

E_ECL check with had.FEI + D*lnu

2023/5/31

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Motivation

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- data/MC difference of E_ECL using D*lnu, hadronic FEI
- share information
- near future plan

Setup

-Dataset: MC14, 189fb-1

-Reconstruction:

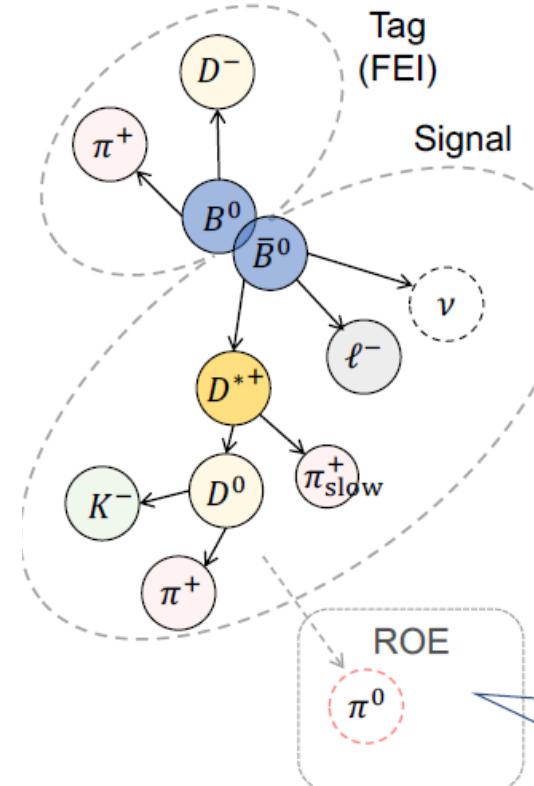
-Btag: hadronic FEI, sigProb>0.01, Mbc>5.27, -0.15< ΔE <0.1GeV

-Bsig: $D^* l(\nu)$ with $D^* 0 \rightarrow D 0 \pi 0$, $D^* 0 \rightarrow D 0 \gamma$,
 $D^* + \rightarrow D 0 \pi +$, $D^* + \rightarrow D + \pi 0$

-ROE:

ROE	Tracks $dr < 5$ cm, $ dz < 10$ cm, $p_T > 0.1$ GeV/c, nCDCHits > 0
	Clusters <u>gamma:eff40_May2020</u> , $ \text{clusterTiming} < 200$ ns, $\text{minC2TDist} > 20$ cm <u>roeCharge == 0</u> , nROE_Tracks < 1

$E\gamma > 80$ (FW), 30(BR), 60(BW)



- $q^2 < 4$ GeV 2 , $|\text{Mmiss2}| < 1$ GeV 2 required for pure $D^* l \nu$ sample

data/MC difference of E_ECL

-data/MC of E_ECL was bad with run independent MC

-p-value < 0.01 for B+ mode

-data excess at low energy bin

-large run dependence: early runs have large deviation

- Data
- MC total
- $D^* l\nu$
- $D l\nu$
- $D^{*+} l\nu$
- Hadronic B
- $B^0 \leftrightarrow B^\pm$ crossfeed
- Continuum

$B^0 \rightarrow D^* l\nu, D^* \rightarrow \pi D$

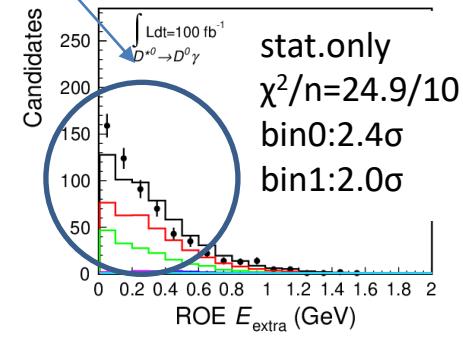
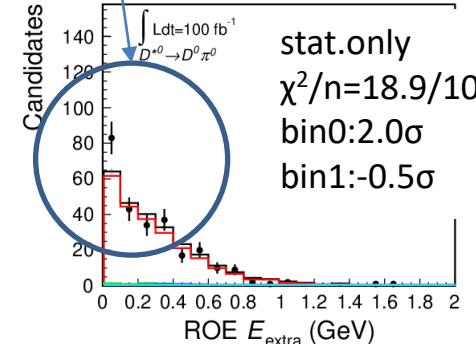
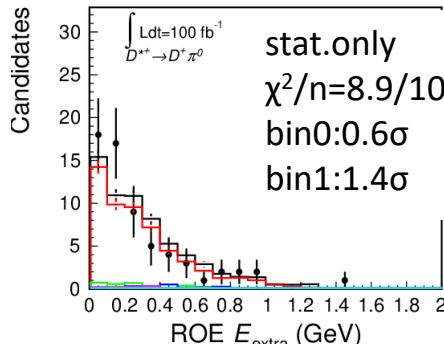
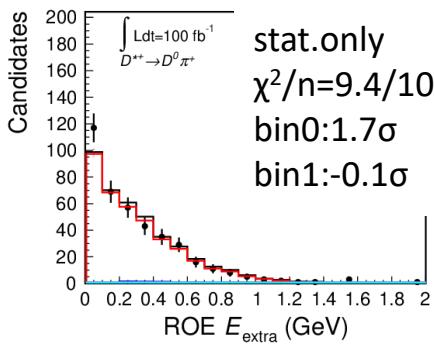
$B^0 \rightarrow D^* l\nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l\nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l\nu, D^* \rightarrow \gamma D$

MC14 ri proc12,bucket1x

p-value=0.05,0.01:
 $\chi^2/10=18.3,23.2/10$



run dependent MC

-data/MC improved with run dependent MC

- beamBG in early experiments are especially improved (backup)
- p-value >0.05 for all D* mode, similar data/MC tendency

- Data
- MC total
- $D^* l\nu$
- $D l\nu$
- $D^{**} l\nu$
- Hadronic B
- $B^0 \leftrightarrow B^\pm$ crossfeed
- Continuum

$B^0 \rightarrow D^* l\nu, D^* \rightarrow \pi D$

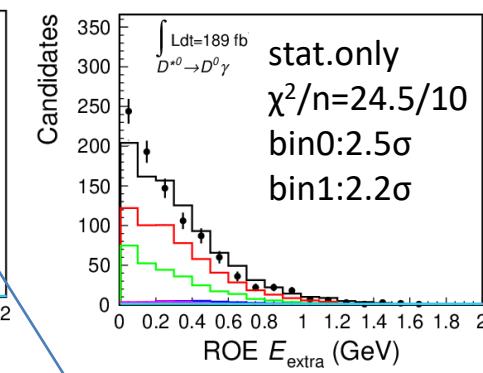
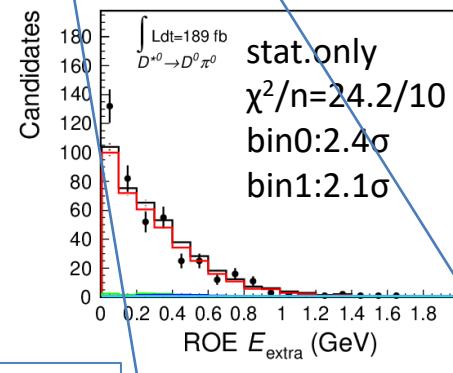
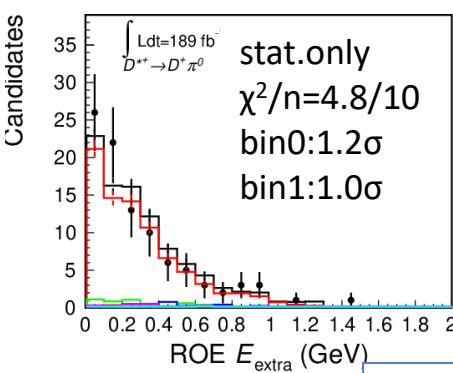
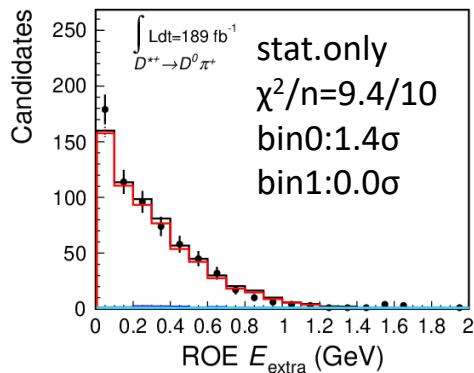
$B^0 \rightarrow D^* l\nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l\nu, D^* \rightarrow \pi^0 D$

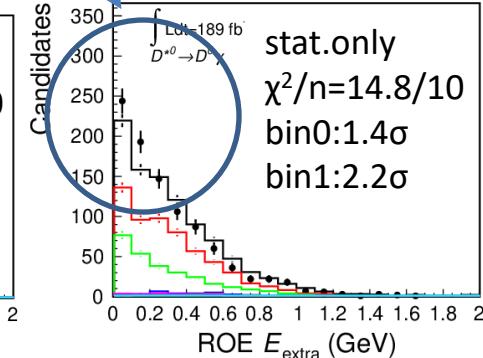
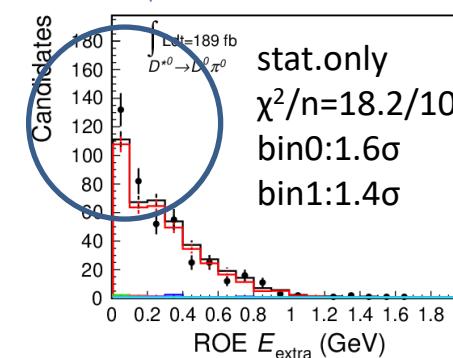
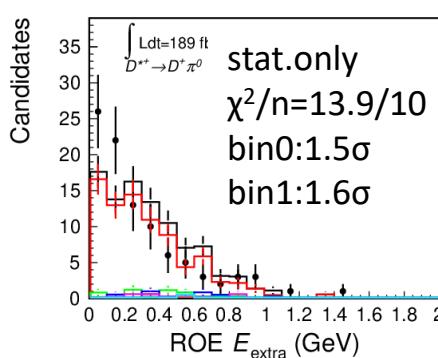
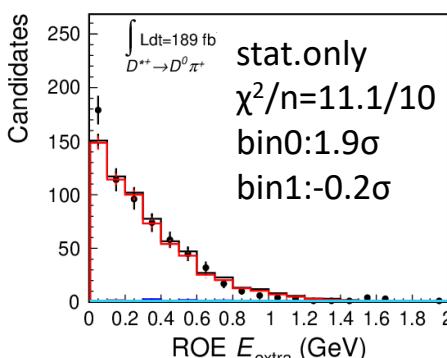
$B^+ \rightarrow D^* l\nu, D^* \rightarrow \gamma D$

MC14 ri

p-value=0.05,0.01:
 $\chi^2/10 = 18.3, 23.2 / 10$



MC14 rd



run dependence: early exp

- MCrd B+: data/MC at low E_ECL gets better than MCri
- MCrd B0: no change or bit worse than MCri

● Data
 — MC total
 — $D^{*+}l\nu$
 — $Dl\nu$
 — $D^{*+}l\nu$
 — Hadronic B
 — $B^0 \leftrightarrow B^\pm$ crossfeed
 — Continuum

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

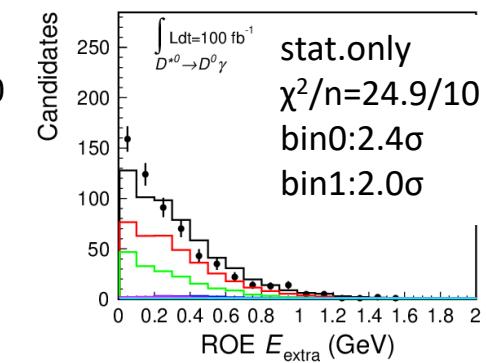
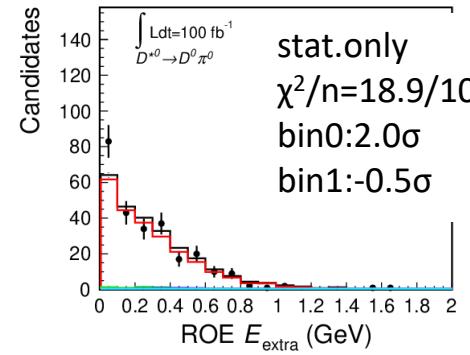
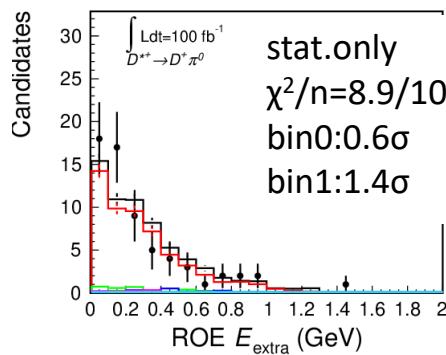
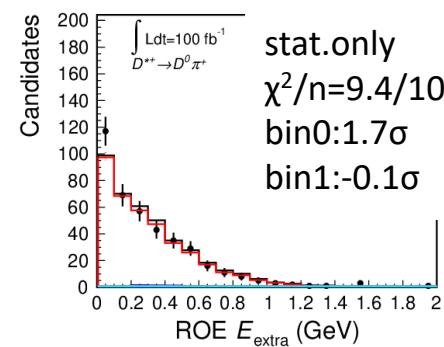
$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

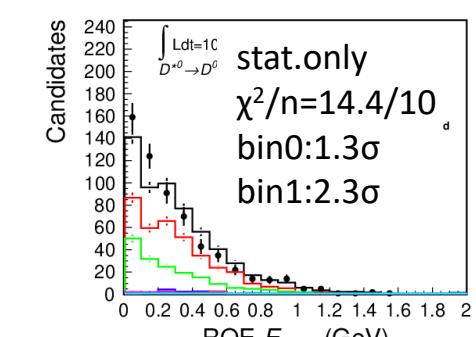
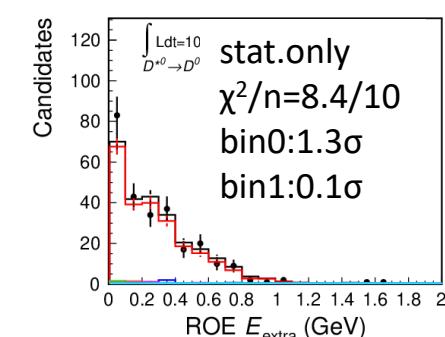
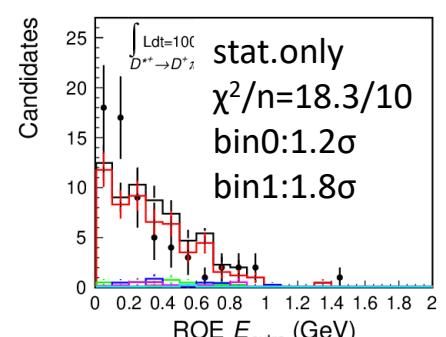
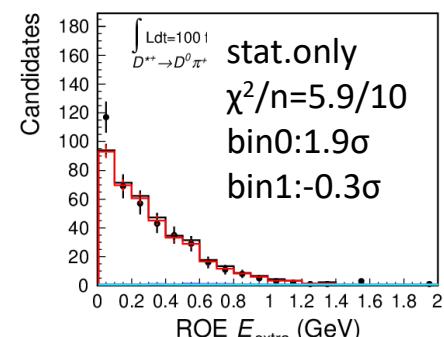
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$

MC14 ri proc12,bucket1x

p-value=0.05,0.01:
 $\chi^2/10 = 18.3, 23.2 / 10$



MC14 rd proc12,bucket1x



run dependence later exp

- no significant difference between MCrd and MCri
- run dependence is improved largely with MCrd

● Data
 — MC total
 — $D^* l \nu$
 — $D l \nu$
 — $D^{**} l \nu$
 — Hadronic B
 — $B^0 \leftrightarrow B^\pm$ crossfeed
 — Continuum

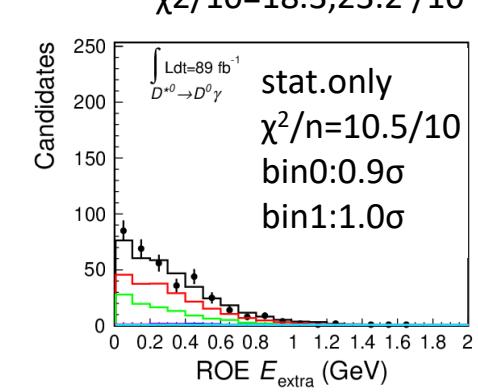
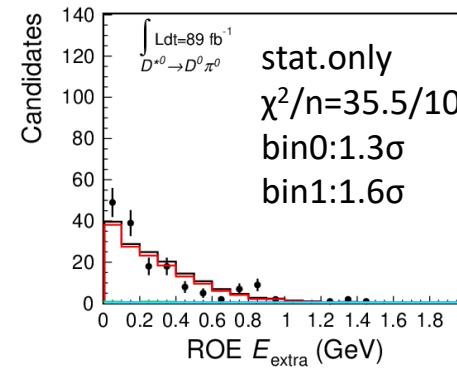
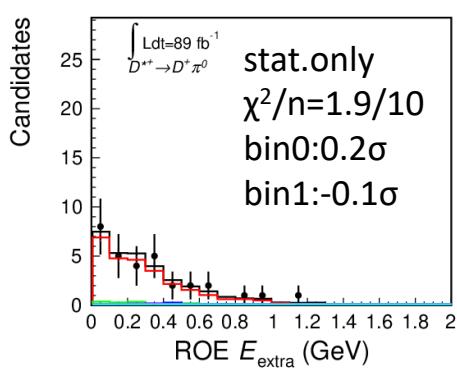
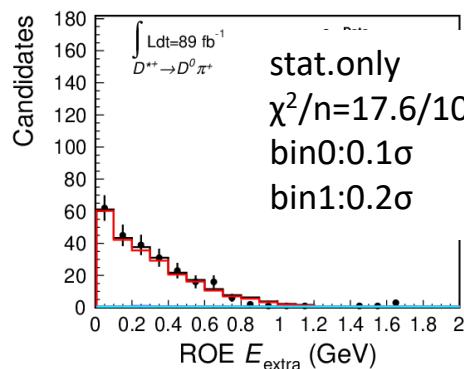
$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

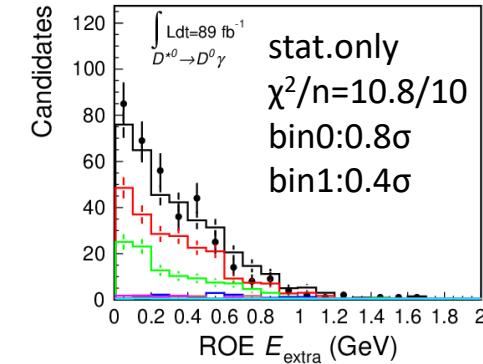
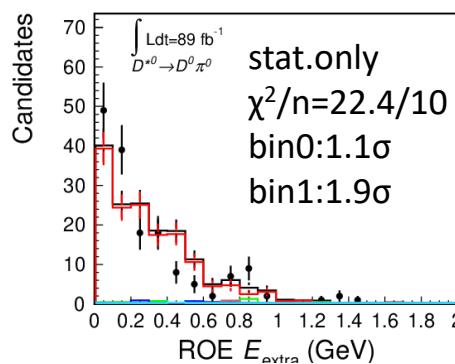
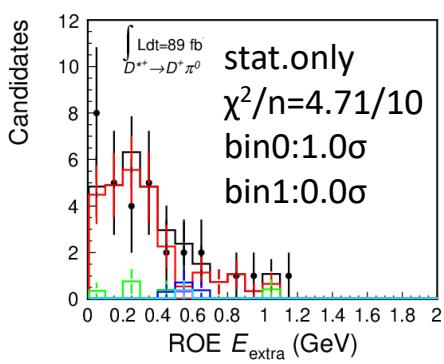
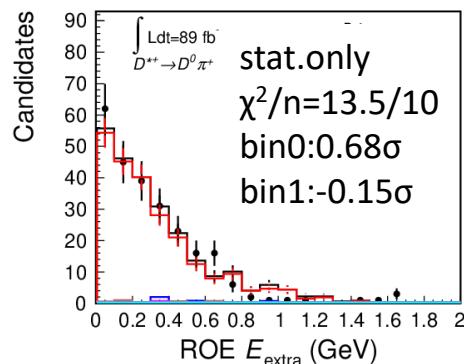
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$

MC14 ri, bucket2x

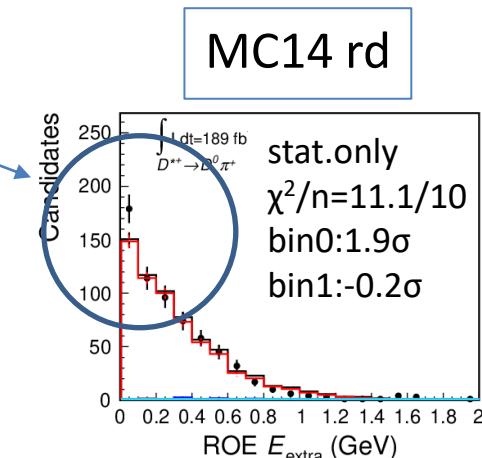


MC14 rd, bucket2x



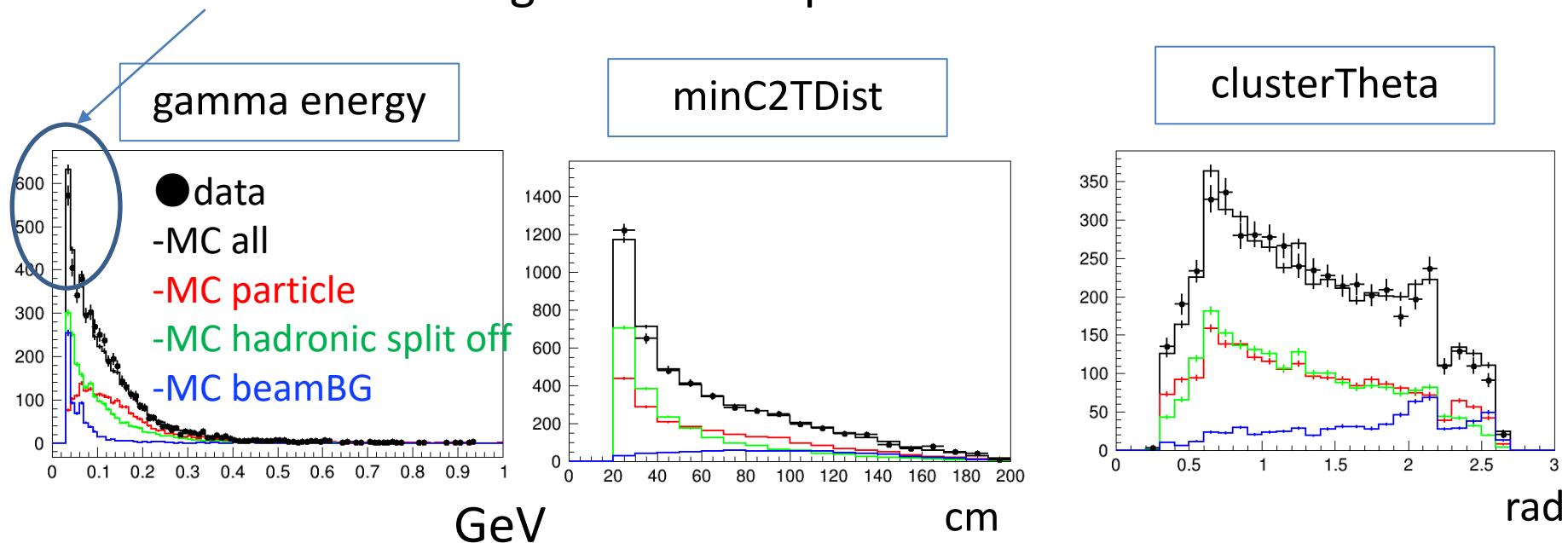
Further E_ECL study with gamma ROE

- Data/MC has still $1.5\text{-}1.9\sigma$ local tensions at low E_ECL, even with MCrd
-for all D* mode. possible systematics.



- Further study is done with gamma list in ROE
 - new ntuple is produced with MC14ri at q2 sideband
 - MC is area normalized

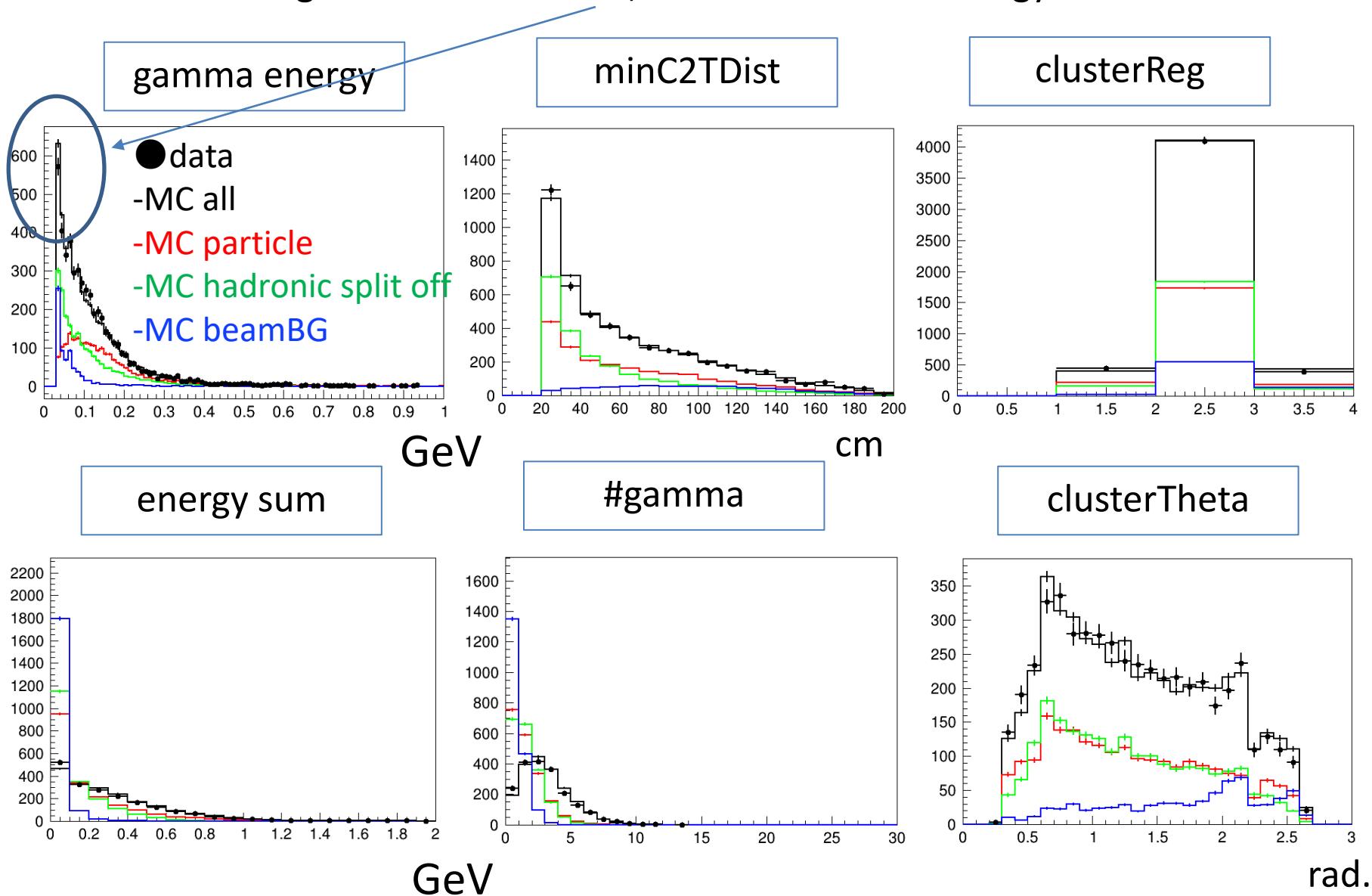
- At $\text{minC2TDist} > 20\text{cm}$, data/MC has tension near gamma energy threshold for ROE. fake gamma have peak.



ROE gamma ($B0 \rightarrow D^* l \nu$, $D^* \rightarrow \pi + D$)

-gamma with $\text{minC2TDist} > 20\text{cm}$

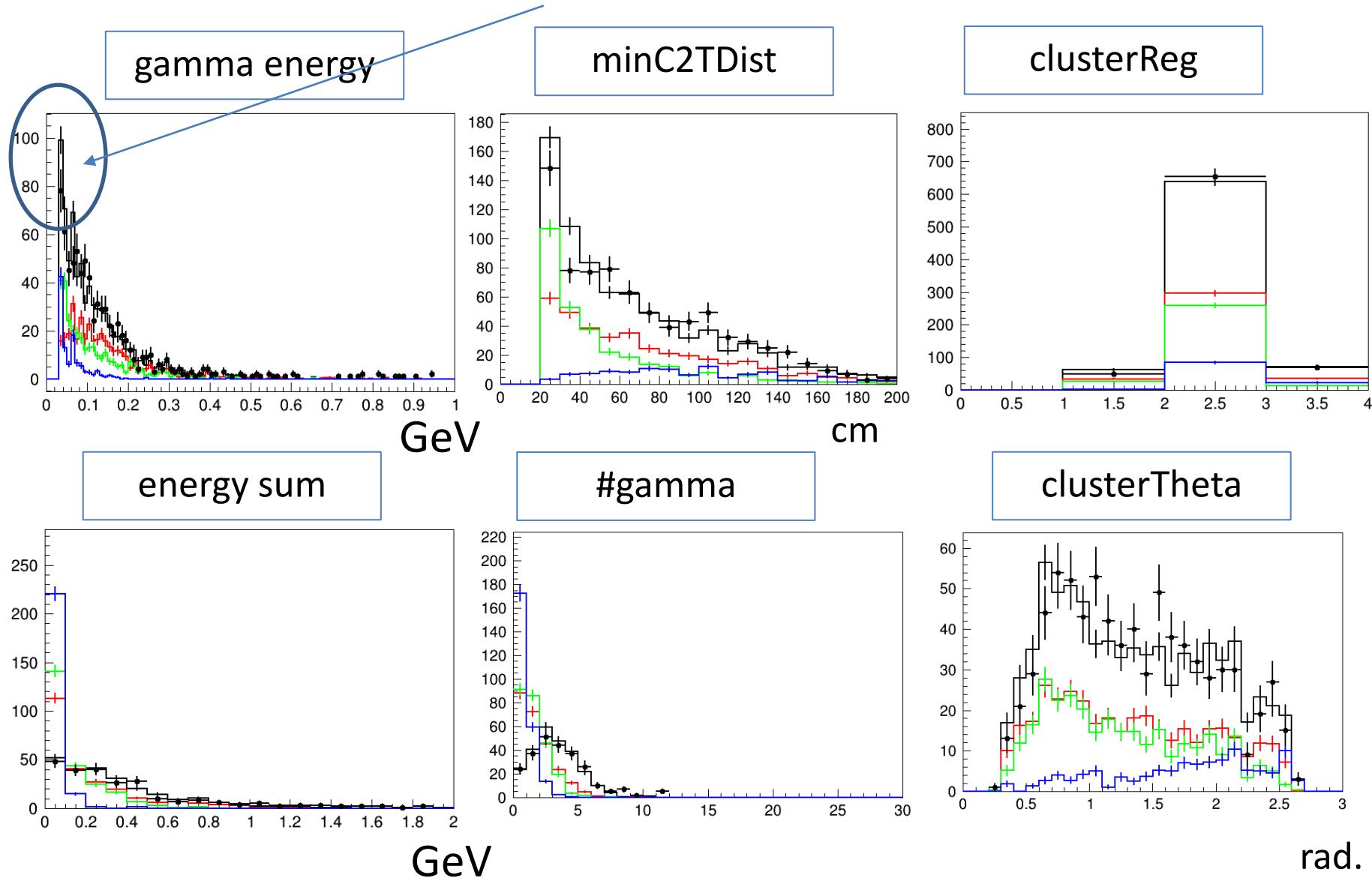
- minC2TDist and angle looks reasonable, deviation around energy threshold



ROE gamma ($B0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$)

-gamma with $\text{minC2TDist} > 20\text{cm}$

- minC2TDist and angle looks reasonable, deviation around energy threshold



E_ECL correction for R(D*)

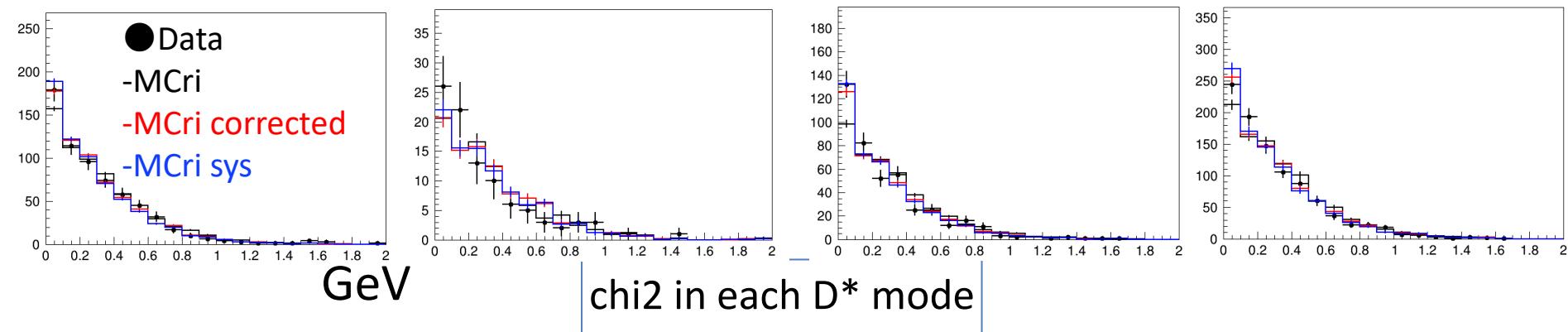
- Based on the studies, following corrections are added to MCri
 - 1. beamBG energy PDF is corrected by run dependent MC
 - 2. energy of hadronic splitoff gamma is scaled by -15MeV ($\sim 10\%$).
- In addition, systematics is assigned by varying the scaling with $\pm 7\text{MeV}$.
- error is determined by $\Delta\chi^2$

$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$



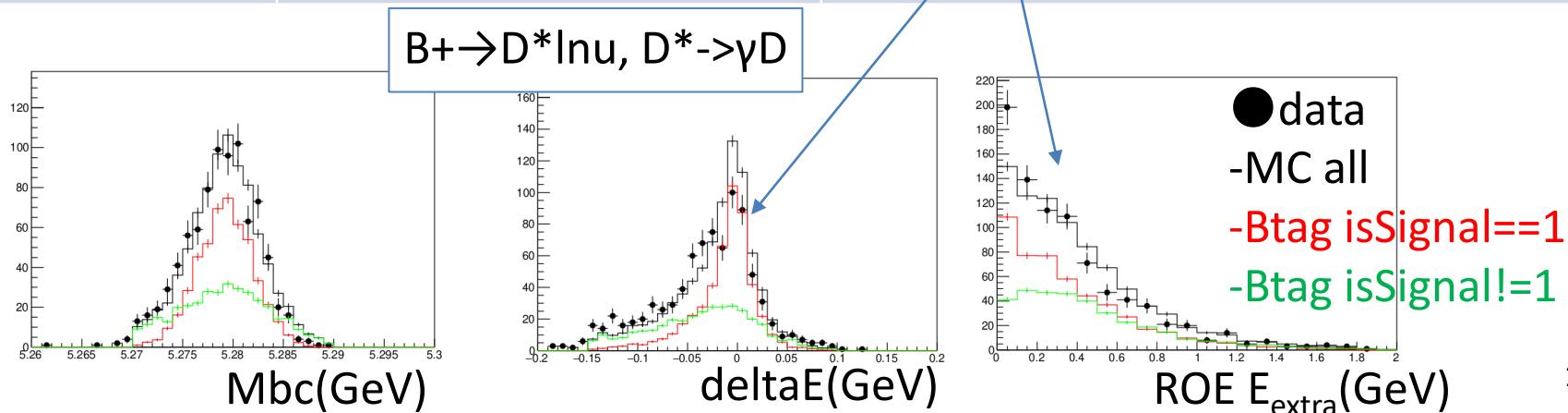
shape only stat. only	MCri	MCri, beambg corrected fake gamma 10MeV	MCri, beambg corrected fake gamma 20MeV
$\chi^2/\text{NDF}, \text{NDF}=10$	1.16, 0.8, 2.7, 1.7 (64/40)	0.63, 0.95, 1.52, 0.98 (49/40)	0.63, 0.84, 1.37, 0.92 (39/40)
bin0 significance	$1.6\sigma, 1.0\sigma, 2.8\sigma, 1.8\sigma$	$0.12\sigma, 1.4\sigma, 0.5\sigma, -0.6\sigma$	$-0.7\sigma, 0.7\sigma, -0.1\sigma, -1.4\sigma$
bin1 significance	$0.2\sigma, 1.3\sigma, 1.0\sigma, 2.0\sigma$	$-0.6\sigma, 0.9\sigma, 1.1\sigma, 1.7\sigma$	$-0.7\sigma, 1.3\sigma, 1.0\sigma, 1.5\sigma$

q^2 sideband: effect from others

[slide](#)

- Following hypothesis are considered to describe data/MC difference of E_{extra}
- Effect from radiative photon, true π^0/γ , Btag can not explain difference

possible hypothesis	investigation	result
π^0 from D decay	D decay mode dependence	no dependence
radiative photon	$D^*\mu\nu$ and $D^*e\nu$ dependence	no dependence
hadronic sprit off	$\text{minC2T}D\text{ist}$ dependence	no dependence
beamBG	run dependence	-large data/MC at early run -better data/MC agreement with beamBGx1/10
Bsig isSignal==1 fraction (π^0, γ from D^* decay)	Constraint from ΔM sideband	no difference w and w/o constraint
Btag decaymode	Btag decay mode dependence	no dependence
Btag isSignal==1 fraction	-check E_{extra} with $\text{isSignal}==1, !=1$ -check deltaE and Mbc of Btag	- E_{extra} is different, if fraction of $\text{isSignal}==1$ is very higher than MC, explain data/MC -fraction is bit lower than MC. not realistic.



Task: ECL clustering and calibration

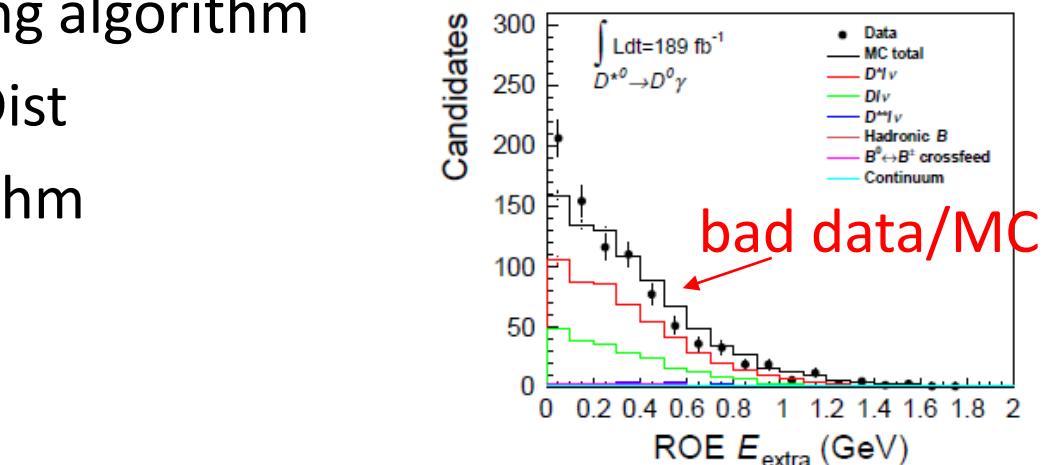
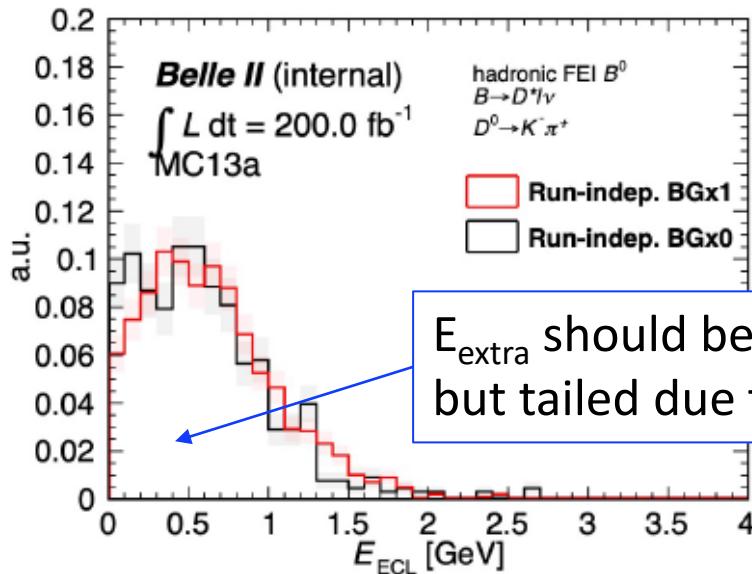
-Improve ECL clustering/matching algorithm

- better variables than minC2TDist
- develop core clustering algorithm

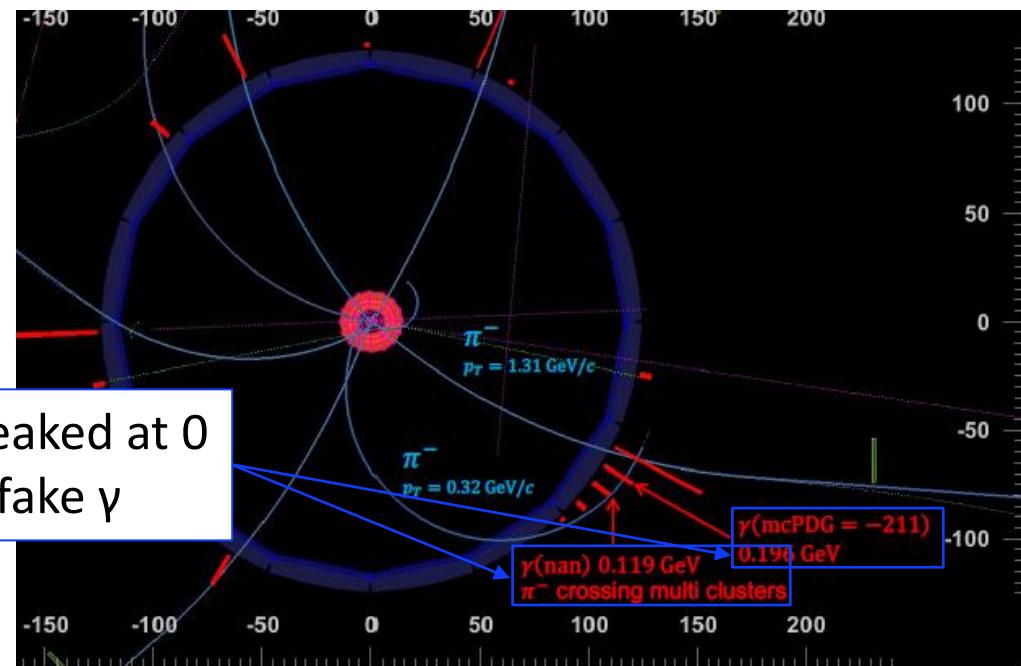
-Improve data/MC agreement

- Calibration of low energy γ
- Tuning of GEANT4 simulation

ECL energy sum in rest of event (E_{extra})
D*lnu signal MC



[slide](#) by Kojima-san



Motivation

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-data/MC difference of E_ECL using D*lnu, hadronic FEI

-share observation

-run dependent MC is useful to improve data/MC of beam BG

-fake photon energy is reduced to improve data/MC

-Effect from radiative photon, true π^0/γ , Btag can not explain difference

-near future plan

-fundamental improvement of ECL clustering, or new track-cluster related variable is needed

-add control sample, learn/check consistency from your study

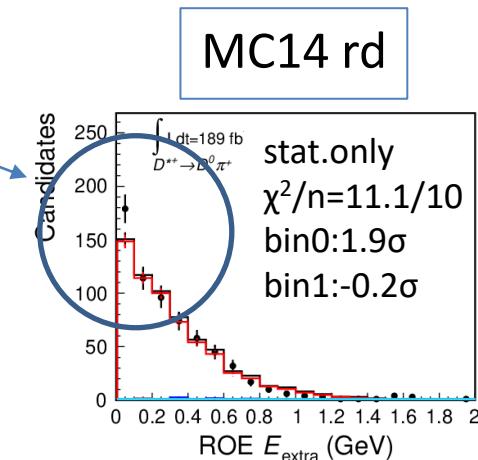
backup

Further E_ECL study with gamma ROE

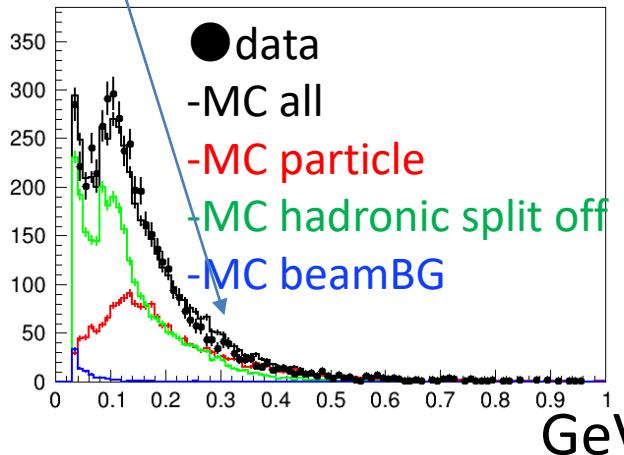
-Data/MC has still $1.5\text{-}1.9\sigma$ local tensions at low E_ECL, even with MCrd
 -for all D* mode. possible systematics

-Further study is done with gamma list in ROE
 [-new ntuple is produced with MC14ri at q2 sideband
 -MC is area normalized

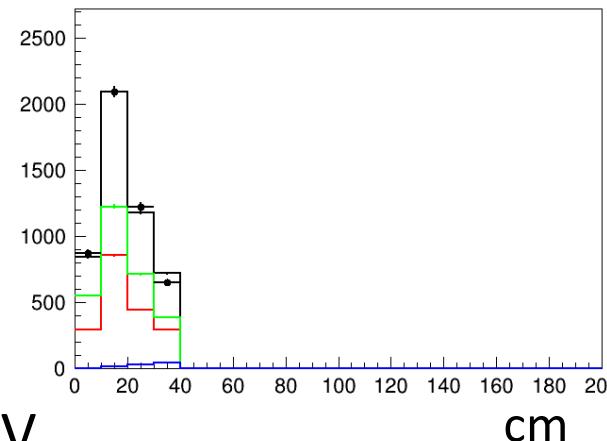
-At $\text{minC2TDist}<20\text{cm}$, data/MC agrees well.
 → major hadronic split off component is reasonably modeled.
 10~20MeV energy shift is seen at ~250MeV.



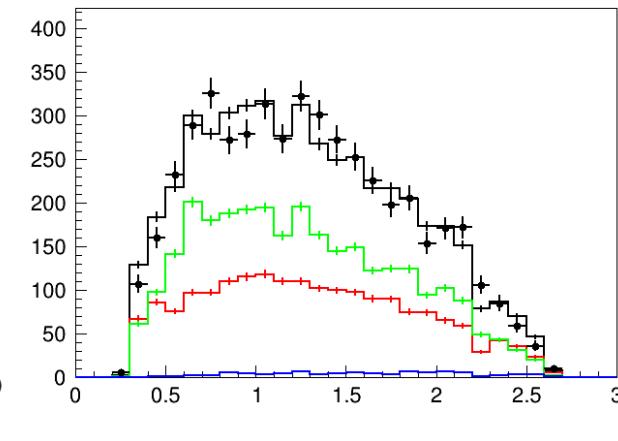
gamma energy



minC2TDist



clusterTheta



E_ECL correction at Mmiss2 sideband

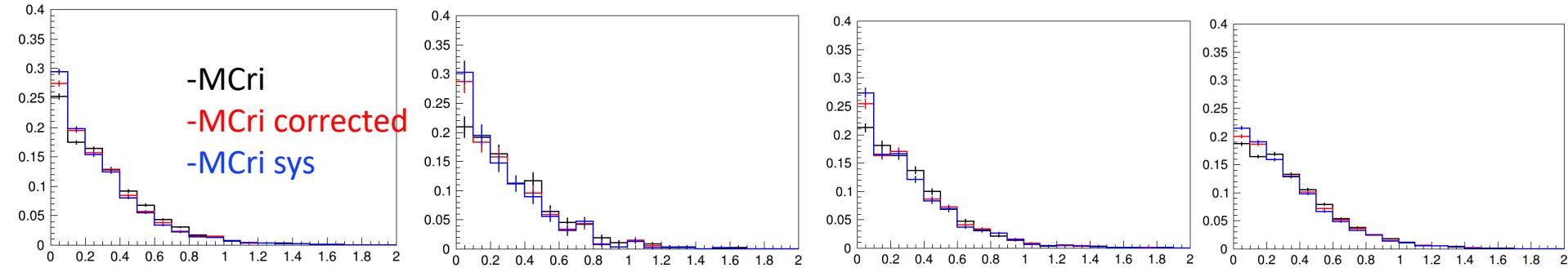
-Fake photon 90%, 80%, beamBG corrected by MCri

$B_0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

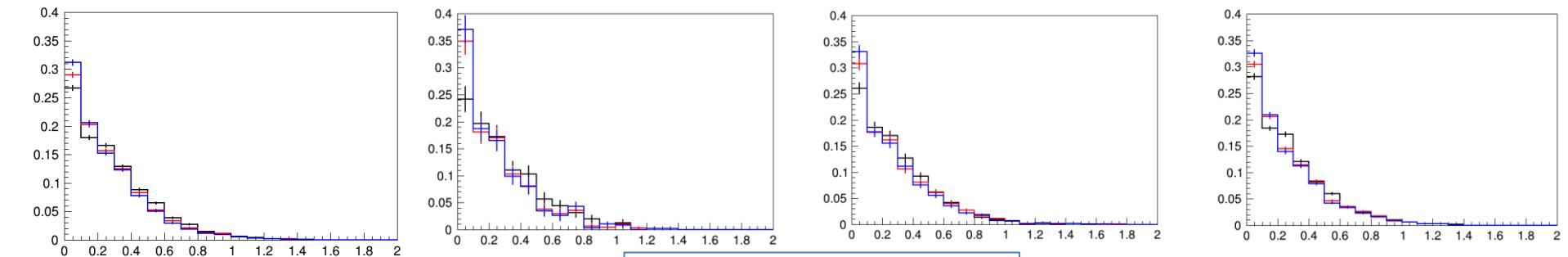
$B_0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

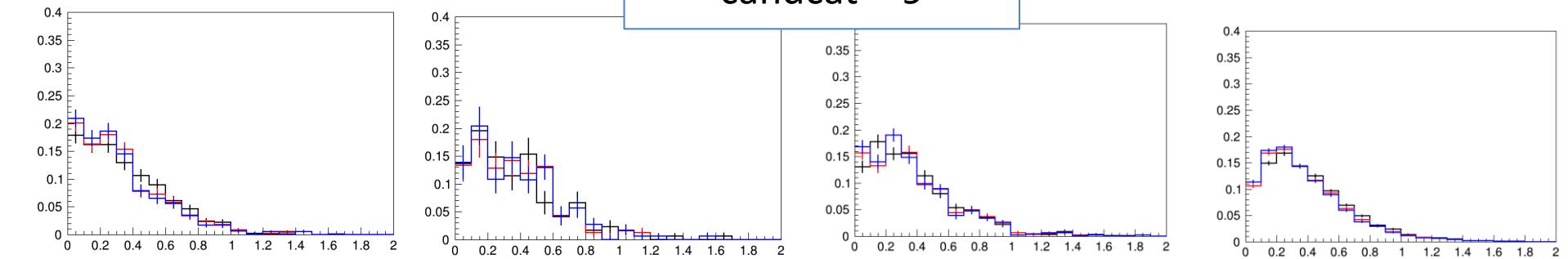
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$



candcat==3



candcat==9



E_ECL correction for R(D*)

-Based on the studies, following corrections are added to MCri

- 1. beamBG energy PDF is corrected by run dependent MC
- 2. energy of fake (MC match failure) gamma is scaled by -10% ($\doteq 5\text{MeV}$).

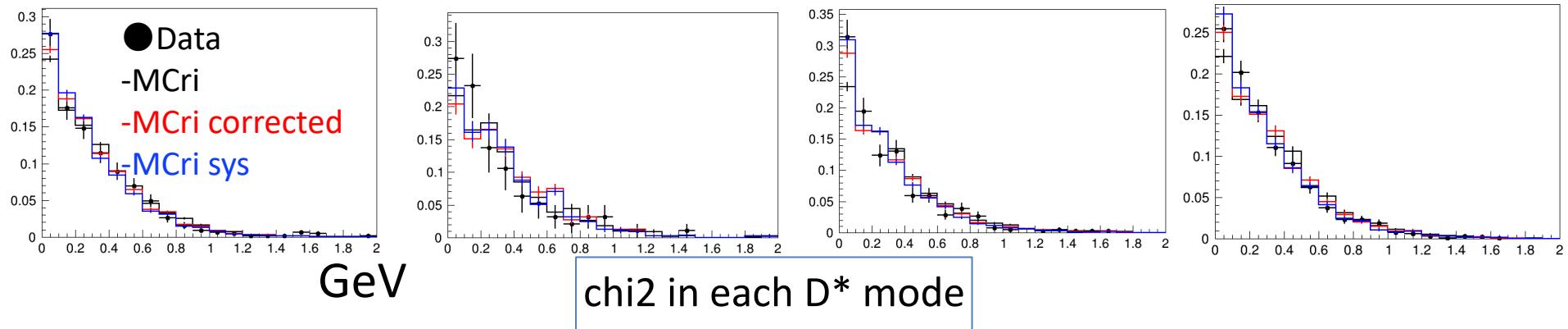
-In addition, systematics is estimated by varying the scaling with $\pm 10\%$.
 -value will be checked again by using low Miss2 sideband

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma \gamma$



shape only stat. only	MCri	MCri, beambg corrected fake gamma 90%	MCri, beambg corrected fake gamma 80%
$\chi^2/\text{NDF}, \text{NDF}=10$	1.16, 0.8, 2.7, 1.7 (64/40)	0.76, 1.3, 1.82, 0.98 (49/40)	0.79, 1.0, 1.55, 0.6 (39/40)
bin0 significance	$1.6\sigma, 1.0\sigma, 2.8\sigma, 1.8\sigma$	$1.0\sigma, 1.2\sigma, 0.9\sigma, 0.2\sigma$	$-0.1\sigma, 0.8\sigma, 0.2\sigma, -0.9\sigma$
bin1 significance	$0.2\sigma, 1.3\sigma, 1.0\sigma, 2.0\sigma$	$-0.7\sigma, 1.5\sigma, 1.4\sigma, 1.7\sigma$	$-1.0\sigma, 1.4\sigma, 1.0\sigma, 1.1\sigma$

Scaling factor of E_ECL (1st-10th bin)

-estimated at q2 sideband (will be updated to Mmiss2 sideband)

-10% scaling

-dmID=100:

1.045, 1.083, 1.056, 0.893, 0.989, 0.923, 0.816, 1.059, 0.684, 0.865

-dmID=200:

0.960, 0.934, 0.961, 1.054, 1.105, 1.166, 1.978, 0.628, 1.259, 0.710

-dmID=300:

1.247, 0.963, 1.017, 0.880, 0.983, 0.901, 0.943, 0.993, 0.838, 0.744

-20% scaling

-dmID=100:

1.138, 1.127, 1.066, 0.843, 0.927, 0.842, 0.750, 0.965, 0.574, 0.760

-dmID=200:

1.058, 0.979, 0.938, 1.058, 1.025, 0.836, 1.817, 0.717, 0.960, 0.709

-dmID=300:

1.342, 1.014, 1.022, 0.853, 0.862, 0.886, 0.898, 0.798, 0.720, 0.745

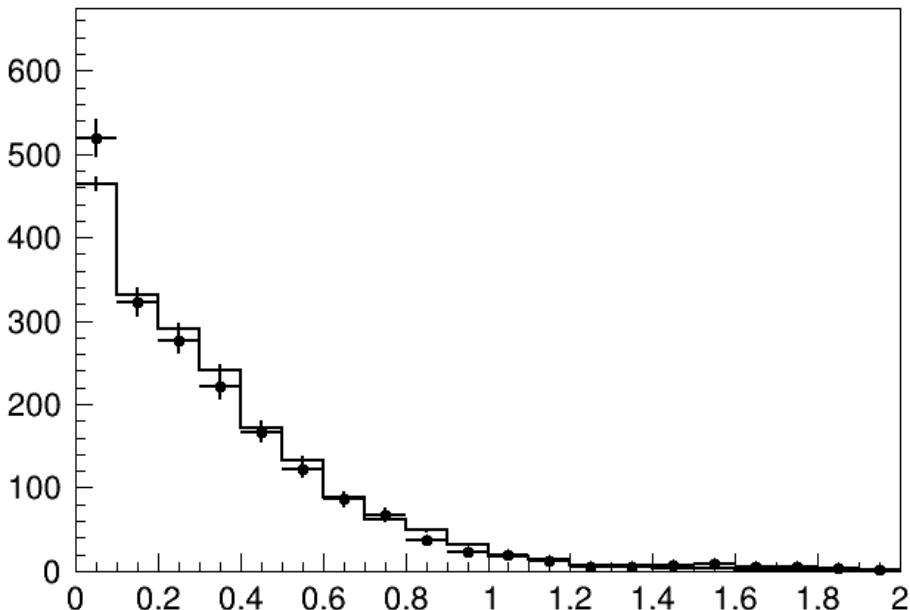
beambackground suppression MVA

-No significant difference

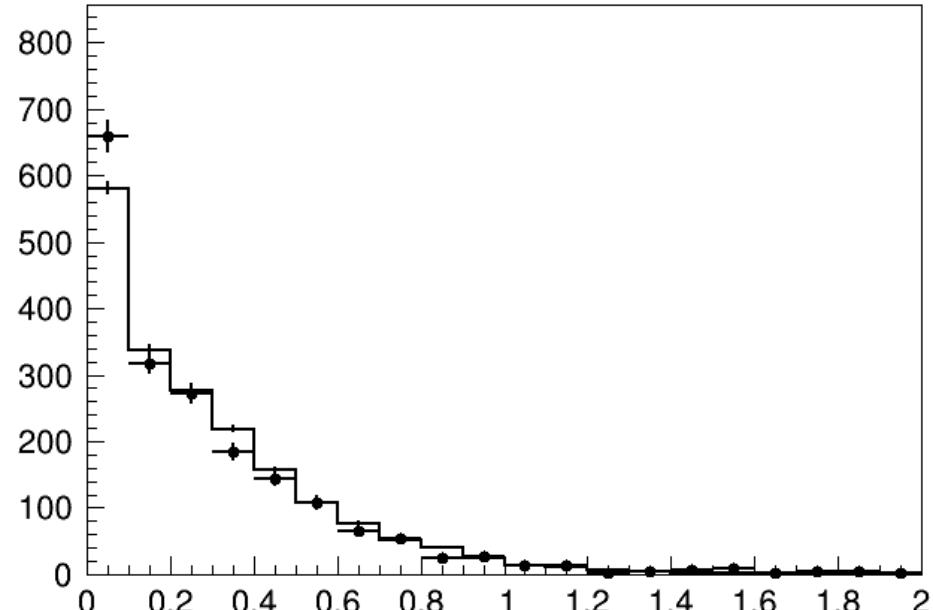
$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

p-value=0.05,0.01:
 $\chi^2/10=18.3,23.2 / 10$

MC14 ri



MC14 ri beamBG MVA>0.5



beamBG with run dependent MC

-beamBG simulation is improved by run dependent MC

- in early runs: beamBG of MCrd is $\sim 50\%$ smaller than MCri
- in latter runs: beamBG of MCrd is $\sim 30\%$ larger than MCri

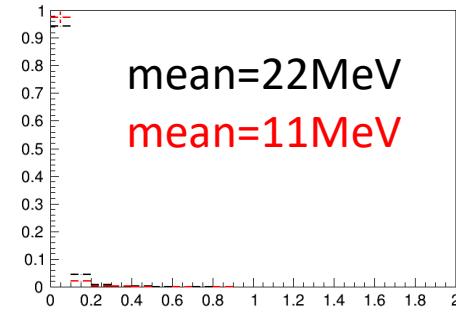
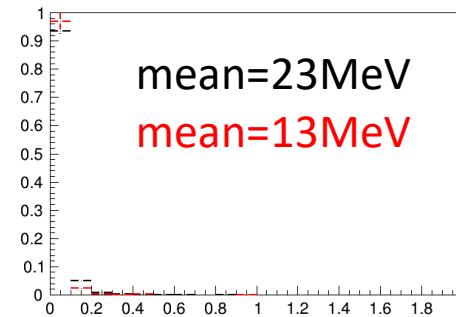
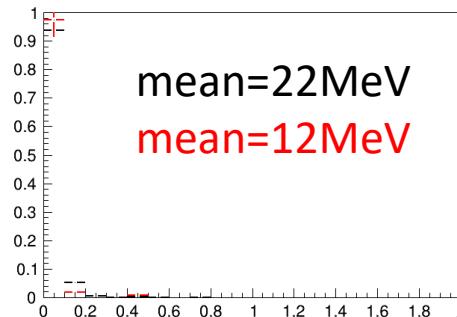
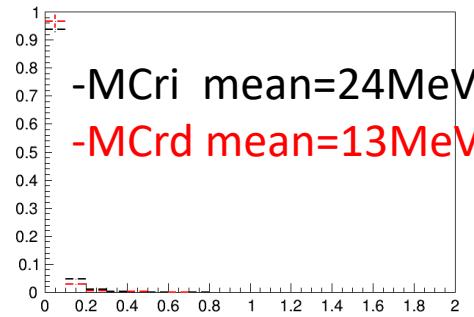
$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

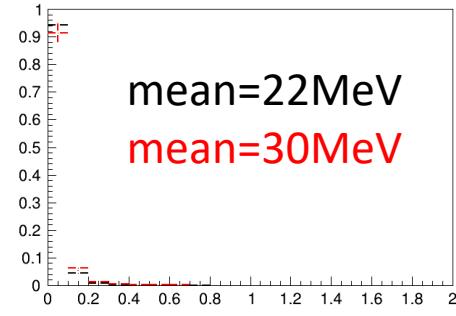
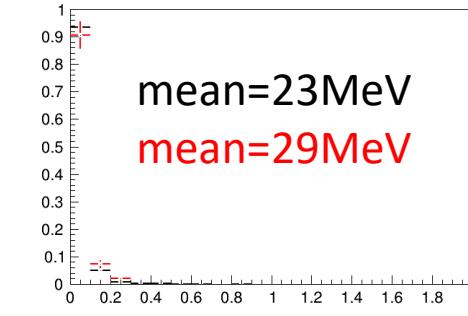
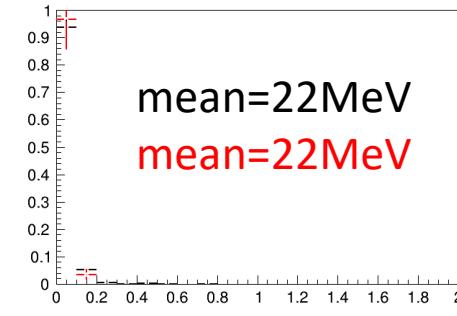
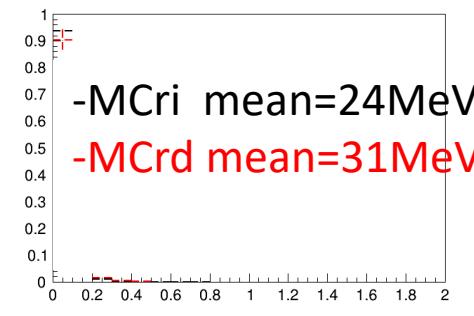
$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$

E_ECL of MC beamBG, proc12+bucket1x

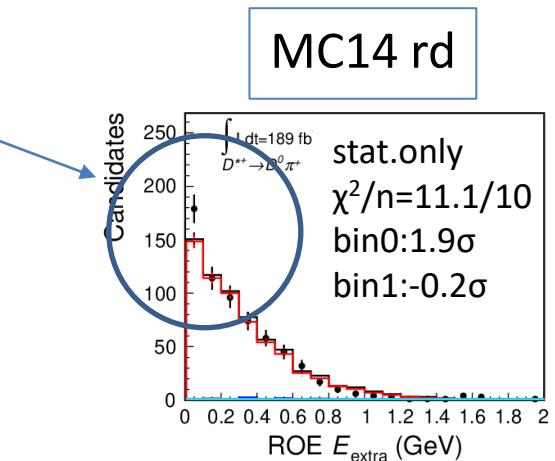


E_ECL of MC beamBG, bucket2x



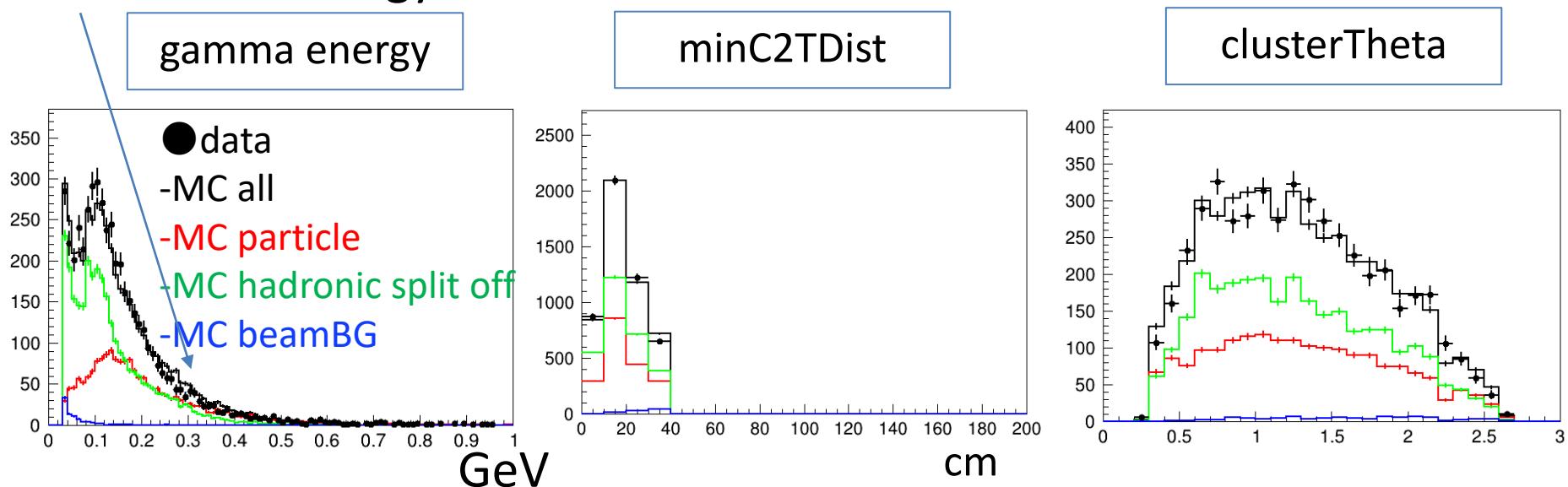
Further E_ECL study with gamma ROE

- Data/MC has still $1.5\text{-}1.9\sigma$ local tensions at low E_ECL, even with MCrd
 - for all D* mode. possible large systematics



- Further study is done with gamma list in ROE
 - new ntuple is produced with MC14ri at q2 sideband
 - MC is area normalized

-At $\text{minC2TDist} < 20\text{cm}$, data/MC agrees well.
 → major hadronic split off component is reasonably modeled.
 $10\text{--}20\text{MeV}$ energy shift is seen at $\sim 250\text{MeV}$.



E_ECL correction

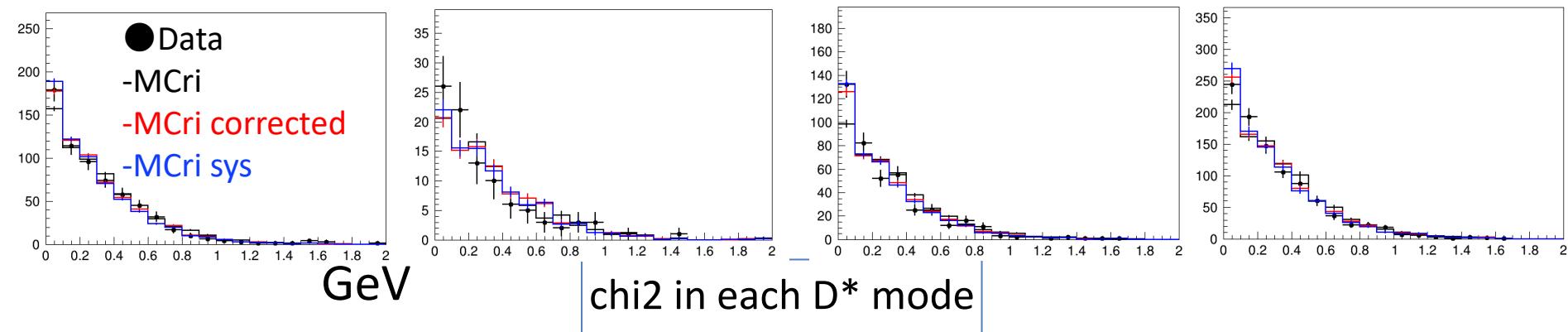
- Based on the studies, following corrections are added to MCri
 - 1. beamBG energy PDF is corrected by run dependent MC
 - 2. energy of hadronic splitoff gamma is scaled by -10MeV ($\sim 10\%$).
- In addition, systematics is assigned by varying the scaling with $\pm 10\text{MeV}$.
- χ^2 value will be checked again by using low Miss2 sideband

$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$



shape only stat. only	MCri	MCri, beambg corrected fake gamma 10MeV	MCri, beambg corrected fake gamma 20MeV
$\chi^2/\text{NDF}, \text{NDF}=10$	1.16, 0.8, 2.7, 1.7 (64/40)	0.63, 0.95, 1.52, 0.98 (49/40)	0.63, 0.84, 1.37, 0.92 (39/40)
bin0 significance	$1.6\sigma, 1.0\sigma, 2.8\sigma, 1.8\sigma$	$0.12\sigma, 1.4\sigma, 0.5\sigma, -0.6\sigma$	$-0.7\sigma, 0.7\sigma, -0.1\sigma, -1.4\sigma$
bin1 significance	$0.2\sigma, 1.3\sigma, 1.0\sigma, 2.0\sigma$	$-0.6\sigma, 0.9\sigma, 1.1\sigma, 1.7\sigma$	$-0.7\sigma, 1.3\sigma, 1.0\sigma, 1.5\sigma$

Check of ROE gamma

- gamma in ROE is stored in ntuple
 - run independent MC, **data added**

- basic distribution is checked in q2 sideband with category of MC match

- true MC particle:

- MCmatch=true

- hadronic split off:

- MCmatch=false, $\text{gamma_clusterTotalMCMatchWeight}/\text{gamma_clusterE} > 0.4$

- beamBG:

- MCmatch=false, $\text{gamma_clusterTotalMCMatchWeight}/\text{gamma_clusterE} < 0.4$

E_ECL run dependent: early exp

- MCrd B+: data/MC at low E_ECL gets better than MCri
- MCrd B0: no change or bit worse than MCri

• Data
 — MC total
 — $D^{*+}l\nu$
 — $Dl\nu$
 — $D^{*+}l\nu$
 — Hadronic B
 — $B^0 \leftrightarrow B^\pm$ crossfeed
 — Continuum

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

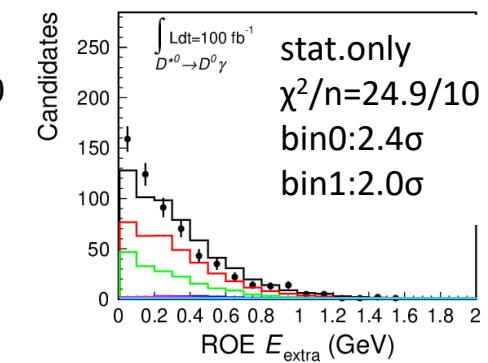
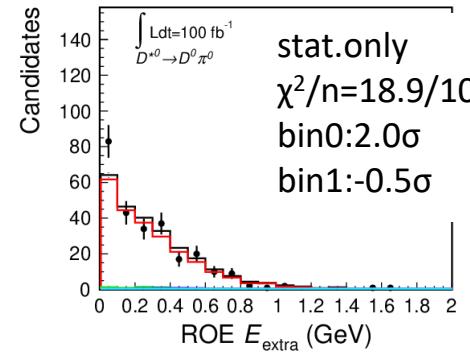
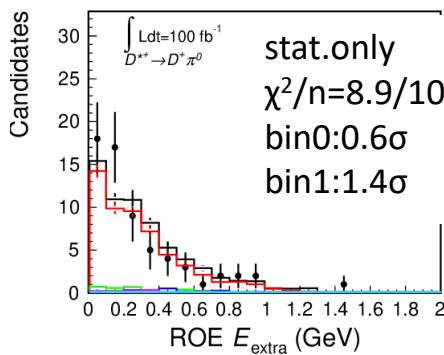
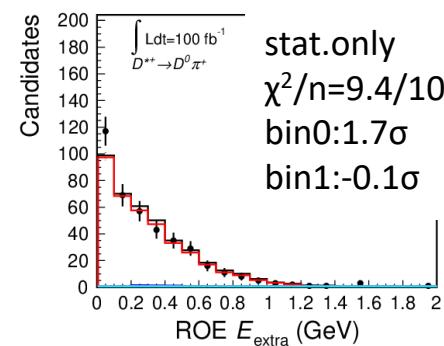
$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

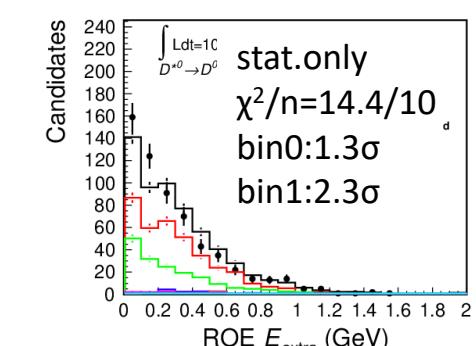
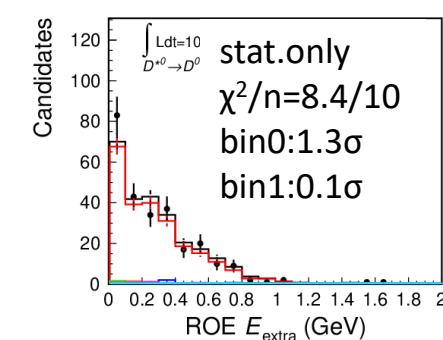
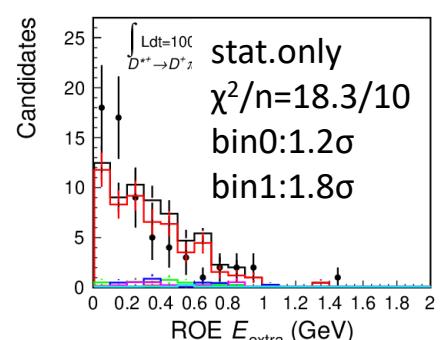
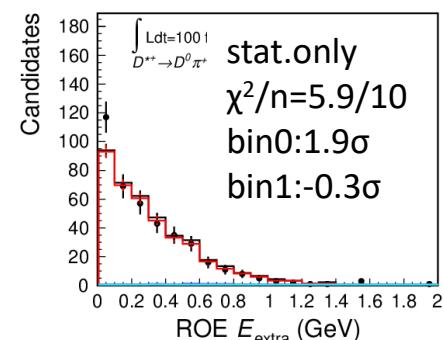
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$

MC14 ri proc12,bucket1x

p-value=0.05,0.01:
 $\chi^2/10 = 18.3, 23.2 / 10$



MC14 rd proc12,bucket1x



E_ECL run dependent later exp

- no significant difference between MCrd and MCri
- run dependence is improved largely with MCrd

• Data
 — MC total
 — $D^* l \nu$
 — $D l \nu$
 — $D^{**} l \nu$
 — Hadronic B
 — $B^0 \leftrightarrow B^\pm$ crossfeed
 — Continuum

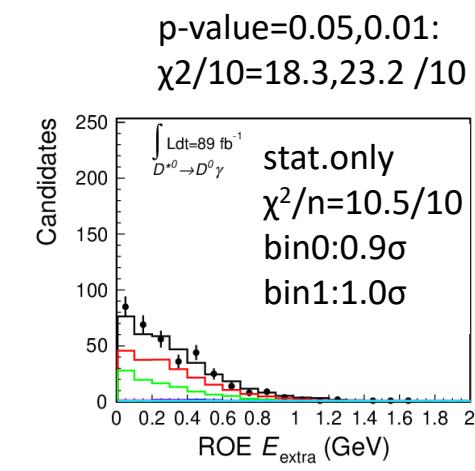
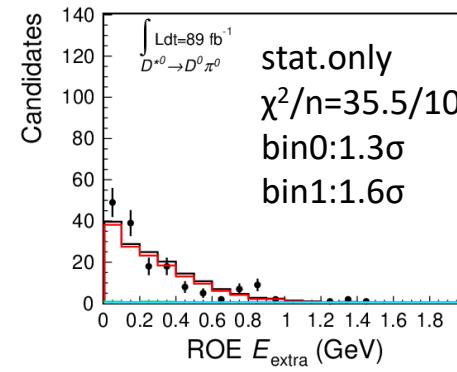
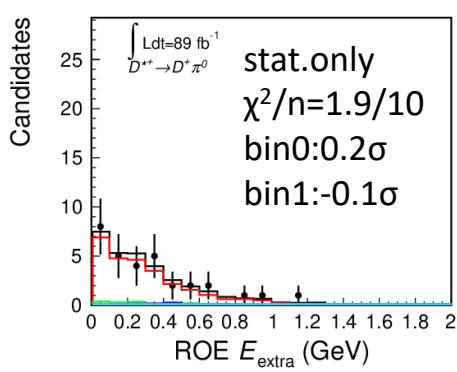
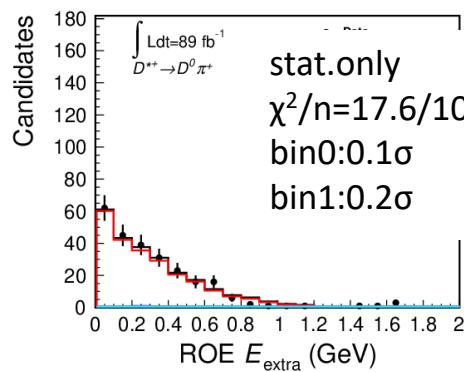
$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

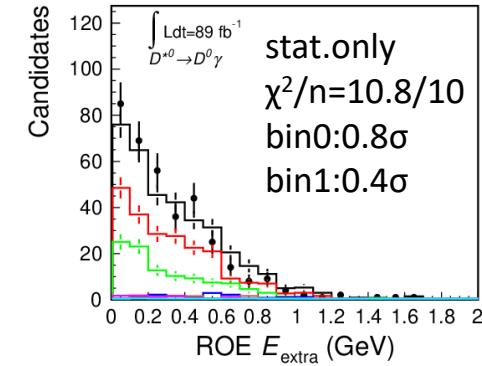
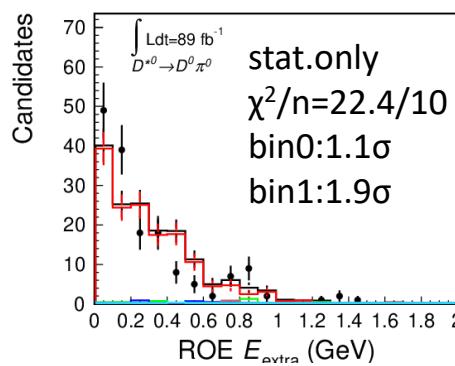
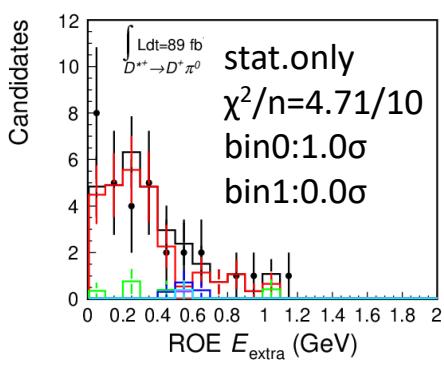
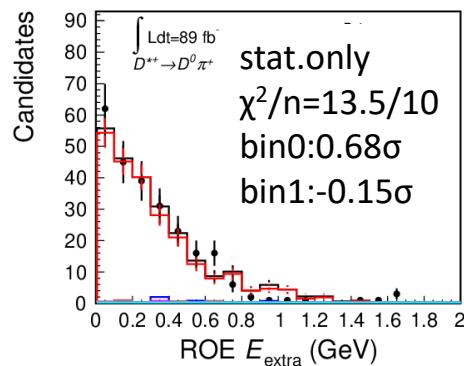
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$

MC14 ri, bucket2x



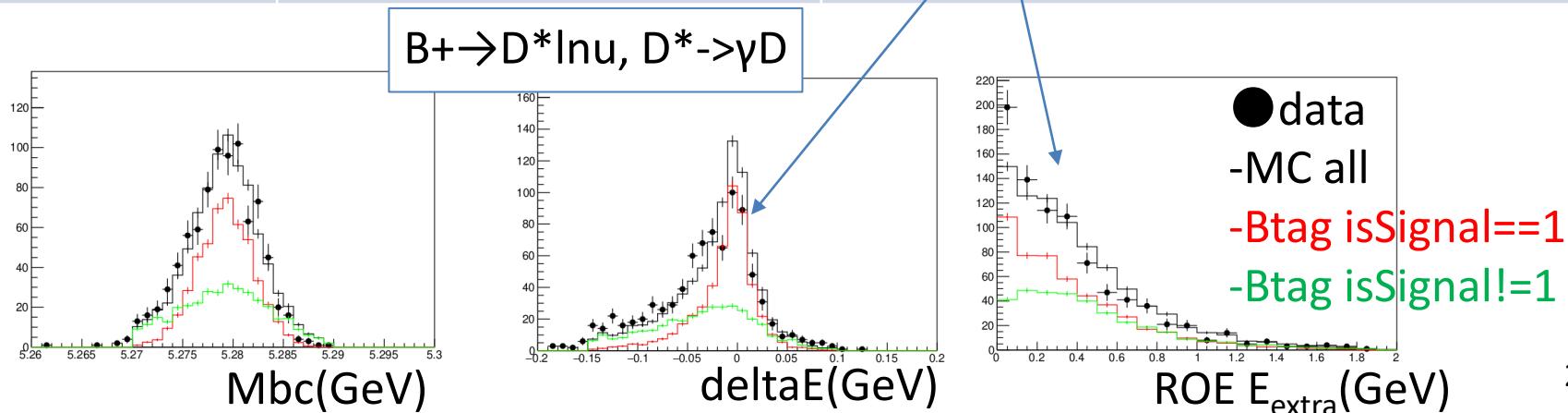
MC14 rd, bucket2x



q^2 sideband: effect from others

- Following hypothesis are considered to describe data/MC difference of E_{extra}
- Except for beamBG, there is no reasonable explanation [slide](#)

possible hypothesis	investigation	result
π^0 from D decay	D decay mode dependence	no dependence
radiative photon	$D^*\mu\nu$ and $D^*e\nu$ dependence	no dependence
hadronic sprit off	$\text{minC2T}D\text{ist}$ dependence	no dependence
beamBG	run dependence	-large data/MC at early run -better data/MC agreement with beamBGx1/10
Bsig isSignal==1 fraction (π^0, γ from D^* decay)	Constraint from ΔM sideband	no difference w and w/o constraint
Btag decaymode	Btag decay mode dependence	no dependence
Btag isSignal==1 fraction	-check E_{extra} with $\text{isSignal}==1, !=1$ -check deltaE and Mbc of Btag	- E_{extra} is different, if fraction of $\text{isSignal}==1$ is very higher than MC, explain data/MC -fraction is bit lower than MC. not realistic.



E_ECL data/MC: D decay mode

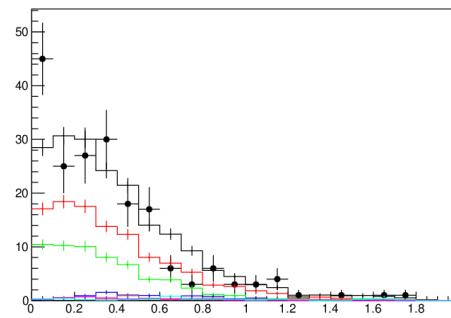
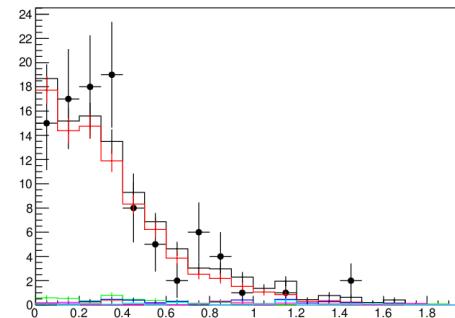
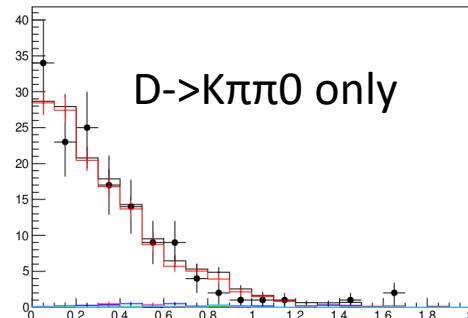
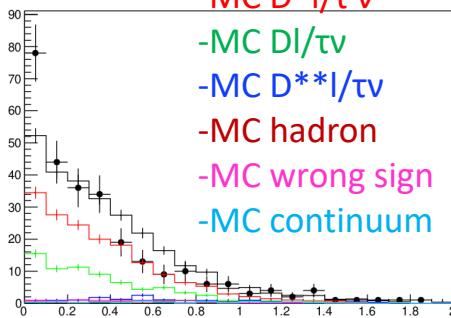
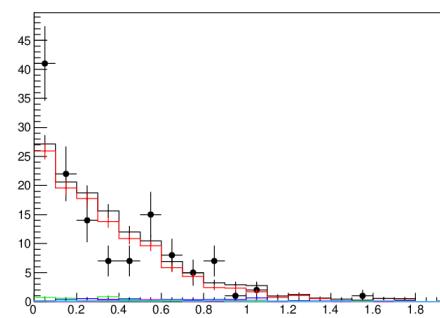
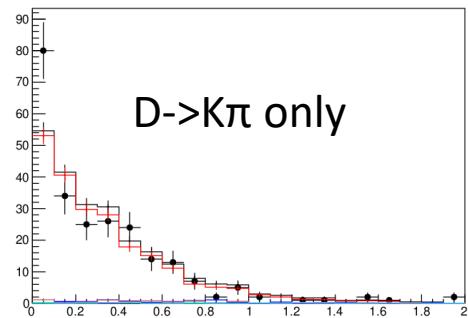
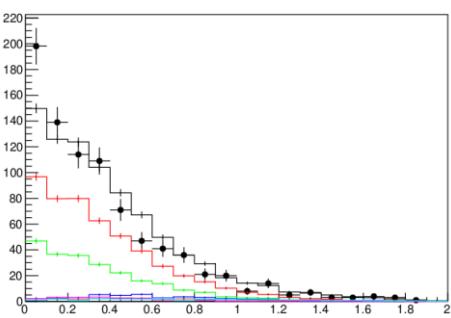
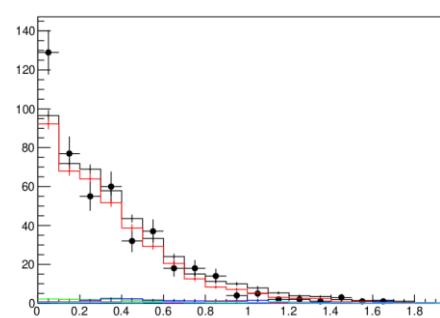
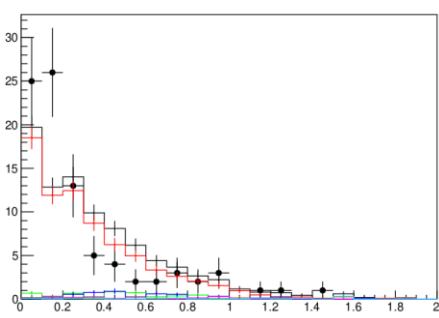
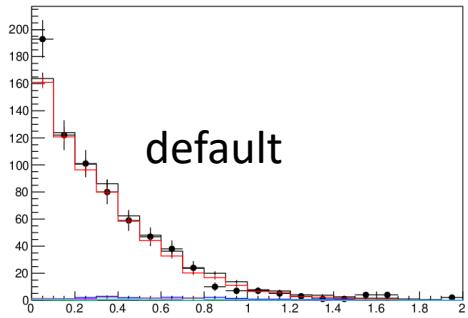
-Even with cleanest mode of $D \rightarrow K\pi$, discrepancy is seen at low energy.

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



E_ECL data/MC: e and μ mode

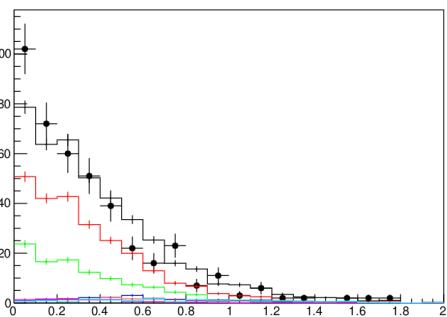
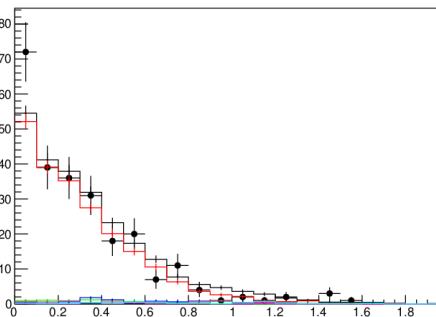
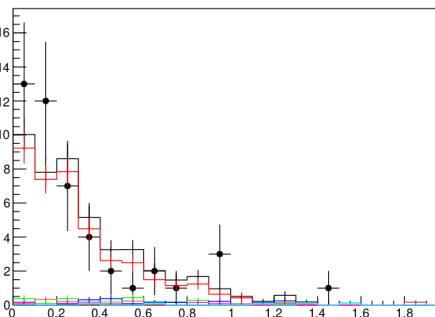
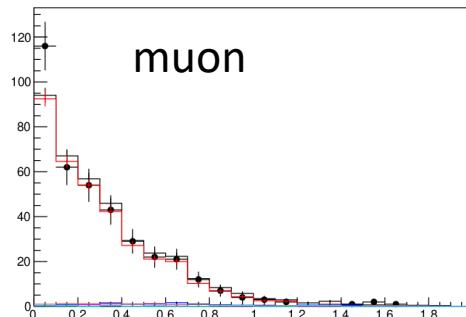
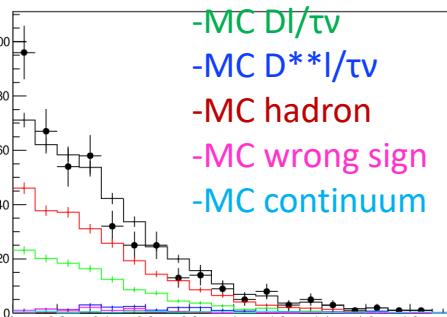
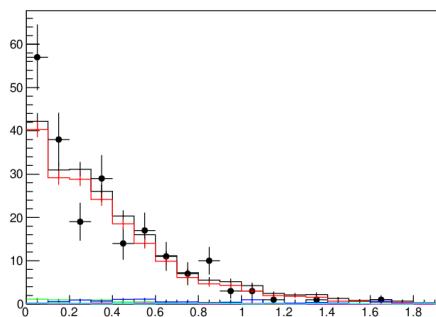
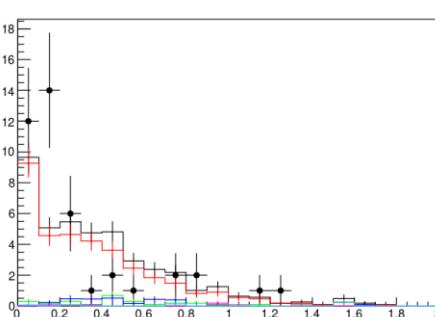
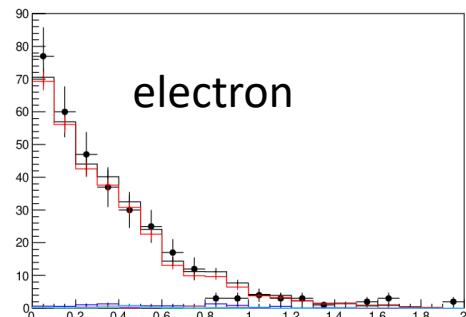
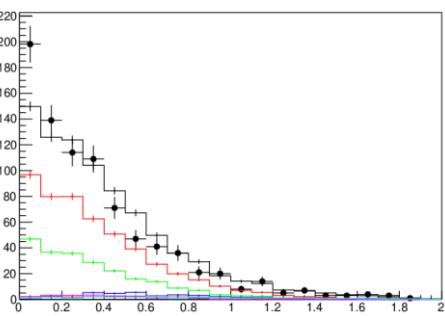
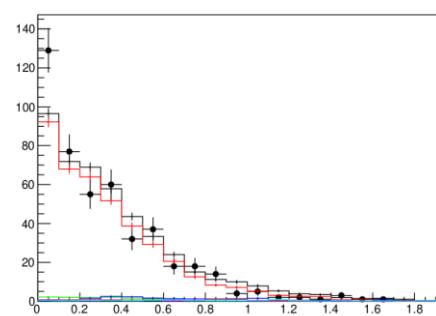
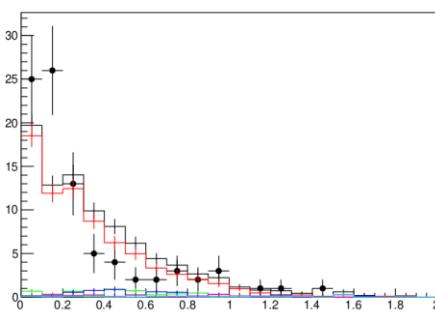
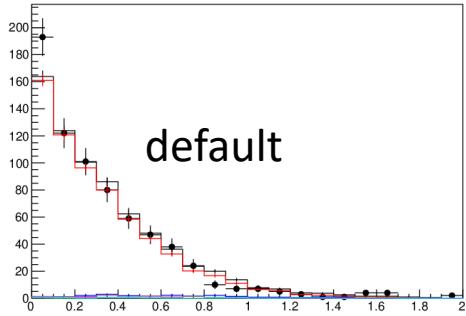
-No clear difference between e and μ

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



E_ECL MC components

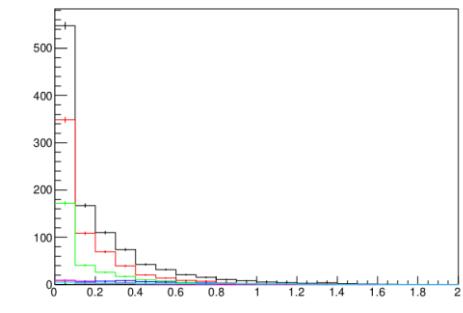
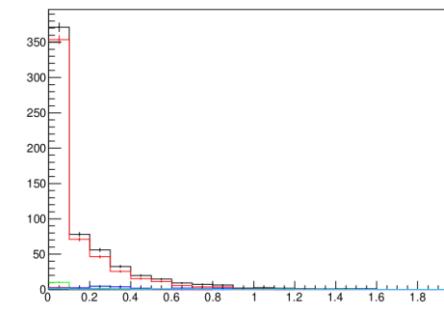
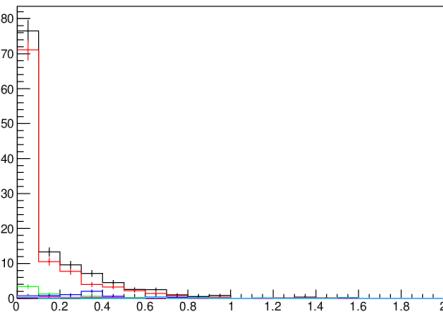
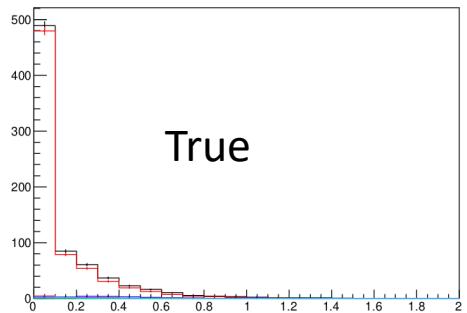
-MC categorized by E_ECL of true particles, hadronic split off, beamBG. Clear difference.

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

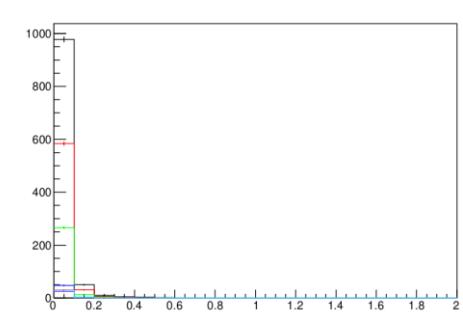
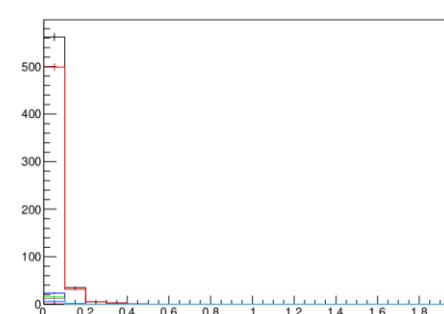
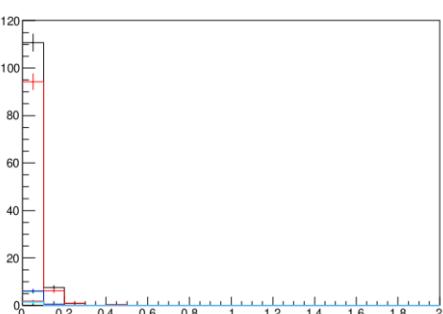
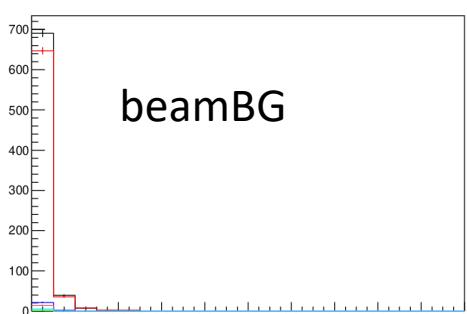
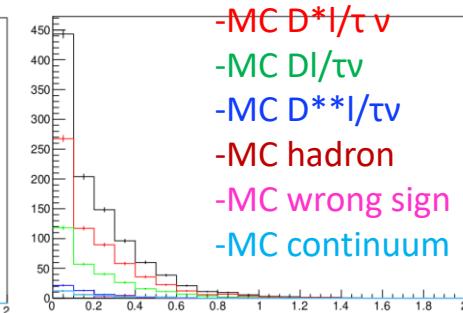
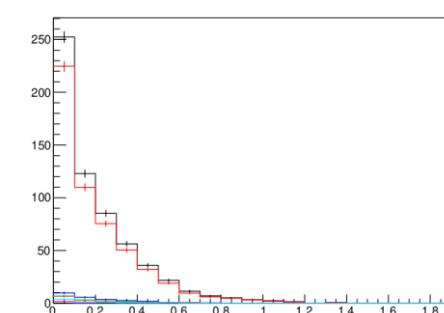
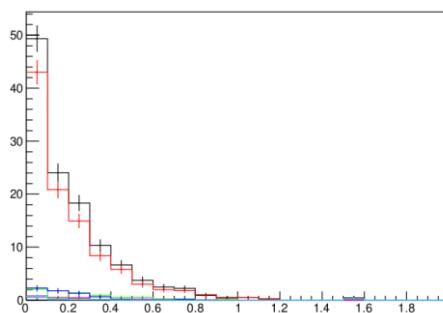
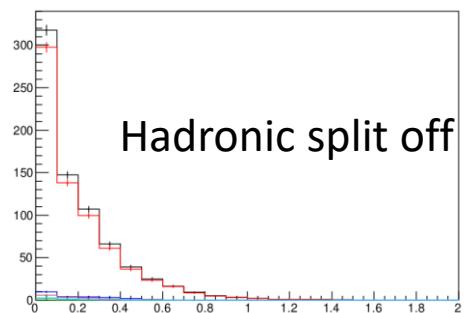
$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



-MC total

- MC $D^- l \bar{\nu}$
- MC $D^- l \bar{\nu}$
- MC $D^{*-} l \bar{\nu}$
- MC hadron
- MC wrong sign
- MC continuum



E_{ECL} data/MC: true scaled

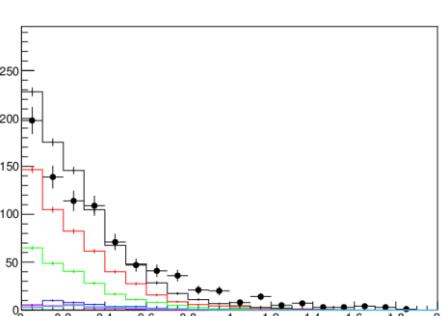
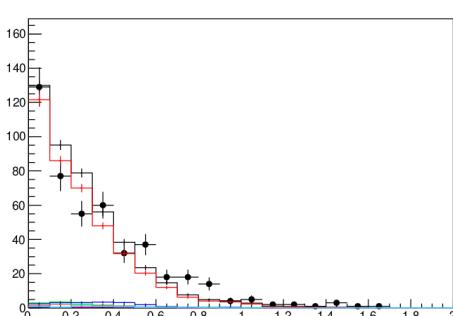
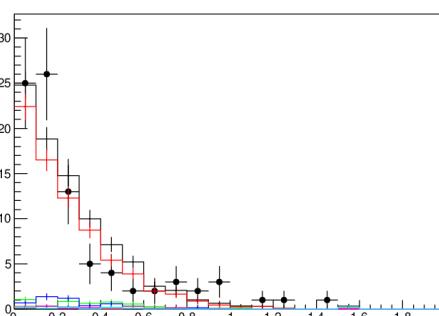
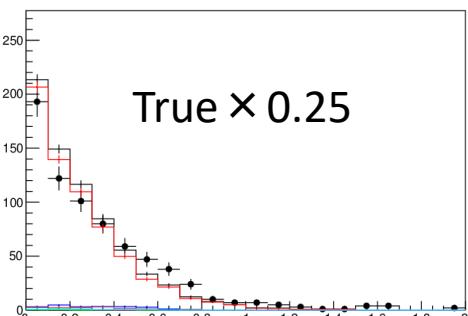
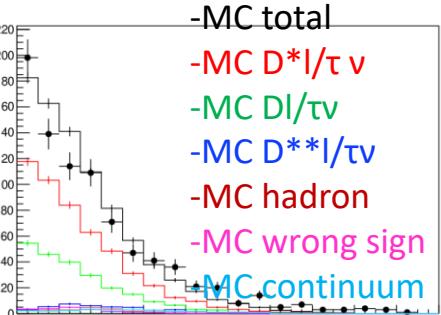
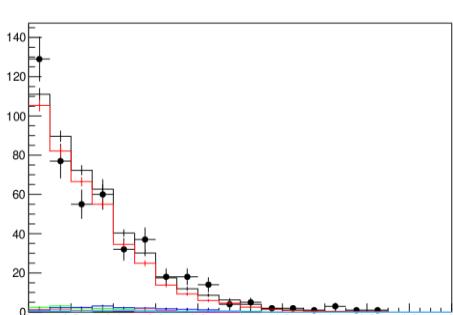
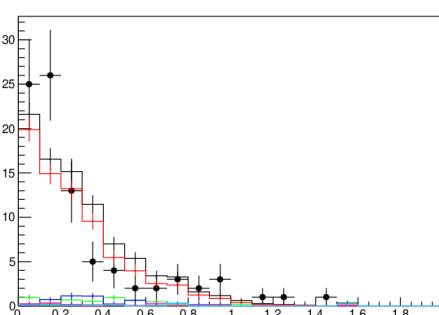
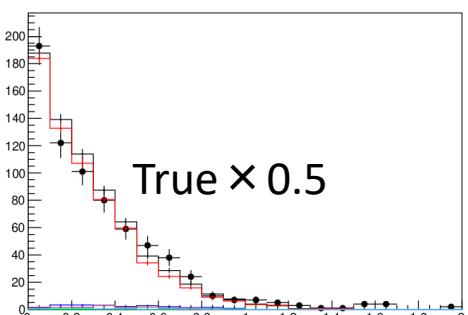
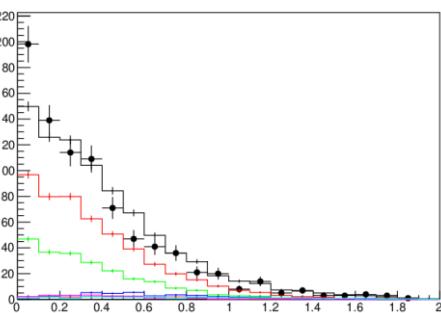
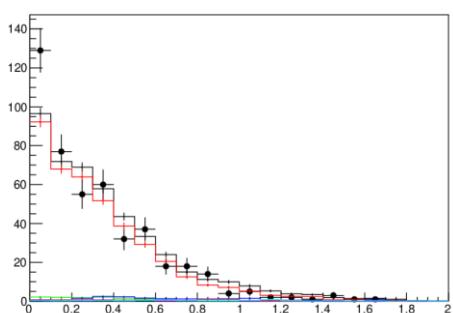
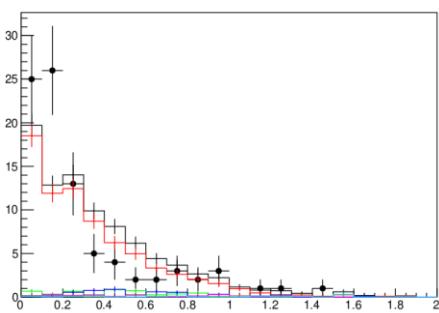
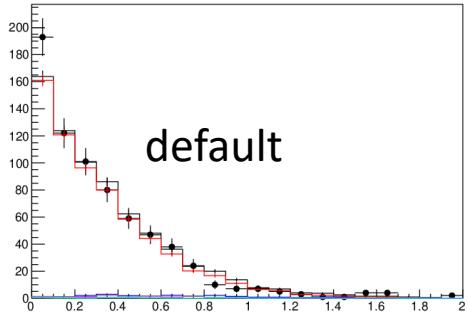
-Data/MC get better with $\times 0.5$ but not perfect.

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



E_ECL data/MC: hadronic splitoff scaled

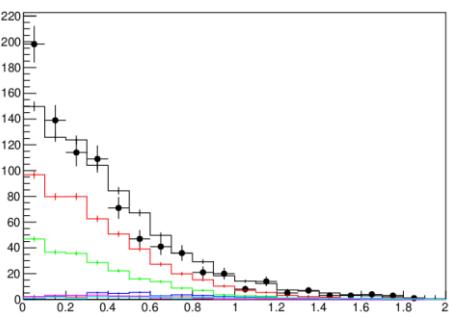
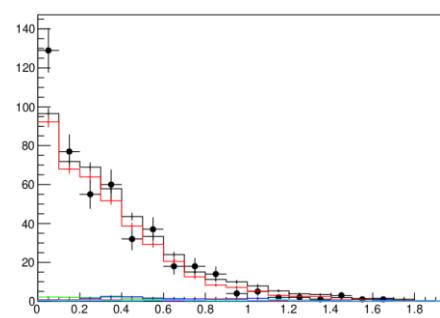
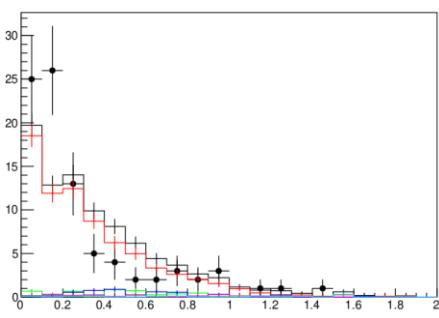
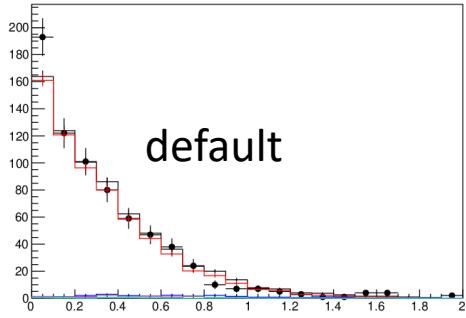
-Data/MC get better with $\times 0.6$ but not perfect.

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

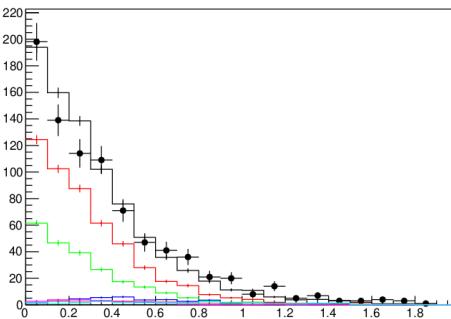
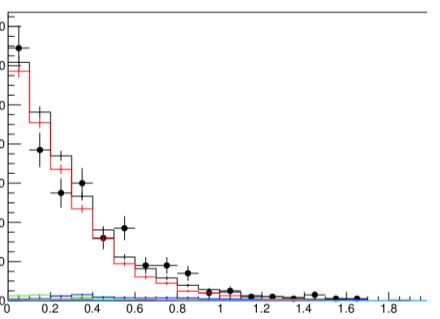
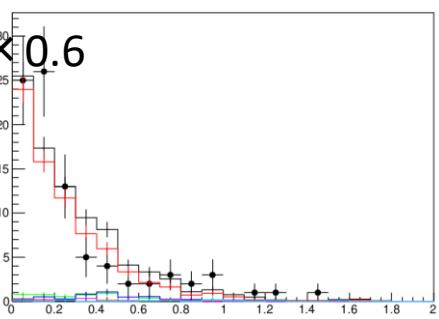
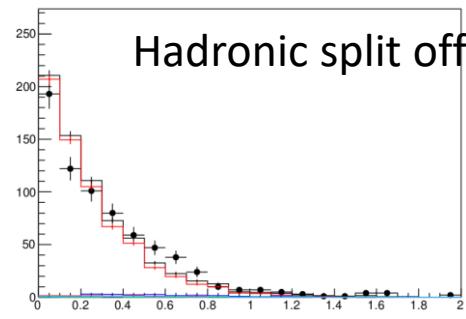
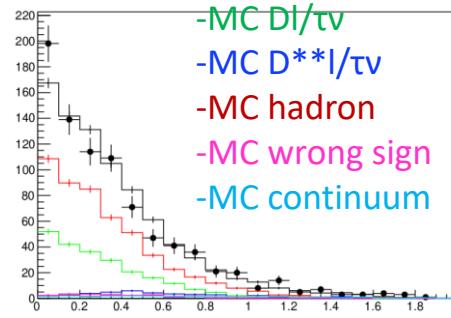
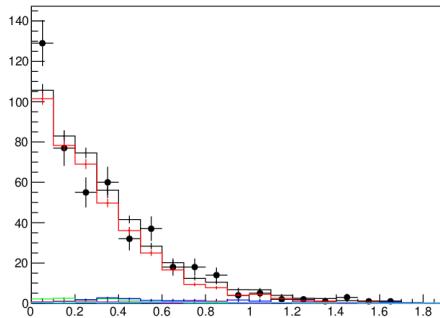
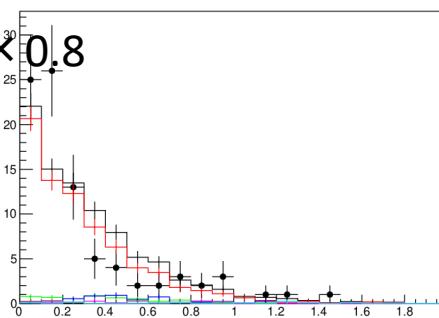
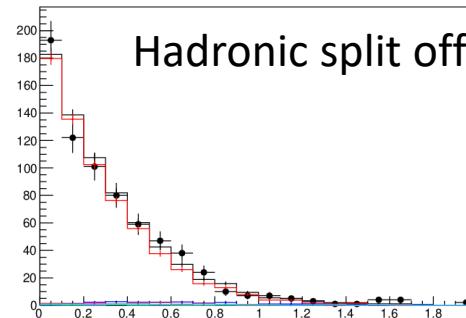
$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



- MC total
- MC $D^* l / \tau v$
- MC $D l / \tau v$
- MC $D^{**} l / \tau v$
- MC hadron
- MC wrong sign
- MC continuum



E_{ECL} data/MC: minC2TDist dependency

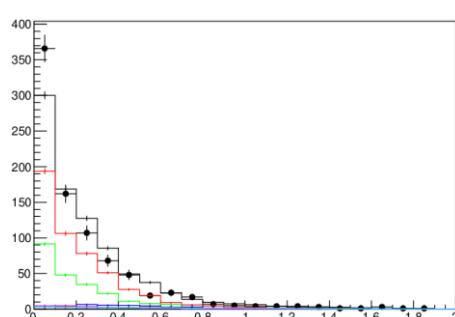
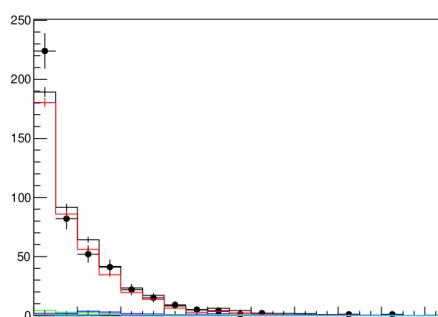
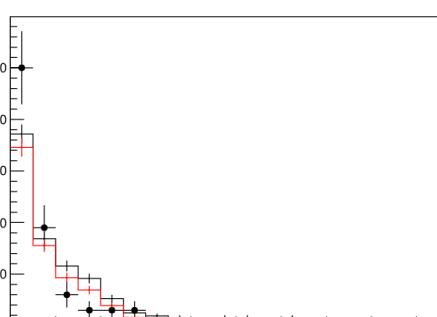
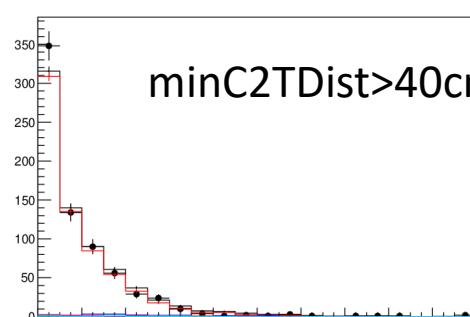
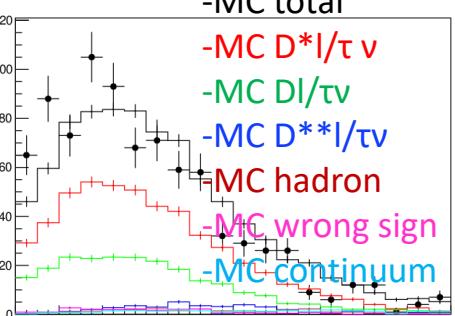
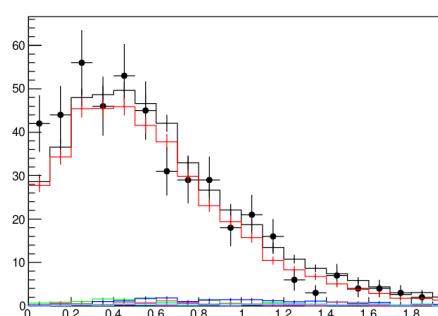
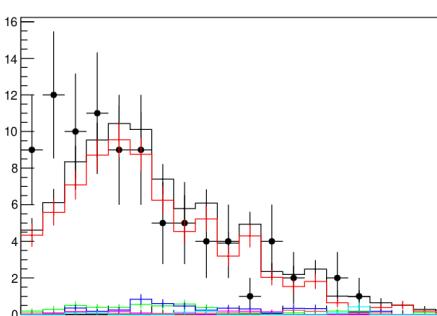
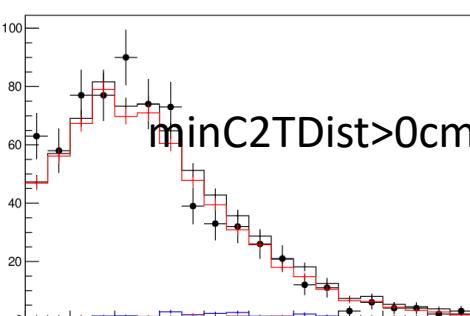
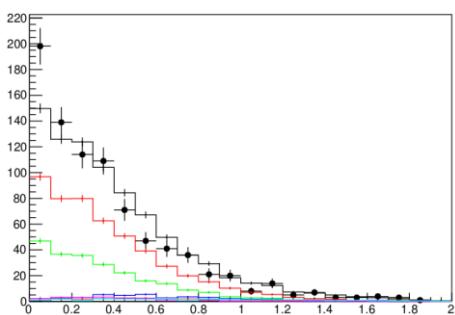
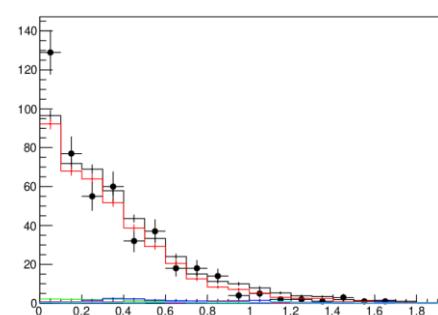
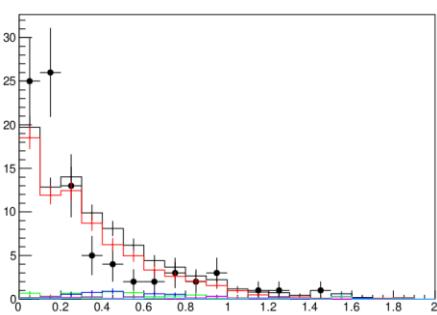
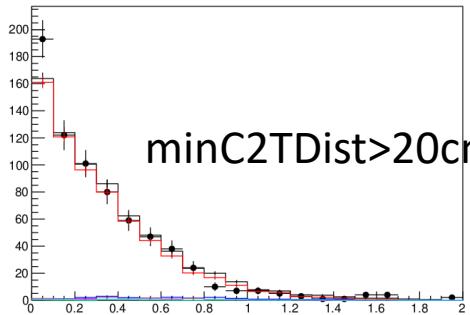
-tendency is not changed with minC2TDist: hadronic split off is not suspicious

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



E_ECL data/MC: beamBG scaled

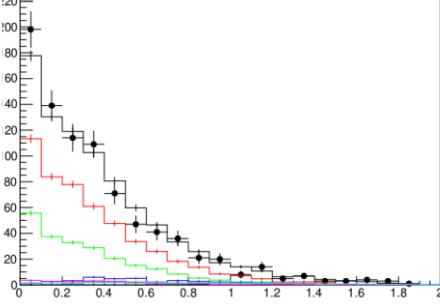
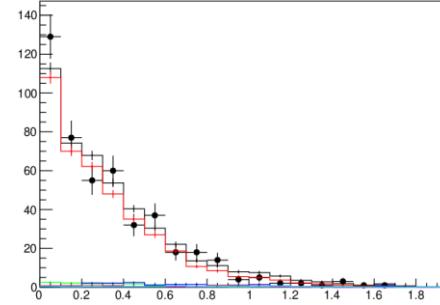
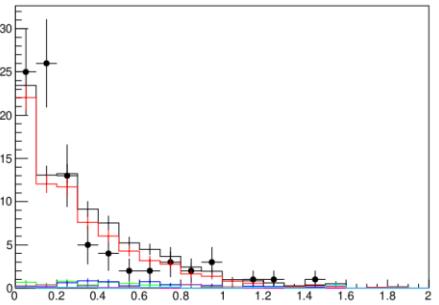
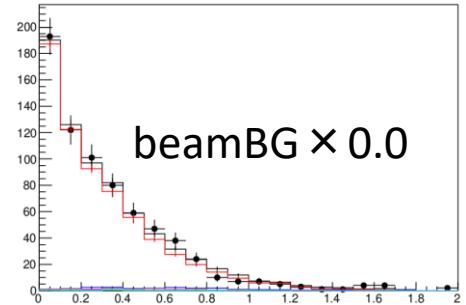
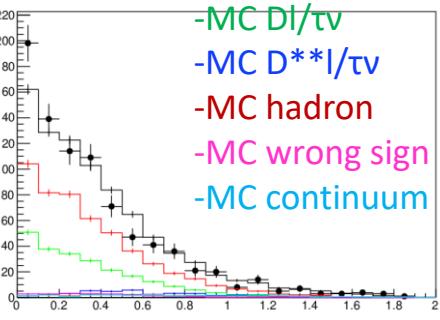
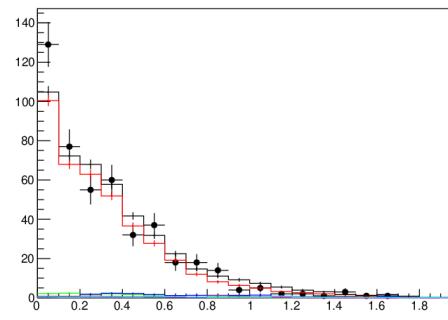
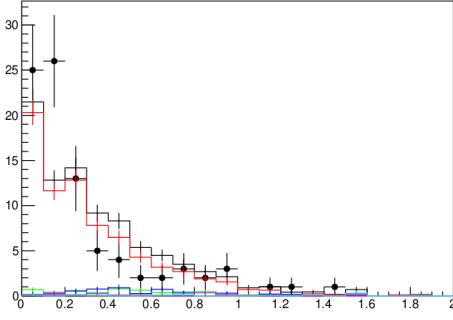
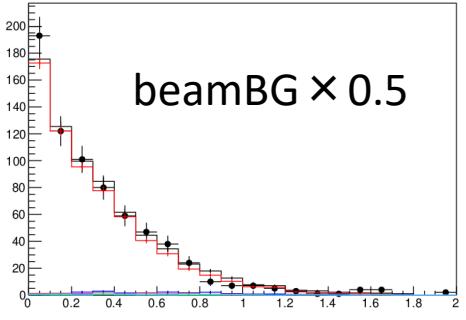
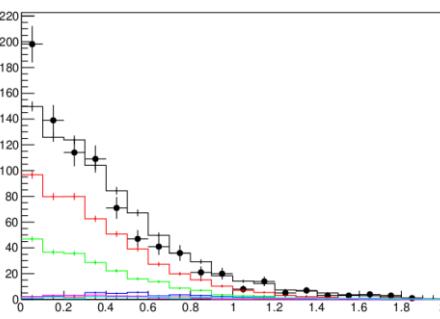
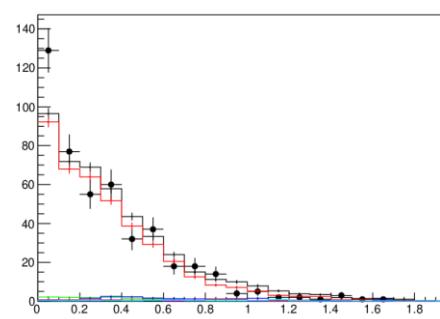
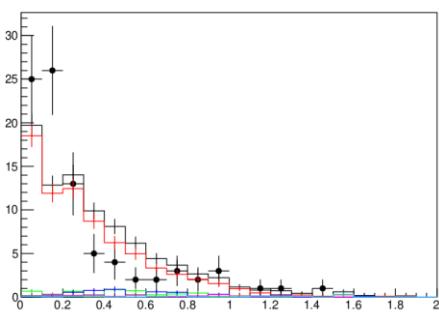
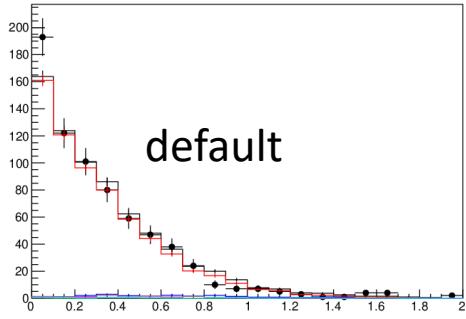
-Data/MC get better with $\times 0.0$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



- MC total
- MC $D^* l/\tau v$
- MC $D l/\tau v$
- MC $D^{**} l/\tau v$
- MC hadron
- MC wrong sign
- MC continuum

E_ECL data/MC: run dependence

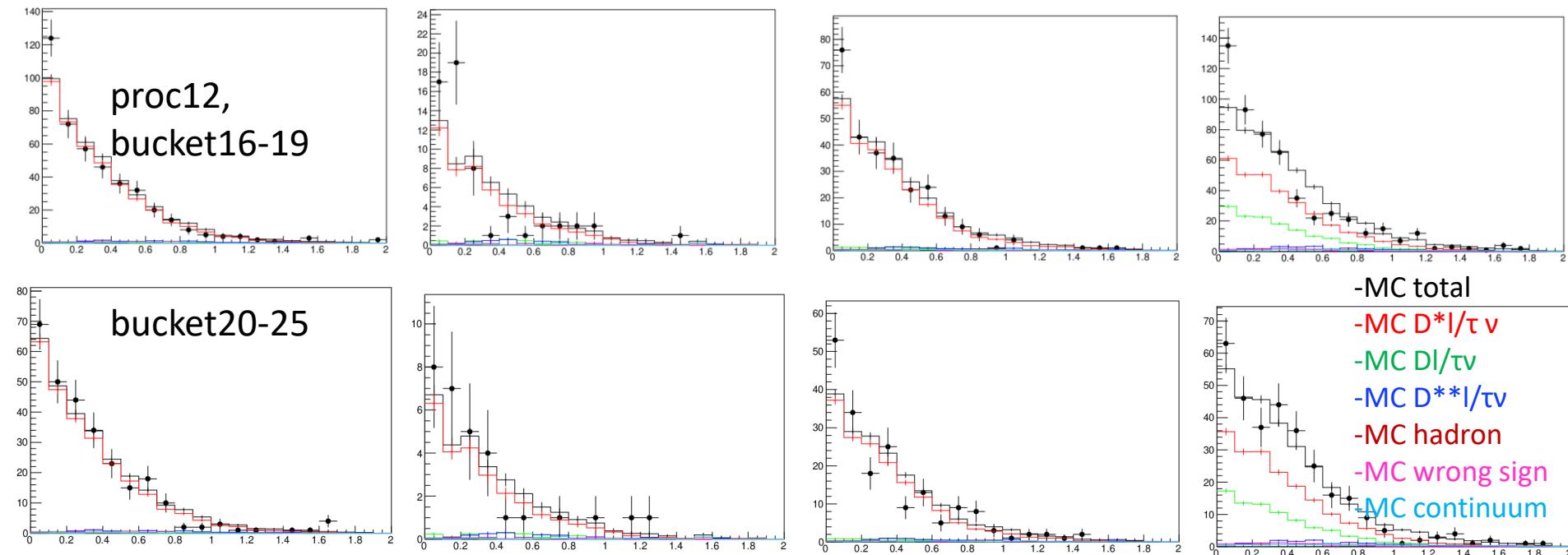
-Data/MC is worse at early experiments and better at latter experiments.
Support hypothesis of beamBG mismodeling.

$B_0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B_0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi 0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$

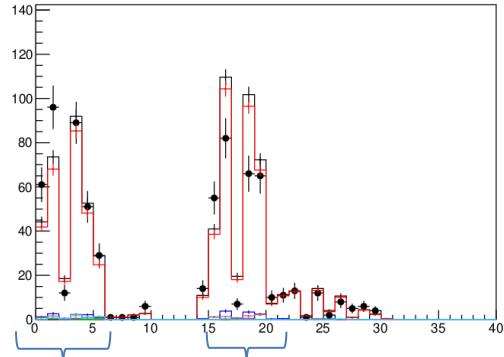


decayModelID

TABLE III: The hadronic B -meson decay channels supported by the FEI algorithm, along with their `decayModeID` flags.

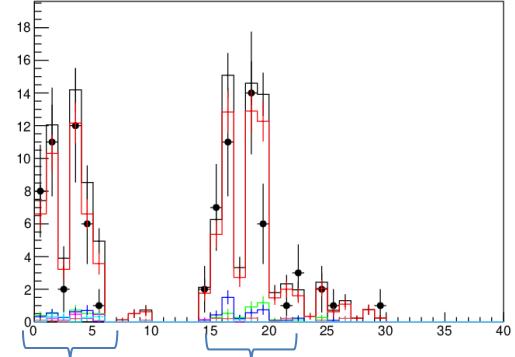
Charged B_{tag} Modes		Neutral B_{tag} Modes	
decayModeID	Channel	decayModeID	Channel
0	$B^+ \rightarrow D^0 \pi^+$	0	$B^0 \rightarrow D^- \pi^+$
1	$B^+ \rightarrow D^0 \pi^+ \pi^0$	1	$B^0 \rightarrow D^- \pi^+ \pi^0$
2	$B^+ \rightarrow D^0 \pi^+ \pi^0 \pi^0$	2	$B^0 \rightarrow D^- \pi^+ \pi^0 \pi^0$
3	$B^+ \rightarrow D^0 \pi^+ \pi^+ \pi^-$	3	$B^0 \rightarrow D^- \pi^+ \pi^+ \pi^-$
4	$B^+ \rightarrow D^0 \pi^+ \pi^+ \pi^- \pi^0$	4	$B^0 \rightarrow D^- \pi^+ \pi^+ \pi^- \pi^0$
5	$B^+ \rightarrow D^0 D^+$	5	$B^0 \rightarrow D^0 \pi^+ \pi^-$
6	$B^+ \rightarrow D^0 D^+ K_S^0$	6	$B^0 \rightarrow D^- D^0 K^+$
7	$B^+ \rightarrow D^{*0} D^+ K_S^0$	7	$B^0 \rightarrow D^- D^{*0} K^+$
8	$B^+ \rightarrow D^0 D^{*+} K_S^0$	8	$B^0 \rightarrow D^{*-} D^0 K^+$
9	$B^+ \rightarrow D^{*0} D^{*+} K_S^0$	9	$B^0 \rightarrow D^{*-} D^{*0} K^+$
10	$B^+ \rightarrow D^0 D^0 K^+$	10	$B^0 \rightarrow D^- D^+ K_S^0$
11	$B^+ \rightarrow D^{*0} D^0 K^+$	11	$B^0 \rightarrow D^{*-} D^+ K_S^0$
12	$B^+ \rightarrow D^0 D^{*0} K^+$	12	$B^0 \rightarrow D^- D^{*+} K_S^0$
13	$B^+ \rightarrow D^{*0} D^{*0} K^+$	13	$B^0 \rightarrow D^{*-} D^{*+} K_S^0$
14	$B^+ \rightarrow D_S^+ D^0$	14	$B^0 \rightarrow D_S^+ D^-$
15	$B^+ \rightarrow D^{*0} \pi^+$	15	$B^0 \rightarrow D^{*-} \pi^+$
16	$B^+ \rightarrow D^{*0} \pi^+ \pi^0$	16	$B^0 \rightarrow D^{*-} \pi^+ \pi^0$
17	$B^+ \rightarrow D^{*0} \pi^+ \pi^0 \pi^0$	17	$B^0 \rightarrow D^{*-} \pi^+ \pi^0 \pi^0$
18	$B^+ \rightarrow D^{*0} \pi^+ \pi^+ \pi^-$	18	$B^0 \rightarrow D^{*-} \pi^+ \pi^+ \pi^-$
19	$B^+ \rightarrow D^{*0} \pi^+ \pi^+ \pi^- \pi^0$	19	$B^0 \rightarrow D^{*-} \pi^+ \pi^+ \pi^- \pi^0$
20	$B^+ \rightarrow D_S^+ D^0$	20	$B^0 \rightarrow D_S^+ D^-$
21	$B^+ \rightarrow D_S^+ D^{*0}$	21	$B^0 \rightarrow D_S^+ D^{*-}$
22	$B^+ \rightarrow D^0 K^+$	22	$B^0 \rightarrow D_S^{*+} D^{*-}$
23	$B^+ \rightarrow D^- \pi^+ \pi^+$	23	$B^0 \rightarrow J/\psi K_S^0$
24	$B^+ \rightarrow D^- \pi^+ \pi^+ \pi^0$	24	$B^0 \rightarrow J/\psi K^+ \pi^-$
25	$B^+ \rightarrow J/\psi K^+$	25	$B^0 \rightarrow J/\psi K_S^0 \pi^+ \pi^-$
26	$B^+ \rightarrow J/\psi K^+ \pi^+ \pi^-$	26	$B^0 \rightarrow \bar{\Lambda}_e^- p^+ \pi^+ \pi^-$
27	$B^+ \rightarrow J/\psi K^+ \pi^0$	27	$B^0 \rightarrow D^0 p^+ p^-$
28	$B^+ \rightarrow J/\psi K_S^0 \pi^+$	28	$B^0 \rightarrow D^- p^+ p^- \pi^+$
29	$B^+ \rightarrow \bar{\Lambda}_e^- p^+ \pi^+ \pi^0$	29	$B^0 \rightarrow D^{*-} p^+ p^- \pi^+$
30	$B^+ \rightarrow \bar{\Lambda}_e^- p^+ \pi^+ \pi^- \pi^+$	30	$B^0 \rightarrow D^0 p^+ p^- \pi^+ \pi^-$
31	$B^+ \rightarrow D^0 p^+ p^- \pi^+$	31	$B^0 \rightarrow D^{*0} p^+ p^- \pi^+ \pi^-$
32	$B^+ \rightarrow D^{*0} p^+ p^- \pi^+$		
33	$B^+ \rightarrow D^{*+} p^+ p^- \pi^+ \pi^-$		
34	$B^+ \rightarrow D^{*+} p^+ p^- \pi^+ \pi^- \pi^+$		
35	$B^+ \rightarrow \bar{\Lambda}_e^- p^+ \pi^+$		

$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

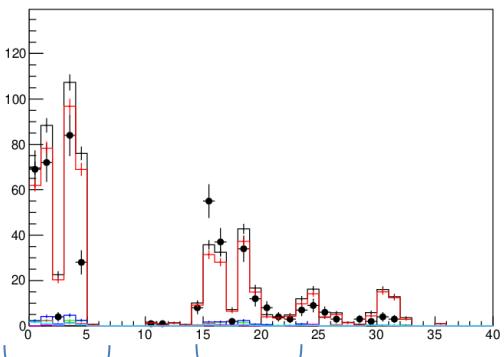


decayModeID

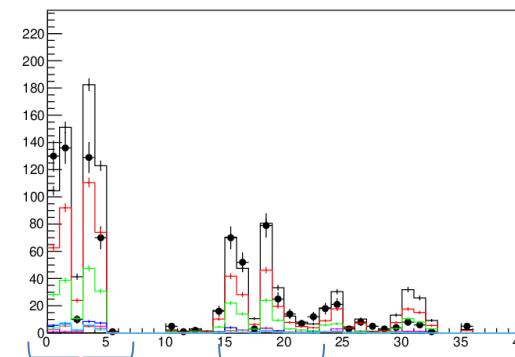
$B0 \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$



$B+ \rightarrow D^* l \nu, D^* \rightarrow \pi 0 D$



$B+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$



E_ECL data/MC: decayModeID

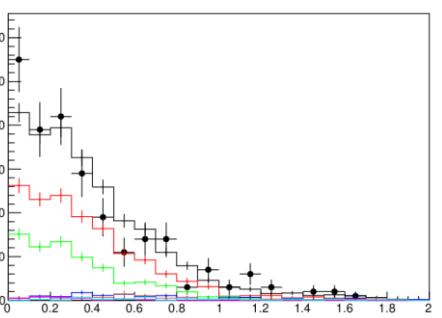
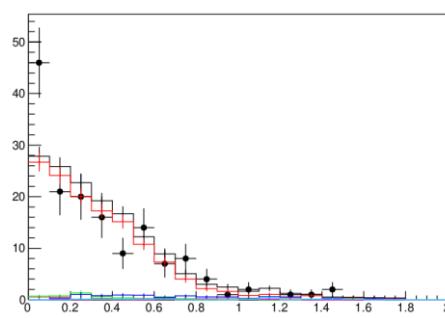
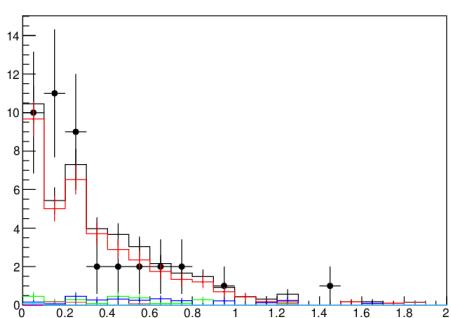
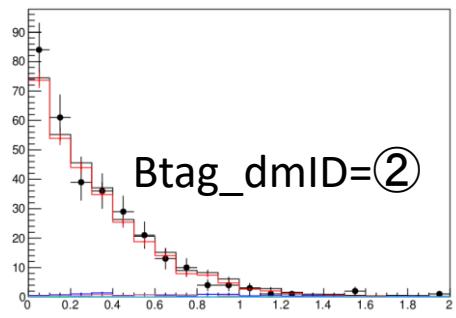
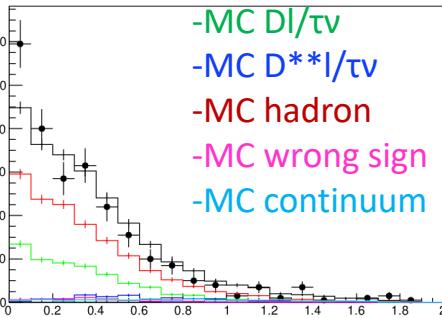
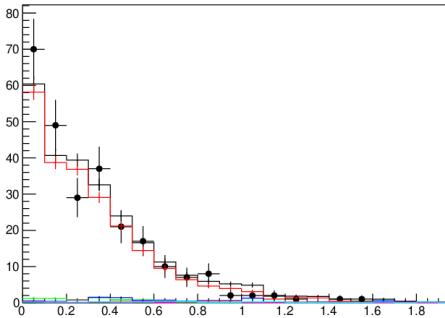
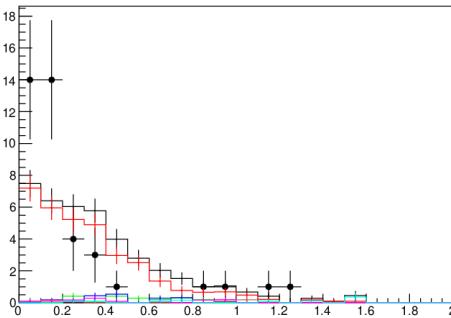
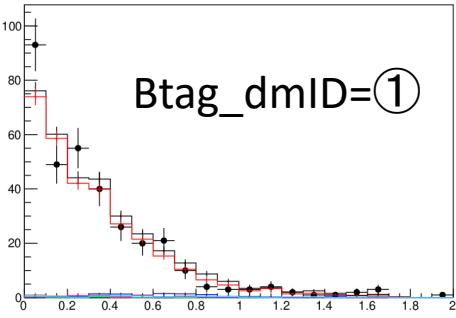
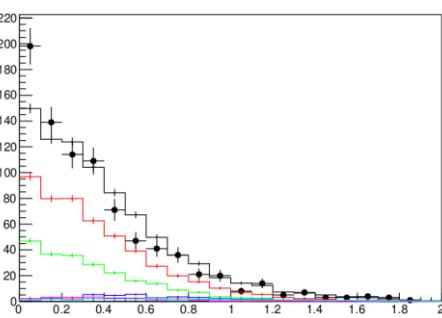
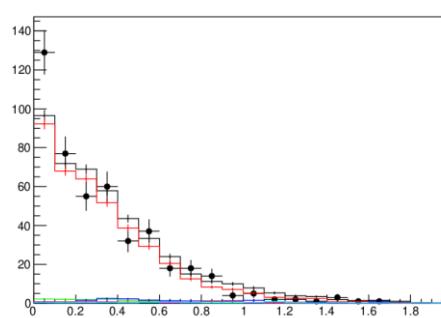
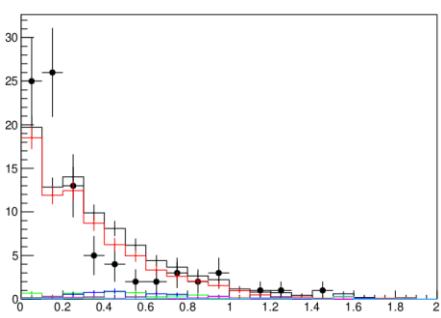
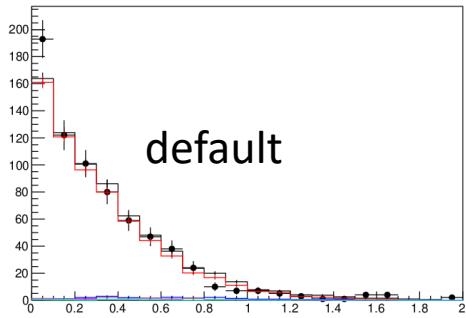
-No clear difference between Btag decayMode

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



E_ECL data/MC: decayModeID

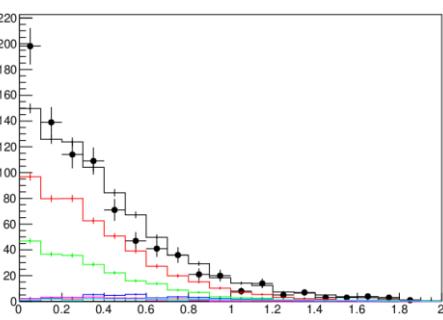
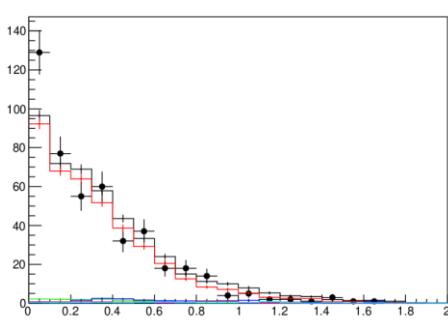
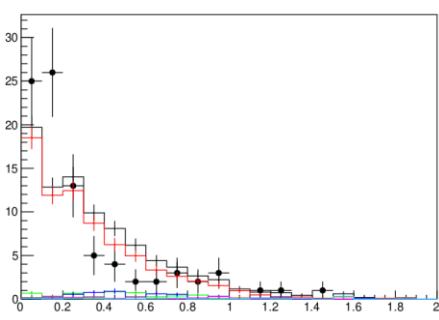
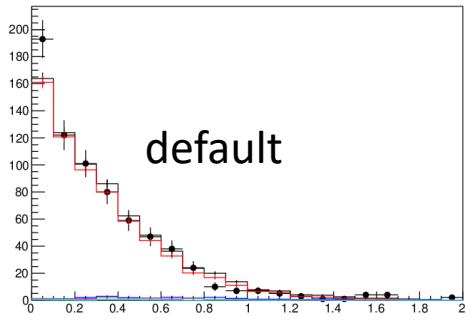
-No clear difference between Btag decayMode

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

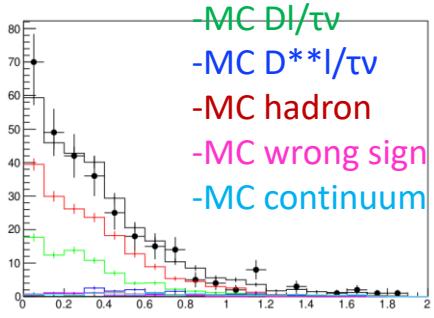
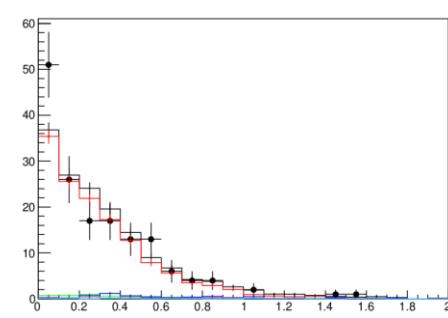
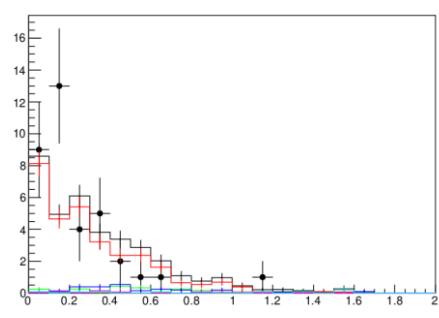
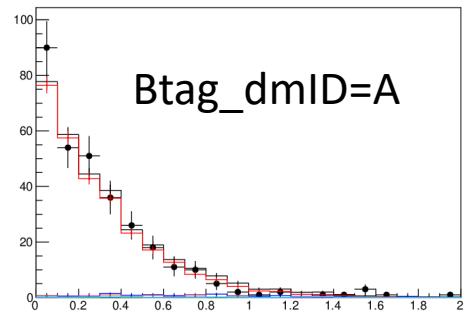
$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$

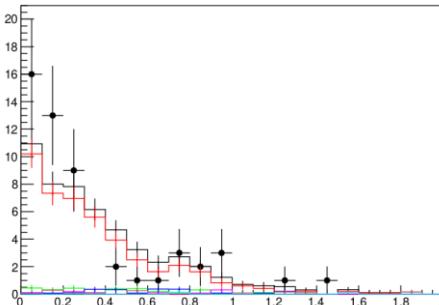
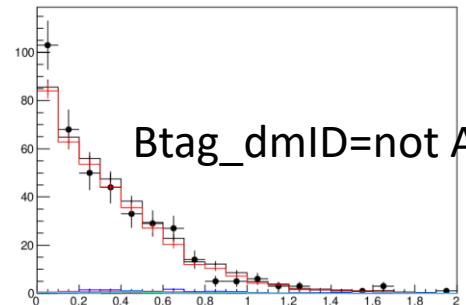


default

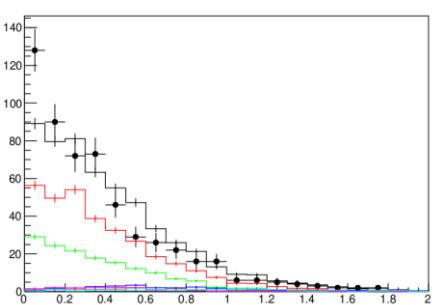
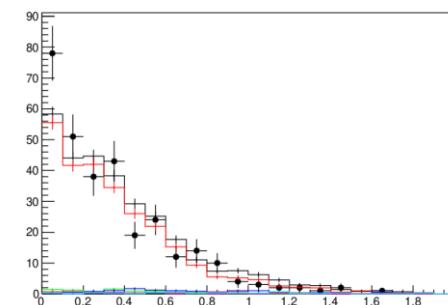
- MC total
- MC $D^* l/\tau \bar{\nu}$
- MC $D l/\tau \bar{\nu}$
- MC $D^{**} l/\tau \bar{\nu}$
- MC hadron
- MC wrong sign
- MC continuum



Btag_dmID=A



Btag_dmID=not A



E_ECL data/MC: decayModeID

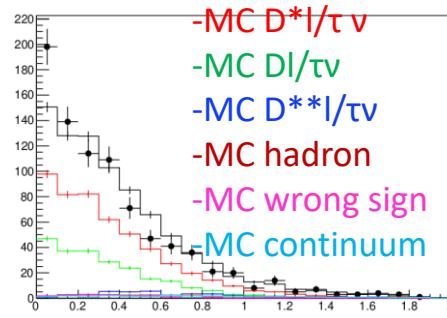
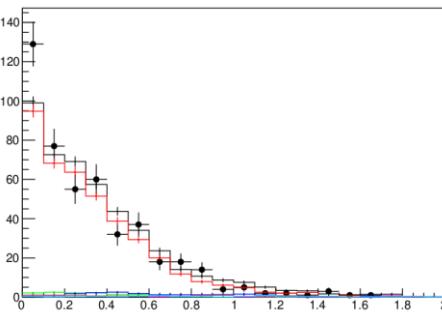
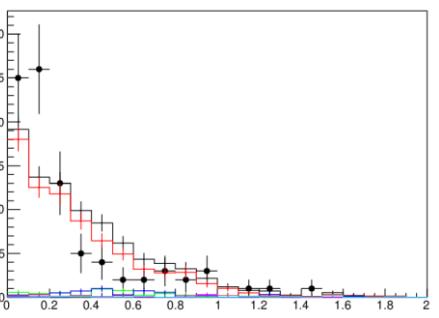
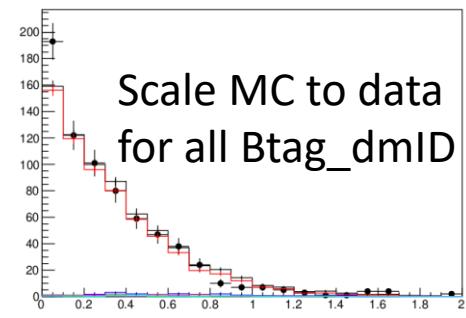
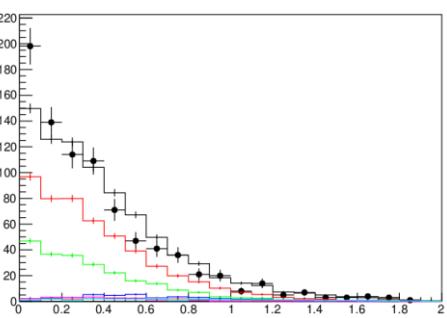
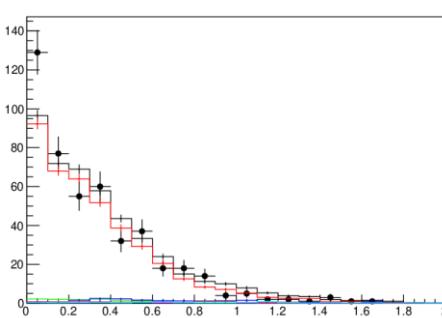
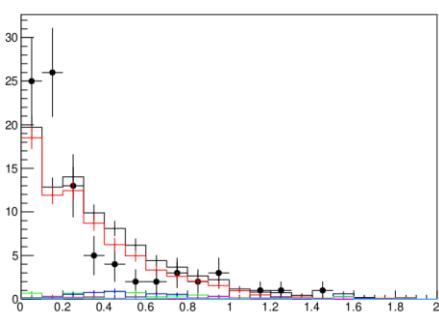
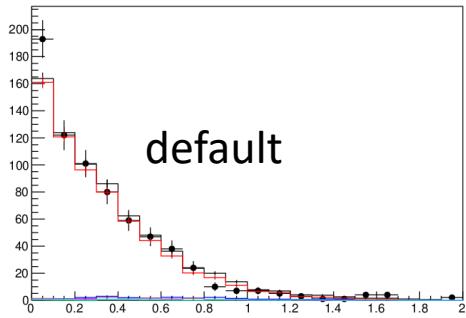
-No clear difference between Btag decayMode

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

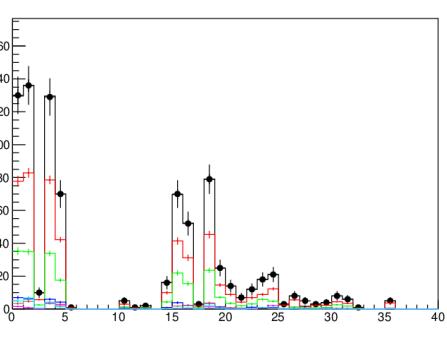
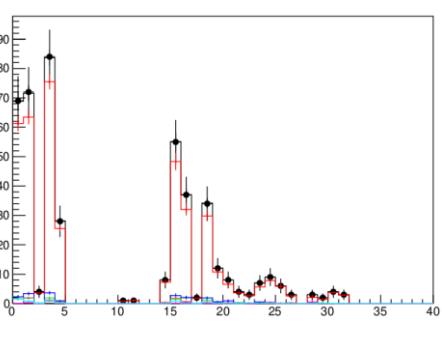
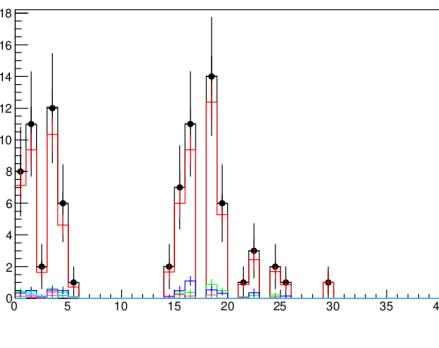
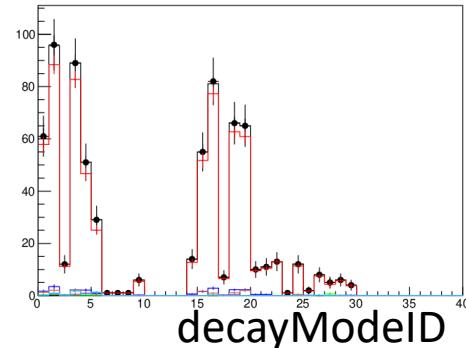
$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



- MC total
- MC $D^* l/\tau \bar{\nu}$
- MC $D l/\tau \bar{\nu}$
- MC $D^{**} l/\tau \bar{\nu}$
- MC hadron
- MC wrong sign
- MC continuum



decayModeID

Btag isSignal: Mbc, deltaE, E_ECL

-all
 -Btag isSignal==1
 -Btag isSignal!=1

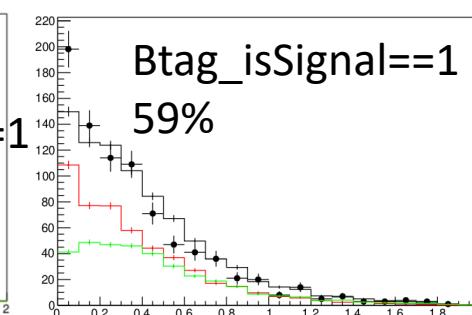
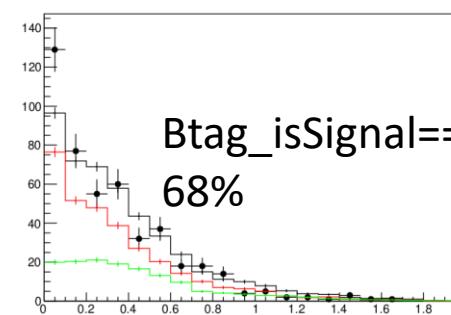
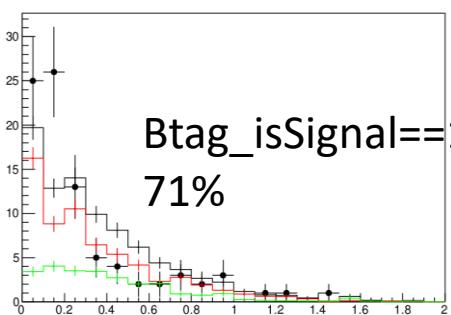
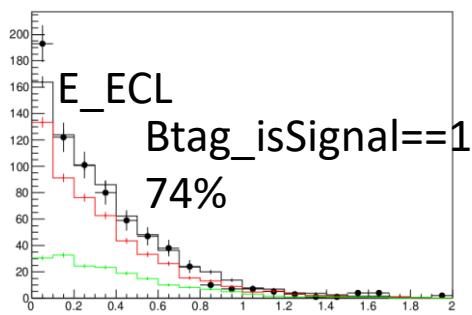
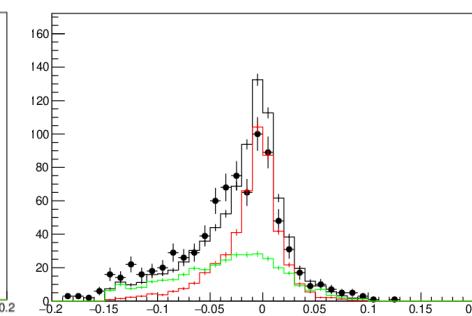
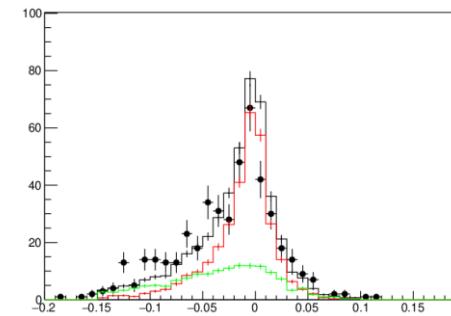
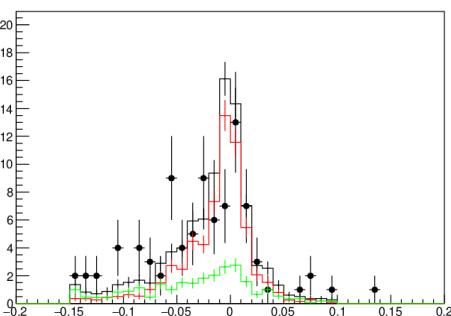
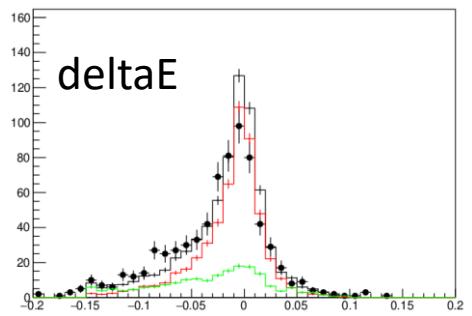
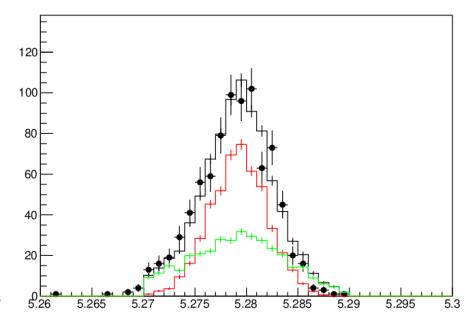
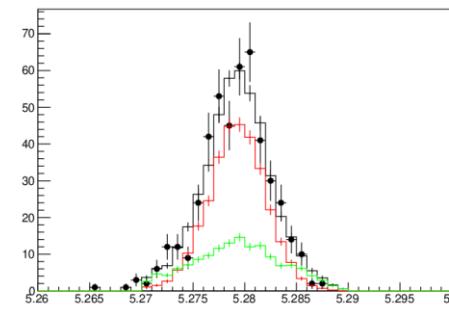
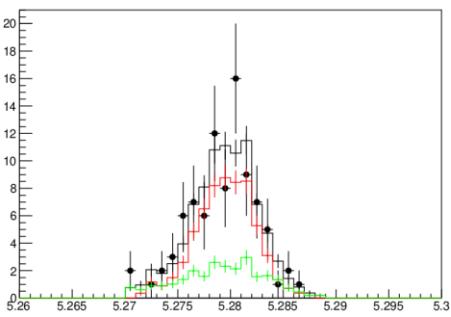
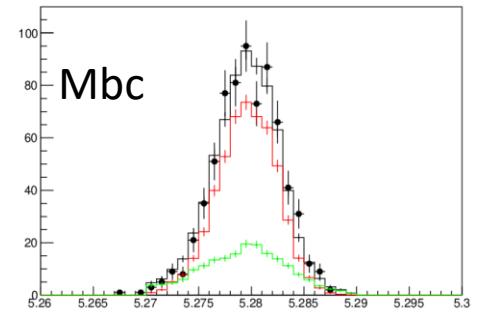
-E_ECL is clearly different between Btag_isSignal==1, !=1.

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

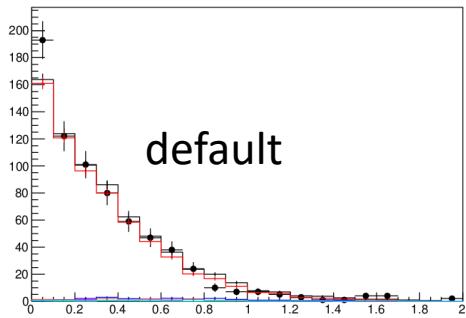
$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$



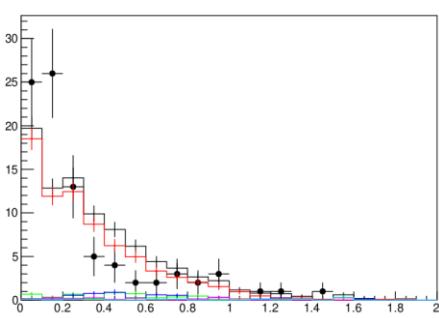
E_ECL data/MC: Btag isSignal

-Data/MC get better with +20% of isSignal==1. (from Mbc and deltaE, unrealistic.)

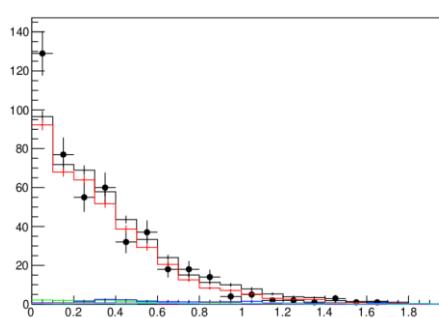
$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi D$



$B^0 \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$

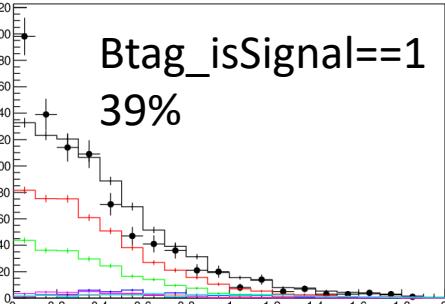
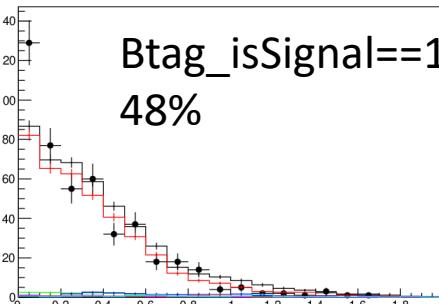
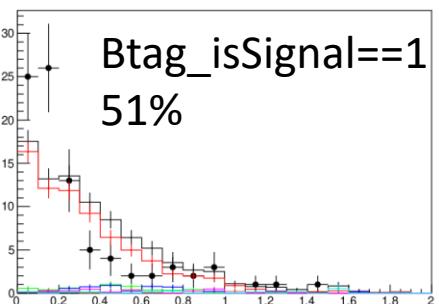
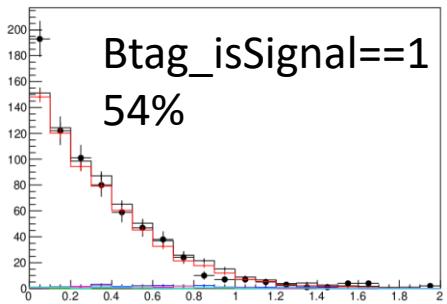
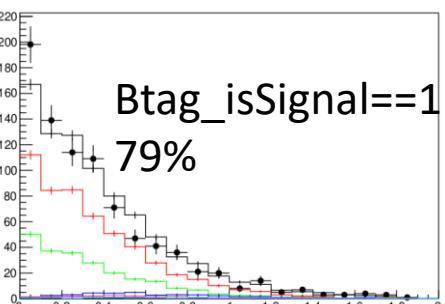
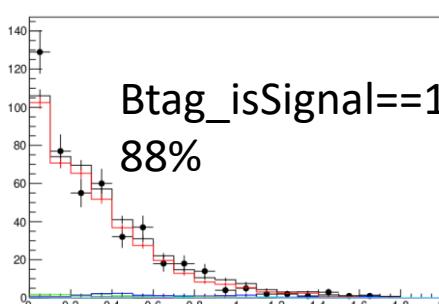
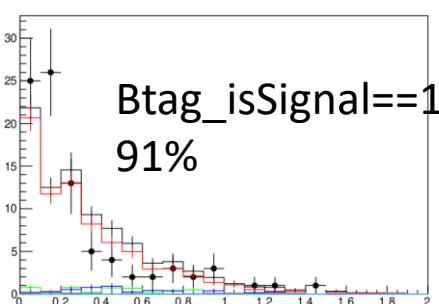
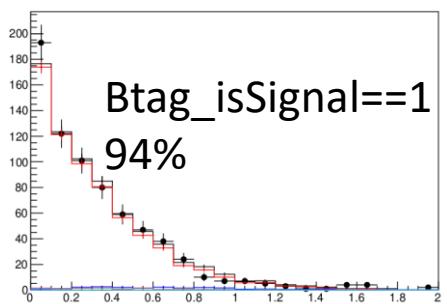


$B^+ \rightarrow D^* l \nu, D^* \rightarrow \pi^0 D$



$B^+ \rightarrow D^* l \nu, D^* \rightarrow \gamma D$

- MC total
- MC $D^* l/\tau v$
- MC $D l/\tau v$
- MC $D^{**} l/\tau v$
- MC hadron
- MC wrong sign
- MC continuum



Bsig_isSignalADFNormB

- all
- Bsig isSignalADFNormB==1**
- Bsig isSignalADFNormB!=1**

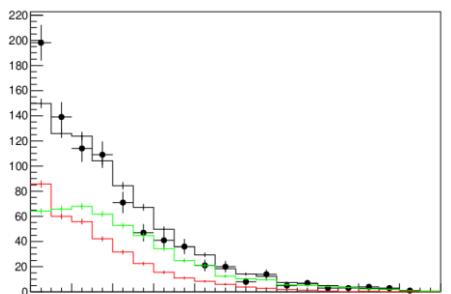
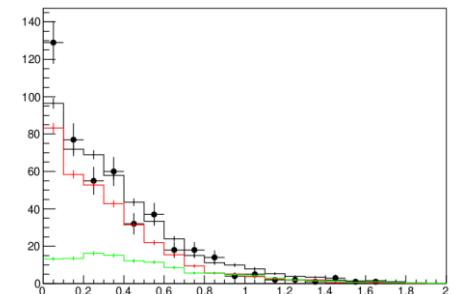
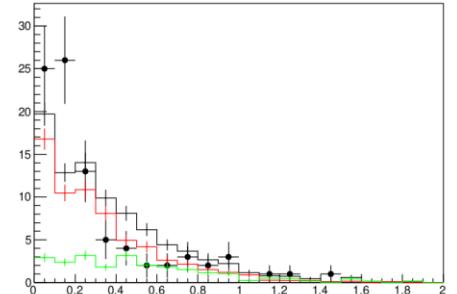
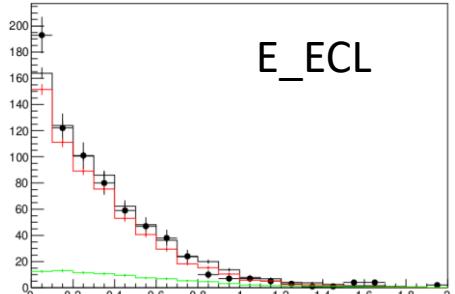
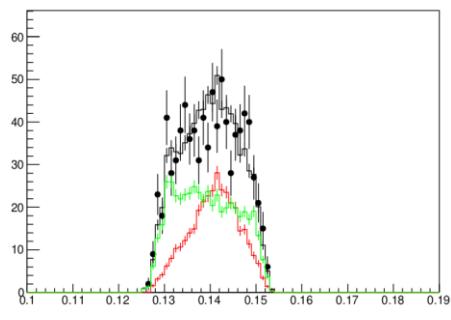
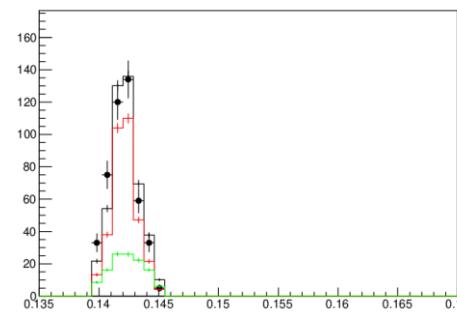
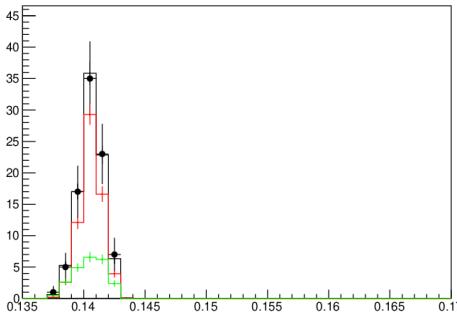
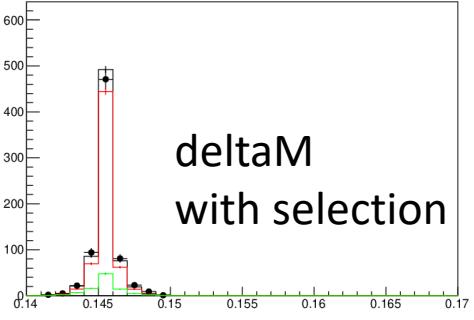
- E_{ECL} is different between $Btag_isSignalADFNormB==1$, $!=1$.
-data/MC of δM looks reasonable.

$B0 \rightarrow D^* l \bar{\nu}, D^* \rightarrow \pi D$

$B0 \rightarrow D^* l \bar{\nu}, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \bar{\nu}, D^* \rightarrow \pi 0 D$

$B+ \rightarrow D^* l \bar{\nu}, D^* \rightarrow \gamma D$



E_ECL data/MC: Bsigt_isSignalADFNormB

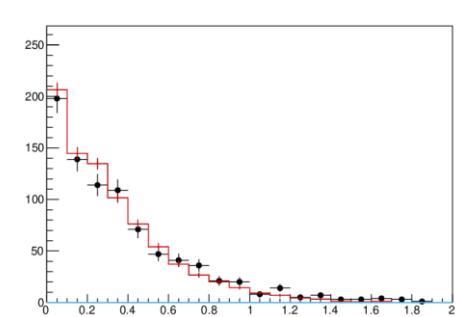
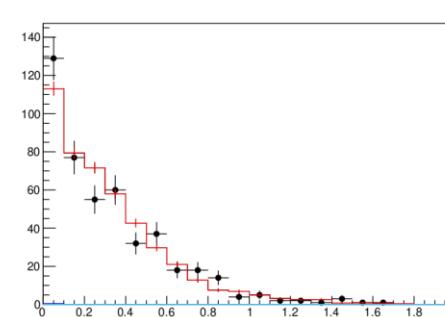
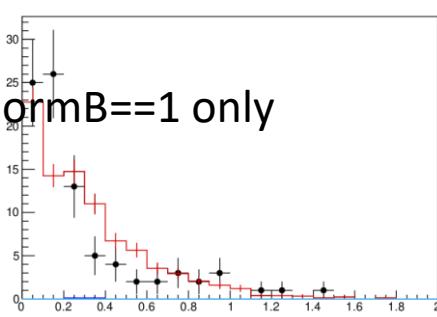
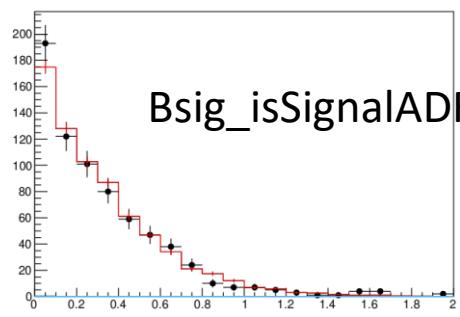
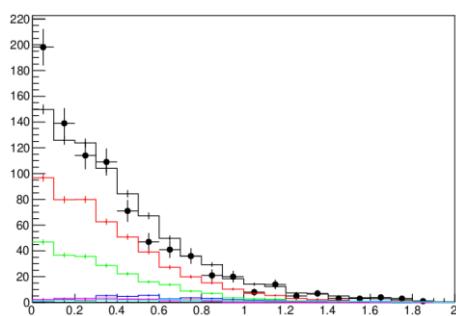
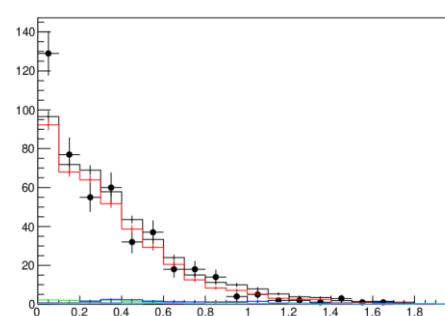
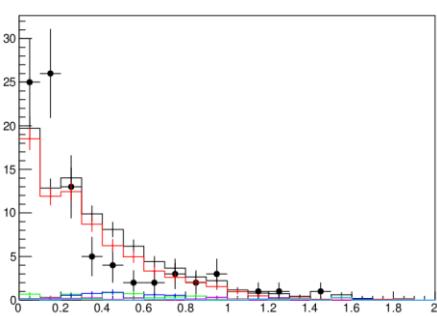
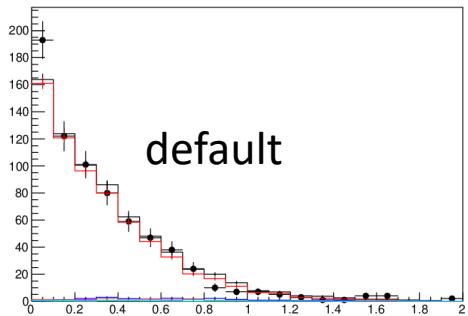
-If Bsigt_isSignalADFNormB==1 only, data/MC got better. (from deltaM, unrealistic.)

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi D$

$B^0 \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \pi^0 D$

$B^+ \rightarrow D^* l \bar{\nu}$, $D^* \rightarrow \gamma D$



- MC total
- MC $D^* l / \tau \nu$
- MC $D l / \tau \nu$
- MC $D^{**} l / \tau \nu$
- MC hadron
- MC wrong sign
- MC continuum