From Beauty to Charm, From ATLAS to LHCb

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MINISTRY OF EDUCATION, YOUTH AND SPORTS

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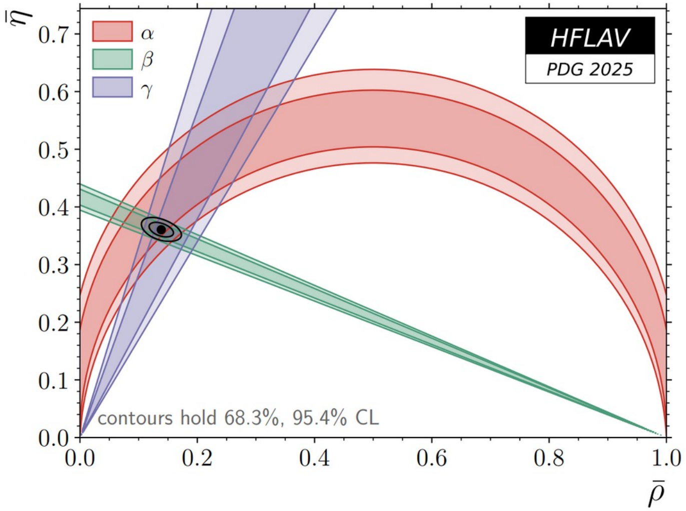
Heavy Flavour Physics

- What is **flavour** physics?
  - Studies transitions between different quark types (flavours) via weak interactions.
  - Sensitive to quantum loop effects → **indirect probe** of physics beyond the Standard Model (BSM).
- What is **heavy flavour** (HF) physics?
  - Physics of hadrons containing bottom (*b*) or charm (*c*) quarks.
  - Includes beauty-physics (*B*-physics) and charm-physics.
  - Focus on rare decays, CP violation (CPV), mixing, and lepton-flavour universality.
- Experiments:
  - **ATLAS**/CMS: Mainly high-p_T physics, but also HF programme large datasets.
  - **LHCb**: Dedicated heavy-flavour experiment; forward geometry, high resolution.
  - Belle II, BES III: e^+e^- environment; complementary reach.

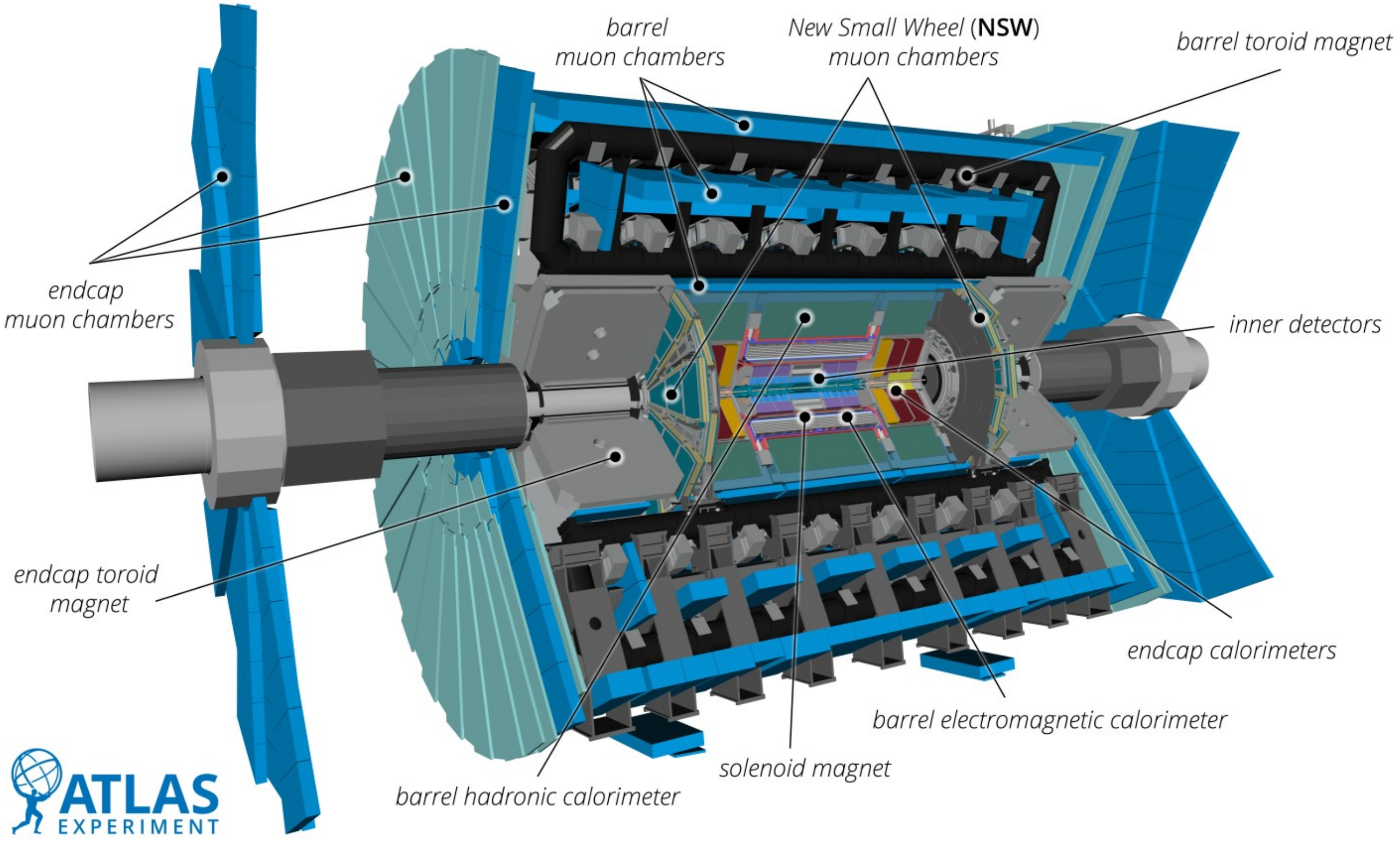
Why Does HF Physics Matter?

- First of all – most of it is ***beauty*** :-)!
- **Precision** tests of the Standard Model (SM):
  - Measuring the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix.
  - *B*-hadron lifetimes can test our understanding of the weak interaction.
- Exploring **CPV**: matter-antimatter asymmetry.
- Hadron spectroscopy and **exotics** states.
- Heavy flavour **production** measurements.
- Probing **New Physics** (NP):
  - Indirect sensitivity to heavy new particles (e.g., through loop processes).
  - **It complements direct searches!**

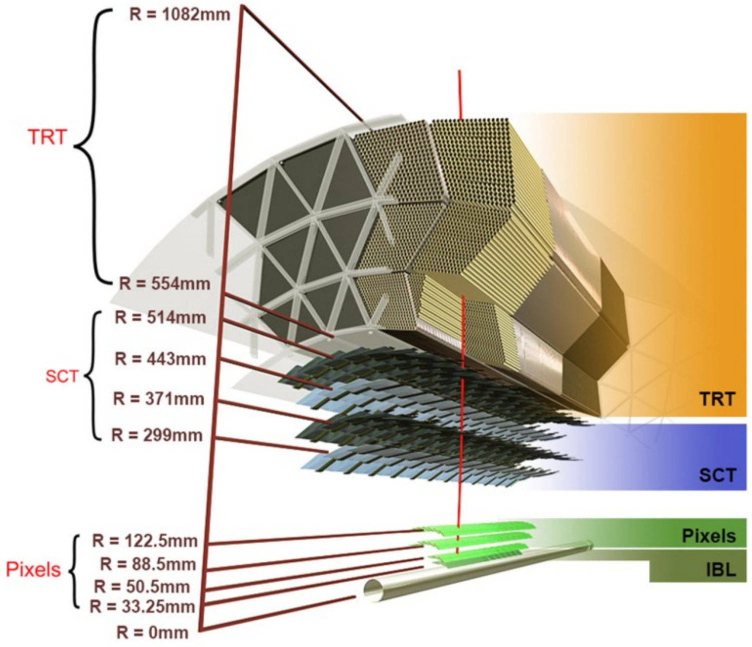


CERN, LHC… and the Key Points of Interest

The ATLAS Experiment

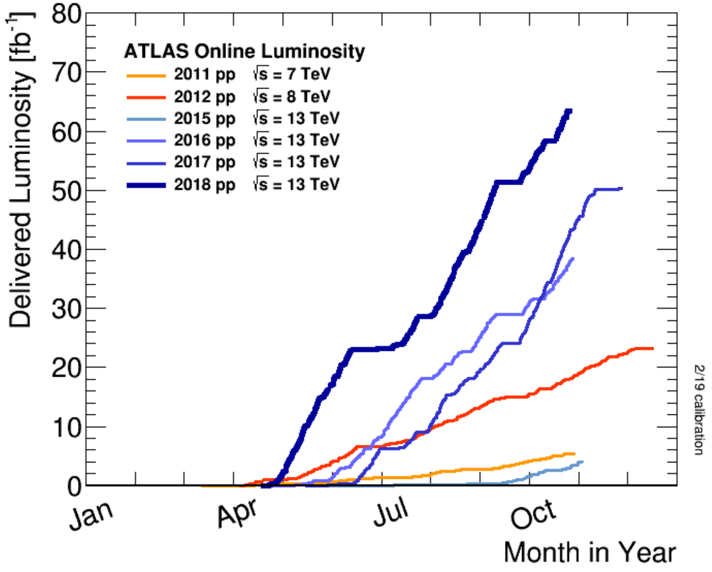


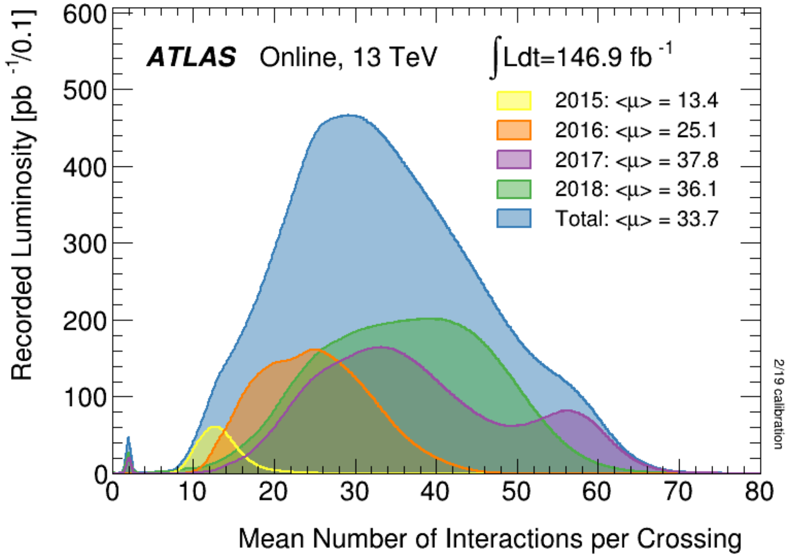
- l = 44 m, d = 25 m, m = 7000 t.
- **IBL** for Run2, **NSW** for Run3.
- ID, MS, (EMCal).



No "*B*" in ATLAS?

- General purpose detector, mainly for high-p_T physics…





- Hard to live there, but it has some pros: ATLAS covers central $b\bar{b}$ production region, *b*-jet tracks are well separated, it can work at full LHC luminosity → high statistics.
- See ATLAS B-physics public results!

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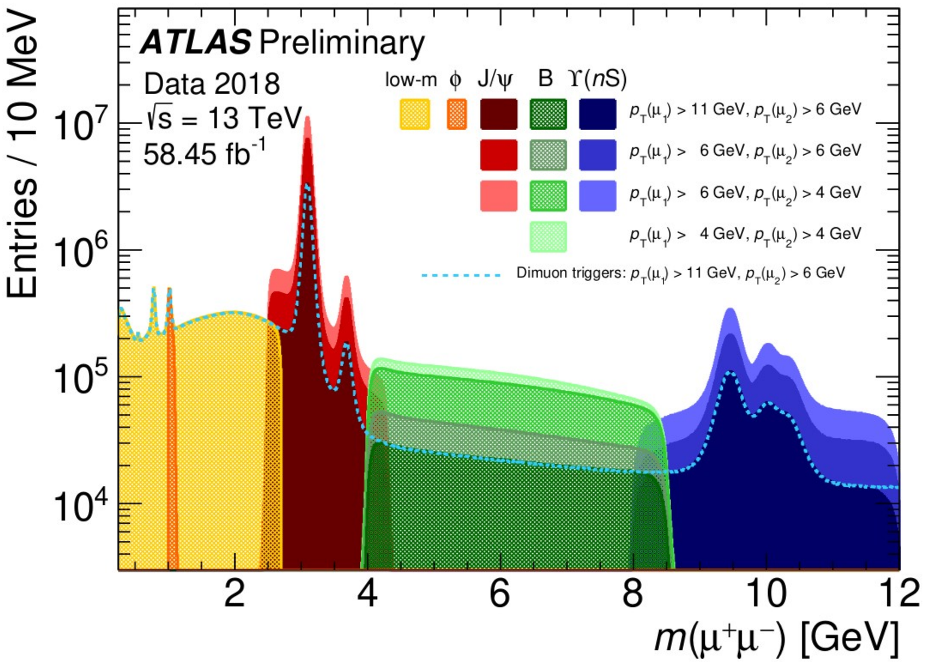
ATLAS *B*-physics Triggers and Data

- Run 2: 139 fb^{-1} of *pp* collisions at 13 TeV collected in 2015-2018 (Run 1: 25 fb^{-1} at 7 and 8 TeV).
- Producing 2.5M $b\bar{b}$ pairs/second, B_s, B_c, Λ_b, etc. available.
- Focus mostly on final states with muons, fully reconstructable.
- Typical B-physics trigger:
  - Low-p_T di-muons at low invariant mass, using information from ID and MS.
  - Further topological (analysis-like) selections.
  - Rate up to ∼200 Hz.
- **In mid-2018, a low-p_T di-electron high-level trigger (HLT) implemented.**



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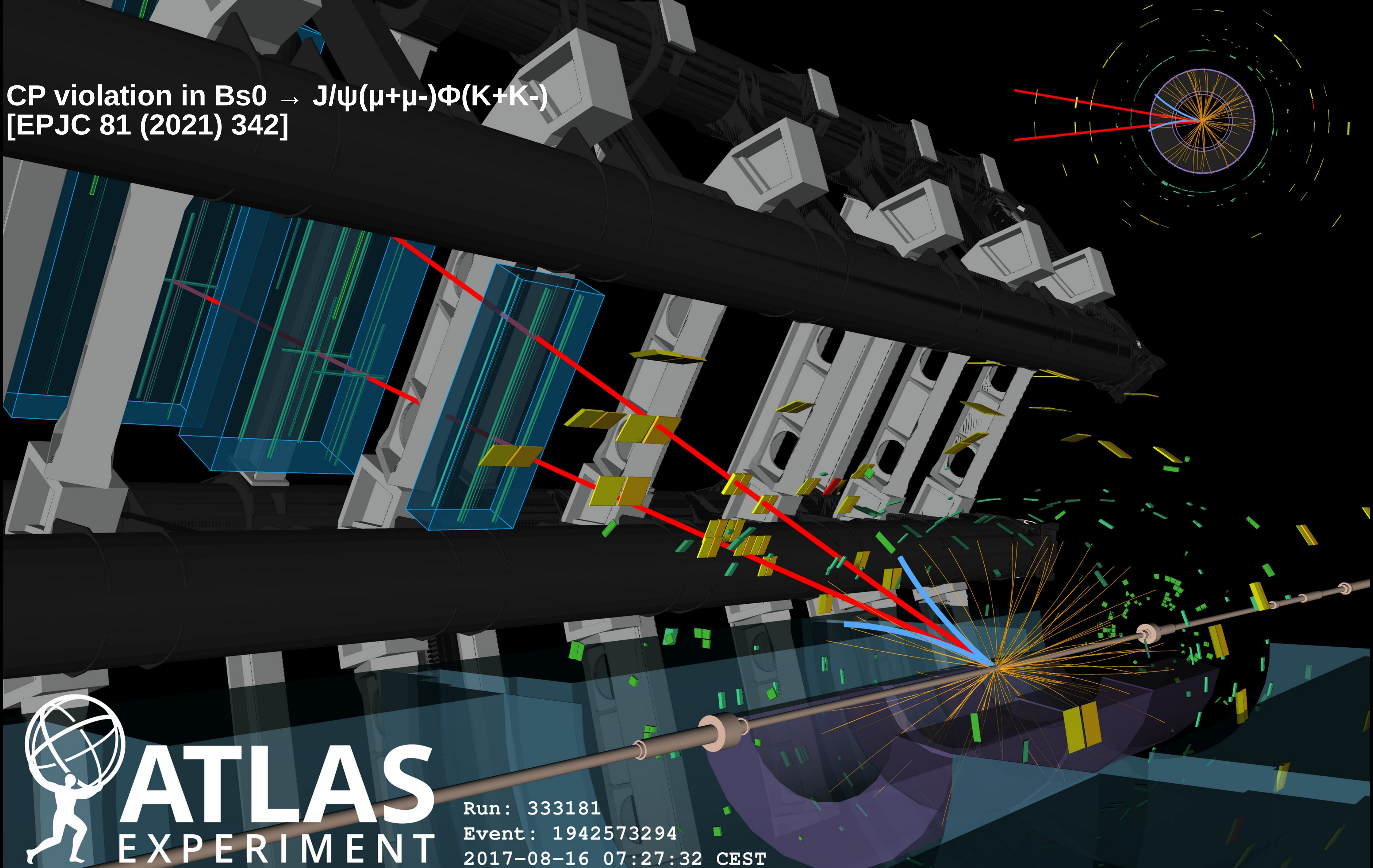
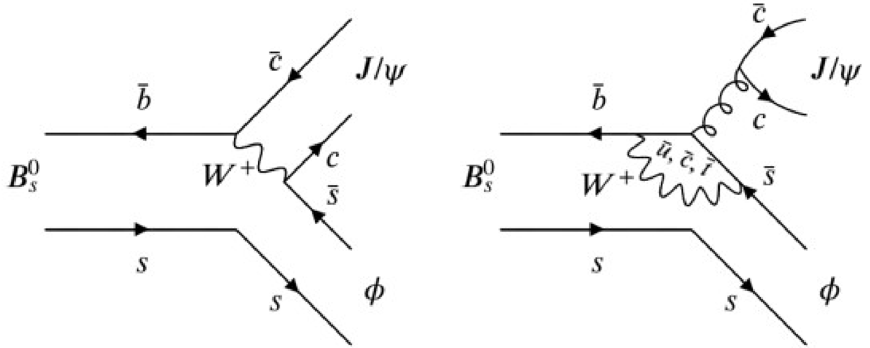
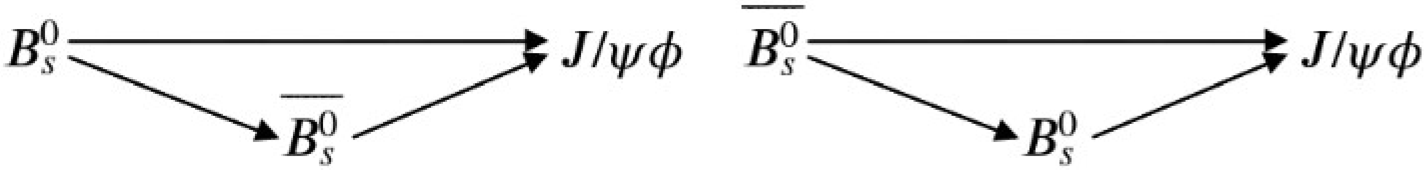

CP violation in Bs0 → J/ψ(μ+μ-)Φ(K+K-)
[EPJC 81 (2021) 342]
ATLAS
EXPERIMENT
Run: 333181
Event: 1942573294
2017-08-16 07:27:32 CEST

CPV in $B_s^0 \to J/\psi\Phi$: Introduction

- Decay $B_s^0 \to J/\psi\Phi$ is expected to be very sensitive to NP contributions to CPV.
- Neutral B_s^0 meson can oscillate into its antiparticle (and vice versa).
- The oscillation frequency is characterised by the mass difference Δm_s of the heavy (B_H) and light (B_L) mass eigenstates.
- In the absence of CPV, the B_H state would correspond to the *CP*-odd state and the B_L to the *CP*-even state.
- CPV in **interference of mixing and decay**: the common final state is reached via two different decay chains:





CPV in $B_s^0 \to J/\psi\Phi$: Motivation

- *CP*-violating phase is defined as the **weak phase difference** between the B_s^0–$\overline{B}_s^0$ mixing amplitude and the $b \to c\bar{c}s$ decay amplitude.
- In the SM it can be related to the CKM matrix

$$\phi_s \simeq -2\beta_s = -2\arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right)$$

- Predicted with high precision**:** $\mathbf{-0.0376^{+0.0006}_{-0.0005}}$ **rad**.
- Any sizeable deviation from this value would be a sign of BSM physics.
- $B_s^0 \to J/\psi\Phi$: pseudoscalar to vector-vector final state → admixture of *CP*-odd and *CP*-even states → distinguishable through **time-dependent angular analysis**.

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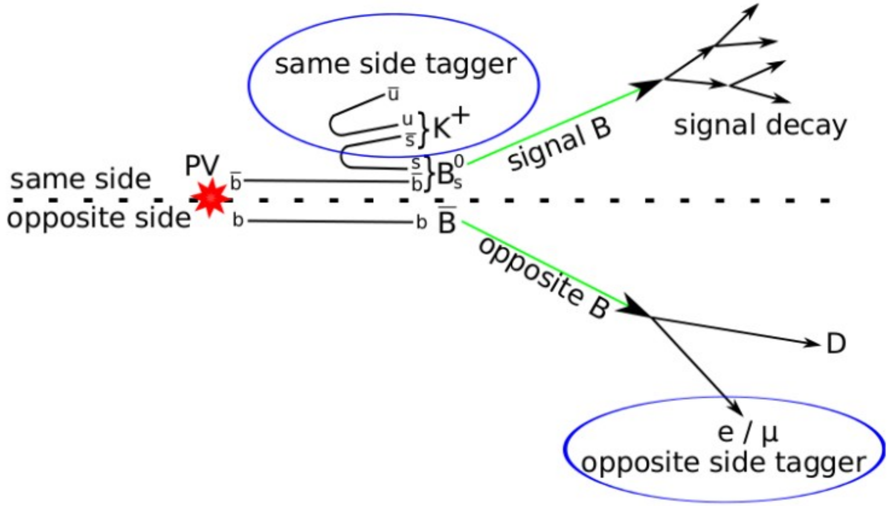
CPV in $B_s^0 \to J/\psi\Phi$: Fit in 5D

- Unbinned maximum likelihood (UML) fit to extract parameters of interest.
- Observables:
  - Mass, lifetime, 3 angles (between final state particles).
  - Conditional observables per-candidate:
    - Resolution: mass and lifetime (in 6 p_T bins)
    - B-meson p_T.
    - B_s^0 flavour tagging probability.
- Physics parameters:
  - CPV phase Φ_s, decay widths: $\Delta\Gamma_s$, Γ_s.
  - Decay amplitudes: $|A_0(0)|^2$, $|A_{||}(0)|^2$, $\delta_{||}$, $\delta_\perp$.
  - S-wave: $|A_S(0)|^2$, δ_S.
  - Δm_s fixed to PDG.

$$
\begin{aligned}
\ln \mathcal{L} = \sum_{i=1}^{N} \{ w_i \cdot \ln(& f_s \cdot \mathcal{F}_s(m_i, t_i, \sigma_m, \sigma_t, \Omega_i, P(B|Q), p_{T_i}) \\
& + f_s \cdot f_{B_d^0} \cdot \mathcal{F}_{B_d^0}(m_i, t_i, \sigma_m, \sigma_t, \Omega_i, P(B|Q), p_{T_i}) \\
& + f_s \cdot f_{\Lambda_b} \cdot \mathcal{F}_{\Lambda_b}(m_i, t_i, \sigma_m, \sigma_t, \Omega_i, P(B|Q), p_{T_i}) \\
& + (1 - f_s \cdot (1 + f_{B_d^0} + f_{\Lambda_b})) \cdot \mathcal{F}_{\mathrm{bkg}}(m_i, t_i, \sigma_m, \sigma_t, \Omega_i, P(B|Q), p_{T_i}))\}
\end{aligned}
$$



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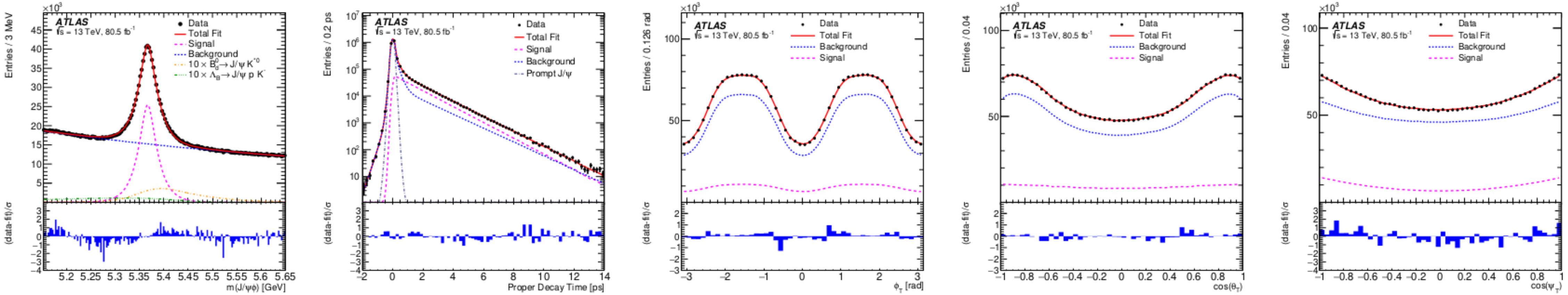
CPV in $B_s^0 \to J/\psi\Phi$: How to Get the PDFs*

* where PDF = Probability Density Function.

$$\frac{d^4\Gamma}{dt\, d\Omega} = \sum_{k=1}^{10} \mathcal{O}^{(k)}(t) g^{(k)}(\theta_T, \psi_T, \phi_T)$$

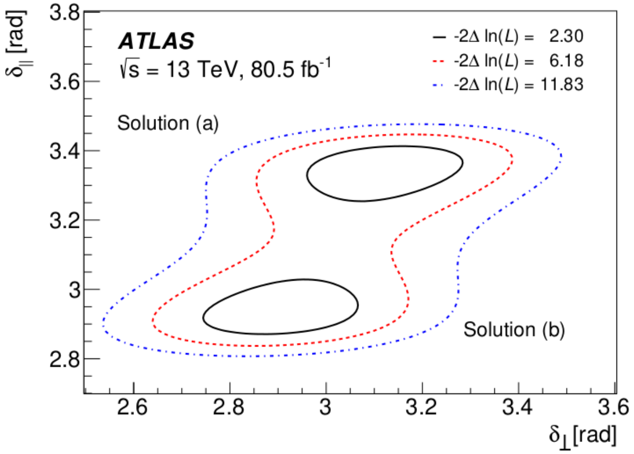
k	$O^{(k)}(t)$	$g^{(k)}(\theta_T, \psi_T, \phi_T)$
1	$\frac{1}{2}\lvert A_0(0)\rvert^2 \left[(1+\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1-\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \pm 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$2\cos^2\psi_T(1-\sin^2\theta_T\cos^2\phi_T)$
2	$\frac{1}{2}\lvert A_\parallel(0)\rvert^2 \left[(1+\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1-\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \pm 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$\sin^2\psi_T(1-\sin^2\theta_T\sin^2\phi_T)$
3	$\frac{1}{2}\lvert A_\perp(0)\rvert^2 \left[(1-\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1+\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \mp 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$\sin^2\psi_T\sin^2\theta_T$
4	$\frac{1}{2}\lvert A_0(0)\rvert\lvert A_\parallel(0)\rvert\cos\delta_\parallel \left[(1+\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1-\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \pm 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$\frac{1}{\sqrt{2}}\sin 2\psi_T\sin^2\theta_T\sin 2\phi_T$
5	$\lvert A_\parallel(0)\rvert\lvert A_\perp(0)\rvert[\frac{1}{2}(e^{-\Gamma_L^{(s)}t} - e^{-\Gamma_H^{(s)}t})\cos(\delta_\perp-\delta_\parallel)\sin\phi_s \pm e^{-\Gamma_s t}(\sin(\delta_\perp-\delta_\parallel)\cos(\Delta m_s t) - \cos(\delta_\perp-\delta_\parallel)\cos\phi_s\sin(\Delta m_s t))]$	$-\sin^2\psi_T\sin 2\theta_T\sin\phi_T$
6	$\lvert A_0(0)\rvert\lvert A_\perp(0)\rvert[\frac{1}{2}(e^{-\Gamma_L^{(s)}t} - e^{-\Gamma_H^{(s)}t})\cos\delta_\perp\sin\phi_s \pm e^{-\Gamma_s t}(\sin\delta_\perp\cos(\Delta m_s t) - \cos\delta_\perp\cos\phi_s\sin(\Delta m_s t))]$	$\frac{1}{\sqrt{2}}\sin 2\psi_T\sin 2\theta_T\cos\phi_T$
7	$\frac{1}{2}\lvert A_S(0)\rvert^2 \left[(1-\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1+\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \mp 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$\frac{2}{3}\left(1-\sin^2\theta_T\cos^2\phi_T\right)$
8	$\lvert A_S(0)\rvert\lvert A_\parallel(0)\rvert[\frac{1}{2}(e^{-\Gamma_L^{(s)}t} - e^{-\Gamma_H^{(s)}t})\sin(\delta_\parallel-\delta_S)\sin\phi_s \pm e^{-\Gamma_s t}(\cos(\delta_\parallel-\delta_S)\cos(\Delta m_s t) - \sin(\delta_\parallel-\delta_S)\cos\phi_s\sin(\Delta m_s t))]$	$\frac{1}{3}\sqrt{6}\sin\psi_T\sin^2\theta_T\sin 2\phi_T$
9	$\frac{1}{2}\lvert A_S(0)\rvert\lvert A_\perp(0)\rvert\sin(\delta_\perp-\delta_S) \left[(1-\cos\phi_s)\, e^{-\Gamma_L^{(s)}t} + (1+\cos\phi_s)\, e^{-\Gamma_H^{(s)}t} \mp 2e^{-\Gamma_s t}\sin(\Delta m_s t)\sin\phi_s\right]$	$\frac{1}{3}\sqrt{6}\sin\psi_T\sin 2\theta_T\cos\phi_T$
10	$\lvert A_0(0)\rvert\lvert A_S(0)\rvert[\frac{1}{2}(e^{-\Gamma_H^{(s)}t} - e^{-\Gamma_L^{(s)}t})\sin\delta_S\sin\phi_s \pm e^{-\Gamma_s t}(\cos\delta_S\cos(\Delta m_s t) + \sin\delta_S\cos\phi_s\sin(\Delta m_s t))]$	$\frac{4}{3}\sqrt{3}\cos\psi_T\left(1-\sin^2\theta_T\cos^2\phi_T\right)$

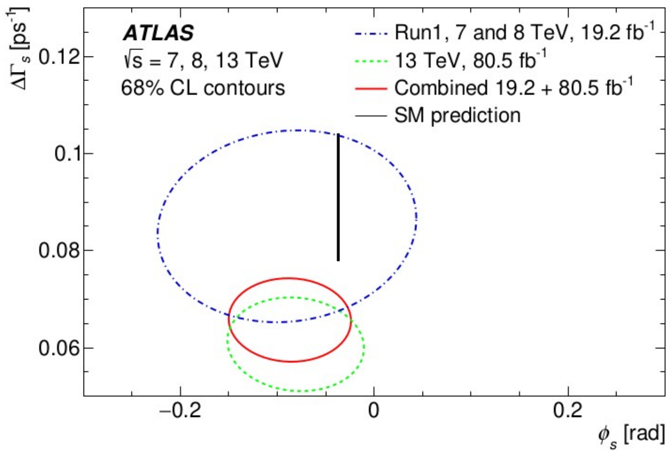
CPV in $B_s^0 \rightarrow J/\psi\Phi$: Results



$$\phi_s = -0.087 \pm 0.036\ (\text{stat.}) \pm 0.021\ (\text{syst.})\ \text{rad}$$
$$\Delta\Gamma_s = 0.0657 \pm 0.0043\ (\text{stat.}) \pm 0.0037\ (\text{syst.})\ \text{ps}^{-1}$$
$$\Gamma_s = 0.6703 \pm 0.0014\ (\text{stat.}) \pm 0.0018\ (\text{syst.})\ \text{ps}^{-1}$$

- Dominant systematics on Φ_s from tagging.
- Consistent with CMS, LHCb, and with the SM prediction.
- Still to add ~60 fb^{-1} from 2018.





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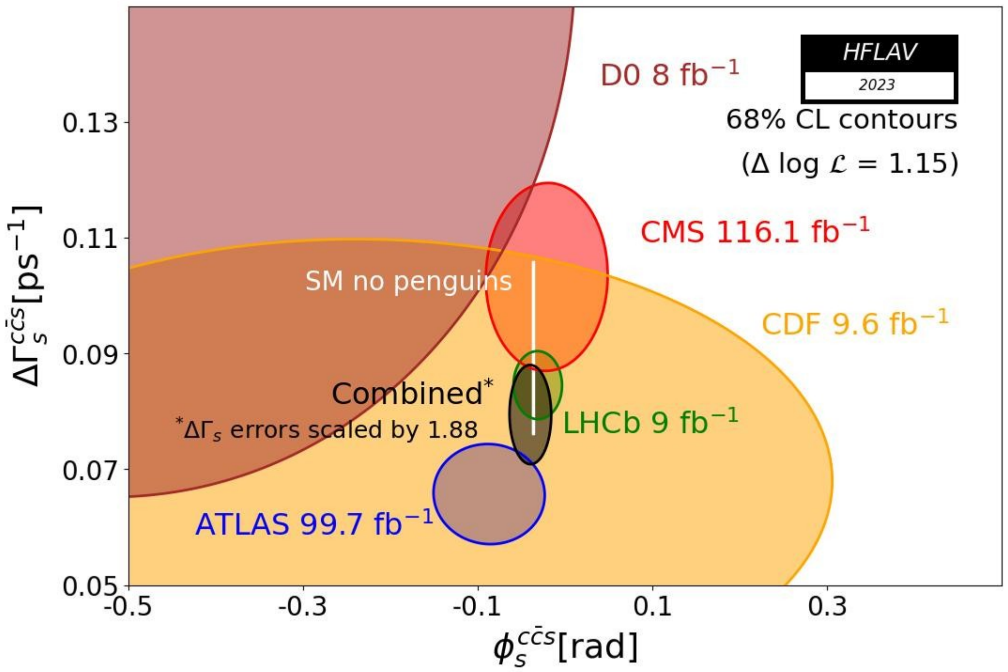
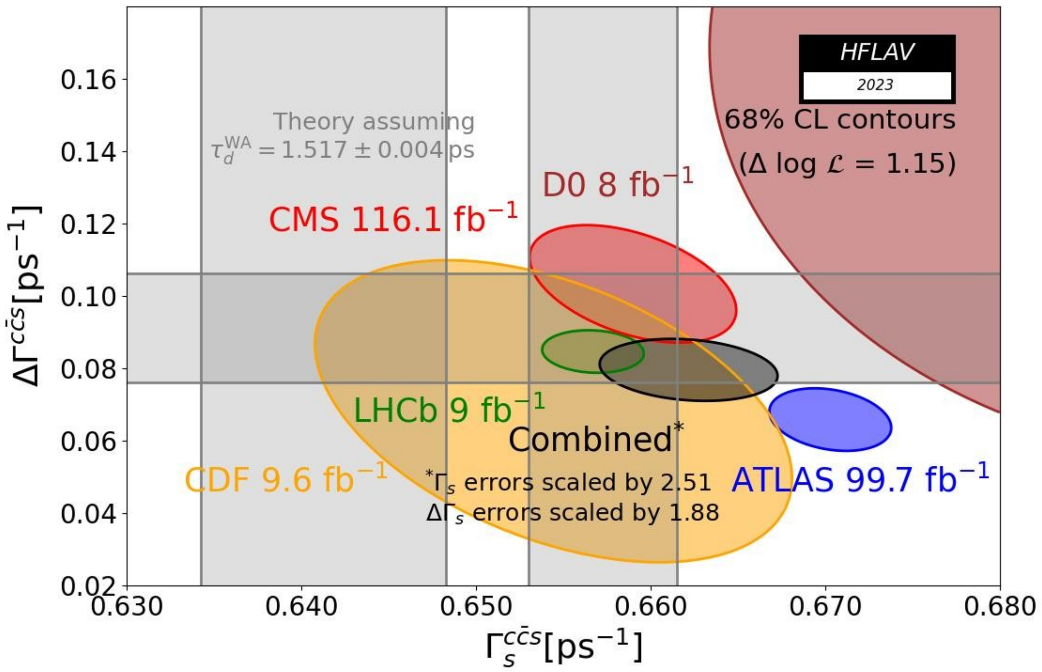
CPV in $B_s^0 \to J/\psi\Phi$: Comparison 1

- From HFLAV: -0.040 ± 0.016 rad.
- From SM: $-0.0376^{+0.0006}_{-0.0005}$ rad.





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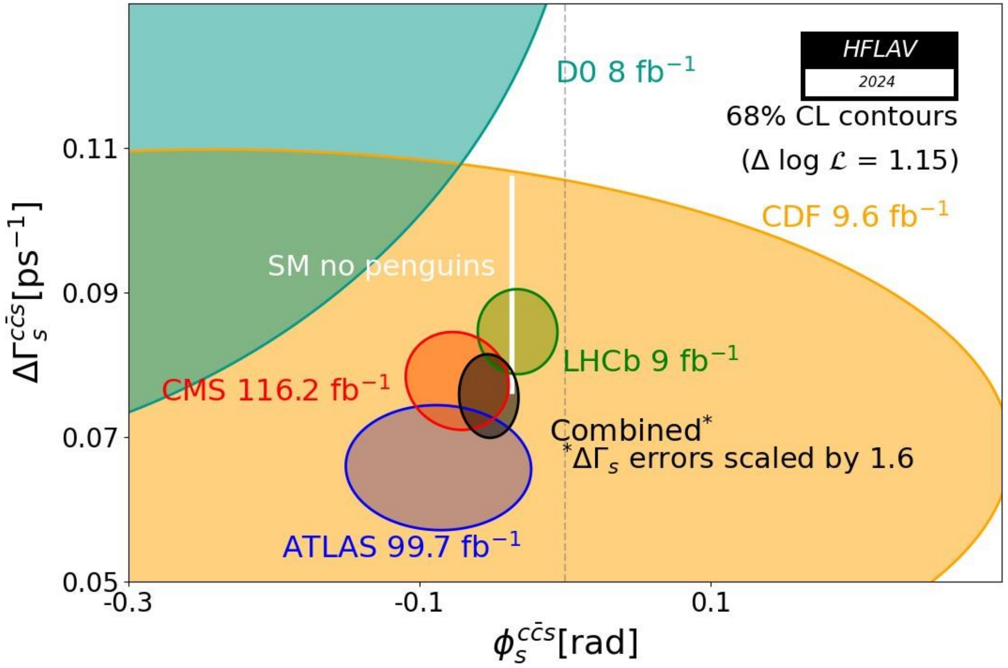
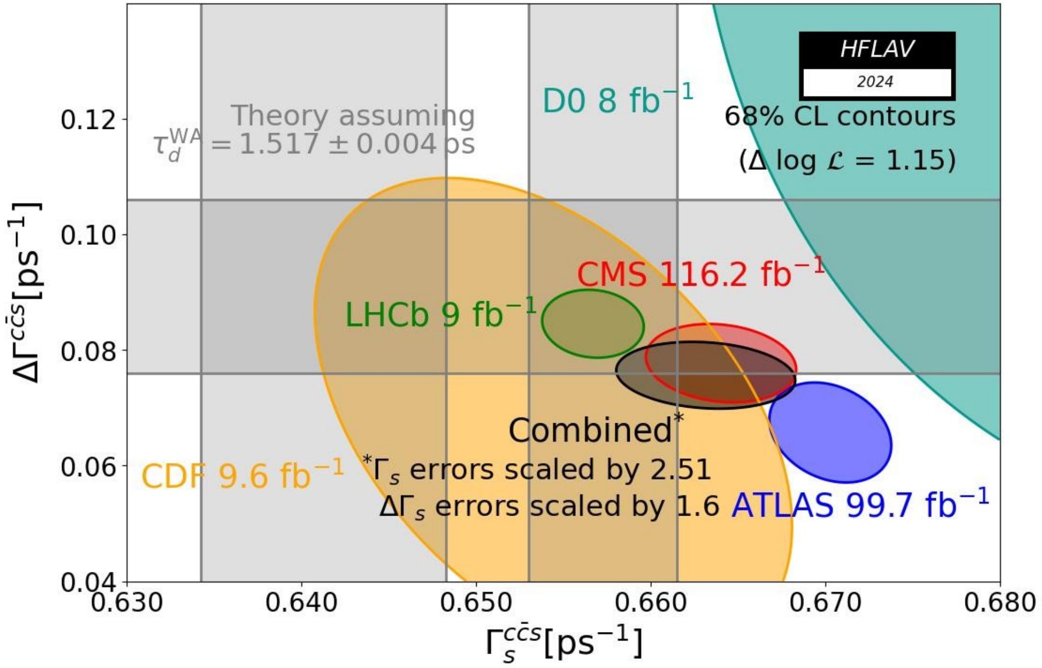
CPV in $B_s^0 \to J/\psi\Phi$: Comparison 2

- From HFLAV: −0.052 ± 0.013 rad.
  - Including new CMS-BPH-23-004 (Submitted to PRL), 26 Dec 2024.
- From SM: $-0.0376^{+0.0006}_{-0.0005}$ rad.





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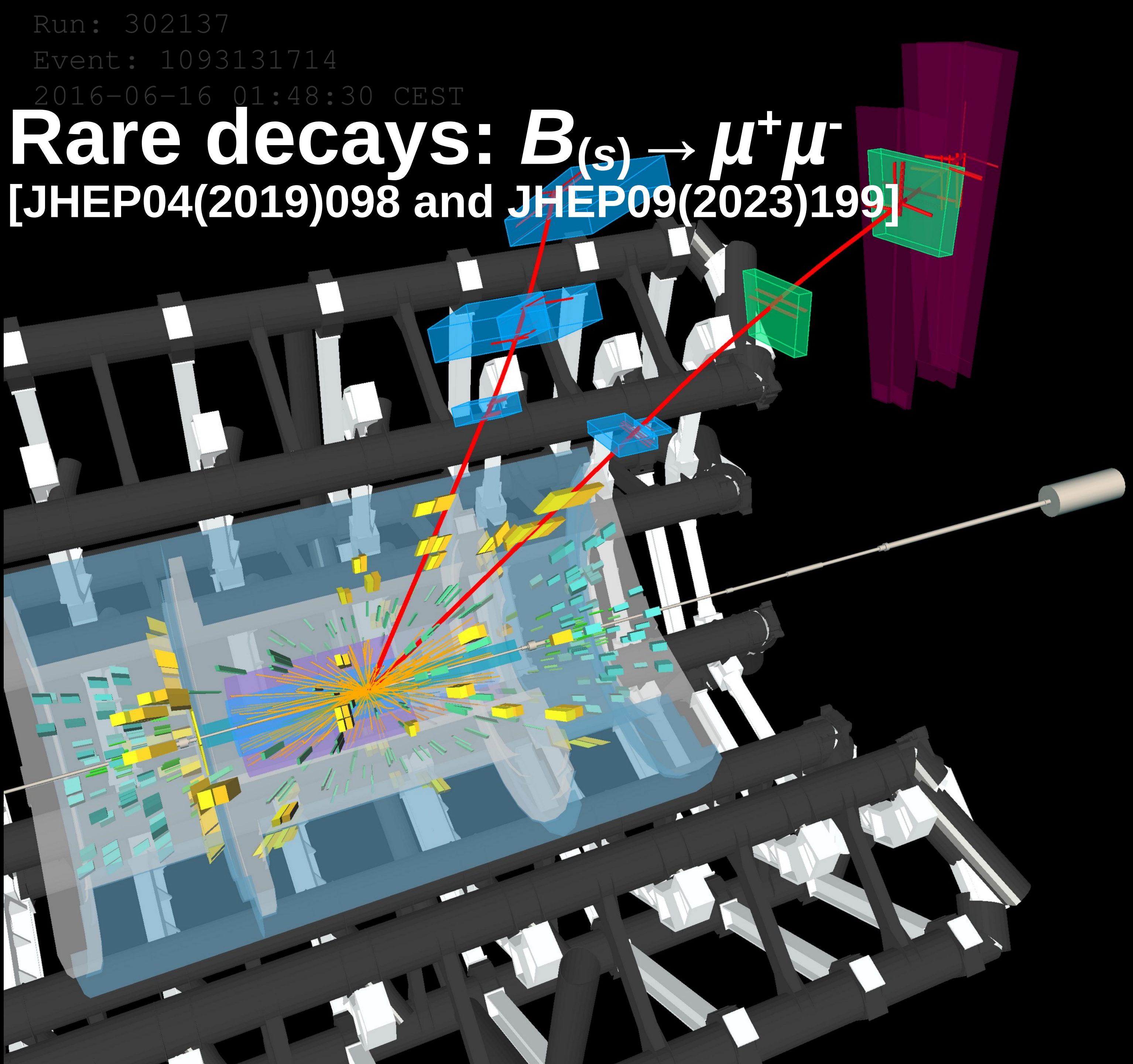
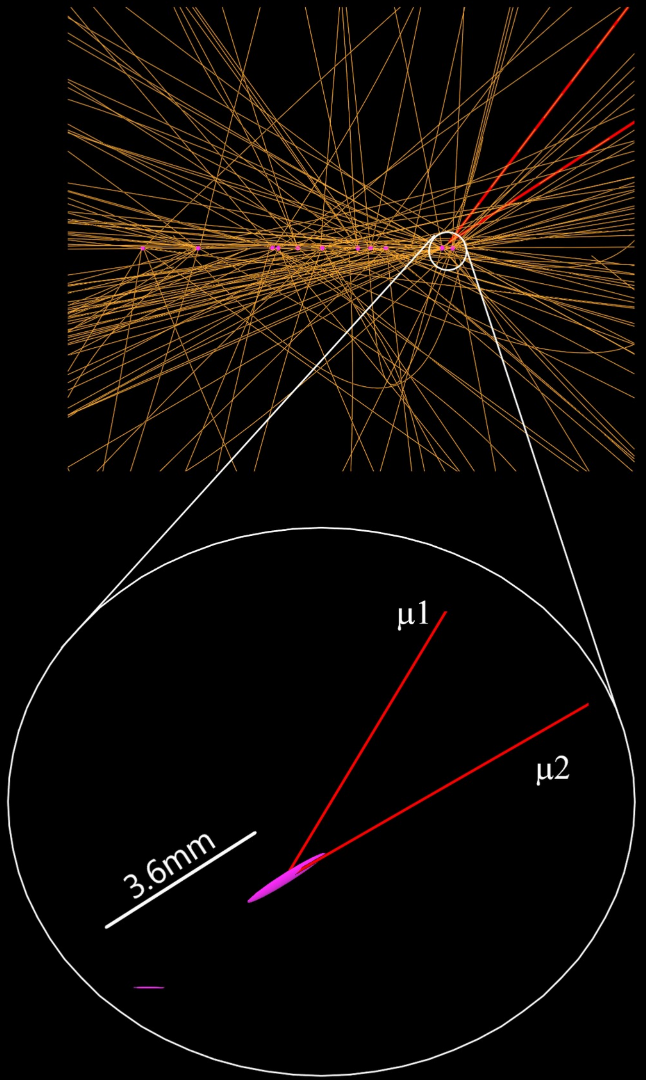
Rare decays: $B_{(s)} \rightarrow \mu^+\mu^-$

[JHEP04(2019)098 and JHEP09(2023)199]



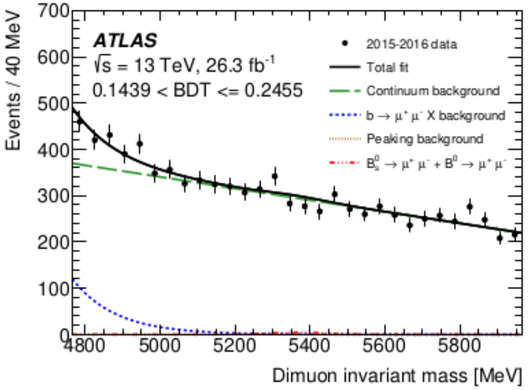


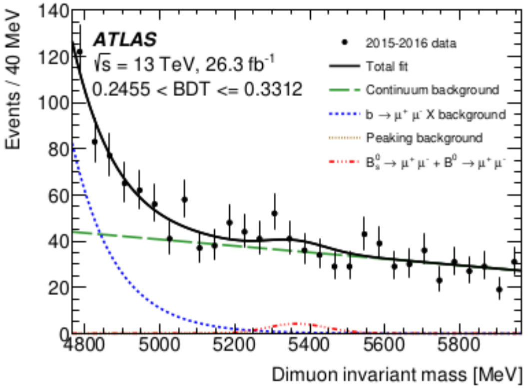
ATLAS EXPERIMENT

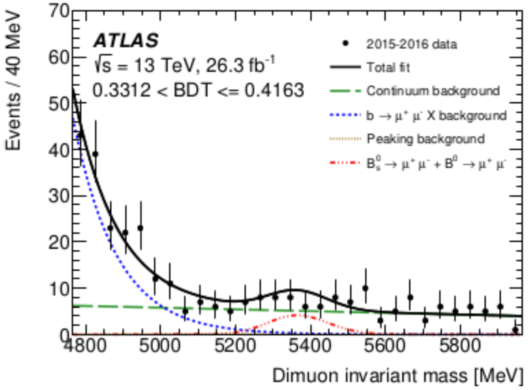
$\mathcal{B}(B_{(s)} \to \mu^+\mu^-)$: Motivation

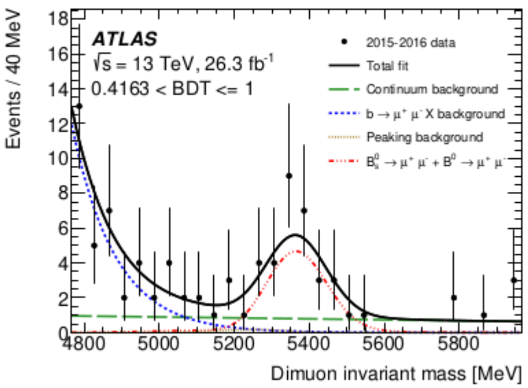
- Flavour-changing neutral-current processes **highly suppressed** in the SM, $B_{(s)} \to \mu^+\mu^-$ also **helicity suppressed** $\to \mathfrak{B} \sim 10^{-9}$.
- 36.2 fb^{-1} dataset of 2015-2016 *pp* data taking, but effectively 26.3 fb^{-1} for $B_{(s)} \to \mu^+\mu^-$.
- $\mathcal{B}(B_{(s)} \to \mu^+\mu^-)$ measurement relative to $\mathcal{B}(B^\pm \to J/\psi K^\pm)$.
- $B_s^0 \to J/\psi\Phi$ as a control channel.
- BDT based background suppression, trained on **sidebands data**.
- Yields $N_{d,s}$ and $N_{J/\psi K\pm}$ obtained from UML fits to the mass spectra.

$\mathscr{B}(B_{(s)} \to \mu^+\mu^-)$: Results

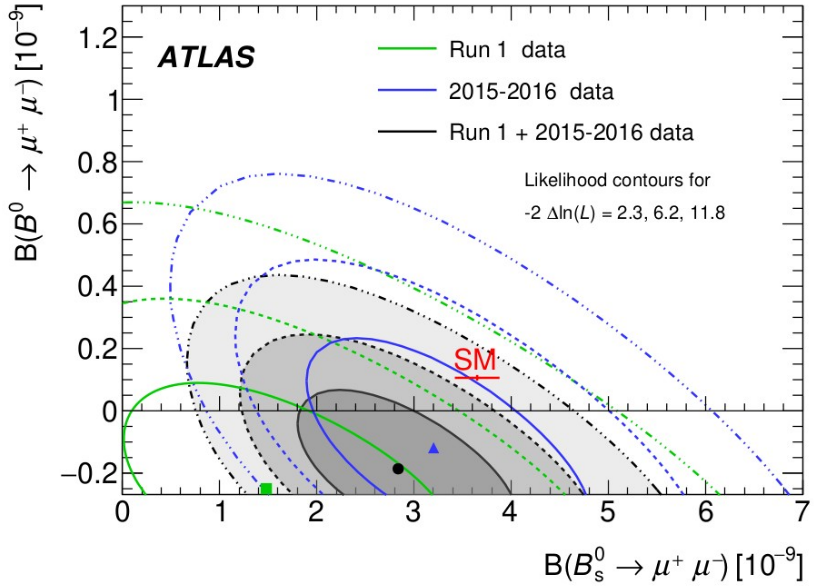








- Signal region divided into 4 BDT bins with constant signal efficiency.
- Simultaneous UML fit to di-muon mass distributions in the 4 BDT bins to extract $B_{(s)} \to \mu^+\mu^-$ yields.
- Unconstrained yields: $N_s = 80 \pm 22$ and $N_d = -12 \pm 20$.
- SM expectation: $N_s = 91$ and $N_d = 10$.
- Run1 + Run2 (2015+2016) combined measurement compatible with SM at 2.4σ. Statistic uncertainties dominate.



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$B_s^0 \rightarrow \mu^+\mu^-$ lifetime: Motivation

- $\mathscr{B}$ and **lifetime** measurements are **independent** tests of possible NP contributions.
- Not only is the decay rare...
- … but in the SM only the ***CP*-odd** (heavy) state decays to $\mu^+\mu^-$.
- NP could introduce ***CP*-even amplitudes** with significant effects on effective lifetime:

$$\tau(B_H) = 1.622 \pm 0.008 \text{ ps},$$

$$\tau(B_L) = 1.429 \pm 0.006 \text{ ps},$$

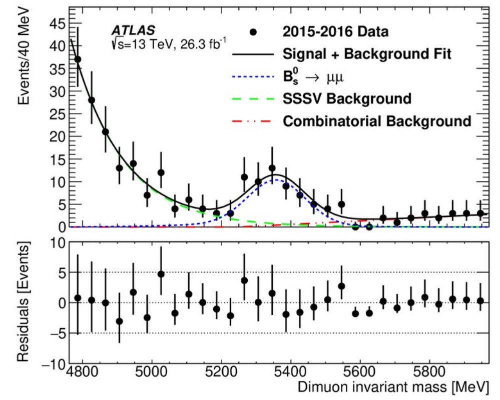
$$\Delta\tau = 0.193 \text{ ps}.$$

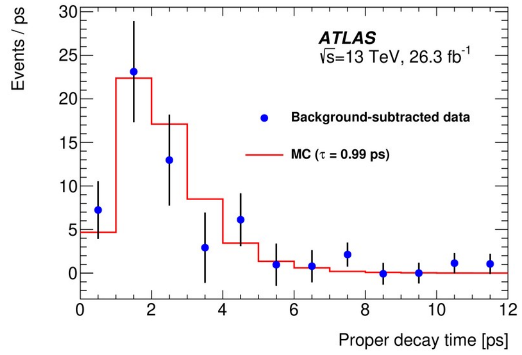
$B_s^0 \to \mu^+\mu^-$ lifetime: Results

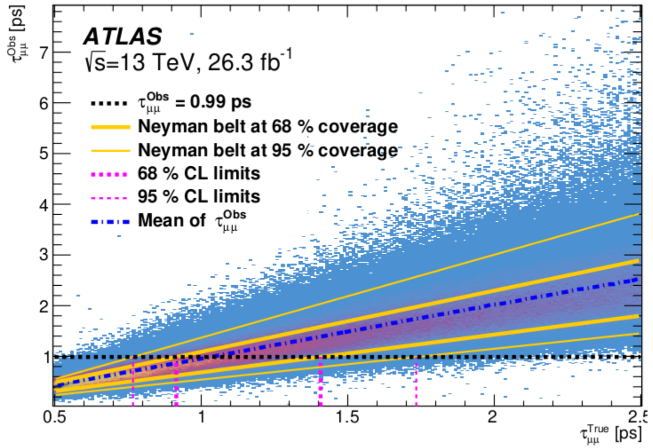
- Limited statistics → selection simplified to **one BDT bin** and BDT re-optimised.
- UML fit to $m(\mu^+\mu^-)$. Signal yield 58 ± 13 events.
- Extraction of the signal proper decay time distribution with **sPlot**.
- χ^2 fit of that distribution with MC templates for $\tau_{\mu\mu}$.
- Dominant systematics: **signal MC modelling**.
- Stat. unc. evaluated with Neyman construction using toyMC fits.
- Measured value consistent with the SM and other experiments:

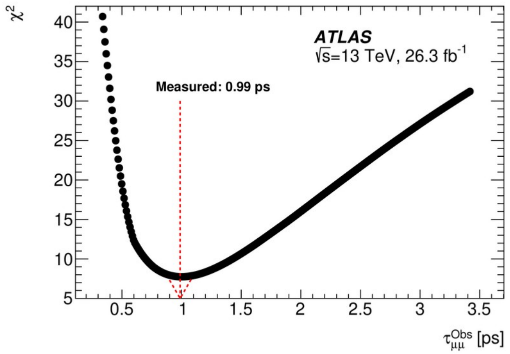
$$\tau_{\mu\mu} = 0.99^{+0.42}_{-0.07}(\text{stat.}) \pm 0.17(\text{syst.})\ \text{ps}$$

- Full Run2 dataset analysis underway.









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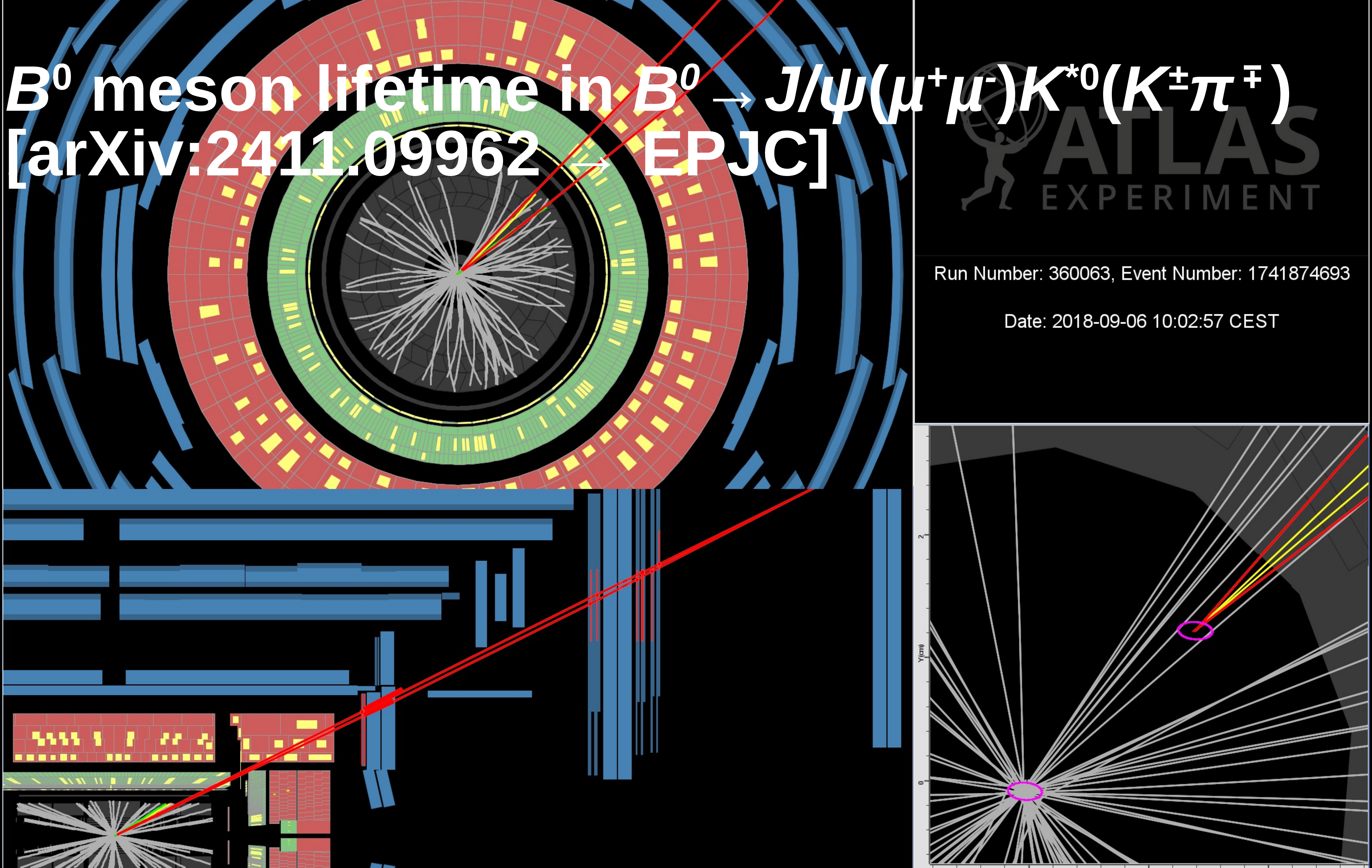
B^0 meson lifetime in $B^0 \to J/\psi(\mu^+\mu^-)K^{*0}(K^\pm\pi^\mp)$ [arXiv:2411.09962 → EPJC]



$B^0 \to J/\psi K^{*0}$ lifetime: Motivation

- SM and BSM theories are capable to precisely calculate **ratios** τ_d/τ_s (or Γ_d/Γ_s) → experiment needs to measure two lifetimes...
- … and ATLAS has already published Γ_s measurement in the topologically similar $B_s^0 \to J/\psi \Phi$ (CPV measurement)!
- The most precise *B*-lifetime measurement:
  - Using full Run2 dataset ATLAS achieves 3 times better statistical precision than PDG.

Model	Γ_d/Γ_s
HQE	1.003 ± 0.006
Lattice QCD	1.00 ± 0.02

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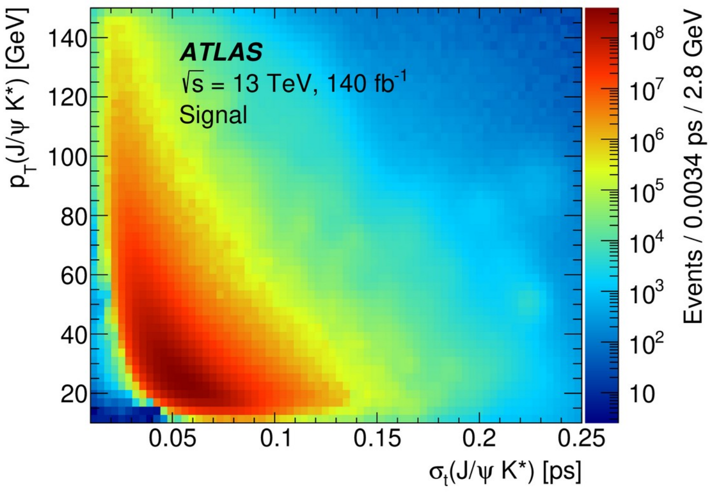
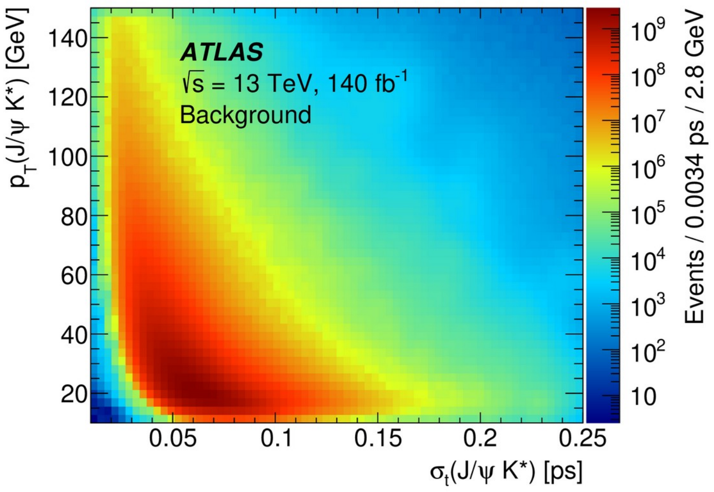
$B^0 \rightarrow J/\psi K^{*0}$ lifetime: The fit

- A bit tricky: no PID on ATLAS, but we need to assign $K^{\pm}\pi^{\mp}$ mass hypothesis.
- 2D unbinned maximum likelihood fit (mass, lifetime).
  - Conditional observables: lifetime resolution and *B*-meson p_{T} (**2D map** instead of 6 p_{T} bins).

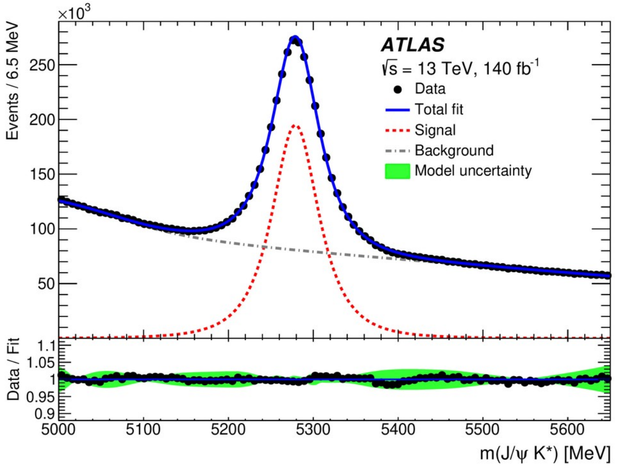
$$\ln L = \sum_{i=1}^{N} w(t_i) \ln[f_{\mathrm{sig}} \mathcal{M}_{\mathrm{sig}}(m_i) \mathcal{T}_{\mathrm{sig}}(t_i, \sigma_{t_i}, p_{\mathrm{T}_i}) + (1 - f_{\mathrm{sig}}) \mathcal{M}_{\mathrm{bkg}}(m_i) \mathcal{T}_{\mathrm{bkg}}(t_i, \sigma_{t_i}, p_{\mathrm{T}_i})]$$

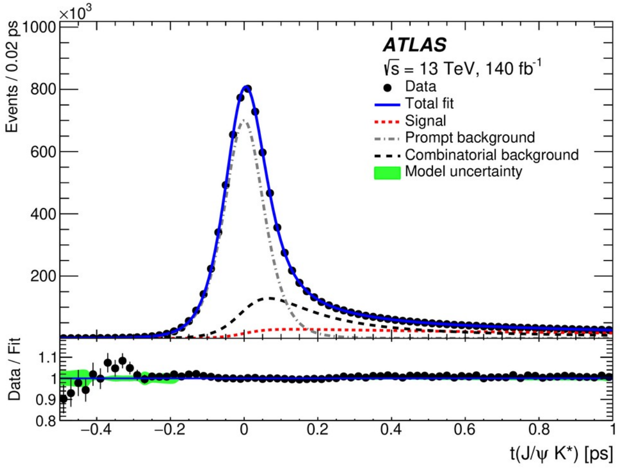


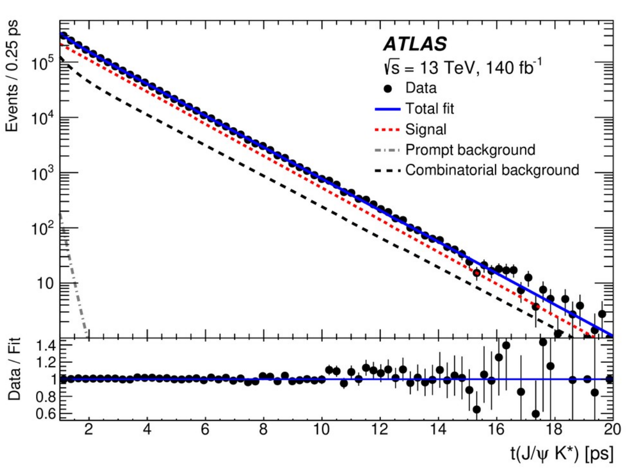


- More than 10.5M *B*-meson candidates enter the fit!

$B^0 \rightarrow J/\psi K^{*0}$ lifetime: Results







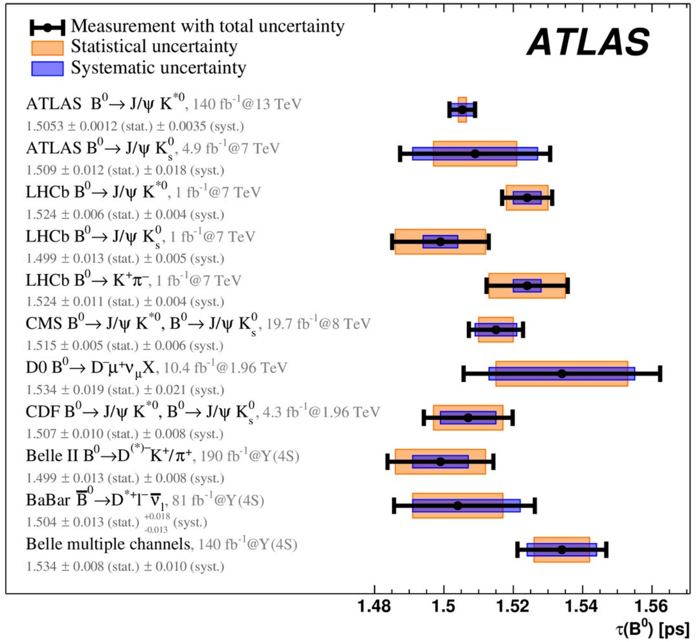
$$\tau_{B^0} = 1.5053 \pm 0.0012\ (\text{stat.}) \pm 0.0035\ (\text{syst.})\ \text{ps}$$

- Then using external sources (HFLAV):

$$\Gamma_d = 0.6639 \pm 0.0005\ (\text{stat.}) \pm 0.0016\ (\text{syst.}) \pm 0.0038\ (\text{ext.})\ \text{ps}^{-1}$$

- And using ATLAS CPV paper:

$$\frac{\Gamma_d}{\Gamma_s} = 0.9905 \pm 0.0022\ (\text{stat.}) \pm 0.0036\ (\text{syst.}) \pm 0.0057\ (\text{ext.})$$



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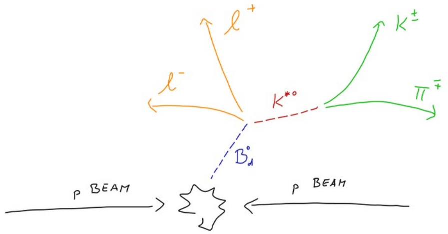
Measurement of...

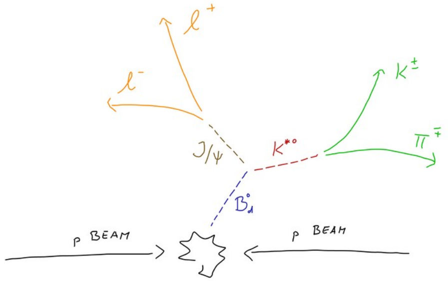
$R(K^*)$ Measurement

- Test of the **lepton flavour universality** using $R(K^*) = \left.\frac{\mathcal{B}(B_d^0 \to K^*\mu\mu)}{\mathcal{B}(B_d^0 \to K^*ee)}\right|_{q^2}$

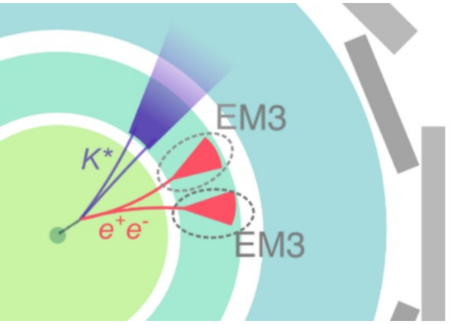


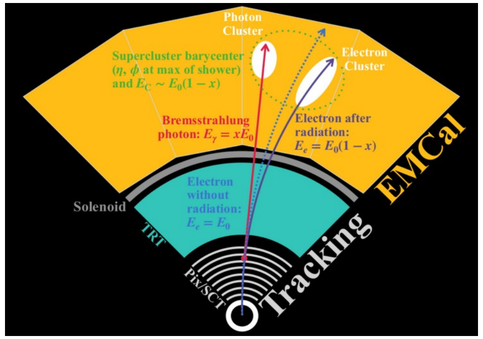
- Measuring double-ratio to reduce systematic uncertainties

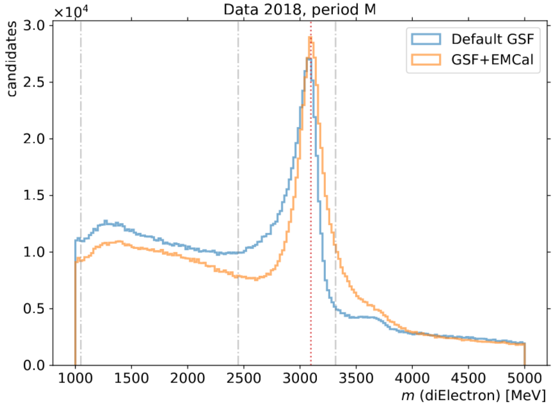
$$R(K^*) = \left.\frac{\mathcal{B}(B_d^0 \to K^*\mu\mu)}{\mathcal{B}(B_d^0 \to K^*J/\psi(\to \mu\mu))} \cdot \frac{\mathcal{B}(B_d^0 \to K^*J/\psi(\to ee))}{\mathcal{B}(B_d^0 \to K^*ee)}\right|_{q^2}$$

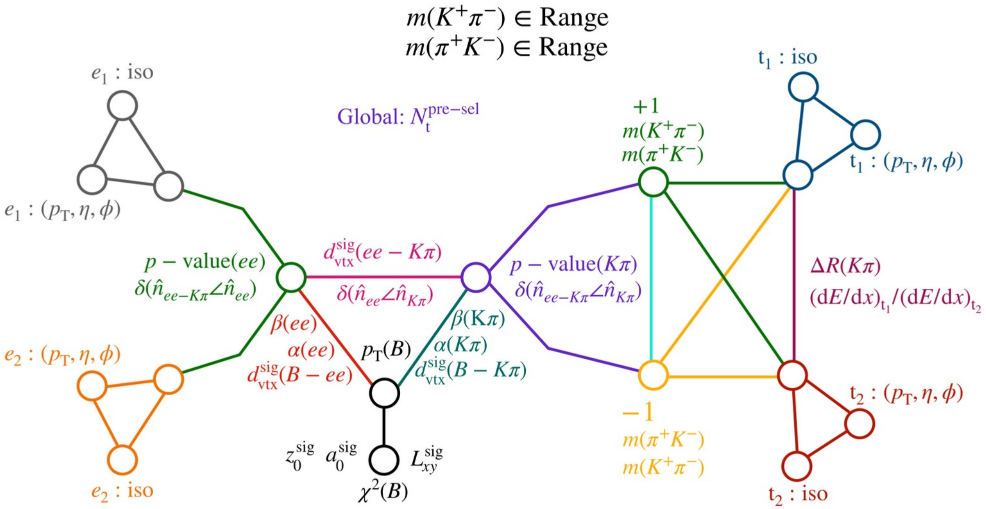


- Finally a playground for **new ideas**!
  - „Un-seeded“ low-p_T di-electron HLT.
  - Improved electron track reconstruction (GSF+EMCal).
  - Machine Learning (GNN).

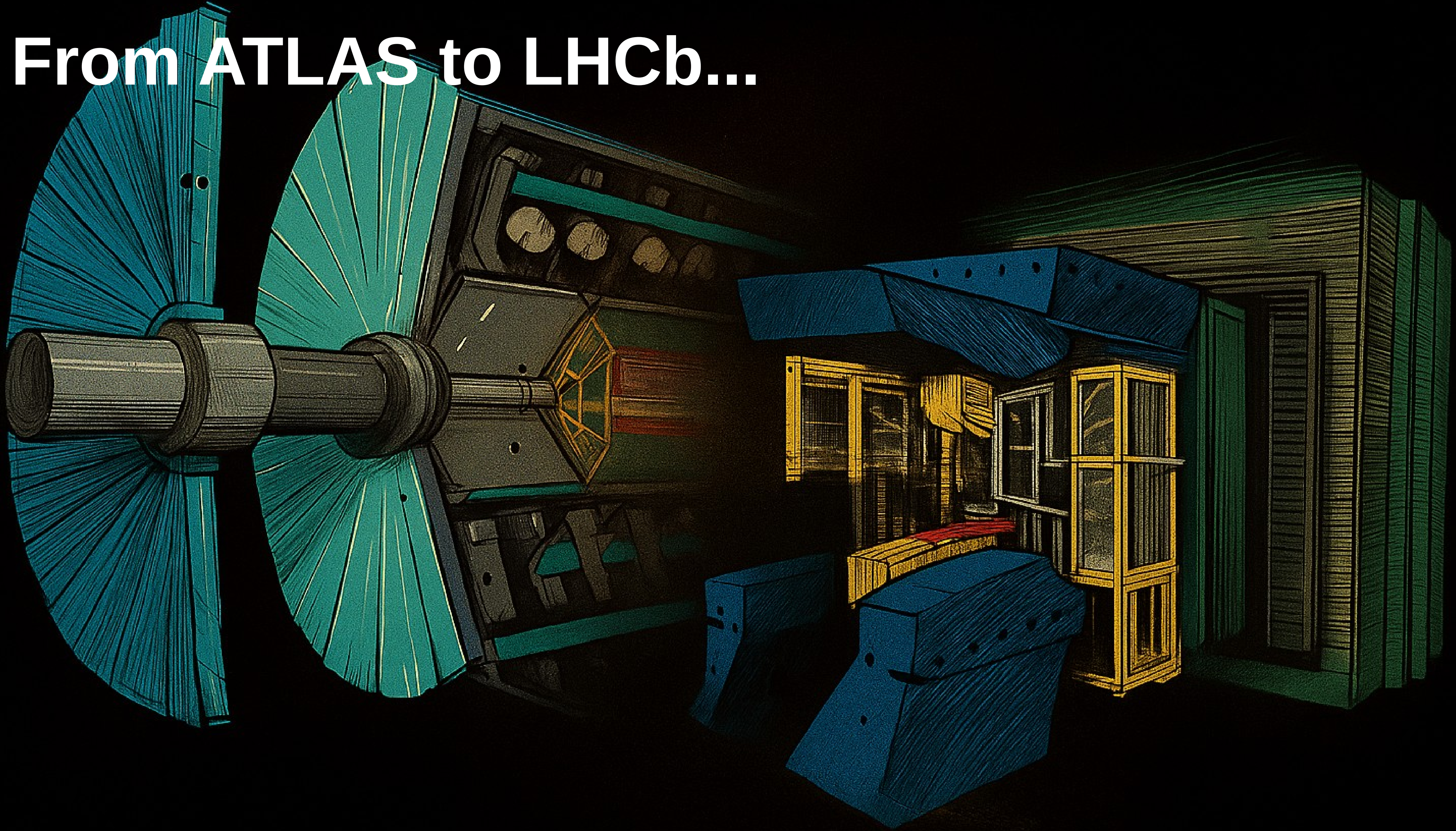






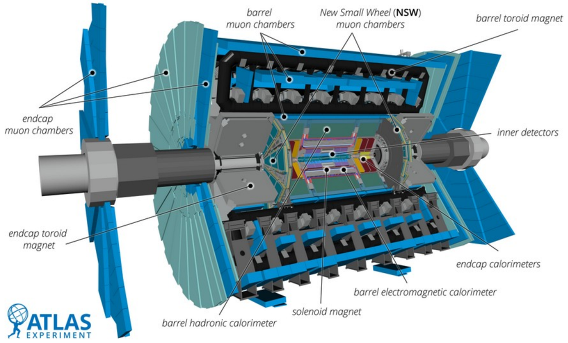


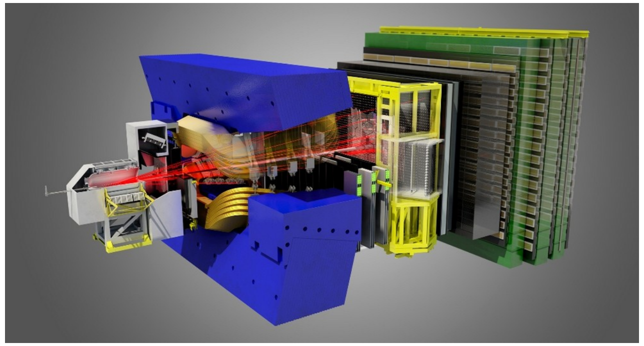
From ATLAS to LHCb...



Why *LHCb*?

- The story begins with a simple question…



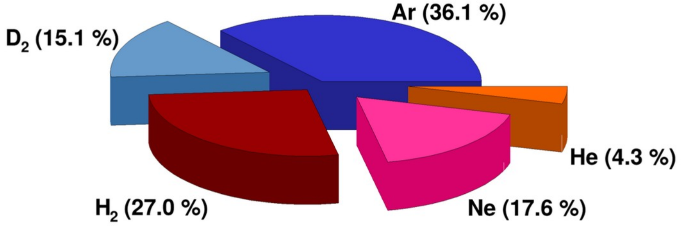


- General-purpose, cylindrical geometry
- $|\eta| < 2.5$
- Broad physics: Higgs, top, SUSY...
- HW+SW trigger, high-p_T optimised
- No PID (well, it can tell muons and electrons)
- Maybe too conservative?

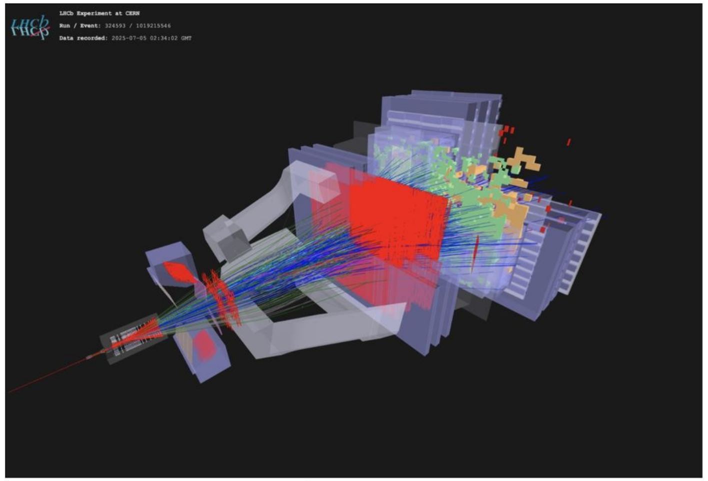
- Forward spectrometer, single-arm
- $2 < |\eta| < 5$
- *B* mixing, CPV, rare decays, B/D decays...
- All-SW trigger, HF optimised
- PID using RICH
- Open to new ideas – a lot of potential!

A Small Step Aside: SMOG2

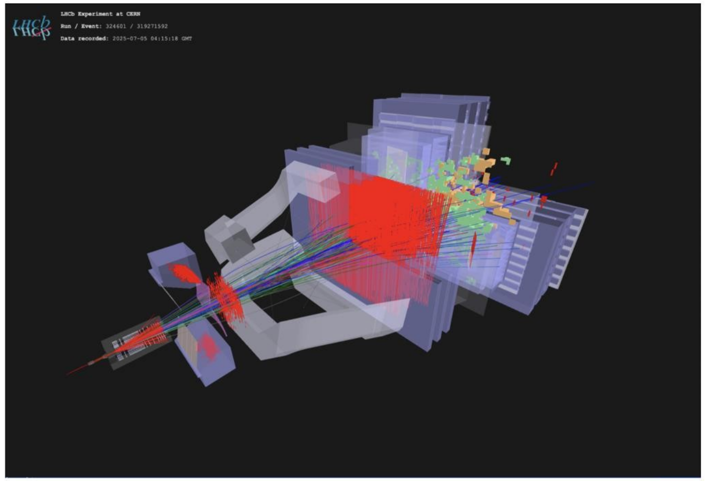
- LHCb is a **simultaneous** *pp* and fixed-target experiment!
- System for Measuring Overlap with Gas.
- Used both in *pp* runs and special runs.



OO collisions in LHCb



Fixed target collisions in SMOG



	Center of Mass Energy	Integrated Recorded Luminosity (/nb)
pO (collisions)	9.62 TeV	30.55
OO (collisions)	5.36 TeV	5.50
NeNe (collisions)	5.36 TeV	0.56
OH_2 (fixed target)	70.9 GeV	0.9
NeNe (fixed target)	70.9 GeV	0.023

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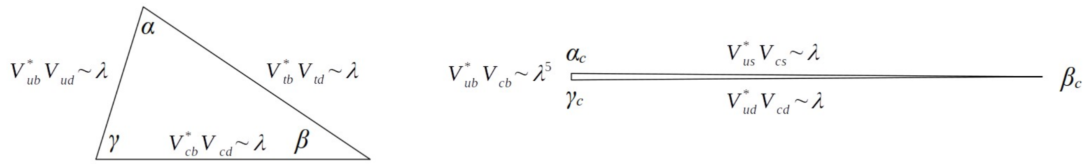
Why *Charm*?

- Largely **unexplored**: most experimental focus has been on beauty hadrons.
- **Challenging**: shorter lifetimes and higher backgrounds, but they open a new window for discovery.
- CPV is expected to be much smaller:
  - tiny CPV related to preferred charm processes,
  - larger asymmetries for suppressed (rare) decays.



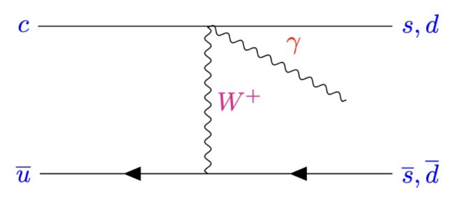
- Though *charm* and *beauty* decays *<u>can</u> look similar*, their underlying quark transitions and loop dynamics differ, probing distinct couplings of possible new particles.
- *Charm* and *beauty* are **complementary**; both are needed for a full picture.
- With Run3 statistics and upgraded detectors, **precision charm** measurements have become **feasible**.

Radiative Charm Decays

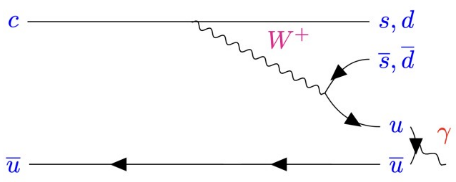
- Very limited experimental data so far – only <u>one</u> notable measurement from Belle (e^+e^- collider).

$$\mathcal{B}\left(D^0 \to \rho^0\gamma\right) = (1.77 \pm 0.30 \pm 0.07) \times 10^{-5}, \quad \mathcal{A}_{CP}\left(D^0 \to \rho^0\gamma\right) = +0.056 \pm 0.152 \pm 0.006$$
$$\mathcal{B}\left(D^0 \to \phi\gamma\right) = (2.76 \pm 0.19 \pm 0.10) \times 10^{-5}, \quad \mathcal{A}_{CP}\left(D^0 \to \phi\gamma\right) = -0.094 \pm 0.066 \pm 0.001$$
$$\mathcal{B}\left(D^0 \to \bar{K}^{*0}\gamma\right) = (4.66 \pm 0.21 \pm 0.21) \times 10^{-4} \quad \mathcal{A}_{CP}\left(D^0 \to \bar{K}^{*0}\gamma\right) = -0.003 \pm 0.020 \pm 0.000$$

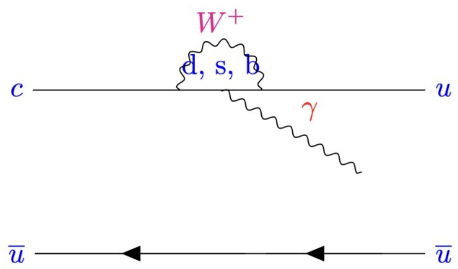
- **No results from hadron colliders yet!**
- Search for signs of NP: measuring *CP*-asymmetry (A_{CP}) and γ polarisation in $\boldsymbol{D^0 \to V\gamma}$.
- Dominated by long-distance ($\sim 10^{-4}$).
- Sensitive to FCNC transition $c \to u\gamma$ (short-distance contribution, $\sim 10^{-8}$).
- Could get sizeable CPV in $D^0 \to \phi\gamma$ and $D^0 \to \rho^0\gamma$.
  - Up to $A_{CP} \simeq 10^{-3}$ for the SM.
  - Could be enhanced by NP contributions.
- Sorry, no plots to show… but they would be $m(V\gamma)$, $\cos\theta$ and $\Delta m = m(D^{*+}) - m(D^0)$.
  - With more background <u>types</u> than in ATLAS HF analyses ;-)
- Internal: LHCb Run2 – factor of 2 improvement over Belle measurements.



Radiative W-exchange (CF)



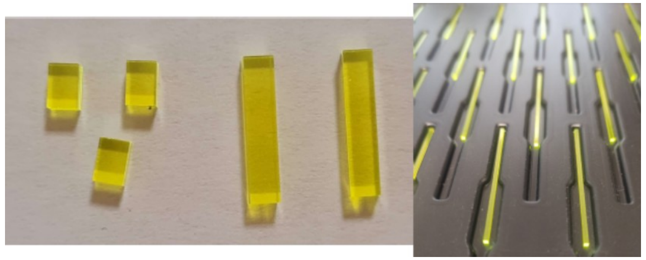
Long-distance diagram



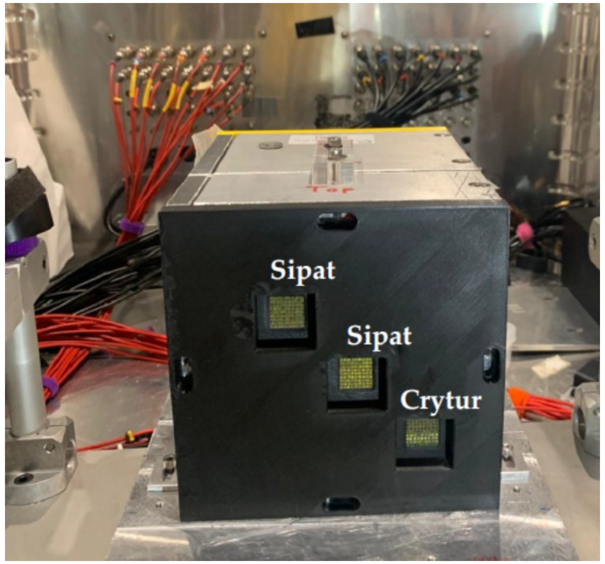
Short-distance Penguin

Building a Czech LHCb Programme

- Technical Associate Institute since 2023:
  - Martin Nikl (dept. of Optical Materials) – **scintillator** development.
  - Super-accelerated **GAGG** development and testing.
  - Actual reason for „radiative“.
  - Collaboration with the Czech company **CRYTUR**.
  - 5 cm and **10 cm** samples! **LHCb interested** (ECal Upgrade II)!
- Associate Institute(*) since July 2025!
  - Group expected to grow in the next couple of years:
    - Already advertised **undergraduate** and **PhD** LHCb-related thesis projects.
    - Looking for a **post-doc**(s) (MSCA, MSCA-COFUND).
  - Interesting **ideas** for „what and how“ to measure – pitching first to the grant committee ;-)



Test-beam @ CERN (Crystal Clear Collaboration) in 10/2024.



(*) Full member but no CB vote

Summary

- HF results ~compatible with the SM – more precision needed (Run3 and HL-LHC).
- Even though ATLAS is a general-purpose detector, it has competitive results in this field...
  - But the future there is not clear :-|
- LHCb is the leading experiment in the field (so where else?)
  - New opportunities!

Thank you

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