Karlsruhe Institute of Technology

Plasma investigation during ramp up

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Institute of Experimental Particle Physics (ETP)

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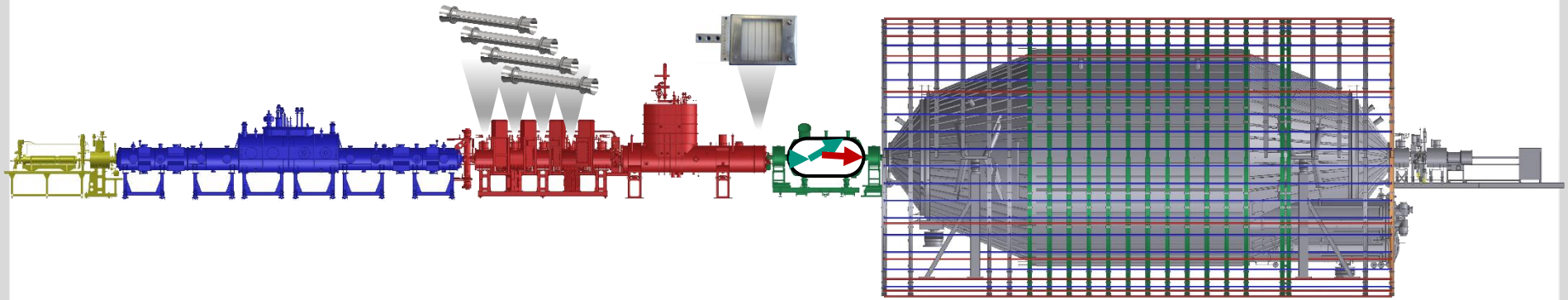
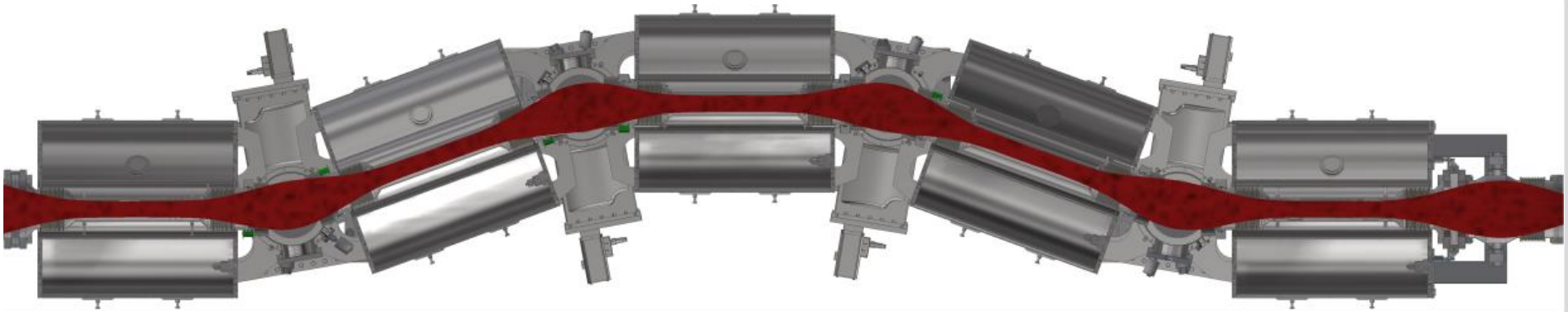


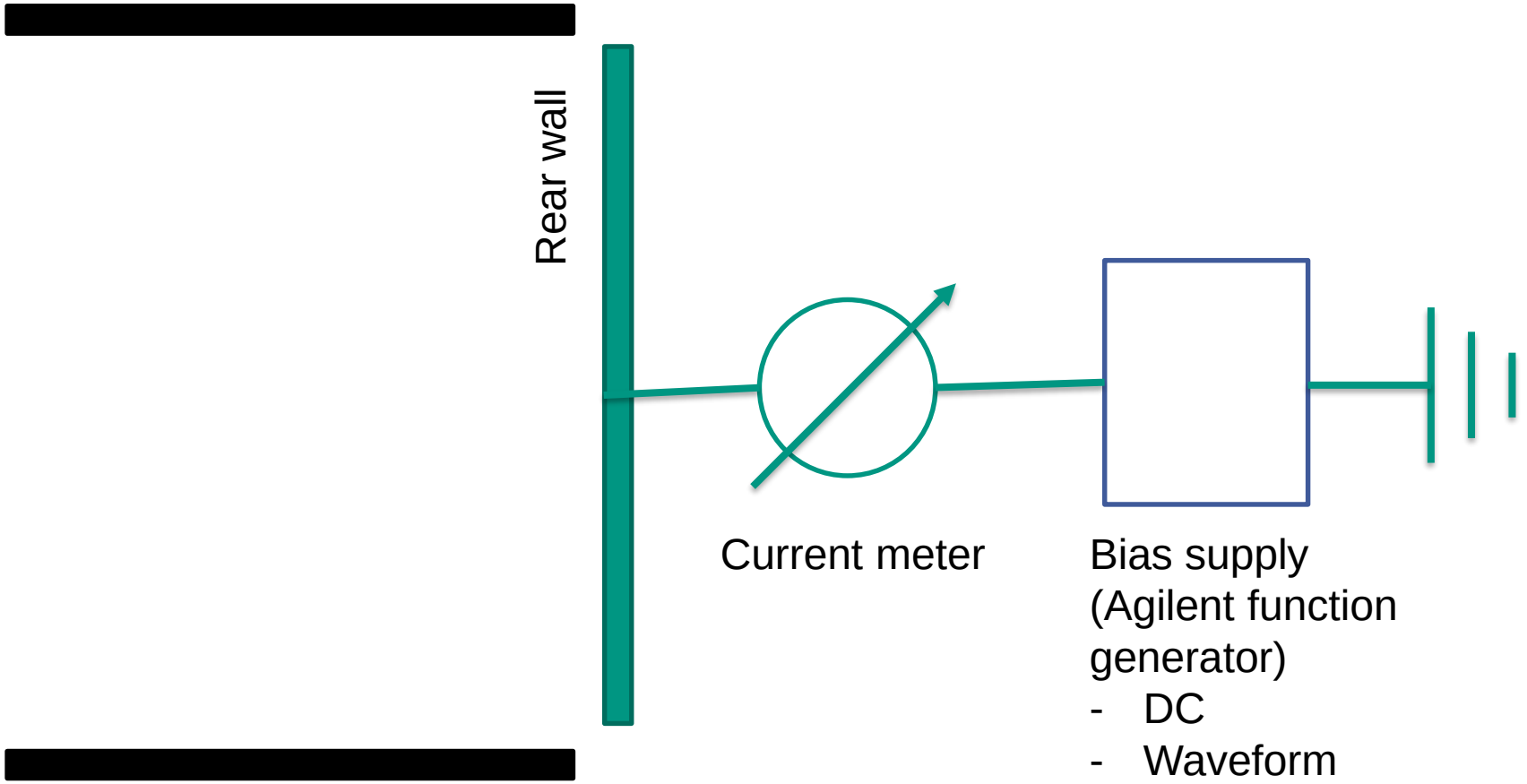
Hardware for ion current detection



- Dipole 1: -15 / -5 V (ion drifting)
- Dipole 2: -35 / -5 V (ion drifting)
- Dipole 3: -85 / -5 V (ion drifting)
- Dipole 4: +20 / +25 V (blocking mode)

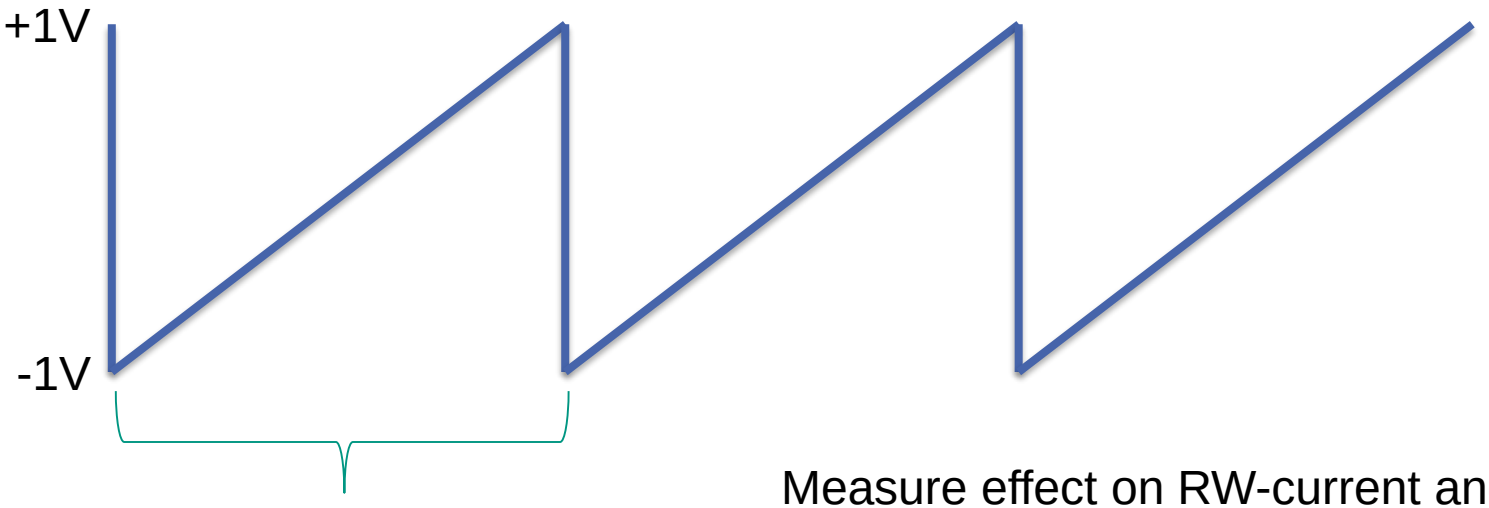
- The ion which are drifted out are measured by a picoamperemeter

Rear wall


Rear wall
Current meter
Bias supply
(Agilent function
generator)
- DC
- Waveform

Plasma measurements with ramping rear wall

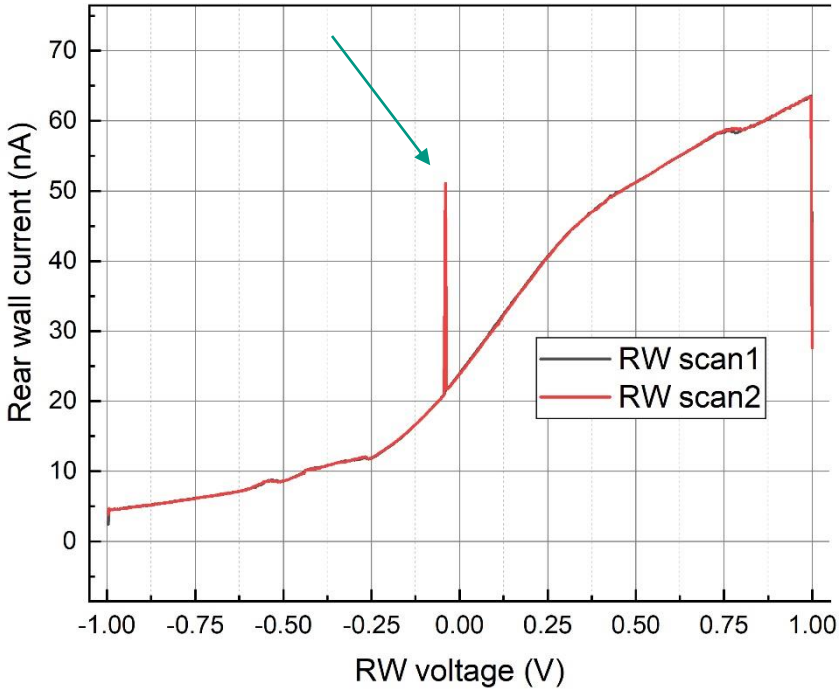
- We applied a saw-tooth from the Agilent Function generator to the rear wall

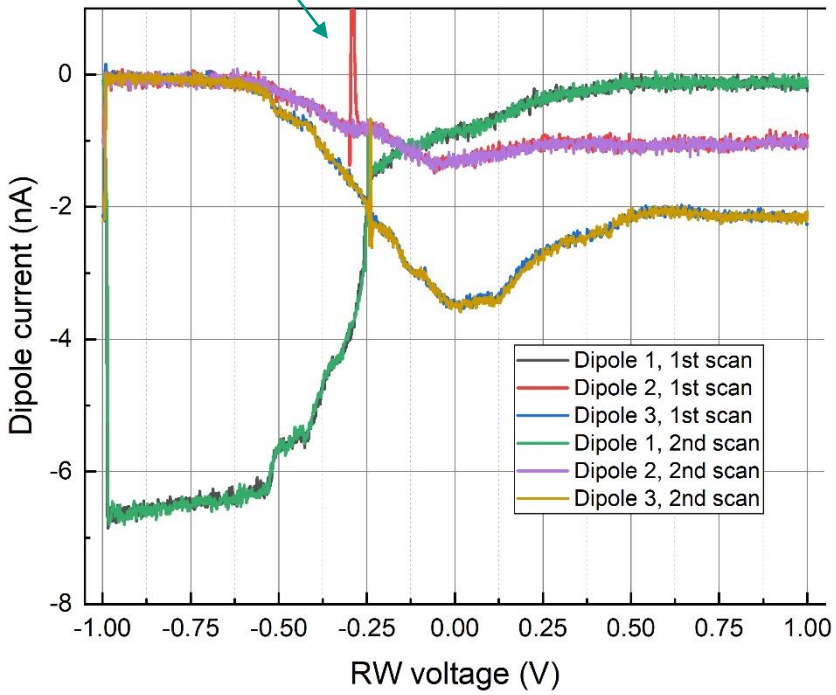


Measure effect on RW-current and dipole electrodes

SCAN RESULTS FOR 50 % COLUMN DENSITY

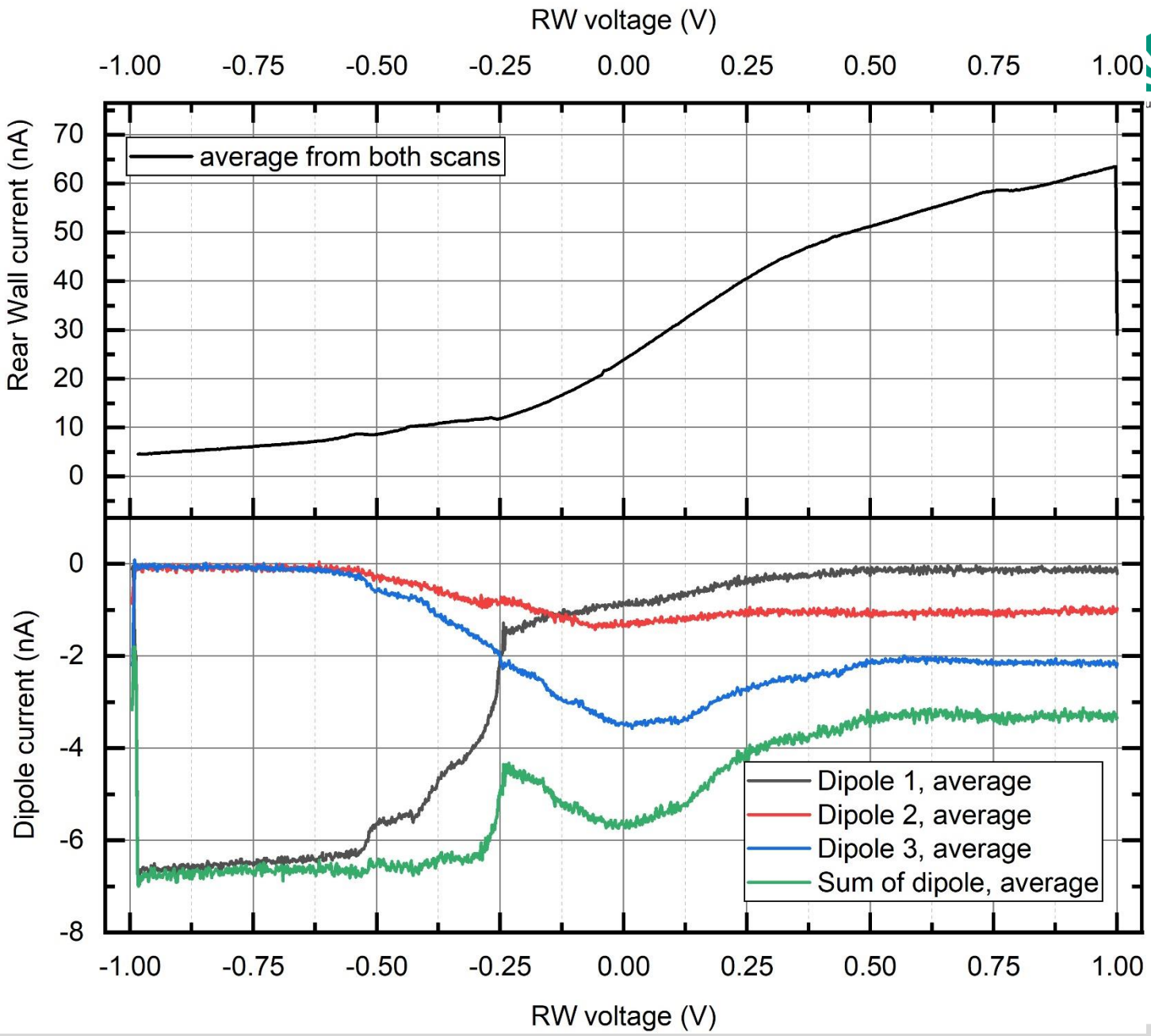
Reproducibility of two back-to-back scans





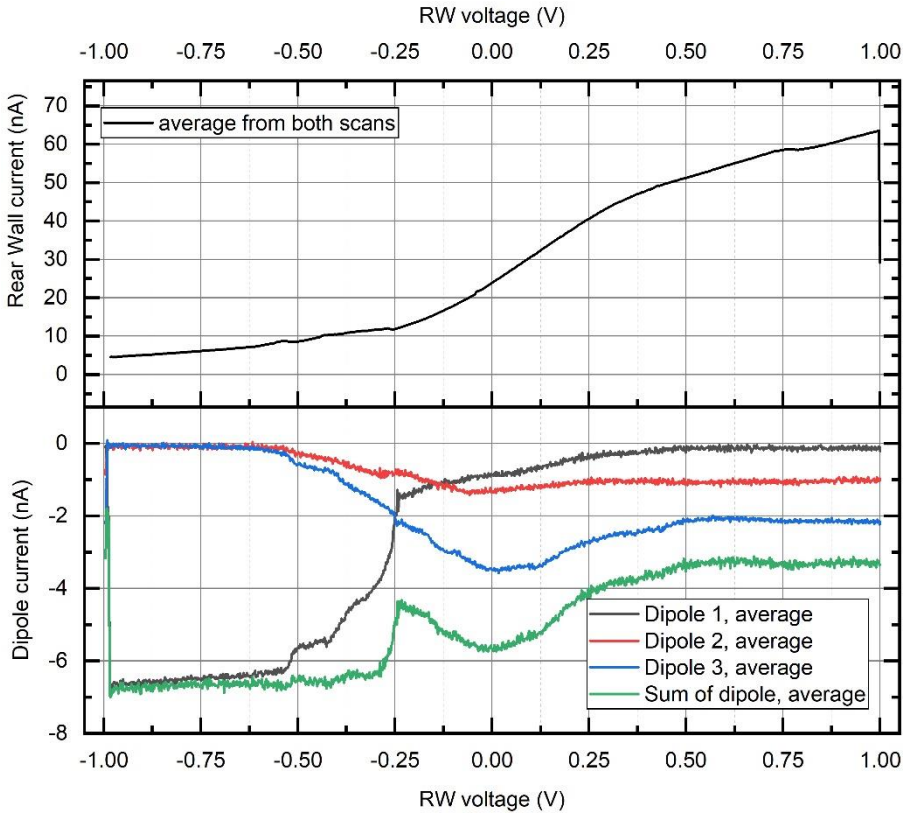
Reproducibility very high!
Some spikes only appeared in one of both runs

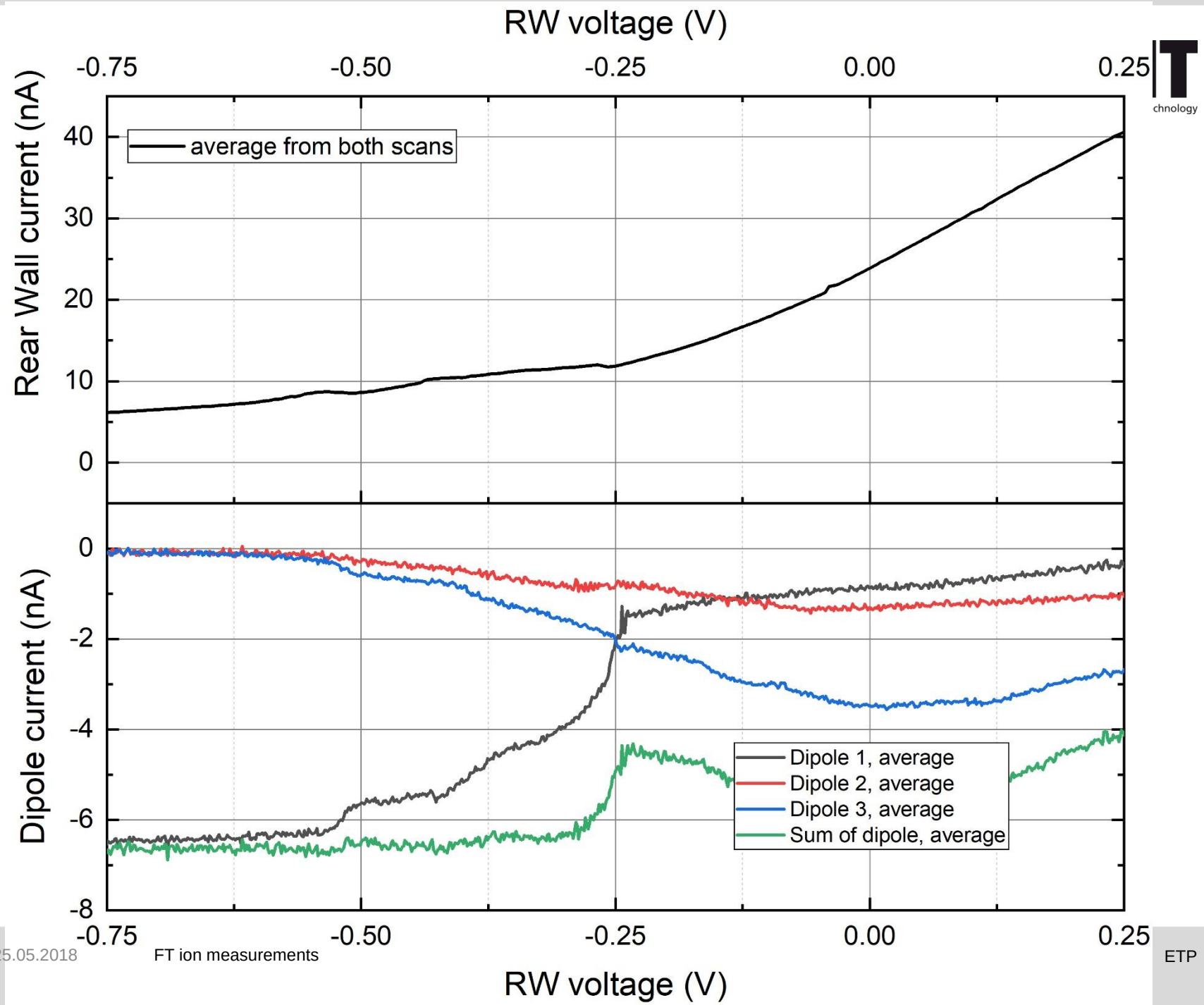
Further data → average of both runs + manual spike removal

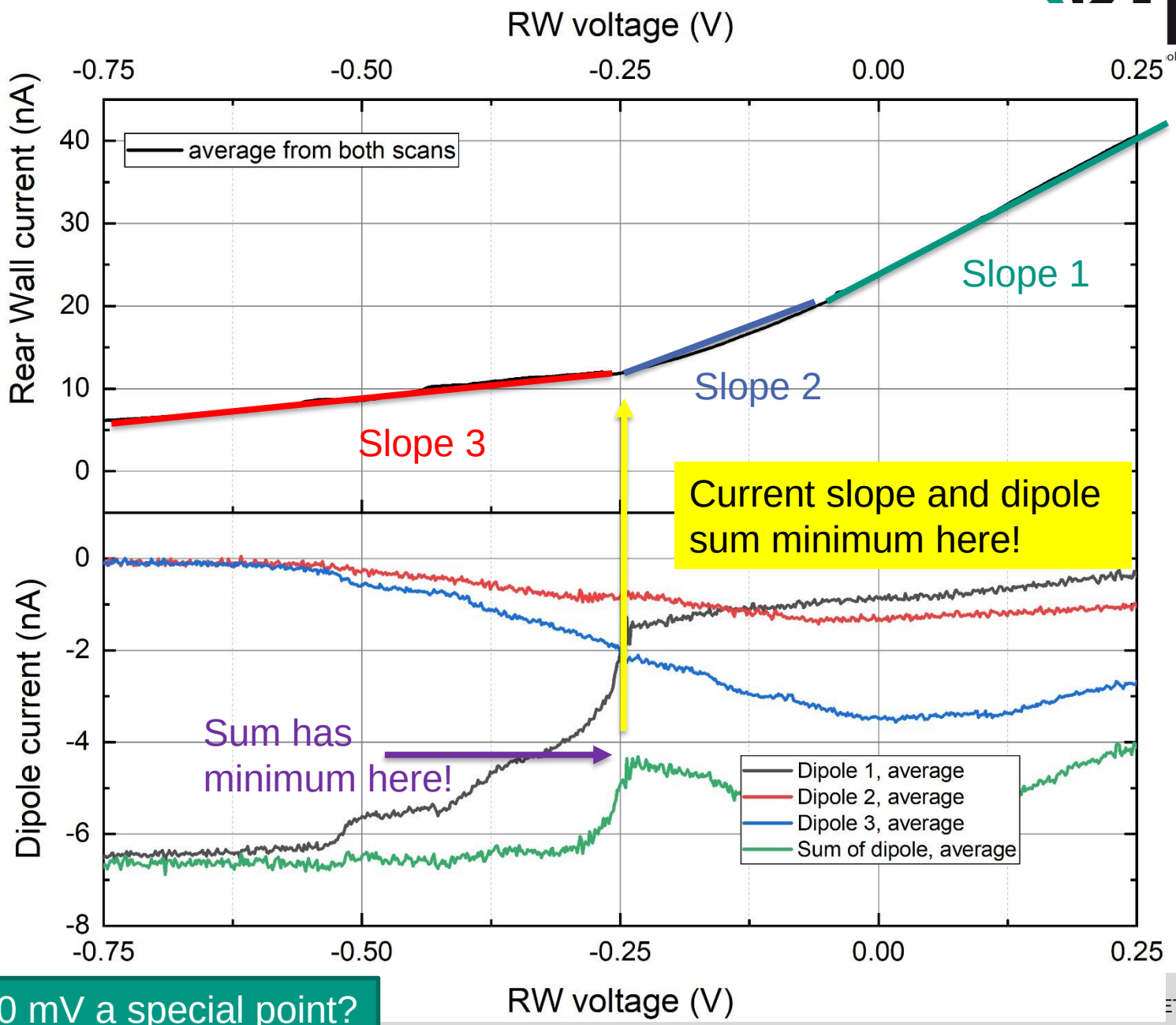

RW voltage (V)
-1.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
Rear Wall current (nA)
70
60
50
40
30
20
10
0
average from both scans
Dipole current (nA)
0
-2
-4
-6
-8
Dipole 1, average
Dipole 2, average
Dipole 3, average
Sum of dipole, average
RW voltage (V)

Some comments

- At strong negative bias voltage (-1V)
  - Dipole 2 + 3 see almost NO dipole current
  - Dipole 1 see all of the dipol current
  - The RW current is low and probably tends towards the beta-decay current limit
- At strong positive bias voltage (> 0.5 V)
  - All dipole currents see current which is not increasing with stronger bias (> 0.5 V)
- The interesting is probably happening in between
- ➔ next slide shows a zoom in

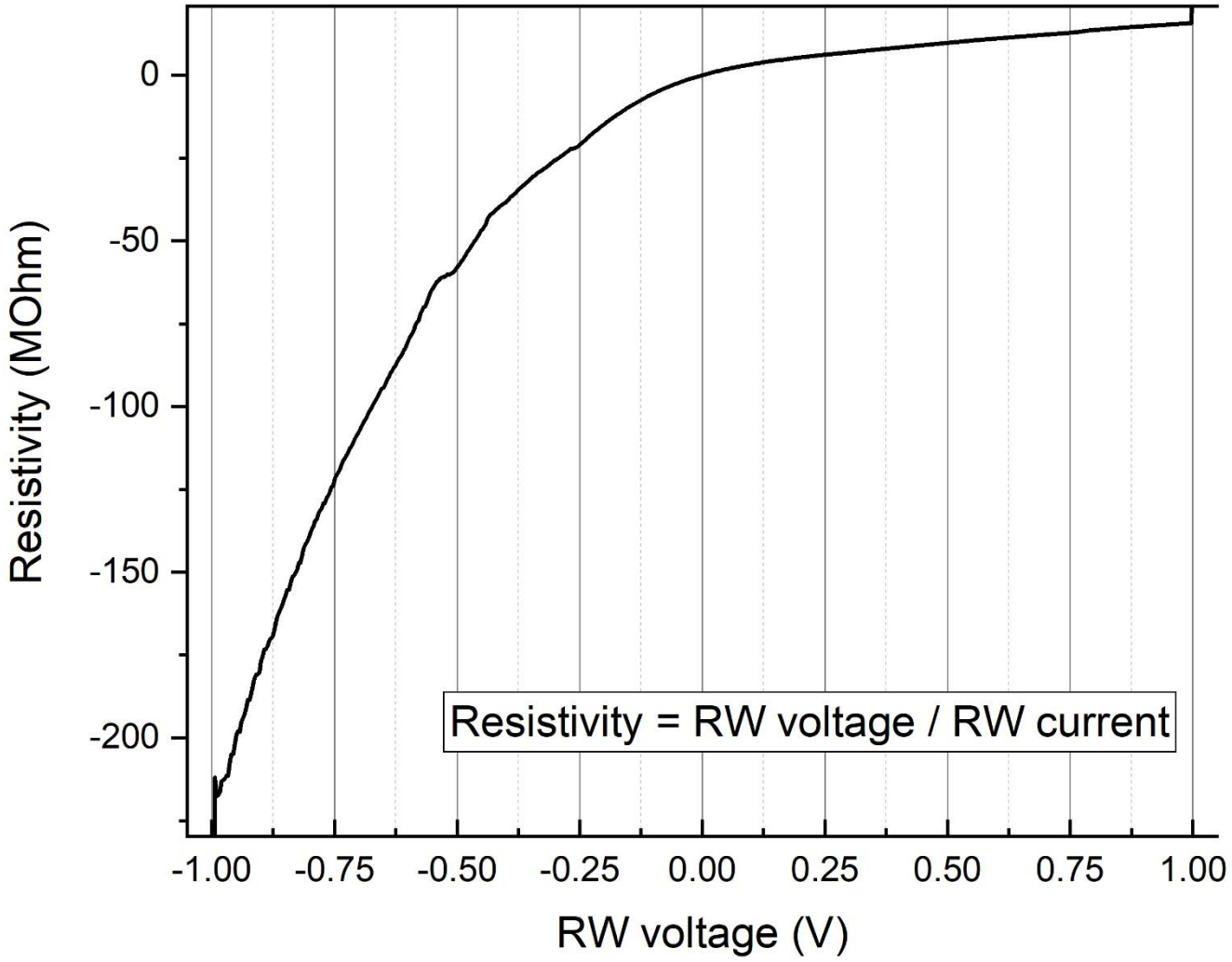



RW voltage (V)
-0.75
-0.50
-0.25
0.00
0.25
Rear Wall current (nA)
40
30
20
10
0
average from both scans
0
-2
-4
-6
-8
Dipole current (nA)
Dipole 1, average
Dipole 2, average
Dipole 3, average
Sum of dipole, average
RW voltage (V)



Is -250 mV a special point?

Rear wall resistivity



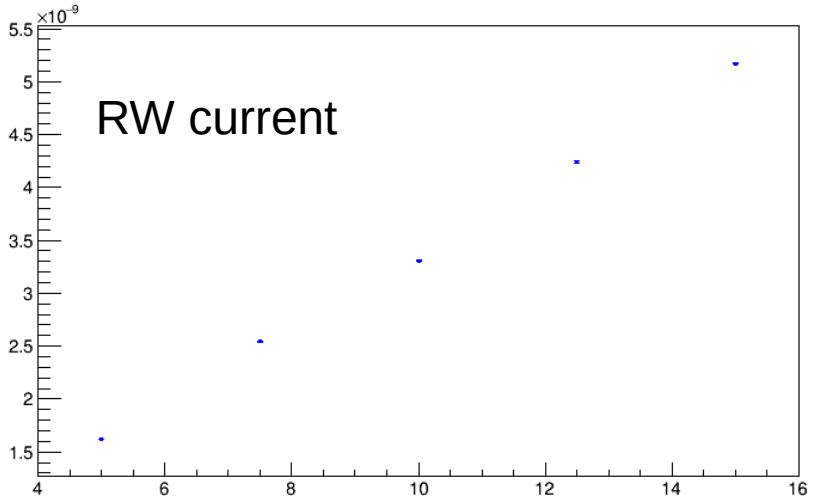
Comments by Guido (Part I)

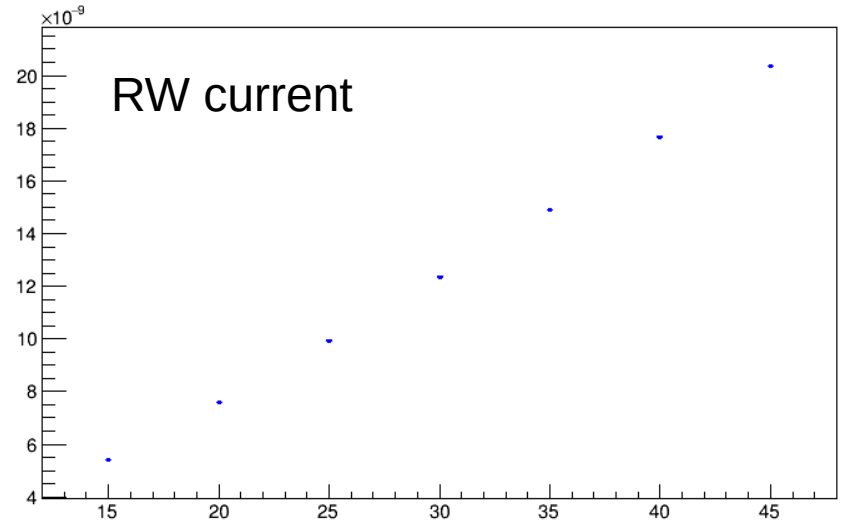
- The current on the RW is higher than the expected beta electron current by a factor of 2-3 ➔ we see a net signal of secondary electrons
- The RW current rises more than linear with the CD
- There is a general imbalance of negative RW current and positive dipole currents (factor of 3-4) ➔ somewhere in DPS or WGTS there is neutralization of ions, which are not producing a measurement current in the picoampermeters. ➔ we are not knowning where that happens!
- The fluctuation of the RW current appears to be less than 1%. However, frequency of the fluctuation varies with the neutral particle density form second scale to the min-scale.
- The current-voltage characteristics of the RW show different ranges. Is there a hint on the offsets of the workfunctions of RW and WGTS-R?
- ➔ Would an ingenious option for determination of offset and variance determination.
- The effect of U_RW on ions and secondary electrons in the WGTS plasma should be cross-checked and studied with Lauras thesis.
- The current I_RW at strong negatives Bias (-1V) tends asymptotically to the beta-electrons signal. More positive bias brings more net secondary electron signal into the system.
- At certain bias values, there is increase fluctuations.

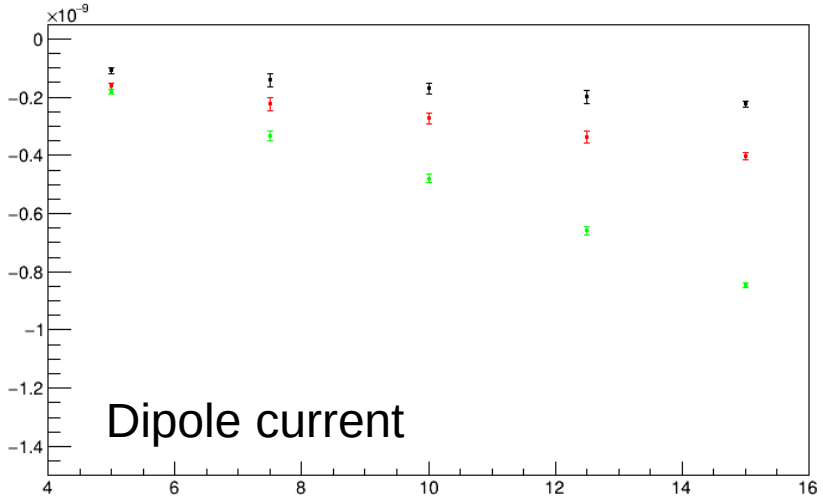
Comments by Guido (Part II)

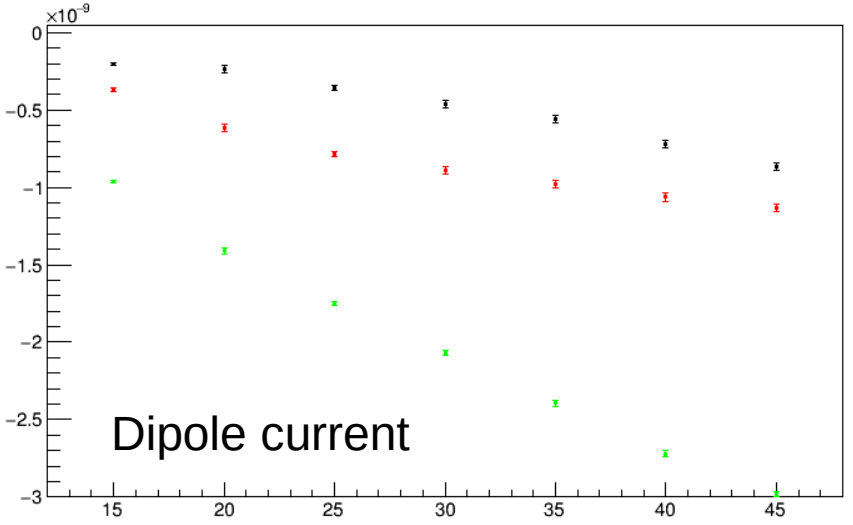
- At 15% CD there is a I_RW Peak at U_RW = -0.4 V (Adaption of RW and WGTS-Workfunctions?)
- The dipole electrodes may be neutralized analog to the ring electrodes by ionization of residual gas. E.g. we observe the decrease of the ion current in electrode 1 which is compensated by an increase of current in dipole electrode 3. Probbly, we are storing secondary electrons in the dipole elements – as in the ring electrodes – and reduce the dipole field at parts of high neutral particle densities.
- In general: at low RW-bias values (-0.5 ... + 0.5 V) we observe low I_RW fluctuations (<1%), even at higher column densities (this is not totally true, MS). We will investigate amplitude and frequency dependence of the fluctuations (also as function of the RW bias)
- With the RW current measurement we are integrating for long times ms and above (compare to the typical transit time of keV electrons in the WGTS)
- The I_RW and U_RW appear interesting tools of plama effect to to meV scale. Therefore, the Agilent is good device for the study. A segmented RW would be very interesting for radial studies ☺
- We have to measure several hardware parameters like R_RW (ohmic) and C_RW (capacity) – without column density to determine leakage current and parasitic capacities (Klasu Schlösser did already part of it)

Rear wall and dipole evolutions









PRO-KATRIN

- We can do the Ramp generator or stepping and waiting?
  - Ramp generator
    + smooth measurement
    + automated
    - no good statistics for a rate change
  - Stepping waiting
    + good statistics for a rate change
    - not mainy measurement points

CERMAX lamp

- Using the CERMAX lamp for ion pre-tests lead to extremly fast neutralization when the rear wall was at -15 .. -100 V
  - Is there a danger?

- CERMAX lamp is not homogenous → Current measurement will be spoiled?

Measurements at 50 %

- Monday, 11.03.2019

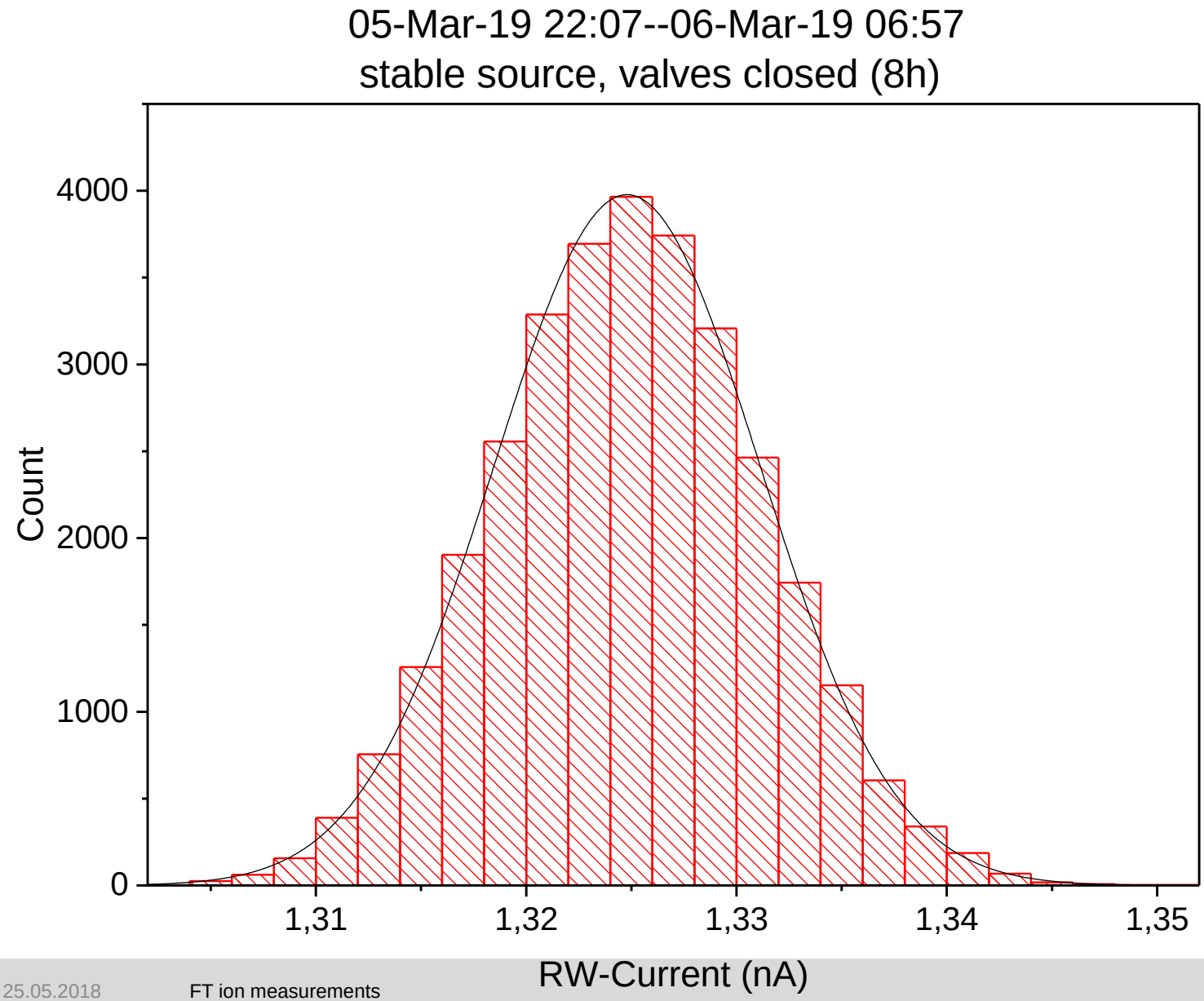
Measure	Time
Penning trap	9:30 – 13:30
CD	13:30 – 14:45
PRO-KATRIN / Plasma	15:00 – 18:00
Ion neutral check / trap empyting	18:00 – 19:00
E-gun (integral)	19:00 – over night (8:00)

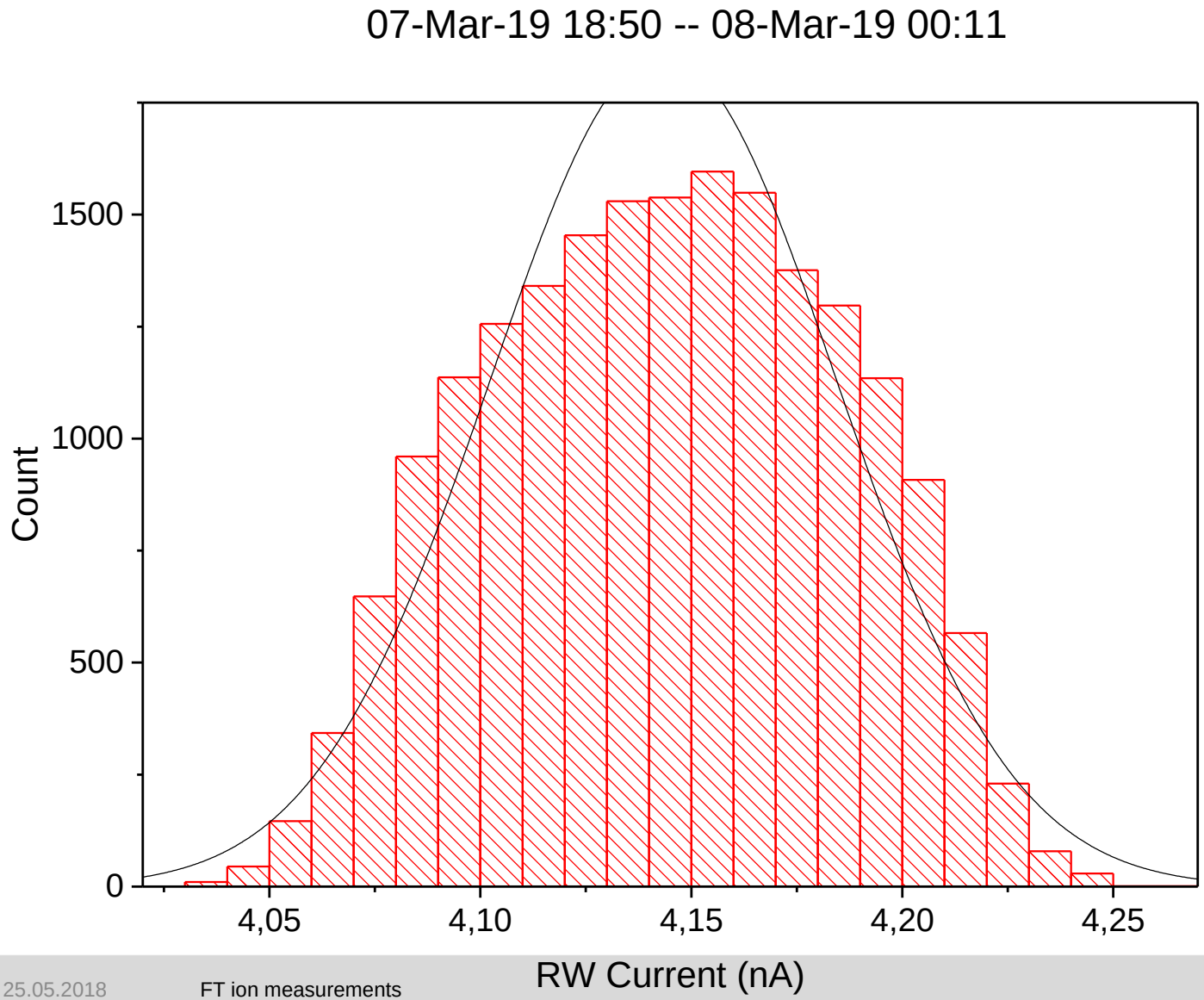
- Tuesday, 12.03.2019

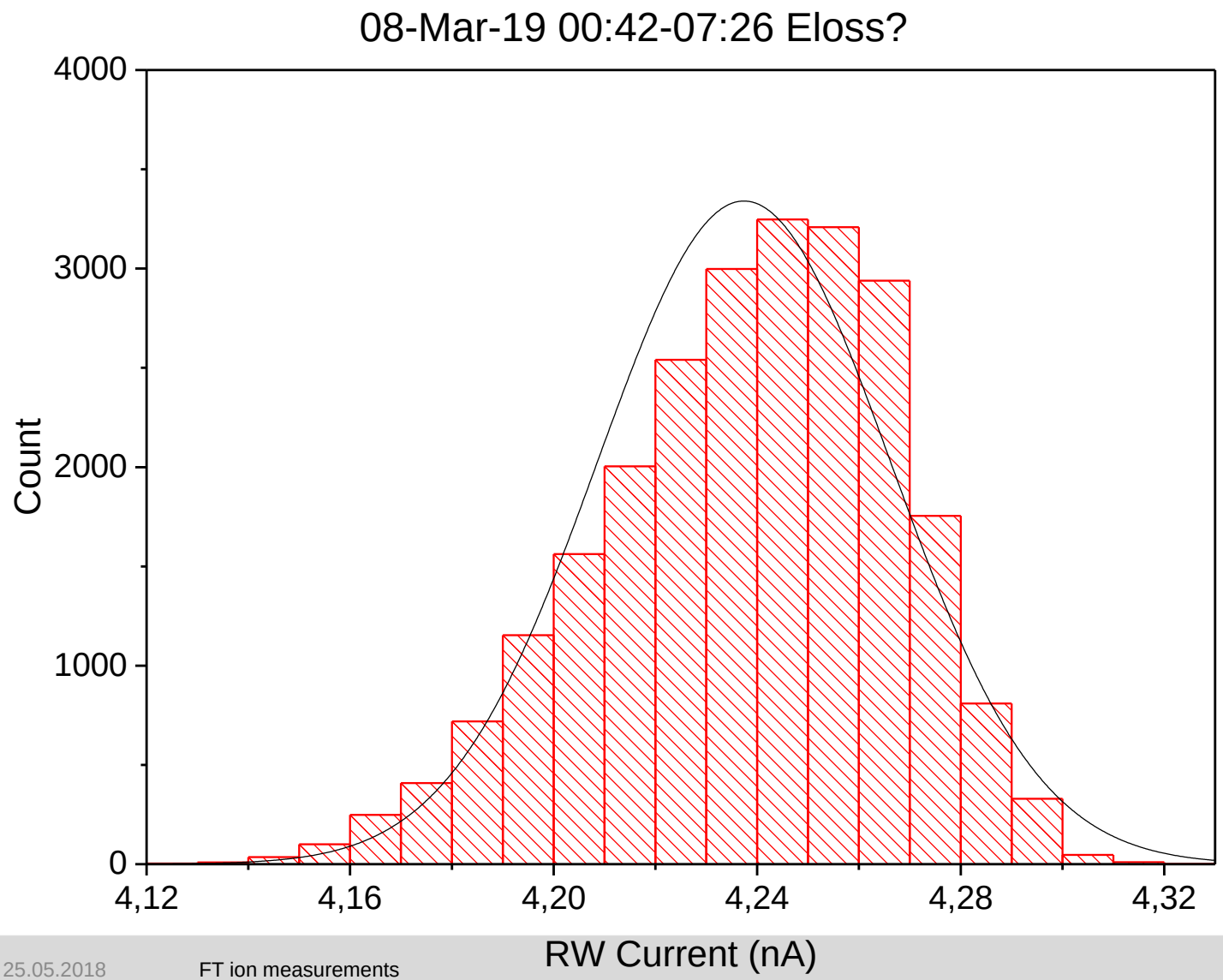
Measure	Time
Ion neutral check / trap empyting	8:00 – 9:00
PRO-KATRIN / Plasma (+ CERMAX)	9:00 – 18:00
Ion check / trap empyting	18:00
E-gun	19:00

Planning of the measurements

- Monday (~3 h)
  - Do not use CERMAX lamp!
  - Ramp generator or stepping and waiting?
    - Ramp generator
      + smooth measurement
      + automated
      - no good statistics for a rate change
    - Stepping waiting
      + good statistics for a rate change
      - not mainy measurement points
- Tuesday (~ 10 h)
  - May use CERMAX for the second half of the day


05-Mar-19 22:07--06-Mar-19 06:57
stable source, valves closed (8h)
Count
4000
3000
2000
1000
0
1,31
1,32
1,33
1,34
1,35
RW-Current (nA)


07-Mar-19 18:50 -- 08-Mar-19 00:11
Count
1500
1000
500
0
4,05
4,10
4,15
4,20
4,25
RW Current (nA)


08-Mar-19 00:42-07:26 Eloss?
Count
4000
3000
2000
1000
0
4,12
4,16
4,20
4,24
4,28
4,32
RW Current (nA)