Signal Strength versus Signal Timing: Achieving Reliability in Multiple Burial Searches

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Multiple Burials Can Be Challenging

- How common are multiple-victim beacon searches?
- Modern digital beacons have a variety of features designed to simplify them.

Multiple Search Features - Signal Strength Filter

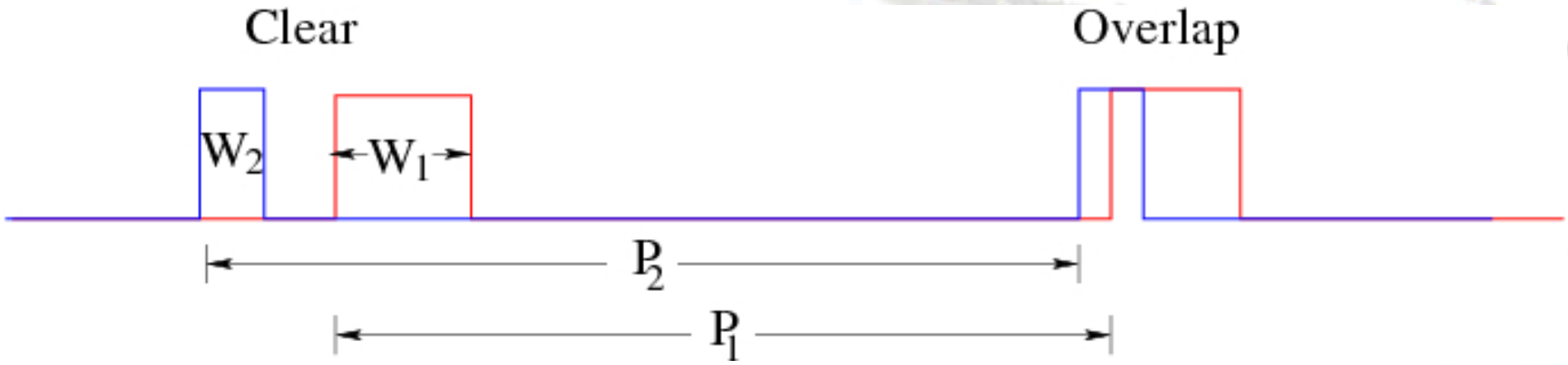
- All digital beacons employ a signal strength filter that locks on to the closest beacon.
- This is a robust system that is easy to use in 99 percent of beacon searches.
- Searches are difficult only when victims are buried very close together–and if the first victim’s beacon cannot be turned off.

Multiple Search Features - Signal Timing Analysis

- Some beacons employ a signal timing and/or frequency analysis (“marking”) that enables the searcher to digitally remove beacons from the search once they are located.
- This system works well as long as the various transmit pulses can be identified clearly.
- However, overlapping signals can confuse the timing analysis and complicate the search.
- In the worst case, it may be difficult or impossible to locate one or more victims while the signals are overlapped.

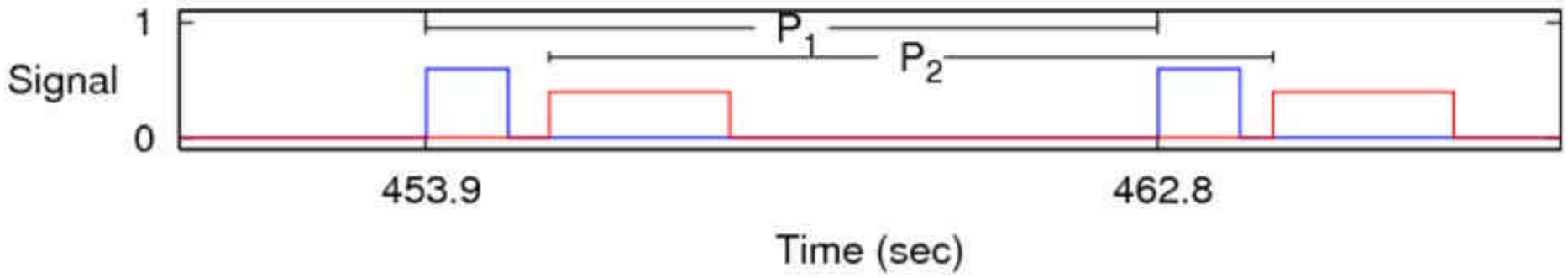
Signal Overlap

- When two or more transmitters are operating, their signals can overlap.
- Differences in the periods cause the signals to come in and out of overlap.



Overlap Severity Can Vary Widely

- Overlap severity depends strongly on the beacon characteristics.
- Beacons with wide pulses and nearly identical pulse periods give rise to long overlaps.



How Common Is Signal Overlap?

- Field testing indicates that signal overlap can be a real threat to timing analysis. Long periods of overlap cause the most trouble.
- How common are long overlaps?
- What factors contribute to the problem?
  - Number of beacons transmitting.
  - Transmitter characteristics.

Analysis - Computer Simulation and Theory

- To measure overlap statistics directly, a computer program was developed to simulate the operation of several transmitters.
- A mathematical model was also developed to predict overlap. The theory provides insight to the key factors that contribute to overlap.

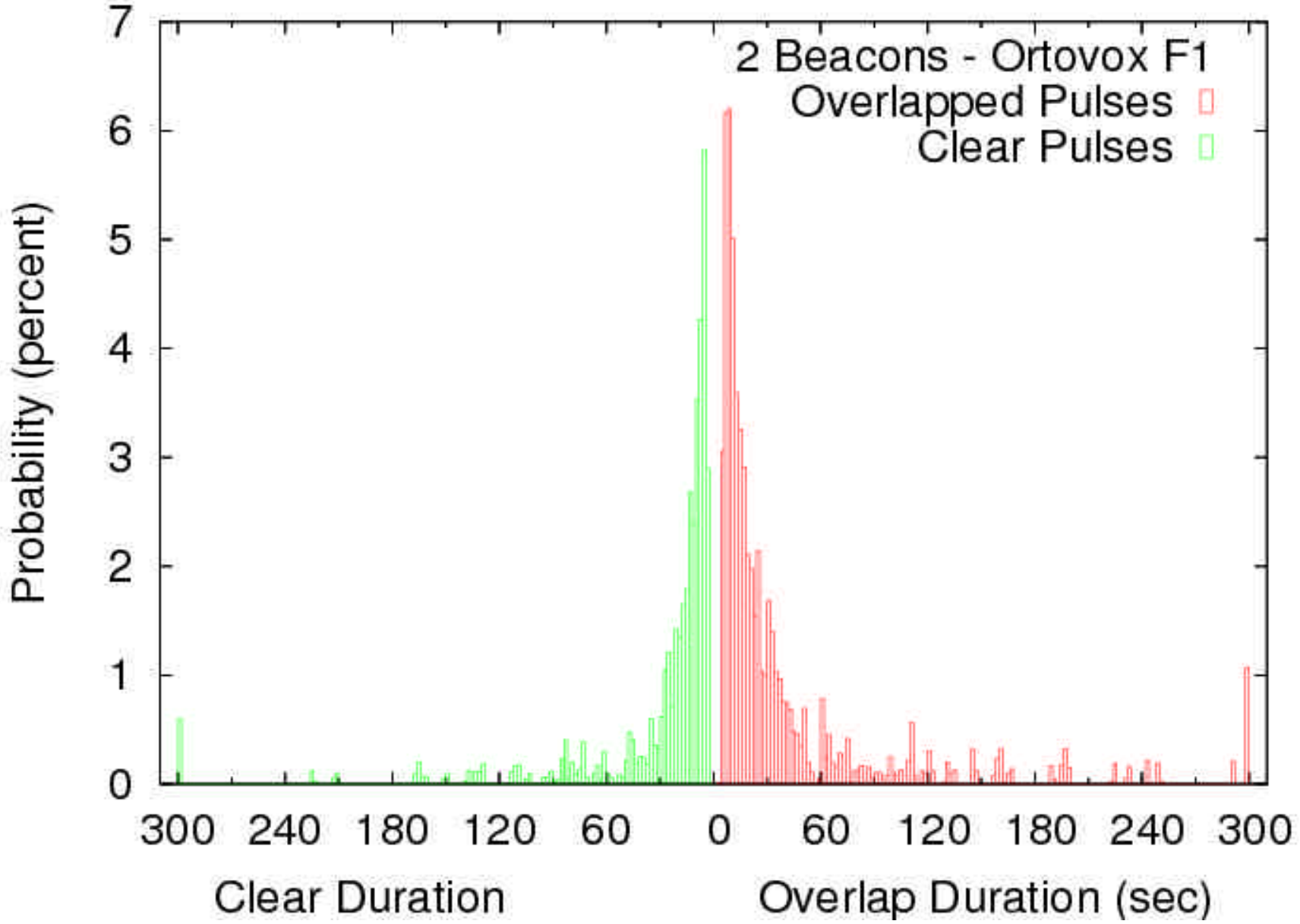
Procedure

- Beacon characteristics were measured and entered into the computer program. We conducted 3 separate trials: 24 Ortovox F1 beacons, 24 Tracker DTS beacons, 24 beacons of different types (compiled by Eck et. al., 2006).
- In each trial, all possible combinations of 2, 3, and 4 beacons were analyzed and the overlap characteristics measured for each.

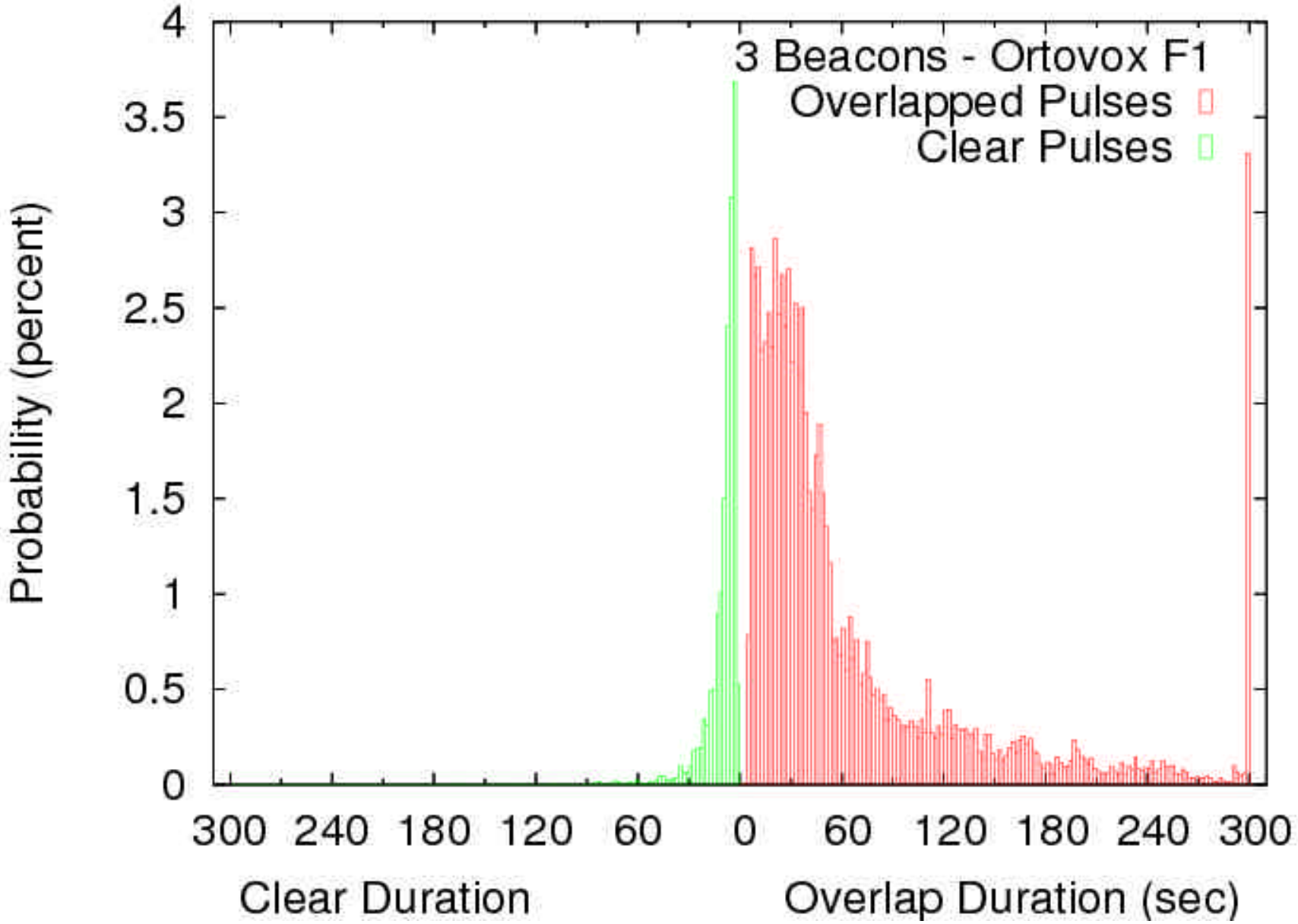
Summary of Results – Ortovox F1 Beacons

Number of Beacons Transmitting	Number of combinations	Average Overlap Duration	Maximum Overlap Duration
2	276	24 sec	16 min
3	2024	58 sec	2.5 hour
4	10626	114 sec	infinite

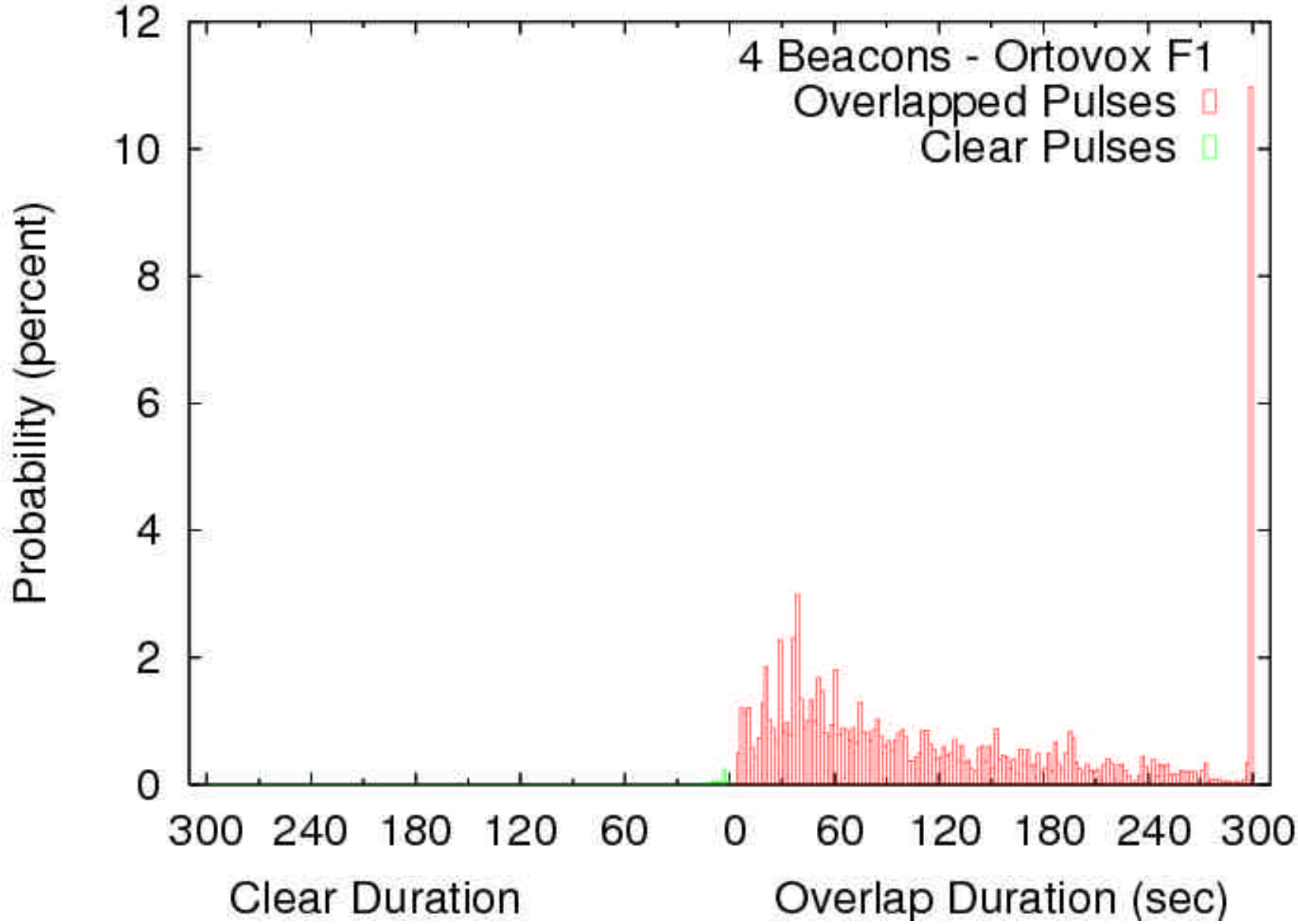
Clear & Overlap Durations – 2 F1 Focus



Clear & Overlap Durations – 3 F1 Focus



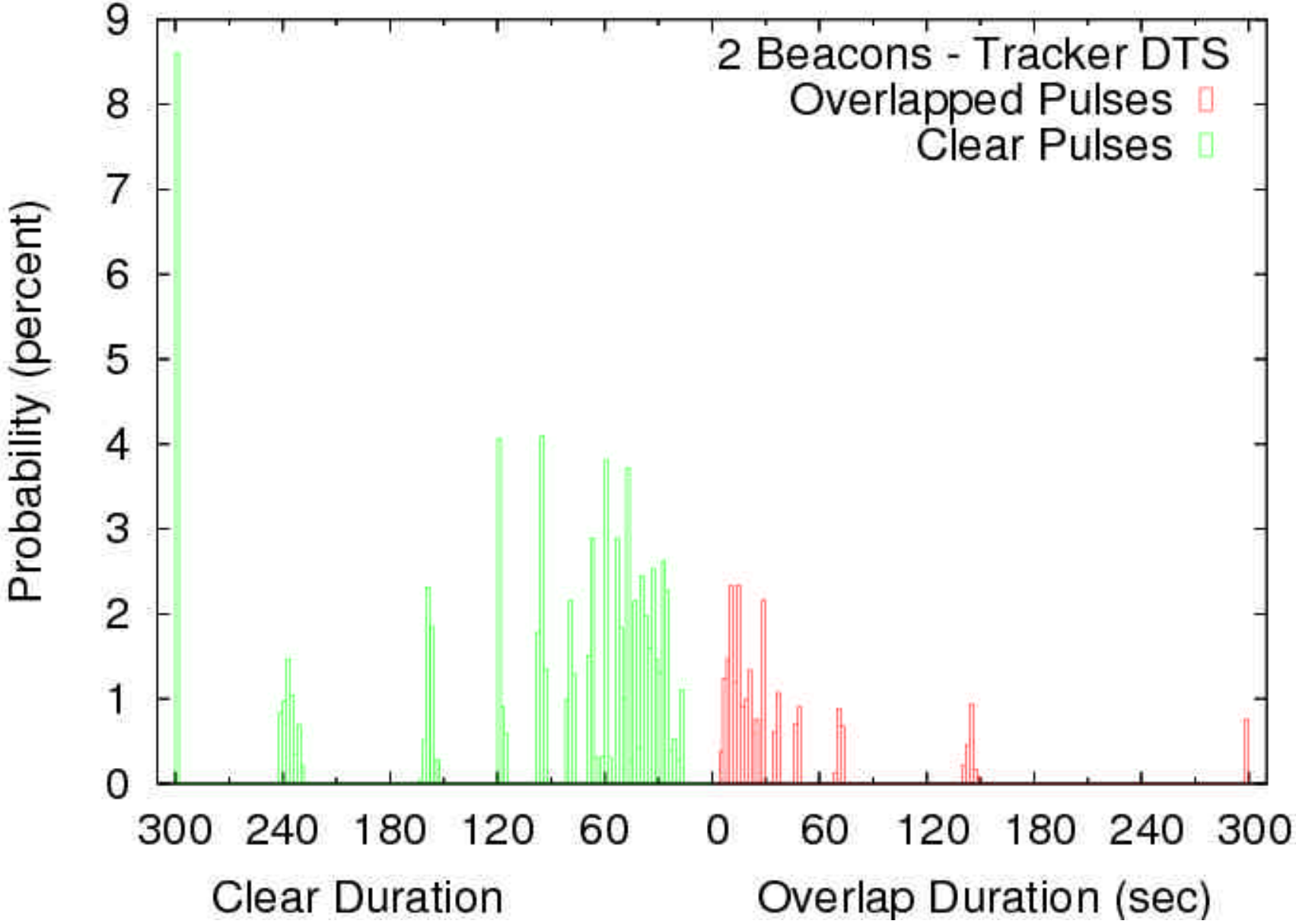
Clear & Overlap Durations – 4 F1 Focus



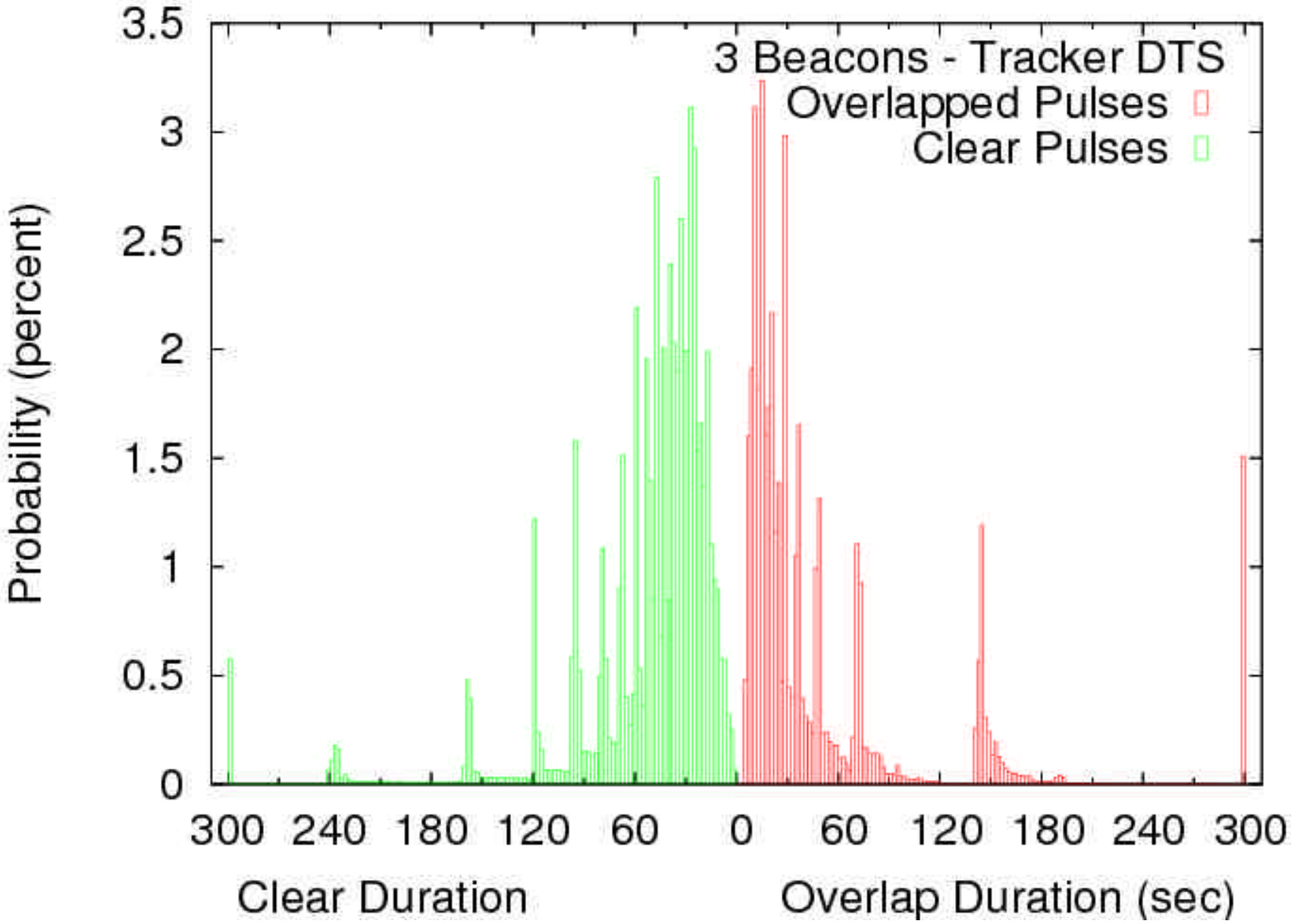
Summary of Results - Tracker DTS Beacons

Number of Beacons Transmitting	Number of combinations	Average Overlap Duration	Maximum Overlap Duration
2	276	10 sec	6 min
3	2024	21 sec	11 min
4	10626	32 sec	16 min

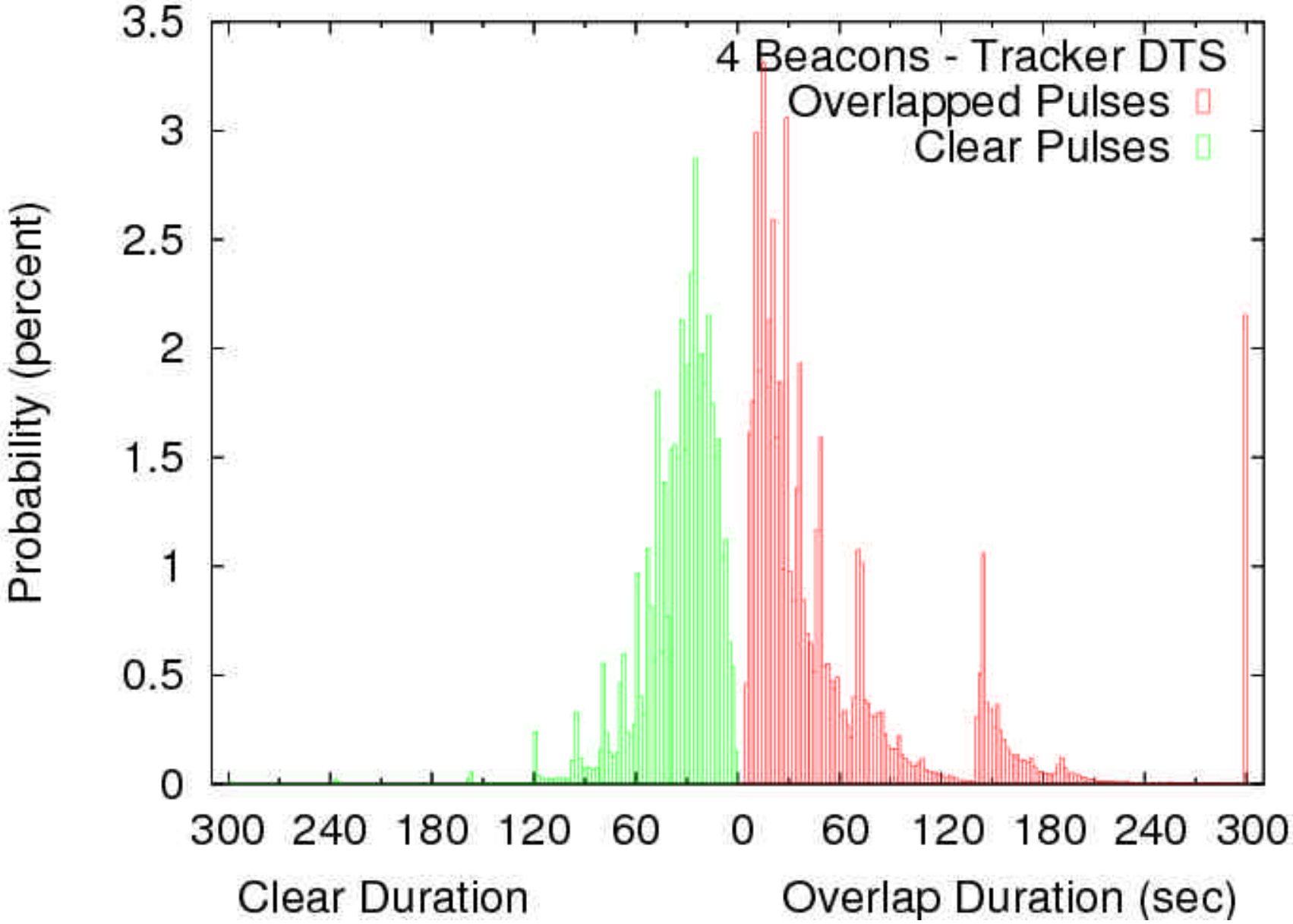
Clear & Overlap Durations – 2 Trackers



Clear & Overlap Durations – 3 Trackers



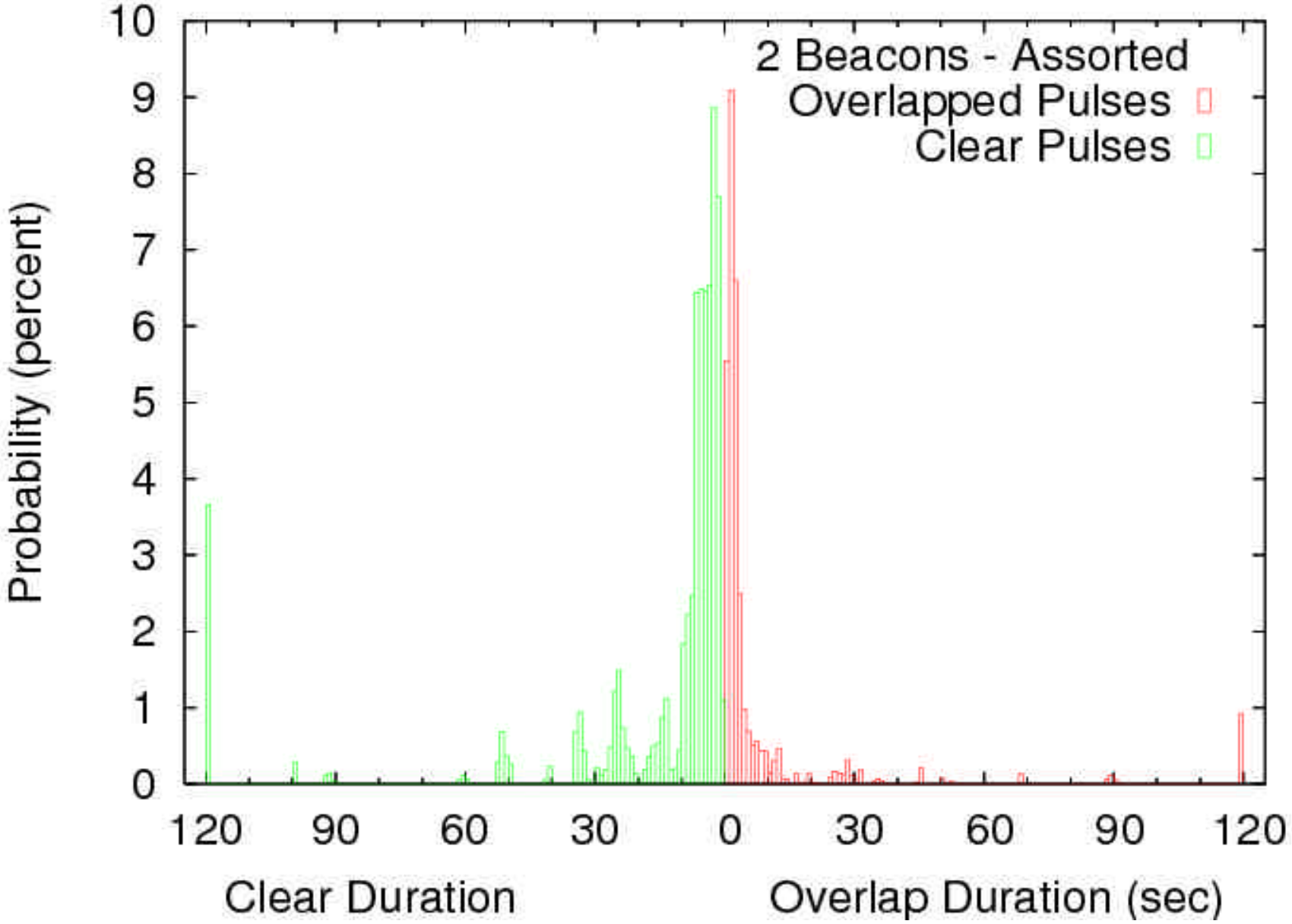
Clear & Overlap Durations – 4 Trackers



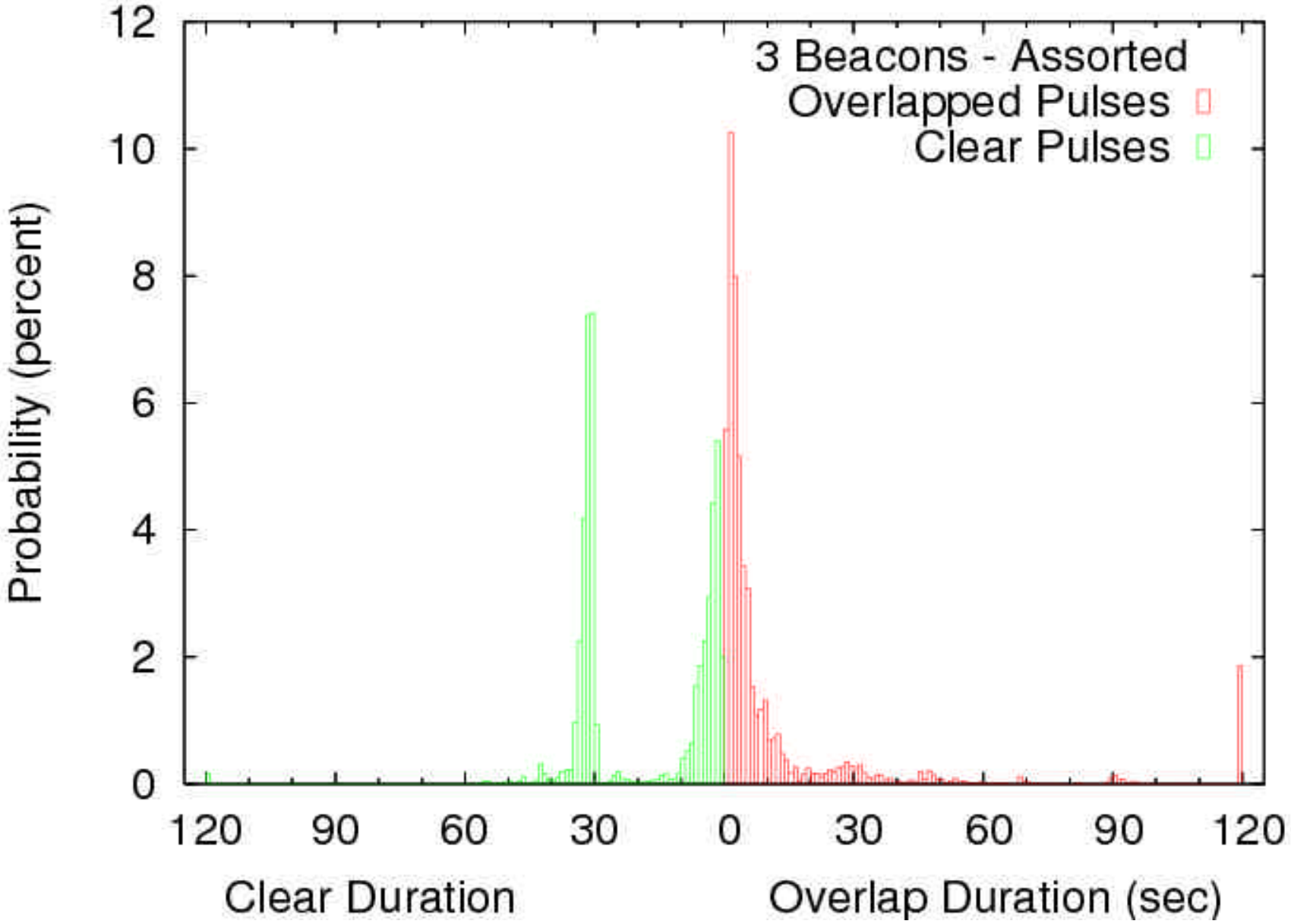
Summary of Results - Assorted Beacon Types

Number of Beacons Transmitting	Number of combinations	Average Overlap Duration	Maximum Overlap Duration
2	276	2.7 sec	4.5 min
3	2024	4.3 sec	9.2 min
4	10626	16.5 sec	infinite

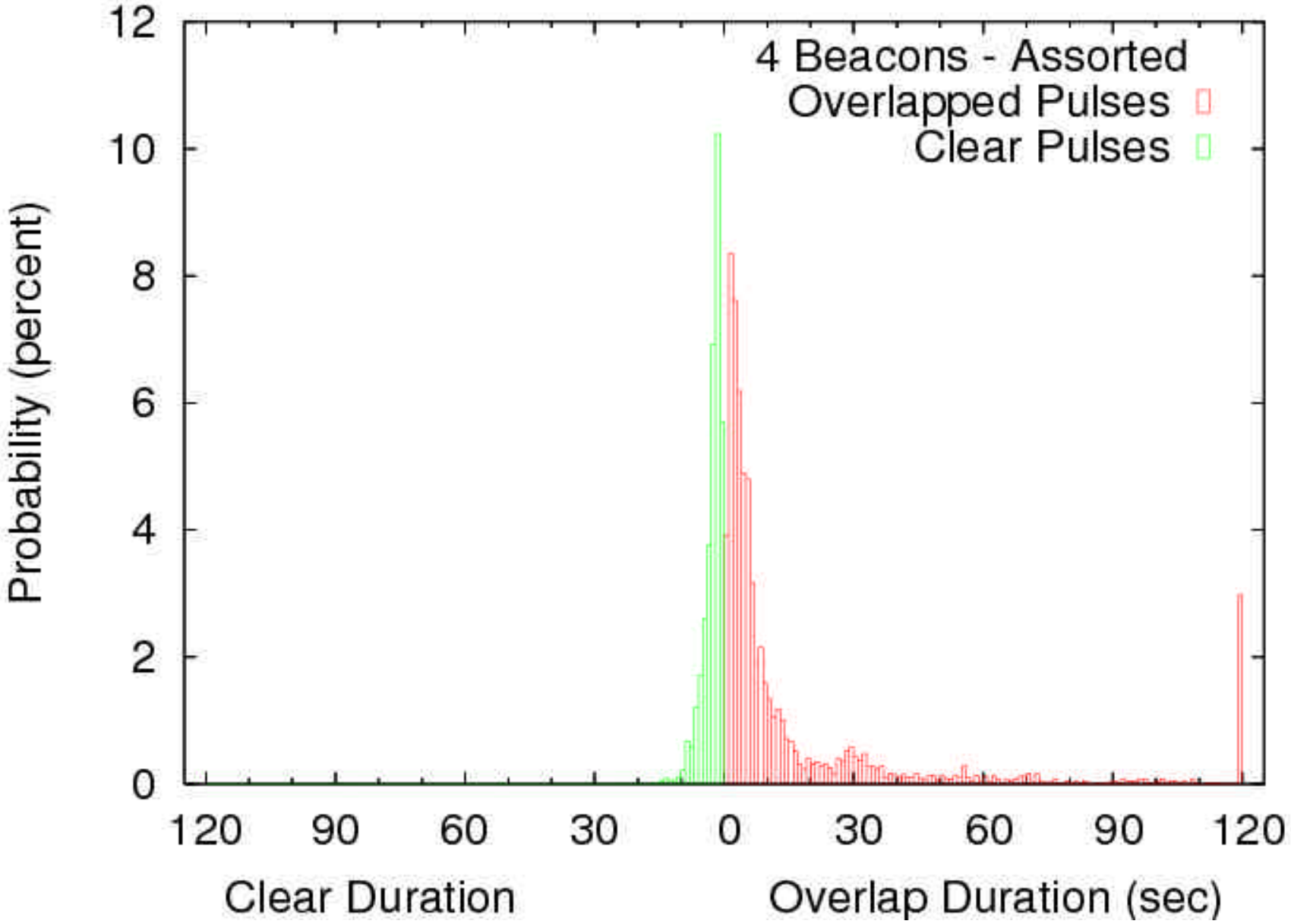
Clear & Overlap Durations – 2 Assorted



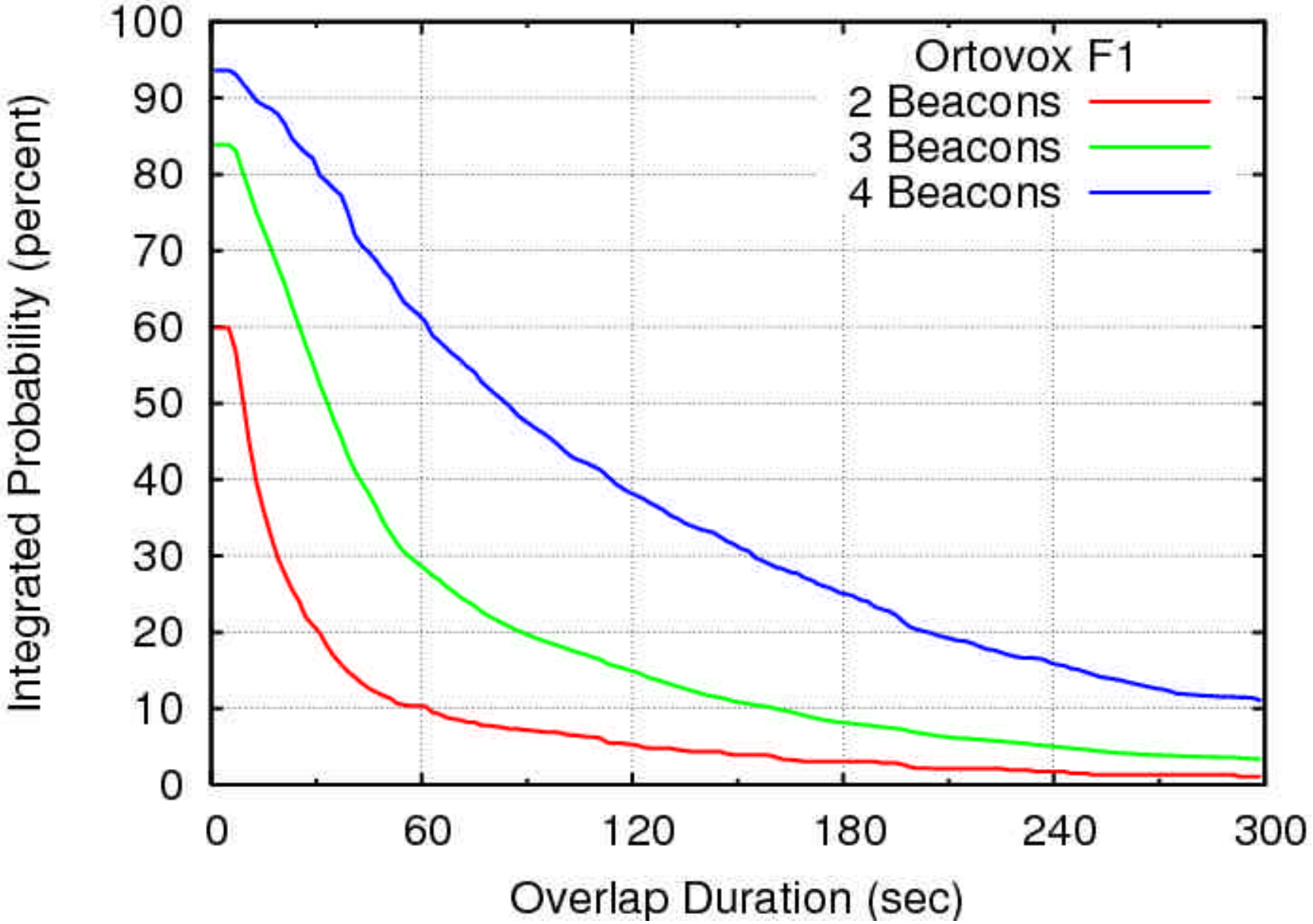
Clear & Overlap Durations – 3 Assorted



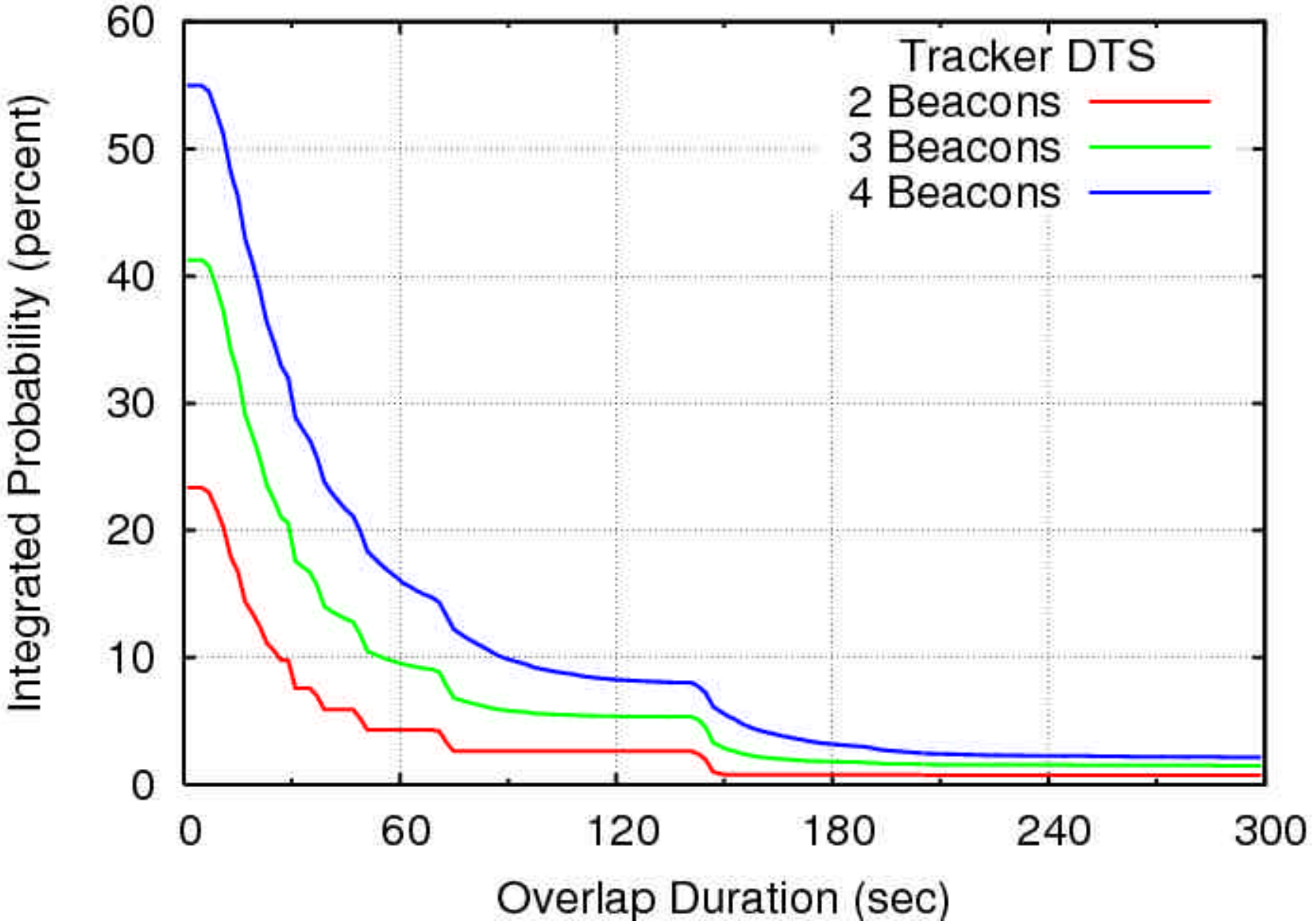
Clear & Overlap Durations – 4 Assorted



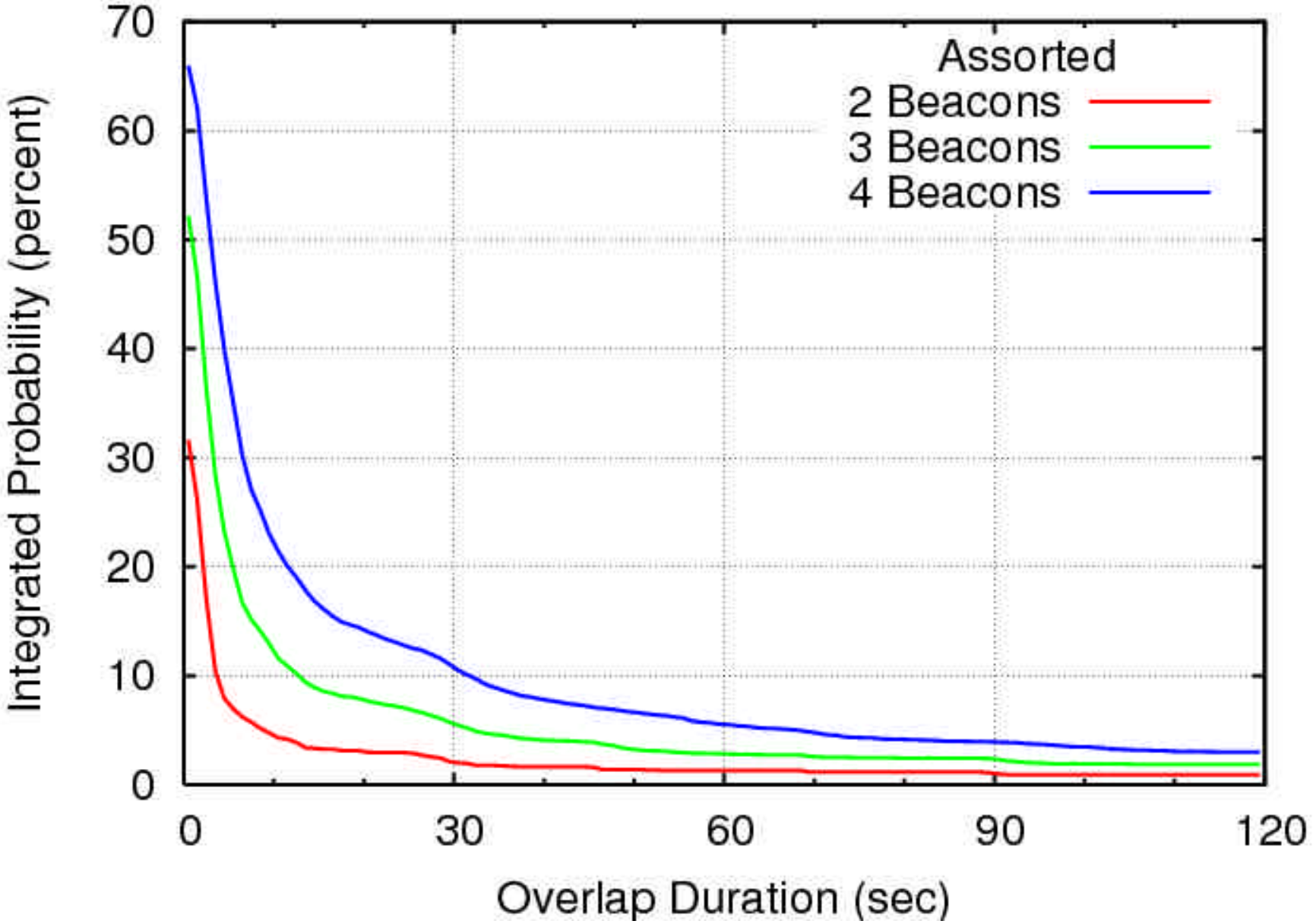
Overlap Probability - Ortovox F1



Overlap Probability - Tracker



Overlap Probability - Assorted Types



Conclusions Regarding Signal Overlap

- Overlaps lasting at least 30 seconds are common (5-50% probability depending on beacon type) for three beacon combinations.

- Overlap durations of more than two minutes also occur with measurable probability (from 2-15% for three beacons).

- The probability of long overlaps increases with increasing beacon number and for units with wide pulses (four Ortovox F1's have an 11% chance for overlaps of at least 5 minutes).

Conclusions Regarding Signal Overlap

- In general, long overlaps are the least likely for combinations of assorted beacon types.
- Manufacturers are attempting to mitigate the problem with randomized pulse periods and “smart transmitters”.
- Signal overlap will remain a problem for beacons with “marking” functions well into the future.

Additional Findings - Field Tests

- Using “marking” features during periods of signal overlap caused misleading or null indications on the searcher’s display.

- In all cases, reverting to a standard signal-strength or analog mode enabled the search to continue normally.

Recommendations

- Users should not rely entirely on “marking” features - they should still learn standard search techniques for multiple burials (such as the Three Circle and Micro-Strip methods).

- All users of beacons with “marking” features should be aware of the signal overlap problem and know how to disengage these features when necessary.