Development of an enhanced lateral drift sensor

Breaking the small-pitch paradigm

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Geneva, 24.1.2018

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

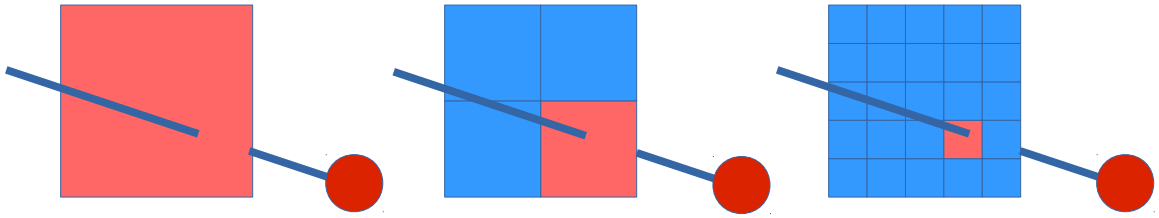
DESY

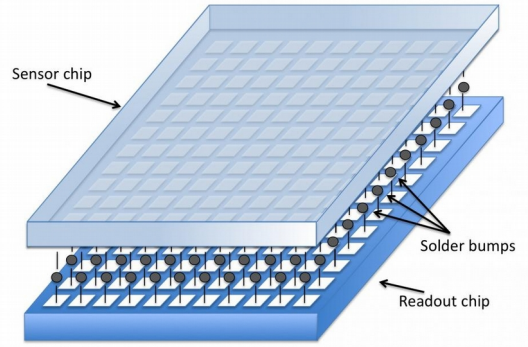
Breaking the small-pitch paradigm

Buried implants for local manipulation of the electric field in planar particle sensors

Achieve improved position resolution of charged particle sensors

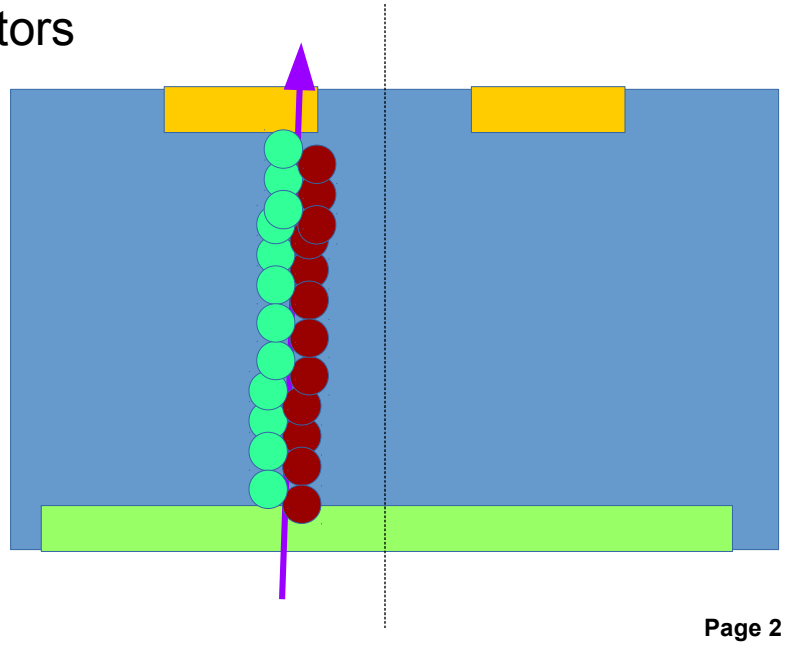
- **This is usually done by down-sizing the pitch**





→ Increases number of readout channels
→ Potentially higher band width from detectors
→ Less area on-chip per channel
→ Higher power dissipation

- **Miniturisation has limits**
  → Size of bump bonds, wire bond pads, cross talk, ...
  → Minimum of logic/processing on-chip



→ Is there another solution?

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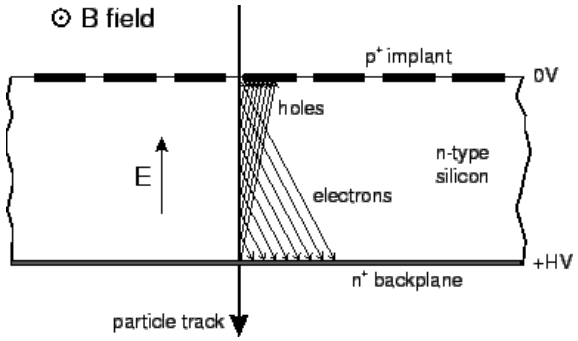
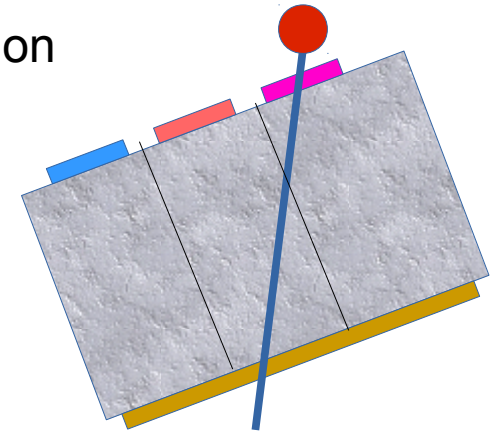
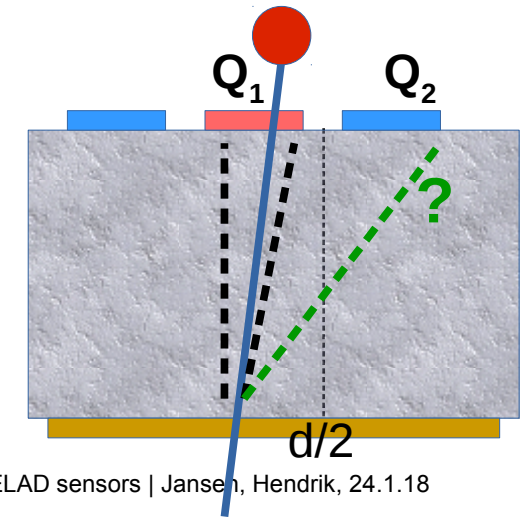
- **For CLIC/ILC (50 um thin sensors),**
  Lorentz drift, diffusion and tilting is no solution





→ **What else can be done?**



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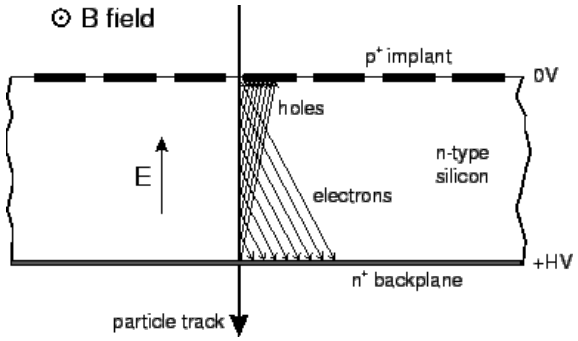

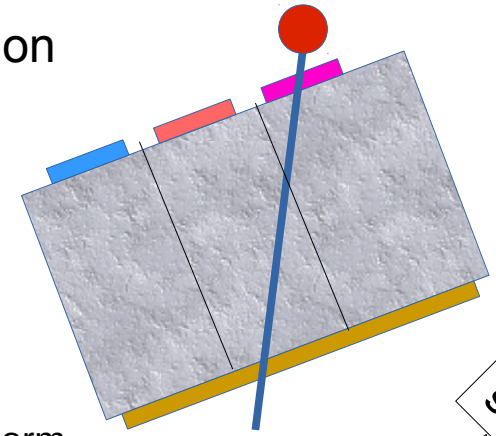

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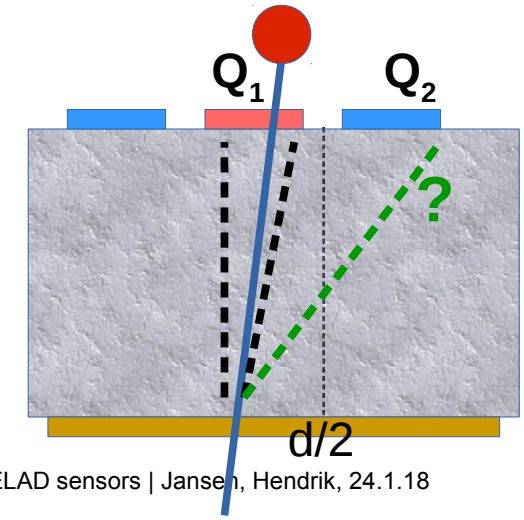

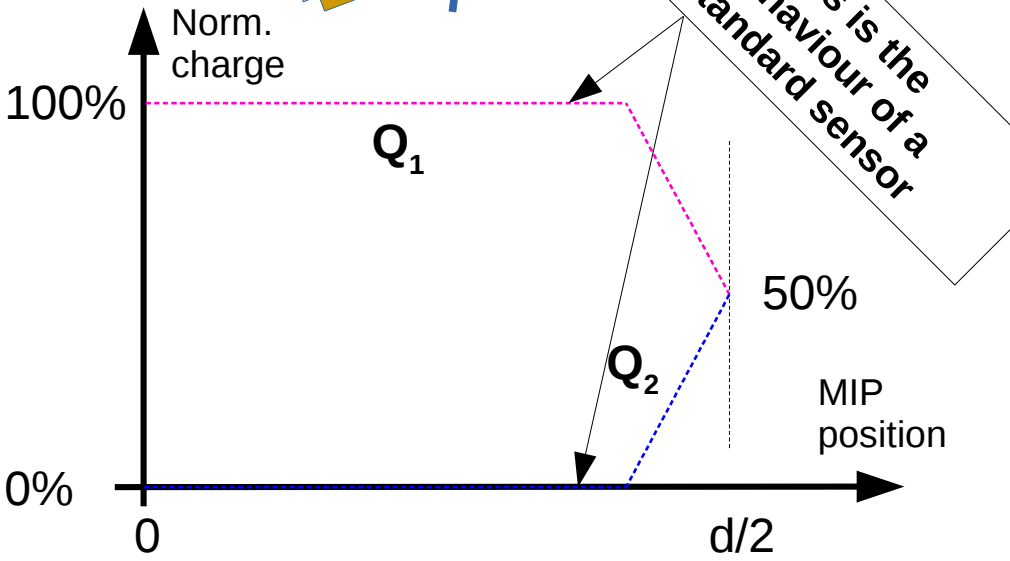

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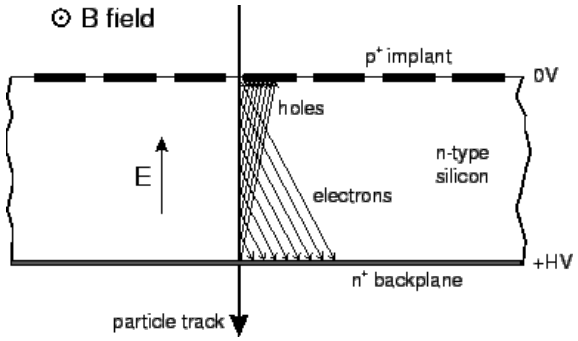

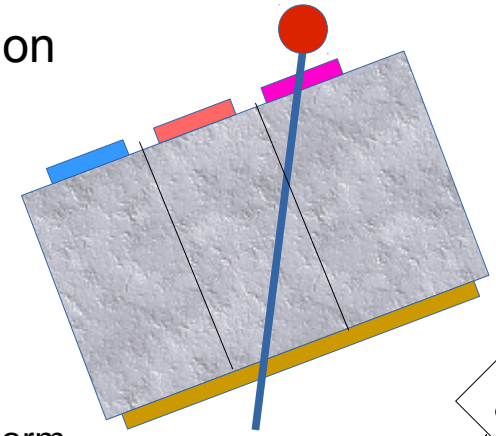

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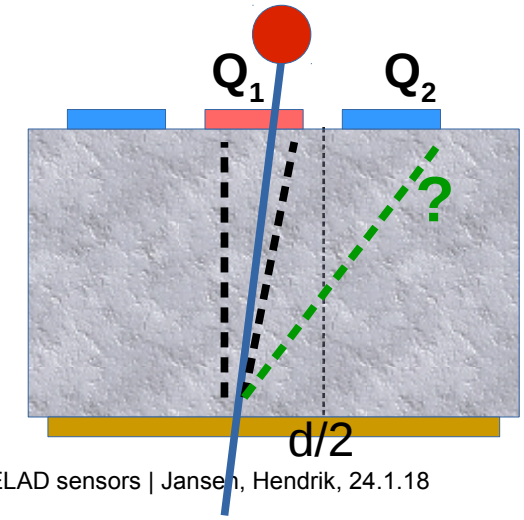
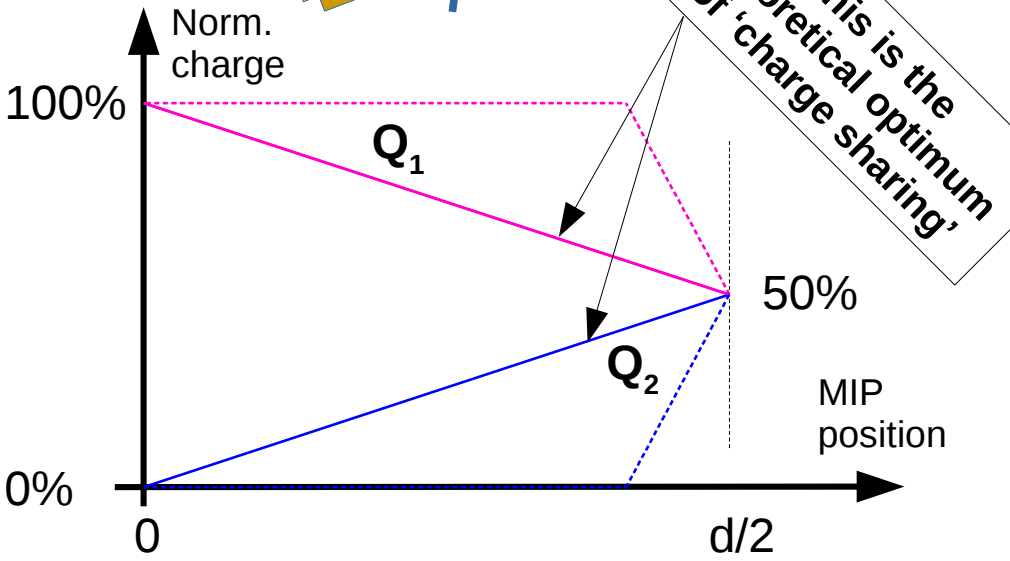


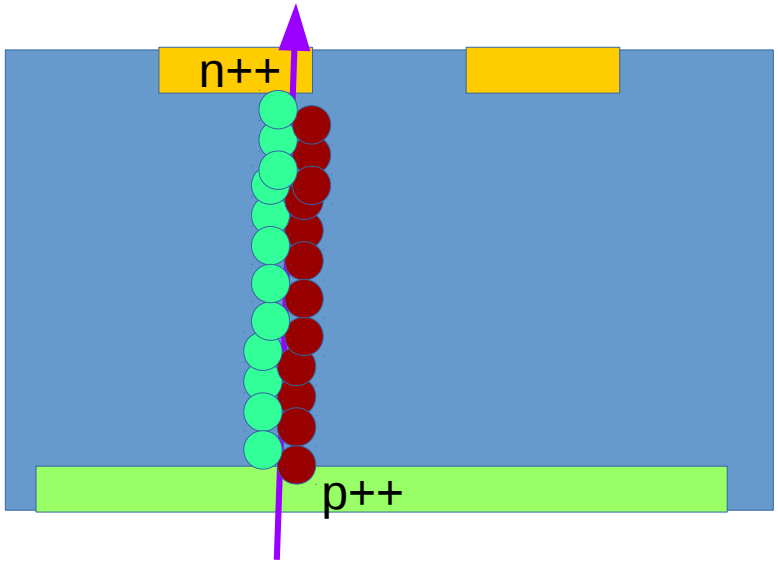


Enhanced lateral drift sensors

Towards the theoretical optimum of position resolution

Achieve improved position resolution of charged particle sensors

- **Induce lateral drift by locally engineering the electric field**



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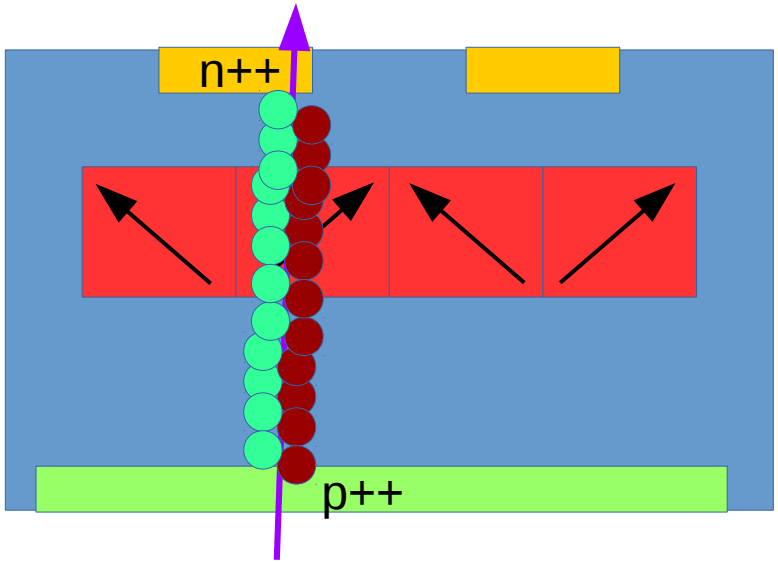

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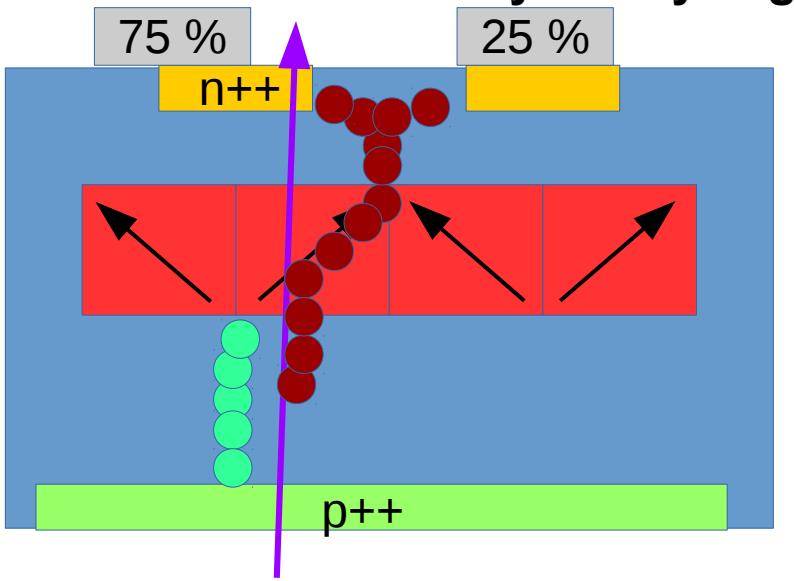

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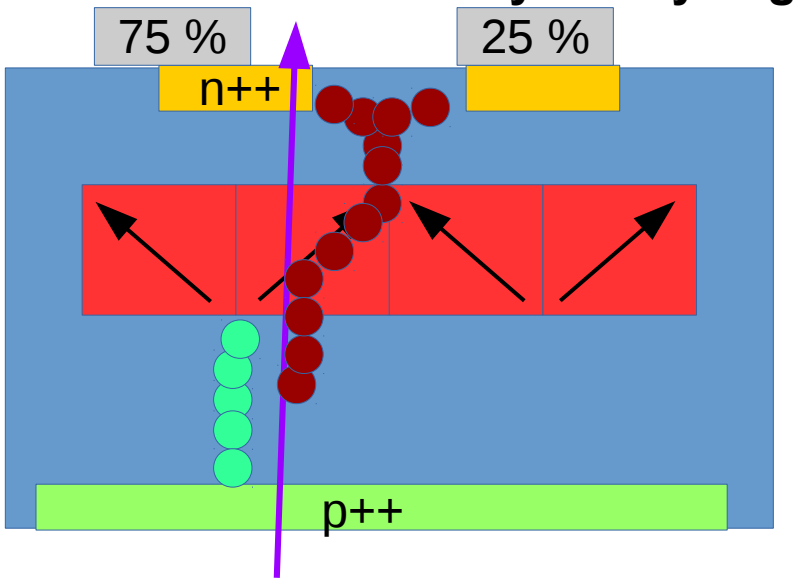

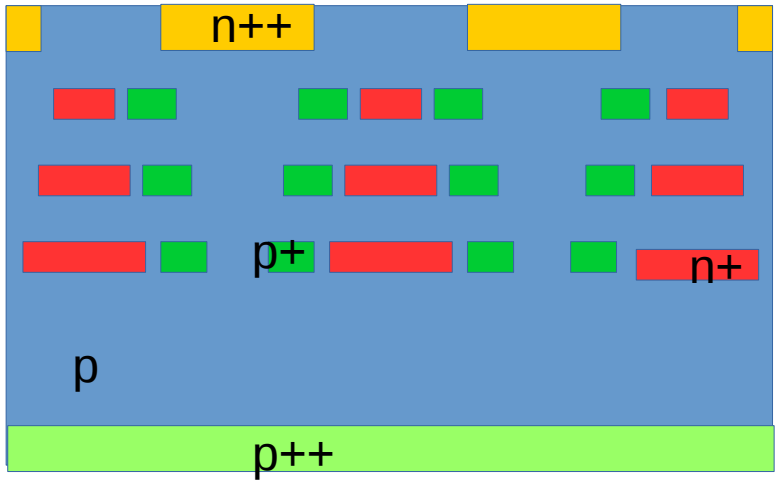

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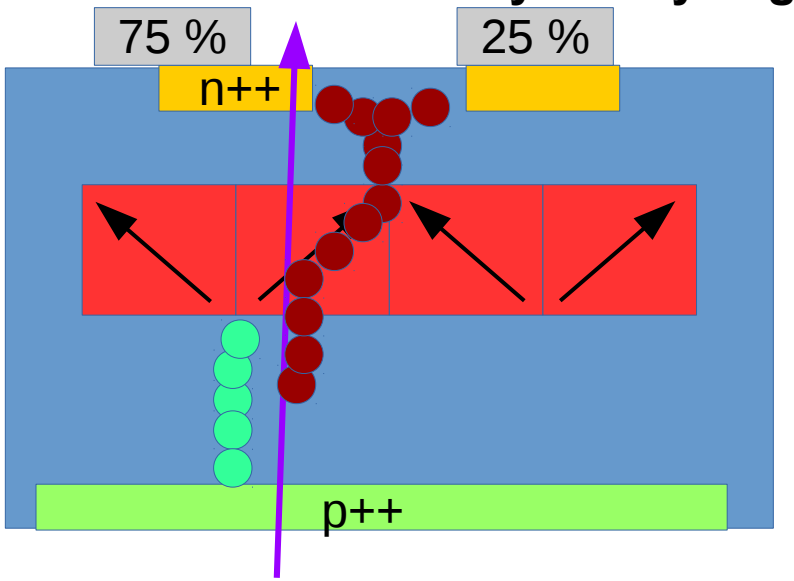
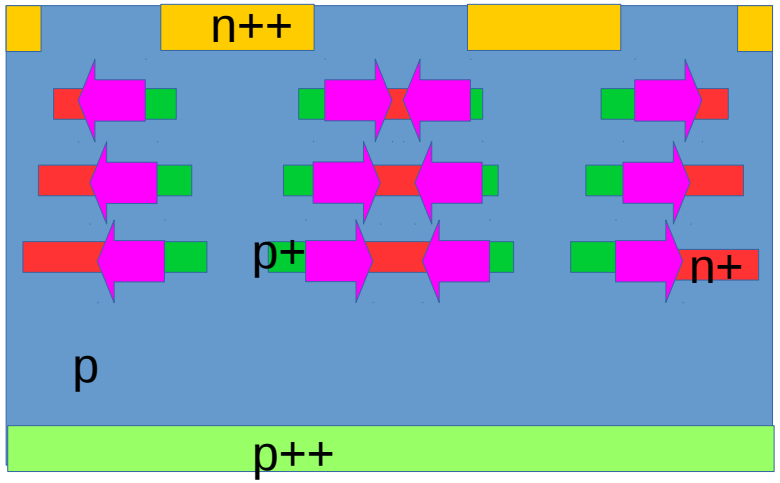




→ **LATERAL electric field**
→ **Position-dependent charge sharing (collection at >1 electrode)**
→ **Awareness of hemisphere (left/right of implant)**

→ ENHANCED LATER DRIFT (ELAD)

No one has done this before

… can we do it?

Produce a *functional prototype* by the end of the funding period

- Extensive **device simulation** studies by Anastasiia Velyka

  → Find optimal parameters for an ELAD sensor

- **Process simulations** to find process for manufacture

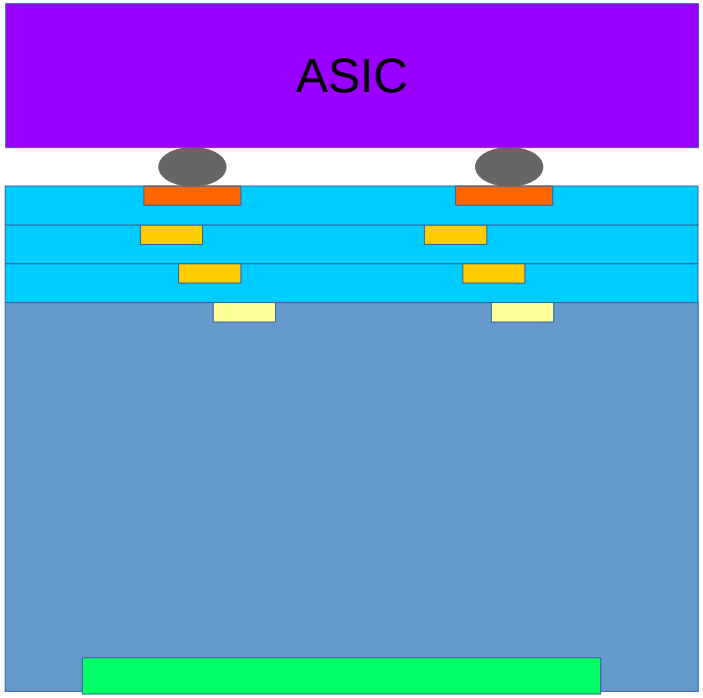
  → alternate implantation and epitaxial growth

- **Define structures and parameters** for production
  → Feed-back to SDE structures

- **Develop process** with partners (ISE, CiS)
  → Test structures
  → Full wafers

- **Flip chipping** with TimePix3 sensor

- **Tests at DESY/CERN**
  - Lab: IV, CV
  - Test beam



Status: Where we are now

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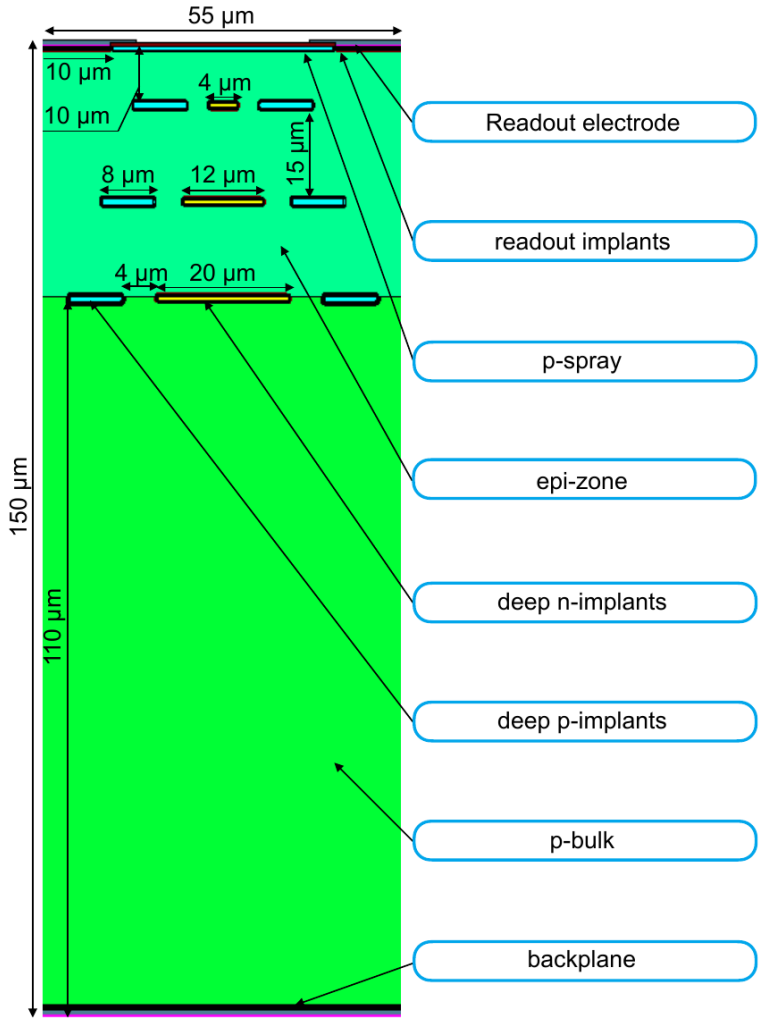

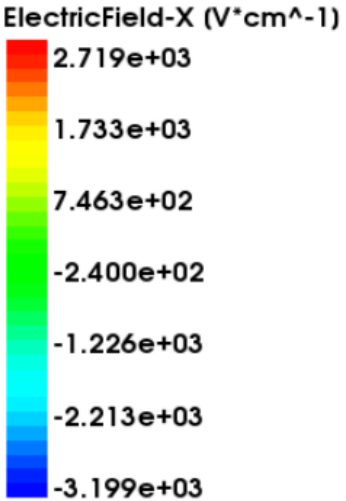

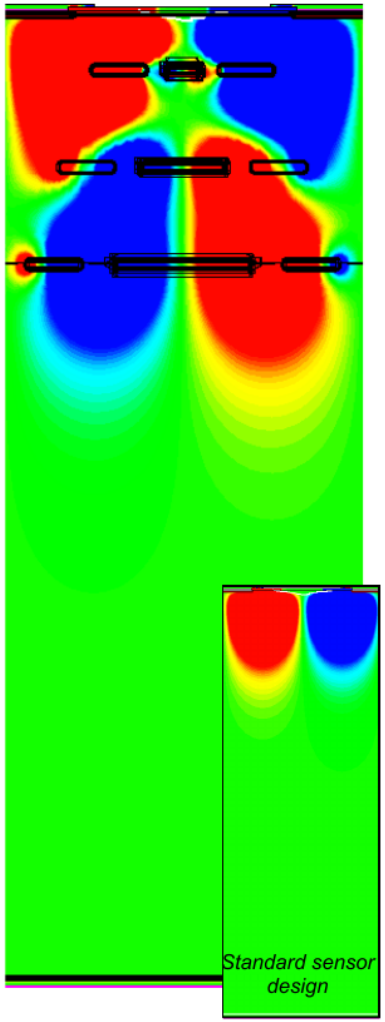

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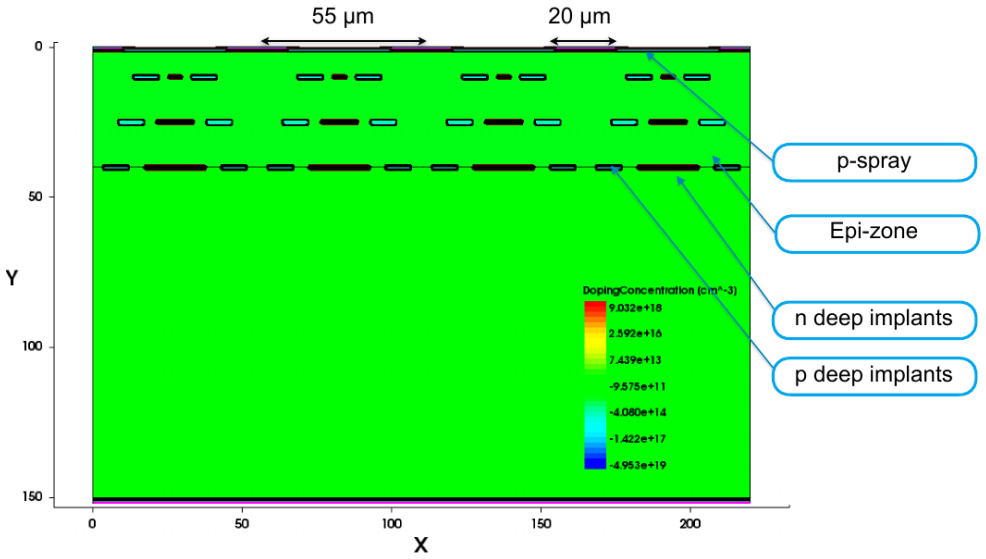
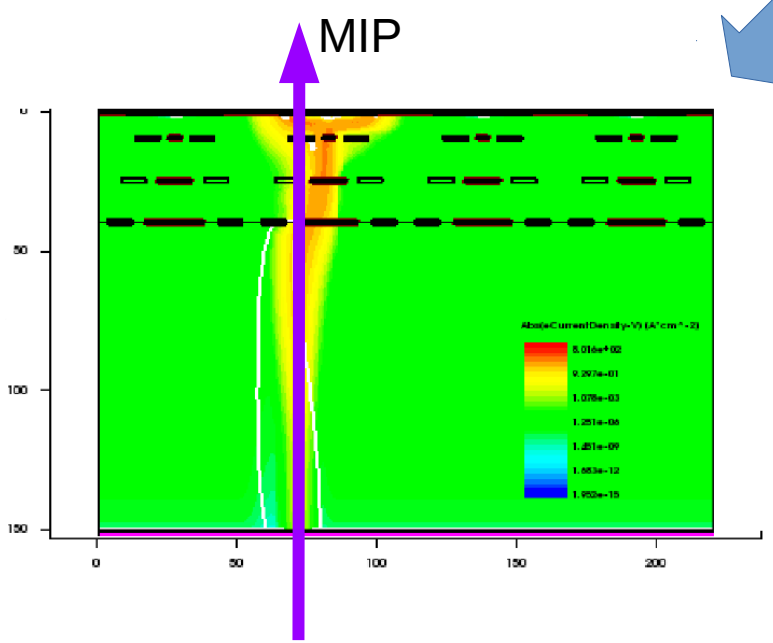
- **Extensive device simulations**
  - → Realistic shapes and sizes of implants
  - → Implant concentration
  - → Distances b/w layers
  - → Distance to first layer





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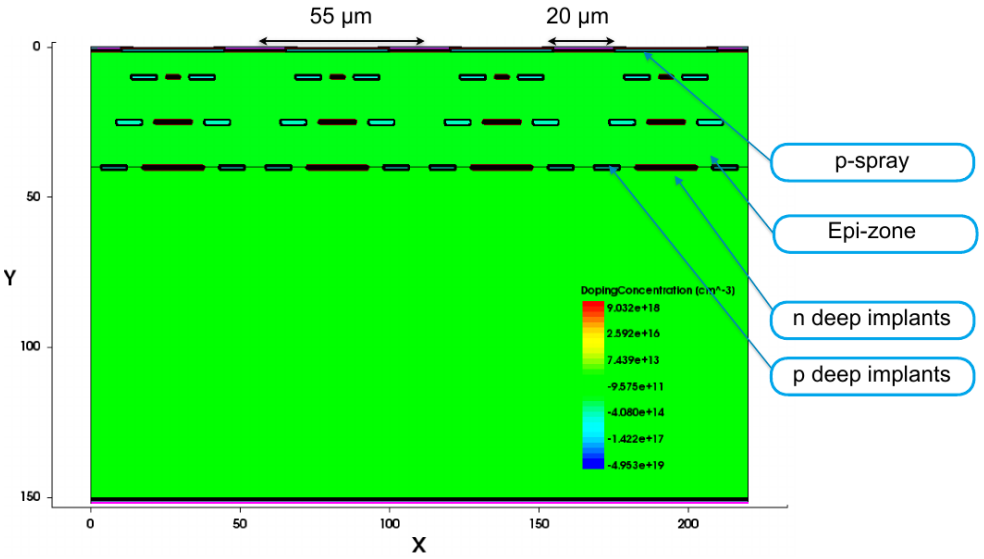
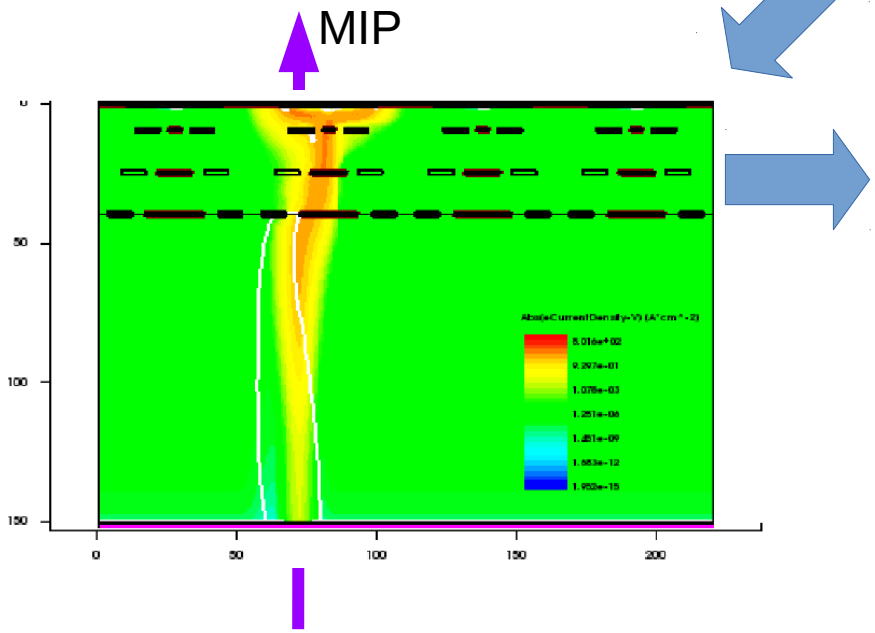
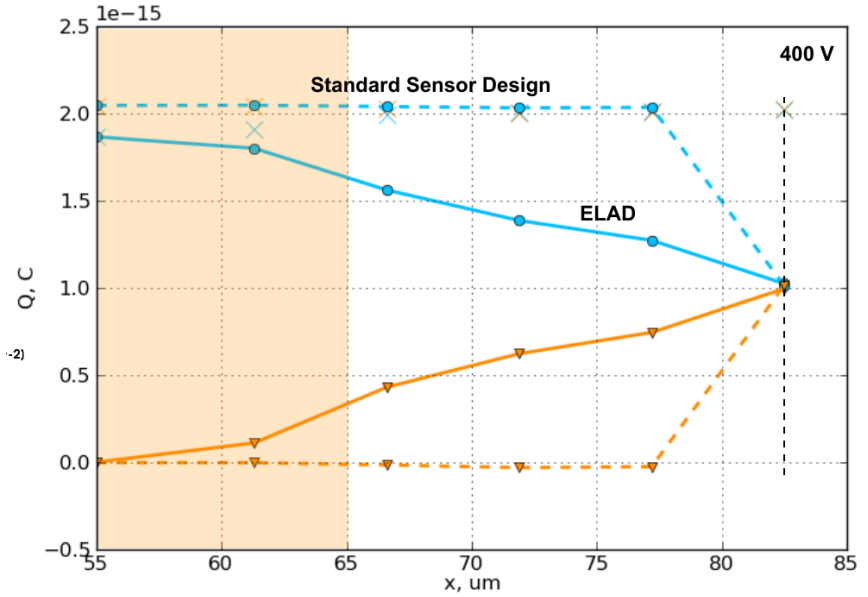
  - → In simulation, **THE ELAD WORKS**







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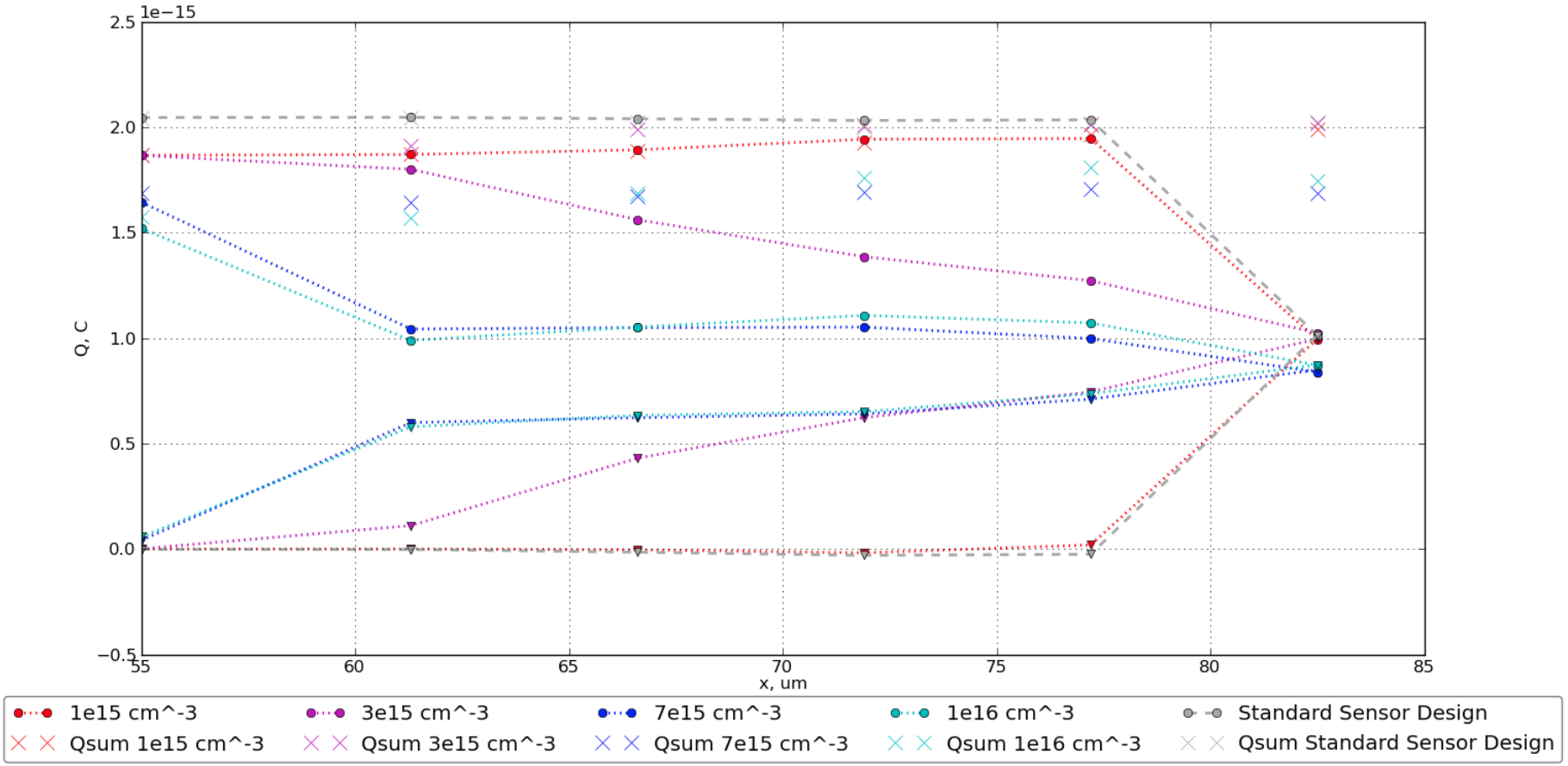
Example of optimisation

- Tuning the implant concentration



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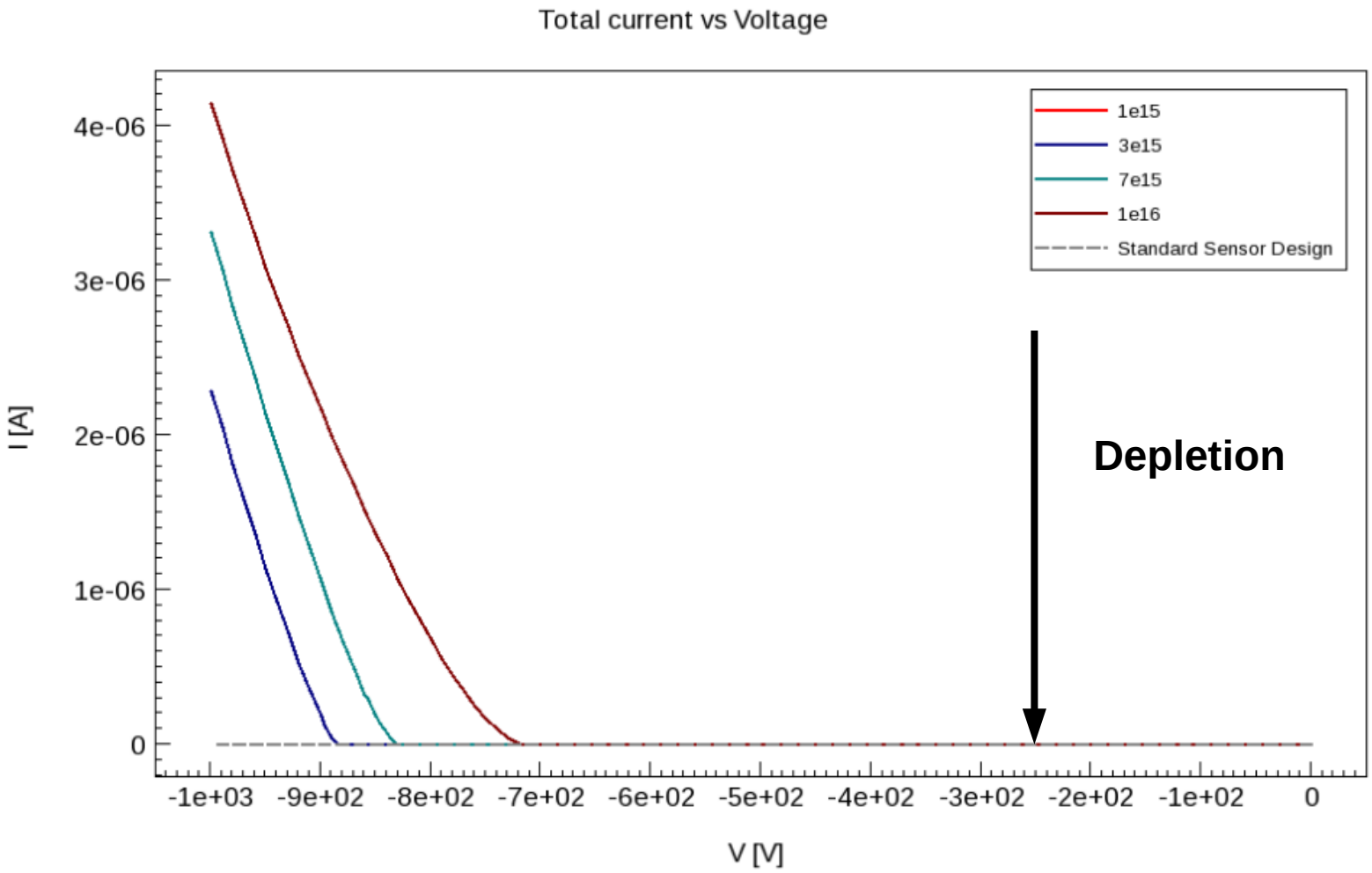

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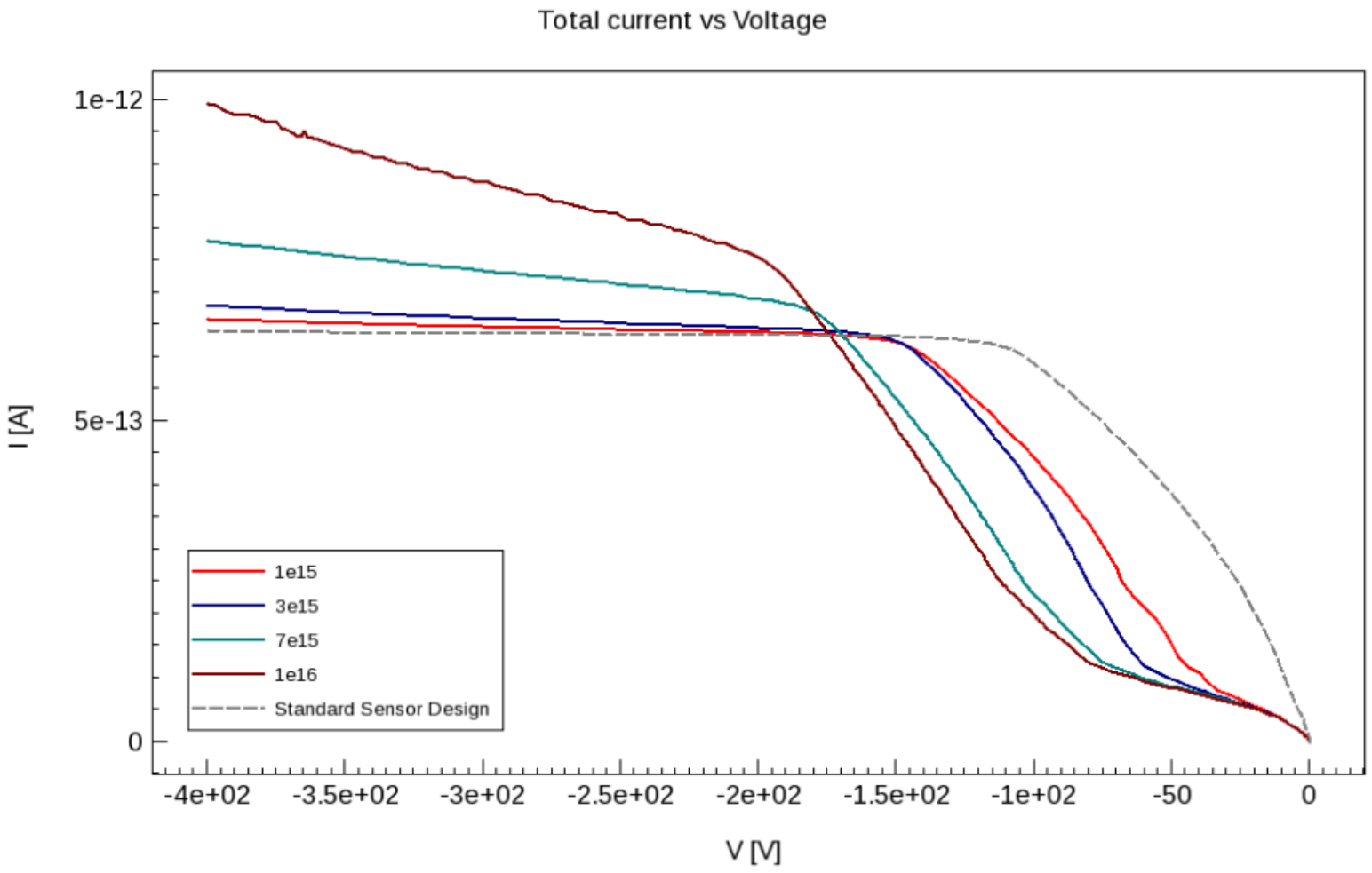
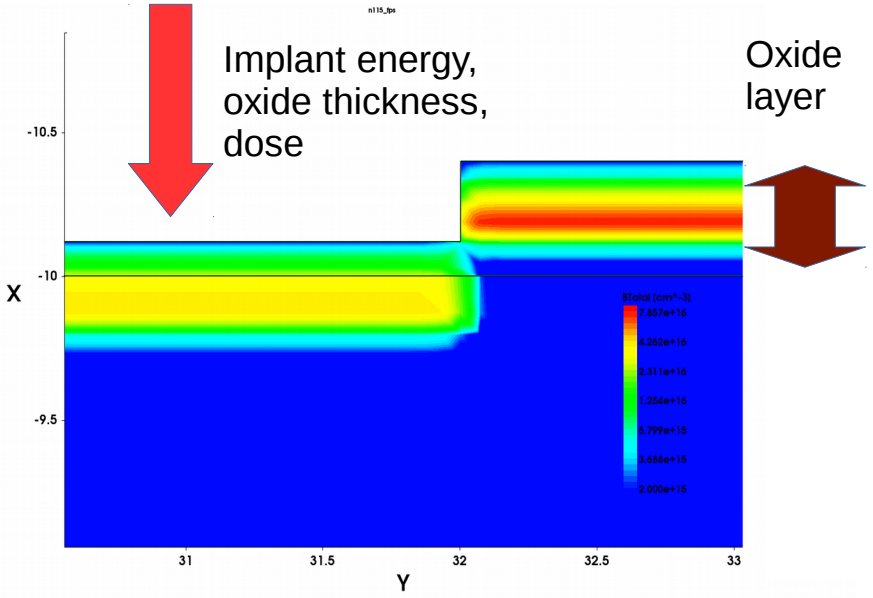
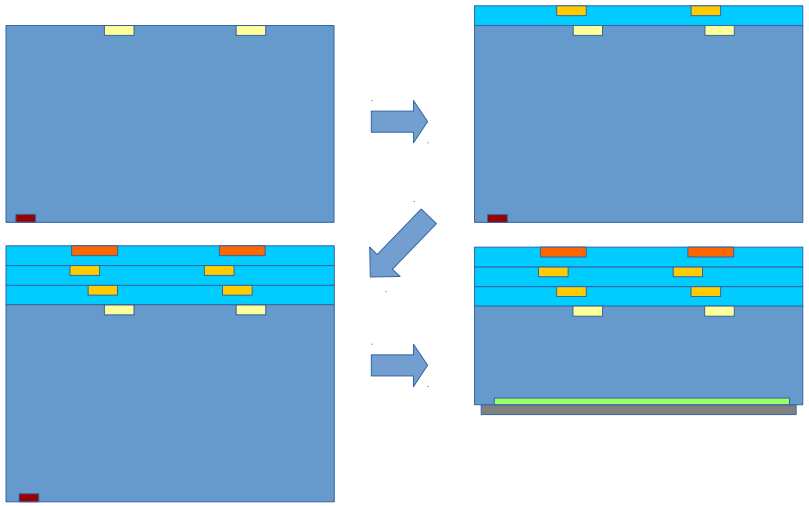


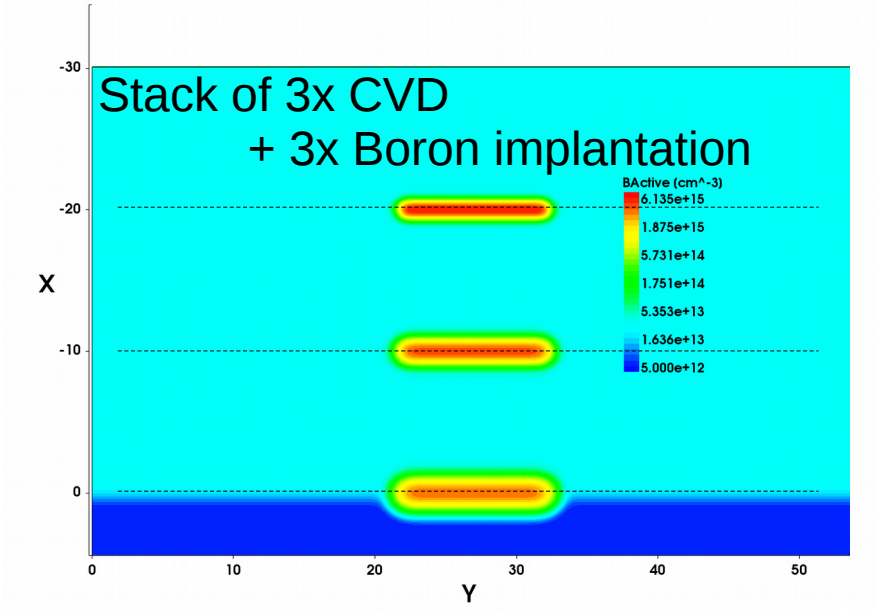
Status: Where we are now

- **Extensive device simulations**

- **Extensive process simulations**
  → Implantation of Boron and Phosphorus
  → Varied the oxide/energy
  → Epitaxial growth (temperature budget)
  → Communicated to ‘fab’





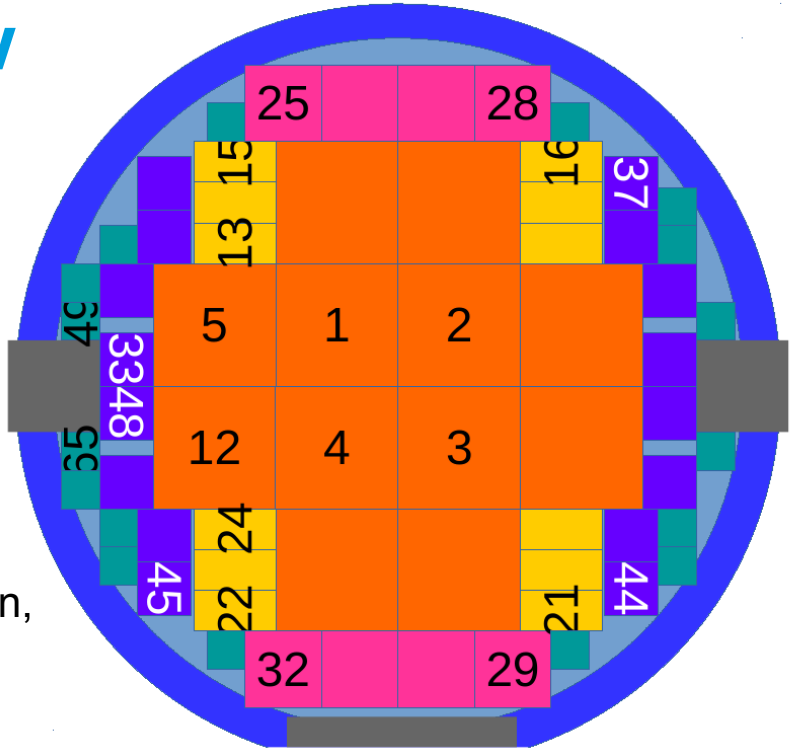


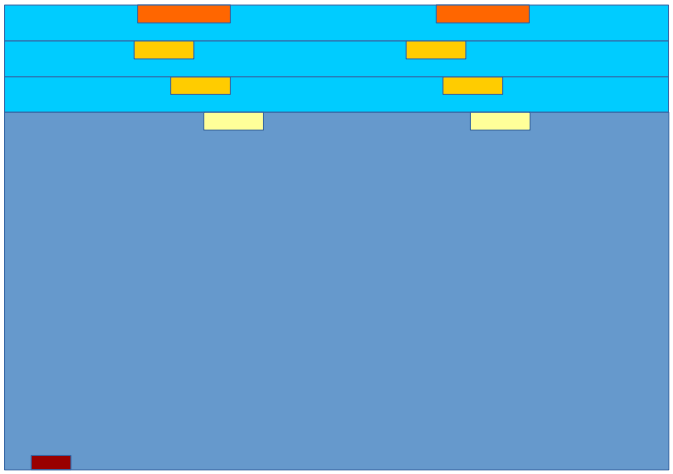
Status: Where we are now

- **Extensive device simulations**
- **Extensive process simulations**
- **End of November**
  - Meeting with project partners (ISE, CiS, DESY) at ISE
  - Discussion of technical feasibility, preproduction, project timeline + tour of laboratory
- **Expert review mid January**
  - very valuable input to make production a success
- **At the moment, in parallel:**

  1) creation of wafer layout files for production (DESY + CiS)

  2) initial tests at ISE for process development (waiting for results)





Conclusion

- **Technologically challenging project**
  (no one tried this before in HEP)
- Try to reach **theoretical optimum**
  of position resolution
- **Interesting technology** for future
  HEP detectors
- **Opens new possibilities** in sensor design
- Prototypes hopefully in Q2/Q3 2018