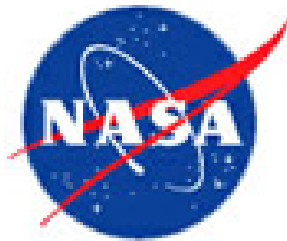


Plots of Path-Stretch Maneuvers for Arrival Delay



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The following plots show symmetric path-stretch maneuvers for arrival delay. The delays are used to fill an arrival time slot and to realize the required wake-vortex spacing behind the previous arrival to the same runway. This kind of maneuver is used after a speed maneuver combined with a final-extension maneuver have both reached their limits.

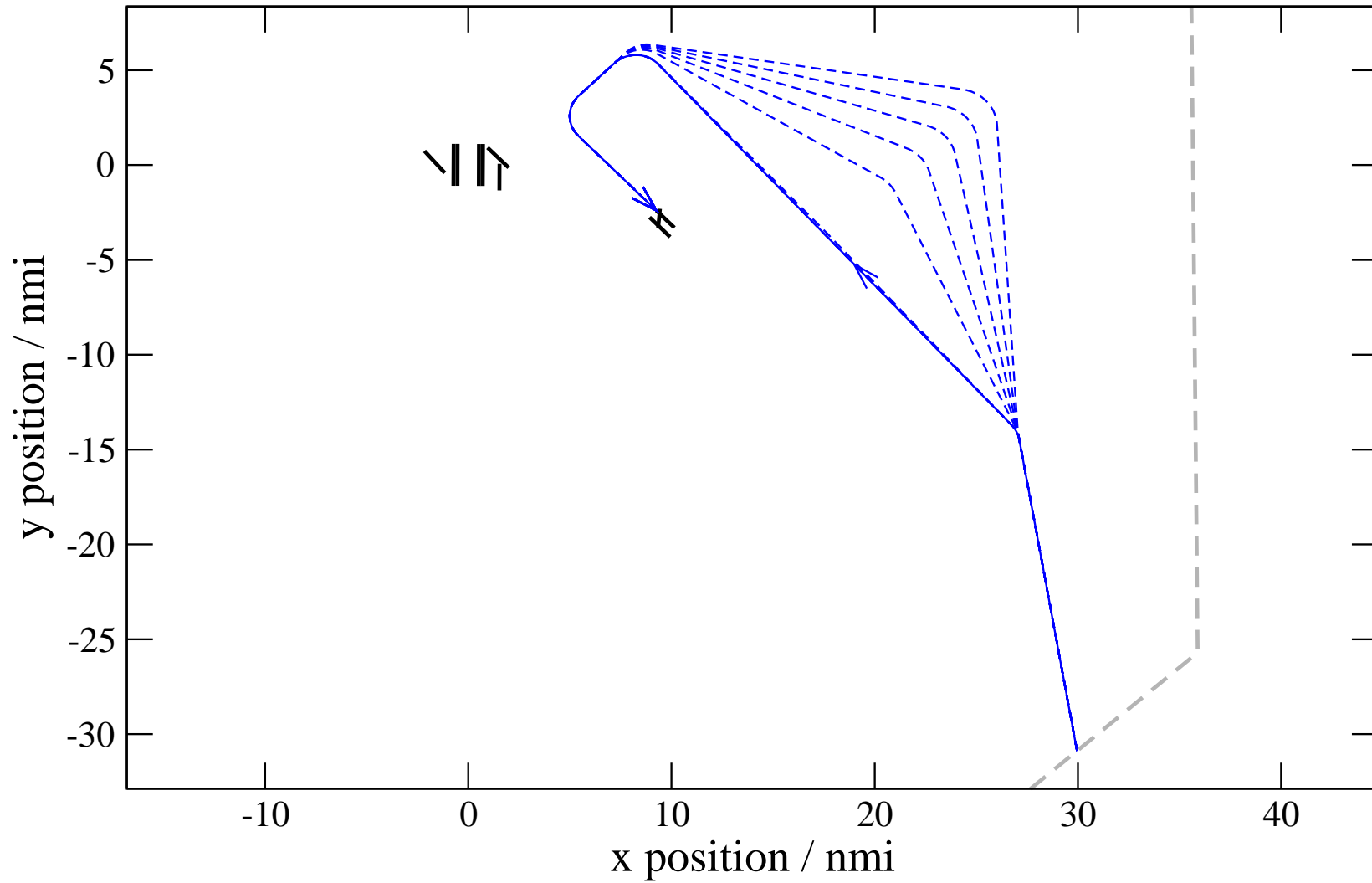
The original route in each plot is shown as a solid line, and the delayed routes are shown as dashed lines. The "original" route in these plots is the route after an extension of final approach has reached its limit. The subtitle of each plot shows the aircraft type and the test results. The required delay for each route was incremented in steps of 20 seconds, and the path stretch necessary to realize each required delay was computed using a bisection algorithm (while maintaining the original altitude and speed profiles and accounting for winds). The maximum path offset was limited to 12 nautical miles (nmi), and the resulting maximum delay (by path stretching alone) is shown in the subtitle.

The error in the resulting delay is also shown in each subtitle. This error applies to the reference trajectory computation only and should not be confused with flight control accuracy. These errors can be made arbitrarily small at the expense of more computation by simply adding more iterations in the bisection algorithm. The maximum error for all runs was ?? seconds, and the computational time was approximately 6 milliseconds per delay solution. That is more than sufficient accuracy and more than fast enough for real time.

[generated using test/SymPathStretchTest.scala]

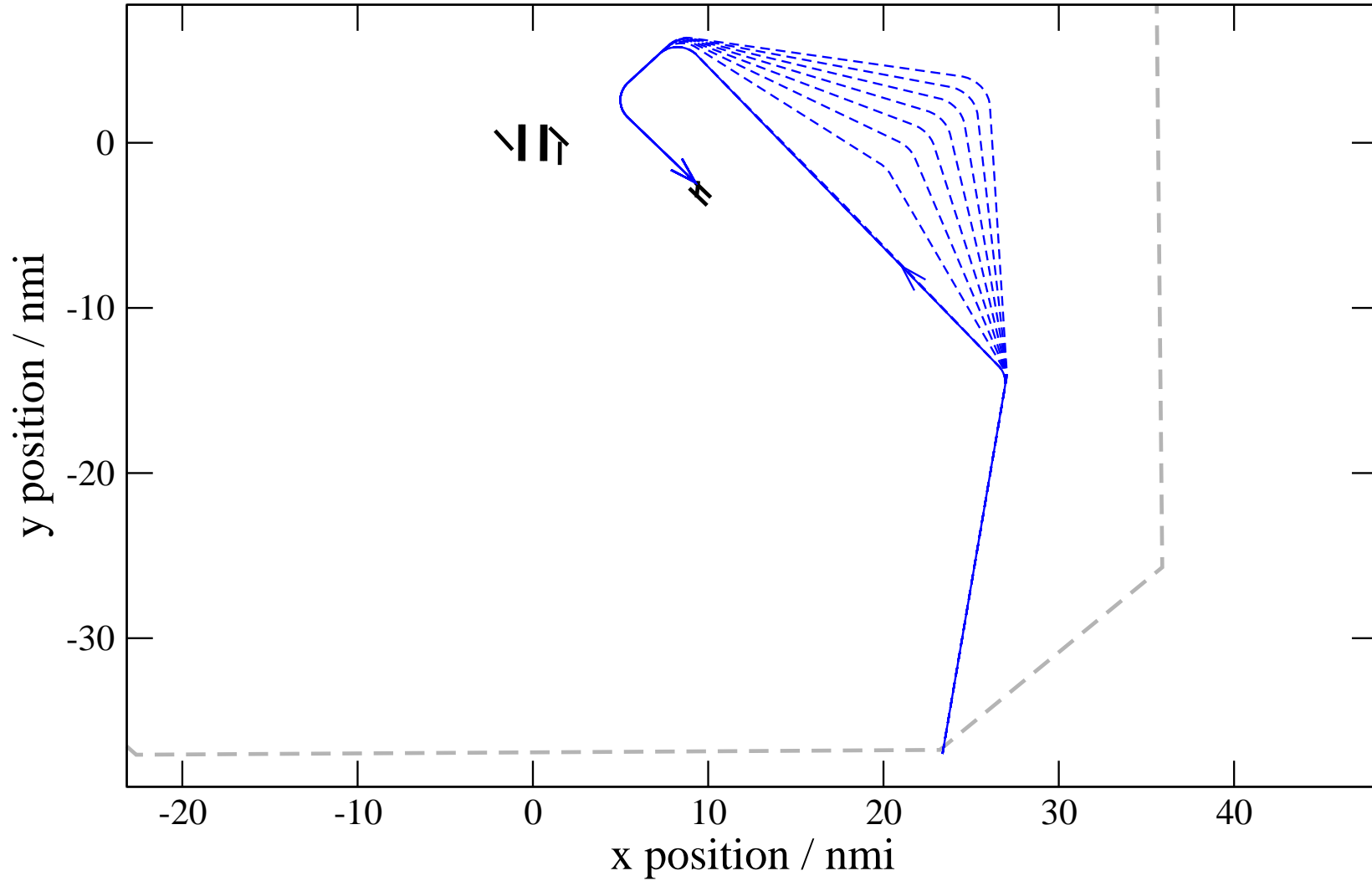
Symmetric Path-Stretch Routes

110 (B737 D DAL/13L Arr) step: 20 sec, max delay: 1.7 min, max err: 0.01 sec



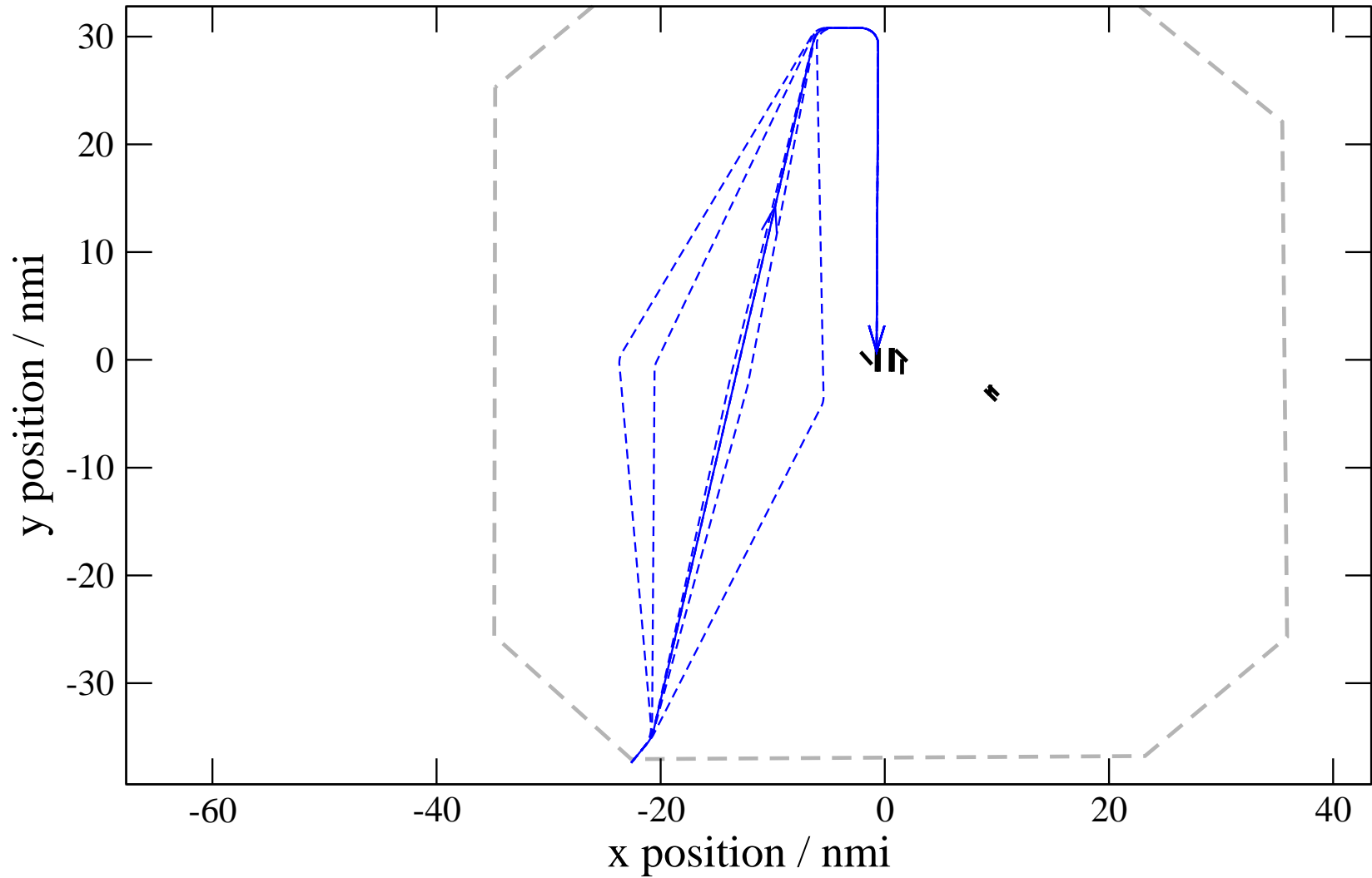
Symmetric Path-Stretch Routes

1322 (BE20 F DAL/13L Arr) step: 20 sec, max delay: 2.3 min, max err: 0.00 sec



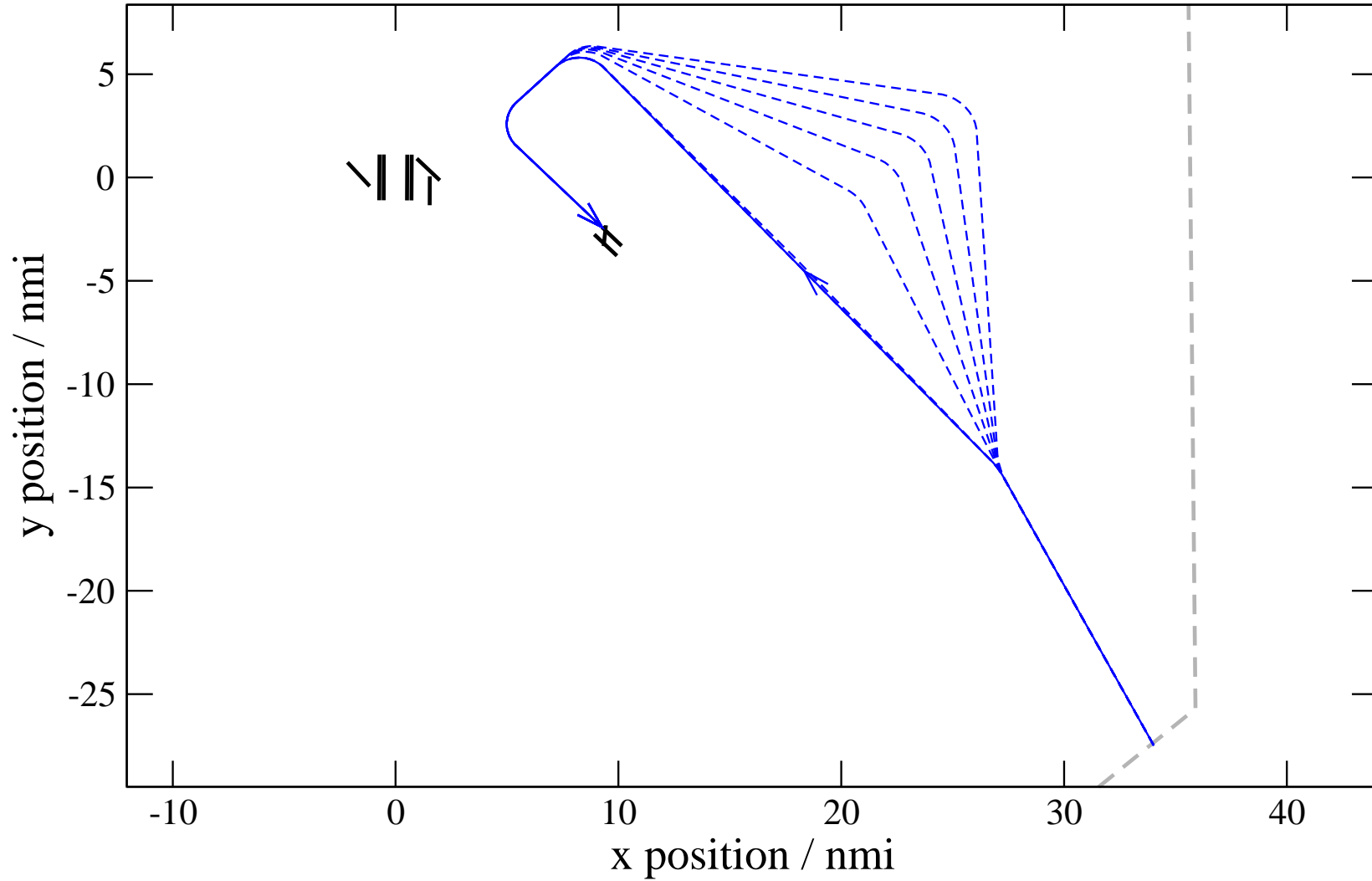
Symmetric Path-Stretch Routes

1334 (E145 E DFW/18R Arr) step: 20 sec, max delay: 0.7 min, max err: 0.04 sec



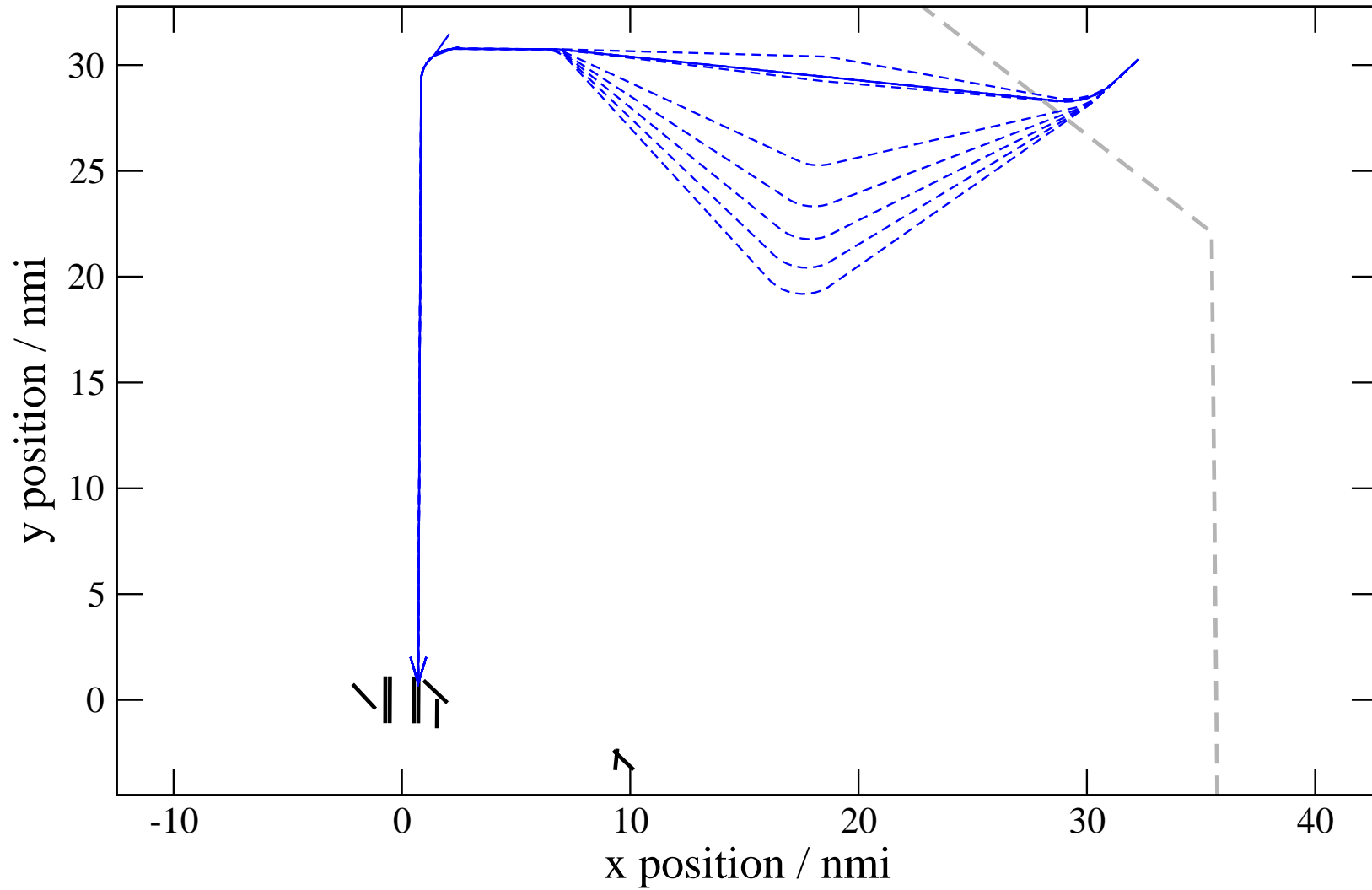
Symmetric Path-Stretch Routes

1419 (CRJ2 E DAL/13L Arr) step: 20 sec, max delay: 1.7 min, max err: 0.01 sec



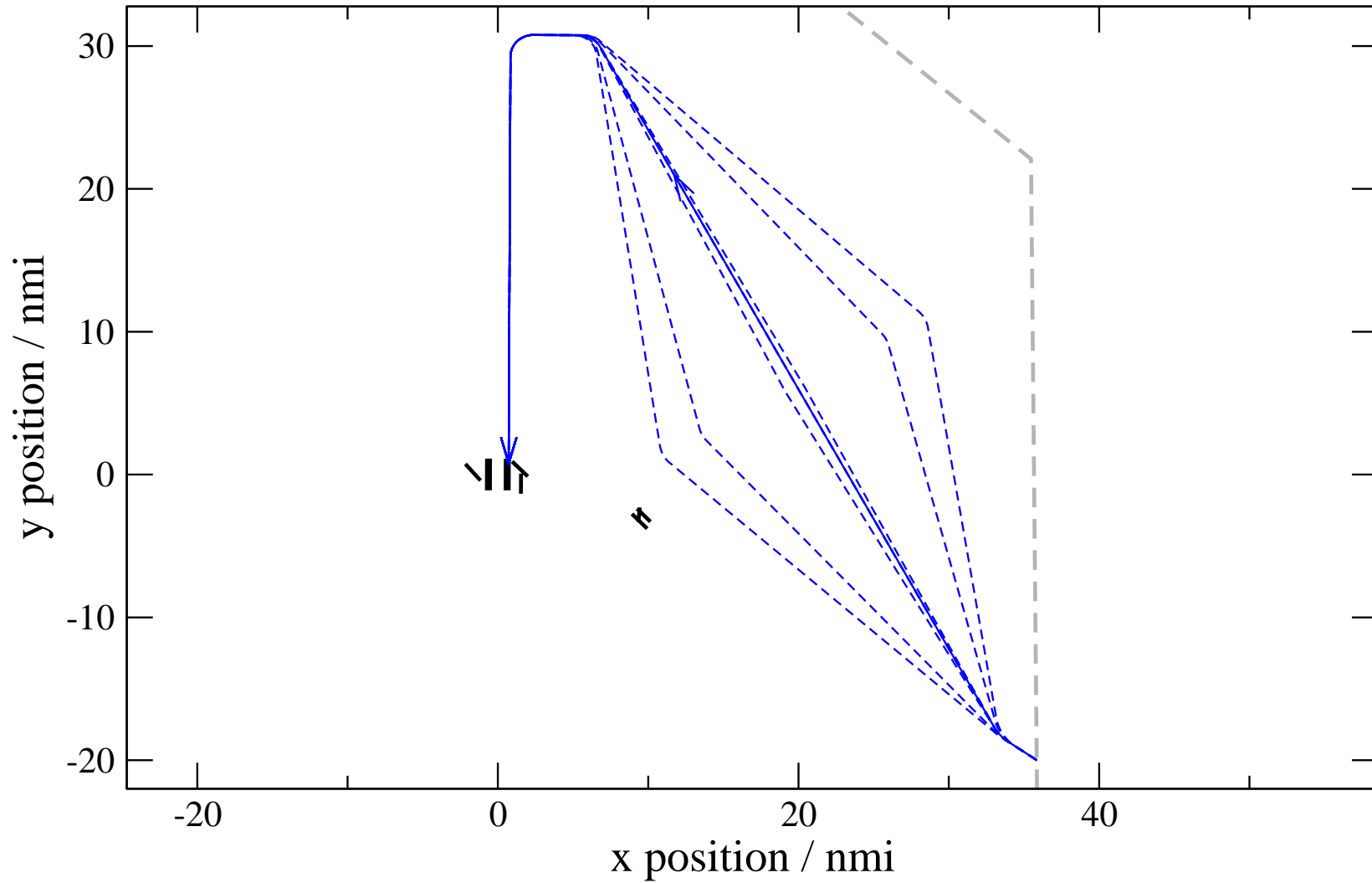
Symmetric Path-Stretch Routes

1439 (DC10 C DFW/17C Arr) step: 20 sec, max delay: 1.7 min, max err: 0.03 sec



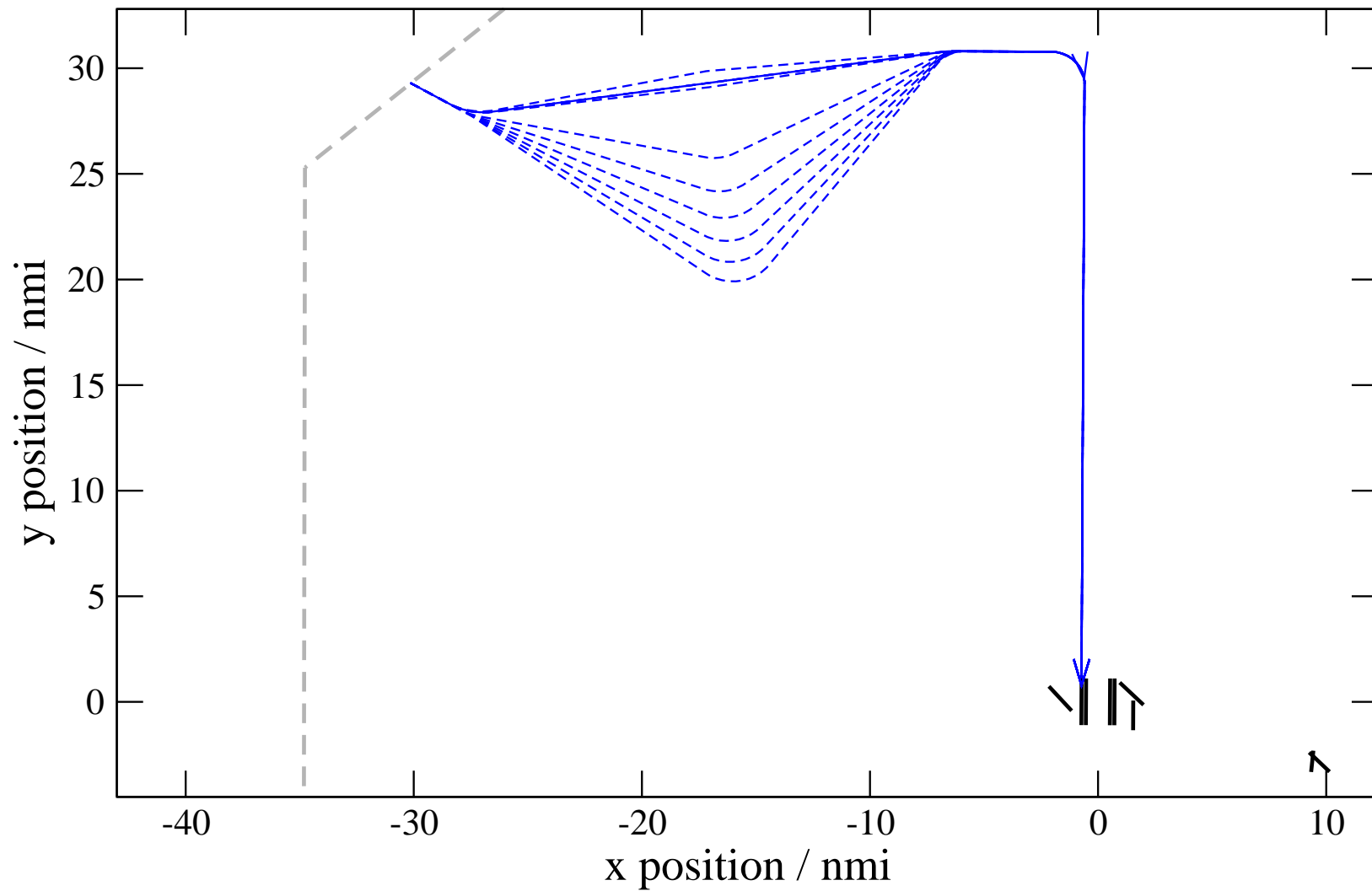
Symmetric Path-Stretch Routes

1448 (LJ45 F DFW/17C Arr) step: 20 sec, max delay: 0.7 min, max err: 0.06 sec



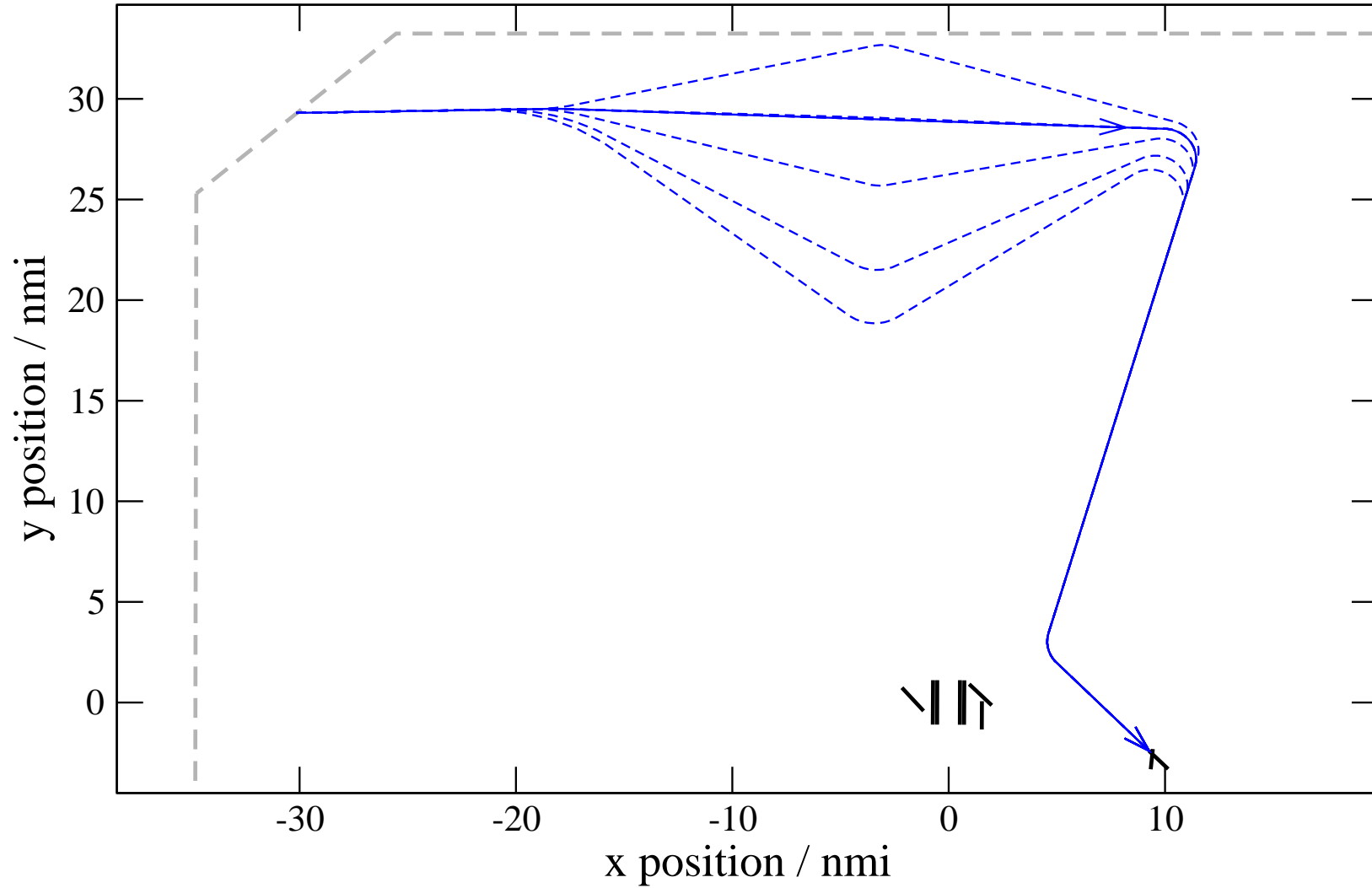
Symmetric Path-Stretch Routes

1512 (BE20 F DFW/18R Arr) step: 20 sec, max delay: 2.0 min, max err: 0.04 sec



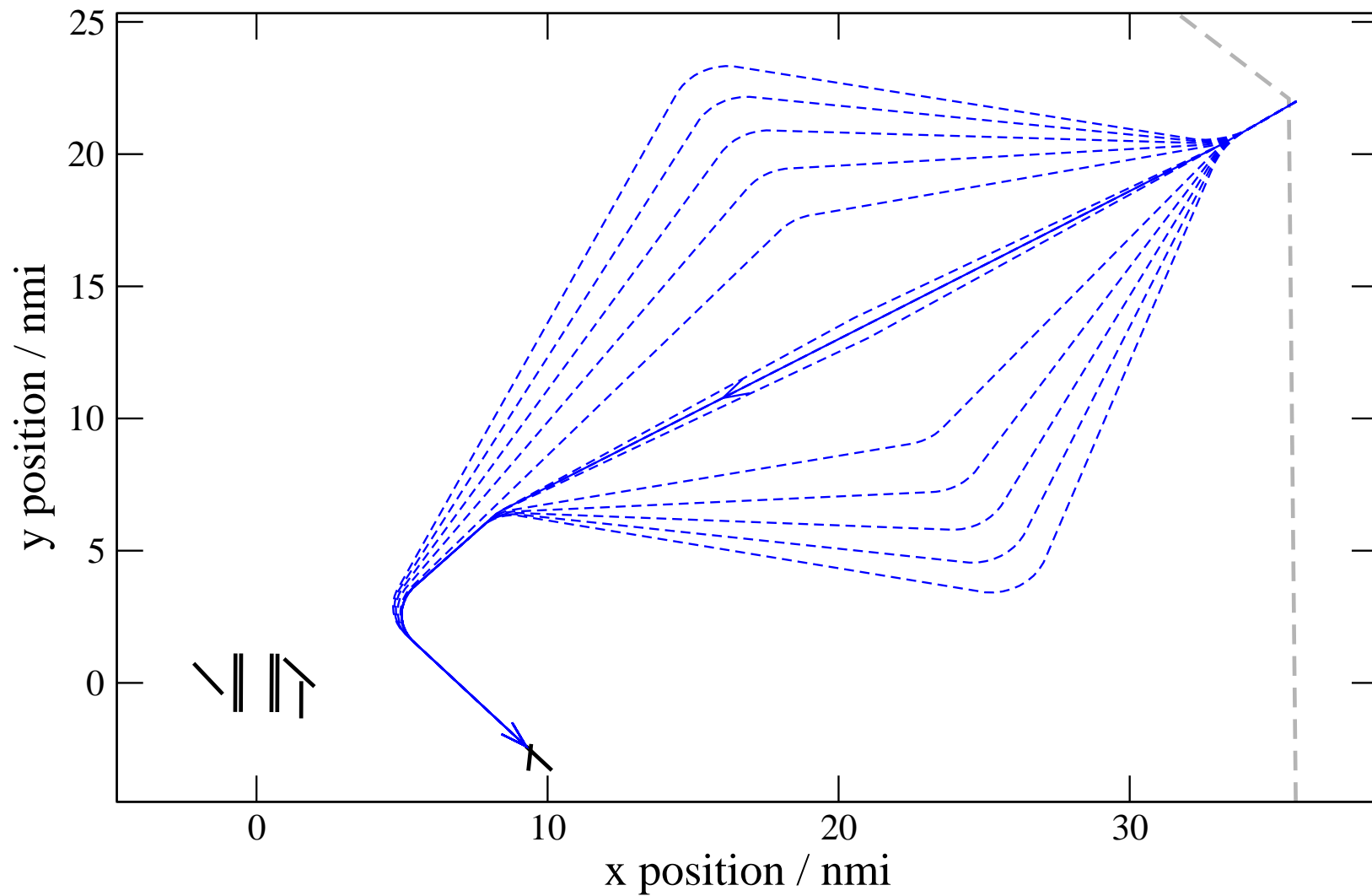
Symmetric Path-Stretch Routes

1514 (B737 D DAL/13L Arr) step: 20 sec, max delay: 0.7 min, max err: 0.01 sec



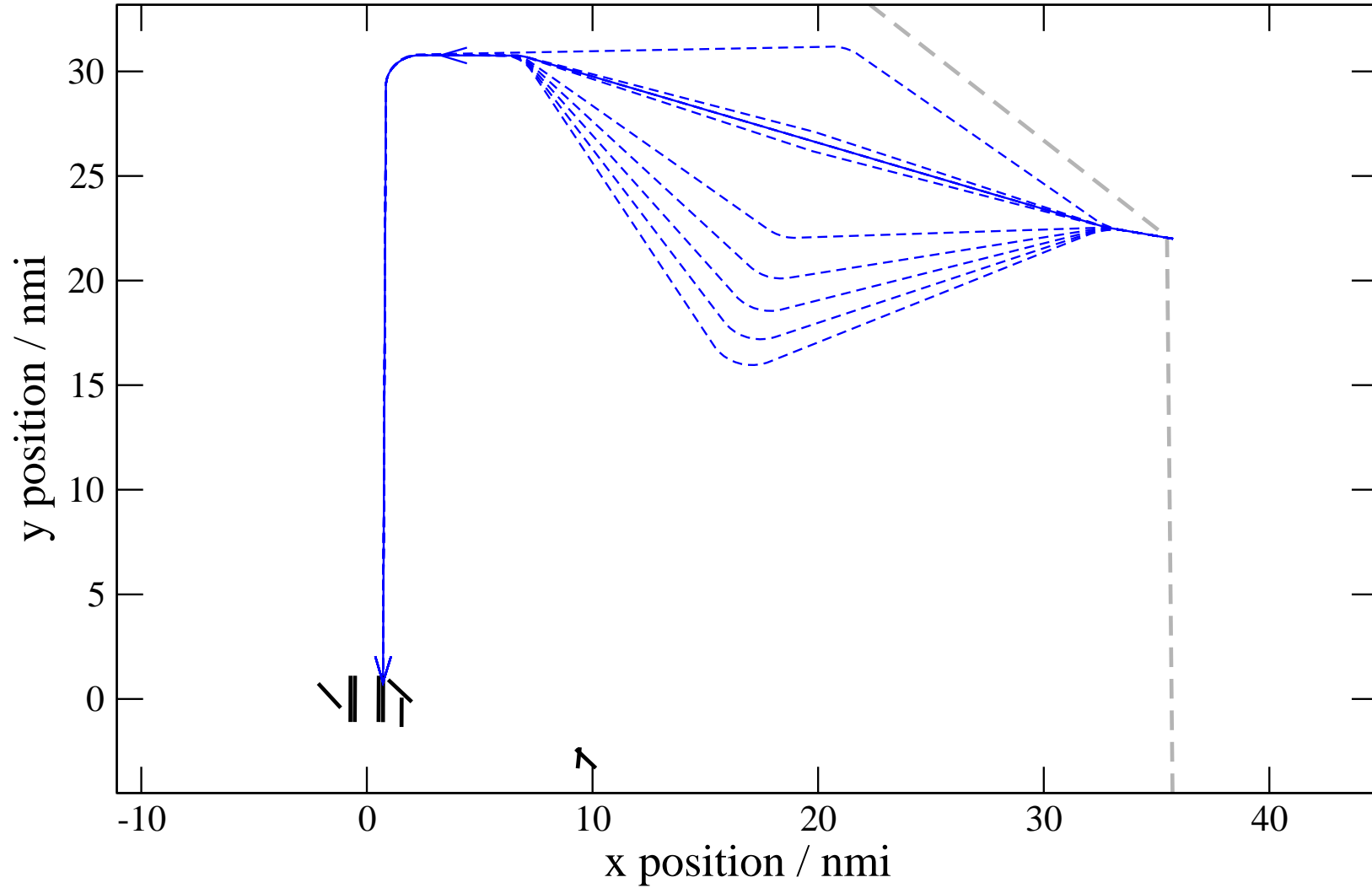
Symmetric Path-Stretch Routes

1558 (B733 D DAL/13L Arr) step: 20 sec, max delay: 1.7 min, max err: 0.02 sec



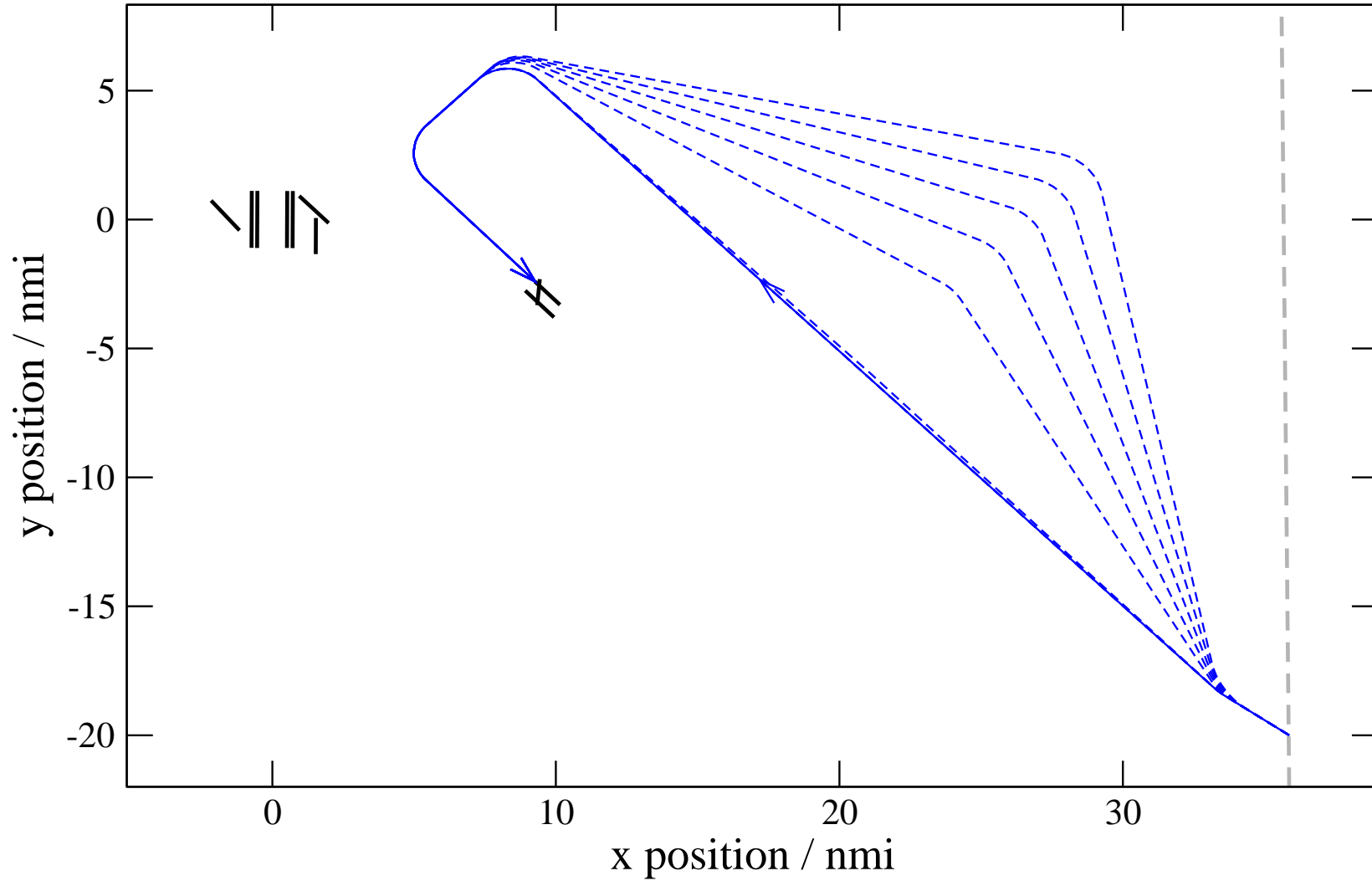
Symmetric Path-Stretch Routes

1620 (DC10 C DFW/17C Arr) step: 20 sec, max delay: 1.7 min, max err: 0.02 sec



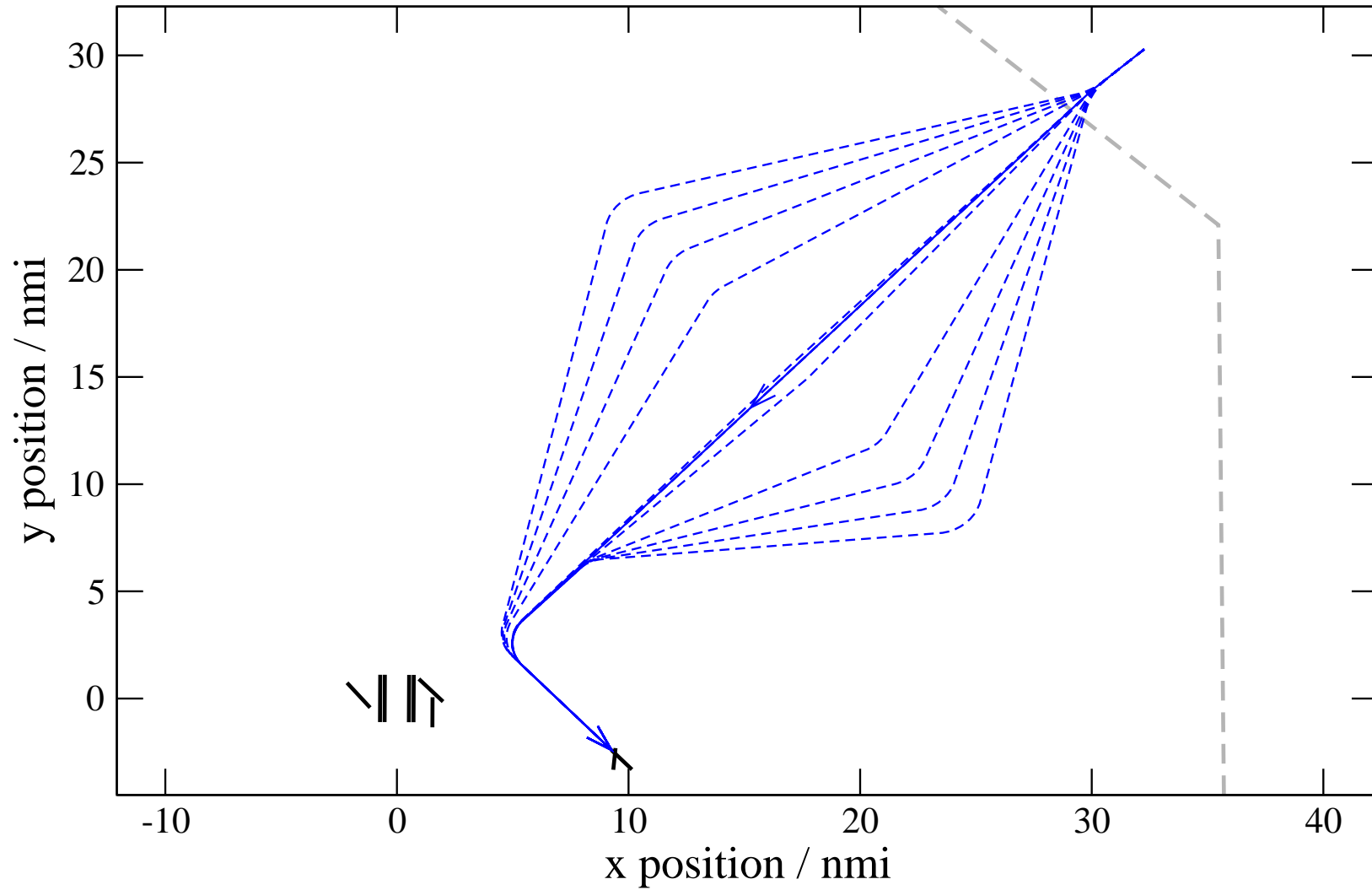
Symmetric Path-Stretch Routes

1688 (B737 D DAL/13L Arr) step: 20 sec, max delay: 1.7 min, max err: 0.00 sec



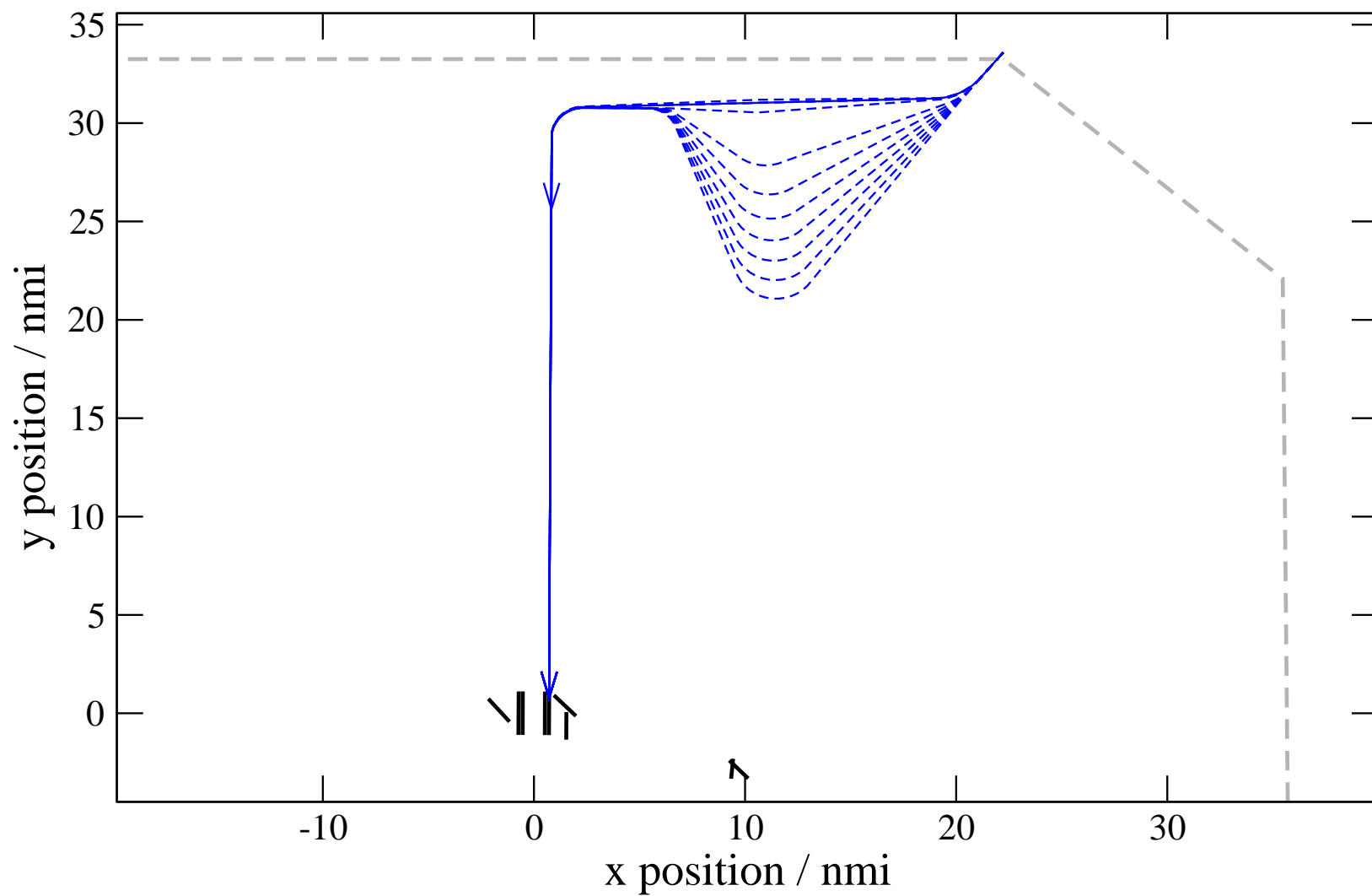
Symmetric Path-Stretch Routes

1704 (B737 D DAL/13L Arr) step: 20 sec, max delay: 1.3 min, max err: 0.02 sec



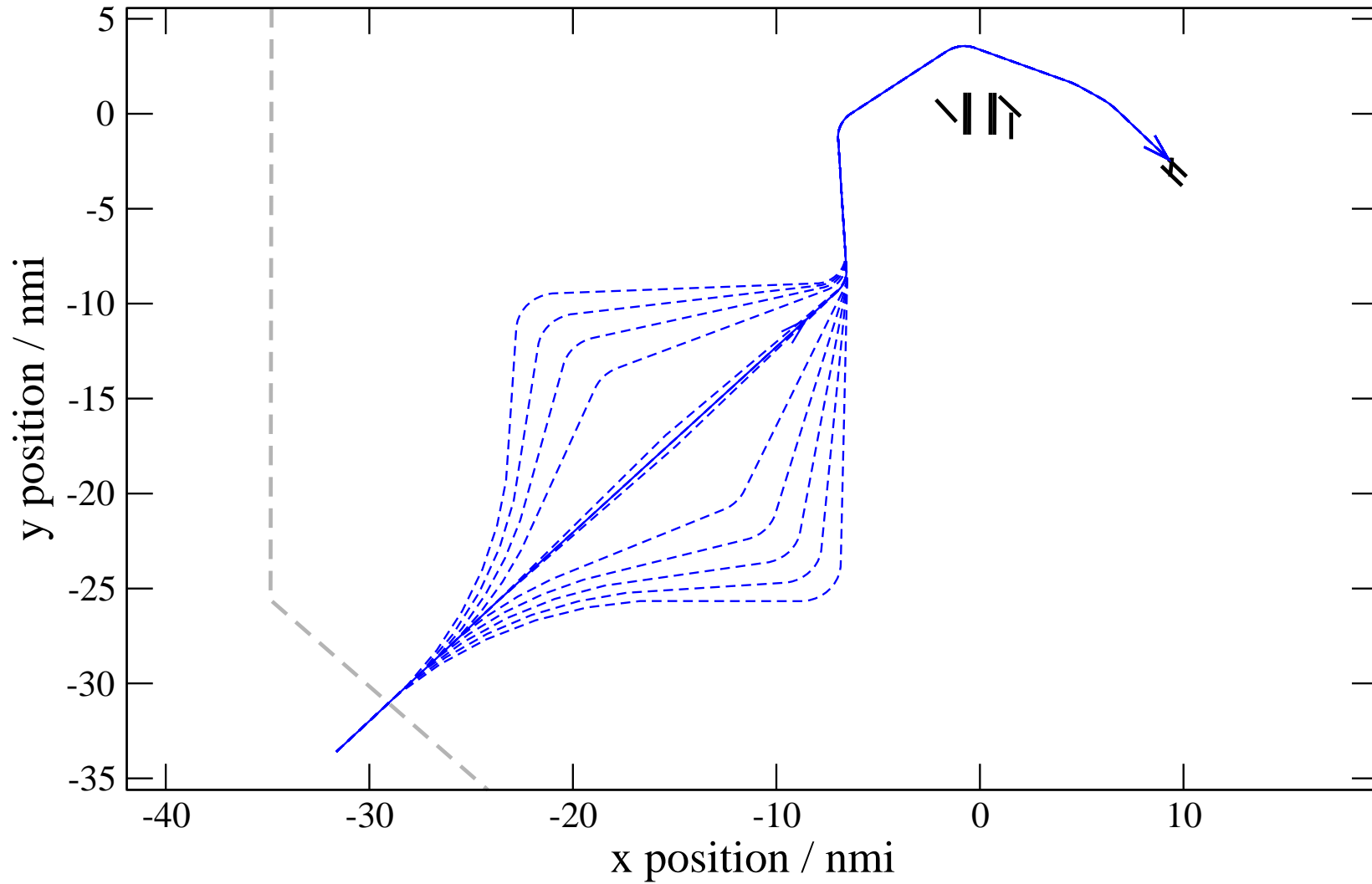
Symmetric Path-Stretch Routes

1809 (A306 C DFW/17C Arr) step: 20 sec, max delay: 2.3 min, max err: 0.05 sec



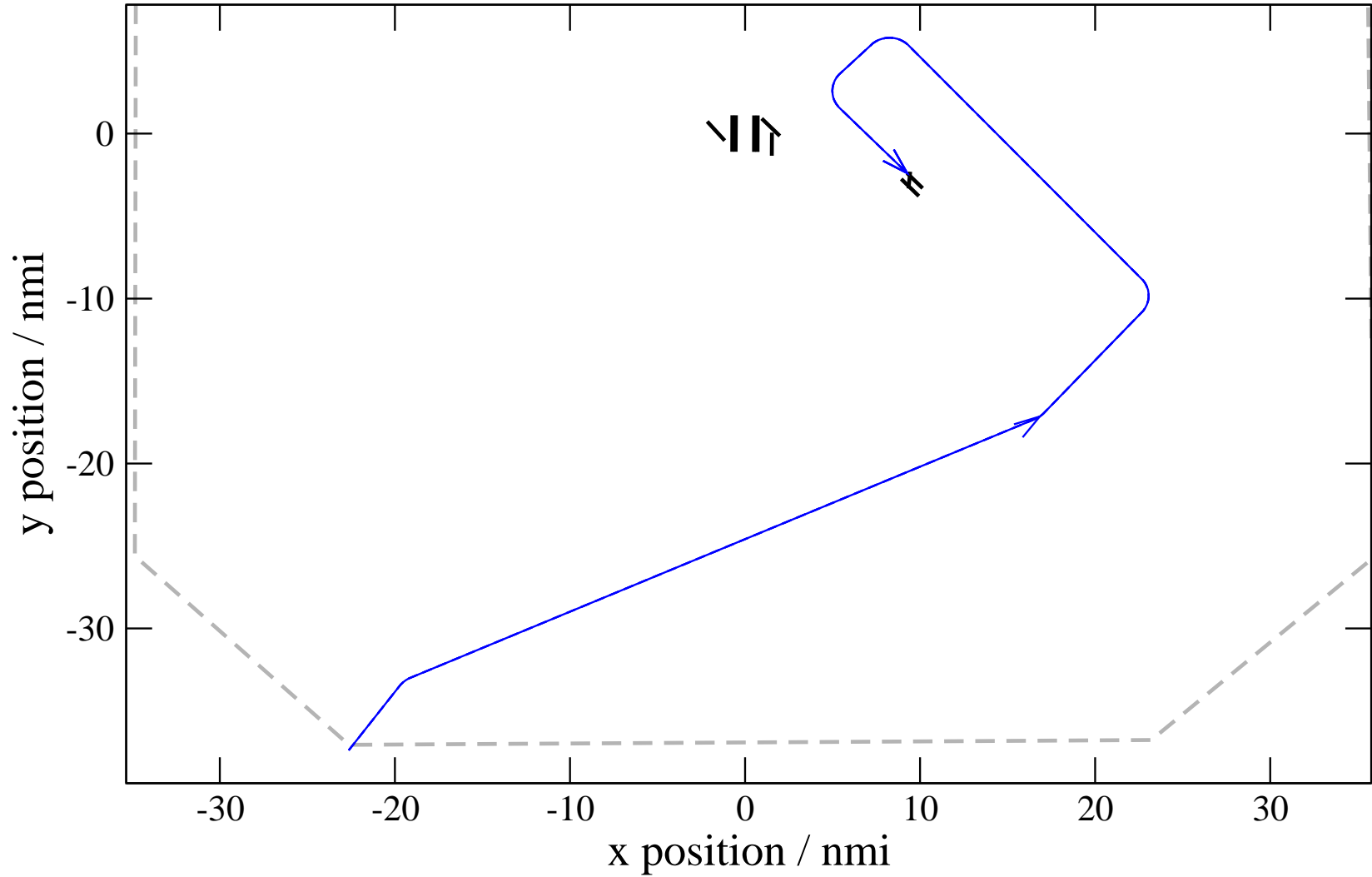
Symmetric Path-Stretch Routes

1841 (B733 D DAL/13L Arr) step: 20 sec, max delay: 1.7 min, max err: 0.13 sec



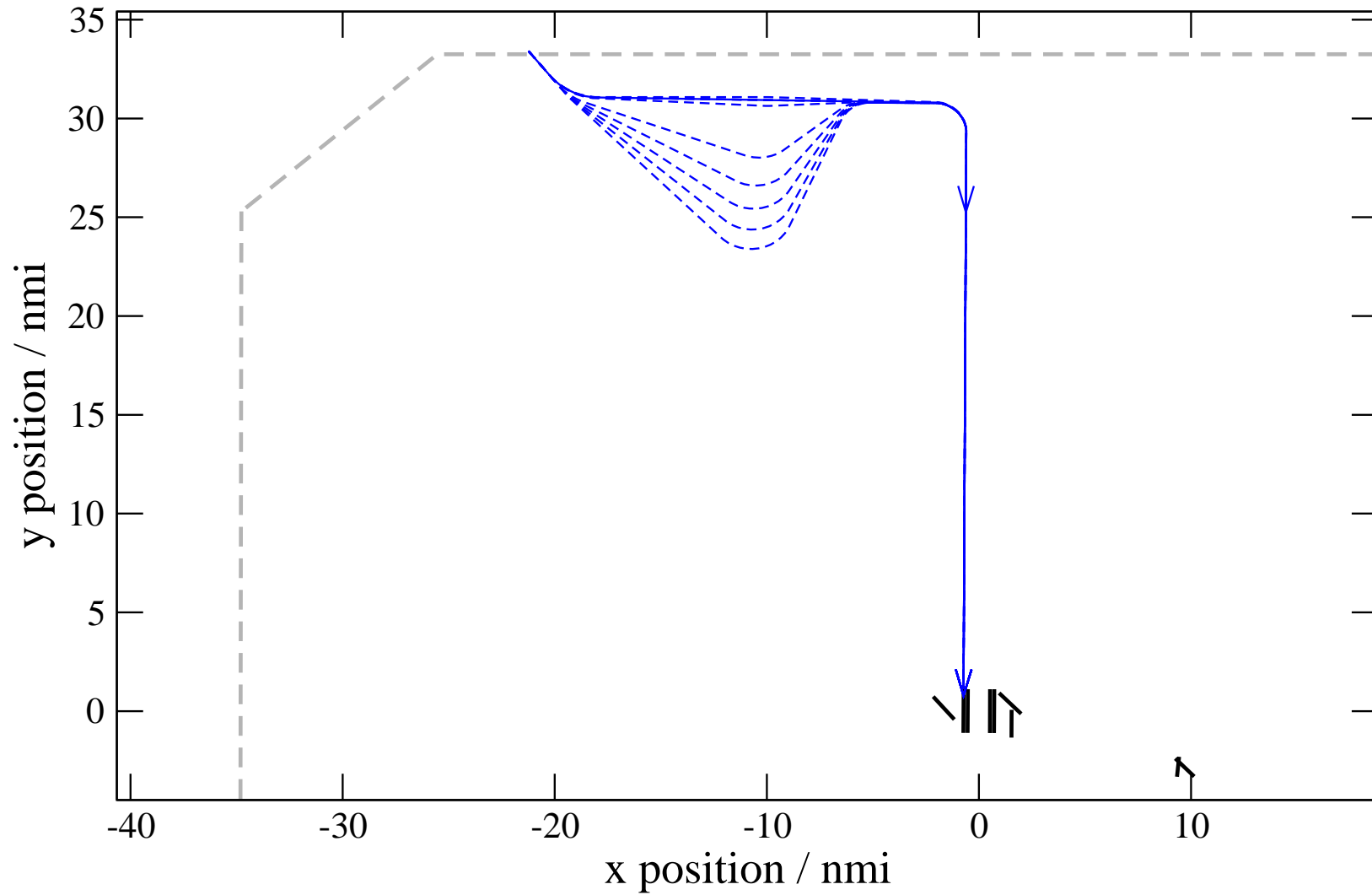
Symmetric Path-Stretch Routes

1842 (B733 D DAL/13L Arr) step: 20 sec, max delay: 0.0 min, max err: 0.00 sec



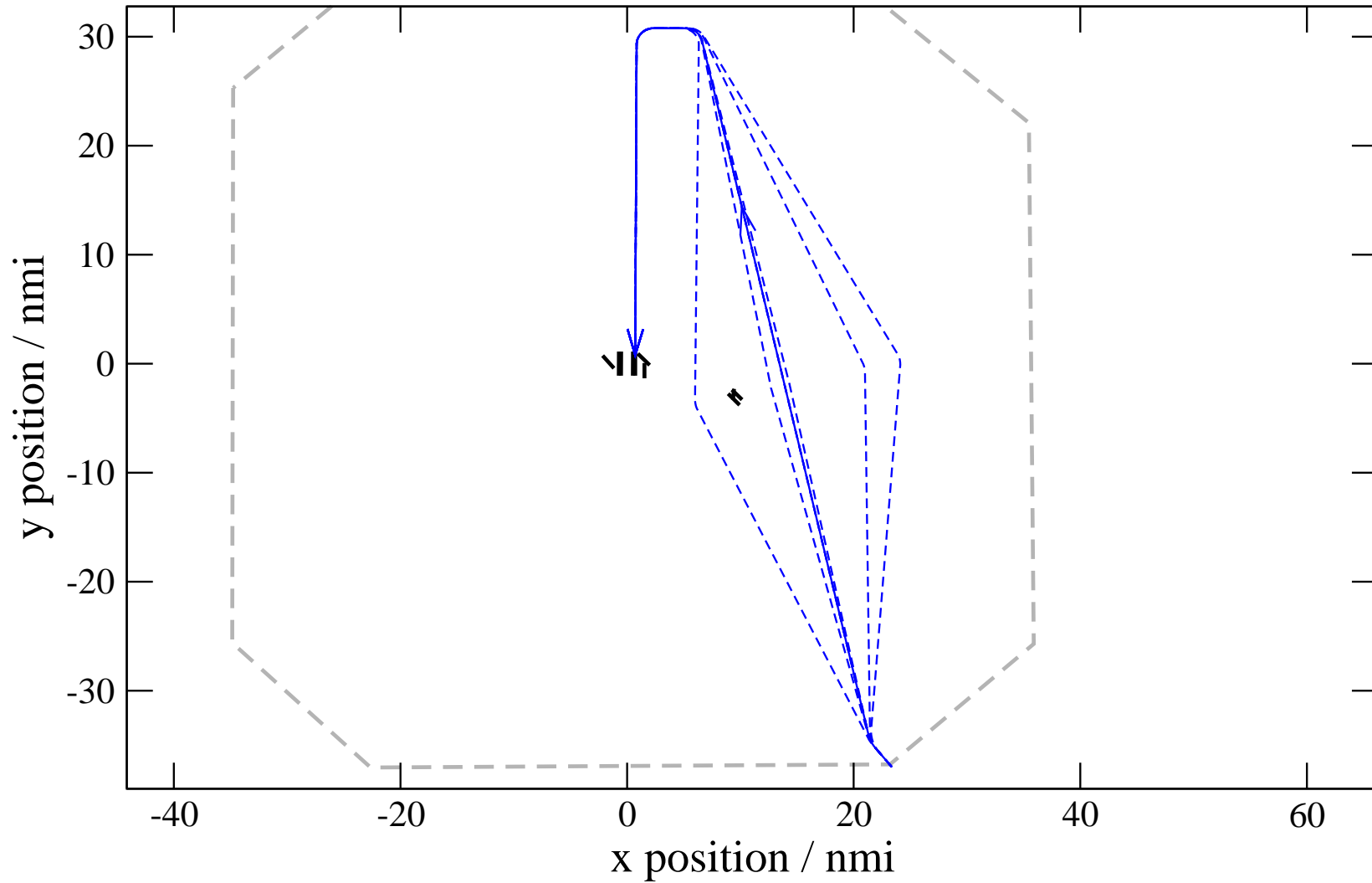
Symmetric Path-Stretch Routes

1911 (E145 E DFW/18R Arr) step: 20 sec, max delay: 1.7 min, max err: 0.00 sec



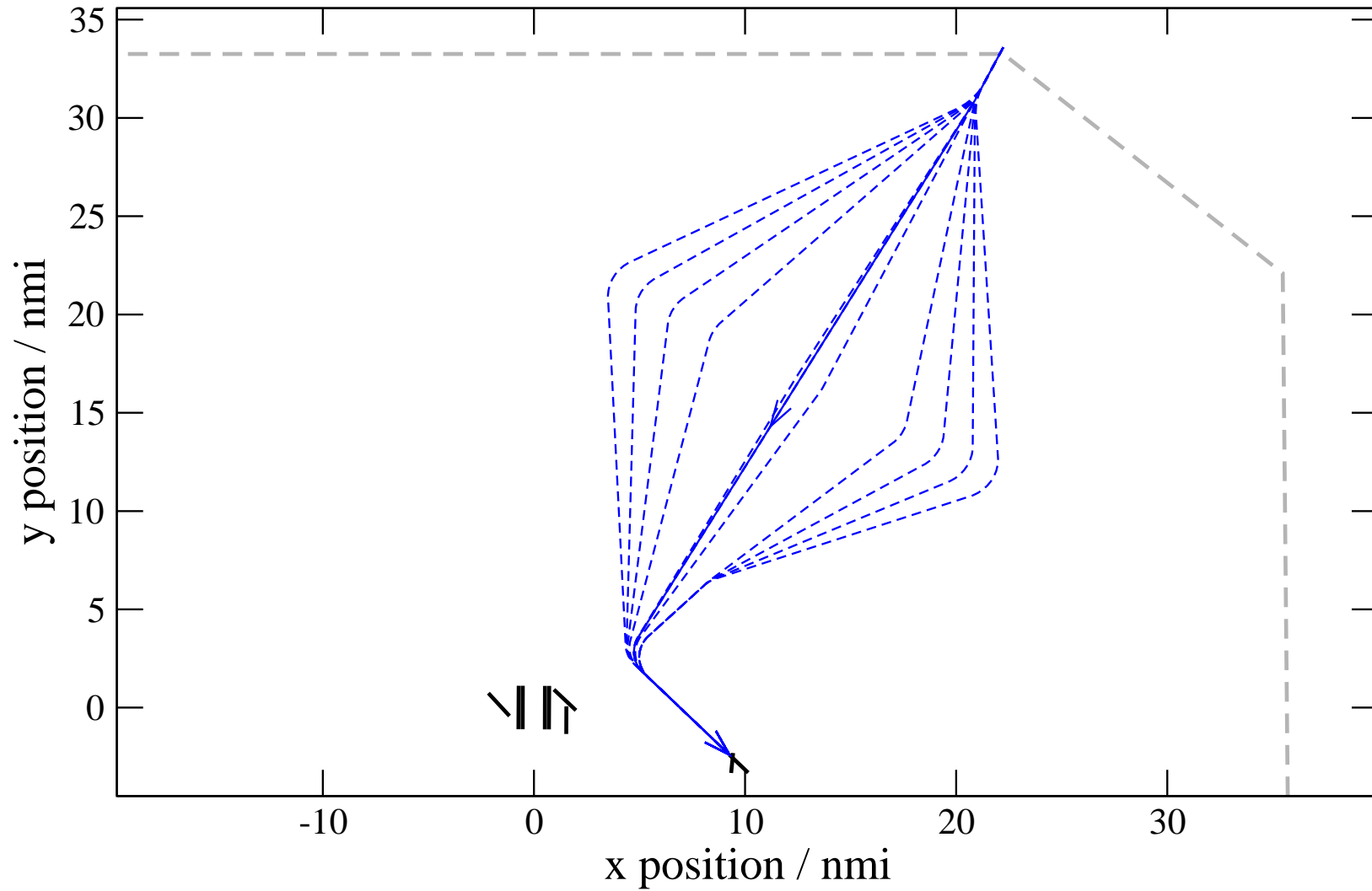
Symmetric Path-Stretch Routes

1922 (E135 E DFW/17C Arr) step: 20 sec, max delay: 0.7 min, max err: 0.02 sec



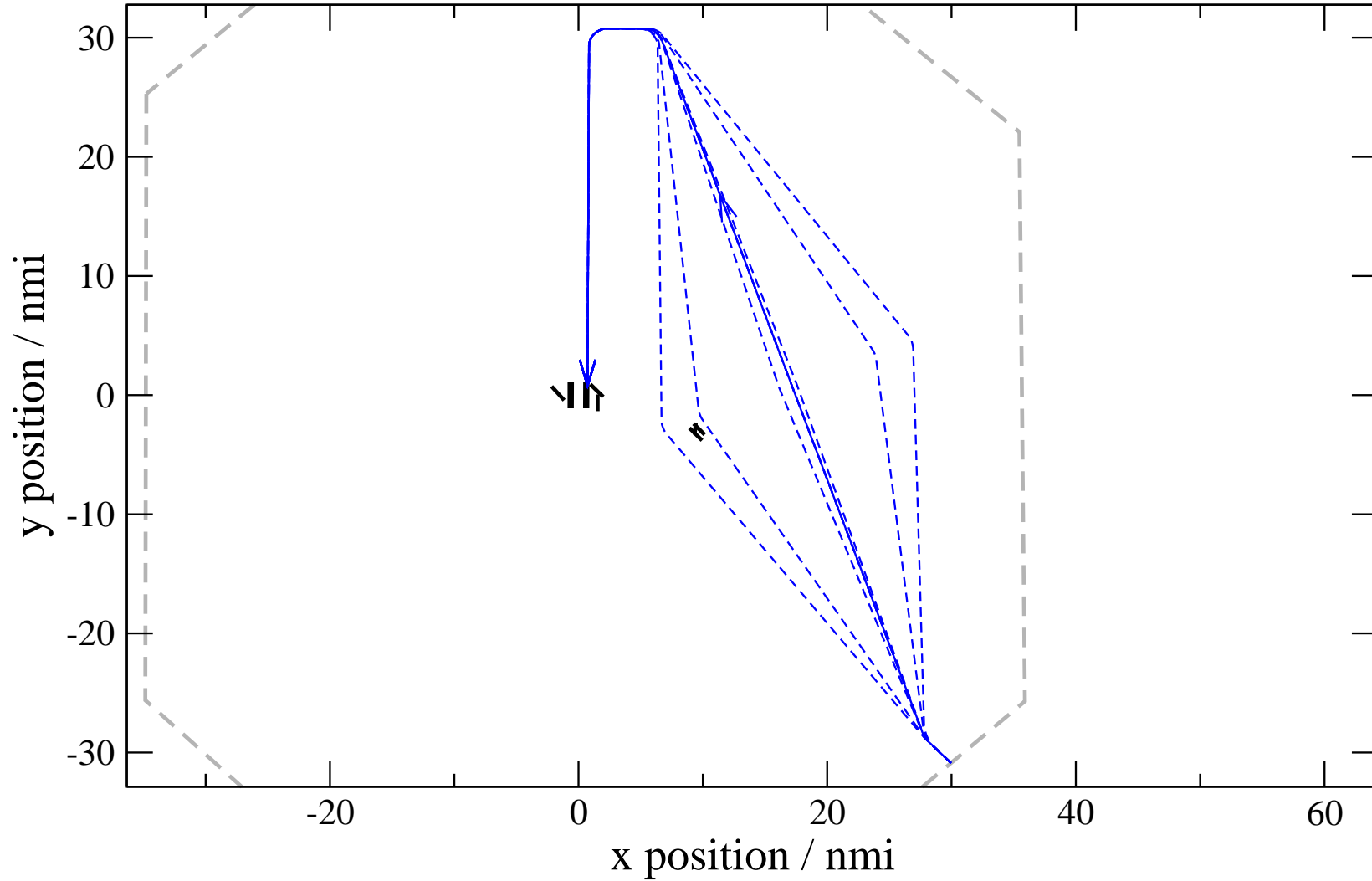
Symmetric Path-Stretch Routes

2002 (B737 D DAL/13L Arr) step: 20 sec, max delay: 1.3 min, max err: 0.03 sec



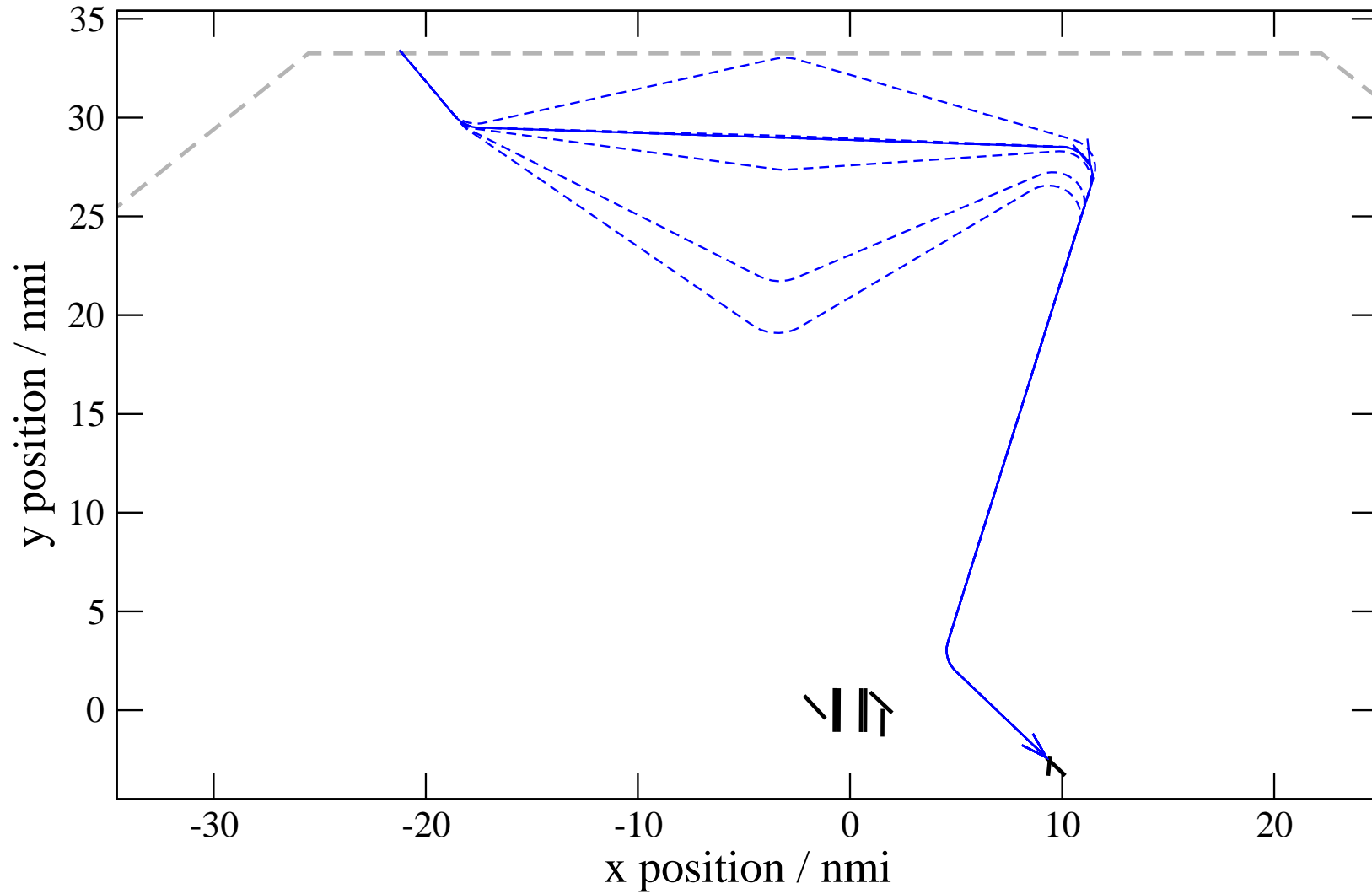
Symmetric Path-Stretch Routes

2118 (B763 C DFW/17C Arr) step: 20 sec, max delay: 0.7 min, max err: 0.05 sec



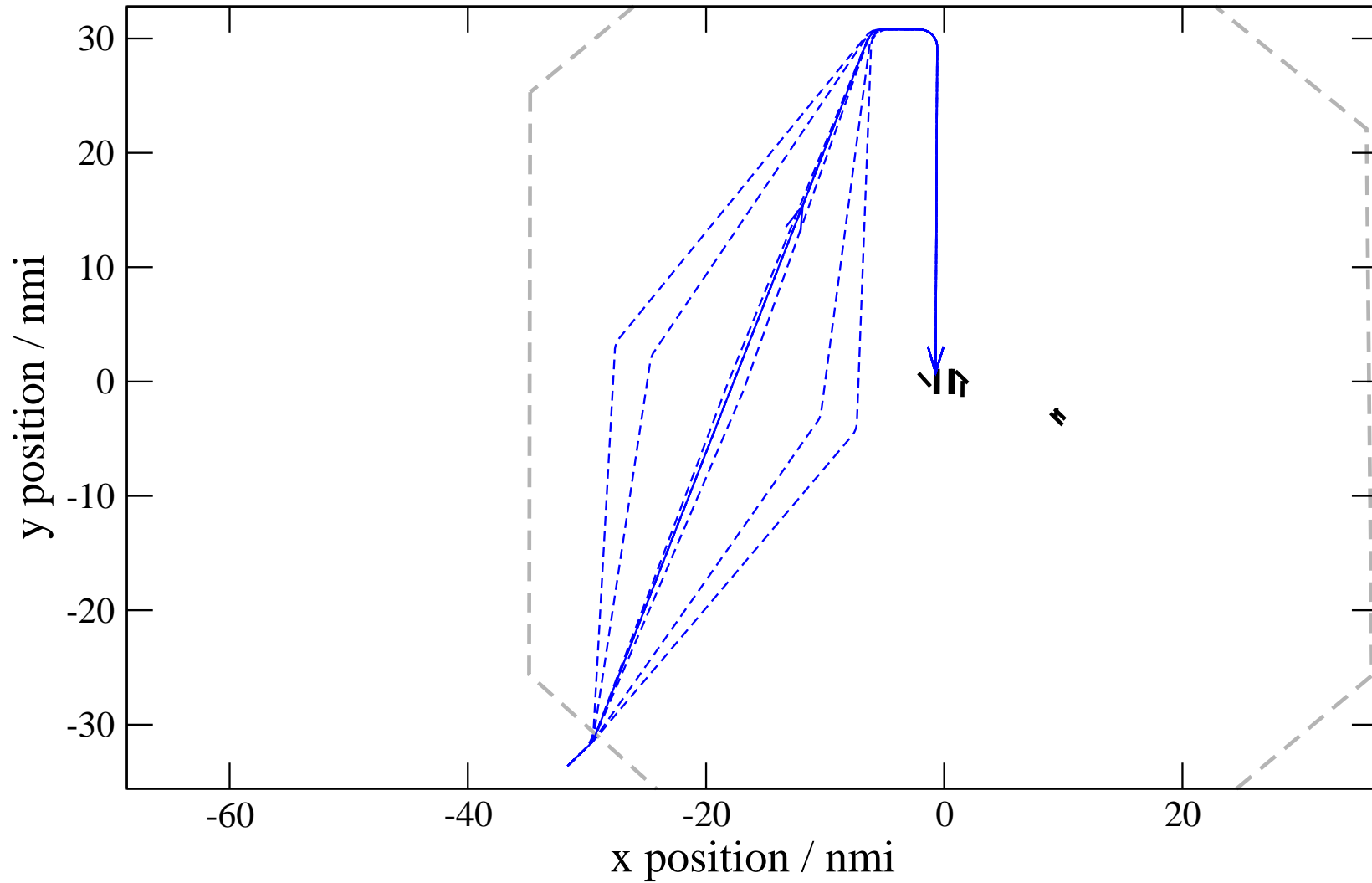
Symmetric Path-Stretch Routes

23 (C441 F DAL/13L Arr) step: 20 sec, max delay: 0.7 min, max err: 1.49 sec



Symmetric Path-Stretch Routes

25 (E135 E DFW/18R Arr) step: 20 sec, max delay: 0.7 min, max err: 0.05 sec



Symmetric Path-Stretch Routes

54 (E135 E DFW/17C Arr) step: 20 sec, max delay: 0.7 min, max err: 0.05 sec

