The last L digits can be efficiently computed in $\mathrm{poly}(\log n, L)$ time. See e.g. `https://emathgroup.github.io/blog/factorial-tail`.
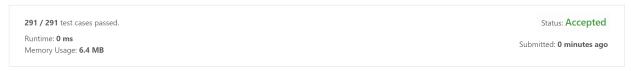
It suffices to compute $n!$ (or the Gamma function) to some constant precision, and we can use Stirling's approximation in $O(\mathrm{polylog}\, n)$ time.
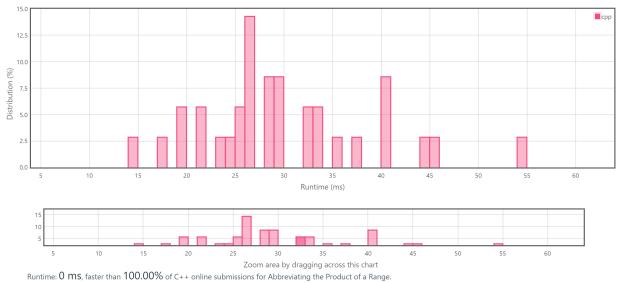
The total running time is $O(\mathrm{polylog}\, n)$.

Remark. most of the accepted solutions have precision issues, see my article `https://leetcode-cn.com/problems/abbreviating-the-product-of-a-range/solution/yi-ge-shu-ju-tuan-mie-jue-da-bu-fen-dai-234yd/`.

References