Silicon Strip Sensor Simulations

MSSD capacities

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Silicon Strip Sensor Simulations
Phase II Meeting, 20.7.2012

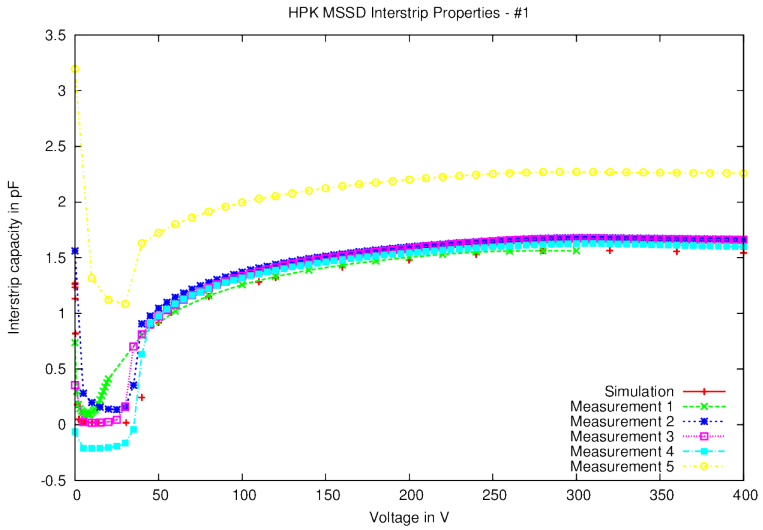
HELMHOLTZ | ASSOCIATION

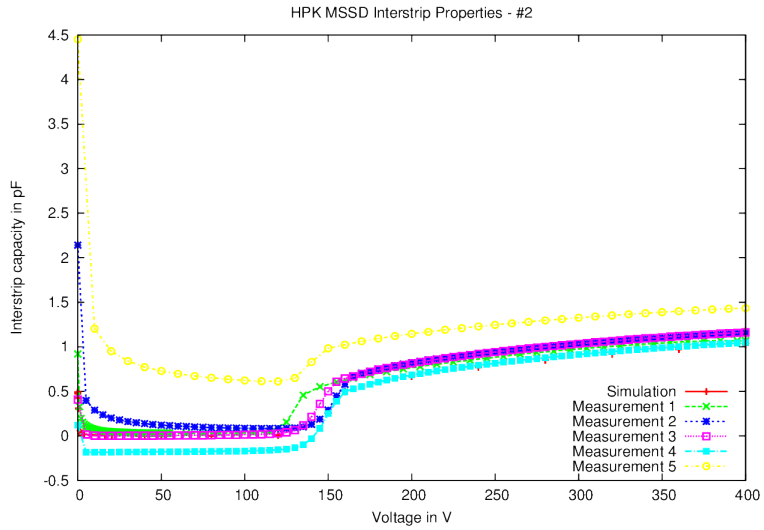
DESY

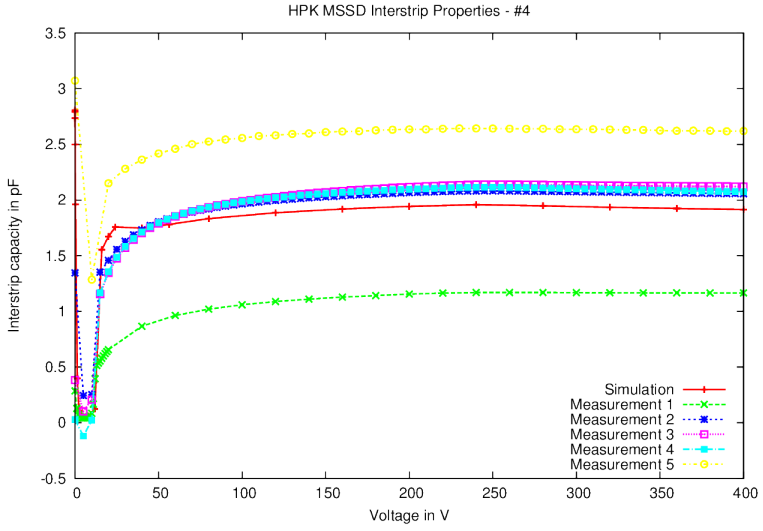
Status

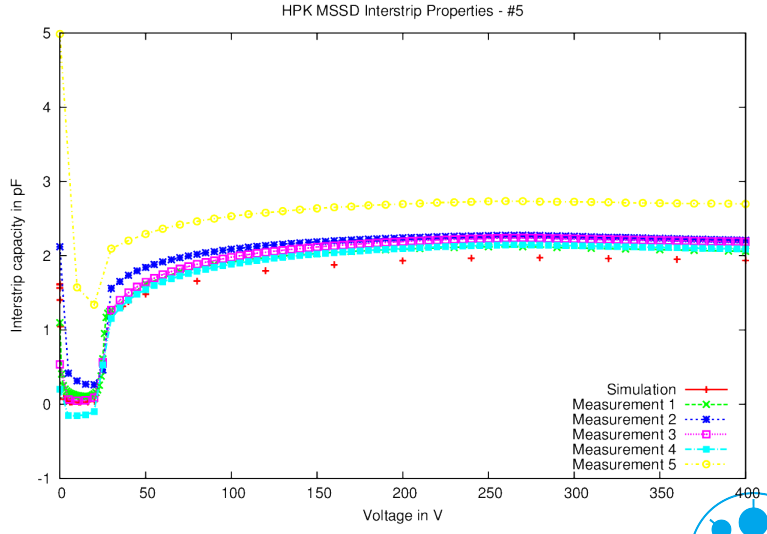
- Simulated inter-stip capacities (C_{int}) should now correspond to measurements
- Data taken from LyonDB (CERN, FermiLab, Firenze, KIT)
  - Other parameters (C_{back}, C_{tot}, I_{leak}, V_{dep}, etc.) not always recorded
- Comparison with first sensor (FZ320N) shows agreement within < 10%
  - Could be further corrected by adjusting material (Si, SiO_2, etc.) parameters
- Other sizes (FZ200, FZ120) and P/Y-types have been simulated, will be compared
  - Only manual data selection from database :-(
- Simulation results for one region (FZ320N #03) available from Uni Delhi, waiting for more
  - Agreement between both simulation programs (Synopsys & Silvaco) !

Results – FZ320N #1, #2, #4, #5

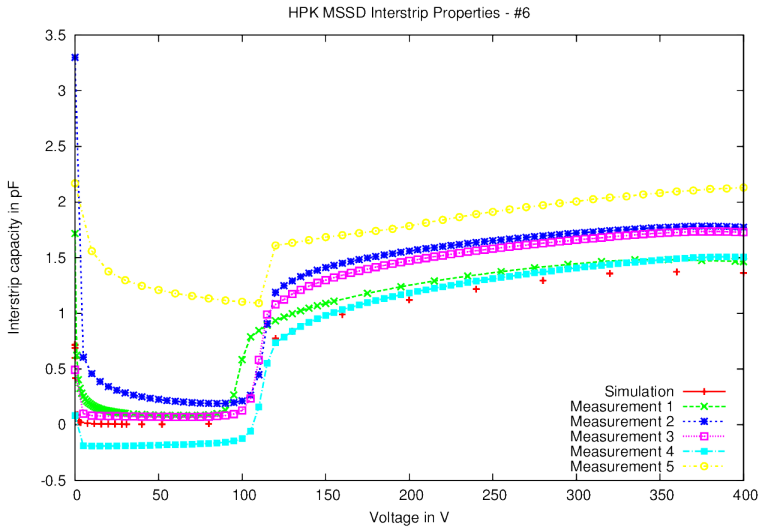


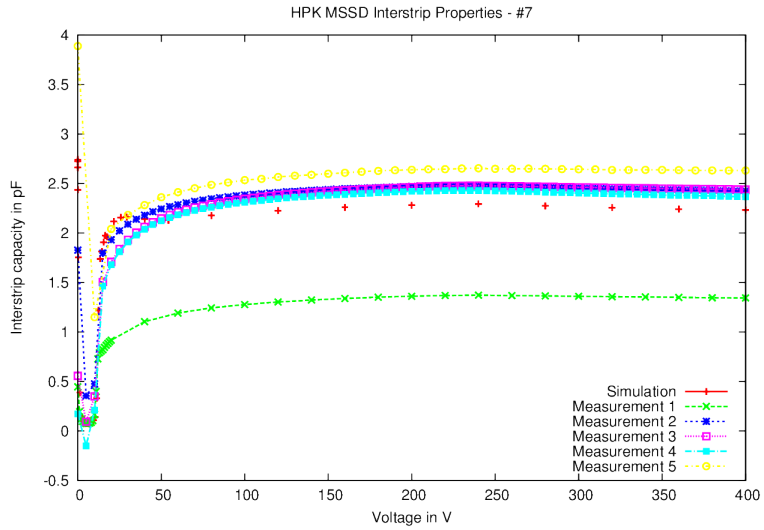


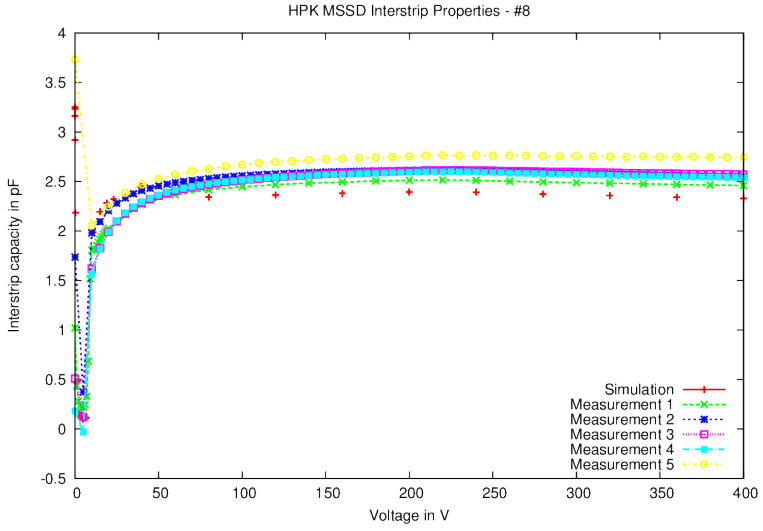


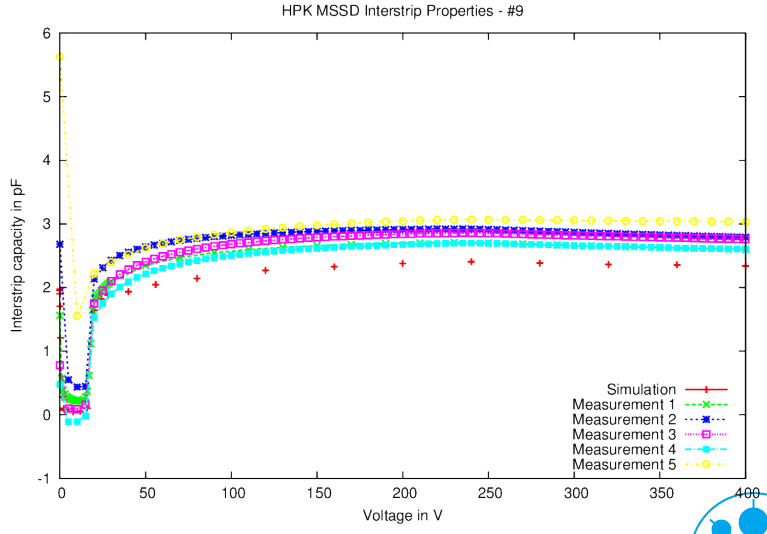


Results – FZ320N #6, #7, #8, #9

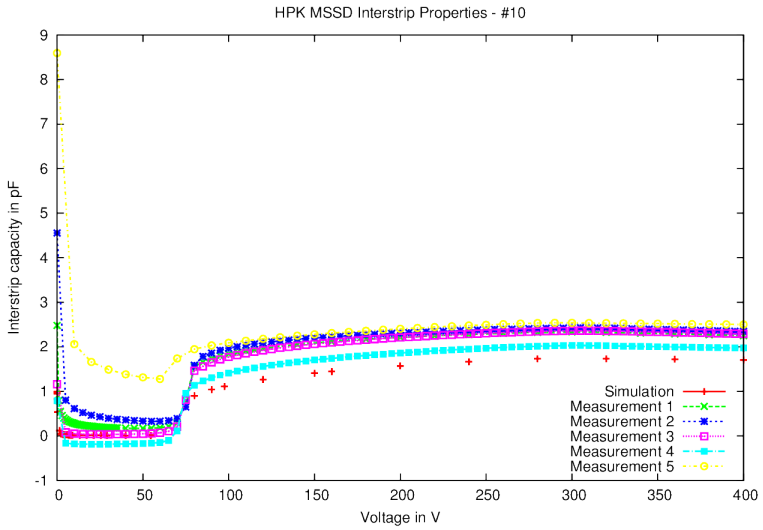


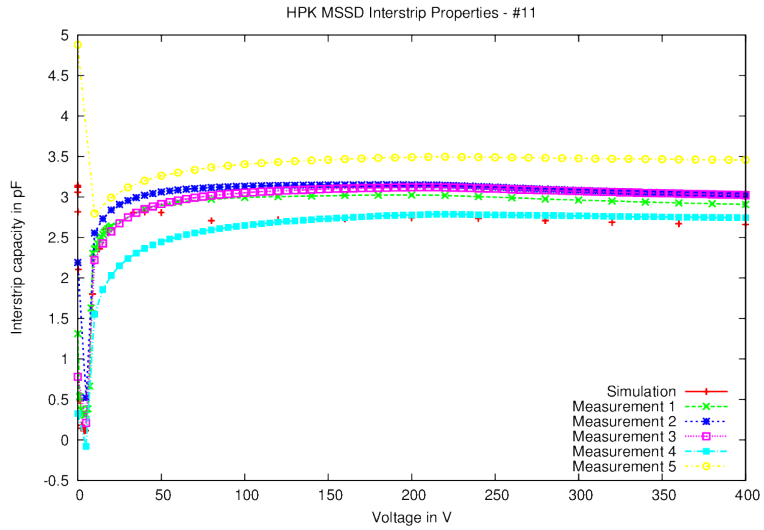


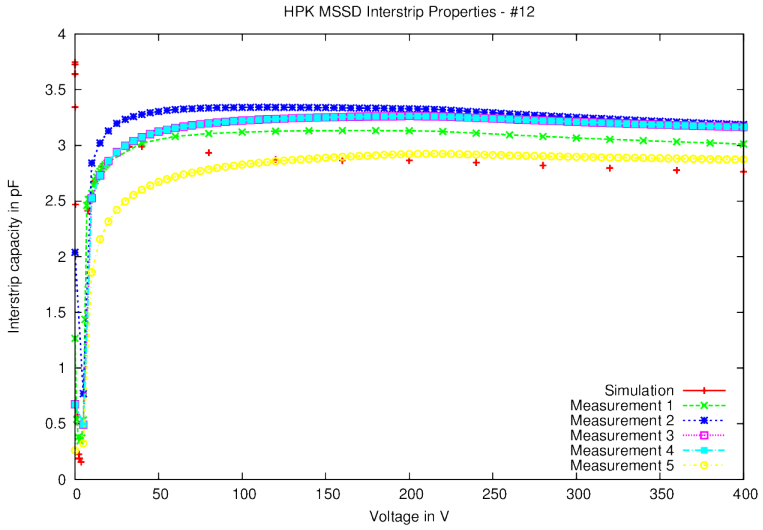




Results – FZ320N #10, #11, #12

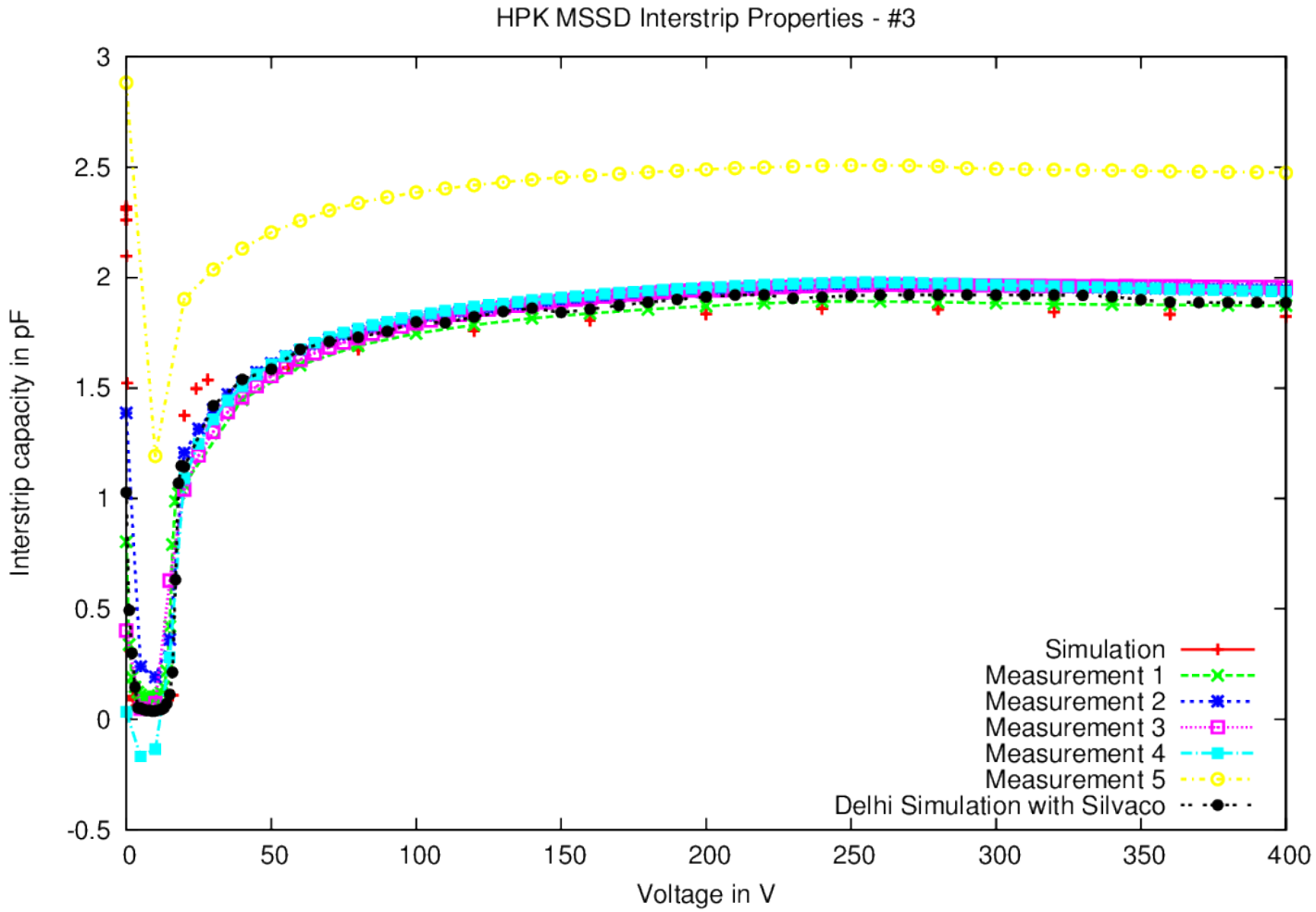






- Quality of results differs between regions
- Curve “shape” is reproduced
- Simulated C_{int} usually lower
- Large improvement achieved

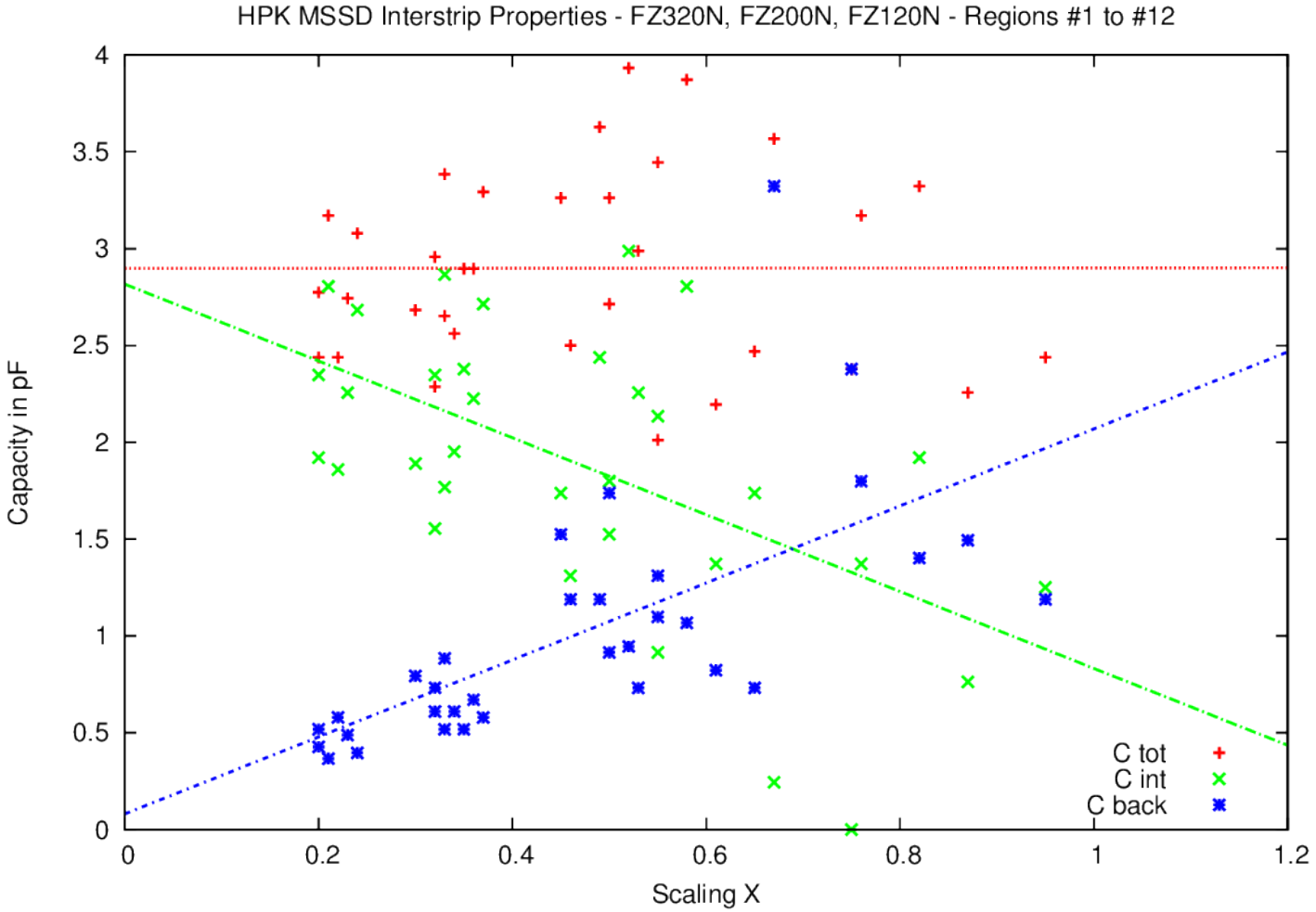
Results FZ320N #3



- Synopsys and Silvaco give the same results, in agreement with data!

DESY

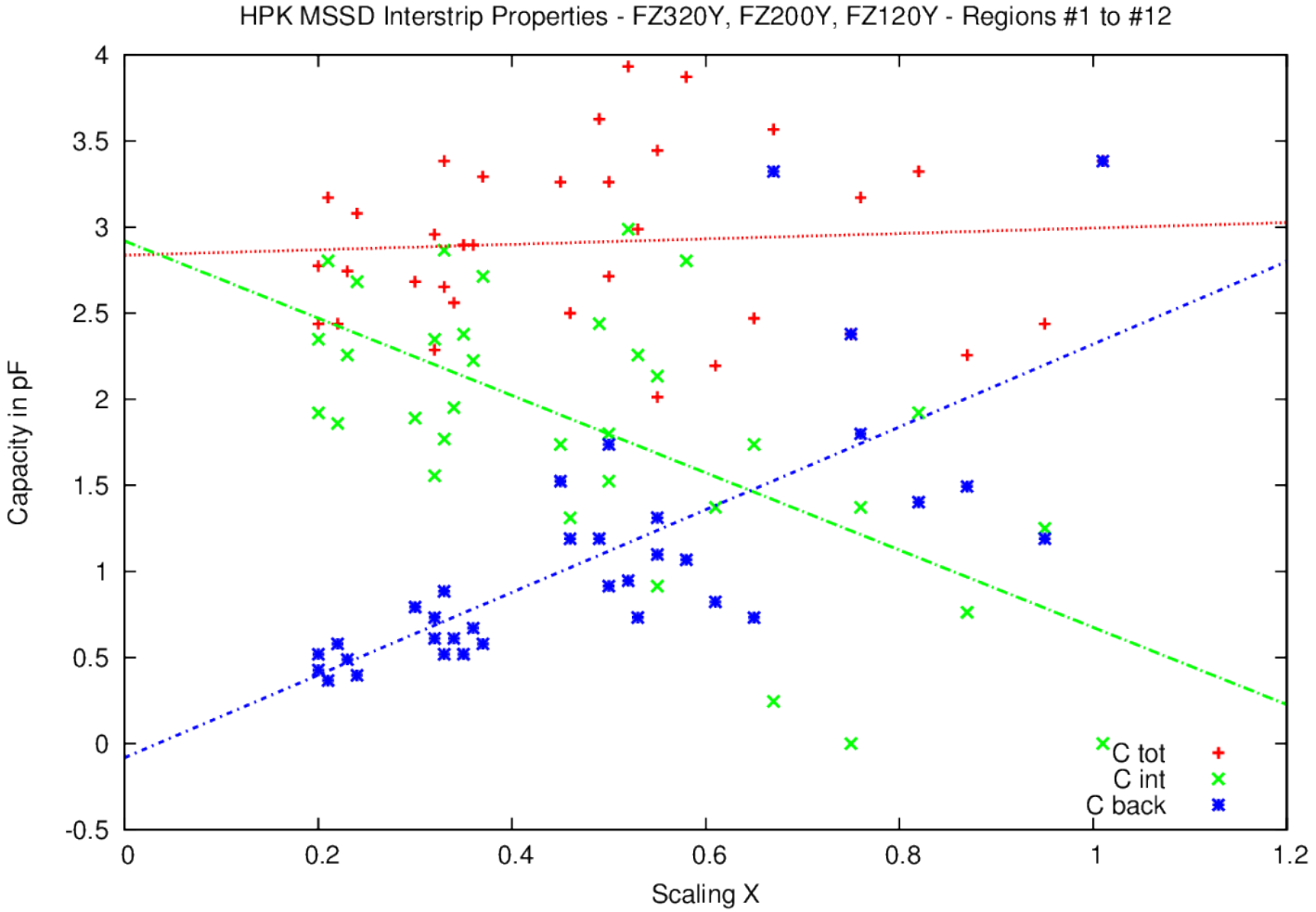
Summary of n-type capacities



- $C_{tot} = C_{int} + C_{back}$
- Now constant over all sensor sizes and regions

DESY

Summary of p-spray capacities

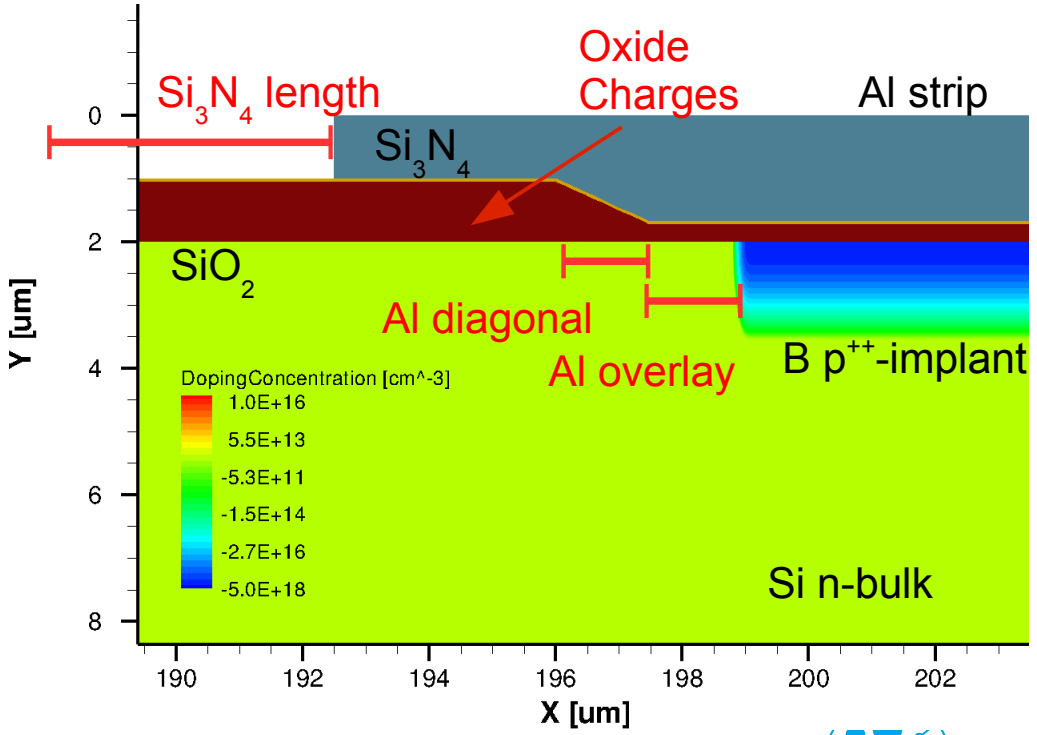


- Y-type may need improvement – curve comparison with data will show
- Additional parameters: isolationdose, -thickness, -length, etc.

DESY

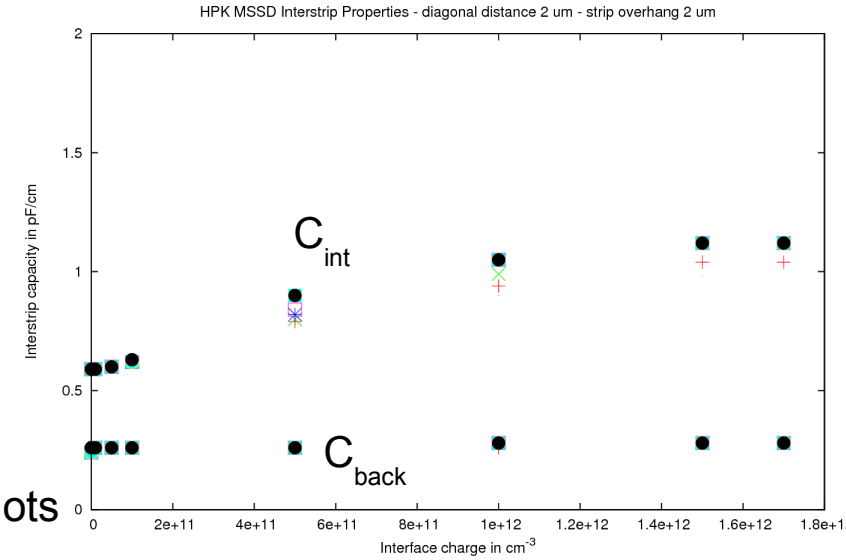
Simulation details – parameter settings

- Unchanged: all specified sensor geometries, measurement protocols:
  - Strip width & pitch, sensor thickness, temperature (21°C), AC frequency (1MHz)
- Fixed by previous simulations:
  - Doping concentration (bulk: 3e12cm^{-3}, back/strips: 5e18cm^{-3}), doping profile (strip: gaussian, back: erf)
- Fixed by measurements:
  - Al, SiO_2, Si_3N_4 and implant thicknesses (1µm, 0.68µm, 0.05µm & 1,5µm resp.)
- Adjusted to obtain capacities:
  - Al diagonal & overlay, Si_3N_4 length, SiO_2 charge, SiO_2/Si interface charge, Si_3N_4 charge, Si_3N_4/SiO_2 interface charge



Parameter influence on C_{int}

- Si_3N_4 length (0µm - pitch), Si_3N_4 charge (0 – 1.7e12cm^{-3}), Si_3N_4/SiO_2 interface charge (0 – 1.5e12cm^{-3}):
  - No influence (<1%) seen, could be relevant for P/Y-isolation
  - Simulation does not converge for higher charges
- Al diagonal, Al overlay (0µm – (width-implant)/2):
  - Raises C_{int} up to 10%, “optimal” value depends on strip and implant width, ~ 2µm
- SiO_2 charge (0 – 1.2e12cm^{-3}):
  - Small influence on C_{int}, increases simulation time
- SiO_2/Si interface charge (0 – 1.7e12cm^{-3})
  - Can double C_{int}! 1e11cm^{-3} used for previous plots



Next steps

- Obtain measurement and Delhi simulation data for further comparison
  - p-spray / p-stop might need adjustment
- Recheck / compare other sensor properties:
  - Depletion voltage V_{dep}, leakage current I_{leak}, etc.
- Some quantities still not simulated correctly
  - E.g. interstrip resistance R_{int} still ~10GΩ, values of ~100GΩ expected
- SWB program: device construction, meshing, simulation, curve generation and value extraction work automatically for all possible strip sensor configurations
  - Extraction of all curve data points into ROOT needed
  - Future (esp. with radiation damage): V_{dep} from CV-curve, not from bulk doping
- Impement radiation damage!

Backup

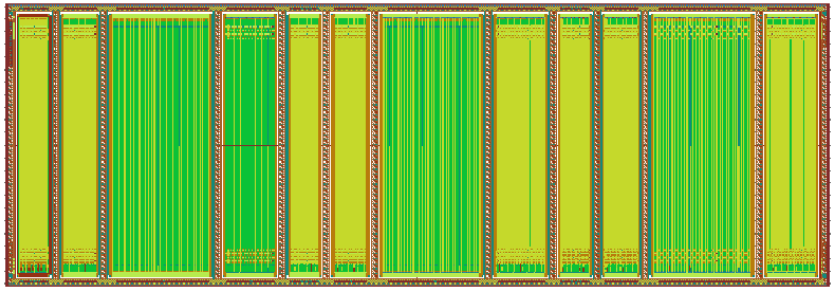
MSSD properties

- 12 strip sensor regions with different pitch and width → interstip capacitance C_{int} should vary
- Scaling factor X for comparison:

$$X = p / [d + p*f(w/p)] \quad \text{with}$$

$$f(w/p) = -0{,}00111(w/p)^{-2} + 0{,}0586(w/p)^{-1} + 0{,}24 - 0{,}651(w/p) + 0{,}355(w/p)^2$$

- Measurements: total sensor capacity $C_{tot} = C_{int} + C_{back}$ is constant for all X → try to reproduce in simulations



Sensor	Pitch [µm]	Implant width [µm]	Alu width [µm]	w/p	X
1	120	16	29	0,133	0,31
2	240	34	47	0,142	0,54
3	80	10	23	0,125	0,22
4	70	8,5	21,5	0,121	0,19
5	120	28	41	0,233	0,33
6	240	58	71	0,242	0,6
7	80	18	31	0,225	0,23
8	70	15,5	28,5	0,221	0,2
9	120	40	53	0,333	0,35
10	240	82	95	0,342	0,64
11	80	26	39	0,325	0,24
12	70	22,5	35,5	0,321	0,21