Rare (and semi-rare) decays searches with the ATLAS detector

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on behalf of the ATLAS collaboration

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Introduction

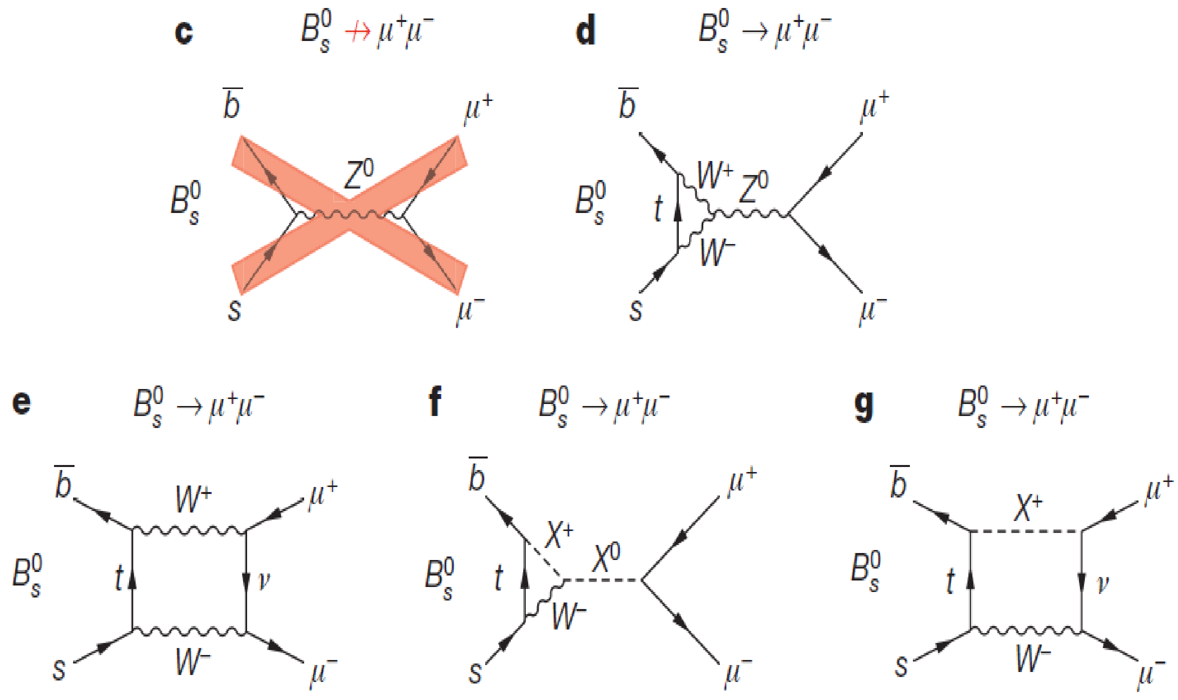
- $B_d^0 \rightarrow \mu\mu K^*$ semi-rare measurement with full Run-1 dataset is ongoing but not published yet

- Focus of the talk is on $B_{(s)}^0 \rightarrow \mu\mu$ BR measurement with ATLAS detector (arXiv: [hep-ex] 1604.04263)

- Outline:
  - Triggers, objects selections and preselection cuts
  - "Fake" muons and di-muon backgrounds rejection
  - $B^+ \rightarrow J/\Psi K^+$ reference channel yield extraction and efficiency computation
  - Signal extraction and BR($B_{(s)}^0 \rightarrow \mu\mu$) measurement

Motivations

- A real window towards New-Physics!!
- FCNC strongly suppress this process
- Clean in terms of theoretical calculations



- Experimental signature very clean: 2 muons in the final state coming from a Bs or a Bd meson.

SM vs experiments

- **SM predictions:**
  - BR(Bs→μμ) = (3.65 + 0.23)x10^{-9}
  - BR(Bd→μμ) = (1.06 + 0.09) x10^{-10}

C. Bobeth et al., Phys. Rev. Lett. 112 (2014) 101801

- **Measurements:**
  - **CMS & LHCb combined**
    - BR(Bs→μμ) = ($2.8^{+0.7}_{-0.6}$) x10^{-9}
    - BR(Bd→μμ) = ($3.9^{+1.6}_{-1.4}$) x10^{-10}

Nature **522**, 68–72

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- BRs extracted applying the "Master Formula"

Hadronisation probabilities

$$\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) = N(B^0_{(s)} \to \mu^+\mu^-) \times [\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu^+\mu^-)] \times \frac{f_u}{f_{s/d}} \times \frac{1}{\mathcal{D}_{\text{norm}}}$$

$$\mathcal{D}_{\text{norm}} = \sum_k N^k_{J/\psi K^\pm} \alpha_k \left(\frac{\varepsilon_{\mu^+\mu^-}}{\varepsilon_{J/\psi K^\pm}} \right)_k$$

Number of Bs/Bd events from an unbinned ML fit to m(μμ) distribution

Reference channel: $B^+ \to J/\psi K^+$ Extracted from an unbinned ML fit to $m(\mu\mu K^+)$ distribution

Trigger categories and luminosity prescales*

Acceptance and efficiencies from simulation

** k runs over the 4 mutually exclusive data categories (2012 data split in 3 trigger categories and whole 2011 data) and α_k is the relative integrated luminosity of the two channels for the 4 data categories*

- **$B^+ \to J/\Psi K^+ \to \mu\mu K^+$** acts as reference channel: BR($B^0_{(s)} \to \mu\mu$) is extracted relative to it to reduce systematic uncertainties.
- $B^+ \to J/\Psi K^+ / B^+ \to J/\Psi \pi^+$ is measured as a natural output of the reference channel yield evaluation

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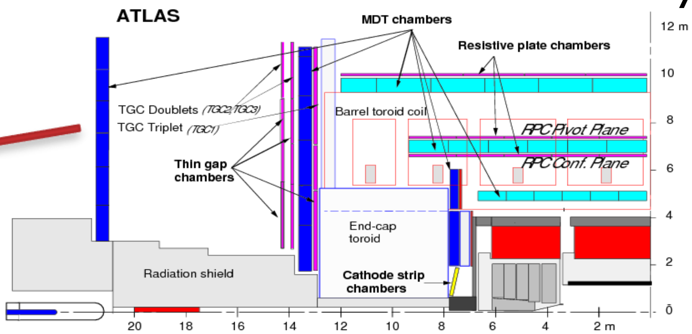
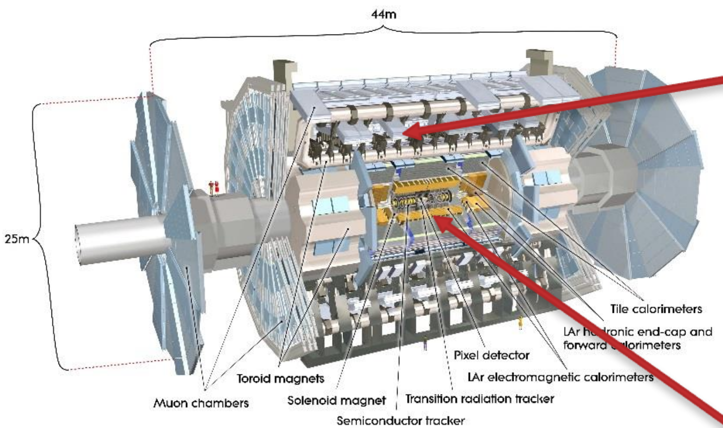
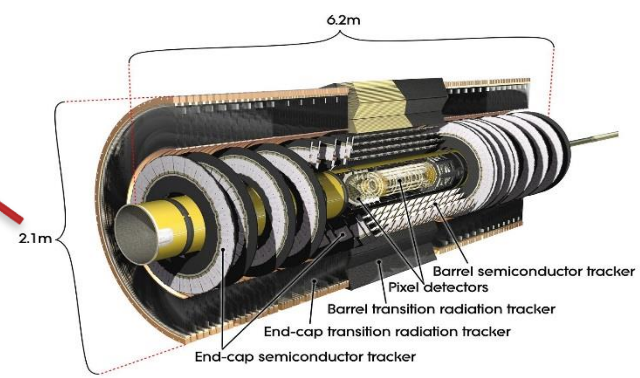
Data samples

- Muon triggers for 2011 and 2012 data
- 5 (20) fb^{-1} for 2011 (2012) → 25 fb^{-1}
- Detector requirements: muon and tracking system fully operational
- Blinded region: 5166 < m(μμ) < 5526 MeV (m(Bs) = 5367 MeV; m(Bd) = 5280 MeV)

Muon system







Inner tracking system

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Triggers, μ, K and B selections

- 4 mutually exclusive categories for all channels:
  - 2011 data based on di-muon with $P_T > 4$ GeV (22%)
  - 2012 data split into three mutually exclusive categories:
    - T1 → One muon with $P_T > 6$ GeV and one muon with $P_T > 4$ GeV (68%)
    - T2 → Both muons with $P_T > 4$ GeV and at least one with $|\eta| < 1.05$ (6%)
    - T3 → Both muons with $P_T > 4$ GeV and $|\eta| > 1.05$ (4%)
- Muons: $P_T(\mu) > 4$ GeV, $|\eta(\mu)| < 2.5$
- Kaons: $P_T(K) > 1$ GeV, $|\eta(K)| < 2.5$

- Bs, Bd, B^+, $J/\psi\Phi$ candidates: $P_T(B) > 8$ GeV; $|\eta(B)| < 2.5$

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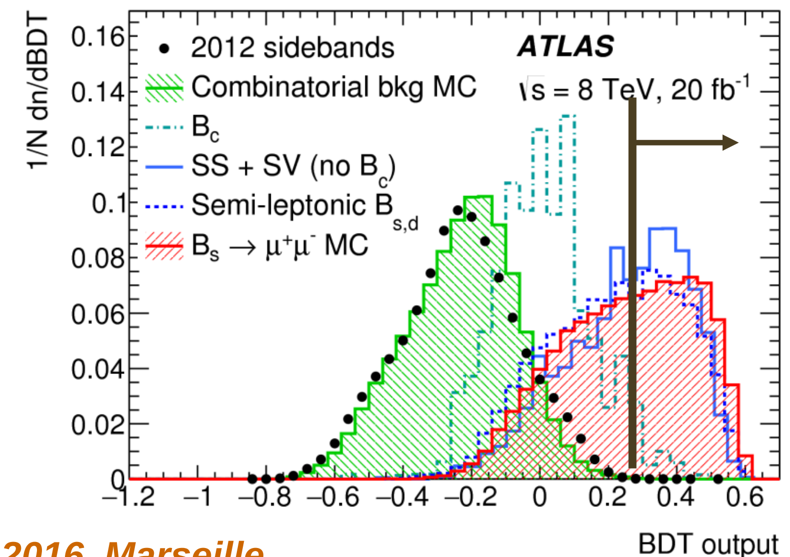
Backgrounds

- Main backgrounds to the measurement:
  - Combinatorial background: real muons coming from the decay chain of b and $\bar{b}$ initial quarks
  - Partially reconstructed B decays: real muons coming from B → μμ+X decays
  - "Peaking background": Bs/Bd → hh (where h = π, K) decays when both hadrons are misidentified as muons
- "Fake muons": π, K misidentified as muons fulfilling the muon and vertex selection criteria.
  - Present in partially reconstructed (e.g. B→μh+X) and in the "peaking background".

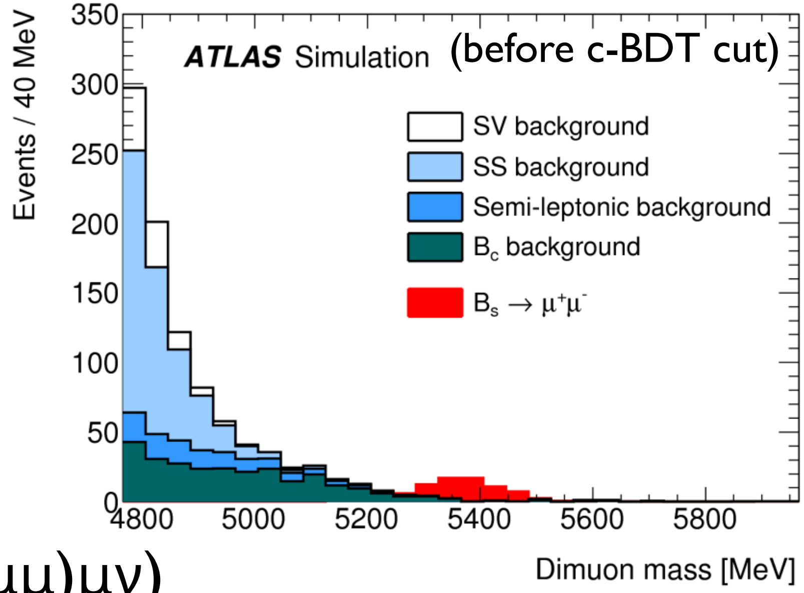
Combinatorial background

- Real muons from semileptonic heavy-quark decays
- Dominated by $b\bar{b} \rightarrow \mu\mu X$ decays
- Largest background component.
- BDT is applied (c-BDT) to reduce its contribution
  - B-meson kinematic
  - Secondary vertex displacement (L_{xy} , d_0 , …)
  - Properties of muons
  - Rest of the event (X^2 w.r.t other vertices, B isolation…)
- BDT trained on 1.4G events MC samples with μ coming from b/c quarks decay chains (~8 times more statistics than in sideband data)
  - MC validated on sideband data
- Signal efficiency: 54%
- Background reduction: ~10^3
- Strong improvement w.r.t. 7TeV analysis!



Partially reconstructed decays

- B decays with two real muons produced in association with other particles (PRD)
- m(μμ) peaks below Bs/Bd masses
- Sources:
  - b → cμν → s(d)μμνν ("same-side" muons)
  - B decays with a muon pair (e.g. Bd→μμK*, B→J/ψ+X) ("same vertex" muons)
  - Bc decays (e.g. Bc→J/ψ(μμ)μν)
  - Semileptonic b-hadron decays with a misidentified μ (e.g. Bd → μπν, Bs →μKν)



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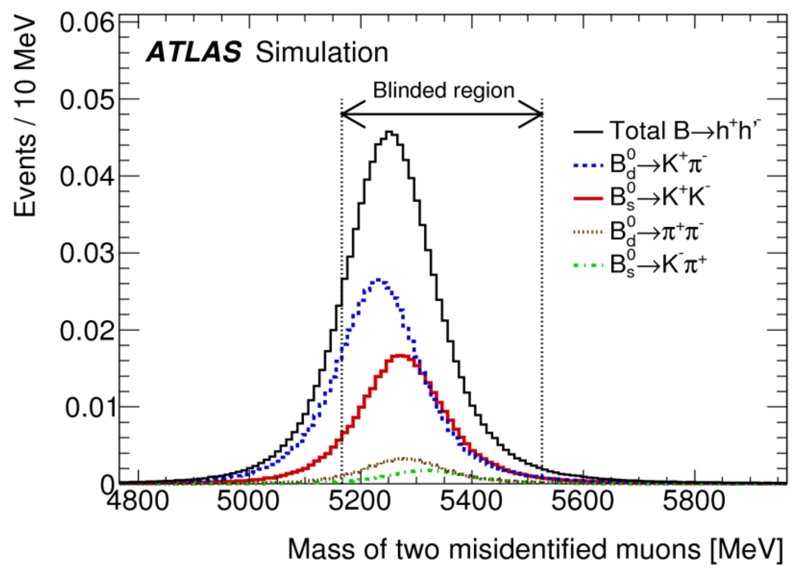
"Peaking background" & fake muons

- $B \rightarrow h^+h^-$ decays (where h = π, K) with both hadrons misidentified as muons
- Problematic background!
  - Production cross-section several orders of magnitude larger than Bs/Bd signal
  - $m(h^+h^-)$ peaks inside the signal region
- BDT applied (f-BDT) to reduce them
  - Based on tracking ID and calorimetric variables
  - Trained on MC and validated in data
  - Signal efficiency: 95% on Bs/Bd→μμ events
- **7 times higher rejection** w.r.t. 7TeV analysis!
- **1.0±0.4 events** expected in the signal region.
- Cross-checked in Bs→μμ background-enhanced sample with inverted f-BDT cut: 0.5 ± 3.0 events.



Analysis strategy

➢ BRs extracted applying the "Master Formula"

Hadronisation probabilities

$$\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) = N(B^0_{(s)} \to \mu^+\mu^-) \times [\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu^+\mu^-)] \times \frac{f_u}{f_{s/d}} \times \frac{1}{\mathcal{D}_{\mathrm{norm}}}$$

$$\mathcal{D}_{\mathrm{norm}} = \sum_k N^k_{J/\psi K^\pm} \alpha_k \left(\frac{\varepsilon_{\mu^+\mu^-}}{\varepsilon_{J/\psi K^\pm}} \right)_k$$

Number of Bs/Bd events from an unbinned ML fit to m(μμ) distribution

Reference channel: $B^+ \to J/\psi K^+$ Extracted from an unbinned ML fit to $m(\mu\mu K^+)$ distribution

Trigger categories and luminosity prescales*

Acceptance and efficiencies from MC simulation

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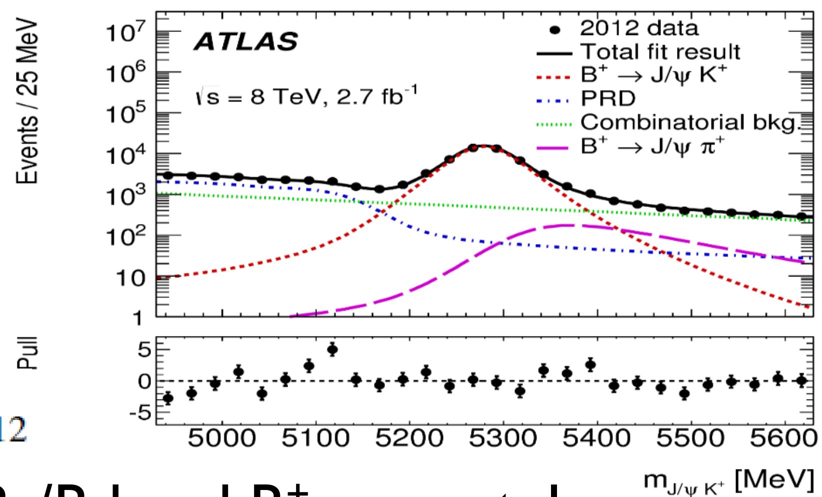
B^+ fit and efficiency ratio

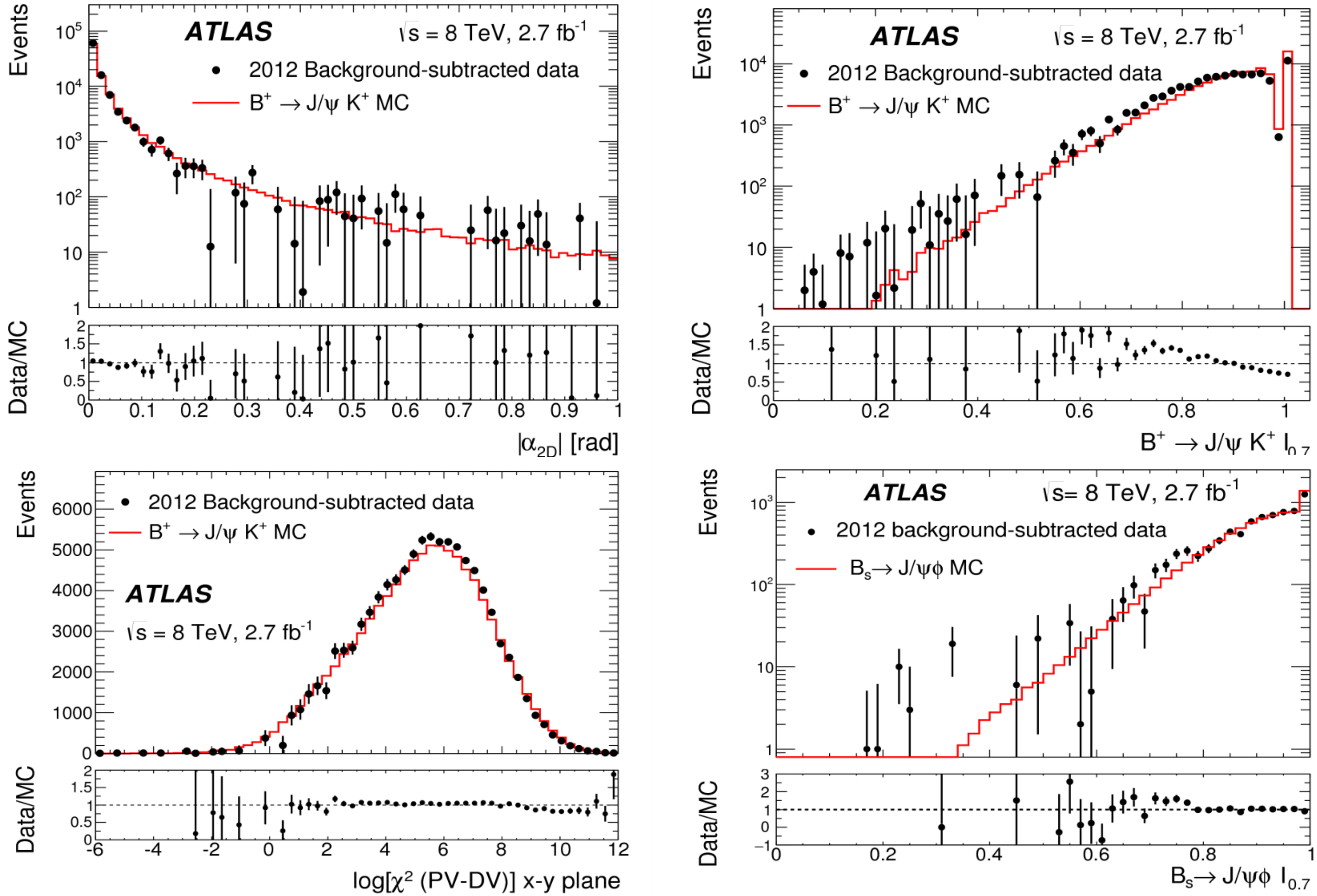
- Reference channel: **$B^+ \rightarrow J/\psi K^+$**
- Unbinned extended ML fit to the m($\mu\mu K^+$) distribution in data to extract **$B^+ \rightarrow J/\psi K^+$** and **$B^+ \rightarrow J/\psi \pi^+$** yields
- Functional forms from MC
  - Shape parameters from simultaneous fit to data-MC
  - PRD shapes from MC
  - Normalisations, mass scale and resolution free

$$\rho_{\pi/K} = \frac{\mathcal{B}(B^+ \to J/\psi \pi^+)}{\mathcal{B}(B^+ \to J/\psi K^+)} = 0.035 \pm 0.003 \pm 0.012$$



- Efficiencies computed for Bs/Bd and B^+ separately
- Simulated MC samples are used
  - P_T(B) and η(B) spectra corrected using B^+ data
  - Trigger efficiencies corrected using J/ψ and Υ data
  - Bs$\rightarrow\mu\mu$ lifetime and B isolation corrections (from B^+ or Bs $\rightarrow$ J/$\psi\phi$ data)
- Fiducial volume: P_T(B) > 8 GeV, |η(B)| < 2.5
- Uncertainty of **5.9%** on the Bs/B+ efficiency ratio

Data/MC comparisons



- Good data/MC agreement in all discriminating variables (but the isolation). We reweighted our MC samples (Bs/Bd and B^+) to match data

Analysis strategy

- BRs extracted applying the "Master Formula"

Hadronisation probabilities

$$\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) = N(B^0_{(s)} \to \mu^+\mu^-) \times [\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu^+\mu^-)] \times \frac{f_u}{f_{s/d}} \times \frac{1}{\mathcal{D}_{\rm norm}}$$

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Bs/Bd signal fit

- 3 separated bins in c-BDT output variable
  - 0.242-0.351; 0.351-0.454; > 0.454 .
  - Each bin has a nominal efficiency of 18% on Bs MC
- Unbinned extended **simultaneous** maximum likelihood fit on m(μμ) in the 3 c-BDT bins to extract N(Bs) and N(Bd)
- Other parameters (shapes and background normalisations) are left free
- Signal modelling:
  - Double Gaussian (same mean)
  - All shape parameters extracted from MC
  - Bd contribution (Bs/Bd = 0.113 in SM) has a similar shape taken from MC
  - Fixed mass shape in the 3 c-BDT bins
  - Fixed relative fraction in the 3 c-BDT bins

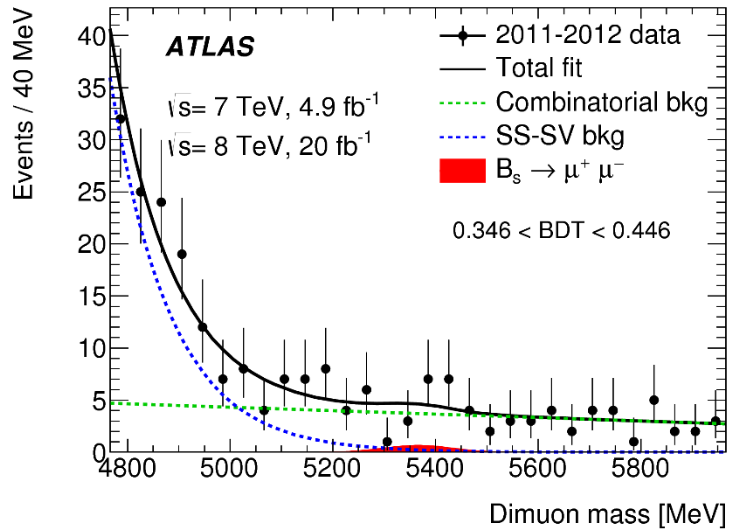
Background modelling

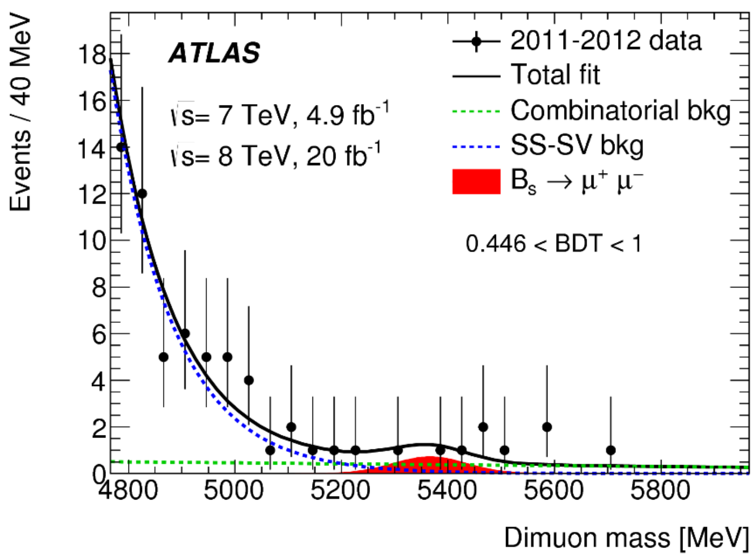
- **μμ combinatorial:**
  - Fitted using a 1st order Chebychev polynomial
  - Mass slope and relative fractions different in the 3 c-BDT bins
- **SS-SV:**
  - Both peaks far below the signal region → sensitive to tails
  - Fitted with an exponential function
  - Fixed mass shape in the three c-BDT bins
  - Relative fractions in the three c-BDT bins is fitted
- **Semileptonic background:**
  - Main contributions: Bd → πμν, Bs → Kμν, Λ_b → pμν
  - Contribution in the low m(μμ) region
  - m(μμ) distribution behaves like Gaussian tail. No additional PDF in the default fit. Only used for systematic studies.
- **"Peaking" background:**
  - Signal-like PDF with fixed normalisation 1.0±0.4
  - Fixed mass shape and relative fractions in the 3 c-BDT bins
- Backgrounds **normalised independently** in each c-BDT bin

Fit systematics

- Dominant systematics assessed with toy MC:
  - Alternative PDF for SS-SV
    - Semileptonic background parameterised using MC templates (including also Bc → J/ψμν component)
    - Full effect is considered as systematic
  - Alternative PDF for combinatorial background
  - Mass scale and mass resolution uncertainties
- Combined fit uncertainty on N(Bs) and N(Bd):
  - $\sigma_{syst}(N(Bd)) = 3$
  - $\sigma_{syst}(N(Bs)) = \sqrt{4 + (0.06N(Bs))^2}$
- Additional systematics:
  - Uncertainty in the relative efficiencies of the 3 c-BDT bins (10-15%)
- Feed all uncertainties (as Gaussian constraints) into the likelihood before the fit to data

Fit results





- Background normalisations extracted in the sidebands and interpolated in the signal region

- Expected yields:
  - N(Bs) = 41
  - N(Bd) = 5

- Fitted yields:
  - N(Bs) = 16 ± 12
  - N(Bd) = -11 ± 9

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External factors

- BR ($B^+ \rightarrow J/\Psi K^+$) = 0.1027 + 0.0031 % (PDG)
- BR ($J/\Psi \rightarrow \mu\mu$) = 5.961 + 0.033 % (PDG)
- $f_u / f_{s,d}$
  - Taken from a specific ATLAS measurement based on $Bd \rightarrow J/\psi K^*$ and $Bs \rightarrow J/\psi\phi$ events
  - f_s / f_d = 0.240 + 0.020 (*Phys. Rev. Lett.* ***115***, *262001*)
  - f_u / f_d = 1
- $D_{norm}(Bs)$ = (2.88 + 0.17) x10^6
- $D_{norm}(Bd)$ = (2.77 + 0.16) x10^6
- Normalisation uncertainties included as Gaussian constraints in the likelihood

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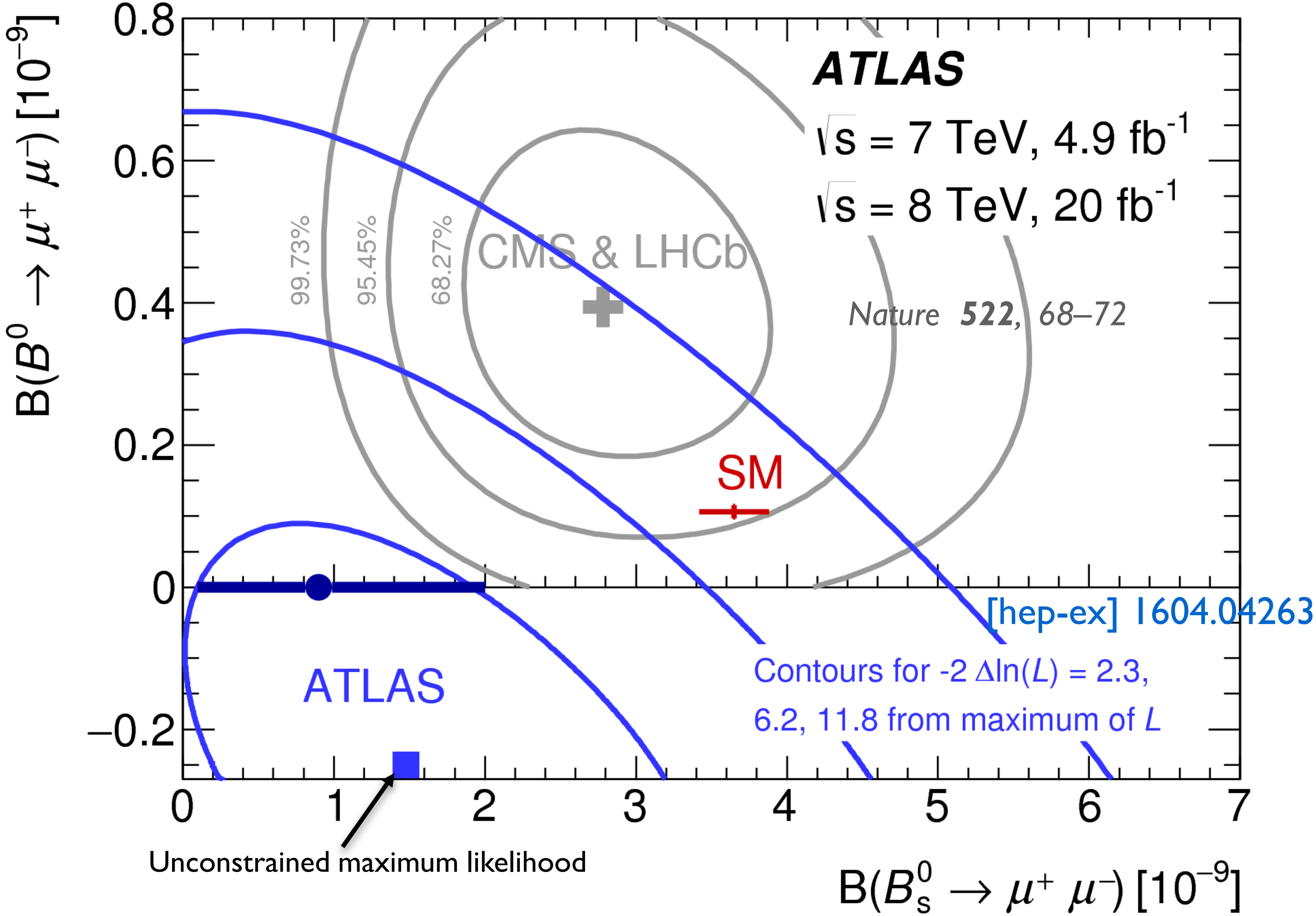
BRs extraction

- Single-event-sensitivity
  - $(8.9 \pm 1.0) \times 10^{-11}$ for Bs , $(2.21 \pm 0.15) \times 10^{-11}$ for Bd
- **Expected sensitivity: 3.1σ**
- BR(Bs) extracted looking at the minimum of the likelihood imposing N(Bs), N(Bd) > 0
- **BR(Bs) = $0.9^{+1.1}_{-0.8}$ x10^{-9} (stat. + syst.)**
  - Uncertainty on BR(Bs) comparable with CMS and LHCb
  - Uncertainty dominated by the statistical component (systematic component ~0.3)
  - Neyman construction to estimate the 68.3% CL interval
  - **p-value** for SM hypothesis = **0.048 (i.e. 2.0σ)** (computed with the profile likelihood ratio)
  - Upper limit: **BR(Bs) < 3.0x10^{-9} (95% CL using CLs)**
- **BR(Bd) = 0** at the likelihood minimum
  - Upper limit **BR(Bd) < 4.2x10^{-10} (95% CL using CLs)** (expected limit $5.7^{+2.1}_{-1.5}$ x10^{-10})

BRs in the world… now…



Conclusions & next steps

- The measurement of the BR(Bs/Bd→μμ) performed with the whole Run1 (25 fb^{-1}) datasets by ATLAS has been presented
- ATLAS has **comparable precision** w.r.t. CMS and LHCb despite their better m(μμ) resolution (a factor ~1.5 for CMS and ~3 for LHCb).
- N(Bs) and N(Bd) are extracted **simultaneously** from an unbinned extended ML fit to m(μμ) distribution
- **BR(Bs) = $0.9^{+1.1}_{-0.8}$ x10^{-9} (stat. + syst.)**
  - **p-value** for **SM** hypothesis = **0.048 (i.e. 2.0σ)**
  - Upper limit: **BR(Bs) < 3.0 x10^{-9} (95% CLs)**
- **Upper limit** on **BR(Bd)** placed at **4.2x10^{-10} (95% CLs)**

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BACKUP

Triggers, μ, K and B selections

- 4 mutually exclusive categories for all channels:
  - 2011 data based on di-muon with $P_T > 4$ GeV
  - 2012 data split into three mutually exclusive categories:
    - T1 → One muon with $P_T > 6$ GeV and one muon with $P_T > 4$ GeV
    - T2 → Both muons with $P_T > 4$ GeV and at least one with $|\eta| < 1.05$
    - T3 → Both muons with $P_T > 4$ GeV and $|\eta| > 1.05$
    - Relative yields:
      - 2011 → 22% of the total events
      - 2012 → 78% of the total events. T1 has 68%, T2 has 6% and T3 has 4%
- Muons: $P_T(\mu) > 4$ GeV, $|\eta(\mu)| < 2.5$
- Kaons (for $B^+ \to J/\Psi K^+$ and $Bs \to J/\Psi\Phi$)
  - No particle-ID → Mass hypothesis to reconstruct kaons 4-momenta. $P_T(K) > 1$ GeV, $|\eta(K)| < 2.5$
- Bs, Bd, B^+, $J/\psi\Phi$ candidates:
  - Di-muon vertex (w. or w/o J/ψ mass constraint)
  - Add 1 or 2 tracks (with Φ mass constraint)
  - Fiducial volume: $P_T(B) > 8$ GeV; $|\eta(B)| < 2.5$
  - Resolution on μμ mass: 65-120 MeV (better at low η)
  - Association with Primary Vertex: minimum Δz (99.8% efficient)

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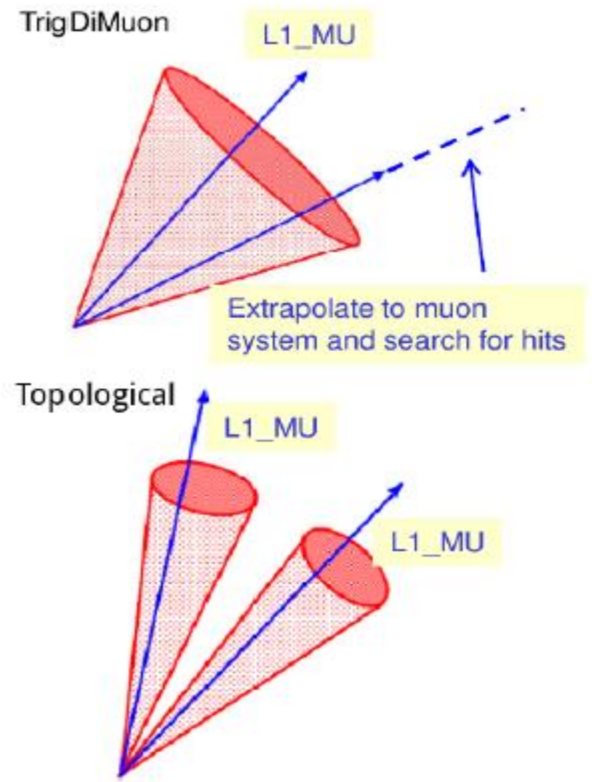
B-physics triggers for Run I

- Two approaches based on instantaneous luminosity:
  - TrigDiMuon algorithm – low luminosity periods
    - Seeded by a single muon RoI
    - Look for Inner Detector track in the RoI and extrapolate to Muon Spectrometer
    - Efficient for low-P_T J/Ψ but high rate.
  - Topological algorithms
    - Seeded by two muon RoIs
    - Lower rate but less efficient for low-P_T
    - Primary trigger in most of Run1

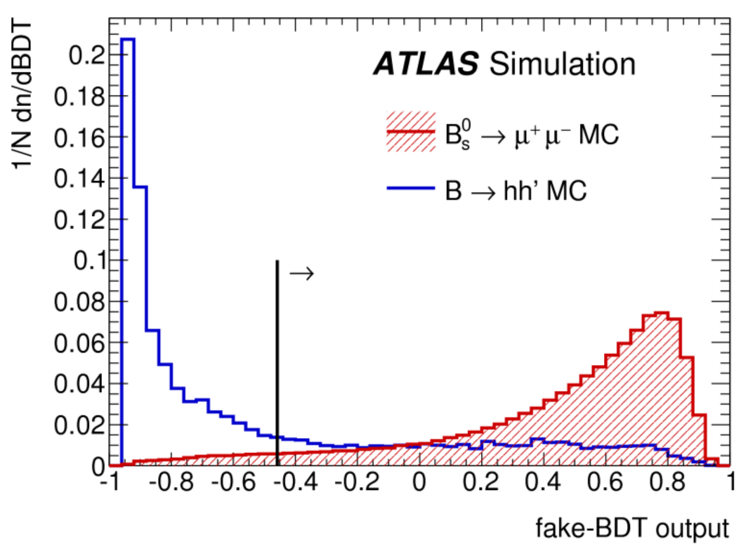


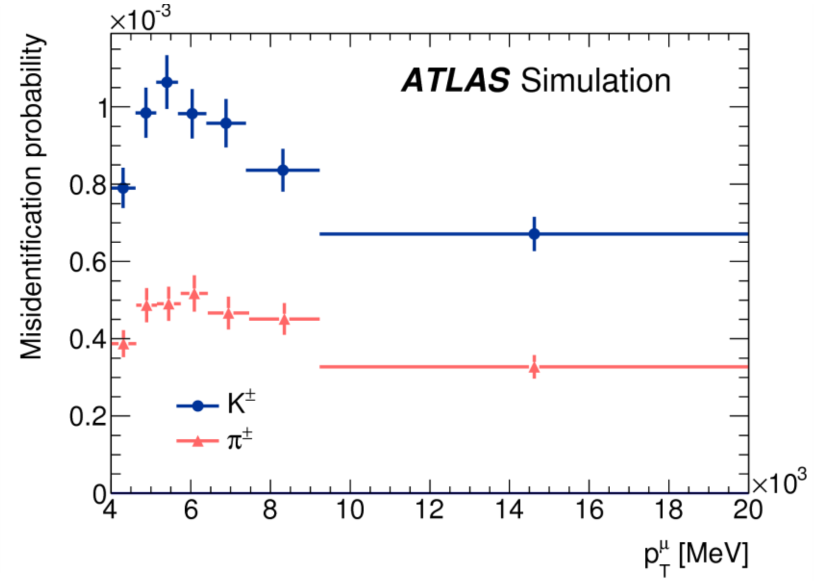
Signatures looked at:

- Jpsimumu: 2.5–4.3 GeV
- Bmumu: 4–8.5 GeV
- Upsimumu: 8–12 GeV
- Dimu: 1.5–14 GeV, prescaled

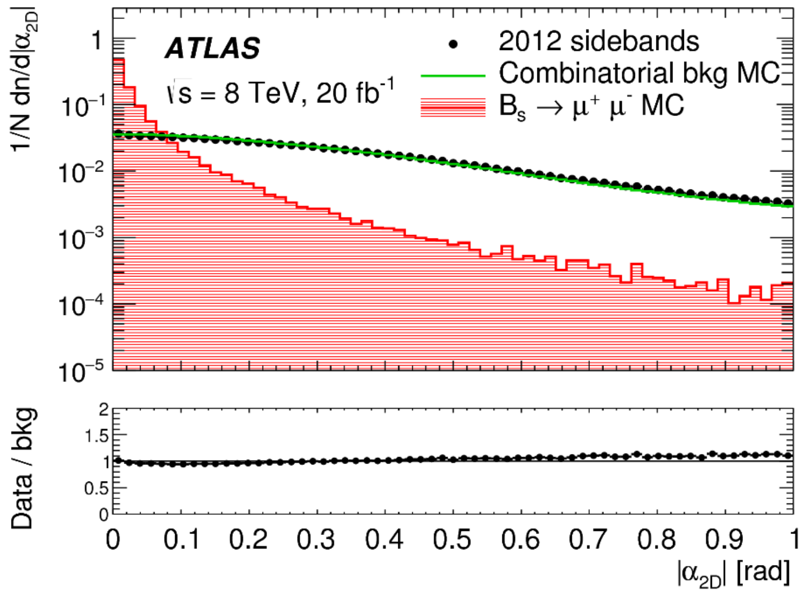
f-BDT variables

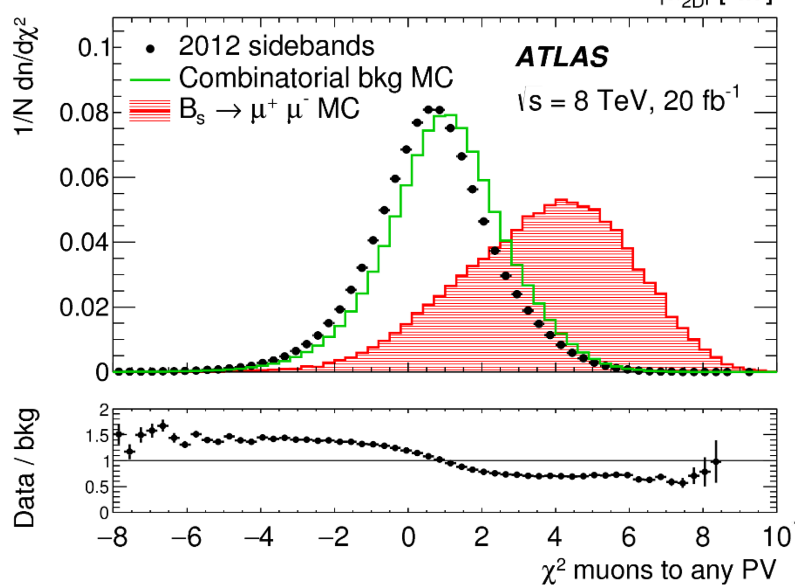
1. Absolute value of the track rapidity measured in the ID.
2. Ratio q/p (charge over momentum) measured in the MS.
3. Scattering curvature significance: maximum variation of the track curvature between adjacent layers of the ID.
4. χ^2 of the track reconstruction in the MS.
5. Number of hits used to reconstruct the track in the MS.
6. Ratio of the values of q/p measured in the ID and in the MS, corrected for the average energy loss in the calorimeter.
7. χ^2 of the match between the tracks reconstructed in the ID and MS.
8. Energy deposited in the calorimeters along the muon trajectory obtained by combining ID and MS tracks.





c-BDT variables





Variable	Description
p_T^B	Magnitude of the B candidate transverse momentum $\overrightarrow{p_T}^B$.
$\chi^2_{\mathrm{PV,DV}\ xy}$	Significance of the separation $\overrightarrow{\Delta x}$ between production (*i.e.* associated PV) and decay (DV) vertices in the transverse projection: $\overrightarrow{\Delta x}_T \cdot \Sigma^{-1}_{\overrightarrow{\Delta x}_T} \cdot \overrightarrow{\Delta x}_T$, where $\Sigma_{\overrightarrow{\Delta x}_T}$ is the covariance matrix.
ΔR	three-dimensional opening between $\overrightarrow{p}^B$ and $\overrightarrow{\Delta x}$: $\sqrt{\alpha_{2D}{}^2 + \Delta\eta^2}$
$\lvert\alpha_{2D}\rvert$	Absolute value of the angle between $\overrightarrow{p_T}^B$ and $\overrightarrow{\Delta x}_T$ (transverse projection).
L_{xy}	Projection of $\overrightarrow{\Delta x}_T$ along the direction of $\overrightarrow{p}^B_T$: $(\overrightarrow{\Delta x}_T \cdot \overrightarrow{p_T}^B)/\lvert\overrightarrow{p_T}^B\rvert$.
IP^{3D}_B	three-dimensional impact parameter of the B candidate to the associated PV.
$\mathrm{DOCA}_{\mu\mu}$	Distance of closest approach (DOCA) of the two tracks forming the B candidate (three-dimensional).
$\Delta\phi_{\mu\mu}$	Difference in azimuthal angle between the momenta of the two tracks forming the B candidate.
$\lvert d_0\rvert^{\max}$-sig.	Significance of the larger absolute value of the impact parameters to the PV of the tracks forming the B candidate, in the transverse plane.
$\lvert d_0\rvert^{\min}$-sig.	Significance of the smaller absolute value of the impact parameters to the PV of the tracks forming the B candidate, in the transverse plane.
$P_L^{\min}$	Value of the smaller projection of the momenta of the muon candidates along $\overrightarrow{p_T}^B$.
$I_{0.7}$	Isolation variable defined as ratio of $\lvert\overrightarrow{p_T}^B\rvert$ to the sum of $\lvert\overrightarrow{p_T}^B\rvert$ and of the transverse momenta of all additional tracks contained within a cone of size $\Delta R < 0.7$ around the B direction. Only tracks with $p_T > 0.5$ GeV and matched to the same PV as the B candidate are included in the sum.
$\mathrm{DOCA_{xtrk}}$	DOCA of the closest additional track to the decay vertex of the B candidate. Tracks matched to a PV different from the B candidate are excluded.
$N^{\mathrm{close}}_{\mathrm{xtrk}}$	Number of additional tracks compatible with the decay vertex (DV) of the B candidate with $\ln(\chi^2_{\mathrm{xtrk,DV}}) < 1$. The tracks matched to a PV different from the B candidate are excluded.
$\chi^2_{\mu,\mathrm{xPV}}$	Minimum χ^2 for the compatibility of a muon in the B candidate with a PV different from the one associated with the B candidate.

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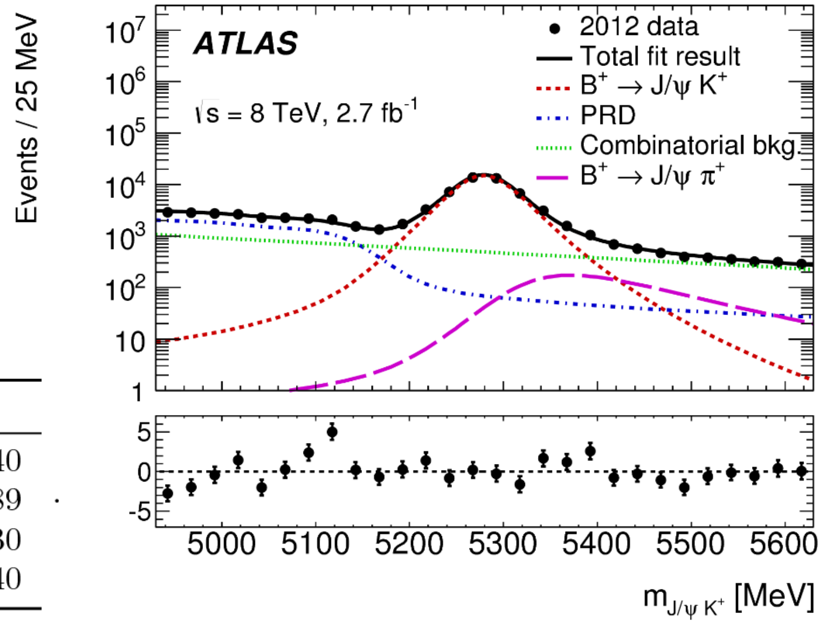
B+ yield extraction

- Reference channel: **$B^+ \to J/\psi K^+$**
- Goal: extract **$B^+ \to J/\psi K^+$** and **$B^+ \to J/\psi \pi^+$** yields from data
- Technique: Unbinned extended maximum likelihood (ML) fit to the m($\mu\mu K^+$) distribution in data
- Functional forms from MC
  - Shape parameters from simultaneous fit to data-MC
  - PRD shapes from MC
  - Normalisations, mass scale and resolution free

Category	$N_{J/\psi K^+}$	$N_{J/\psi \pi^+}$
T_1	$46\,860 \pm 290 \pm 280$	$1\,420 \pm 230 \pm 440$
T_2	$5\,200 \pm 84 \pm 100$	$180 \pm 51 \pm 89$
T_3	$2\,512 \pm 91 \pm 42$	$85 \pm 77 \pm 30$
2011	$95\,900 \pm 420 \pm 1\,100$	$3\,000 \pm 340 \pm 1\,140$



- **$B^+ \to J/\psi K^+$** and **$B^+ \to J/\psi \pi^+$** yields simultaneously extracted → Measure the ratio of BRs

$$\rho_{\pi/K} = \frac{\mathcal{B}(B^+ \to J/\psi \pi^+)}{\mathcal{B}(B^+ \to J/\psi K^+)} = 0.035 \pm 0.003 \pm 0.012$$

LHCb (0.0383 + 0.0011 + 0.0007)
BABAR (0.0537 + 0.0045 + 0.0011)

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Efficiencies ratio

- Efficiencies computed for Bs/Bd and B^+ separately
- Simulated MC samples are used
  - $P_T(B)$ and $\eta(B)$ spectra corrected using B^+ data
  - Trigger efficiencies corrected using J/ψ and Υ data
  - Bs→μμ lifetime and B isolation corrections (from B^+ or Bs → J/ψϕ data)
- Fiducial volume: $P_T(B) > 8$ GeV, $|\eta(B)| < 2.5$
- Logically split in acceptance **A** and "pure" efficiency **ε** terms
  - **A** takes care of the effects of the cuts on muons and kaons kinematics
  - ε takes care of identification, trigger, reconstruction and selection cuts
- Main systematics:
  - MC modelling (c-BDT variables compared one by one with B^+ data)
  - Trigger and P_T, $\eta(B)$ reweighting; B^+ and K^+ reconstruction

Statistical uncertainty in simulation	0.5%
p_T, η reweighting and trigger efficiency	1.3%
Data to MC discrepancy in discriminating variables	4.2%
K^+ and B^+ reconstruction	3.6%
Residual trigger efficiency systematic uncertainty	1.5%
B^+ yield	0.8%
Total uncertainty	5.9%

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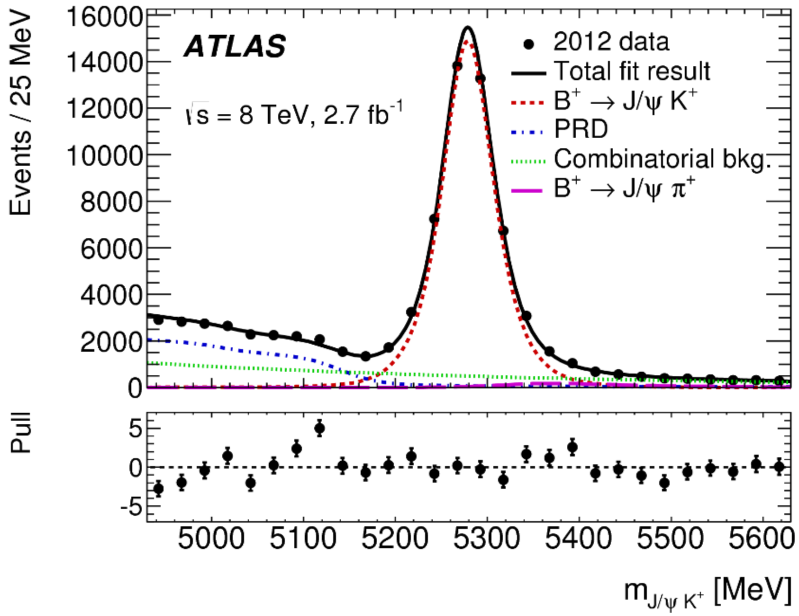
B^+ yield extraction

- Main components:
  - $B^+ \rightarrow J/\psi K^+$: Gaussian + Johnson S_U function
  - PRD background: Fermi-Dirac + exponential functions
  - $B^+ \rightarrow J/\psi \pi^+$: Gaussian + Johnson S_U function
  - Combinatorial background: exponential
- Functional forms from MC studies
  - Shape parameters from simultaneous fit to data and MC
  - Normalisations, mass scale and resolution free
- Main systematics:
  - Combinatorial background shape
  - PRD relative composition
  - Signal charge asymmetry (K^- less efficiently reconstructed)



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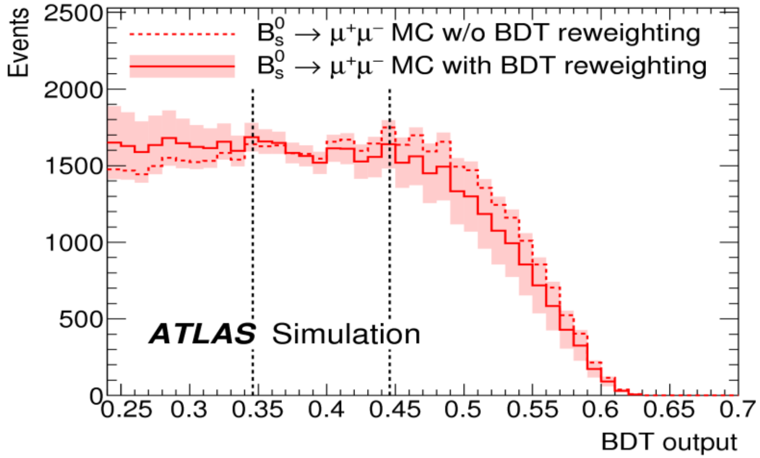
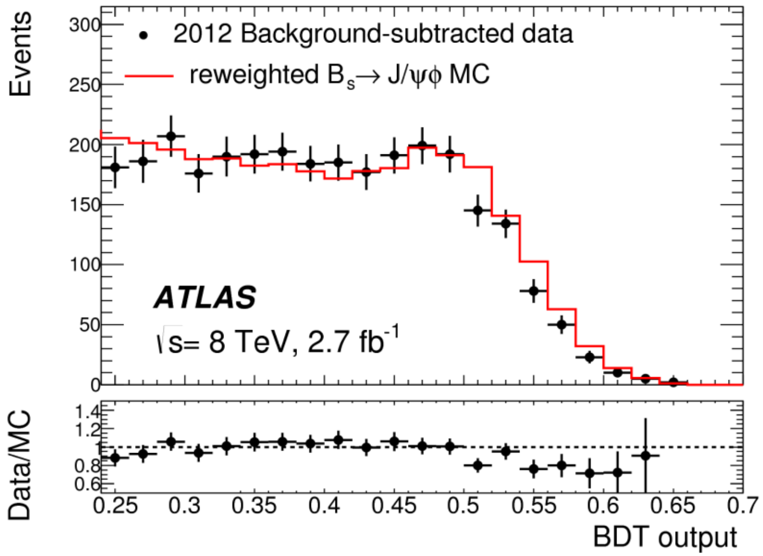
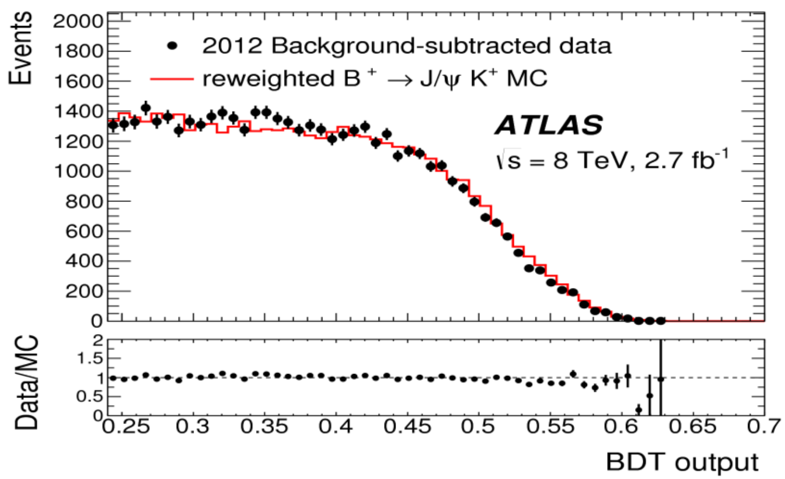
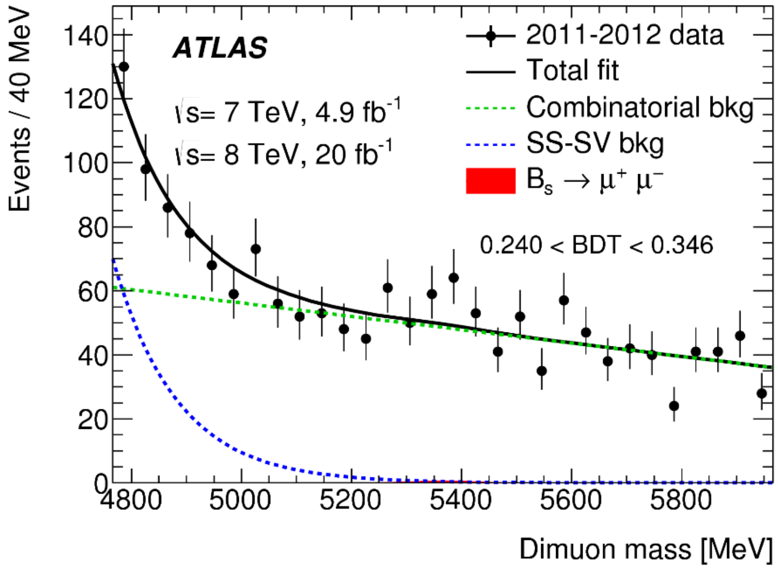
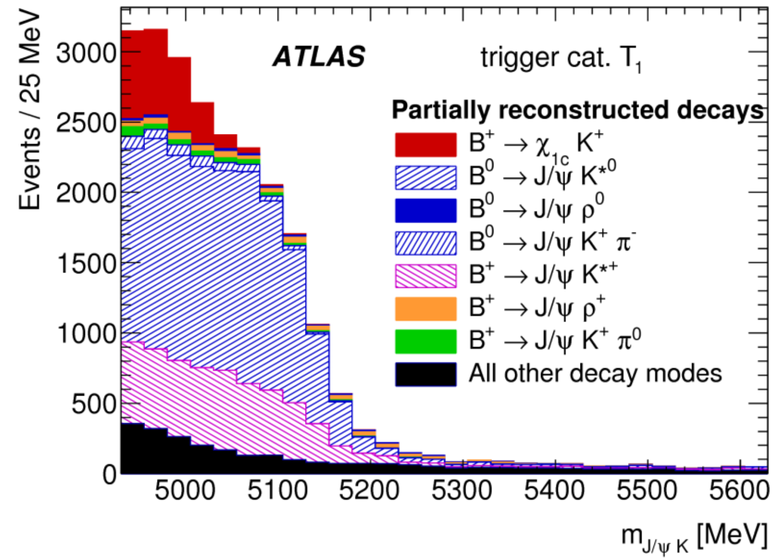
Data-MC comparisons



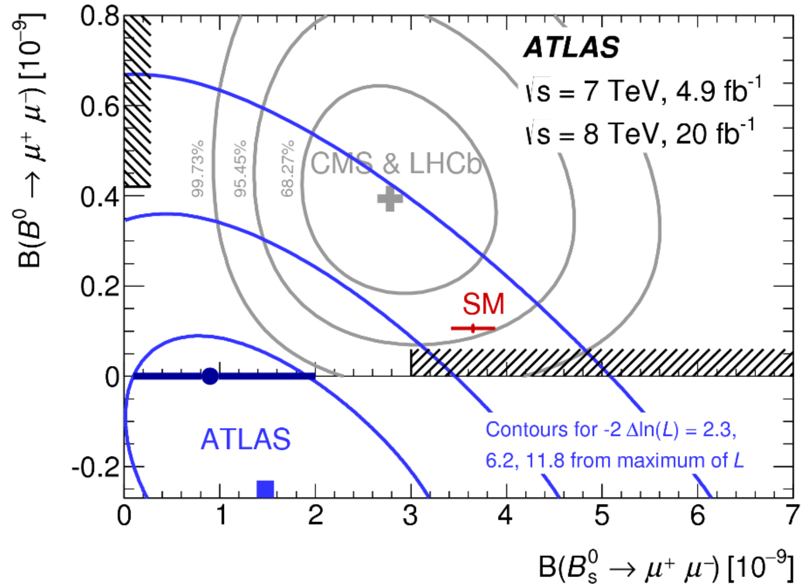








	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	$\mathcal{B}(B^0 \to \mu^+\mu^-)$
Scale uncertainties		
$\mathcal{B}(B^+ \to J/\psi K^+) \times \mathcal{B}(J/\psi \to \mu\mu)$ branching fractions	3.1%	3.1%
$B^0_{(s)}/B^+$ production ratio	8.3%	0
B^+ yield and $B^0_{(s)}/B^+$ efficiency ratio	5.9%	5.9%
Relative efficiency of continuum-BDT intervals	9%	9%
Signal and background model	6%	0
Total scale uncertainty	16%	11%
Offset uncertainties		
Signal and background model	0.2×10^{-9}	0.7×10^{-10}



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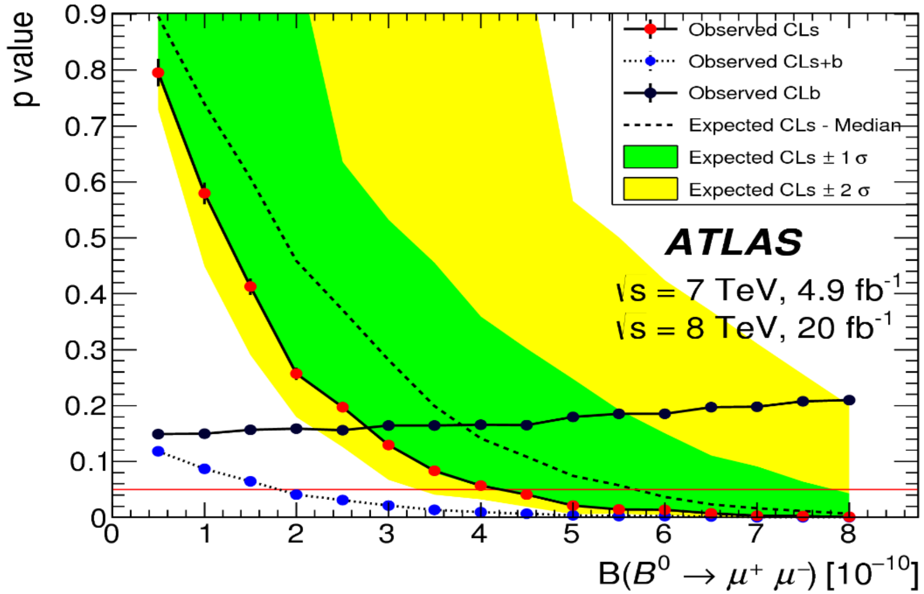
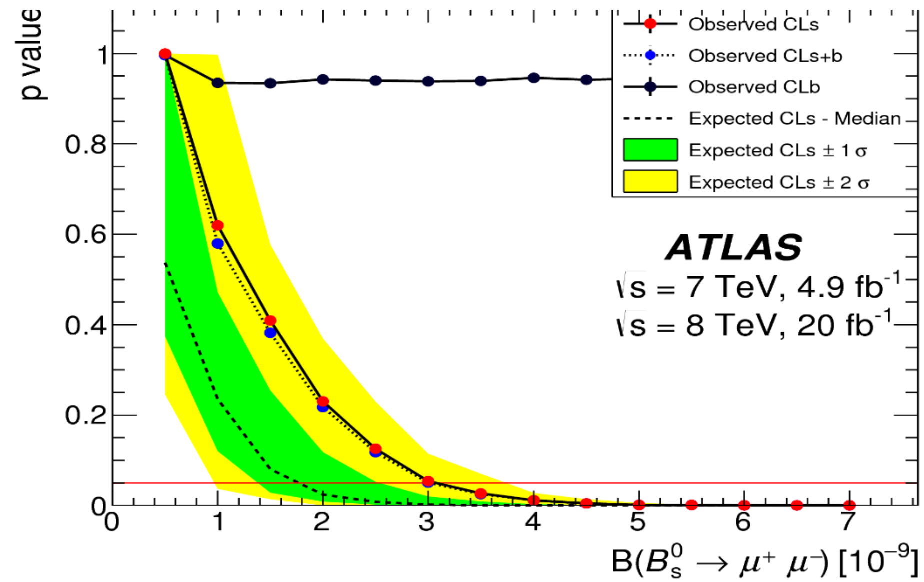
Upper limits...



Bd

BR(Bd) < 4.2 x10^{-10} (95% CLs)



Bs

BR(Bs) < 3.0 x10^{-9} (95% CLs)

Perspectives for Run2

- Measurement still dominated by statistical uncertainty → Run2 (~100 fb^{-1}) can give significant improvement

- Production cross-section higher at 13 TeV: great!

- But: higher instantaneous luminosity →
  - More pile-up (affordable)
  - Need to raise di-muon trigger P_T thresholds (terrible!)
  - First estimates: 15 fb^{-1}@13 TeV to have the same "statistical power" of 25 fb^{-1} (best case scenario)

- Solution: Topological trigger!
  - Add L1 decision based on the kinematic properties of the di-muon pair (m(μμ), angular distance, etc..)
  - Higher background rejection (and then lower bandwidth) for the same signal efficiency

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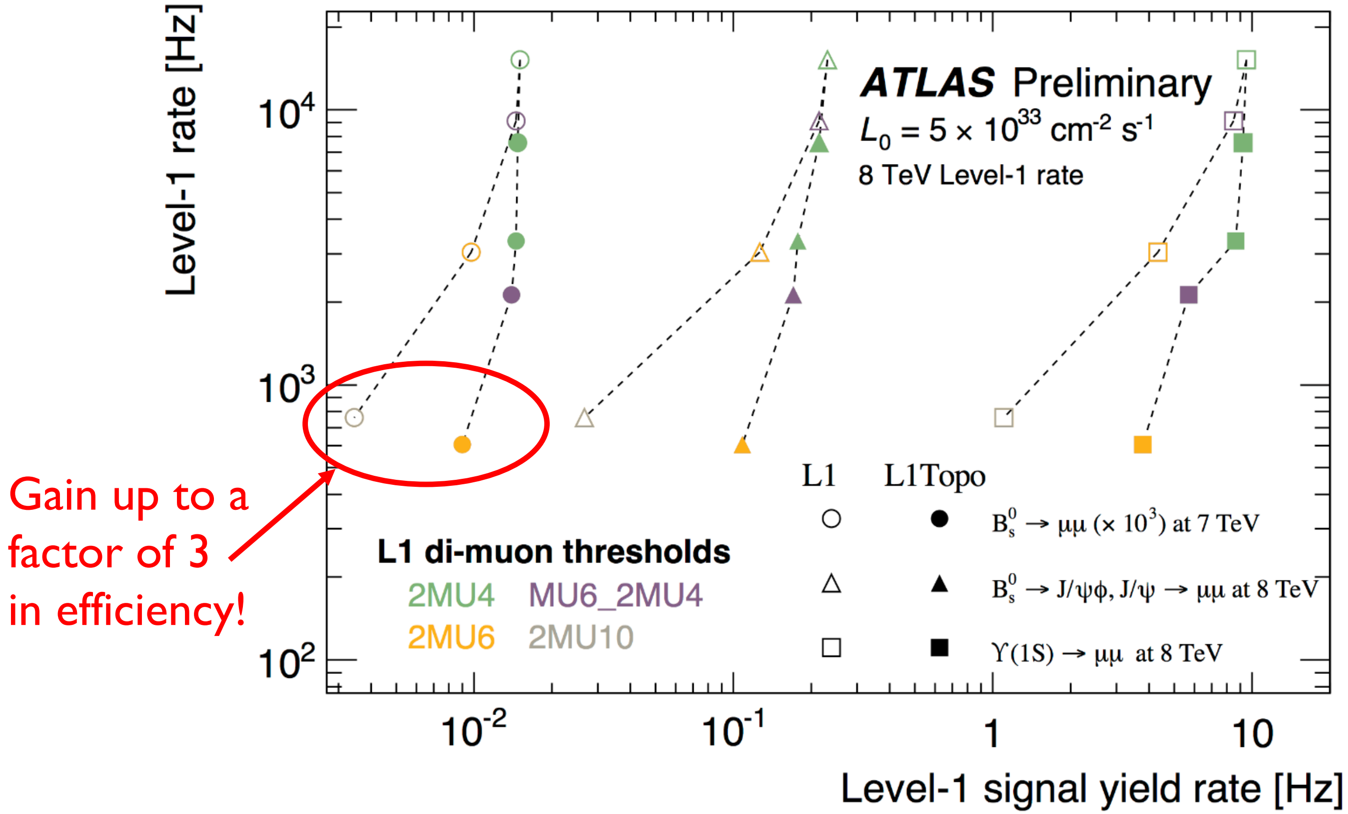
L1Topo at work….



Menu developed and optimised for all B-physics channels.
Actually under commissioning for 2016 data