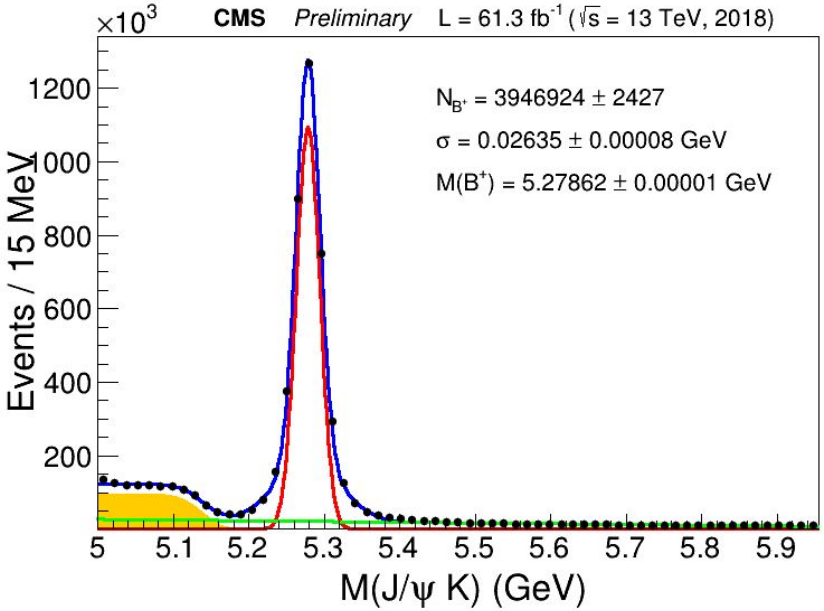


Differential measurement of the cross section of B→ J/ψK

Motivation

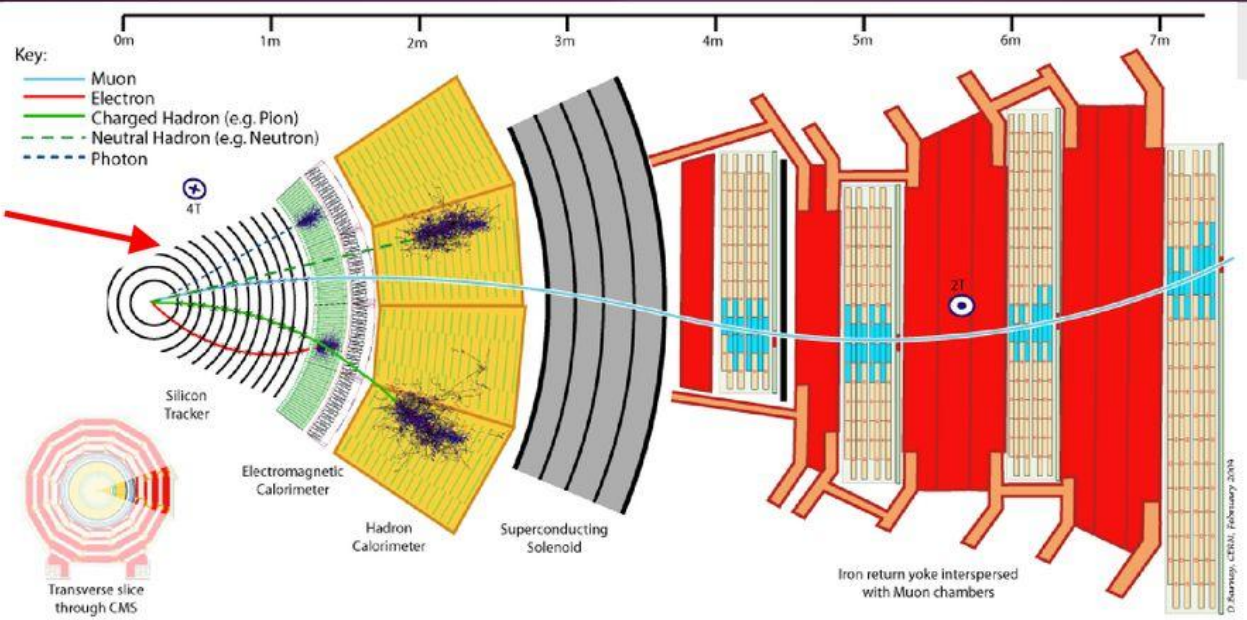
Although quantum chromodynamics (QCD) is well established as the theory of the strong interaction, a complete understanding of the (nonperturbative) processes that lead to the binding of quarks and gluons into hadrons is still lacking.

- The study of heavy quark production in high energy hadronic interactions plays a critical role in testing next-to-leading order (NLO) Quantum Chromodynamics (QCD) calculations.

  CMS. CMS-PAS-BPH-13-002,

- Therefore, precise measurements of the Bu cross sections at CMS will provide useful information on the production mechanism of Bu mesons.

CMS Detector System



Monte Carlo generation

For efficiency studies and analysis selection we have used Samples generated by Pythia8 for hadronization and to EvtGen for decaying the B states to follow the channels of interest.

The simulated events include multiple proton-proton interactions in the same or nearby beam crossings (pileup), with the distribution matching that observed in data (2018), official MC campaigns.

2 samples per channel, to account for the gen pre-filter:

- The first sample has no cuts
- The second sample has the gen filter cuts: $|\eta(\mu)|<2.5$, $|\eta(K)|<2.5$, $pT(\mu)>3.8$ GeV and $pT(K)>0.5$ GeV.
- The two samples are used for efficiency measurement.

Quality cuts

Final cuts:

B Prob(vtx) > 0.01
p_T(K) > 1.2 GeV
p_T(B) > 10.0 GeV

- We used PV with best pointing angle.

- All tracks satisfy high quality requirements, besides at least 1 pixel hits and at least 5 tracker hits.

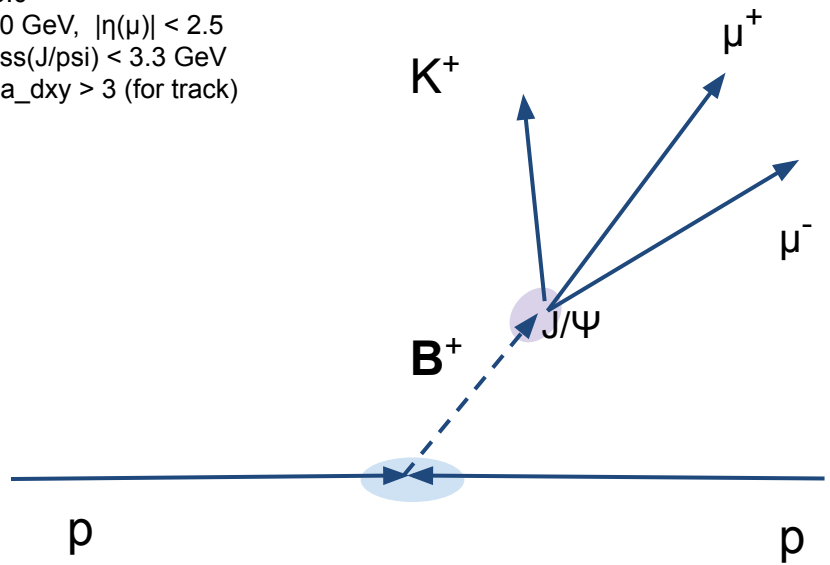
- Each muon has to pass the soft identification requirement.

- When multiple B candidates are found in the same event, only the one with the highest fit chi2 probability is kept.

Trigger details:

Prob(vtx) > 0.01
Lxy/σ > 3.0
p_T(μ) >4.0 GeV, |η(μ)| < 2.5
2.9 < Mass(J/psi) < 3.3 GeV
dxy/sigma_dxy > 3 (for track)

|y(B)| < 2.4
10 < p_T(B) < 100 GeV

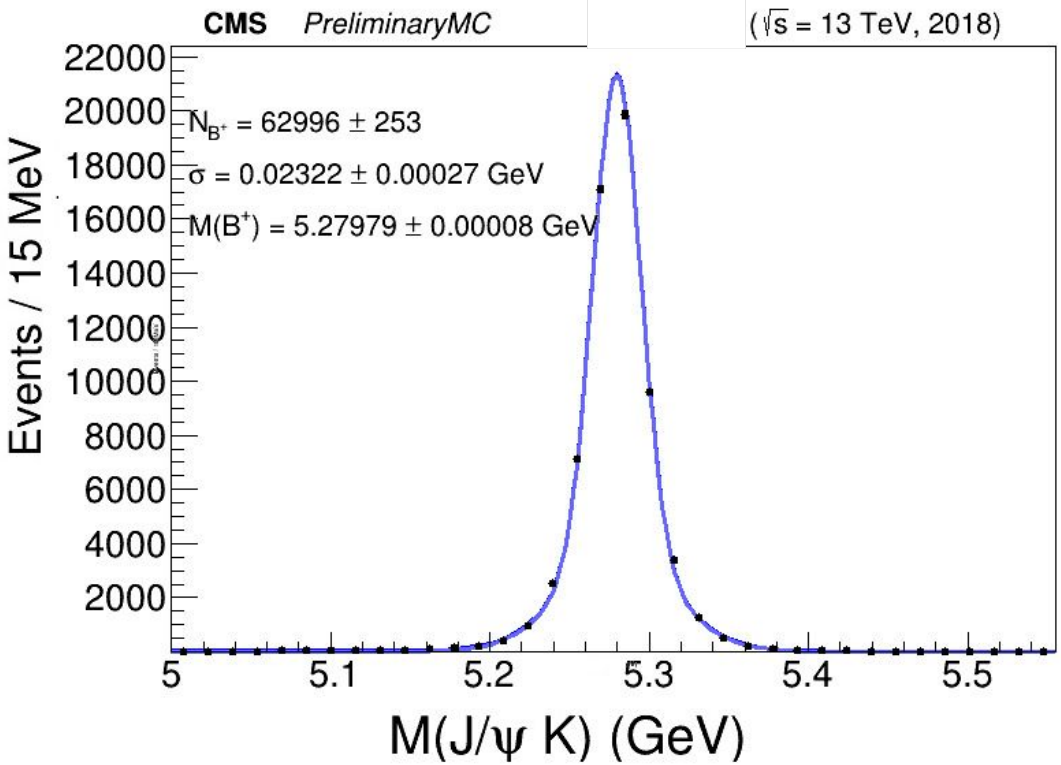


Yield Extraction

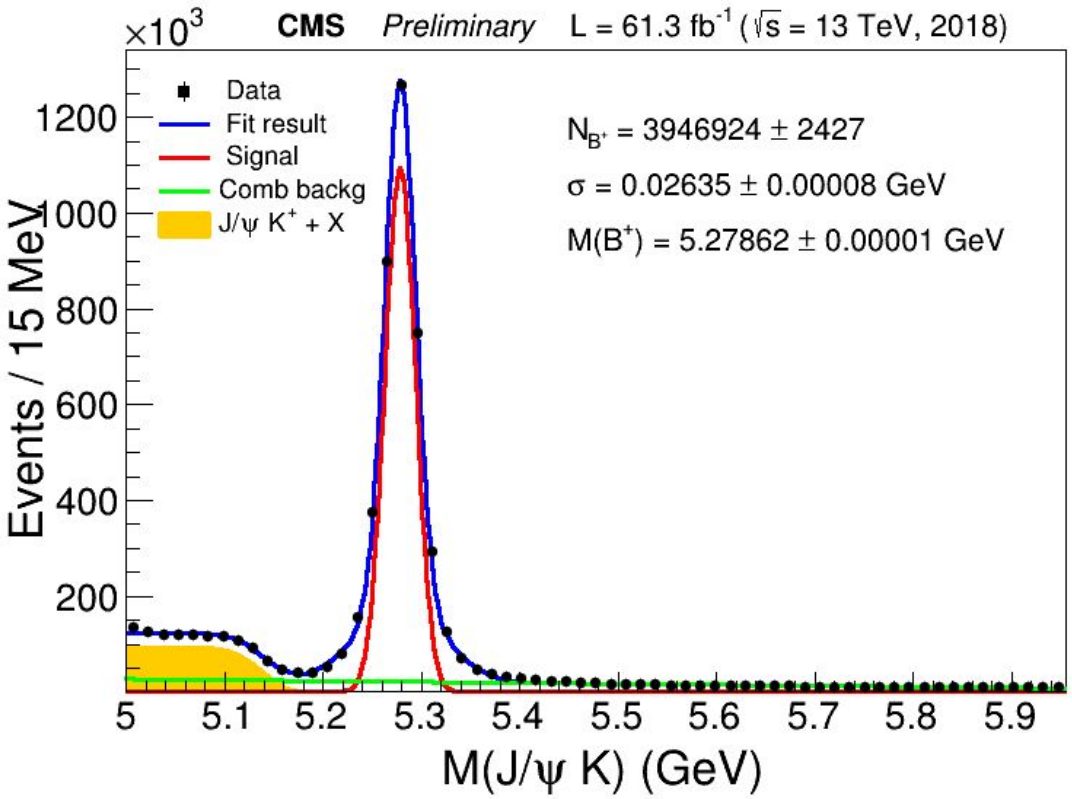
The B^+ yields are extracted using unbinned maximum likelihood fits:

- ➔ Signal model: double Gaussian with common mean.
- ➔ Background model: Chebyshev polynomial
- ➔ Additional background contributions:
  - **B^+**: $B^+ \rightarrow J/\psi K+X$ decays are modelled with an error function, while $B^+ \rightarrow J/\psi \pi$ they are not modeled, because their contribution is approximately 4%

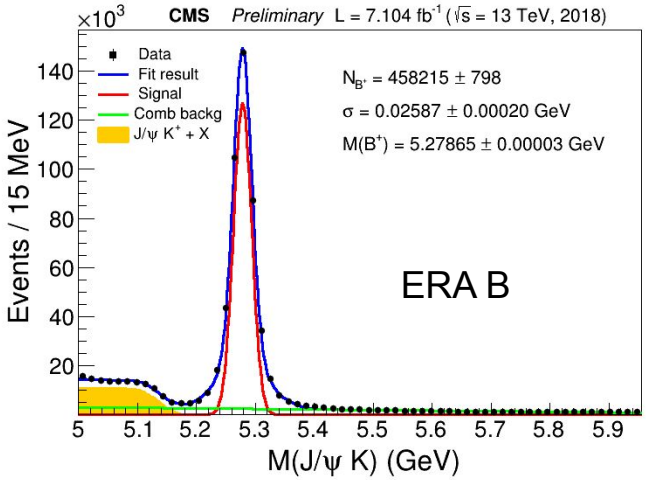
Reconstruction of B^+ in Monte Carlo

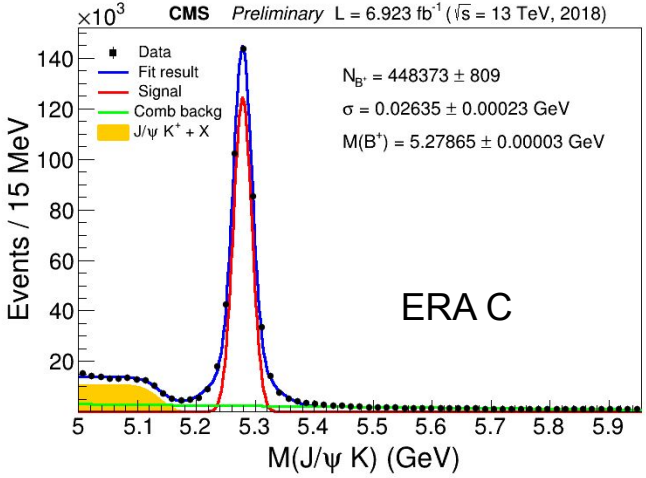


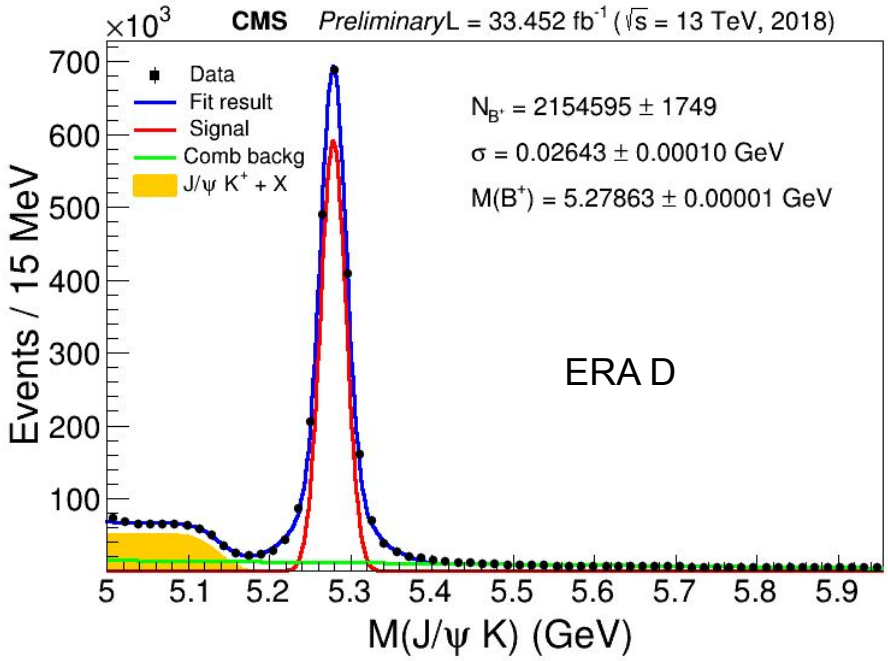
Reconstruction of the mass of B^+



B^+ fit by eras


×10^3
CMS Preliminary L = 7.104 fb^-1 (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K^+ + X
N_B+ = 458215 ± 798
σ = 0.02587 ± 0.00020 GeV
M(B^+) = 5.27865 ± 0.00003 GeV
ERA B
Events / 15 MeV
M(J/ψ K) (GeV)


×10^3
CMS Preliminary L = 6.923 fb^-1 (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K^+ + X
N_B+ = 448373 ± 809
σ = 0.02635 ± 0.00023 GeV
M(B^+) = 5.27865 ± 0.00003 GeV
ERA C
Events / 15 MeV
M(J/ψ K) (GeV)


×10^3
CMS Preliminary L = 33.452 fb^-1 (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K^+ + X
N_B+ = 2154595 ± 1749
σ = 0.02643 ± 0.00010 GeV
M(B^+) = 5.27863 ± 0.00001 GeV
ERA D
Events / 15 MeV
M(J/ψ K) (GeV)

Efficiencies

Is the number of reconstructed B events after the full selection divide the number of generated B decays in the fiducial region of the analysis specified by the B kinematic window: 10 < pT(B) < 100 GeV and |y(B)| < 2.4

➔ It includes the acceptance and offline selection.

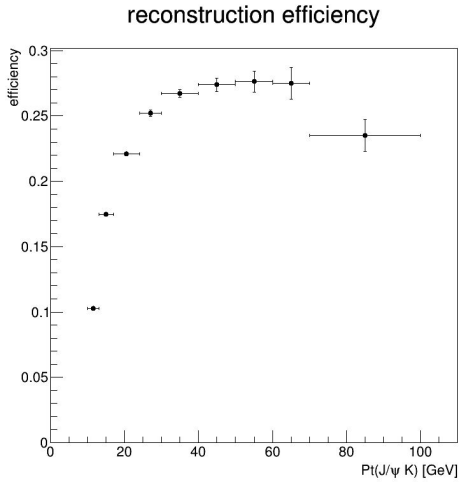
➔ It is determined from MC simulations, using 2 samples per channel:

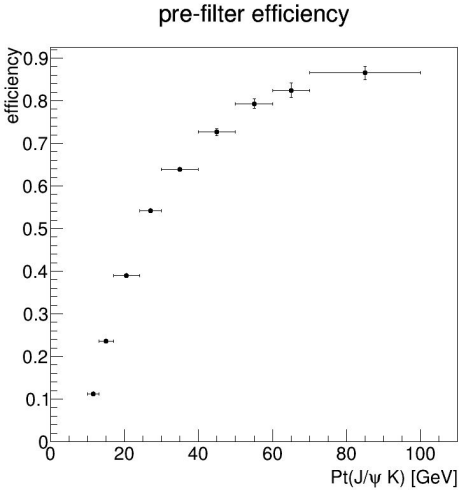
- The first sample has no cuts (with gen-info only).
- The second sample has the gen filter cuts: $|\eta(\mu)|<2.5$, $|\eta(K)|<2.5$, $pT(\mu)>3.8$ GeV and $pT(K)>0.5$ GeV.

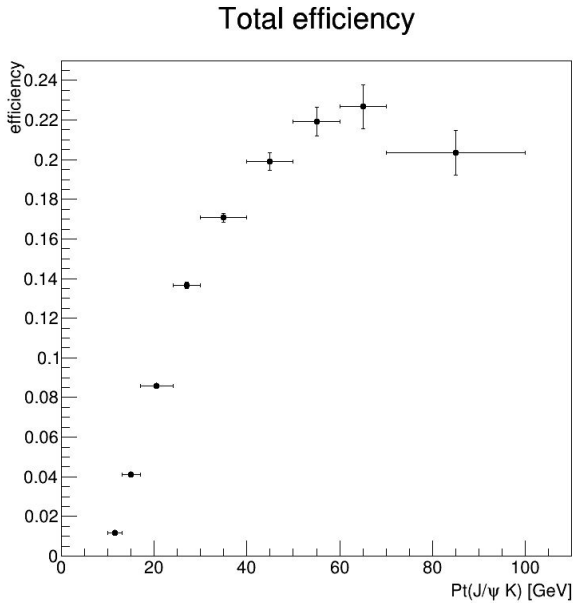
➔ The efficiency is split into two terms:

- The "pre-filter efficiency" measures the efficiency of the gen pre-filter.
- The "efficiency of reconstruction" measures the event selection efficiency given the pre-filter selection.
- The “total efficiency” is the product of the two efficiencies above.

B^+ Efficiencies







pre-filter efficiency	0,224841
efficiency of reconstruction	0,198611
total efficiency	0,044656

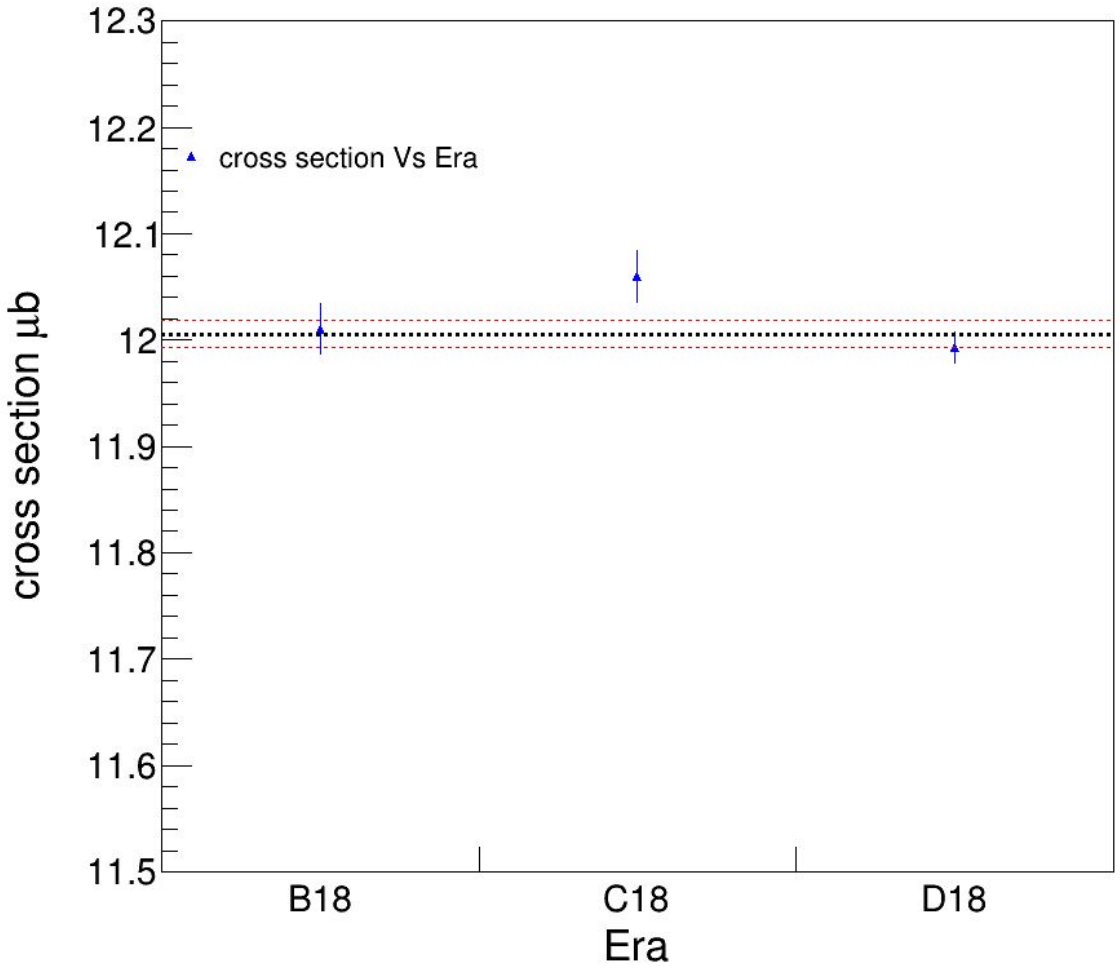
Cross section

$$\frac{\mathrm{d}\sigma(\mathrm{pp} \to \mathrm{B}^{+} X)}{\mathrm{d}p_{\mathrm{T}}^{\mathrm{B}}} = \frac{n_{\mathrm{sig}}(p_{\mathrm{T}}^{\mathrm{B}})}{2\,A \cdot \epsilon(p_{\mathrm{T}}^{\mathrm{B}})\,\mathcal{B}\,\mathcal{L}\,\Delta p_{\mathrm{T}}^{\mathrm{B}}}$$

$$\mathcal{B}(\mathrm{B}^{+} \to \mathrm{J}/\psi \mathrm{K}^{+}) = (1.026 \pm 0.031) \times 10^{-3}$$

$$\mathcal{B}(\mathrm{J}/\psi \to \mu^{+}\mu^{-}) = (5.961 \pm 0.033) \times 10^{-2}$$

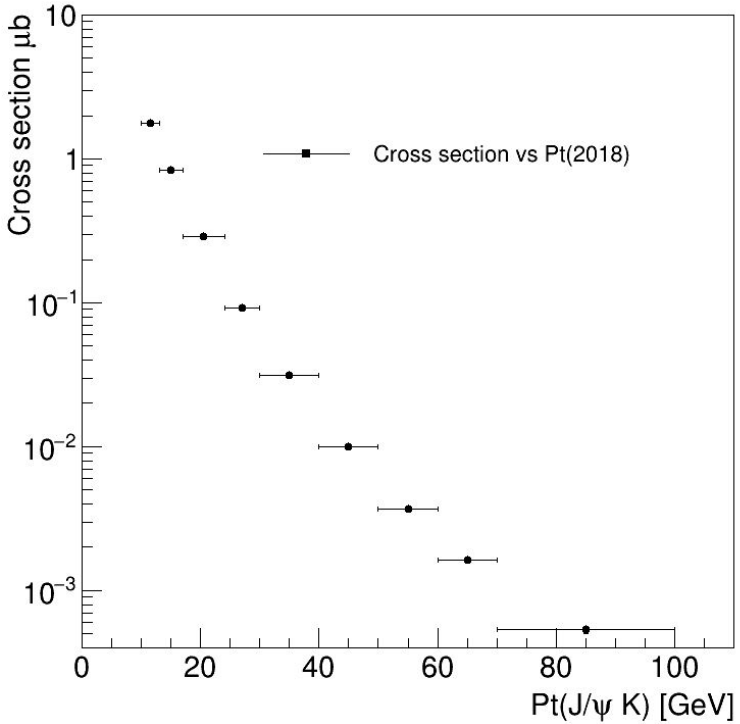
Integrated cross section B^+



ERA	Cross section(µb)	Error
B	12,01	0,023
C	12,05	0,024
D	11,99	0,014

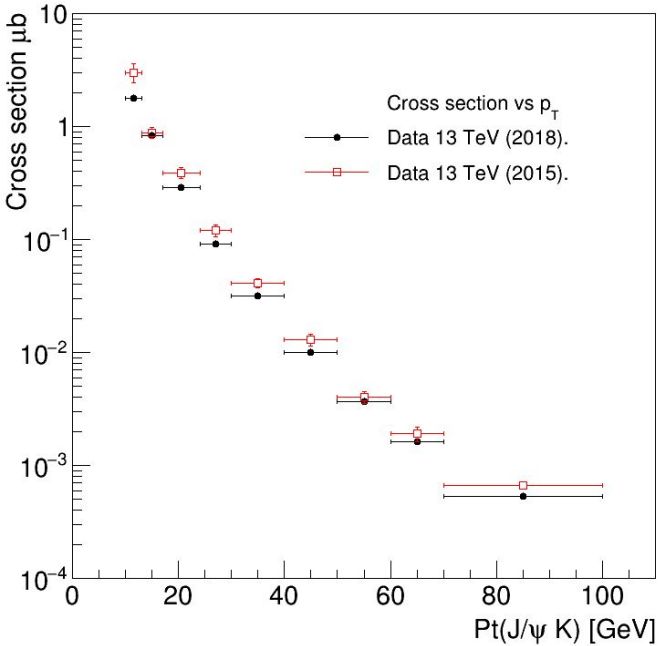
Cross section(µb) Integrated(2018)	Error
12,005	0,023

Differential cross section



pT	Cross section(µb) 2018	Error
10-13	1,77	0,0224
13-17	0,83	0,0072
17-24	0,28	0,0022
24-30	0,091	0,0010
30-40	0,031	0,00042
40-50	0,0099	0,00022
50-60	0,0036	0,00012
60-70	0,0016	0,000082
70-100	0,00053	0,000029

Comparing the cross section

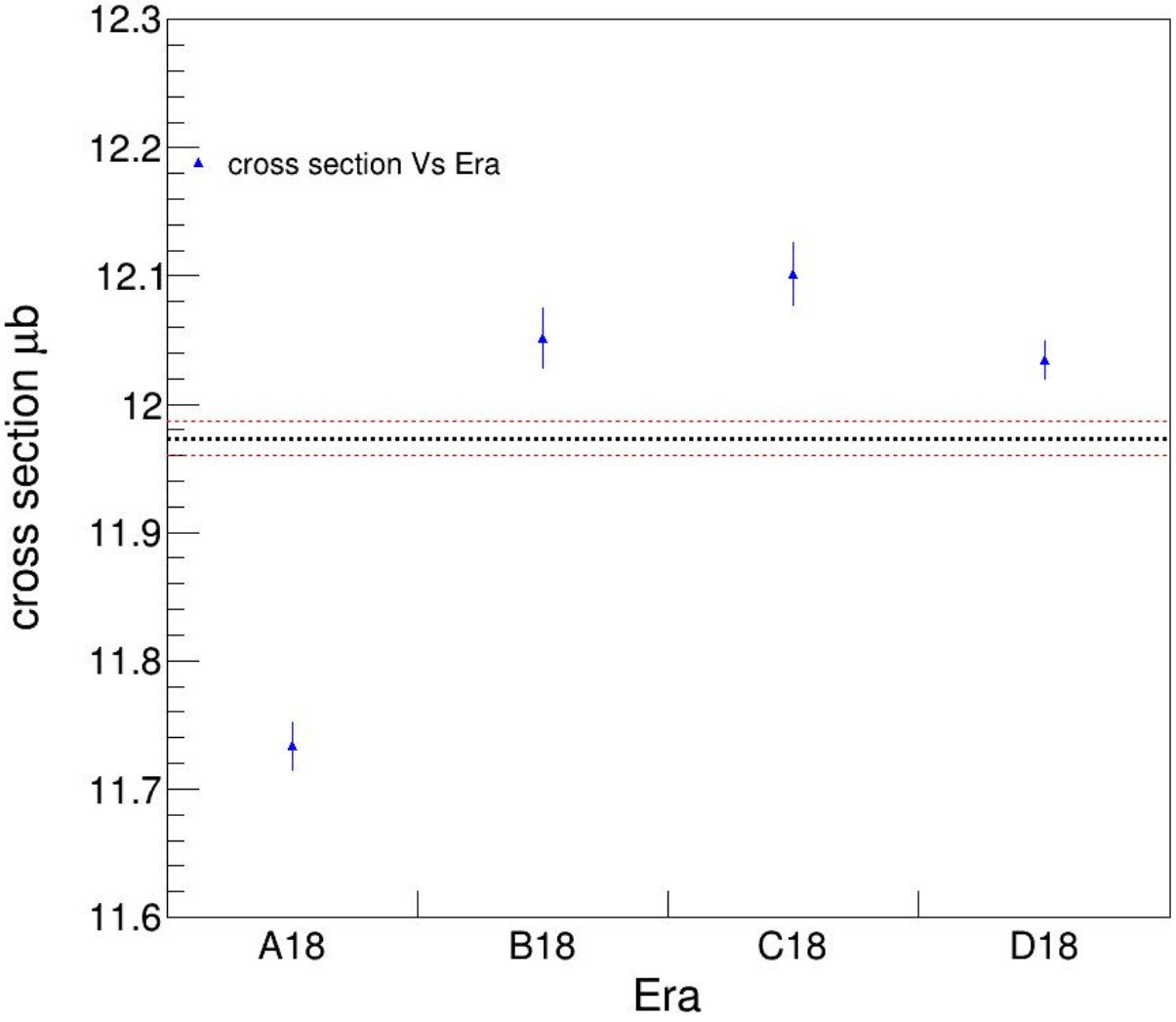


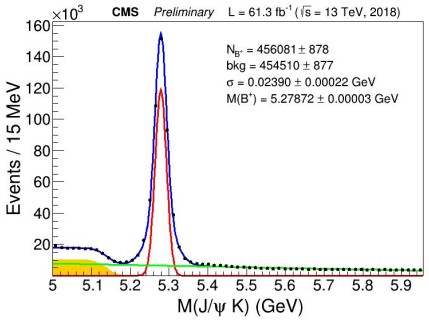
pT	Cross section(μb) 2018	Error
10-13	1,77	0,022
13-17	0,83	0,0072
17-24	0,28	0,0022
24-30	0,091	0,0010
30-40	0,031	0,00042
40-50	0,0099	0,00022
50-60	0,0036	0,00012
60-70	0,0016	0,000080
70-100	0,00053	0,000029

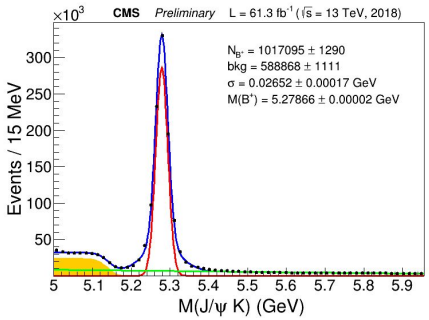
pT	Cross section(μb) 2015	Error
10-13	3	0,41
13-17	0,88	0,076
17-24	0,39	0,034
24-30	0,12	0,011
30-40	0,041	0,0039
40-50	0,013	0,0016
50-60	0,004	0,00048
60-70	0,0019	0,00028
70-100	0,00067	0,000010

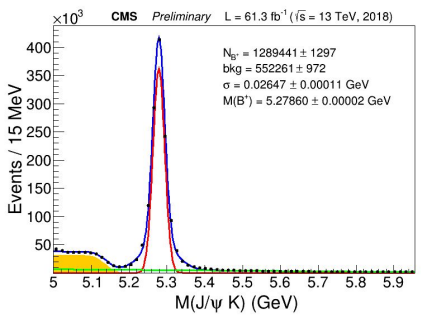
Summary

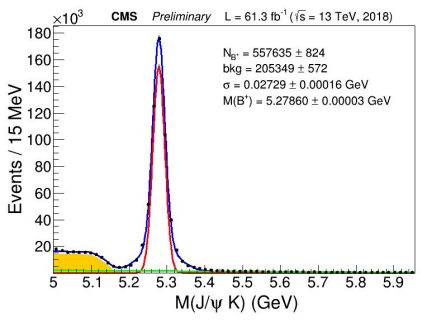
- ❏ Reconstruction of the mass B+
- ❏ Calculate the efficiencies
- ❏ Calculate Cross section in ERAS
- ❏ Calculate Cross section differential in bines Pt

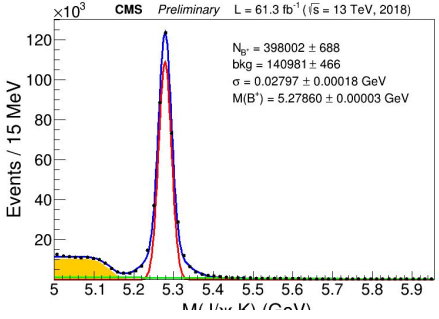

cross section Vs Era
cross section µb
12.3
12.2
12.1
12
11.9
11.8
11.7
11.6
A18
B18
C18
D18
Era

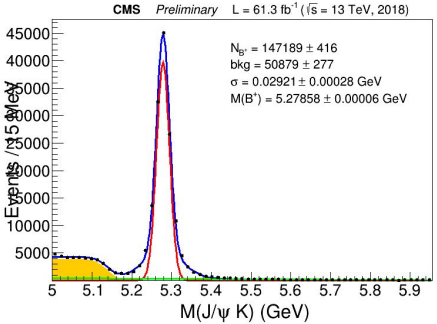

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 456081 ± 878
bkg = 454510 ± 877
σ = 0.02390 ± 0.00022 GeV
M(B$^+$) = 5.27872 ± 0.00003 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

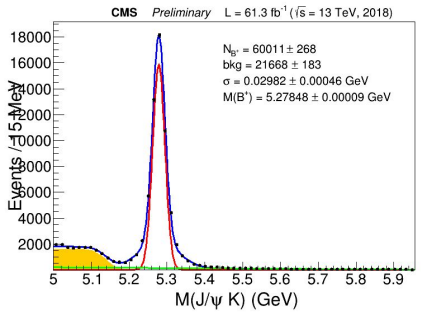

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 1017095 ± 1290
bkg = 588868 ± 1111
σ = 0.02652 ± 0.00017 GeV
M(B$^+$) = 5.27866 ± 0.00002 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

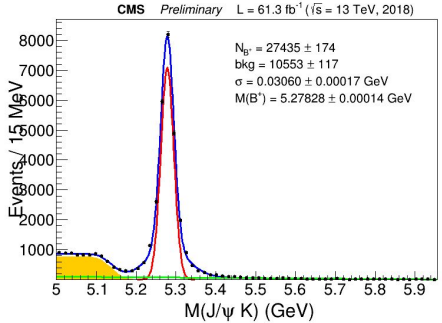

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 1289441 ± 1297
bkg = 552261 ± 972
σ = 0.02647 ± 0.00011 GeV
M(B$^+$) = 5.27860 ± 0.00002 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

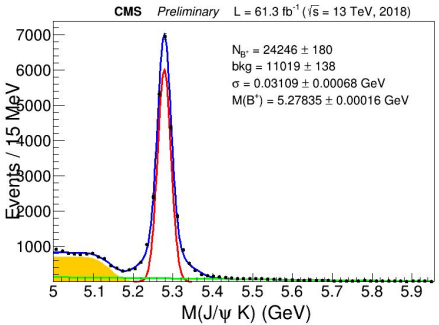

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 557635 ± 824
bkg = 205349 ± 572
σ = 0.02729 ± 0.00016 GeV
M(B$^+$) = 5.27860 ± 0.00003 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 398002 ± 688
bkg = 140981 ± 466
σ = 0.02797 ± 0.00018 GeV
M(B$^+$) = 5.27860 ± 0.00003 GeV
Events / 15 MeV

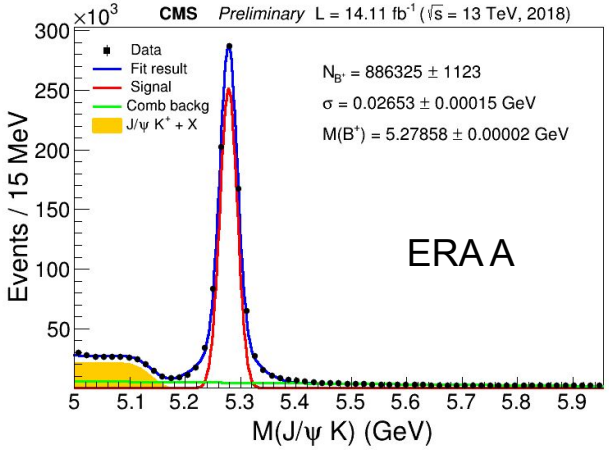

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 147189 ± 416
bkg = 50879 ± 277
σ = 0.02921 ± 0.00028 GeV
M(B$^+$) = 5.27858 ± 0.00006 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

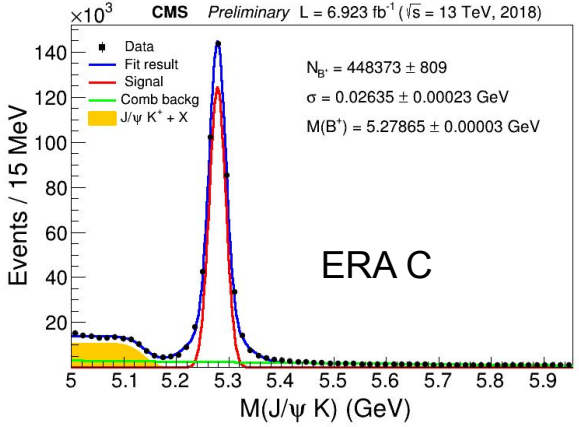

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 60011 ± 268
bkg = 21668 ± 183
σ = 0.02982 ± 0.00046 GeV
M(B$^+$) = 5.27848 ± 0.00009 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

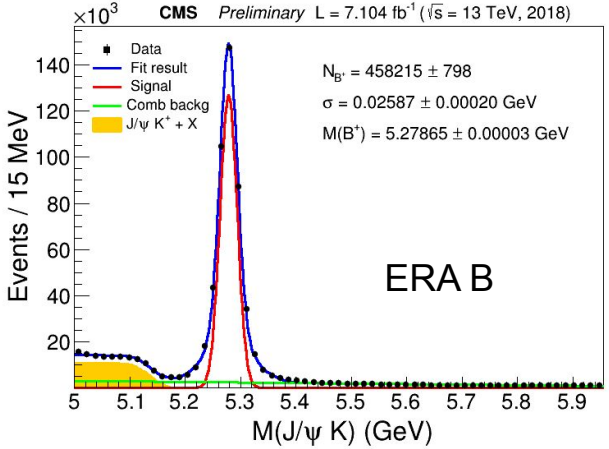

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 27435 ± 174
bkg = 10553 ± 117
σ = 0.03060 ± 0.00017 GeV
M(B$^+$) = 5.27828 ± 0.00014 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

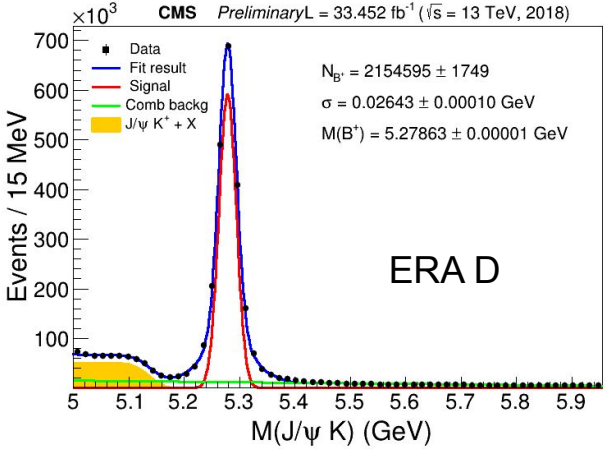

CMS Preliminary L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 24246 ± 180
bkg = 11019 ± 138
σ = 0.03109 ± 0.00068 GeV
M(B$^+$) = 5.27835 ± 0.00016 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

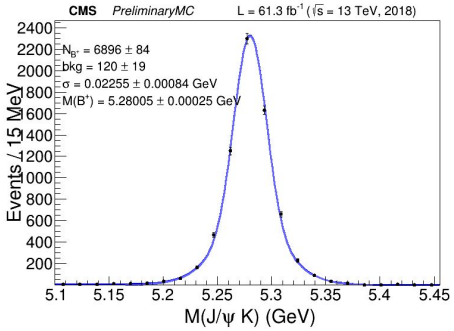
B^+ fit by eras

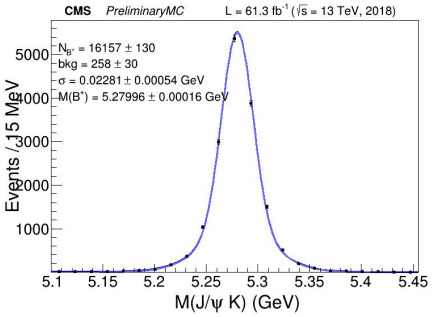

×10³ CMS Preliminary L = 14.11 fb⁻¹ (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K⁺ + X
N_B⁺ = 886325 ± 1123
σ = 0.02653 ± 0.00015 GeV
M(B⁺) = 5.27858 ± 0.00002 GeV
ERA A
Events / 15 MeV
M(J/ψ K) (GeV)

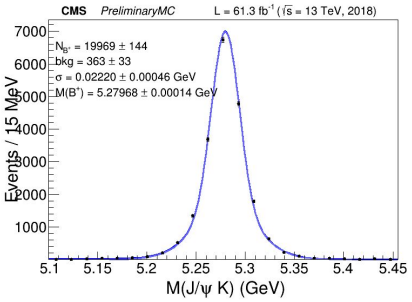

×10³ CMS Preliminary L = 6.923 fb⁻¹ (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K⁺ + X
N_B⁺ = 448373 ± 809
σ = 0.02635 ± 0.00023 GeV
M(B⁺) = 5.27865 ± 0.00003 GeV
ERA C
Events / 15 MeV
M(J/ψ K) (GeV)

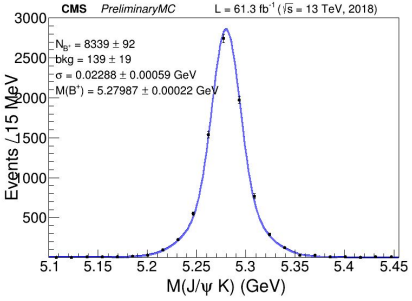

×10³ CMS Preliminary L = 7.104 fb⁻¹ (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K⁺ + X
N_B⁺ = 458215 ± 798
σ = 0.02587 ± 0.00020 GeV
M(B⁺) = 5.27865 ± 0.00003 GeV
ERA B
Events / 15 MeV
M(J/ψ K) (GeV)

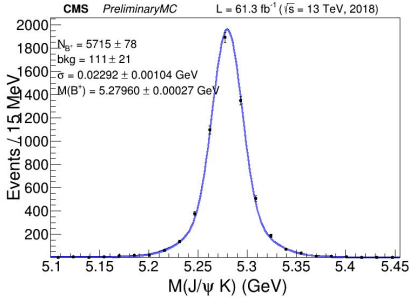

×10³ CMS PreliminaryL = 33.452 fb⁻¹ (√s = 13 TeV, 2018)
Data
Fit result
Signal
Comb backg
J/ψ K⁺ + X
N_B⁺ = 2154595 ± 1749
σ = 0.02643 ± 0.00010 GeV
M(B⁺) = 5.27863 ± 0.00001 GeV
ERA D
Events / 15 MeV
M(J/ψ K) (GeV)

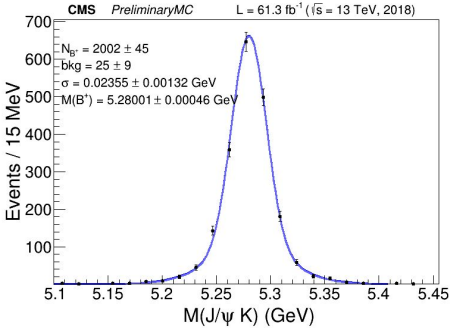

CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 6896 ± 84
bkg = 120 ± 19
σ = 0.02255 ± 0.00084 GeV
M(B$^+$) = 5.28005 ± 0.00025 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

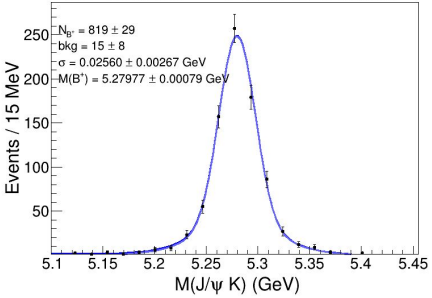

CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 16157 ± 130
bkg = 258 ± 30
σ = 0.02281 ± 0.00054 GeV
M(B$^+$) = 5.27996 ± 0.00016 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

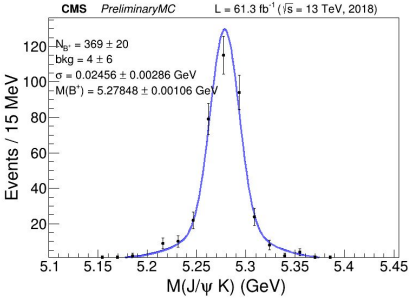

CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 19969 ± 144
bkg = 363 ± 33
σ = 0.02220 ± 0.00046 GeV
M(B$^+$) = 5.27968 ± 0.00014 GeV
Events / 15 MeV
M(J/ψ K) (GeV)

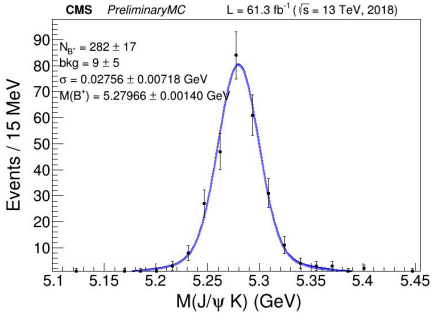

CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 8339 ± 92
bkg = 139 ± 19
σ = 0.02288 ± 0.00059 GeV
M(B$^+$) = 5.27987 ± 0.00022 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 5715 ± 78
bkg = 111 ± 21
σ = 0.02292 ± 0.00104 GeV
M(B$^+$) = 5.27960 ± 0.00027 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 2002 ± 45
bkg = 25 ± 9
σ = 0.02355 ± 0.00132 GeV
M(B$^+$) = 5.28001 ± 0.00046 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 819 ± 29
bkg = 15 ± 8
σ = 0.02560 ± 0.00267 GeV
M(B$^+$) = 5.27977 ± 0.00079 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 369 ± 20
bkg = 4 ± 6
σ = 0.02456 ± 0.00286 GeV
M(B$^+$) = 5.27848 ± 0.00106 GeV
Events / 15 MeV
M(J/ψ K) (GeV)


CMS PreliminaryMC
L = 61.3 fb^{-1} ($\sqrt{s}$ = 13 TeV, 2018)
N_{B^+} = 282 ± 17
bkg = 9 ± 5
σ = 0.02756 ± 0.00718 GeV
M(B$^+$) = 5.27966 ± 0.00140 GeV
Events / 15 MeV
M(J/ψ K) (GeV)