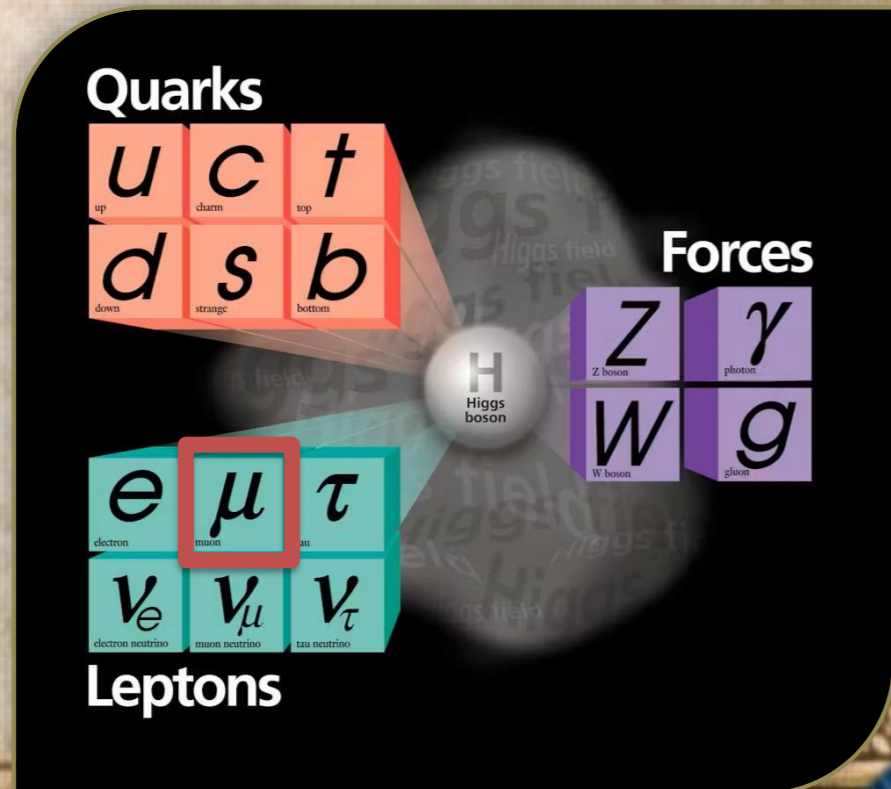


Finding Evidence of the Higgs's faintest footprint: The Muon Decay

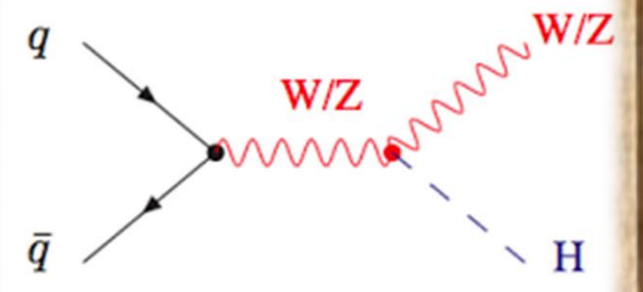
The Standard Model & Higgs

- Particles and Forces Framework
- Predicts interaction strengths
- Particles initially massless
- Higgs generates Particle mass
- Completing the Standard Model
- **Muons** heavy "brothers" of electrons

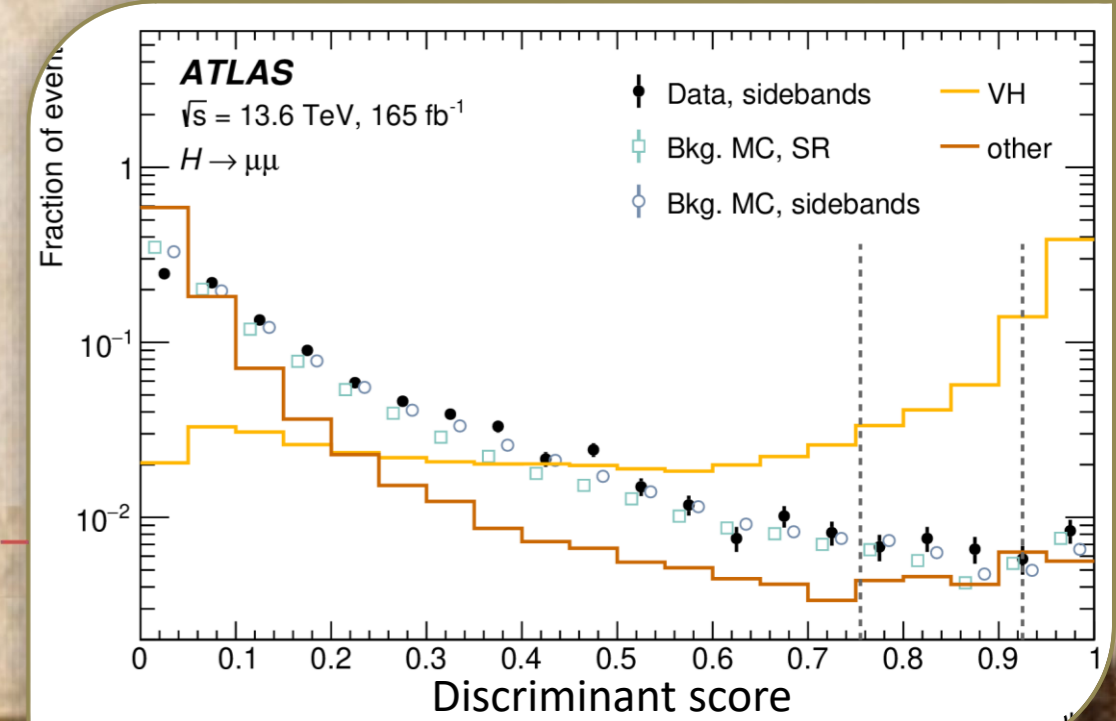
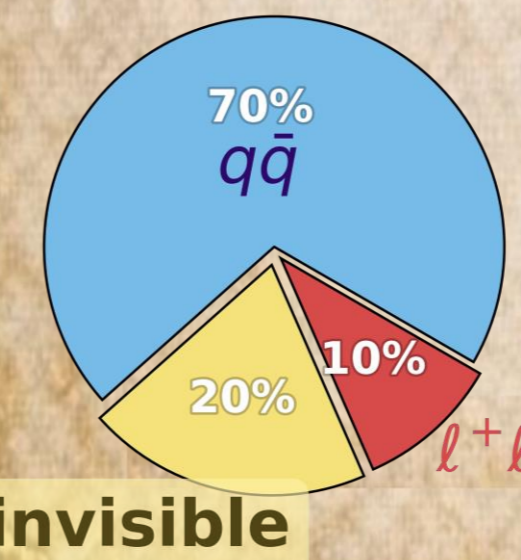


Extracting Rare Events

- Faint signal over Large background
- Concentrated on VH
- Dominant backgrounds $Z \rightarrow \mu\mu$ & $ZZ \rightarrow \nu\nu\mu\mu$
- Train AI models to separate signal-background
- Define Regions "rich" in signal

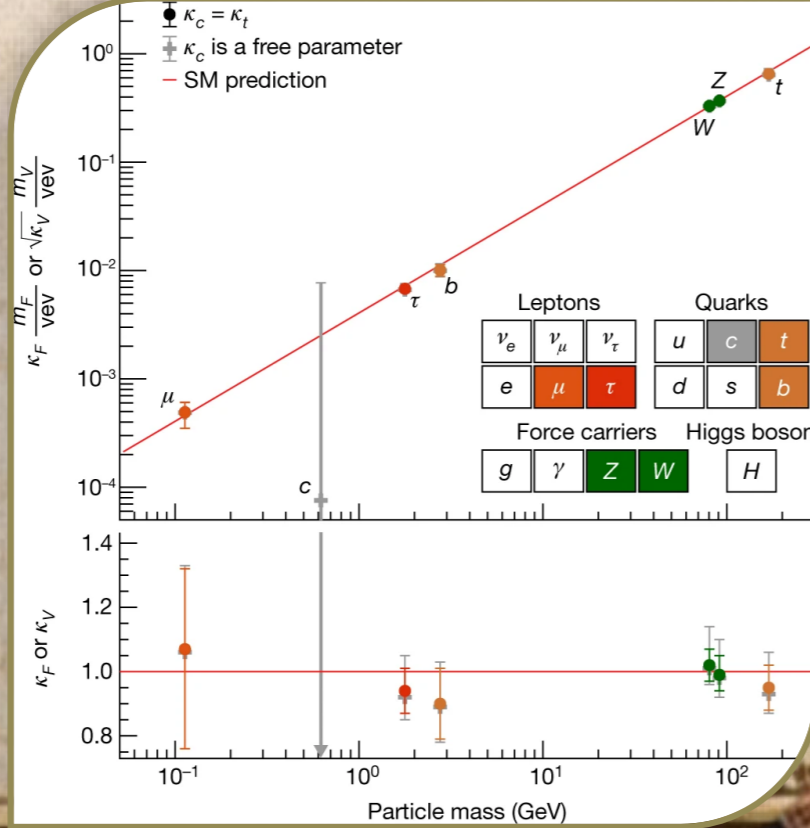


Z boson decays



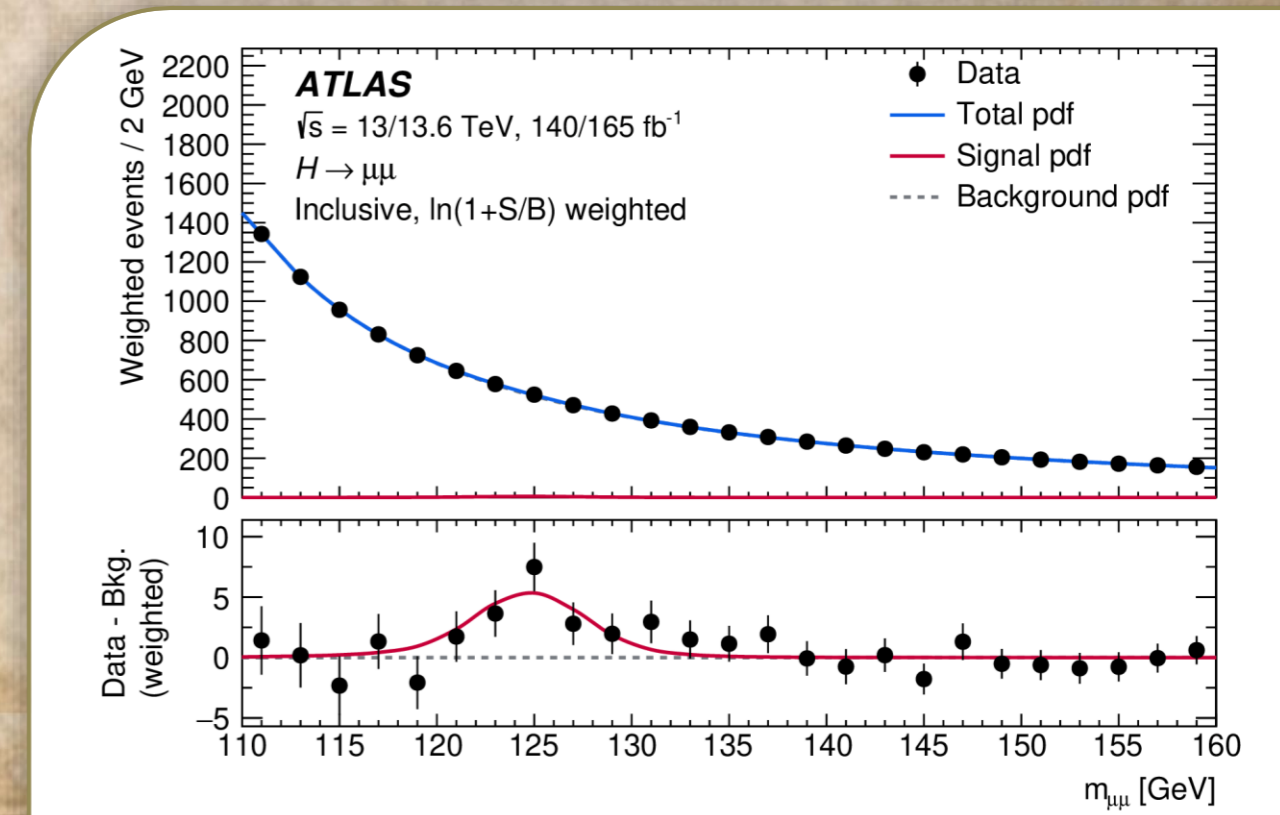
The Higgs Footprints

- Discovered by ATLAS & CMS Collaborations at the Large Hadron Collider
- Multiple production mechanisms
- Does Higgs match Predictions?
- Decays to Heavy
- Decays to Muons: Clean precision probe
- Extremely rare! (1:4,600 Higgs decays)
- Remains unobserved



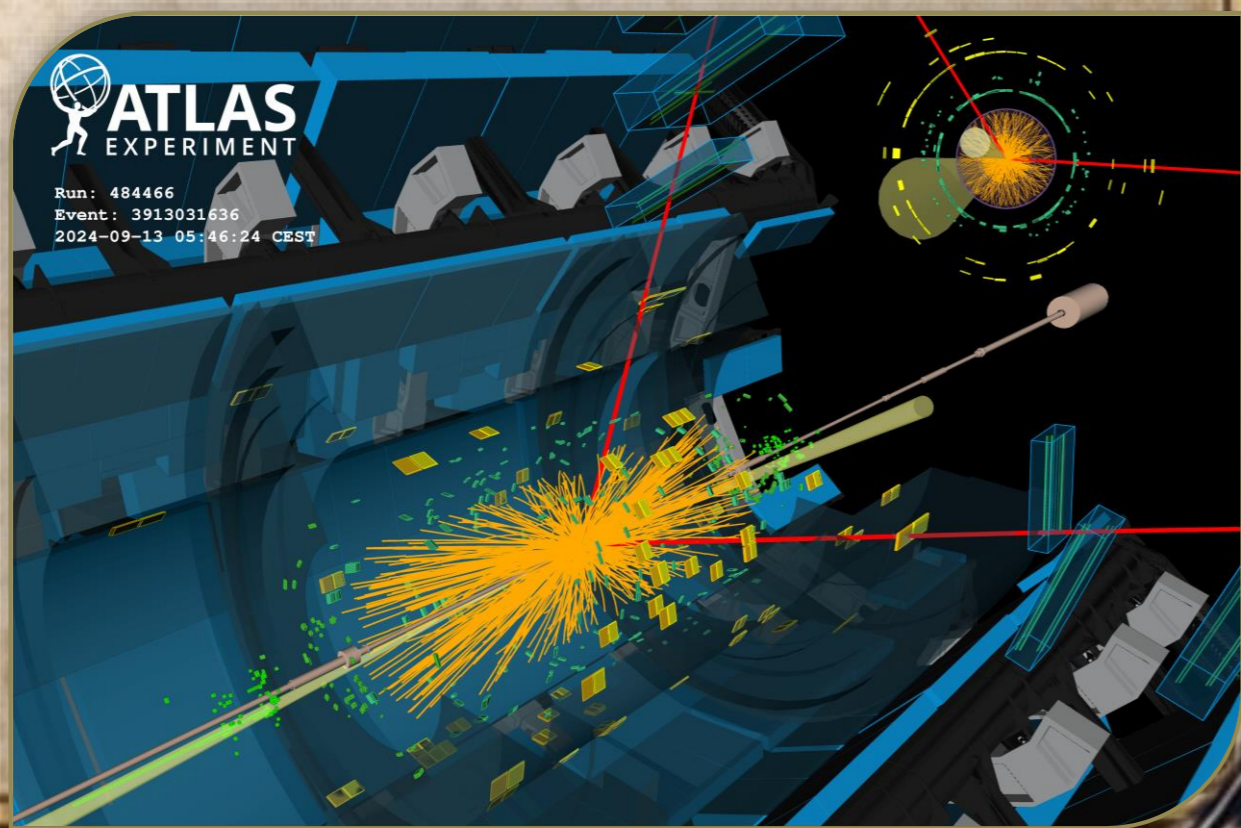
Main Physics Outcome

- Combined channels and previous analysis
- 3.4σ Excess observed (<0.07% Fluctuation error)
- Evidence-level achieved by ATLAS
- Consistent with Standard Model Higgs



ATLAS at the LHC

- General Purpose detector
- Recorded 165 fb^{-1} pp-collision data
- Excellent Muon identification
- Precise momentum measurement

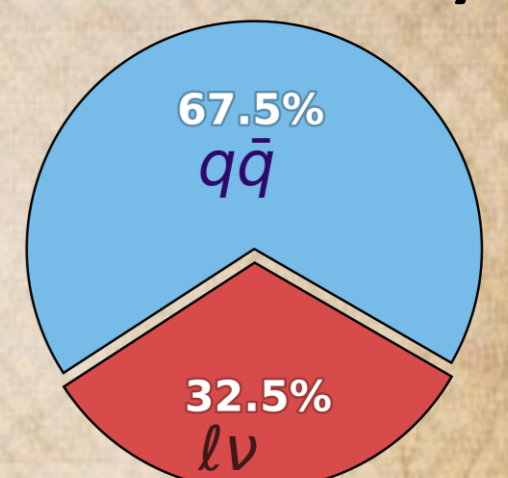


Results and Prospects

- Experimental evidence of $H \rightarrow \mu\mu$ decays
- Branching ratio measurement: $B(H \rightarrow \mu\mu) = 300 \pm 90$ per million
- Confirming Standard Model Higgs theory

W boson decays

- More data recorded currently
- Many ideas for improvements
- Observation within reach



Bibliography

- The ATLAS Collaboration, Evidence for the dimuon decay of the Higgs boson in pp collisions with the ATLAS detector – Phys. Rev. Lett. 135 (2025) 231802
- The ATLAS Collaboration, A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery – Nature 607, 52–59 (2022)