Ω_c^0 lifetime measurement

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Ω_c^0 lifetime measurement meeting

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Outline

1. Measure $\tau(D^0)$ with $D^0 \to K^-K^+\pi^-\pi^+$
   - Prompt yield extraction
     - Strategy to extract prompt yields
     - Fit to MC samples of signal, normalization and control modes
     - Sanity checks
     - Fit to D^0 data
   - Efficiency estimation
     - Comparison of Dalitz distributions for MC and data of D^0 mode
     - Comparison of kinematic distributions for MC and data of D^0 mode
     - Comparison of topological distributions for MC and data of D^0 mode
     - Comparison of samples with different L0 trigger
     - Comparison of event multiplicity
     - Corrections to MC by weighting
     - Decay time distribution with MC corrections
   - Efficiency studies of L0 Hadron TOS sample
   - Efficiency studies of L0 Global TIS sample
2. Measure $\tau(\Xi_c^0)$ with $\Xi_c^0 \to pK^-K^-\pi^+$

Section 1

Measure $\tau(D^0)$ with $D^0 \to K^-K^+\pi^-\pi^+$

Strategy to extract prompt yields

- Contamination from b-hadron decays is evident in large decay time bins
- Use $\log_{10}(\chi^2_{\text{IP}})$ as discriminating variable
- Model the prompt and secondary components with the Bukin function

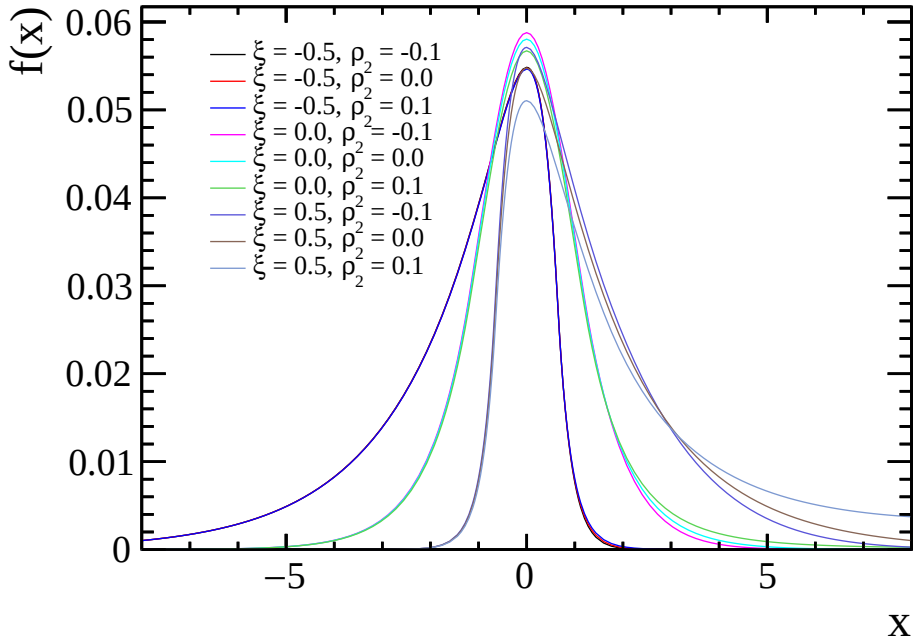
$$\mathcal{P}(x;\mu,\sigma,\xi,\rho_1,\rho_2) = \begin{cases} \exp\left\{ \dfrac{(x-x_1)\xi\sqrt{\xi^2+1}\sqrt{2\ln 2}}{\sigma\left(\sqrt{\xi^2+1}-\xi\right)^2 \ln\left(\sqrt{\xi^2+1}+\xi\right)} + \rho_1\left(\dfrac{x-x_1}{\mu-x_1}\right)^2 - \ln 2 \right\} & x \le x_1, \\ \exp\left\{ -\left[\dfrac{\ln\left(1+2\xi\sqrt{\xi^2+1}\dfrac{x-\mu}{\sigma\sqrt{2\ln 2}}\right)}{\ln\left(1+2\xi^2-2\xi\sqrt{\xi^2+1}\right)}\right]^2 \times \ln 2 \right\} & x_1 < x < x_2, \\ \exp\left\{ \dfrac{(x-x_2)\xi\sqrt{\xi^2+1}\sqrt{2\ln 2}}{\sigma\left(\sqrt{\xi^2+1}-\xi\right)^2 \ln\left(\sqrt{\xi^2+1}+\xi\right)} + \rho_2\left(\dfrac{x-x_2}{\mu-x_2}\right)^2 - \ln 2 \right\} & x \ge x_2. \end{cases}$$

where

$$x_1 = \mu + \sigma\sqrt{2\ln 2}\left(\frac{\xi}{\sqrt{\xi^2+1}} - 1\right)$$

Illustration of the Bukin functions

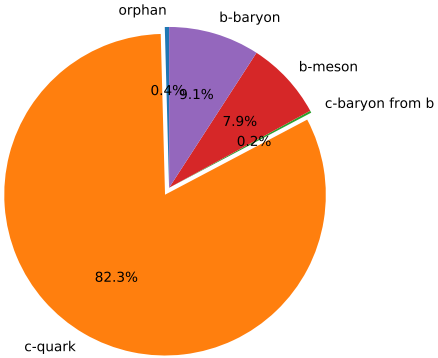
- Bukin functions with various asymetry and tail parameters with $\mu = 0, \sigma = 1, \rho_1 = 0$



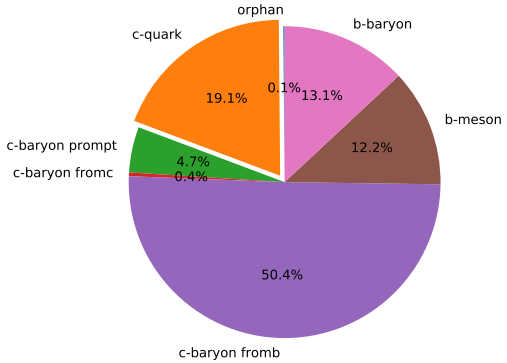
Prompt and secondary MC samples

- Prompt and secondary MC samples of Ω_c^0, Ξ_c^0 and D^0: acquired by apply `MC_MOTHER_ID` requirements to inclusive MC samples
- Components after all selections

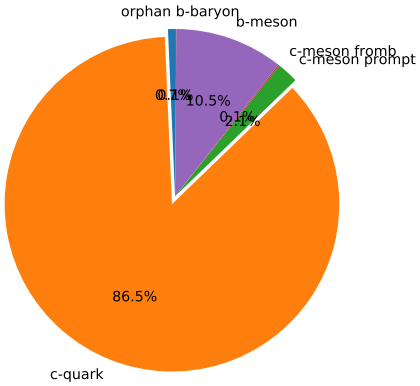
Components	orphan	c-quark	c-meson	c-baryon	b-meson	b-baryon
`abs(MC_MOTHER_ID)`	0	4	(400,500)	(4000,5000)	(500,600)	(5000,6000)



Ω_c^0



Ξ_c^0



D^0

- Validation needed with b-decay MC samples

The defination of the decay time

- Decay time t is defined as

$$t \equiv \frac{\vec{p} \cdot \vec{r}}{p^2} \times m$$

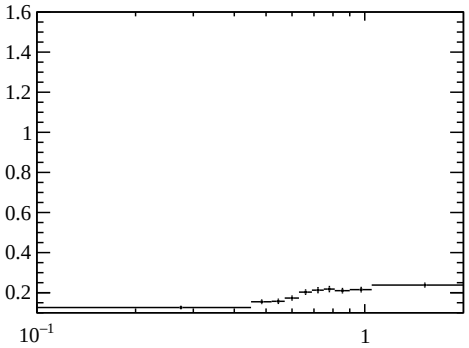
where $\vec{p}$ is the momentum vector, $\vec{r}$ the vector pointing from PV to decay vertex, and m the invariant mass of the charm hadron

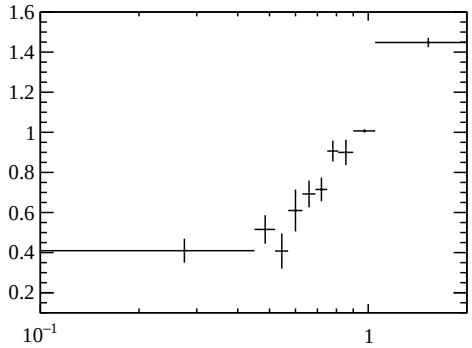
Fit with all parameters free in all decay time bins

- All fits converge with accurate error matrix
- μ: dependent on t with clear pattern for prompt and secondary
- σ: vary with t for prompt and secondary
- ξ: vary with t for prompt and secondary
- ρ_1, ρ_2: vary with t for prompt and secondary

Fit results in decay-time bins: μ

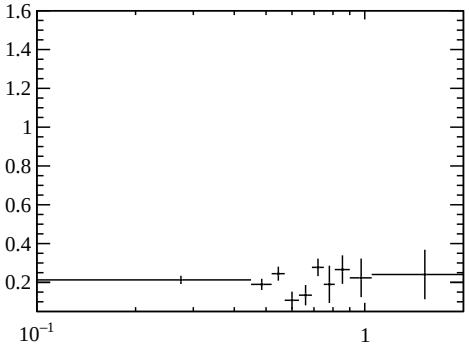
Prompt Ω_c^0

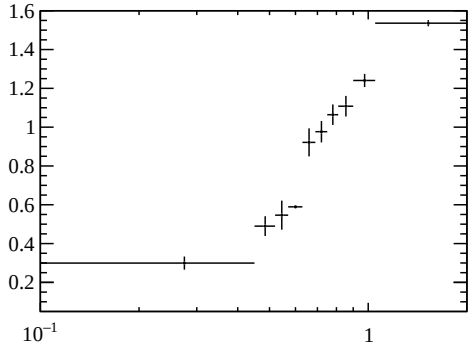




Secondary Ω_c^0

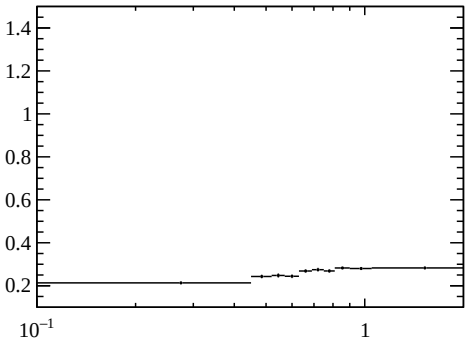
Prompt Ξ_c^0

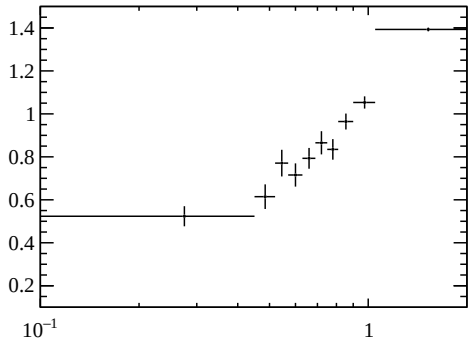




Secondary Ξ_c^0

Prompt D^0

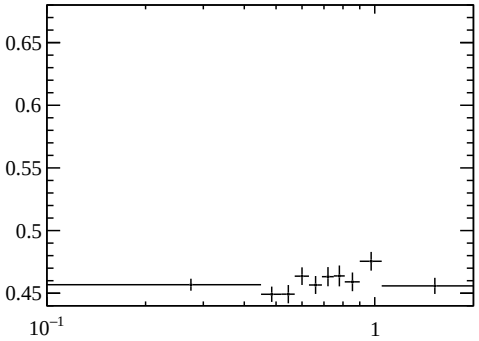


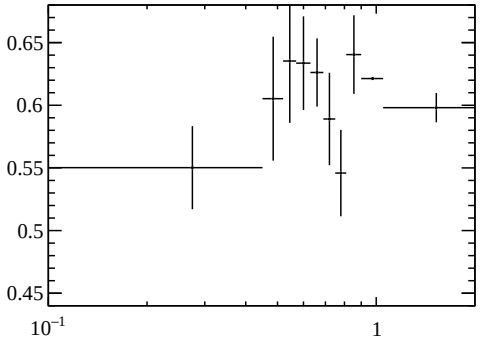


Secondary D^0

Fit results in decay-time bins: σ

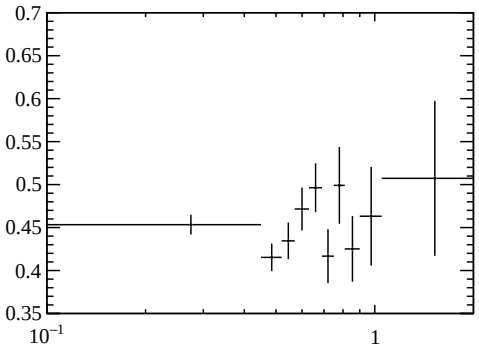
Prompt Ω_c^0

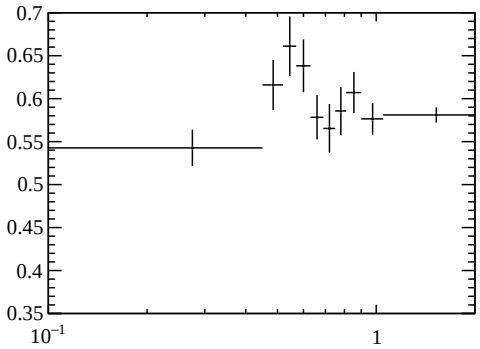




Secondary Ω_c^0

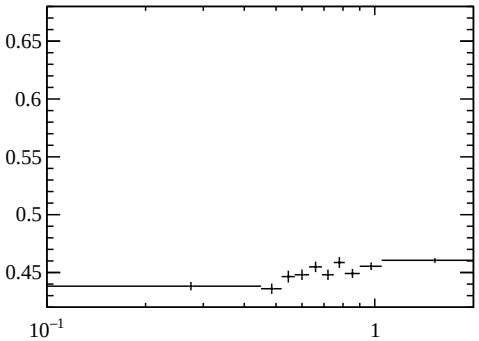
Prompt Ξ_c^0

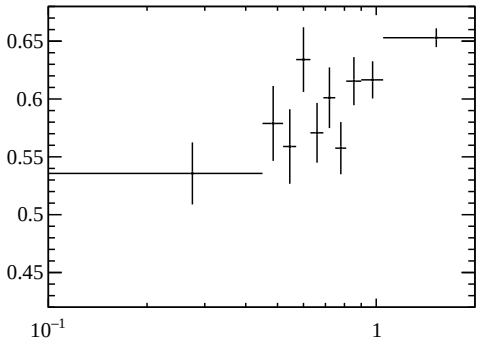




Secondary Ξ_c^0

Prompt D^0

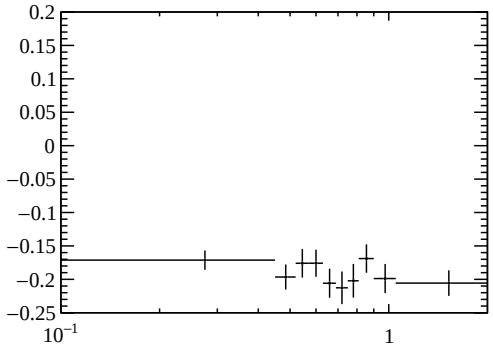


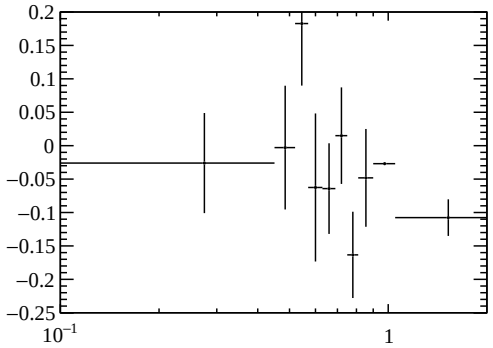


Secondary D^0

Fit results in decay-time bins: ξ

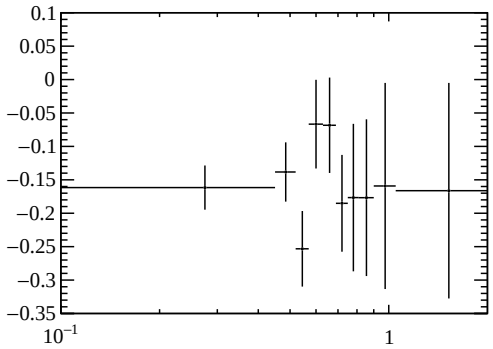
Prompt Ω_c^0

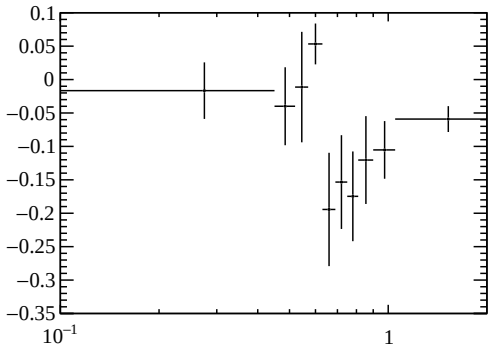




Secondary Ω_c^0

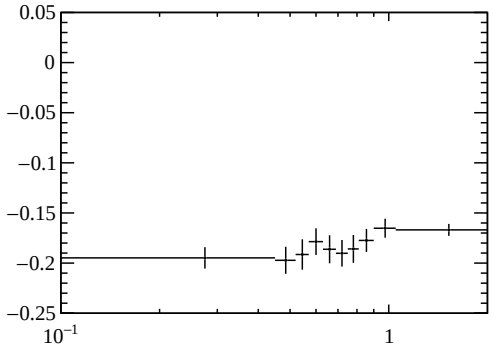
Prompt Ξ_c^0

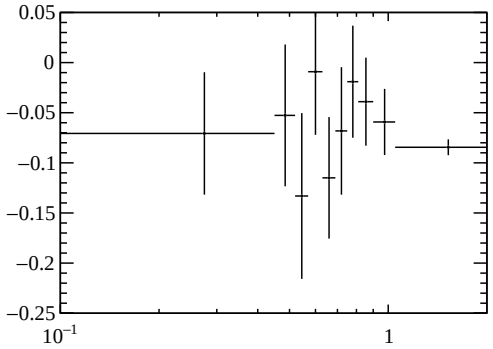




Secondary Ξ_c^0

Prompt D^0

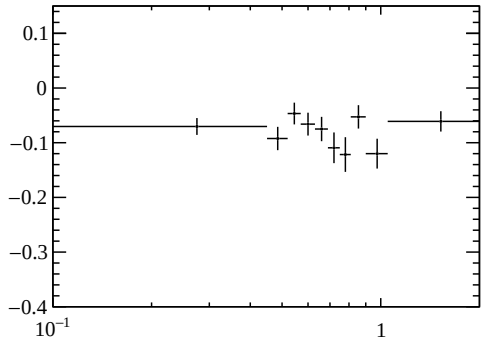


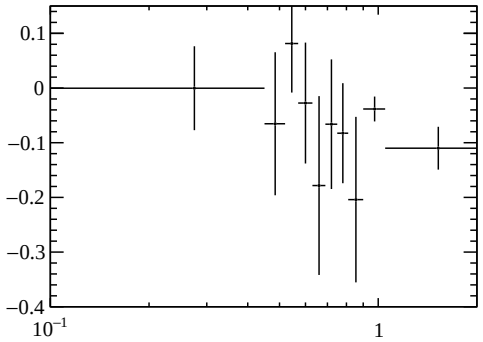


Secondary D^0

Fit results in decay-time bins: ρ_1

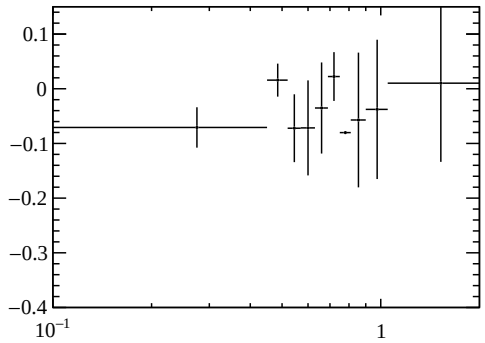
Prompt Ω_c^0

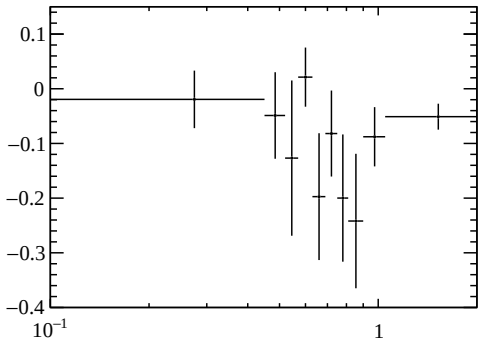




Secondary Ω_c^0

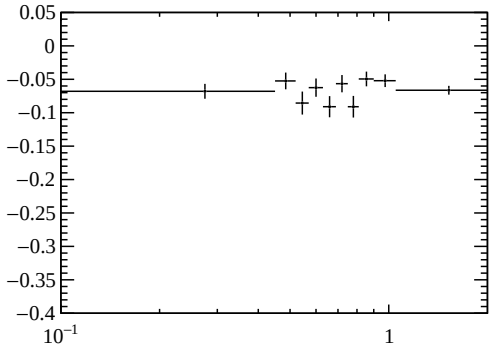
Prompt Ξ_c^0

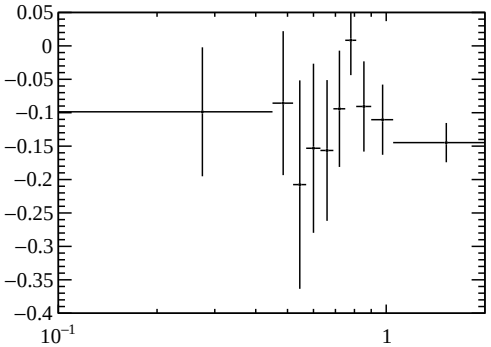




Secondary Ξ_c^0

Prompt D^0

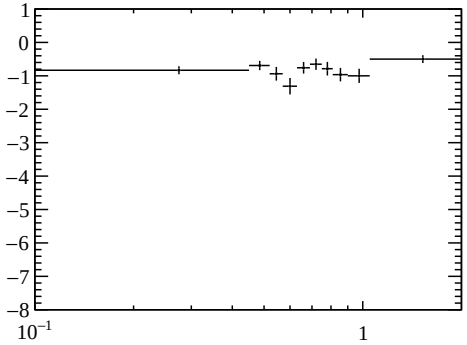


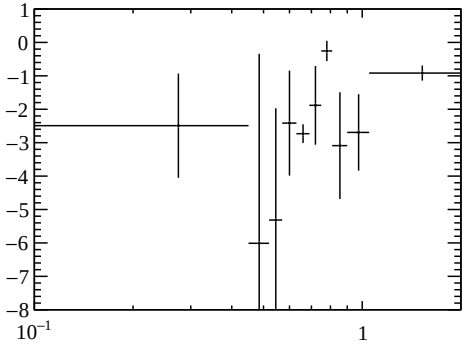


Secondary D^0

Fit results in decay-time bins: ρ_2

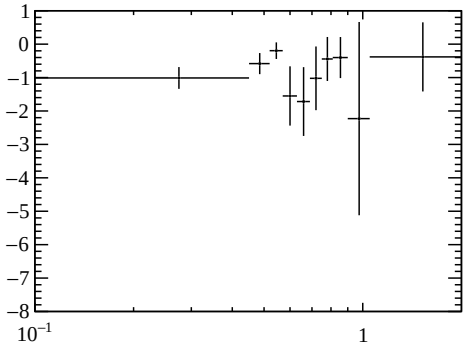
Prompt Ω_c^0

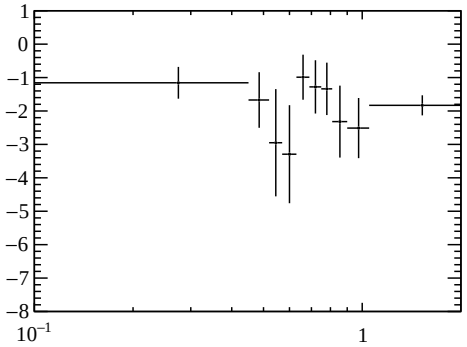




Secondary Ω_c^0

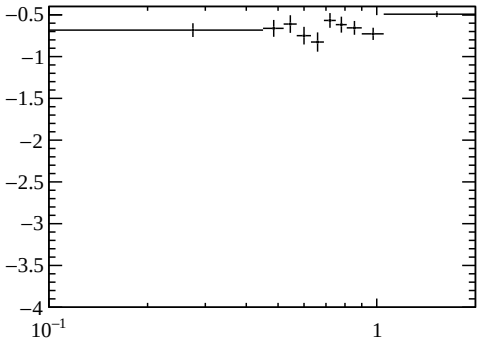
Prompt Ξ_c^0

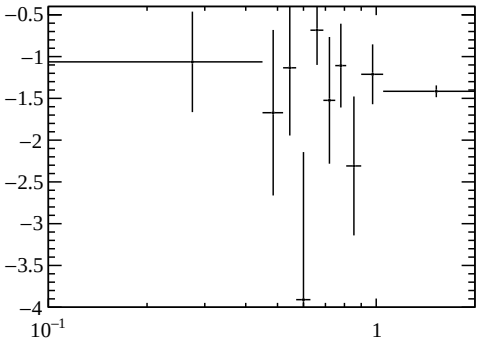




Secondary Ξ_c^0

Prompt D^0





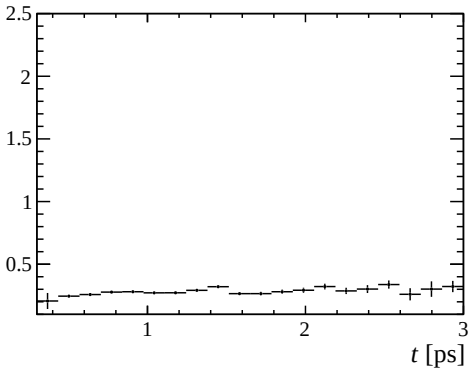
Secondary D^0

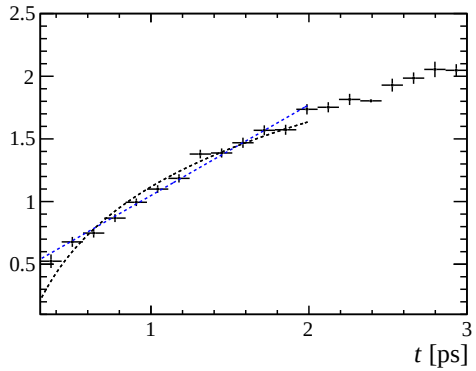
Fit D^0 MC in even decay time bins

- Fit with all parameters free in equally-sized 20 decay time bins between $0.3\,\mathrm{ps}$ and $3\,\mathrm{ps}$

D^0 results in even decay-time bins: μ

Prompt D^0

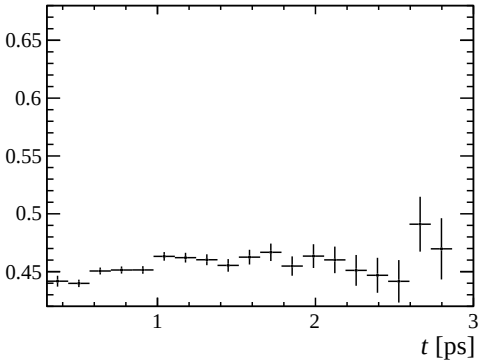


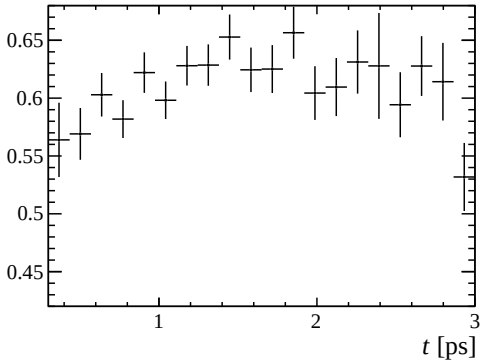


Secondary D^0

D^0 results in even decay-time bins: σ

Prompt D^0

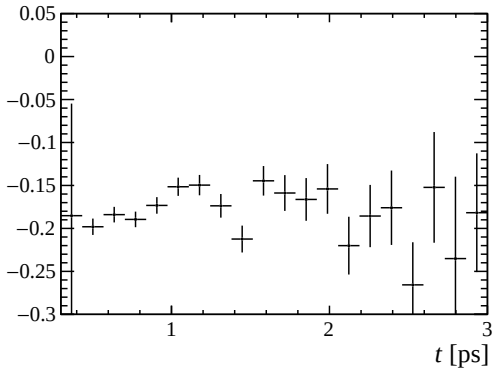


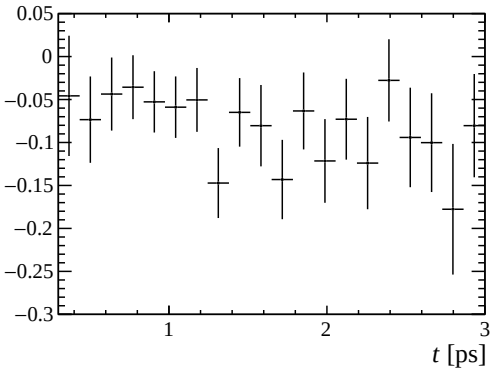


Secondary D^0

D^0 results in even decay-time bins: ξ

Prompt D^0

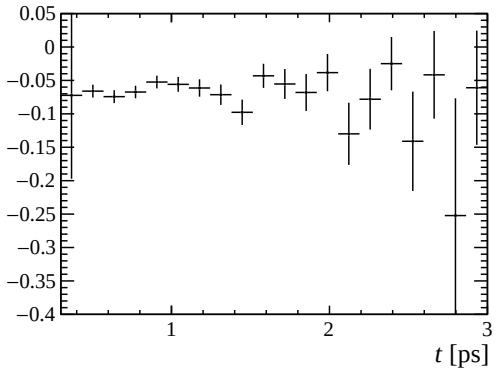


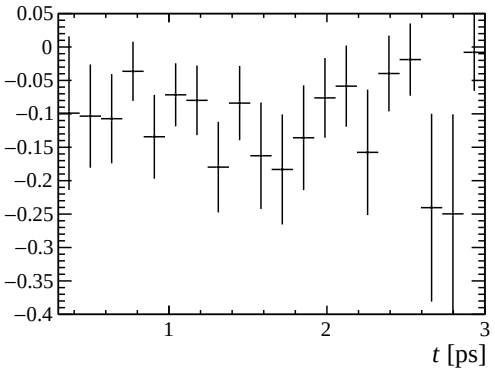


Secondary D^0

D^0 results in even decay-time bins: ρ_1

Prompt D^0

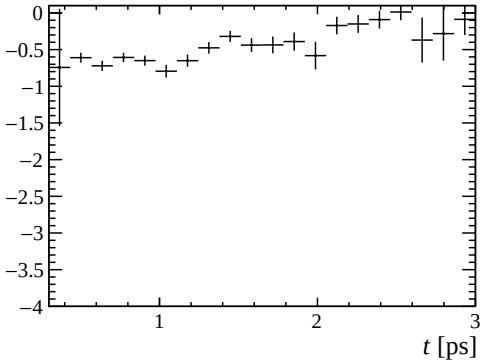


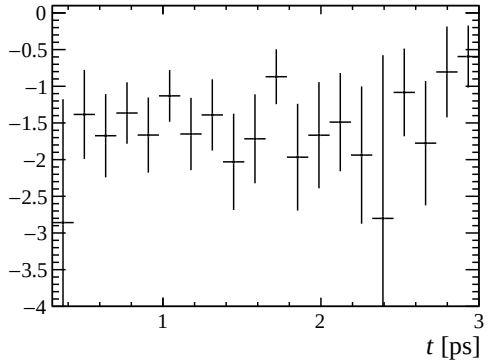


Secondary D^0

D^0 results in even decay-time bins: ρ_2

Prompt D^0



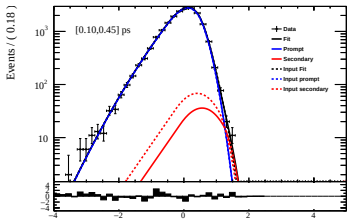


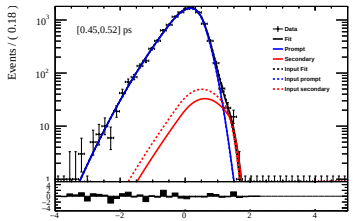
Secondary D^0

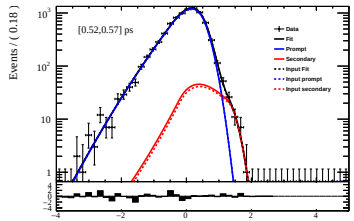
Sanity check: fit combined MC samples

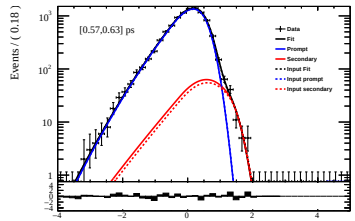
- Check whether the fit can re-produce the input prompt fraction with MC samples
- Fit the combined (prompt+secondary) MC with free μ_{prompt} and $\mu_{\mathrm{secondary}}$, while fixing other parameters to values of seperate fits

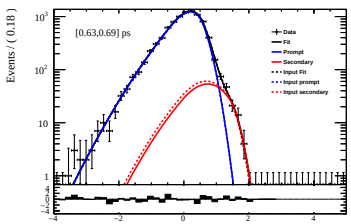
Fit results of combined MC samples: Ω_c^0

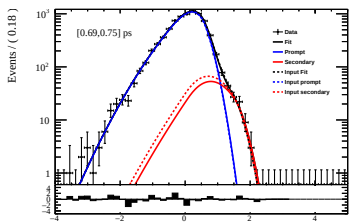


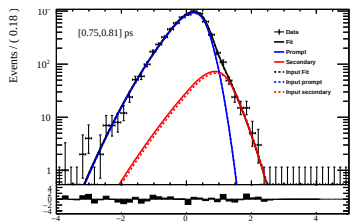


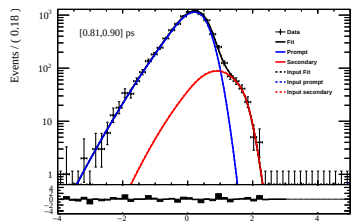


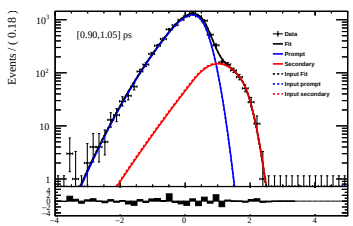


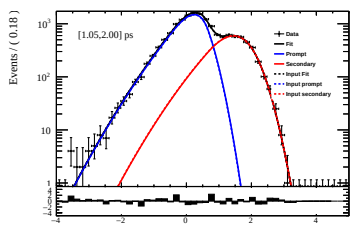




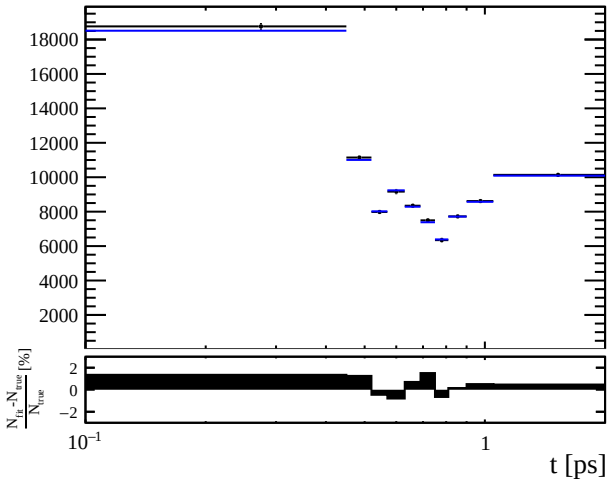




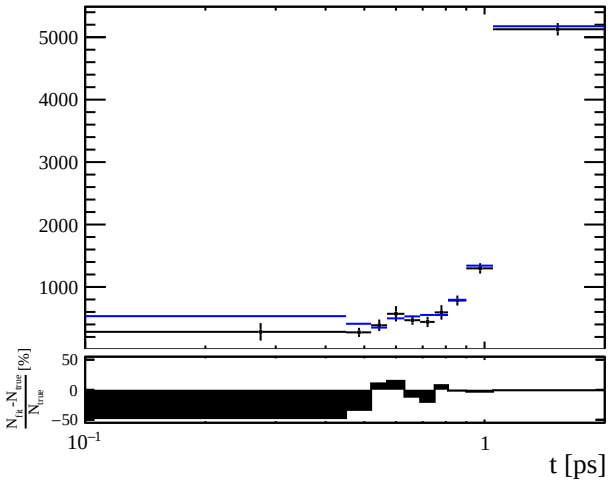




Comparison of input and extracted yield: Ω_c^0



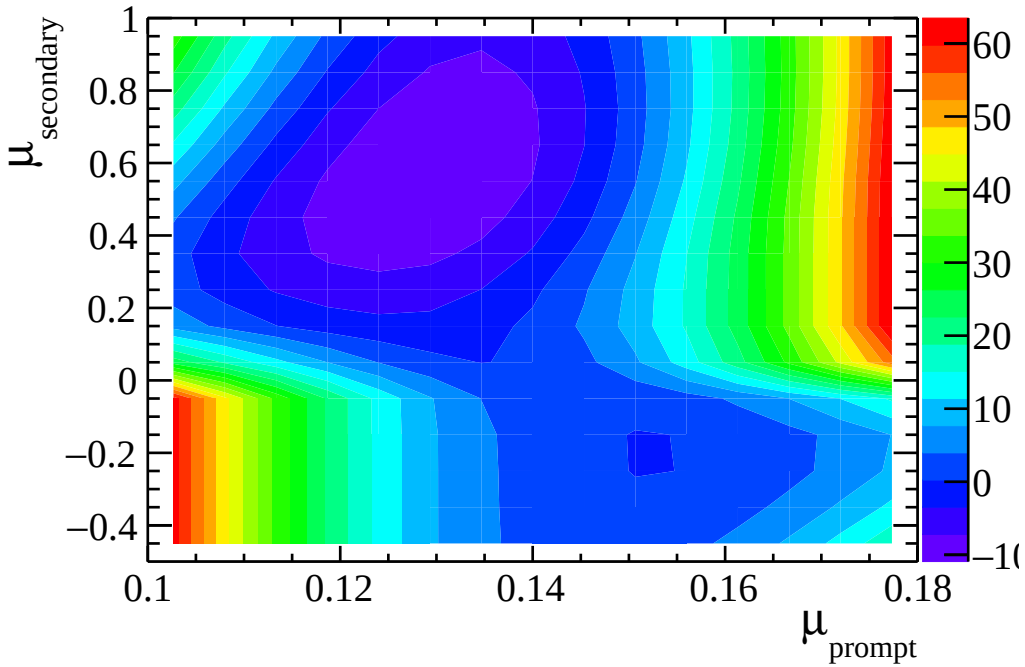
Prompt



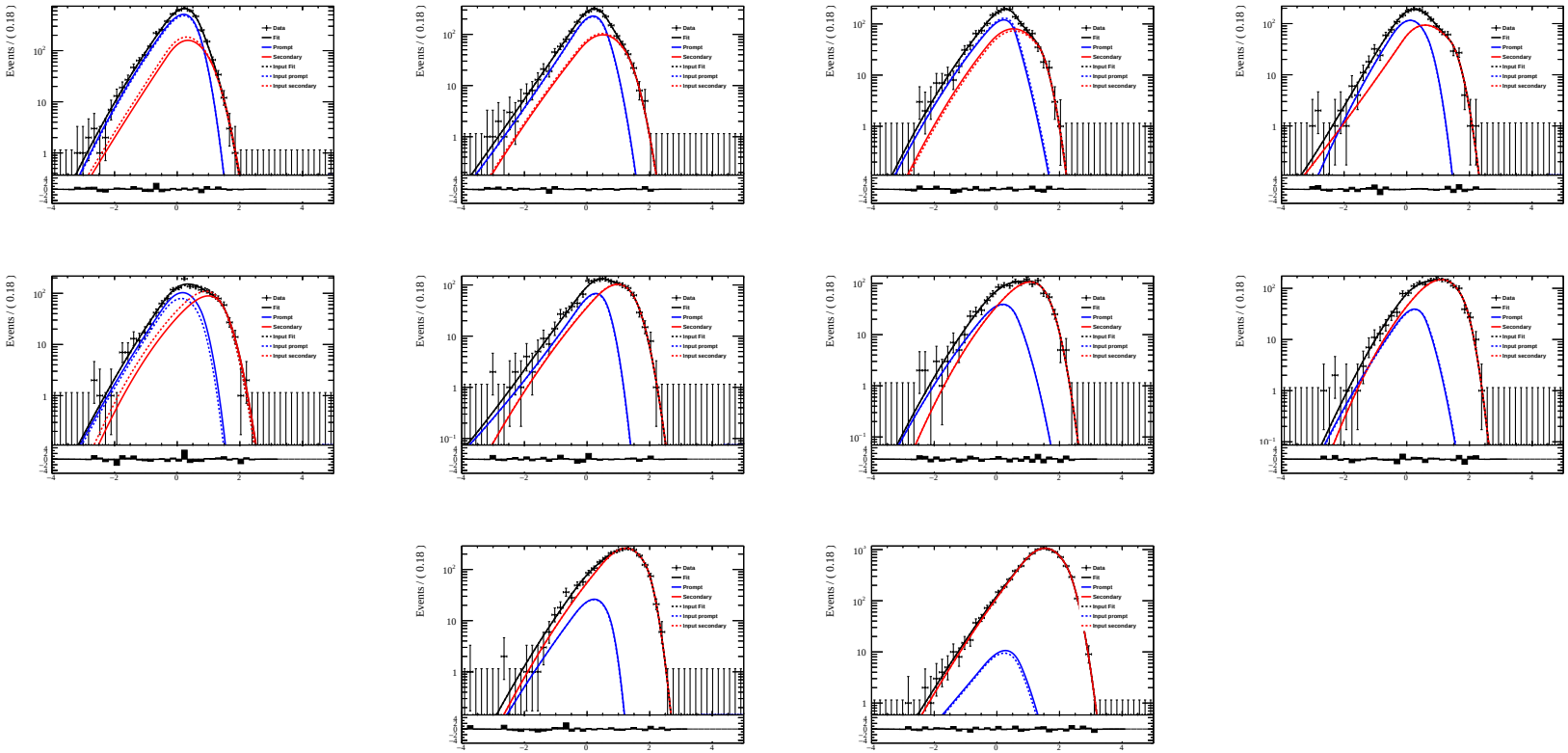
Secondary

Likelihood scan of μ_{prompt} and $\mu_{\text{secondary}}$

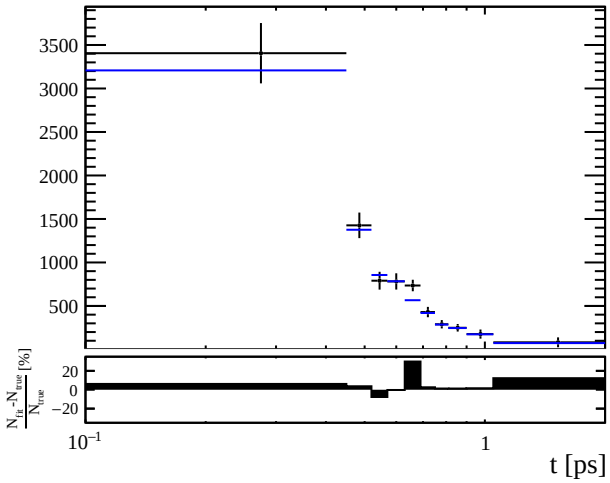
- Ω_c^0 bin 0



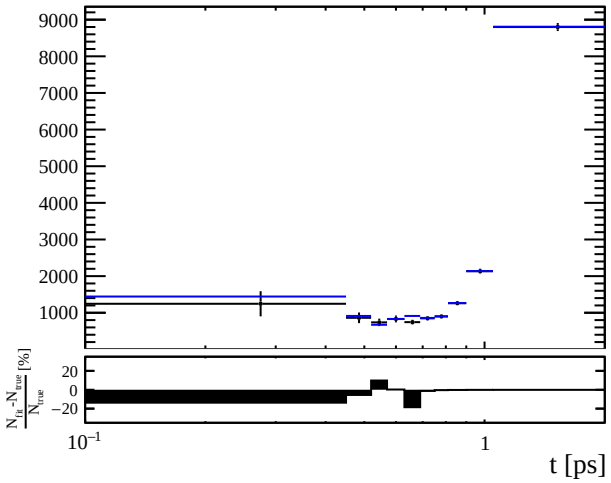
Fit results of combined MC samples: Ξ_c^0



Comparison of input and extracted yield: Ξ_c^0



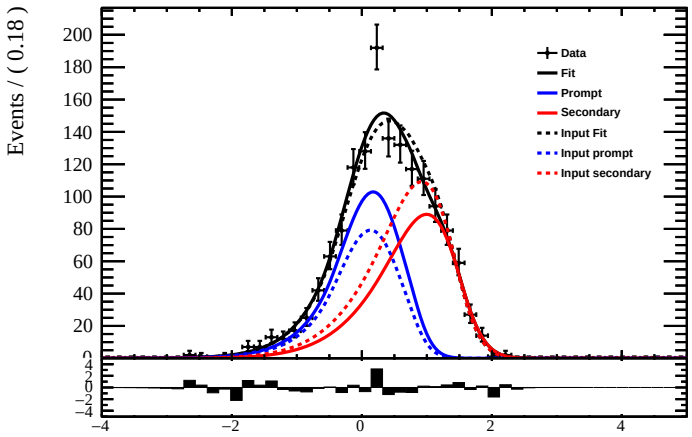
Prompt

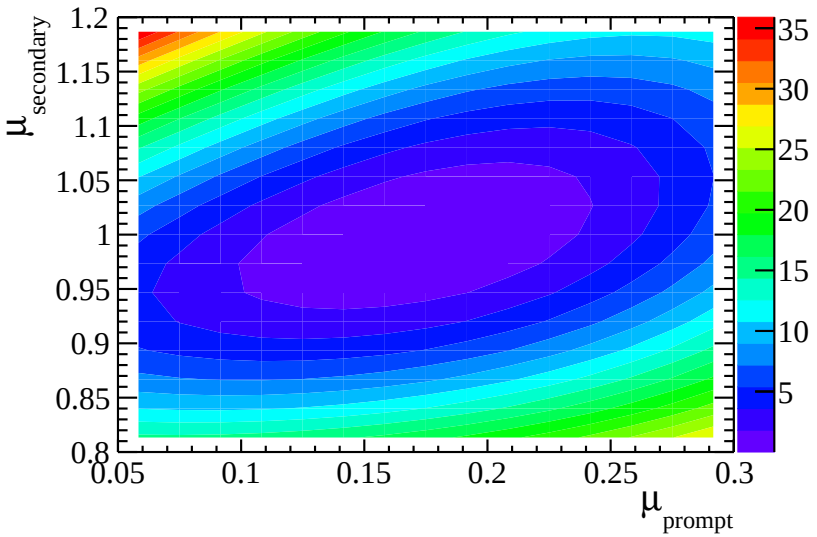


Secondary

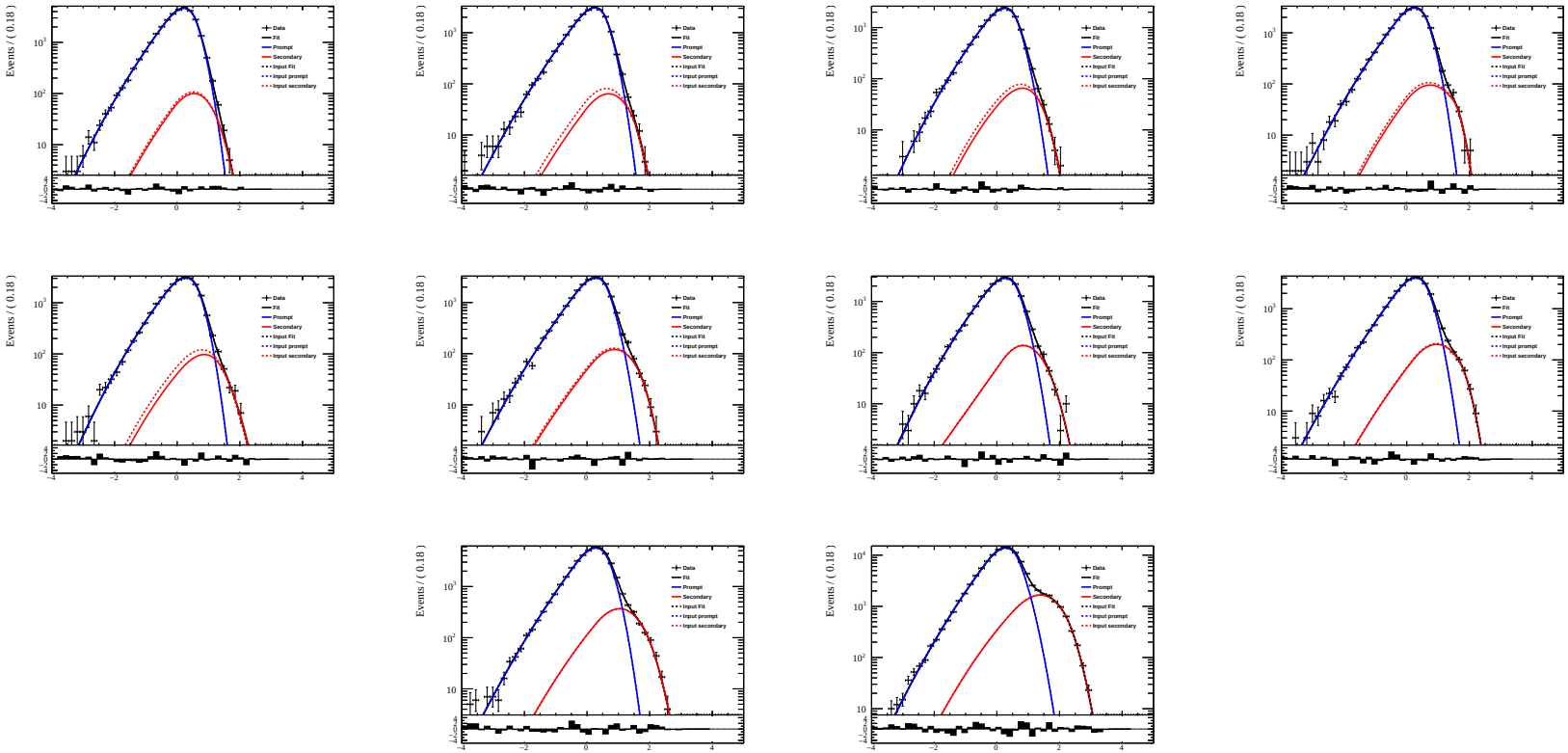
Likelihood scan of μ_{prompt} and $\mu_{\text{secondary}}$

- Ξ_c^0 bin 4

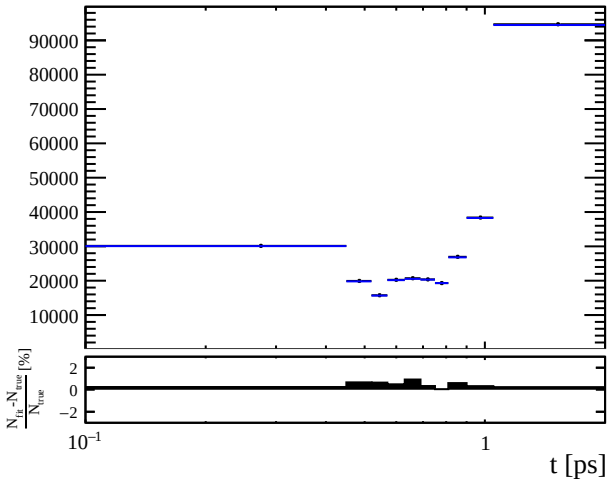




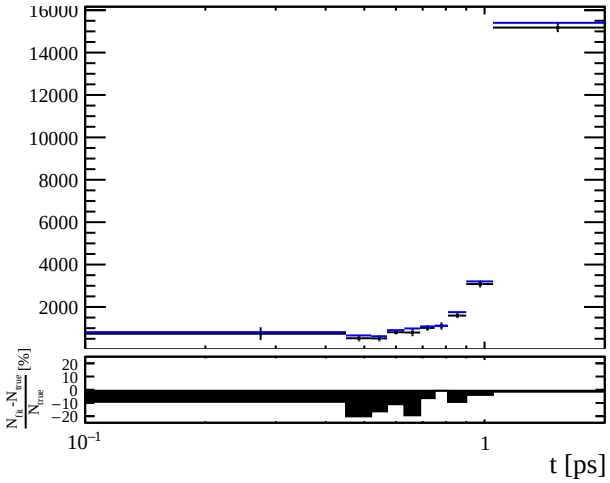
Fit results of combined MC samples: D^0



Comparison of input and extracted yield: D^0



Prompt

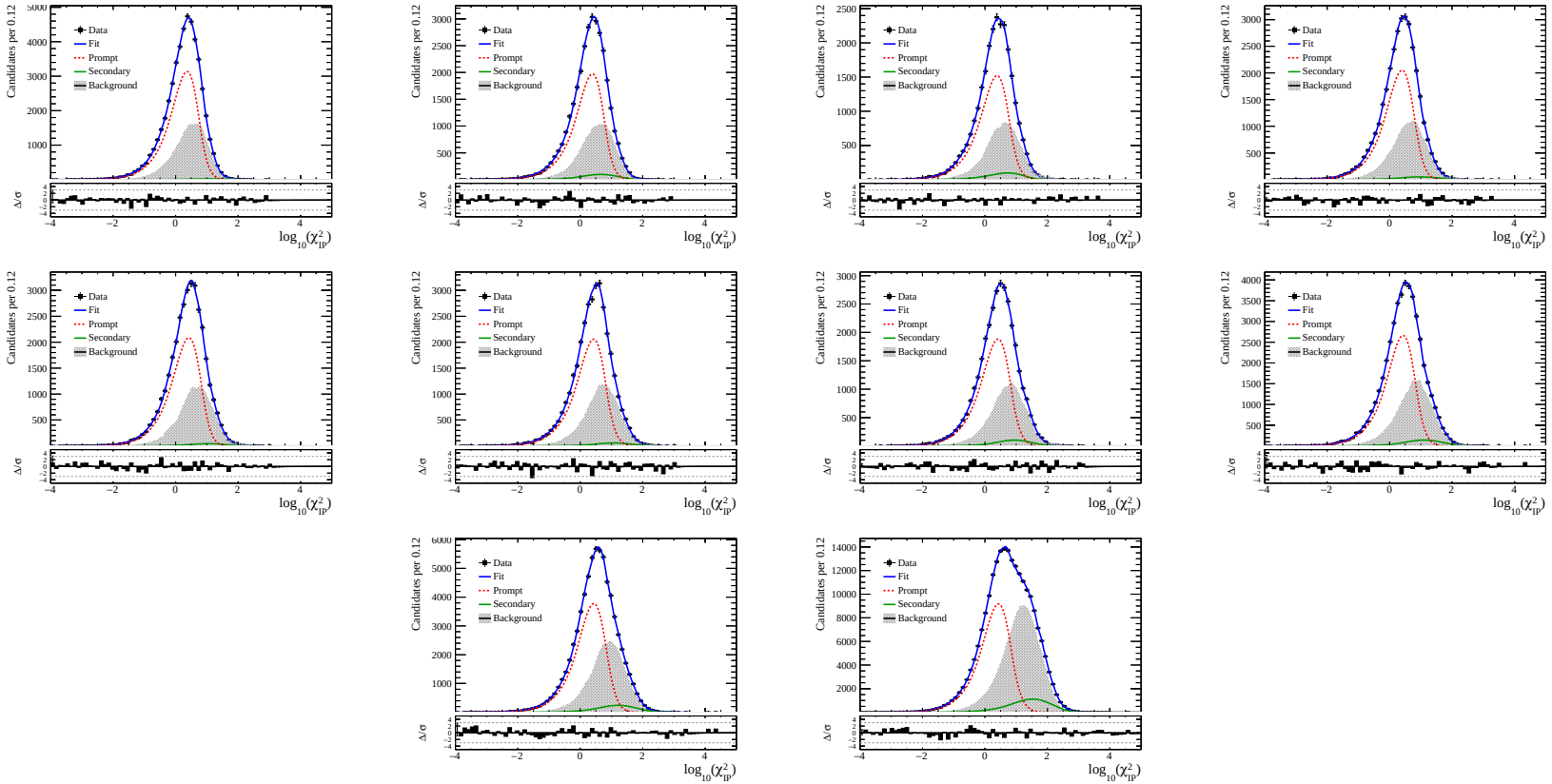


Secondary

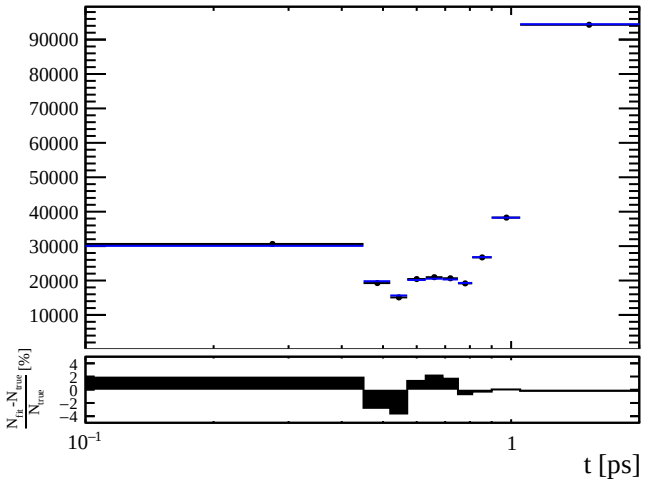
Sanity check: fit background-injected combined MC

- Check whether the fit can re-produce the input prompt fraction
- Fit the combination of prompt MC, secondary MC and background from data
  - Background sample is generated from the RooKeysPdf of mass-sideband data
  - Background sample size is determined from the signal/background ratio in data
  - logIPCHI2 of MC sample is shifted by 0.15 to match the data
- Fit configuration
  - μ_{prompt} and $\mu_{\mathrm{secondary}}$ free to float
  - Other parameters fixed to separately-fit results
  - Number of background fixed to the input value

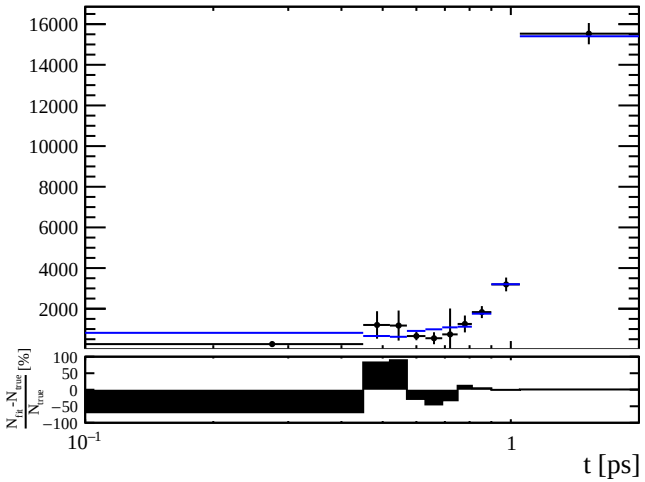
Fit results of background-injected combined MC



Comparison of input and extracted yield: D^0



Prompt



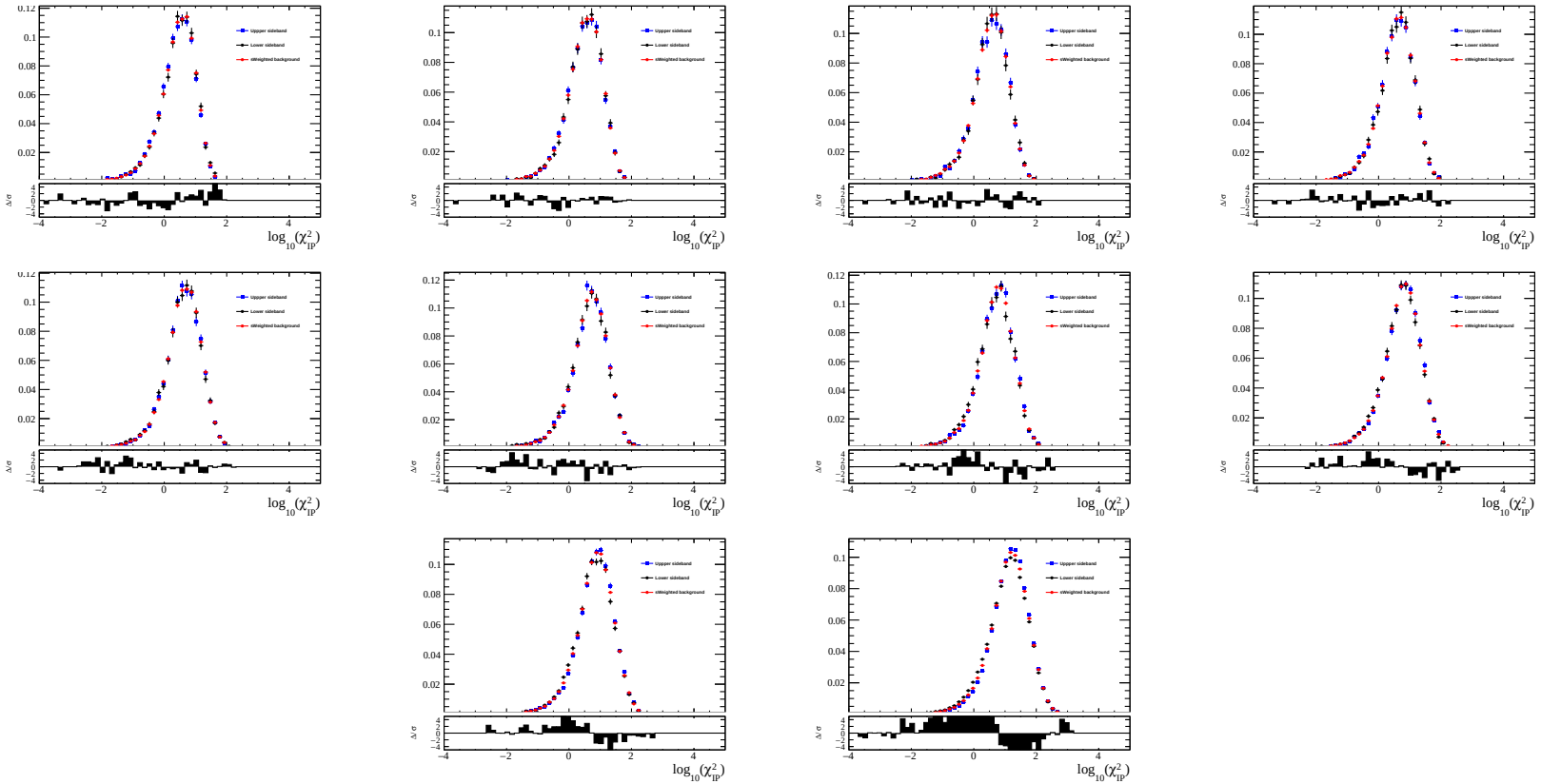
Secondary

Fit to $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$ data

- Mass fit
  - In $1865 \pm 45\,\mathrm{MeV}/c^2$ mass region
  - Gaussian + 2^{nd}-order Chebychev
- IPCHI2 fit
  - In $1865 \pm 2.5 \times 5.65\,\mathrm{MeV}/c^2$ signal region
  - Prompt and secondary signal components: μ_{prompt} and $\mu_{\mathrm{secondary}}$ free and other parameters fixed to MC
  - Background: kernel estimation with mass-sideband data
    Lower sideband: $[1820, 1830]\,\mathrm{MeV}/c^2$
    Upper sideband: $[1900, 1910]\,\mathrm{MeV}/c^2$
  - The total number of backgrounds fixed to values from mass fit
  - Binning scheme: the same as the signal mode

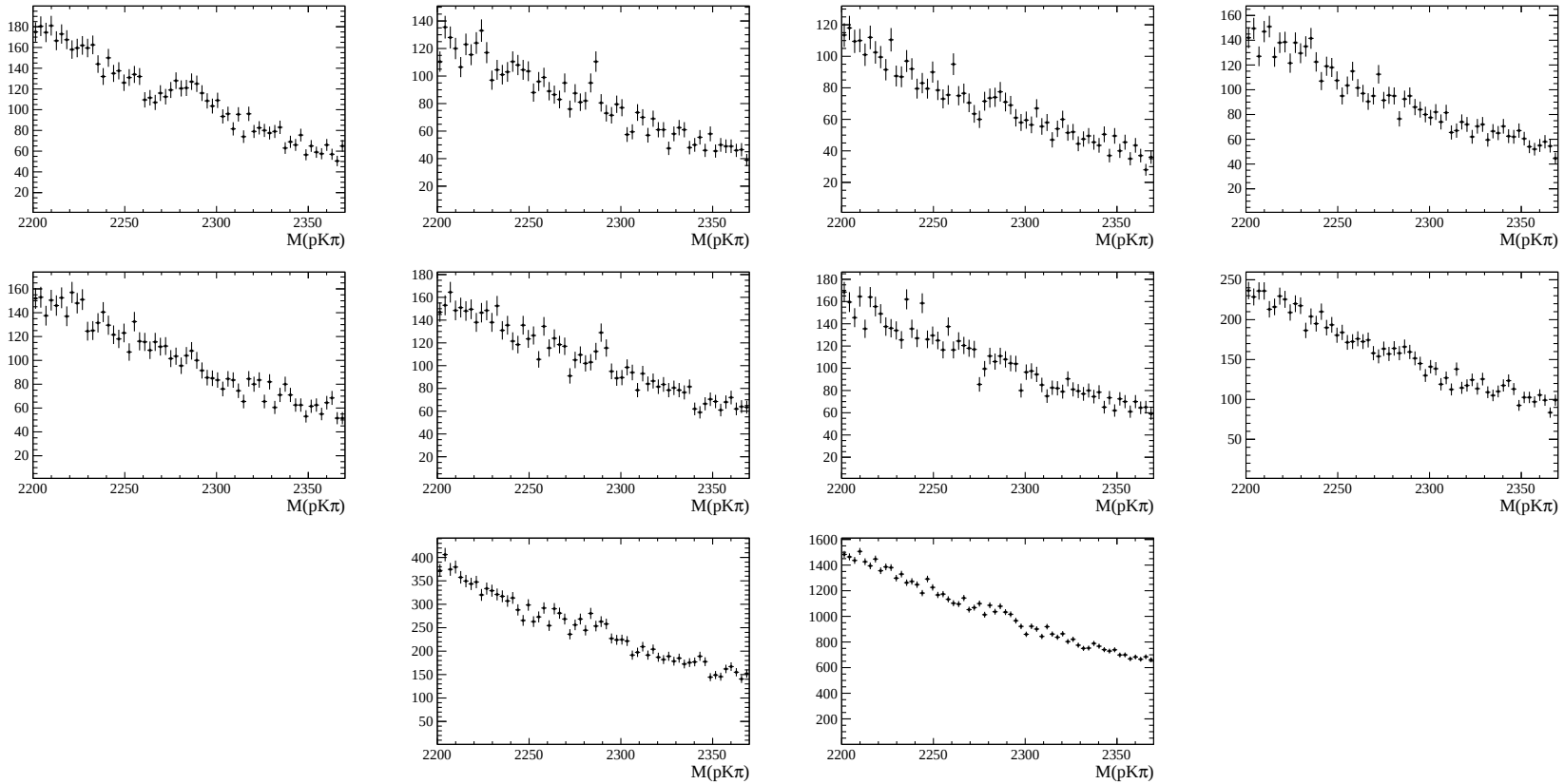
Comparison of background logIPCHI2

- MC cannot provide a large combinatorial background sample
- Real data is necessary for background studies



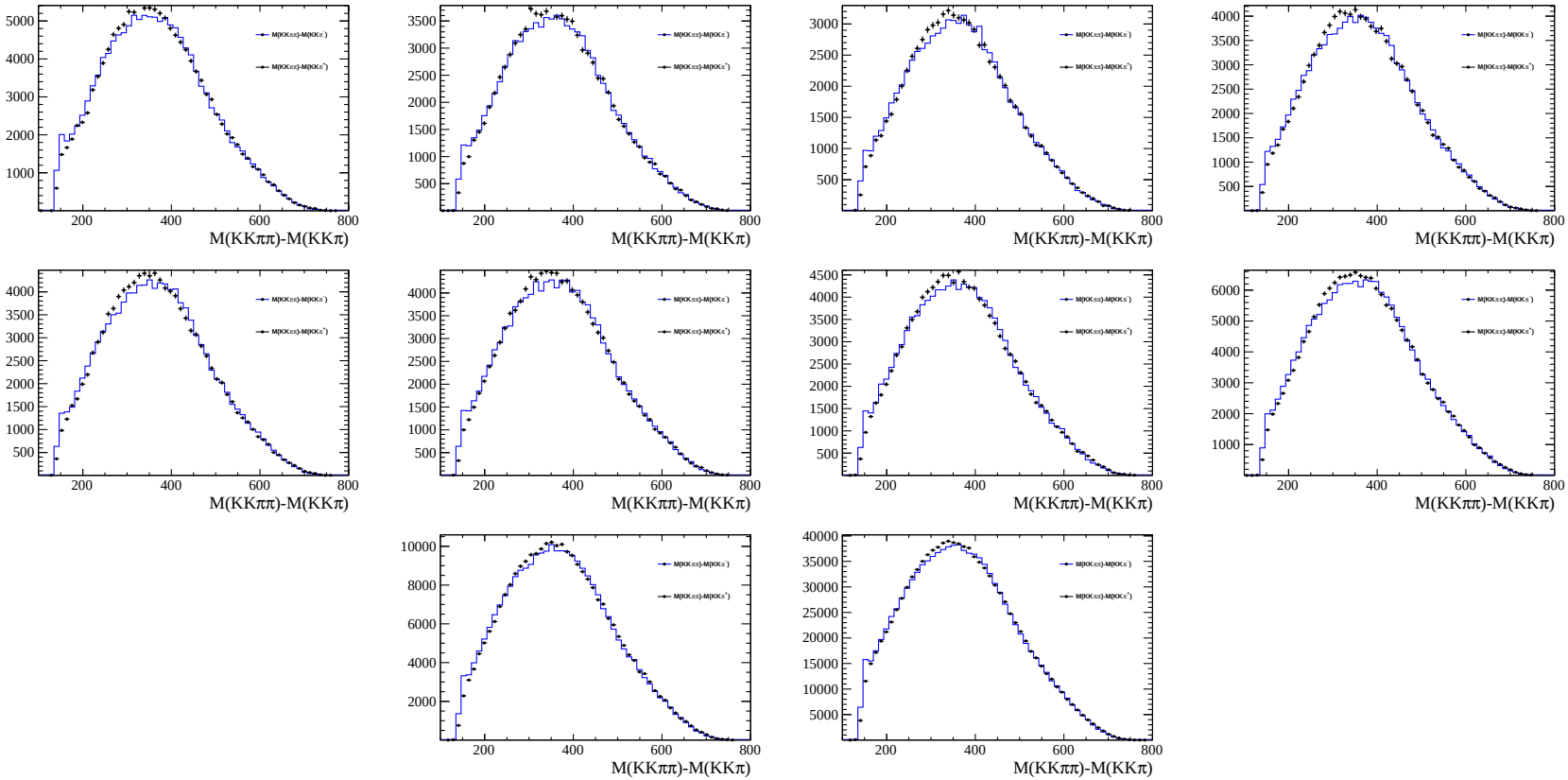
Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

- Λ_c^+ background: p mis-identified as K^-
- Suppressed by tight PID cuts



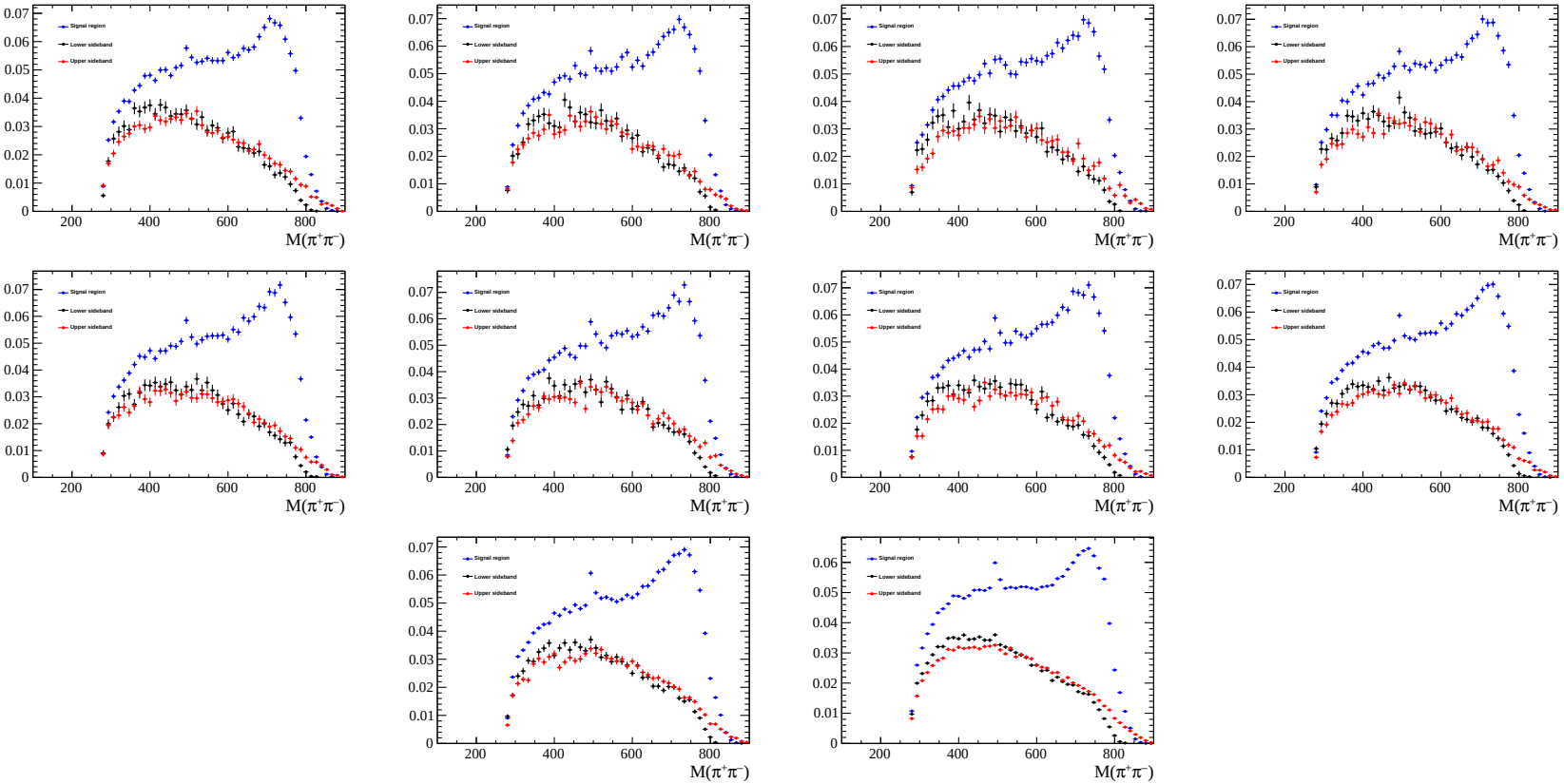
Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

- π swap: $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$
- Not significant due to tight χ^2_{IP} cuts

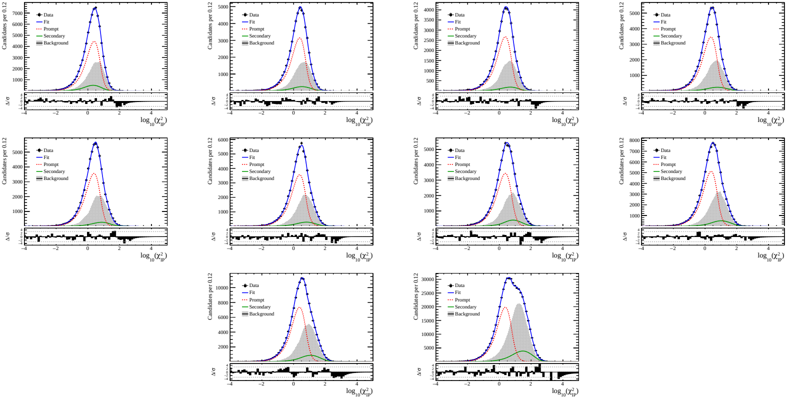


Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

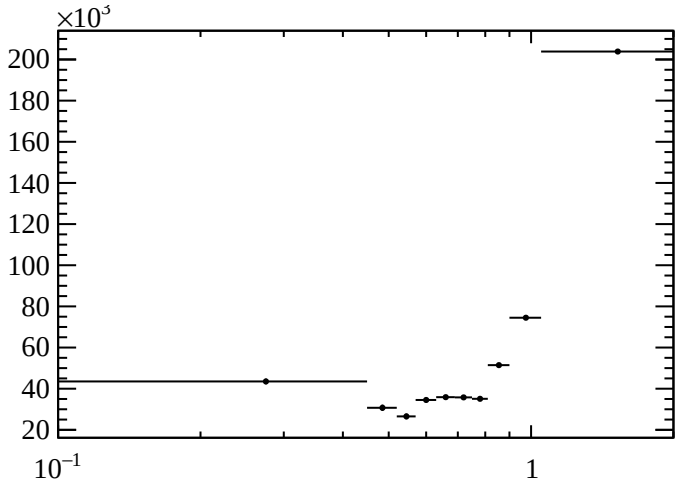
- K^0_S background: $D^0 \to K^- K^+ K^0_S (\to \pi^+ \pi^-)$
- Exist but not significant in the signal region



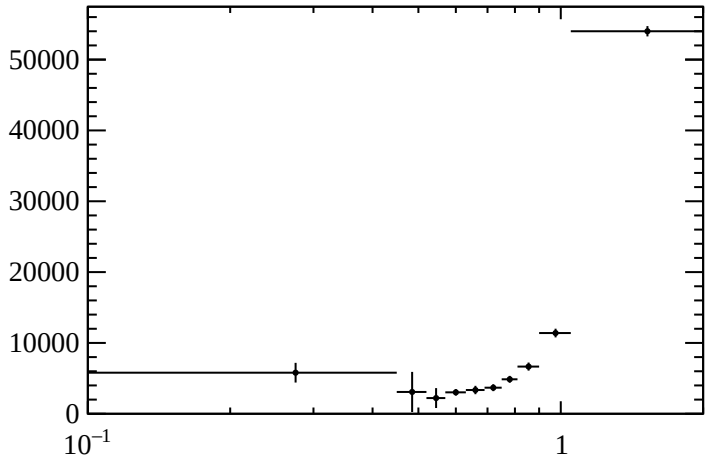
Fit results of D^0 data



Fit results of yields

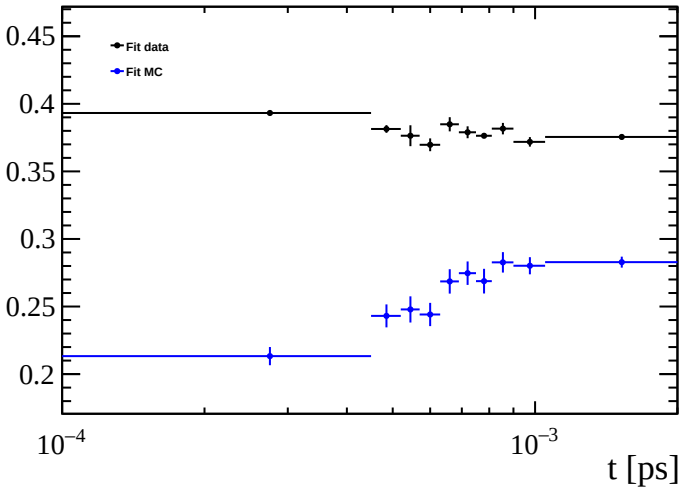


Prompt

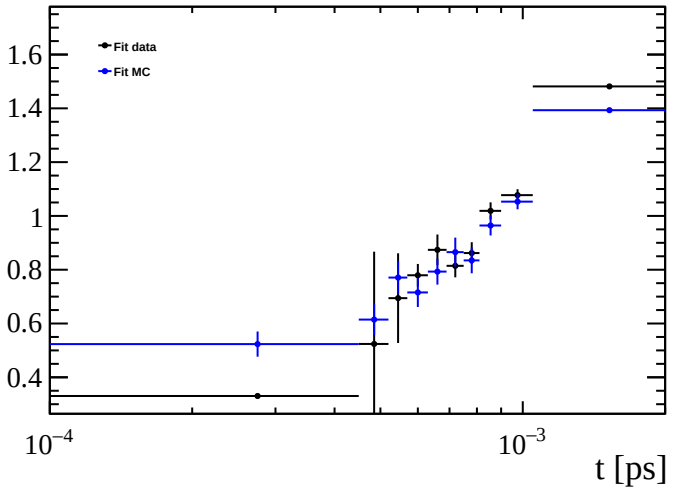


Secondary

Fit results of μ

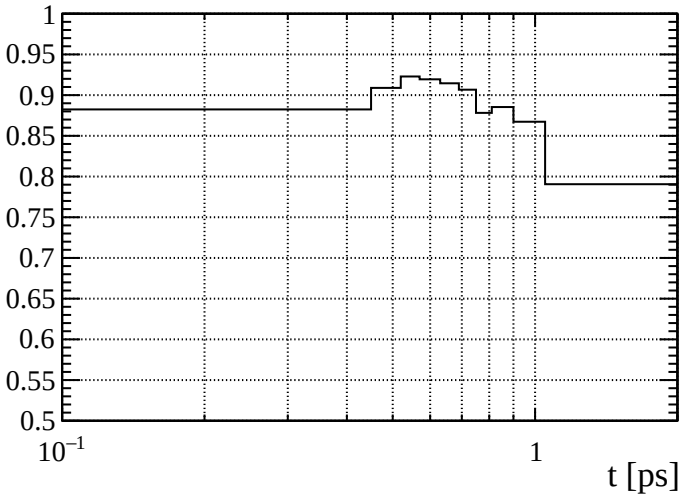


Prompt

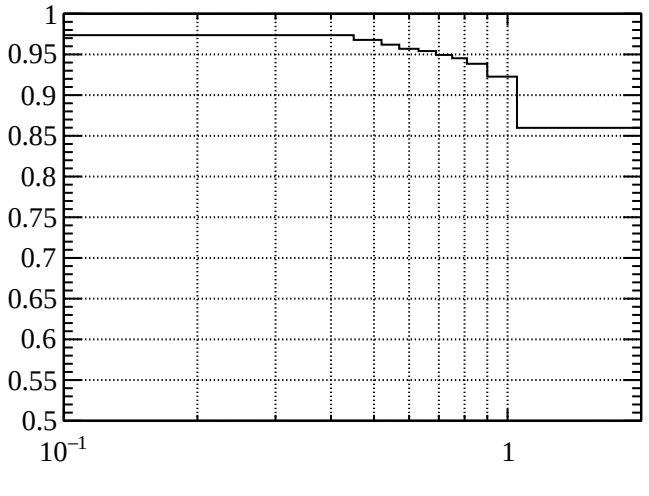


Secondary

Comparison of data and MC: prompt fraction

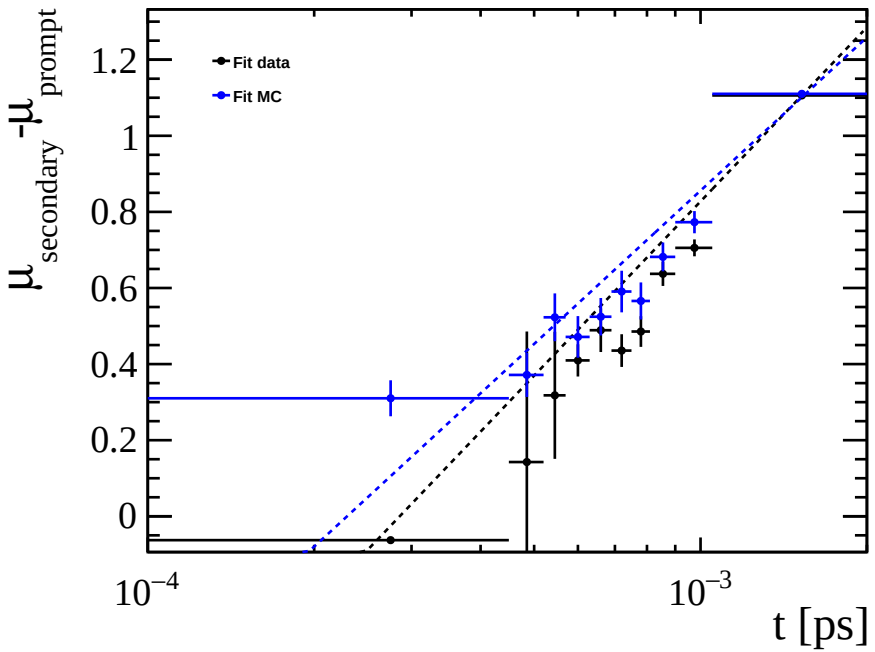


Data

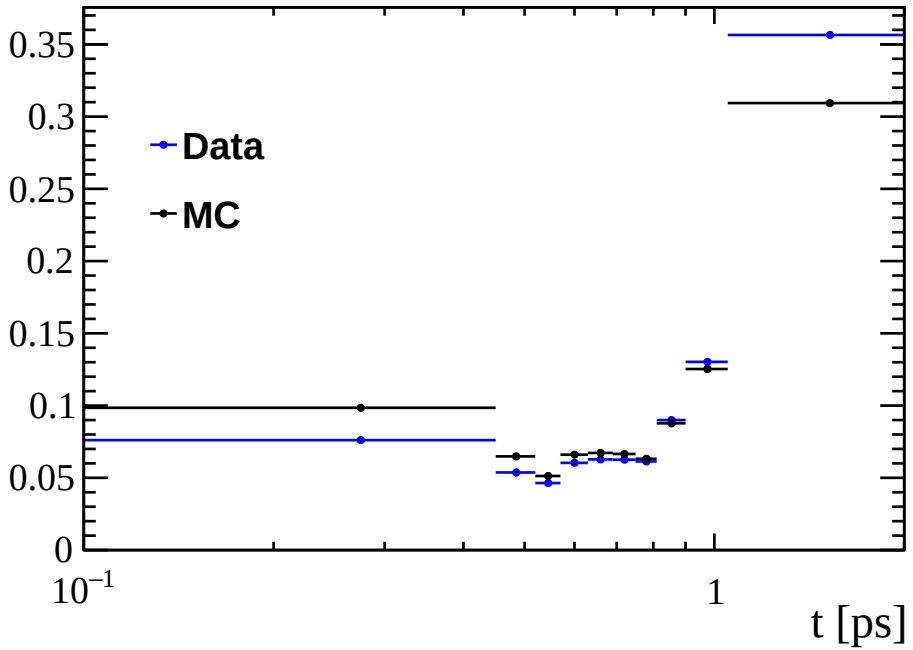


MC

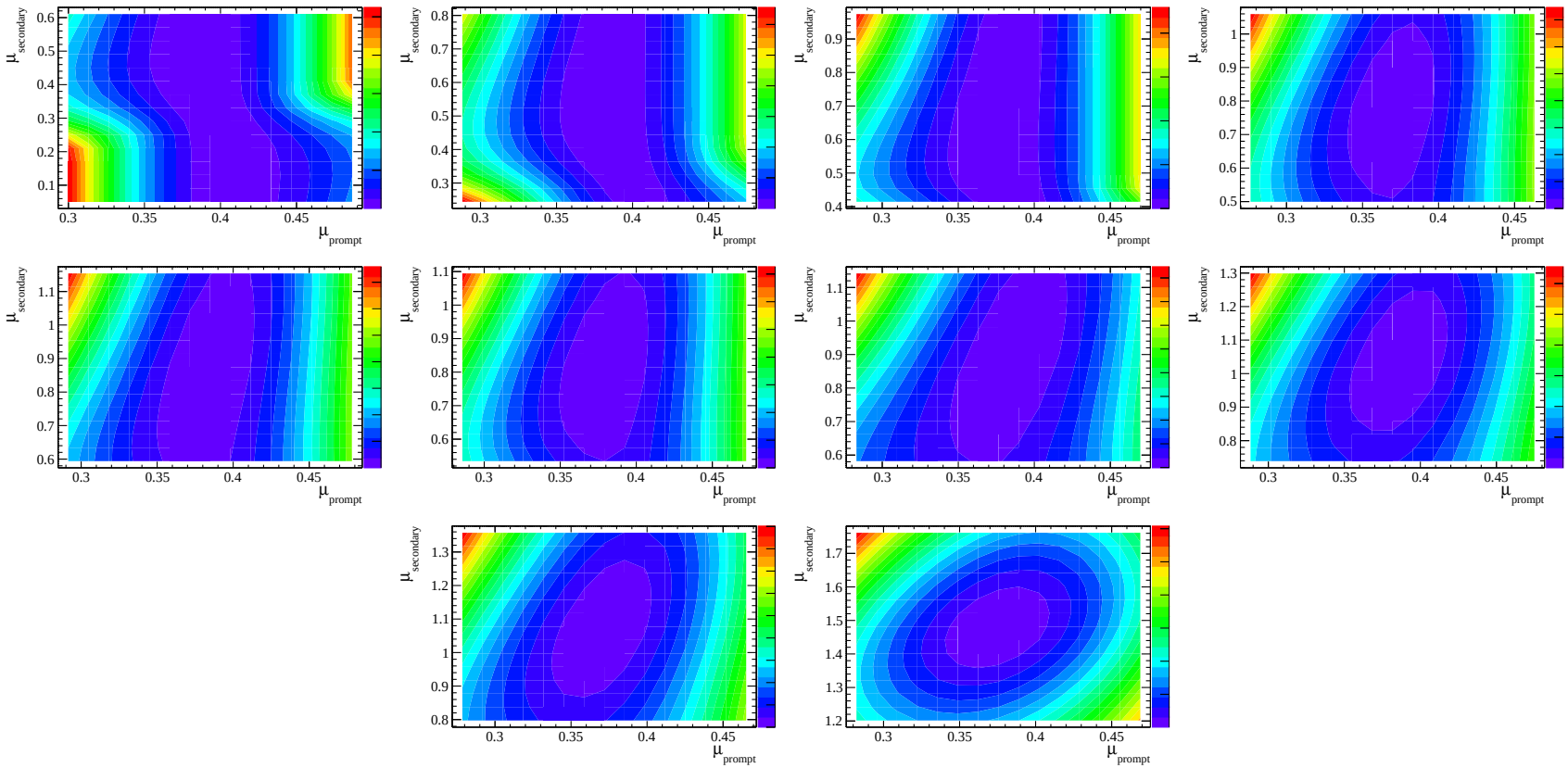
Comparison of data and MC: $\mu_{\text{prompt}} - \mu_{\text{secondary}}$



Comparison of data and MC: prompt yield

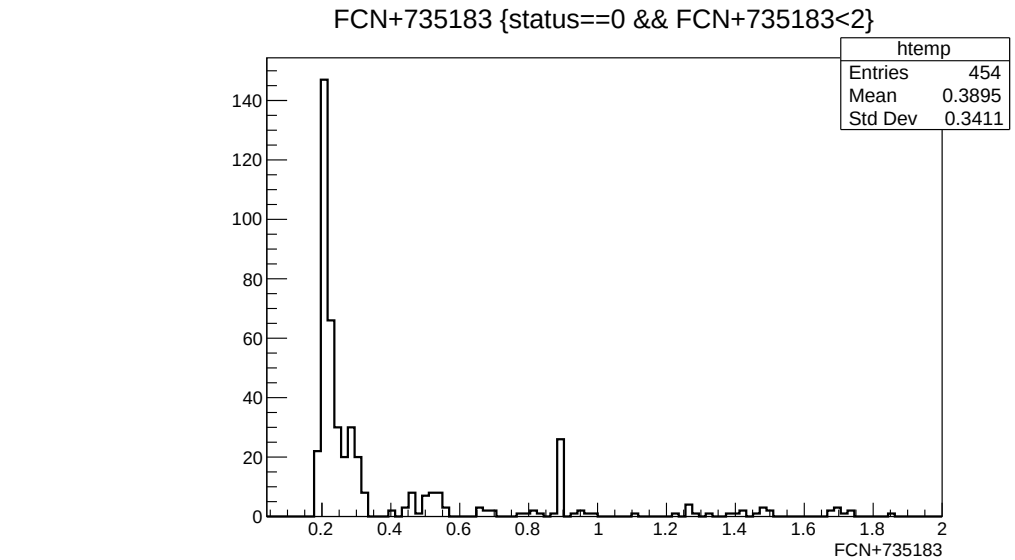


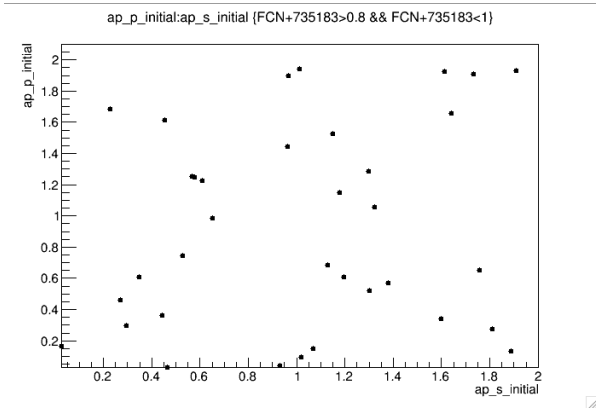
Likelihood scan of μ_{prompt} and $\mu_{\text{secondary}}$

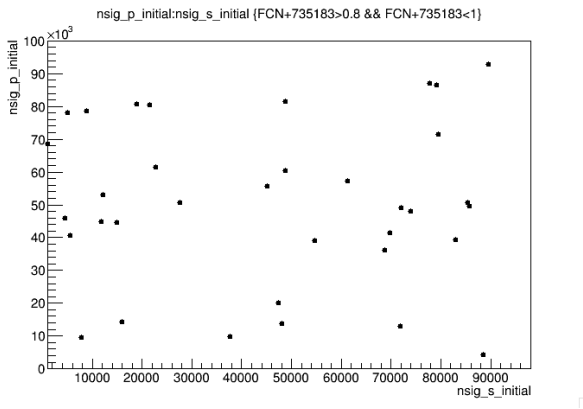


Effect of initial values

- Repeat the fit (bin 0) with random initial values in parameter space ($\mu_{\text{prompt}}, \mu_{\text{secondary}}, N_{\text{prompt}}, N_{\text{secondary}}$)



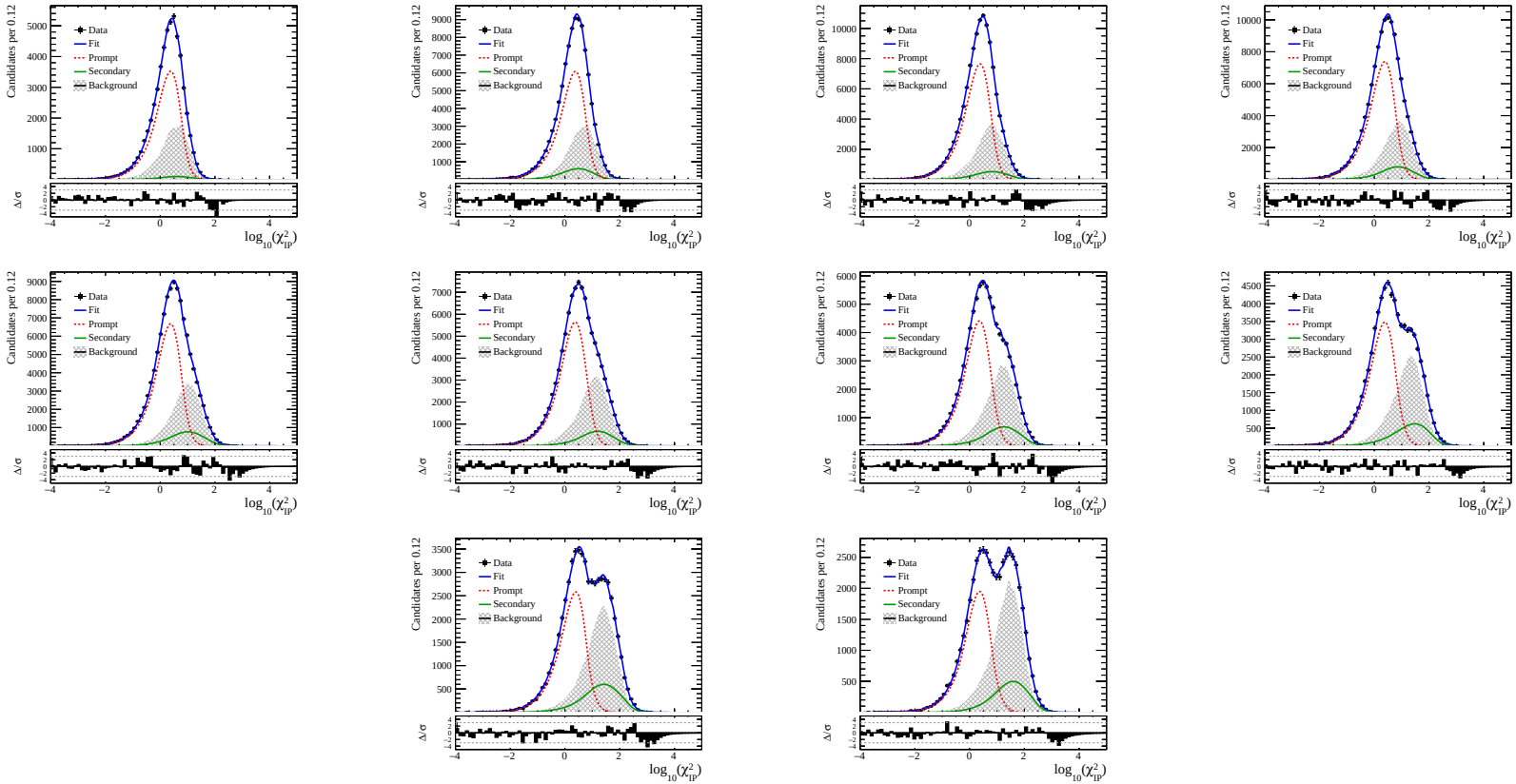




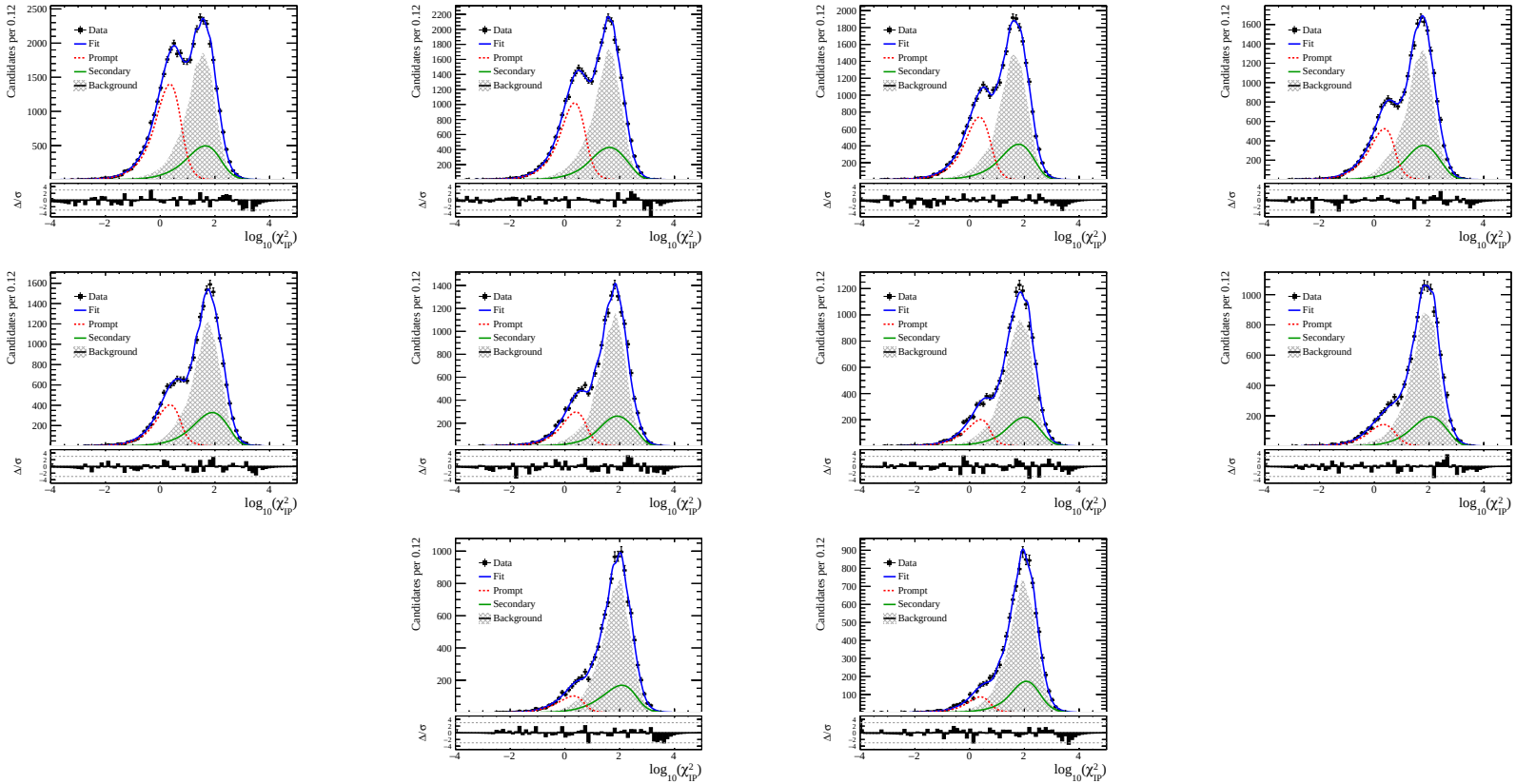
Fit D^0 data in even decay time bins

- Study the effect of unequal binning scheme
- Fit data in equally-sized 20 decay time bins between 0.3 ps and 3 ps

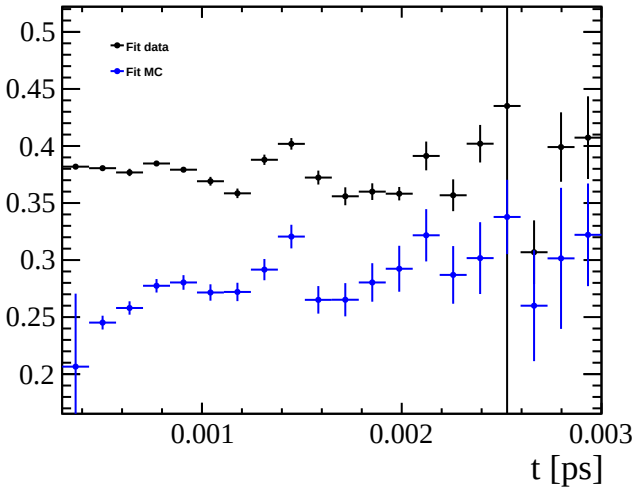
Fit results of D^0 data in even bins: bin 0-9



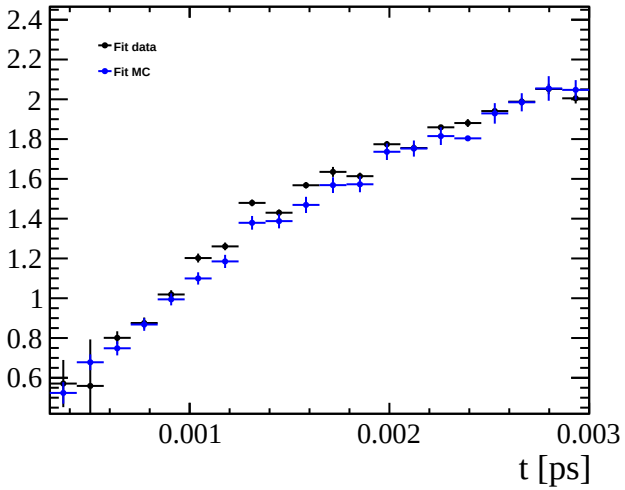
Fit results of D^0 data in even bins: 10-19



Fit results of μ in even bins

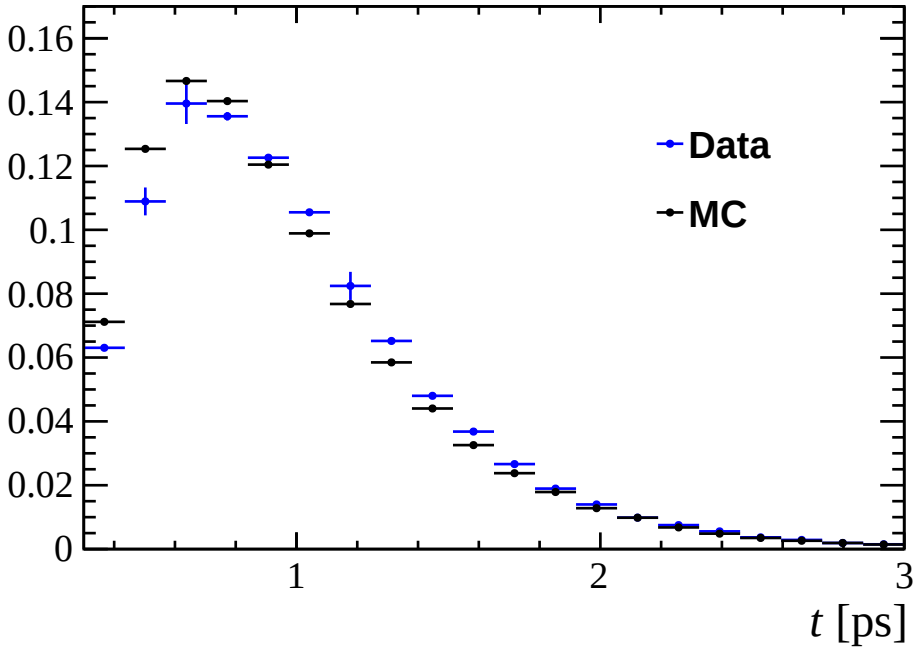


Prompt



Secondary

Comparison of prompt yield in even decay-time bins

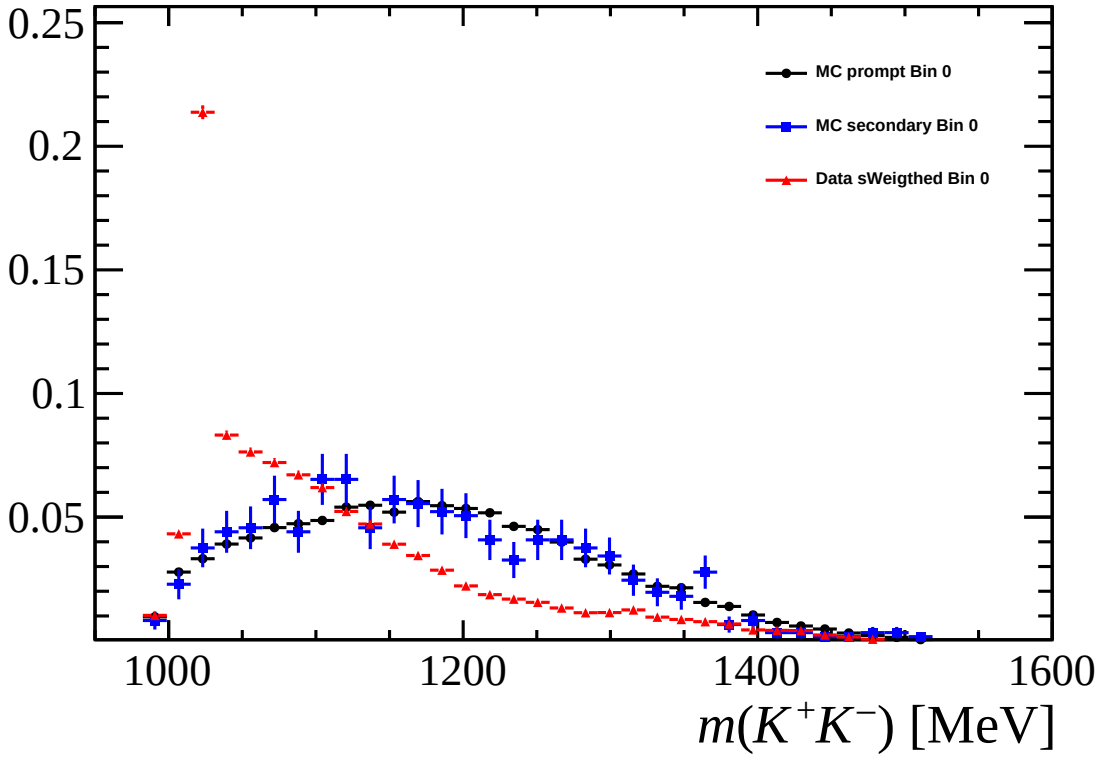


Comparison of Dalitz distributions for MC and data of D^0 mode

- Five variables are needed to describe the $D^0 \to K^+K^-\pi^+\pi^-$ decay
- Choose Cabibbo-Maksymowicz (CM) variables
  - $m(K^+K^-)$
  - $m(\pi^+\pi^-)$
  - $\cos(\theta^{K^+K^-}_{K^+})$: the cosine of the angle between the direction of the D^0 and that of one of the kaons in the rest frame of the two kaons
  - $\cos(\theta^{\pi^+\pi^-}_{\pi^+})$: the cosine of the angle between the direction of the D^0 and that of one of the pions in the rest frame of the two pions
  - $\cos(\phi)$: the cosine of the angle in the D^0 rest frame between the plane defined by the directions of the two kaons and the plane defined by the directions of the two pions
- Data sWeights are calcualted from mass fit
- Decay time binning scheme: equally-sized 20 decay time bins between 0.3 ps and 3 ps

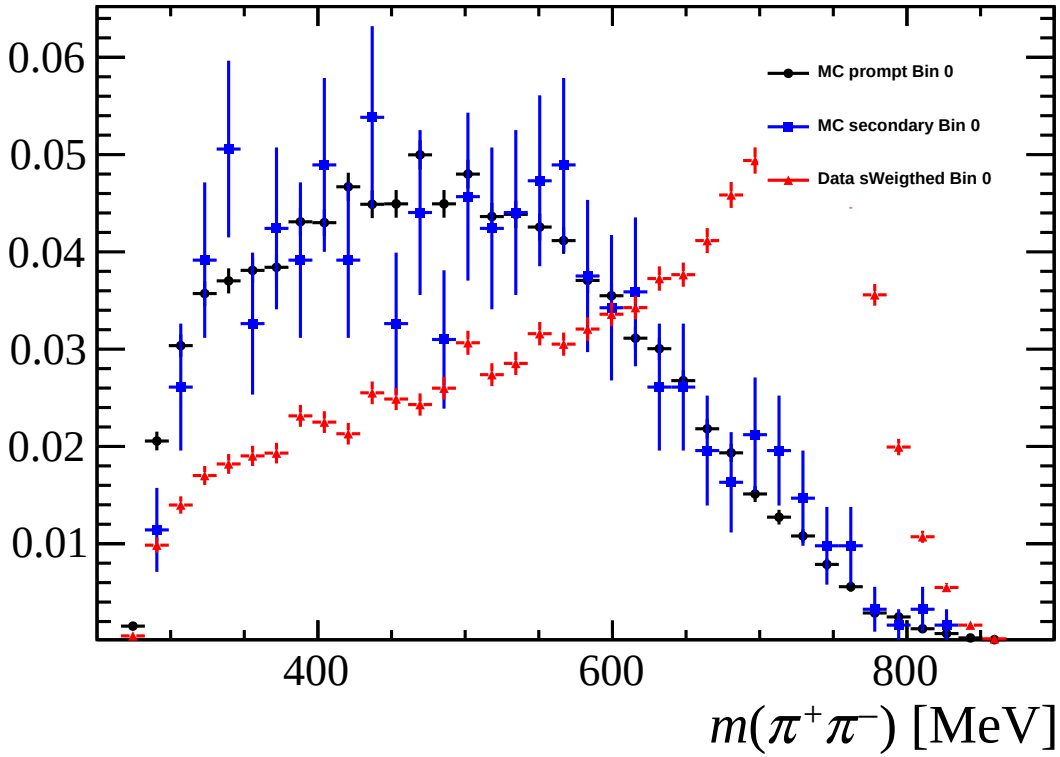
Comparison of $m(K^+K^-)$ in Bin 0

- No ϕ resonance in phase-space MC
- Prompt and secondary MC agree well



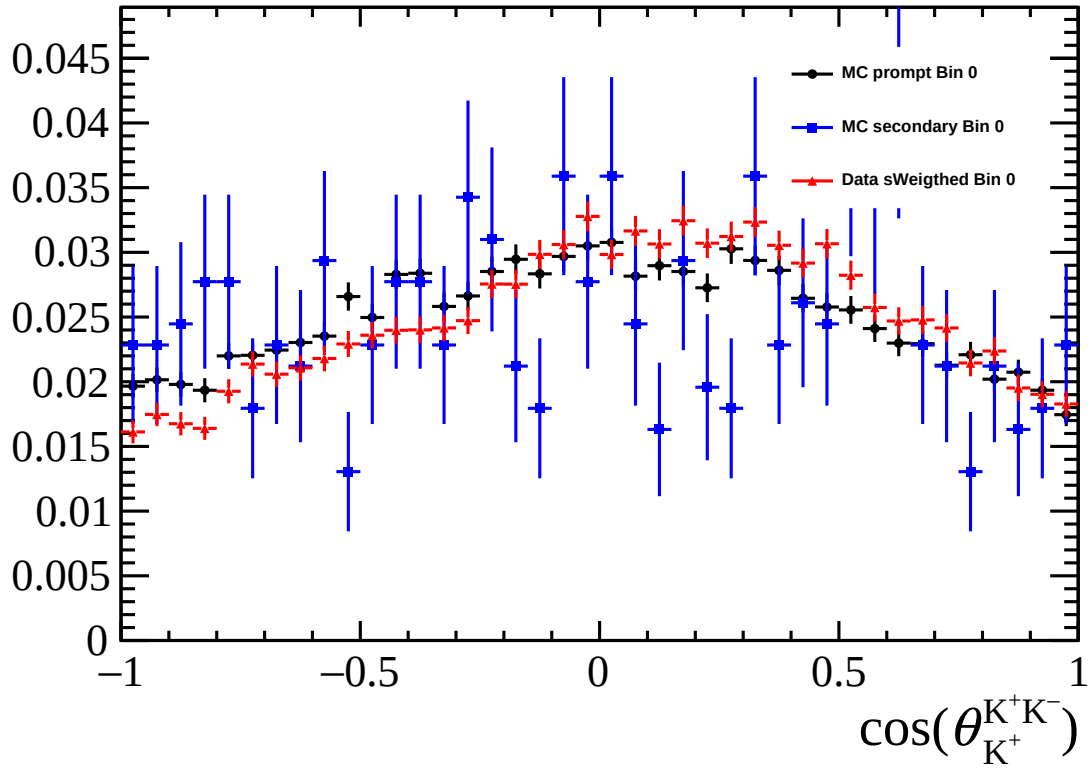
Comparison of $m(\pi^+\pi^-)$ in Bin 0

- No ρ resonance in phase-space MC
- Prompt and secondary MC agree well



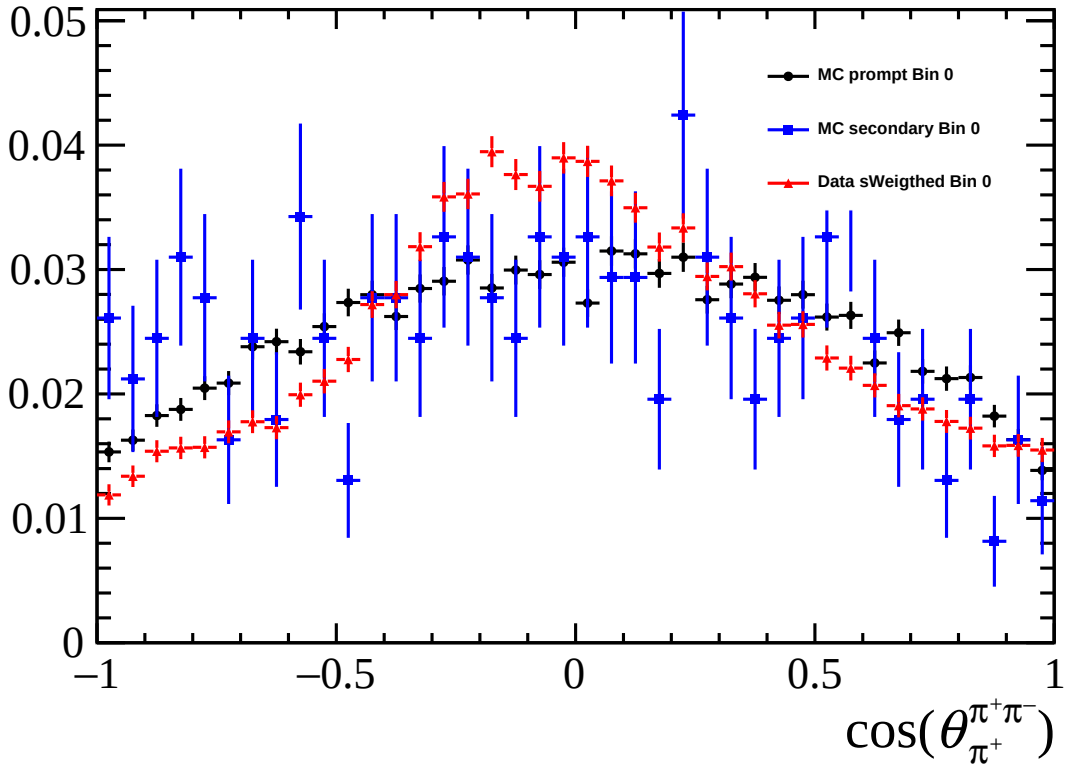
Comparison of $\cos(\theta^{K^+K^-}_{K^+})$ in Bin 0

- Data-MC discrepency is small
- Data is not symmetric w.r.t. 0
- Prompt and secondary MC agree well



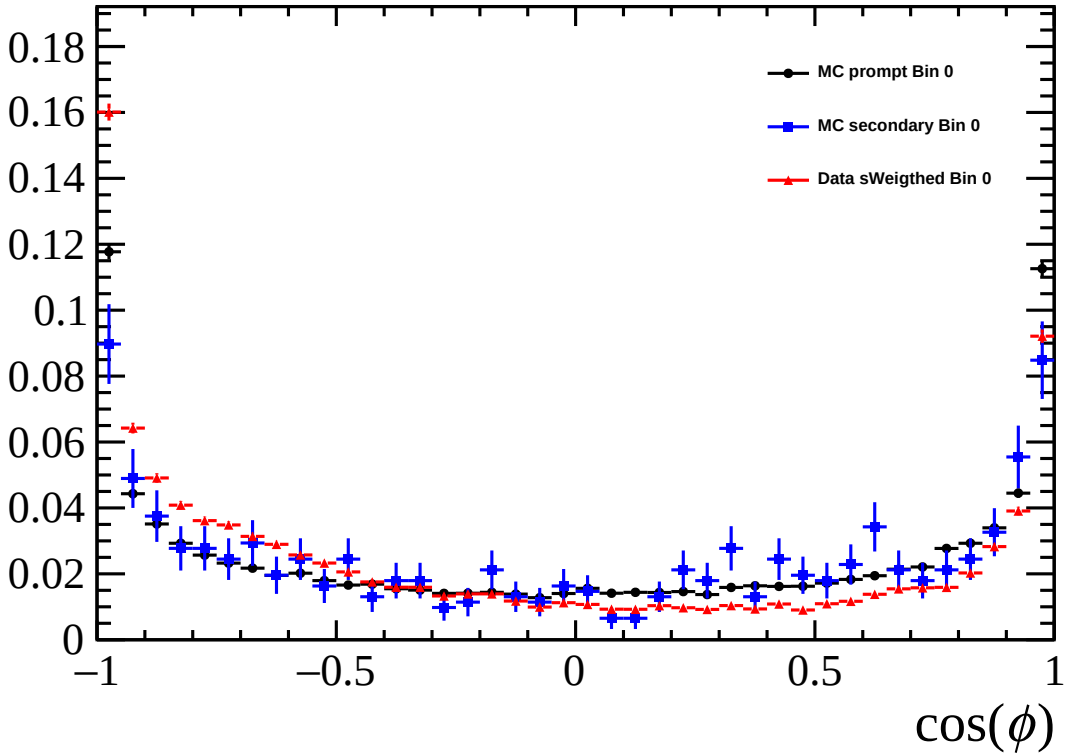
Comparison of $\cos(\theta^{\pi^+\pi^-}_{\pi^+})$ in Bin 0

- Data is not symmetric w.r.t. 0
- Prompt and secondary MC agree well



Comparison of cos(ϕ) in Bin 0

- Data is not symmetric w.r.t. 0
- Prompt and secondary MC agree well

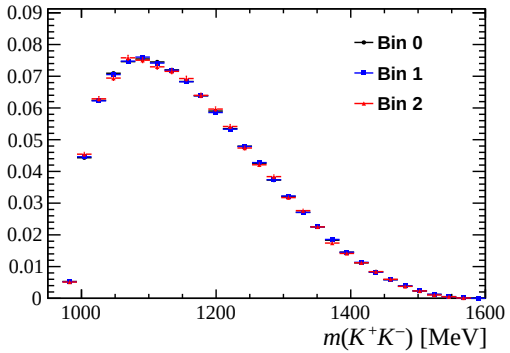


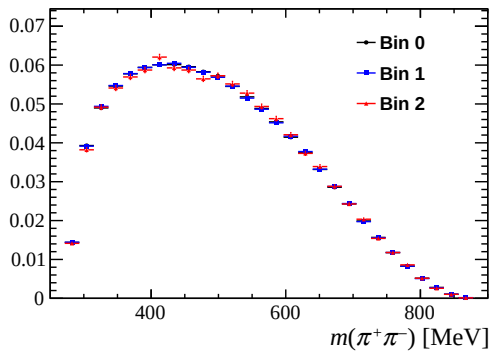
Decay time dependence of CM variables

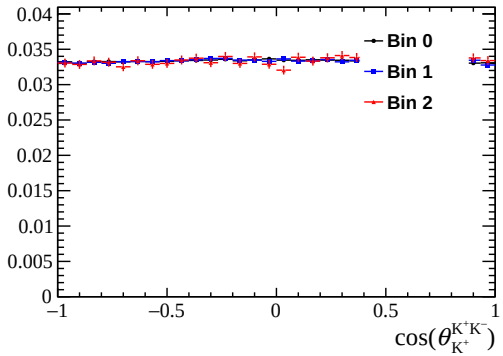
- Only the decay-time-dependent discrepency is relevant in this measurement
- Use three coasre decay time bins to study the effect
  - Bin 0: [0.0003, 0.0012] ns
  - Bin 1: [0.0012, 0.0021] ns
  - Bin 2: [0.0021, 0.0030] ns

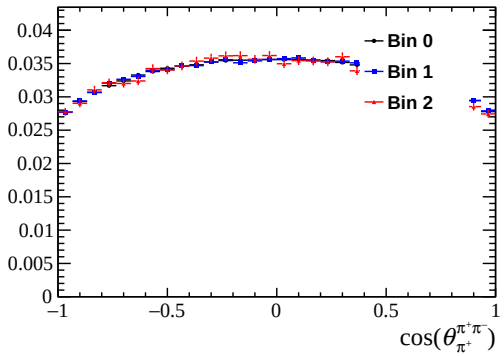
Generator-level MC distributions

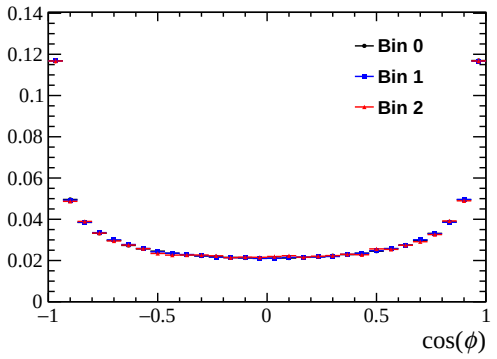
- No difference at generator level





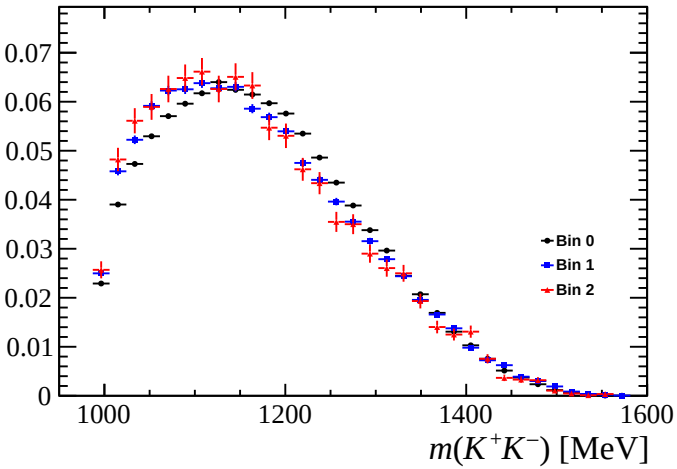


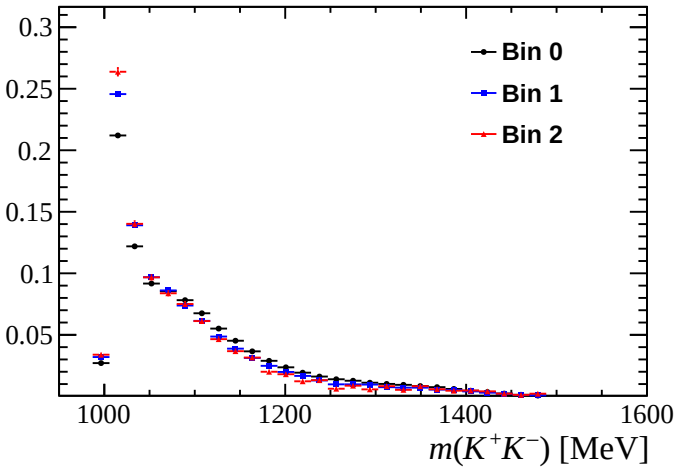


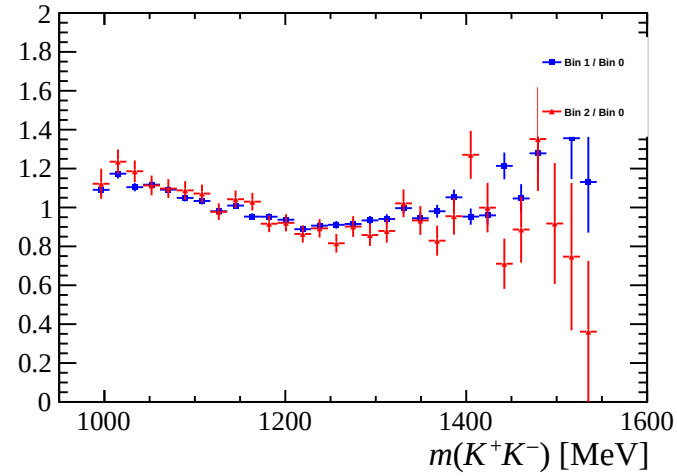


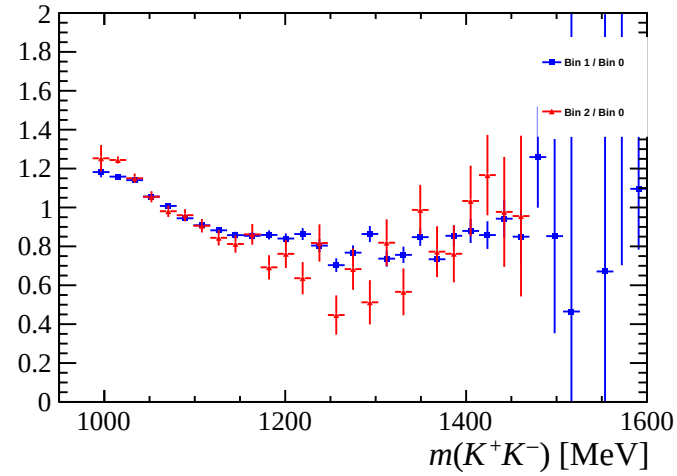
Decay time dependence of $m(K^+K^-)$

- (Top) distributions and (bottom) ratios







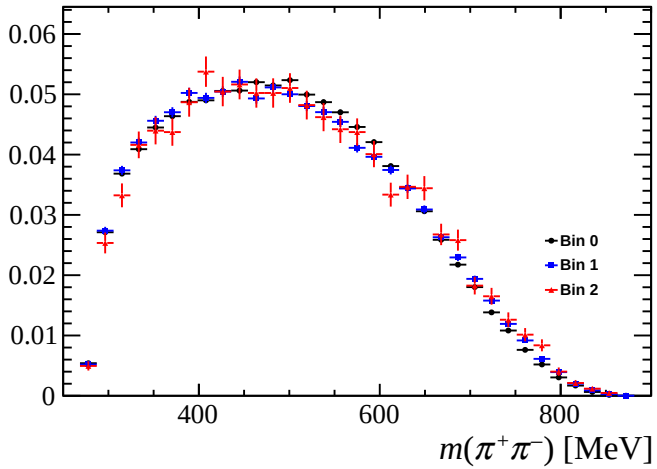


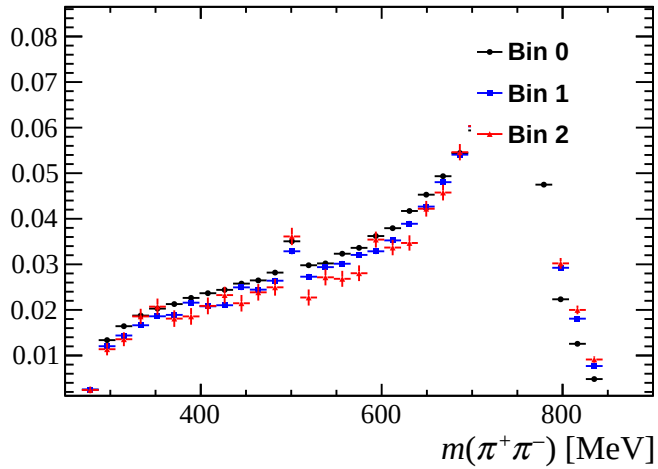
Prompt MC

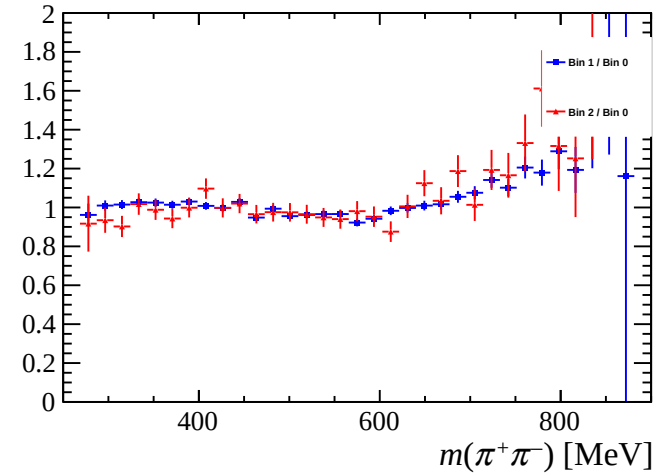
sWeighted data

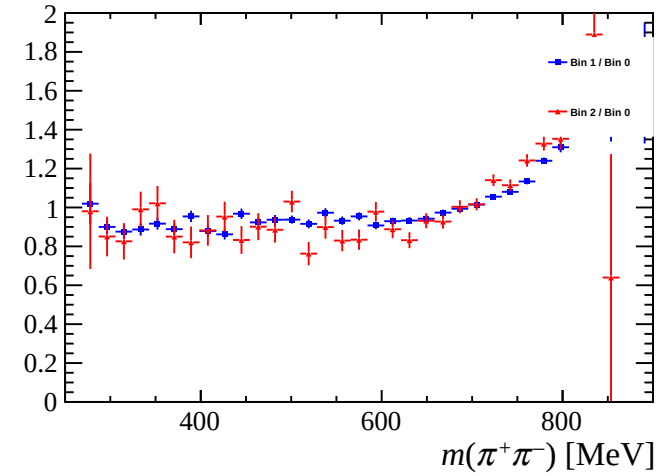
Decay time dependence of $m(\pi^+\pi^-)$

- (Top) distributions and (bottom) ratios







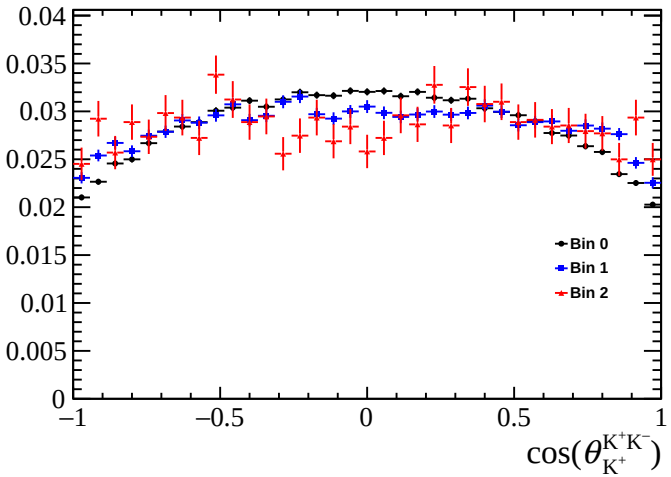


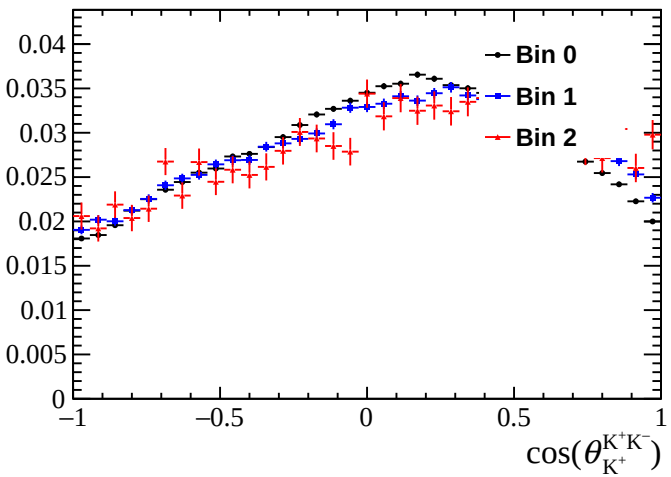
Prompt MC

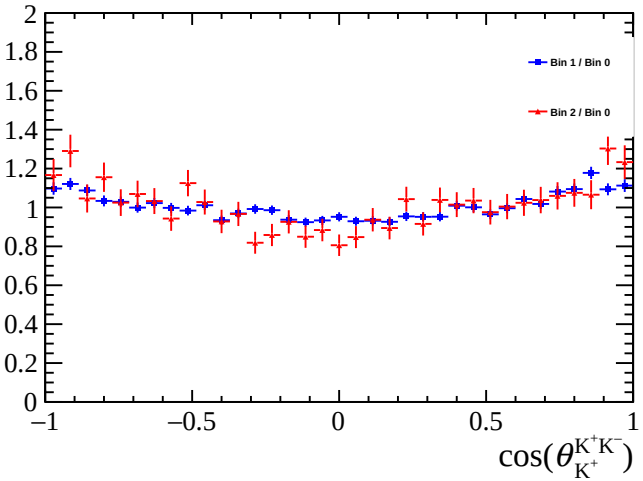
sWeighted data

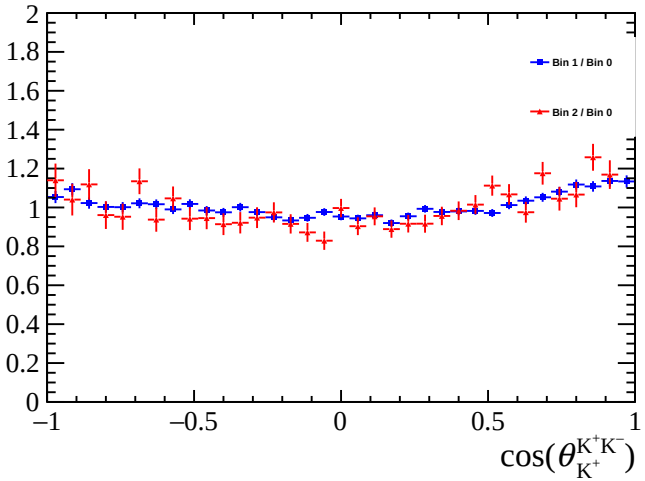
Decay time dependence of $\cos(\theta^{K^+K^-}_{K^+})$

- (Top) distributions and (bottom) ratios







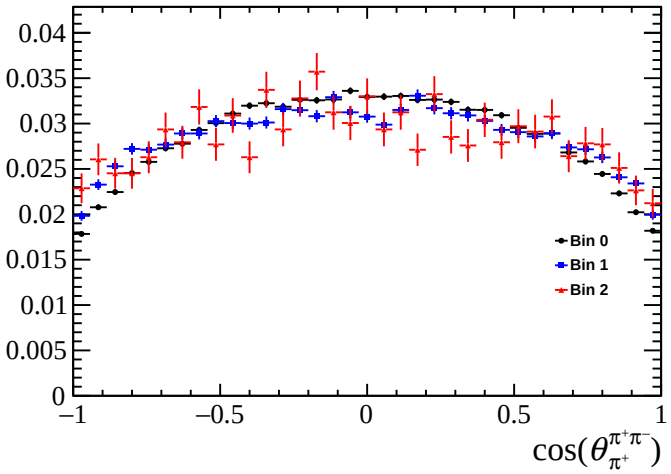


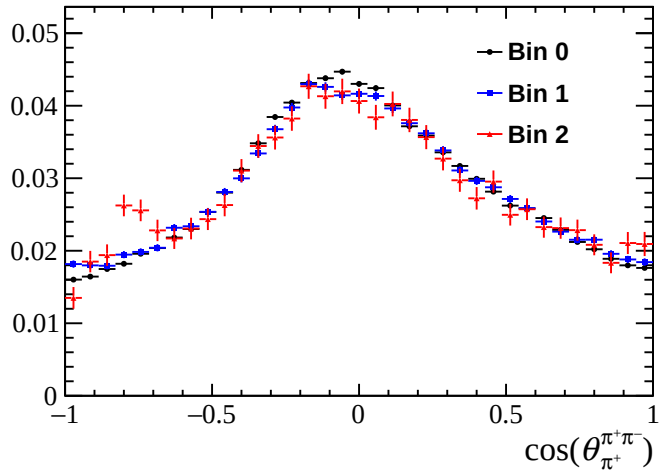
Prompt MC

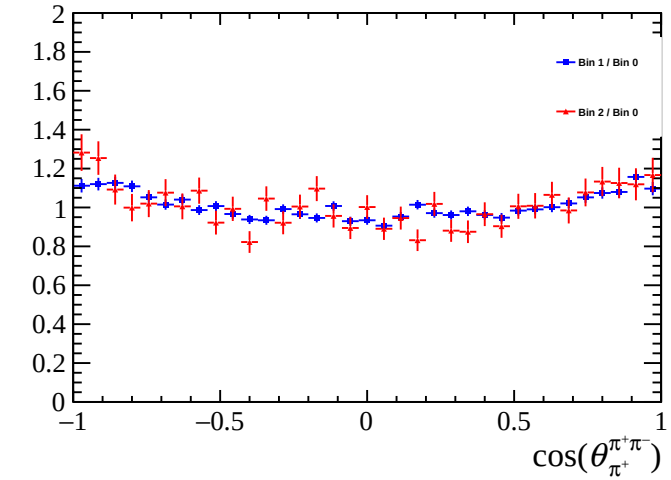
sWeighted data

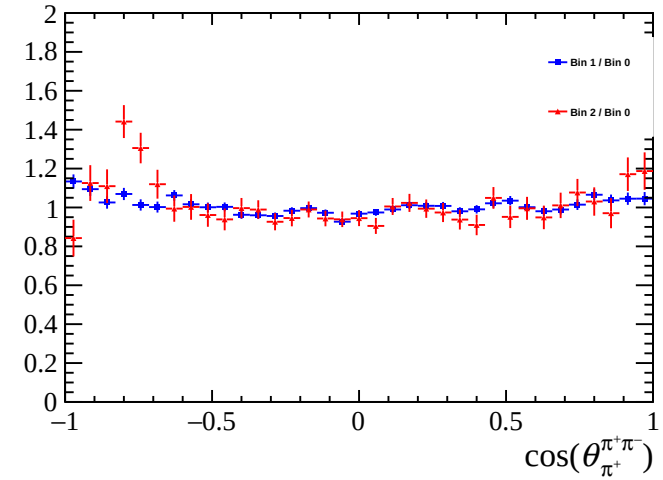
Decay time dependence of $\cos(\theta^{\pi^+\pi^-}_{\pi^+})$

- (Top) distributions and (bottom) ratios







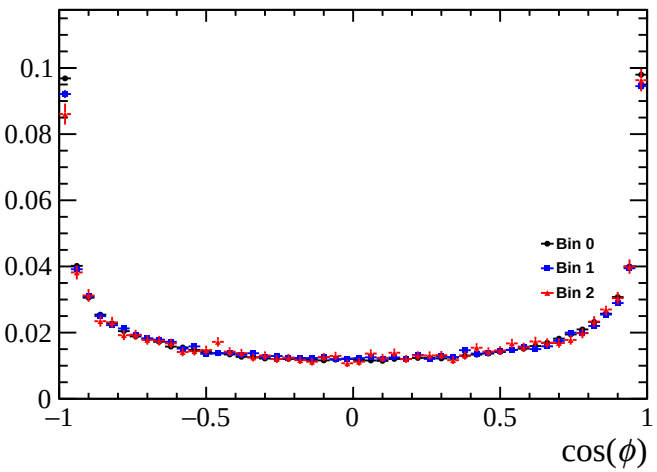


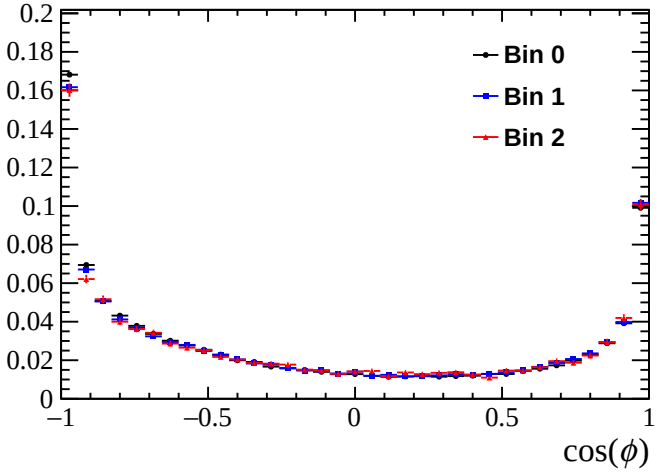
Prompt MC

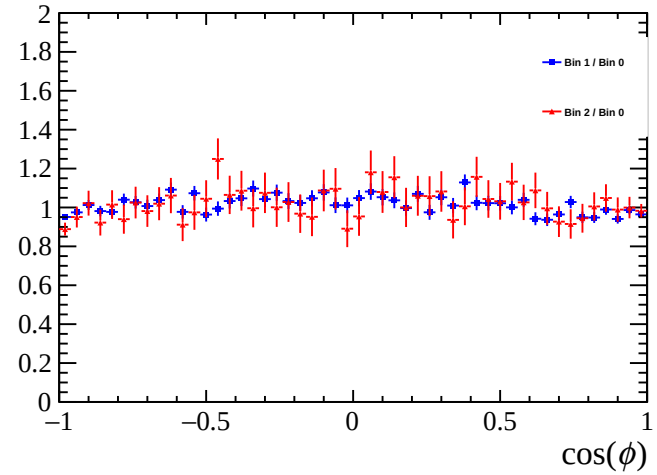
sWeighted data

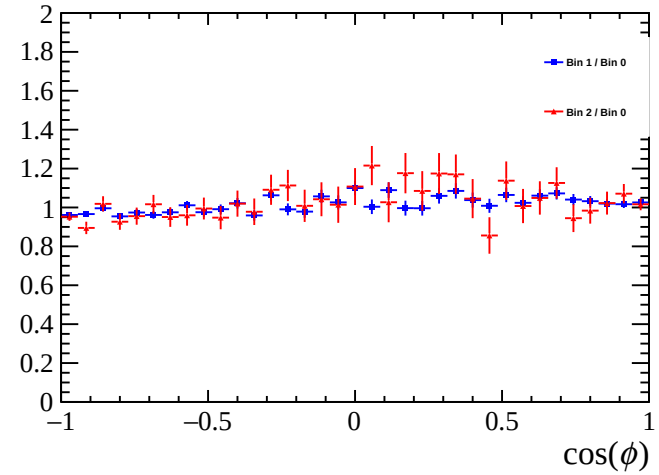
Decay time dependence of $\cos(\phi)$

- (Top) distributions and (bottom) ratios





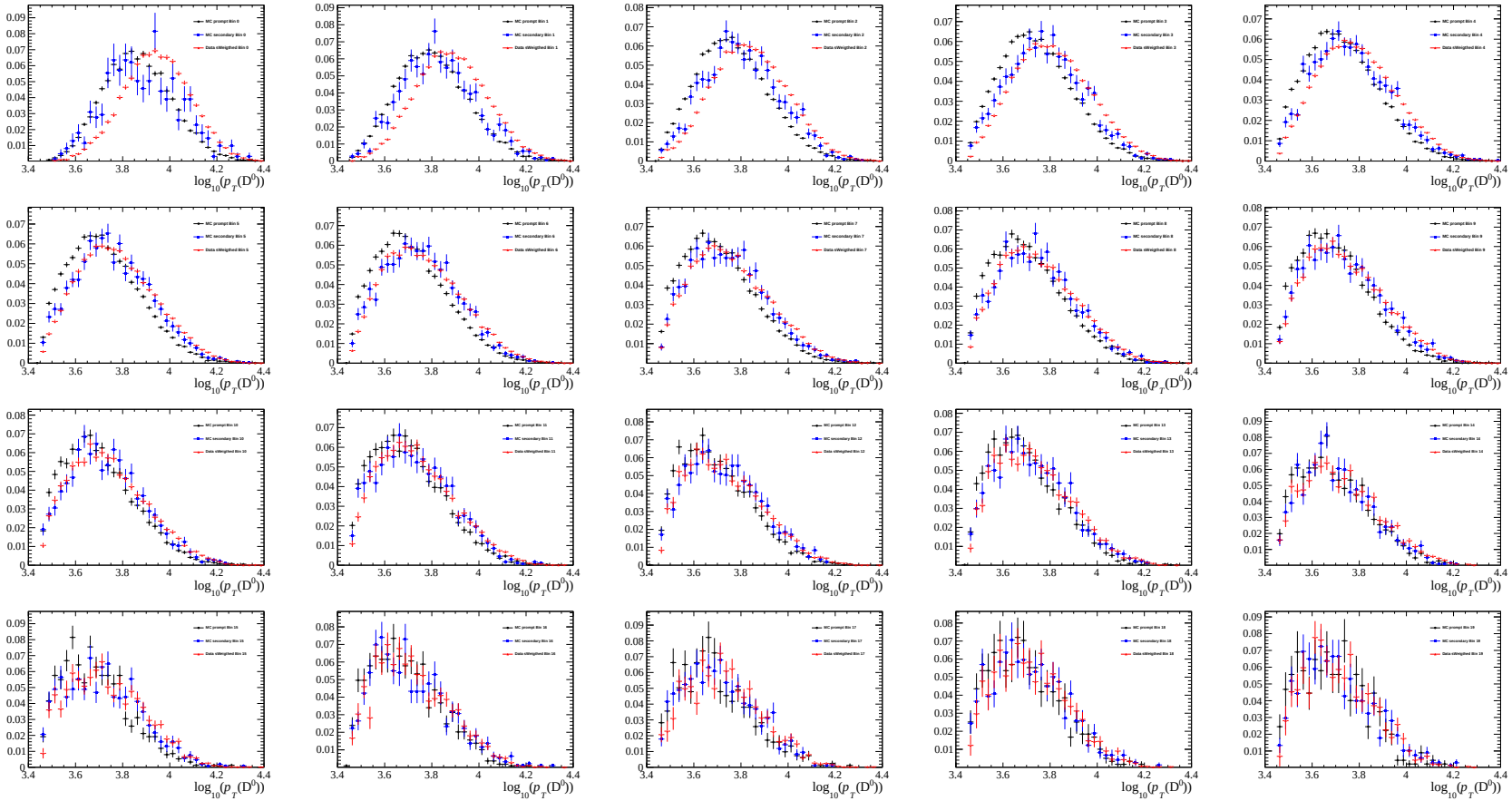




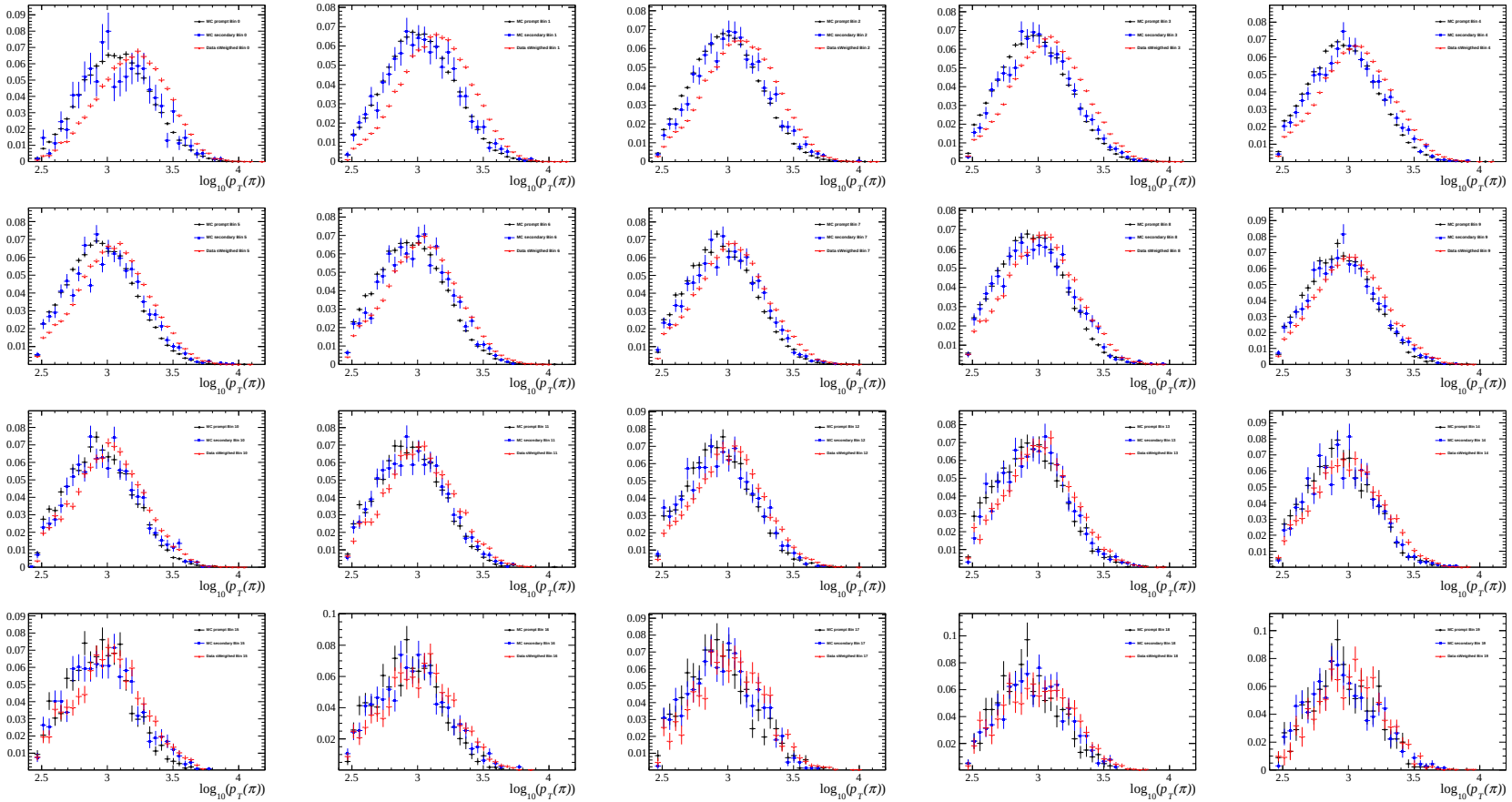
Prompt MC

sWeighted data

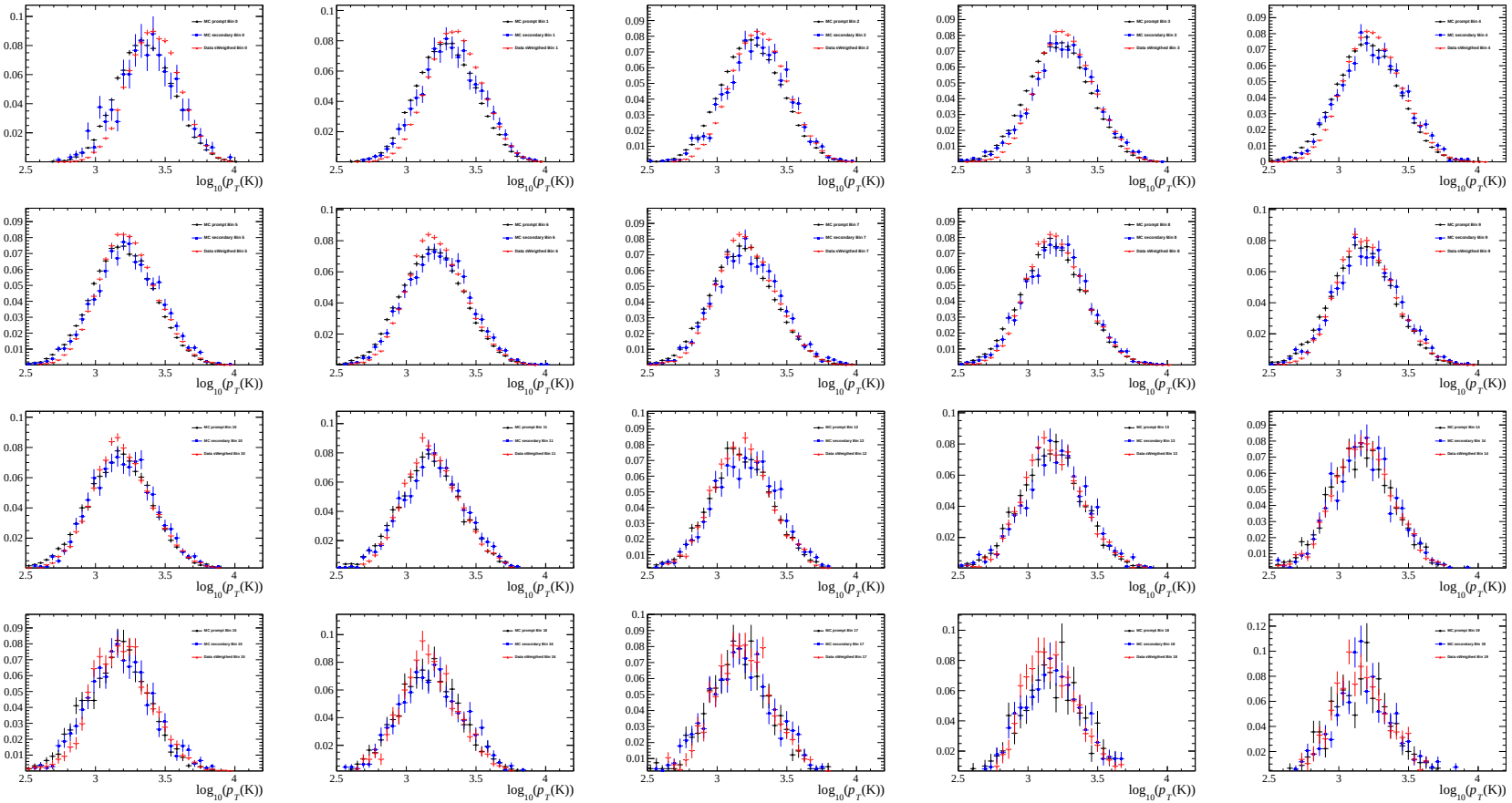
Comparison of p_{T} (D^0)



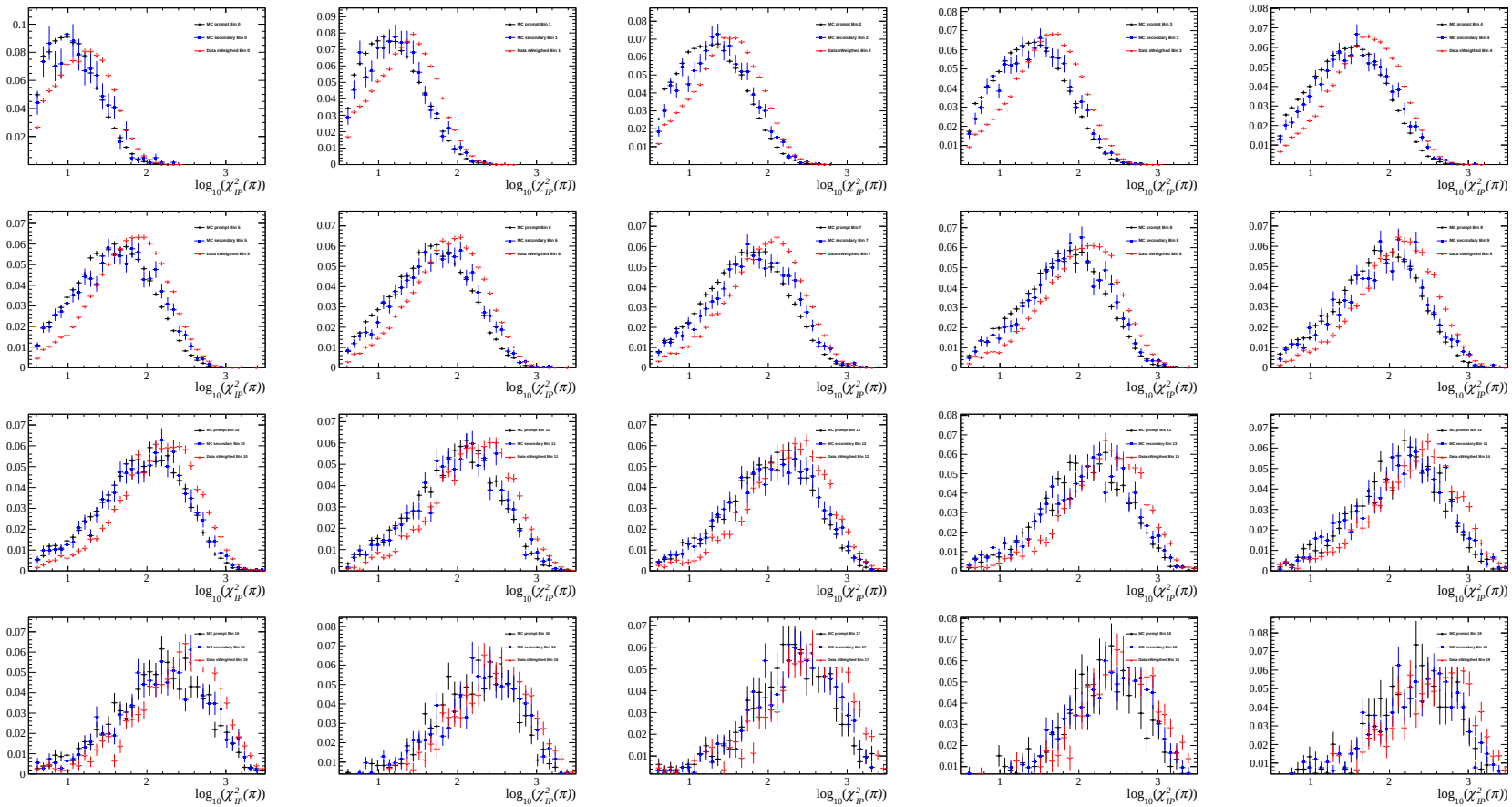
Comparison of p_{T} (π^+)



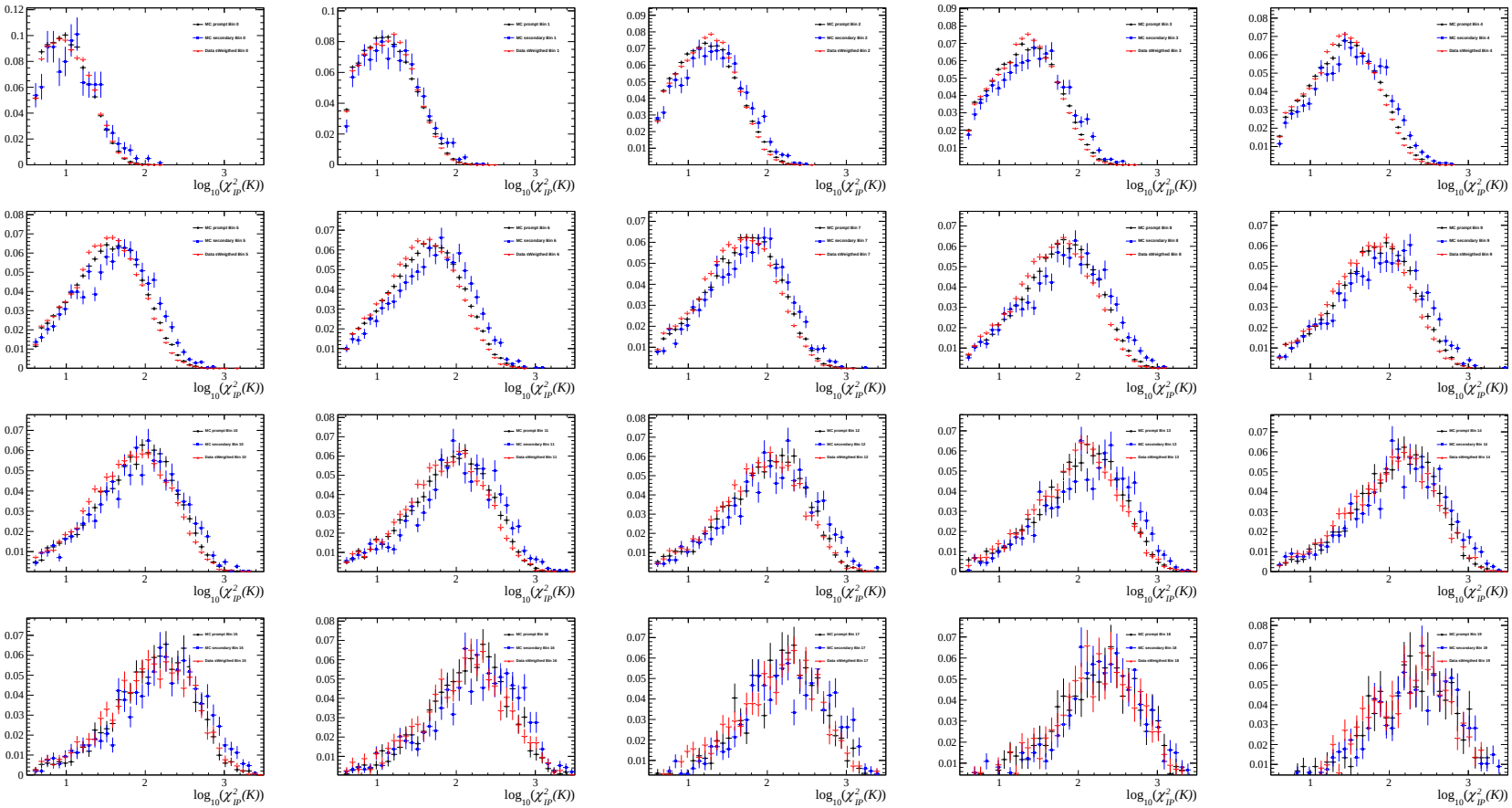
Comparison of p_{T} (K^-)



Comparison of $\log(\chi^2_{\text{IP}}(\pi^+))$

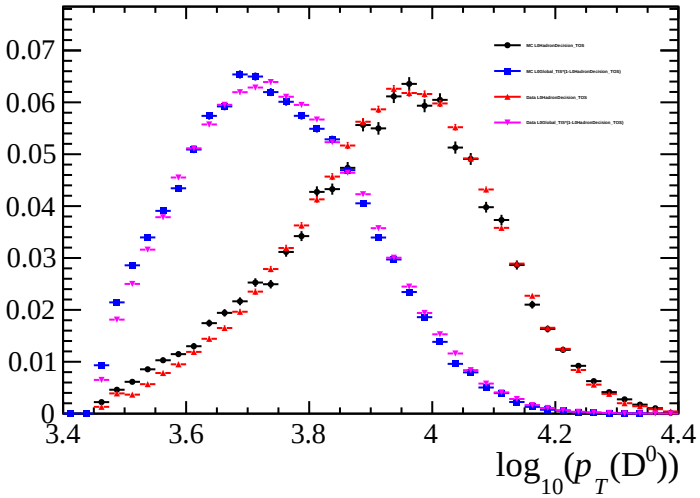


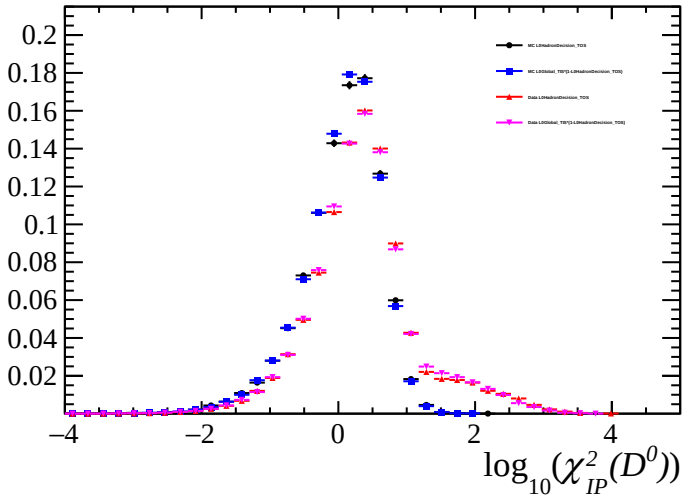
Comparison of $\log(\chi^2_{\mathrm{IP}}(K^-))$

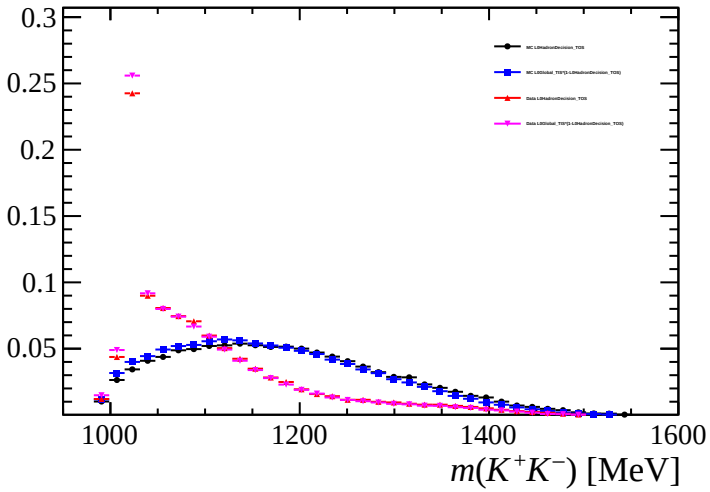


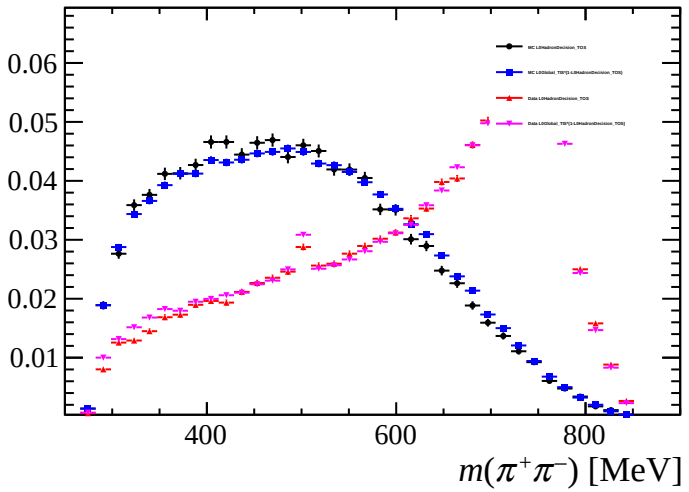
Comparison of samples with different L0 trigger

- `L0HadronDecision_TOS` v.s. `L0Global_TIS && !L0HadronDecision_TOS`
- D^0 p_{T} is quite different



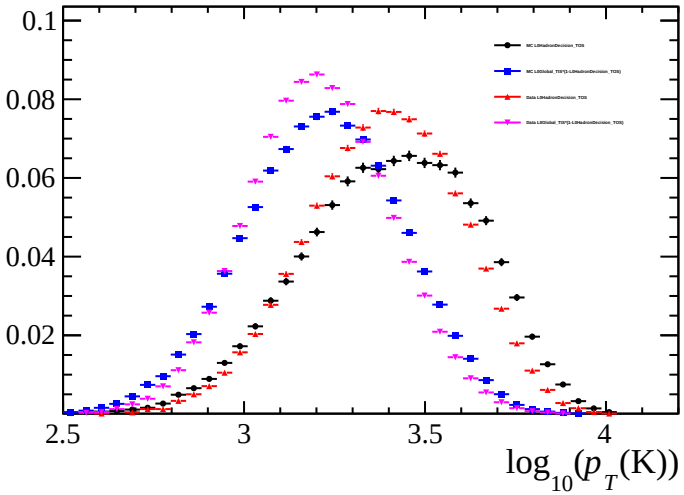


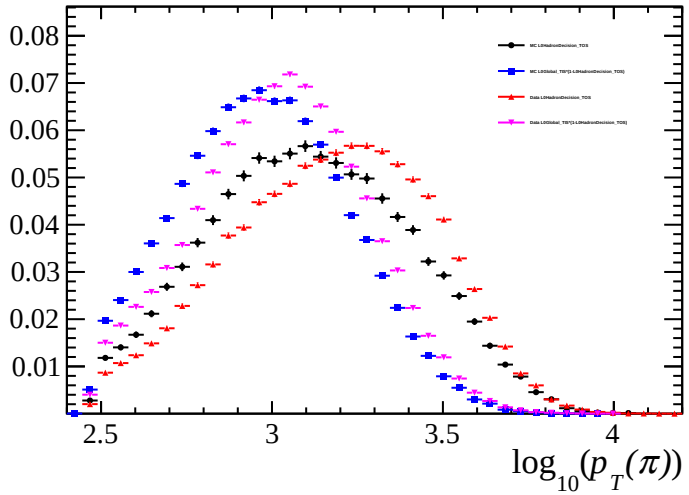


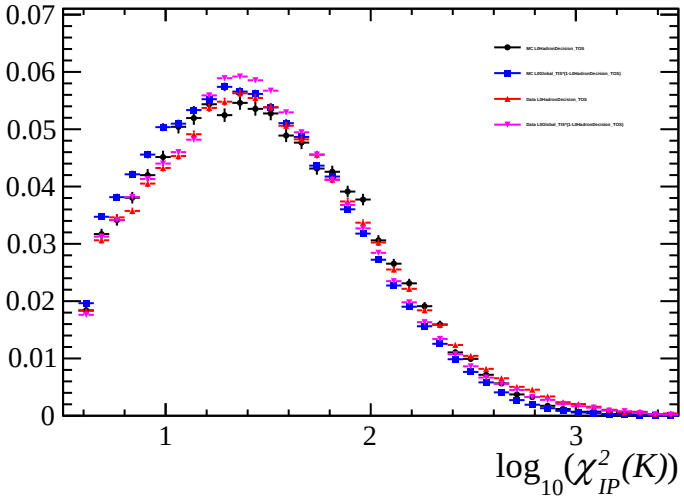


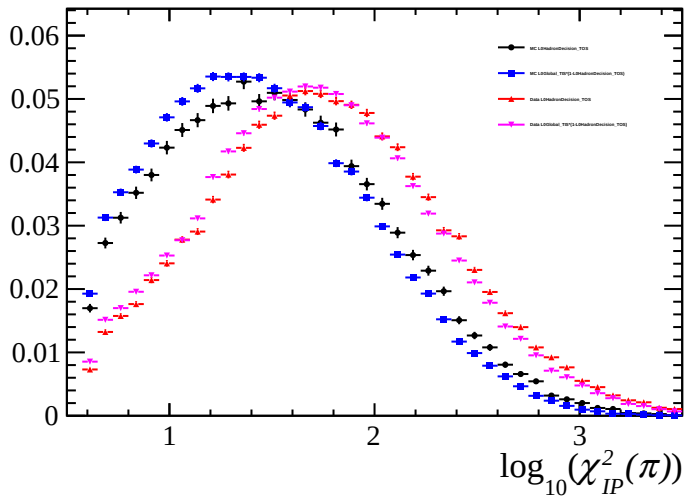
Comparison of samples with different L0 trigger (cont.)

- `L0HadronDecision_TOS` v.s. `L0Global_TIS && !L0HadronDecision_TOS`
- Daughters' p_{T} is quite different

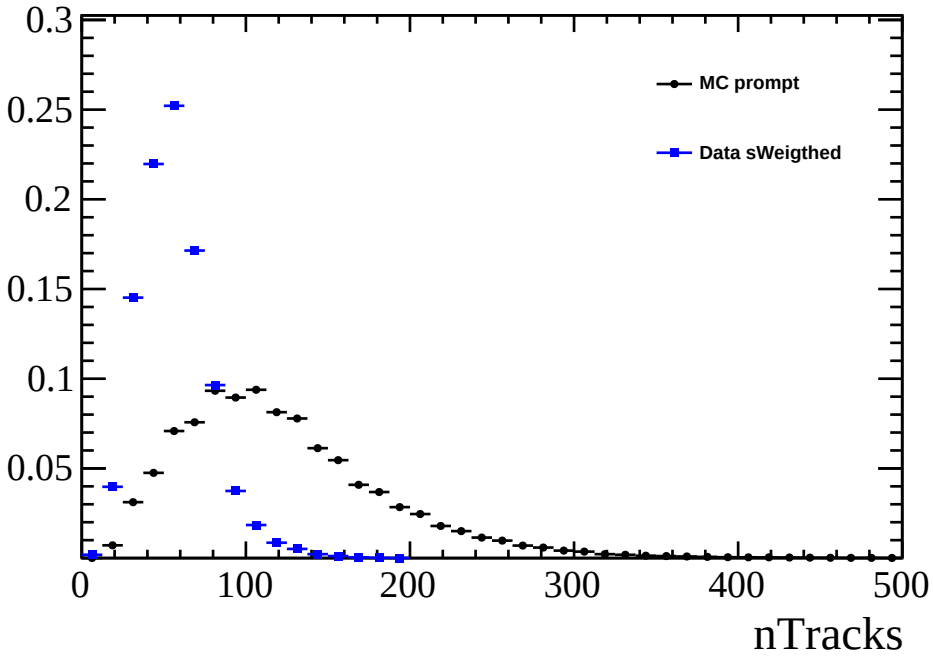








Comparison of nTracks

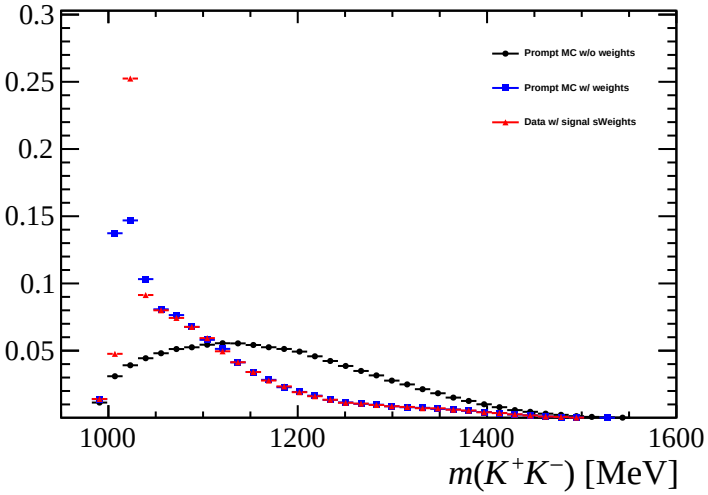


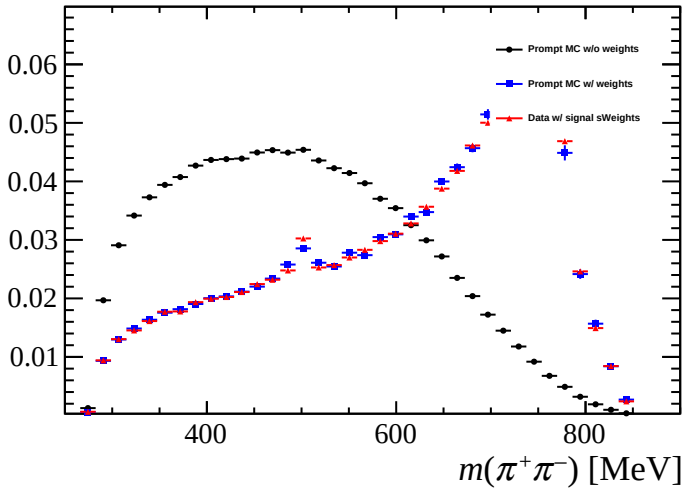
Corrections to MC by weighting

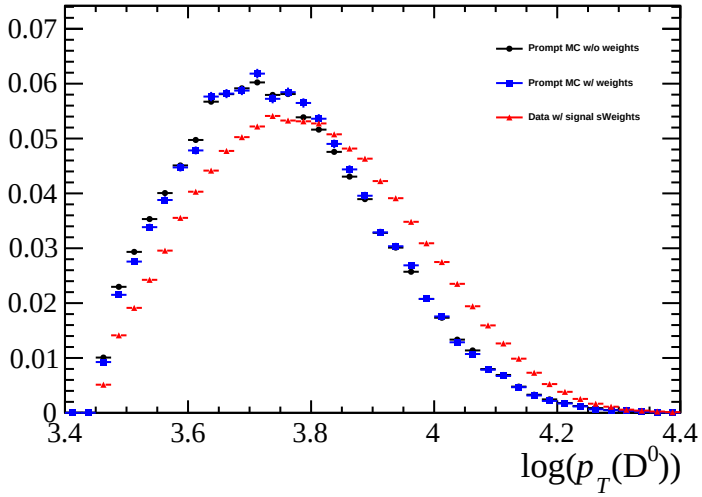
- Weights are calculated sequentially by comparing the decay-time-integrated MC prompt sample and sWeighted data
  - PID weights from PIDCalib
  - Based on PID weights, calculate $(m(K^+K^-), m(\pi^+\pi^-))$ weights
  - Based on PID and $(m(K^+K^-), m(\pi^+\pi^-))$ weights, calculate $p_{\mathrm{T}}(D^0)$ weights
- $\cos(\theta^{K^+K^-}_{K^+})$, $\cos(\theta^{\pi^+\pi^-}_{\pi^+})$, $\cos(\phi)$ not weighted due to weak dependence on decay time
- Here we assume the relevant distributions of the prompt and secondary components in data are the same

Comparison before and after corrections to MC

- Consider PID and $(m(K^+K^-), m(\pi^+\pi^-))$ weights

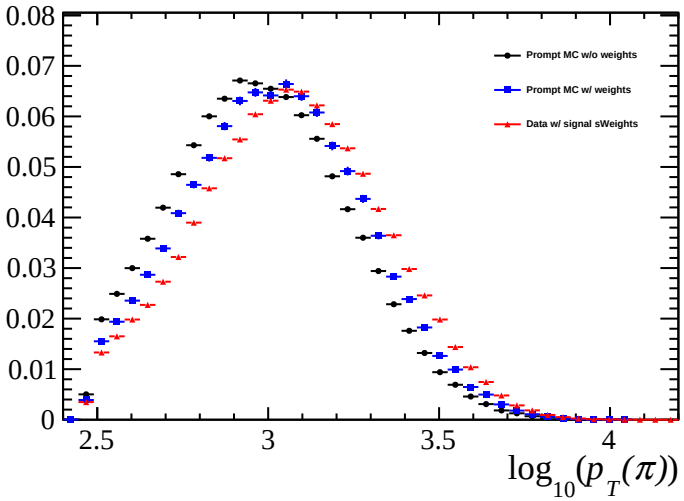


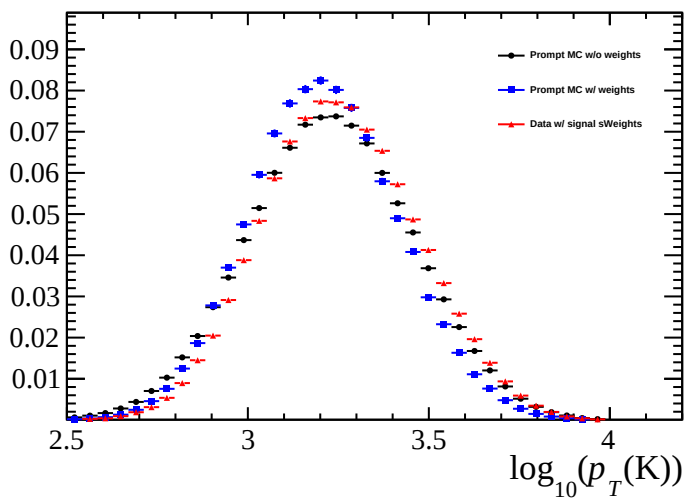


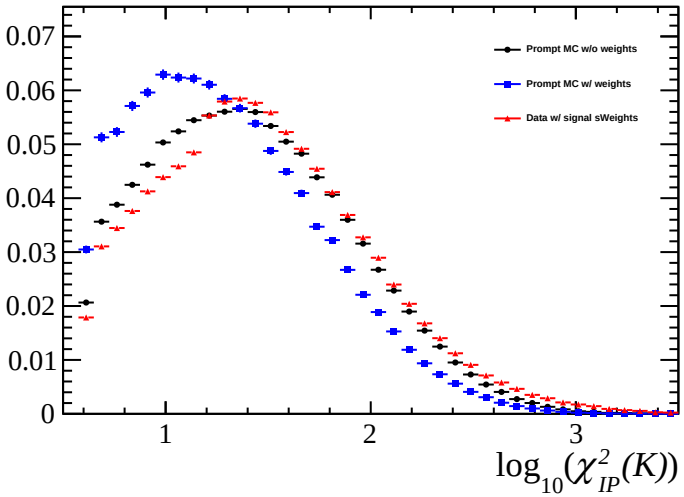


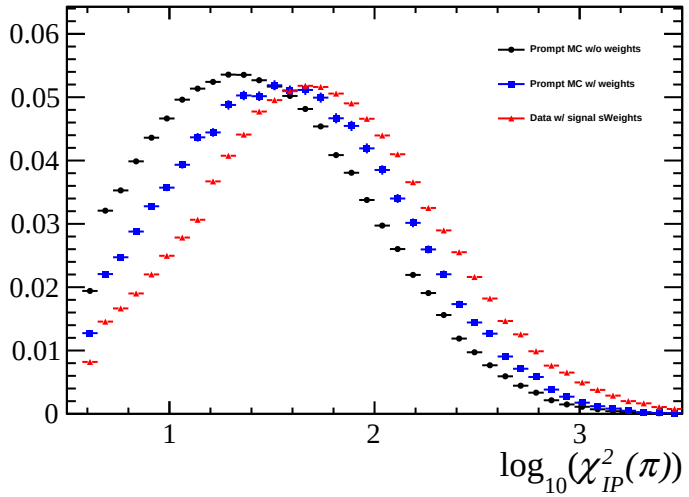
Comparison before and after corrections to MC (cont.)

- Consider PID and $(m(K^+K^-), m(\pi^+\pi^-))$ weights



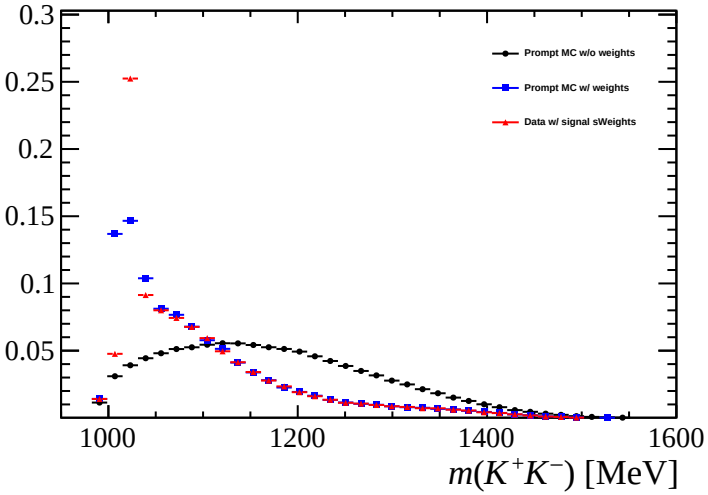


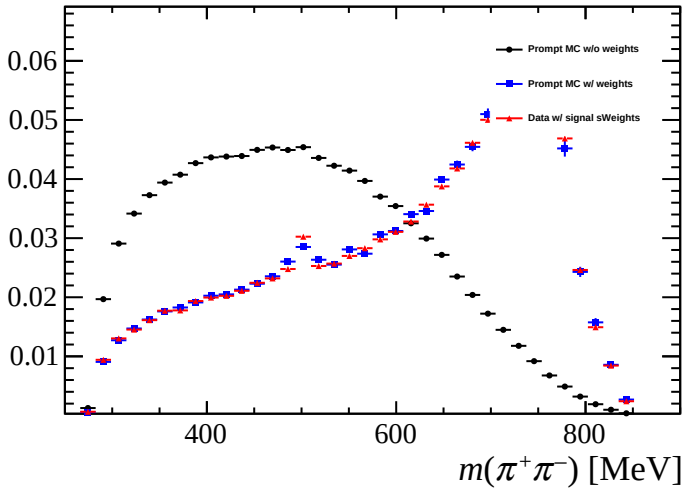


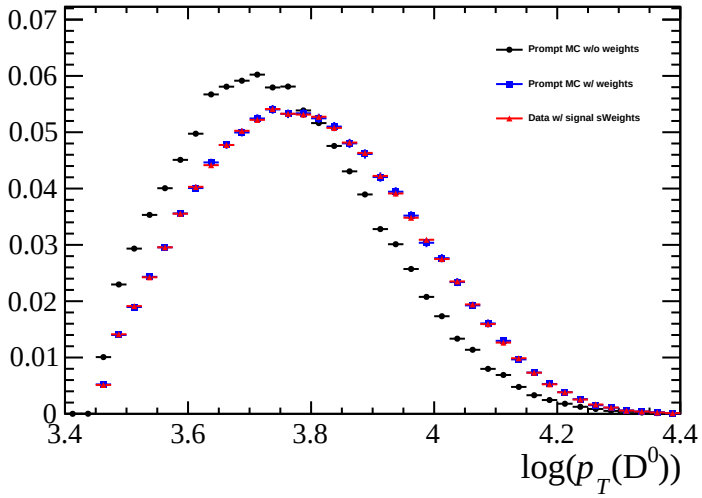


Comparison before and after corrections to MC

- Consider PID, $(m(K^+K^-), m(\pi^+\pi^-))$ and $p_{\mathrm{T}}(D^0)$ weights

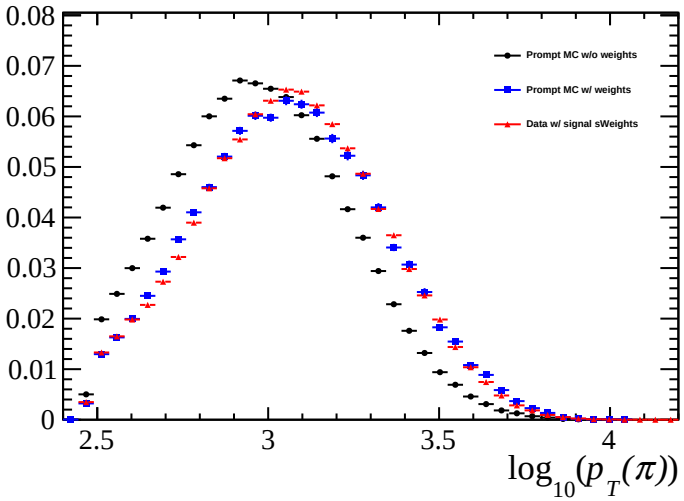


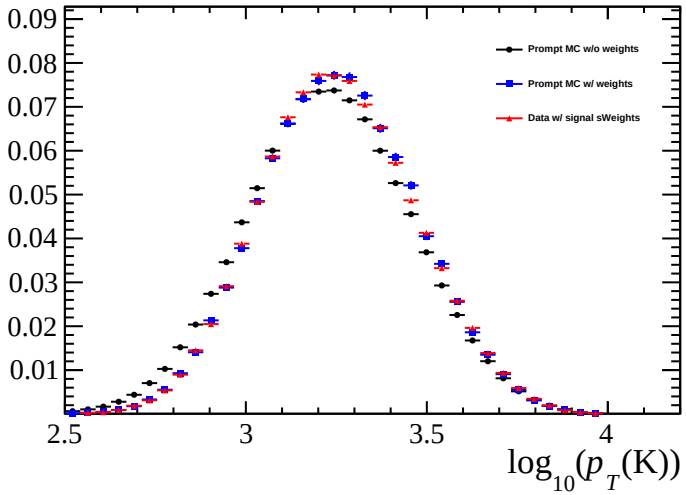


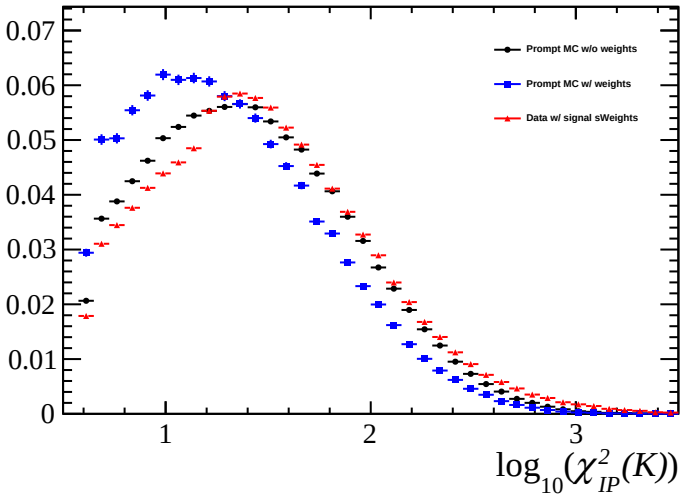


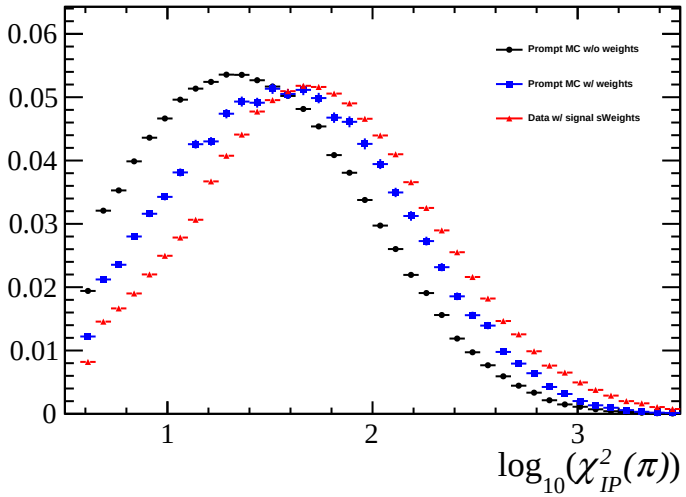
Comparison before and after corrections to MC (cont.)

- Consider PID, $(m(K^+K^-), m(\pi^+\pi^-))$ and $p_{\mathrm{T}}(D^0)$ weights



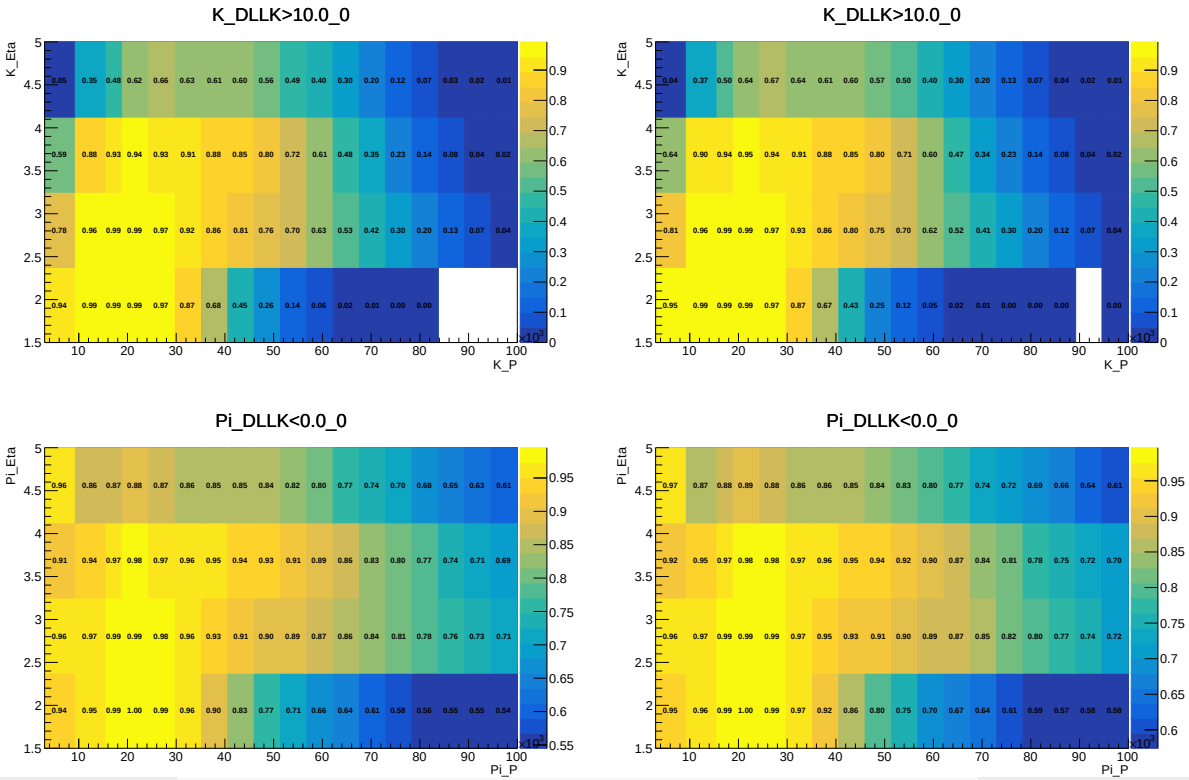






PID corrections with PIDCalib

- PID cuts applied: Kaon $DLL_{K\pi} > 10$ and Pion $DLL_{K\pi} < 0$
- Use PIDCalib to get the correct PID efficiency
- Use default binning scheme
  - $P[\mathrm{GeV}/c]$:
    `[ 3.0, 9.3, 15.6, 19.0, 24.4, 29.8, 35.2, 40.6, 46.0, 51.4 ]`
    `[ 51.4, 56.8, 62.2, 67.6, 73.0, 78.4, 83.8, 89.2, 94.6, 100.0 ]`
  - η: `[ 1.5, 2.375, 3.25, 4.125, 5.0 ]`
- Performance histograms: (left) Magdown and (right) MagUp



Reweighting with Boosted Decision Trees

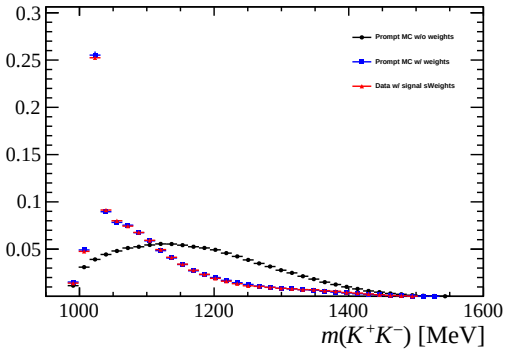
- Try to reweight MC with `GBReweighter` from the `hep_ml` package, a reweighter algorithm based on ensemble of regression trees
  - PID weights from PIDCalib
  - Based on PID weights, calculate

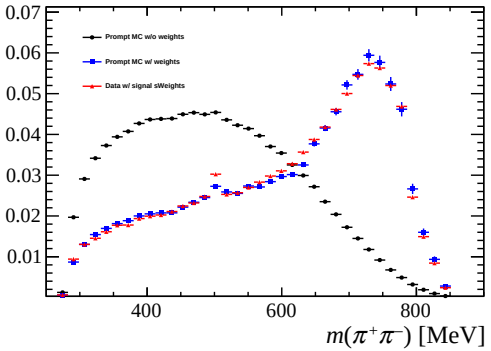
$$w(m(K^+K^-), m(\pi^+\pi^-), \cos(\theta_{K^+}^{K^+K^-}), \cos(\theta_{\pi^+}^{\pi^+\pi^-}), \cos(\phi))$$

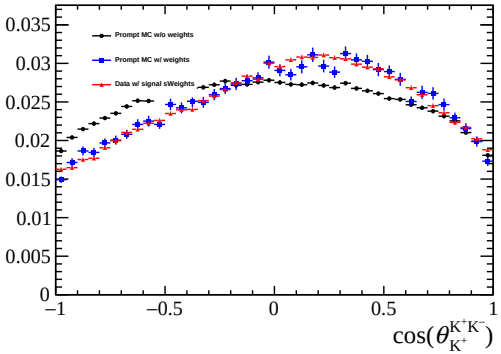
- Build unbiased predictions with folding algorithm
  - training data is splitted into n equal parts
  - train n reweighters, each one is trained using n-1 folds
  - predict each event with the reweighter that did not use it during training
- Here we assume the relevant distributions of the prompt and secondary components in data are the same, i.e. subtract the background in real data by fitting the mass spectrum

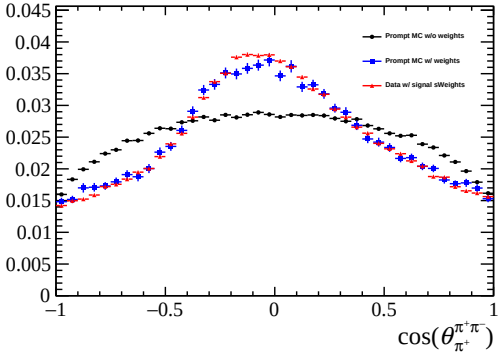
Comparison before and after corrections to MC

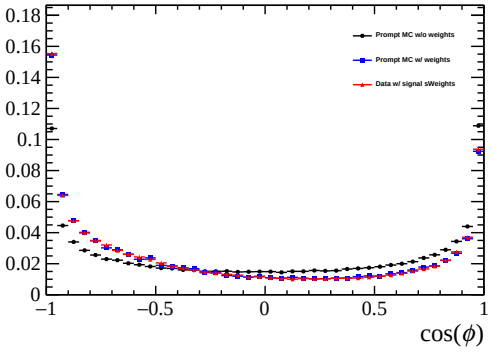
- Reweighting with `GBReweighter`





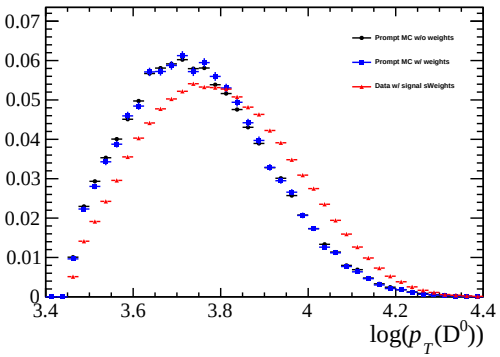


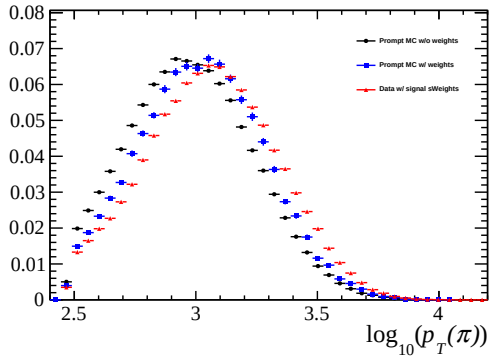


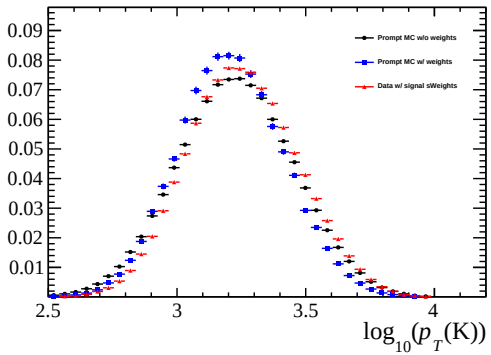


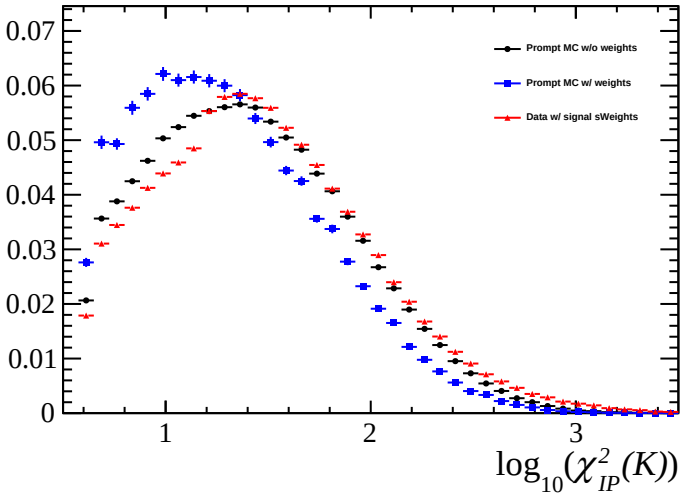
Comparison before and after corrections to MC (cont.)

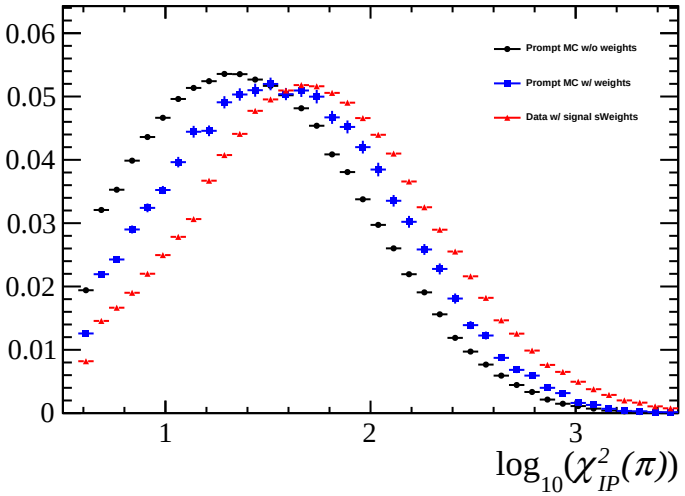
- Reweighting with `GBReweighter`



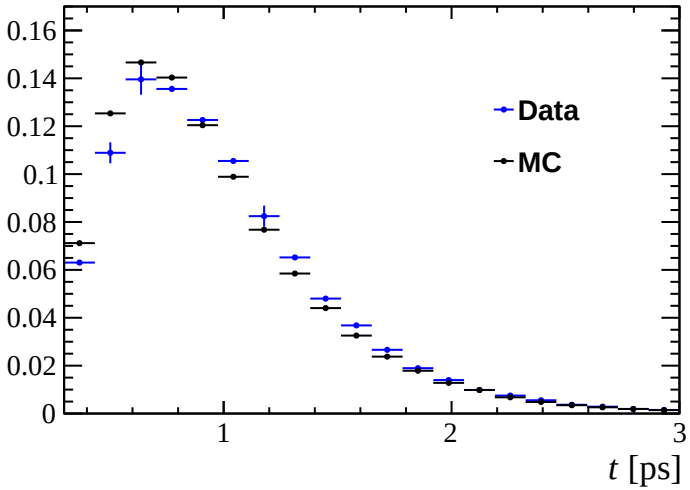




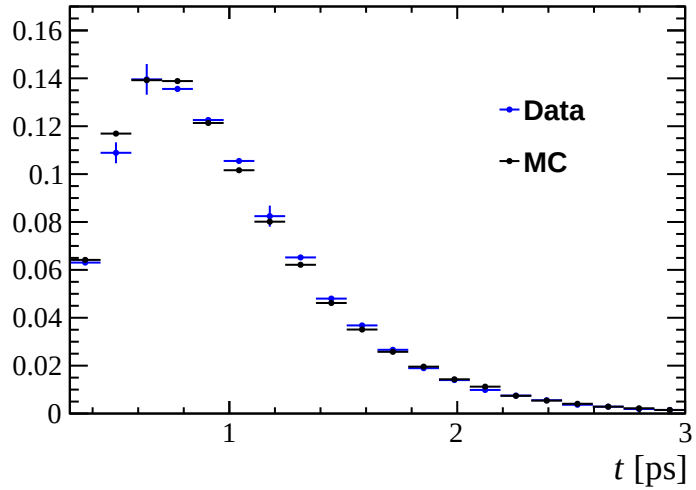




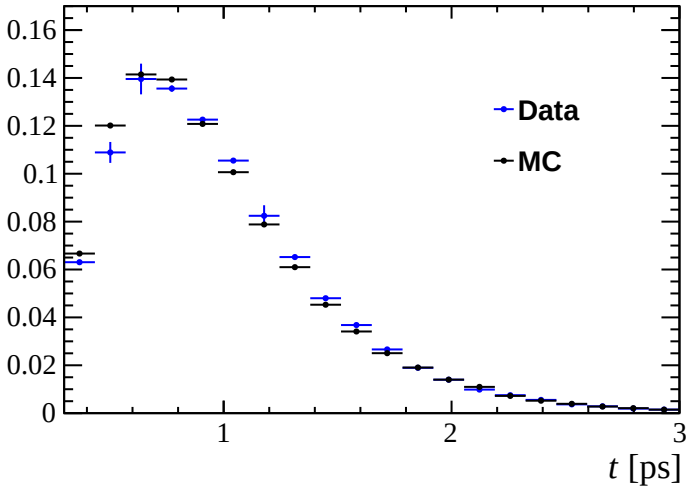
Decay time distribution with MC corrections



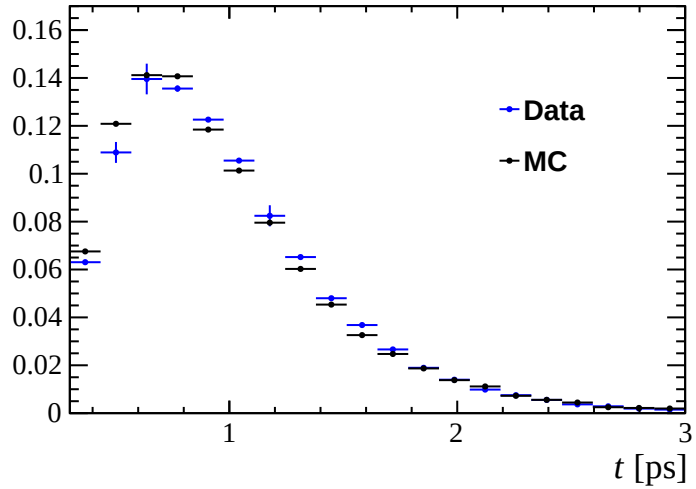
MC w/o corrections



MC w/ Dalitz weights



MC w/ PID and 2D-Dalitz weights



MC w/ PID and 5D-Dalitz weights

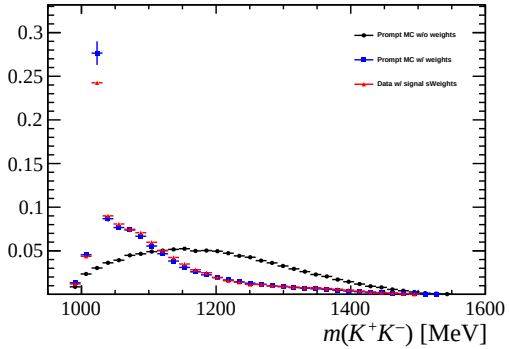
Efficiencies of L0 trigger requirements in MC

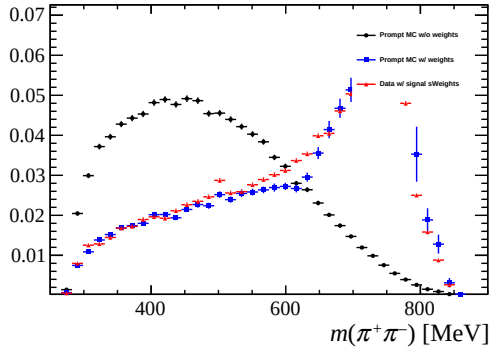
D^0	TOS [%]	TIS [%]
L0Global	14	39
L0HadronDecision	12	22
L0ElectronDecision	2	16
L0PhotonDecision	0	8
L0MuonDecision	1	6
L0DiMuonDecision	0	1

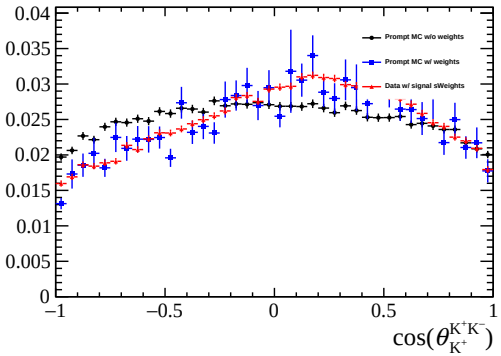
- Require L0HadronDecision TOS on D^0 in the following studies
- Fit the mass and IPCHI2 of the L0 TOSed data sample to estimate the prompt yield
- Apply PIDCalib and Dalitz weights to MC sample for comparison

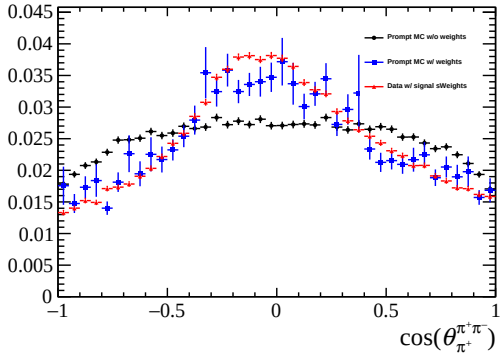
Comparison before and after corrections to MC

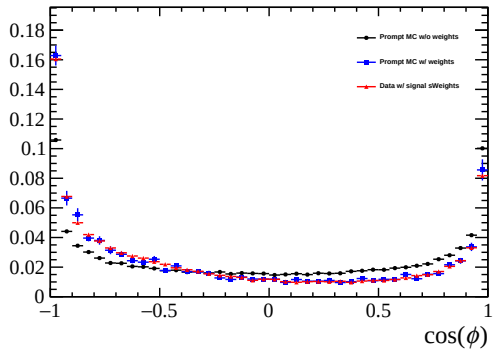
- Reweighting with `GBReweighter`





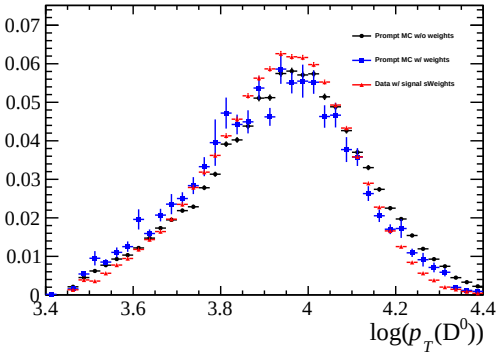


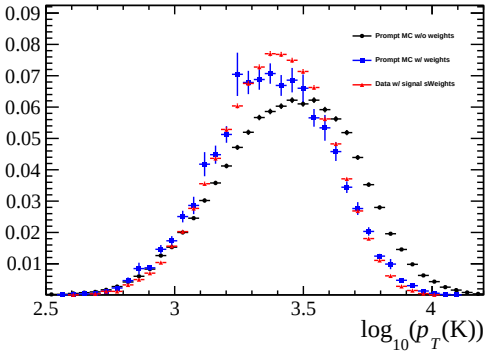


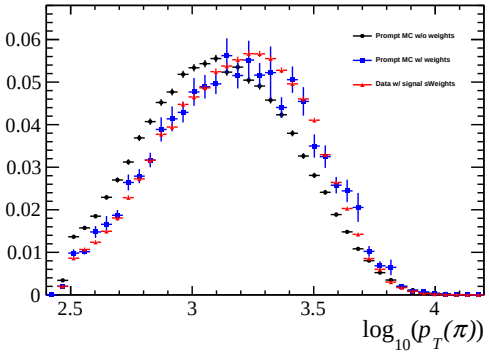


Comparison before and after corrections to MC (cont.)

- p_{T} agrees well

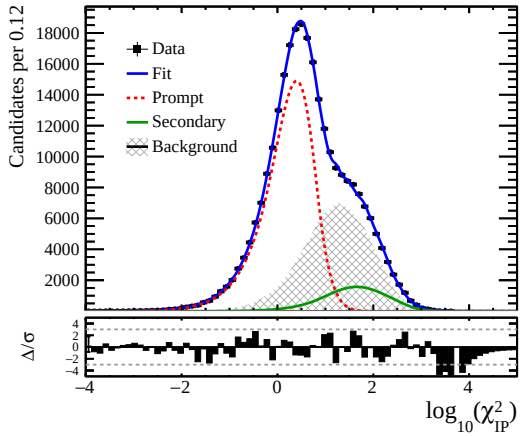


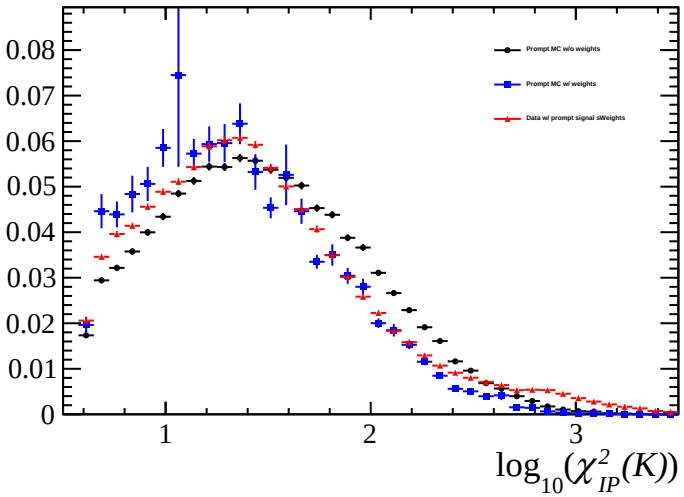


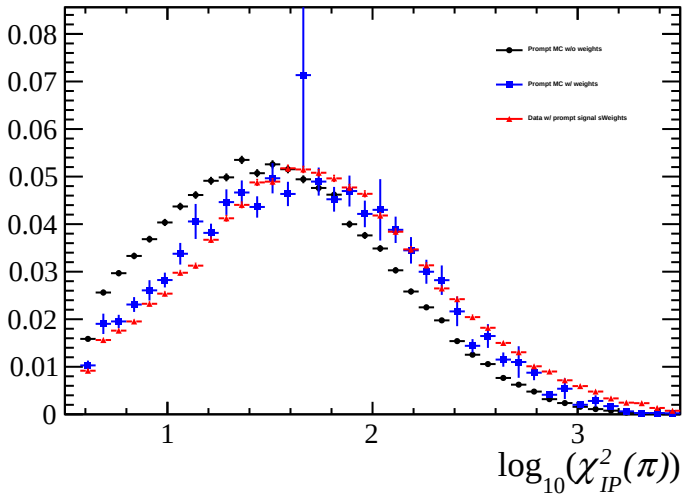


Comparison before and after corrections to MC (cont.)

- IPCHI2 still agrees well if we extract the prompt component in data and make an "Apple-to-Apple" comparison
- Note: the IPCHI2 of D^0 and its daughters are correlated







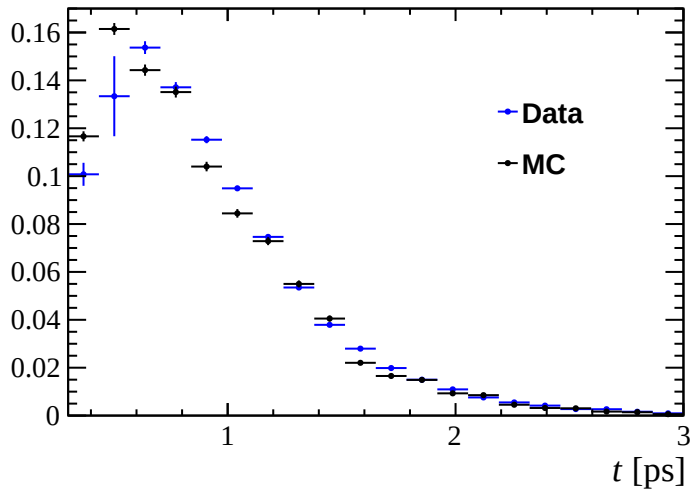
Decay time distribution and the bias

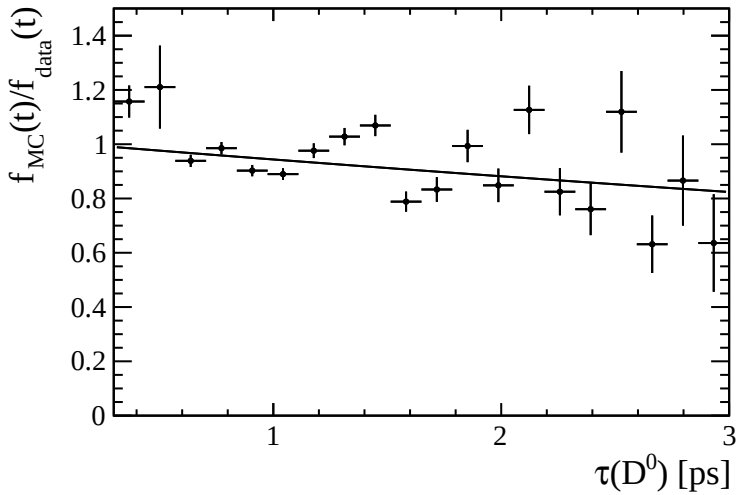
- Try to describe the difference in

$$N_{\mathrm{data}}(t) = \frac{N_0}{\tau} \times \exp\left(-\frac{t}{\tau}\right) \times A_{\mathrm{data}}(t),\ N_{\mathrm{MC}}(t) = \frac{N_0}{\tau} \times \exp\left(-\frac{t}{\tau}\right) \times A_{\mathrm{MC}}(t)$$

with

$$\frac{N_{\mathrm{MC}}(t)}{N_{\mathrm{data}}(t)} \propto \exp\left(\frac{1}{\tau} - \frac{1}{\tau + \Delta\tau_{\mathrm{eff}}}\right) \times t$$





MC w/ PID and Dalitz weights

$\Delta\tau_{\mathrm{eff}} = -11.1 \pm 3.4\,\mathrm{fs}$

The effect of L0 Hadron correction

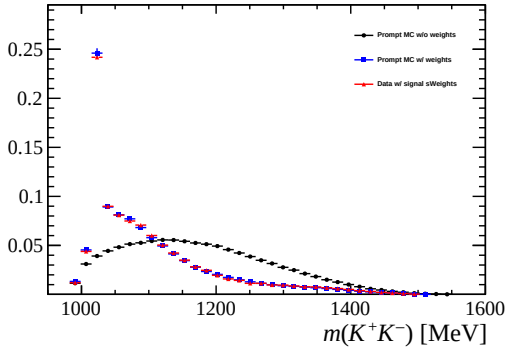
- Estimate the effect of $\varepsilon_{\mathrm{L0}}$ correction with 2012 efficiency tables provided by Calo objects group

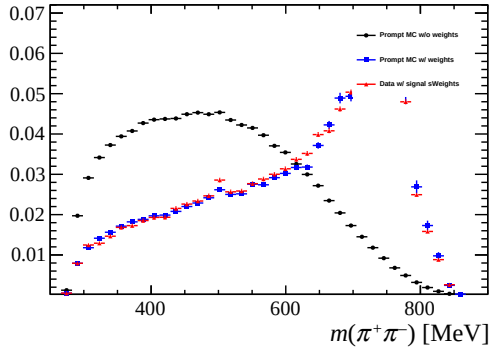
$$\varepsilon_{D^0} = 1 - (1 - \varepsilon_{K^-}) \cdot (1 - \varepsilon_{K^+}) \cdot (1 - \varepsilon_{\pi^-}) \cdot (1 - \varepsilon_{\pi^+})$$

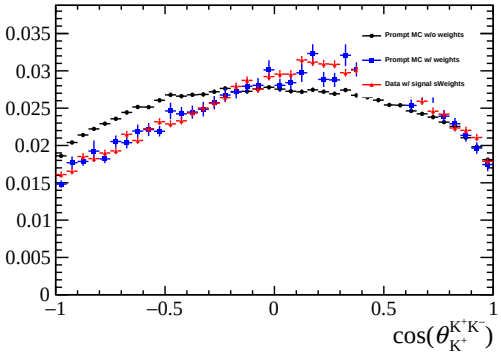
- Remove the `D0_L0_HadronDecision_TOS` requirement from the MC and weight the MC with ε_{D^0} defined above
- Dalitz weights are calculated based on the PID and L0 weights

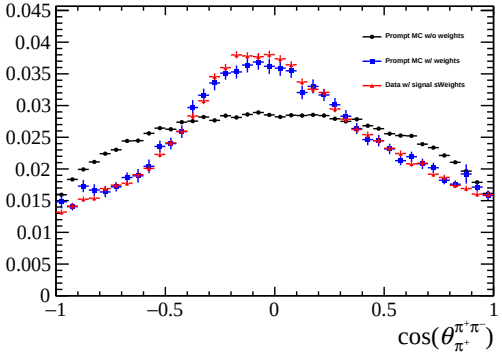
Comparison before and after corrections to MC

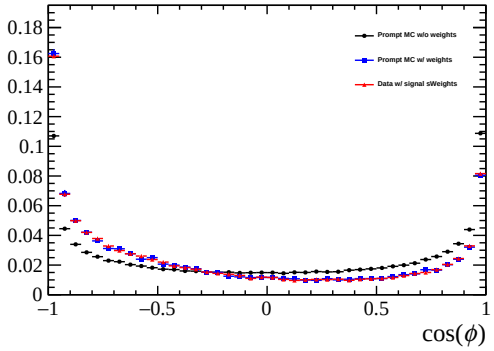
- Reweighting with `GBReweighter`





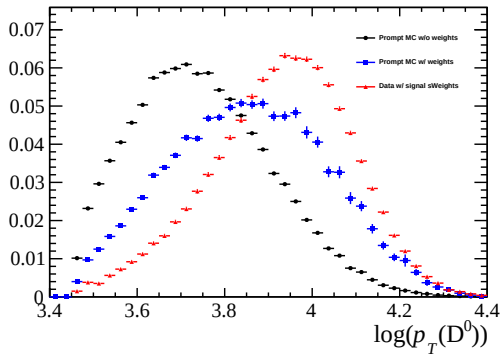


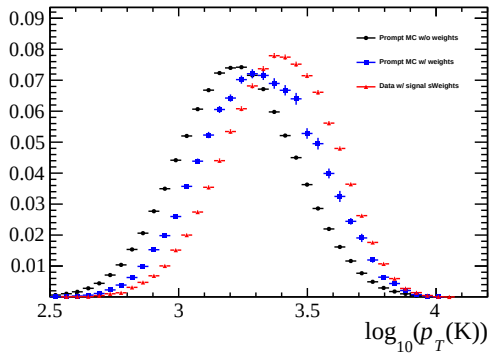


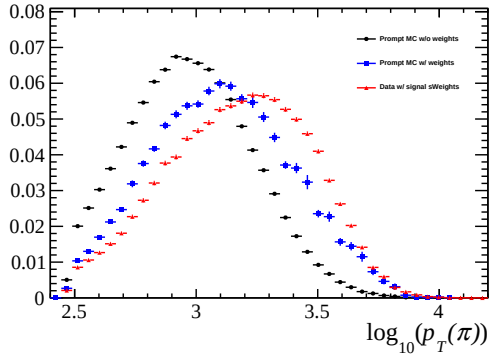


Comparison before and after corrections to MC (cont.)

- p_{T} do not agree well

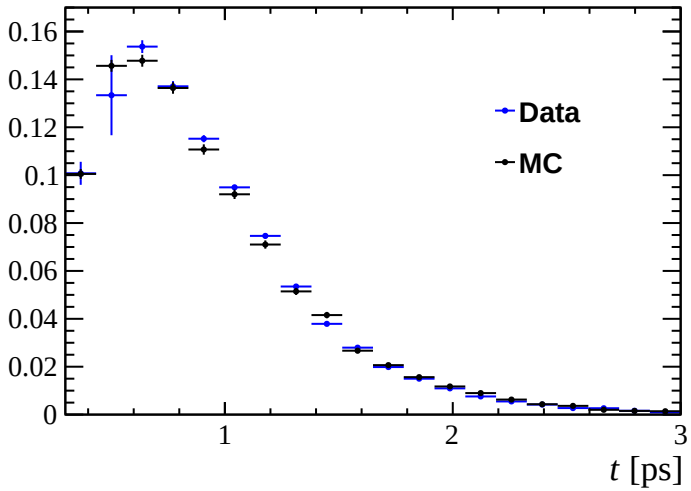




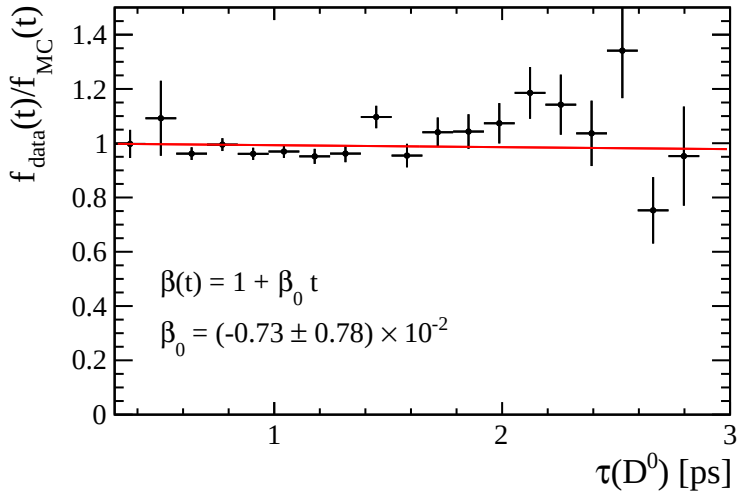


Decay time distribution with MC corrections

- Correct the efficiency of velo tracking by fitting the ratio of data to MC with $\beta(t) = 1 + \beta_0(t)$
- The residual disagreement seems to be described by this correction



MC w/ L0, PID and Dalitz weights



The ratio of data to MC

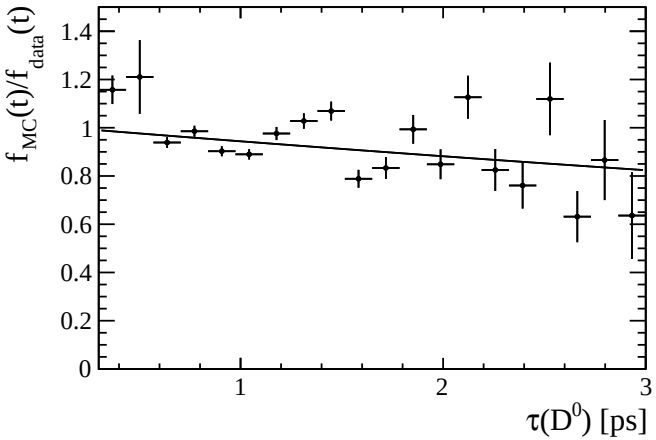
Decay time distribution and the bias

- Try to describe the difference in

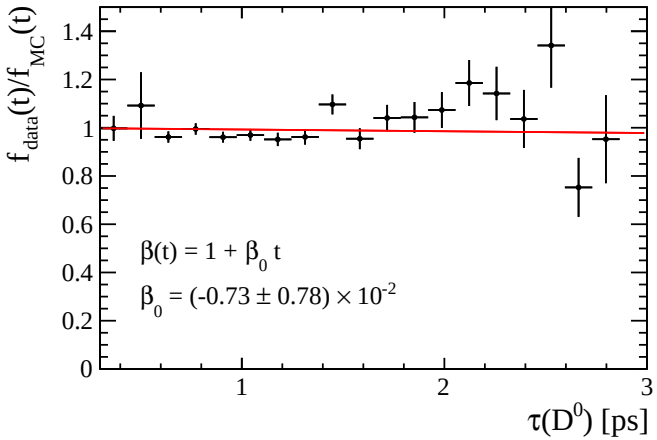
$$N_{\mathrm{data}}(t) = \frac{N_0}{\tau} \times \exp\left(-\frac{t}{\tau}\right) \times A_{\mathrm{data}}(t),\ N_{\mathrm{MC}}(t) = \frac{N_0}{\tau} \times \exp\left(-\frac{t}{\tau}\right) \times A_{\mathrm{MC}}(t)$$

with

$$\frac{N_{\mathrm{MC}}(t)}{N_{\mathrm{data}}(t)} \propto \exp\left(\frac{1}{\tau} - \frac{1}{\tau + \Delta\tau_{\mathrm{eff}}}\right) \times t$$



$\Delta\tau_{\mathrm{eff}} = -11.1 \pm 3.4\,\mathrm{fs}$



$\Delta\tau_{\mathrm{eff}} = 8.1 \pm 3.7\,\mathrm{fs}$

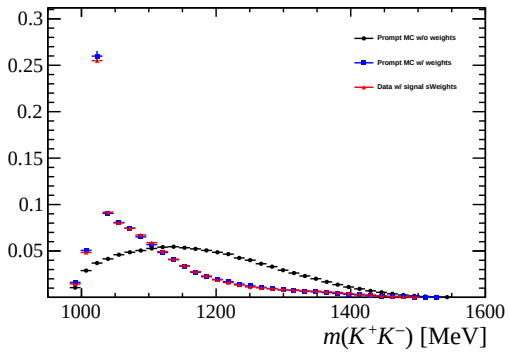
Efficiencies of L0 trigger requirements in MC

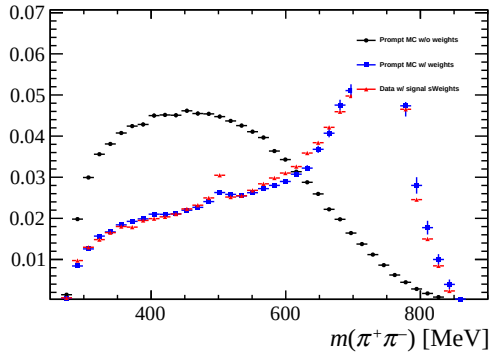
D^0	TOS [%]	TIS [%]
L0Global	14	39
L0HadronDecision	12	22
L0ElectronDecision	2	16
L0PhotonDecision	0	8
L0MuonDecision	1	6
L0DiMuonDecision	0	1

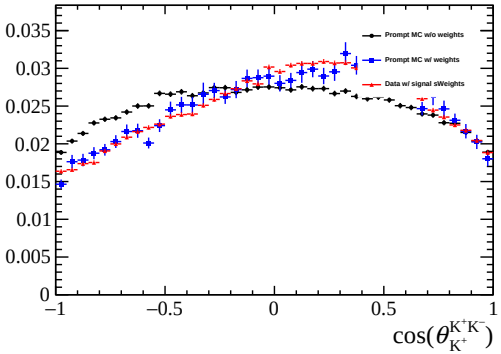
- Require L0Global_TIS on D^0 in the following studies
- Fit the mass and IPCHI2 of the TIS data sample to estimate the prompt yield
- Apply PIDCalib and Dalitz weights to MC sample as correction

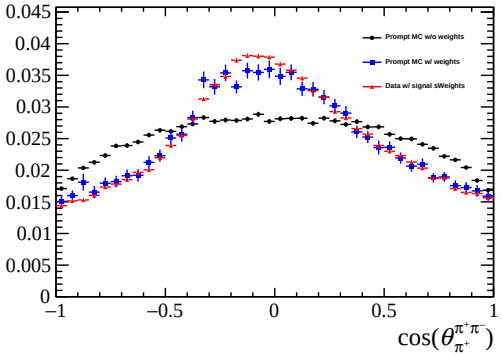
Comparison before and after corrections to MC

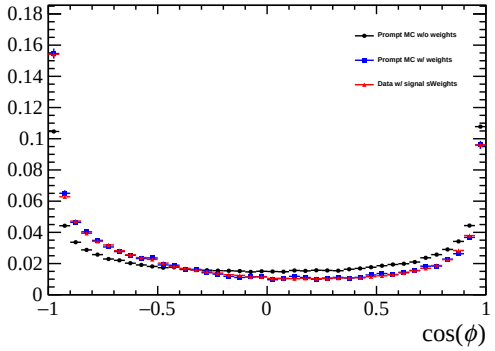
- Reweighting with `GBReweighter`





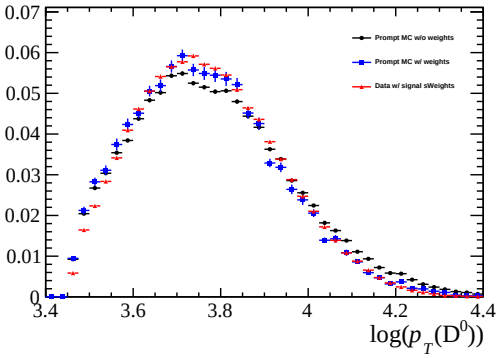


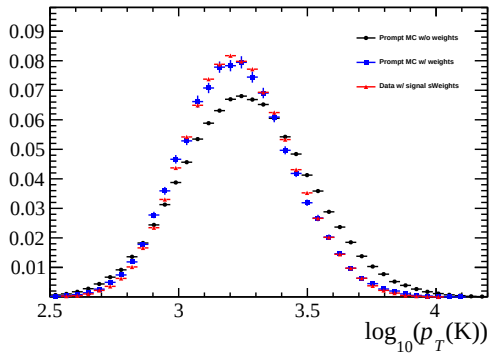


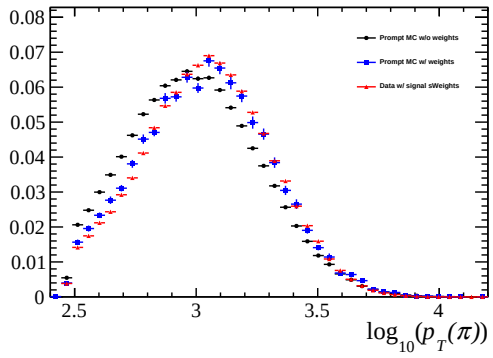


Comparison before and after corrections to MC (cont.)

- p_{T} agrees well

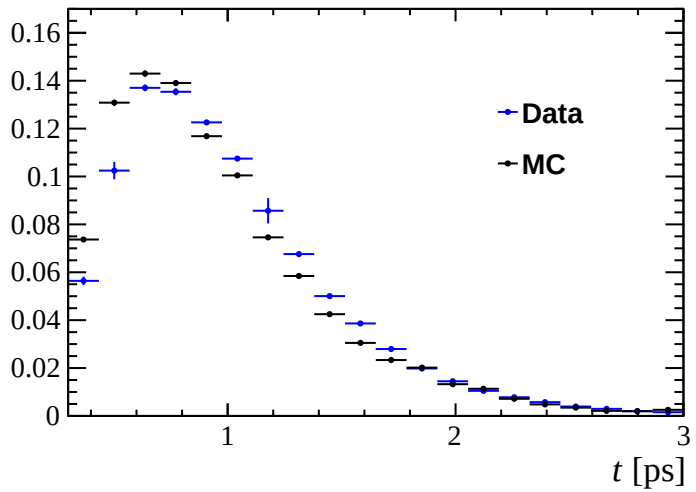




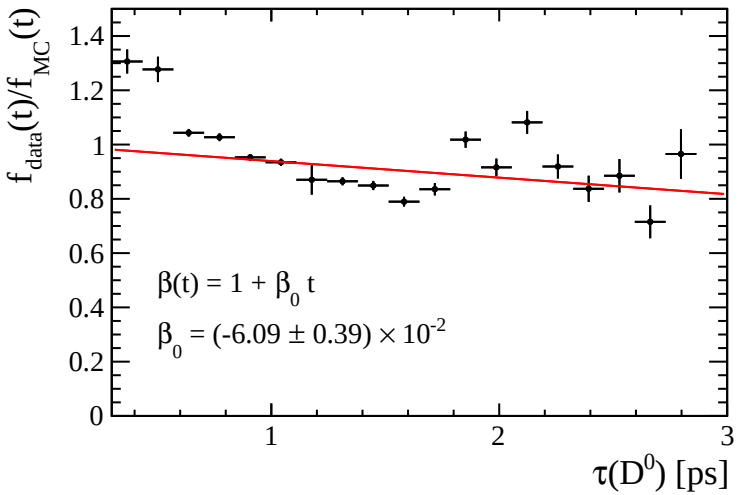


Decay time distribution and the bias

- The discrepency between data and MC is large
- There may exist other effects beyond the velo tracking correction



MC w/ PID and Dalitz weights



The ratio of data to MC

Section 2

Measure $\tau(\Xi_c^0)$ with $\Xi_c^0 \to pK^-K^-\pi^+$

Measure $\tau(\Xi_c^0)$ with $\Xi_c^0 \to pK^-K^-\pi^+$

- Validate the procedure of extracting the prompt yield and correcting the efficiency
- Extract the prompt yield (split the sample by L0)
  - Fit mass
  - Fit χ^2_{IP} in MC
  - Fit χ^2_{IP} in Data
- Correct the efficiency (split the sample by L0)
  - L0 Hadron TOS (for L0 TOS sample)
  - PID correction
    - Use PID variables in the BDT $\Rightarrow$ need to correct the PID distributions
    - nTracks problems in Run2
  - Describe the $\Xi_c^0 \to pK^-K^-\pi^+$ decay

New Ξ_c^0 MC sample

- Will be ready soon

FastSimulationT...	Sim/Run conditions	Proc. pass	Event type	Events requested	Events in BK	Progress (%)
ReDecay	Beam6500GeV-2016-MagDown-Nu1....	Sim09f-ReDecay01/Trig0x6138160F/...	26104880	10,000,000	8,406,790	84
ReDecay	Beam6500GeV-2016-MagUp-Nu1.6-...	Sim09f-ReDecay01/Trig0x6138160F/...	26104880	10,000,000	8,040,992	80

Discussion

- ProbNN variables are correlated with track displacement (e.g. MINIPCHI2).
  - Via tracking variables, such as ghost probability, track χ^2.
  - Causes problems if calibration sample has different lifetime than your signal.
- This becomes apparent for ProbNNp in Run2
  - Only available calibration sample: $\Lambda \to p\pi$, long lived
  - CombDLL seem not affected, ProbNNpi,K much less than ProbNNp
  - Disagreement is pronounced for high-P tracks, around ProbNNp>0.9
- Issue is possibly present in Run1 as well, but there we have IncLc.
  - No corresponding variables in PIDCalib samples to check.
- Possible fixes:
  - Use $\Lambda \to p\pi$, but cut MINIPCHI2$< X$ for calibation: loose stats, still biased
  - Use $\Lambda \to p\pi$, but reweigh tracking distributions?
  - Use $\Lambda_b \to \Lambda_c\pi$, but low stats
  - Use SL $\Lambda_c\mu$, but $P_T > 1$ GeV cut on proton (can be relaxed)?
  - Resurrect IncLc sample?

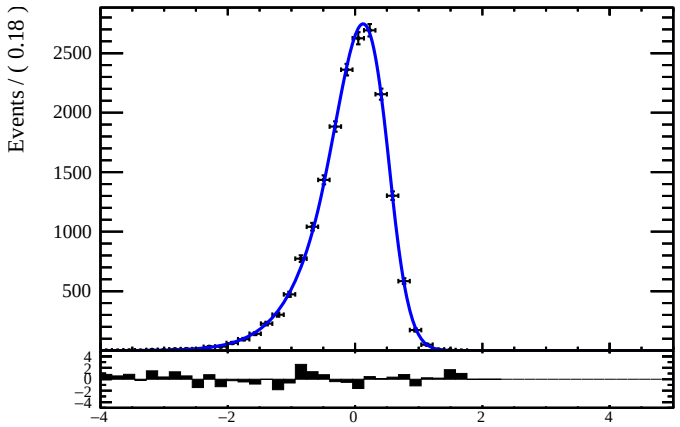
Backup

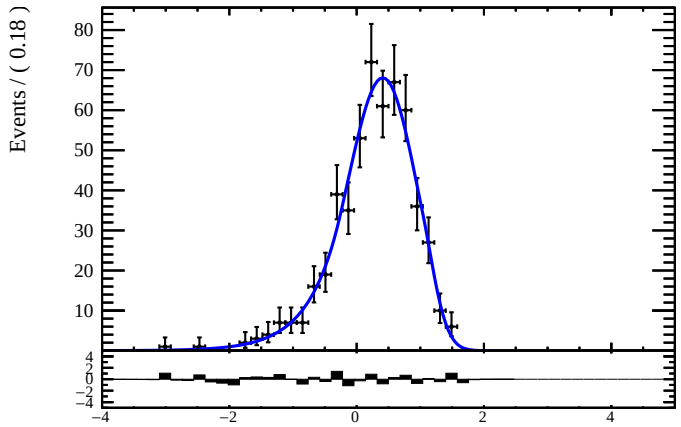
Hlt2CharmHadDstp2D0Pip_D02KmKpPimPipTurbo

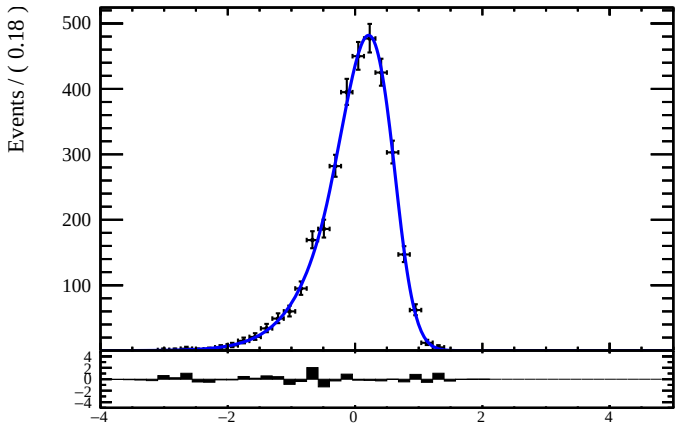
DaughtersCuts	TRCHI2DOF < 3.0 PT > 250.0 P > 1000.0 MIPCHI2DV(PRIMARY) > 3.0
K	PIDK > 5
π	PIDK < 5
CombinationCuts	(APT1+APT2+APT3+APT4) > 1800.0 AP > 25000.0 ADOCA(i,4) < 100.0, i=1,2,3 ACHI2DOCA(i,4) < 10.0, i=1,2,3
MotherCuts	CHI2VXNDOF < 12.0 PT > 2000.0 P > 30000.0 BPVDIRA > cos(0.02) BPVLTIME() > 0.0001 BPVVDCHI2 > 25

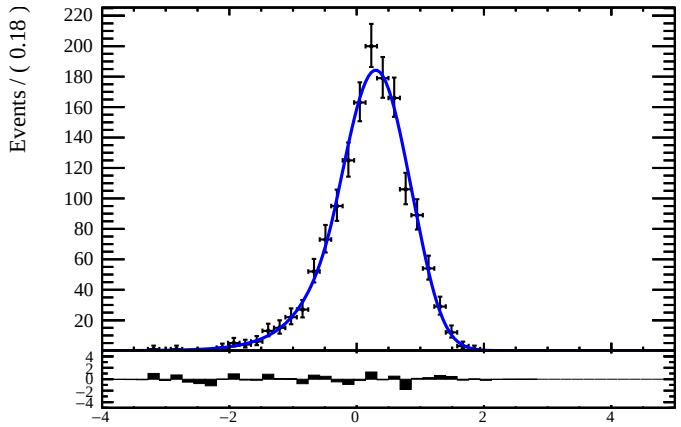
Fit with all parameters free: bin 0

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



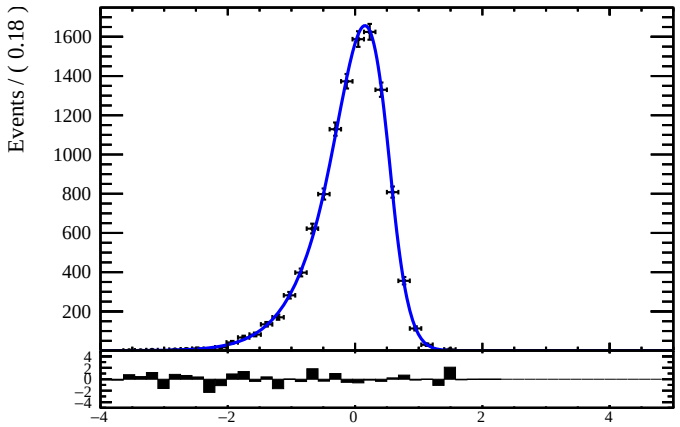


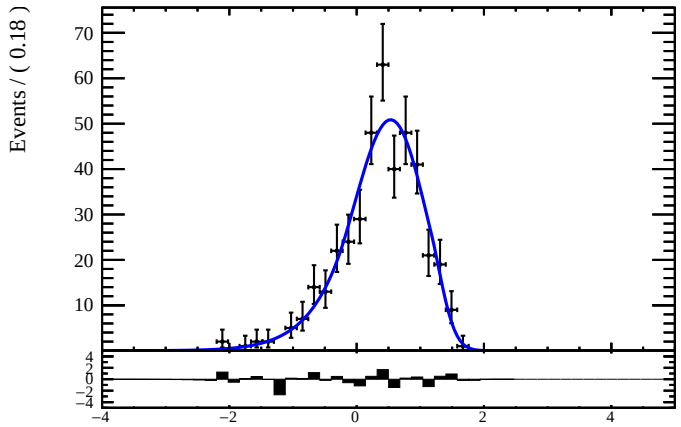


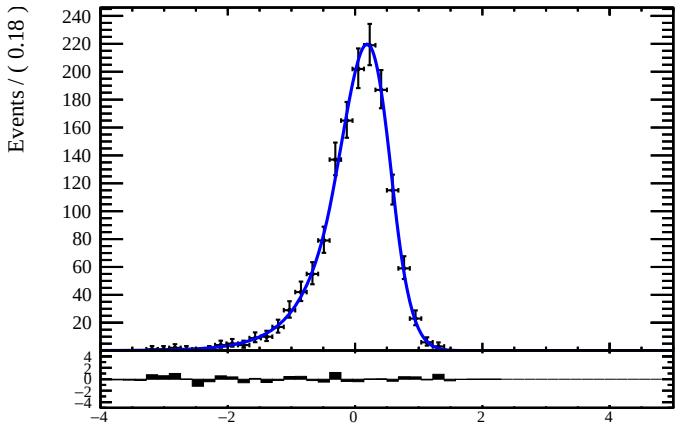


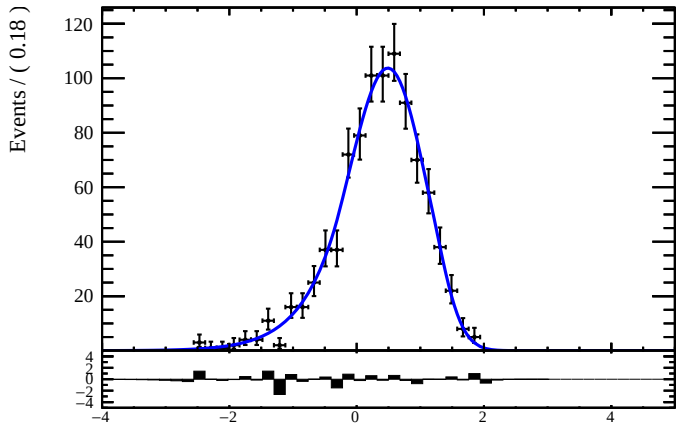
Fit with all parameters free: bin 1

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



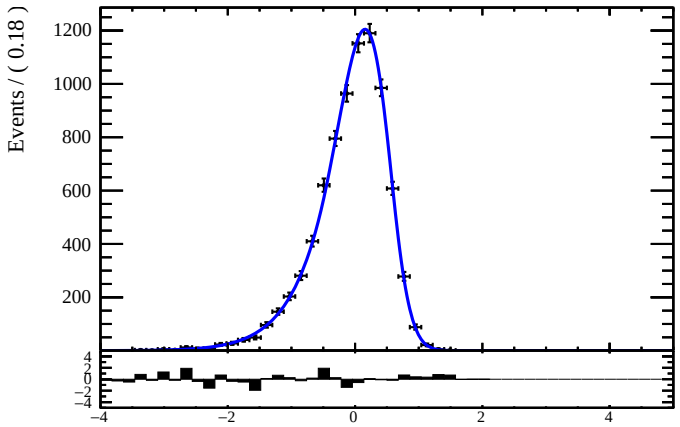


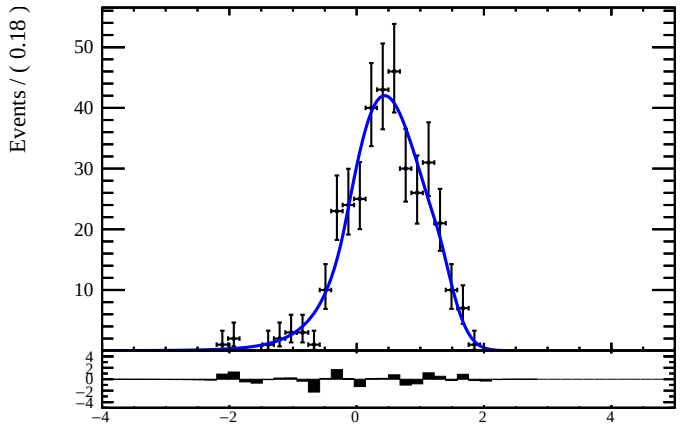


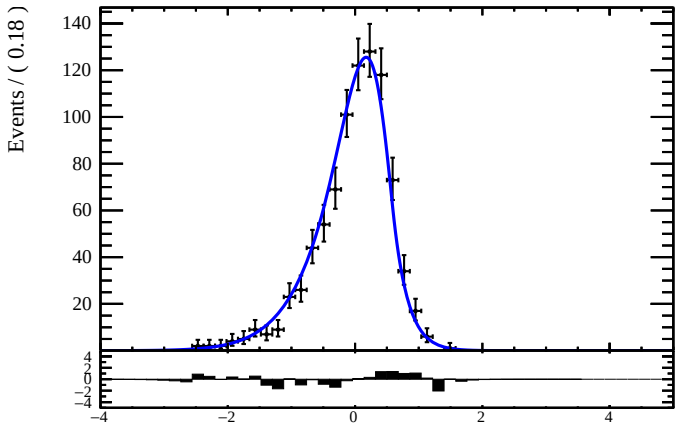


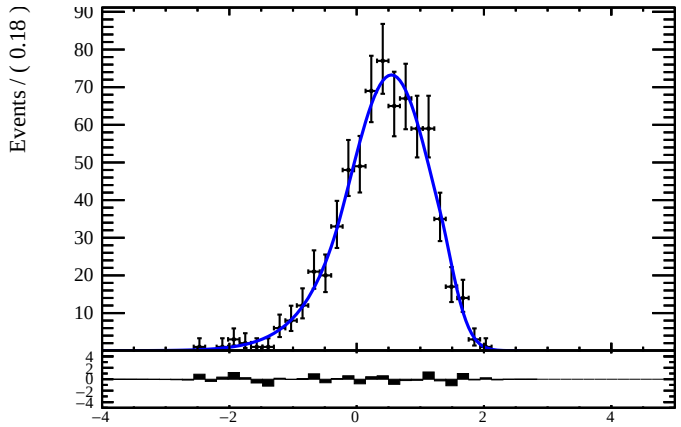
Fit with all parameters free: bin 2

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



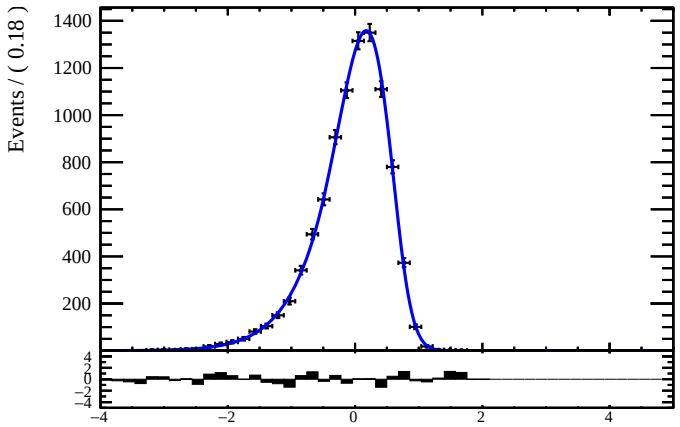


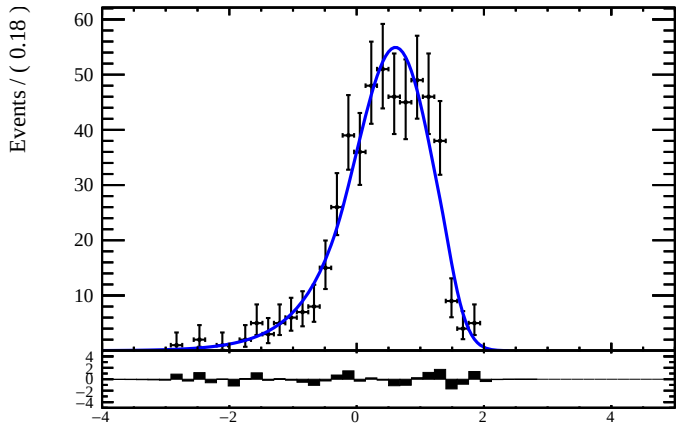


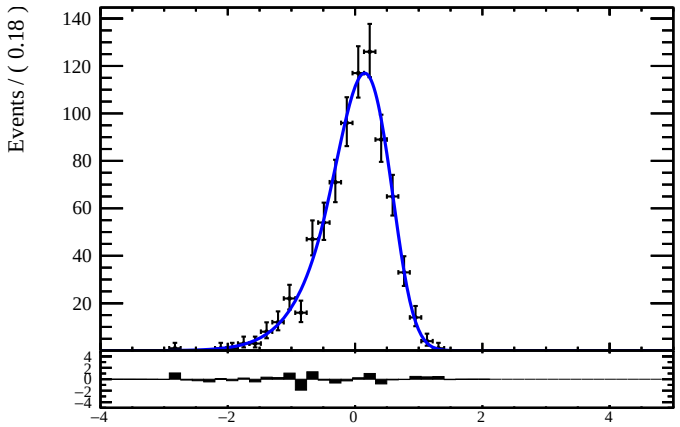


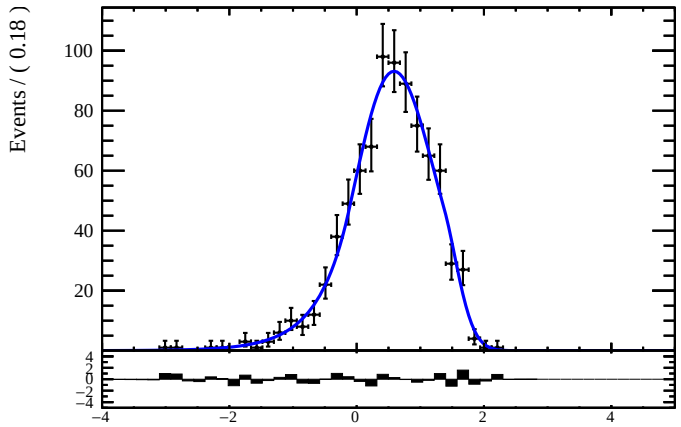
Fit with all parameters free: bin 3

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



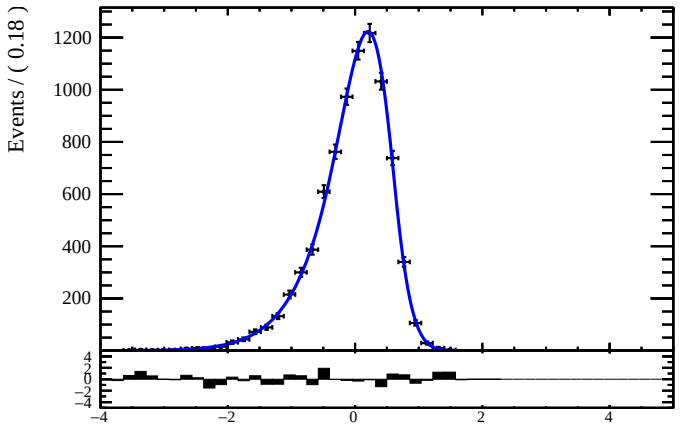


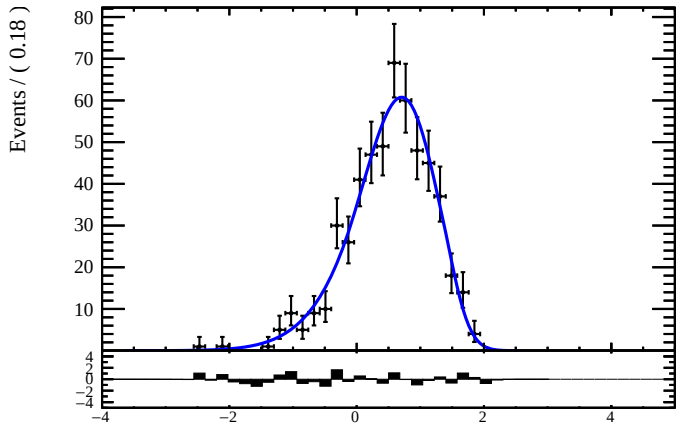


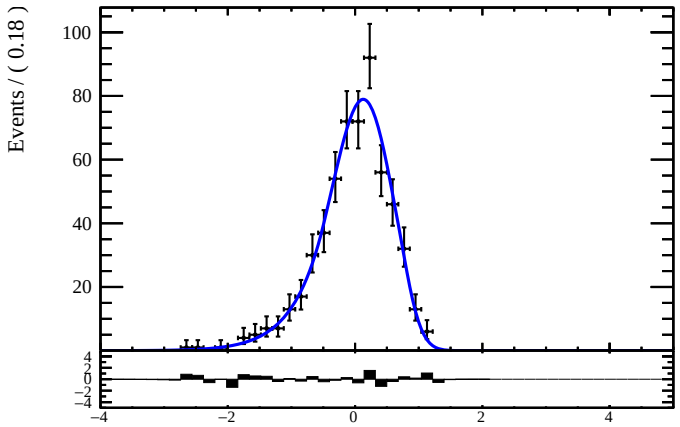


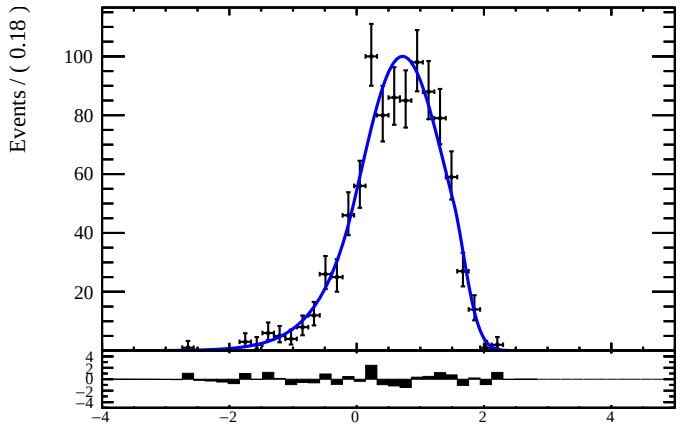
Fit with all parameters free: bin 4

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



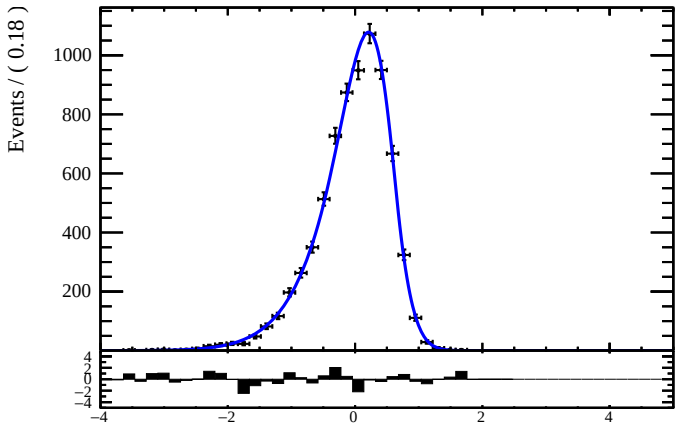


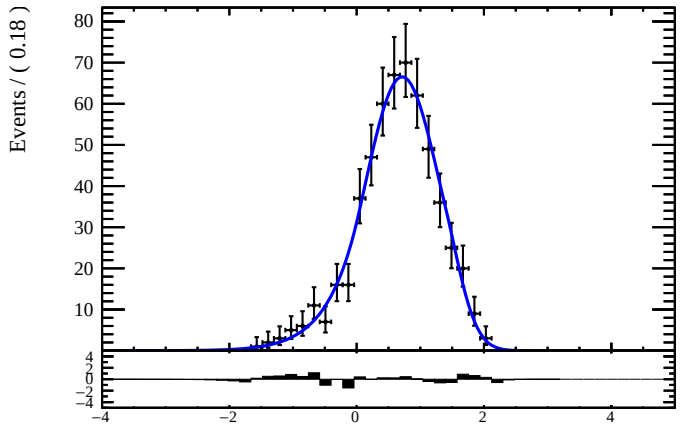


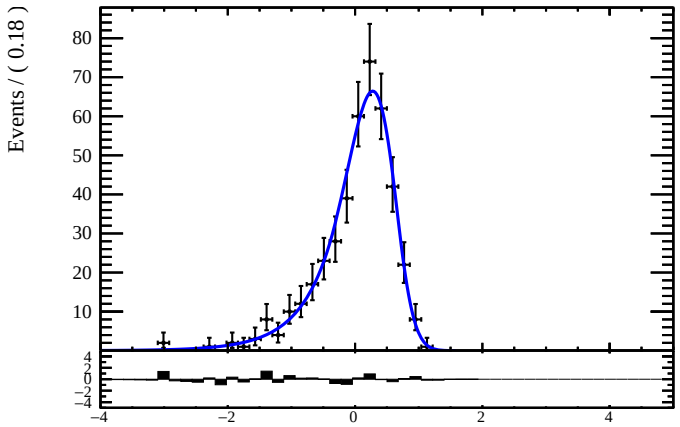


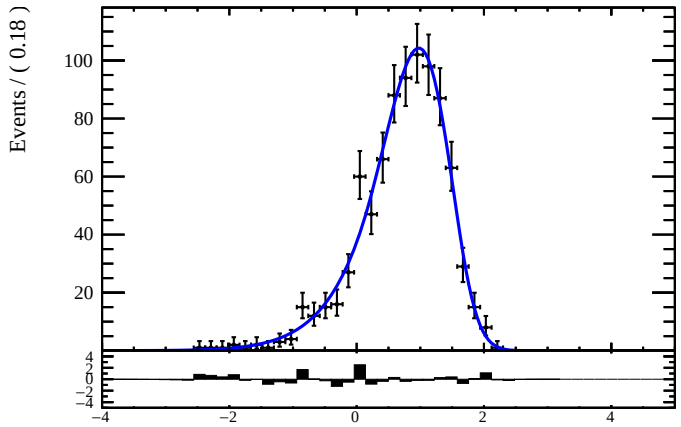
Fit with all parameters free: bin 5

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



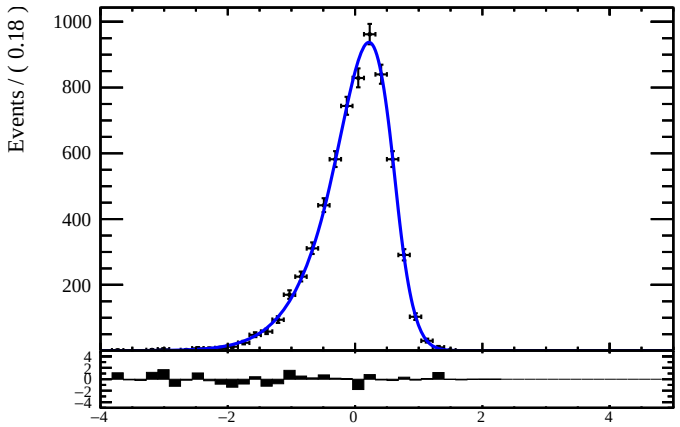


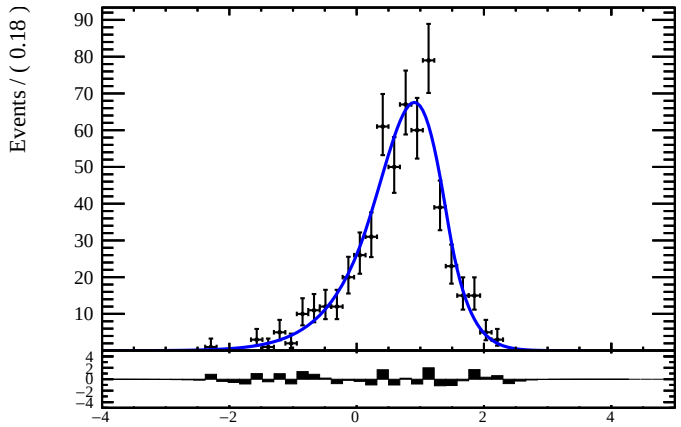


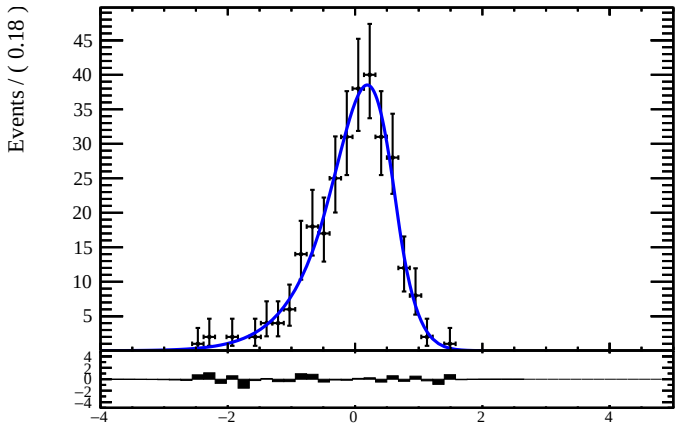


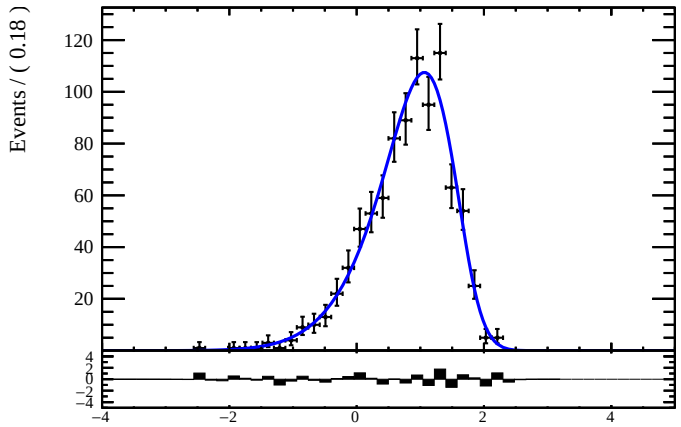
Fit with all parameters free: bin 6

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



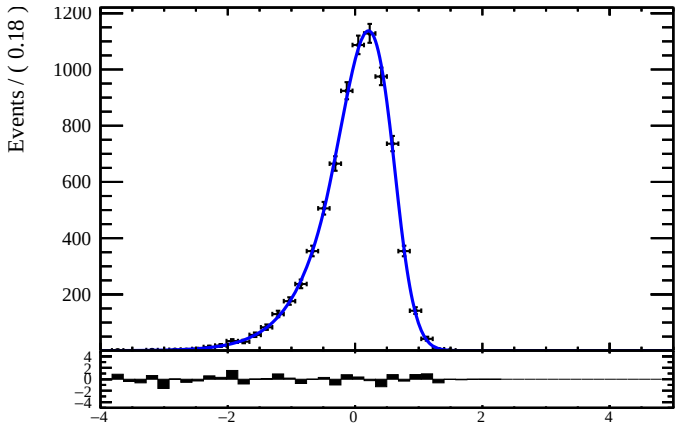


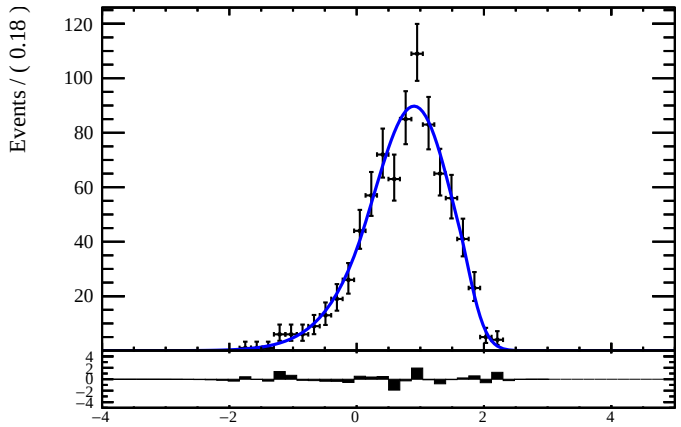


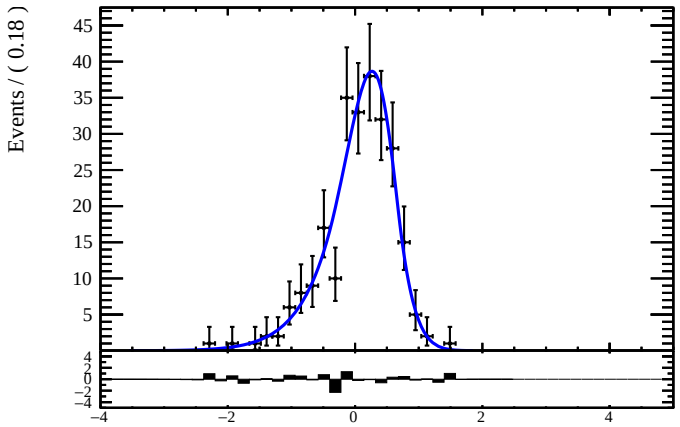


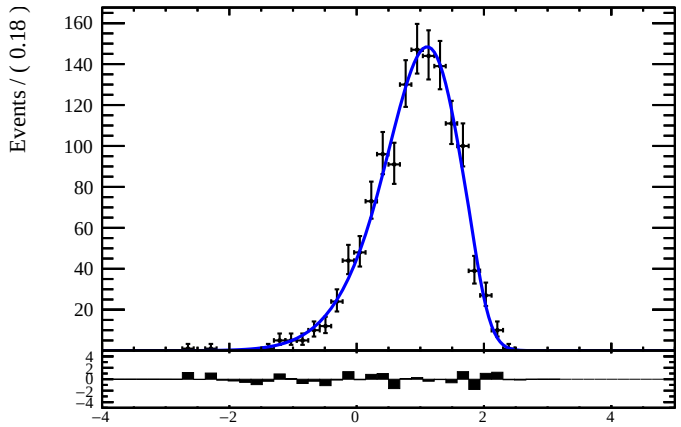
Fit with all parameters free: bin 7

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



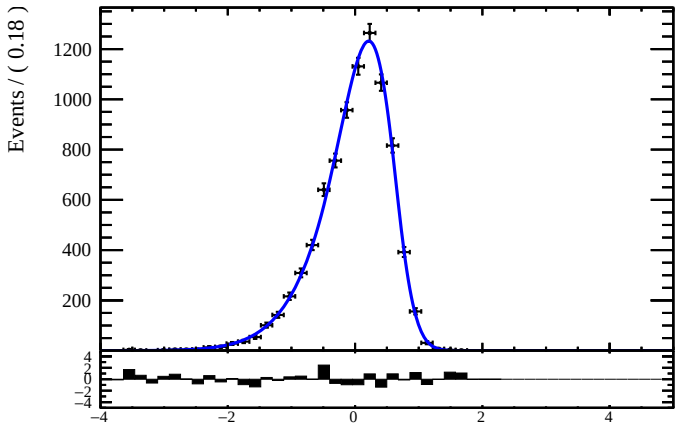


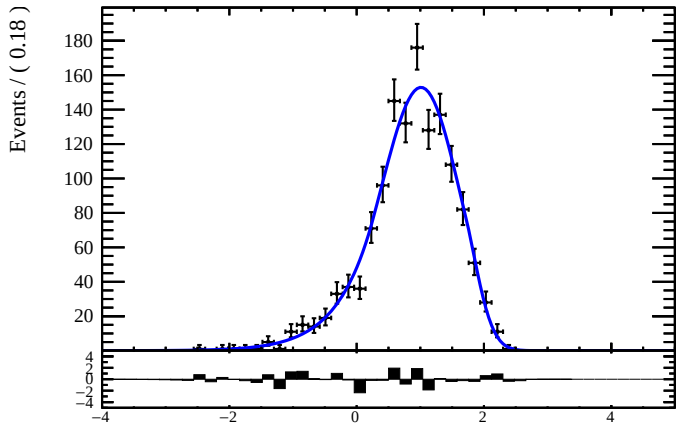


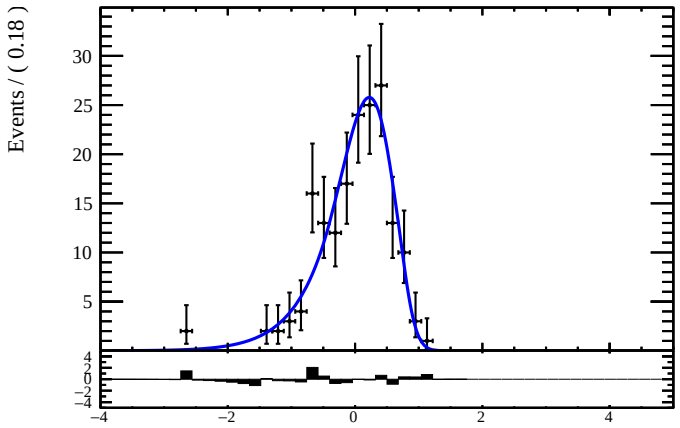


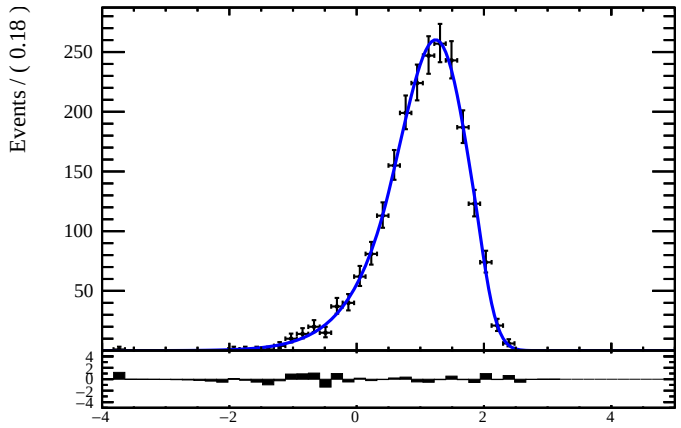
Fit with all parameters free: bin 8

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



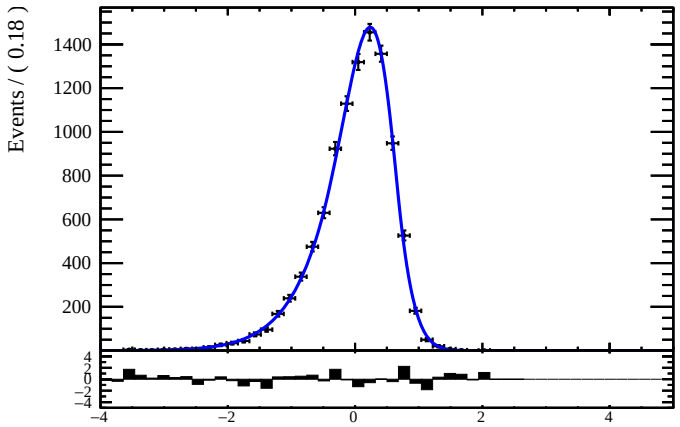


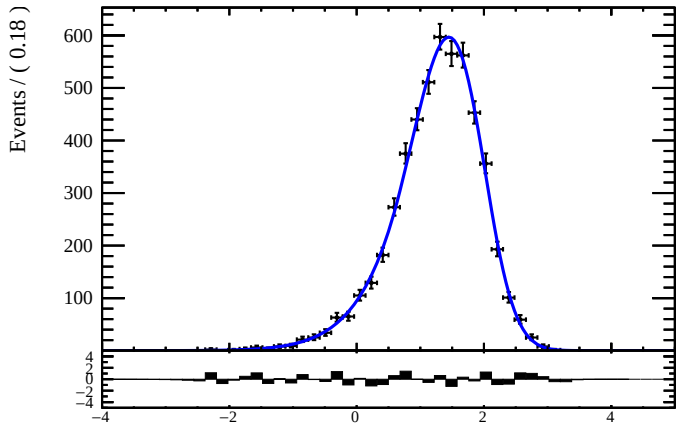


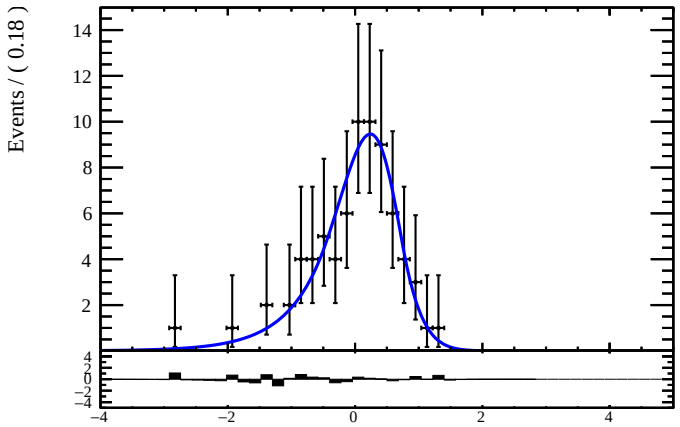


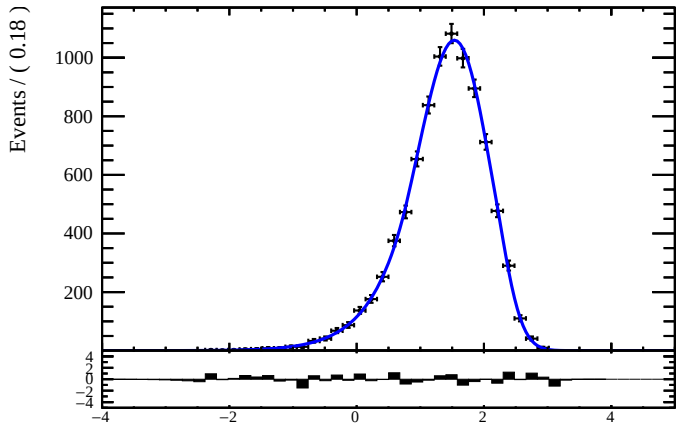
Fit with all parameters free: bin 9

- (left) Prompt and (right) secondary for (top) Ω_c^0 and (bottom) Ξ_c^0



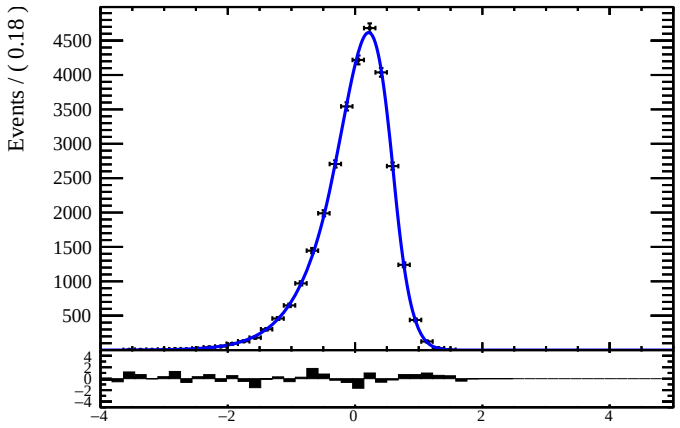


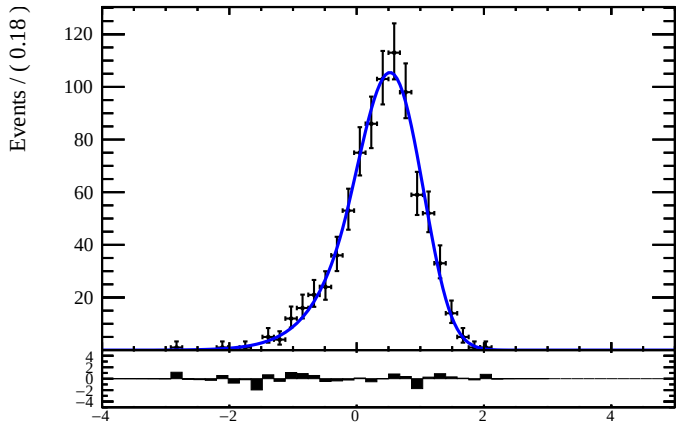




Fit D^0 MC with all parameters free: bin 0

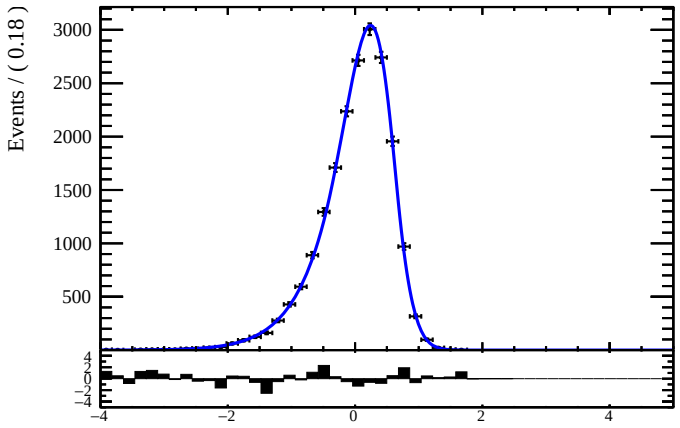
- (left) Prompt and (right) secondary

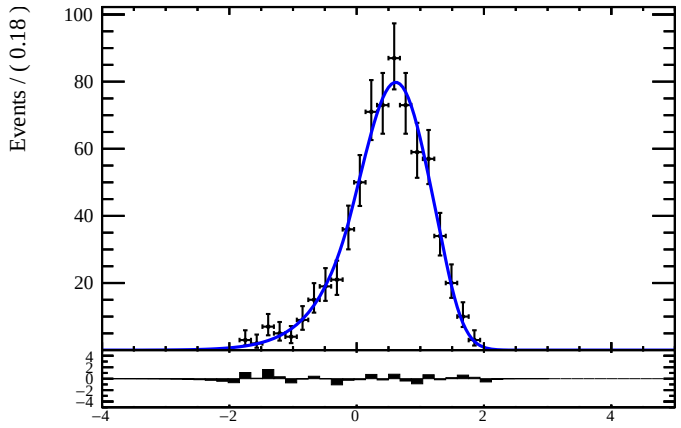




Fit D^0 MC with all parameters free: bin 1

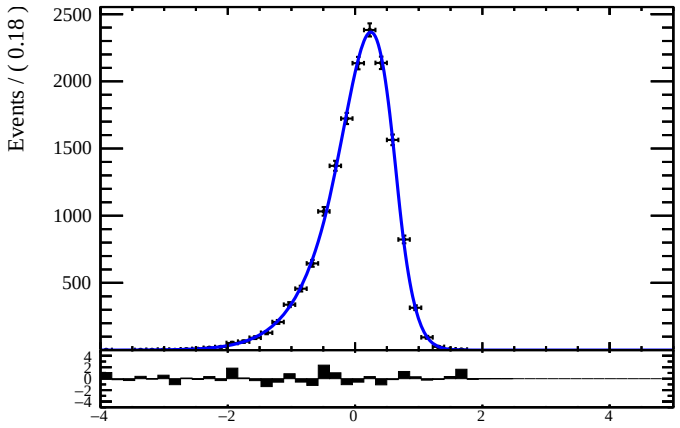
- (left) Prompt and (right) secondary

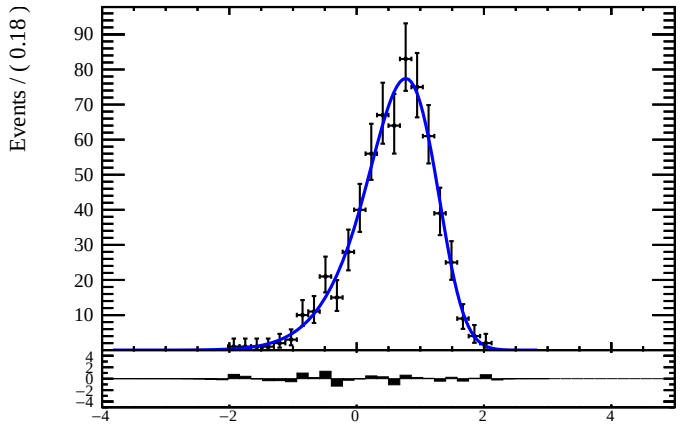




Fit D^0 MC with all parameters free: bin 2

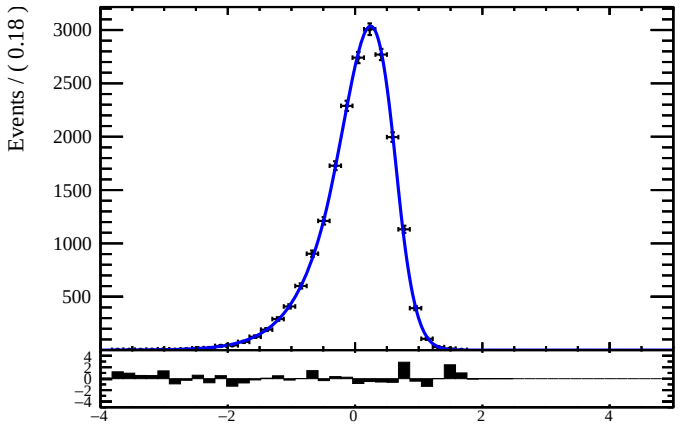
- (left) Prompt and (right) secondary

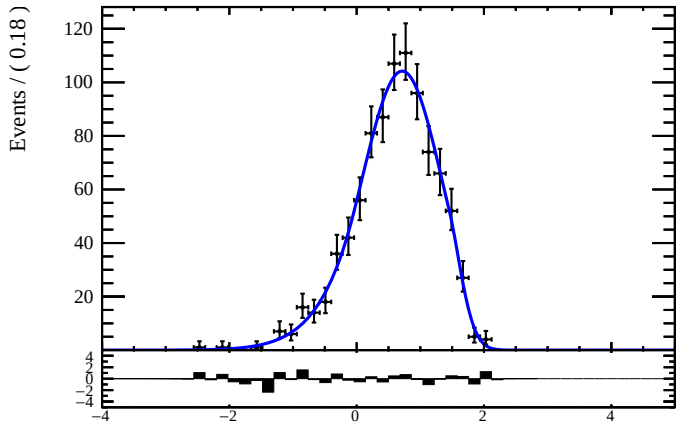




Fit D^0 MC with all parameters free: bin 3

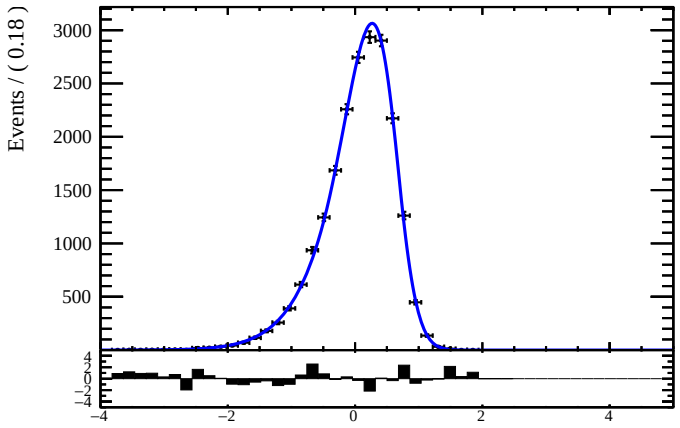
- (left) Prompt and (right) secondary

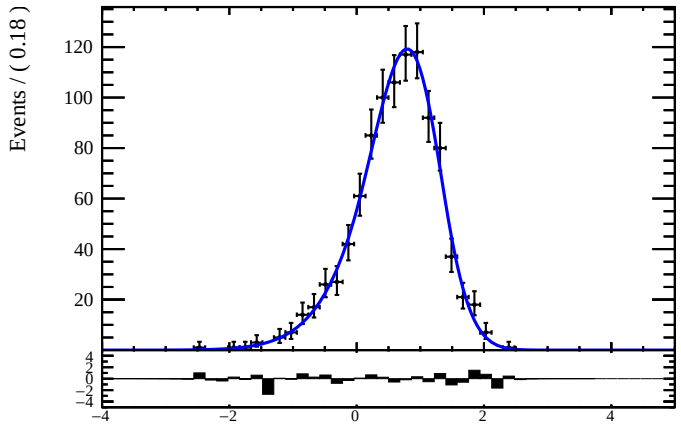




Fit D^0 MC with all parameters free: bin 4

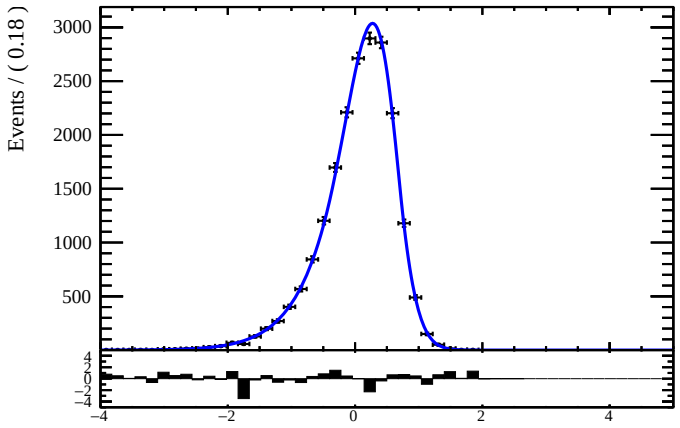
- (left) Prompt and (right) secondary

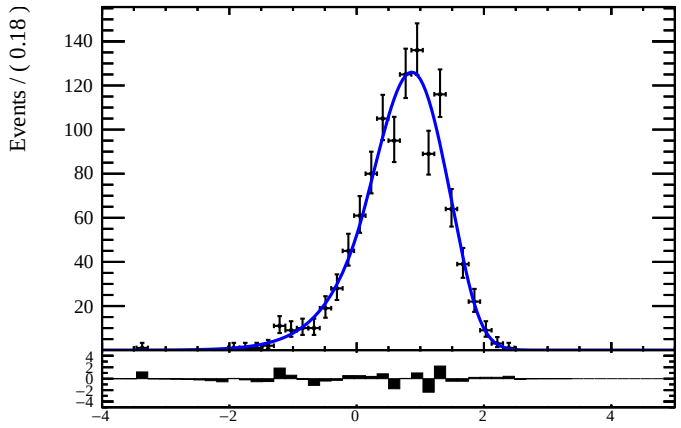




Fit D^0 MC with all parameters free: bin 5

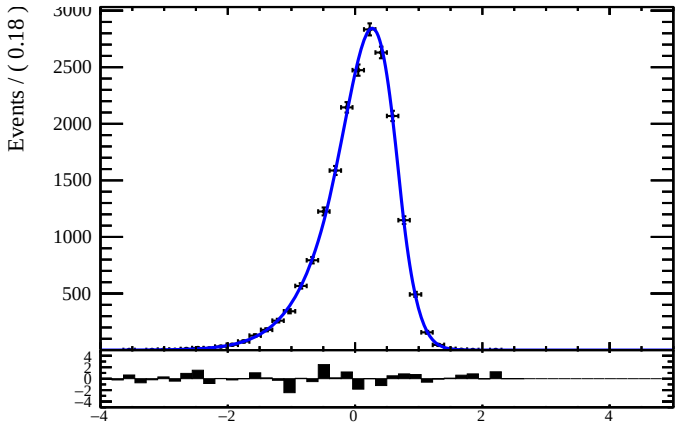
- (left) Prompt and (right) secondary

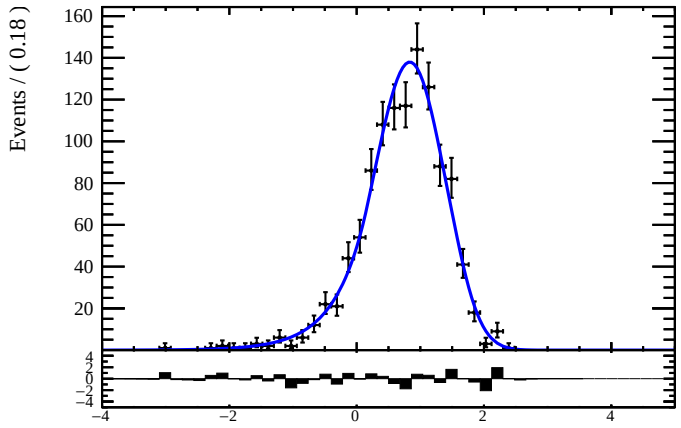




Fit D^0 MC with all parameters free: bin 6

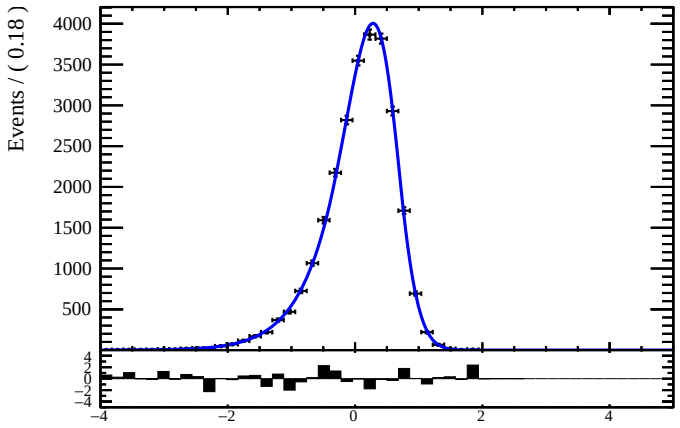
- (left) Prompt and (right) secondary

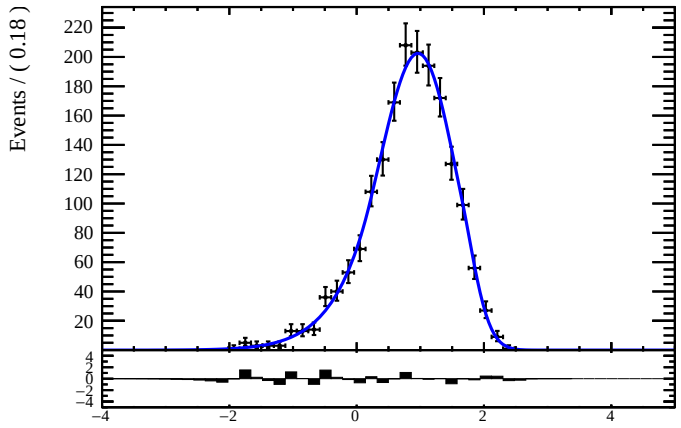




Fit D^0 MC with all parameters free: bin 7

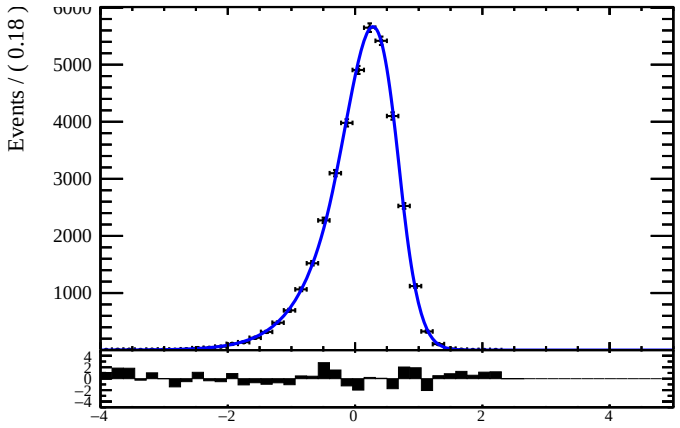
- (left) Prompt and (right) secondary

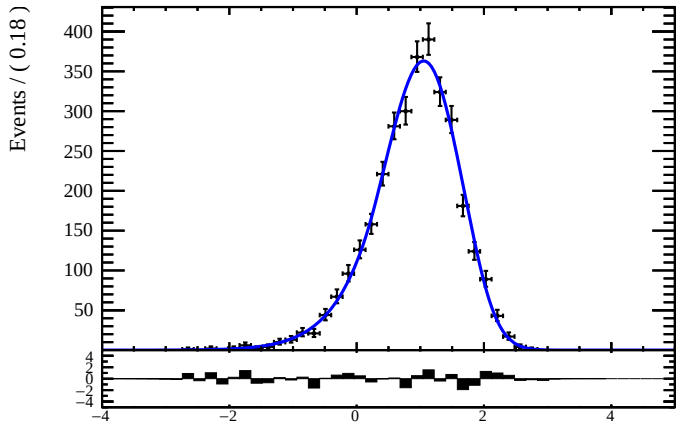




Fit D^0 MC with all parameters free: bin 8

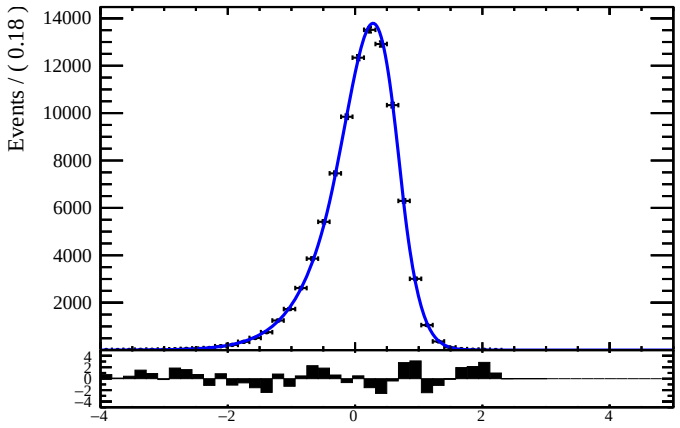
- (left) Prompt and (right) secondary

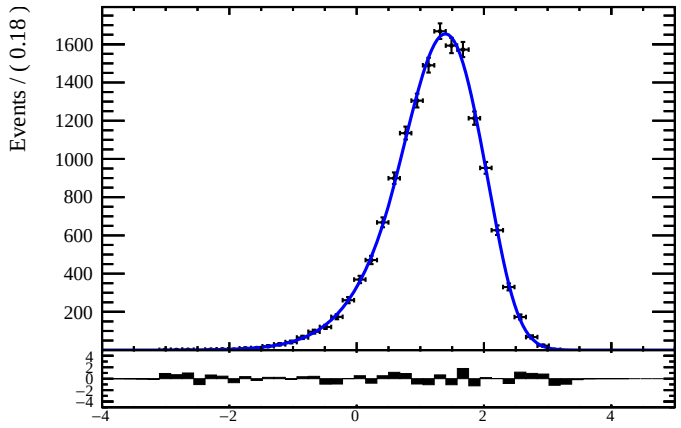




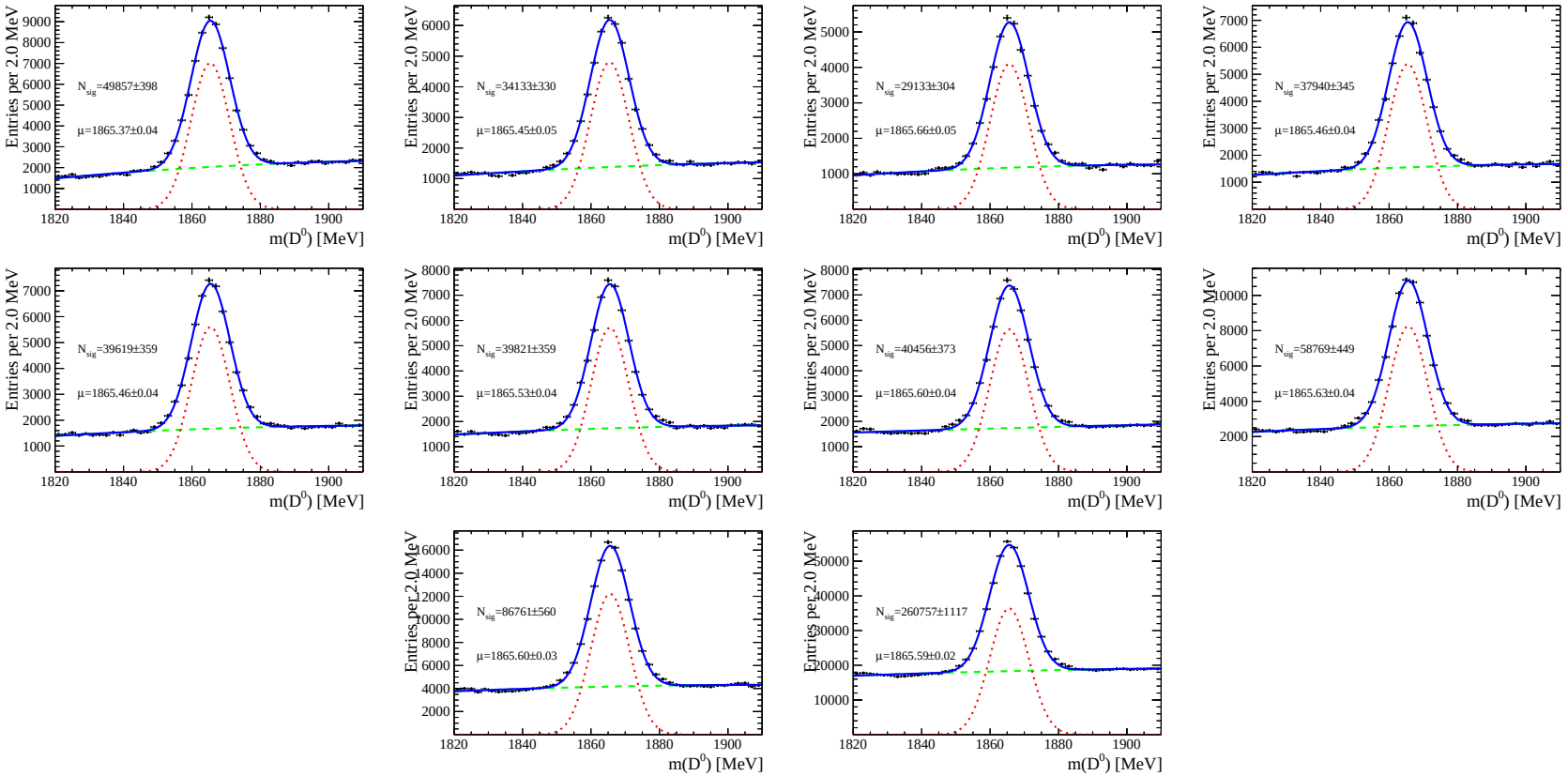
Fit D^0 MC with all parameters free: bin 9

- (left) Prompt and (right) secondary

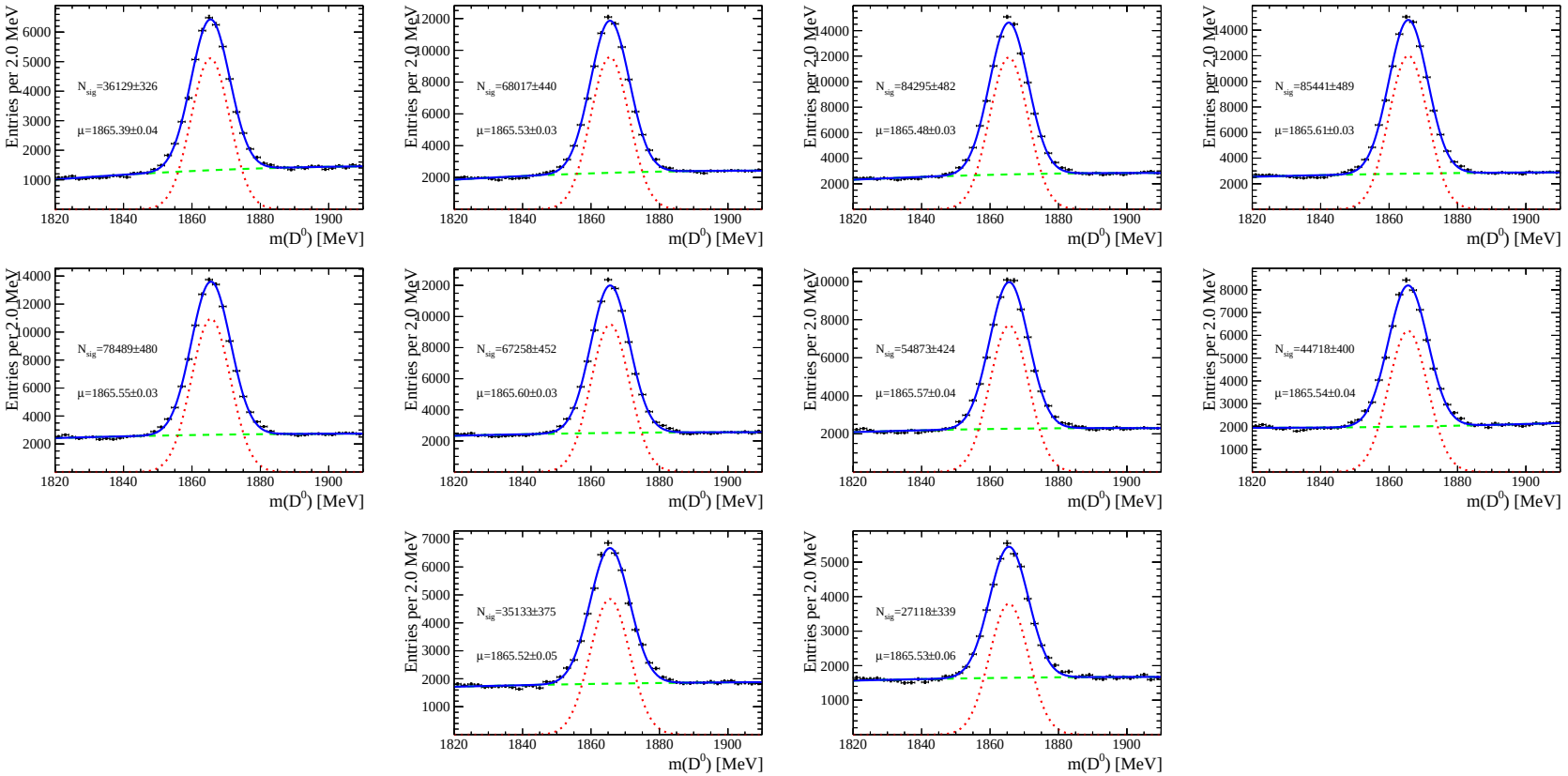




Fit mass of D^0 data



Fit mass of D^0 data in even bins: bin 0-9



Fit mass of D^0 data in even bins: bin 10-19