# News from LHCb
# Including EW Perspective

Nate Grieser, on behalf of the collaboration

University of Cincinnati

**2024 PDF4LHC Meeting**

02-12-2024


# Table of Contents

# Overview

→ LHCb geometry provides a unique coverage at the LHC to provide complimentary physics results useful to the PDF community!

**Today we will consider two recent topics:**

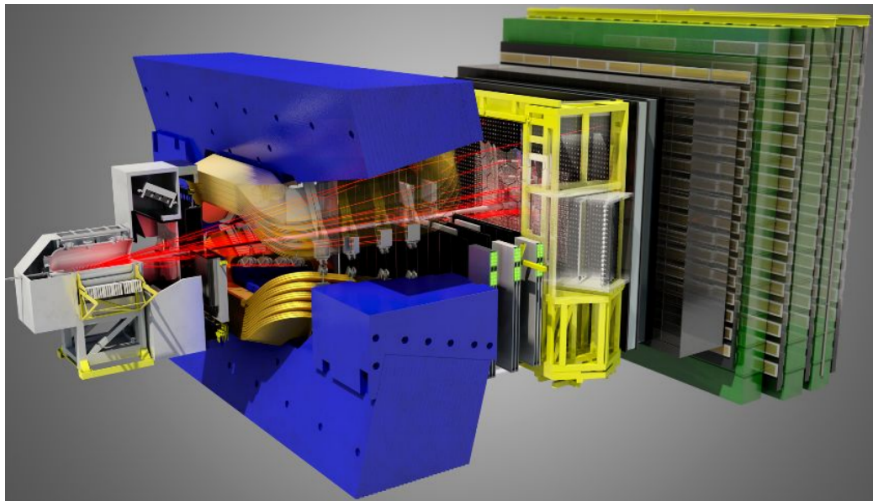
1. Effective Weak Mixing Angle Measurement at 13 TeV
2. Single-jet Cross Section Measurement at 5.36 TeV

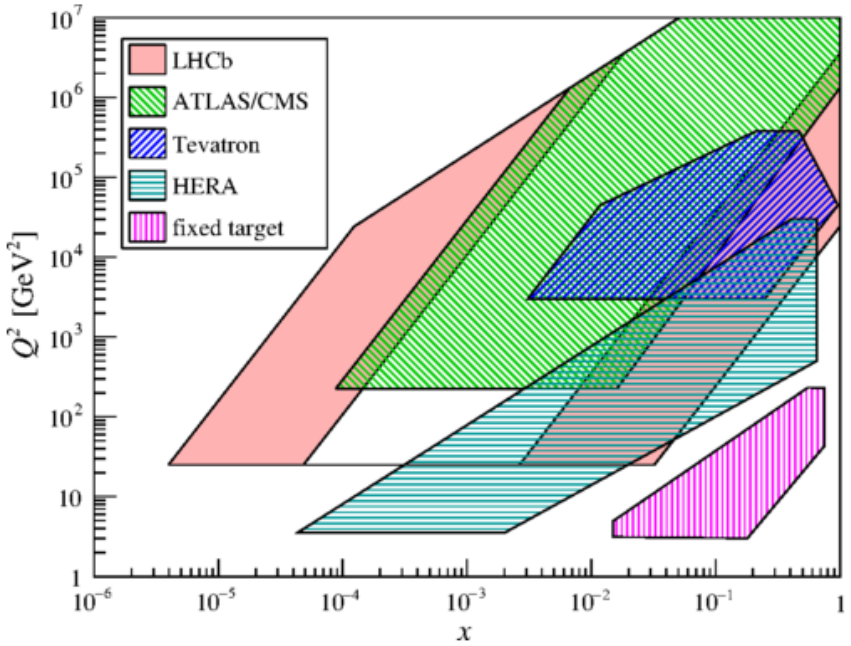
# LHCb Detector Overview

JINST 3 (2008) S08005

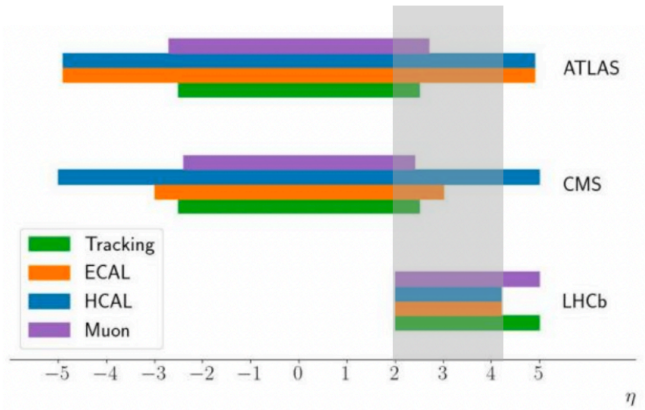
## → LHCb Strengths of Design:

- Long tracking distances for improved flavour physics
- Ring-Imaging Cherenkov (RICH) detectors for particle identification (PID)






PRD 93, 074008 (2016)




- Forward design allows for LHC-unique coverage of low- and high-x partons

# Table of Contents

## Measurement of the Effective Leptonic Weak Mixing Angle

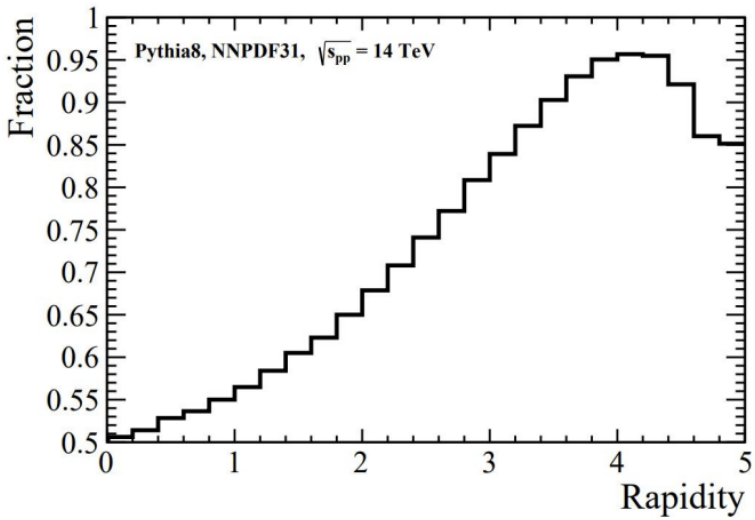
arXiv:2410.02502

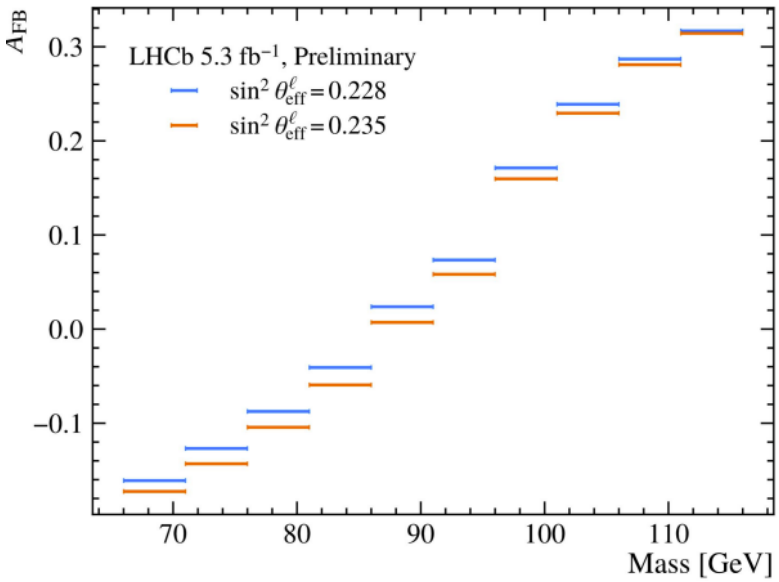
Significant probe of EW theory; relation of U(1) and SU(2) gauge couplings

$$\sin\theta_W = \left(1 - \frac{m_W^2}{m_Z^2}\right)$$

$q$–$\bar{q}$ differences at high-x and low-x has significant sculpting of Z relations to initial-state partons

Fraction of events with Z in line with initial-state quark ↓




↑ Extract $\sin\theta_W$ using $A_{FB}$:

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

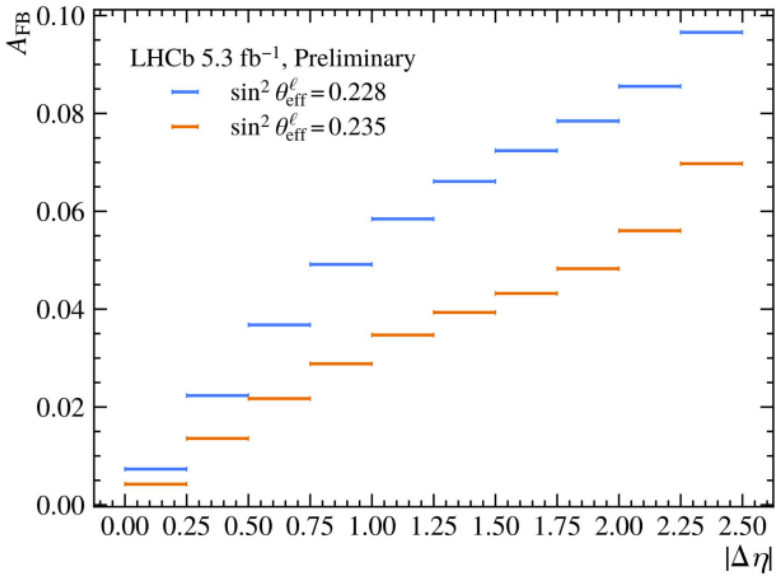
Mass dependent $\sin\theta_W$ no gain, *Could* be used for PDF profiling

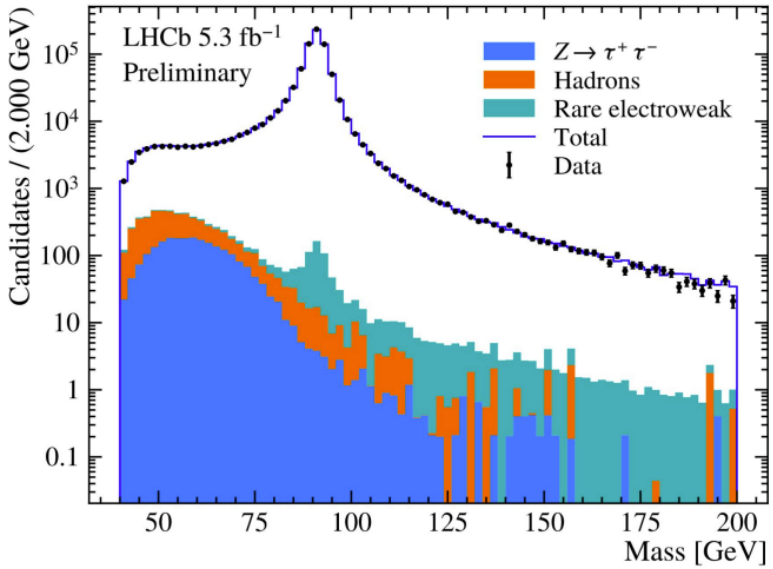
## Measurement of the Effective Leptonic Weak Mixing Angle arXiv:2410.02502

Separate events at large and small $\cos\theta^*$ to increase sensitivity

$$\frac{d\sigma}{d\cos\theta^*} \propto 1 + \cos^2\theta^* + \frac{8}{3} A_{FB} \cos\theta^*$$

Bin the measurement of $A_{FB}$ in $\Delta\eta$ of the muons shows significant sensitivity to $\sin\theta_W$ ↓



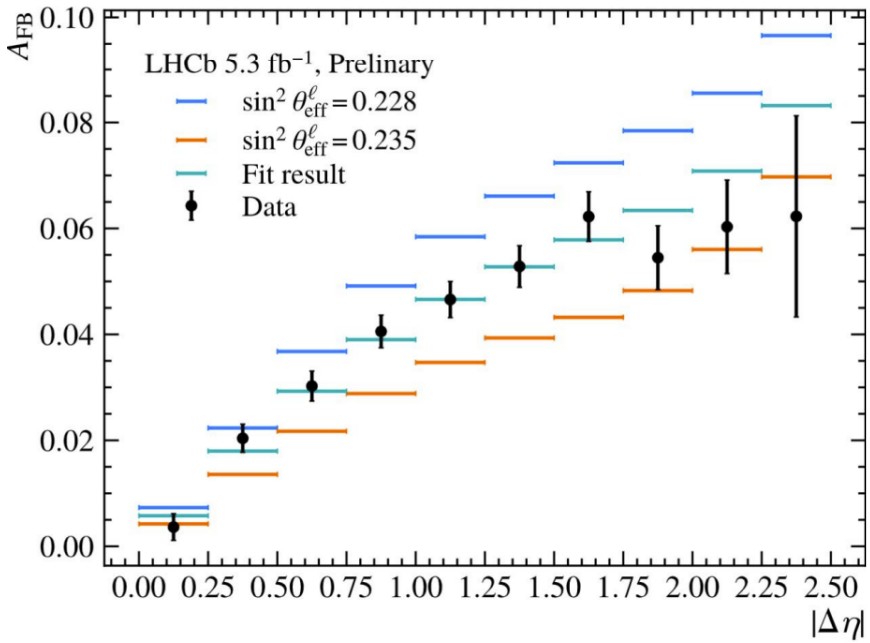




↑ Can use single, large window mass bin due to very pure signal selection

$$66\text{GeV} \leq M_Z \leq 116\text{GeV}$$

## Measurement of the Effective Leptonic Weak Mixing Angle arXiv:2410.02502

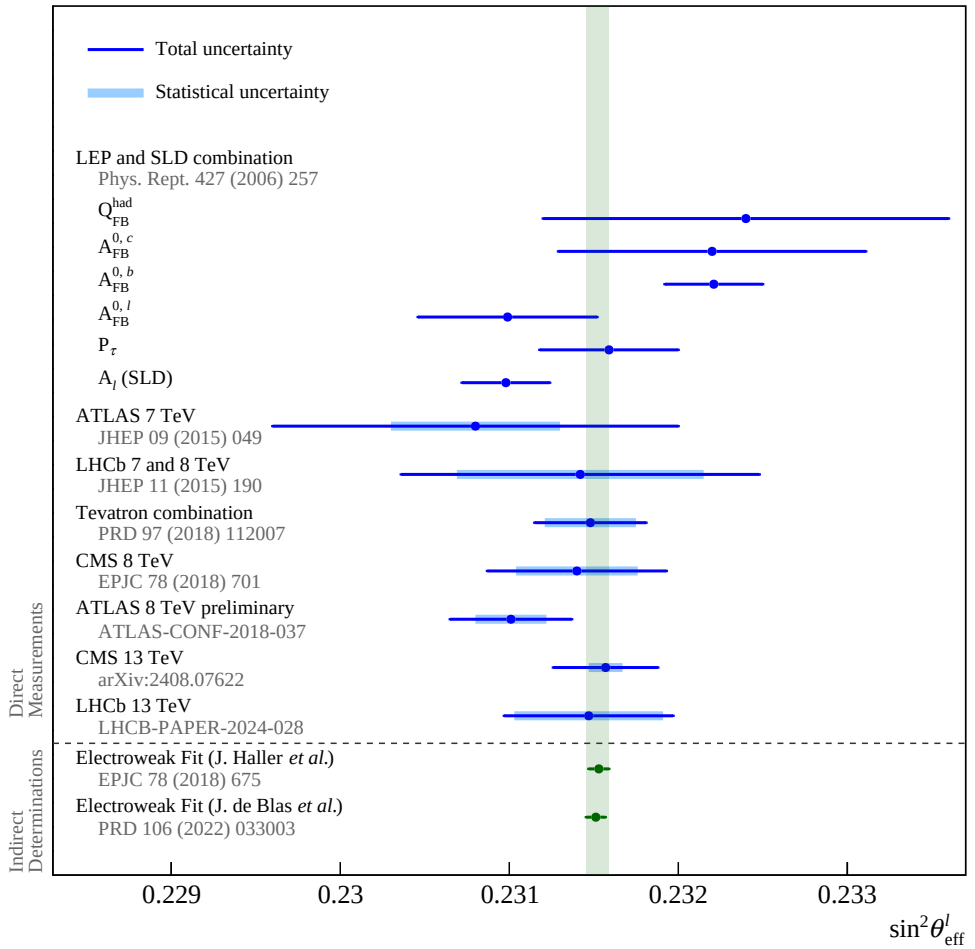
**Results:** $\sin\theta^{\ell}_{\text{eff}} = 0.23152 \pm 0.00044\ (\text{stat.}) \pm 0.00005\ (\text{syst.}) \pm 0.00022\ (\text{theory})$




Stats are significant limitation in the most sensitive bins

**No deviation from SM observed**

Menglin's CERN Seminar



## Treatment of PDFs in $\sin\theta^{\ell}_{\text{eff}}$ Measurement

arXiv:2410.02502

→ Forward region has smallest PDF uncertainties before profiling due to lower dilution between partonlevel and particle-level in this region

**How We Treat Them:**

- Find results for each PDF set considered, with uncertainties evaluated following the prescription given by the PDF fitting group
  → No Profiling
- PDF uncertainties evaluated through by reweighting based on $x$ and $Q^2$
  → Extremely quick to make cross-check and adaptations to other PDFs
- No favoured PDF in report of central results
  → Arithmetic average taken for central value and PDF uncertainty

→ Current results do not require profiling, but next iteration will have to consider

## Treatment of PDFs in $\sin\theta^{\ell}_{\text{eff}}$ Measurement

arXiv:2410.02502

| PDF set | $\sin^2\theta^{\ell}_{\text{eff}}$ | Shift | Fit $\chi^2$/ndof |
|---|---|---|---|
| NNPDF31_nlo_as0118 | 0.23133 | – | 13.1/6 |
| CT18NLO | 0.23139 | 0.00006 | 19.8/6 |
| MSHT20nlo_as118 | 0.23119 | -0.00015 | 10.8/6 |
| CT18ZNLO | 0.23126 | -0.00007 | 17.1/6 |
| NNPDF40_nlo_as_01180 | 0.23120 | -0.00014 | 9.4/6 |

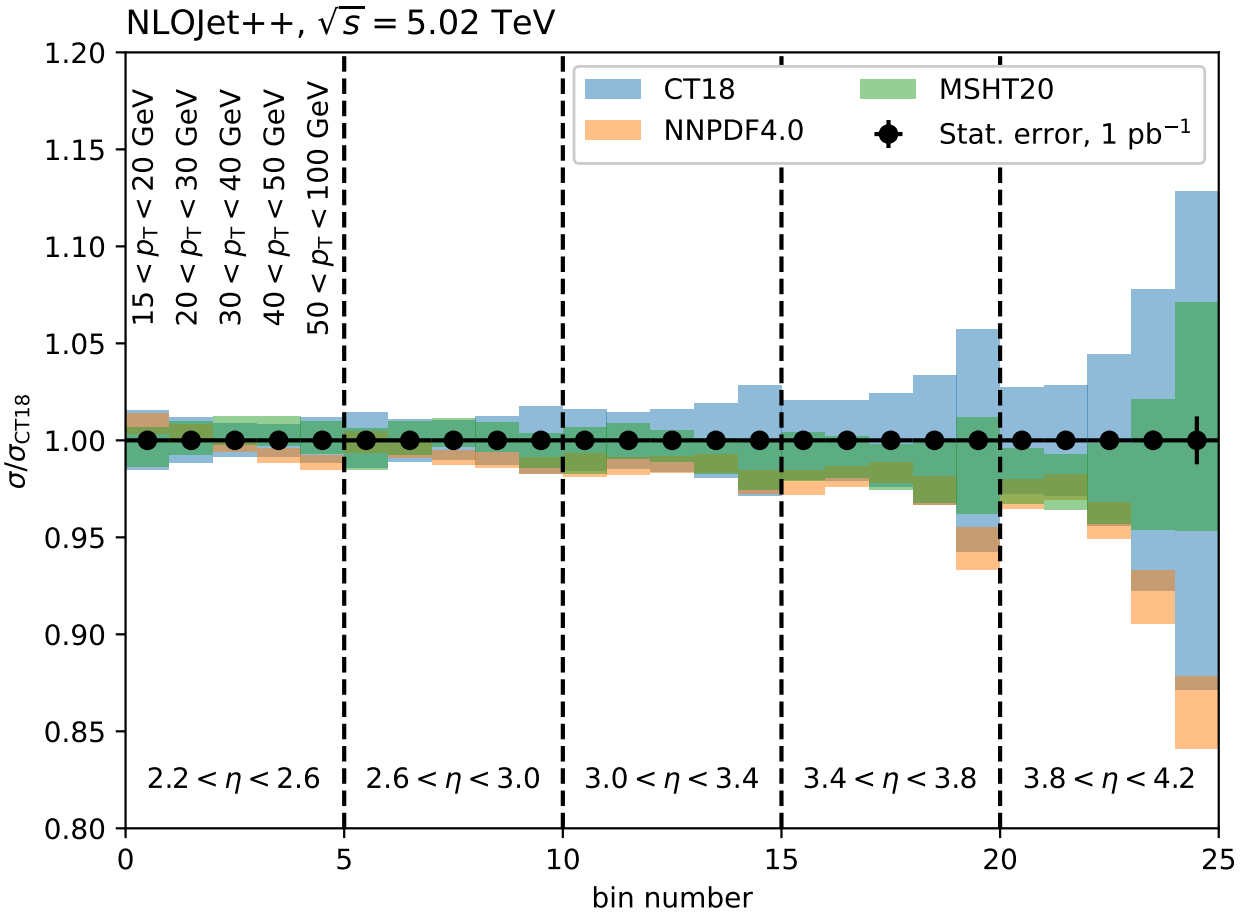
$\rightarrow$ Cross-Check of measurement with a variety of PDFs shows consistency

**Note:** Not a full re-analysis, difference in $\chi^2$ expected

# Table of Contents

# Probing Very High x With $\sqrt{s} = 5.36$ TeV $pp$ Collisions

Plot Courtesy T. Boettcher




→ Inclusive single-jet cross sections show significant differences in gluon PDFs

# Probing Very High x With $\sqrt{s} = 5.36$ TeV $pp$ Collisions

→ Single jet cross section measurement using $pp$ reference run will study the differences in PDFs experimentally

**Data is already taken!**

- Utilize an inclusive jet trigger that alleviates bias of previous jet collections due to HLT1 being primarily heavy-flavour focused
- $\sqrt{s} = 5.36$ TeV $pp$ delivered $\geq 200$ fb$^{-1}$ in October 2024
- No prescale necessary on single jet selection as low as $p_T^{\text{jet}} = 30$ GeV

→ Be on the lookout for results in the near future!

# Table of Contents

# Conclusions and Outlook

$\rightarrow$ LHCb geometry provides a unique coverage at the LHC to provide complimentary physics results useful to the PDF community!

- A plethora of EW measurements continue to come out of Run 2 data
  - To-date, no PDF profiling is necessary $\rightarrow$ May change in Run 3
- Jet measurements targeting high-$x$ space to come in near future
- Other interesting measurements are planned in Run 2 that can contribute to PDF ecosystem:
  1. **Electro-Weak:** $Z$ mass, $WW$, $W$ helicity + XSec, ...
  2. **Jet-focused:** Single jet XSec, Dijet XSec, $W$ + jets, $W$ + charm, ...

**Anything else?**

# BACKUP