Sensors

Getting Ready for the production of EC Strip Sensors

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The numbers

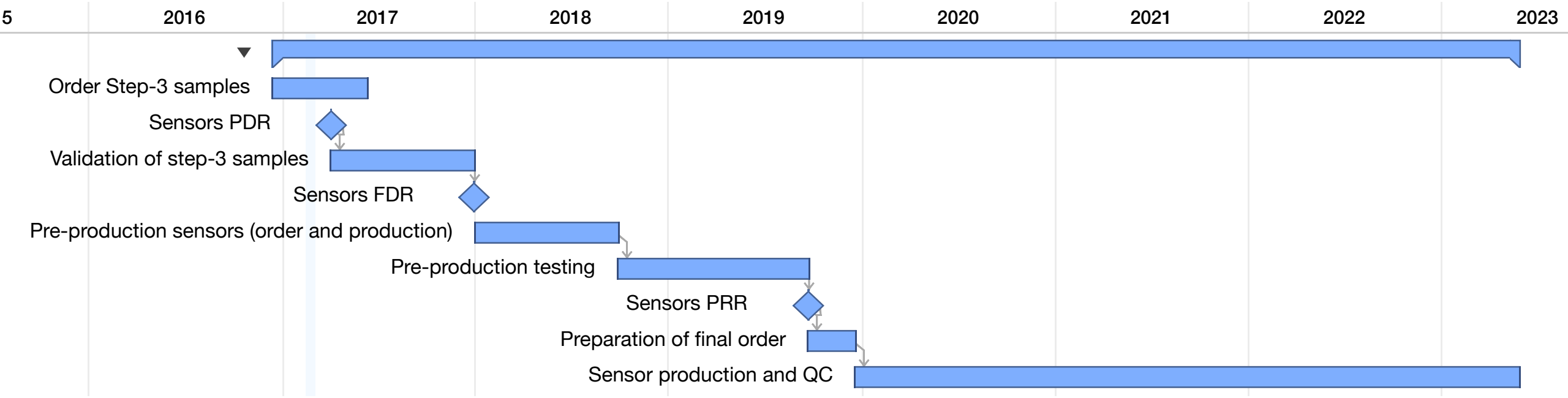
Assuming a 20% contingency, rough numbers are

	R0	R1	R2	R3	R4	R5	Total
Number of sensors	1000	1000	1000	2000	2000	2000	**9000**
Number of rows	4	4	2	4	2	2	
Channel per sensor	4360	5640	3076	3592	2052	2308	

9000 sensors to receive and test to different levels of detail.

Preproduction is a 5% of the total: 450 sensors

The schedule



Validation of MS-3 sensors during this year (barrel)
Final Design Review by end of this year. Preproduction starts.
One year to validate and have the Production Readiness Review

The work

1. Design of all 6 sensor types (more or less done)
2. Getting ready to validate preproduction.
    a. What ? Which tests, equipment needed? Irradiations ?
    b. Who ?
    c. How different shapes are distributed ?
        ✓ One shape at least 2 sites ?

2.1. Specifications of ITk production testing

Tests to be performed on every sensor:

Action	Equipment needed	Quality Control Spec.
Storage of Components	Storage Cabinets with dry atmosphere	
Visual Inspection: • Check for scratches, blemishes, trace continuity, sensor edge roughness, bias rail and guard ring	Optical Microscope (with automated inspection software),	No chips, cracks or no other irregularities clean sensor
Sensor bow	Non-contact Coordinate Measurement Machine SCC	Total bow < 200µm
IV 0..-700 V with 10V/10s	Probe station with N2/RH control, SCC or Dry atm.	I < 0.1µm/cm^2 @ 700V, @ Room Temperature No onset of micro-discharge up to 700V
CV 0..-700V with 10V/5s	As above	Full Depletion Voltage < 330V

Definitions:

- Standard Cleanroom Conditions (SCC): ISO 7 (class 10000), Temperature = 19±1^{o}C, Relative Humidity = 40 ±10 %
- Dry atmosphere: Relative Humidity < 5% at 21^{o}C dry air or nitrogen

2.1. Specifications of ITk production testing

Tests to be performed on a subset of sensors (10% - 1% of total), all done at SCC:

ActionData	Equipment needed	Quality Control Spec.
Full Strip tests • R_{bias}, $C_{coupling}$, $I_{leakage}$ on every strip	Automatic Probe Station (multi-channel probe card, switching matrix, …)	Number of strips with problem (pinhole, shorts, opens, implant breaks…) <2%
Current stability test at Vbias=-700 V	Probe-station or a test box Dry atm., 20°C	Current variation less then 15% in 24Hours
Additional tests • Cint, • Rint, • PTP, • Top metal resistance	Probe station	1 pF/cm at 300V at 100 kHz GΩ range at 600V (nonirrad.) < 15 Ω/cm
Database • Sensor is registered, data uploaded to database	PC + internet	

2.1 EC Sensor testing rate

- **Time estimation prepared for a site with 1 probe station**
- **All tests are equivalent for barrel and EC sensors except the full strip tests that will be very probably more complicated for EC sensors**

- **100% of sensors**
  - Visual inspection,
  - Metrology
  - IV,CV
  - Sensor registration in database
  - **1:40 hours/sensor → 4 sensors/day**

- **Subset of sensors - starts at 10% and reduced to 1% of total**
  - Full strip tests: **- ≈ 14 hours/sensor** - single needle strip–by–strip (overnight running possible)
    - **≈ 5 hours/sensor** - with EC specific multi-channel probe card (including alignments for every individual segments)
  - PTP, Cint, Rint
  - Current stability (24h running in a test box, multiple sensors at time, parallel measurement)
  - Sensor registration in database
  - **1 sensor/day**

- **e.g. one site** ≈ 1000 sensors → 250 + 100 = 350 days

2.2 Number of sites involved in ITk EC sensor testing

Table 13.2: Intended Number of Production Build Sites for the ITk Strip Detector

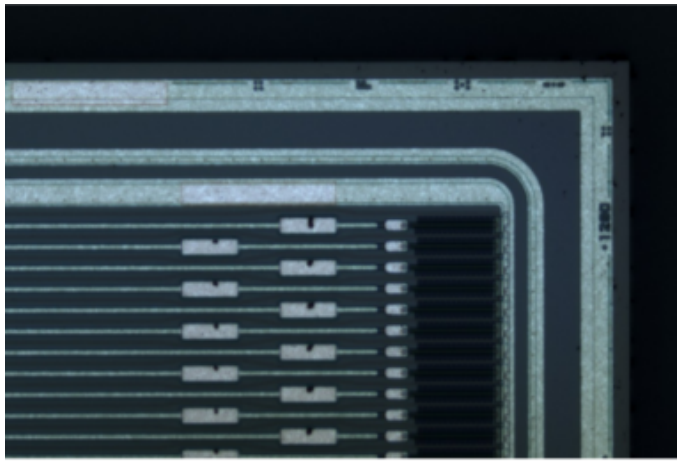
Item	Sites
Sensor Testing	4
ABCStar Wafer Probing	2
HCCStar Wafer Probing	2
Power Board Assembly	2
Barrel Hybrid Assembly	2
End-cap Hybrid Assembly	2
Barrel Module Assembly	8
End-cap Module Assembly	7
EoS Card Assembly	2
Barrel Bus Tape Testing	2
End-cap Bus Tape Testing	2
Barrel Core Production	2
End-cap Core Production	2
Barrel Module on Core Assembly	2
End-cap Module on Core Assembly	2

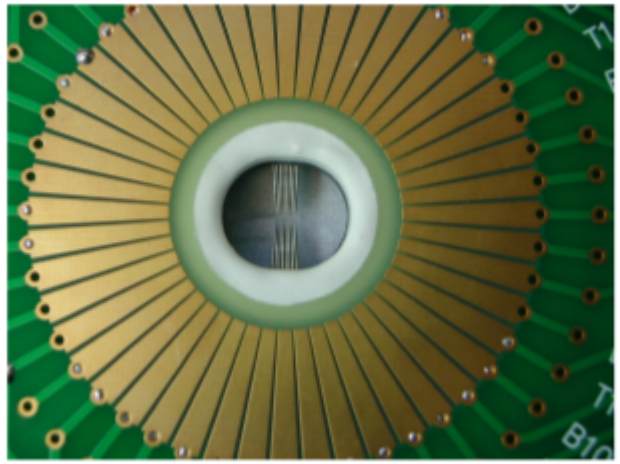
9000 EC sensors to be tested,
only 2 EC sensor testing sites is insufficient

Q: how many sites will be included in production testing of EC sensors / number of EC sensors per site?

Full strip tests – barrel sensor

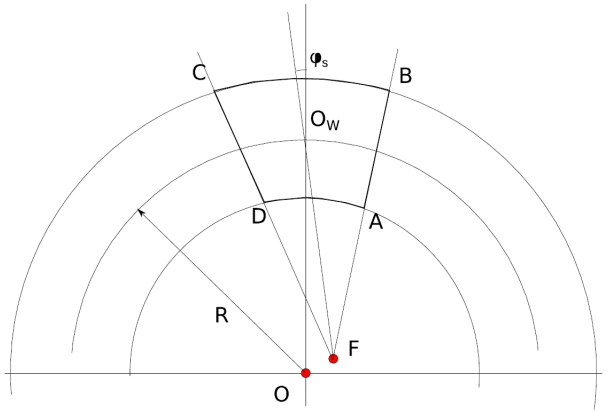
- R_{bias}, $C_{coupling}$, $I_{leakage}$ on each sensor strip
- for barrel sensors the testing contact pads are in line
- measurement set-up with a custom 32 channel low-leakage probe card with associated switching and multiplexing equipment developed at Cambridge Uni.
- Time required for one sensor full strip test reduced from 14 hours with single needle to less than 3 hours.



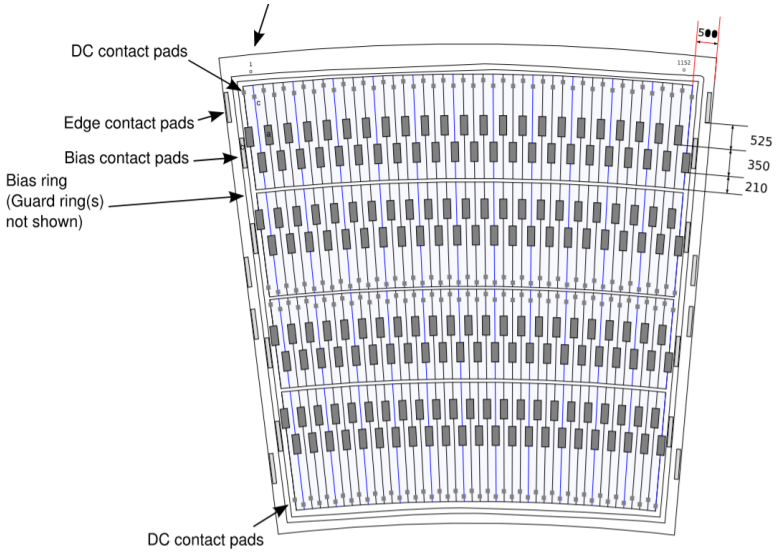


Full strip tests – EC sensors specific

- 6 different EC sensor designs
- wedge shaped strips with a stereo angle implemented in the sensors
- 2 or 4 columns of strips on a sensor
- contact pads positioned on circular arch
- **the angular pitch** is constant for given segment but may be different among segments of one sensor
- Different absolute pitch of contact pads
- Number of strips in columns may differ (e.g. R0: Column 1 and 2 : 1024 strips , Column 3 and 4 1152 strips)
- **-> up to 4 different multi-channel probe-cards needed for one sensor**



The sensor is drawn connecting ABCD.
The arcs CB and DA are centered at O
Strips have F as focus.
Sensor center O_W at radius R



Full strip tests of EC sensors are not straightforward – single-needle vs multi-channel probe cards

The nearer Future: R0s

Group	1st Delivery	2nd Delivery	3rd Delivery	All	
Melbourne	-	-	5	5	
Toronto/Carleton	5	3	12	20	
Vancouver	-	8	12	20	
Charles U.	-	1	2	3	
IoP AS CR.	5	-	-	5	(2 belong to Charles U)
Freiburg	5	3	6	14	
Dortmund	1	4	8	13	
Berlin	1	3	5	9	
DESY	8	7	13	28	
NIKHEF	-	2	4	6	
IFIC	5	4	6	15	
Uppsala	-	5	10	15	
Ljubljana	2	-	-	2	
Total	32	40	83	155	

Already at CERN

On hold until green light from our side

The nearer future: R0

- Need to start an irradiation campaign
  - Miniatures:
    - some already irradiated or being irradiated at CYRIC
    - Might want to irradiate with neutrons
  - Large sensors: at CERN ?
- Need to characterize fast the first 2 batches so that the third one is delivered soon.
  - A bit of reshuffling of distribution queue so that testing centers receive first.