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FRICKE DOSIMETRY AS A PRIMARY STANDARD AND REFERENCE FOR ABSORBED DOSE TO WATER IN ULTRA HIGH PULSE DOSE RATE ELECTRON BEAMS

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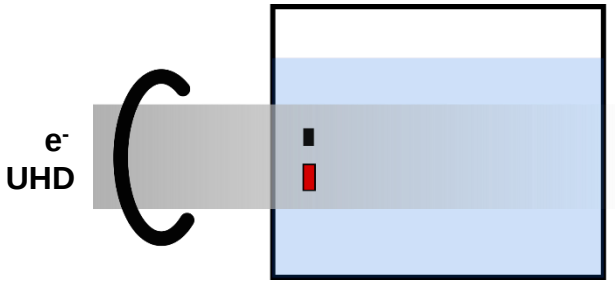
Faculty Disclosure

✓	No, nothing to disclose
	Yes, please specify:

Company Name	Honoraria/ Expenses	Consulting/ Advisory Board	Funded Research	Royalties/ Patent	Stock Options	Ownership / Equity Position	Employee	Other (please specify)

Agenda

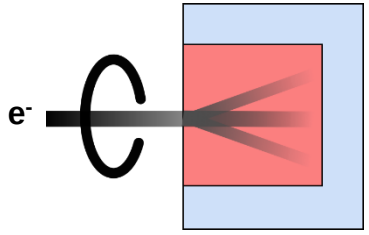
1. Calibration using Fricke solution



3. Consequences for using Fricke dosimetry in UHD electron beams.

$\varepsilon \cdot G$ **measure** or **ICRU90** or **compare**

2. Determination of radiation chemical yield
-> Total absorption technique

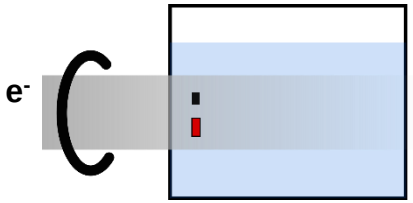


to transfer instruments: Alanine, EBT3, ionisation chamber, …

For 1L Fricke solution @ METAS:

392.14 mg	Fricke salt	$(NH_4)_2Fe(II)(SO_4)_2$
+ 58.44 mg	Sodium chloride	NaCl
+ up to 1L	Aqueouse sulfuric acid	H_2SO_4 , 0.4mol/L

Calibration using Fricke solution



- Irradiation of the Fricke solution leads to the oxidation of Fe2+ to Fe3+.
- The increase of Fe3+ is proportional to the absorbed dose.


Accelerator: M22 from Scanditronix

Absorbed dose in Fricke solution in Gy

Transfer factor

$$D_W = D_F \cdot f_{F/W} = \dots = \frac{\Delta A \cdot f_{F/W}}{\rho \cdot l \cdot \varepsilon(\lambda) \cdot G}$$

measured Monte Carlo

Change in absorbance $A_{irradiated} - A_{unirradiated}$

Chemical yield in mol/J

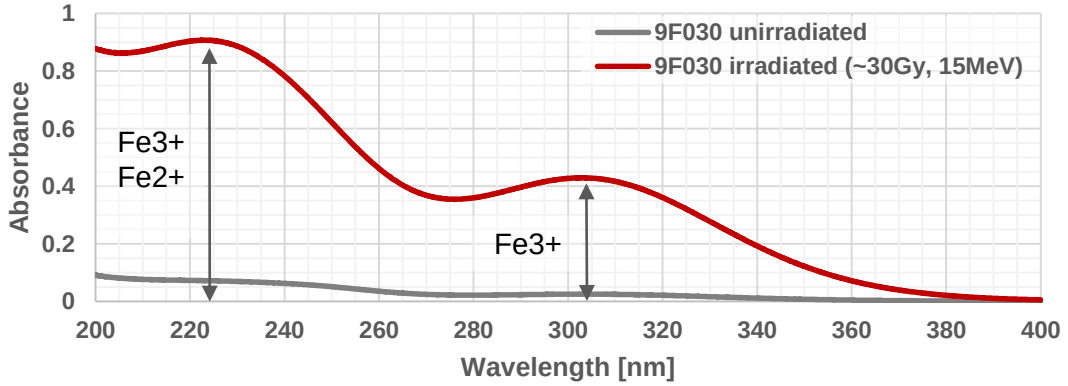
Density of Fricke solution in kg/l

Path length through cuvette in cm

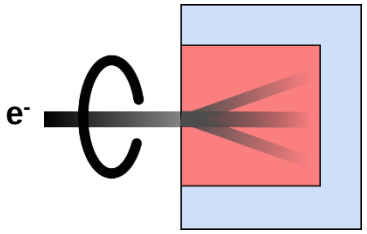
Molar extinction coefficient in l/cm/mol

Fricke dosimeter:

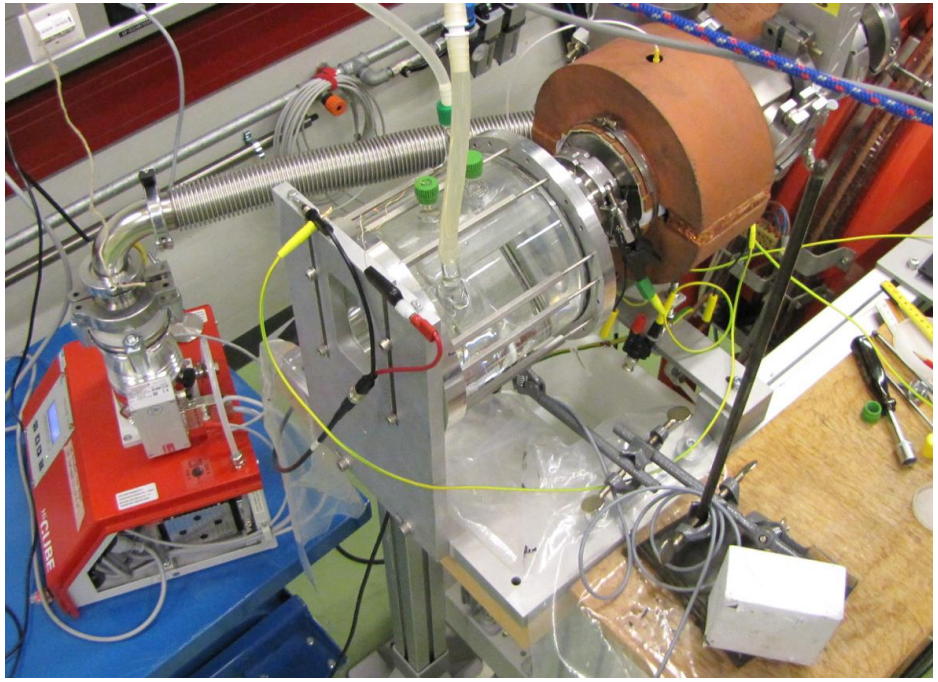
- Closely water-equivalent ($f_{F/W}$: 1.005 - 1.008, depending on the electron energy)
- Independent of irradiation energies for energies > 2 MeV
- Bag (50 µm thick polyethylene foil) of size 30×40×3 mm³



Determination of radiation chemical yield -> Total absorption



- Special electron beam.
- Glass vessel, closed using a 50μm polyethylene foil (volume: 1L or 2L)
- Temperature stabilised to 25°C using circulating water



$$\varepsilon \cdot G = \frac{\Delta A \cdot f_{F/W}}{\rho \cdot l \cdot D_W} = \frac{\Delta A}{\rho \cdot l} \cdot \frac{f_{F/W} \cdot m}{E_{el} \cdot N \cdot f_p}$$

Mass of Fricke solution

measured

Monte Carlo

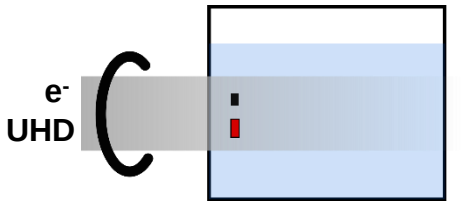
Electron energy

Number of electrons

Fraction of incident electron beam energy deposited

- Fraction of incident beam electrons energy deposited in the Fricke solution: f_p: $92 - 97\%$ (depending on energy and vessel)
- Uncertainty total absorption: aiming for $\boldsymbol{\varepsilon \cdot G}$ @304nm 1.4% (k=2)
- Next step: measurement campaign to compare to other primary standards

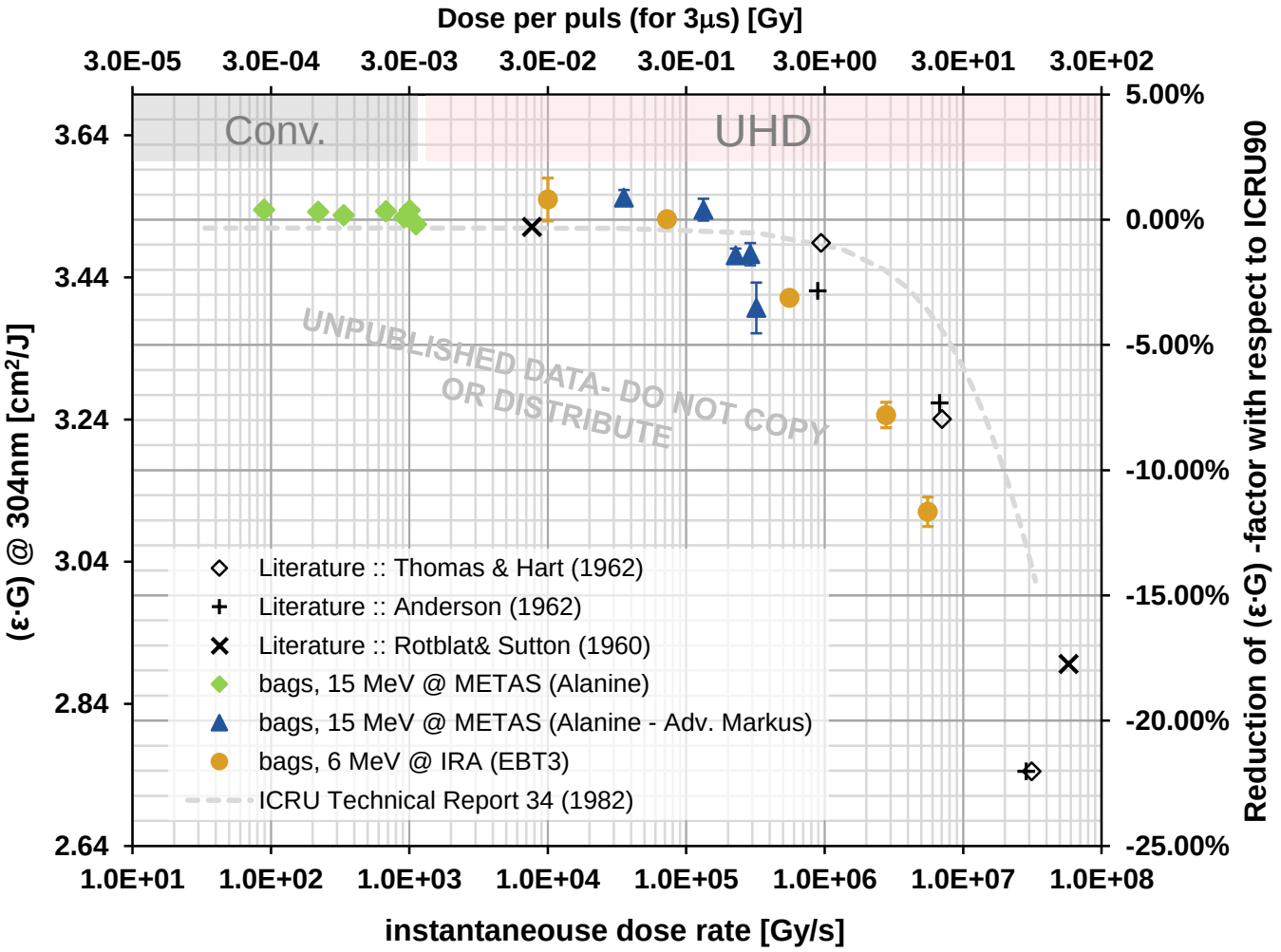
Consequences for using Fricke dosimetry in UHD electron beams



compare

to transfer instruments: Alanine, EBT3, ionisation chamber, …

- Allows measurements in the «UHD-reference beam»
- At ~> 1Gy/pulse (of 3µs) radical-radical reactions start to reduce the value of radiation yield G.
- Next step: further characterize the Fricke dosimeter at higher instantaneous dose rates to determine correction factors.
- Uncertainty for conventional: $N_{W,Q}$ 1.7% (k=2)



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Thank you very much for your attention