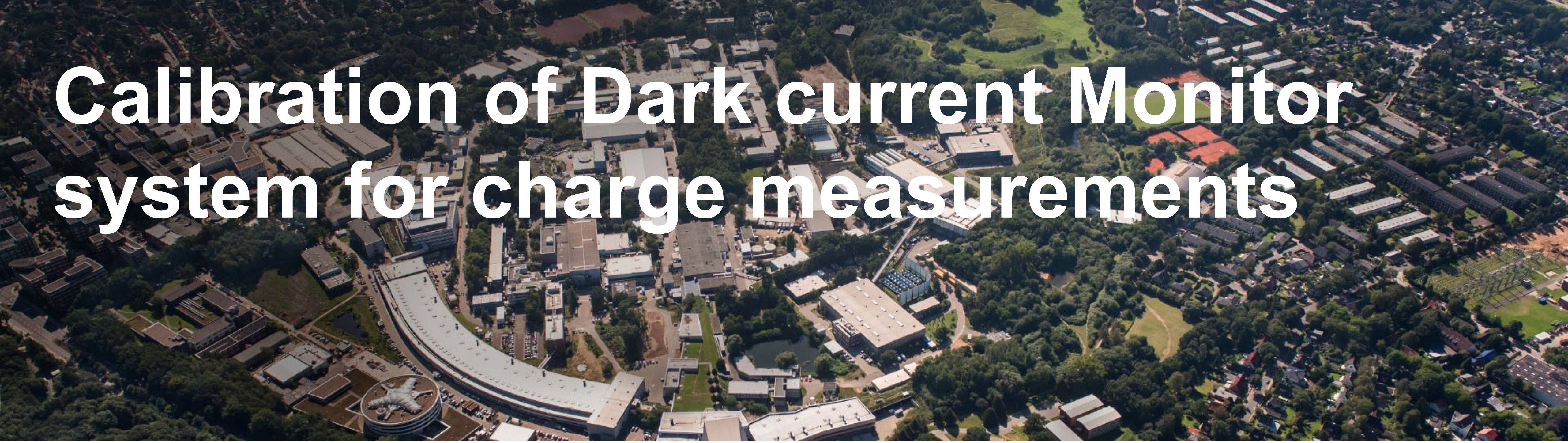

Calibration of Dark current Monitor system for charge measurements

D. Lipka, T. Lensch, M. Werner, R. Neumann
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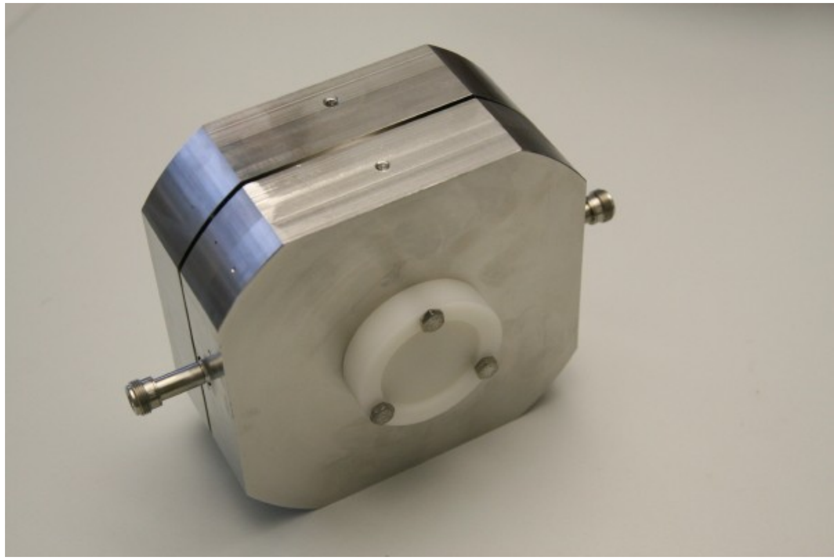
Overview

Dark current Monitor (DaMon) is used for bunch charge measurements

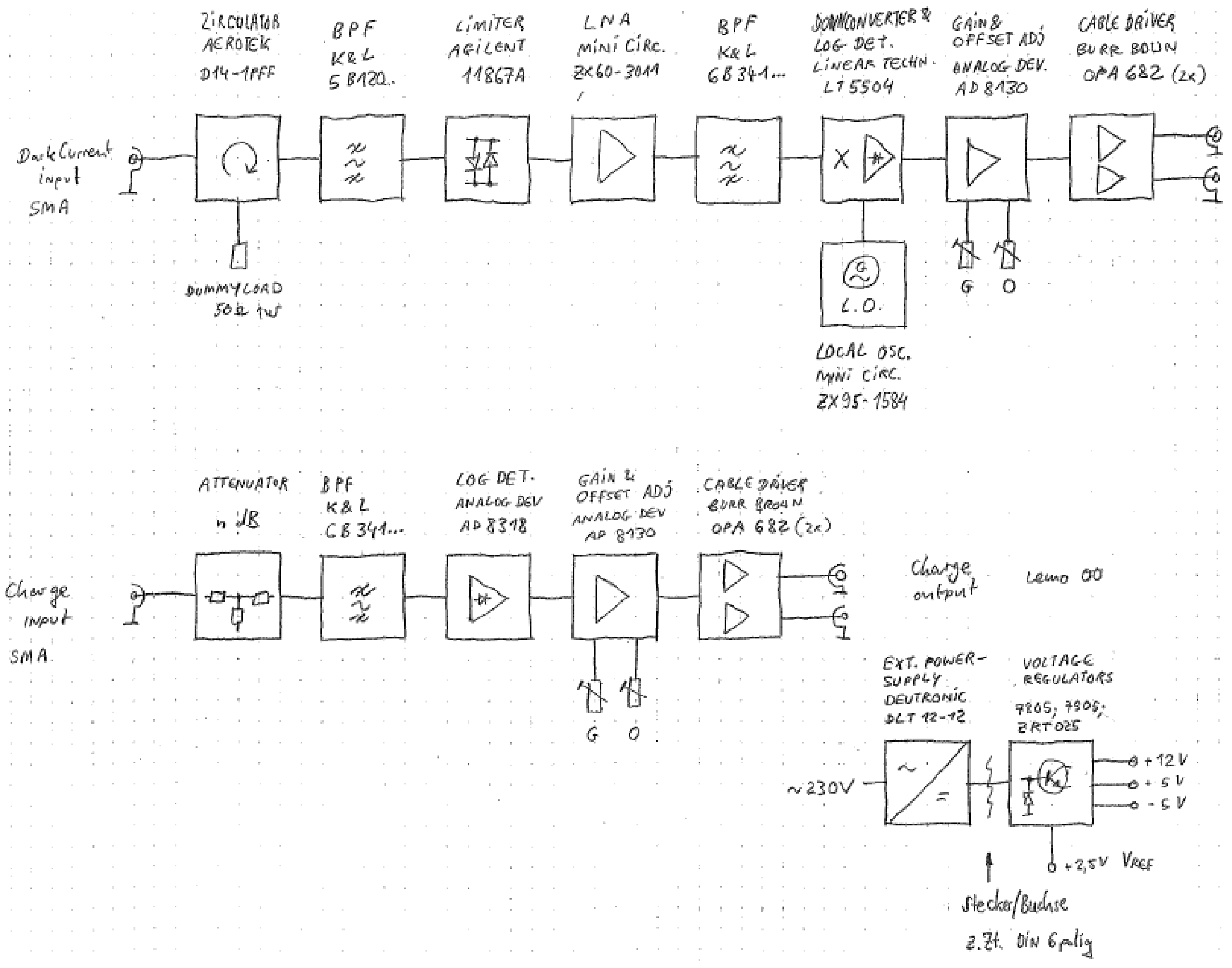
- System consist of DaMon monitor with 1.3 GHz monopole mode resonance
- For dark current measurement (DC) the resonance is amplified due to superimposing several bunches: dark current rep. rate = 1/1.3GHz ~= 0.77 ns, resonance decay time 50 ns.
- This channel is used for accelerators without 1.3 GHz acceleration frequency for bunch charge measurements
- Additional charge channel provided of the electronics



DaMon electronics and calibration

Two different channels

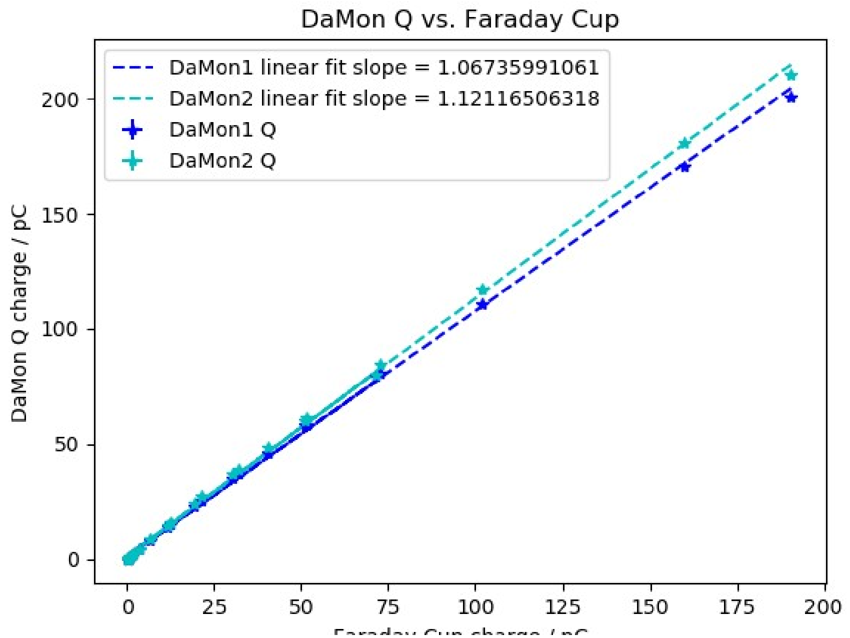
- Both channels uses bandpass filters and logarithmic detectors
- Difference between DC and charge channel: a down converter is used with local clock
- The electronics is measured by using a CW 1.3 GHz input amplitude and the output is monitored
- The data are used together with cable attenuation and resonator properties to calculate from the ADC amplitude back to bunch charge and dark current provided in look-up tables
- For charge measurement with the DC channel a beam based calibration factor was observed

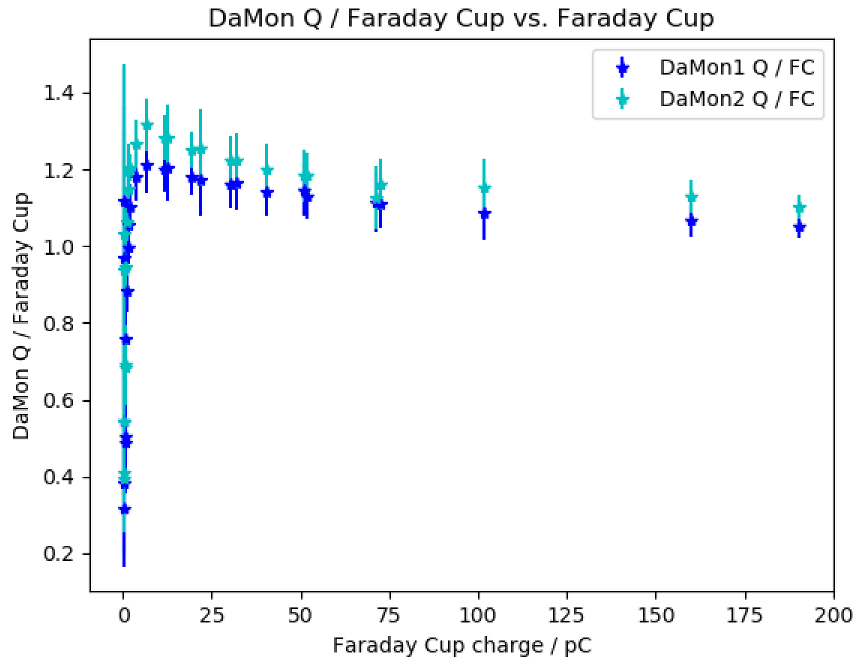


Old charge Measurement at ARES

Charge channel in comparison with Faraday Cup

- Plot above: the charges of two DaMons charge channels are shown as a function of Faraday Cup charges. Faraday data are proven with ICT and T-ICT and are in agreement to each other within 1%
- DaMons show higher charges of about 7 and 12%
- The lower plot shows the ratio of DaMon and Faraday Cup charges as a function of Faraday Cup charge
- A non-linearity is visible for charges below 100 pC, below 2 pC the sensitivity of the DaMon charge channel is low therefore the ratio shows low values
- This can be corrected with a 4th order polynomial but this only is applicable for the measured charge range. For higher charges this correction will overestimate the charge. Therefore this correction is not implemented.

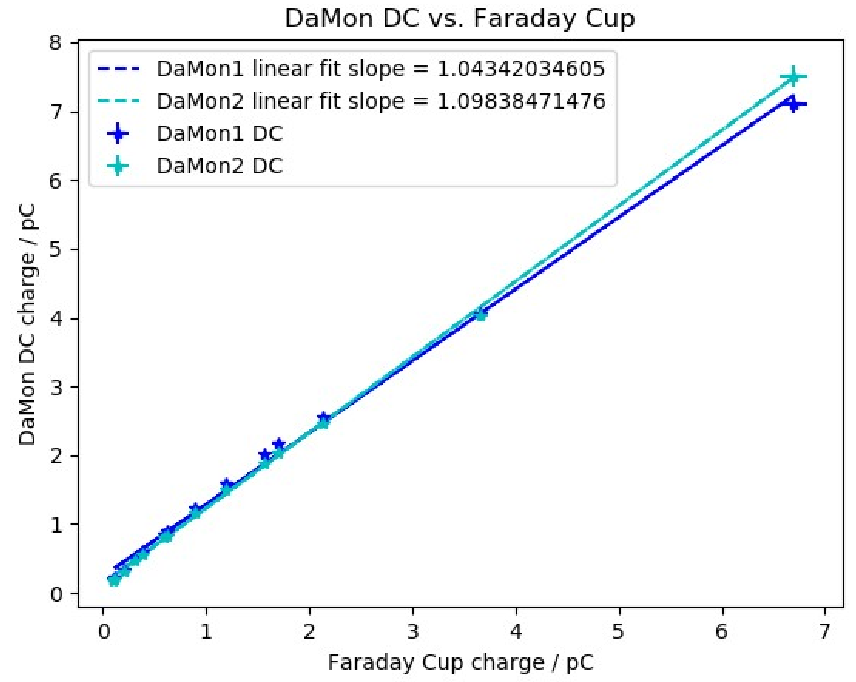


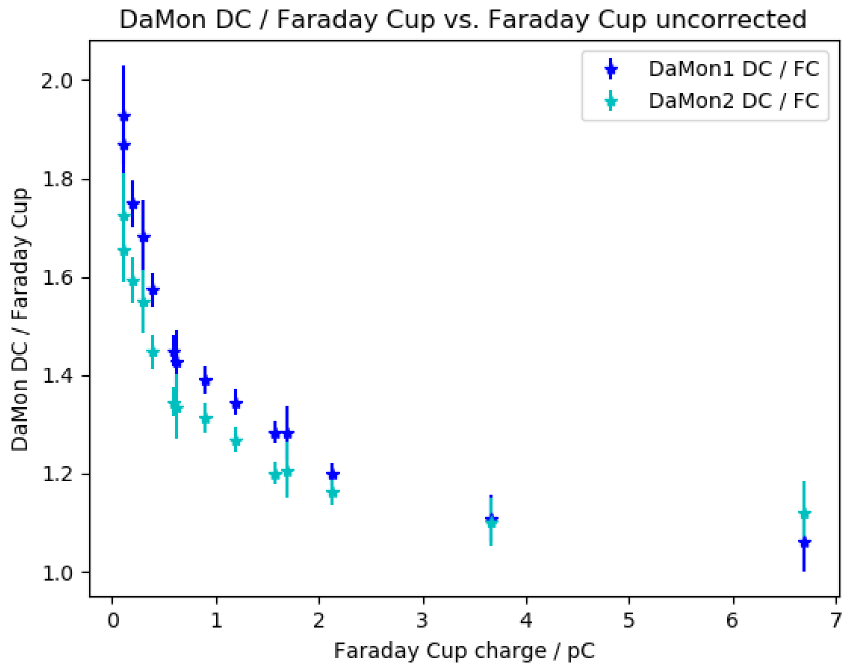


Old charge Measurement at ARES

DC channel in comparison with Faraday Cup

- This channel is intended to provide the bunch charges for low values for accelerators without 1.3 GHz system
- Measurement of charge restricted to 10 pC
- Below 1 pC the charge is overestimated by almost factor 2
- Correction with polynomial 3rd order possible (not implemented), but would only suitable for the specific DaMon channel

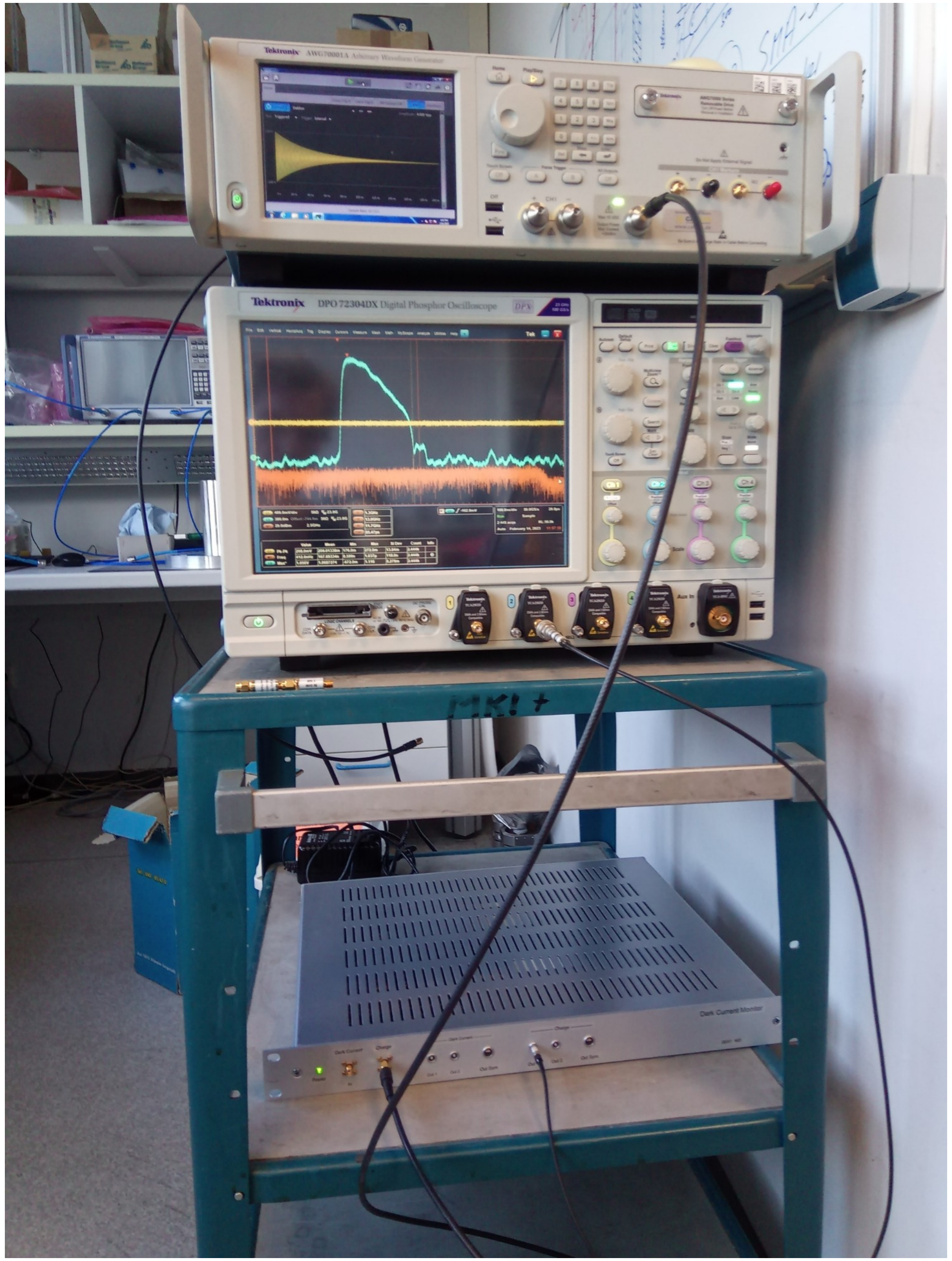




Electronics response function

Measurement with CW and pulsed signal

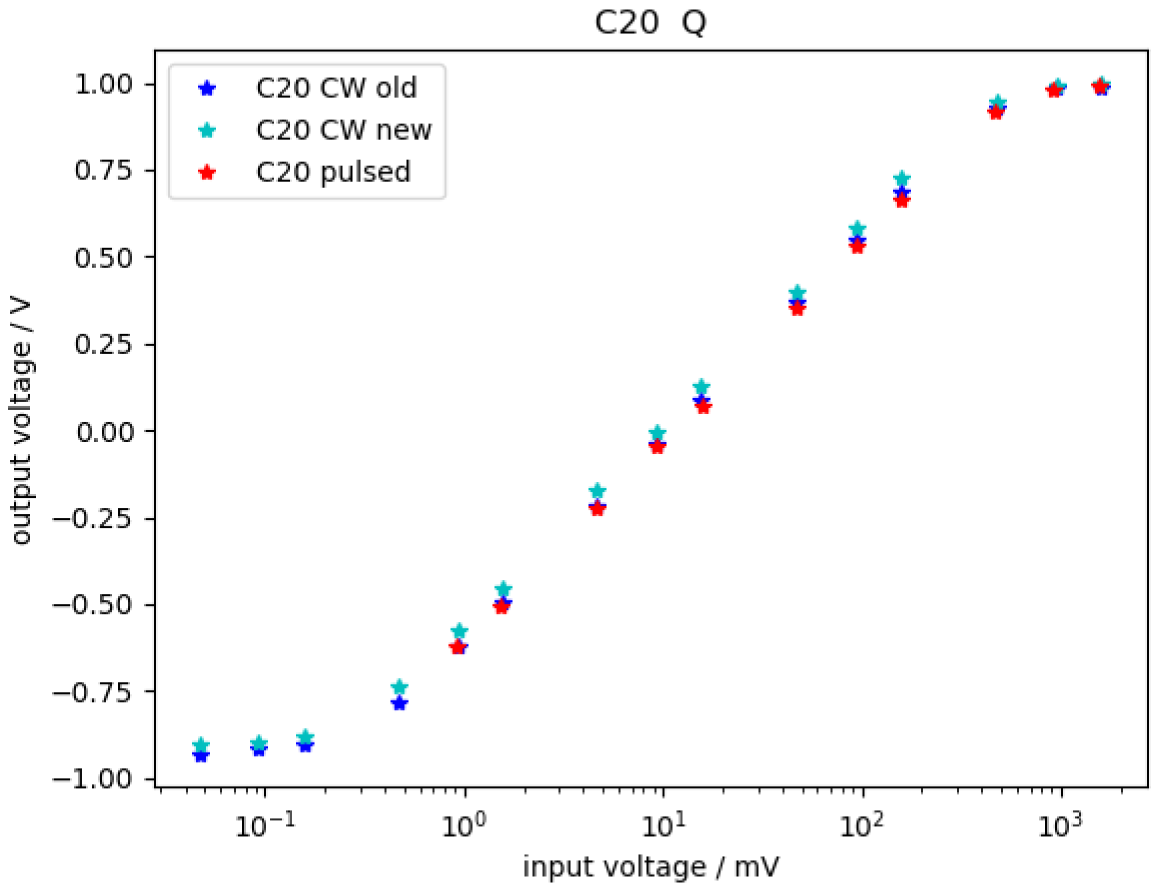
- Up to now the electronics response function is measured with a CW signal generator. The number of data points are increased by a factor of about 4 last year, but the non-linearities are still visible
- The DaMon delivers a short ringing signal with decay time of about 50 ns which is different compared to a CW signal. This could address different parts of the logarithmic detector and therefore end with a different calibration of pulsed signals
- Idea: compare CW and pulsed electronics response function
- Setup: Arbitrary waveform generator monitored with 8 bit oscilloscope 23 GHz, averaged



Electronics response function from laboratory measurements

Electronics serial number C20

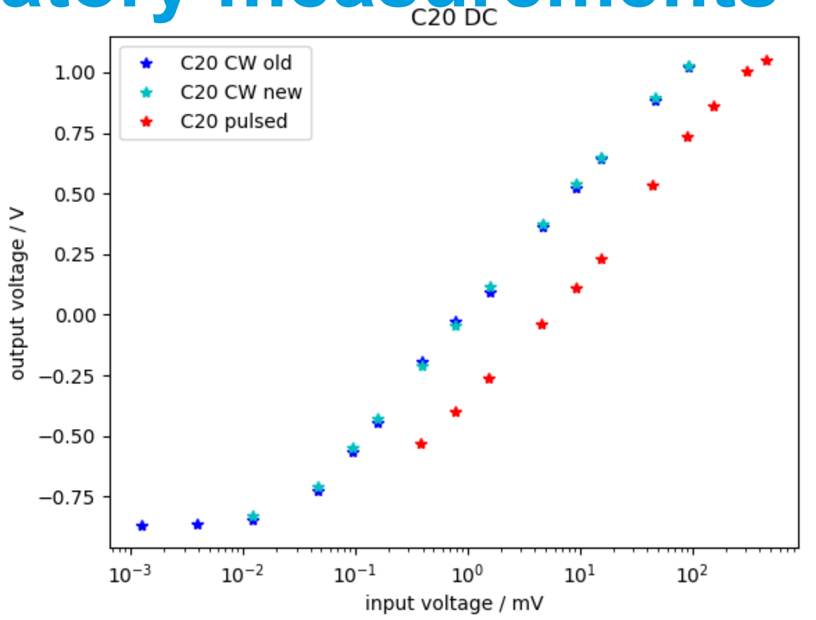
- Charge channel shown for
  - Old measurement with another signal generator in CW and multimeter, does not measure the peak it measures the mean of the DC voltage which is lower compared to the peak
  - New measurement with AWG and CW and scope and peak voltage
  - New measurement with AWG and pulsed signal, below 0.9 mV input amplitude the noise was higher compared to the signal
- All three measurements agree to each other

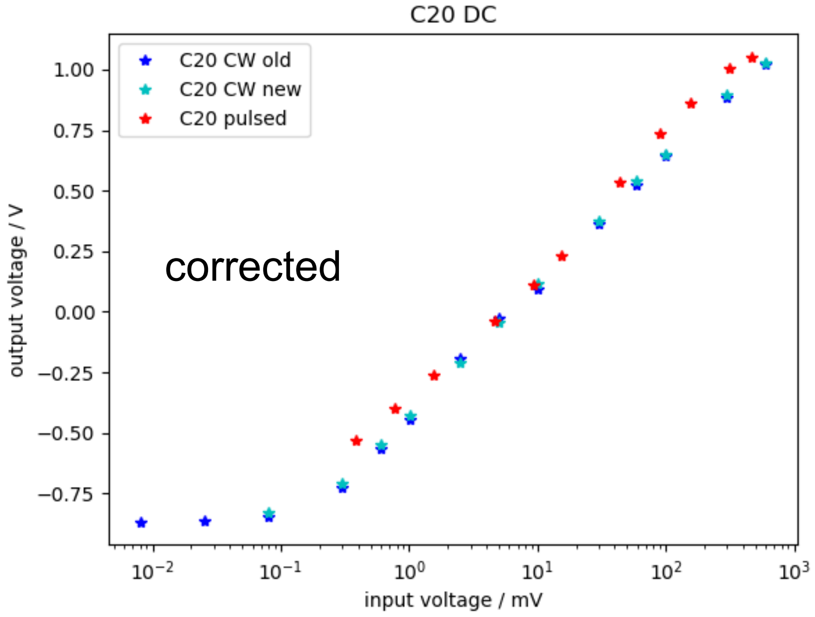


Electronics response function from laboratory measurements

Electronics serial number C20

- DC channel shown for
  - Old measurement with another signal generator in CW
  - New measurement with AWG and CW
  - New measurement with AWG and pulsed signal, below 0.3 mV input amplitude the noise was higher compared to the signal
- The pulsed signal input need higher amplitude to reach the same output amplitude because due to the short pulse a smaller superimpose effect is happen
- The corrected diagram shows the shifted CW data by the beam based calibration data, in this case all three agree to each other
- For lower amplitudes a trend for a disagreement could be possible, therefore access to lower amplitudes is necessary





AWG measurement with 16 Bit ADC

To get access to lower amplitude

- The AWG and oscilloscope are moved to ARES and connected to the installed DaMon electronics: 2 systems installed
- AWG and μTCA with ADCs are triggered by machine timing system

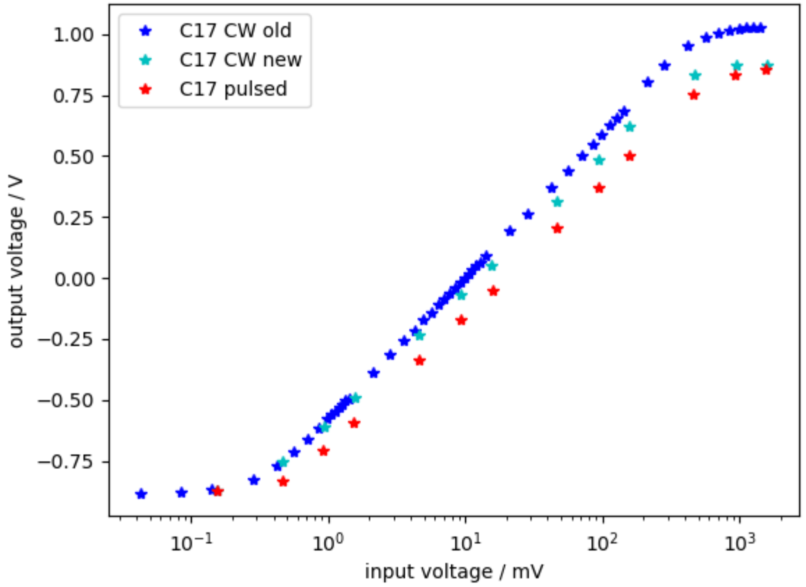
New electronics response function at ARES

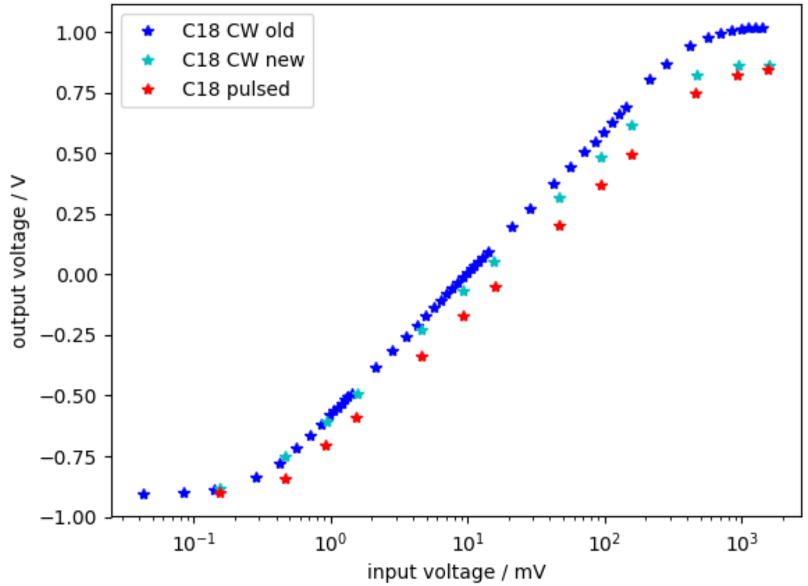
To verify the difference of CW and pulsed calibration of the charge channel

At ARES 2 DaMon systems are installed with electronics serial number C17 and C18

Charge channel:

- Old data with more data points to try to reduce non-linearities
- New CW data in agreement with old data for low amplitudes
- For higher amplitudes the CW data are more different
- A different amplitude for CW and pulsed data visible
- C17 and C18 show similar behavior

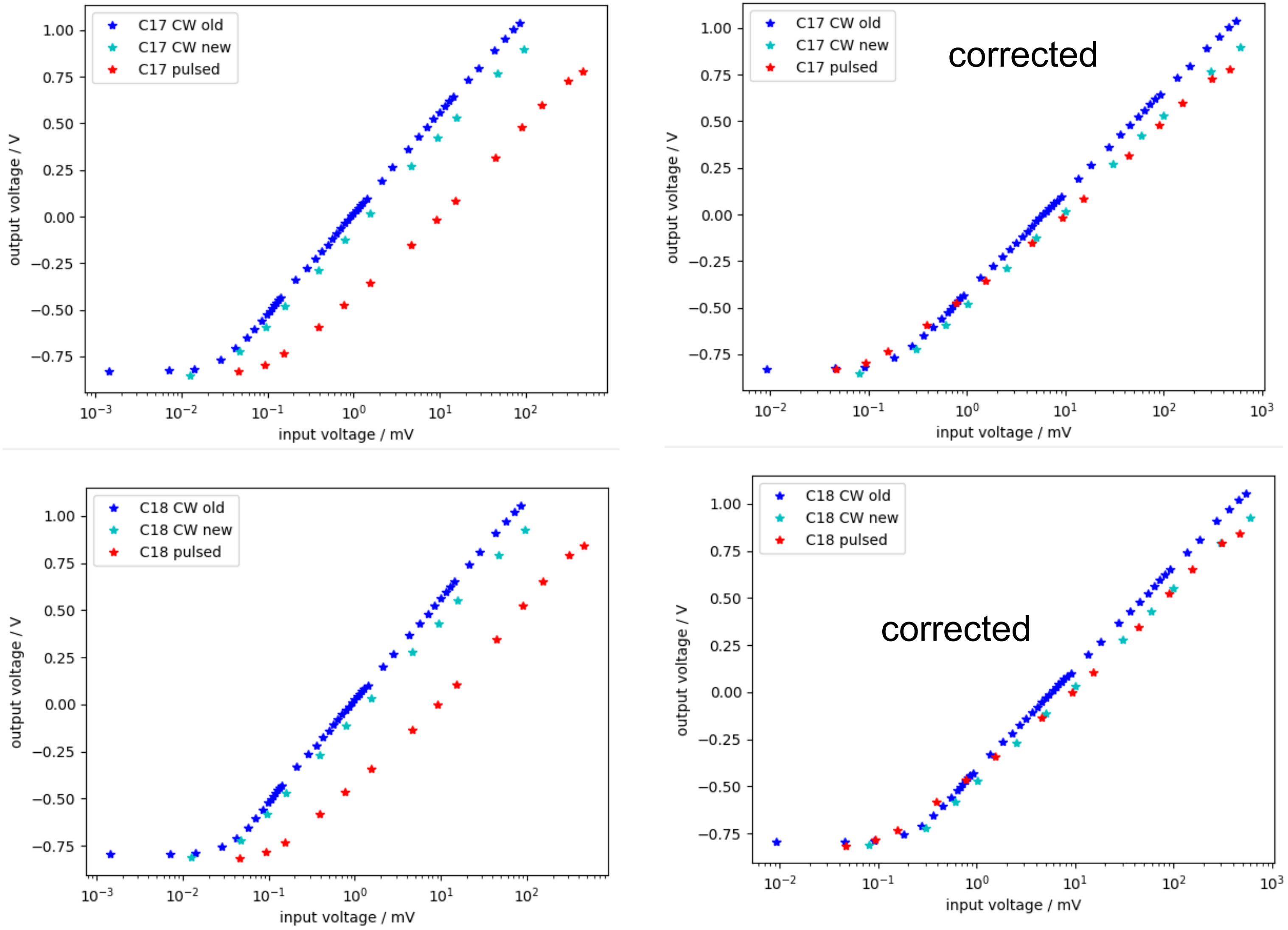




New electronics response function at ARES

DC channel

- Similar behavior for both DaMon systems
- CW old and new show better agreement for low amplitudes
- The linear correction shows good agreement for low amplitudes, for higher amplitudes a difference is visible between CW old and pulsed
- Better agreement between CW new and pulsed
- The differences between old CW and pulsed could be the reason for the non-linear dependency with the beam measurement

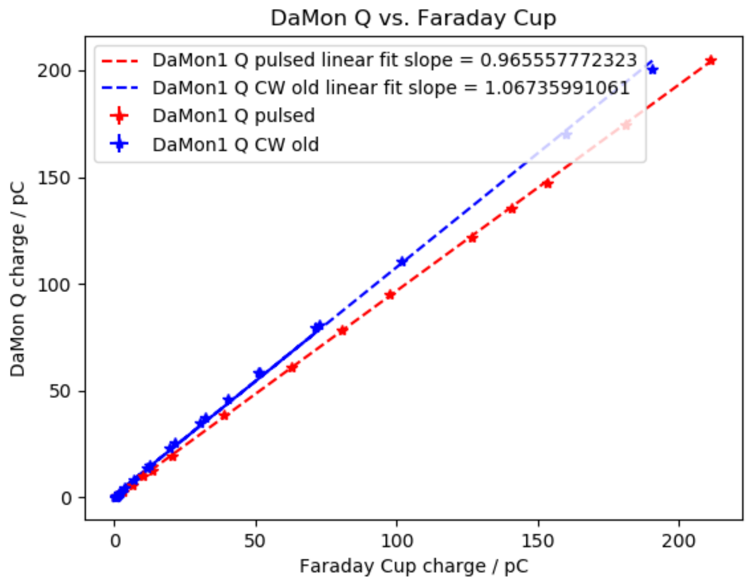


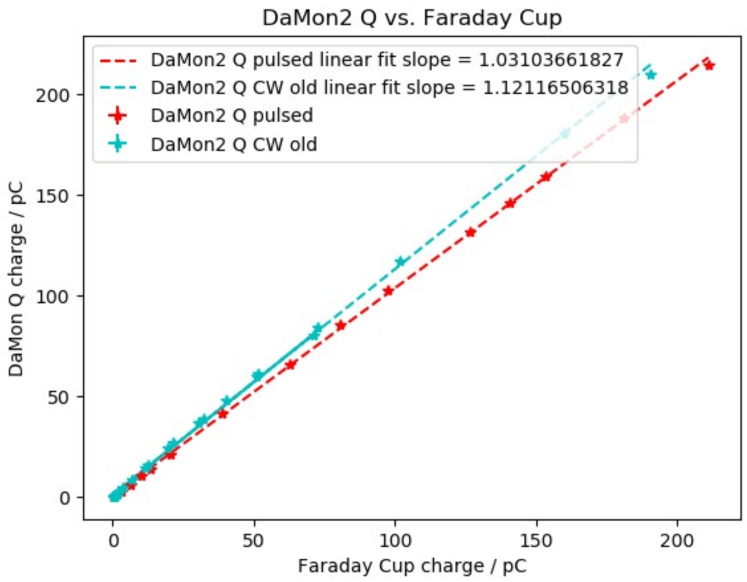
Beam measurement at ARES with new calibration

Using the pulsed electronics response function and provide a new calibration

Here for Charge channel

- New measurement from low charges up to about 210 pC from the Faraday cup
- All calibration factors are removed for the new calibration
- Slopes for both DaMons after new calibration better agreement with Faraday Cup

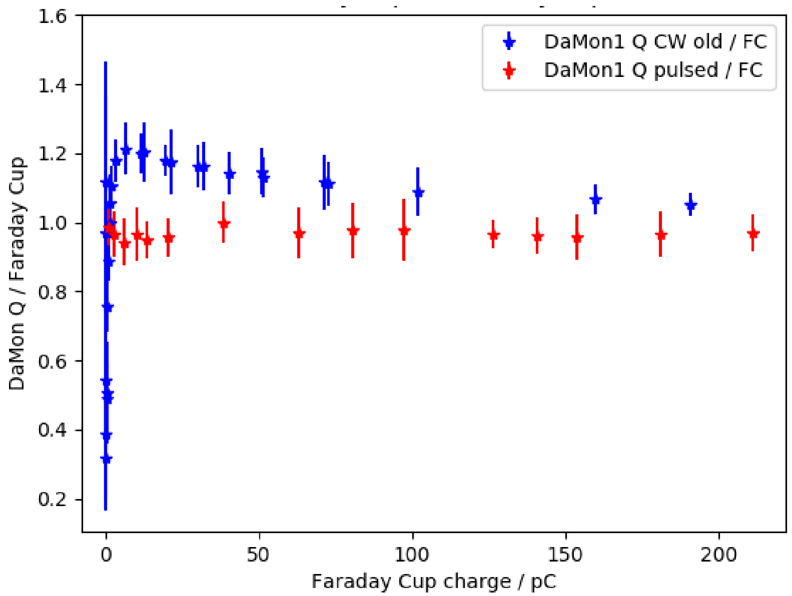


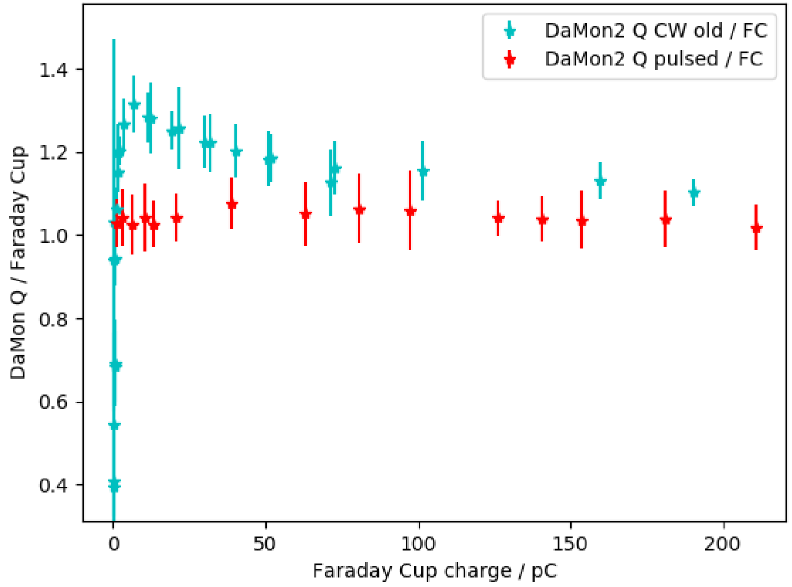


Beam measurement at ARES with new calibration

DaMon charge channel ratio to Faraday Cup

- Error bars are the beam charge jitter
- With the pulsed calibration the non-linearity value deviation is reduced
- Variation from the true value (when Faraday cup values are true) can be reduced from +/-16% to +/-3%
- Much better linearity of pulsed calibration compared to CW calibration

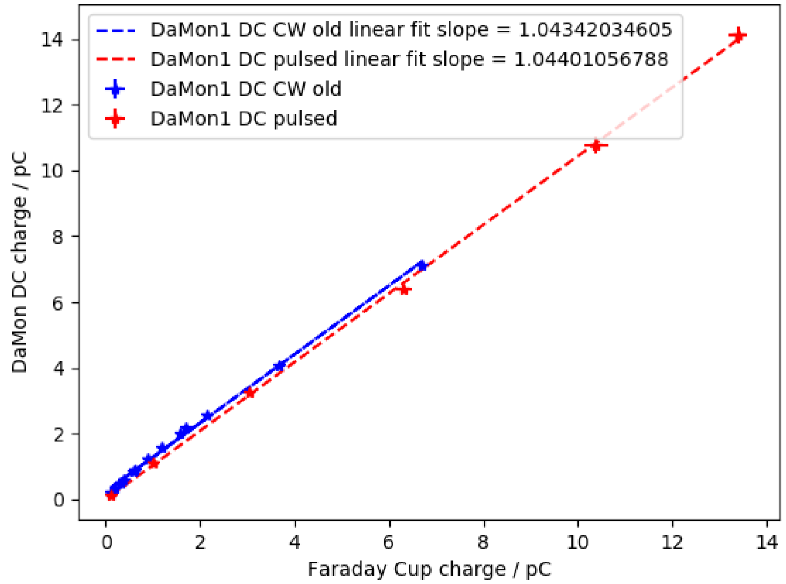


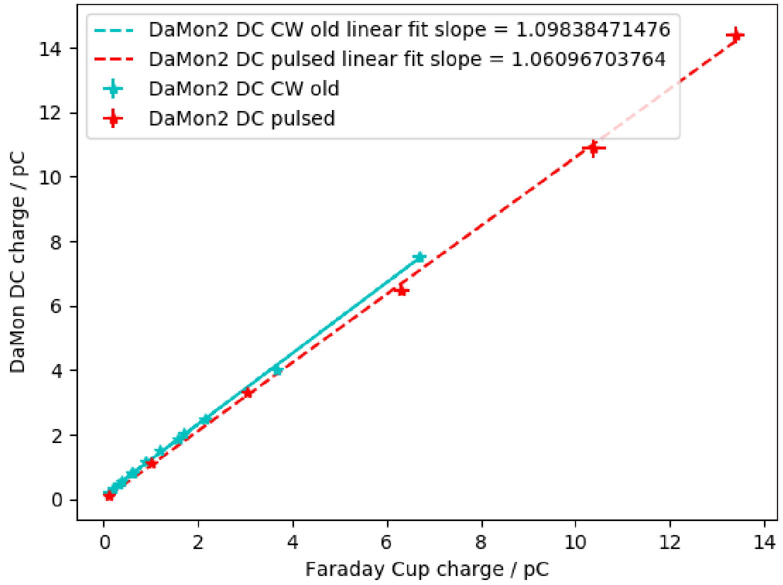


Beam measurement at ARES with new calibration

DC channel absolute values

- Data of new measurement with >20 pC Faraday Cup charges are excluded, strong non-linear but this channel is intended for low charges
- Calibration beam based calibration is removed
- Similar slopes between both calibrations for the given charge range

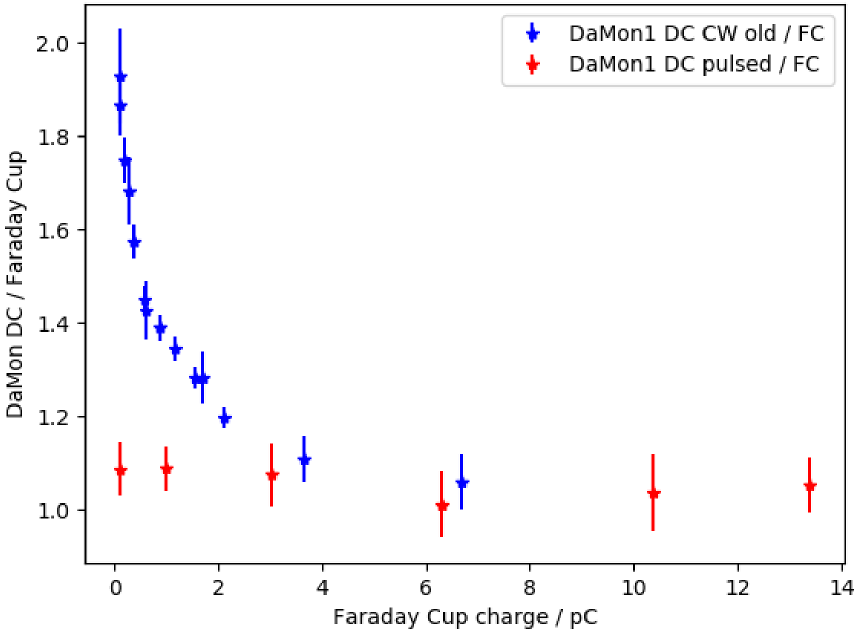


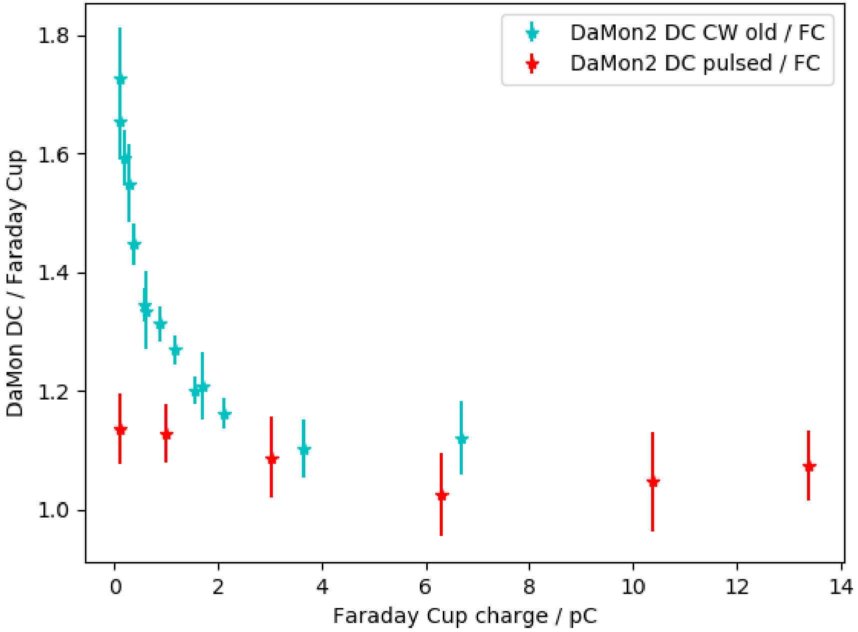


Beam measurement at ARES with new calibration

DC channel relative values

- For both monitors the non-linearity variation is reduced
- The would cause a reduction of the variation to about +/-5%
- Beam based re-calibration possible in comparison with charge channel





Summary

- Beam charge measurement with DaMon channels showed strong non-linearities
- New calibration with pulsed AWG and without beam correction done
- Reduced non-linearities
- In comparison with Faraday Cup the charge values are within 10% difference without correction
- DC channel can be further improved beam based with charge channel

Outlook

- Automatic response function calibration
- New RFFE with µTCA standard as RTM

Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Dirk Lipka
Machine Diagnostics Instrumentation (MDI)
Dirk.Lipka@desy.de