Major Product Crisis: 8D Resolution Process With JMP®

Véronique Audran-Esturillo, Jerome Bonnouvrier, Franck Richard

ULIS

Abstract

In the past, ULIS faced a major crisis which impacted the functionality of the big-runner products.

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The application JMP® was successfully used during the main steps of crisis resolution, using the 8D methodology: JMP® has been a key contributor to the success of this crisis resolution within the phases

- ❑ Problem description
- ❑ Root cause analysis
- ❑ Permanent Corrective Action

Objective

To show the Ulis application of the JMP® platform which has been used as a graphical and statistical "tool box" in order to facilitate analysis or provide a new way of looking at data.

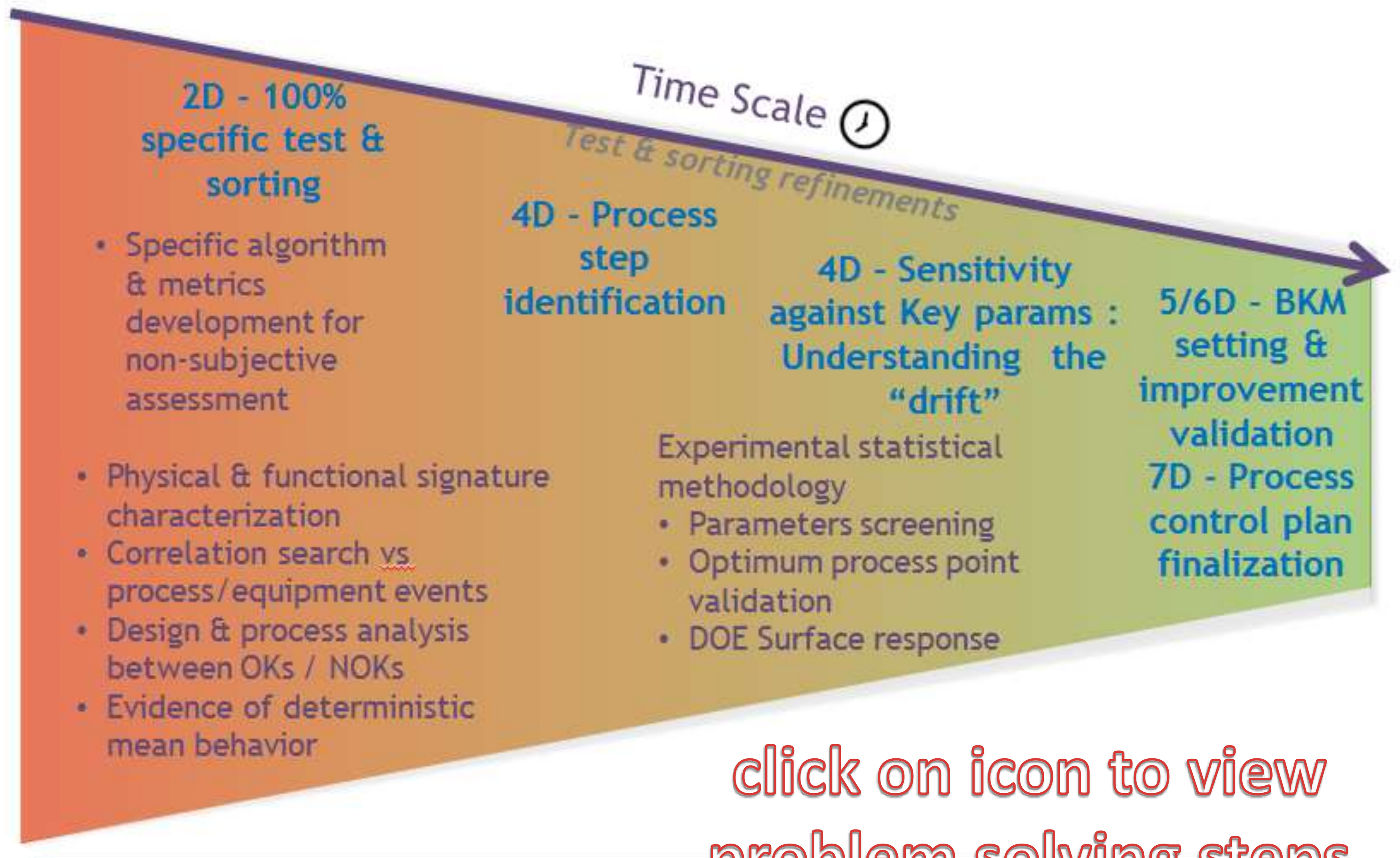
We will focus on a broad variety of JMP® tools such as:

- X by Y analysis
- Graph builder
- Distribution platform
- DOE (screening and response surface
- Power platform

Methods

- Use of the 8D methodology
- Use of JMP® as a statistical and graphical "toolbox"

1D • Team formation
2D • Problem Description
3D • Interim Containment Actions
4D • Root cause Analysis
5D • Corrective Actions
6D • Validate Corrective Actions
7D • Identify and Implement Preventive Actions
8D • Team and individual recognition



click on icon to view problem solving steps

Conclusions

click on icon to view final improvement

- An efficient support to production was delivered using different JMP tools for 8D problem resolution with a combination of powerful statistics and dynamic graphics
- Communication on subject was reinforced by the graph builder - clear, concise and compelling visualizations

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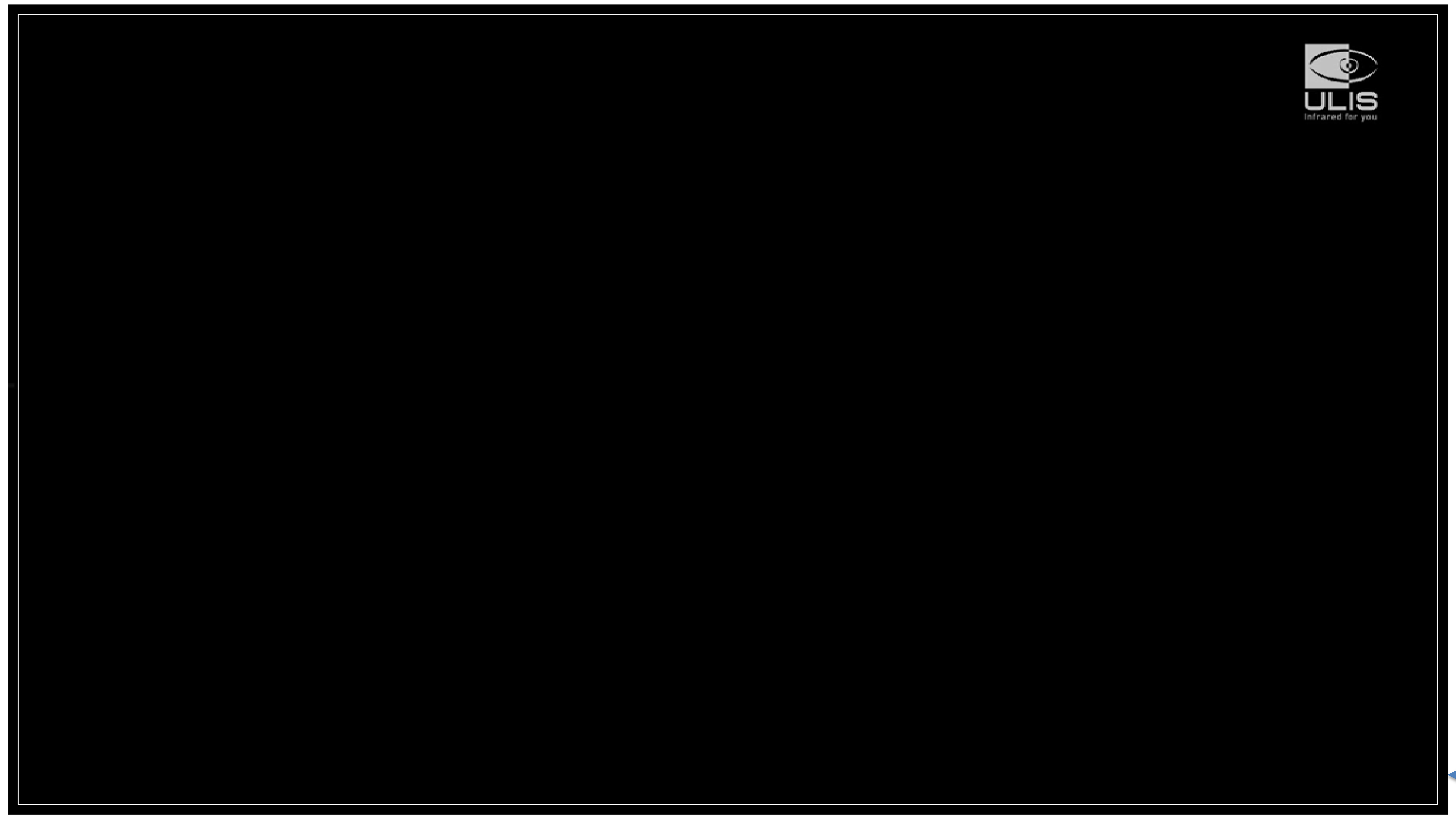
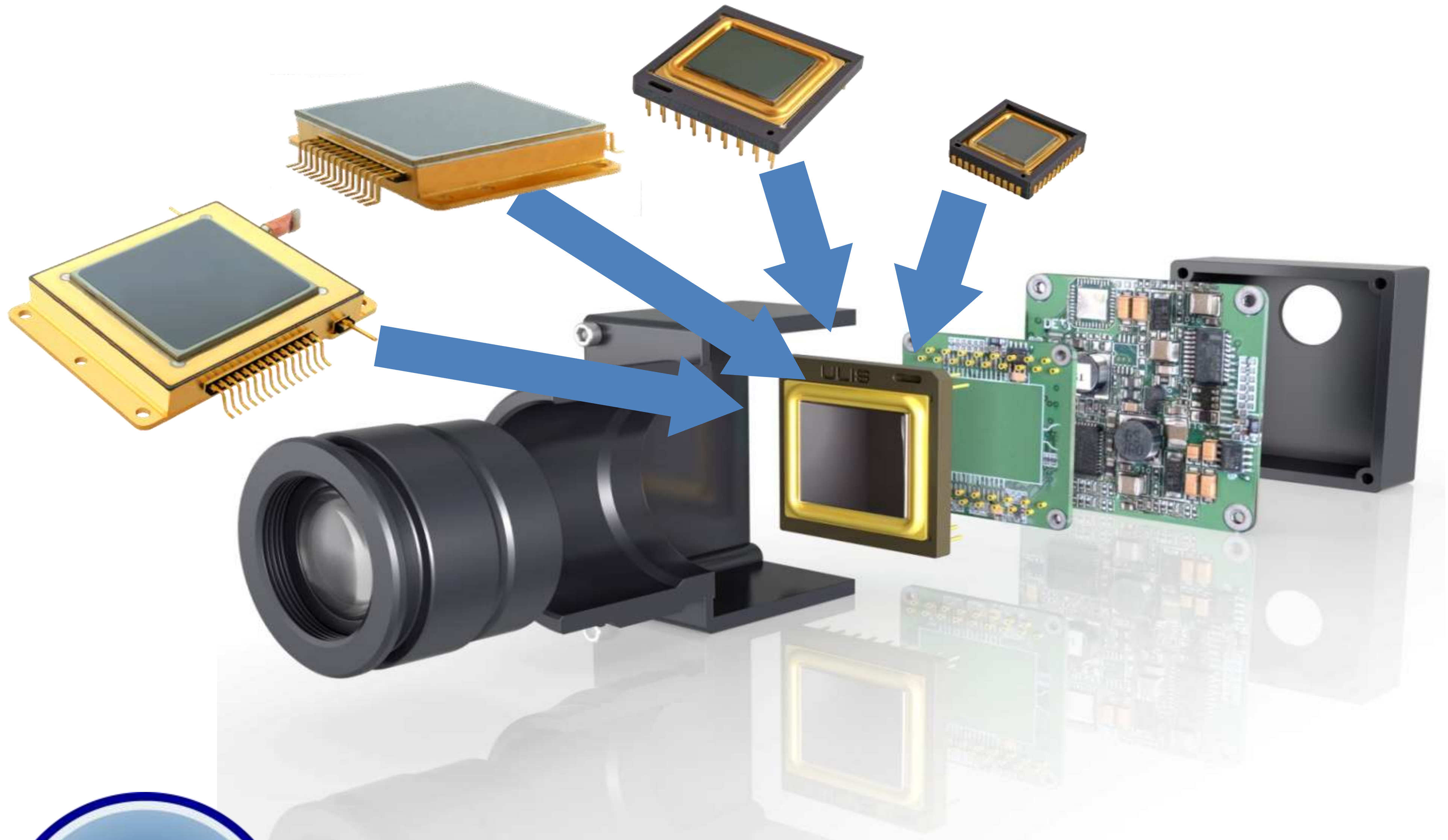




ULIS AT A GLANCE

Independent Merchant Supplier: ULIS Inside!

ULIS manufactures high-volume infrared detectors for lightweight, low power consumption and cost-effective IR cameras

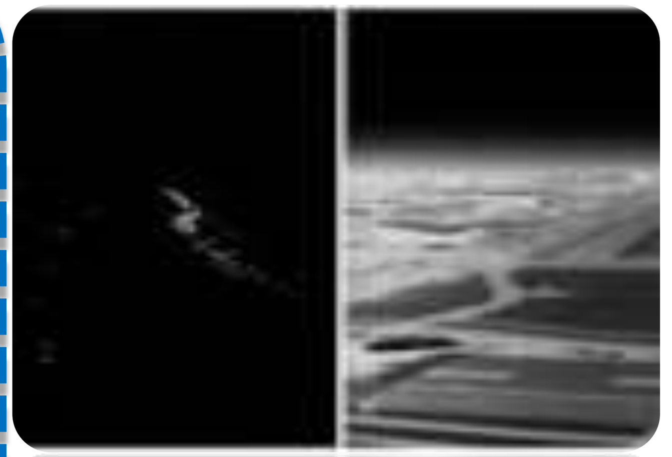
Markets & Applications

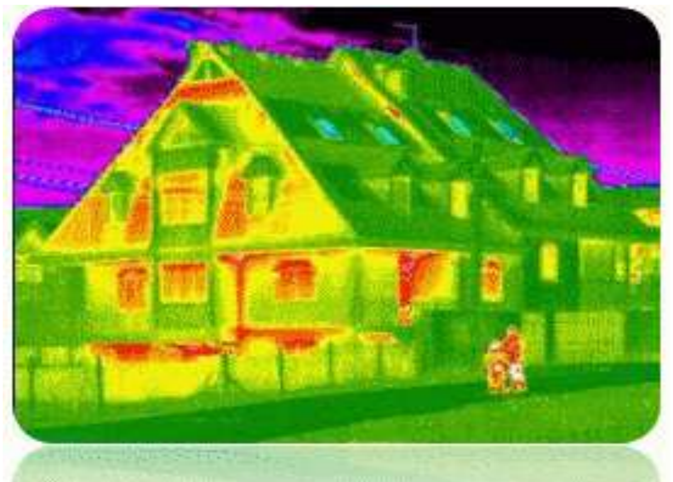

Gas detection


Health checks

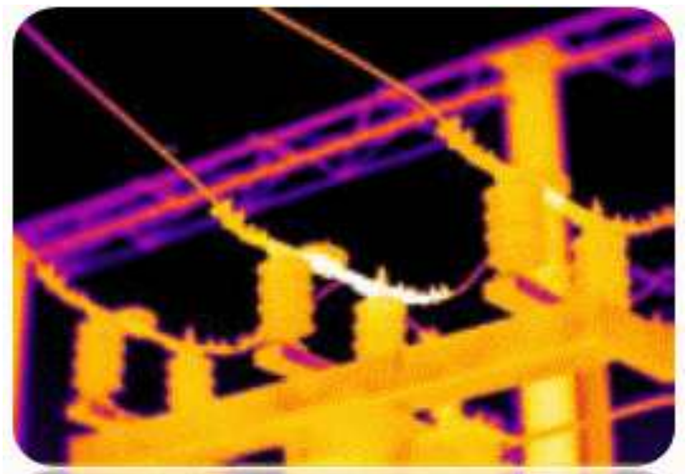

Military/Paramilitary


Firefighting

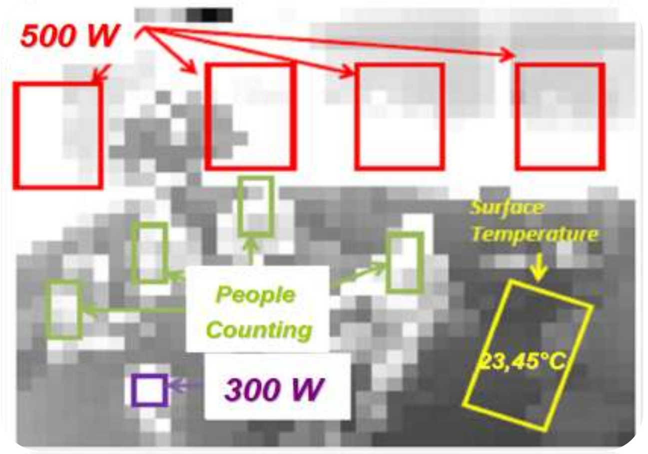

Flight aids


Building inspection


Surveillance/Security


Predictive maintenance


Automotive / AEB



Building automation

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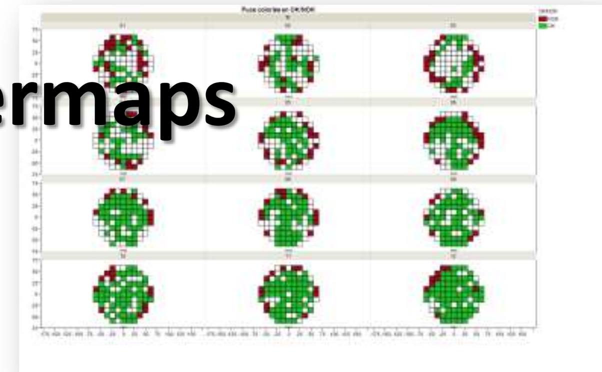
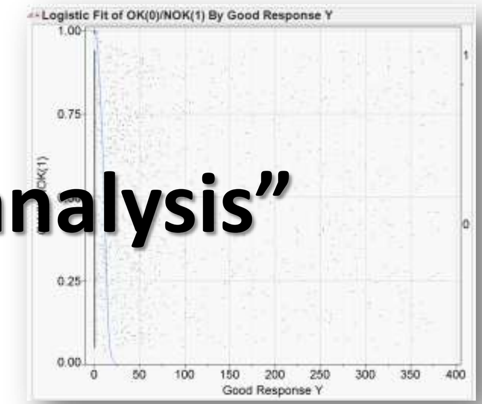
Results

JMP® Custom Wafermaps



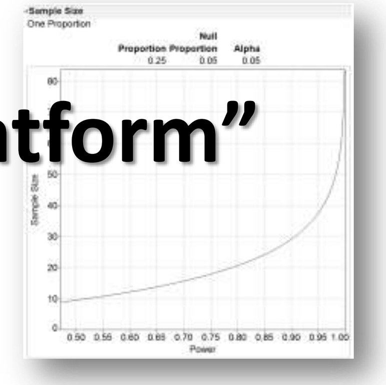
JMP® "X by Y analysis"



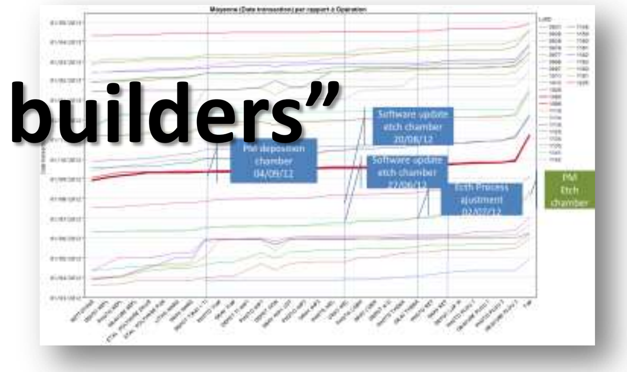
Time Scale

Test & sorting refinements

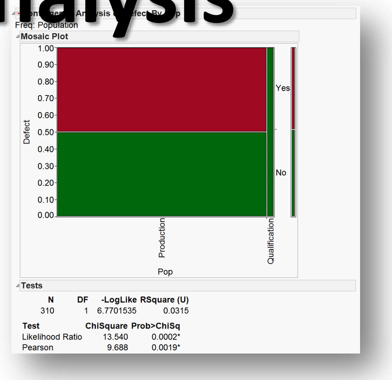
JMP® "power platform"



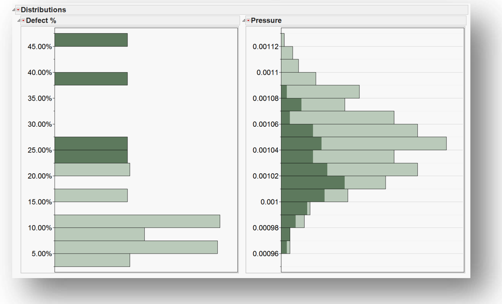
JMP® "graph builders"



JMP® "X by Y analysis"



JMP® "distribution platform"



2D - 100% specific test & sorting

- Specific algorithm & metrics development for non-subjective assessment

4D - Process step identification

4D - Sensitivity against Key params : Understanding the "drift"

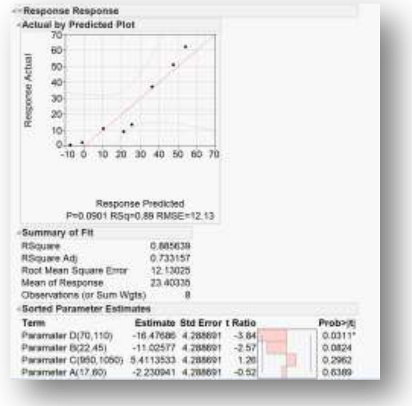
5/6D - BKM setting & improvement validation

7D - Process control plan finalization

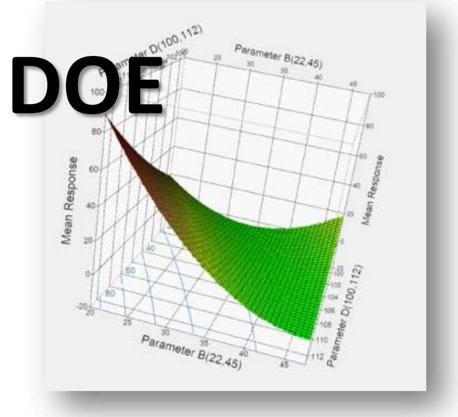
- Physical & functional signature characterization
- Correlation search vs process/equipment events
- Design & process analysis between OKs / NOKs
- Evidence of deterministic mean behavior

- Experimental statistical methodology
- Parameters screening
- Optimum process point validation
- DOE Surface response

JMP® screening DOE



JMP® response surface DOE



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ZOOM

- Team formation
- Problem Description
- Interim Containment Actions
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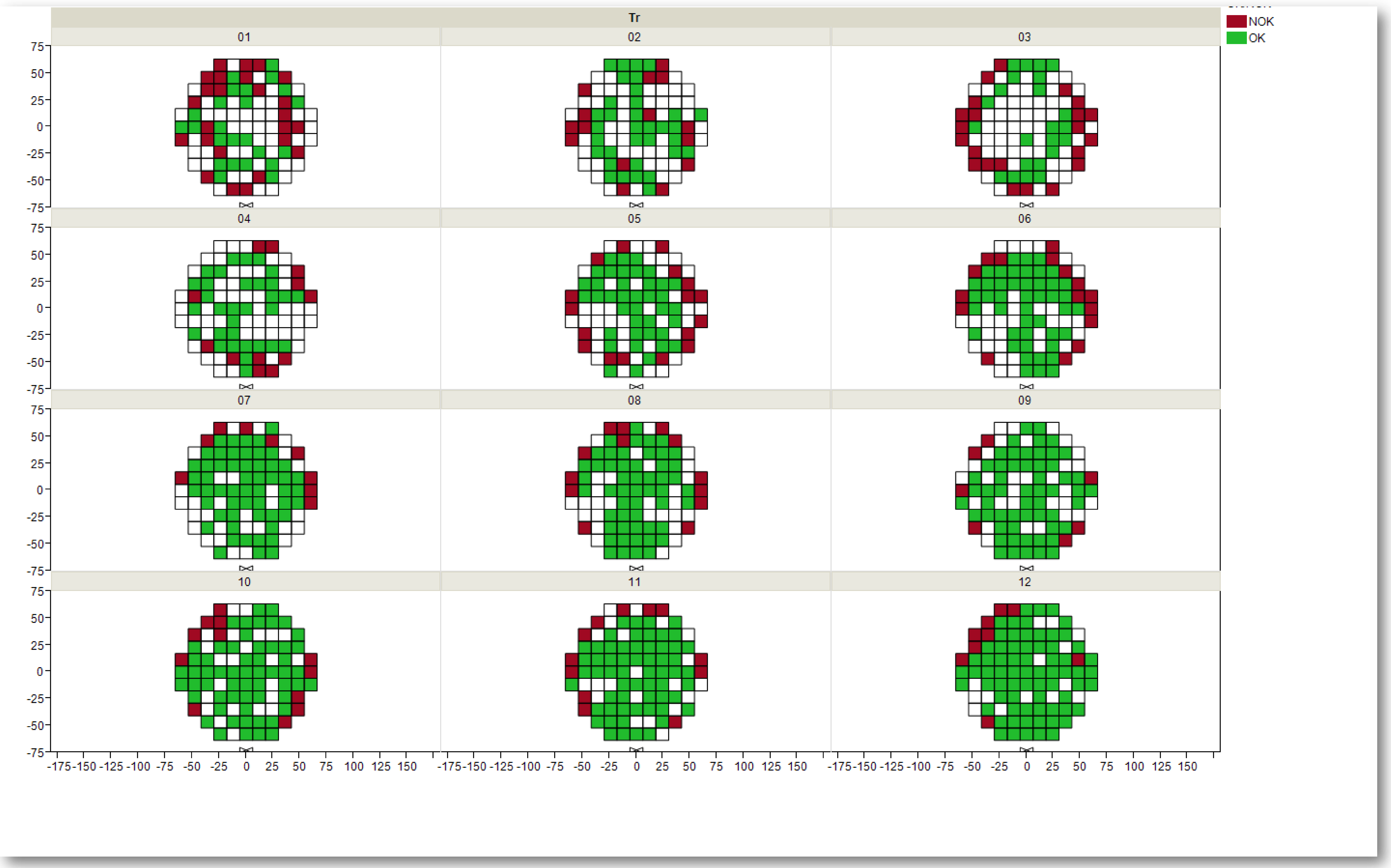
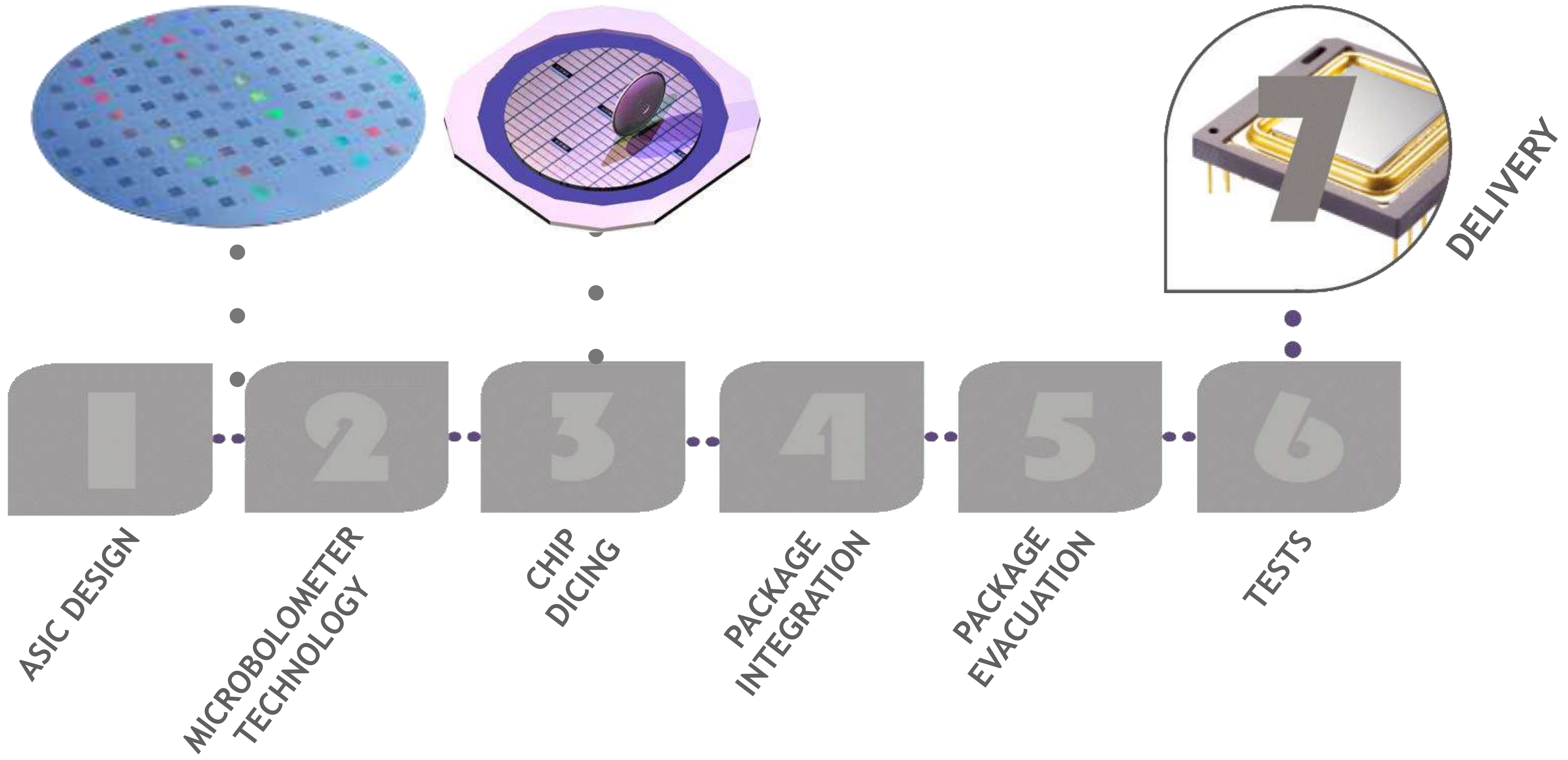
Return to global view

Custom Wafermaps were created in the "Graph builder platform" in order to locate the defect on silicon wafers.



8D description: Defect location (NOK = Bad dice) using custom wafermaps

Manufacturing flow chart



Analysis of wafermaps: defect not located randomly on wafers (wafer edge) → Defect most probably generated before dicing

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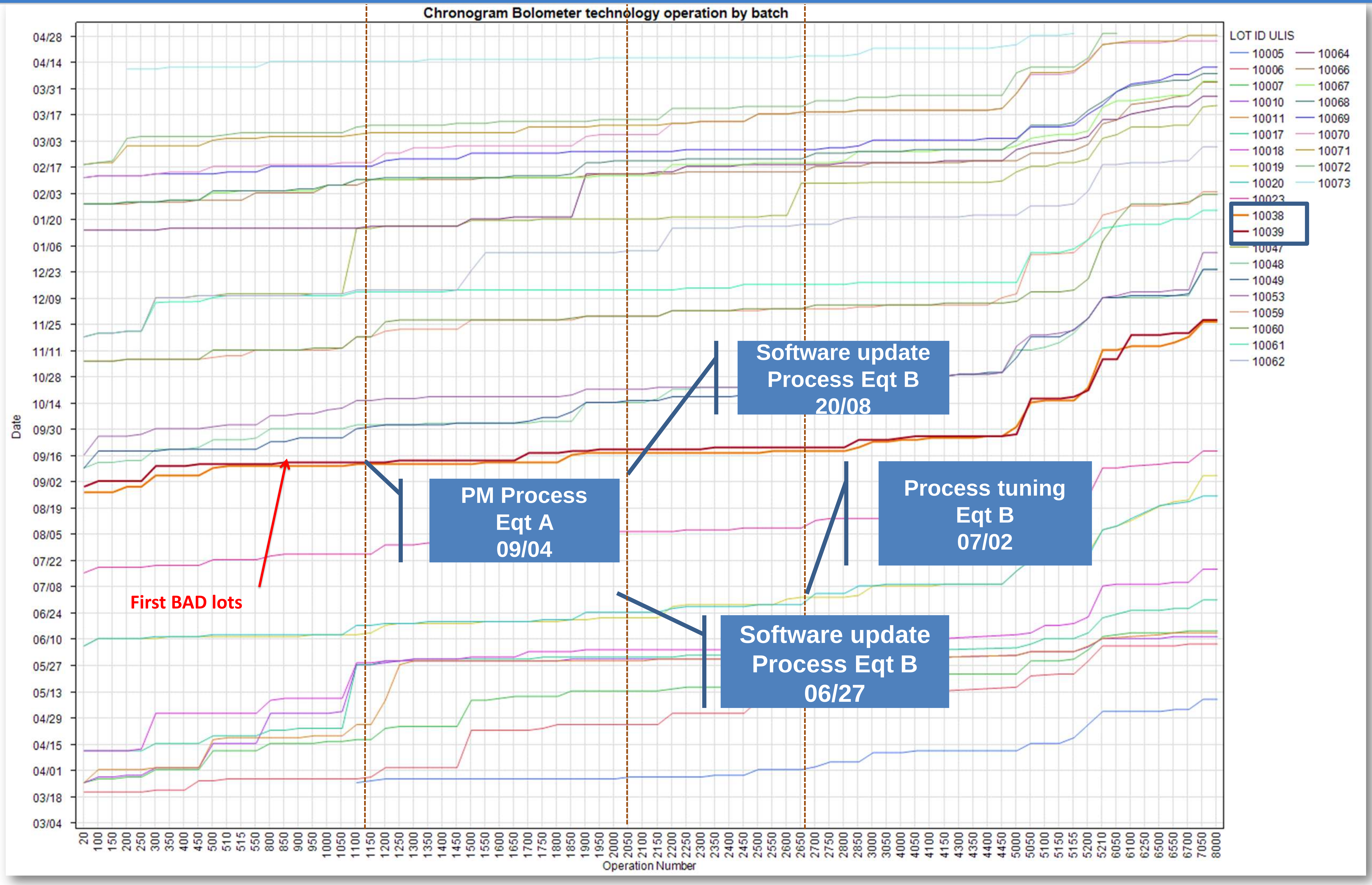
The graph builders' user-friendly interface was also helpful in creating chronograms of batch process histories and in determining when the problem appeared



8D description: Chronogram of bolometer technology operation by batch

Chronogram of lots by process steps before dicing: Preventive Maintenance on Process Equipment A appears to be a serious suspect

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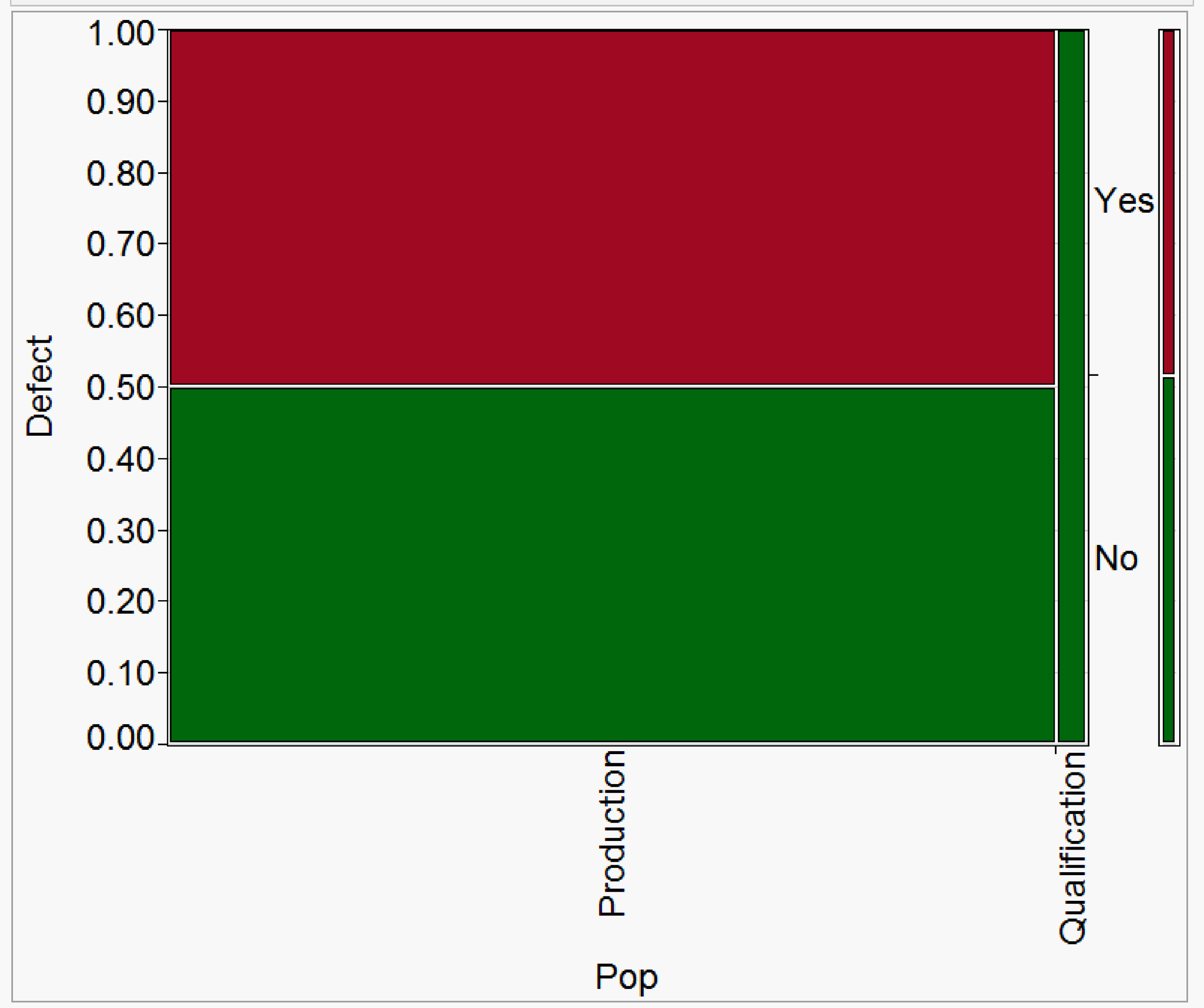
A calculation of confidence was used in order to compare the failure rates by product and to check if the defect was originally present during the qualification

Contingency Analysis of Defect By Pop

Freq: Population

Mosaic Plot



Tests

N	DF	-LogLike	RSquare (U)
310	1	6.7701535	0.0315

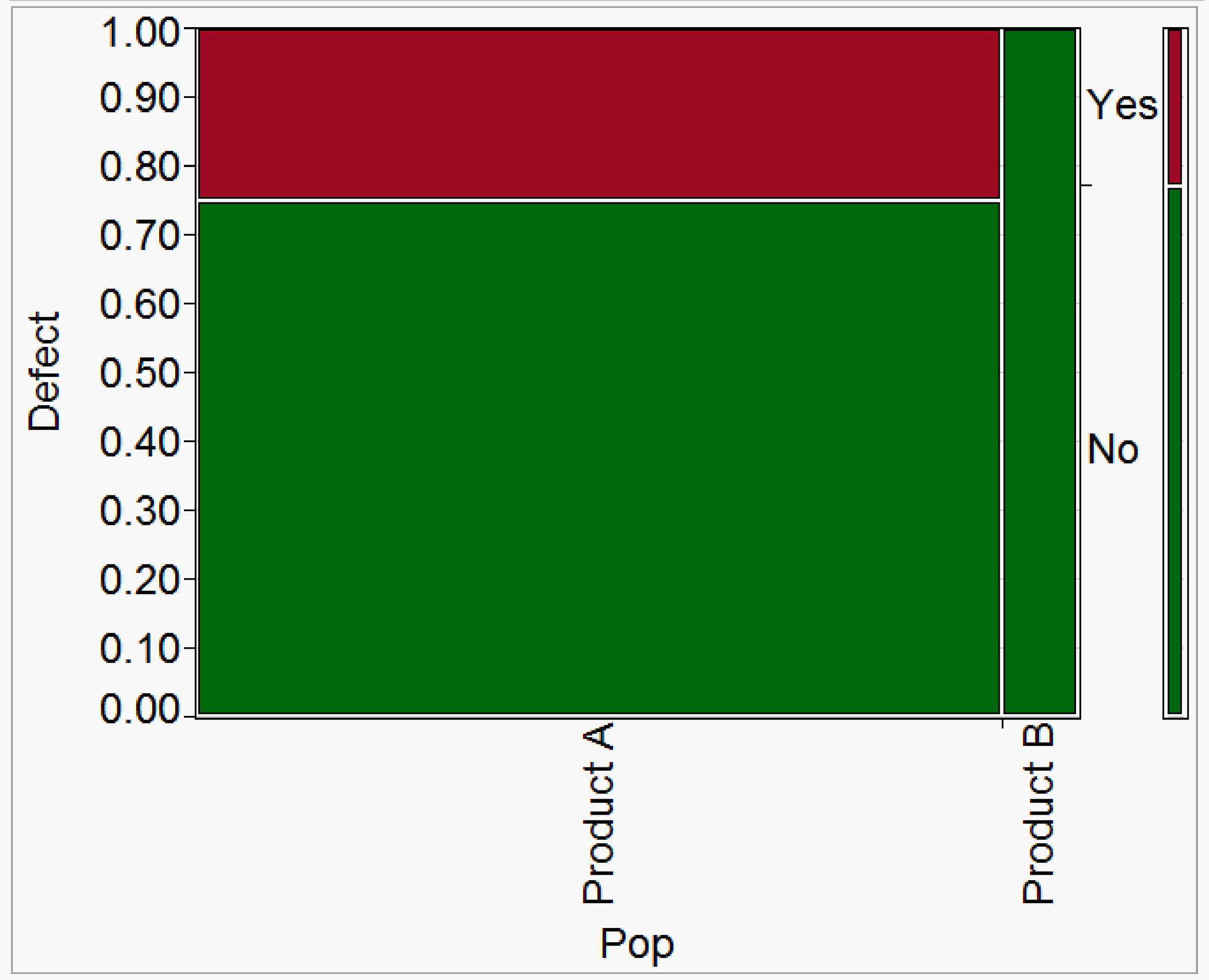
Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	13.540	0.0002*
Pearson	9.688	0.0019*

8D description: Defect rate detected during product qualification and during production

Contingency Analysis of Defect By Pop

Freq: Population

Mosaic Plot



Tests

N	DF	-LogLike	RSquare (U)
848	1	19.674016	0.0431

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	39.348	<.0001*
Pearson	23.339	<.0001*

8D description: Defect rate by product: Product B is statistically different

- Defect rate between qualification and production is statistically different → Process drift suspected

- Products not impacted at the same level: Important clue for root cause investigation

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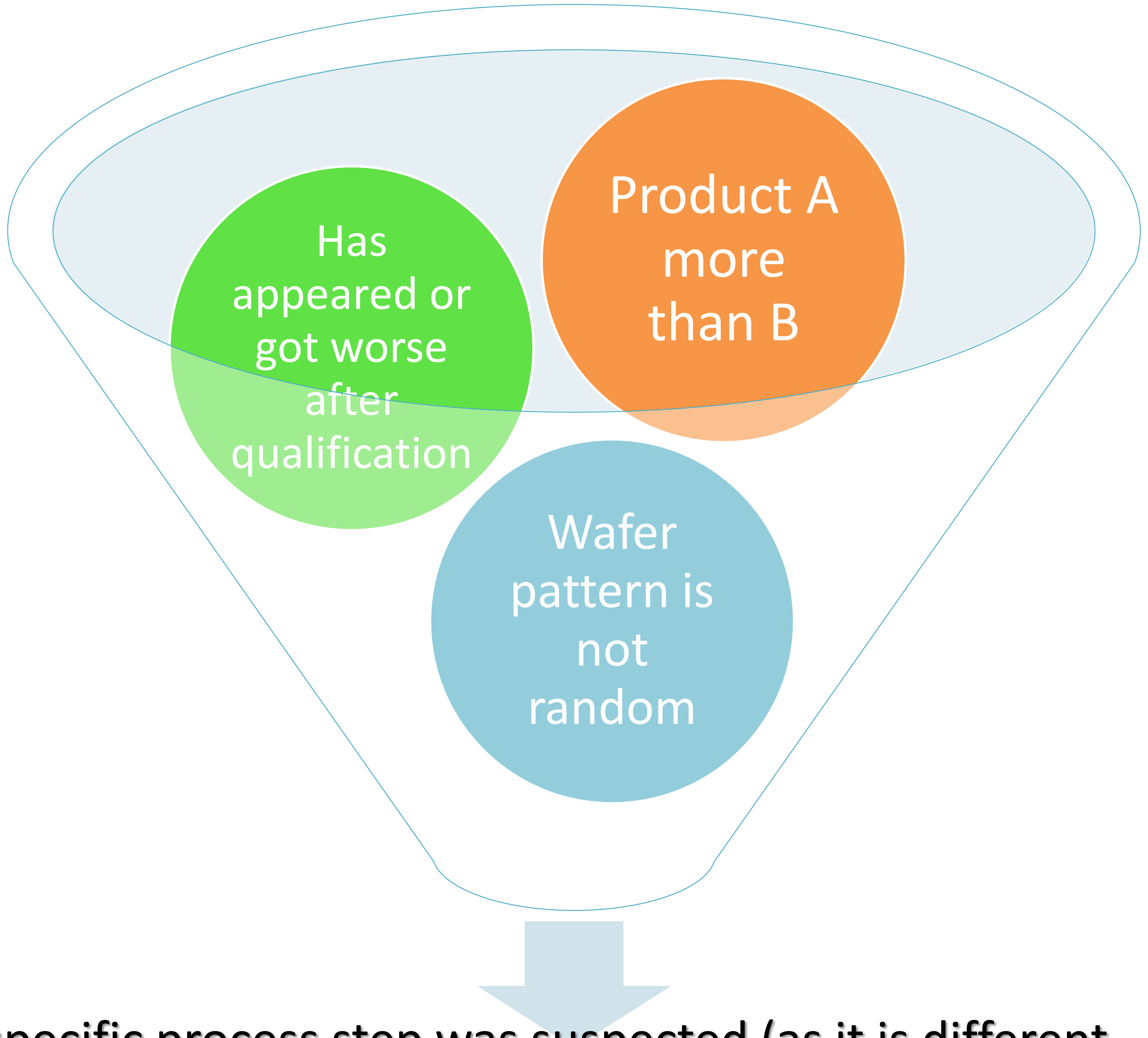
Return to global view

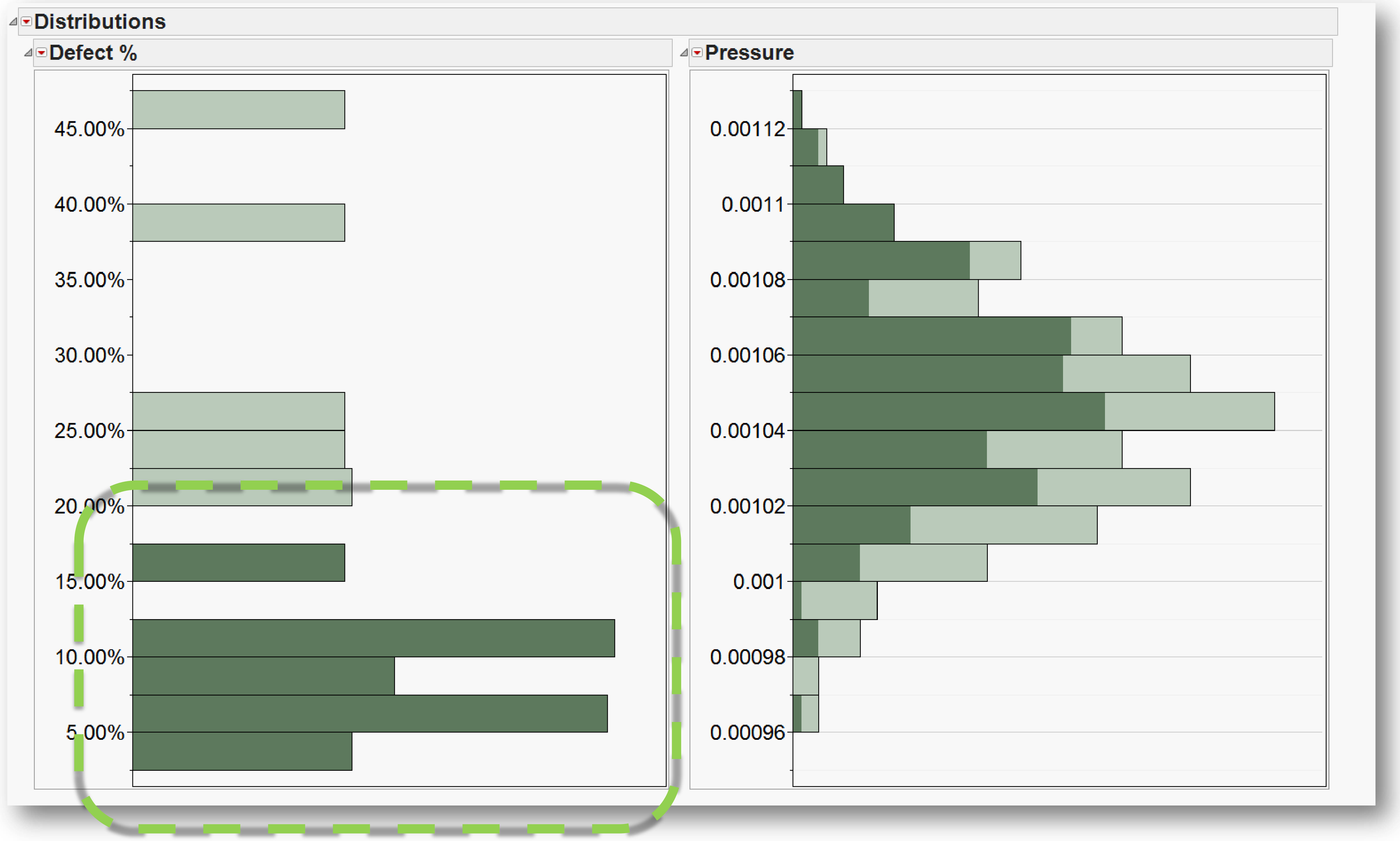


A specific process step was suspected (as it is different between product A and B)

This process step was also suspected because a preventive maintenance was done just before the defect appeared (see chronogram)

20 equipment's parameters during standard processing were collected and then analyzed. One of them was very interesting

Bad defect ratios are at lower pressure



Good defect ratios are at higher pressure

Datamining : Correlation between Equipment chamber pressure during process and defect ratio

The chamber pressure was clearly correlated to the defect ratio!
Root cause search was now focused on Equipment A

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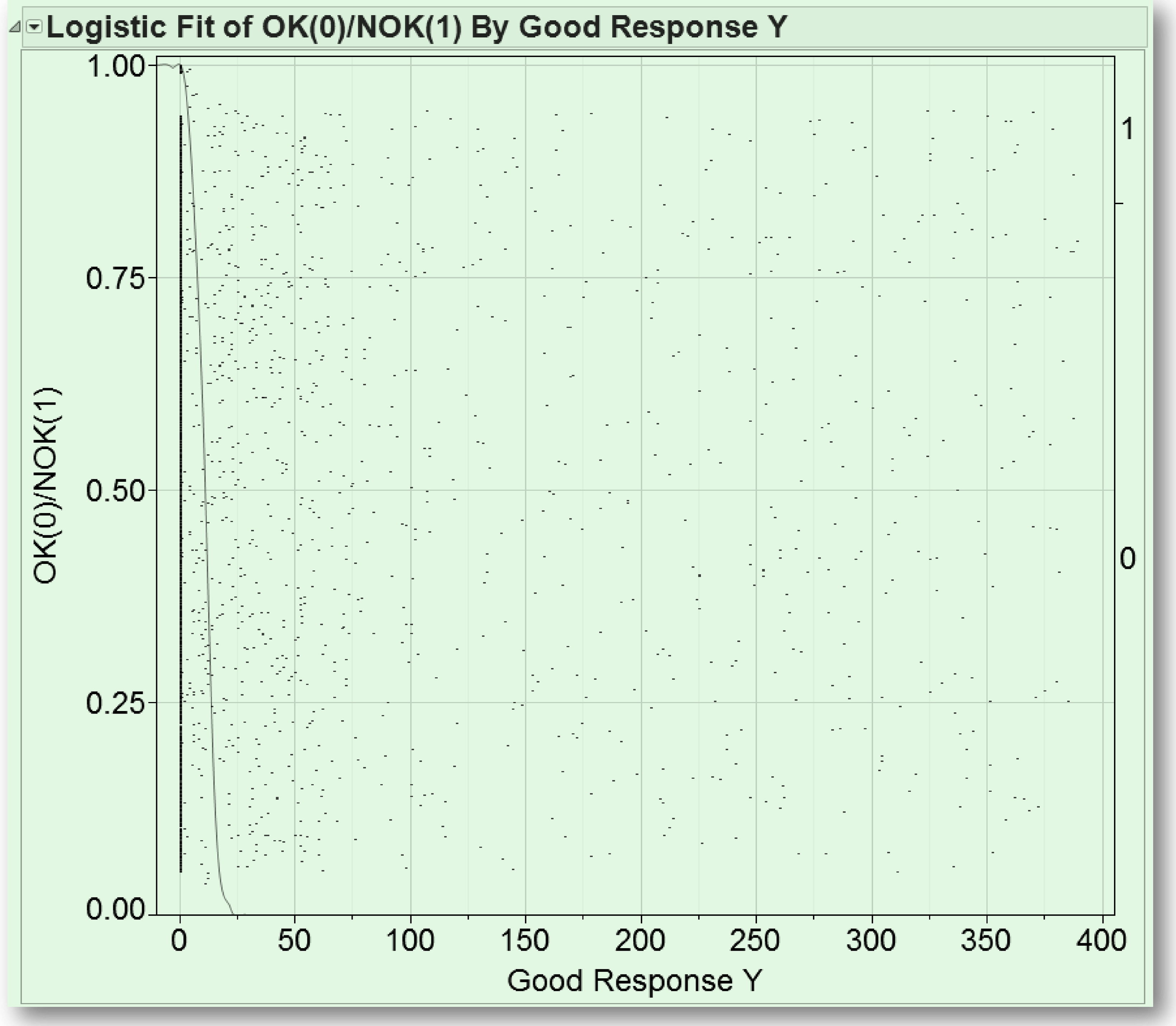
So far, the product was sorted based on a visual, qualitative criteria (OK/NOK)

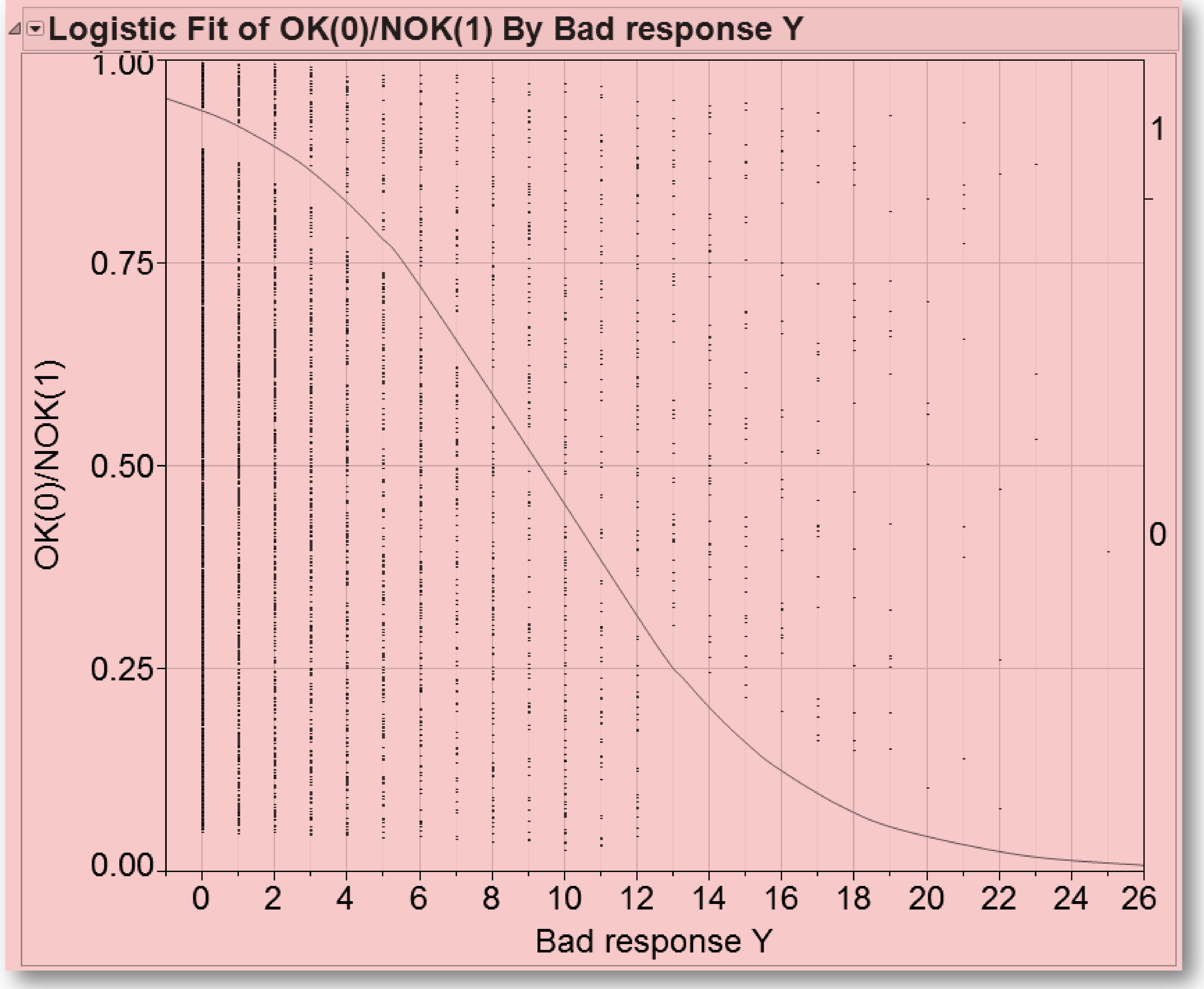
The most difficult part was to find a continuous response for DOE (defect rate is too limited from a statistical point of view for DOE analysis).

The experts proposed 4 continuous responses

These responses were used in order to create a continuous ranking of the responses.

Logistic fit and Kendal's τb correlation value were performed using "X by Y platform"





Measures of Association

Measure	Value	Std Error	Lower 95%	Upper 95%
Gamma	0.9971	0.0005	0.9962	0.9980
Kendall's Tau-b	0.8774	0.0056	0.8663	0.8884

Logistic Fit and Kendal correlation coefficient

A response was found to be able to accurately determine if the product is OK or NOT OK (steep slope) with a good confidence level
=> Selected for further DOEs

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Return to global view

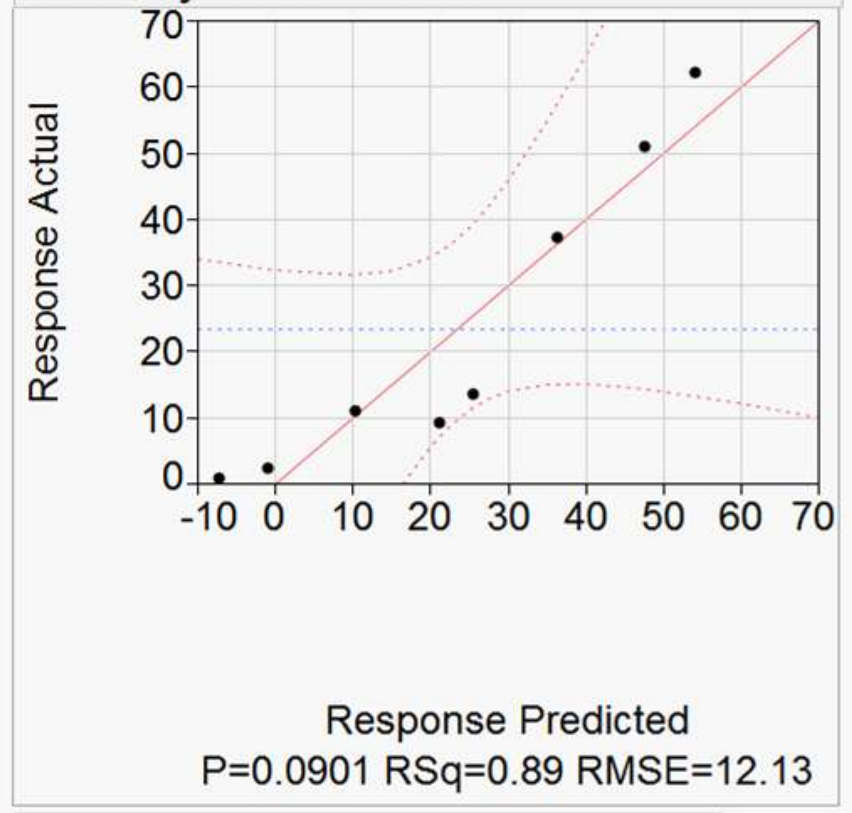
A brainstorming was organized in order to determine the parameters that influence the chamber pressure and their range of variation for trials.

→ 4 parameters were chosen

→ A Taguchi L8 (screening) was performed

Response Response

Actual by Predicted Plot



Summary of Fit

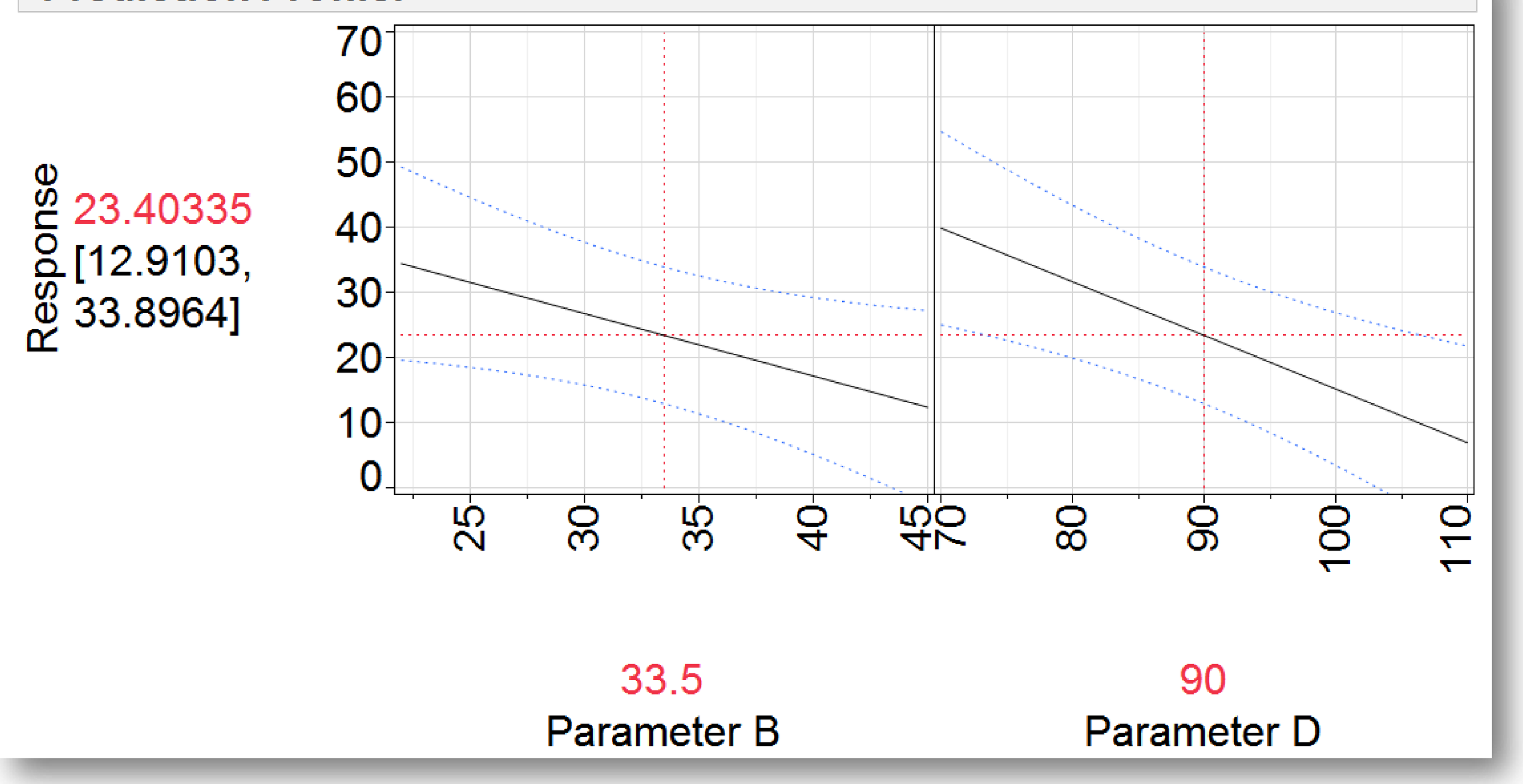
RSquare	0.885639
RSquare Adj	0.733157
Root Mean Square Error	12.13025
Mean of Response	23.40335
Observations (or Sum Wgts)	8

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Parameter D(70,110)	-16.47686	4.288691	-3.84	0.0311*
Parameter B(22,45)	-11.02577	4.288691	-2.57	0.0824
Parameter C(950,1050)	5.4113533	4.288691	1.26	0.2962
Parameter A(17,60)	-2.230941	4.288691	-0.52	0.6389

DOE actual by predicted plot

Prediction Profiler



DOE Prediction profiler: was used to find a predicted value (in this example: center value) with experiment and check if this linear model is accurate

The model was validated with experimental points but a response surface was necessary due to a strong quadratic behavior
=> 2 parameters were chosen for the next step based on the screening DOE

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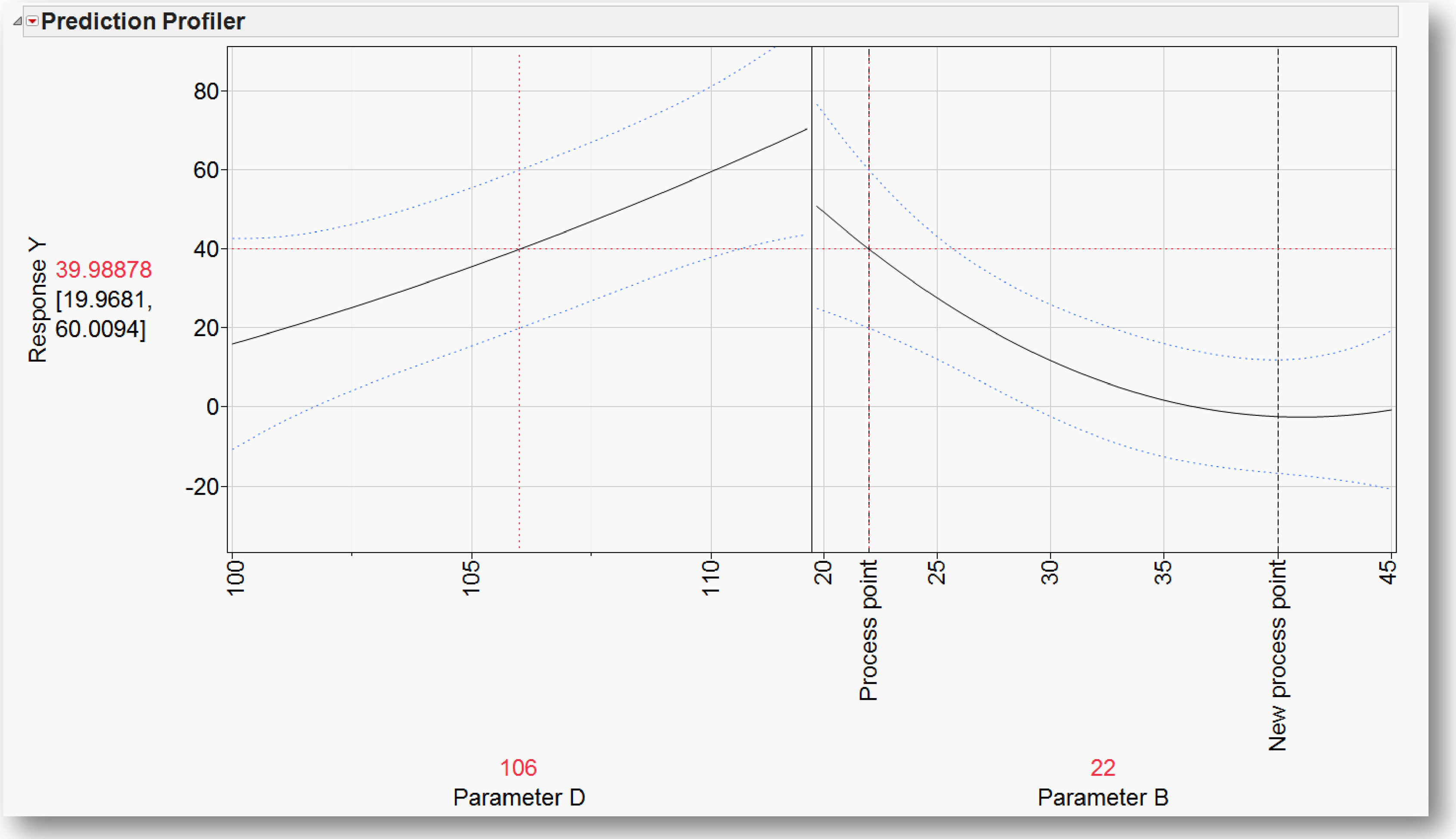
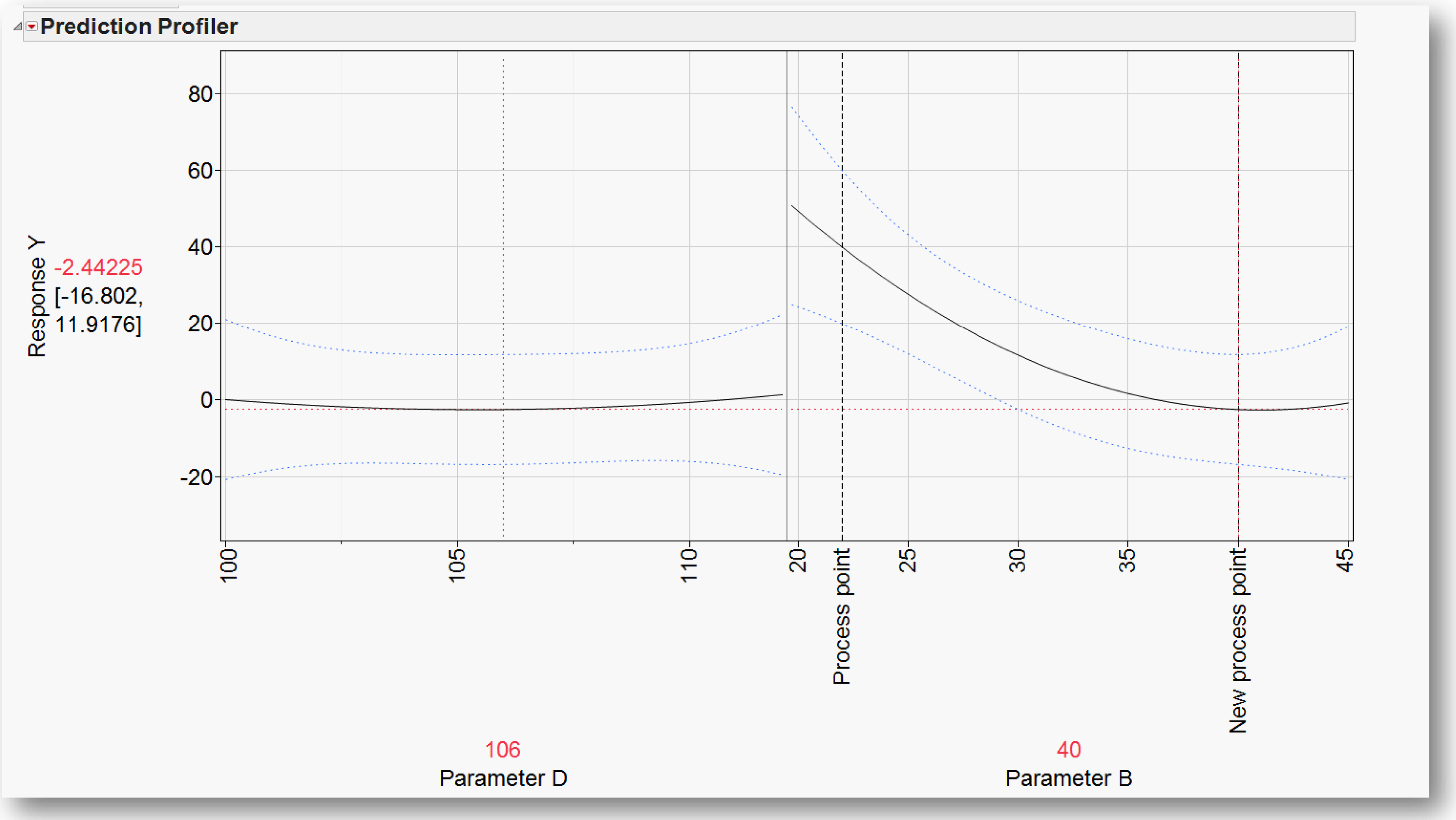
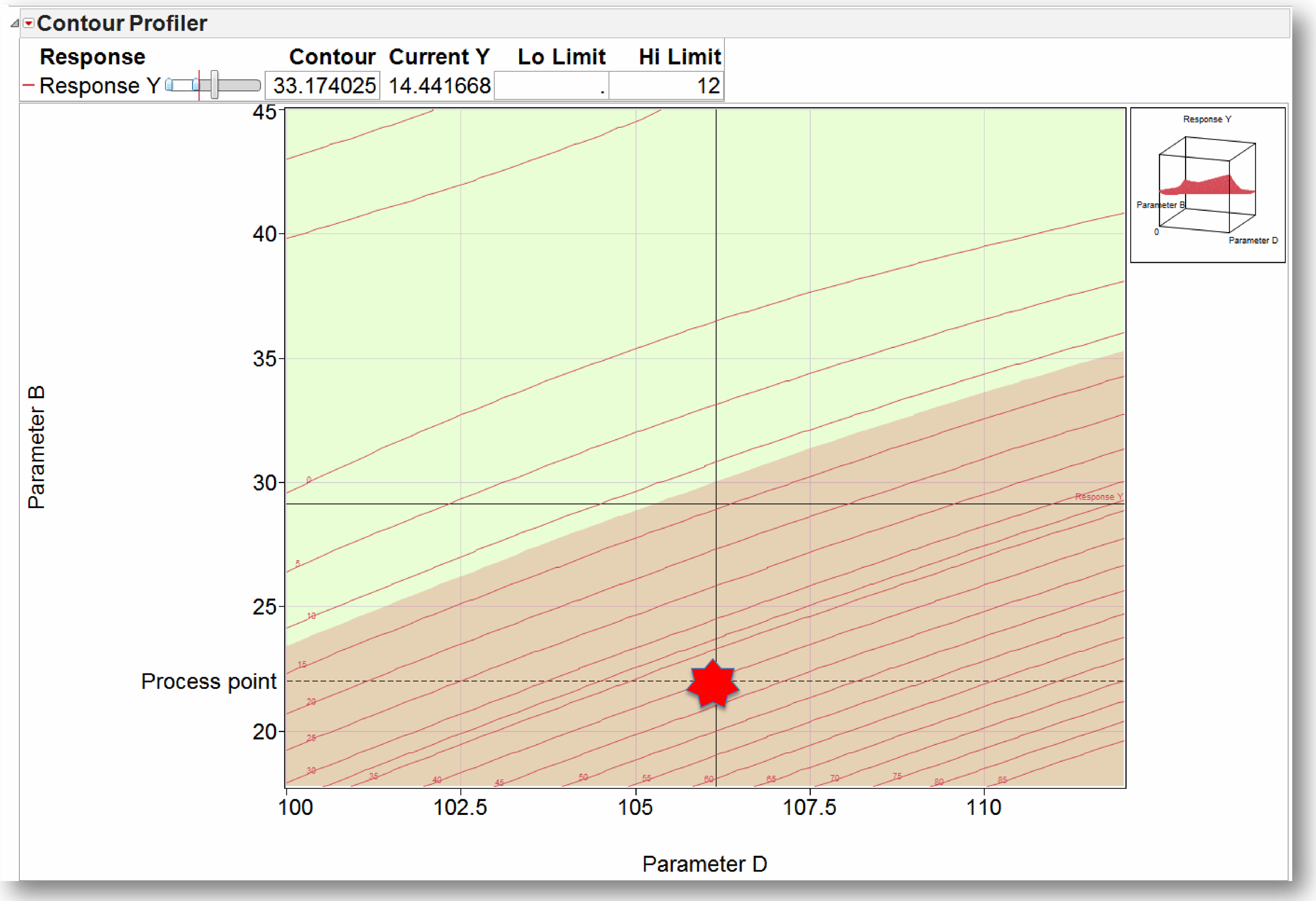
A central composite design was performed





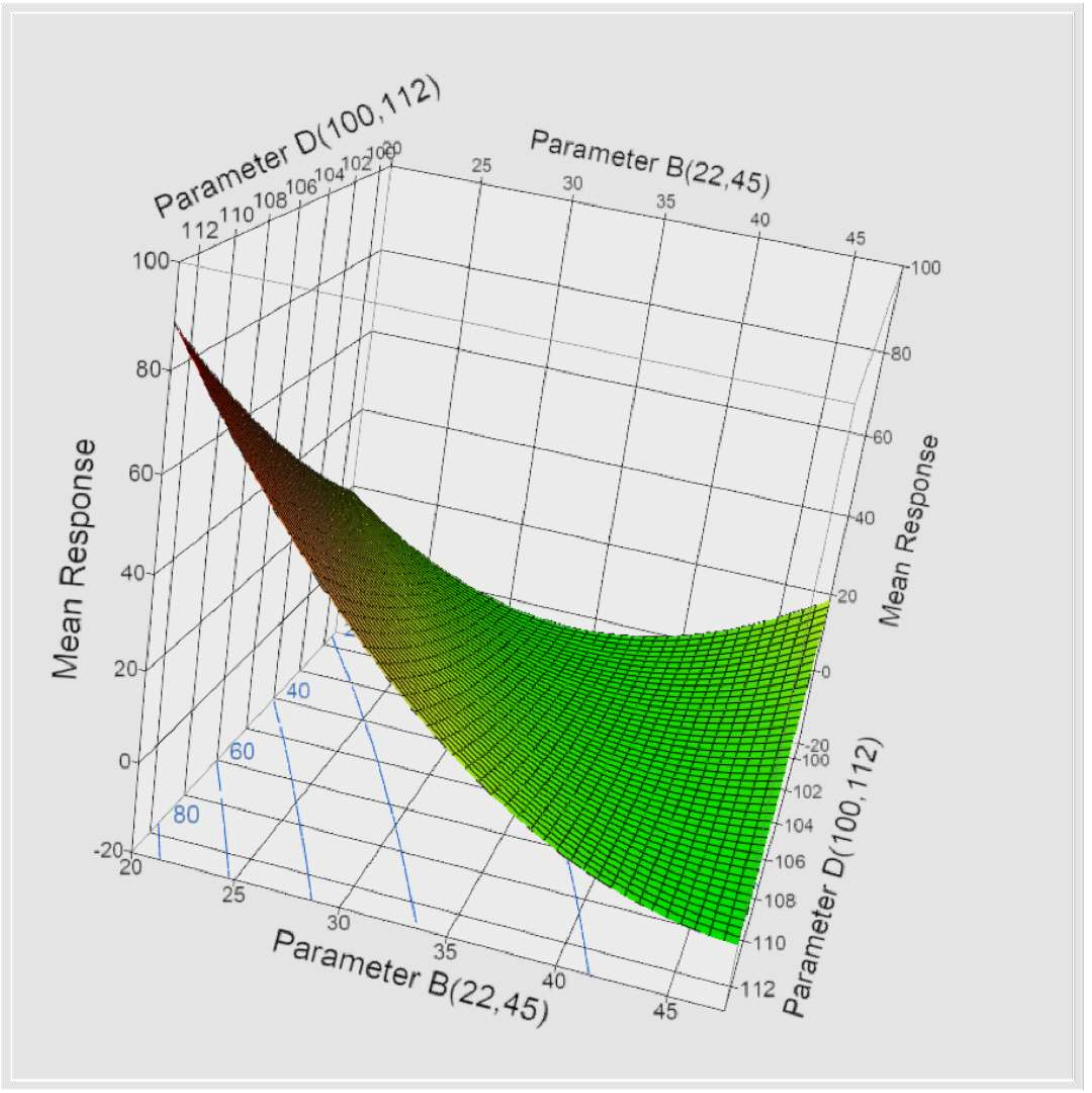
DOE prediction profiler

An optimal process was determined as well as a process control limit, in agreement with product specifications



Experimental domain restriction in order to fit product specifications

The DOE response surface also helped to explain why the defect appeared: during the preventive maintenance, **a spare part** had to be changed on the hardware, drifting the process toward a very unstable domain



Response surface animation (video)

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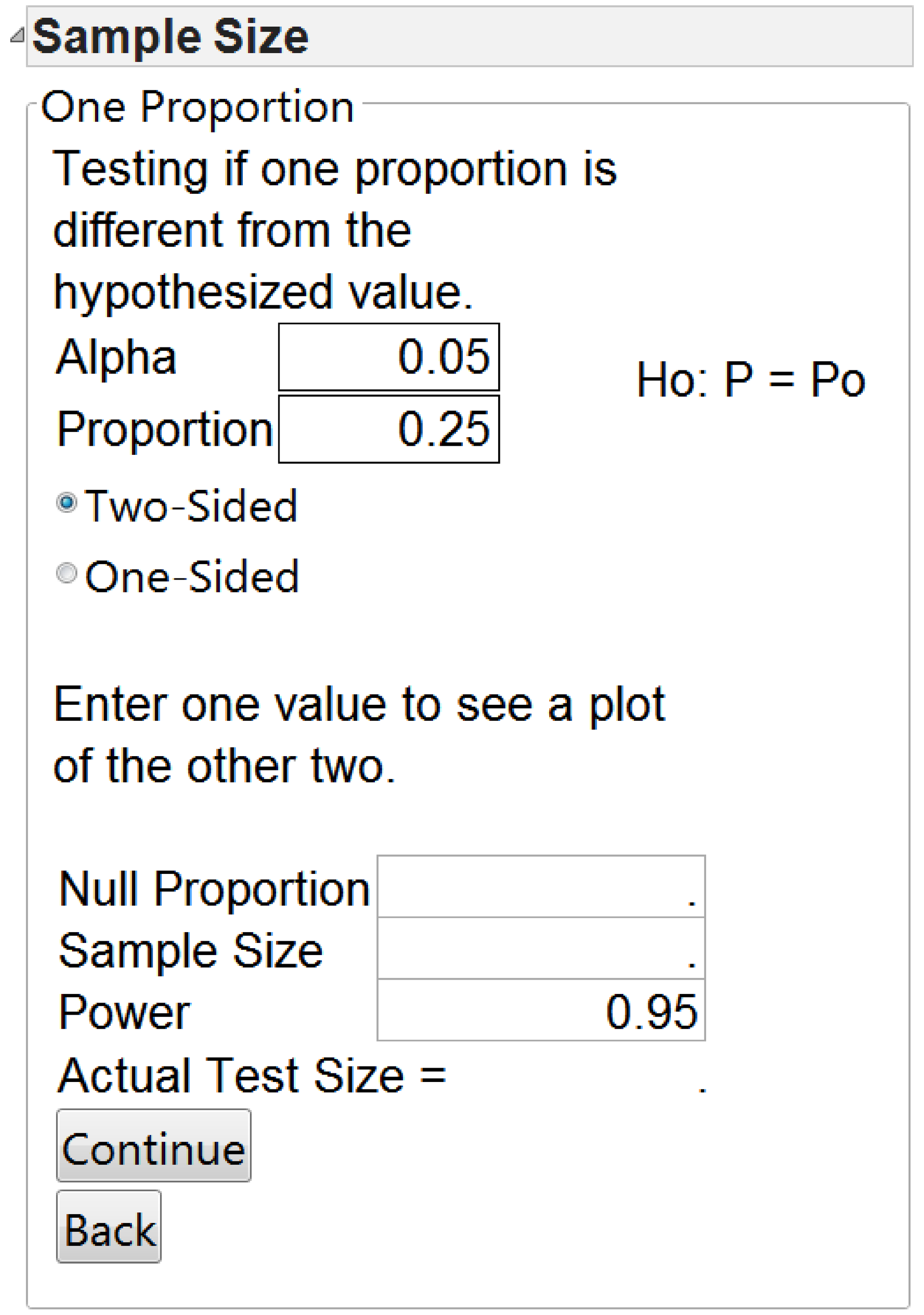
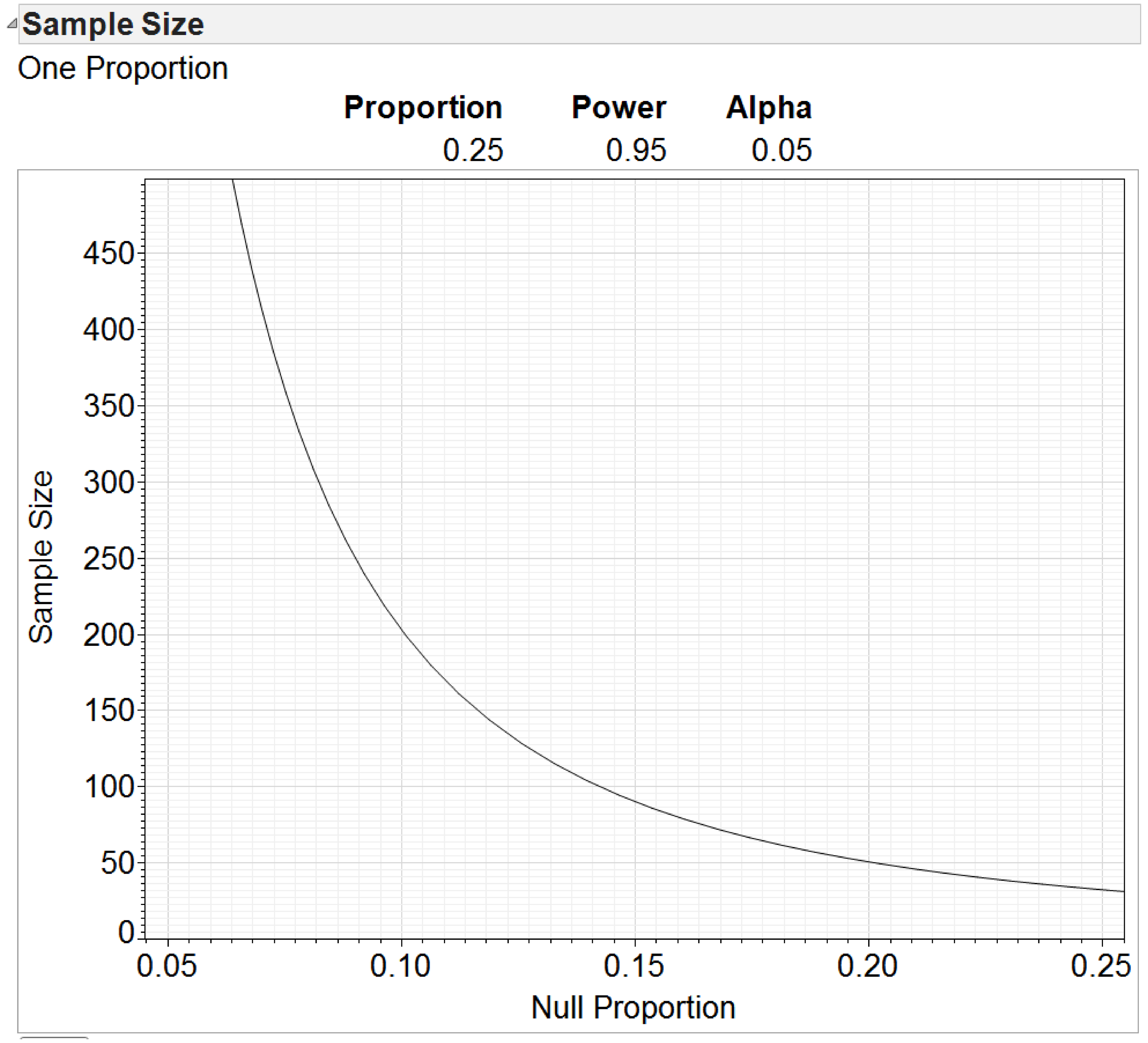
In order to validate the corrective action the power platform was used.
We calculated the sample size required to validate an improvement of the defect rate (more than xx% increase on the current rate)



Minimum sample size determination (alpha risk of 5%)



Minimum sample size calculation. In this case, the 8D could only be closed for a defect rate below 5% (Null Proportion=0.20 in this example, with a power of 95%) → sample size = 50

95% power was chosen to be sure to detect the difference if it occurs. Finally, the sample size was large enough because the defect, after process improvement, has completely disappeared.

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Mean defect quantification by wafer

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