Mass fit of $B_s \rightarrow J/\psi\ \eta'[\rho\gamma]$

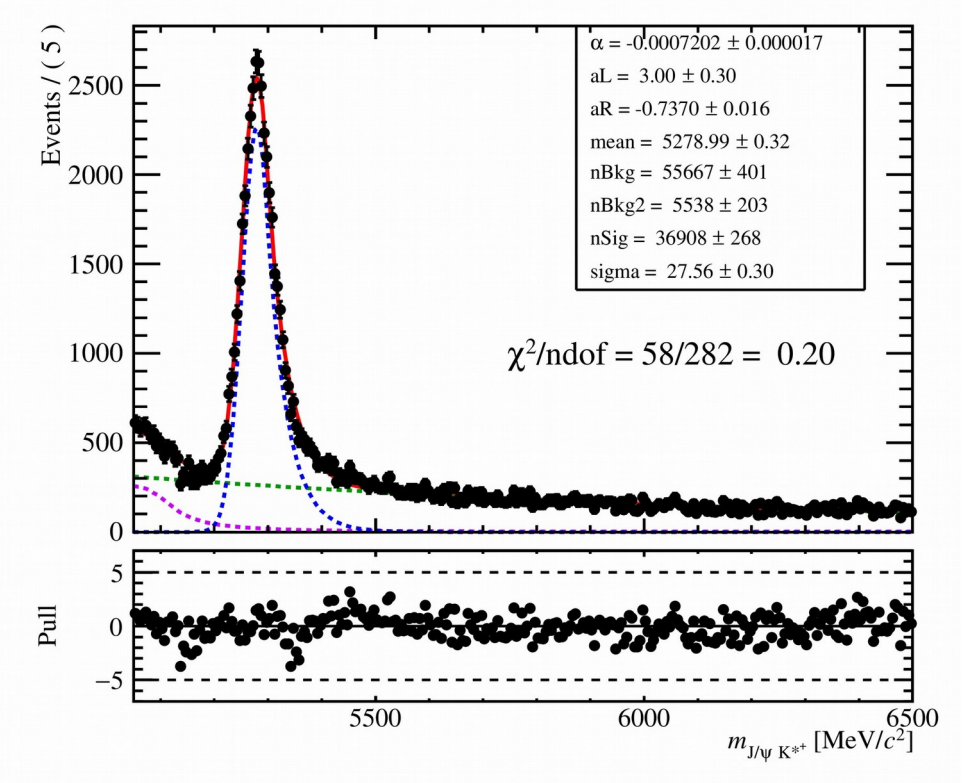
Nov 25th 2019, Annecy/Edinburgh meeting, M. Chefdeville

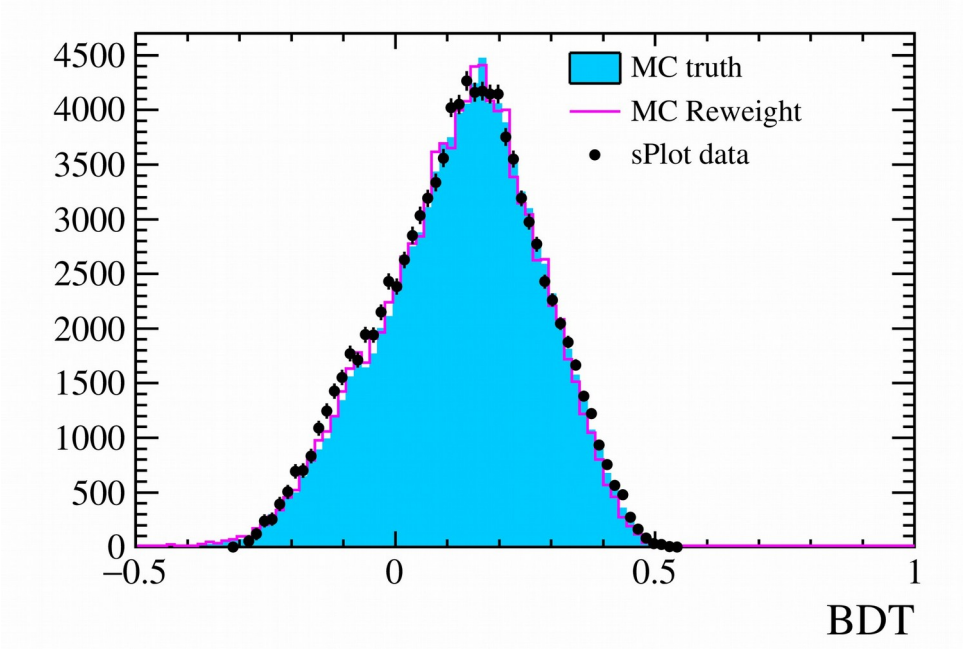
Outline

- Selections, BDT and vetoes
- Efficiencies & fit

Reminder – JpsiK* BDT

- Control BDT input variables with double-sPlot of JpsiK*[Kpi0]
- Vertex and kinematics very well reproduced ($\rightarrow$ predictable eff.): *gamma_PT, B_PT, B_DIRA, B_IP, B_VTXCHI2, B_dChi21Trk, Jpsi_DIRA, Jpsi_IP, mu_IPCHI2_MIN(MAX)*





JpsiEtap selections

```
MyRho2PiPi = CombineParticles("MyRho2PiPi",
                DecayDescriptor= "rho(770)0 -> pi+ pi-",
                Inputs = ["Phys/StdLoosePions/Particles"],
                CombinationCut = "(AM>600*MeV) & (AM<900*MeV) & (ADOCACHI2CUT(15, ''))",
                MotherCut = "(BPVVDZ>0) & (VFASPF(VCHI2)<9) & (BPVDIRA>0.95) & (BPVVDCHI2>25)")
```

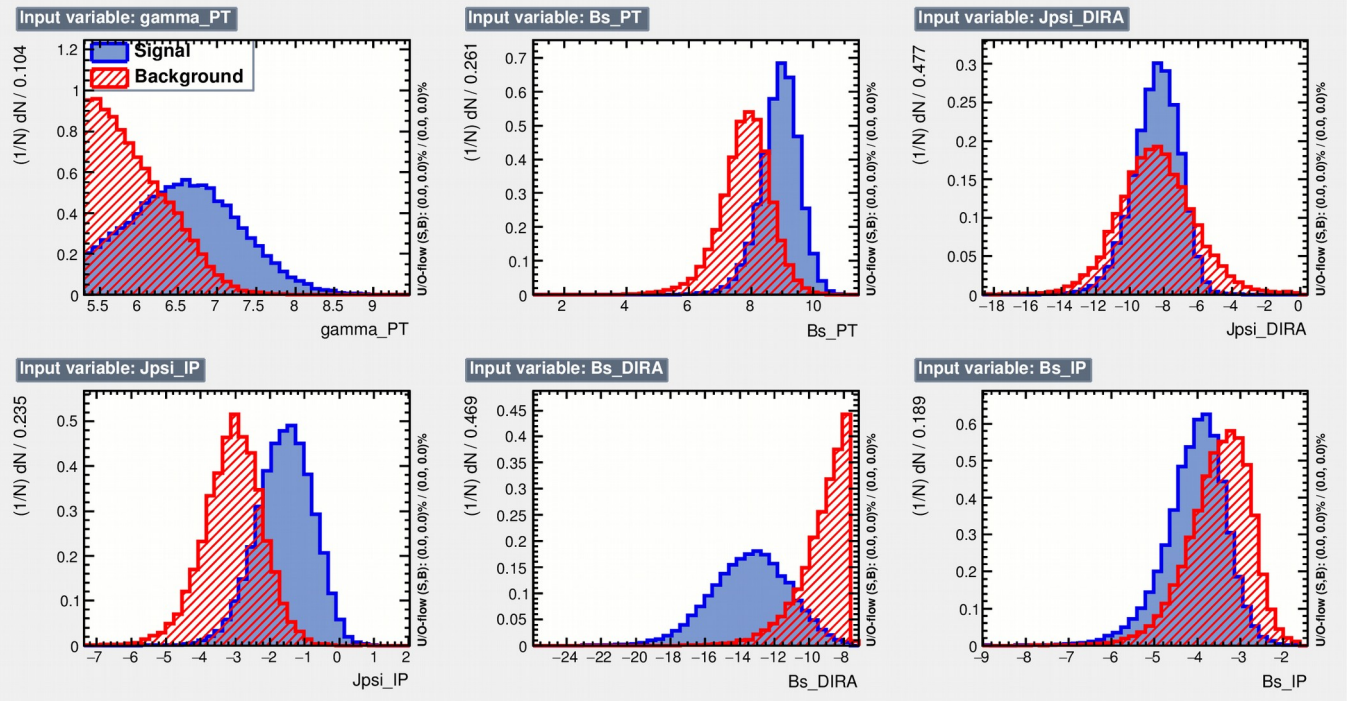
```
MyEtap2RhoGamma = CombineParticles("MyEtap2RhoGamma",
                        DecayDescriptor = "eta_prime -> rho(770)0 gamma",
                        Inputs = ["Phys/MyRho2PiPi" , "Phys/StdLooseAllPhotons/Particles"],
                        DaughtersCuts = { "gamma" : "(CL>0.05)"},
                        CombinationCut = "(ADAMASS('eta_prime')< 100*MeV) & (APT>1500*MeV)",
                        MotherCut = "ALL")
```

```
MyBs2JpsiEtap2RhoGamma = CombineParticles("MyBs2JpsiEtap2RhoGamma",
                                DecayDescriptor= "B_s0 -> J/psi(1S) eta_prime",
                                Inputs = ["/Event/AllStreams/Phys/FullDSTDiMuonJpsi2MuMuDetachedLine/Particles"
                                , "Phys/MyEtap2RhoGamma/Particles"],
                                CombinationCut = "(AM>4500*MeV) & (AM<7000*MeV)",
                                MotherCut = "(BPVDIRA>0.9995) & (BPVIP()<0.2) & (BPVIPCHI2()<20) &
                               (VFASPF(VCHI2PDOF)<10)")
```

Offline: PROBNNpi*(1-PROBNNk)>0.4, for each pion

JpsiEtap BDT

- New MC (no gen-level cut): 2+4M Std+ReDecay (2015-2016)
- MVA: 80k signal events VS 80k bkg 2016 events defined as: *abs(Jpsi_MM-3096)<30 && Bs_MM>6000*



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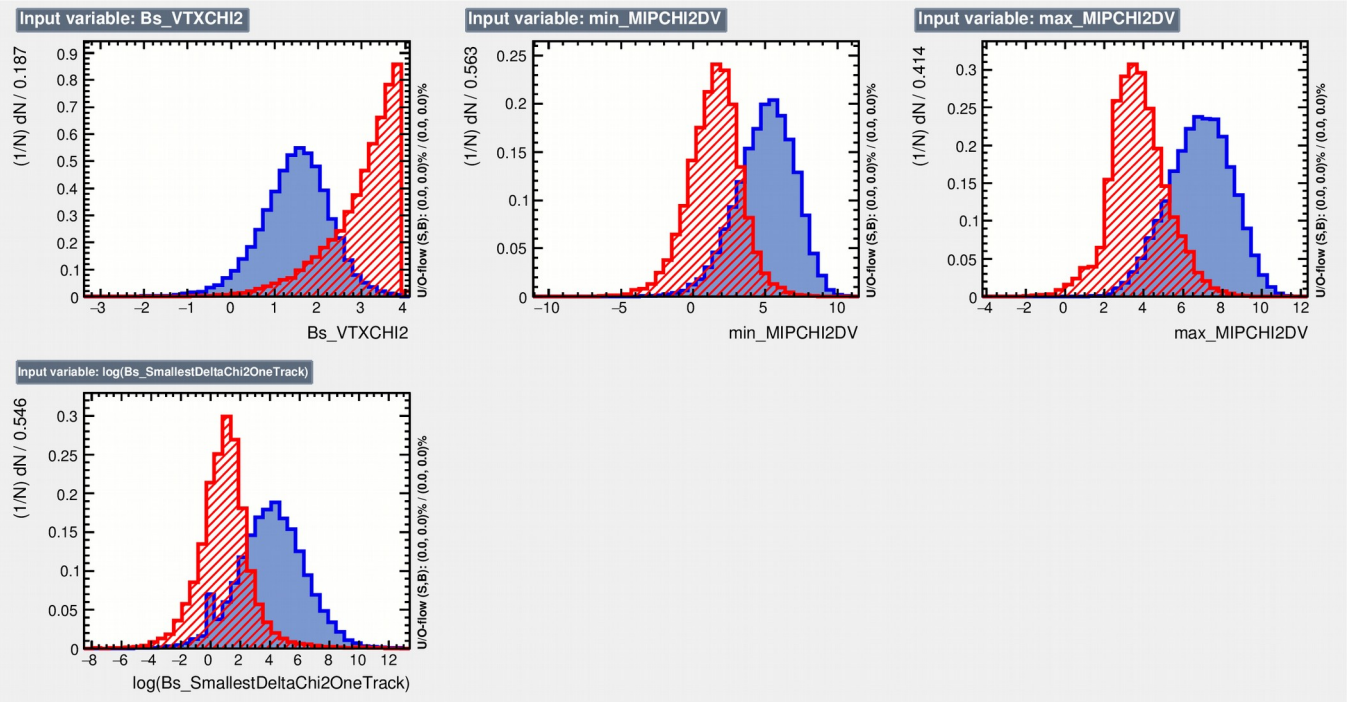

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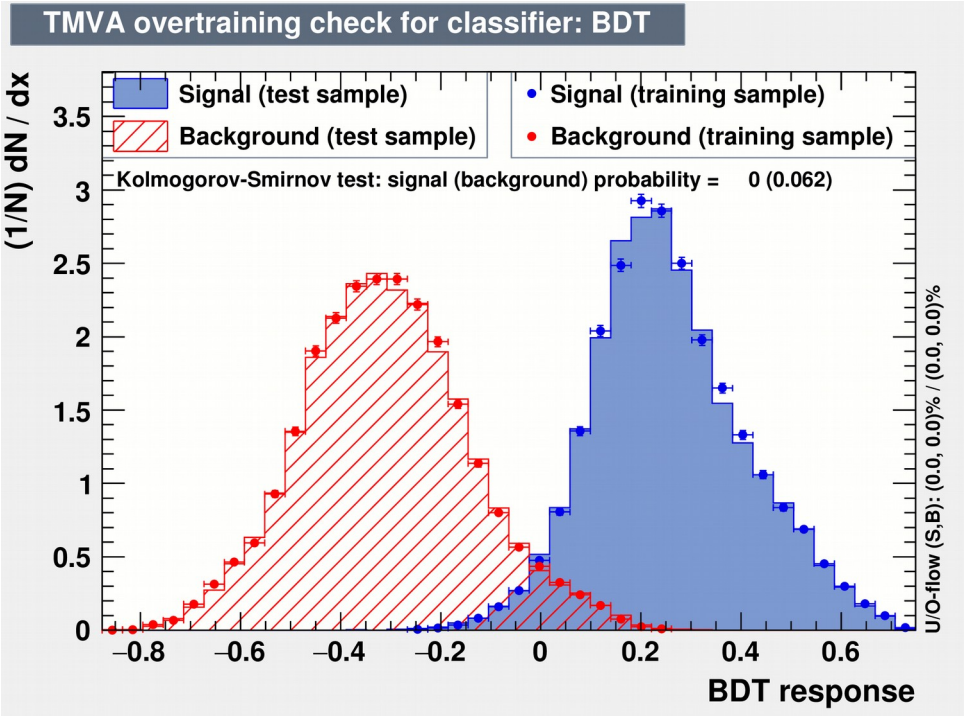
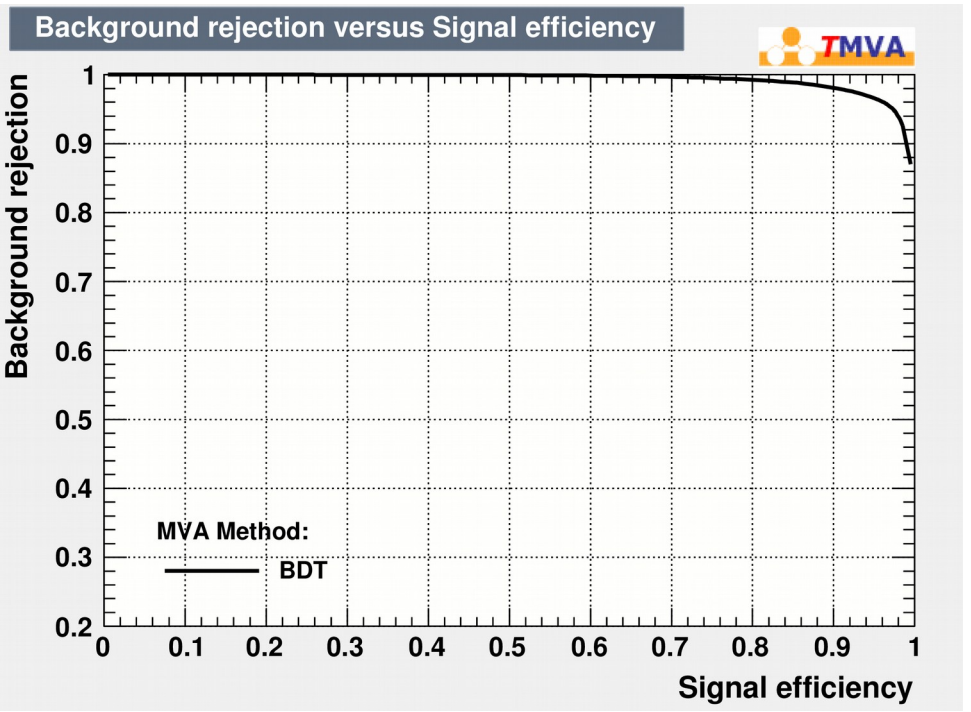
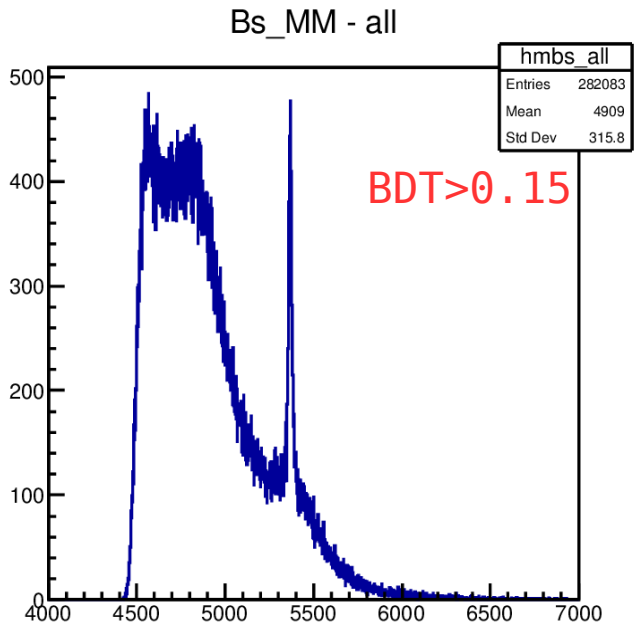
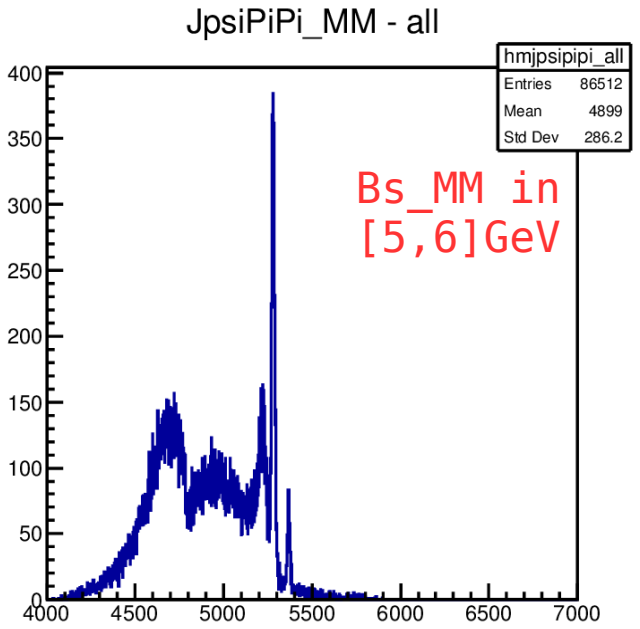


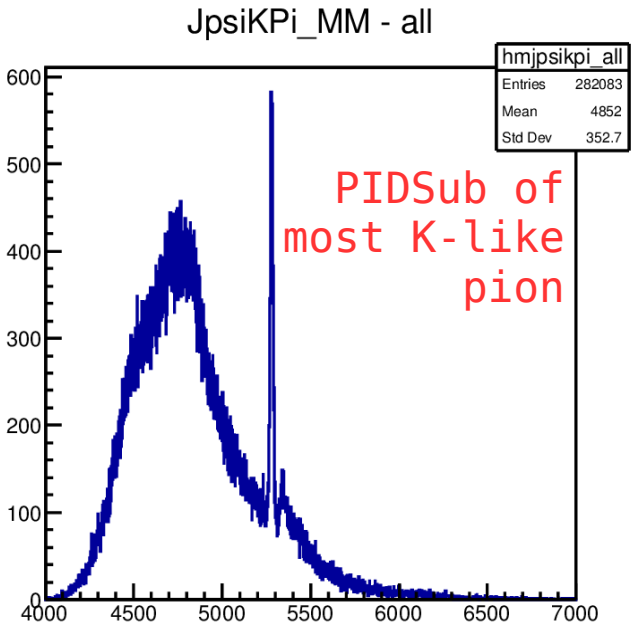


BDT cut (2016-17-18 data)

- Calculate significance (S/sqrt(S+B)) for various cut
  - S(x) = N(BDT>0) * eff (BDT>x), with eff deduced from MC BDT distribution and N(BDT>0) from simple mass fit (gauss+expo)
  - B(x) = N(B) taken from an expo fit of sideband region (>6 GeV). Expo function is then extrapolated to the signal region
- The significance reaches a maximum (of 76) at BDT = 0.15

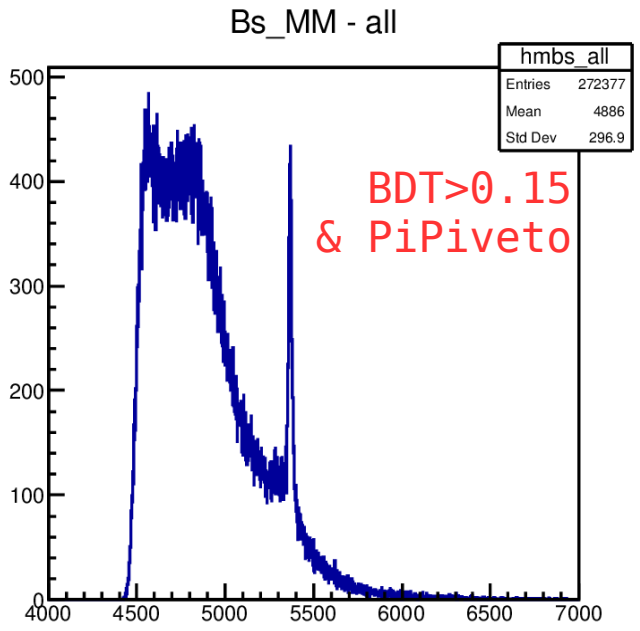


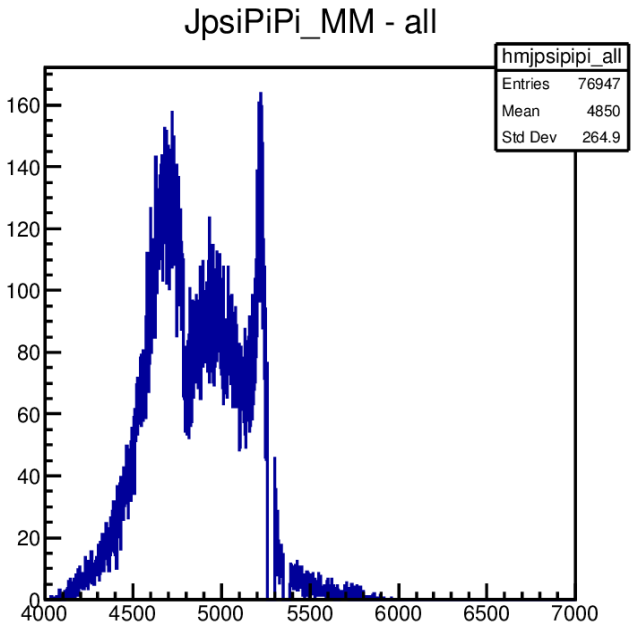


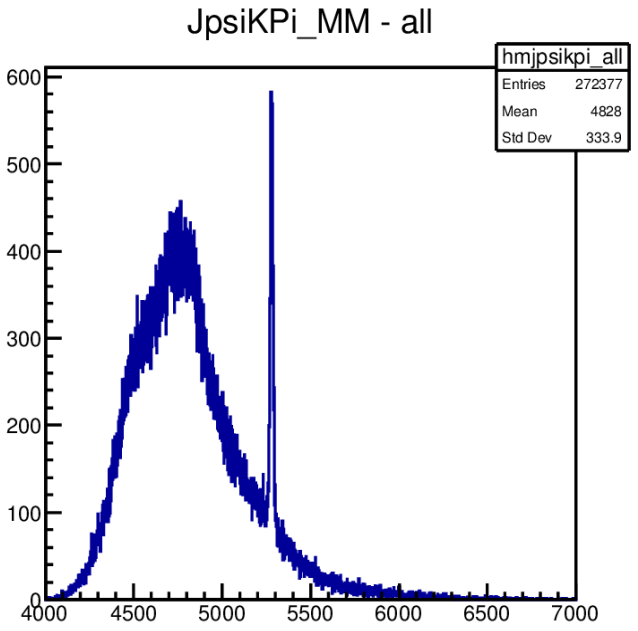


JpsiPiPi vetoes

- Veto events with mass within 2.5 sigma of $B_{d,s}$ masses (20 MeV)
  - Signal efficiency (98.1%)
  - JpsiPiPi efficency (8.2%). JpsiPiPi mass distribution not gaussian ← calculated from DTF 4-v with etap mass constrain: quite some outliers at lower mass.

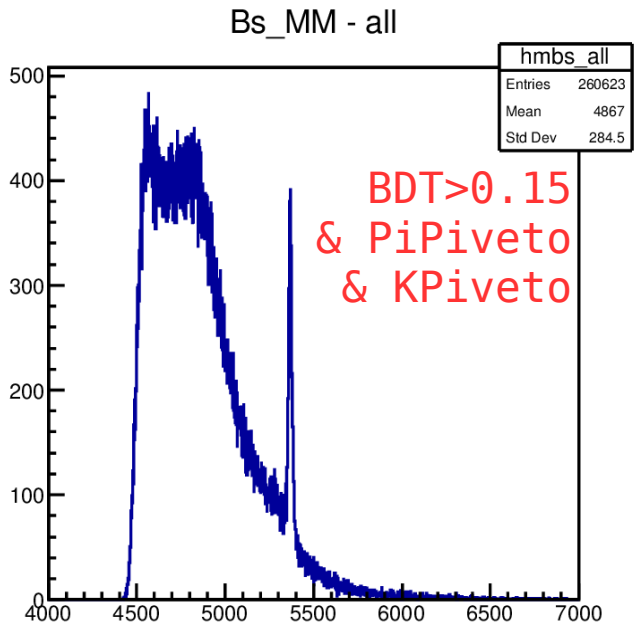


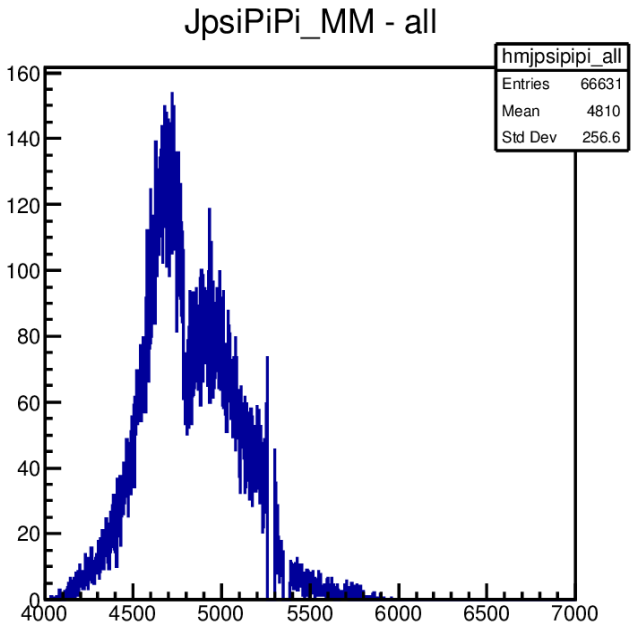


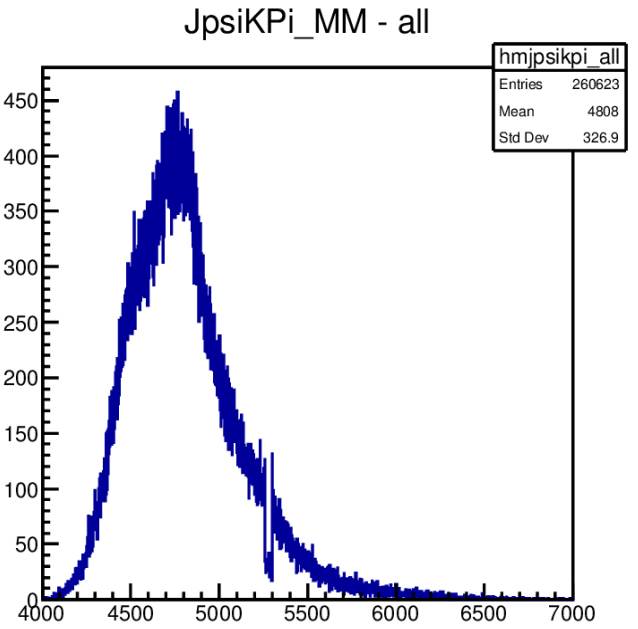


JpsiKPi veto

- For events with mass within 2.5 sigma of B_d masses (20 MeV): tigher PID cut (PID<0.95) on most kaon-like pion (highest PID). Preferable to just a veto on [m($(\pi_1 \rightarrow)K_1\pi_2$) or m($(\pi_2 \rightarrow)K_2\pi_1$)]*
  - Signal efficiency, eff = 96.9% (88.2%*)
  - JpsiK*^{0} efficency: eff = 13.8% (5%*)

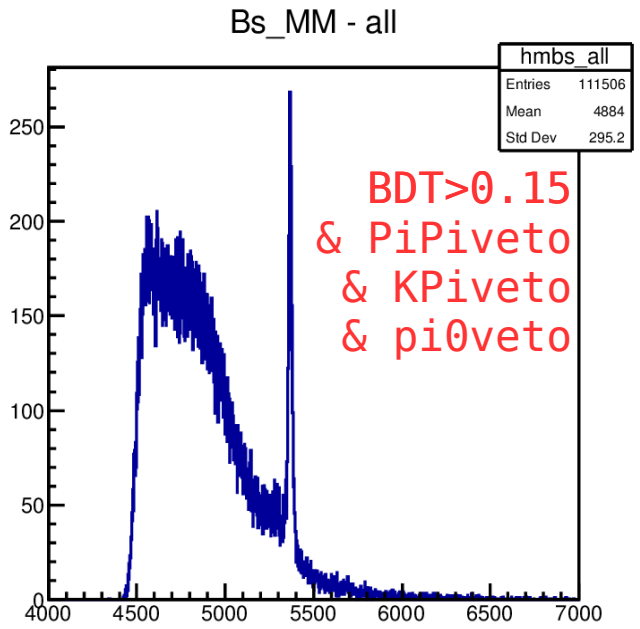


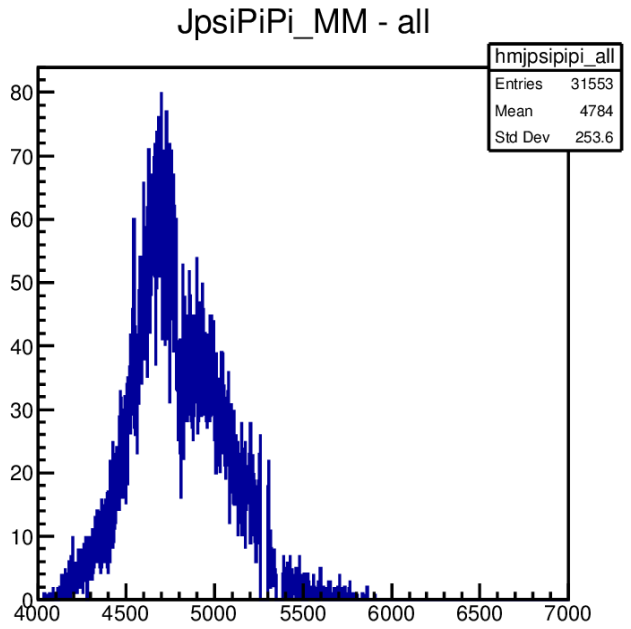


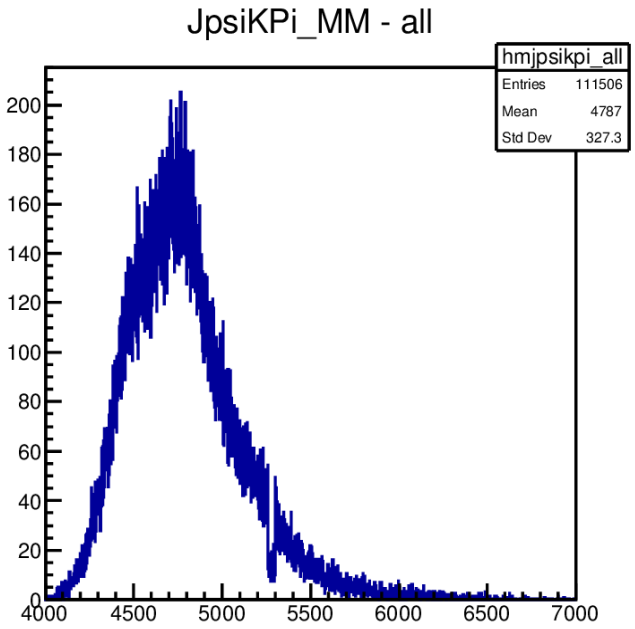


JpsiPhi veto

- With Phi $\rightarrow$ PiPiPi0, hard to veto as pi0 not fully reco'ed
- Try with pi0veto on the reco'ed photon
  - Signal: 72.0% $\rightarrow$ wrong association 28.0% of time
  - JpsiPhi: 52.4% $\rightarrow$ correct association 19.6% of time but high cost on signal







JpsiPhi decays

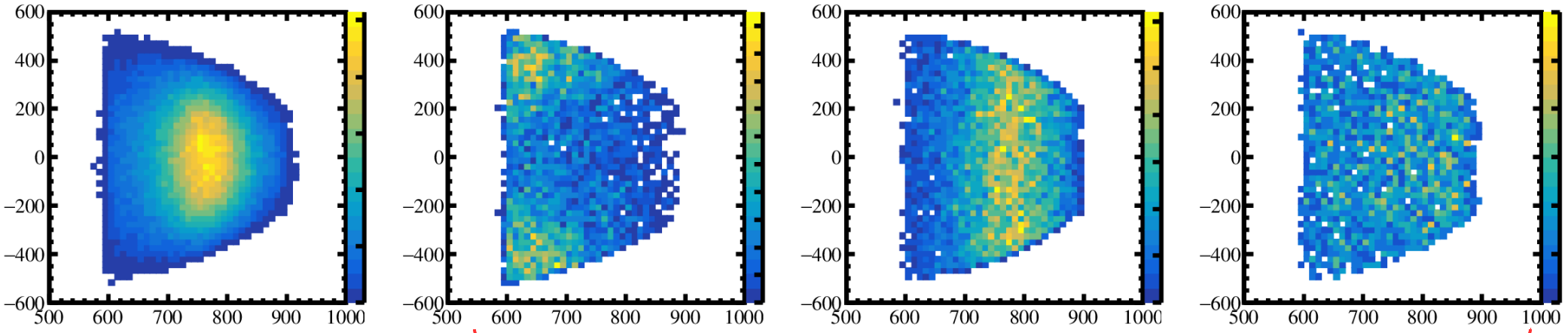
- MC sample is a cocktail of the resonant and non-R decays

  $\rho^+\pi^-$ (27.8%), $\rho^-\pi^+$ (27.8%), $\rho^0\pi^0$ (27.8%), $\pi^+\pi^-\pi^0$ (16.6%)

- Kinematics closest to signal when charged pions come from ρ^0

  Charged ρ^+: different kinematics $\rightarrow$ $m(\pi_1\gamma)$-$m(\pi_2\gamma)$ VS $m(\pi\pi)$
  Use $|\Delta m| < 320$ MeV and $m(\pi\pi)>650$ MeV

$\rho^0\gamma$ $\rho^+\pi^-$ $\rho^0\pi^0$ $\pi\pi\pi^0$

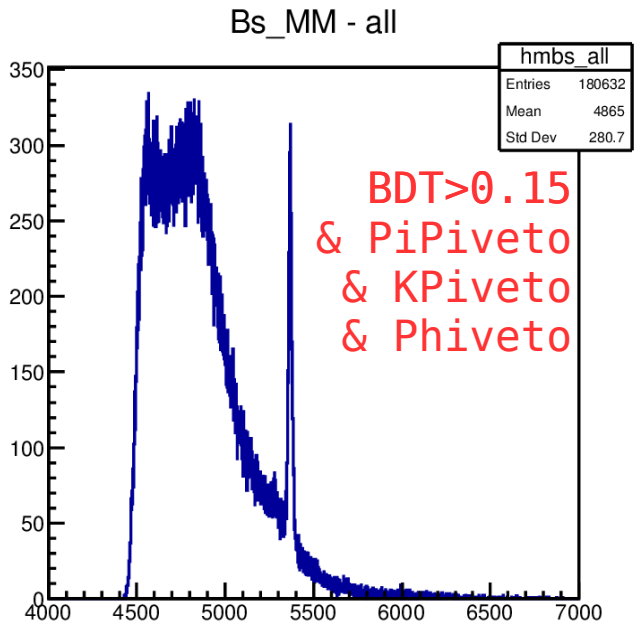


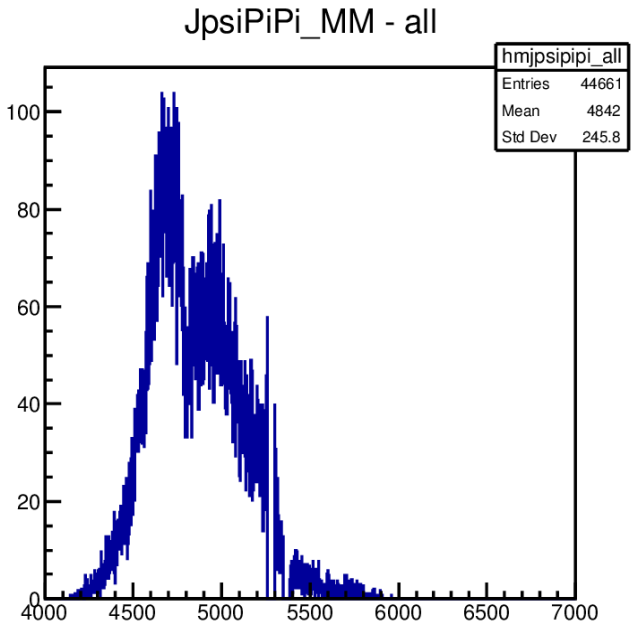
JpsiEtap

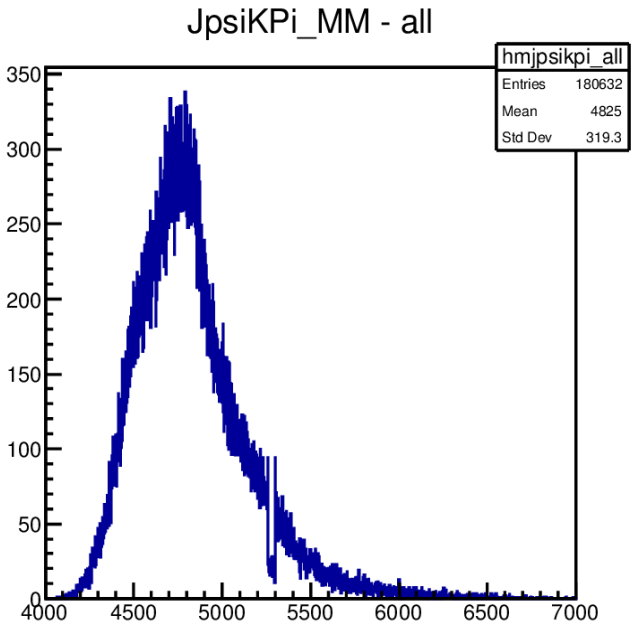
JpsiPhi

JpsiPhi veto

- With $|\Delta m| < 320$ MeV and $m(\pi\pi)>650$ MeV
  - Signal: 86.6% (VS 72.0% with pi0 veto)
  - JpsiPhi: 39.9% ($\rho\pi$), 76.9% ($\rho^0\pi^0$), 68.9% ($\pi\pi\pi^0$)
    = 65.4% (VS 62.4% with pi0 veto)







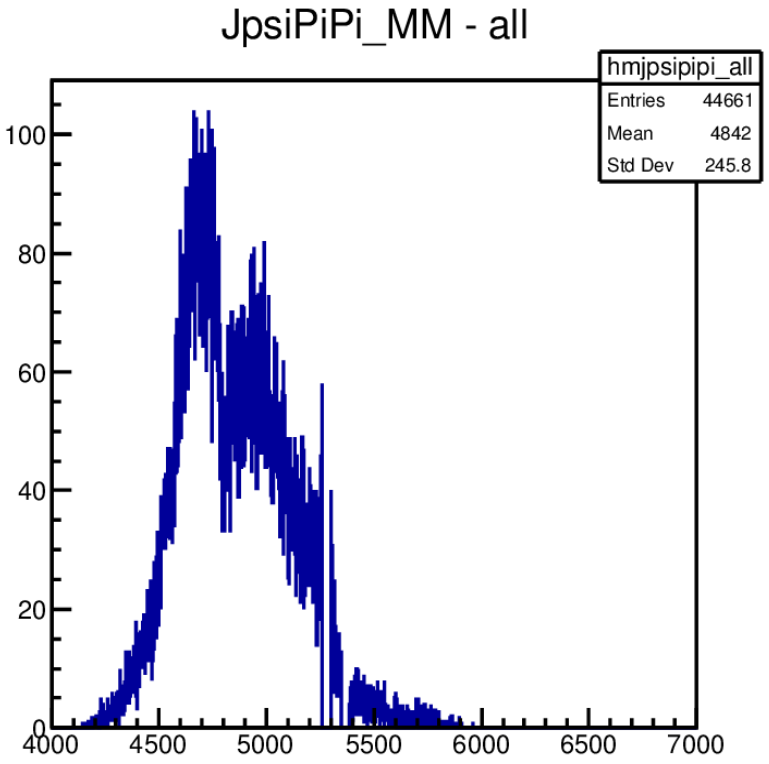
Expected yields after sel. & vetoes

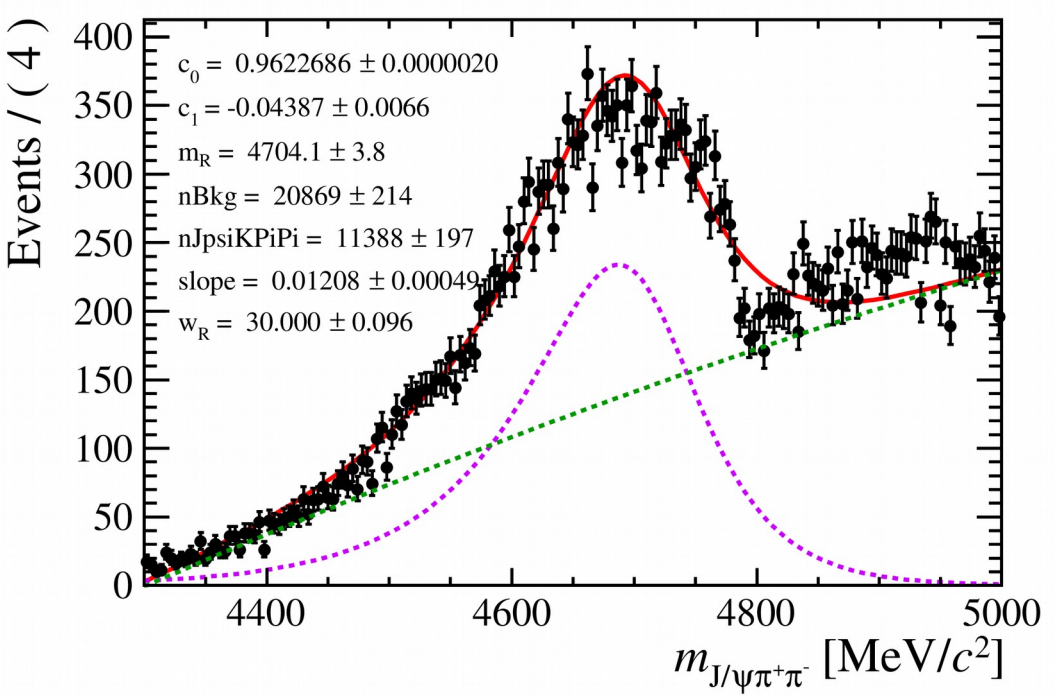
- For the yield of $B^+ \rightarrow$ Jpsi KPiPi (new Run2 MC available)
  - We can also consider the neutral decay to Jpsi K^0pipi and add a factor of 2 to BR. Case of kaon misID is not considered.
- Relevant bkg: JpsiPhi23Pi & JpsiKPiPi = 0.47 & 0.12 of signal

Mode	Bs → JpsiPiPi	B0 → JpsiPiPi	Bs → JpsiPhi Phi[KK]	Bs → JpsiPhi Phi[pipipi0]	B0 → JpsiK*	B+ → JpsiKpipi	Signal
eff (%)	0.02%	Assume same as Bs mode	6×10^{-7}	0.51%	0.003%	0.003%	1.81%
BR	2.13×10^{-4}	1.61×10^{-4}	5.2×10^{-4}	1.6×10^{-4}	5.12×10^{-3}	$2\times3.2\times10^{-3}$	0.96×10^{-4}
eff.BR$\times10^6$	0.035	0.026	0.00031	**0.82**	0.00017	**0.20**	**1.74**

More on JpsiKPiPi

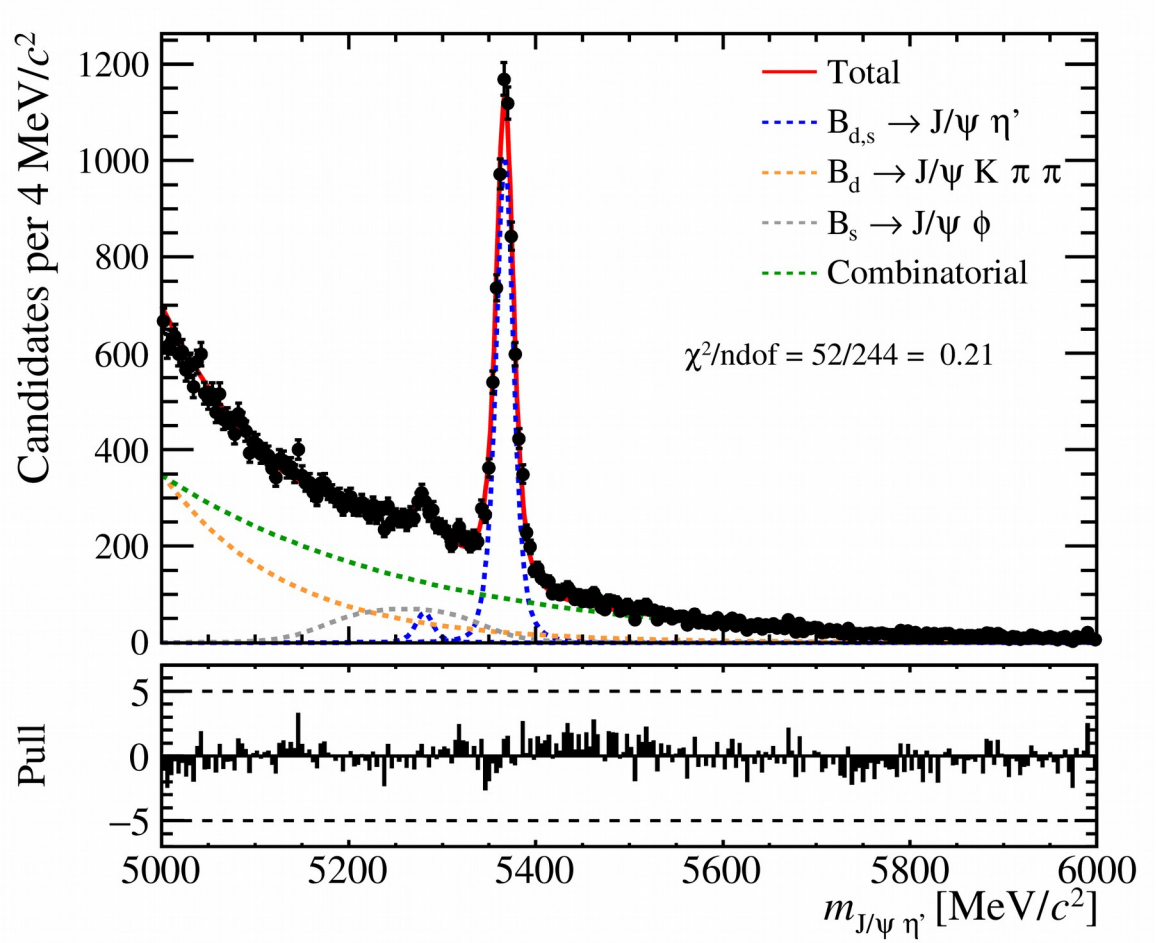
- To constrain the JpsiEtap fit more
  - Try to get the JpsiKPiPi yield from the JpsiPiPi fit
  - At this stage, I don't have the shapes yet (forget the fit)
  - N(JpsiKPiPi) around 11388





Fit model & results

- Parameters: 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).

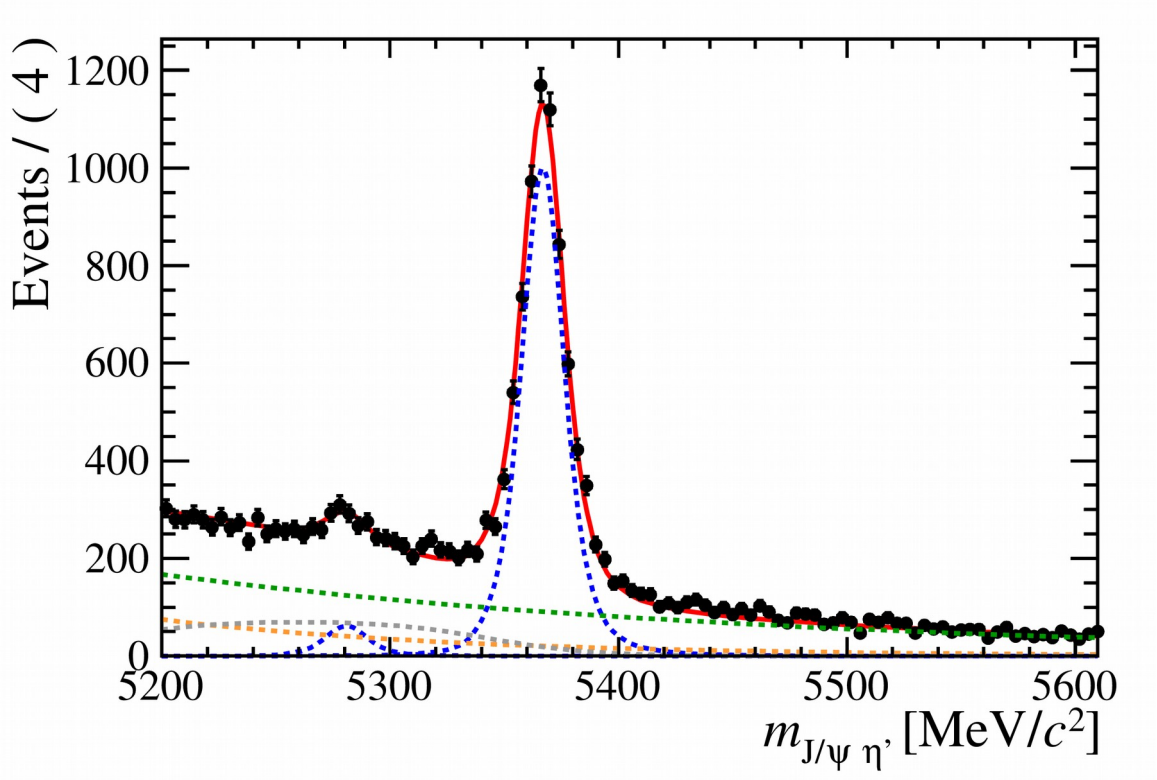


N_{Bs} = 6.63192e+03 (1.00436e+02)
N_{B0} = 4.08152e+02 (6.49563e+01)
N_{Bkg} = 2.32254e+04 (2.36847e+02)
R_{Phi} = 4.66127e-01 (2.83615e-02)

S_σ = 1.20694e+00 (2.17750e-02)
α = -3.64928e-03 (3.43603e-05)

Fit model & results

- Signal yields: 6631 Bs (1.5%) & 408 Bd (16%)
- JpsiPhi yield is 0.47 that of signal when 0.47 is expected
- JpsiKPiPi yield was fixed. Given N_{Bs}, relative yield is 20 times off!
- Low Chi2: poor description of region on the right side of peak



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Outlook

- With current cuts: we measure the BR of the Bs to 1.5% precision, and the Bd to 15% only. What purity do we want?
  - Physics case dependent: BR, eta/eta' mixing, lifetime, TD
  - For absolute BR with JpsiK* normalisation: 8.4%

    + fs/fd (5.8% at 7 TeV) $\rightarrow$ 10.2%

    Current PDG value for JpsiEtap (12%)

    $\rightarrow$ do we want to use another decay? JpsiPhi (σ(BR) 7.4%)
- This analysis:
  - Why is JpsiKPiPi so large?
  - Further improvement to JpsiPhi: when pi0veto=1 and a second photon is reco'ed, fully reconstruct the Bs decay and check the mass. Not practical to do with DV but will try.
  - Right-hand side of Bs mass: fake photons?