Prompt yield extraction

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Ω_c^0 *lifetime measurement meeting*

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Outline

News

Data and simulation

Strategy to extract prompt yields

Fit to MC samples of signal, normalization and control modes

Fit to D^0 data

Ongoing tests

Ξ_c^0 dec file with modified lifetime

- The problem may be caused by the EventType
  - 2610408x
    $\Longrightarrow$ `Generation().SignalPlain.SignalPIDList=[4132,-4132]`
  - 2610409x
    $\Longrightarrow$ `Generation().SignalPlain.SignalPIDList=[4232,-4232]`
  - 2610407x
    $\Longrightarrow$ `Generation().SignalPlain.SignalPIDList=[4214,-4214]`

Data and simulation

- 2016 data and simulation samples available for this analysis

Modes	Data	MC	
signal	$\Omega_c^0 \to pK^-K^-\pi^+$	Turbo	ReDecay $\tau = 250\,\mathrm{fs}, 500\,\mathrm{fs}$
normalization	$\Xi_c^0 \to pK^-K^-\pi^+$	Turbo	ReDecay
control	$\Omega_b^- \to \Omega_c^0(\to pK^-K^-\pi^+)\,\pi^-$	Stripping	Full Sim.
control	$\Omega_b^- \to \Omega_c^0(\to pK^-K^-\pi^+)\,\mu^-\overline{\nu}_\mu$	Stripping	Full Sim. $\tau = 250\,\mathrm{fs}$
control	$\Xi_b \to \Xi_c^0(\to pK^-K^-\pi^+)\,\mu^-\overline{\nu}_\mu$	Stripping	Full Sim.
control	$D^{*+} \to D^0(\to K^-K^+\pi^-\pi^+)\pi^+$	Turbo	ReDecay
control	$B^+ \to \overline{D}^0(\to K^+K^-\pi^+\pi^-)\pi^+$	Stripping	Full Sim.

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

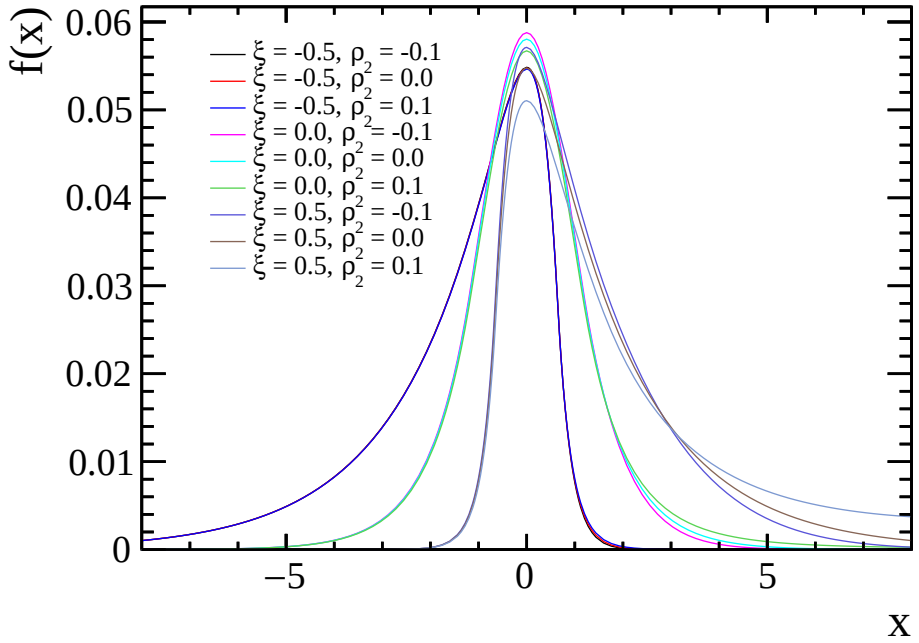
$$\mathcal{P}(x;\mu,\sigma,\xi,\rho_1,\rho_2) = \begin{cases} \exp\left\{ \dfrac{(x-x_1)\xi\sqrt{\xi^2+1}\sqrt{2\ln 2}}{\sigma\left(\sqrt{\xi^2+1}-\xi\right)^2 \ln\left(\sqrt{\xi^2+1}+\xi\right)} + \rho_1\left(\dfrac{x-x_1}{\mu-x_1}\right)^2 - \ln 2 \right\} & x \le x_1, \\ \exp\left\{ -\left[\dfrac{\ln\left(1+2\xi\sqrt{\xi^2+1}\dfrac{x-\mu}{\sigma\sqrt{2\ln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

where

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

Illustration of the Bukin functions

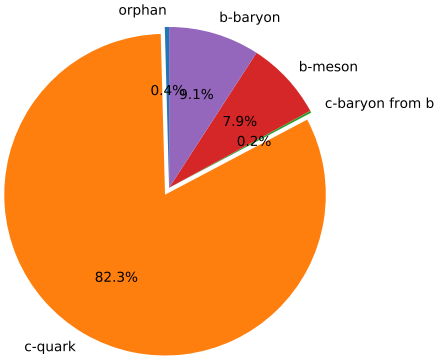
- Bukin functions with various asymetry and tail parameters with $\mu = 0, \sigma = 1, \rho_1 = 0$



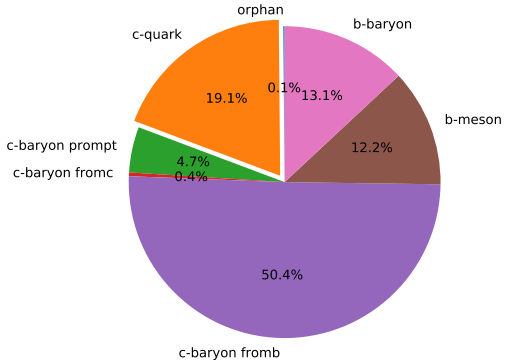
Prompt and secondary MC samples

- 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

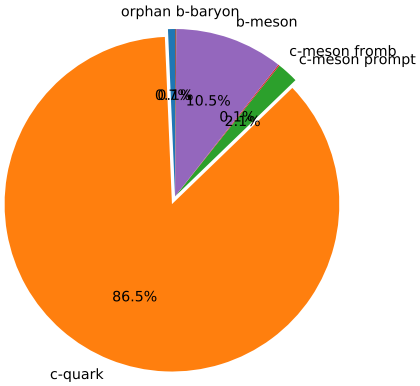
Components	orphan	c-quark	c-meson	c-baryon	b-meson	b-baryon
abs(MC_MOTHER_ID)	0	4	(400,500)	(4000,5000)	(500,600)	(5000,6000)



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

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

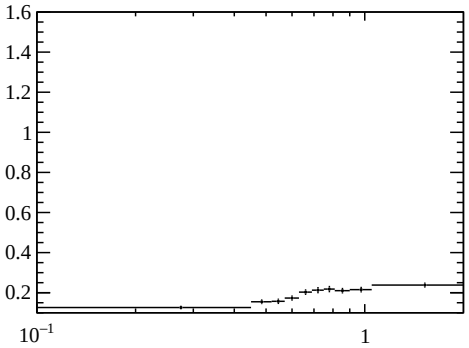
where $\vec{p}$ is the momentum vector, $\vec{r}$ the vector pointing from PV to decay vertex, and m the invariant mass of the charm hadron

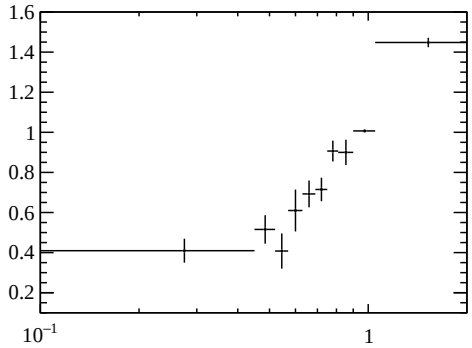
Fit with all parameters free in all decay time bins

- 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

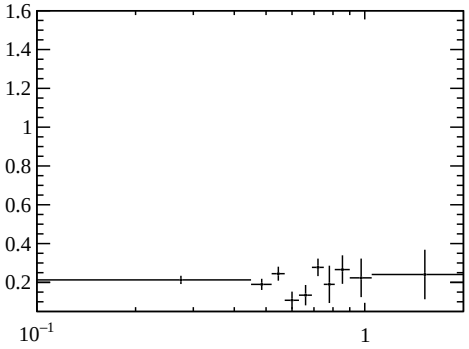
Prompt Ω_c^0

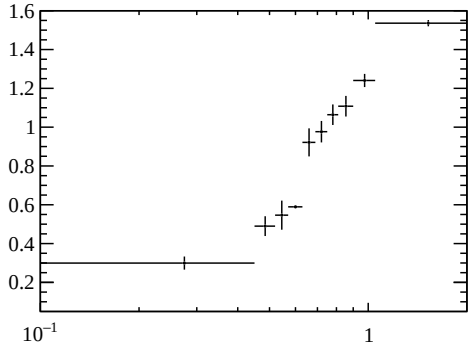




Secondary Ω_c^0

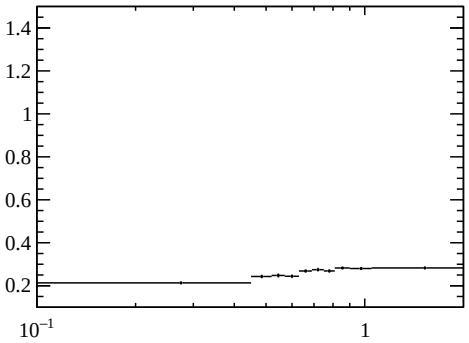
Prompt Ξ_c^0

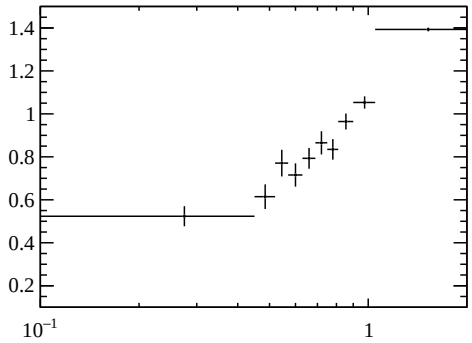




Secondary Ξ_c^0

Prompt D^0

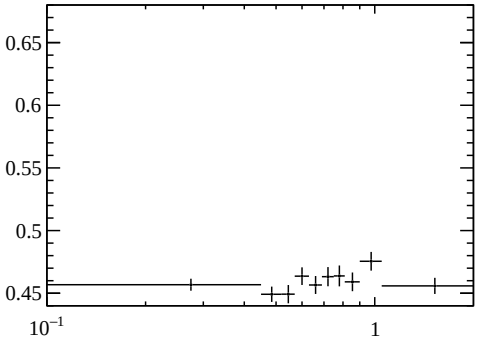


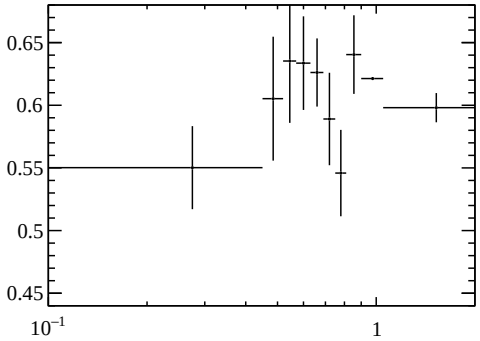


Secondary D^0

Fit results in decay-time bins: σ

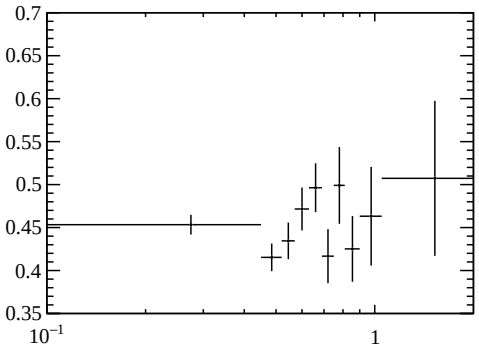
Prompt Ω_c^0

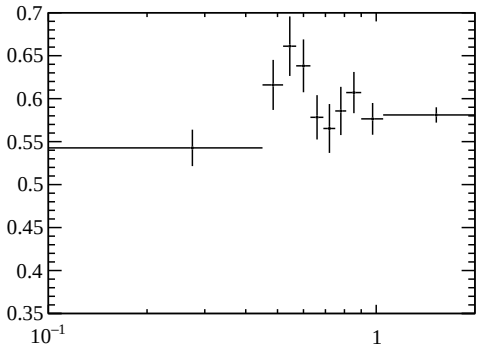




Secondary Ω_c^0

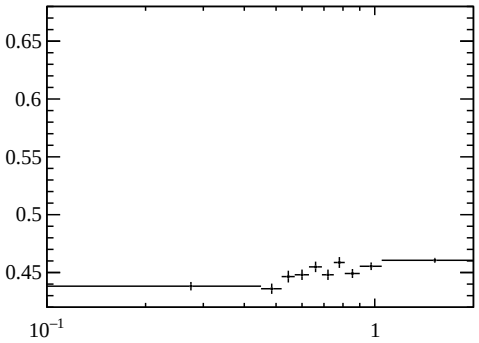
Prompt Ξ_c^0

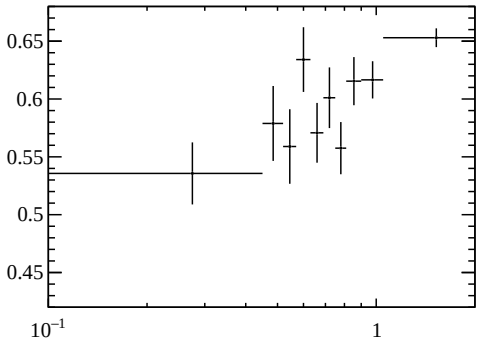




Secondary Ξ_c^0

Prompt D^0

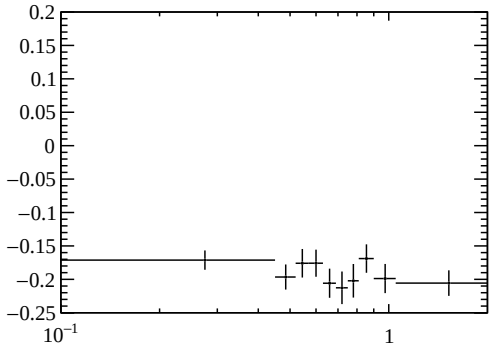


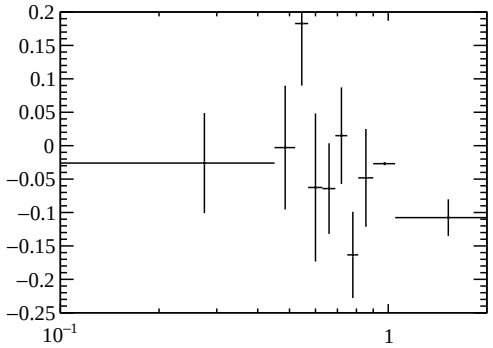


Secondary D^0

Fit results in decay-time bins: ξ

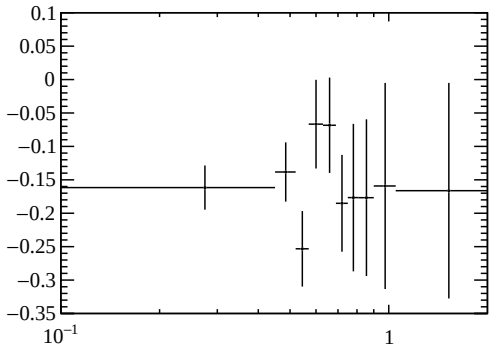
Prompt Ω_c^0

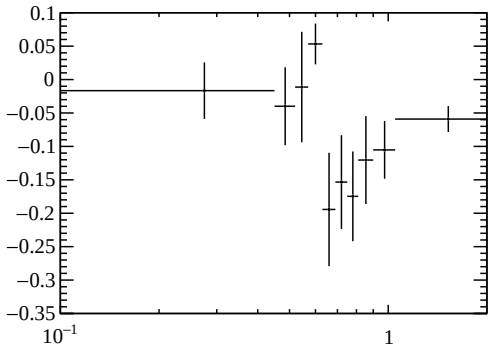




Secondary Ω_c^0

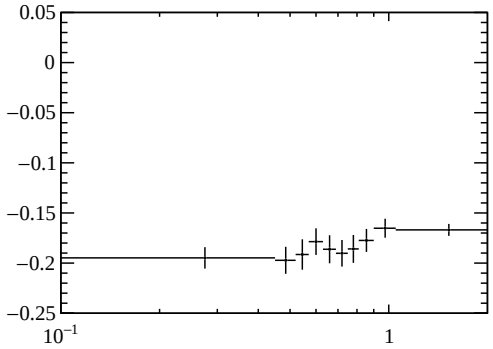
Prompt Ξ_c^0

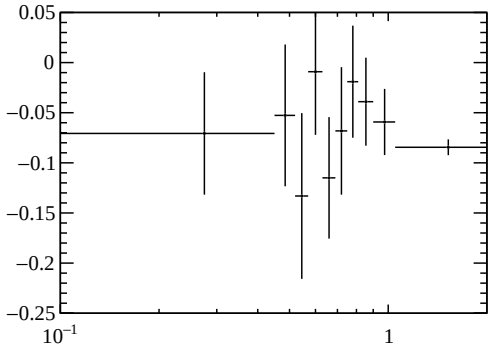




Secondary Ξ_c^0

Prompt D^0

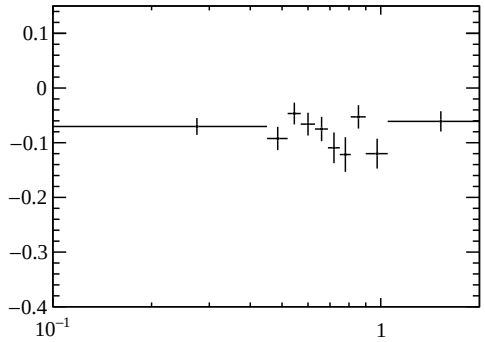


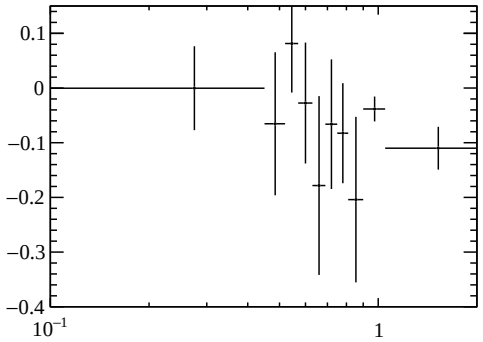


Secondary D^0

Fit results in decay-time bins: ρ_1

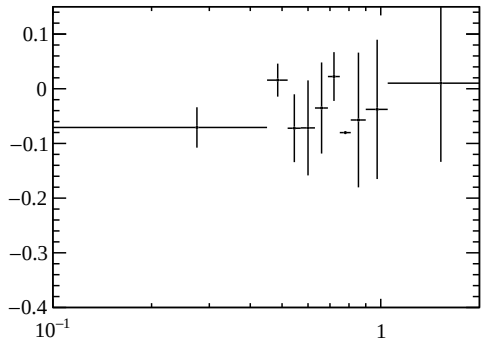
Prompt Ω_c^0

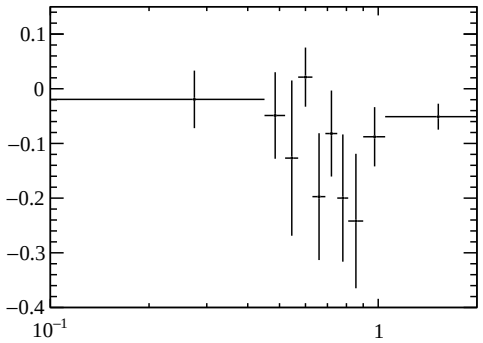




Secondary Ω_c^0

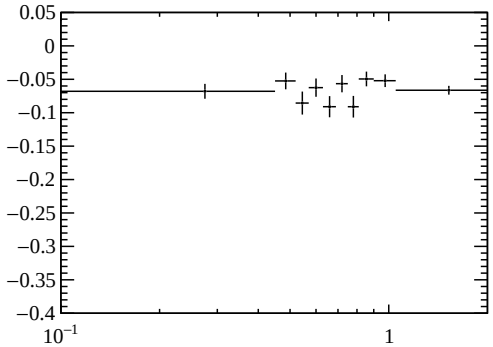
Prompt Ξ_c^0

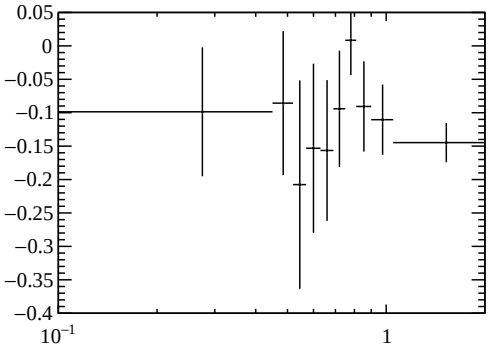




Secondary Ξ_c^0

Prompt D^0

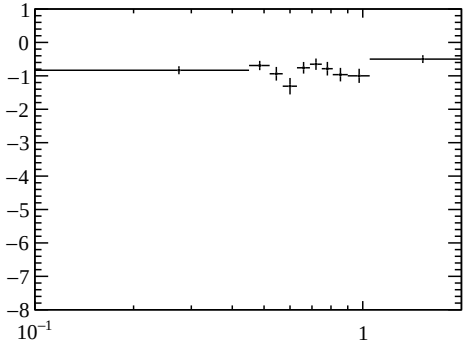


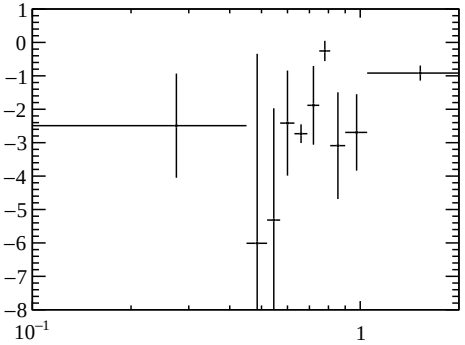


Secondary D^0

Fit results in decay-time bins: ρ_2

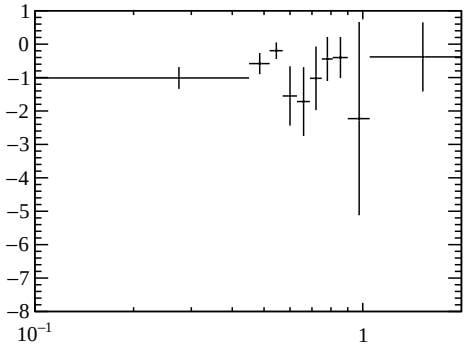
Prompt Ω_c^0

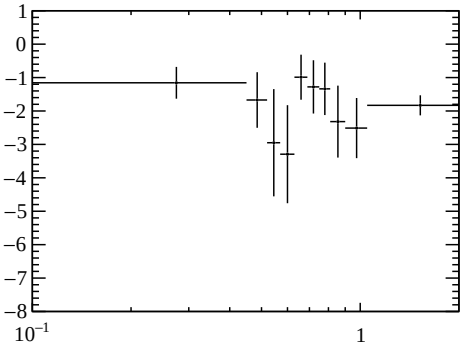




Secondary Ω_c^0

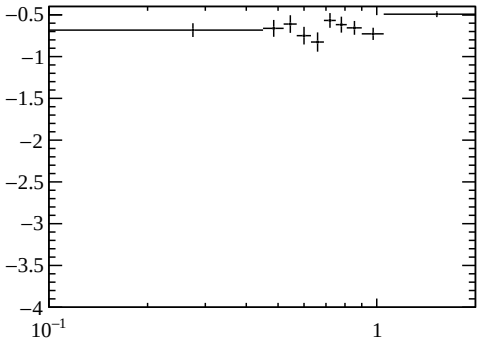
Prompt Ξ_c^0

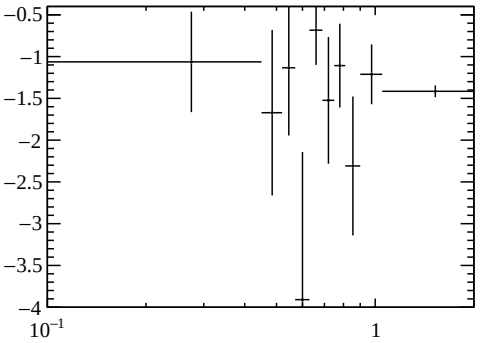




Secondary Ξ_c^0

Prompt D^0



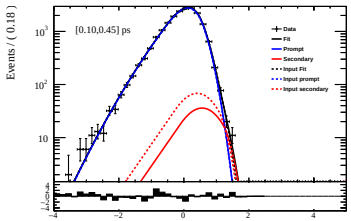


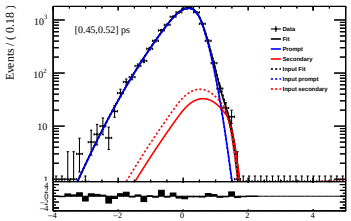
Secondary D^0

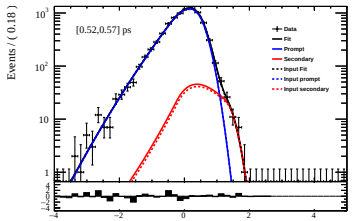
Sanity check: fit combined MC samples

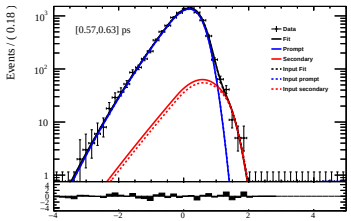
- Check whether the fit can re-produce the input prompt fraction with MC samples
- Fit the combined (prompt+secondary) MC with free μ_{prompt} and $\mu_{\mathrm{secondary}}$, while fixing other parameters to values of seperate fits

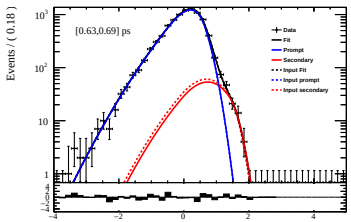
Fit results of combined MC samples: Ω_c^0

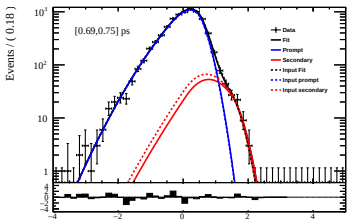


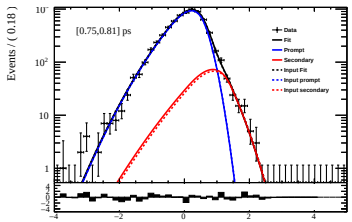


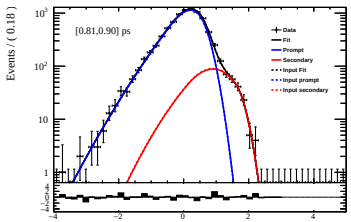


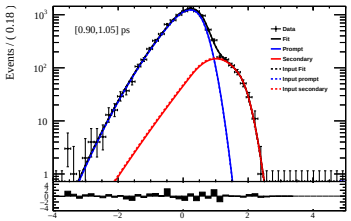


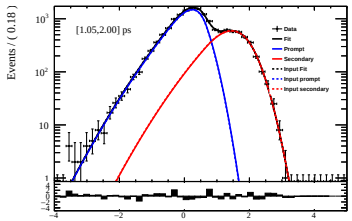




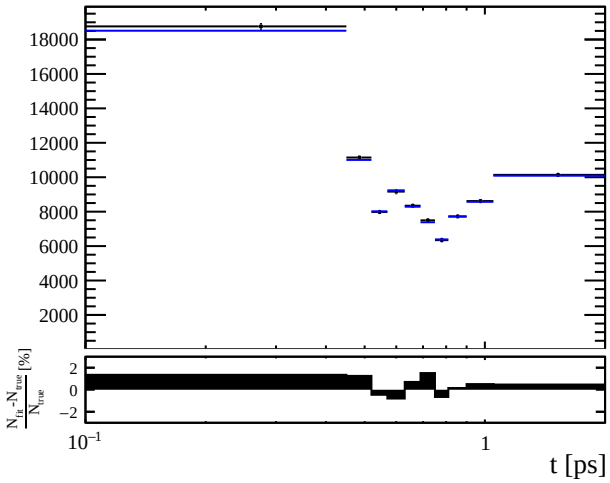




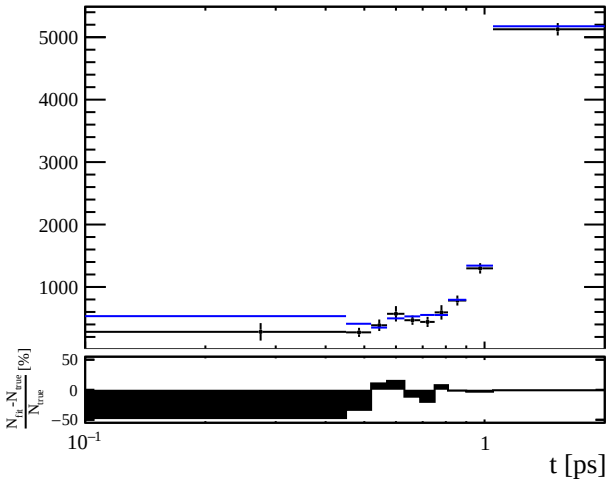




Comparison of input and extracted yield: Ω_c^0



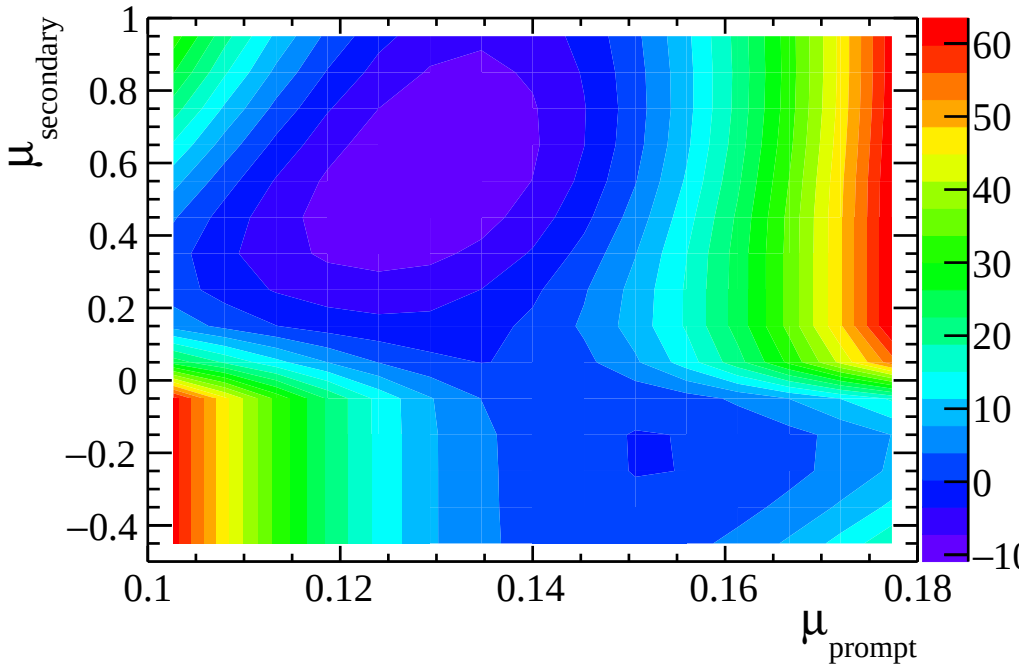
Prompt



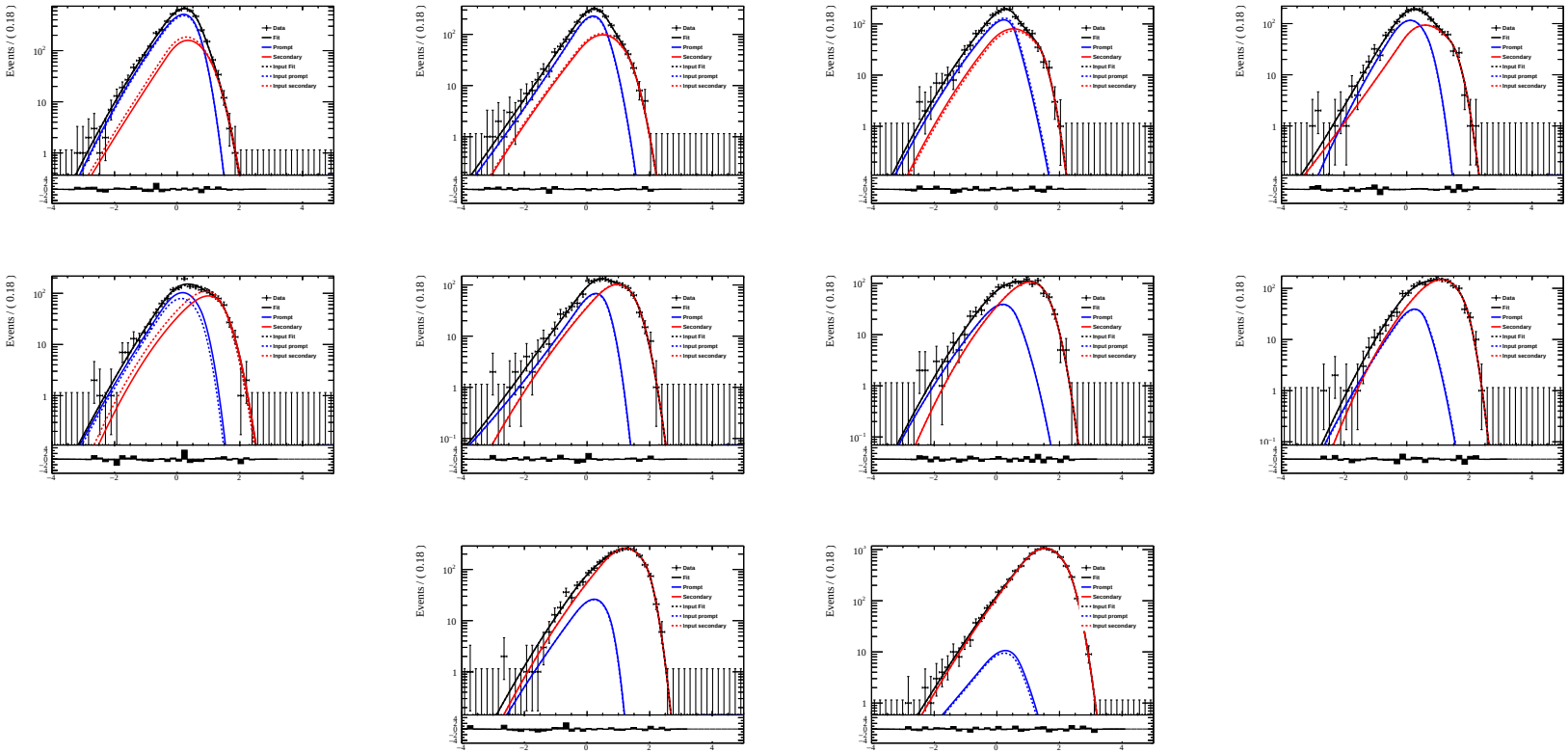
Secondary

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

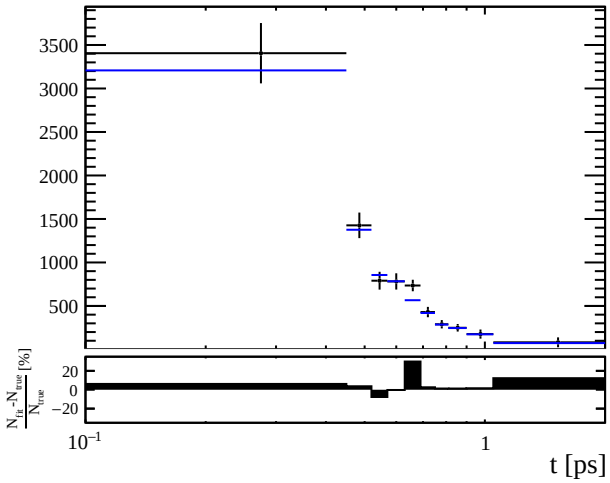
- Ω_c^0 bin 0



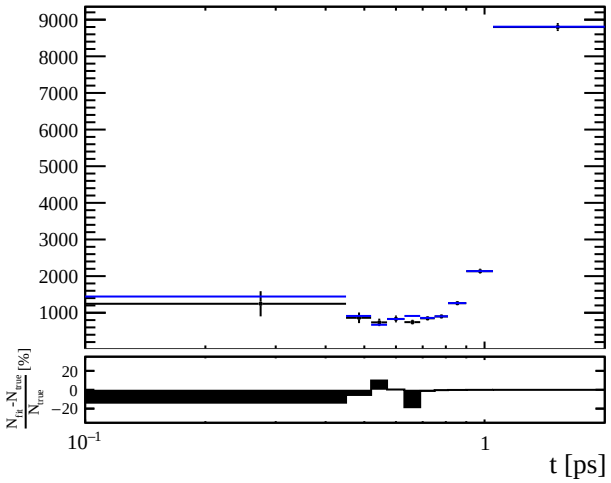
Fit results of combined MC samples: Ξ_c^0



Comparison of input and extracted yield: Ξ_c^0



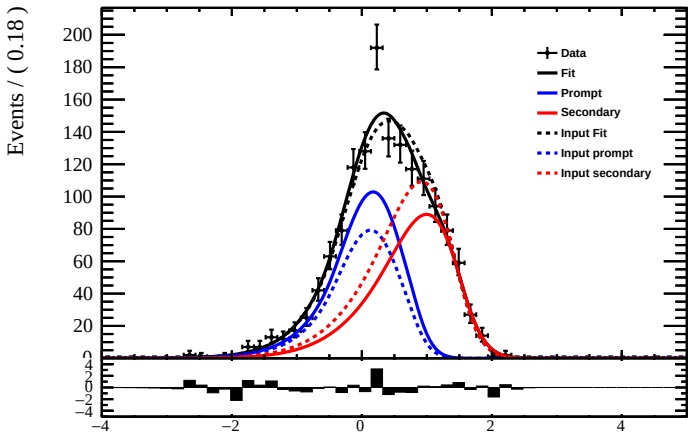
Prompt

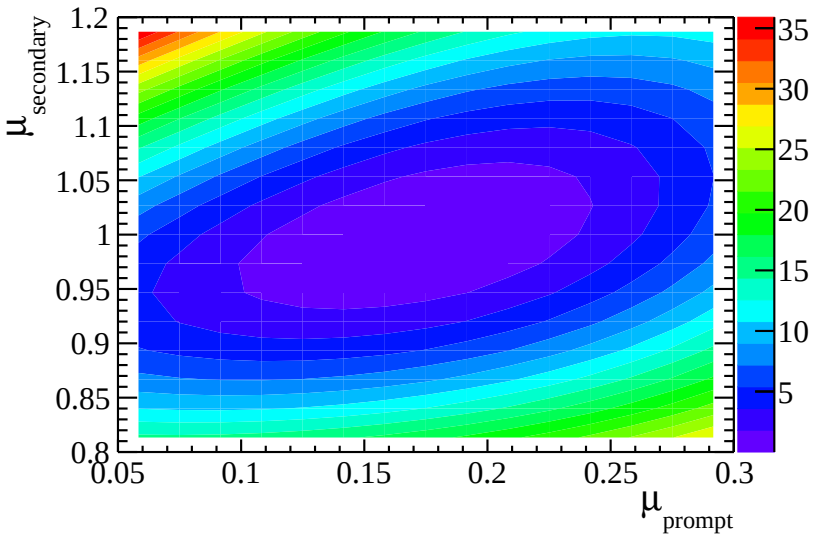


Secondary

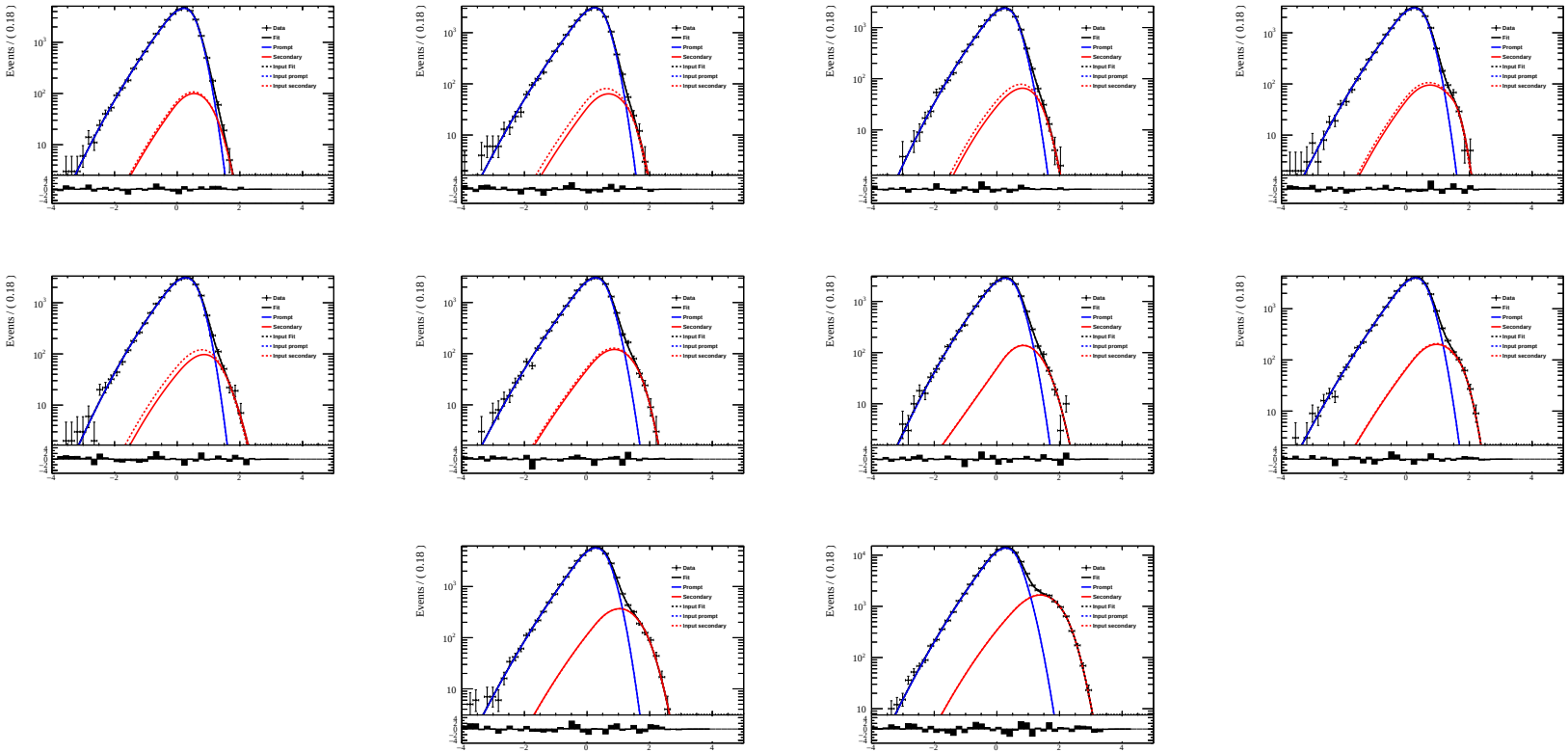
Likelihood scan of μ_{prompt} and $\mu_{\text{secondary}}$

- Ξ_c^0 bin 4

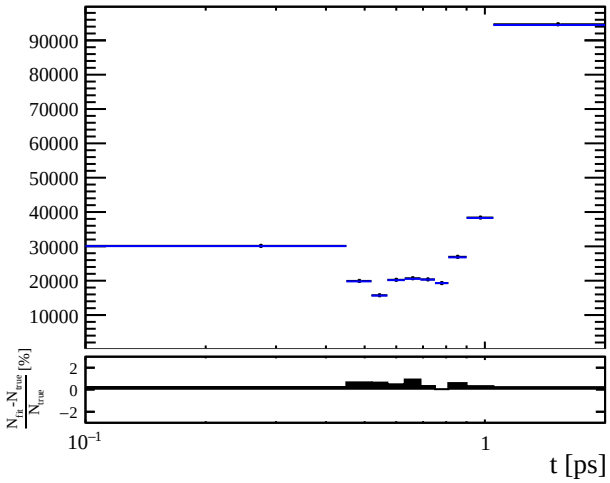




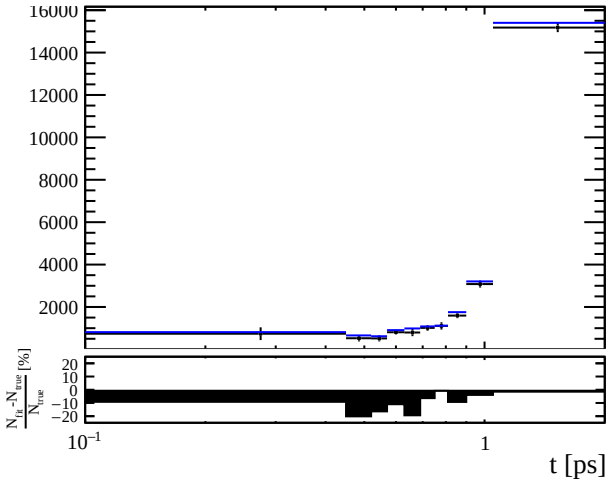
Fit results of combined MC samples: D^0



Comparison of input and extracted yield: D^0



Prompt



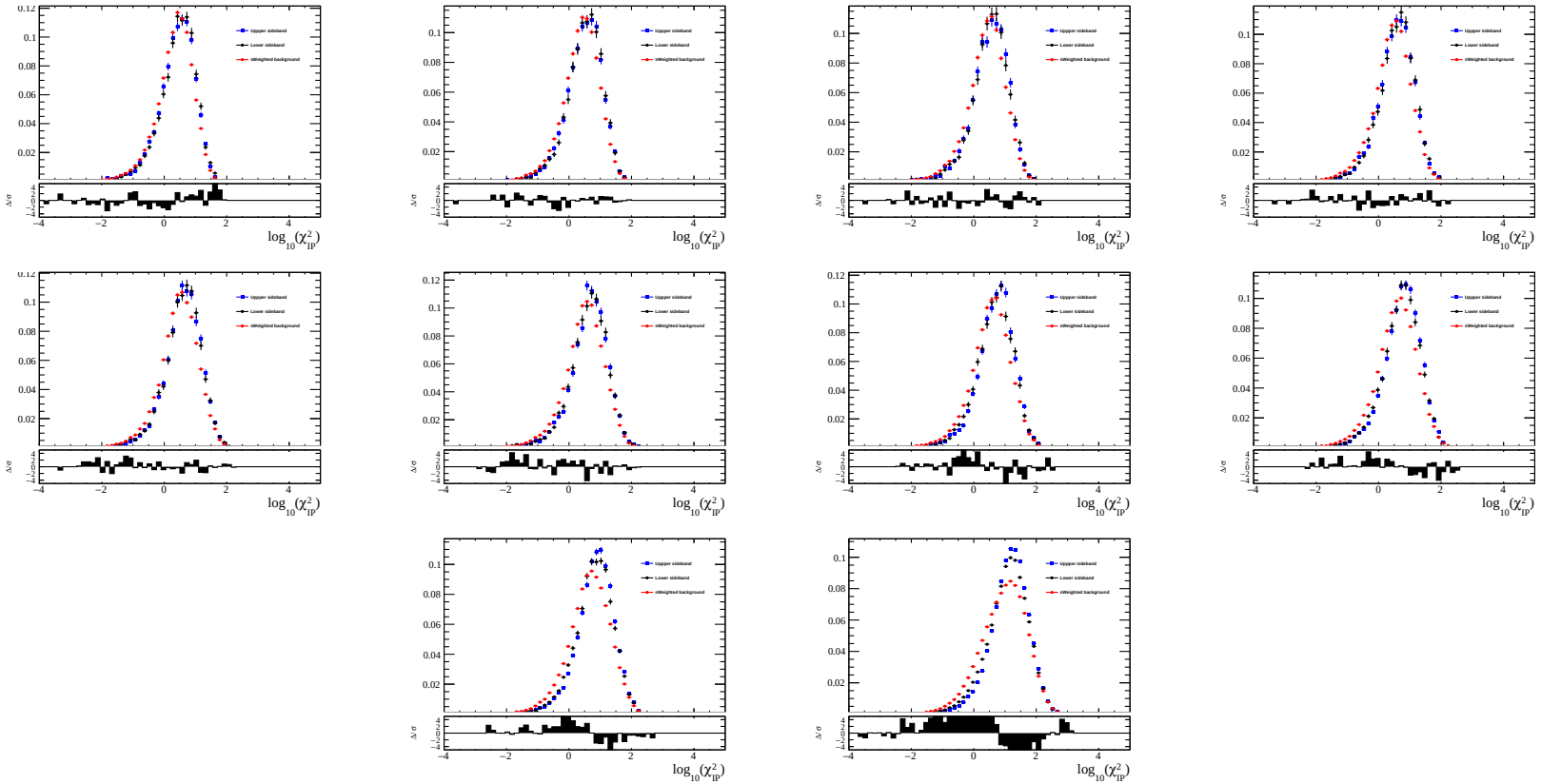
Secondary

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

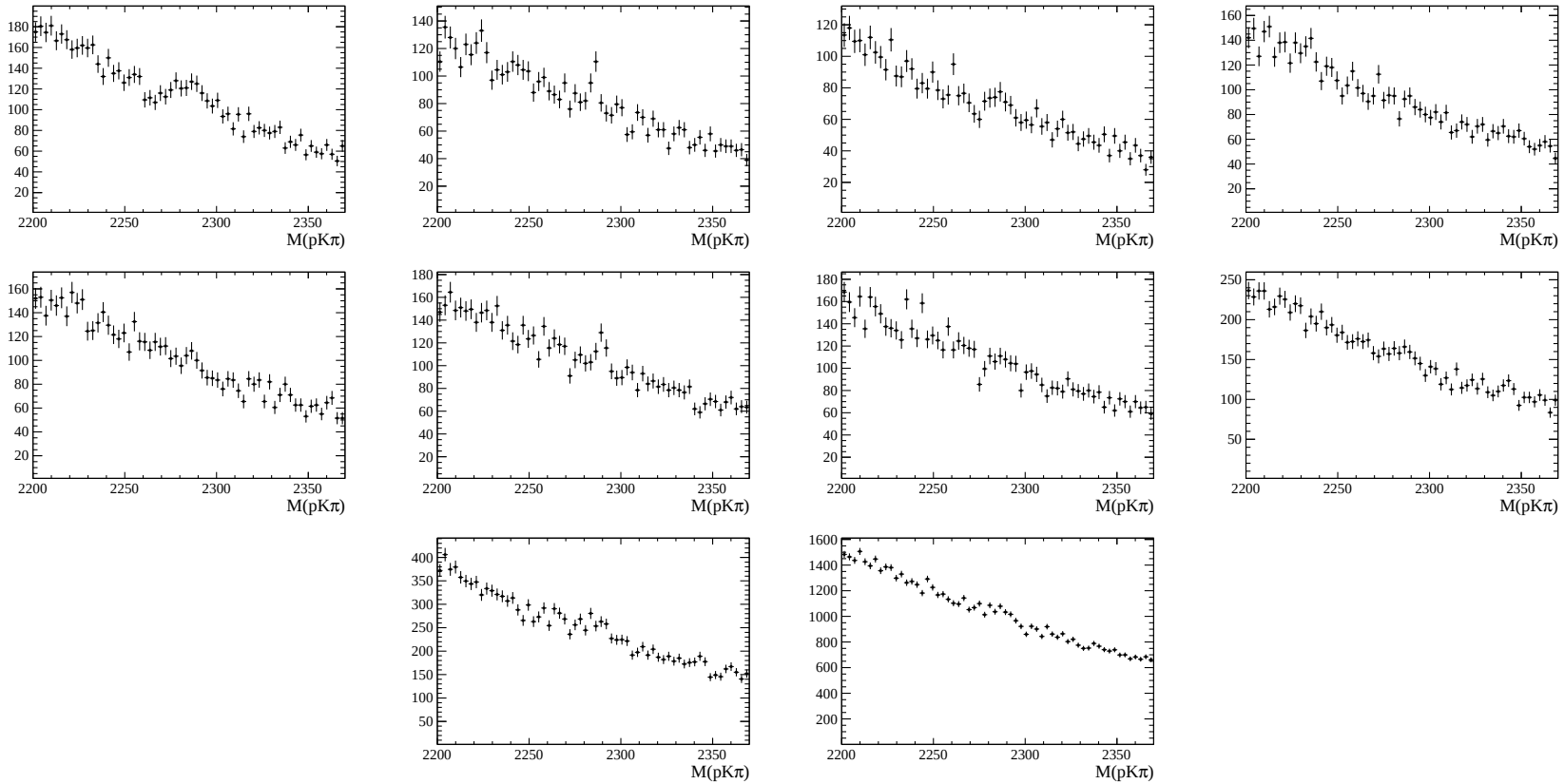
Comparison of background logIPCHI2

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



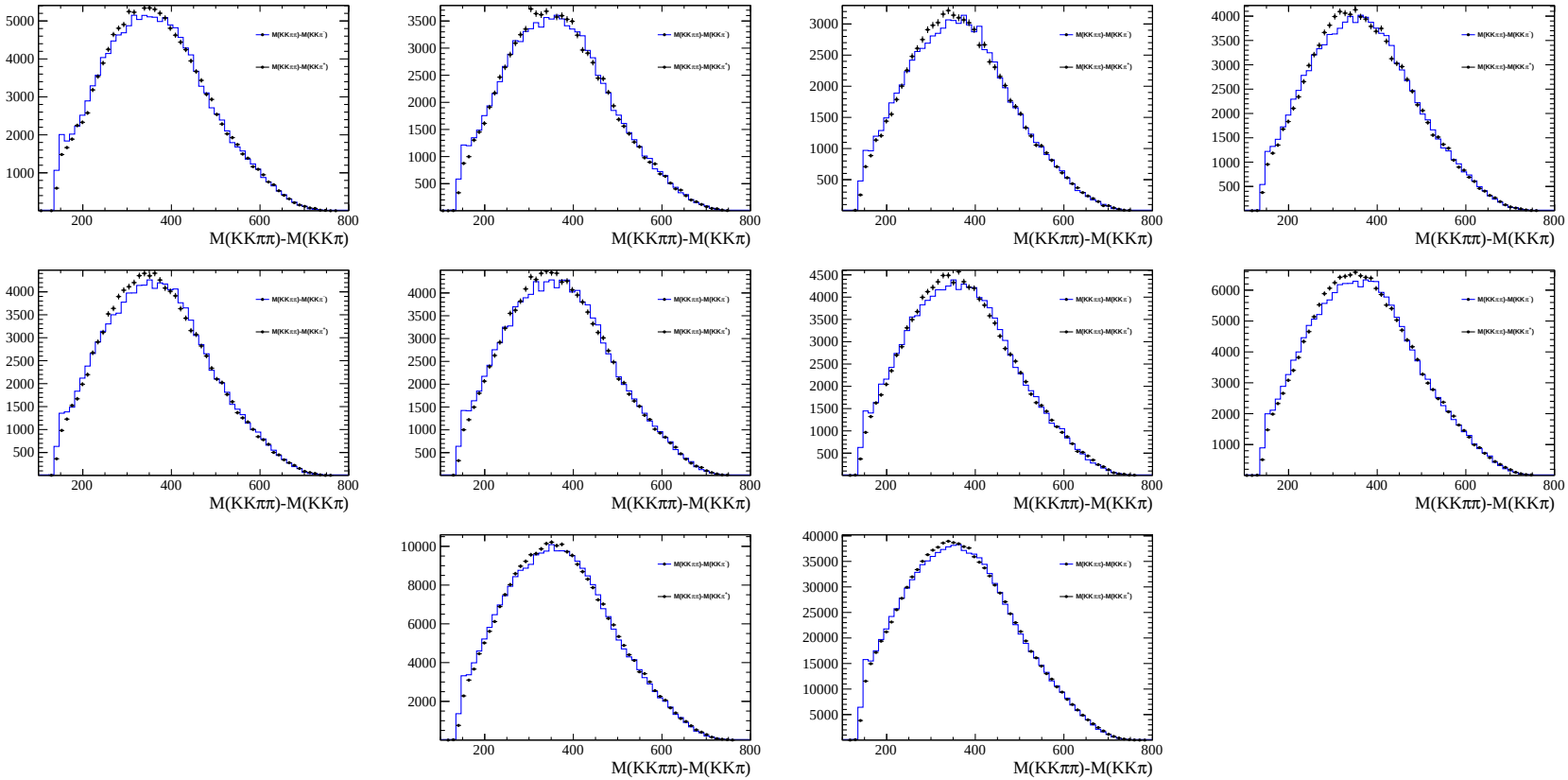
Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

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



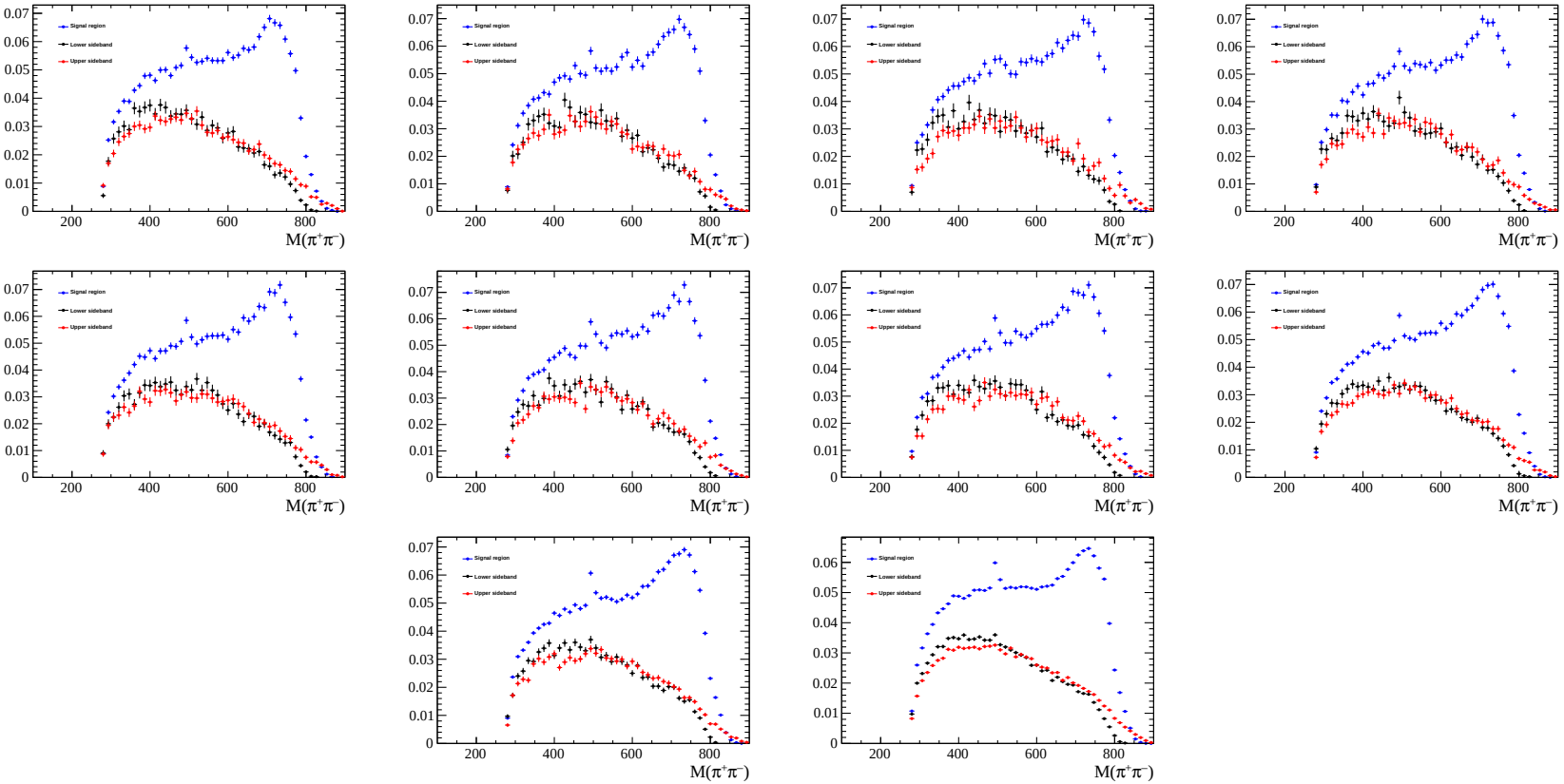
Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

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

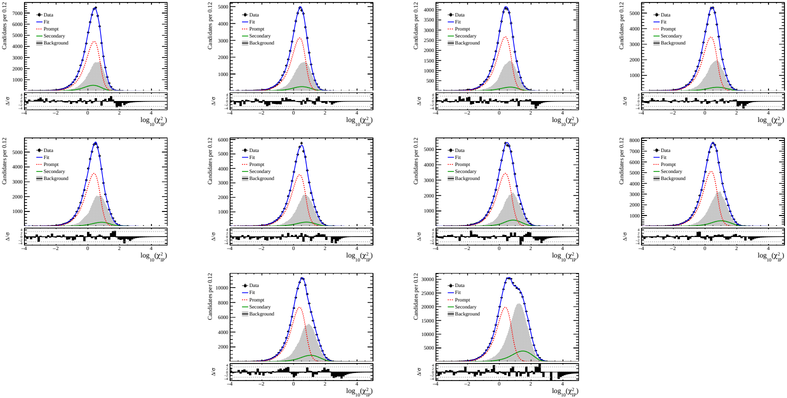


Physics backgrounds in $D^{*+} \to \pi^+ D^0 (\to K^- K^+ \pi^- \pi^+)$

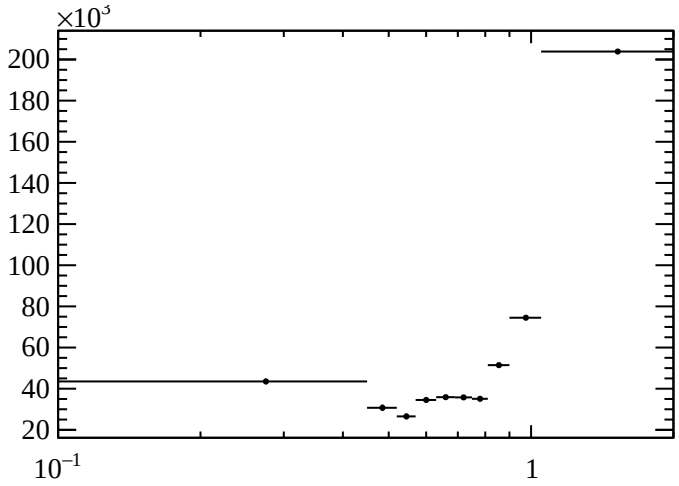
- K^0_S background: $D^0 \to K^- K^+ K^0_S (\to \pi^+ \pi^-)$
- Exist but not significant in the signal region



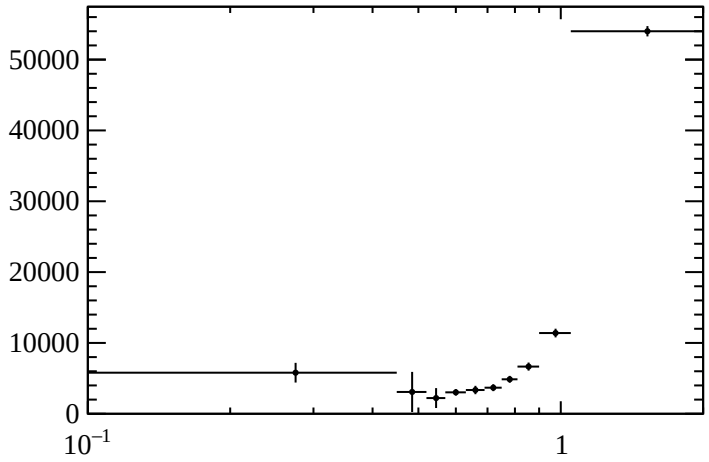
Fit results of D^0 data



Fit results of yields

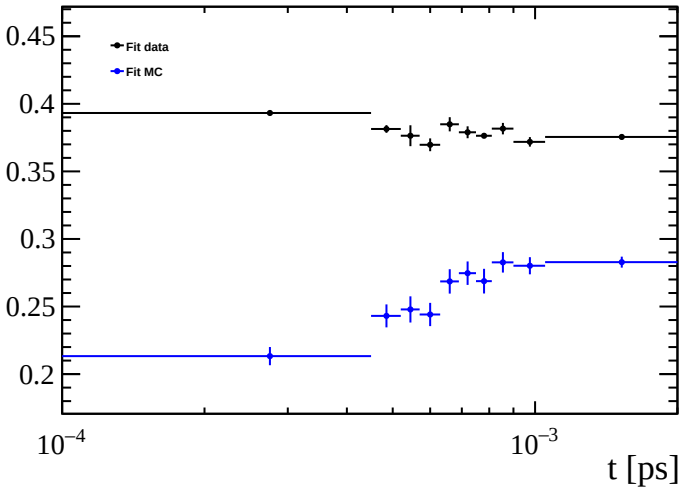


Prompt

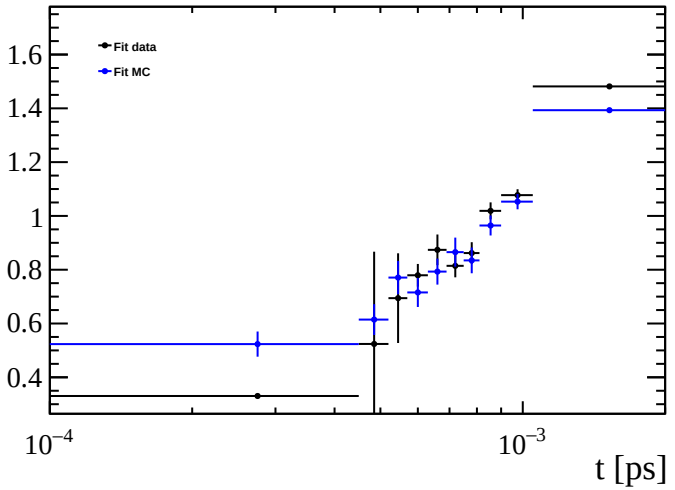


Secondary

Fit results of μ

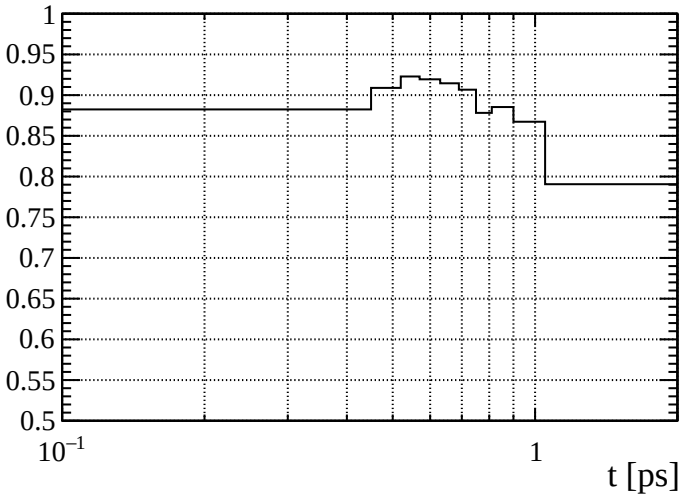


Prompt

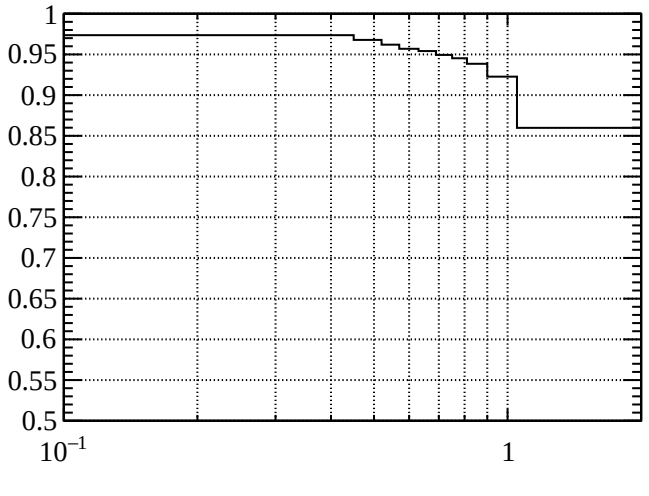


Secondary

Comparison of data and MC: prompt fraction

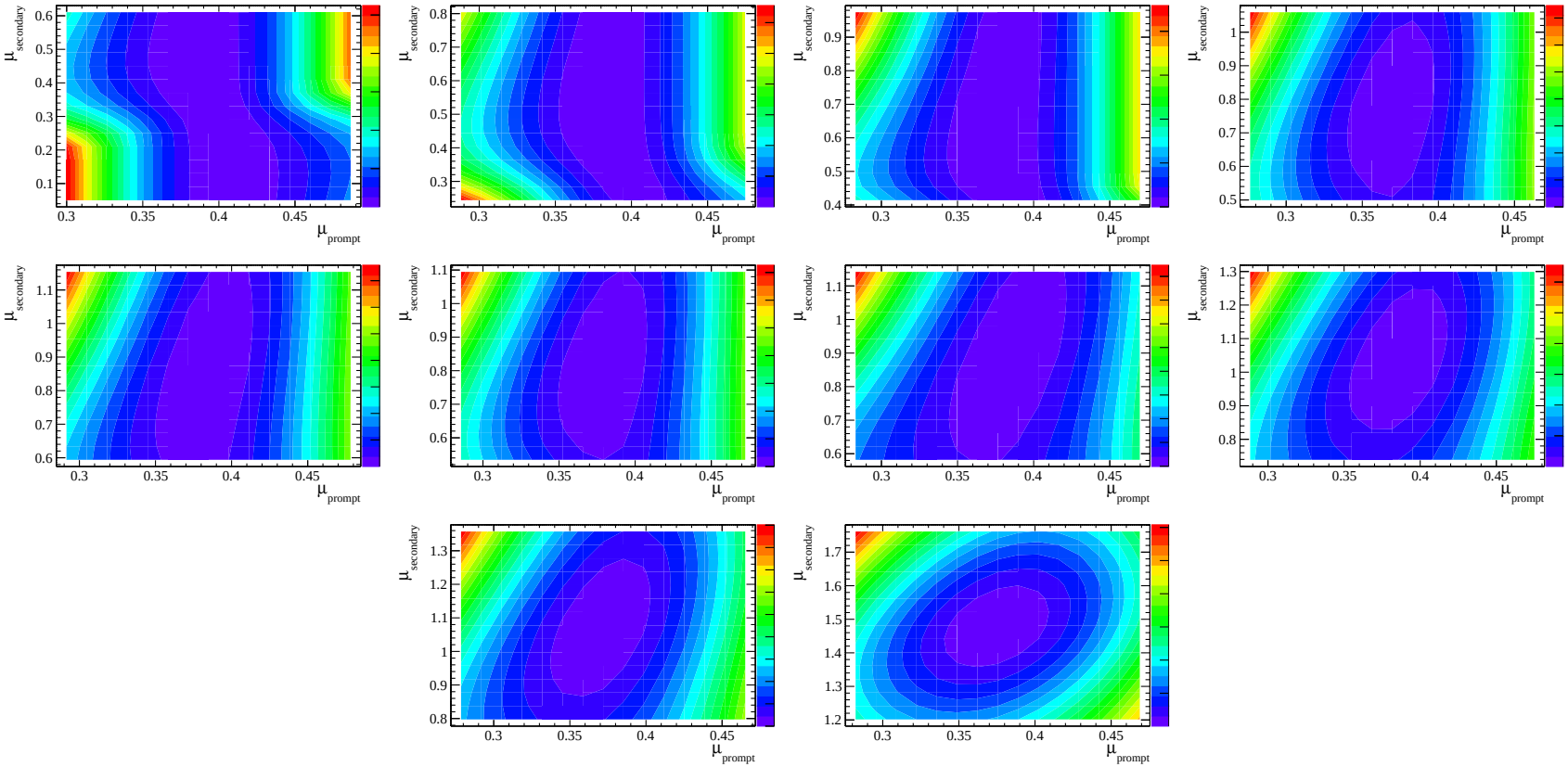


Data

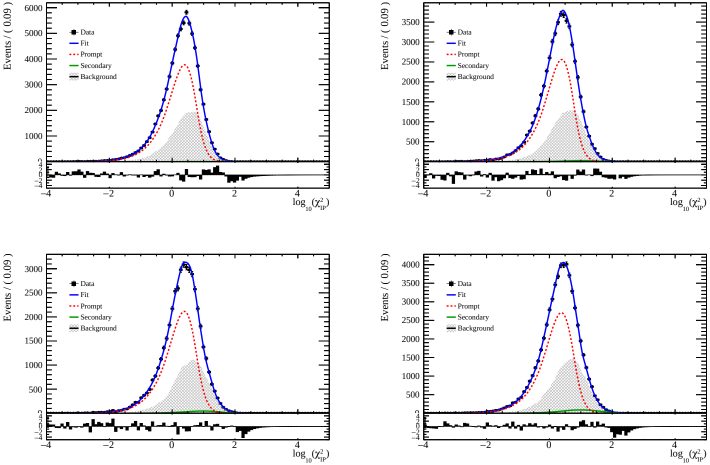


MC

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

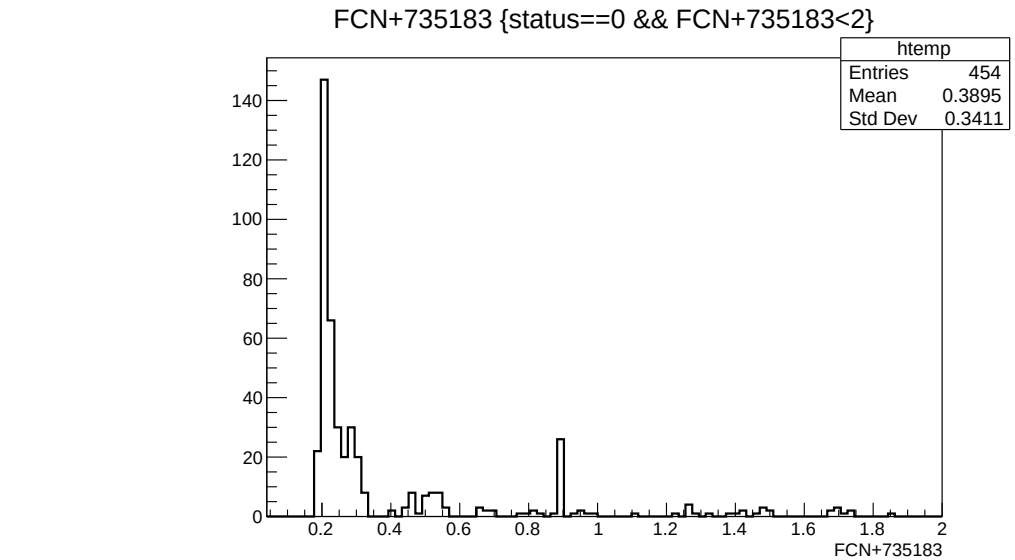


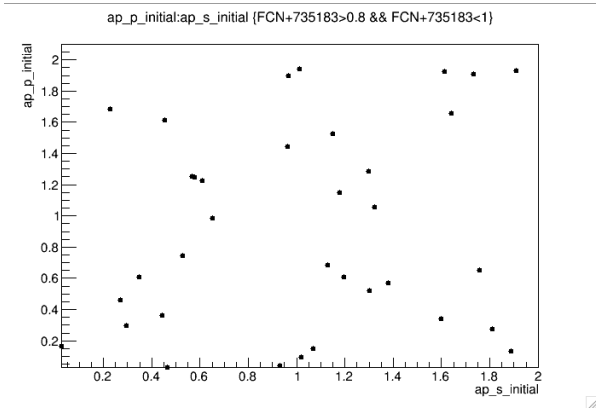
The first four bins with old configuration

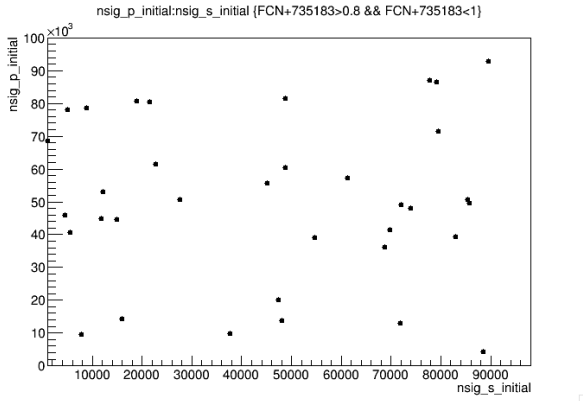


Effect of initial values

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







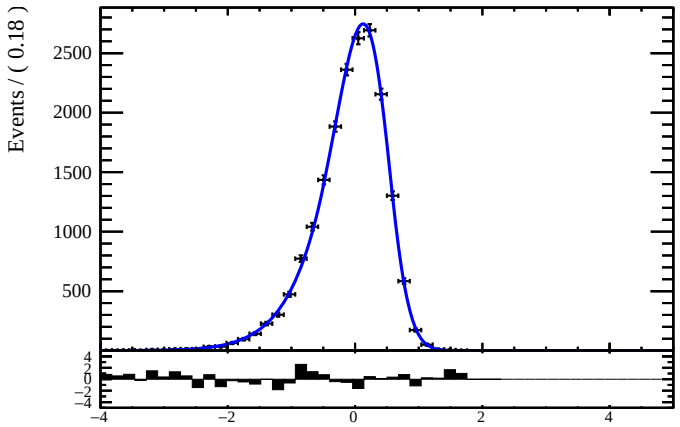
Ongoing tests

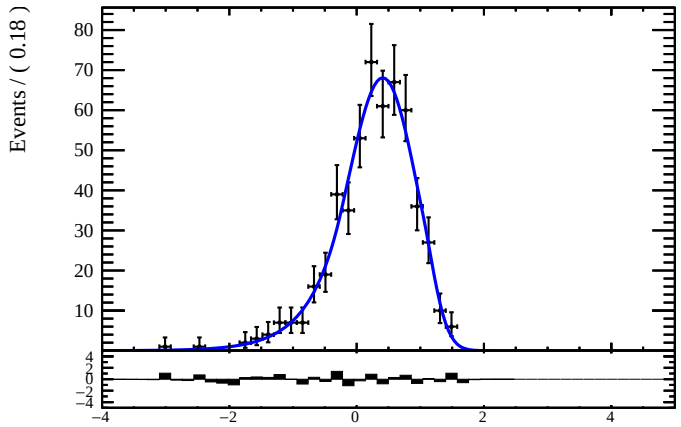
- D^0 decay time fit

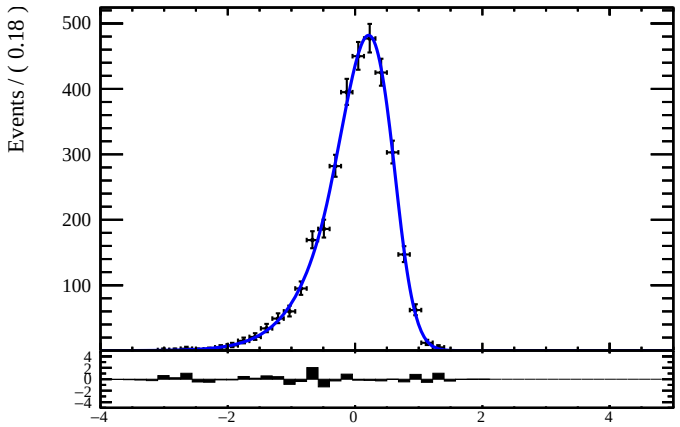
Backup

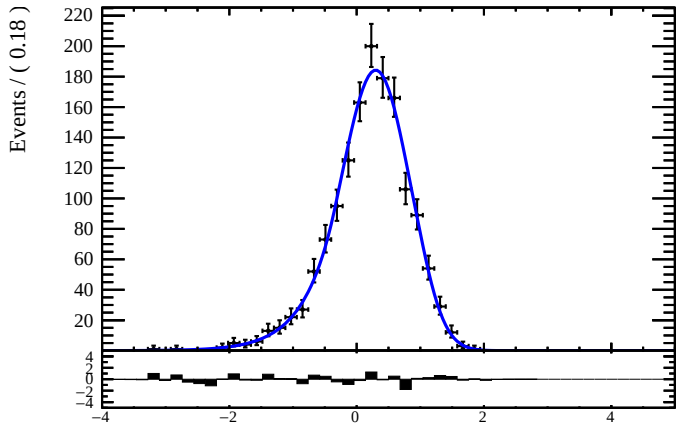
Fit with all parameters free: bin 0

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



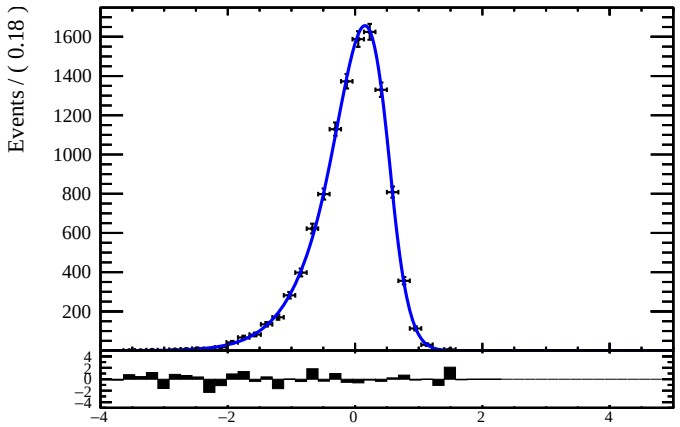


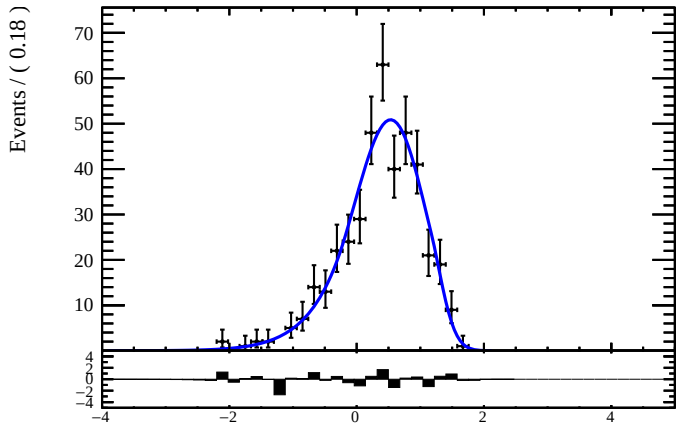


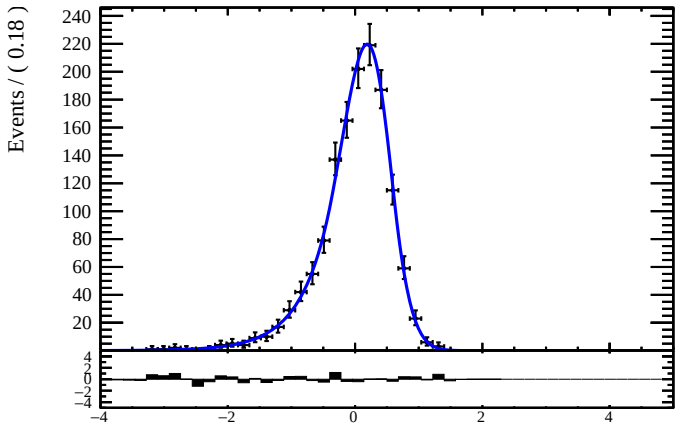


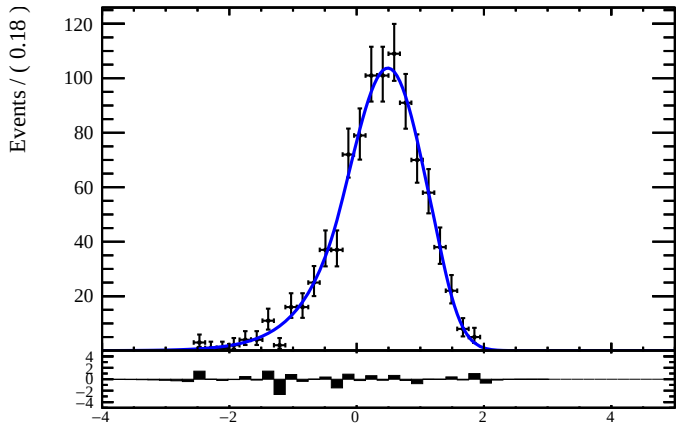
Fit with all parameters free: bin 1

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



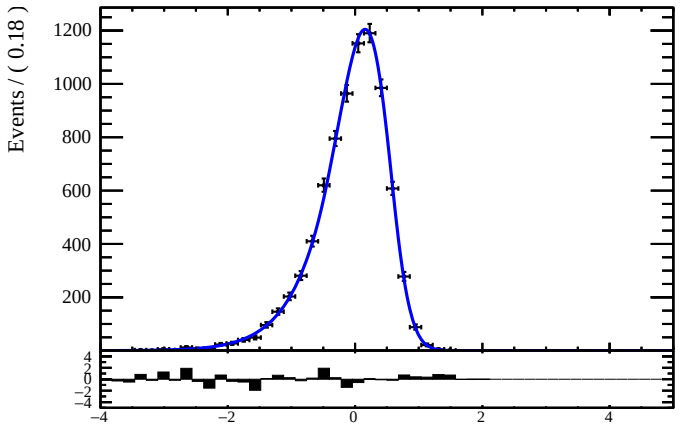


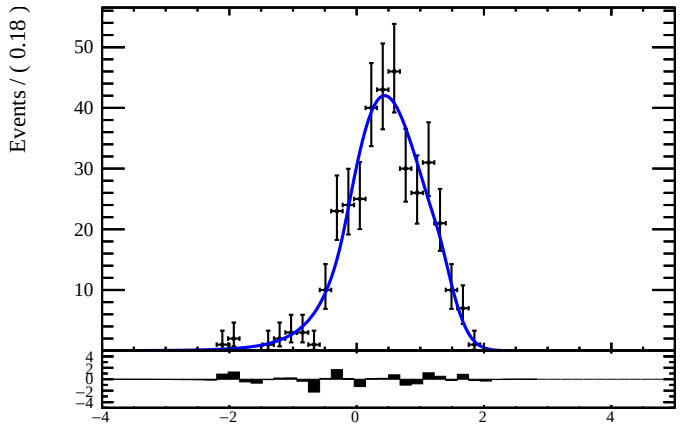


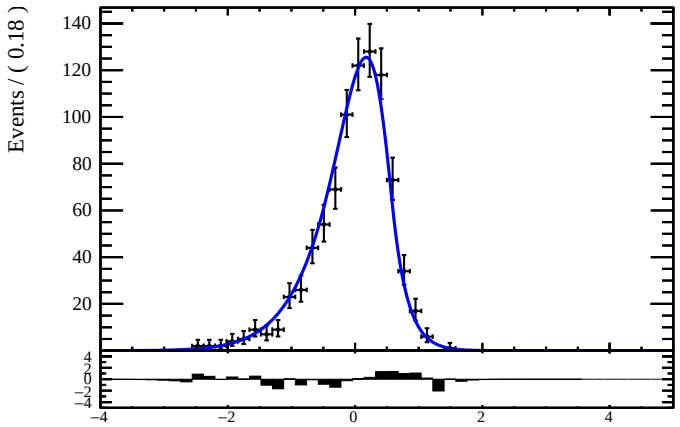


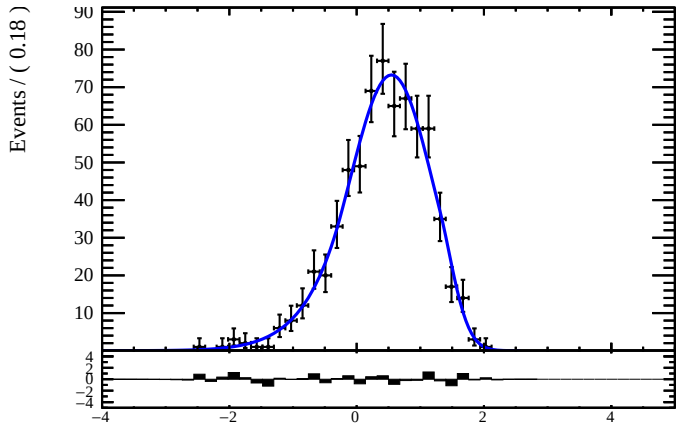
Fit with all parameters free: bin 2

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



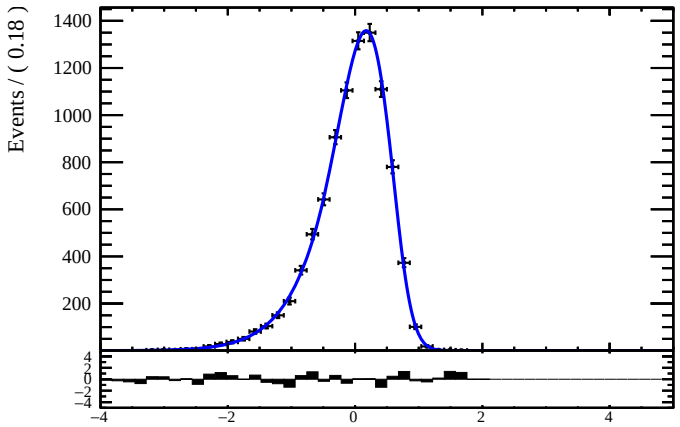


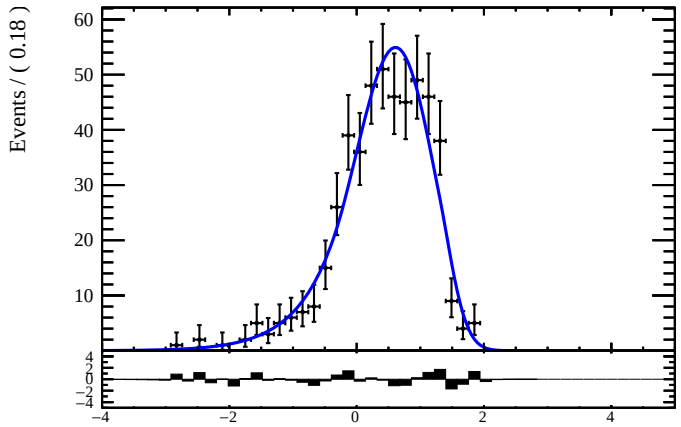


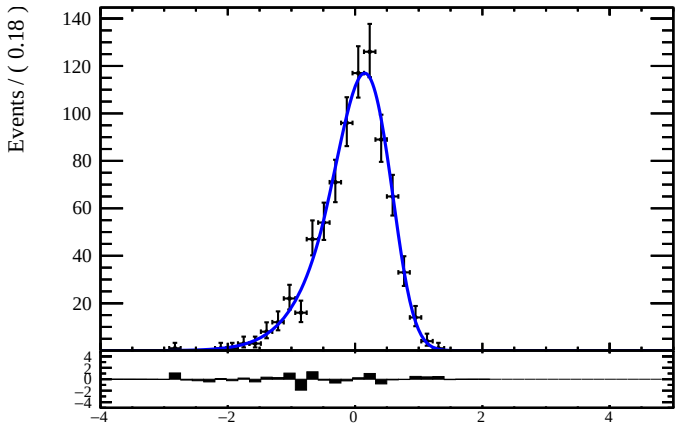


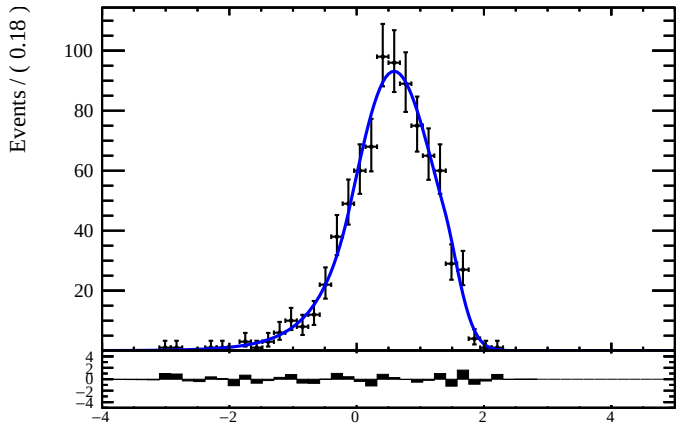
Fit with all parameters free: bin 3

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



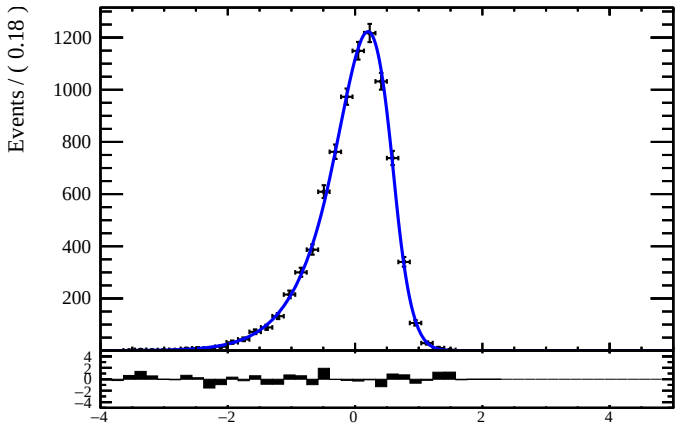


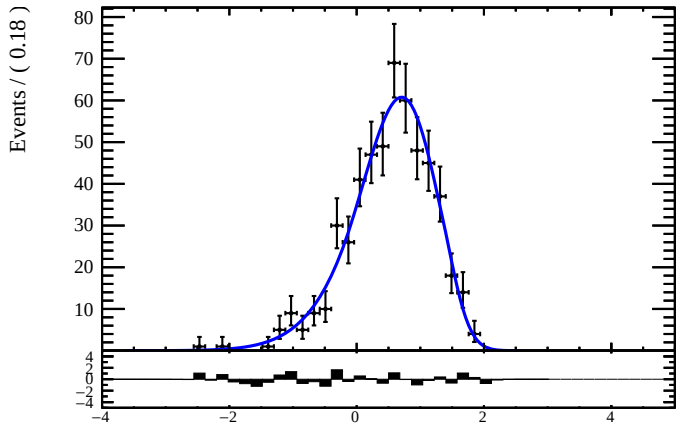


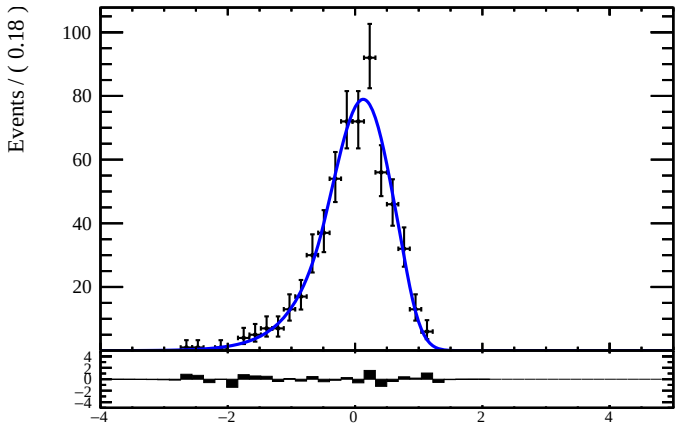


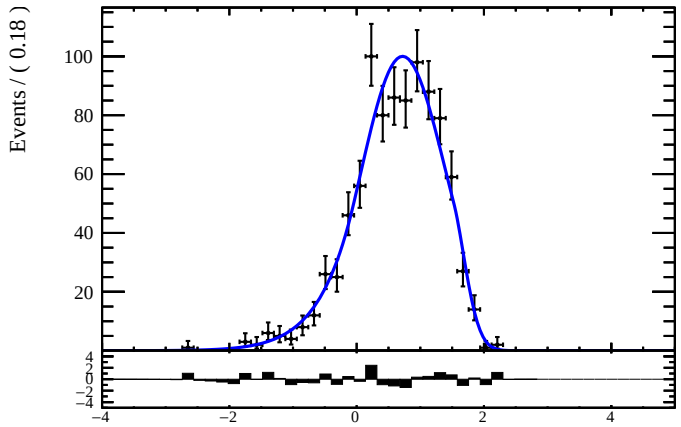
Fit with all parameters free: bin 4

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



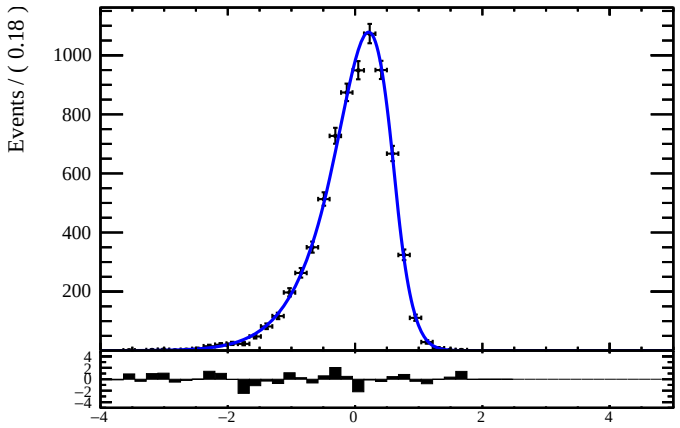


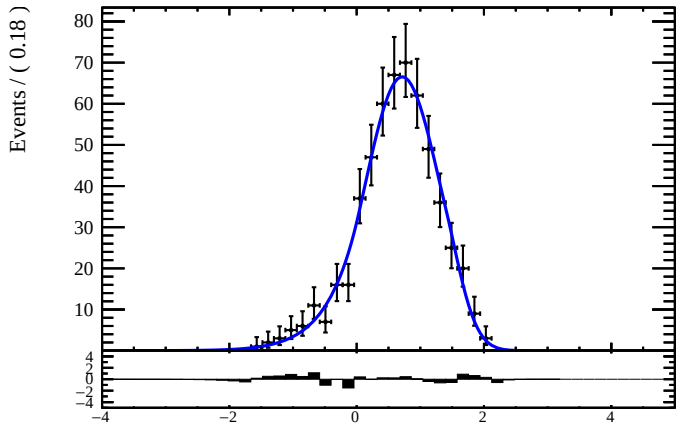


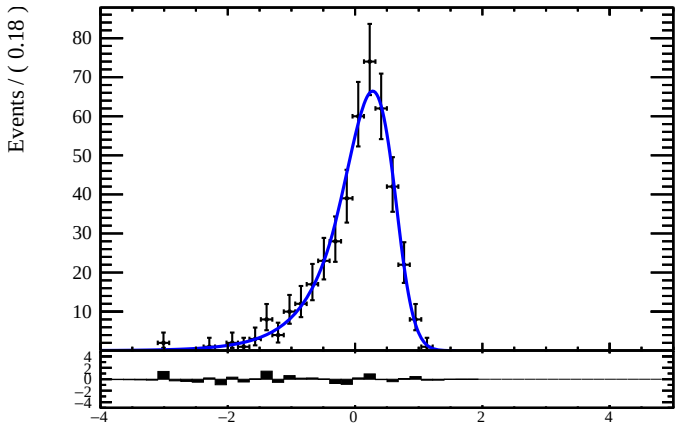


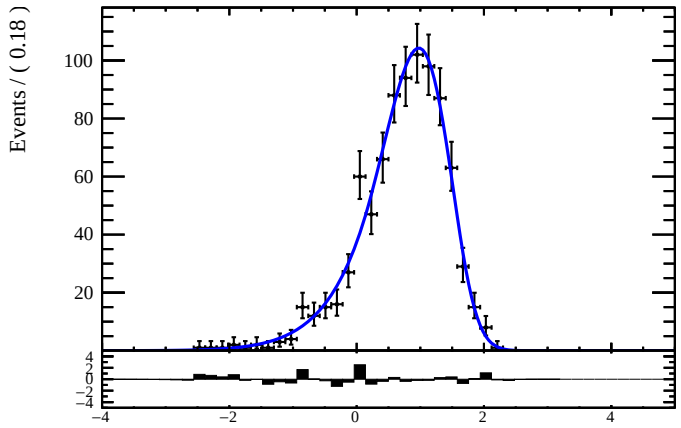
Fit with all parameters free: bin 5

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



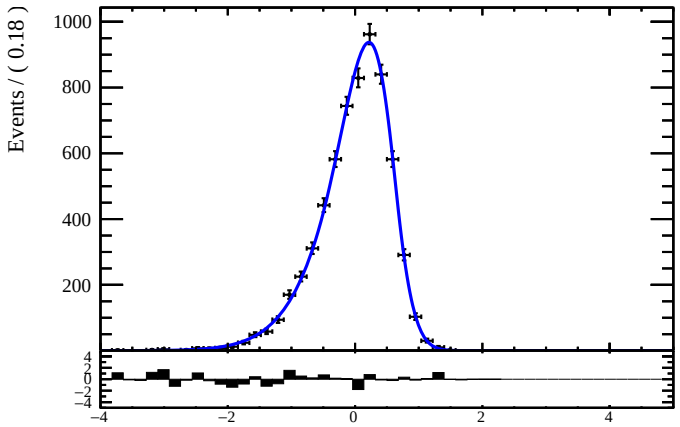


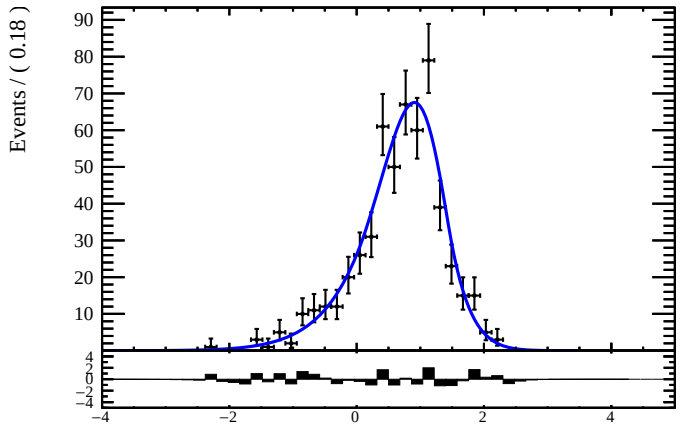


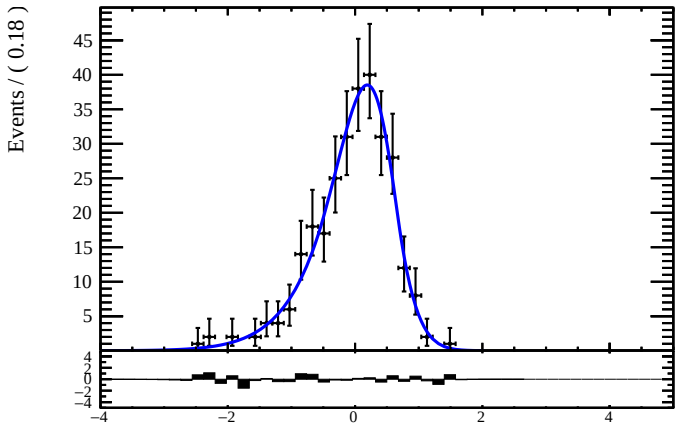


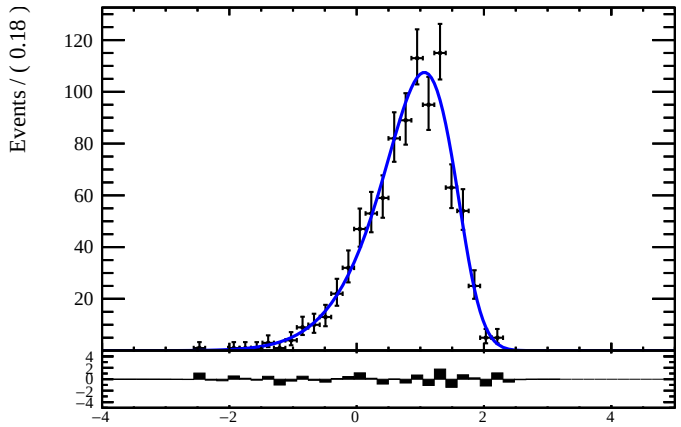
Fit with all parameters free: bin 6

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



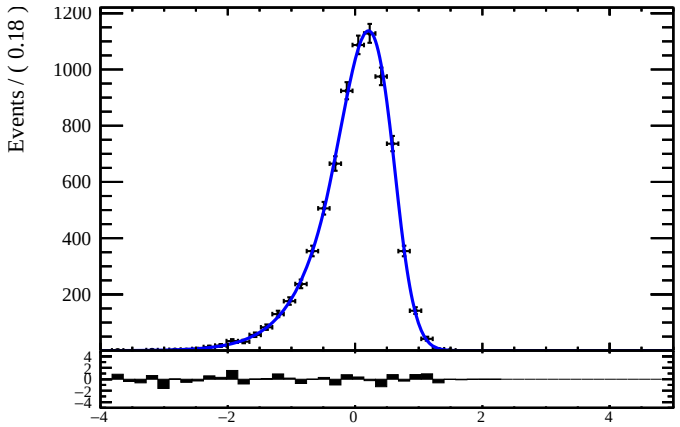


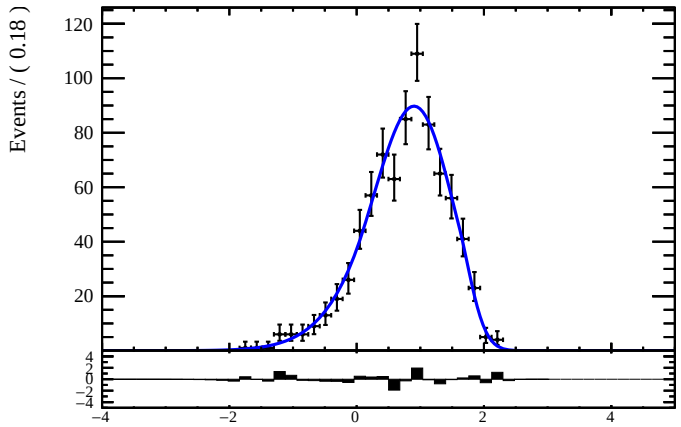


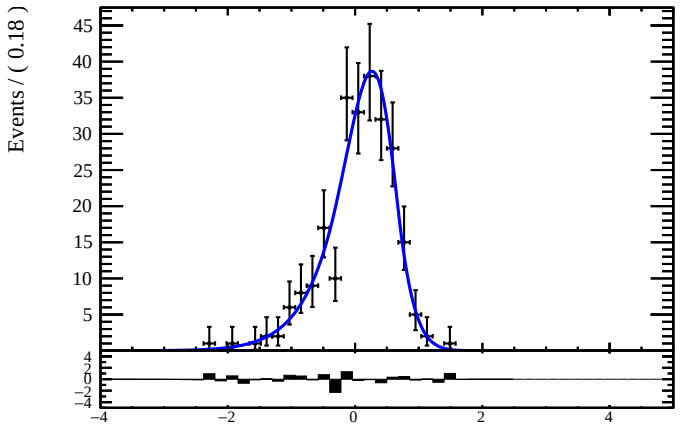


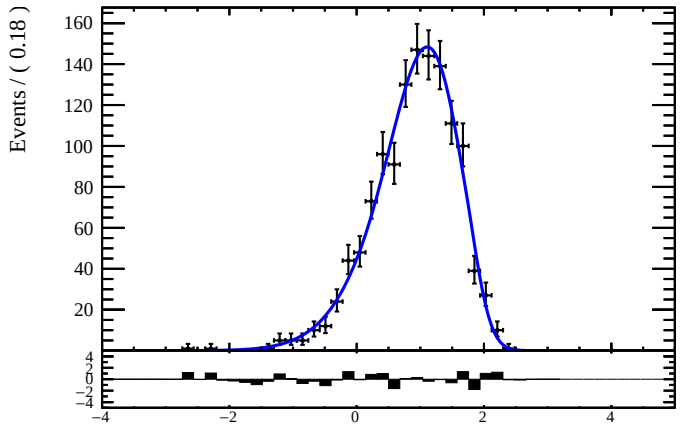
Fit with all parameters free: bin 7

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



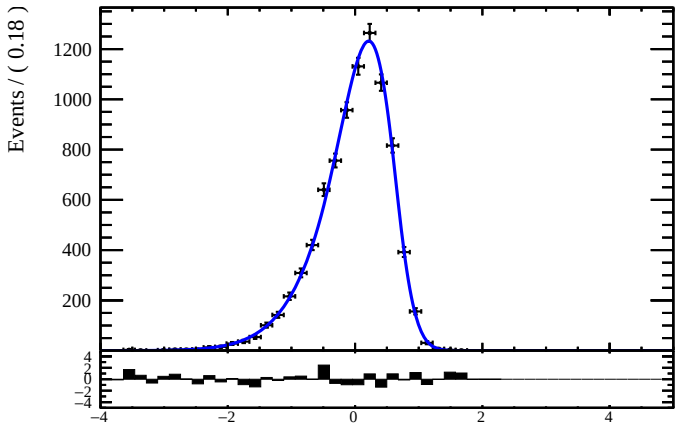


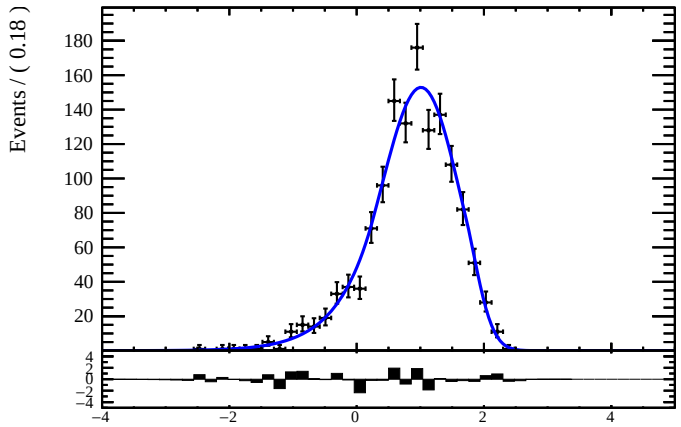


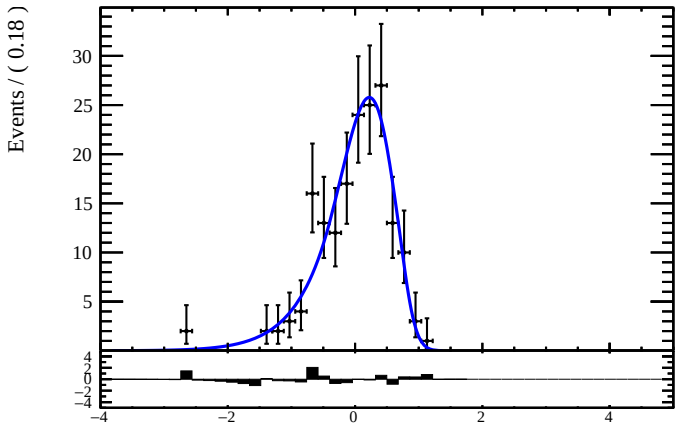


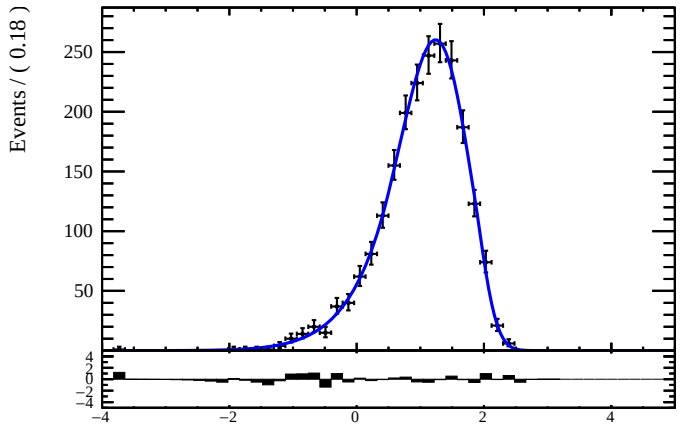
Fit with all parameters free: bin 8

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



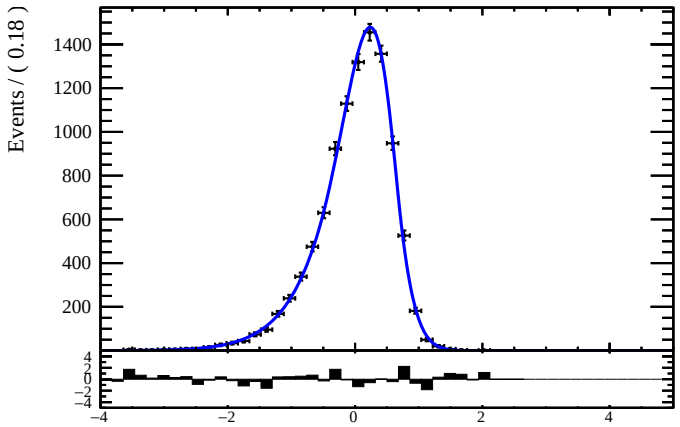


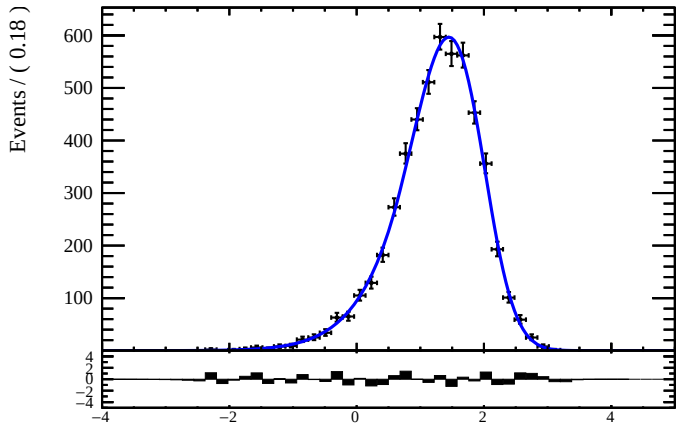


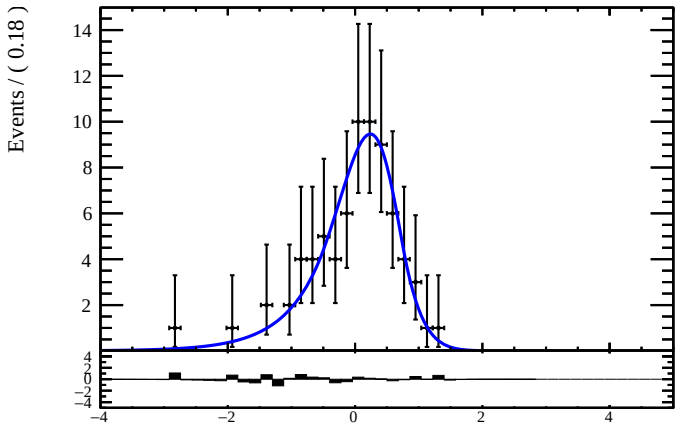


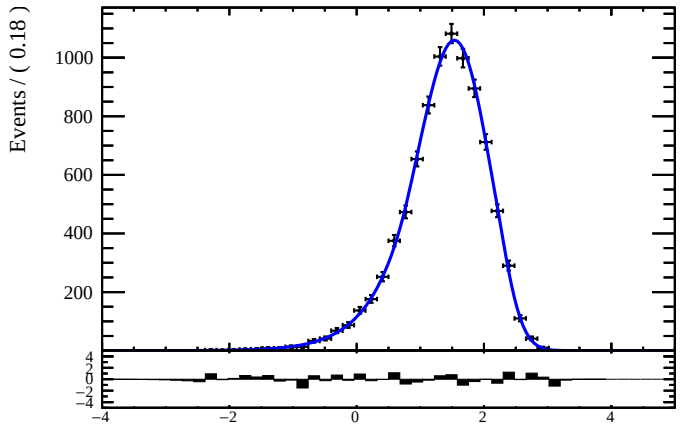
Fit with all parameters free: bin 9

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



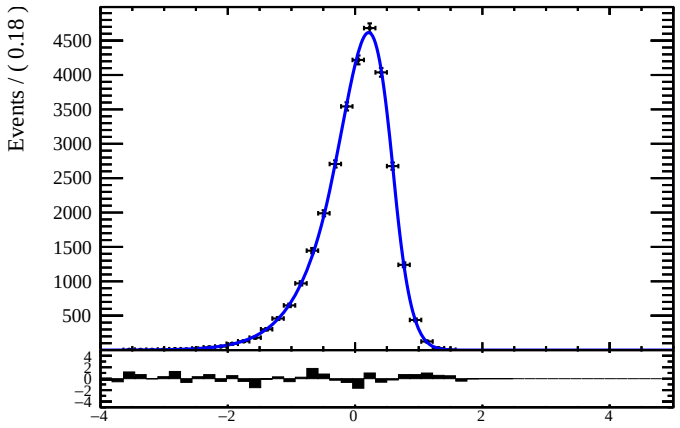


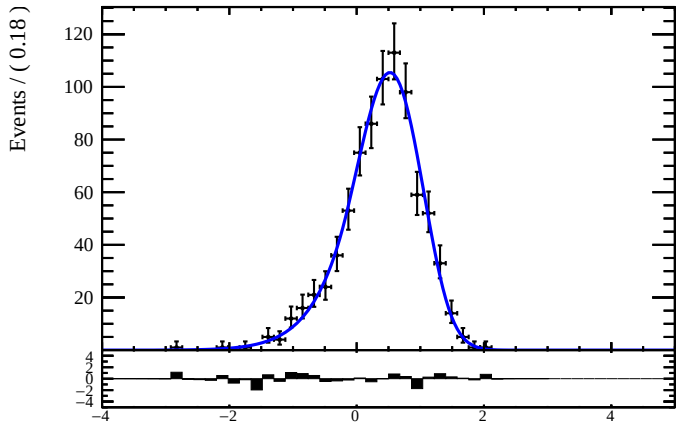




Fit D^0 MC with all parameters free: bin 0

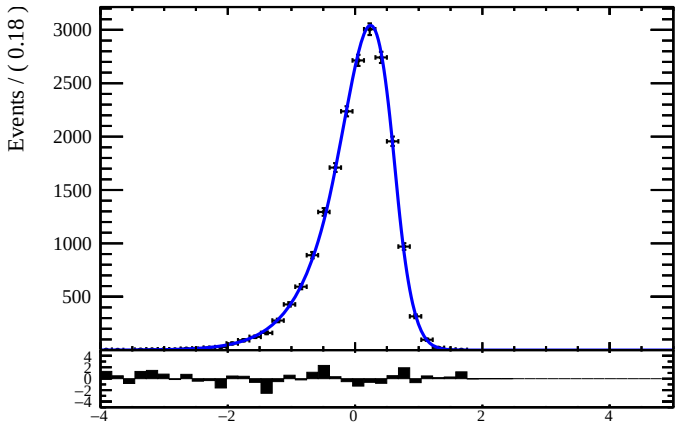
- (left) Prompt and (right) secondary

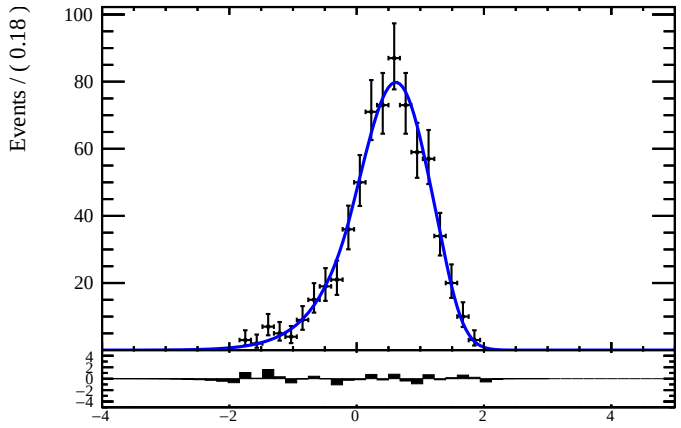




Fit D^0 MC with all parameters free: bin 1

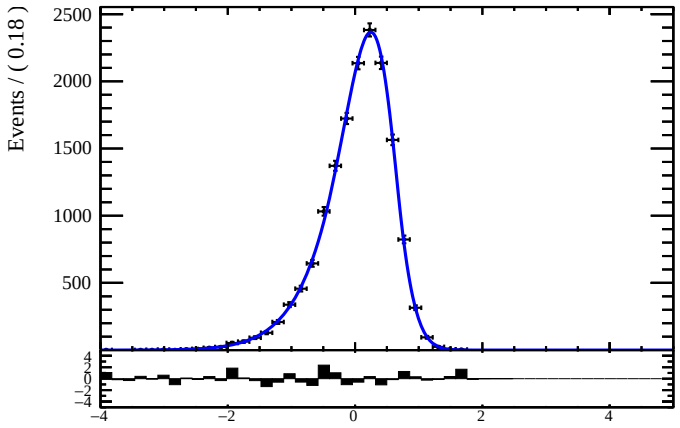
- (left) Prompt and (right) secondary

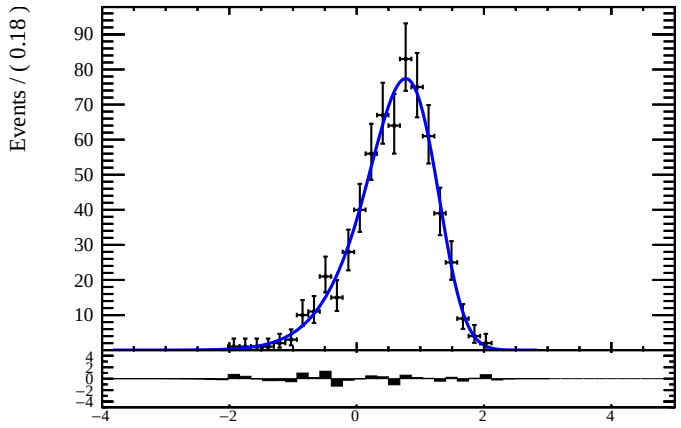




Fit D^0 MC with all parameters free: bin 2

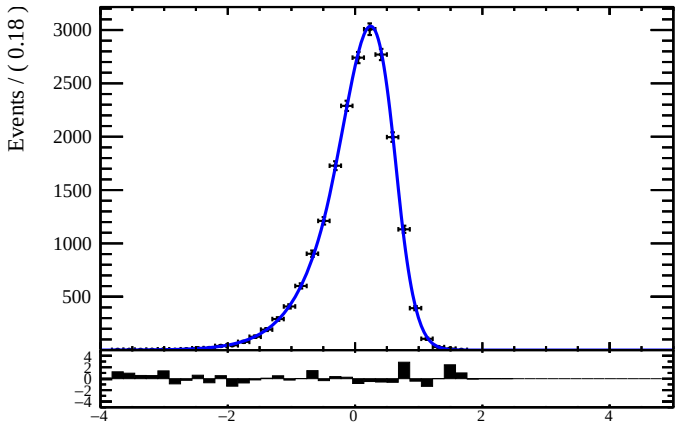
- (left) Prompt and (right) secondary

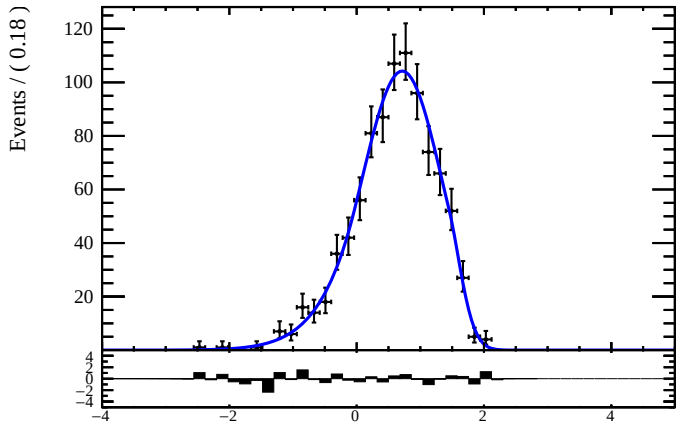




Fit D^0 MC with all parameters free: bin 3

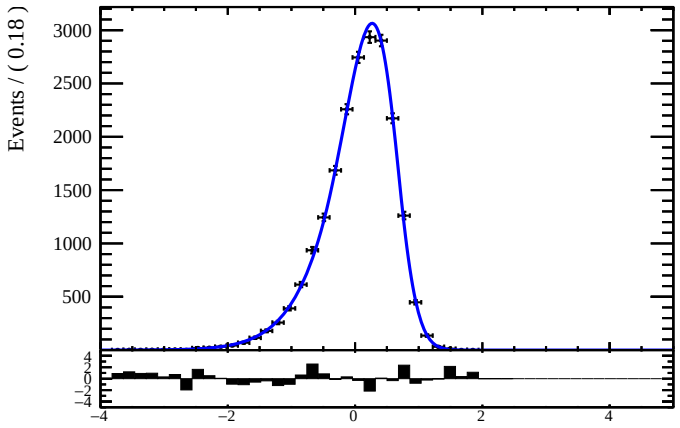
- (left) Prompt and (right) secondary

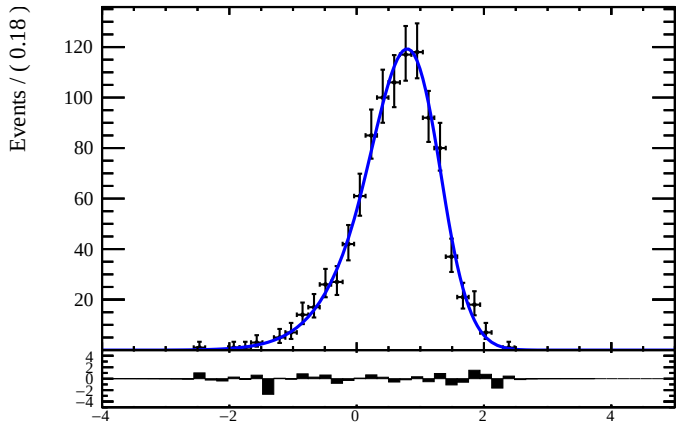




Fit D^0 MC with all parameters free: bin 4

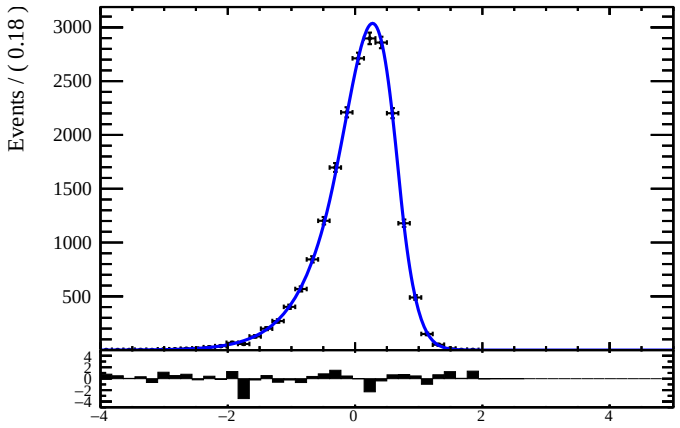
- (left) Prompt and (right) secondary

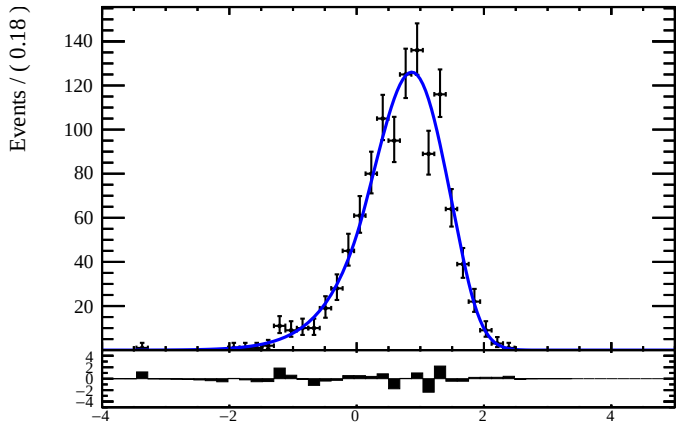




Fit D^0 MC with all parameters free: bin 5

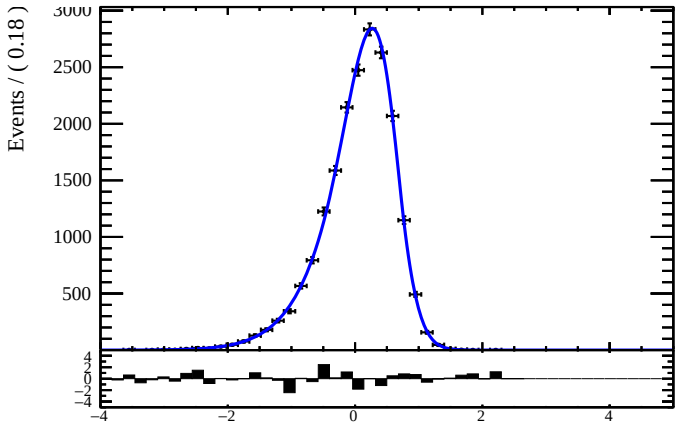
- (left) Prompt and (right) secondary

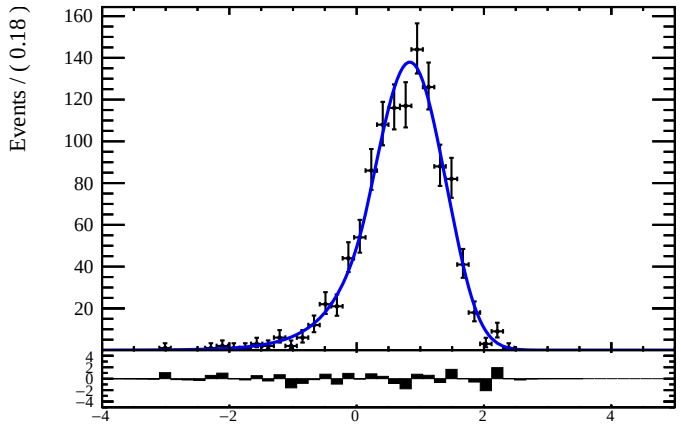




Fit D^0 MC with all parameters free: bin 6

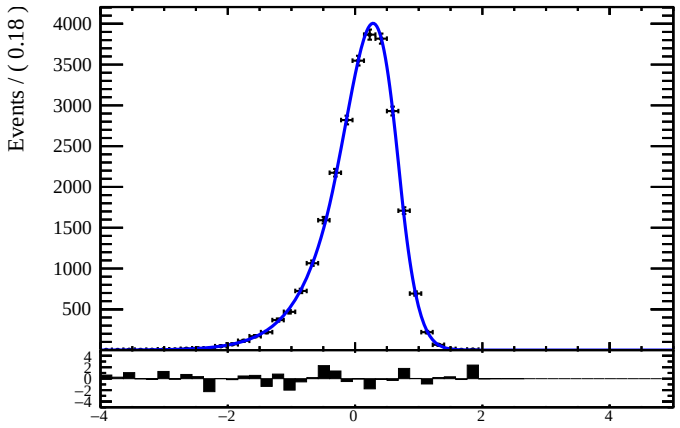
- (left) Prompt and (right) secondary

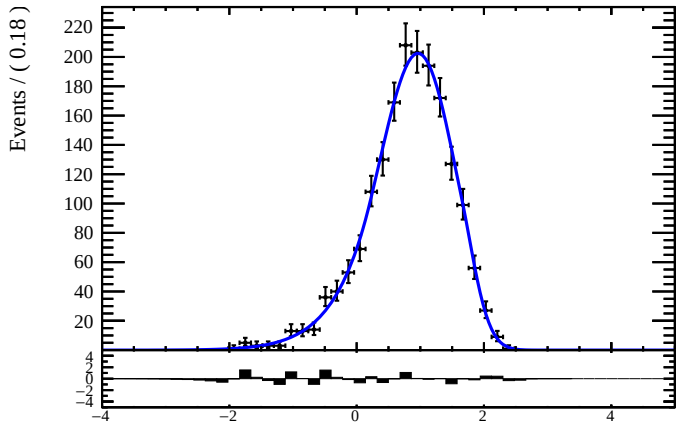




Fit D^0 MC with all parameters free: bin 7

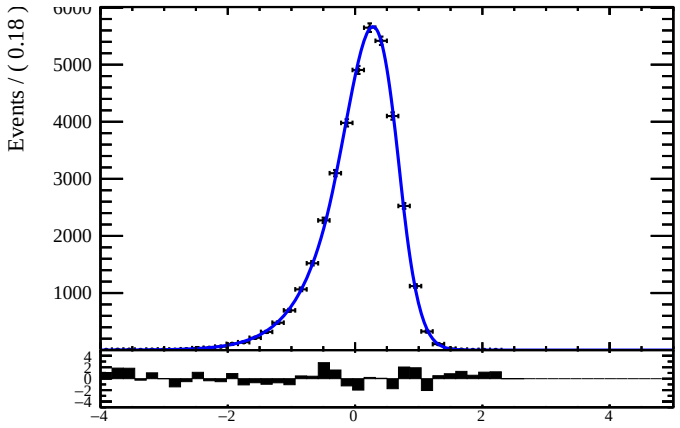
- (left) Prompt and (right) secondary

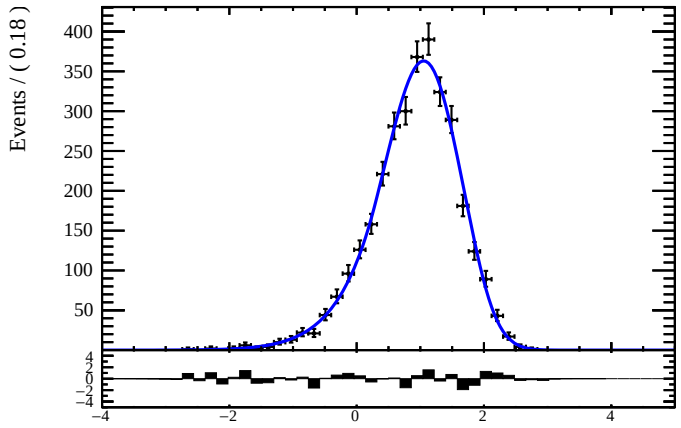




Fit D^0 MC with all parameters free: bin 8

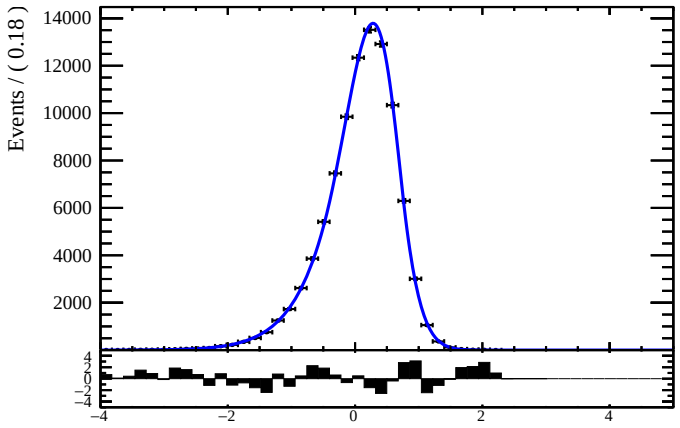
- (left) Prompt and (right) secondary

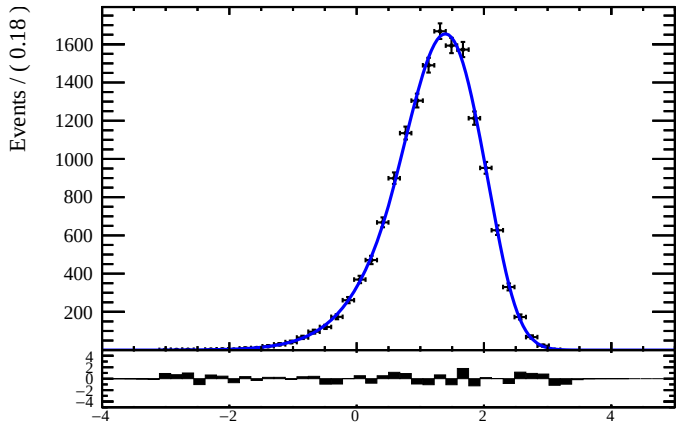




Fit D^0 MC with all parameters free: bin 9

- (left) Prompt and (right) secondary





Fit mass of D^0 data