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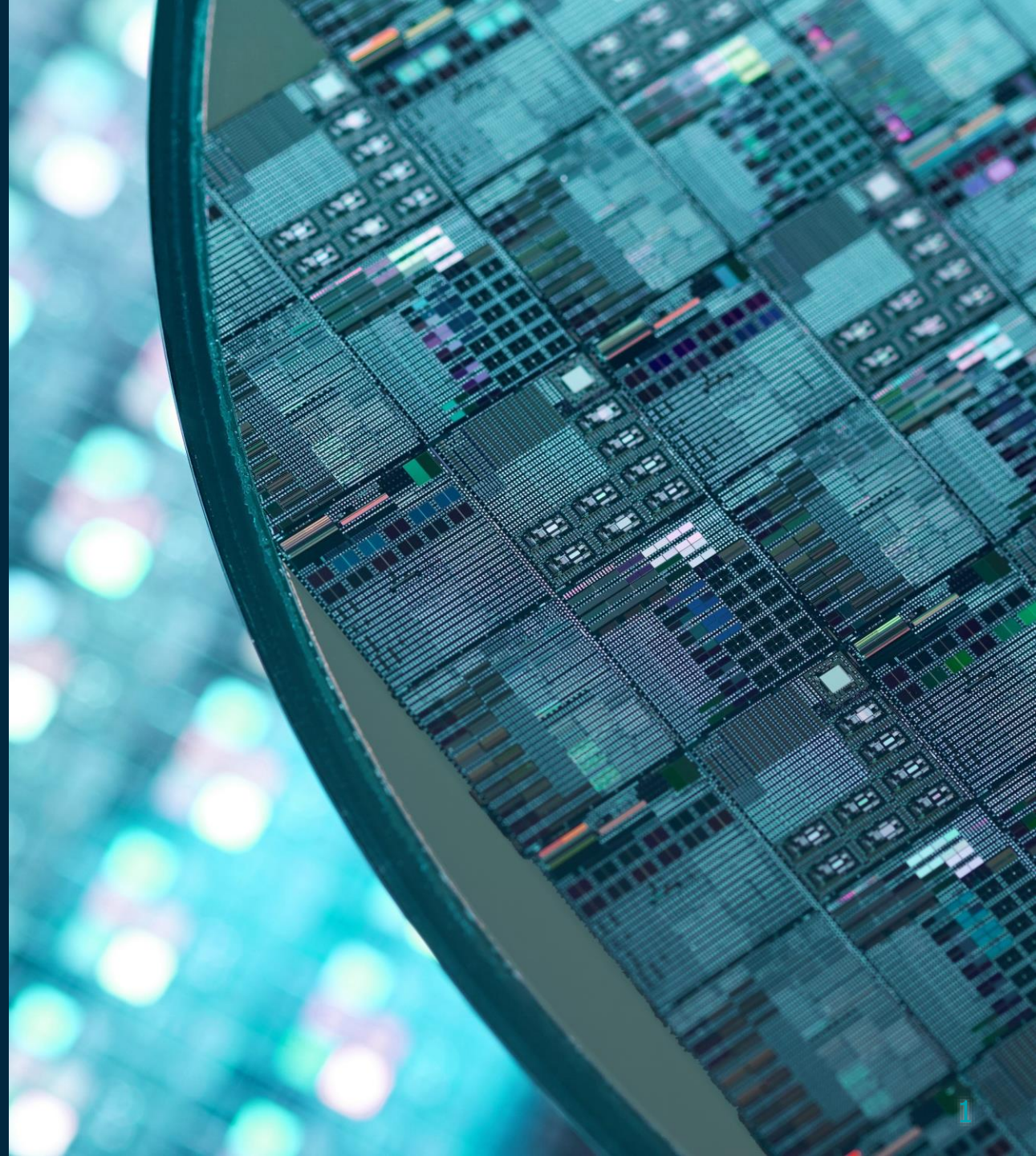
A guide to full autonomous operation using MLTRL calibration on and off the wafer

TMA13

Gavin Fisher



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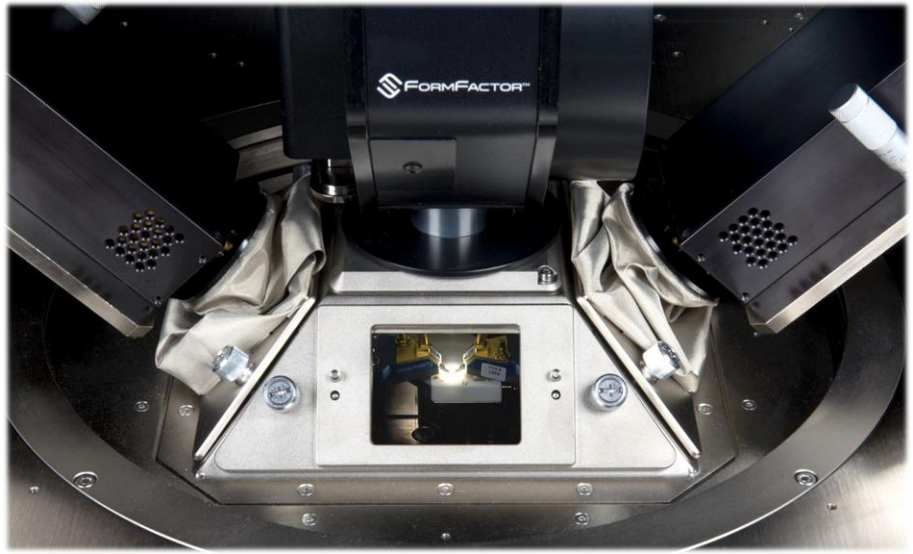
What is Autonomous RF?

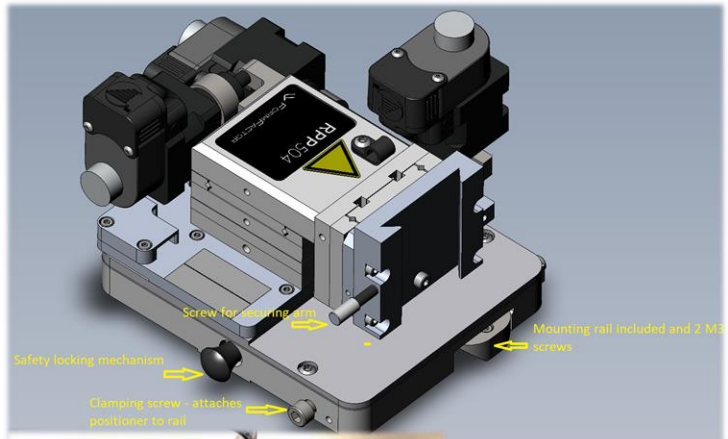


- Autonomous RF system allows all aspects of on wafer RF test and calibration beyond initial setup to be carried out <u>without</u> human intervention
- Involves the intelligent use of
  - Motorised positioners to adjust probe spacing
  - Pattern recognition to find probes and wafer
  - Auto focusing evue microscope to gain Z position data
  - WinCalXE™ calibration software
  - Velox software

What's needed?

The solutions includes:

- **RPP 504** motorized positioners (Minimum of 1) and platen adaptors for Summit 12k
- **Application specific RFA Arm** - 67 GHz Coax, N5291A 130 GHz coax, VDI Waveguide using Infinity or DMPI probes
- **MPX or ECX box** used to drive positioners – either type now with any station (Velox 3.3)
- **eVue** Vision system (handles all the necessary pattern recognition and focus scans)
- **Velox 3.x with Auto RF** software license required for full automation
- **WinCalXE** 4.8 or higher



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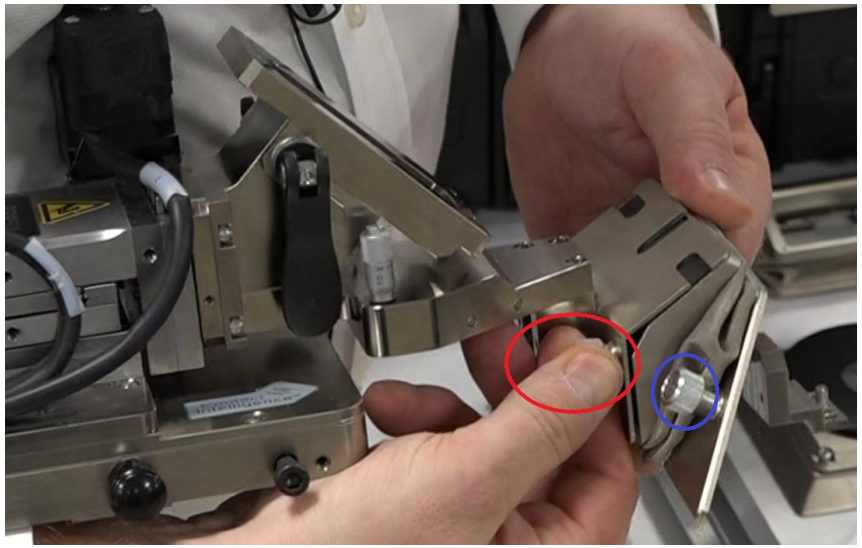
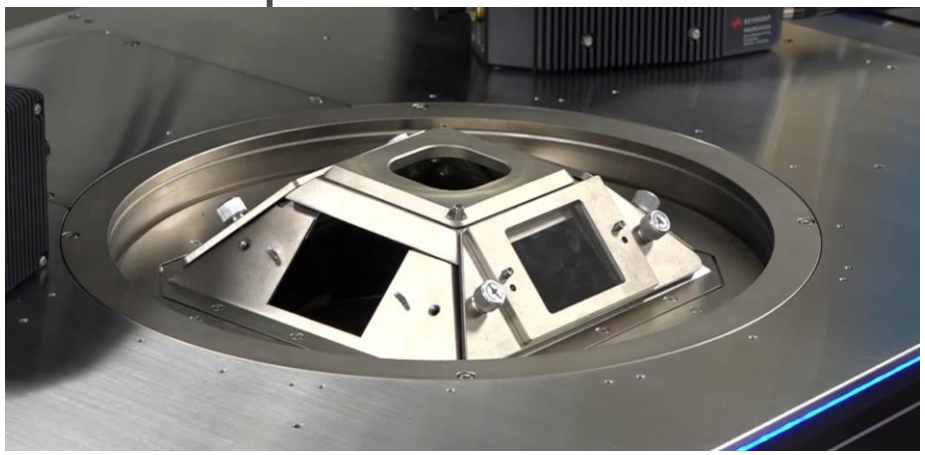
What's needed – Shielded system?

- FlexShield™ boot kit - allows frictionless probe motion in TopHat
- RF Tophat - for flexshield if dry/ dark / shielded is required and application above 67 GHz
- Sub67 use only needs regular 8 sided tophat

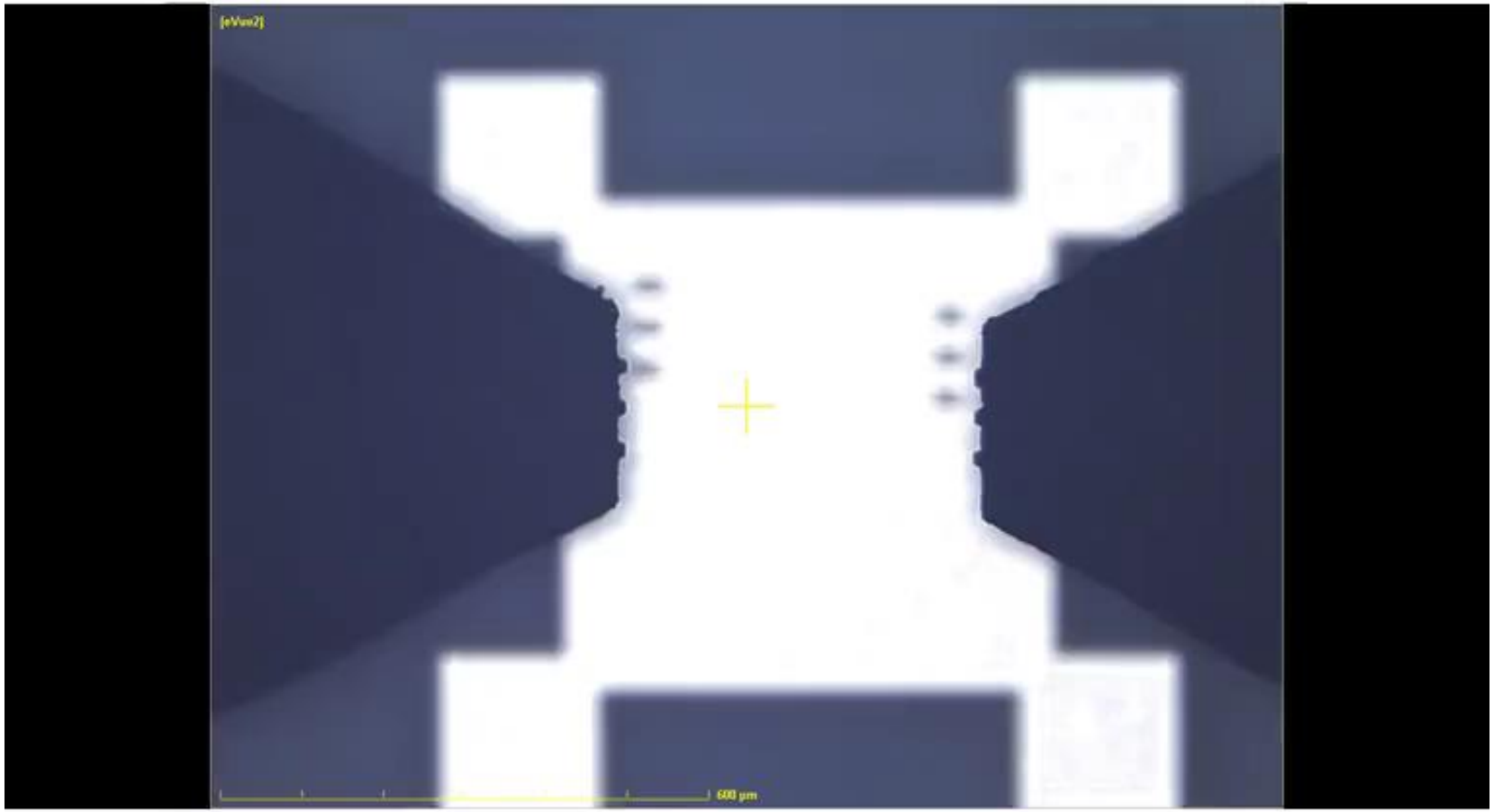




Pain points – Probe Expansion

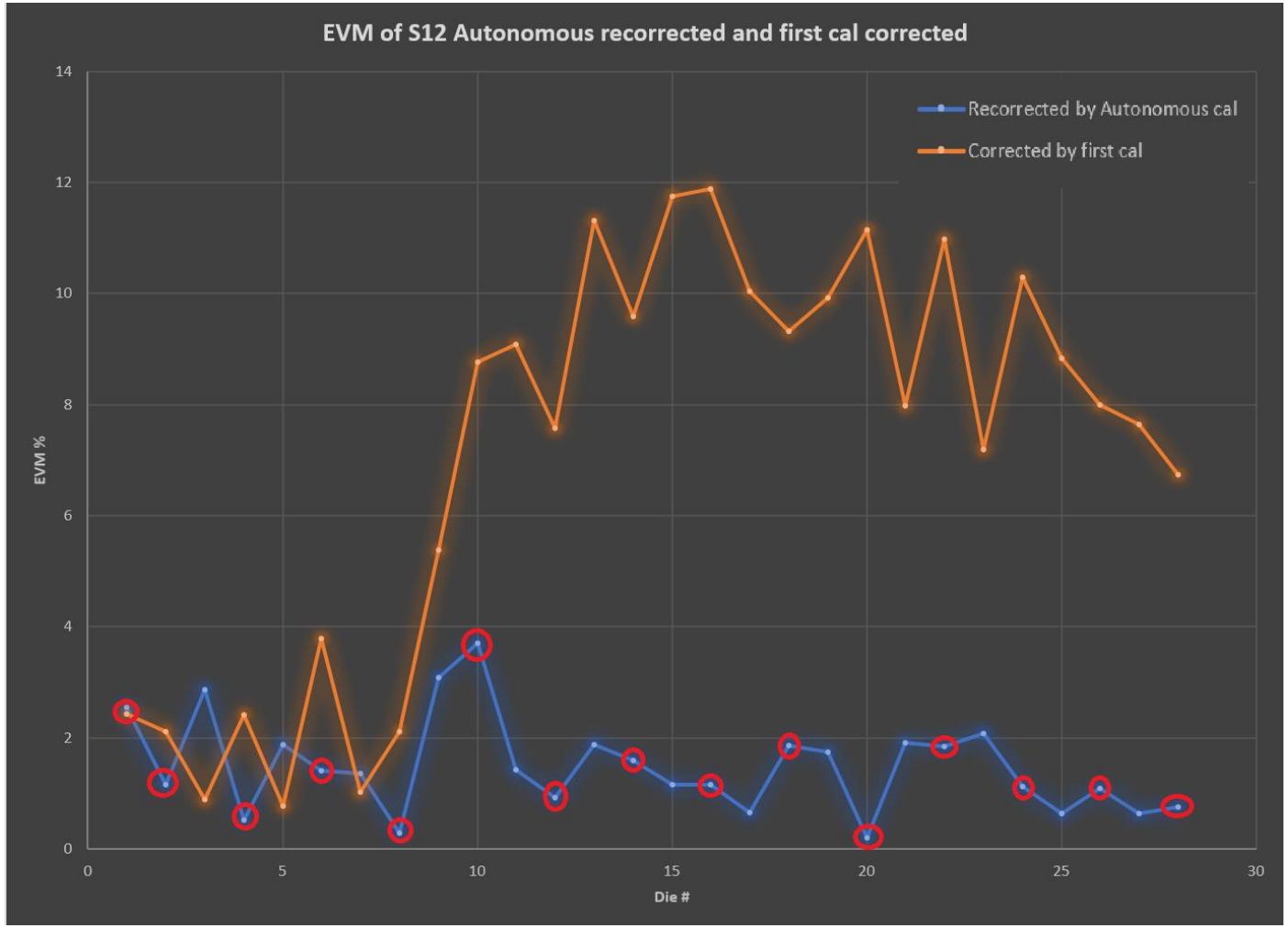
- Probes grow / retract with temperature in X and Z
- Some movement in Y but comparatively minimal
- For significant thermal changes evaluate theta also
- Chuck expands in XYZ as a function of displacement from centre and also shifts axially

Pain points - Probe expansion from Ambient to 125 degree Summit 12k (video)



- Probes grow as temperature goes from 25 to 125 and then shrink going to 25

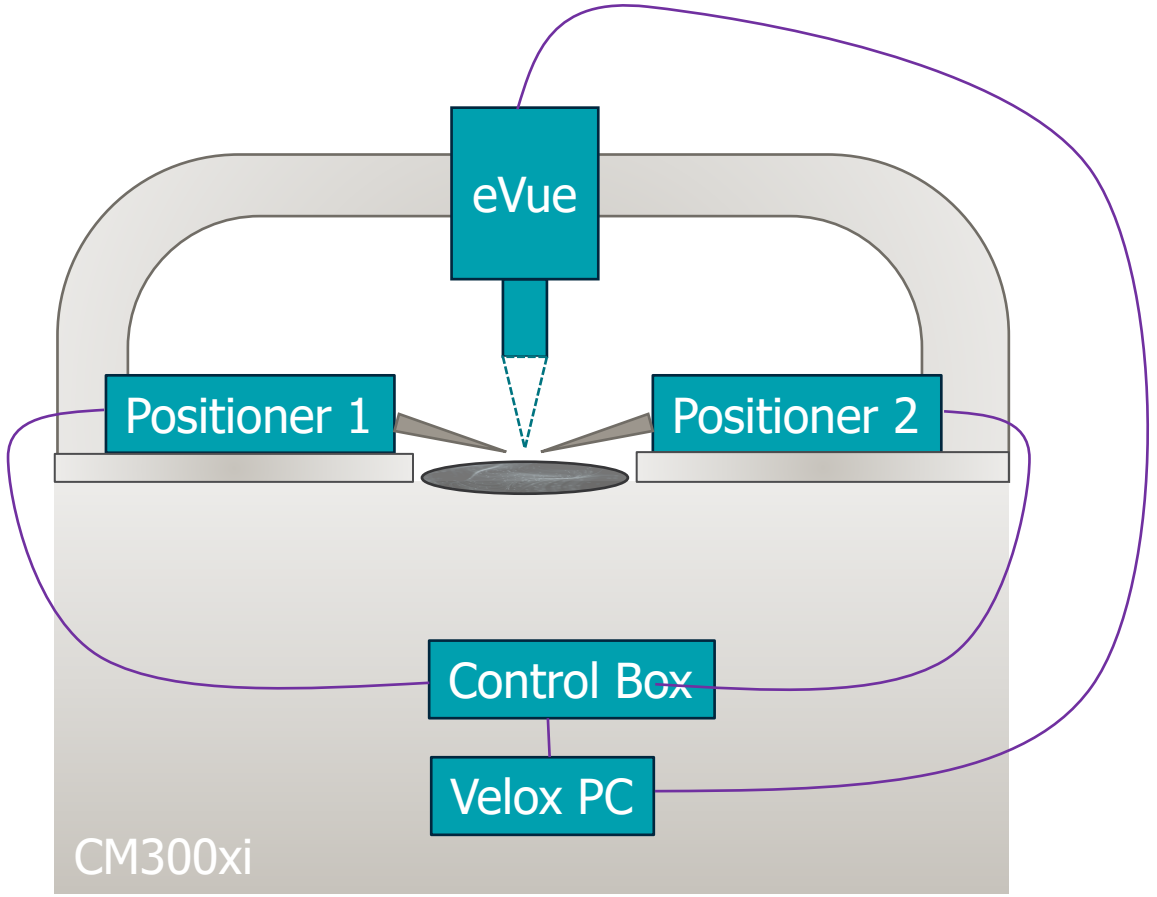
Pain points – Drift means recalibration



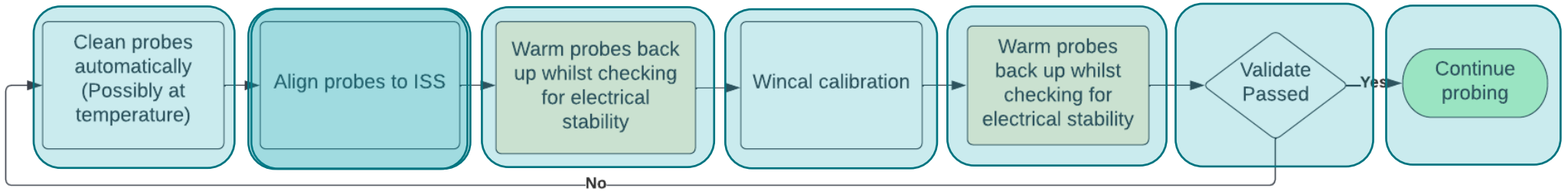
- Blue delta is using Autonomous
- Orange is same measurements but using original cal (system drifted as probe temperature changes)

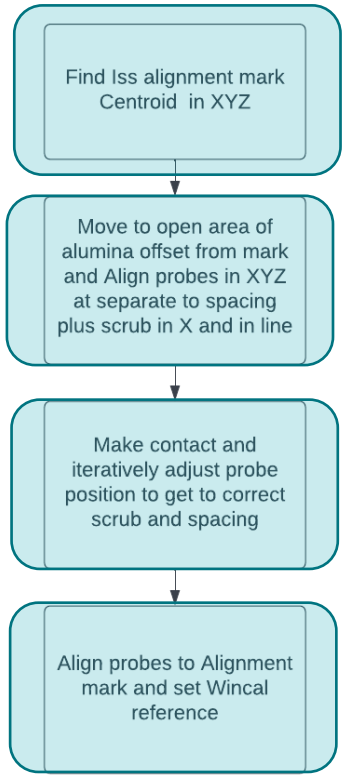
How does Autonomous RF Work – Die stepping

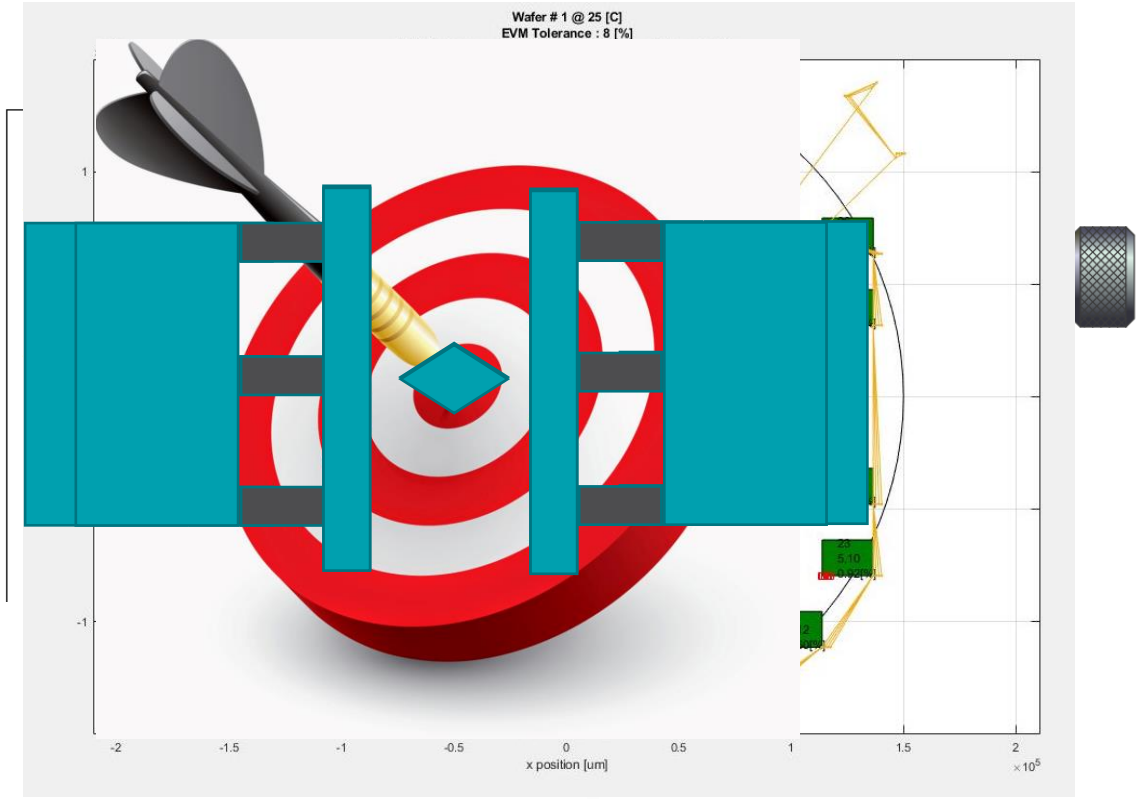
- Probes are setup manually by user on a home device with appropriate placement and scrub (ideally using optical align markers)
- Velox vision system training learns the probe XYZ position
- When automating, Velox reproduces original trained geometry moving positioners and chuck until tolerance reached during each alignment cycle
- Autonomous RF difference from DC autonation (Vuetrack pro) is addition of Monitor step to see if cal is valid still….If not a recalibration is triggered



How does Autonomous RF Work – Calibration

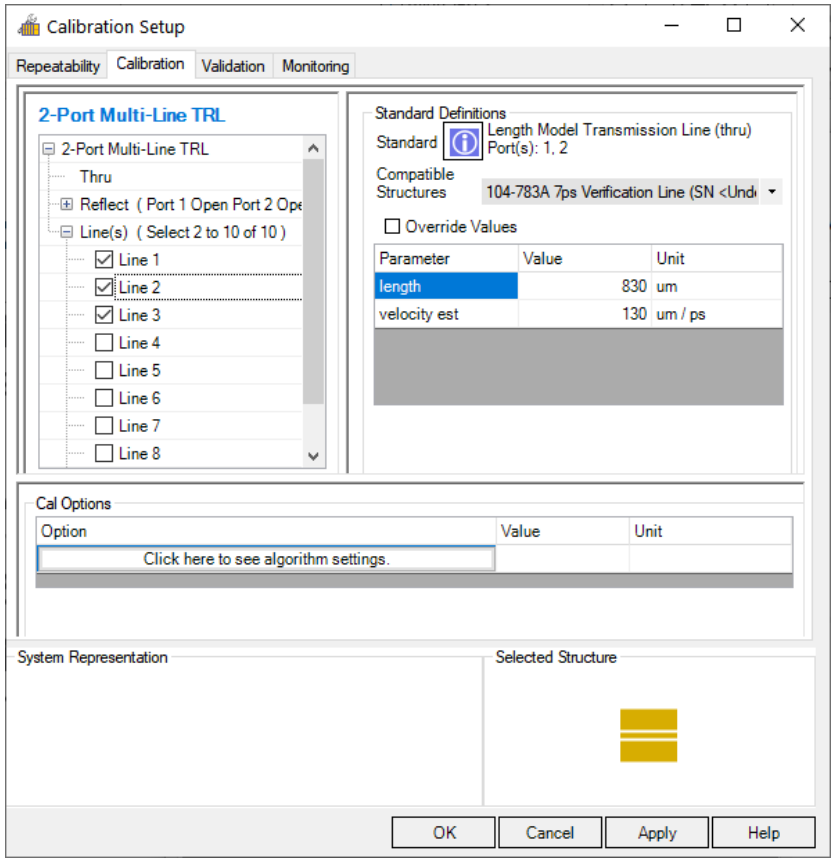


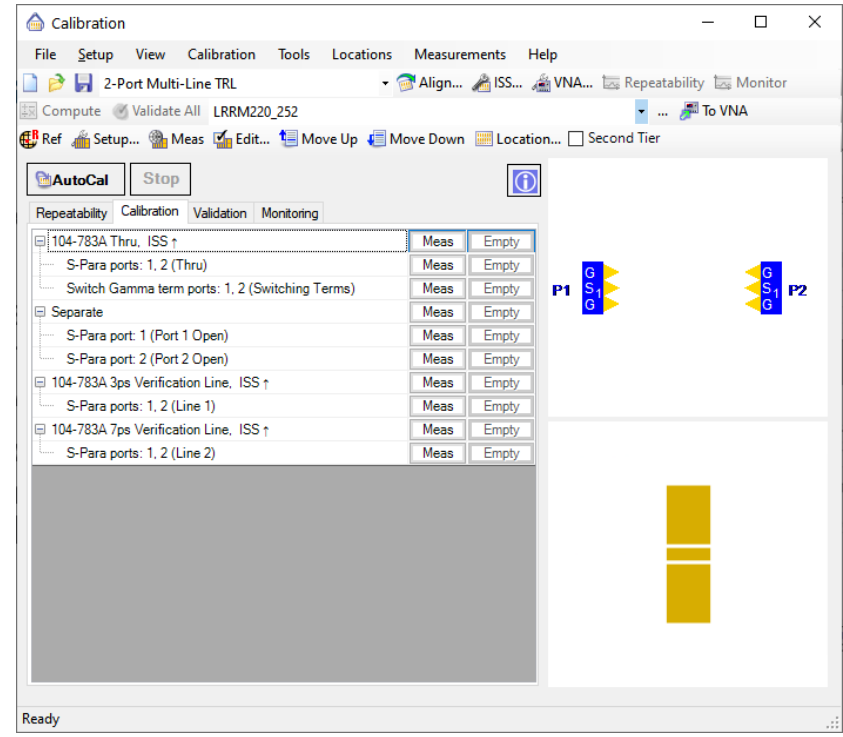




How to setup for MLTRL in WinCal on an Auxiliary site

- MLTRL with autonomous using an ISS is purely an extension of standard LRRM approach
- Autonomous finds correct spacing at the alignment mark but any ISS cal substrate or calibration approach will work
- If ISS is known to WinCal then all probe and chuck moves in an autocal performed automatically by WinCal





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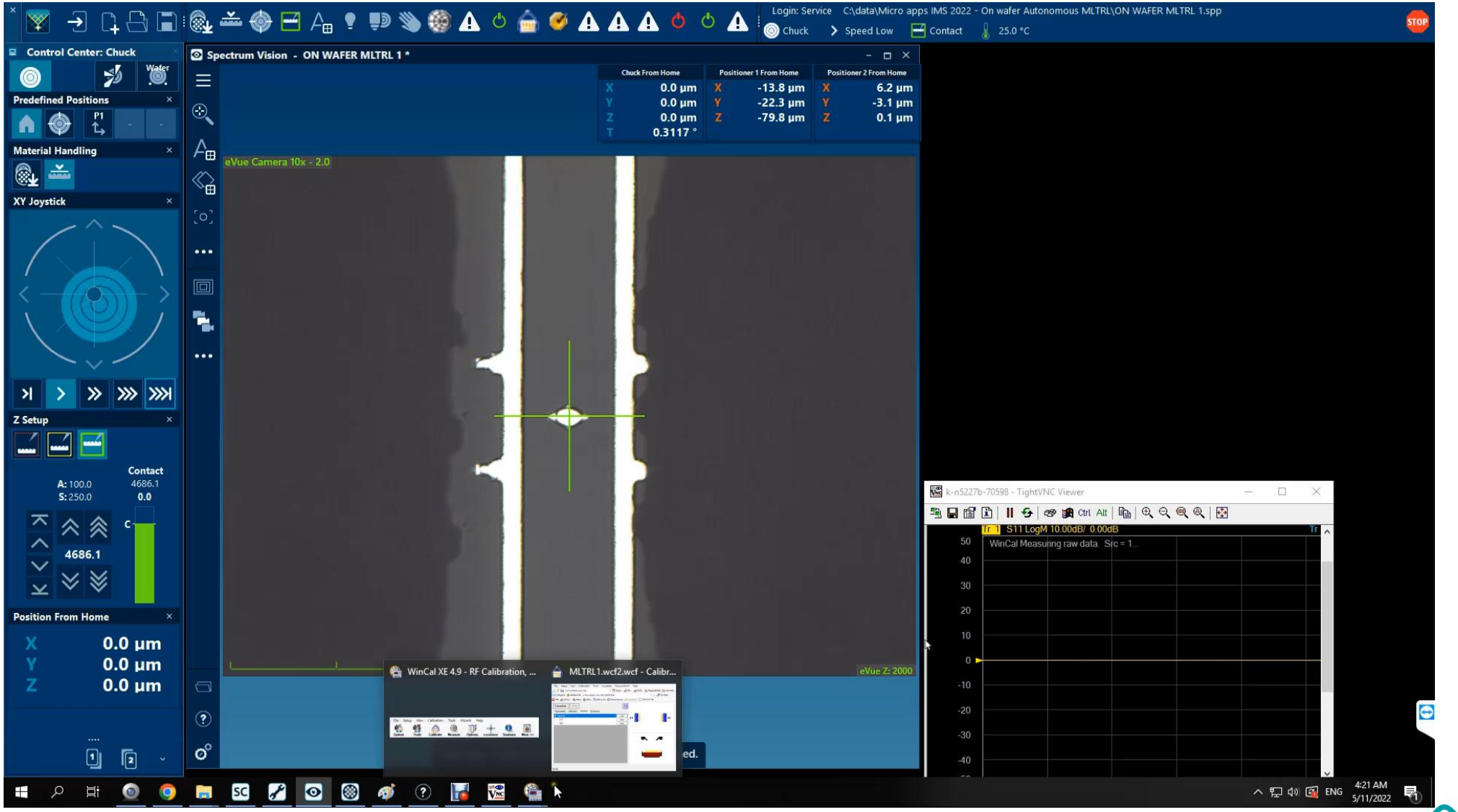
Video – Setting up autonomous for MLTRL using ISS



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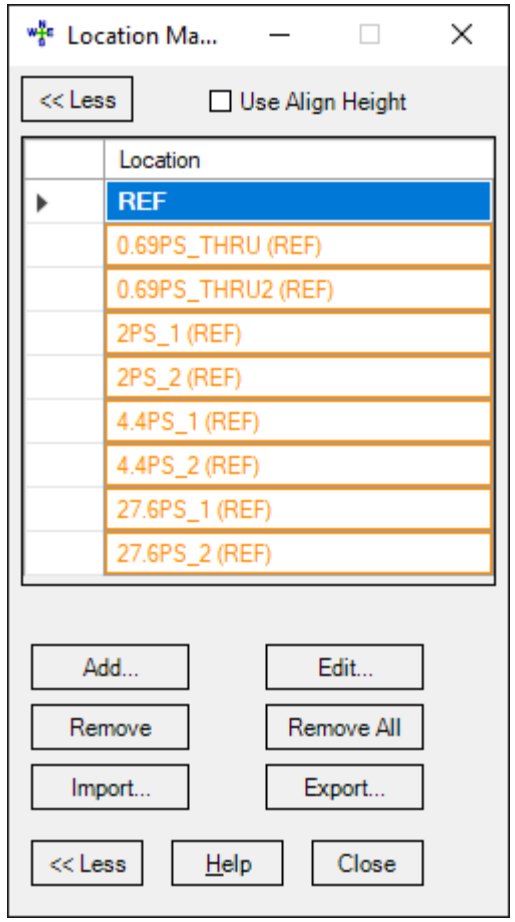
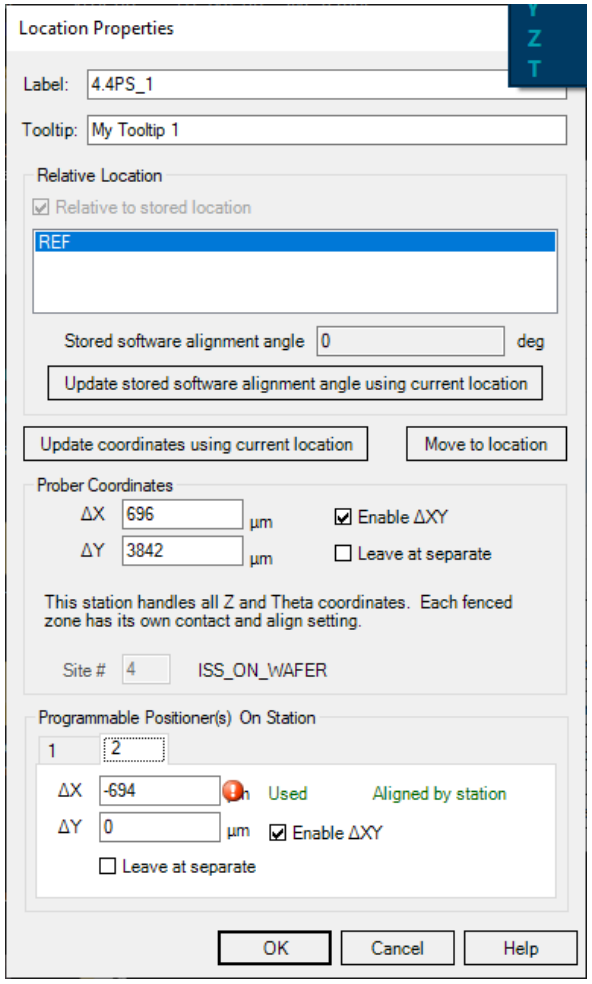
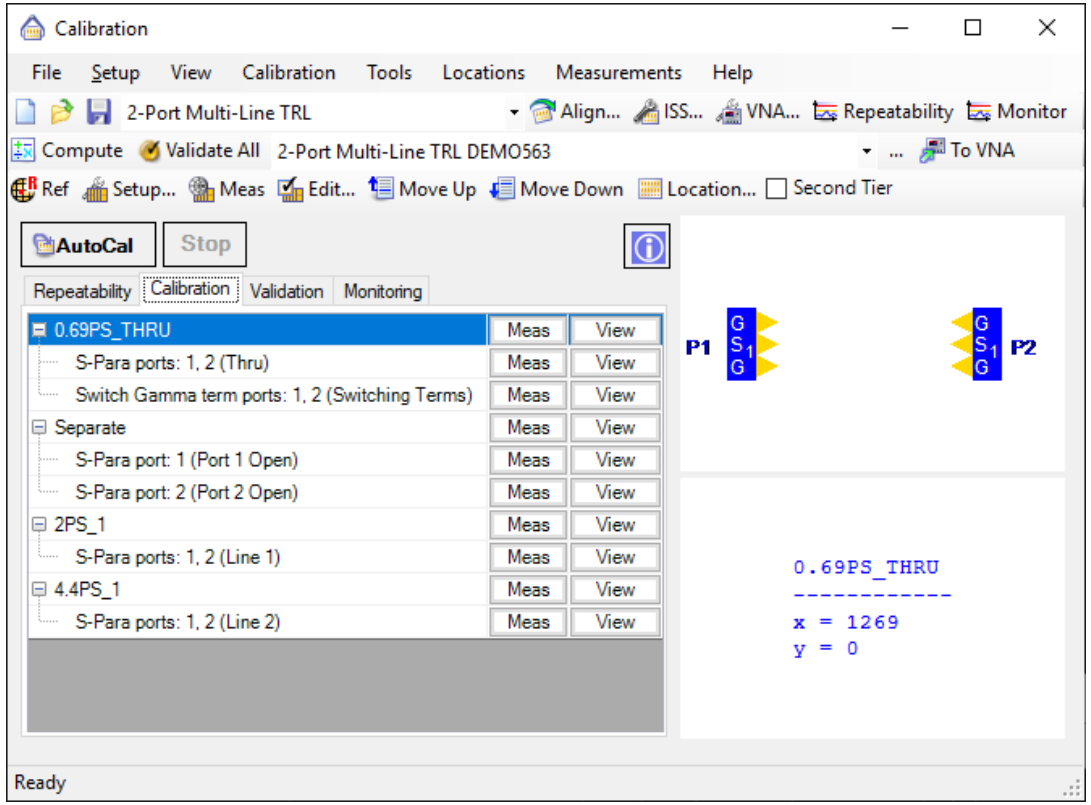
MLTRL Using location manager

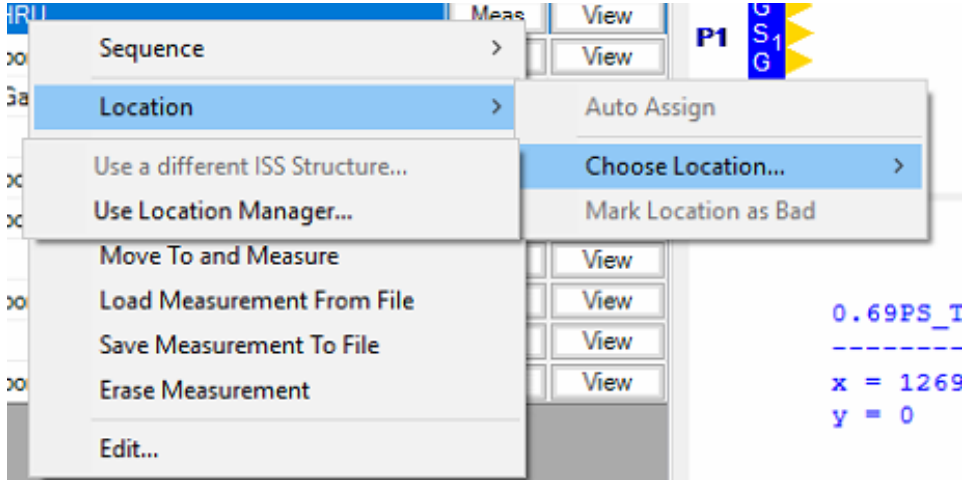




- Location manager is one of the simplest and safest means within WinCal to define custom standard arrangement
- Each location has its own chuck and positioner location
- Locations can be used for calibration OR for custom device measurements in test executive

Setup of MLTRL using custom locations





- Calibration measurements point to the appropriate location from location manager
- Its also possible to create a custom ISS in the same way as Formfactor do but this is a little time consuming but good for greater flexibility

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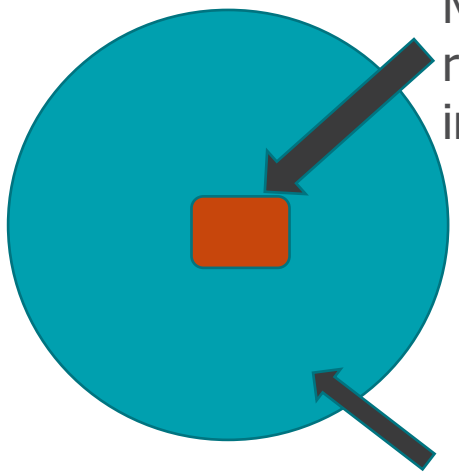
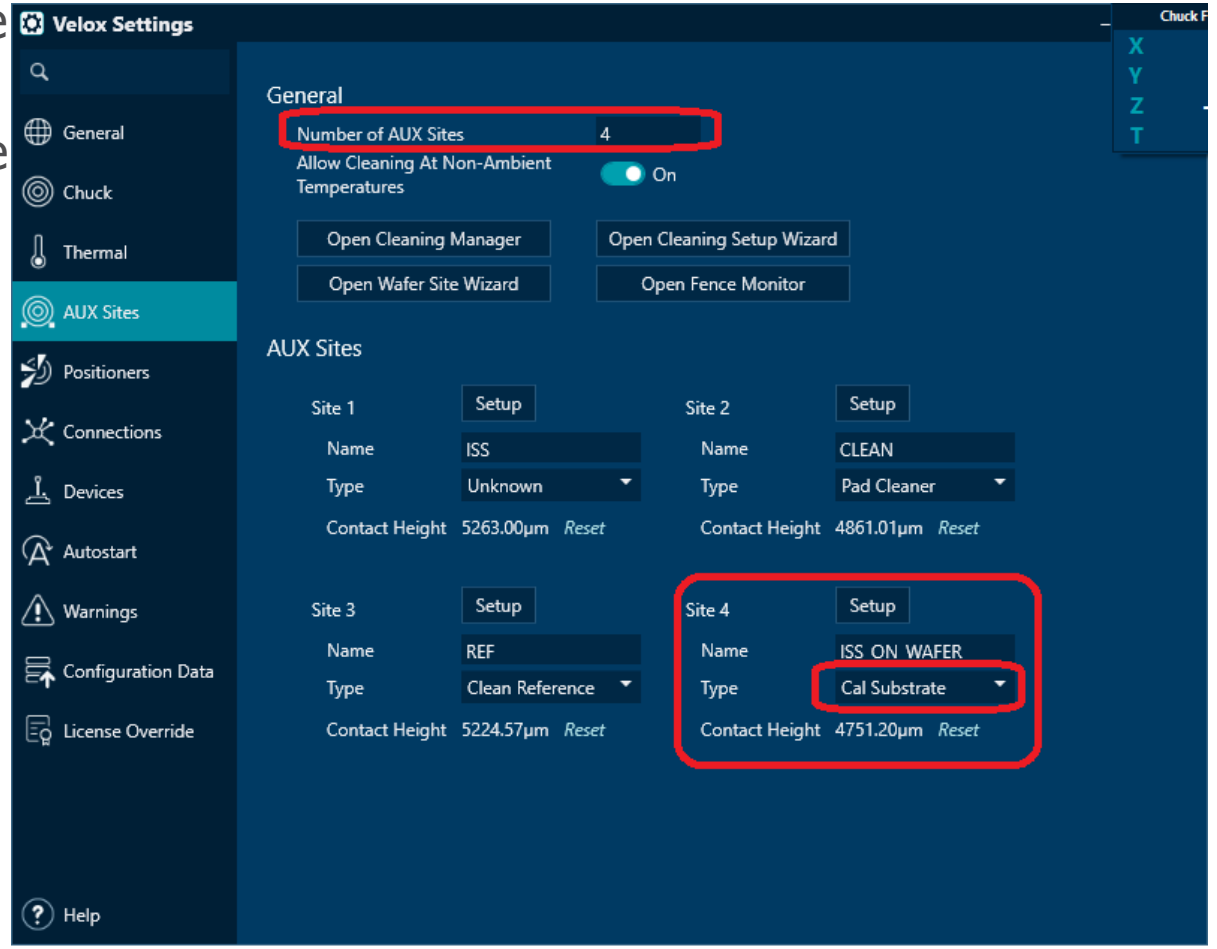
Autonomous MLTRL On the wafer

- Autonomous system expects the ISS to be on a separate auxiliary chuck from the wafer
- However its possible for an auxiliary chuck to actually be a region of the main wafer chuck
- To add a site increase the Aux chuck count by 1, restart Velox and then follow the auxiliary chuck setup wizard
- ONLY the new Aux site should be the Cal substrate
- Each aux site has independent theta, home and Z contact

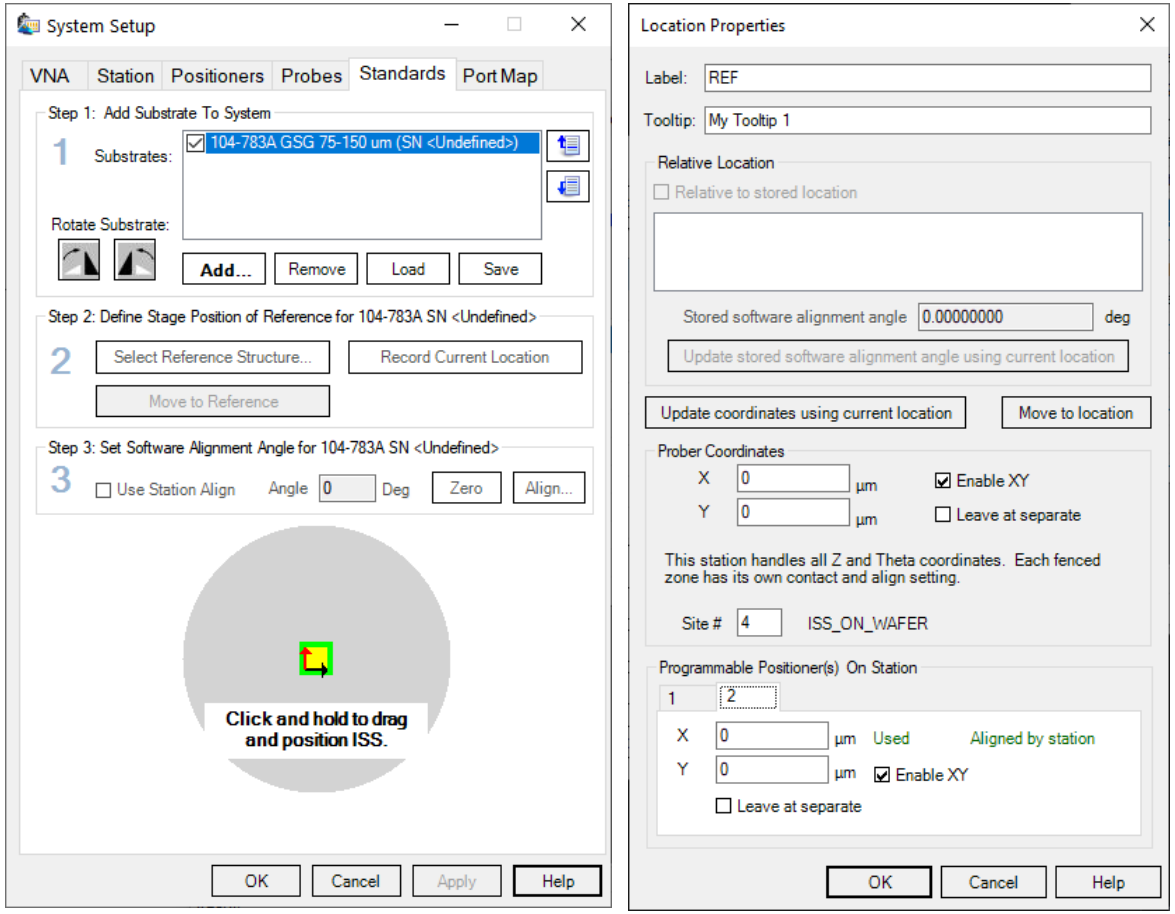


Aux site where the MLTRL standards reside – Aux site 4 in this case

Main wafer chuck – Aux site 0

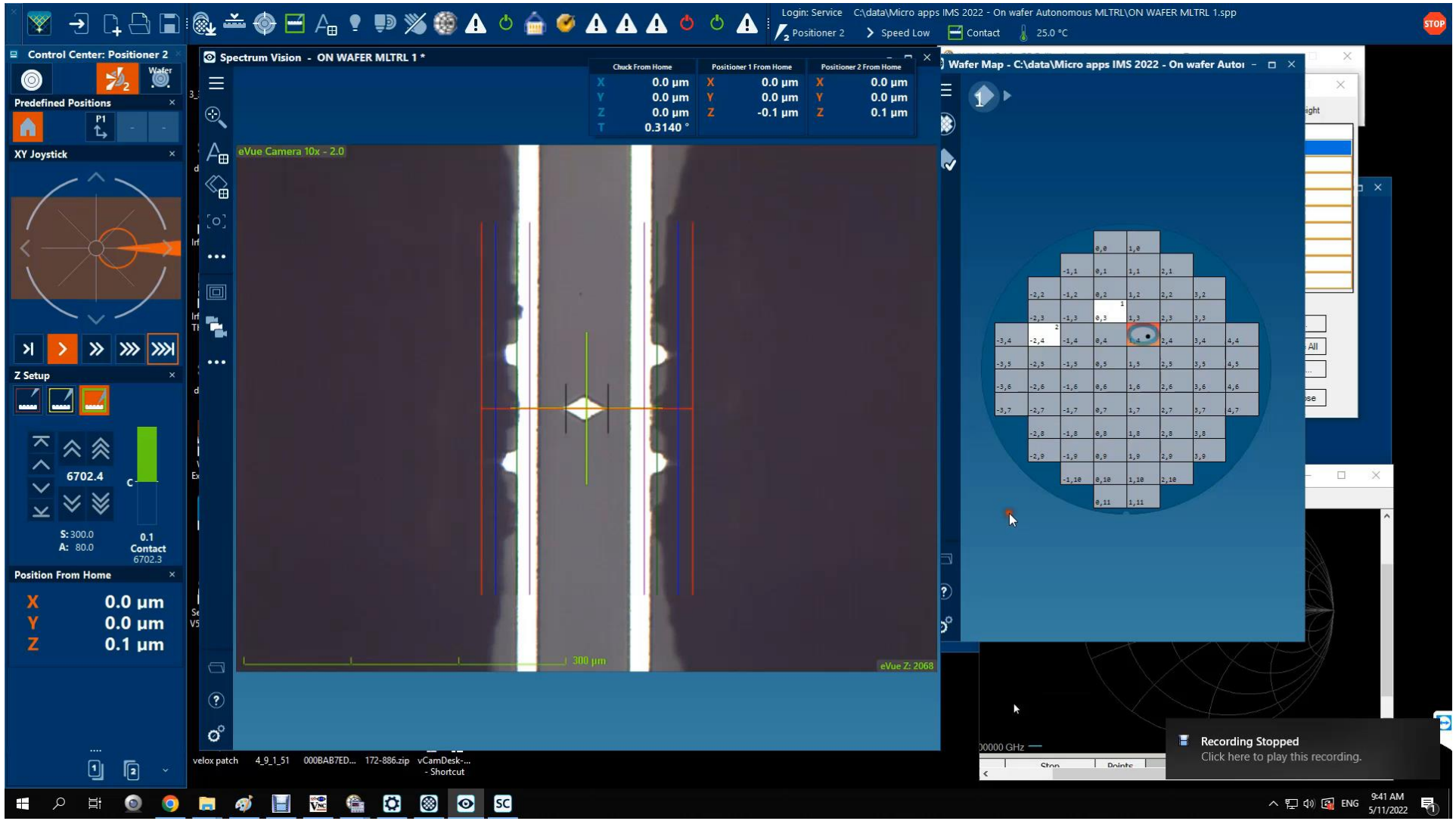


Autonomous MLTRL On the wafer



- Autonomous expects a regular iss on an aux site
- One (any type) must be specified kind of as a placeholder and its reference set to virtual aux site home position
- Reference site for location manager is set as home also (ie iss home and location manager home are the same place)
- Autonomous is trained as normal and automation functions properly
- If different line set are needed due to wear a separate cal wcf file can be created that references the different locations which would be opened by test exec on demand

Training Autonomous on the wafer



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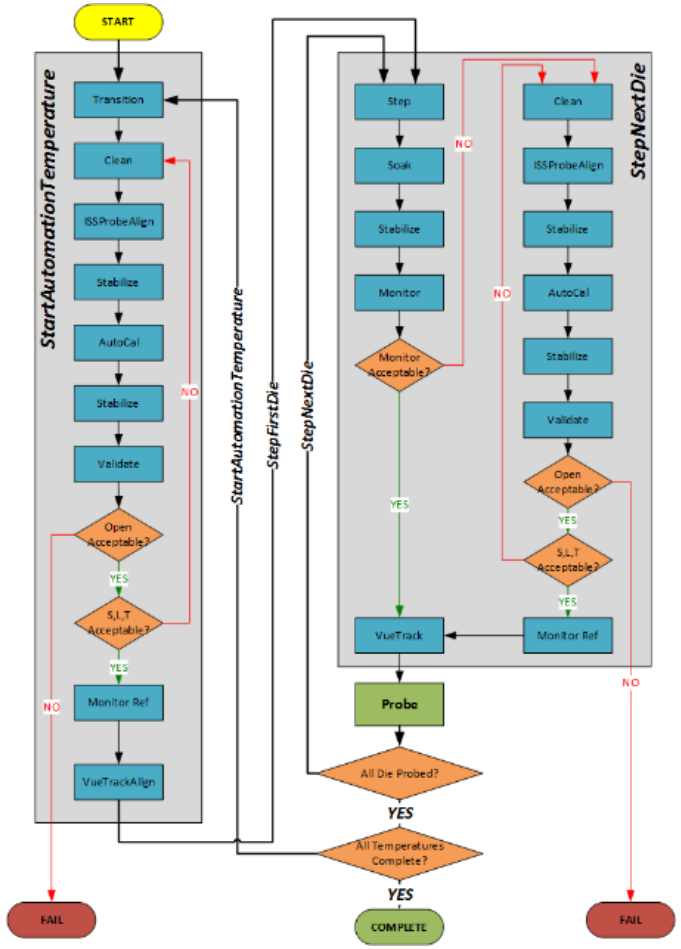
Integrating Automation assistant into test executive

- **StartAutomationTemperature X** does all this…
  - Changes temperature and maintains probe to probe, and probe to wafer geometry at Separate
  - Die soak at end of transition at align height always maintaining geometry
  - Checks using VNA to test for electrical stability
  - Moves bias probes out of field of view
  - Aligns probes at ISS using defined spacings
  - Re-checks stability to ensure probes didn't cool down
  - Calibrates system
  - Verifies
  - Takes monitoring data to check system is stable later on
  - Returns probes to wafer Geometry ready for test
  - Additional options of this command performs Theta align and sizing
  - This command would already be used by Vuetrack customers although typically they typically don't do RF



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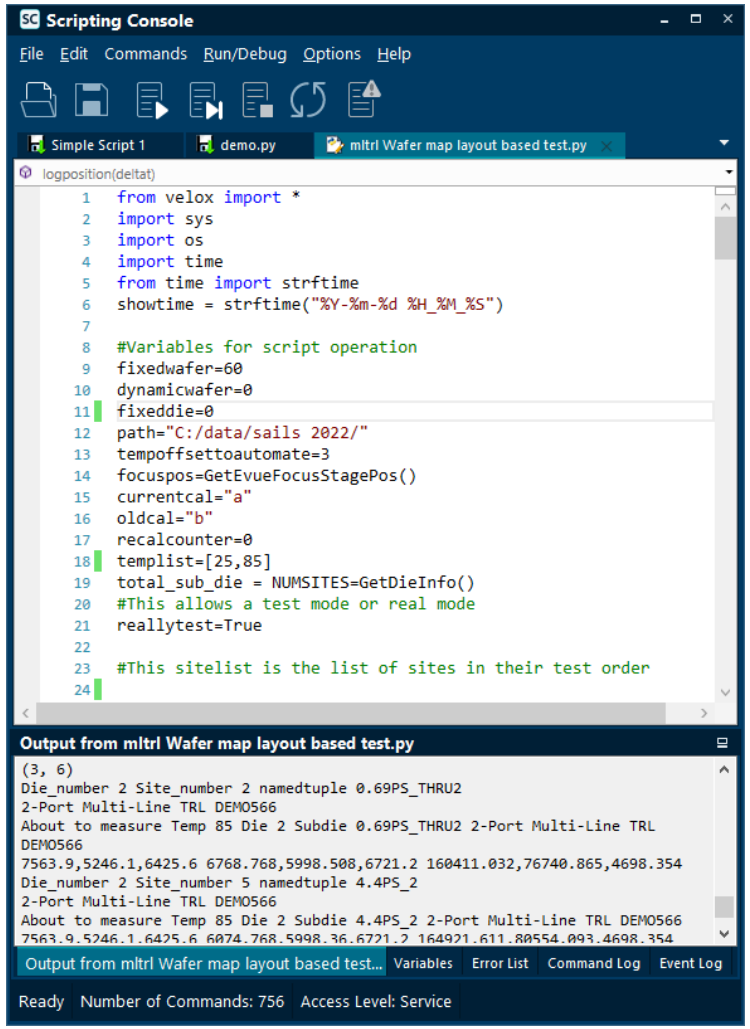
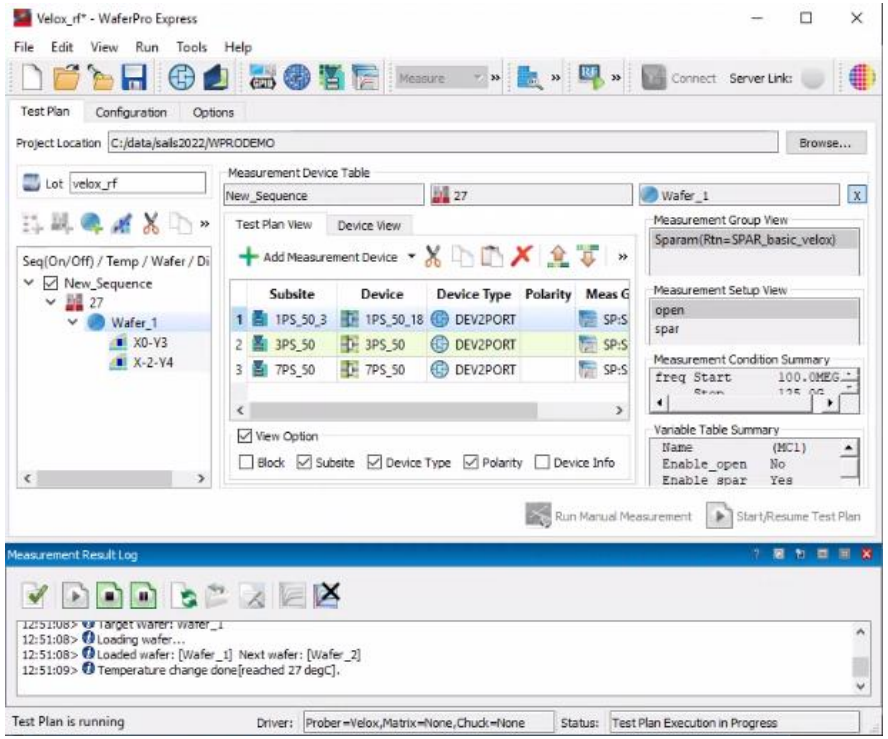
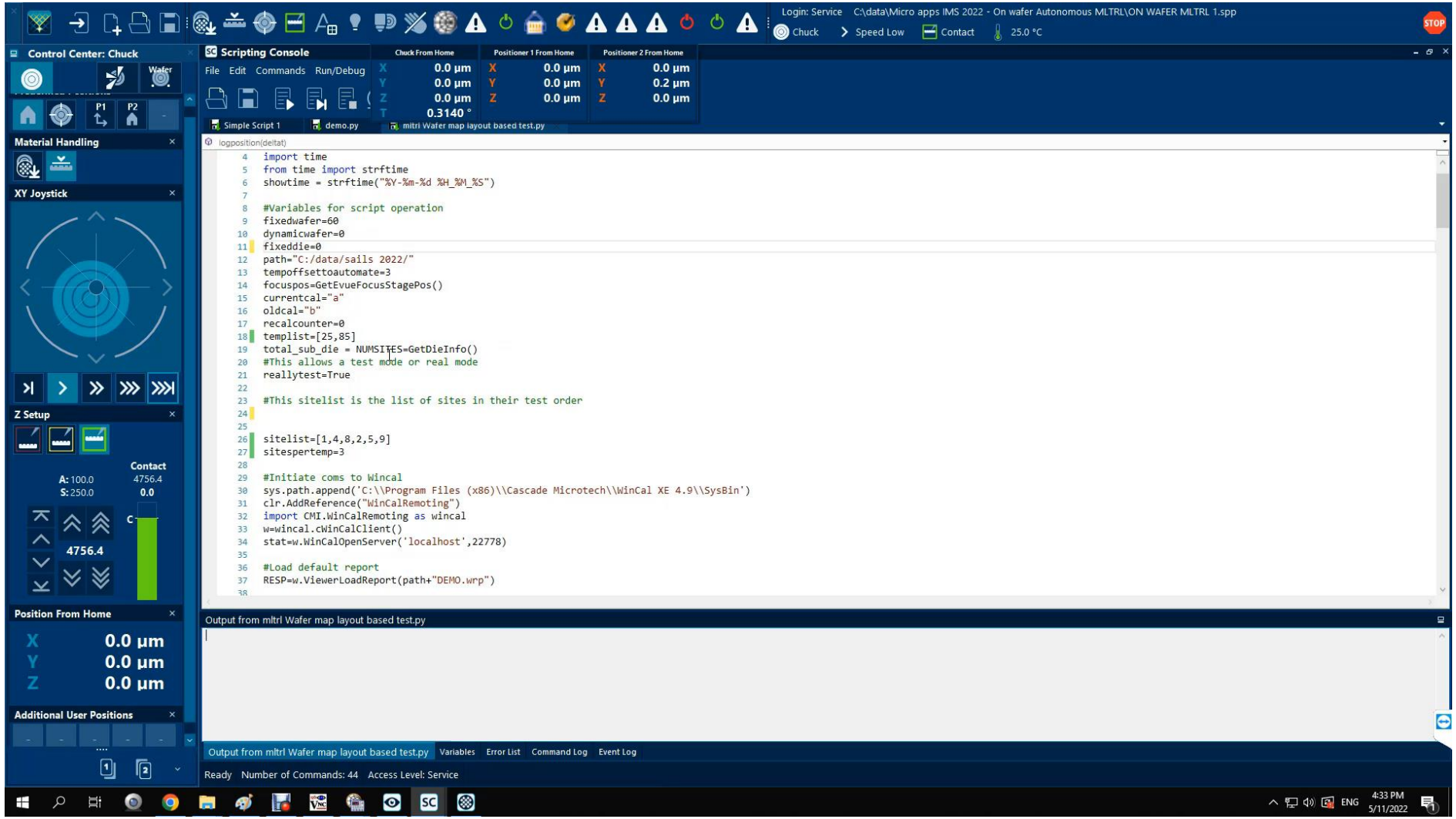
Measuring Using Autonomous RF Measurement assistant





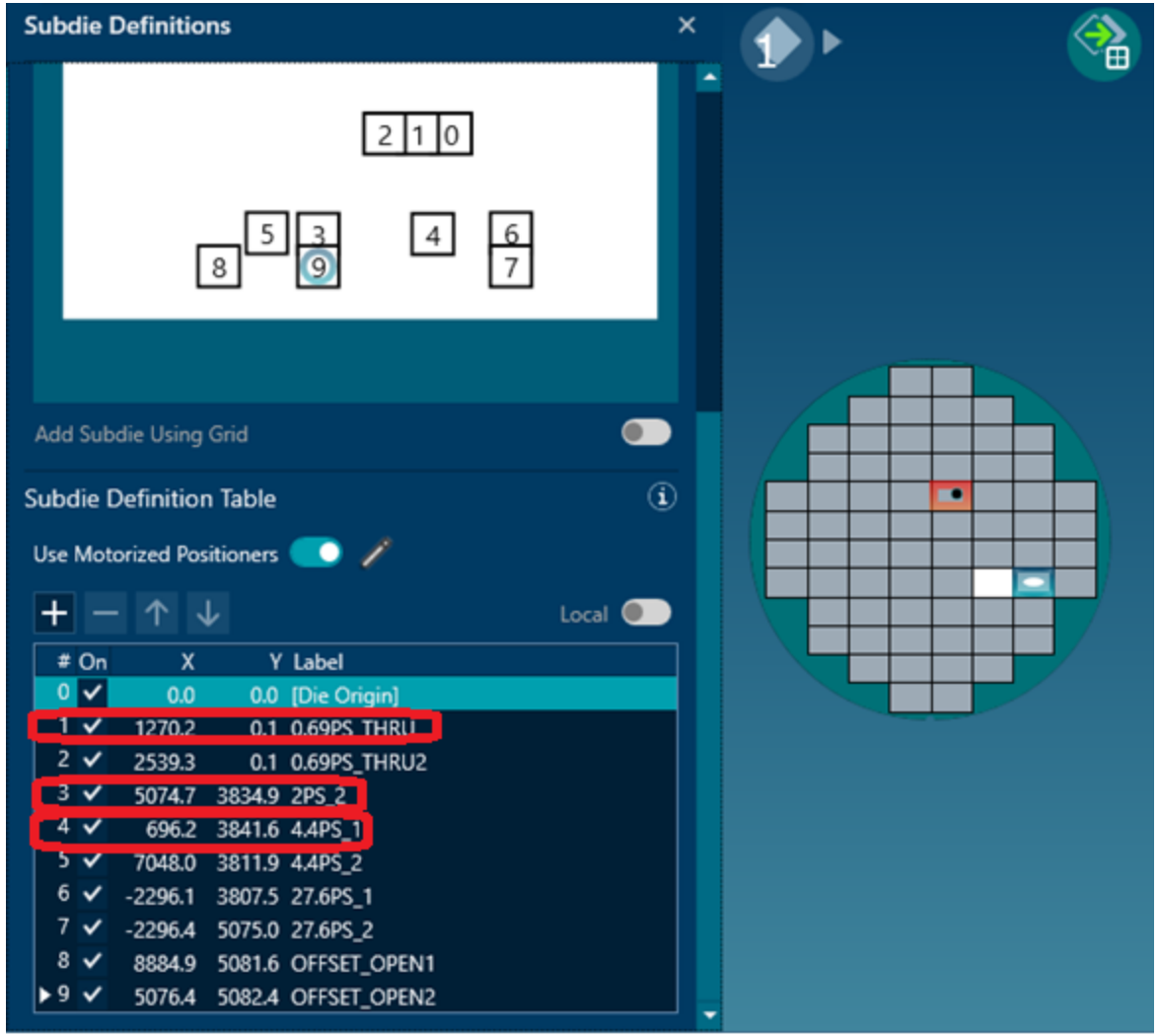
- Autonomous RF has few additional commands beyond regular prober control
- Demo test was with Python but Keysight Wafer Pro Express is used also as well as ICCAP or any high level language
- Wincal and Velox remote control available using existing libraries via socket connection
- Python or other high level languages using WinCal can act as test exec

Quick video on wafer autonomous temperature run



"VueTrack"™ only implementation

- Potentially every die has cal structures a user might choose to calibrate with but virtual aux site approach in nominally limited to single set of standards
- Reset of the home on the virtual aux chuck is possible and then regular autonomous will work (for instance after a die step to the reference structure)
- There is another way though …. Use WinCal sequences within the calibration itself which will use the relevent structure on the current die



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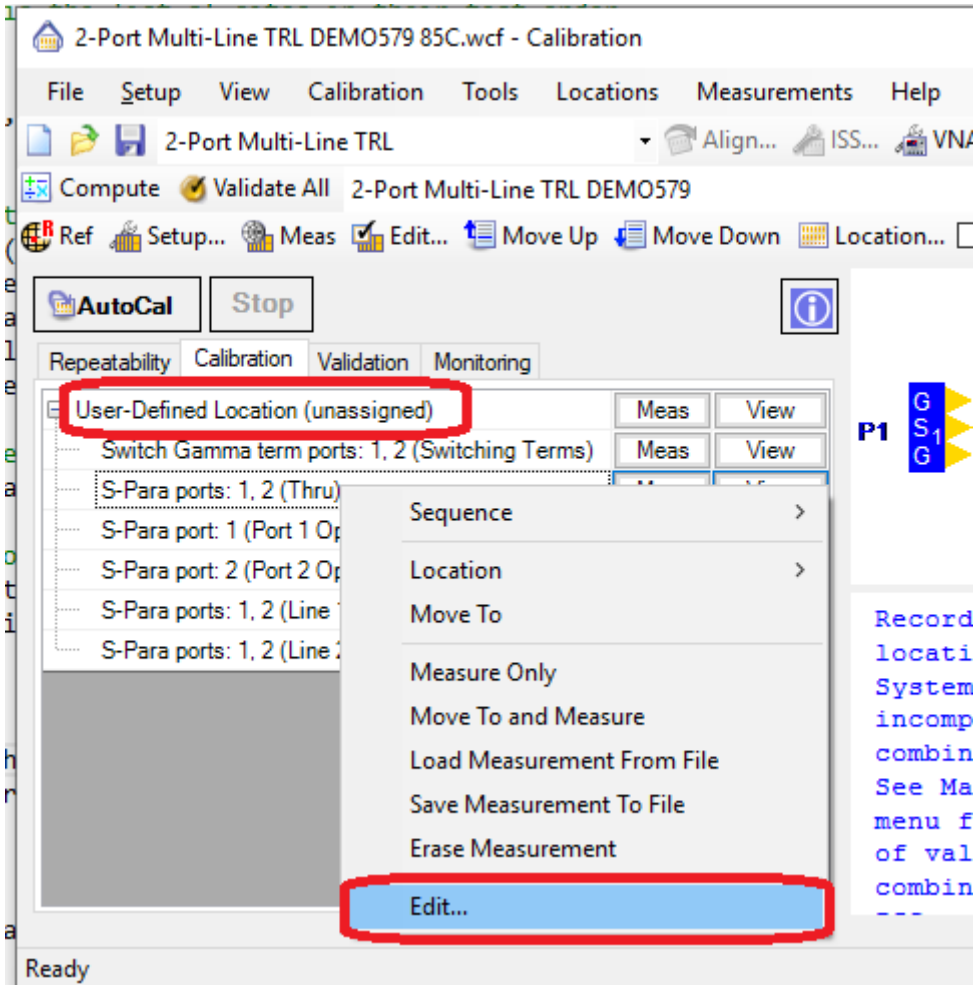
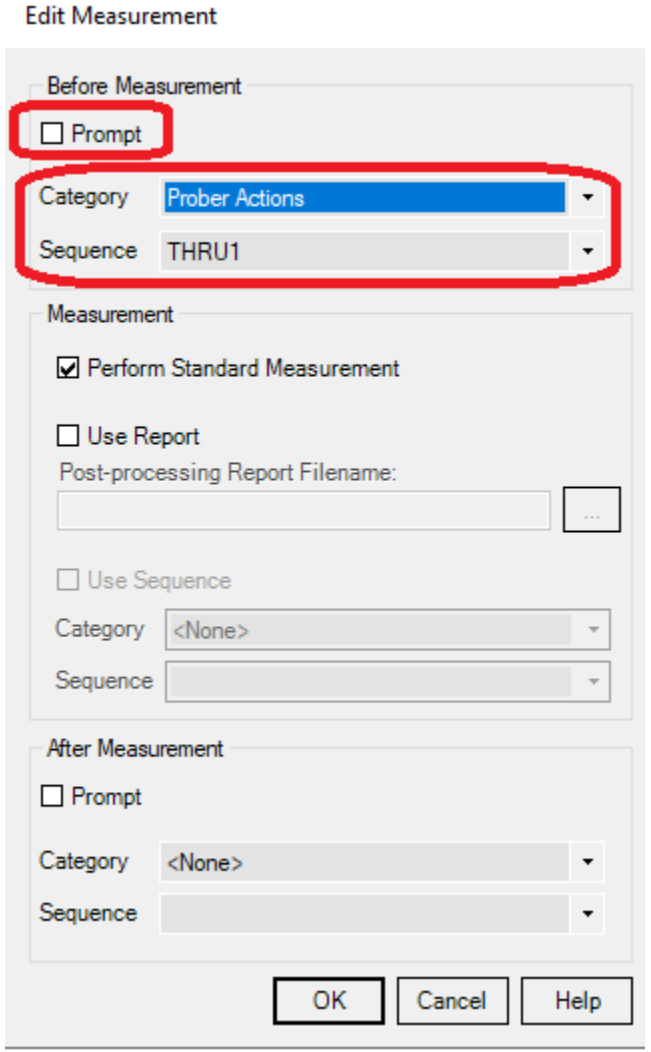
"VueTrack"™ only implementation





- Standard has no location associated with it
- Instead the measurement is edited such that a sequence is performed prior to measurement

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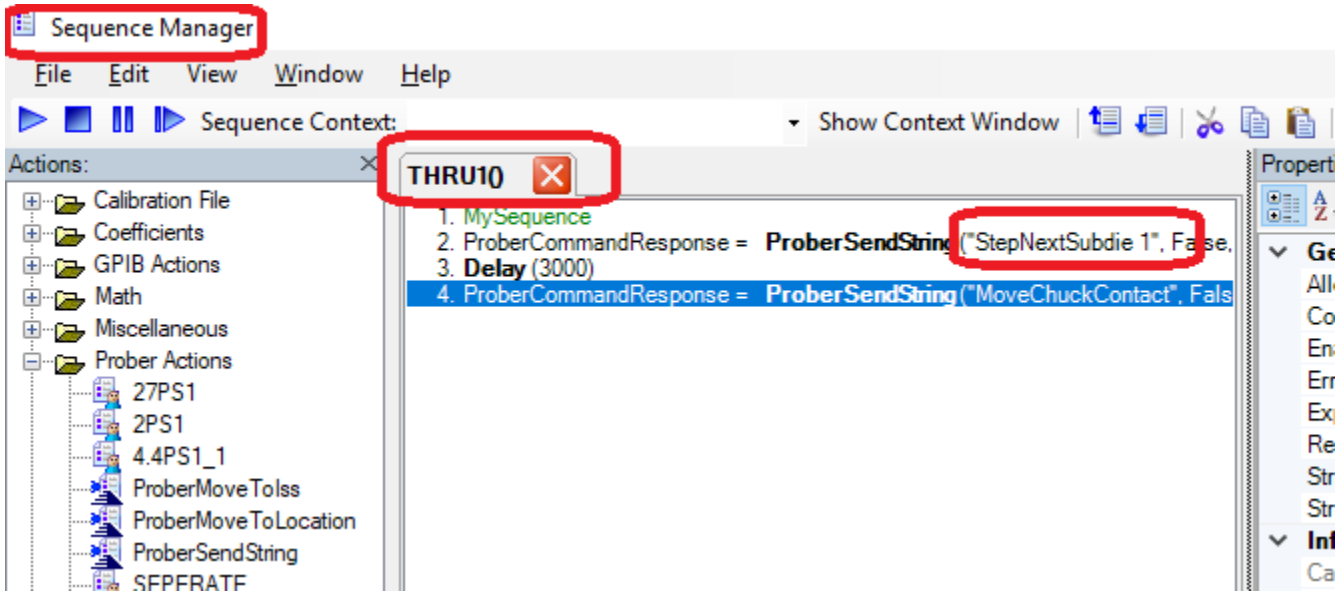
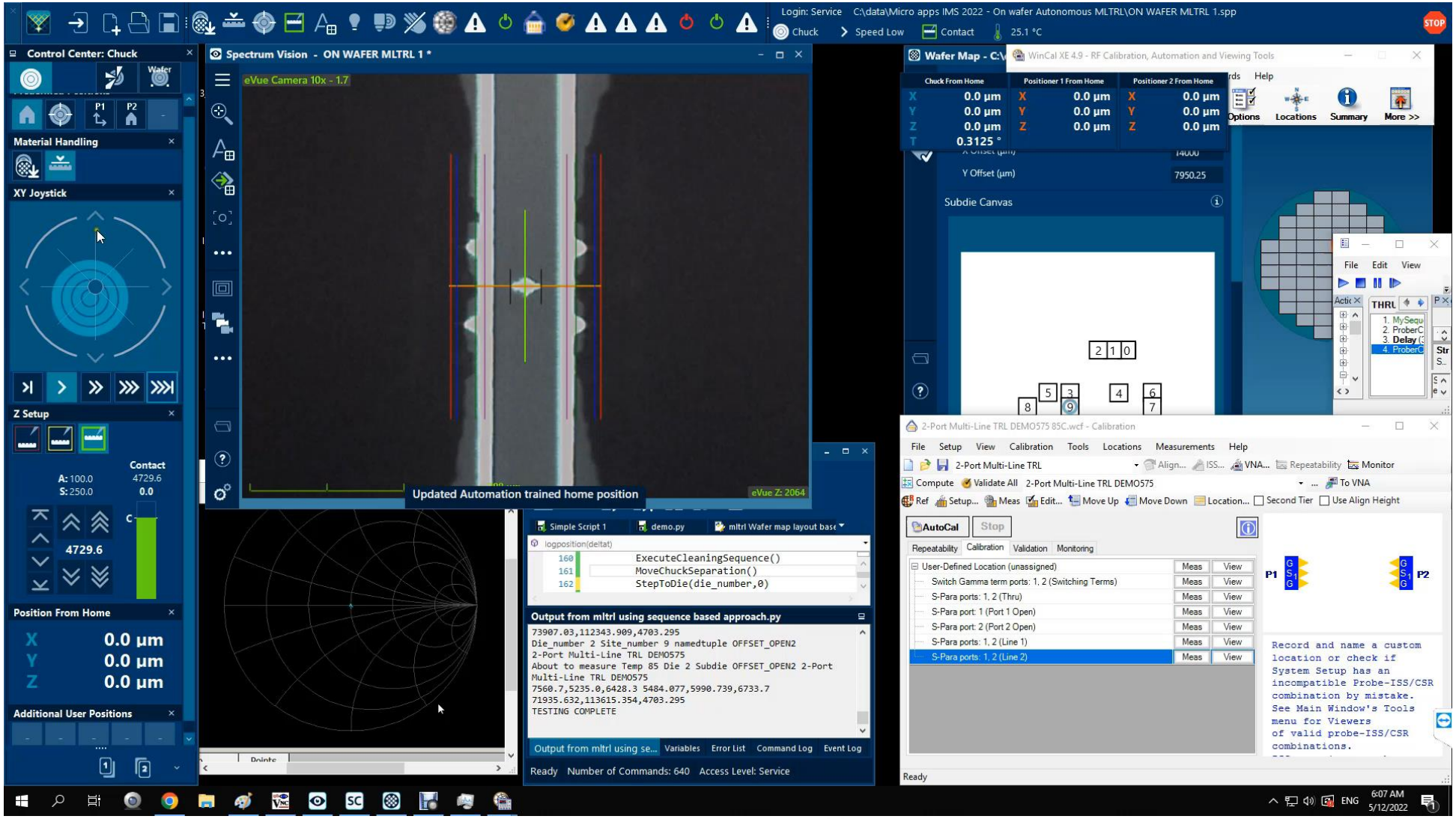
"VueTrack"™ only implementation



- Sequence has prober command for movement to Subdie 1 (Thru1)
- Subdie tool in Velox automatically handles probe and chuck movement
- This approach DOES NOT automatically test for drift and recalibrate
- It does not dynamically adjust the the probe placement at reference but is recreating the trained geometry. It is essentially a work around but does work pretty well

“VueTrack”™ only measurement run



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Summary

- Autonomous RF works well with MLTRL either off or on wafer
- Off wafer using existing ISS's is easiest but this loses the benefit of the reference plane being at the DUT
- Best on wafer approach uses location manager which is simple to setup but will need re-referencing if there are cal structures on different die required
- Other approaches using sequence tools within WinCalXE are possible