B_s \to J/\psi \phi \text{ RUN-1 RESULTS AND STUDIES OF B^{\pm} MASS WITH RUN-2 DATA AT ATLAS}

**A. B_s \to J/\psi \phi** in RUN-1

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: \phi_s = 0.0368 \pm 0.0018 rad. New physics can enhance \phi_s whilst satisfying all existing constraints.

**A1. CP violation in B_s system**

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 (CPV eigenstates \# mass eigenstates)

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

**A2. Data and candidate selection**

- Opposite-charged muon pair
- \rho(S) \geq 4 GeV
- \eta depending mass cuts
- Vertex \rho(S) < 10
- Opposite-charged track pair (no PID)
- \rho(S) > 1 GeV
- \eta(B_s) \leq 1 MeV

**A3. Flavour tagging**

Knowledge of the initial B_s meson flavour enhances the fit sensitivity to \phi_s. It can be inferred using the other B_s meson in the event (Opposite-Side Tagging).

Muon/electron tagging:
- Semi-leptonic decay of the B-s meson
- Using combined muons (have full tracks in the MS and in the ID), segment-tagged muons (have full tracks in the ID matched to segment(s) in the MS) or electrons
- Momentum weighted charge of the lepton and tracks around
- Diluted through \chi = s - l, even so it has good separation power

Jet-tagging:
- Used if the lepton is absent
- Momentum weighted track-charge in jet

Initial flavour hypothesis is expressed as probability that an event has a signal decay containing a B_s quark.

**A4. Angular analysis**

- B_s \to J/\psi \phi \to pseudoscalar \to vector-vector \to admixture of CP-odd and CP-even final states
- CP states separated statistically in the combined lifetime-angular event-by-event fit

**A5. Fitting model**

Unbinned maximum likelihood fit uses per-variable candidates:
- B_s mass m, and proper decay time \tau, and its uncertainty
- 3 angles between final-state particles in transversity basis \Omega
- B_s momentum p_{B_s}
- B_s tag probability and tagging method

Fit determines 9 physics variables that describe B_s \to J/\psi \phi and S-wave (B_s \to J/\psi \phi K^+ or B_s \to J/\psi \phi l(K^+)) component: \Delta \Gamma, \rho, \phi_s, \langle |O(0)| \rangle, \langle |A(0)| \rangle, \langle A(0) \rangle, \delta_0, \delta_1, \delta_2

**A6. Fit projections and \phi_s - \Delta \Gamma contour plot**

**A7. Results**

- 2011 and 2012 results statistically combined into the final RUN-1 result
- \phi_s and other parameters consistent with the Standard Model prediction

**A8. Systematic uncertainties (2012)**

Uncertainty in the calibration of the tag probability

Effect of residual misalignment (studied in signal MC)

Uncertainty in the relative fraction of B_s background (contaminations from B_s \to J/\psi \phi K^+ and B_s \to J/\psi \phi l(K^+)) misreconstructed as B_s \to J/\psi \phi

Uncertainties of fit model derived in pseudo-experiment studies

**B. B^\pm mass in RUN-2**

Performance needed for the future B_s \to J/\psi \phi and other B-mass measurements with the new data is tested using reconstructed B^ in 2015 data (3.2 fb^{-1} of 13 TeV pp collisions).

- ATLAS has a new Pixel layer (IBL) in RUN-2, 13 TeV
- Better ID performance

**References:**

Tomas Jakoubek (IoP ASCR, Prague), for the ATLAS Collaboration