Perspectives for 65nm technology: timing and charge collection

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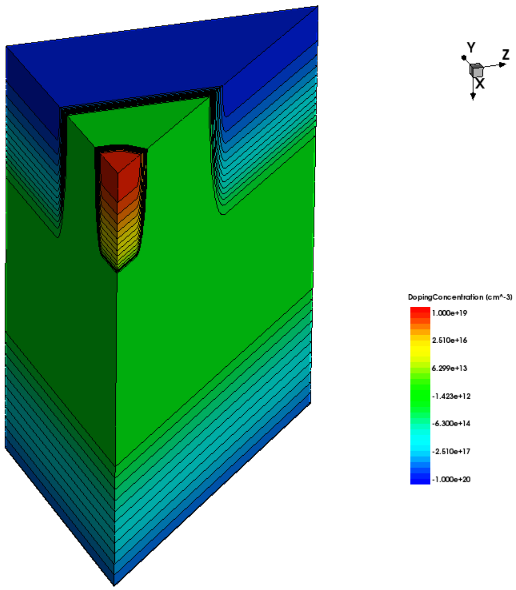
internal note, 19/04/2021

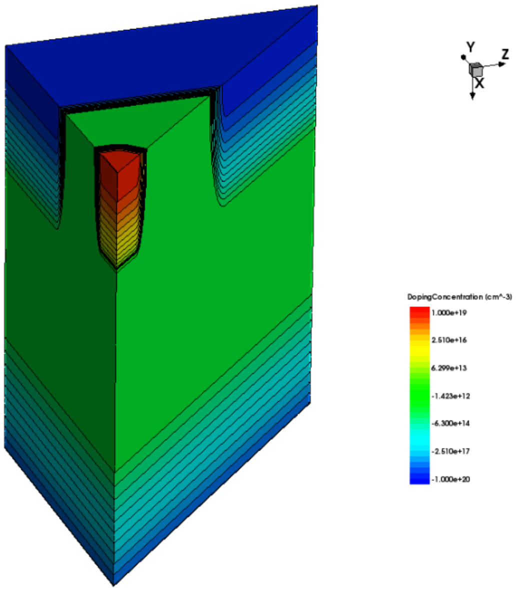
Simulations with TCAD, sensor properties

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

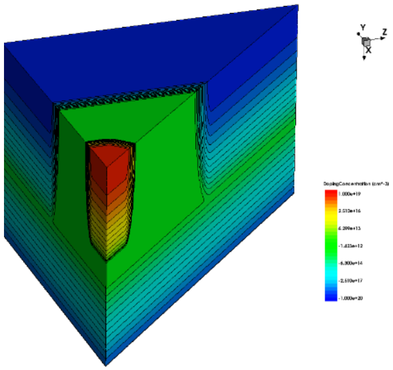


EPI_10um_1000ohm

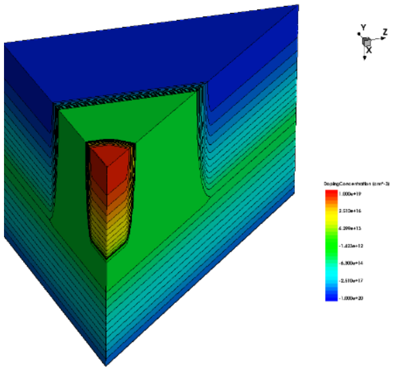
Pitch 30um x30 um,
Charge collecting electrode 2um octagonal same as in MIMOSIS chip



EPI_10um_500ohm

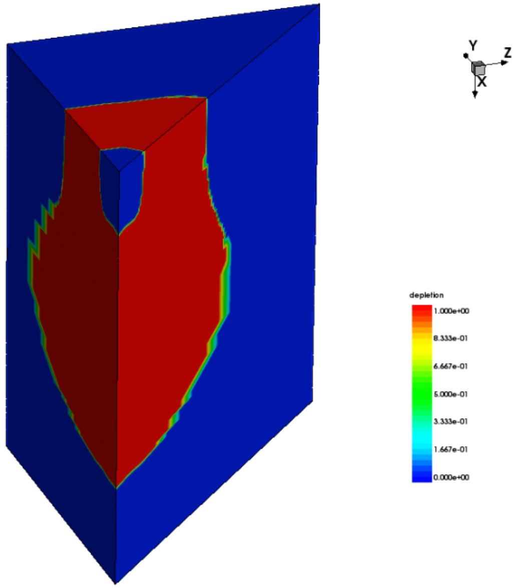


EPI_5um_1000ohm

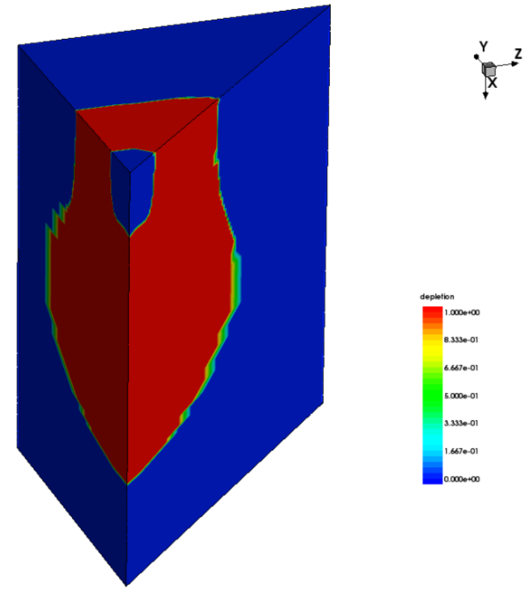


EPI_5um_500ohm

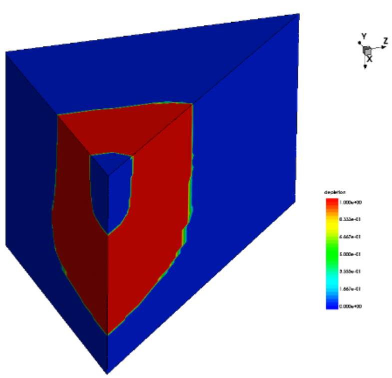
Different versions of EPI substrates: depletion (bias 16V)



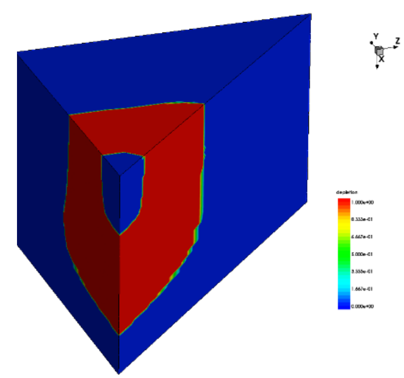
EPI_10um_1000ohm



EPI_10um_500ohm

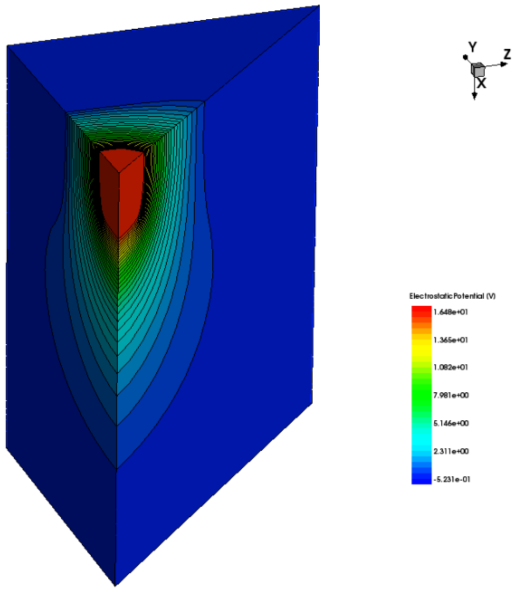


EPI_5um_1000ohm

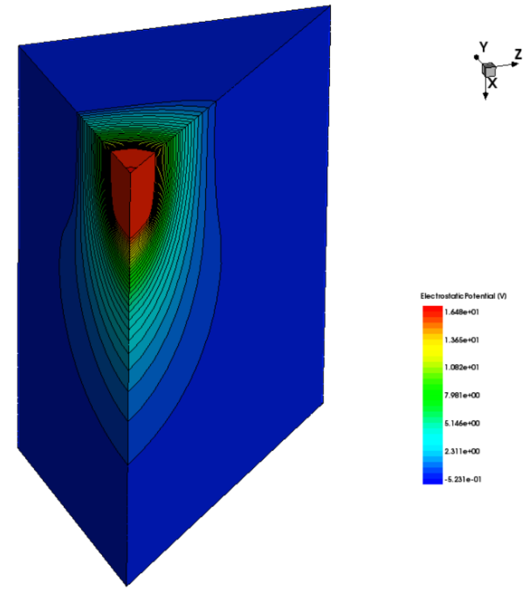


EPI_5um_500ohm

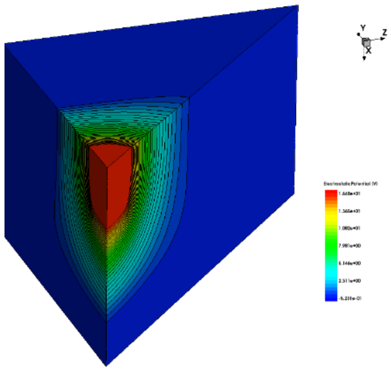
Different versions of EPI substrates: electrostatic potential (bias=16V)



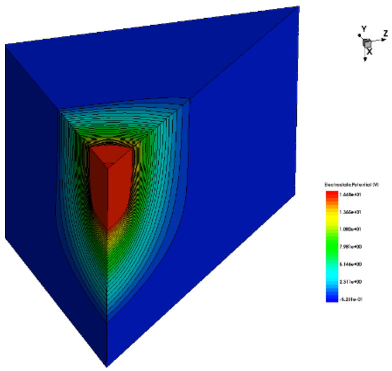
EPI_10um_1000ohm



EPI_10um_500ohm

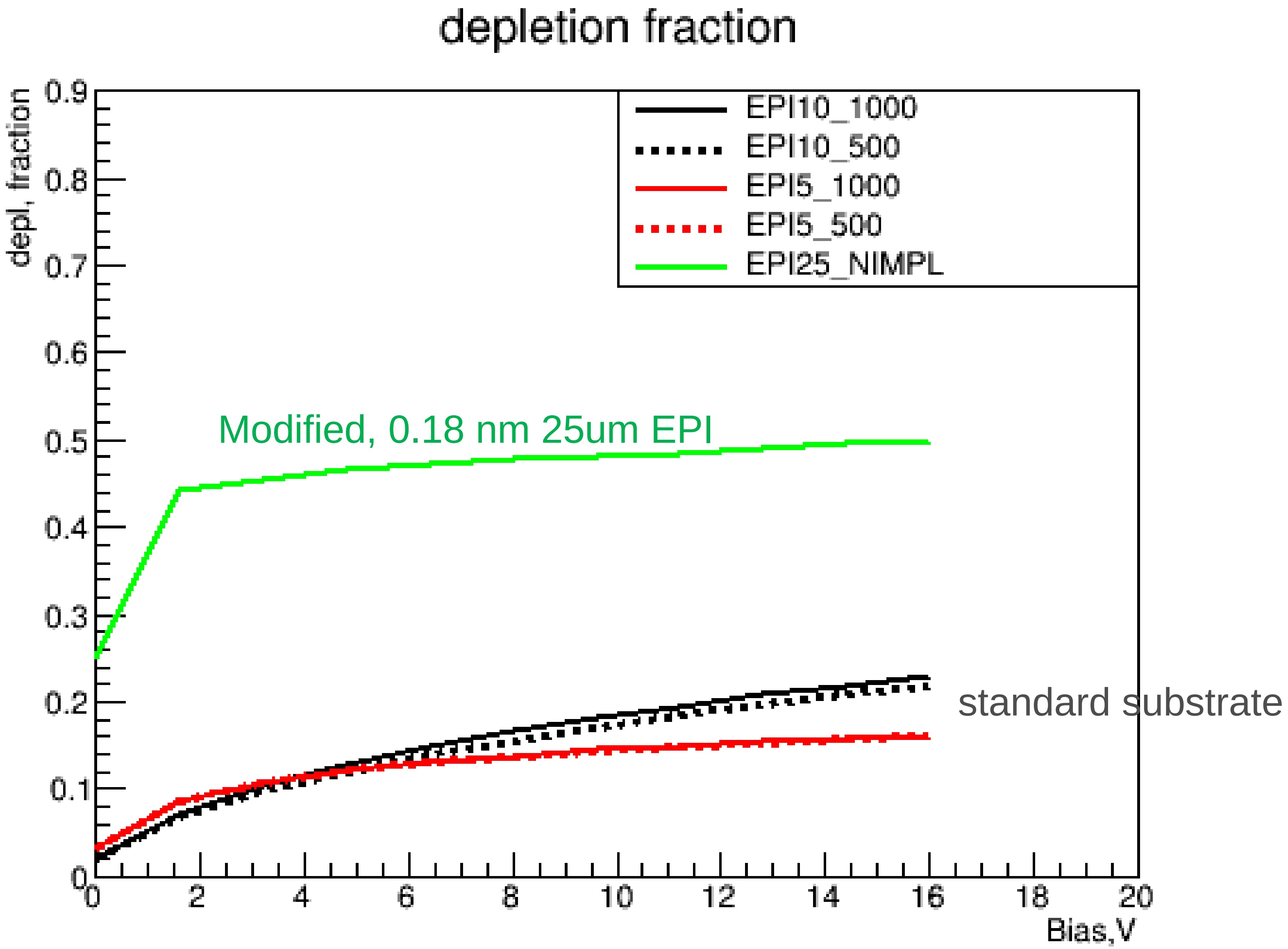


EPI_5um_1000ohm

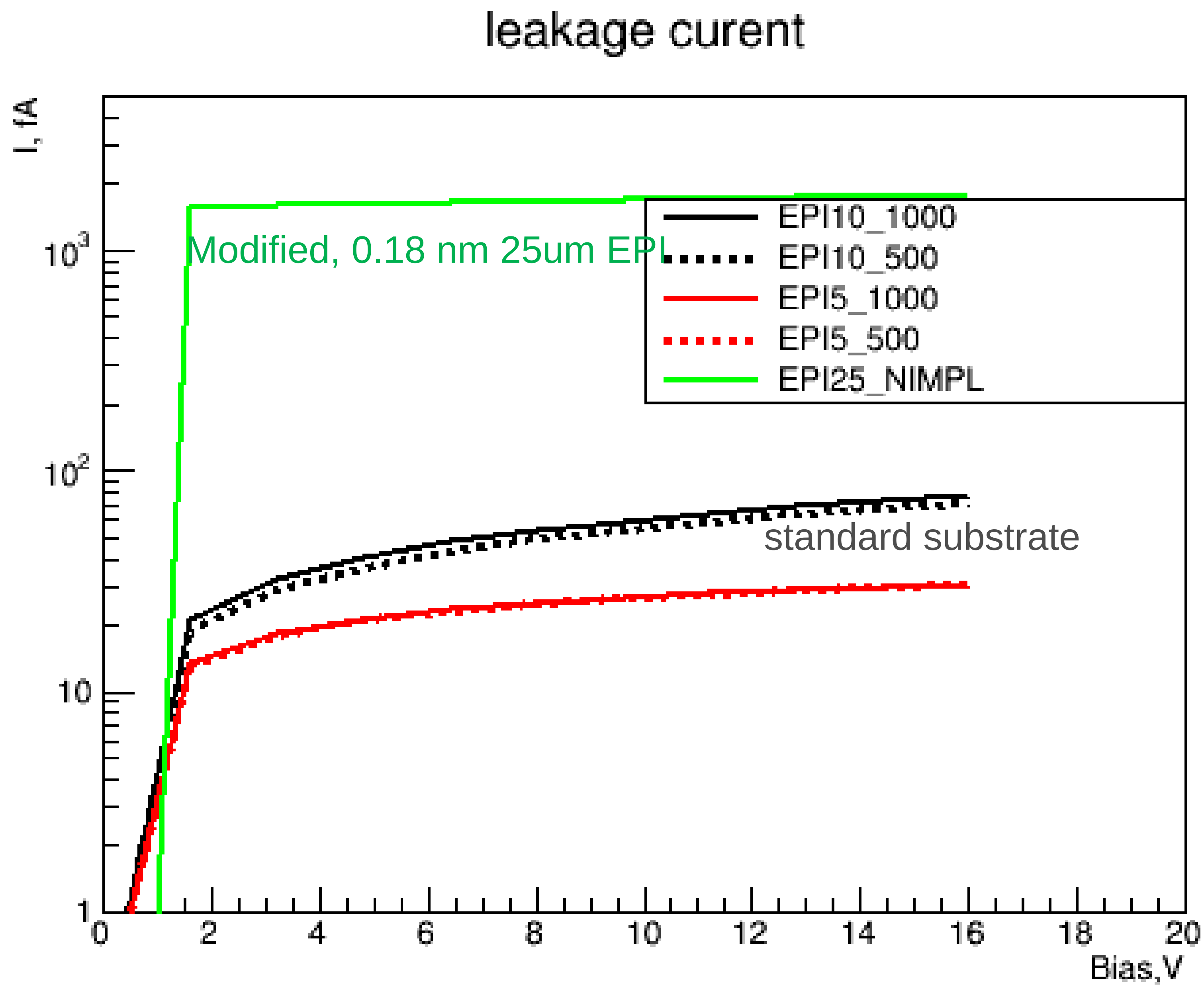


EPI_5um_500ohm

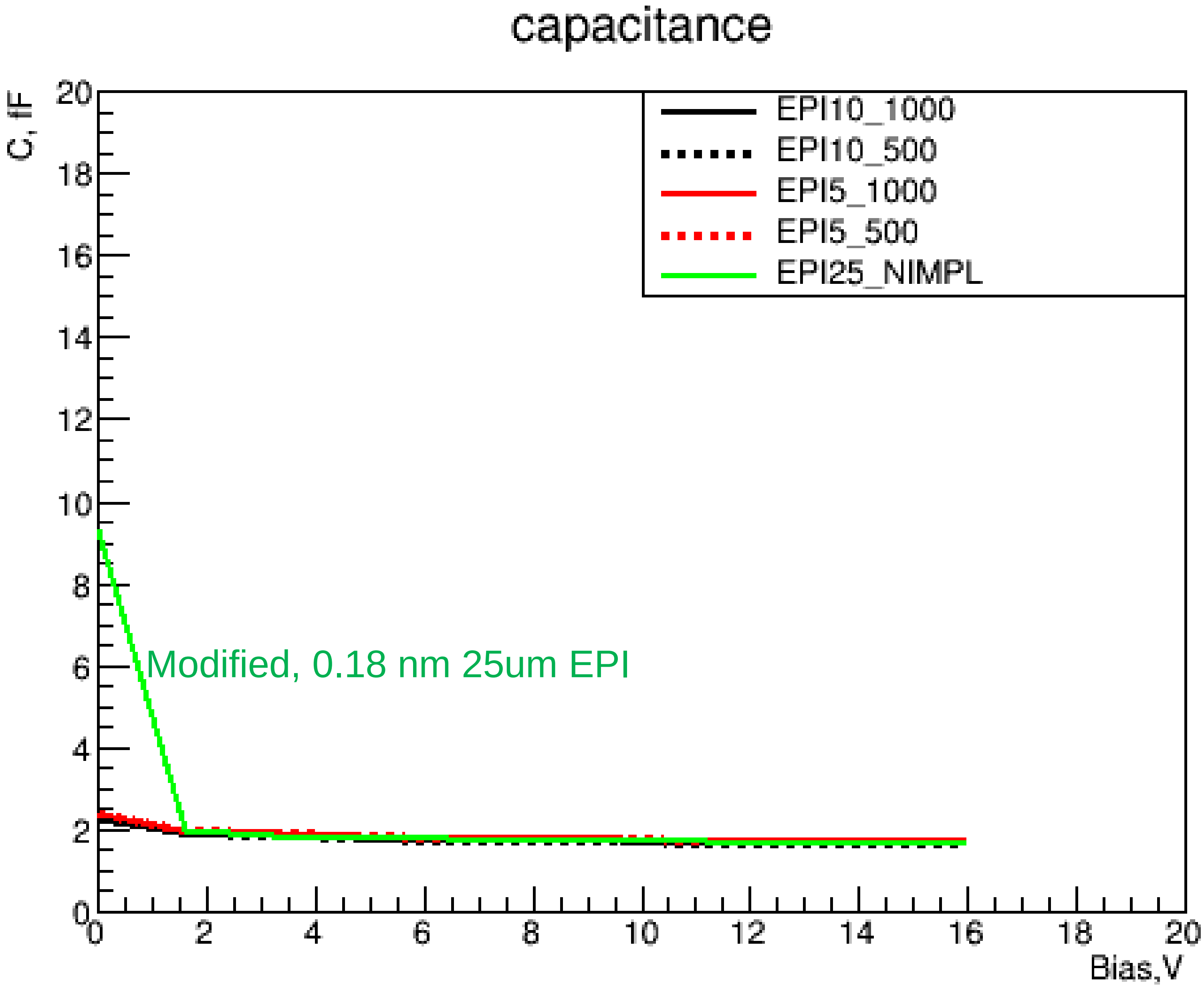
Different versions of EPI substrates



Different versions of EPI substrates

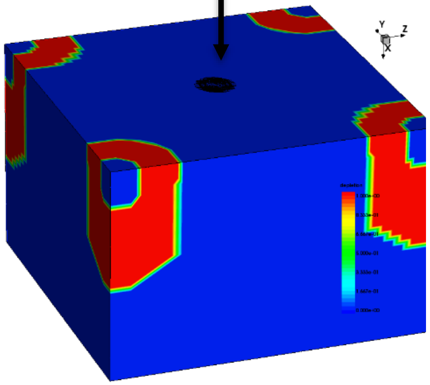


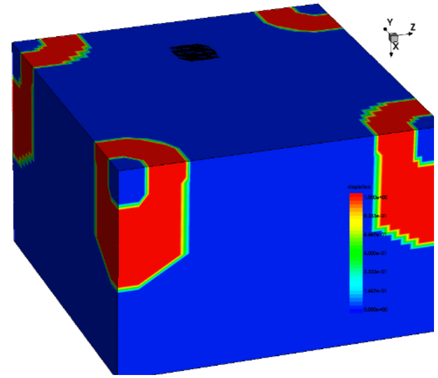
Different versions of EPI substrates

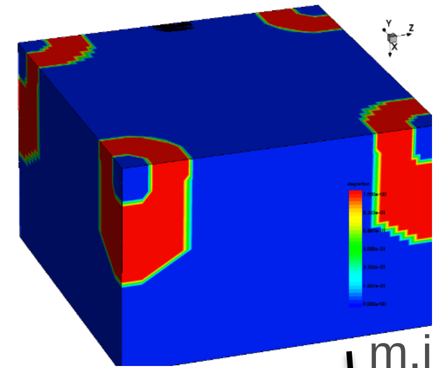


Transient simulation with m.i.p.

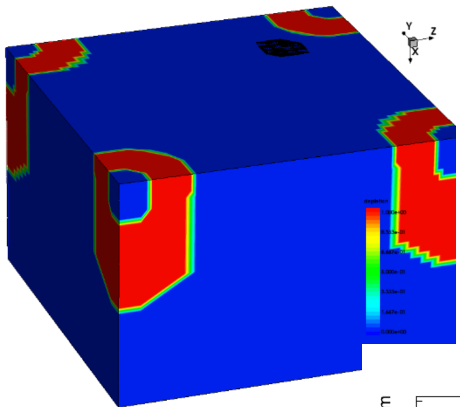
m.i.p.

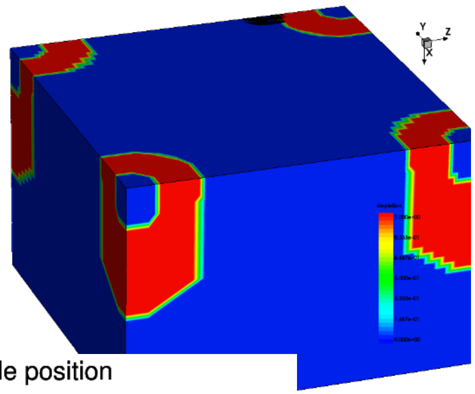


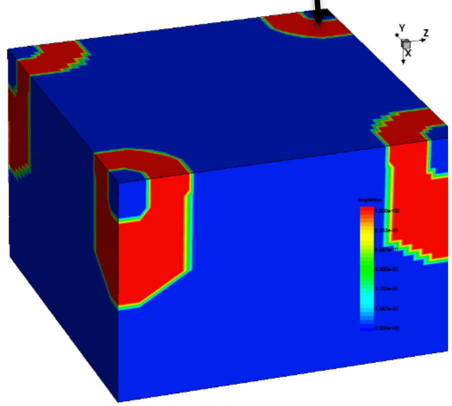


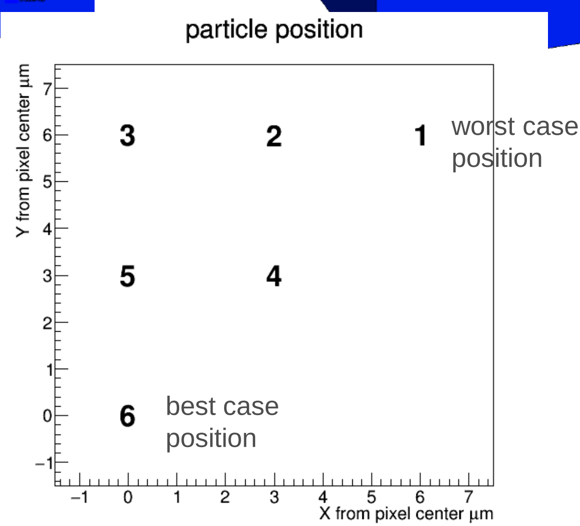


m.i.p.



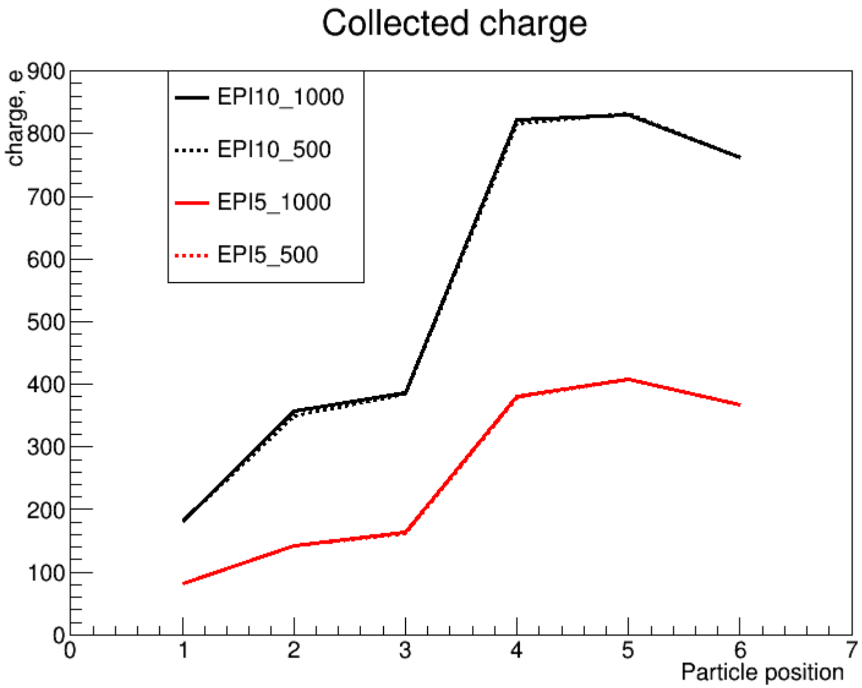


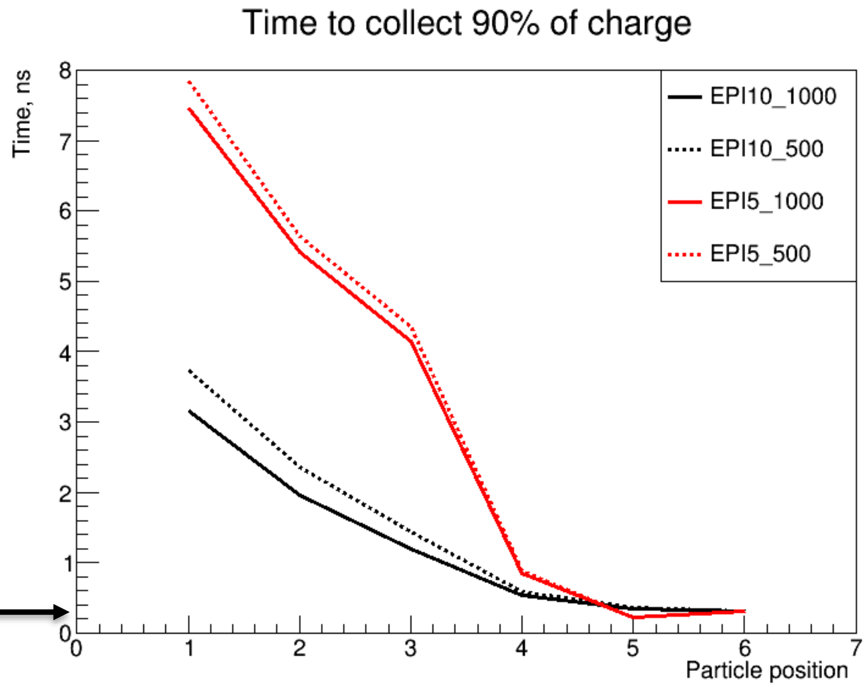




m.i.p. position index

Transient simulation with m.i.p.



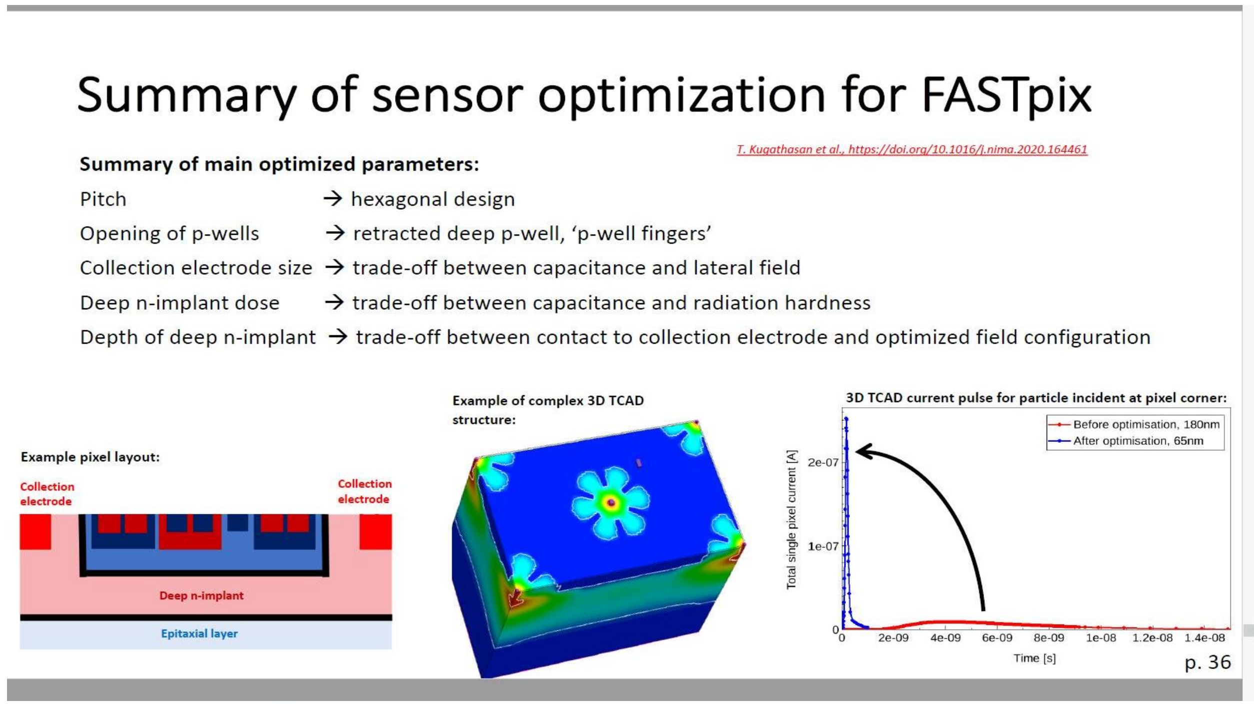


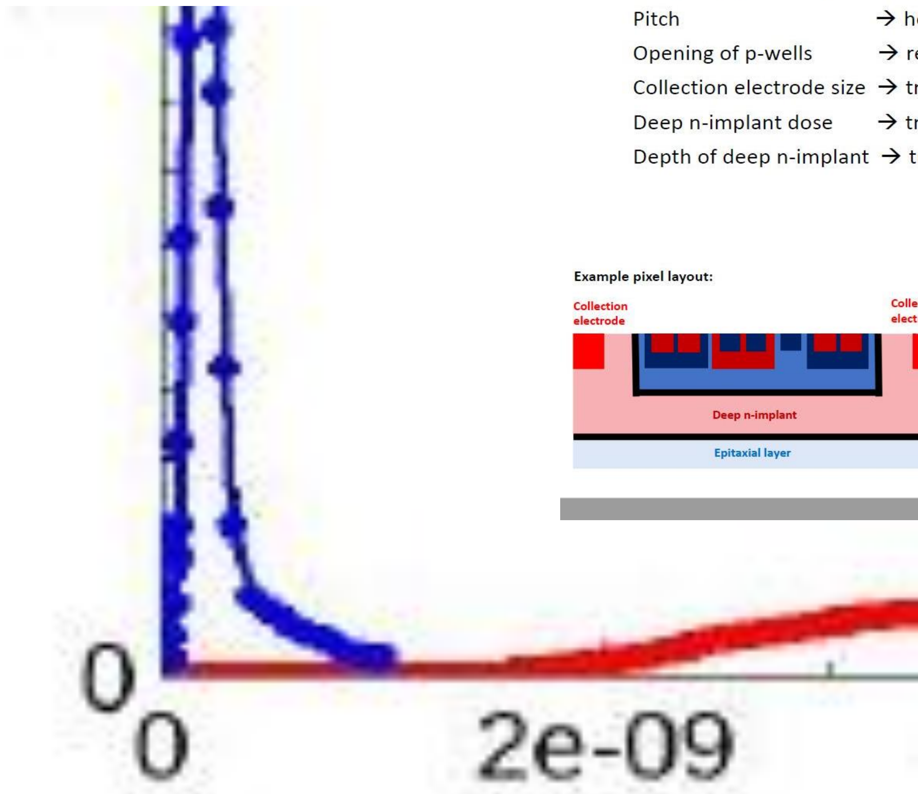
standard substrate

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:



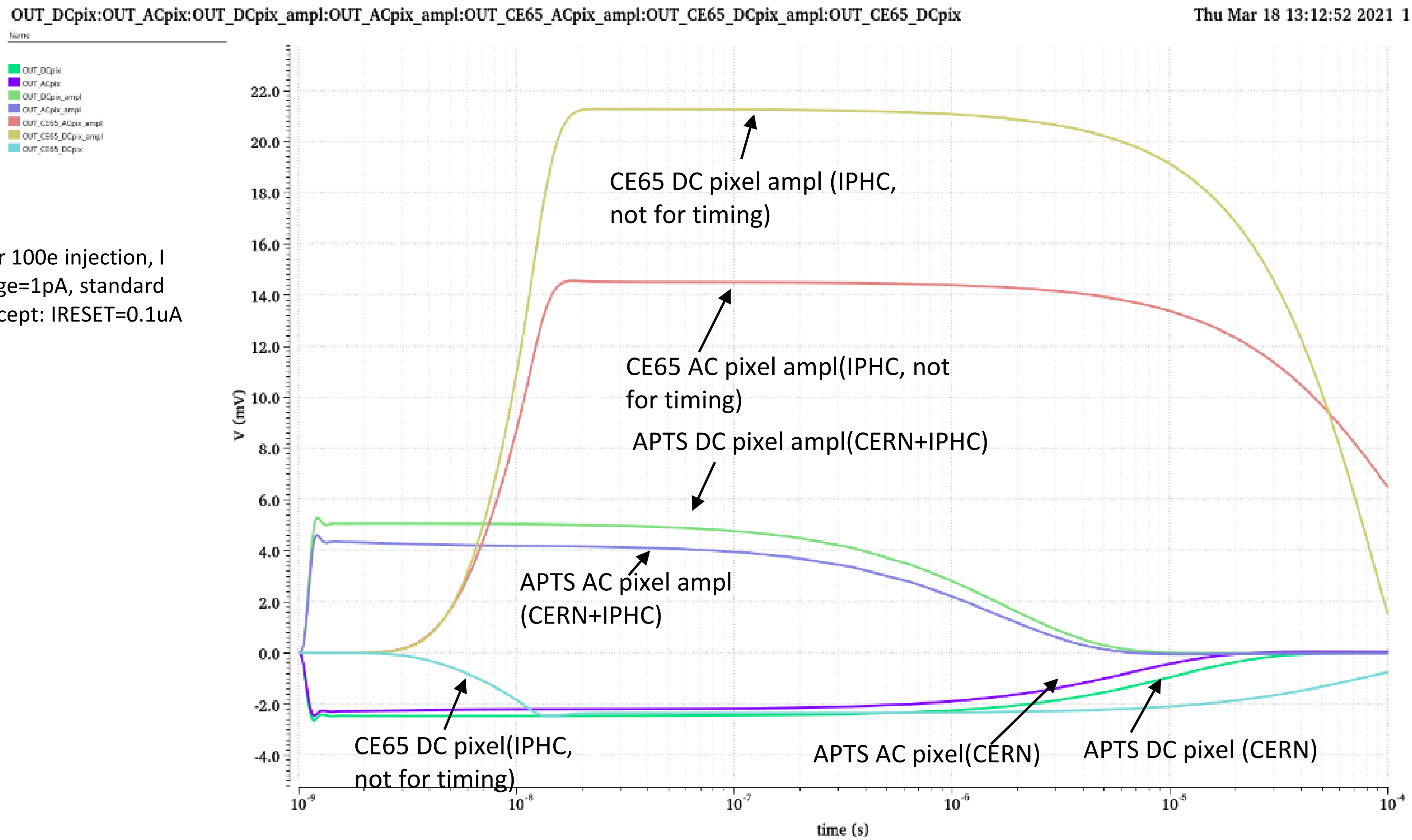


Even at worst case position collection time ~200ps

Simulations with spectre, basic circuits properties

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

Outputs for 100e injection, I 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=((80eh*10um total charge) /(3..4 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..