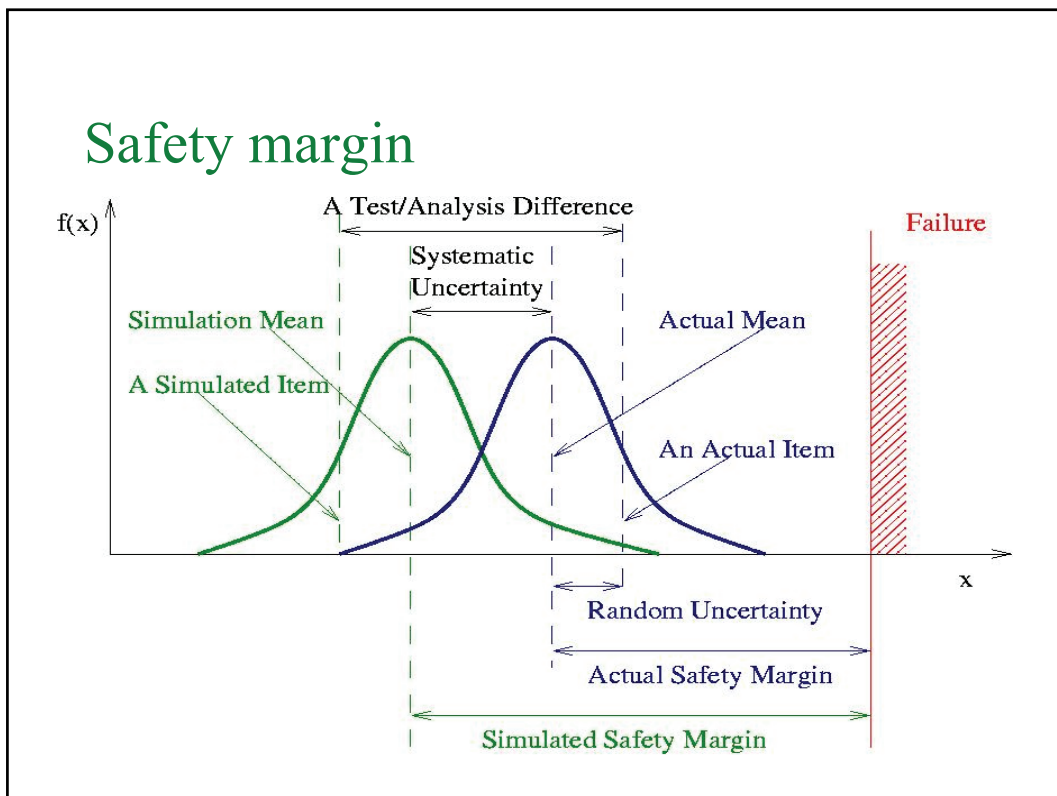


Robust Design in LS-OPT 3

Willem Roux, Nielen Stander
Livermore Software Technology Corporation, 2005

Benefits

- Estimate of Random Uncertainty required for:
 - Accurate margin of safety – cost of production
 - Estimate systematic uncertainty – accuracy of analysis
- Design for Robustness & Stability
 - Repeatable products – reducing the variability and therefore the required safety margin



Simulation

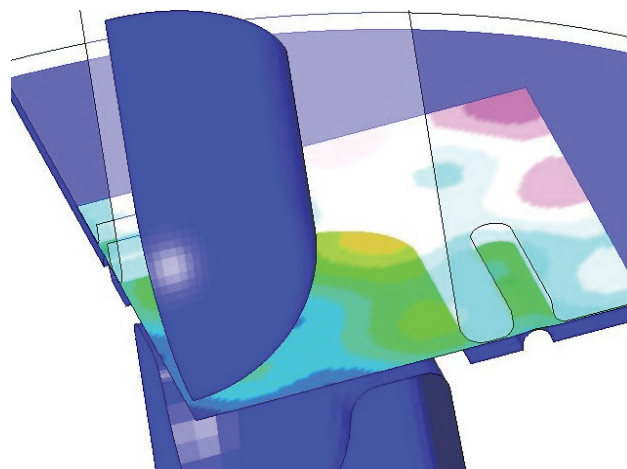
- Stochastic variables and fields
- Design of experiments
 - About FE 30 runs
- LS-PREPOST Plots:
 - Variance (std dev) etc.
 - Influence factors (important variables) etc.
 - Safety margin (scaled by standard deviations)

Stochastic Fields

- A stochastic field allows a property (e.g. shell thickness) to vary over a part.
- Entities
 - Nodal locations
 - Shell thicknesses
- Methods
 - Harmonic Fields
 - Import DYNA displacements or eigen mode
- LS-DYNA keywords added for stochastic fields.

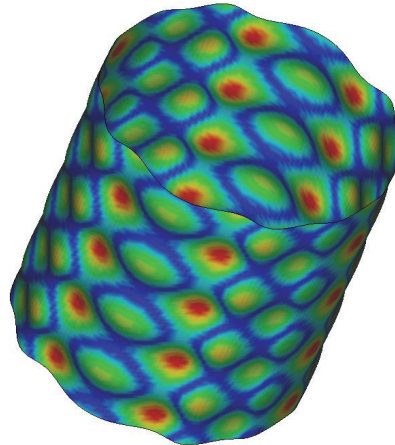
Stochastic Fields

- Harmonic functions (sine expansion)



Stochastic Fields

- Import LS-DYNA displacement or eigen modes.

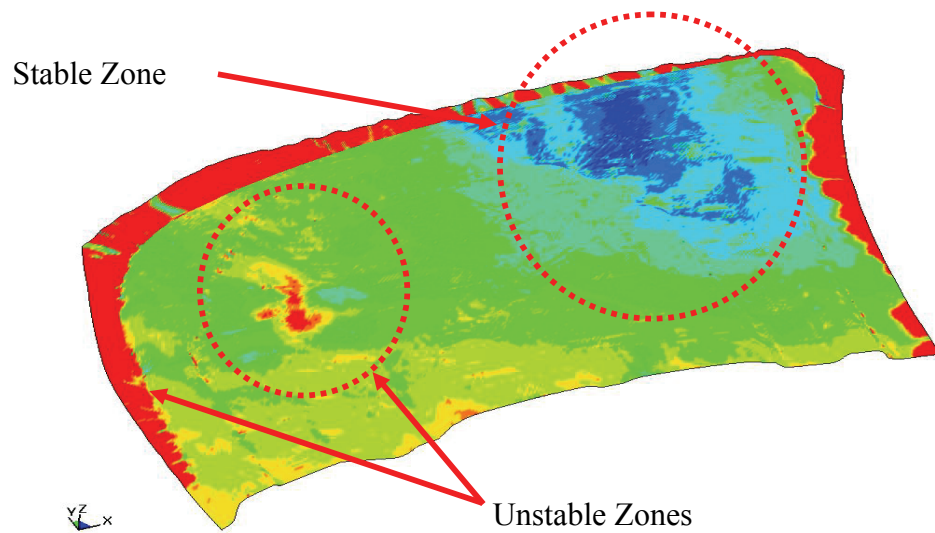


Improved Visualization of Stochastics

Creates LS-PREPOST plots

- Speed improvements (X10 faster)
- Any LS-PREPOST response e.g FLD
- Stochastic contribution of a variable
 - Variation of the response due to the variation of the variable.
- Safety Margins
- Expanded history plotting

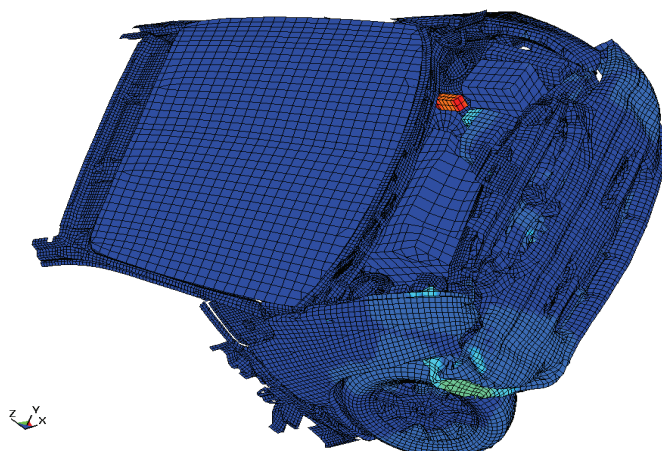
Visualization

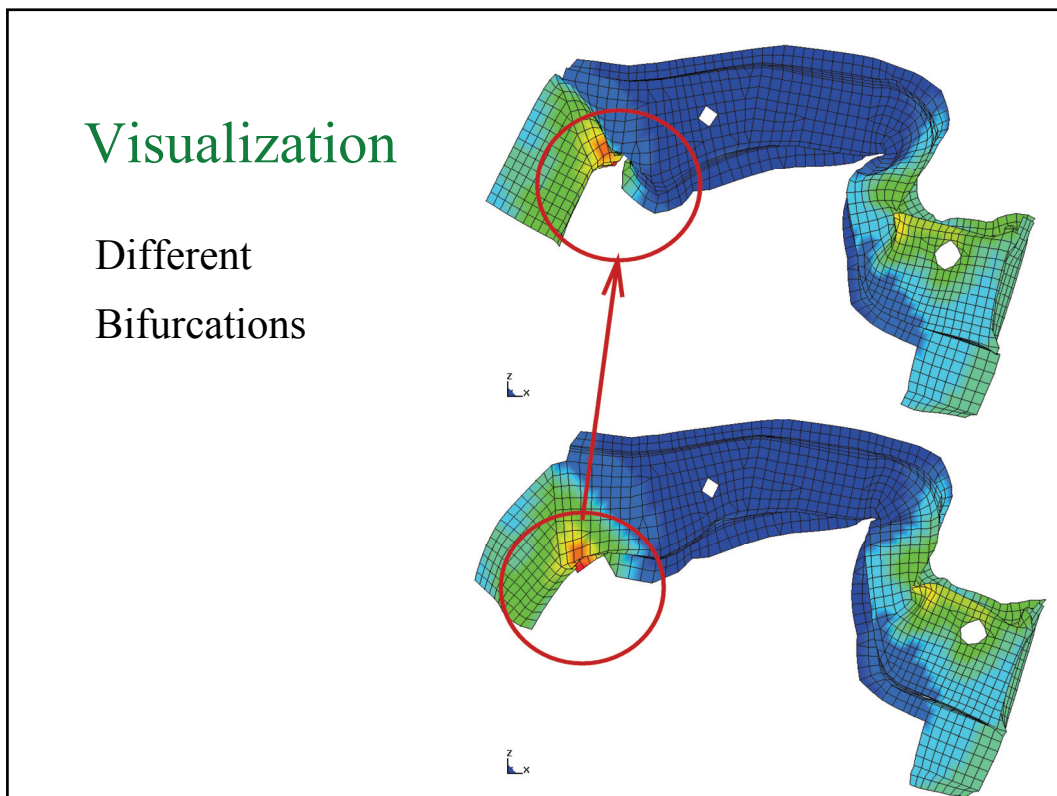


Blue: deformation always the same; Red: may differ by 1mm

Visualization

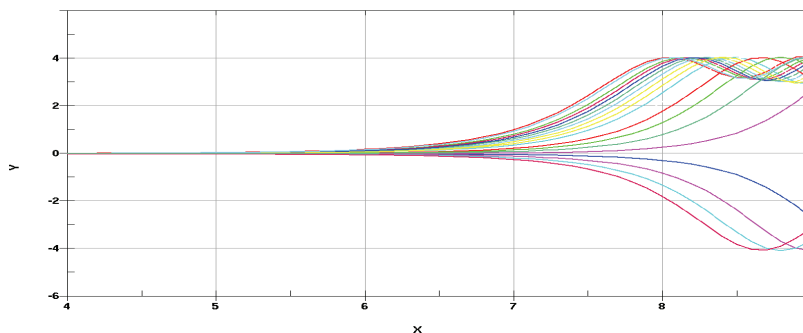
- Loose component





Display of LS-DYNA Histories

- Collect all LS-DYNA histories generated in a Monte Carlo analysis and display in LS-PREPOST.
- In addition to the current history statistics capability.

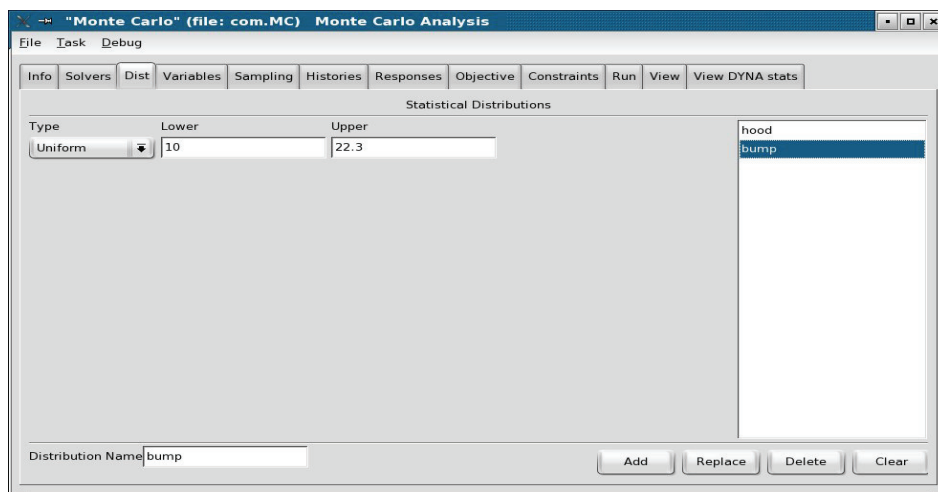


Reliability Based Design Optimization (RBDO)

- Specify:
 - Distributions associated with design variables
 - Allowable probability of exceeding bound
- Optimize as usual.
- Some extra output quantities

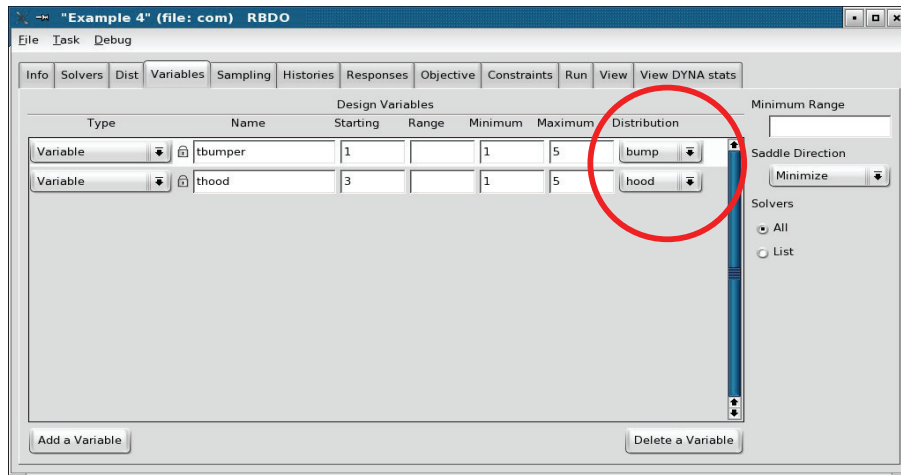
GUI: RBDO Problem Specification

- Create statistical distribution



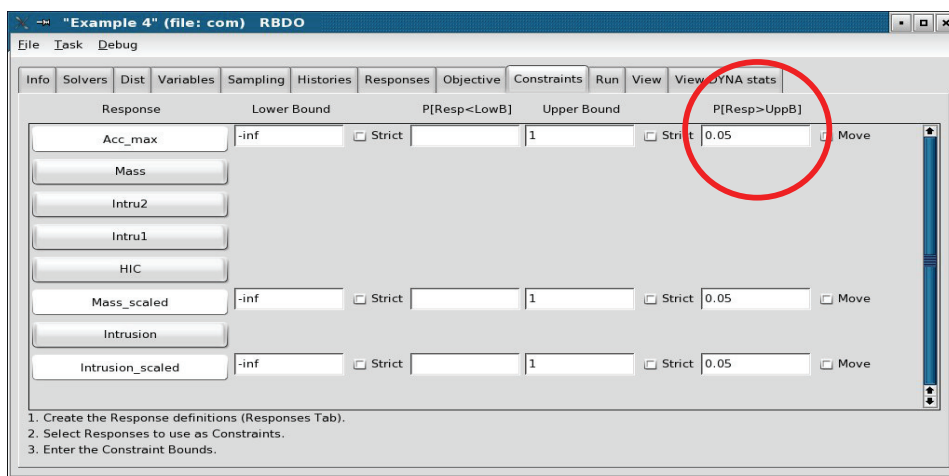
GUI: RBDO Problem Specification

- Assign distributions to variables

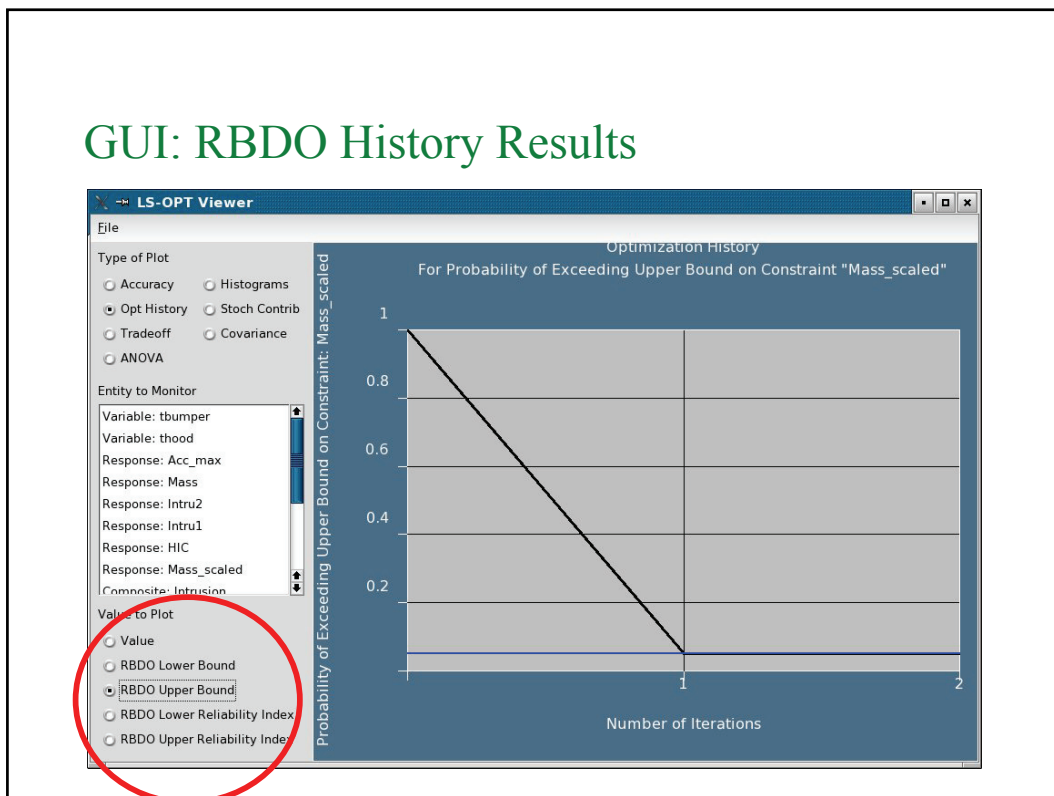


GUI: RBDO Problem Specification

- Add probability to relevant constraints



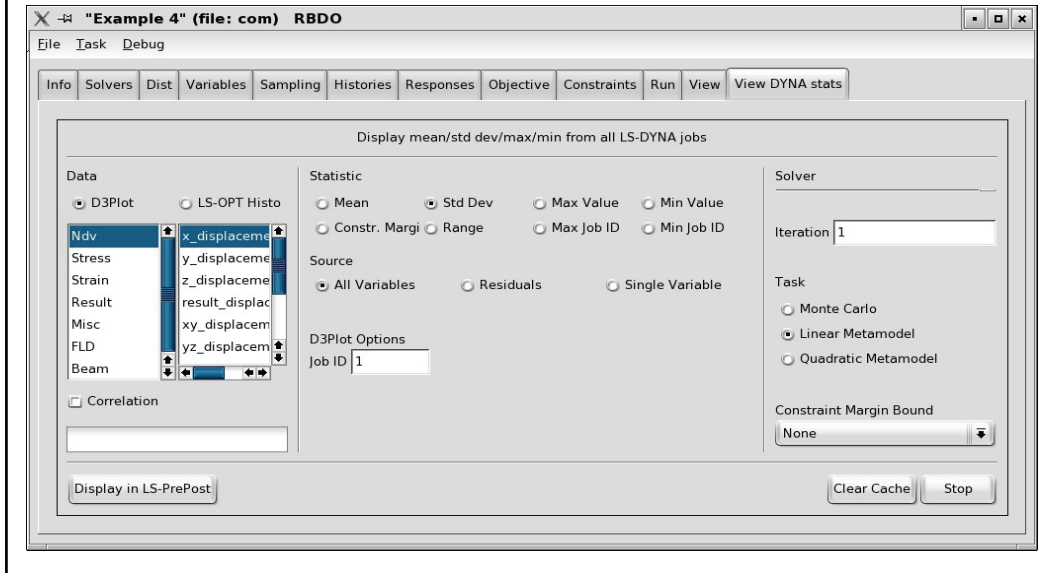
GUI: RBDO History Results



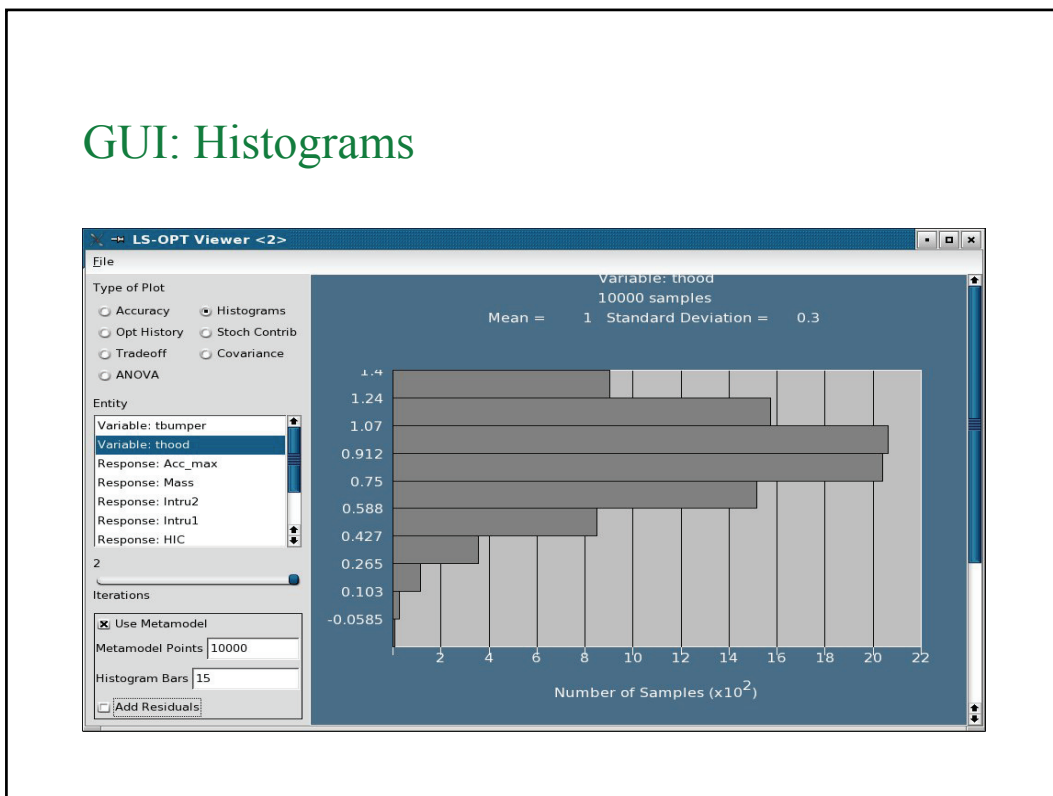
More GUI

- DynaStats panel was redesigned
 - Easier to detect bifurcations
 - Plot histories from all LS-DYNA jobs
 - Constraint/Safety Margin added
- Histogram, stochastic contribution, and correlation viewing works as before.

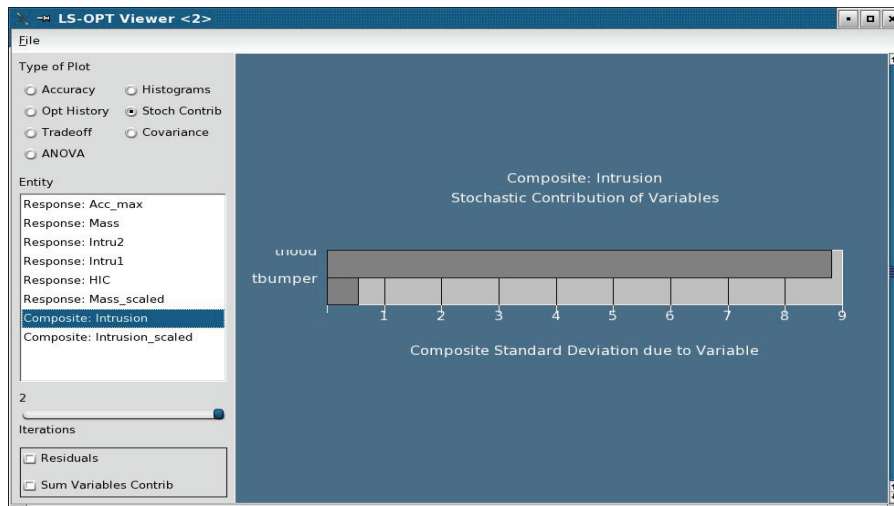
GUI: LS-DYNA Results Statistics



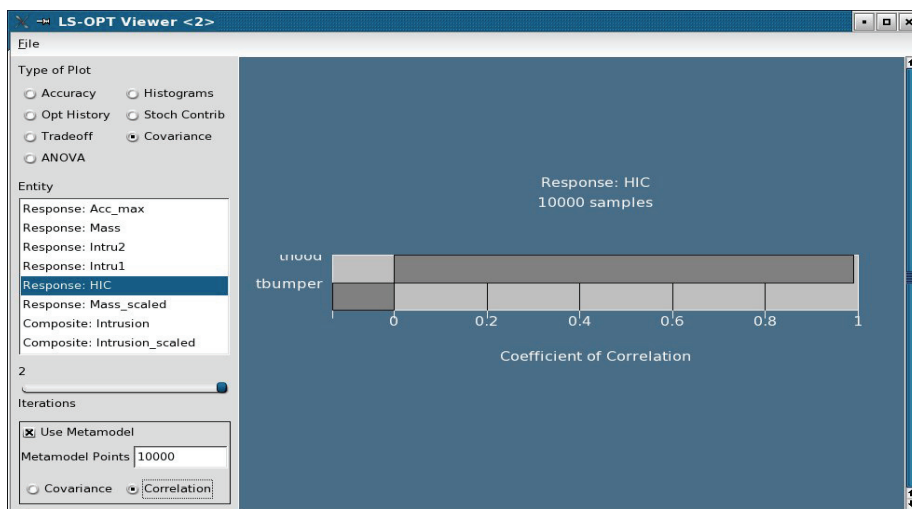
GUI: Histograms



GUI: Stochastic Contribution



GUI: Covariance and Correlation



Summary

- Why:
 - Estimate of variability is required to judge accuracy and quality.
 - Understanding of variability required for redesign.
- How:
 - Stochastic fields & variables
 - RBDO
 - A number of plots and visualization techniques
- When:
 - End of 2005.