# Bump bonding requirements for R&D (RD50 investigation of rad-hard silicon)

G. Casse

# Example of an effective approach

- Huge amount of data accumulated with micro-strip detectors
- Reason: possibility of irradiation separated from electronics
- Room temperature bonding (µ-wire bonding)
- Bondable (and re-bondable) after irradiation
- Use of dedicated readout, laboratory source tests (mip)
- Fast turnover
- Possibility of test-beam (as definitive proof for performances)

OUTCOME:

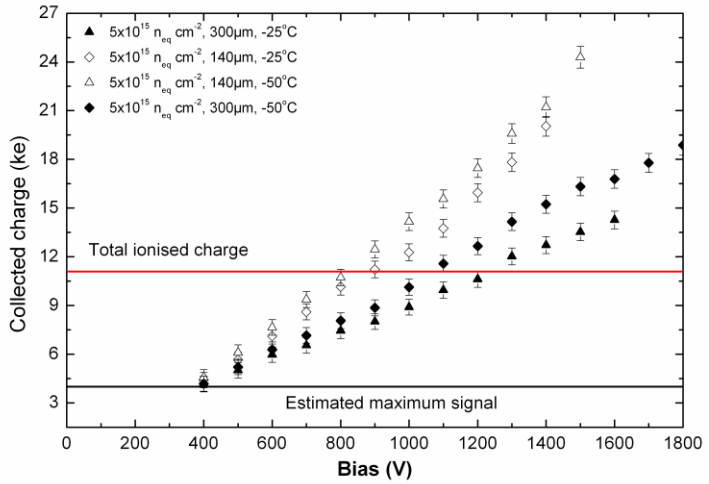
Thorough investigation of properties of segmented detectors up to inner layers of HL-LHC doses (>$2\times10^{16}$ $n_{eq}$ $cm^{-2}$).

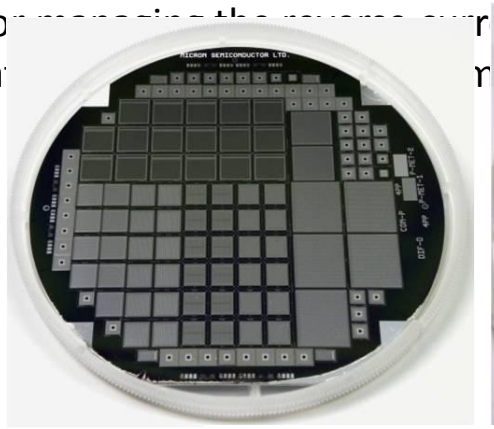
Results have informed experiments on performances of sensors.

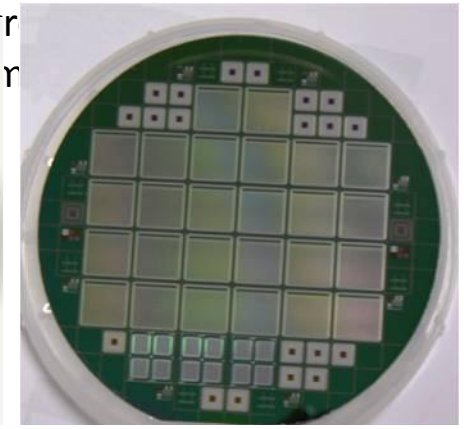
# Activity in the CERN/RD50 collaboration

The RD50 collaboration is dedicated to the development of Radiation hard semiconductor devices for very high luminosity colliders.

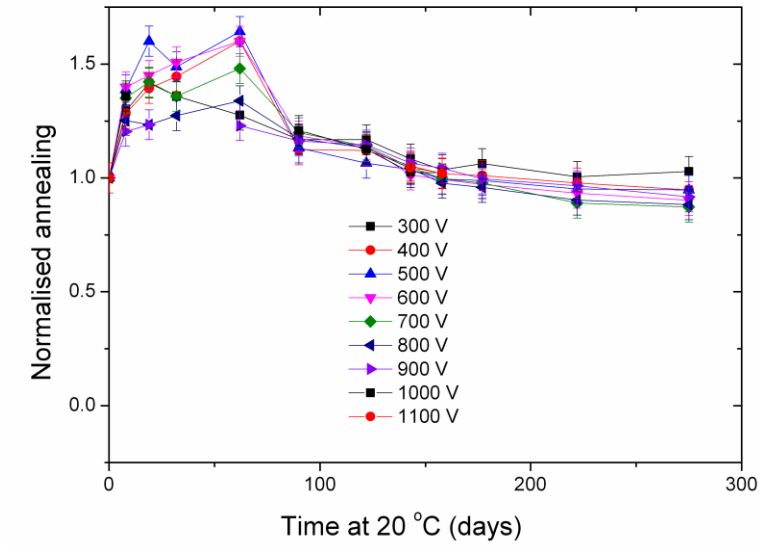
Results from this collaboration have become technological baseline (for future detector upgrades at the HL-LHC) or operation practices (for current and future detectors) for building and running silicon vertex and tracker sensors. The use of n-in-p sensors, the discovery of charge multiplication in irradiated micro-strip and pixel sensors and the use of annealing fo[illegible] irradiation are example of findings from RD50 tha[illegible]





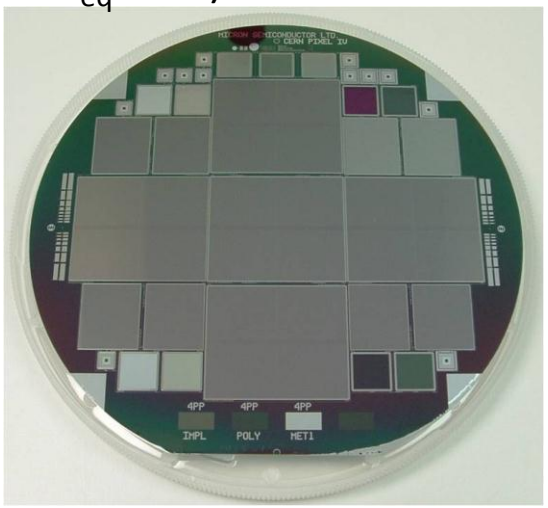
Minimum ionising particle signal recorded with 140 µm and 300µm micro-strip n-in-p Si sensors after $5x10^{15}$ $n_{eq}$ $cm^{-2}$. The ionised charge in the thin detector is increased by about a factor of 2.

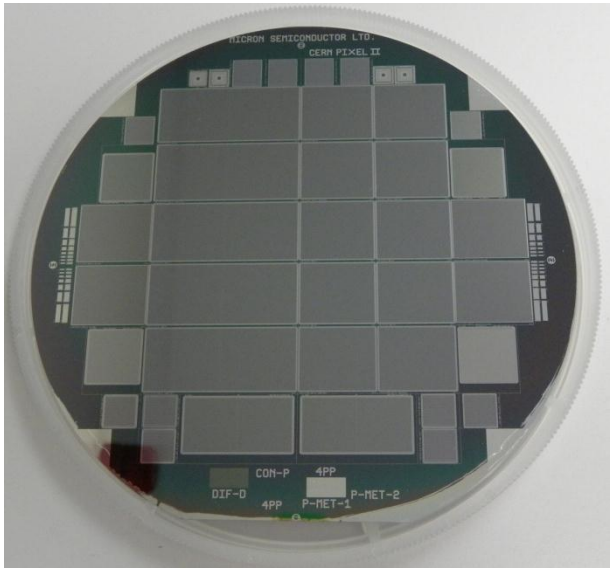



Charge recovery as a function of annealing time at 20°C with a 300µm micro-strip n-in-p Si sensors after $2x10^{15}$ $n_{eq}$ $cm^{-2}$. This plot shows that annealing can be advantageously used for recovering a substantial fraction of the signal loss due to charge trapping after irradiation.

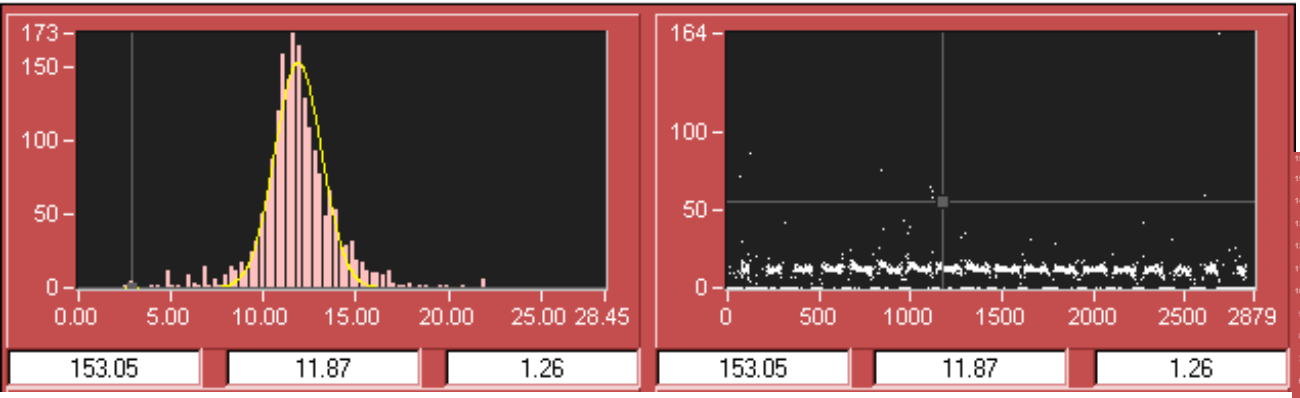
# Pixel sensors for Vertex detectors

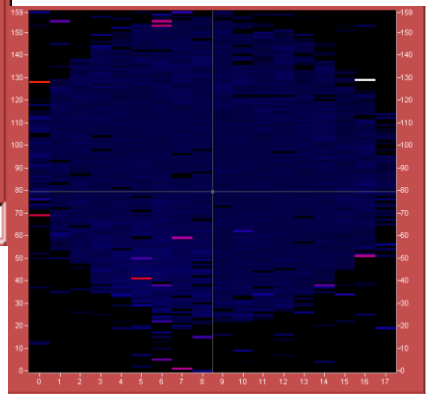
Pixel detectors applicable to the innermost layers of upgraded ATLAS and LHCb detectors are being developed. They are designed to sustain the radiation doses required by these experiments (> $2 \times 10^{16}$ $n_{eq}$ $cm^{-2}$).




Minimum ionising particle signal recorded with pixel n-in-p Si sensors after various doses of irradiation up to $2 \times 10^{16}$ $n_{eq}$ $cm^{-2}$.



Imaging a $^{90}Sr$ beta source with n-in-p pixel Si sensors after $7 \times 10^{15}$ $n_{eq}$ $cm^{-2}$.

# “Easy access” bump bonding essential

Needed to *invent* dedicated structures for chaining together pixels to readout with µ-strip sensors electronics.