

W Mass Measurement at CEPC

Presented by ¹Pei-Zhu Lai (賴培築)

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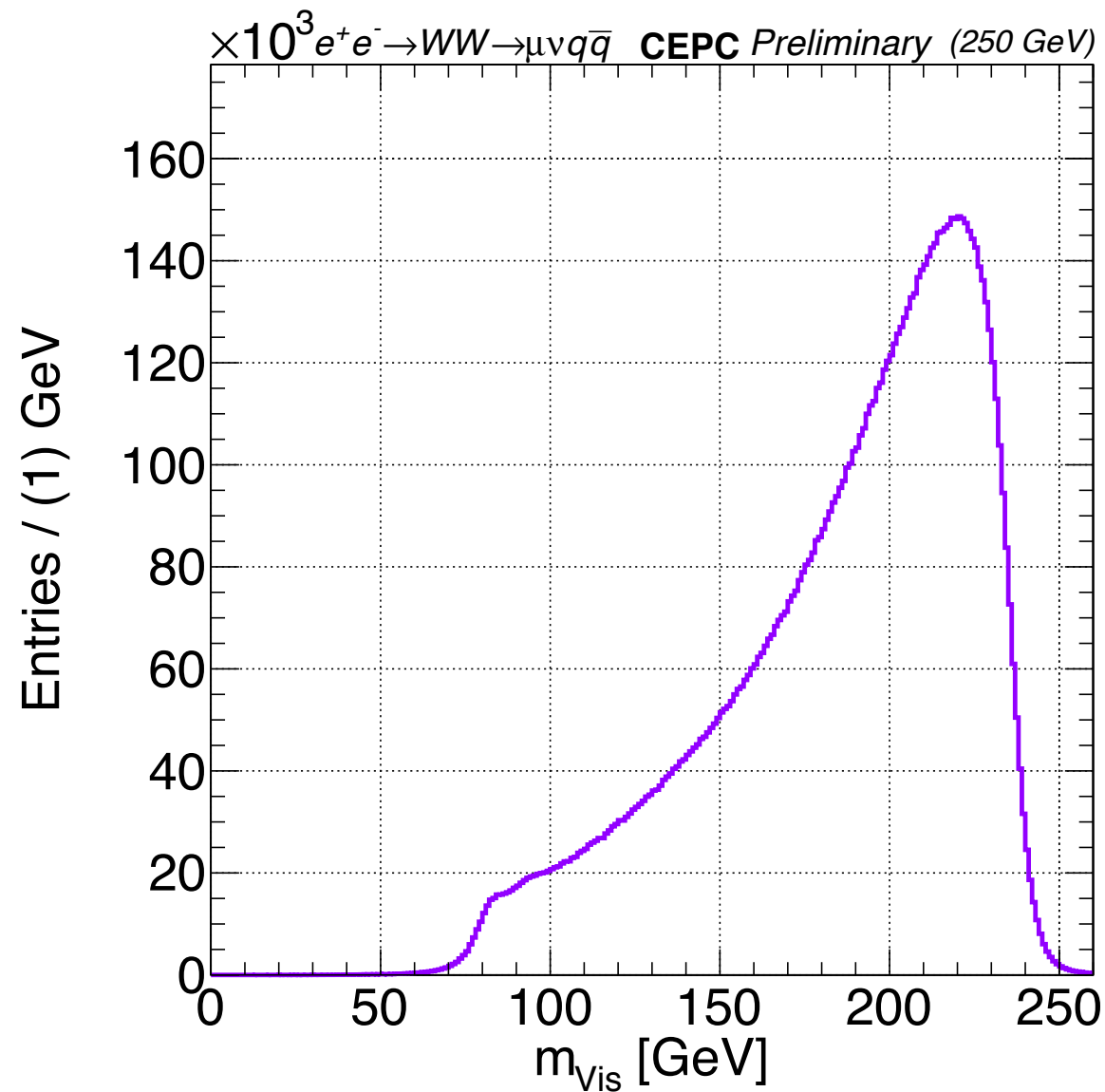
²Institute of High Energy Physics, China

EW Meeting

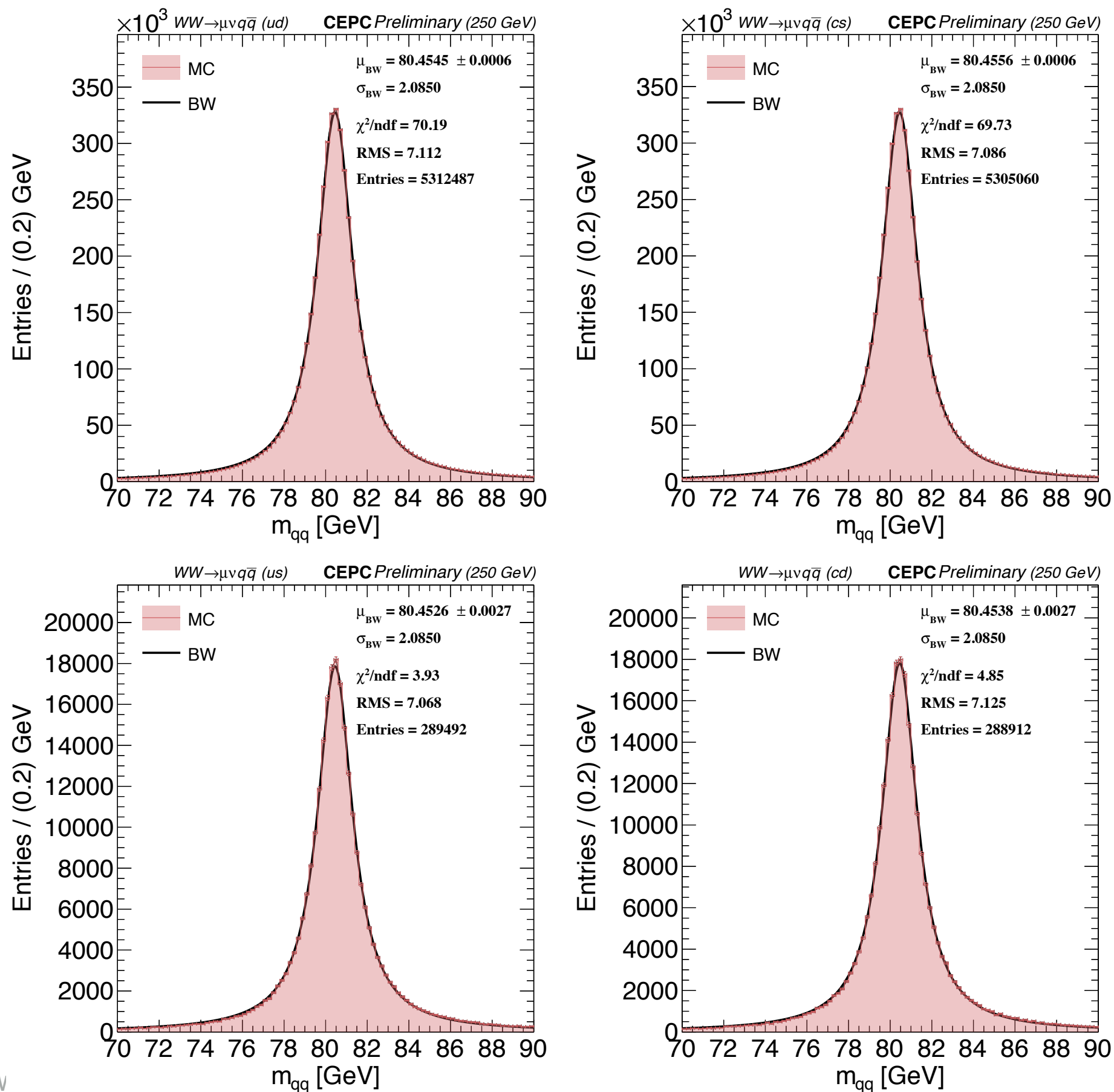
Jul 24, 2018



- **Visible mass distribution**
- **di-Parton invariant mass distribution**
- **The selection efficiencies of signal sample added c-tagging**
- **Results after event selections**
 - **Without b- & c-tagging**
 - **With b-tagging score < 0.5 for two jets**
 - **With b-tagging score < 0.5 & c-tagging score < 0.6 for two jets**
- **Comparison between these three categories**



- ◆ We have a cut called “Visible mass $> 0.5 \cdot \sqrt{s}$ ”. In other words we will cut one Visible mass $> 125 \text{ GeV}$.



V1(WW $\rightarrow\mu\nu q\bar{q}$)	ud	cs	us	cd
μ_{BW}	80.4545 ± 0.0006	80.4556 ± 0.0006	80.4526 ± 0.0027	80.4538 ± 0.0027
σ_{BW}	2.085	2.085	2.085	2.085
Entries	5312487	5305060	289492	288912
RMS	7.112	7.086	7.068	7.125
RMS/ $\sqrt{N_w}$	0.003	0.003	0.013	0.013

◆ Before fragmentation, di-Parton invariant masses are the same.

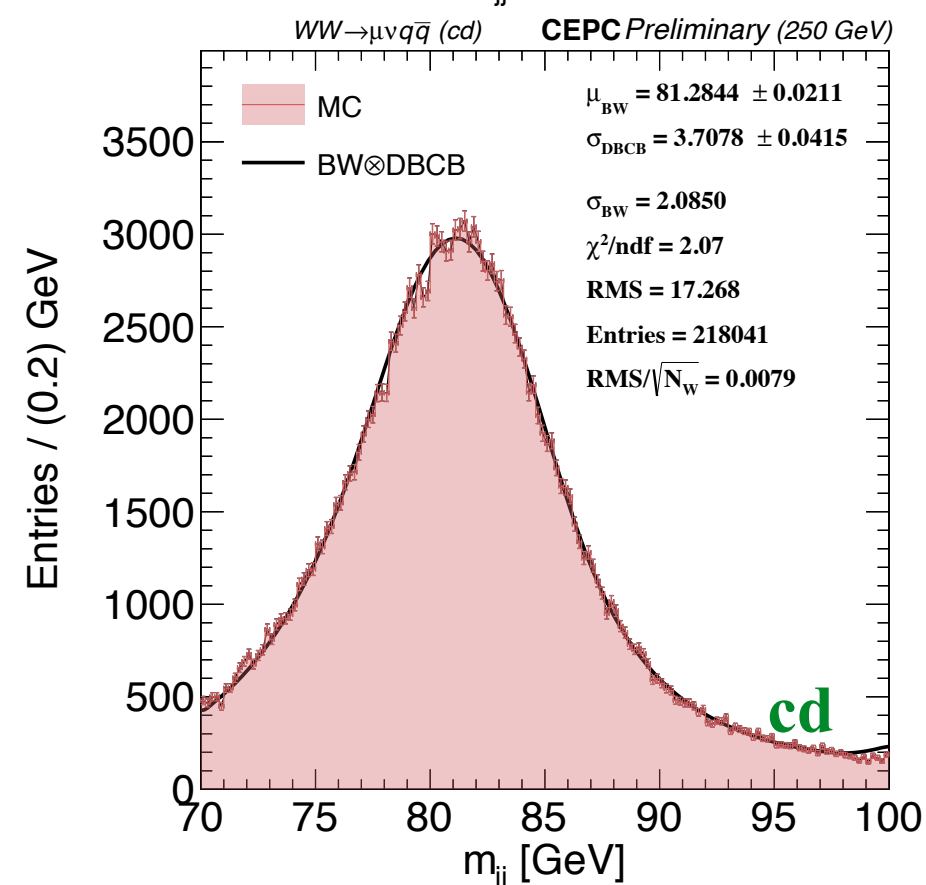
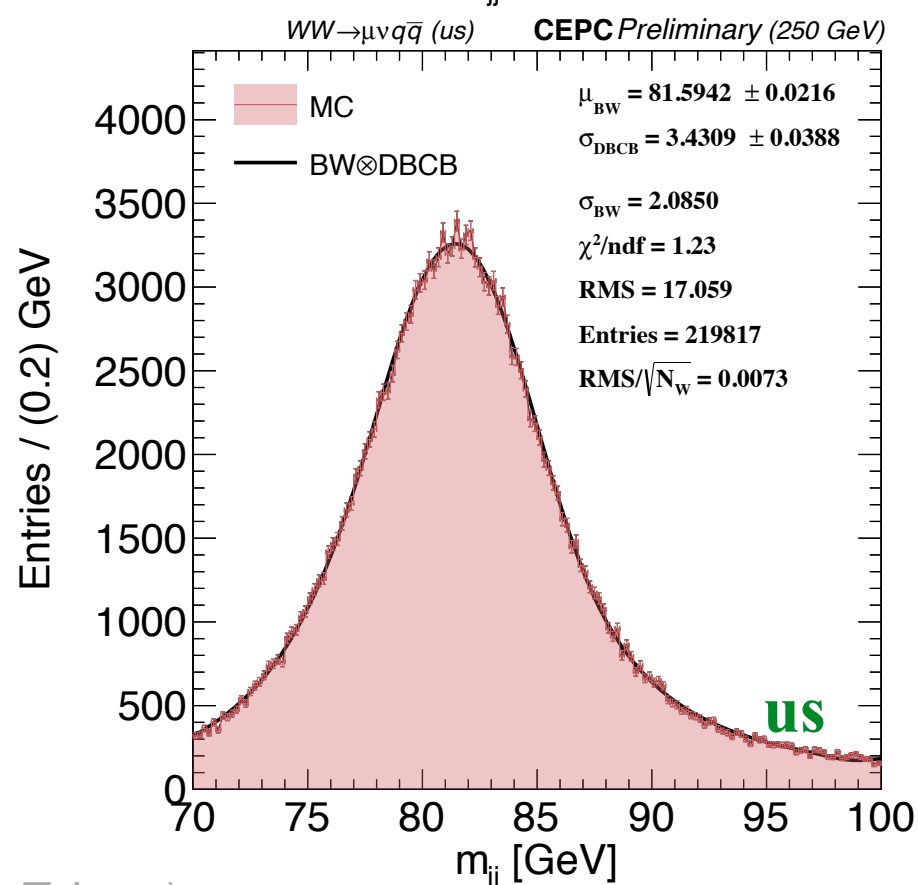
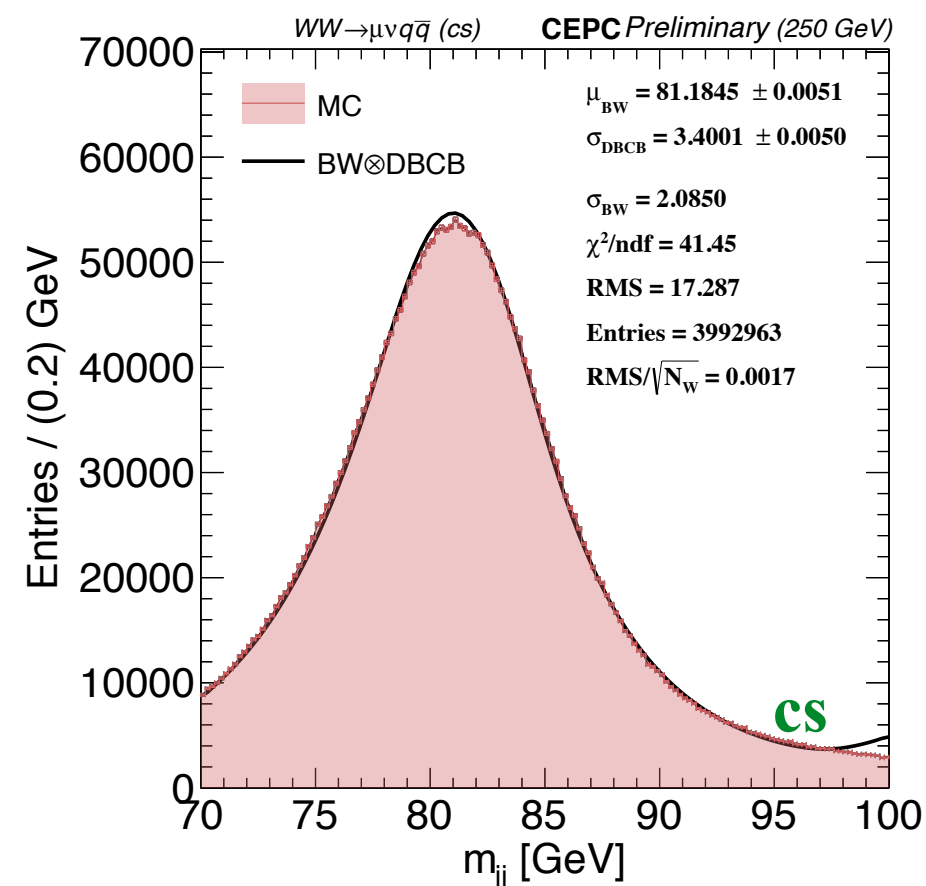
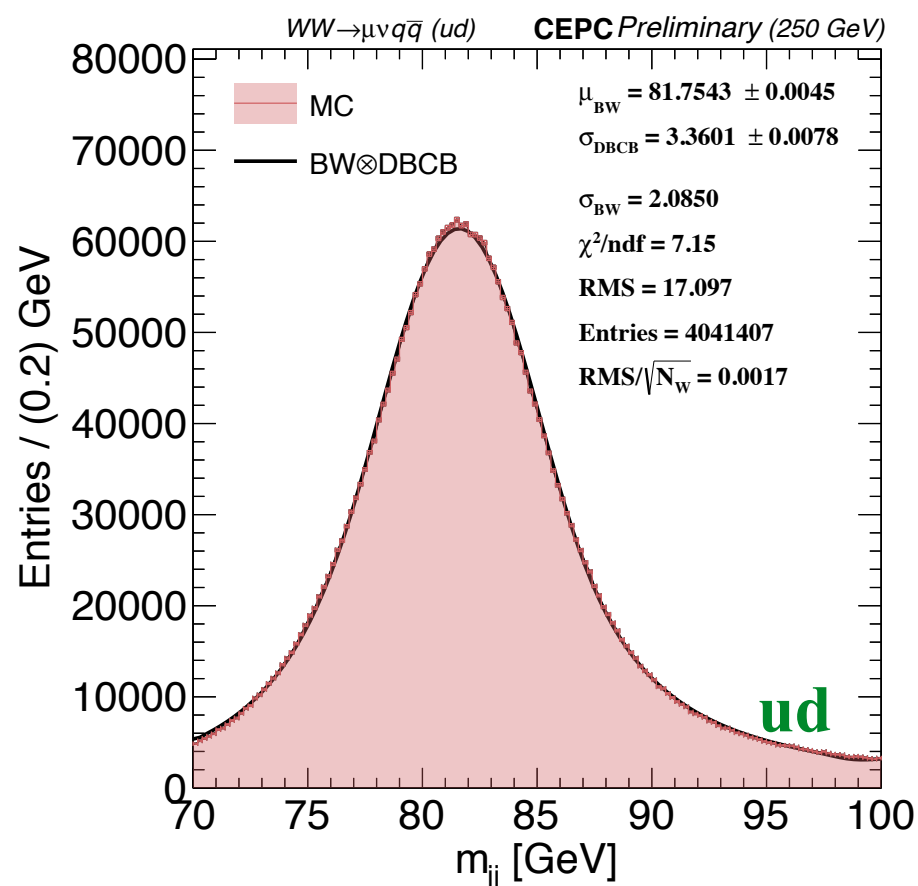
V1($WW \rightarrow \mu\nu q\bar{q}$)	# of event	Efficiency	Efficiency w.r.t. previous
Tot # of event	11206127	—	—
Muon Selection	9570465	85.4%	—
Detector acceptance $ \cos(\theta_\mu) < 0.995$	9570465	85.4%	100%
$P_{t\text{Miss}} > 10 \text{ GeV}$	9197450	82.0%	96.1%
Visible mass $> 0.5\sqrt{s}$	8479808	75.6%	92.1%
Two jets b-tag score < 0.5	7990921	71.3%	94.2%
Two jets c-tag score < 0.6	5507341	49.1%	68.9%

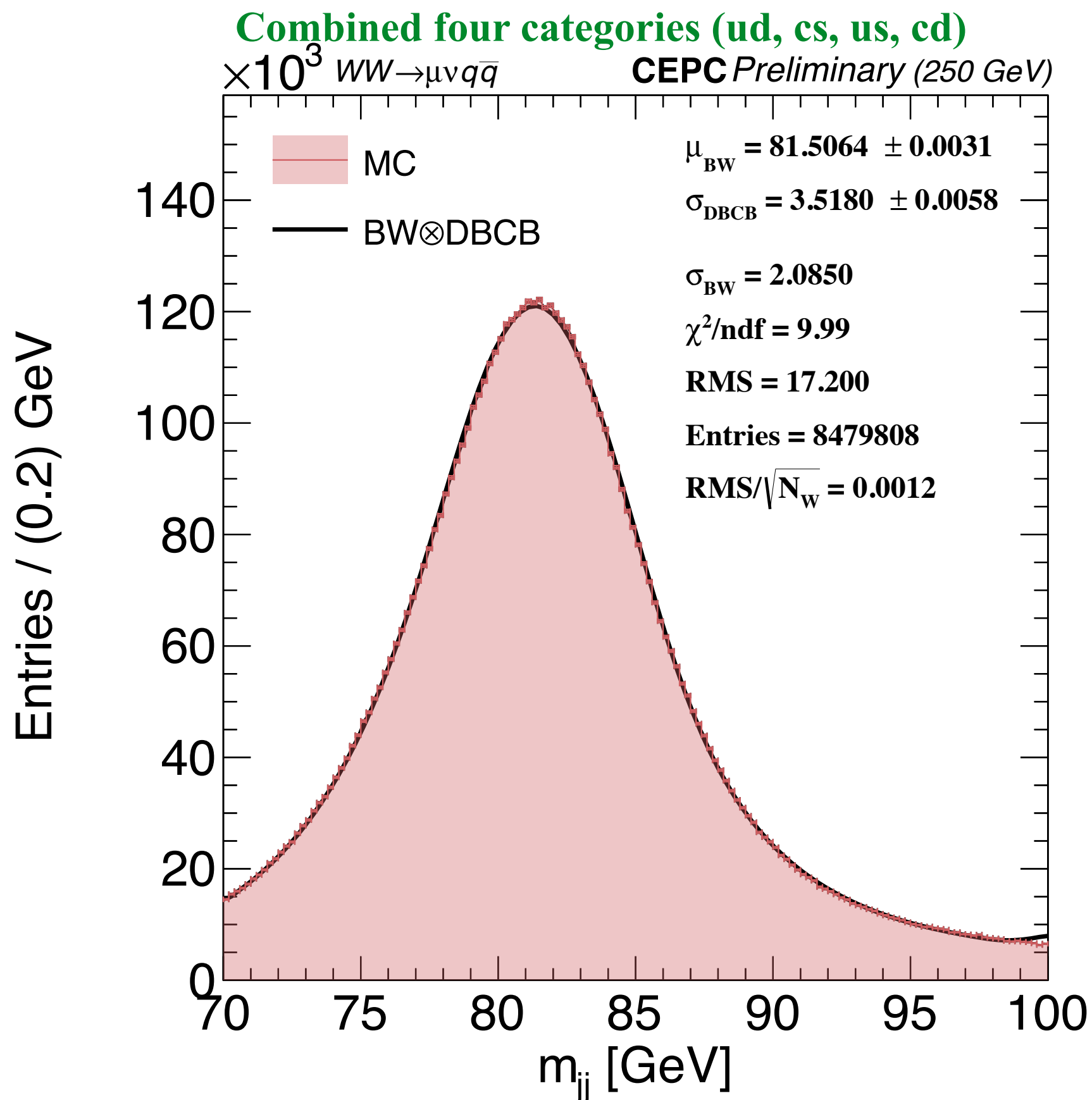
- These selection are following Maarten's suggestions and then add one more category with c-tagging.
- The effective luminosity is 10 ab^{-1} .
- Muon selections: ID=13 & $R0 < 0.01\text{mm}$ & $E_\mu \geq 10 \text{ (GeV)}$.
- Jet reconstruction: force all events to two jets
- There are three categories, **without b- & c-tagging**, with b-tagging, **with b- & c-tagging**.

$$R0 = \sqrt{D0^2 + Z0^2}$$

Results(without b- & c-tagging)

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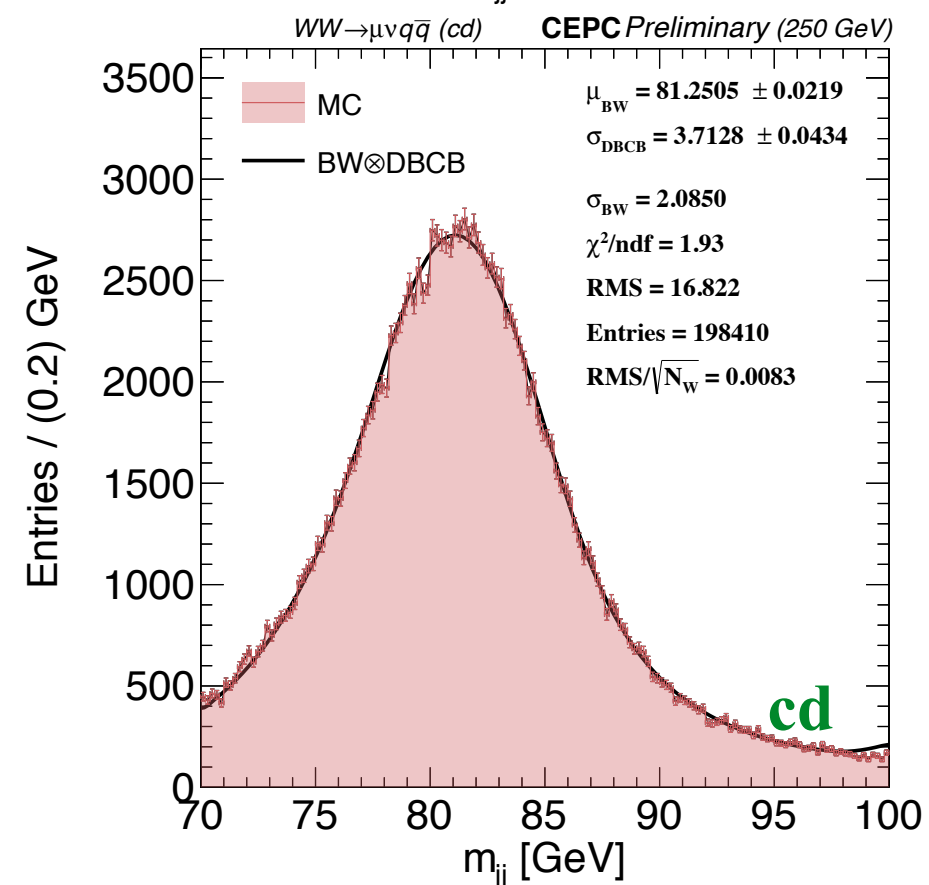
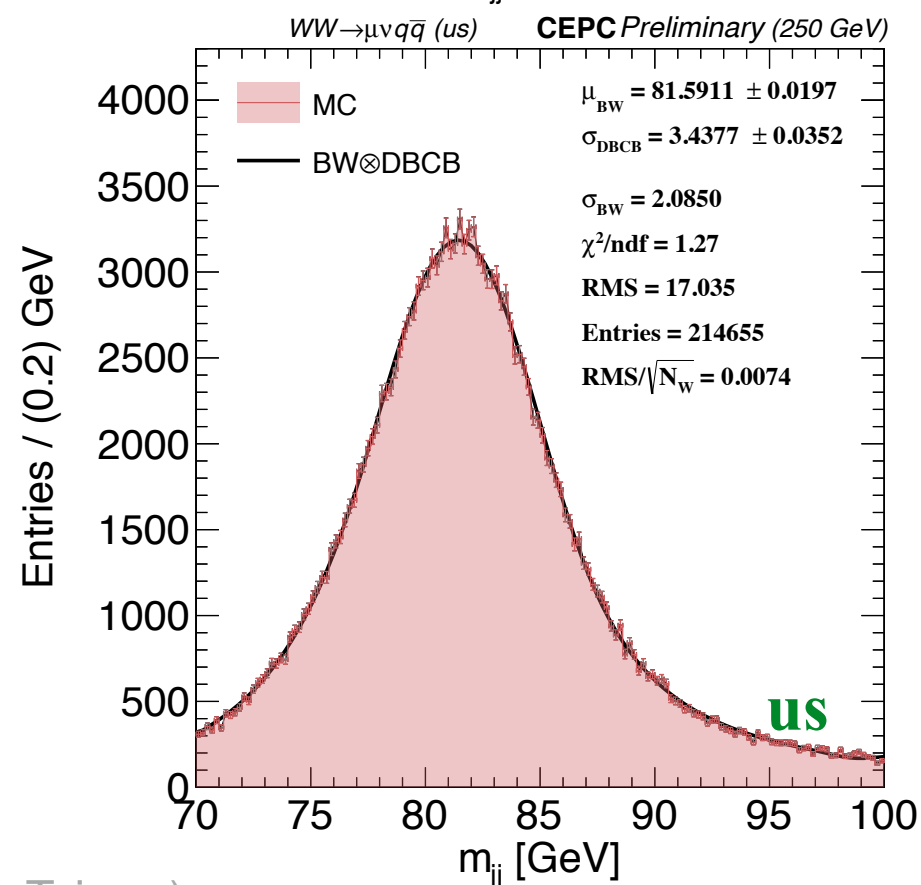
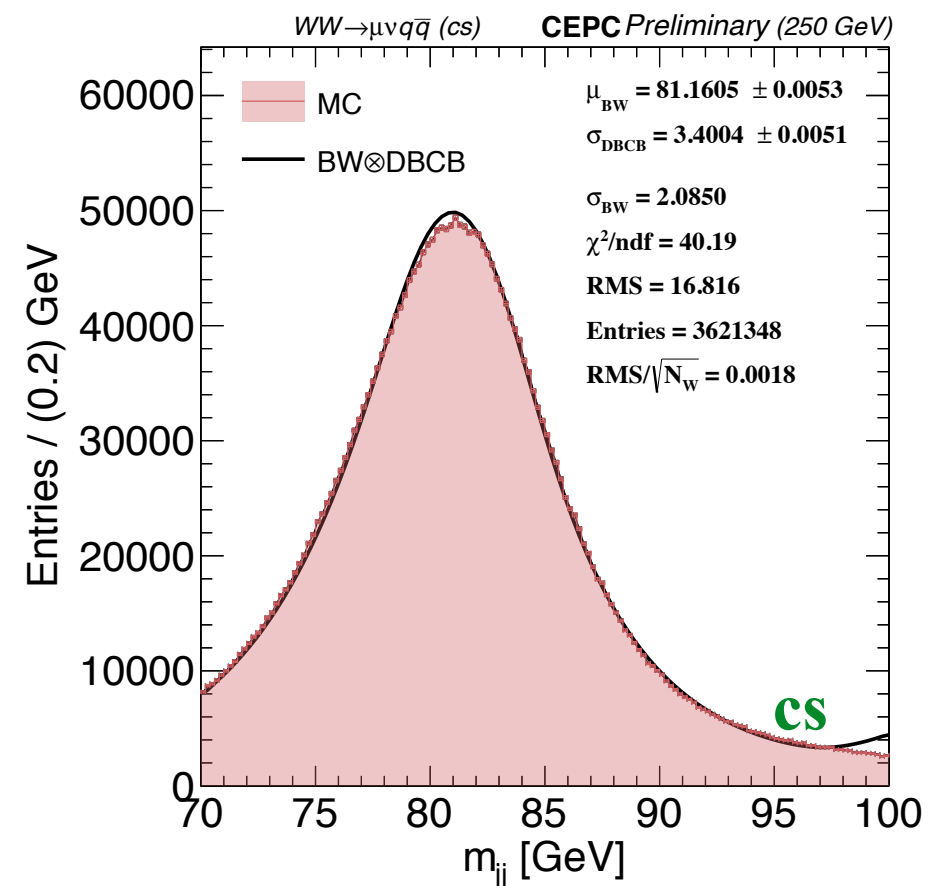
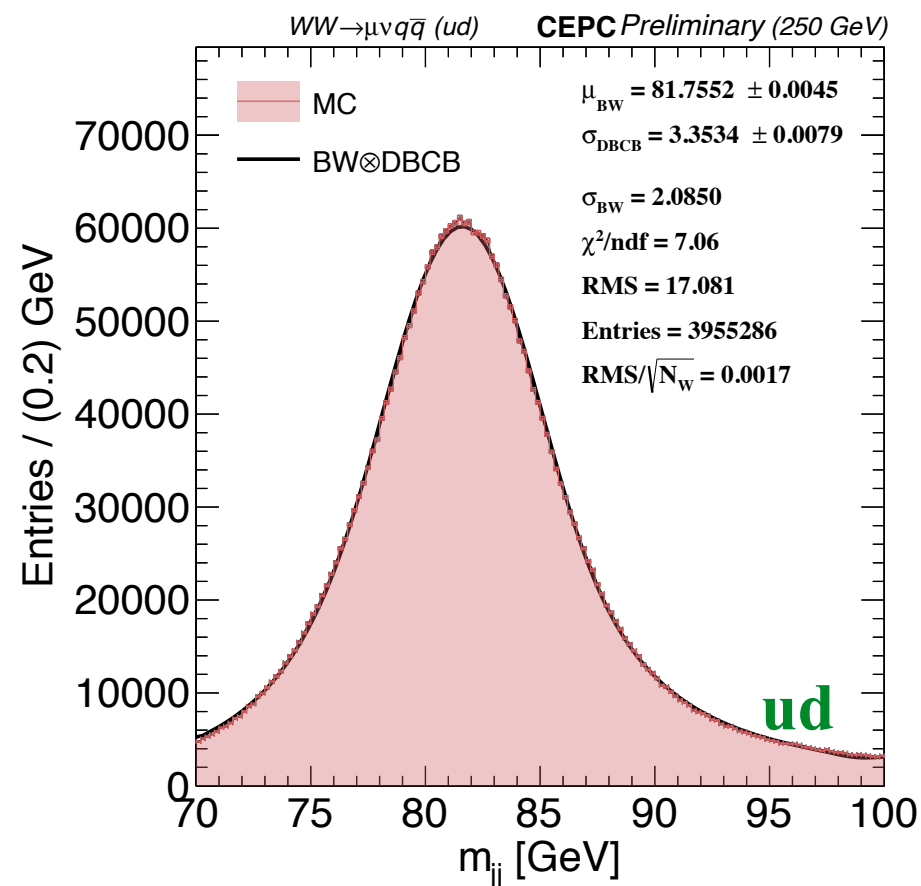


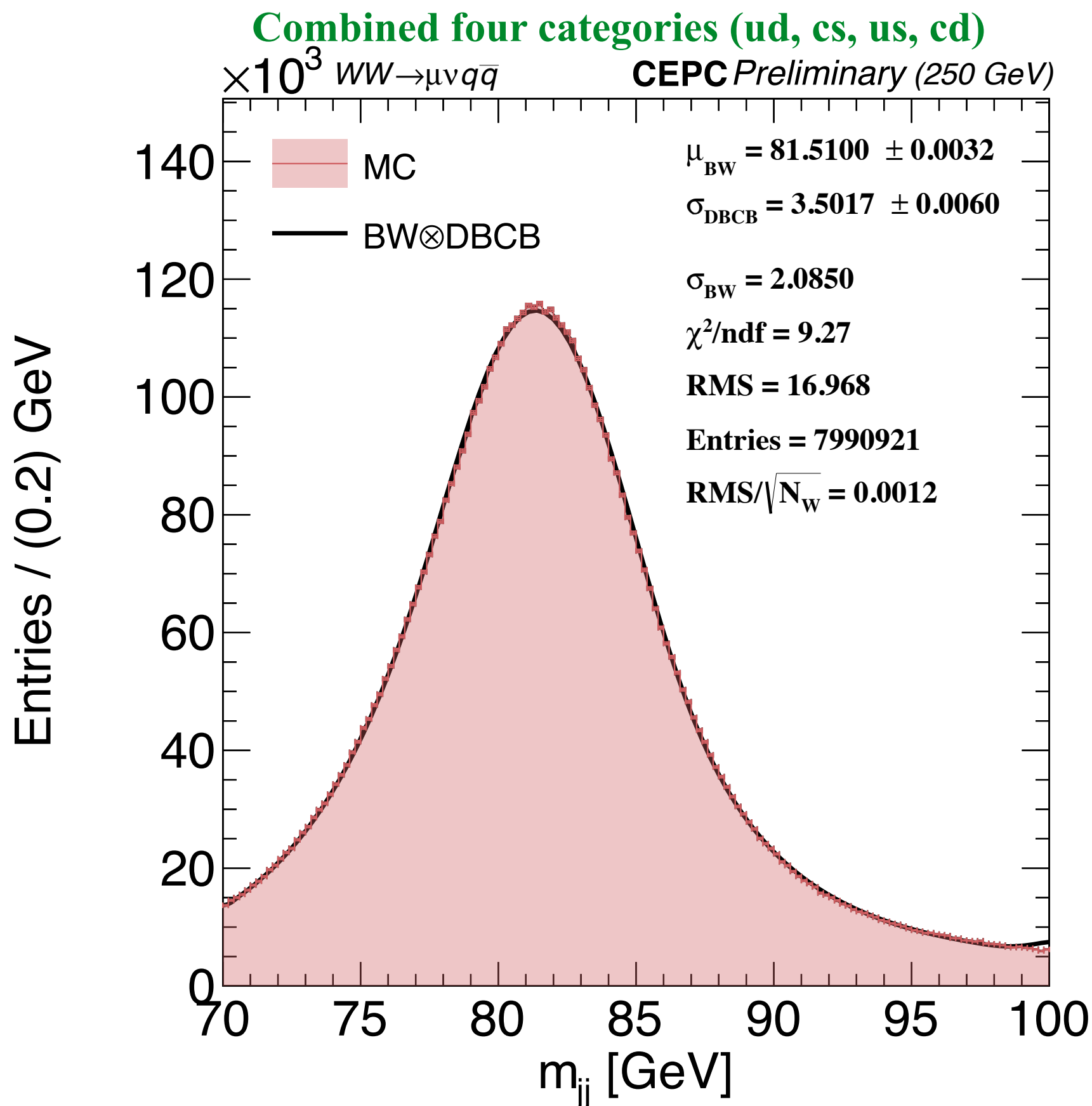
V1(WW→ $\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7543 ± 0.0045	81.1845 ± 0.0051	81.5942 ± 0.0216	81.2844 ± 0.0211	81.5064 ± 0.0031
σ_{DBCB}	3.3601 ± 0.0078	3.4001 ± 0.0050	3.4309 ± 0.0388	3.7078 ± 0.0415	3.5180 ± 0.0058
Entries	4041407	3992963	219817	218041	8479808
RMS	17.097	17.287	17.059	17.268	17.200
RMS/ $\sqrt{N_w}$	0.0017	0.0017	0.0073	0.0079	0.0012

- ◆ The categories with c-quark would have less μ_{BW} and lower jet energy resolution.
- ◆ Entry of same generation are similar.(e.g. ud & cs)

Results(with b-tagging score < 0.5)

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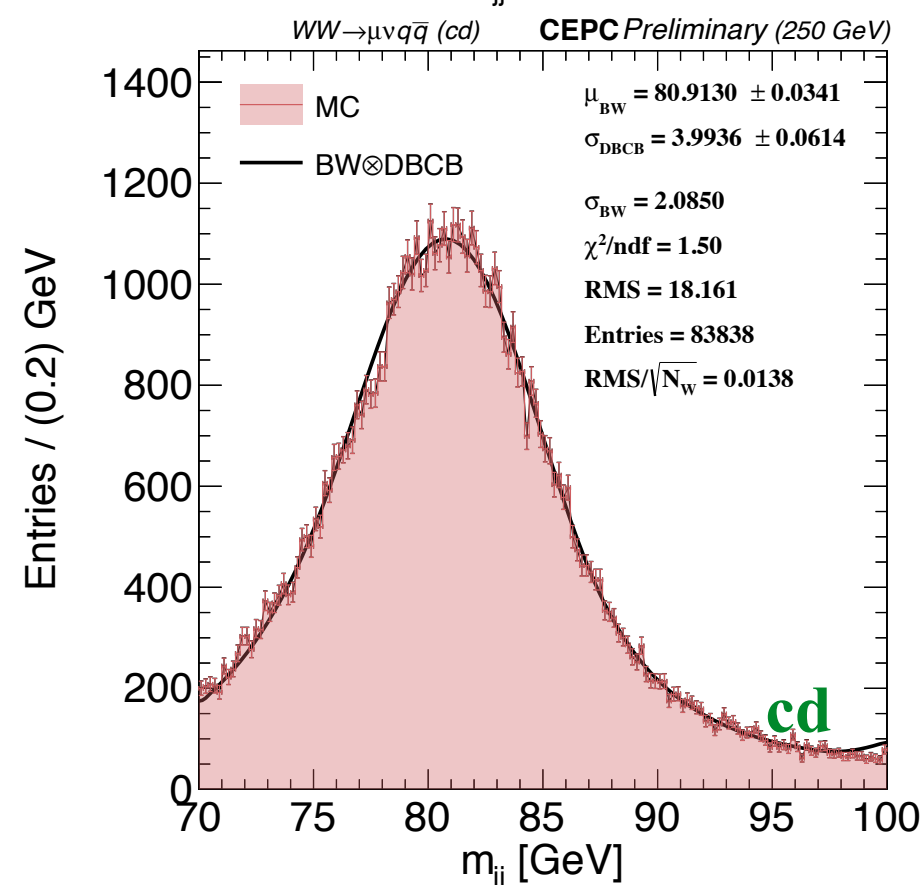
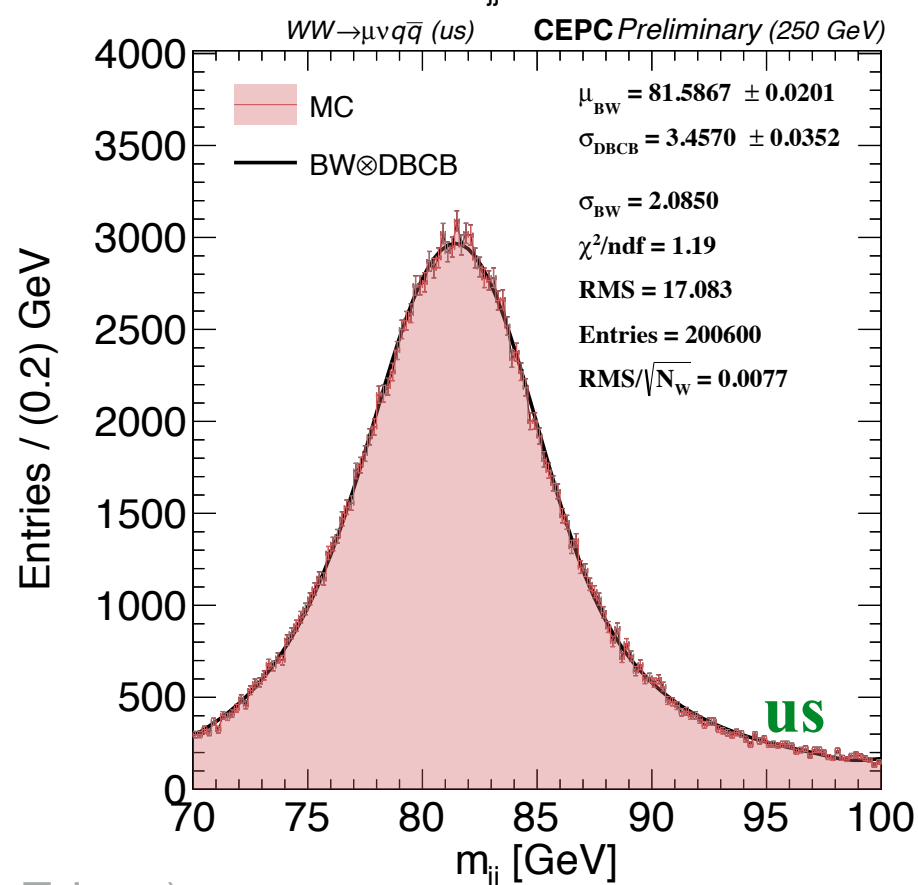
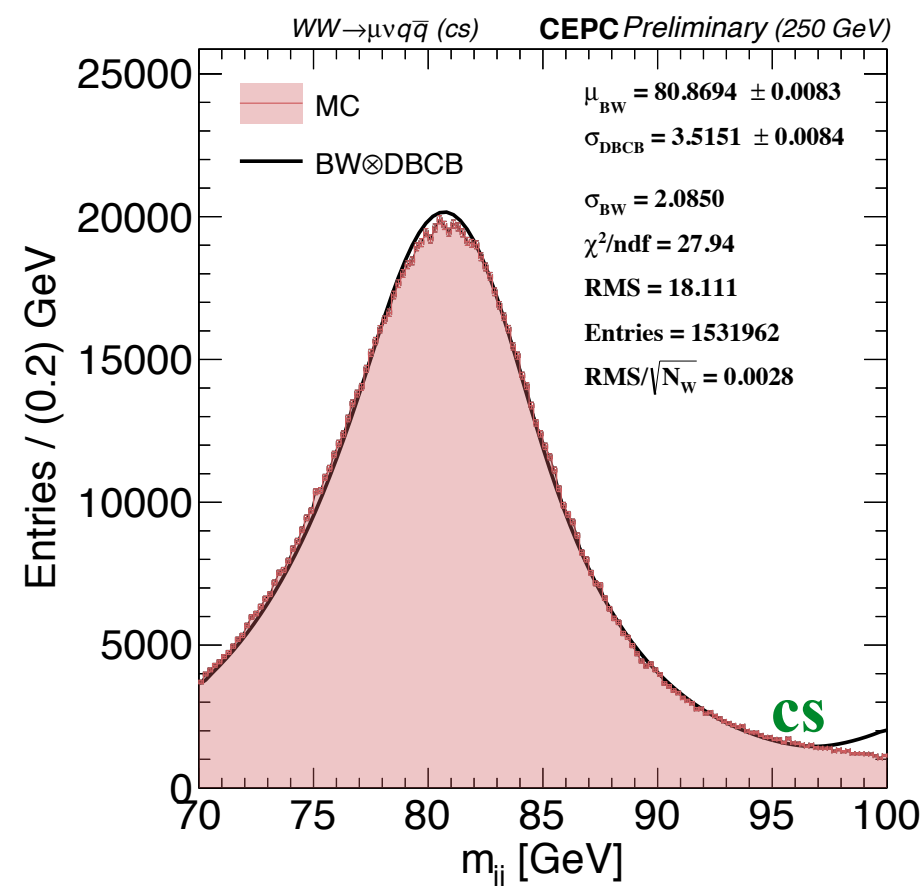
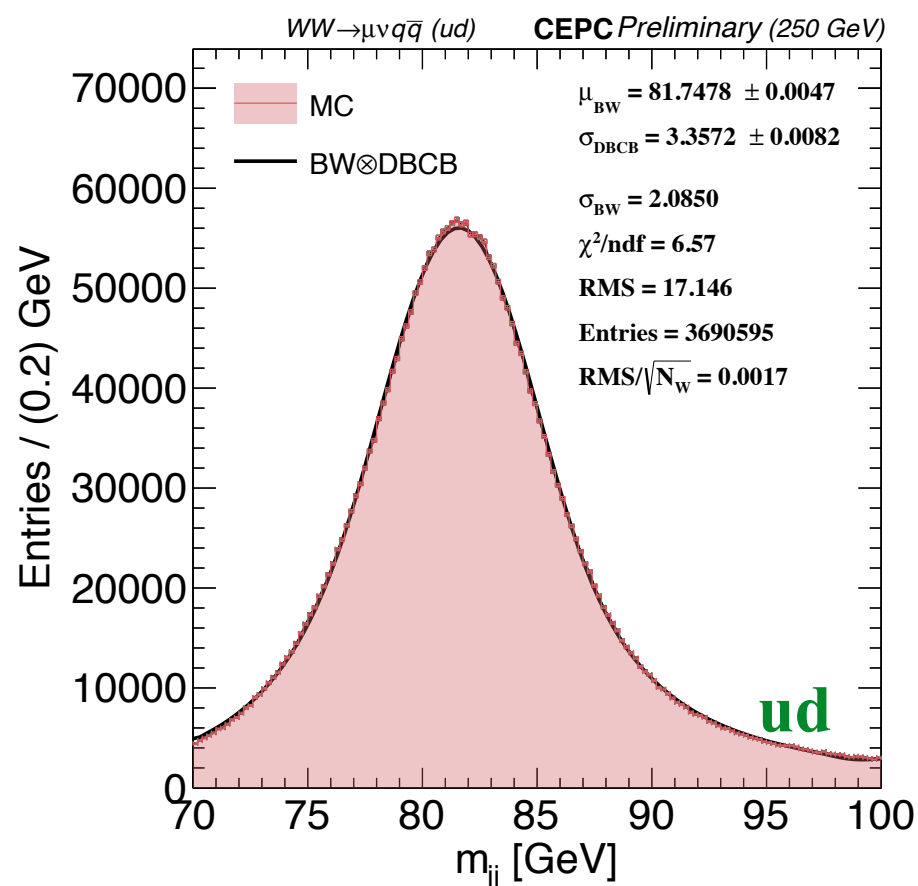


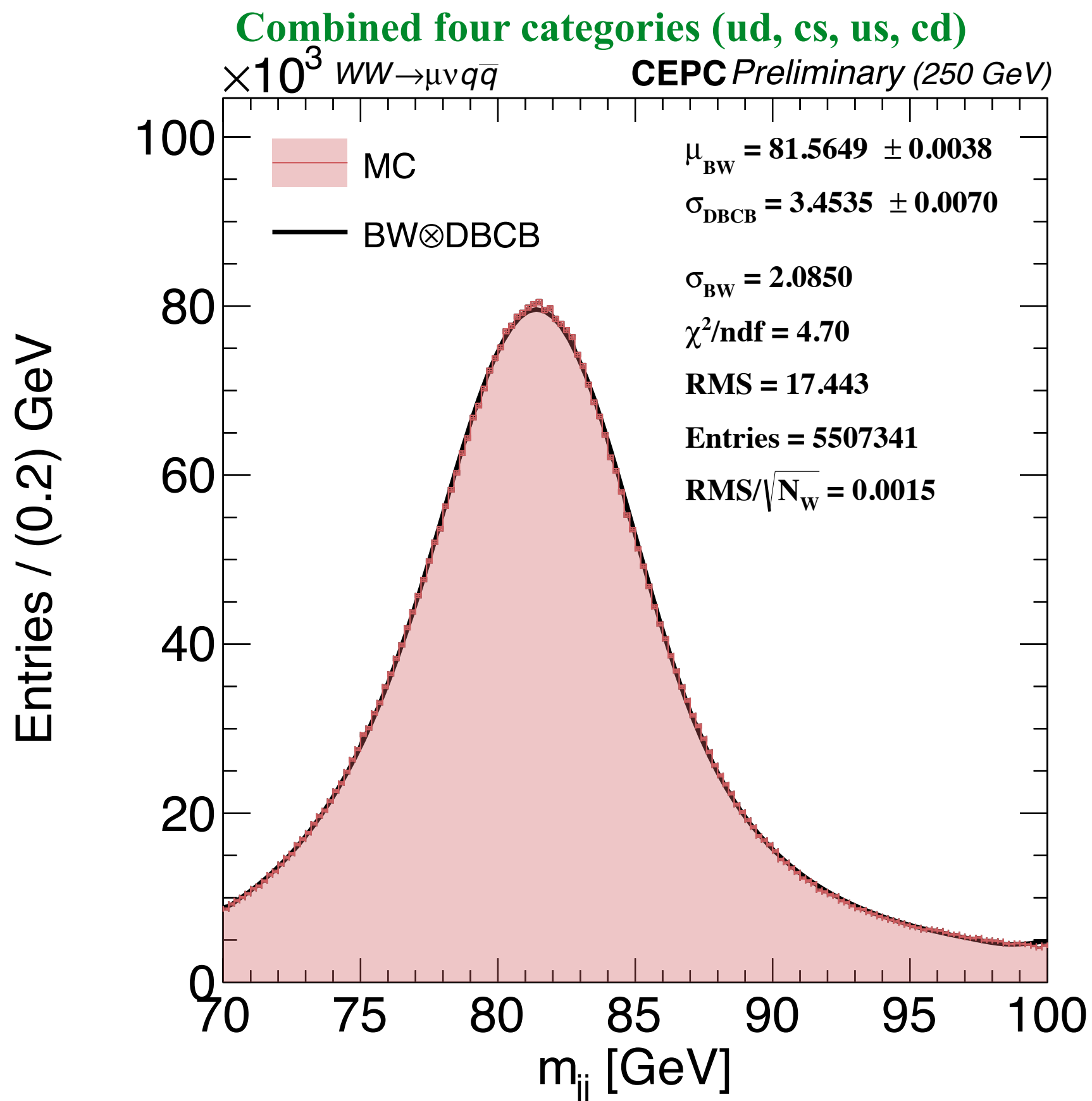


V1(WW $\rightarrow\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7552 ± 0.0045	81.1605 ± 0.0053	81.5911 ± 0.0197	81.2505 ± 0.0219	81.5100 ± 0.0032
σ_{DBCB}	3.3524 ± 0.0079	3.4004 ± 0.0051	3.4377 ± 0.0352	3.7128 ± 0.0434	3.5017 ± 0.0060
Entries	3955286	3621348	214655	198410	7990921
RMS	17.081	16.816	17.035	16.822	16.968
RMS/ $\sqrt{N_w}$	0.0017	0.0018	0.0074	0.0083	0.0012

- ◆ The categories with c-quark would have less μ_{BW} and lower jet energy resolution.
- ◆ Entry of same generation are similar.(e.g. ud & cs) However, the categories with c-quark would have a litter bit lower entries since b-vetoing may reject some c-quark.

Results(with b- & c- tagging)





V1(WW $\rightarrow\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7478 ± 0.0047	80.8694 ± 0.0083	81.5867 ± 0.0201	80.9130 ± 0.0341	81.5649 ± 0.0038
$\sigma_{DBC B}$	3.3572 ± 0.0082	3.515 ± 0.0084	3.4570 ± 0.0352	3.9936 ± 0.0614	3.4535 ± 0.0070
Entries	3690595	1531962	200600	83838	5507341
RMS	17.146	18.111	17.083	18.161	17.443
RMS/ $\sqrt{N_w}$	0.0017	0.0028	0.0077	0.0138	0.0015

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- ◆ Entry of same generation are similar.(e.g. ud & cs) However, the categories with c-quark would have a litter bit lower entries since b-vetoing may reject some c-quark.
- ◆ After adding c-vetoing, there are about 60% c-quarks been discarded. In addition, the μ_{BW} go lower. It seems that the fraction between c-jet and b-jet are changed. There fraction of b-quark jets becomes higher.

Mass window (70,100), without b-tagging

V1(WW→μνq $\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7543 ± 0.0045	81.1845 ± 0.0051	81.5942 ± 0.0216	81.2844 ± 0.0211	81.5064 ± 0.0031
σ_{DBCB}	3.3601 ± 0.0078	3.4001 ± 0.0050	3.4309 ± 0.0388	3.7078 ± 0.0415	3.5180 ± 0.0058
Entries	4041407	3992963	219817	218041	8479808
RMS	17.097	17.287	17.059	17.268	17.200
RMS/√N _w	0.0017	0.0017	0.0073	0.0079	0.0012

Mass window (70,100), with b-tagging < 0.5

V1(WW→μνq $\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7552 ± 0.0045	81.1605 ± 0.0053	81.5911 ± 0.0197	81.2505 ± 0.0219	81.5100 ± 0.0032
σ_{DBCB}	3.3524 ± 0.0079	3.4004 ± 0.0051	3.4377 ± 0.0352	3.7128 ± 0.0434	3.5017 ± 0.0060
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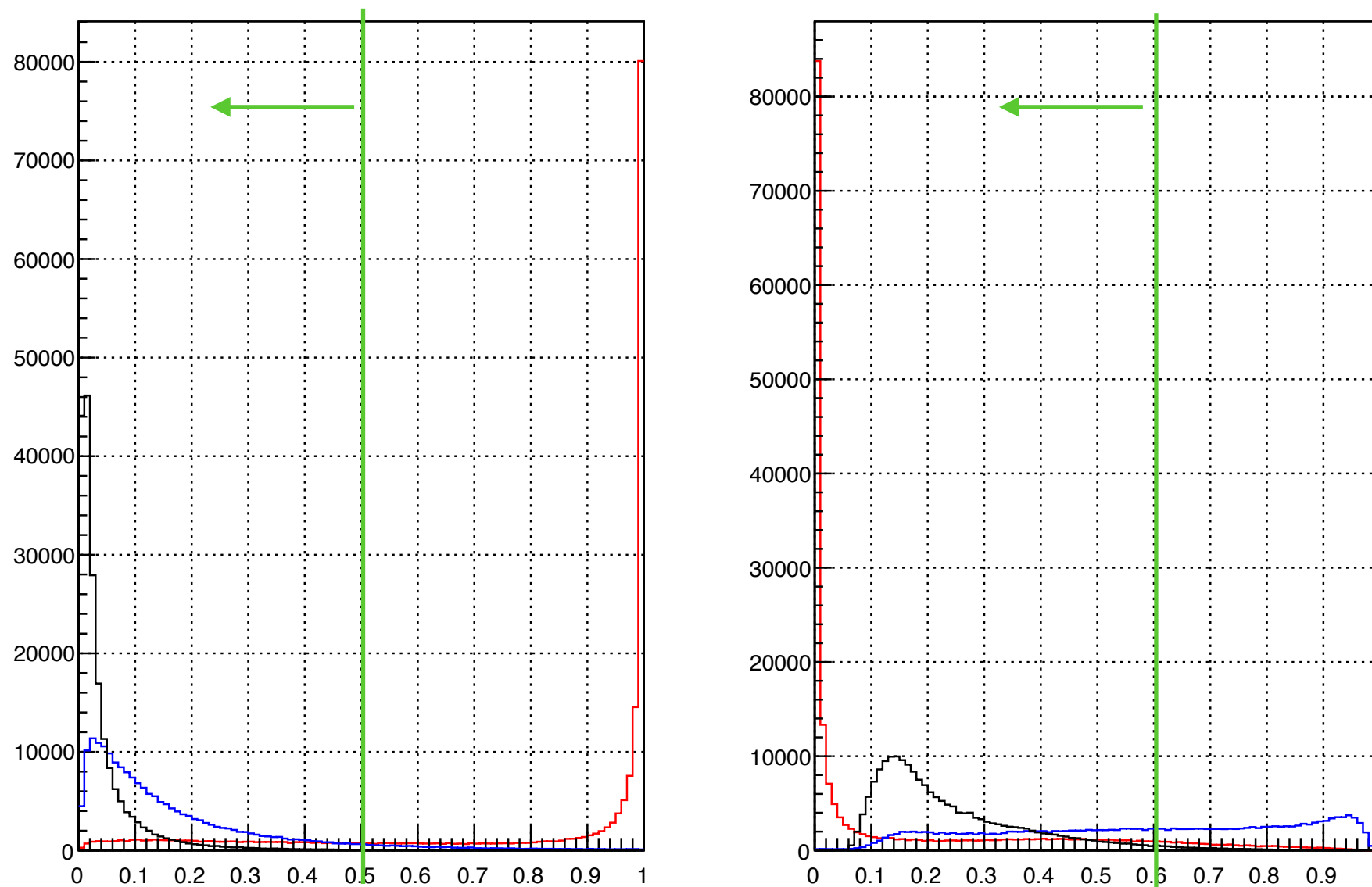
Mass window (70,100), with b-tagging < 0.5 & c-tagging < 0.6

V1(WW→μνq $\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	81.7478 ± 0.0047	80.8694 ± 0.0083	81.5867 ± 0.0201	80.9130 ± 0.0341	81.5649 ± 0.0038
σ_{DBCB}	3.3572 ± 0.0082	3.515 ± 0.0084	3.4570 ± 0.0352	3.9936 ± 0.0614	3.4535 ± 0.0070
Entries	3690595	1531962	200600	83838	5507341
RMS	17.146	18.111	17.083	18.161	17.443
RMS/√N _w	0.0017	0.0028	0.0077	0.0138	0.0015

- Required “Visible mass $> 0.5 \cdot \sqrt{s}$ ” is a loose cut.
- Before fragmentation, di-Parton invariant masses are the same.
- The categories with c-quark would have less μ_{BW} and lower jet energy resolution.
- Entry of same generation are similar.(e.g. ud & cs) However, the categories with c-quark would have a litter bit lower entries since b-vetoing may reject some c-quark.
- After adding c-vetoing, there are about 60% c-quarks been discarded. In addition, the μ_{BW} go lower. It seems that the fraction between c-jet and b-jet are changed. There fraction of b-quark jets becomes higher.
- Totally, after requiring b- and c-tagging, μ_{BW} becomes lower and jet energy resolution become worse.
- There are some pattern when we added b- and c-tagging into analysis. These pattern would be consistent in the narrow mass window (70, 100).



Back up



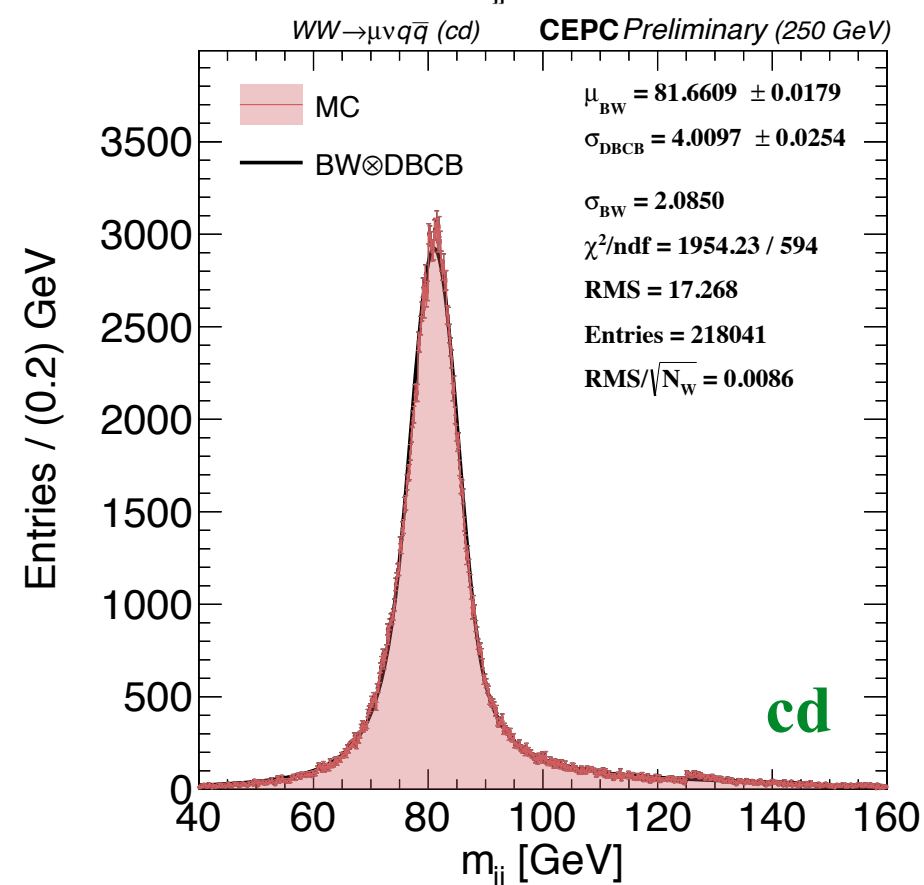
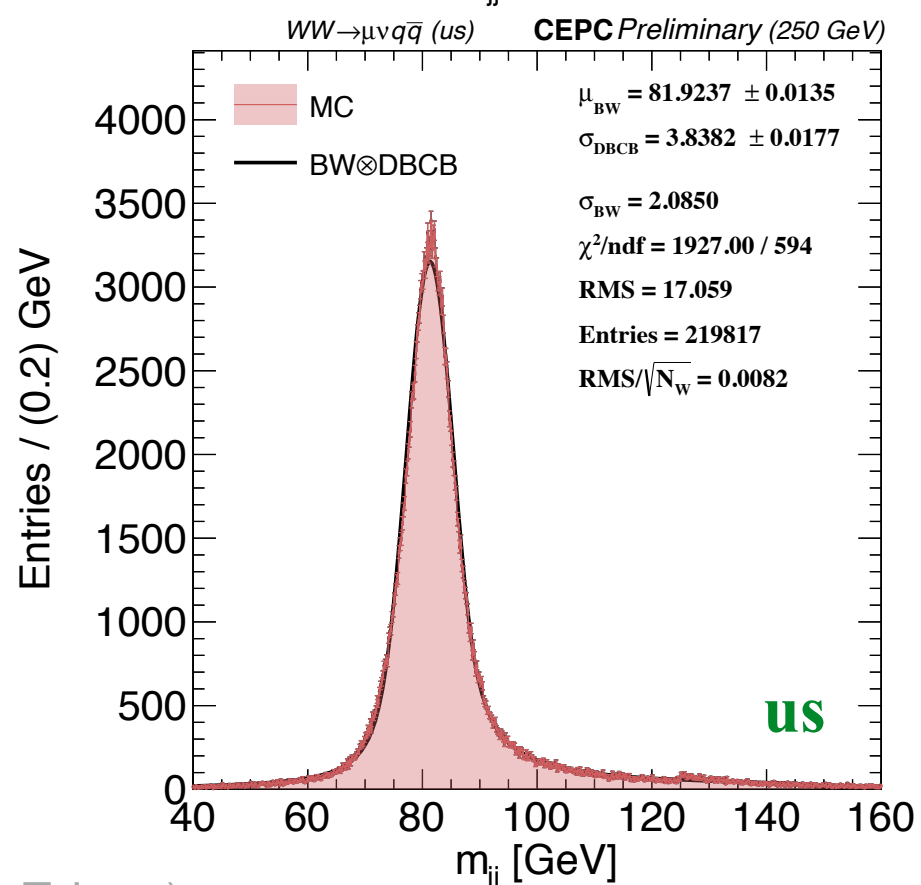
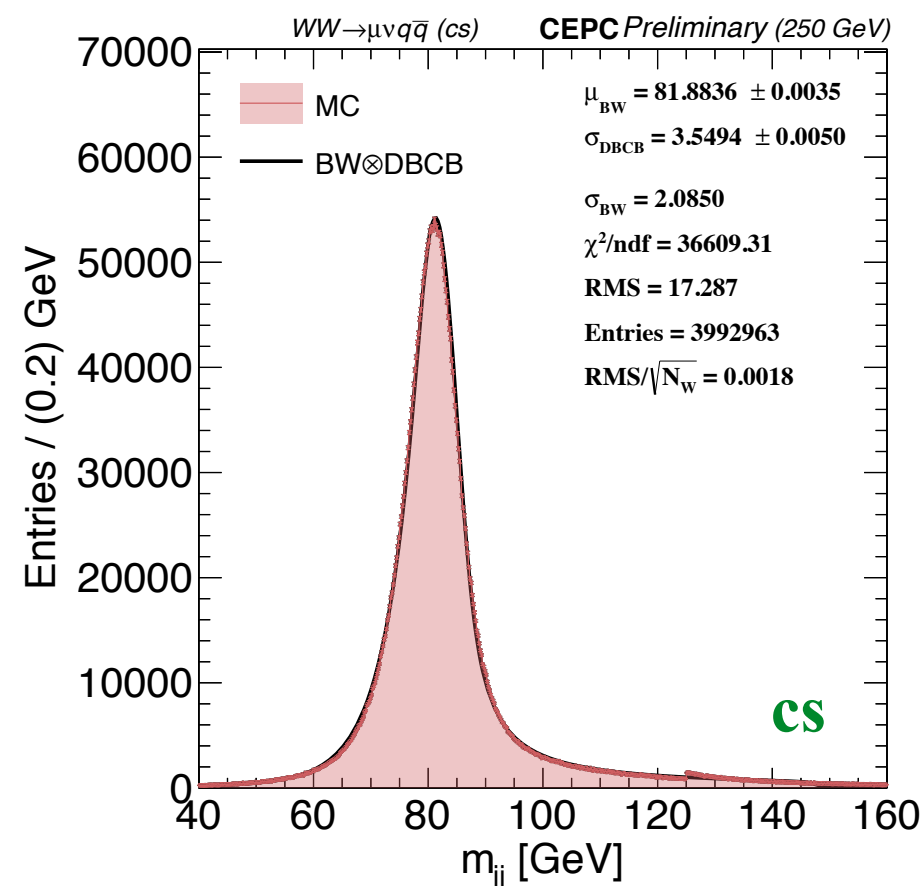
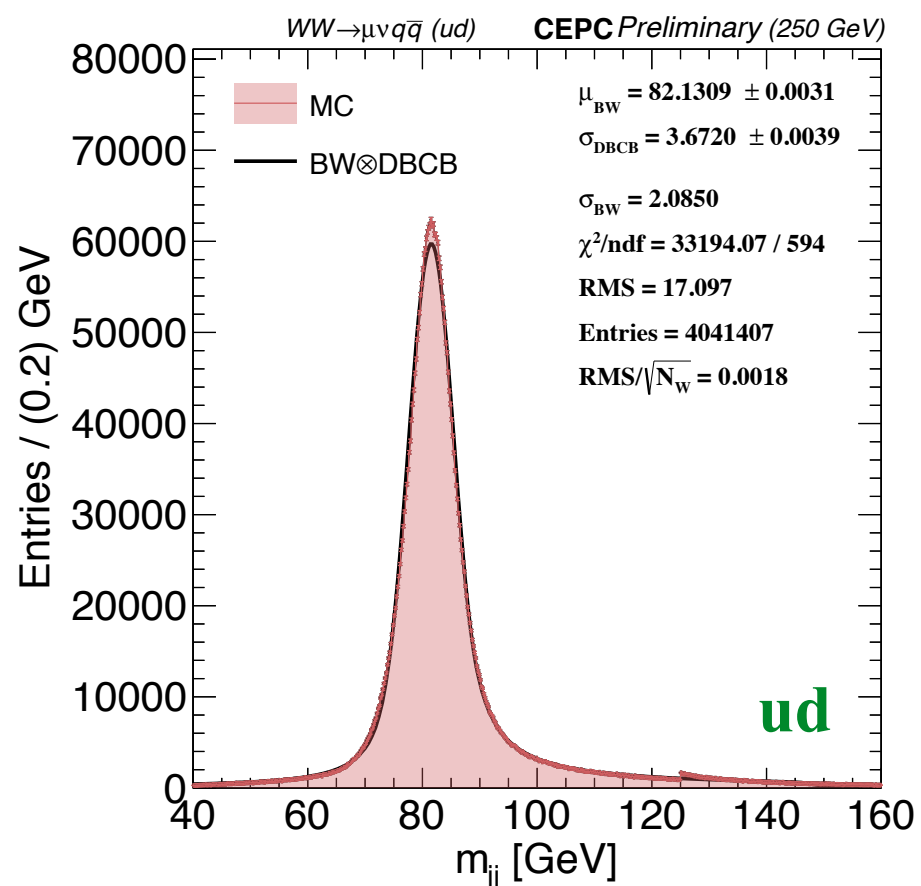
■ Red line is for b-jet, blue line is for c-jet, and black line is for light-jet.

■ According to left plot, if want to reject b-jet, the score is recommended less than 0.9; if want to select b-jet, the score is recommended greater than 0.8.

■ According to right plot, if want to reject c-jet, the score is recommended less than 0.6; if want to select c-jet, the score is recommended greater than 0.4.

Results(without b- & c-tagging)

Results(without b- & c-tagging)

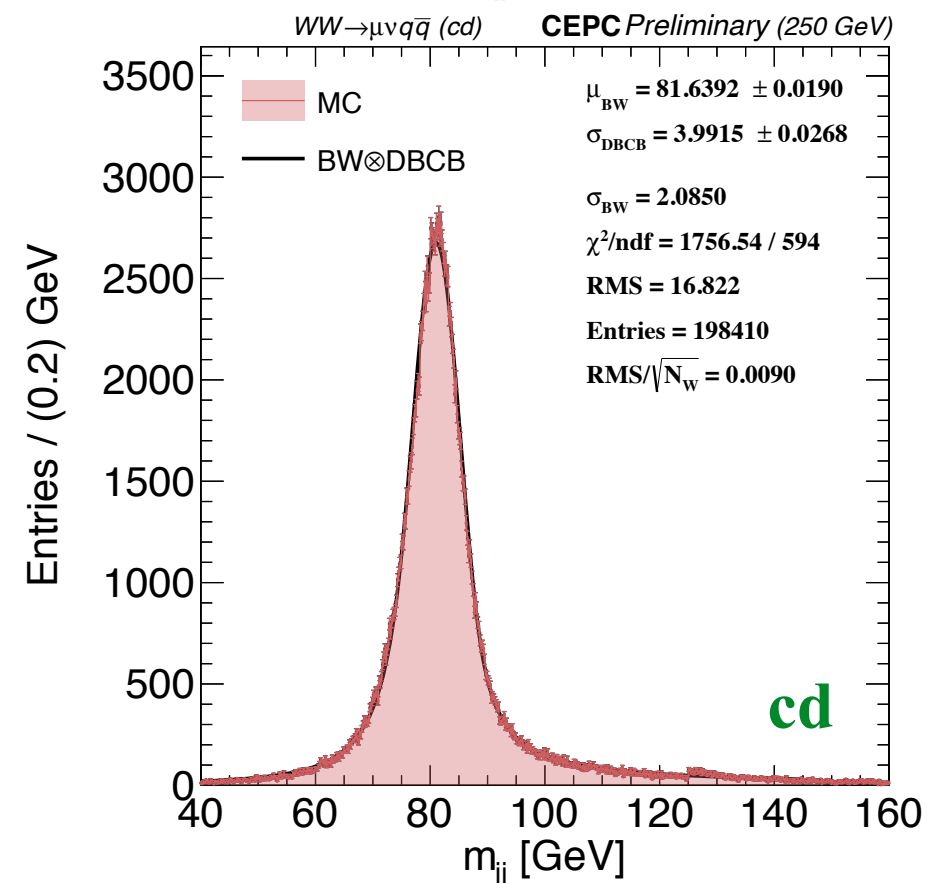
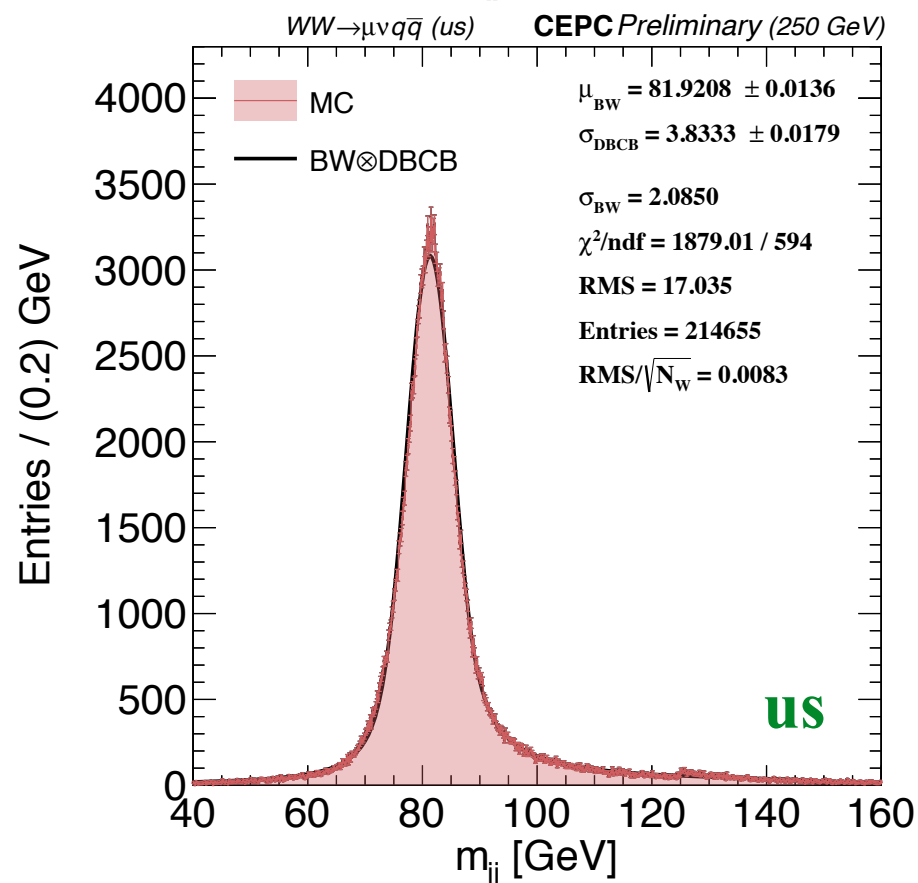
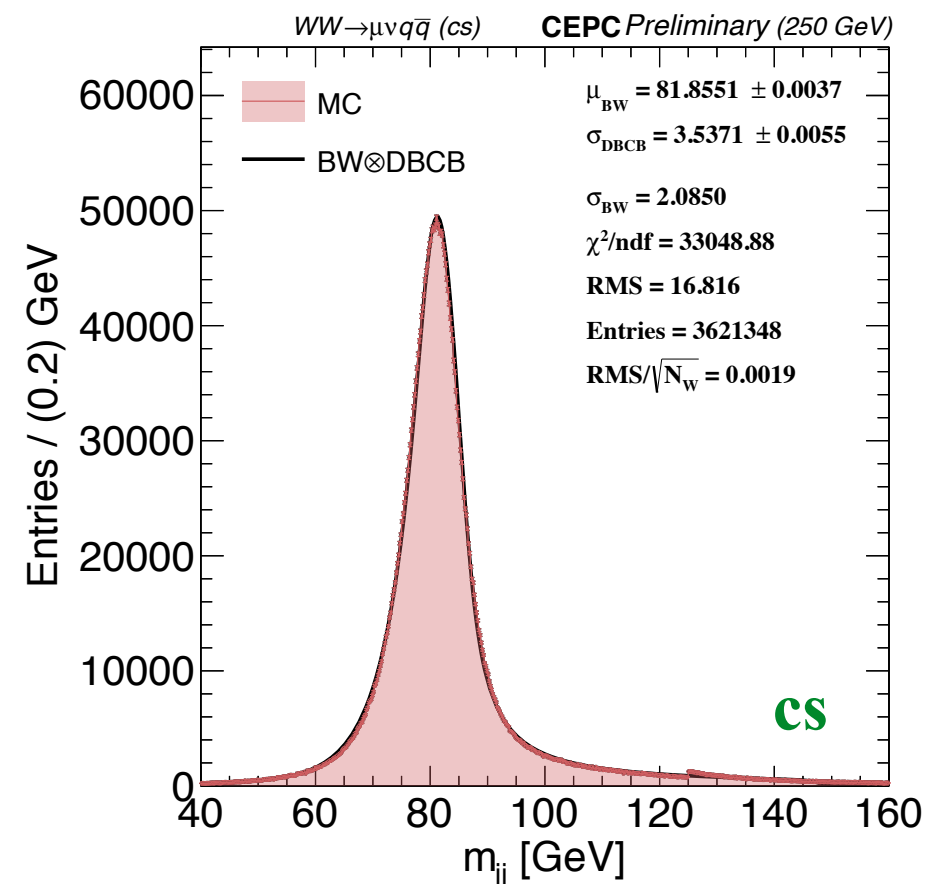
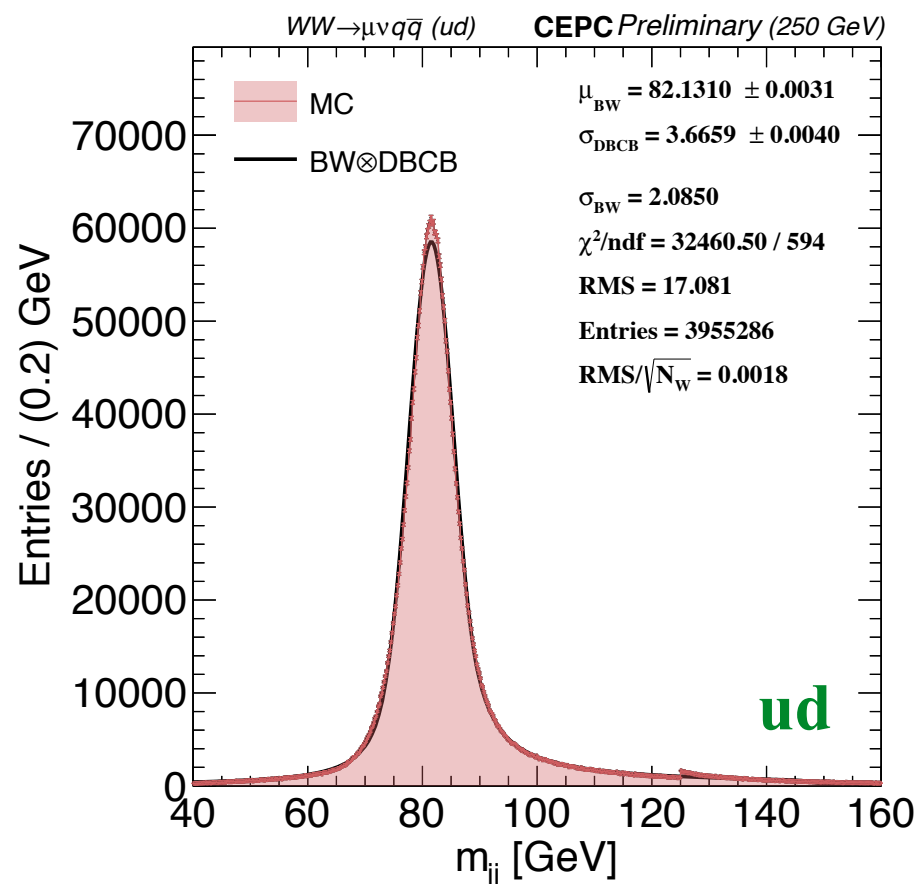


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μ_{BW}	82.1309 ± 0.0031	81.8836 ± 0.0035	81.9237 ± 0.0135	81.6609 ± 0.0179	81.8524 ± 0.0024
$\sigma_{DBC B}$	3.6720 ± 0.0039	3.5494 ± 0.0050	3.8382 ± 0.0177	4.0097 ± 0.0254	3.8843 ± 0.0036
Entries	4041407	3992963	219817	218041	8479808
RMS	17.097	17.287	17.059	17.268	17.200
RMS/ $\sqrt{N_w}$	0.0018	0.0018	0.0082	0.0086	0.0013

- ◆ The categories with c-quark would have less μ_{BW} .
- ◆ Entry of same generation are similar.(e.g. ud & cs)

Results(with b-tagging score < 0.5)

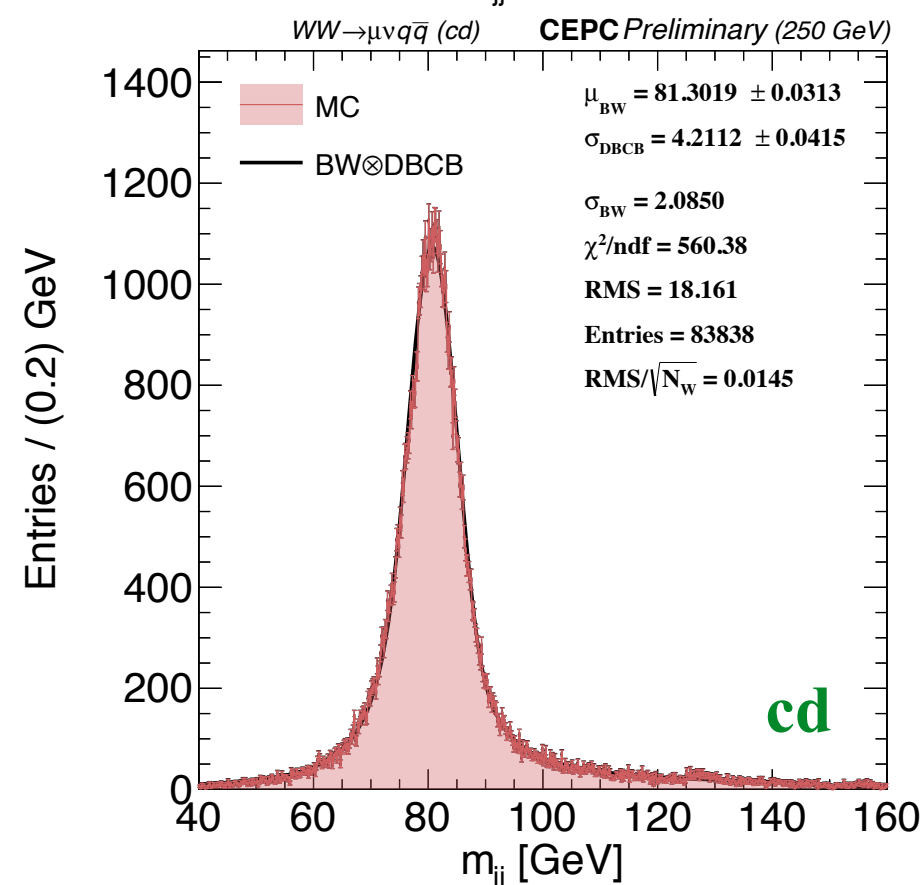
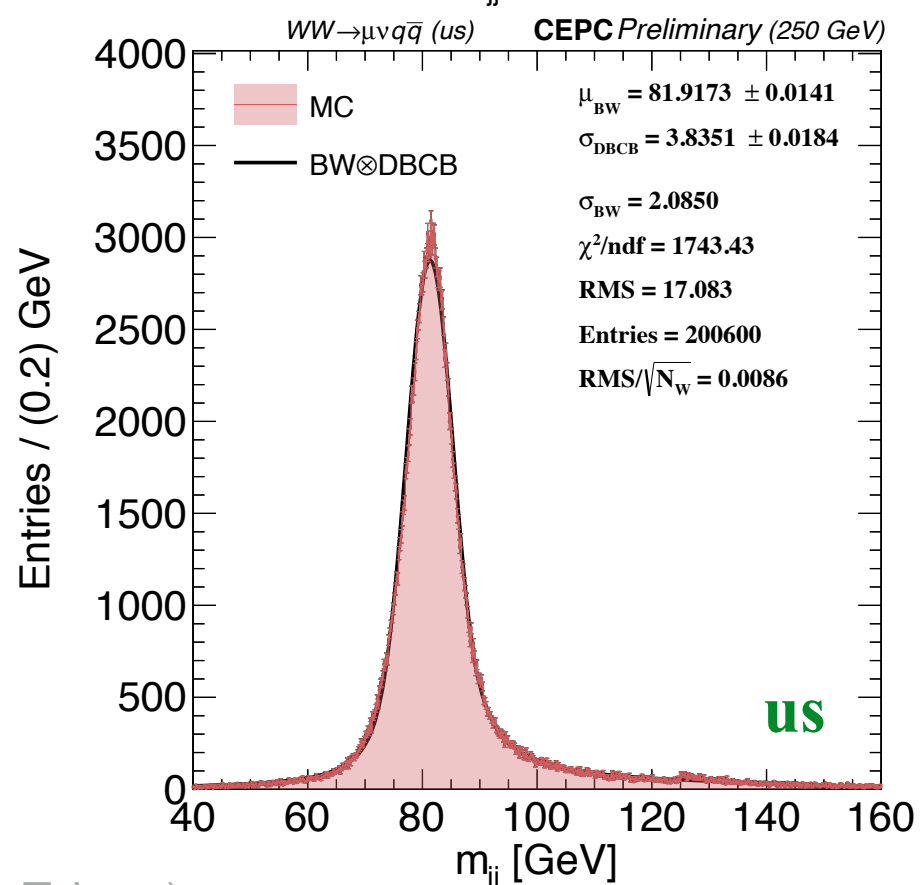
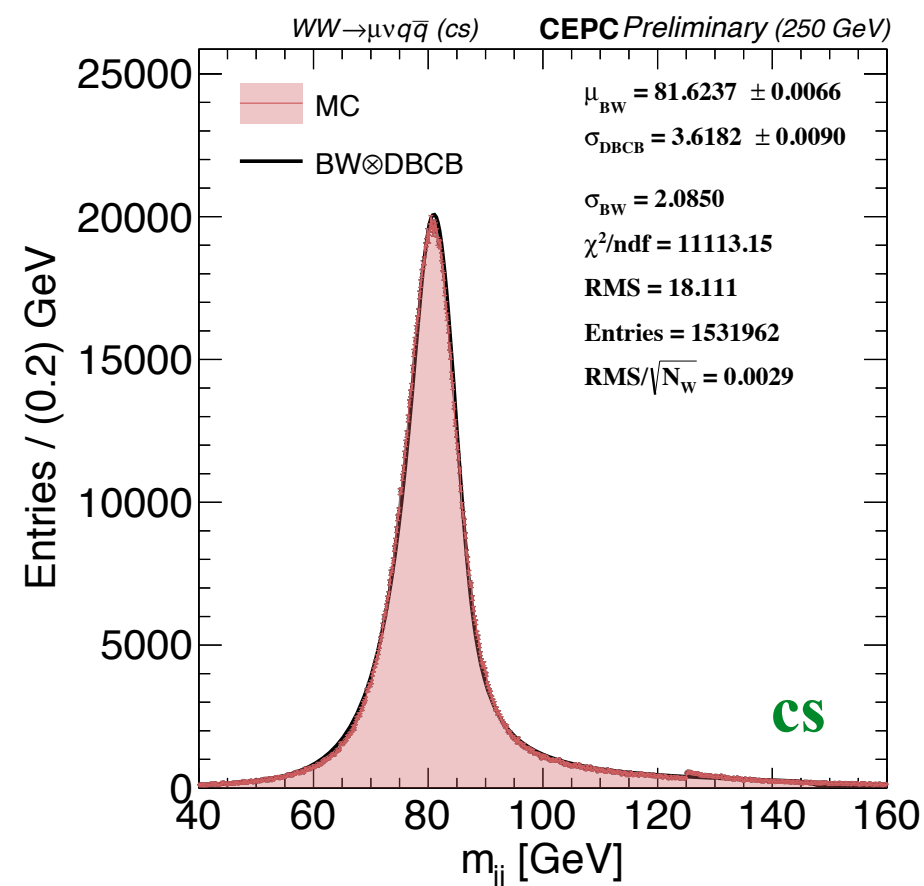
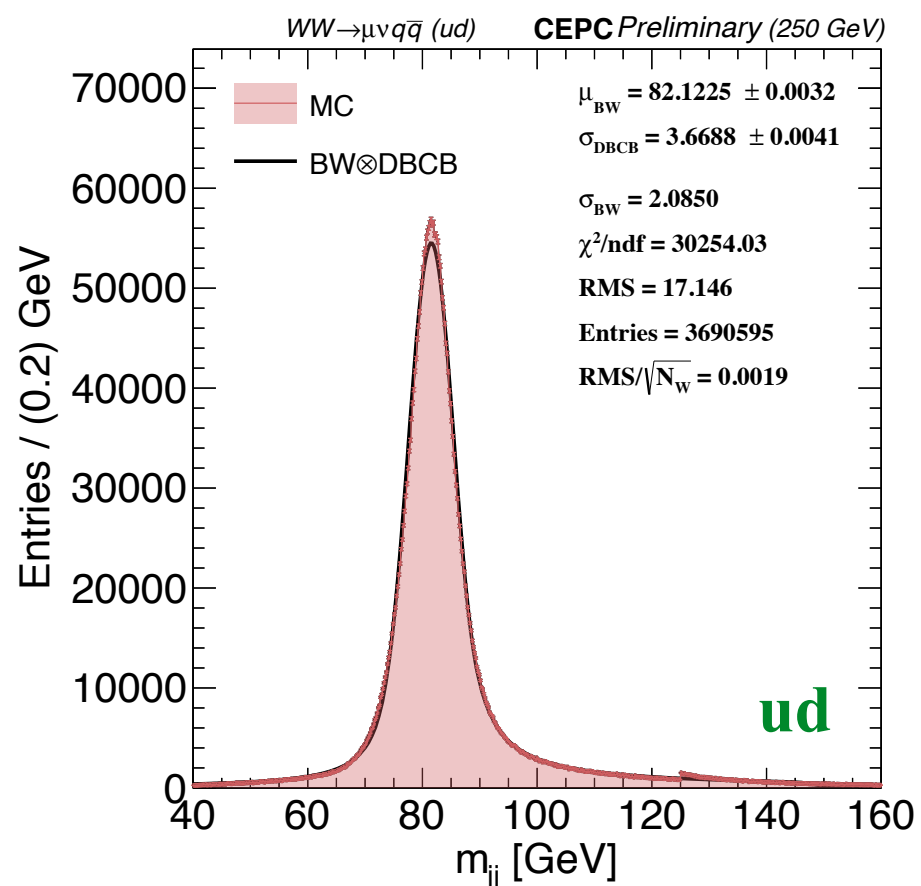
Results(with b-tagging score < 0.5)



V1(WW $\rightarrow \mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	82.1310 ± 0.0031	81.8551 ± 0.0037	81.9208 ± 0.0136	81.6392 ± 0.0190	81.8673 ± 0.0025
σ_{DBCB}	3.6659 ± 0.0040	3.5371 ± 0.0055	3.8333 ± 0.0179	3.9915 ± 0.0268	3.8592 ± 0.0038
Entries	3955286	3621348	214655	198410	7990921
RMS	17.081	16.816	17.035	16.822	16.968
RMS/ $\sqrt{N_w}$	0.0018	0.0019	0.0083	0.0090	0.0014

- ◆ The categories with c-quark would have less μ_{BW} .
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Results(with b- & c-tagging)



V1(WW $\rightarrow \mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	82.1225 ± 0.0032	81.6237 ± 0.0066	81.9173 ± 0.0141	81.3019 ± 0.0313	81.9048 ± 0.0028
$\sigma_{DBC B}$	3.6688 ± 0.0041	3.6182 ± 0.0090	3.8351 ± 0.0184	4.2112 ± 0.0415	3.8265 ± 0.0040
Entries	3690595	1521962	200600	83838	5507341
RMS	17.146	18.111	17.083	18.161	17.443
RMS/ $\sqrt{N_w}$	0.0019	0.0029	0.0086	0.0145	0.0016

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Mass window (40,160)

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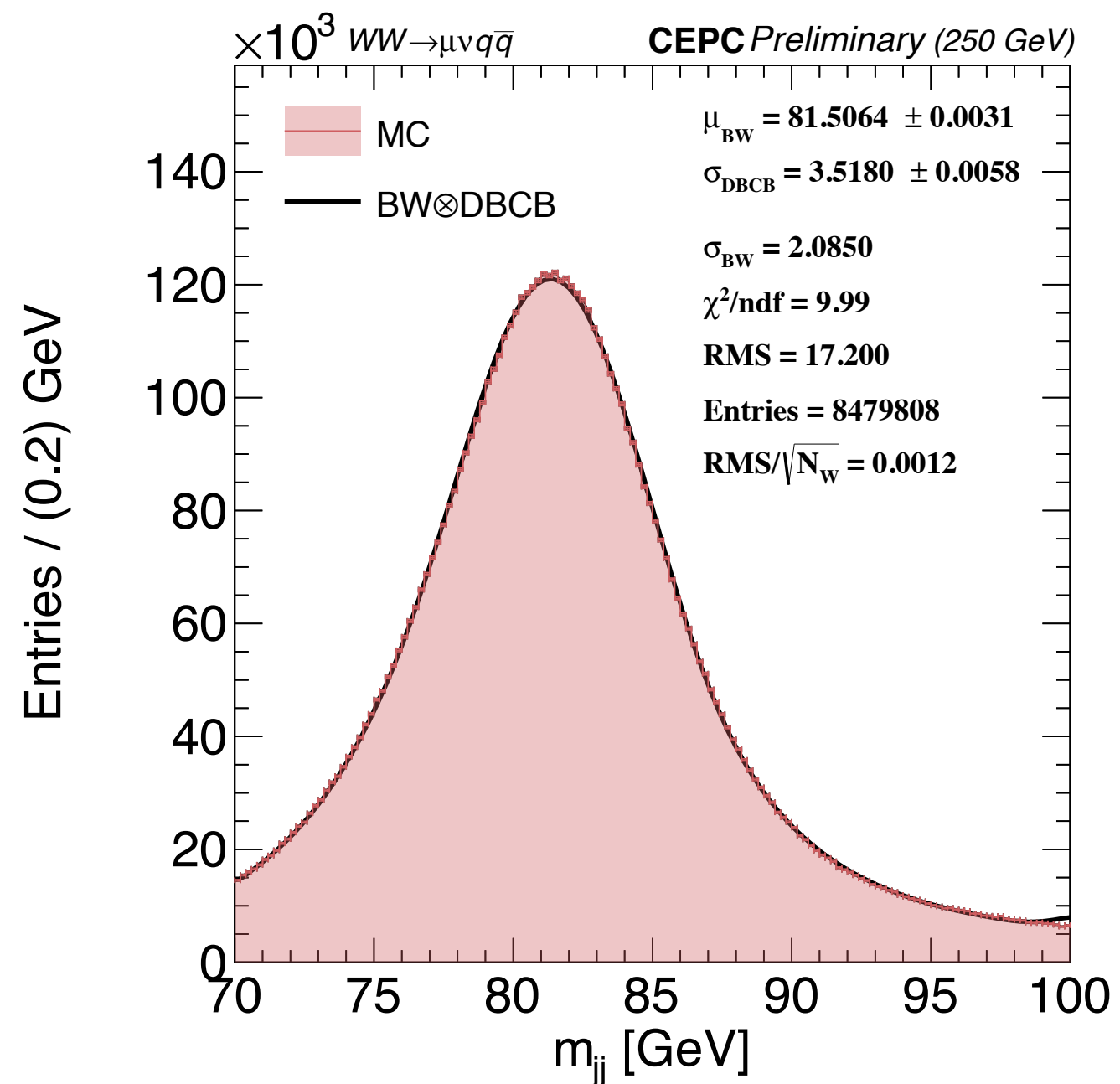
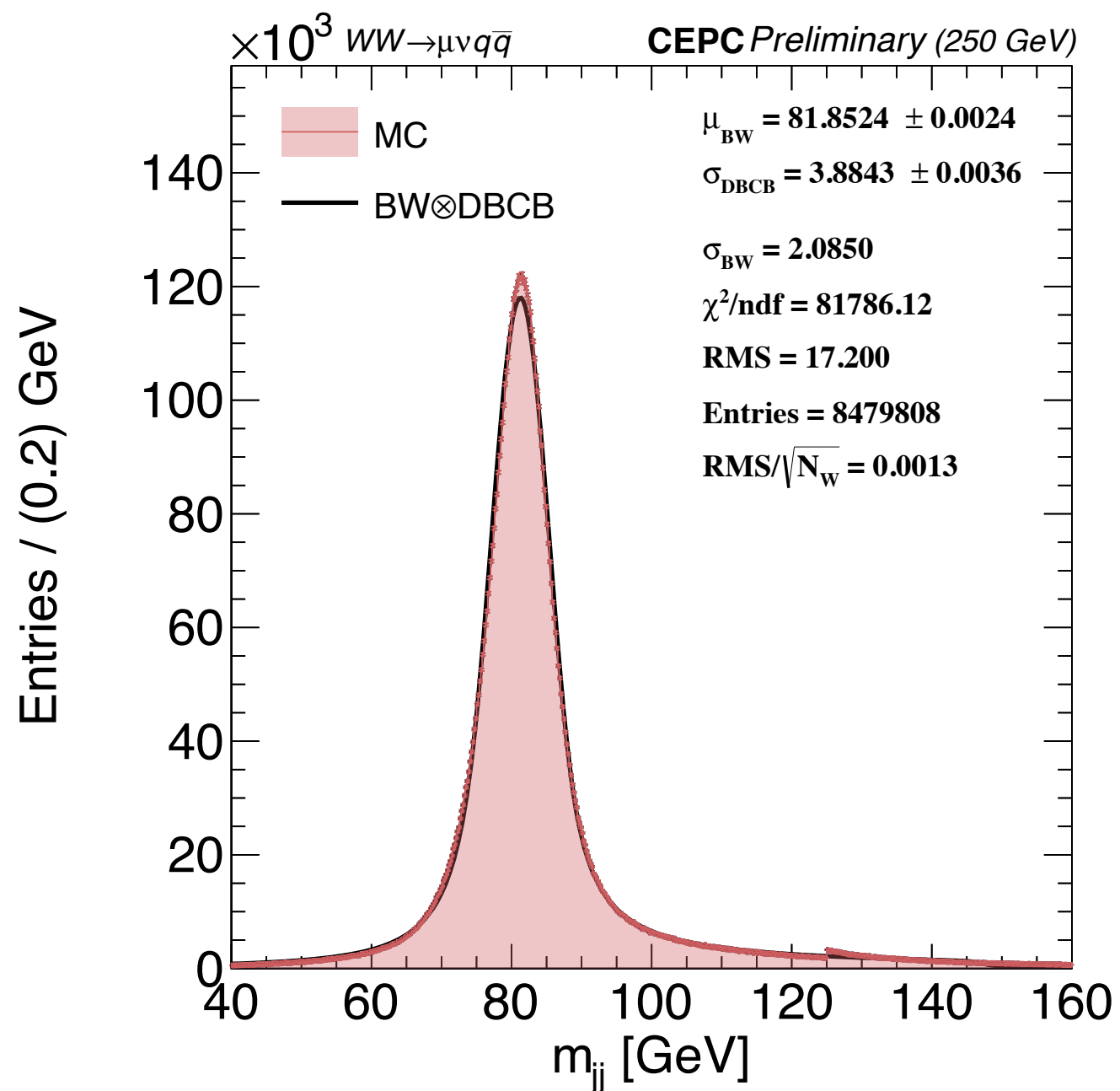
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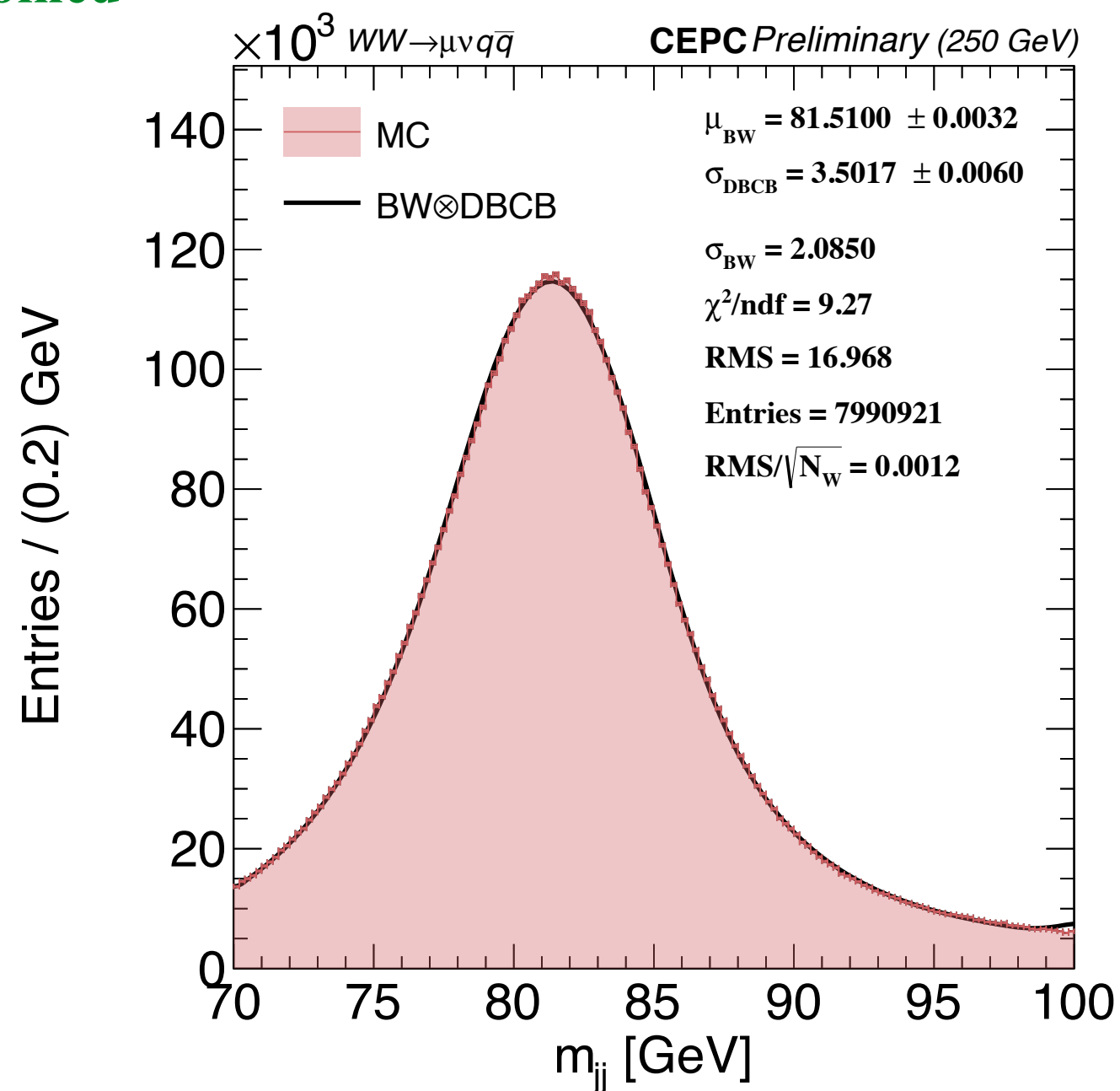
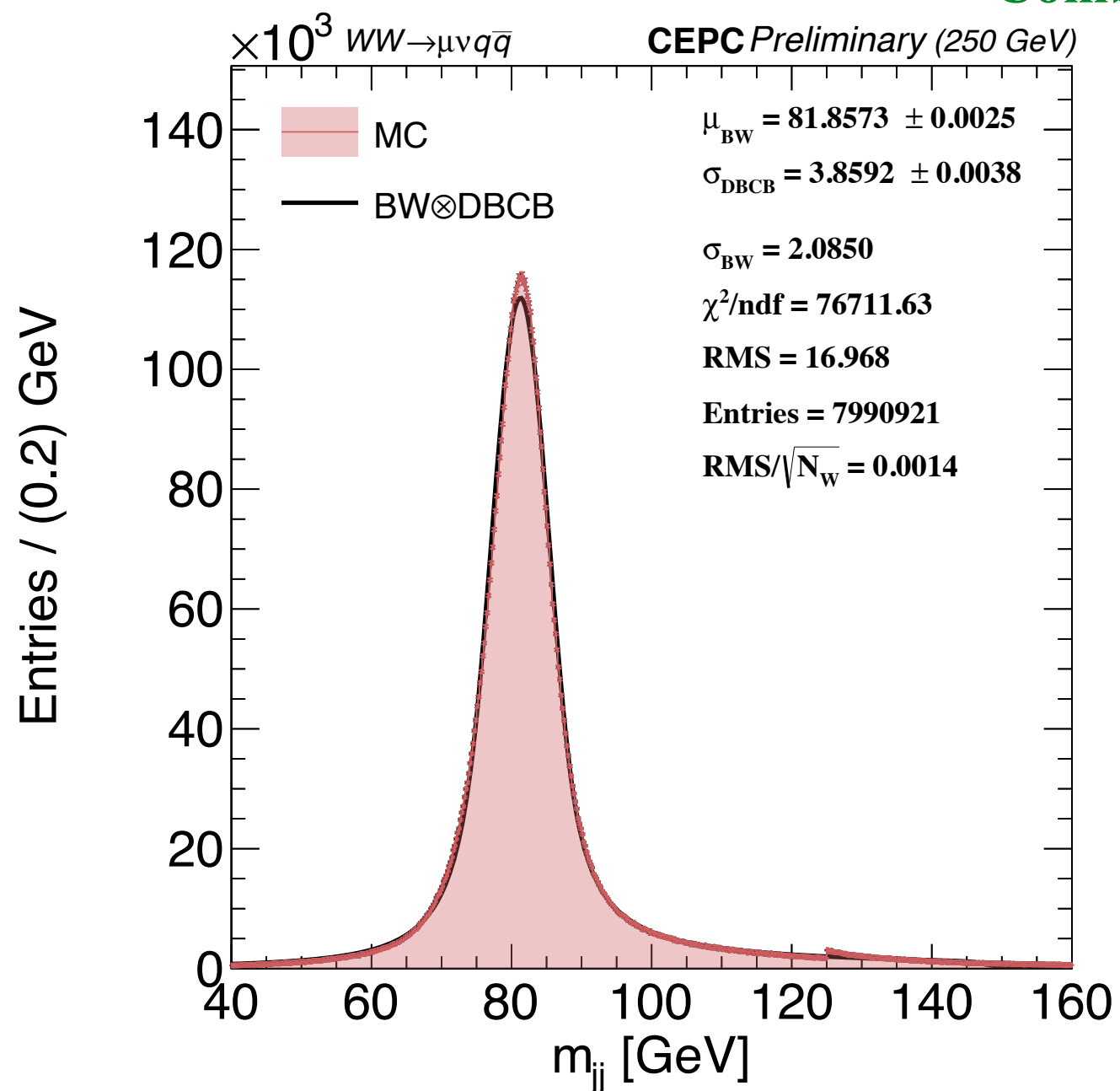
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RMS/ $\sqrt{N_w}$	0.0017	0.0028	0.0077	0.0138	0.0015

- ◆ The fitting results are different after changing the mass window. The μ_{BW} and σ_{DBCB} are smaller than the wide mass window.

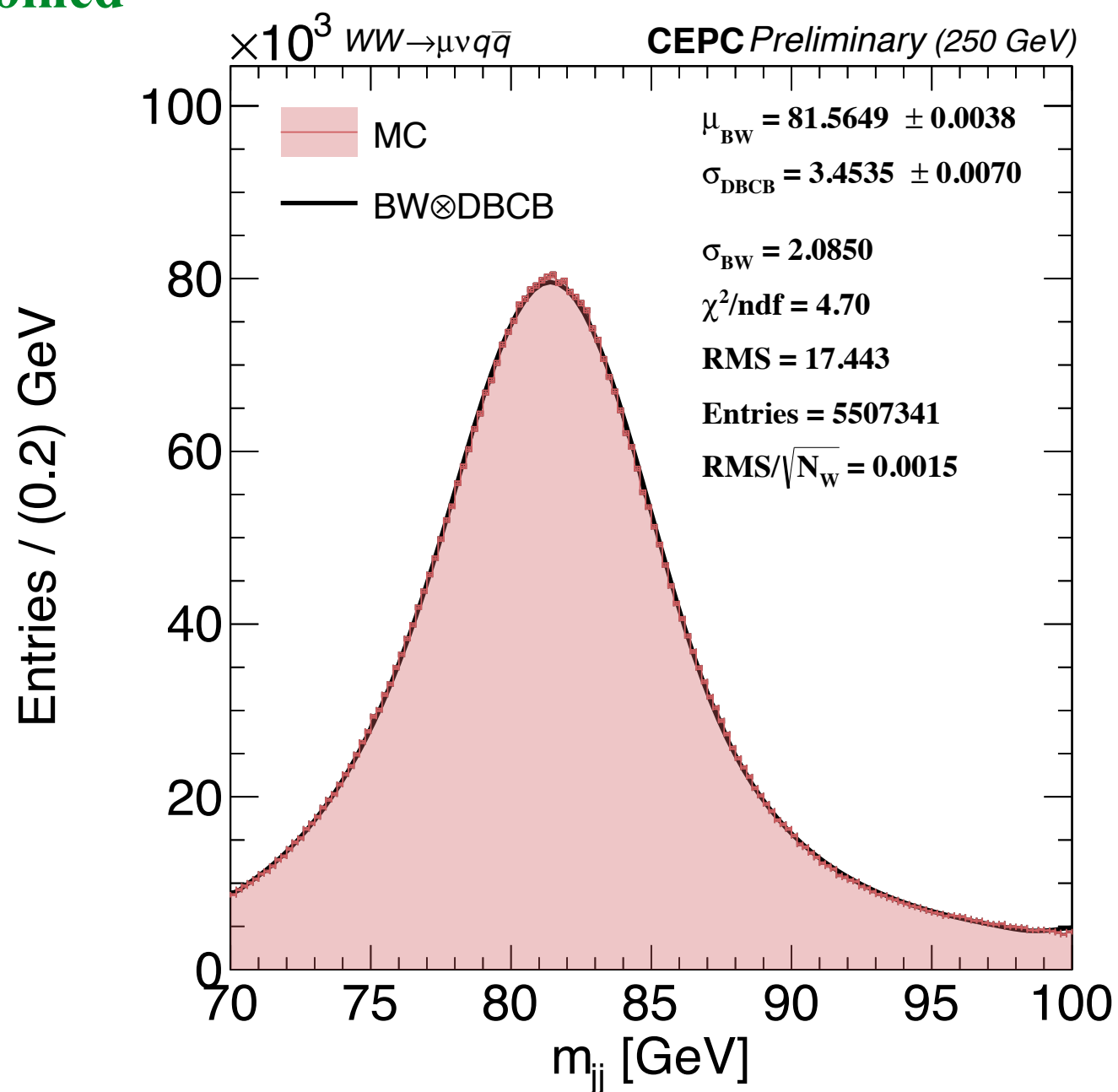
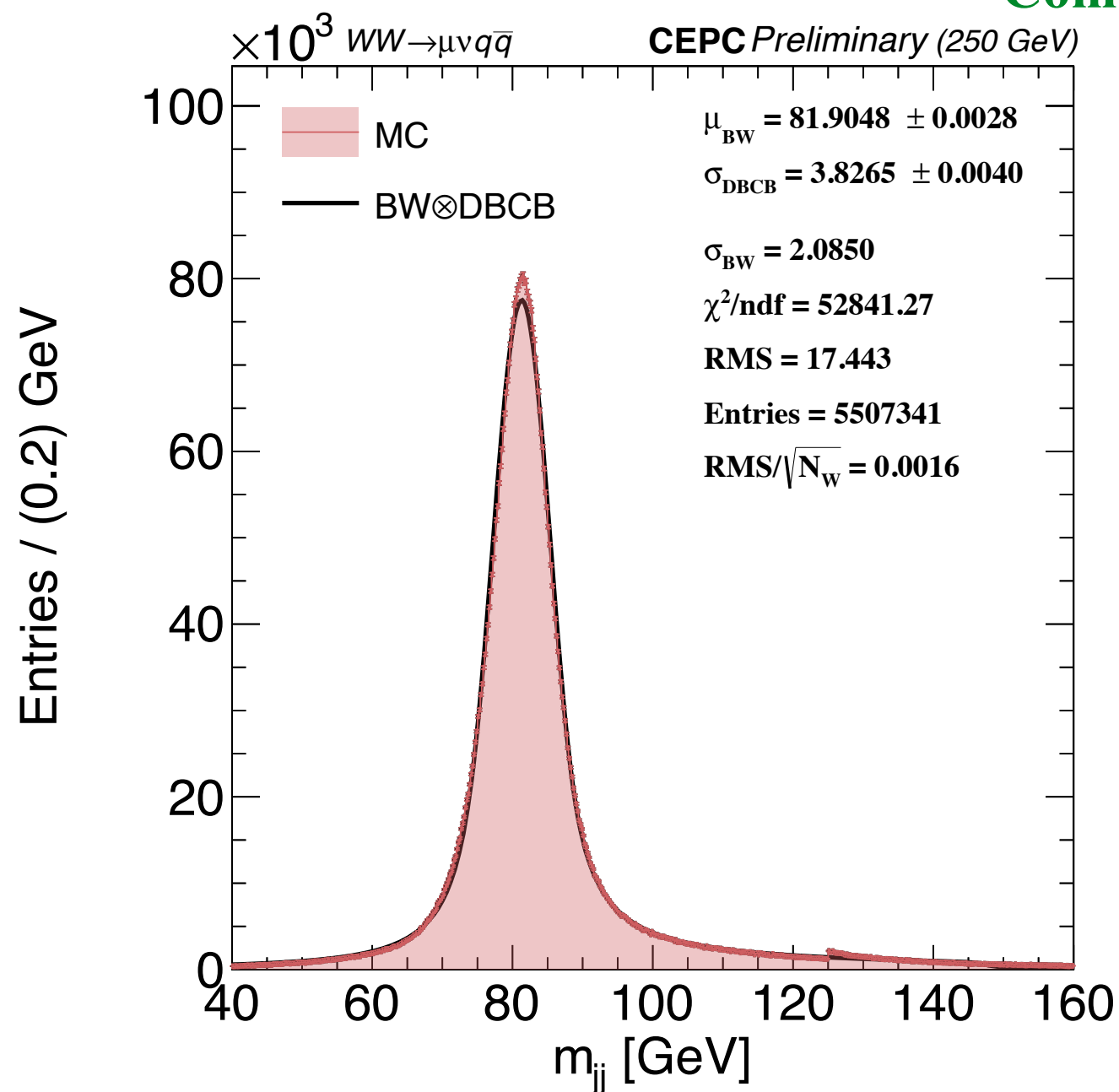
Combined



Combined



Combined



Mass window (40,160), without b-tagging

V1(WW→ $\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	82.1309 ± 0.0031	81.8836 ± 0.0035	81.9237 ± 0.0135	81.6609 ± 0.0179	81.8524 ± 0.0024
σ_{DBCB}	3.6720 ± 0.0039	3.5494 ± 0.0050	3.8382 ± 0.0177	4.0097 ± 0.0254	3.8843 ± 0.0036
Entries	4041407	3992963	219817	218041	8479808
RMS	17.097	17.287	17.059	17.268	17.200
RMS/ $\sqrt{N_W}$	0.0018	0.0018	0.0082	0.0086	0.0013

Mass window (40,160), with b-tagging < 0.5

V1(WW→ $\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	82.1310 ± 0.0031	81.8551 ± 0.0037	81.9208 ± 0.0136	81.6392 ± 0.0190	81.8673 ± 0.0025
σ_{DBCB}	3.6659 ± 0.0040	3.5371 ± 0.0055	3.8333 ± 0.0179	3.9915 ± 0.0268	3.8592 ± 0.0038
Entries	3955286	3621348	214655	198410	7990921
RMS	17.081	16.816	17.035	16.822	16.968
RMS/ $\sqrt{N_W}$	0.0018	0.0019	0.0083	0.0090	0.0014

Mass window (40,160), with b-tagging < 0.5 & c-tagging < 0.6

V1(WW→ $\mu\nu q\bar{q}$)	ud	cs	us	cd	Combined
μ_{BW}	82.1225 ± 0.0032	81.6237 ± 0.0066	81.9173 ± 0.0141	81.3019 ± 0.0313	81.9048 ± 0.0028
σ_{DBCB}	3.6688 ± 0.0041	3.6182 ± 0.0090	3.8351 ± 0.0184	4.2112 ± 0.0415	3.8265 ± 0.0040
Entries	3690595	1521962	200600	83838	5507341
RMS	17.146	18.111	17.083	18.161	17.443
RMS/ $\sqrt{N_W}$	0.0019	0.0029	0.0086	0.0145	0.0016