DISCUSSION

TCAD milestones for the next 5 years:

- **M1: Comparison of commercial TCAD tools; preparation of a recommendation for parameters and physics models. (Q4/2019)**
- **M2: Development of a reliable radiation damage model covering the HL-LHC fluences for protons and neutrons for a given operation temperature. The model shall be able to reproduce I-V, C-V, CCE and the E-field including double junction effects. (Q4/2020)**
- **M3: Model M1 extended to cover temperature dependence of the bulk-damage related effects from room temperature down to -30 °C. (Q3/2021):**
- **M4: Model from M2 extended to cover annealing effects (Q3/2022):**
- **M5: Model of the donor and acceptor removal (SiPMs, LGAD, CMOS,..) (Q3/2020):**
- **M6: Surface damage model with correct modelling of surface damage in p-type segmented sensors. (Q1/2021)**
- **M7: Evaluation of the possibility of the implementation of cluster related defects in the commercial TCAD device simulators by using a charge carrier occupation dependent energy level distribution. (Q2/2021)**

Hamburg Penta Trap Model (HPTM)

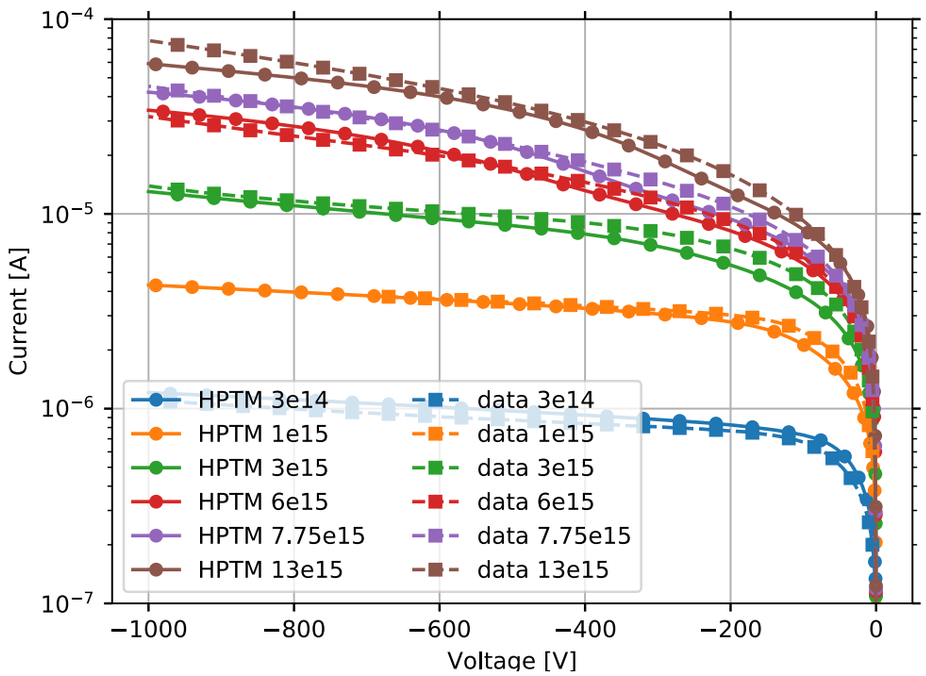
https://indico.cern.ch/event/719814/contributions/3022491/

Defect	Type	Energy	g_{int} [cm^{-1}]	σ_e [cm^2]	σ_h [cm^2]
E30K	Donor	E_C-0.1 eV	0.0497	2.300E-14	2.920E-16
V_3	Acceptor	E_C-0.458 eV	0.6447	2.551E-14	1.511E-13
I_p	Acceptor	E_C-0.545 eV	0.4335	4.478E-15	6.709E-15
H220	Donor	E_V+0.48 eV	0.5978	4.166E-15	1.965E-16
C_iO_i	Donor	E_V+0.36 eV	0.3780	3.230E-17	2.036E-14

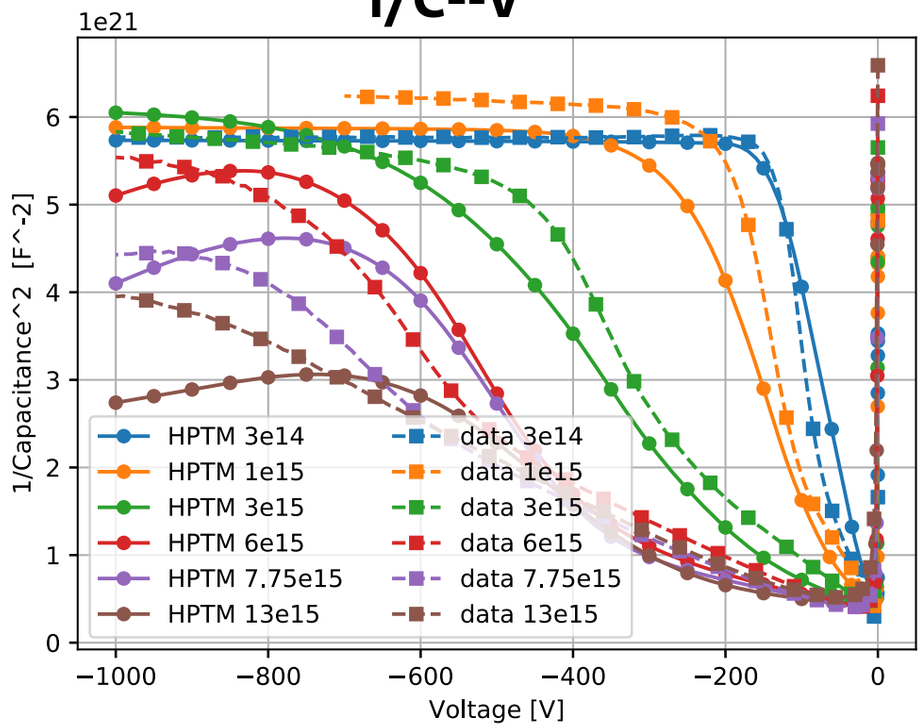
- Trap concentration of defects: $\mathbf{N = g_{int} \cdot \Phi_{neq}}$
- Simulations for the optimization have been performed at **T= -20 °C** with:
  1. Slotboom band gap narrowing
  2. Impact ionisation (van Overstaeten-de Man)
  3. TAT Hurkx with tunnel mass = **0.25 m_e** (default value: 0.5 m_e) in case of the I_p
  4. Relative permittivity of silicon = 11.9 (default value : 11.7)
- Both cross section for the E30K and the electron cross section for the C_iO_i were fixed
  ➔ 12 free parameter
- Optimization done with the nonlinear simplex method

I-V, C-V, CCE-v 0.3 - 13•10^{15} n_{eq}/cm^2 at T= -20 °C

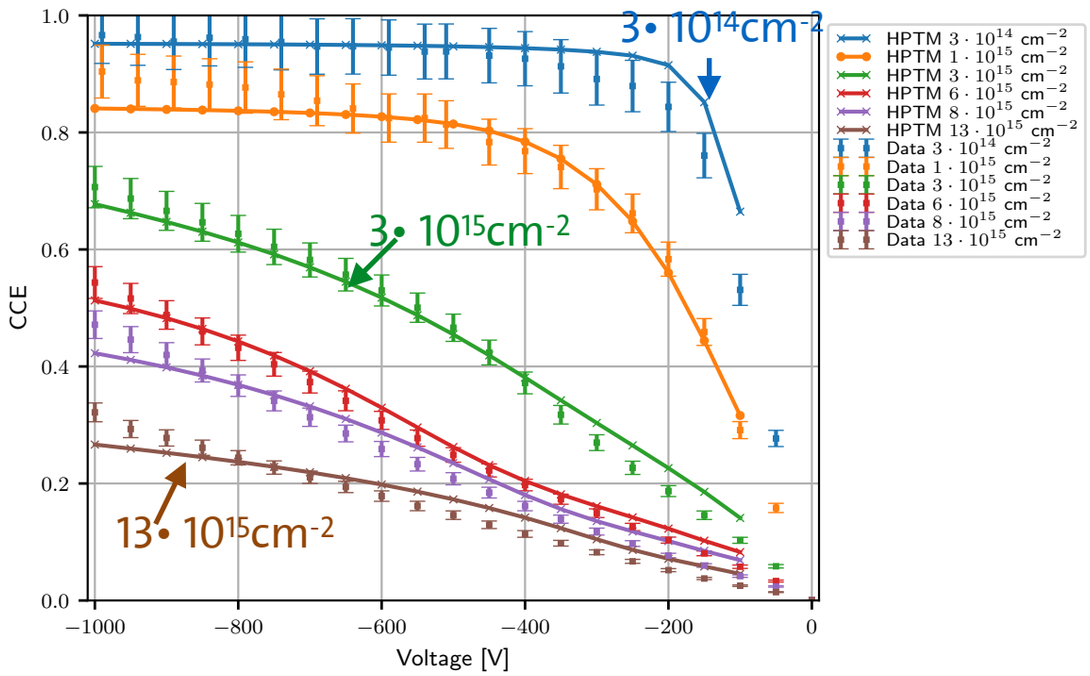
I-V



1/C^2-V



CCE-V



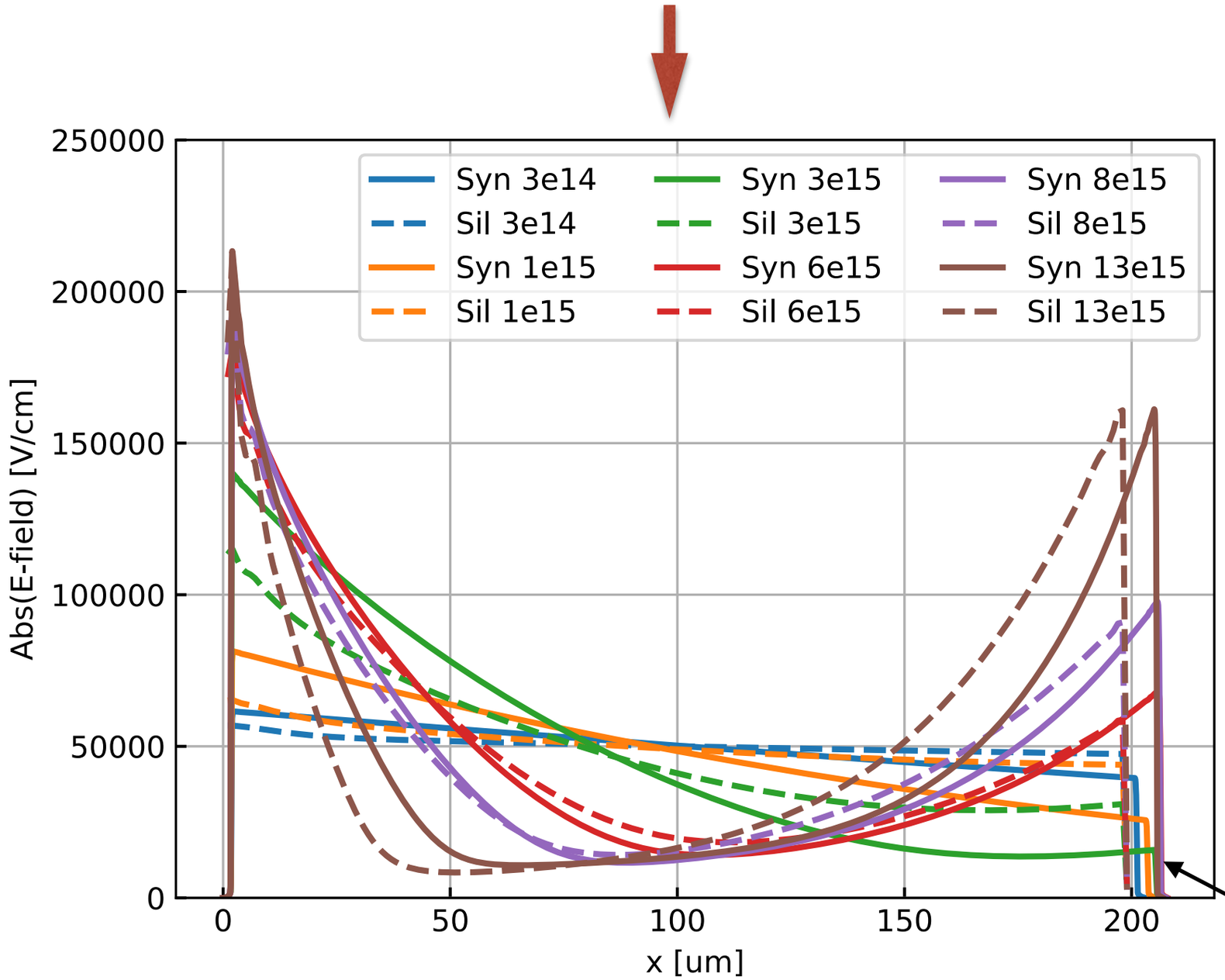
- The simulation for 0.3 and 1•10^{15} n_{eq}/cm^2 are extrapolations and the 7.75•10^{15} n_{eq}/cm^2 is a interpolation (not included in the optimization)
- The simulations of I-V/C-V agrees with the measurements within 20% for all fluences and voltages
- The simulations of CCE-V agrees with the measurements within 20% for all fluences and high voltages

M1: SYNOPSYS/SILVACO TCAD

HPTM E-field as function of position for different fluences at 1000V

- Synopsys and Silvaco TCAD use different parameterisations for band gap, N_C, N_V, thermal velocities etc. as function of temperature

➡ Adjust Silvaco parameter to match Synopsys values in certain T range (253 K to 293 K)



Syn = Synospys TCAD
Sil = Silvaco TCAD

Adjusted Silvaco parameter:
EG300 = 1.12415
NC300 = 2.825E19
NV300 = 3E19
MVTHN = 0.32713
MVTHP = 0.55865

Silvaco simulations by Marco B.

Different thicknesses used