

# BEAMER

Mixed Exposure Strategies for Optimized  
Writing

BEAMER allows users to combine exposure strategies into one pattern, such as different field sorting and shape ordering strategies. This note demonstrates the two methods:

## Multiple Export Modules

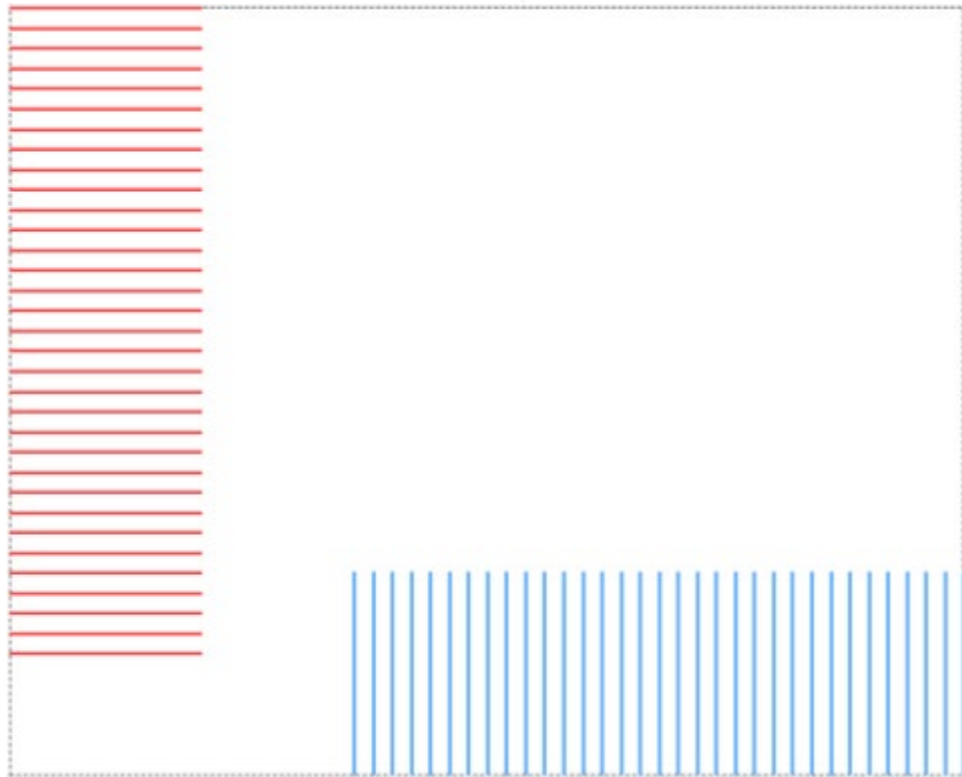
Each region of data is processed in separate export module, reimported, merged and then exported with “Cell To Field” on

## Fracture Module

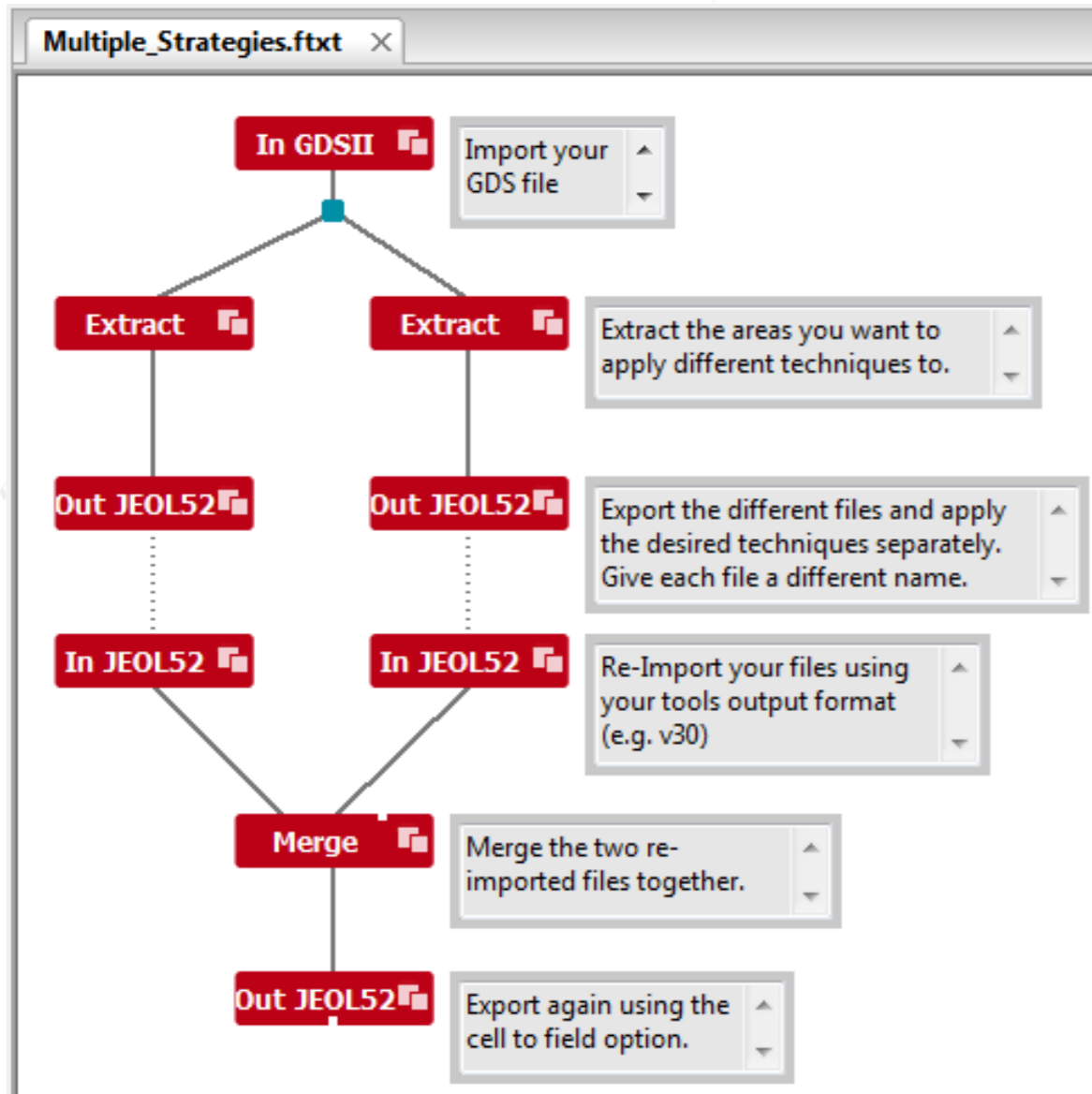
Each region of data is selected in Fracture module, and final result is exported with “Cell To” Field on

# Export Module Method

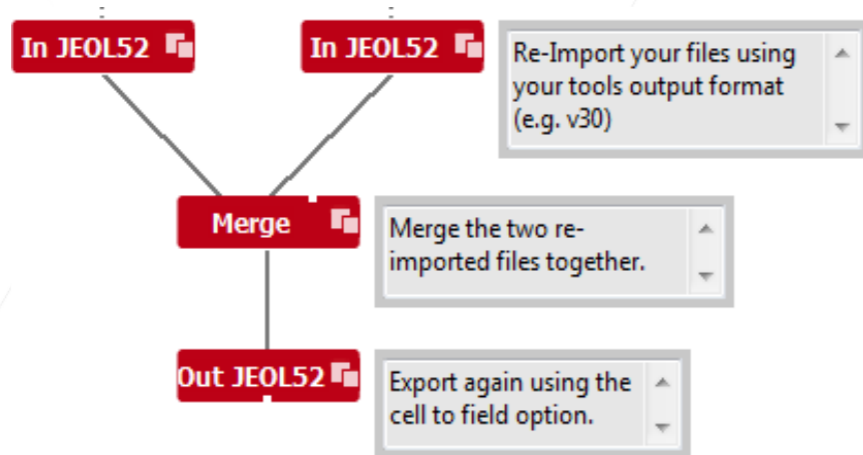
1. Combining Raster X & Raster Y Field Sorting



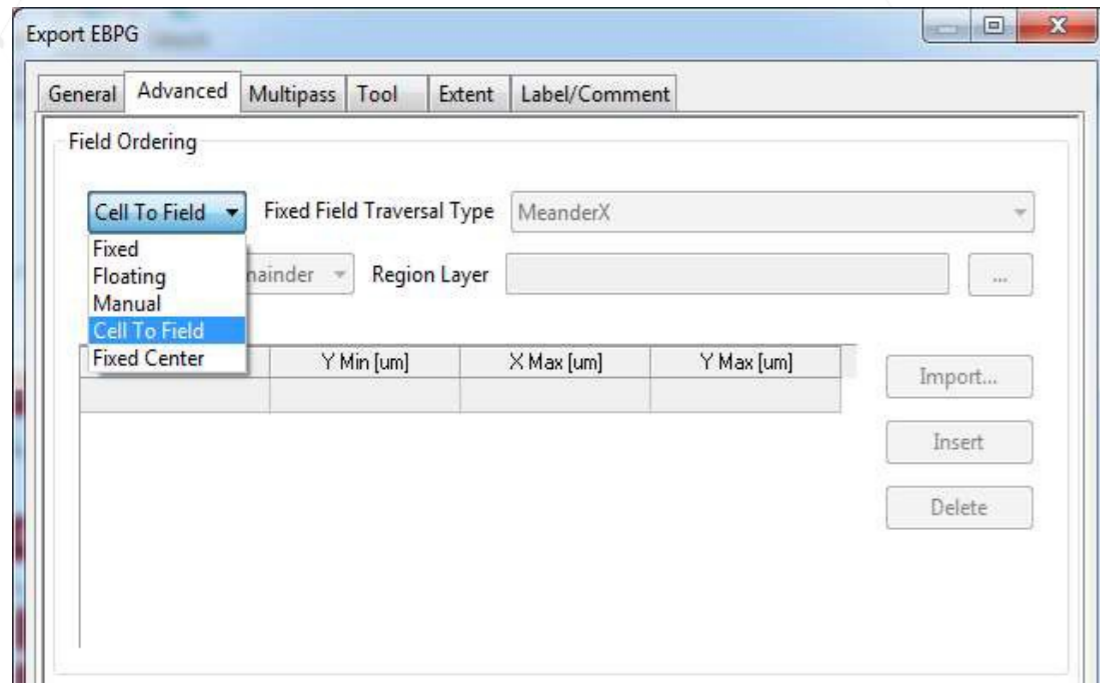
- For this mixed direction grating design, the red data can be optimized utilizing Field Ordering option of 'Raster Y'. The blue data is optimized using 'Raster X'.
- Generally, one would divide the data into two separate exposures to apply each method.

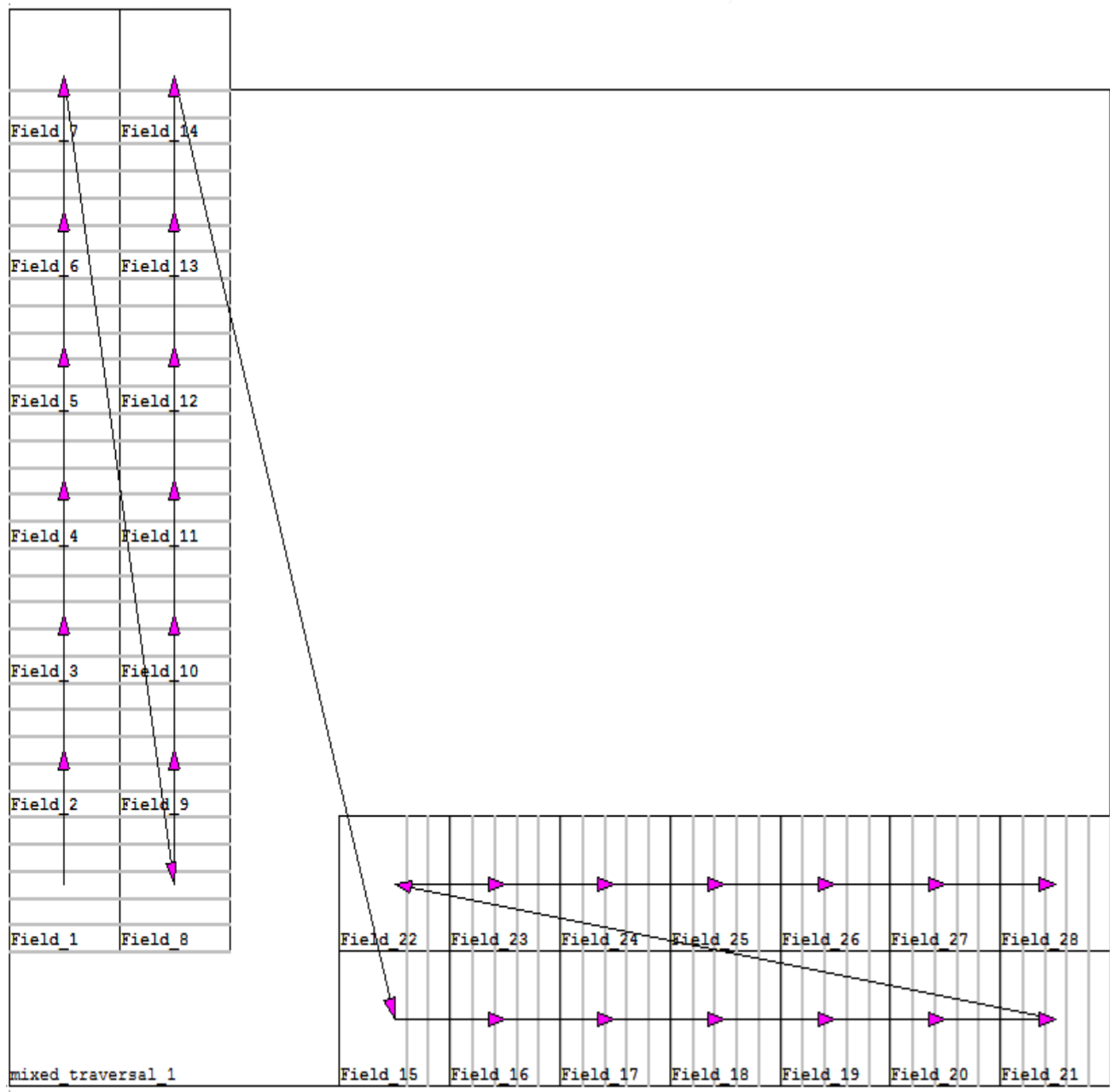


- If your patterns are on different layers, simply extract the desired layer.
- To extract a certain area of your pattern from a single layer, select “Region” then “Edit Layout” and manually select it by drawing a bounding box (green dotted line) by clicking left mouse button at start/end while holding down the shift key.
- If you have defined cells, you can select them by using the ‘Cell Definition’ option.
- Select the desired areas with two different extract modules.



- Next connect the ‘Merge’ module to the imports in the order in which you want the data exposed. The first module attached to the merge will be exposed first.
- The final step is to re-export your flow by attaching an ‘export’ module to your merge. Select the “Cell To Field” option for field ordering in the Advanced tab to achieve the desired result.





- The data is exposed in the order it is sent to the Merge module and both the 'Raster Y' and 'Raster X' field ordering methods are applied to the selected areas in a single exposure file.

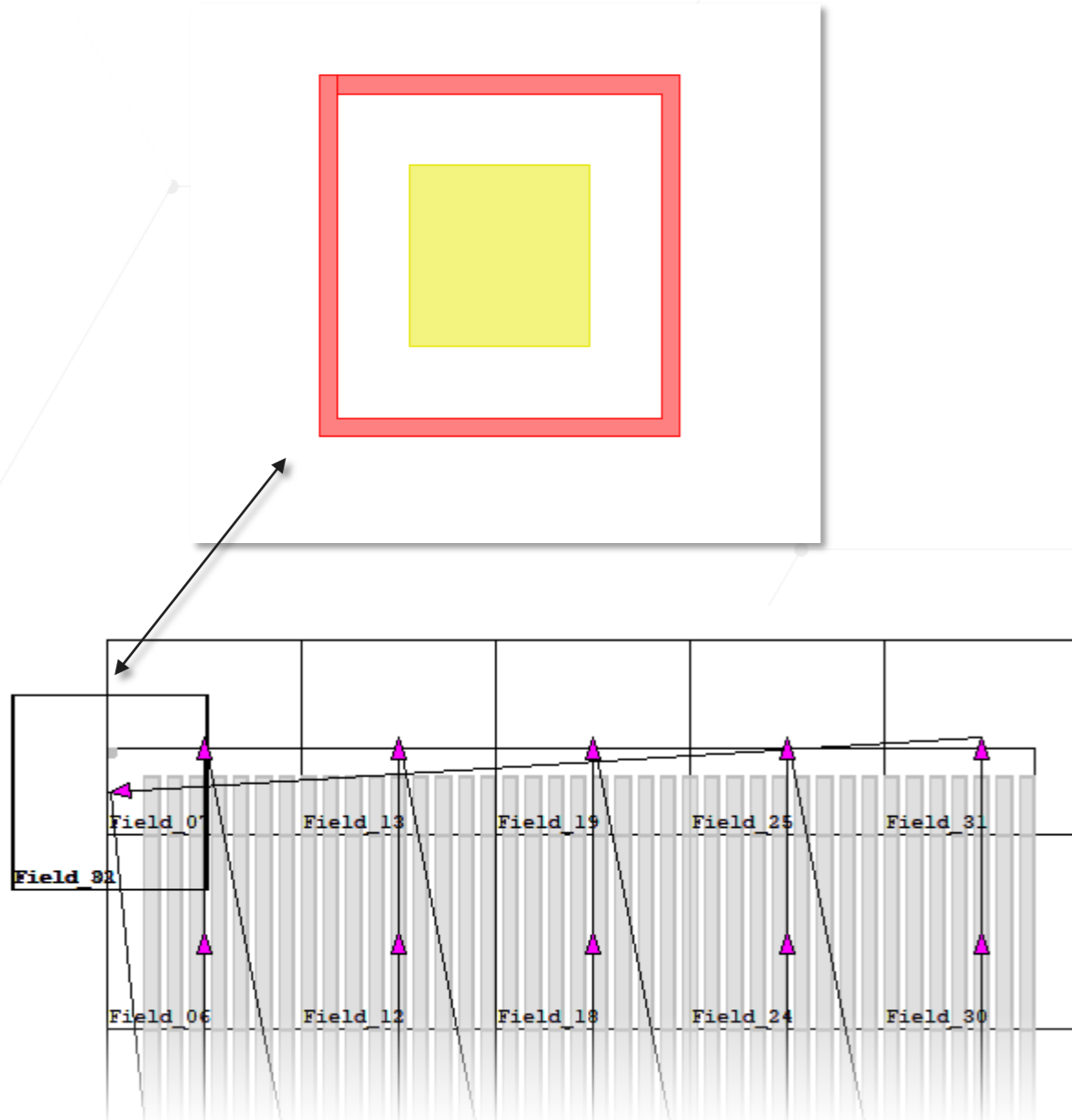
# Export Module Method

## 2. Closure Test Example



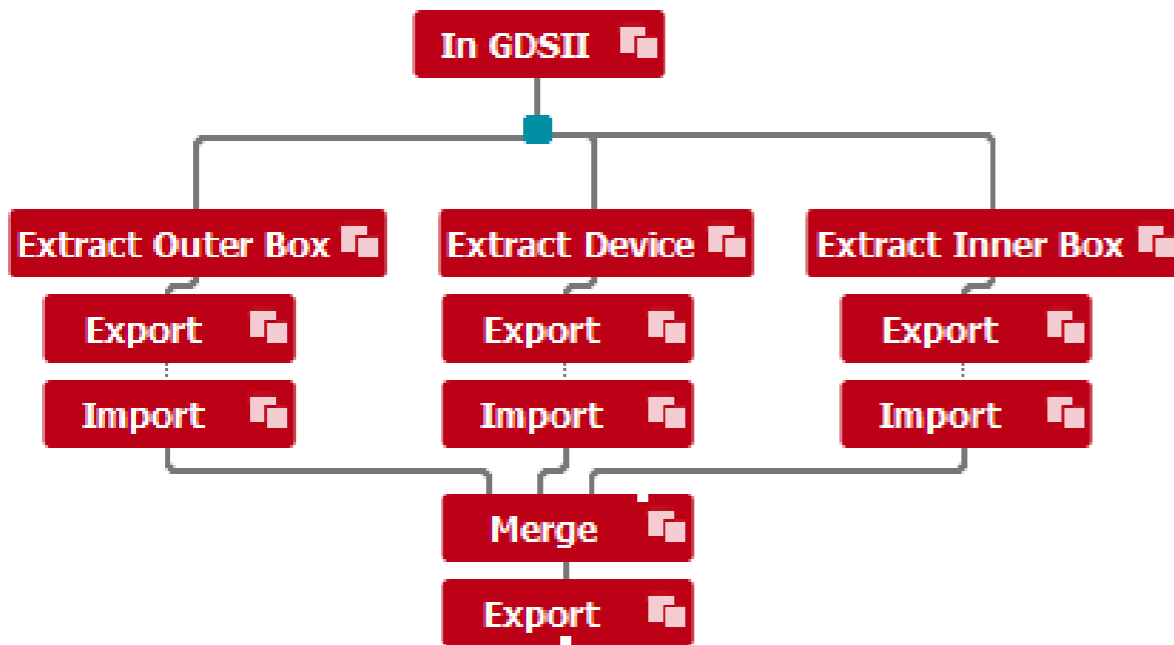
# Closure Test

- Quantify tool drift by measuring shape position accuracy at beginning and end of exposure using box-in-box pattern
  - Order: Outer box → devices → Inner box

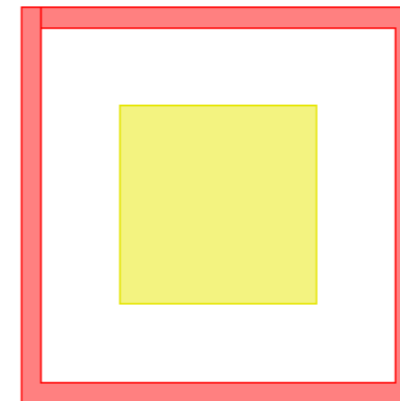
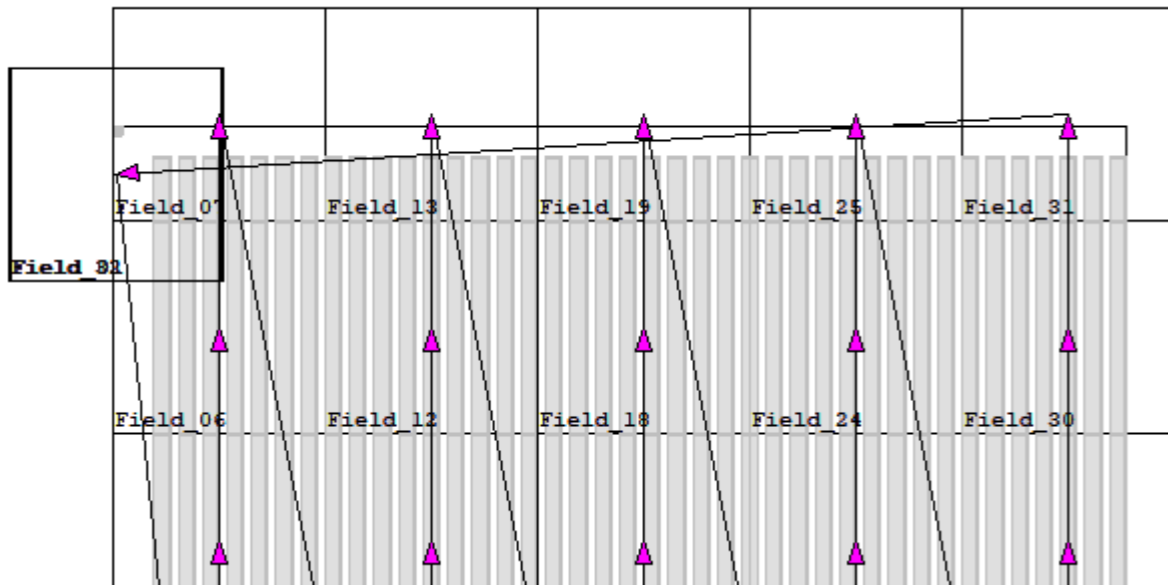


# Closure Test

1. Extract outer box, inner box and device to separate modules
2. Export to separate tool formats
3. Import and merge each file
4. Export with "Cell to Field" on

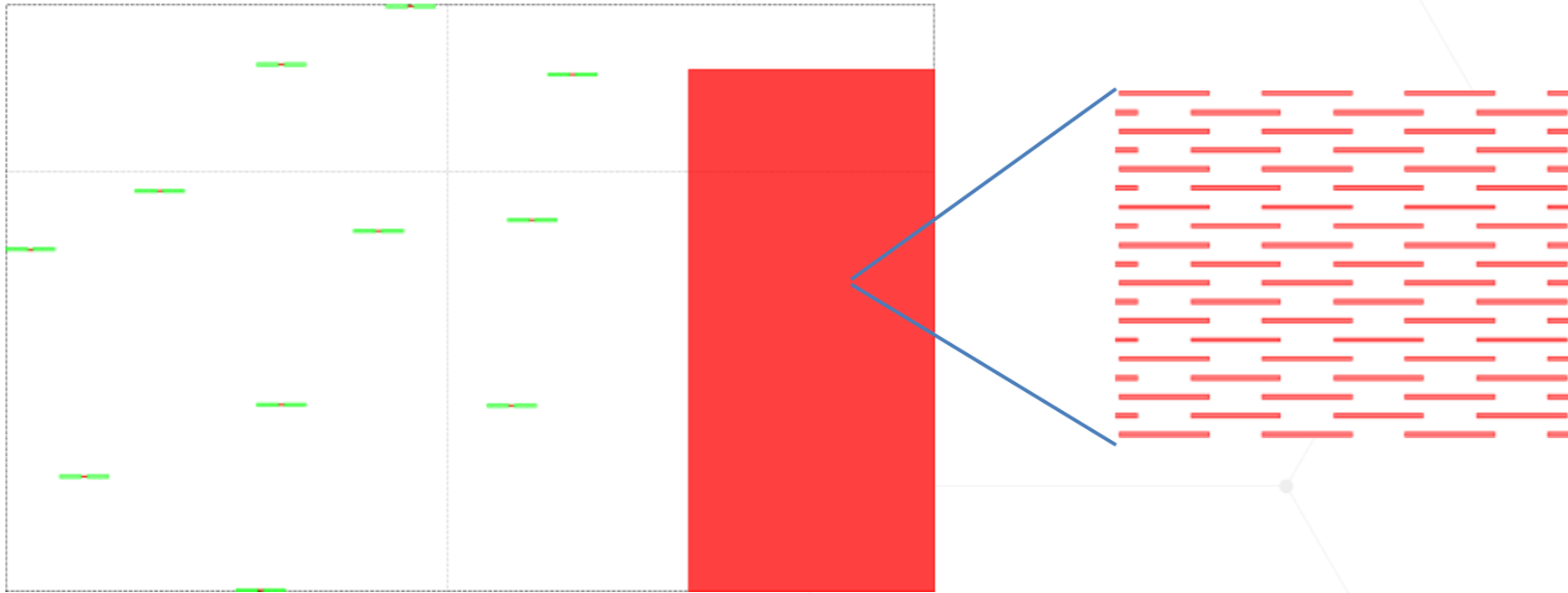


- Outer-box is exposed first
- Pattern of interest exposed second (the grating in this example)
- Inner-box is exposed finally

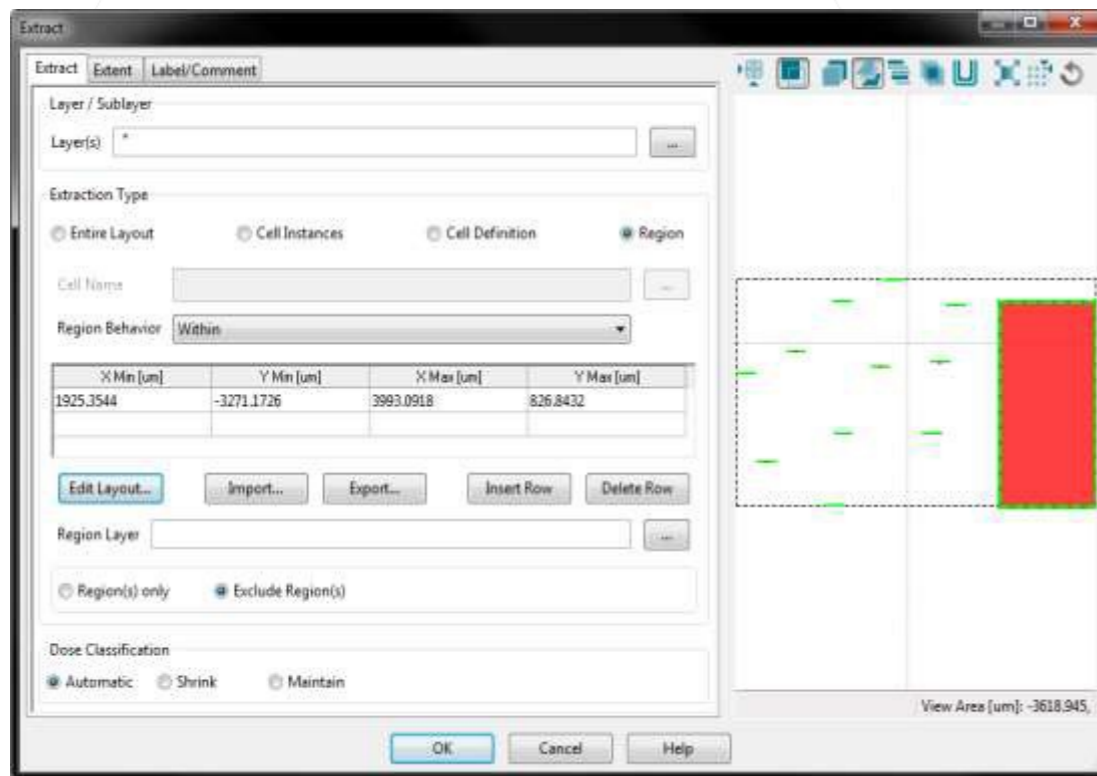
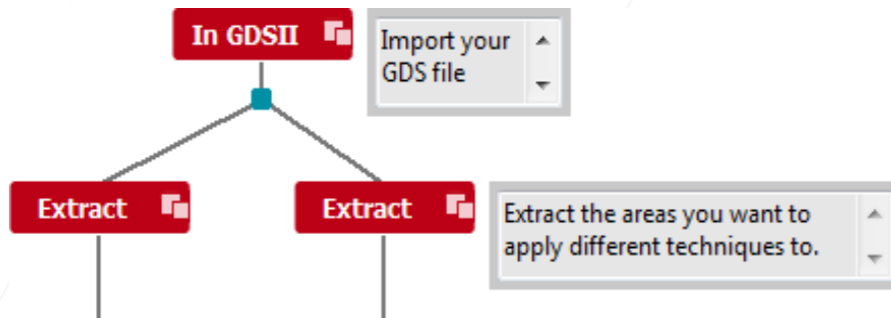


# Export Module Method

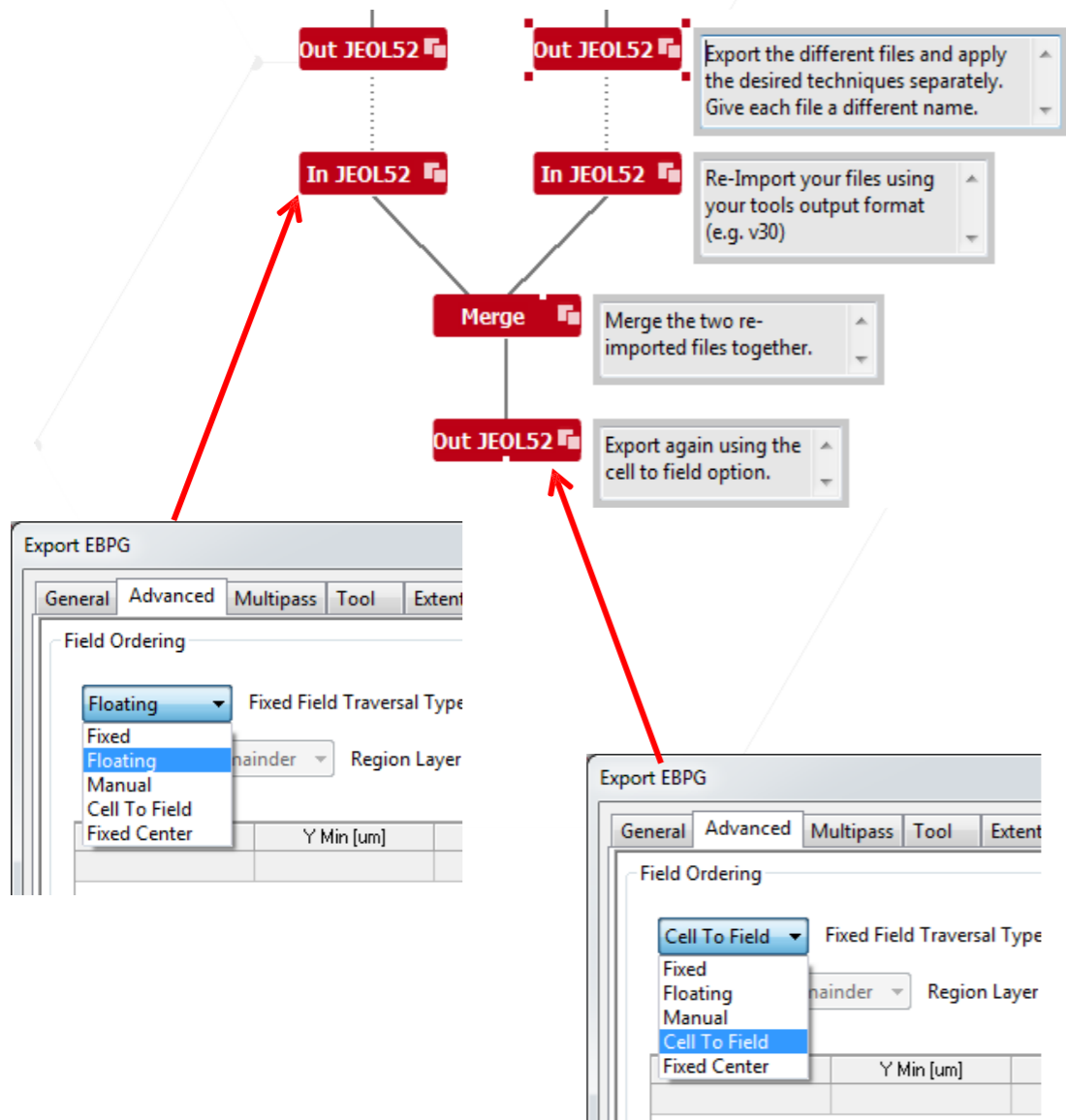
## 3. Combining Floating and Overlapping Fields



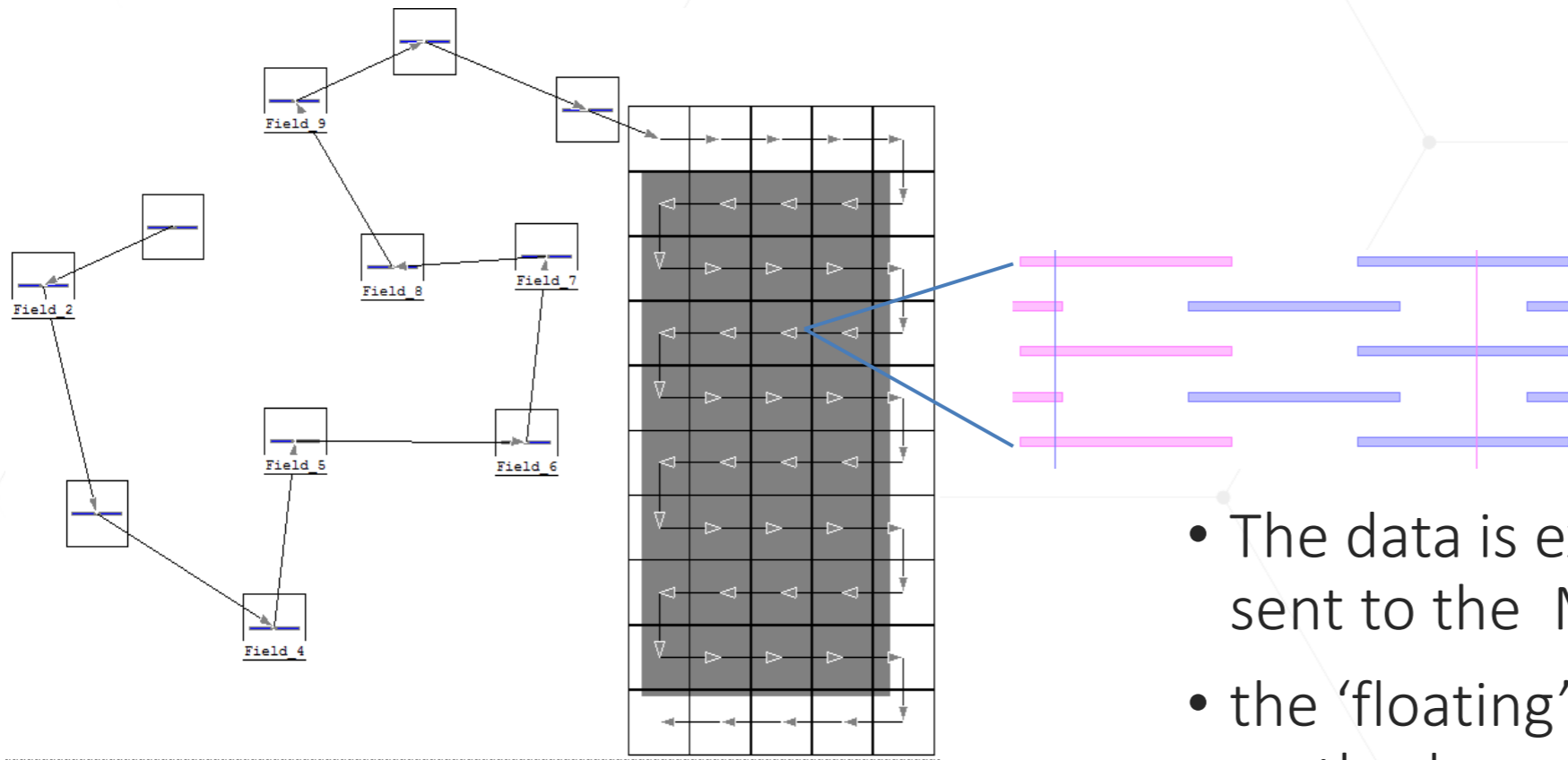
- For this design, the sparse green data can be optimized utilizing 'floating fields'. The dense red data is optimized using 'field overlaps'.



- Extract the desired areas with two different extract modules using Region definition, Cell Definition, or Layers.
- These examples presented only show two different areas selected, but there is no limit to how many areas you can define and subsequently process with different export options.



- Export the files separately to apply the desired field control options.
- Make sure to give two different names to each of the files.
- Re-import them by attaching an 'Import' module to the exports.
- Then use the 'merge' module in the order you want the data exposed.
- Finally export with "Cell To Field"



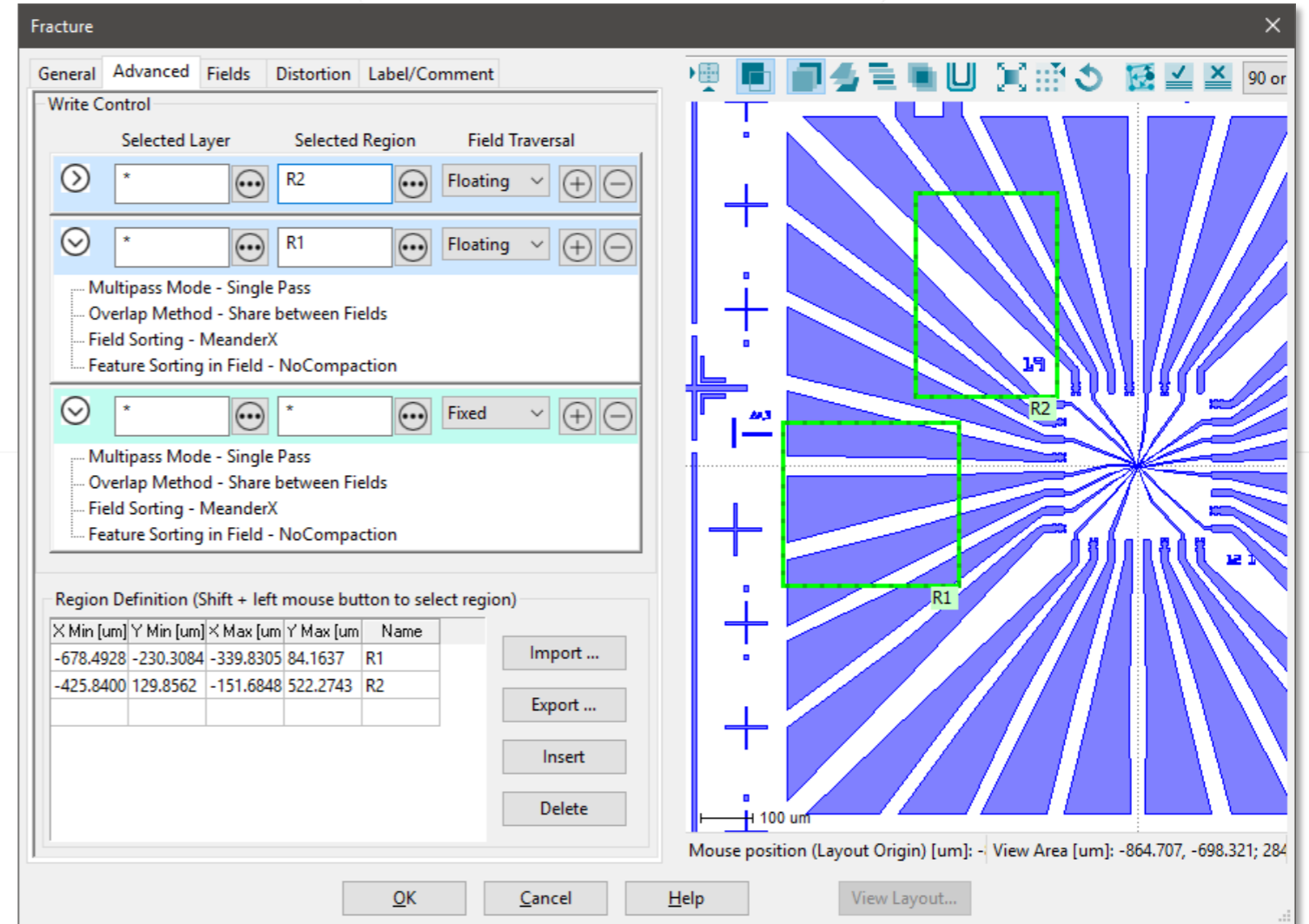
- The data is exposed in the order it is sent to the Merge module and both
- the 'floating' and 'field overlap' methods are applied to the selected areas in a single exposure file.



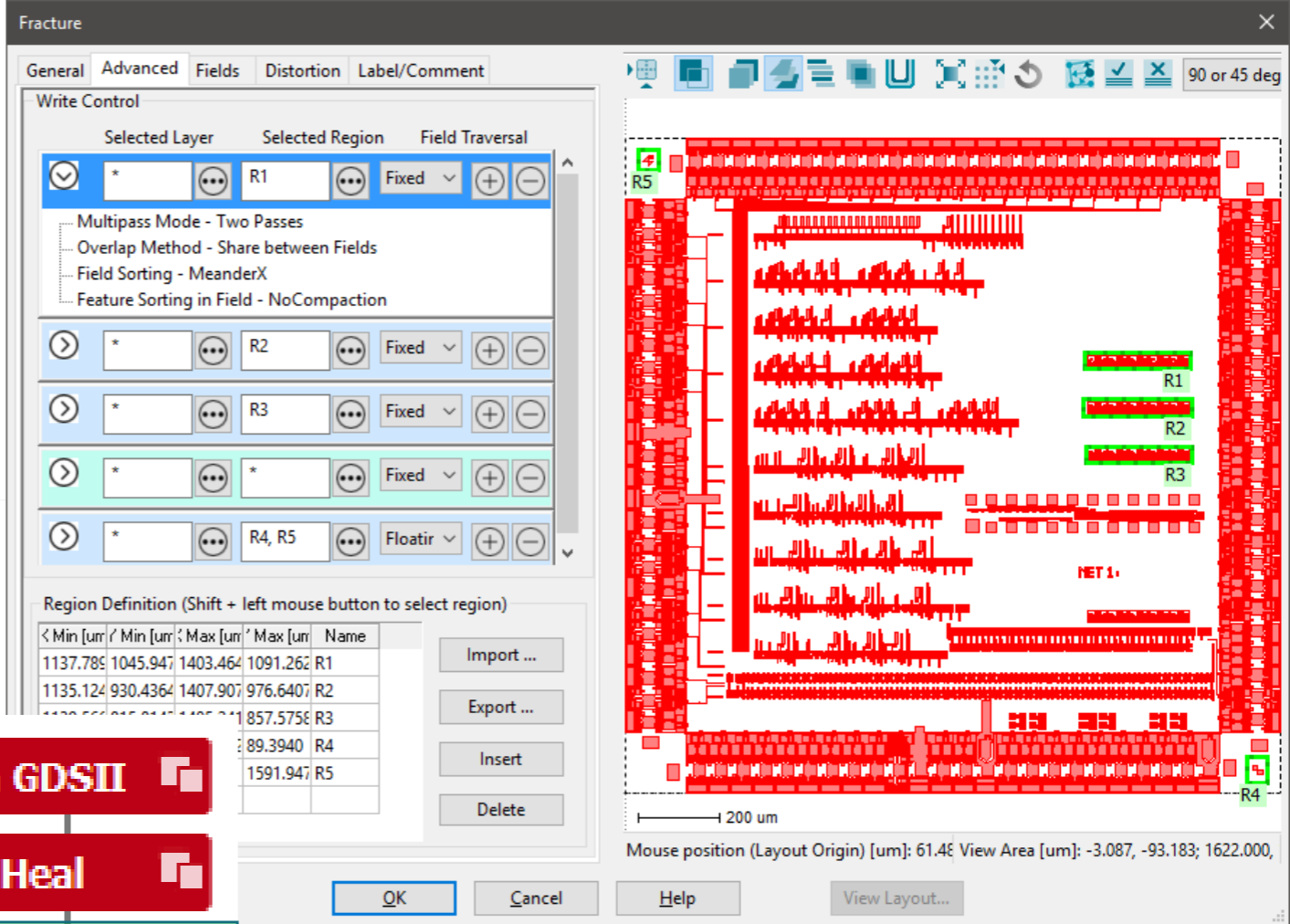
# Fracture Module Method

Concept

- The Fracture module is essentially a tool independent “Export” module – except the data stays in BEAMER
- Allows shape fracturing and region/layer specific field sorting before the *Export* module



- Same result as multiple export modules can be achieved with one *Fracture* module
- Each region can be selected and manually ordered
- Single output that can be passed to any EXPORT module



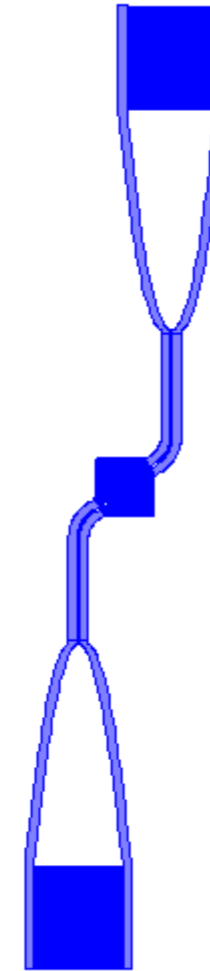
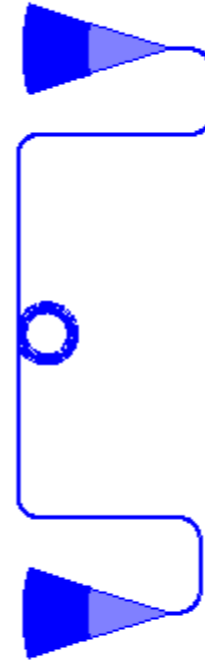
The screenshot shows the 'Fracture' software interface. The 'Write Control' panel is visible, showing a list of regions (R1, R2, R3, R4, R5) with their respective field traversal settings (Fixed, Floatir). The 'Region Definition' table is also shown, listing the coordinates and names of the regions.

< Min [um]	Min [um]	Max [um]	Max [um]	Name
1137.789	1045.947	1403.464	1091.262	R1
1135.124	930.4364	1407.907	976.6407	R2
			857.5758	R3
			89.3940	R4
			1591.947	R5

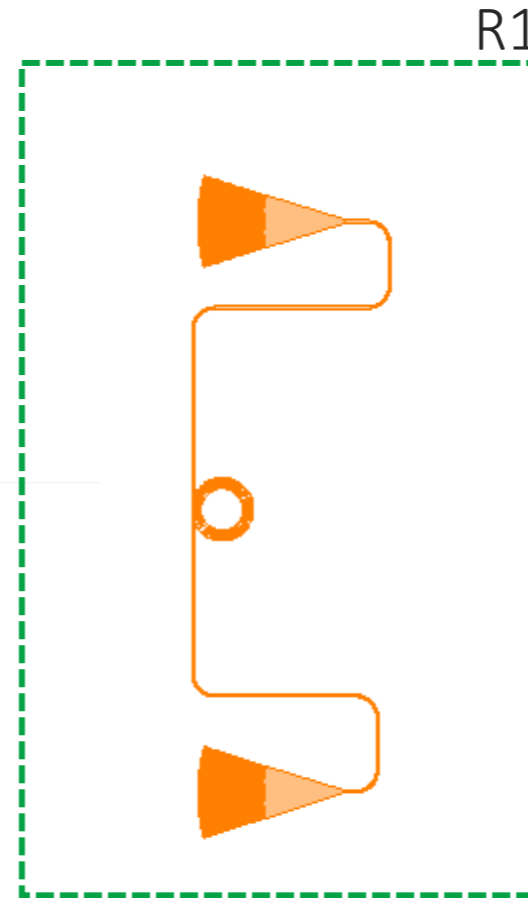
Below the screenshot, a vertical stack of buttons is shown: 'In GDSII', 'Heal', 'Fracture', and 'Export'. The 'Fracture' button is highlighted in green, indicating it is the active or selected module.

1. Import full layout
2. Divide layout into partitions
3. Define field sorting for each partition
4. Process partitions and combine to one output layout

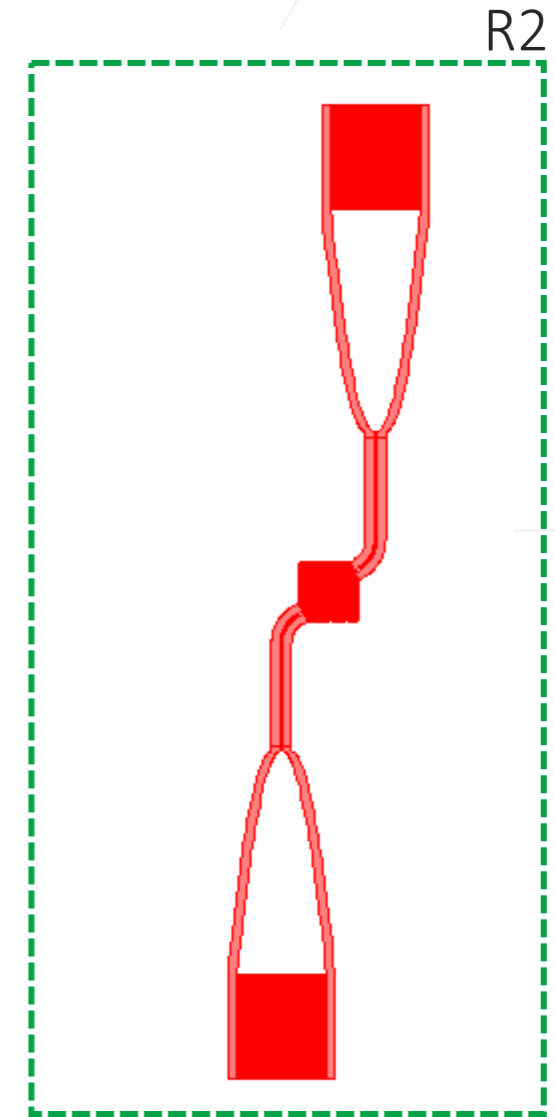
## Fracture Concept



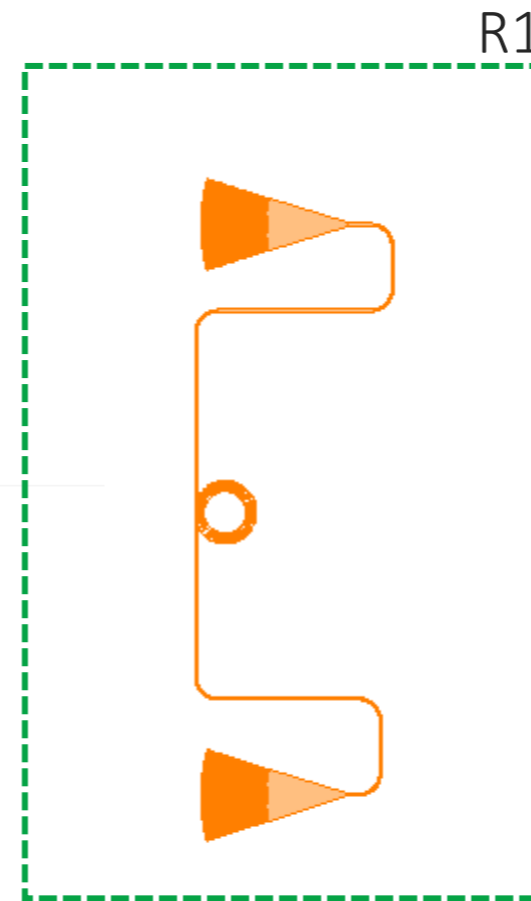
1. Import full layout
2. **Divide layout into partitions**
3. Define field sorting for each partition
4. Process partitions and combine to one output layout



# Fracture Concept

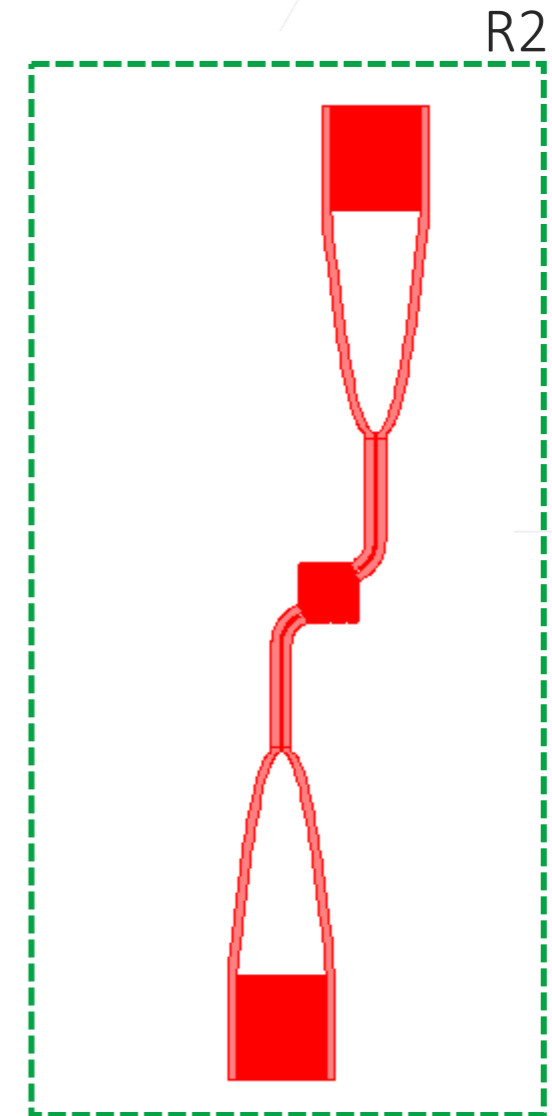


1. Import full layout
2. Divide layout into partitions
- 3. Define field sorting for each partition**
4. Process partitions and combine to one output layout



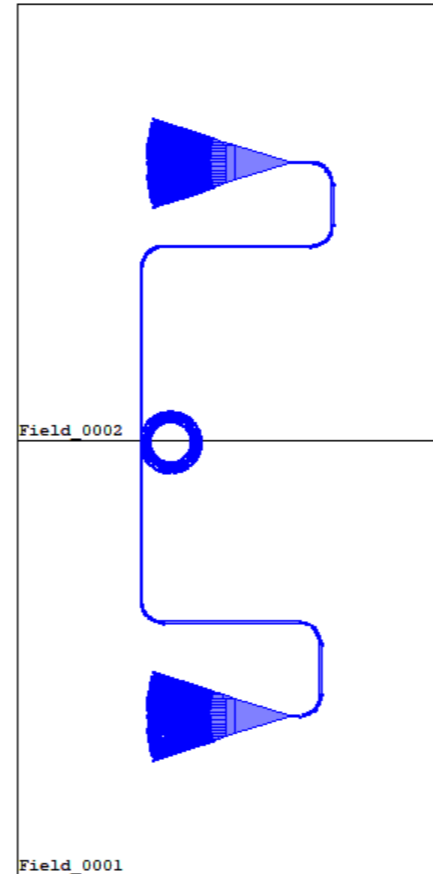
Fixed Fields

# Fracture Concept



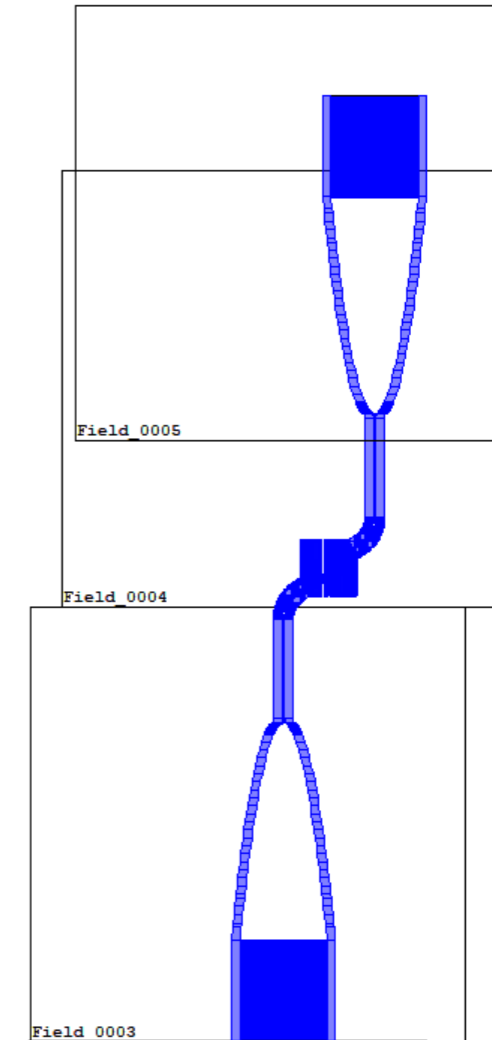
Floating Fields

1. Import full layout
2. Divide layout into partitions
3. Define field sorting for each partition
4. Process partitions and combine to one output layout

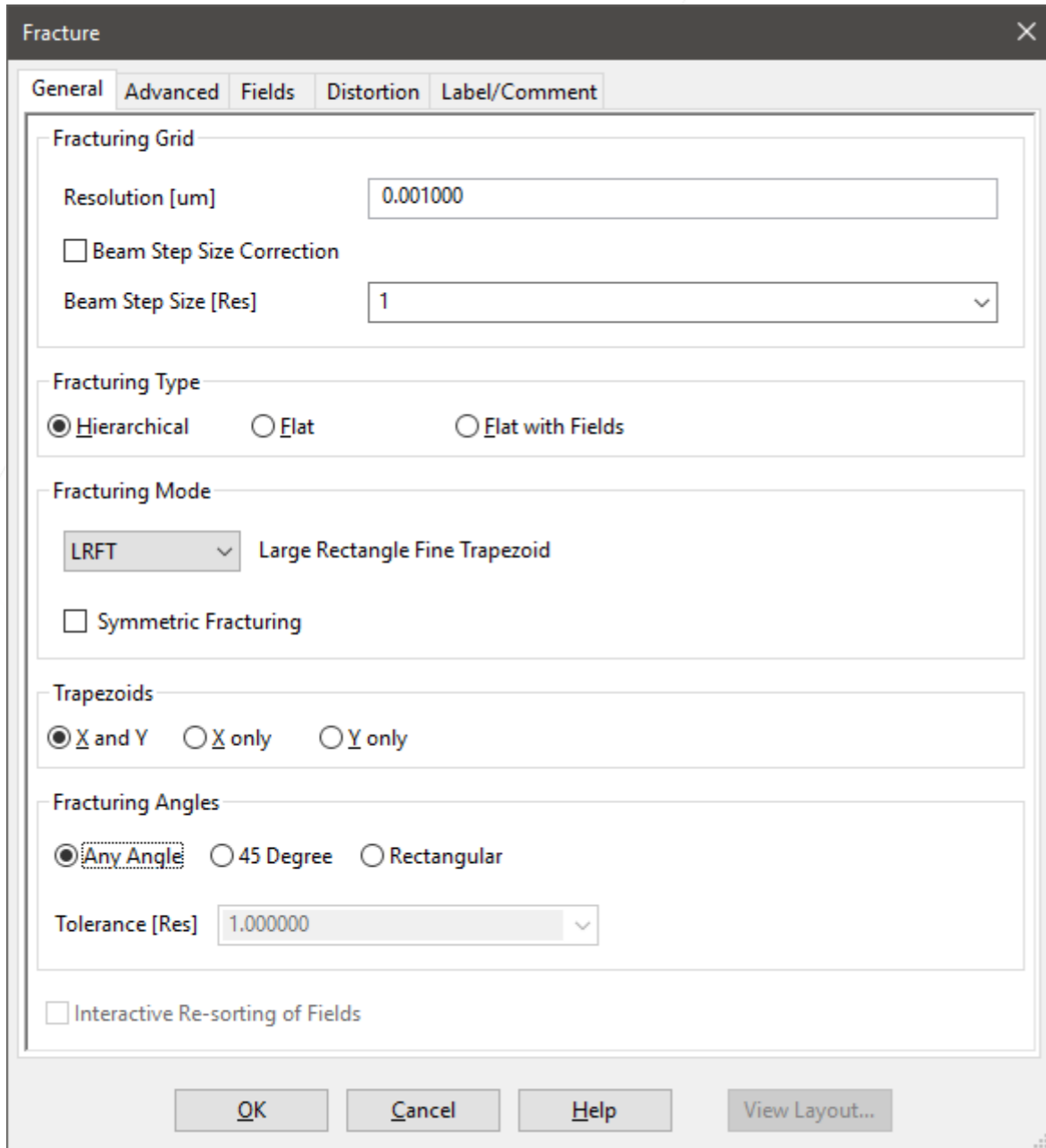


Fixed Fields

# Fracture Concept



Floating Fields



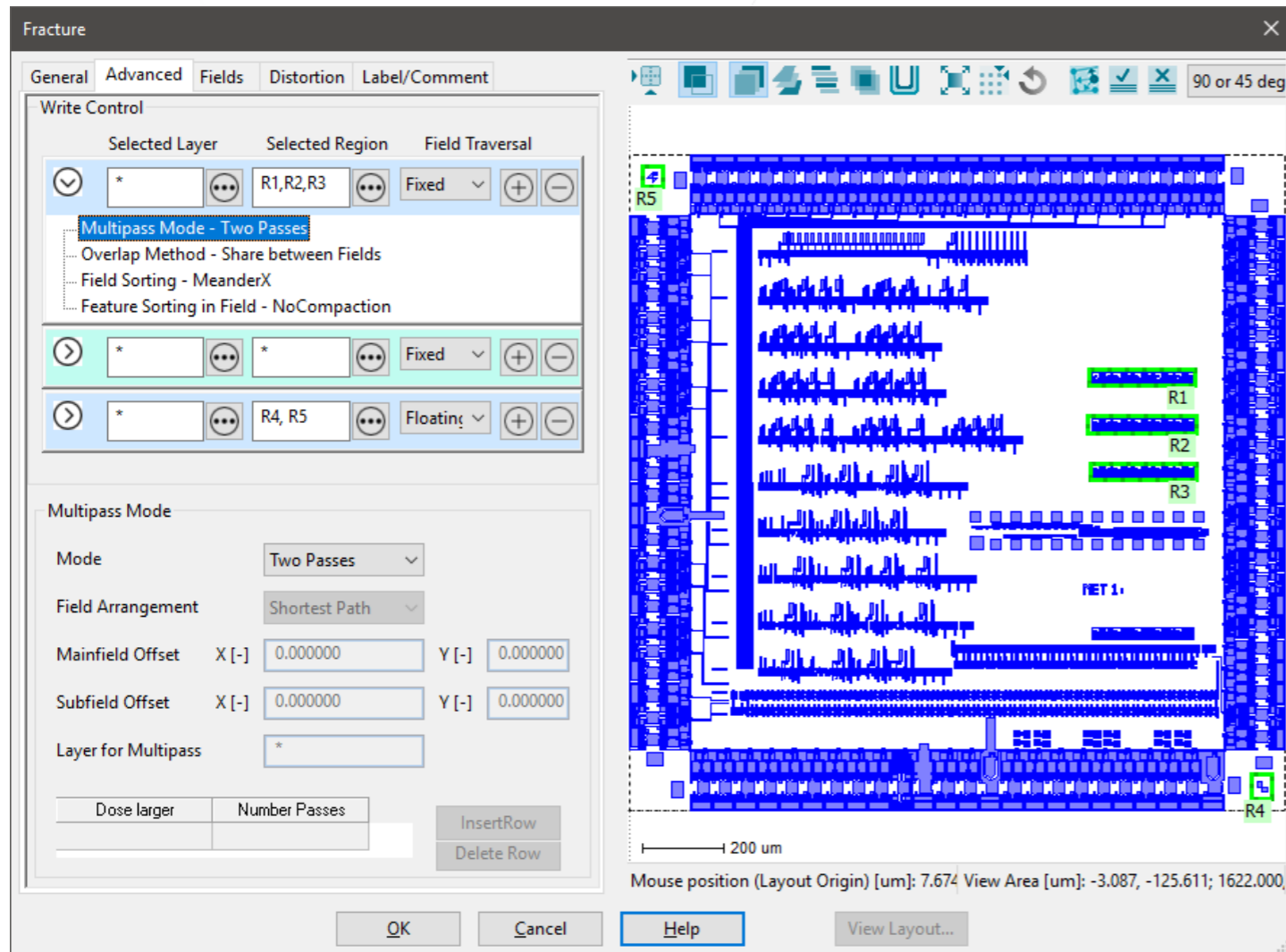
The screenshot shows the 'Fracture' dialog box with the 'General' tab selected. The dialog is divided into several sections:

- Fracturing Grid:** Resolution [um] is set to 0.001000. There is an unchecked checkbox for 'Beam Step Size Correction' and a dropdown for 'Beam Step Size [Res]' set to 1.
- Fracturing Type:** Radio buttons for 'Hierarchical' (selected), 'Flat', and 'Flat with Fields'.
- Fracturing Mode:** A dropdown menu is set to 'LRFT' with the text 'Large Rectangle Fine Trapezoid' next to it. There is an unchecked checkbox for 'Symmetric Fracturing'.
- Trapezoids:** Radio buttons for 'X and Y' (selected), 'X only', and 'Y only'.
- Fracturing Angles:** Radio buttons for 'Any Angle' (selected), '45 Degree', and 'Rectangular'. Below this is a dropdown for 'Tolerance [Res]' set to 1.000000.
- At the bottom, there is an unchecked checkbox for 'Interactive Re-sorting of Fields'.

Buttons at the bottom include 'OK', 'Cancel', 'Help', and 'View Layout...'.

- Applies to *all data* processed in FRACTURE module
- Set resolution and beam step size to match tool export *if doing shape fracturing*
- Fracturing type
  - Use Flat With Fields for Field Sorting
- Fracturing mode
  - Conventional, LRFT, Curved, **No Fracturing**
- Manually re-sort fields

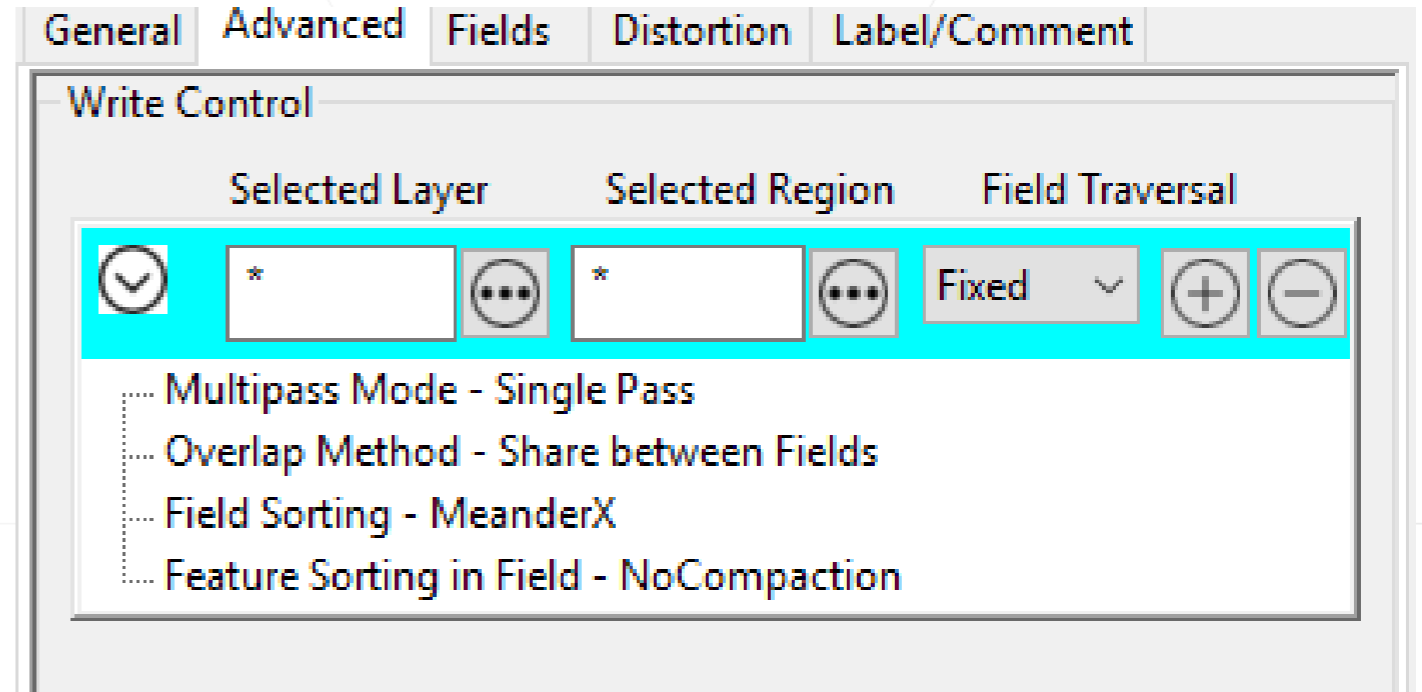




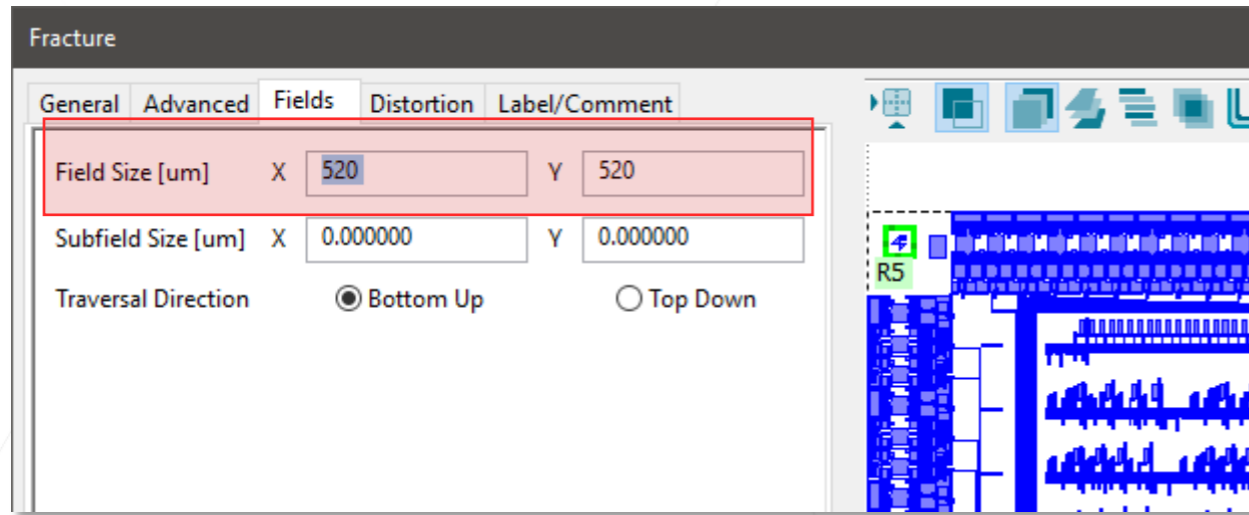
- Enabled after “Flat with Fields” selected
- Add new panels, select data by region or layer, and select field traversal method and parameters
  - Multipass, Field Overlap, Field Sorting and Feature Sorting in Field
- Can be as granular as desired....

Select the data for a writing method by:

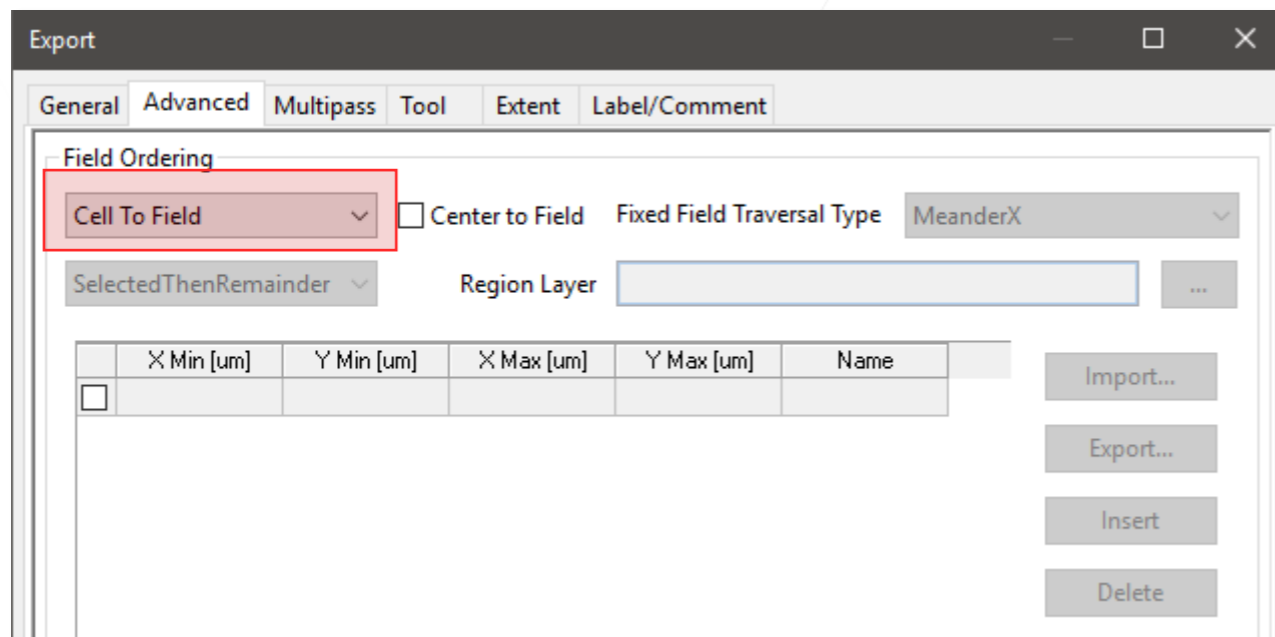
- Layer
  - \* = all layers (use for remainder)
  - 1,2,3 = Lists
  - 5-10 = layer ranges
- Region
  - Layer region boxes
  - Interactive (region definition in GUI, shift-left-click and drag as in *Extract*).
  - Table
- Both methods can be combined
- Remember to define a “Remainder Pass” with \* in the Selected Layer and Selected Region fields to fracture data that wasn’t explicitly selected



# Fields and “Cell To Field”



- Set Field Size to match field size used in *Export* module



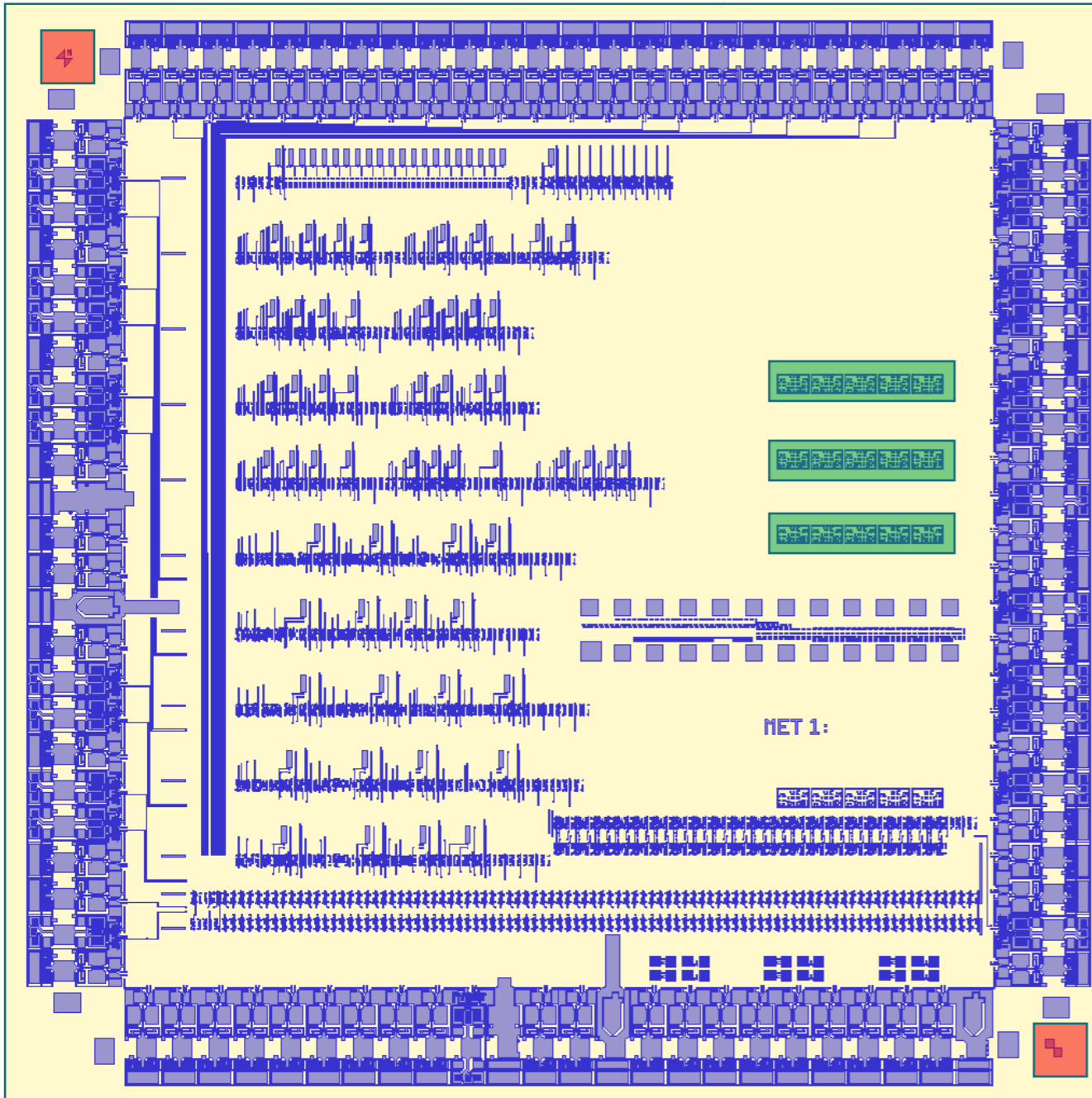
- Use “Cell To Field” Field ordering in final *Export* module

- Fields are sorted and treated as “Cells” by *Fracture* module

# Fracture Module Method

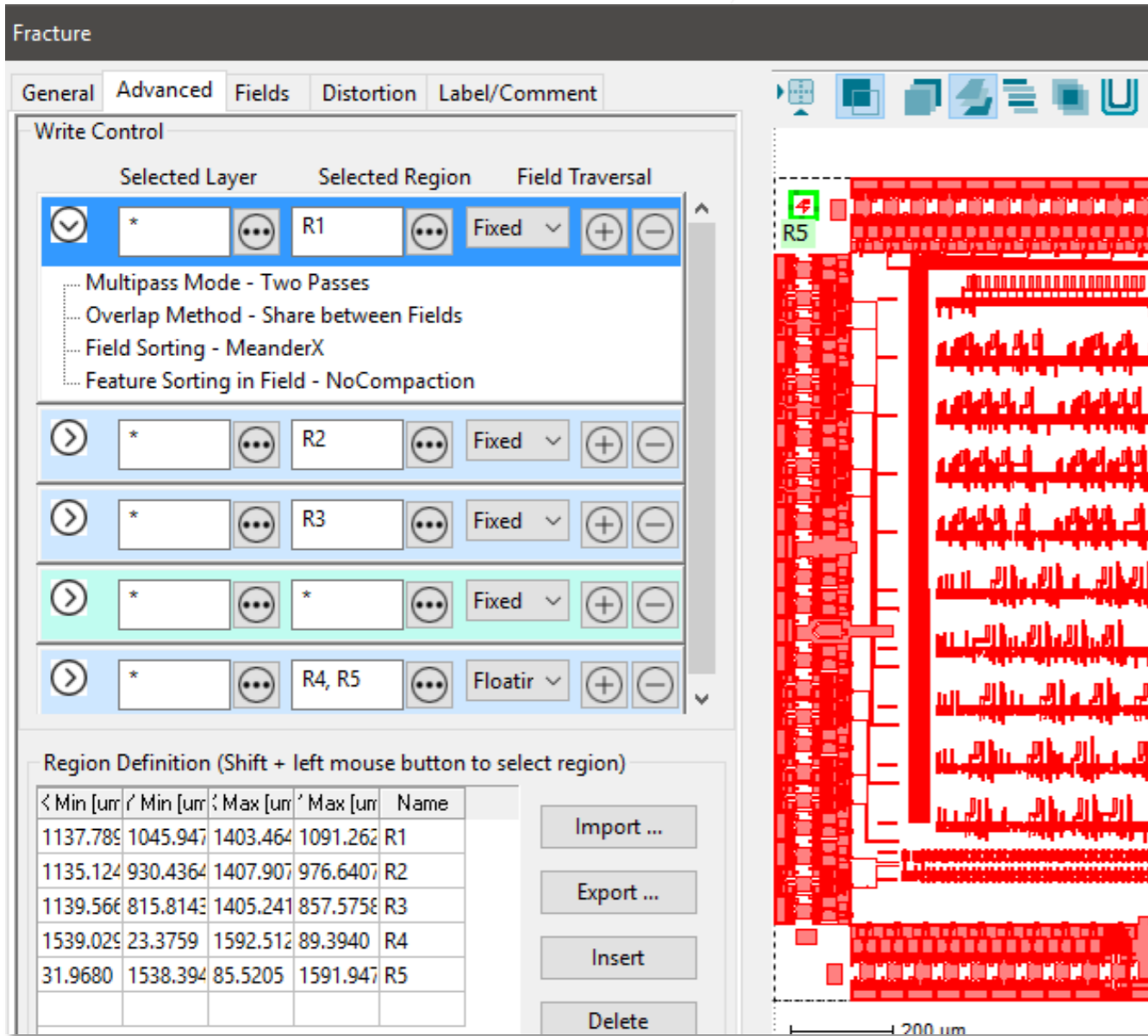
Example 1: CMOS field ordering

# Why use Fracture?



- Controlling write order can be difficult...
- Write critical devices **first**
- Write rest of layout **second**
- Write markers **last**

# Fracture Example



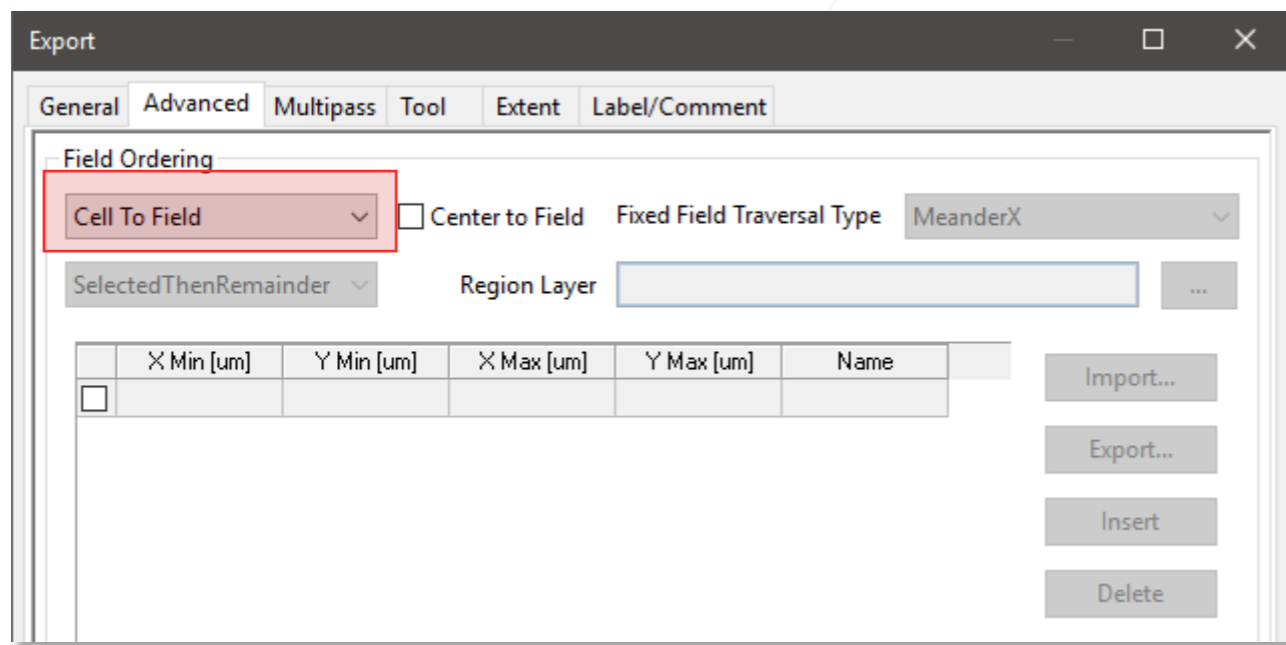
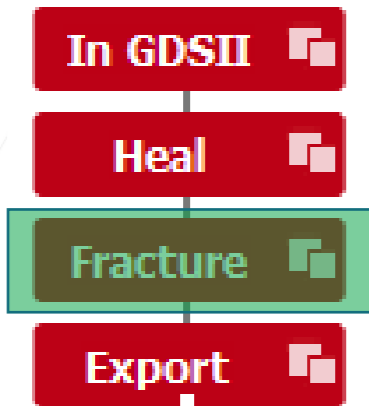
The screenshot shows the 'Fracture' software interface. The 'Advanced' tab is active, displaying the 'Write Control' section with five region definitions (R1 to R5). Below this is a 'Region Definition' table with columns for Min [um], Max [um], and Name. The PCB layout view on the right shows the regions highlighted in red.

< Min [um]	Min [um]	Max [um]	Max [um]	Name
1137.789	1045.947	1403.464	1091.262	R1
1135.124	930.4364	1407.907	976.6407	R2
1139.566	815.8143	1405.241	857.5756	R3
1539.029	23.3759	1592.512	89.3940	R4
31.9680	1538.394	85.5205	1591.947	R5

- On Advanced Tab, define “Panels” for each region.
- Features are selected in each panel (similar to using EXTRACT modules), then ordered in descending order
- Create R1, R2, R3 for critical devices, R4 and R5 for markers
  - Use “Insert” button to add each region
- Note panel 4 has \*, \* - this is “remainder” selection for all regions not explicitly defined

# Fracture Example

- Single output that can be passed to any EXPORT module
- Reminder: in EXPORT module, use “Cell To Field” Field Ordering

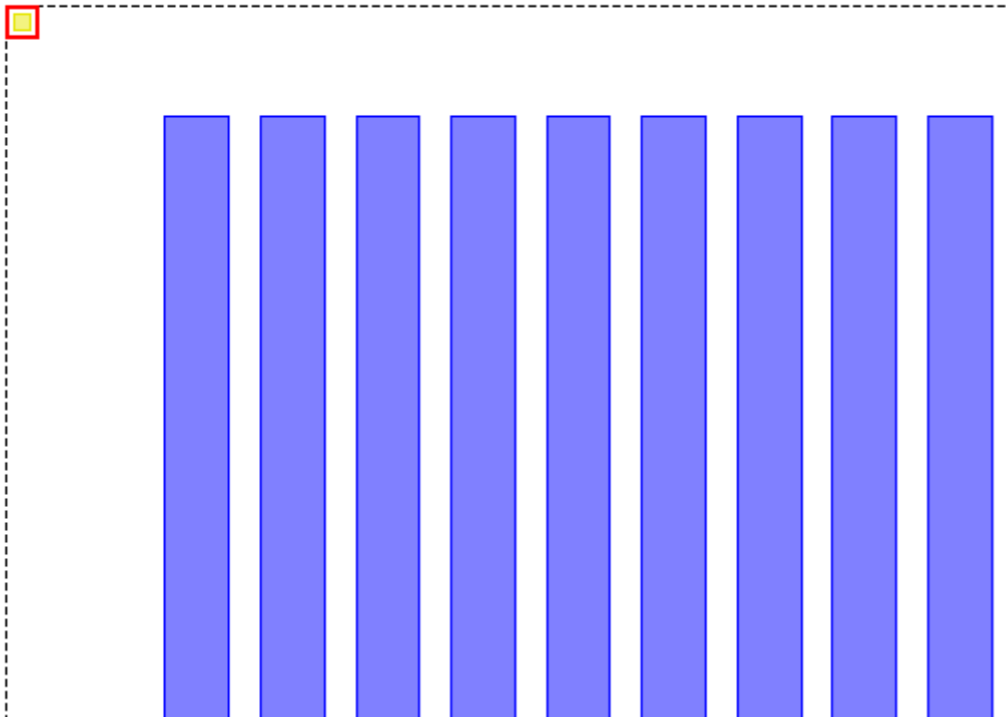


# Fracture Module Method

## 2. Returning to Closure Test

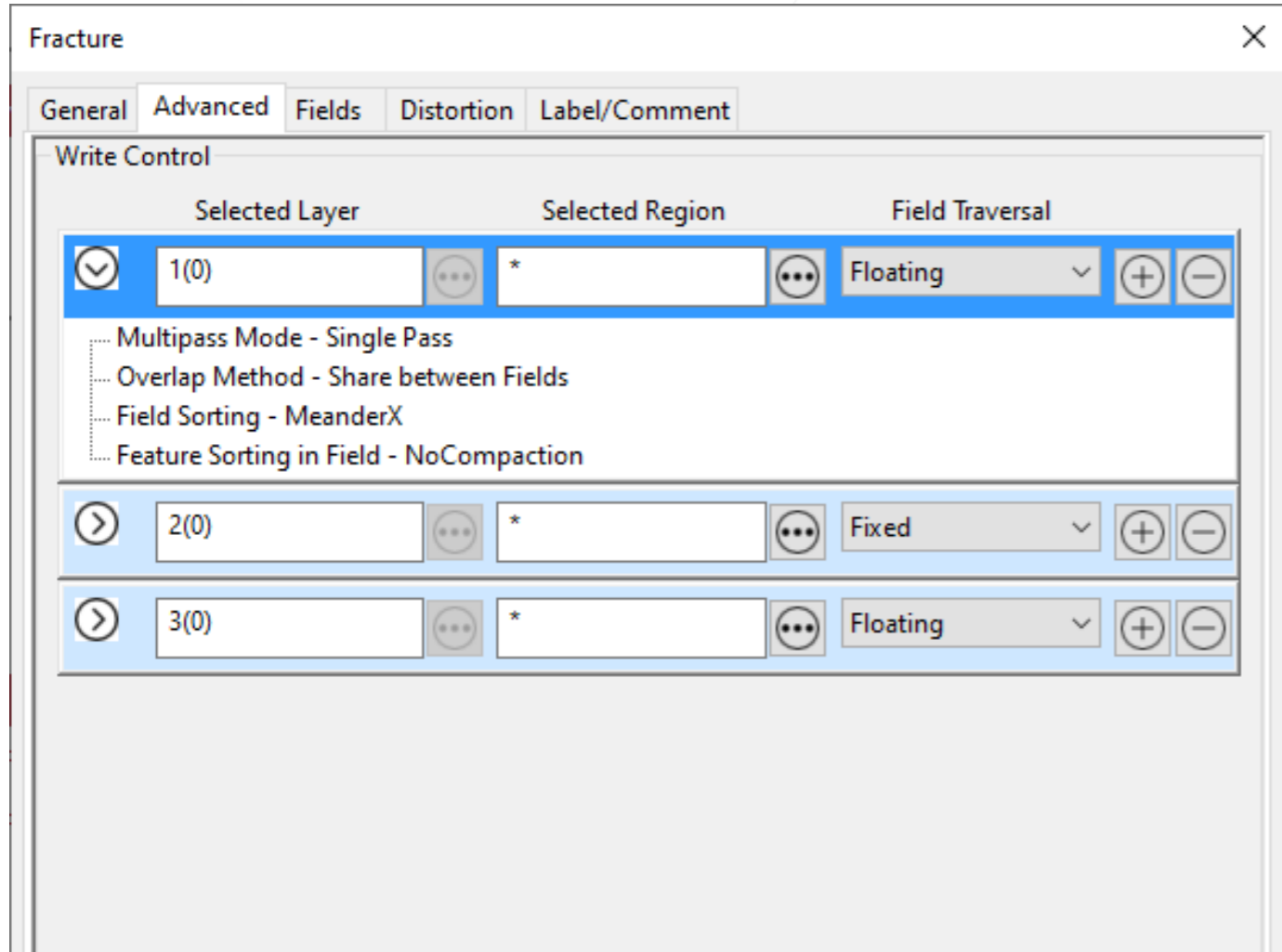


- In *Fracture*, use layer assignments to select and order data
  - Outer box on layer 1, grating on layer 2, inner box on layer 3



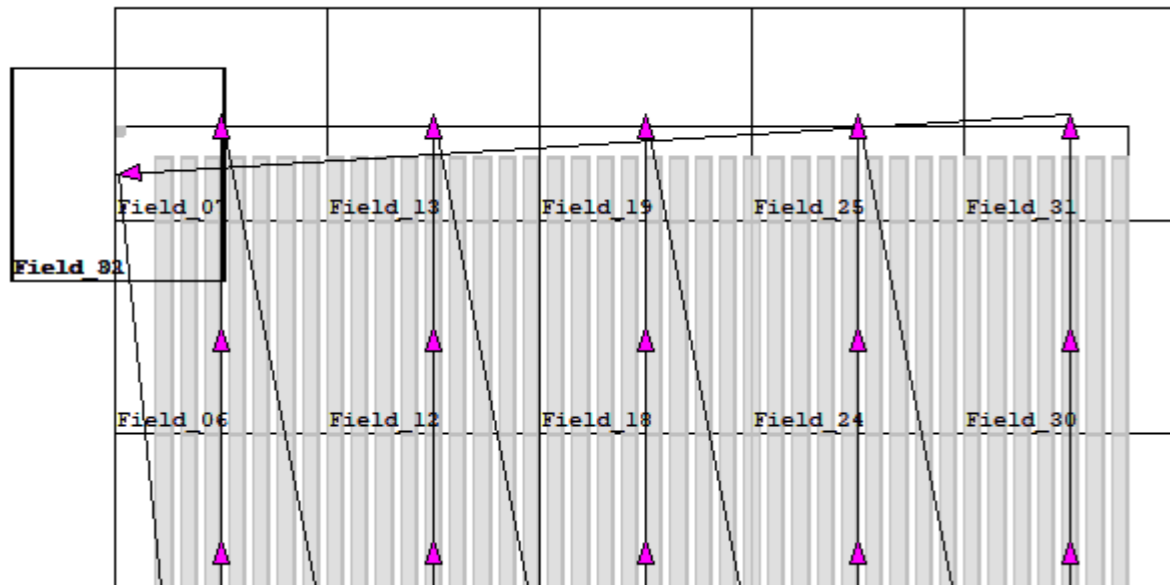
Layer	Tree	Doses	Cell Selection
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	In GDSII - box_in_box_demo_6_co...
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1(0)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2(0)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3(0)

# Closure Test

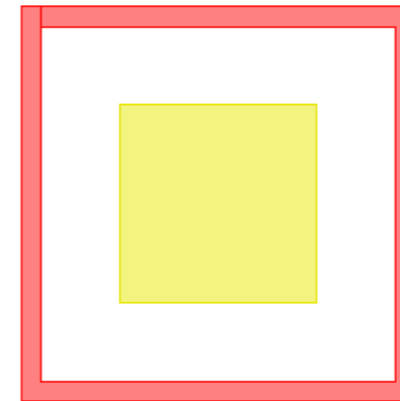


- Add 3 Panels, one for outer-box, inner-box and device (grating)
- Select Layer 1 in panel 1, Layer 2 in Panel 2, etc.
- Floating fields on box-in-box, fixed fields (y-traversal) for grating





- Same as multiple-export-module but with less work
- Outer-box is exposed first
- Pattern of interest exposed second (the grating)
- Inner-box is exposed finally



- Using BEAMER, it is possible to create a single exposure that uses multiple field control and other export options.
- This is achieved by using the “Cell To Field” option in the final export module to merge different strategies
- This general technique can be used for other challenging layouts that require mixing overlapping fields and floating fields, multi-pass and floating, feature writing orders, plus many more
- Both the “Multiple Export Module” and “Fracture Module” methods will work. Fracture module is often faster, but this is up to your preference.