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**Federal Institute of Metrology METAS**



## **Absolute Charge Measurement in UHDpulse electron beams**

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# Calibration of absolute charge measurement

**Jinst**

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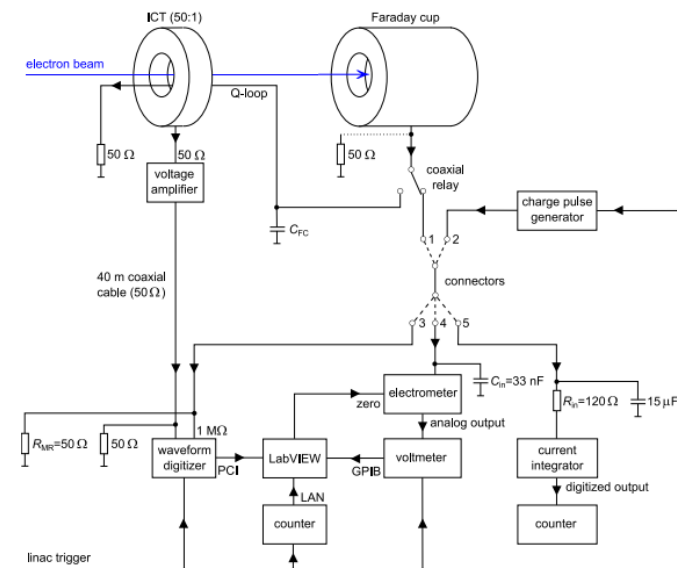
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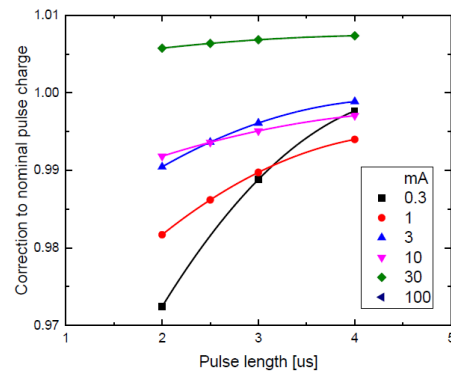
## Traceable charge measurement of the pulses of a 27 MeV electron beam from a linear accelerator

A. Schüller,<sup>1</sup> J. Illeemann, F. Renner, C. Makowski and R.-P. Kapsch

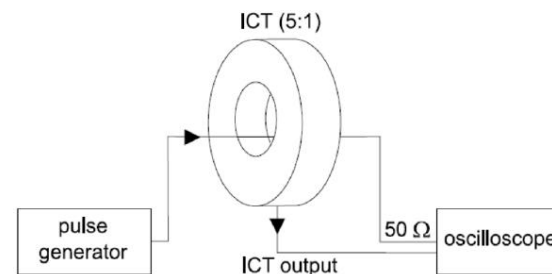
Physikalisch-Technische Bundesanstalt,  
Bundesallee 100, 38116 Braunschweig, Germany



## Reference charge pulse generator (PTB) A1.1.3

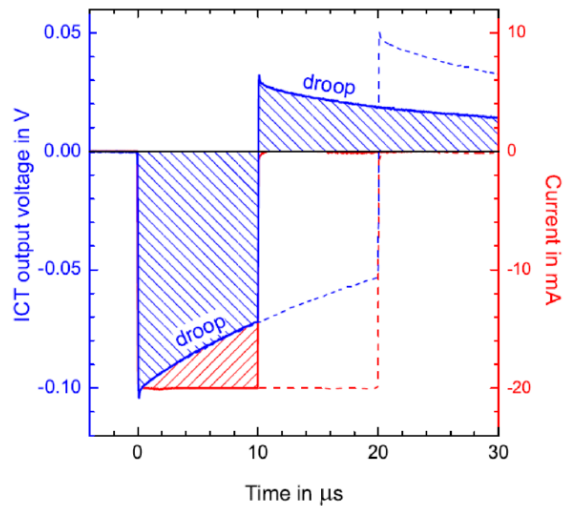


- result: a correction regarding nominal pulse charge given as function (second order polynomial) of pulse length for each current setting (residua < 0.02 %)
- uncertainty < 0.1 %



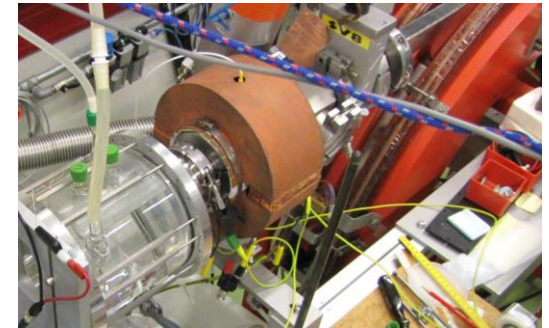
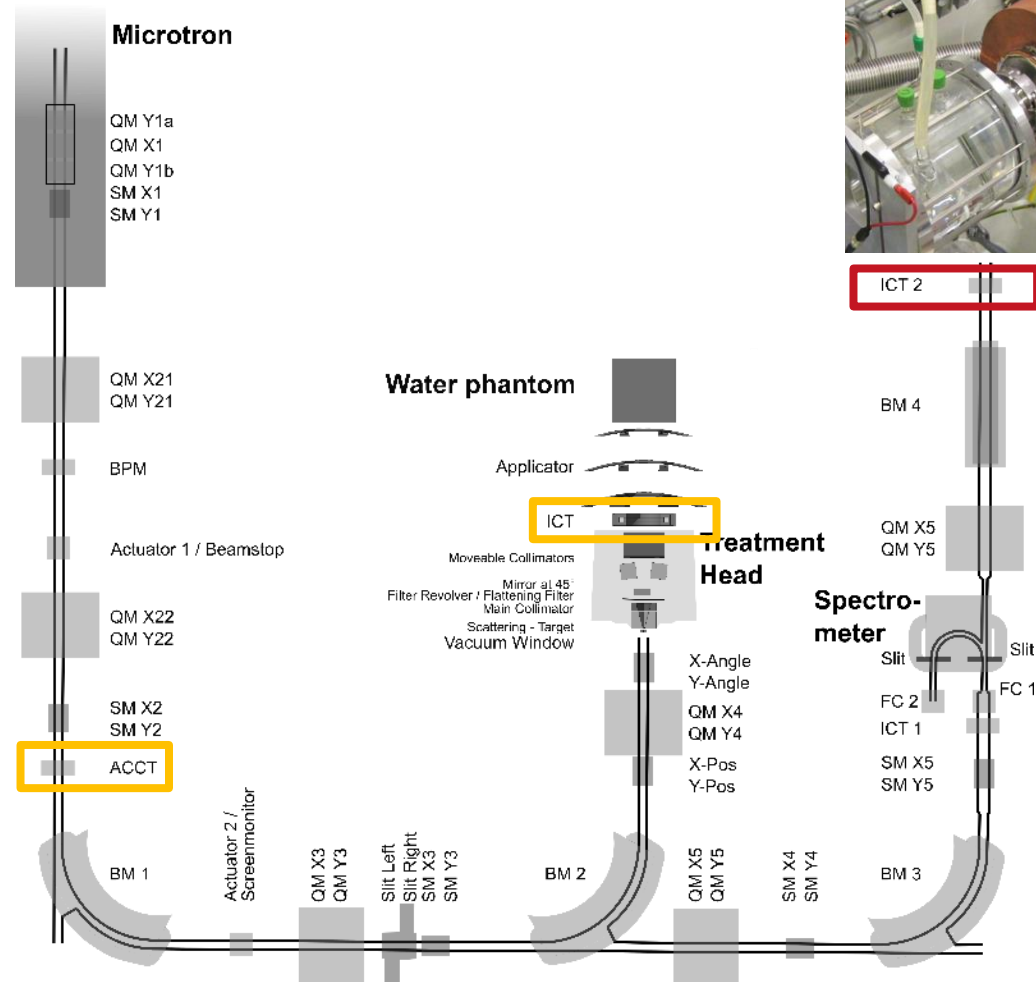
# Calibration of absolute charge measurement

## Reference charge pulse generator (PTB)

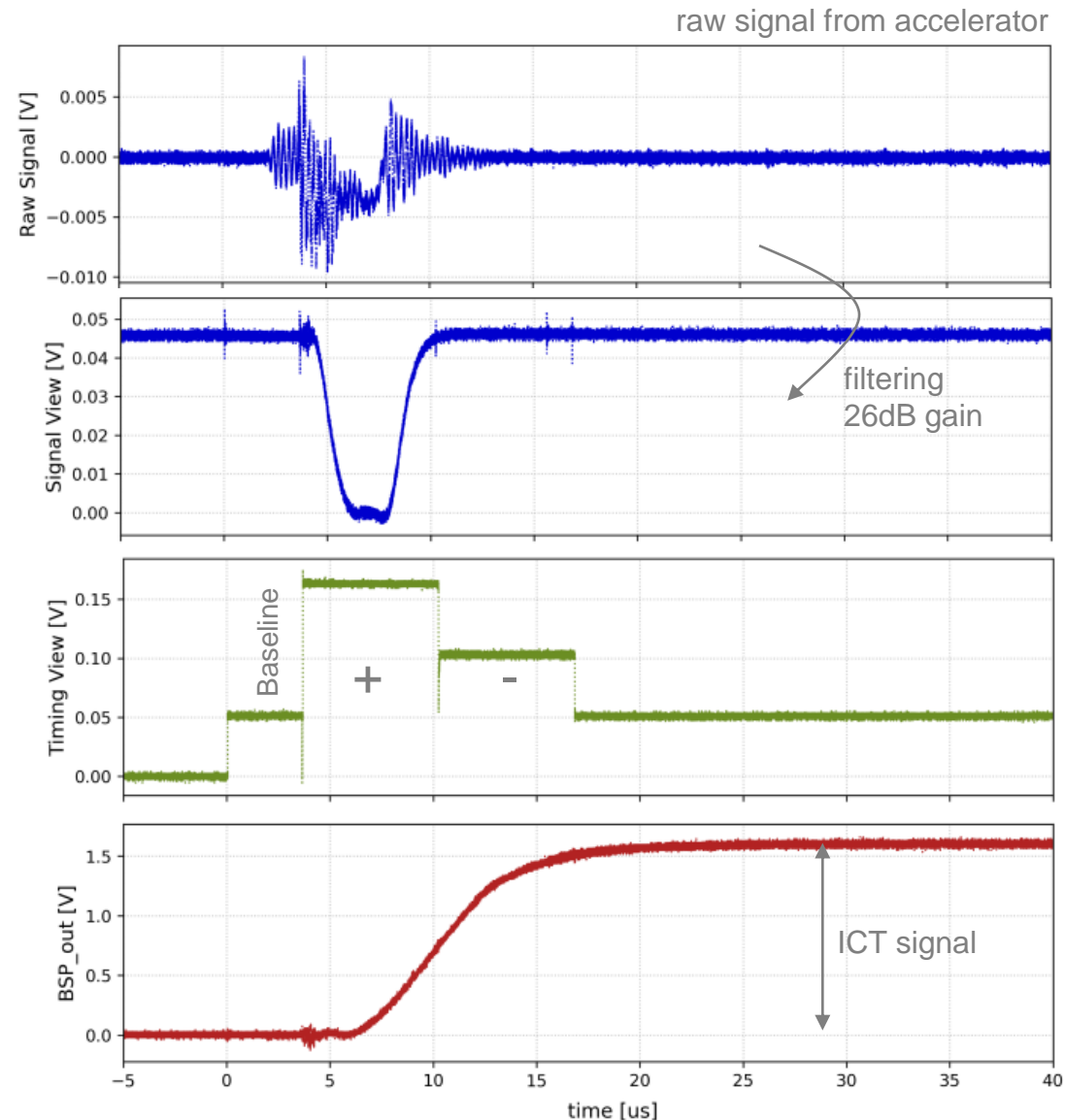
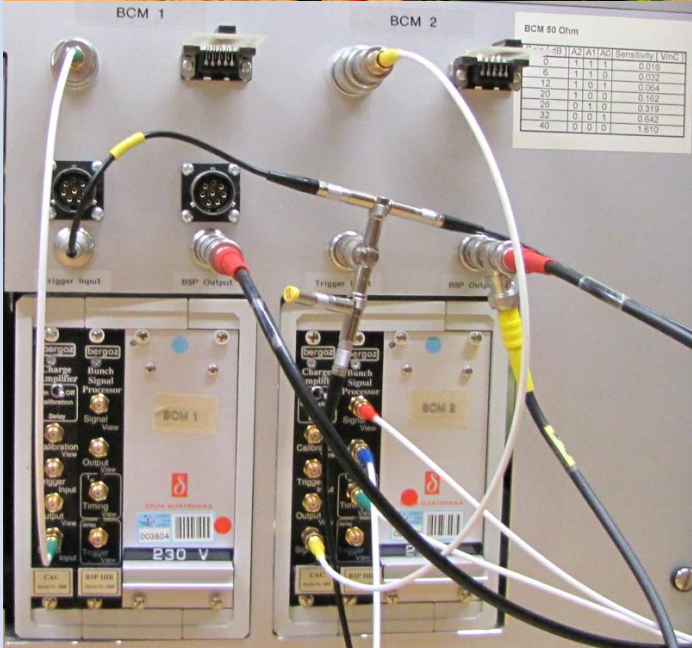
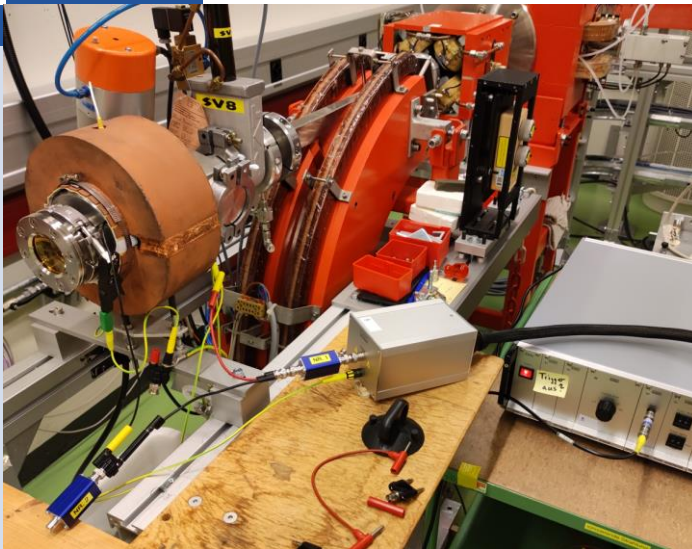


ICT signal and thus the calibration factor depends on pulse width and end of integration window due to the droop effect

## ICTs and ACCT@METAS



# Calibration of absolute charge measurement



## VERIFICATIONS

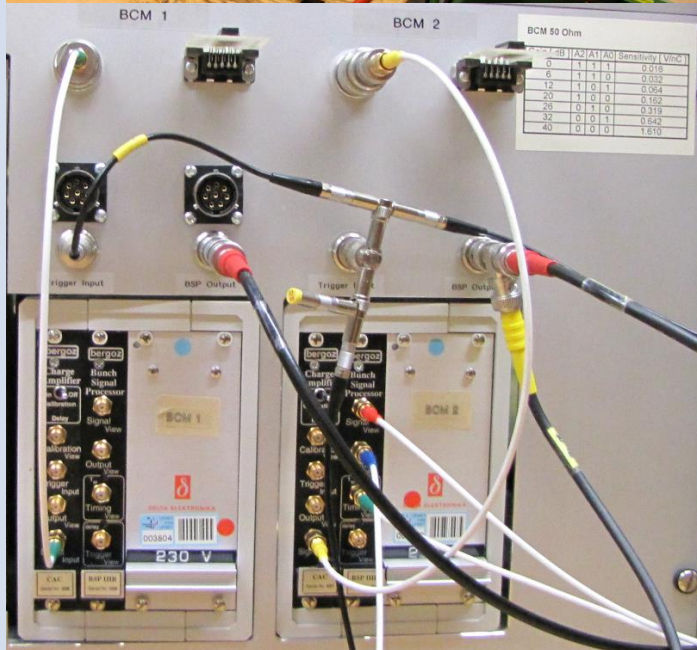
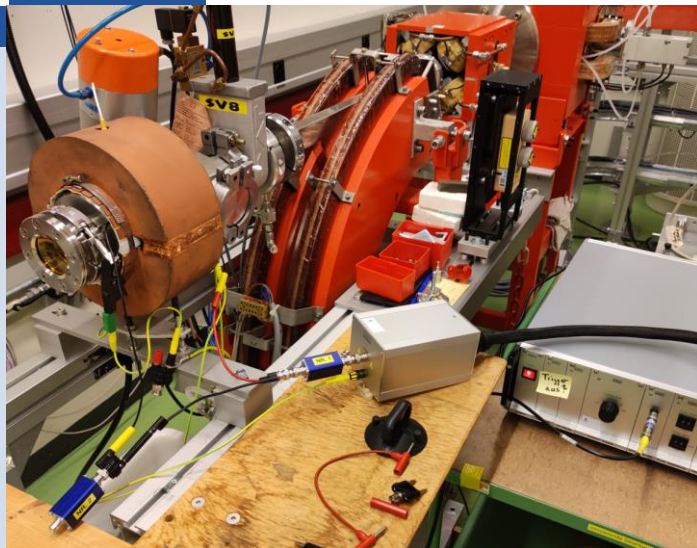
### Using accelerator:

- Connecting full measurement chain including proper readout electronics
- Record traces with respect to timing windows
- Check center of mass
- Check relative signal contributions in timing windows

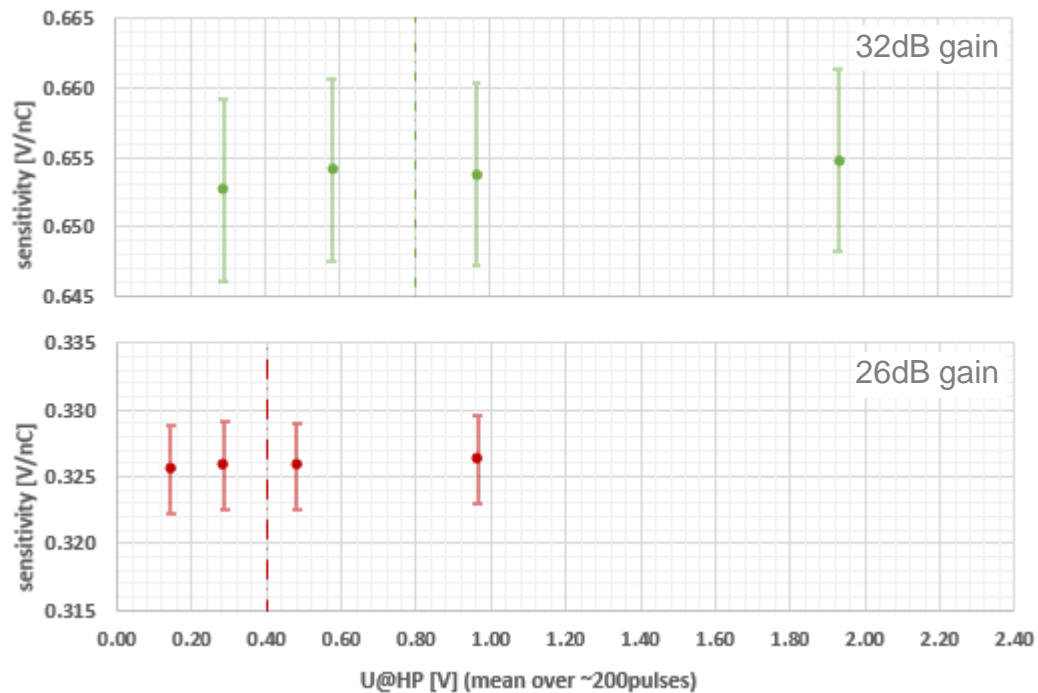
### Connecting calibrated reference charge pulse generator:

- Set proper pulse length (3us)
- Adjust delay to match situation with accelerator (center of mass with respect to timing windows)
- Verify relative signal contributions in timing windows

# Calibration of absolute charge measurement



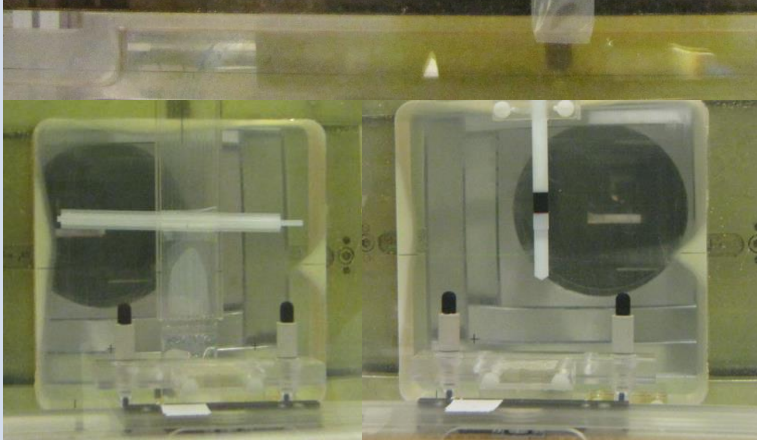
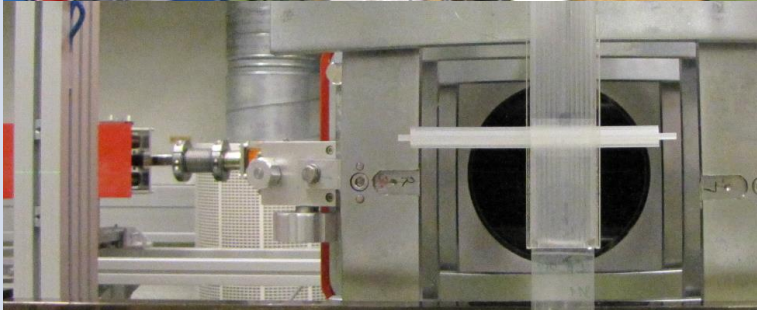
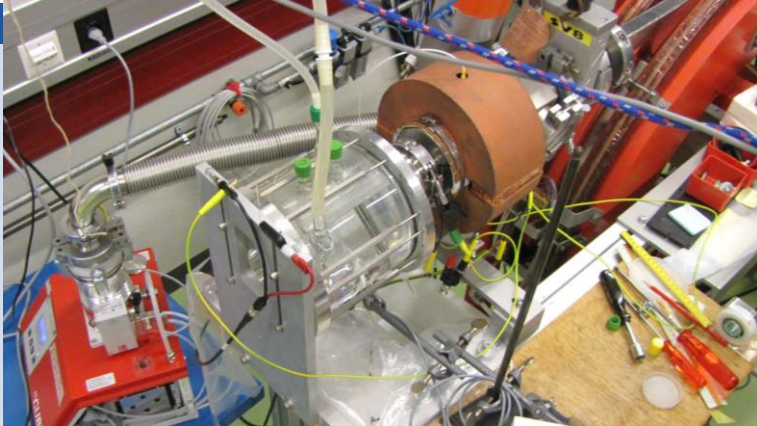
With calibrated reference charge pulse generator:



**Expanded uncertainty of deduced sensitivity: 1% (k=2)**

Dominant contribution from: correction factor of nominal pulse charge given as a function of pulse length for each current setting.

# Absolute charge measurement used for Fricke dosimetry



Fricke total absorption:

$$\varepsilon \cdot G = \frac{\Delta A}{\rho \cdot l \cdot D_F} = \frac{\Delta A}{\rho \cdot l} \cdot \frac{m}{E_{el} \cdot \boxed{N} \cdot f_p}$$

number of electrons

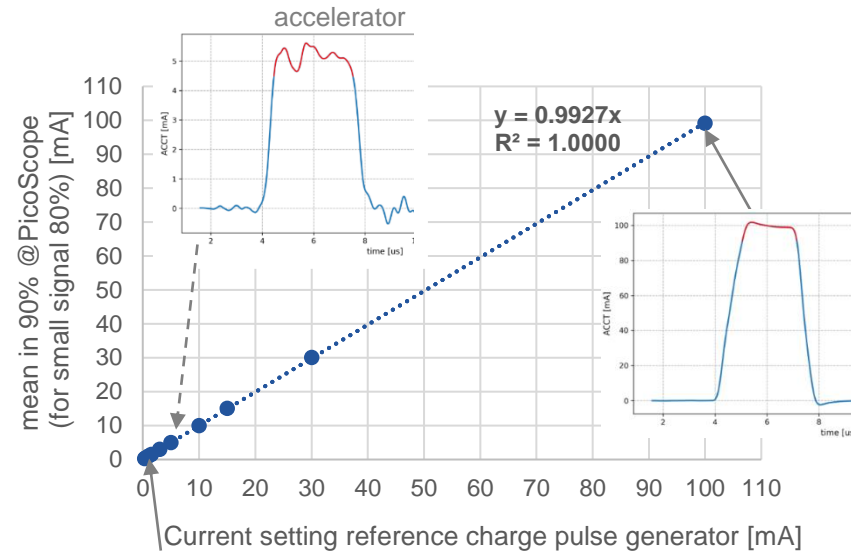
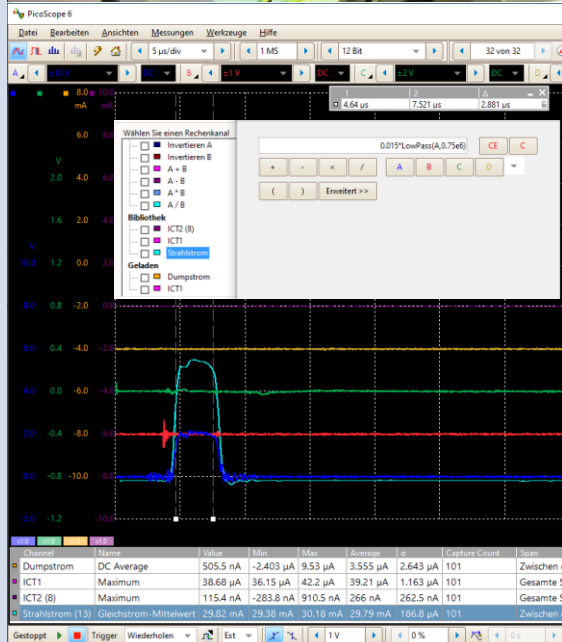
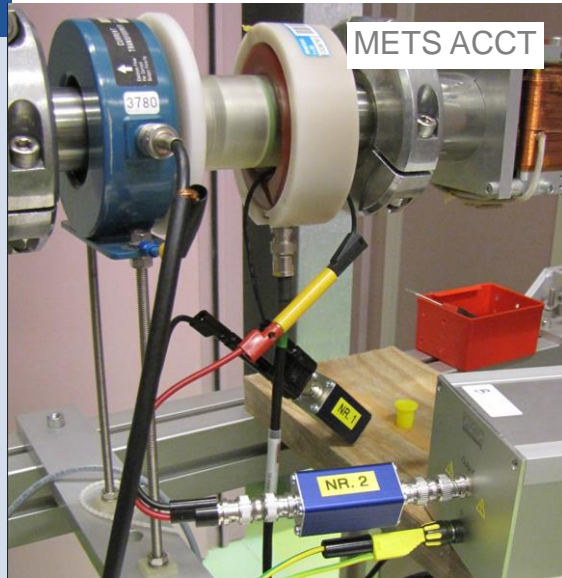
Fricke dosimeter in bags:

$$D_W = D_F \cdot f_{F/W} = \frac{\Delta c \cdot f_{F/W}}{\rho \cdot G} = \frac{\Delta A \cdot f_{F/W}}{\rho \cdot l \cdot \boxed{\varepsilon \cdot G}}$$

Comparison of the primary standards of PTB and METAS for absorbed dose to water in ultra-high dose per pulse electron beams via alanine dosimeters provided by the National Research Council of Canada (NRC).

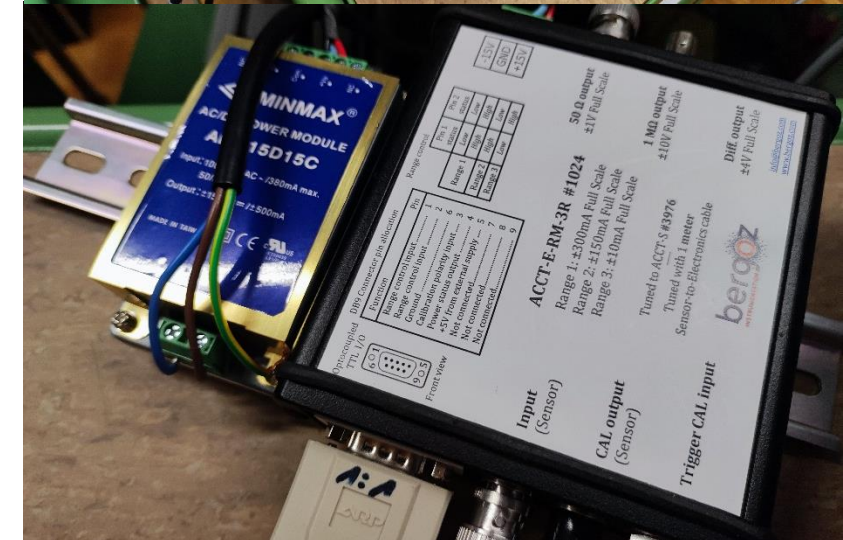
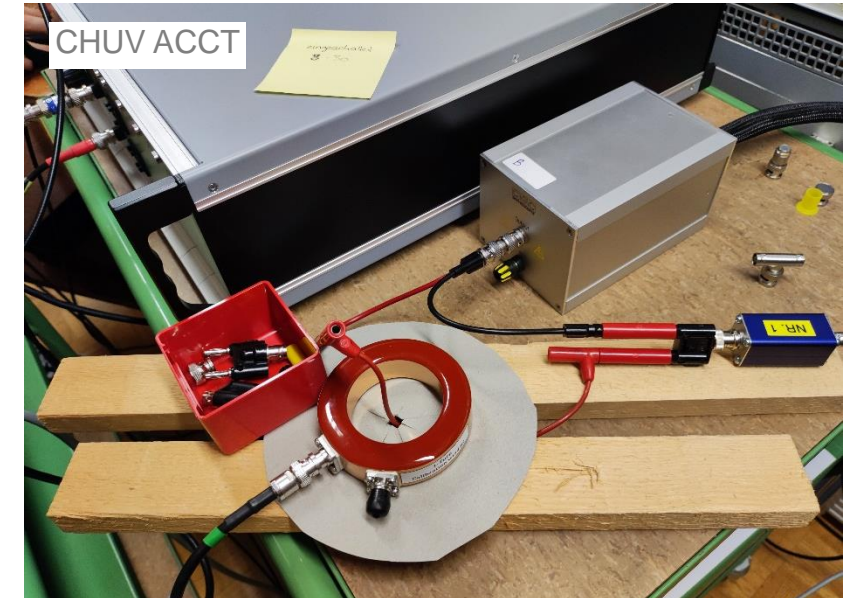
The summary of this analysis is that the standards of the METAS and PTB for UHDR electron beams agree within the combined standard uncertainty of the comparison measurement,  $R_{\text{METAS/PTB}} = 1.002 \pm 0.012$  (k=1). -> Deliverable 3 (See talk 24. of Alexandra Bourgoïn, PTB).

# Calibration of ACCT



## @METAS:

- Existing calibration in good agreement with the calibrated reference charge pulse generator.
- Since the ACCT signal is only used for rough beam setup, the calibration coefficient were not updated.



# Acknowledgement

The project 18HLT04 UHDpulse has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.



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Thank you very much for your attention