Workshop on the physics of HL-LHC, and perspectives at HE-LHC
30 October 2017 - 1 November 2017, CERN

B-physics studies for HL-LHC ATLAS upgrade

Motivation: CP violation in $B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$

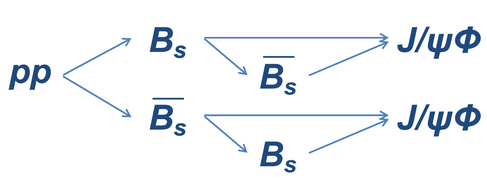
In the Standard Model *CP* violation (CPV) is described by a phase in the CKM matrix. One of the manifestations of this complex phase is a phase shift between direct and mixing-mediated B_s decays producing a common final state. In the case of $B_s \to J/\psi\phi$ this phase shift is predicted to be small: ϕ_s = 0.0368 ± 0.0018 rad. New physics can enhance ϕ_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.

CP violation in B_s system, Run-1 results

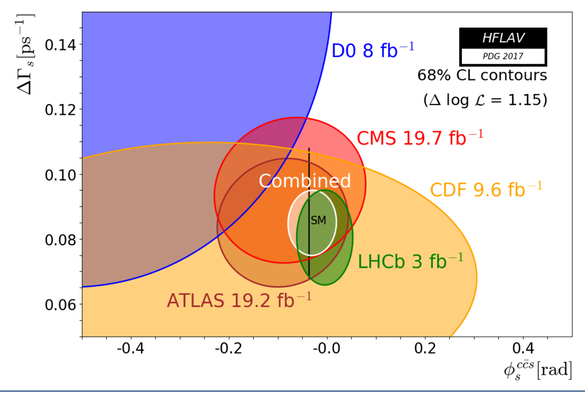
Different *CP* violating effects:

- **CPV in decay:** decay amplitudes of *B*-meson and anti *B*-meson are different
- **CPV in mixing:** asymmetry in particle-antiparticle oscillations (*CP* eigenstates ≠ mass eigenstates)

In the $B_s \to J/\psi\phi$ channel the CPV occurs in **interference of mixing and decay**

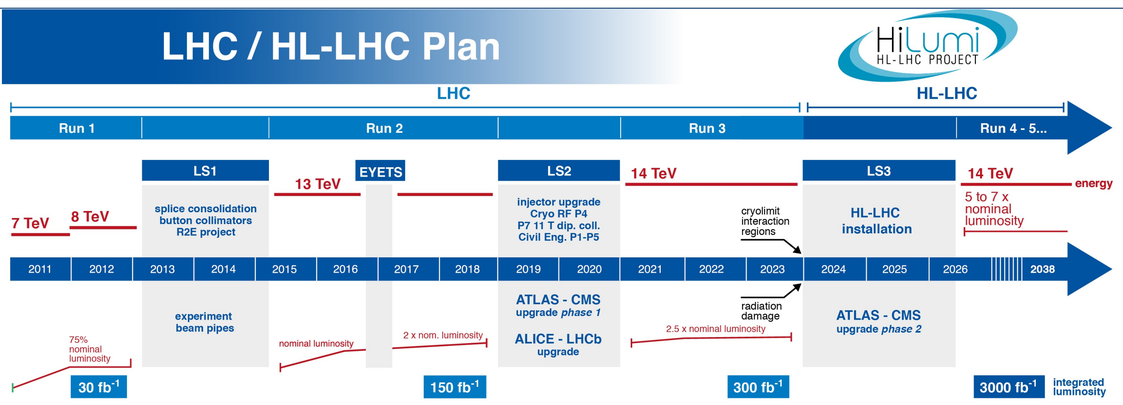


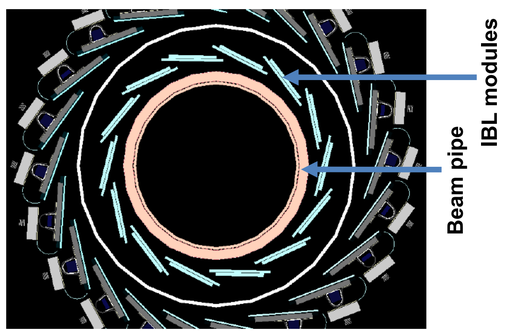
	Lumi	ϕ_s [rad]
ATLAS RUN1	19.2 fb^{-1}	$-0.098 \pm 0.084 \pm 0.040$
LHCb RUN1	3.0 fb^{-1}	$-0.058 \pm 0.049 \pm 0.006$
CMS 2012	19.7 fb^{-1}	$-0.075 \pm 0.097 \pm 0.031$
Standard Model	-	-0.037 ± 0.002



ATLAS Upgrade

LHC / HL-LHC Plan



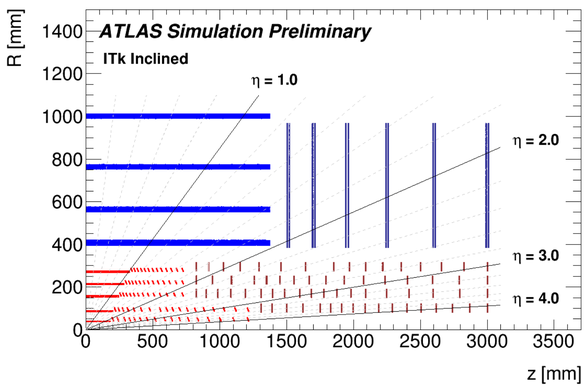


Insertable B-Layer (IBL) for Run-2

- New inner-most pixel layer at r = 33 mm
- Small radius *Be* beam pipe with lower x/X_0

Inner Tracker (ITk) for High Luminosity LHC (HL-LHC)

- Completely new *Si* based tracker



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, $\langle\mu\rangle$ ~ 20
- MC15, with IBL, 13 TeV, $\langle\mu\rangle$ ~ 20
- HL-LHC MC, ITk inclined layout, 14 TeV, $\langle\mu\rangle$ ~ 200

J/ψ

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

Φ

- Oppositely-charged track pair (no PID)
- $p_T(K) > 1$ GeV
- $|m(K^+K^-) - m_{PDG}(\phi)| < 11$ MeV

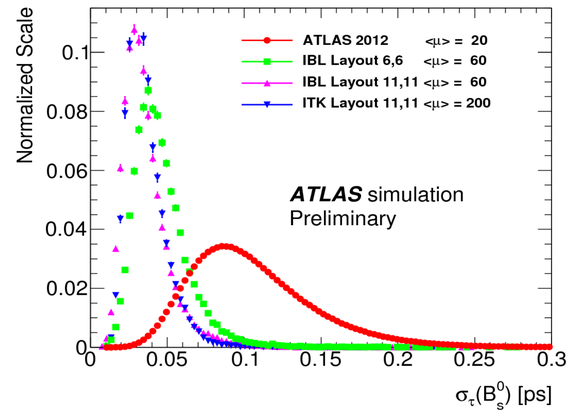
B_s

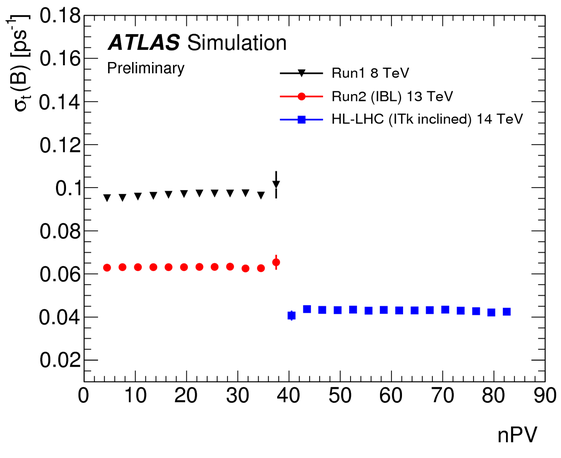
- Coming from same vertex
- $\mu^+\mu^-K^+K^-$ vertex fit with J/ψ mass constraint
- Vertex χ^2/ndf < 3
- 5.15 GeV < $m(J/\psi K^+K^-)$ < 5.65 GeV

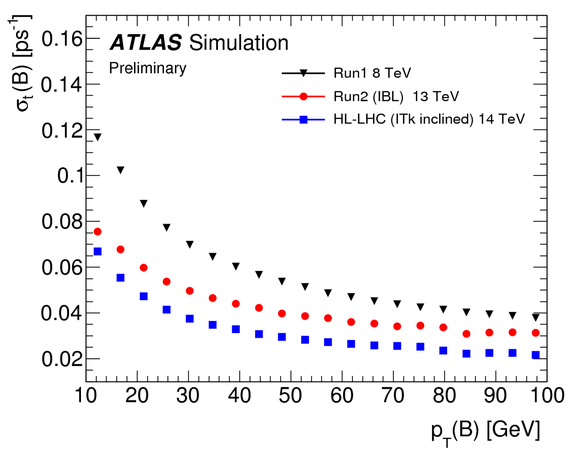
Proper decay time uncertainty - simulation

Proper decay time uncertainty extracted for $B_s \to J/\psi\phi$ decay 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



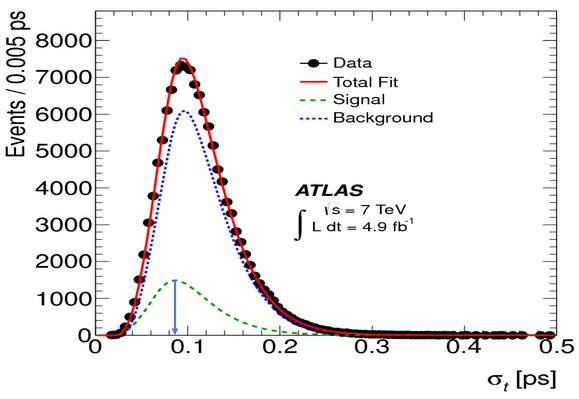




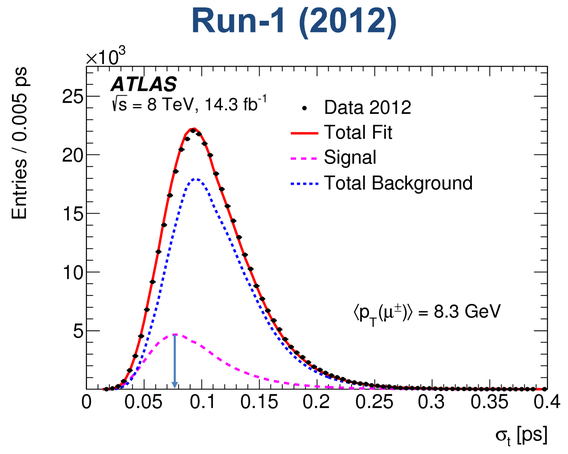
Proper decay time uncertainty in real data

- Distributions extracted from the $B_s \to J/\psi\phi$ decay candidates
- Sideband-subtraction method: fitting the background component in the B_s mass sidebands (5.150 - 5.317) GeV and (5.417 - 5.650) GeV

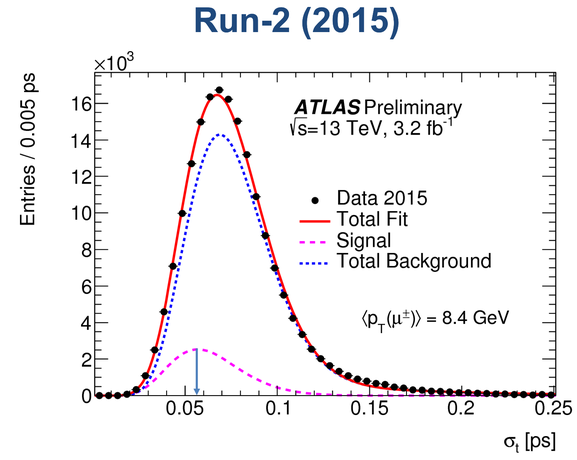
Run-1 (2011)



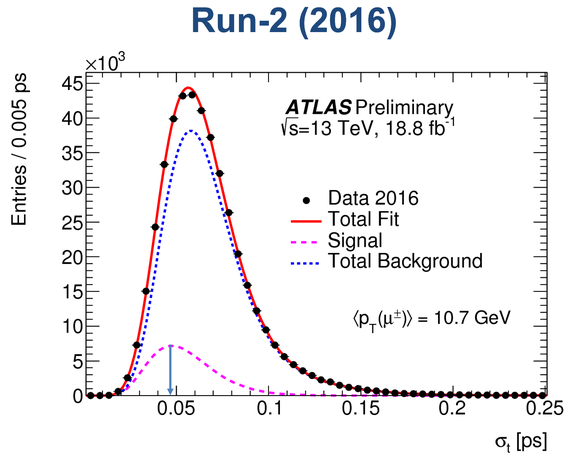
Run-1 (2012)



Run-2 (2015)



Run-2 (2016)



[1] atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/BPHYS-2016-001
[2] ATL-PHYS-PUB-2016-026
[3] ATL-PHYS-PUB-2013-010
[4] JHEP 08 (2016) 147
[5] Phys. Rev. D 90, 052007
[6] JHEP 12 (2012) 072
[7] CERN-LHCC-2010-013, ATLAS-TDR-19
[8] hilumilhc.web.cern.ch/

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ATLAS EXPERIMENT