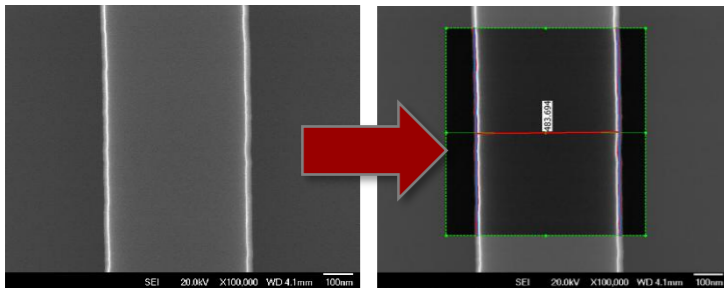
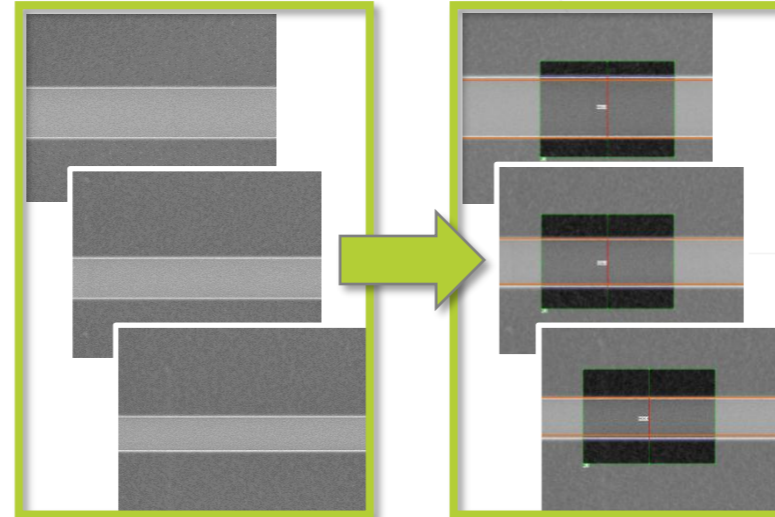


SEM Metrology Scenarios

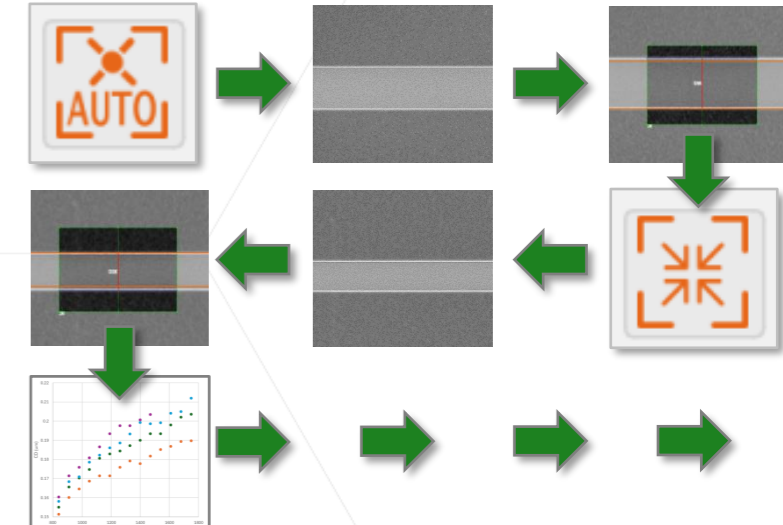
Offline SEM Image Metrology



External SEM Control and Image Metrology



Integrated Automation for SEM Metrology



SEM Metrology Solutions



SEM Image Analysis & Metrology Software

- Easy-to-use software
- Offline image metrology
- SEM tool external control
- Single chip and few sites



Integrated SEM Metrology & Inspection Upgrade Kit

- Advanced solution upgrade kit
- Integrated tool for experts
- True SEM metrology automation
- Multiple chips and many sites

ProSEM

SEM Metrology & Automation Software

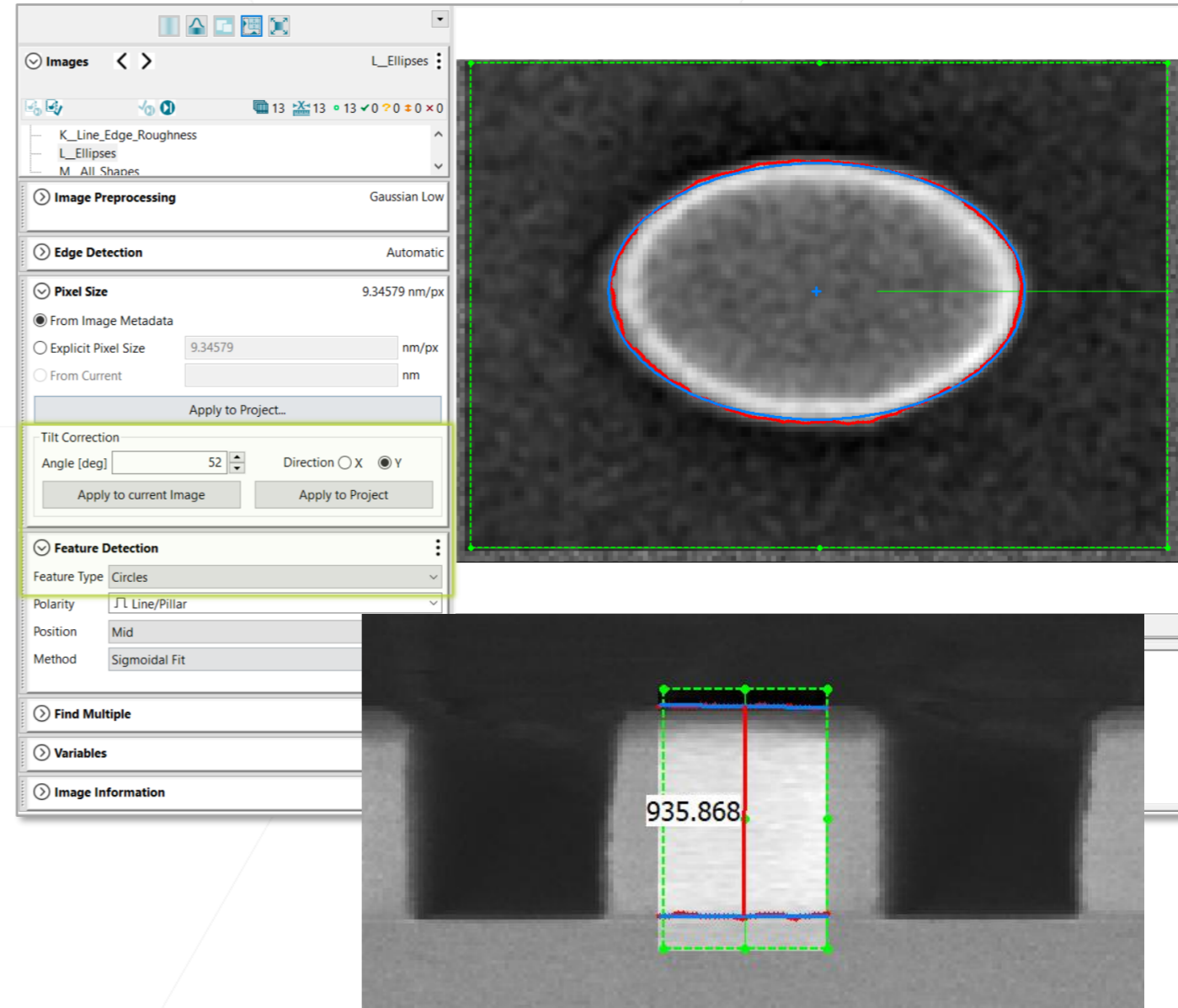
ProSEM 3.6 Key News

- General
 - Update on Operating System support
- Feature Detection and Measurements
 - Edge Roughness and PSD plots for groups
 - Advanced Package: User control for template matching
 - Advanced Package: Tilt projection correction of measurements
 - Advanced Package: New feature type “Rounded Rectangles”
- Layout Integration/ SEM Tool Control
 - Control of image polarity in registration
 - Image registration and standard measurements/ recipes
 - SEM drive with 1-click shortcut
 - New SEM interfaces available (JEOL, Hitachi, Thermo Fisher)

→ See “What’s New”
document on website

Measurements on tilted images

- Set tilt angle/ direction of view on image
 - Correction for:
 - Measurement results
 - Shape fitting
 - Display of image and contour uncorrected
 - Example shown: fitted as circle
 - Available in Advanced package or higher
- Especially for cross-section analysis
- Better usability with less data processing



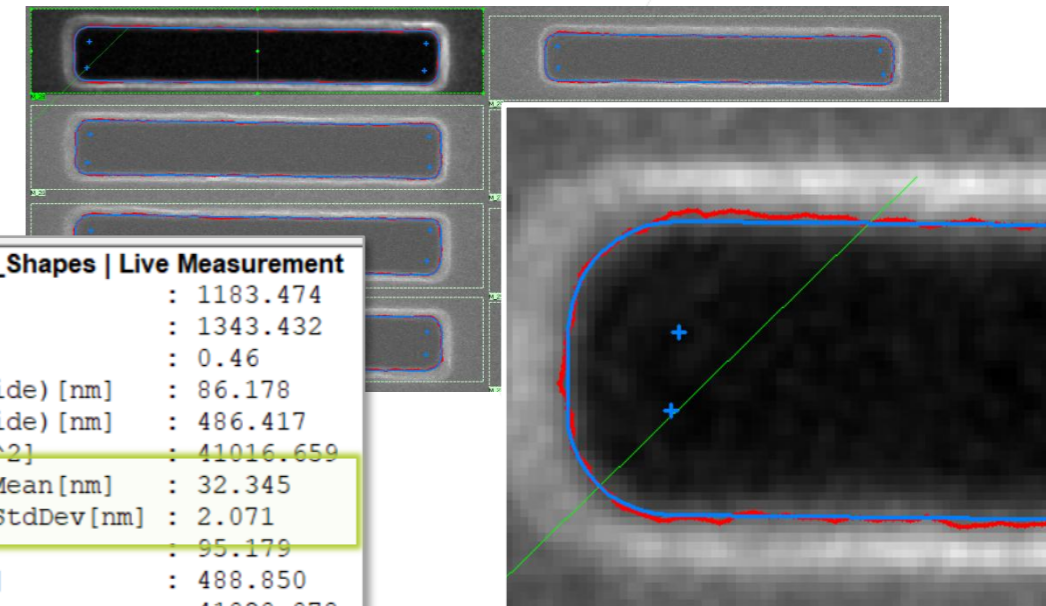
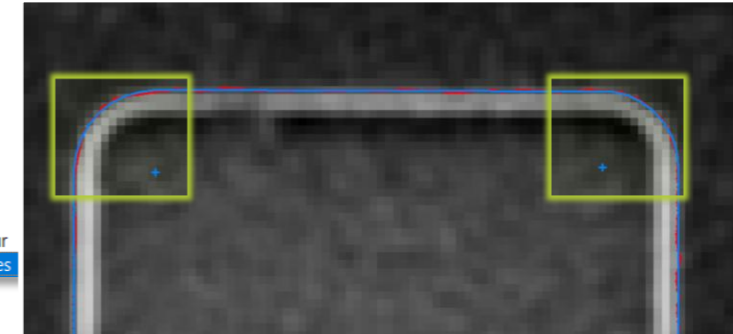
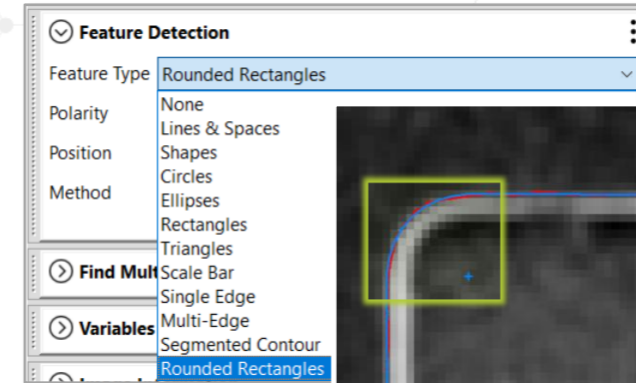
New Feature Type “Rounded Rectangles”

Fitted rectangles including corner rounding

- Measures corner radius mean and standard deviation
- Fits rectangle sides and 4 corners
- Individual results accessible via script
- Available in Advanced package or higher

→ Improves fitting being closer to SEM contour

→ Provides important results for process parameters



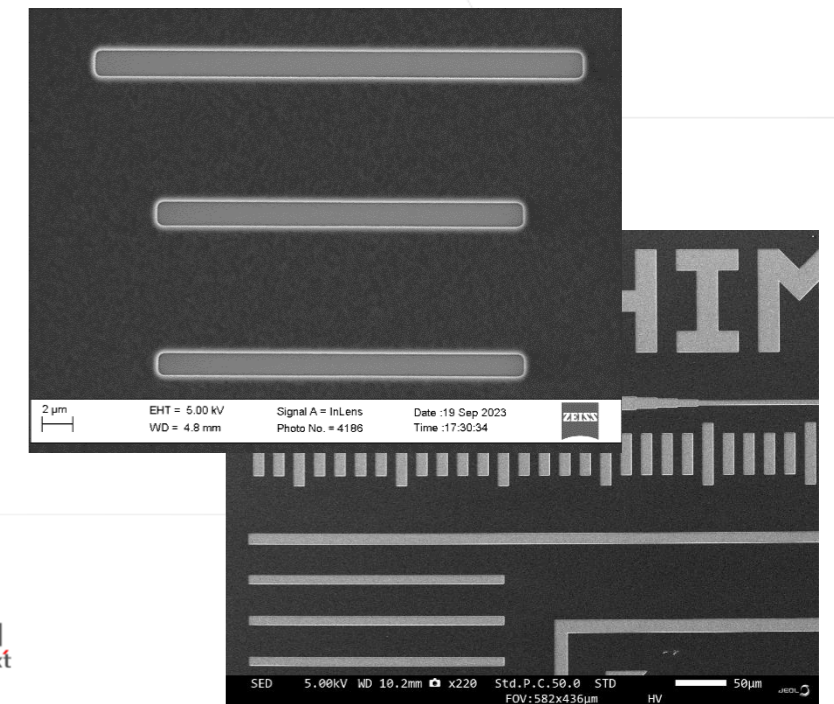
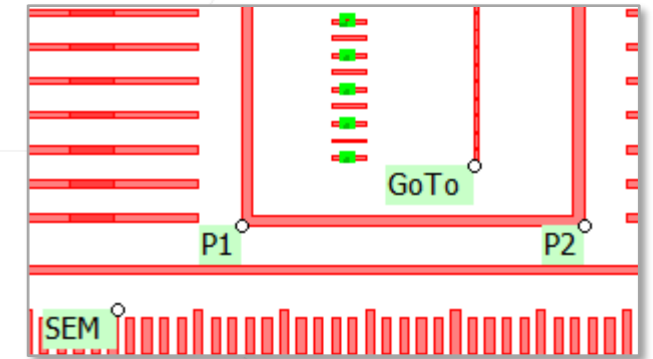
J_Rectangles_or_Shapes Live Measurement	
Center X[nm]	: 1183.474
Center Y[nm]	: 1343.432
Rotation[deg]	: 0.46
Width (short side)[nm]	: 86.178
Height (long side)[nm]	: 486.417
Fitted Area[nm ²]	: 41016.659
Corner Radius Mean[nm]	: 32.345
Corner Radius StdDev[nm]	: 2.071
BBox Width[nm]	: 95.179
BBox Height[nm]	: 488.850
Area[nm ²]	: 41020.078

Convenience shortcut for SEM drive

- 1-click command for stage navigation (Alt + left click)
- Available with valid global alignment
- Shortcut for: pick XY – GoTo – Move to

Supported SEM interfaces (ref. InSPEC)

- ZEISS serial interface (Remcon32)
 - JEOL ethernet interfaces (Eik, MEC)
 - Hitachi interfaces (RS232, ethernet)
 - Thermo Fisher (new ethernet)
 - Other (Tescan) possible and pilot sites welcome
- ➔ Please contact GenISys team for details



Features planned for ProSEM 3.7

- Down-sampling to image preprocessing and import
- Improve color image import (optical)
- Speed up re-calculation for changes in pixel size
- PSD with characteristic peaks: display or report key frequencies (?)
- SEM tool control: semi-automatic and navigation mode

Next major release ProSEM 4.0

- GUI based on qt technology
- Improved integration of layout
- New algorithm for contour detection → enabling complementary workflow

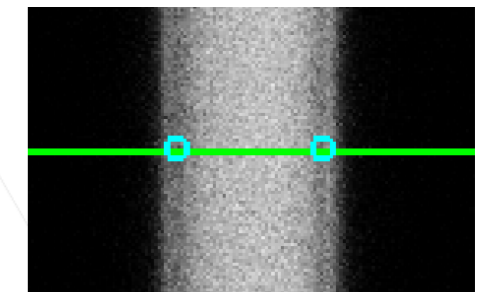
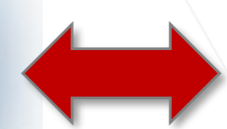
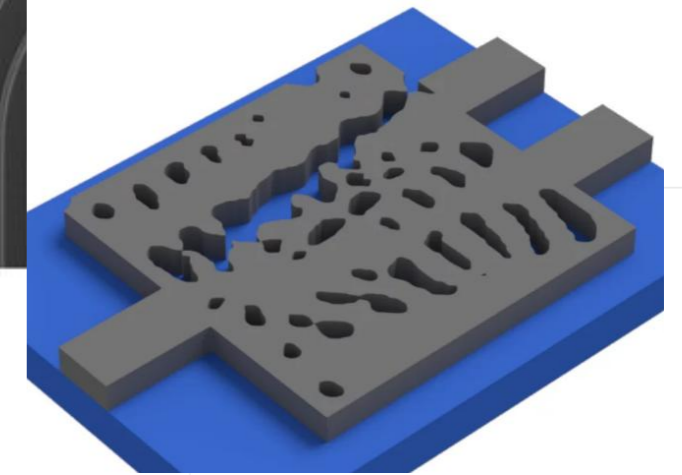
Nov 2025



End of 2026

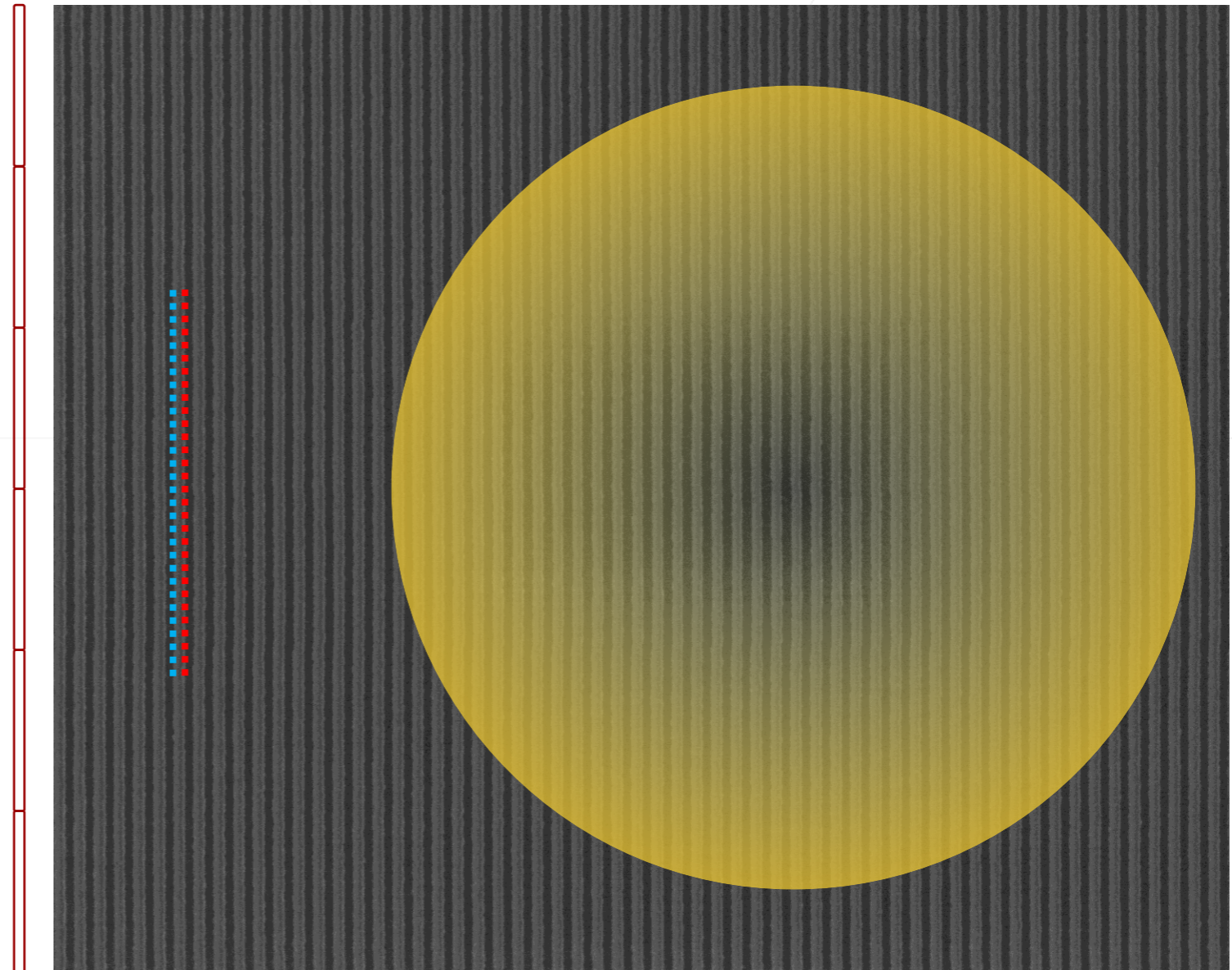
Requirements in Photonics

- **Patterns:** circles, ellipses, curvilinear
- Large arrays, long waveguides
- **“Complex CD”:** comparison to target layout
- Placement and accurate to shape
- Inverse design, computer generated holograms
- **Measurement:** principle and sensitivity
- Optics/ photonics: averaging and “amplification”
- SEM: highly resolved and local



- Contour Analysis vs. Optical Performance
→ *Everything perfect?*
 - Smallest errors make a difference
 - Systematic kinks from sub-fields, stitching etc.
 - Local contour vs. averaged optical response
 - Metrology should correspond to performance

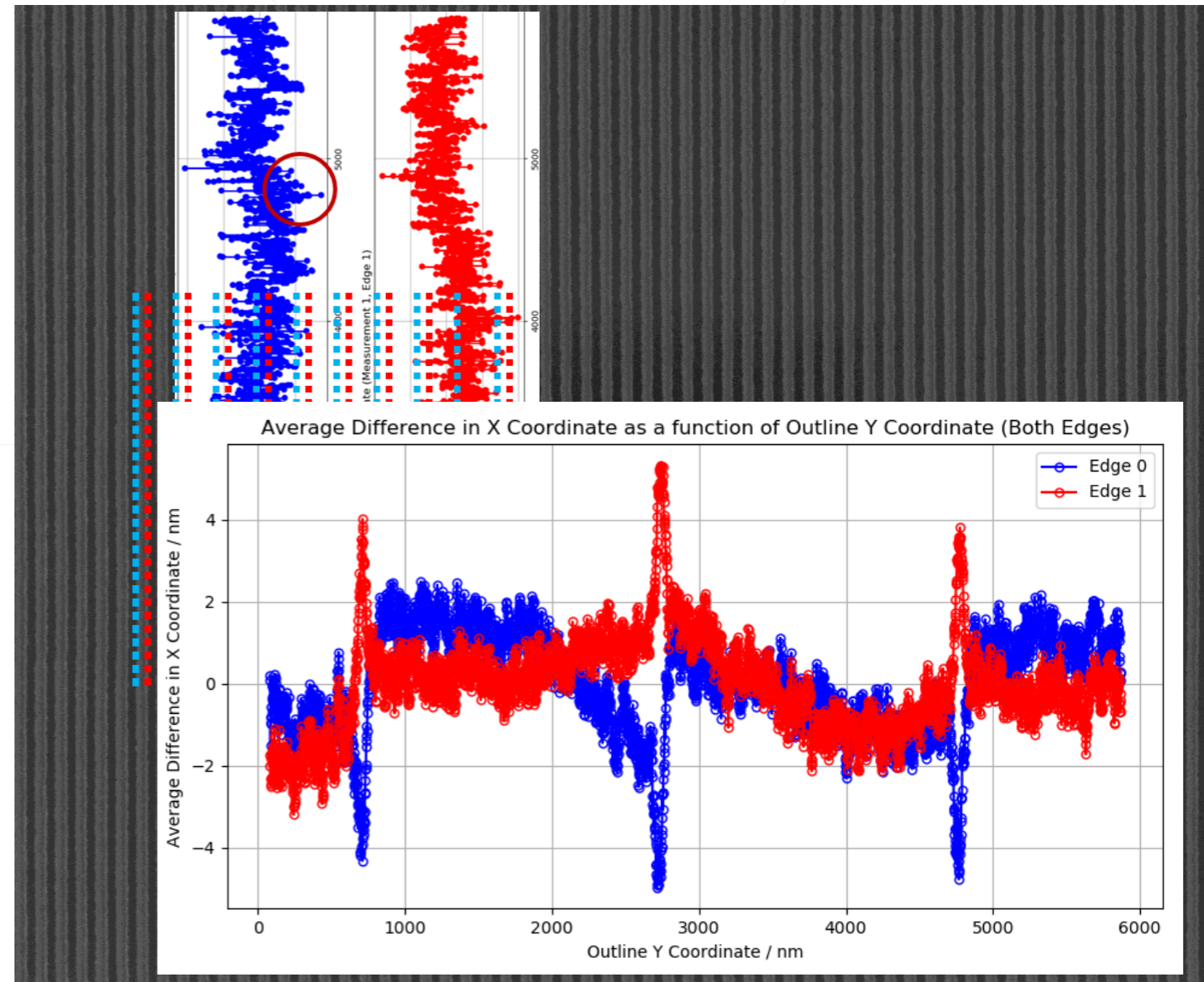
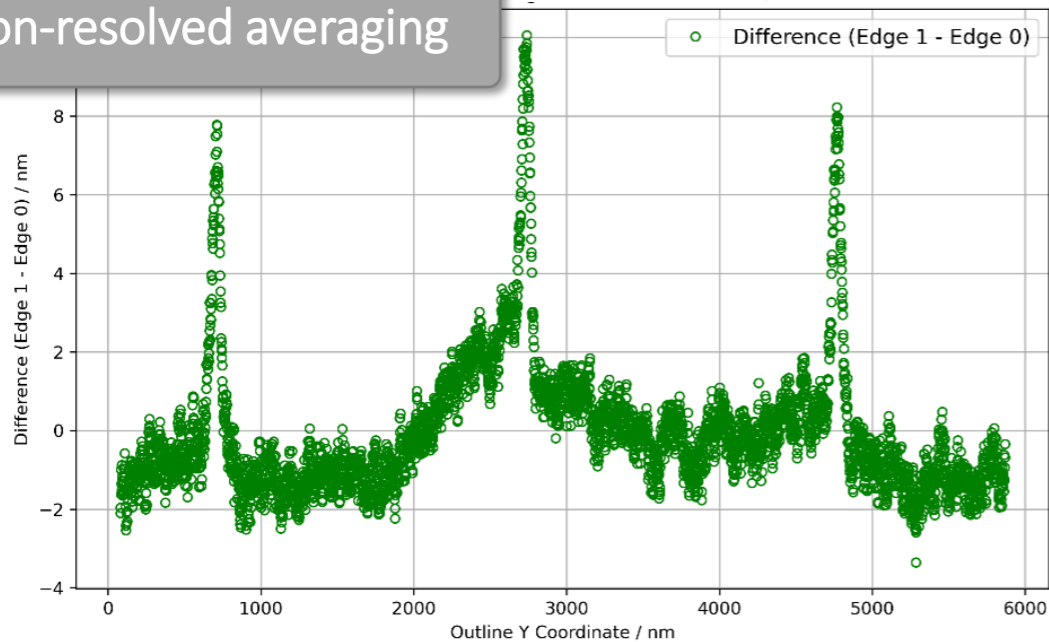
→ Mimic the optical response
in SEM metrology?



IMS Chips

- Contour Analysis for photonics applications
 - Export all points of contour for both edges
 - Calculate average per side
 - Calculate difference of side averages

→ Data processing with position-resolved averaging



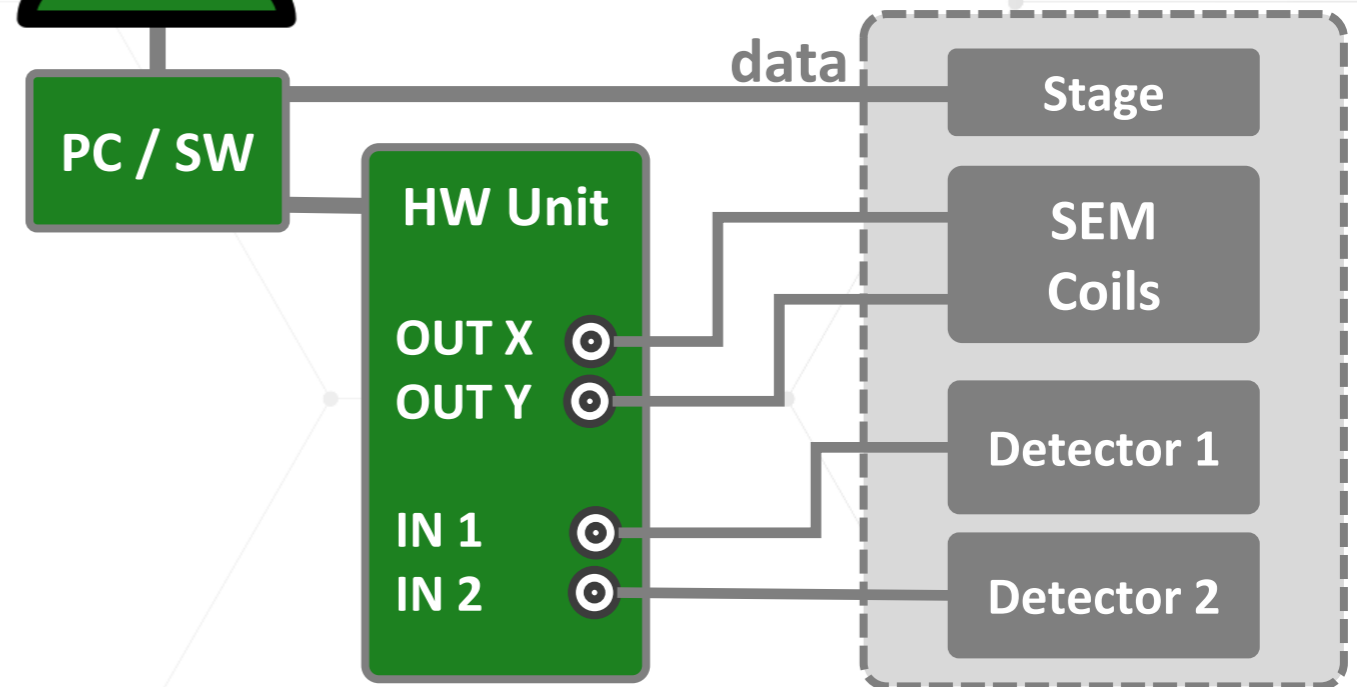
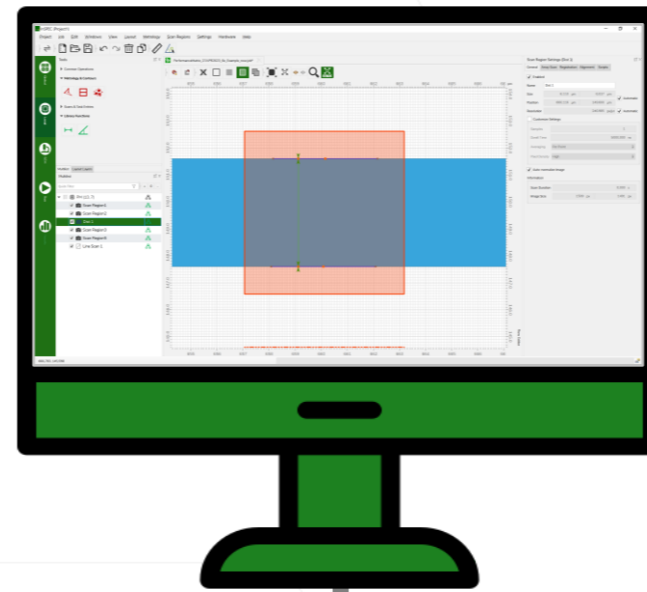
InSPEC

SEM Metrology & Inspection Kit

Integrated Metrology & Inspection Kit

- Software package (1x tool + 2x offline)
- PC and screen
- Scanning and I/O hardware

- Analog integration for SEM beam and detectors
- Stage via digital I/F with safety mechanisms
- Scanning and tool operation through InSPEC



Integrated Workflow along 5 Main Modes

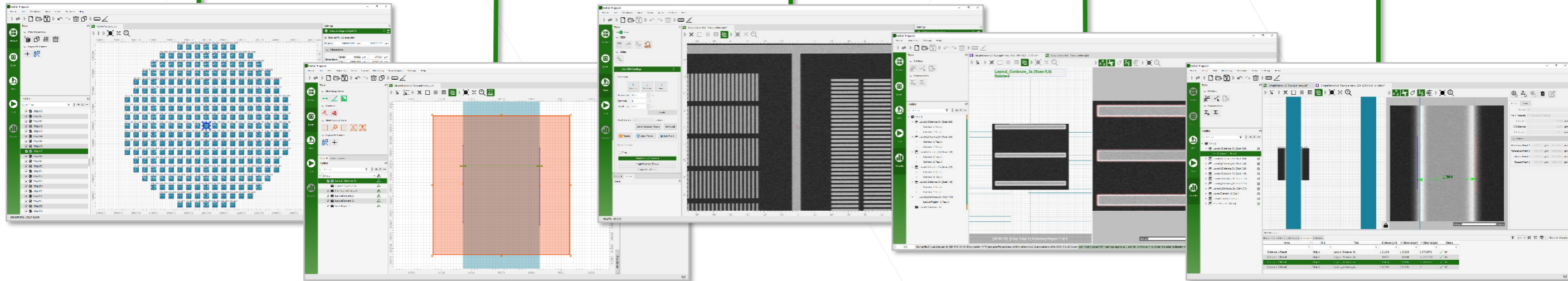
 **Global**

 **Local**

 **SEM**

 **Run**

 **Results**



General sample/
job arrangement

Chip/ field level
scans & metrology

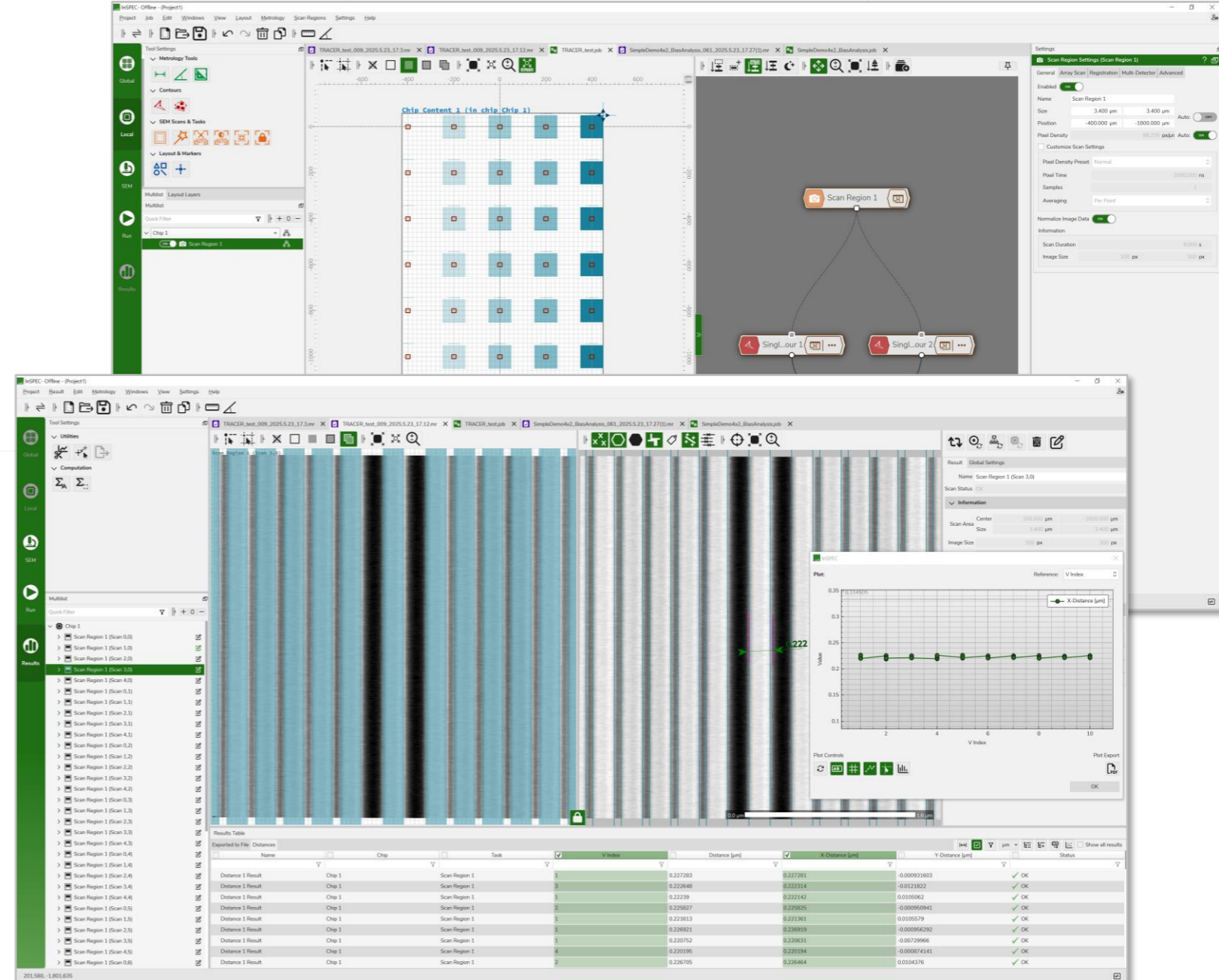
SEM beam and
imaging control

Automatic job
execution

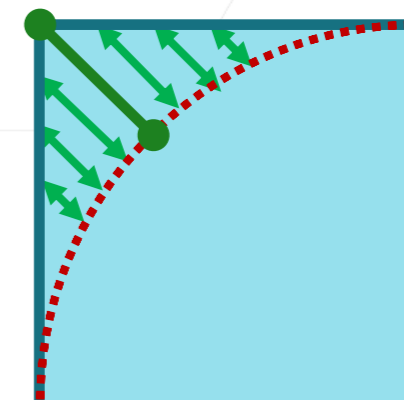
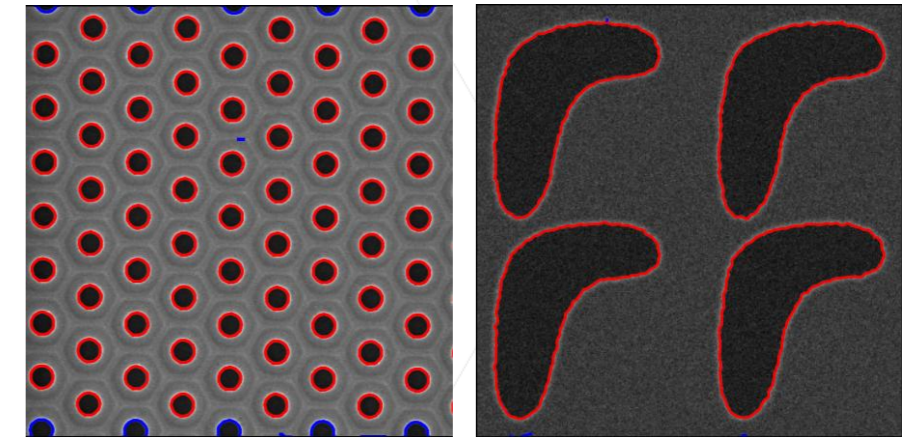
Review & tune
metrology data

→ See introduction movie on:
www.genisys-gmbh.com/products/inspec.html

- Key improvements with pilot feedback
 - GUI, usability, and many small things
 - User manual
 - SEM calibration, scanning, and navigation
 - User account system
 - Flow simulation
 - Export module for TRACER
 - Results quick plotting
 - Add measurements after running jobs
 - Better registration image-to-layout
 - Contour-to-layout comparison (basic)
 - Handling of large layouts and files
 - Data pack/ unpack
 - Python scripting, documentation wip



- Various useful features (short-term)
 - Improved and faster de-noising of SEM scans
 - Scan strategies for “dose sensitive samples” (resist, charging)
 - Duplicate/ advanced array copies and templates
 - Import coordinate lists or “metrology layers” for metrology jobs
- Additional algorithms for contour detection
 - New approach for “raw” contour (same fine detection and metrology)
 - More flexible (no ROI, multiple features), faster, more robust
- True contour-based analysis and Layout comparison
 - Detection and analysis of arbitrary curvi-linear shapes
 - Comparison to layout or other references
 - Shift of reference points (corner, center)
 - Edge placement error EPE (complete shape or segments)
 - Area comparison, segments for corner or line, LER with arbitrary reference...



Routine process calibration

- Test pattern with density vs. dose
- Simple line CD measurement
- Finer variations for better data
- Auto scan/ measure 100's of images
- InSPEC provides SEM metrology results
- Export into csv file including layout data



The screenshot displays the InSPEC software interface. On the left, a grid of test patterns is visible, labeled "Chip Content 1 (in chip Chip 1)". The central area shows a workflow diagram with two main steps: "Collector 1" and "Export...ata 1". On the right, the "Metrology Settings (Export TRACER Data 1)" dialog box is open, showing various configuration options:

- Name:** Export TRACER Data 1
- Export As:** CSV file
- Export path:** TRACERtest_<chip_name>.csv
- Exposure Dose:** Base Dose ($\mu\text{C}/\text{cm}^2$) is set to 360.000. Automatic Dose (from Layout) is turned off.
- Dose Factor Steps:** Reference Dose Factor is 0.700, U Direction Step is 0.000, and V Direction Step is 0.050.
- Background Density:** Automatic Background Density is turned off. Manual Background Density Settings include Reference Background Density (%) at 0.000, U Direction Step (%) at 25, and V Direction Step (%) at 0.
- Target CD:** Enable Custom Target CD is turned off, and Target CD is set to 200.000 nm.

The InSPEC logo is visible in the bottom right corner of the software interface.

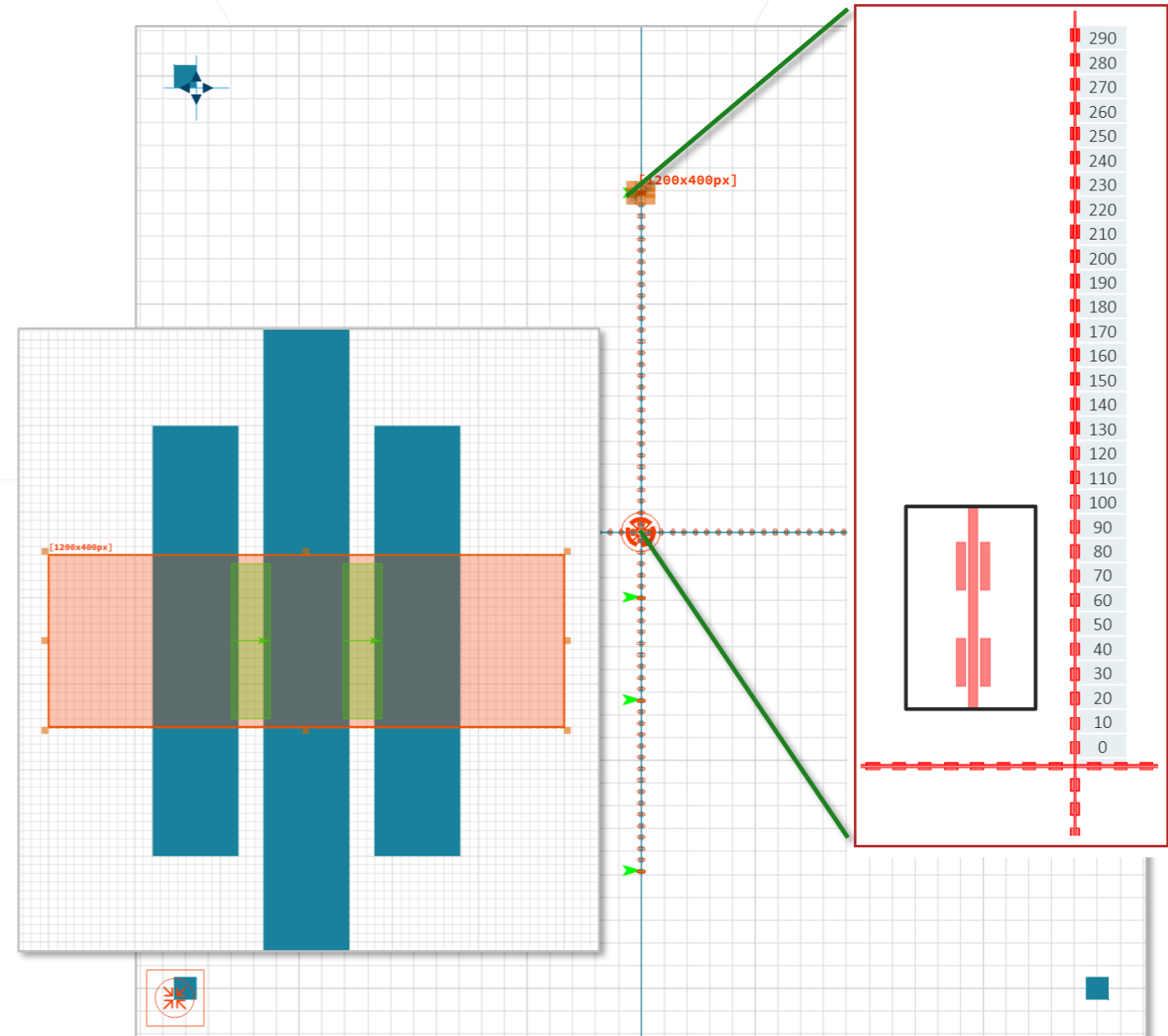
Routine process calibration

- Test pattern with density vs. dose
- Simple line CD measurement
- Finer variations for better data
- Auto scan/ measure 100's of images
- InSPEC provides SEM metrology results
- Export into csv file including layout data
- Seamless integration with TRACER

→ *Minimum manual effort for process calibration and monitoring*



- Metal electrode gaps
 - Gap distance is crucial for device performance
 - Employ metrology to tune gap
- Optimization for different dimensions
 - 4x60 gaps across 1 mm write field
 - Investigate doses and exposure strategies
 - Check multiple chips across wafer



- Metal electrode gaps

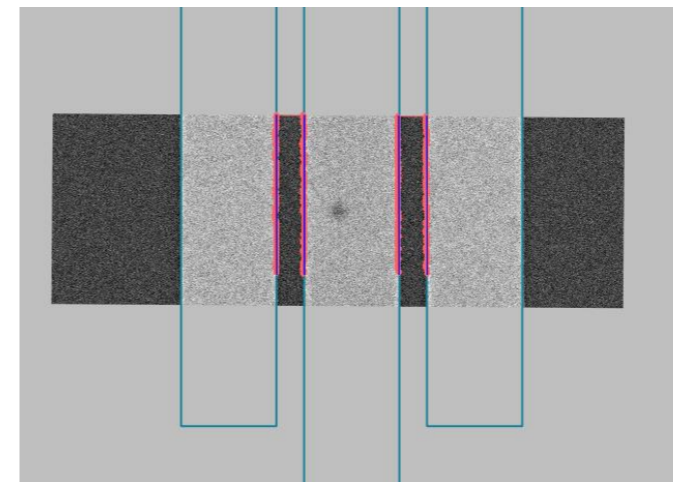
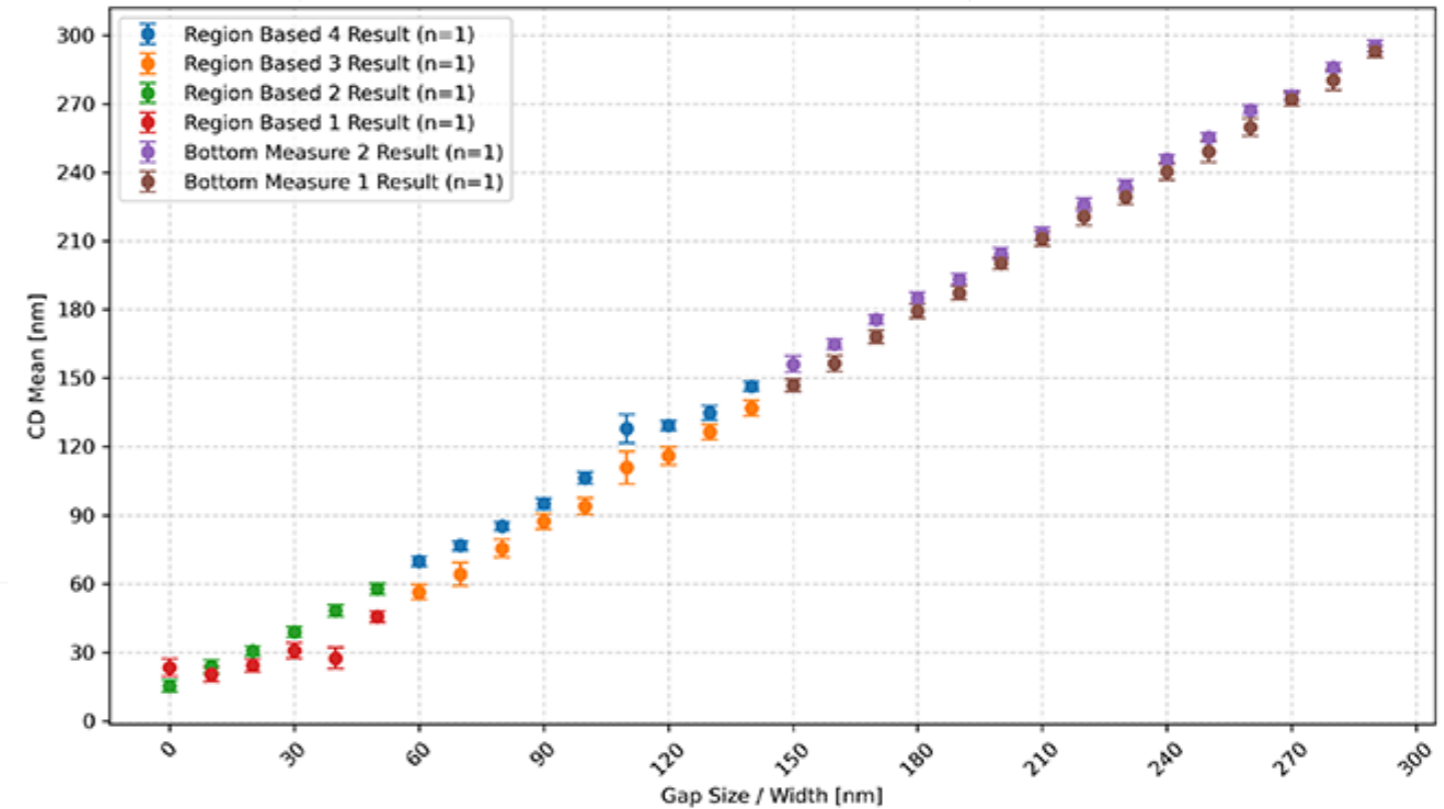
- Gap distance is crucial for device performance
- Employ metrology to tune gap
- Optimization for different dimensions
- 4x60 gaps across 1 mm write field
- Investigate doses and exposure strategies
- Check across wafer

→ Measurements down to ~20 nm gaps

→ Limited by residues

→ Method and parameter optimization

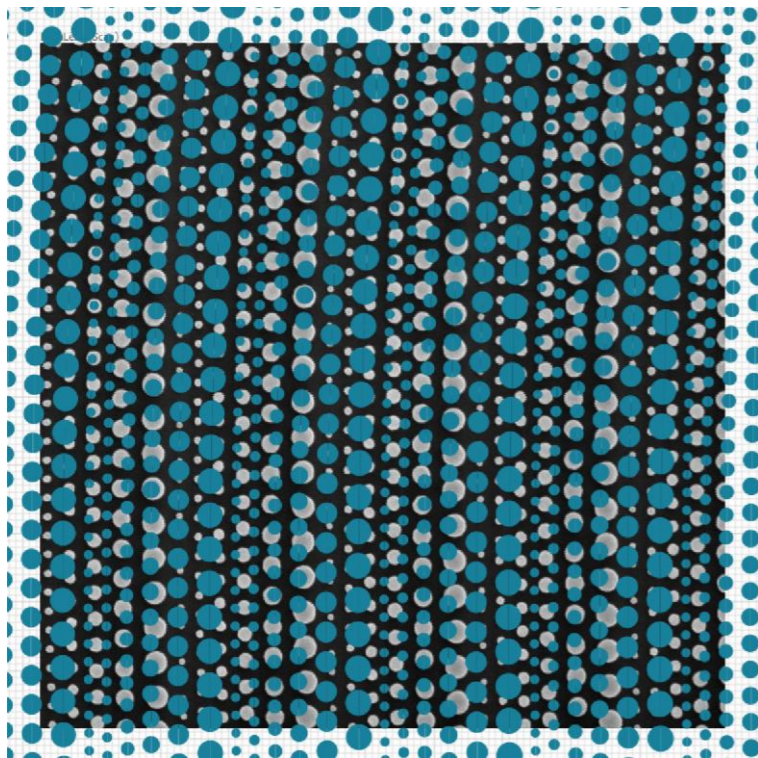
Optimization of Critical Device CD



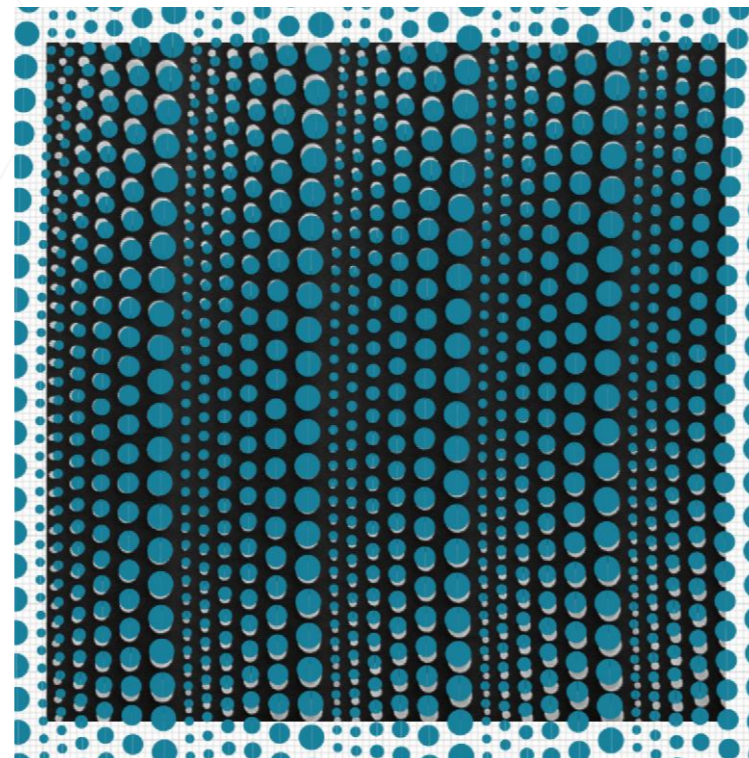
Layout comparison

- Compare contours to target design
- Analysis for different shapes types
- Use for bias analysis (CD, density)

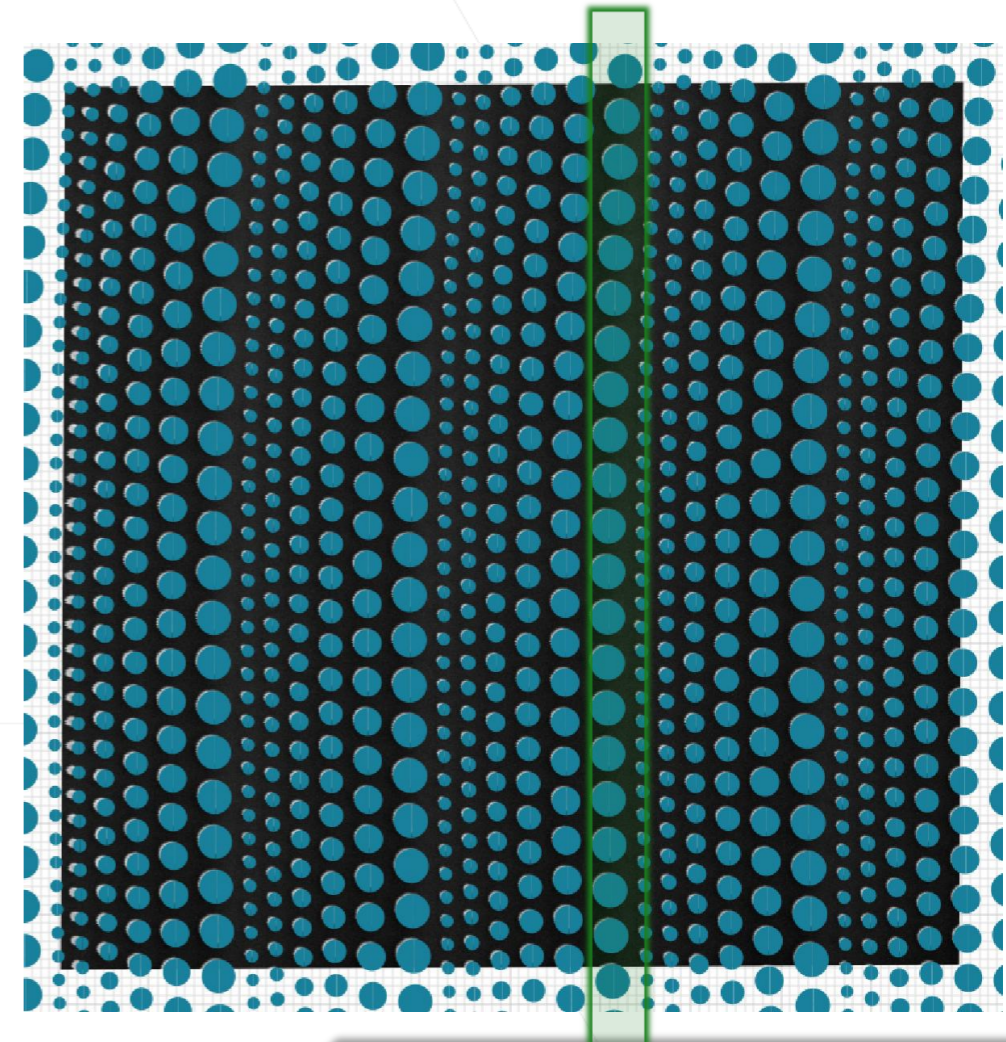
→ Image-to-layout matching is crucial



No correction

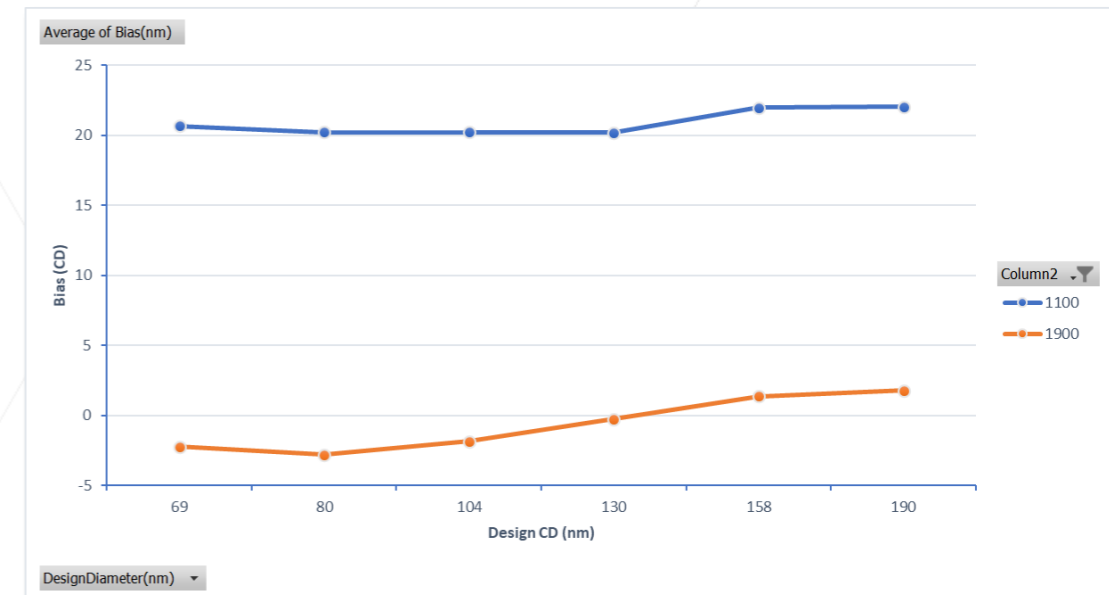
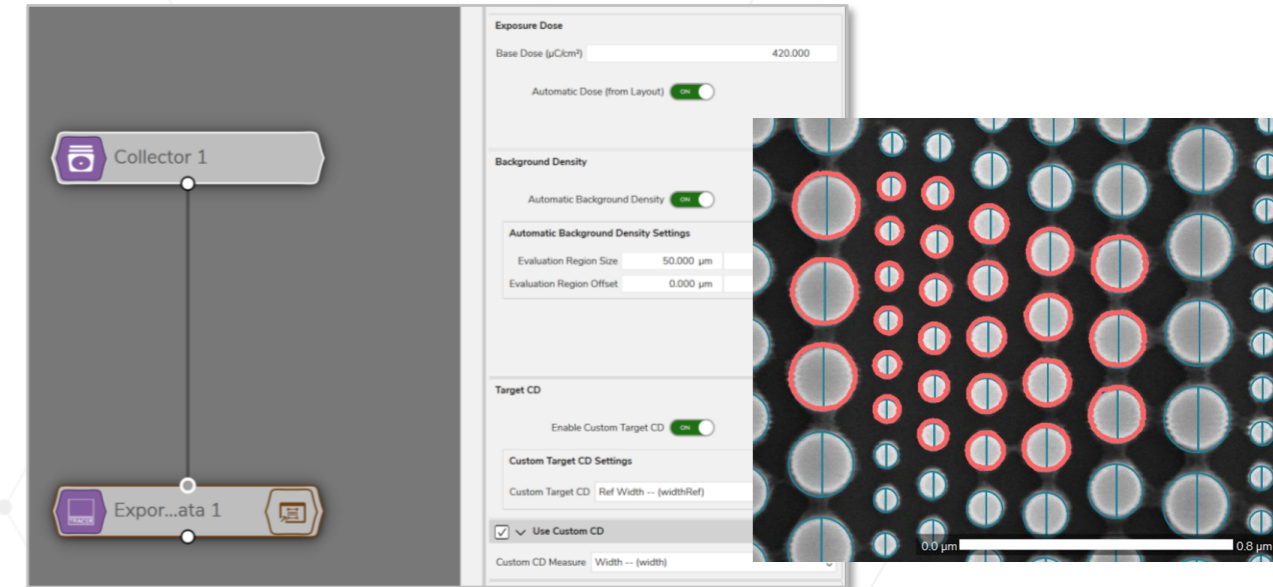


X-Y shift only

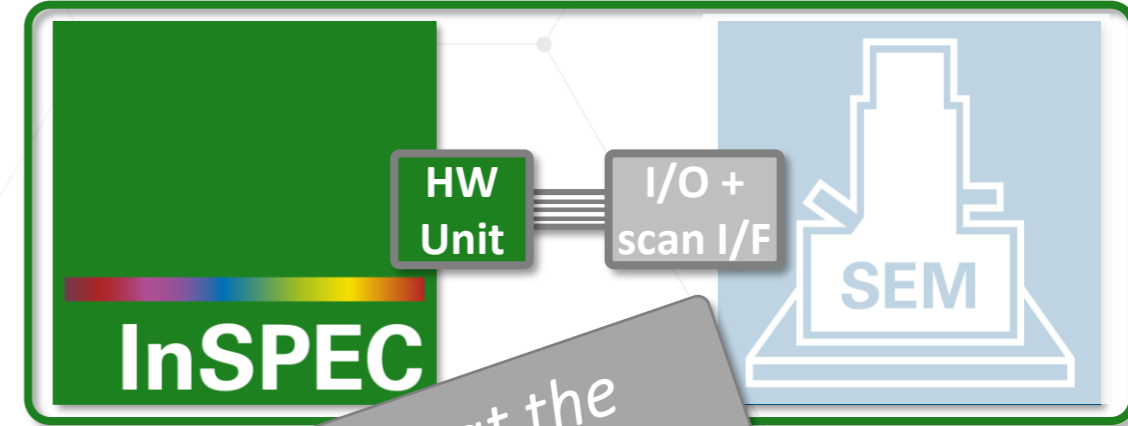
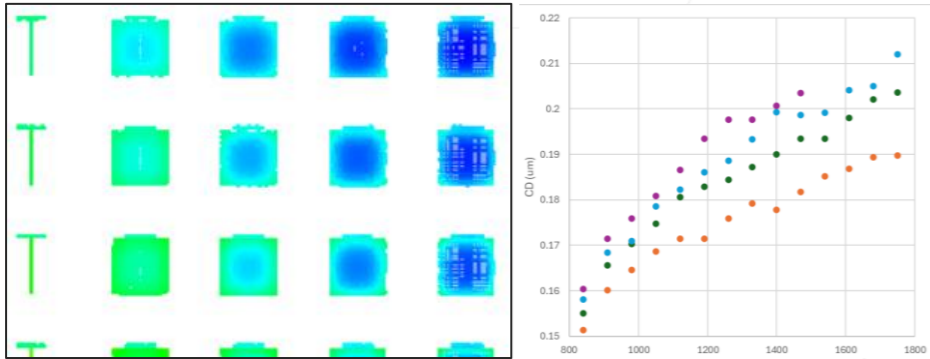


Contour and layout measurement

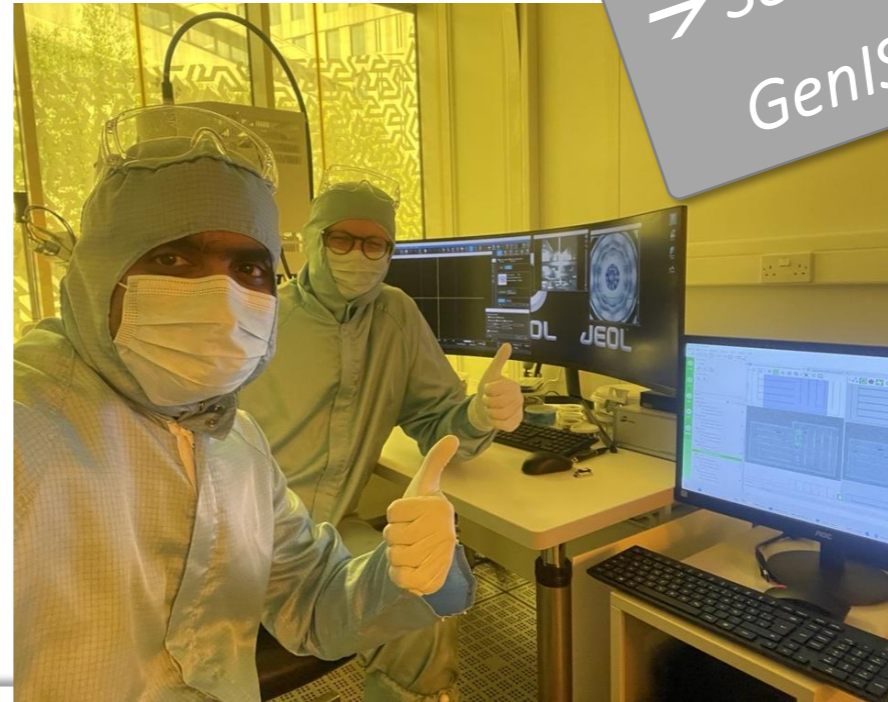
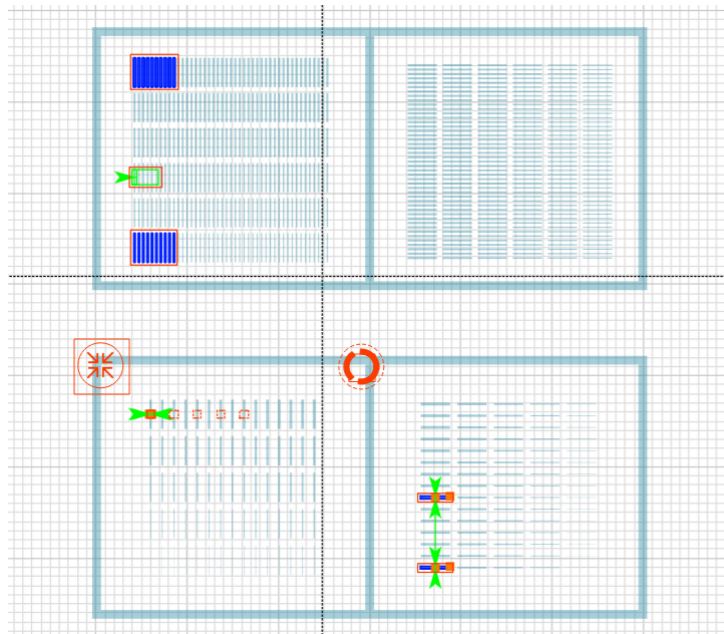
- Extract SEM contours and measure “CD”
- Analysis of (any) layout parameters
 - Dose, density, and “CD”
- Automatically identify corresponding features/ layout elements
- Export file with key parameter
- Calculate direct comparison → bias



- Measurements for Process Calibration



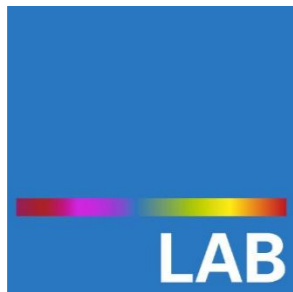
- Multi-Chip Metrology Job



→ See Us at the GenISys Booth!

Thank You!

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