



CMS Masterclass 2026

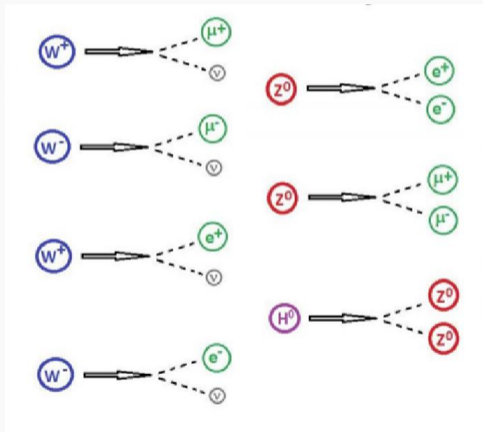
Exercise Results

Enrico Lusiani, Federica Primavera, Jacopo de Piccoli, Patrizia Azzi

17 Marzo 2026

INFN Sezione di Padova

Reminder: which particles to identify?

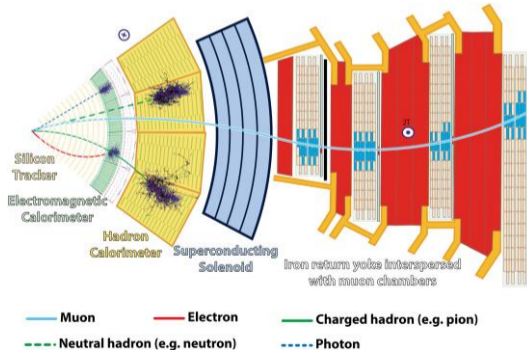


Questions:

- Which quantities are conserved?
- Describe the decays of the Higgs candidates

Questions:

- In which detector do you search for muons?
- Which detectors do you need to find electrons?
- How do you determine the particle charge?



Questions:

- What do you expect the ratio of electron events to muon events to be?
- Is your result consistent with this?
- What is the ratio of W_+ to W_- bosons?
- What does this ratio tell us about protons? What do you think is the ratio between the number of decays of W in electrons versus muons?

Expected value [ratio e / μ] = 1

Expected value [ratio W_+ / W_-] = 1 . 4

Lepton Counts		
e	μ	e: μ
6567	5202	1.262399077
W boson counts		
W+	W-	W+:W-
2828	2470	1.144939271

Measure [ratio e / μ] = 1.2624 ± 0.0004

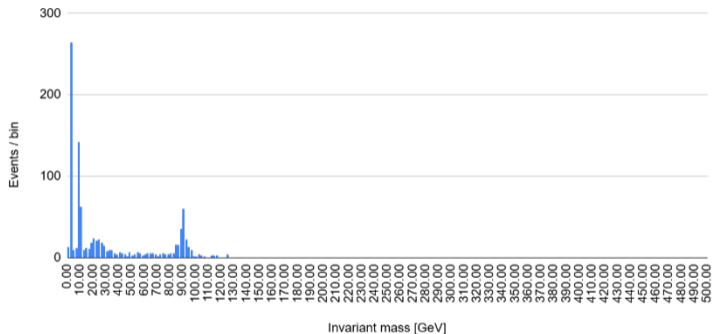
Measure [ratio W_+ / W_-] = 1.1449 ± 0.0006

Results from Padova: invariant mass

Questions

- Where are the peaks in the Mass Histograms? What do they represent?
- Where is Z boson in the 2-lepton plot? What are the other peaks, then?

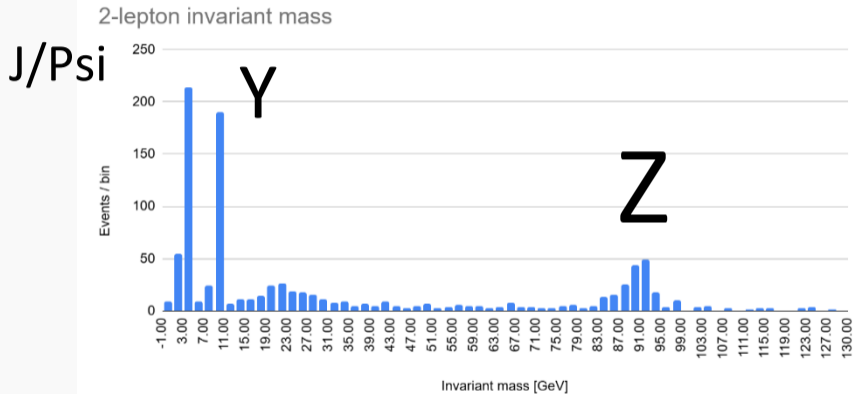
2-lepton invariant mass



From Particle Data Book (particle physics bible):

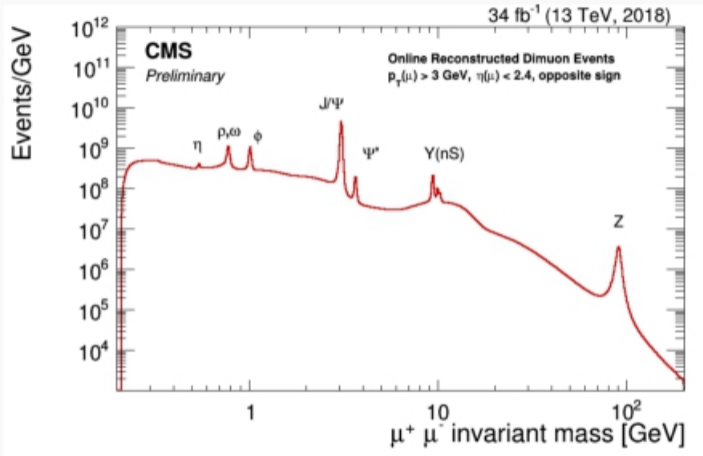
- $\text{Mass}(Z) = 91.1876 \pm 0.0021 \text{ GeV}/c^2$
- $\text{Mass}(J/\Psi) = 3,0969 \pm 0.00011 \text{ GeV}/c^2$
- $\text{Mass}(\Upsilon) = 9,46030 \pm 0.00026 \text{ GeV}/c^2$

Results from Padova: invariant mass distribution



The power of LHC and CMS: 50 years of particle physics and several Nobel prizes in a couple of hours

Dimuon invariant mass from CMS



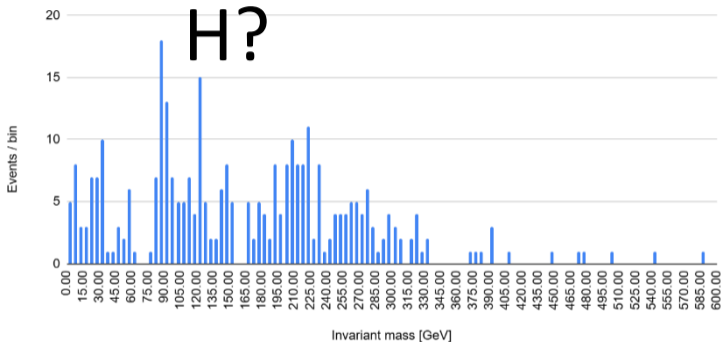
Same idea, more data

Results from PadovaA+B: invariant mass 4 leptons

Questions

- Do you have possible Higgs events in the 4-lepton plot? Where? Can we claim discovery?
- Why does there appear to be a Z peak in the 4-lepton plot as well? Since the Z does not directly decay to 4 leptons, how do we explain this?
- Is there anything else significant in the 4-lepton plot?

4-lepton invariant mass



- **Questions:** How many peaks are there in the mass plot? What do the peaks mean?
Can we claim a discovery?
- **From Particle Data Book (particle physics bible):** $\text{Mass}(\text{H}) = (125.25 \pm 0.17) \text{ GeV}$

INSTITUTIONS

Padova

Varna

SanPaulo SPRACE

A Coruna

Székesfehérvár

Possible questions that You can ask:

- * Life at CERN
- * Motivation to do physics
- * Life as a scientist