A beamer tutorial

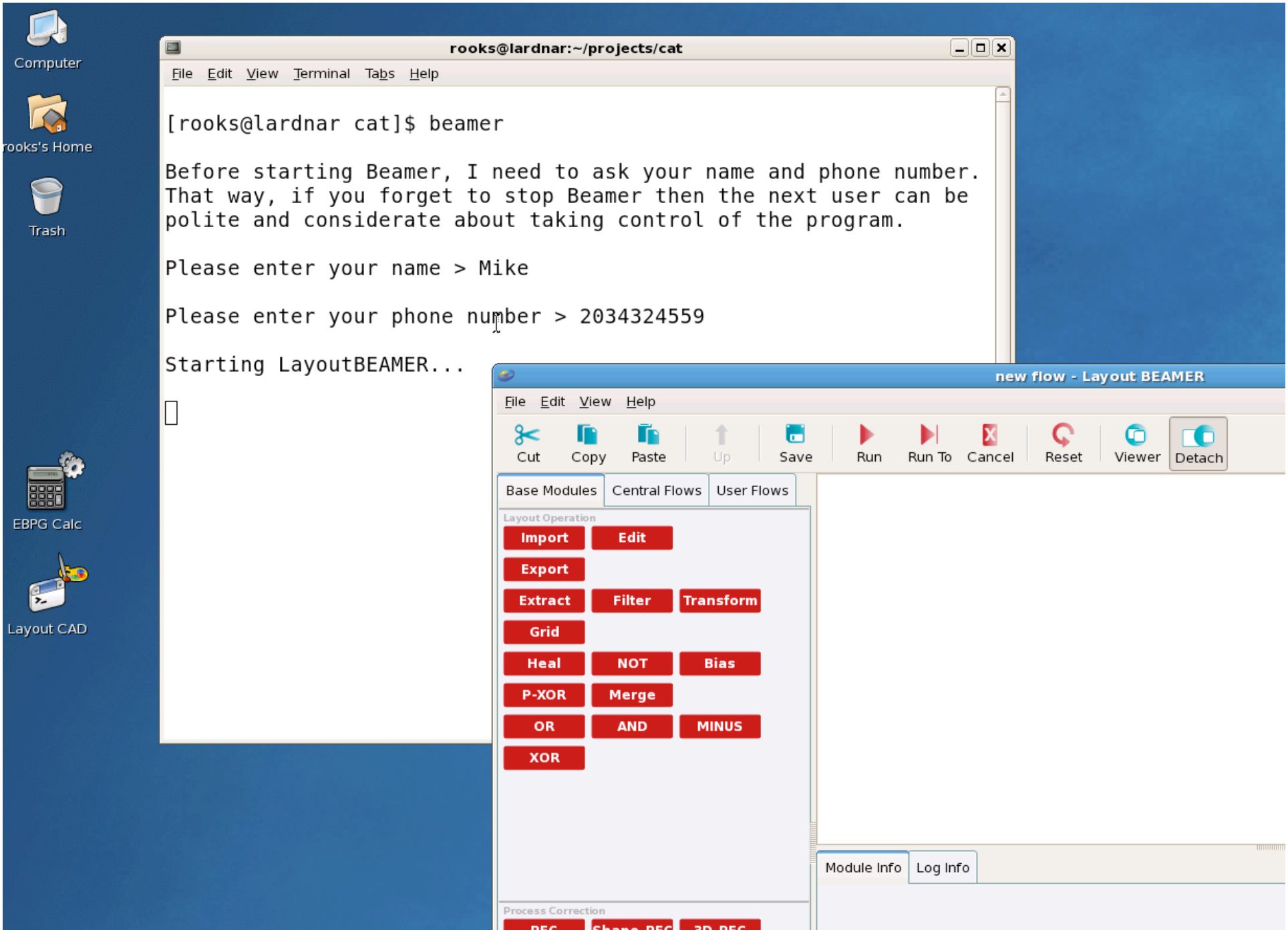
LayoutBeamer, from GenISys GmbH

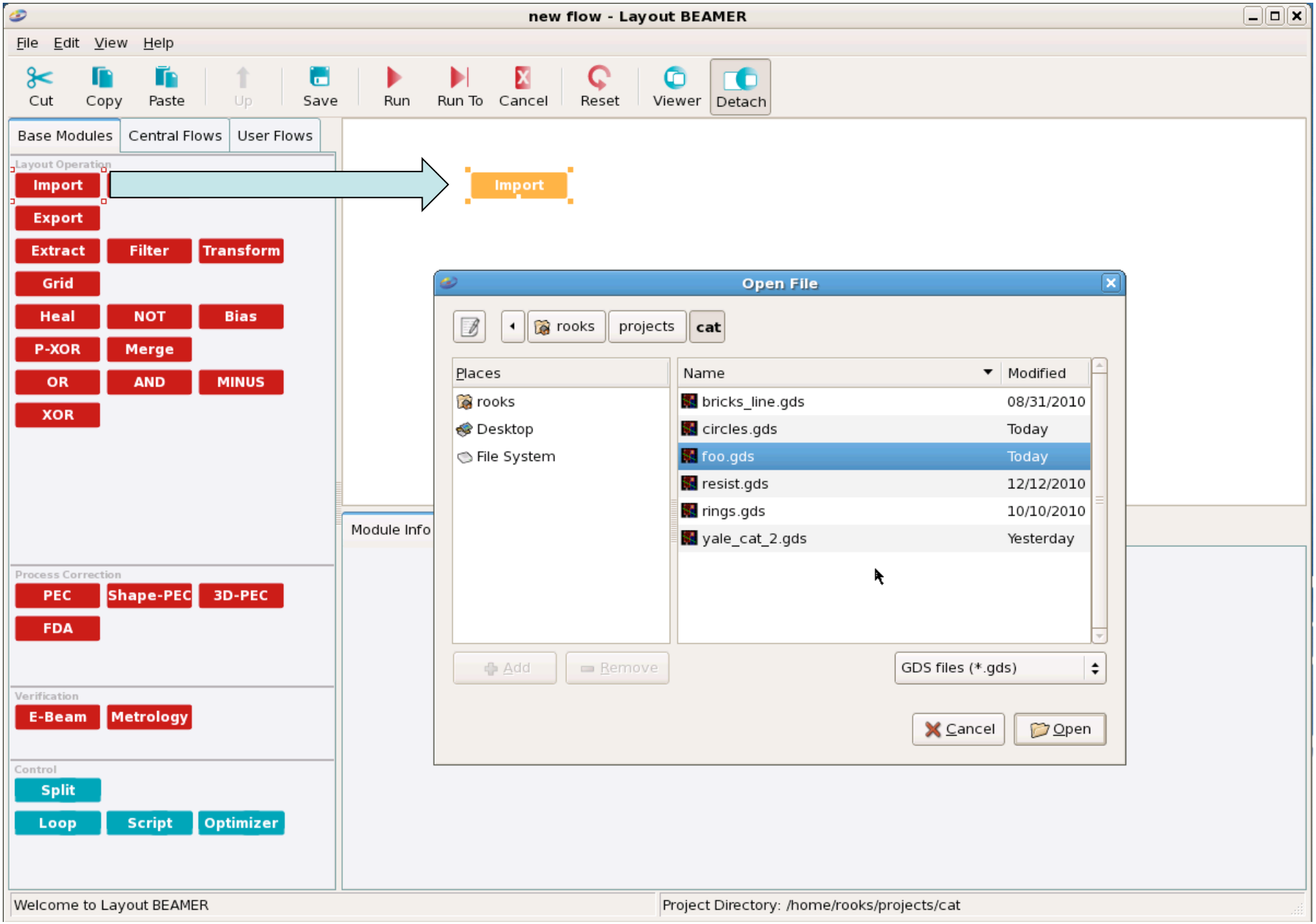
M. Rooks, Yale University

Beamer, or “LayoutBeamer” is a program which converts pattern shapes to machine-specific formats, chopping polygons into trapezoids, and cutting large patterns at exposure field boundaries. Patterns will be stitched together by writing each field, then moving the stage.

Many e-beam systems and mask writers can use the same pattern fracturing software, and so a company such as GeniSys can provide better support with a broader customer base than Vistec et al.

The main competitor is “Cats” from Synopsys, which has been the defacto standard (until recently), and is used on many e-beam writers. Cats is very mature and bug-free, but also very expensive.


Computer
rooks's Home
Trash
EBPG Calc
Layout CAD
rooks@lardnar:~/projects/cat
File Edit View Terminal Tabs Help
[rooks@lardnar cat]$ beamer
Before starting Beamer, I need to ask your name and phone number.
That way, if you forget to stop Beamer then the next user can be
polite and considerate about taking control of the program.
Please enter your name > Mike
Please enter your phone number > 2034324559
Starting LayoutBEAMER...
new flow - Layout BEAMER
File Edit View Help
Cut Copy Paste Up Save Run Run To Cancel Reset Viewer Detach
Base Modules Central Flows User Flows
Layout Operation
Import Edit
Export
Extract Filter Transform
Grid
Heal NOT Bias
P-XOR Merge
OR AND MINUS
XOR
Process Correction
Module Info Log Info


new flow - Layout BEAMER
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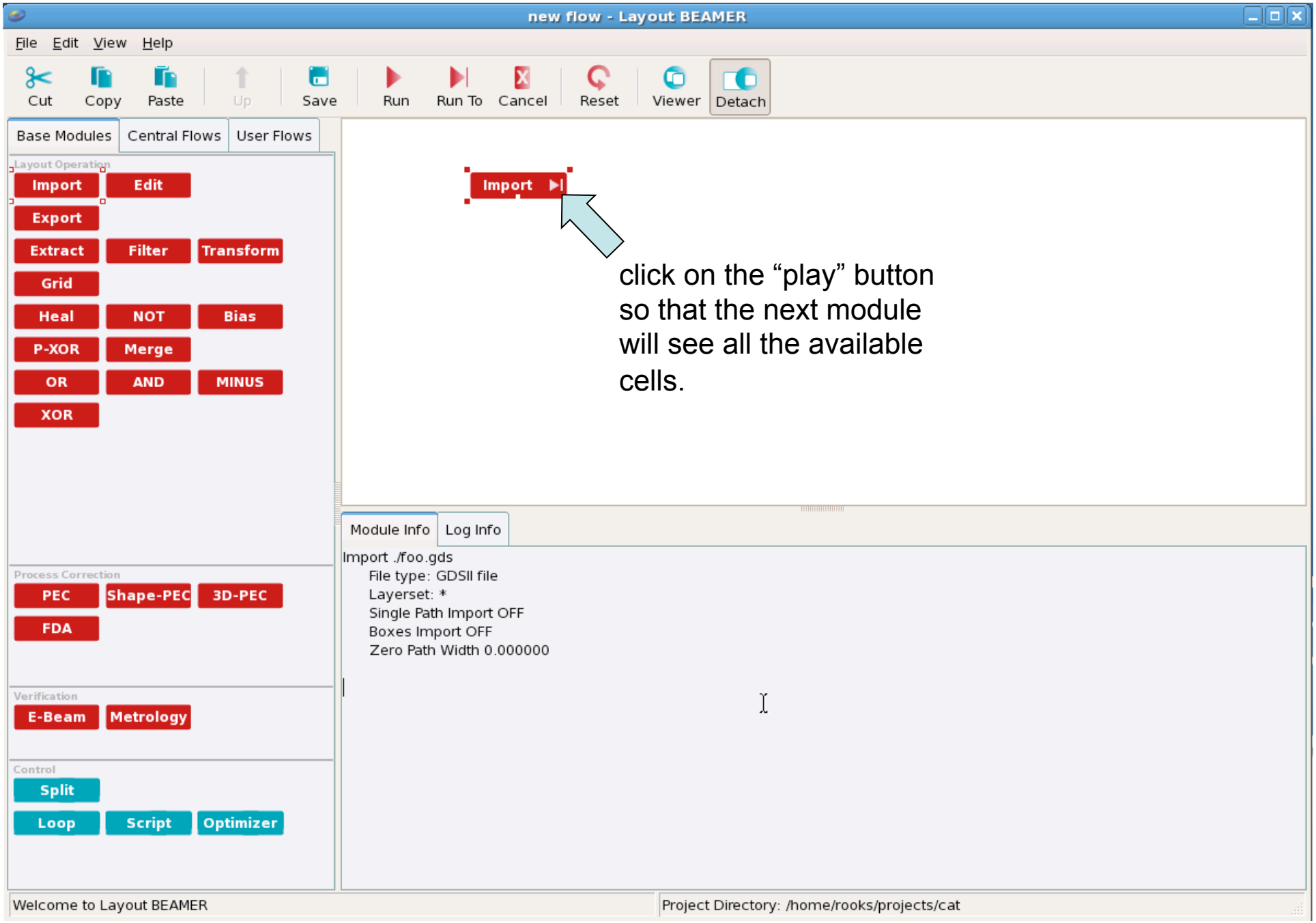
OR AND MINUS
XOR
Process Correction
PEC Shape-PEC 3D-PEC
FDA
Verification
E-Beam Metrology
Control
Split
Loop Script Optimizer
Import
Module Info
Open File
rooks projects cat
Places
rooks
Desktop
File System
Name Modified
bricks_line.gds 08/31/2010
circles.gds Today
foo.gds Today
resist.gds 12/12/2010
rings.gds 10/10/2010
yale_cat_2.gds Yesterday
Add Remove
GDS files (*.gds)
Cancel Open
Welcome to Layout BEAMER
Project Directory: /home/rooks/projects/cat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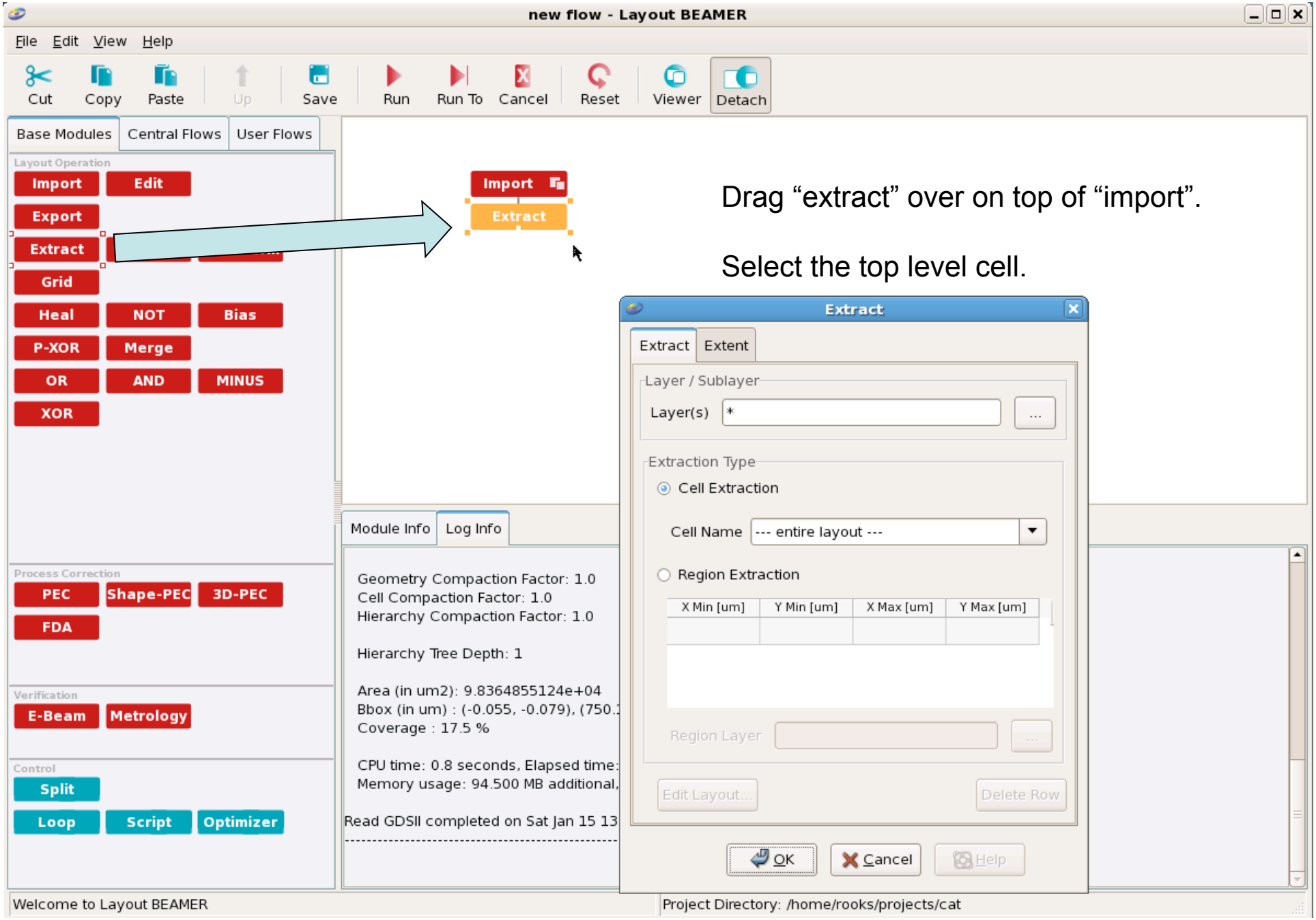
XOR
Process Correction
PEC Shape-PEC 3D-PEC
FDA
Verification
E-Beam Metrology
Control
Split
Loop Script Optimizer
Import
click on the “play” button so that the next module will see all the available cells.
Module Info Log Info
Import ./foo.gds
File type: GDSII file
Layerset: *
Single Path Import OFF
Boxes Import OFF
Zero Path Width 0.000000
Welcome to Layout BEAMER
Project Directory: /home/rooks/projects/cat


new flow - Layout BEAMER
File Edit View Help
Cut Copy Paste Up Save Run Run To Cancel Reset Viewer Detach
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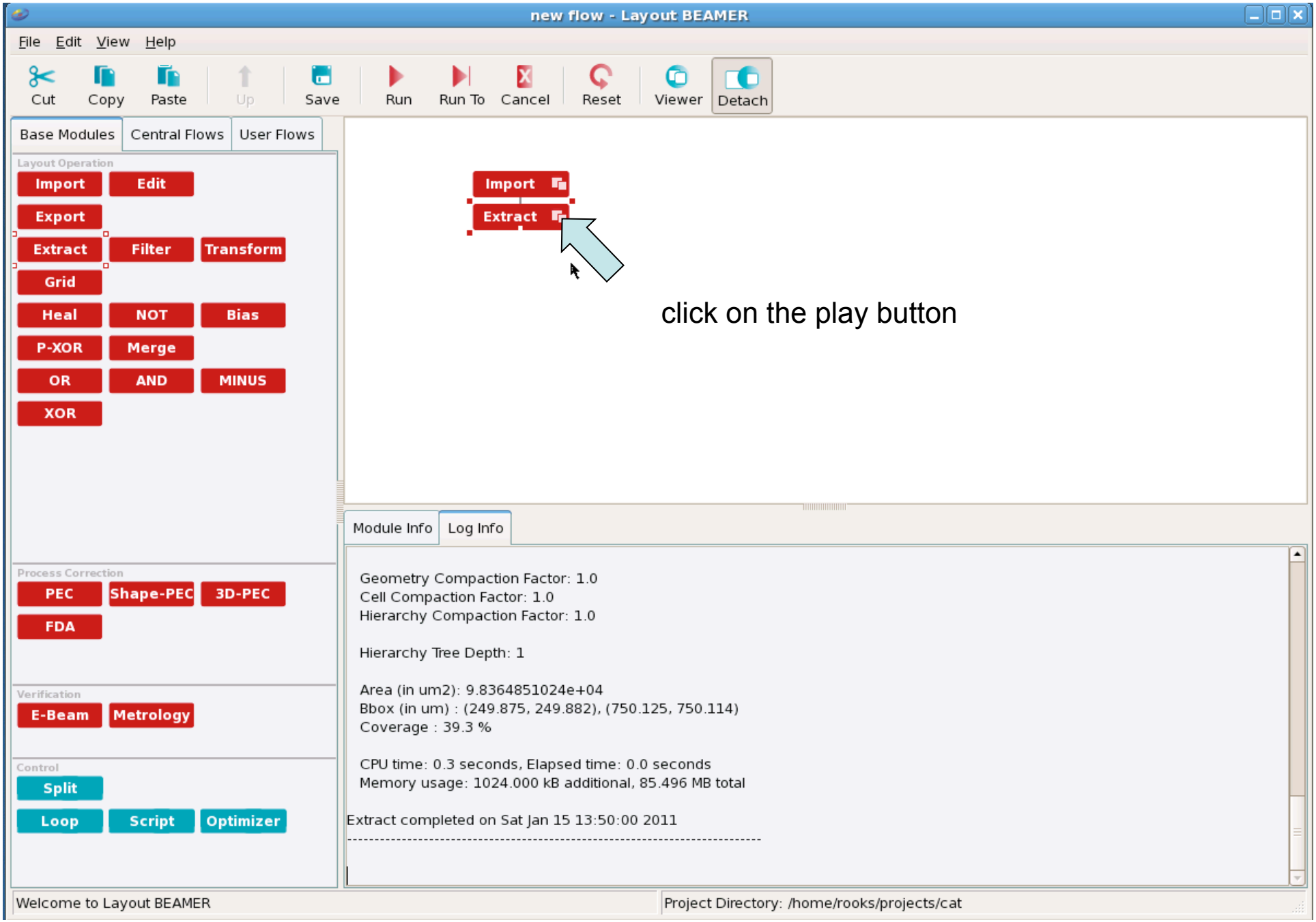
Process Correction
PEC Shape-PEC 3D-PEC
FDA
Verification
E-Beam Metrology
Control
Split
Loop Script Optimizer
Import
Extract
Drag “extract” over on top of “import”.
Select the top level cell.
Module Info Log Info
Geometry Compaction Factor: 1.0
Cell Compaction Factor: 1.0
Hierarchy Compaction Factor: 1.0
Hierarchy Tree Depth: 1
Area (in um2): 9.8364855124e+04
Bbox (in um) : (-0.055, -0.079), (750.
Coverage : 17.5 %
CPU time: 0.8 seconds, Elapsed time:
Memory usage: 94.500 MB additional,
Read GDSII completed on Sat Jan 15 13
Extract
Extract Extent
Layer / Sublayer
Layer(s) *
Extraction Type
Cell Extraction
Cell Name --- entire layout ---
Region Extraction
X Min [um] Y Min [um] X Max [um] Y Max [um]
Region Layer
Edit Layout... Delete Row
OK Cancel Help
Welcome to Layout BEAMER
Project Directory: /home/rooks/projects/cat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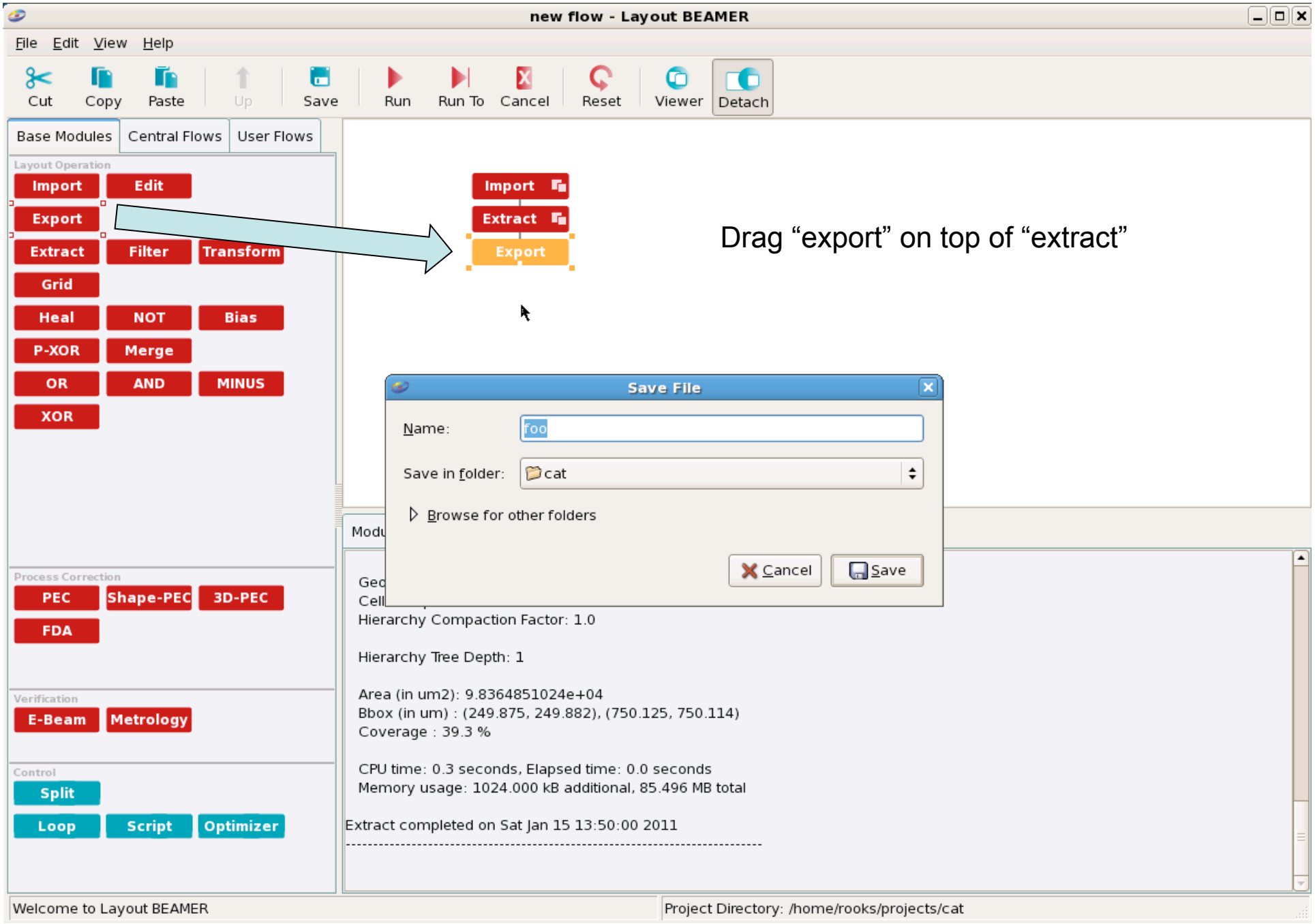
Control
Split
Loop Script Optimizer
Import
Extract
click on the play button
Module Info Log Info
Geometry Compaction Factor: 1.0
Cell Compaction Factor: 1.0
Hierarchy Compaction Factor: 1.0
Hierarchy Tree Depth: 1
Area (in um2): 9.8364851024e+04
Bbox (in um) : (249.875, 249.882), (750.125, 750.114)
Coverage : 39.3 %
CPU time: 0.3 seconds, Elapsed time: 0.0 seconds
Memory usage: 1024.000 kB additional, 85.496 MB total
Extract completed on Sat Jan 15 13:50:00 2011
Welcome to Layout BEAMER
Project Directory: /home/rooks/projects/cat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FDA
Verification
E-Beam Metrology
Control
Split
Loop Script Optimizer
Import
Extract
Export
Drag “export” on top of “extract”
Save File
Name: foo
Save in folder: cat
Browse for other folders
Cancel Save
Hierarchy Compaction Factor: 1.0
Hierarchy Tree Depth: 1
Area (in um2): 9.8364851024e+04
Bbox (in um) : (249.875, 249.882), (750.125, 750.114)
Coverage : 39.3 %
CPU time: 0.3 seconds, Elapsed time: 0.0 seconds
Memory usage: 1024.000 kB additional, 85.496 MB total
Extract completed on Sat Jan 15 13:50:00 2011
Welcome to Layout BEAMER
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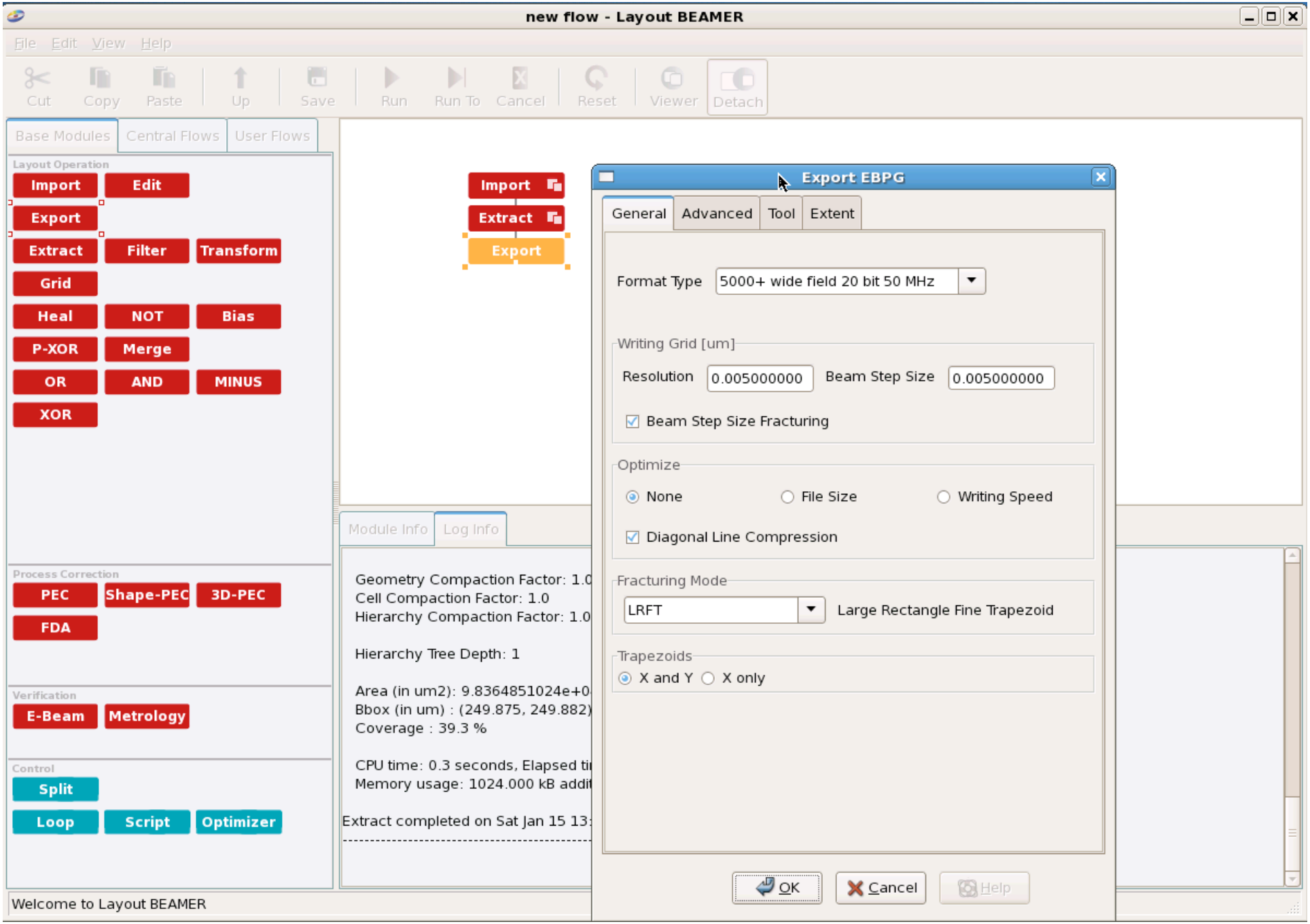
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Import
Extract
Export
Module Info Log Info
Geometry Compaction Factor: 1.0
Cell Compaction Factor: 1.0
Hierarchy Compaction Factor: 1.0
Hierarchy Tree Depth: 1
Area (in um2): 9.8364851024e+0
Bbox (in um) : (249.875, 249.882)
Coverage : 39.3 %
CPU time: 0.3 seconds, Elapsed ti
Memory usage: 1024.000 kB addit
Extract completed on Sat Jan 15 13:
Welcome to Layout BEAMER
Export EBPG
General Advanced Tool Extent
Format Type 5000+ wide field 20 bit 50 MHz
Writing Grid [um]
Resolution 0.005000000
Beam Step Size 0.005000000
Beam Step Size Fracturing
Optimize
None File Size Writing Speed
Diagonal Line Compression
Fracturing Mode
LRFT
Large Rectangle Fine Trapezoid
Trapezoids
X and Y X only
OK Cancel Help

The default settings are almost always the best choices.

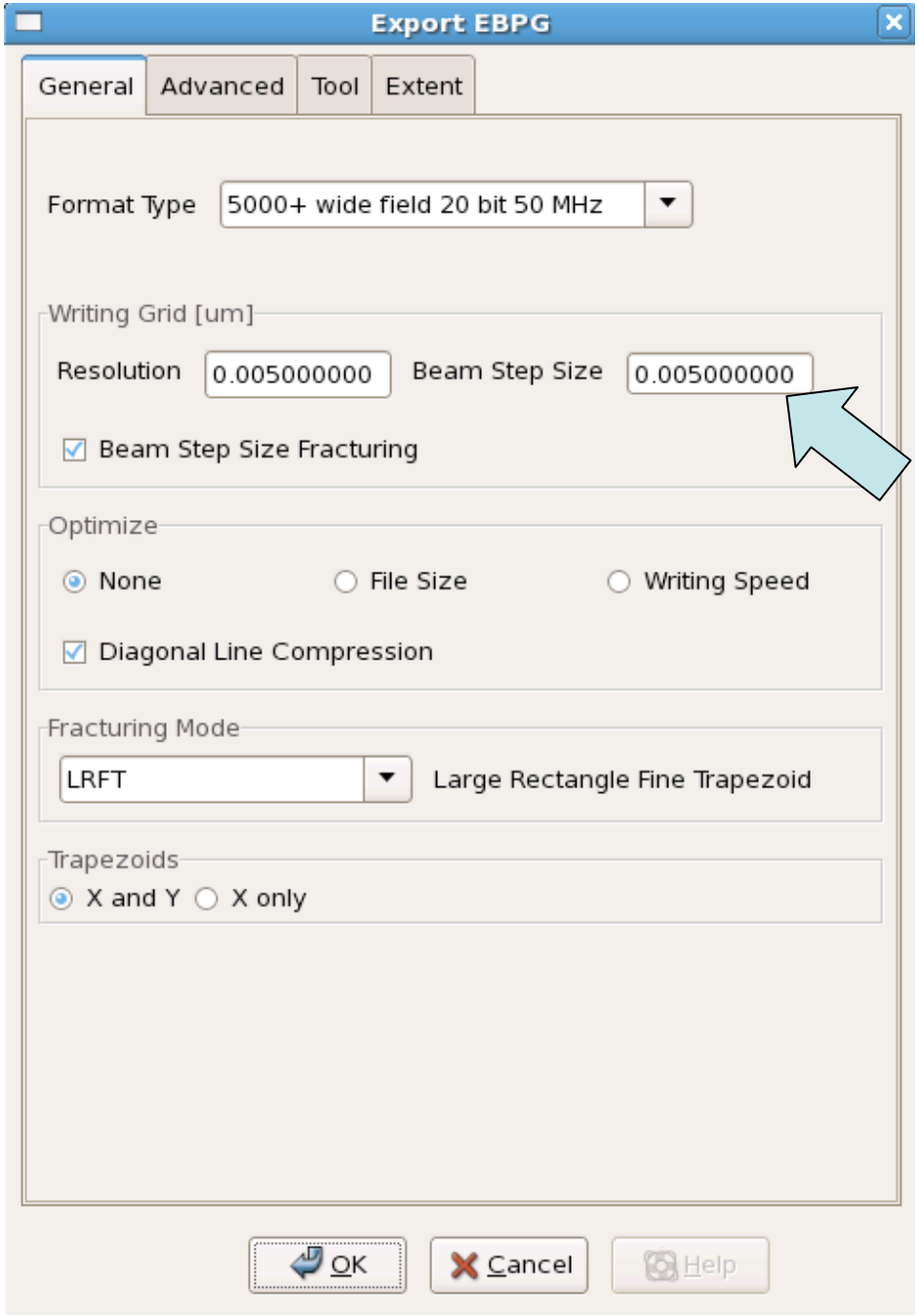
The two things you will have to choose: beam step size and field size.

In **this** dialog box, “resolution” means “fracturing resolution”. It should always equal the beam step size.

You should calculate the best beam step based on resist sensitivity and resolution requirements.

One way to do this is to use the EBPG calculator.

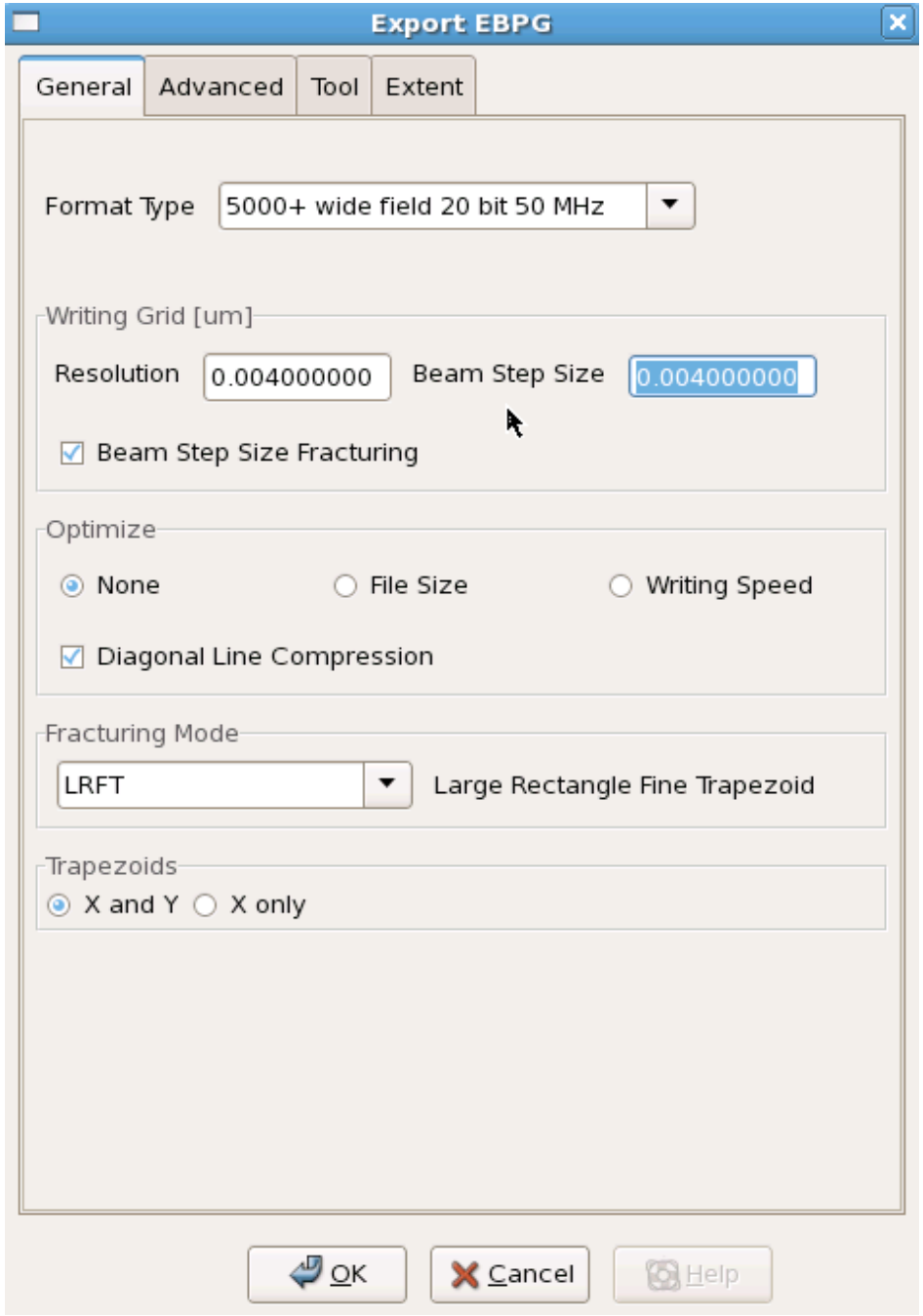
But really, you should have thought about the beam step long ago, before doing the CAD.



Let's change the beam step to 0.004 microns (4 nm).

Make sure the "resolution" is also 0.004 microns. It may or may not change by itself.

Next switch to the "Advanced" tab.



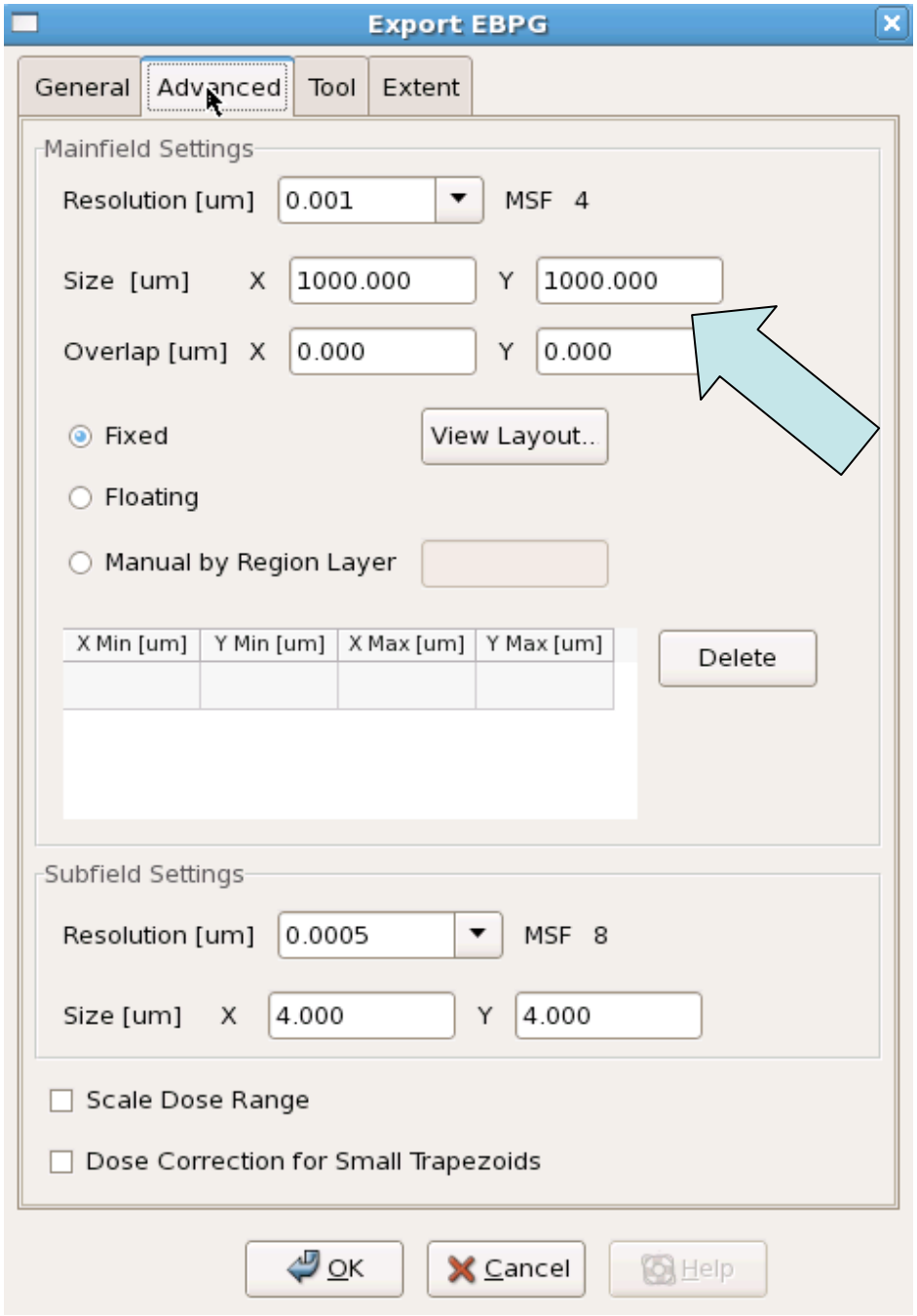
Here the term “resolution” means the EBPG’s bit size; that is, one DAC bit equals 1 nm. That’s the default, and you should not change it.

It’s unfortunate that Beamer uses the term “resolution” to mean two different things.

Now look at the “Mainfield Size”. This is a subset of the maximum exposure field (1 nm)(2^{20}) ≈ 1 mm. Some folks call this the “block size”, because the pattern will be chopped into blocks of this size.

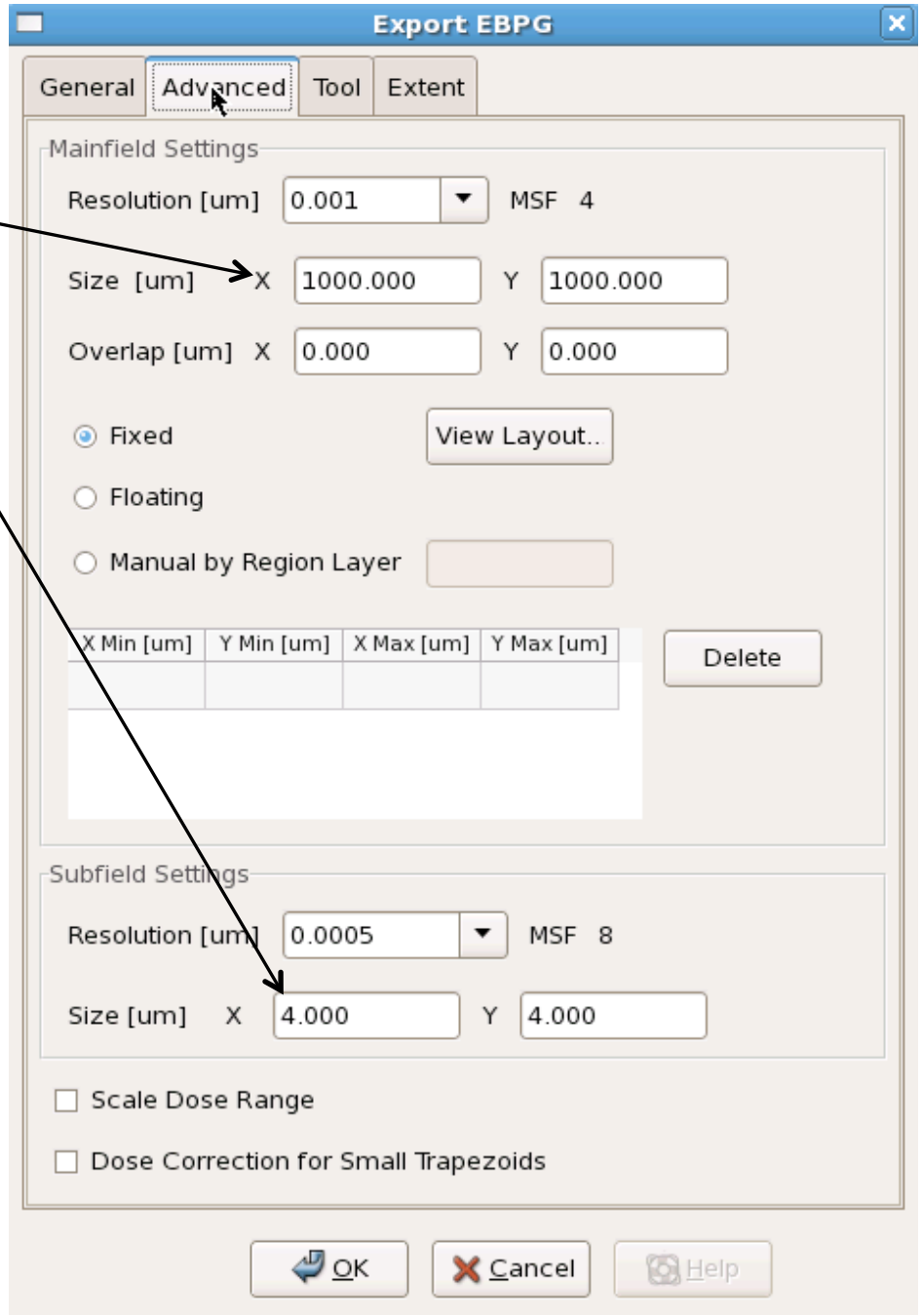
The default size was 600 μm, but Beamer changed it to 1000 μm when you changed the step size. Why? Because it seemed like a good idea to someone, long ago.

Now you should change it to some sensible number, like… 600 μm.

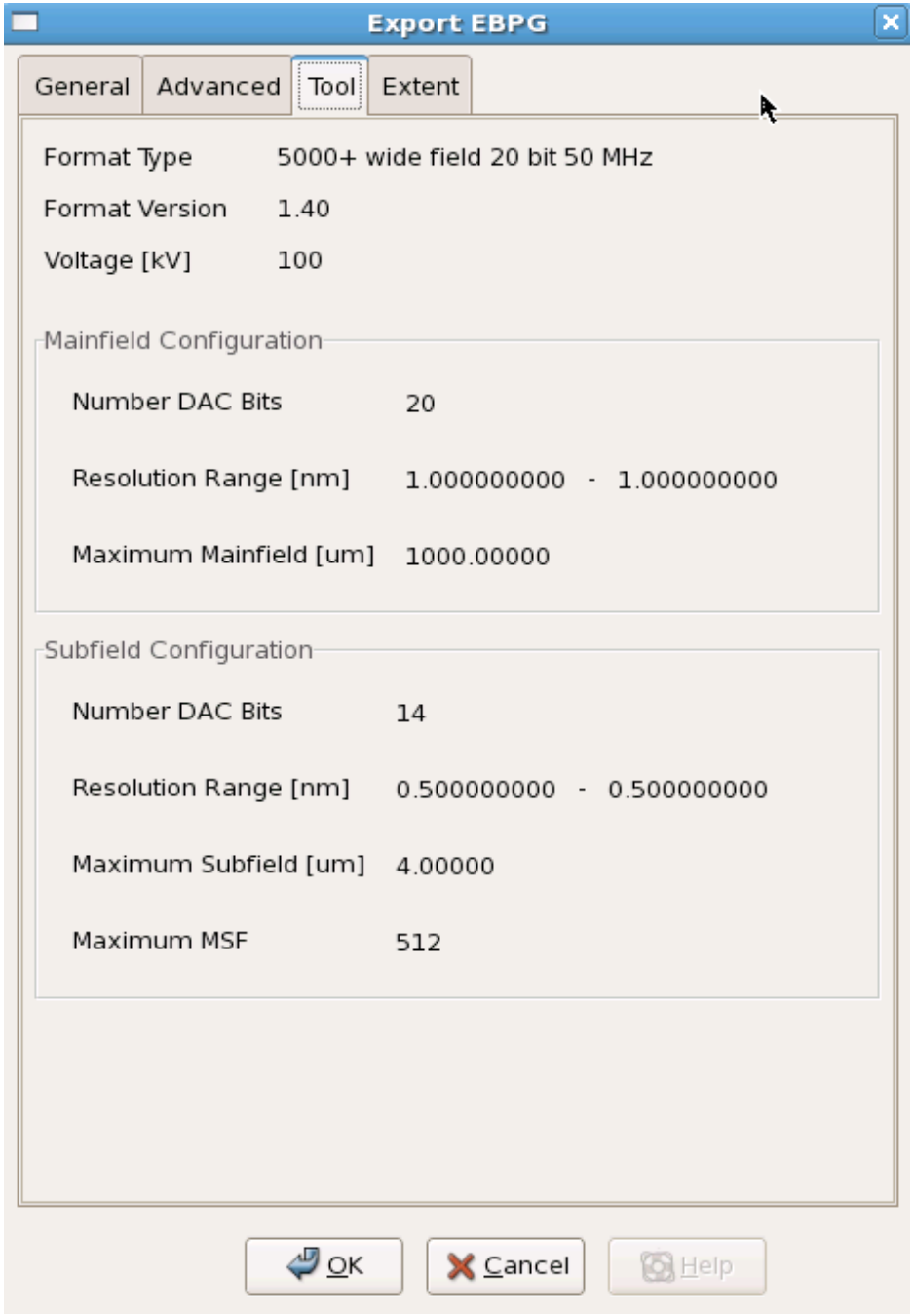


Make sure that the field (block) size is a multiple of the subfield size.

Otherwise, the left-over subfield will be written long after the others, leading to subfield misplacement due to drift.



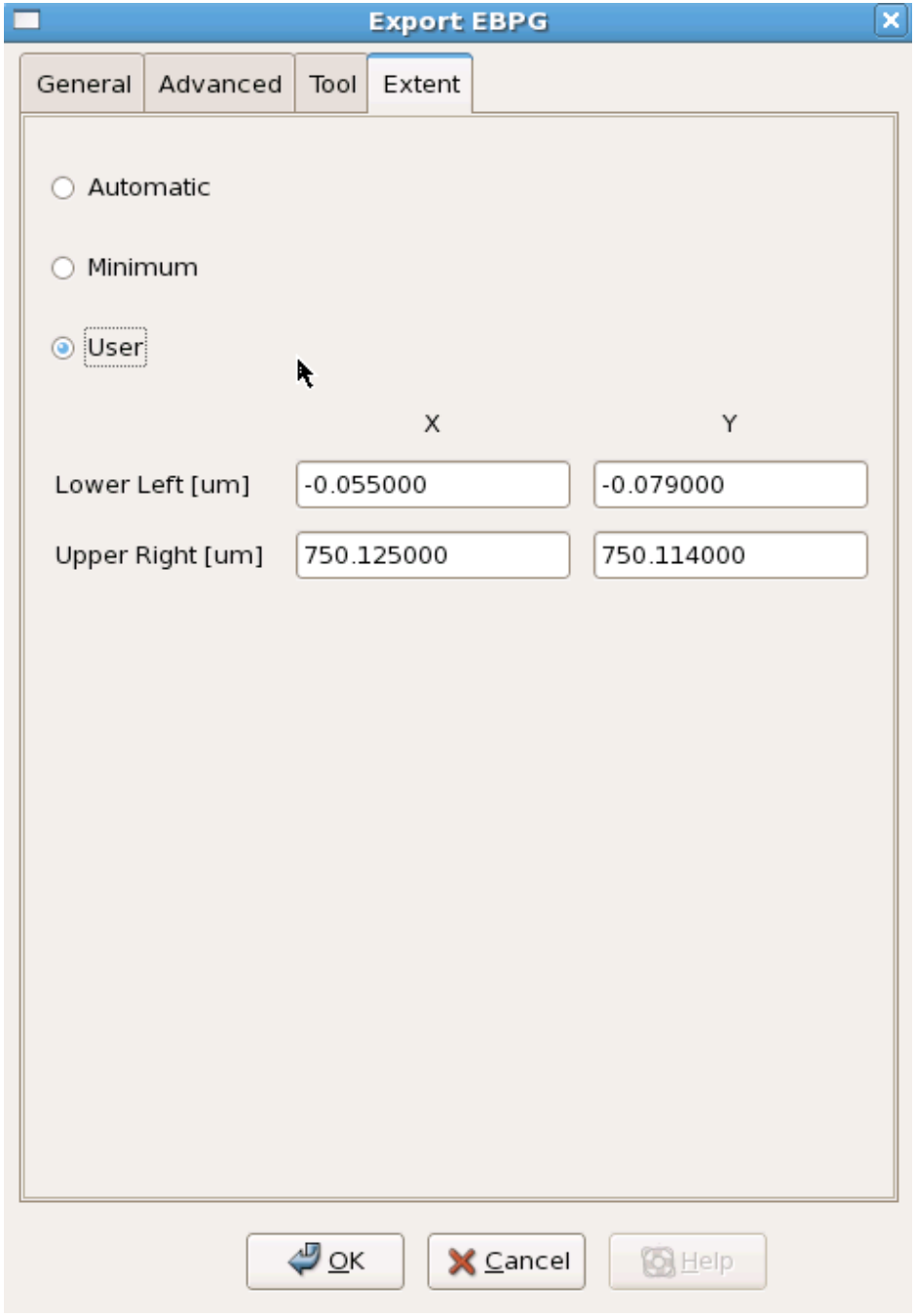
Thank goodness we can't change anything on the "tool" tab.



On the “extent” tab you may want to change the lower-left corner to control the field fracturing.

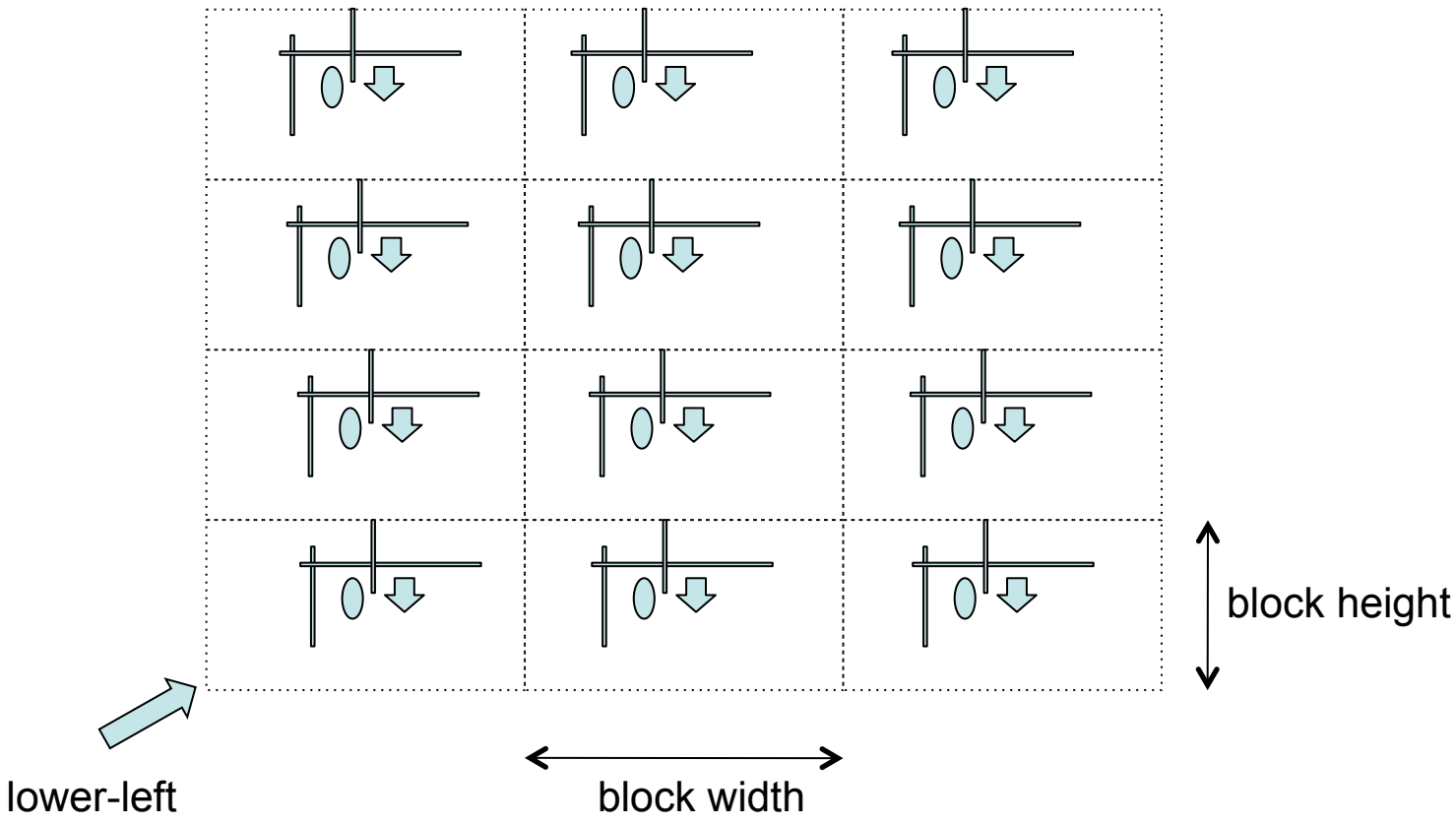
You should also pay attention to the upper-right corner, since the average of these coordinates will be the “chip center”.

The “chip center” will be the reference point for placement and alignment in Vistec’s exposure job software.



Click on the play button to start the fracturing process.
When that is done, click on the same spot to see
the fractured pattern

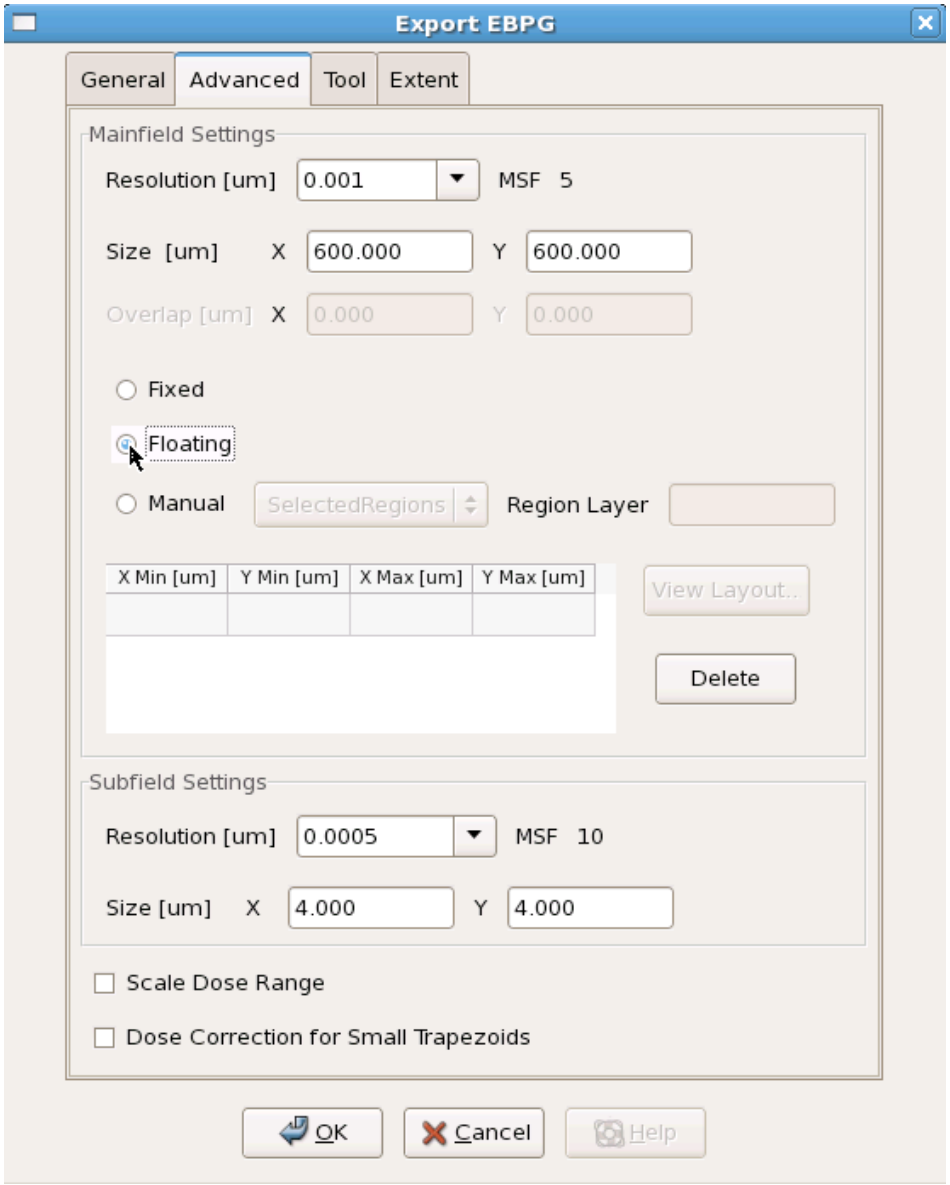
Choose the lower-left point and the block size
so that stitching boundaries will avoid critical features.
The sample stage will move at block boundaries,
causing stitching errors of 15-20 nm.



Actually, you should think about field stitching while planning the design.
You may have to go back to the CAD program and start over.

Alternatively, try using the “floating field” option, which will let Beamer attempt to center isolated features inside exposure fields.

For some designs this can be very handy.

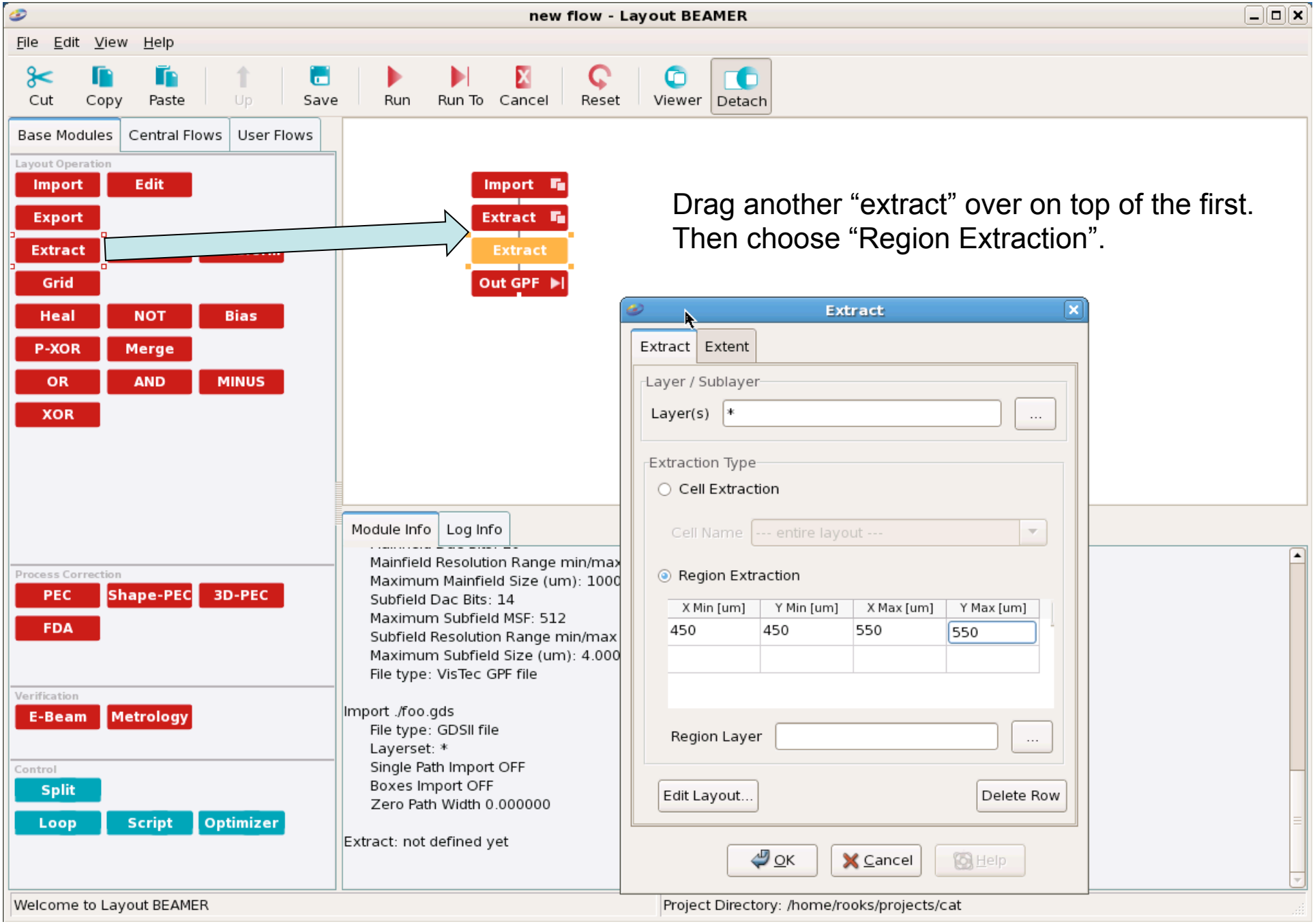


Those are the three basic steps you always need:

Import
Extract
Export

But there are all sorts of other things you might need to do.

For example, suppose you need to crop the pattern.
You'll find that you cannot simply set the lower-left and upper-right corners in the "export" box. Instead, you'll need an extra "extract" step.


new flow - Layout BEAMER
File Edit View Help
Cut Copy Paste Up Save Run Run To Cancel Reset Viewer Detach
Base Modules Central Flows User Flows
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XOR
Process Correction
PEC Shape-PEC 3D-PEC
FDA
Verification
E-Beam Metrology
Control
Split
Loop Script Optimizer
Import
Extract
Extract
Out GPF
Drag another “extract” over on top of the first.
Then choose “Region Extraction”.
Module Info Log Info
Mainfield Resolution Range min/max
Maximum Mainfield Size (um): 1000
Subfield Dac Bits: 14
Maximum Subfield MSF: 512
Subfield Resolution Range min/max
Maximum Subfield Size (um): 4.000
File type: VisTec GPF file
Import ./foo.gds
File type: GDSII file
Layerset: *
Single Path Import OFF
Boxes Import OFF
Zero Path Width 0.000000
Extract: not defined yet
Extract
Extract Extent
Layer / Sublayer
Layer(s) *
Extraction Type
Cell Extraction
Cell Name --- entire layout ---
Region Extraction
X Min [um] Y Min [um] X Max [um] Y Max [um]
450 450 550 550
Region Layer
Edit Layout...
Delete Row
OK Cancel Help
Welcome to Layout BEAMER
Project Directory: /home/rooks/projects/cat

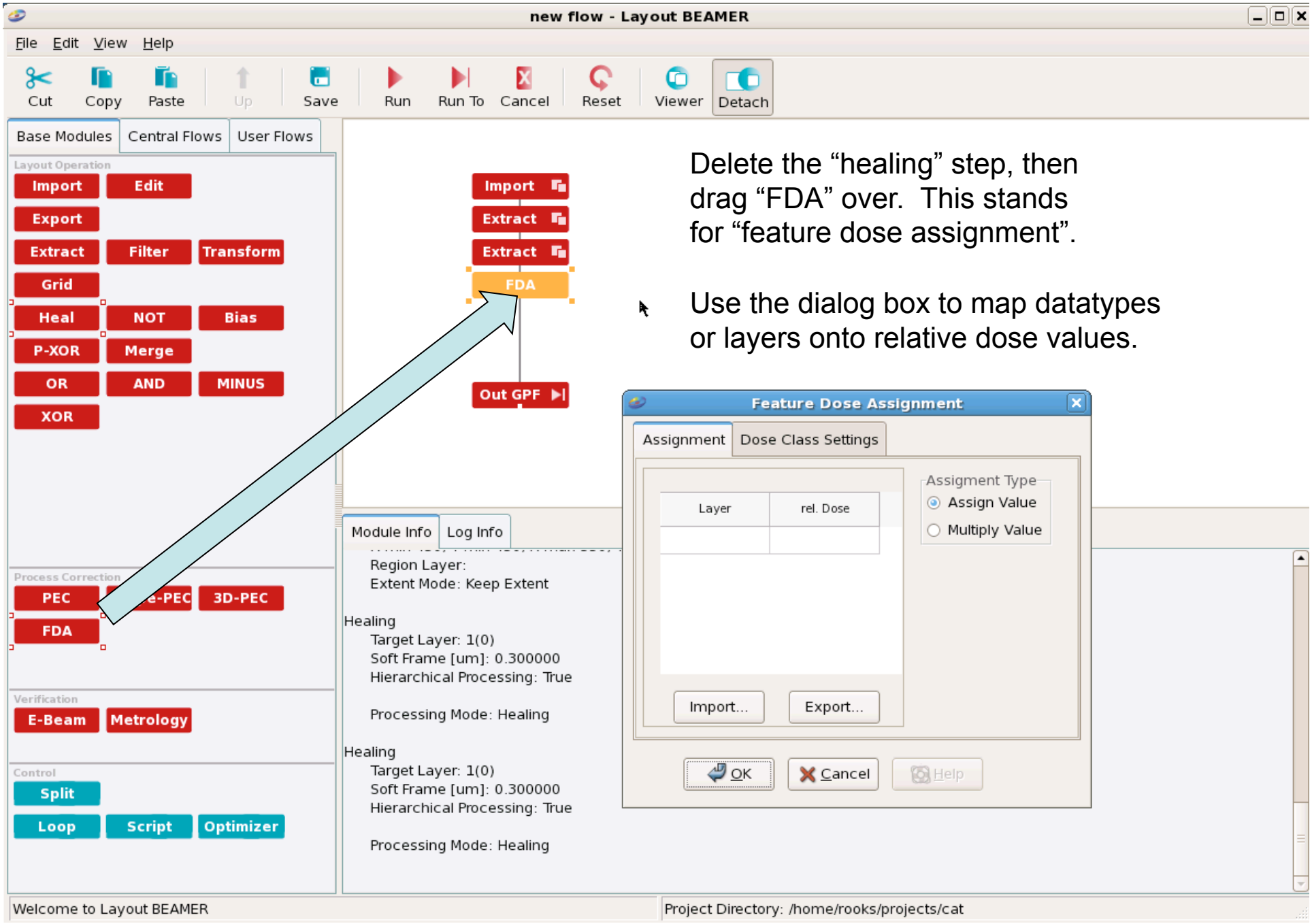
click on “play” at the bottom to rerun the steps.

Then click there again to view the pattern.

Another important function is overlap removal, or “healing”. Actually, healing and overlap removal are two things, but in practice you always want to heal the shapes (merge them) after removing overlaps.

If you remove overlaps and heal the pattern, any information about layers and datatypes will be lost. So… healing is not allowed, if you need to assign doses.

How do you assign doses?


new flow - Layout BEAMER
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Control
Split
Loop Script Optimizer
Import
Extract
Extract
FDA
Out GPF
Module Info Log Info
Region Layer:
Extent Mode: Keep Extent
Healing
Target Layer: 1(0)
Soft Frame [um]: 0.300000
Hierarchical Processing: True
Processing Mode: Healing
Healing
Target Layer: 1(0)
Soft Frame [um]: 0.300000
Hierarchical Processing: True
Processing Mode: Healing
Delete the “healing” step, then drag “FDA” over. This stands for “feature dose assignment”.
Use the dialog box to map datatypes or layers onto relative dose values.
Feature Dose Assignment
Assignment Dose Class Settings
Layer rel. Dose
Assigment Type
Assign Value
Multiply Value
Import... Export...
OK Cancel Help
Welcome to Layout BEAMER
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When you pull down the list box under “layer”, you should see a list of all the layers and datatypes in your pattern.

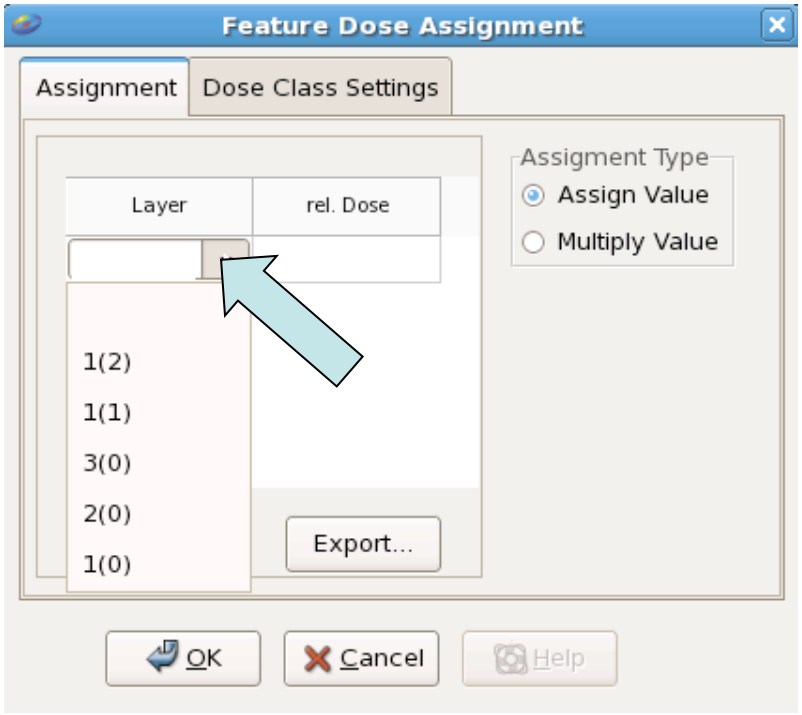
They are listed as

layer (datatype)

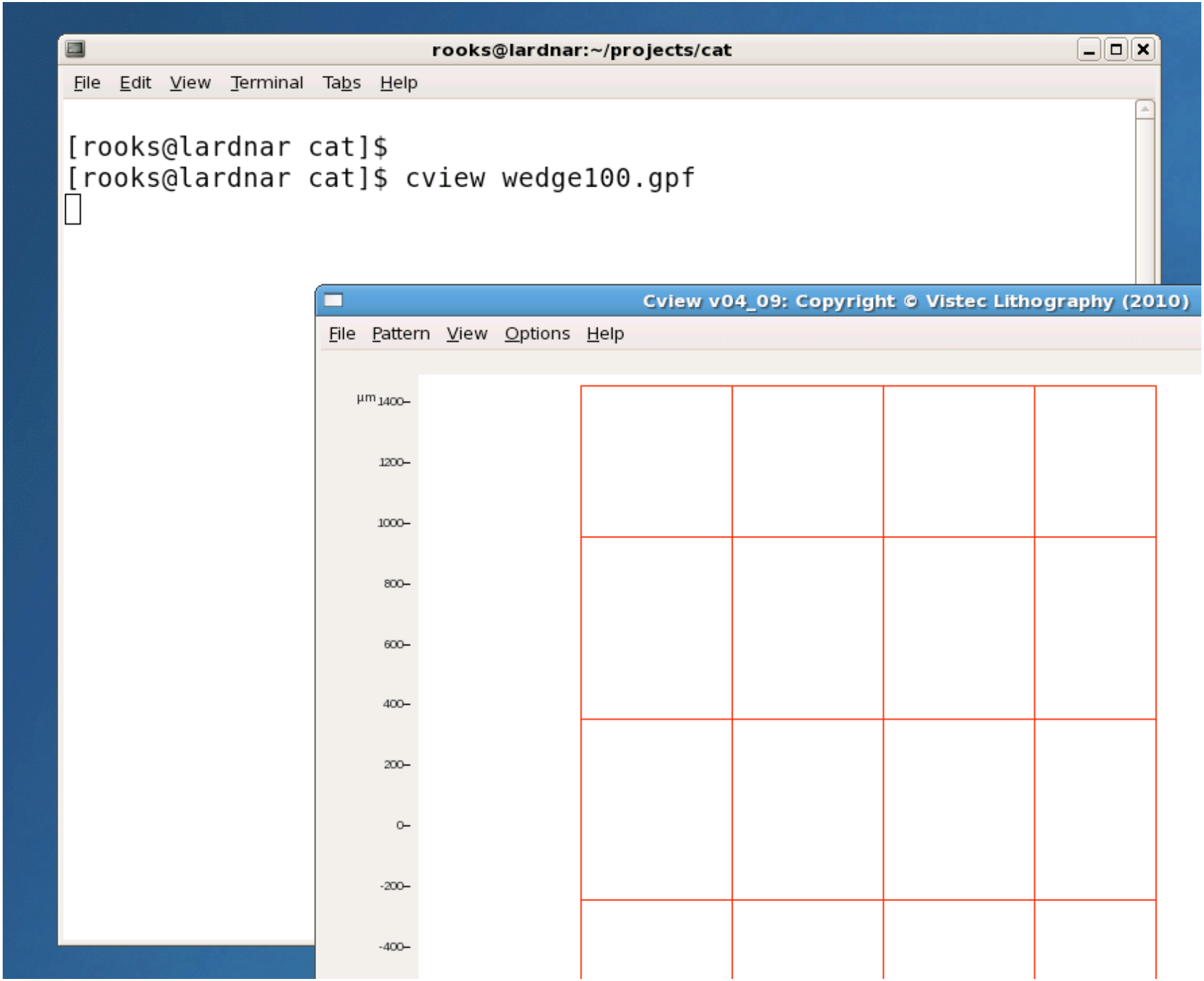
In this pattern, layer 0 includes shapes with datatypes 0, 1, 2.

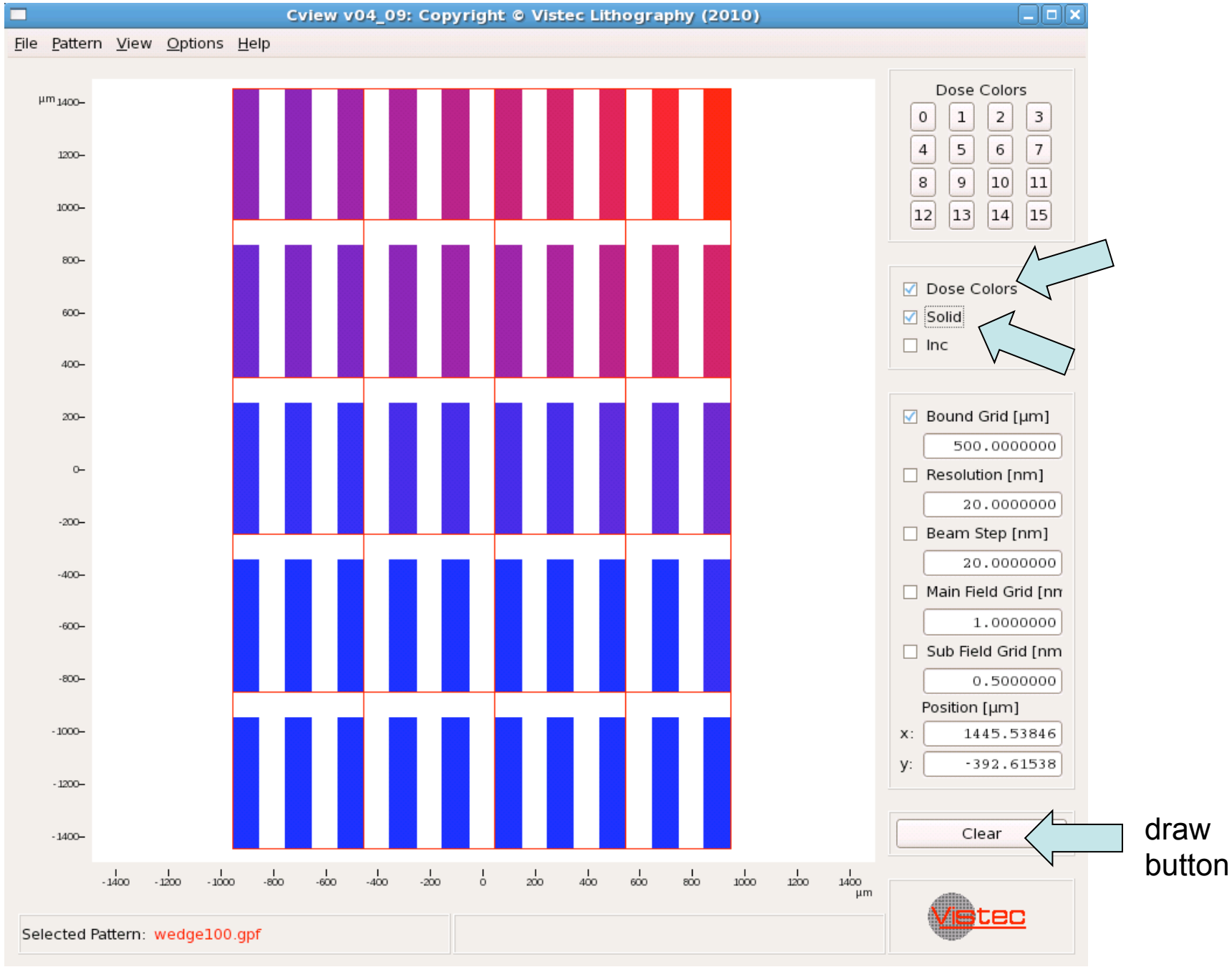
The EBPG accepts RELATIVE dose values. Other e-beam writers let you create a dose variable that can be assigned at run-time. Not the EBPG.

(The “assignment type” choice seems to be irrelevant for the EBPG.)



Checking the GPF file with Cview

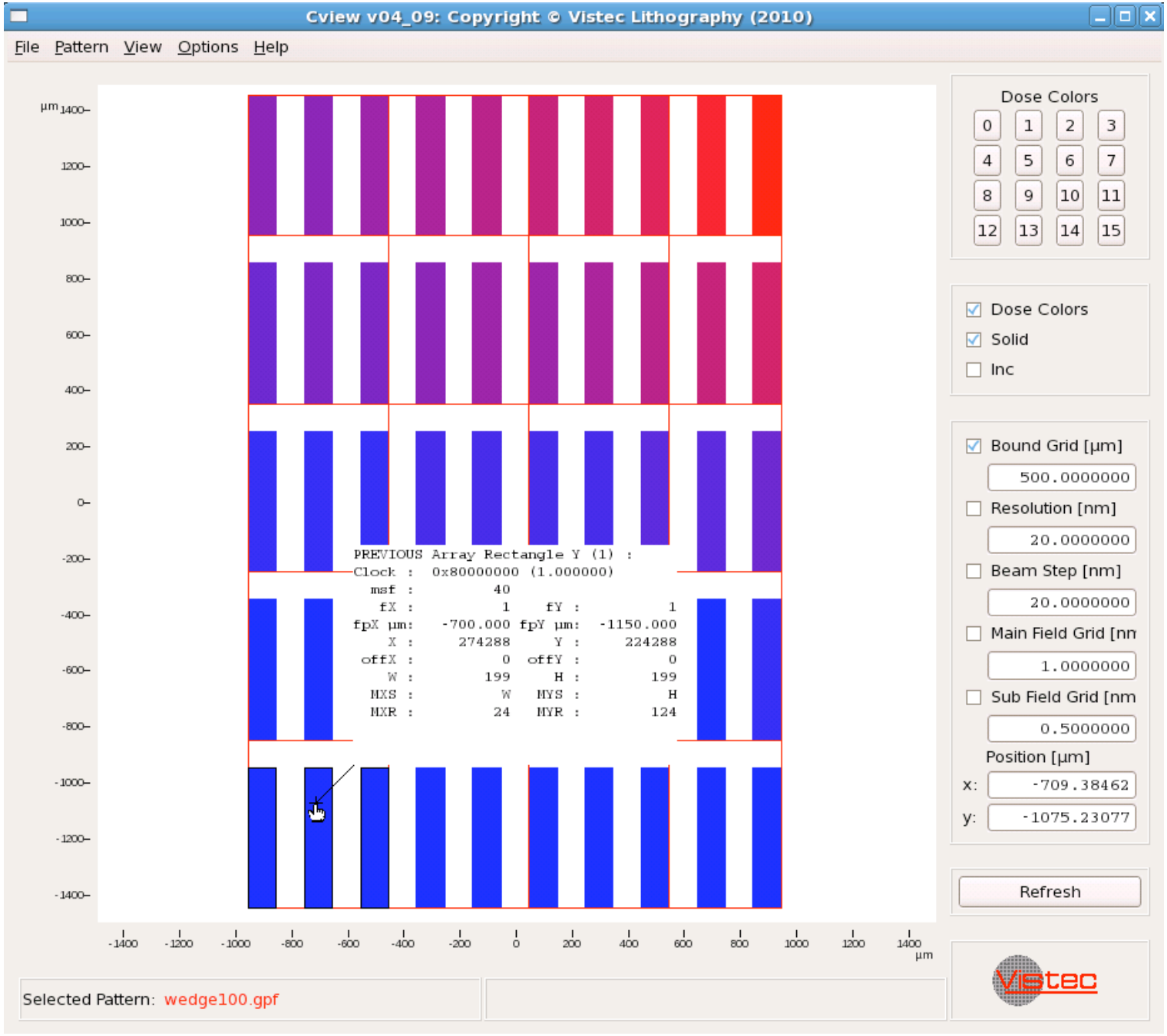

rooks@lardnar:~/projects/cat
File Edit View Terminal Tabs Help
[rooks@lardnar cat]$
[rooks@lardnar cat]$ cview wedge100.gpf
Cview v04_09: Copyright © Vistec Lithography (2010)
File Pattern View Options Help
µm
1400
1200
1000
800
600
400
200
0
-200
-400



draw button

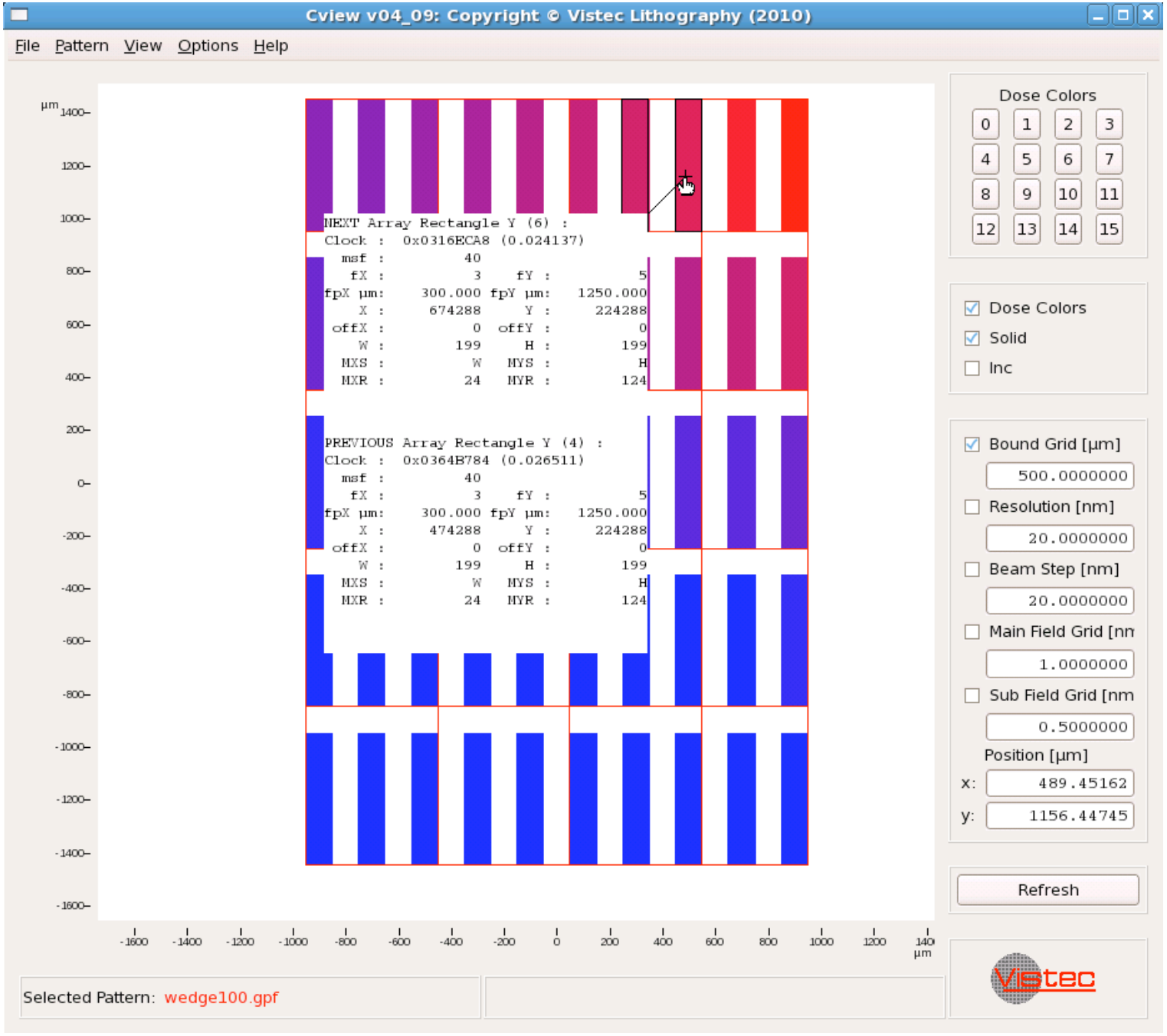
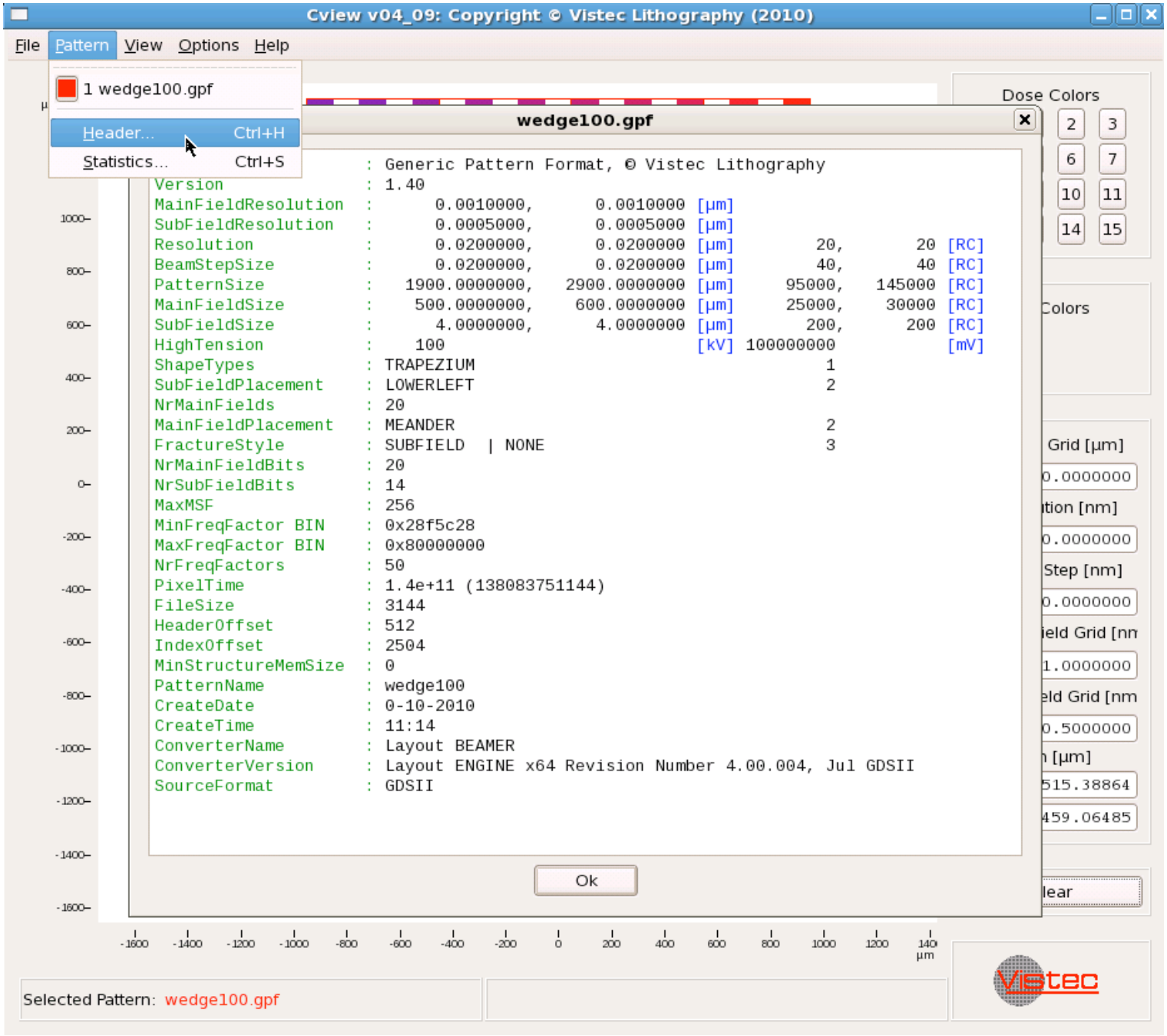
Same zooming action: UL to LR zooms in, LR to UL zooms out

Hover over a shape and press the Ctrl key to reveal details of a shape.



If you get a double report, that means there are overlapping shapes.

In this example, the overlap was intentional. In your pattern, maybe not.



Use
pattern → header
to reveal all
the gory details.