



# Exercise 3: A First Layout

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# The (Layout) Editor Window

**CHECK and save**

**Zoom in/out/..**

**Create Instance**

**LSW**  
Layer Selection Window

Select here which Layers to view


Select here which Types of Objects to view

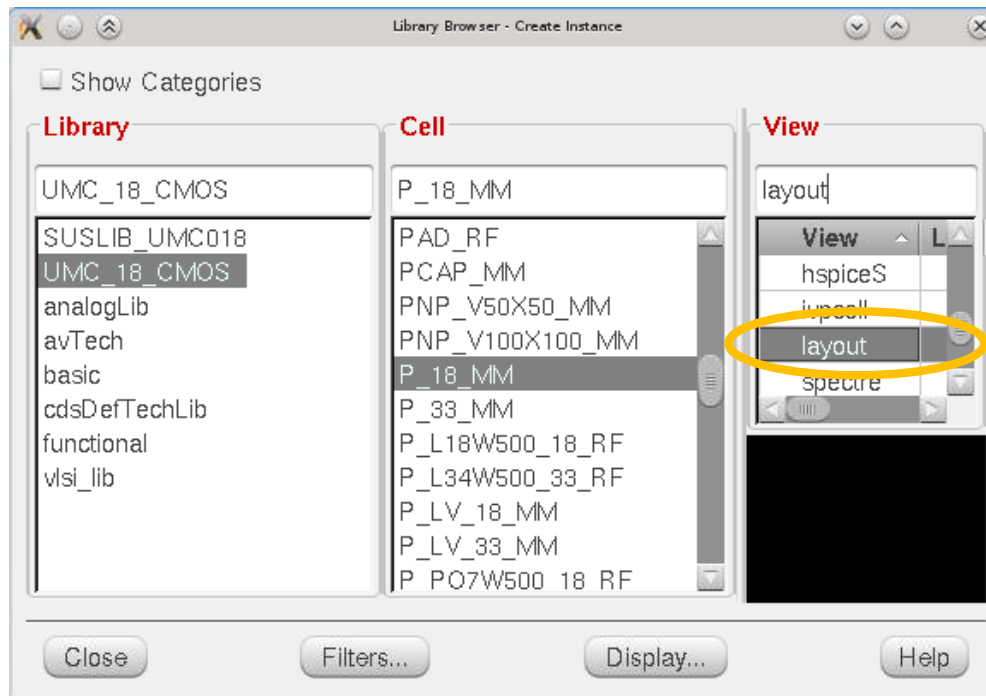
Layer	Purpose	V	S
GAA	GAASYMBOL	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
DIFF	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
NWEL	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TWEL	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
PPL...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Object	V	S
Shapes	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Circle/Ellipse	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Donut	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Label	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Path	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
PathSeg	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>




# Adding a Transistor

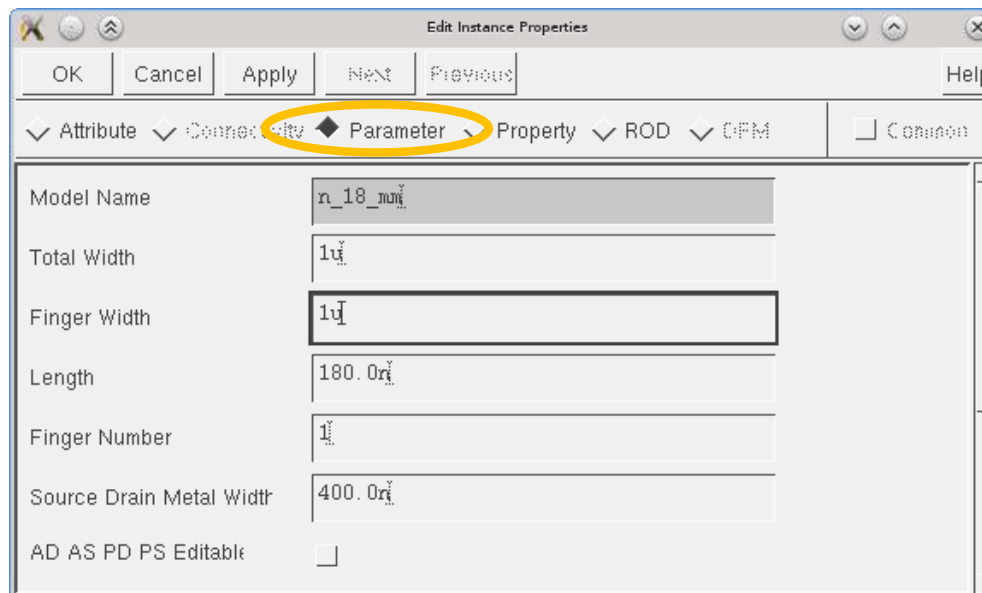
- To add a component ('instance') to a layout:
  - Press the 'Create Instance' button  or
  - select **Create** → **Instance** or
  - press 'i'
- Browse to the **UMC\_18\_CMOS** library
- Choose **N\_18\_MM** or **P\_18\_MM**, view layout





# Changing Component Parameters

- To change *parameters* of an instance
  - Press the 'Edit Properties' button  or
  - select **Create** → **Properties** → **Object** or
  - press 'q' or
  - use the **Property Editor Panel**
- Chose the 'Parameter' tab



- Observe how the layout of the part changes!



# Intermezzo: Executing Commands

- Two possibilities for most commands:

## 1. Execute command **once**:

- Select object(s)
- Press command key
- Execute command (once)

## 2. **Multiple** execution:

- Press command key → switch to command mode (new cursor)
- Select objects to execute commands on them
- Press **ESC = escape** to end

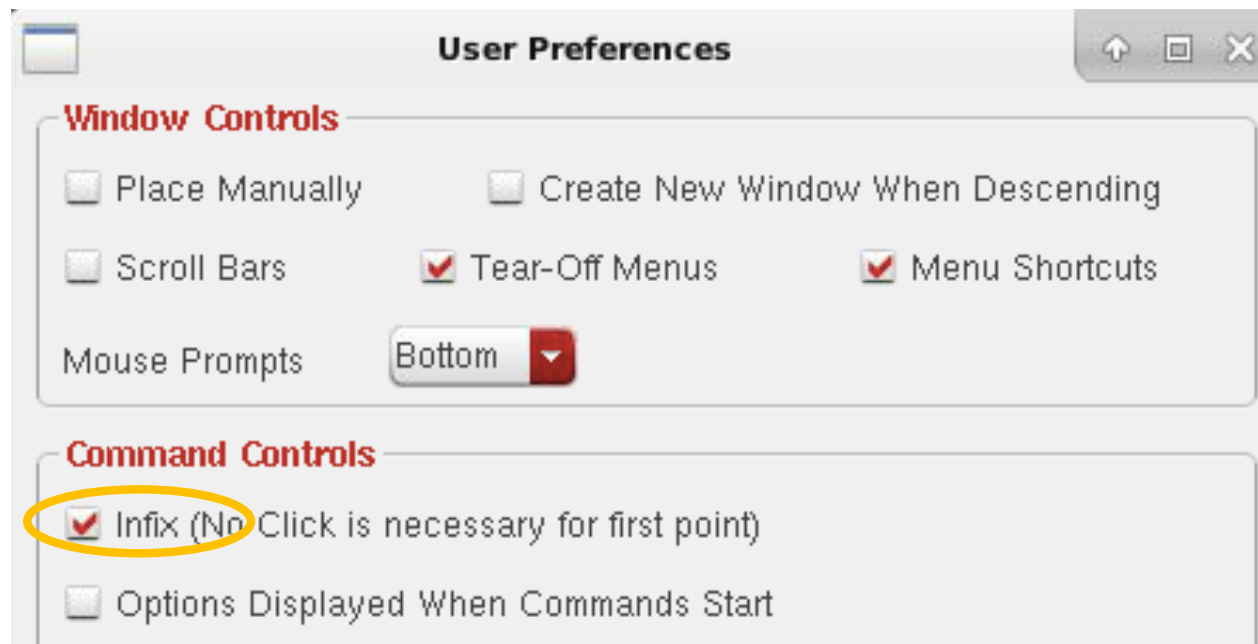
- **Example**:

- Select – delete delete one instance
- Delete – click – click ... - click – escape delete multiple



# Changing User Preferences

- You can change the behaviour somewhat under **CIW** → **Options** → **User Preferences**
  - 'InFix' can be selected so that commands take action immediately, without extra mouse-click






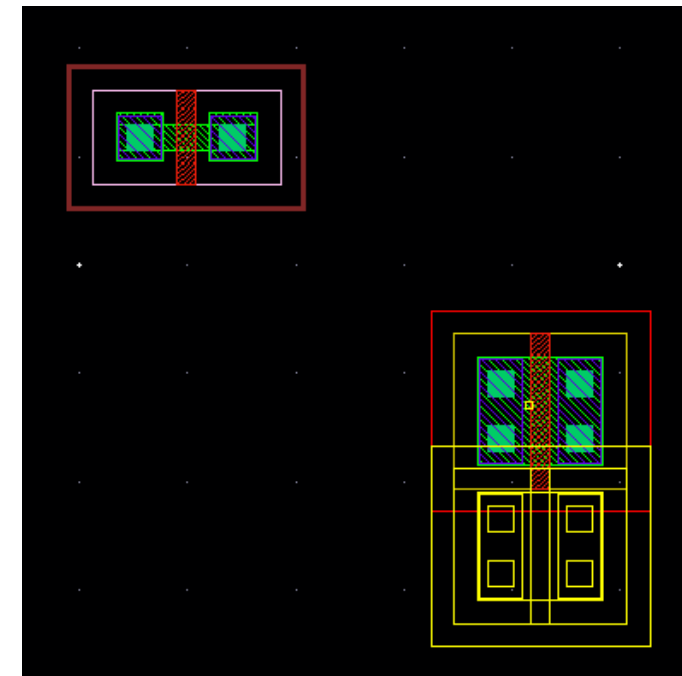
## Intermezzo: Getting more Command Options

- In general, pressing **F3** while executing a command opens a window with more options.
  - rotate, flip
  - allowed routing angles
  - colors
  - ...
  
- Sometimes need to press **F3 twice**



# Moving an Instance


- **Select** the instance with the mouse
  - leftclick to select individual instances
  - shift – leftclick to **add** instances to selection
  - ctrl – leftclick to **remove** instances from selection
  - drag rectangle select instances in area
- **To move**
  - Press ‘Move’ button  or
  - select **Edit** → **Move** or
  - press ‘m’
- **Alternative:**
  - First press ‘m’
  - select – move – drop, ...ESC
- **Alternative:**
  - click – drag – drop
- For options (**snap mode**, rotate, flip,..): **F3**







# Setting User Mode Details

- By pressing 'g', the 'gravity' mode can be toggled. With gravity on, the cursor 'snaps' to 'interesting' locations.
  - You see the new gravity state in the CIW
  - For now, keep gravity off
- **Important:** F4 (  ) toggles between
  - full select - a shape is always *completely* selected
  - Partial select - can select *parts* of a shape
- The Origin can be moved via **Edit → Advanced → Move Origin** (+ click with new position of origin)
  - This is a dangerous command if you have already used the cell in other places: The cell will shift *everywhere!*



# The Display Options Window

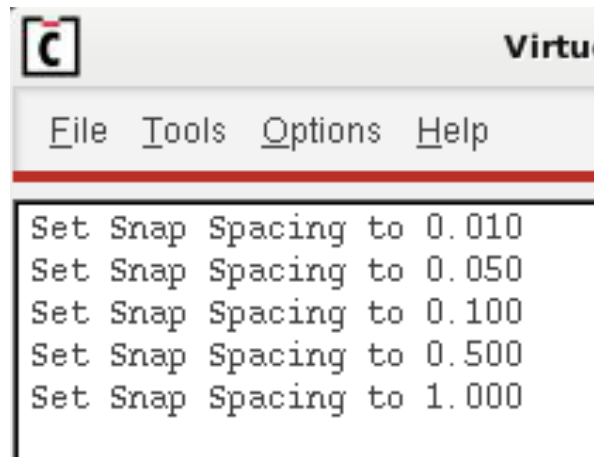
- Pressing 'e' brings up the Display Options Window
- It allows to set many things:
  - Axis on off
  - Dot Grid
  - **SNAP GRID**
  - Display Levels
  - ...
- Switch Display Levels with
  - Shift-F or Ctrl-F
- You can save the settings to the cell





## Additional Bind Keys for SNAP - Grid

- Changing the grid to the largest reasonable value is useful
- We have therefore created some extra short cuts to do this:
  - Keys 1, 2, 3, ... change the grid to increasingly coarse values
  - The value is displayed in the CIW:



- You will learn how these keys are defined in the SKILL part



# Adding Shapes

- Before drawing a shape, select the layer in the Layer Selection Window (LSW)

- Start with Metal 1 = ME1

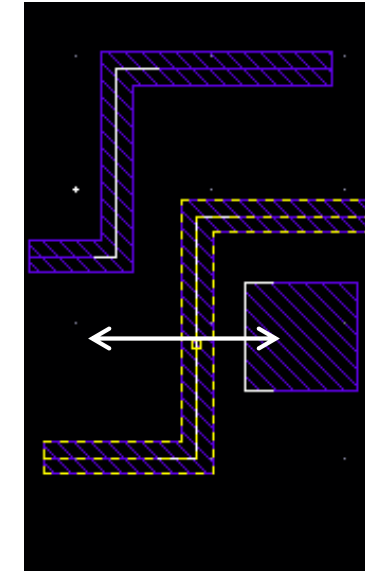
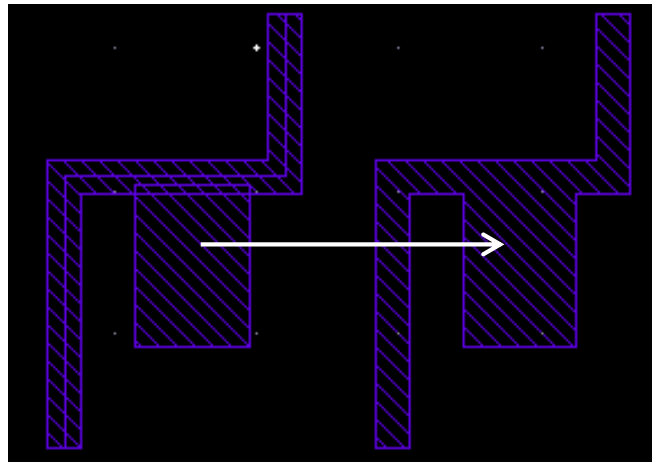
Layer	Purpose	V	S
PO1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
CONT	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME2	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI2	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

- There are 3 different shape types
  - Rectangles Create → Shape → Rectangle or 'r'
  - Polygons Create → Shape → Polygon or 'Shift-P'  
(double click to finish)
  - Paths Create → Shape → Path or 'p'  
(double click to finish)
- **Paths** have a *width* which can be changed by **F3**.



# Modifying Shapes

- When partial selection is enabled (F4), a part of a shape can be selected and stretched or deleted
- Multiple segments can be selected
  - This is very powerful in Virtuoso!!
- Several selected shapes can be *merged* with 'Shift-M'



- Shapes can be *chopped* (cut) with 'Shift-C' (+ cut shape)
- Shapes can be converted to Polygons with Edit → Convert → to Polygon



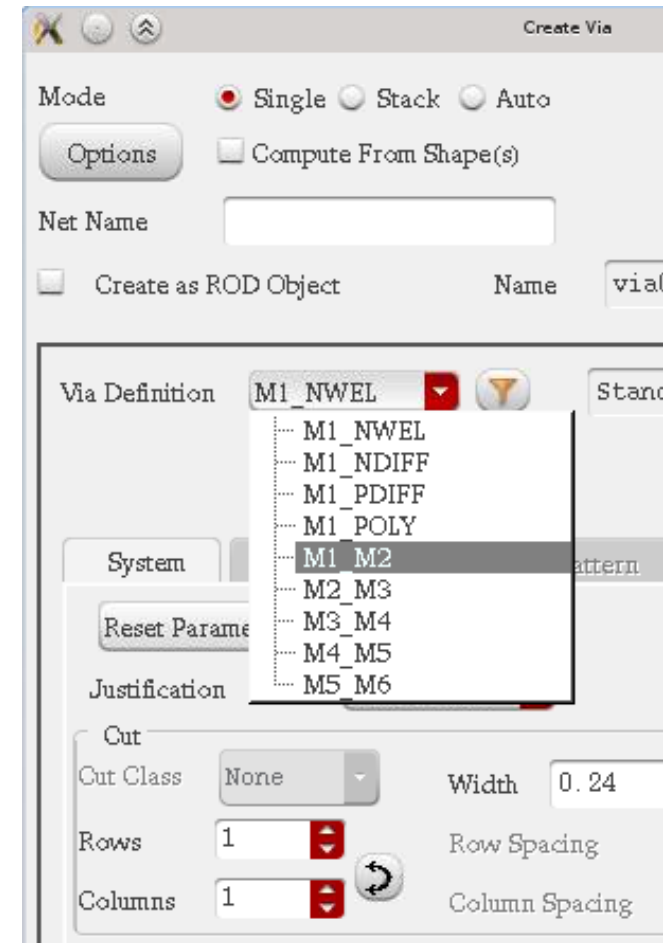
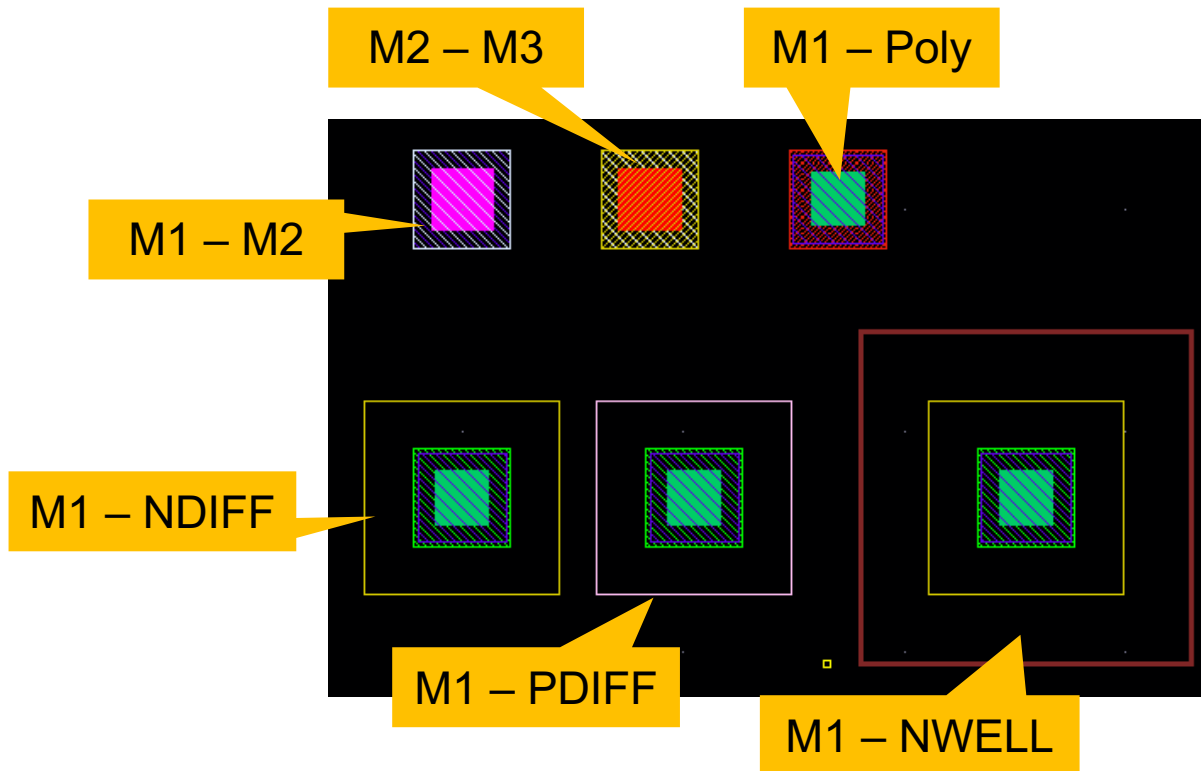
# Flatten

- All objects in an instance can be moved to the active cell view using the **Flatten** command.
  - The instance does not exist any more after this command, it is replaced by its content
- In fact, *everything* is ‘pulled up’ by one level in the hierarchy
- More than one level can be flattened at once
- When PCELLs are flattened, there are often several shapes on one layer. These can be **MERGED**.
  - Also, special (symbolic, vendor, ...) information may be present and should be removed.
- The reverse functionality is to make a layout cell from a selected set of shapes: **Edit → Hierarchy → Make Cell**



# Adding Vias and Contacts

- **Vias** are connections between adjacent *metal* layers
- **Contacts** go to active devices (M1 – Poly or M1 – Implant)
- Press ‘o’ to add a via
  - Select the correct layer pair





## Zooming ...

- show everything: 'f' (fit)
  - scroll: arrow keys
  - zoom in: ctrl-z or ]
  - zoom out: shift-z or [
  - zoom area: right mouse – drag
  - pan selection: tab
  - last view: w
  - top/bottom/...: ctrl - arrow
- 
- See menu **View**→ ...





# The Routing Layers / The LSW

**ALL visible** (points to AV, NV, AS, NS)

**ALL selectable** (points to AV, NV, AS, NS)

**NONE visible** (points to ME1 drawing)

**NONE selectable** (points to ME1 drawing)

**Poly** (points to PO1)

**M1 – Poly Contact** (points to CONT)

**Metal 1** (points to ME1)

**Vias Metal 1 – Metal 2** (points to VI1)

**Layer is visible** (points to V checkbox)

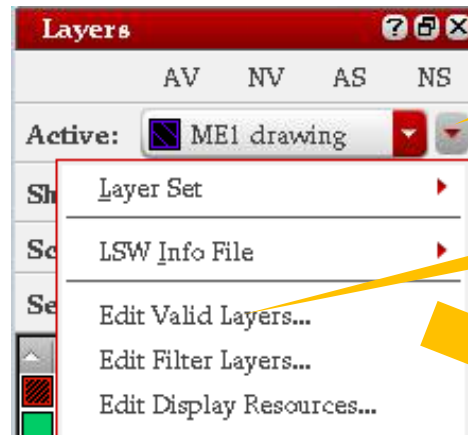
**Layer is selectable** (points to S checkbox)

Layer	Purpose	V	S
PO1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
CONT	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME2	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI2	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME3	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI3	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME4	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
VI4	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME5	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>



# Modifying & Saving a Layer Map

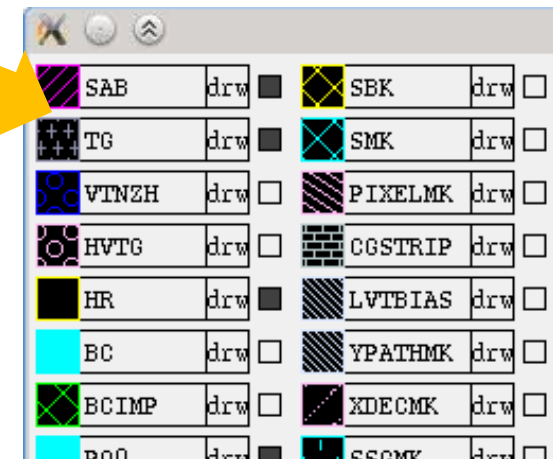
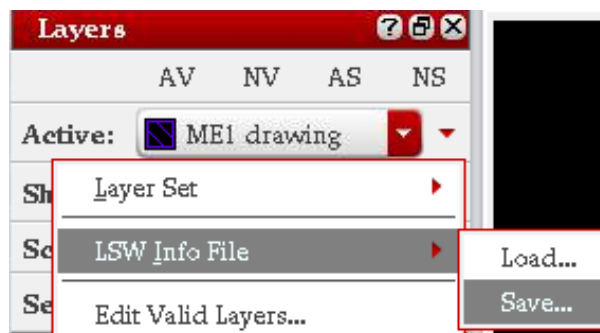
- It is convenient to show only some layers in the LSW
- Chose your layers in the *Edit Layers* Dialog



Open Dialog

Chose this

- Save your choice:



- Load a LSW Info file from there



# Pre-Defined Layer Sets

- We have pre-defined two layer sets
  - Use keys 8 ('transistors') and 9 ('routing')

	DIFF	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	PWEL	drawing	<input type="checkbox"/>	<input type="checkbox"/>
	NW...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	TWEL	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	PPL...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	NPL...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	VTP...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	VTNI	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	VT...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	SAB	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	TG	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	HR	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	PO0	drawing	<input type="checkbox"/>	<input type="checkbox"/>
	PO1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	VA...	drawing	<input type="checkbox"/>	<input type="checkbox"/>
	CO...	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	ME1	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	VI1	drawing	<input type="checkbox"/>	<input type="checkbox"/>

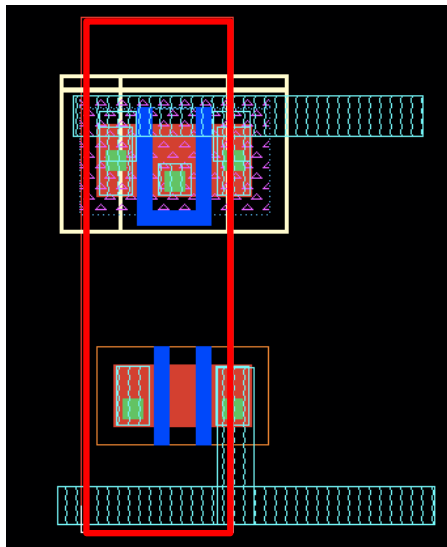
Layer	Purpose	V	S
CO...	drawing	<input type="checkbox"/>	<input type="checkbox"/>
	ME1	drawing	<input checked="" type="checkbox"/>
	VI1	drawing	<input checked="" type="checkbox"/>
	ME2	drawing	<input checked="" type="checkbox"/>
	VI2	drawing	<input checked="" type="checkbox"/>
	ME3	drawing	<input checked="" type="checkbox"/>
	VI3	drawing	<input checked="" type="checkbox"/>
	ME4	drawing	<input checked="" type="checkbox"/>
	VI4	drawing	<input checked="" type="checkbox"/>
	ME5	drawing	<input checked="" type="checkbox"/>
	VI5	drawing	<input checked="" type="checkbox"/>
	ME6	drawing	<input checked="" type="checkbox"/>
	MMC	drawing	<input checked="" type="checkbox"/>
	PAD	drawing	<input type="checkbox"/>
	TV_...	drawing	<input type="checkbox"/>
	NWR	drawing	<input type="checkbox"/>
	TEXT	drawing	<input checked="" type="checkbox"/>
	ME1	nin	<input type="checkbox"/>



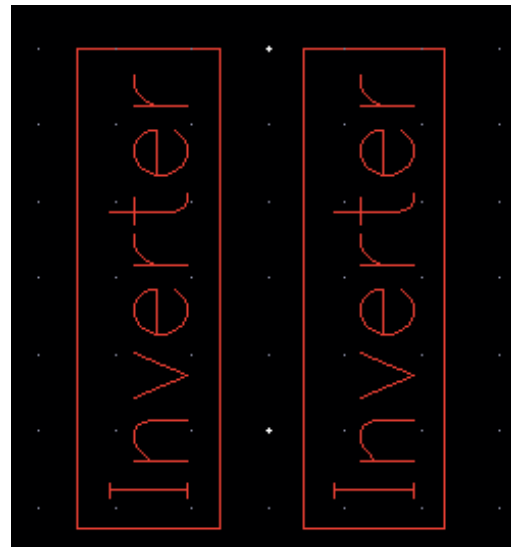
# The 'Bounding-Box' and Display Level

- Similar to the *selection box* of a symbol, a layout can have a '*Bounding Box*' which will be displayed in the next hierarchy level (above) when display level is decreased.
  - It is drawn on layer 'instance – drawing'
  - You may need to turn the layer on (see prev.)
- If you instantiate the cell (layout):
  - you see only the bounding box if display level = 0 (**Ctrl-F**)
  - you see 'into' the cell for level > 0 (**Shift-F** sets level to 20)

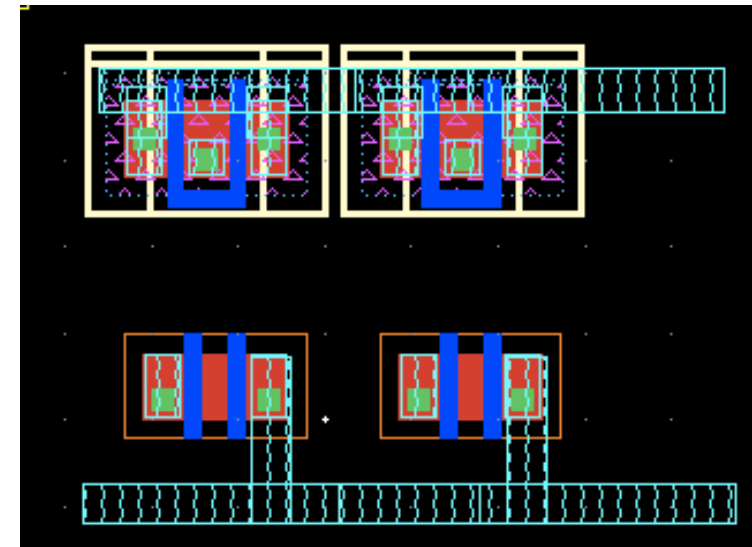
Layer	Purpose	V	S
SYMBOL MM		<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> instance	drawing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
prBndry	boundary	<input type="checkbox"/>	<input type="checkbox"/>



Inverter - Layout



Top cell – Level = 0

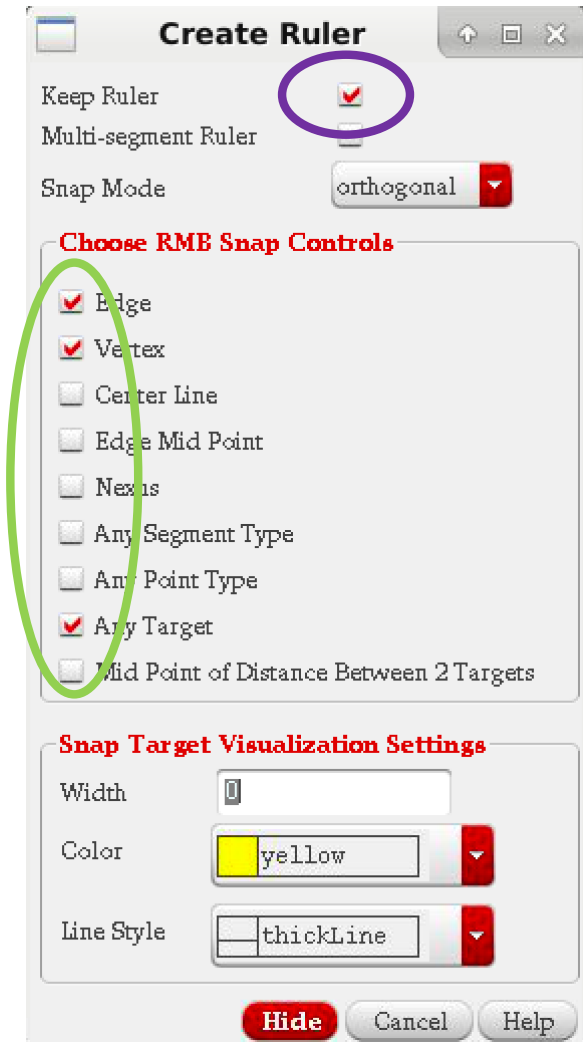
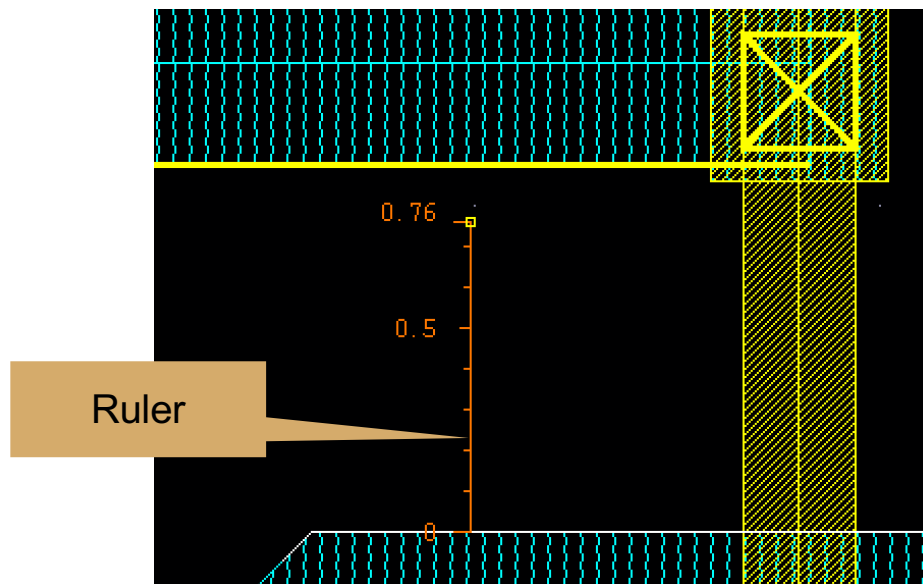


Same Top cell – Level > 0



# The Ruler: Measuring Distances

- To measure, you can create a 'ruler' (k)
- **F3** brings up the usual options form. I usually disable all 'Snap' entries.
- When selected, the rulers are kept (and stored for later!)
- **All** rulers in a view can be deleted with **shift-K**





# EXERCISE



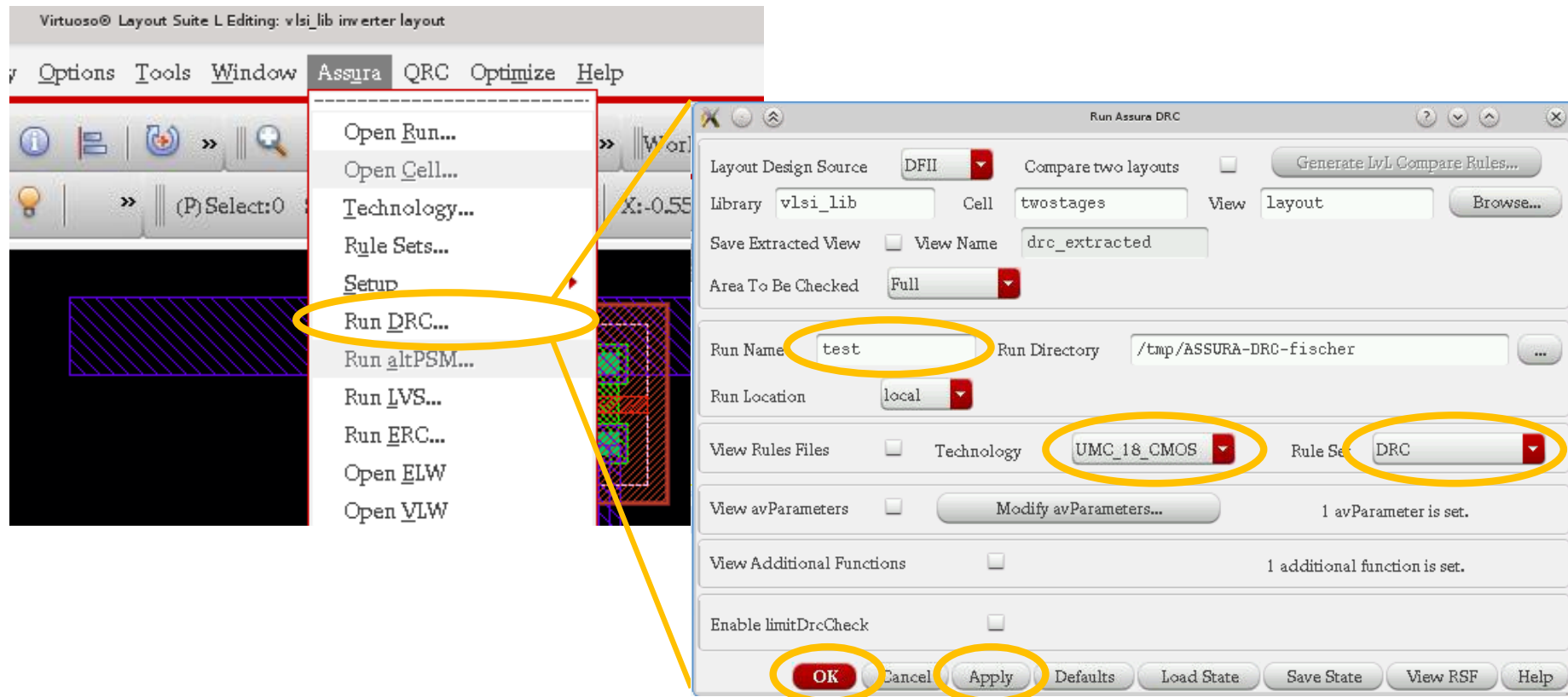
# Warmup

- Play around with the layout editor:
  - Get a PMOS and an NMOS (N\_18\_MM)
  - Turn on and off layers
  - Draw some metal traces, use Rectangles and Paths
  - Shift things around
  - Modify the paths
  - Get some contacts



# Run a DRC for your Layout Tests

- Select from the top menu **Assura** → **Run DRC...**
  - Make sure *Rule Set DRC* is selected
  - Make sure you have set a *run name*
  - *OK* closes the window, *APPLY* keeps it







# Inverter and NAND3

- Produce the layout of an inverter
  - Have the PMOS 3 times as wide as the NMOS
  - Put the PMOS at the top, the NMOS at the bottom
  - Put the input on the left side on ME1, the output right on ME2
  - Run power / ground horizontally at top/bottom
  - Connect also the NWEELL and the substrate
  
- Try the layout of a NAND3
  - Try to make the inverter and the layout the same 'height' so that the power connects automatically when placing two cells side-by-side (see next slide)



# Layouts

- Do the layout such that multiple gates can be easily placed side by side.
  - Power/ground should run horizontal at bottom and top
  - Find good distances of power traces, wells, ...

