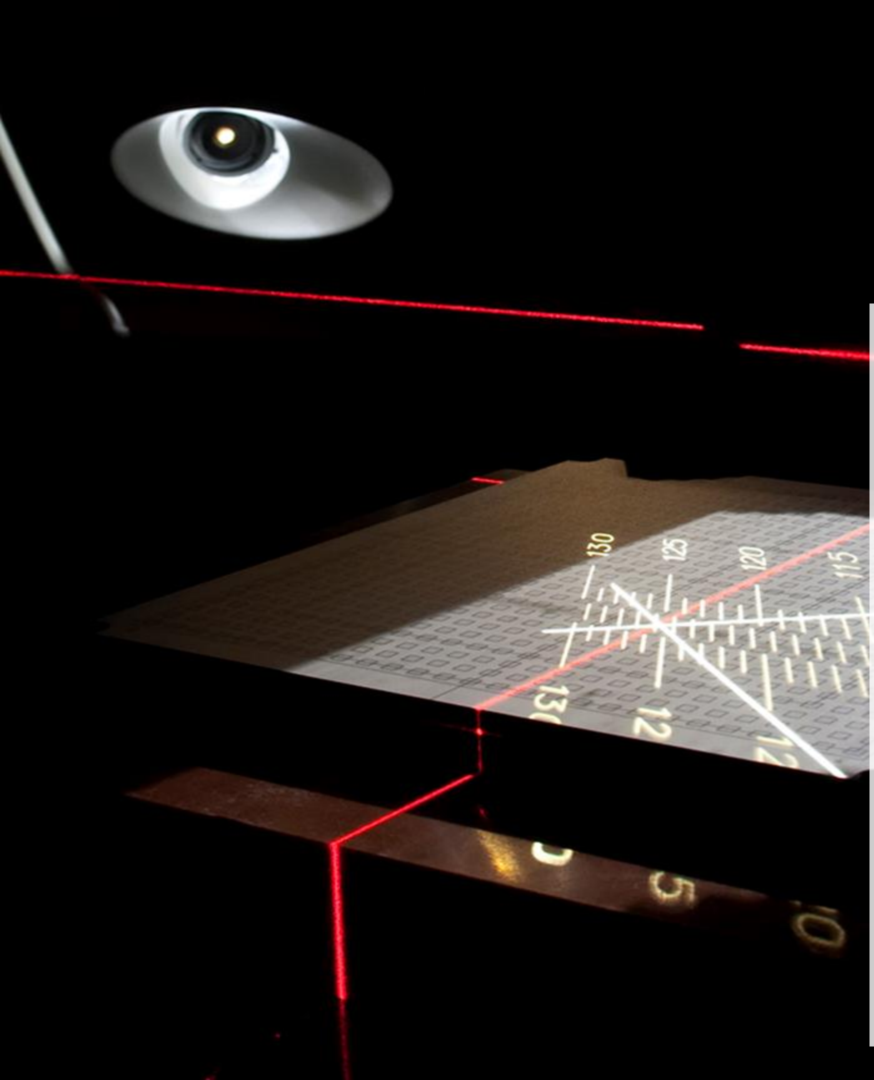

Institut de radiophysique

Dosimetry of ultra high dose rate irradiation for studies on the biological effect induced in normal brain and GBM

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Introduction

- Why is radiotherapy with ultra-high dose-rate (Flash) of interest?
  - Possible increase in differential response between normal tissue and tumors.

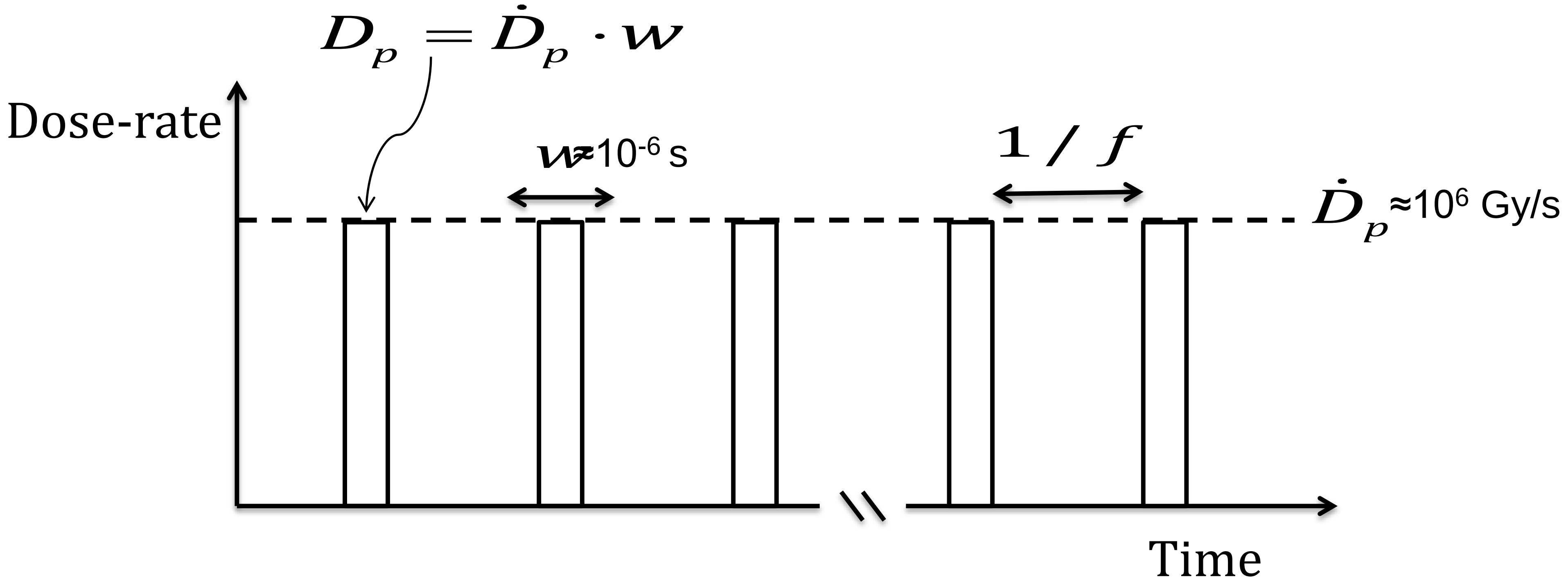
    Favudon *et al.* 2014, Institut Curie, France
  - Short treatment times (<1s)
    - Motion management, i.e. remove intra-fraction motion
    - Patient comfort
    - Improved treatment efficiency

    Cherry Kemmerling *et al*. 2015, Stanford University, USA
- Dosimetric challenges!
  - Many of the commonly used dosimeters in radiotherapy are known to saturate

    E.g. ionization chambers, diods, diamond detectors

Prototype 6 MeV electron Linac
PMB-Alcen, Peynier, France

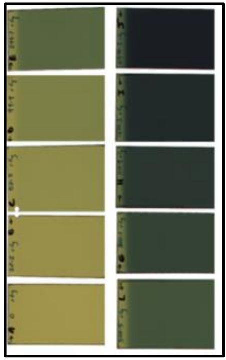
4-6 MeV pulsed electron beam

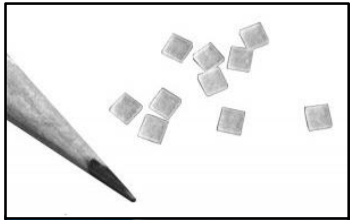


$D_p = \dot{D}_p \cdot w$: dose per pulse $\in [10^{-3}; 5]\,Gy$

$\dot{D}_m = \dot{D}_p \cdot w \cdot f$: mean dose-rate $\in [10^{-2}; 1000]\,Gy/s$

Tested dose-rate dependence for five types of dosimeters



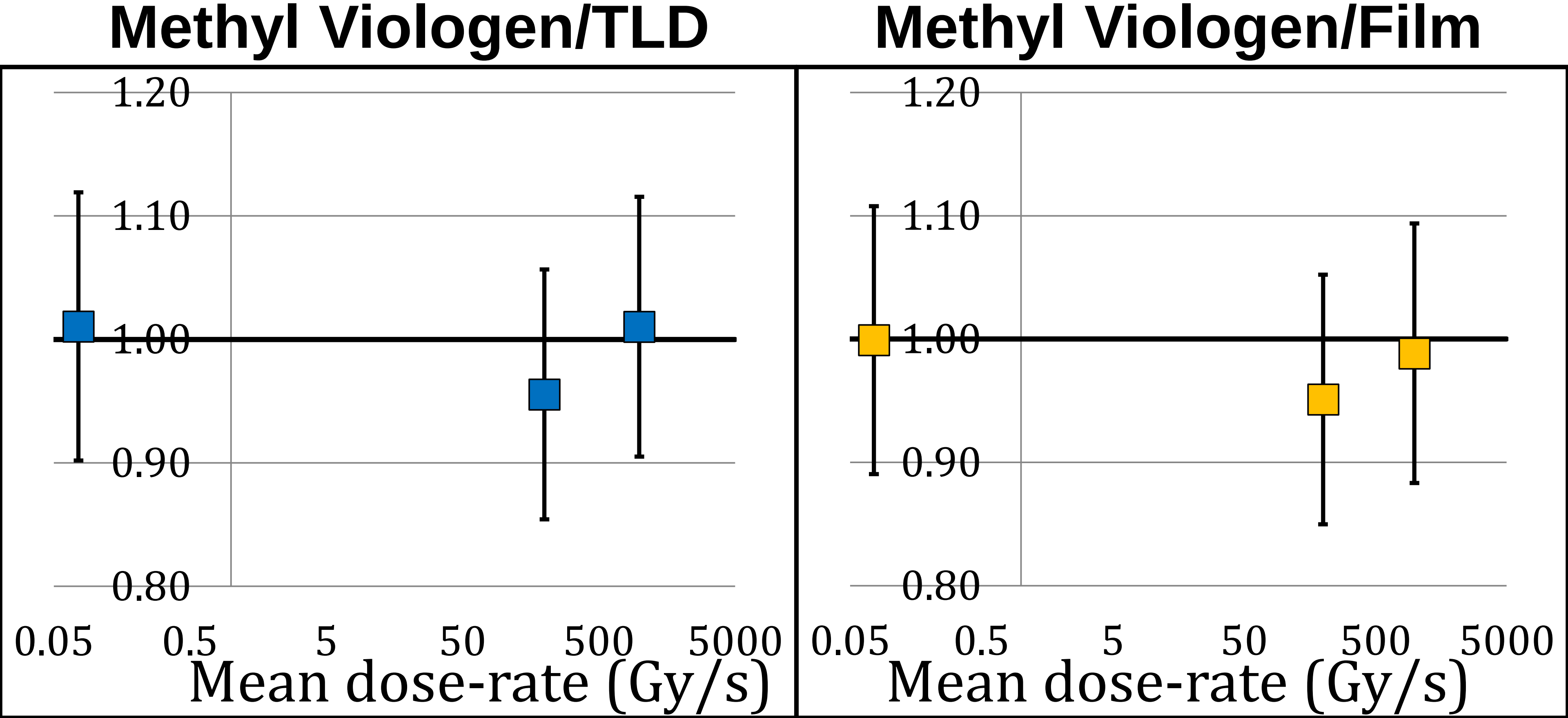


- Dose-rate independent dosimeters?
    - Radiochromic films (Gafchromic EBT3)
    - Thermoluminescent dosimeter (TLD-100)
        - > 10^9 Gy/s, Karsch *et al*. 2012
    - Alanine pellets (IRSN)
        - NIST, NPL
    - Methyl viologen
        - > 10^7 Gy/s, Favaudon *et al*. 2014

- Dose-rate dependent
    - Advanced Markus Ionization chamber

Mean dose-rate range: $\dot{D}_m \in [10^{-2}; 1000]\, Gy/s$

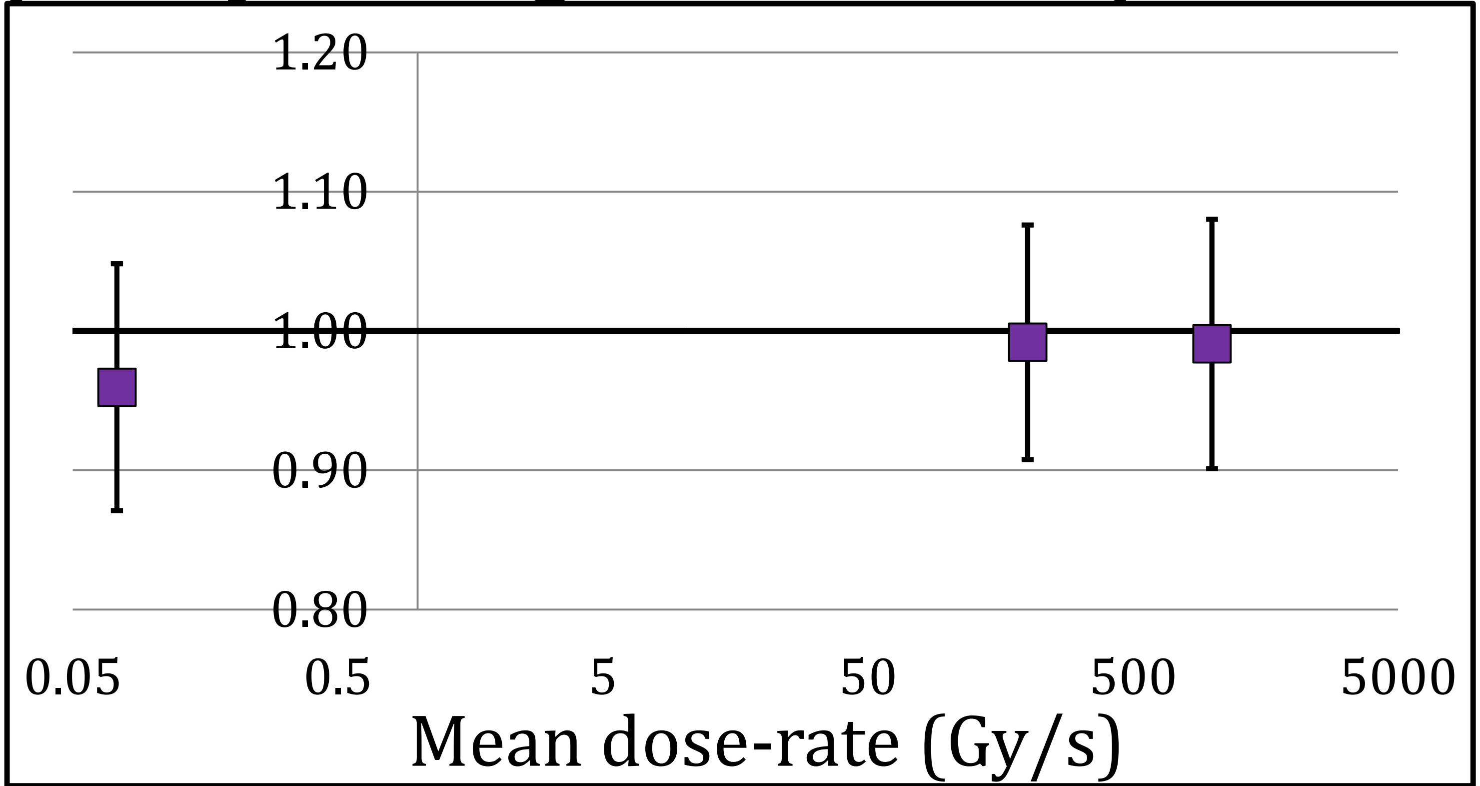
Dose/pulse range: $D_p \in [10^{-3}; 5]\, Gy$



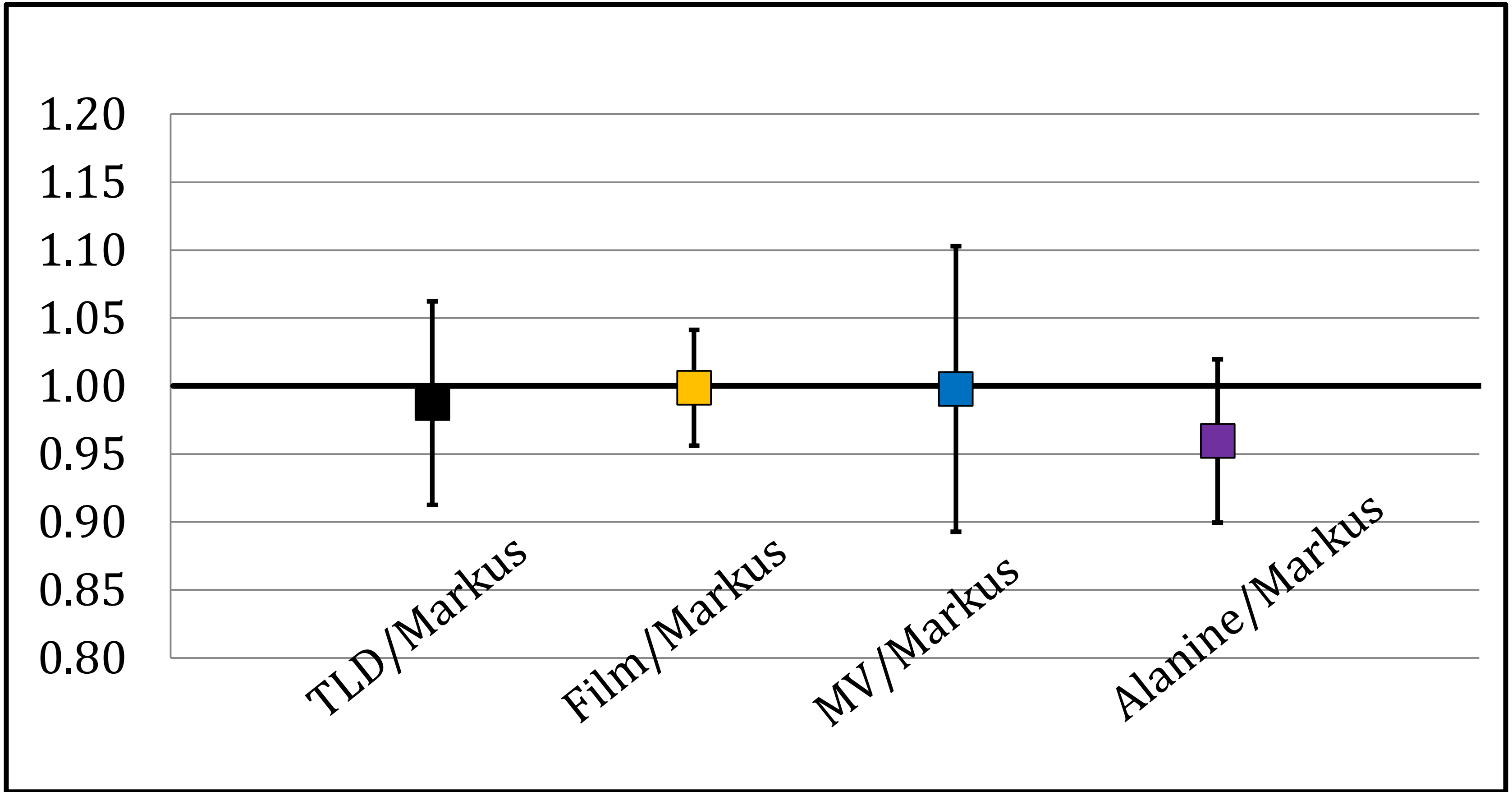
Mean dose-rate range: $\dot{D}_m \in \left[10^{-2}; 1000\right] Gy/s$

Dose/pulse range: $D_p \in \left[10^{-3}; 5\right] Gy$

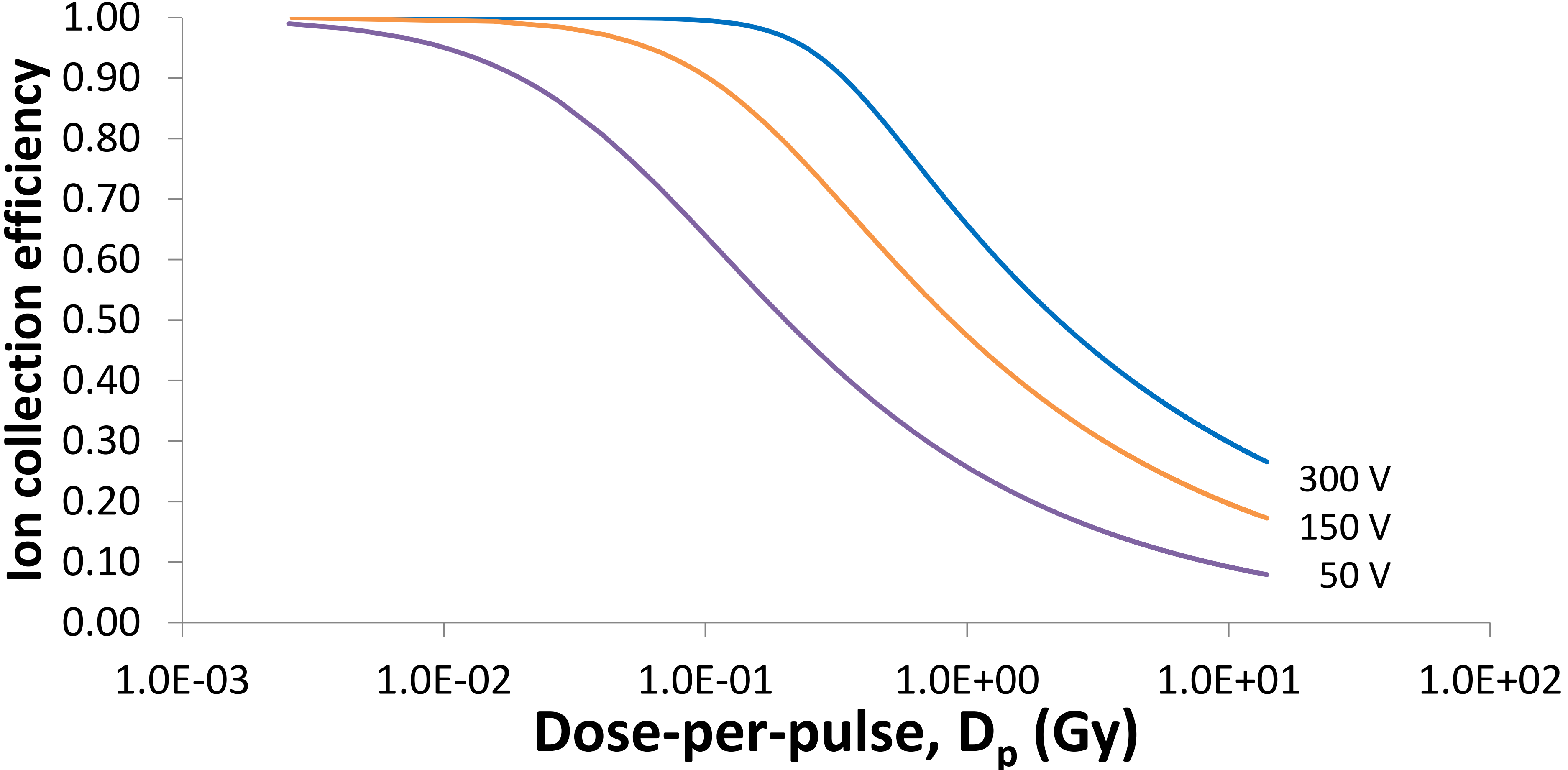
(Methyl Viologen, Film, TLD)/Alanine



Advanced Markus at low dose rate
4 Gy/min



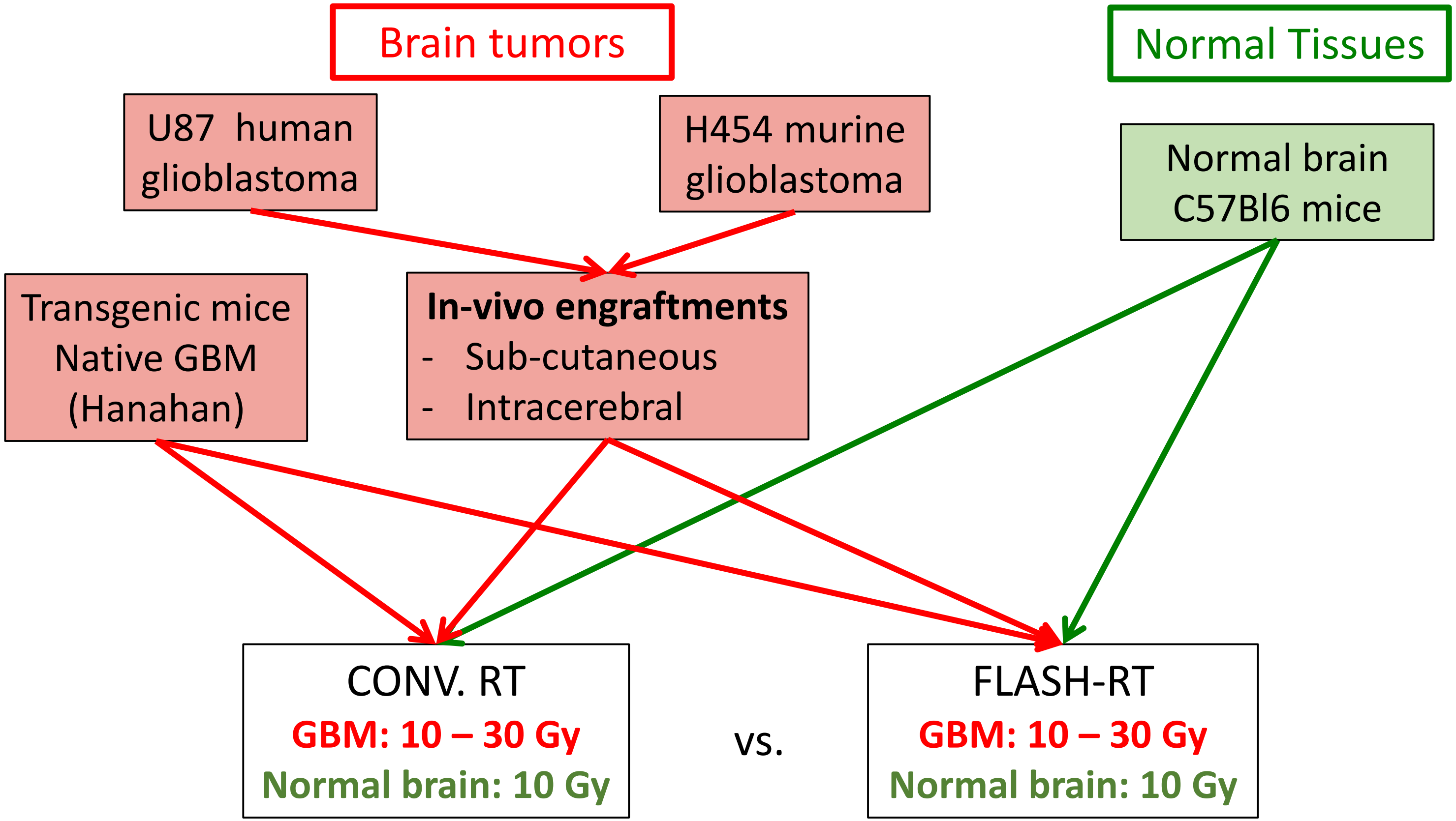
Advanced Markus saturation



Summary
Dosimetry

- Verified that TLD, MV, Film and Alanine are indeed dose-rate independent (> 10^6 Gy/s)
  - Off-line read-out
    - Result: minutes-days after RT
- Advanced Markus ion-chamber saturates but still useful for Flash if saturation taken into account.
  - On-line read-out
    - Direct result
- Well prepared to perform accurate dosimetry, needed for pre-clinical studies.

Biological strategies and models



Future

- Continue with ongoing pre-clinical studies
- Investigate any biological dose-rate effect in mammals (cats, piglets)
- Investigate any biological dose-rate effect for
  - Proton therapy (beam scanning)
  - Synchrotron therapy (broad beam)

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