

# Topology Analysis <sup>\*†‡§</sup>

(v2.12.3)

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<sup>\*</sup>Xingyu Zhou, Liaoning Normal University, zhouxy@lnnu.edu.cn

<sup>†</sup>This package is implemented referring to a program called TOPO, which is first developed by Prof. Shuxian Du from Zhengzhou University and later extended and maintained by Prof. Gang Li from Institute of High Energy Physics, Chinese Academy of Sciences. The TOPO program has been widely used by colleagues in BESIII collaboration. Several years ago, when I was a Ph.D. student working on the BESIII experiment, I learned the idea of topology analysis and a lot of programming techniques from the TOPO program. So, I really appreciate the original works of Prof. Du and Prof. Li very much. To meet my own needs and to practice developing analysis tools with C++, ROOT, and LaTeX, I wrote the package from scratch. At that time, the package functioned well but was relatively simple. At the end of 2017, when I just started my post-doctoral research at Beihang University, my co-supervisor Prof. Chengping Shen reminded me that it could be a useful tool for the Belle II experiment as well. So, I revised and extended it, making it more well-rounded and suitable for the Belle II experiment. Now, it also applies to many other similar high energy physics experiments. Here, I would like to thank Prof. Du and Prof. Li for their original works, and Prof. Shen for his suggestion, guidance, support, and encouragement.

<sup>‡</sup>Besides, I would like to thank all of the people who have helped me in the development of the program. I am particularly grateful to Prof. Xingtao Huang for his comments on the principles and styles of the program, to Remco de Boer for his suggestions on the tex output and the use of GitHub, and to Xi Chen for his discussions on the core algorithms. I am especially indebted to Prof. Xiqing Hao, Longke Li, Xiaoping Qin, Ilya Komarov, Yubo Li, Guanda Gong, Suxian Li, Junhao Yin, Prof. Xiaolong Wang, Yeqi Chen, Hannah Wakeling, Hongrong Qi, Hui Li, Ning Cao, Sanjeeda Bharati Das, Kazuki Kojima, Tingting Han, Fang Yan, Lin Wang, Meiru An, and Noreen Rauls for their advice in extending and perfecting the program. Also, I thank Xi'an Xiong, Runqiu Ma, Wencheng Yan, Sen Jia, Lu Cao, Dong Liu, Hongpeng Wang, Jiawei Zhang, Jiajun Liu, Maoqiang Jing, Yi Zhang, Wei Shan, and Yadi Wang for their efforts in helping me test the program.

<sup>§</sup>The paper on the tool has been published by *Computer Physics Communications*. You can find this paper and the preprint corresponding to it in the links [Comput. Phys. Commun. 258 \(2021\) 107540](#) and [arXiv:2001.04016](#), respectively. If the tool really helps your researches, we would appreciate it very much if you could cite the paper in your publications.

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Table 1: Decay trees and their respective initial-final states.

| rowNo | decay tree<br>(decay initial-final states)   | iDcyTr | nEtr | nCEtr |
|-------|--|--------|------|-------|
| 1     | $\Upsilon(4S) \rightarrow B^0 B^0, B^0 \rightarrow \pi^0 K^+ K^-, B^0 \rightarrow \pi^0 K^+ K^-$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 K^+ K^+ K^- K^-$ )   | 8      | 3437 | 3437  |
| 2     | $\Upsilon(4S) \rightarrow B^0 B^0, B^0 \rightarrow \pi^0 K^+ K^-, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 K^+ K^+ K^- K^- \gamma^F$ )   | 3      | 968  | 4405  |
| 3     | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 235    | 104  | 4509  |
| 4     | $\Upsilon(4S) \rightarrow B^0 B^0, B^0 \rightarrow \pi^0 K^+ K^-, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F \gamma^F$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 K^+ K^+ K^- K^- \gamma^F \gamma^F$ )   | 27     | 84   | 4593  |
| 5     | $\Upsilon(4S) \rightarrow B^0 B^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 K^+ K^+ K^- K^- \gamma^F \gamma^F$ )   | 535    | 70   | 4663  |
| 6     | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 405    | 64   | 4727  |
| 7     | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )   | 173    | 56   | 4783  |
| 8     | $\Upsilon(4S) \rightarrow B^0 B^0, B^0 \rightarrow \pi^0 K^+ K^-, B^0 \rightarrow \pi^0 K^+ K^-, \pi^0 \rightarrow e^+ e^- \gamma^F$<br>( $\Upsilon(4S) \rightarrow e^+ e^- \pi^0 K^+ K^+ K^- K^- \gamma^F$ )  | 91     | 33   | 4816  |
| 9     | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 447    | 28   | 4844  |
| 10    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^0 \pi^+ \pi^- \pi^- D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^- K^-$ )   | 532    | 27   | 4871  |
| 11    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 553    | 26   | 4897  |
| 12    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )  | 934    | 24   | 4921  |
| 13    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 1051   | 23   | 4944  |
| 14    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^-$ )   | 283    | 22   | 4966  |
| 15    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^- \gamma^F$ )   | 3324   | 20   | 4986  |
| 16    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \pi^0 \rho^+, \rho^+ \rightarrow \pi^0 \pi^+$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ ) | 3495   | 20   | 5006  |
| 17    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 295    | 19   | 5025  |

| rowNo | decay tree<br>(decay initial-final states)  | iDcyTr | nEtr | nCEtr |
|-------|---|--------|------|-------|
| 18    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ \pi^- K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^-$ )   | 184    | 18   | 5043  |
| 19    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )  | 562    | 18   | 5061  |
| 20    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \mu^+ \nu_\mu K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^+ K^+ K^- K^-$ )  | 864    | 18   | 5079  |
| 21    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^+ K^{*-}, \rho^+ \rightarrow \pi^0 \pi^+, K^{*-} \rightarrow \pi^0 K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )                                      | 998    | 18   | 5097  |
| 22    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \mu^+ \nu_\mu K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^+ K^+ K^- K^- \gamma^F$ )  | 1221   | 18   | 5115  |
| 23    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^0 \pi^- D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )  | 275    | 17   | 5132  |
| 24    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )  | 752    | 17   | 5149  |
| 25    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )  | 1996   | 17   | 5166  |
| 26    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^-$ )   | 2766   | 17   | 5183  |
| 27    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \mu^+ \nu_\mu K^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^+ \mu^- \nu_\mu \bar{\nu}_\mu \pi^0 \pi^+ K^+ K^- K^-$ )  | 157    | 16   | 5199  |
| 28    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^-$ )  | 1225   | 16   | 5215  |
| 29    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )  | 1612   | 16   | 5231  |
| 30    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )   | 2426   | 16   | 5247  |
| 31    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )  | 2944   | 16   | 5263  |
| 32    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^- \gamma^F$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )  | 1278   | 15   | 5278  |
| 33    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow e^+ \nu_e \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \dashrightarrow e^+ e^- \nu_e \bar{\nu}_e \pi^0 \pi^0 K_L^0 K^+ K^-$ )   | 2014   | 15   | 5293  |
| 34    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^+ K^{*-}, \rho^+ \rightarrow \pi^0 \pi^+, K^{*-} \rightarrow \pi^- \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^-$ ) | 2408   | 15   | 5308  |

| rowNo | decay tree<br>(decay initial-final states)   | iDcyTr | nEtr | nCEtr |
|-------|--|--------|------|-------|
| 35    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )   | 299    | 14   | 5322  |
| 36    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \rho^- D^+, \rho^- \rightarrow \pi^0 \pi^-, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )   | 419    | 14   | 5336  |
| 37    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )   | 444    | 13   | 5349  |
| 38    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ \pi^- \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )  | 1195   | 13   | 5362  |
| 39    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow e^+ \nu_e K^-$<br>( $\Upsilon(4S) \dashrightarrow e^+ e^- \nu_e \bar{\nu}_e \pi^0 \pi^+ K^+ K^- K^- \gamma^F$ )   | 1589   | 13   | 5375  |
| 40    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )   | 1631   | 13   | 5388  |
| 41    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F \gamma^F$<br>( $\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 K^+ K^+ K^- K^- \gamma^F \gamma^F \gamma^F$ )   | 3355   | 13   | 5401  |
| 42    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \pi^0 \rho^+, \rho^+ \rightarrow \pi^0 \pi^+$<br>( $\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 4378   | 13   | 5414  |
| 43    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^0 \pi^0 K_L^0$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^-$ )   | 7889   | 13   | 5427  |
| 44    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )   | 86     | 12   | 5439  |
| 45    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^0 \pi^+ K^+ K^- K^-$ )  | 269    | 12   | 5451  |
| 46    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K_L^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )   | 302    | 12   | 5463  |
| 47    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 K_L^0 K^+ K^-$ )   | 431    | 12   | 5475  |
| 48    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- \gamma^F$ )   | 1281   | 12   | 5487  |
| 49    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^0, \bar{K}^0 \rightarrow K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^+ \pi^- K^+ K^-$ )  | 1683   | 12   | 5499  |
| 50    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^-$ )  | 68     | 11   | 5510  |
| 51    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow K^{*-} \bar{\Lambda} \Sigma_c^+, K^{*-} \rightarrow \pi^- \bar{K}^0, \bar{\Lambda} \rightarrow \pi^+ \bar{p}, \Sigma_c^+ \rightarrow \pi^0 \Lambda_c^+, \bar{K}^0 \rightarrow K_S^0, \Lambda_c^+ \rightarrow \pi^0 \pi^+ \pi^+ \pi^- \Sigma^0, K_S^0 \rightarrow \pi^0 \pi^0, \Sigma^0 \rightarrow \Lambda \gamma, \Lambda \rightarrow \pi^0 n$<br>( $\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- K^+ K^- n \bar{p} \gamma$ ) | 223    | 11   | 5521  |

| rowNo | decay tree<br>(decay initial-final states)   | iDcyTr | nEtr | nCEtr |
|-------|--|--------|------|-------|
| 52    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^+ \pi^+ \pi^- \pi^- \pi^- D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- K^+ K^- K^-$ )   | 248    | 11   | 5532  |
| 53    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )  | 910    | 11   | 5543  |
| 54    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^0 K_L^0 K^+ K^-$ )  | 1054   | 11   | 5554  |
| 55    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \rho^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )   | 2508   | 11   | 5565  |
| 56    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K_L^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )   | 3657   | 11   | 5576  |
| 57    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \rightarrow \mu^+ \mu^- \nu_\mu \bar{\nu}_\mu \pi^0 \pi^0 K_L^0 K^+ K^-$ )  | 4618   | 11   | 5587  |
| 58    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )   | 7815   | 11   | 5598  |
| 59    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )  | 1457   | 10   | 5608  |
| 60    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K_L^0 \omega, \omega \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )  | 2232   | 10   | 5618  |
| 61    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F \gamma^F$ )   | 2434   | 10   | 5628  |
| 62    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ \omega K^-, \omega \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )  | 2968   | 10   | 5638  |
| 63    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow D^{*+} D_s^{*-}, D^{*+} \rightarrow \pi^+ D^0, D_s^{*-} \rightarrow D_s^- \gamma, D^0 \rightarrow \pi^0 K_L^0 \eta, D_s^- \rightarrow \rho^- \eta, K_L^0 \rightarrow \pi^0 \pi^0 \pi^0, \eta \rightarrow \pi^0 \pi^+ \pi^-, \rho^- \rightarrow \pi^0 \pi^-, \eta \rightarrow \pi^0 \pi^0 \pi^0$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- \gamma^F \gamma$ ) | 3273   | 10   | 5648  |
| 64    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow e^+ \nu_e K^-$<br>( $\Upsilon(4S) \rightarrow e^+ \nu_e \mu^- \bar{\nu}_\mu \pi^0 \pi^+ K^+ K^- K^-$ )   | 3445   | 10   | 5658  |
| 65    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \pi^0 \pi^+ \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )   | 445    | 9    | 5667  |
| 66    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 \pi^+ \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-$ )  | 523    | 9    | 5676  |
| 67    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F \gamma^F$ )   | 1031   | 9    | 5685  |
| 68    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \rho^- D^+, \rho^- \rightarrow \pi^0 \pi^-, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ \pi^- K^+ K^-$ )   | 1419   | 9    | 5694  |

| rowNo | decay tree<br>(decay initial-final states)   | iDcyTr | nEtr | nCEtr |
|-------|--|--------|------|-------|
| 69    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^+ K^{*-}, \rho^+ \rightarrow \pi^0 \pi^+,$<br>$K^{*-} \rightarrow \pi^- \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>$(\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^-)$   | 1659   | 9    | 5703  |
| 70    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^0, \bar{K}^0 \rightarrow K_L^0$<br>$(\Upsilon(4S) \dashrightarrow \mu^+ \mu^- \nu_\mu \bar{\nu}_\mu \pi^0 K_L^0 K^+ K^-)$   | 1873   | 9    | 5712  |
| 71    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow e^+ \nu_e K^-$<br>$(\Upsilon(4S) \dashrightarrow e^+ e^- \nu_e \bar{\nu}_e \pi^0 \pi^+ K^+ K^- K^-)$   | 2087   | 9    | 5721  |
| 72    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^+ K^{*-}, \rho^+ \rightarrow \pi^0 \pi^+,$<br>$K^{*-} \rightarrow \pi^- \bar{K}^0, \bar{K}^0 \rightarrow K_S^0, K_S^0 \rightarrow \pi^0 \pi^0$<br>$(\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-)$                                      | 2937   | 9    | 5730  |
| 73    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \pi^+ \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ \pi^+ \pi^- K^+ K^- K^-)$  | 4970   | 9    | 5739  |
| 74    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \rho^0 \pi^- D^{*+}, \rho^0 \rightarrow \pi^+ \pi^-, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ K^-$<br>$(\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- K^+ K^- K^-)$  | 5267   | 9    | 5748  |
| 75    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^0 \omega \eta' D^0, \omega \rightarrow \pi^0 \pi^+ \pi^-, \eta' \rightarrow \omega \gamma, D^0 \rightarrow \pi^0 \pi^0 \pi^0 K_S^0,$<br>$\omega \rightarrow \pi^0 \pi^+ \pi^-, K_S^0 \rightarrow \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- K^+ K^- \gamma)$                           | 11451  | 9    | 5757  |
| 76    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow \pi^+ \pi^- \rho^- K^0 \bar{K}^0 D^{*+}, \rho^- \rightarrow \pi^0 \pi^-, K^0 \rightarrow K_L^0, \bar{K}^0 \rightarrow K_L^0,$<br>$D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 K_L^0 K_L^0 K_L^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- K^+ K^- \gamma^F)$ | 683    | 8    | 5765  |
| 77    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^+ K^{*-}, \rho^+ \rightarrow \pi^0 \pi^+,$<br>$K^{*-} \rightarrow \pi^0 K^-$<br>$(\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^-)$  | 701    | 8    | 5773  |
| 78    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ \pi^- \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>$(\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- K^+ K^- K^- \gamma^F)$  | 1145   | 8    | 5781  |
| 79    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-)$  | 1272   | 8    | 5789  |
| 80    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow \pi^0 K_L^0 \pi^+$<br>$(\Upsilon(4S) \dashrightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 K_L^0 \pi^+ K^+ K^- \gamma^F)$  | 1705   | 8    | 5797  |
| 81    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \pi^0 \rho^+,$<br>$\rho^+ \rightarrow \pi^0 \pi^+$<br>$(\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F)$  | 1756   | 8    | 5805  |
| 82    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K^- a_1^+, a_1^+ \rightarrow \rho^0 \pi^+,$<br>$\rho^0 \rightarrow \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ \pi^+ \pi^- K^+ K^- K^-)$  | 2577   | 8    | 5813  |
| 83    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow K_L^0 \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow e^- \bar{\nu}_e \pi^0 K_L^0 \pi^+ \pi^+ \pi^- K^+ K^- \gamma^F)$   | 2635   | 8    | 5821  |

| rowNo | decay tree<br>(decay initial-final states)   | iDcyTr | nEtr | nCEtr |
|-------|--|--------|------|-------|
| 84    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ \pi^- \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )  | 3167   | 8    | 5829  |
| 85    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )   | 4146   | 8    | 5837  |
| 86    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu \eta D^+, \eta \rightarrow \pi^0 \pi^0 \pi^0, D^+ \rightarrow \pi^0 \pi^+ \pi^+ \pi^- \eta, \eta \rightarrow \pi^0 \pi^0 \pi^0$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^-$ )  | 4385   | 8    | 5845  |
| 87    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \pi^0 \rightarrow e^+ e^- \gamma^F$<br>( $\Upsilon(4S) \rightarrow e^+ e^- \pi^0 K^+ K^+ K^- K^- \gamma^F \gamma^F$ )  | 6635   | 8    | 5853  |
| 88    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^- D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^-$ )   | 7437   | 8    | 5861  |
| 89    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \bar{K}^0 D^{*+} D^{*-}, \bar{K}^0 \rightarrow K_L^0, D^{*+} \rightarrow \pi^0 D^+, D^{*-} \rightarrow \pi^- \bar{D}^0,$<br>$D^+ \rightarrow K_L^0 a_1^+, \bar{D}^0 \rightarrow \pi^0 \pi^0 \pi^0 K_S^0, a_1^+ \rightarrow \pi^+ \pi^+ \pi^- \gamma^F, K_S^0 \rightarrow \pi^0 \pi^0$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 K_L^0 K_L^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^- \gamma^F$ ) | 11941  | 8    | 5869  |
| 90    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow \pi^+ \rho^- \omega K^* K^{*-} D^+, \rho^- \rightarrow \pi^0 \pi^-, \omega \rightarrow \pi^0 \pi^+ \pi^-, K^* \rightarrow \pi^0 K^0,$<br>$K^{*-} \rightarrow \pi^0 K^-, D^+ \rightarrow \pi^+ K^+ K^-, K^0 \rightarrow K_L^0$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^0 \pi^0 \pi^0 K_L^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- K^+ K^+ K^- K^- \gamma^F$ )  | 13940  | 8    | 5877  |
| 91    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ \omega K^-, \omega \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^- \gamma^F$ )  | 352    | 7    | 5884  |
| 92    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+ \gamma^F, D^+ \rightarrow \pi^+ \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F$ )  | 434    | 7    | 5891  |
| 93    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \rho^0 \bar{K}^*, \rho^0 \rightarrow \pi^+ \pi^-,$<br>$\bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ \pi^- K^+ K^- K^-$ )  | 548    | 7    | 5898  |
| 94    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \tau^- \bar{\nu}_\tau D^{*+}, \tau^- \rightarrow \nu_\tau \pi^0 \pi^-, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^0 \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \nu_\tau \bar{\nu}_\tau \pi^0 \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^-$ )  | 676    | 7    | 5905  |
| 95    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^{*+}, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ \pi^- K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>( $\Upsilon(4S) \rightarrow \mu^- \bar{\nu}_\mu \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^-$ )  | 799    | 7    | 5912  |
| 96    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \mu^- \bar{\nu}_\mu D^+, D^+ \rightarrow e^+ \nu_e \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^+ \nu_e \mu^- \bar{\nu}_\mu \pi^0 \pi^+ K^+ K^- K^-$ )   | 1032   | 7    | 5919  |
| 97    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^+, D^+ \rightarrow \mu^+ \nu_\mu \bar{K}^*, \bar{K}^* \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \mu^+ \nu_\mu \pi^0 \pi^+ K^+ K^- K^-$ )   | 1118   | 7    | 5926  |
| 98    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^- \gamma^F, \bar{B}^0 \rightarrow \pi^- D^{*+} \Lambda \bar{\Sigma}^0, D^{*+} \rightarrow \pi^+ D^0, \Lambda \rightarrow \pi^- p, \bar{\Sigma}^0 \rightarrow \bar{\Lambda} \gamma,$<br>$D^0 \rightarrow \pi^0 \pi^+ K^-, \bar{\Lambda} \rightarrow \pi^+ \bar{p}$<br>( $\Upsilon(4S) \rightarrow \pi^0 \pi^0 \pi^+ \pi^+ \pi^- \pi^- K^+ K^- K^- p \bar{p} \gamma^F \gamma$ )   | 1239   | 7    | 5933  |
| 99    | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow e^- \bar{\nu}_e D^{*+} \gamma^F \gamma^F, D^{*+} \rightarrow \pi^+ D^0, D^0 \rightarrow \pi^+ K^-$<br>( $\Upsilon(4S) \rightarrow e^- \bar{\nu}_e \pi^0 \pi^+ \pi^+ K^+ K^- K^- \gamma^F \gamma^F$ )   | 1280   | 7    | 5940  |



| rowNo | decay tree<br>(decay initial-final states)  | iDcyTr | nEtr  | nCEtr |
|-------|---|--------|-------|-------|
| 100   | $\Upsilon(4S) \rightarrow B^0 \bar{B}^0, B^0 \rightarrow \pi^0 K^+ K^-, \bar{B}^0 \rightarrow \pi^0 \pi^+ \pi^- \pi^- D^{*+}, D^{*+} \rightarrow \pi^0 D^+, D^+ \rightarrow \pi^0 \pi^+ K_S^0, K_S^0 \rightarrow \pi^+ \pi^-$<br>$(\Upsilon(4S) \dashrightarrow \pi^0 \pi^0 \pi^0 \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^- K^+ K^-)$ | 1742   | 7     | 5947  |
| rest  | $\Upsilon(4S) \rightarrow \text{others (16540 in total)}$<br>$(\Upsilon(4S) \dashrightarrow \text{corresponding to others})$  | —      | 20249 | 26196 |