Quantum Obs Workshop Notes:

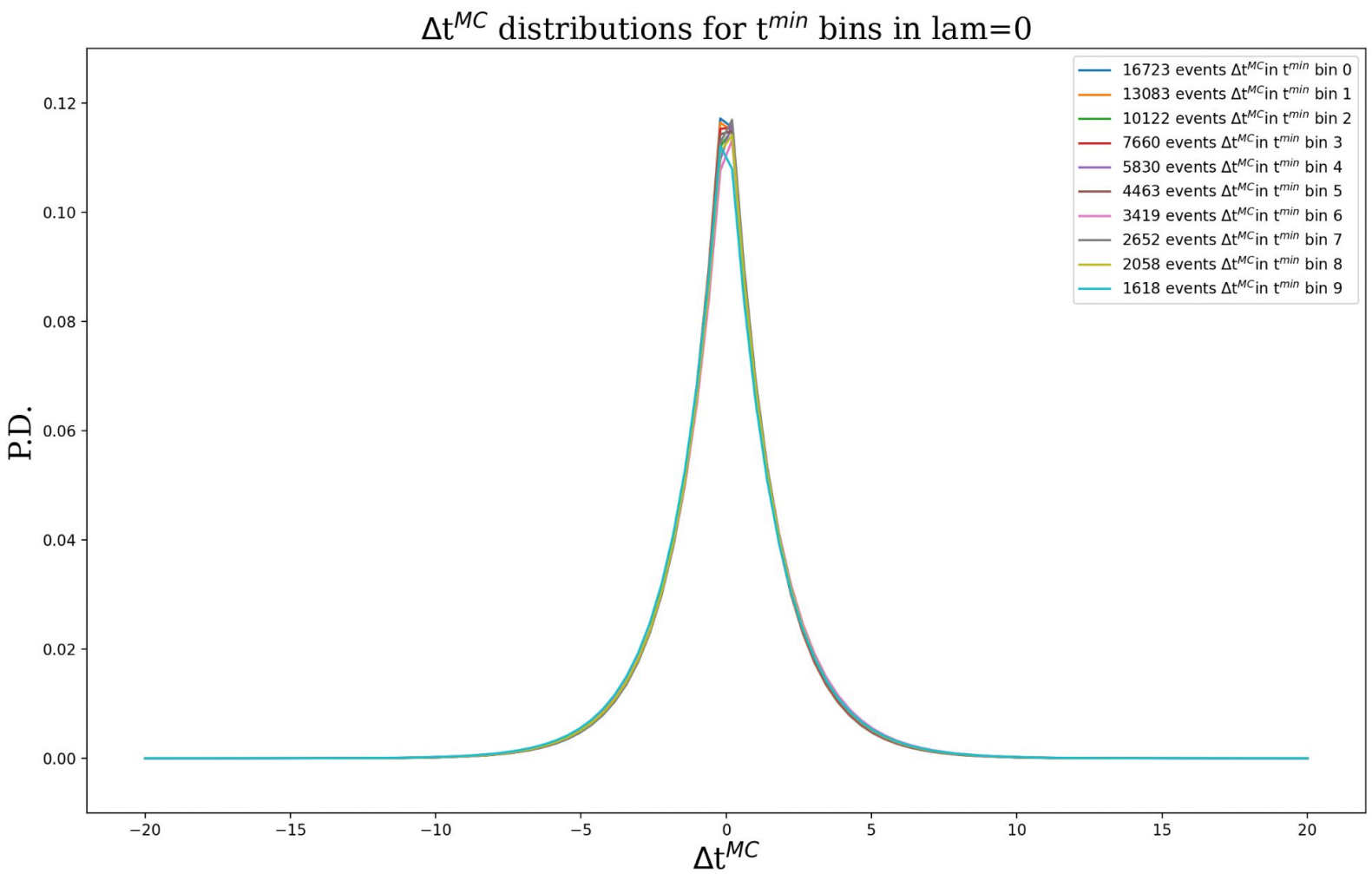
- Quantum Machine learning for Ethan?
- From Quantum Tomography talk by Kun Cheng (Pitt), it seems like he wants compute full density matrix of flavour entangled meson pairs.
- Computing/testing magic/entanglement at Belle II could potentially be done, but expect magic=0/entanglement=max (Martin White & Matthew Low).
- Tests of contextuality at Belle II. Marco Fabbrichesi has values for $B \rightarrow J/\Psi K^*$; endorses performing tests.
- Performing a “test of time” at Belle II was brought up, but doubtful as to whether it is truly feasible (correlation of Bs is lost after the first B meson decays , the 2^{nd} B decay is “statistical” on an event-by-event basis)
- Similar thought process on using Belle II for Quantum Computing & why it is also doubtful
- Marco seemingly supports performing Bell tests, Tao Han disagrees → “EPR long gone. Rest in peace.”
- “Lack of Instant Realism” seemed to indicate using flavour entangled mesons. Need to go thoroughly through slides.

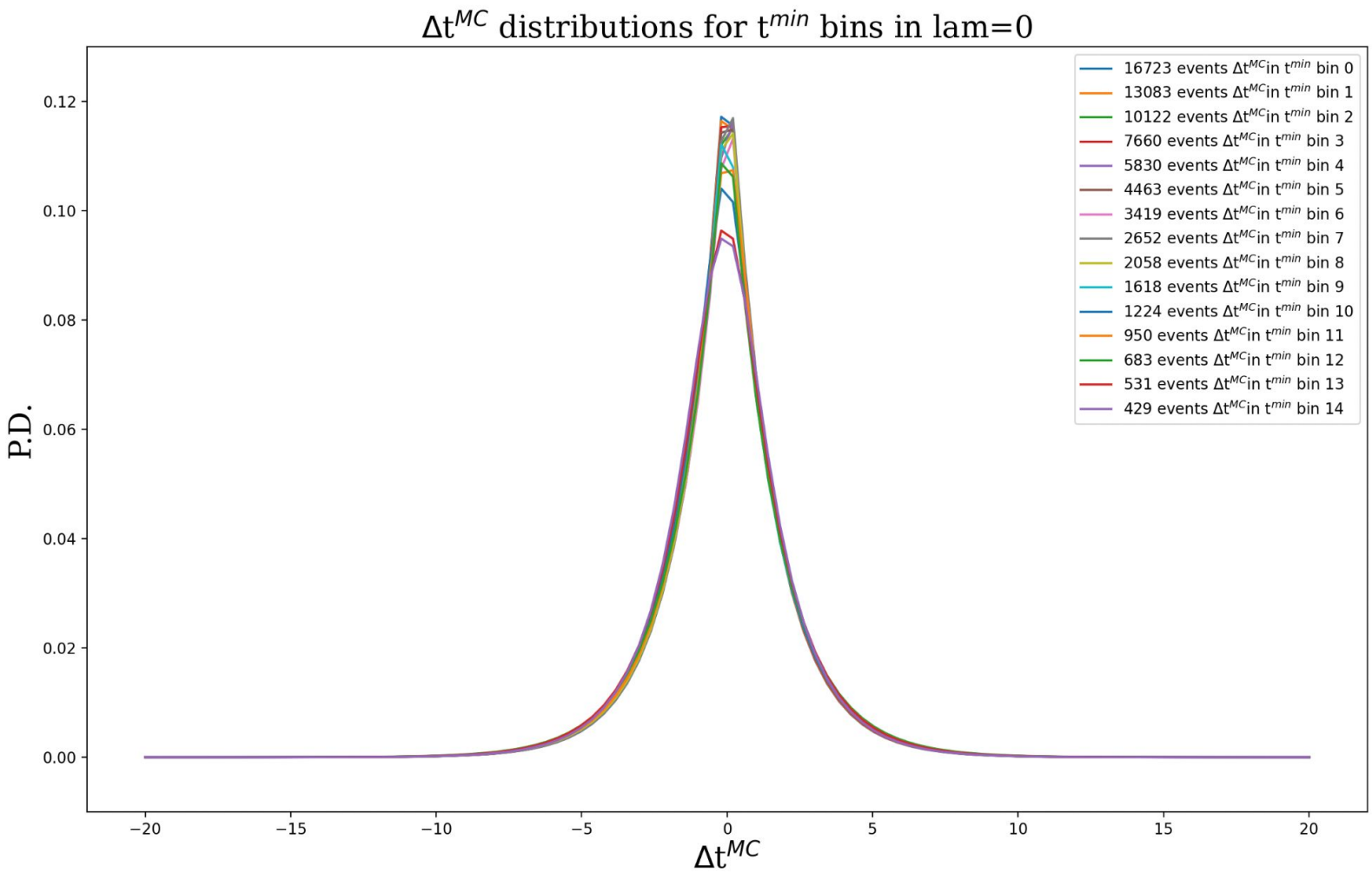
Fun Stuff:

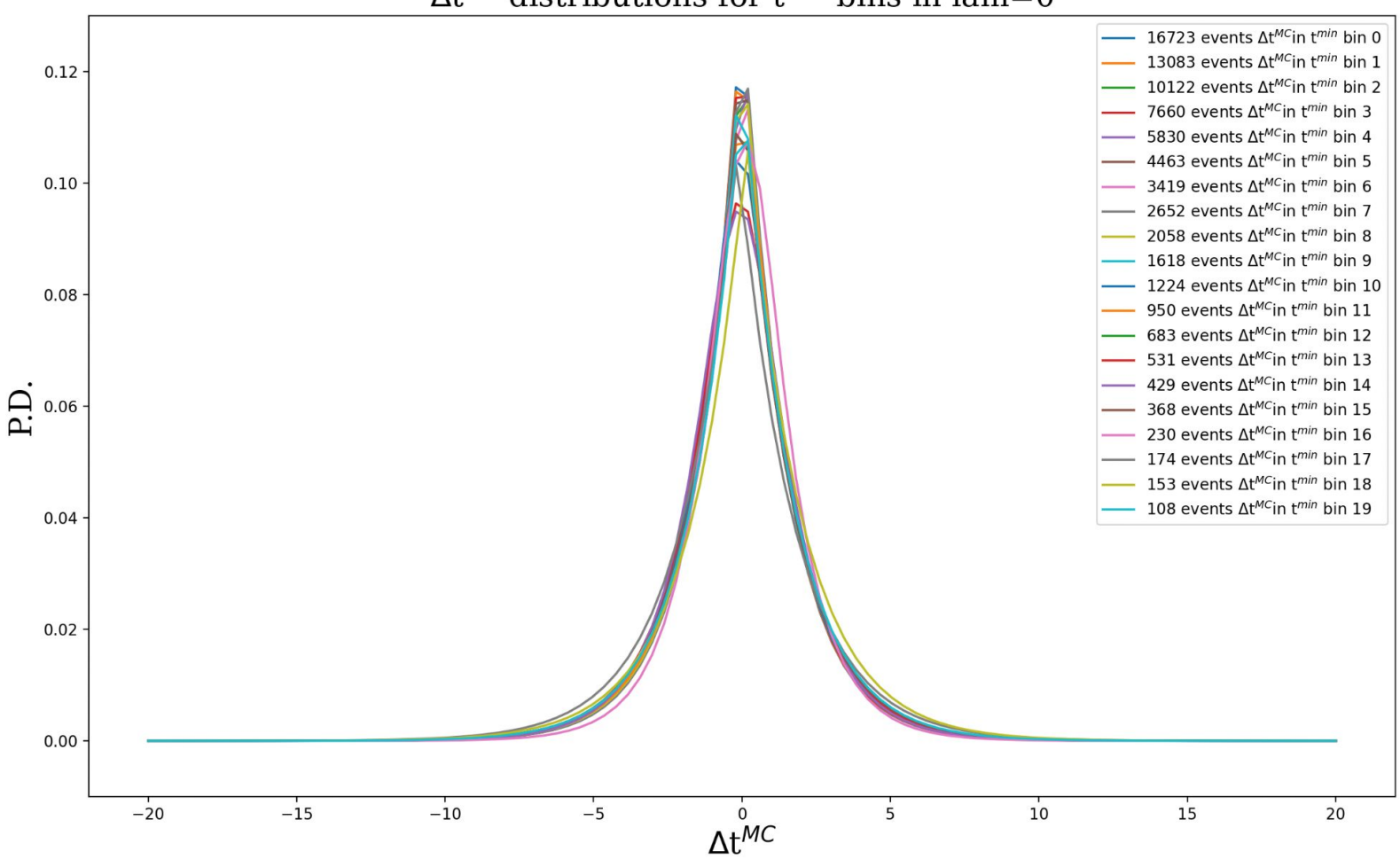
- Symmetries as an emergent property of entanglement
- Decoherence at black hole horizons

Meeting with Kenta Uno:
→ Want beam parameter plots done by ~end of April

Thesis proposal:
→ Seems like all committee is good to go. Need to request room.
→ Asked Matthew Low if he wished to join in for the talk. He accepted.
    → Tao Han then inquired about the results of the theory position at UH…


Δt^{MC} distributions for t^{min} bins in lam=0
16723 events Δt^{MC} in t^{min} bin 0
13083 events Δt^{MC} in t^{min} bin 1
10122 events Δt^{MC} in t^{min} bin 2
7660 events Δt^{MC} in t^{min} bin 3
5830 events Δt^{MC} in t^{min} bin 4
4463 events Δt^{MC} in t^{min} bin 5
3419 events Δt^{MC} in t^{min} bin 6
2652 events Δt^{MC} in t^{min} bin 7
2058 events Δt^{MC} in t^{min} bin 8
1618 events Δt^{MC} in t^{min} bin 9
P.D.
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20
Δt^{MC}


Δt^{MC} distributions for t^{min} bins in lam=0
P.D.
Δt^{MC}
16723 events Δt^{MC} in t^{min} bin 0
13083 events Δt^{MC} in t^{min} bin 1
10122 events Δt^{MC} in t^{min} bin 2
7660 events Δt^{MC} in t^{min} bin 3
5830 events Δt^{MC} in t^{min} bin 4
4463 events Δt^{MC} in t^{min} bin 5
3419 events Δt^{MC} in t^{min} bin 6
2652 events Δt^{MC} in t^{min} bin 7
2058 events Δt^{MC} in t^{min} bin 8
1618 events Δt^{MC} in t^{min} bin 9
1224 events Δt^{MC} in t^{min} bin 10
950 events Δt^{MC} in t^{min} bin 11
683 events Δt^{MC} in t^{min} bin 12
531 events Δt^{MC} in t^{min} bin 13
429 events Δt^{MC} in t^{min} bin 14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20


Δt^{MC} distributions for t^{min} bins in lam=0
P.D.
Δt^{MC}
16723 events Δt^{MC} in t^{min} bin 0
13083 events Δt^{MC} in t^{min} bin 1
10122 events Δt^{MC} in t^{min} bin 2
7660 events Δt^{MC} in t^{min} bin 3
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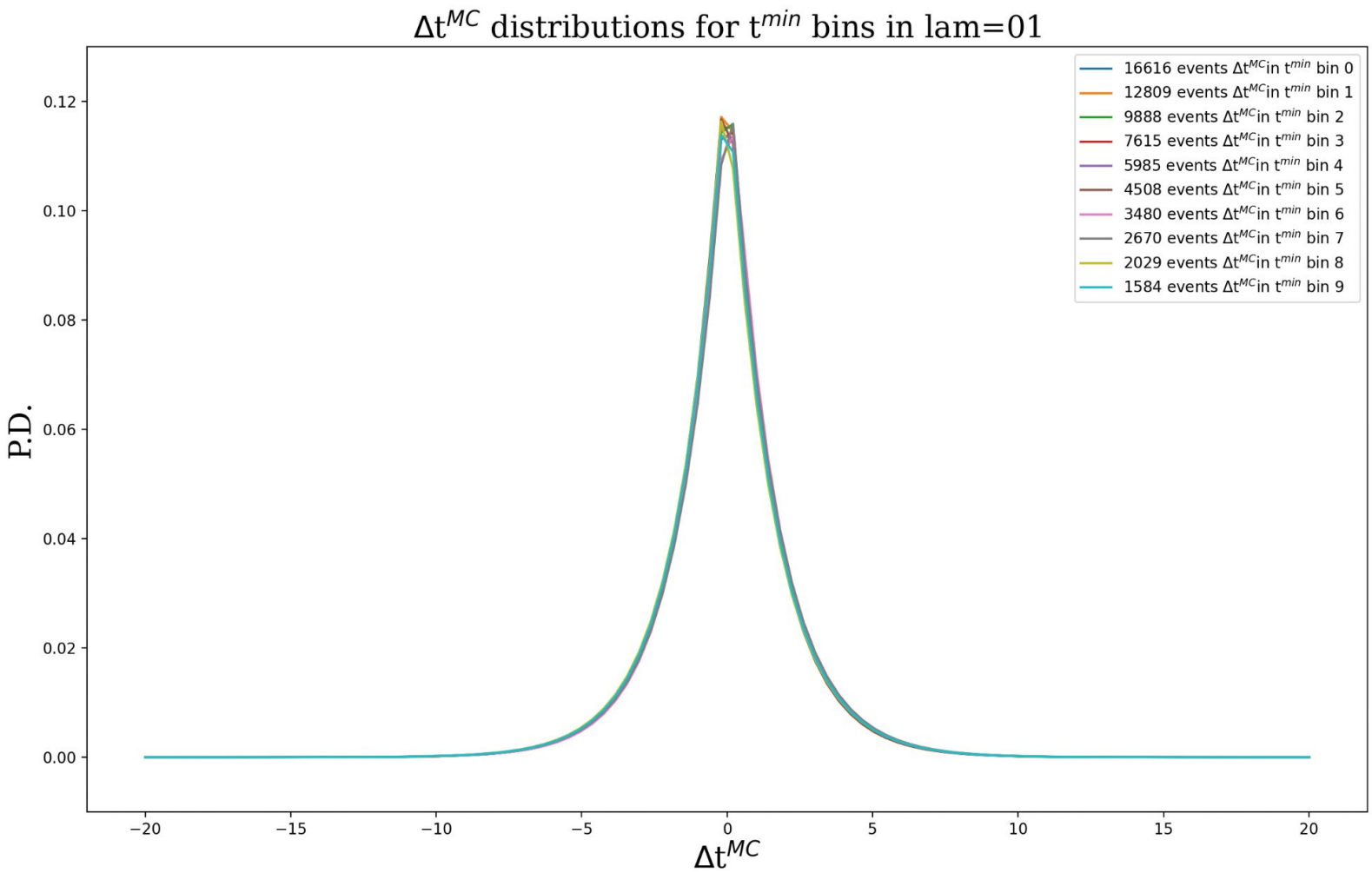
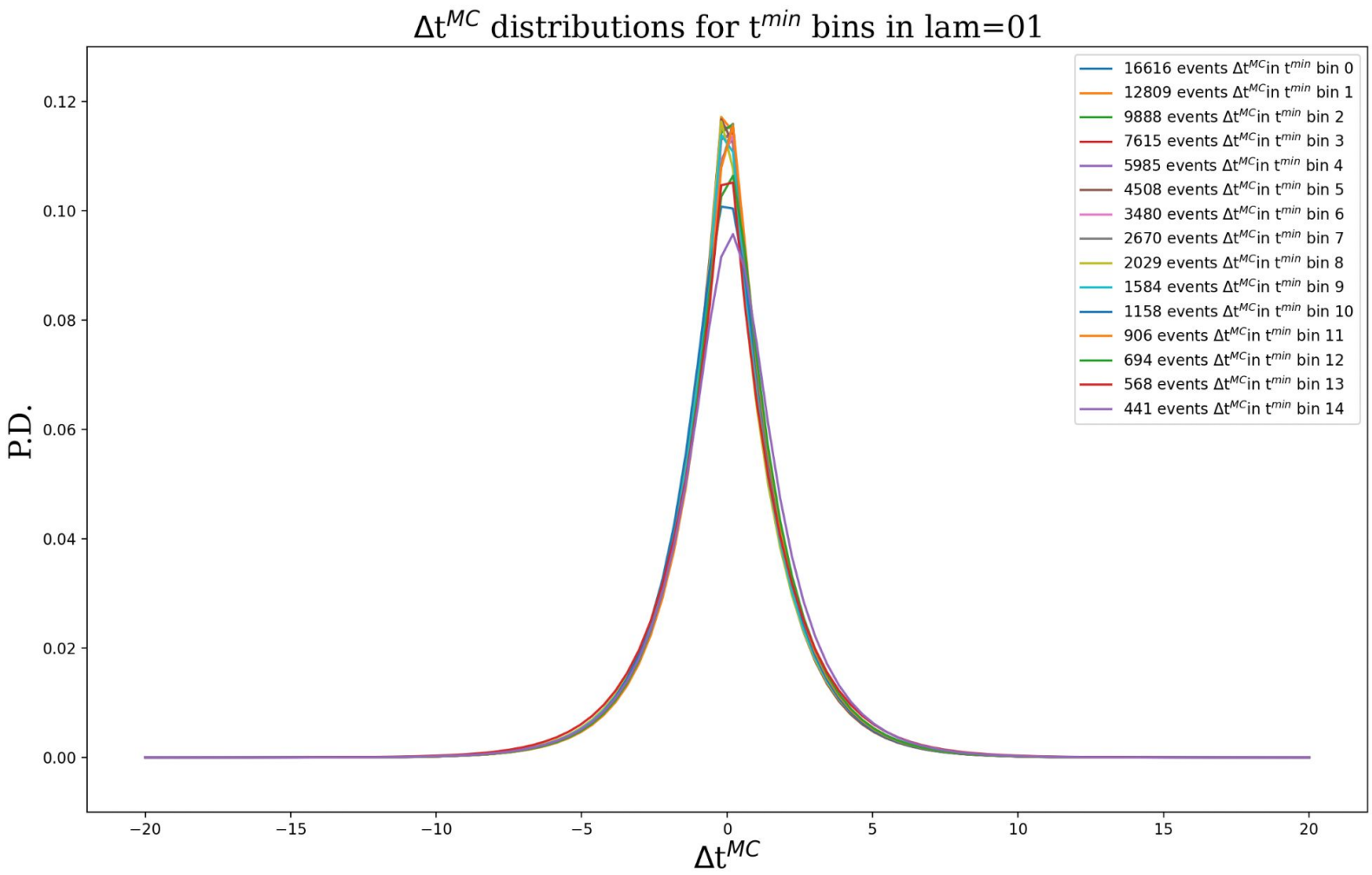
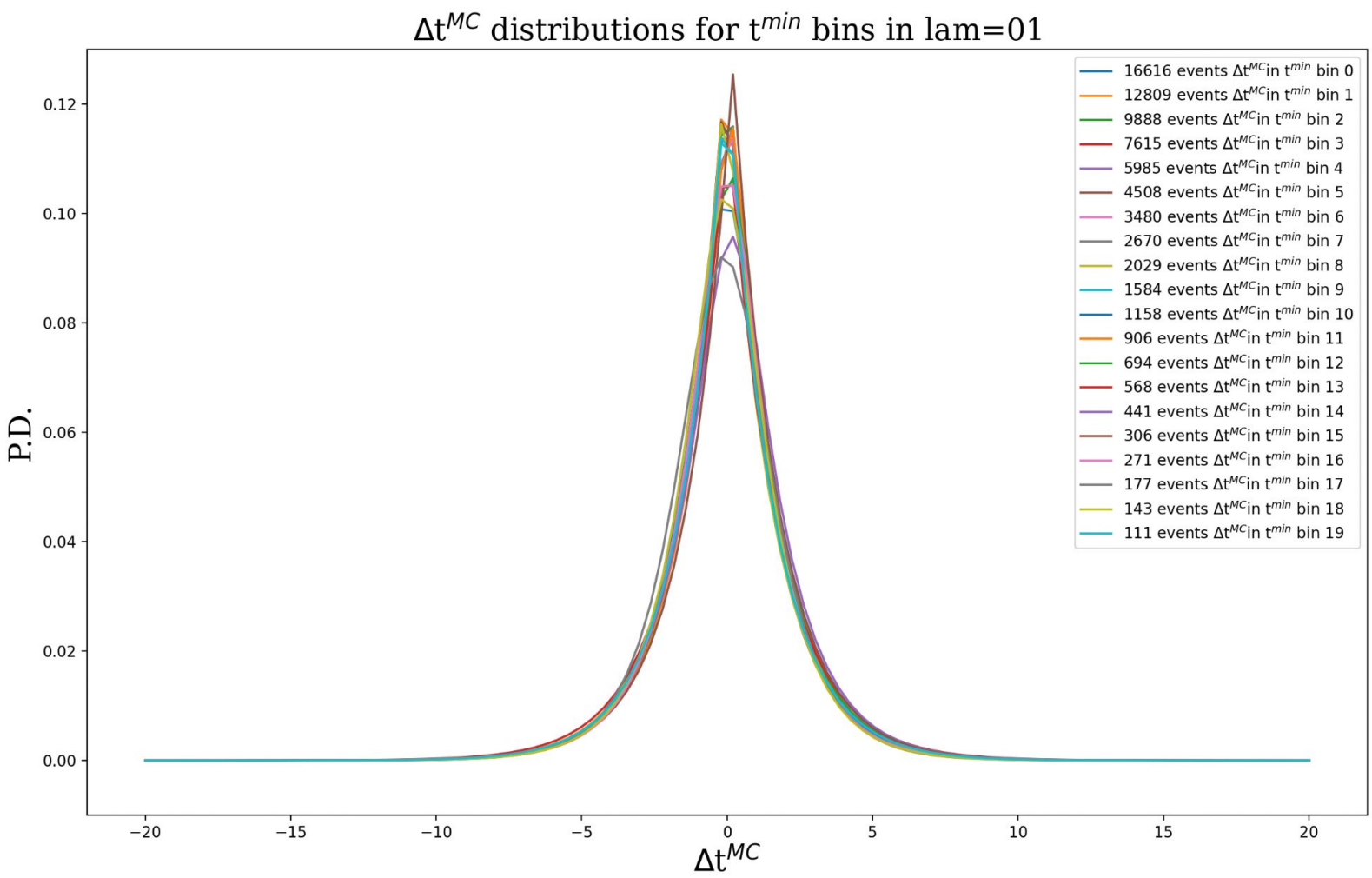
4463 events Δt^{MC} in t^{min} bin 5
3419 events Δt^{MC} in t^{min} bin 6
2652 events Δt^{MC} in t^{min} bin 7
2058 events Δt^{MC} in t^{min} bin 8
1618 events Δt^{MC} in t^{min} bin 9
1224 events Δt^{MC} in t^{min} bin 10
950 events Δt^{MC} in t^{min} bin 11
683 events Δt^{MC} in t^{min} bin 12
531 events Δt^{MC} in t^{min} bin 13
429 events Δt^{MC} in t^{min} bin 14
368 events Δt^{MC} in t^{min} bin 15
230 events Δt^{MC} in t^{min} bin 16
174 events Δt^{MC} in t^{min} bin 17
153 events Δt^{MC} in t^{min} bin 18
108 events Δt^{MC} in t^{min} bin 19
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20


Δt^{MC} distributions for t^{min} bins in lam=01
16616 events Δt^{MC} in t^{min} bin 0
12809 events Δt^{MC} in t^{min} bin 1
9888 events Δt^{MC} in t^{min} bin 2
7615 events Δt^{MC} in t^{min} bin 3
5985 events Δt^{MC} in t^{min} bin 4
4508 events Δt^{MC} in t^{min} bin 5
3480 events Δt^{MC} in t^{min} bin 6
2670 events Δt^{MC} in t^{min} bin 7
2029 events Δt^{MC} in t^{min} bin 8
1584 events Δt^{MC} in t^{min} bin 9
P.D.
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20
Δt^{MC}


Δt^{MC} distributions for t^{min} bins in lam=01
P.D.
Δt^{MC}
16616 events Δt^{MC} in t^{min} bin 0
12809 events Δt^{MC} in t^{min} bin 1
9888 events Δt^{MC} in t^{min} bin 2
7615 events Δt^{MC} in t^{min} bin 3
5985 events Δt^{MC} in t^{min} bin 4
4508 events Δt^{MC} in t^{min} bin 5
3480 events Δt^{MC} in t^{min} bin 6
2670 events Δt^{MC} in t^{min} bin 7
2029 events Δt^{MC} in t^{min} bin 8
1584 events Δt^{MC} in t^{min} bin 9
1158 events Δt^{MC} in t^{min} bin 10
906 events Δt^{MC} in t^{min} bin 11
694 events Δt^{MC} in t^{min} bin 12
568 events Δt^{MC} in t^{min} bin 13
441 events Δt^{MC} in t^{min} bin 14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20


Δt^{MC} distributions for t^{min} bins in lam=01
P.D.
Δt^{MC}
16616 events Δt^{MC} in t^{min} bin 0
12809 events Δt^{MC} in t^{min} bin 1
9888 events Δt^{MC} in t^{min} bin 2
7615 events Δt^{MC} in t^{min} bin 3
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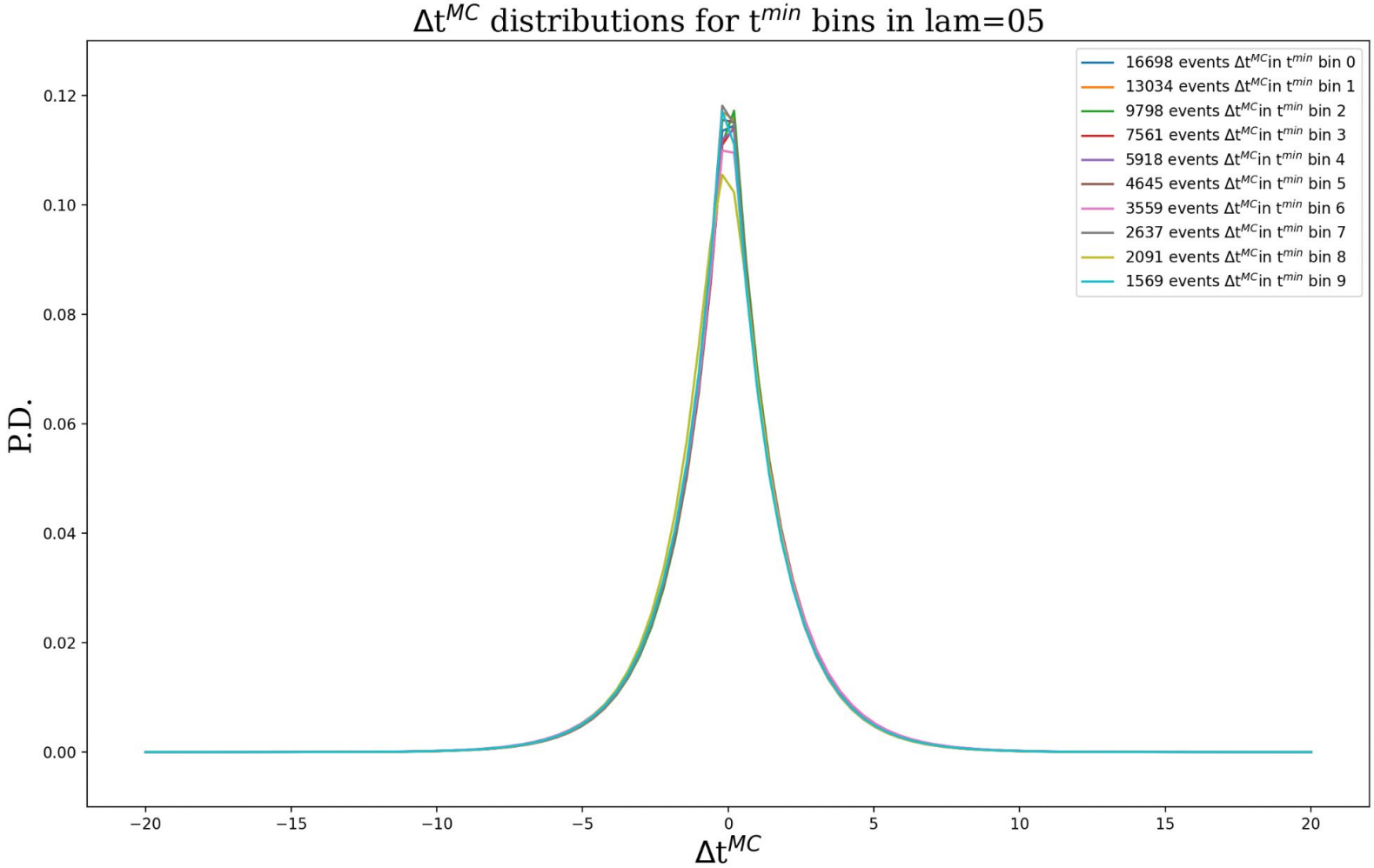
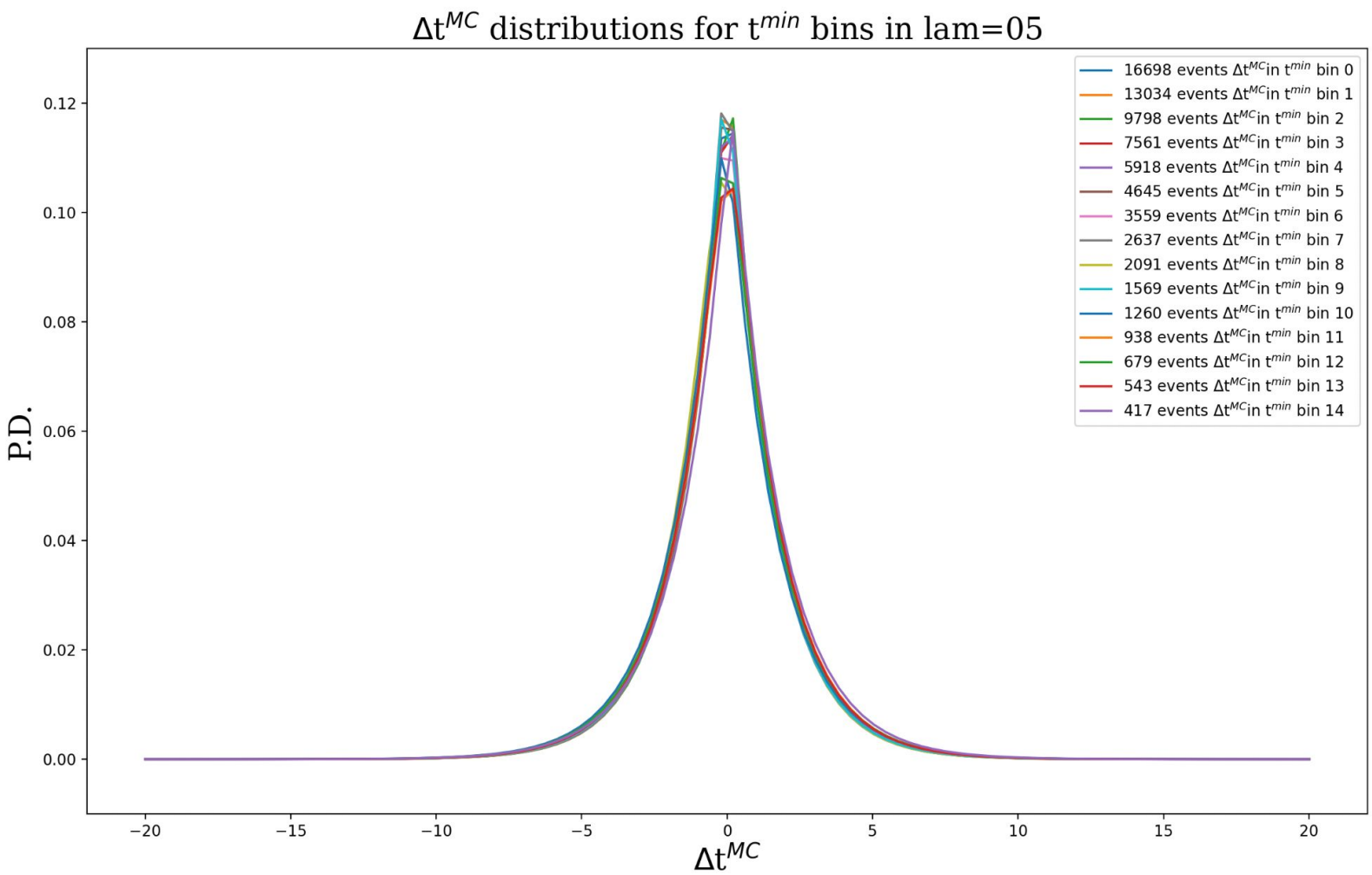
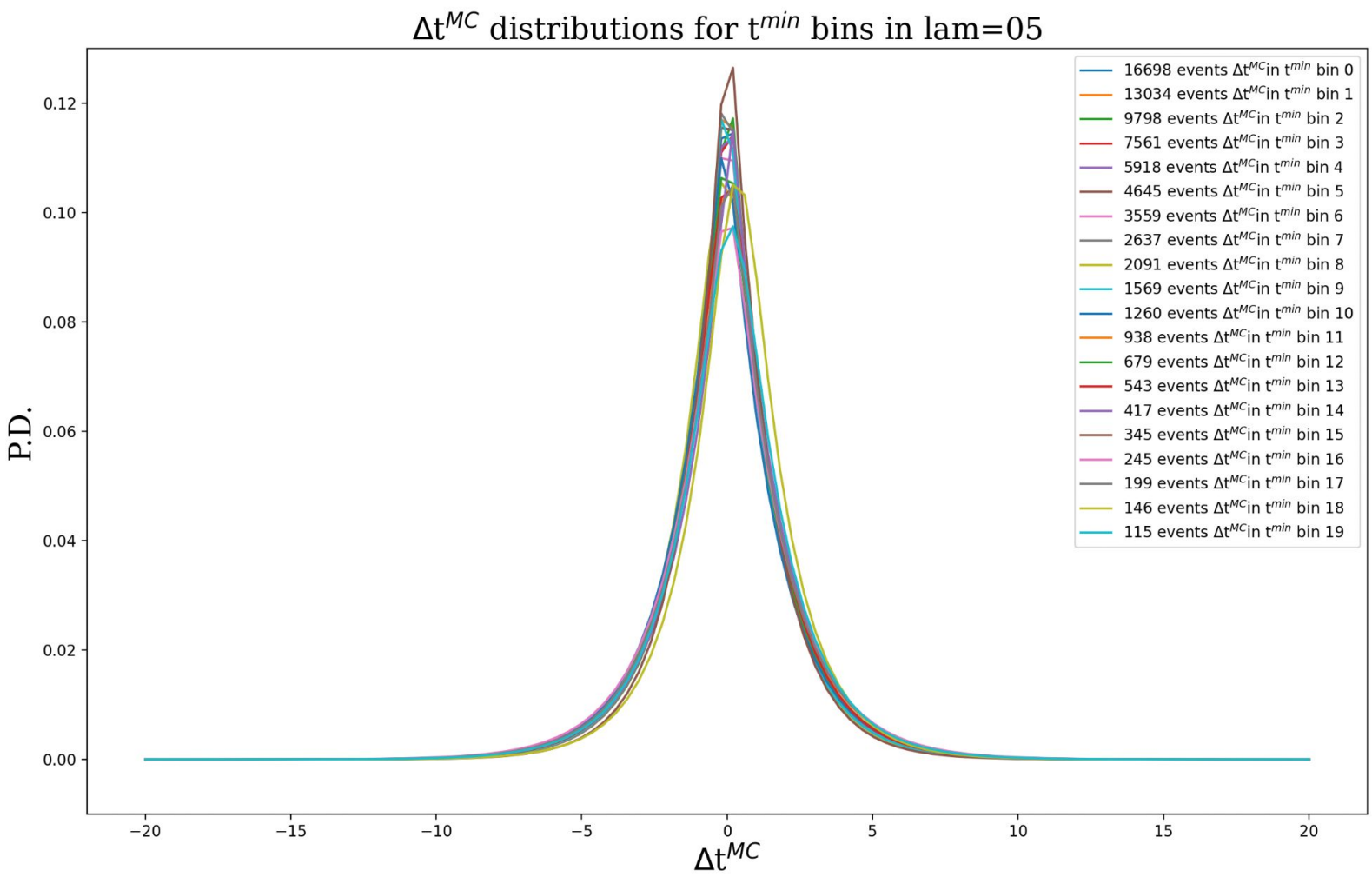
4508 events Δt^{MC} in t^{min} bin 5
3480 events Δt^{MC} in t^{min} bin 6
2670 events Δt^{MC} in t^{min} bin 7
2029 events Δt^{MC} in t^{min} bin 8
1584 events Δt^{MC} in t^{min} bin 9
1158 events Δt^{MC} in t^{min} bin 10
906 events Δt^{MC} in t^{min} bin 11
694 events Δt^{MC} in t^{min} bin 12
568 events Δt^{MC} in t^{min} bin 13
441 events Δt^{MC} in t^{min} bin 14
306 events Δt^{MC} in t^{min} bin 15
271 events Δt^{MC} in t^{min} bin 16
177 events Δt^{MC} in t^{min} bin 17
143 events Δt^{MC} in t^{min} bin 18
111 events Δt^{MC} in t^{min} bin 19
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20


Δt^{MC} distributions for t^{min} bins in lam=05
16698 events Δt^{MC} in t^{min} bin 0
13034 events Δt^{MC} in t^{min} bin 1
9798 events Δt^{MC} in t^{min} bin 2
7561 events Δt^{MC} in t^{min} bin 3
5918 events Δt^{MC} in t^{min} bin 4
4645 events Δt^{MC} in t^{min} bin 5
3559 events Δt^{MC} in t^{min} bin 6
2637 events Δt^{MC} in t^{min} bin 7
2091 events Δt^{MC} in t^{min} bin 8
1569 events Δt^{MC} in t^{min} bin 9
P.D.
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20
Δt^{MC}


Δt^{MC} distributions for t^{min} bins in lam=05
P.D.
Δt^{MC}
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20
16698 events Δt^{MC} in t^{min} bin 0
13034 events Δt^{MC} in t^{min} bin 1
9798 events Δt^{MC} in t^{min} bin 2
7561 events Δt^{MC} in t^{min} bin 3
5918 events Δt^{MC} in t^{min} bin 4
4645 events Δt^{MC} in t^{min} bin 5
3559 events Δt^{MC} in t^{min} bin 6
2637 events Δt^{MC} in t^{min} bin 7
2091 events Δt^{MC} in t^{min} bin 8
1569 events Δt^{MC} in t^{min} bin 9
1260 events Δt^{MC} in t^{min} bin 10
938 events Δt^{MC} in t^{min} bin 11
679 events Δt^{MC} in t^{min} bin 12
543 events Δt^{MC} in t^{min} bin 13
417 events Δt^{MC} in t^{min} bin 14


Δt^{MC} distributions for t^{min} bins in lam=05
P.D.
Δt^{MC}
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−20
−15
−10
−5
0
5
10
15
20
16698 events Δt^{MC} in t^{min} bin 0
13034 events Δt^{MC} in t^{min} bin 1
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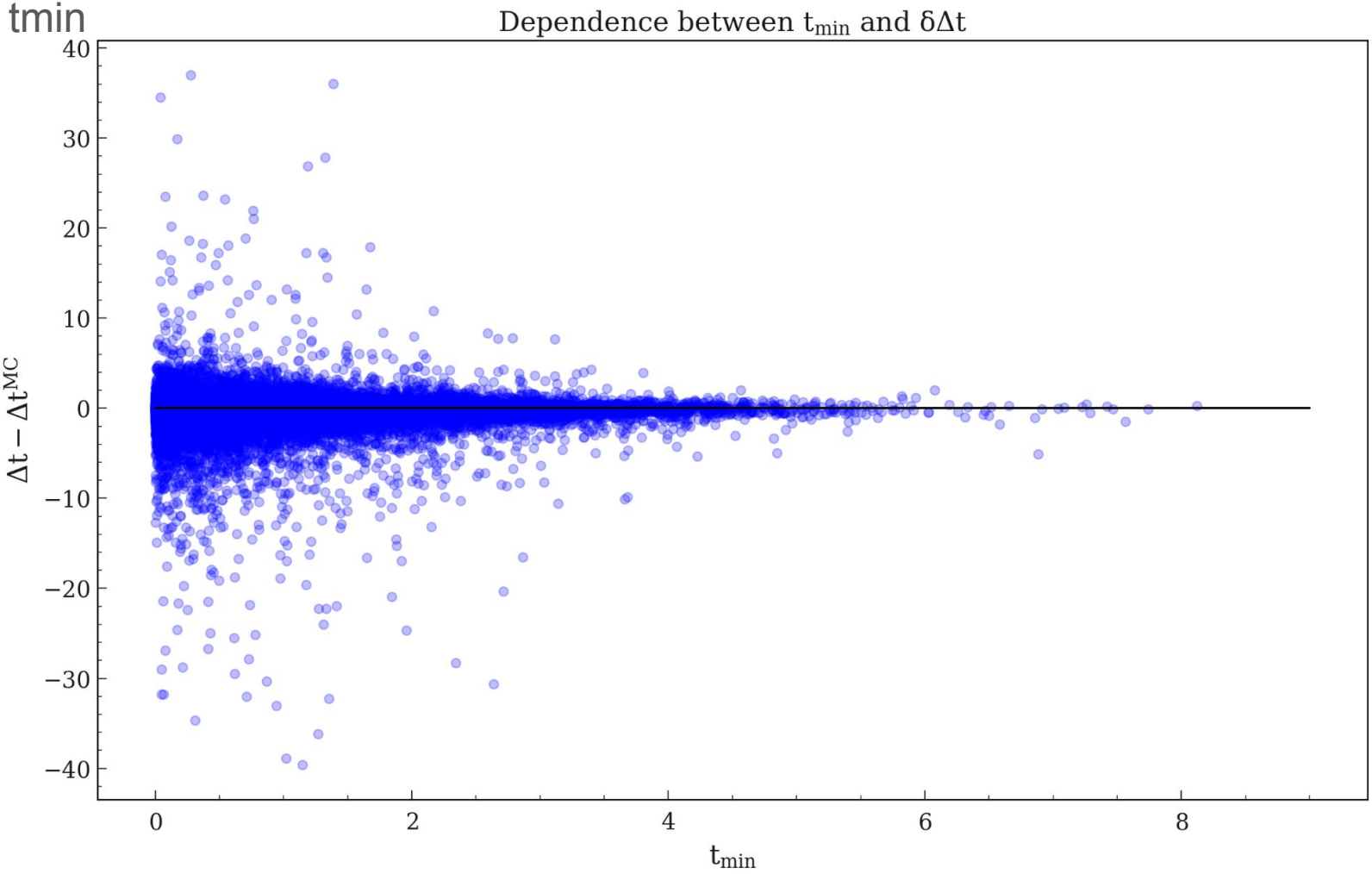
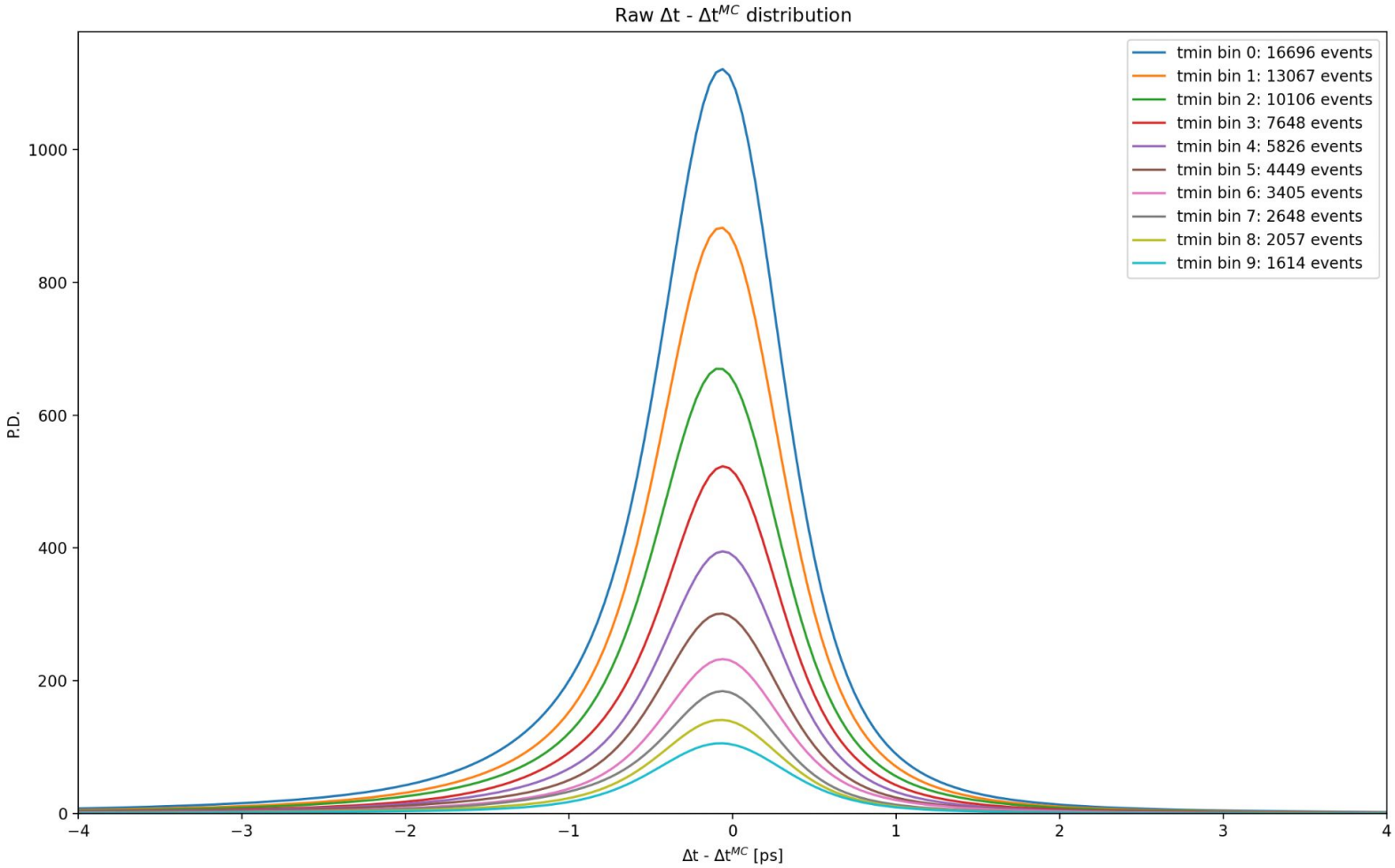
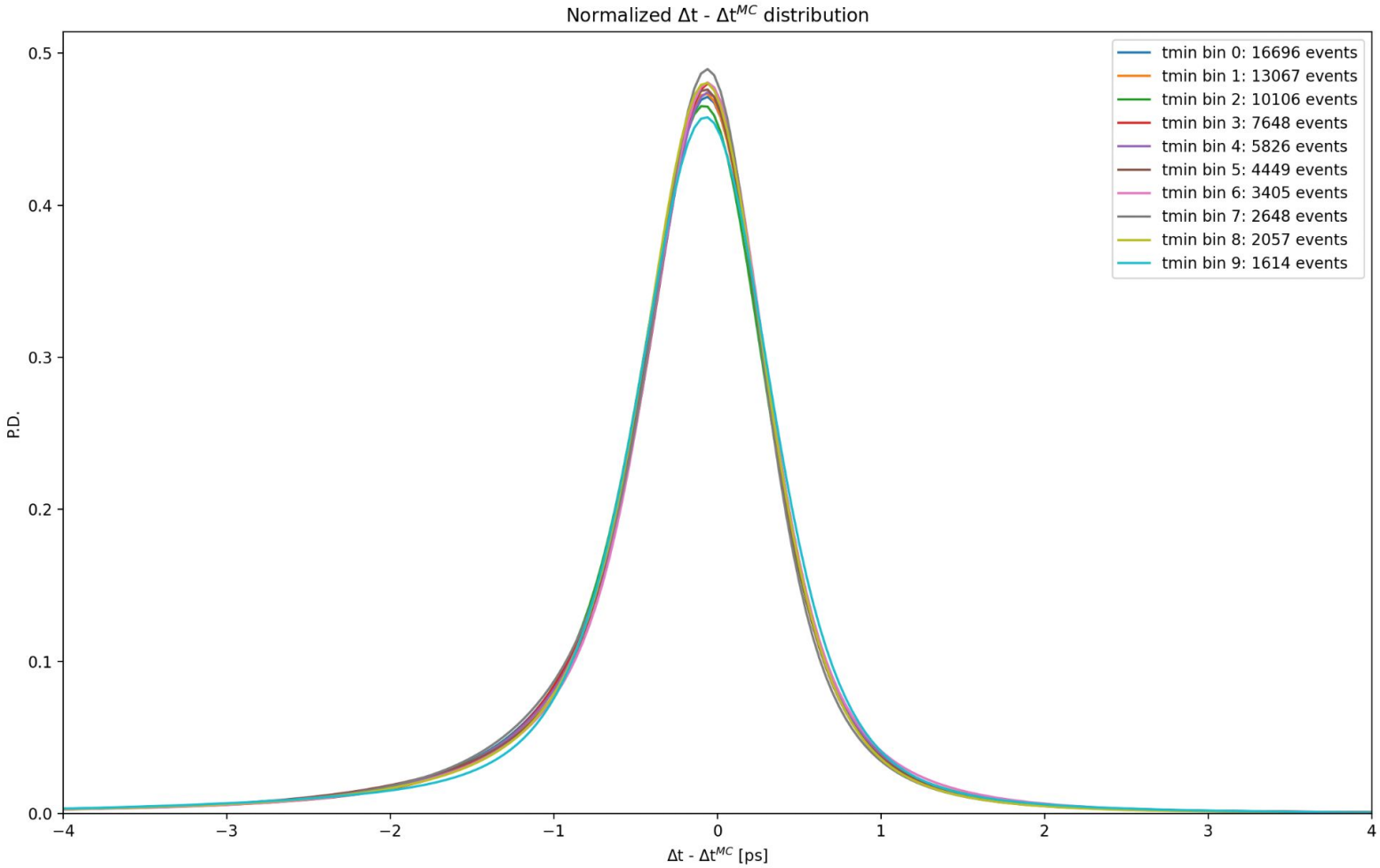
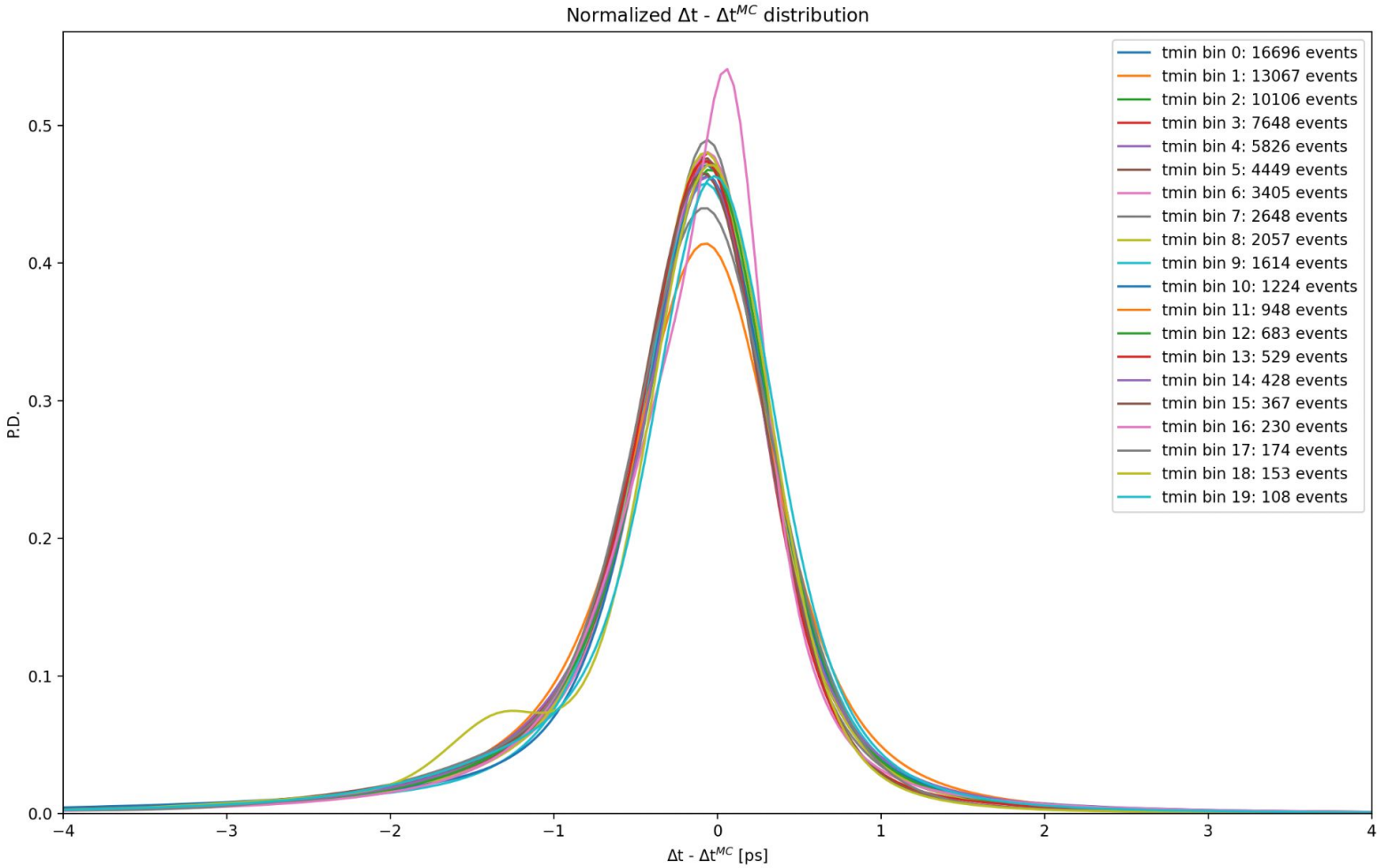
2091 events Δt^{MC} in t^{min} bin 8
1569 events Δt^{MC} in t^{min} bin 9
1260 events Δt^{MC} in t^{min} bin 10
938 events Δt^{MC} in t^{min} bin 11
679 events Δt^{MC} in t^{min} bin 12
543 events Δt^{MC} in t^{min} bin 13
417 events Δt^{MC} in t^{min} bin 14
345 events Δt^{MC} in t^{min} bin 15
245 events Δt^{MC} in t^{min} bin 16
199 events Δt^{MC} in t^{min} bin 17
146 events Δt^{MC} in t^{min} bin 18
115 events Δt^{MC} in t^{min} bin 19

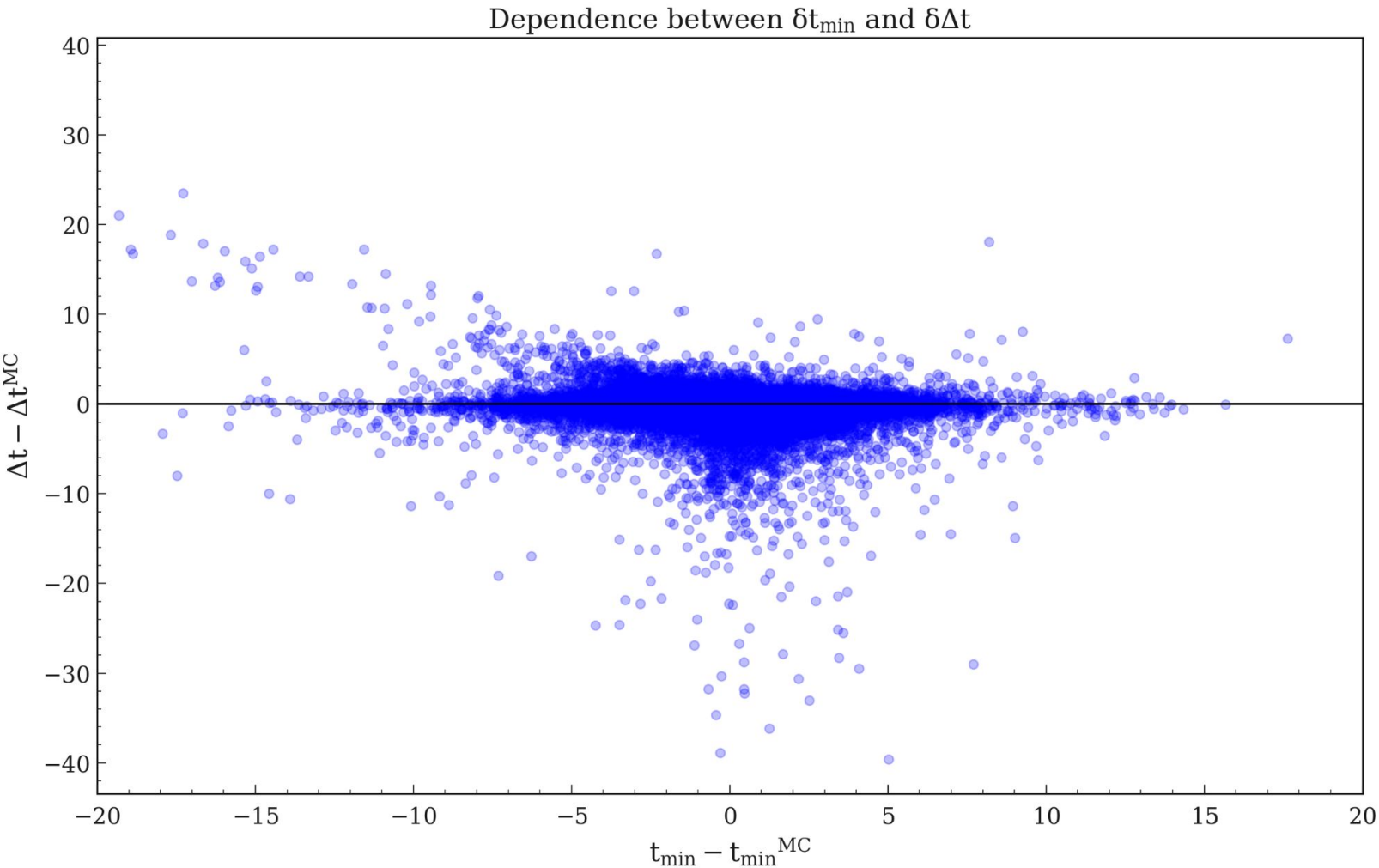
truth tmin


Dependence between t_{min} and $\delta\Delta t$
$\Delta t - \Delta t^{MC}$
t_{min}
40
30
20
10
0
−10
−20
−30
−40
0
2
4
6
8

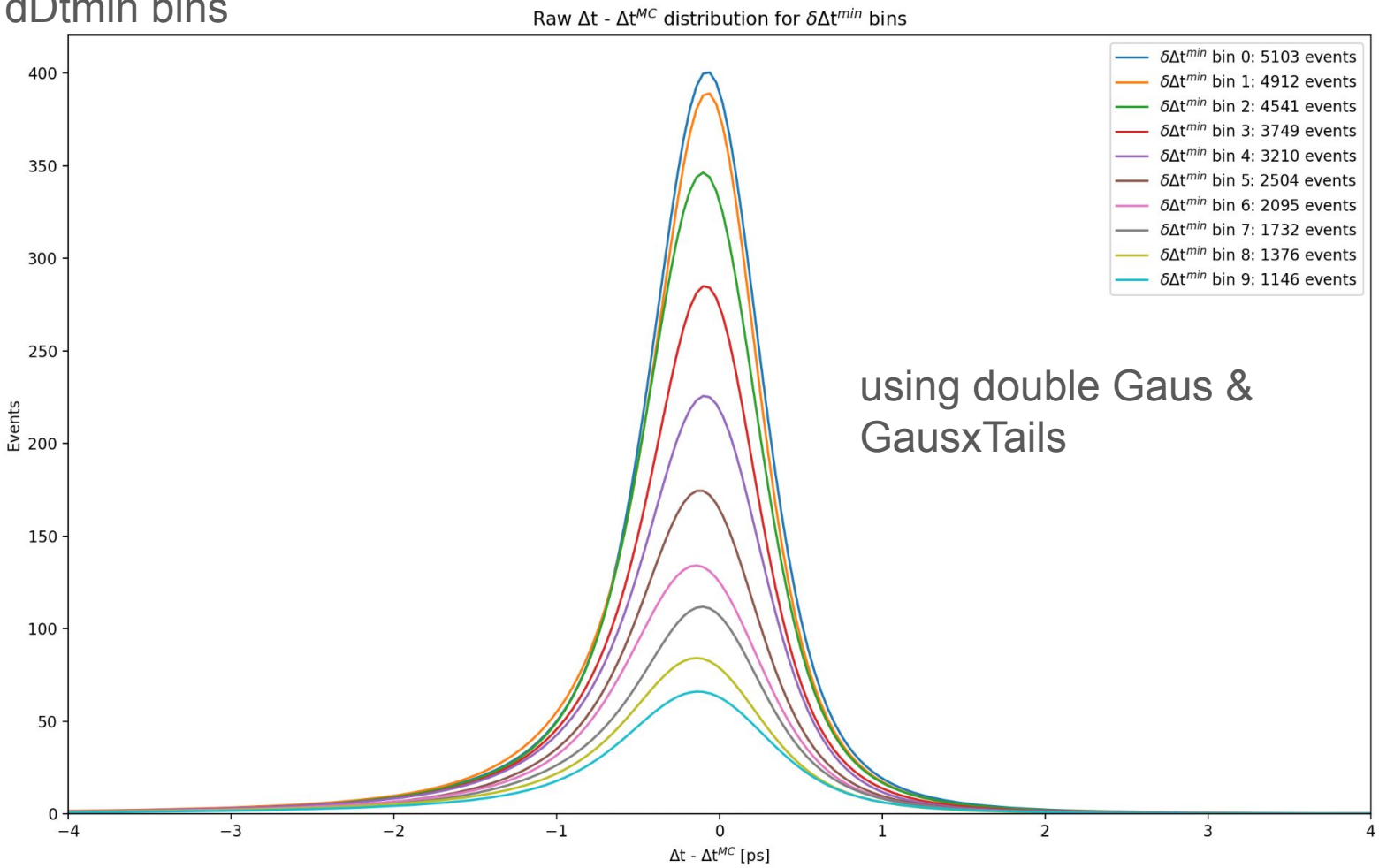

Raw Δt - Δt^{MC} distribution
tmin bin 0: 16696 events
tmin bin 1: 13067 events
tmin bin 2: 10106 events
tmin bin 3: 7648 events
tmin bin 4: 5826 events
tmin bin 5: 4449 events
tmin bin 6: 3405 events
tmin bin 7: 2648 events
tmin bin 8: 2057 events
tmin bin 9: 1614 events
P.D.
0
200
400
600
800
1000
−4
−3
−2
−1
0
1
2
3
4
Δt - Δt^{MC} [ps]


Normalized Δt - Δt^{MC} distribution
P.D.
Δt - Δt^{MC} [ps]
tmin bin 0: 16696 events
tmin bin 1: 13067 events
tmin bin 2: 10106 events
tmin bin 3: 7648 events
tmin bin 4: 5826 events
tmin bin 5: 4449 events
tmin bin 6: 3405 events
tmin bin 7: 2648 events
tmin bin 8: 2057 events
tmin bin 9: 1614 events
0.0
0.1
0.2
0.3
0.4
0.5
−4
−3
−2
−1
0
1
2
3
4

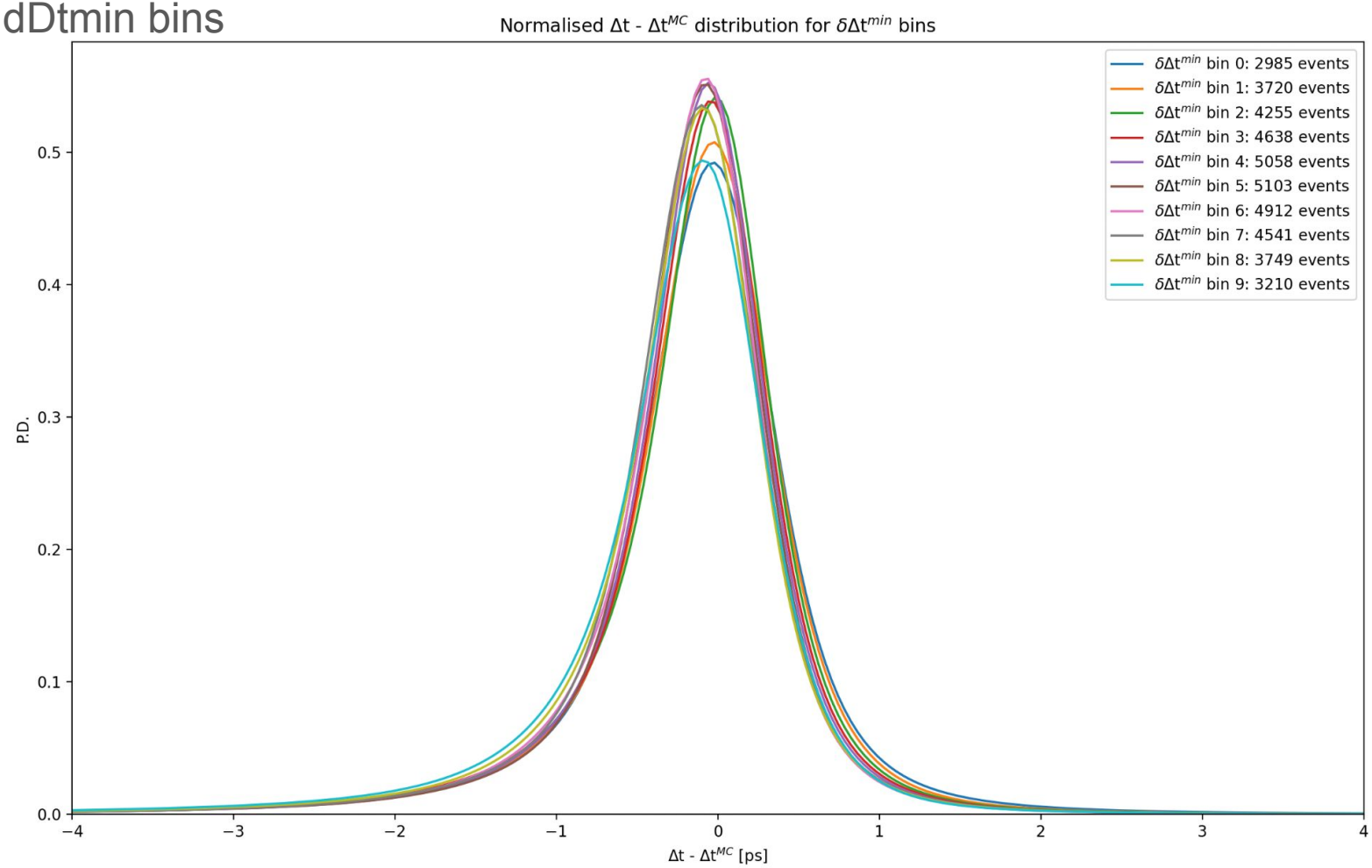

Normalized Δt - Δt^{MC} distribution
P.D.
Δt - Δt^{MC} [ps]
0.0
0.1
0.2
0.3
0.4
0.5
−4
−3
−2
−1
0
1
2
3
4
tmin bin 0: 16696 events
tmin bin 1: 13067 events
tmin bin 2: 10106 events
tmin bin 3: 7648 events
tmin bin 4: 5826 events
tmin bin 5: 4449 events
tmin bin 6: 3405 events
tmin bin 7: 2648 events
tmin bin 8: 2057 events
tmin bin 9: 1614 events
tmin bin 10: 1224 events
tmin bin 11: 948 events
tmin bin 12: 683 events
tmin bin 13: 529 events
tmin bin 14: 428 events
tmin bin 15: 367 events
tmin bin 16: 230 events
tmin bin 17: 174 events
tmin bin 18: 153 events
tmin bin 19: 108 events


Dependence between δt_min and δΔt
Δt − Δt^MC
t_min − t_min^MC
40
30
20
10
0
−10
−20
−30
−40
−20
−15
−10
−5
0
5
10
15
20

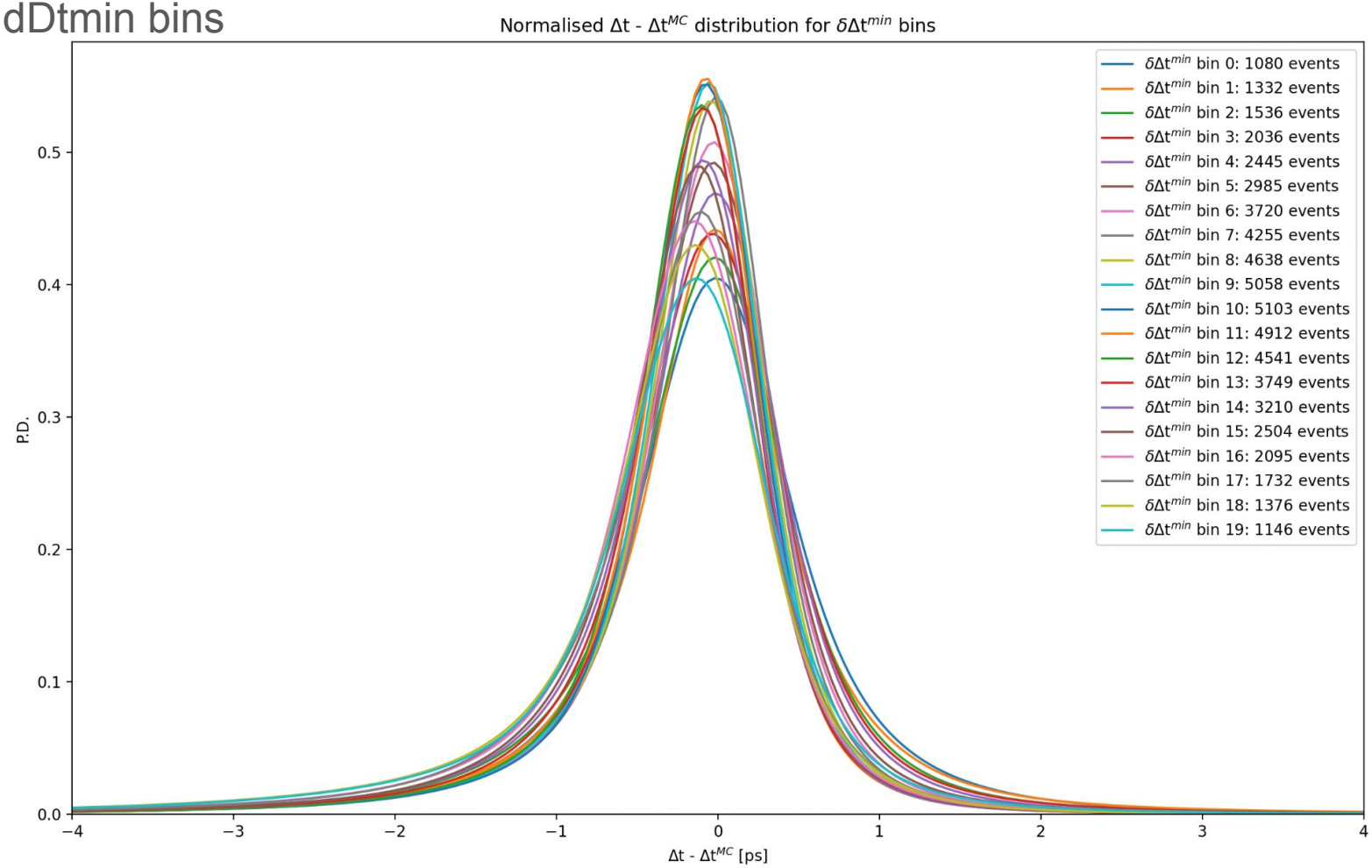
0-2 ps dDtmin bins

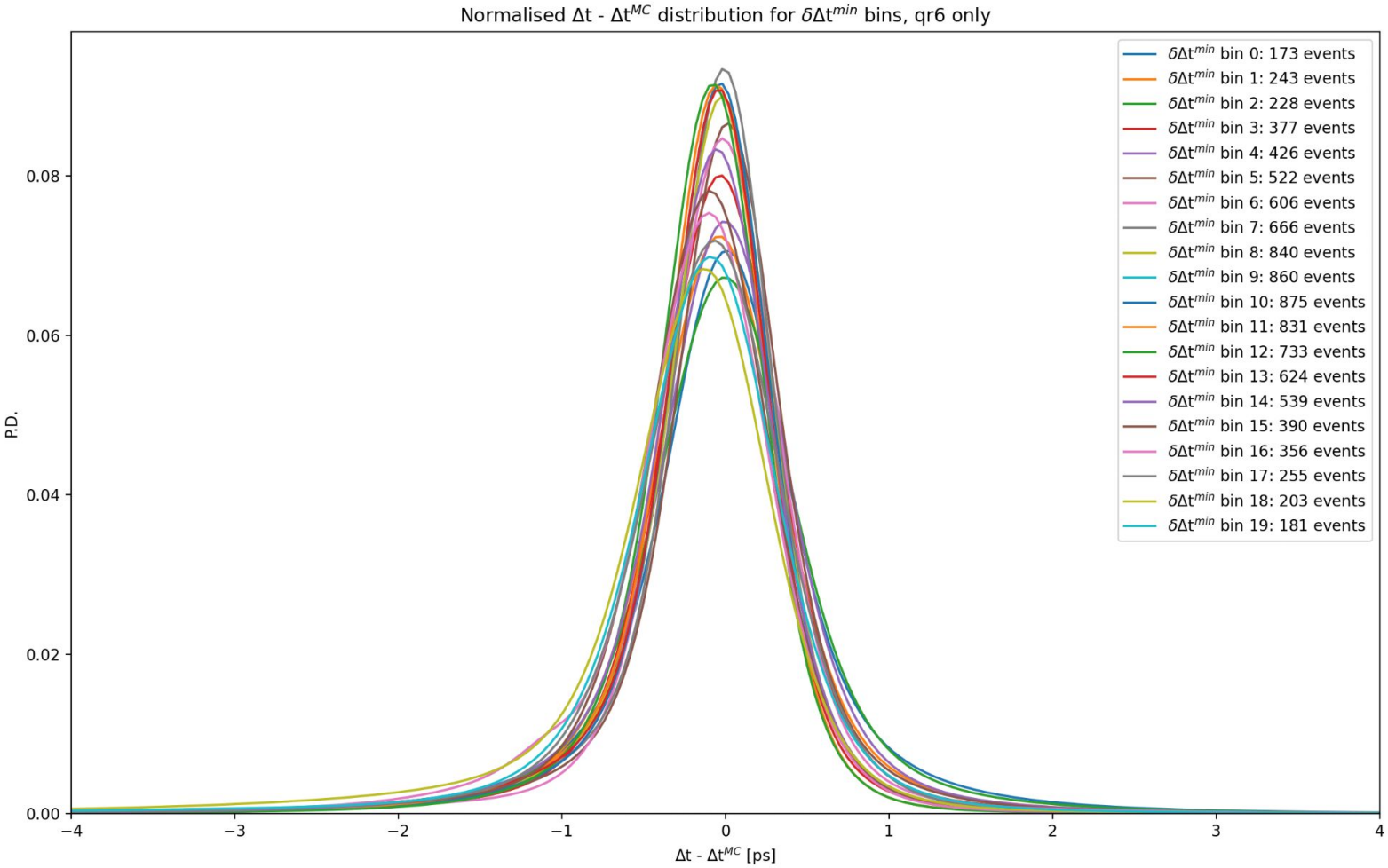


(-1, 1) dDtmin bins

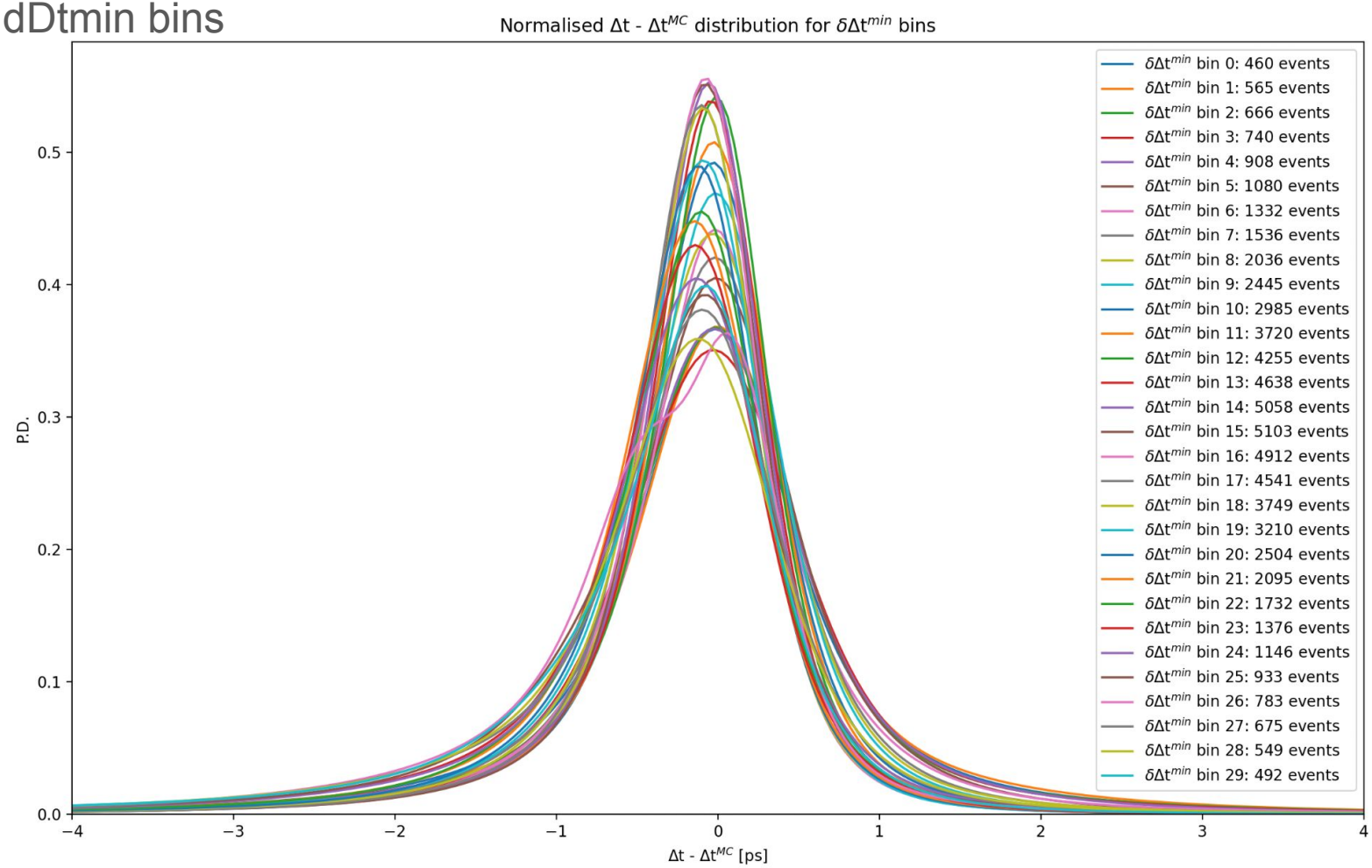


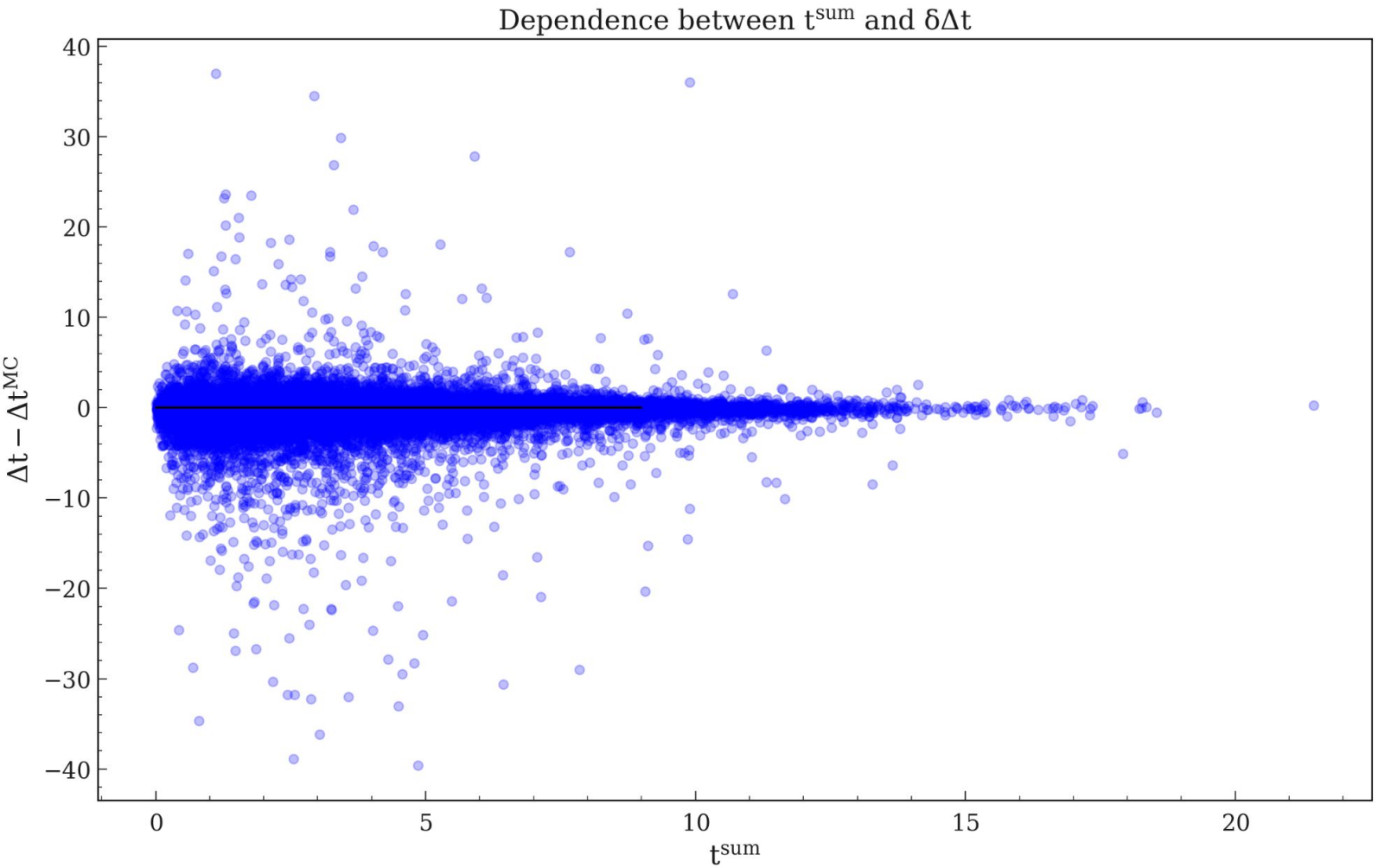
(-2, 2) dDtmin bins

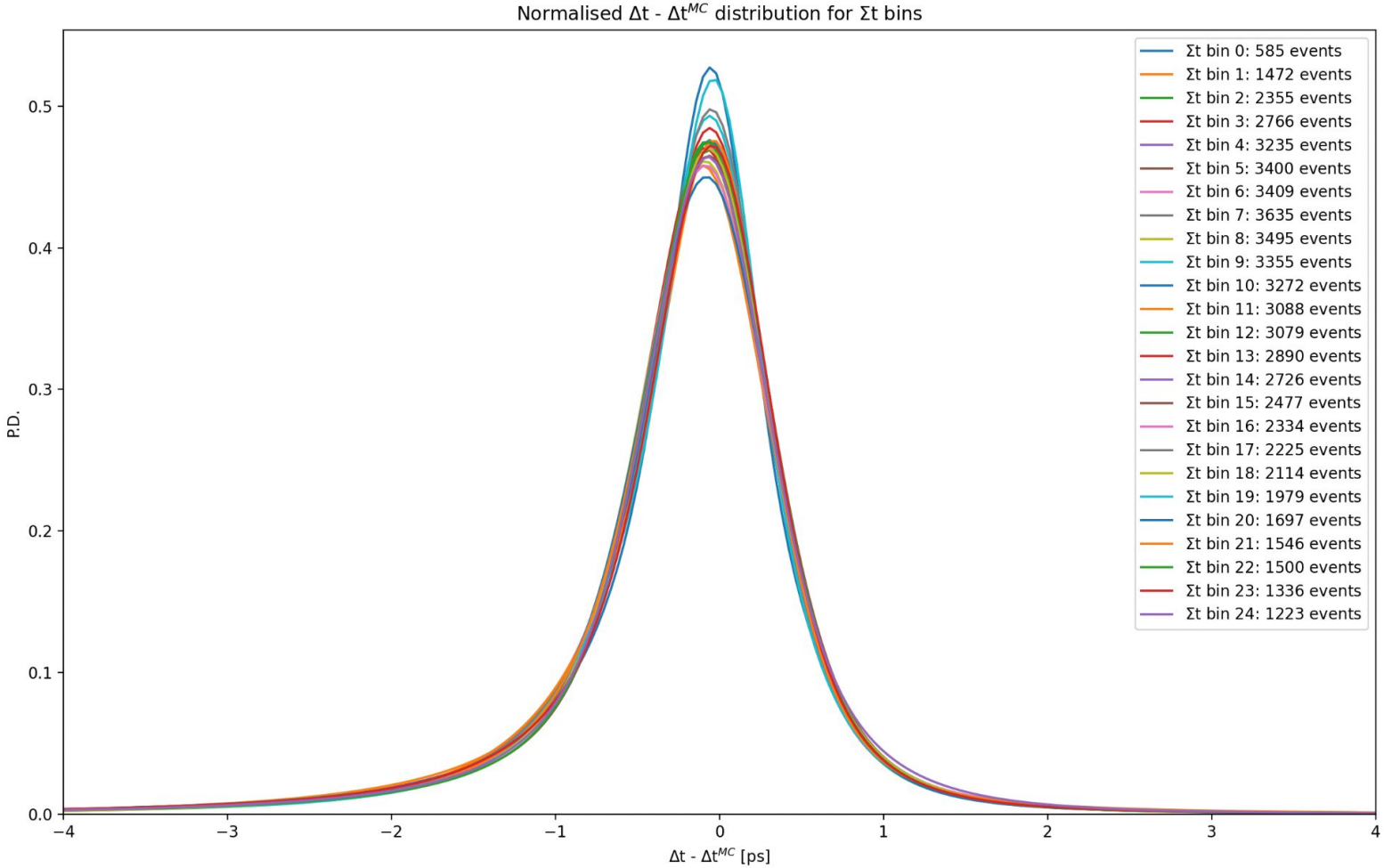


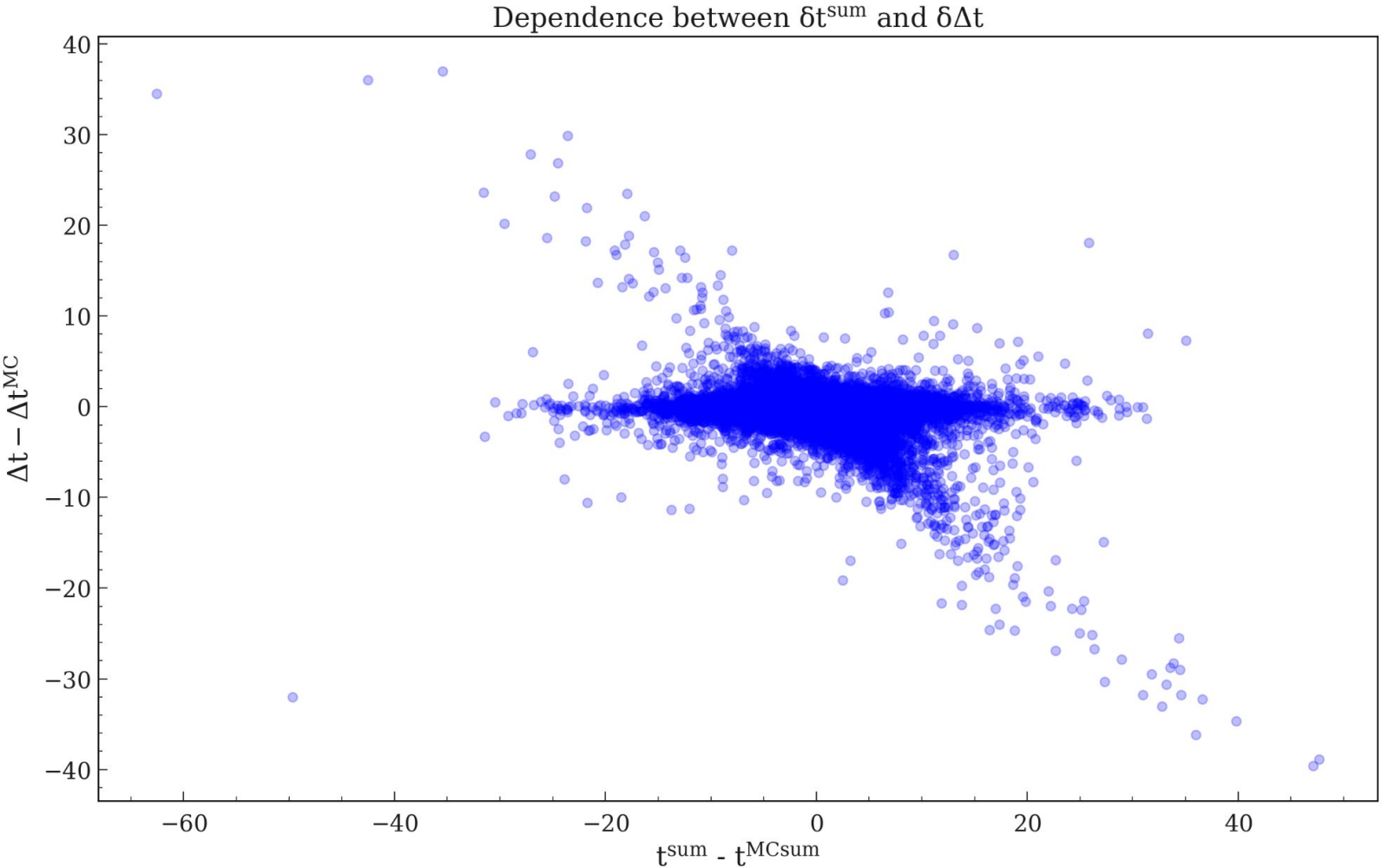

Normalised Δt - Δt^MC distribution for δΔt^min bins, qr6 only
P.D.
Δt - Δt^MC [ps]
0.00
0.02
0.04
0.06
0.08
−4
−3
−2
−1
0
1
2
3
4
δΔt^min bin 0: 173 events
δΔt^min bin 1: 243 events
δΔt^min bin 2: 228 events
δΔt^min bin 3: 377 events
δΔt^min bin 4: 426 events
δΔt^min bin 5: 522 events
δΔt^min bin 6: 606 events
δΔt^min bin 7: 666 events
δΔt^min bin 8: 840 events
δΔt^min bin 9: 860 events
δΔt^min bin 10: 875 events
δΔt^min bin 11: 831 events
δΔt^min bin 12: 733 events
δΔt^min bin 13: 624 events
δΔt^min bin 14: 539 events
δΔt^min bin 15: 390 events
δΔt^min bin 16: 356 events
δΔt^min bin 17: 255 events
δΔt^min bin 18: 203 events
δΔt^min bin 19: 181 events

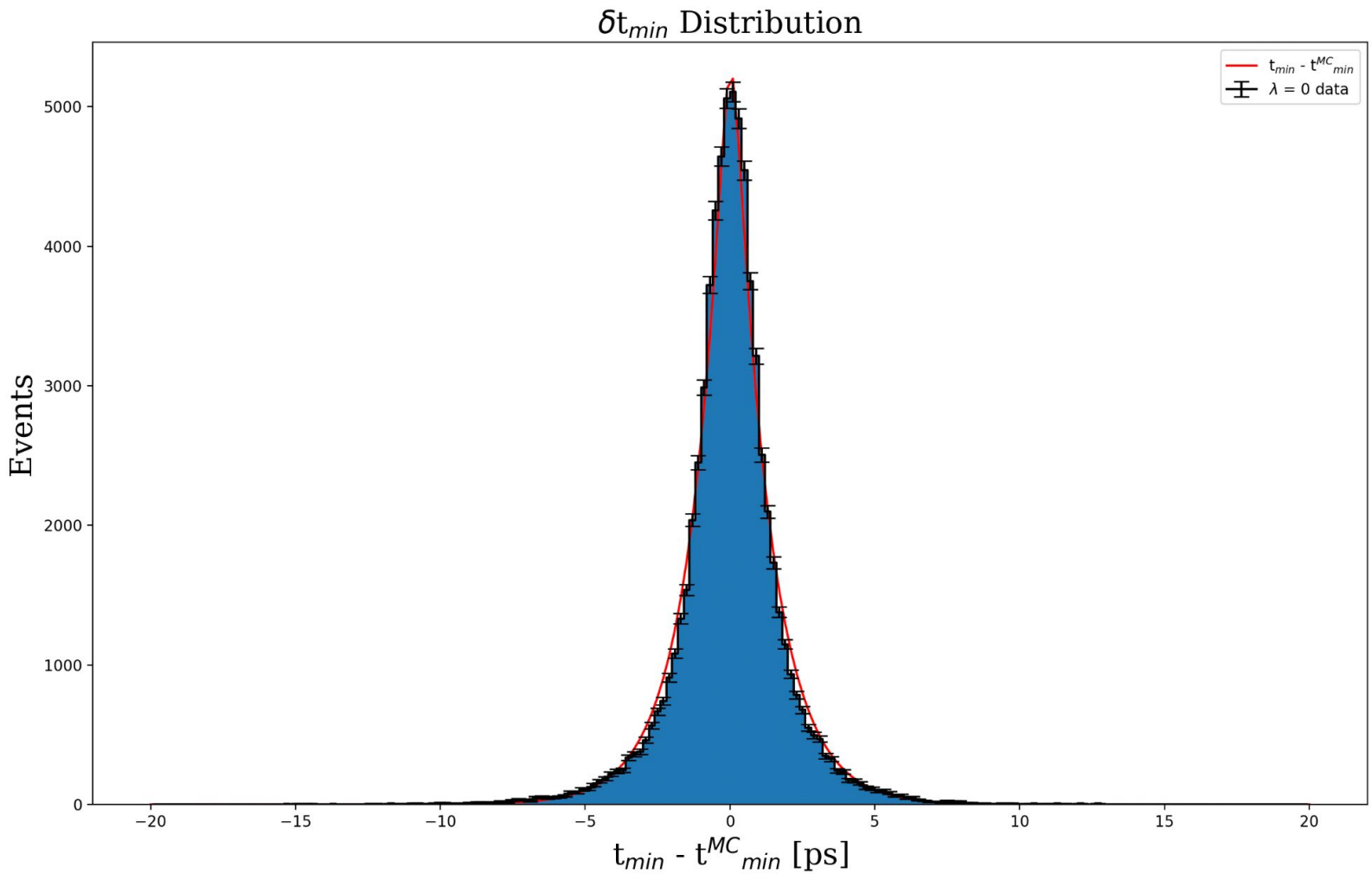
(-3, 3) dDtmin bins

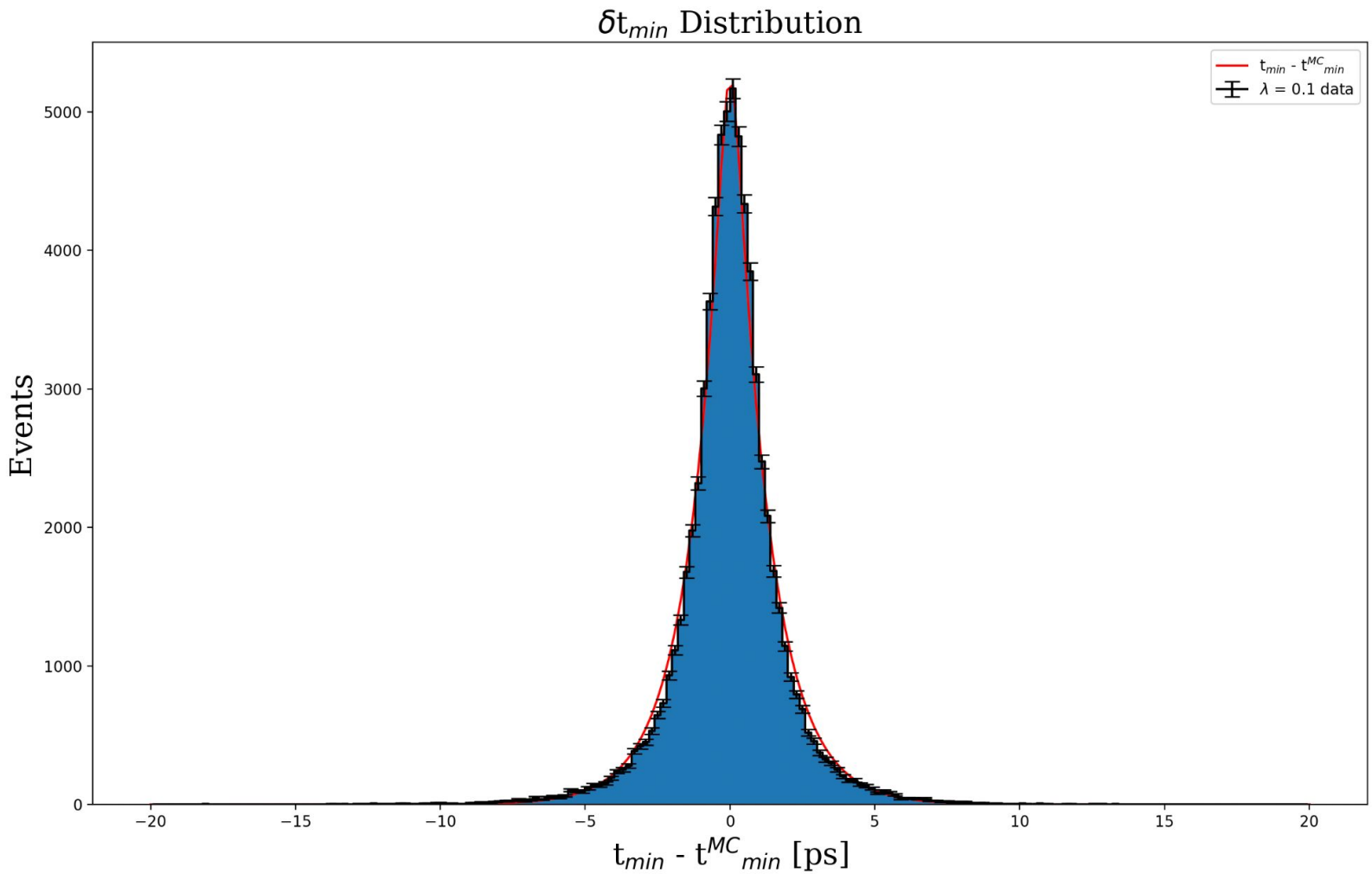


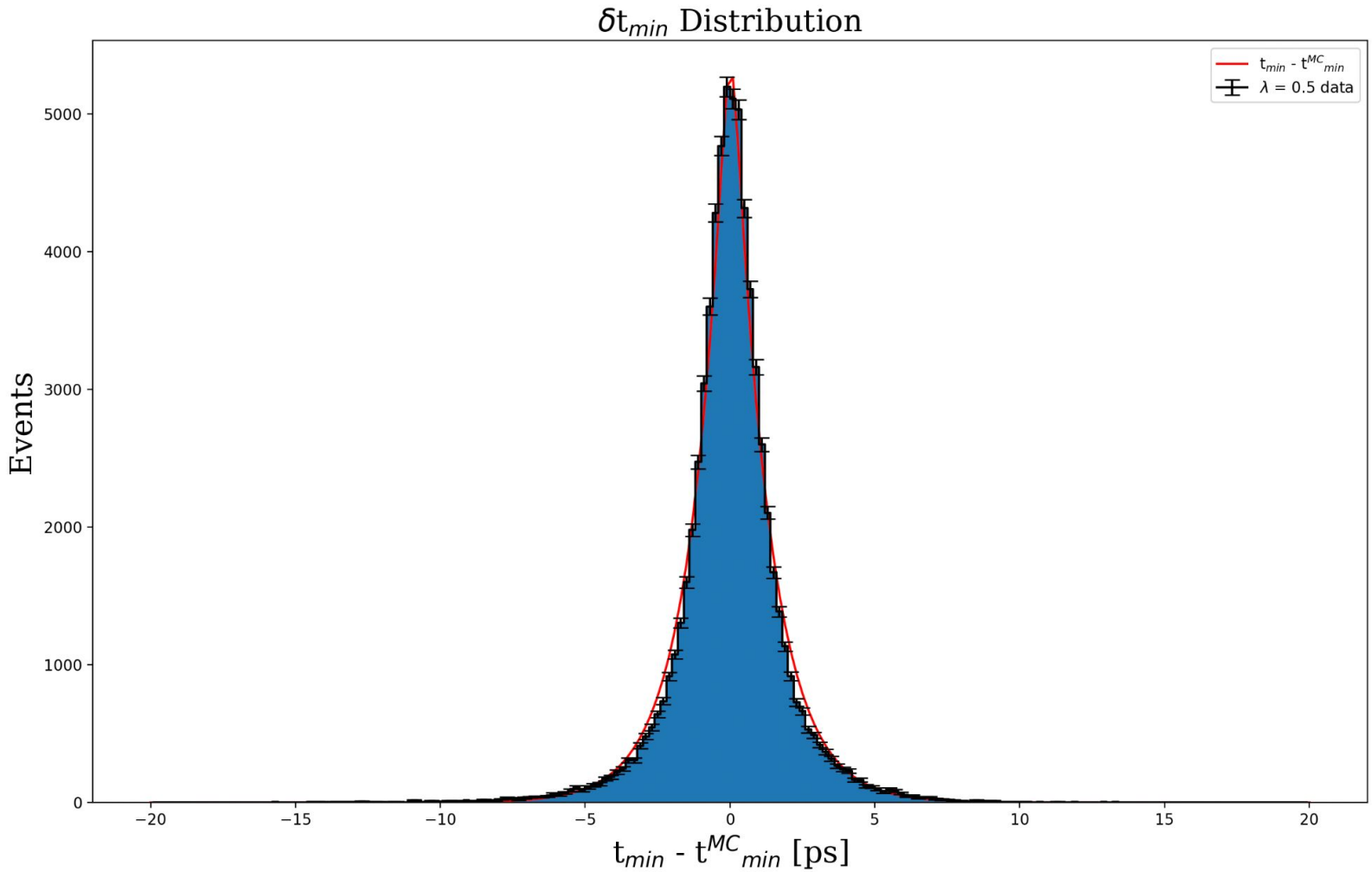

Dependence between t^{sum} and $\delta\Delta t$
$\Delta t - \Delta t^{MC}$
t^{sum}
40
30
20
10
0
−10
−20
−30
−40
0
5
10
15
20


Normalised Δt - Δt^{MC} distribution for Σt bins
P.D.
Δt - Δt^{MC} [ps]
0.0
0.1
0.2
0.3
0.4
0.5
−4
−3
−2
−1
0
1
2
3
4
Σt bin 0: 585 events
Σt bin 1: 1472 events
Σt bin 2: 2355 events
Σt bin 3: 2766 events
Σt bin 4: 3235 events
Σt bin 5: 3400 events
Σt bin 6: 3409 events
Σt bin 7: 3635 events
Σt bin 8: 3495 events
Σt bin 9: 3355 events
Σt bin 10: 3272 events
Σt bin 11: 3088 events
Σt bin 12: 3079 events
Σt bin 13: 2890 events
Σt bin 14: 2726 events
Σt bin 15: 2477 events
Σt bin 16: 2334 events
Σt bin 17: 2225 events
Σt bin 18: 2114 events
Σt bin 19: 1979 events
Σt bin 20: 1697 events
Σt bin 21: 1546 events
Σt bin 22: 1500 events
Σt bin 23: 1336 events
Σt bin 24: 1223 events


Dependence between δt^sum and δΔt
Δt − Δt^MC
t^sum - t^MCsum
40
30
20
10
0
−10
−20
−30
−40
−60
−40
−20
0
20
40


δt_{min} Distribution
t_{min} - $t^{MC}{}_{min}$
λ = 0 data
Events
5000
4000
3000
2000
1000
0
−20
−15
−10
−5
0
5
10
15
20
t_{min} - $t^{MC}{}_{min}$ [ps]


δt_{min} Distribution
t_{min} - $t^{MC}{}_{min}$
λ = 0.1 data
Events
0
1000
2000
3000
4000
5000
−20
−15
−10
−5
0
5
10
15
20
t_{min} - $t^{MC}{}_{min}$ [ps]


δt_{min} Distribution
t_{min} - $t^{MC}{}_{min}$
λ = 0.5 data
Events
0
1000
2000
3000
4000
5000
−20
−15
−10
−5
0
5
10
15
20
t_{min} - $t^{MC}{}_{min}$ [ps]