Dosimetric Characterisation of Glass Bead TLDs in Proton Beams

Shakardokht M. Jafari[1, 2,*], Russell Thomas[3], D. A. Bradley[1], N. M. Spyrou[1], A. Nisbet[1, 4], C. H. Clark[1,3,4]

[1]Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH, UK

[2]Radiology Department, Faculty of Medicine, Kabul Medical University, Kabul, Afghanistan

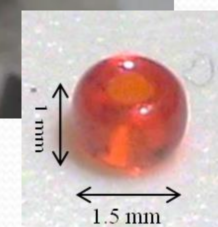
[3]National Physical Laboratory, Teddington, Middlesex TW11 0LW, U.K

[4]Department of Medical Physics, Royal Surrey County Hospital NHS Trust, Guildford, GU2 7XX Surrey, UK

PPRIG Proton Therapy Physics Workshop At the National Physical Laboratory, 12th – 13th March

Motivation for use of glass bead TLDs for Proton Dosimetry

- Spherical physical shape with a hole in the middle
- Chemically inert nature
- Small size of 1.5 mm diameter and 1 mm thickness
- Inexpensive and readily available
- Reusable
- **TL light transparency** with negligible self-attenuation

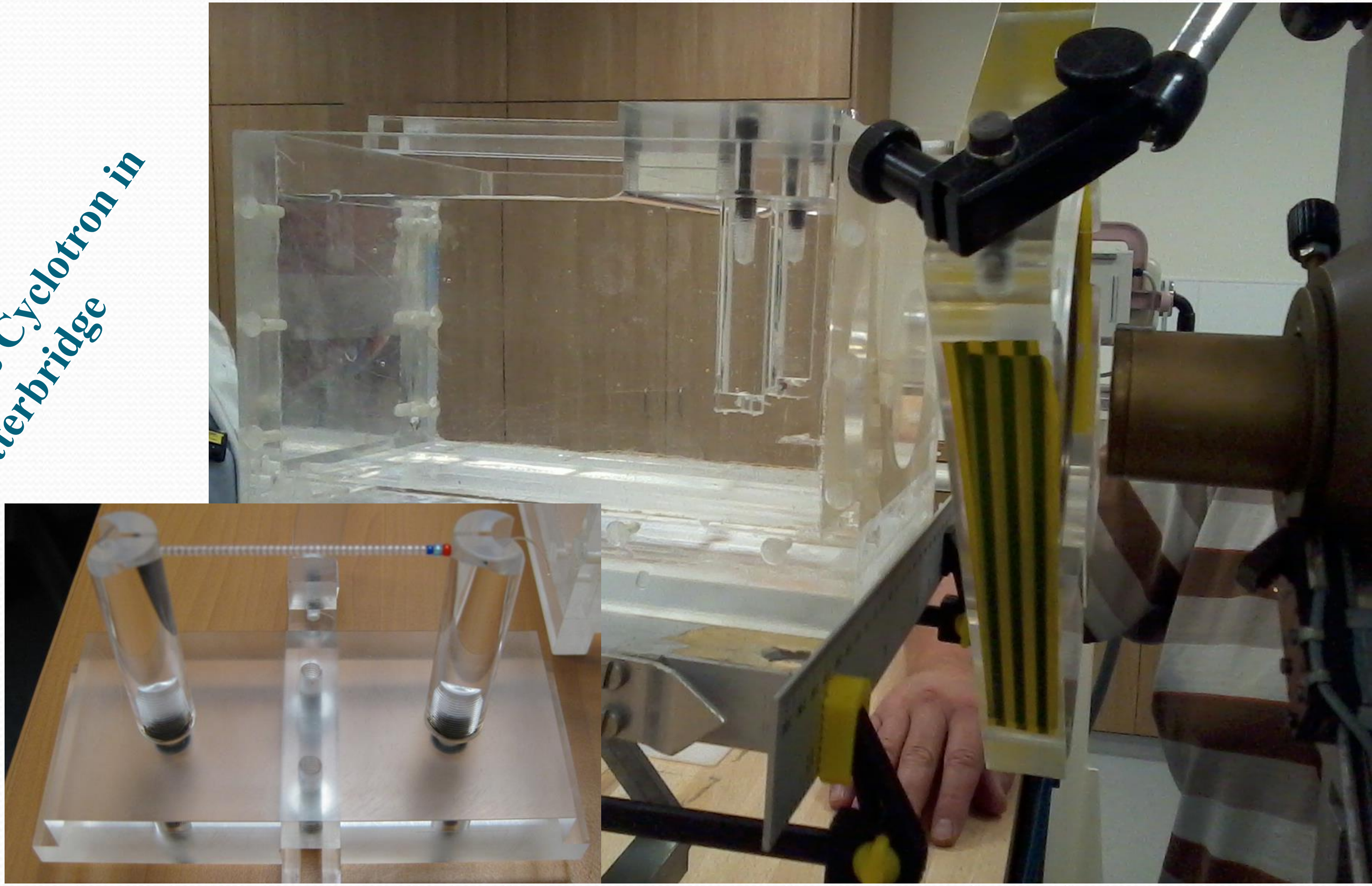


Methods

- Sample preparation
  - Cleaning
  - Mass screening
  - Annealing

Characterization measurements

Douglas Cyclotron in Clatterbridge

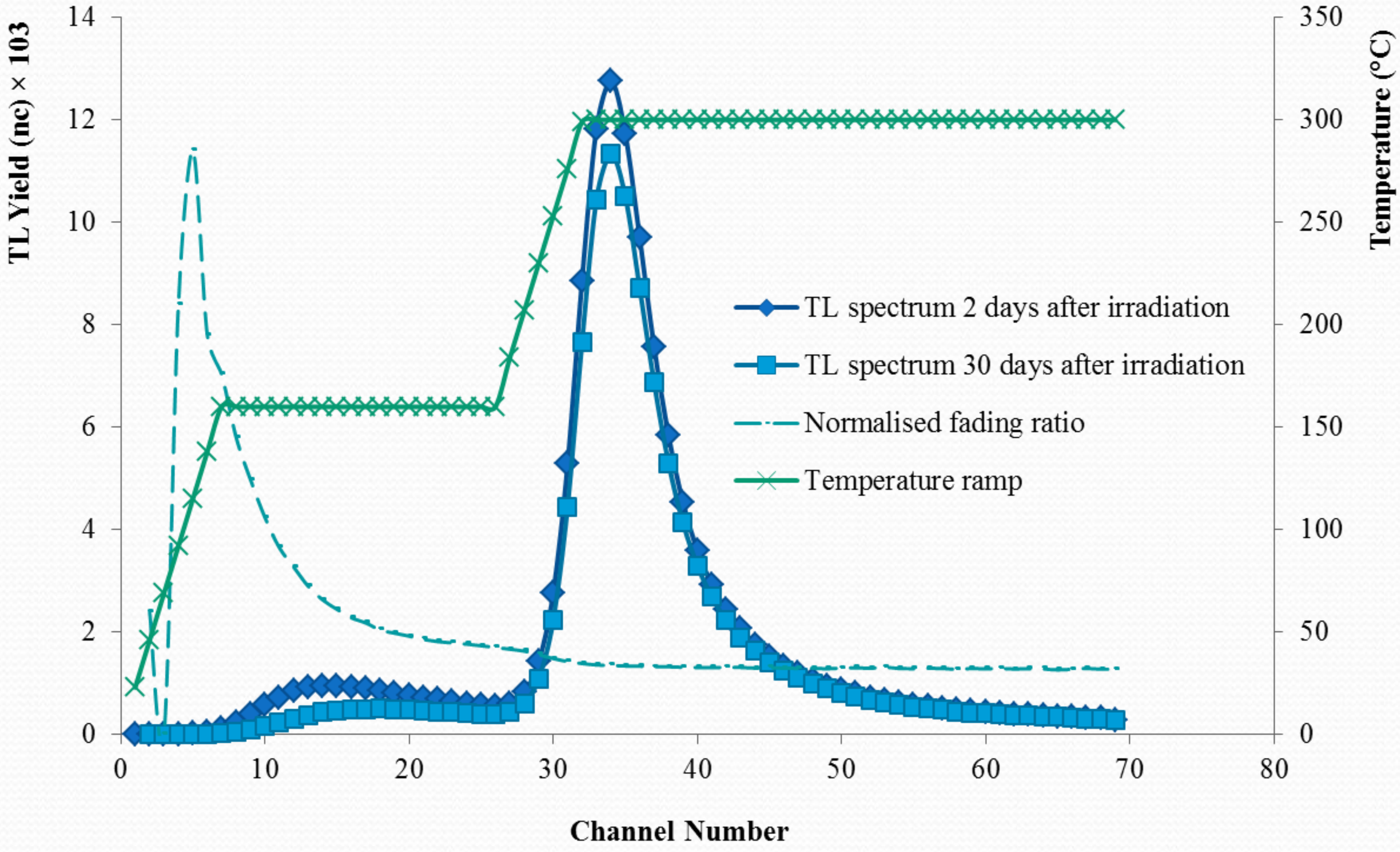


A thin window (0.1 mm thickness) phantom to position the glass beads in water.

Readout systems?

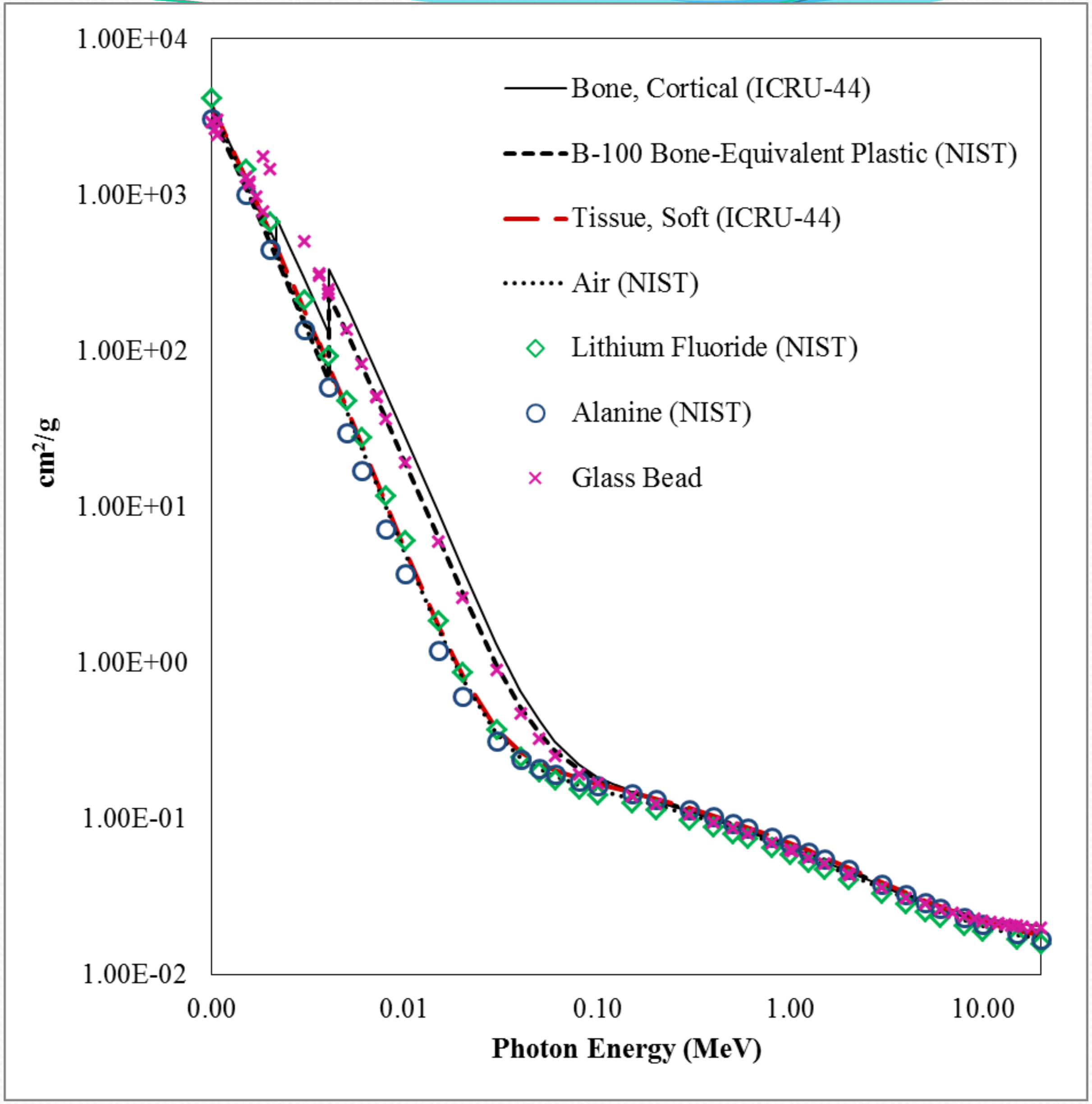
TLD reader at Royal Surrey County Hospital

Dosimetric peak with TL system



Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

mass attenuation coefficient

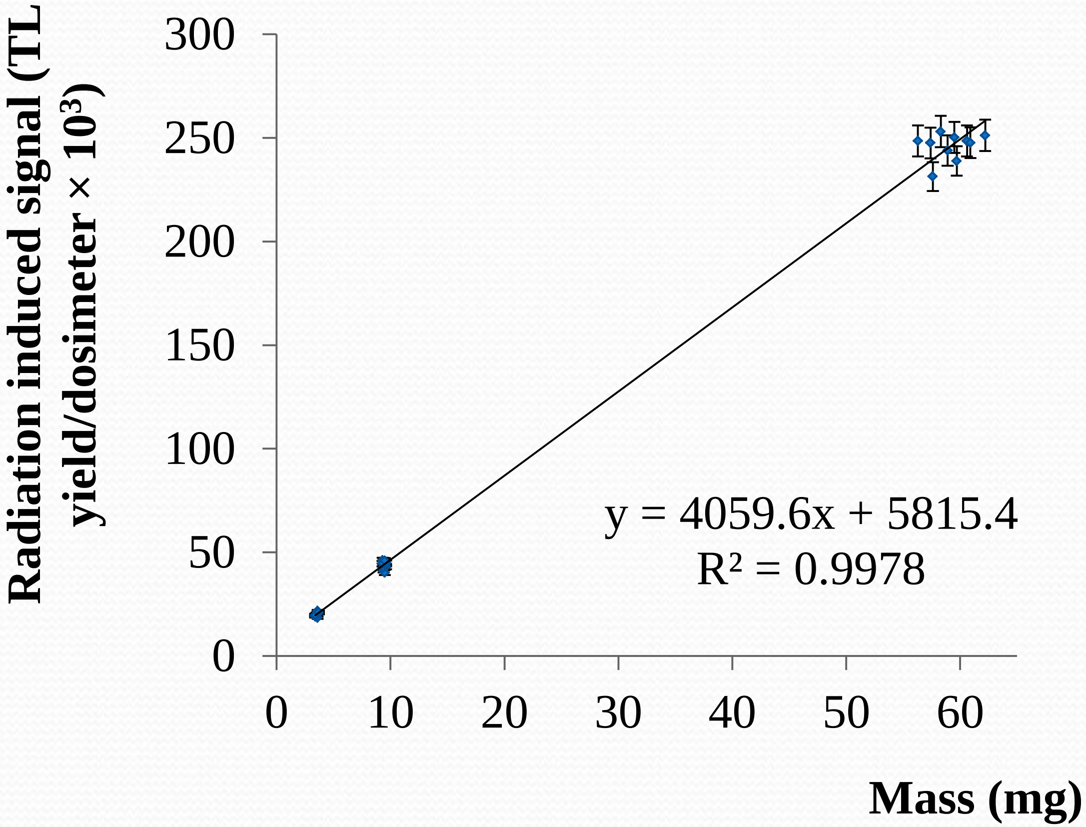


Element	Weight%	Atomic%
C	8.93	14.38
O	42.18	51.01
Na	10.55	8.88
Al	1.35	0.97
Si	33.62	23.16
K	1.09	0.54
Ca	1.92	0.93
Fe	0.37	0.13
Totals	**100.00**	

Density: 2.09

CT Number: 800-1300

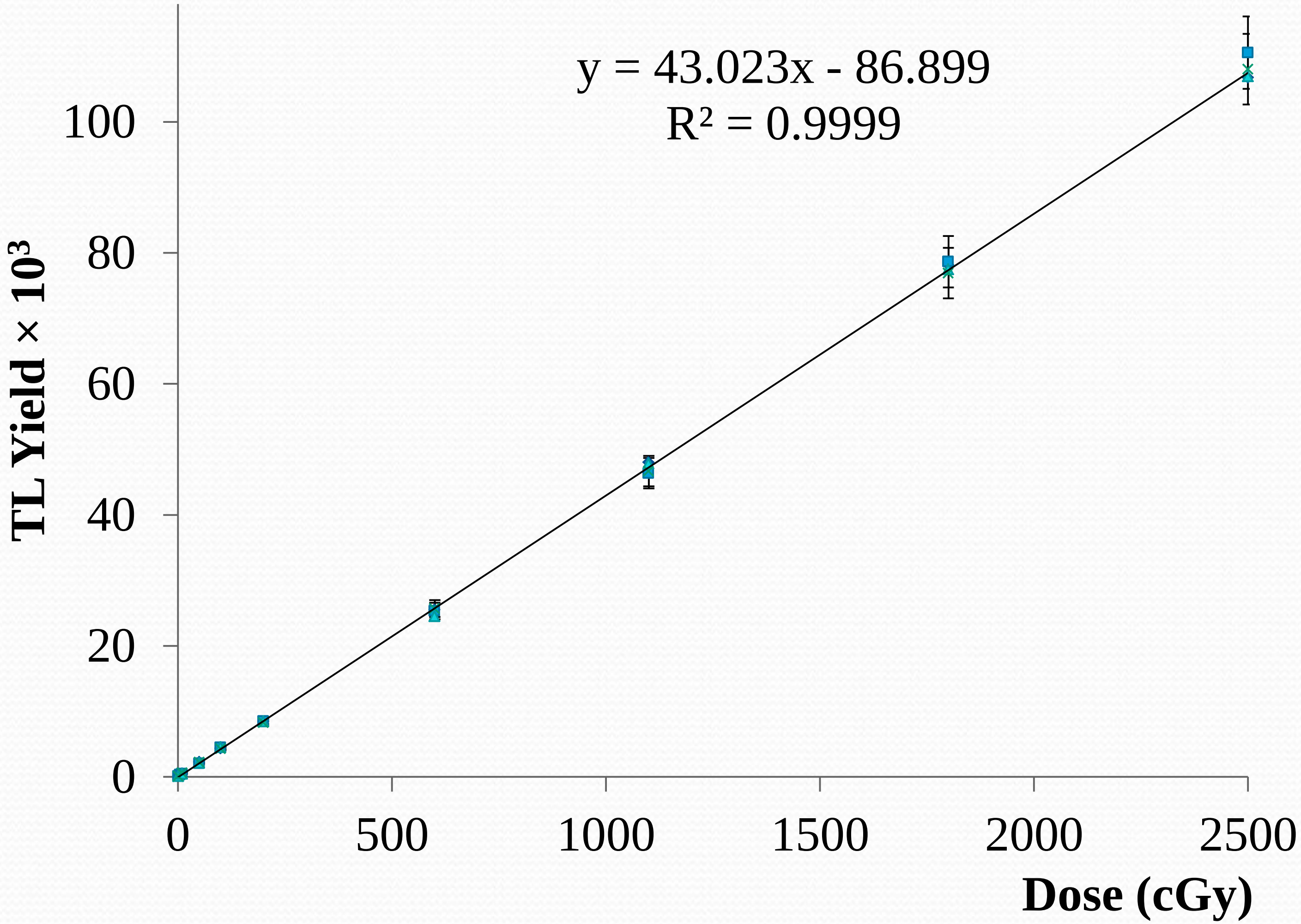
Bead mass and radiation response



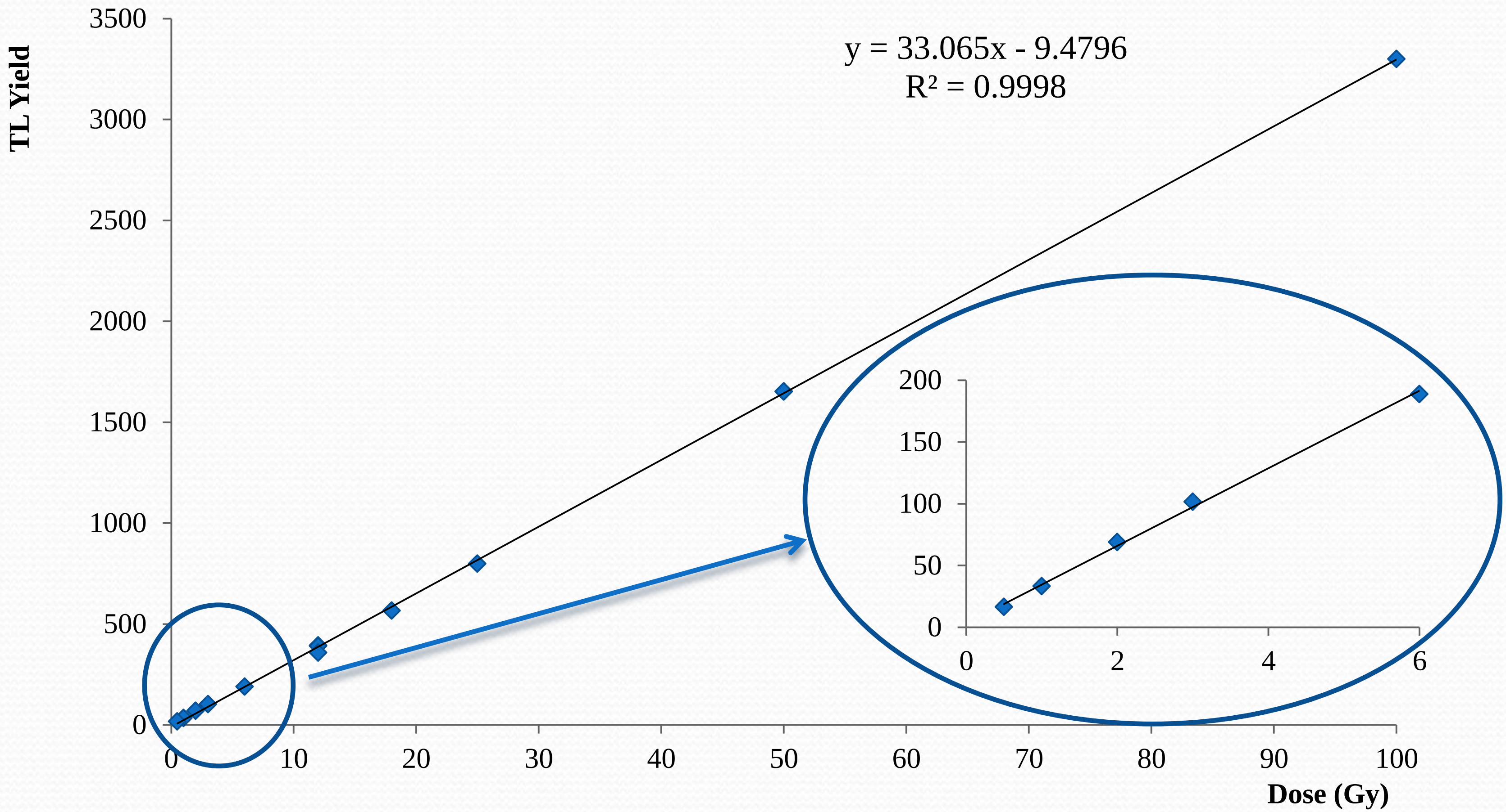
- No self absorption
- Important to use for high LET radiation beams such as proton and ion beam dosimetry

Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

Radiation response to photon beams

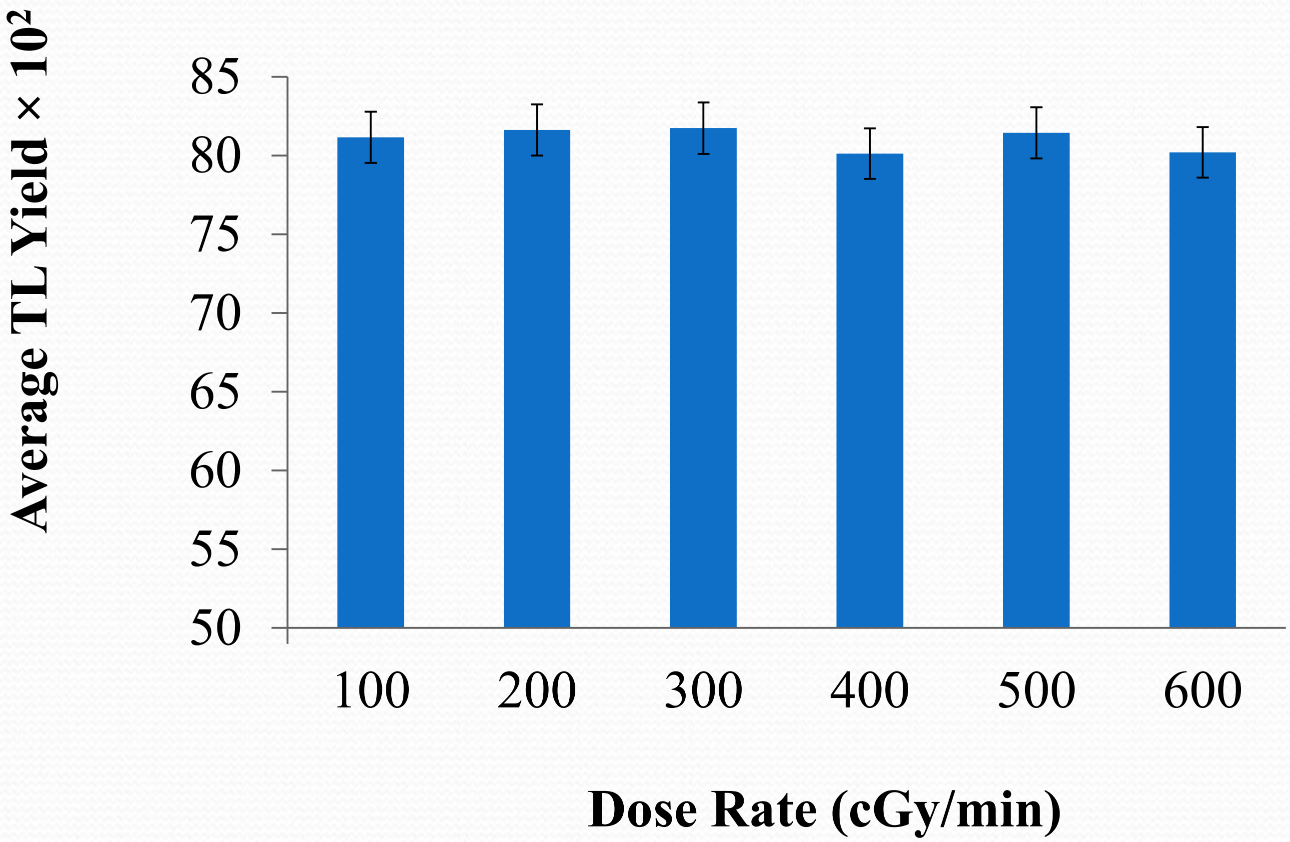


Radiation response to proton beams

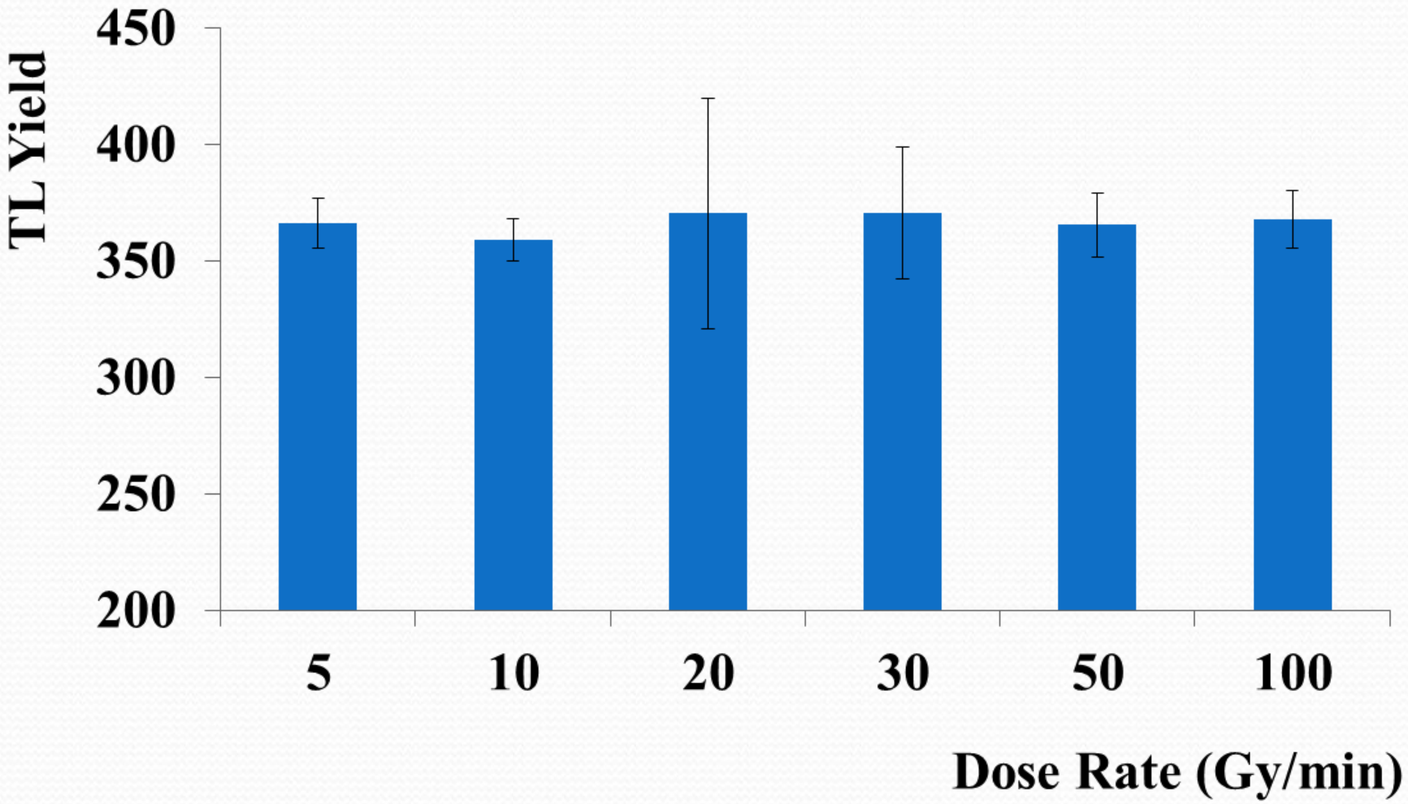


Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

Dose rate response (photon Beams)

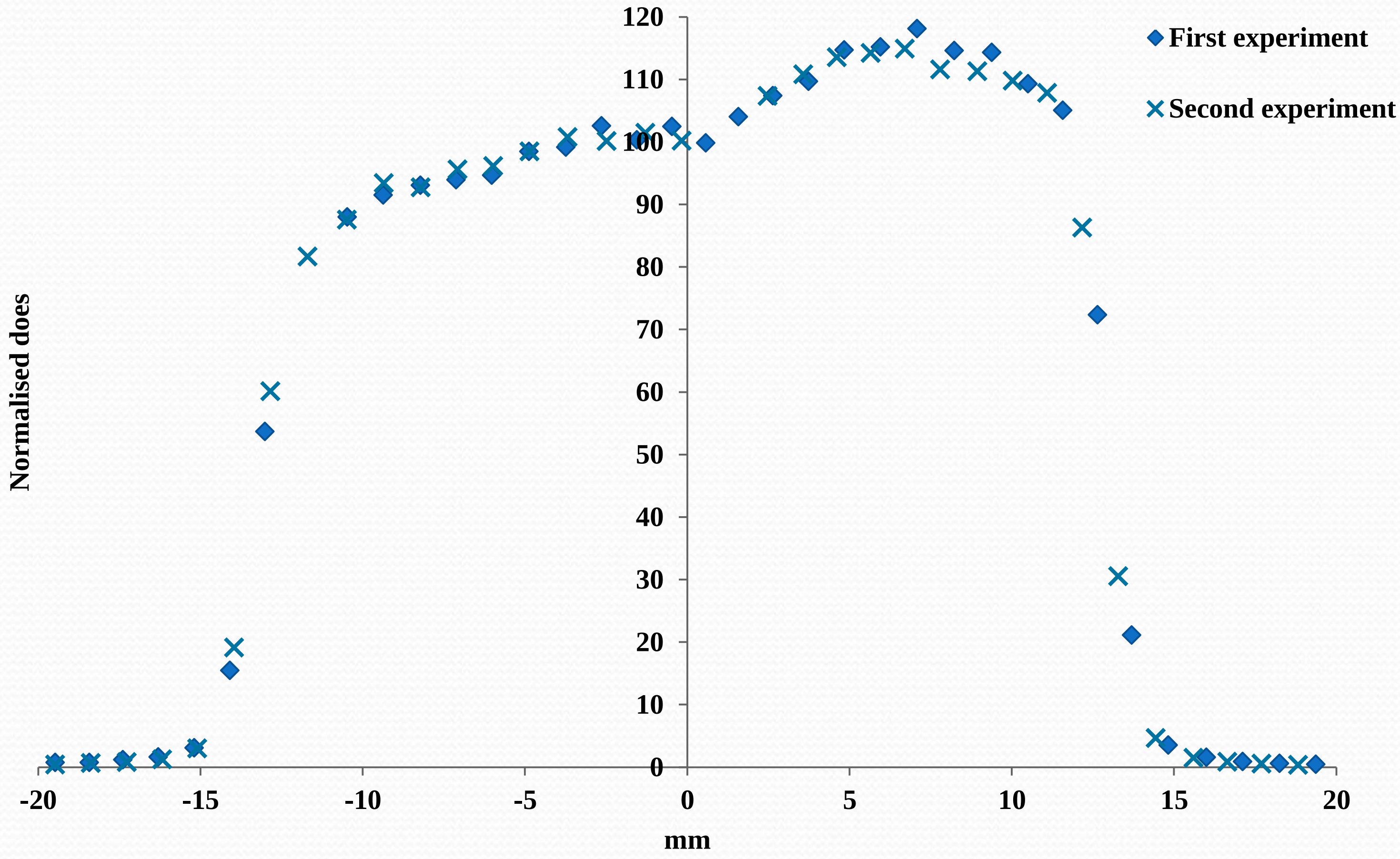


Dose rate response (proton Beams)

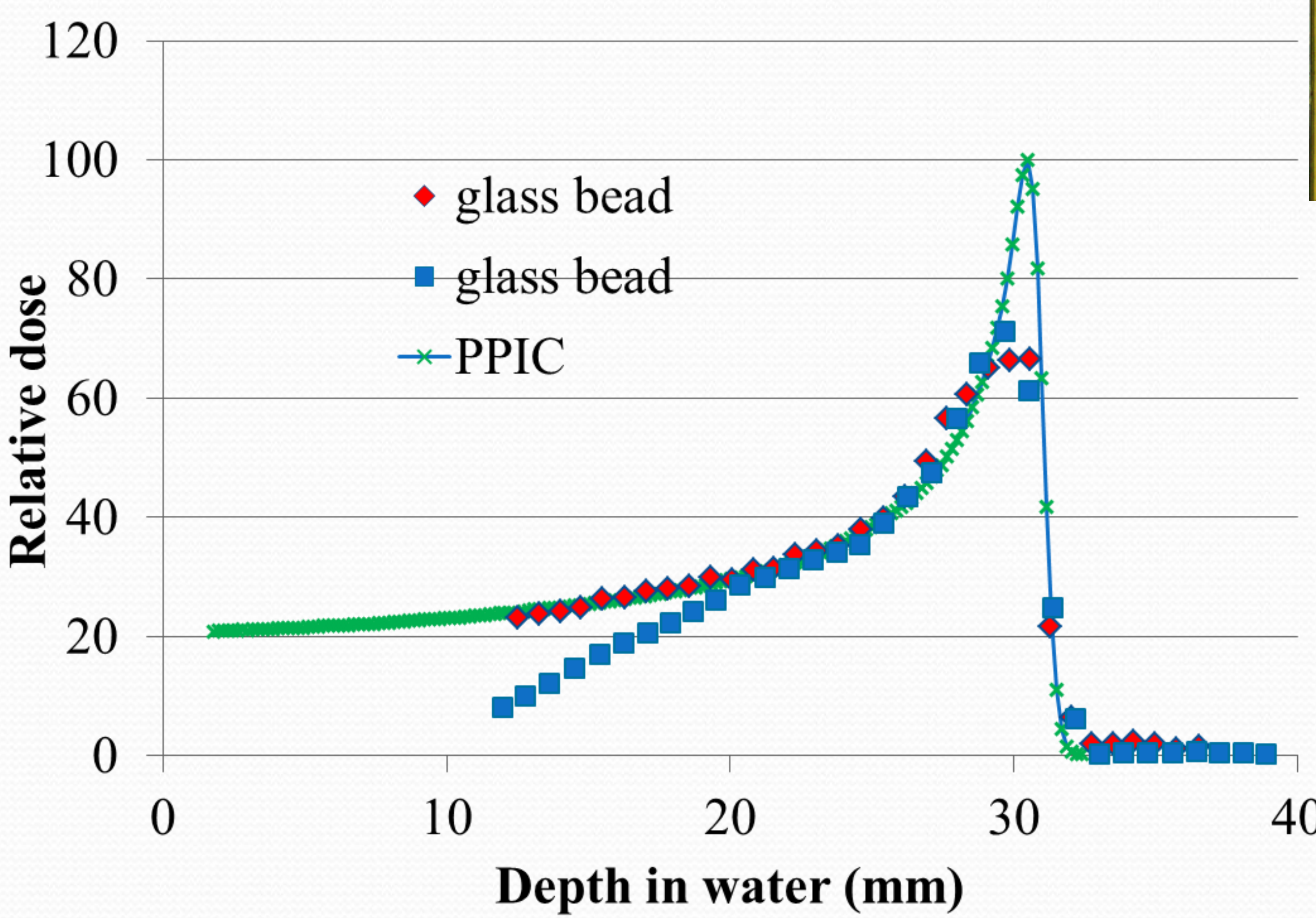


Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

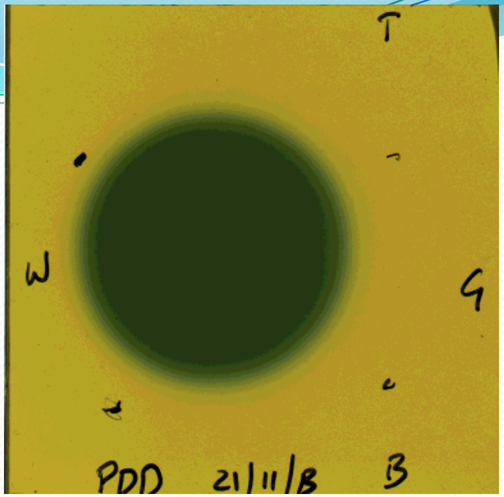
Proton beam profile



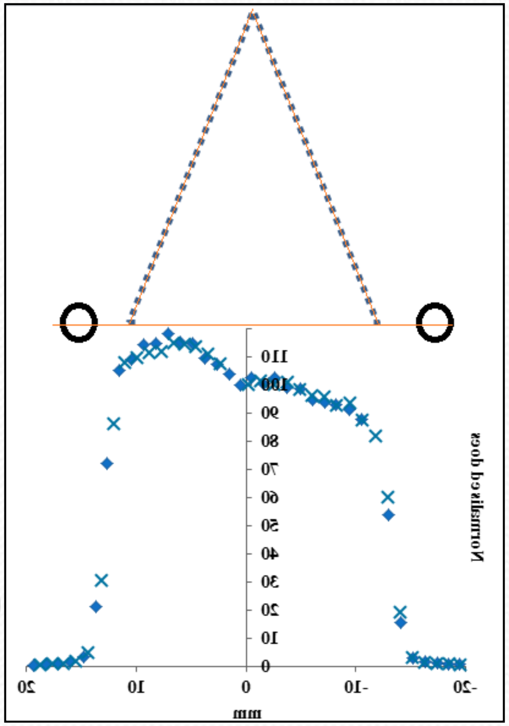
Bragg Peak



Relative dose
120
100
80
60
40
20
0
0
10
20
30
40
Depth in water (mm)
glass bead
glass bead
PPIC



T
W
G
B
PDD



Batch homogeneity & reproducibility

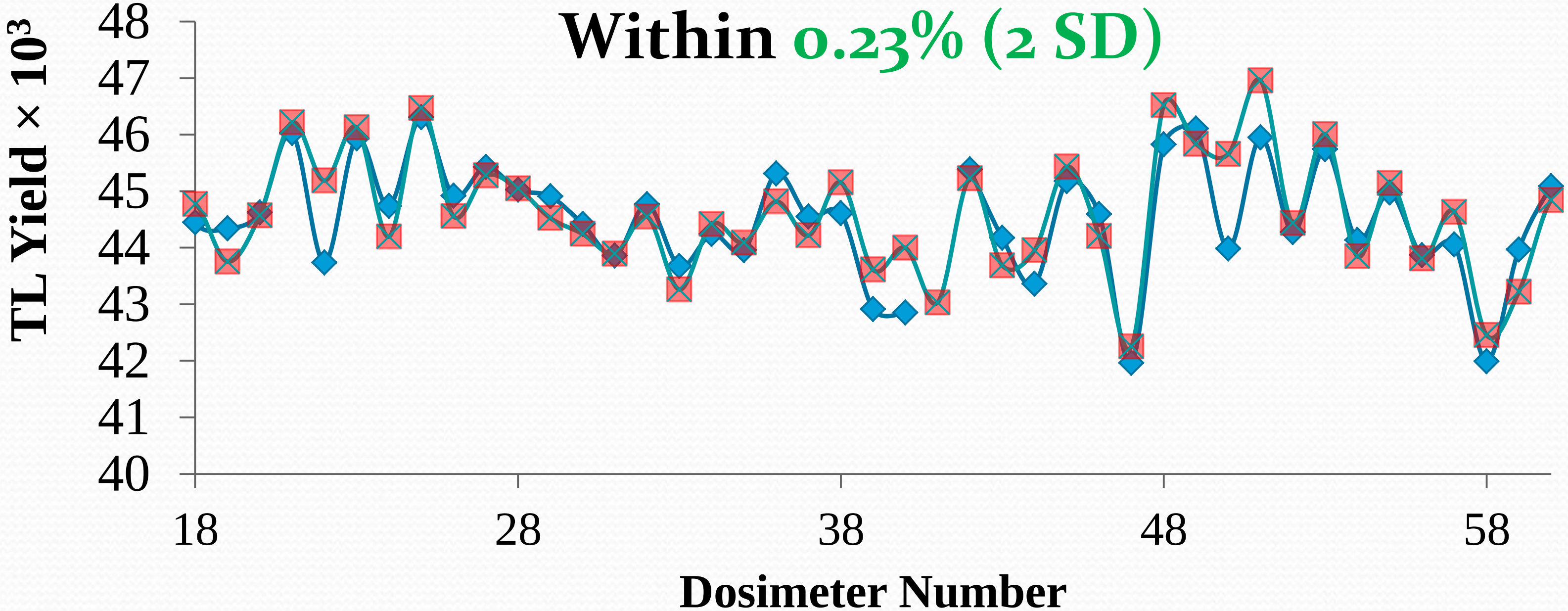
Batch homogeneity: ± 7.4% (2 SD)

Uncertainty of the entire TLD process:

1.7% (1 SD)

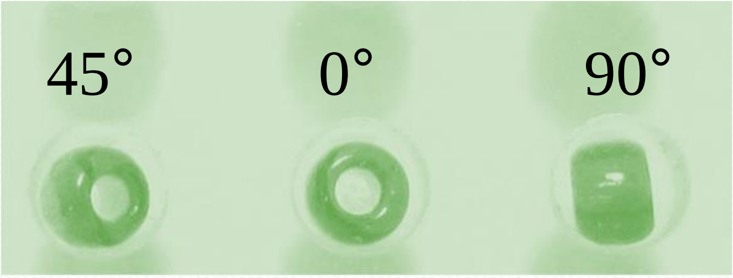
Mean reproducibility for 138 dosimeter:

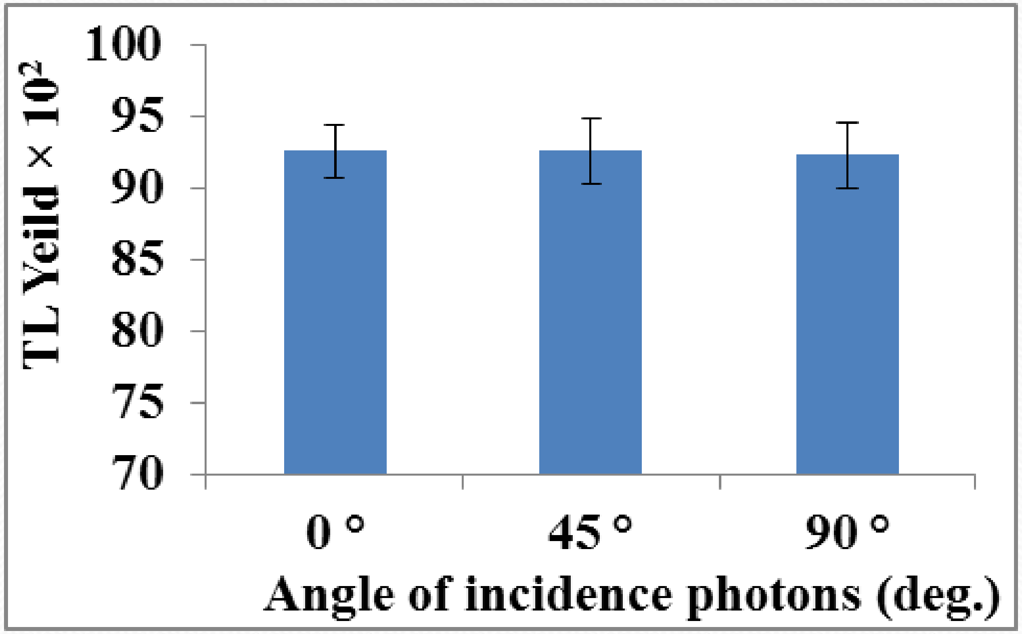
Within 0.23% (2 SD)



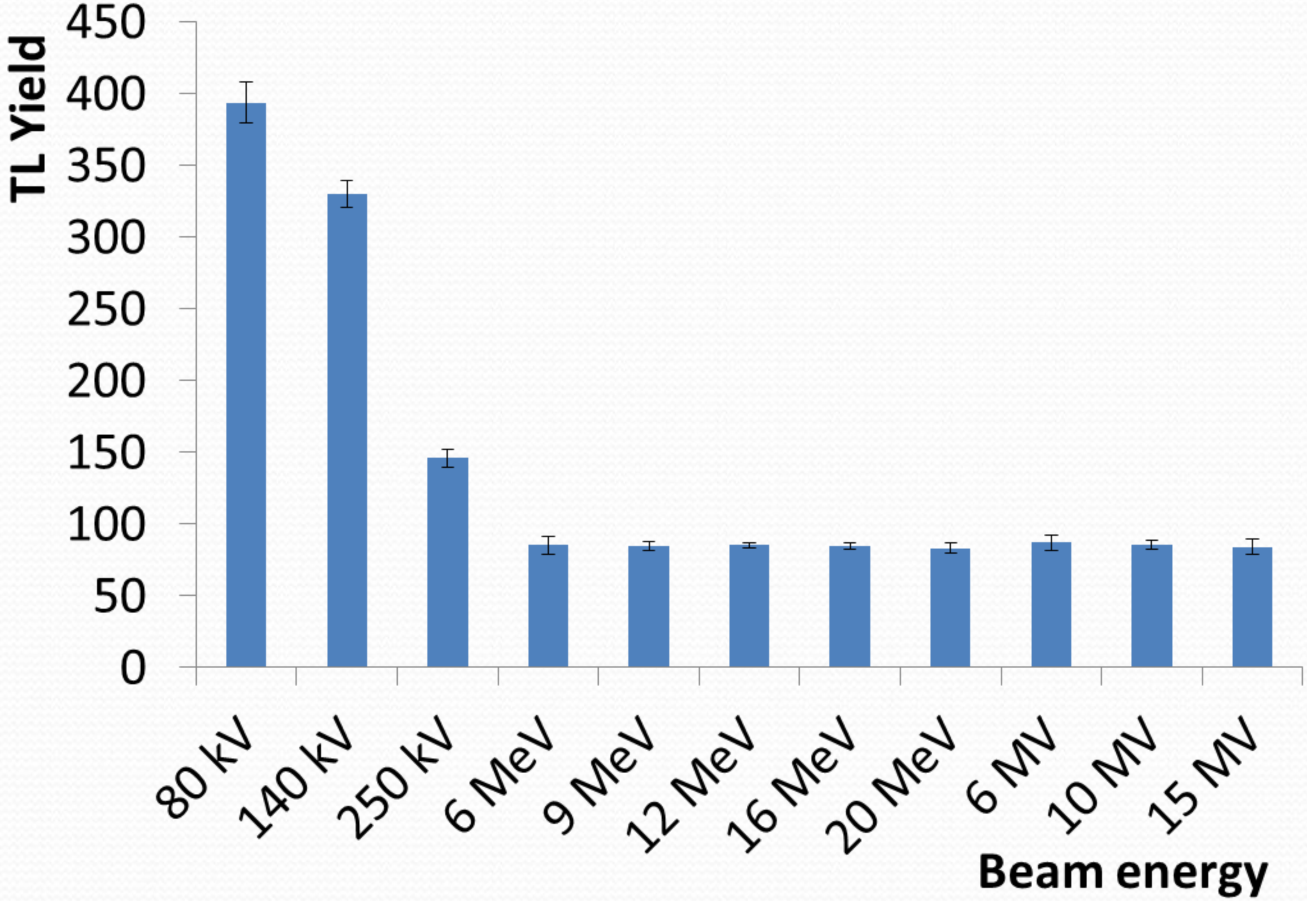
Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

Directional response





Energy response



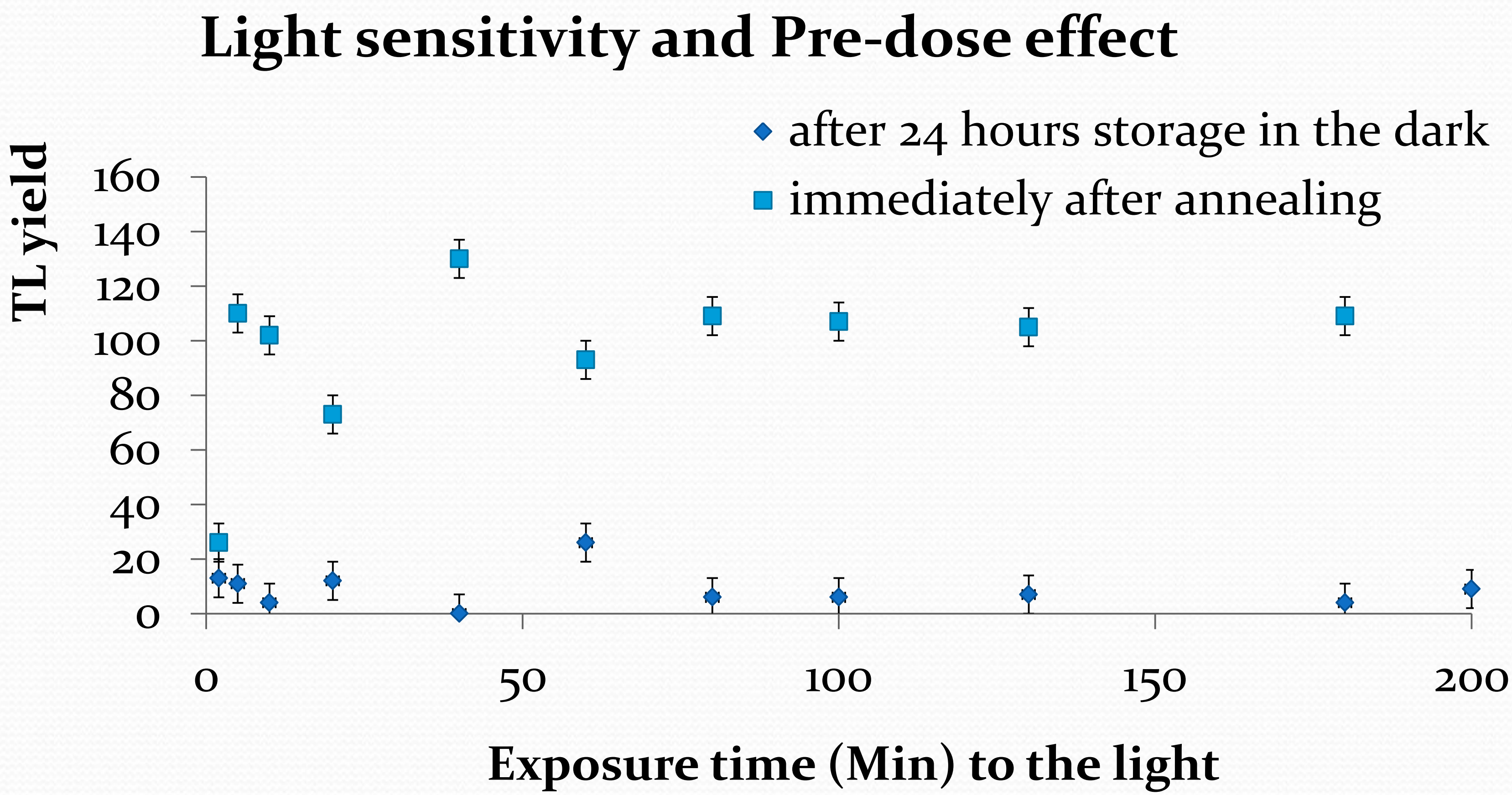
Thermal neutron response

- **The neutron absorbed dose / Gy for 15 MV energy**

0.28×10^{-3} Gy,

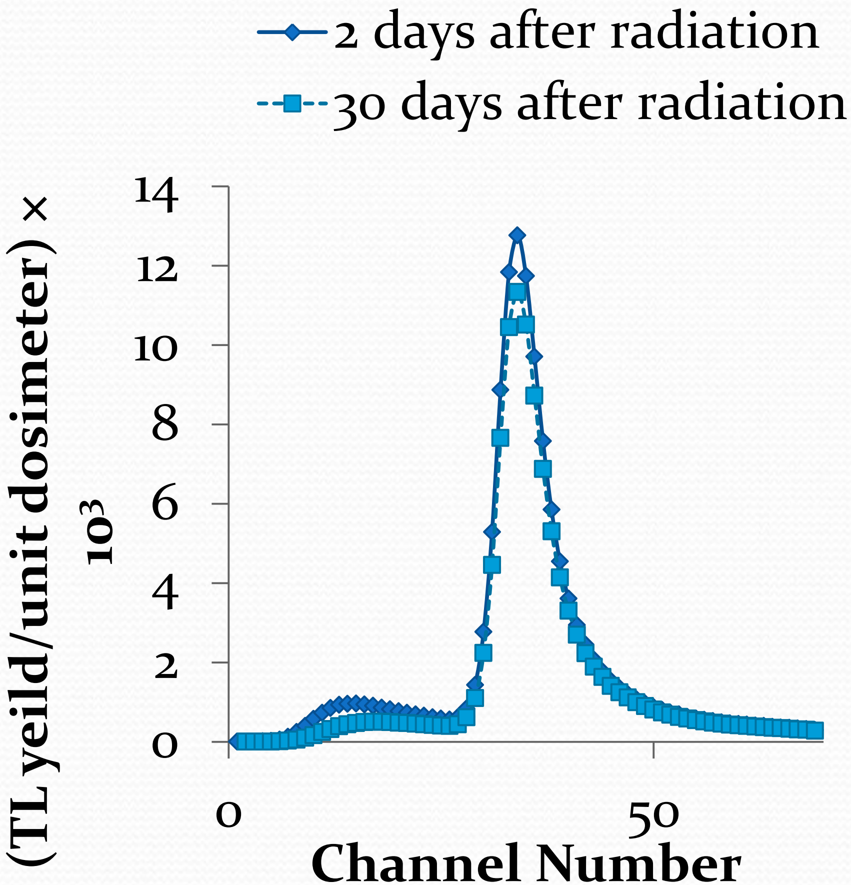
in agreement with **0.27×10^{-3} Gy** (McGinley and Landry, 1989) measured with Bonner sphere radiation detectors.

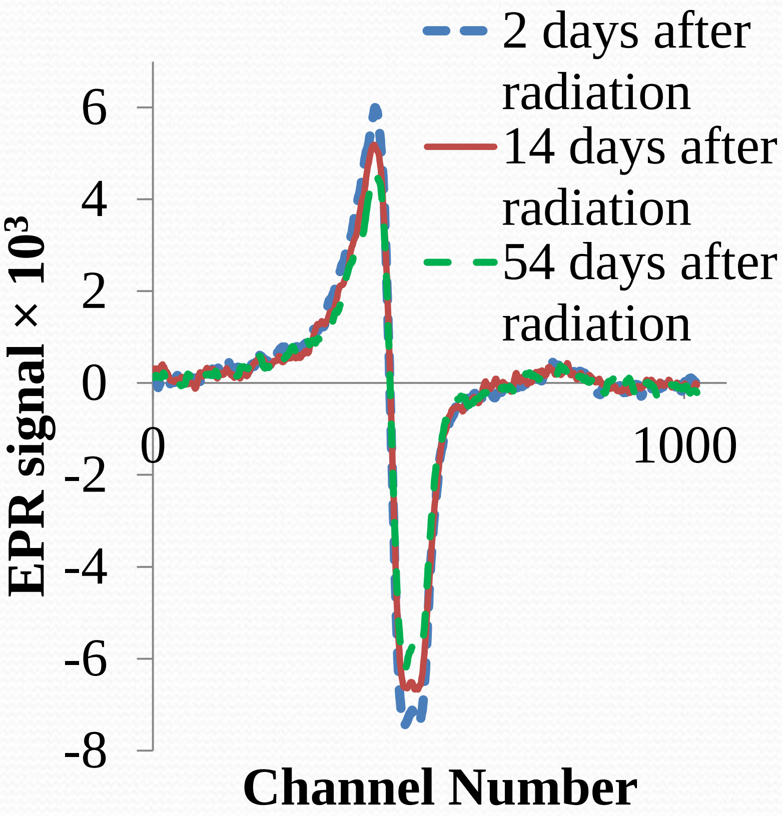
Storage & handling



Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

Fading Rate: 10%/30 days





Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March

Conclusion

- The **dose linearity** and **dose rate independency** shown suggest that glass beads have potential as TLDs for verification measurement in proton therapy.

Acknowledgment

- University of Surrey for an Overseas Research Scholarship
- Radiotherapy Department of the Royal Surrey County Hospital (RSCH) for the facilities for irradiations
- National Physical Laboratory
- Clatterbridge Cancer Centre NHS Trust for the facilities for proton irradiations
- Schlumberger foundation for the Faculty for The Future Scholarship

Refrences

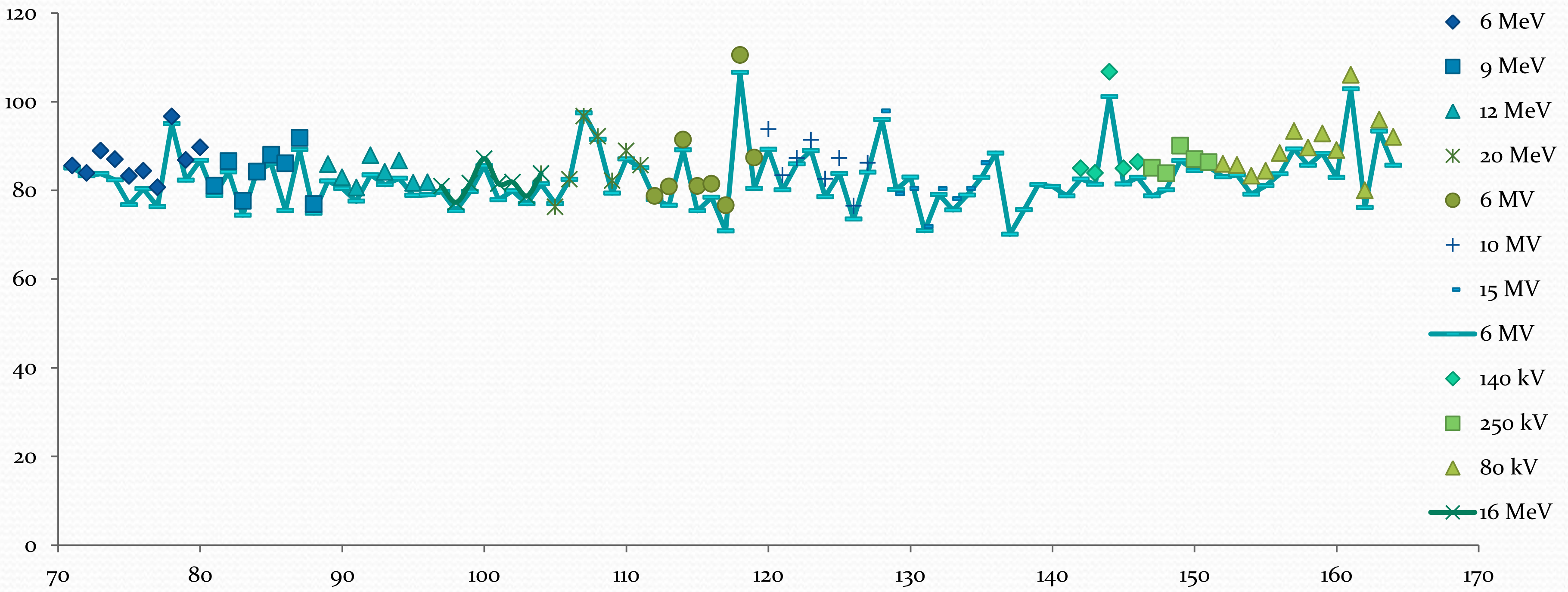
- D. A. Bradley, Siti F. Abdul Sani, Amani I. Alalawi, S.M. Jafari, Noramaliza M.Noor, Hairul Azhar A. R, Ghafour Amouzad Mahdiraji, Nizam Tamchek, A. Nisbet (2014). Development of tailor-made silica fibres for TL dosimetry. *Radiation Physics and Chemistry*, in press.
- Jafari, S.M, Bradley, D. A., Goldstone, C.A., Sharpe, P.H.G., Alalawi, A.I., Jordan, T.J., Clark, C.H., Nisbet, A., Spyrou, N. M., 2014. Low-cost commercial glass beads as dosimeters in radiotherapy. *Radiation Physics and Chemistry*, 97 95-101
- Jafari, S.M., Jordan, T.J., Hussein, M., Bradley, D.A., Clark, C.H., Nisbet, A., Spyrou, N.M., (2014) Energy response of glass bead TLDs irradiated with radiation therapy beams. *Radiation Physics and Chemistry*, in press.
- Jafari, S. M., Distefano, G., Bradley, D. A., Spyrou N. M., Nisbet, A., Clark, C. H., 2014. Validation of glass bead TLDs for radiotherapy treatment verification. European society for radiotherapy and oncology conference 33 (ESTRO33) 4-8 April 2014 Vienna Austria.
- McGinley P. H. and Landry J. C., 1989. Neutron contamination of x-ray beams produced by the Varian Clinac 1800. Phys. Med. Biol 34 (6) 777-783.
- R. Thomas, S. M. Jafari, D. A. Bradley, N. M. Spyrou, A. Nisbet, C. H. Clark, Dosimetric characterisation of glass bead TLDs in proton beams. European society for radiotherapy and oncology conference 33 (ESTRO33) 4-8 April 2014 Vienna Austria.

THANKS FOR YOUR ATTENTION

QUESTIONS

?

Reproducibility of calibration factors at different energies



Jafari et al., PPRIG Proton Therapy Physics Workshop, At the National Physical Laboratory, 12th – 13th March