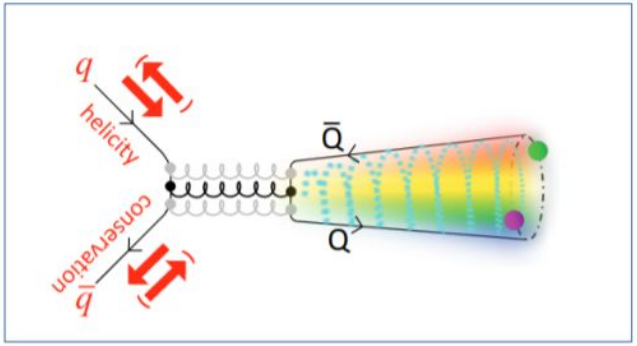
LIP Summer Internship Program 2020

The hidden charm of the COMPASS experiment at CERN

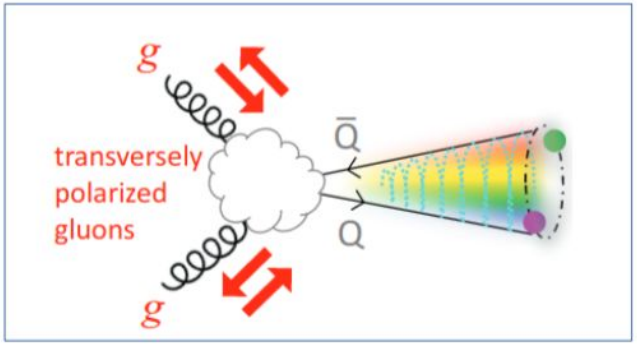
Supervisors: Catarina Quintans and Márcia Quaresma

Catarina Corte-Real | Francisco Feliciano

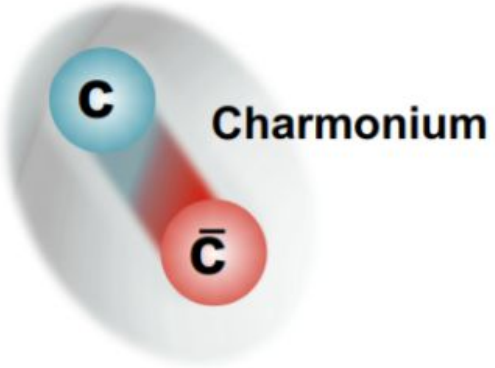
J/ψ production processes



q-qbar annihilation



gluon - gluon fusion



- J/ψ is the lightest c-cbar resonance (a short-lived particle, with mass M=3.097 GeV/c²)
- It is experimentally observed in COMPASS from its decay to a pair of opposite charge muons

Catarina Corte-Real | Francisco Feliciano

COMPASS experiment

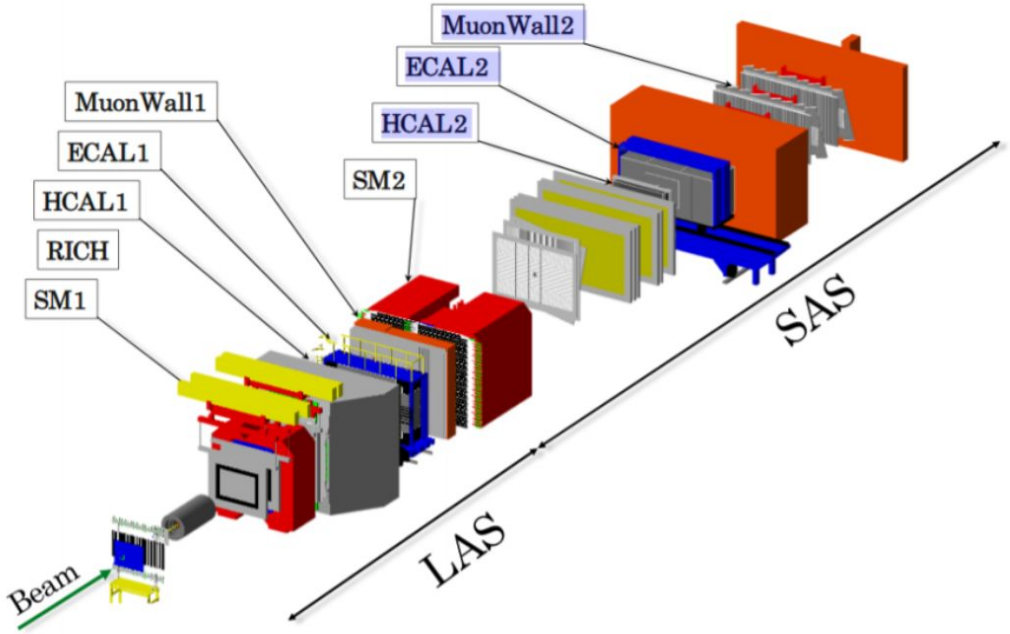
COmmon Muon Proton
Apparatus for Structure and Spectroscopy

A fixed target experiment at CERN

Two runs used

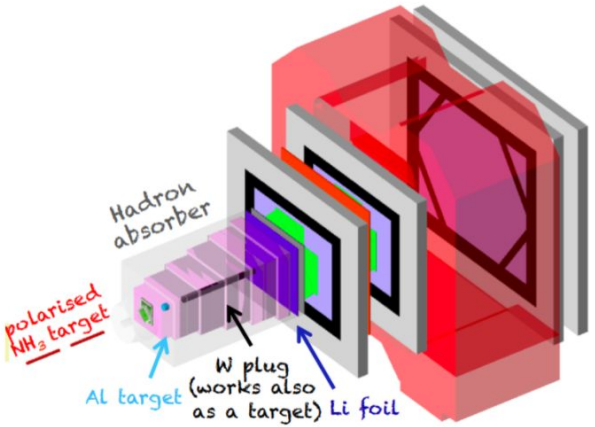
Catarina Corte-Real | Francisco Feliciano

COMPASS experiment: Drell-Yan data taking (2015 and 2018)



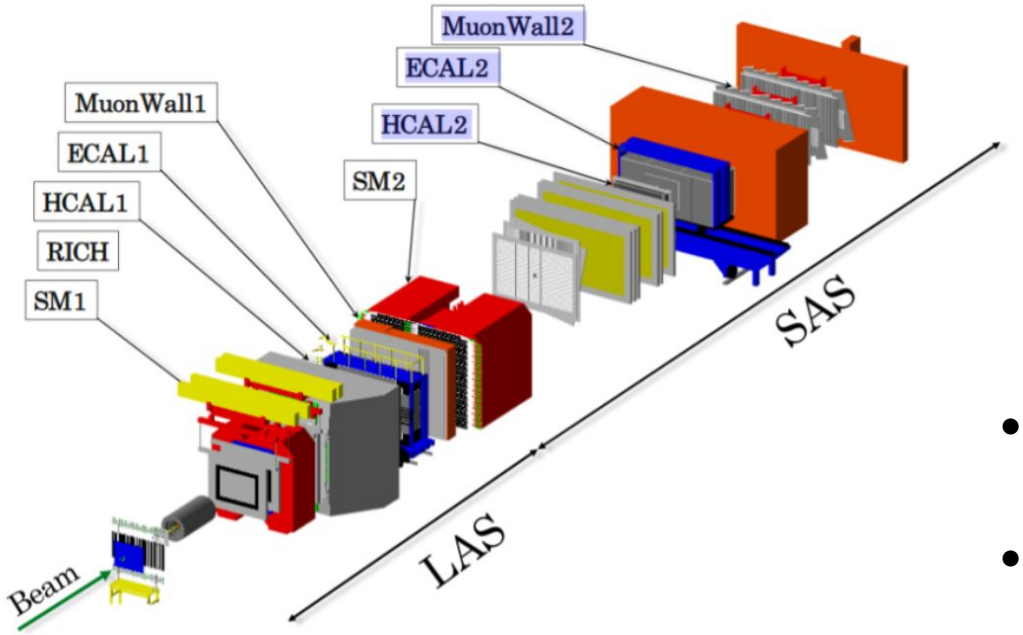
DY targets:

- NH_3 - 17 nucleons (3 polarizable)
- Al - 27 nucleons
- W - 184 nucleons



Catarina Corte-Real | Francisco Feliciano

COMPASS experiment: Drell-Yan data taking (2015 and 2018)



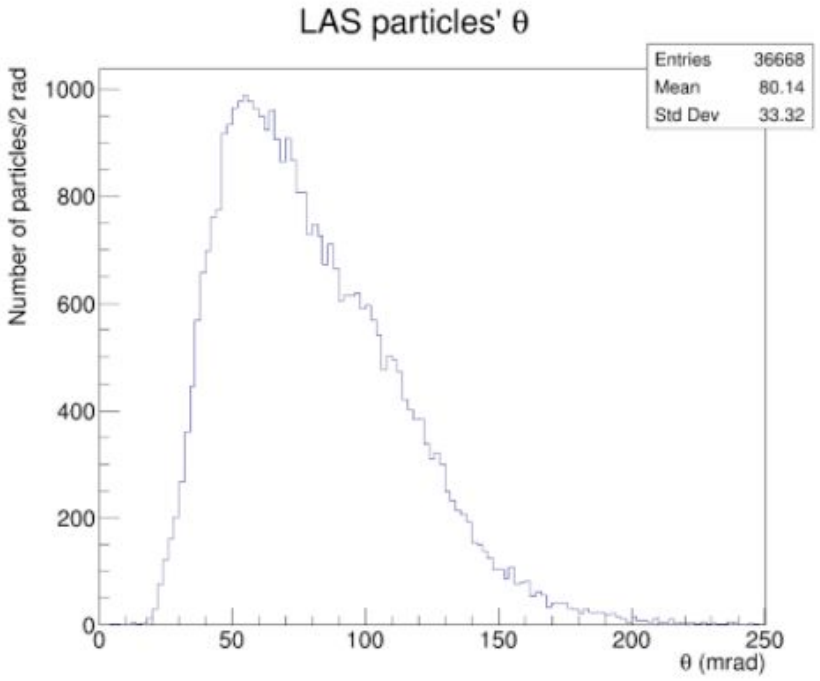
DY trigger setup:

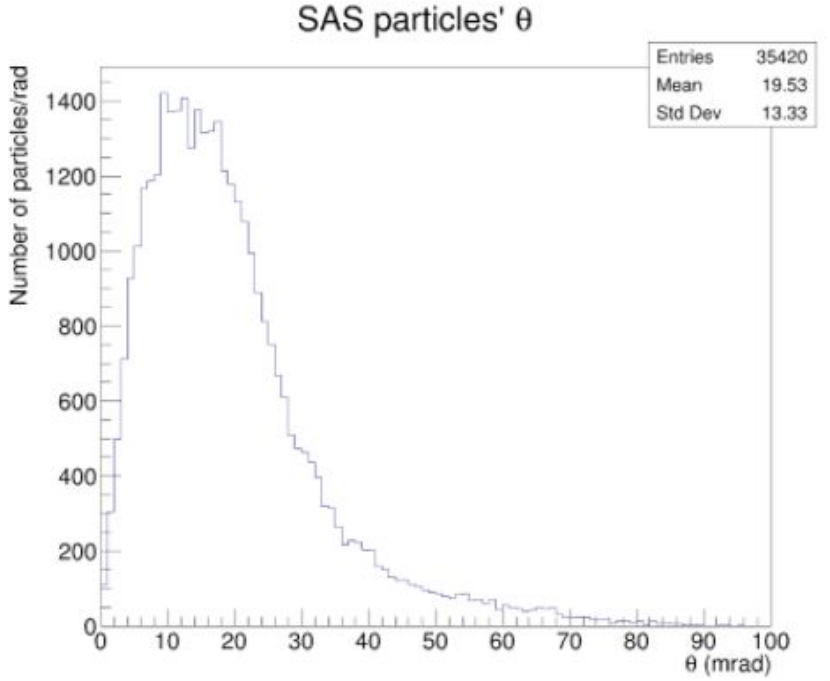
- Middle (SAS) and LAS
- Outer (SAS) and LAS
- LAS and LAS

} Dimuon Triggers

- Each trigger system (Middle, Outer, LAS) is composed of 2 hodoscopes
- Hodoscopes are fast detectors made of plastic scintillator and placed after walls of heavy material, for muon detection

Hodoscopes' angular acceptance

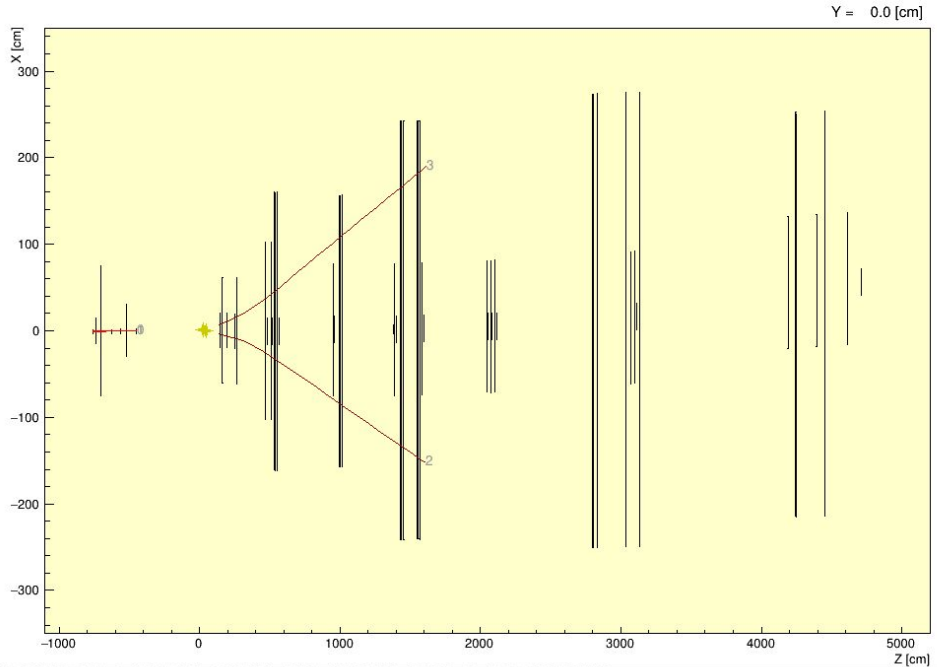




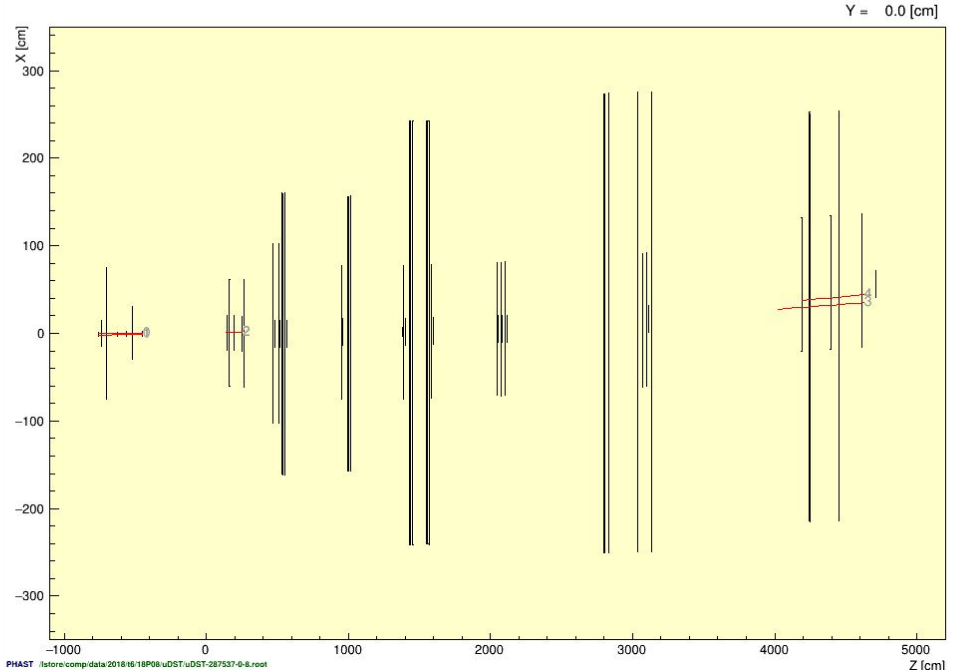
Large **a**ngle **s**pectrometer (LAS): 30 mrad < θ < 200 mrad
Small **a**ngle **s**pectrometer (SAS): θ < 70 mrad

PHAST software: the COMPASS data analysis package

Interactive mode

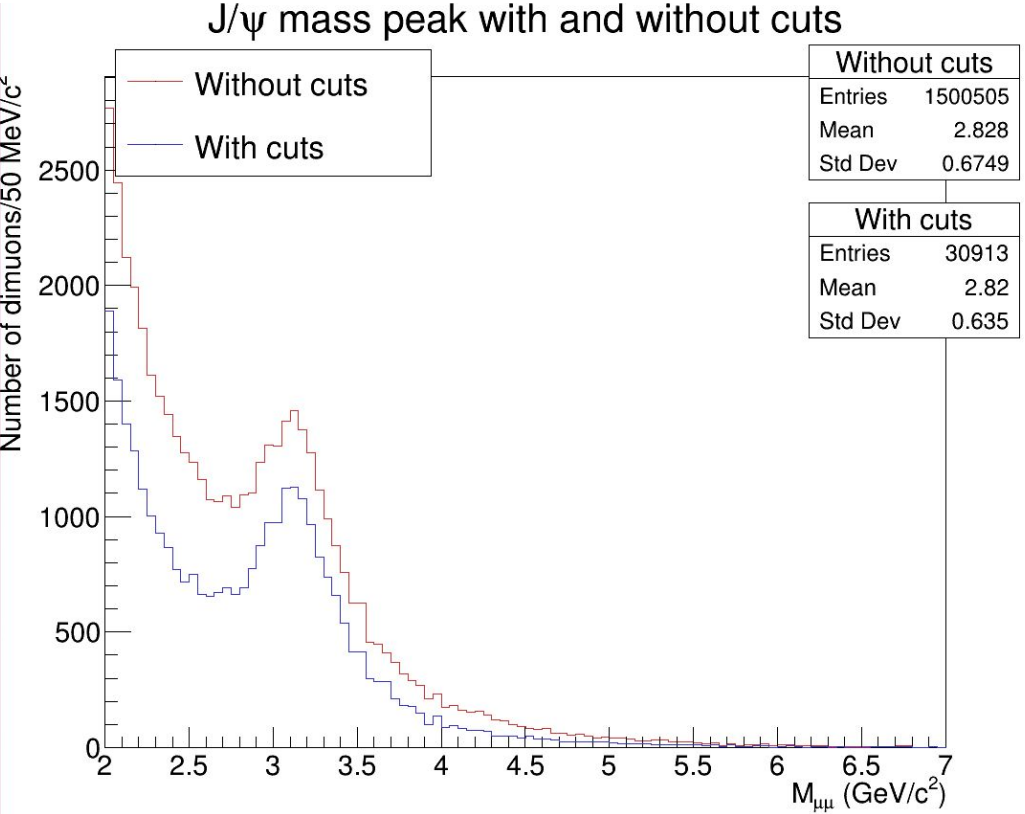


Dimuon event



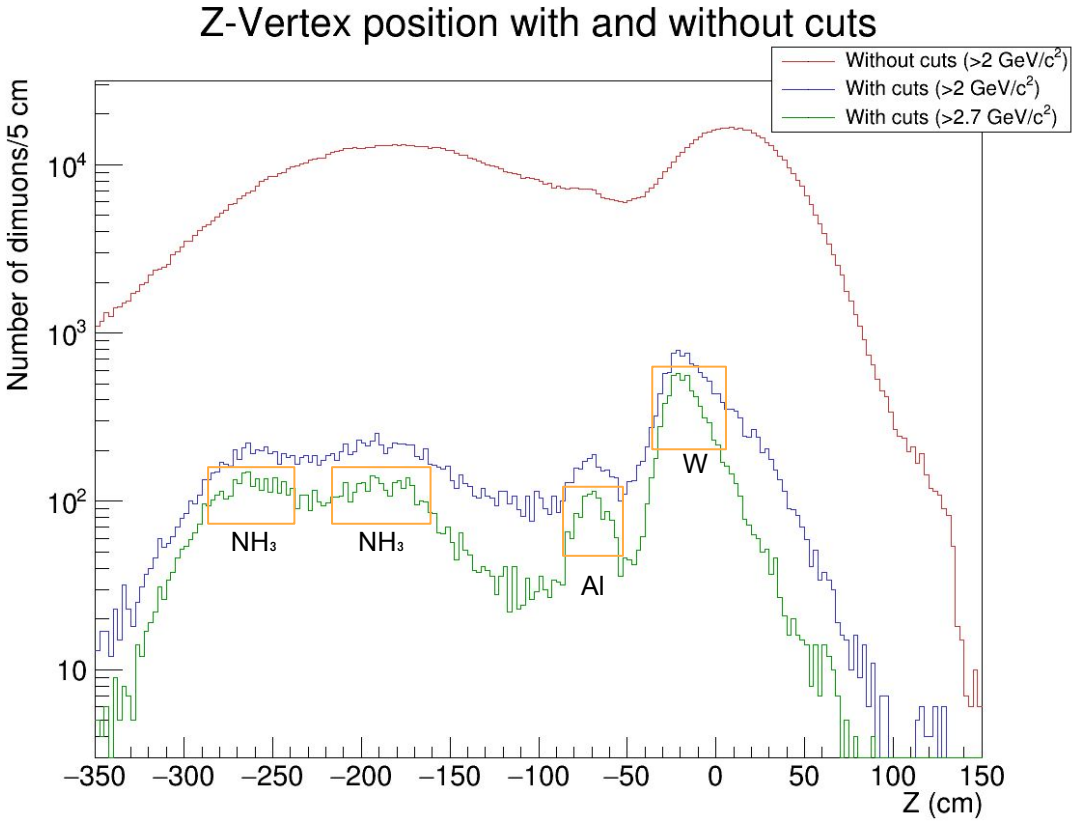
Failed reconstruction

Dimuon cuts



- Dimoun trigger selection
- Opposite charge muons produced in the same primary vertex
- Particles' mean time < 10 ns
- Particle's track χ^2/nDF < 10
- Z-first < 300 cm and Z-last > 1500 cm
- Distance from the center of the target < 2 cm

Dimuon cuts

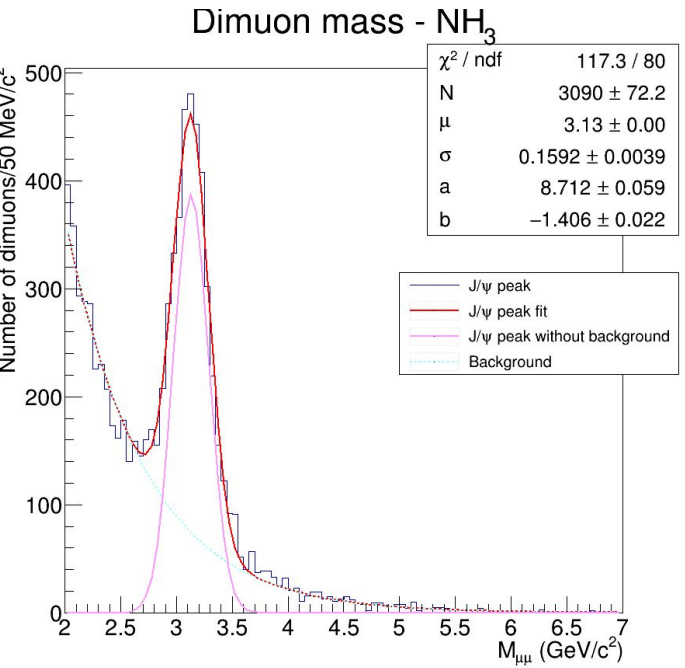


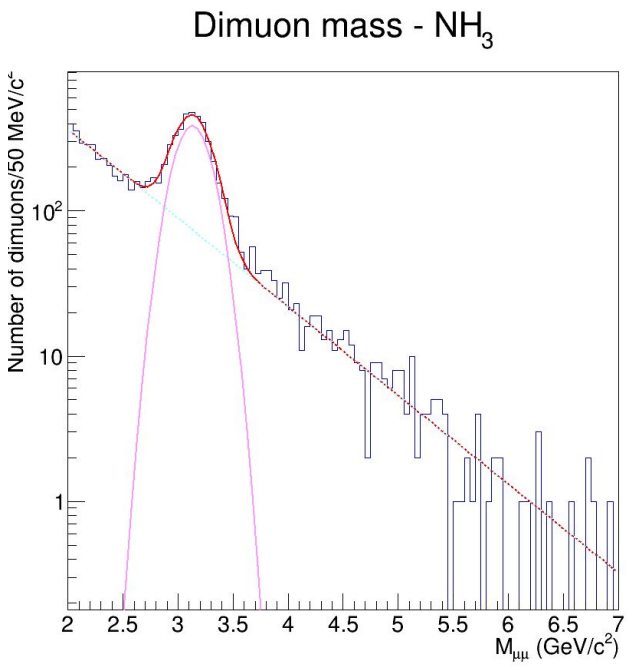
Without cuts (>2GeV/c²): 1500505 entries
With cuts (>2GeV/c²): 30913 entries
With cuts (>2.7GeV/c²): 16606 entries

↓

Cuts eliminated at least 98% of the initial data

J/ψ peak for each target - NH_3



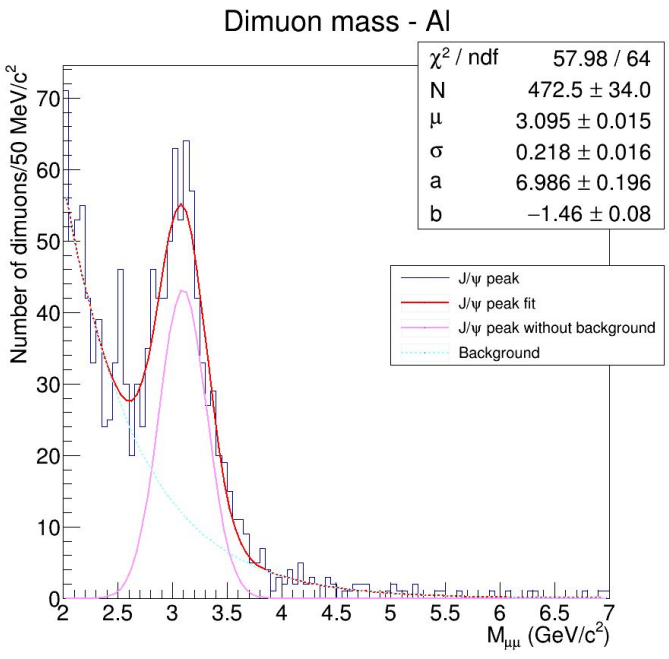


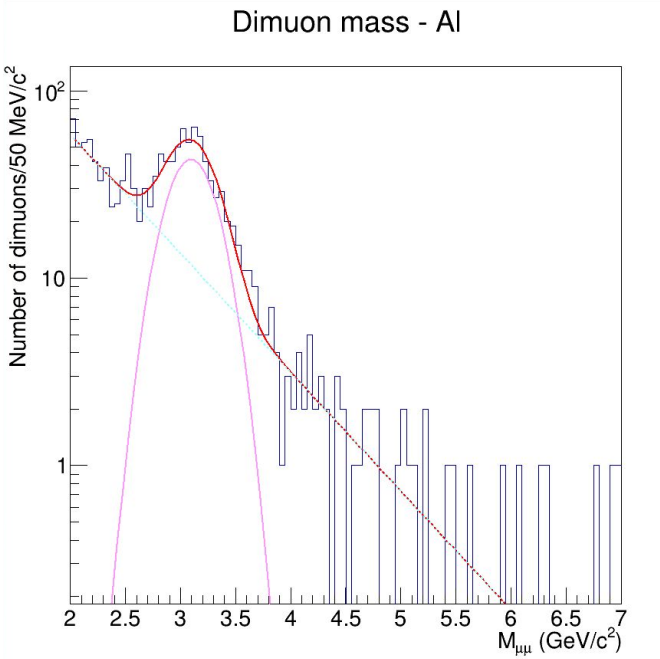
$$\underbrace{\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}}_{\text{J/ψ Peak without background}} + \underbrace{e^{a+bx}}_{\text{background}}$$

18.5 ± 4.1% background in the range [3.0, 3.3] GeV/c²

16686 total entries

J/ψ peak for each target - Al





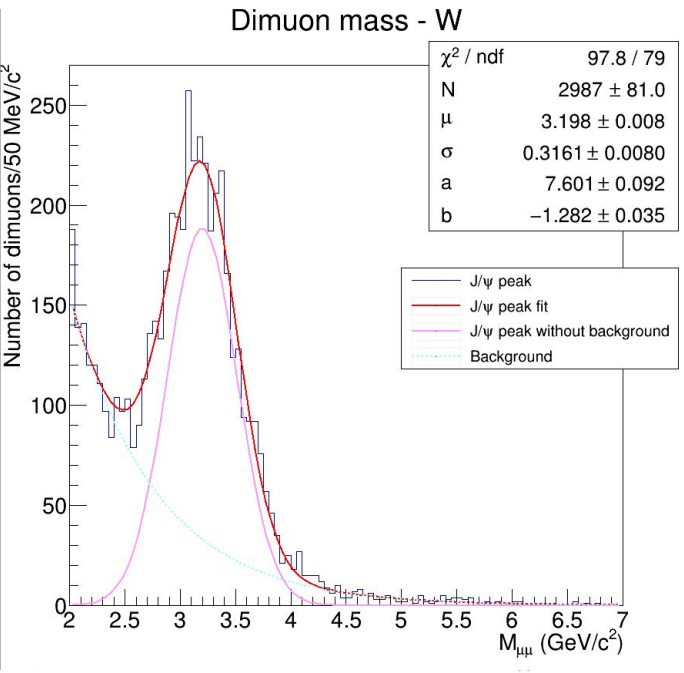
$$\underbrace{\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}}_{\text{J/ψ Peak without background}} + \underbrace{e^{a+bx}}_{\text{background}}$$

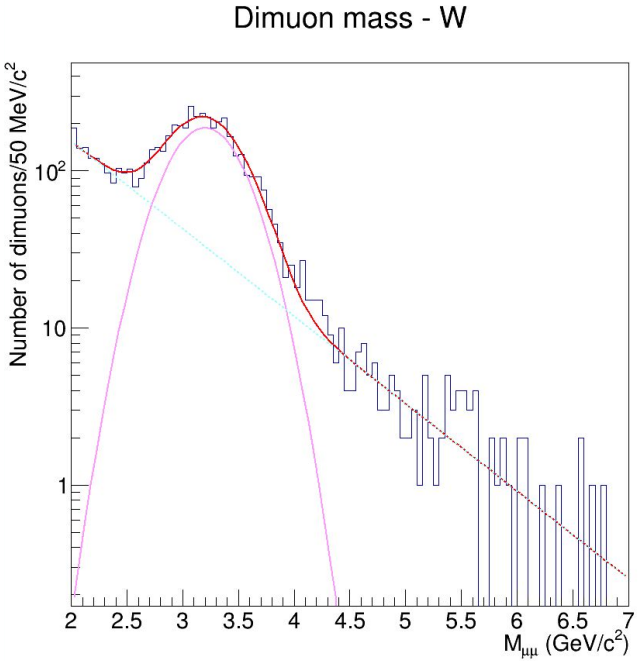
24.5 ± 11.9% background in the range [2.9, 3.3] GeV/c²

2685 total entries

Catarina Corte-Real | Francisco Feliciano

J/ψ peak for each target - W



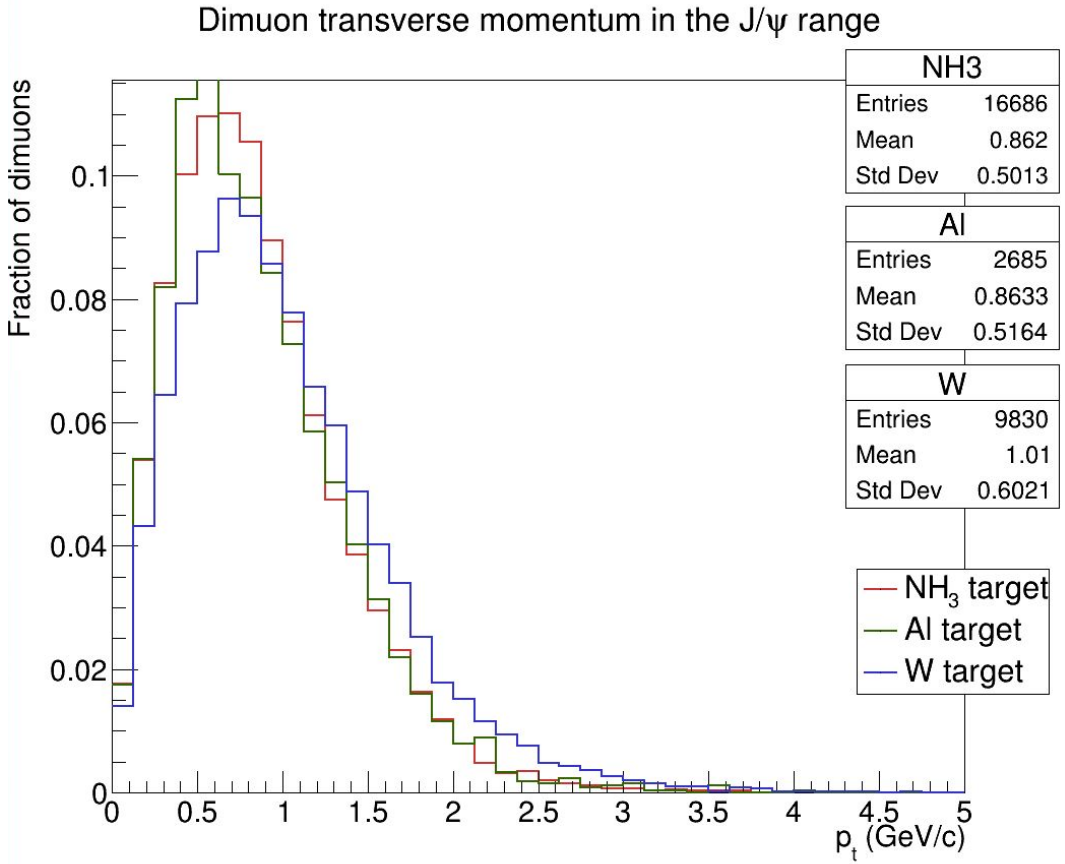


$$\underbrace{\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}}_{\text{J/ψ Peak without background}} + \underbrace{e^{a+bx}}_{\text{background}}$$

17.5 ± 4.1% background in the range [2.9, 3.5] GeV/c²

9830 total entries

Dimuon transverse momentum in the J/ψ range



The heavier the material in which the particle interacts, the larger its transverse momentum

Final thoughts

- J/ψ peak is distinguishable in invariant mass spectrum of opposite charge muon pairs
- J/ψ peak characteristics depend on the target material they originated from
- In the J/psi range within 1σ from the pole, there is ~20% background
- COMPASS collected a very large sample of J/ψ's. In this work we analysed two runs, which corresponds to the data collected in ~2 hours. In 2018 COMPASS collected data during 6 months

What next?

Study of kinematic properties of J/ψ particles might hint at production processes behind it