Design and fabrication of Endcap prototype sensors (petalet) for the ATLAS Upgrade

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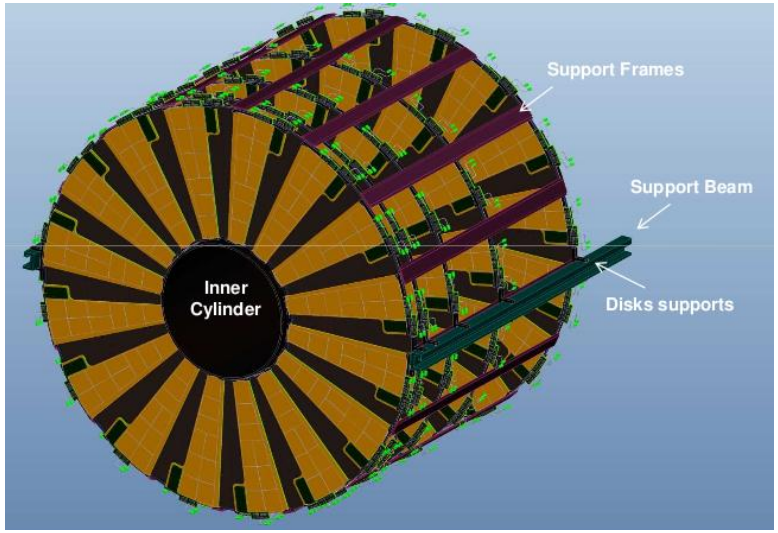
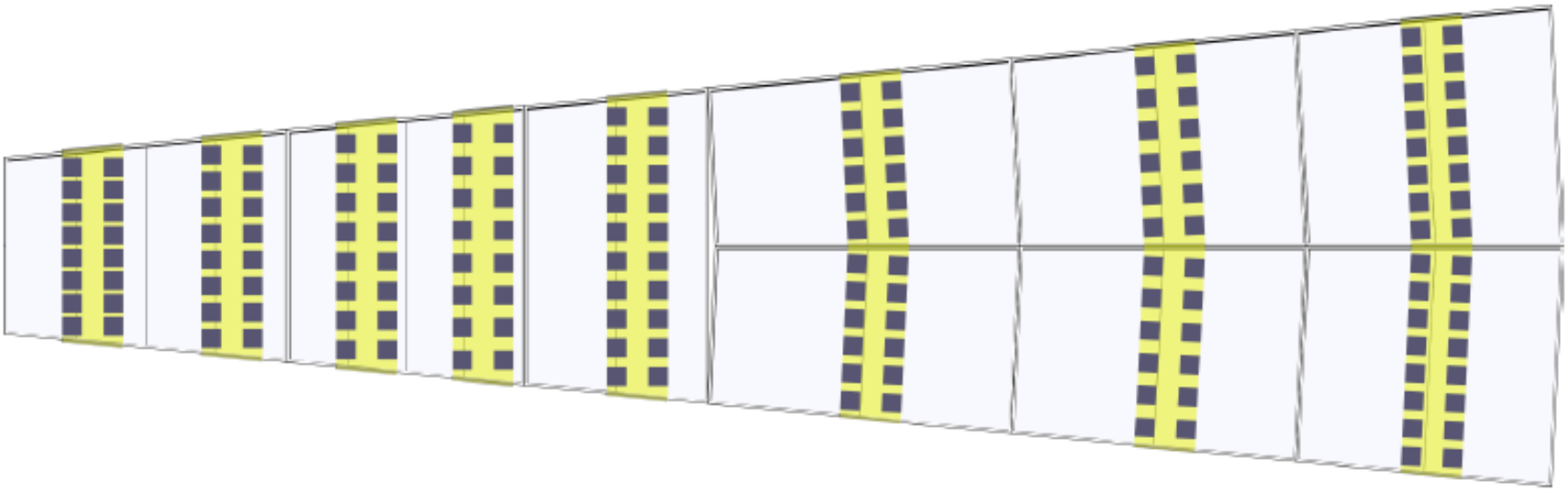
Petal

- Endcap Upgrade.
- 5 disks on each side of the barrel.
- Each disk is made of 32 petals.
- 6 sensor rings.
- Built-in stereo angle (±20 mrad)



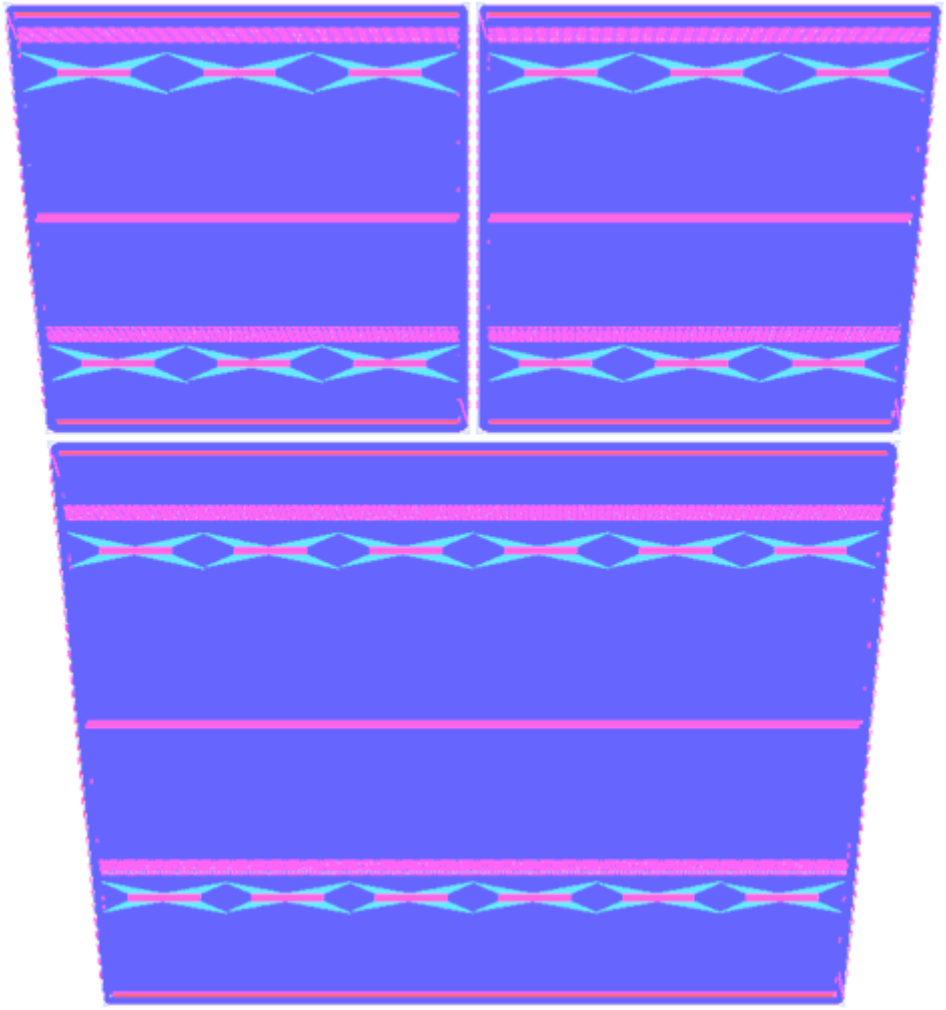


Petalet

- We better concentrate on a smaller concept that helps understanding the whole model.

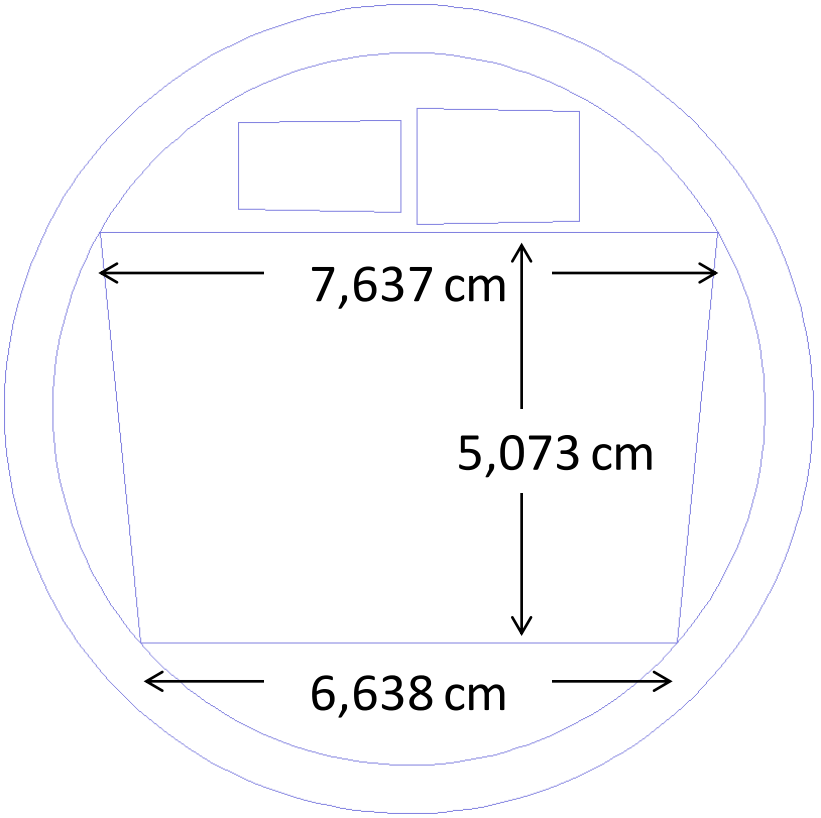
- Addresses most of the issues that make a petal different than a stave.
  - Built-in stereo angle.
  - Different pitch.
  - Bonding angle.
  - Embedded pads.
  - Incomplete strips.

- Mechanical, cooling, electrical, test beams, Irradiations, …



Petalet

- Sensor dimensions based on wafer "safe area" (90 mm of 100 mm) and distance from lower edge to interaction point.
- All structures use the maximum wafer area available.
- Other structures were added in the remaining wafer areas.
- Designs made automatically by a developed Python script.



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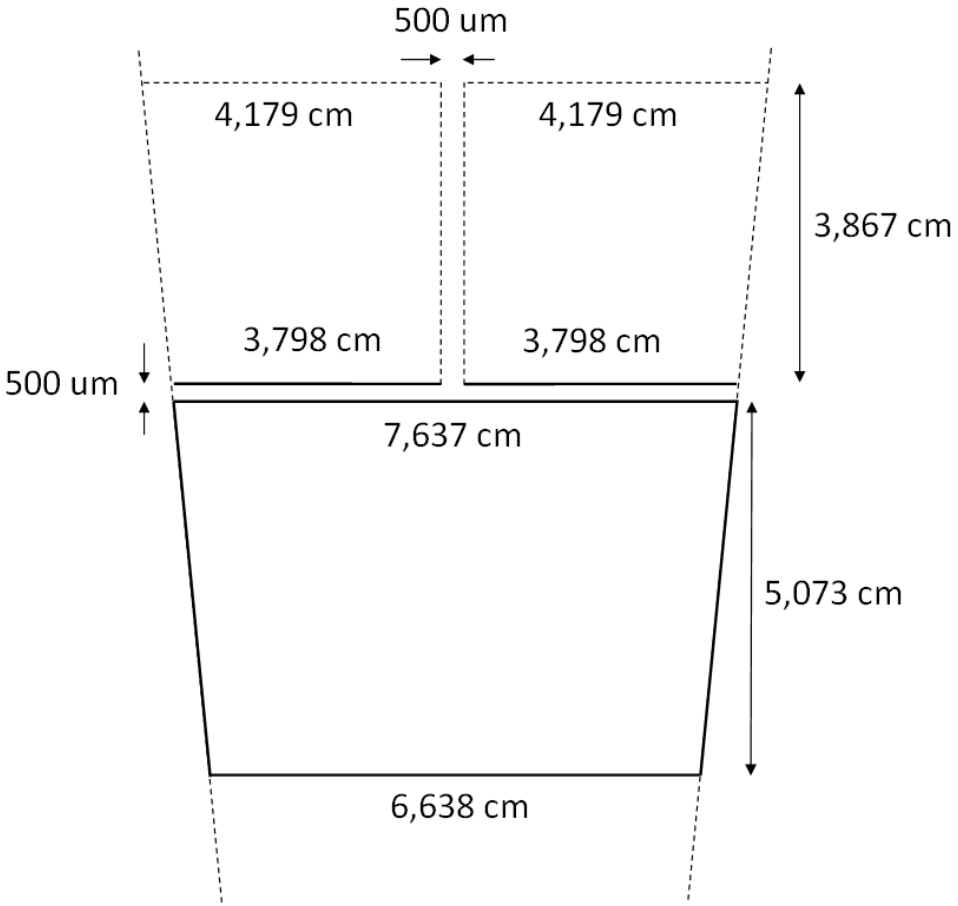
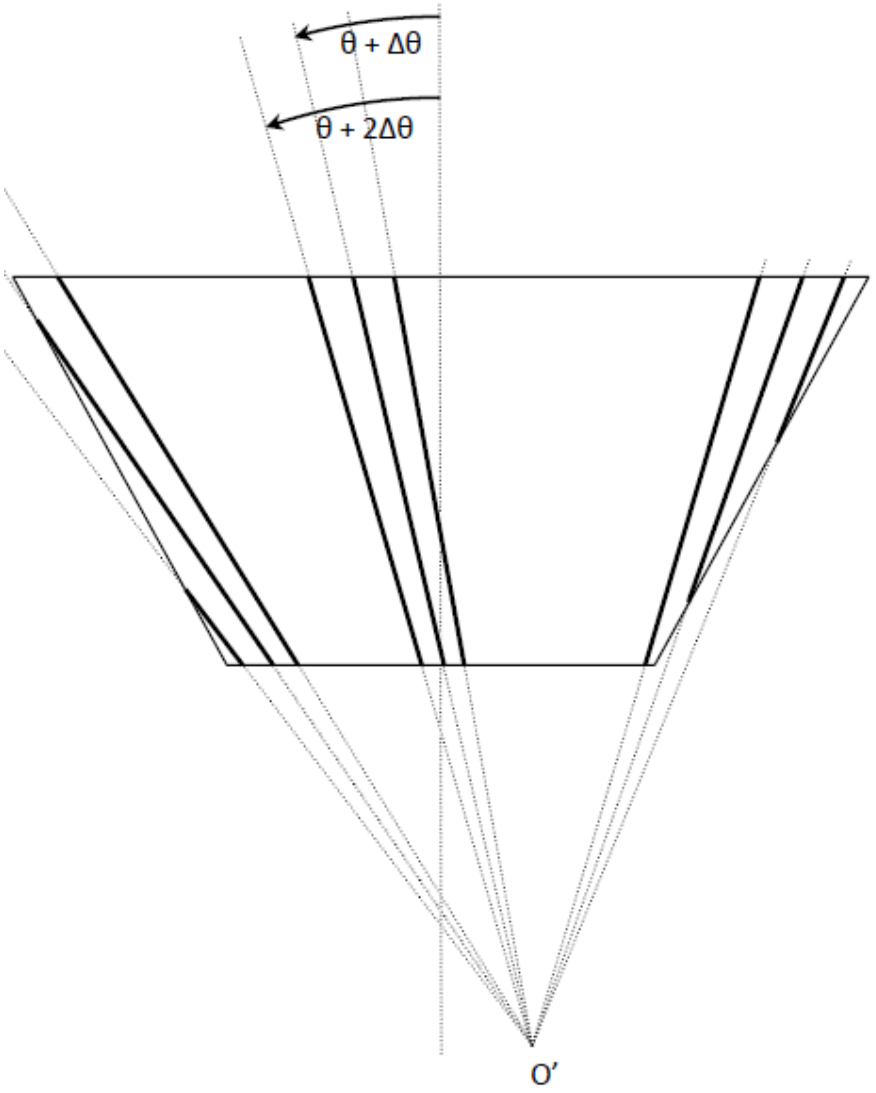


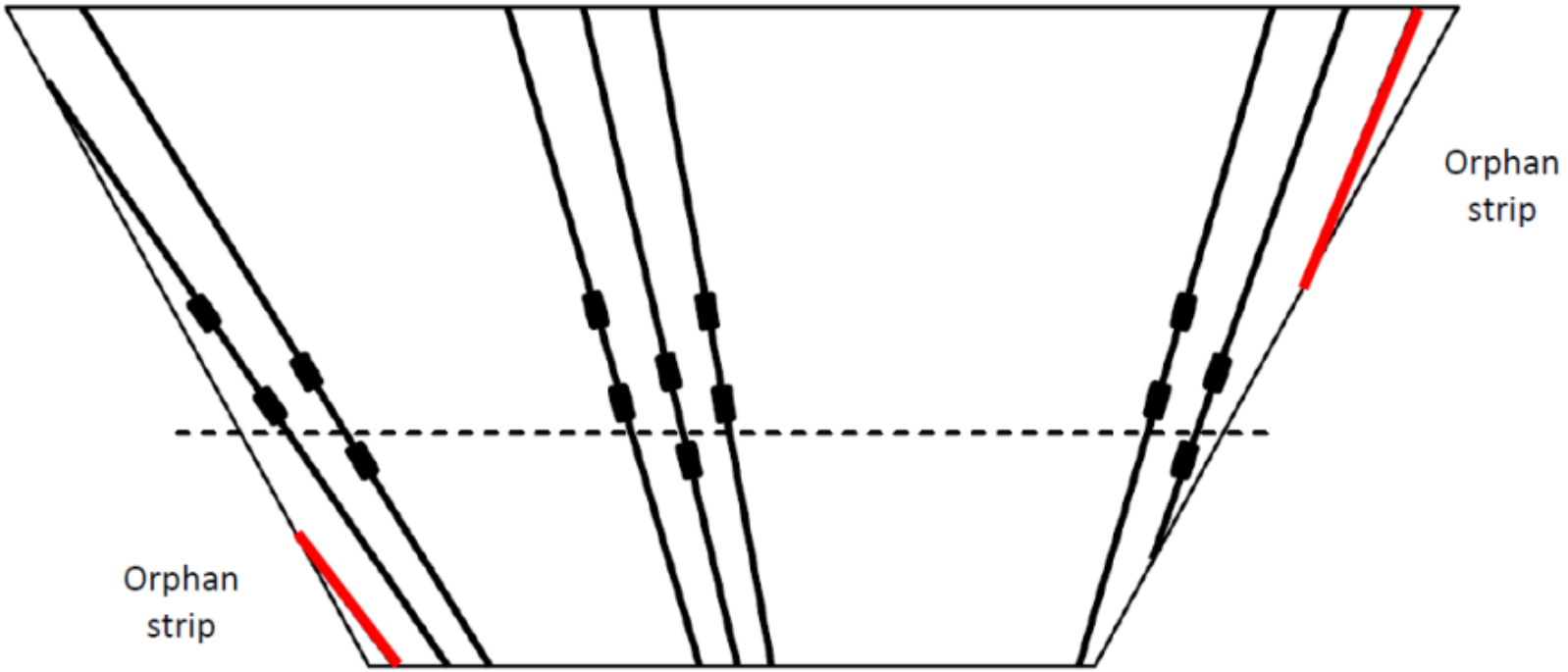
Prototype issues

- Built-in stereo angle.
- Edge strips not parallel to edge angle.
- Truncated edge strips.
- Some pads must be placed in non-standard positions.
- Orphan area with tracking resolution.



Orphan strips

- Strips which do not have a bonding pad.
- They are connected to the last complete strip.



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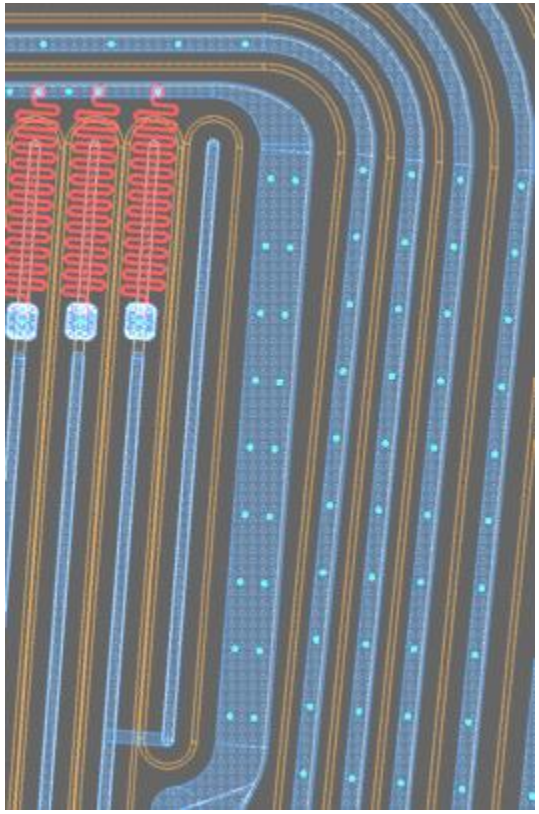
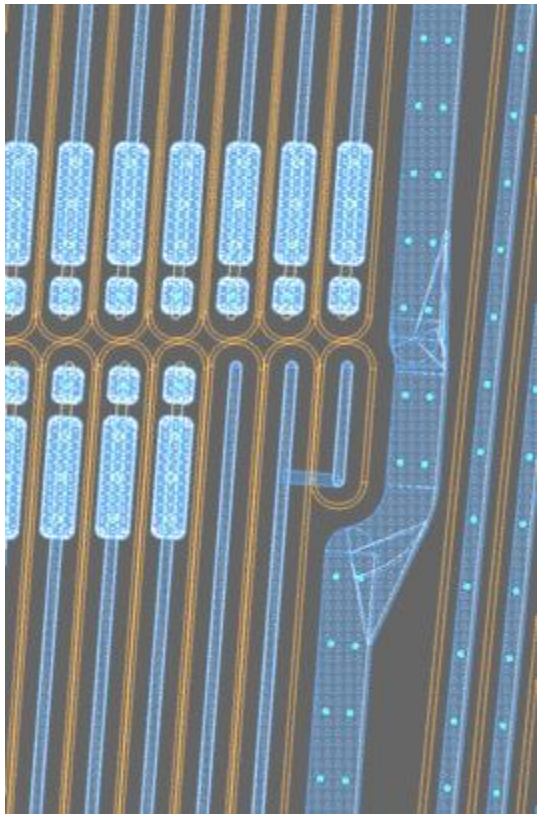
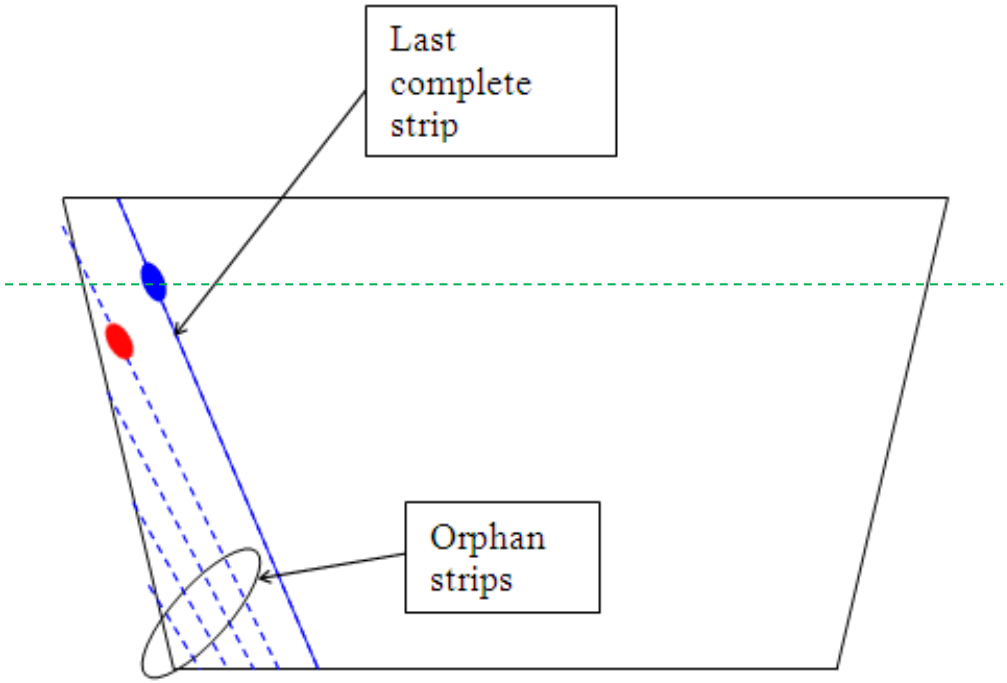




Orphan strips

- Only if their added length is larger than twice the average strip length (capacitance), an extra pad is added for the orphan strips. The total number of bonding pads (channels) remains the same.

- Extra pad is shifted from the bonding axis but as close as possible.



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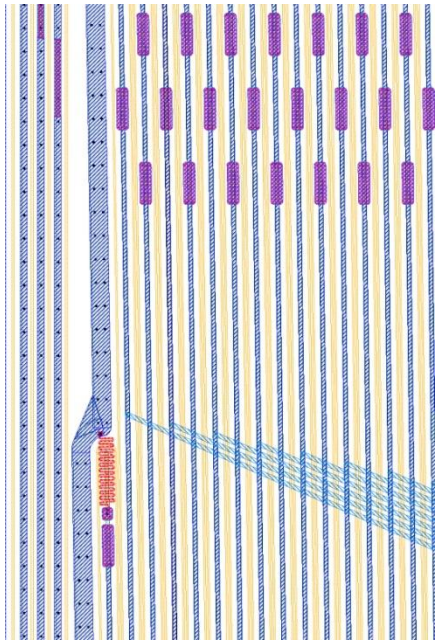
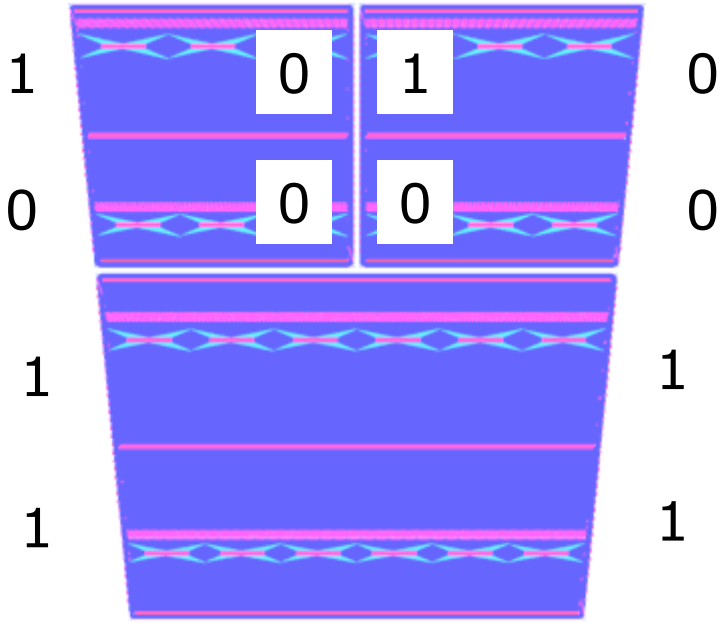
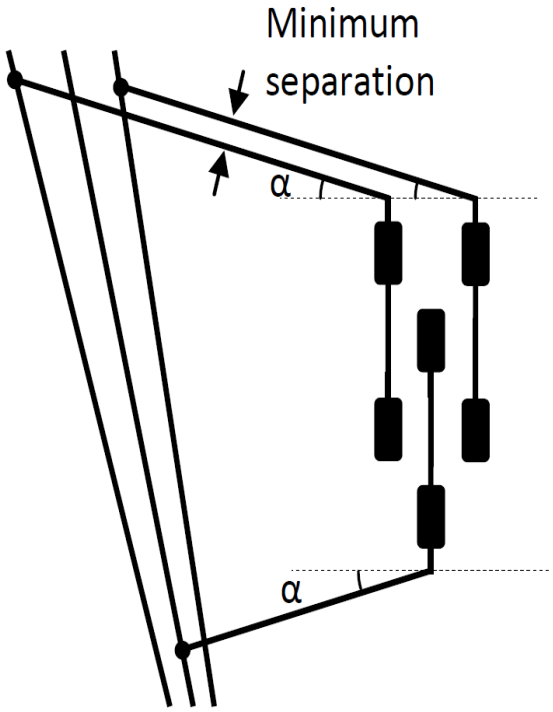




Embedded fanins

- Built-in pitch adaptors in the detector using second metal.
  - Minimum track length.
  - Maximum crossing angle.



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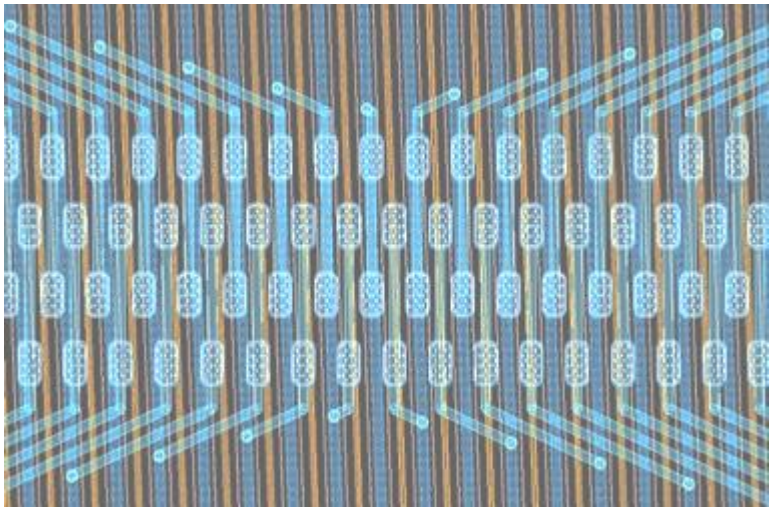
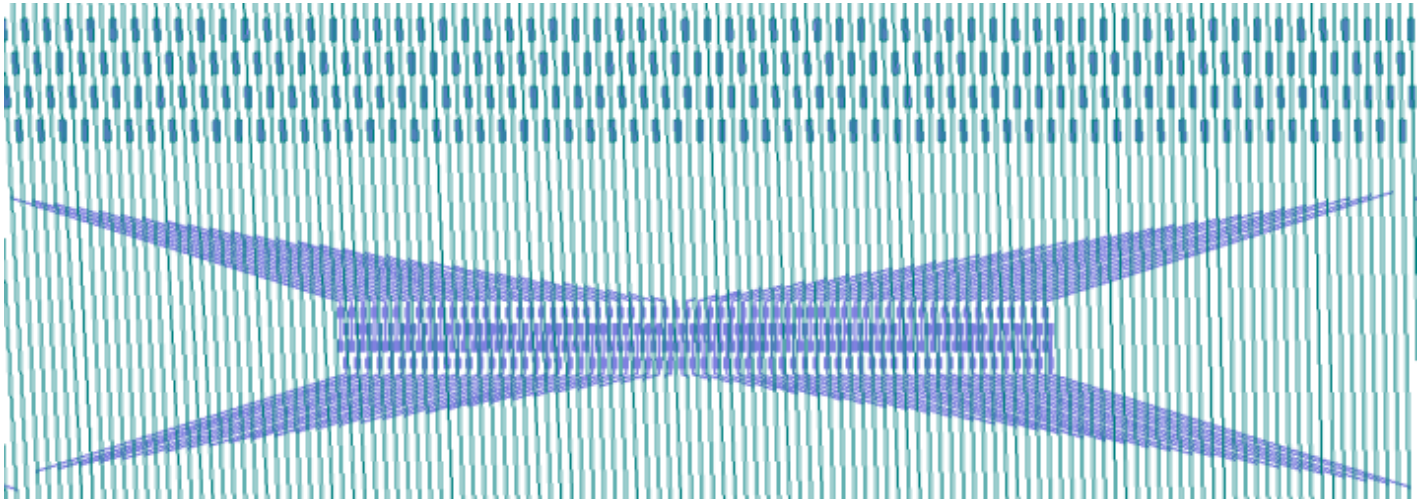
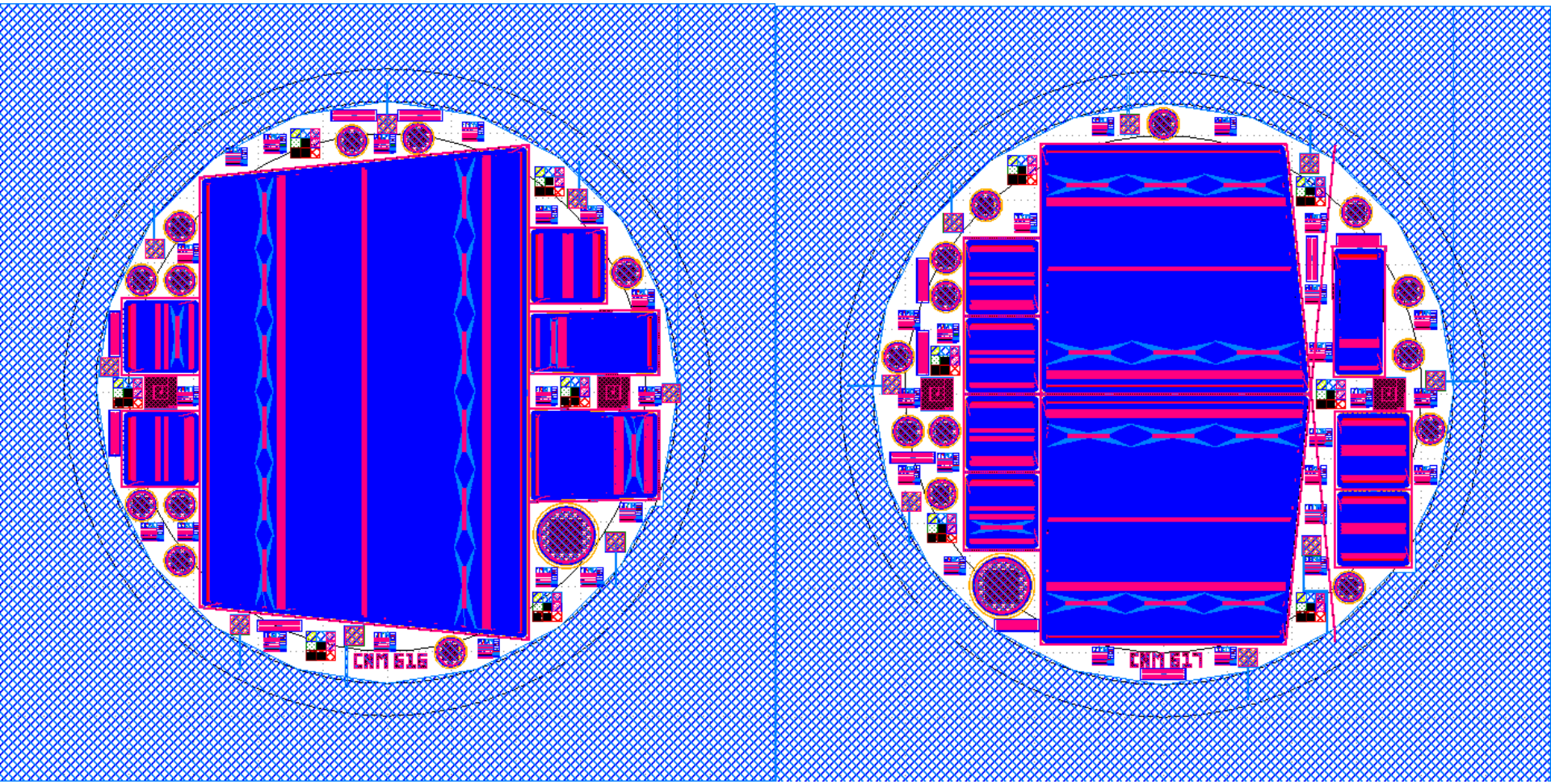




Automatic layout design tool

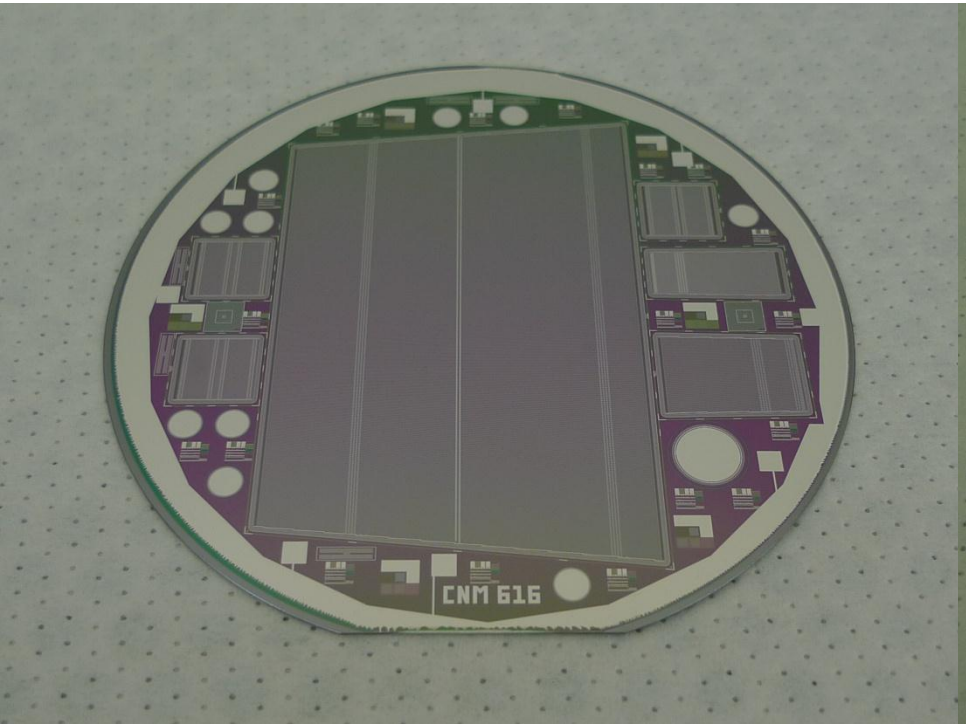
- A Python script was developed to create complete microstrip sensors.
- It is based in GDSPY, an existing python module which was released by Lucas Heitzmann Gabrielli.
- The complete algorithm to design the petalet sensors was coded.
- It has been very useful to try different solutions for the existing issues in the petalet sensors.
- The developed tool is being adapted and used for other projects such as in trapezoidal double side sensors and also in Low-R strips sensors (see Miguel's presentation on Friday).

Final designs



Big_Sensor Top

Wafers fabricated



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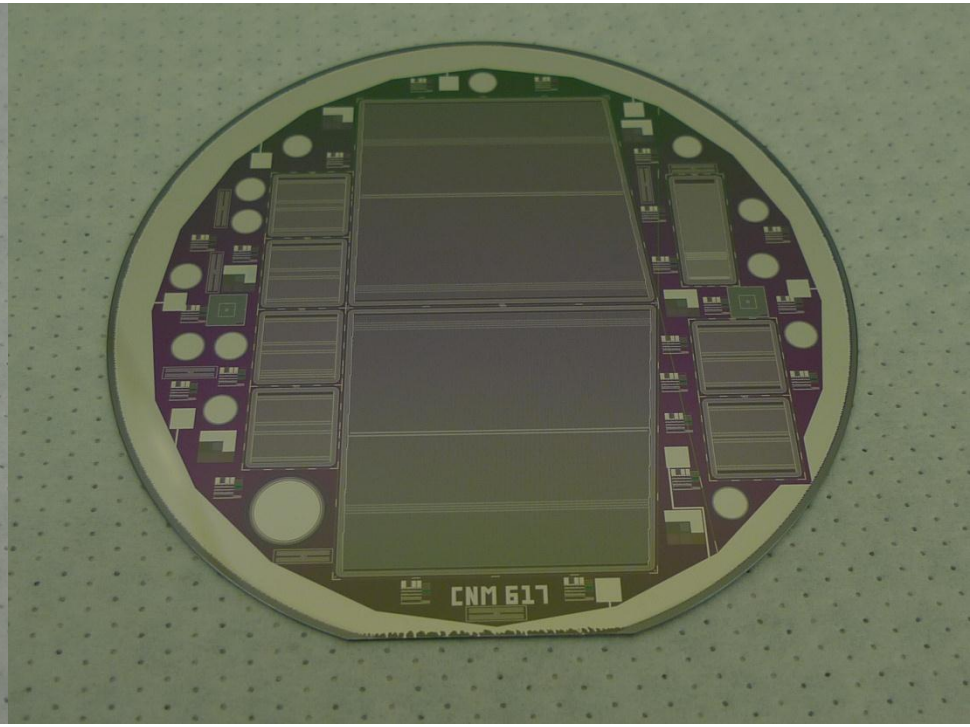
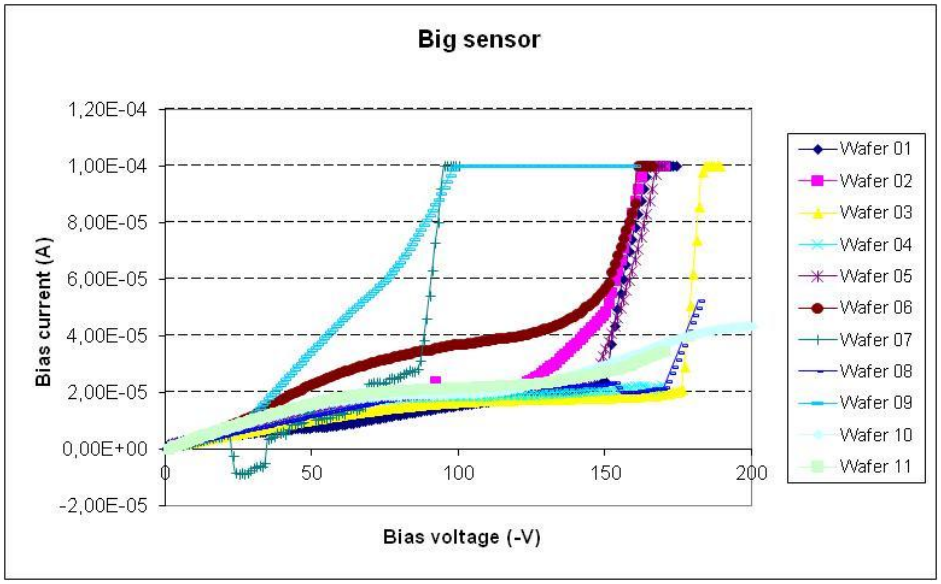


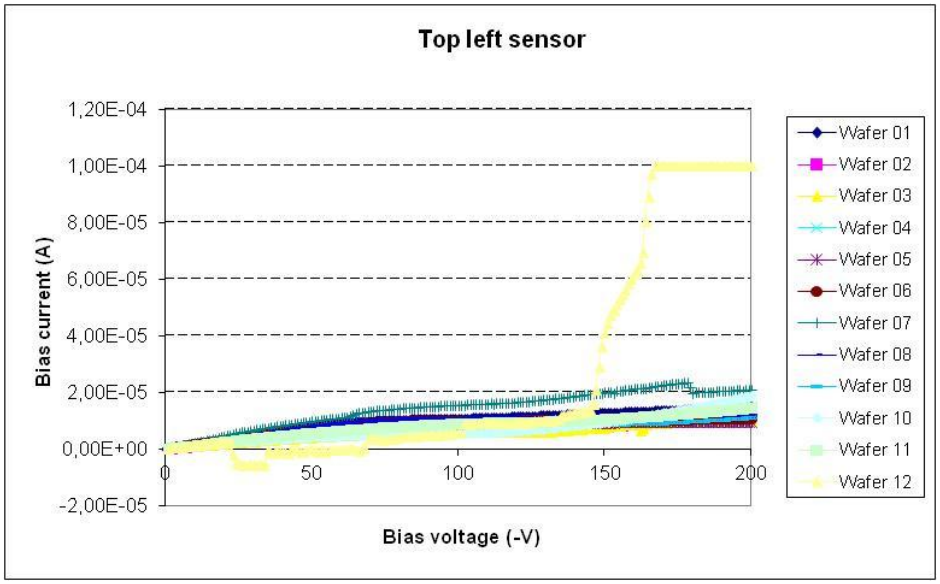
Top

- Wafers with one metal layer already finished
- Wafers with two metal layers still in process.

Preliminary measurements

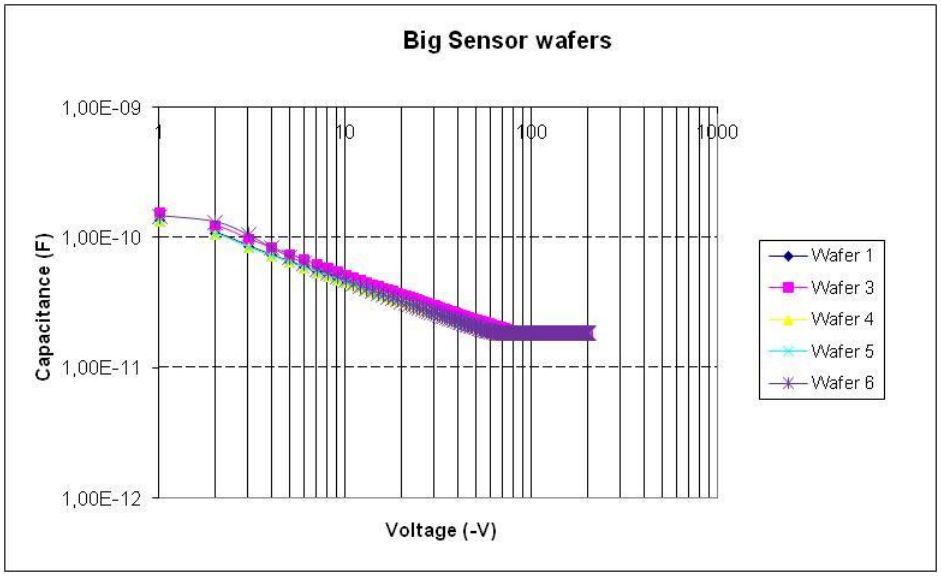
- IV measurements
  - Voltage ramps from 0 V up to 200 V.
  - Guard ring forced to the same potential as bias ring.
  - Bias leakage current around 20 uA.

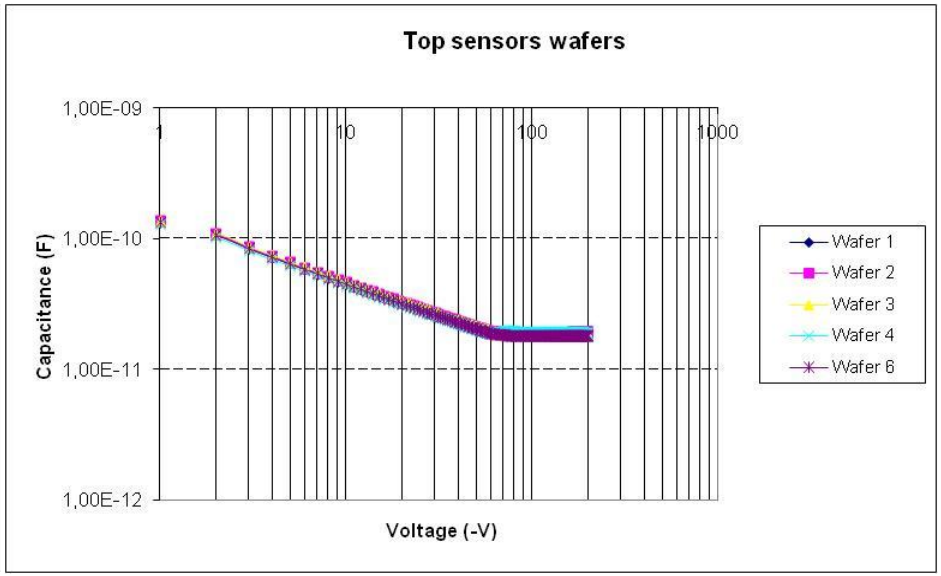




Preliminary measurements

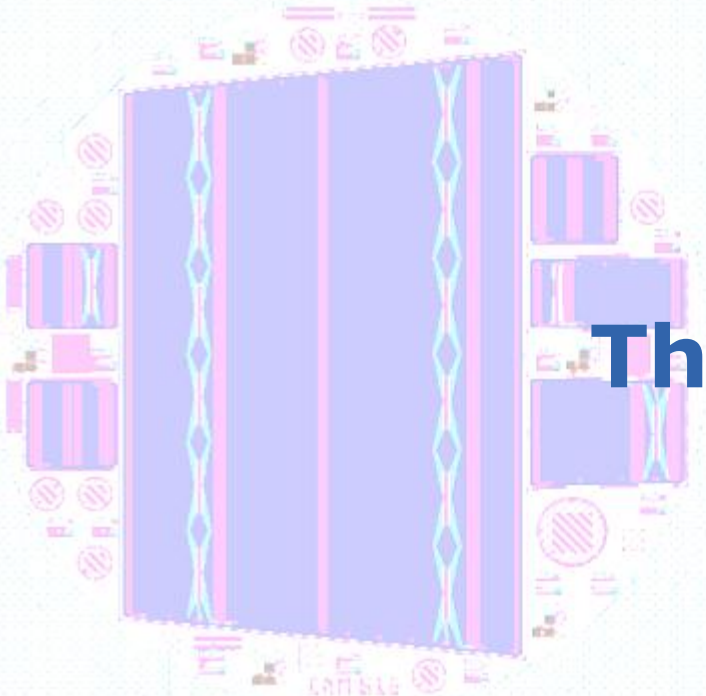
- CV measurements.
  - Positive and negative ramps applied on diode pads.
  - Full depletion voltage around 80 V.



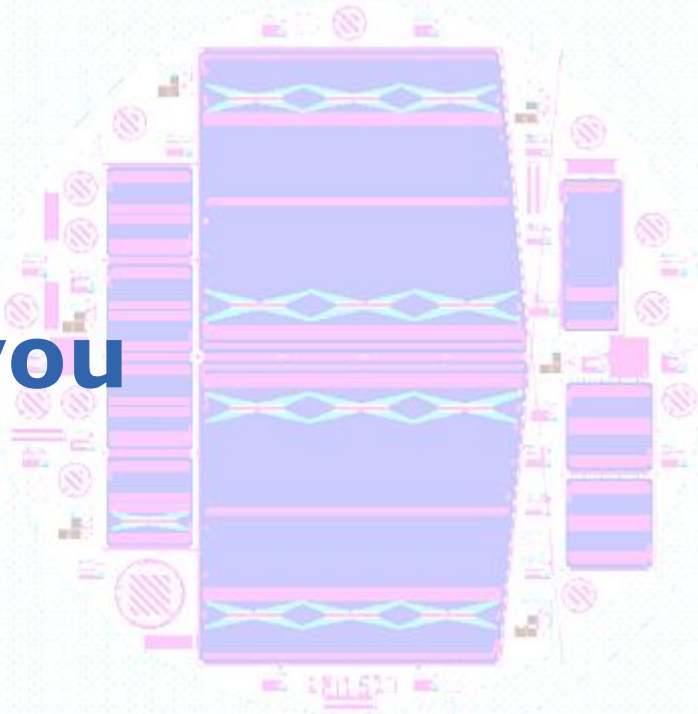


Conclusions

- Sensors for the petalet prototype have been designed.
- An automatic tool for layouts design of microstrip sensors has been developed.
- Petalet issues were studied and new solutions have been proposed implemented.
- Truncated strips have been joint in a single channel not to lose tracking area.
- Embedded pitch adaptors (fanins) have been included in the design and next wafers will feature them.
- First wafers processed at CNM clean room are being tested and first results are presented.



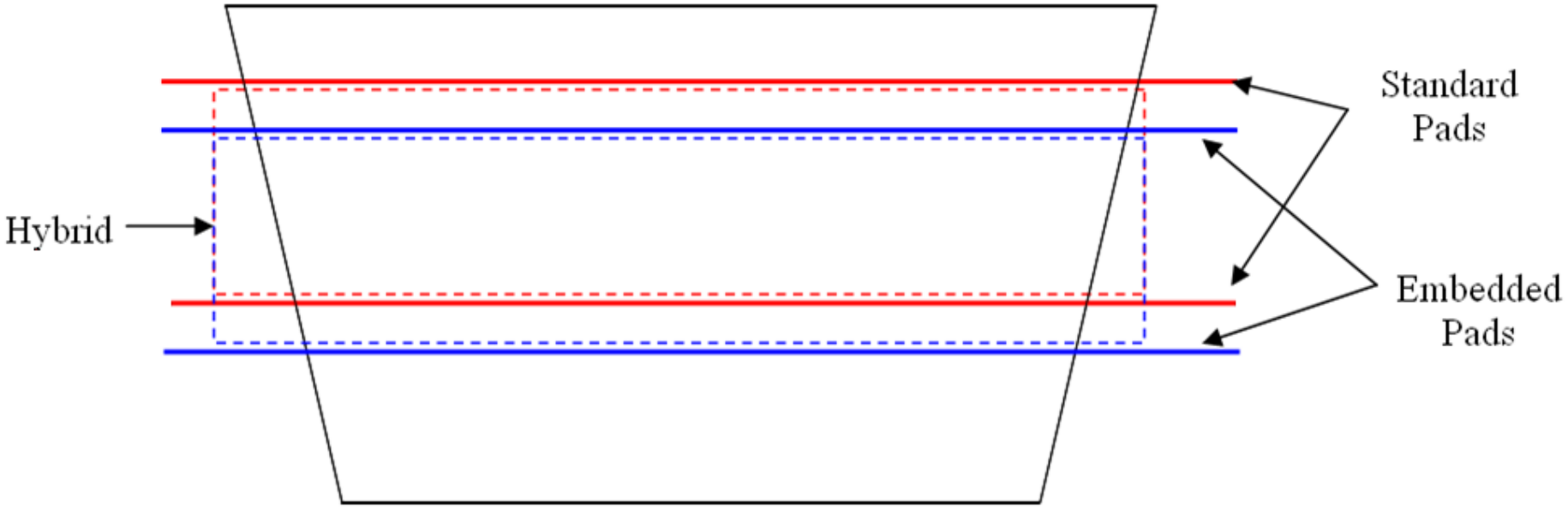
Thank you



Extra slides

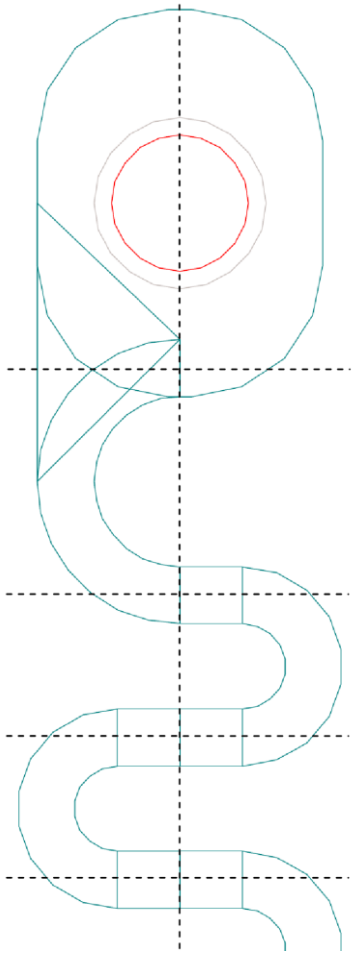
Embedded fanins

- Embedded pad position:
  - Symmetrical to centre.
  - Separated by 3 cm. (maximum hybrid height).
  - Standard bonding pads location (2 mm up).
  - Allows bonding to embedded or standard pads.



Bias resistors

- Formed by an arrangement of lineal and curved sections, besides its respective contacts.
- Each strip, that has bonding pads, has its respective bias resistor with its particular angle.
- It can be parametrized in order to use the available area in an efficient manner.
- As it is a geometrical construction, the total resistance depends on the number of sections used.
- High resistance precision is not needed as 50 % tolerance is specified.



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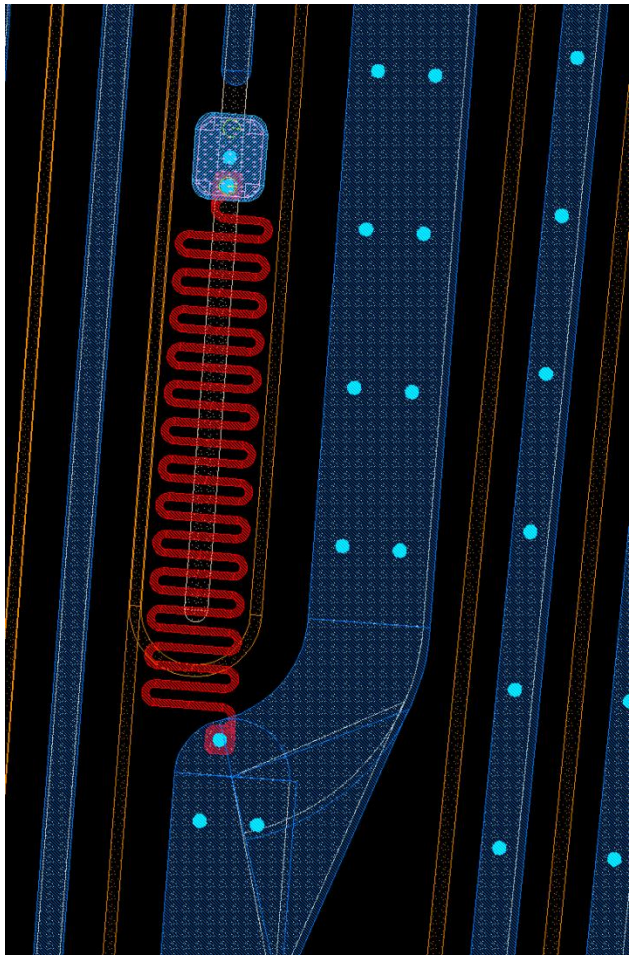
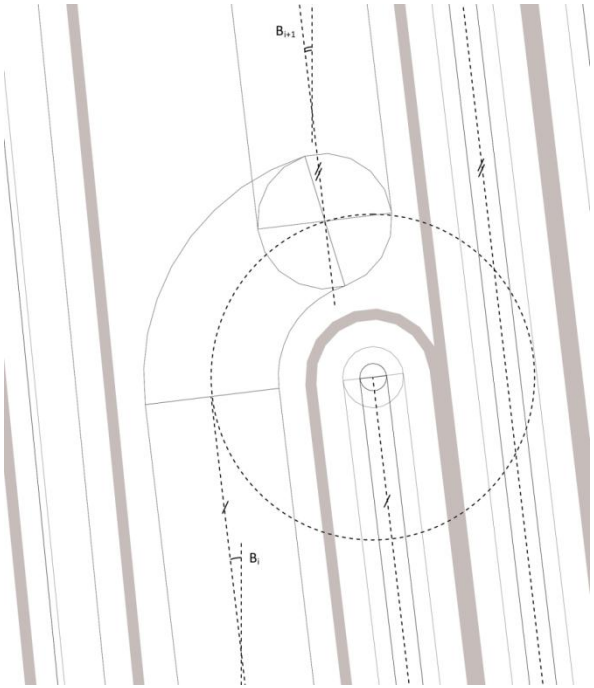


Bias ring

- Always at the same distance from the strips, but…
- The strips have varying angles, so…
- It is necessary to consider data from the actual strip, the previous and next ones.
- A parallel path is first created, with βi as its main angle, then an arc is done until the point where the next path, with βi+1 as main angle, starts.



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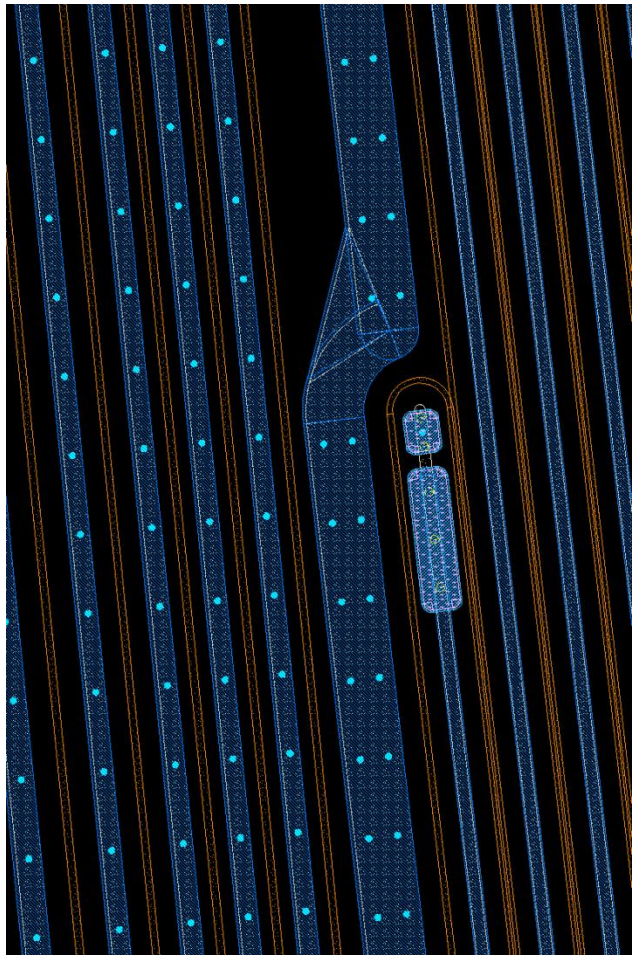

Guard rings

- There are not specific details on how the guard rings should be constructed.
- The guard ring area plus the minimum separation with bias line defines the “active strip area”
- The chip geometry (trapezium) defines how the guards are, and then the available are for the strips to be generated.