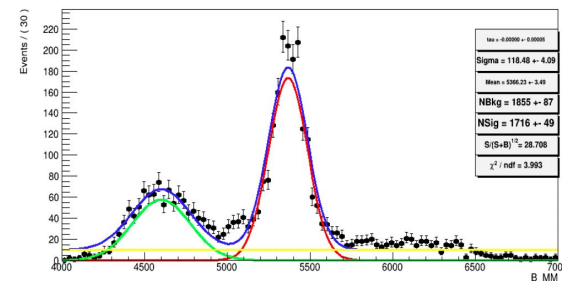
Unique opportunity to access instrumentation and data from ongoing Particle Physics and Astrophysics experiments!



Joan Oro telescope (CAM)



Credit: V. Costa



Credit: A. Santander

**Thanks for the attention**

**Questions?**

**Comments?**