Characterization of LGAD sensors from CNM Run 7062

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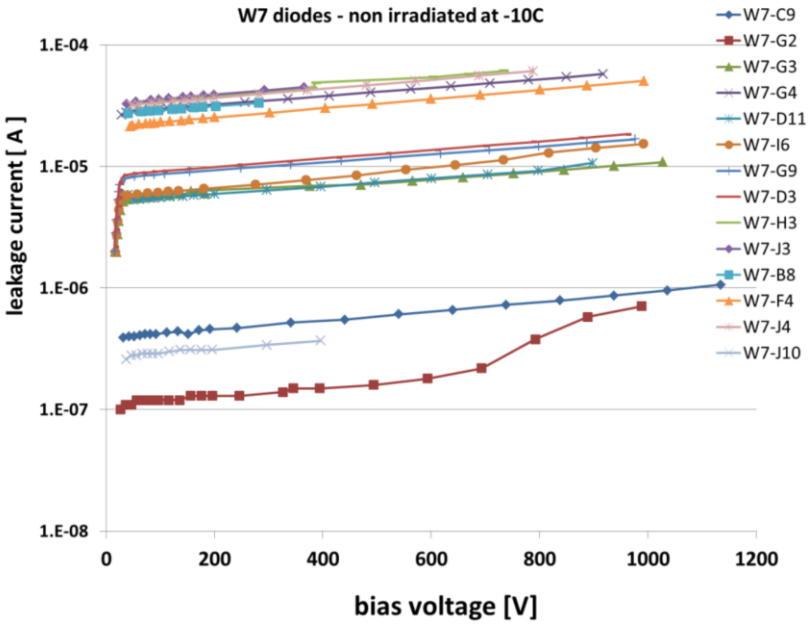
Outline

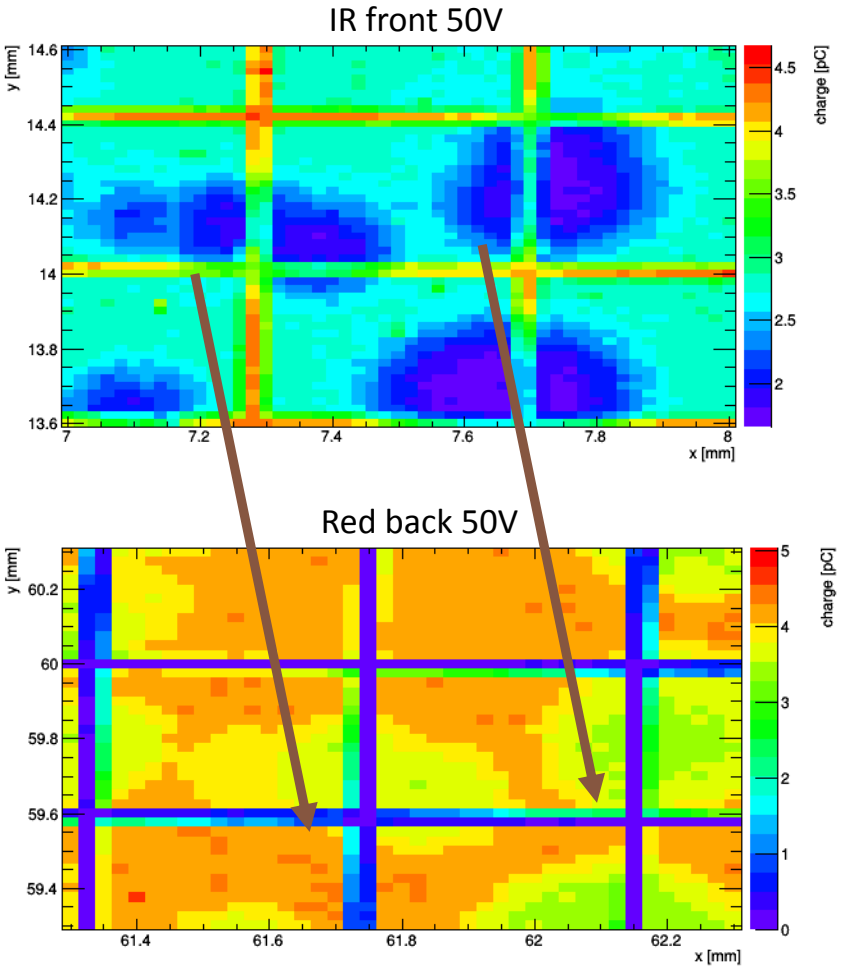
1. Reminder of previous work
2. Reports on defect investigation using TSC measurements
3. Conclusions

Reminder: previous work

- Devices had a current spread of 2-3 orders of magnitude before irradiation (G.Kramberger, 25th RD50 workshop)
- TCT measurements on high leakage current (I_L) samples showed inhomogeneous charge collection below depletion voltage before irradiation (C.Gallrapp, 26th RD50 workshop)



(Effects of irradiation on LGAD devices with high excess current. G.Kramberger, 25th RD50 ws.)

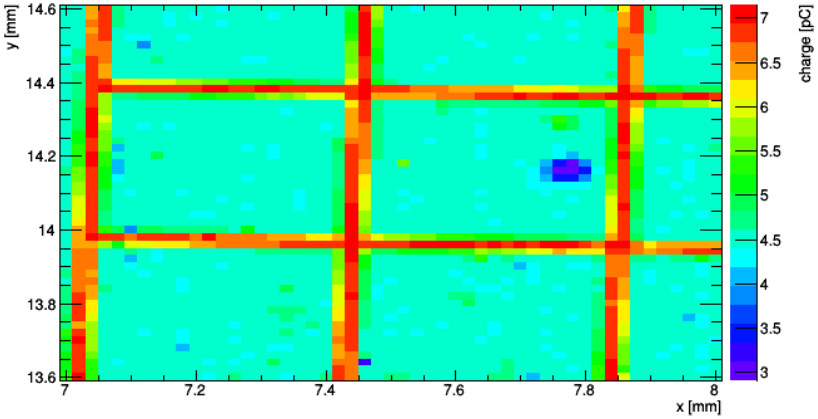


(TCT measurements on neutron and proton irradiated LGAD diodes. C.Gallrapp, 26th RD50 ws.)

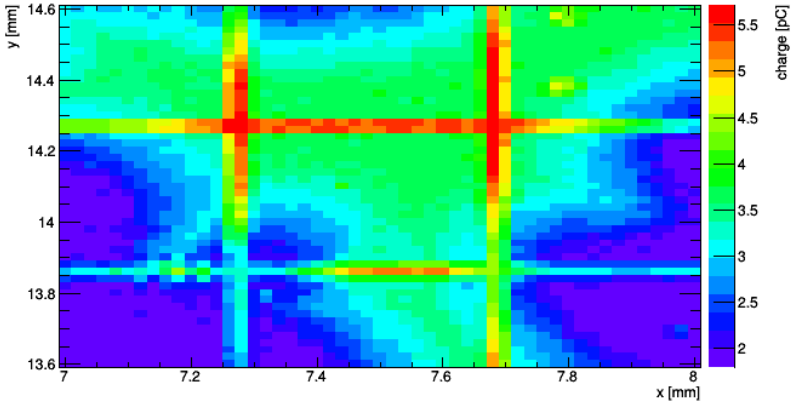
Reminder: previous work (II)

- Inhomogeneities were observed also after irradiation, up to 1000V (op. voltage)
- High I_L could be related to the presence of defects ➔ TSC measurements performed on unirradiated samples with different I_L levels

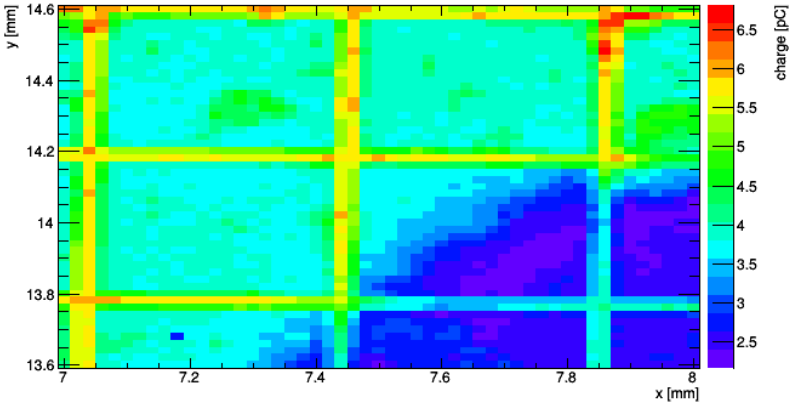
IR front: p-irrad 1.36E13 200V



IR front: n-irrad 1E14 200V



IR front: p-irrad 1.04E14 1000V



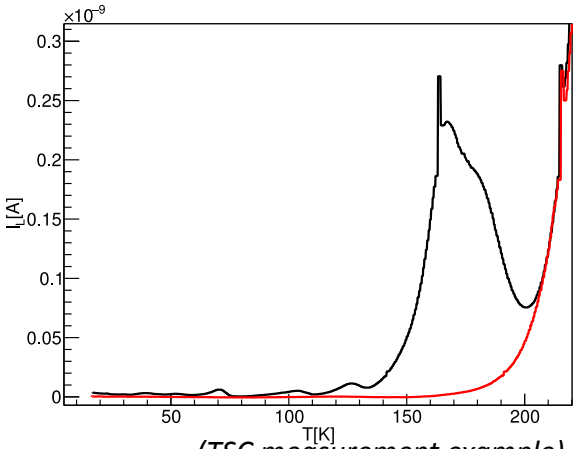
(TCT measurements on neutron and proton irradiated LGAD diodes. C.Gallrapp, 26th RD50 ws.)

TSC measurements performed

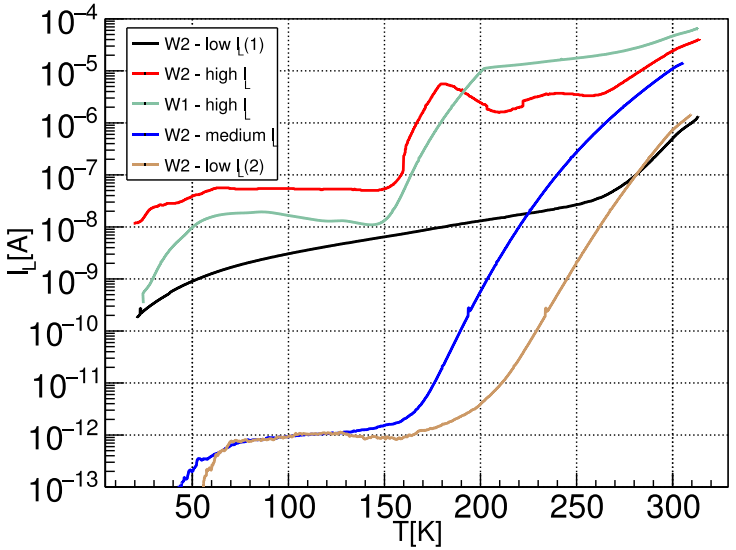
- *Thermally stimulated current (TSC)* technique is commonly used to investigate defects in irradiated silicon detectors

- The measurement is performed in several steps:
  1. Cooling down the sample
  2. "Filling" of the charge traps (Forward bias, 200s @ I_{fwd} = 1 mA)
  3. Recording of $I_L(T)$ under reverse bias and constant heating rate (Vb = 100V). Trapped charges are emitted when reaching a specific energy ➔ current peak in the spectrum
  4. Repetition of the measurement, this time without "filling" of the traps
  5. Subtraction of the two curves to remove the steady state generation current contribution

- Samples measured (all unirradiated!):
  - 2 with "high" I_L (W1 and W2)
  - 2 with "low" I_L (W2)
  - 1 with "medium" I_L (W2)



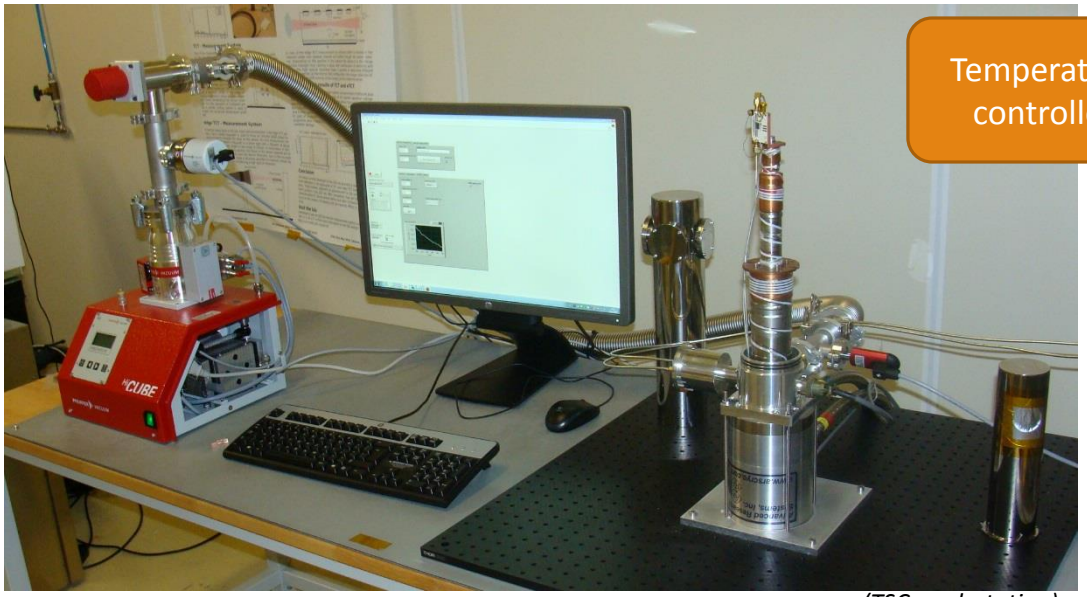
(TSC measurement example)



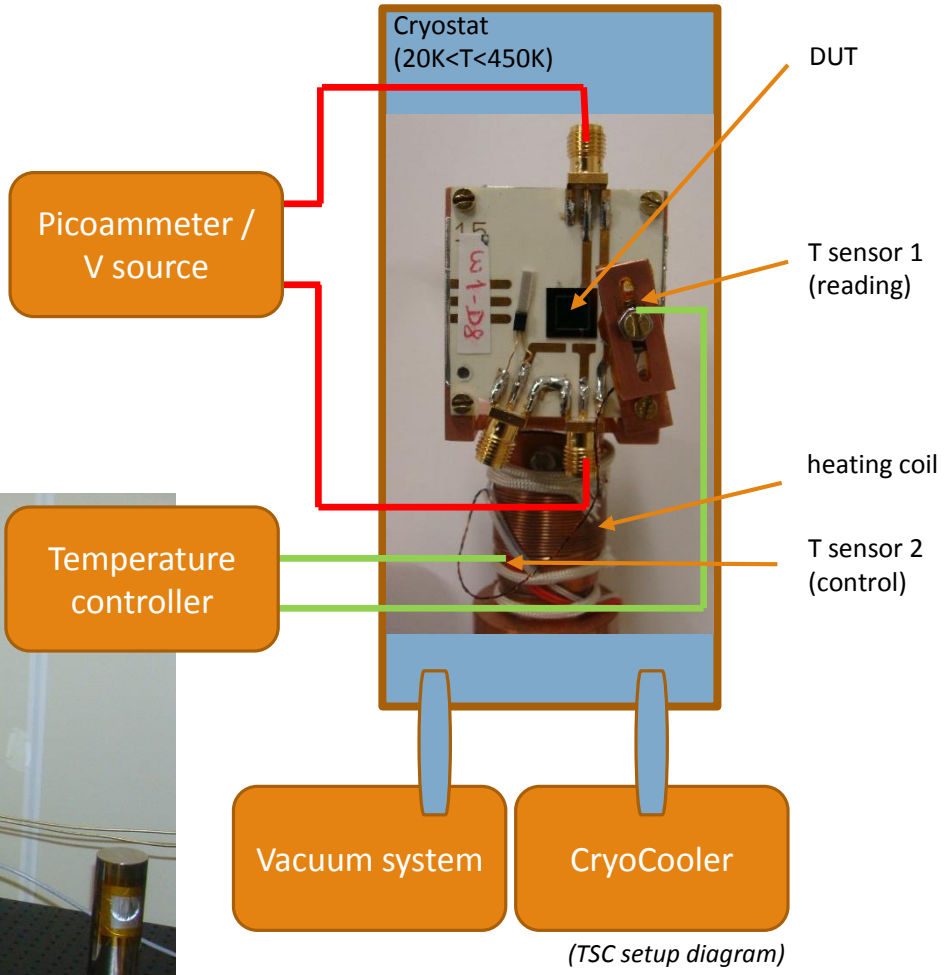
(Summary of measured samples)

TSC measurements setup

- New setup built this summer
- $I_L(T)$ down to 20K
- $I_L(V)$ at controlled temperature
- Resolution < 1 pA
- Work in progress



(TSC work station)

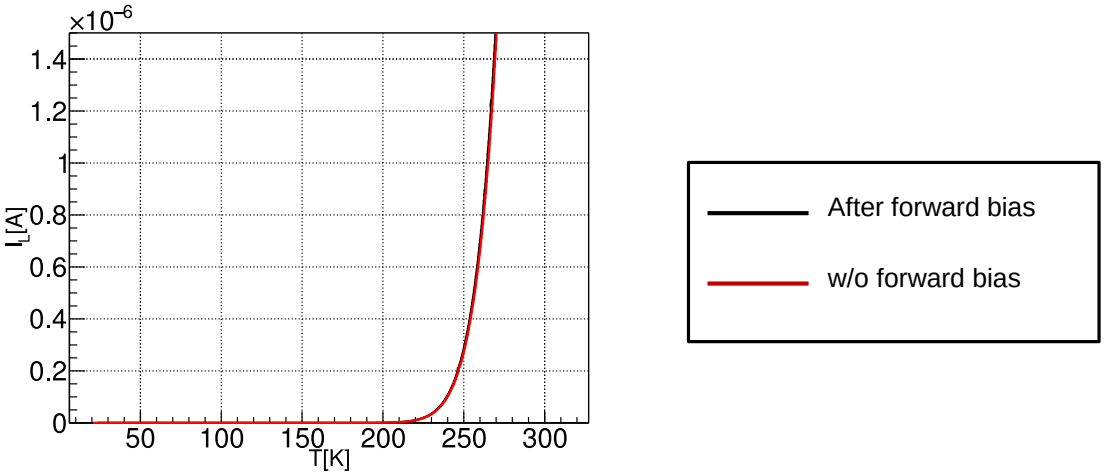


(TSC setup diagram)

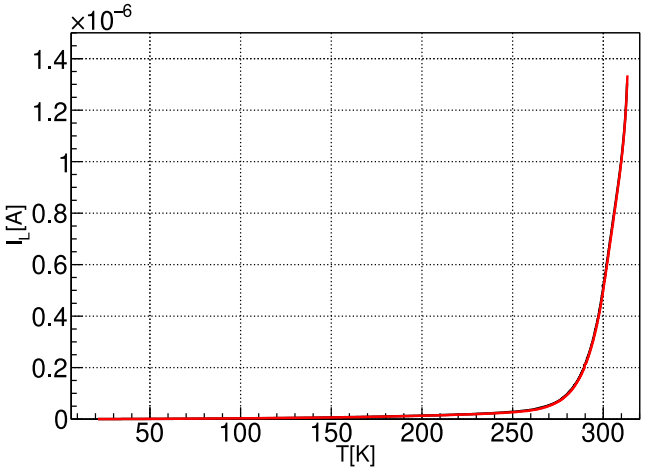
Defects inspection – Samples with medium and low I_L

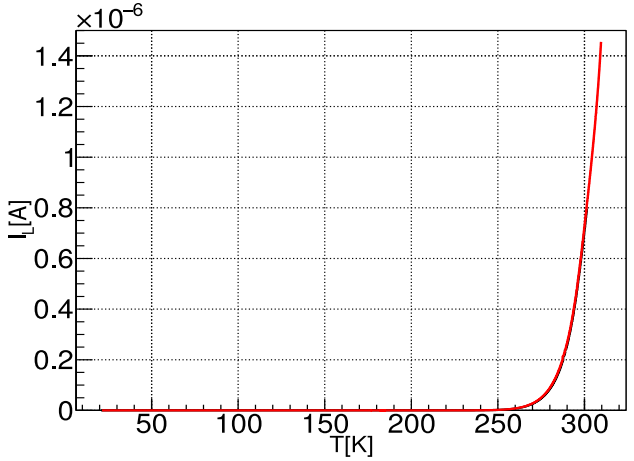
Perfect match of the $I_L(T)$ curves with and without forward bias. No peaks observed when subtracting the two measurements

Medium I_L



Low I_L

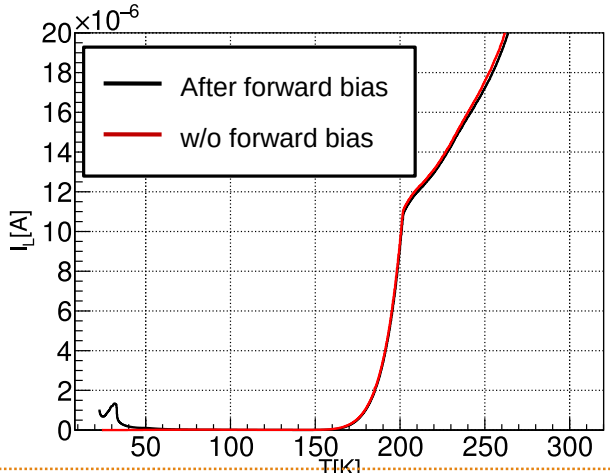


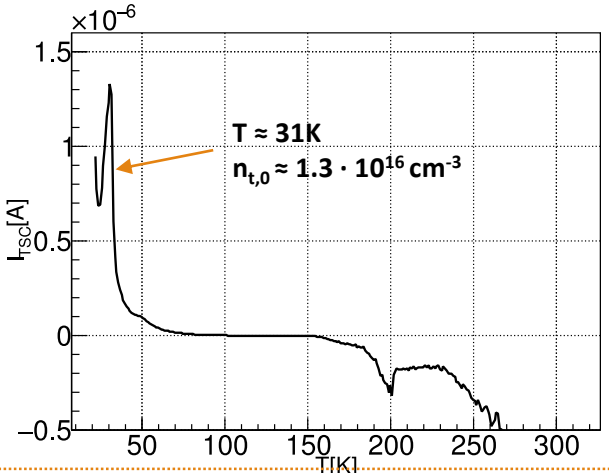


Defects inspection – Samples with high I_L

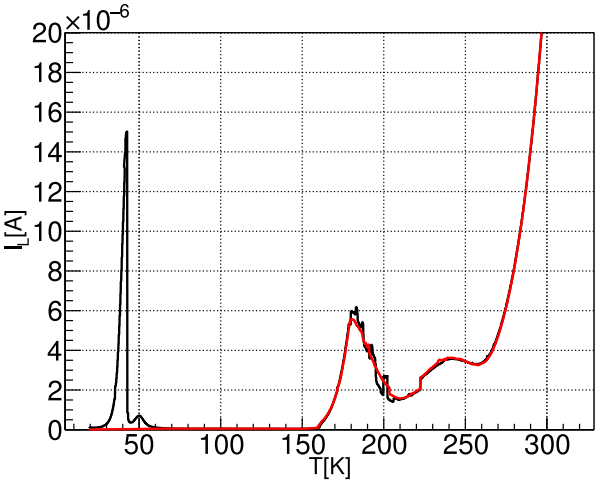
Current peaks are observed at low temperature values with very high concentration levels

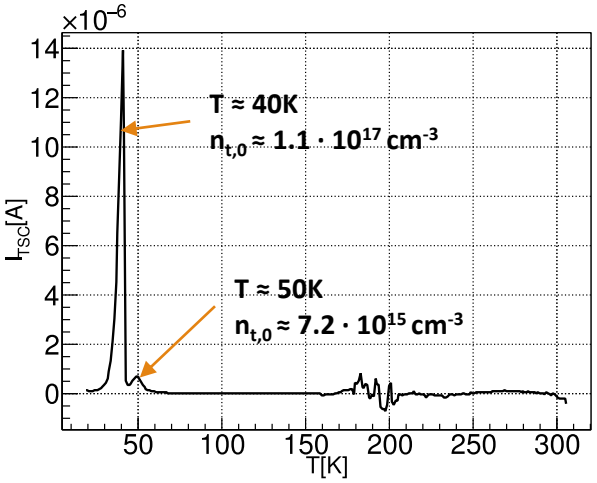
Wafer 1





Wafer 2





Conclusions

- Inhomogeneous charge collection had been measured on samples from LGAD run #7062 presenting high leakage current
- In addition, charge traps have been observed in unirradiated diodes from the same run (also with high leakage current)
- No defects observed for samples with low and medium leakage current
- Homogeneity problems have not been observed in run #7859 (see presentation from S. Otero Ugobono)
- Hypothesis: contamination during fabrication process
- Future work: TSC measurements on samples from run #7859