Visualizing size-security tradeoffs for lattice-based encryption

Daniel J. Bernstein

Horizontal axis: ciphertext size

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but `sntrup` beats `ntrulpr` in ciphertext size.

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— Google's 2016 experiment used key+ciphertext. But long term: Use IND-CCA2 to multicast+cache public keys (2015 McGrew). Lattice traffic is then much closer to ciphertext than to key+ciphertext.

Vertical axis: Core-SVP security estimate

Beware (potential/actual) oversimplifications inside lattice security estimates. Can lead to:

- Overstating security.
- Understating security—damaging deployment.
- Damaging comparisons: e.g. omitting "hybrid attacks"; e.g. overstating `sntrup` "rotations".

Vertical axis: Core-SVP security estimate

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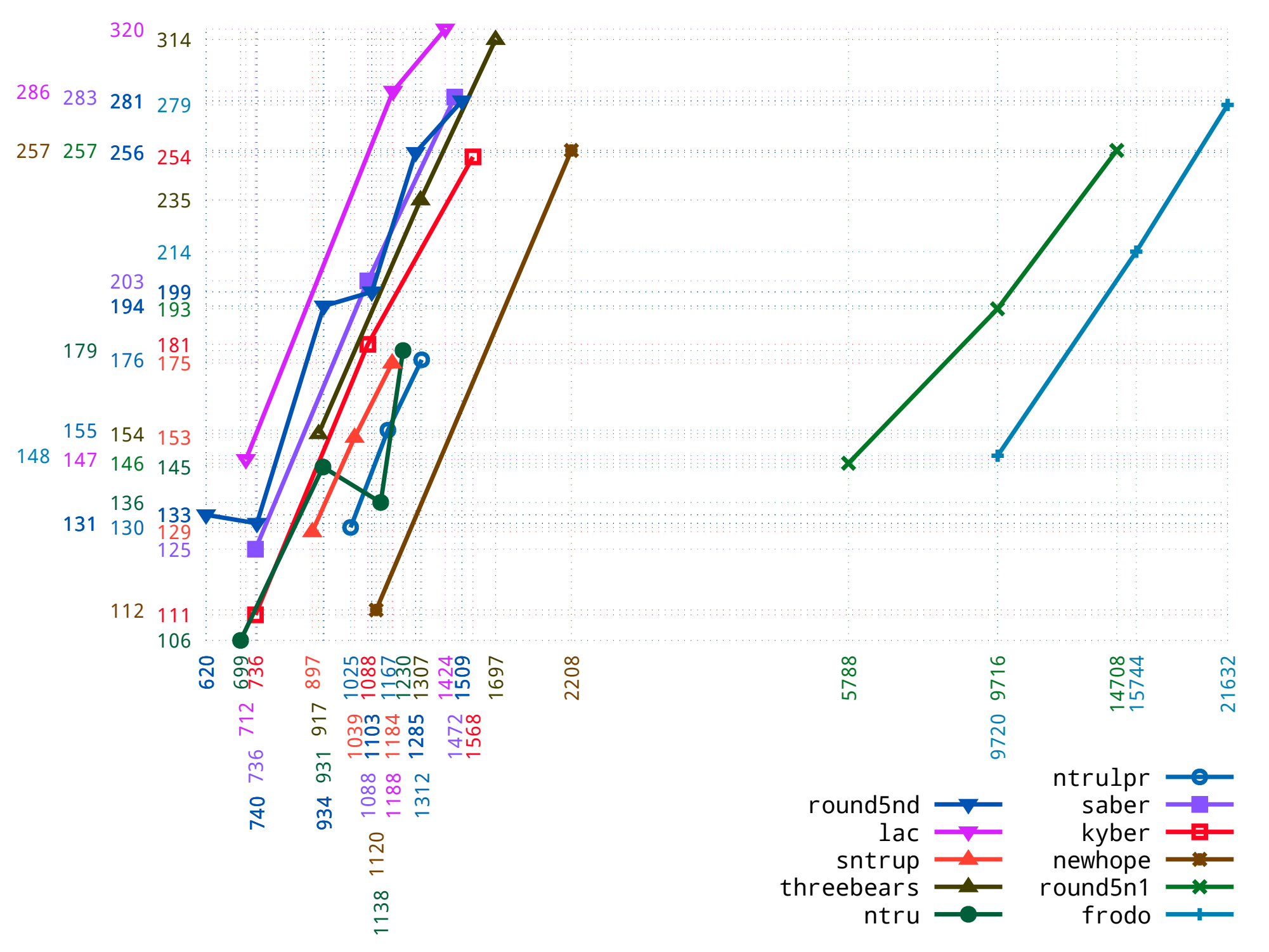
Some work on better estimates; should continue this work, re-estimate all the schemes, draw new graphs.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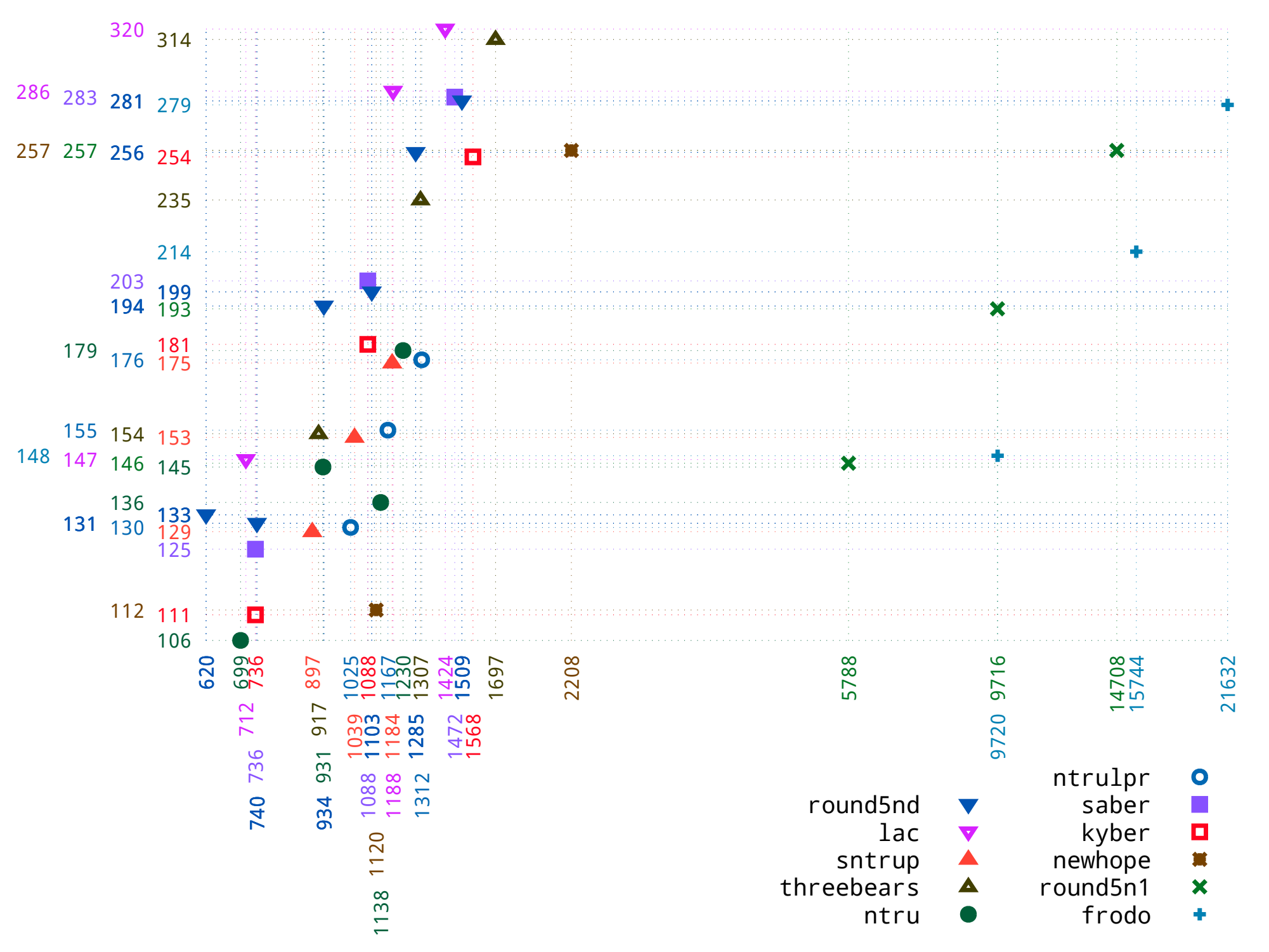
sntrup
threebears
ntru
ntrulpr
saber
kyber
newhope
round5n1
frodo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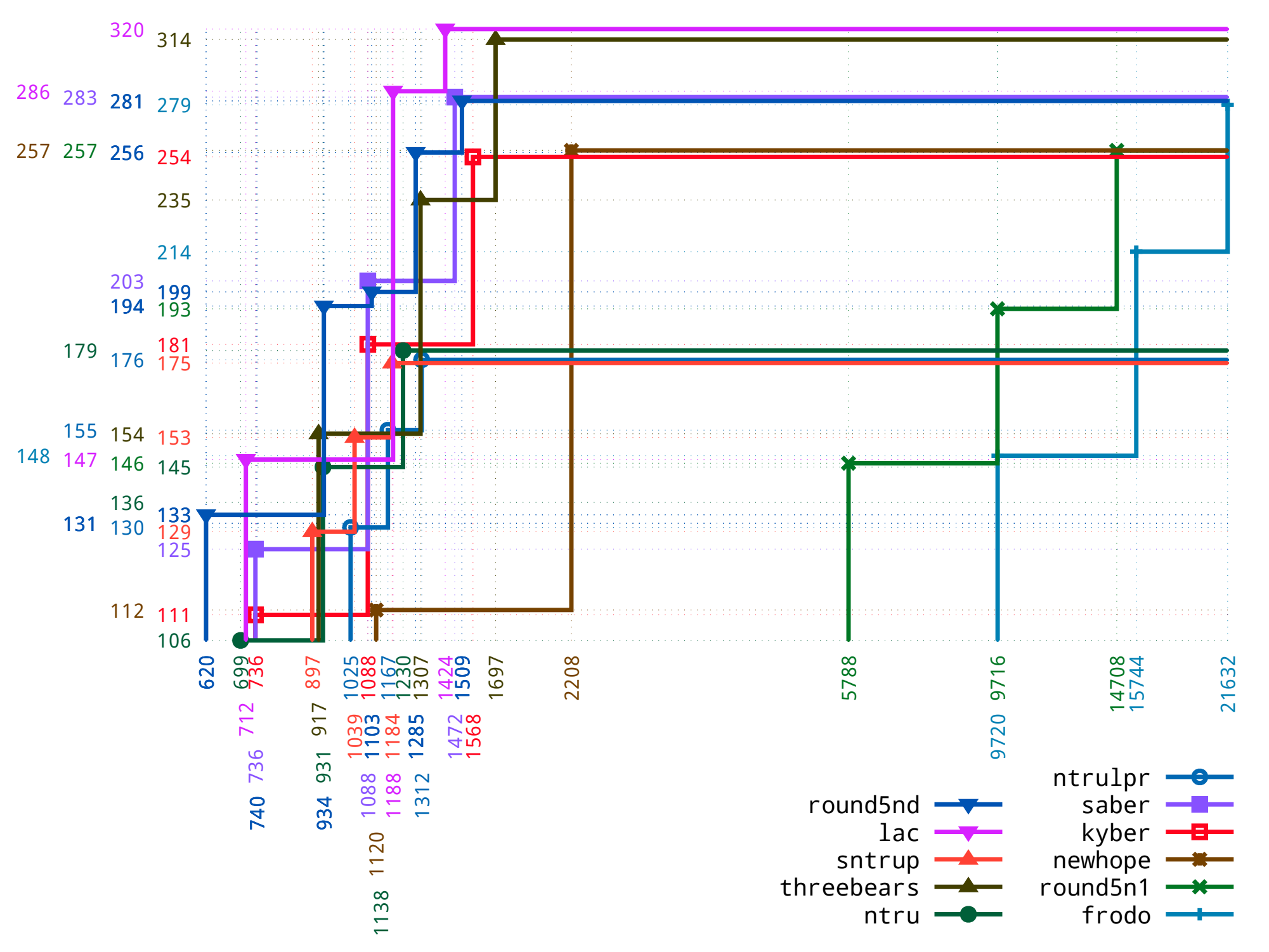
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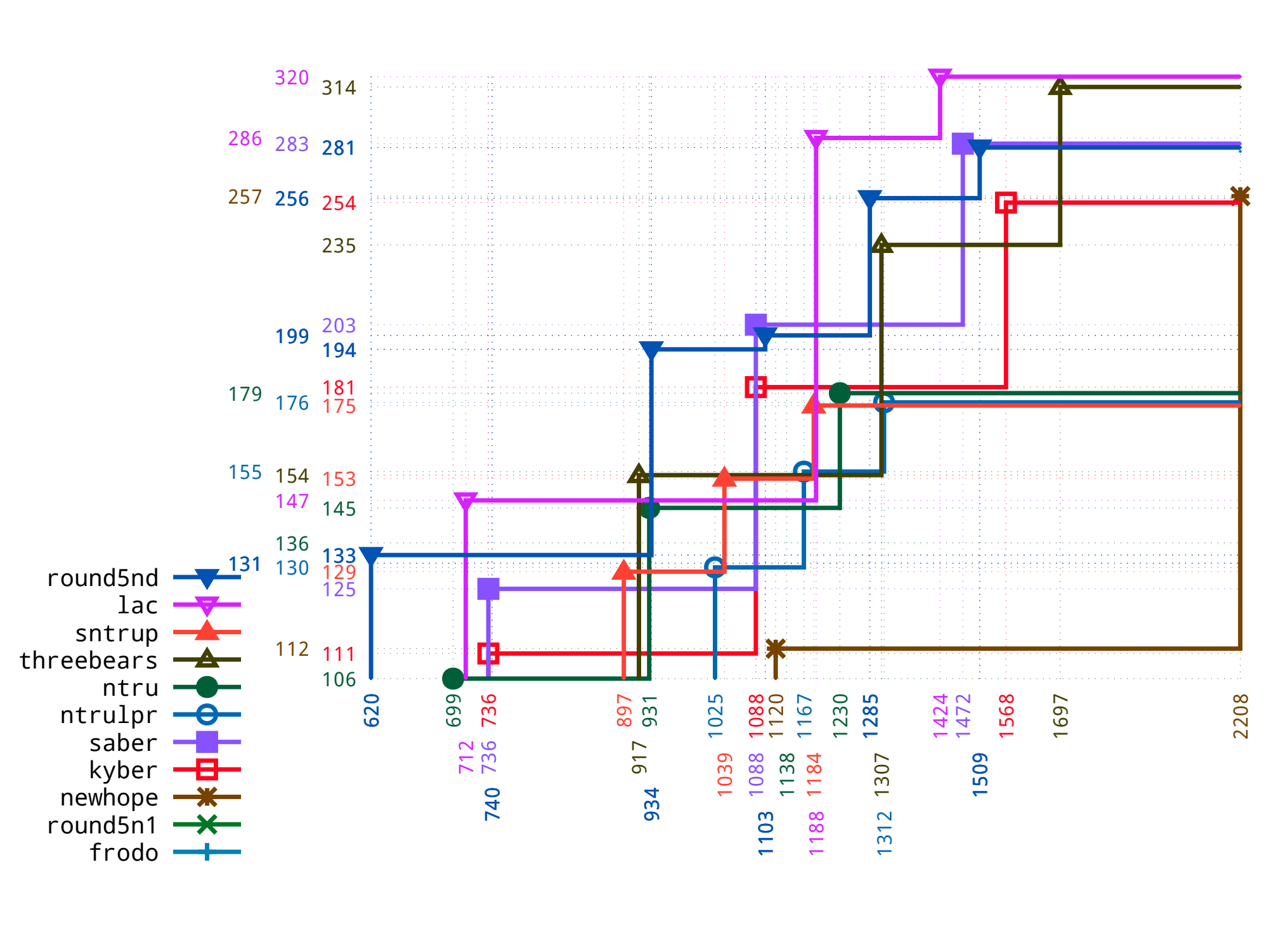
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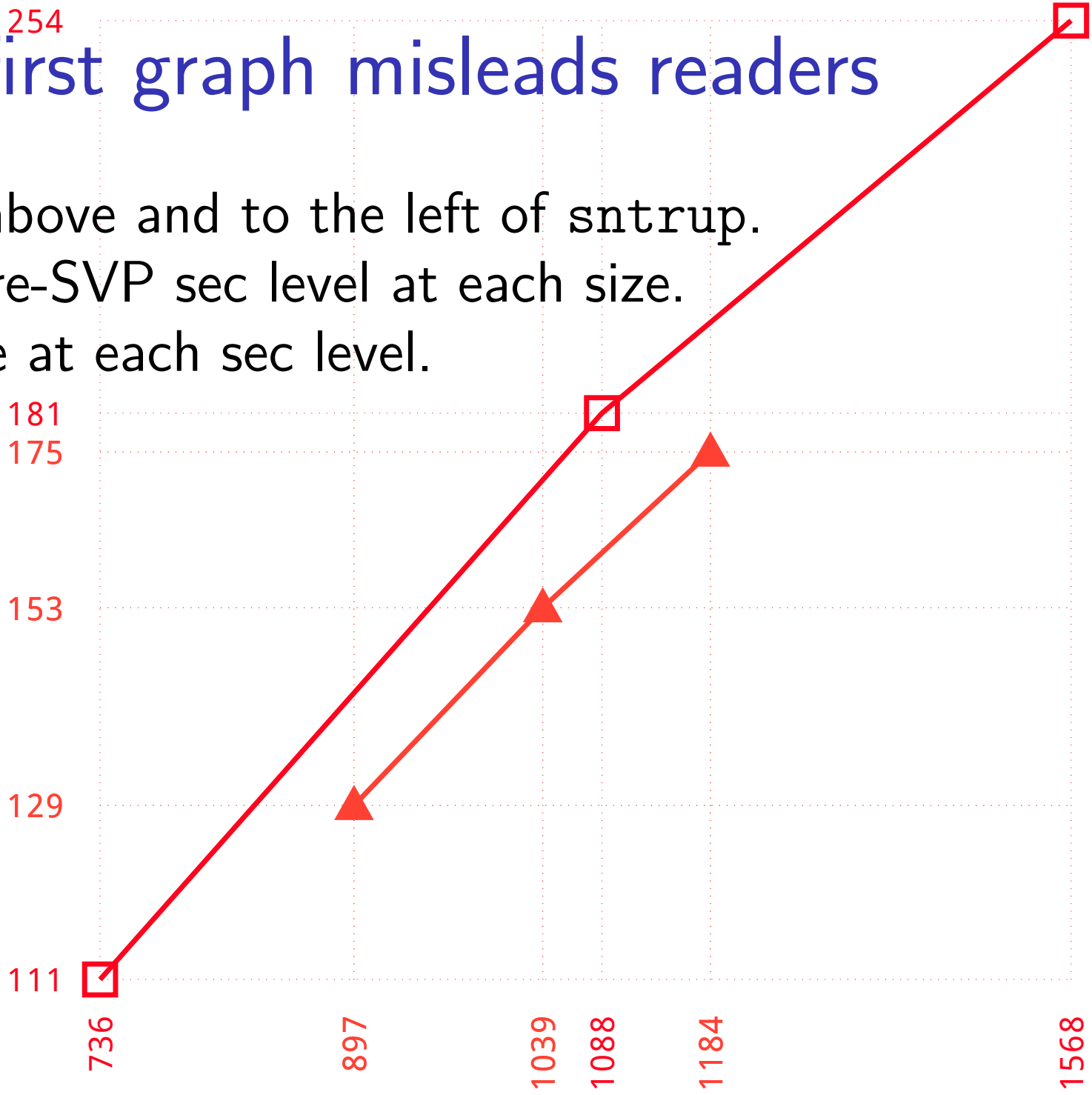
How the first graph misleads readers

`kyber` is above and to the left of `sntrup`.
Better Core-SVP sec level at each size.
Better size at each sec level.



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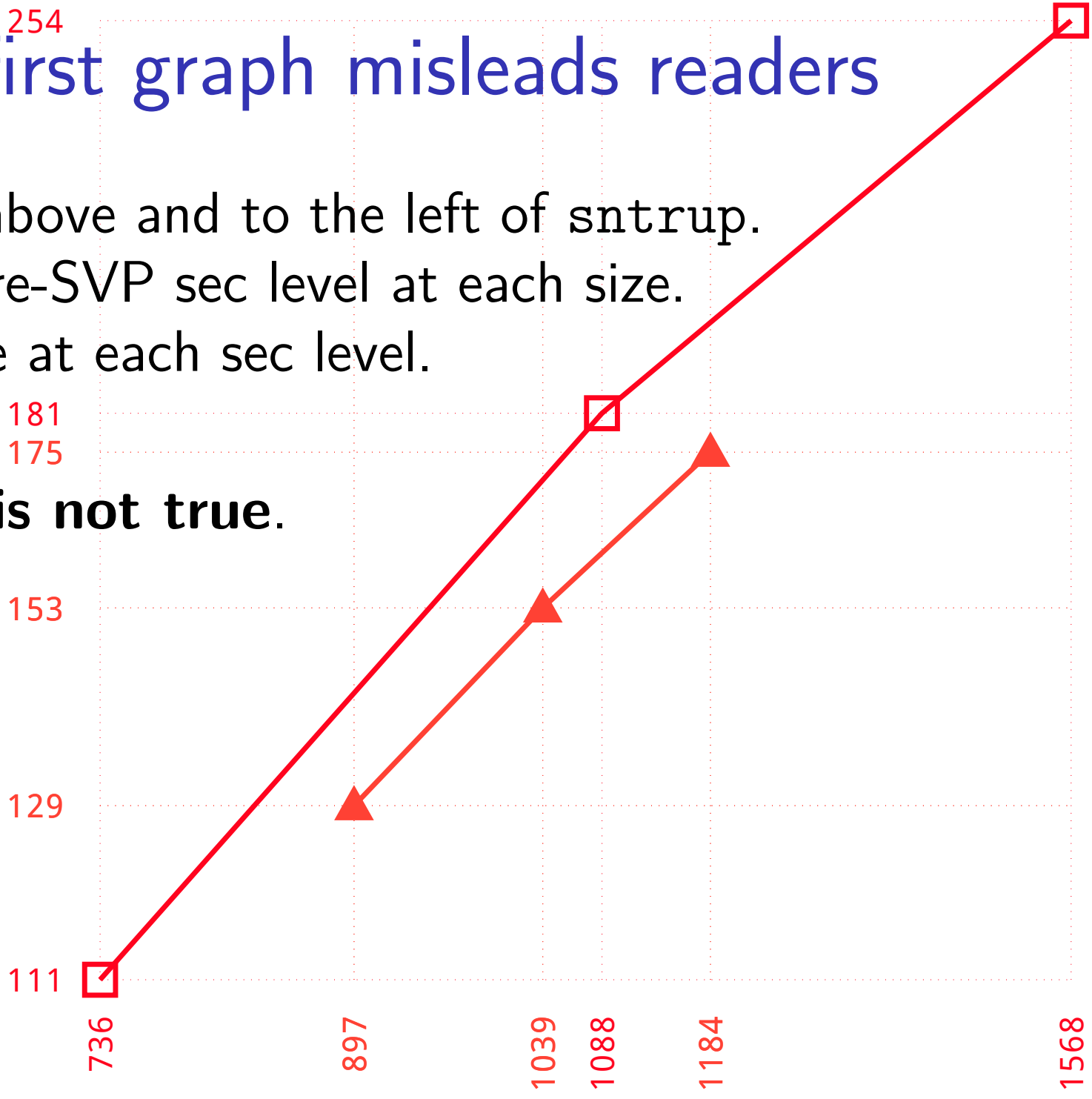

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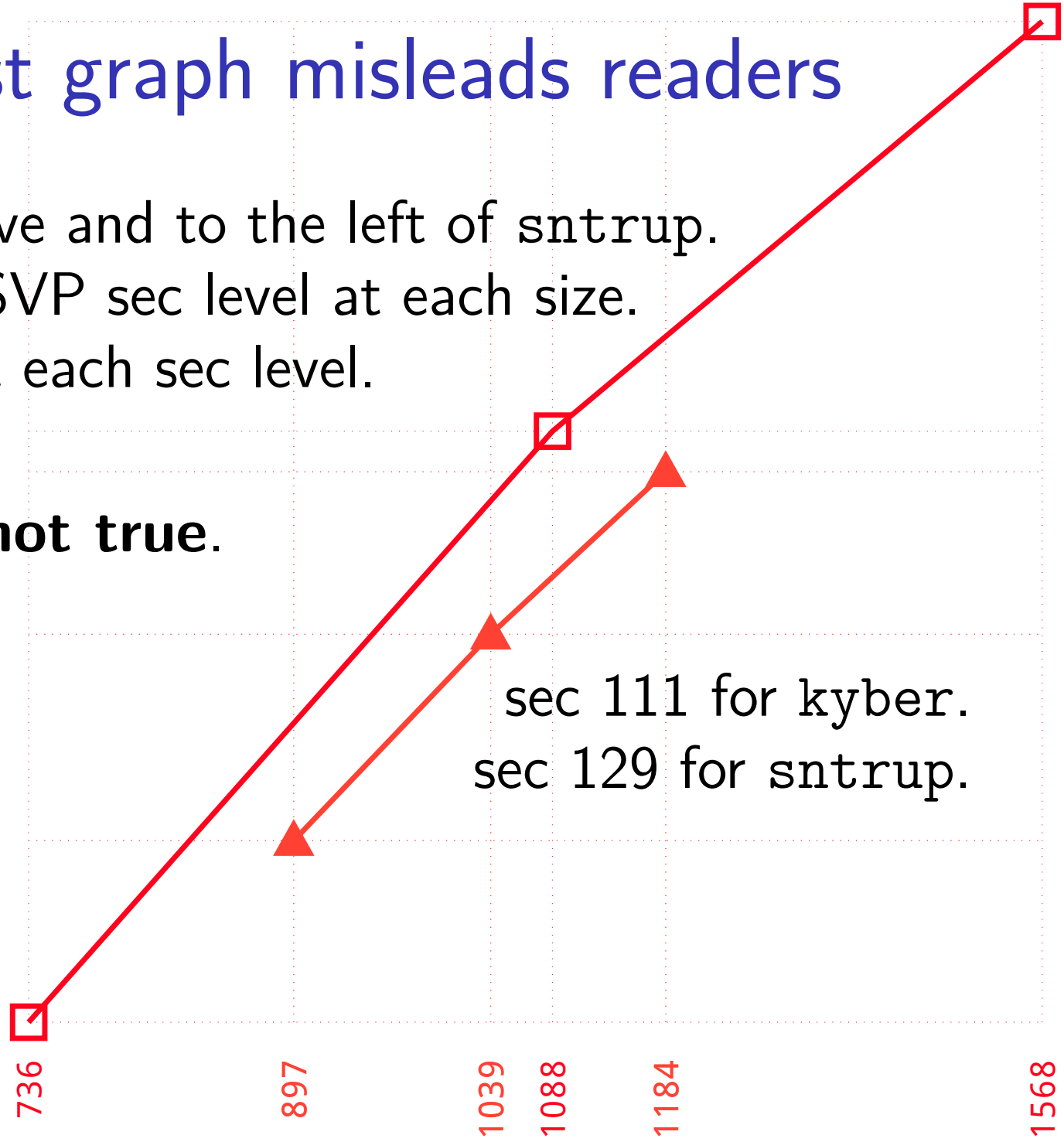
User requires size ≤ 1024:



sec 111 for `kyber`.
sec 129 for `sntrup`.

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User requires size ≤ 1024:
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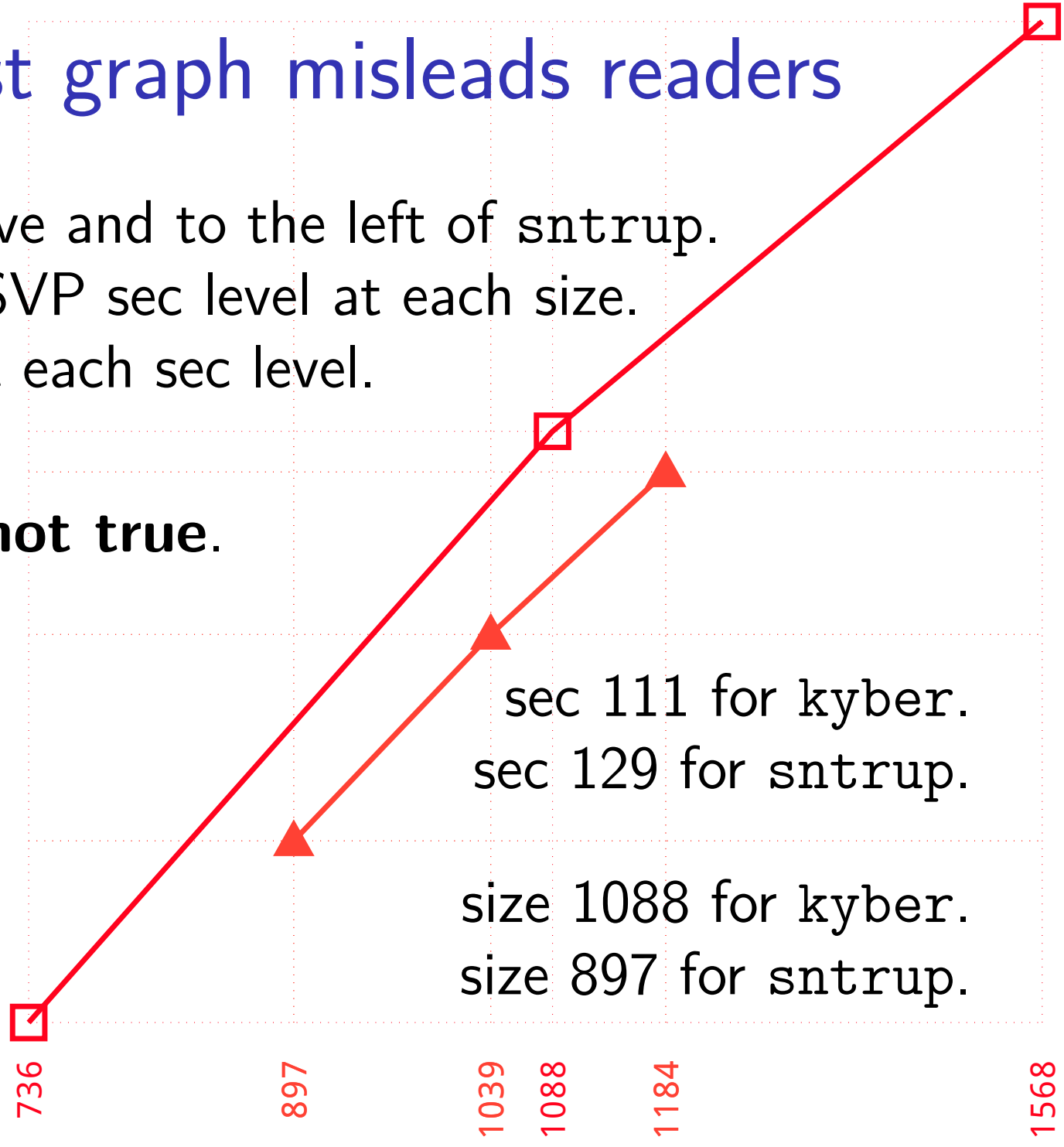
User requires sec ≥ 128:
size 1088 for `kyber`.
size 897 for `sntrup`.



Ciphertext-size comparison examples

Core-SVP for `sntrup` options: 129, 153, 175.
User picks $\lambda \geq 100$, requires Core-SVP $\geq \lambda$.

X	size(`sntrup`) $<$ size(X) for λ in
`frodo`	$\{100, \ldots, 175\}$
`kyber`	$\{112, \ldots, 153\}$
`lac`	$\{148, \ldots, 175\}$
`newhope`	$\{100, \ldots, 175\}$
`ntru`	$\{107, \ldots, 129\} \cup \{146, \ldots, 175\}$
`round5n1`	$\{100, \ldots, 175\}$
`round5nd`	$\{\}$
`saber`	$\{126, \ldots, 153\}$
`threebears`	$\{100, \ldots, 129\} \cup \{155, \ldots, 175\}$

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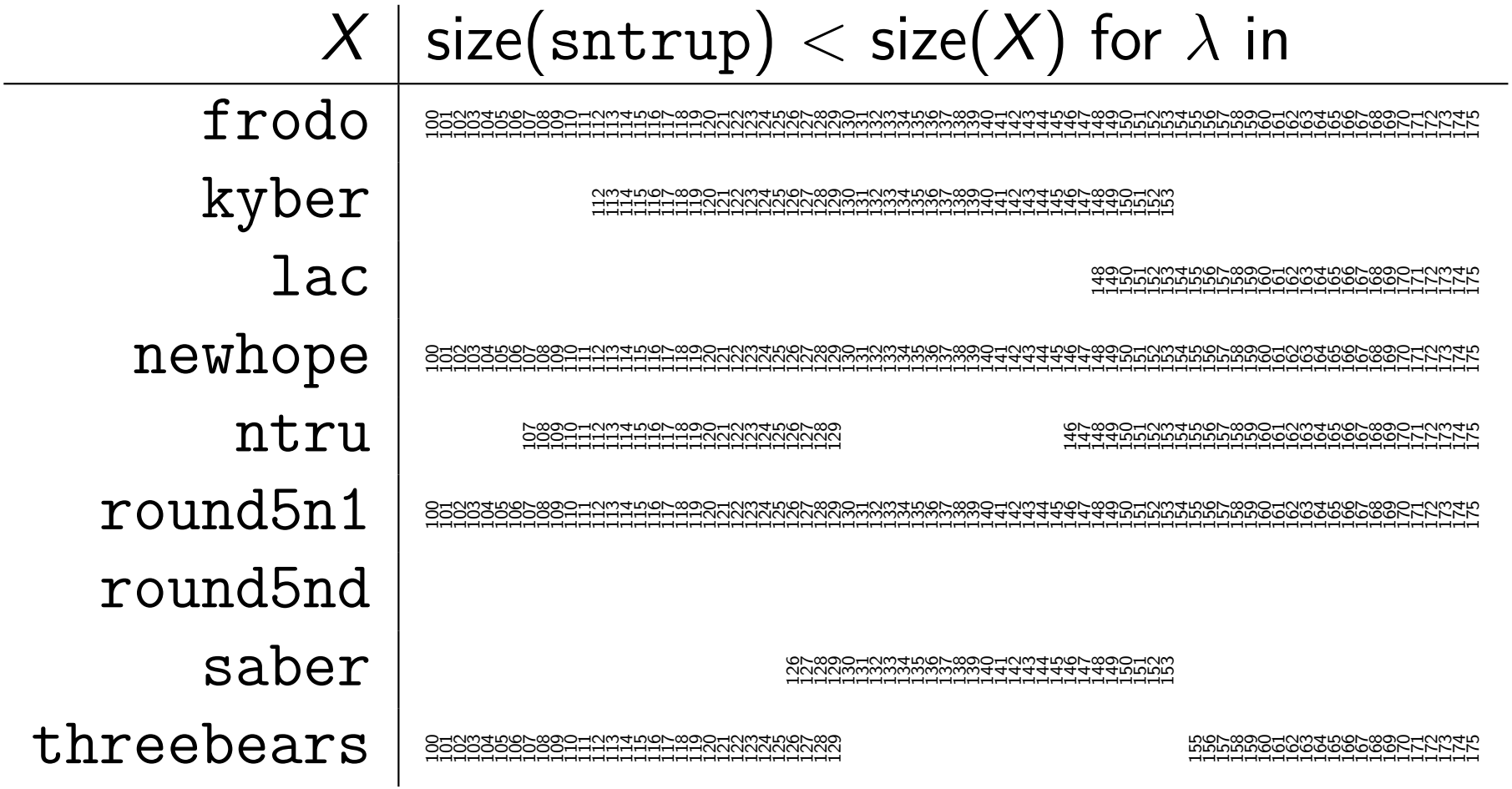


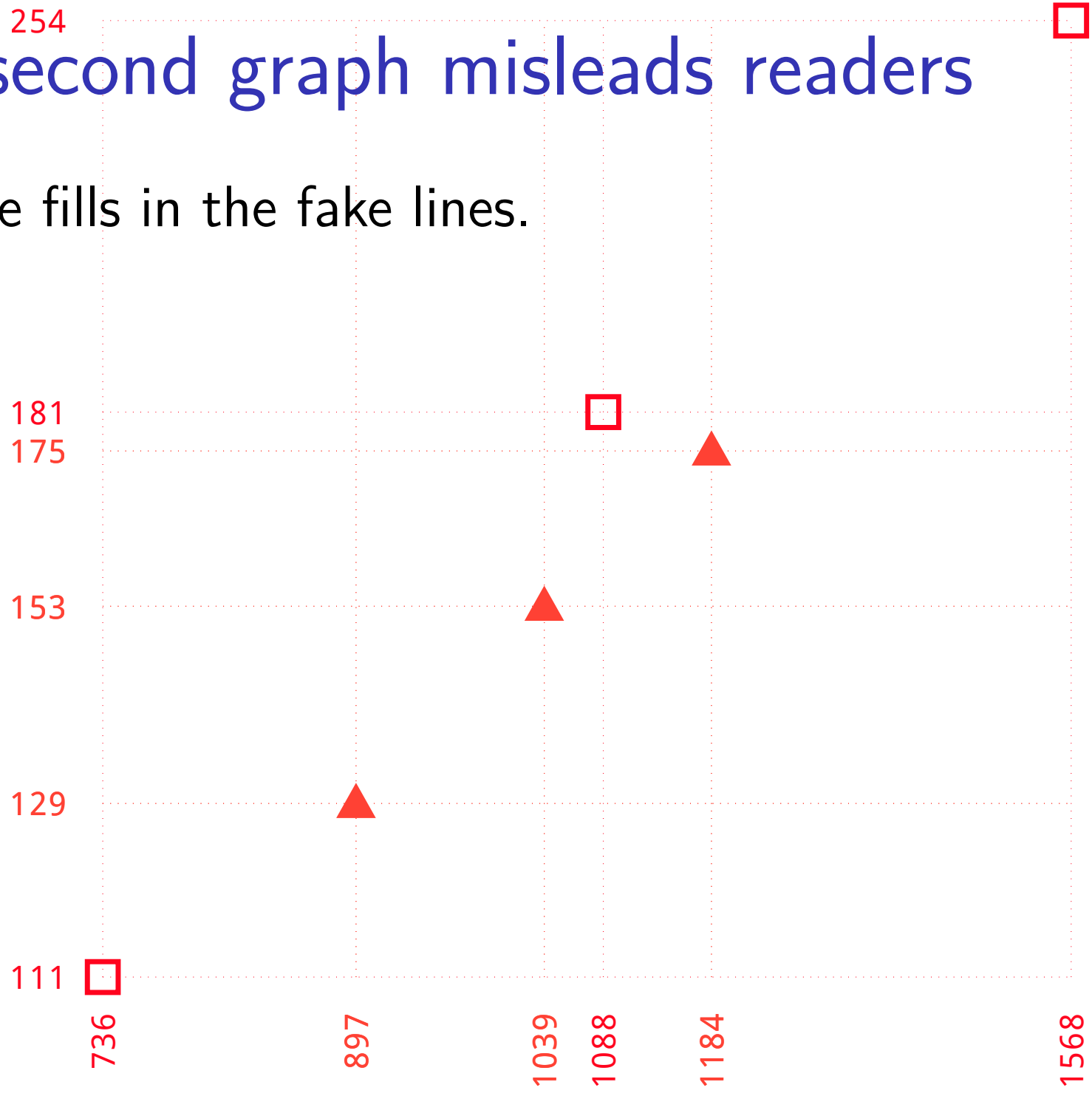
Core-SVP comparison examples

Ciphertext sizes for `sntrup`: 897, 1039, 1184.
User picks $S \leq 1280$, requires ciphertext size $\leq S$.

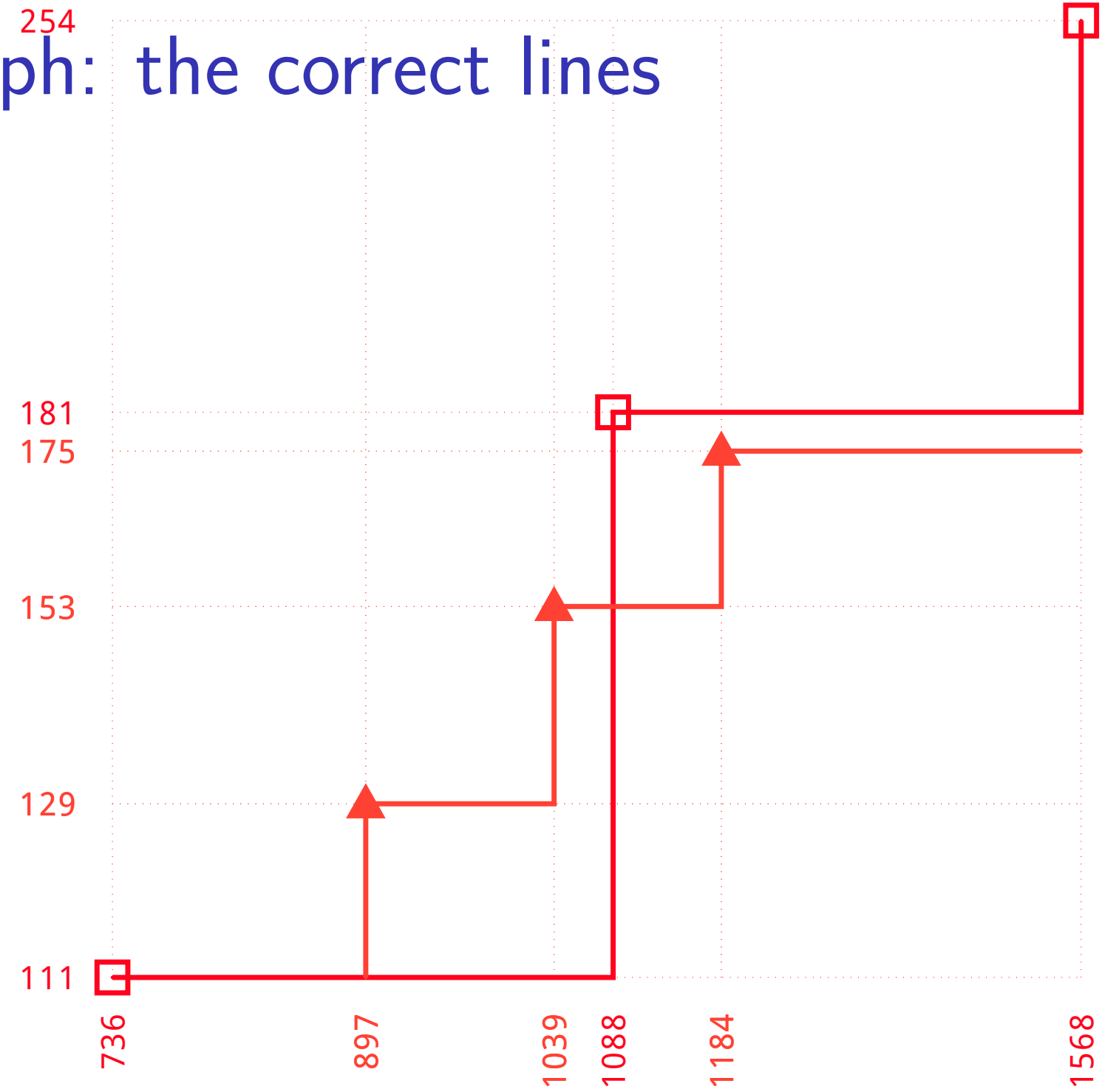
X	$\mathsf{sec}(\texttt{sntrup}) > \mathsf{sec}(X)$ for S in
`frodo`	$\{897, \ldots, 1280\}$
`kyber`	$\{897, \ldots, 1087\}$
`lac`	$\{1039, \ldots, 1187\}$
`newhope`	$\{897, \ldots, 1280\}$
`ntru`	$\{897, \ldots, 930\} \cup \{1039, \ldots, 1229\}$
`round5n1`	$\{897, \ldots, 1280\}$
`round5nd`	$\{\}$
`saber`	$\{897, \ldots, 1087\}$
`threebears`	$\{897, \ldots, 916\} \cup \{1184, \ldots, 1280\}$

How the second graph misleads readers

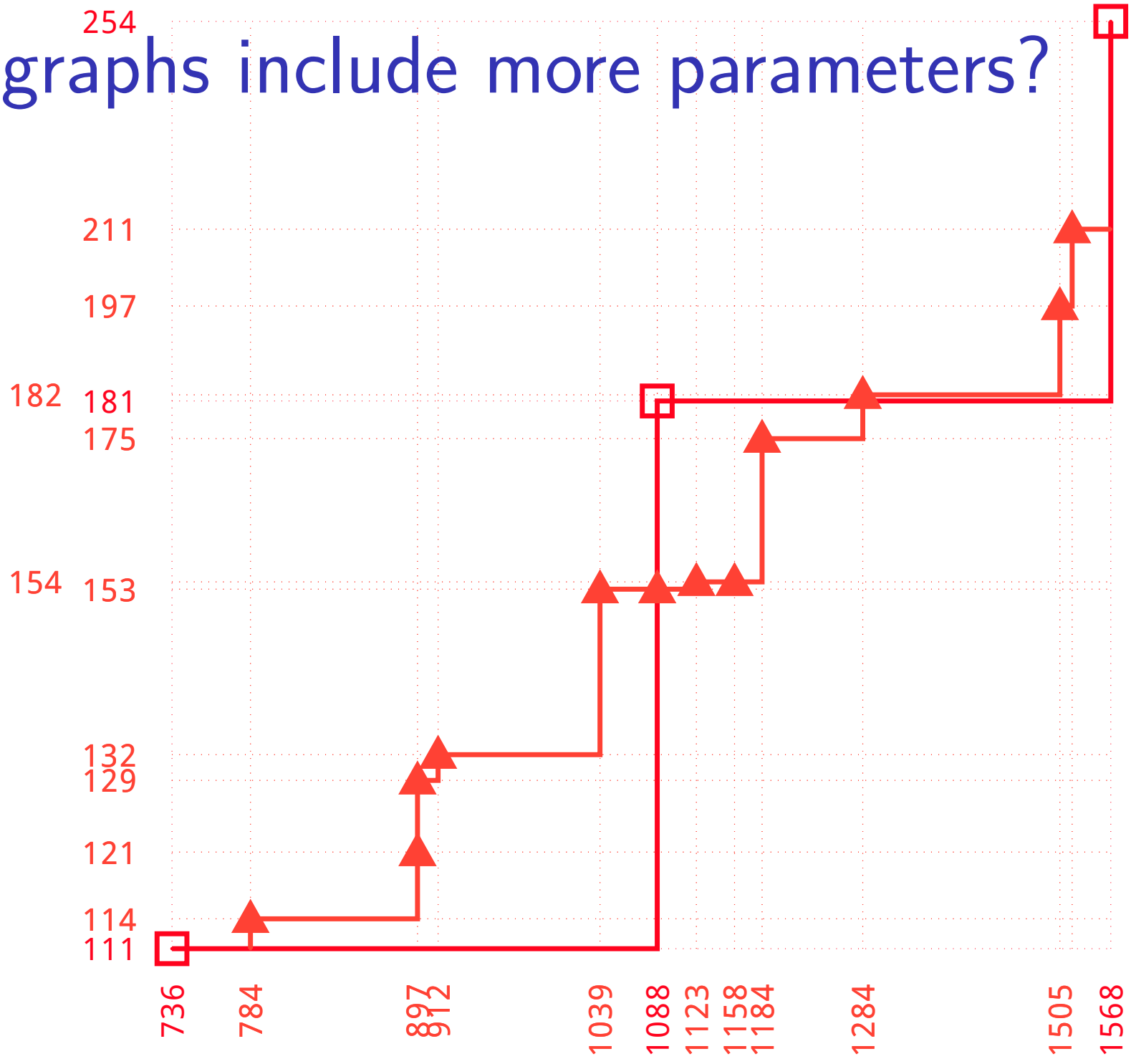
Human eye fills in the fake lines.



Third graph: the correct lines



Should graphs include more parameters?



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