Design of the first full size ATLAS ITk Strip Sensor for the Endcap Region

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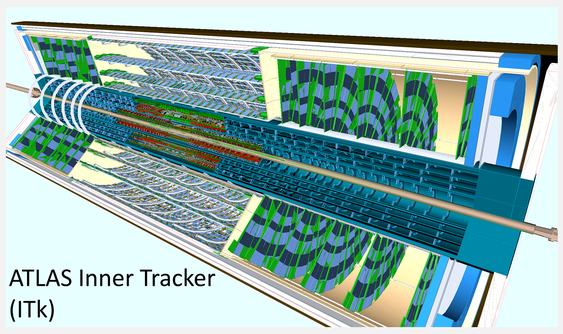
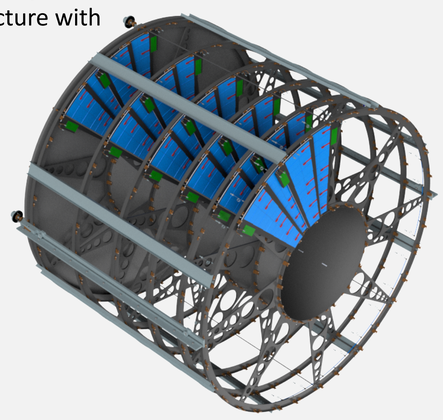
The ATLAS Inner Tracker (ITk) strip detector

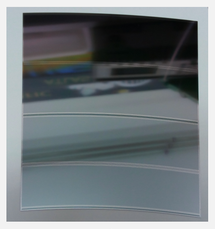


ATLAS Inner Tracker (ITk)

ITk Strips Endcap Global support structure with petals



The first R0 sensor



A petal, with its 9 sensors in the front side

ATLAS will need a new **all-silicon tracker** for the HL-LHC phase.

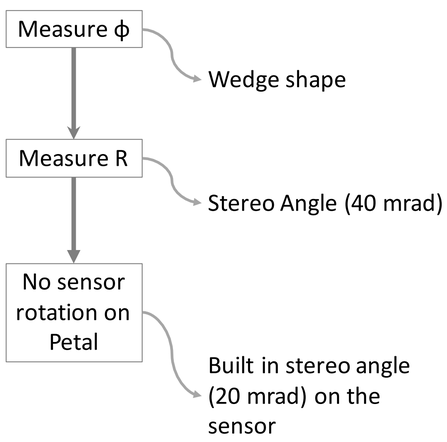
The ATLAS Inner Tracker (ITk) Strip detector has 4 cylinders in the barrel and **6 disks in each endcap.**

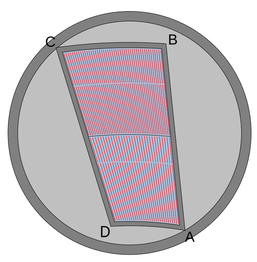
Each wheel will cover from an inner radius of 385 mm to 970 mm and will be made of **32 identical petals**.

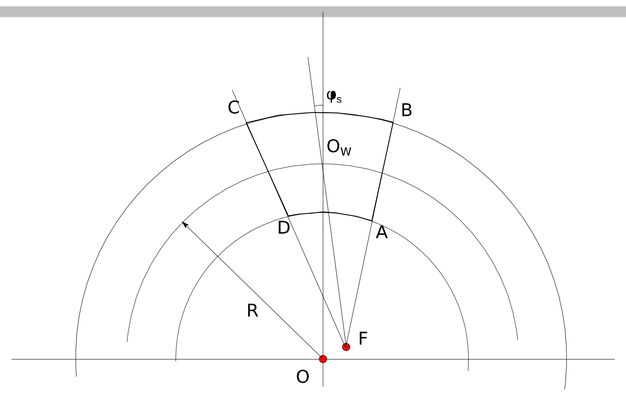
Each petal has 9 sensors on each side. The strips on the sensors have to lie on the **azimuthal direction** apart from a small **stereo rotation** to measure the second coordinate.

The sensors are built with n-strips on 6” p-bulk wafers.

The strips are AC coupled and biased with polysilicon resistors.







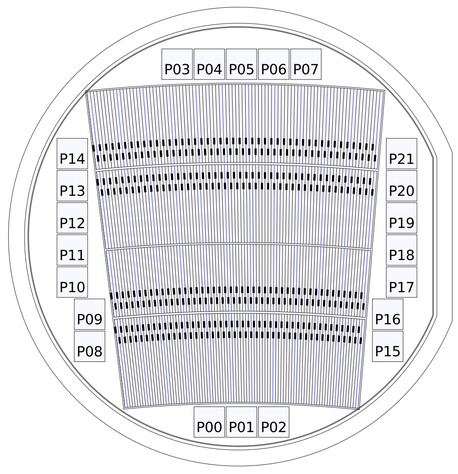
The sensor shape depends on the radius where it will be located. Sensors are designed to optimize the area in the wafer. The width, however, is limited by the wafer size.

Top and bottom arcs centred in O (the interaction point) are implemented with 16 flats.

Strips point to F to implement the stereo angle φ_s. Sensor sides also point to F.

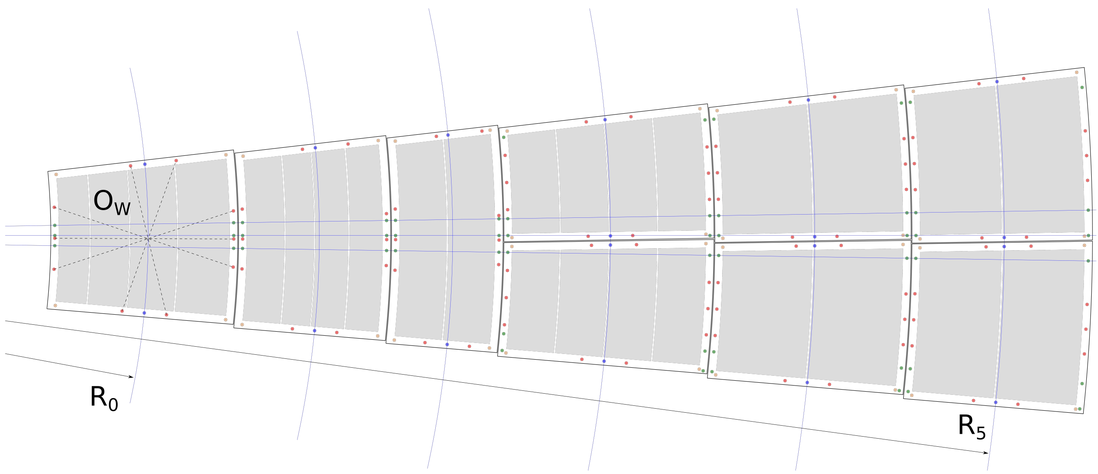
The strip length depends on the occupancy expected at the sensor radius and sensors will have 2 or 4 strip rows. The number of strips depends on the number of ASICs that fit the given sensor width.

Sensors have been optimized to have an average strip pitch of about 75 µm.



The first implementation of an endcap sensor has been the **R0 sensor**, at the lowest radius.

It has **4 strip rows**, the upper two with 1152 read out strips and the lower two with 1024. Strip rows have 2 extra field shaping strips at both ends which are not read out.



Fiducials:

Sensors are placed in the petal by positioning the centre of the wafer (O_W) at a given radius and angle. Provide markers to determine the centre of the wafer.

Sensor assembly at front and back of the petal rotated by 3.5 mrad to cover gaps between sensors. Blue lines pointing to origin help checking the proper location of the sensors. Provide markers to build those lines.

Provide markers to give redundancy in checking the radial position of the sensor.

Usual markers at the corner of the sensor.

See R0 in the figure for details.

The R0 sensor

An active area of about 90 cm² with **4 strip rows** and total of 4352 readout strips.

Hamamatsu photonics K. K. produced 155 of them.

Row	Length (mm)	I-pitch (µm)	O-pitch (µm)	Pitch (µrad)
0	18.981	74.314	77.983	193.2745
1	23.981	77.983	82.617	193.2745
2	28.981	73.454	78.434	171.8368
3	31.981	78.434	83.929	171.8368

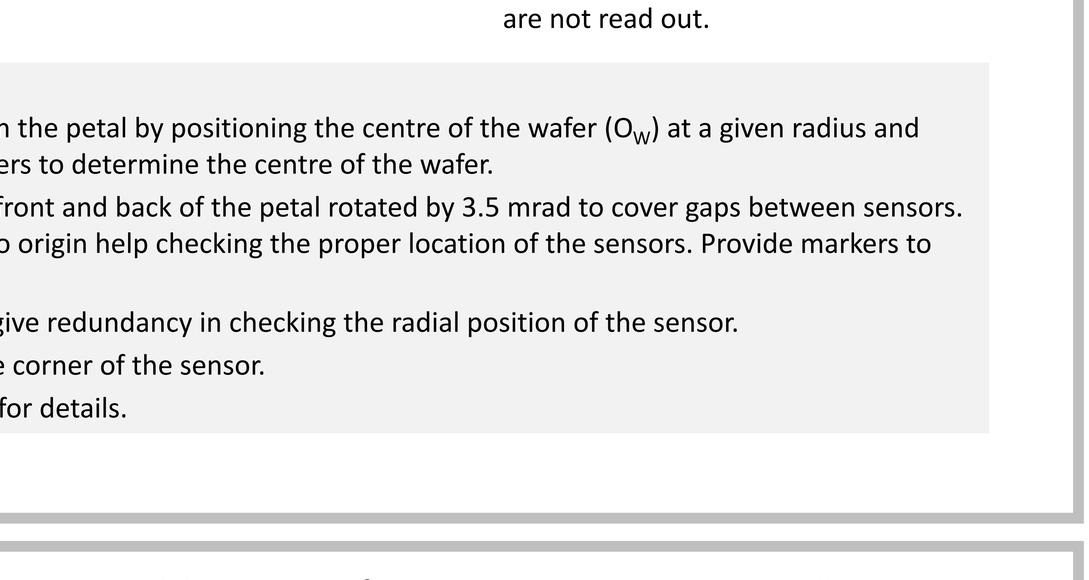
23 miniature (1x1 cm²) sensors in the wafer (see above), different strip coupling, PTP and strip pitch (narrow: 70µm, default: 75.5 µm, wide: 84 µm)

	PTP			Without PTP		
Coupling	Narrow	Default	Wide	Narrow	Default	Wide
AC	2	5	2			
DC	1	5	1	1	5	1

Sensor Specifications	ATLAS12EC
Wafer size	150 mm
Thickness	310 +/- 25 μm
Orientation	<100>
Type	P
Ingot	FZ
Resistivity	>3 kΩcm
Strip segments	4
Strip implant	N
Strip implant Width	16 μm
Strip bias resistor	Polysilicon
Strip bias resistance (R_b)	1.5+/-0.5 MΩ
Strip readout coupling	AC
Strip readout metal	Pure Aluminium
Strip readout metal width	20 μm
Strip AC coupling capacitance	>20 pF/cm
Strip isolation	>10×R_b at 300 V
Strip isolation method	Narrow-common p-stop
Punch Through Protection (PTP)	Gated
Gap between strip segments	56 μm (rail region) 70 μm (no rail region)
Microdischarge onset voltage	>600 V
Maximum operation voltage	600 V
Leakage current	<2 μA/cm² at 600 V
Radiation tolerance	1.5×10¹⁵ 1-MeV n_{eq}/cm²

Very high quality sensors. There is a program for testing sensor performance, many parameters evaluated and the studies are continuing.

See talk by **Robert Hunter** for details and talk by **Vladimir Cindro** for performance after irradiations



~500 µm slim edge

The R0 sensor requires circular dicing for the top and bottom arcs.