Characterization of scattering for an HTS Josephson junction (JJ) technology is usually based on critical current \( I_C \) (and normal resistance \( R_n \)) defined by the Resistively Shunted Junction (RSJ) model. Accounting for thermal noise e.g. using Ambegaokar and Halperin (AH) model [1] is necessary but time consuming and not always sufficient.

We propose the thermal noise voltage (TNV) criterion for the determination of critical current, using AH model. At \( R_n \), the noise voltage \( V_n \) is related to the junction parameters \( I_C, R_n \) and \( \gamma = \text{nicZ}\text{e}^n \) where \( T \) is the physical temperature. An empirical analytical function has been found to fit the normalized thermal noise/voltage relation given by AH.

We present the results of the TNV criterion on JJ based on the ion damage barrier technology described in [2] and compare it to the usual “prefixed voltage threshold” (PVT) method.

Fixed Voltage Threshold (FVT): \( I_C = (V_n/V_{\text{thres}}) \)
- Simple (typ. \( V_{\text{thres}} = 1 \mu V) \)
- For N JJ series array \( = (V_n/V_{\text{thres}}) \)
- Widely used (easy comparison)
- The extracted value of \( I_C \) is lowered by thermal noise
- In case of \( I_C \) scattering, TM essentially probes the JJ with the smallest critical current.

Ambegaokar & Halperin (AH): Adjust the full V/I curve \( V/I \) in \( I_C \). 
- No hypothesis made on any of the parameter \( (T>\text{thres}) \)
- Very sensitive to deviation from RSJ model (and scattering)
- Computation time is larger (and convergence is not guaranteed)

Ambegaokar & Halperin (limited to very small \( I_C \)): \( I_C = \gamma I_C, R_n, T \) where \( R_n \) is the dynamic resistance at \( I = 0 \)
- Simple
- Not applicable when Josephson energy > \( I_C, T \)

The extracted value of \( I_C \) using TNV method and scattering

The extracted \( I_C \) value for a series array is an average lying in the lower range of the \( I_C \) of its constituents (but larger than the minimum \( I_C \) due to the larger voltage threshold).

The expression we propose for the voltage measured at the terminals of an RSJ device biased at its critical current (TNV) is:
- Analytical (fast)
- Accurate (to within ~1% for a purely RSJ device)
- \( + \) tunable with 2 parameters
- Useful for critical current determination from experimental results (provided \( R_n \) and \( T \) are known)
- Basically robust against noise
- Applicable when either \( I_C = 0 \) or the noise is very small.

It can be applied to series, parallel and 2D arrays of JJ.

Scattering in JJ parameters results in a weighted average of the critical current. This "average" is useful for choosing the bias point for operation of an array.