News from APD screening @ PL

Capacitance measurements

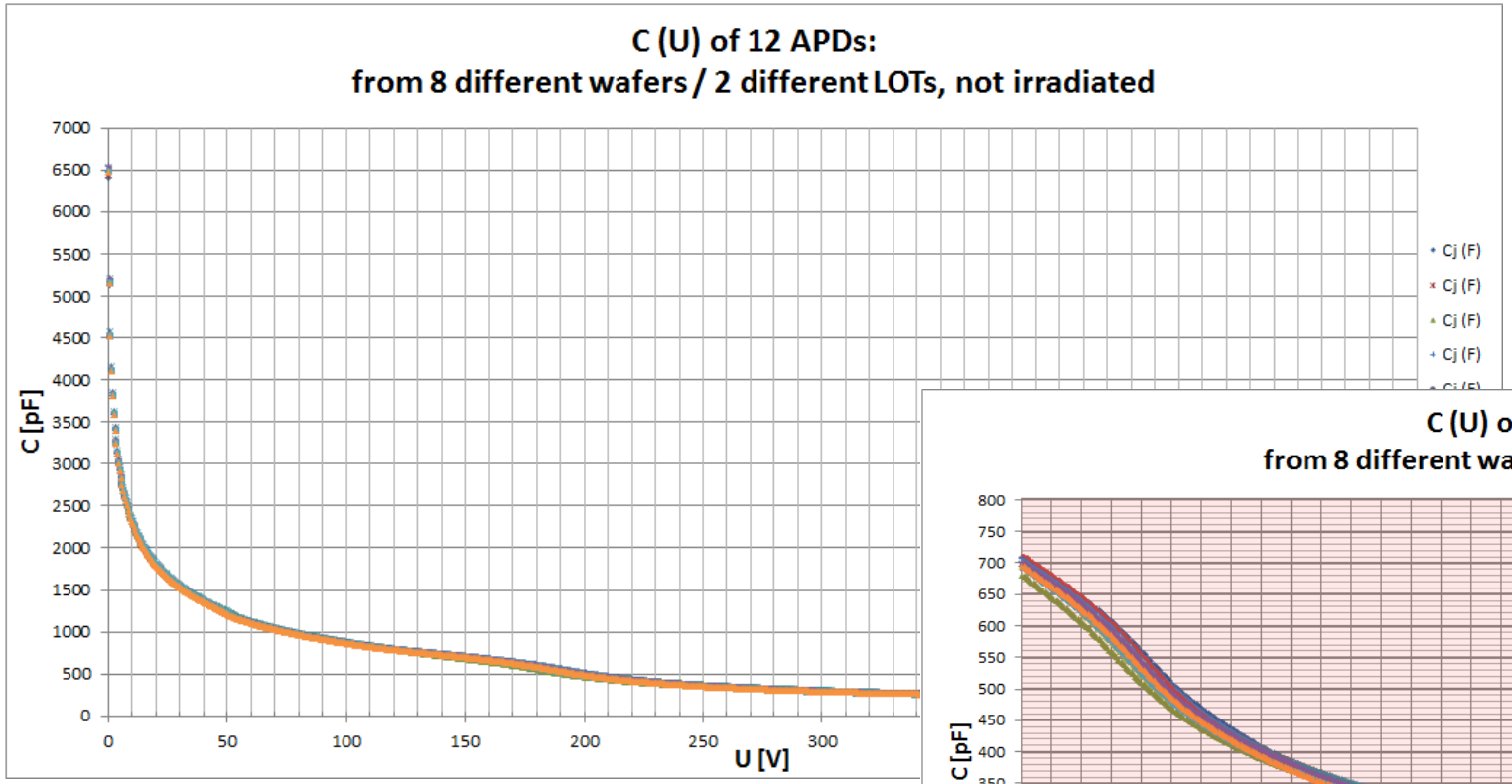
What could capacitance measurements be used for?

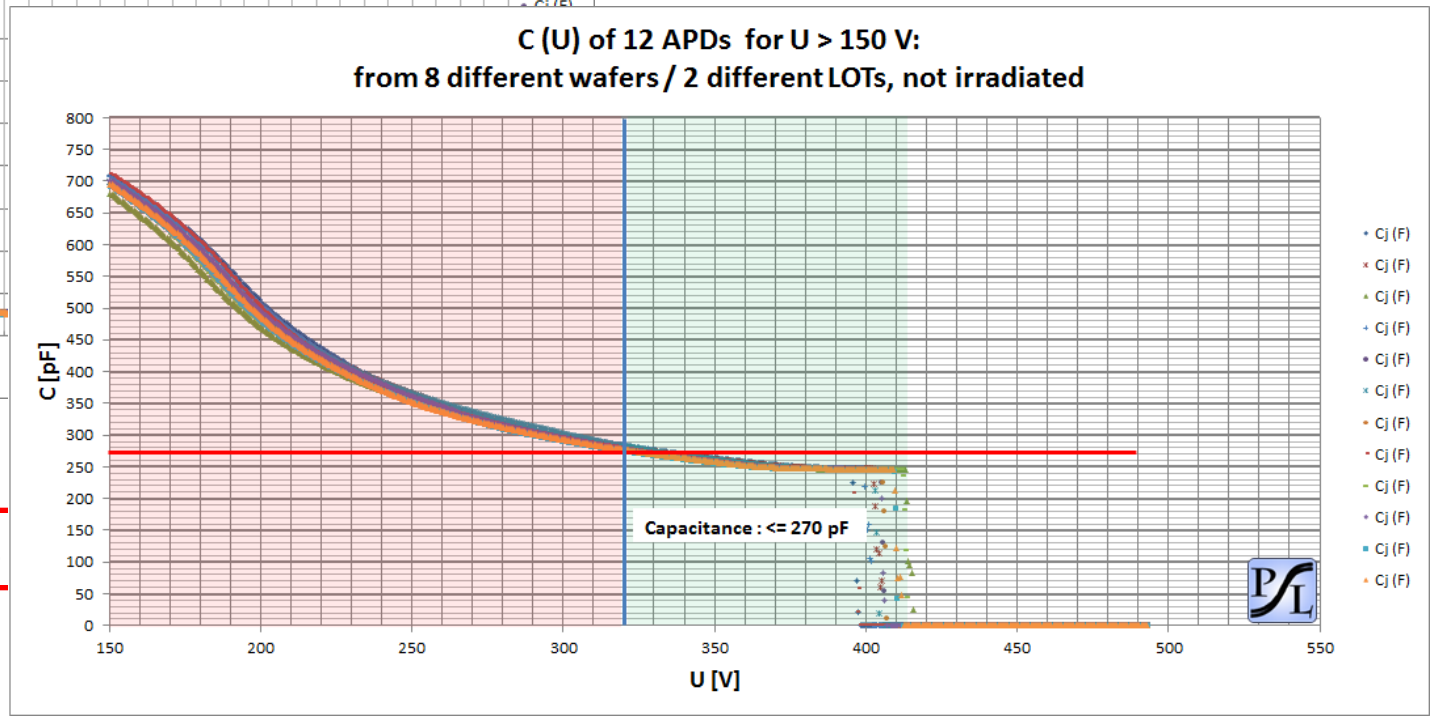
- Determination of Capacitance @ M = 50 (Quality Assurance)
- Determination of full depletion voltage U_{FD}
- (Verification of breakdown condition (U_{Br}) given by manufacturer: $U_{br} \stackrel{def}{=} U_{bias}$ @ I_d = 100 µA)
- Extraction of doping profile

Technical specifications at 20 °C:

max. Terminal capacitance @ M = 50 and with f = 100 kHz: $C \leq 270$ pF

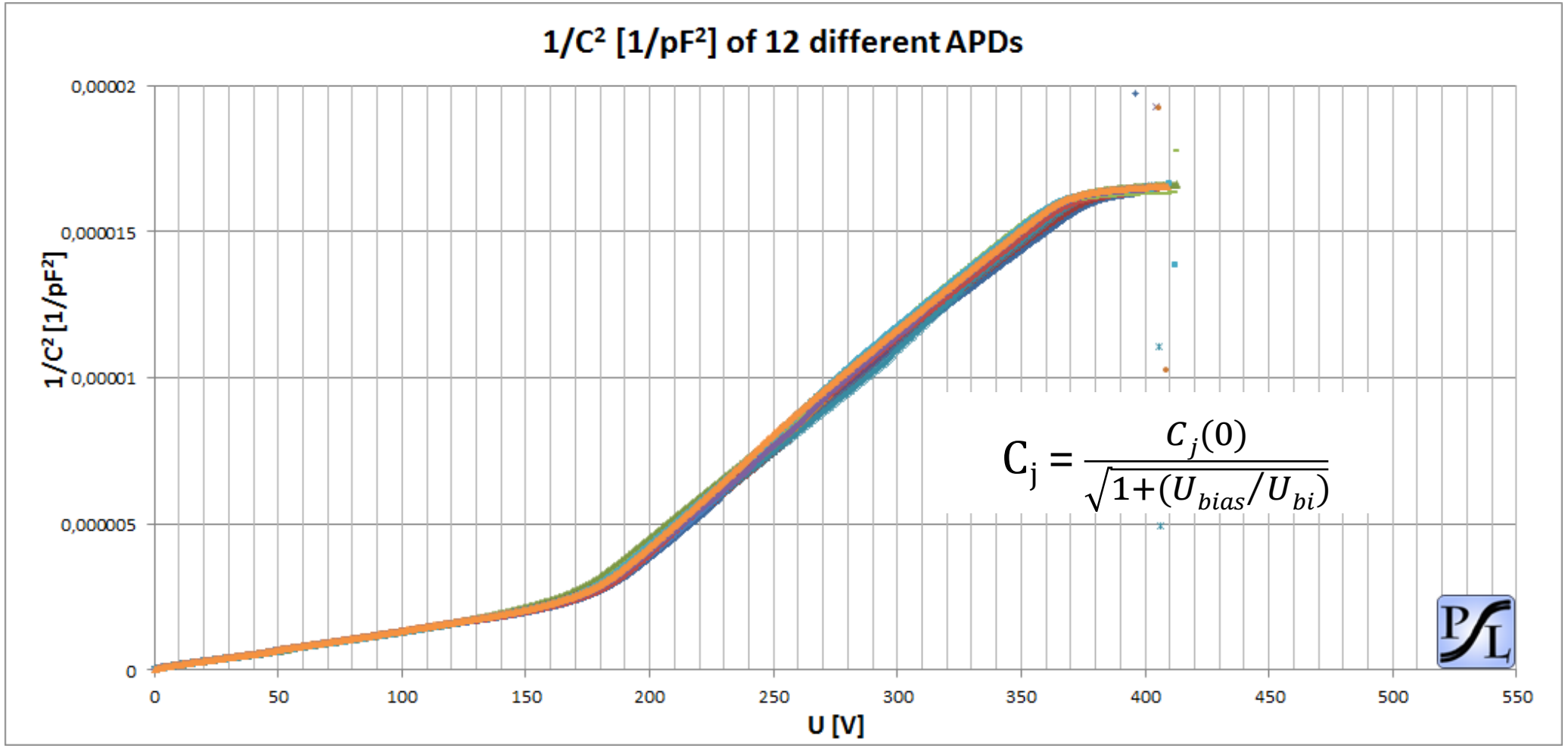
Capacitance measurements



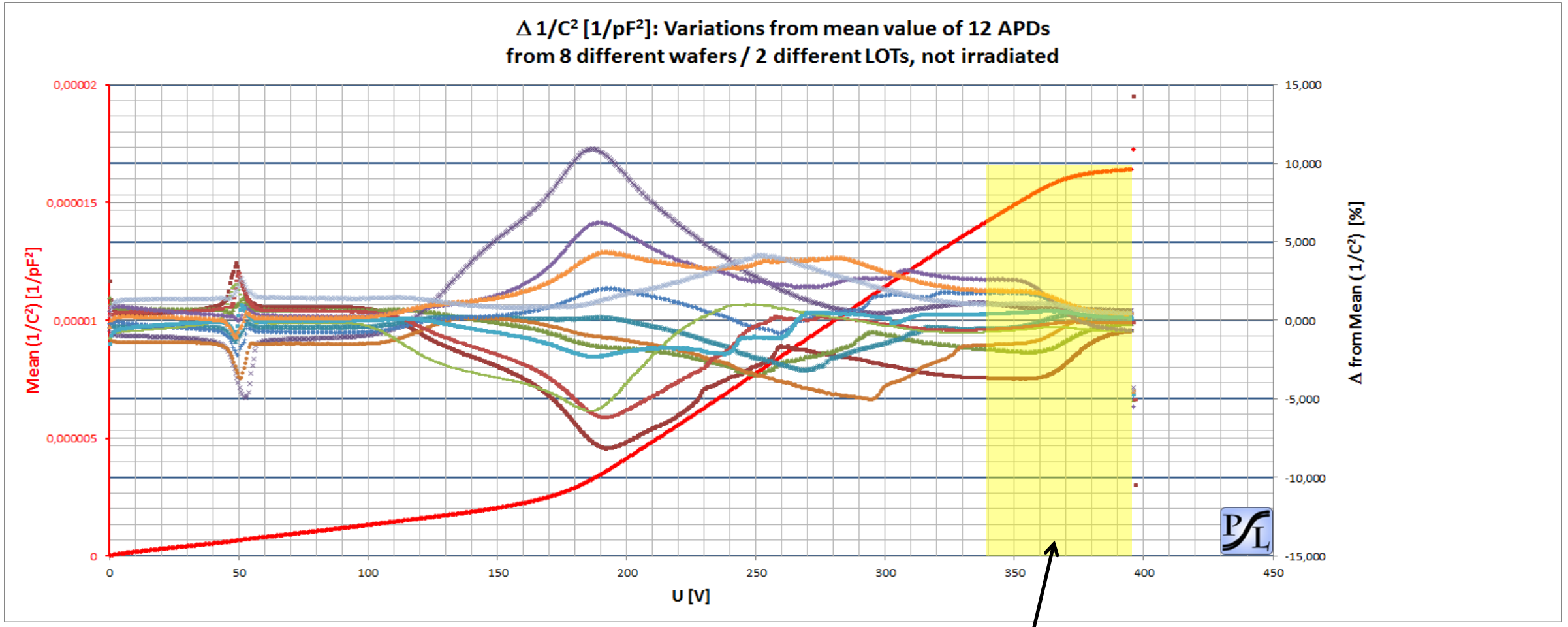


Different U_{br}

Capacitance measurements



Capacitance measurements



Bias voltage area used

Full depletion

Two different methods of APD gain determination (without using radioactive sources) are possible:
continous and pulsed light illumination

We know already:

A reference value for gain normalization between these two methods is needed

Therefore:

The individual full depletion voltage of each APD should be used as reference point for this investigation.

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
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Characterization of avalanche photodiodes for calorimetry applications

A. Karar[a], Y. Musienko[b,1], J.Ch. Vanel[a,*]

For the calculation of the pulsed light gain measured with an LED pulse, the value of the gain measured with continuous light at the bias where the APD is fully depleted is used as a reference. The gain measured with the pulsed LED light at higher bias coincides within 1.5% accuracy with the values found using continuous light (Fig. 7).

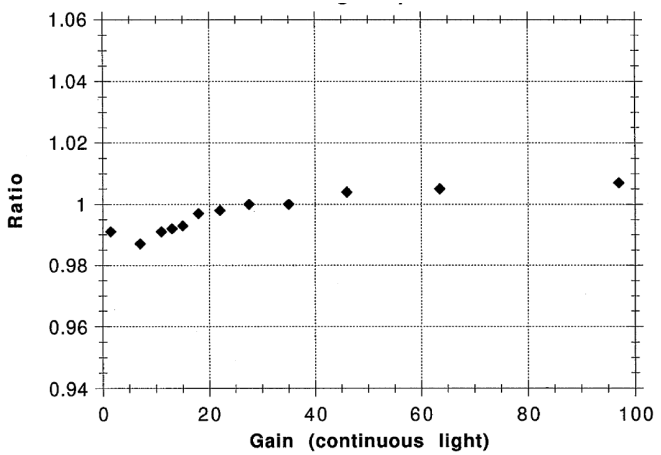
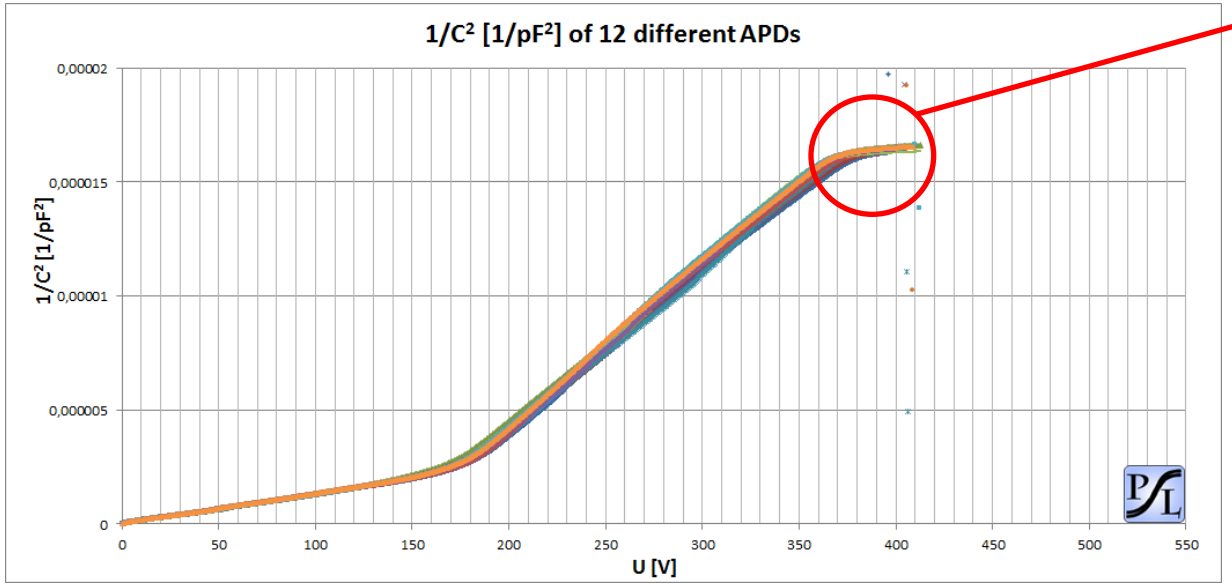
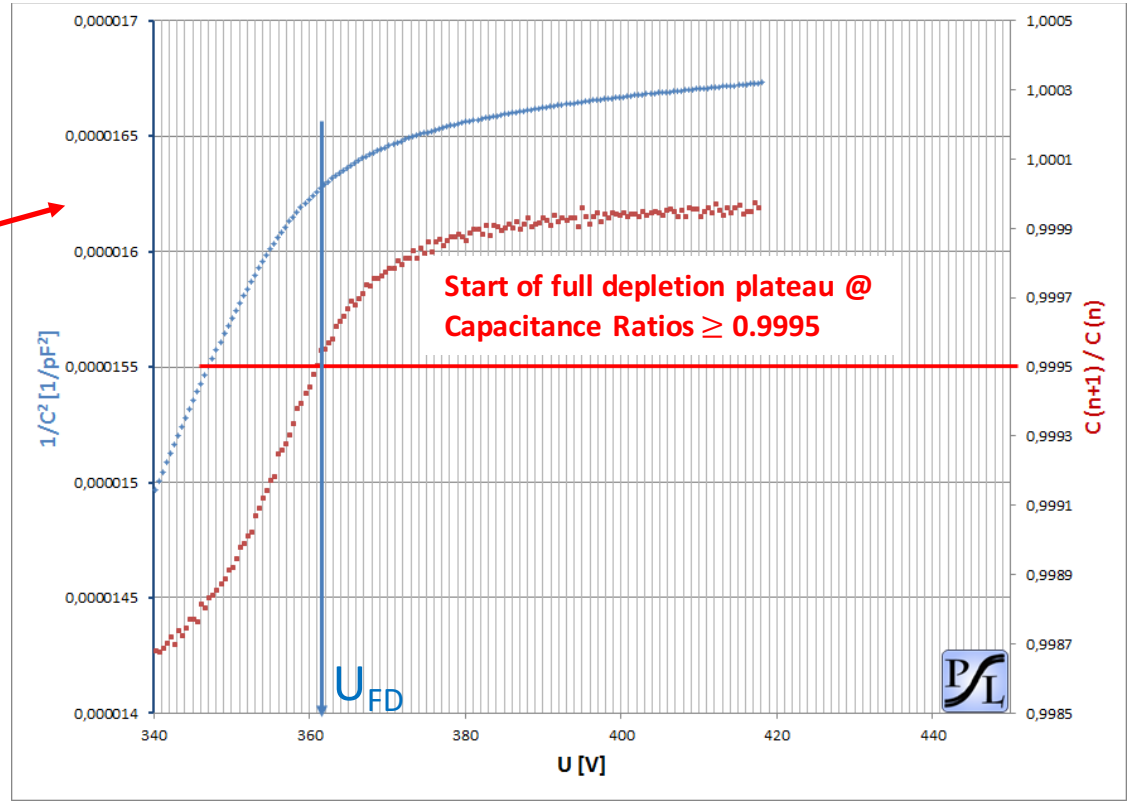


Figure 7

Full depletion

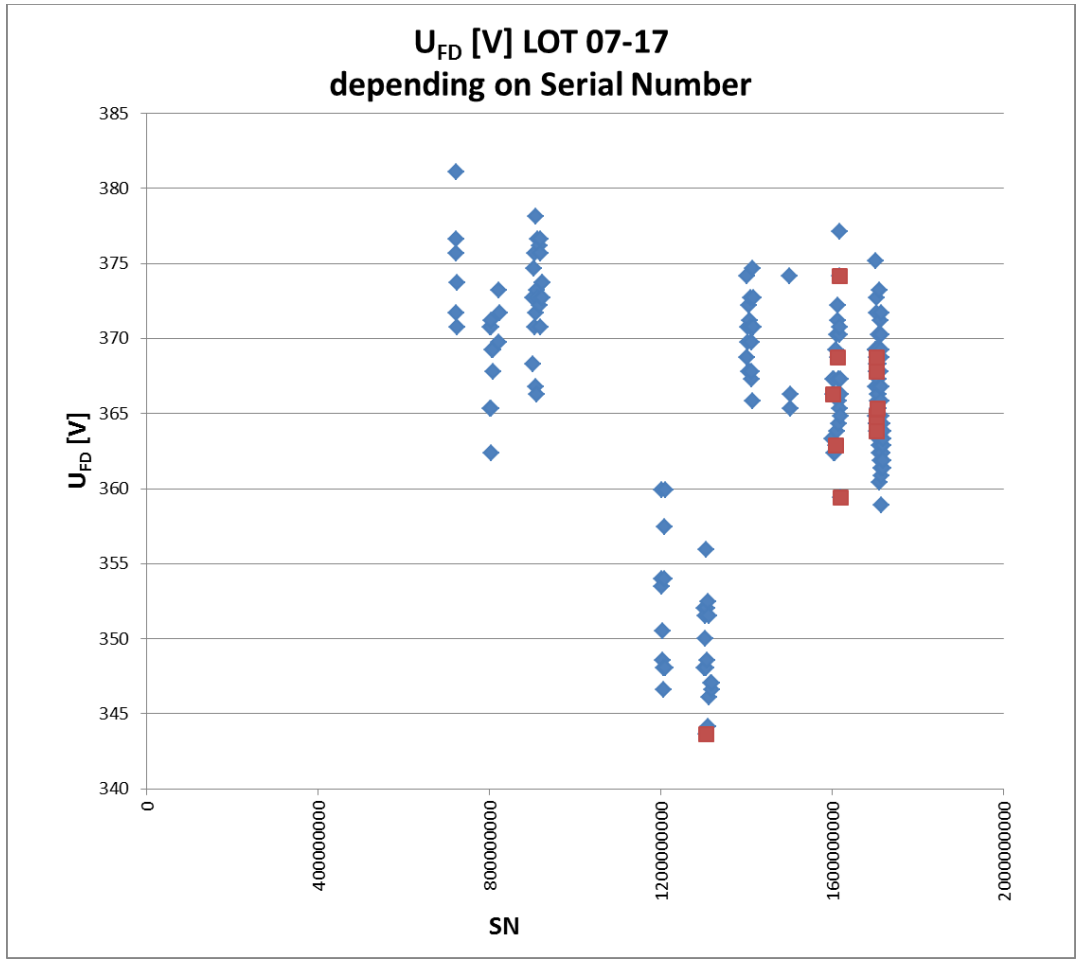
Determination of full depletion voltage U_{FD}

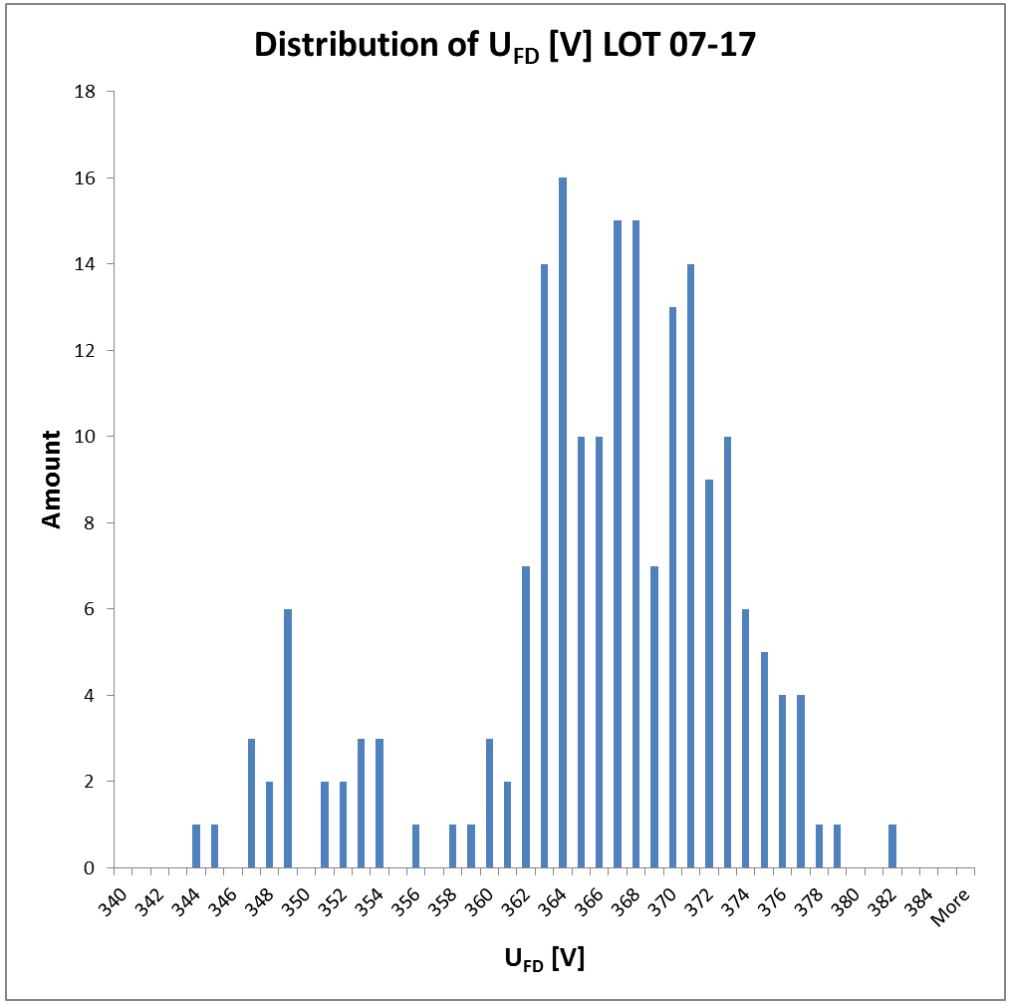




Full depletion

194 APD samples measured so far

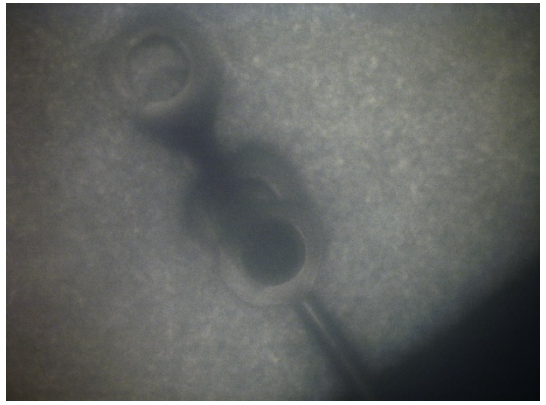




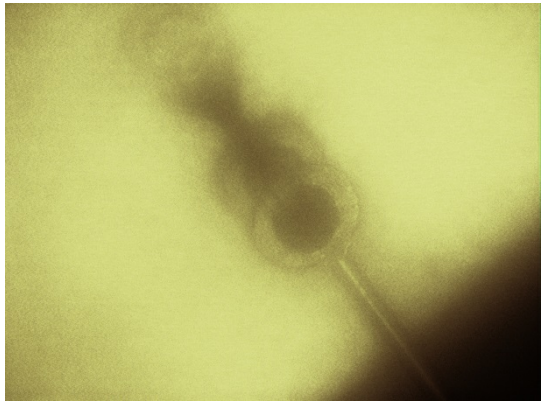
Full depletion

„Ground“ bonding:

SN 1305103897

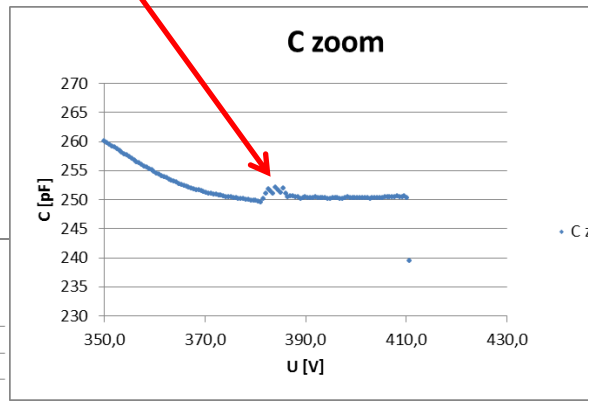


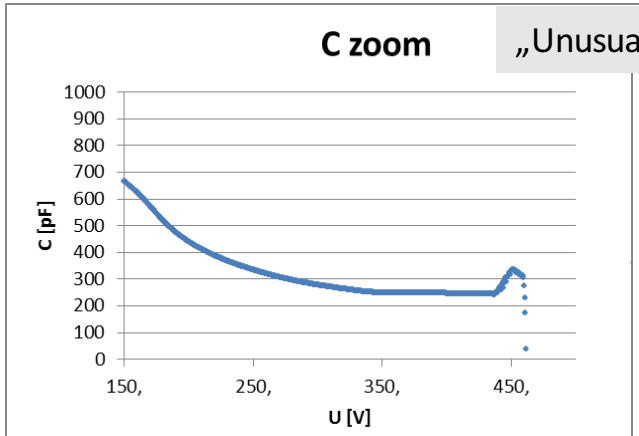
SN 1703018749



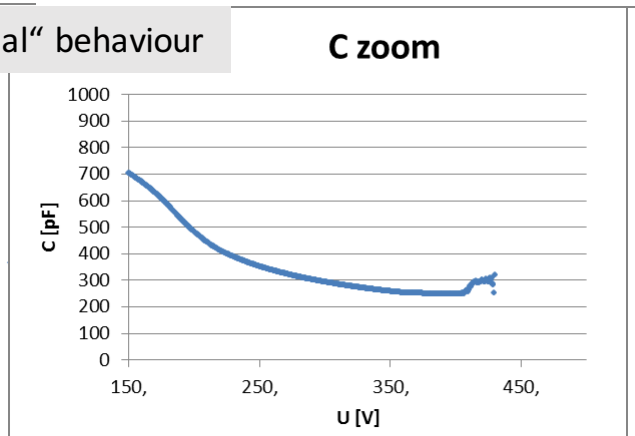
SN 1715019518

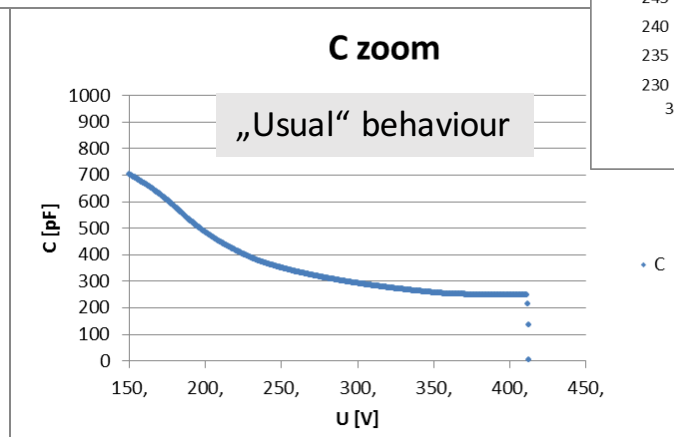
APD outside specs, reached us by accident, not part of delivery





„Unusual“ behaviour



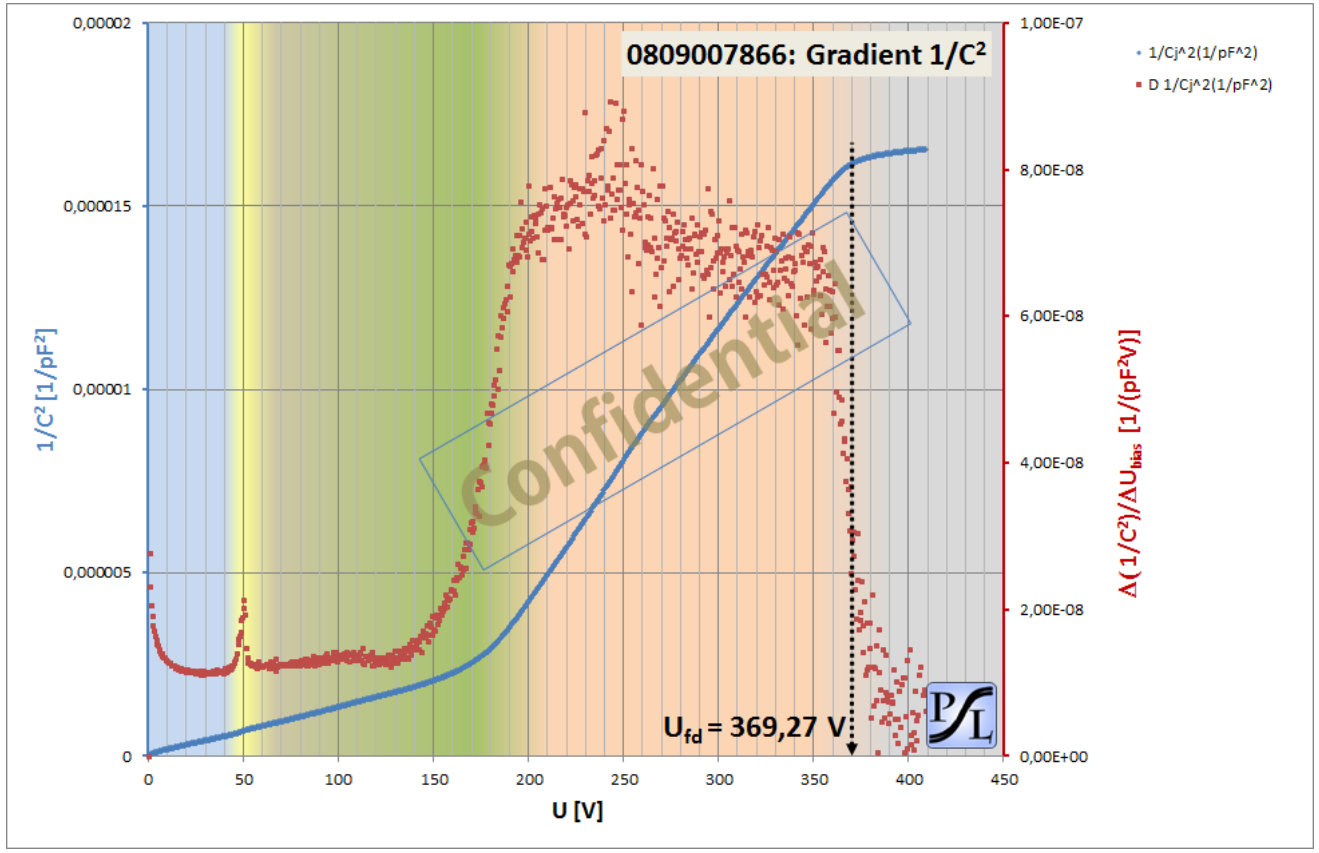


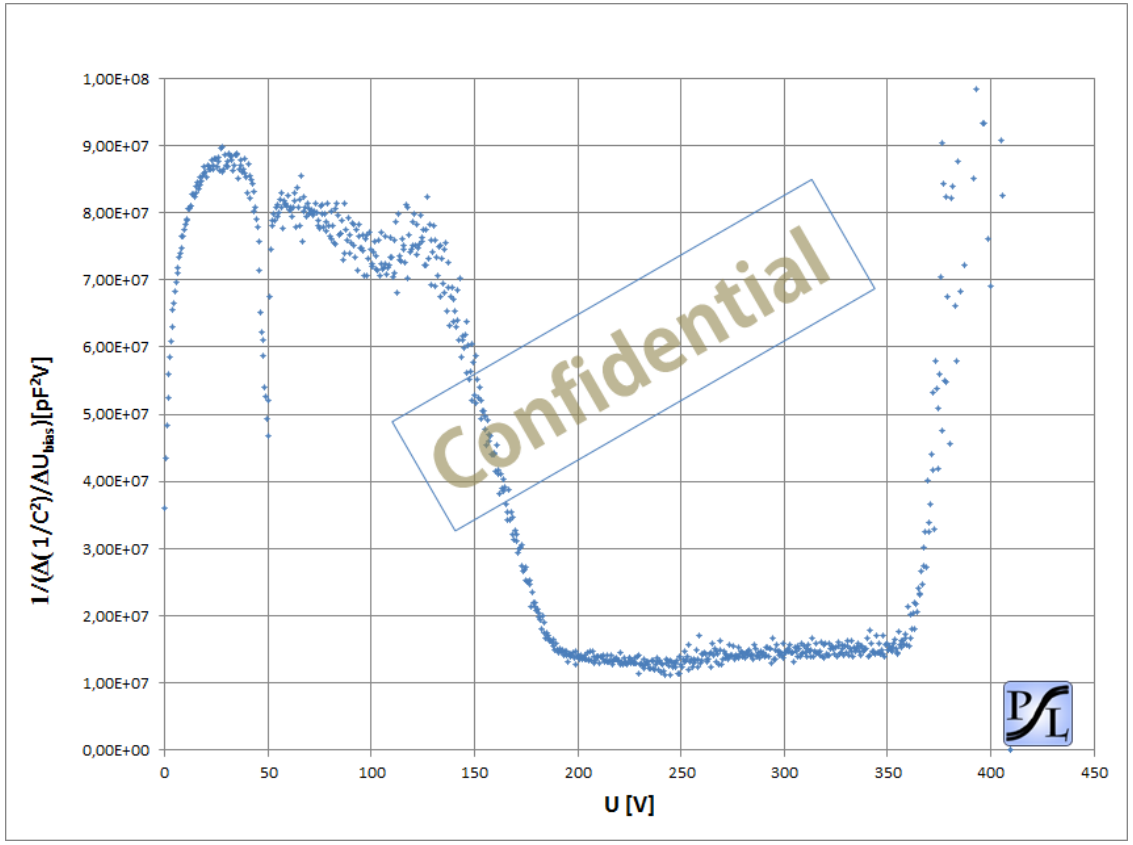
All of them inside techn. specs.

Doping profile

$$\frac{\partial(1/C^2)}{\partial U}$$

$$N \sim \frac{Const.}{\frac{\partial(1/C^2)}{\partial U}}$$





Doping profile

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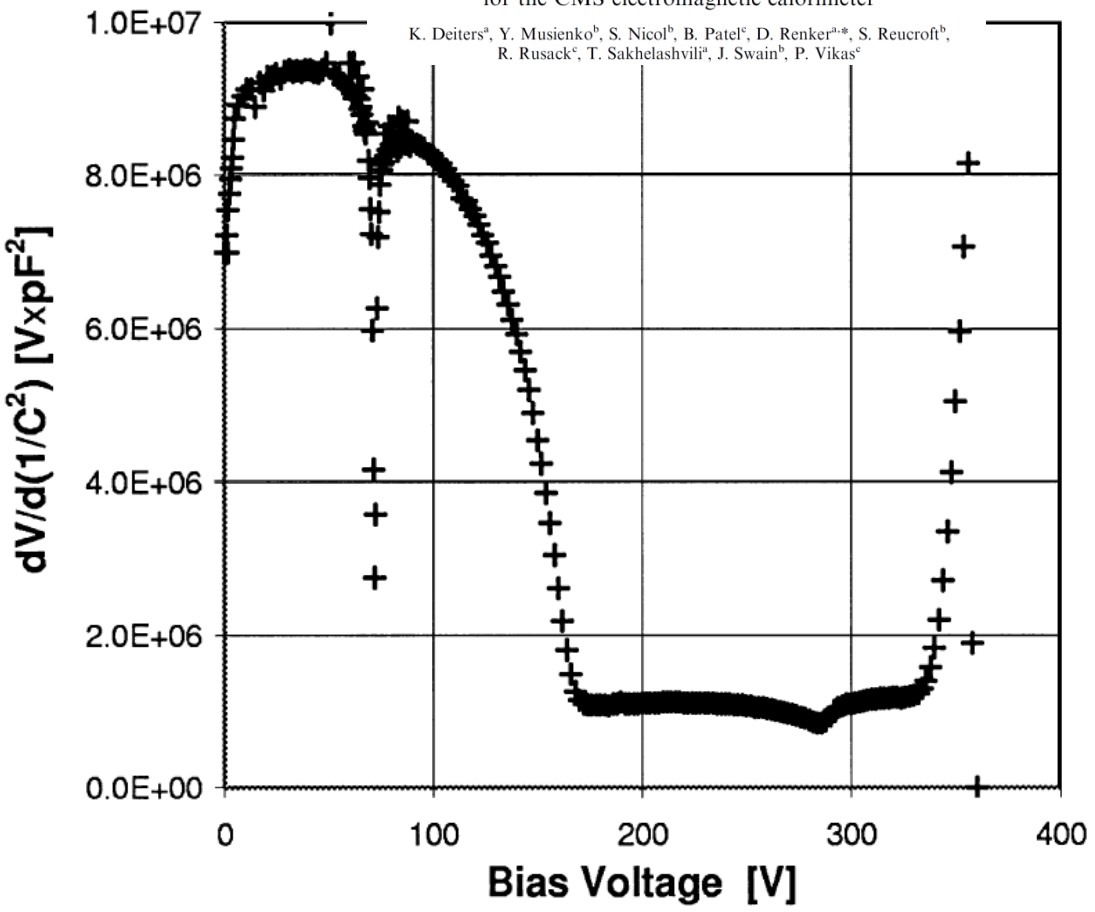
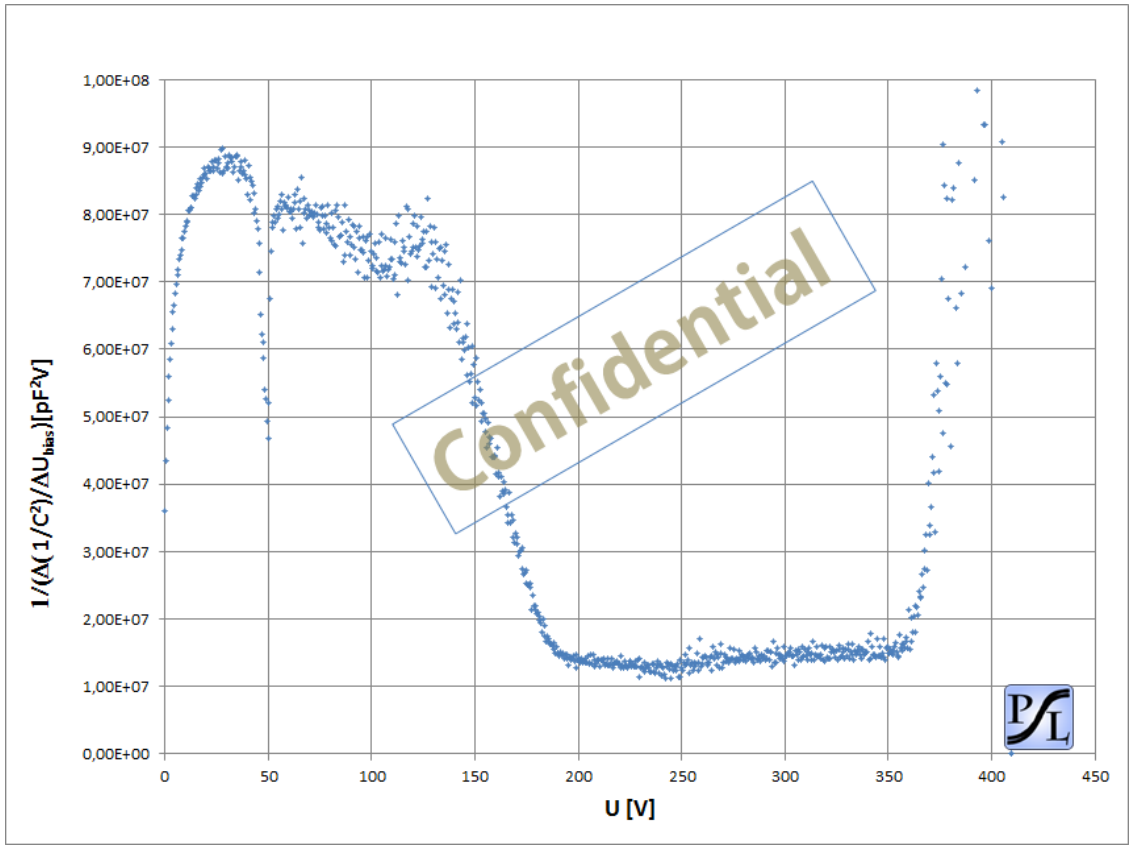
Properties of the most recent avalanche photodiodes for the CMS electromagnetic calorimeter

K. Deiters[a], Y. Musienko[b], S. Nicol[b], B. Patel[c], D. Renker[a,*], S. Reucroft[b], R. Rusack[c], T. Sakhelashvili[a], J. Swain[b], P. Vikas[c]





Summary:

- Capacitance measurements ongoing (Lot 07-Lot 17 finished)
- ALL Capacitances measured so far are inside techn. specs.
- Unusual behaviour of individual APDs above Breakdown under investigation
- Capacitance variances inside regime of operation in the order of ± 2 %
- Full depletion voltages determined in addition: Mean value at ~370 V (using a fixed boundary condition for the capacitance ratio)
- Doping profiles extracted for each APD passing the Capacitance determination cycle (~ 200 doping profiles available)
- Doping profiles in very good agreement with CMS APD: nearly identical internal structure
- overall screening status: further ~6000 APDs pre-validated @ T = -25 °C -> in pipe for final validation, all APDs (with available MoU) passed the first screening cycle, MoU with Mainz signed last month