Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

UHDpulse

Ion collection efficiency (CCE) in ultra-high dose per pulse electron beams

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Faculty Disclosure

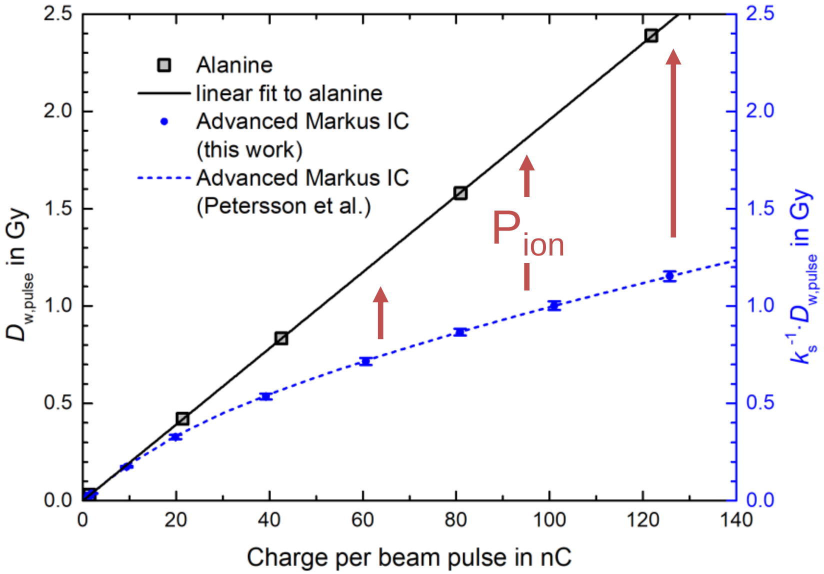
No, nothing to disclose

Ionometry of Flash beam

- Ultra-high dose rate means that ion recombination is very large

- Do not follow current model (Boag)

- Alanine can be use to measure the ion recombination



Bourgouin *et al.*, DOI:10.3389/fphy.2020.567340

Dose equation

$$D_w = M \cdot k_{R_{50}} \cdot N_{D,w}^{Co}$$

Dose equation

Dose

Beam quality correction factor

$$D_w = M \cdot k_{R_{50}} \cdot N_{D,w}^{Co}$$

Charge Measurement

Cobalt calibration factor

Dose equation

Dose

Beam quality correction factor

$$D_w = M \cdot k_{R_{50}} \cdot N_{D,w}^{Co}$$

Cobalt calibration factor

$$M = (Q_{raw} \cdot Q_{leak}) \cdot k_{sat} \cdot k_{elec} \cdot k'_{elec} \cdot k_{pol} \cdot k_{TP} \cdot k_{field}$$

Charge measurement equation

Raw meas. - leakage

$$M = (Q_{raw} \cdot Q_{leak}) \cdot k_{sat} \cdot k_{elec} \cdot k'_{elec} \cdot k_{pol} \cdot k_{TP} \cdot k_{field}$$

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Saturation effect

Charge measurement equation

Electrometer calibration +

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Saturation effect

Polarity effect

Charge measurement equation

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Electrometer calibration +

Temperature pressure

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Saturation effect

Polarity effect

Non-homogeneity of beam profile

Charge measurement equation

$$M = (Q_{raw} \cdot Q_{leak}) \cdot k_{sat} \cdot k_{elec} \cdot k'_{elec} \cdot k_{pol} \cdot k_{TP} \cdot k_{field}$$

↓

$$M = Q'' \cdot k_{sat}$$

+

$$D_w = M \cdot k_{R_{50}} \cdot N_{D,w}^{Co}$$

~~Dose~~ k_{sat} equation

$$k_{sat} = \frac{D_w}{Q" \cdot k_{R_{50}} \cdot N_{D,w}^{Co}}$$

~~Dose~~ k_{sat} equation

Dose to water estimated from Alanine calibration

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~~Dose~~ k_{sat} equation

Dose to water estimated from Alanine calibration

$$k_{sat} = \frac{D_w}{Q" \cdot k_{R_{50}} \cdot N_{D,w}^{Co}}$$

Calculated by Monte Carlo

Measurement set-up

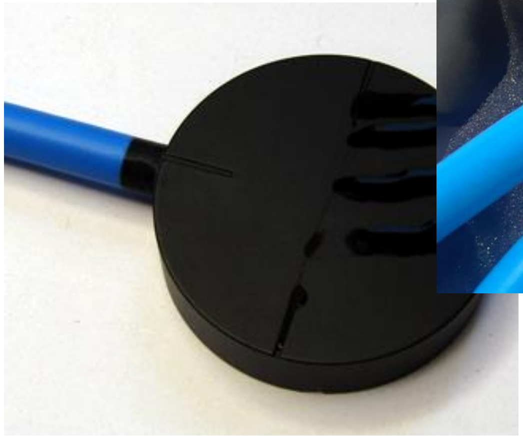
- Metrological Electron Accelerator Facility (MELAF) at PTB, Germany

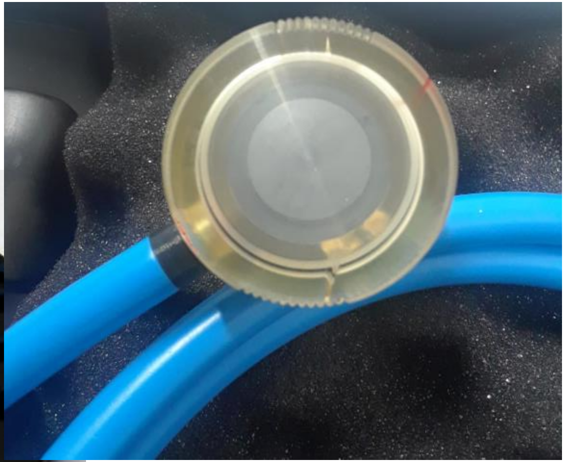
- Tests carried out at 20 MeV, 5 Hz PRF, pulse width of 2.5 µs
- Dose varied between 0.1 Gy and 6.3 Gy per pulse
- Beam current monitor;

Integrating Current Transformer (ICT)

Detectors

- Alanine was evaluated using the PTB's Alanine/SPR system
- 6 parallel plate ionization chamber models
  - 6 Advanced Markus (gap of 1.0 mm)
  - 4 Roos (gap of 2.0 mm)





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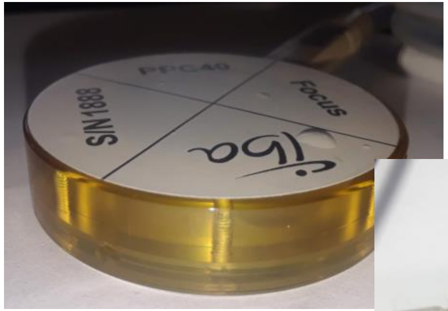
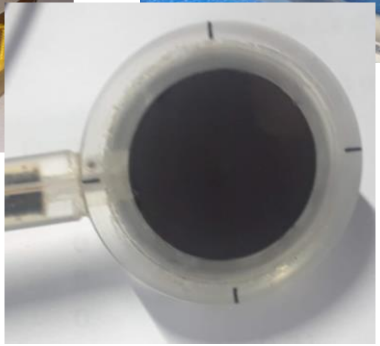
  - 5 PPC05 (gap of 0.6 mm)
  - 3 PPC40 (gap of 2.0 mm)
  - 2 NACP02 (gap of 2.0 mm)





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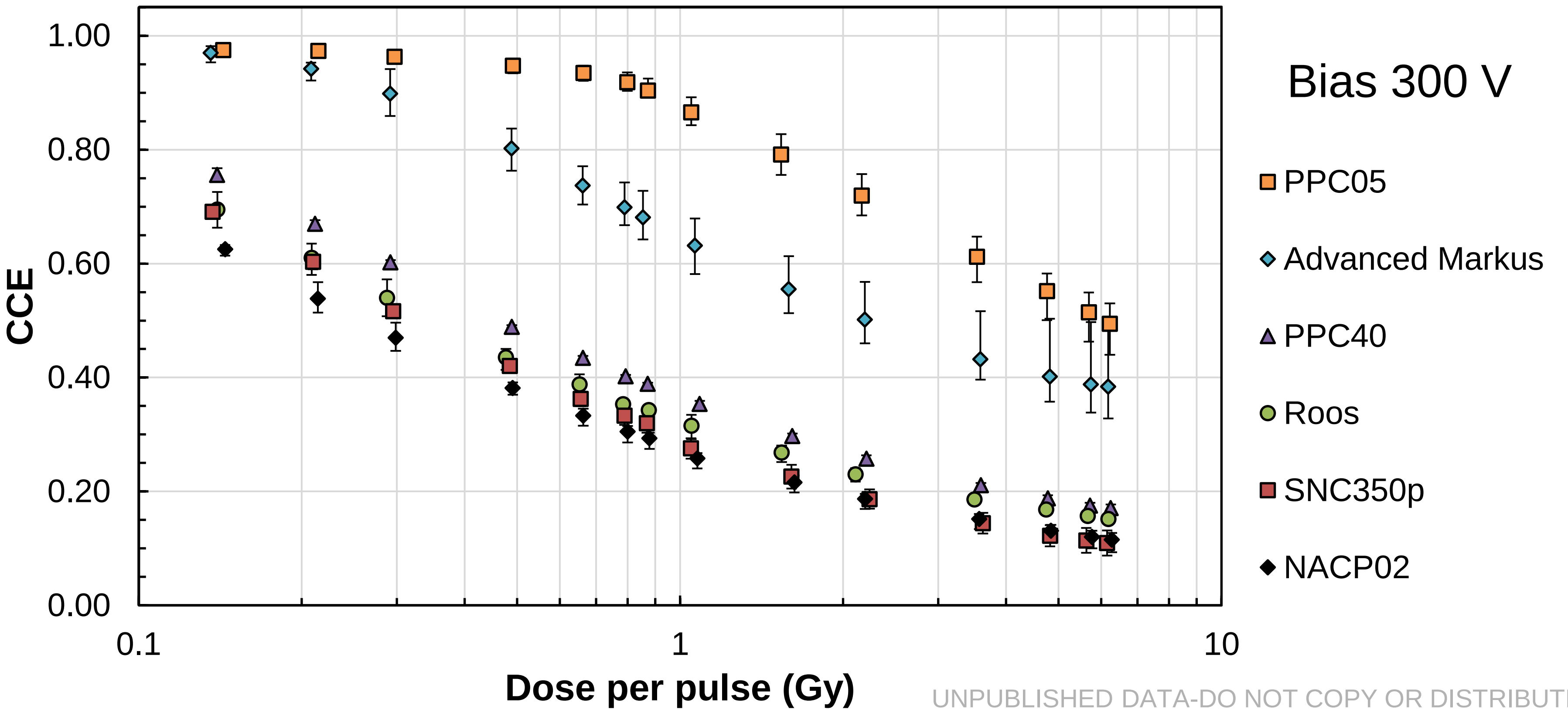
  - 2 SNC350p (gap of 2.0 mm)

Charge collection efficiency



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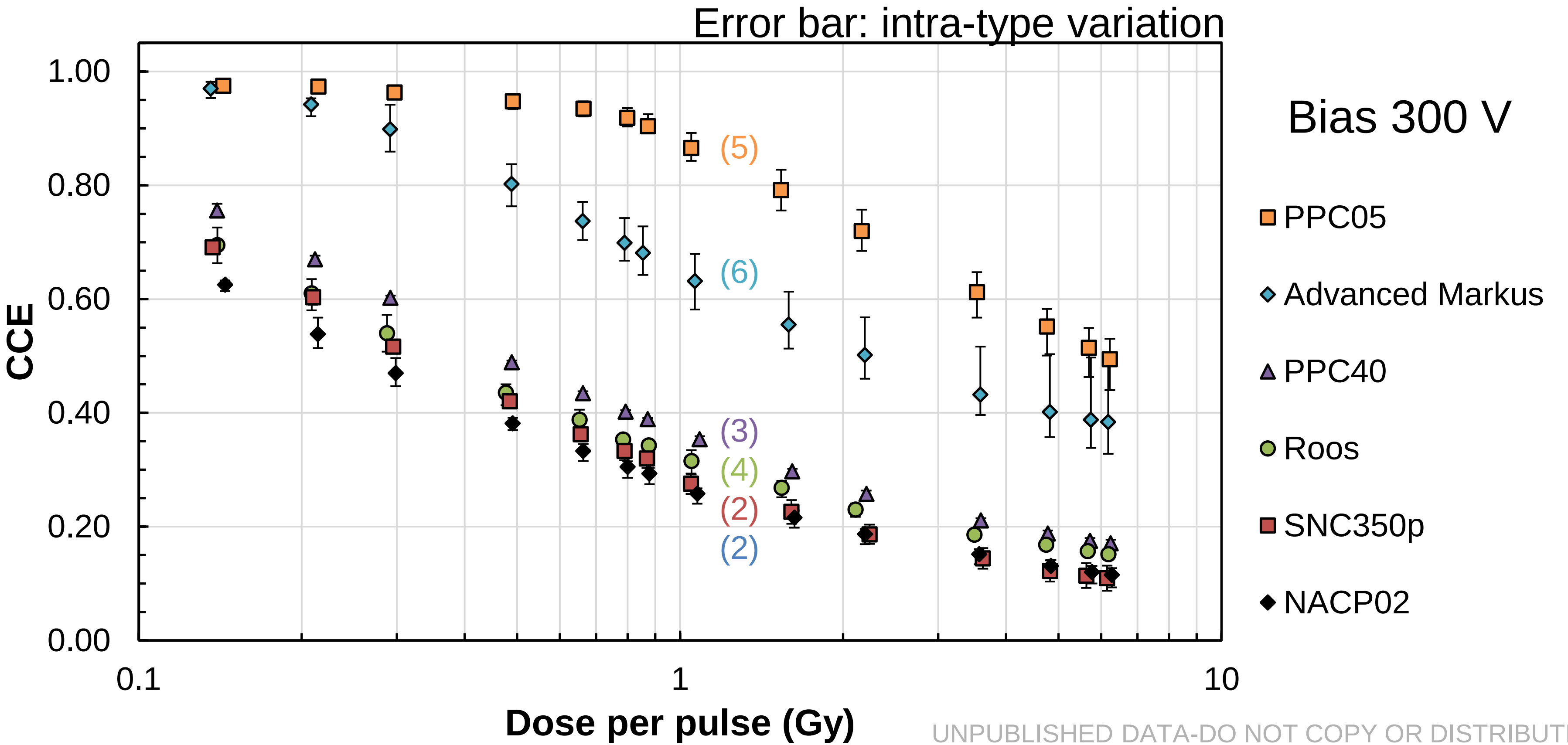
Charge collection efficiency



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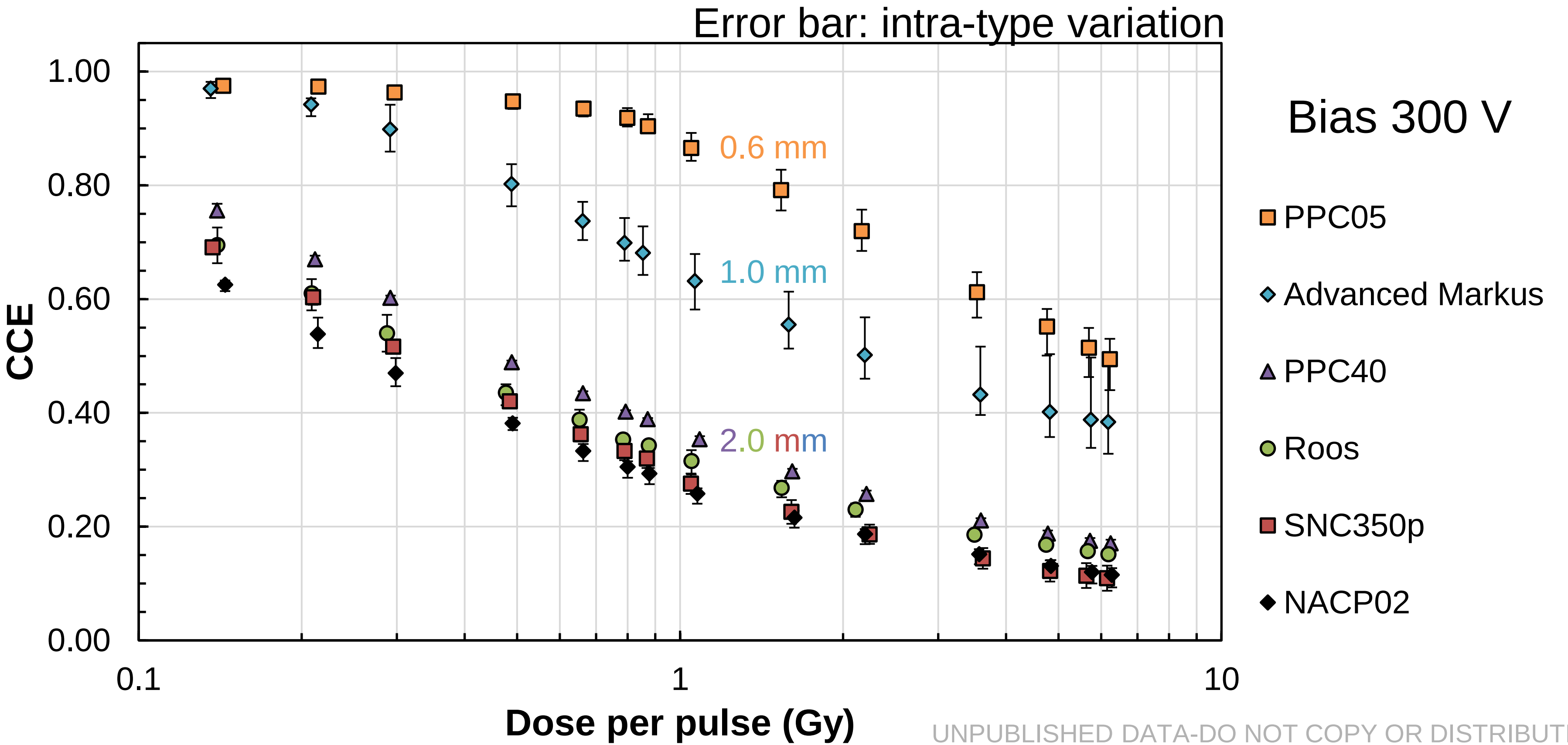

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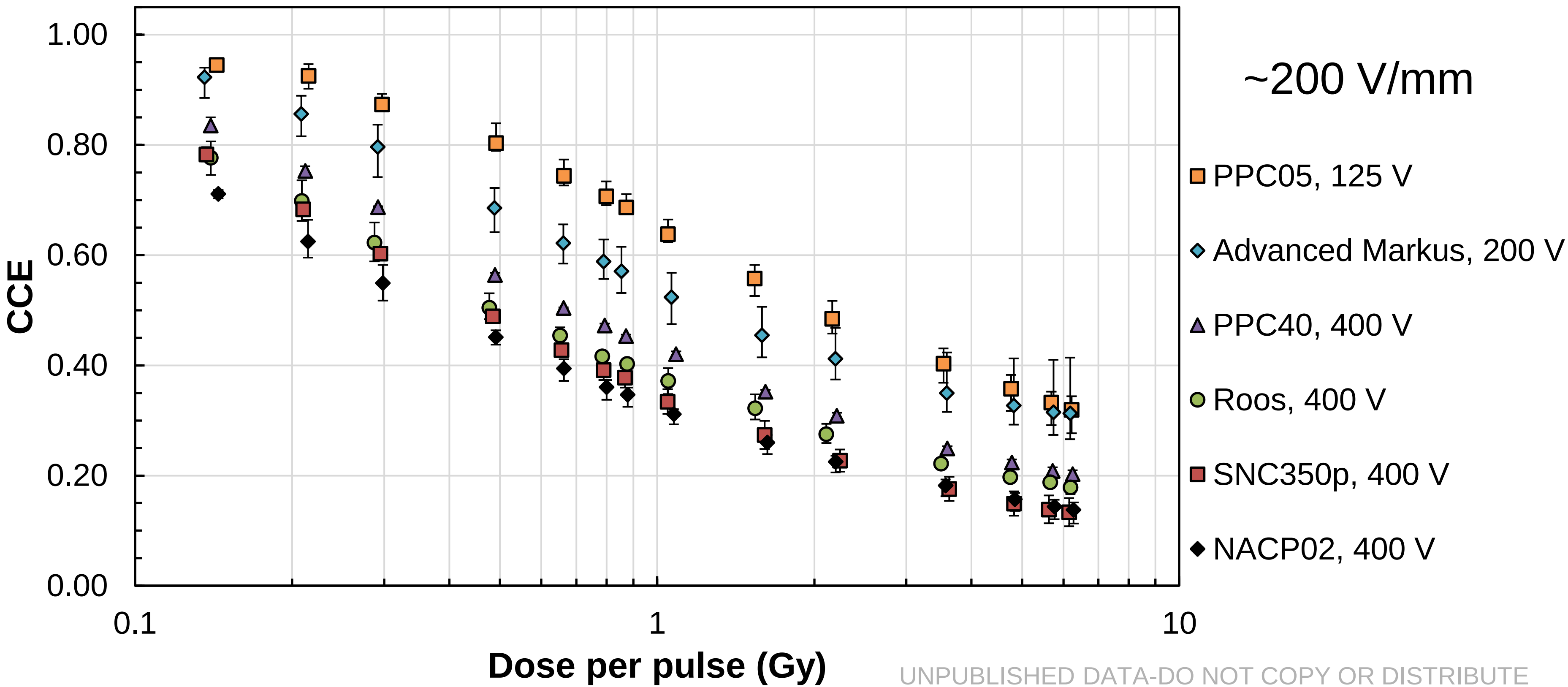

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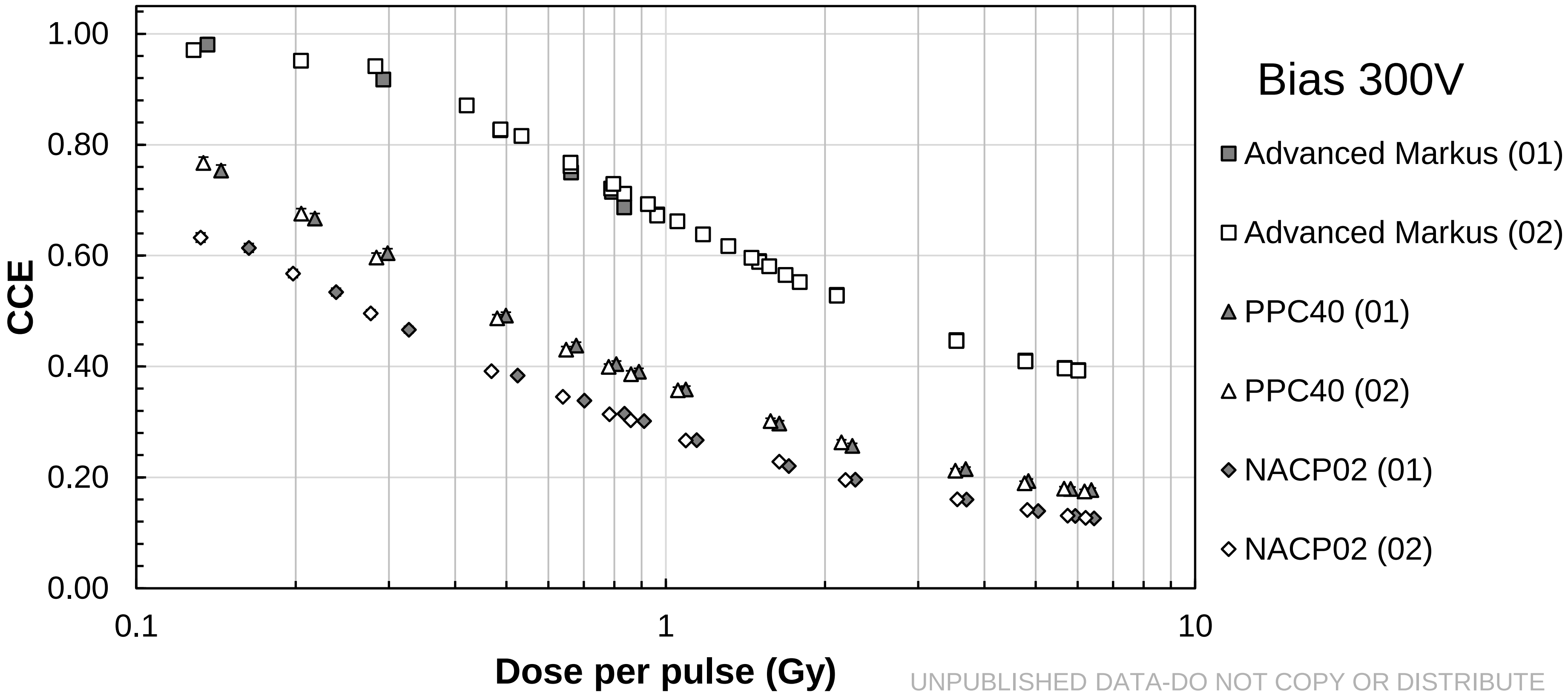
Reproducibility



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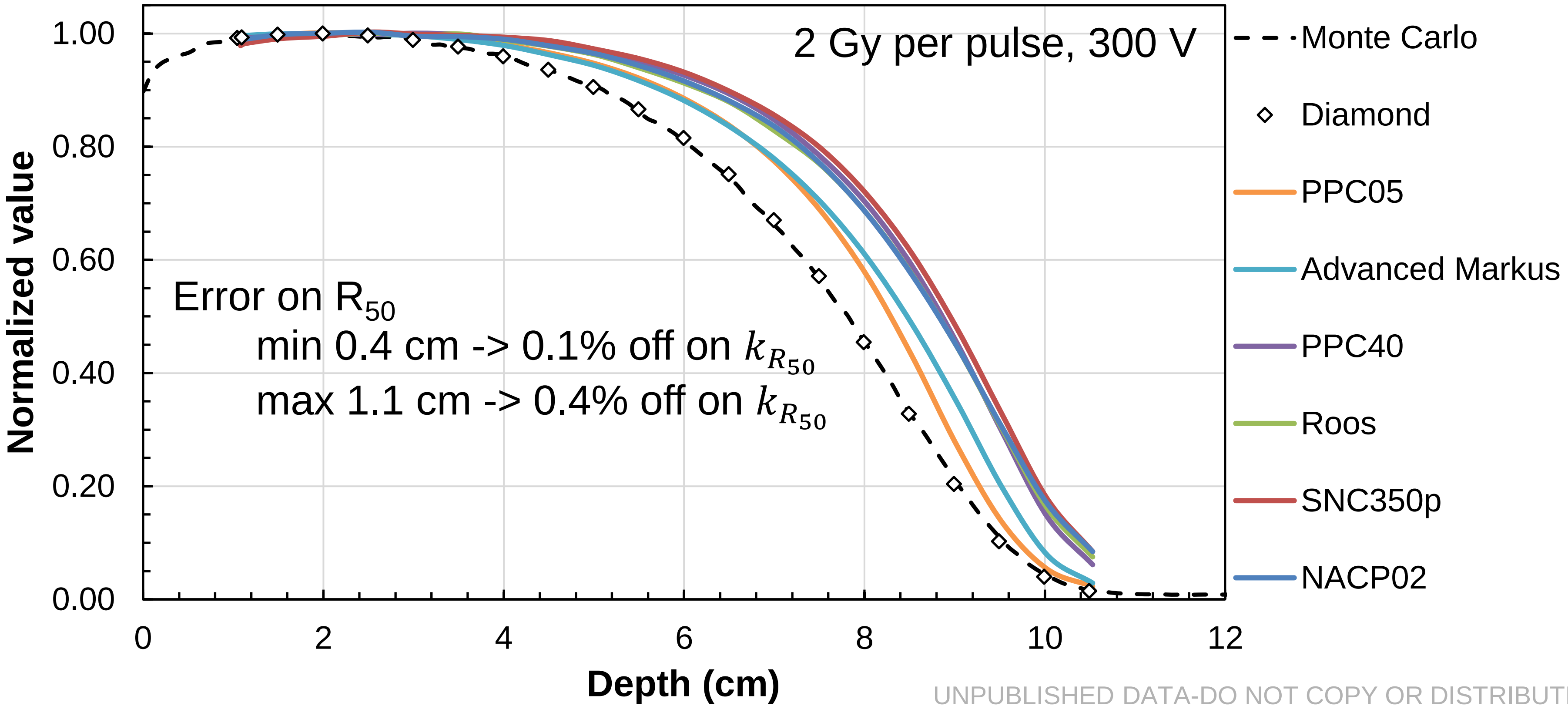
Relative Measurement (not corrected)



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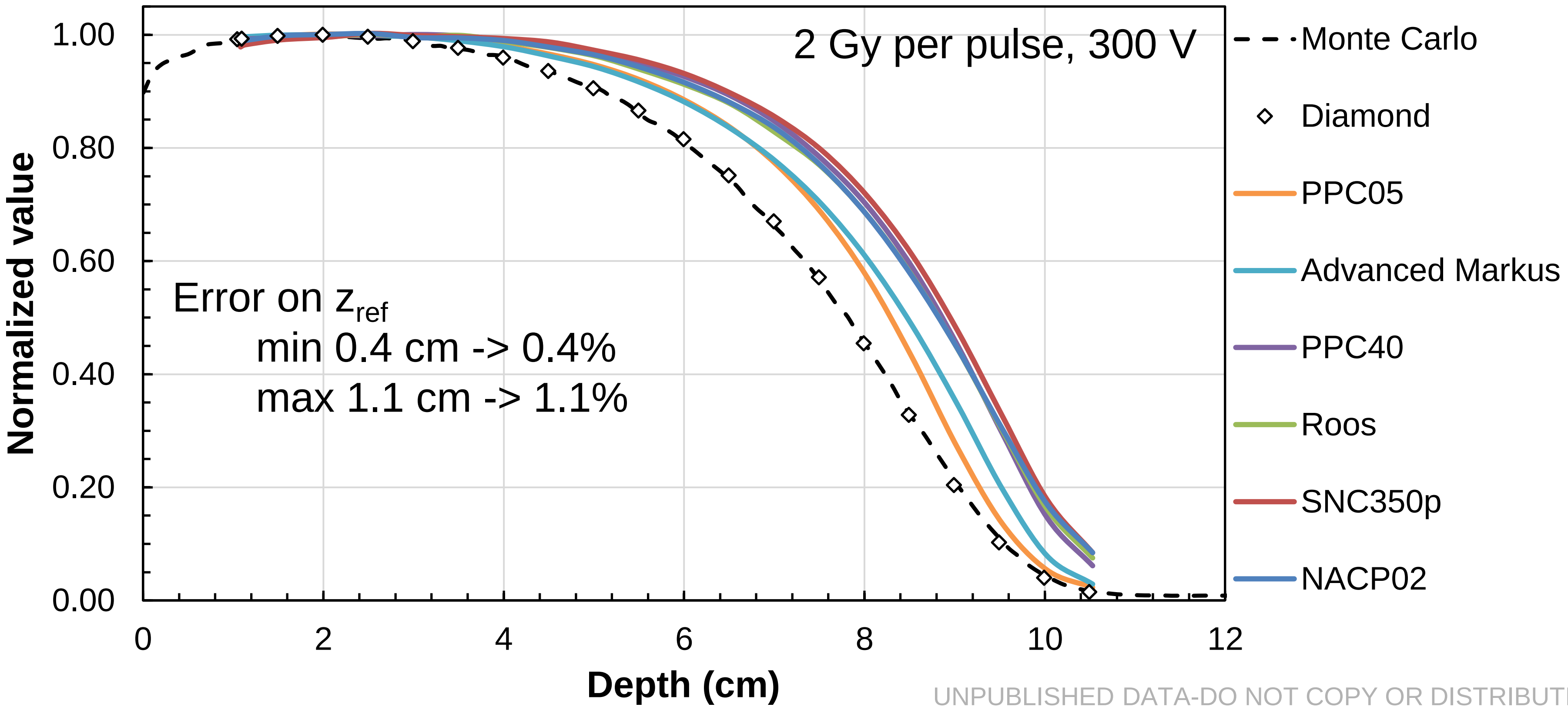

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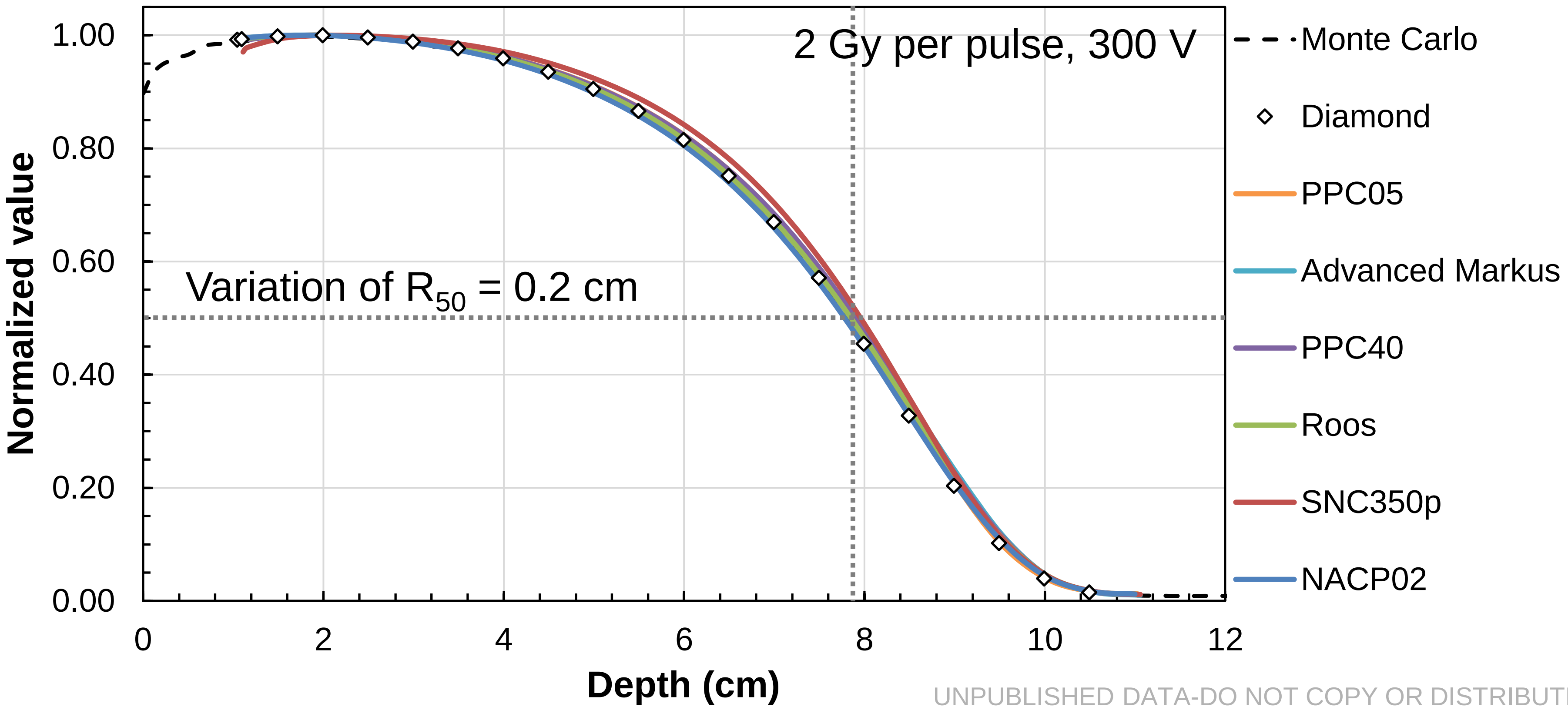


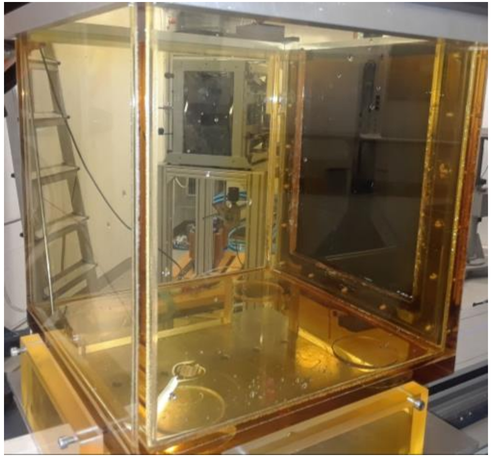
Conclusion

- Absolute dosimetry
  - Intra-type variations up to 10 %
- Polarity effect
  - up to 10 %
- Electrometer used in current mode
  - Test yours!
- Relative measurement
  - k_{sat} as to be used even for relative measurement
  - Published model work, good enough

A FLASH moment of silence

~~Advanced~~ Markus
Drowned

~~Roos~~
Weep



Water ~~tank~~
tomb

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UHDpulse

http://uhdpulse-empir.eu/

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Merci
Thank you
Dankeschön