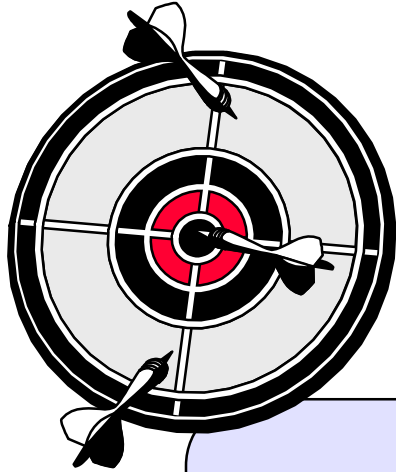


Custom Compiler

Simulation and Analysis Environment (SAE)
Monte Carlo Analysis

O-2018.09

Unit Objectives



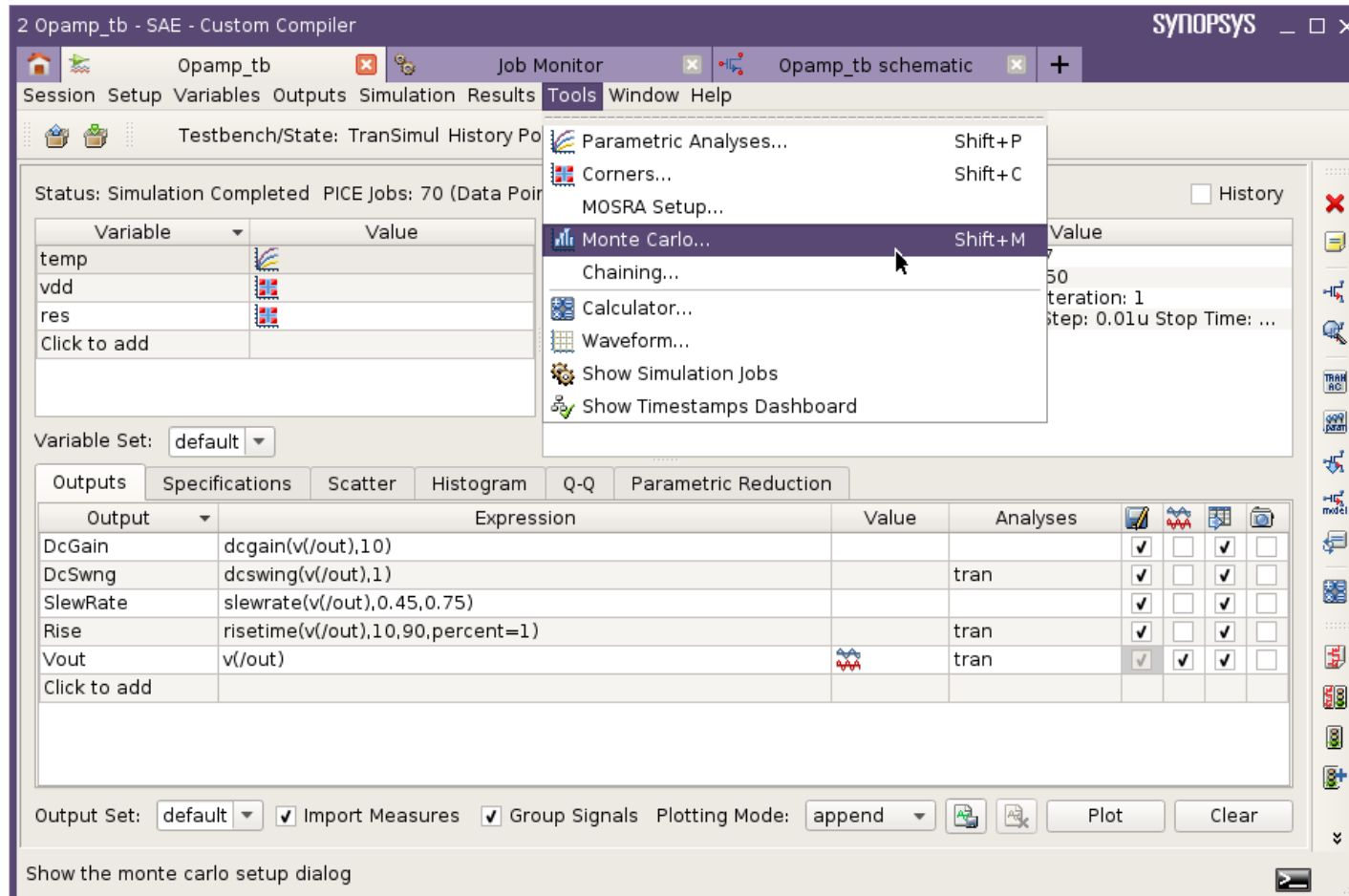
Use Monte Carlo Analysis in SAE to model the effects of process variations on circuit performance.

Monte Carlo Analysis

- Monte Carlo analysis is used to model the effects of process variations on circuit performance
- Dialog to specify simulator input parameters
- Interface for plotting and printing Monte Carlo results
- Users need to specify a model file containing variation definition
- Or specify parameter variation from SAE main console

Launching Monte Carlo Interface

■ SAE Window using Tools → Monte Carlo Setup



HSPICE Monte Carlo Setup

■ Dialog to specify simulator input parameters

The screenshot shows the 'Monte Carlo - MonteCarlo/Opamp_tb/schematic' dialog box. It is divided into several sections: 'Enabled' (checked), 'Iterations' (Number: 5, Start: 1, Last: 5, Use List Syntax: 4, 8, Save Operating Points, Use Sigma Scaling), 'Sampling' (Seed: 1, Method: SRS, Random), 'Variation Scope' (Include, Instances, text field), and 'Advanced' (Multiple runs: Number of runs, 1, Other Options). Annotations point to various fields: 'Enable Monte Carlo analysis' points to the 'Enabled' checkbox; 'Number of Monte Carlo iterations to be run' points to the 'Number' field; 'Specify sampling method' points to the 'Method' dropdown; 'To run the Monte Carlo simulation as separate simulations instead of one big simulation job' points to the 'Multiple runs' checkbox; 'Start iteration of a Monte Carlo run' points to the 'Start' field; 'Select tail indices' points to the 'Use List Syntax' field; 'Use List Syntax to specify an iteration range: "1 5:10 15 20:30"' points to the 'Use List Syntax' field; 'Enable sigma scaling flow' points to the 'Use Sigma Scaling' checkbox; 'Control variation scope' points to the 'Variation Scope' section; 'Monte Carlo simulation options' points to the 'HSPICE Options...' button; and 'Other Monte Carlo Options' points to the 'Other Options' text field.

Enable Monte Carlo analysis

Number of Monte Carlo iterations to be run

Specify sampling method

To run the Monte Carlo simulation as separate simulations instead of one big simulation job

Start iteration of a Monte Carlo run

Select tail indices

Use List Syntax to specify an iteration range: "1 5:10 15 20:30"

Enable sigma scaling flow

Control variation scope

Monte Carlo simulation options

Other Monte Carlo Options

Selecting Tail Indices

- **Helps the user to choose subsets of Monte Carlo iterations to re-run**
 - Specification-Failing Iterations
 - Iterations in Measurement 'Tails'
 - Iterations for Measurement Extremes (min/max values)
 - Select from Results Viewer
- **Two Levels of Granularity**
 - All
 - Per-Measurement
- **List syntax is composed from chosen indices**

The image displays three overlapping screenshots of the 'Select Tail Indices' dialog box, illustrating different selection methods for Monte Carlo iterations.

Top Screenshot: Select Tail Indices (Spec-Failing Iterations)

Selected Iterations: 50, 52, 54, 56, 60, 63, 66, 67, 69, 73, 74, 75, 76, 78, 79, 81, 83, 84, 86, 91, 93, 94, 98

From: ALL Spec-Failing Iterations

Measurement	Spec-Failed Iterations
DcSwng	4, 7, 13, 15, 18, 31, 39, 41, 49, 50, 52, 73, 74, 75, 78, 79, 91
DcGain	4, 7, 11, 13, 15, 18, 24, 29, 31, 39, 41, 42, 49, 50, 56, 60, 63, 66, 67, 73, 78, 79, 81, 83
SlewRate	2, 4, 7, 13, 15, 18, 20, 23, 24, 31, 33, 34, 39, 41, 48, 49, 50, 52, 54, 60, 69, 73, 74, 75

Middle Screenshot: Select Tail Indices (Measurement Distribution Tails)

Selected Iterations: 4, 6, 42, 52, 60, 73, 75, 78, 79, 80, 83, 86, 87, 89, 93

From: Measurement Distribution Tails, by Measurement

Measurement	Select Left Tail	Select Right Tail	Left Tail Indices	Right Tail Indices
DcSwng	<input checked="" type="checkbox"/>	<input type="checkbox"/>	78, 73, 79, 4	93, 60, 83, 11
Rise	<input type="checkbox"/>	<input checked="" type="checkbox"/>	6, 89, 80, 87	52, 78, 86, 75
DcGain	<input type="checkbox"/>	<input type="checkbox"/>		
SlewRate	<input type="checkbox"/>	<input type="checkbox"/>		

Bottom Screenshot: Select Tail Indices (Measurement Extreme Value Iterations)

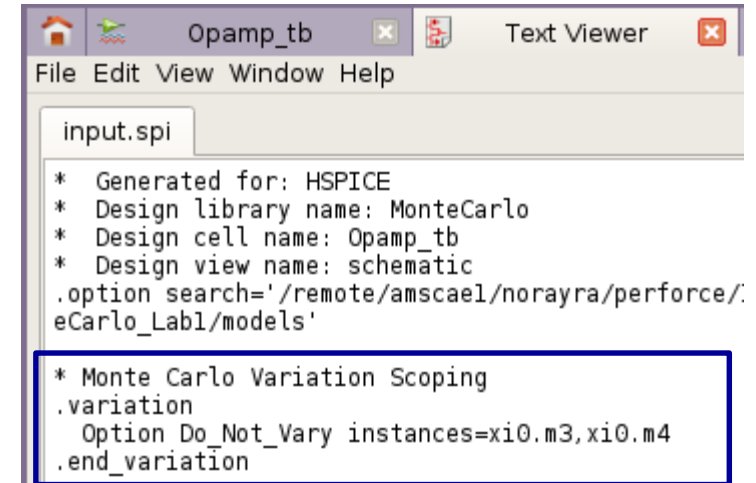
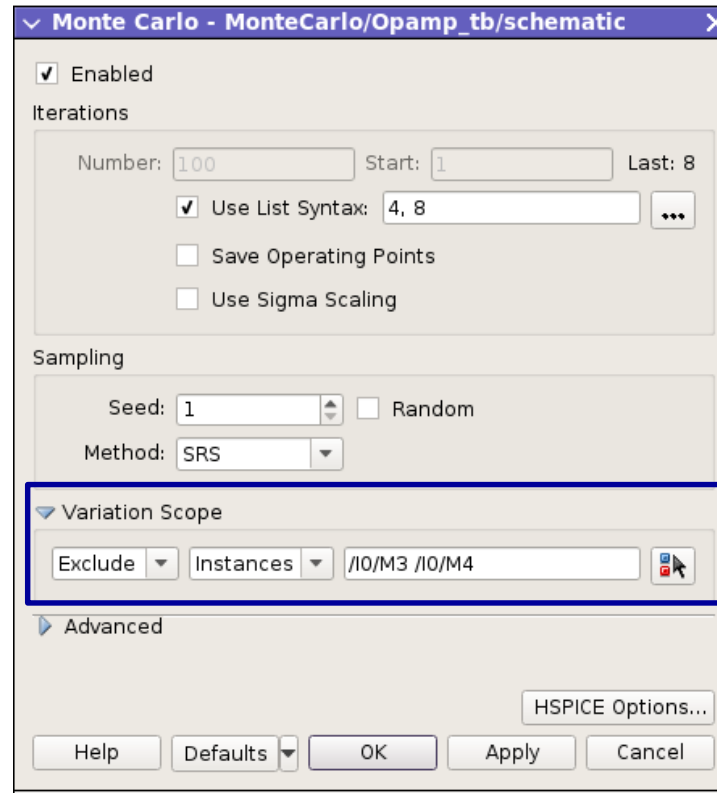
Selected Iterations: 6, 52, 78, 93

From: Measurement Extreme Value Iterations, by Measurement

Measurement	Select Min Val Index	Min Value Index	Select Max Val Index	Max Value Index
DcSwng	<input checked="" type="checkbox"/>	78	<input checked="" type="checkbox"/>	93
Rise	<input checked="" type="checkbox"/>	6	<input checked="" type="checkbox"/>	52
DcGain	<input type="checkbox"/>	93	<input type="checkbox"/>	6
SlewRate	<input type="checkbox"/>	52	<input type="checkbox"/>	6

Scope-based Variation

- Specify blocks or instances where variation is applied/not applied
 - Picking a subcircuit (cell) requires netlisting to be done first



Sigma Scaling/Modified Distribution

- **Enable/Disable Sigma Scaling capability**
 - Directly enter the 'Scaling Factor'
 - Assist with Sigma Scaling factor calculation
- **Use number of iterations, block instances, and target sigma to auto-calculate**
 - Required per Block Sigma
 - Sigma Scaling Factor for process parameter samples

The screenshot shows a dialog box titled "Sigma Scaling Calculator" with a close button (X) in the top right corner. Below the title bar, there is a text area that says "Calculate an appropriate sigma scaling factor based on the inputs below (hover for additional help)" and a help icon (question mark). The dialog is divided into two main sections: "Inputs" and "Calculated Values".

Inputs:

- Number of Iterations: 100
- Number of Block Instances: 1
- Overall Target Sigma: 3.0

Calculated Values:

- Single Block Required Sigma: 3
- Sigma Scaling: 1.16467

Below the calculated values, there is a text prompt: "Press OK to use the calculated sigma scaling factor". At the bottom of the dialog, there are four buttons: "Help", "OK", "Apply", and "Cancel".

HSPICE Monte Carlo Simulation Options

■ Monte Carlo analysis simulation options

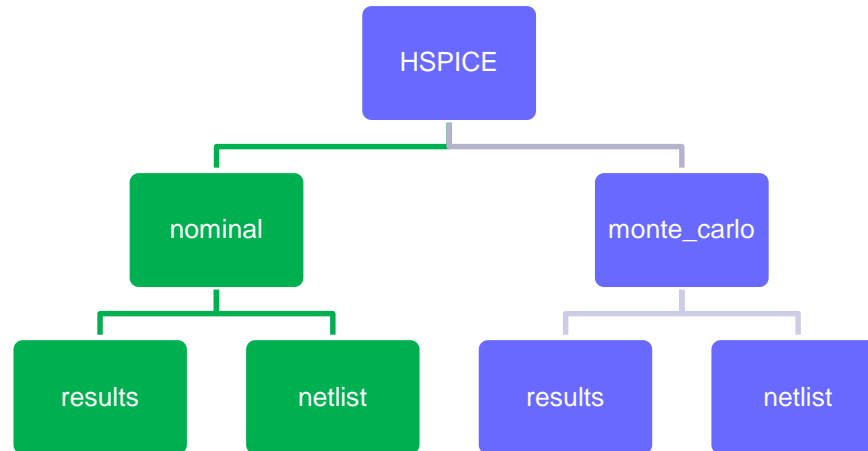
The screenshot shows the 'HSPICE Global Simulation Options - MonteCarlo/Opamp_tb/schematic' dialog box. The 'Category' is set to 'Monte Carlo Analysis'. The 'Filter' field is empty. The dialog contains a table of simulation options with columns for Name, Local, Value, and Sim Default.

Name	Local	Value	Sim Default
▼ General Options			
MONTECON	<input type="checkbox"/>	<input checked="" type="checkbox"/>	yes
MODMONTE	<input type="checkbox"/>	<input type="checkbox"/>	yes
MCBRIEF	<input type="checkbox"/>	Write Monte Carlo parameters to .lis file only (2)	yes
▼ Variation Options			
IGNORE_VARIATION_BLOCK	<input type="checkbox"/>	<input type="checkbox"/>	yes
IGNORE_LOCAL_VARIATION	<input type="checkbox"/>	<input type="checkbox"/>	yes
IGNORE_GLOBAL_VARIATION	<input type="checkbox"/>	<input type="checkbox"/>	yes
IGNORE_SPATIAL_VARIATION	<input type="checkbox"/>	<input type="checkbox"/>	yes
IGNORE_INTERCONNECT_VARIATION	<input type="checkbox"/>	<input type="checkbox"/>	yes
NORMAL_LIMIT	<input type="checkbox"/>	4	yes
OUTPUT_SIGMA_VALUE	<input type="checkbox"/>	1	yes
RANDOM_GENERATOR	<input type="checkbox"/>	1	yes
STREAM	<input type="checkbox"/>	Default	yes

At the bottom of the dialog are buttons for 'Help', 'Defaults' (with a dropdown arrow), 'OK', 'Apply', and 'Cancel'.

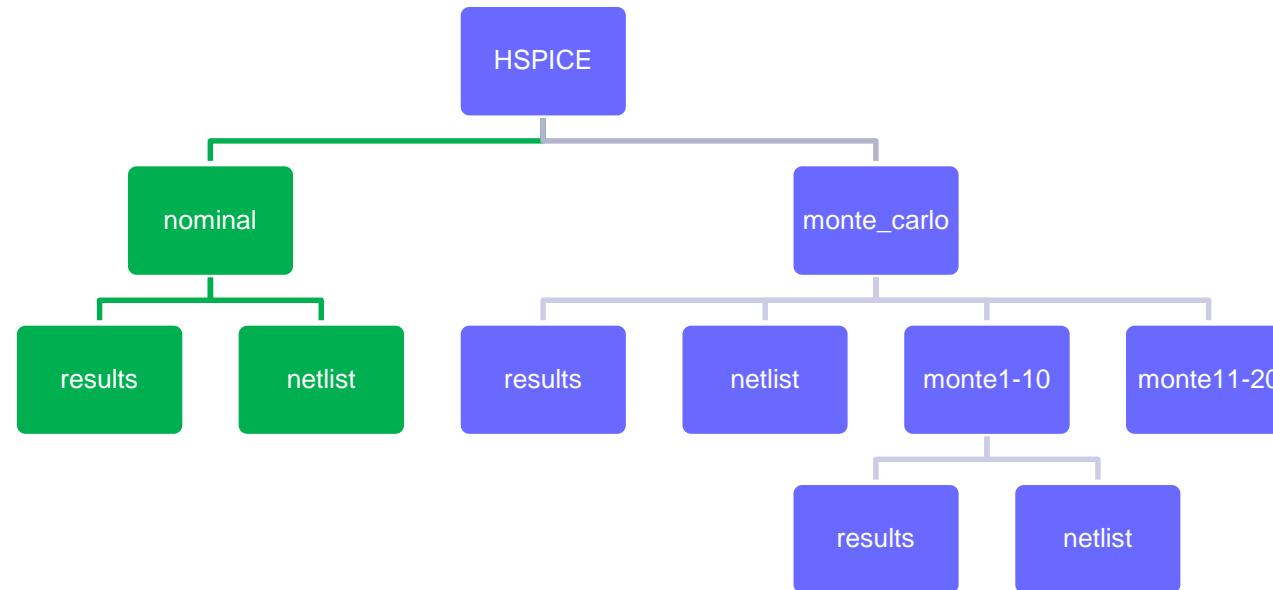
Monte Carlo Simulation Results Directory

■ Single Netlist



Monte Carlo Simulation Results Directory

■ Multiple Netlists



Expression Evaluation

- **Evaluates scalar expressions for all iterations**
- **Evaluation results are written into a file in table format**
- **WaveView is able to write that file**
- **WaveView can plot the evaluation results in histogram or scatter plot modes**

Expression Evaluation Example

■ Scalar expressions in the output pane

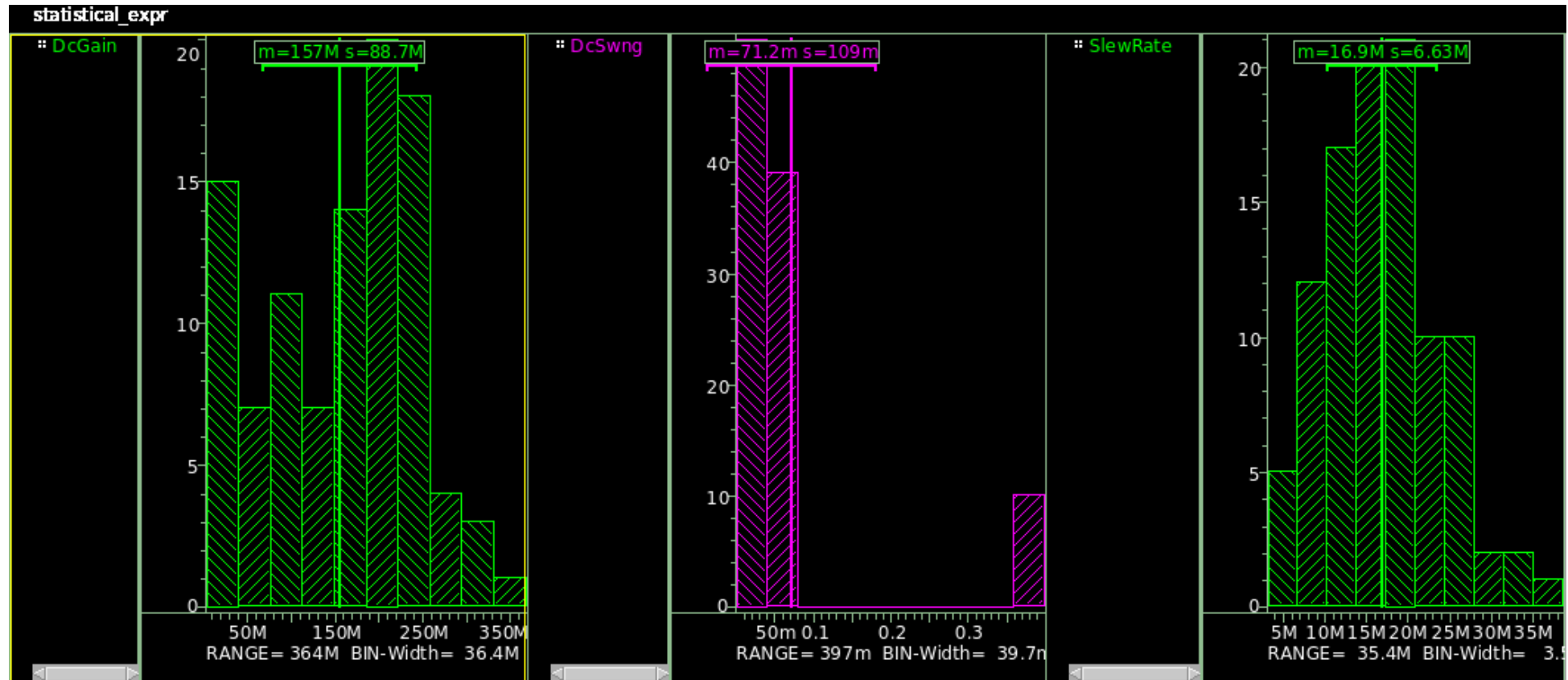
The screenshot shows the Synopsys Opamp_tb - SAE - Custom Compiler window. The 'Outputs' tab is selected, displaying a table of scalar expressions. The table has columns for Output, Expression, Value, and Analyses. The 'Value' column shows the results of the expressions, and the 'Analyses' column shows the analysis type (tran) and a set of checkboxes for various analysis options.

Output	Expression	Value	Analyses
DcGain	dcgain(v(/out),10)		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
DcSwng	dcswing(v(/out),1)		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
SlewRate	slewrte(v(/out),0.45,0.75)		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
Rise	risetime(v(/out),10,90,percent=1)		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
Vout	v(/out)		<input checked="" type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>
Click to add			

Below the table, the 'Output Set' is set to 'default', and the 'Import Measures' and 'Group Signals' checkboxes are checked. The 'Plotting Mode' is set to 'append'. The 'Plot' and 'Clear' buttons are visible at the bottom right.

Expression Evaluation Example

■ Evaluated histograms

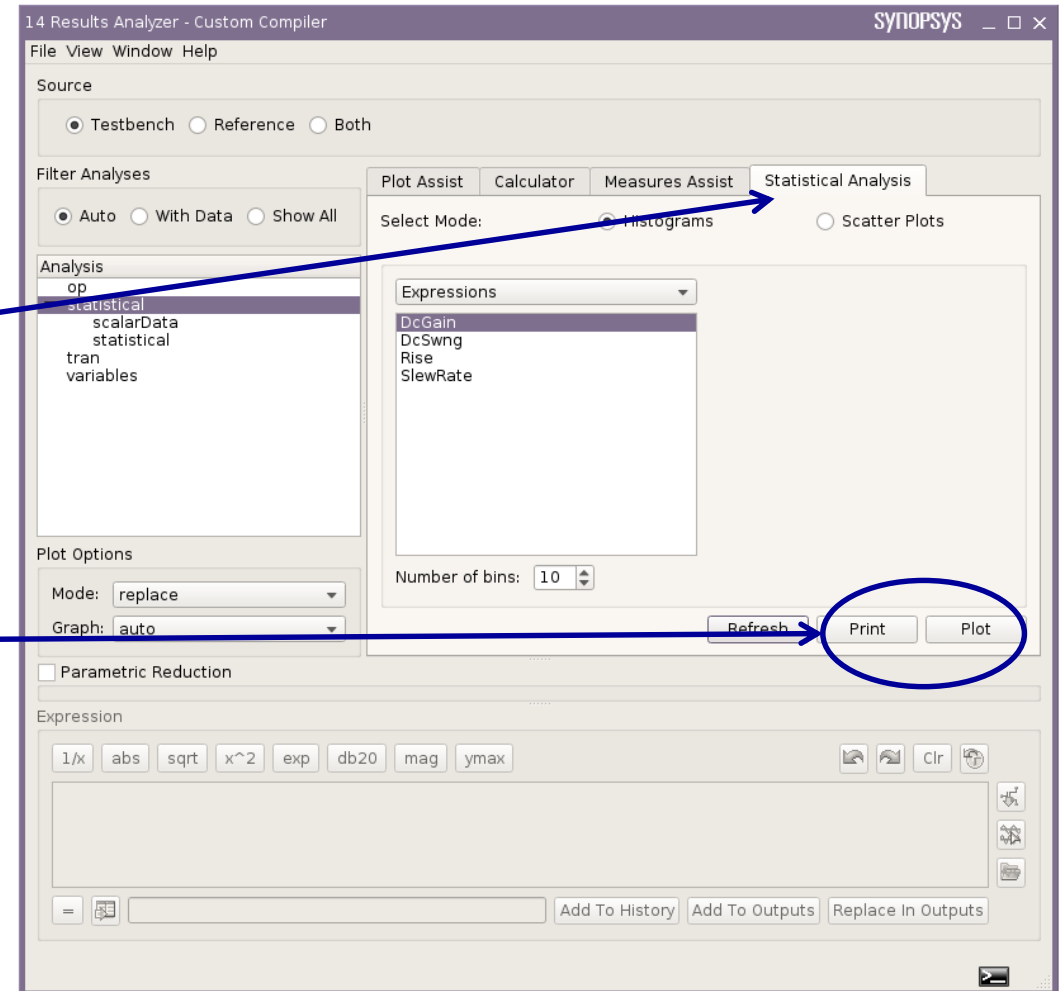


Statistical Data Analysis

■ Statistical Analysis tab in Results Analyzer (RA)

A new tab to RA that controls for viewing statistical data

Plot and Print of statistical data are available



Statistical Data Printing

- To print statistical data
 - Select expression or input parameter
 - Press Print

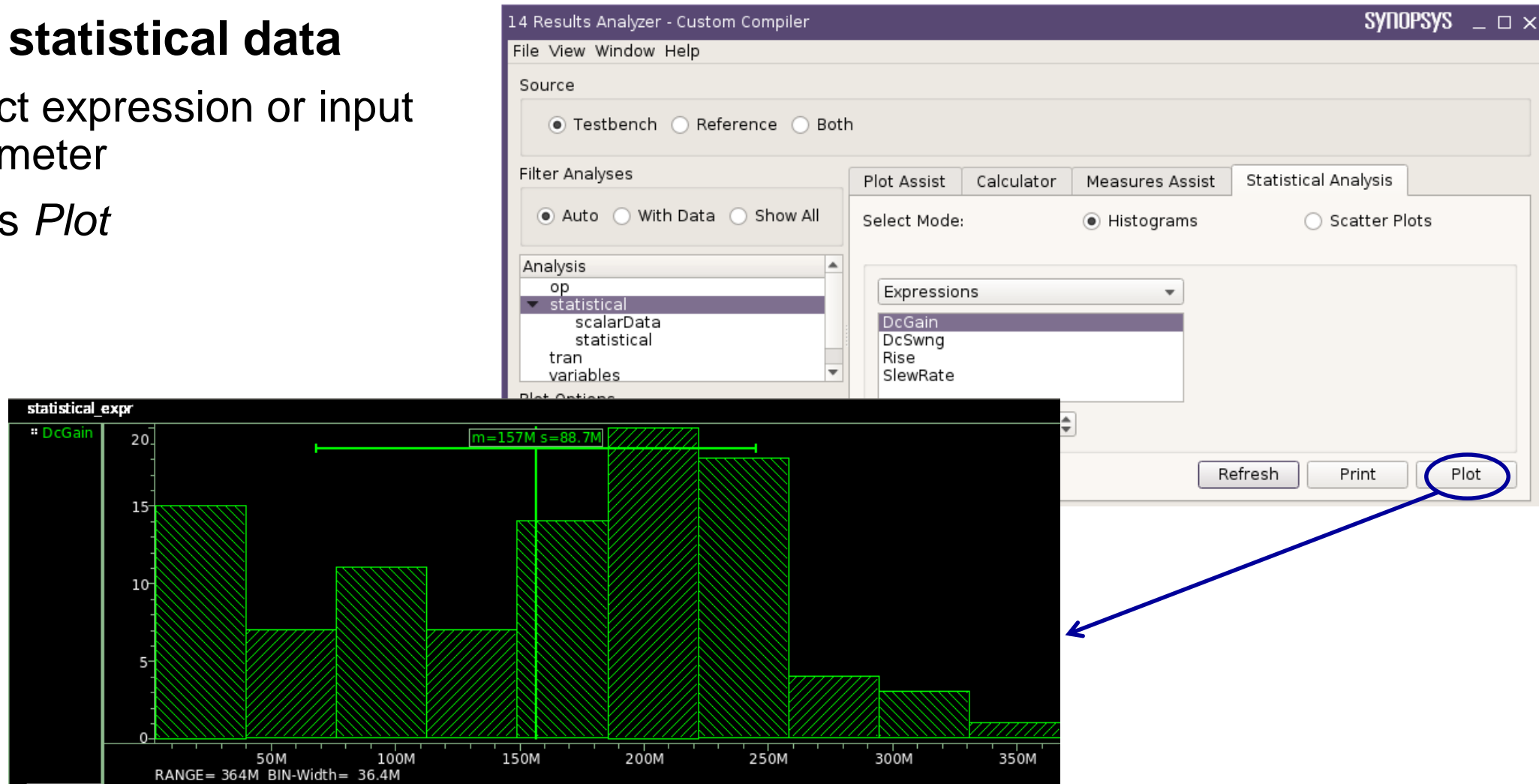
The screenshot displays the Synopsys Results Analyzer interface. The main window is titled "14 Results Analyzer - Custom Compiler" and features a menu bar (File, View, Window, Help) and a toolbar. The "Statistical Analysis" tab is active, showing "Select Mode: Histograms" and "Number of bins: 10". The "Expressions" list contains "FALL" and "RISE". The "Print" button is visible. The "Monte Carlo Results" window is open on the right, showing a table of results for 18 iterations.

	MONTE_CARLO	RISE	FALL
1	1	5.78914e-10	6.94026e-10
2	2	7.64722e-10	5.12594e-10
3	3	5.43683e-10	6.3492e-10
4	4	4.49173e-10	1.93565e-09
5	5	4.29001e-10	8.28647e-10
6	6	3.13771e-10	5.10287e-10
7	7	9.14624e-10	9.51356e-10
8	8	5.11173e-10	5.83617e-10
9	9	3.96752e-10	9.39484e-10
10	10	6.53234e-10	5.72536e-10
11	11	5.57573e-10	7.99556e-10
12	12	5.9816e-10	7.514e-10
13	13	6.50449e-10	8.49504e-10
14	14	5.25599e-10	5.51948e-10
15	15	7.01181e-10	8.0253e-10
16	16	5.03529e-10	7.80962e-10
17	17	5.28256e-10	4.99656e-10
18	18	5.65675e-10	8.42435e-10

Plotting Histograms

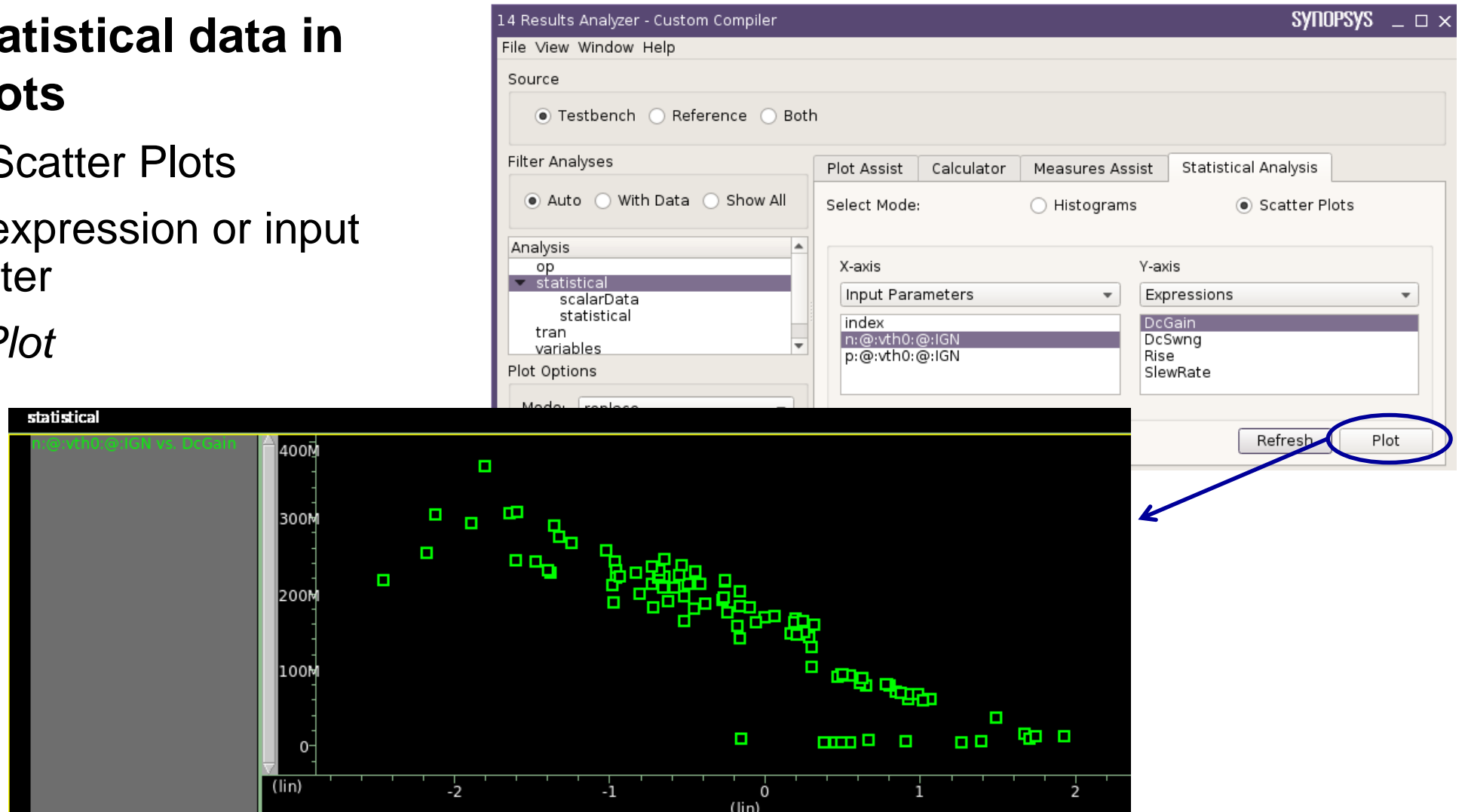
■ To plot statistical data

- Select expression or input parameter
- Press *Plot*



Scatter Plots

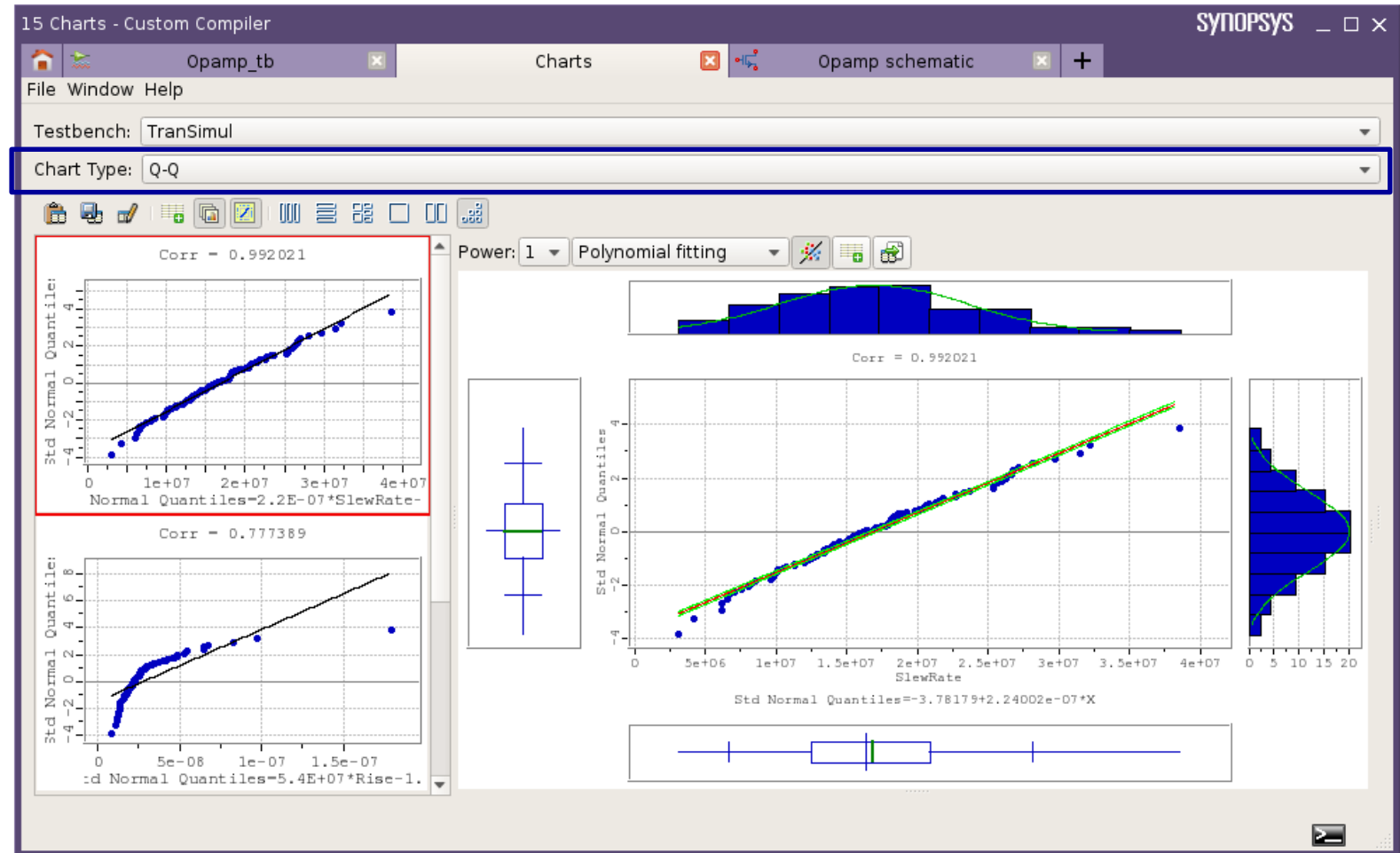
- To plot statistical data in scatter plots
 - Select Scatter Plots
 - Select expression or input parameter
 - Press *Plot*



Q-Q Plots in Charts

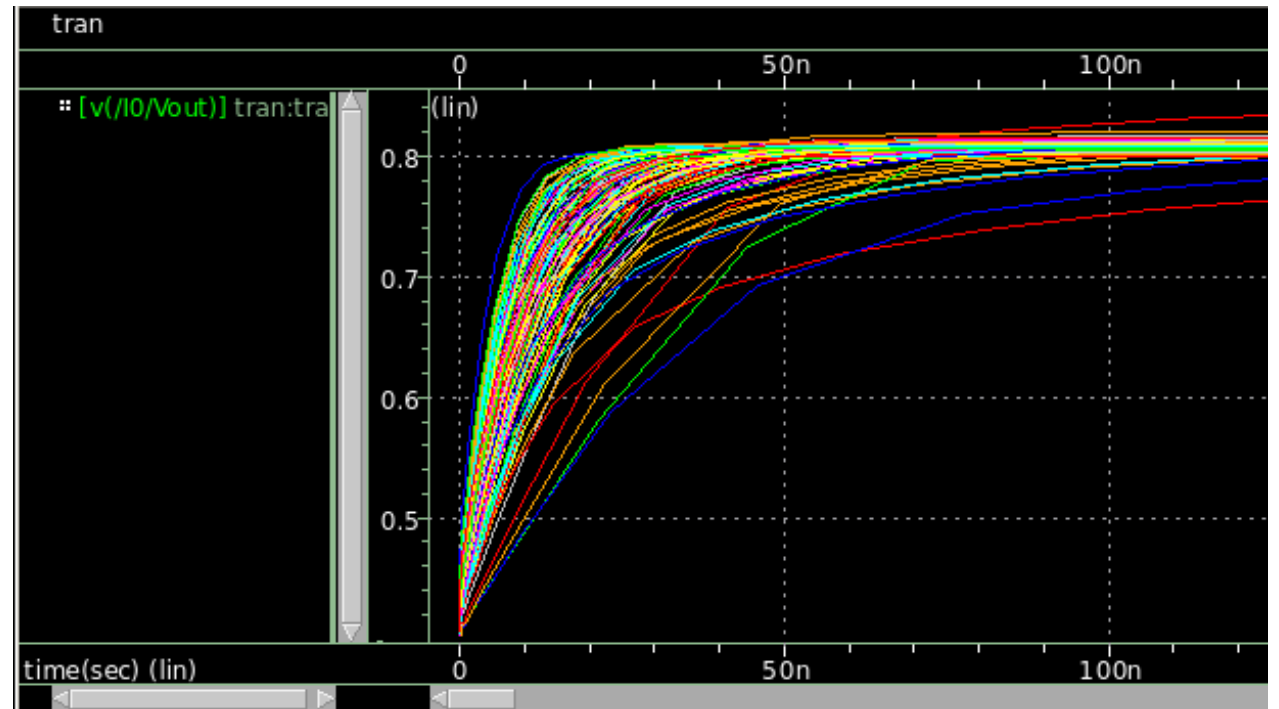
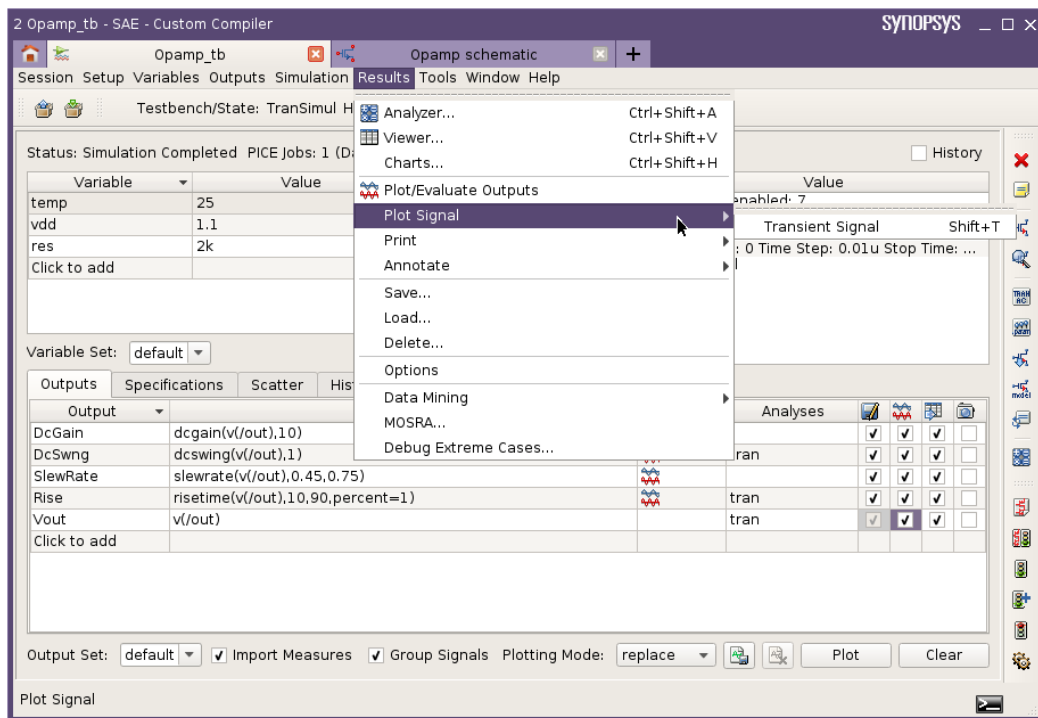
■ Improved Visualization

- Visualize any data anomalies
- Get a straight line relationship if measurements have a true Gaussian distribution



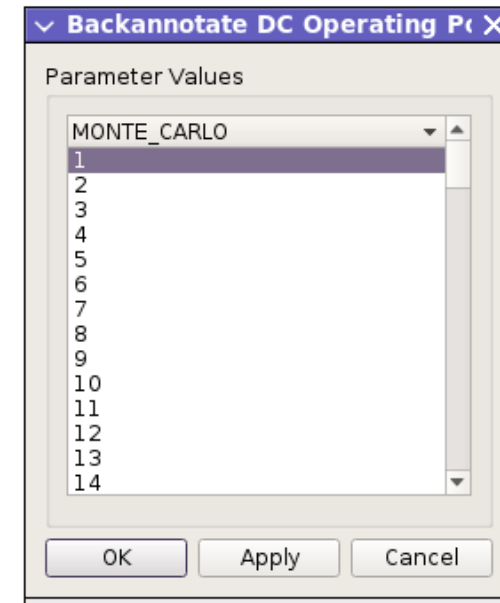
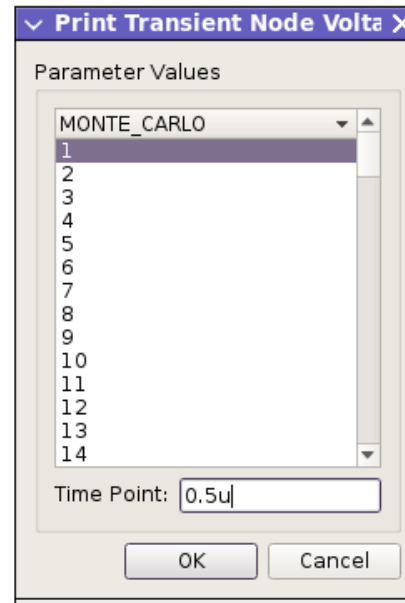
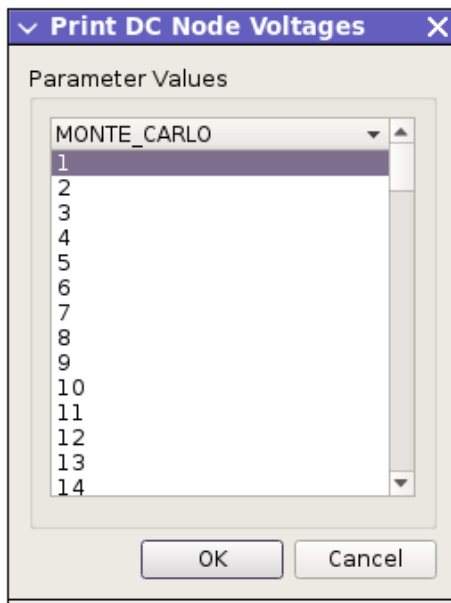
Signals Plotting

- Signals can be directly plotting from SAE GUI
- WaveView is being used to display the waves



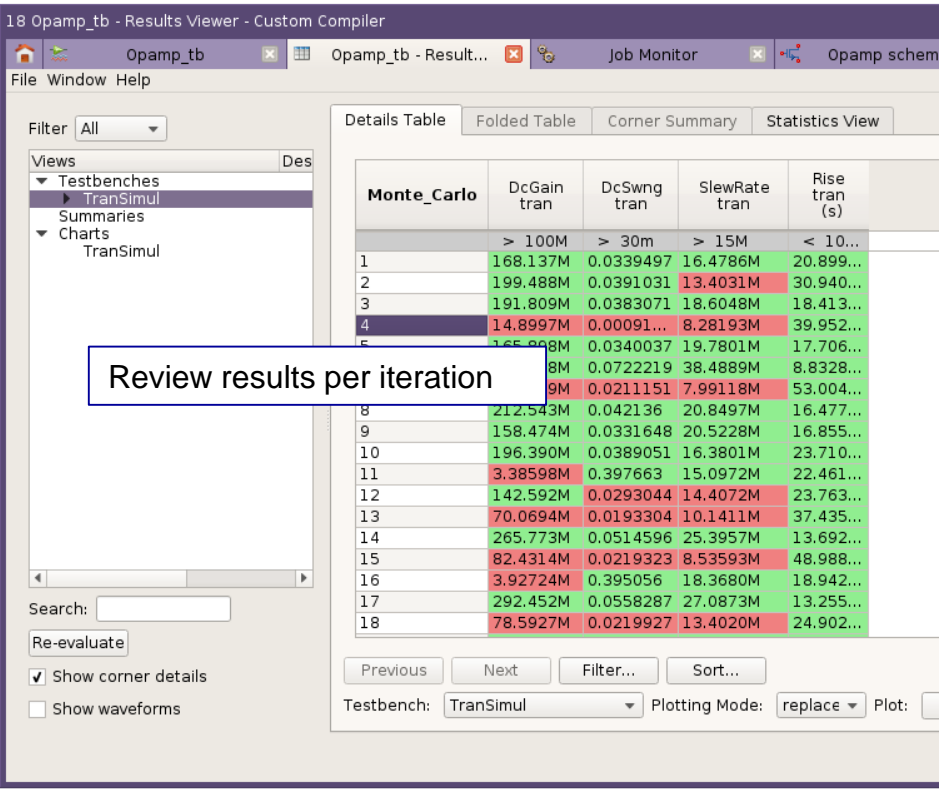
Printing and Annotation

- Signals can be directly printed and annotated from SAE main window

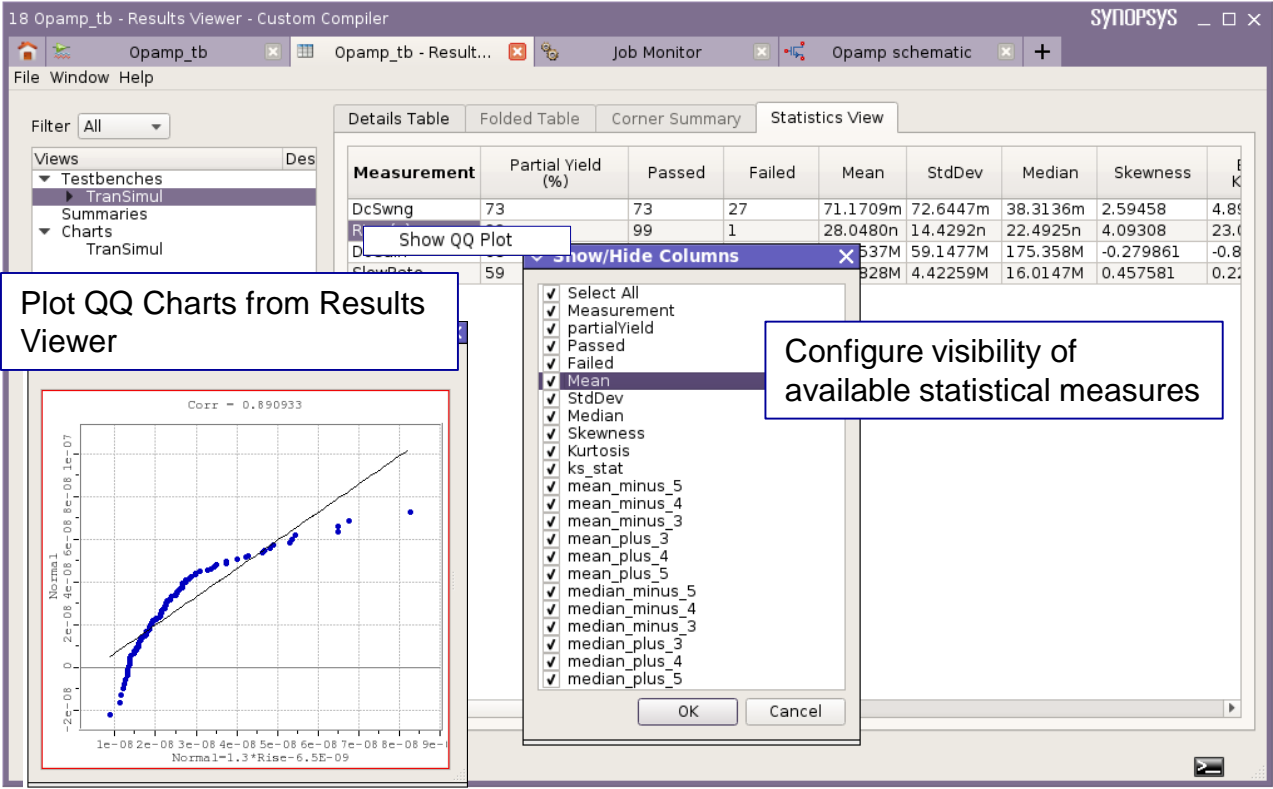


Monte Carlo Results in Results Viewer

■ Explore Monte Carlo results using Results Viewer



Details Table



Statistics View

Lab 1: Monte Carlo Analysis



30 minutes

Goals:

- Perform Monte Carlo analysis
- View and Analyze the results in WaveView

