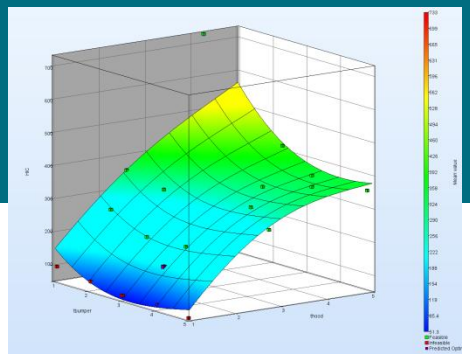
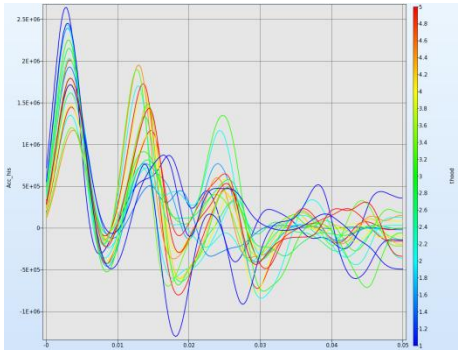




LS-OPT®: Status and Outlook

Nielen Stander[1], Anirban Basudhar[1], Imtiaz Gandikota[1]
Katharina Witowski[2], Åke Svedin[3], Christoffer Belestam[3]

[1]Livermore Software Technology Corporation
[2]DYNAmore GmbH
[3]DYNAmore Nordic AB

Bamberg, 12.10.2016

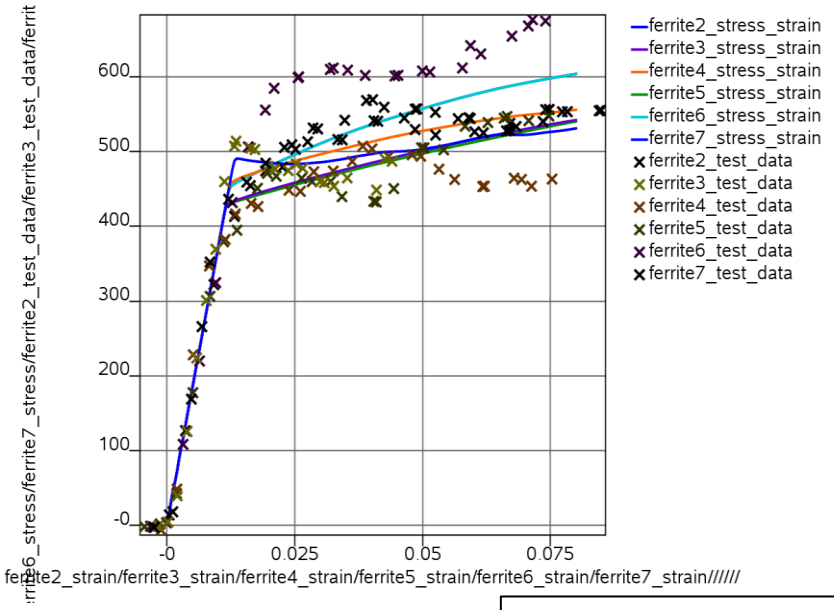
Outline

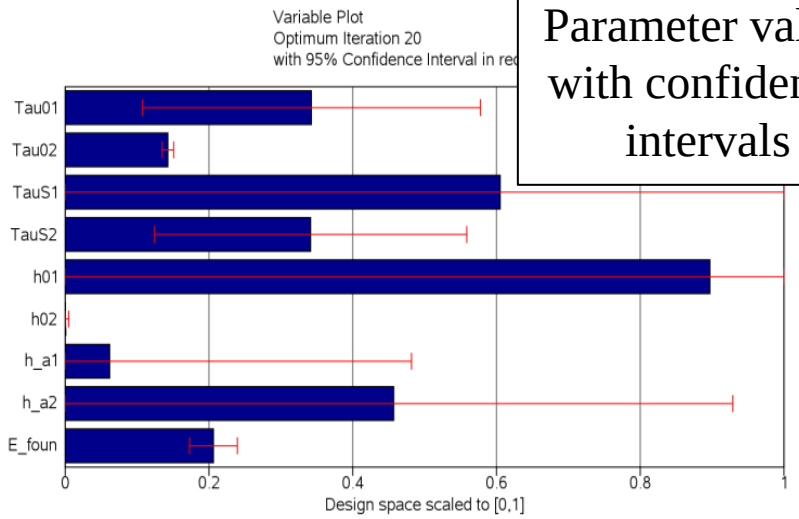
- Current Development
  - Digital Image Correlation based Parameter Identification
  - Interactive Tables
  - Support Vector Classification
- Summary

Digital Image Correlation (DIC) based System Identification

Parameter Identification

- Uniaxial experiments do not necessarily predict non-uniform deformations
- Local phenomena such as coupon necking/barreling missed
- Instability is typical in inverse problems of this nature
- Spatially distributed (full field) data can provide more information
- See e.g. work by Mahnken and Stein, U. Hannover (1997-2001)



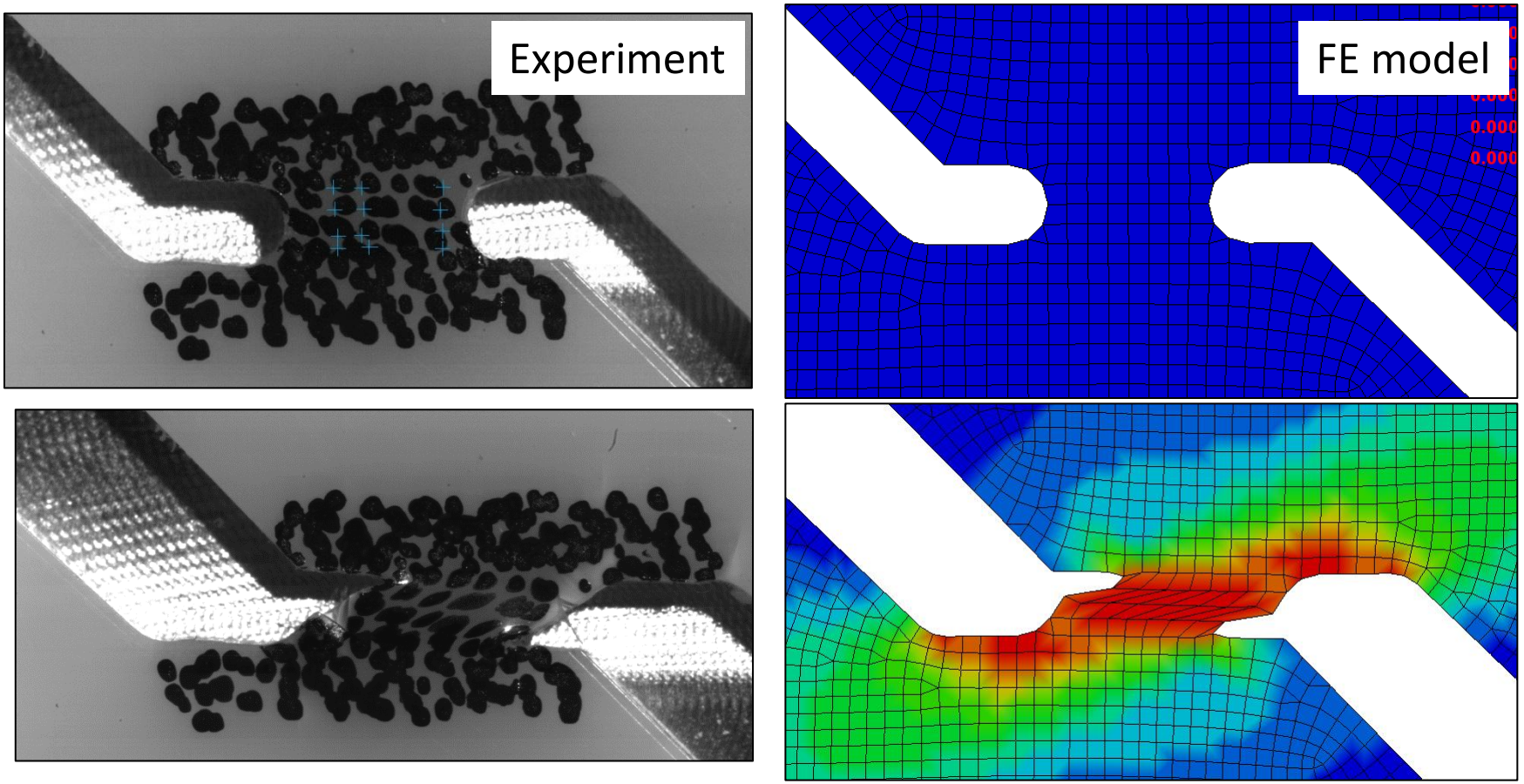


Parameter values with confidence intervals

Ferrite single crystal calibration

Digital Image Correlation

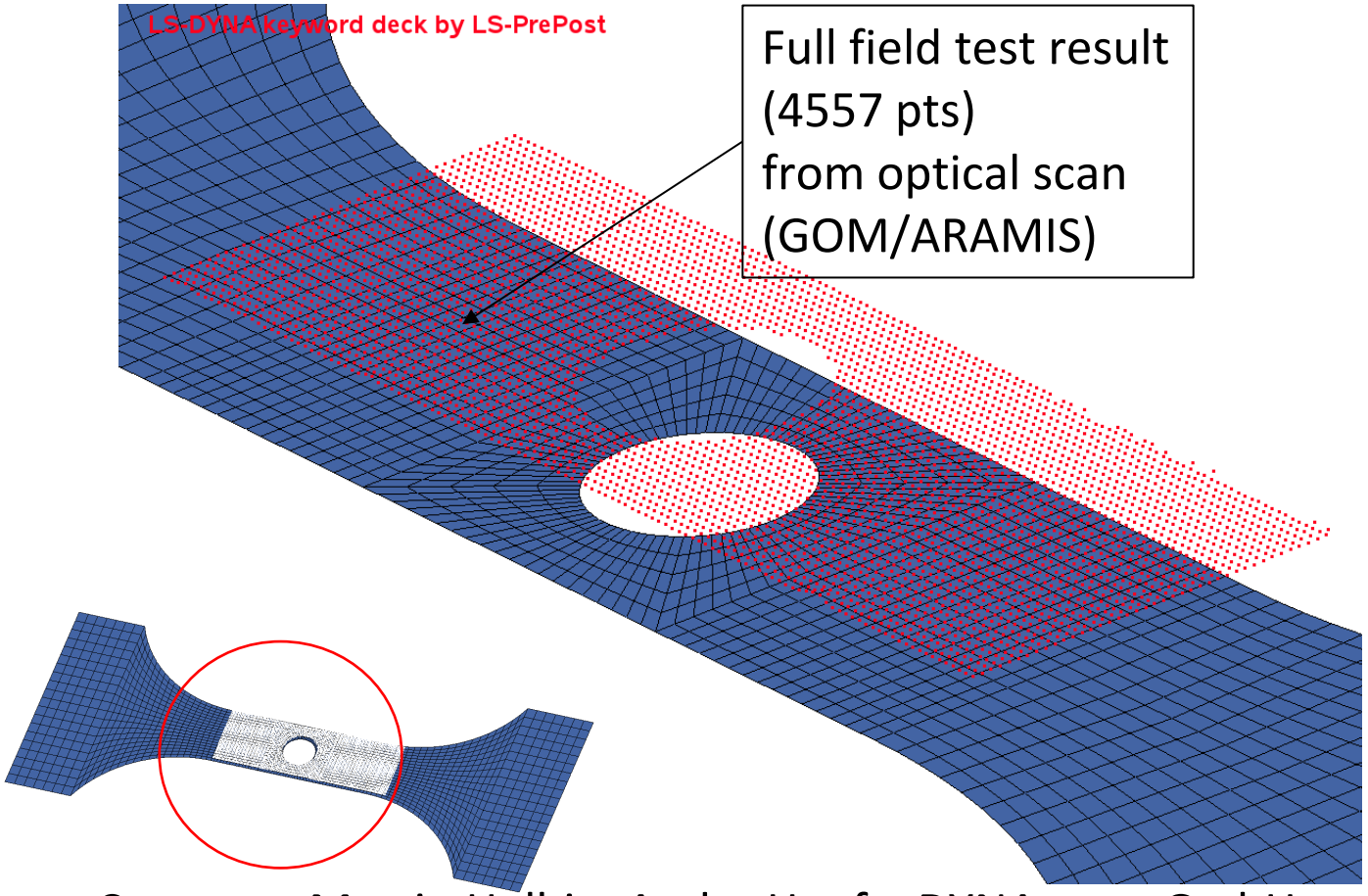
- Example: Shear

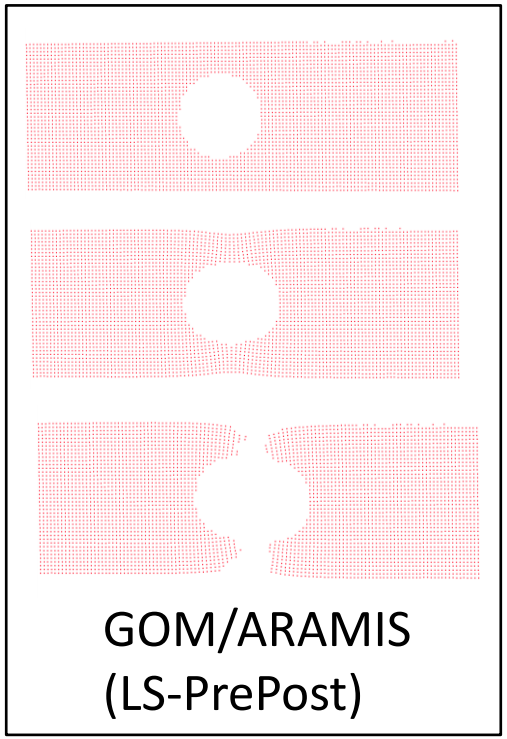


Courtesy: Veronika Effinger, DYNAmore GmbH; Andreas Hirth, Daimler AG

DIC-based Calibration

- Matching in time and space: Example (tensile)



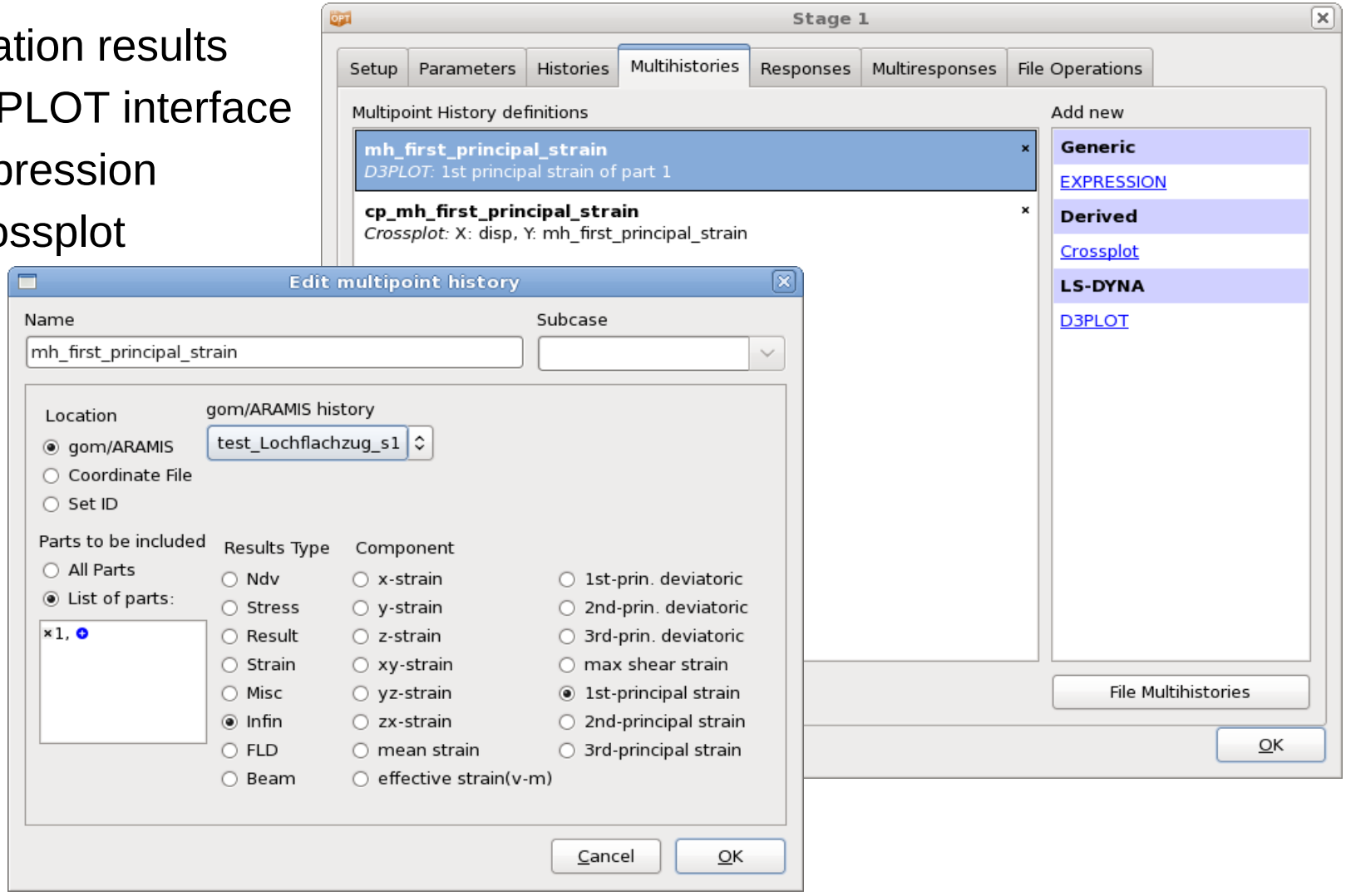


Courtesy: Martin Helbig, Andre Haufe, DYNAmore GmbH

LS-OPT: Multipoint Histories

Simulation results

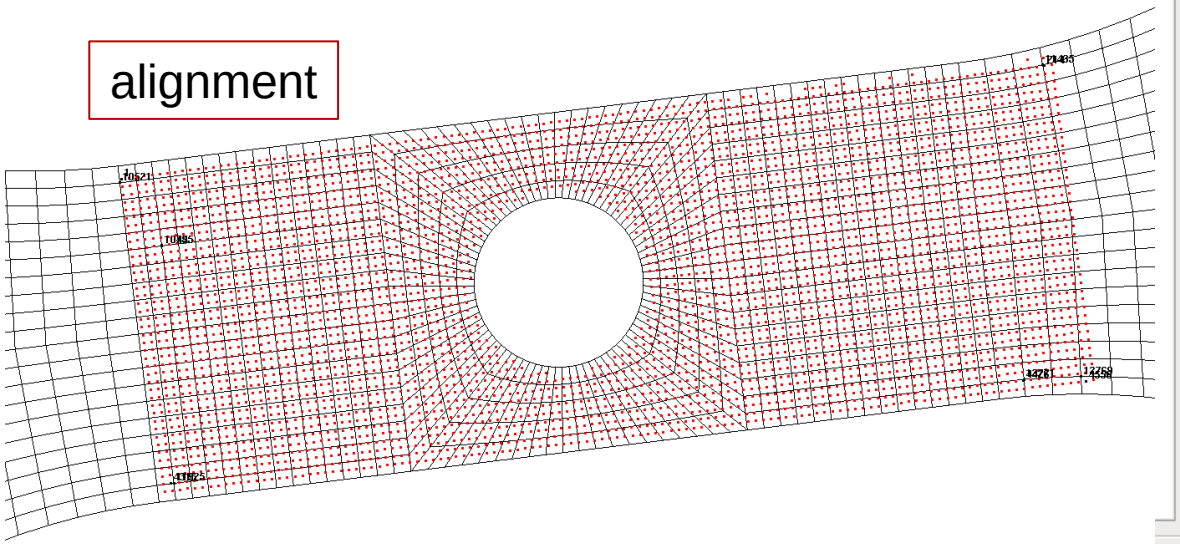
- D3PLOT interface
- Expression
- Crossplot

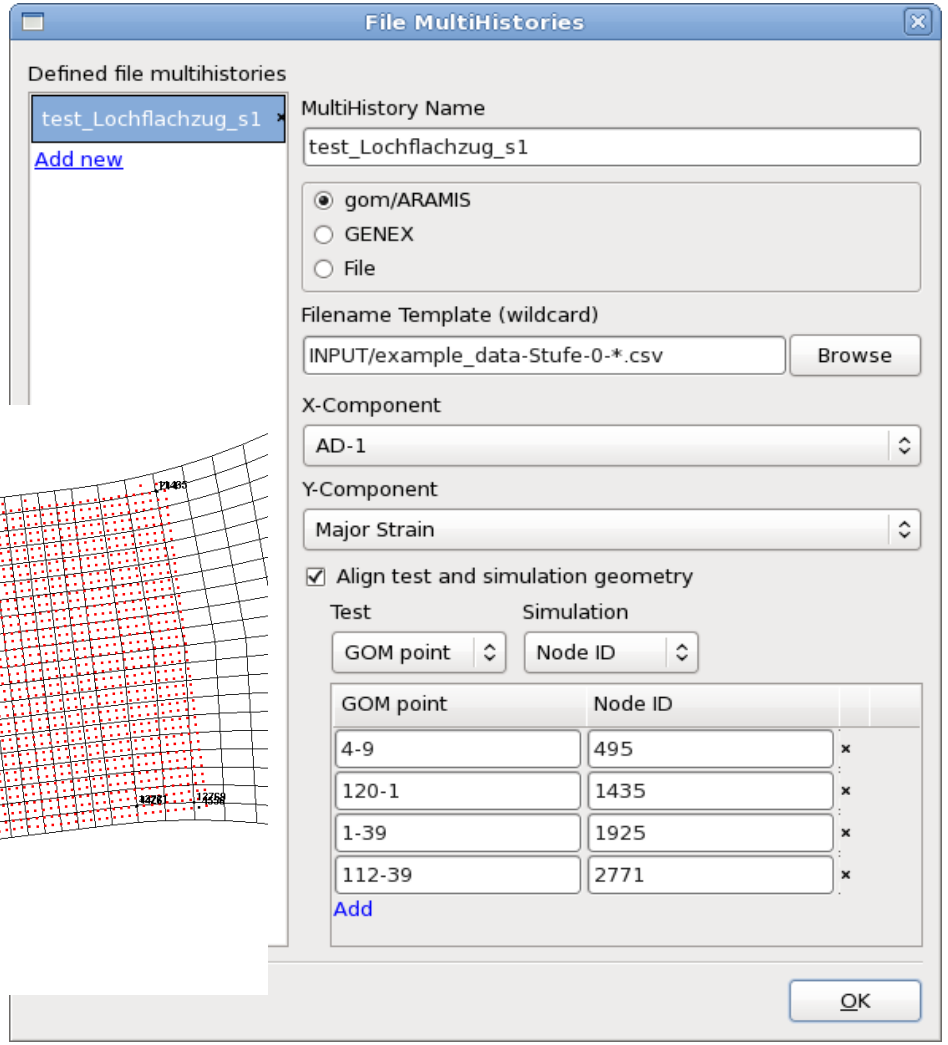


LS-OPT: File Multihistories

Test data

- GOM/Aramis interface
- GenEx
- File

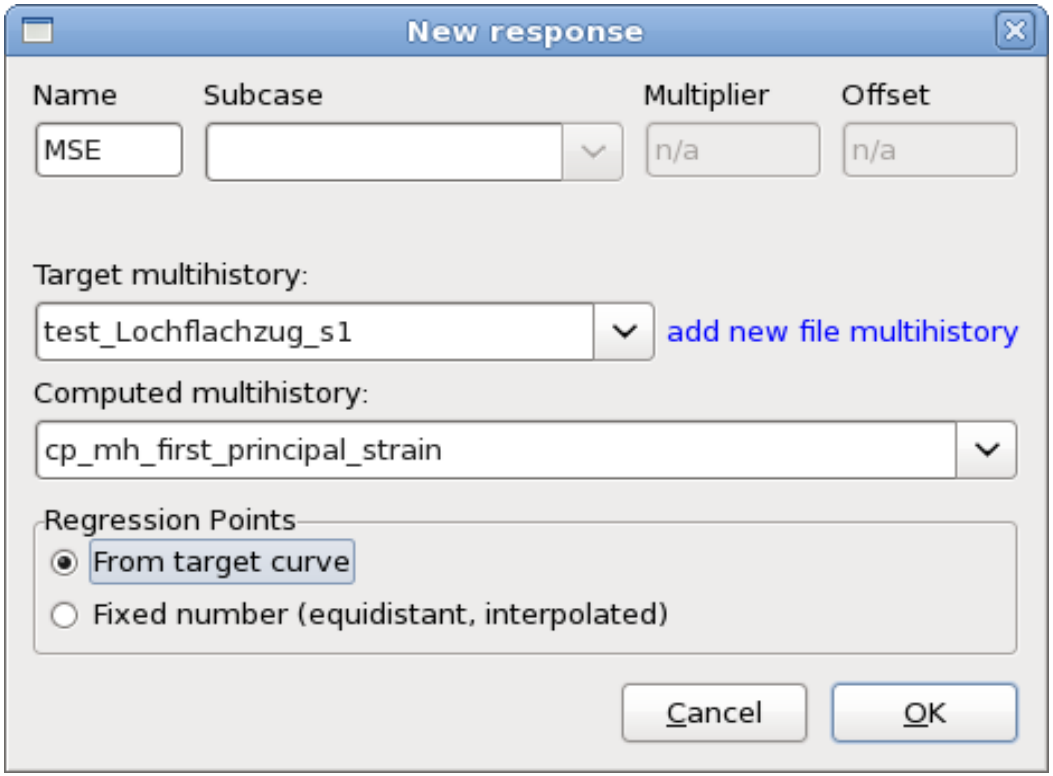




LS-OPT: Multipoint MSE

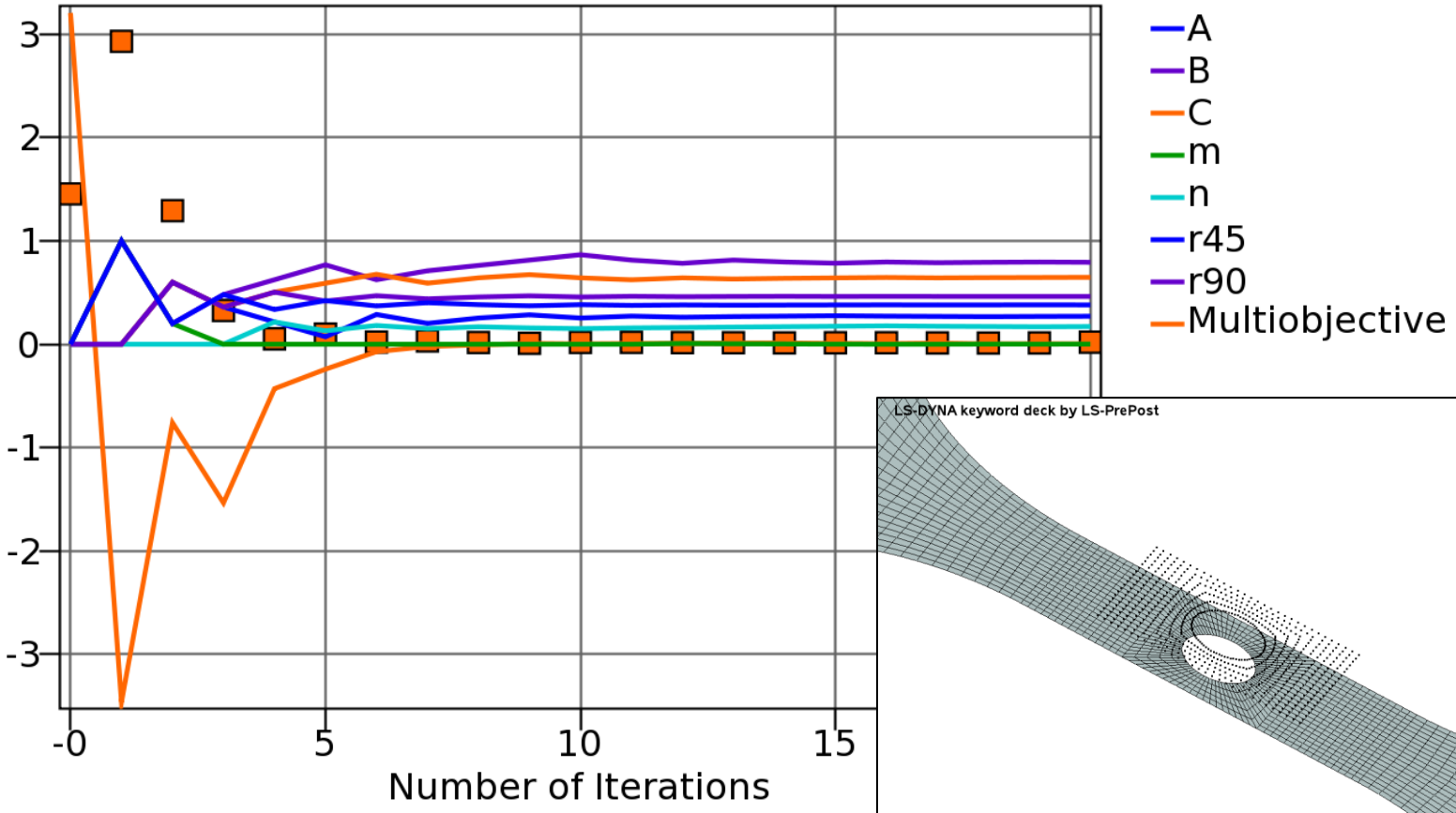
Curve matching metric

- Multipoint Mean Square Error



Coordinate-based re-identification

- GISSMO model using displacement field

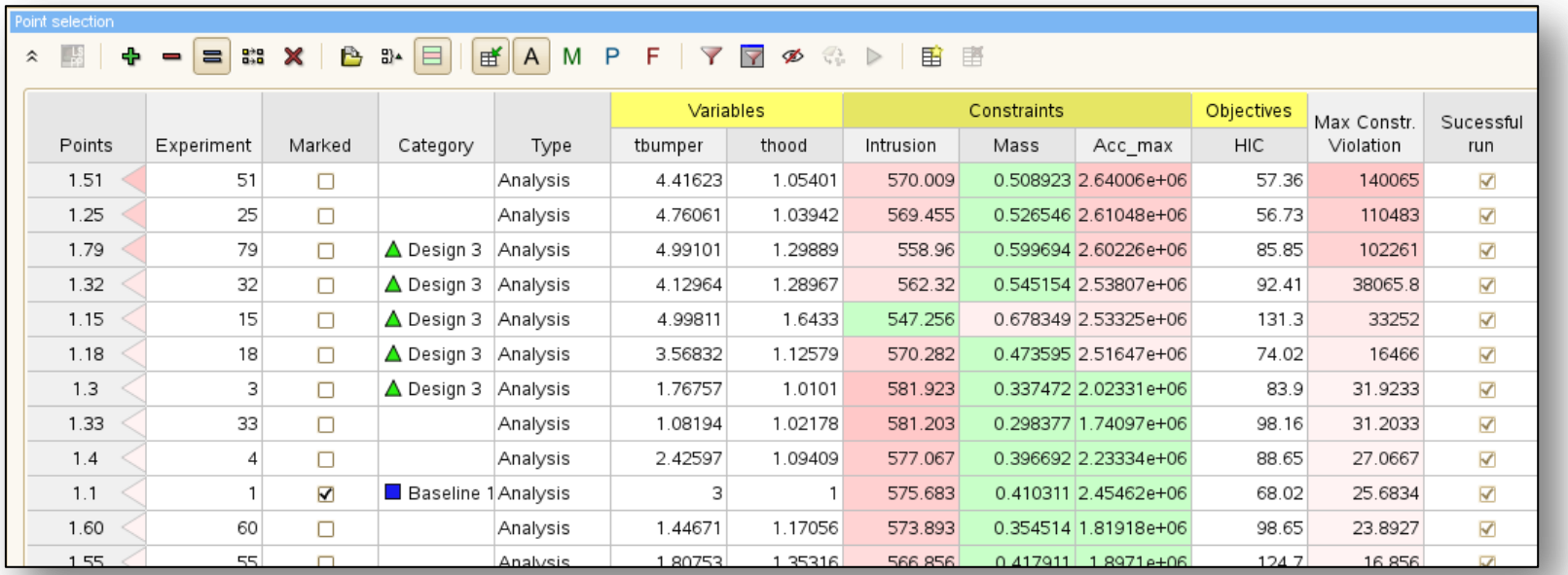


Interactive Tables

Interactive Tables

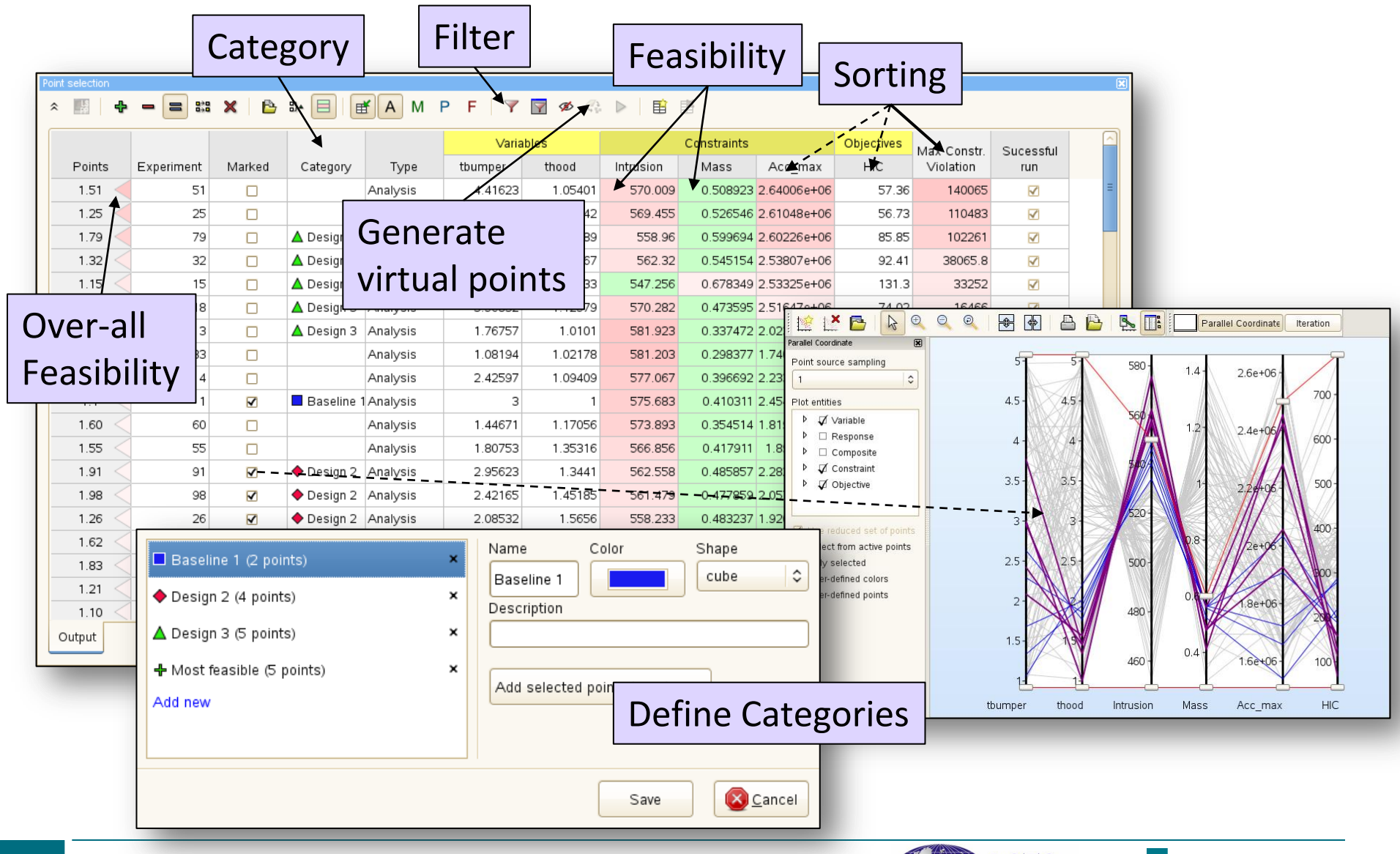
Enhanced visualization and interactive features

- Create multiple tables by filtering, sorting, …
- Calculate Statistics
- Generate large sets of virtual results from Viewer
- Select and run new simulations from Viewer



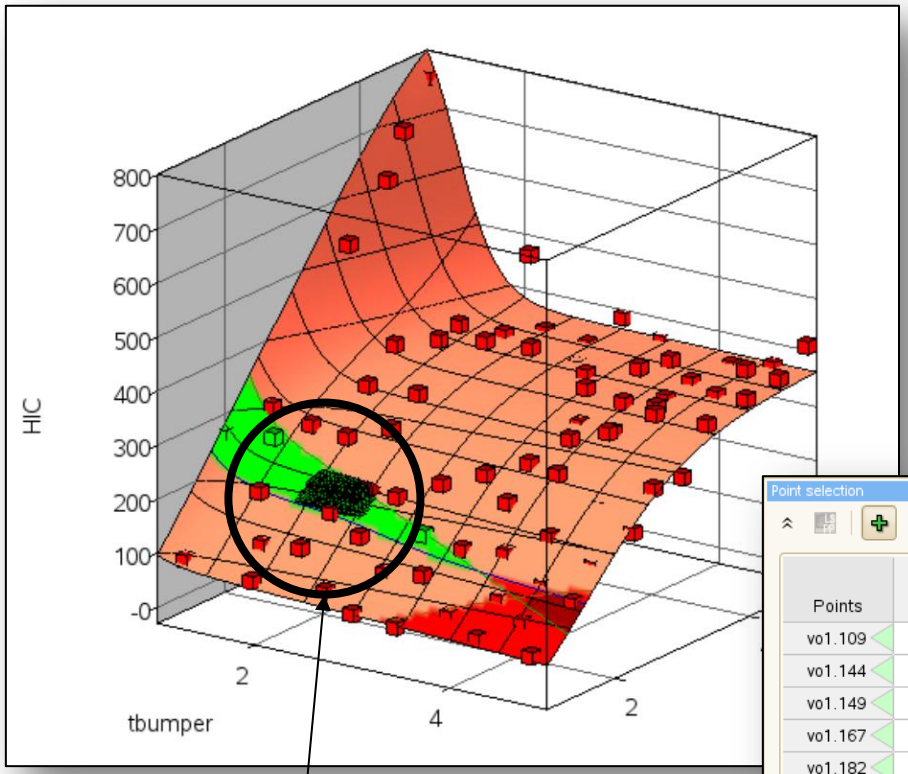
Points	Experiment	Marked	Category	Type	Variables		Constraints			Objectives	Max Constr. Violation	Sucessful run
					tbumper	thood	Intrusion	Mass	Acc_max	HIC		
1.51	51	☐		Analysis	4.41623	1.05401	570.009	0.508923	2.64006e+06	57.36	140065	☑
1.25	25	☐		Analysis	4.76061	1.03942	569.455	0.526546	2.61048e+06	56.73	110483	☑
1.79	79	☐	Design 3	Analysis	4.99101	1.29889	558.96	0.599694	2.60226e+06	85.85	102261	☑
1.32	32	☐	Design 3	Analysis	4.12964	1.28967	562.32	0.545154	2.53807e+06	92.41	38065.8	☑
1.15	15	☐	Design 3	Analysis	4.99811	1.6433	547.256	0.678349	2.53325e+06	131.3	33252	☑
1.18	18	☐	Design 3	Analysis	3.56832	1.12579	570.282	0.473595	2.51647e+06	74.02	16466	☑
1.3	3	☐	Design 3	Analysis	1.76757	1.0101	581.923	0.337472	2.02331e+06	83.9	31.9233	☑
1.33	33	☐		Analysis	1.08194	1.02178	581.203	0.298377	1.74097e+06	98.16	31.2033	☑
1.4	4	☐		Analysis	2.42597	1.09409	577.067	0.396692	2.23334e+06	88.65	27.0667	☑
1.1	1	☑	Baseline 1	Analysis	3	1	575.683	0.410311	2.45462e+06	68.02	25.6834	☑
1.60	60	☐		Analysis	1.44671	1.17056	573.893	0.354514	1.81918e+06	98.65	23.8927	☑
1.55	55	☐		Analysis	1.80753	1.35316	566.856	0.417911	1.8971e+06	124.7	16.856	☑

Interactive Tables

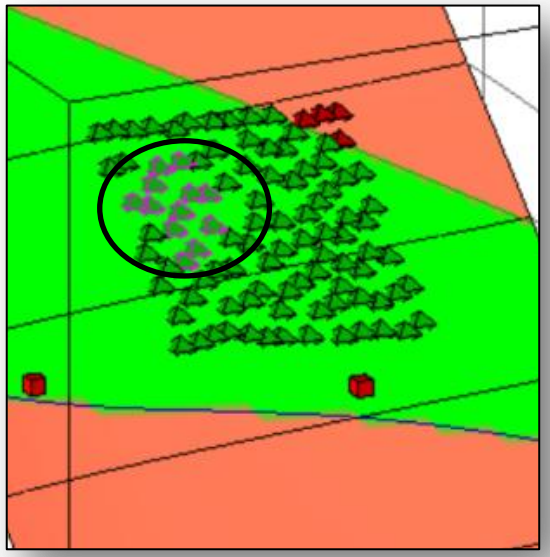


Interactive Tables

- Generate virtual points → new simulations



Select



Virtual points

Run simulations

Generate in Viewer

Point selection

Points	Marked	Type	Variables		Constraints			Objectives	Ma
			tbumper	thood	Intrusion	Mass	Acc_max	HIC ▲	V
vo1.109	☑	Virtual	2.25259	1.86465	544.755	0.561377	1.88095e+06	200.142	
vo1.144	☑	Virtual	2.19286	1.87575	544.488	0.560259	1.85526e+06	202.227	
vo1.149	☑	Virtual	2.23566	1.9226	542.64	0.573522	1.85635e+06	208.534	
vo1.167	☑	Virtual	2.16694	1.93914	542.235	0.573095	1.82604e+06	211.42	
vo1.182	☑	Virtual	2.3141	1.89203	543.545	0.571354	1.89467e+06	203.571	
vo1.196	☑	Virtual	2.12216	1.88888	544.171	0.558934	1.82481e+06	204.703	
vo1.200	☑	Virtual	2.3527	1.84454	545.248	0.562909	1.92413e+06	196.428	

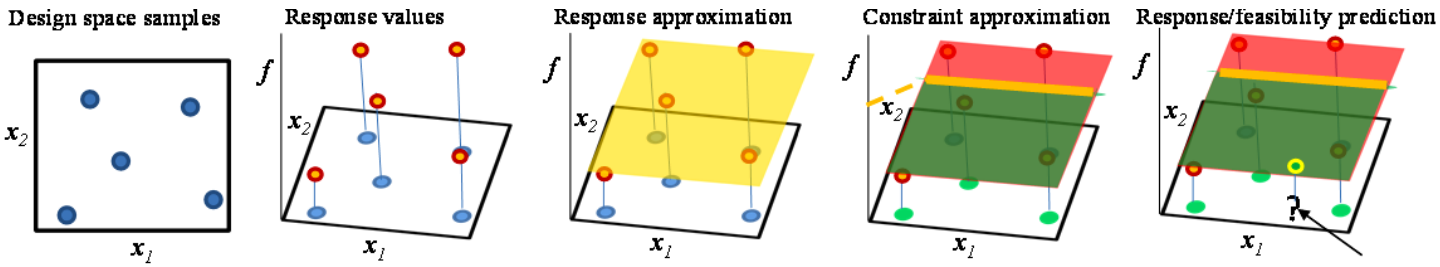
Output | Table1

Support Vector Classification

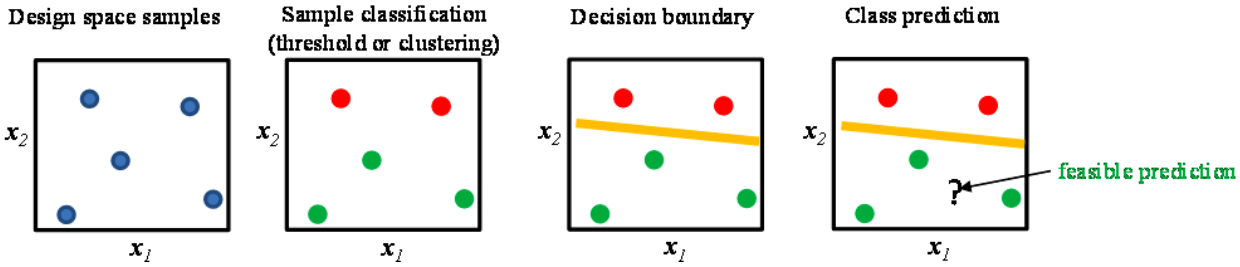
Support Vector Classification

- Discontinuous and binary responses
  - Map input data to category

Metamodeling



Basic classification method

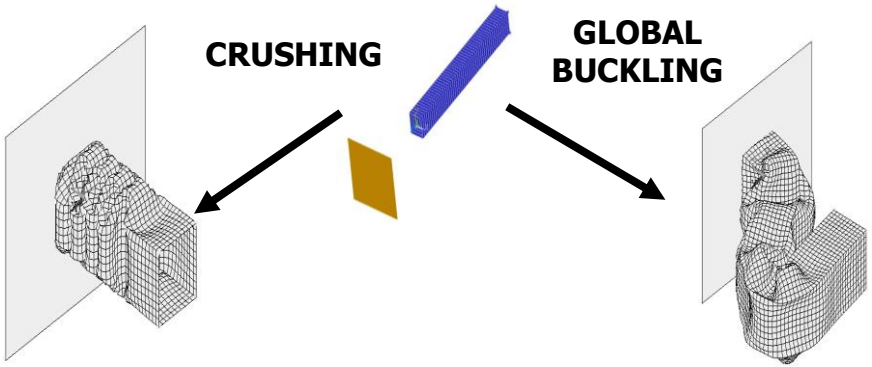


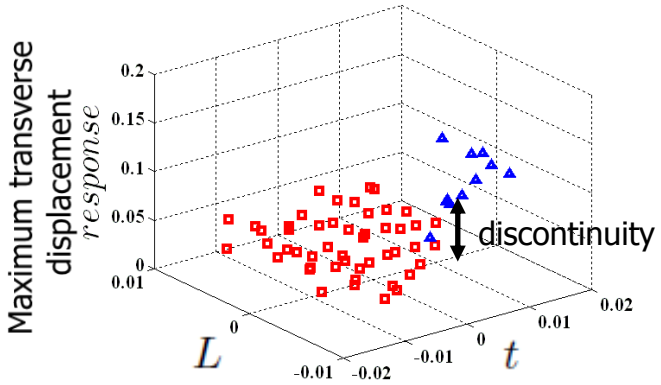
- Adaptive multi-objective optimization
  - classifier defines the boundary of the Pareto optimal designs

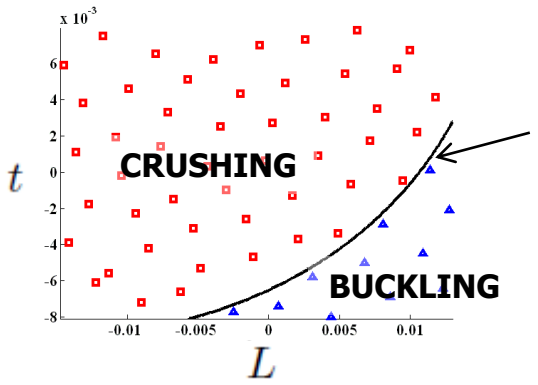
Basudhar, A. (2015). Multi-objective Optimization Using Adaptive Explicit Non-Dominated Region Sampling. In 11th World Congress on Structural and Multidisciplinary Optimization.

Support Vector Classification

- Example: Tube impact







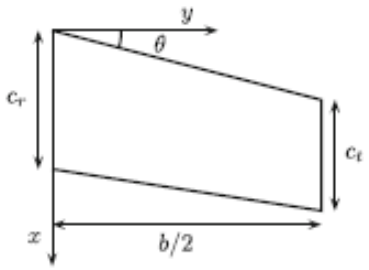
Explicit classifier boundary

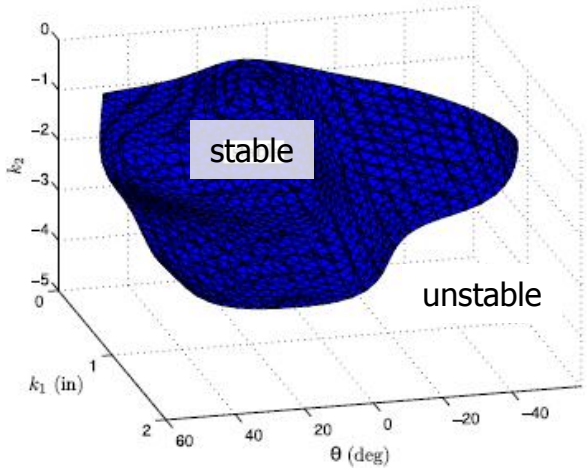
Design Space (length and thickness)

Support Vector Classification

- Example: Wing Aeroelasticity
- Binary constraints
  - **Divergence instability**
    - Zero vs Non-zero Modal Frequency
  - **Flutter instability**
    - Positive vs Negative damping coefficient

***Basudhar**, Anirban, et al. "Constrained efficient global optimization with support vector machines." Structural and Multidisciplinary Optimization 46.2 (2012): 201-221.*





Decision Surface in Design Space

Summary

Current Development

- DIC-based parameter identification
  - Multihistories
  - GOM interface
  - Multi MeanSqErr
- Interactive tables
  - Sorting, filtering …
  - Generation of virtual points
  - Run new simulations from Viewer
- Support Vector Classification
  - Discontinuous/binary responses

→ Will be available in Version 6.0

Thank you!