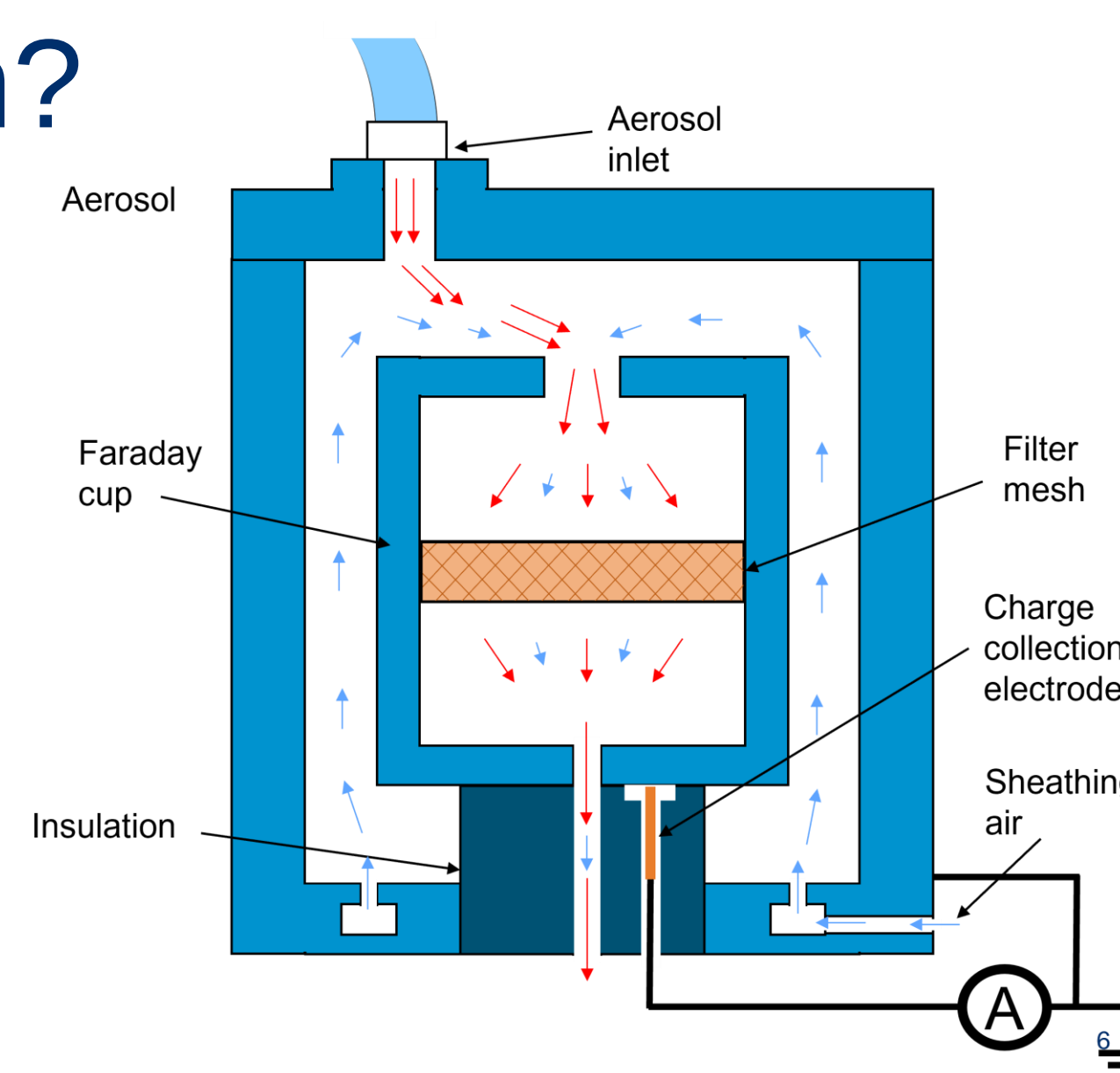


1. Air quality and low currents – why the connection?

Faraday cup electrometer (FCE, diagram at right)
Measures current due to flow of charged aerosol particles
Current = flow rate of particles $\times$ charge on each particle

Ambient air monitoring:
Currents in range 1 fA to 100 fA



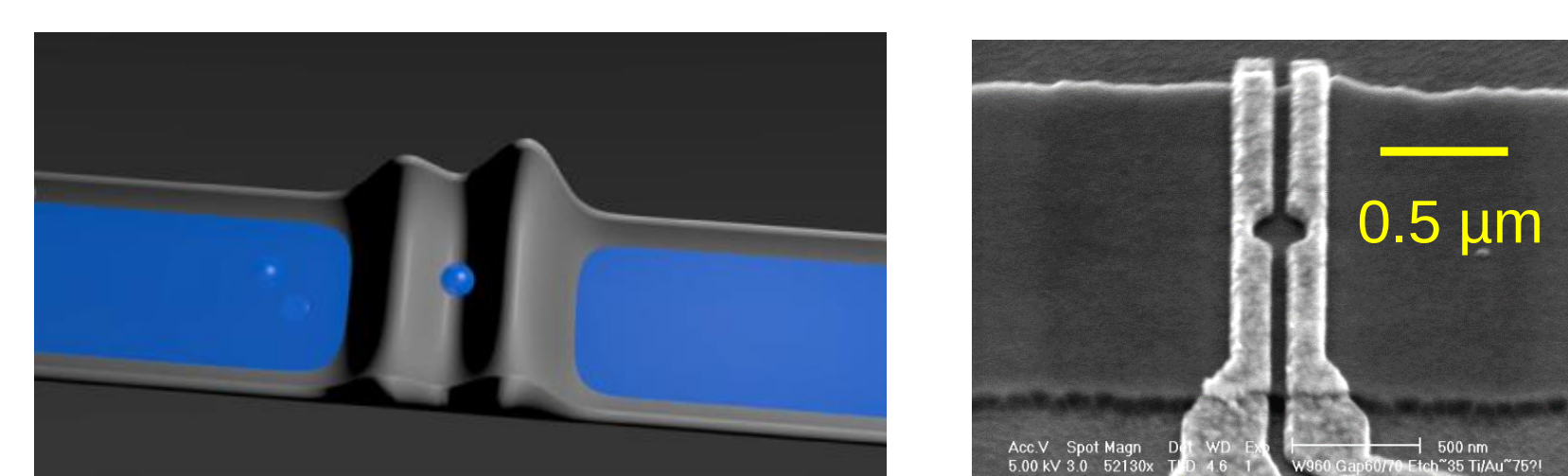
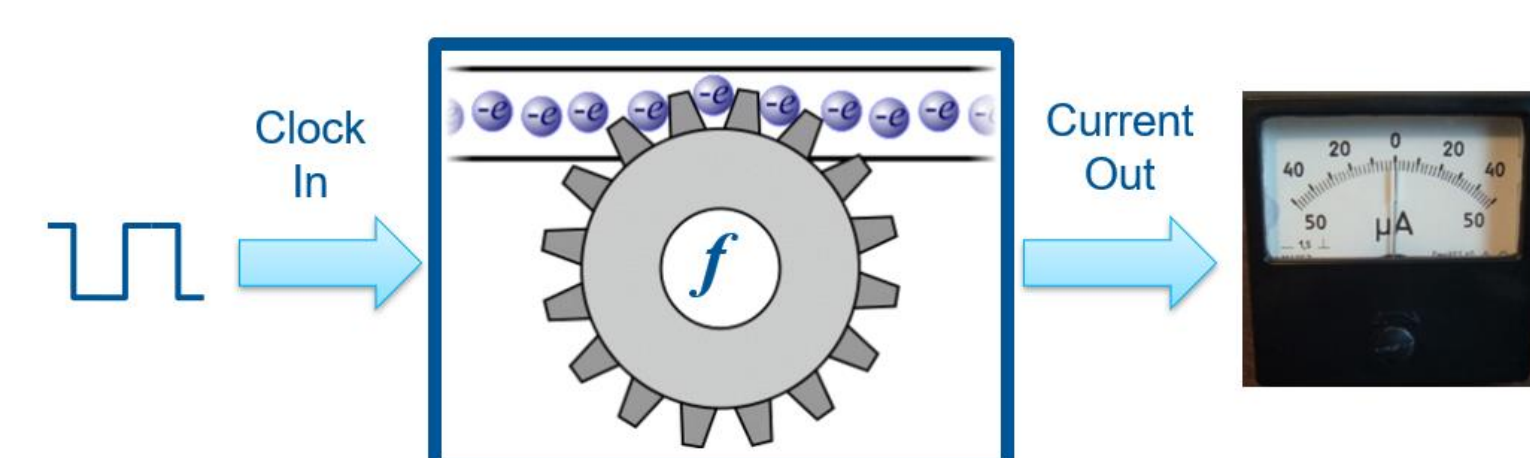
Summary

Improved air quality standards require traceability for **DC currents in the fA to pA range**.
This traceability is now provided using **new, stable types of current source** developed for basic research into quantum current standards.

2. Research into quantum current standards leads to better metrology tools

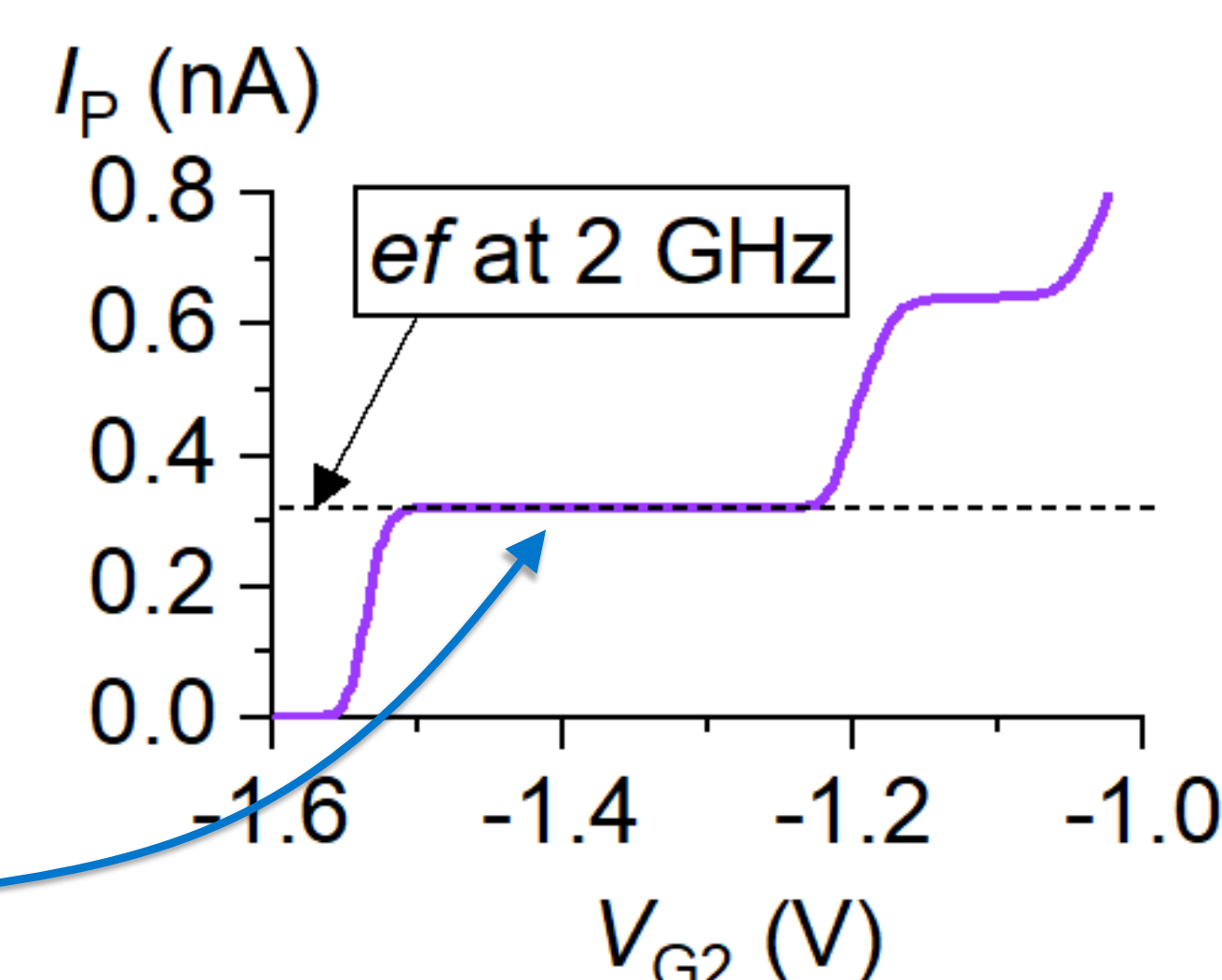
Electron pumps

Prototype realisations of SI ampere²

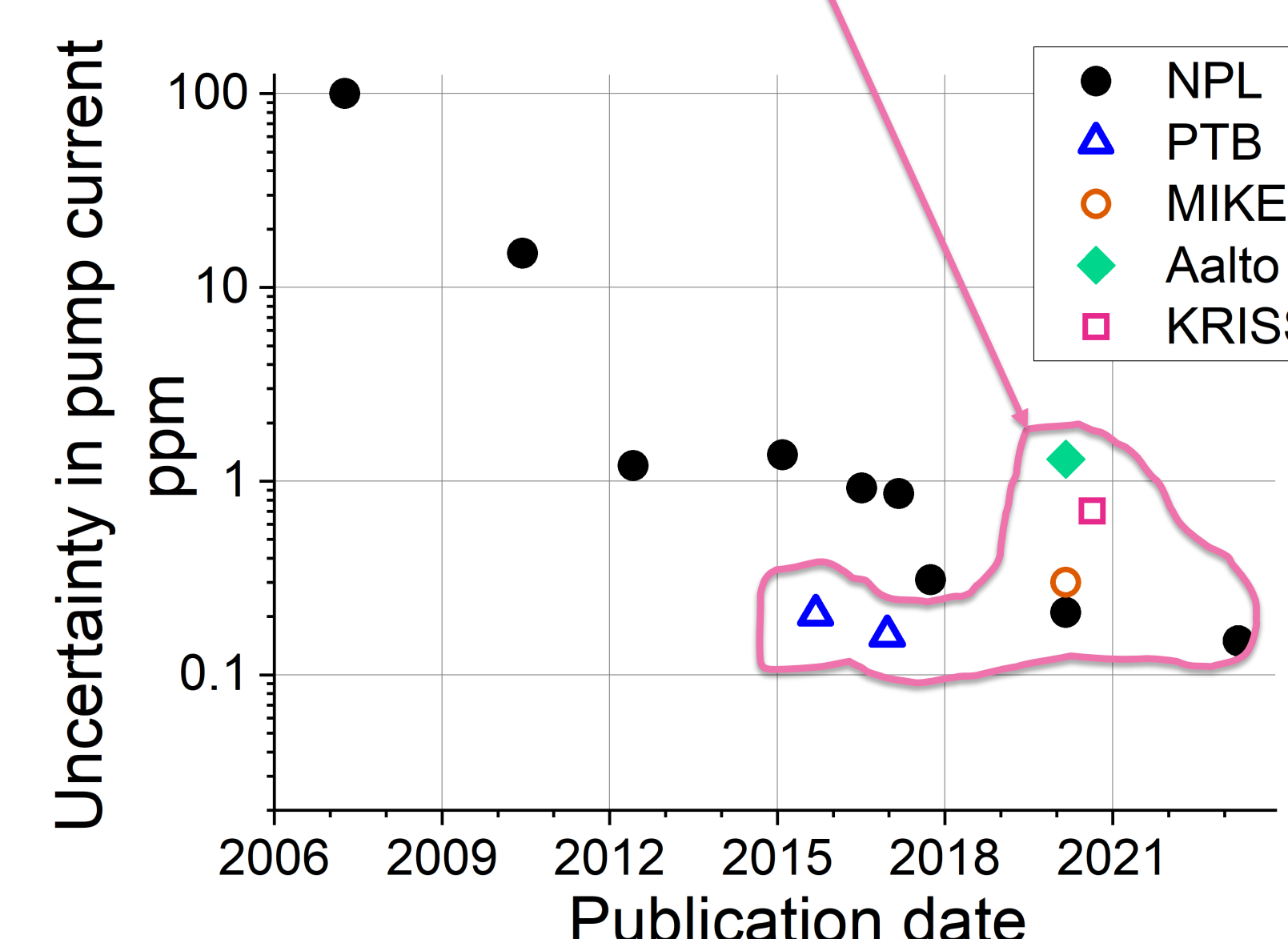


Does pump current = ef ?

Measure ~100 pA at sub-ppm uncertainty!
This research needed better measurements of small currents

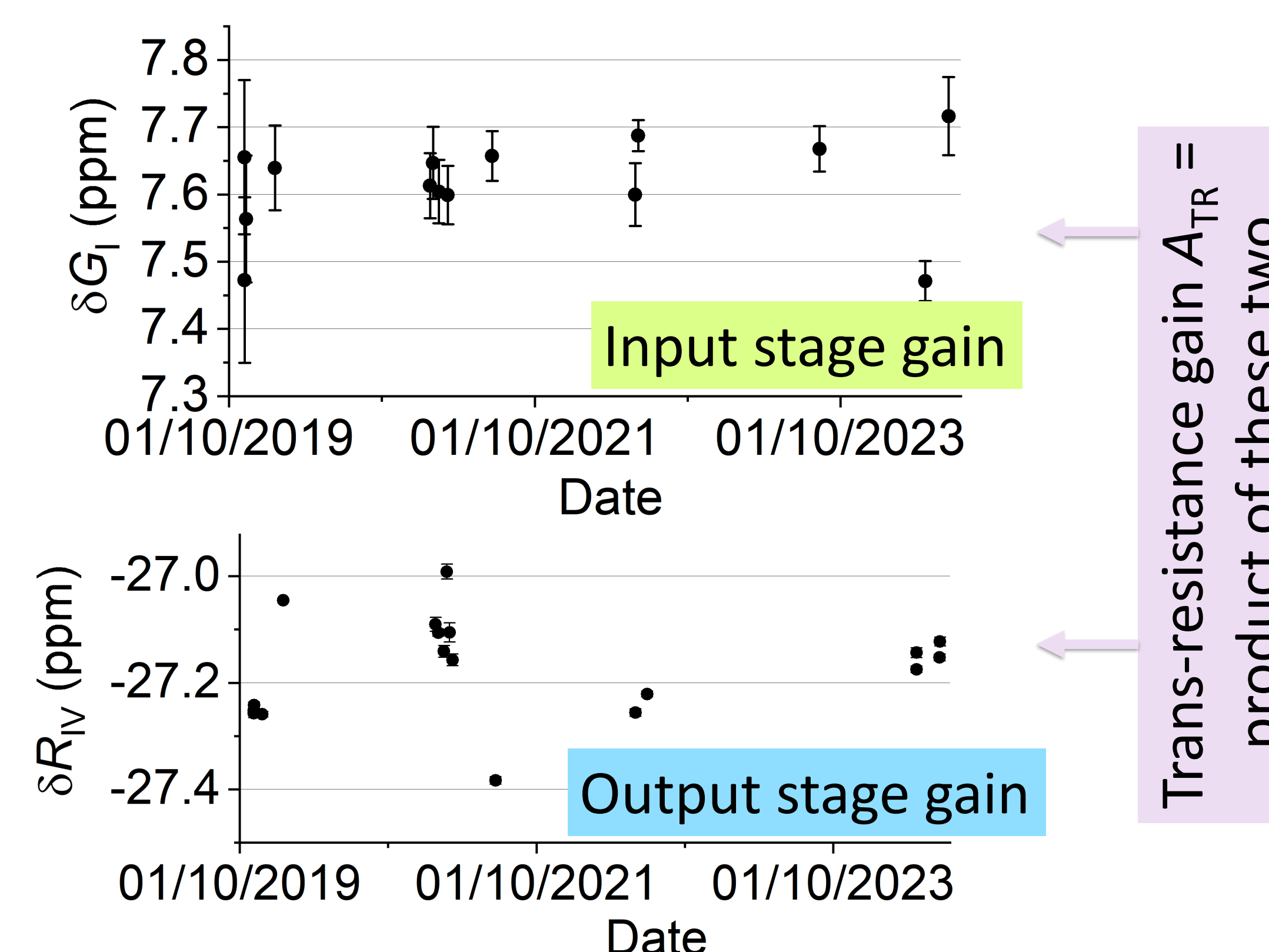


Used ultrastable low-noise current amplifier (ULCA)³



ULCA

sub-nA current source/meter stable at ppm level



3. Practical calibrations of aerosol electrometers

Primary traceability

QHR: SI Ohm



JVS: SI Volt



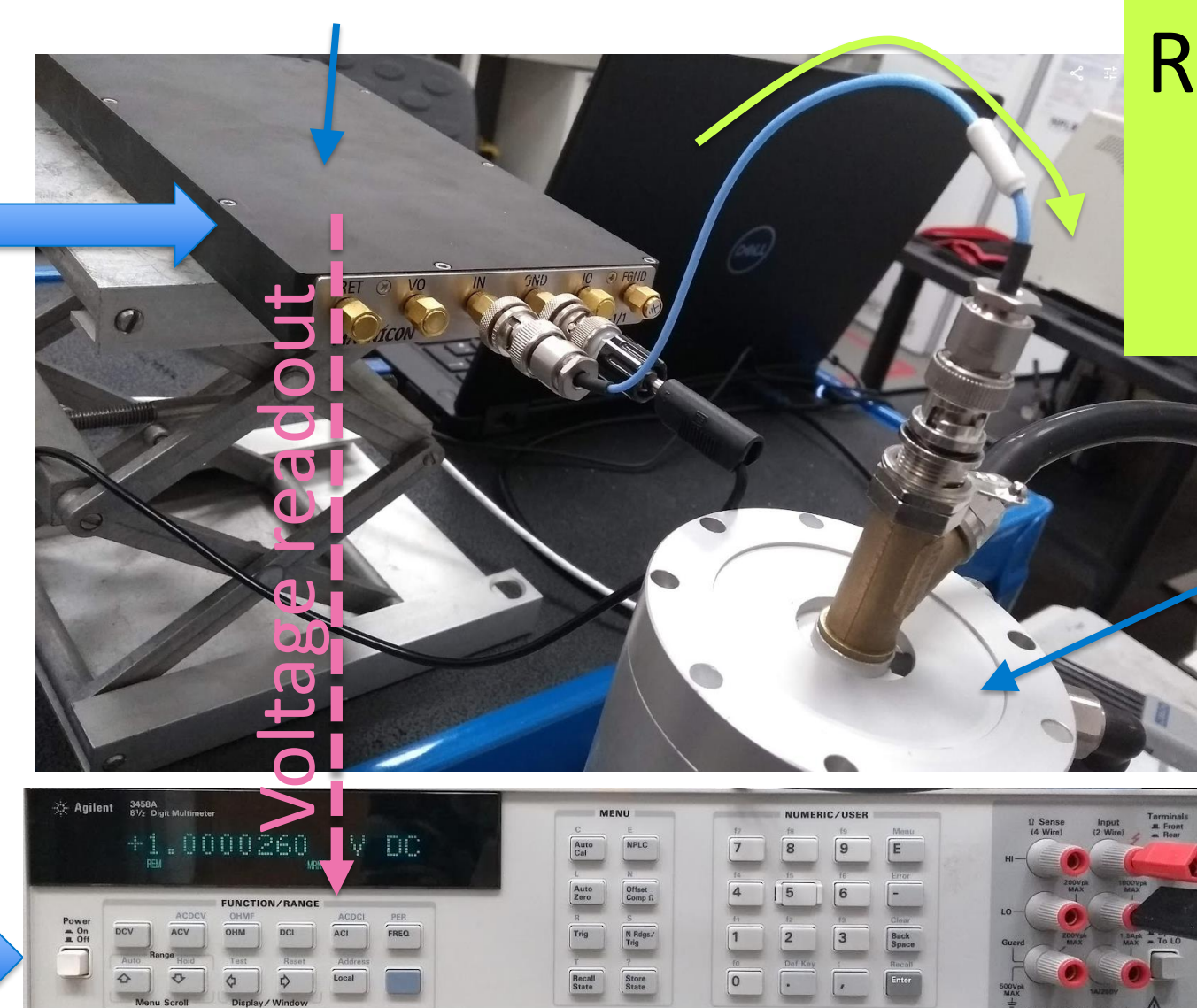
CCC

Current scaling



Calibration in air quality lab

ULCA (in current source mode)



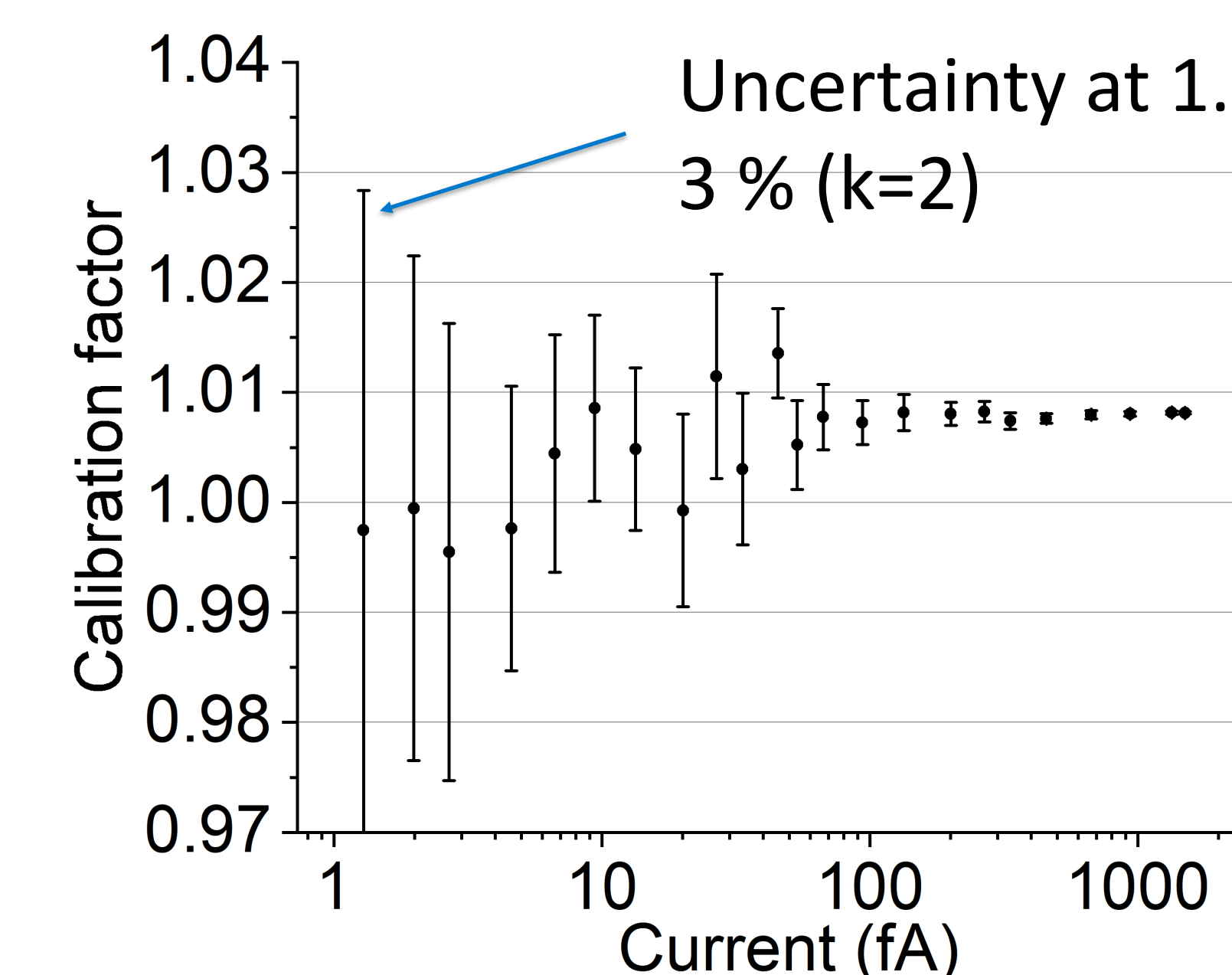
Reference current
SI amps
 $= V_{OUT} / A_{TR}$

Aerosol
Electrometer

Precision DVM
 V_{OUT}

End result

calibration factor of aerosol electrometer



1 R. Hogstrom et al, "First inter-comparison of aerosol electrometers for particle sizes up to 200 nm and concentration range 1000 cm⁻³ to 17000 cm⁻³", *Metrologia* **51**, 293-303 (2014).

2. S. P. Giblin et al, "Evidence for universality of tunable-barrier electron pumps", *Metrologia* **56**, 044004 (2019).

3. D. Drung, C. Krause, U. Becker, H. Scherer and F. J. Ahlers, "Ultrastable low-noise current amplifier: a novel device for measuring small electric currents with high accuracy", *Rev. Sci. Instr.* **86**, 024703 (2015). Available commercially from www.magnicon.de

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