Mass fit of JpsiK*$^{+}$

March 13th 2019, Annecy/Edinburgh meeting, M. Chefdeville

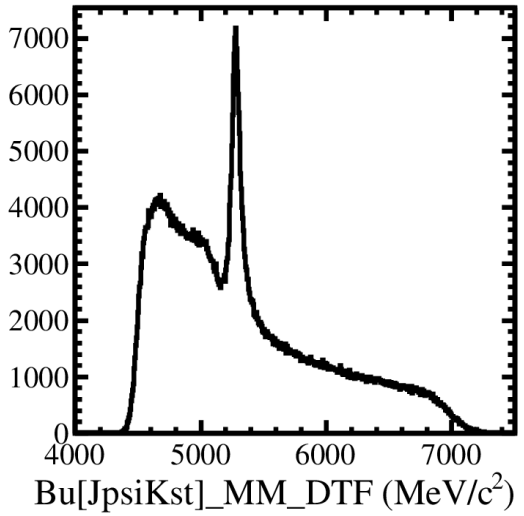
Status

- BR measurement strategy
  - BR_1 (JpsiX^0) = BR_2 (JpsiK^{*+}) . N_1/N_2 . $\varepsilon_2/\varepsilon_1$, with $\varepsilon = \varepsilon^{data}(x$ = e.g. BDT)
  - For variables well described by MC: $\kappa = \varepsilon^{data}/\varepsilon^{MC} = 1 \rightarrow BR_1 = BR_2 \,.\, N_1/N_2 \,.\, \varepsilon_2{}^{MC}/\varepsilon_1{}^{MC}$
  - If not well described, two cases:
    - Same MC distributions for x_1 and x_2 (e.g. ProbNNmu) $\rightarrow \kappa_1 = \kappa_2 \rightarrow \varepsilon_2{}^{data} \,/\, \varepsilon_1{}^{data} = \varepsilon_2{}^{MC} \,/\, \varepsilon_1{}^{MC}$
    - Different MC distributions (e.g. pi0_IT) $\rightarrow$ reweight x_2 to match $x_1 \rightarrow$ recalculate $\varepsilon_2{}^{MC}$

- 1 BDT for each neutral modes (vertex, kinematics, isolation variables)
  - First BDT: trained on JpsiK^{*+} signal MC (possibility to use sPlot data, if really useful)

  1) Data/MC agreement: BDT cut efficiency on abundant JpsiK^{*+} $\rightarrow$ fit model
  2) Identify problematic variables $\rightarrow$ sPlot
  3) Compare MC variables between JpsiK^{*+} and JpsiX^0 (e.g. JpsiPi0)

Data and BDT



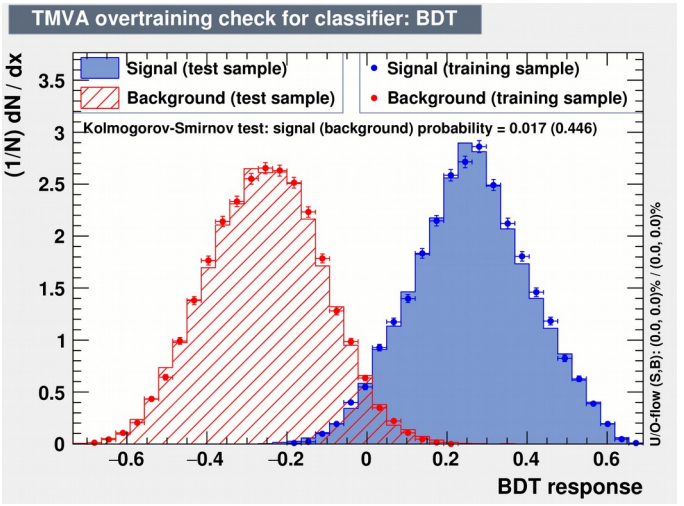
Run II data

CL(g1,g2)>0.05, PT(pi0)>1.5 GeV/c, PROBNNk(K^+)>0.1,
$\Delta m(K^{*+})$=150 MeV/c^2, Δm(pi0)=30 MeV/c^2, Δm(Jpsi)=100 MeV/c^2
DIRA>0.9995, IP<0.2, IPCHI2<20, VTXCHI2/NDOF<10
Fisher(B^+)>-1.1

BDT

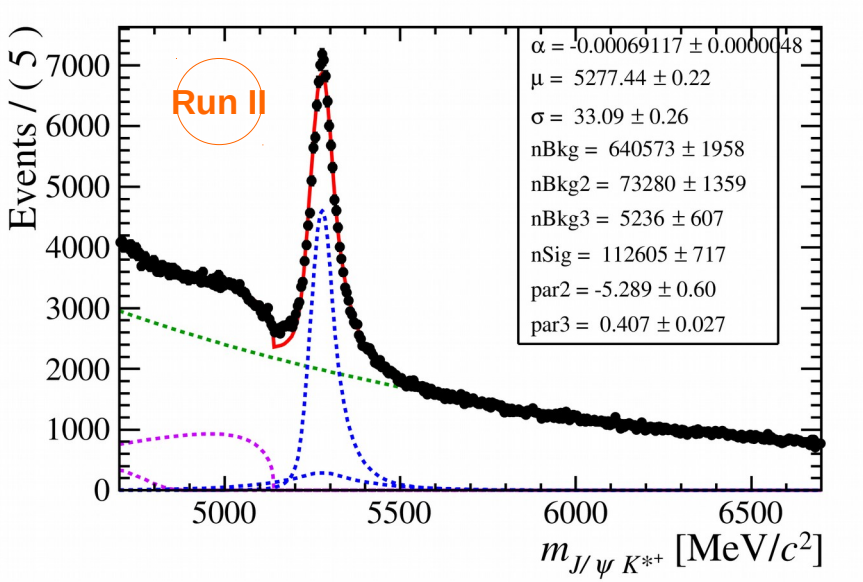
$JpsiK^{*+}$ 2015+2016 MC truth-matched
Bkg: data sidebands

Rank	Variable	Variable Importance
1	Bplus_PT	8.746e-02
2	Bplus_DIRA	8.154e-02
3	min_MIPCHI2DV	8.023e-02
4	pi0_PT	7.177e-02
5	Bplus_IP	6.034e-02
6	max_MIPCHI2DV	5.983e-02
7	Bplus_VTXCHI2	5.951e-02
8	Jpsi_DIRA	5.765e-02
9	log(Bplus_SmallestDeltaChi2OneTrack)	5.732e-02
10	min_IsNotH	5.340e-02
11	pi0_0.40_IT	5.339e-02
12	max_IsNotE	5.170e-02
13	pi0_0.40_nc_mult-2+pi0_0.40_cc_mult	4.950e-02
14	Jpsi_IP	4.660e-02
15	min_IsNotE	4.469e-02
16	max_IsNotH	4.325e-02
17	Bplus_NumVtxWithinChi2WindowOneTrack	4.183e-02



Fit model

Previous fit



- Signal → double-sided CB (tails from Run II MC)

  $B^+ \to J/psi\ K^{*+}[K^+\ pi0[gg]] \to \mu, \sigma, nSig$

- Combinatorics → exponential (α, nBkg)

- Tricky peaking backgrounds:
  between part-reco'ed & combinatorics ($\overline{\text{overlined}}$)
  1) $B^+ \to J/psi\ K^{*+}[K^+\ pi0[g\bar{g}]]$
  2) $B^+ \to J/psi\ K^{*+}[K^+\ \overline{pi0[gg]}]$
  3) $B^0 \to J/psi\ K^{*0}[K^+\ (pi^-)\ \overline{pi0[gg]}]$
  4) $B^+ \to J/psi\ K^+\ \overline{pi0[gg]}$

Try to contrain relative fractions using known BR and Run II MC efficiencies. Pdf shapes from MC. Only yield floating: nBkg1.

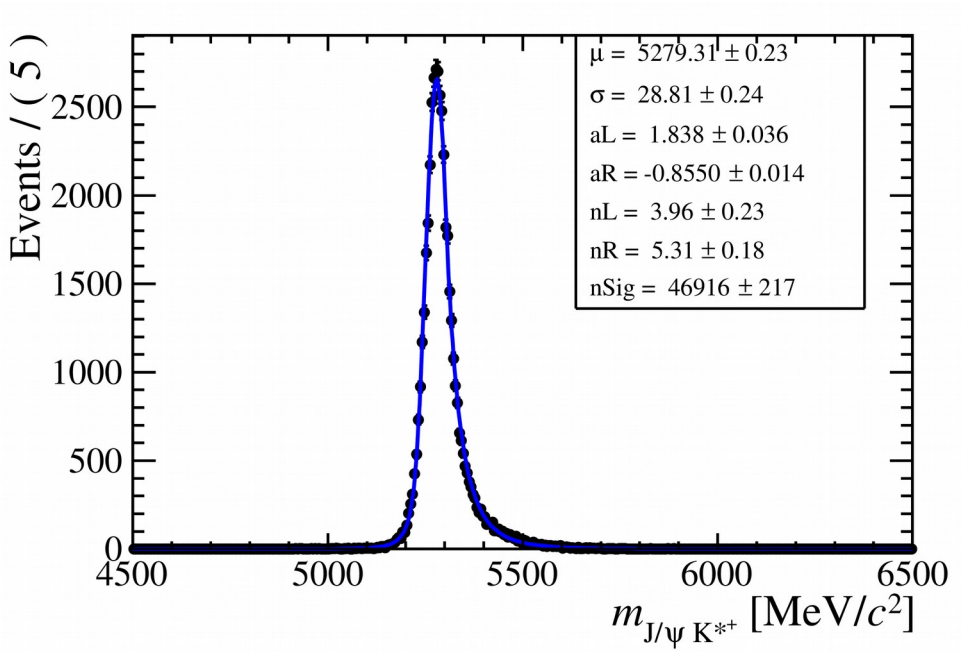
- Partially reconstructed:
  - $B^+ \to$ psi(2S) [J/psi (pi^+pi^-)] K^{*+}, restrict fit range to [5050,6000] MeV/c2
  - $B \to J/psi\ K_1[K^{*+}\ pi]$, pdfShape from Run I MC, only yield floating nBkg2

Signal J/psi K*+

- MC sample:
  - 4M, 1516UpDw, Event type: 12143401, decfile
  - Sim09e, Stripping28r1NoPrescalingFlagged, ALLSTREAMS.DST
- 47k events after selection (all truth-matched)
- Fit: double Crystal-Ball function

In fit range:

BR . ε
= 1.44e-3 . 1/3 . 1.217%
= 5.84e-6

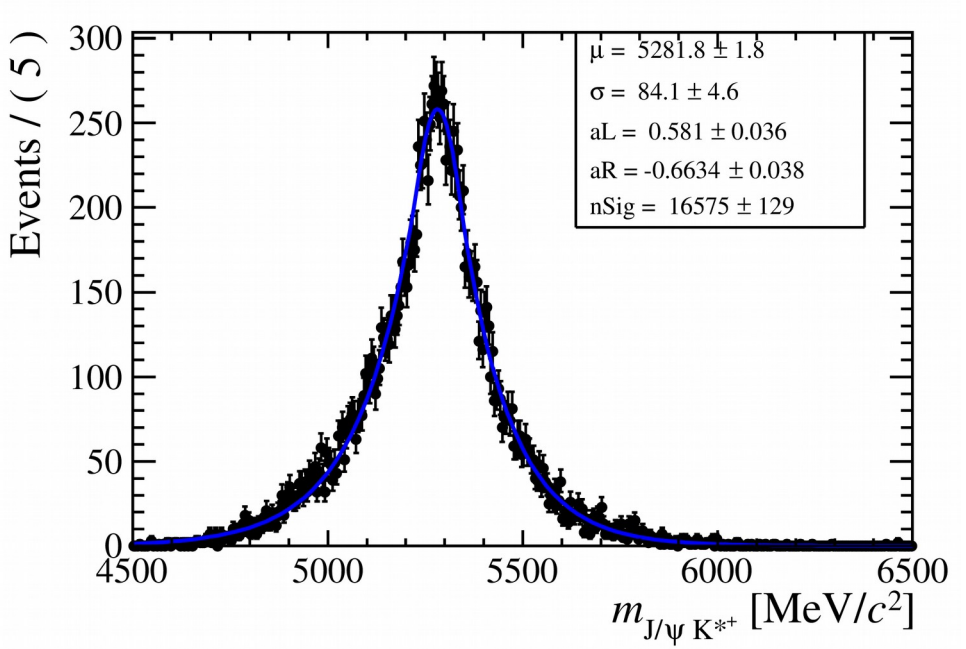


Peaking J/psi K*+[K+ pi0[gg̅]]

- MC sample:
  - 4M, 1516UpDw, Event type: 12143401, decfile
  - Sim09e, Stripping28r1NoPrescalingFlagged, ALLSTREAMS.DST
- 17k events after selection (only one photon is truth-matched)
- Fit: gaussian function with expo tails

In fit range:

BR . ε
= 1.44e-3 . 1/3 . 0.426%
= 2.05e-6

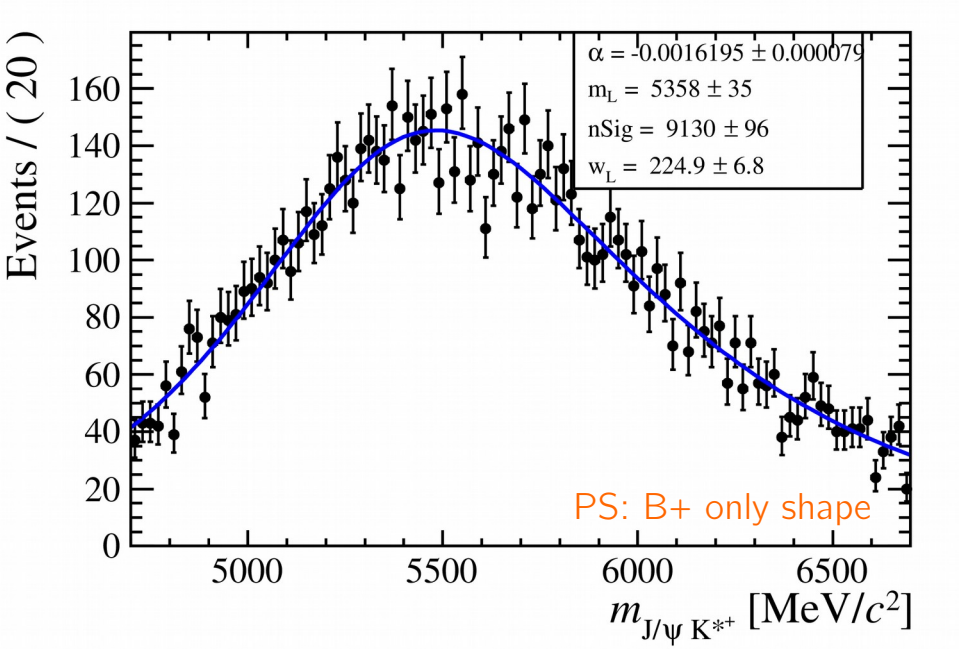


Peaking J/psi K*+[K+ pi0[$\overline{gg}$]]

- Same MC sample as previous. Add **B^0 → Jpsi K*0[Kpi]**
  - 2.8 M, 16Up (way more avail.), Event type: 11144001, decfile
  - Sim09b, Stripping26NoPrescalingFlagged (L0 bug?), ALLSTREAMS.LDST
- 6k-3k evts after sel. (JpsiK*+-JpsiK*0), photons not truth-matched
- Fit: gaussian function with expo tails

In fit range:

BR . ε
= 1.44e-3 . 1/3 . 0.155%
+ 1.32e-3 . 2/3 . 0.109%
= 1.70e-6

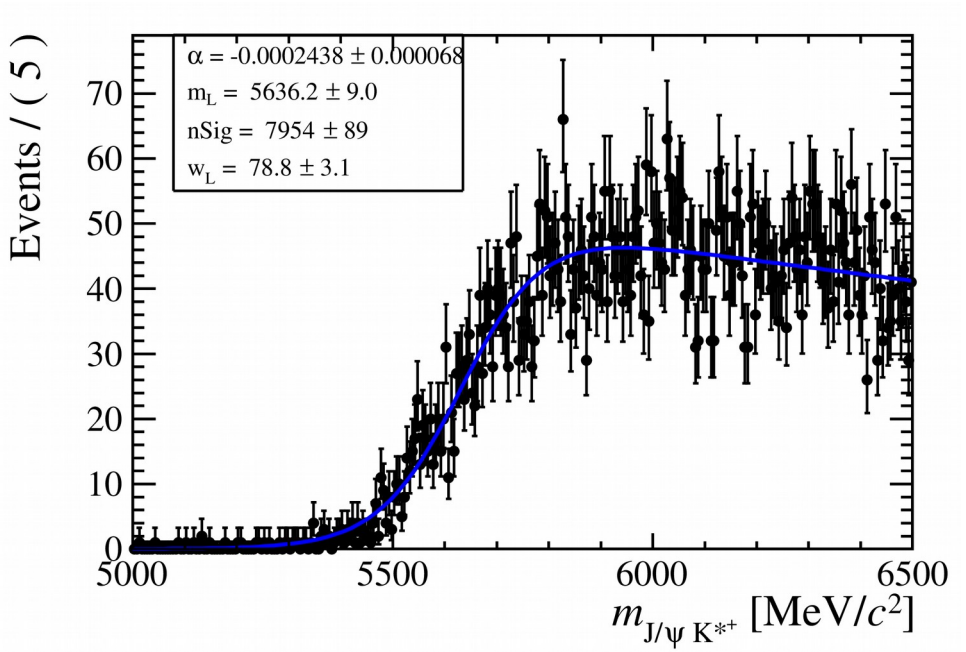


Peaking J/psi K^+

- MC sample:
  - 4M, 2016UpDw (+4M ReDecay), Event type: 12143001, decfile
  - Sim09e, Stripping28r1NoPrescalingFlagged, ALLSTREAMS.LDST
- 3.5k events after selection
- Fit: sigmoid x exponential function

In fit range:

BR . ε
= 1.027e-3 . 0.082%
= 0.837e-6



Merge peaking backgrounds

$K^{*+} \to K^+ \overline{pi0[gg]}$

BR . ε
= 1.44e-3 . 1/3 . 0.426%
= 2.05e-6

45%

$K^{*+} \to K^+ \overline{pi0[gg]}$
$K^{*0} \to K^+ (pi^-) \overline{pi0[gg]}$

BR . ε
= 1.44e-3 . 1/3 . 0.155%
+ 1.32e-3 . 2/3 . 0.109%
= 1.70e-6

37%

$K^+ + \overline{pi0[gg]}$

BR . ε
= 1.027e-3 . 0.082%
= 0.837e-6

18%

Sum yields 4.59e-6, compared to 5.84e-6 for signal, i.e. nSig/nBkg1 = 1.27

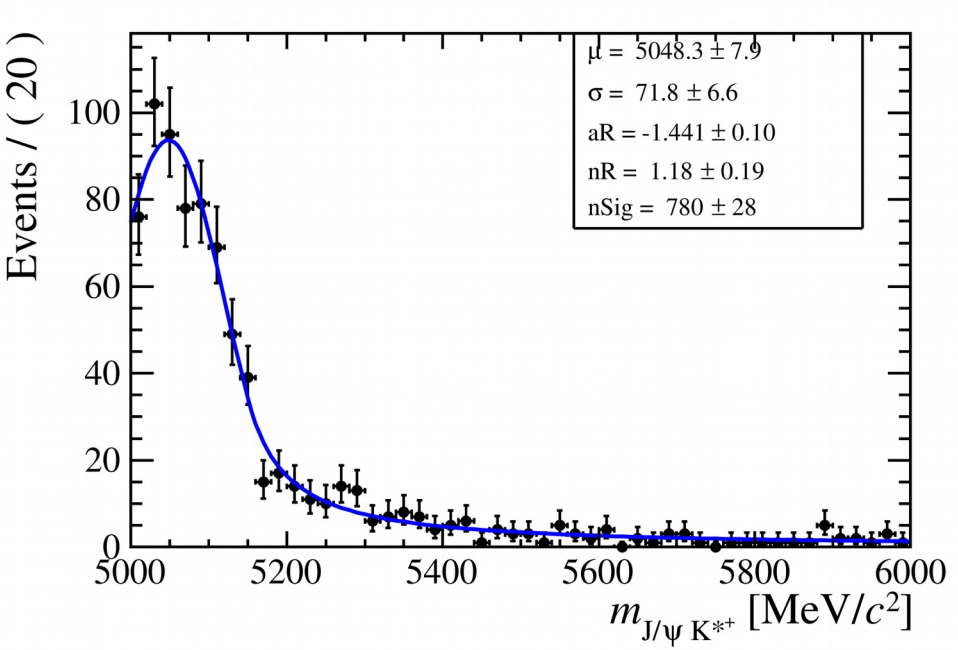
Part. reco'ed J/psi $K_1(1270)$

- MC sample:
  - 4M, 1112UpDw, Event type: 12443401
  - decfile : 10% of K_1 decaying to $K^{*+}\pi^0$, 1/3 of K^{*+} to $K^+\pi^0$ → 130 k events
  - Sim08i, Stripping21NoPrescalingFlagged (!MC bug!), ALLSTREAMS.DST
- 800 events after selection (photon and pi0s are not truth-matched)
- Fit: Crystal-Ball function

In fit range:

BR . ε
= 2.9e-4 . 0.567%
= 1.64e-6

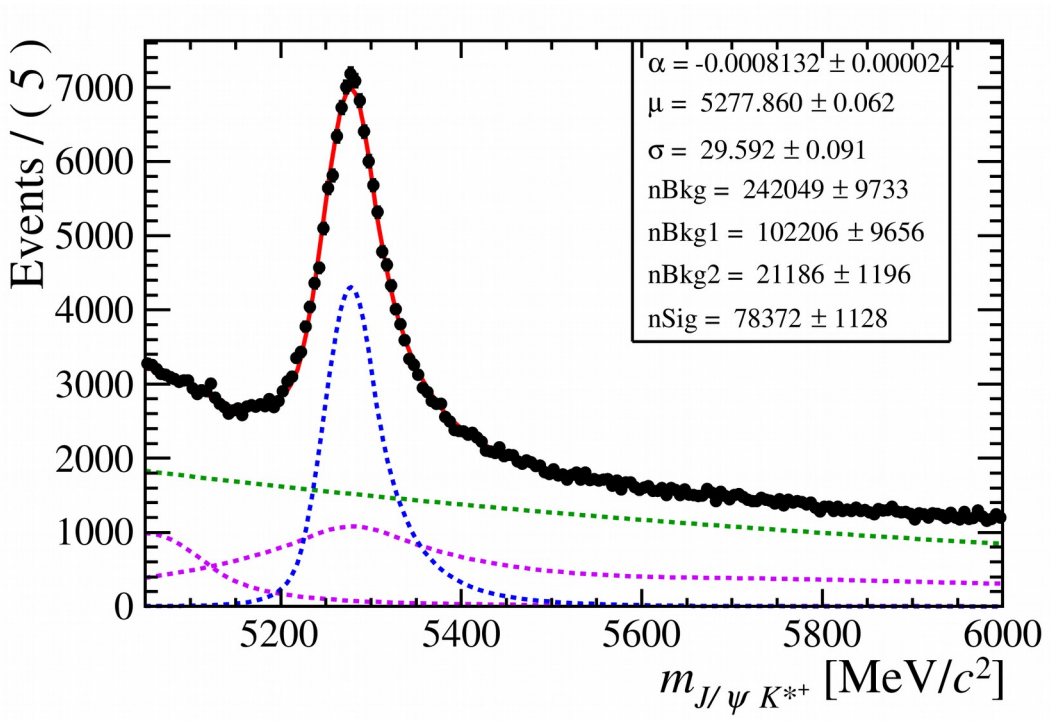
Compared to 5.84e-6 for signal,
i.e. nSig/nBkg2 = 3.56



Fit results

1) Signal 78.3 k VS 138 k expected from:
   σ_{pp} (72.24 μb) . Lumi (5.9 /fb) . BR (2.66e-5) . ε (1.22e-2) = 138k
2) Signal / Bkg1 = 0.77 (1.27 expected)
3) Signal / Bkg2 = 3.7 (3.6 expected)

1 & 2 point at an under-estimated signal yield

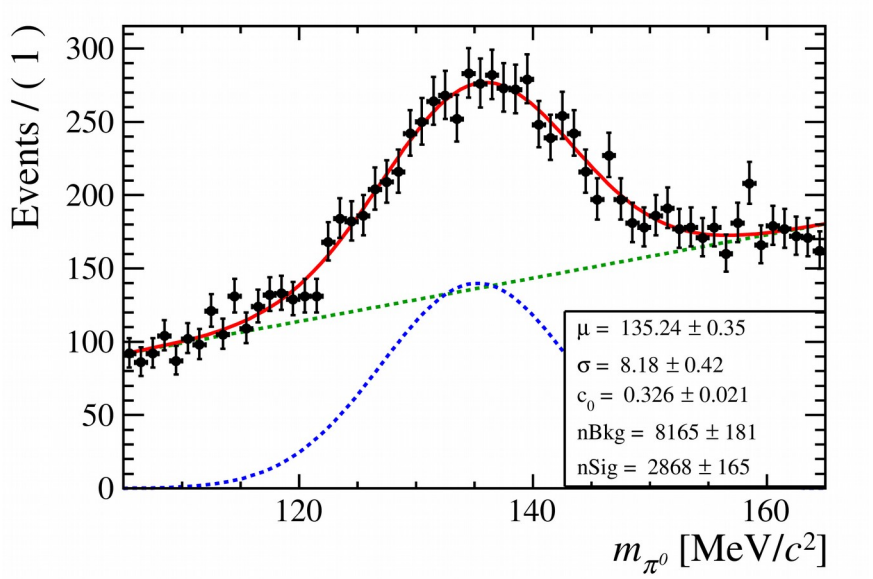


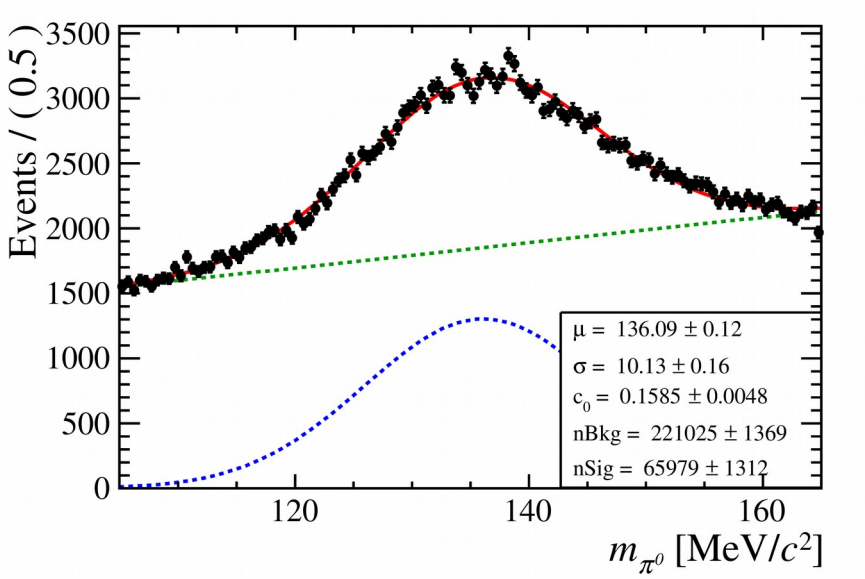
Pi0 purity

- Comparison between:
  - Random MC pi0 (from JpsiK+ sample) → $p_{MC} = S_{MC}/(S_{MC}+B_{MC}) = 0.26$ (left plot)
  - High-mass data sideband (soft pi0 as well) → $p_{data} = 0.23$ (right plot)
- For equal signal yields in data and MC:

  $B_{data}/B_{MC} = p_{MC}/p_{data} \cdot (1-p_{data})/(1-p_{MC}) = 1.17$

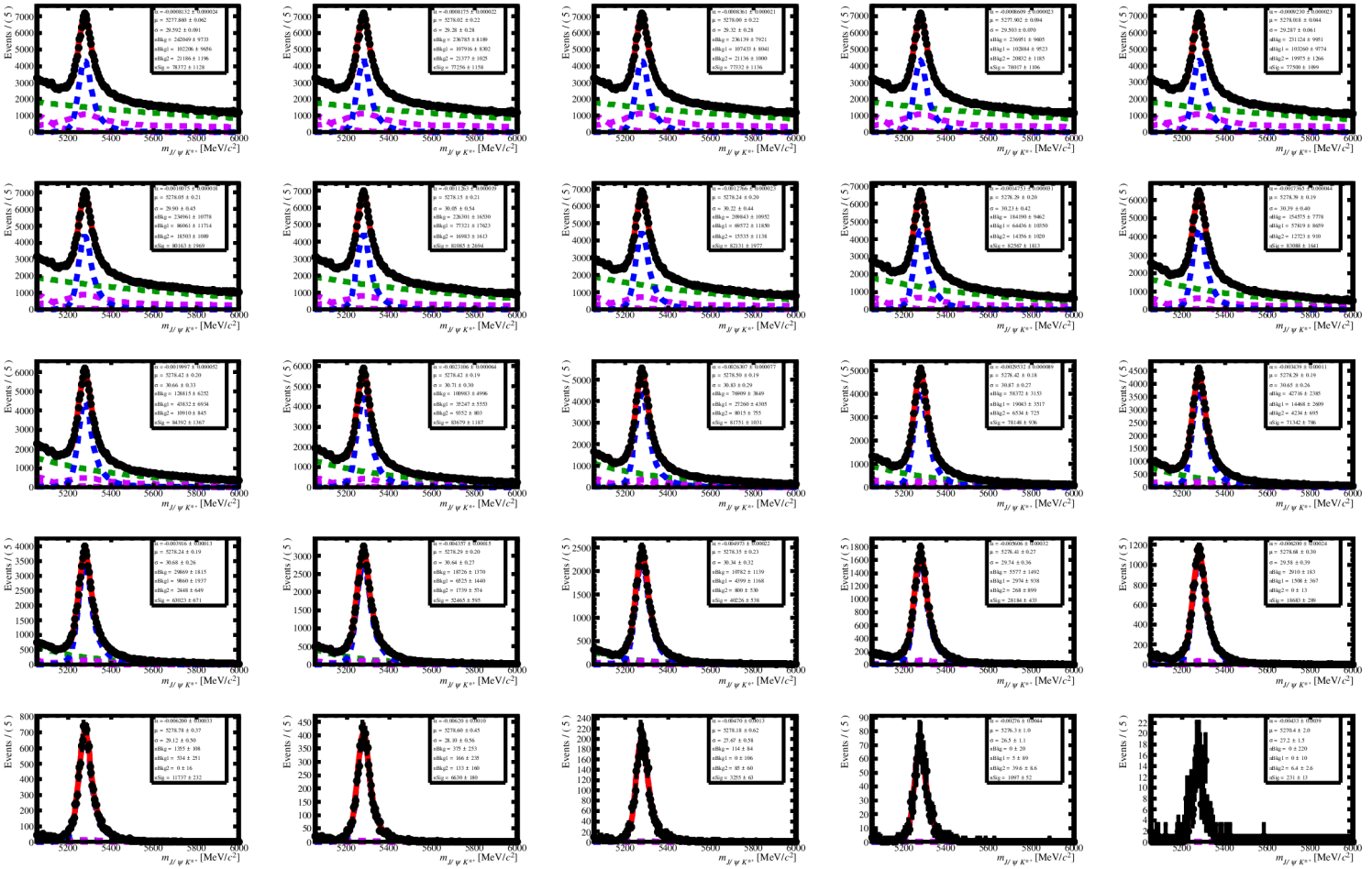
  Takes expected nSig/nBkg1 from 1.27 to 1.08 (still larger than fitted 0.77)





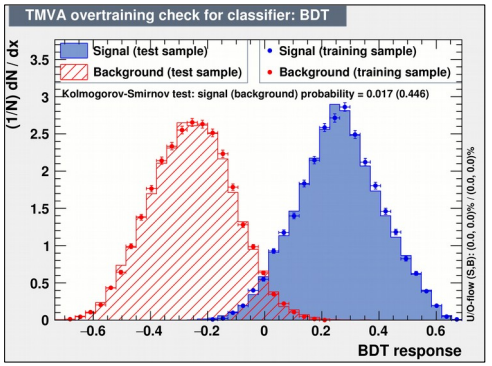
BDT scan

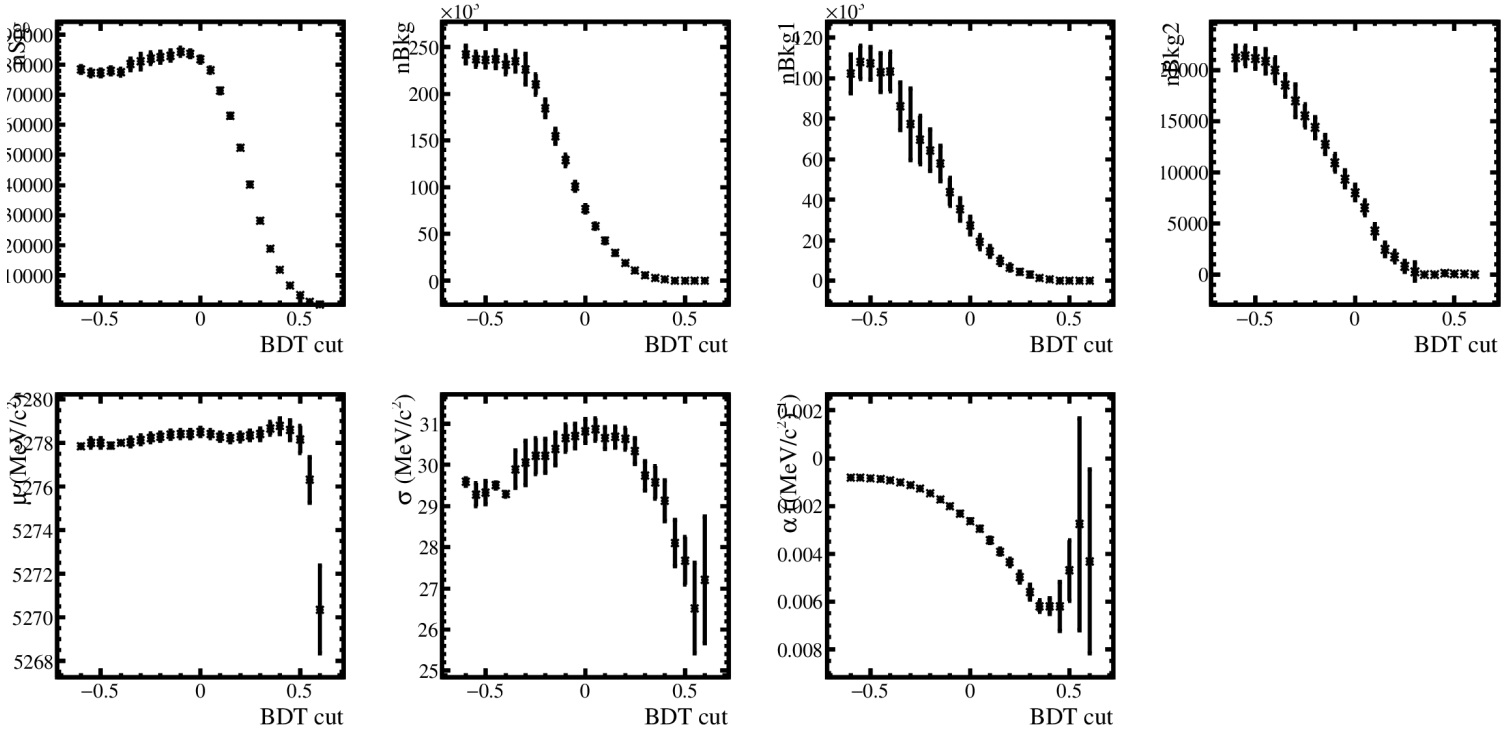
- For each BDT cut value
  - Re-calculate relative yields of peaking bkgs & signal
  - Re-fit MC mass shapes
  - Re-fit data



Fit parameters VS BDT

- Unexpected trend of signal yield (should be flat for BDT< -0.2)
- Normalise data efficiency to mass fit with no BDT cut
  - Data/MC ratio quickly off 1 when cutting on BDT
- Point towards not enough signal @ low BDT cut





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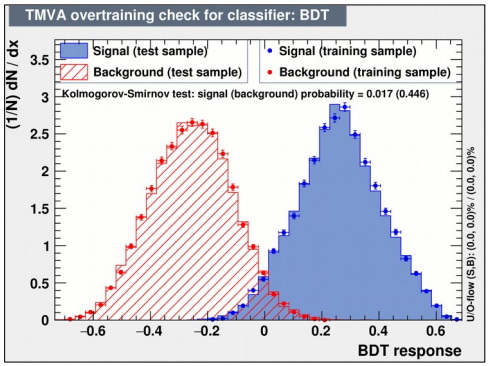
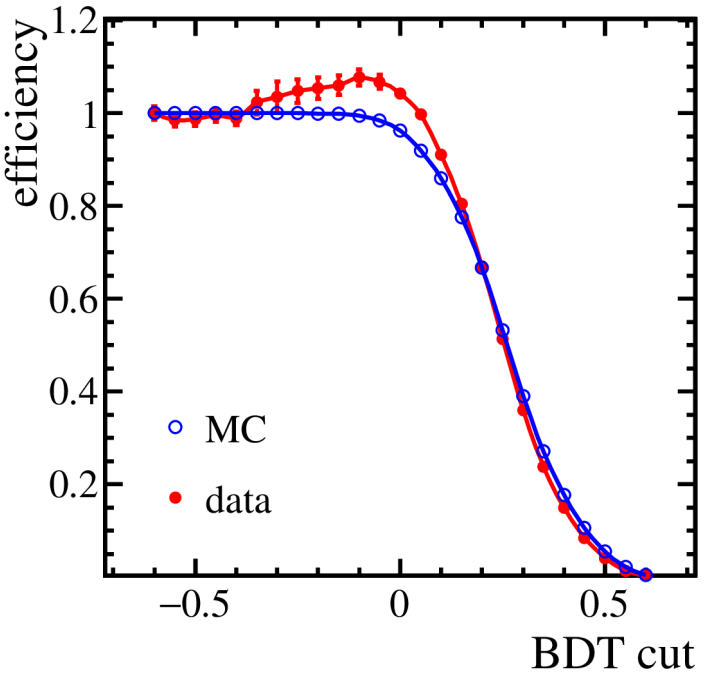
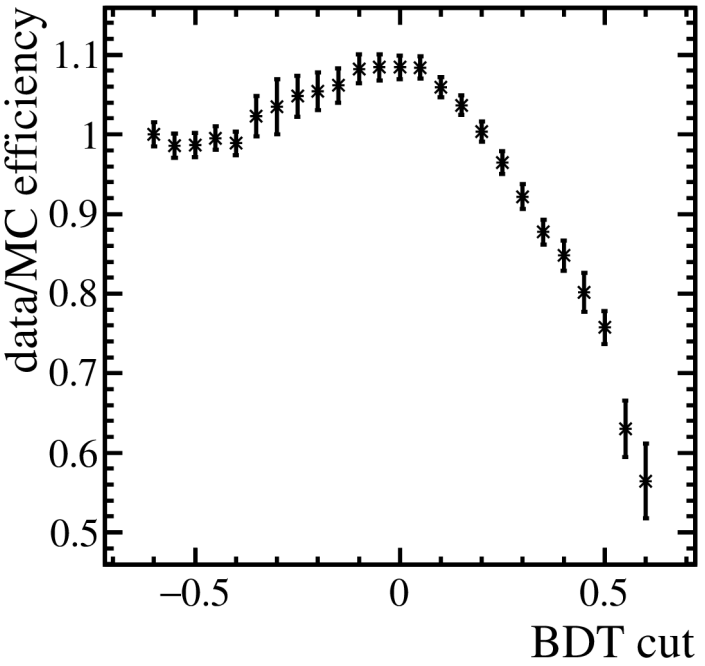


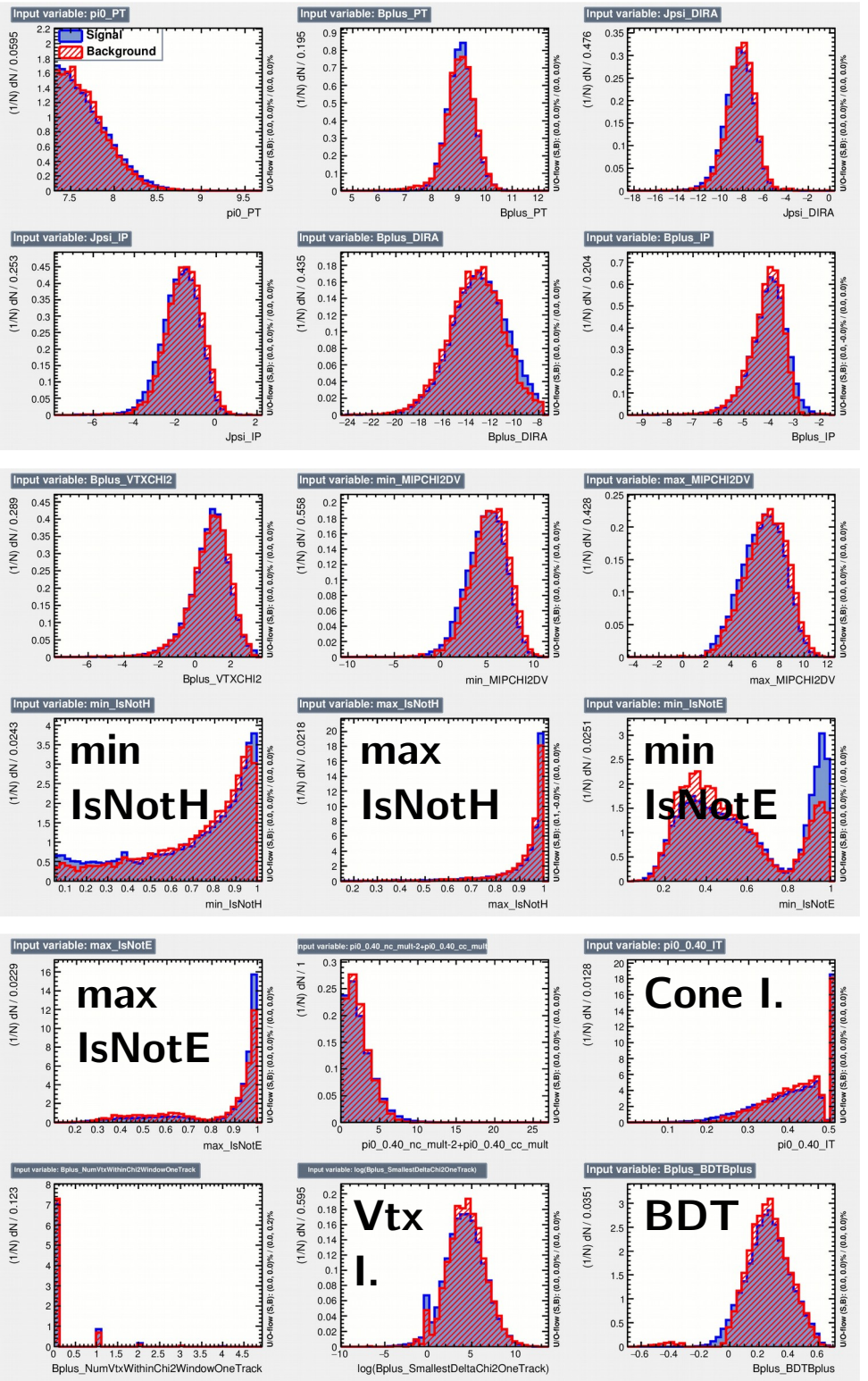




sPlot data VS MC-truth

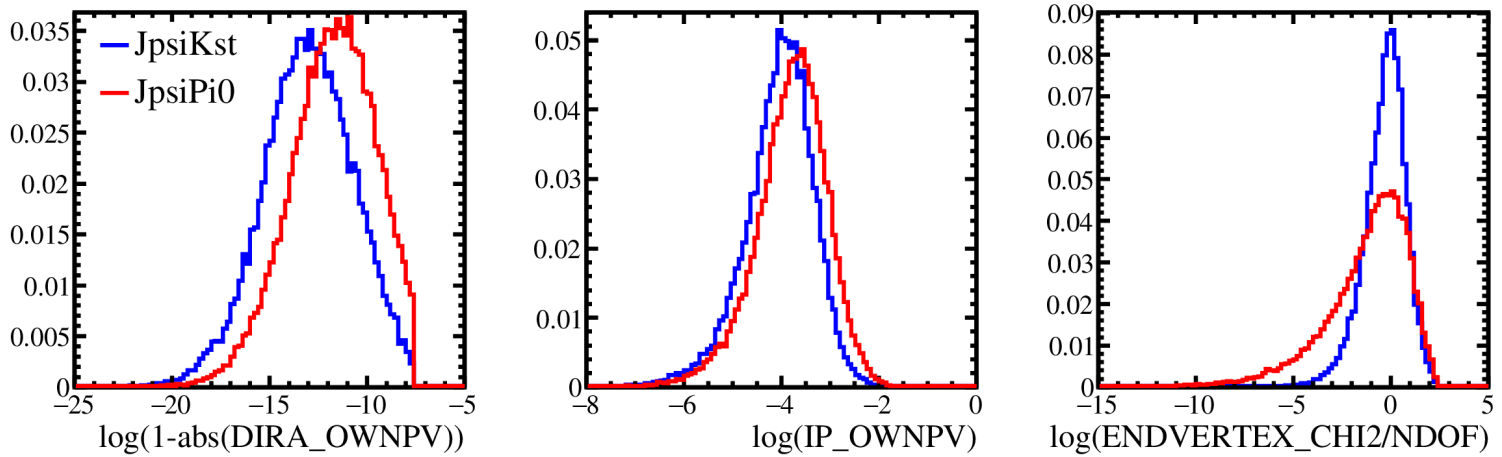
- Comparison
  - Run II MC, no weights
  - sWeighted data (previous fit, slide 11)

- Small offset in VTX var.
- Photon PID (isNotE) differently peaked @ 1
- Cone isolation quite OK
- Vertex isolation peak at log(0)=0
  - Less tracks to add in MC
- sWeighted BDT (bottom right)
  - Has negative entries...
  - **Agreement much better than cut and fit**



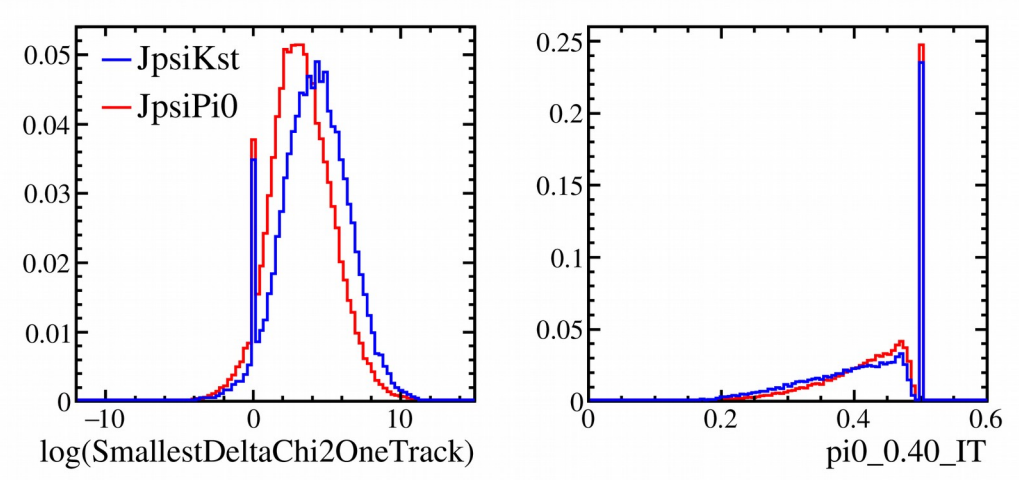
MC variables (1/3)

- 2016 MC, JpsiKst VS JpsiPi0
- Vertex variables: better vertex fit with 3 tracks
  - Expect good data/MC match (not too occupancy dependent)



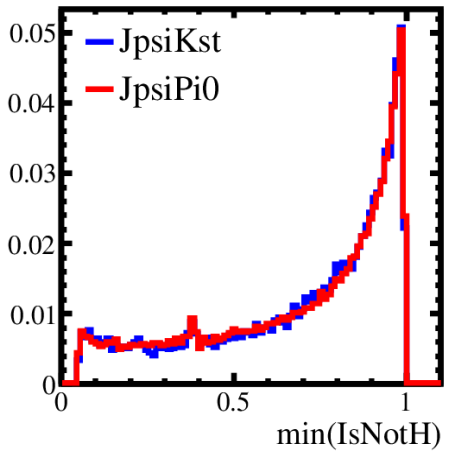
MC variables (2/3)

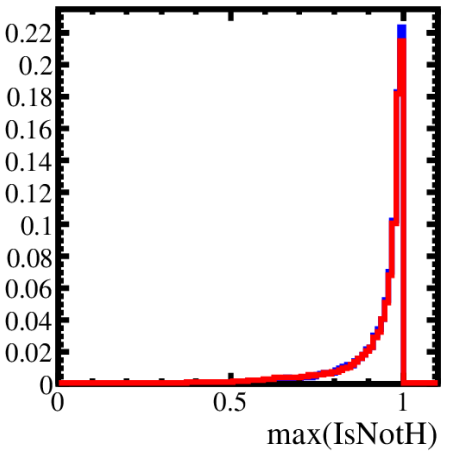
- 2016 MC, JpsiKst VS JpsiPi0
- Occupancy variables:
  - TupleToolVertexIsoIn applied to B $\rightarrow$ expect same shape
  - Transerve isolation better for JpsiPi0 due to harder PT

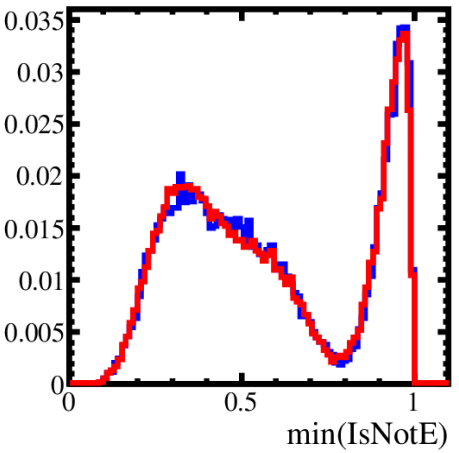


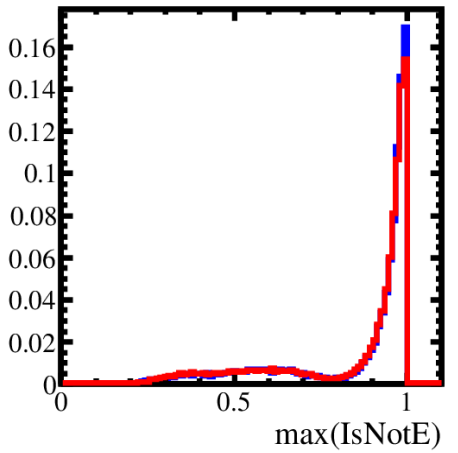
MC variables (3/3)

- 2016 MC, JpsiKst VS JpsiPi0
- Photon PID variables:
  - Similar shapes, max(IsNotH) shows small PT-dependence?









Outlook

1) More work needed on the fit
   a) Try to better constrain the peaking bkgs (use data/MC pi0 purity)
   b) Need more JpsiK$_1$ MC, produce dedicated decfile

2) BR-analysis strategy in place
   1) Start training BDTs for JpsiX^0
   2) And working out fit models