A simultaneous analysis of $B \to D\ell\nu$ and $B \to D^*\ell\nu$ decays

M. Dorigo and M. Mantovano
(University and INFN Trieste)

TS Analysis Meeting
July 8, 2024

Recap

Last time:

- Study of $X\ell\nu$ sample composition. Find a sideband enriched of these decays.

  Split the gap modes into $D^{(*)}\pi\pi\ell\nu$ and $D^{(*)}\eta\ell\nu$ templates.

- Split the “real D” background to constrain better the sub-components in the sideband region (inclusive D decays, fake leptons, secondary...).

- Test a simultaneous fit between the electron and muon samples in the sideband region to constrain the $X\ell\nu$ and real D components.

Presented these results at the last SL meeting [talk@SLmeeting].

Sideband region

Found a $cos\theta_{BY}$ sideband region [-12,-3] to validate these decays.

Divided the $X\ell\nu$ component in different sub-components:

1. $D_1\ell\nu$
2. $D_1^{'}\ell\nu$
3. $D_0^*\ell\nu$
4. $D_2^*\ell\nu$
5. $D^{(*)}\pi\pi\ell\nu$
6. $D^{(*)}\eta\ell\nu$

gap modes

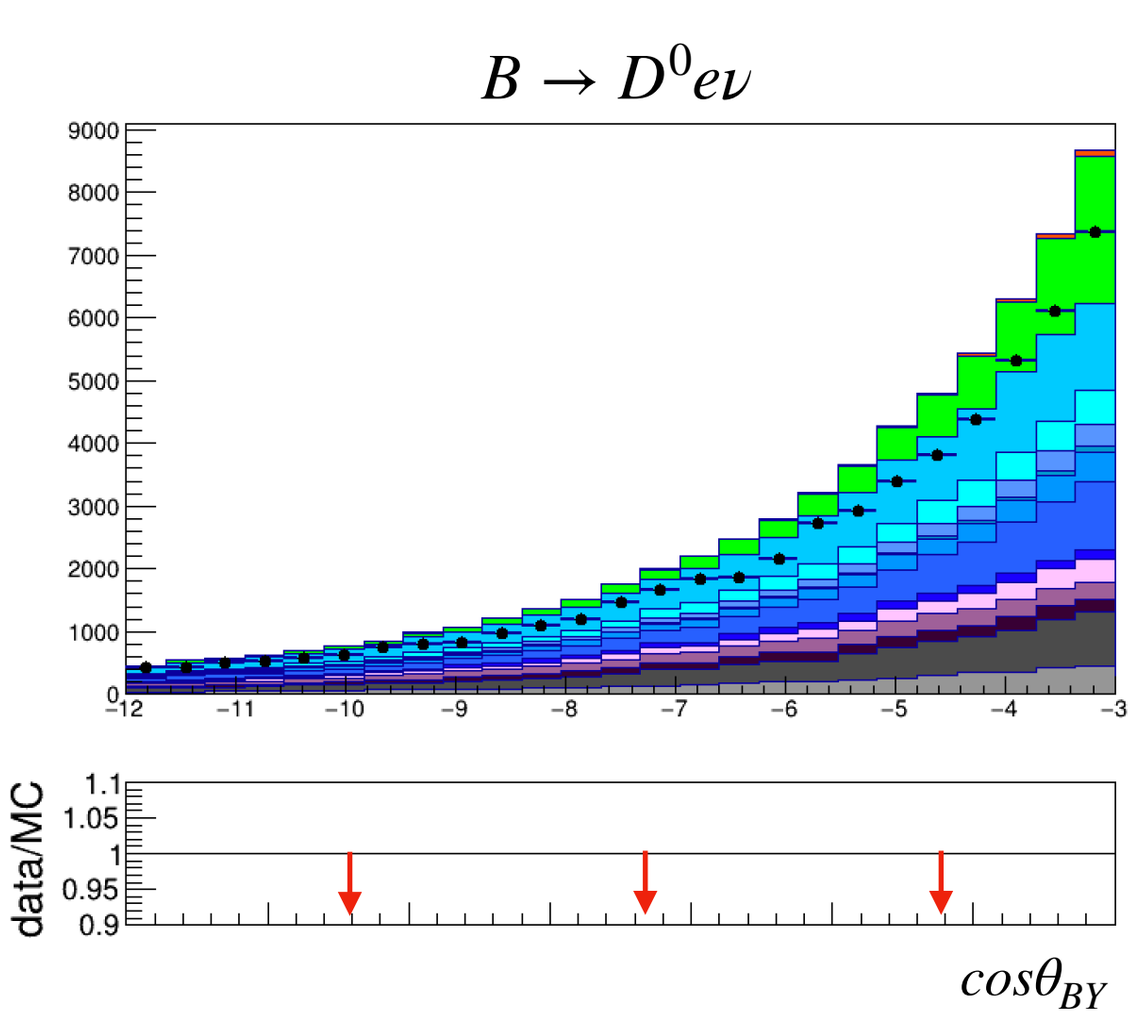
7. $X\ell\nu(rest)$ | $D^{(**)}\tau\nu, D^{(*)}\ell\nu$, ℓ= misID lepton

Real D → divided in three sub-components

fake D
continuum | Take from off-res data and InvM(D) sideband

$D\ell\nu$
$D^*\ell\nu$ | signal

enriched $X\ell\nu$ decays in the $cos\theta_{BY}$ sideband



Data/MC disagreement observed in the $cos\theta_{BY}$ sideband.

Fit results

The simultaneous fit returns the following results:

$\chi^2 = 103.6, dof = 388$

Fit parameters	Constraints	Fit results	Pulls	Fitted/Expected
$\mathcal{B}(B \to D_1 \ell \nu)$	(0.64 +- 0.10)%	(0.73 +- 0.08)%	-0.9	1.15
$\mathcal{B}(B \to D_1^{'} \ell \nu)$	(0.28 +- 0.04)%	(0.29 +- 0.04)%	-0.25	1.03
$\mathcal{B}(B \to D_0^{*} \ell \nu)$	(0.13 +- 0.03)%	(0.13 +- 0.03)%	0	1.05
$\mathcal{B}(B \to D_2 \ell \nu)$	(0.32 +- 0.03)%	(0.33 +- 0.03)%	-0.33	1.03
$\mathcal{B}(B \to D^{(*)} \pi\pi \ell \nu)$	(0.30 +- 0.13)%	(0.25 +- 0.08)%	0.38	0.85
$\mathcal{B}(B \to D^{(*)} \eta \ell \nu)$	(1.80 +- 1.80)%	(0.19 +- 0.12)%	0.89	0.11

Data returns a smaller BR values for the gap modes, in particular for $D^{(*)}\eta\ell\nu$ decays.

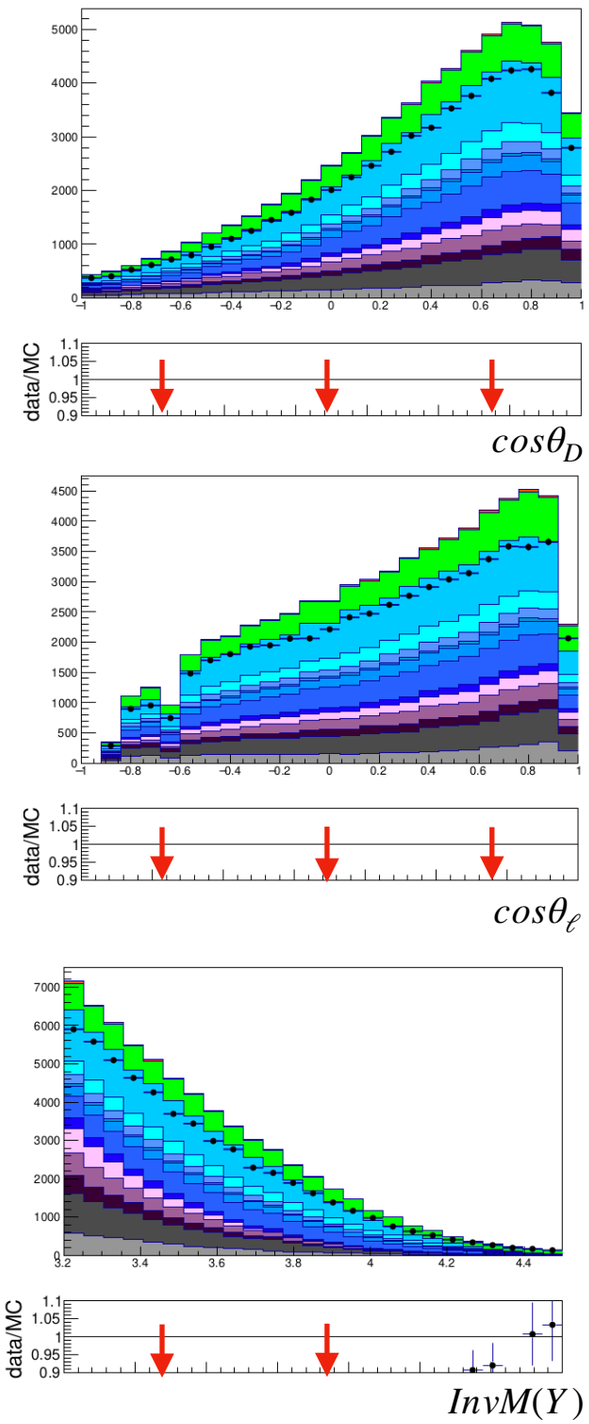
Use the fit results to scale the D^{**} and real D components.

Data/MC agreement: $D^0 e\nu$ sample

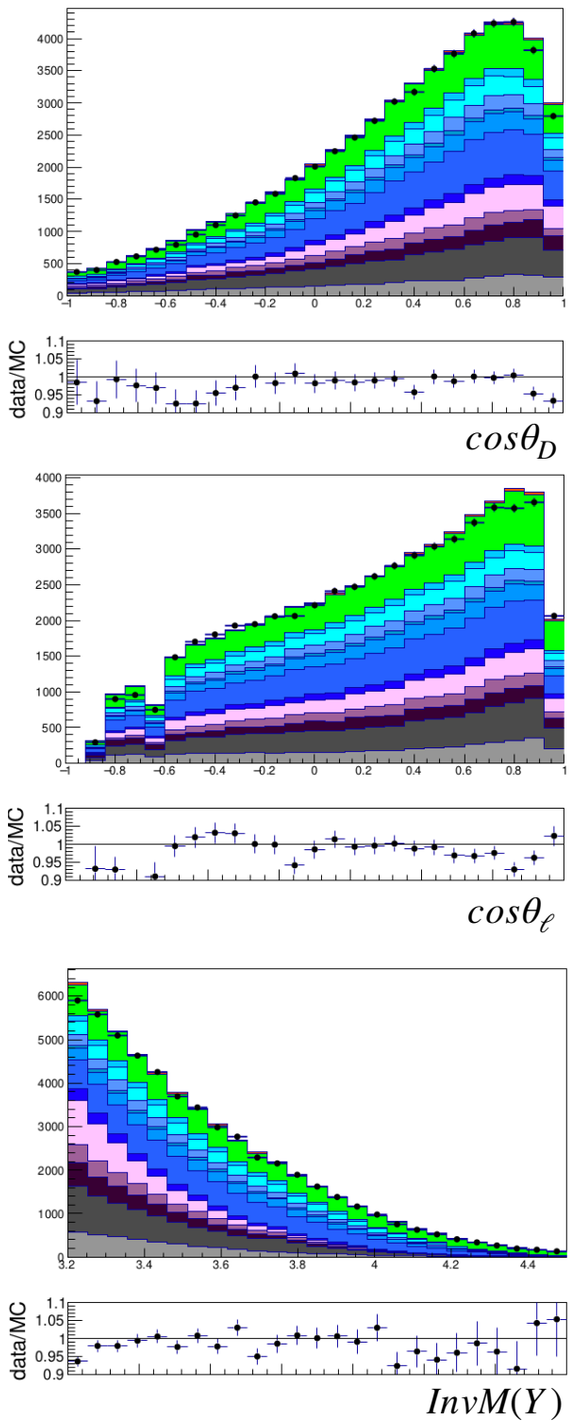
Other comparisons in backup

Check data/MC agreement after scaling D^{**} and real D components according to the fit results.

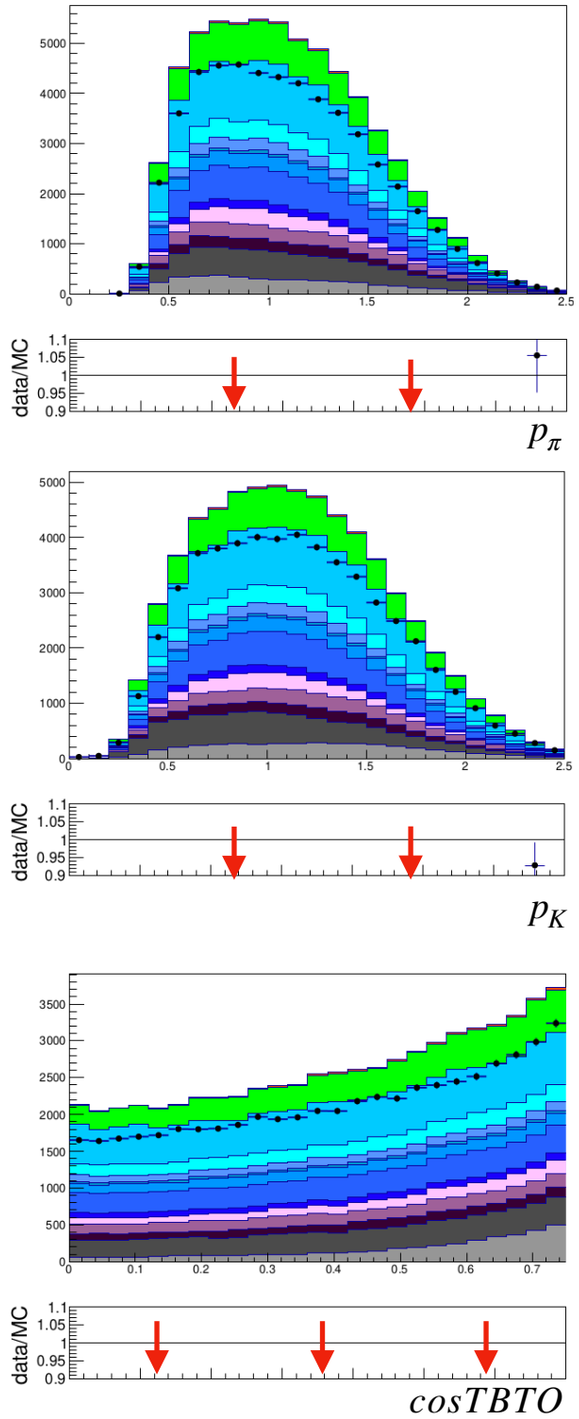
Before



After



Before



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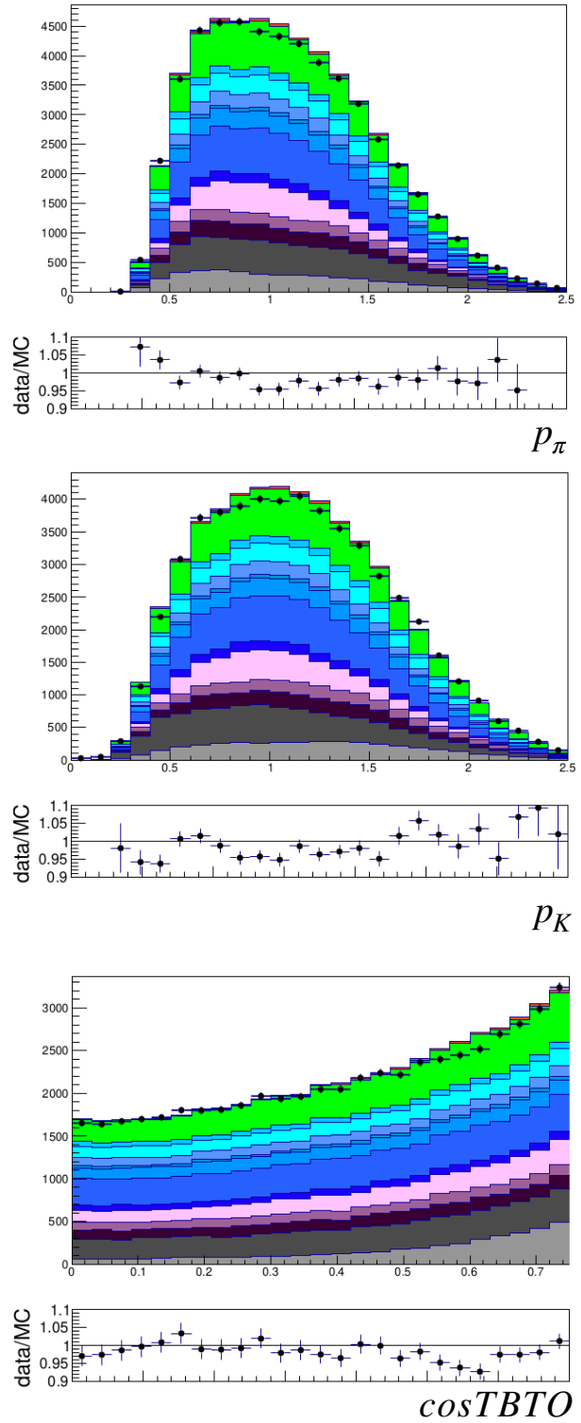


Data/MC agreement improves after scaling D^{**} and real D components.

Next steps from last time

- Rescale $X\ell\nu$ and real D background using these sideband-fit results and check the data-MC agreement of several distributions (but fit variables) in the signal region (done).

- Consider either to make a simultaneous fit of the signal and sideband regions (ongoing) or to use sideband-fit results in the signal-region fit. (done: it works but the data/MC disagreement in $(p^*_D, p^*_\ell, cos\theta_{BY})$ is still there → focus on this).

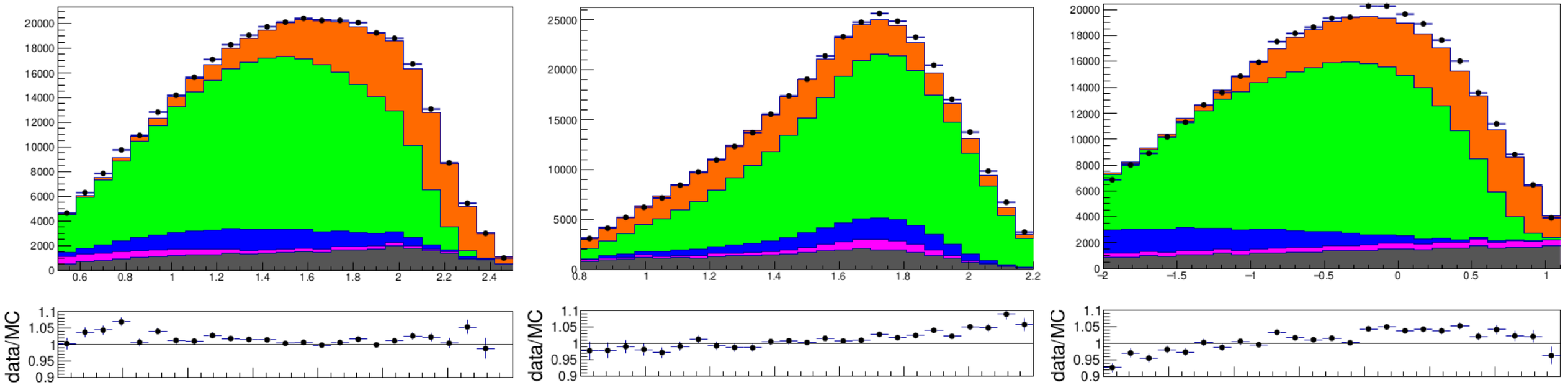
- Redo simulation/toys studies with new sample composition (following latest improvements) to confirm all previous results (e.g. unbiased estimates) for form-factors, V_{cb}, BR, f_{+-}/f_{00}. (To do)

- Start working on systematic uncertainties. (To do)

Data/MC agreement

Data/MC agreement: fit variables

The greatest data/MC disagreement is observed for the $D^0 e\nu$ sample.



p_D^* p_ℓ^* $cos\theta_{BY}$

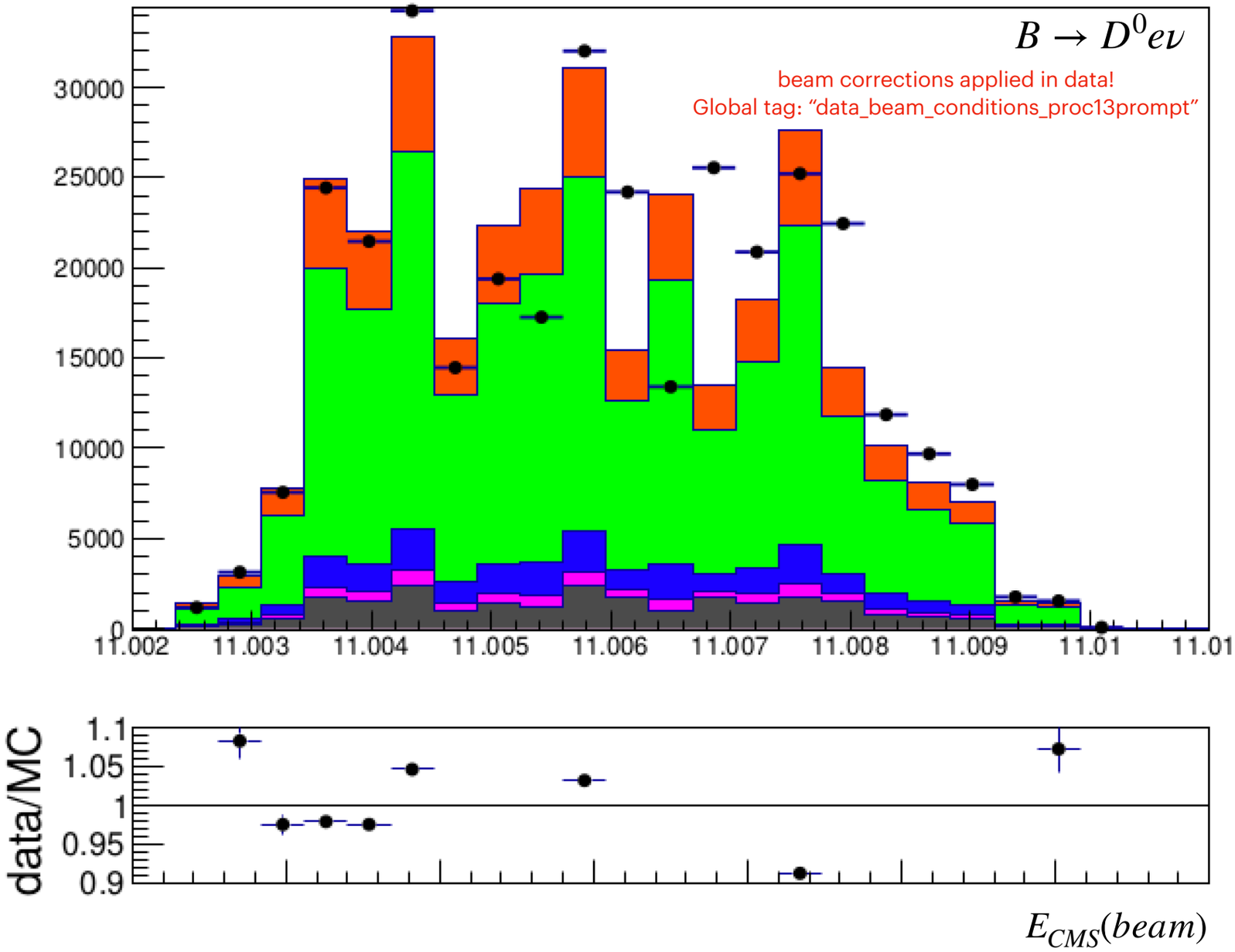
Last month, I investigated a lot the possible causes of this disagreement w/o finding any solution. Since all these variables are correlated each others, I focus on $cos\theta_{BY}$ in which the disagreement is more evident.

$$cos\theta_{BY} = \frac{2E_B^* E_{D\ell}^* - m_B^2 - m_{D\ell}^2}{2|\vec{p}_B^*||p_{D\ell}^*|}$$

$E_B^* = E_{CMS}(beam)/2$

Could the disagreement be due to the $E_{CMS}(beam)$?

Data/MC agreement: E_{CMS}

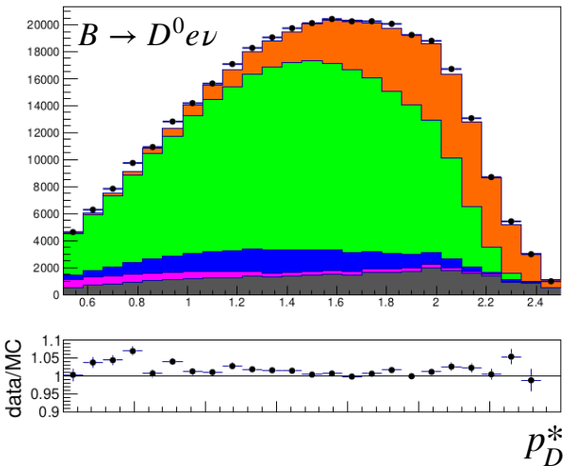


Observed a large data/MC disagreement.

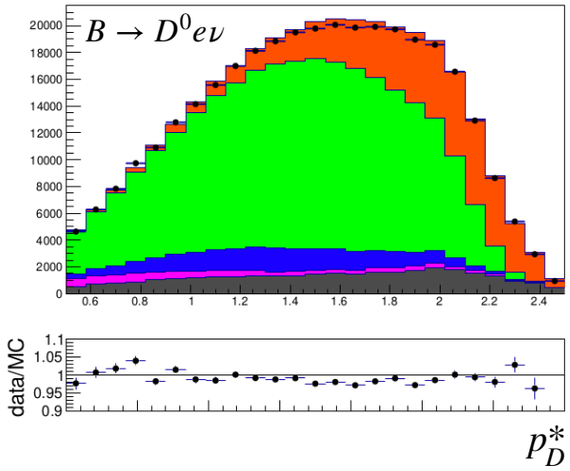
Reweight the fit variables according to the weights from $E_{CMS}(beam)$ distribution.

Data/MC agreement: fit variables

Before



Reweight



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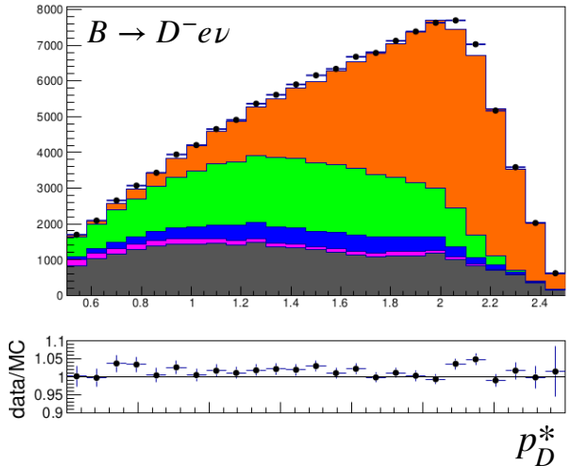

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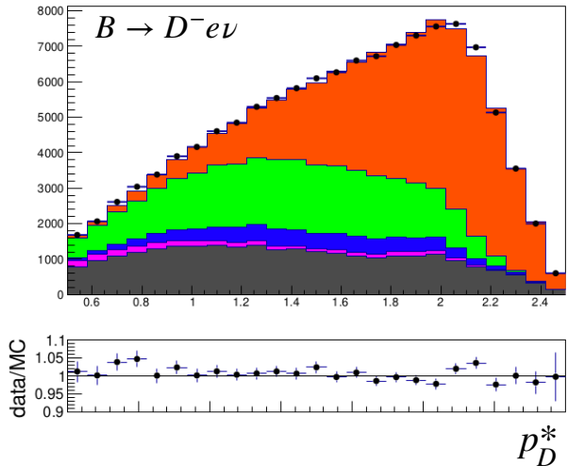
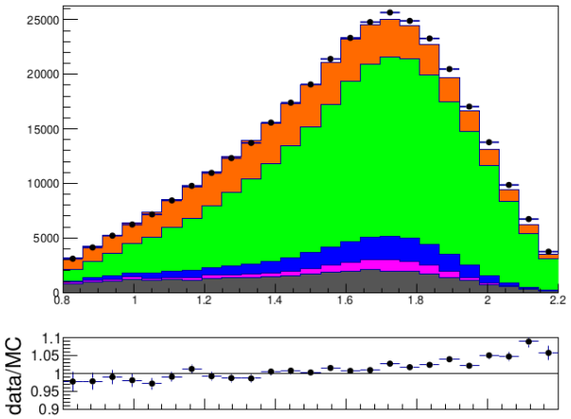
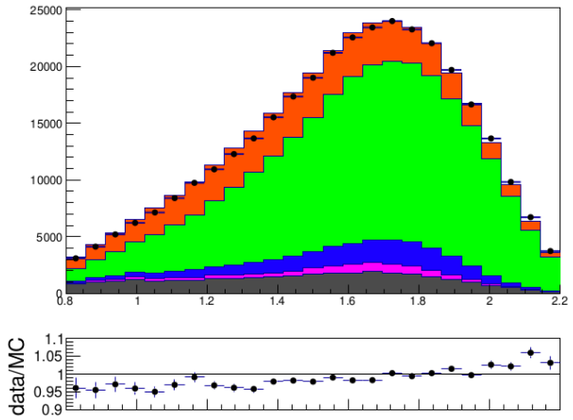
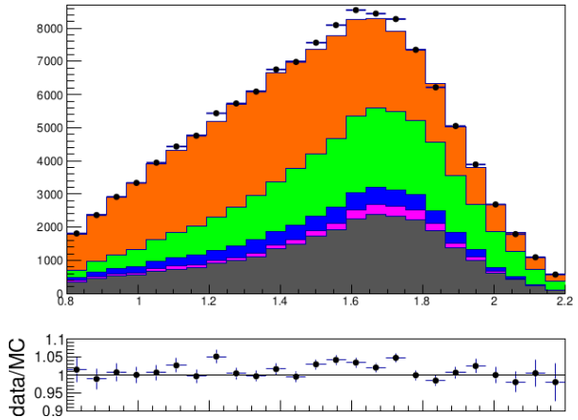
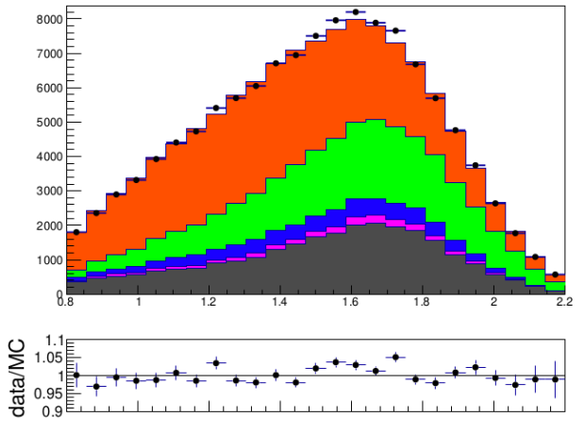
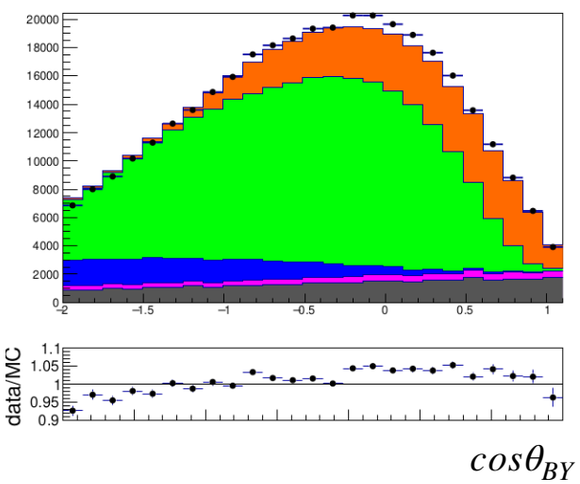


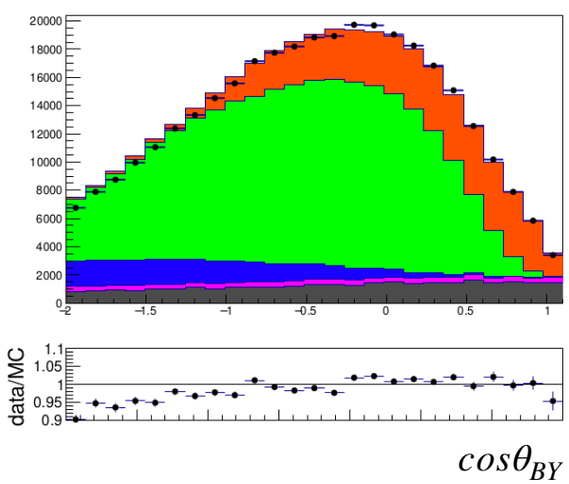


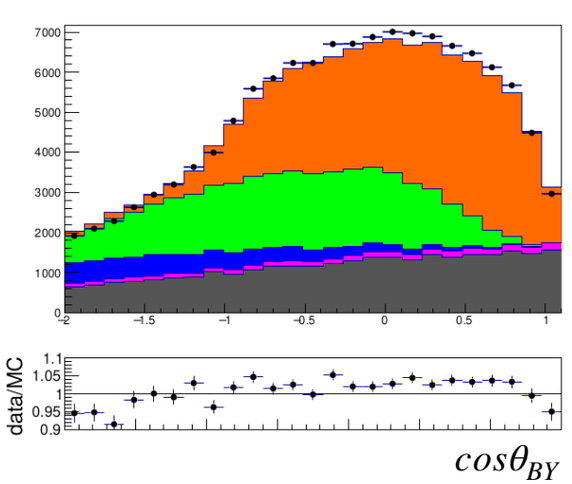


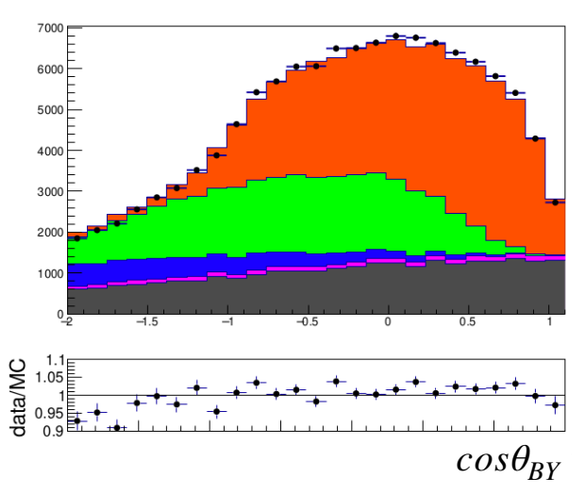






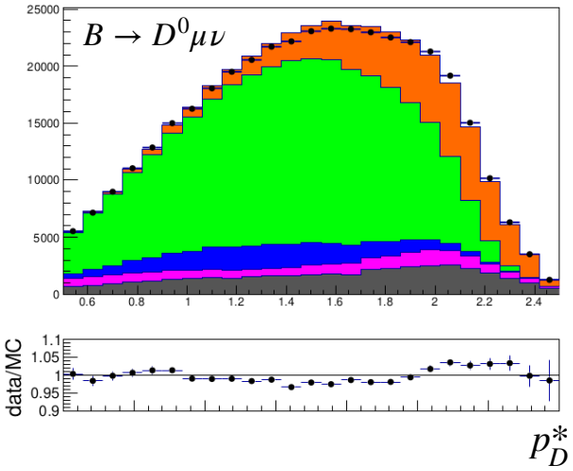




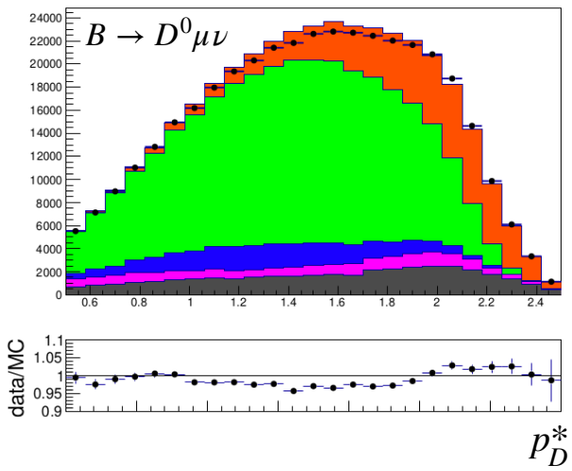


Data/MC agreement: fit variables

Before



Reweight



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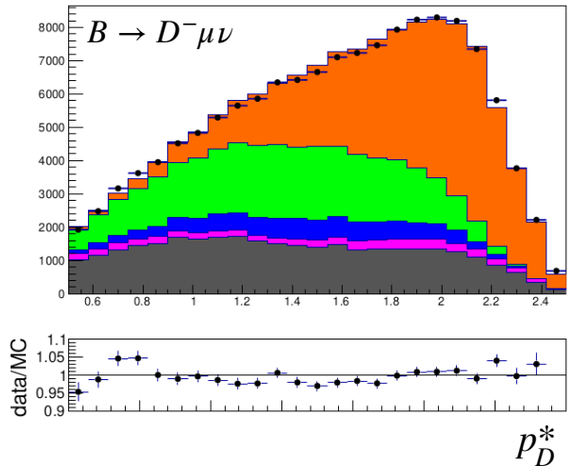

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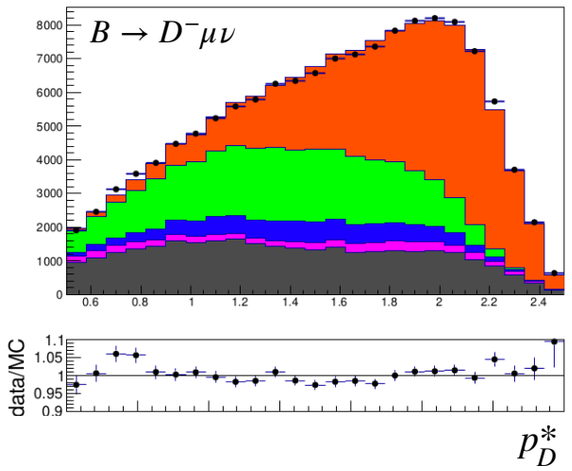
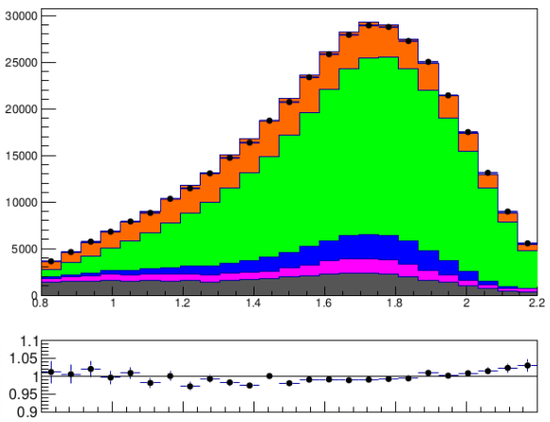
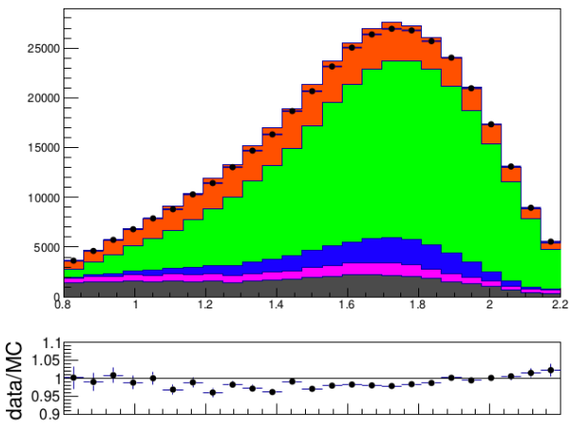
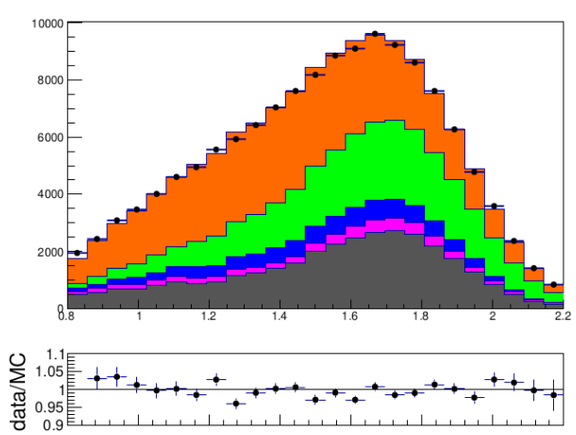
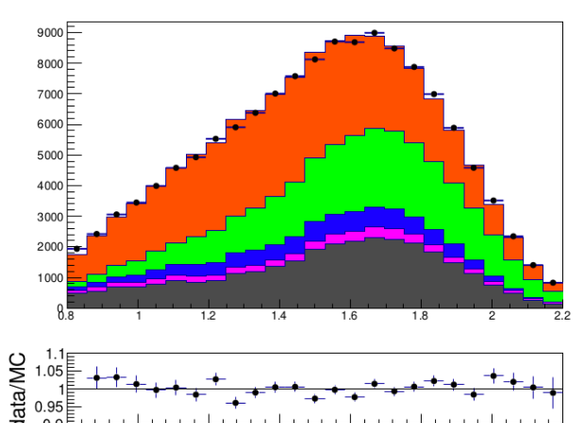
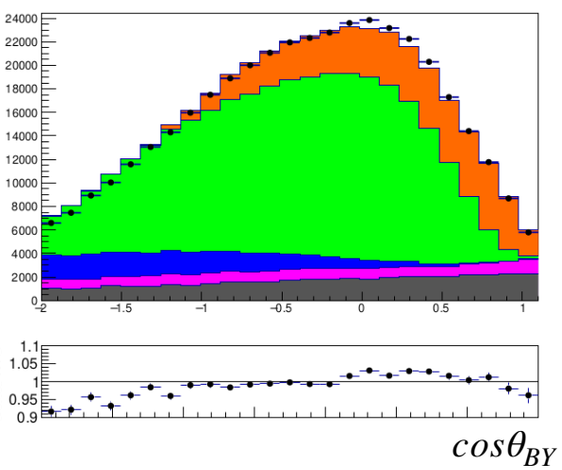


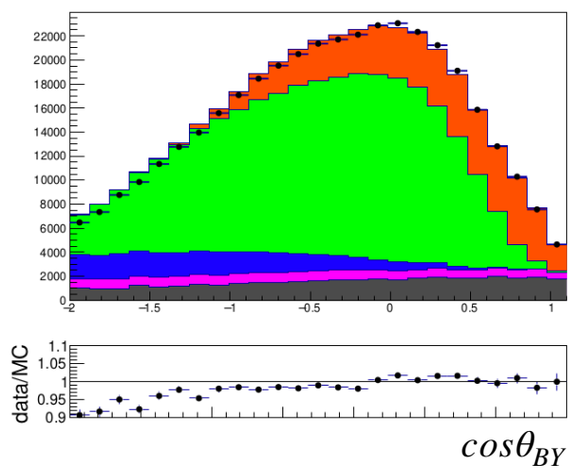


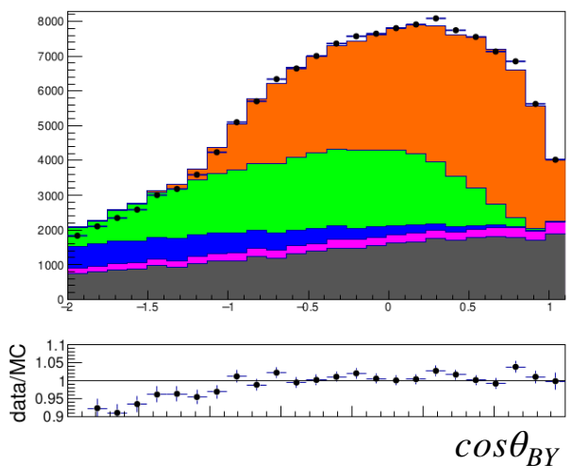


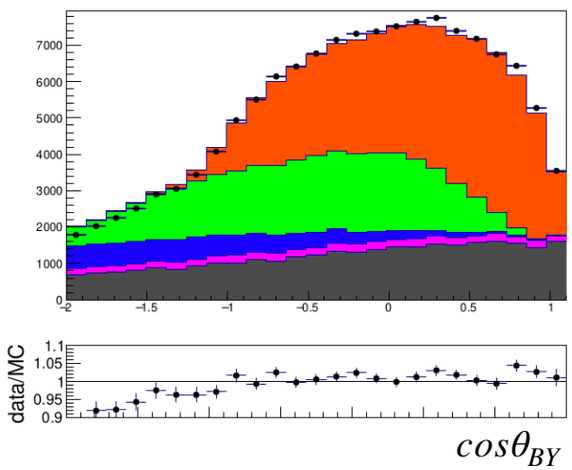






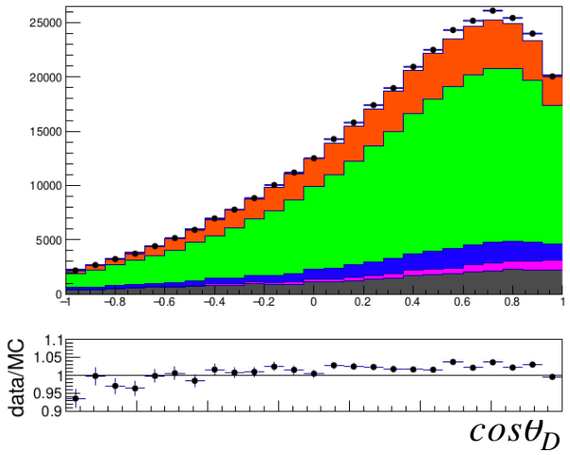




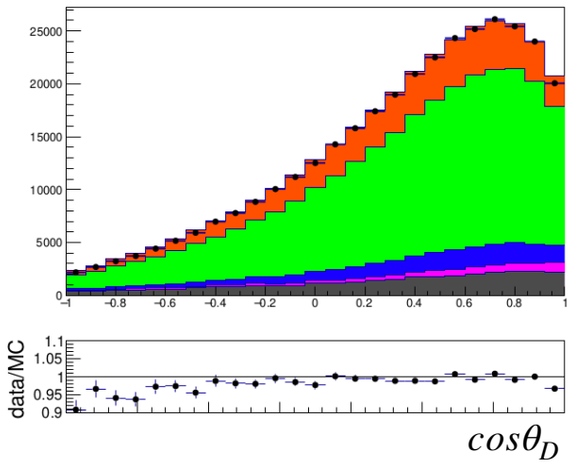


Data/MC agreement: $D^0 e\nu$ sample

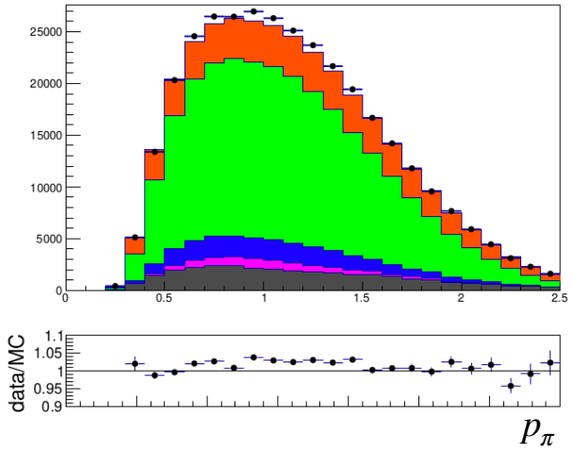
Before



Reweight



Before



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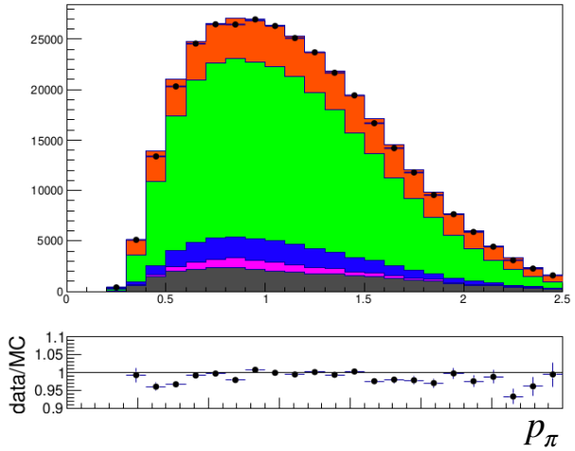
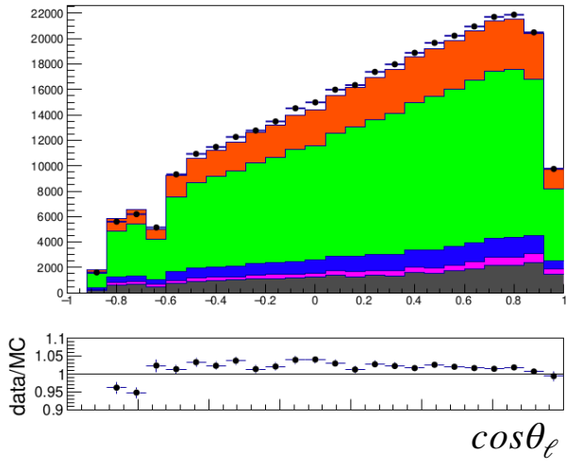
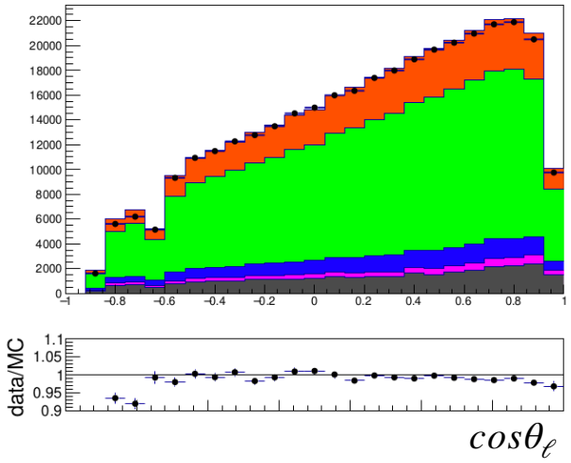
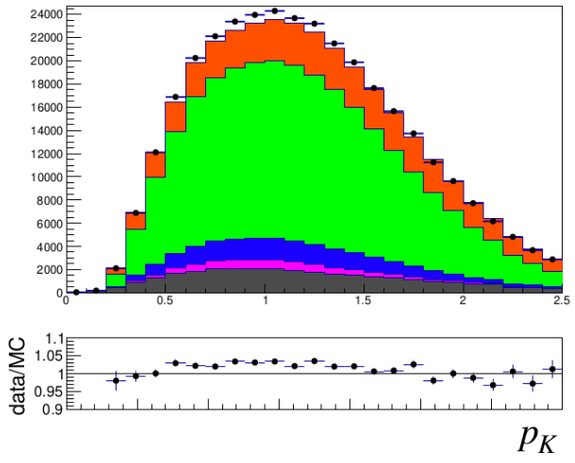
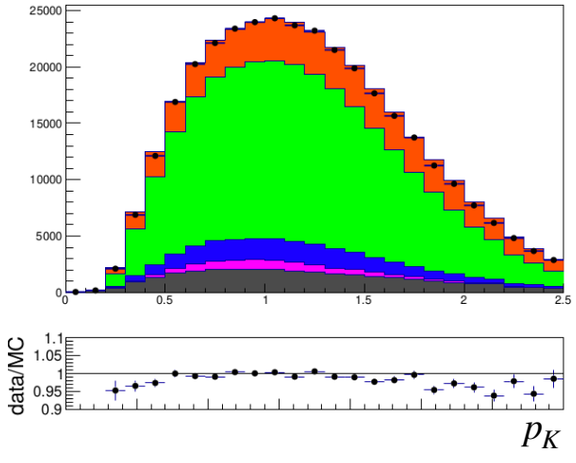
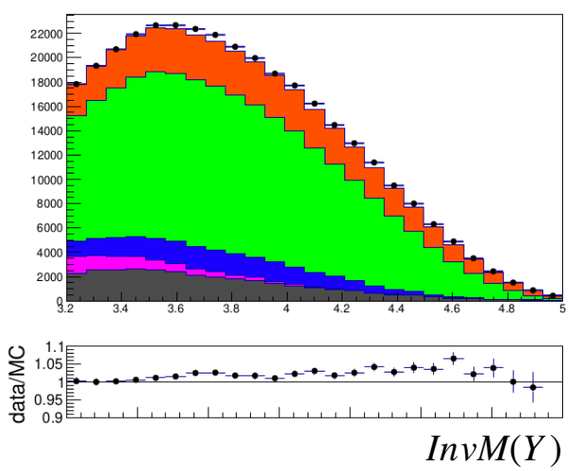


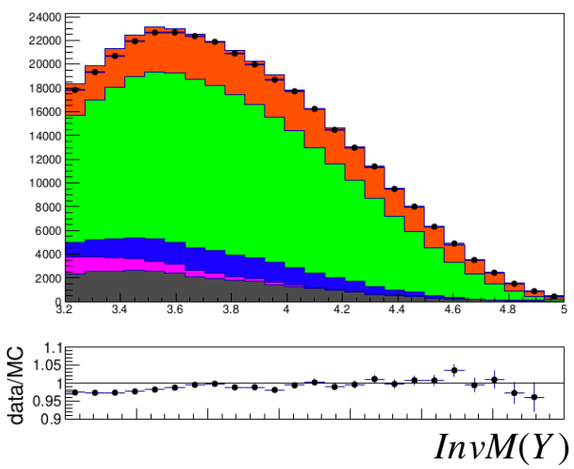


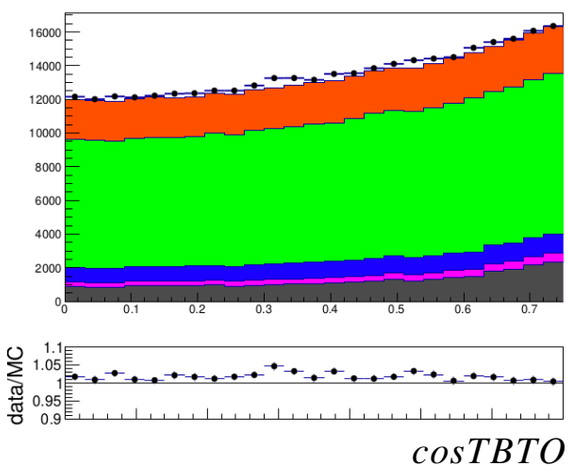


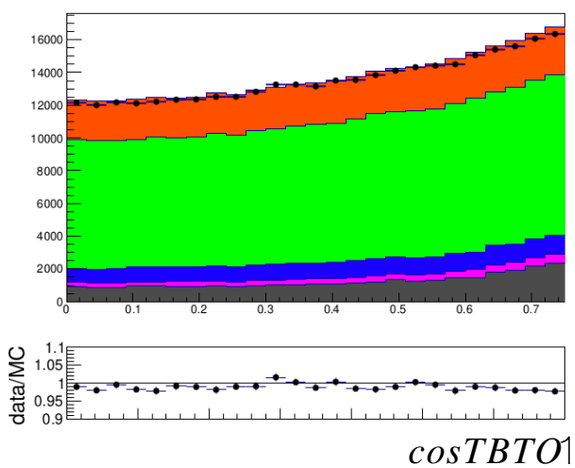






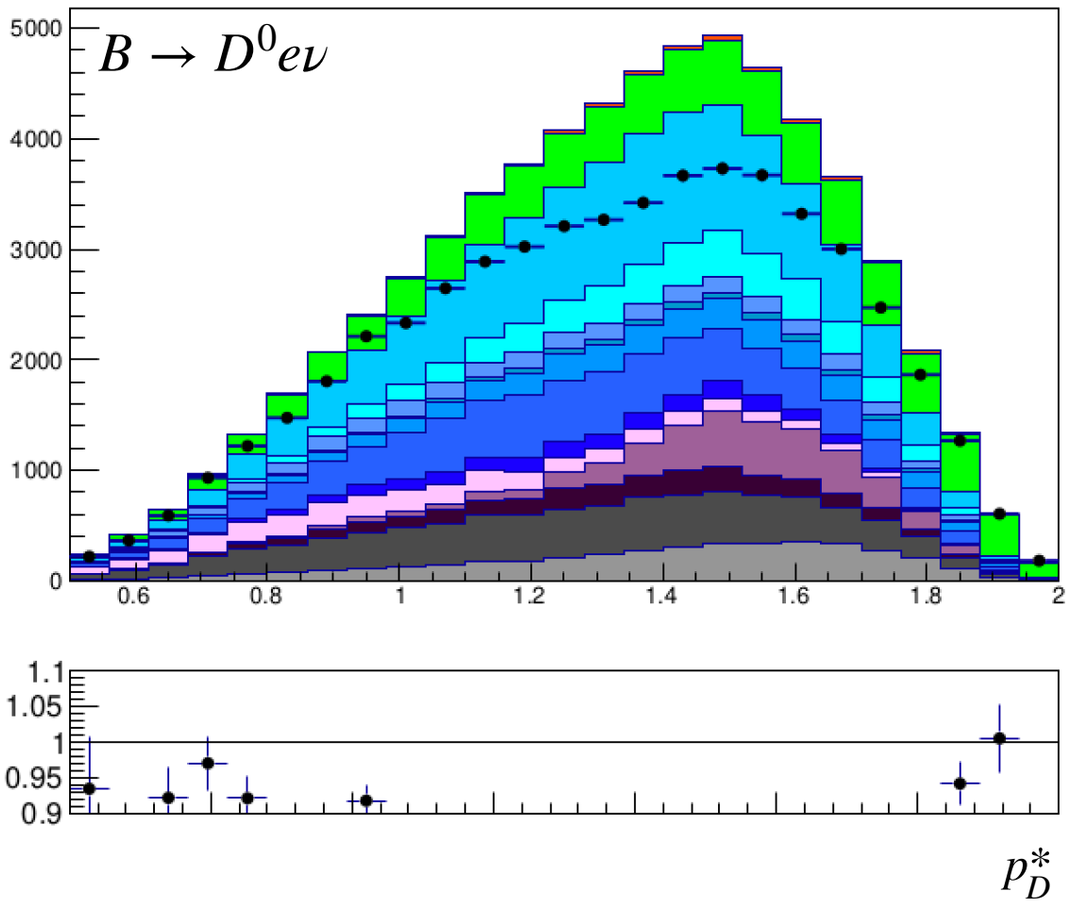




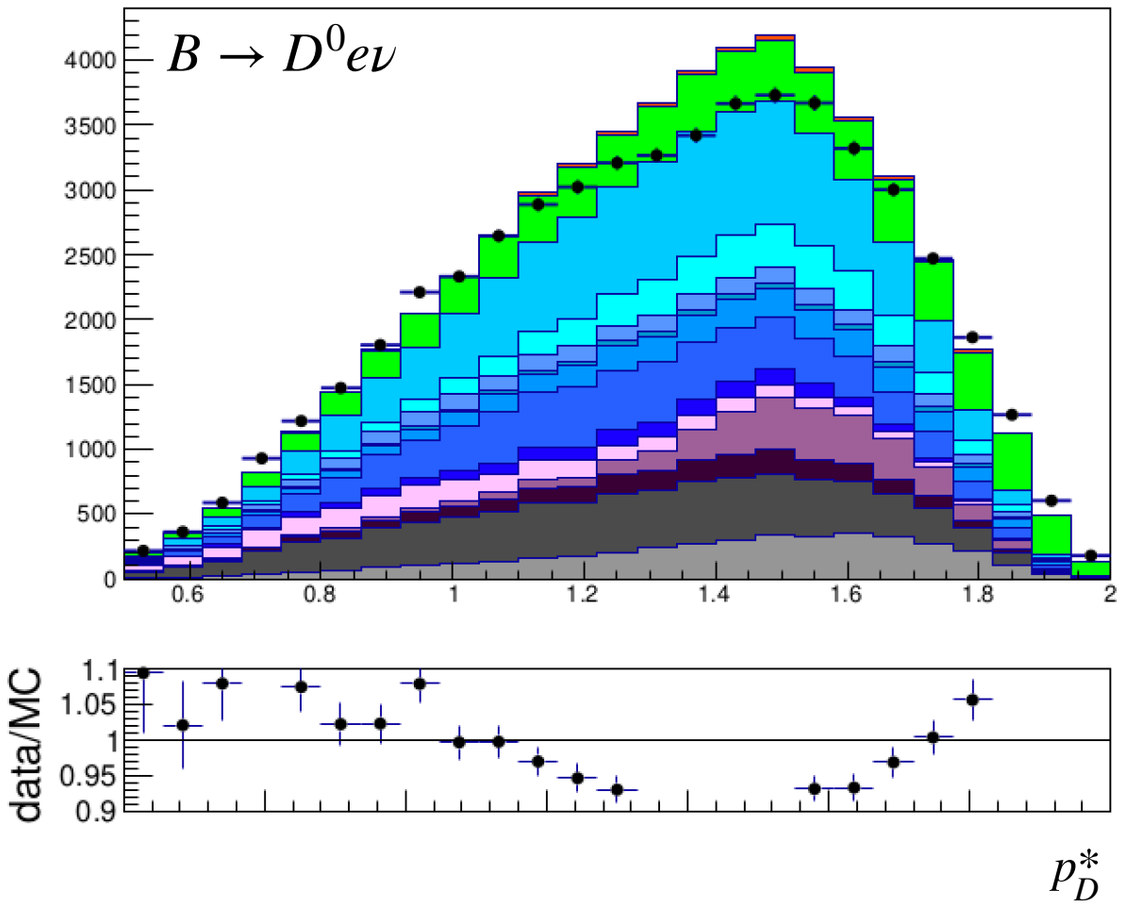


Data/MC agreement: sideband region

Before



Reweight



Observed a large data/MC disagreement.
It has an impact on the previous D** BR determinations.

Summary

- Found a data/MC disagreement in the $E_{CMS}(beam)$ distribution.
- Reweight the fit variables according to the weights evaluated by using the $E_{CMS}(beam)$ distribution. Observed an improvement of data/MC agreement in my signal region.

Next steps

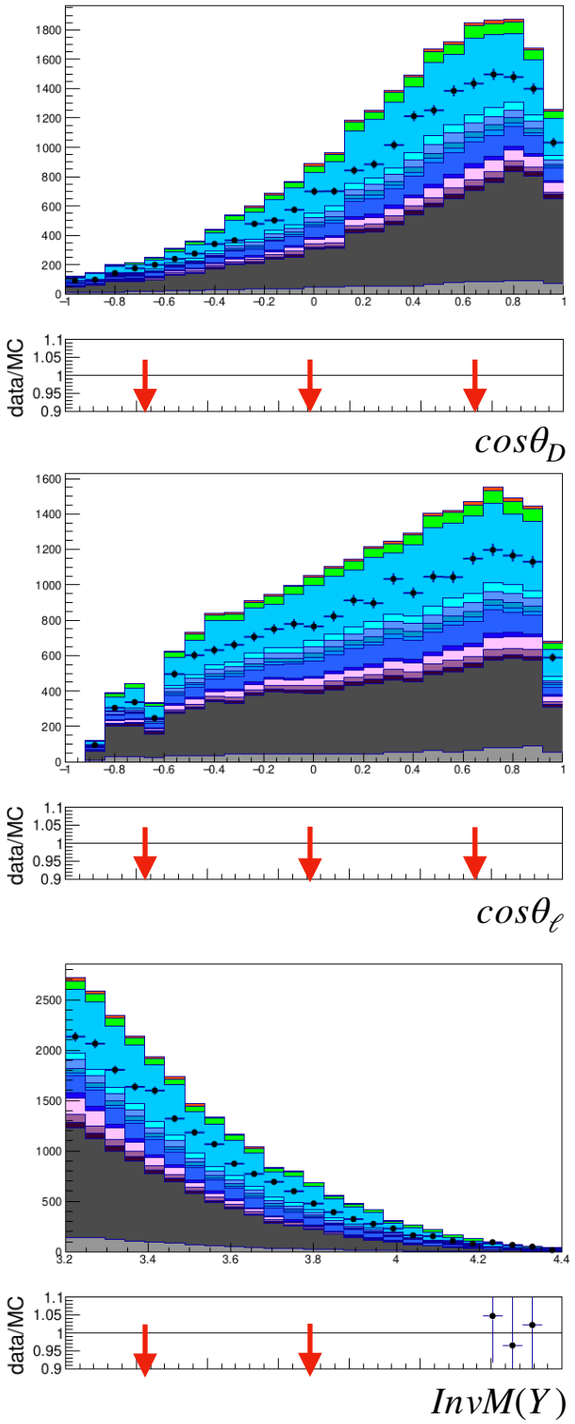
- Repeat the simultaneous fit in the sideband region to validate in data the D^{**} modelling and real D after reweighting also the p^*_D, p^*_ℓ distributions.
- Rescale $X\ell\nu$ and real D background using the sideband-fit results and check again the data/MC agreement in my signal region.

Backup

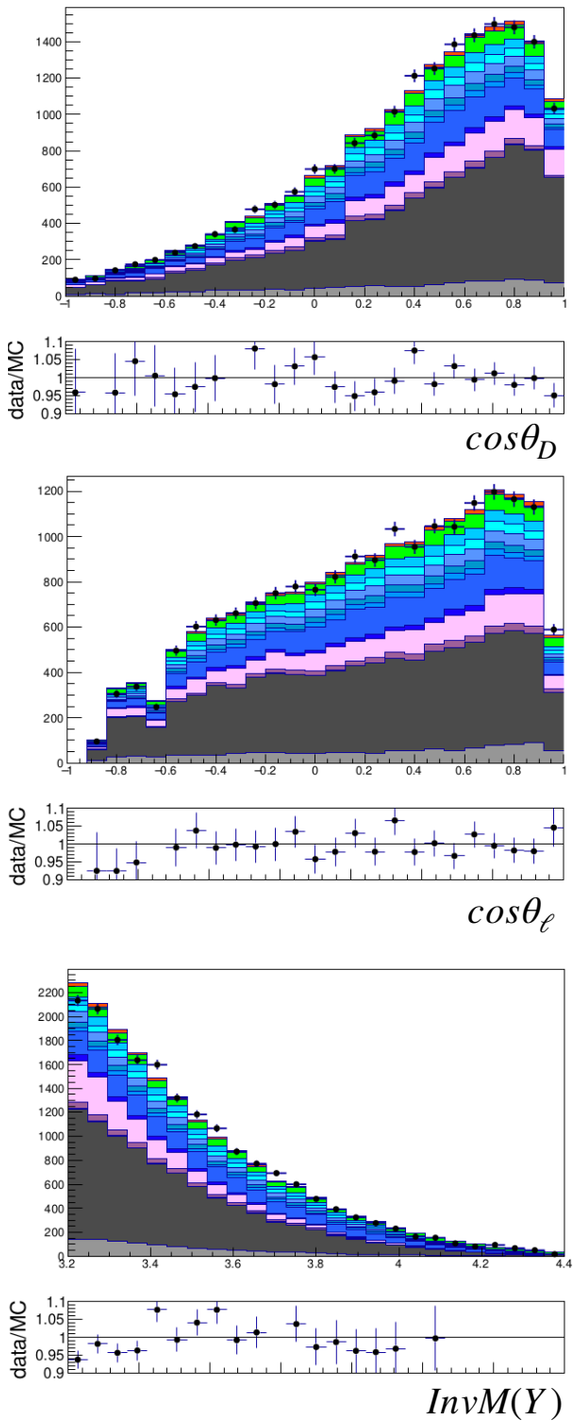
Data/MC agreement: $D^{-}e\nu$ sample

Check data/MC agreement after scaling D^{**} and real D components according to the fit results.

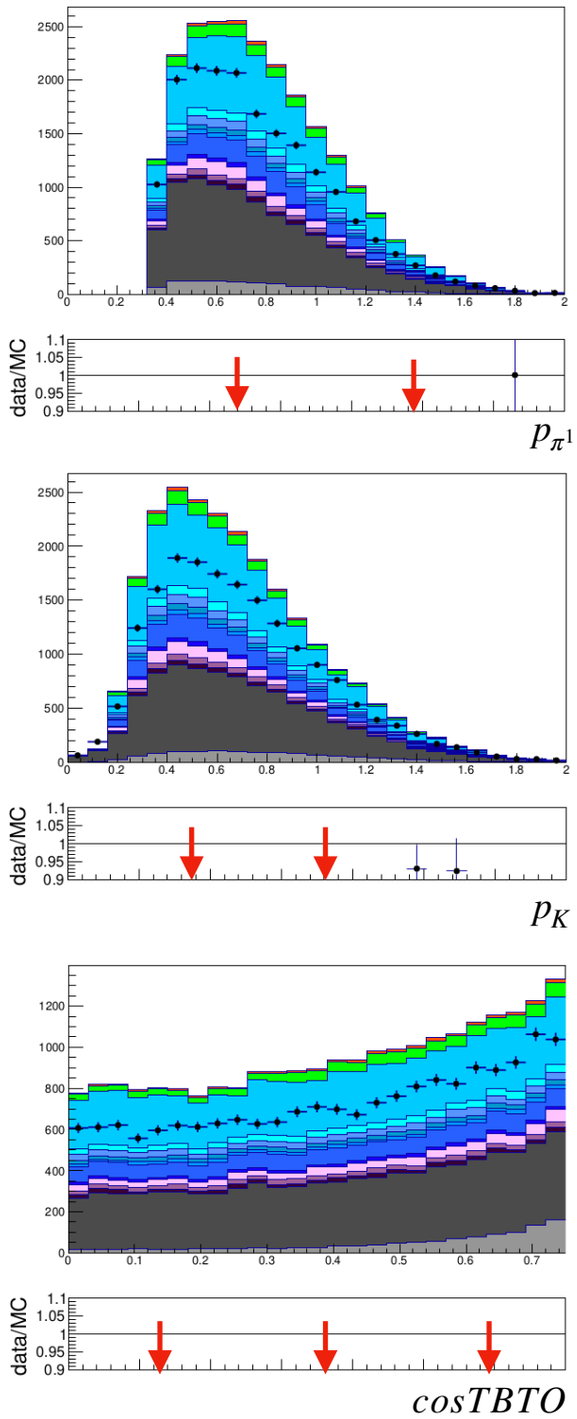
Before



After



Before



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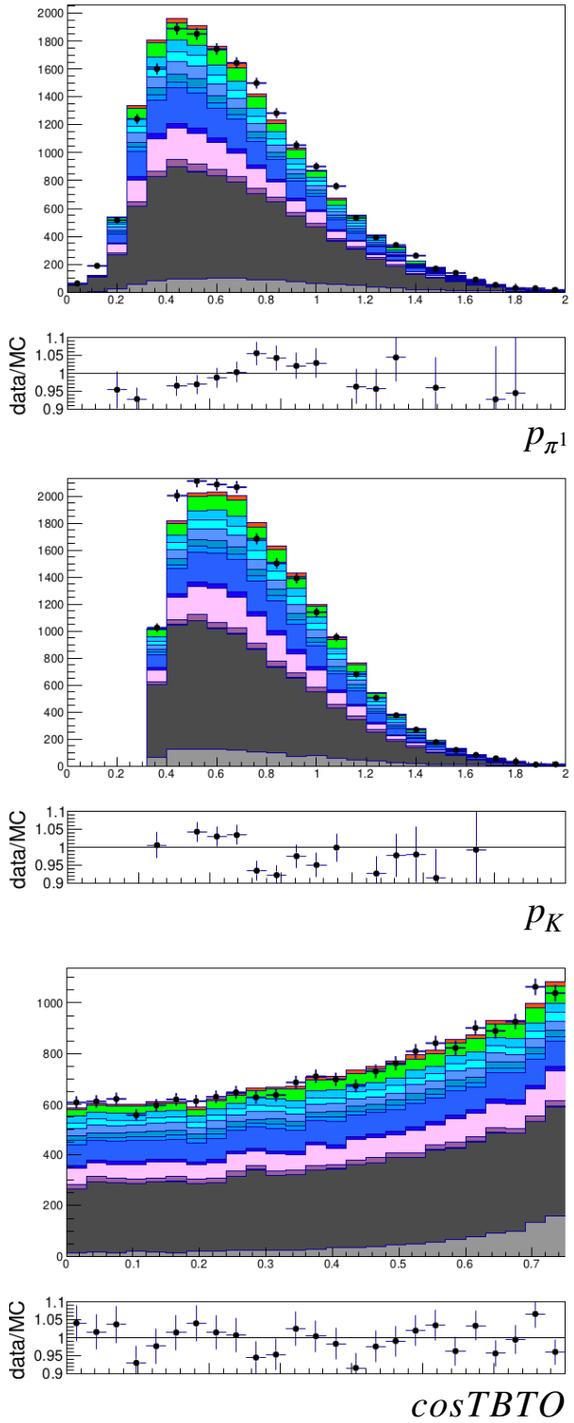
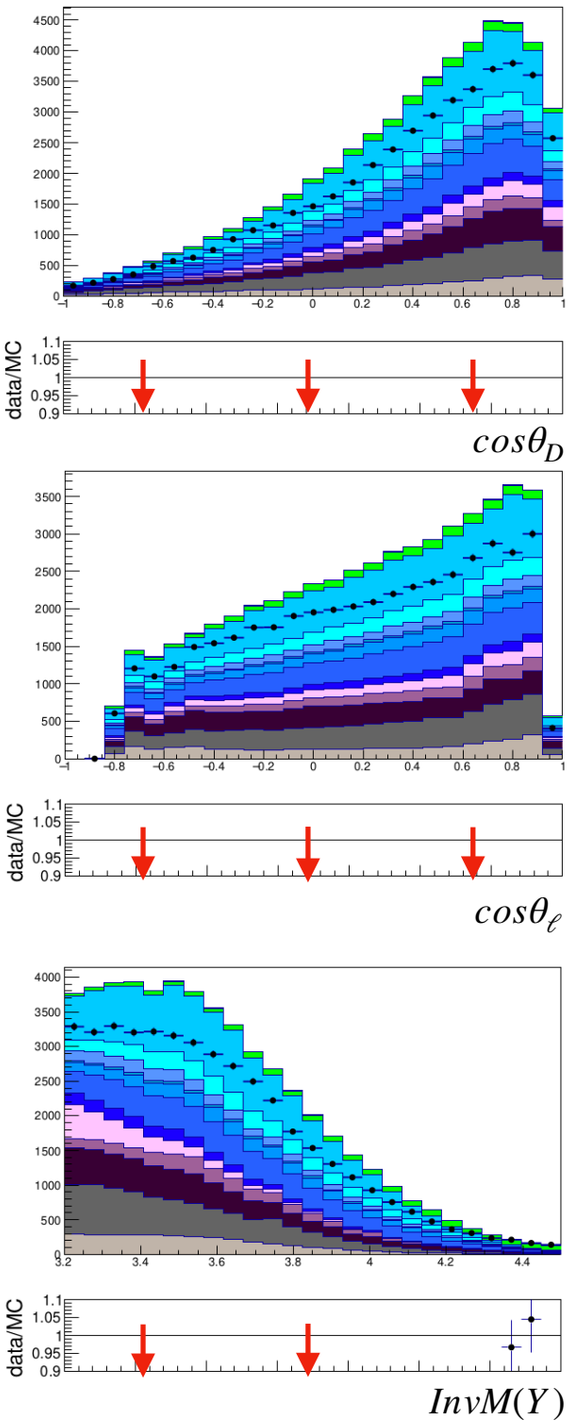


Data/MC agreement improves after scaling D^{**} and real D components.

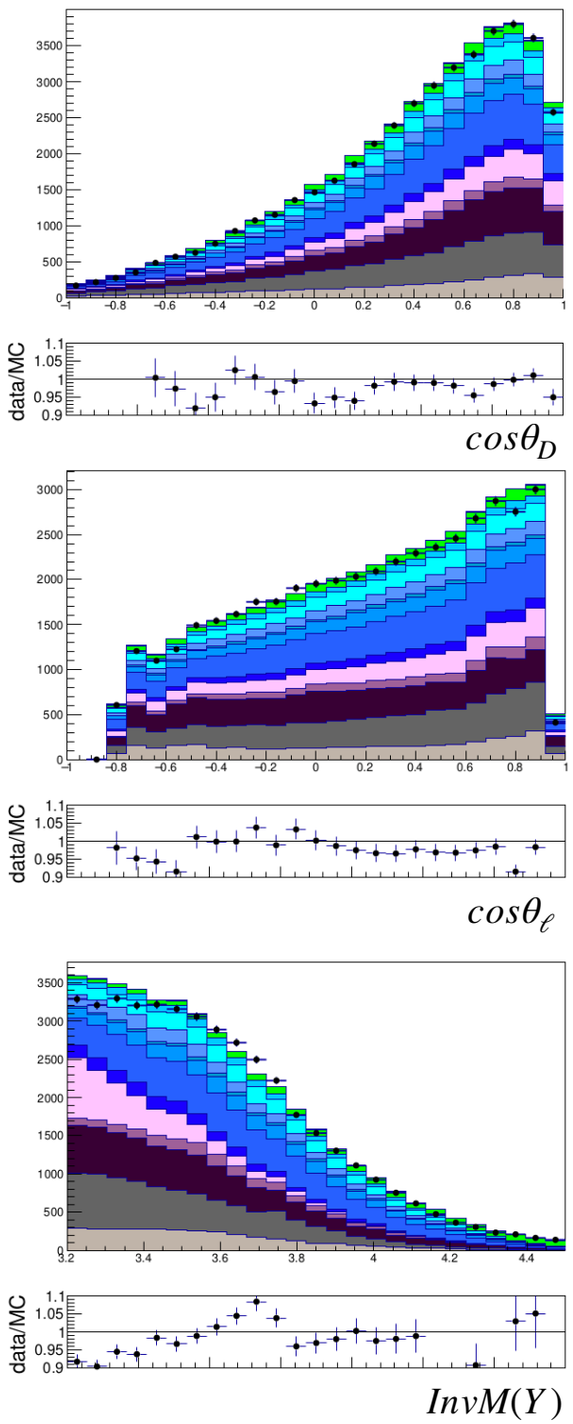
Data/MC agreement: $D^0\mu\nu$ sample

Check data/MC agreement after scaling D^{**} and real D components according to the fit results.

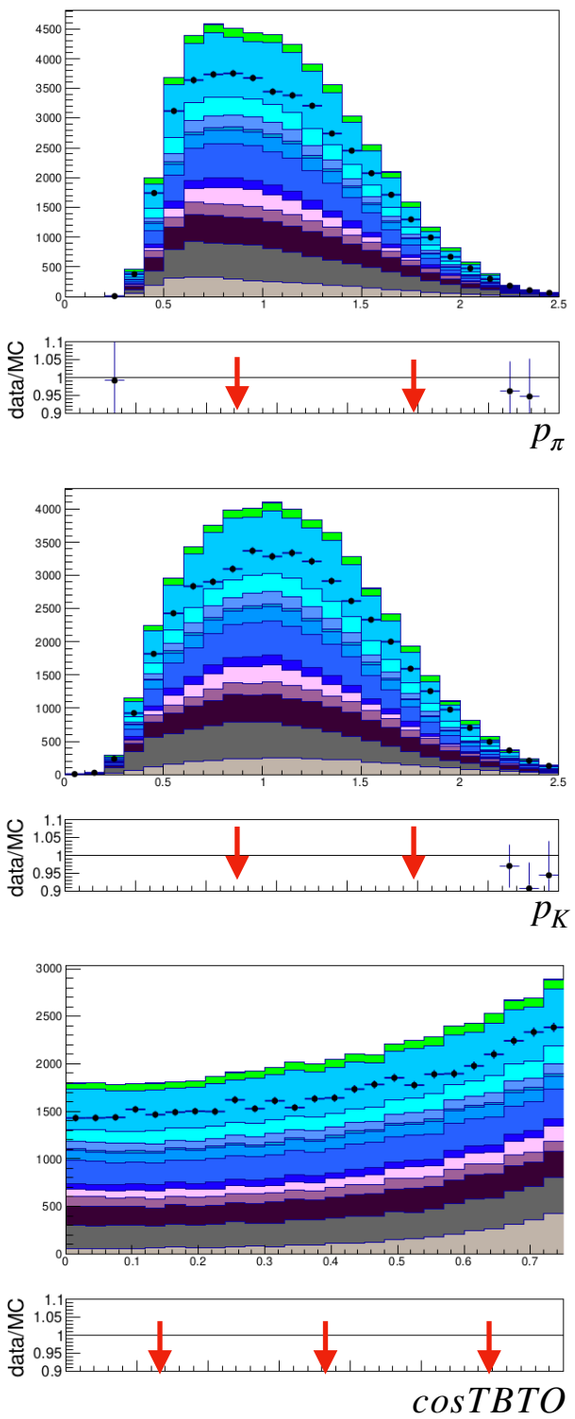
Before



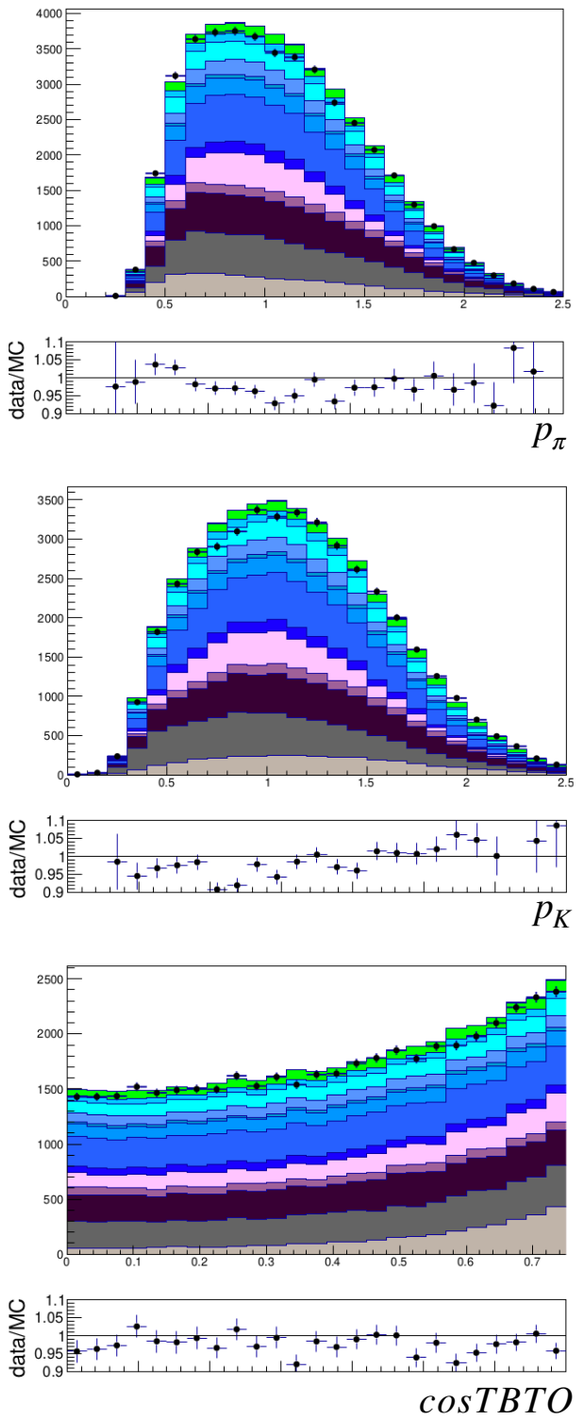
After



Before



After

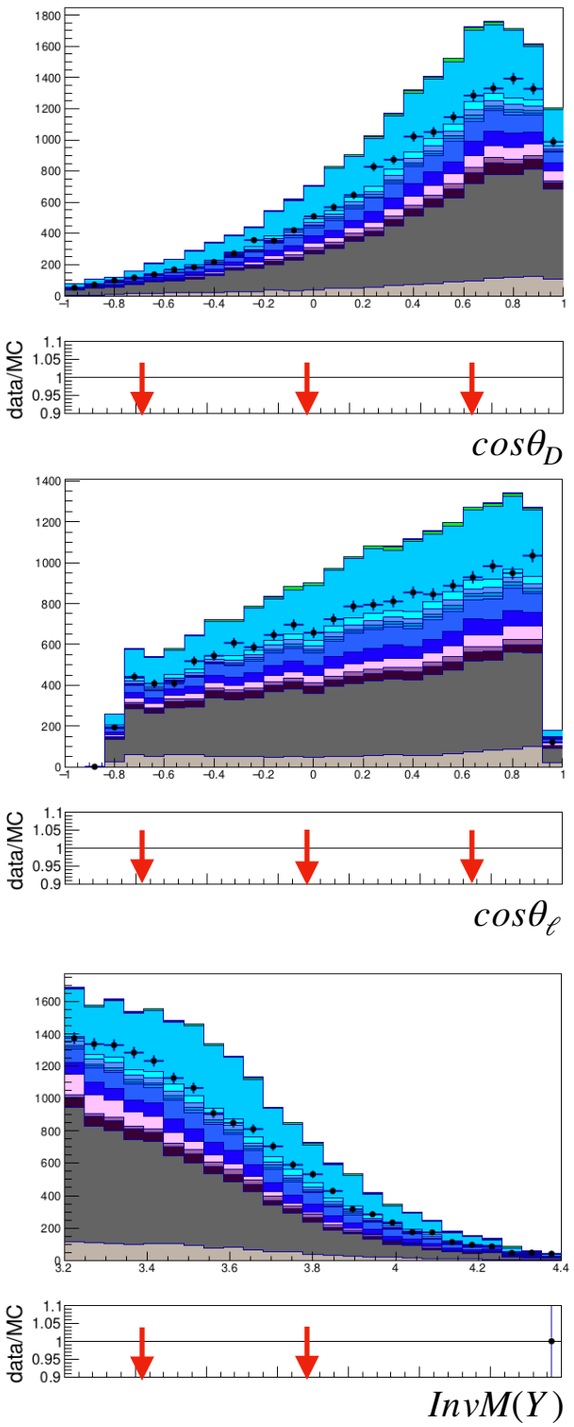


Data/MC agreement improves after scaling D^{**} and real D components.

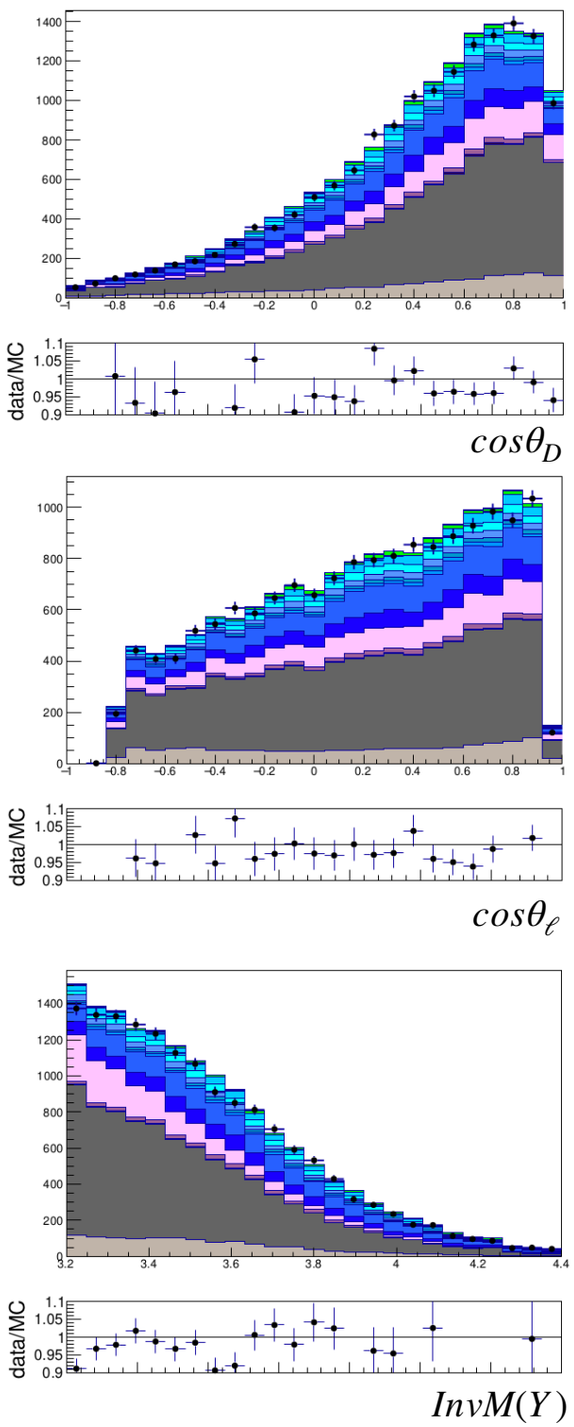
Data/MC agreement: $D^{-}\mu\nu$ sample

Check data/MC agreement after scaling D^{**} and real D components according to the fit results.

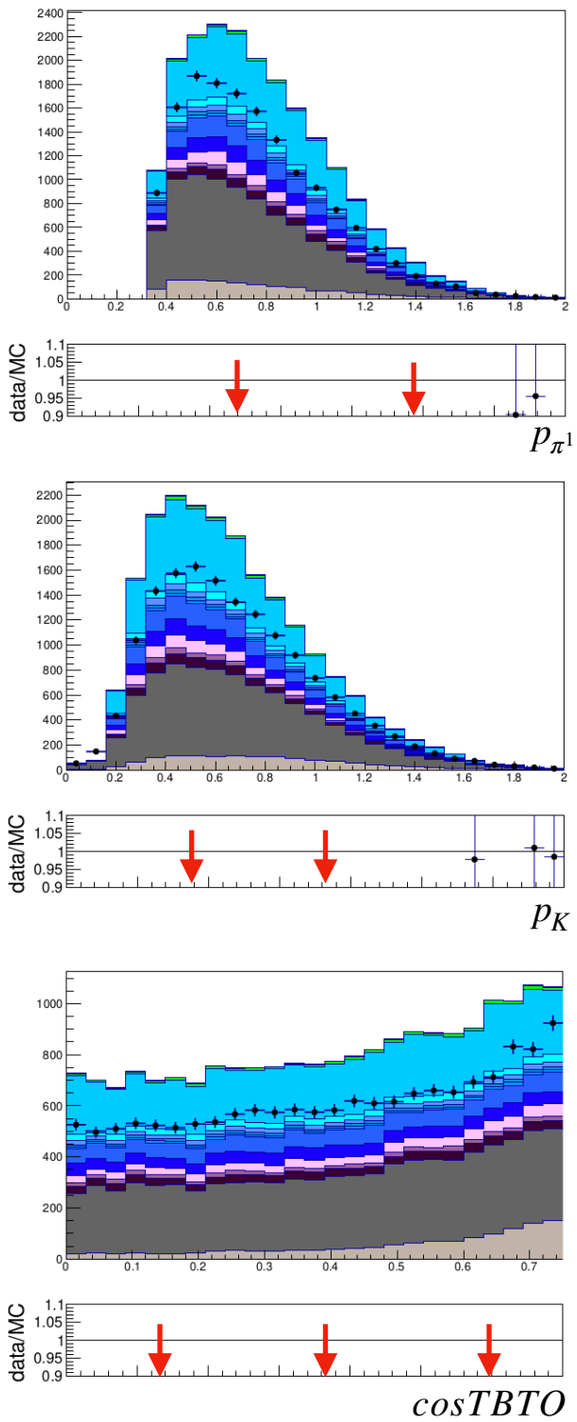
Before



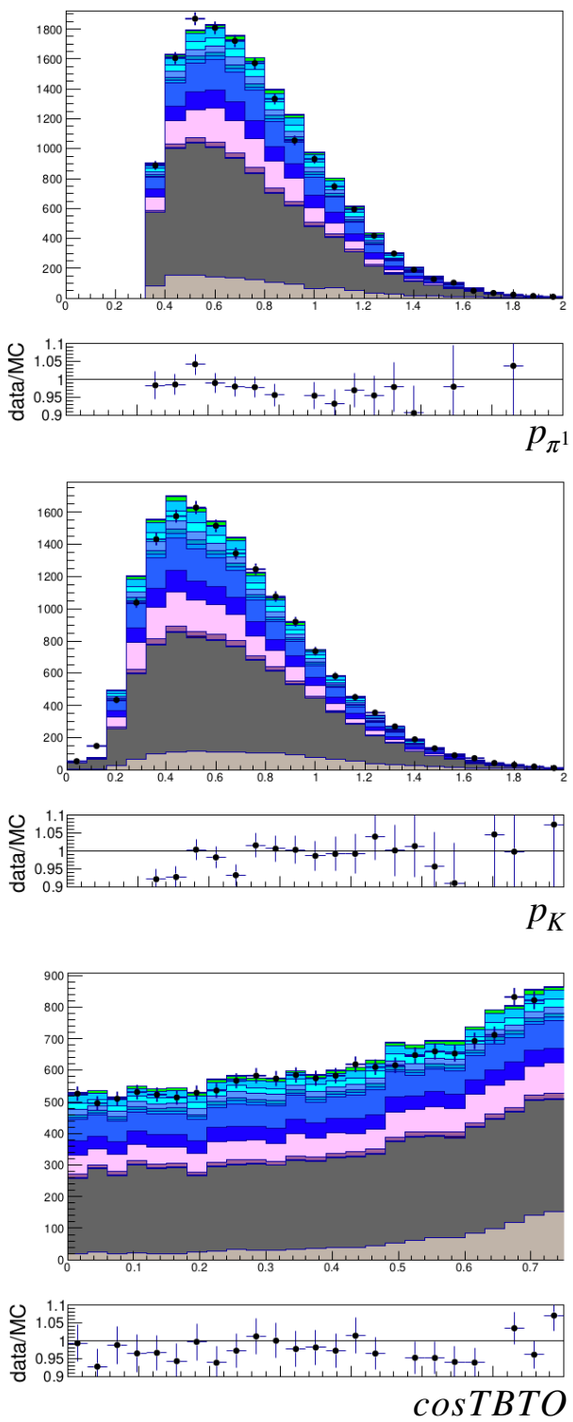
After



Before



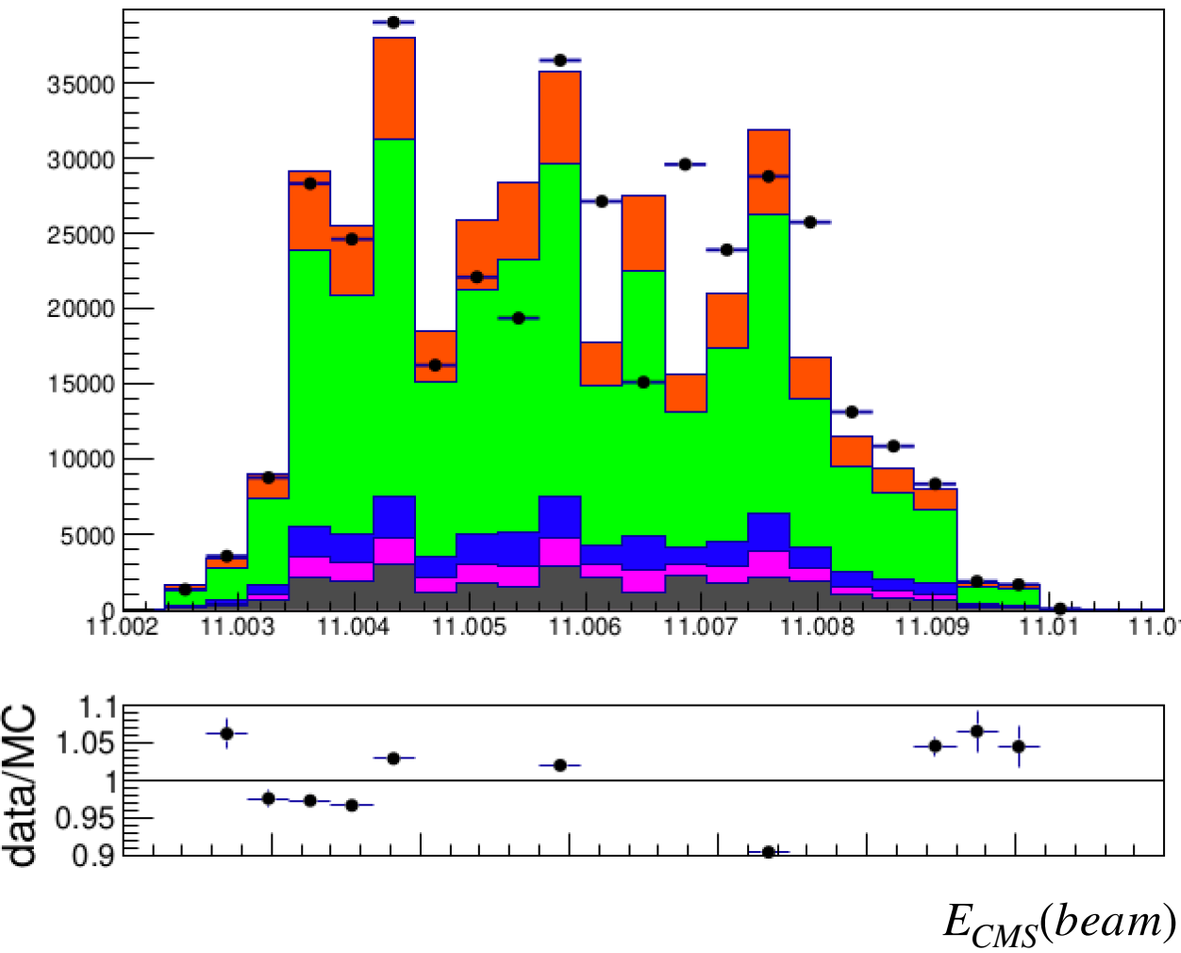
After

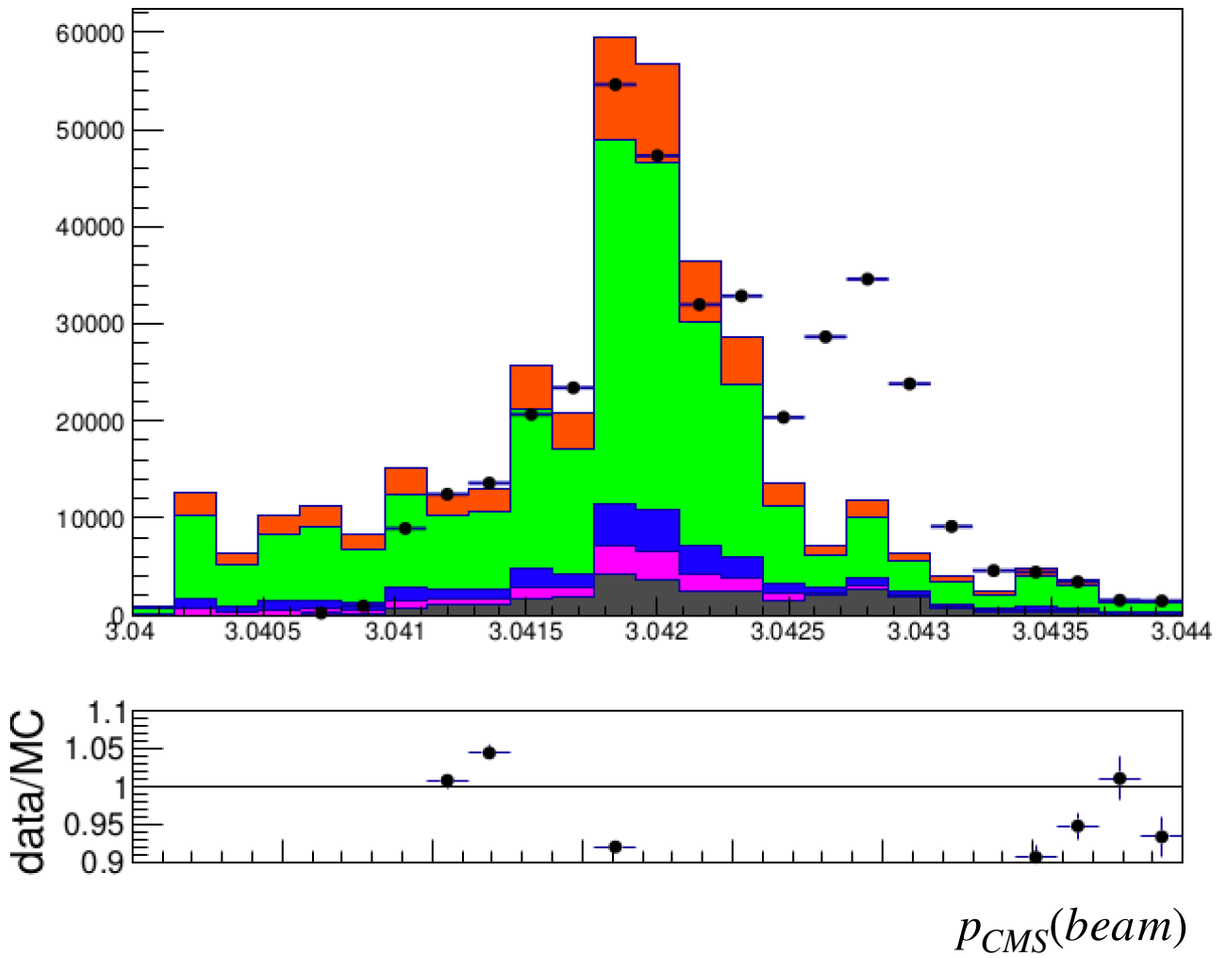


Data/MC agreement improves after scaling D^{**} and real D components.

Data/MC agreement

$$B \to D^0 \mu \nu$$





Observed a large data/MC disagreement.