Comparative cost and preferred method

Direct pair enumeration uses exactly n^2 pair sums. The transform uses $O(n \log n)$ field operations and $O(n)$ storage for the bounded range. This proves the asymptotic arithmetic improvement for the specified range. Prime/root construction and bit arithmetic are additional costs outside the unit-field-operation bound. For sparse, small sets the direct algorithm may win, and it remains the exact benchmark control.