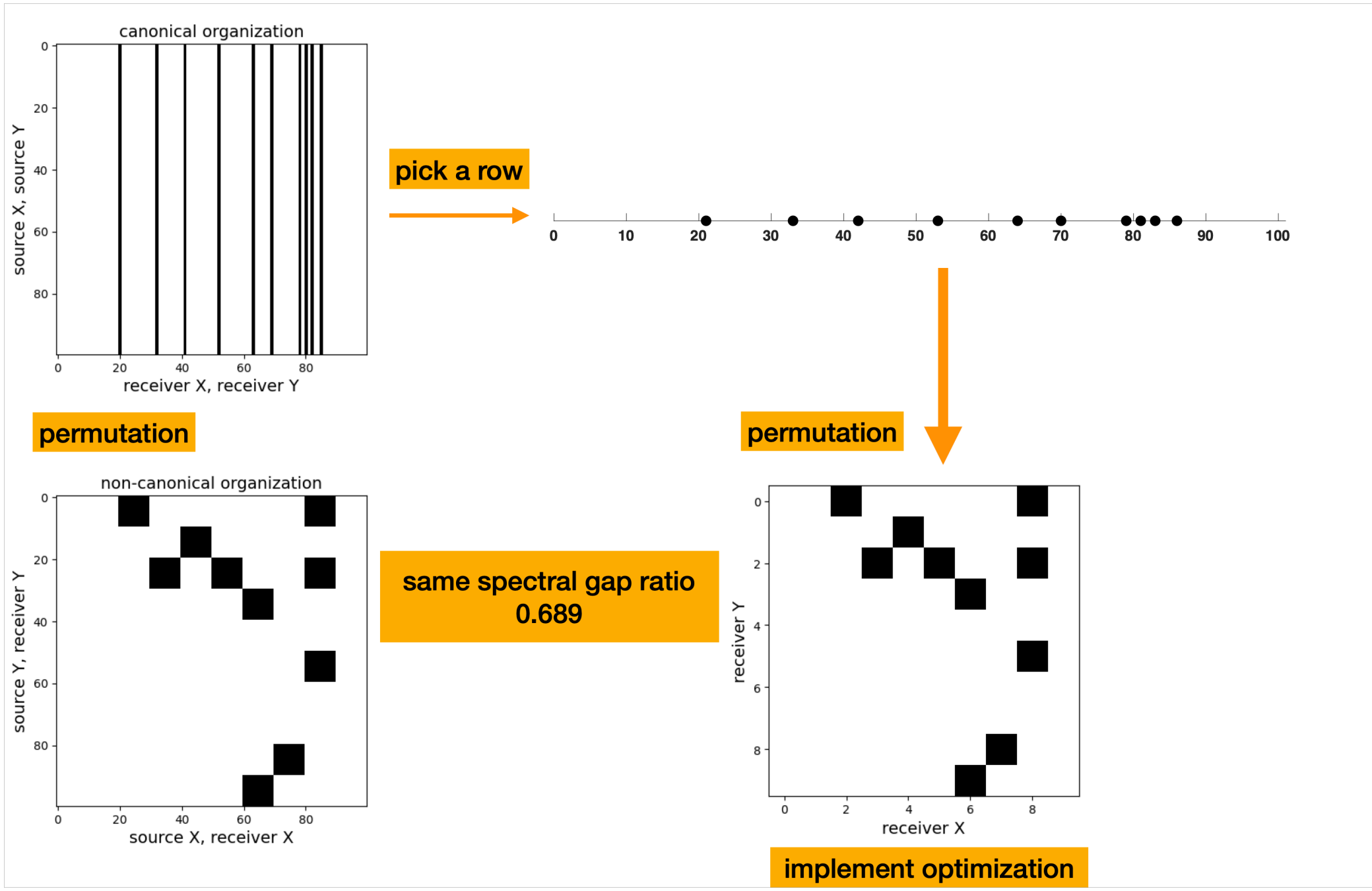
An intriguing property of spectral gap ratio in 3D seismic

When sources are fully sampled, each single-receiver block of the global sampling matrix is either fully sampled or empty depending on whether that specific receiver is sampled. Consequently, the block structure of the global matrix leads to the exact same singular values as a single-source receiver sampling mask. We can therefore optimize a single-source mask to obtain the global optimized mask. The main computational cost therein is computing the first two singular values of the receiver sampling mask, which is negligible compared to approaches that require wave simulations.

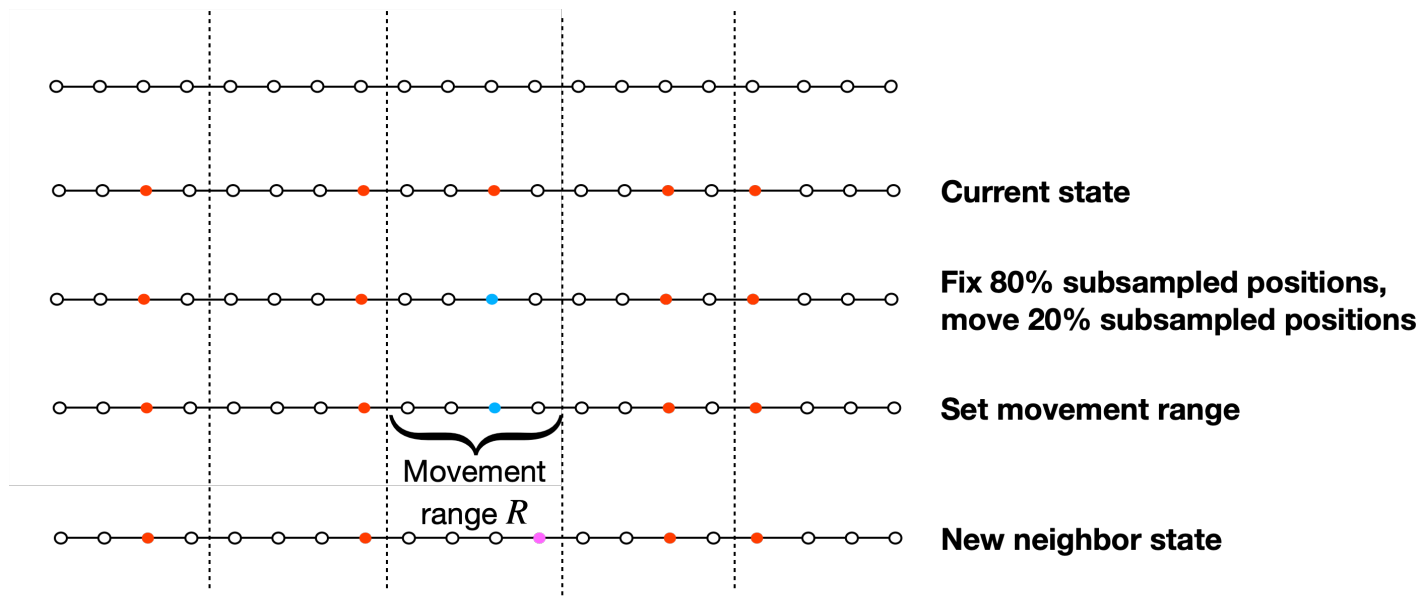


A black square is a matrix of all 1s
A white square is a matrix of all 0s

A black square is 1
A white square is 0

Simulated annealing algorithm for spectral gap ratio minimization

The design of acquisition masks that minimize the SGR is an NP-hard problem whose solution requires a brute-force search through all combinatorial possibilities. For this reason, we propose to obtain a near optimal solution using simulated annealing, a stochastic local search optimization technique that is straightforward to implement, apply, and computationally feasible.



Simulated annealing algorithm

Inputs:

$\mathbf{M}_0$: initial receiver sampling mask

$\mathrm{maxiter}$: maximum number of iterations

$p(\delta L, k) = \exp\left(\dfrac{-\delta L}{T_0 \times \alpha^k}\right)$ transition probability function

for $k = 0, \cdots, \mathrm{maxiter}$

  $\widetilde{\mathbf{M}_k} \leftarrow$ randomly select a neighboring state

  $\delta L = \mathrm{SGR}(\widetilde{\mathbf{M}_k}) - \mathrm{SGR}(\mathbf{M}_k)$ # compute the change of SGR

  if $\delta L \leq 0$

    $\mathbf{M}_{k+1} = \widetilde{\mathbf{M}_k}$ # always take improving move

  else # might take a worsening move

    $\mathbf{M}_{k+1} = \begin{cases} \widetilde{\mathbf{M}_k} \text{ with probability } p(\delta L, k) \\ \mathbf{M}_k \end{cases}$

  endif

endfor

Output: $\mathbf{M}_{\mathrm{maxiter}}$