Usage of Hercules inside commercial FDC System Maestria

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Why are Plasma Parameters ideal for FDC in Etch ?

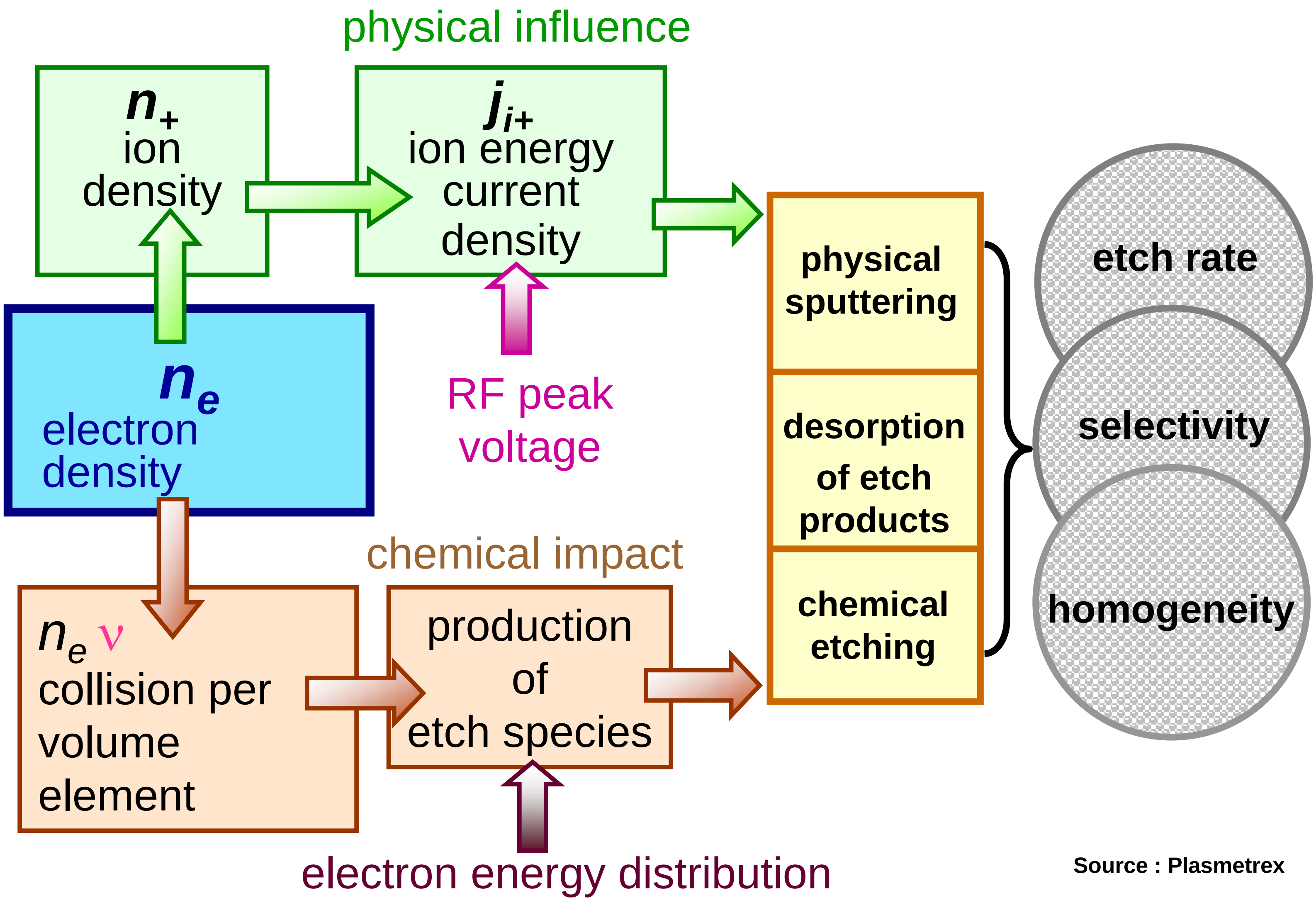
Electron Density and **Collision Rate** are sensitive to

- Process parameters (e.g. gas flow, pressure, power)
- Process / chamber drift (conditioning, clean, WAC)
- Product differences (e.g. open area)
- Tool failure (e.g. baratron, rf, MFC)

Plasma Parameters provided by HERCULES® help to

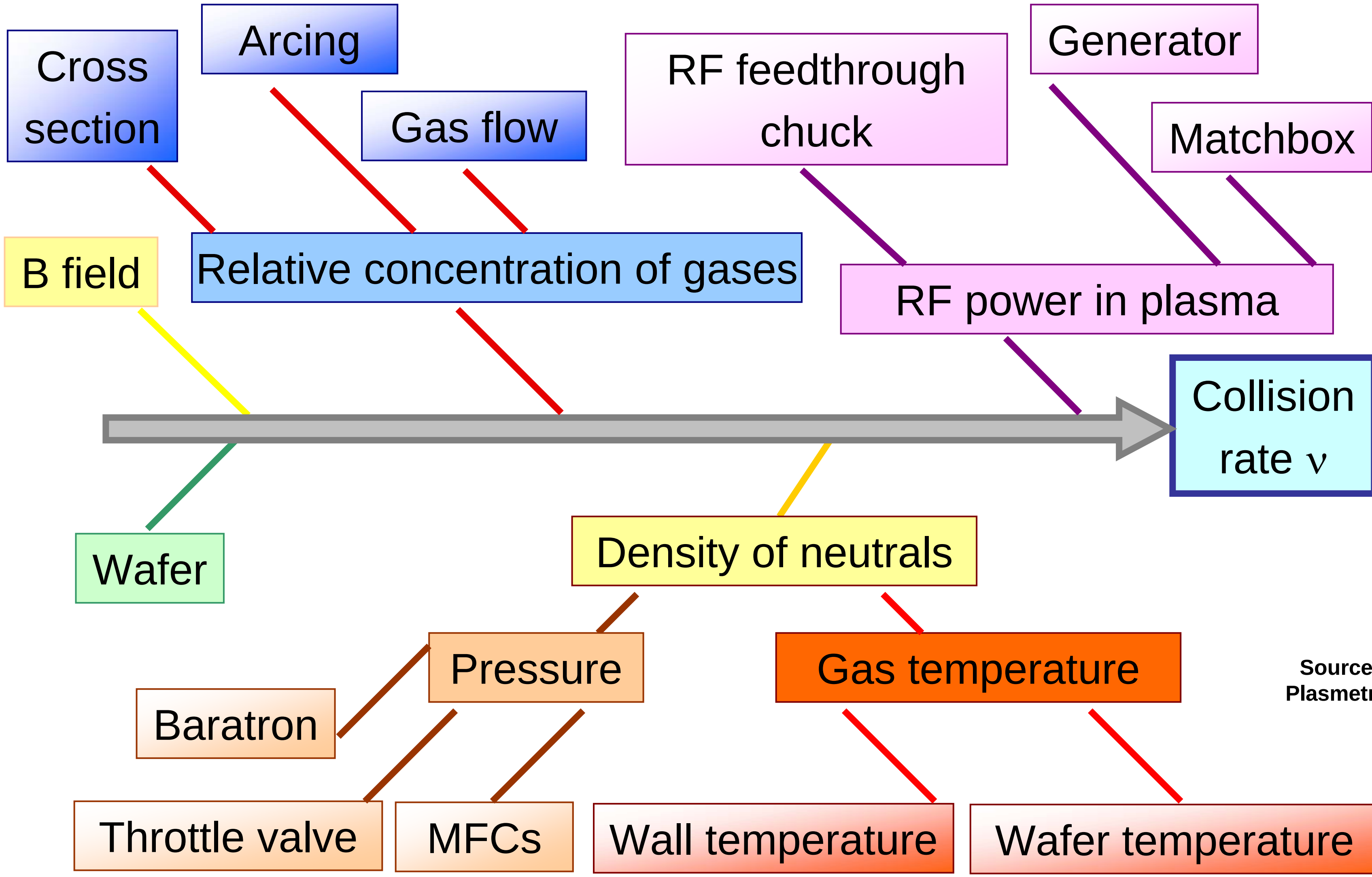
- optimize conditioning, WAC, MTBC, cleaning procedures
- understand process / tool issues

Influence of Electron Density on Etch Process



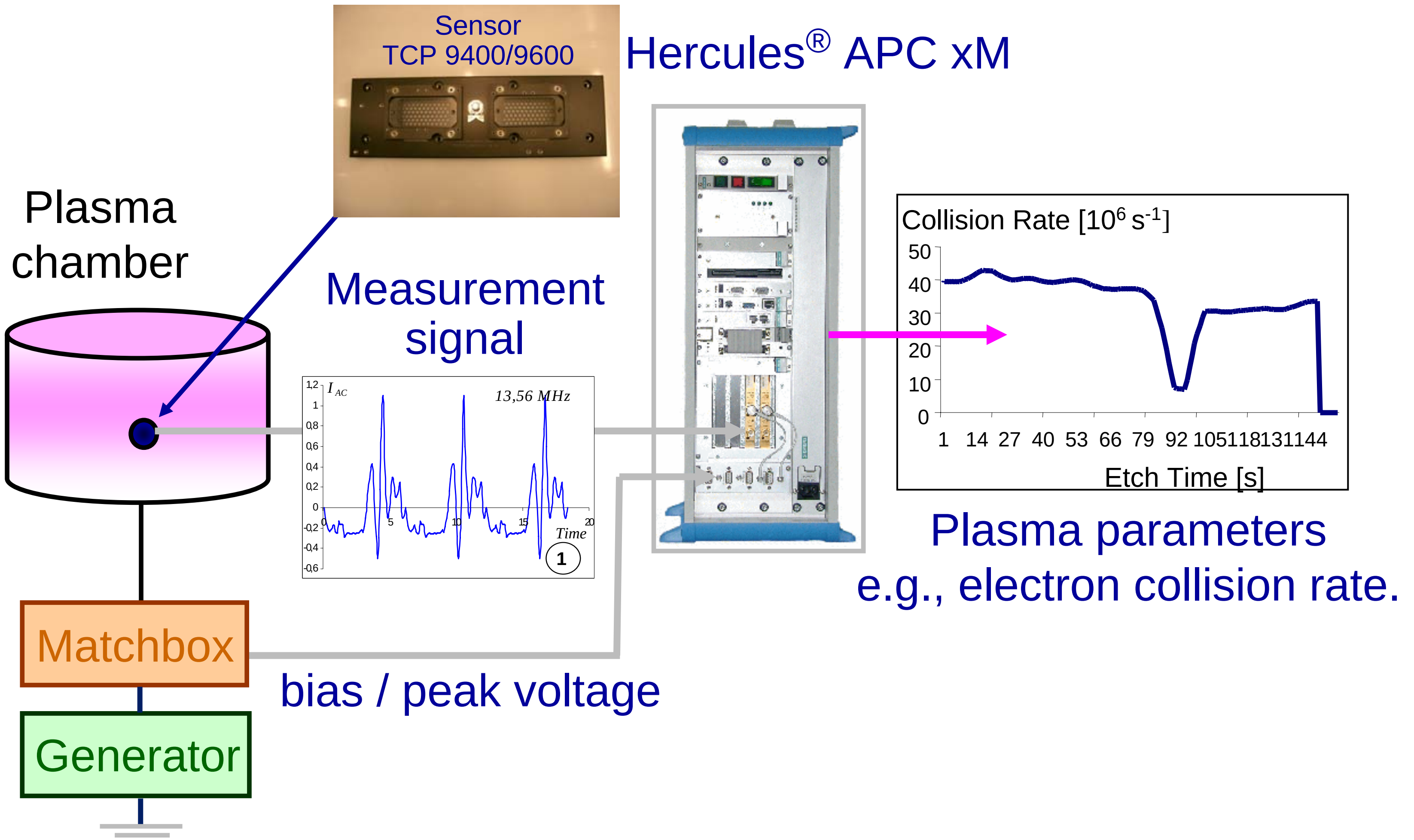
Source : Plasmetrex

Influence of Tool / Process Parameters on Collision Rate



Source : Plasmetrex

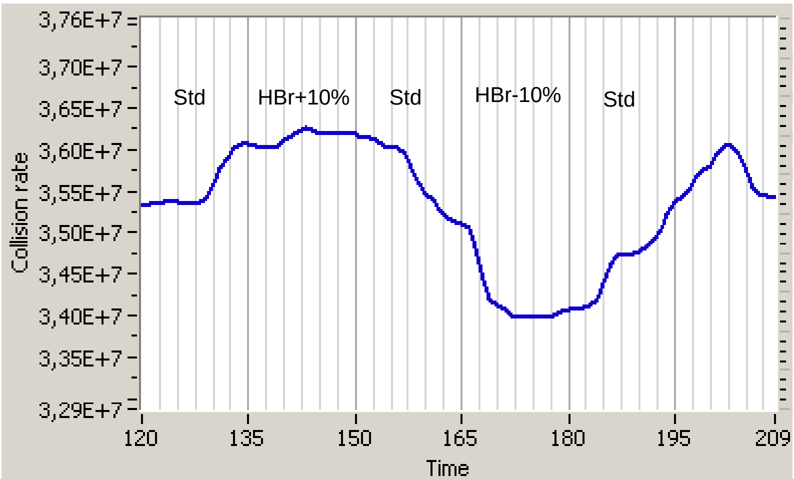
Basic Setup of *Hercules*®



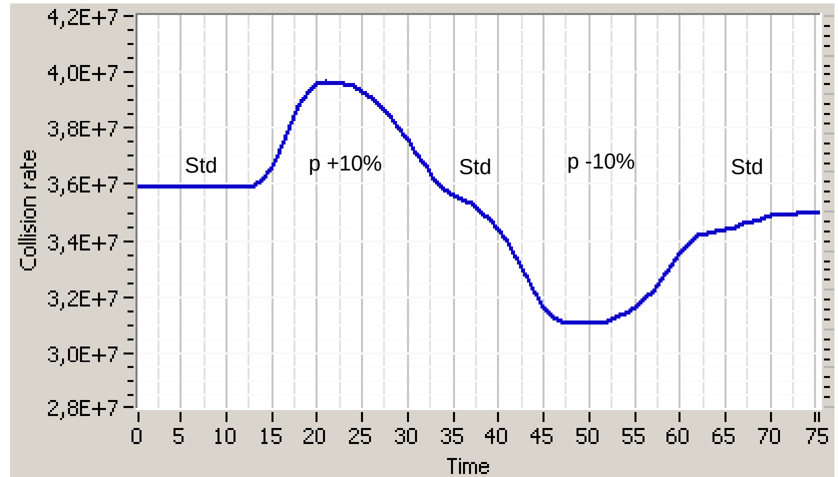
Source : Plasmetrex

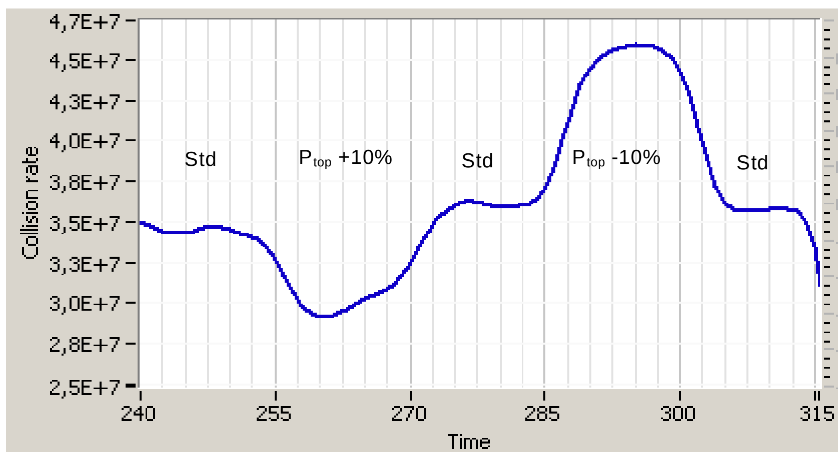
Influence of Poly TCP Process Parameters on Collision Rate

±10% HBr = ca. ±3% change in collision-rate



±10% pressure = ca. ±11% change in collision-rate

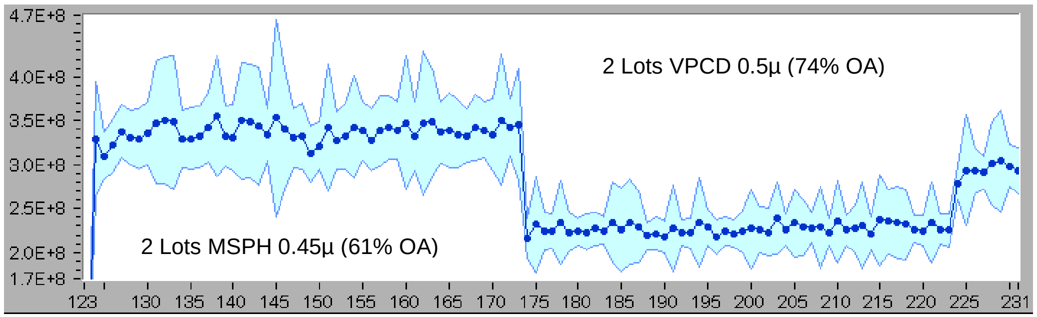




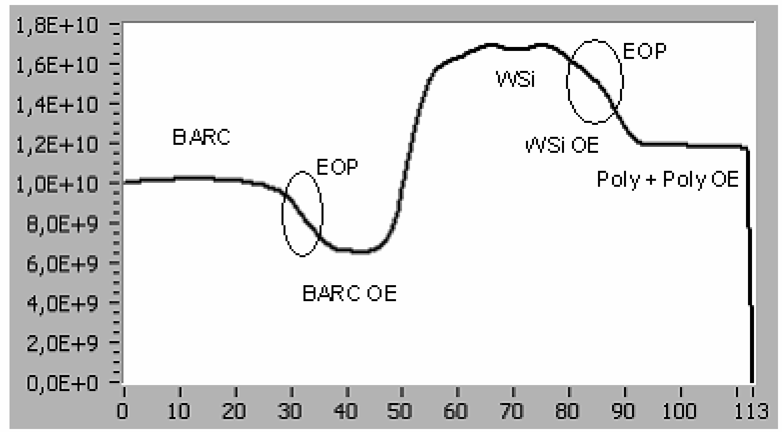
±10% TCP-Power = ca. 15-25% change in collision-rate

Collision Rate vs. Open Area & Endpoint Sensitivity

Gate-Poly MSPH 0.45µ - VPCD 0.5µ (Poly-OE-Step)



Collision Rate



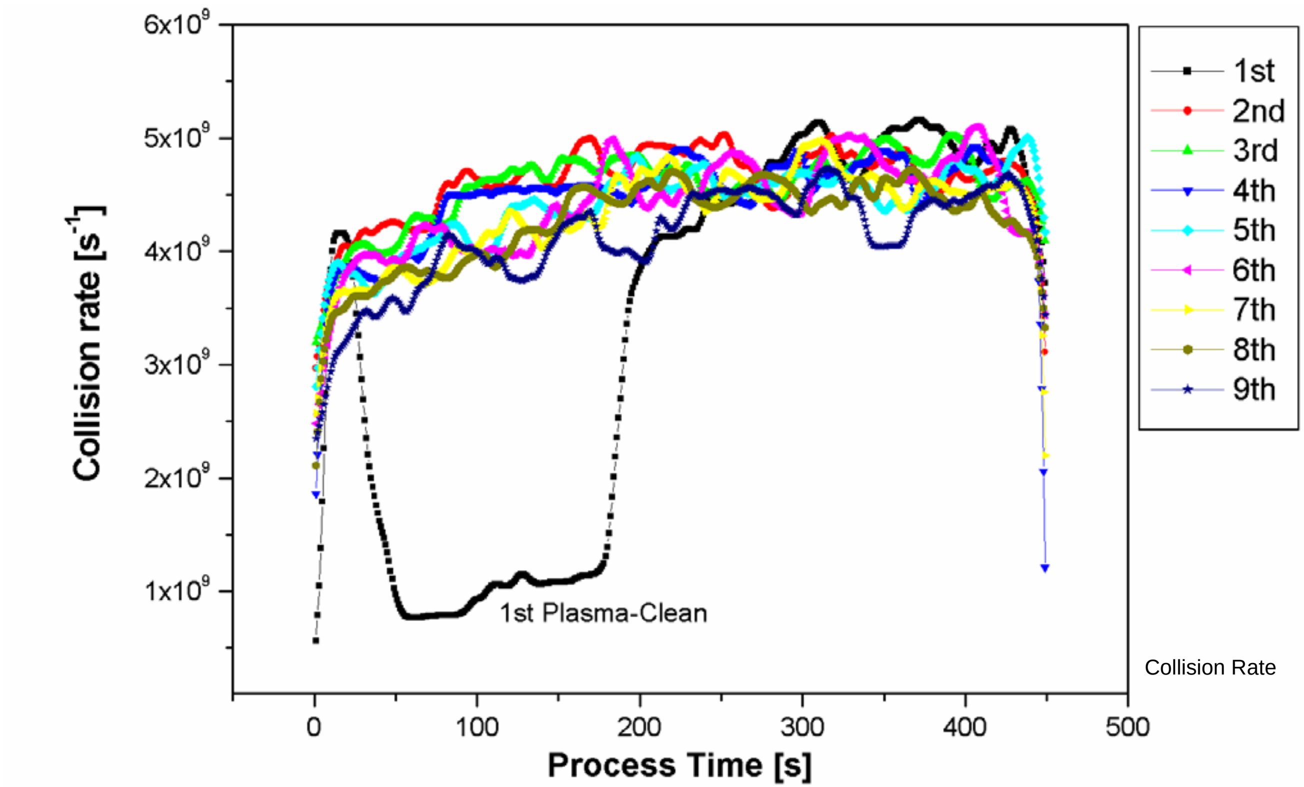
Electron Density

Plasma parameters are very sensitive

to the etched open area (OA)

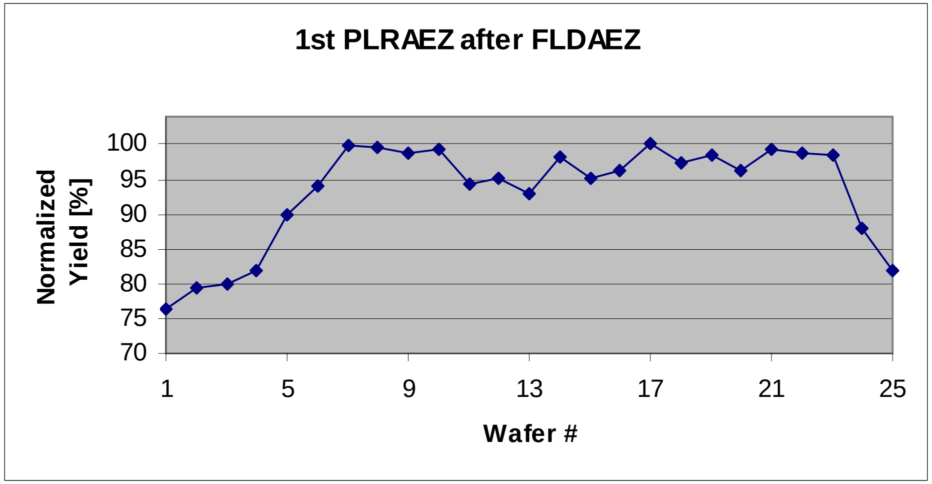
Possibility of EOP detection.

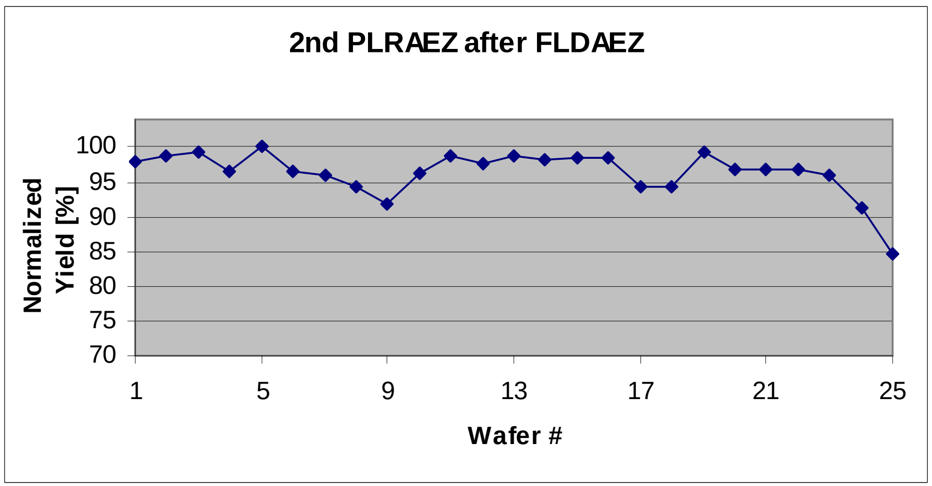
Plasma Clean Cycles before Wet Clean

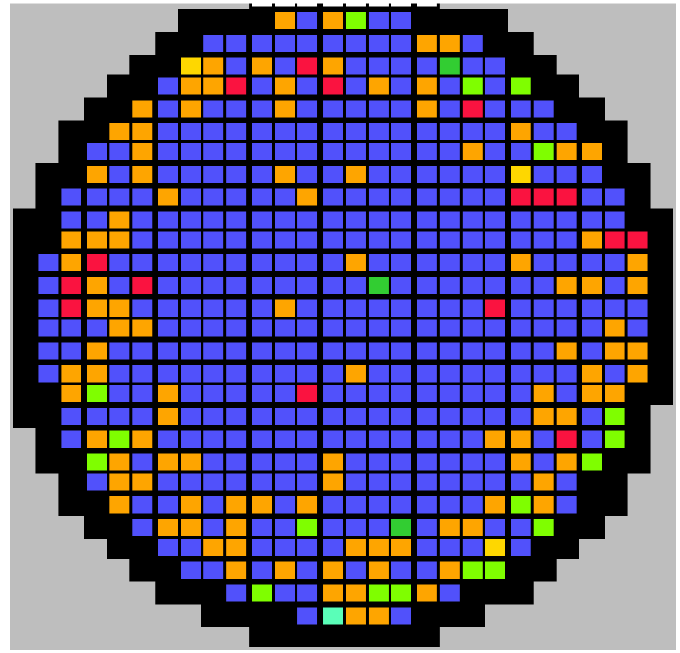


Large change inside chamber during 1st cycle only. 3-5 cycles are sufficient for stable chamber before chamber opening. Already implemented in production without any negative impact on cleaning efficiency. (time saving : 1 hr.)

Effect of Nitride to Poly Switch w/o Seasoning



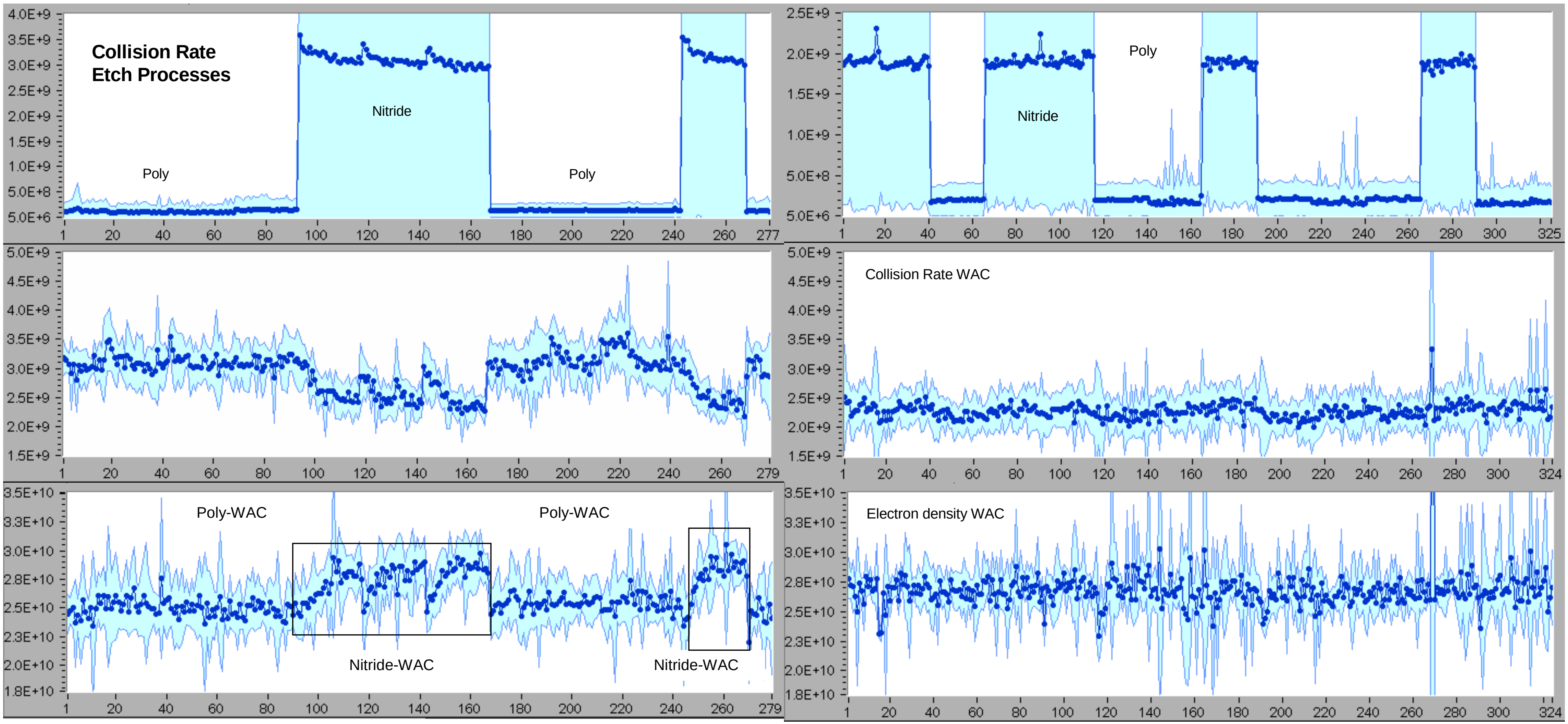




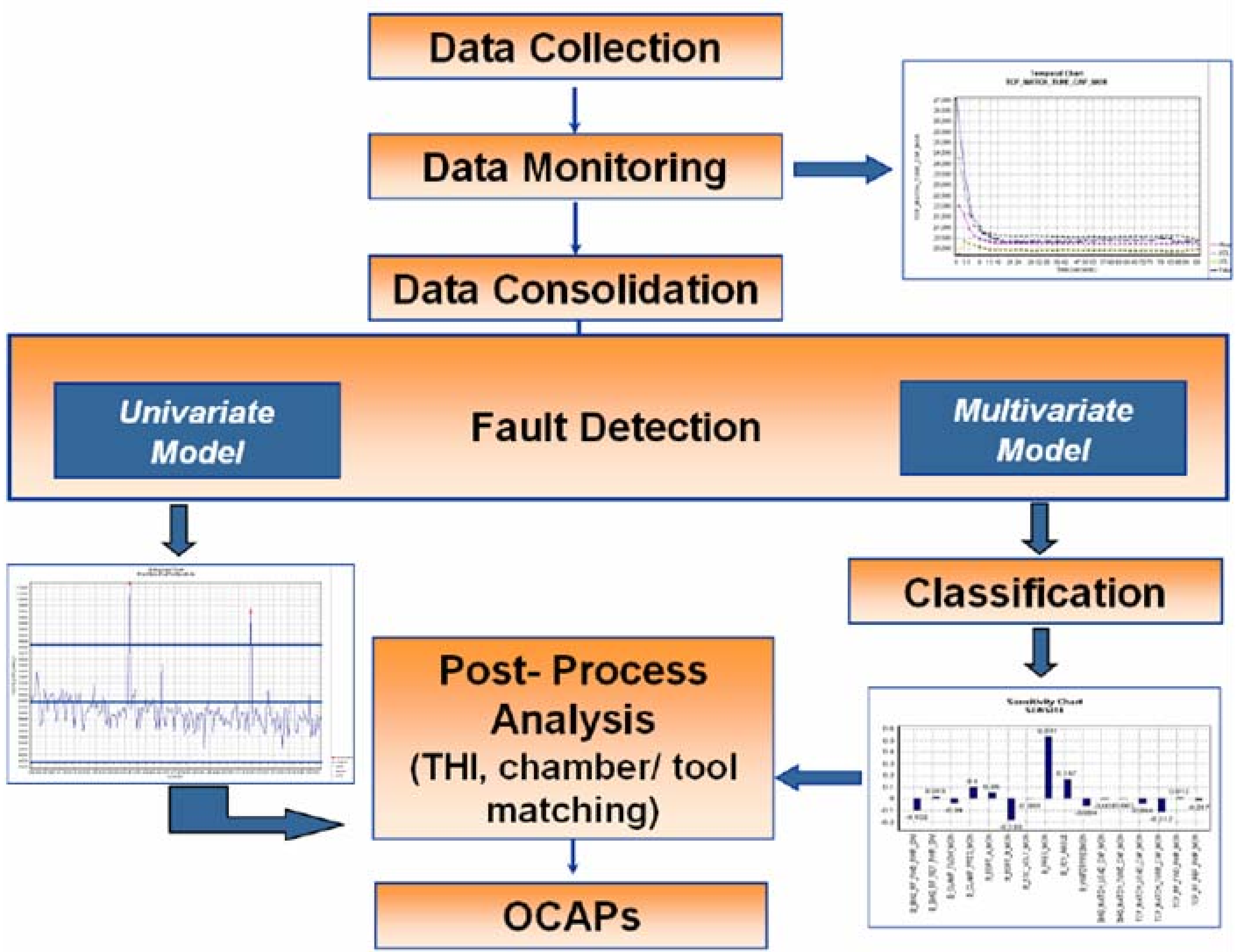
Switching between fluorine-based chemistry and chlorine-based chemistry could cause yield loss due to particles falling from top plate !

Comparison Continuous / Random Switch

random switch | continuous switch



FDC-Software *Maestria* (PDF Solutions / Si Automation)



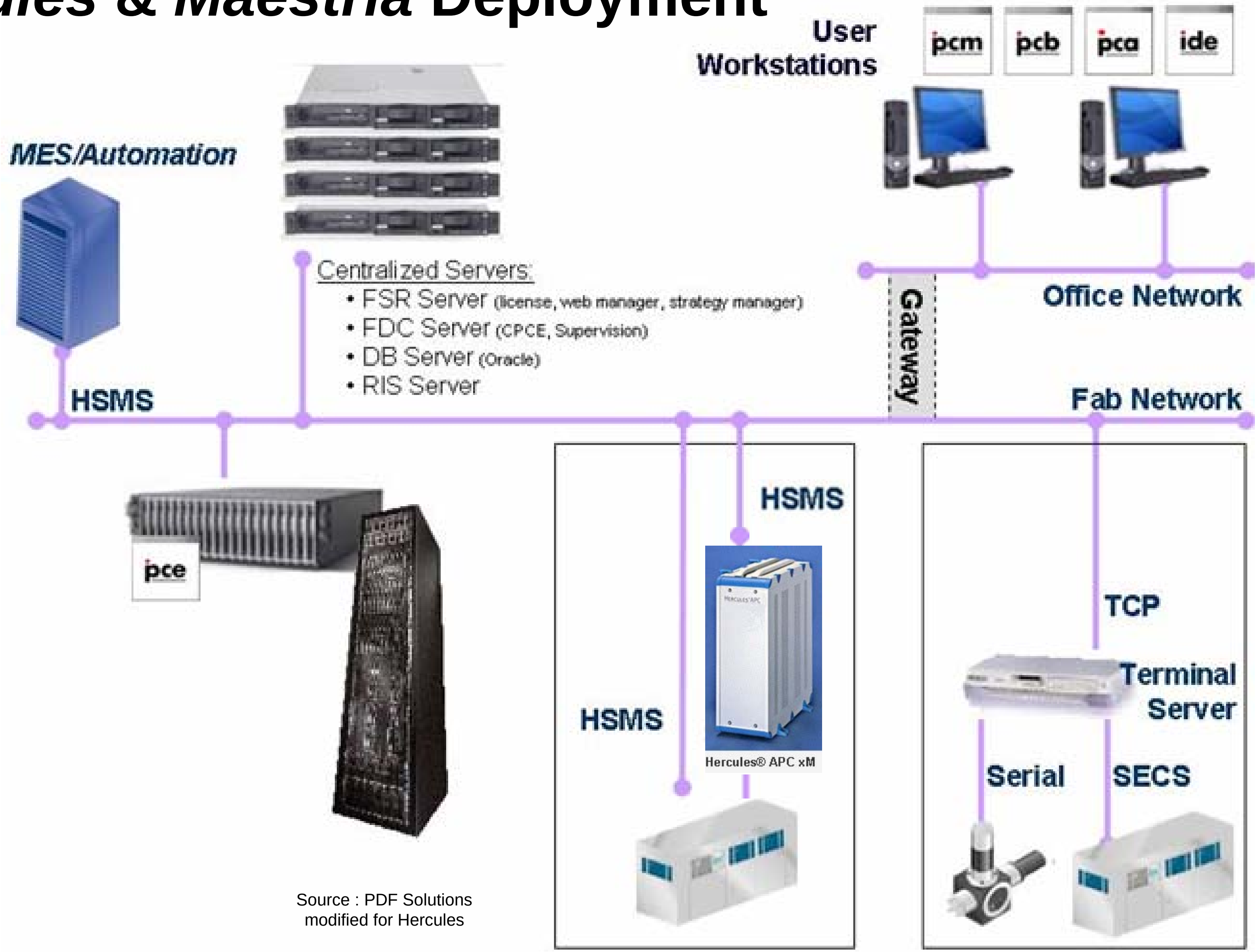
Maestria Deployment Status @ Micronas

- Etch : Lam Alliance + Lam Rainbow + FSI Mercury + Mattson Aspen II
- Diffusion : ASM 400
- Implant : Varian EHP 500
- Litho : Canon I5+ Stepper
- Thinfilm : AMAT Endura

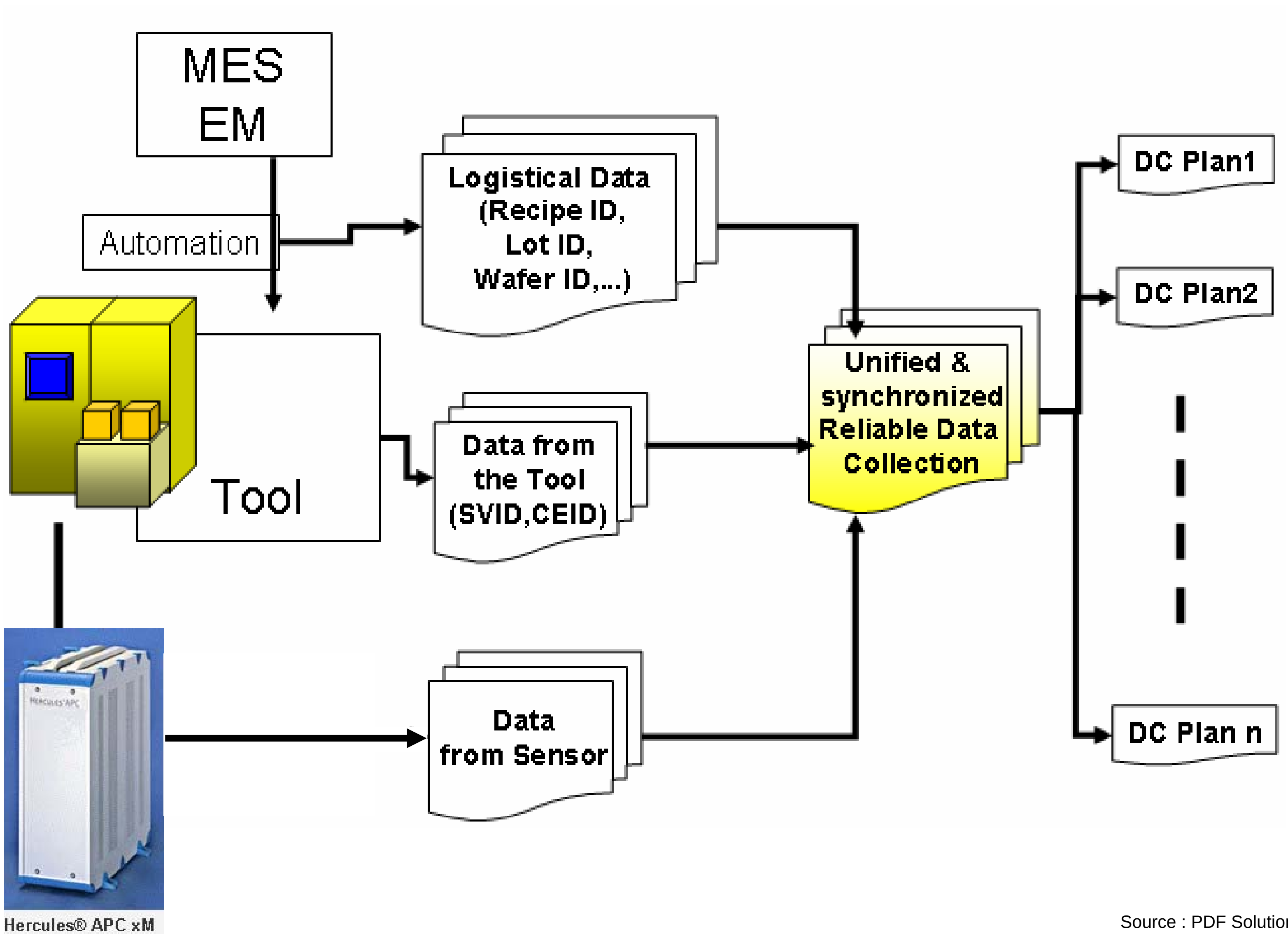
- 32 Tools incl. 65 modules / chambers
- 850 strategies active, 130 with OCAPs, 420 with limits
- PCA (Process Control Analyzer) training for process & maintenance (30 engineers)
- PCA implemented in daily work

- but : sometimes internal tool data is not enough, additional sensors are necessary...

Hercules & *Maestria* Deployment



Source : PDF Solutions
modified for Hercules



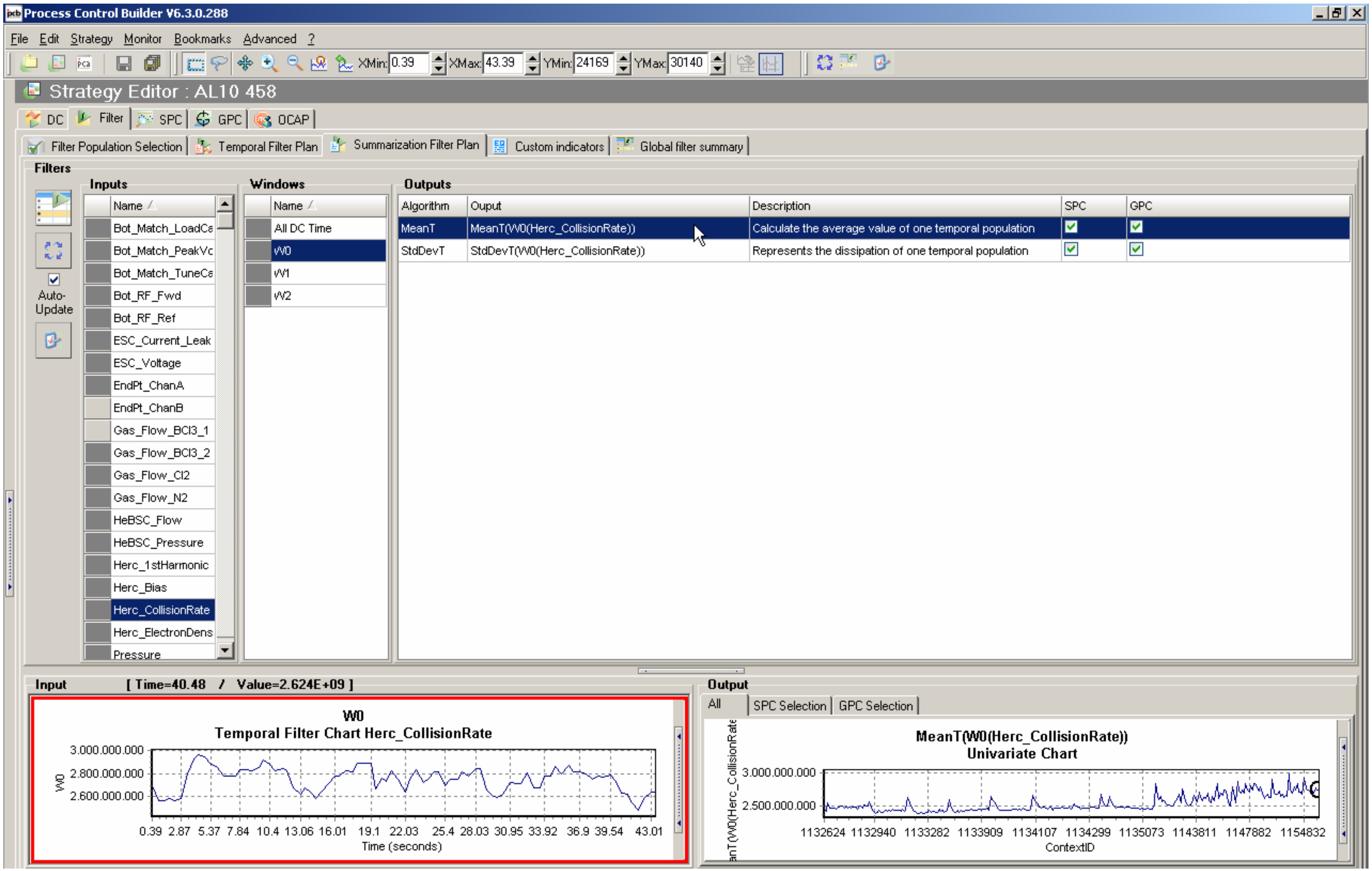
Source : PDF Solutions
modified for Hercules

DC Plan : Integration of *Hercules* Variables

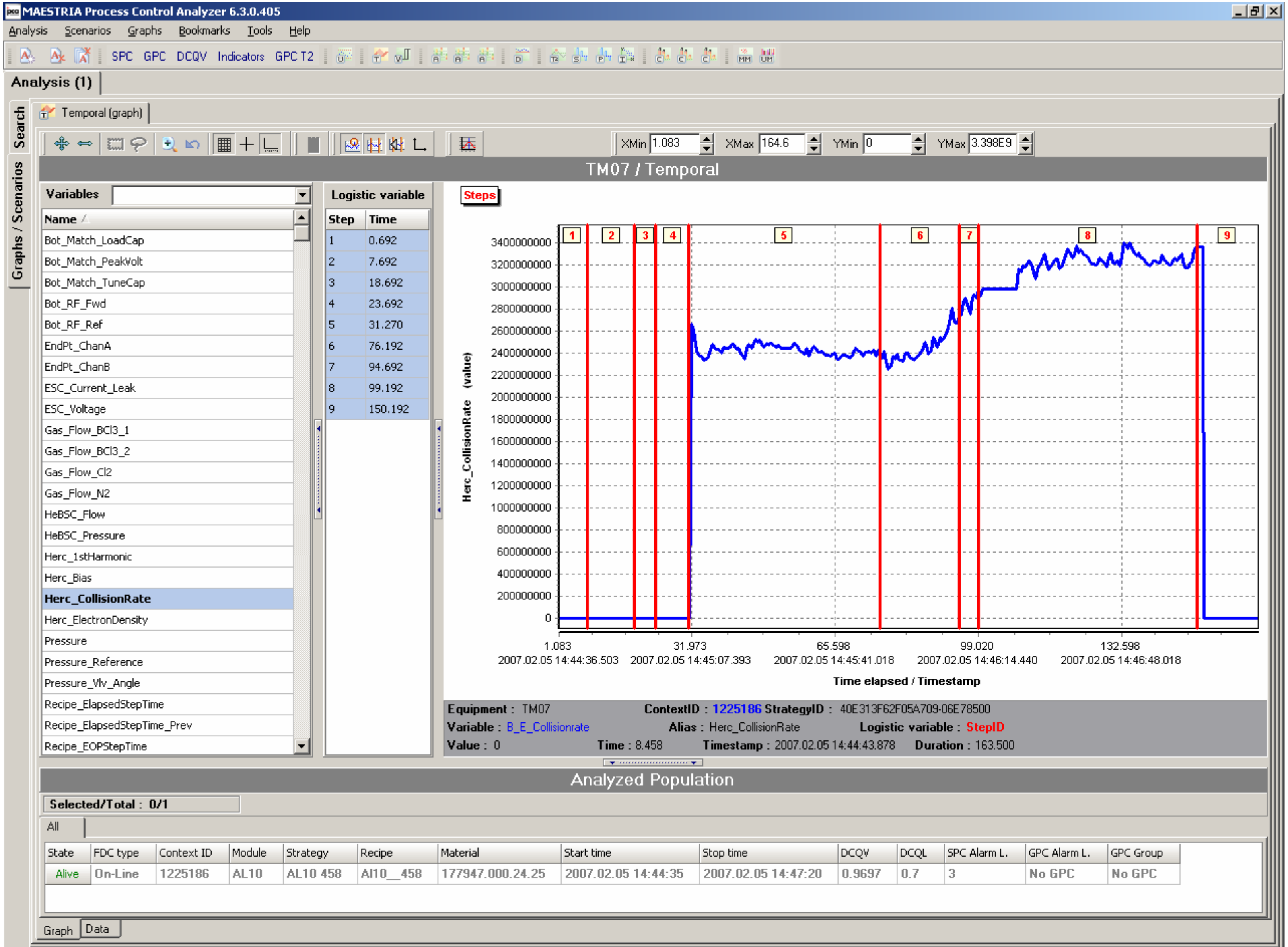
Selected variables: 38

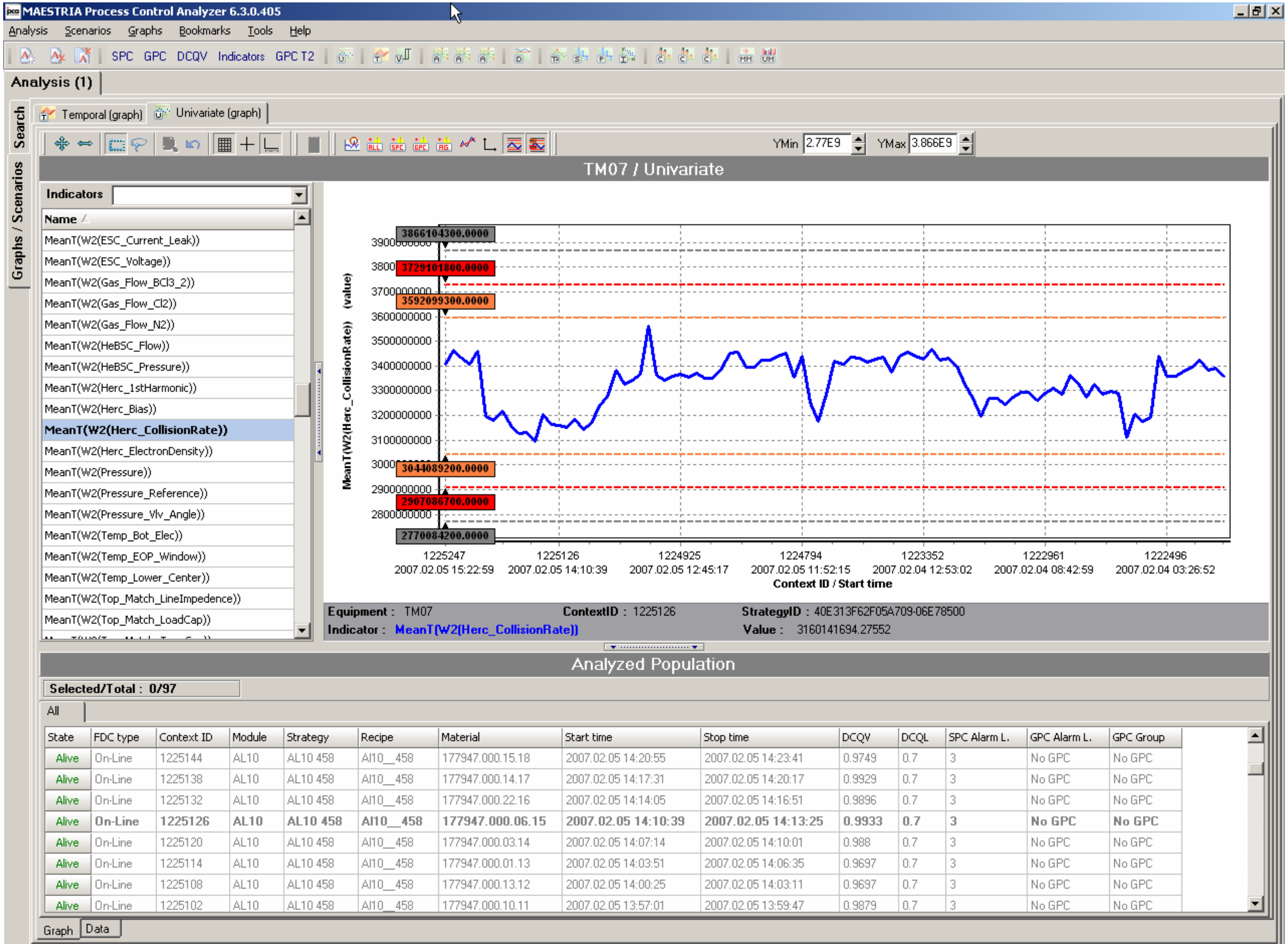
Alias	Module	Label	SVID	Type	Unit	Minimum	Maximum	Sampling Period
ESC_Voltage	AL10	AL10_ProcChm_ESC_Voltage_In	20181051	LAM Alliance Status variable				500
EndPt_ChanA	AL10	AL10_ProcChm_EndPt_ChanA_In	20181032	LAM Alliance Status variable				500
EndPt_ChanB	AL10	AL10_ProcChm_EndPt_ChanB_In	20181034	LAM Alliance Status variable				500
Gas_Flow_BCl3_1	AL10	AL10_Gas_02_BCl3_50_Flow_Mon	20191510	LAM Alliance Status variable	sccm			500
Gas_Flow_BCl3_2	AL10	AL10_Gas_03_BCl3_100_Flow_Mon	20191516	LAM Alliance Status variable	sccm			500
Gas_Flow_Cl2	AL10	AL10_Gas_01_Cl2_Flow_Mon	20191504	LAM Alliance Status variable	sccm			500
Gas_Flow_N2	AL10	AL10_Gas_05_N2_Flow_Mon	20191528	LAM Alliance Status variable	sccm			500
HeBSC_Flow	AL10	AL10_Gas_09_HeBSC_Flow_In	20191549	LAM Alliance Status variable	sccm			500
HeBSC_Pressure	AL10	AL10_Gas_09_HeBSC_Pressure_Mon	20181565	LAM Alliance Status variable	sccm			500
Herc_1stHarmonic	AL10	B_1_Harmonic	0.0.0.1103	SECS_DAQSensor_Dictionary	A			500
Herc_Bias	AL10	B_Estimated_Bias	0.0.0.1102	SECS_DAQSensor_Dictionary	V			500
Herc_CollisionRate	AL10	B_E_Collisionrate	0.0.0.1101	SECS_DAQSensor_Dictionary	s^-1			500
Herc_ElectronDensity	AL10	B_E_Density	0.0.0.1100	SECS_DAQSensor_Dictionary	cm^-3			500
Pressure	AL10	AL10_ProcChm_Pressure_Mon	20183515	LAM Alliance Status variable				500
Pressure_Reference	AL10	AL10_ProcChm_Mano_RefrnPres_In	20183510	LAM Alliance Status variable				500
Pressure_Vlv_Angle	AL10	AL10_ProcChm_Pres_Vlv_Angle	20183514	LAM Alliance Status variable				500
Recipe_EOPStepTime	AL10	AL10_ProcChm_EndPt_Step_FloatTime	20181081	LAM Alliance Status variable				2000
Recipe_ElapsedStepTim	AL10	AL10_RecipeElapsedStepTime	20180533	LAM Alliance Status variable				500

Definition of Indicators

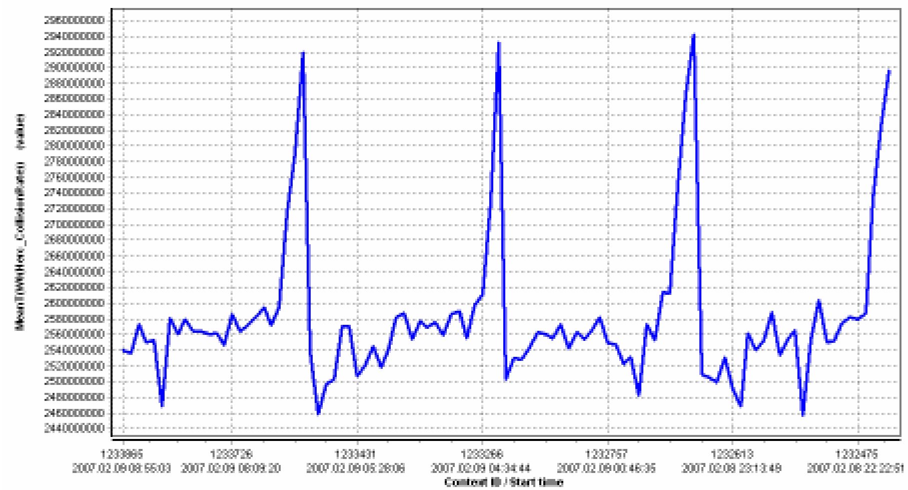


MICRONAS

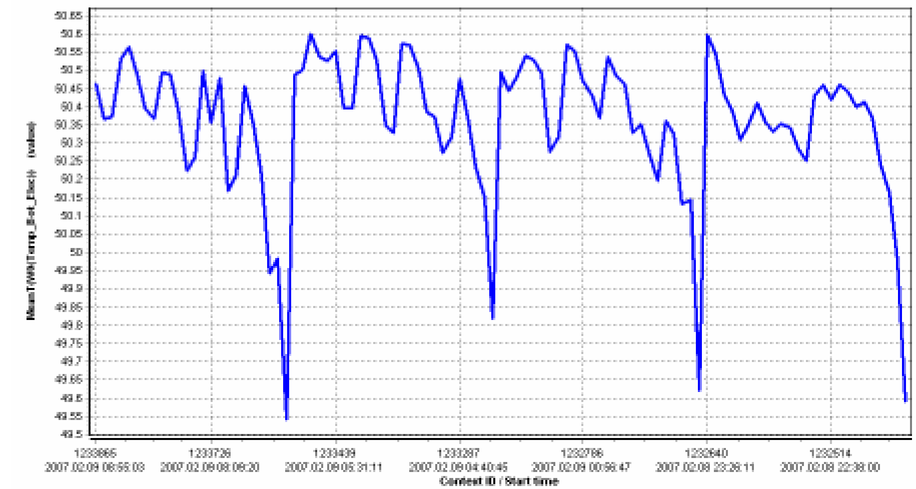

MAESTRIA Process Control Analyzer 6.3.0.405
Analysis Scenarios Graphs Bookmarks Tools Help
SPC GPC DCQV Indicators GPC T2
Analysis (1)
Search
Graphs / Scenarios
Temporal (graph)
XMin 1.083 XMax 164.6 YMin 0 YMax 3.398E9
TM07 / Temporal
Variables
Name
Bot_Match_LoadCap
Bot_Match_PeakVolt
Bot_Match_TuneCap
Bot_RF_Fwd
Bot_RF_Ref
EndPt_ChanA
EndPt_ChanB
ESC_Current_Leak
ESC_Voltage
Gas_Flow_BCl3_1
Gas_Flow_BCl3_2
Gas_Flow_Cl2
Gas_Flow_N2
HeBSC_Flow
HeBSC_Pressure
Herc_1stHarmonic
Herc_Bias
Herc_CollisionRate
Herc_ElectronDensity
Pressure
Pressure_Reference
Pressure_Vlv_Angle
Recipe_ElapsedStepTime
Recipe_ElapsedStepTime_Prev
Recipe_EOPStepTime
Logistic variable
Step Time
1 0.692
2 7.692
3 18.692
4 23.692
5 31.270
6 76.192
7 94.692
8 99.192
9 150.192
Steps
1 2 3 4 5 6 7 8 9
Herc_CollisionRate (value)
3400000000
3200000000
3000000000
2800000000
2600000000
2400000000
2200000000
2000000000
1800000000
1600000000
1400000000
1200000000
1000000000
800000000
600000000
400000000
200000000
0
1.083 2007.02.05 14:44:36.503
31.973 2007.02.05 14:45:07.393
65.598 2007.02.05 14:45:41.018
99.020 2007.02.05 14:46:14.440
132.598 2007.02.05 14:46:48.018
Time elapsed / Timestamp
Equipment : TM07 ContextID : 1225186 StrategyID : 40E313F62F05A709-06E78500
Variable : B_E_Collisionrate Alias : Herc_CollisionRate Logistic variable : StepID
Value : 0 Time : 8.458 Timestamp : 2007.02.05 14:44:43.878 Duration : 163.500
Analyzed Population
Selected/Total : 0/1
All
State | FDC type | Context ID | Module | Strategy | Recipe | Material | Start time | Stop time | DCQV | DCQL | SPC Alarm L. | GPC Alarm L. | GPC Group
Alive | On-Line | 1225186 | AL10 | AL10 458 | Al10__458 | 177947.000.24.25 | 2007.02.05 14:44:35 | 2007.02.05 14:47:20 | 0.9697 | 0.7 | 3 | No GPC | No GPC
Graph Data


MAESTRIA Process Control Analyzer 6.3.0.405
Analysis Scenarios Graphs Bookmarks Tools Help
SPC GPC DCQV Indicators GPC T2
Analysis (1)
Search
Graphs / Scenarios
Temporal (graph)
Univariate (graph)
YMin 2.77E9
YMax 3.866E9
TM07 / Univariate
Indicators
Name
MeanT(W2(ESC_Current_Leak))
MeanT(W2(ESC_Voltage))
MeanT(W2(Gas_Flow_BCl3_2))
MeanT(W2(Gas_Flow_Cl2))
MeanT(W2(Gas_Flow_N2))
MeanT(W2(HeBSC_Flow))
MeanT(W2(HeBSC_Pressure))
MeanT(W2(Herc_1stHarmonic))
MeanT(W2(Herc_Bias))
MeanT(W2(Herc_CollisionRate))
MeanT(W2(Herc_ElectronDensity))
MeanT(W2(Pressure))
MeanT(W2(Pressure_Reference))
MeanT(W2(Pressure_Vlv_Angle))
MeanT(W2(Temp_Bot_Elec))
MeanT(W2(Temp_EOP_Window))
MeanT(W2(Temp_Lower_Center))
MeanT(W2(Top_Match_LineImpedence))
MeanT(W2(Top_Match_LoadCap))
3866104300.0000
3729101800.0000
3592099300.0000
3044089200.0000
2907086700.0000
2770084200.0000
3900000000
3800000000
3700000000
3600000000
3500000000
3400000000
3300000000
3200000000
3100000000
3000000000
2900000000
2800000000
MeanT(W2(Herc_CollisionRate)) (value)
1225247 2007.02.05 15:22:59
1225126 2007.02.05 14:10:39
1224925 2007.02.05 12:45:17
1224794 2007.02.05 11:52:15
1223352 2007.02.04 12:53:02
1222961 2007.02.04 08:42:59
1222496 2007.02.04 03:26:52
Context ID / Start time
Equipment : TM07
ContextID : 1225126
StrategyID : 40E313F62F05A709-06E78500
Indicator : MeanT(W2(Herc_CollisionRate))
Value : 3160141694.27552
Analyzed Population
Selected/Total : 0/97
All
State | FDC type | Context ID | Module | Strategy | Recipe | Material | Start time | Stop time | DCQV | DCQL | SPC Alarm L. | GPC Alarm L. | GPC Group
Alive | On-Line | 1225144 | AL10 | AL10 458 | Al10__458 | 177947.000.15.18 | 2007.02.05 14:20:55 | 2007.02.05 14:23:41 | 0.9749 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225138 | AL10 | AL10 458 | Al10__458 | 177947.000.14.17 | 2007.02.05 14:17:31 | 2007.02.05 14:20:17 | 0.9929 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225132 | AL10 | AL10 458 | Al10__458 | 177947.000.22.16 | 2007.02.05 14:14:05 | 2007.02.05 14:16:51 | 0.9896 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225126 | AL10 | AL10 458 | Al10__458 | 177947.000.06.15 | 2007.02.05 14:10:39 | 2007.02.05 14:13:25 | 0.9933 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225120 | AL10 | AL10 458 | Al10__458 | 177947.000.03.14 | 2007.02.05 14:07:14 | 2007.02.05 14:10:01 | 0.988 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225114 | AL10 | AL10 458 | Al10__458 | 177947.000.01.13 | 2007.02.05 14:03:51 | 2007.02.05 14:06:35 | 0.9697 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225108 | AL10 | AL10 458 | Al10__458 | 177947.000.13.12 | 2007.02.05 14:00:25 | 2007.02.05 14:03:11 | 0.9697 | 0.7 | 3 | No GPC | No GPC
Alive | On-Line | 1225102 | AL10 | AL10 458 | Al10__458 | 177947.000.10.11 | 2007.02.05 13:57:01 | 2007.02.05 13:59:47 | 0.9879 | 0.7 | 3 | No GPC | No GPC
Graph Data

Easy Correlation Tool Parameters - Sensor Data



Collision Rate

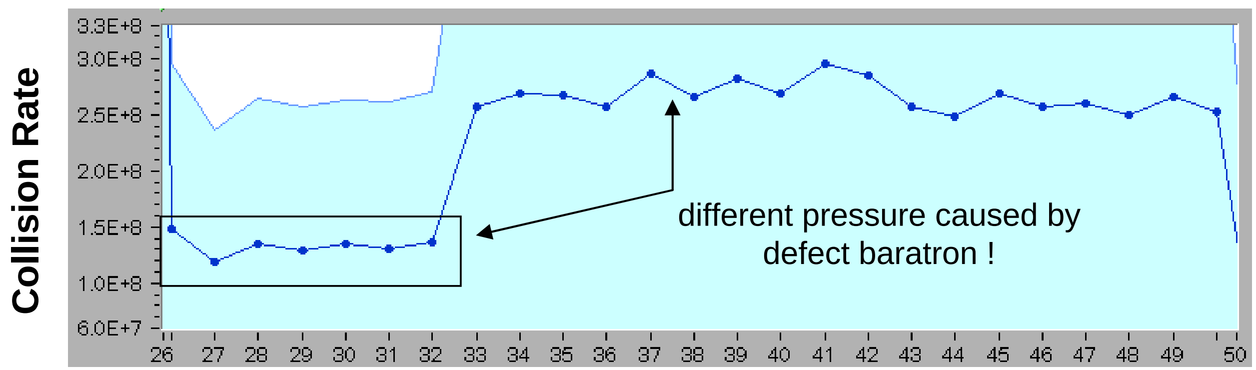


Bottom-Temp

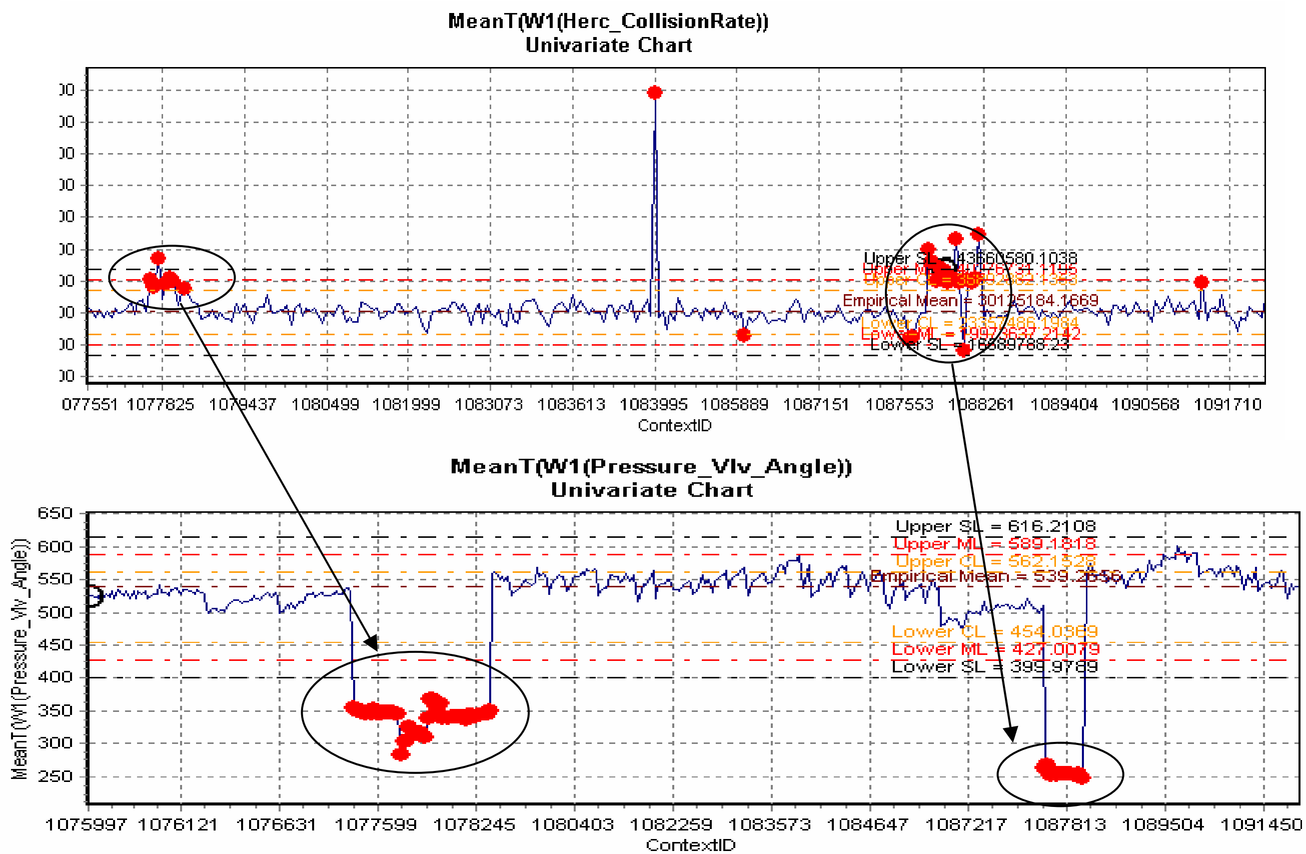
Implementation of external sensor data into *Maestria* system allows easy comparison / correlation of tool and sensor data

FDC Example : Defect Baratron (1)

Because of sensitivity to process / tool parameters, collision rate and electron density are ideal for detecting tool failures resulting in process parameter drifts. In this example a baratron had a defect causing a shift in real pressure. The process was **not** aborted by the tool because the defect baratron fooled the tool with the "correct" pressure. Additional parameters like plasma parameters are helpful for FDC.

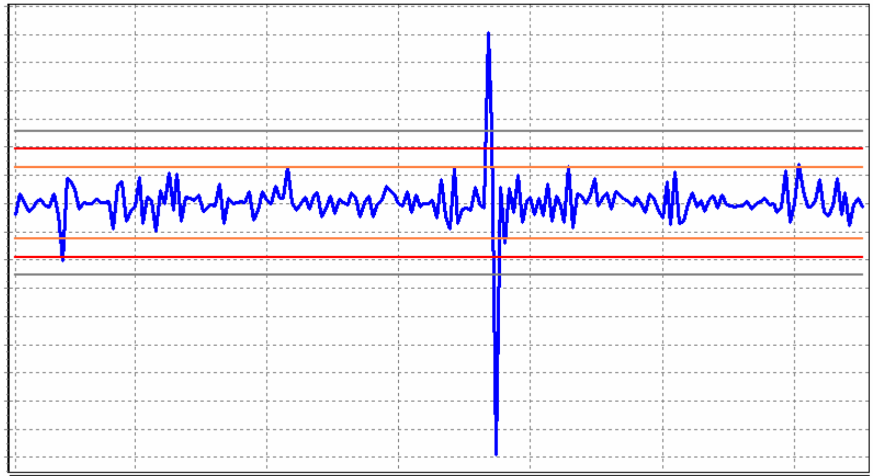


FDC Example : Defect Baratron (2)

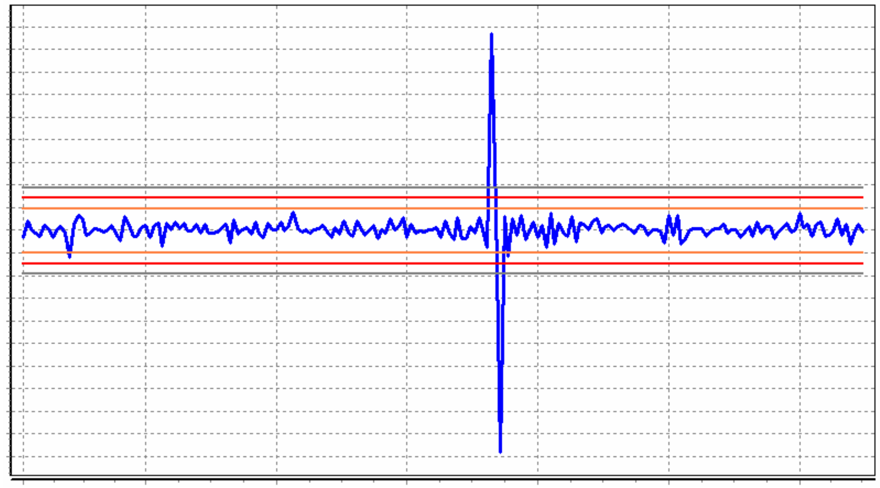


Problem is indicated only by collision rate & VATvalve angle. Collision rate is a convenient in situ parameter for the real process status inside the chamber !

Process Control by Wafer-to-Wafer-Difference



Collision Rate



Electron Density

Wafer-to-wafer-difference of plasma parameters is
an easy recipe independent process/tool control ;
easy identification of excursions, tool & process problems !

MICRONAS

MANAGED BY PEOPLE

POWERED BY IDEAS

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