CALICE Silicon ECal Sensors

Status and prospects

Vaclav Vrba

Institute of Physics, AS CR, Prague

Test Beam Campaign – CERN 2006

Irradiations from August to October 2006 at H6B SPS test beam area

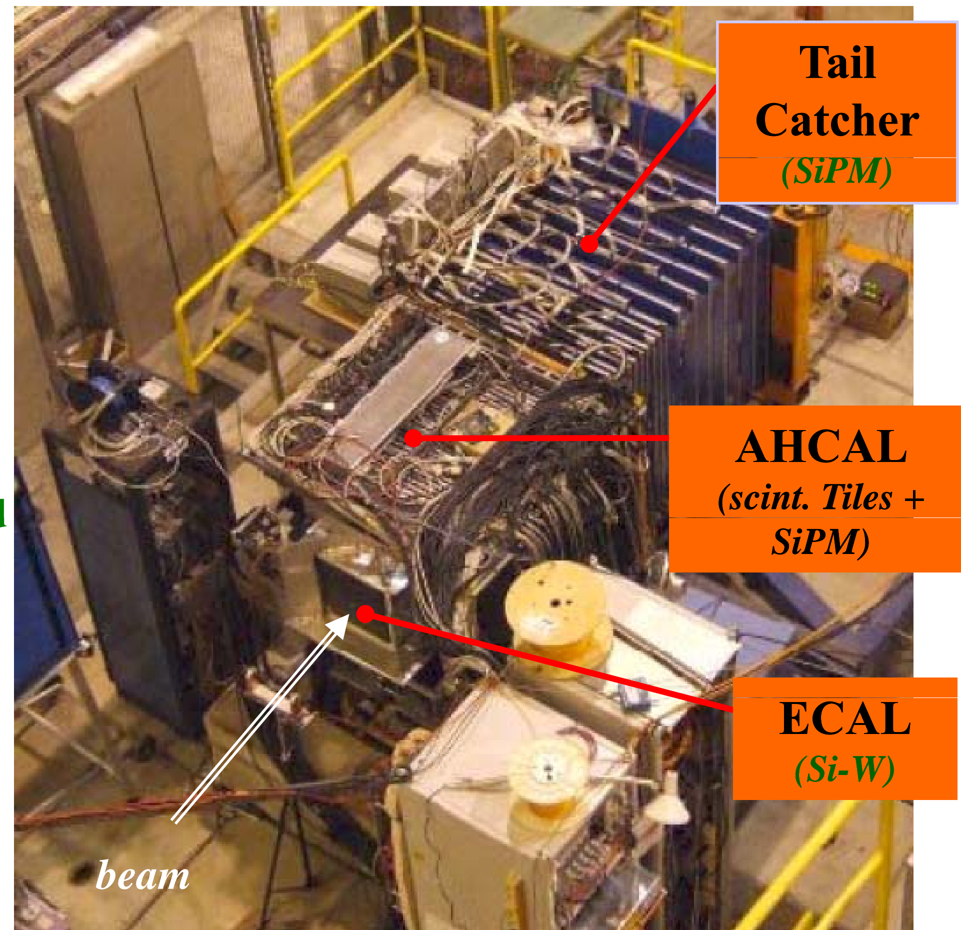
For ECal the most important data have been obtained in October in the *combined ECal+ AnalogHCal + TailCatcher&Muon Tracker run*

❖ ECal : 70% equipped Si-W prototype: 30 layers (10 with 1.4 mm W, 10 with 2.8 mm W and 10 with 4.2 mm W) interleaved by 18x12 cm^2 of Si 1x1 cm^2 pad arrays ➔ 6480 channels

❖ Positron beam energy scan: 10, 15, 16, 18, 20, 30 and 50 GeV; about 300k events, each energy

❖ Electron beam energy scan: 6, 10, 15, 20 GeV; several 100k events, each

❖ more than 30M muons for calibration



Setup for the combined ECal+ AnalogHCal + TailCatcher&MuonTracker run at CERN

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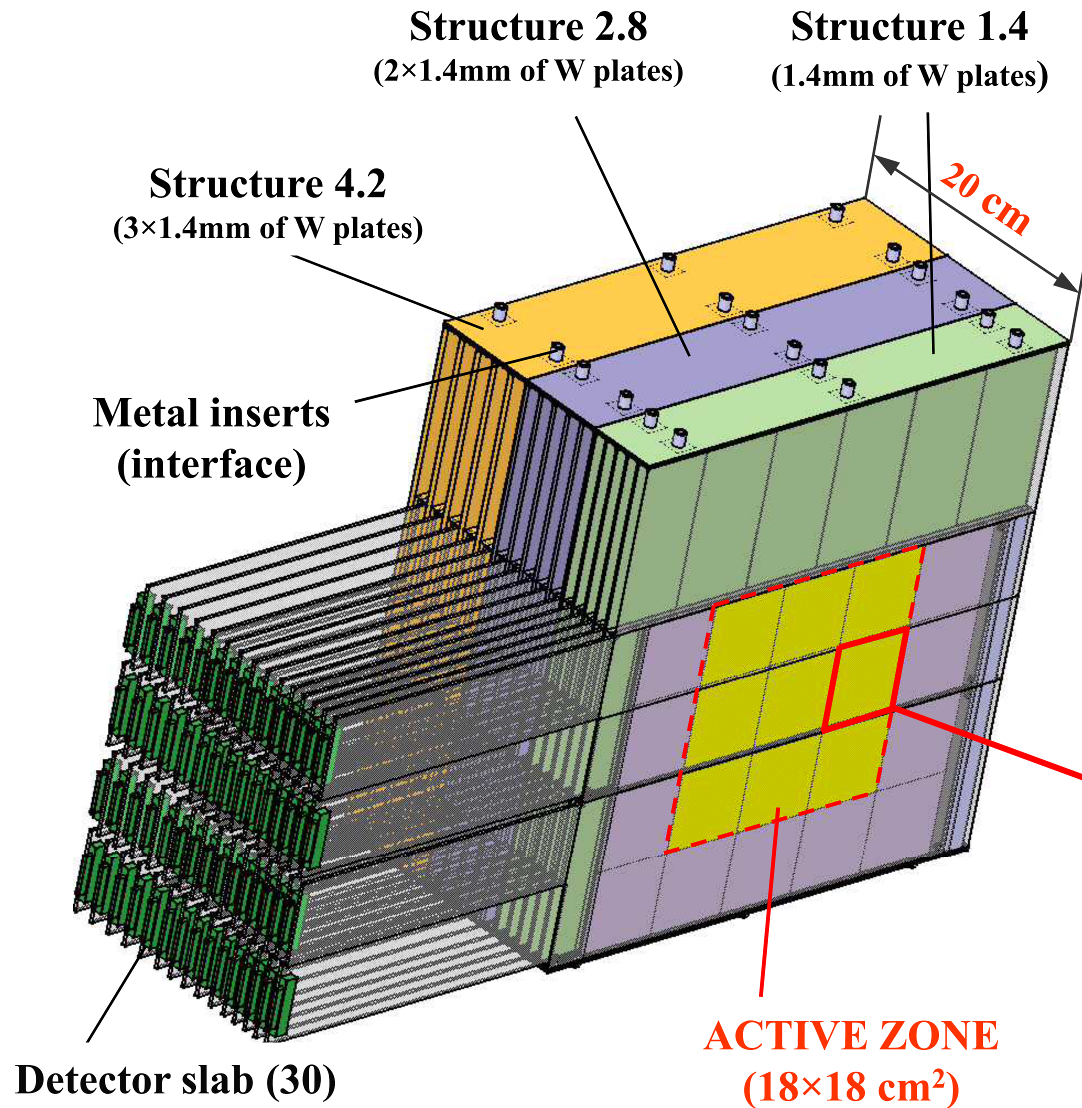
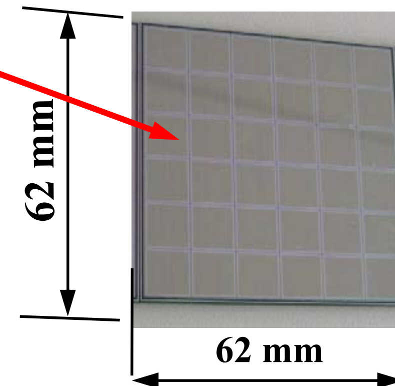
ECal physics prototype



Multi-layer (30) W-Si Prototype :

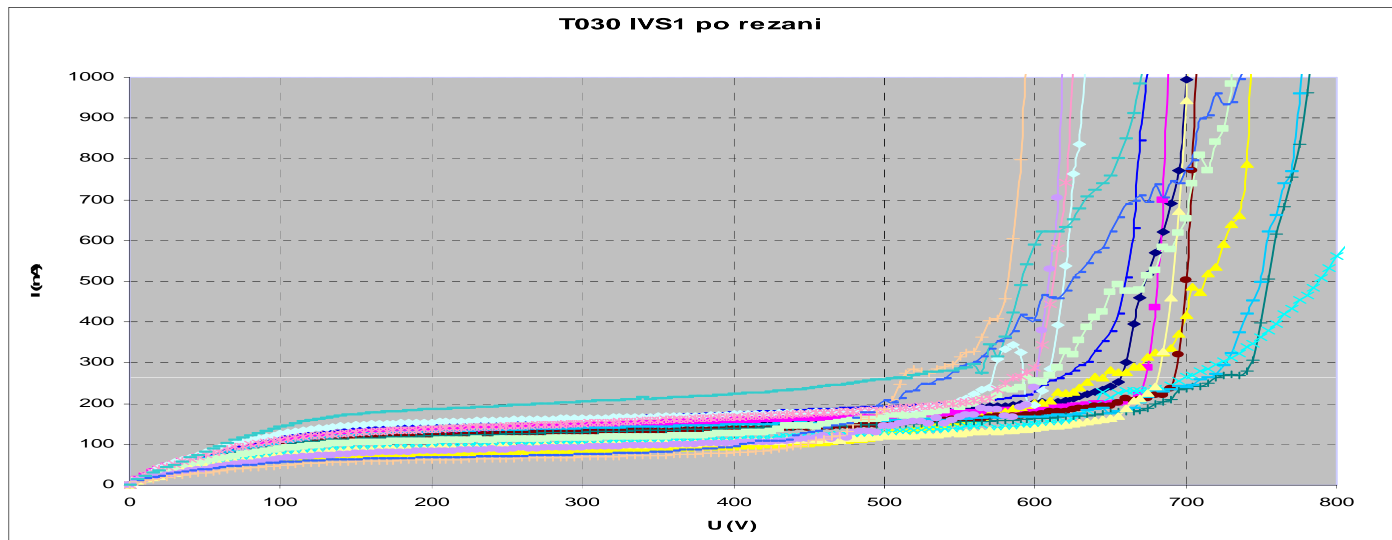
- 3 independent C-W alveolar structures , 10 layer each, with thickness of tungsten plates (1.4, 2.8 and 4.2 mm)
- 30 detector slabs which are slid into central and bottom cells of each structure
- Active layers : 3×3 pad matrices in 30 layers

9720 pixels



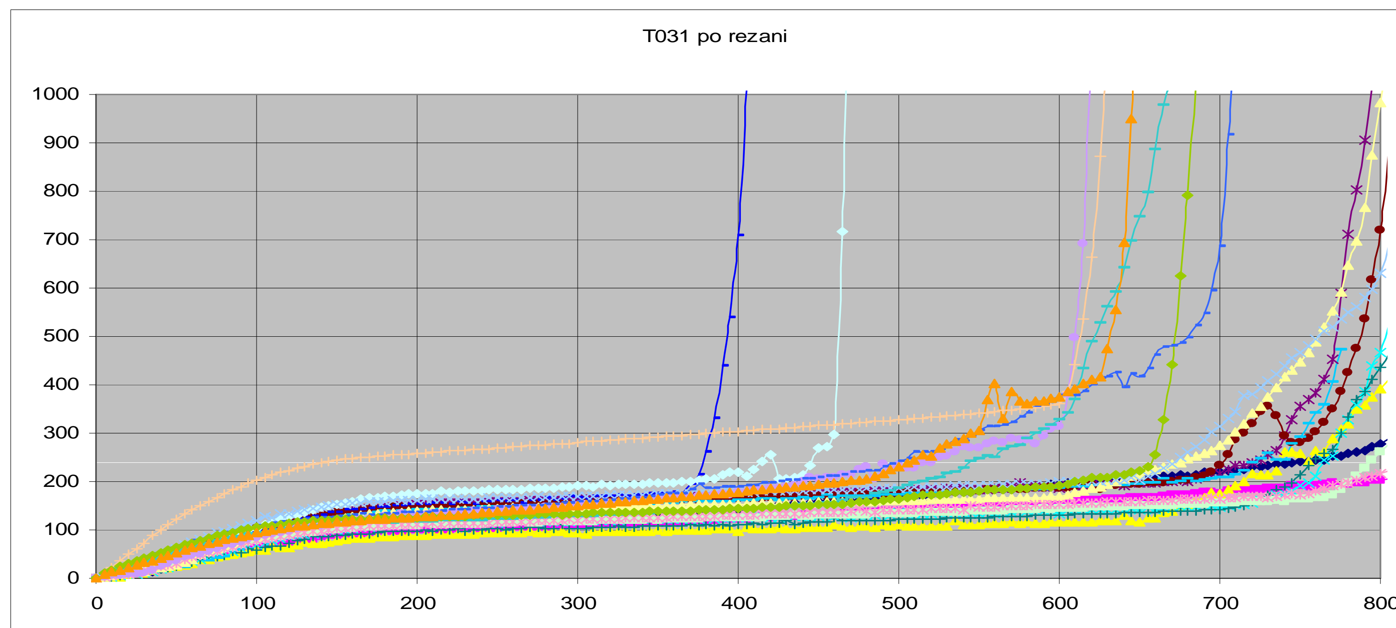
Present production (1)

- The completion of the physics prototype requires 90 wafers (30 layers, one row of 3 wafers in each);
- January 2007 delivery: 36 wafers



Present production (2)

- February 2007 delivery: 41 wafers

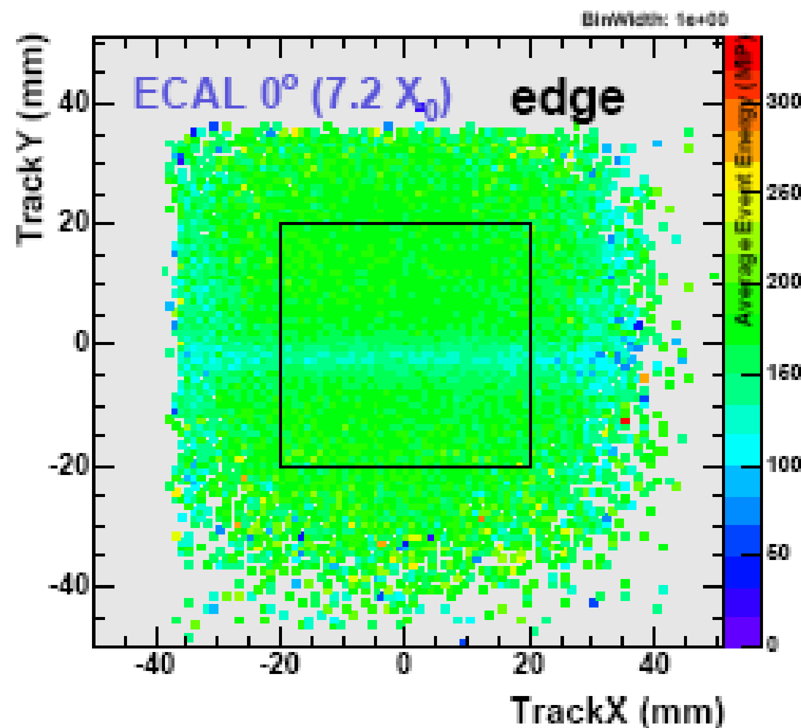


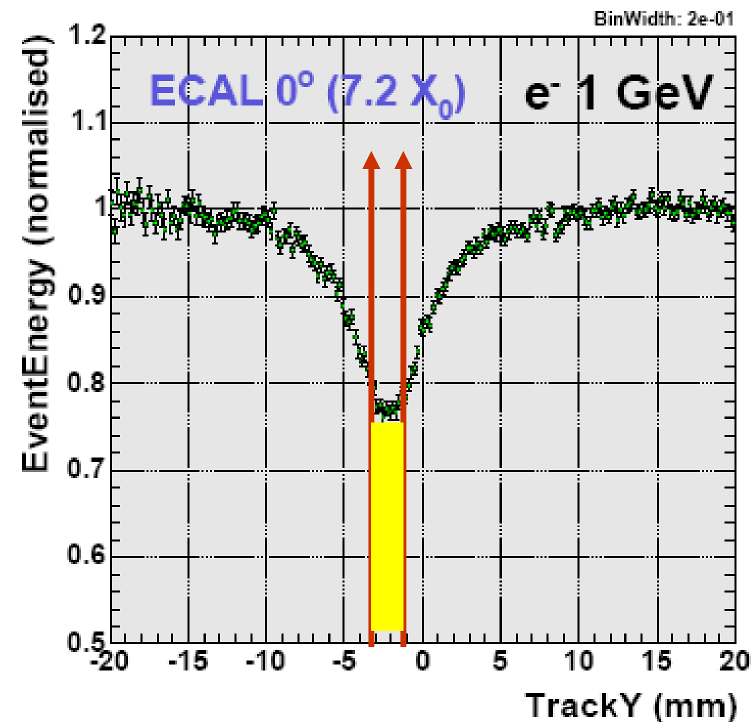
Present production (3)

- Earlier problems associated with gluing are not reported any more;
- Wafers have more less always such good performance as shown above at the exit from the production line and after dicing (measured twice – before and after dicing). But …
- For the last delivery there were reported big number wafer rejections from the assembly side. After sending them back and inspection there were found frequent scratches (which don't have origin on the wafer production side) and some other degradations of quality which can be caused by packing, shipment, test bench, humidity etc. Majority of wafers have been recuperated by additional surface treatment at ON Semi. The measures to eliminate above problems have been taken.
- At the moment about 100 wafers are in the line – to be ready in 1-2 weeks: shall be enough for the physics prototype completion + spare.

Lectures from the test beams (1)

- **With regard to the sensor design, the clear message concerns the dead area in the region of guard rings. The loss of the charge collection efficiency on the edge of wafers is shown here (courtesy of Georgios Mavromanolakis):**





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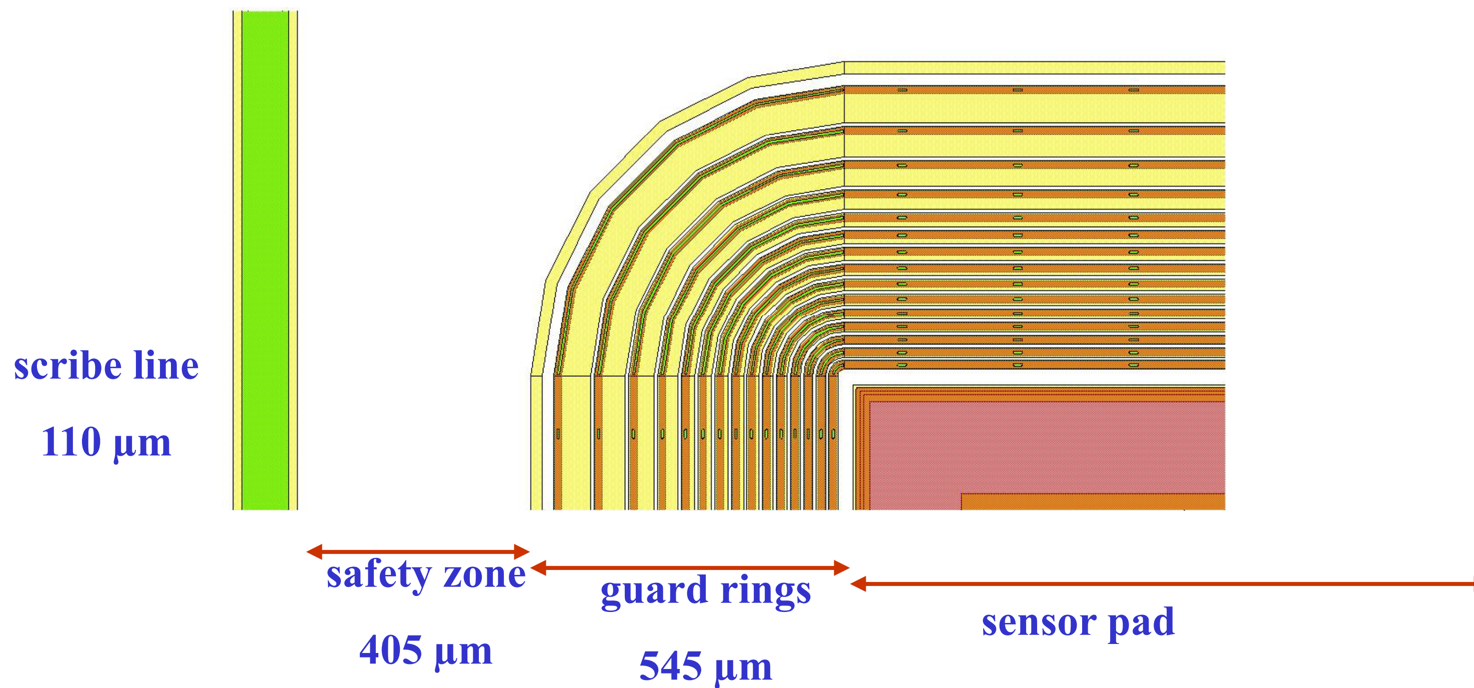
Lectures from the test beams (2)

- **Analysis of Michal Marčišovský in this respect shows that ECal resolution improves greatly if we select showers which do not overlap wafer edges. Other words: detection inefficiency on the wafer edges impose additional fluctuation in the energy measurement.**
- **The charge losses can be corrected (analysis of Michal Marčišovský – not fully finished yet), but the correction is more precise if the dead zone is smaller.**

- **Another visual effect – “square showers” – is interpreted (Akli Karaar) as charge dissipation of strong shower in the guard ring area though the capacitance coupling with outer pads of the wafer. This visual effect is to some extent “cosmetic” , itself it does not do much harm, but indicates that some parts of detection area are not under full control.**

Edge less sensors? (1)

- The solution can be “edge less” sensors 🡐 trivial statement, but solution is far from trivial (and probably also expensive).
- Anyway, the reconsideration of guard rings and safety zone between guard rings and scribe line shall be done.



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Edge less sensors? (2)

- **Not 100% edge less, but optimized;**
- **First step already done: we will use Si-wafer thickness 300µm, instead of 525µm, what allows shrinkage of the guard ring area (where the width usually is ≈ wafer thickness);**
- **Safety zone shrink and other measures are under investigation.**

Towards EUDET prototype (1)

- For the EUDET module we decided to have 5x5mm^2 pads.

- For 4” wafers we can have:
- 12x12 = 144 cell array, maybe
- 13x13 = 169 cell array;

- For 6” wafers we can have:
- 20x20 = 400 cell array, maybe
- 21x21 = 441 cell array;

- For 6” wafers: first prototypes we can expect in September-October 2007, if we decide now.

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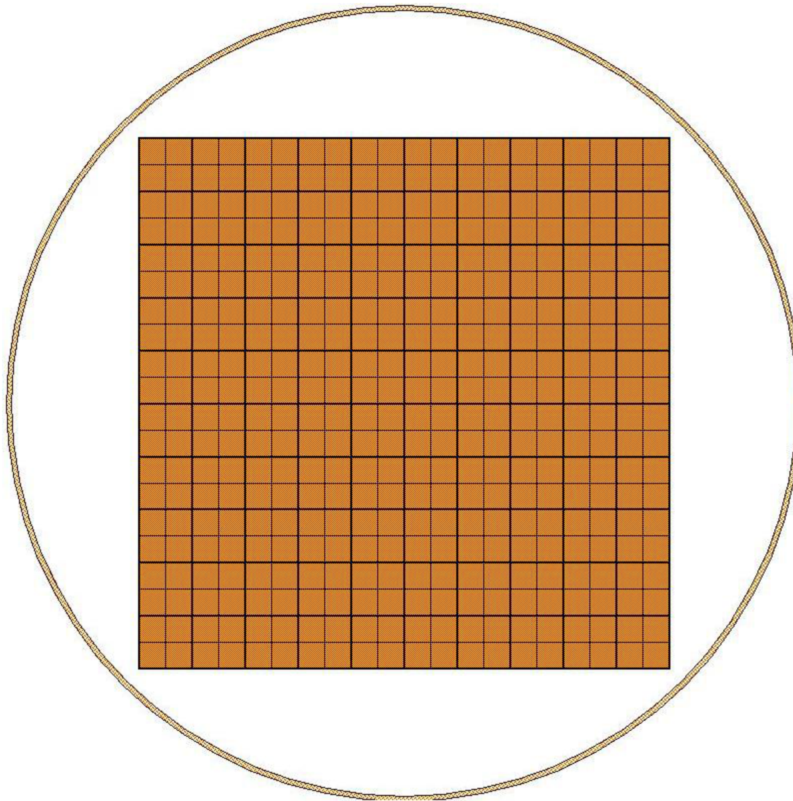
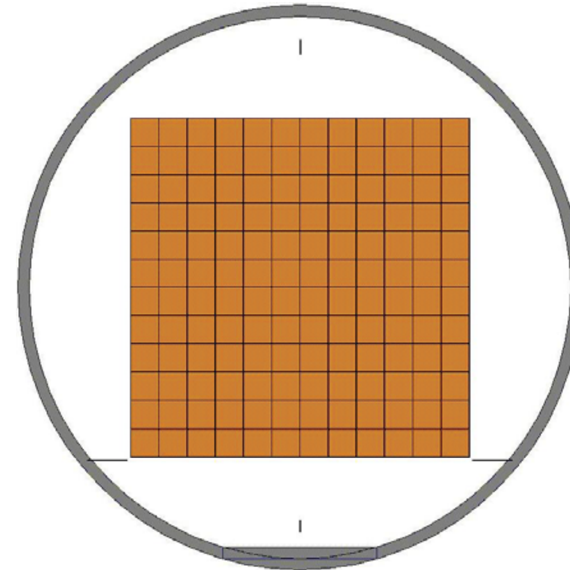
Towards EUDET prototype (2)

6” array module, 10x10 cm^2, 20x20 = 400 pads



4” array module, 6x6 cm^2, 12x12 = 144 pads



Summary

- **Test beam results gave strong motivation to analyze edge effects of sensor wafers and consider corresponding sensor design modifications and optimizations.**

- **For the EUDET module:**

❖ **Thickness from 525μm to 300μm;**

❖ **Pad size from 10x10mm^2 to 5x5mm^2**

❖ **Wafer options: 4” or 6”**