Radiation Damage in Simulations / MSSD capacities

The Eremin Trap Model

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Phase II Meeting, 28.09.2012

EVL-1 (Eremin-Verbitskaya-Li)

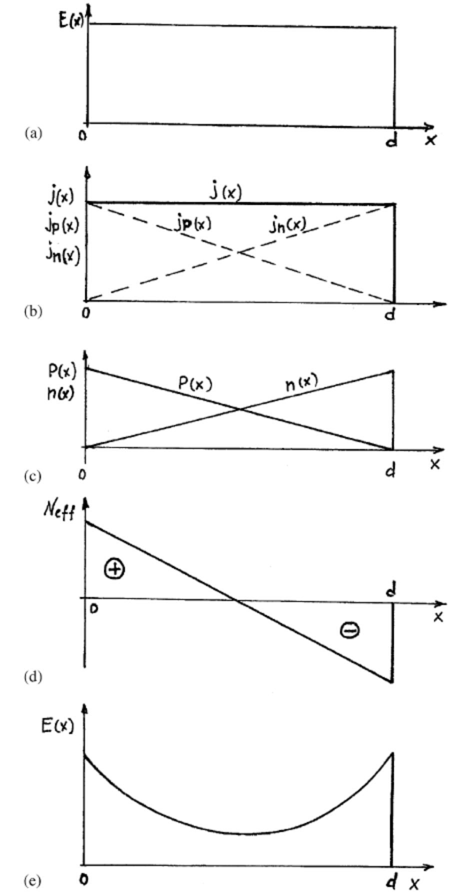
- Eremin's idea: Model the electric field 'observed' in irradiated sensors into only two traps and one trap level

- Two traps for current and space charge:
  - Donor: $E_v + 0.48$ eV, $\sigma_e = \sigma_h$ = 1e-15 cm^{-2}, g = 1 cm^{-1}
  - Acceptor: $E_c - 0.525$ eV, $\sigma_e = \sigma_h$ = 1e-15 cm^{-2}, g = 1 cm^{-1}

$Conc_{Trap} = g * \Phi$

- One level ***only generating current***:
  - E_j = 0.65 eV σ_t = 1e-13 cm^{-2}, Conc = 4e14 cm^{-3}
  - Not includable in either simulation package

- Without current level:
  - Silvaco and Synopsys can't reproduce Eremin data for N_{eff}, I, E, p/n conc.

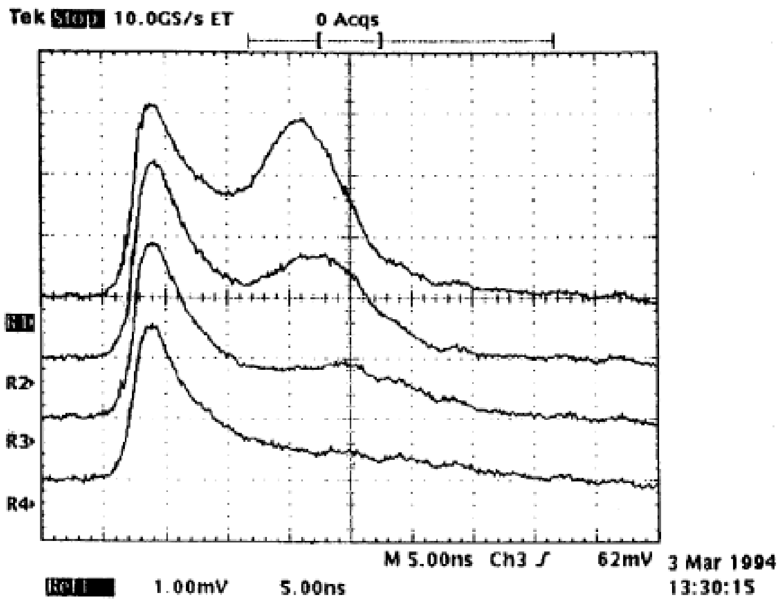


EVL-4

- Tuning of original EVL-1 parameters to include current level
  - $\sigma_e = \sigma_h = 4e\text{-}14\ cm^{-2}$, $g = 0.8\ cm^{-1}$

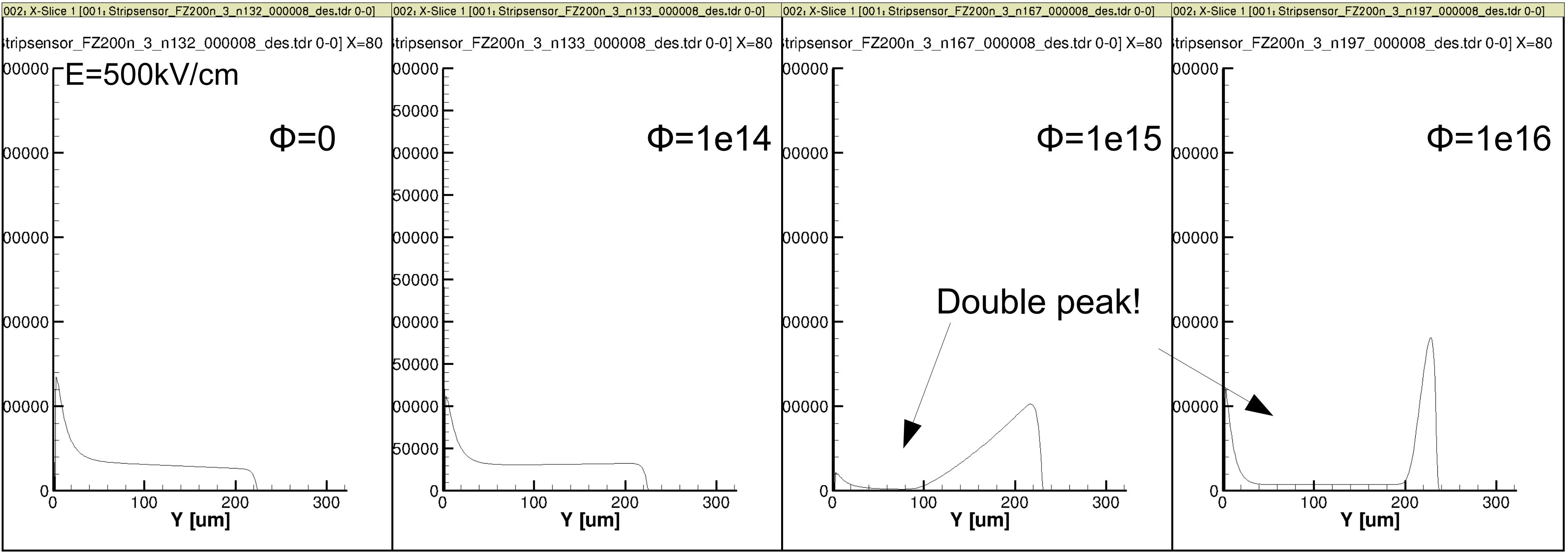
- Other groups can roughly reproduce Eremin data
  - N_{eff}, E, I(?), n conc. fit Eremin data, p conc. ~20% too high (reduced by decreasing hole life time)

- But:
  - Will this model work for HPK sensors?
  - Does Eremin data correspond to any measurements? → Paper only references his own TCT-measurements from 1992-1994
  - Only valid for n-type sensors with neutron irradiation?



First implementation test

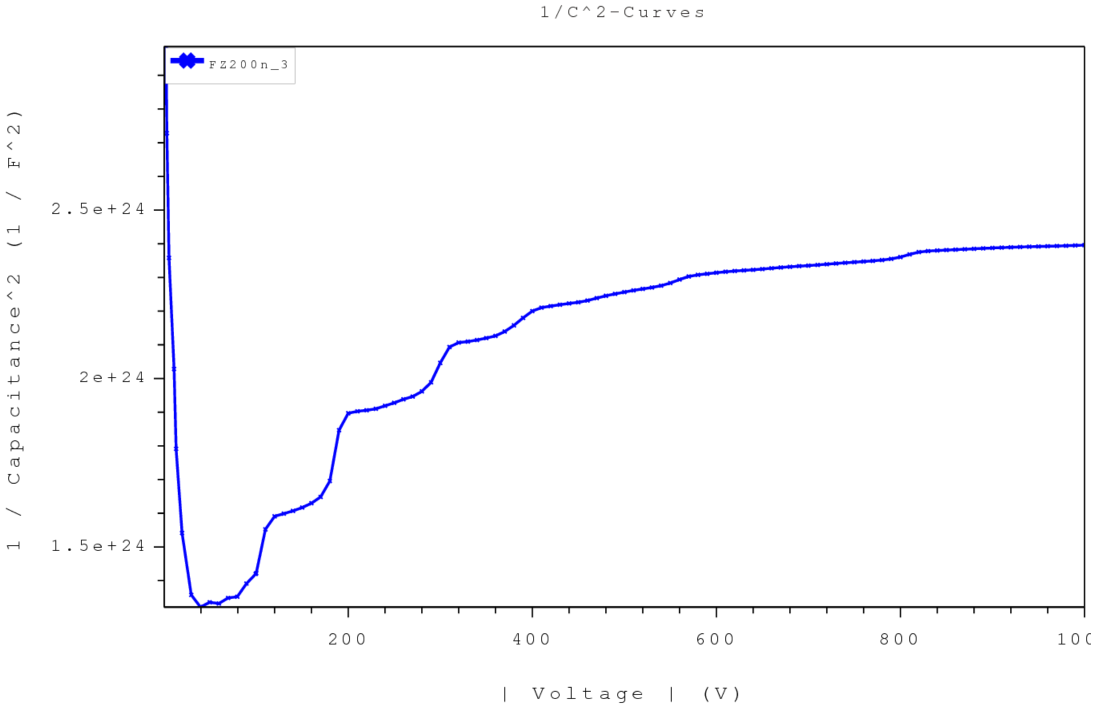
- FZ200N #3, 290K @800V – electric field



- Double peak in electric field visible
- Current too high? ~ 2e-9A @ Φ=1e15

First implementation test

- Electric field extraction now included
- CV/C_{int} curves with strange shapes → V_{dep} extraction not always correct
- Simulations running to see if simple radiation effects (e.g. type inversion) can be reproduced
- Run time increases to ~1h / ramp / parameter set



Unirradiated sensors

- Simulated inter-stip capacities (C_{int}) now correspond to measurements for all FZ-N and FZ-Y thicknesses and regions

- Previous p-spray isolation issues solved, minimal isolation to prevent shorts:

  p-spray concentration: 1e16 cm^{-3}

  p-spray thickness: 1µm

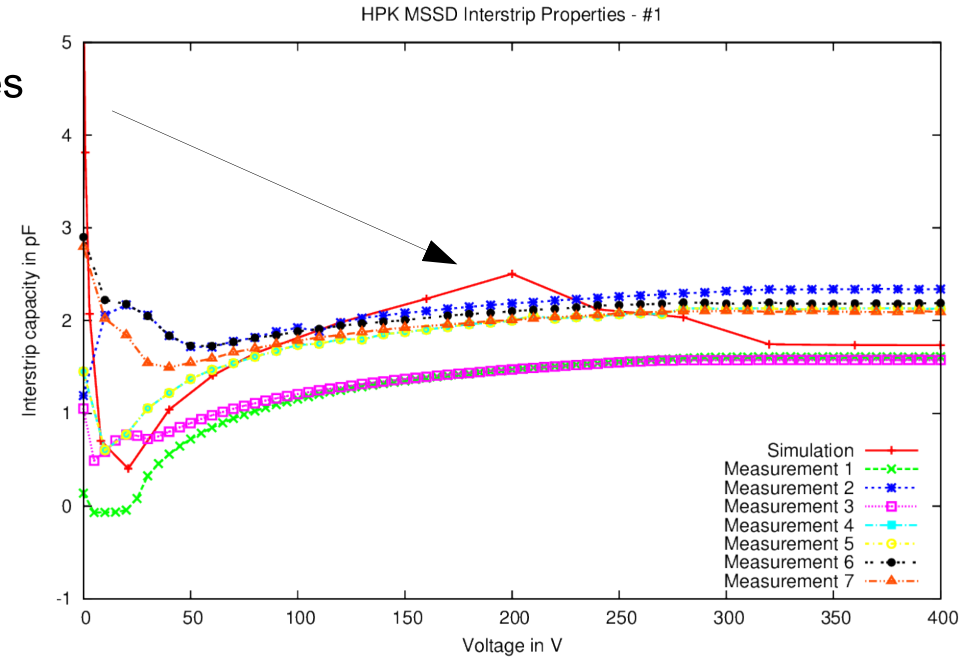
- p-stop isolation still not working correctly

- Experimental measurement procedure of other sensor capacities (C_{back}, C_{tot}) clarified and implemented:
  - C_{int}: Capacity between AC-contact of a strip and its left ***and*** right neighbour
  - CV: Capacity of all DC-contacts to backplane vs. voltage
  - C_{back}: Capacity of all DC-contacts to backplane / stripcount
  - Not much data in database to compare against :-(

p-stop isolation

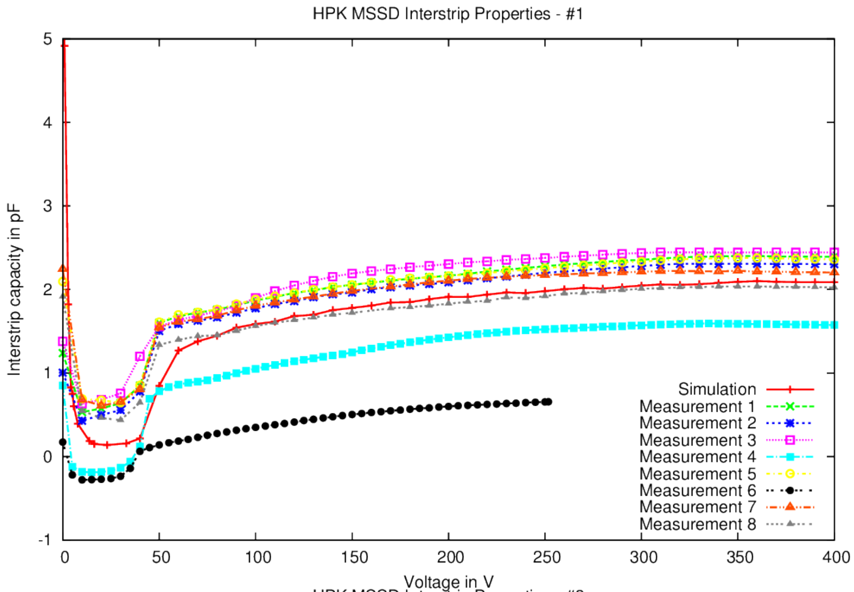
- Problem: insufficient strip isolation for concentrations < 5e16 cm^{-3} and p-stop thicknesses < 2 µm

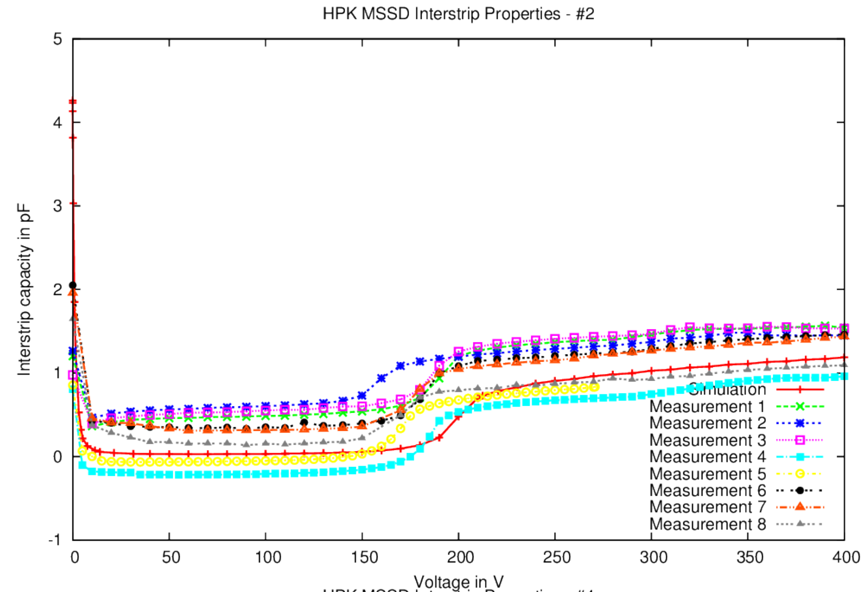
- Can be „detected“ via a bump in C_{int}-curves
  - FZ320P region 1:
  - Same for other regions, cause is e-field and current flowing between strips → incorrect isolation!
  - „final“ C_{int} above ca. 350V corresponds to measurements again

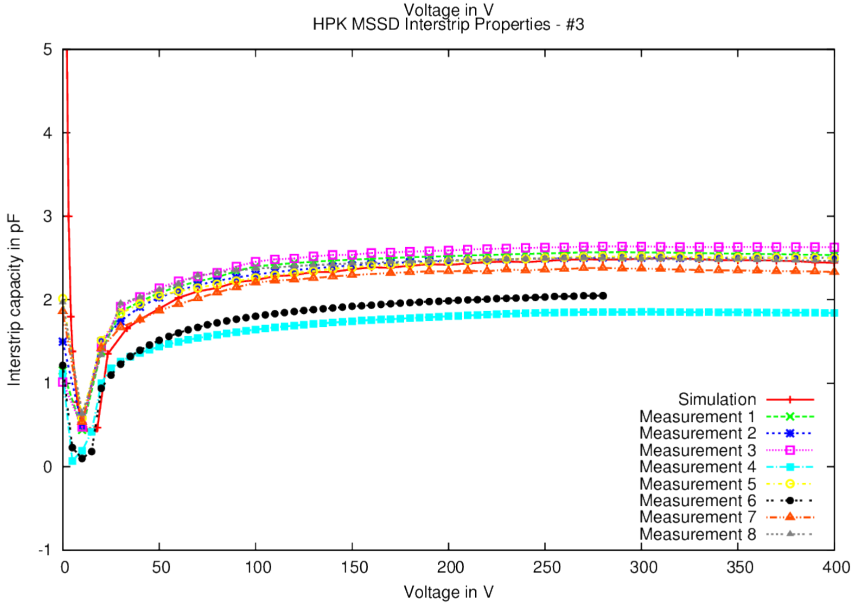


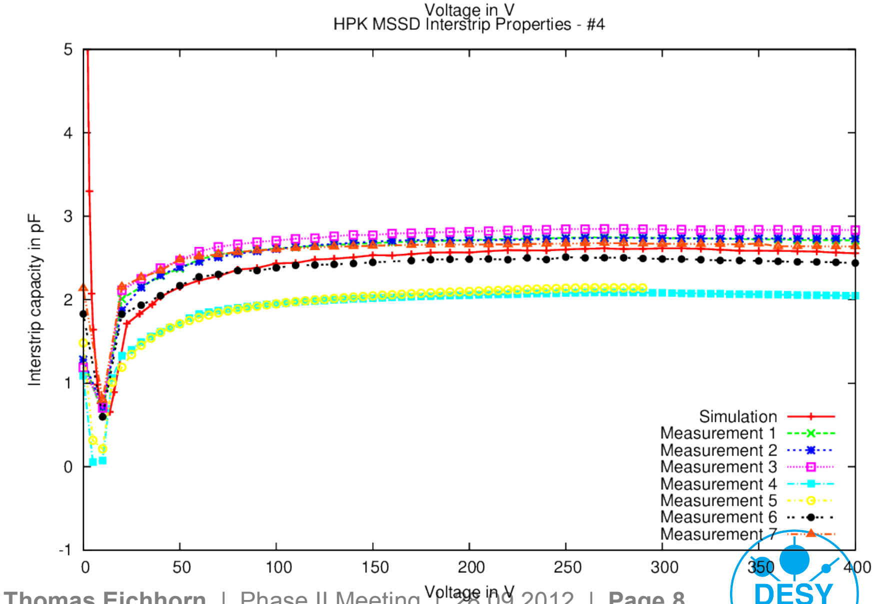
- p-stop position is correct. Isolation thickness and concentration unknown. Other groups have not simulated p-stop capacities yet.

Results – C_{int} for FZ320Y regions #1 to #4

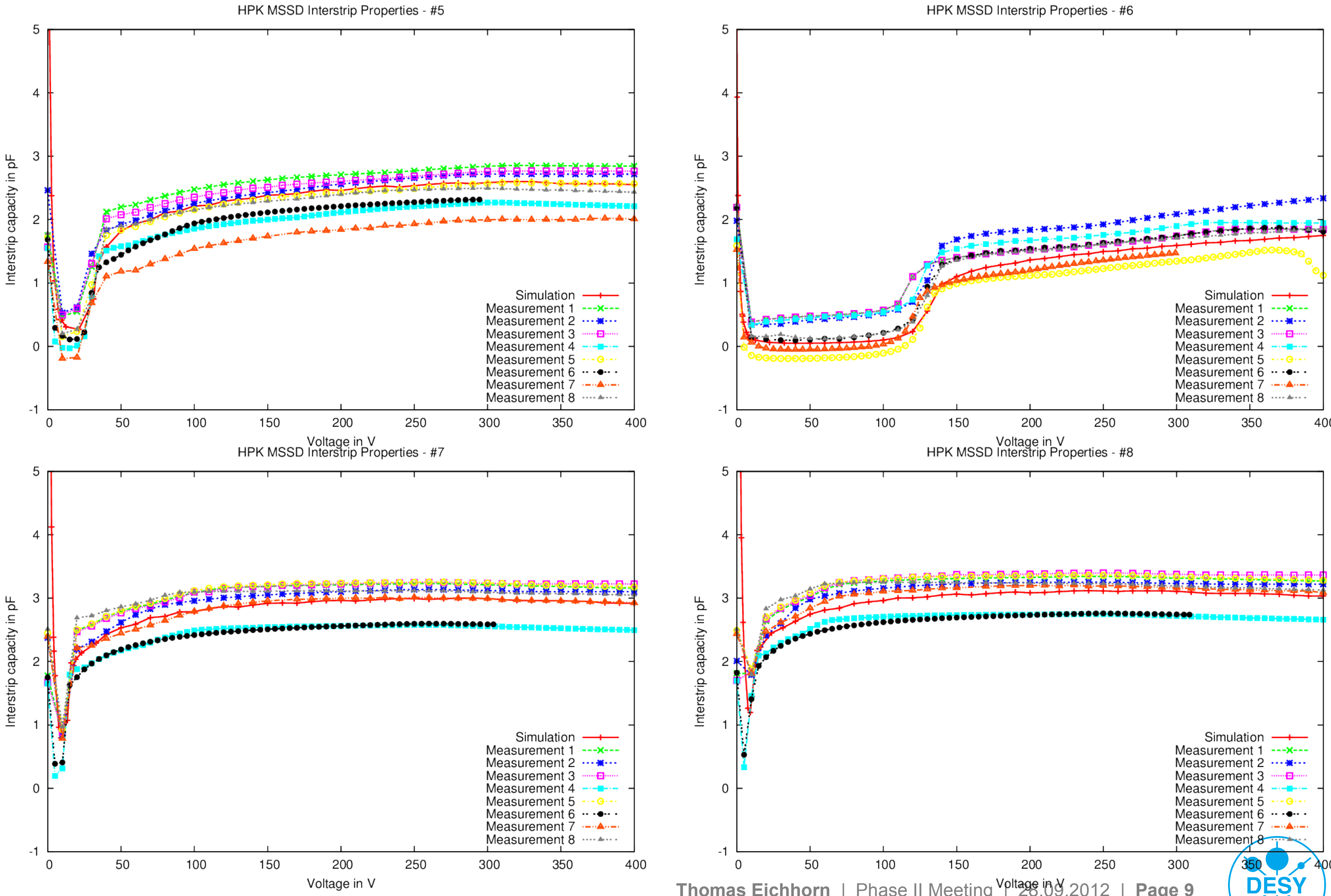




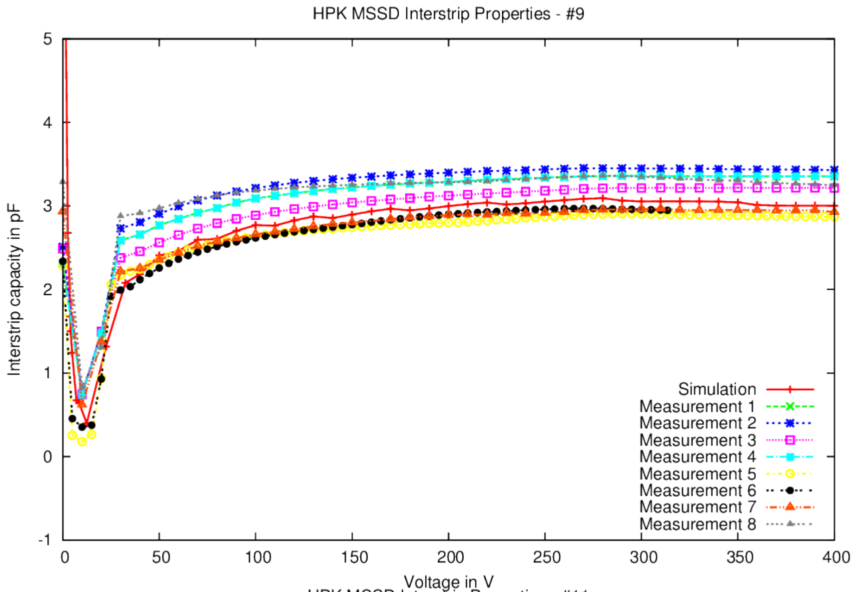


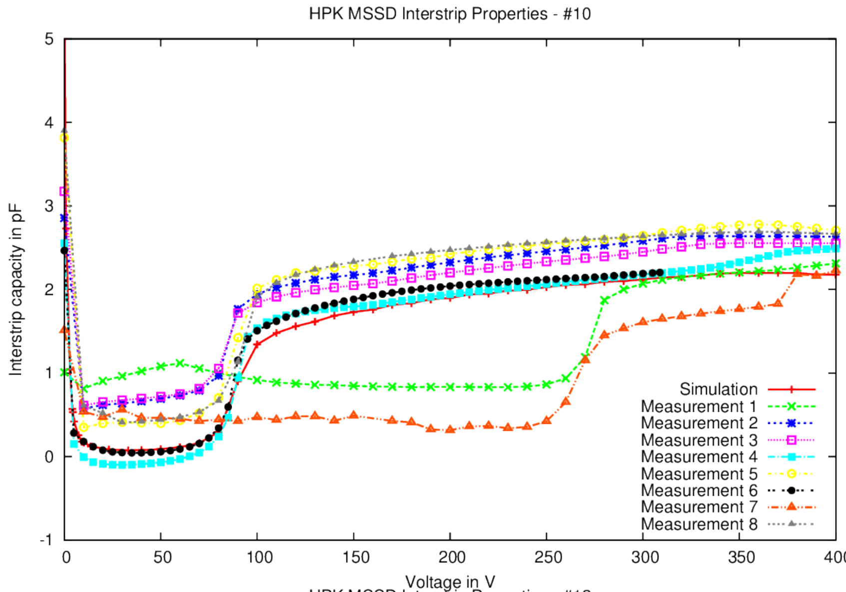


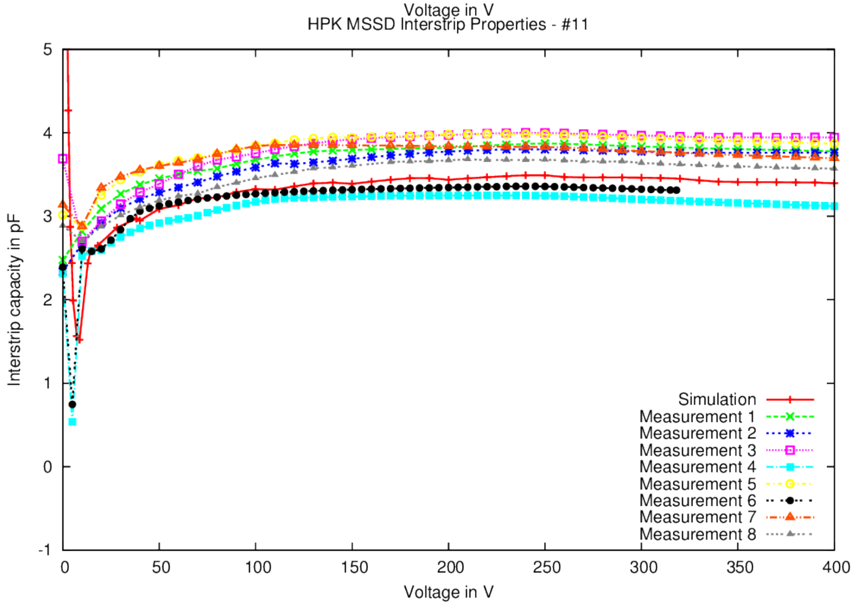
Results – C_{int} for FZ320Y regions #5 to #8

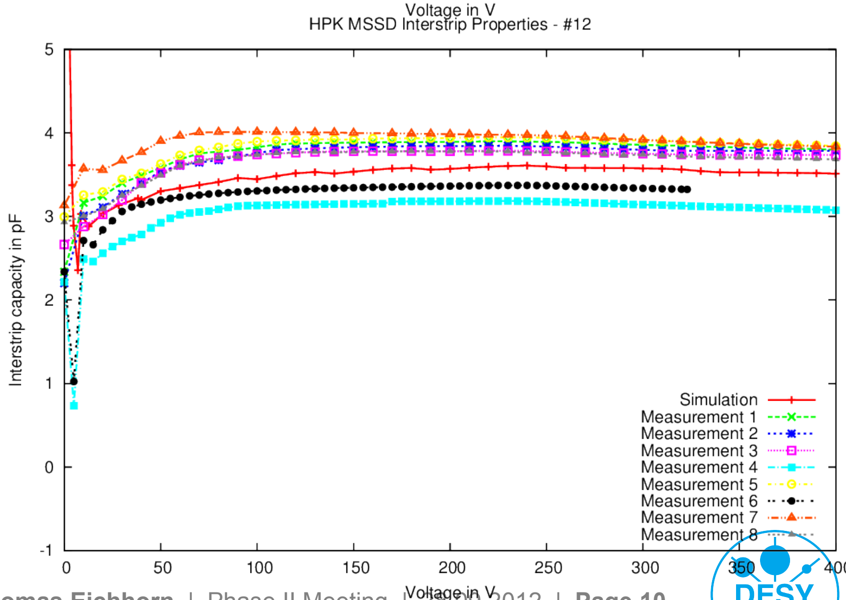


Results – C_{int} for FZ320Y regions #9 to #12

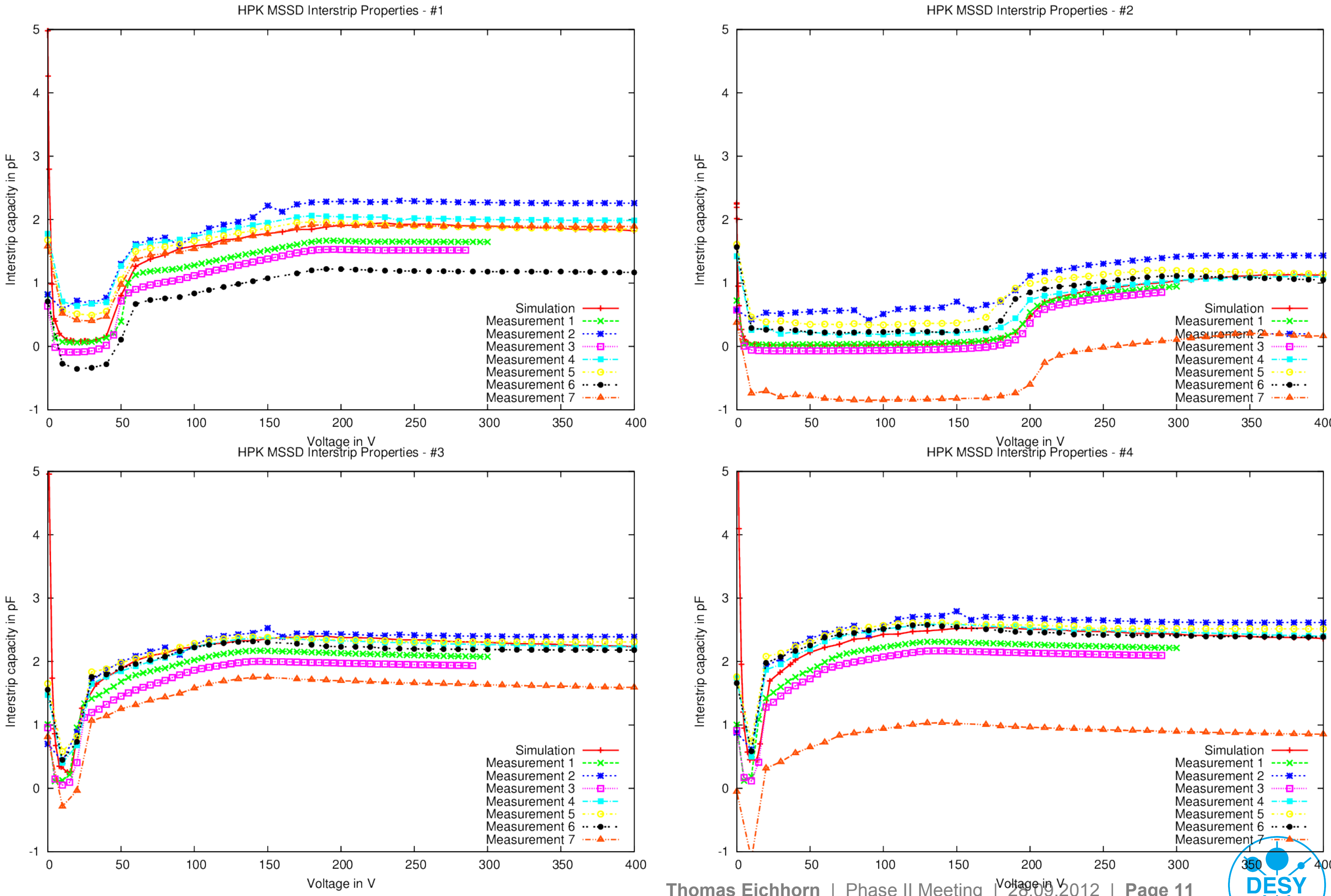




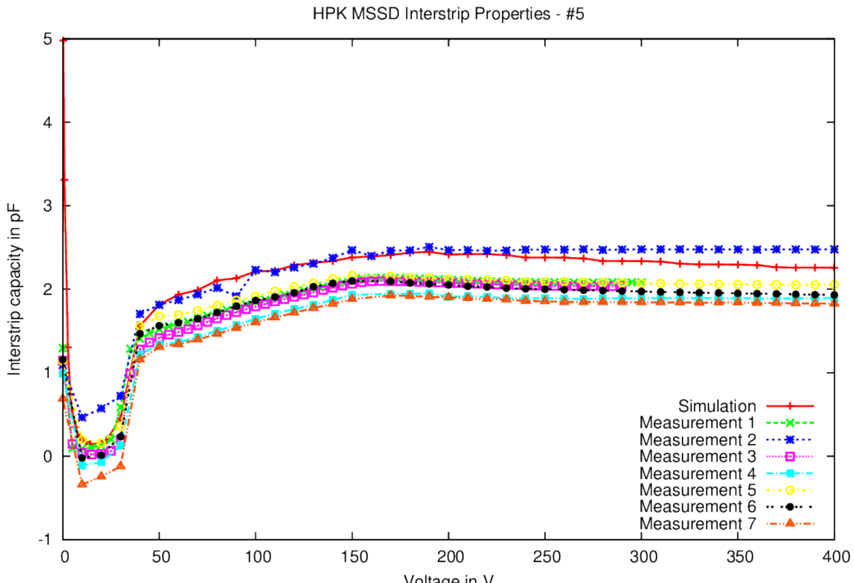


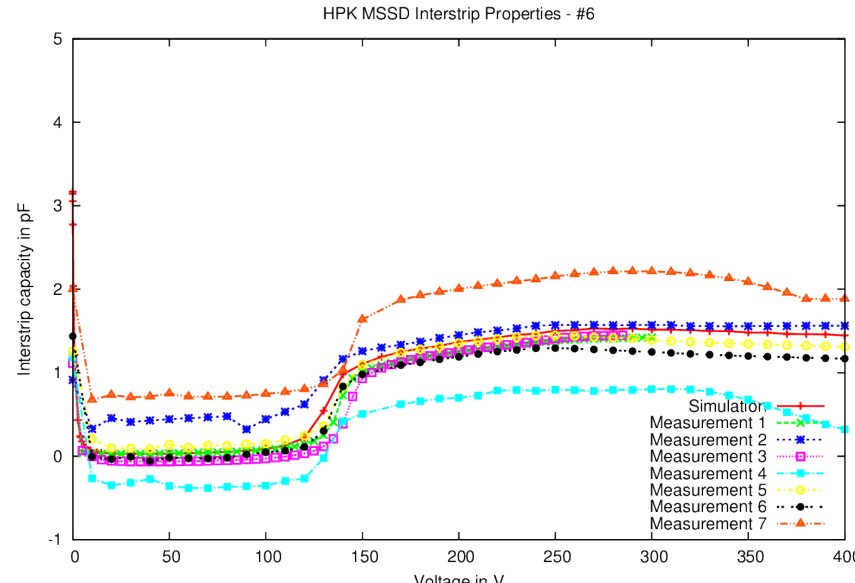


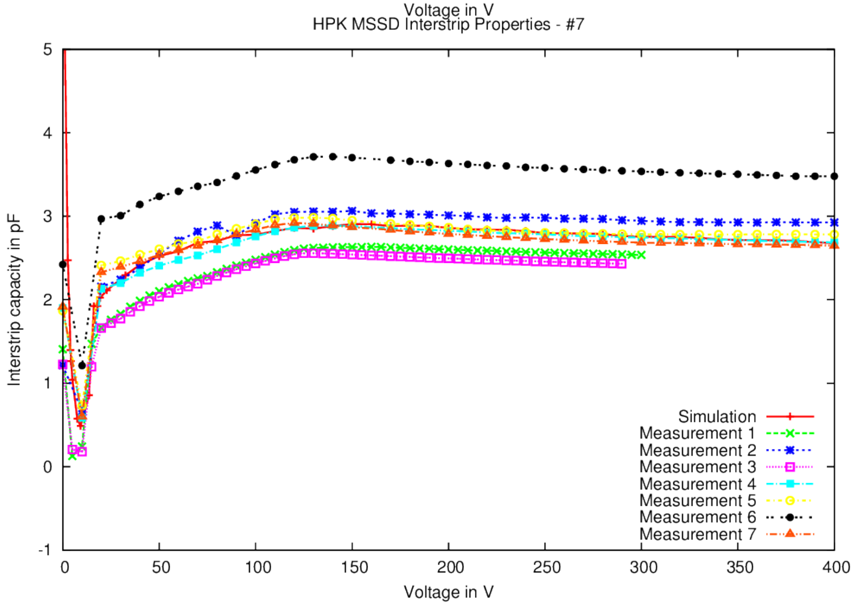
Results – C_{int} for FZ200Y regions #1 to #4

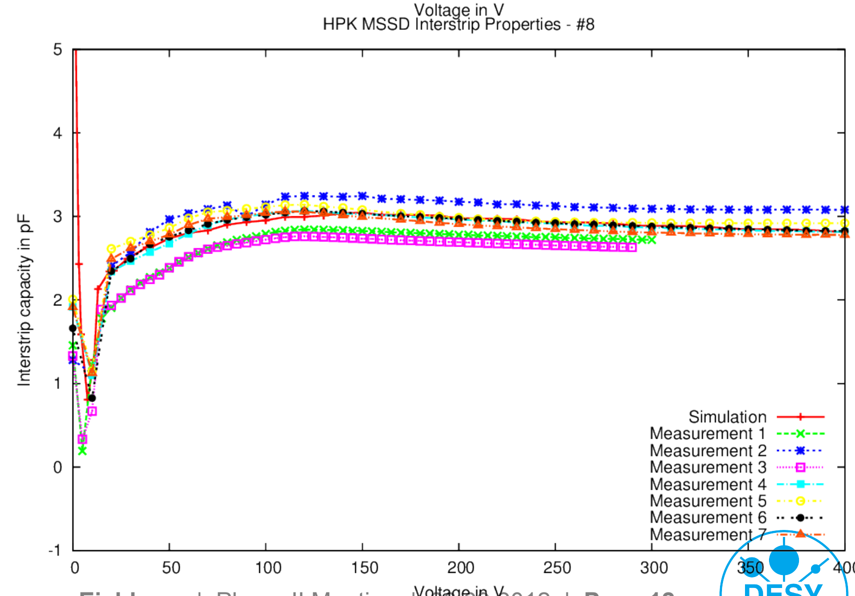


Results – C_{int} for FZ200Y regions #5 to #8

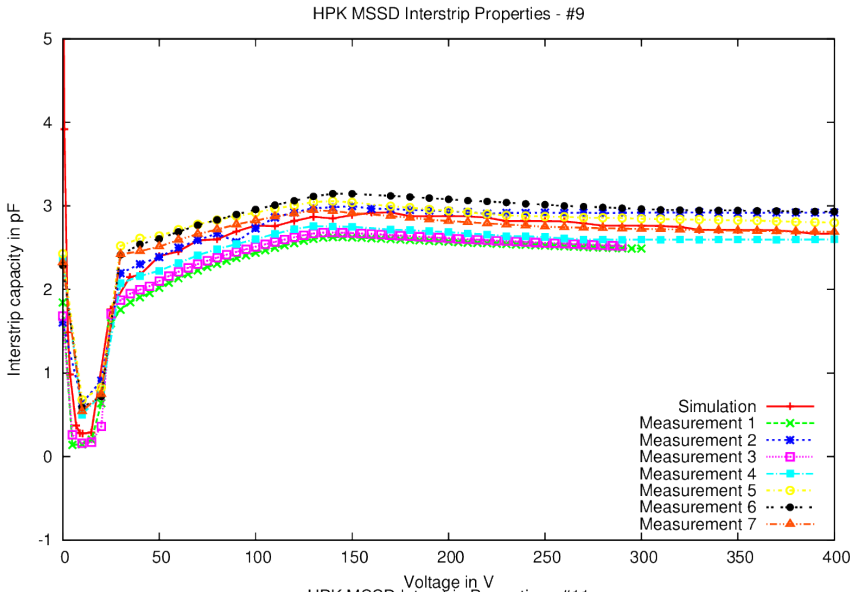


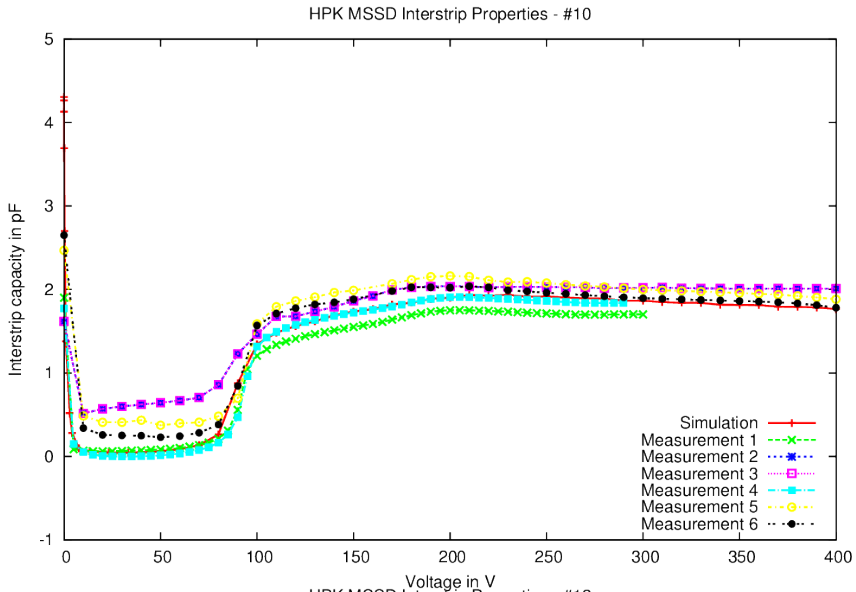


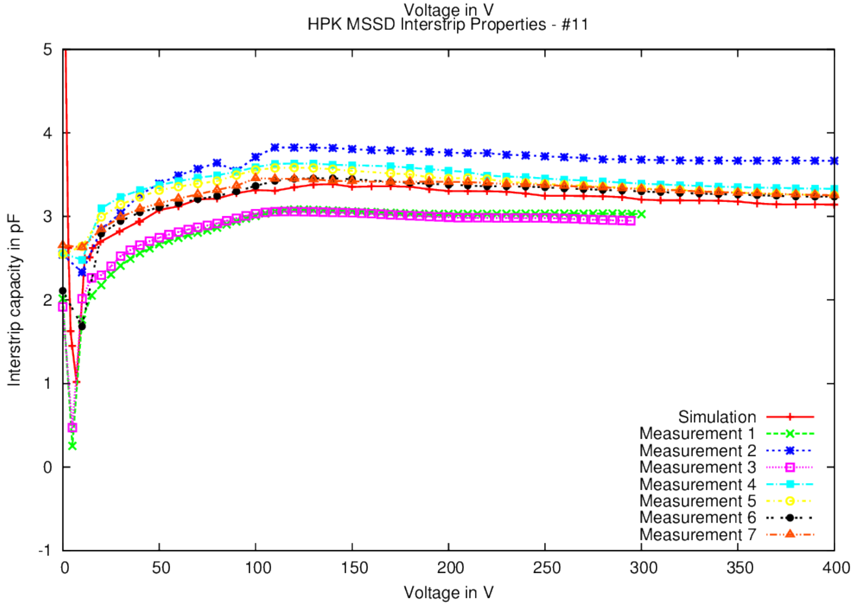


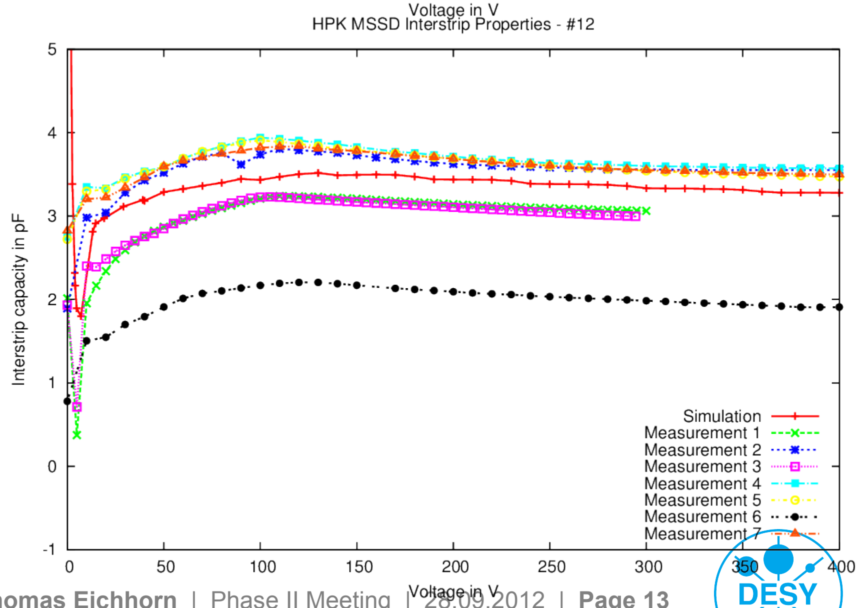


Results – C_{int} for FZ200Y regions #9 to #12

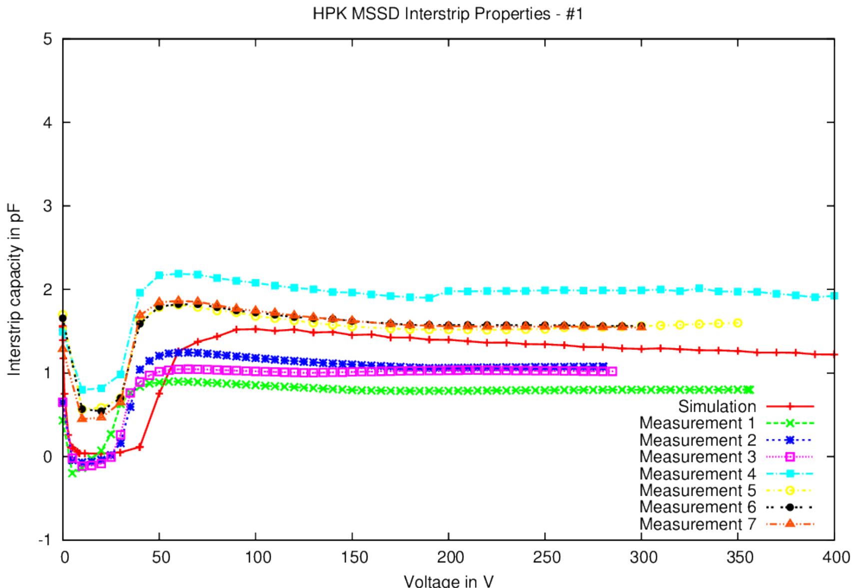


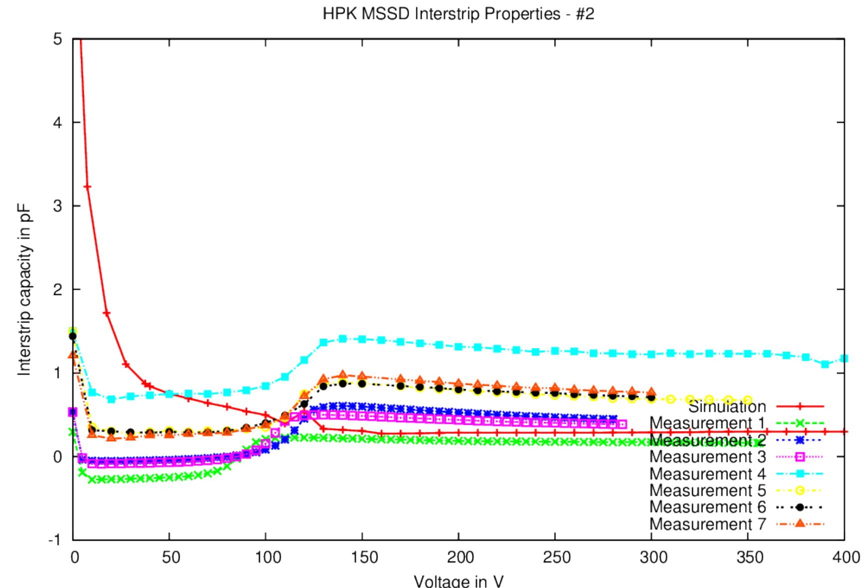


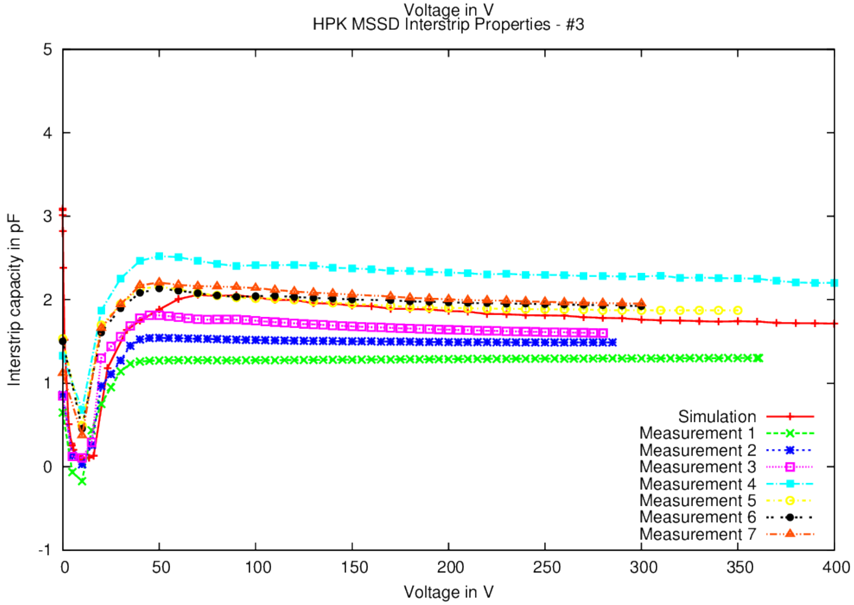


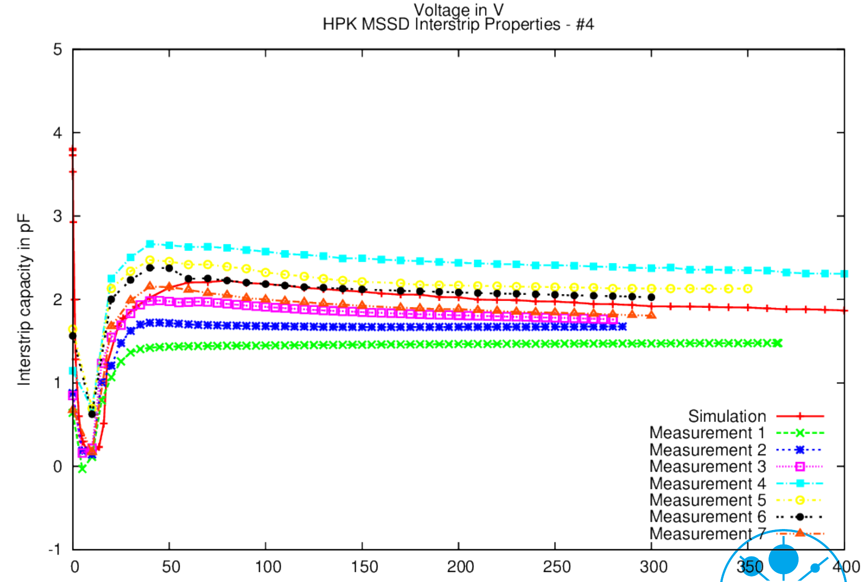


Results – C_{int} for FZ120Y regions #1 to #4

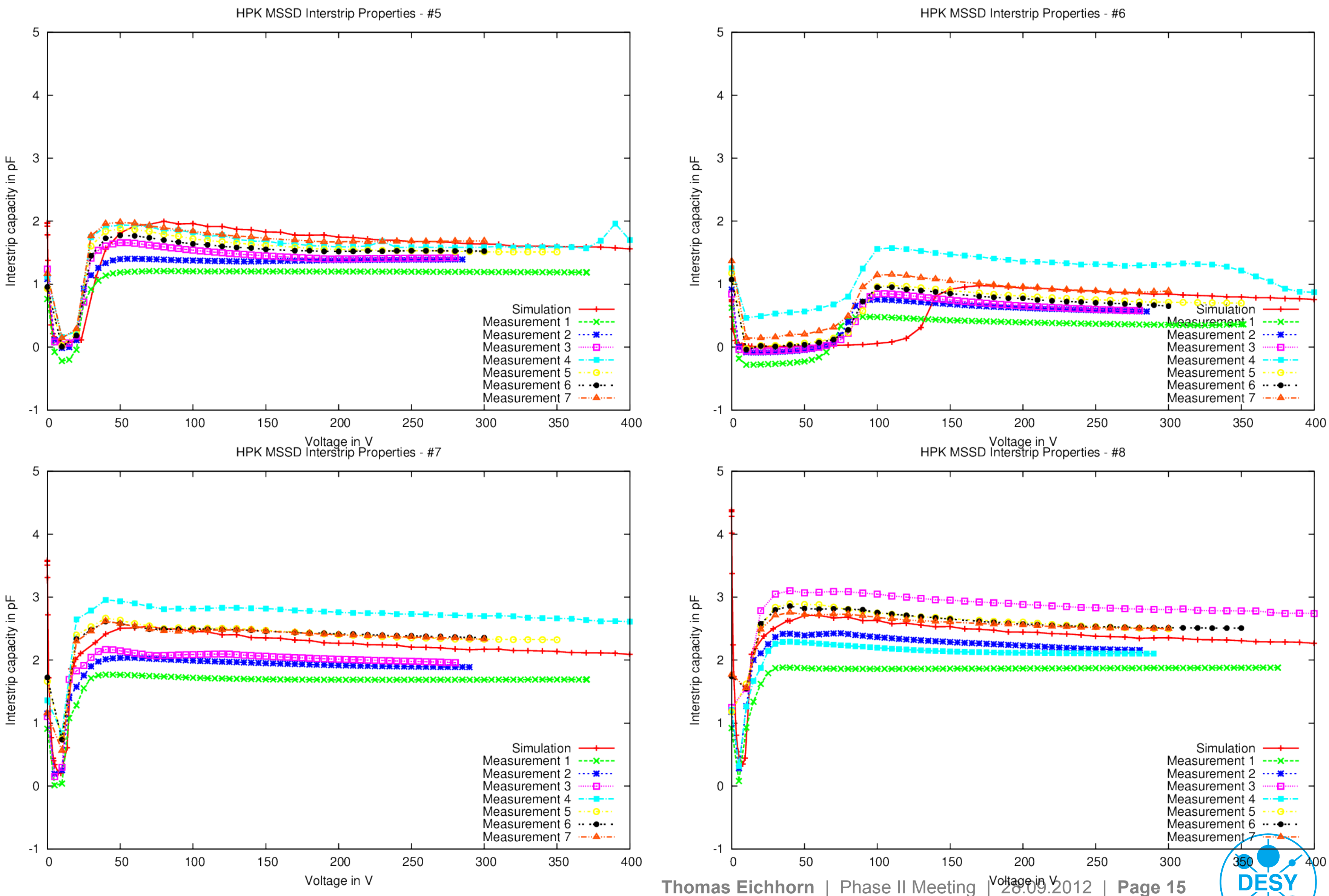




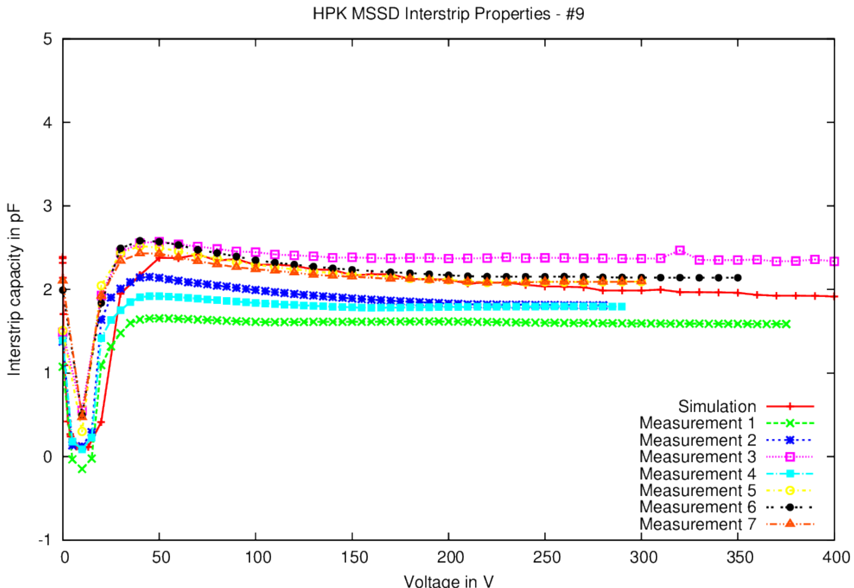


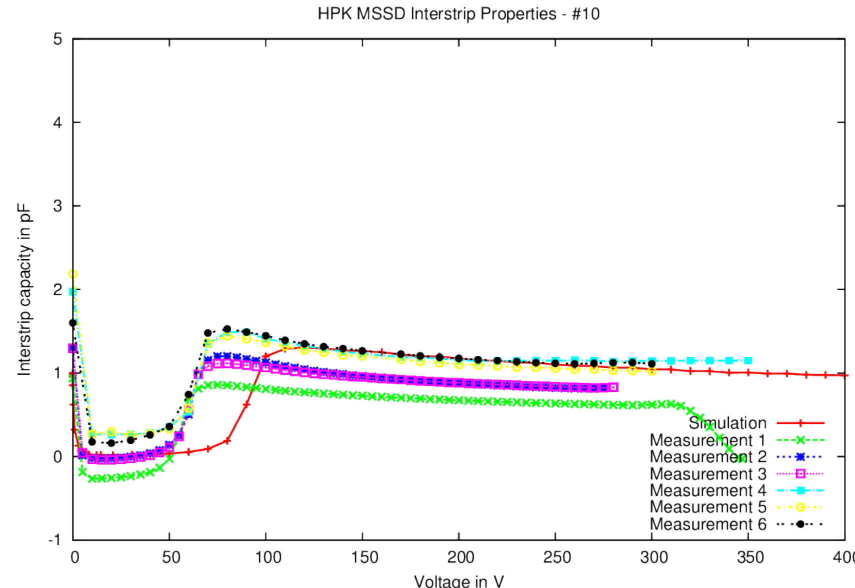


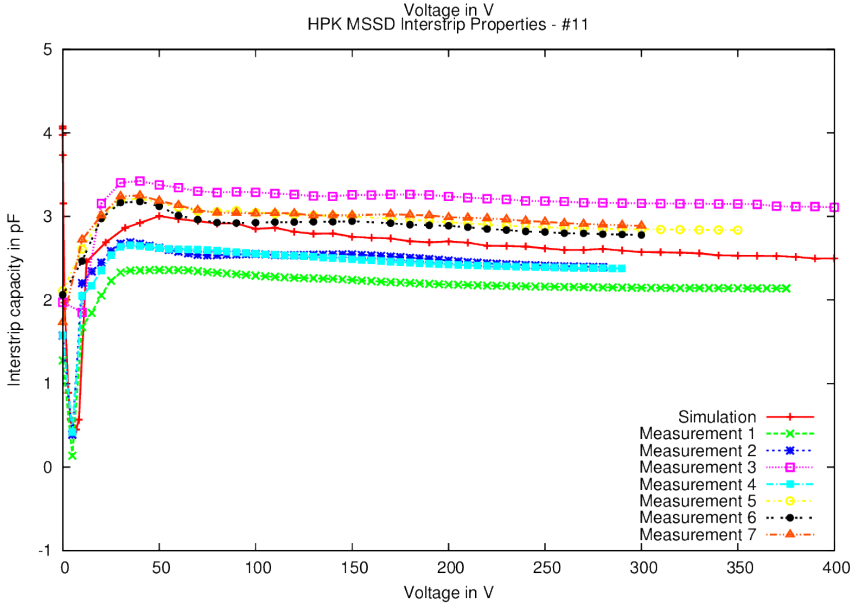
Results – C_{int} for FZ120Y regions #5 to #8

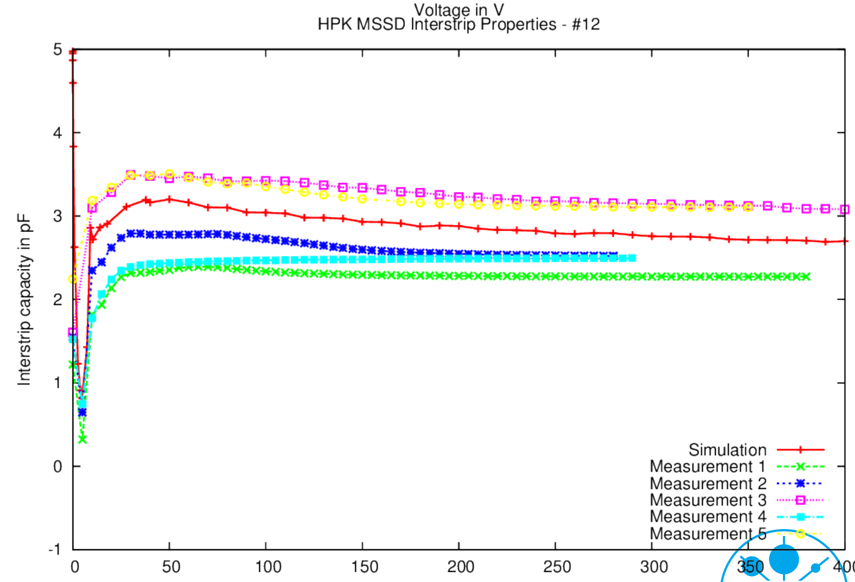


Results – C_{int} for FZ120Y regions #9 to #12

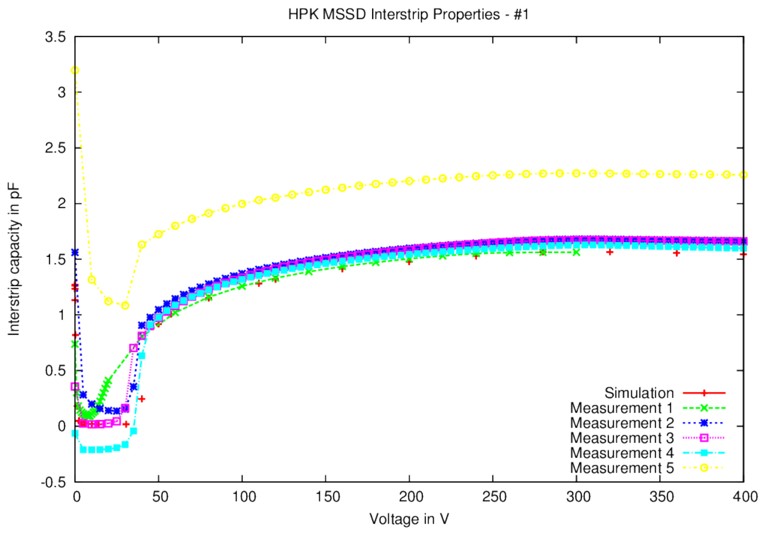


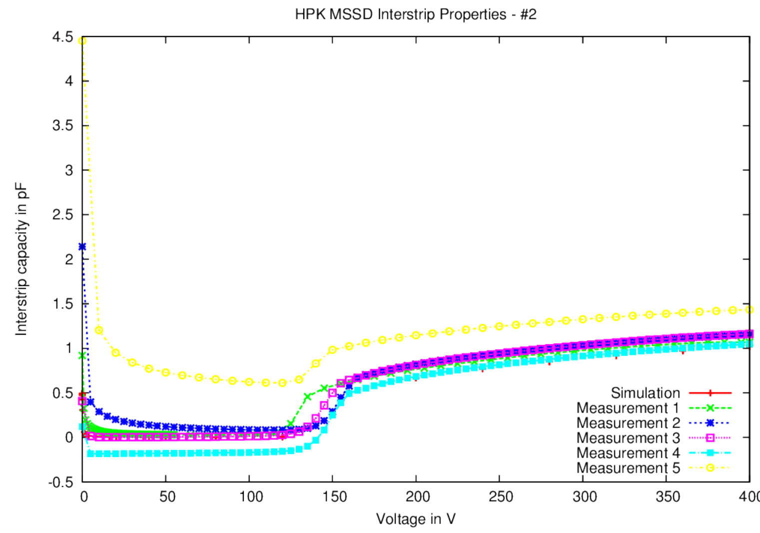


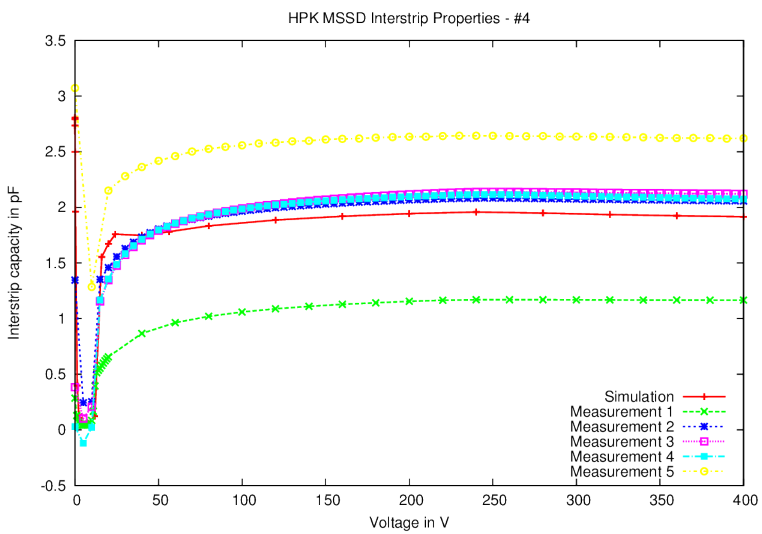


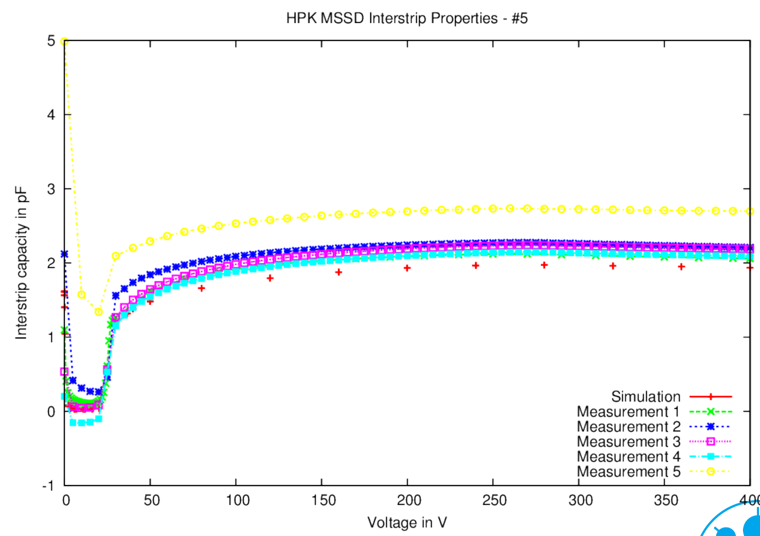


Results – C_{int} for FZ320N regions #1, #2, #4, #5

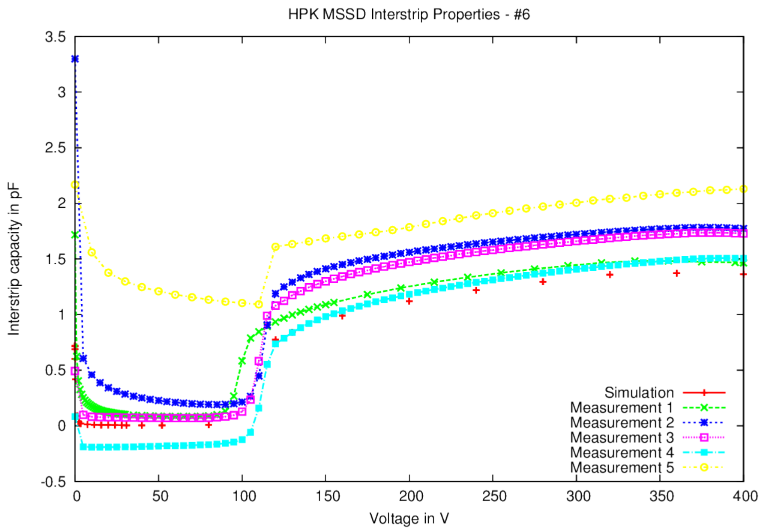


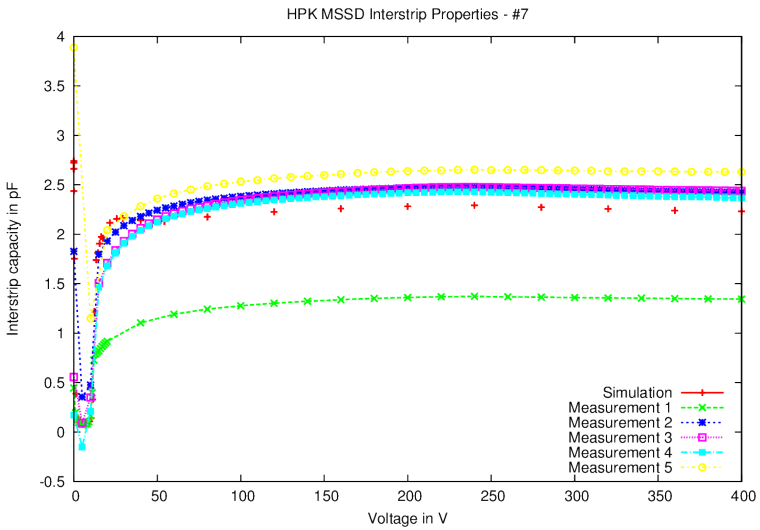


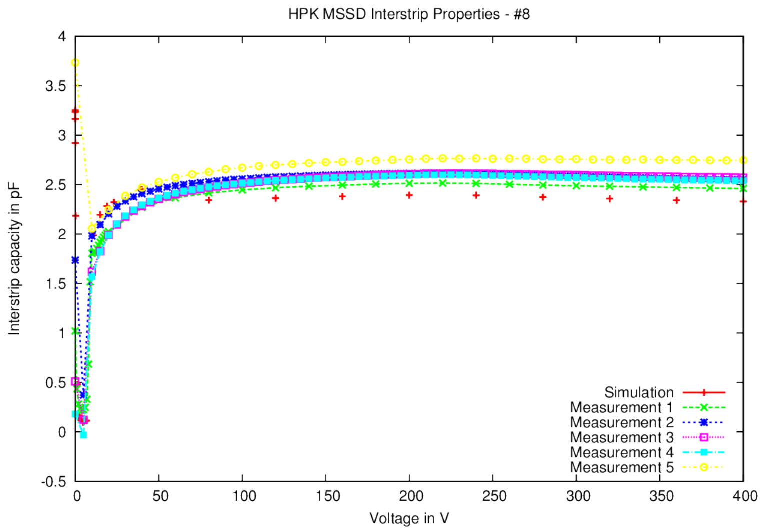


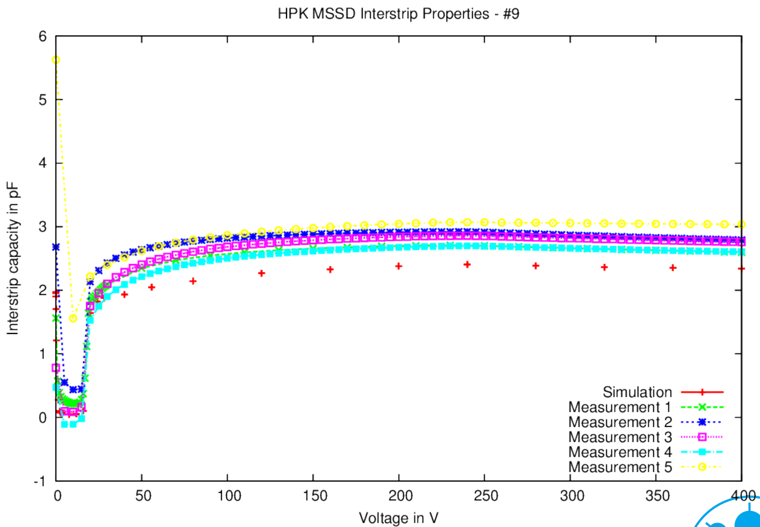


Results – C_{int} for FZ320N regions #6 to #9

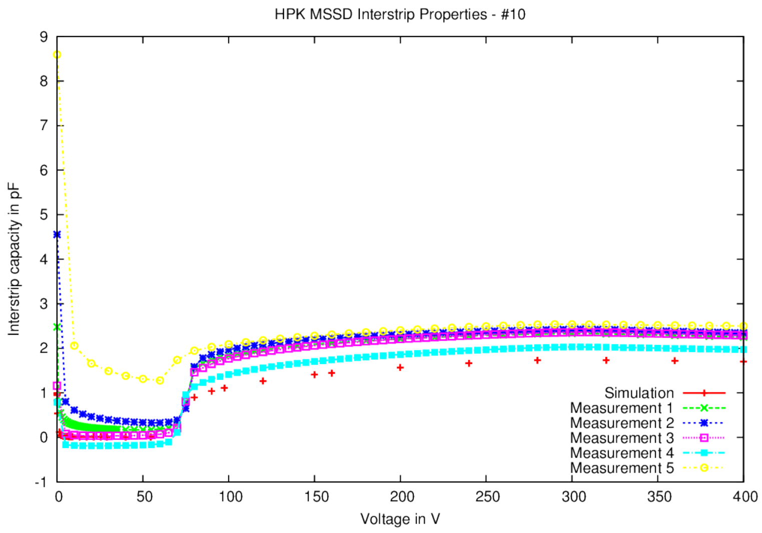


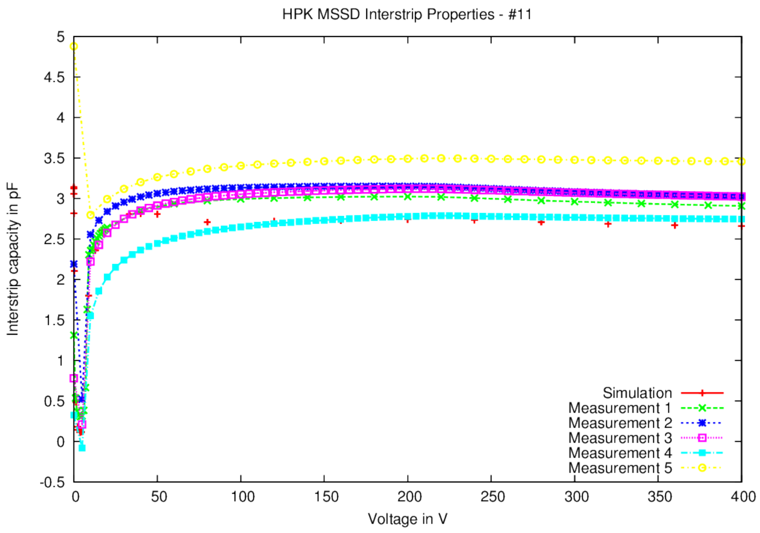


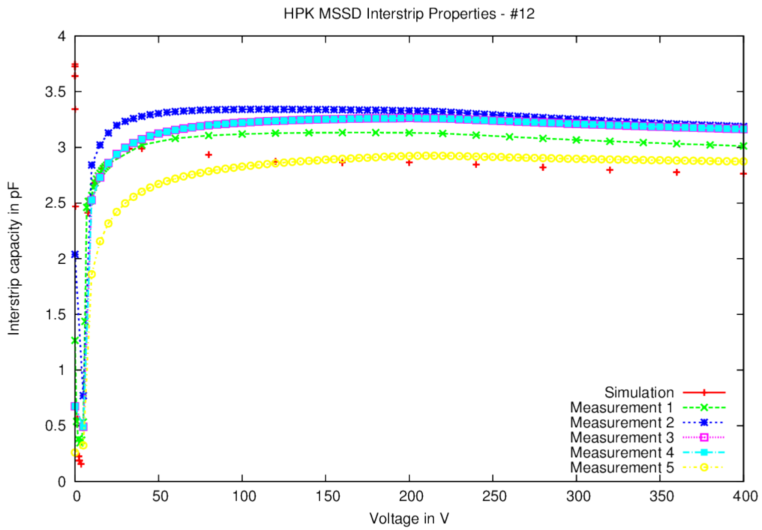




Results – C_{int} for FZ320N regions #10 to #12

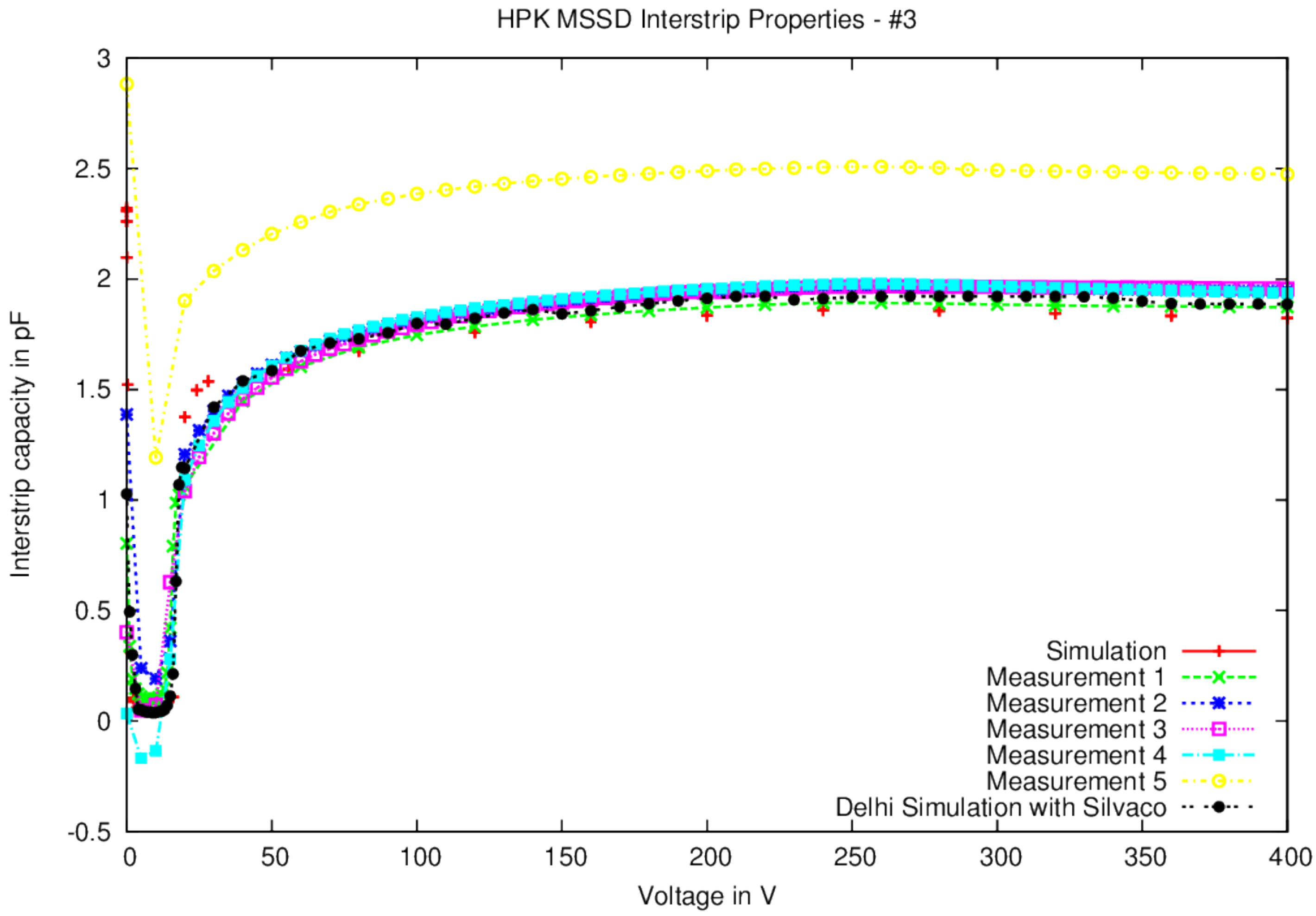






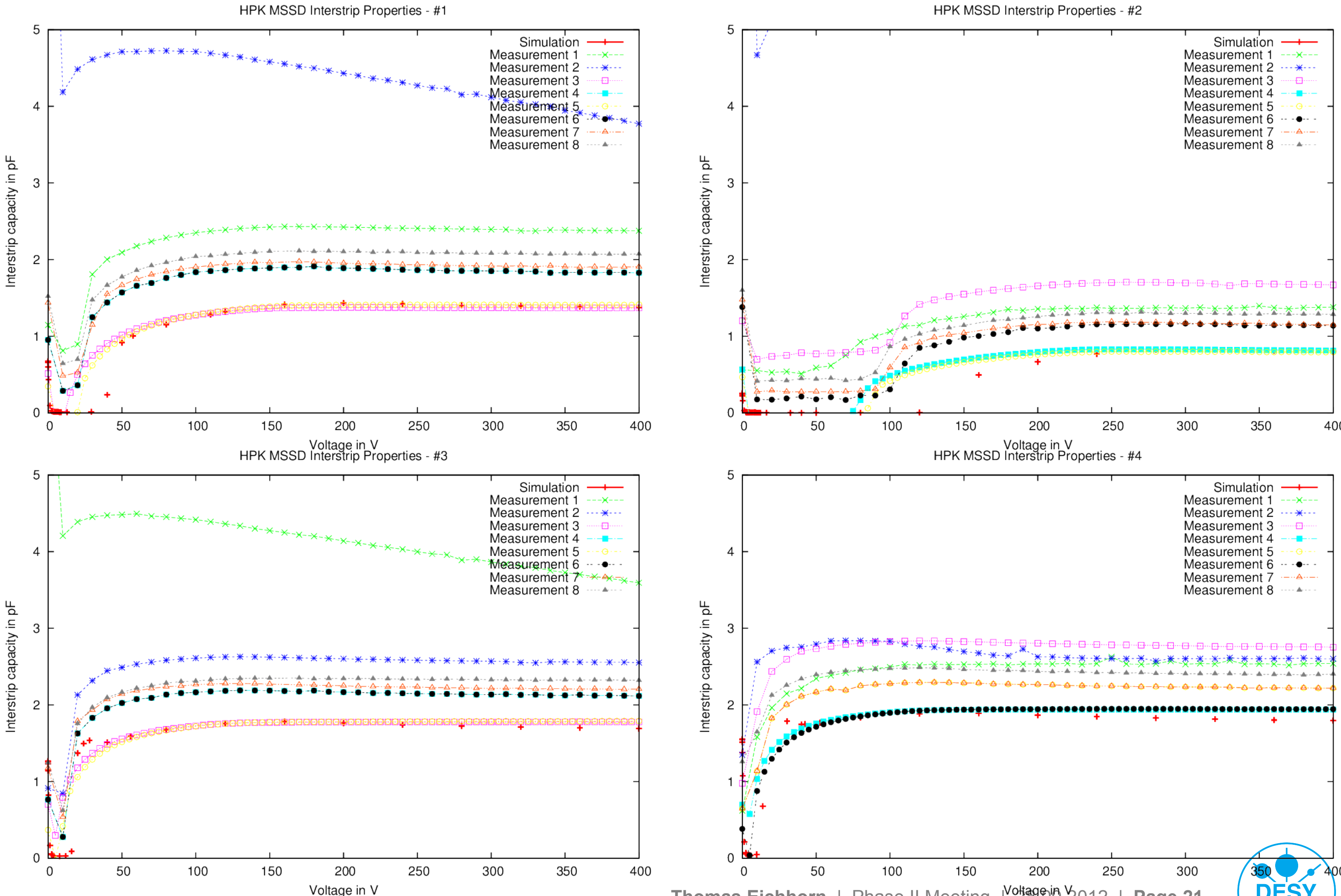
- Quality of results differs between regions
- Curve “shape” is reproduced
- Simulated C_{int} usually lower
- Large improvement achieved

Results – C_{int} for FZ320N region #3

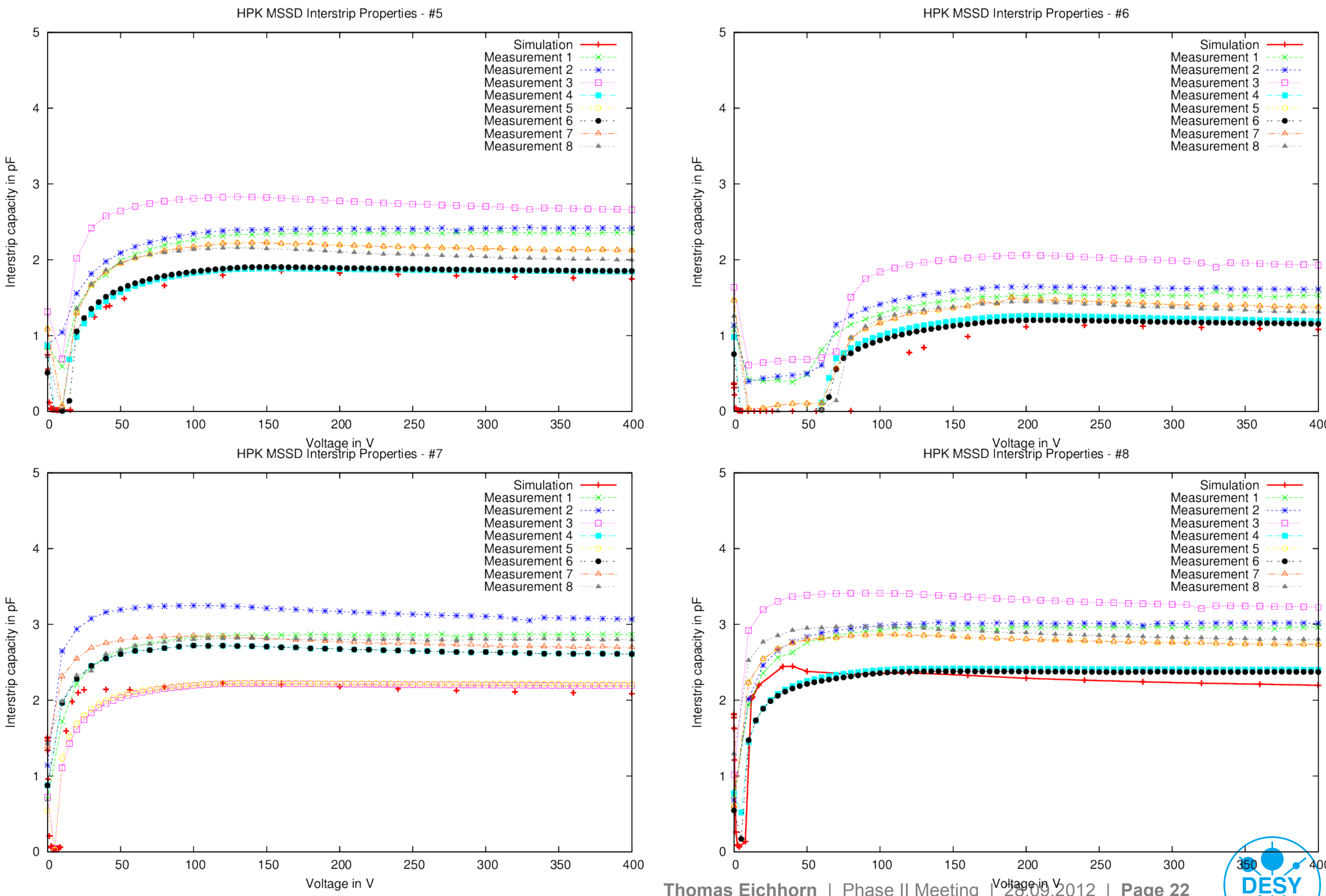


> Synopsys and Silvaco give the same results, in agreement with data!

Results – C_{int} for FZ200N regions #1 to #4

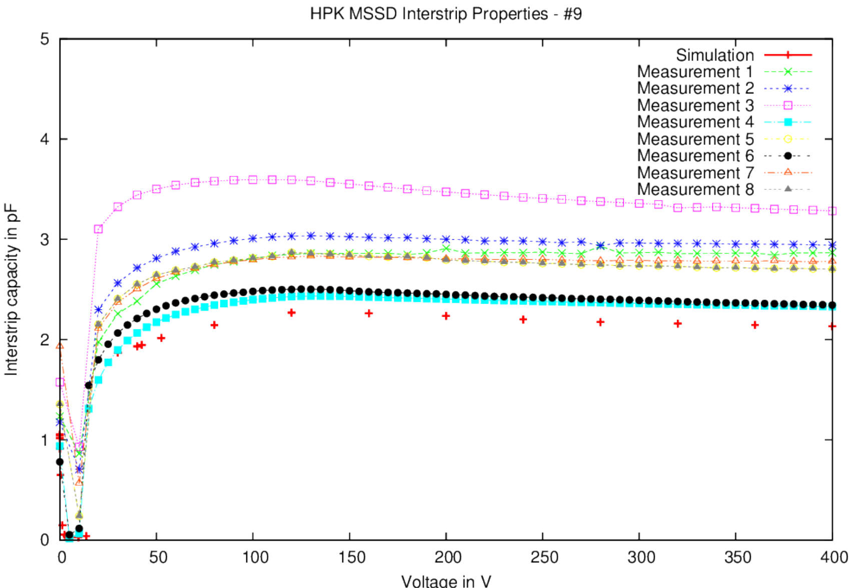


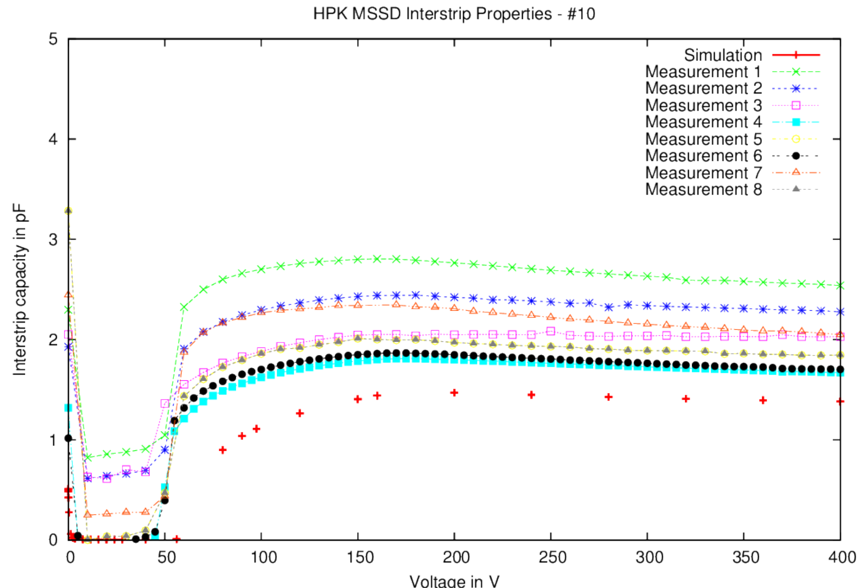
Results – C_{int} for FZ200N regions #5 to #8

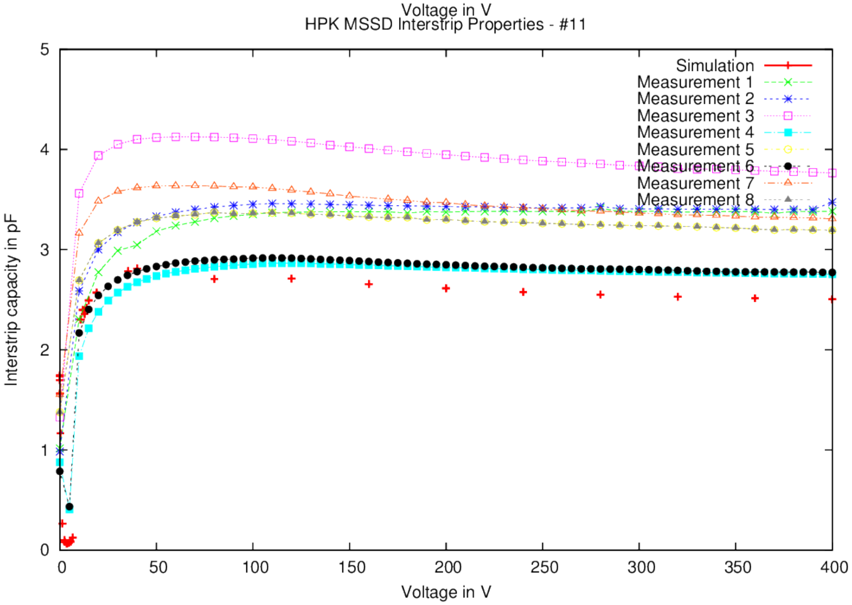


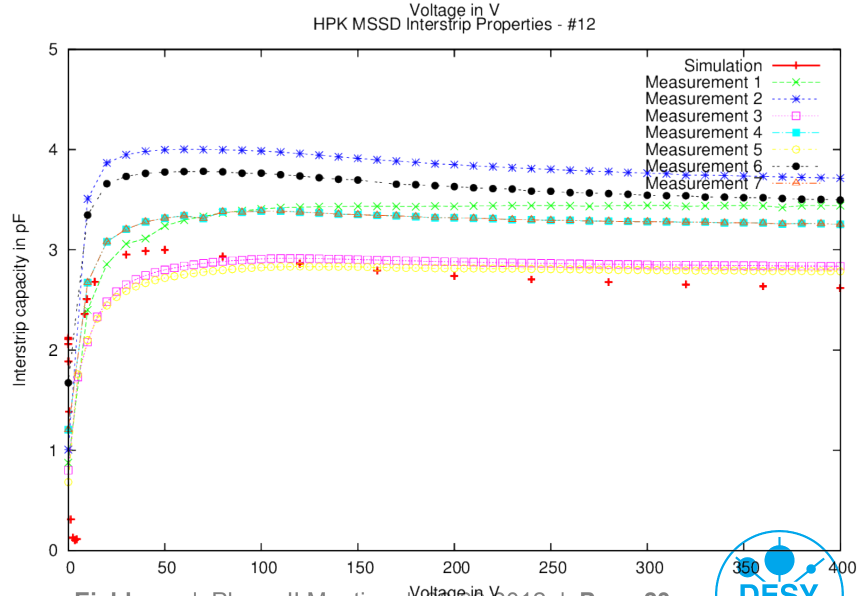
DESY

Results – C_{int} for FZ200N regions #9 to #12

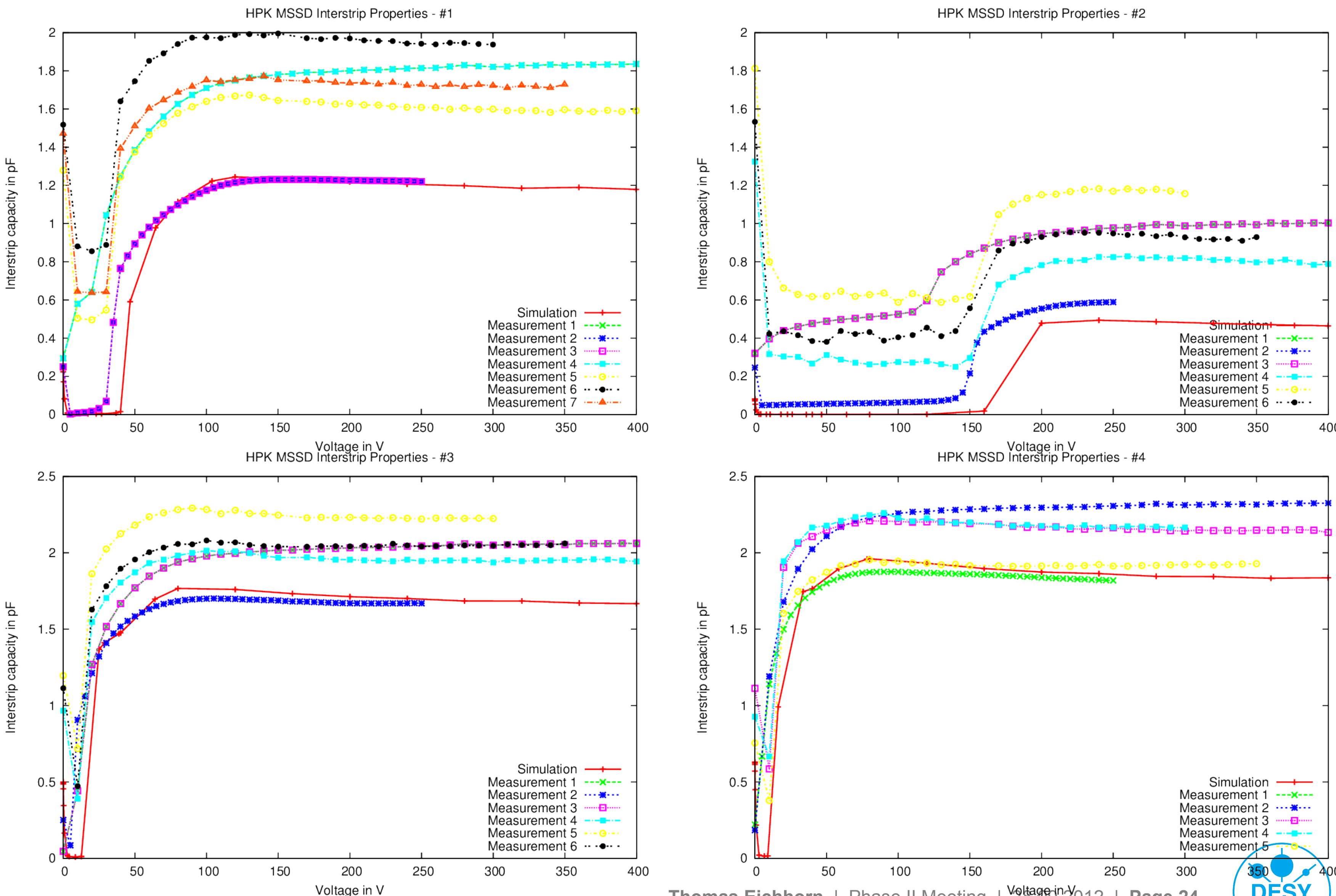




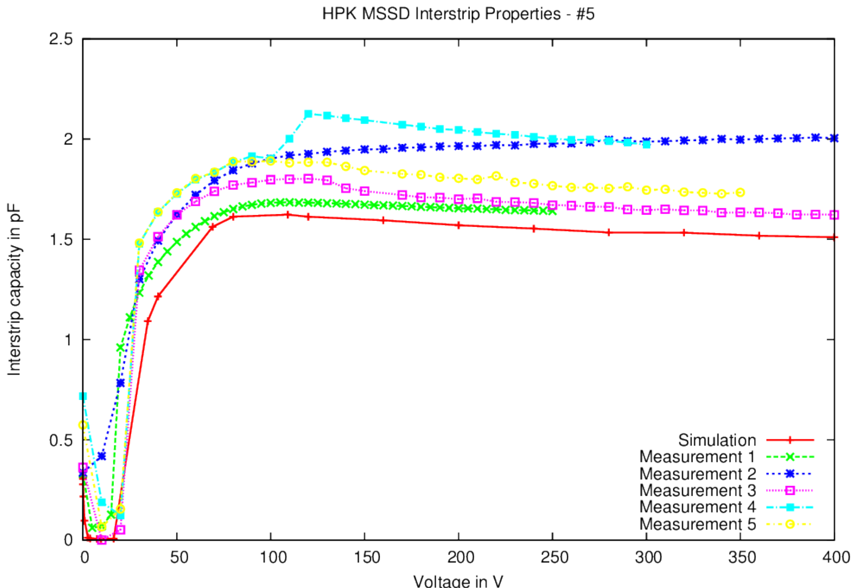


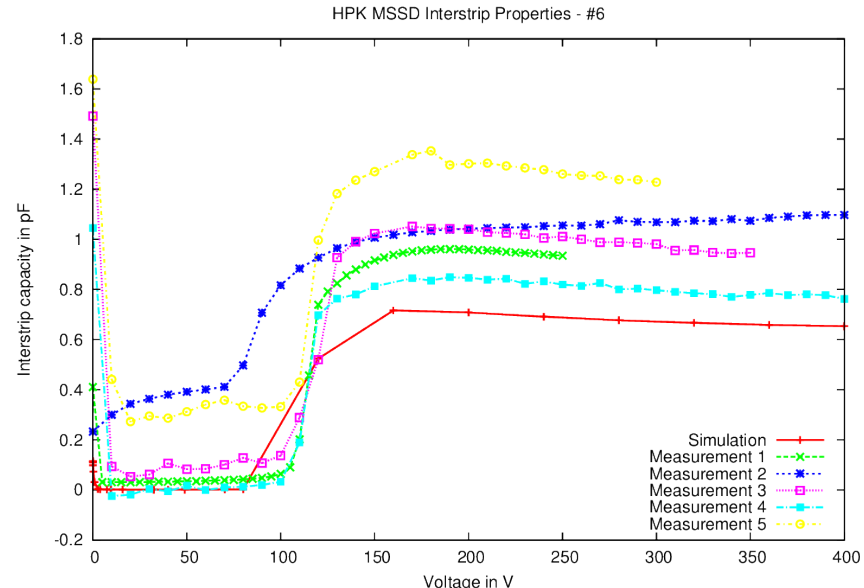


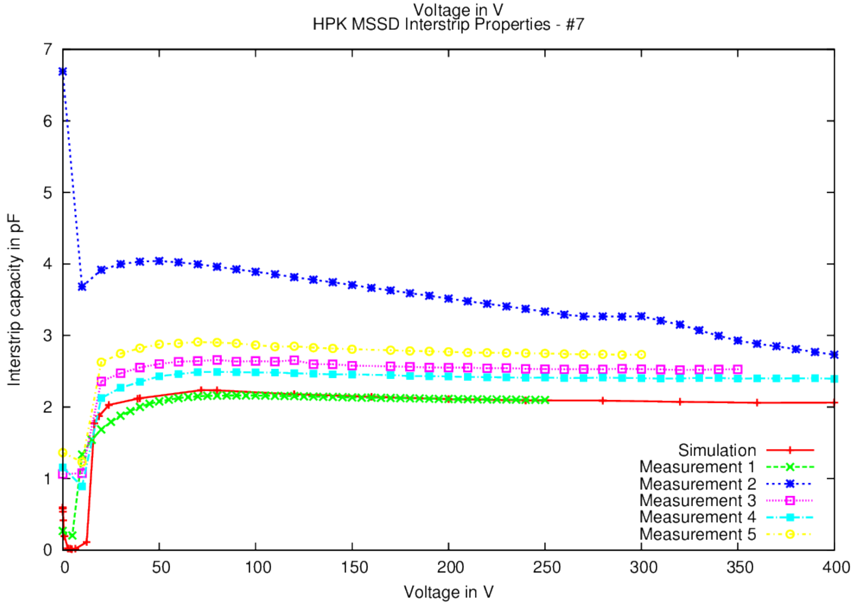
Results – C_{int} for FZ120N regions #1 to #4

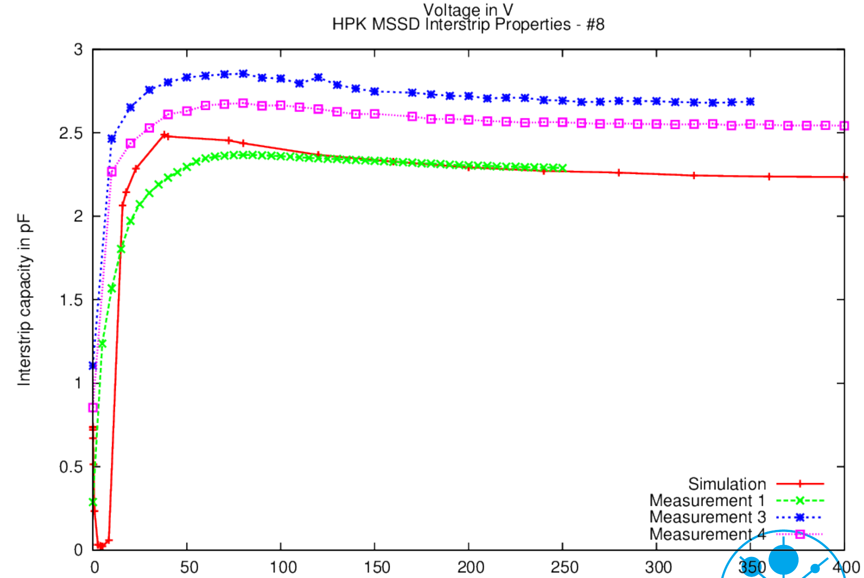


Results – C_{int} for FZ120N regions #5 to #8

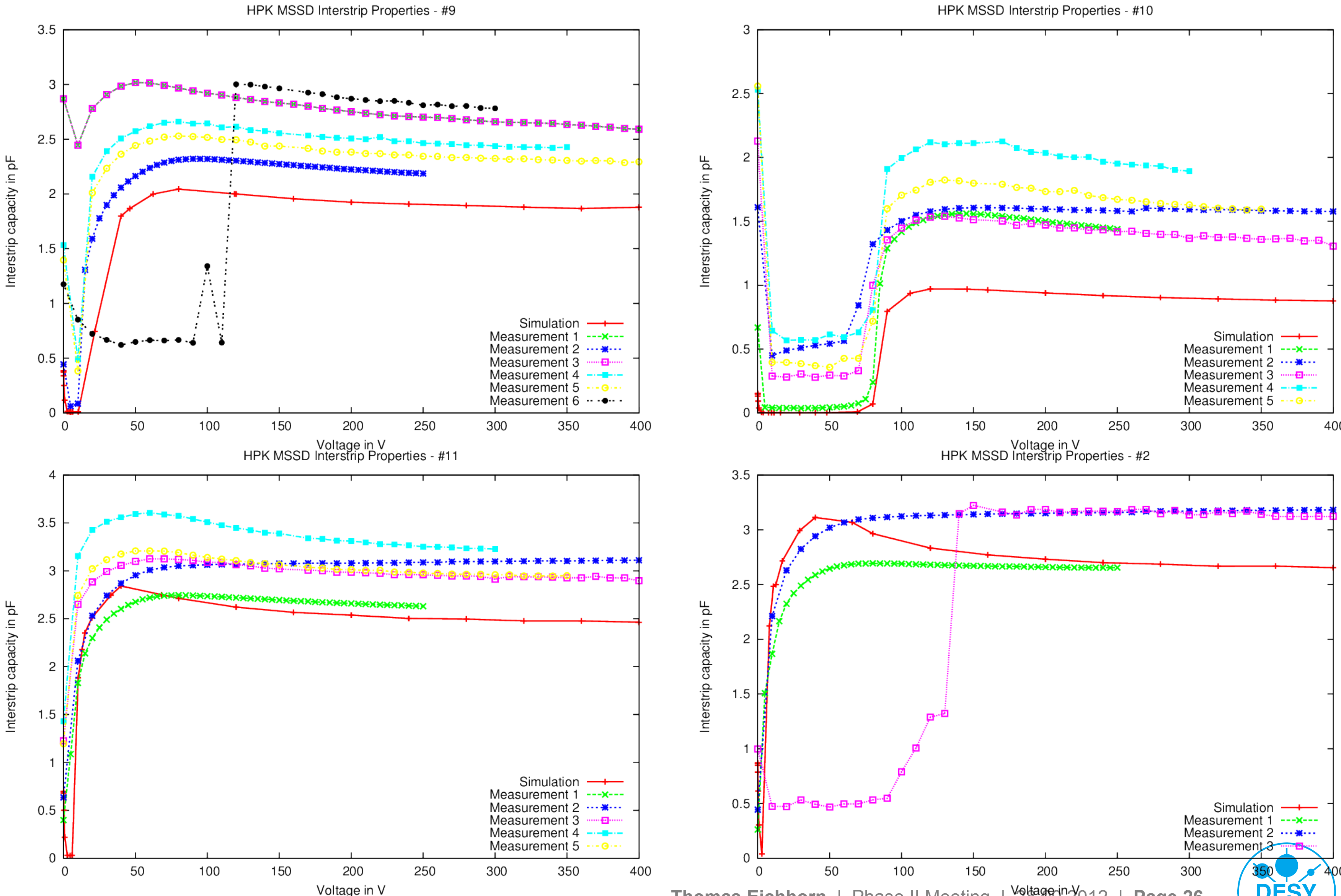








Results – C_{int} for FZ120N regions #9 to #12



Backup