



HF production and properties @ ATLAS & CMS



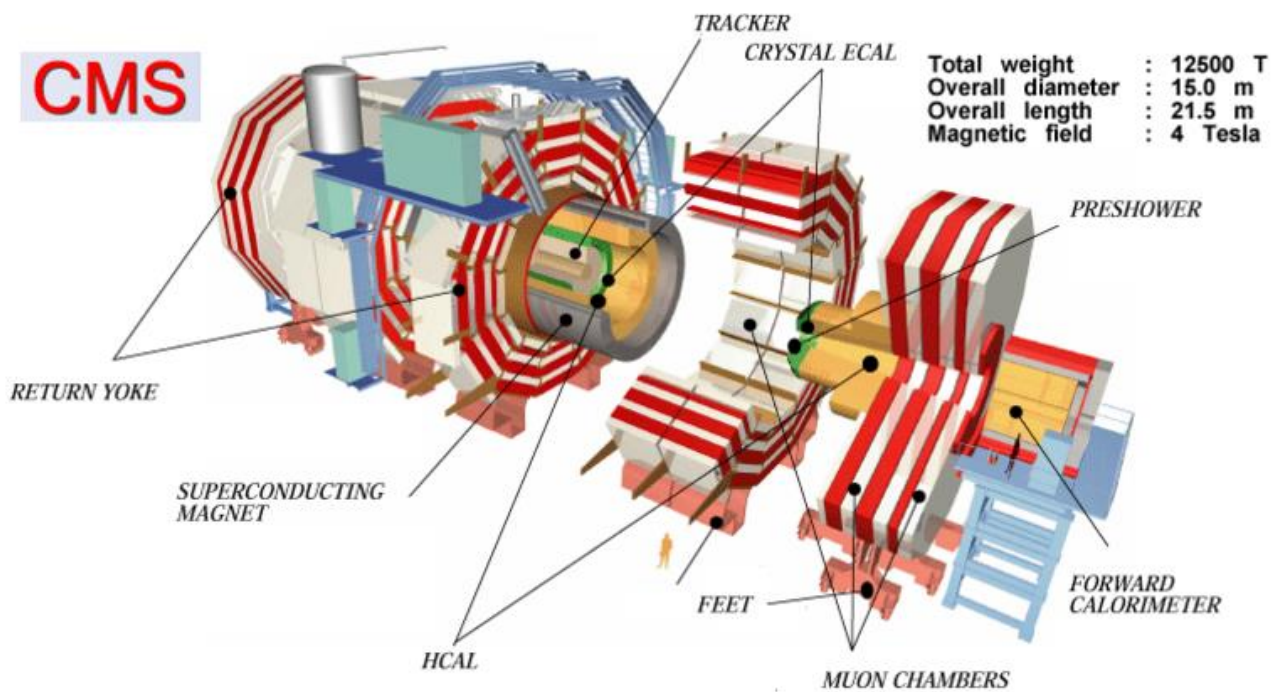
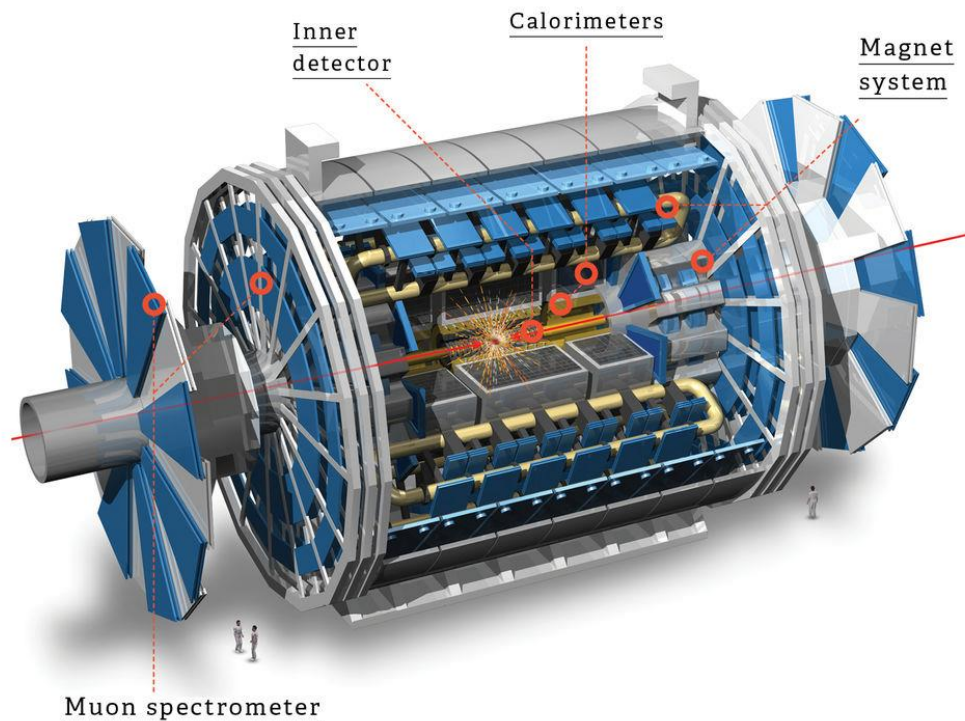
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FOR THE ATLAS AND CMS COLLABORATIONS



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The detectors



Some taste on HF production at ATLAS and CMS

74 results from both experiments, some of them ...

- Quarkonium cross sections (CMS & ATLAS)
- Polarization of the Λ_b^0 (CMS and ATLAS)
- Study of $B_d^0 \rightarrow K^* \mu^+ \mu^-$ (ATLAS)
- Search for $X^+(5558) \rightarrow B_S \pi^+$ (CMS and ATLAS)
- Lifetime of B hadrons (CMS)

Short Title	Journal reference	Date	\sqrt{s} (TeV)	L	Links
Angular analysis of the decay of $B_d^0 \rightarrow K^* \mu^+ \mu^-$	Submitted to JHEP	10-MAY-18	8	20 fb ⁻¹	Documents 1805.04000 Inspire Internal
Measurement of the prompt J/ψ and $\psi(2S)$ polarizations in pp collisions	PLB 727 (2013) 361	23 July 2013	0.06-10.0	4.9 fb ⁻¹	Documents 1802.01840 Inspire Internal
Observation of the $\chi_{c1}(3P)$ and measurement of their masses	JHEP 07 (2013) 163	28 April 2013	5.02	28 nb ⁻¹	Documents 1709.03089 Inspire Internal
Measurement of the Λ_b polarization and angular parameters in $\Lambda_b \rightarrow J/\psi \Lambda$ decays from pp collisions at $\sqrt{s} = 7$ and 8 TeV	PRD 97 (2018) 072010	13 February 2018	5.02	1, 25 pb ⁻¹	Documents 1705.03374 Inspire Internal
Search for the X(5558) state decaying into $B_S^0 \pi^+$ in proton-proton collisions at $\sqrt{s} = 8$ TeV	PLB 120 (2018) 20008	17 December 2017	8	11.5 fb ⁻¹	Documents 1407.5532 Inspire Internal
Measurement of quarkonium production cross sections in pp collisions at $\sqrt{s} = 8$ TeV	PLB 740 (2018) 81	30 October 2017	8	11.44 fb ⁻¹	Documents 1612.02950 Inspire HepData Internal
Measurement of b hadron lifetimes in pp collisions at $\sqrt{s} = 8$ TeV	Accepted by EPJJC	24 October 2017	8	11.4 fb ⁻¹	Documents 1610.09303 Inspire HepData Internal
Measurement of angular parameters from the decay $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ in proton-proton collisions at $\sqrt{s} = 8$ TeV	Accepted by PLB	8 October 2017	8	11.4 fb ⁻¹	Documents 1407.1032 Inspire Internal
Observation of $T(1S)$ pair production in proton-proton collisions at $\sqrt{s} = 8$ TeV	JHEP 05 (2017) 013	23 October 2016	8	4.9 fb ⁻¹	Documents 1605.07485 Inspire Internal
Measurement of the differential inclusive B^0 hadron cross sections in pp collisions at $\sqrt{s} = 13$ TeV	PLB 771 (2017) 435	4 September 2016	7, 8	1, 20.3 fb ⁻¹	Documents 1404.7035 Inspire Internal
Observation of the decay $B^0 \rightarrow \psi(2S) \phi(1020) K^+$ in pp collisions at $\sqrt{s} = 8$ TeV	PLB 764 (2017) 66	10 July 2016	7, 8	1, 20.3 fb ⁻¹	Documents 1604.04263 Inspire Internal
Angular analysis of the decay $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ from pp collisions at $\sqrt{s} = 8$ TeV	PLB 753 (2016) 424	29 July 2015	7, 8	1, 20 fb ⁻¹	Documents 1601.03297 Inspire Internal
Measurement of the CP-violating weak phase ϕ_1 and the decay width difference $\Delta\Gamma_1$, using the $B^0 \rightarrow J/\psi \phi(1020)$ decay channel in pp collisions at $\sqrt{s} = 8$ TeV	PLB 757 (2016) 97	27 July 2015	7, 8	1, 19.2 fb ⁻¹	Documents 1512.03657 Inspire HepData Internal
Measurement of J/ψ and $\psi(2S)$ prompt double-differential cross sections in pp collisions at $\sqrt{s} = 7$ TeV	PRL 114 (2015) 191802	14 February 2015	7, 8	1, 19.2 fb ⁻¹	Documents 1512.02913 Inspire Internal
Measurements of the $T(1S)$, $T(2S)$, and $T(3S)$ differential cross sections in pp collisions at $\sqrt{s} = 7$ TeV	PLB 749 (2015) 14	30 January 2015	7, 8	1, 2.1 fb ⁻¹	Documents 1512.03657 Inspire HepData Internal
Measurement of the ratio $B(B_c^0 \rightarrow J/\psi \phi(980))/B(B_c^0 \rightarrow J/\psi \phi(1020))$ in pp collisions at $\sqrt{s} = 7$ TeV	PLB 756 (2015) 84	25 January 2015	7, 8	1, 11.4 fb ⁻¹	Documents 1512.02913 Inspire HepData Internal
Observation of the rare $B_c^0 \rightarrow \mu^+ \mu^-$ decay from the combined analysis of CMS and LHCb data	Nature (2015) 14474	17 November 2014	7, 8	1, 280 nb ⁻¹	Documents 1507.08925 Inspire Internal
Measurement of the ratio $B(B_c^0 \rightarrow J/\psi \pi^+ \pi^-)/B(B_c^0 \rightarrow J/\psi \pi^+)$ and the production cross sections times branching fractions of $B_c^0 \rightarrow J/\psi \pi^+$ and $B^0 \rightarrow J/\psi K^+$ in pp collisions at $\sqrt{s} = 7$ TeV	JHEP 01 (2015) 063	21 October 2014	7	2.4 fb ⁻¹	Documents 1507.08202 Inspire Internal
Measurement of the production cross section ratio $\sigma(\chi_{c1}(1P))/\sigma(\chi_{c1}(1P))$ in pp collisions at $\sqrt{s} = 8$ TeV	PLB 743 (2015) 363	19 September 2014	7	20.6 fb ⁻¹	Documents 1204.0735 Inspire Internal
Measurement of prompt J/ψ pair production in pp collisions at $\sqrt{s} = 7$ TeV	JHEP 09 (2014) 094	3 June 2014	7	1	
Observation of a peaking structure in the $J/\psi \phi$ mass spectrum from $B^0 \rightarrow J/\psi \phi K^0$ decays	PLB 734 (2014) 261-281	26 September 2013	7	1	
Search for a new bottomonium state decaying to $T(1S) \pi^+ \pi^-$ in pp collisions at $\sqrt{s} = 8$ TeV	PLB 727 (2013) 97	1 September 2013	7	1	
Angular analysis and branching fraction measurement of the decay $B^0 \rightarrow K^{*0} \mu^+ \mu^-$	PLB 727 (2013) 77-100	15 August 2013	7	1	

All heavy flavor results from ATLAS and CMS can be found at:

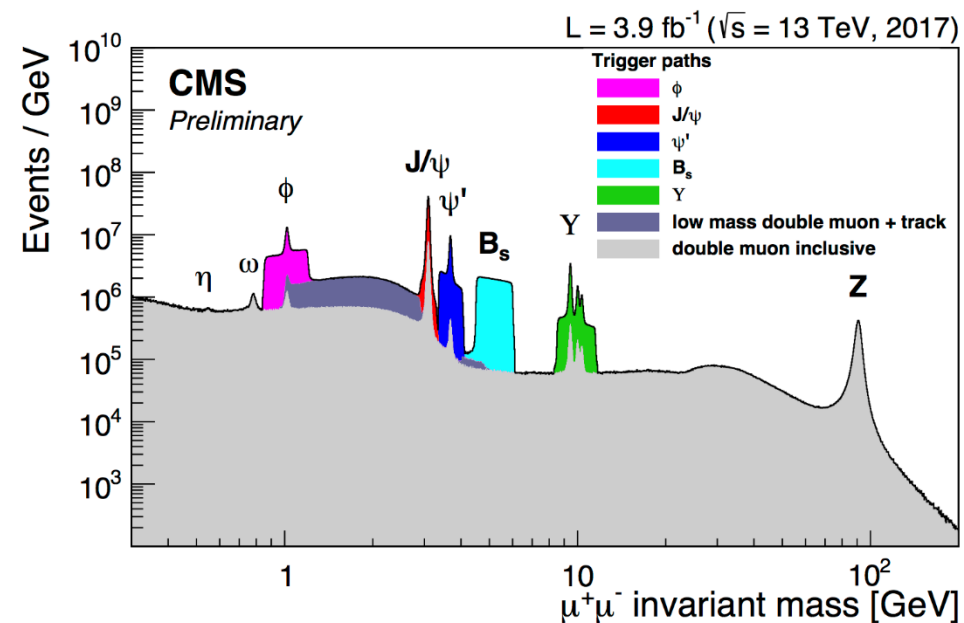
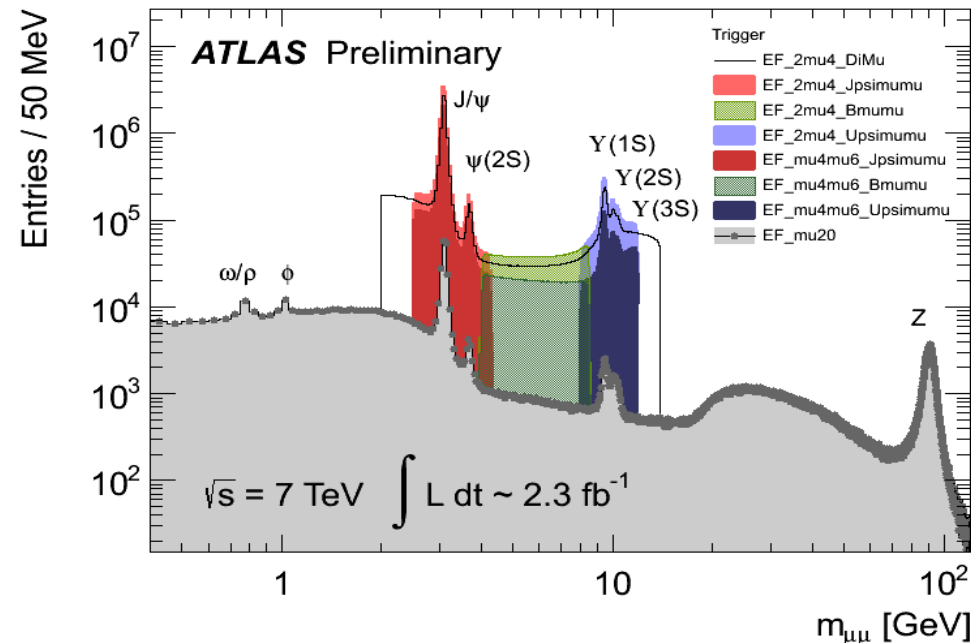
- <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/BPhysPublicResults>
- <https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsBPH>

b physics triggers

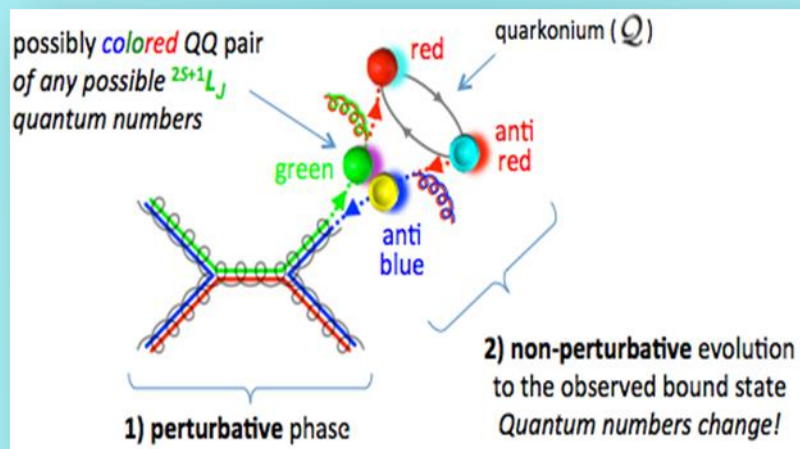
ATLAS & CMS use dimuon triggers for b and charm physics. In general :

- Quarkonia: $J/\psi \rightarrow \mu\mu, \Upsilon \rightarrow \mu\mu$
- Exclusive decays: $B \rightarrow J/\psi(\mu\mu) + X$
- Rare decays: $B \rightarrow \mu\mu + X$

Minimum differences between ATLAS and CMS.



Well established framework: NRQCD \sim factorizes short-dist. (SDCs, perturbative calculations) and universal long-dist. (LDMEs, from fits to data) contributions.



Contrary to expectations, LHC measurements indicate **quarkonia are produced unpolarized** \Rightarrow important to add more data to constrain LDMEs.

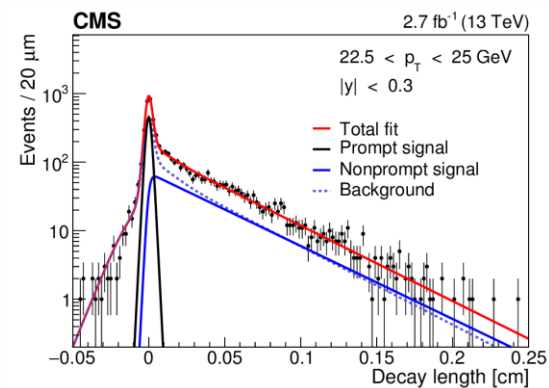
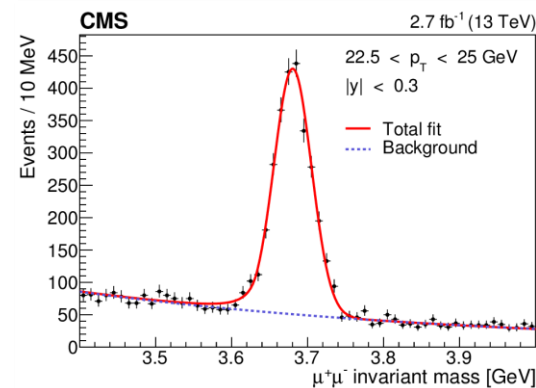
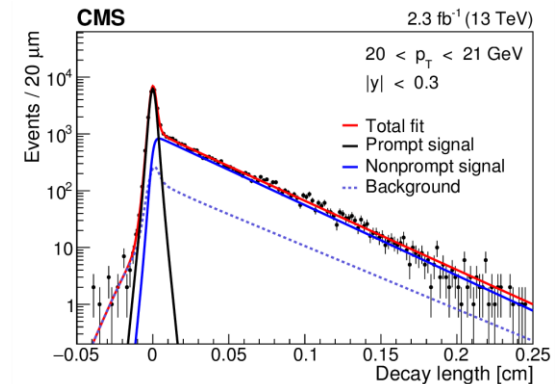
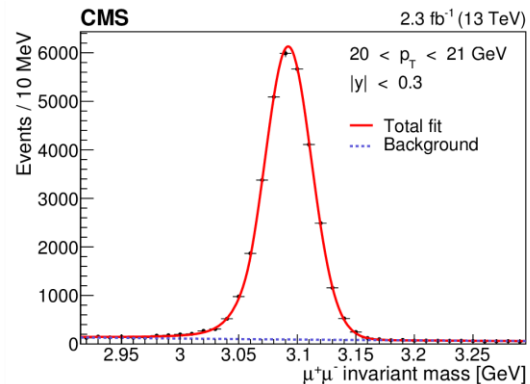
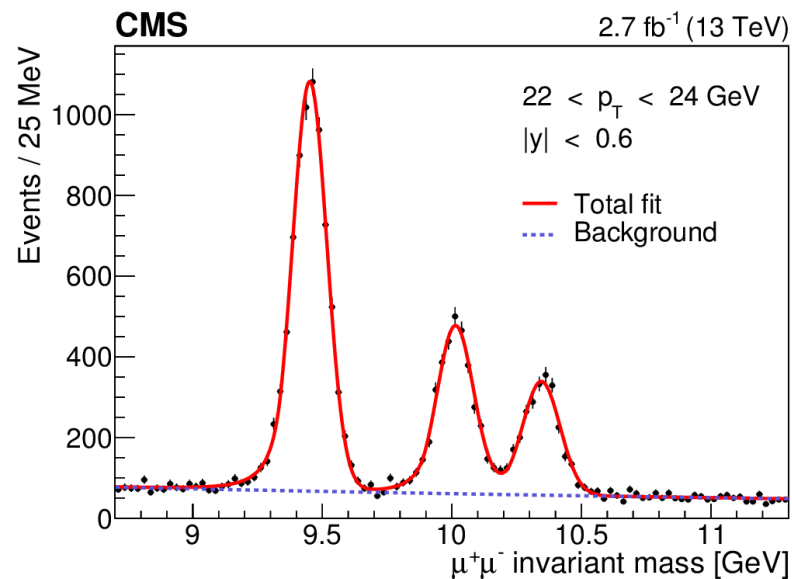
For J/ψ , ψ' and $Y(nS)$ ($n=1,2,3$) @ 13 TeV, CMS measures:

$$B(Q \rightarrow \mu^+ \mu^-) \frac{d^2\sigma}{dp_T dy} = \frac{N(p_T, y)}{\mathcal{L} \Delta y \Delta p_T} \left\langle \frac{1}{\epsilon(p_T, y) \mathcal{A}(p_T, y)} \right\rangle$$

The equation is annotated with boxes:

- prompt signal events (cannot distinguish feed-down decays of heavier $c\bar{c}$)** points to the numerator $N(p_T, y)$.
- integrated lumi** points to the denominator $\mathcal{L} \Delta y \Delta p_T$.
- y and p_T bin widths ($|y| < 1.2$, $p_T = 20 - 150$ (130) GeV)** points to the denominator $\mathcal{L} \Delta y \Delta p_T$.
- Reconstruction efficiency** points to the denominator $\epsilon(p_T, y)$.
- Acceptance** points to the denominator $\mathcal{A}(p_T, y)$.

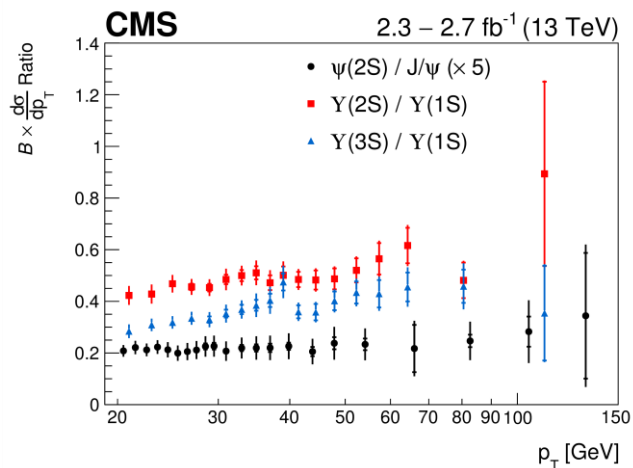
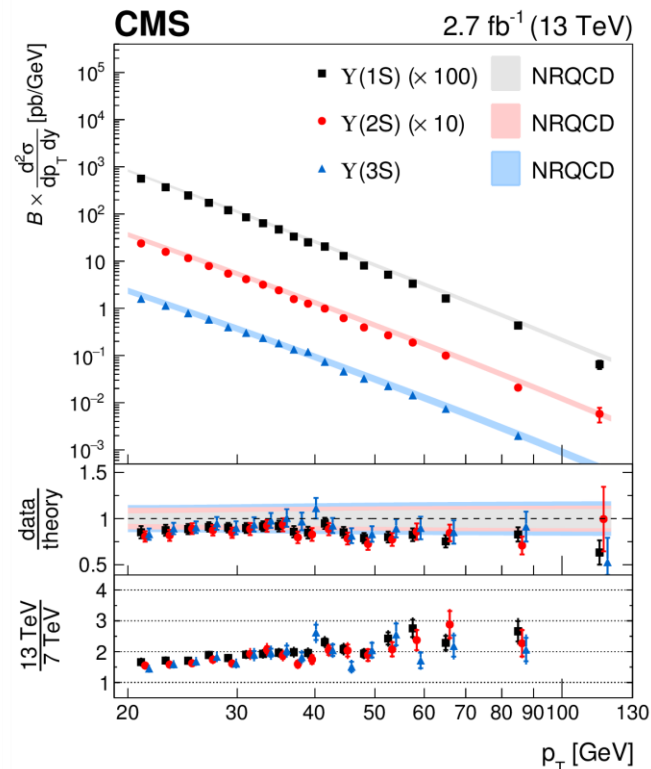
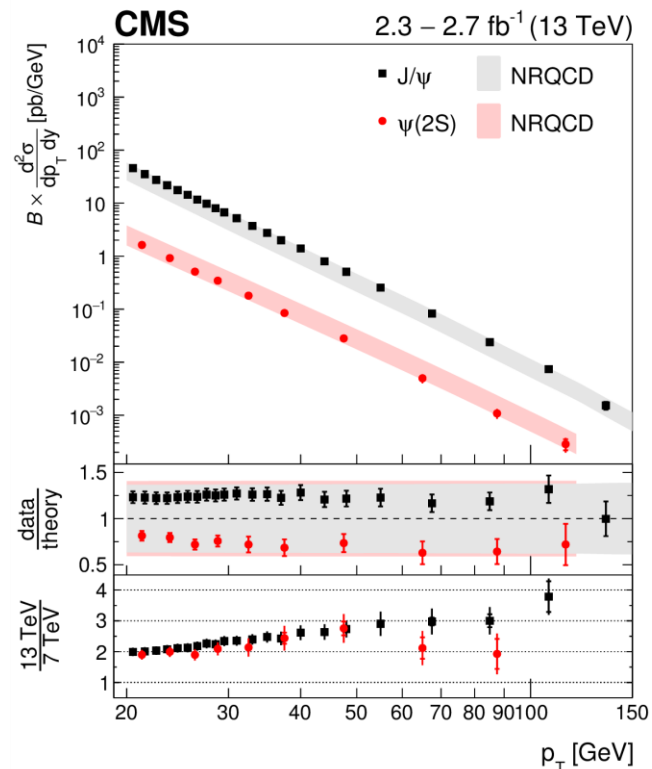
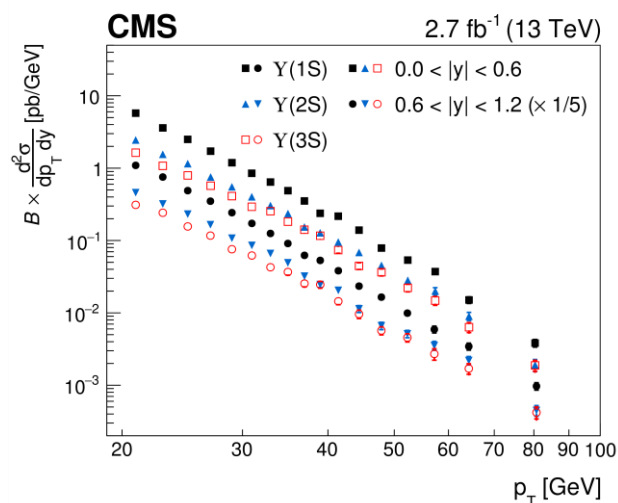
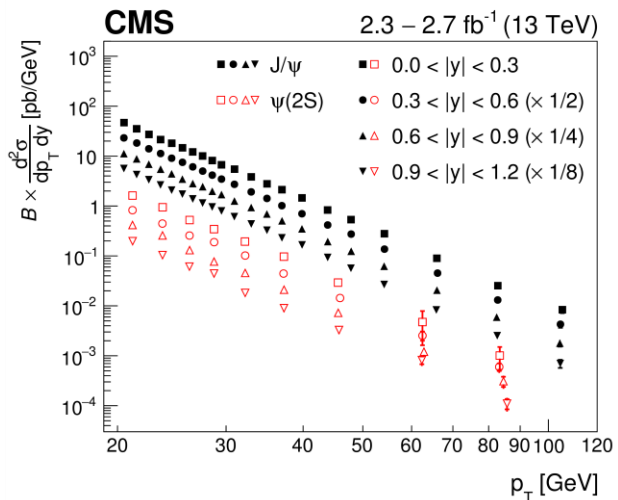
- UML fits to $M_{\mu\mu}$ ($M_{\mu\mu}-ct$) in each y - p_T bin (for J/ψ and ψ'):



- Each: CB icomposed of a Gaussian core.
- Means: fixed · common factor.
- Widths: ~common.
- CB params: constrained to the fit of the p_T -integrated distribution.
- Bkg.: exponential.

- CB (+ Gauss. J/ψ) + exponential bkg.
- Mean and CB params. constrained to p_T -int.

- Prompt = Res. (R): event-by-event-scaled double-Gauss.
- Non-prompt: Exp \otimes R.
- Bkg.: $R' + \text{exp} \otimes R'$.



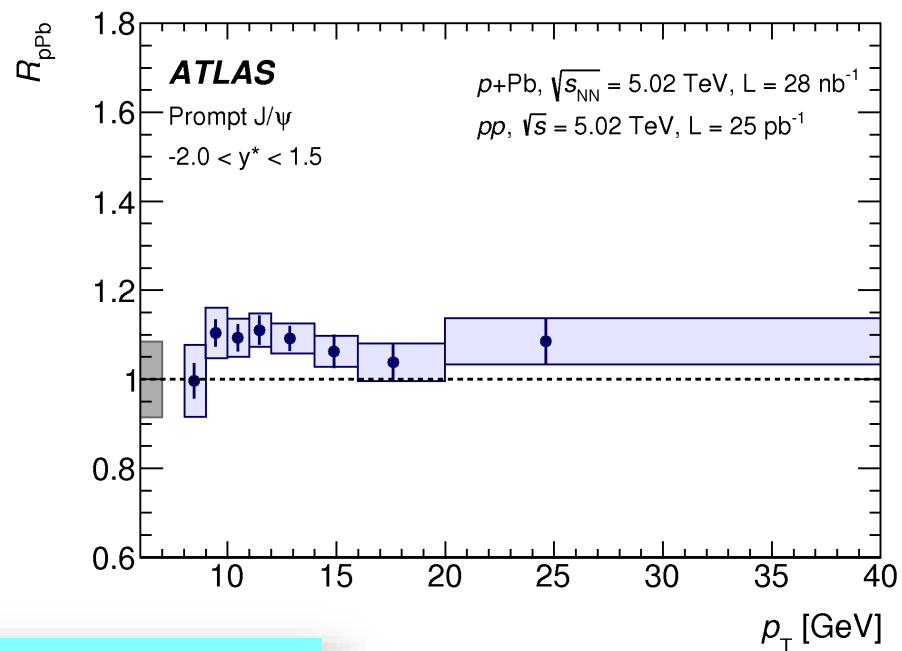
- NLO NRQCD predictions in agreement with data.
- As expected from evolution of PDFs, cross sections increase with energy.
- **These measurements should reduce theoretical uncertainties from the extraction of LDMEs.**

Shapes consistent across y region:
can integrate over y .

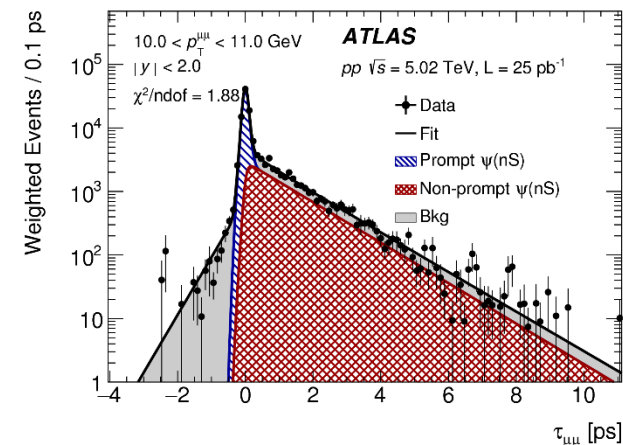
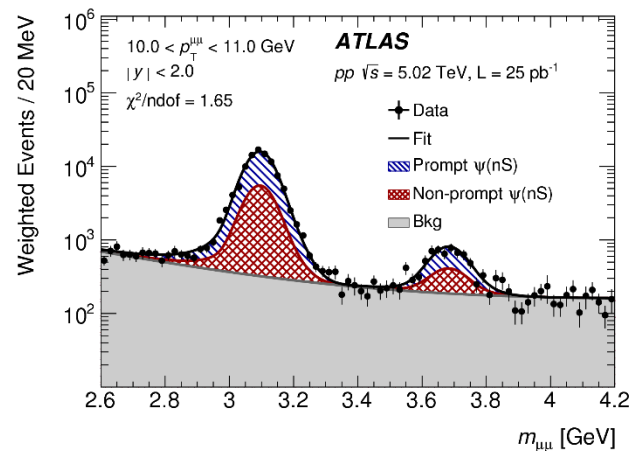
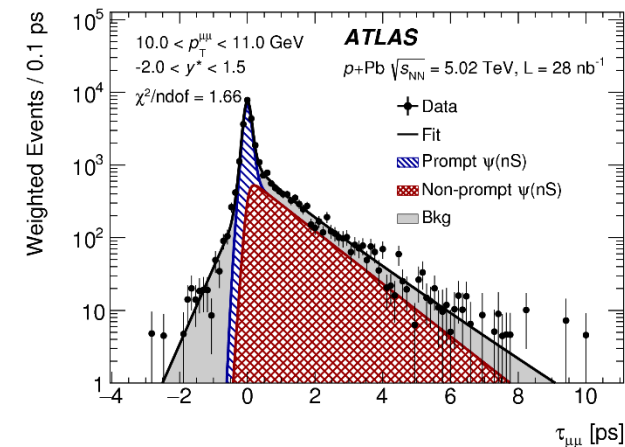
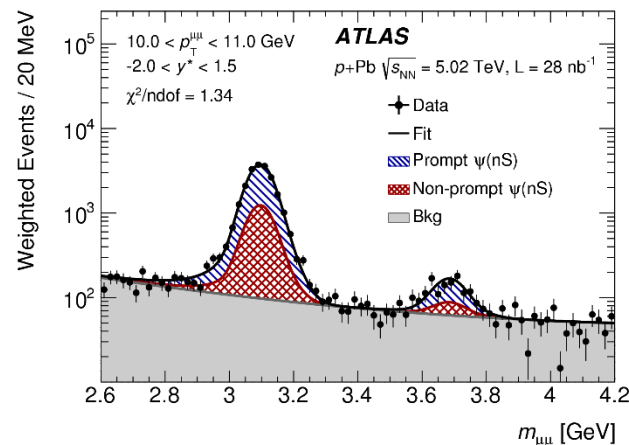
PLB 780, 251 (2018)

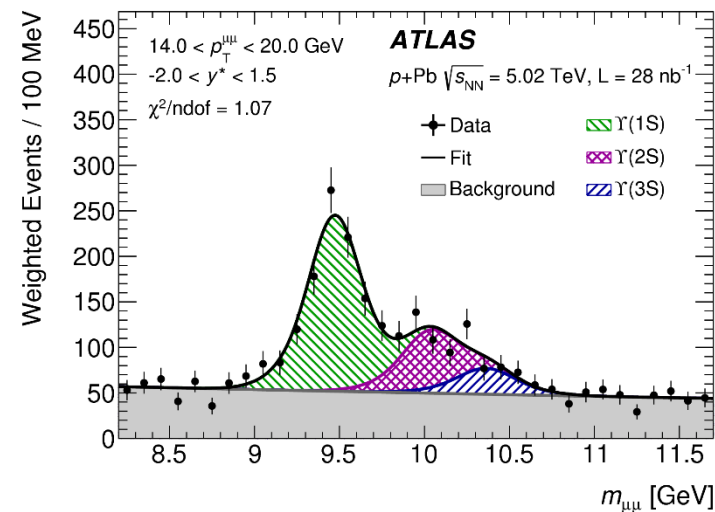
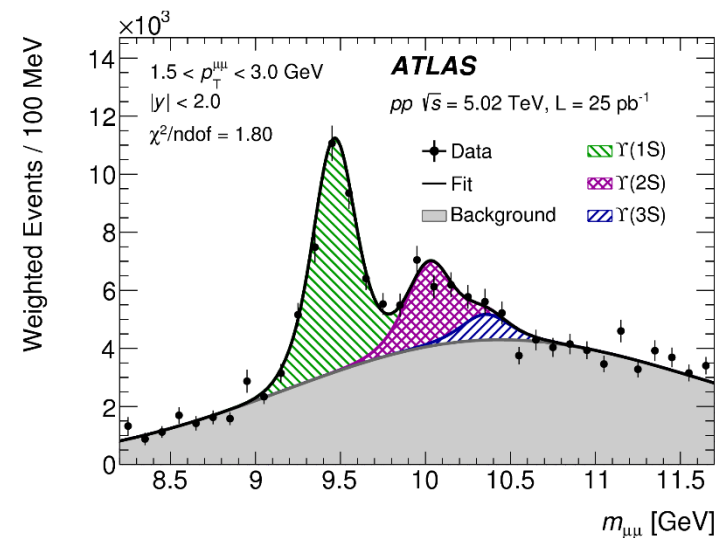
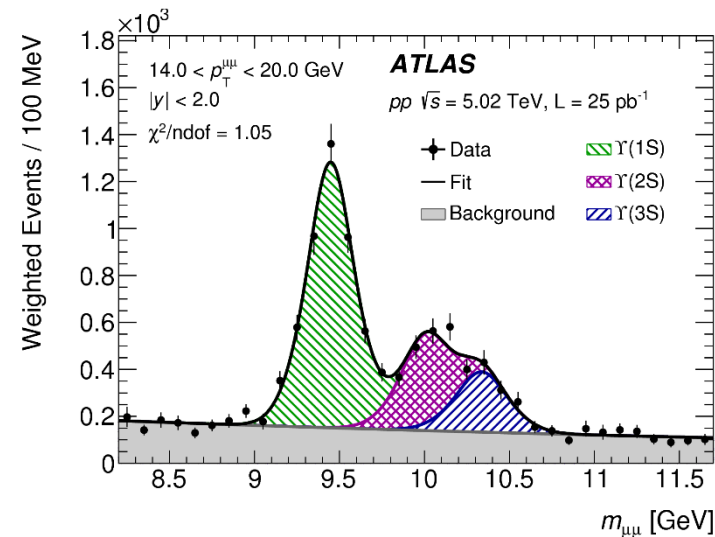
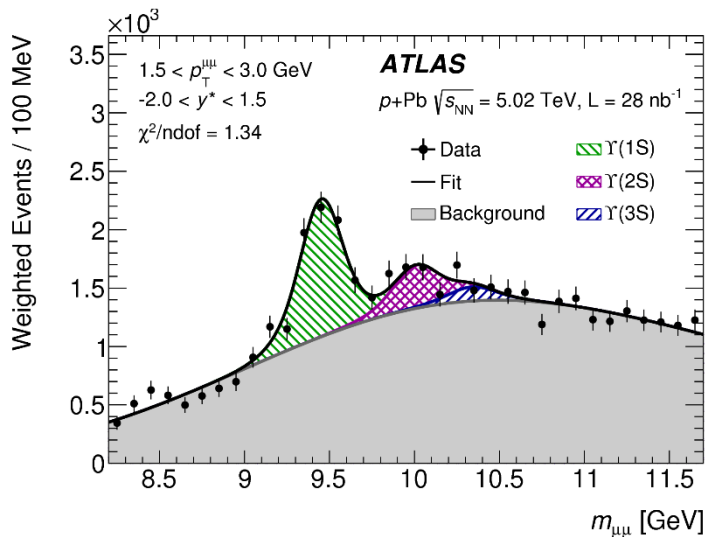
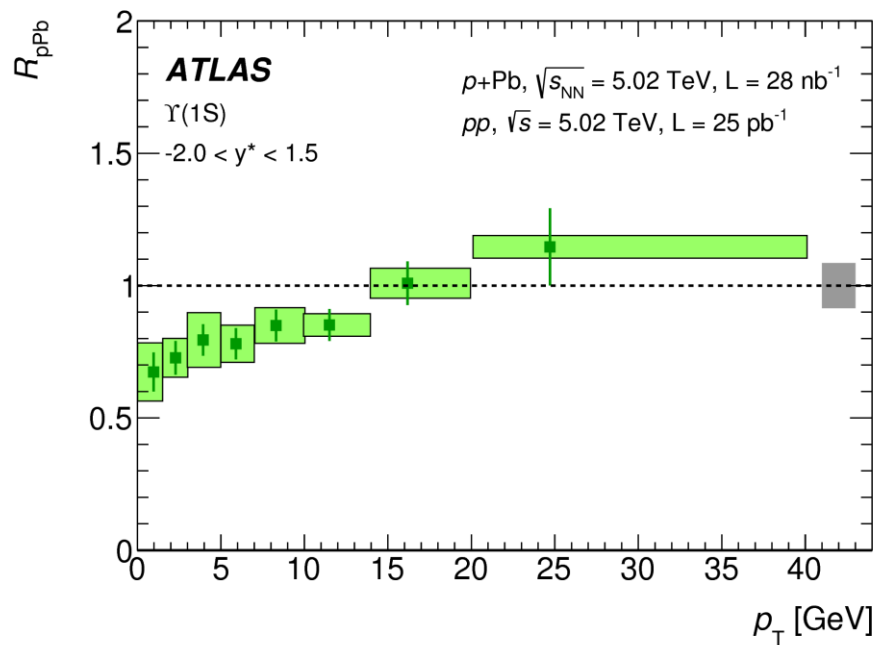
The main goal is to study the modification of J/ψ , ψ' , and $Y(nS)$ ($n=1,2,3$) in p+Pb collisions wrt to their production in pp collisions.

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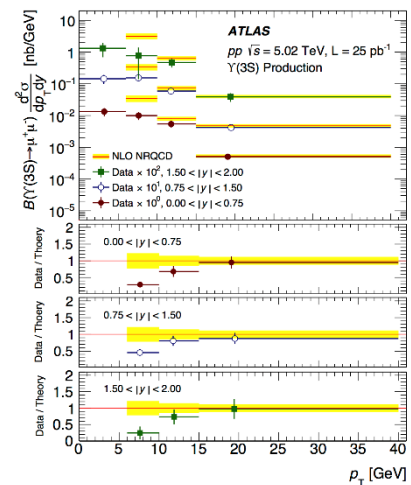
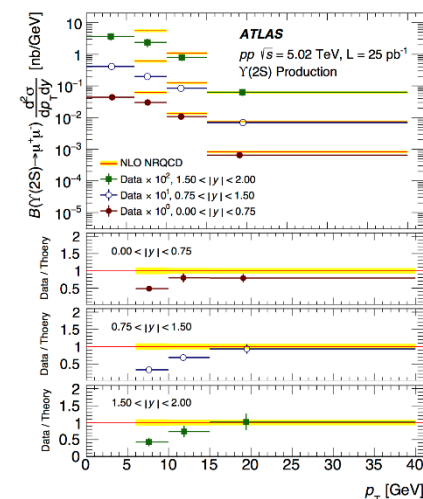
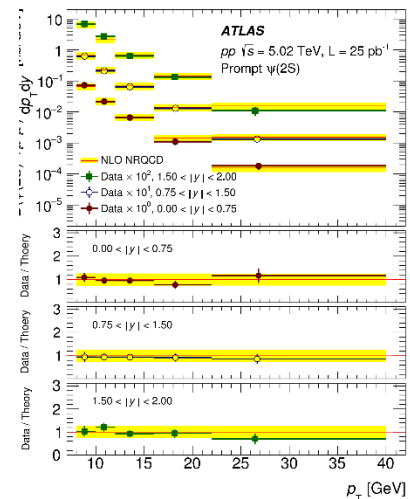
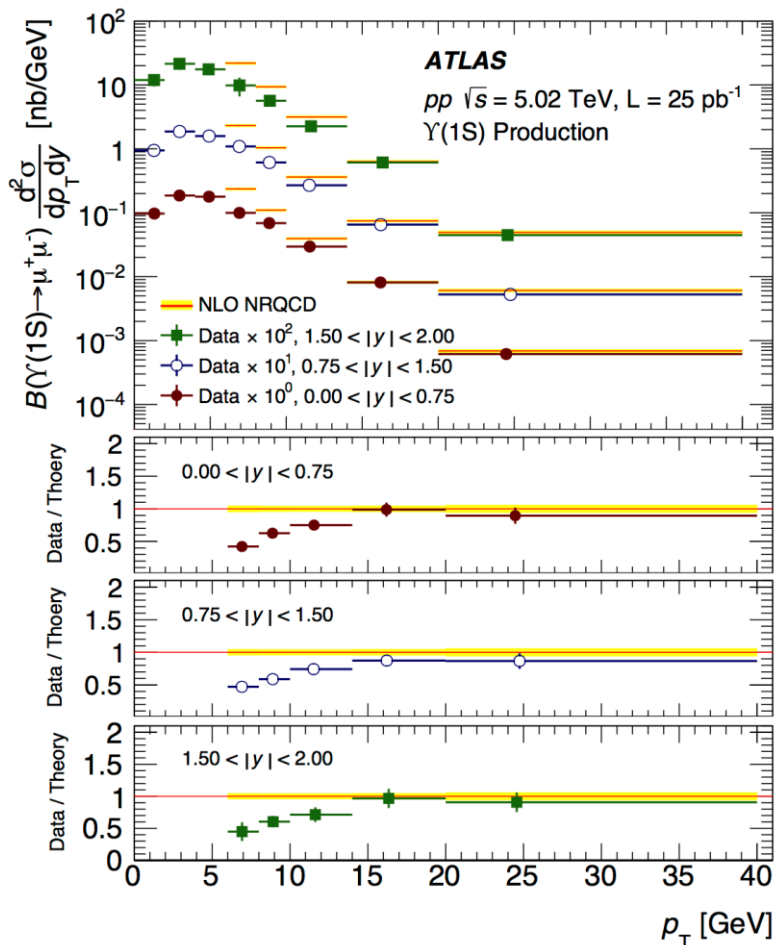
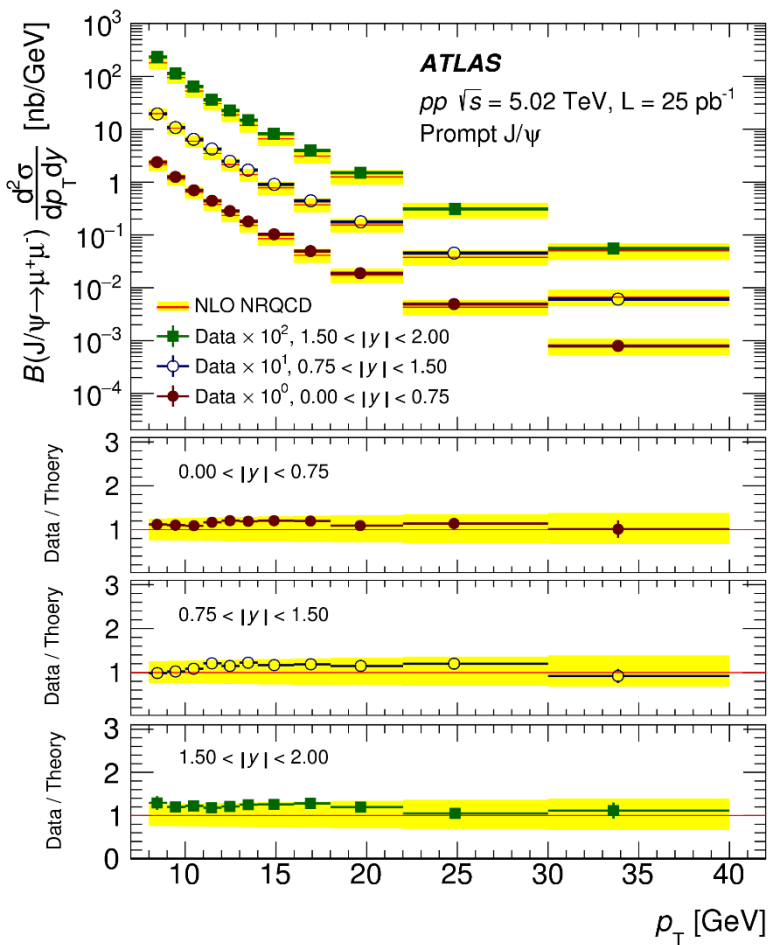


$$R_{pPb} = \frac{1}{208} \frac{\sigma_{p+Pb}^{O(nS)}}{\sigma_{pp}^{O(nS)}}$$





ATLAS quarkonium production in HL and pp collisions



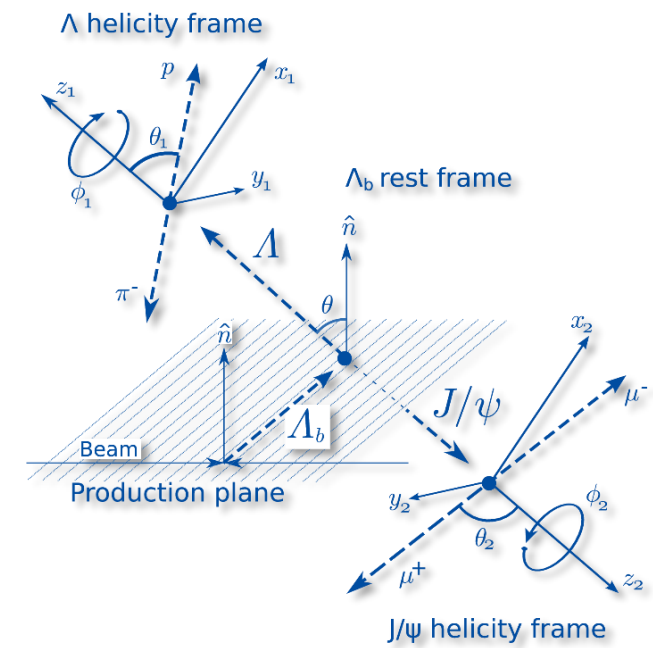
CMS Helicity study of $\Lambda_b^0 \rightarrow J/\psi \Lambda$ decays

HQET: A large fraction of *transverse* b -polarization remains after hadronization.

This analysis: $\Lambda_b \rightarrow J/\psi \Lambda$ 5D angular decay function [Kramer & Simma, *NPB-P.S. 50, 125 (1996)*] is partially integrated:

$$\frac{d^3\Gamma}{d \cos \theta_\Lambda d \cos \theta_p d \cos \theta_\mu}(\theta_\Lambda, \theta_p, \theta_\mu) = \int_{-\pi}^{\pi} \int_{-\pi}^{\pi} \frac{d^5\Gamma}{d \cos \theta_\Lambda d\Omega_p d\Omega_\mu}(\theta_\Lambda, \theta_p, \theta_\mu, \varphi_p, \varphi_\mu) d\varphi_p d\varphi_\mu$$

$$\sim \sum_{i=1}^8 u_i (|T_{\lambda_1 \lambda_2}|^2) v_i(P, \alpha_\Lambda) w_i(\theta_\Lambda, \theta_p, \theta_\mu).$$



α_Λ : asymmetry param. in $\Lambda \rightarrow p \pi^-$ decay (fixed to PDG 0.62 ± 0.013).

- **P**: Λ_b polarization. $1 = |T_{++}|^2 + |T_{+0}|^2 + |T_{-0}|^2 + |T_{--}|^2,$
- **Asymmetry param. in $\Lambda_b \rightarrow J/\psi \Lambda$** $\rightarrow \alpha_1 = |T_{++}|^2 - |T_{+0}|^2 + |T_{-0}|^2 - |T_{--}|^2,$
- Long. polarization of the Λ $\rightarrow \alpha_2 = |T_{++}|^2 + |T_{+0}|^2 - |T_{-0}|^2 - |T_{--}|^2,$
- J/ψ long./transv. pol. Parameter $\rightarrow \gamma_0 = |T_{++}|^2 - 2|T_{+0}|^2 - 2|T_{-0}|^2 + |T_{--}|^2.$

- $\rho^{(\text{LHCb})} = 0.06 \pm 0.07 \pm 0.02$
- $\rho^{(\text{HQET})} = 0.1 - 0.2$
- $\alpha_1^{(\text{LHCb})} = -\alpha_b^{(\text{LHCb})} = -0.05 \pm 0.17 \pm 0.07$
- Many theoretical predictions for α_1 :
 - 0.1 - 0.2 (PQCD, factorization, several quark models).
 - -0.78 (HQET).

CMS Helicity study of $\Lambda_b^0 \rightarrow J/\psi \Lambda$ decays

Simultaneous 3D UML fit to Λ_b^0 and $\overline{\Lambda_b^0}$ in 7 and 8 TeV data assuming CP conservation

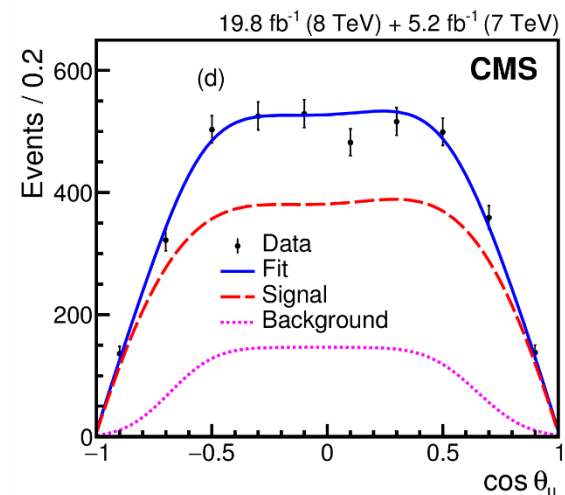
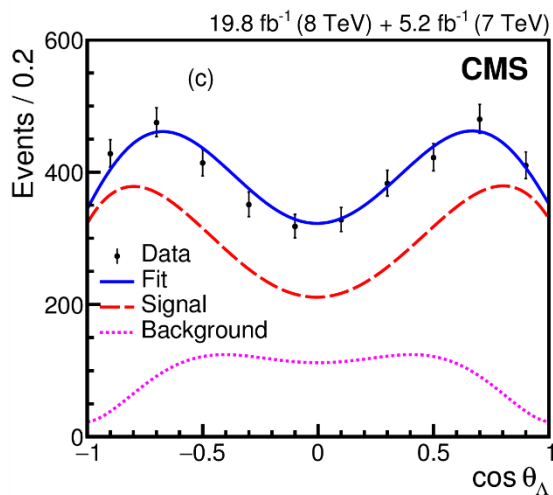
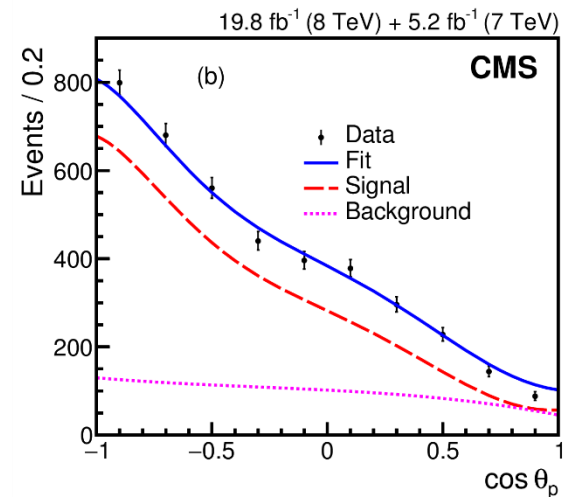
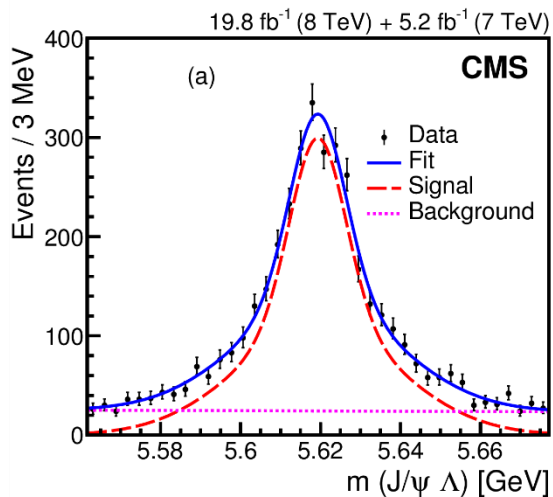
$$P = 0.00 \pm 0.06 \text{ (stat)} \pm 0.06 \text{ (syst)},$$

$$\alpha_1 = 0.14 \pm 0.14 \text{ (stat)} \pm 0.10 \text{ (syst)},$$

$$\alpha_2 = -1.11 \pm 0.04 \text{ (stat)} \pm 0.05 \text{ (syst)},$$

$$\gamma_0 = -0.27 \pm 0.08 \text{ (stat)} \pm 0.11 \text{ (syst)},$$

The measurements are consistent with LHCb results and theoretical predictions.

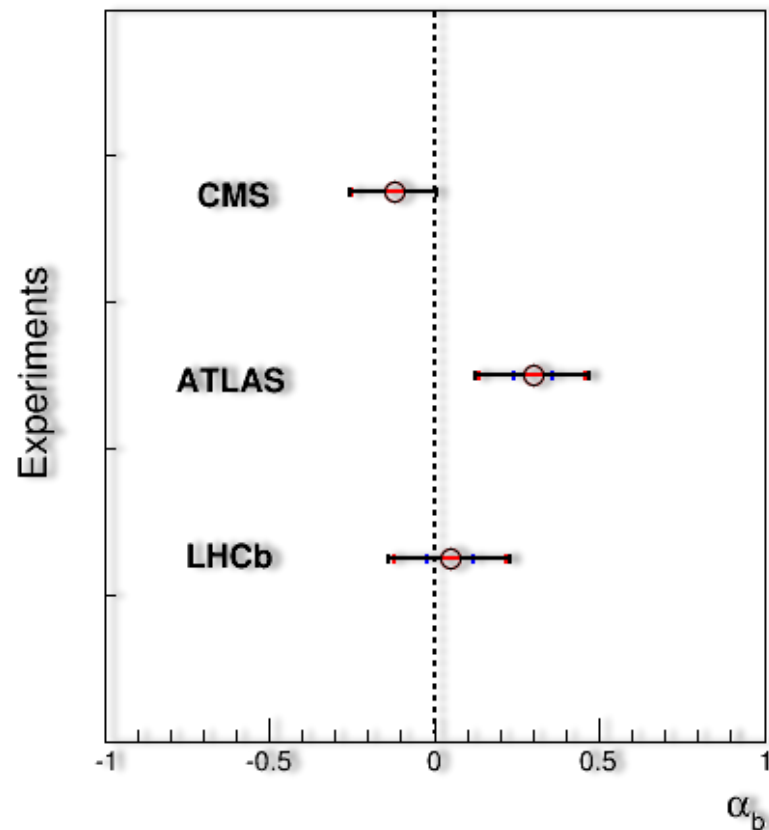
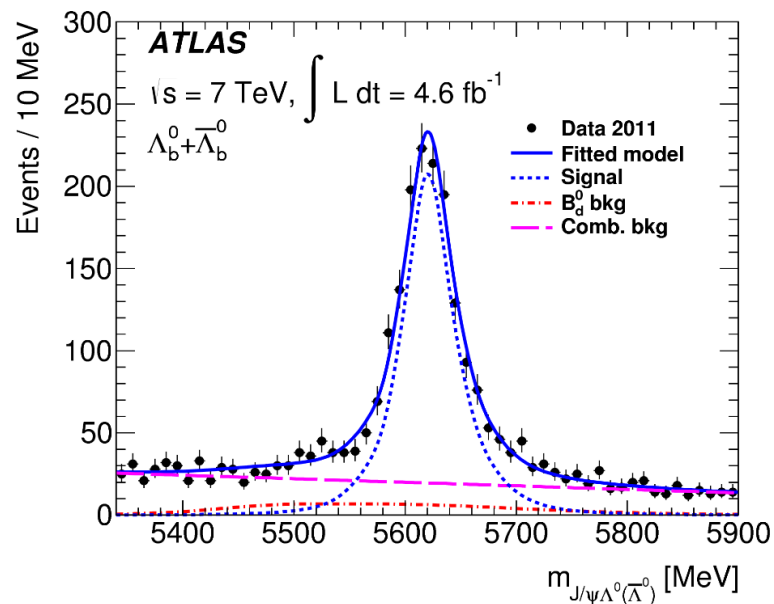


PRD 97 (2018) 072010

ATLAS Helicity study of $\Lambda_b^0 \rightarrow J/\psi \Lambda$ decays

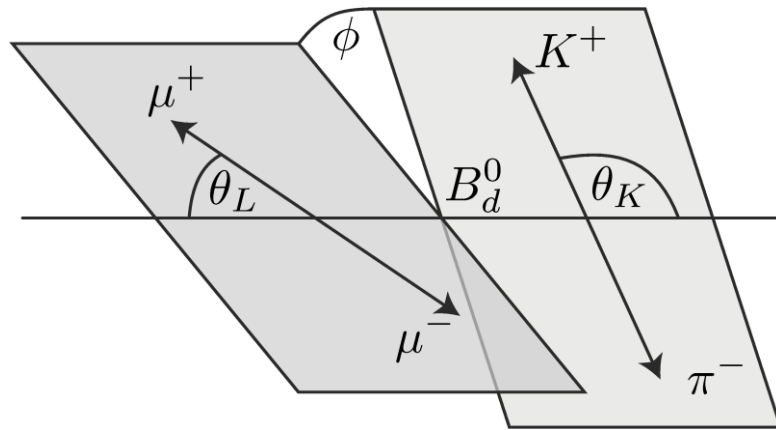
- Study performed by ATLAS with dataset at 7 TeV
- Assume zero polarization.
- Assume CP conservation.

$$\alpha_b = 0.30 \pm 0.16 \text{ (stat)} \pm 0.06 \text{ (syst)}$$



Phys. Rev. D. 89, 092009

ATLAS angular analysis of $B^0 \rightarrow K^{*0} \mu^+ \mu^-$

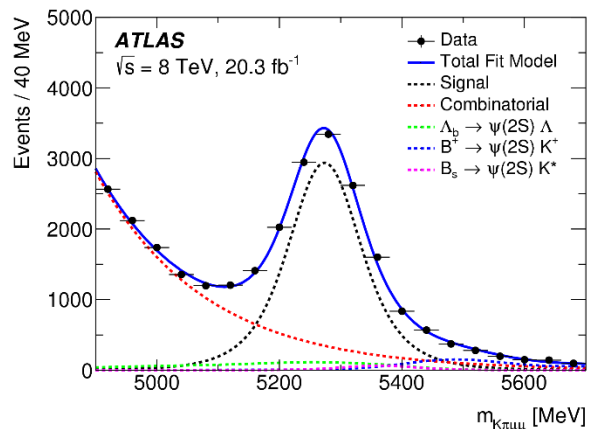
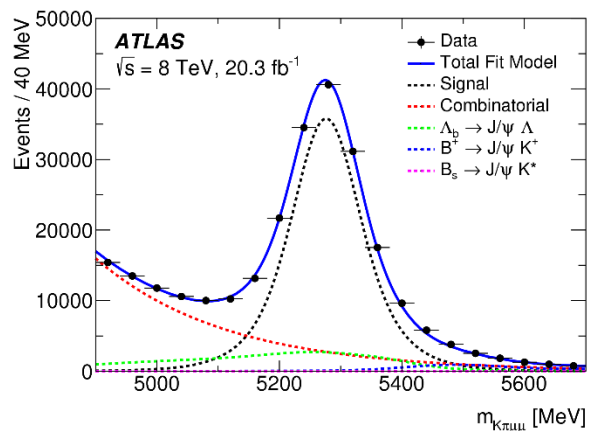


$$\frac{1}{d\Gamma/dq^2 d \cos \theta_L d \cos \theta_K d\phi dq^2} = \frac{9}{32\pi} \left[\begin{aligned} & \frac{3(1-F_L)}{4} \sin^2 \theta_K + F_L \cos^2 \theta_K + \frac{1-F_L}{4} \sin^2 \theta_K \cos 2\theta_L \\ & - F_L \cos^2 \theta_K \cos 2\theta_L + S_3 \sin^2 \theta_K \sin^2 \theta_L \cos 2\phi \\ & + S_4 \sin 2\theta_K \sin 2\theta_L \cos \phi + S_5 \sin 2\theta_K \sin \theta_L \cos \phi \\ & + S_6 \sin^2 \theta_K \cos \theta_L + S_7 \sin 2\theta_K \sin \theta_L \sin \phi \\ & + S_8 \sin 2\theta_K \sin 2\theta_L \sin \phi + S_9 \sin^2 \theta_K \sin^2 \theta_L \sin 2\phi \end{aligned} \right].$$

This is a FCNC decay channel on which LHCb has reported a potential hint on a deviation of 3.4 sigmas from the SM calculations.

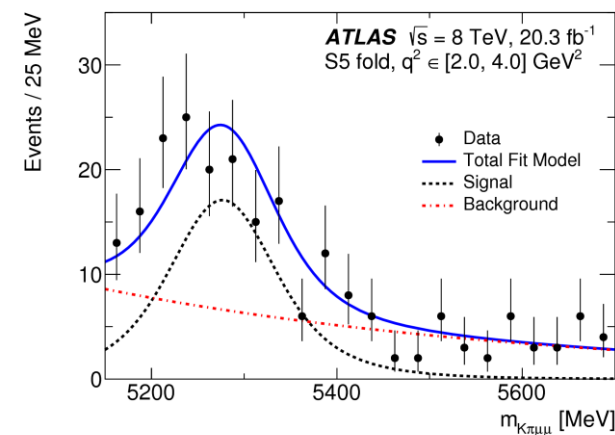
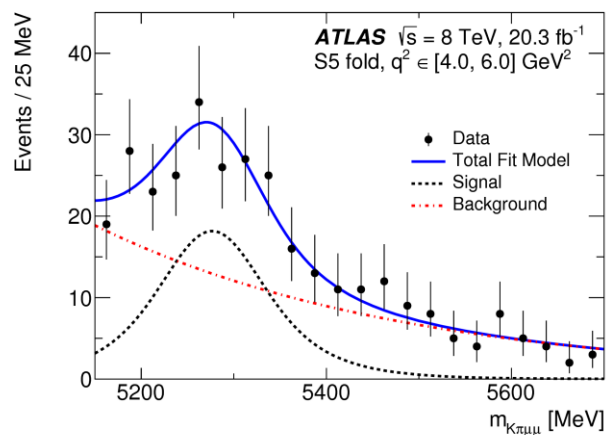
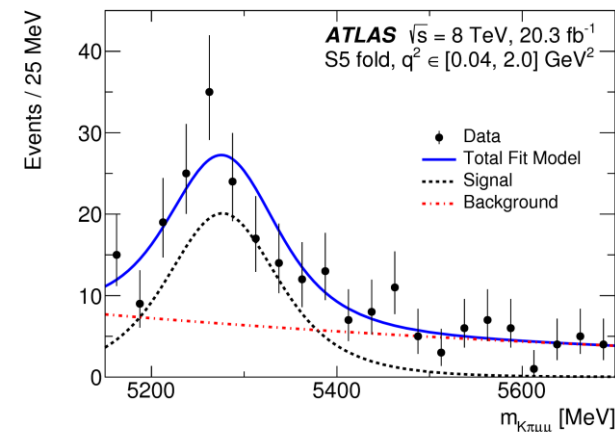
$$\begin{aligned} P_1 &= \frac{2S_3}{1-F_L} \\ P_2 &= \frac{2}{3} \frac{A_{FB}}{1-F_L} \\ P_3 &= -\frac{S_9}{1-F_L} \\ P'_{j=4,5,6,8} &= \frac{S_{i=4,5,7,8}}{\sqrt{F_L(1-F_L)}}. \end{aligned}$$

ATLAS angular analysis of $B^0 \rightarrow K^{*0} \mu^+ \mu^-$

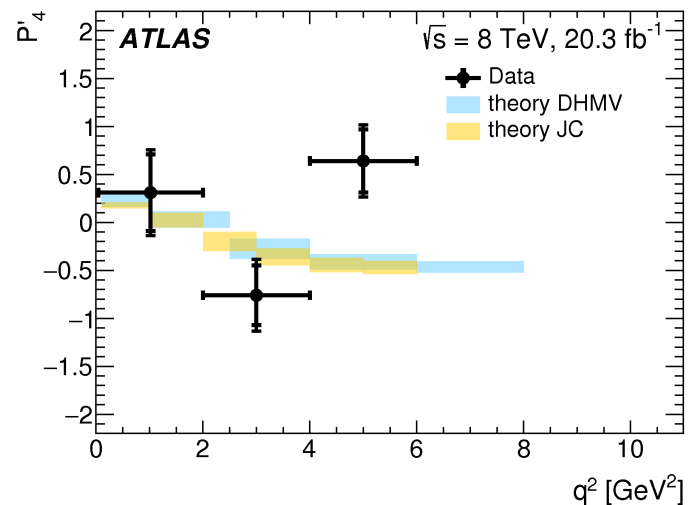
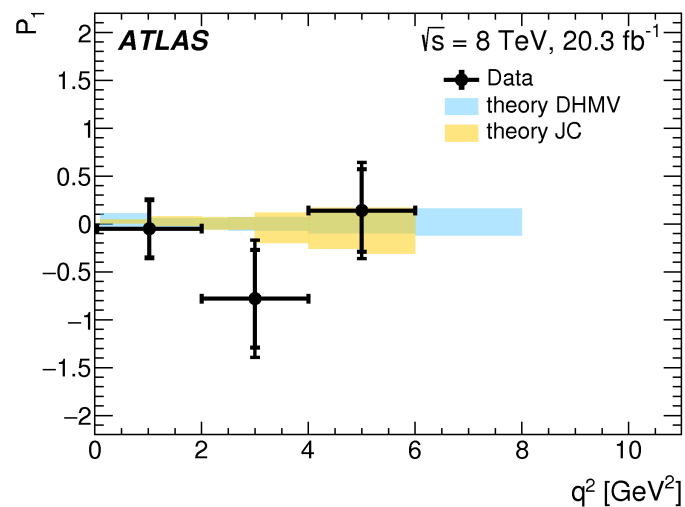
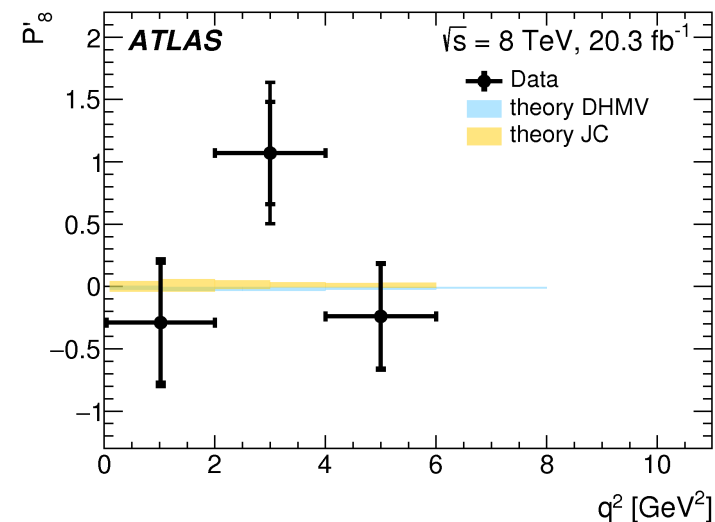
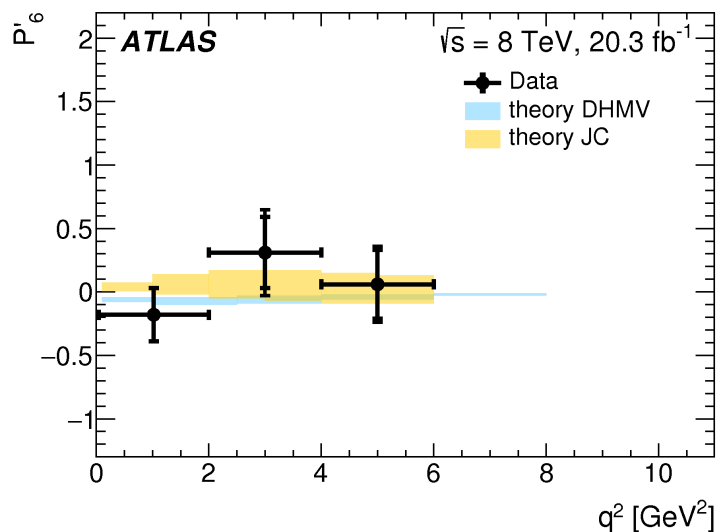
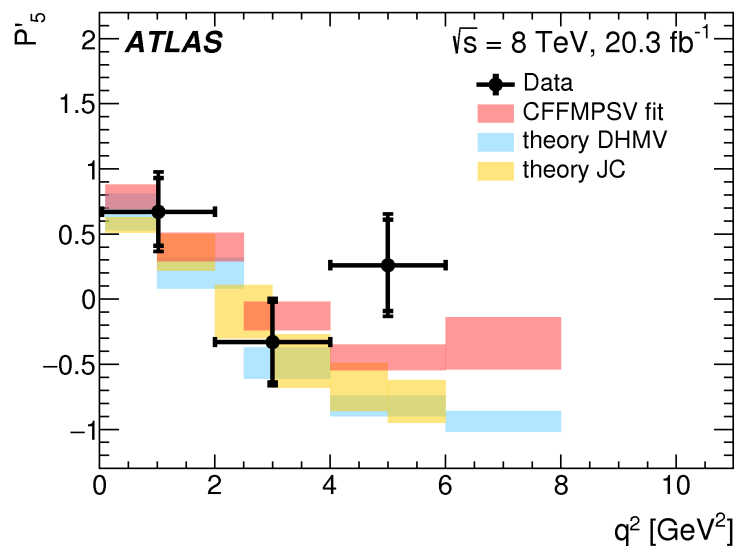


Control samples

q^2 [GeV^2]	n_{signal}	$n_{\text{background}}$
[0.04, 2.0]	128 ± 22	122 ± 22
[2.0, 4.0]	106 ± 23	113 ± 23
[4.0, 6.0]	114 ± 24	204 ± 26
[0.04, 4.0]	236 ± 31	233 ± 32
[1.1, 6.0]	275 ± 35	363 ± 36
[0.04, 6.0]	342 ± 39	445 ± 40



ATLAS angular analysis of $B^0 \rightarrow K^{*0} \mu^+ \mu^-$

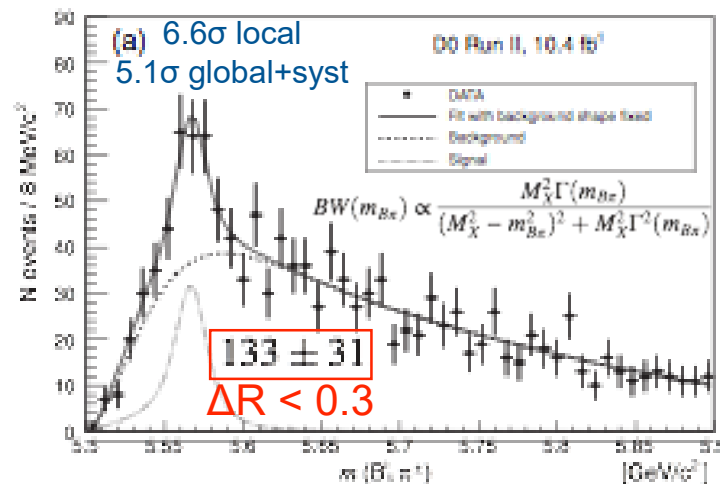


All results are compatible within 3 s.d. with different predictions, and are compatibles with results from the LCHb, CMS, and Belle experiments.

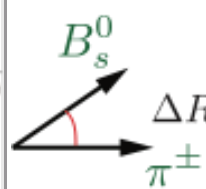
Submitted to JHEP

Search for X^+ (5568) $\rightarrow B_S \pi^+$

- DZero reported the observation of a tetraquark candidate in $X^+(5568) \rightarrow B_S \pi^+$
- LHCb reported a non-confirmation result of these candidate.
- CMS and ATLAS has recollected several thousands of $B_S \rightarrow J/\psi \phi$ decays on what to look for.



$$\begin{aligned}
 M_X &= 5567.8 \pm 2.9^{+0.9}_{-1.9} \text{ MeV} \\
 \Gamma_X &= 21.9 \pm 6.4^{+5.0}_{-2.5} \text{ MeV} \\
 &\text{Strong decay!} \\
 N_X &= 133 \pm 31 \pm 15 \text{ cand.}
 \end{aligned}$$



Loosely Bound Hadronic Molecule?

Not favored due to mass far from B-K thresh.



Tetraquark?

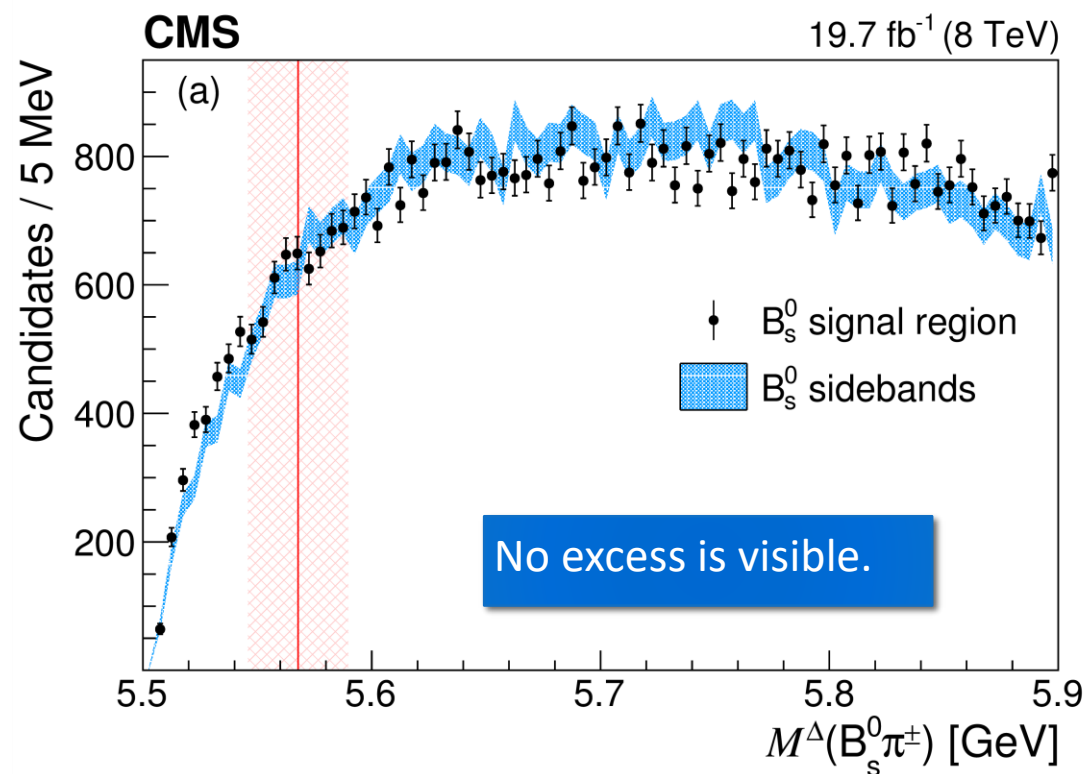
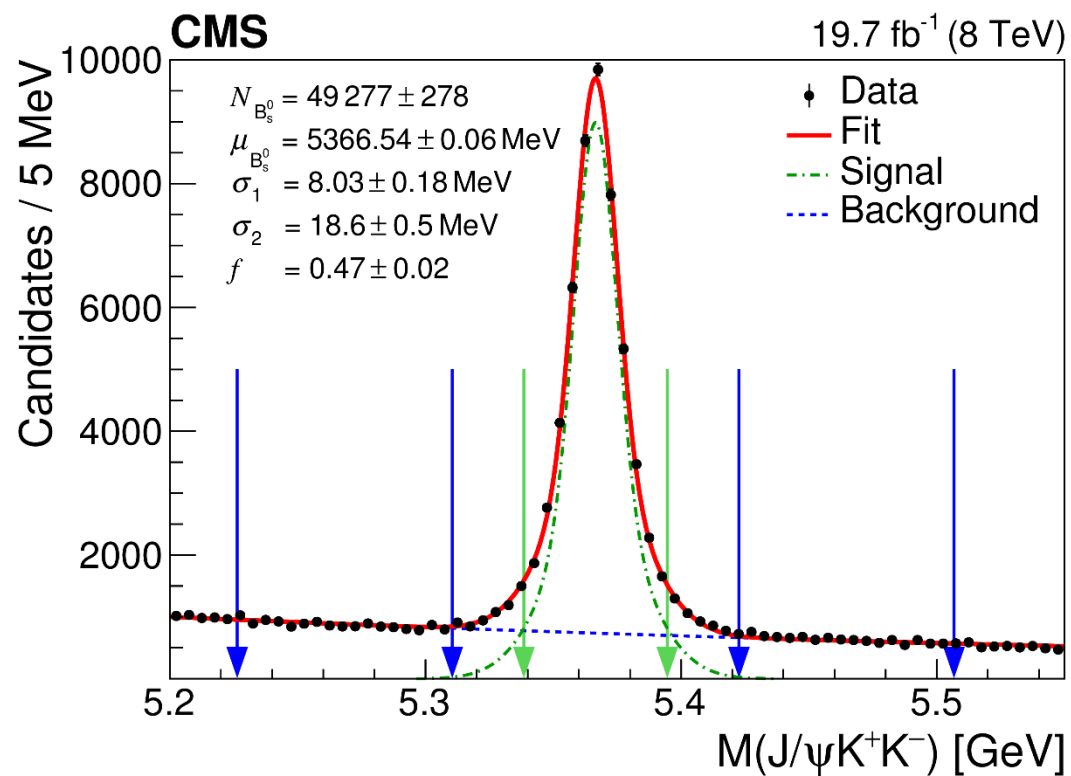
Possible, but theory predicts more states

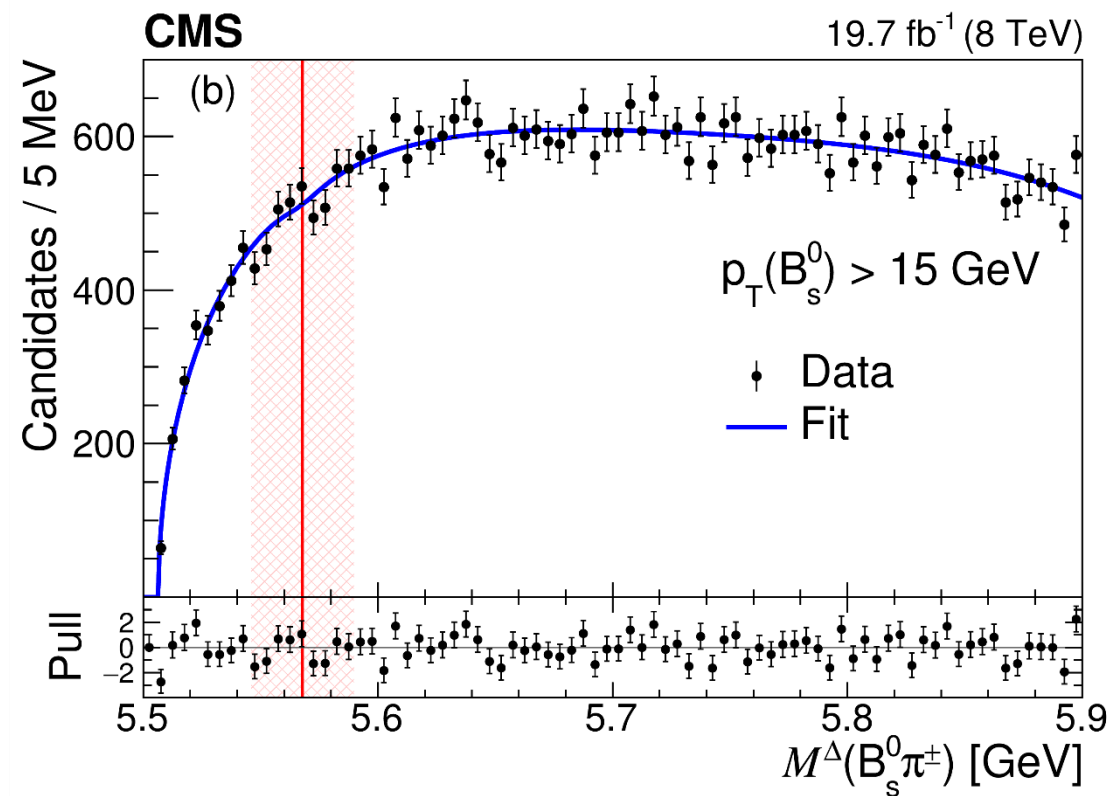
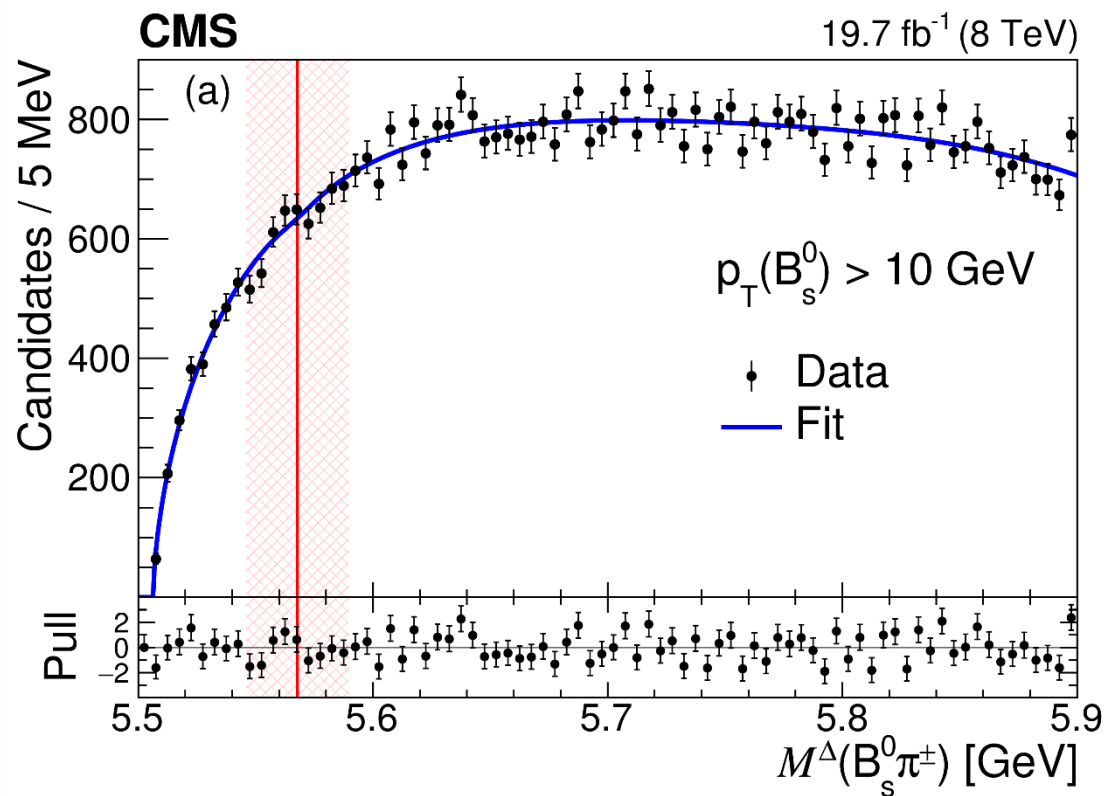
- If $X(5568)^- \rightarrow B_s^0 \pi^-$ then $J^P = 0^+$
- If $X(5617)^- \rightarrow B_s^{0*} \pi^-$ then $J^P = 1^+$
 $\hookrightarrow B_s^0 \gamma$ miss!

$$\rho_X \equiv \frac{\sigma(pp \rightarrow X(5558) + \text{anything}) \times B(X(5558) \rightarrow B_S \pi^\pm)}{\sigma(pp \rightarrow B_S + \text{anything})} = \frac{N_X}{N_{B_S}} \frac{\epsilon_{B_S}}{\epsilon_X}$$

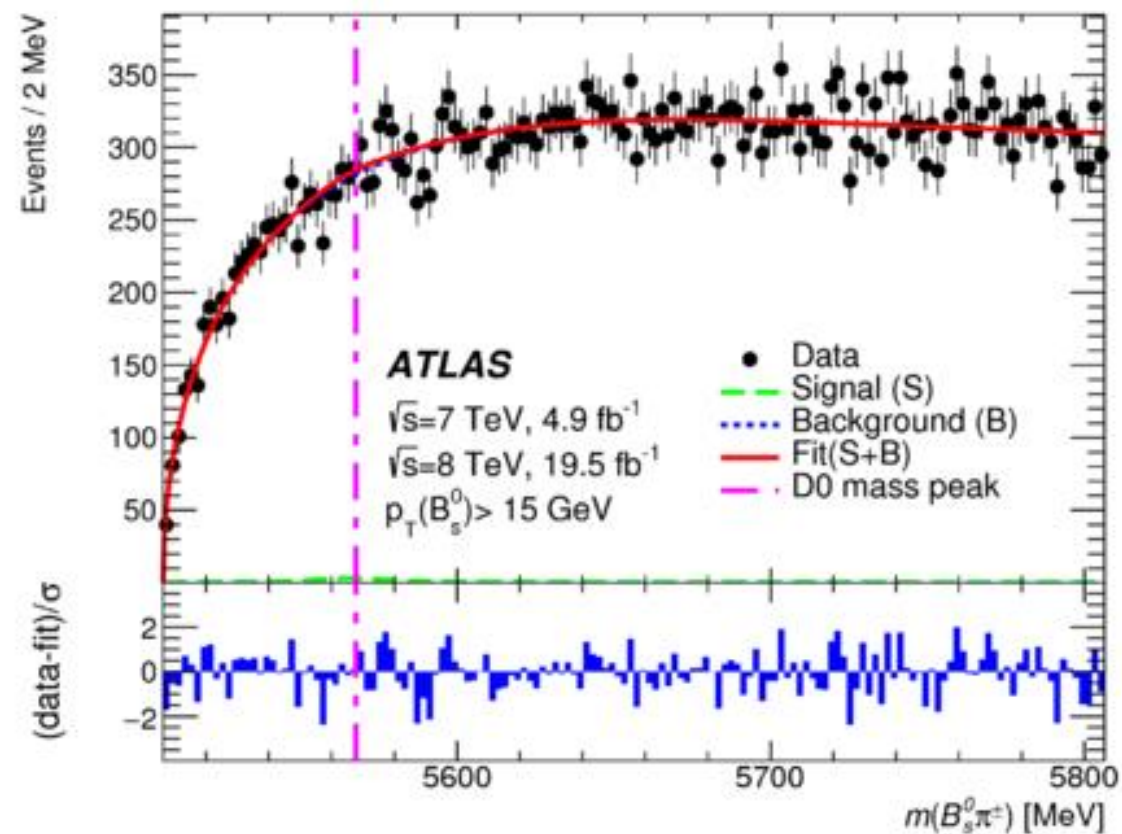
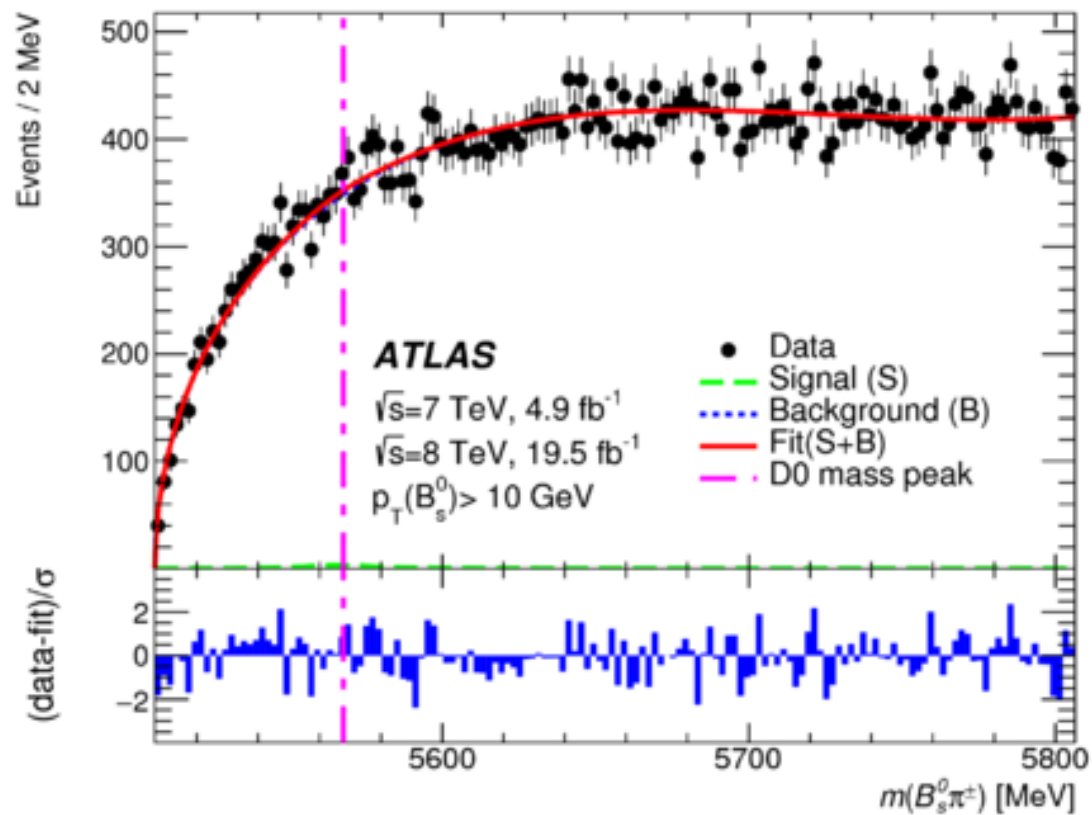
CMS search for $X^+ (5568) \rightarrow B_s \pi^+$

Search for resonances in the $B_s \pi^\pm$ invariant mass spectrum: $B_s (\rightarrow J/\psi \phi(1020)) +$ prompt pion.

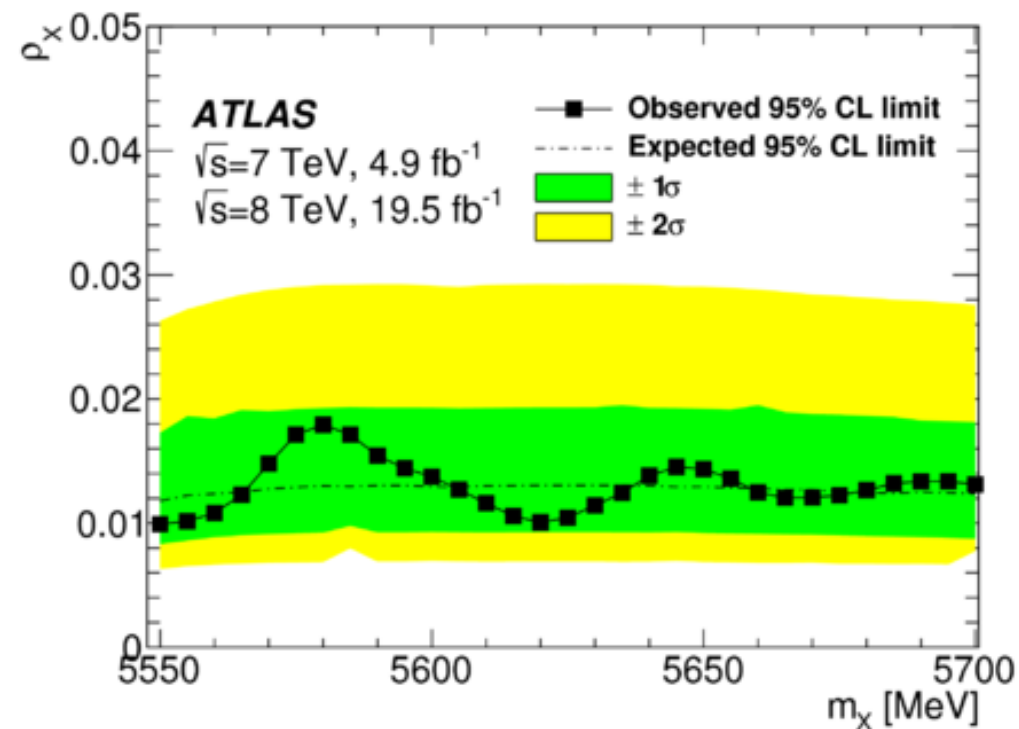
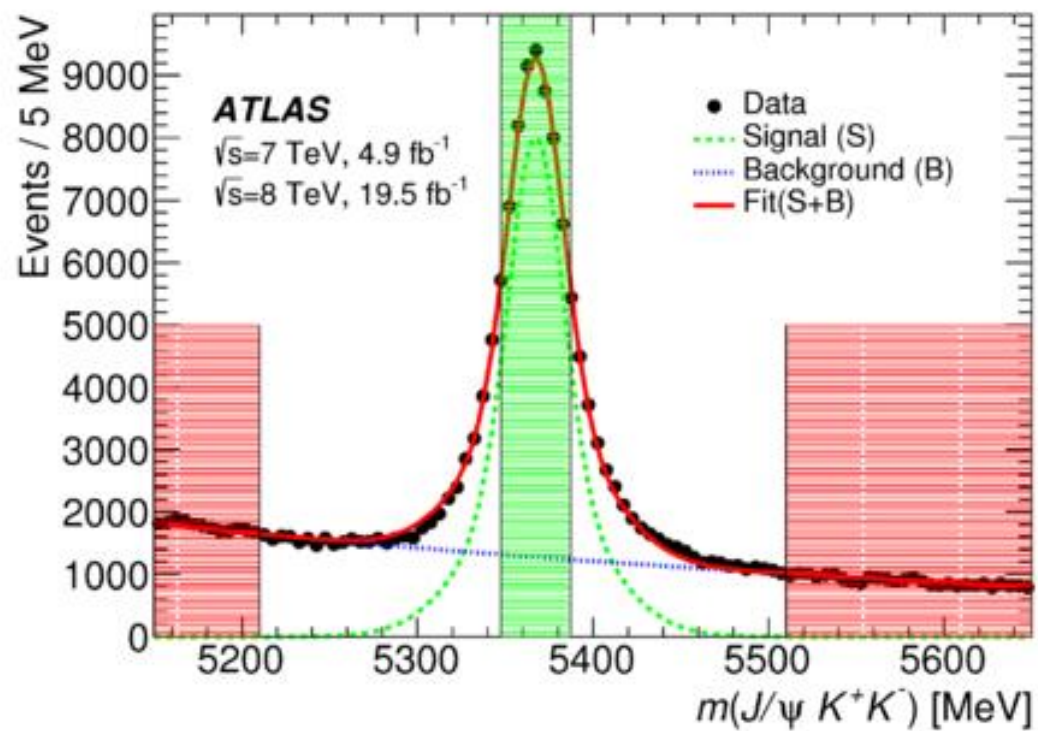




ATLAS search for $X^+ (5568) \rightarrow B_s \pi^+$



ATLAS search for X^+ (5568) $\rightarrow B_s \pi^+$



Summary of the search for $X^+ (5568) \rightarrow B_s \pi^+$

- CMS and ATLAS find not significant structure in $M(B_s \pi^\pm)$ for masses up to 5.9 GeV, disfavoring predictions of tetraquark models.
- No signal found despite trying different kinematic & quality cuts, variants of bkg. modeling and fit regions.

CMS:

$\rho_X < 1.1\%$ @95% C.L. for $p_T(B_s) > 10$ GeV

$\rho_X < 1.0\%$ @95% C.L. for $p_T(B_s) > 15$ GeV

PRL 120, 202005 (2018)

ATLAS:

$\rho_X < 1.5\%$ @95% C.L. for $p_T(B_s) > 10$ GeV

$\rho_X < 1.6\%$ @95% C.L. for $p_T(B_s) > 15$ GeV

PRL 120, 202007 (2018)

More recently
(pub. last week)

CDF: $\rho < 6.7\%$ for $p_T(B_s) > 10$ GeV & $|y| \lesssim 1$
does not favor D0 results [PRL 120, 202006 (2018)]

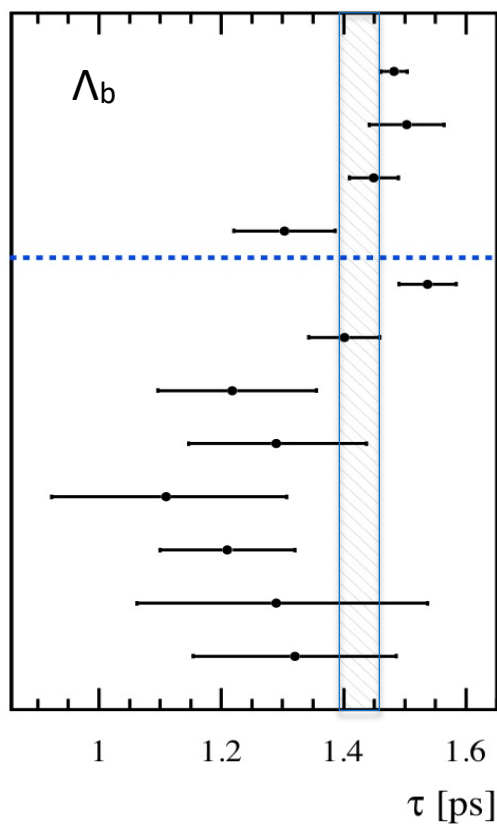
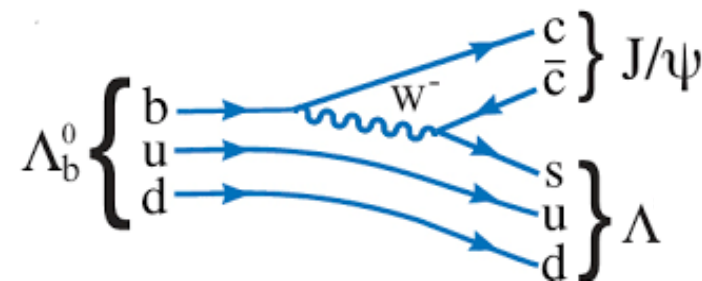
$\rho_X^{DZero} = 8.6 \pm 1.9$ (stat) ± 1.4 (syst.) % hadronic
 $\rho_X^{DZero} = 7.3_{-2.4}^{+2.8}$ (stat) $_{-1.7}^{+0.6}$ (syst.) % Semileptonic

See A. Druskoi presentation.

D0: reconfirms with 6.7σ using B_s semileptonic decays [PRD 97, 092004 (2018)]

b hadron lifetimes

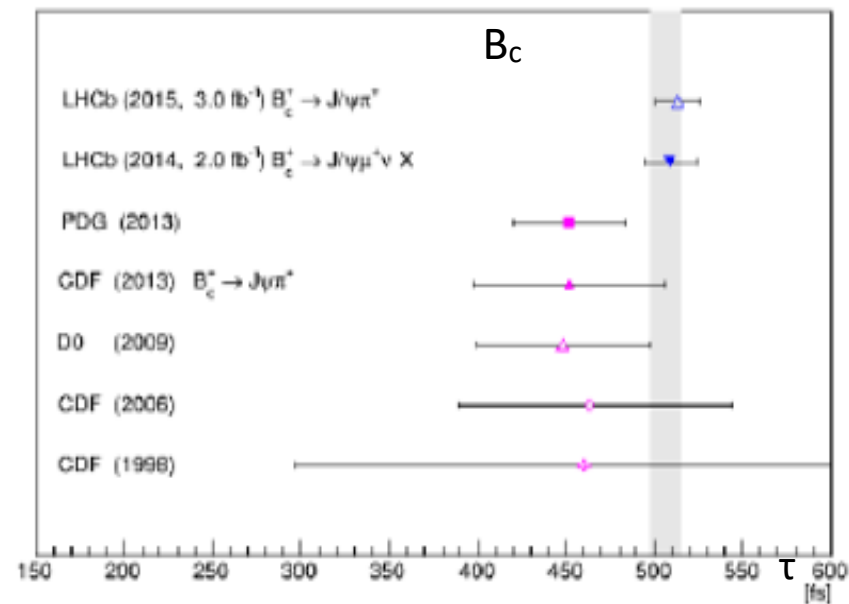
- B-lifetimes determine importance of non-spectator contributions.
- Discrepancies among previous measurements of, e.g., Λ_b & B_c^+ lifetimes:



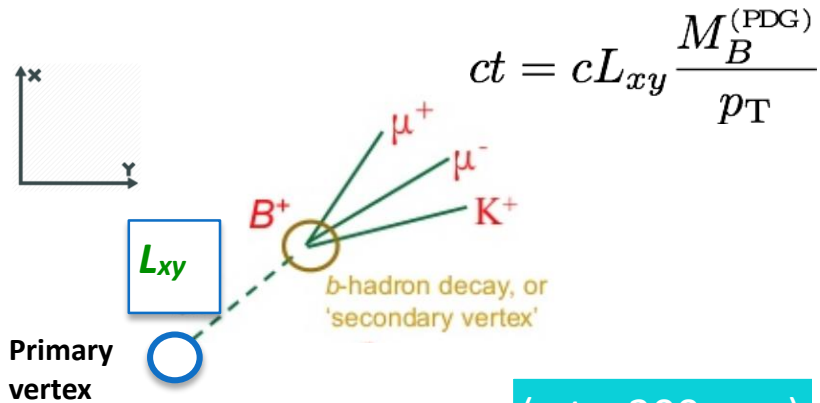
Experiment

- LHCb (2013) [$J/\psi p K^-$]
- CMS (2012) [$J/\psi \Lambda$]
- ATLAS (2012) [$J/\psi \Lambda$]
- D0 (2012) [$J/\psi \Lambda$]
- CDF (2011) [$J/\psi \Lambda$]
- CDF (2010) [$\Lambda_c^+ \pi^-$]
- D0 (2007) [$J/\psi \Lambda$]
- D0 (2007) [Semileptonic decay]
- DLPH (1999) [Semileptonic decay]
- ALEP (1998) [Semileptonic decay]
- OPAL (1998) [Semileptonic decay]
- CDF (1996) [Semileptonic decay]

<http://www.quantumdiaries.org/tag/b-physics/>



LHCb results significantly larger than Tevatron measurements



($ct > 200 \mu\text{m}$)

Measurements **based on reconstruction** of the transverse decay length L_{xy} and UML fits of reco. mass (M), ct and σ_{ct} of the b hadrons:

$$B^+, B^0, B_s, \Lambda_b^0$$

$B^+ \rightarrow J/\psi K^+$: reference mode, for evaluation of syst. uncertainties.

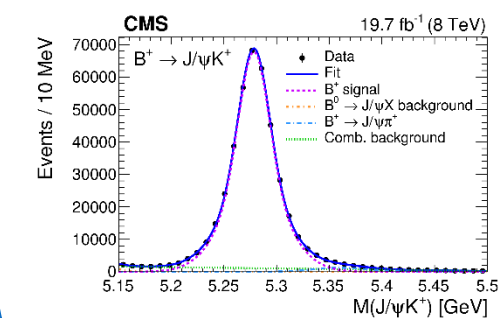
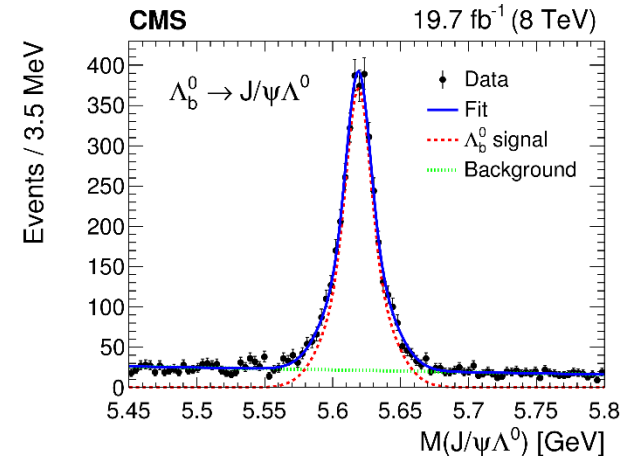
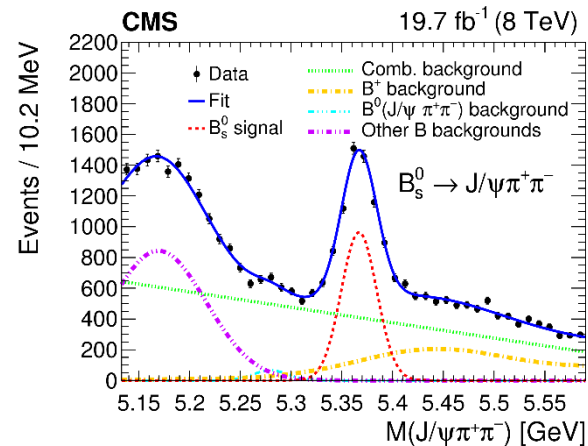
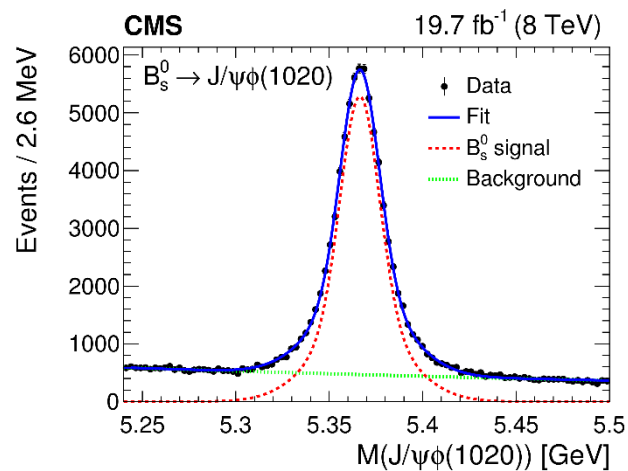
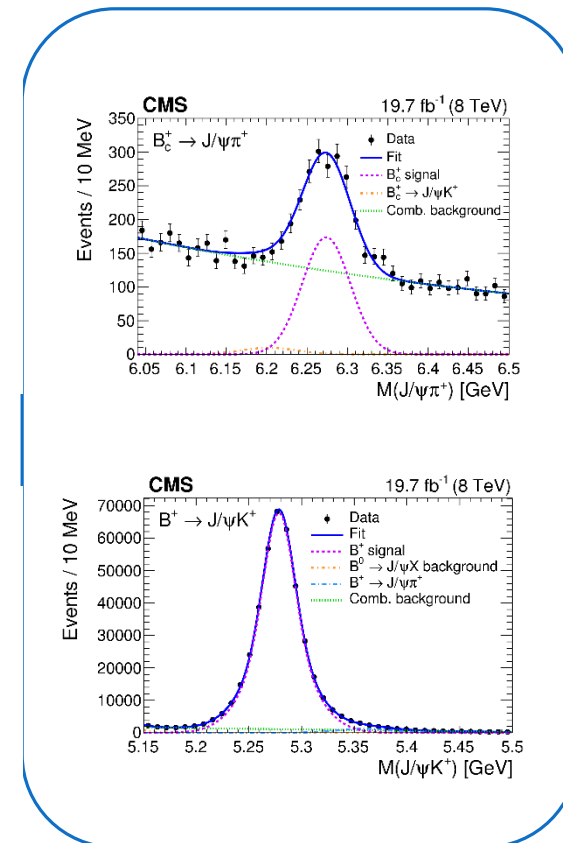
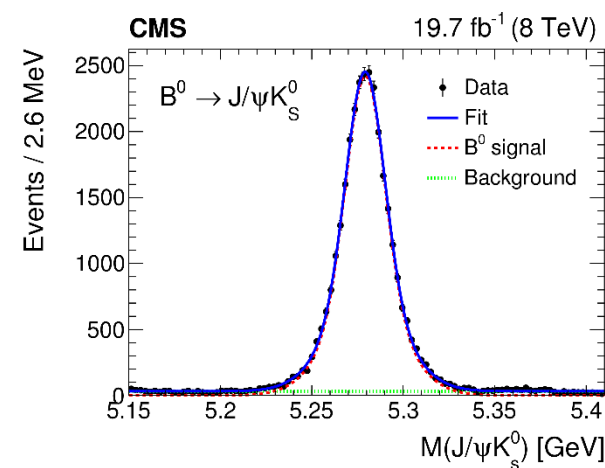
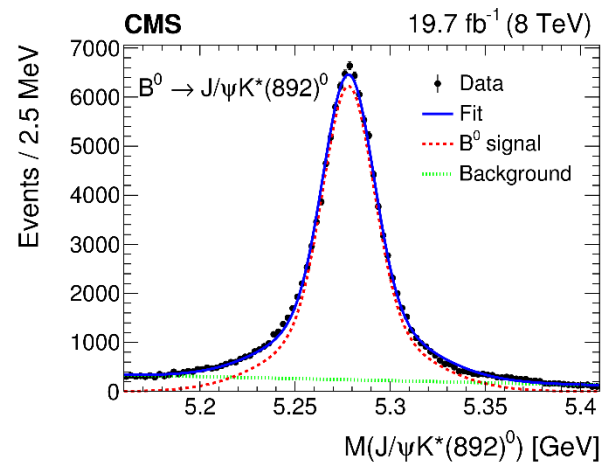
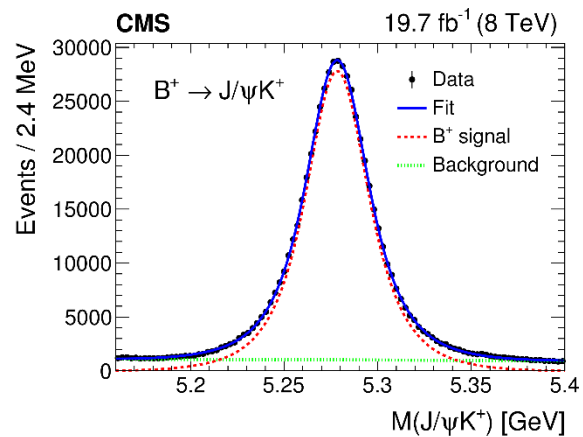
For the B_c meson, we use a ratio technique:

$$R(ct) \equiv \frac{N_{B_c^+}(ct)}{N_{B^+}(ct)} \approx R_\varepsilon(ct) \exp(-\Delta\Gamma t)$$

$$\Delta\Gamma \equiv \Gamma_{B_c^+} - \Gamma_{B^+} = \frac{1}{\tau_{B_c^+}} - \frac{1}{\tau_{B^+}}$$

$$\text{PDF} = f_S M_S(M) T_S(ct) E_S(\sigma_{ct}) + (1 - f_S) M_B(M) T_B(ct) E_B(\sigma_{ct})$$

Mass distributions of b hadrons



$$\left. \begin{aligned}
 c\tau_{B^0 \rightarrow J/\psi K^{*(892)0}} &= 453.0 \pm 1.6 \text{ (stat)} \pm 1.8 \text{ (syst)} \mu\text{m} \\
 c\tau_{B^0 \rightarrow J/\psi K_S^0} &= 457.0 \pm 2.7 \text{ (stat)} \pm 2.8 \text{ (syst)} \mu\text{m} \\
 c\tau_{B_s^0 \rightarrow J/\psi \pi^+ \pi^-} &= 502.7 \pm 10.2 \text{ (stat)} \pm 3.4 \text{ (syst)} \mu\text{m} \\
 c\tau_{B_s^0 \rightarrow J/\psi \phi(1020)} &= 443.9 \pm 2.0 \text{ (stat)} \pm 1.5 \text{ (syst)} \mu\text{m} \\
 c\tau_{\Lambda_b^0} &= 442.9 \pm 8.2 \text{ (stat)} \pm 2.8 \text{ (syst)} \mu\text{m} \\
 c\tau_{B_c^+} &= 162.3 \pm 7.8 \text{ (stat)} \pm 4.2 \text{ (syst)} \pm 0.1 (\tau_{B^+}) \mu\text{m}
 \end{aligned} \right\} c\tau_{B^0} = 454.1 \pm 1.4 \text{ (stat)} \pm 1.7 \text{ (syst)} \mu\text{m}$$

vs. $455.7 \pm 1.2 \mu\text{m}$ (HFAG)
 vs. 495 ± 10 (LHCb), 510 ± 36 (CDF), $508 \pm 45 \mu\text{m}$ (D0)
 vs. $443.4 \pm 3.6 \mu\text{m}$ (HFAG)
 vs. $440.7 \pm 3.0 \mu\text{m}$ (HFAG)
 vs. $152.0 \pm 2.7 \mu\text{m}$ (HFAG)

Precision from each channel is as good as or better than previous measurements.

**Accepted by EPJC
(arXiv:1710.08949)**

$$\begin{aligned}
 \tau_{\Lambda_b^0} / \tau_{B^0 \rightarrow J/\psi K^{*(892)0}} &= 0.978 \pm 0.018 \text{ (stat)} \pm 0.006 \text{ (syst)} && \text{vs. } 0.967 \pm 0.007 \text{ (HFAG)} \\
 \tau_{B_s^0 \rightarrow J/\psi \phi(1020)} / \tau_{B^0 \rightarrow J/\psi K^{*(892)0}} &= 0.980 \pm 0.006 \text{ (stat)} \pm 0.003 \text{ (syst)} && \text{vs. } 0.993 \pm 0.004 \text{ (HFAG)}
 \end{aligned}$$

Ratios compatible with the current W.A. values ($\lesssim 1.5\sigma$)

Combination of these results leads to:

$$\begin{aligned}
 \Gamma_d &= 0.662 \pm 0.003 \text{ (stat)} \pm 0.003 \text{ (syst)} ps^{-1} \\
 \Delta\Gamma_d &= 0.023 \pm 0.015 \text{ (stat)} \pm 0.016 \text{ (syst)} ps^{-1} \\
 \Delta\Gamma_d / \Gamma_d &= 0.034 \pm 0.023 \text{ (stat)} \pm 0.024 \text{ (syst)} && \text{vs. } -0.002 \pm 0.010 \text{ (HFAG)} \\
 c\tau_L(B_s) &= 420.4 \pm 6.2 \mu\text{m} && \text{vs. } 423.6 \pm 1.8 \mu\text{m} \text{ (HFAG)}
 \end{aligned}$$

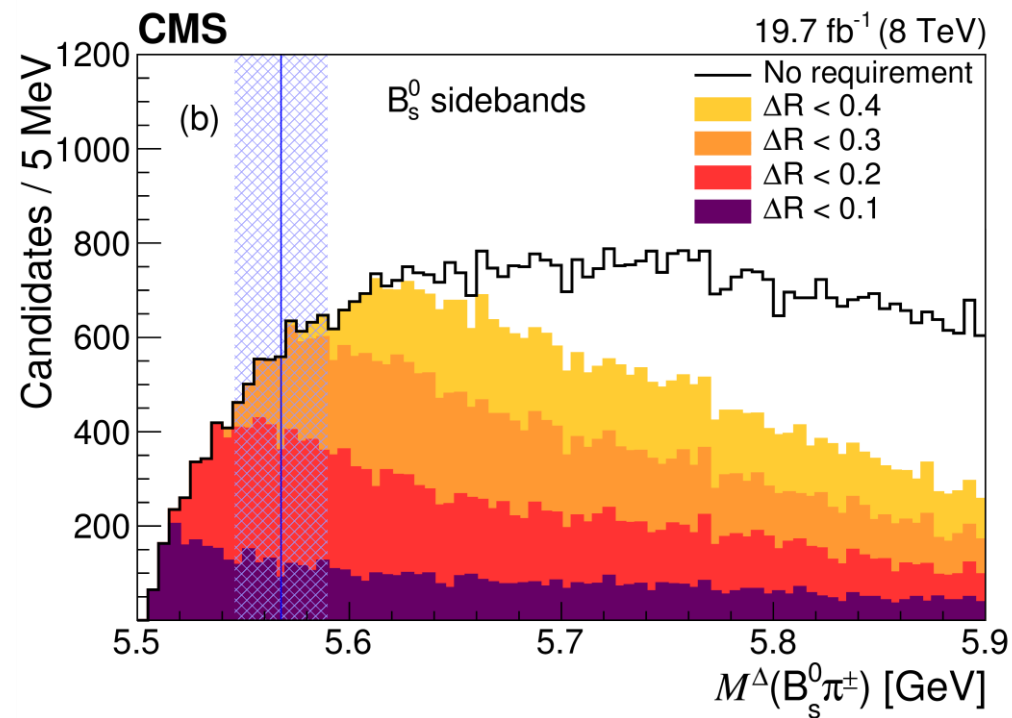
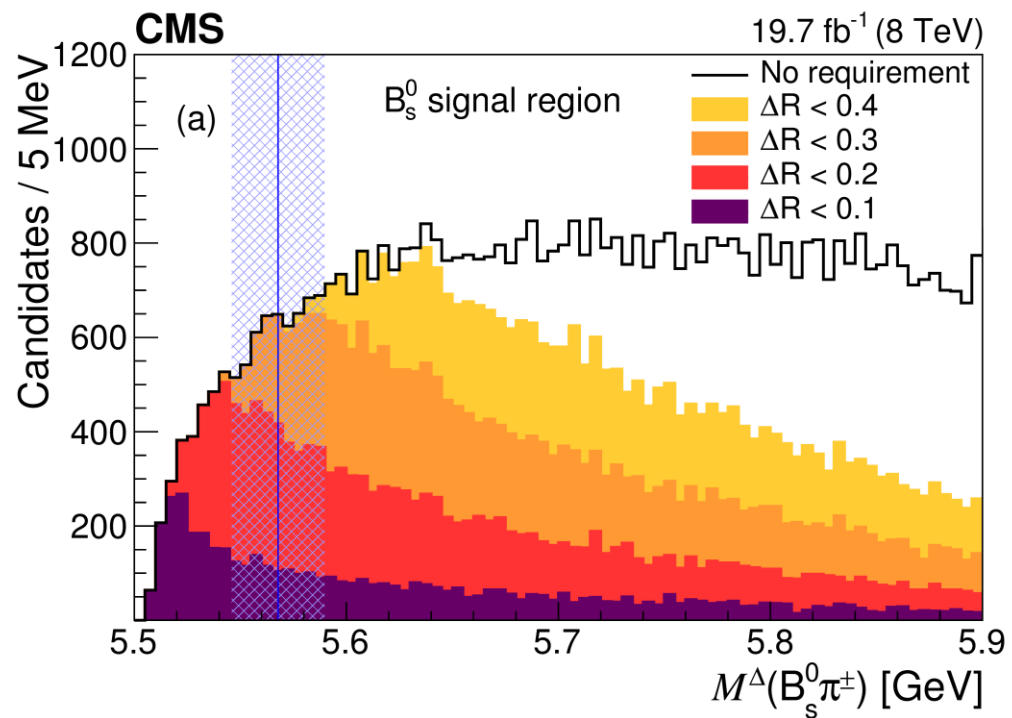
All results are in agreement with current W.A. values and with HQE predictions and other theoretical models

Conclusion and prospects

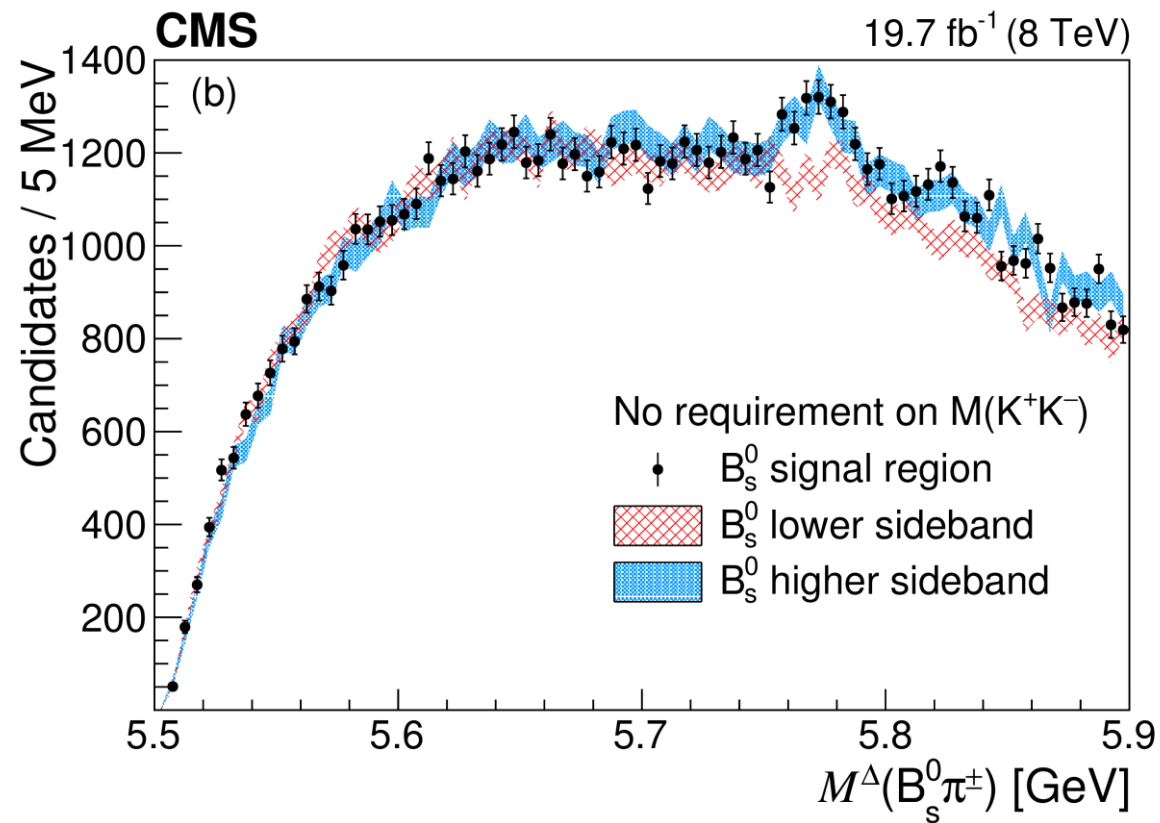
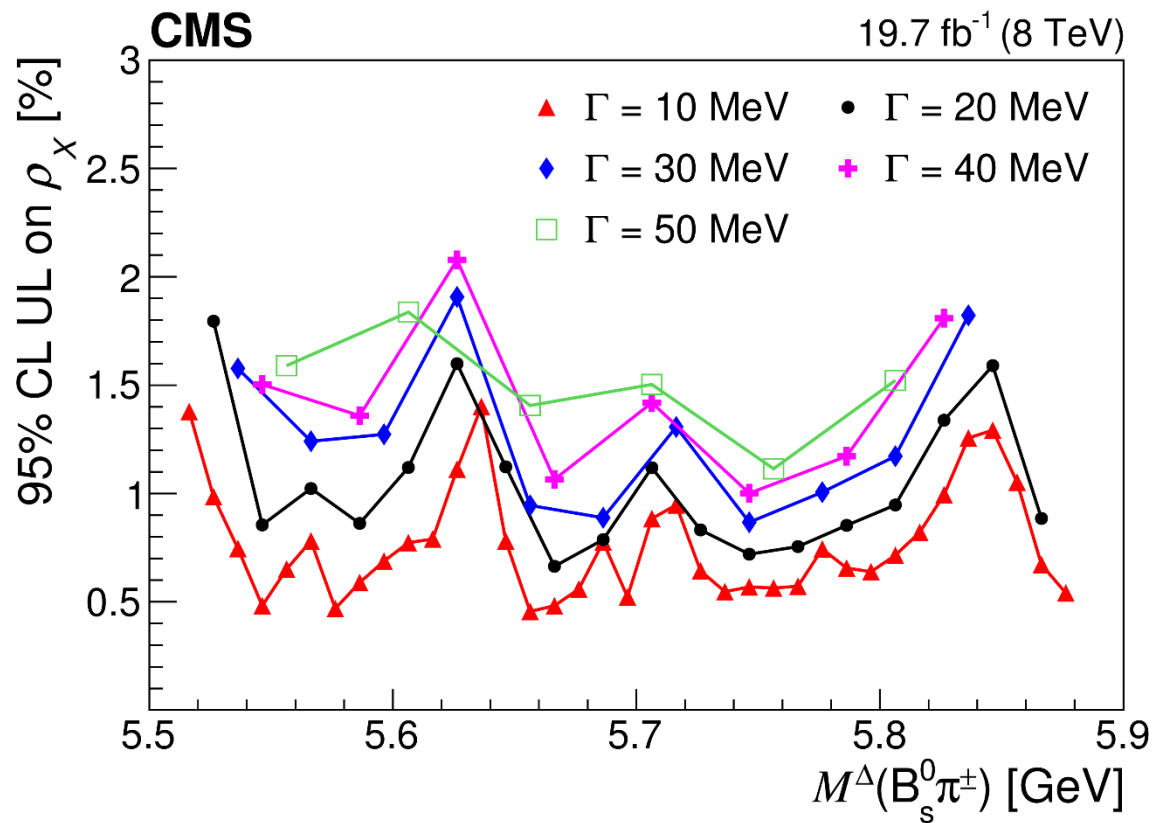
- Data sets of 8 TeV are still producing important results, in addition to the analysis of data at 13 TeV.
- ATLAS and CMS are profiting of their trigger on dimuons, suitable for studies on rare decays of b-hadrons, so new results on that line will come soon, in addition to properties and other observations.
- CMS and ATLAS can not confirm the peaking structure observed by Dzero.
- Both experiments, ATLAS and CMS have a strong opportunities on the study of heavy hadron.
- ATLAS and CMS has produced much more results than what can fit in this talk.

Backups

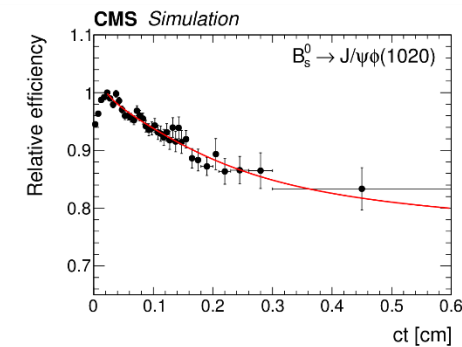
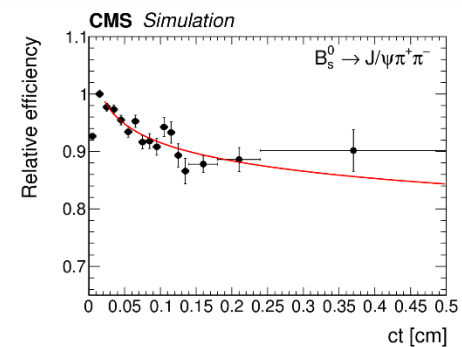
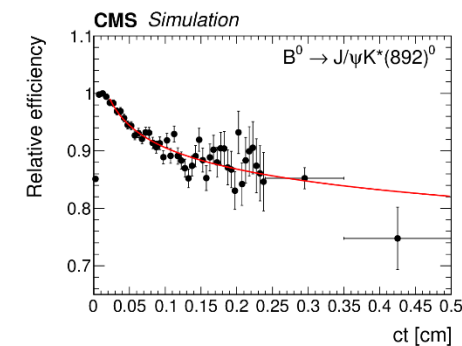
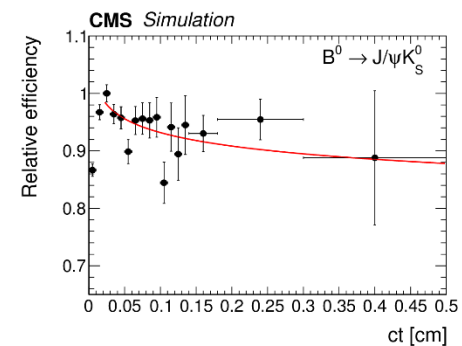
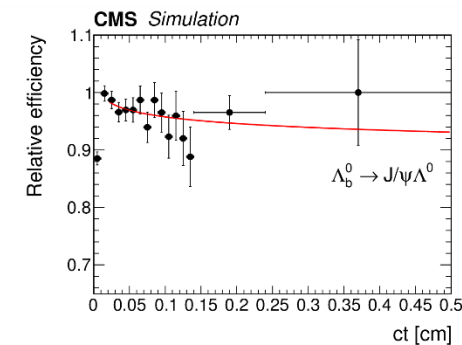
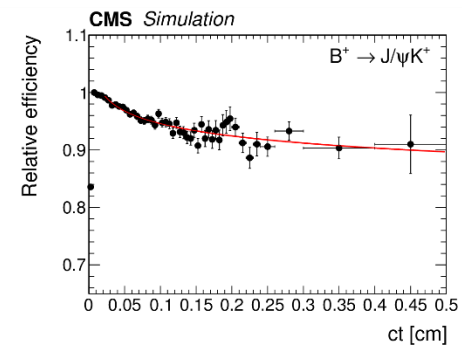
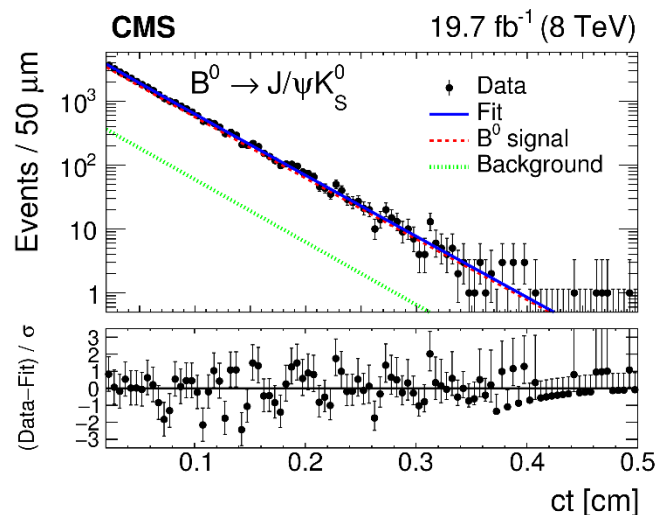
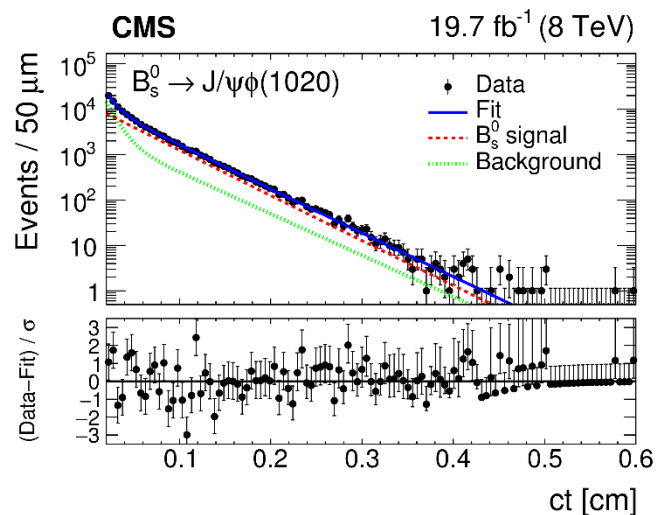
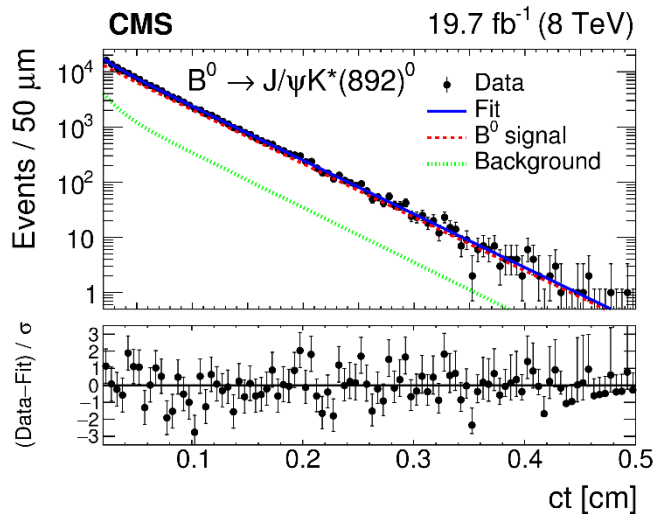
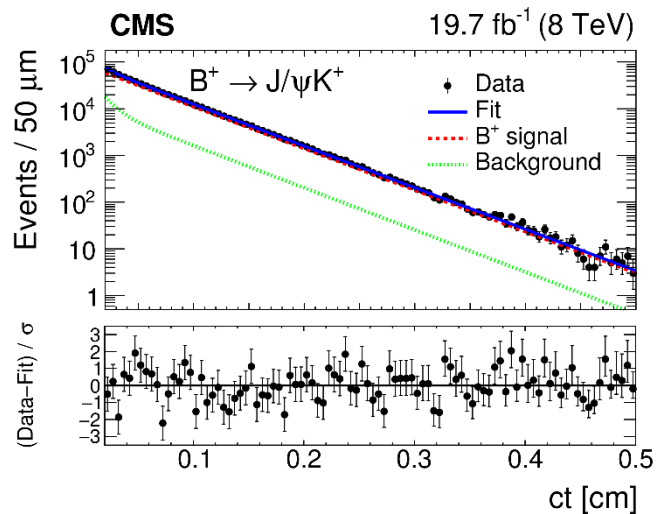
CMS search for $X^+ (5568) \rightarrow B_s \pi^+$



CMS search for $X^+ (5568) \rightarrow B_s \pi^+$



Efficiencies and lifetime fits



Lifetime fits

