Motivation: CP violation in $B_s \rightarrow J/\psi \mu^+ \mu^-$

In the Standard Model CP violation (CPV) is described by a phase in the CKM matrix. One of the manifestations of this complex phase is a phase shift predicted between direct and mixing-mediated $B_s$ decays producing a final state. In the case of $B_s \rightarrow J/\psi \mu^+ \mu^-$ this phase shift is predicted to be small: $\phi_s \sim 0.0368 \pm 0.0018$ rad. New physics can enhance $\phi_s$, whilst satisfying all existing constraints. Increased sensitivity is expected mainly due to the improved decay time resolution obtained with the ATLAS upgraded inner tracking detector.

ATLAS Upgrade

ATLAS Run 3

Insertable B-Layer (IBL) for Run-2

- New inner-most pixel layer at $r = 33$ mm
- Small radius $Be$ beam pipe with lower $xI_x$

Proper decay time uncertainty - simulation

Proper decay time uncertainty - real data

Proper decay time uncertainty extracted for $B_s \rightarrow J/\psi \mu^+ \mu^-$ candidates

- Calculated per-candidate by propagating the uncertainties in track and primary vertex (PV) parameters and uncertainties from $B_s$ decay vertex fit
- Vertical axis: average value within the $p_T$ bin / for the number of PV
- Tracks $p_T$ thresholds: 5.5 GeV for muons and 1 GeV for kaons
- Driven by: tracking performance (with or without IBL) and trigger muon $p_T$ thresholds → average $B_s$ meson momentum

Data and candidate selection

Real Data:

- 2012 pp data, 8 TeV, 14.3 fb$^{-1}$
- 2015 pp data, 13 TeV, 3.2 fb$^{-1}$
- 2016 pp data 13 TeV, 18.8 fb$^{-1}$

Monte Carlo:

- MC12, 8 TeV, $<p_T> \sim 20$
- MC15, with IBL, 13 TeV, $<p_T> \sim 20$
- HL-LHC MC, 17k inclined layout, 14 TeV, $<p_T> \sim 200$

- Oppositely-charged muon pair
- $p_T(\mu) > 4$ GeV
- $|y|$ dependent mass cuts
- Vertex $x^2$/ndf $< 10$

- Oppositely-charged track pair (no PID)
- $p_T(K) > 1$ GeV
- $|m(K\bar{K}) - m_{J/\psi}| < 11$ MeV

- Coming from same vertex
- $\mu^+ \mu^- K\bar{K}$ vertex fit with $J/\psi\mu\mu$ mass constraint
- Vertex $x^2$/ndf $< 3$
- 5.15 GeV < $m(J/\psi K\bar{K})$ < 5.65 GeV

[8] hilumilhc.web.cern.ch/