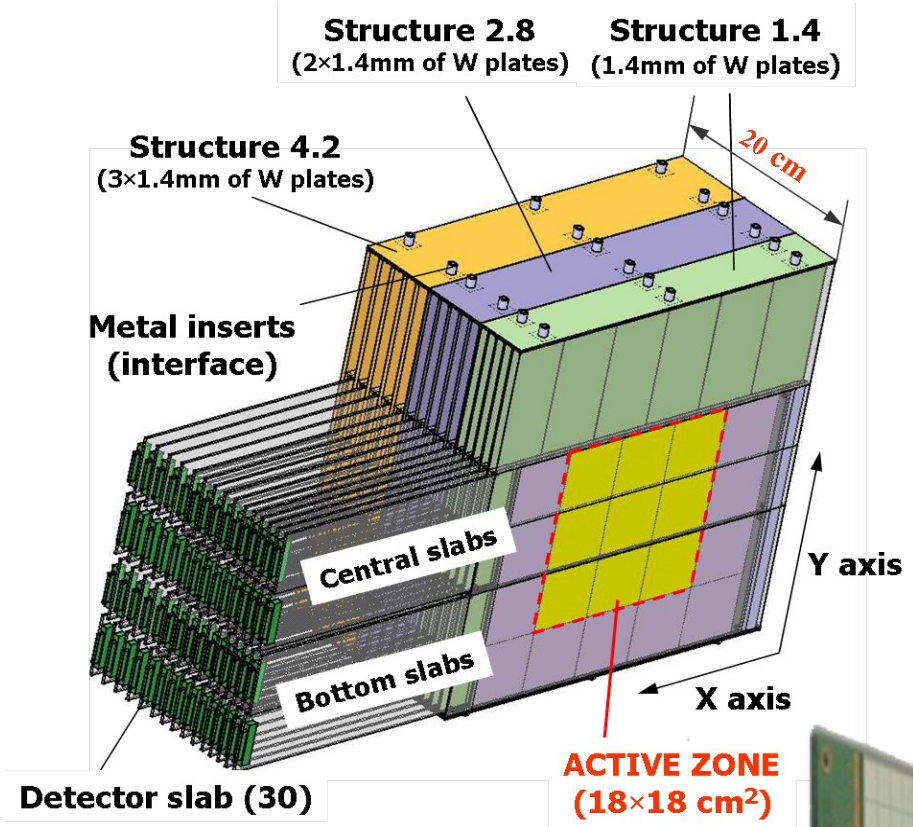
Status of ECAL silicon wafers

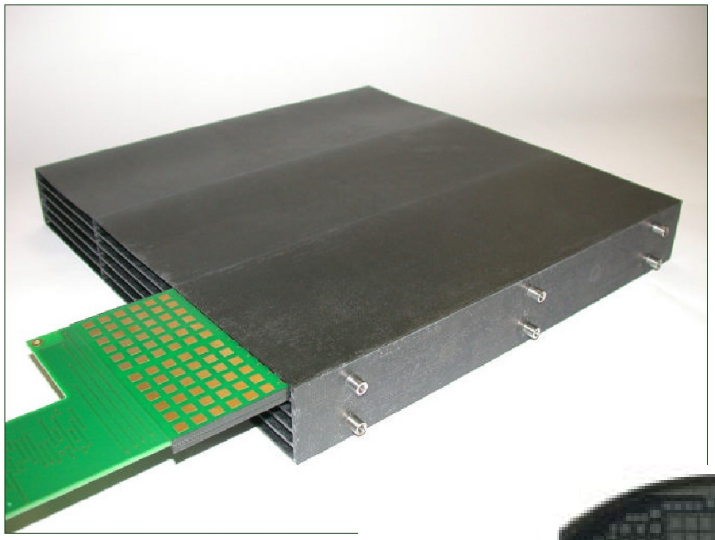
Daniel Jeans, LLR-Ecole Polytechnique
for Remi Cornat *et. al.*

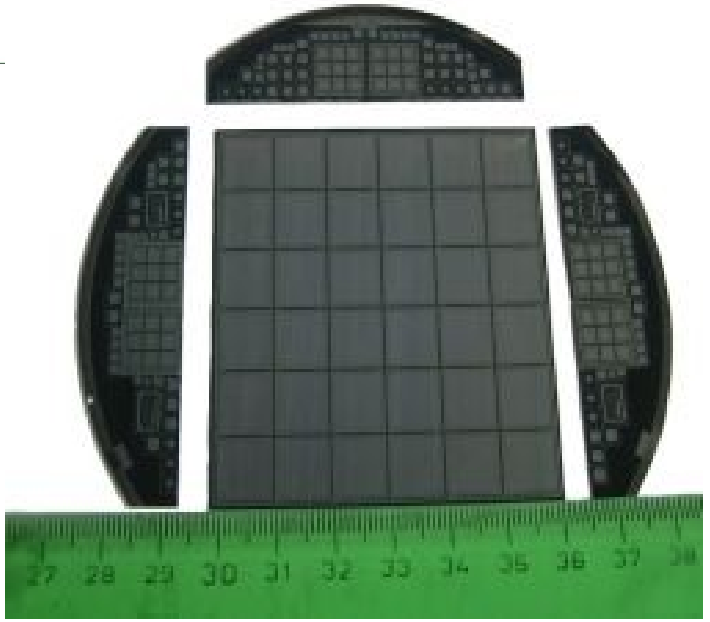
Work done mainly at LLR and LPC (Grenoble)

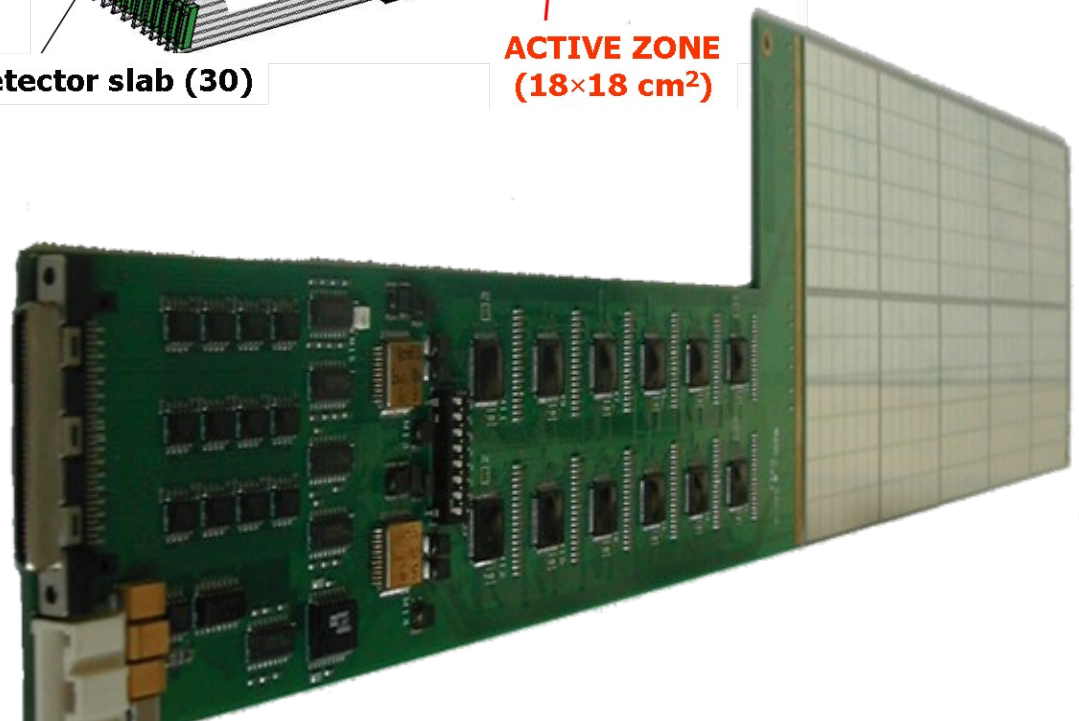
EUDET annual meeting
Uni Geneve 19/10/09

“Physics prototype”









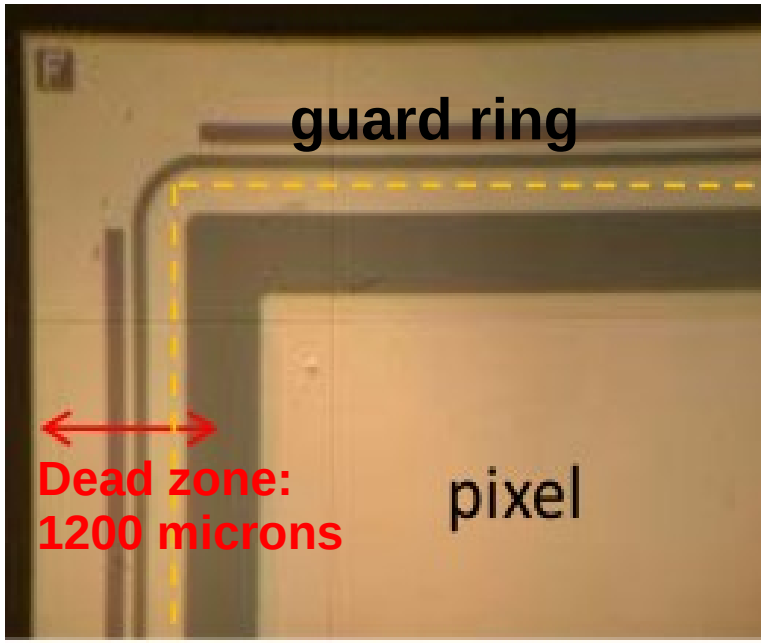
6x6 cm^2 Si sensors, 1x1cm cells

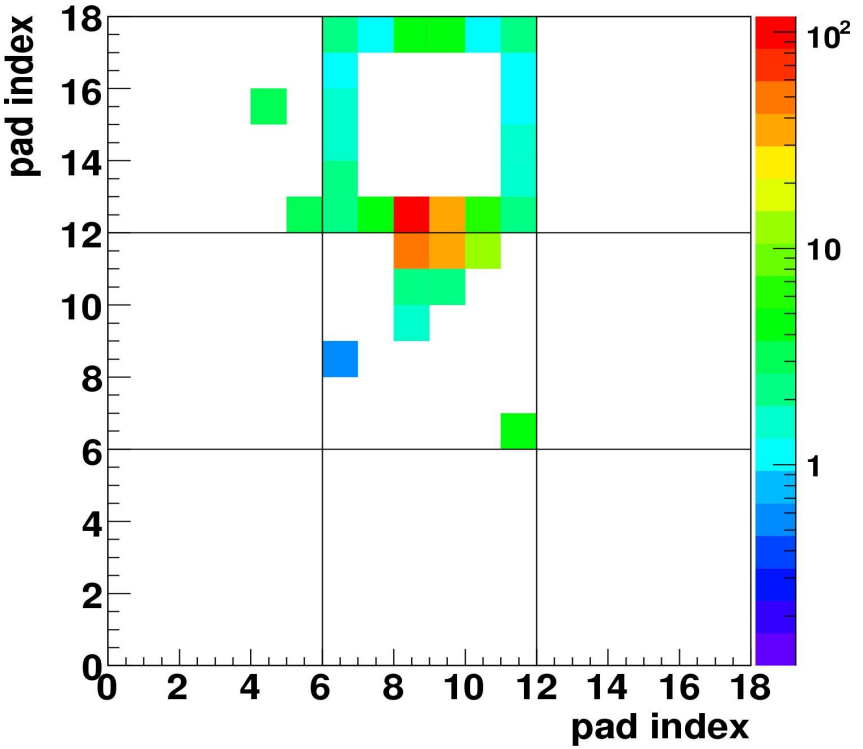
This detector is near the end of a multi-year test-beam programme

Physics prototype behaved largely as expected

"Square events" were a surprise
- hits all around edge of wafer when shower hits wafer edge

Understood as:
- signal propagation along "guard ring" at wafer edge
  (increases detector break-down voltage)
- cross-talk between guard ring and neighbouring cells





Next generation: “EUDET prototype”

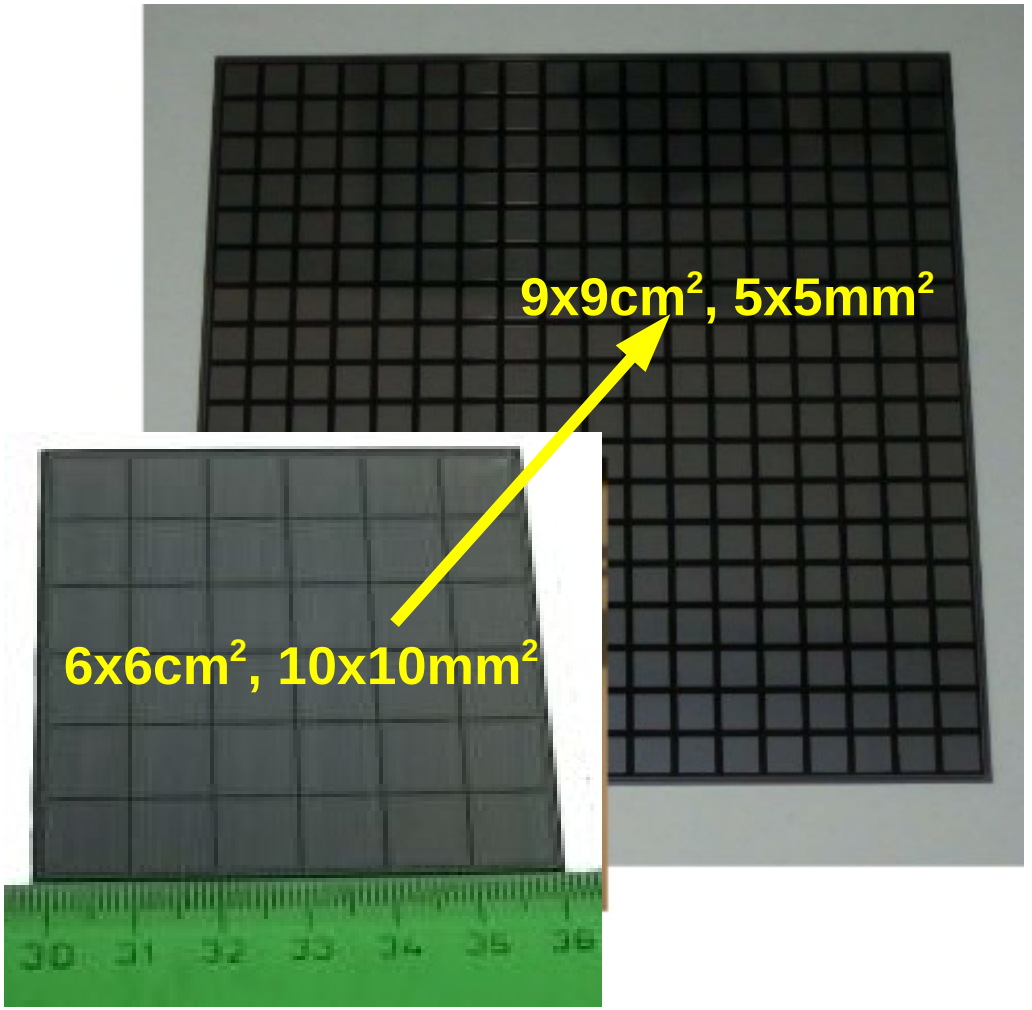
- mechanically close to ILC detector module

- for silicon wafers

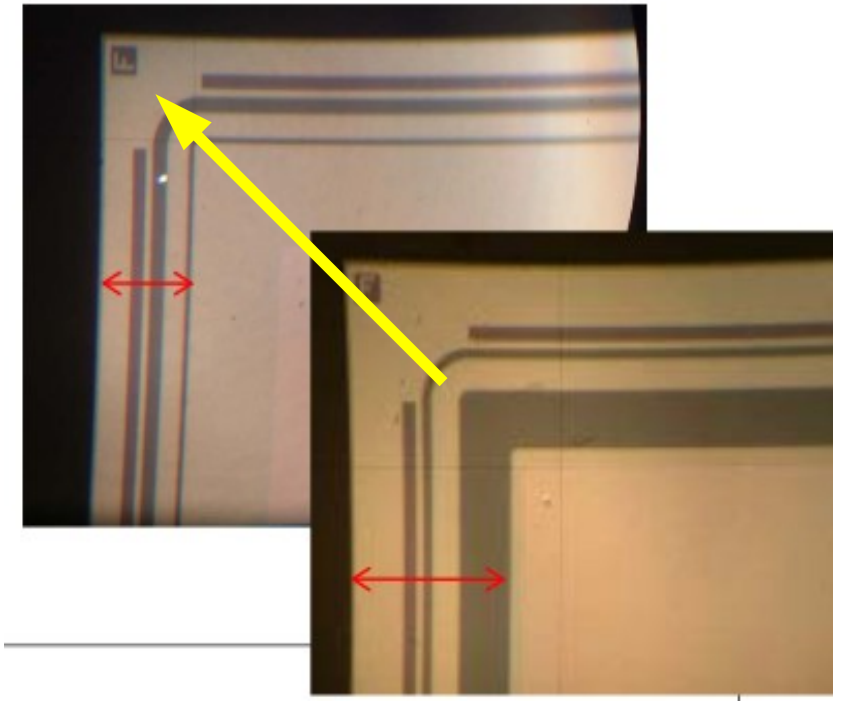
  - address “square events”
  - finer granularity: 10x10 mm^2 -> 5x5 mm^2
  - reduce dead area at wafer edge
  - test various designs
  - use several manufacturers
  - require ~160 sensors in total

Have received 40 wafers from Hamamatsu

Increase wafer size, reduce pixel size



Guard ring width:
1200 -> 750 microns



Electrical characteristics look fine

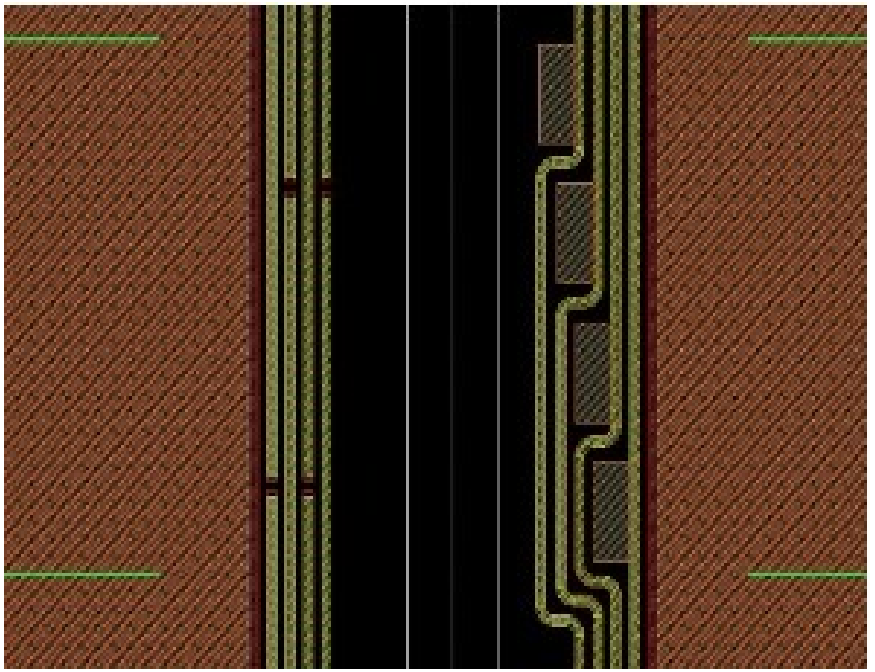
Price rather high: ~10 Euro / cm^2
will not be able to equip ILC ECAL at this price

Segmented guard ring designs

Prevent propagation along sensor edge:

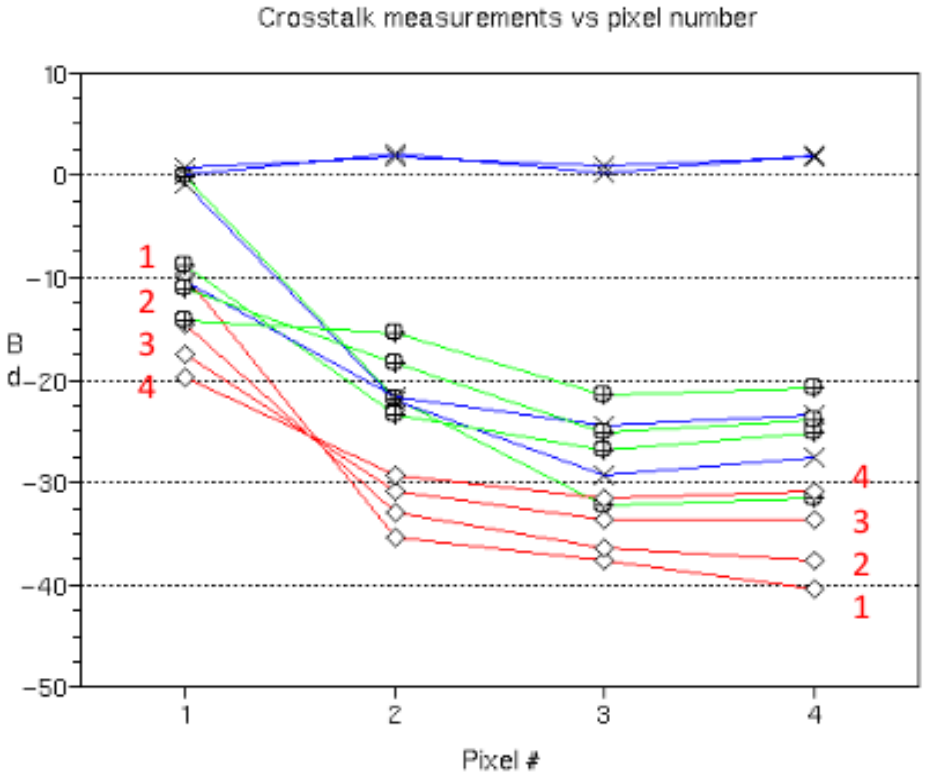
- go from continuous to segmented guard ring design
- study performance as a function of segment lengths, separations
- collaboration with OnSemi (Cz)

A number of 3x3cm^2 test sensors (1x1cm^2 cells) have been produced and tested: continuous, 1cm, 3mm guard rings



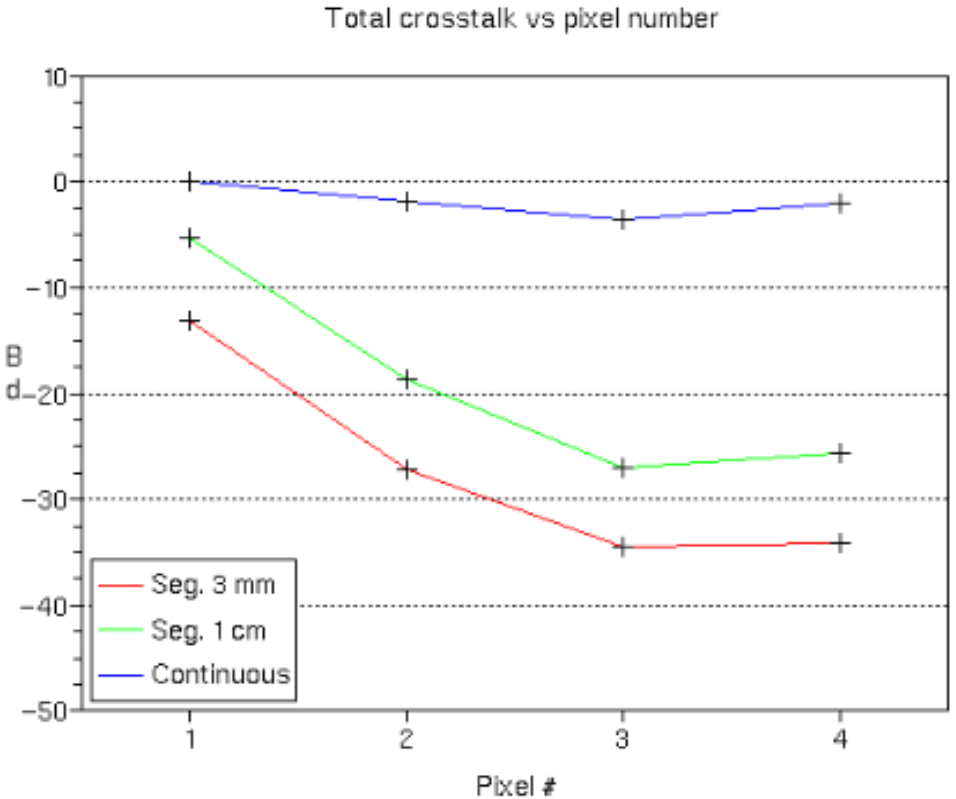
R&D on segmented guard rings crosstalk

Inject charge at centre of edge
Look at signal on 4 corner cells



One lot (no statistics)

Far from the injection point, the injection through the outter GR is dominant

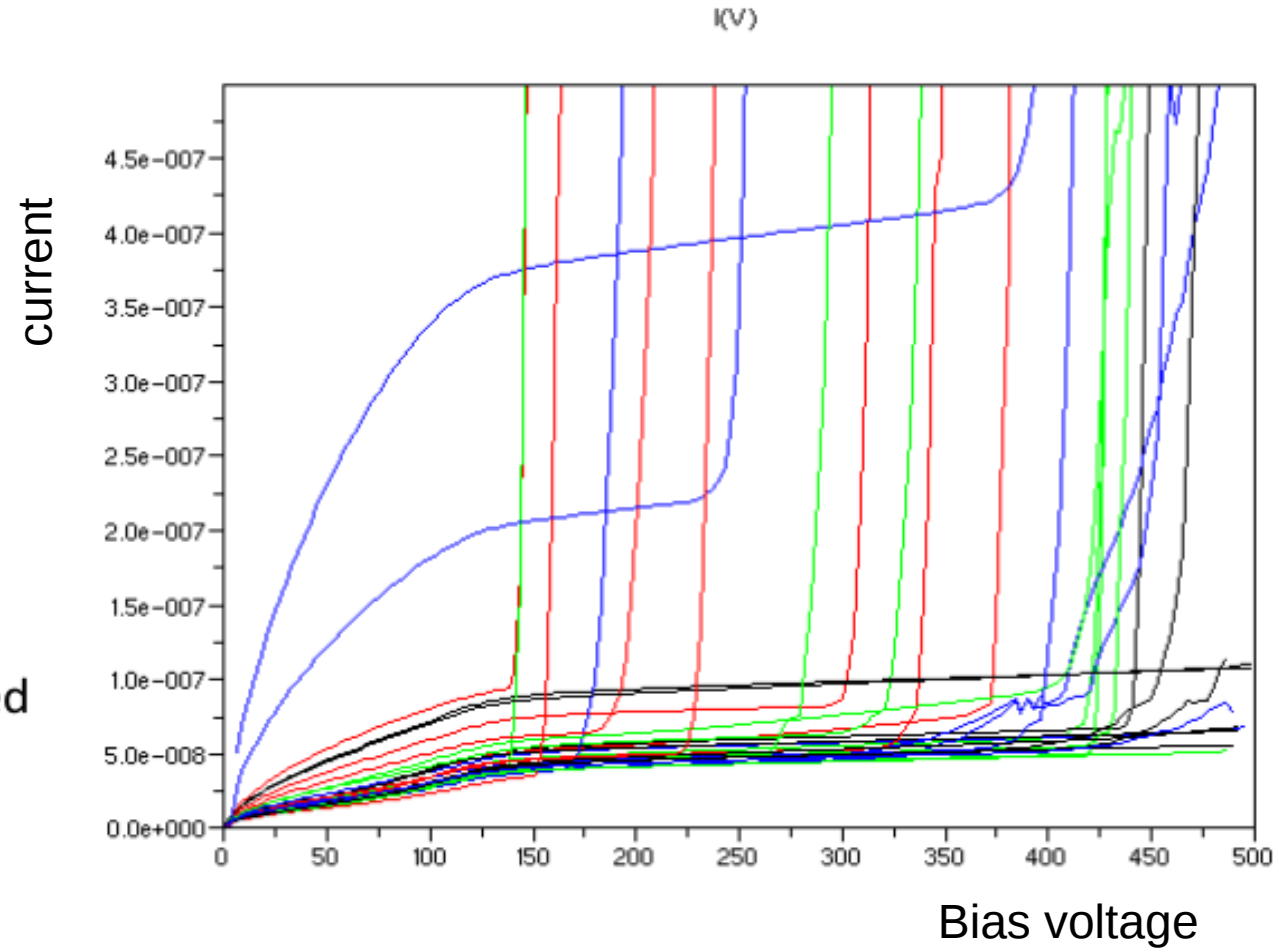


Sum of GRs contribution
Xtalk lowered by a factor 80 (with 3 mm segments

R&D on segmented guard rings
Electrical characteristics

Breakdown >250V
- Continuous: 100%
- 1 cm: 85%
- 3 mm: 40%
- Mixed: 70%

T and RH impact to be studied



Segmented guard rings seem to work

- reduce propagation along sensor edge

- can have reasonable electrical characteristics

More studies required to understand performance

- more samples requested from OnSemi
  (mixed segments lengths, inter-guardring gaps)

- received similar test samples from BhaBha institute (India)
  - properties under study

More sophisticated test bench in preparation

- make measurements by pixel (presently globally by wafer)

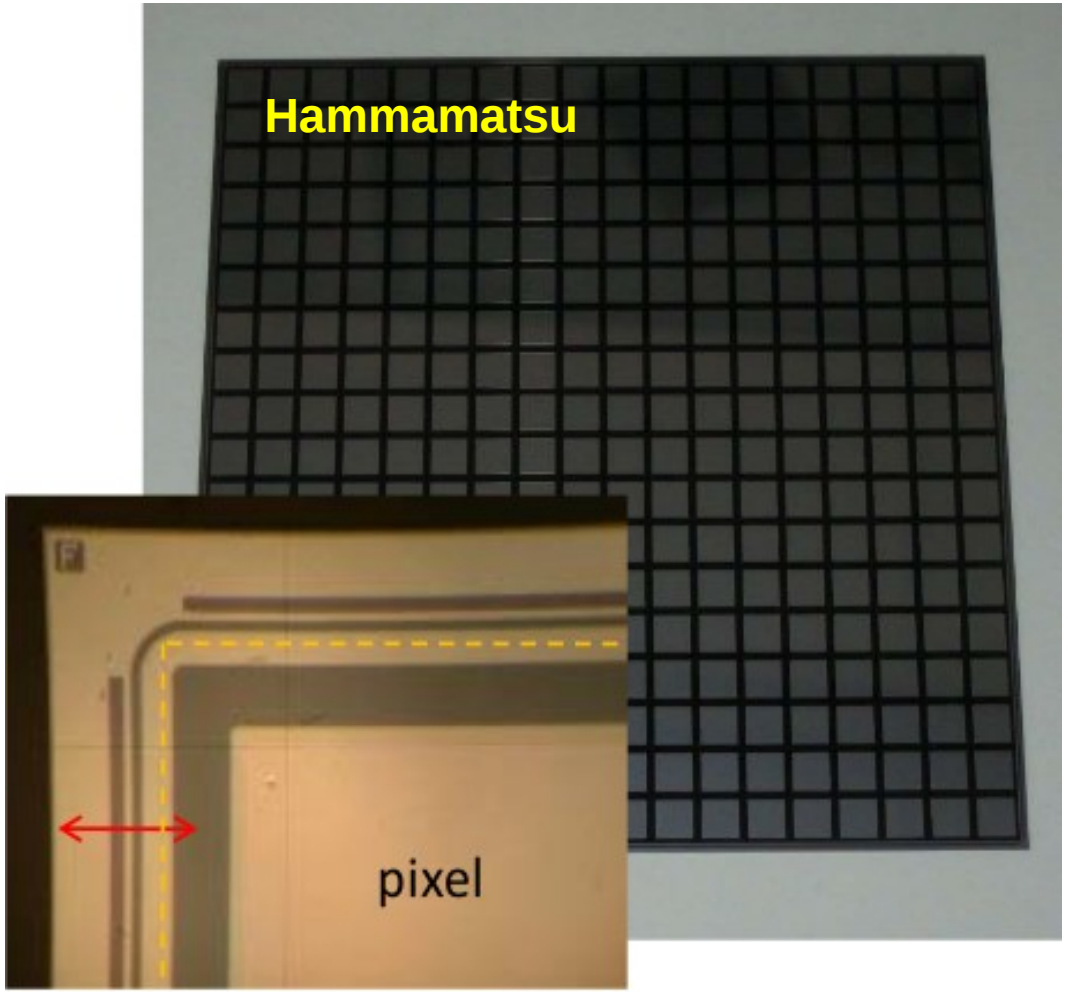
Conclusions

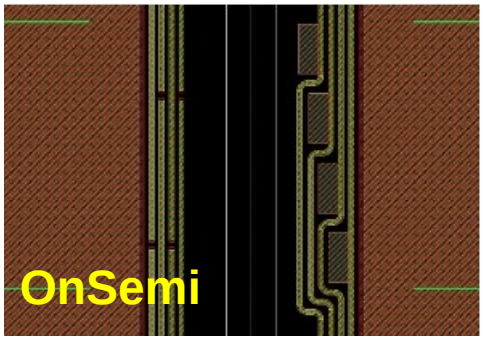
Silicon sensor design evolving for EUDET ECAL prototype
    (~160 sensors required in total)

1st batch of 40 wafers received from Hamamatsu
    Performance looks good

Guard ring segmentation looks promising to reduce x-talk
    Several tests have been performed
    Some further optimisation required

Widening industrial contacts
    reduce sensor cost...

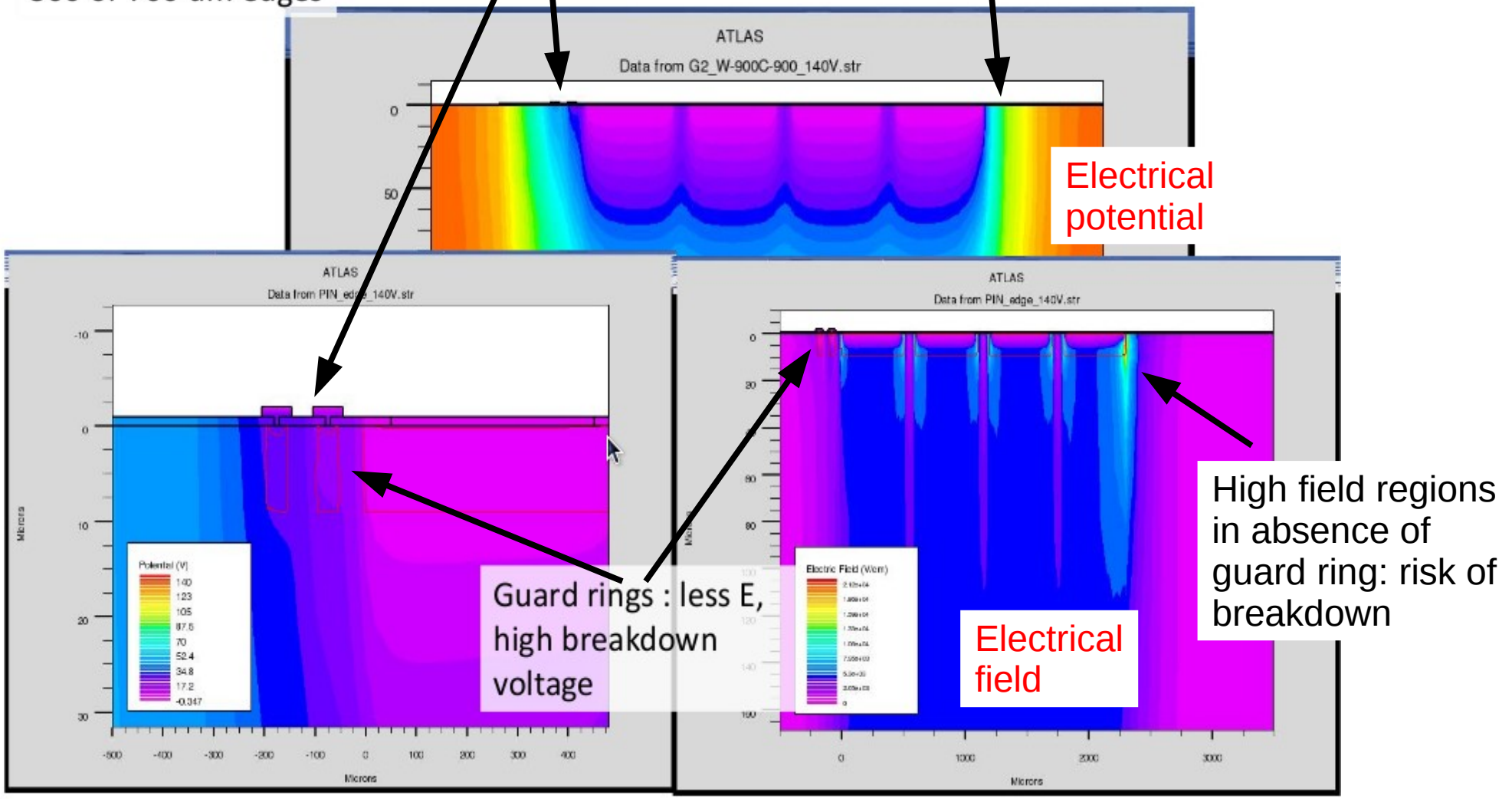

Hammamatsu
pixel


OnSemi

4 pixels (500 um),
500 or 700 um edges

Edge with guard ring

Edge without guard ring



Electrical potential

Guard rings : less E, high breakdown voltage

Electrical field

High field regions in absence of guard ring: risk of breakdown