

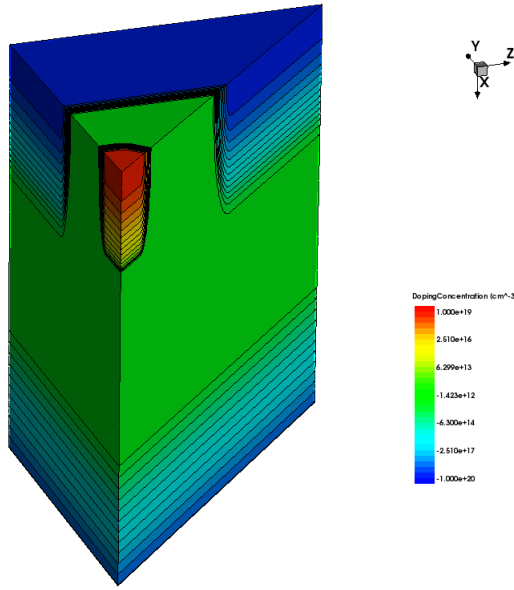
Perspectives for 65nm technology: timing and charge collection

Andrei Dorokhov, IPHC, Strasbourg

internal note, 19/04/2021

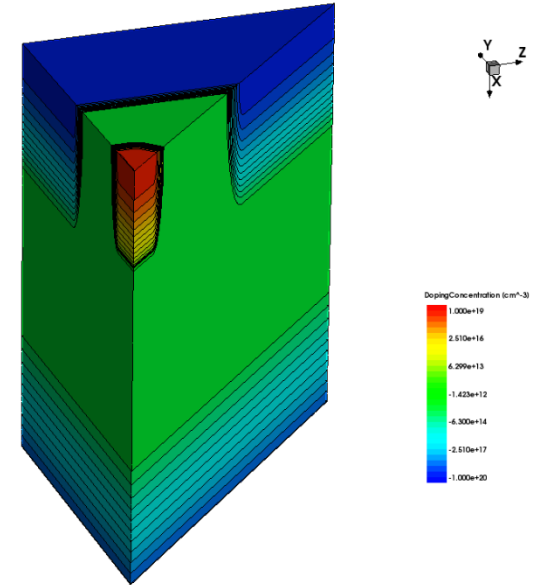
Simulations with TCAD, sensor properties

Different versions of EPI substrates: doping profiles (standard substrate) : not the exact doping but approximation-> so scan few parameters to cover possible deviations

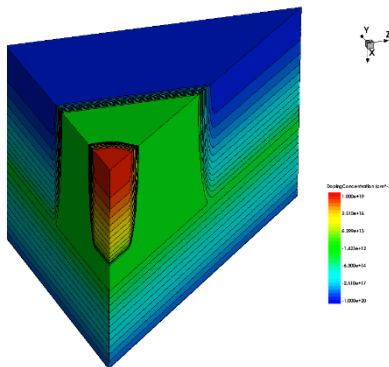


EPI_10um_1000ohm

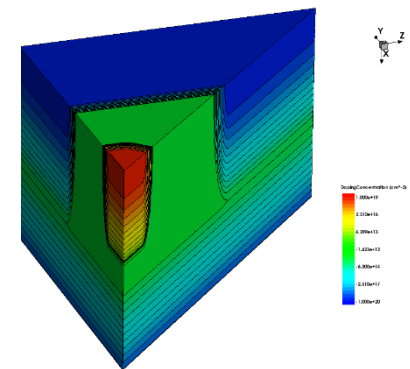
Pitch 30um x30 um,
Charge collecting electrode
2um octagonal same as in
MIMOSIS chip



EPI_10um_500ohm

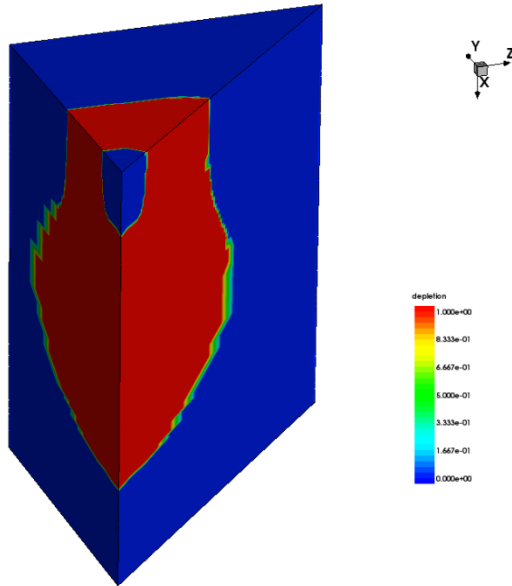


EPI_5um_1000ohm

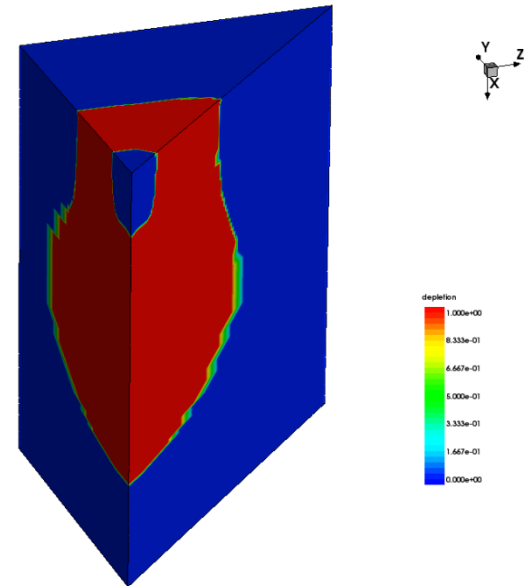


EPI_5um_500ohm

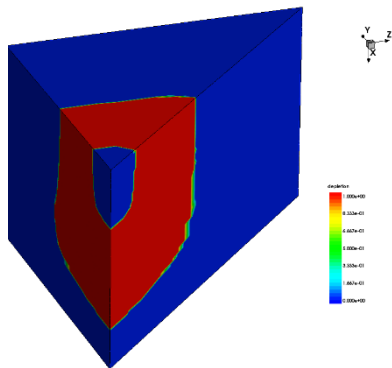
Different versions of EPI substrates: depletion (bias 16V)



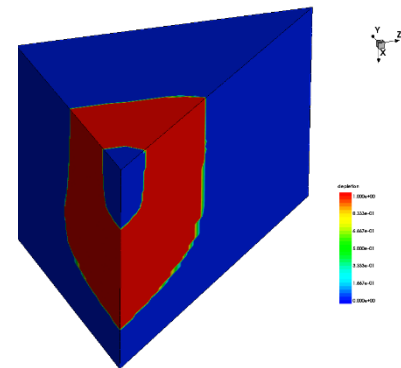
EPI_10um_1000ohm



EPI_10um_500ohm

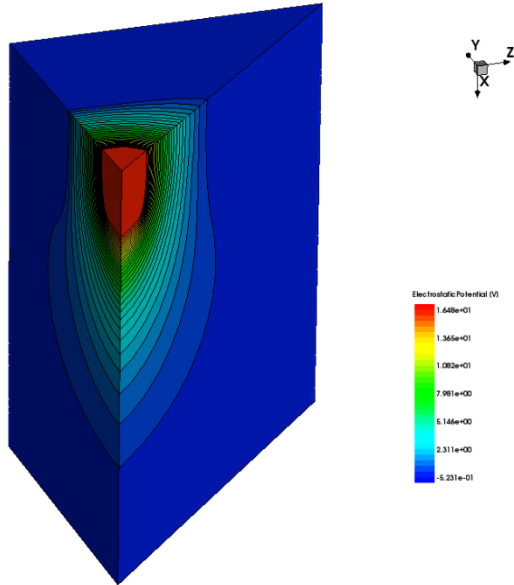


EPI_5um_1000ohm

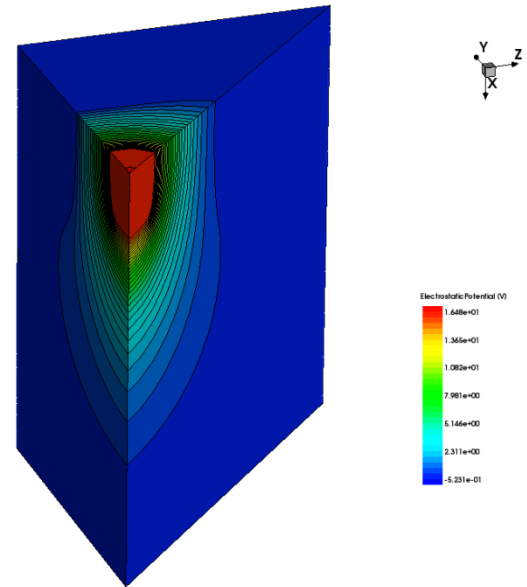


EPI_5um_500ohm

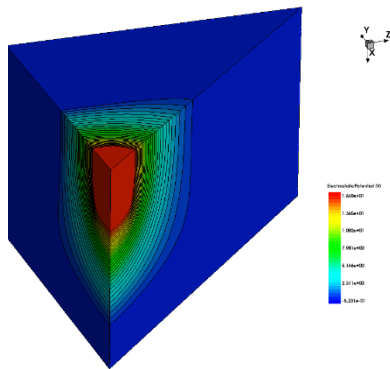
Different versions of EPI substrates: electrostatic potential (bias=16V)



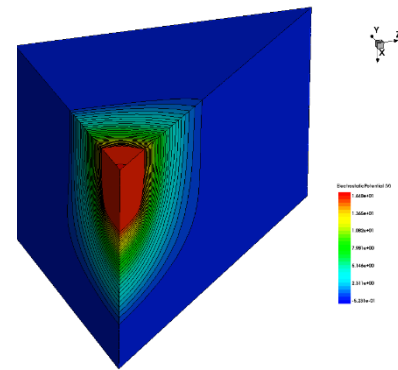
EPI_10um_1000ohm



EPI_10um_500ohm

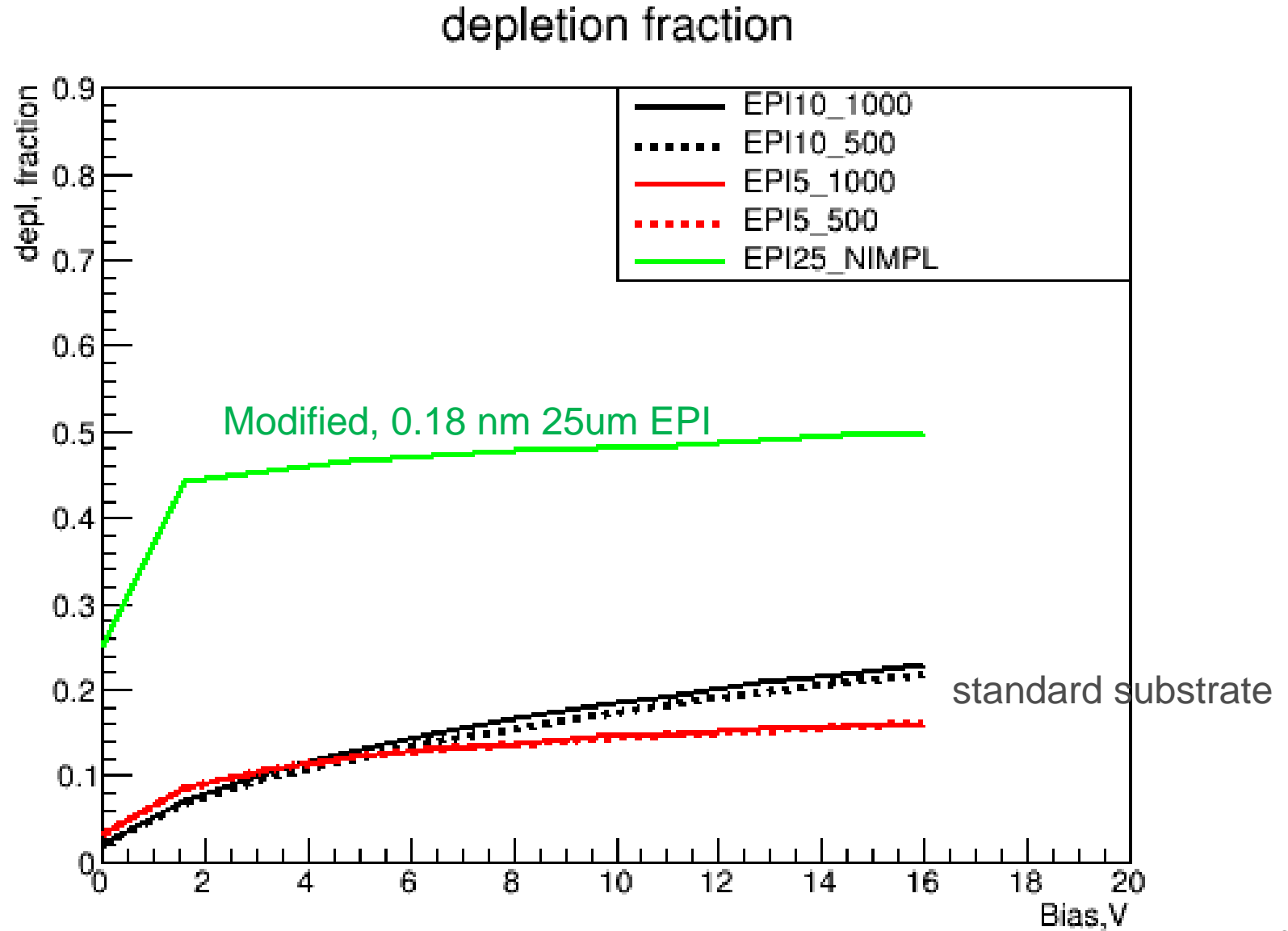


EPI_5um_1000ohm



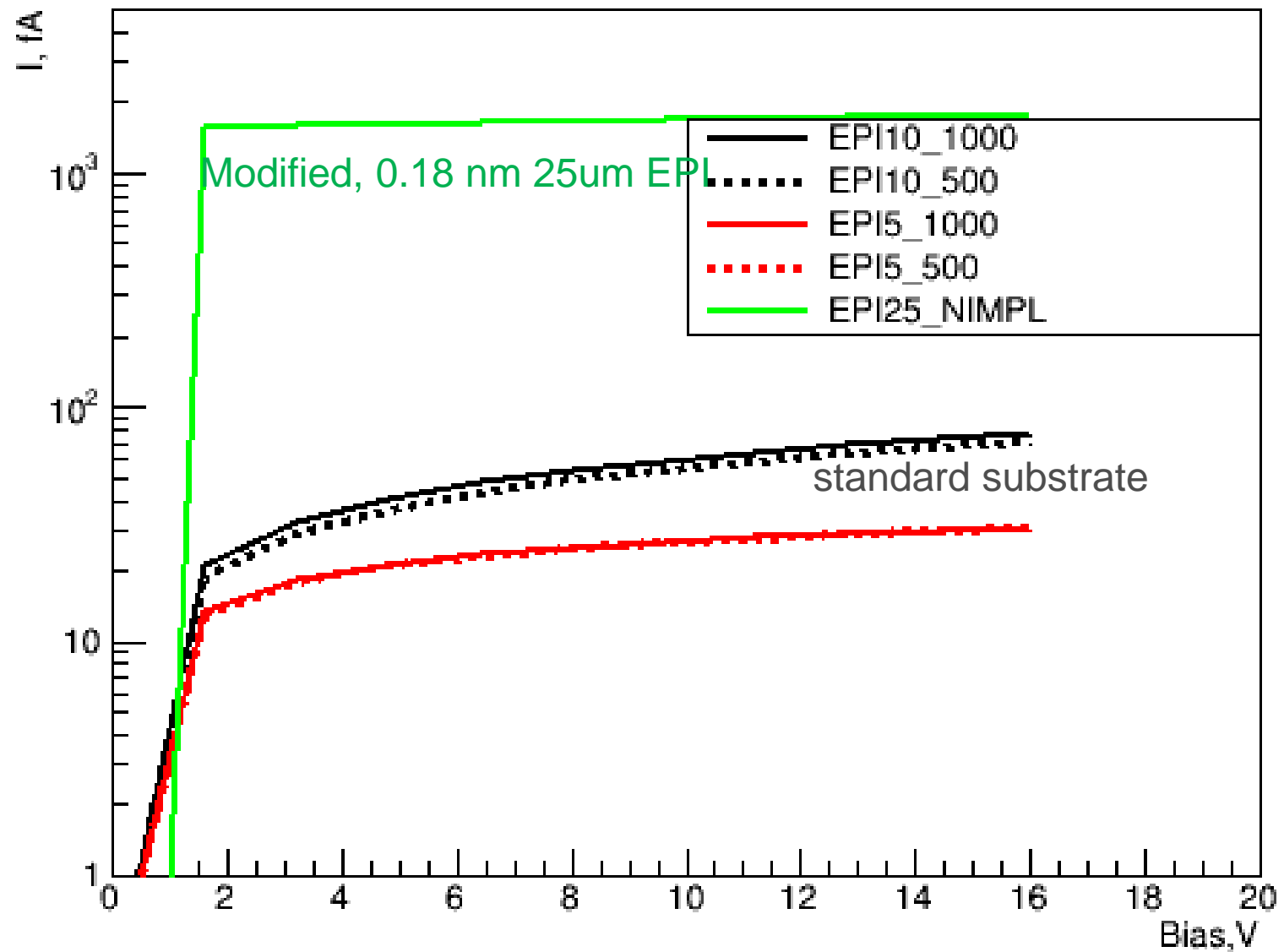
EPI_5um_500ohm

Different versions of EPI substrates



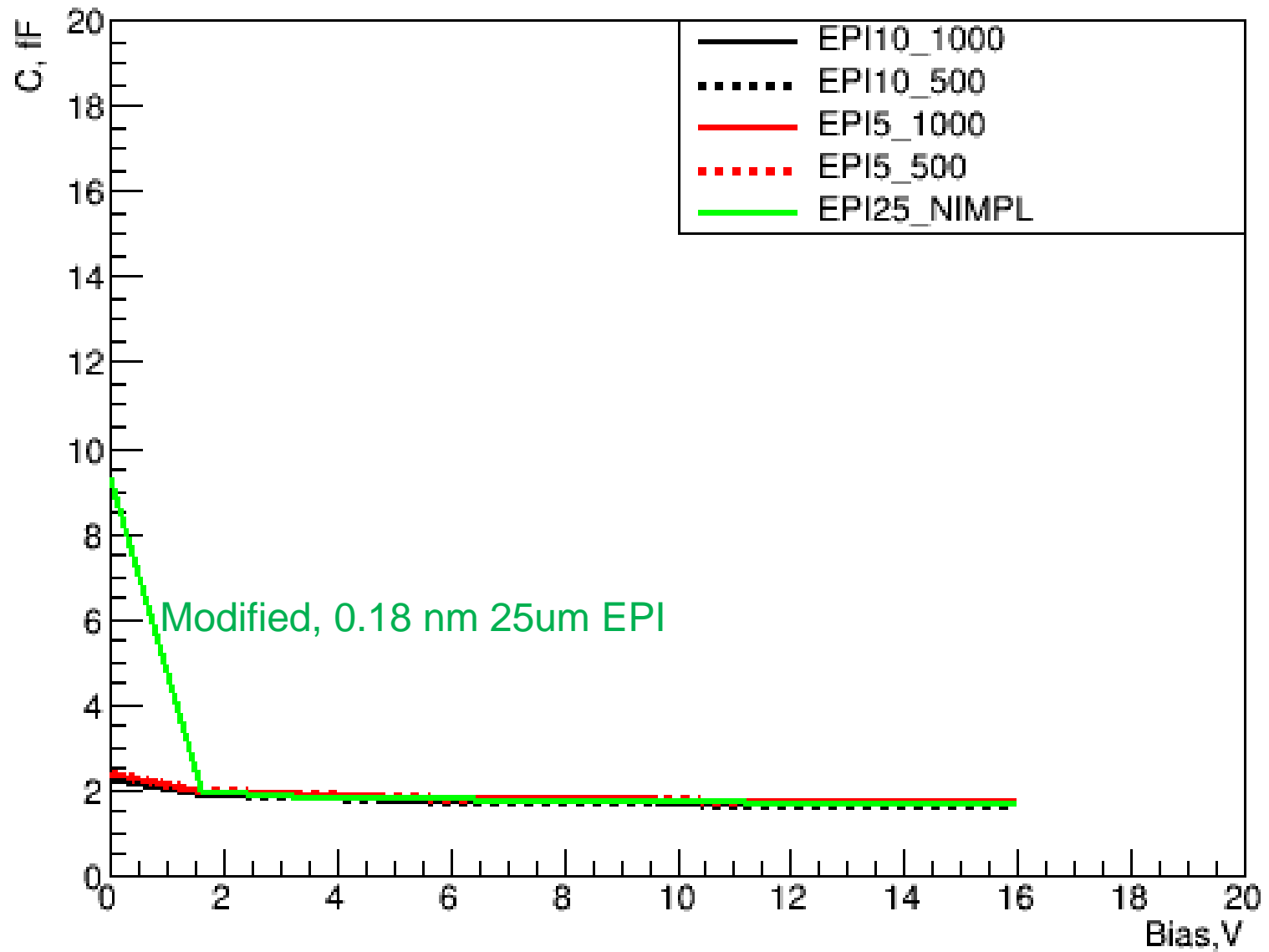
Different versions of EPI substrates

leakage current

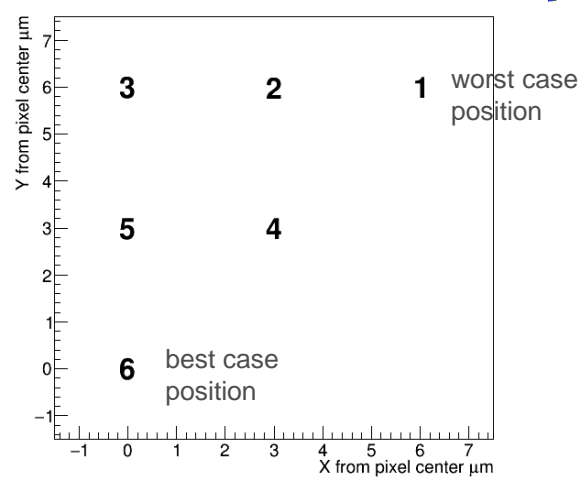
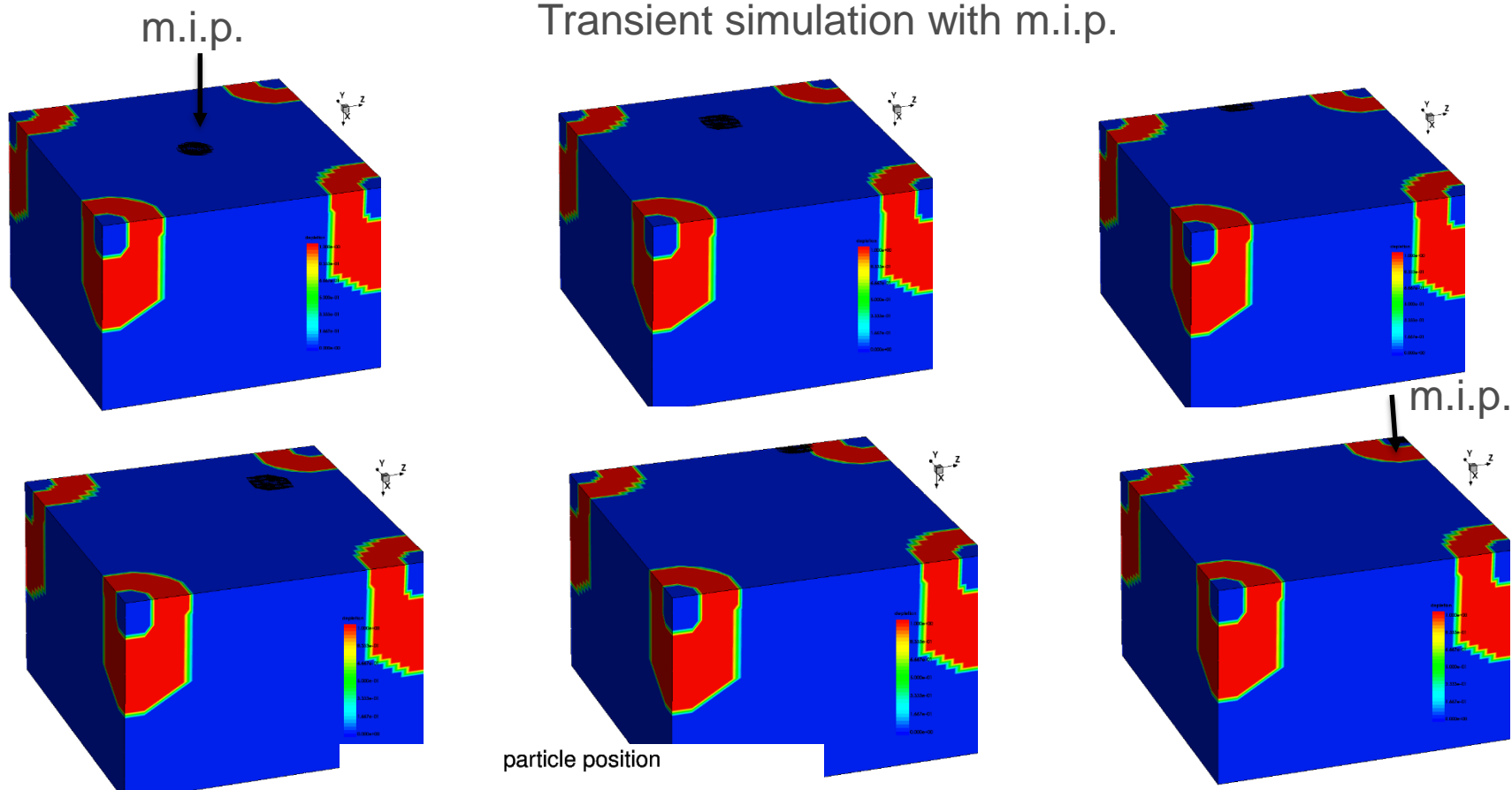


Different versions of EPI substrates

capacitance



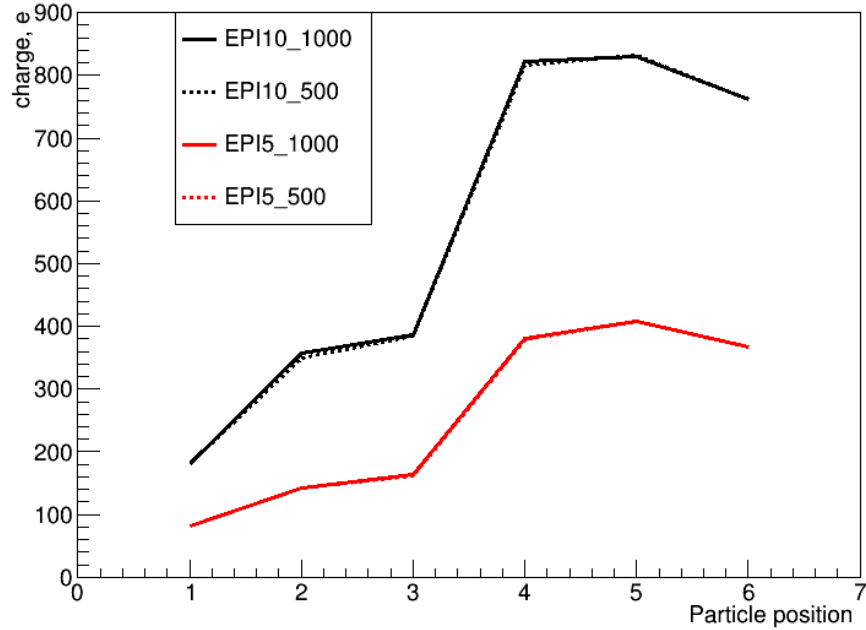
Transient simulation with m.i.p.



m.i.p. position index

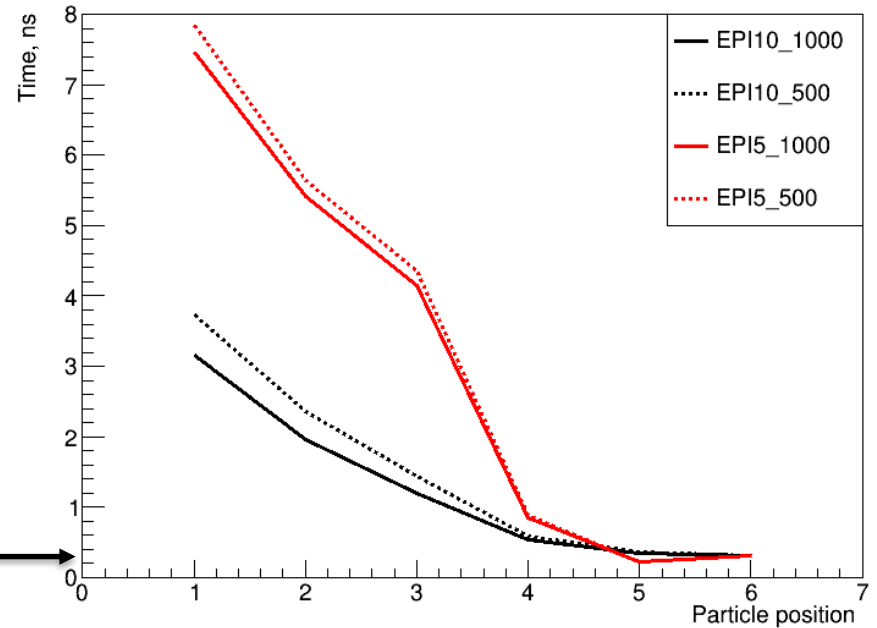
Transient simulation with m.i.p.

Collected charge



standard substrate

Time to collect 90% of charge



Best case position collection time ~200ps



Transient simulations with modified process – we have no detailed information about introduced implants, but CERN has privileged access to foundry ->

Presented by Magdalena Munker, CERN detector seminar, 29/01/2021:

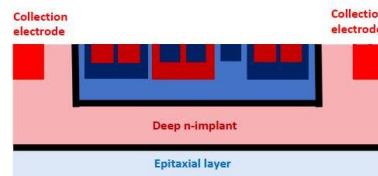
Summary of sensor optimization for FASTpix

Summary of main optimized parameters:

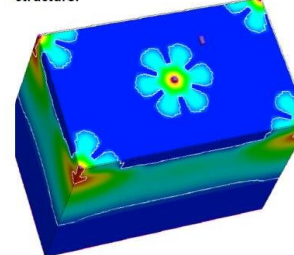
- Pitch → hexagonal design
- Opening of p-wells → retracted deep p-well, 'p-well fingers'
- Collection electrode size → trade-off between capacitance and lateral field
- Deep n-implant dose → trade-off between capacitance and radiation hardness
- Depth of deep n-implant → trade-off between contact to collection electrode and optimized field configuration

T. Kuqathasan et al., <https://doi.org/10.1016/j.nima.2020.164461>

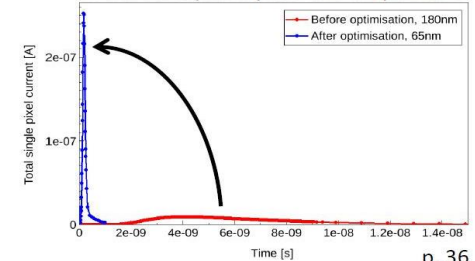
Example pixel layout:



Example of complex 3D TCAD structure:



3D TCAD current pulse for particle incident at pixel corner:



p. 36

Even at worst case position collection time ~200ps

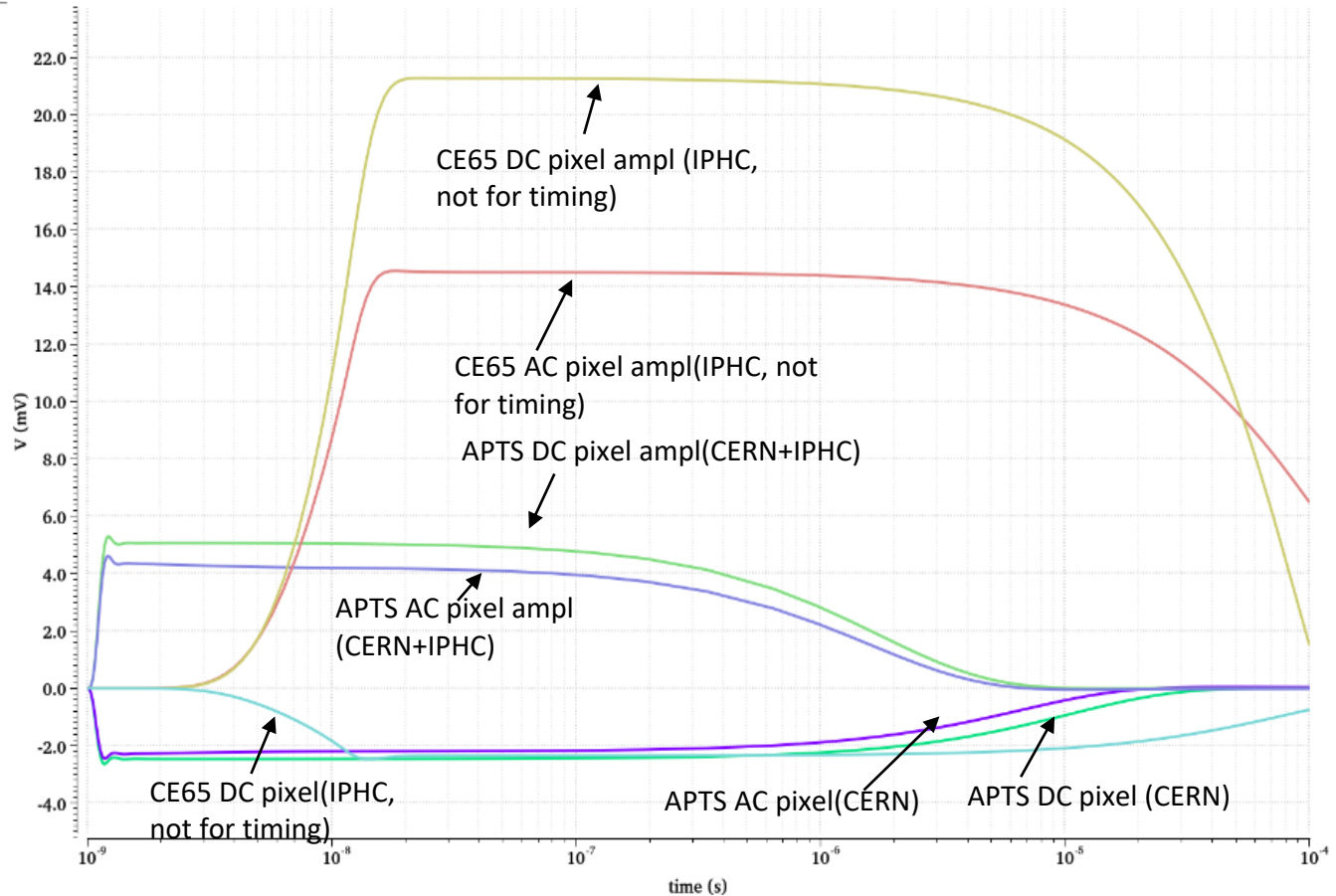
Simulations with spectre, basic circuits properties

Spectre transient simulations of real circuits: different structures submitted in 65nm MLR1

OUT_DCpix:OUT_ACpix:OUT_DCpix_ampl:OUT_ACpix_ampl:OUT_CE65_ACpix_ampl:OUT_CE65_DCpix_ampl:OUT_CE65_DCpix

Thu Mar 18 13:12:52 2021 1

OUT_DCpix
OUT_ACpix
OUT_DCpix_ampl
OUT_ACpix_ampl
OUT_CE65_ACpix_ampl
OUT_CE65_DCpix_ampl
OUT_CE65_DCpix



Outputs for 100e injection, 1 pixel leakage=1pA, standard settings except: IRESET=0.1uA

Rise time with SF < 200ps

Outlook

1. With 65nm charge collection and signal rising can be around 200ps -> so best approximation of time resolution depends on signal-to-noise ratio, if we take $S/N = ((80\text{eh} \cdot 10\mu\text{m total charge}) / (3..4 \text{ pixels in cluster})) / 10e = 26..20$, it could be 10ps, but of course, if we use some time walk compensation techniques (online or offline)
2. If there are no time walk compensation, the time resolution is below 200ps and in both cases:
 - a) Depends very much on amplifier /discriminator and readout circuitry – if we improve signal-to-noise ratio, if we use some time walk compensation techniques, etc..
 - b) Depends on process optimization, doping, pixel geometry
3. We are preparing for testing of basic structures of MLR1 and measure charge collection and timing and verify our assumptions..