Branching fraction of $B_s \rightarrow J/\psi\ \eta'[\rho\gamma]$

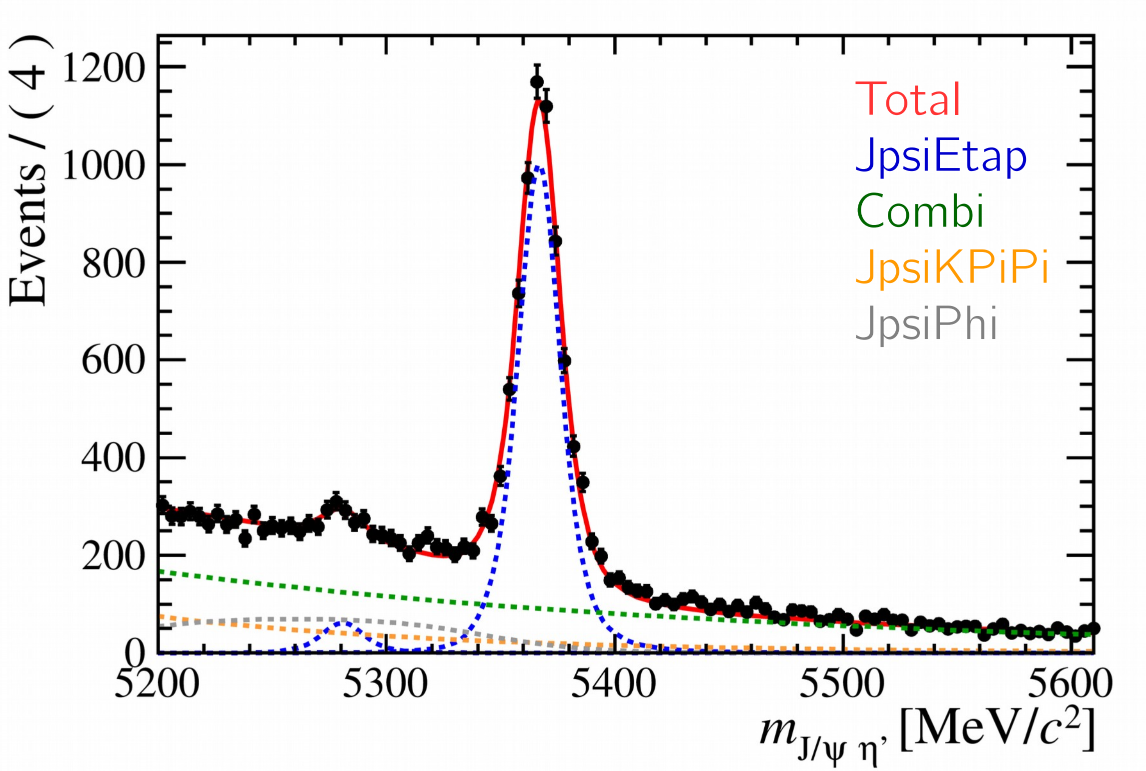
Dec 19th 2019, Annecy/Edinburgh meeting, M. Chefdeville

Outline

- Reminder
- Strategy for BR and new DiMuon data reprocessing
  - JpsiPhi with Phi23Pi and Phi2KK
- Improved fit model
- First BR
- Outlook

Reminder – previous mass fit

- PID + $\Delta m(\rho^0,\eta,J/\psi)$ + BDT + mass vetoes ($\pi\pi$, K^*, φ): eff(S) = 1.8%
- Latest fit: 6631(1.5%) signal candidates, poor χ^2/Ndf (0.21), signal/JpsiPhi ratio as expected (roughly half of signal)
- To be improved: fixed JpsiKpipi contribution (using m(JpsiPiPi) & RapidSim), fit quality on right-hand side of peak (mis-ID'ed contributions)



- Since then:
  - Try to improve the JpsiPhi23Pi veto
  - Improve fit model
  - Select a normalisation mode
  - First BR

Normalisation mode

- Physics goals: eta/eta' mixing and phi_s, but also opportunity to improve BR PDG values. Current average (12%) dominated by:
  - LHCb ratio of JpsiEtap/JpsiRho0 (15%) + abs. JpsiRho0 (7%)
  - Belle absolute measurement of JpsiEtap (28%)

$B_s^0 \to J/\psi(1S)\eta'$ INSPIRE search

▸ expand all datablocks

▸ $\Gamma(B_s^0 \to J/\psi(1S)\eta')/\Gamma(B_s^0 \to J/\psi(1S)\eta)$ Γ_{55}/Γ_{52}

▸ $\Gamma(B_s^0 \to \psi(2S)\eta')/\Gamma(B_s^0 \to J/\psi(1S)\eta')$ Γ_{81}/Γ_{55}

▾ $\Gamma(B_s^0 \to J/\psi(1S)\eta')/\Gamma_{\text{total}}$ Γ_{55}/Γ

VALUE (10^{-4})	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{3.3 \pm 0.4}$	**OUR AVERAGE**			
$3.2\,^{+0.4}_{-0.5} \pm 0.2$	1 AAIJ	2013A	LHCB	pp at 7 TeV
$3.71 \pm 0.61\,^{+0.85}_{-0.60}$	2 LI	2012	BELL	$e^+ e^- \to \Upsilon(4S)$

[1] AAIJ 2013A reports $[\Gamma(B_s^0 \to J/\psi(1S)\eta')/\Gamma_{\text{total}}]$ / [B($B^0 \to J/\psi(1S)\rho^0$)] = $12.7 \pm 1.1\,^{+0.5+1.0}_{-1.3-0.9}$ which we multiply by our best value B($B^0 \to J/\psi(1S)\rho^0$) = $(2.55\,^{+0.18}_{-0.16}) \times 10^{-5}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[2] Observed for the first time with significances over 10 σ. The second error are total systematic uncertainties including the error on N($B_s^{(*)}\overline{B}_s^{(*)}$).

References:

AAIJ	2013A	NP B867 547	Evidence for the Decay $B^0 \to J/\psi\omega$ and Measurement of the Relative Branching Fractions of B_s^0 Meson Decays to $J/\psi\eta$ and $J/\psi\eta'$
LI	2012	PRL 108 181808	First Observation of $B_s^0 \to J/\psi\eta$ and $B_s^0 \to J/\psi\eta'$

Normalisation mode

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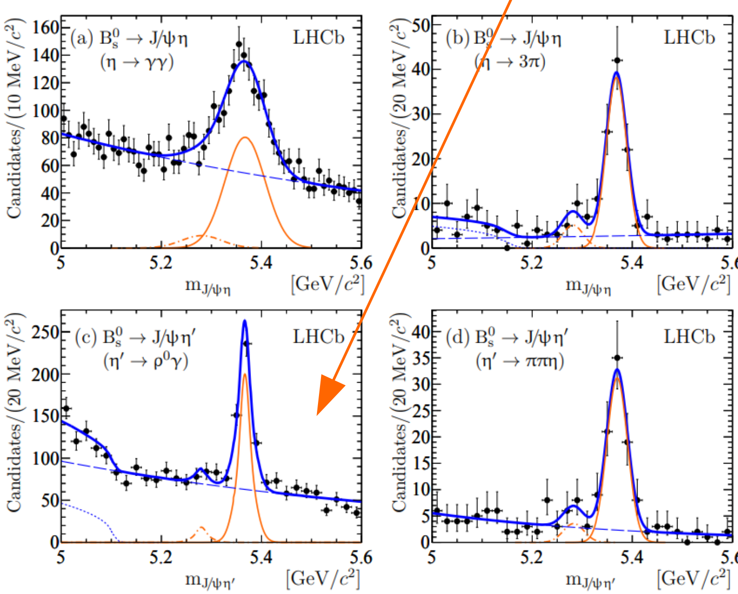
  - LHCb ratio of JpsiEtap/JpsiRho0 (15%) + abs. JpsiRho0 (7%)
  - Belle absolute measurement of JpsiEtap (28%)
- Proposal: normalize to JpsiPhi:
  - Ratio JpsiEtap/JpsiPhi (10.5%, see next slide) + abs. JpsiPhi(7.4%)

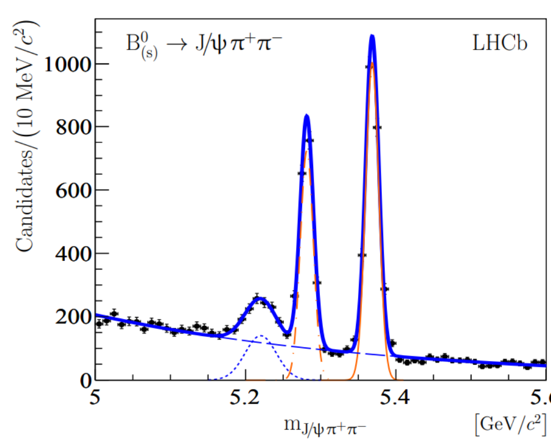
LHCb ratio JpsiEtap/JpsiRho0

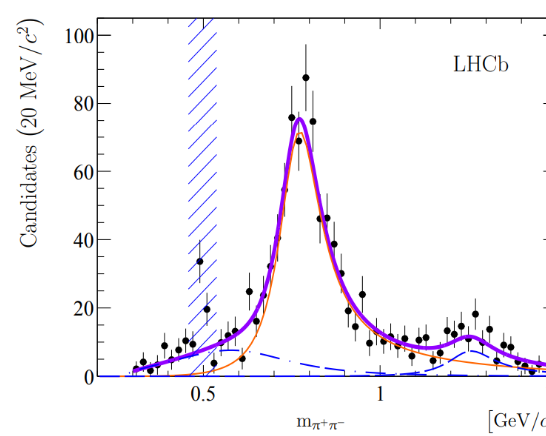
- Uses 1 /fb 7 TeV data (arxiv). Relative error of 15% splits as:
  - Statistical error (8.7%) to be reduced by factor of 4 (full Run1+2)
  - Systematics (+4% and -10%): photon and pion reconstruction will stay. Room for improvement: γ factor with $\chi_{c1}K^+$ / $J/\psi K^+$, $\pi\pi \to KK$ mass fit)
  - Hadronisation fraction (8%) could be absorbed in a Bs normalisation mode

$$\frac{\mathcal{B}(B_s^0 \to J/\psi\,\eta)}{\mathcal{B}(B^0 \to J/\psi\,\rho^0)} = 14.0 \pm 1.2\,(\mathrm{stat})\,{}^{+1.1}_{-1.5}\,(\mathrm{syst})\,{}^{+1.1}_{-1.0}\left(\frac{f_d}{f_s}\right)$$

$$\frac{\mathcal{B}(B_s^0 \to J/\psi\,\eta')}{\mathcal{B}(B^0 \to J/\psi\,\rho^0)} = 12.7 \pm 1.1\,(\mathrm{stat})\,{}^{+0.5}_{-1.3}\,(\mathrm{syst})\,{}^{+1.0}_{-0.9}\left(\frac{f_d}{f_s}\right)$$





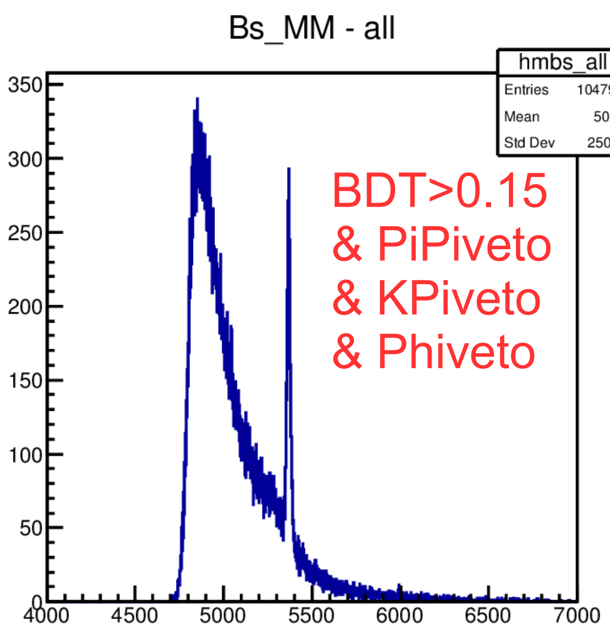


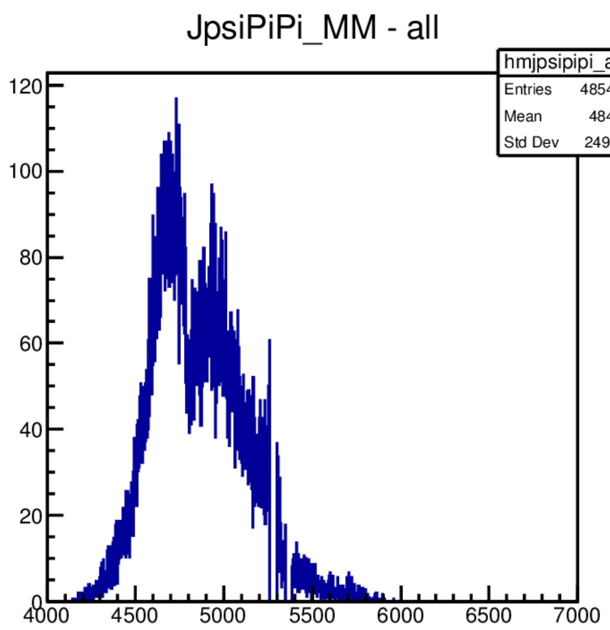
New reprocessing of Run2 DiMuon

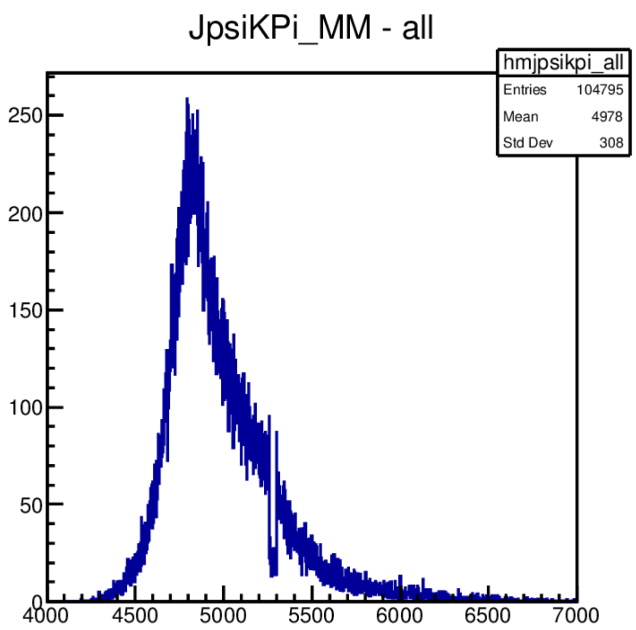
- JpsiEtap (idem)
- JpsiPhi[KK]
  - PT cut on Phi equal to PT cut on Etap = 1.5 GeV
    (VS 0.5 GeV in phi_s analysis)
  - PID: ProbNNk>0.1
- JpsiPhi[PiPiPi0]
  - Last presentation: eff_pi0veto = 72% & 52% for S & B resp.
    → veto genuine pi0 20% of the time but big cost on signal
    → full reco of JpsiPhi + mass veto should reduce the cost on signal
  - Build non-resonant Phi2PiPiPi0 decay and JpsiPhi
  - Use resolved pi0 with PT>1 GeV
- Process 2016-2017-2018

Mass distributions - JpsiEtap

- JpsiEtap (stat consistent with previous Dimuon processing)

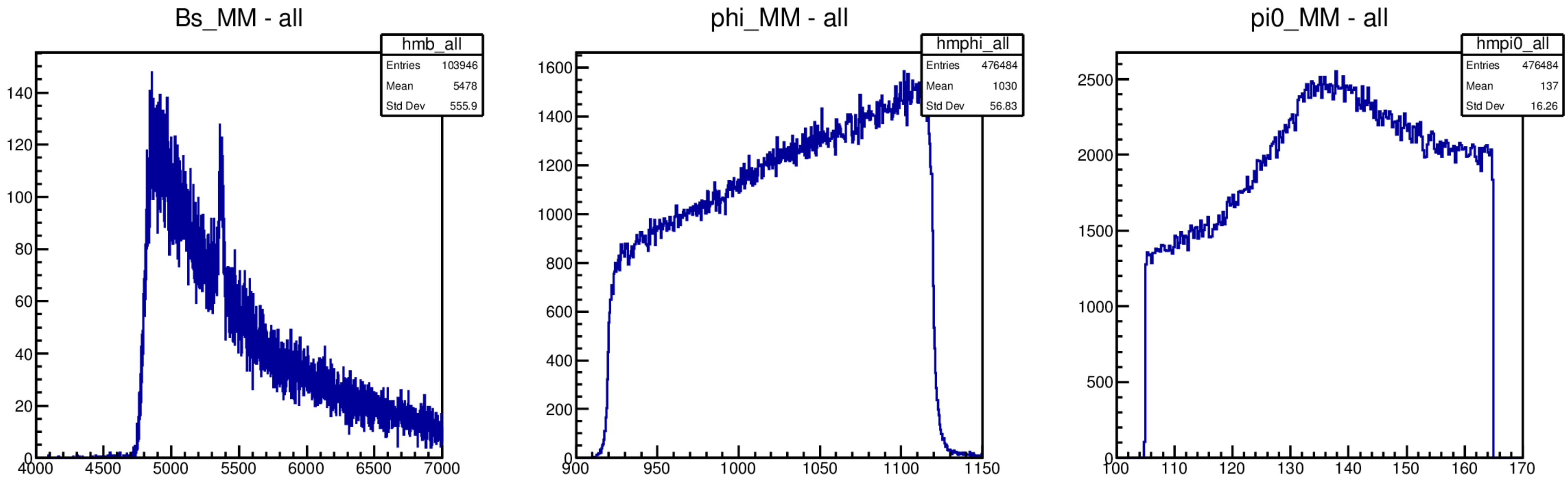






Mass distributions - JpsiPhi23Pi

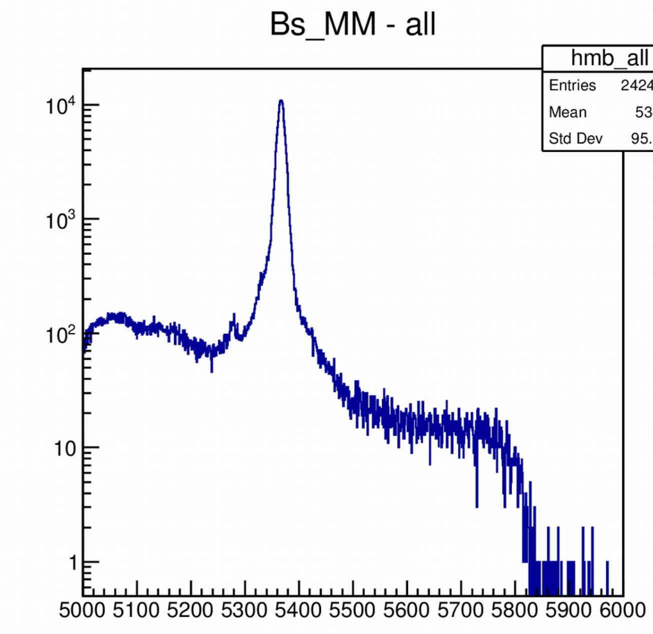
- JpsiEtap (stat consistent with previous Dimuon processing)
- JpsiPhi23Pi: with pi0 and phi mass constrains + mass windows

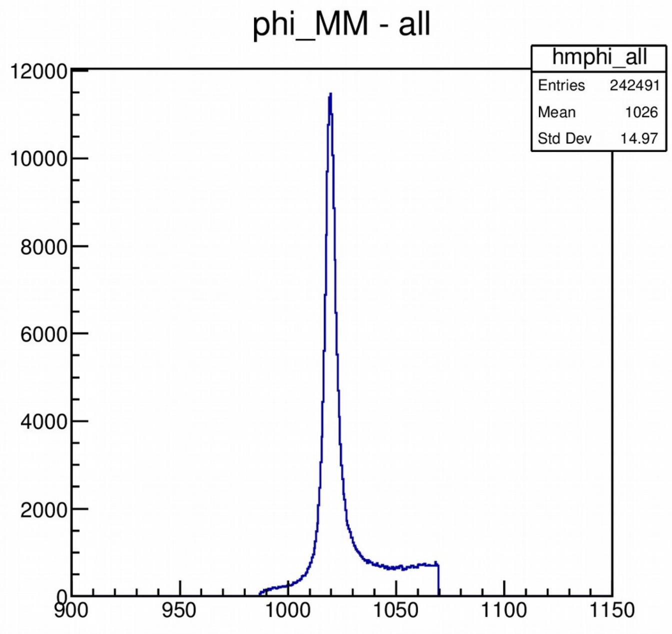


Δm(φ) = 25 MeV
Δm(π) = 25 MeV

Mass distributions - JpsiPhi2KK

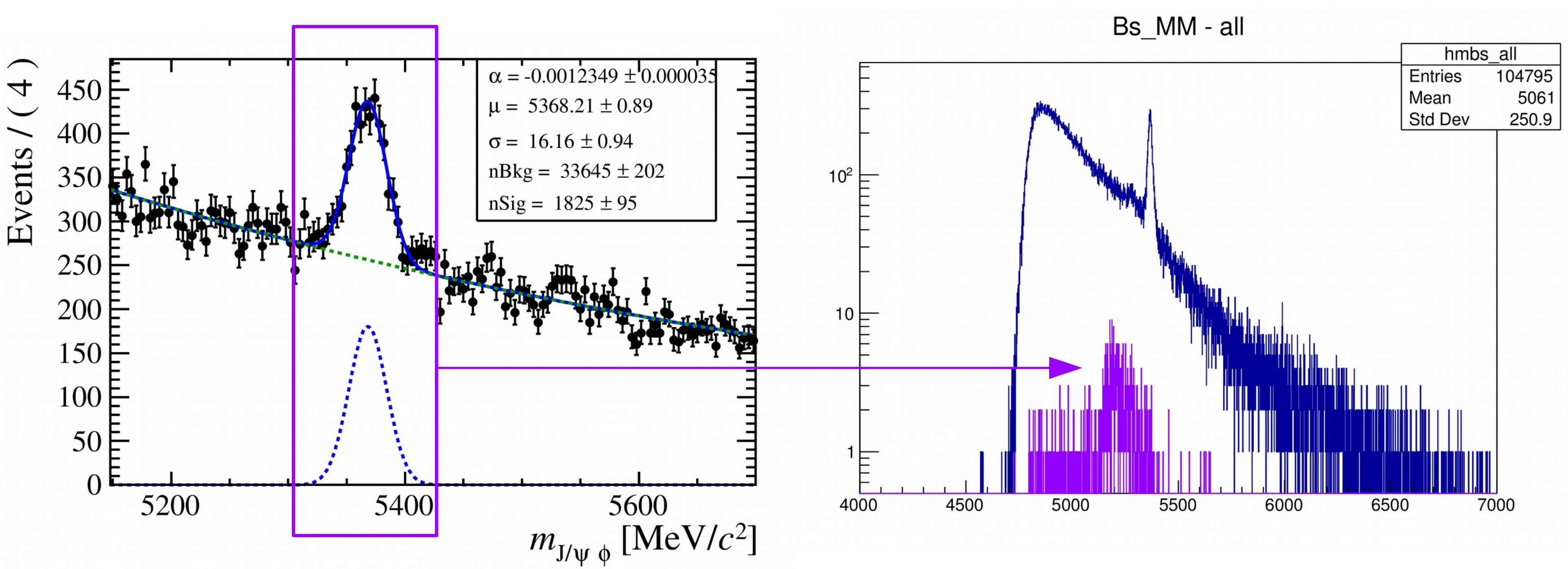
- JpsiEtap (stat consistent with previous Dimuon processing)
- JpsiPhi23Pi: with pi0 and phi mass constrains + mass windows
- JpsiPhi2KK (no offline cuts)





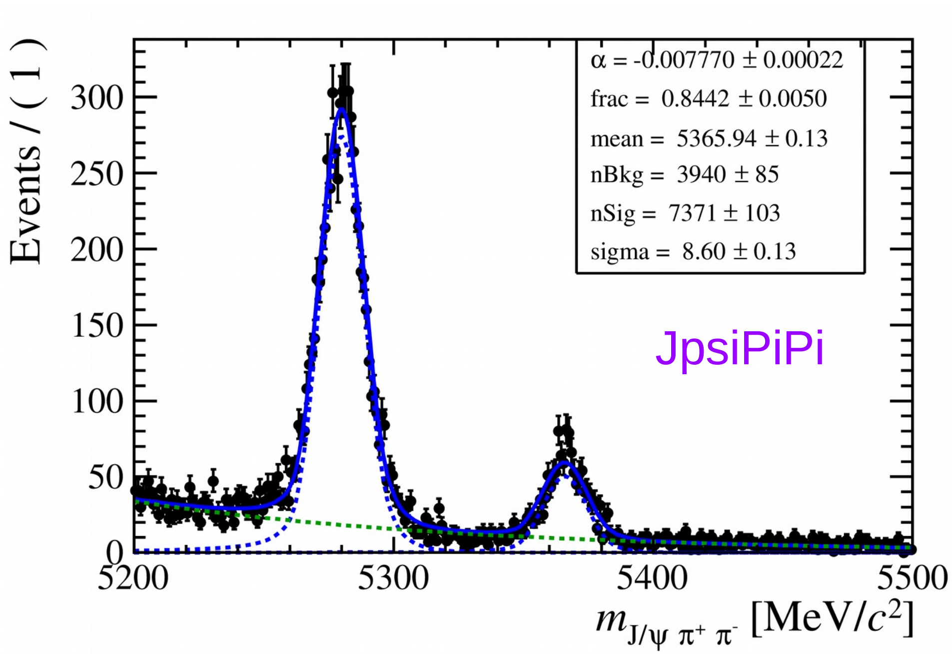
JpsiPhi23Pi veto

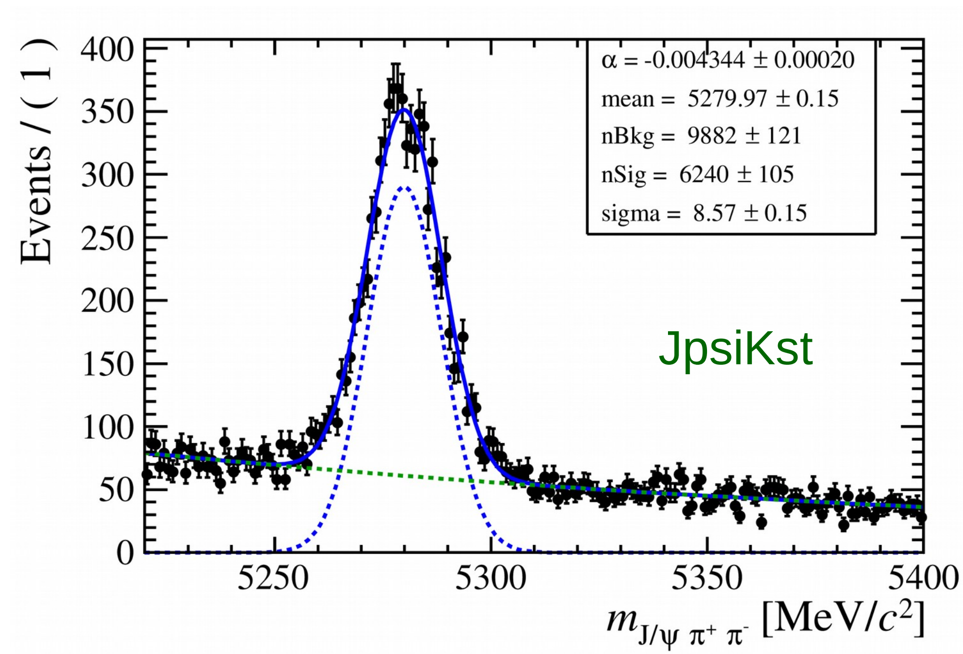
- In 2016-17-18 data set: we find 1825 fully reco'ed candidates
  - Save (in a C++ set) evt number of candidates falling in 3σ around Bs mass
  - Veto JpsiEtap candidates with event number belonging to the set
- In the 3σ window: 685 candidates are also JpsiEtap candidates
- Impact on signal still to be evaluated with MC (expect negligible)



JpsiEtap fit model

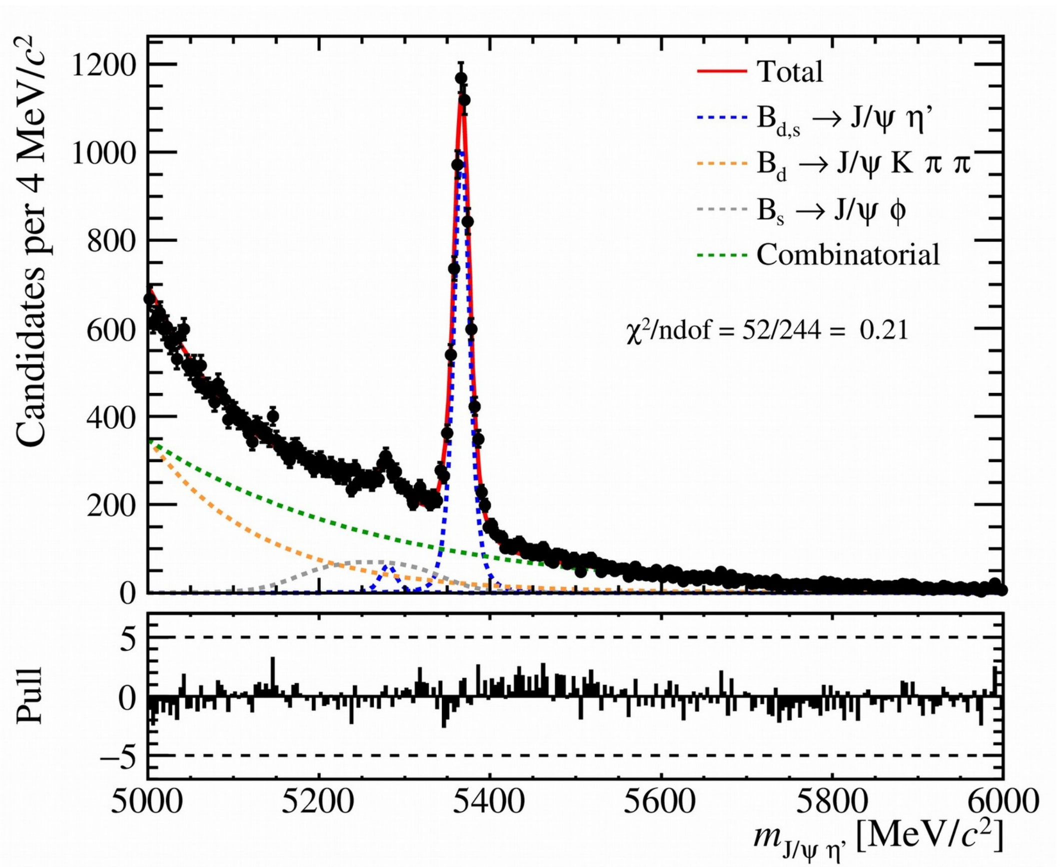
- Adding mis-ID'ed contributions
  - Mass veto efficiency from MC: Bs2JpsiPiPi (92%) and B02JpsiK* (87%)
  - To estimate the yields, we fit the relevant mass distributions before veto and scale them by the expected MC veto efficiency.
  - JpsiPiPi: N = 7371 (and N(B0) = 5.7 x N(Bs)) $\rightarrow$ N(veto) = 590
  - JpsiKPi: N = 6240 $\rightarrow$ N(veto) = 861





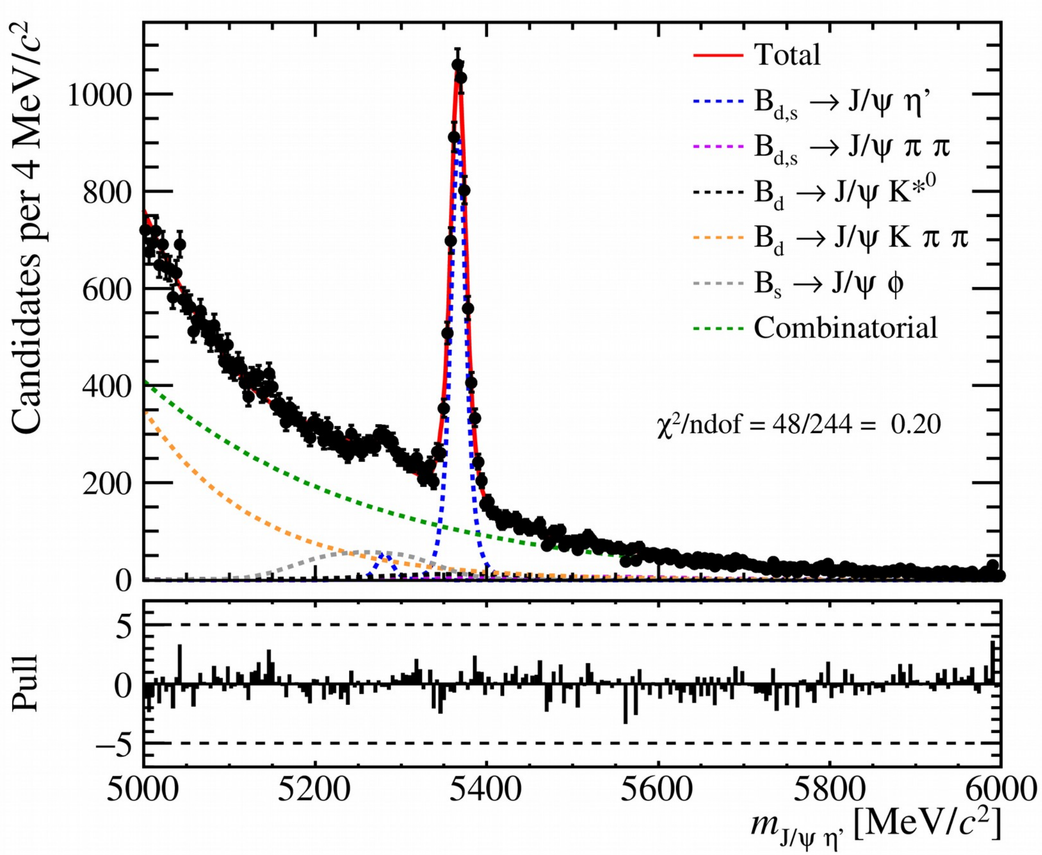
JpsiEtap fit model

- Previous fit model:
  - Yields of signal (N_{Bs} & N_{Bd}), of combinatorial (N_{Bkg}), of JpsiPhi (relative to signal (R_{Phi}), data/MC signal resolution (S_{σ}), slope of combinatorial (α)



JpsiEtap fit model

- New fit model:
  - Add JpsiPiPi and JpsiKPi with shapes taken from MC and fixed yields (i.e. no new parameters)
  - Still bad Chi2 but better residuals. Nsig = 5.74891e+03 (1.7%)



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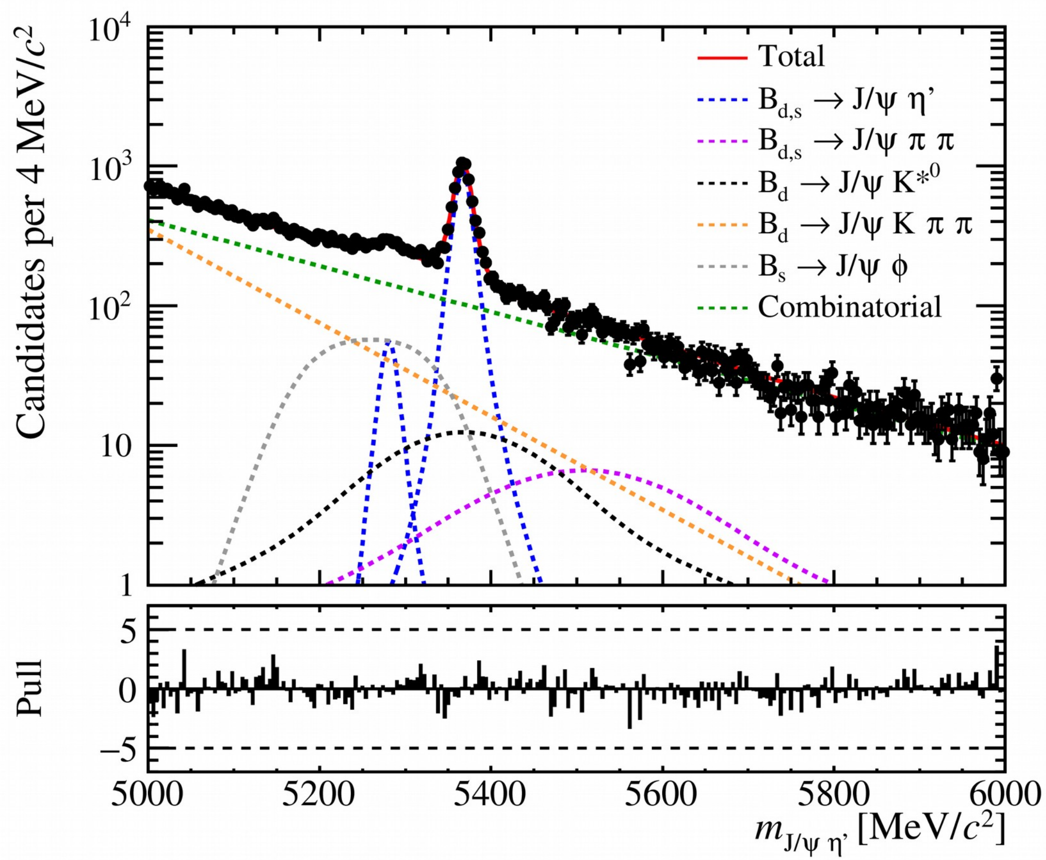
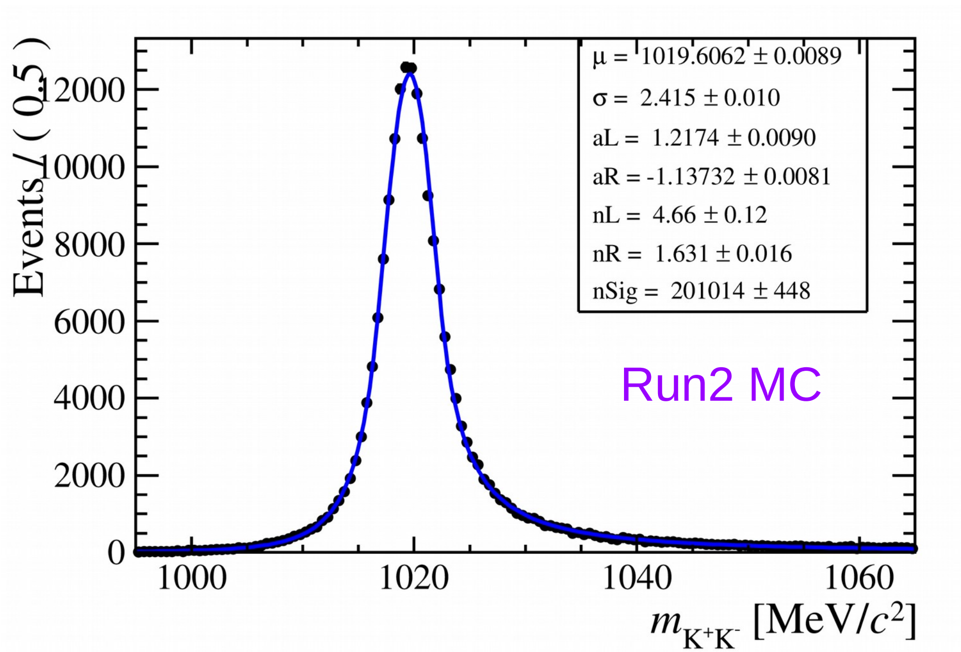
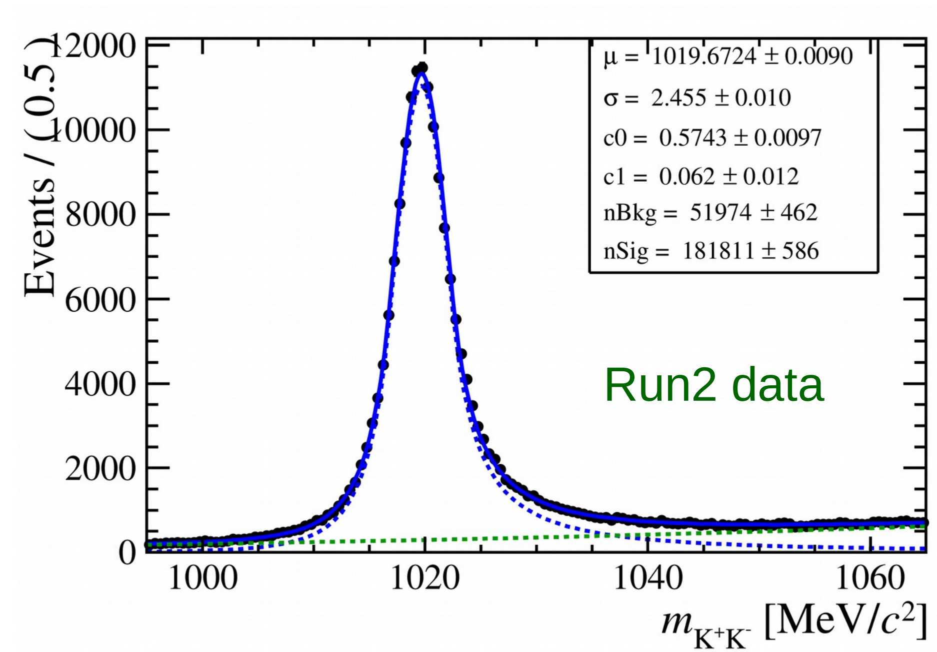


Treatment of JpsiPhi2KK

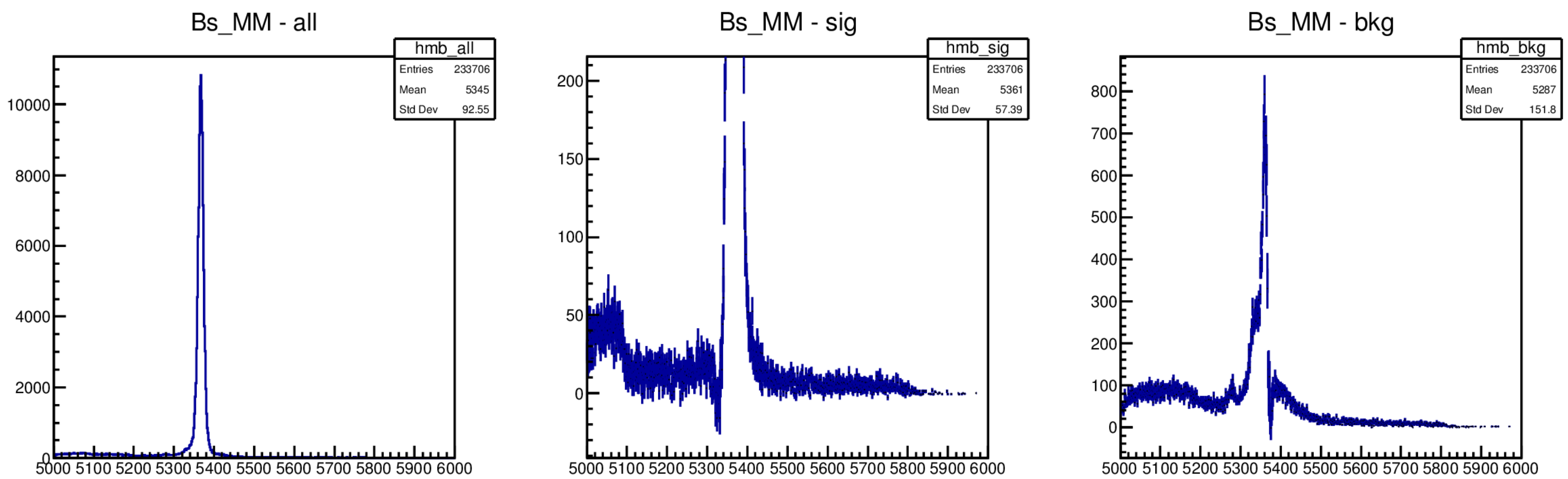
- Super clean mass distribution due to high PT-cut on Phi
- Separate KK resonant from rest using sPlot
  - Get the mass shapes from MC and fix the tails for the data fit





sPlot projections

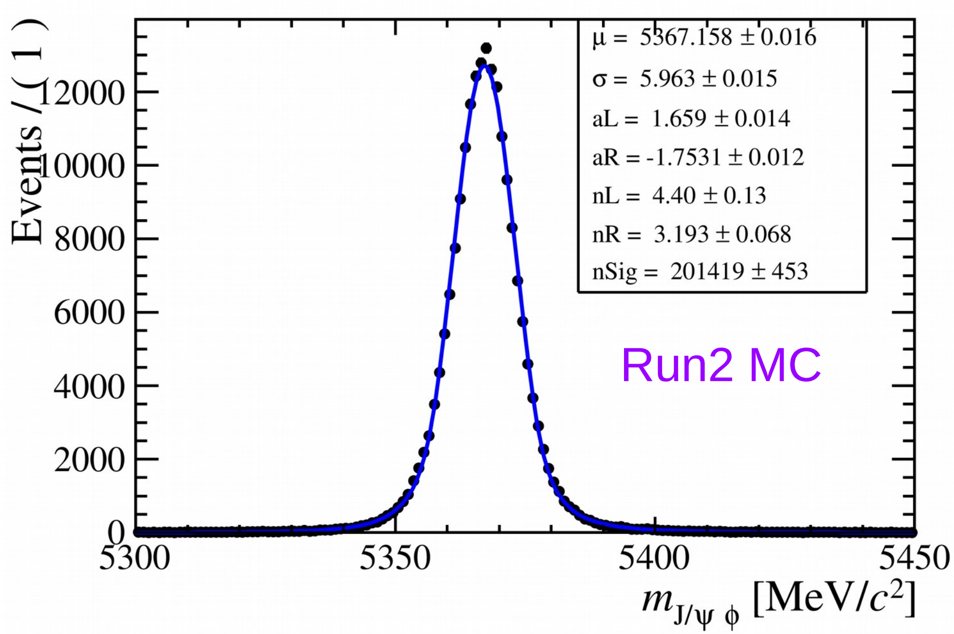
- Super clean mass distribution due to high PT-cut on Phi
- Separate KK resonant from rest using sPlot
  - Get the mass shapes from MC and fix the tails for the data fit
  - Use Phi sPlot weights to project Bs (DTF-)mass

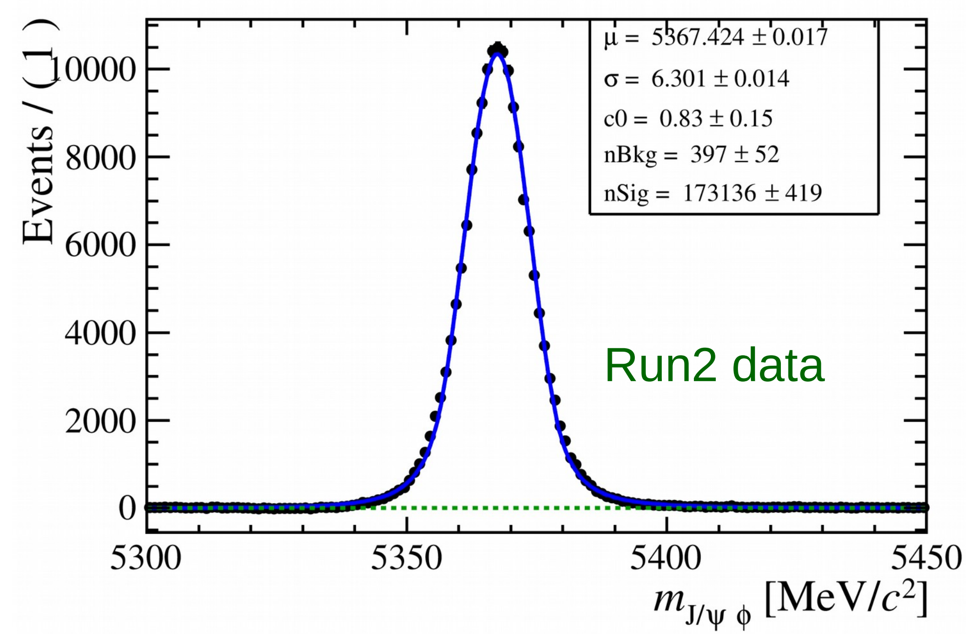


Mass fit of JpsiPhi2KK

- Super clean mass distribution due to high PT-cut on Phi
- Separate KK resonant from rest using sPlot
  - Get the mass shapes from MC and fix the tails for the data fit
  - Use Phi sPlot weights to project Bs (DTF-)mass

    $\rightarrow$ fit yields 173136 events





Putting it together

- Signal mode
  - N1 = 5749 +/- 97
  - BR1 = 3.3x10-4 . 29.1% = 9.60x10-5
  - eff1 = 1.81%
- Normalisation mode
  - N2 = 173136 +/- 419
  - BR2 = 1.08x10-3 . 48.9% = 5.28x10-4
  - eff2 = 10.05%
- Ratio
  - R = N1/N2 . BR2/BR1 . eff2/eff1 = 1.014

    (precision of 15% given by branchings)

Outlook

- Almost there with the fit model
  - Improve control on JpsiKPiPi
  - Understand poor Chi2/Ndf
- Towards branching: dominating systematics:
  - Will need photon efficiency study from Anthony (χ_{c1}K VS J/φK). On-going.
  - Normalisation mode: 2 kaons VS 2 pions. Compare kinematics and PIDCalib studies.
- Towards η/η’ mixing
  - Repeat exercise with: etap2etapipi & eta2pipipi0
- Towards Φs
  - Repeat exercice with: eta2gg & eta2pipig
  - Get hands-on with tagging tools + development of inclusive taggers (Boris & FT group)
- Next year
  - Manpower to make the difference available
  - Support Annecy/Edinburgh collaboration:

    analysis on git (Ntuples, fits etc...), common standards etc...