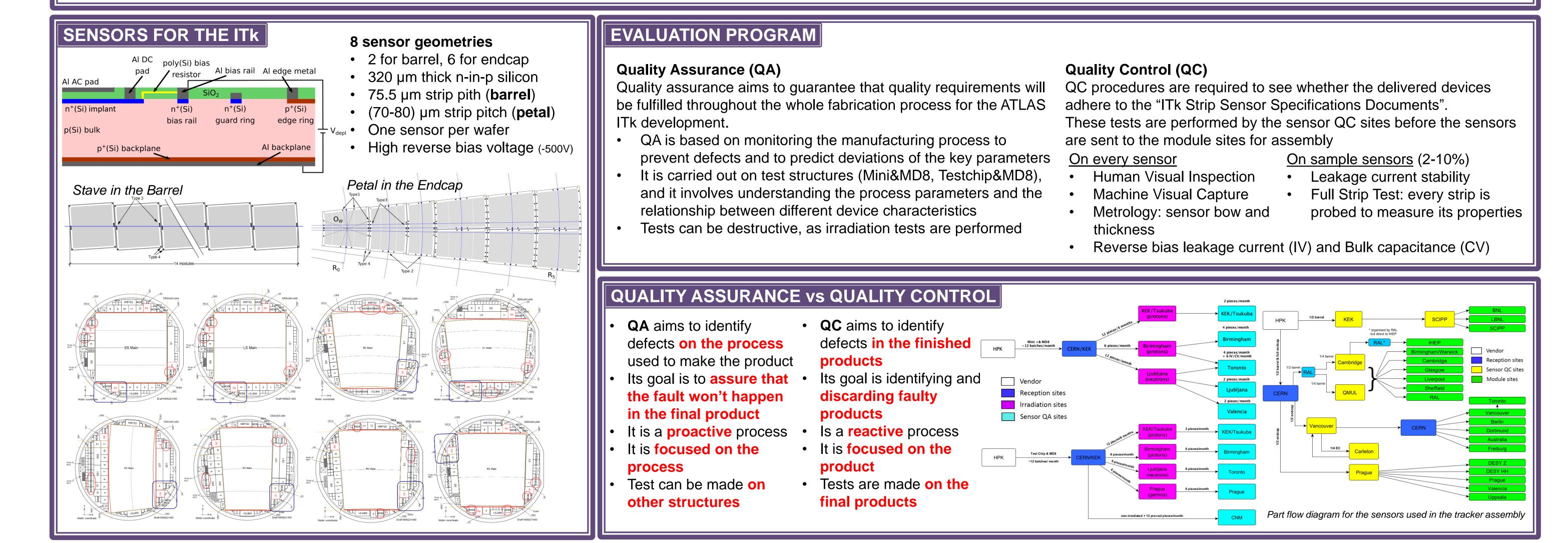


Radiation-Hard Silicon Strip Sensors for the **ATLAS Phase-2 Upgrade**

U.Soldevila^{a,*}, A. Affolder^b, K. Affolder^b, P.P.Allport^c, ^dE.Bach, M.Basso^g, S. Beaupre^e, G.A. Beck^d, J. Bernabeu^a, A. J. Bevan^f, A. Bhardwaj^g, B. Crick^g, I. Dawson^f, A. Dowling^b, V. Fadeyev^b, P. Federicova^h, J. Fernandez -Tejero^e, C.Fleta^d, A. Fournier^e, W.George^c, M. Gignac^b, L.Gonella^c, G. Greig^e, J. Gunnell^b, K. Haraⁱ, S. Hiroseⁱ, B. Hommels^j, A.Hunter^c, T. Ishiiⁱ, C. Jessiman^k, J. Johnson^b, D.Jones^j, S.Kachiguin^b, N. Kang^b, J. Keller^k, C. Klein^k, T.Knight^g, T. Koffas^k, I.Kopsalis^c, J. Kroll^h, J. Kvasnicka^h, C. Lacasta^a, V. Latonova^h, J.Lomas^c, F. Martinez-Mckinney^b, M.Mikestikova^h, P. S. Miyagawa^f, A.Montalbano^e, K.Nakamura^l, R.S.Orr^g, L. Poley^e, D. Rousso^h, A. Shah^f, C. Solaz^a, E. Staats^k, T. L. Stack^e, B. Stelzer^e, P.Tuma^h, M. Ullan^d, Y. Unno^l, J. Yarwick^b, S. C. Zenz^f

*usoldevi@cern.ch; aIFIC/CSIC-UV, bSCIPP, cU.Birmingham, dIMB-CNM(CSIC), eSFU/TRIUMF, dQMUL, gU.Toronto, bFZU Prague, U.Tsukuba, U.Cambridge, Carleton U., KEK

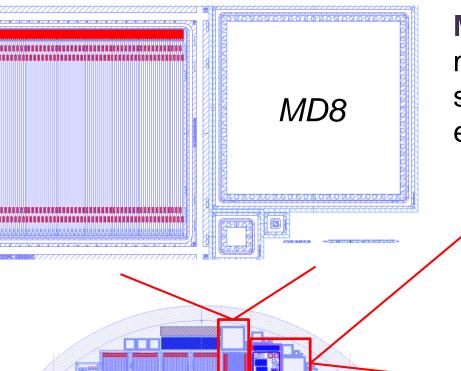
ABSTRACT The ATLAS upgrade for HL-LHC operation includes the installation of an entirely new all-silicon Inner Tracker (ITk). The silicon strip region comprises 165m² of instrumented area, made possible by the mass production of silicon strip sensors. This area is covered in a nearly hermetic way. Multiple sensor shapes are utilized: square sensors in the barrel part and skewed trapezoidal sensors with curved edges to provide continuous coverage of the disc surface in the endcap part of a detector. As a result, there are 8 different strip sensor types in the system. They all feature AC-coupled n⁺-in-p strips with polysilicon biasing, developed to withstand the total fluence of 1.6x10¹⁵n_{ed}/cm² and the total ionizing dose of 66 Mrad. Following many years of R&D and 4 prototype submissions and evaluations, in 2020 the project transitioned into pre-production, where 5% of the total volume was produced in all 8 designs. In this contribution, we will summarize the evaluation program, test results, and experience with the pre-production sensors.



QA RESULTS

- From every wafer one Testchip&MD8 and one Mini+MD8 piece is diced
- From every batch at least:
 - One Mini+MD8 irradiated for displacement damage (protons/neutrons) - One Testchip&MD8 is irradiated for ionization damage (proton/gamma)

Mini



Mini sensors with same layout as main barrel sensors but with 8mm of strip length. Used for charge collection efficiency measurements

Testchip structures: (1) Polysilicon bias resistors (2) Coupling capacitor (3) Interdigitated structures (4) Cross-bridge resistors (5) PTP structure (6) Field oxide MOS capacitor For different measurements:

Bias resistance

Metrology and Visual capture

Sensors in

metrology

(Prague)

frame of CNC

500 machine

Evidence of

required

resolution

(KEK/Tsukuba)



Verify sensor shape and bow. Provide detailed snapshot of sensor condition

Bow

Entries = 2033

Mean = 28.18

Median = 21.93

Std. dev = 20.15

160

140

120

QC RESULTS

100

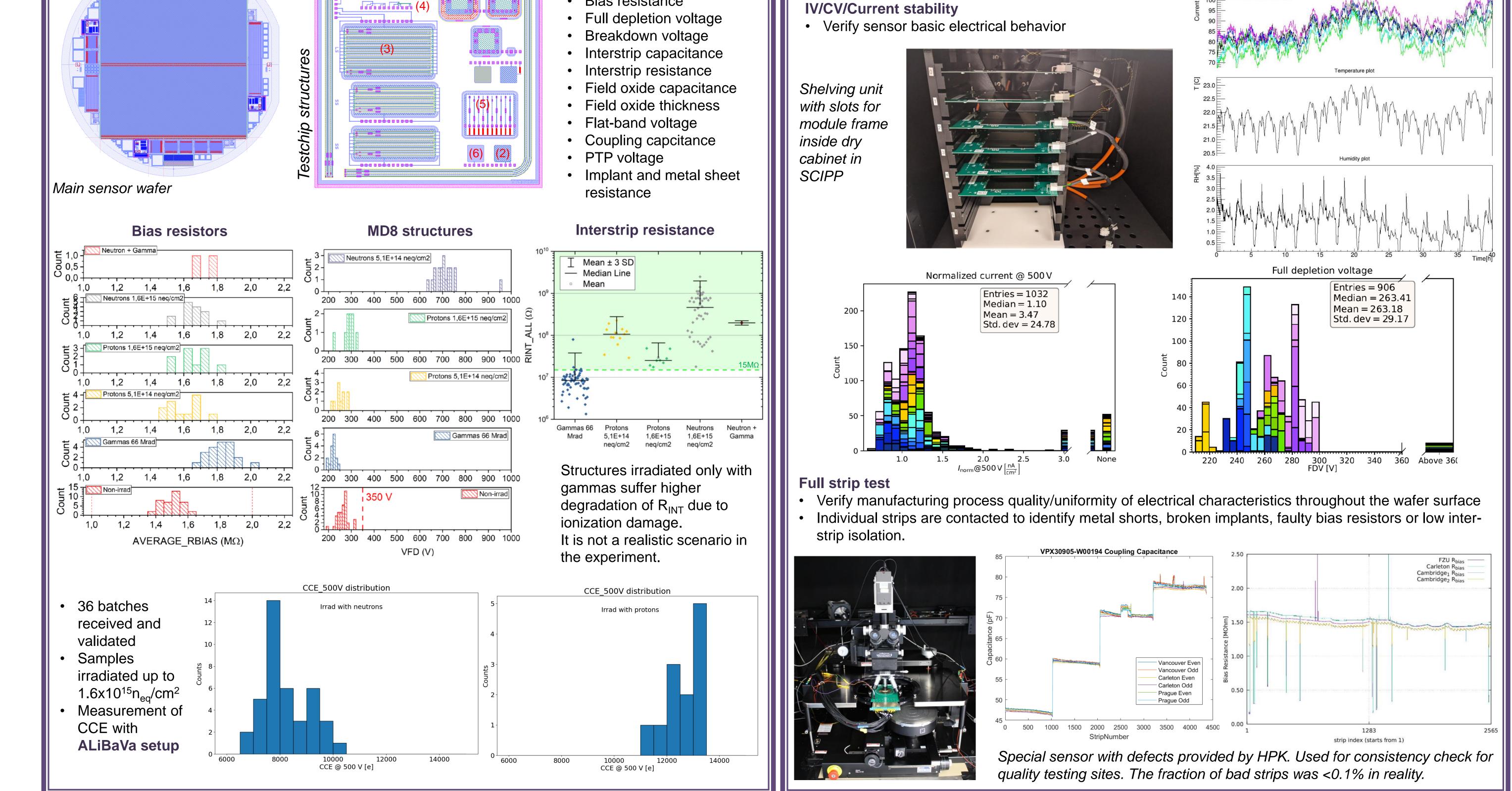
80

Bow [µm]

Stability Plot

MACH

120



CONCLUSIONS

Sensor pre-production provided excellent opportunities to prepare the infrastructure to handle production. Did not find major issues and most of the results are fulfilling the specifications. All 8 sensor types/layouts look OK a significant accomplishment made possible with >23 layout verification iterations with HPK. Despite IV is the most-failed QC test for pre-production sensors different recovery methods applied are showing promising results (not covered in this poster).

QA/QC sensor site qualification and pre-production testing was delayed by the COVID-19 related shutdowns, which in some cases lasted for 6 months of 2020. Despite that, excellent agreement was achieved among sites that matched well the data provided by the manufacturer. All pre-production batches have been validated. Strip sensor production started in Aug-2021 with ~18% of production quantity delivered to date.

ACKNOWLEDGEMENTS

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