MVA Analysis Flow for FDC Data

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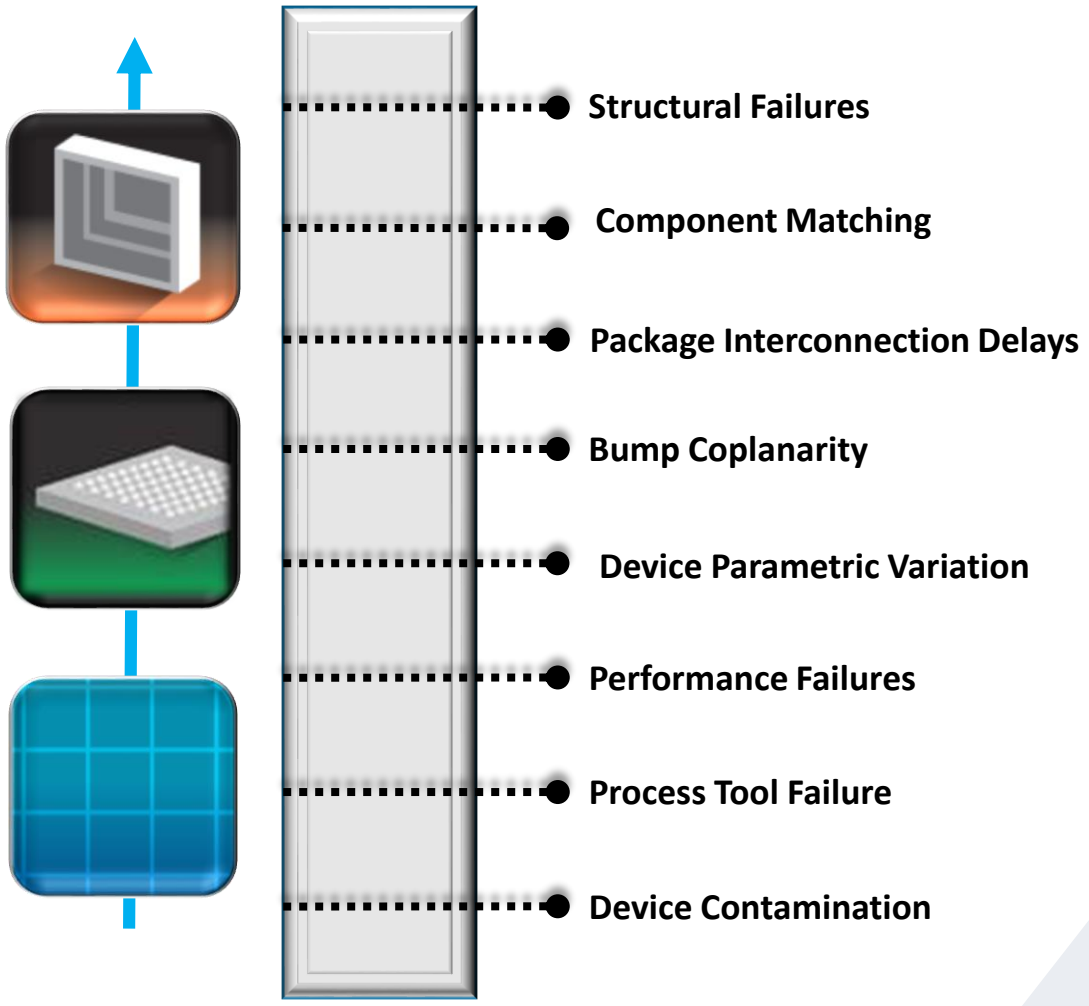
RUDOLPH TECHNOLOGIES

Understanding Supply Chain Yield Dynamics

Requires Complex Enterprise-level Supply Chain Optimization:

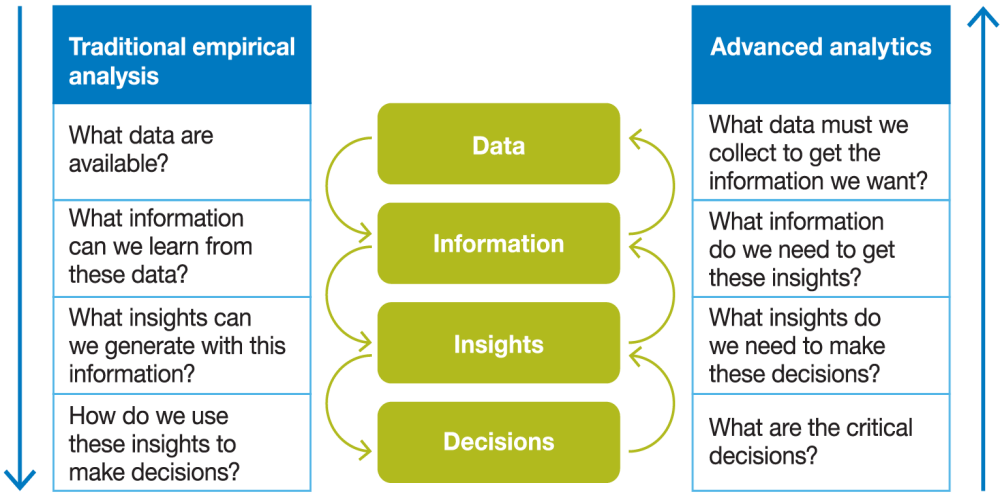
- Big Data
- Digital Threads
- Package to Tool Correlations
- Real-time Dashboards
- Best in Class Yield Analytics



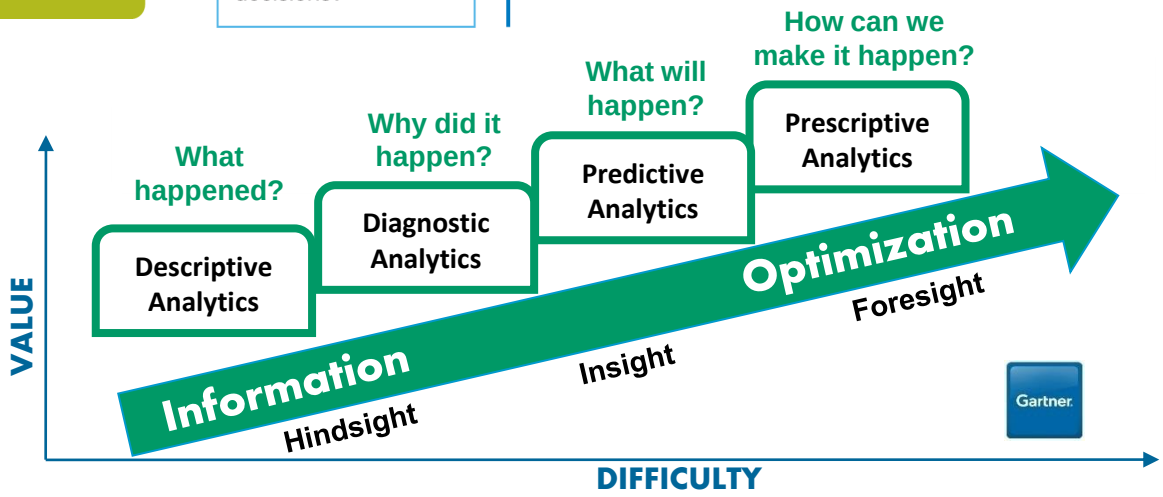
Solutions Must Remove Risk from the Electronics Supply Chain

New Paradigms are Required

Advanced analytics requires an approach completely different from that of traditional empirical analysis.



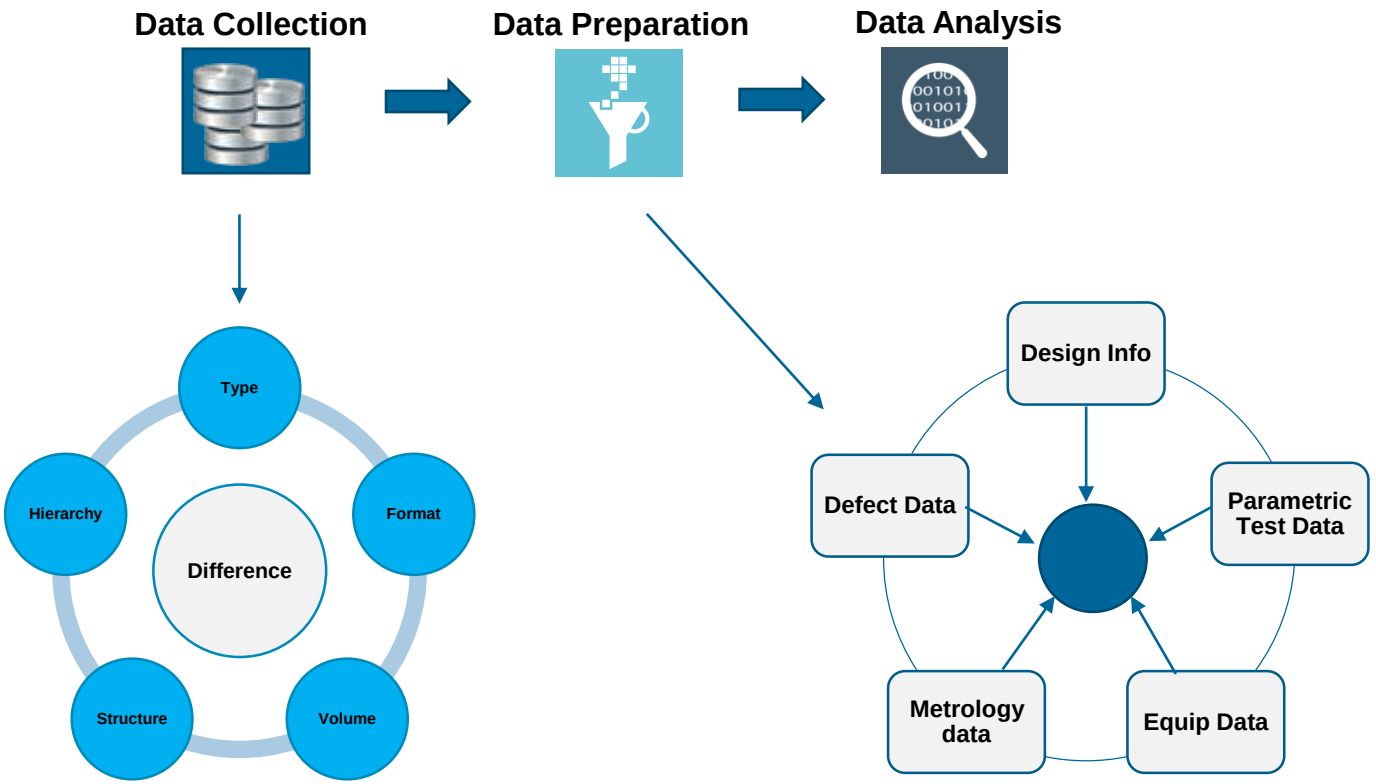
McKinsey&Company



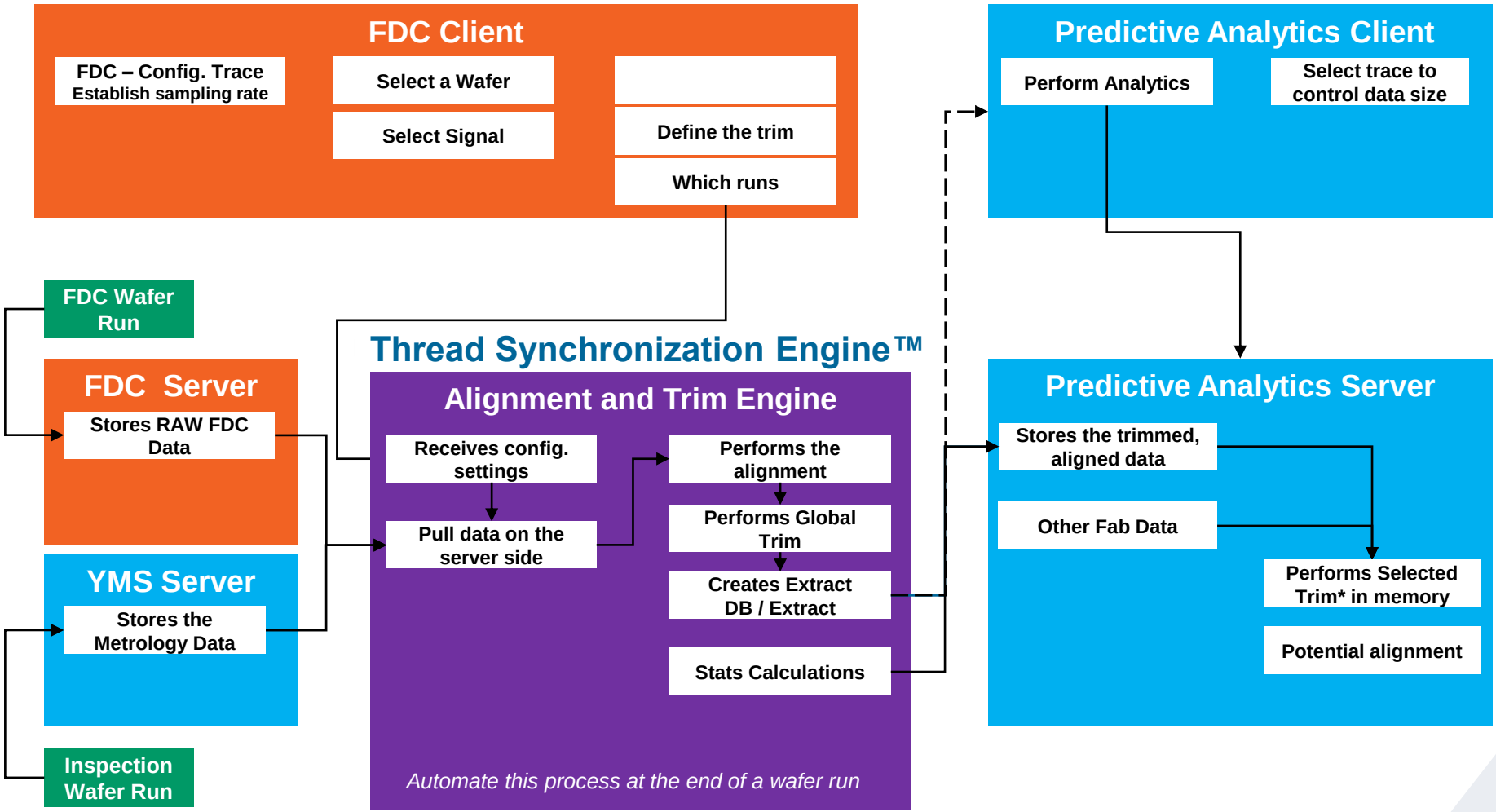
Data Preparation

Data Preparation is Critical

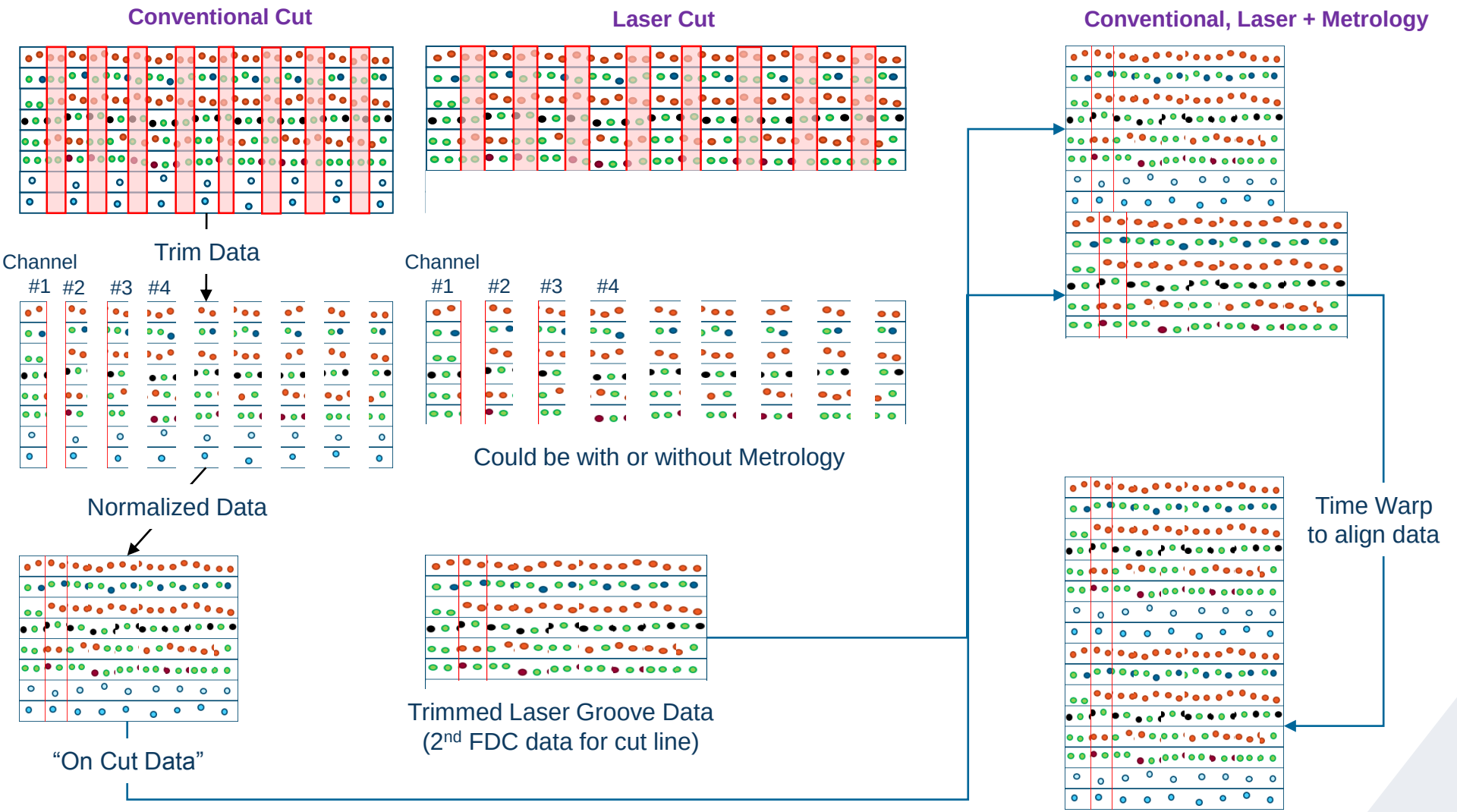
80-20 Rule: 80% of a typical data science project is sourcing, cleaning, and preparing the data, while the remaining 20% is actual data analysis



Thread Synchronization Engine™

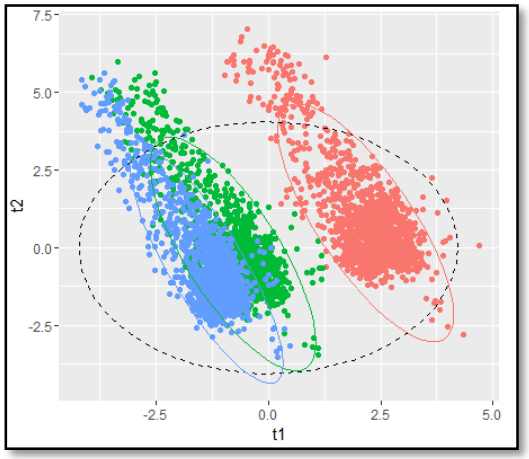


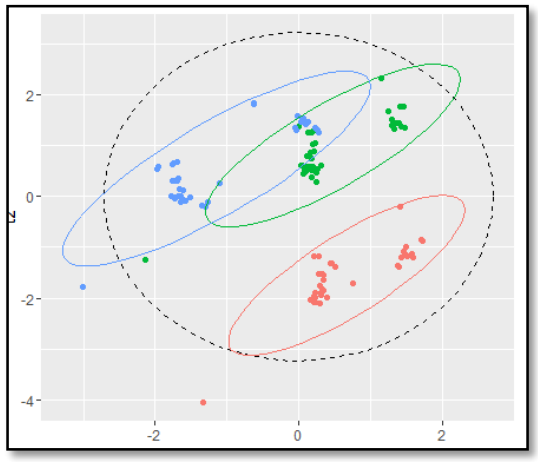
Step Cut Data Joining…



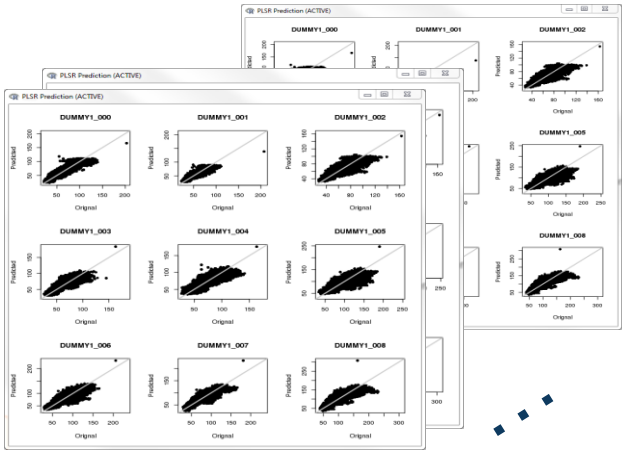
Batch PLSR

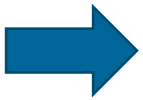
Hoteling T2 for Visualization

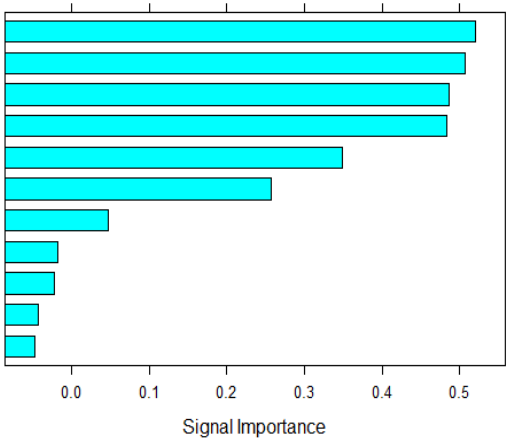




Ranking signals using the prediction errors



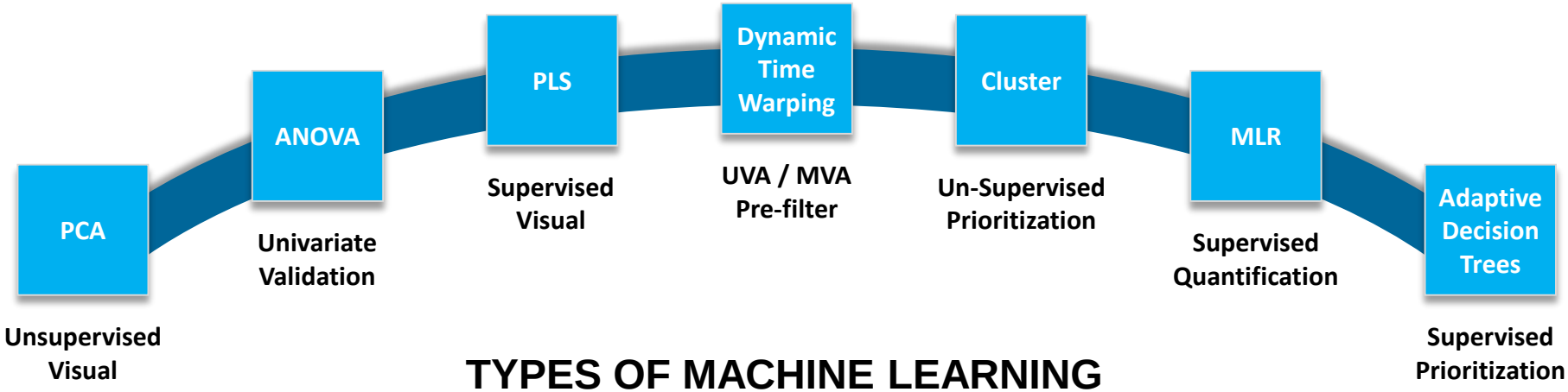




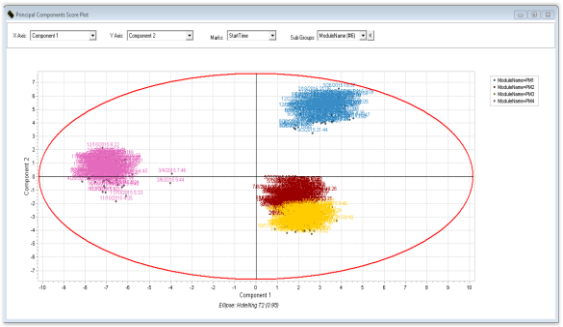
Multiple Algorithms – for Multiple Purposes

Mathematics of Predictive

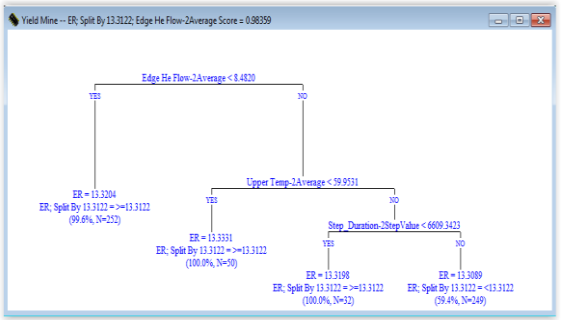
Each Technique has Strengths



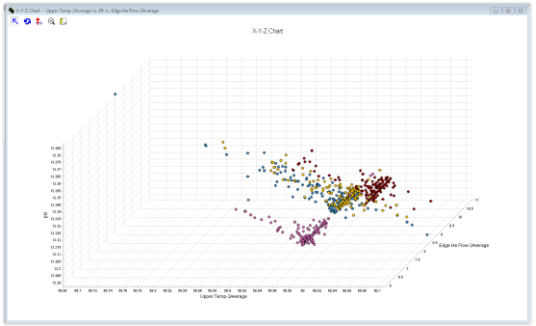
TYPES OF MACHINE LEARNING



PCA – Identify Clusters
What Defect Excursions?



Decision Trees – Prioritize Results
Which Signal to Adjust?

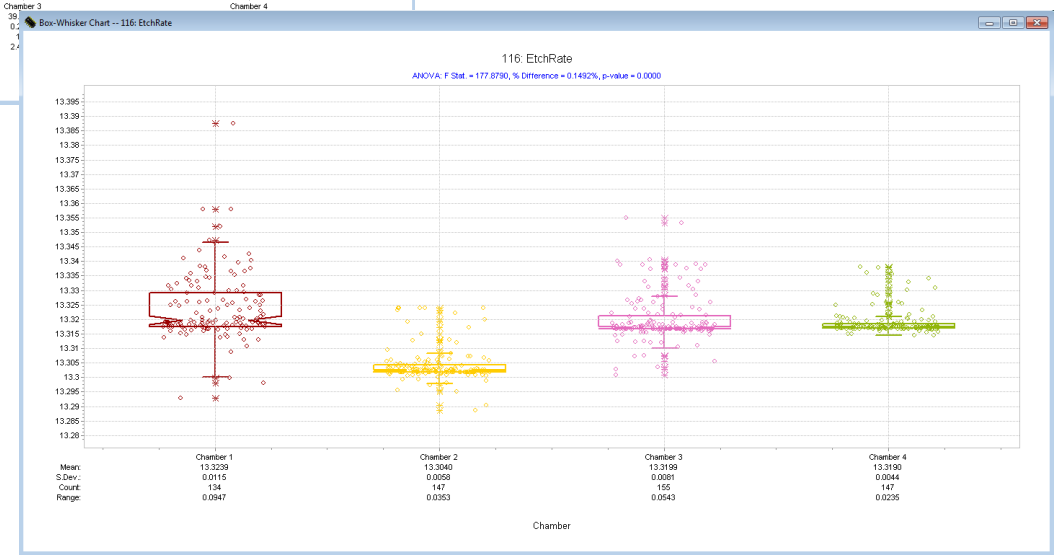


MLR – Quantify Results
How Much to Adjust?

Problem Statement

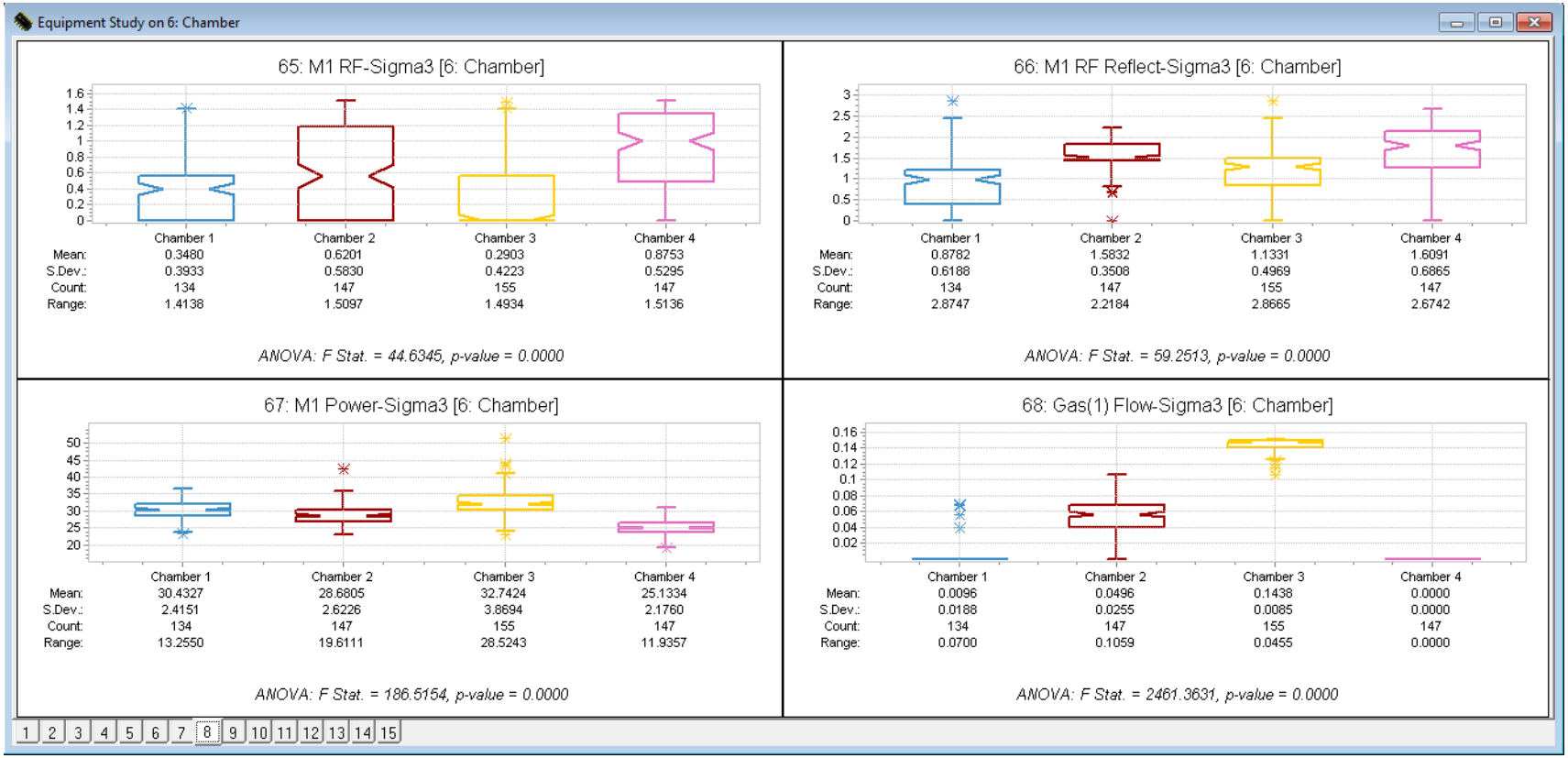
CD control in chamber 1

- Does not match other chambers
- Has a bimodal distribution



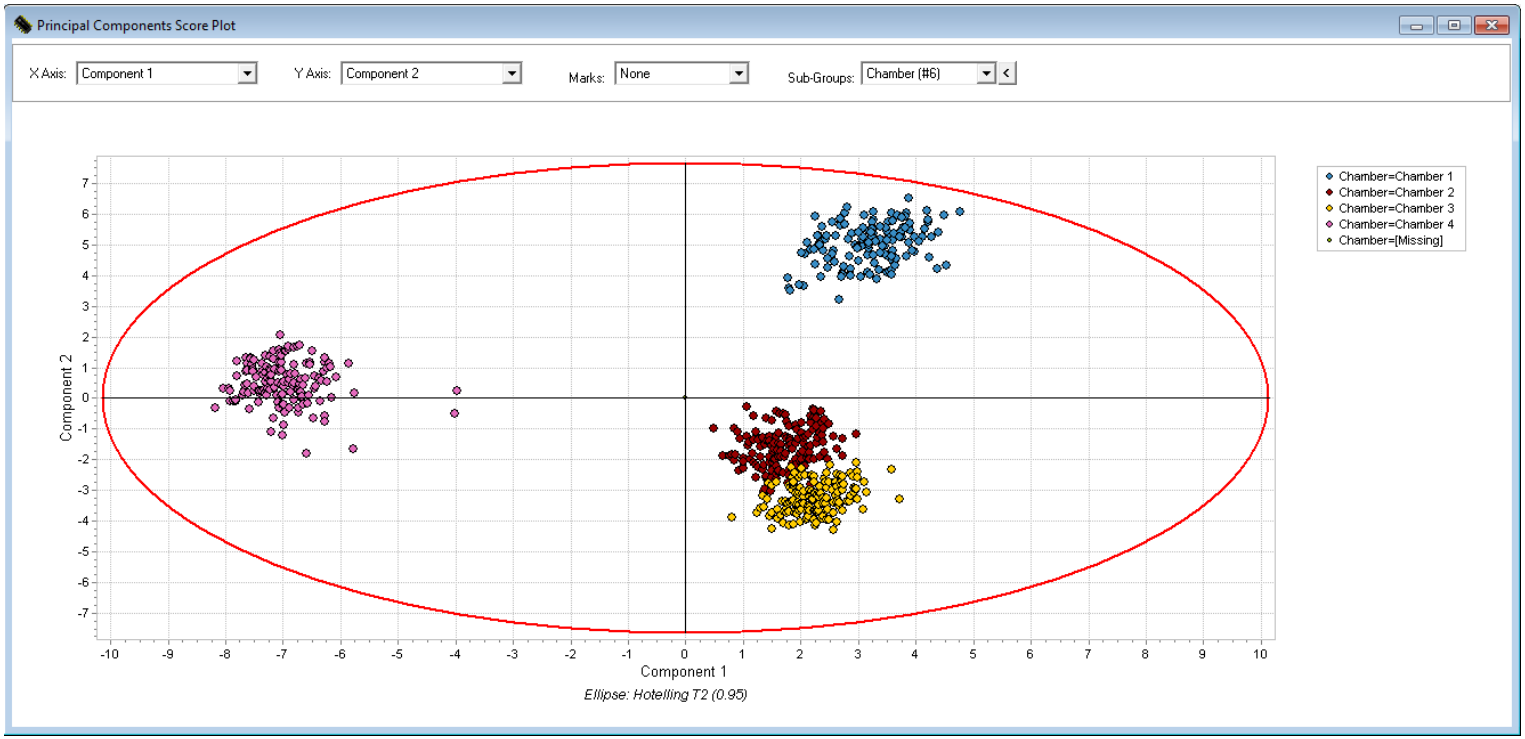
- Etch Rate is tighter in absolute terms
- Chamber 1 still shows a wide distribution

Simple Chamber Matching



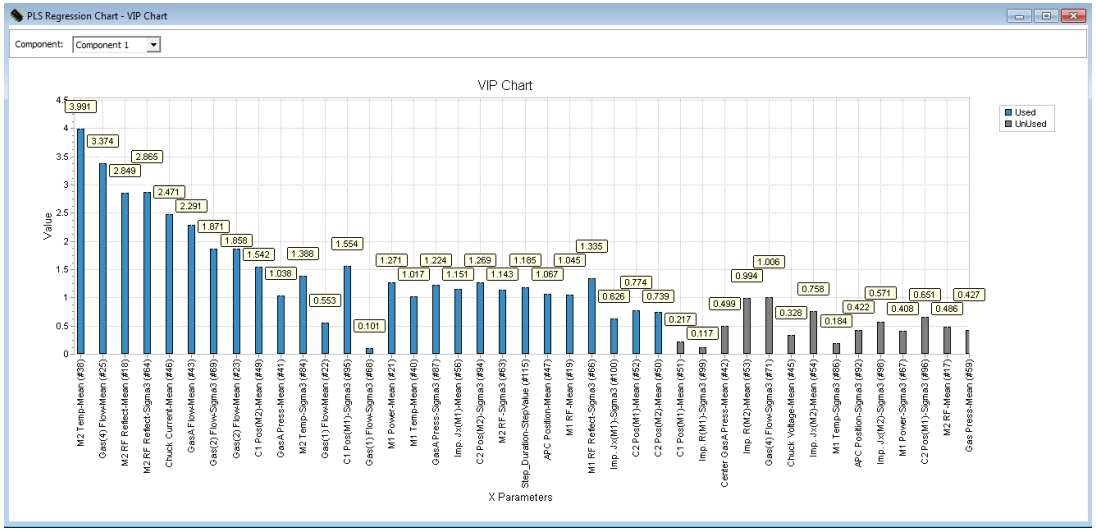
- 59 variables do not match
- F-test values are very significant
- Need a better method

Chamber Match using PCA



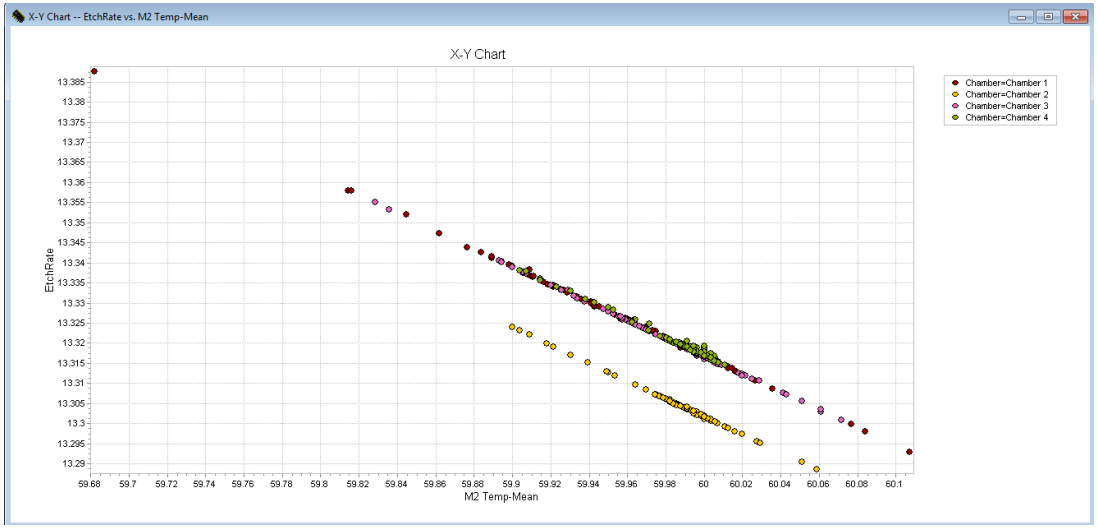
- Hoteling's T2 Graph shows 60% of all chamber variation in 2 dimensional graph
- Circle is “3 sigma”
- Sometimes 3 sigma is not good enough
- What is driving the difference?

PLS Variable Importance Chart – Etch Rate

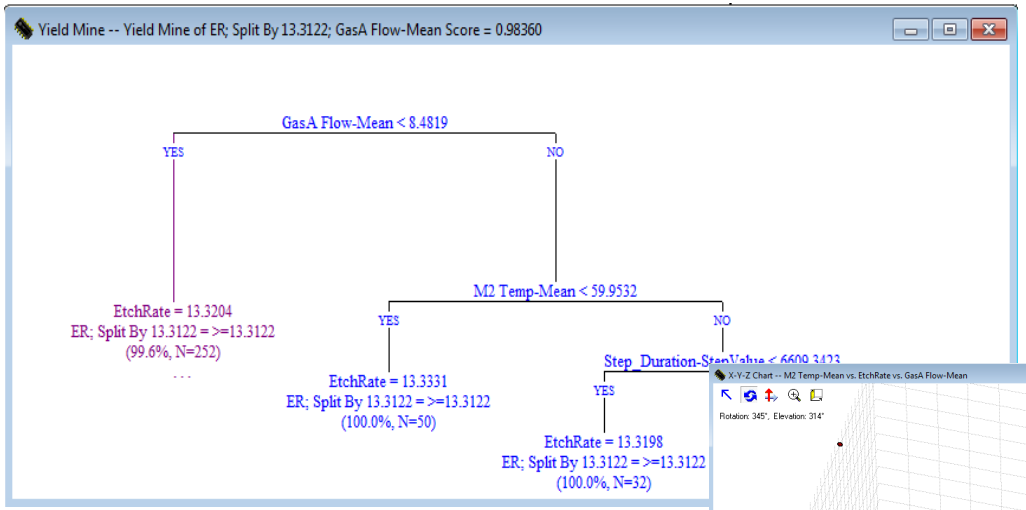


M2 Temp Mean is the most important variable.

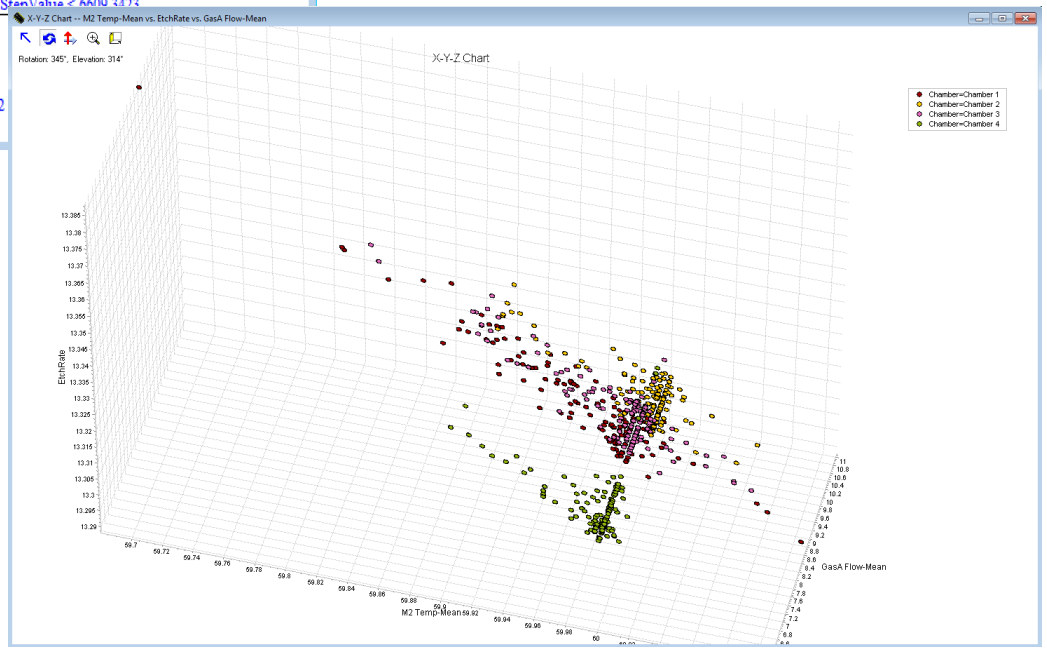
- Etch Rate is stratified by M2 Temp Mean and chamber.
- Second variable needed to explain stratification.



Two Way Interaction - Etch Rate

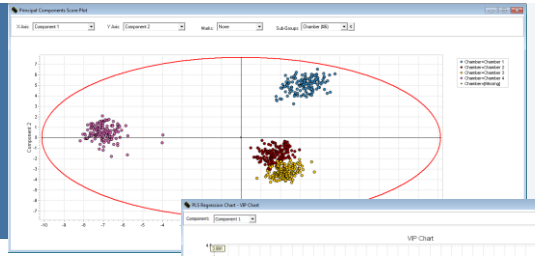


Decision Tree also chooses M2 Temp Mean, but GasA Flow is more important.

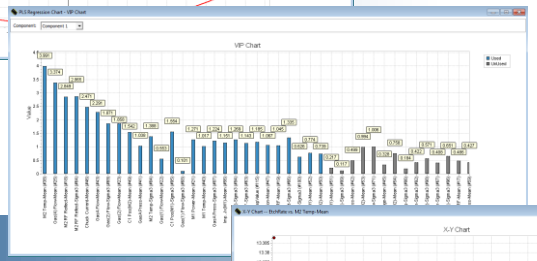


GasA Flow and M2 Temp Mean Impact Etch Rate

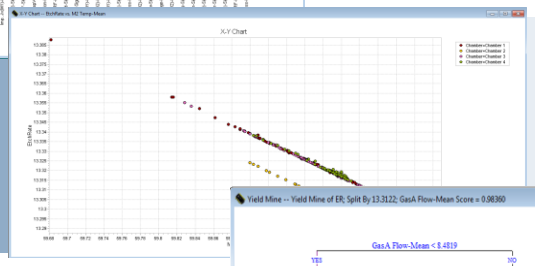
Critical Variables to FDC Sensors



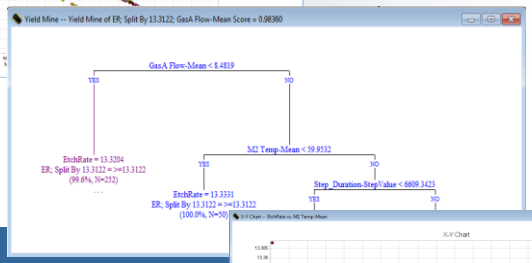
PCA/PLS Model
- Visual display of raw matching



Contribution plot
- Identify top variables



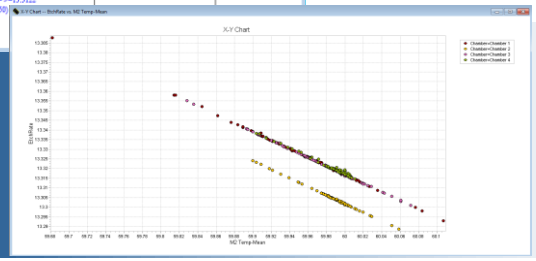
Correlation Plot
- How much do I need to move it?
- How much does it explain?



Yield Mine
- Ranked variables by…

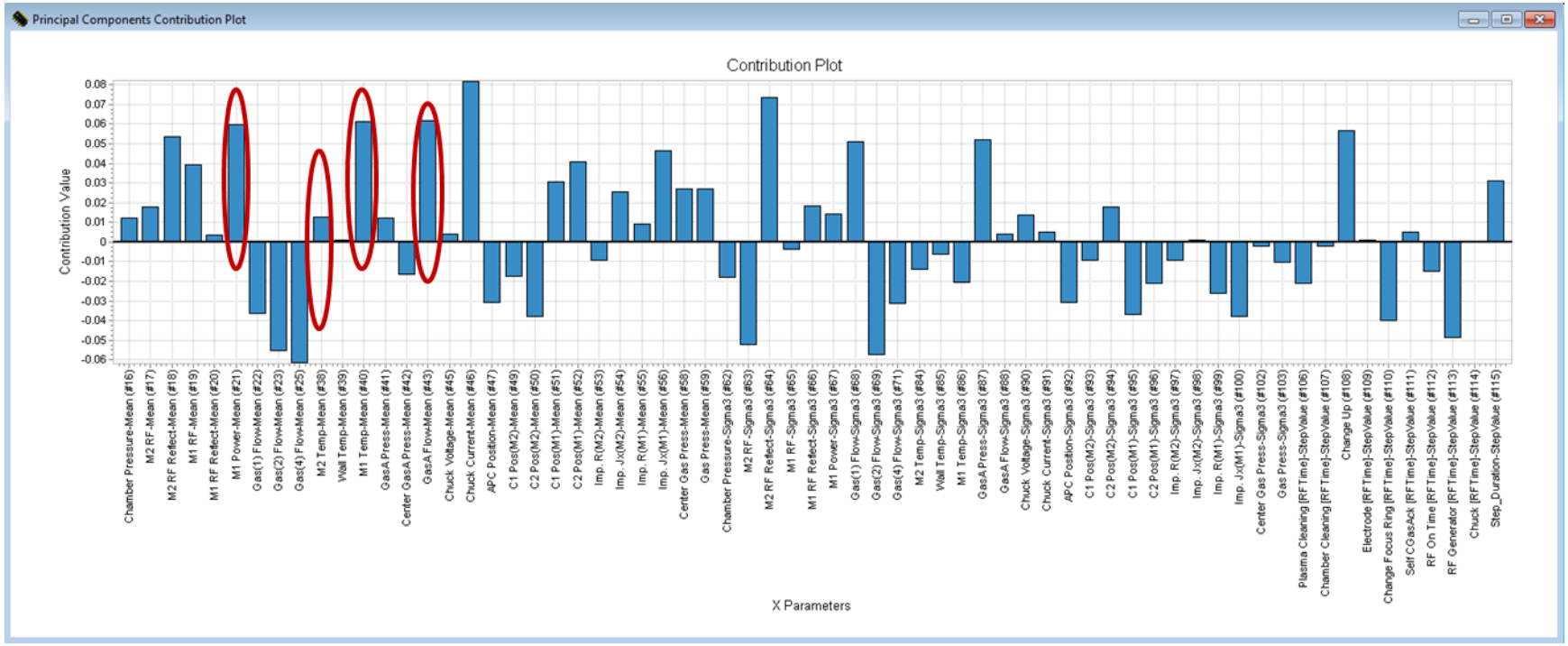
…a second model

How can we identify top parameters for critical variable?



MLR Plot
- How much variation is explained?

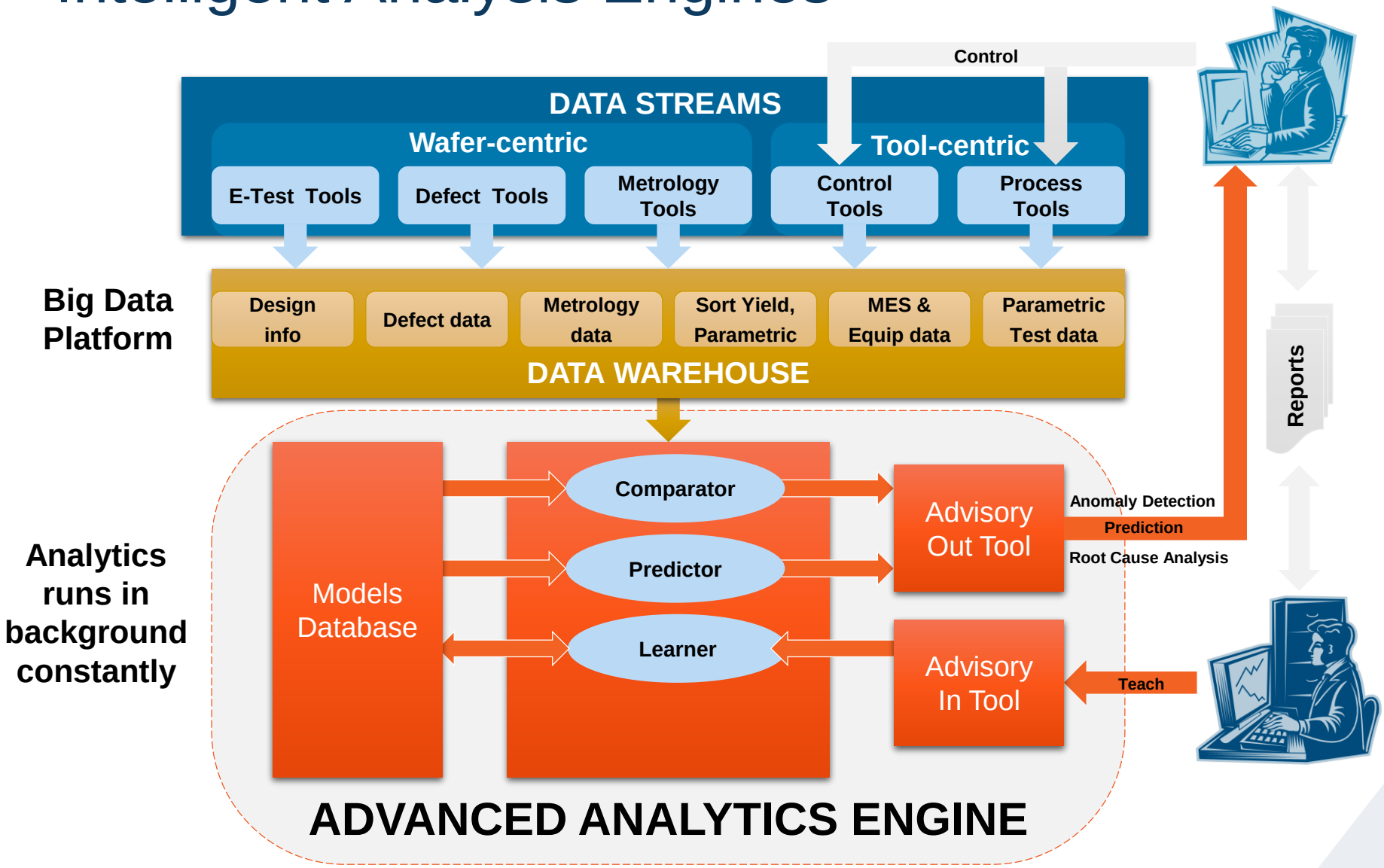
No Quality Data – Contribution Plot



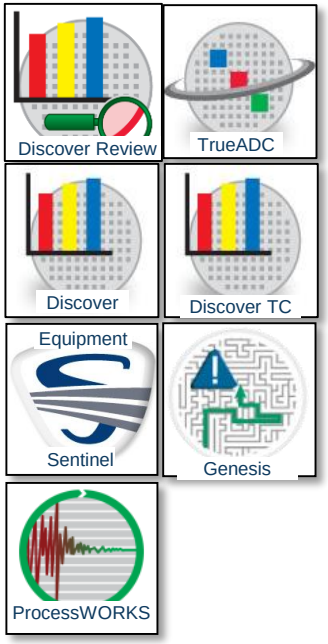
- Top 4 variables control 80% of variation in CD and EtchRate
- Without Quality Data tool matching may be expensive

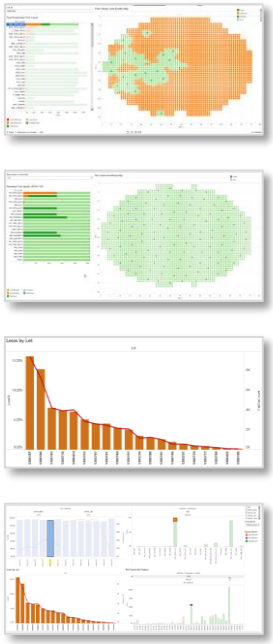
Automation

Intelligent Analysis Engines



Data Democracy





Step 1
Any Supported Product…

Step 2
Create/Select chart Element…

Step 3
Combined to create powerful interactive visualizations !

Easy web based drill down visualizations for the CEOs to Operators

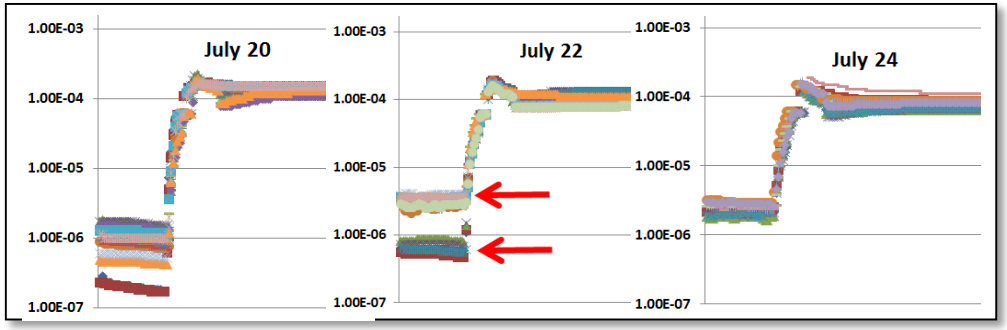
Driving Equipment Productivity

Ion Beam – Water Leak

Case Study: Predicting Unscheduled Downtime

15% Reduction in Maintenance Costs

Field Case Study – Start of Run Pressure



Old Diagnostic Process

- Manually Pull logs – FSE Travel Costs
- Manipulate, Align and Filter data – Man Days
- Offline analysis at HQ – Man Days
- Unscheduled Equipment downtime
- Scrap Potential

5 days to root cause identification

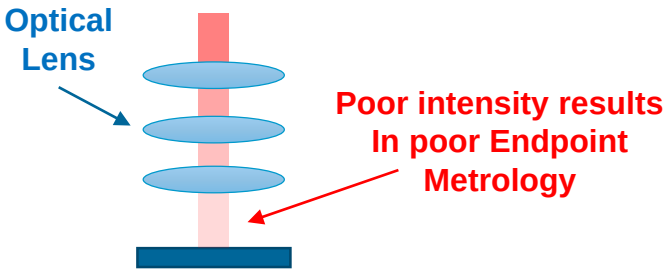
Rudolph Monitoring

- Run Pressure is being constantly monitored
- Critical timing after wafer clamp, before Gas flow starts
- Model detects upward slope and alarms
  - Automation automatically Notified
  - Dashboards displays error state
- Equipment team know exactly what the issue is to resolve
- Standard procedures now at customers site

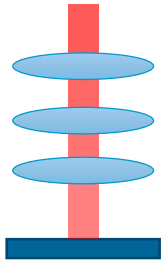
Prevented unscheduled downtime

Ion Beam Optics

Case Study: Optics PM Prediction (Chriss el al, APC Conference, 2016)



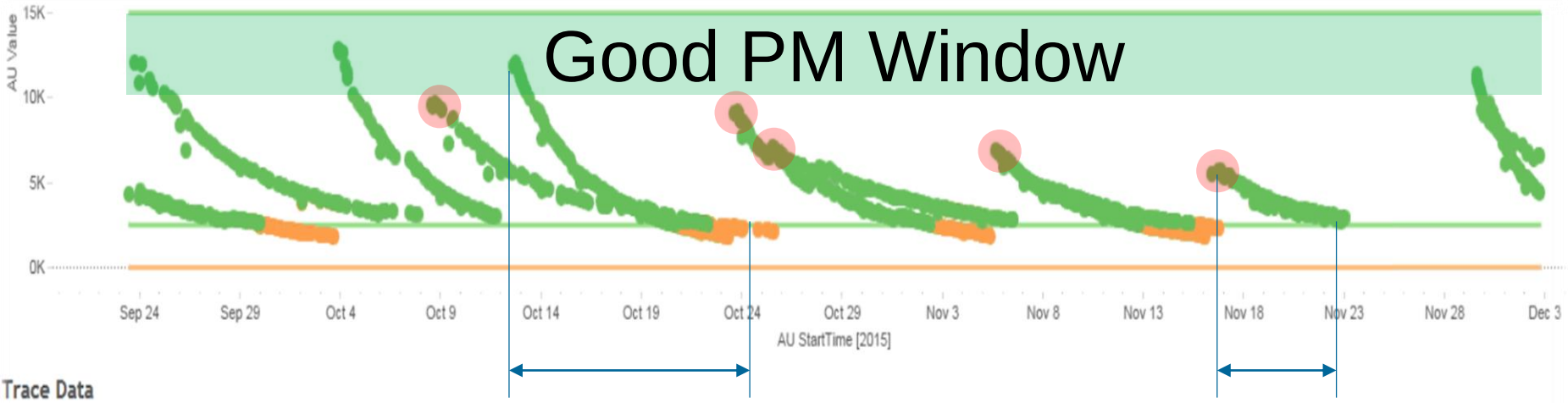
Pre – PM
Low intensity
Un- Stable Metrology



Post – PM
High intensity
Stable Metrology

KEY BENEFITS

- Higher Equipment uptime
- PM Quality Verification
- Ability to predict PM need
- MTBF improvements



Healthy PM…

More frequent PM's needed
Lowers MTBF

Summary

- The Goal is Actionable Intelligence.
- New Analytical Paradigms will be Required.
- Intelligent Digital Threading™ is Essential.
  - Across the Enterprise
  - Deep into the Process
- Visible, Relevant, Secure, High-integrity Data is a Must.

谢谢 | 謝謝

danke

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감사합니다

merci

obrigado

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