# ATLAS Standard Model

## PoF V MU-FPF Retreat 2025

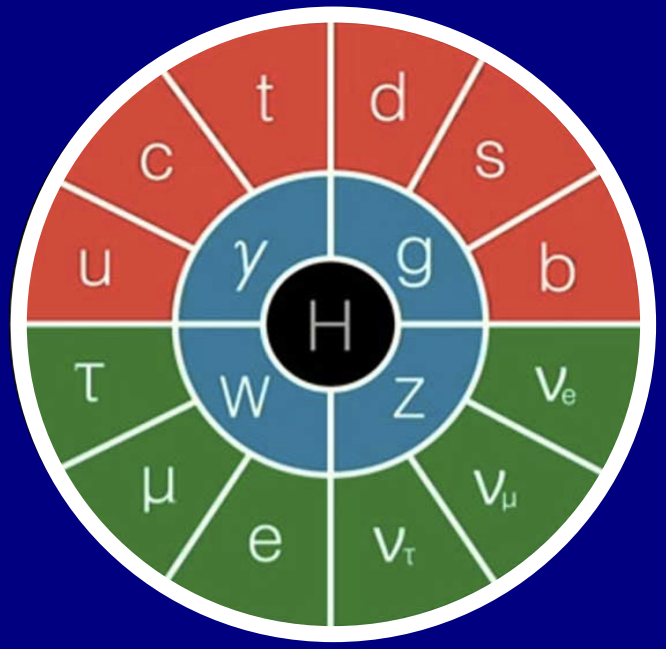
Lydia Beresford on behalf of DESY ATLAS

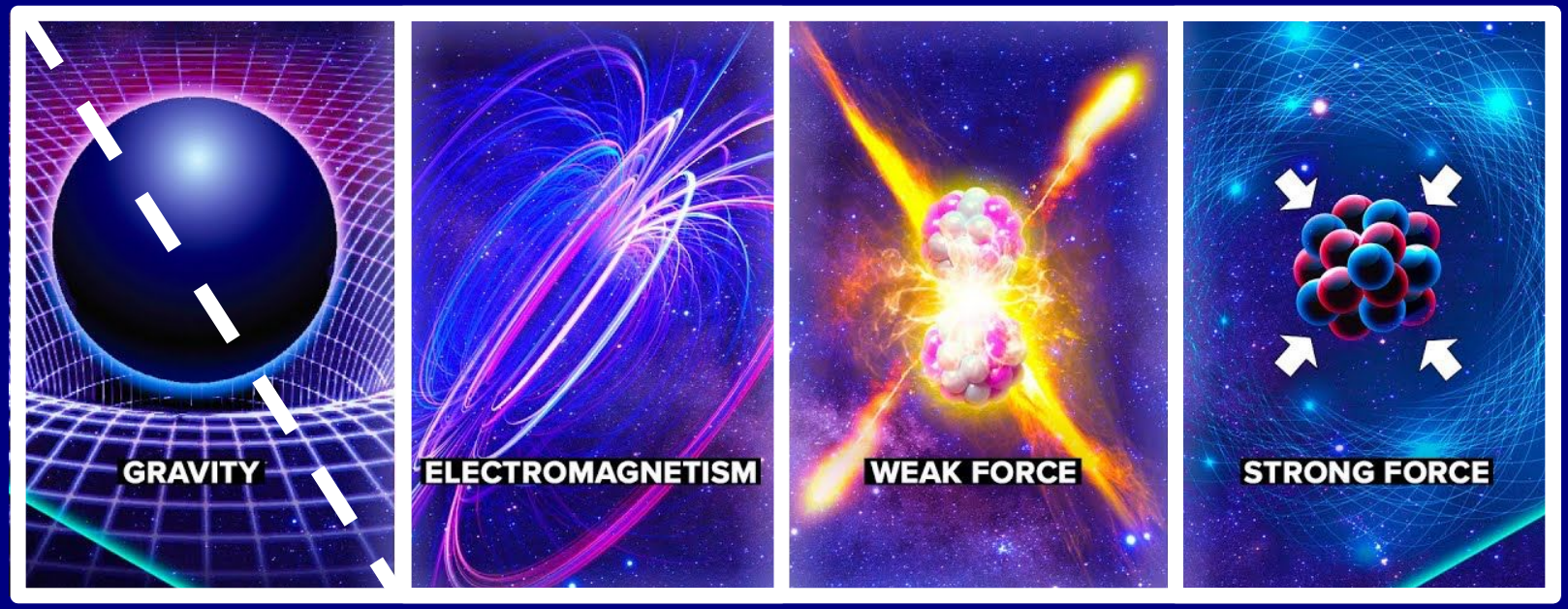
19th June 2025


HELMHOLTZ

# The Standard Model

## Our best description of the particles and forces which make up our Universe




**Foundation for everything … from atoms to stars and galaxies**

**Precise SM measurements test our best understanding and could lead to new insights**

# LHC as a precision tool

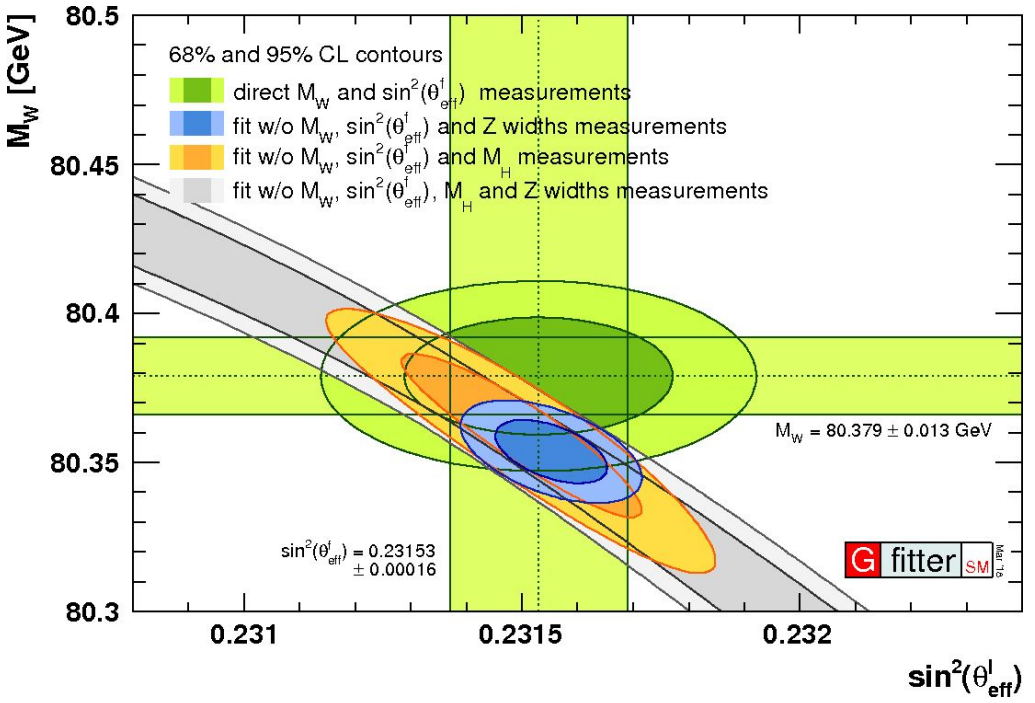
## Over past decade, LHC has proven to be a powerful precision measurement machine

**Custodial symmetry** (protects SM fundamental parameters from large radiative corrections)

- Test internal consistency of the Standard Model
- W mass linked to top quark and Higgs masses
  - Sensitive to new particles in the loop
- Mixing angle determines relative strength of weak and electromagnetic forces

**Key measurement targets:**

- W boson mass in high pile-up conditions
- Running of electroweak mixing angle using $Z/\gamma^* \rightarrow ll$, especially in forward region



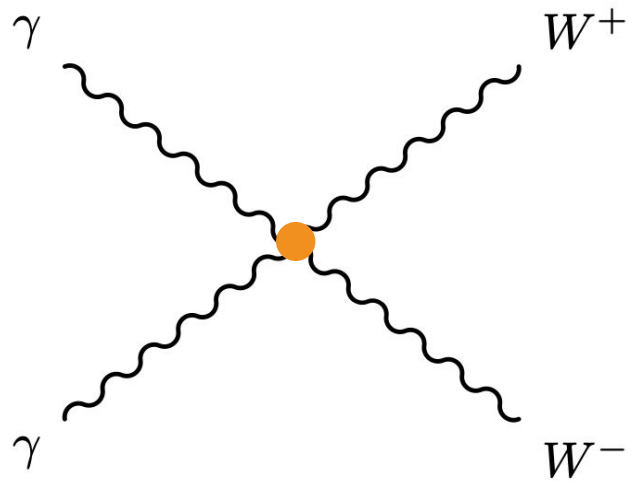
# Energy frontier tests of electroweak sector

## LHC is world's highest energy (virtual) photon collider

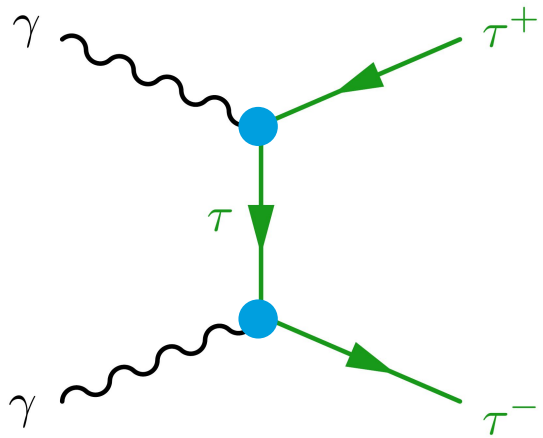
**Explore new kinematic regime for laboratory photon collisions**

**Rare:** larger dataset → more precise differential measurements & probe high mass tails

High mass tails particularly sensitive to BSM but currently limited by data statistics




***Test gauge structure of SM***
***Sensitive to anomalous couplings***

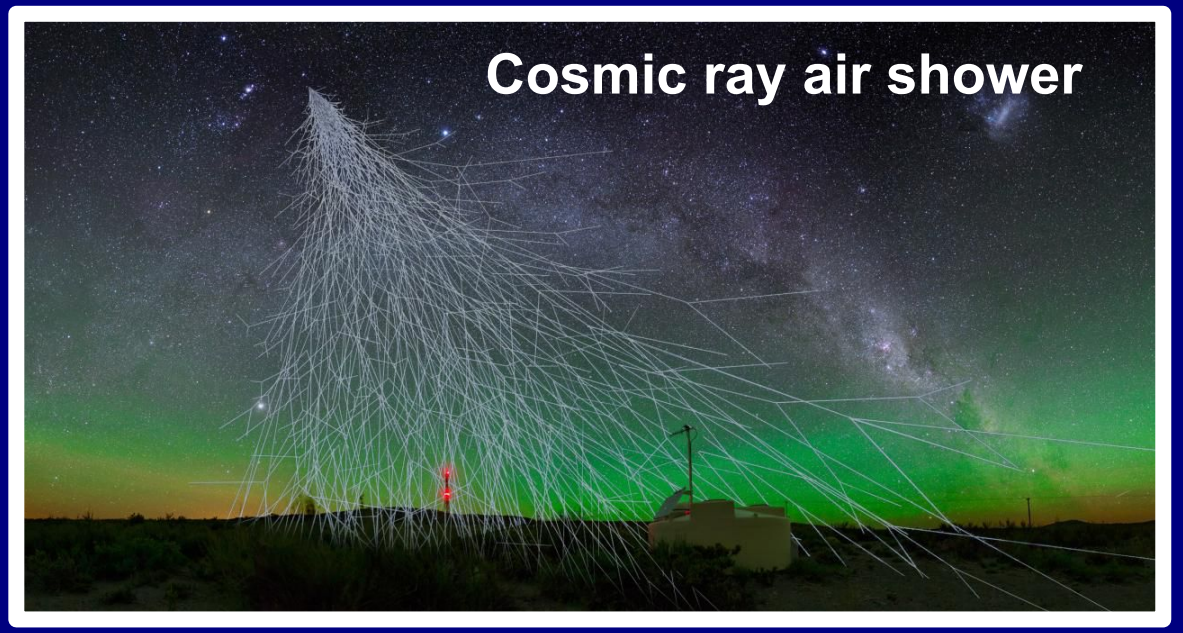



***Measure tau-lepton magnetism (g-2)***
***Search for CP-violating physics via EDM***

# Cosmic connection

**Cosmic rays are the highest energy particles observed in our Universe**

- Origin and acceleration remains enigmatic


- **Limiting factor:** modelling low energy QCD processes which occur in air showers
- **Once in a lifetime:** In 2025 LHC will become world's highest energy proton-Oxygen collider
  - **Measure fundamental processes which occur in cosmic ray air showers in the lab**
  - **Broad program with unique dataset:** Minbias, combine with forward detectors, PID etc

# How to achieve precision?

## Profit from detector upgrades and improved theoretical advancements and tools

- **ITk (Inner Tracker) and HGTD (High-Granularity Timing Detector):**
  - Forward region important for weak mixing angle
  - Track-veto is key tool to identify photon-fusion
- **Precision enhanced by improved theory:** PDF fits/profiling, higher order QCD corrections

## Synergies across experiments/groups:

- Collaboration with theory groups at DESY and beyond
- Combining measurements across LHC experiments increases precision thanks to complementarity and increased statistics for rare processes

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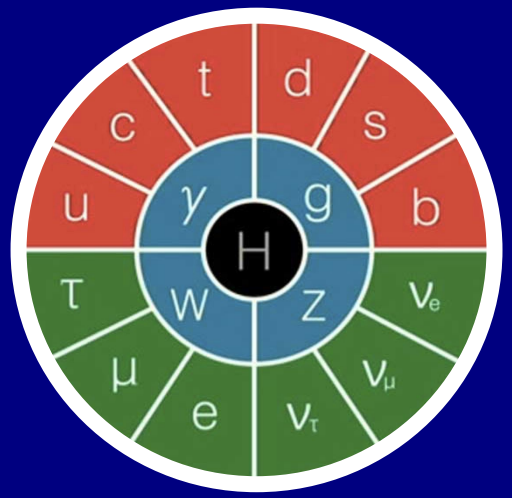


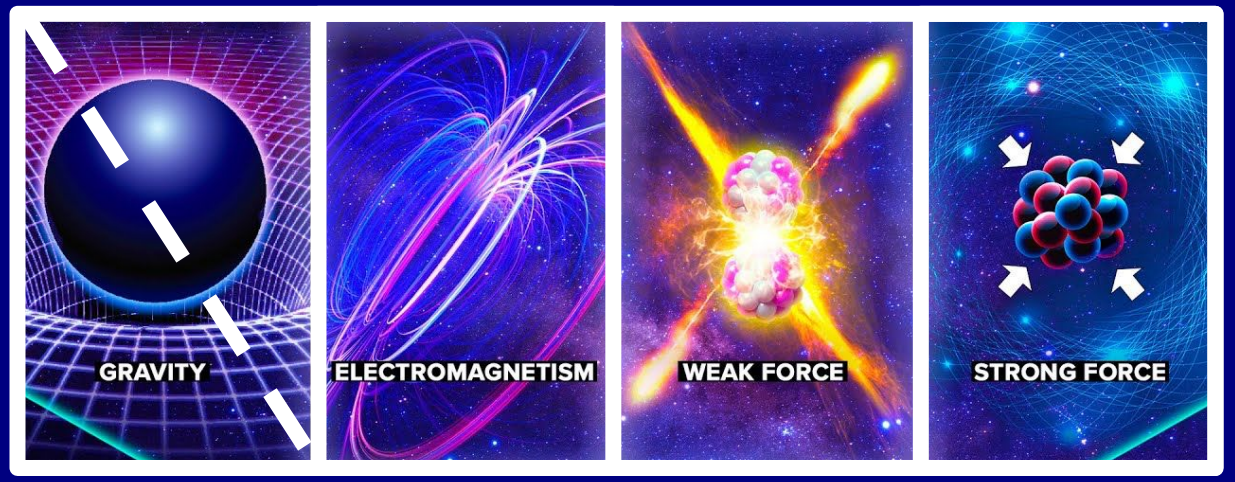


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