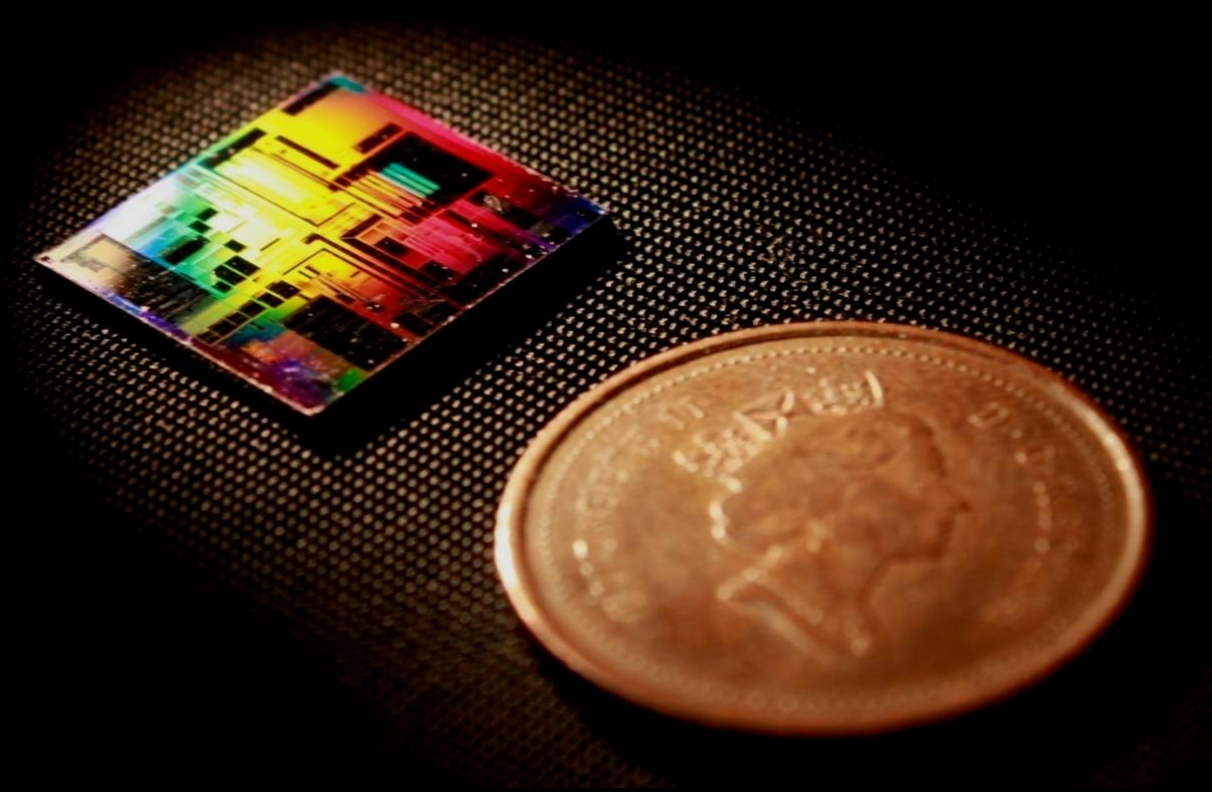
Klayout: Parameterized Cells Scripting

2019 SiEPIC Passive Silicon Photonics Workshop, Vancouver, Canada



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a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

MiNa Microsystems and Nanotechnology Group
Photonics Research Group

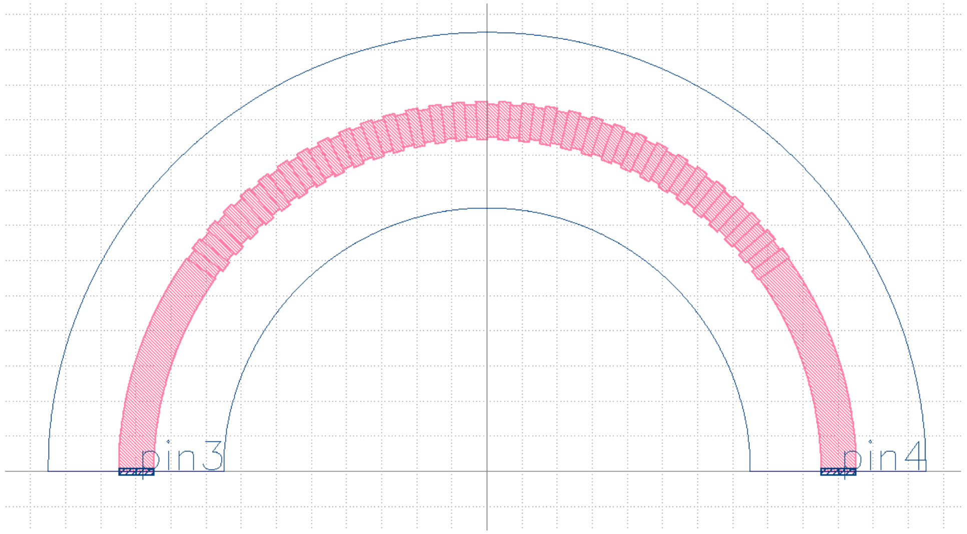
Electrical and Computer Engineering

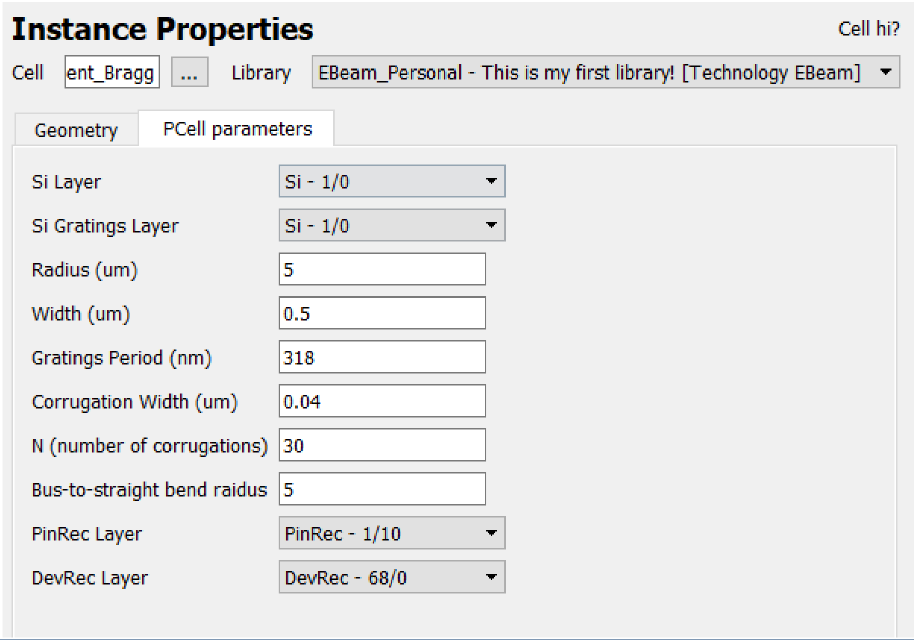
Outline

- **What is a parameterized cell?**
- **How to setup and start creating scripts**
- **Define components library**
- Make your first parameterized cell

Pcell?

- **A method to generate the layout of a parameterized device, contains:**
  - **Physical device parameters**
  - **Ports definitions**
  - **Device region definition**
  - **Compact models (?)**




Instance Properties Cell hi?

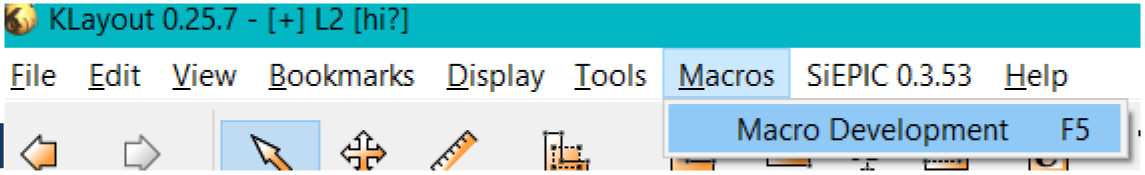
Cell: ent_Bragg ... Library: EBeam_Personal - This is my first library! [Technology EBeam]

Geometry | PCell parameters

Si Layer	Si - 1/0
Si Gratings Layer	Si - 1/0
Radius (um)	5
Width (um)	0.5
Gratings Period (nm)	318
Corrugation Width (um)	0.04
N (number of corrugations)	30
Bus-to-straight bend raidus	5
PinRec Layer	PinRec - 1/10
DevRec Layer	DevRec - 68/0

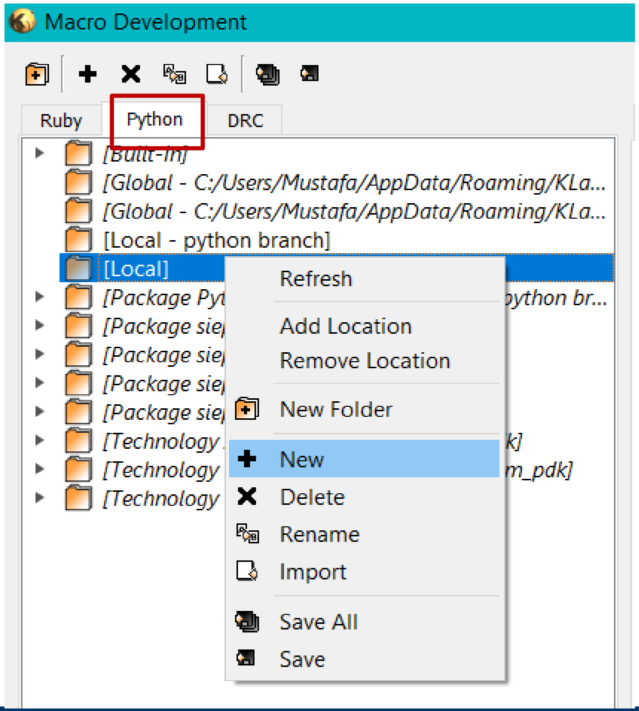
Setup

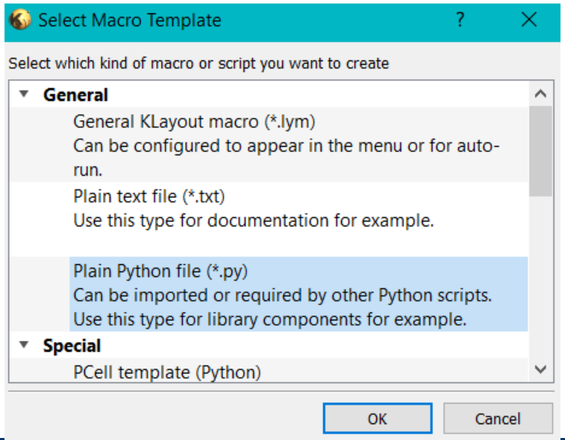
- **Open Macro Development**

[1]


- **Create a new Python script in your local directory**

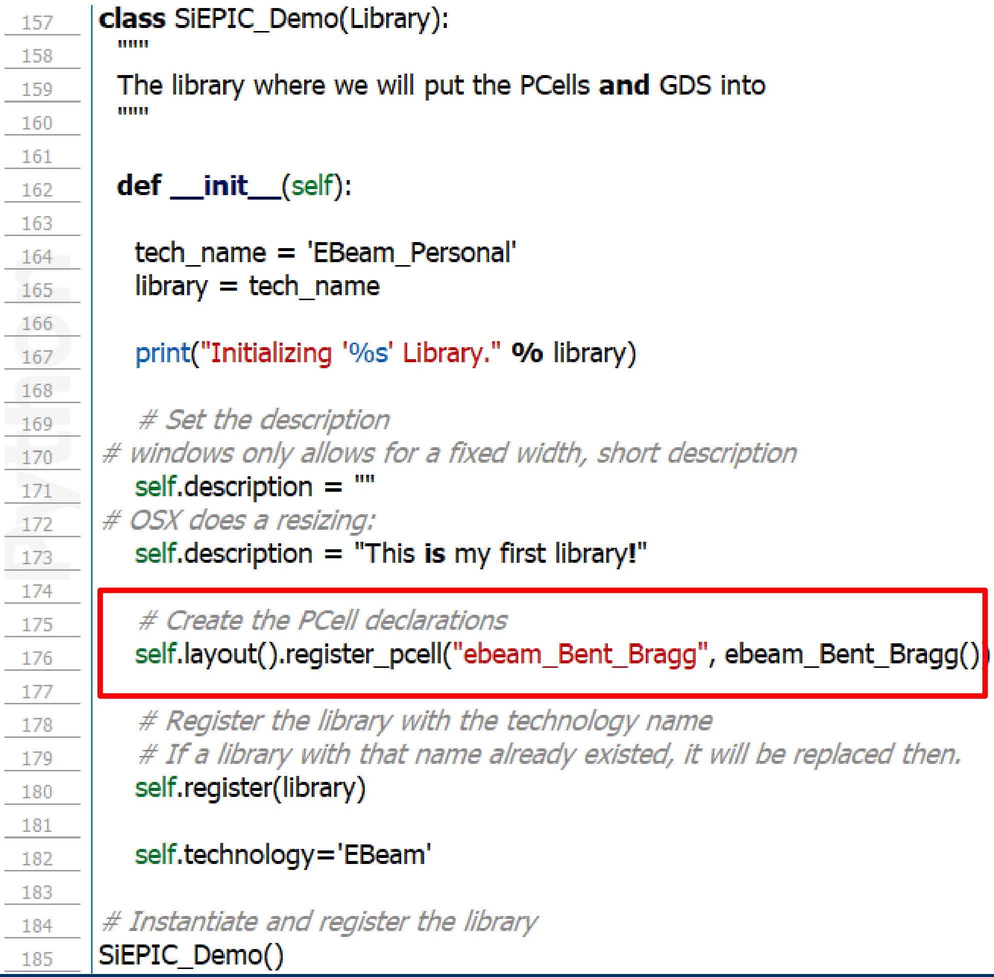
- **Copy content of my_first_script.py**

[2]


[3]

Select Macro Template
Select which kind of macro or script you want to create
General
General KLayout macro (*.lym)
Can be configured to appear in the menu or for auto-run.
Plain text file (*.txt)
Use this type for documentation for example.
Plain Python file (*.py)
Can be imported or required by other Python scripts.
Use this type for library components for example.
Special
PCell template (Python)
OK
Cancel

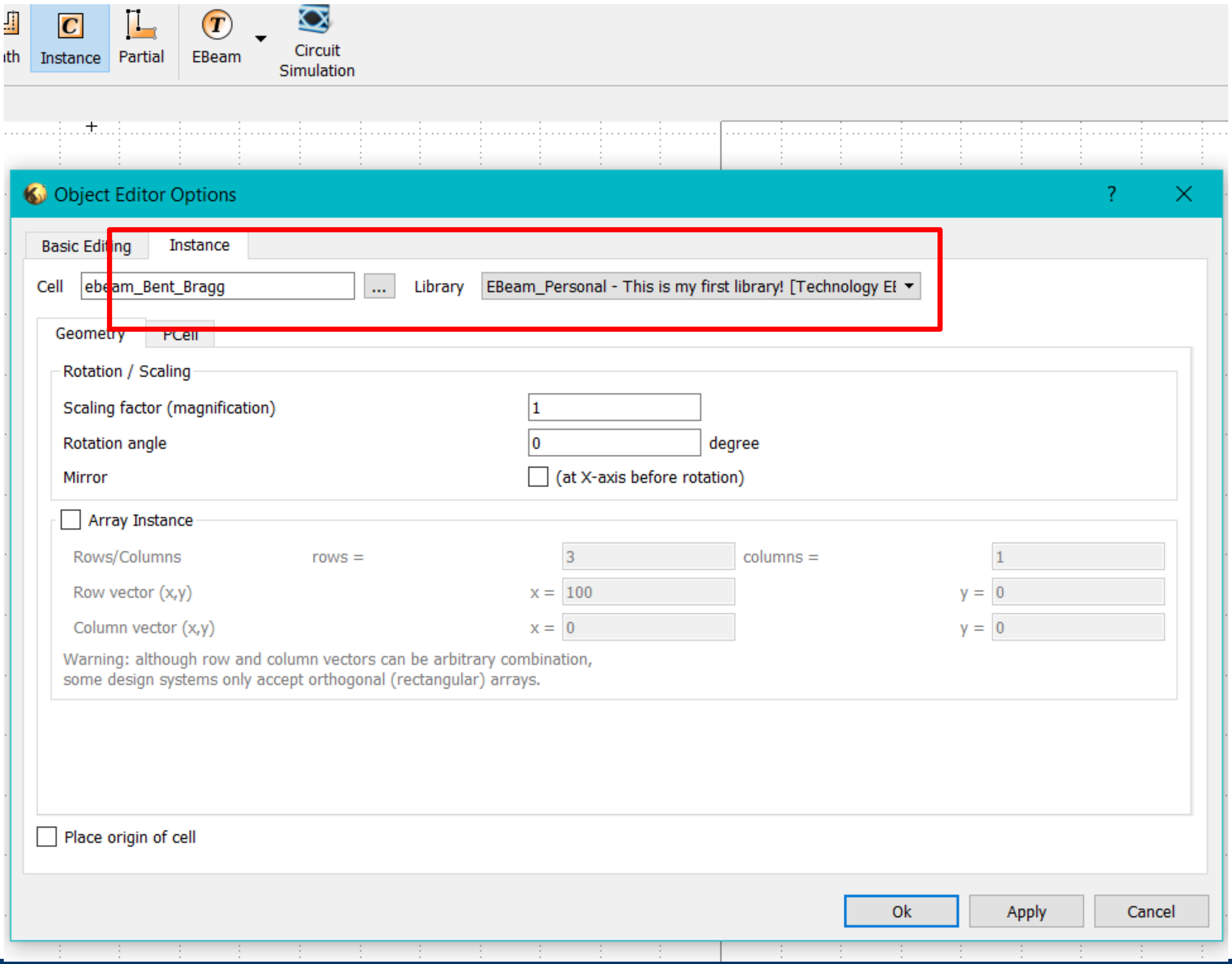
Define components library

- **Call it SiEPIC_Demo**
- **Built on a technology**
  - **‘EBeam’**
- **Register all PCells in the script**
  - **‘Ebeam_Bent_Bragg’**



```
class SiEPIC_Demo(Library):
  """
  The library where we will put the PCells and GDS into
  """

  def __init__(self):

    tech_name = 'EBeam_Personal'
    library = tech_name

    print("Initializing '%s' Library." % library)

    # Set the description
# windows only allows for a fixed width, short description
    self.description = ""
# OSX does a resizing:
    self.description = "This is my first library!"

    # Create the PCell declarations
    self.layout().register_pcell("ebeam_Bent_Bragg", ebeam_Bent_Bragg()

    # Register the library with the technology name
    # If a library with that name already existed, it will be replaced then.
    self.register(library)

    self.technology='EBeam'

# Instantiate and register the library
SiEPIC_Demo()
```

Define components library



Cell: ebeam_Bent_Bragg ... Library: EBeam_Personal - This is my first library! [Technology EE

Rotation / Scaling

Scaling factor (magnification): 1

Rotation angle: 0 degree

Mirror: ☐ (at X-axis before rotation)

☐ Array Instance

Rows/Columns rows = 3 columns = 1

Row vector (x,y) x = 100 y = 0

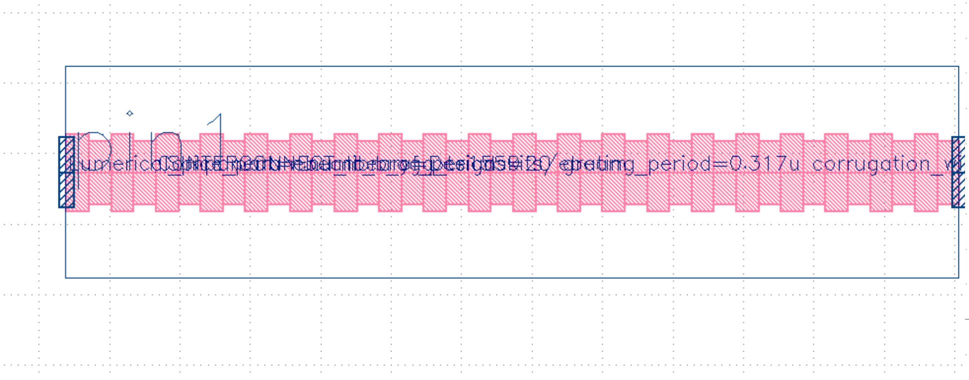
Column vector (x,y) x = 0 y = 0

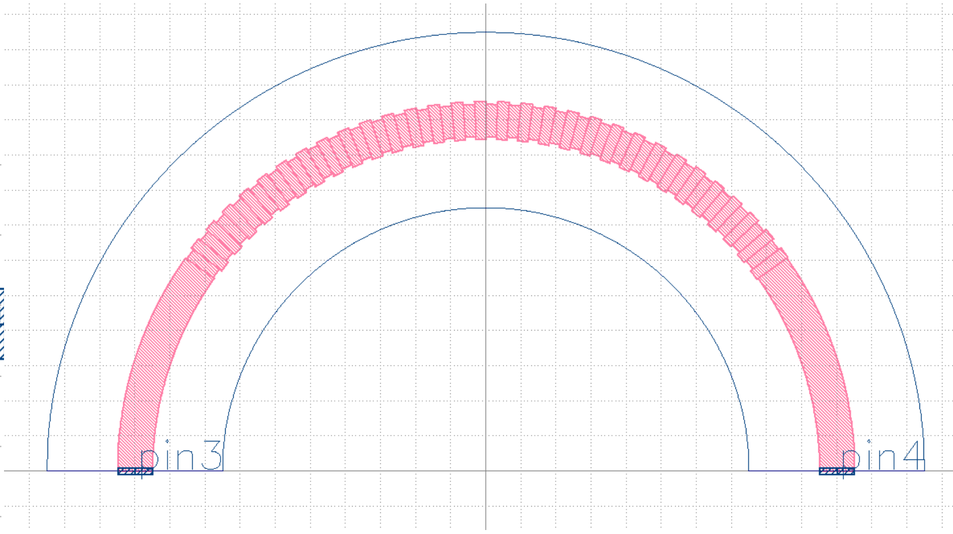
Warning: although row and column vectors can be arbitrary combination, some design systems only accept orthogonal (rectangular) arrays.

☐ Place origin of cell

Pcell: Objective

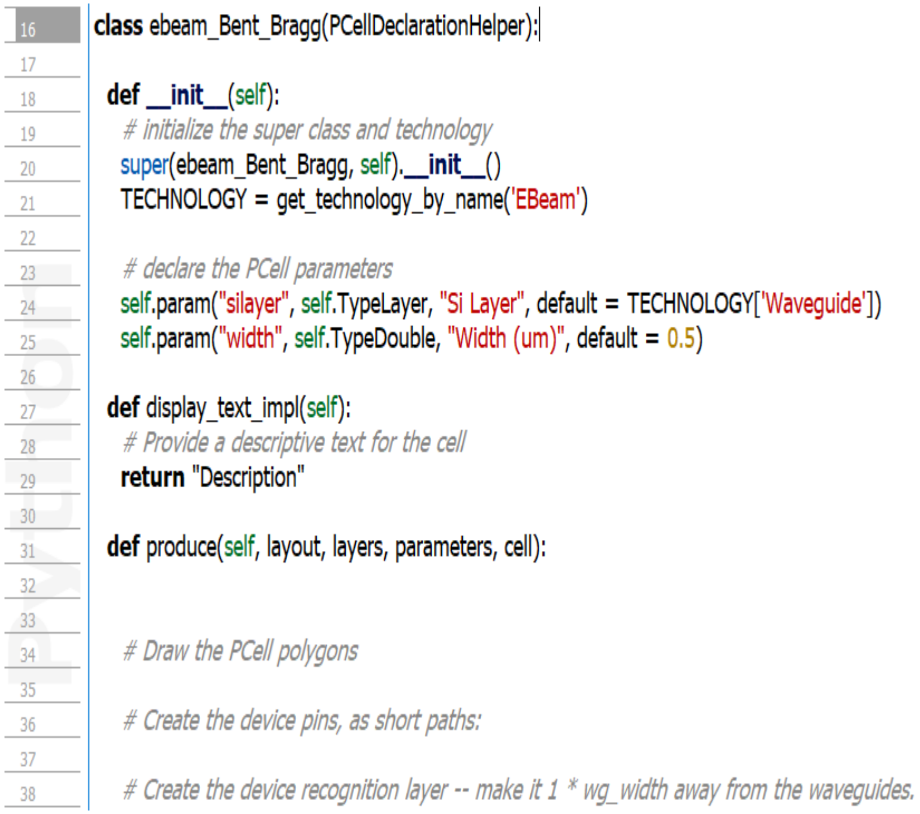
- **We want to turn Bragg gratings from straight to bent over an Arc**
- **Parameters:**
  - **Radius**
  - **Waveguide width**
  - **Bragg period**
  - **Bragg corrugation width**
  - **Number of Bragg periods**
  - **Layers**





Pcell: Format

- __init__: initialize technology and GUI Pcell parameters
- Display_text_impl: Description of the Pcell, appears when selected
- produce: Actual implementation of the Pcell (polygon drawing definition) and ports definition, and device recognition



```
class ebeam_Bent_Bragg(PCellDeclarationHelper):

  def __init__(self):
    # initialize the super class and technology
    super(ebeam_Bent_Bragg, self).__init__()
    TECHNOLOGY = get_technology_by_name('EBeam')

    # declare the PCell parameters
    self.param("silayer", self.TypeLayer, "Si Layer", default = TECHNOLOGY['Waveguide'])
    self.param("width", self.TypeDouble, "Width (um)", default = 0.5)

  def display_text_impl(self):
    # Provide a descriptive text for the cell
    return "Description"

  def produce(self, layout, layers, parameters, cell):


    # Draw the PCell polygons

    # Create the device pins, as short paths:

    # Create the device recognition layer -- make it 1 * wg_width away from the waveguides.
```

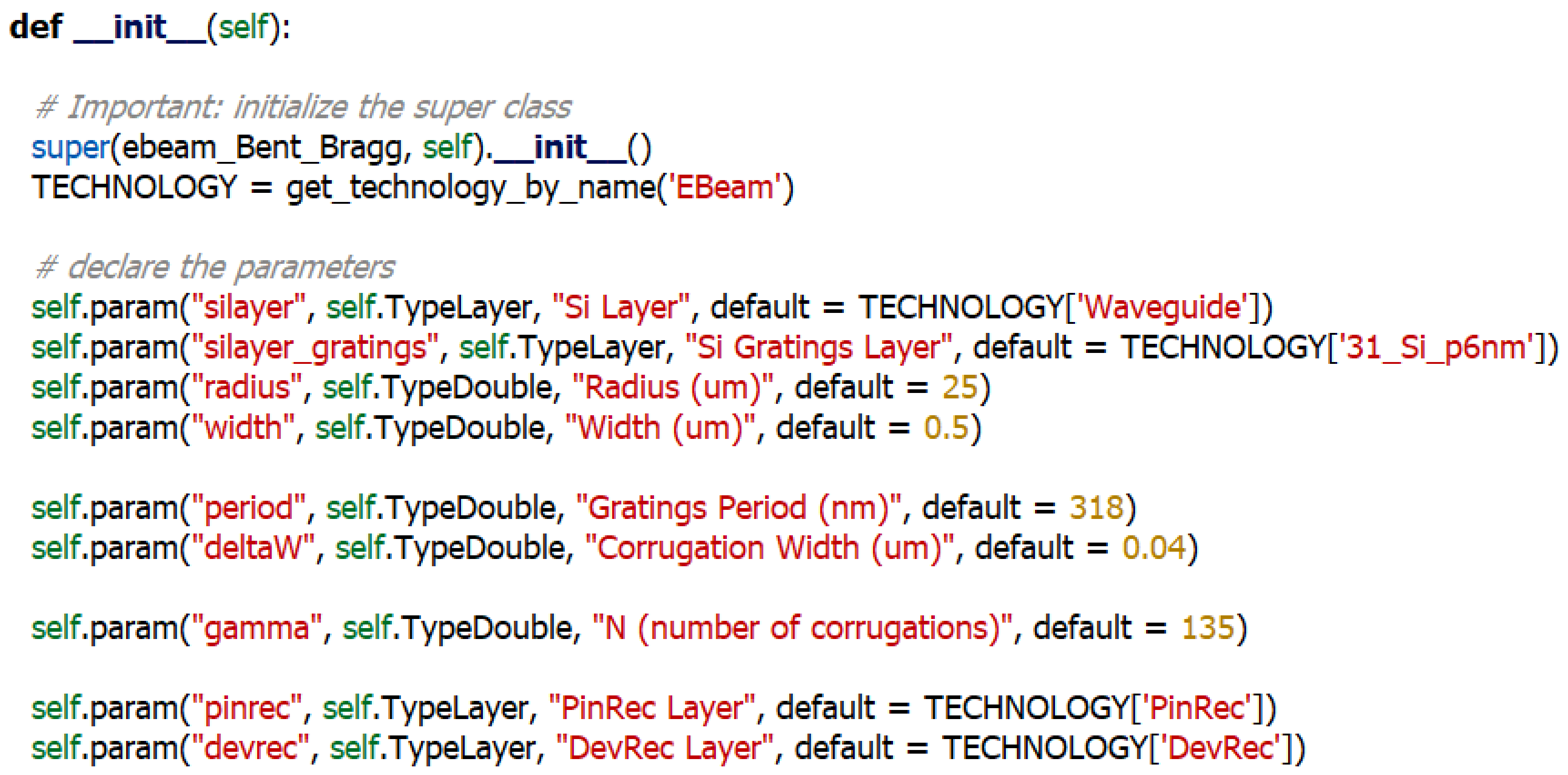
Pcell: Objective

- **We want to turn Bragg gratings from straight to bent over an Arc**

- **Parameters:**
  - **Radius**
  - **Waveguide width**
  - **Bragg period**
  - **Bragg corrugation width**
  - **Number of Bragg periods**
  - **Layers**

Pcell: Script Parameters GUI and tech

- **Method: __init__**

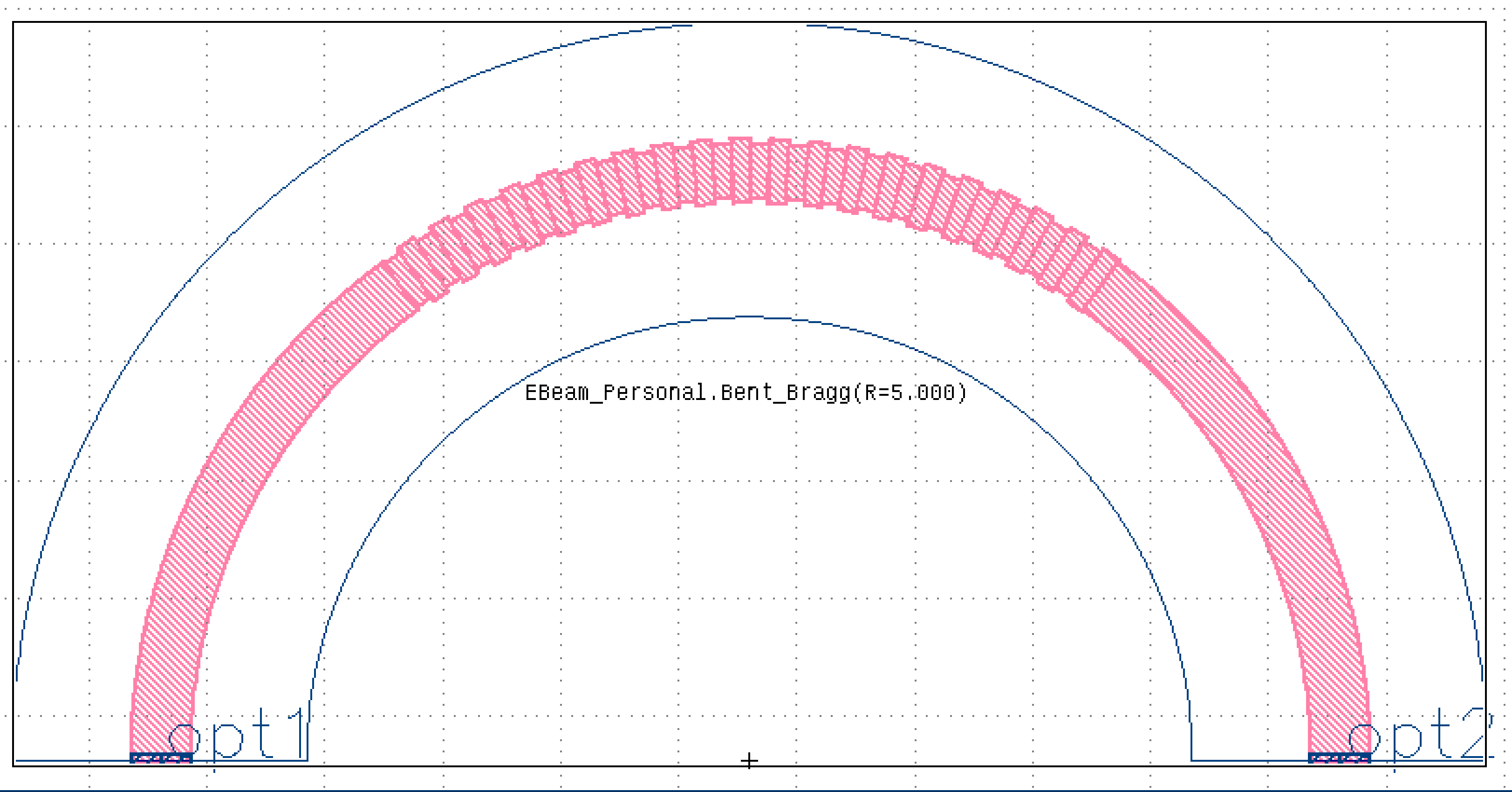


```
def __init__(self):

  # Important: initialize the super class
  super(ebeam_Bent_Bragg, self).__init__()
  TECHNOLOGY = get_technology_by_name('EBeam')

  # declare the parameters
  self.param("silayer", self.TypeLayer, "Si Layer", default = TECHNOLOGY['Waveguide'])
  self.param("silayer_gratings", self.TypeLayer, "Si Gratings Layer", default = TECHNOLOGY['31_Si_p6nm'])
  self.param("radius", self.TypeDouble, "Radius (um)", default = 25)
  self.param("width", self.TypeDouble, "Width (um)", default = 0.5)

  self.param("period", self.TypeDouble, "Gratings Period (nm)", default = 318)
  self.param("deltaW", self.TypeDouble, "Corrugation Width (um)", default = 0.04)

  self.param("gamma", self.TypeDouble, "N (number of corrugations)", default = 135)

  self.param("pinrec", self.TypeLayer, "PinRec Layer", default = TECHNOLOGY['PinRec'])
  self.param("devrec", self.TypeLayer, "DevRec Layer", default = TECHNOLOGY['DevRec'])
```

Pcell: Description

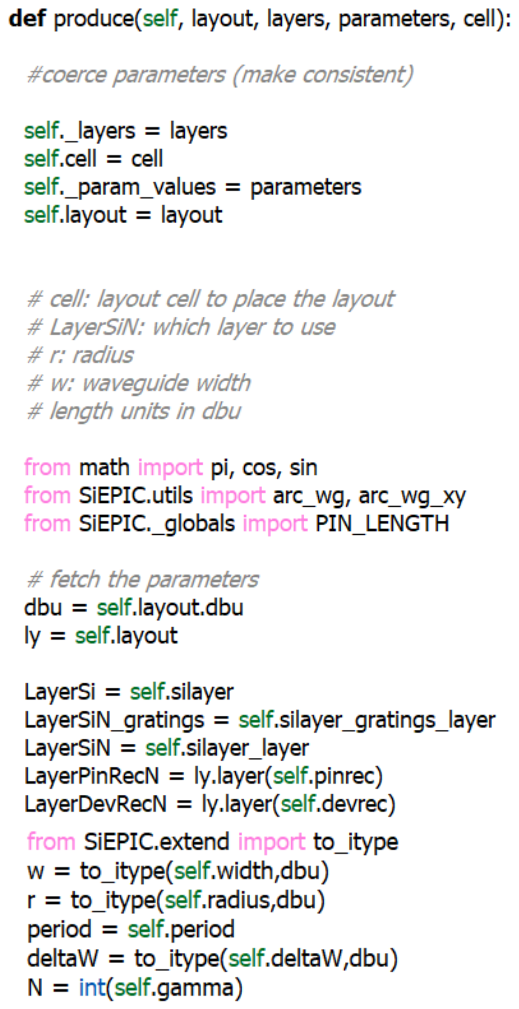
- **Method: display_text_impl**

```
def display_text_impl(self):
  # Provide a descriptive text for the cell
  return "Bent_Bragg(R=" + ('%.3f' % self.radius) + ")"
```



Pcell: Produce: fetch layout parameters

- **Method: Produce**

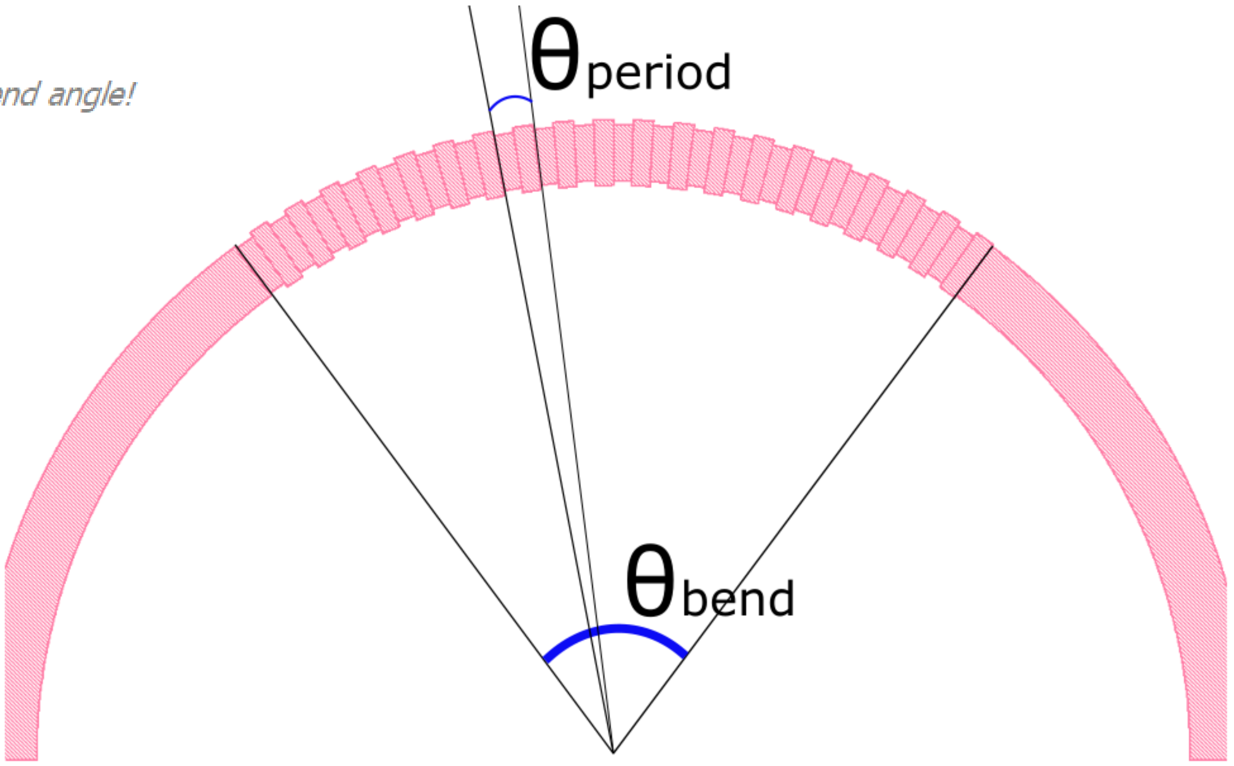


```
def produce(self, layout, layers, parameters, cell):

    #coerce parameters (make consistent)

    self._layers = layers
    self.cell = cell
    self._param_values = parameters
    self.layout = layout


    # cell: layout cell to place the layout
    # LayerSiN: which layer to use
    # r: radius
    # w: waveguide width
    # length units in dbu

    from math import pi, cos, sin
    from SiEPIC.utils import arc_wg, arc_wg_xy
    from SiEPIC._globals import PIN_LENGTH

    # fetch the parameters
    dbu = self.layout.dbu
    ly = self.layout

    LayerSi = self.silayer
    LayerSiN_gratings = self.silayer_gratings_layer
    LayerSiN = self.silayer_layer
    LayerPinRecN = ly.layer(self.pinrec)
    LayerDevRecN = ly.layer(self.devrec)
    from SiEPIC.extend import to_itype
    w = to_itype(self.width,dbu)
    r = to_itype(self.radius,dbu)
    period = self.period
    deltaW = to_itype(self.deltaW,dbu)
    N = int(self.gamma)
```

Pcell: Produce: Draw layout!

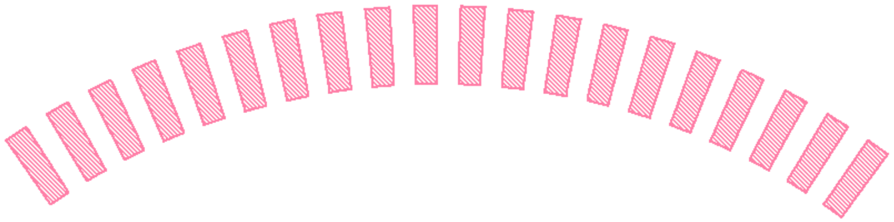
- **Method: Produce**

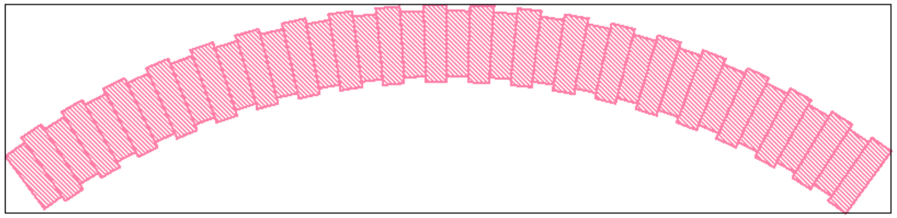
```
# Center of everything
x = 0
y = 0

# Angle of  Bragg corrugated portion, also bend angle!
periodAngle = (180/pi) * (period/2) /r

# Bend angle
bendAngle = (180/pi) * (N*period/2) /r
```



Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw corrugations (wide)**
- **Use an arc function (arg_wg_xy)**
  - **skip every other period**





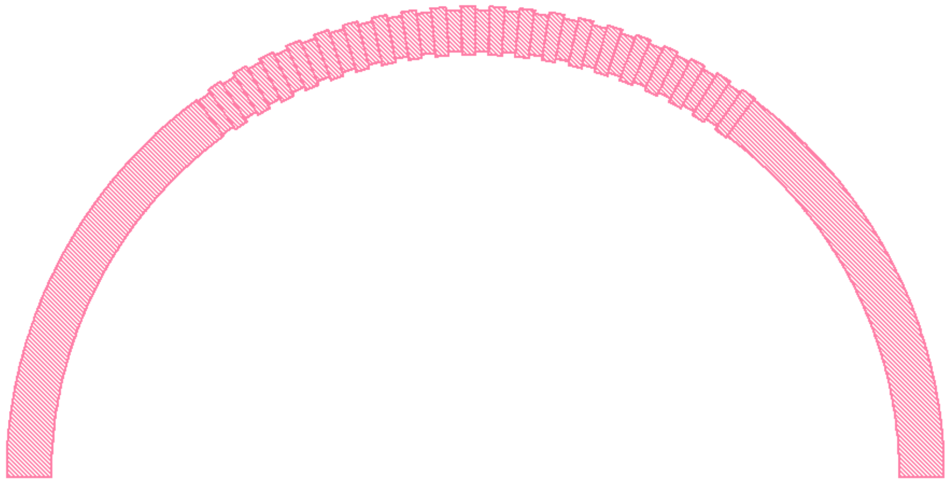
- **Draw corrugations (narrow)**
- **Use an arc function (arg_wg_xy)**
  - **skip every other period**

```
# Bragg wide
ii = periodAngle*2
while ii < N+periodAngle*1.5:
  self.cell.shapes(LayerSiN_gratings).insert(arc_wg_xy(x,y, r, w+deltaW, 90+bendAngle-ii, 90+bendAngle-ii-periodAngle))
  ii = ii+periodAngle
  ii = ii+periodAngle
```

```
# Bragg narrow
ii = periodAngle
while ii < N:
  self.cell.shapes(LayerSiN_gratings).insert(arc_wg_xy(x,y, r, w-deltaW, 90+bendAngle-ii, 90+bendAngle-ii-periodAngle))
  ii = ii+periodAngle
  ii = ii+periodAngle
```

Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw bend sections (uncorrugated)**
- **Use an arc function (arg_wg_xy)**



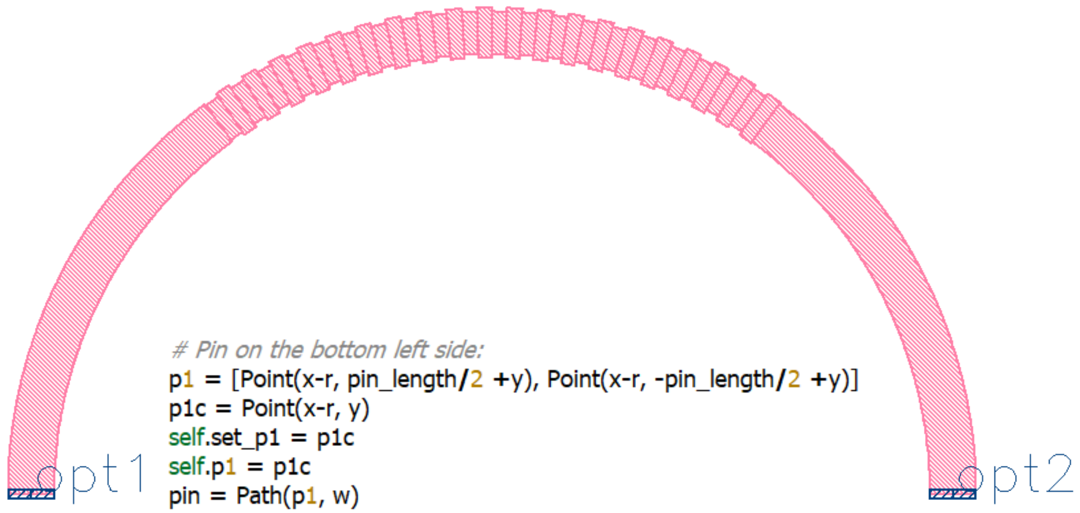
```
# bend non-corrugated left
self.cell.shapes(LayerSiN).insert(arc_wg_xy(x,y, r, w, 180-(90-bendAngle), 180))

# bend non-corrugated right
self.cell.shapes(LayerSiN).insert(arc_wg_xy(x,y, r, w, 0, 90-bendAngle))
```

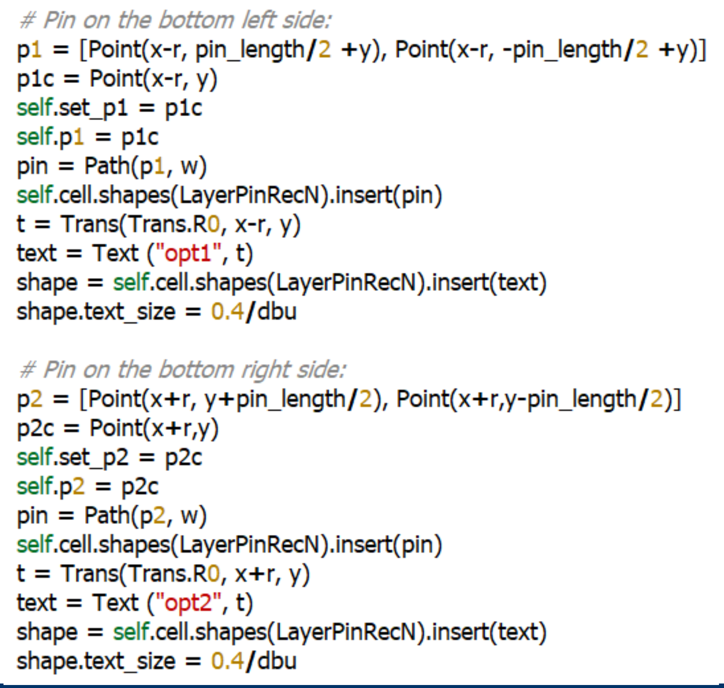
Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw optical input pins**
- **As wide as waveguides width**
- **Be aware of orientation!**

- **This enables component snapping**

- **Used for connectivity/netlist**



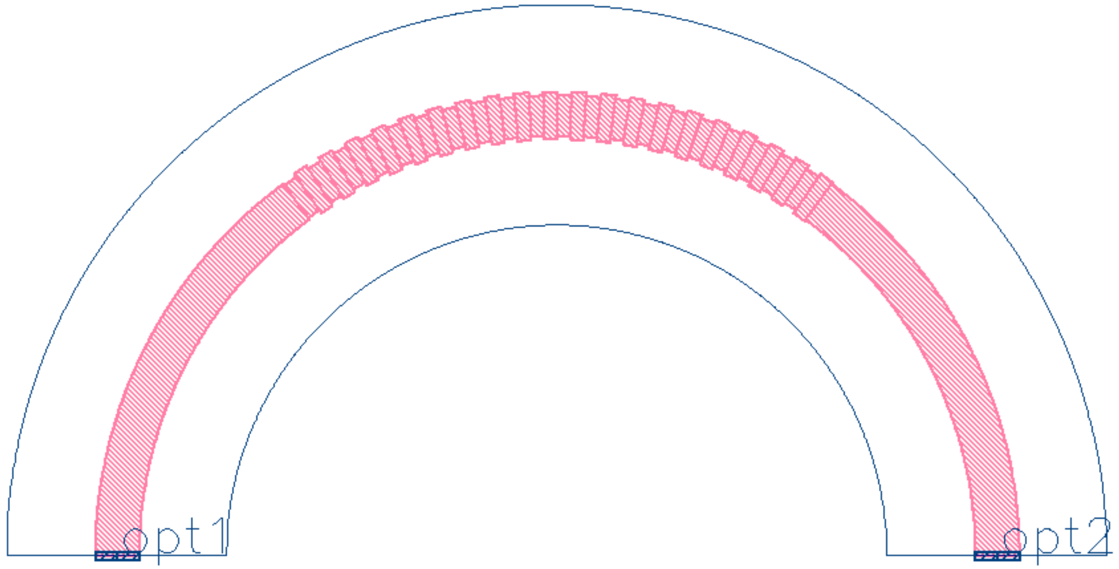


```
# Pin on the bottom left side:
p1 = [Point(x-r, pin_length/2 +y), Point(x-r, -pin_length/2 +y)]
p1c = Point(x-r, y)
self.set_p1 = p1c
self.p1 = p1c
pin = Path(p1, w)
self.cell.shapes(LayerPinRecN).insert(pin)
t = Trans(Trans.R0, x-r, y)
text = Text ("opt1", t)
shape = self.cell.shapes(LayerPinRecN).insert(text)
shape.text_size = 0.4/dbu

# Pin on the bottom right side:
p2 = [Point(x+r, y+pin_length/2), Point(x+r,y-pin_length/2)]
p2c = Point(x+r,y)
self.set_p2 = p2c
self.p2 = p2c
pin = Path(p2, w)
self.cell.shapes(LayerPinRecN).insert(pin)
t = Trans(Trans.R0, x+r, y)
text = Text ("opt2", t)
shape = self.cell.shapes(LayerPinRecN).insert(text)
shape.text_size = 0.4/dbu
```

Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw device recognition (bounding) box**

- **Used for device area recognition, prevents from overlapping with other components**



```
# Create the device recognition layer -- make it 1 * wg_width away from the waveguides.
self.cell.shapes(LayerDevRecN).insert(arc_wg_xy(x ,y, r, w*5, 0, 180))
```