EURADOS European Radiation Dosimetry Group

Mailed dosimetry auditing in Proton Therapy

Eurados intercomparison of passive dosimeter response in proton spot scanning beam

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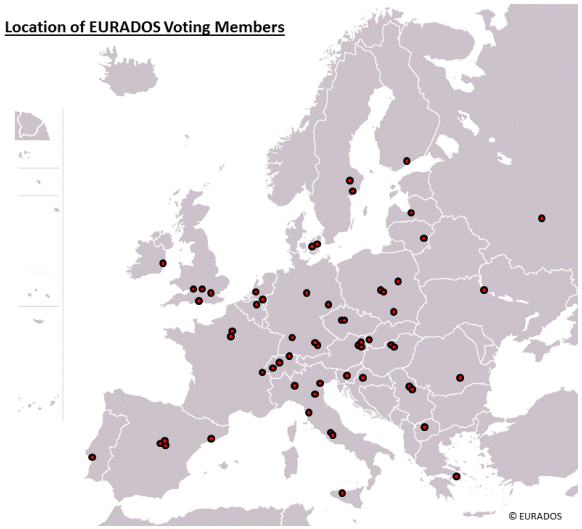
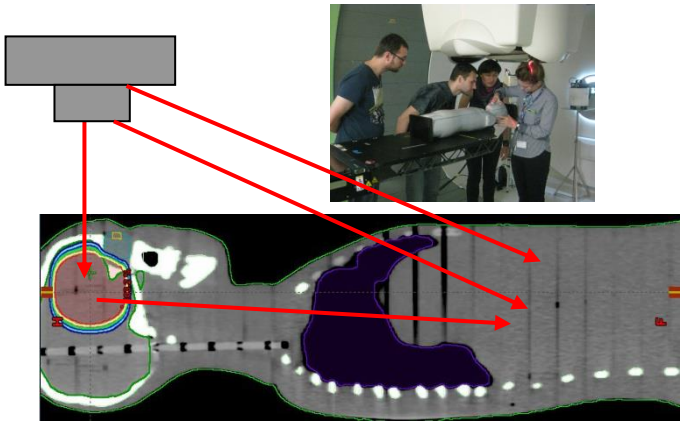
NPL PPRIG Proton Therapy Physics Workshop 2016

Working group 9

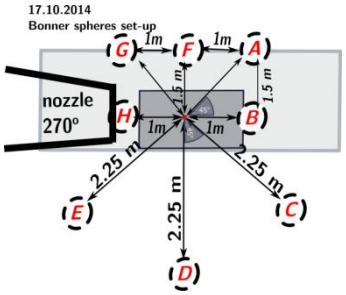
- The **Eu**ropean **Ra**diation **Dos**imetry Group (EURADOS)
  - Network of more than 67 European institutions (Voting Members) and 300 scientists (Associate Members)



- **WG9** – Radiation Dosimetry in Radiotherapy
  - Out-of-field dose assessment in RT
  - Neutron dosimetry in PT
  - Mail dosimetry auditing in PT



Out-of-field dosimetry



Neutron dosimetry in PT

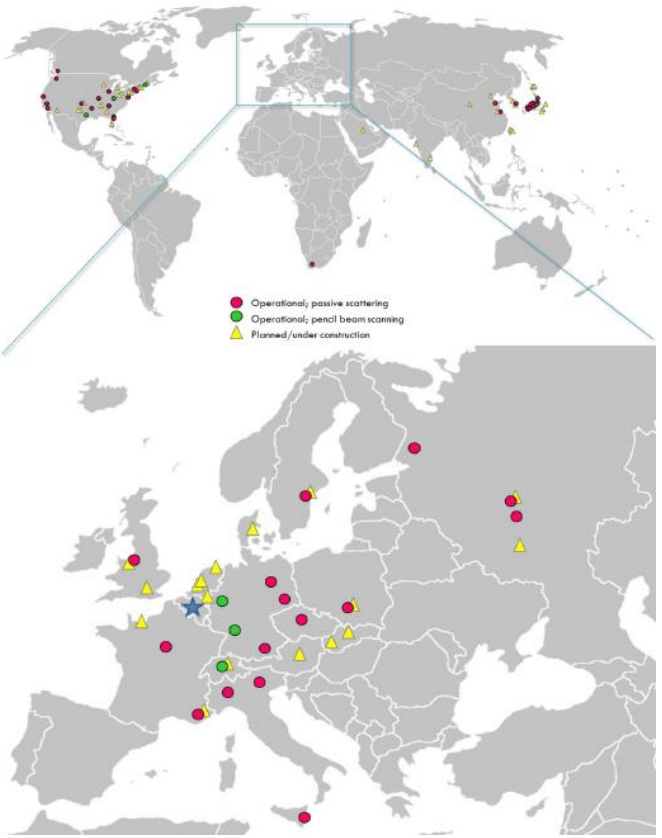
Dosimetry auditing

Dosimetry auditing of proton therapy centres

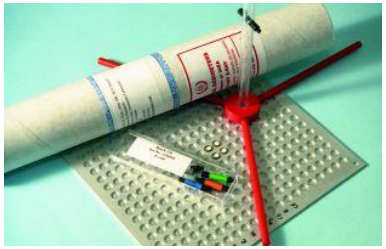
- Not yet available in Europe
- Lack of international and national primary dose standards for proton beams
- Need for harmonization

Dosimetry auditing of photon therapy centres

- International program of IAEA
- National programs for mail auditing radiotherapy centres
- Mainly using Alanine or TLD



TLD Postal Dose Audit Service



IAEA
International Atomic Energy Agency

Detectors

Passive dosimeter systems

- Alanine
- ThermoLuminescent Dosimeters (TLD)
  - MCP-n
  - MTS-n
- Optically stimulated luminescent detectors (OSL)
  - Luxel
- Radiophotoluminescent detectors (RPL)
  - GD-302M
    - No filter
  - GD-352M
    - Filter

SCK-CEN

Technique	Detector
TLD	MCP-n
OSL	Luxel
EPR	Alanine

RBI

Technique	Detector
RPL	GD-302M
RPL	GD-352M

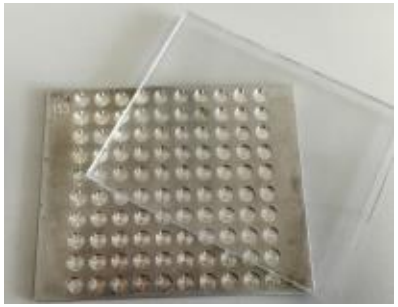
IFJ-PAN

Technique	Detector
TLD	MTS-n
TLD	MCP-n
EPR	Alanine

ISS

Technique	Detector
EPR	Alanine

Alanine



TLDs

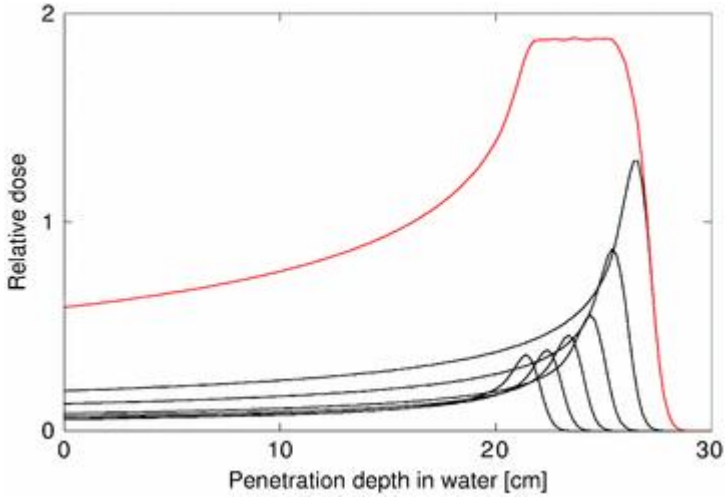
RPL-GD

Proton spot scanning beam

- Cyclotron Center Bronowice (CCB) – IFJ, Krakow, Poland
- Proteus C-235 cyclotron (Ion Beam Applications S.A., Belgium)
- Protons of up to 230 MeV can hence be delivered to the clinical target volume using the Pencil Beam Scanning (PBS)

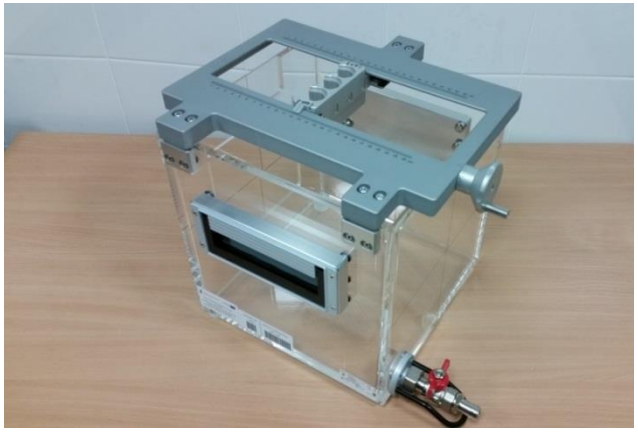
Cyclotron Center Bronowice (CCB) - Poland

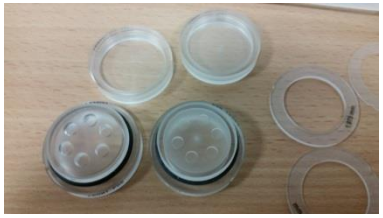
Clinical proton spot scanning - Spread out bragg peak (SOBP)

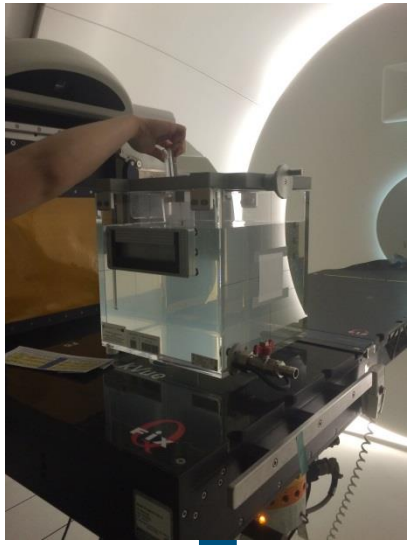


Irradiation conditions

- PTW 41023 water phantom



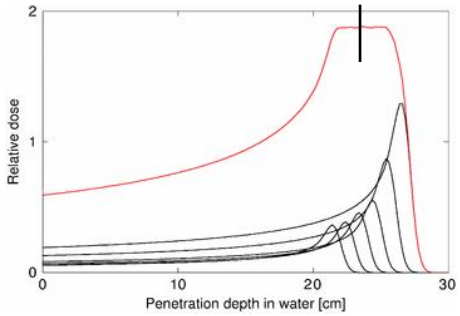




- Proton therapy SOBP
  - 10 cm x 10 cm field
  - Different layers defining
    - ≠ Range
    - ≠ Modulation
- Theratron 780E (Co60)
  - TRS-398

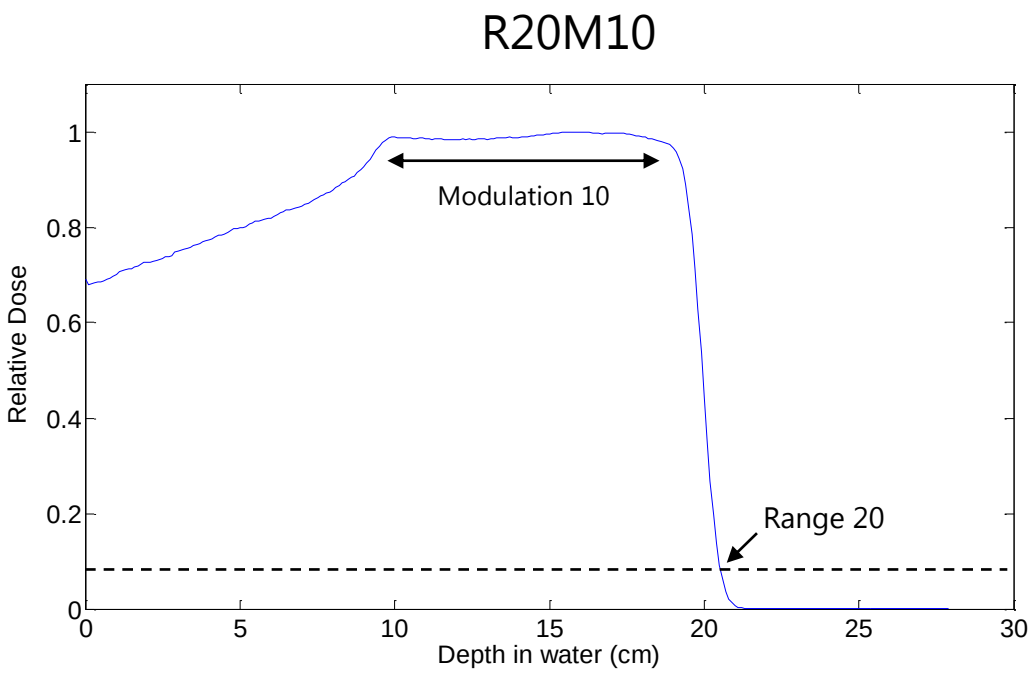
TLD, OSL, RPL
Dw=2 Gy
Alanine
Dw=10Gy

Position the dosimeter reference point in the middle of the SOBP



Study design

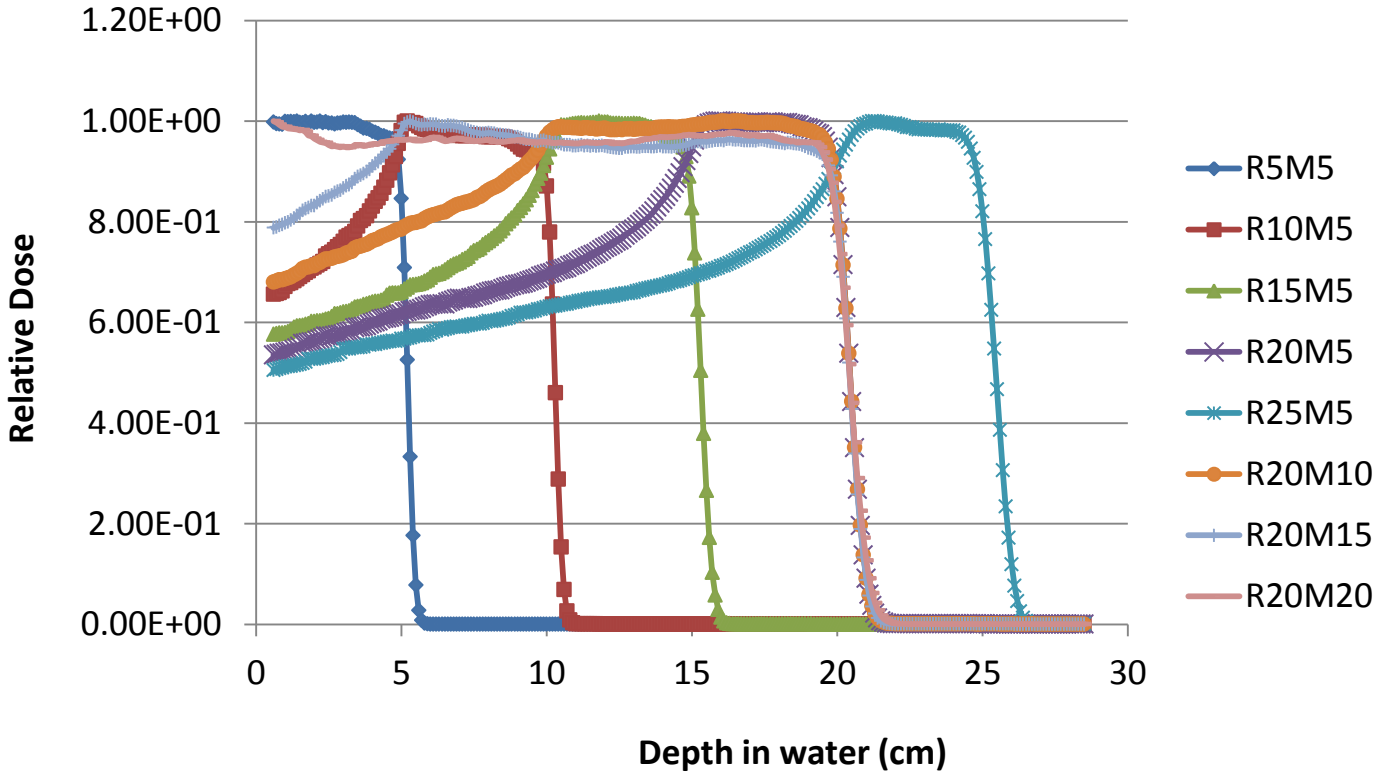
- SOBP configurations
  - Change the **modulation** width
    - Range 20 Modulation 5 (R20M5)
    - Range 20 Modulation 10 (R20M10)
    - Range 20 Modulation 15 (R20M15)
    - Range 20 Modulation 20 (R20M20)
  - Change the **range**
    - Range 5 Modulation 5 (R5M5)
    - Range 10 Modulation 5 (R10M5)
    - Range 15 Modulation 5 (R15M5)
    - Range 20 Modulation 5 (R20M5)
    - Range 25 Modulation 5 (R25M5)



- Data analysis
  - Relative efficiency of the dosimeters to Co60 in the different PT configurations
  - Dosimeter and batch reproducibility (repetitive irradiations and/or readings in Co60 (>5 repetitions))

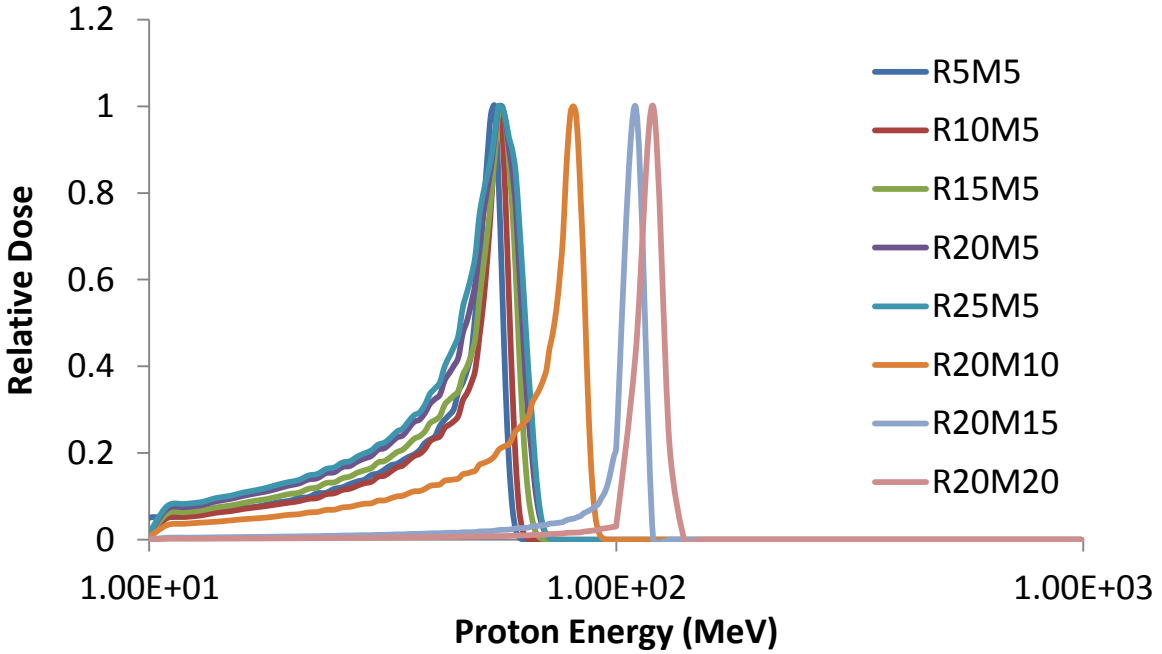
Monte Carlo simulations

- Monte Carlo simulations (using MCNPx 2.7.0)
  - Proton energy spectrum in the position of the dosimeter (middle of the SOBP)
  - Average proton energy/LET



Monte Carlo simulations

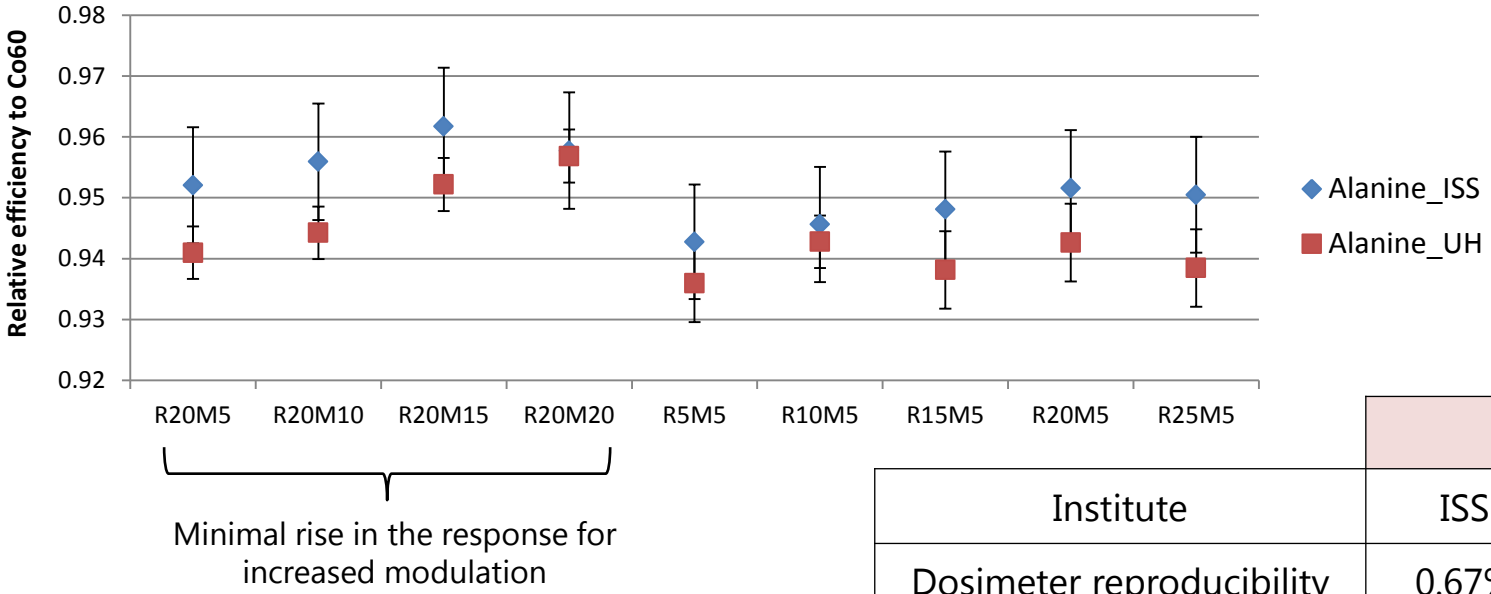
- Increased energy in the middle of the SOBP for larger modulation width
- Comparable energy spectrum for different ranges same modulation in the middle of the SOBP



	R5M5	R10M5	R15M5	R20M5	R25M5	R20M5	R20M10	R20M15	R20M20
Average energy (MeV)	44.3	45.87	47.1	47.6	47.8	47.6	67	85	100.7
Average LET (keV/um)	1.38	1.35	1.32	1.31	1.31	1.31	1.00	0.83	0.73
	→ Range ↑					→ Modulation ↑			

Response Alanine

- Relative response was between 6% and 4% lower in proton fields compared to Co60
- With minimal rise for increased modulation (increased energy/decreased LET)
- No significant difference between alanine (ISS vs UH)

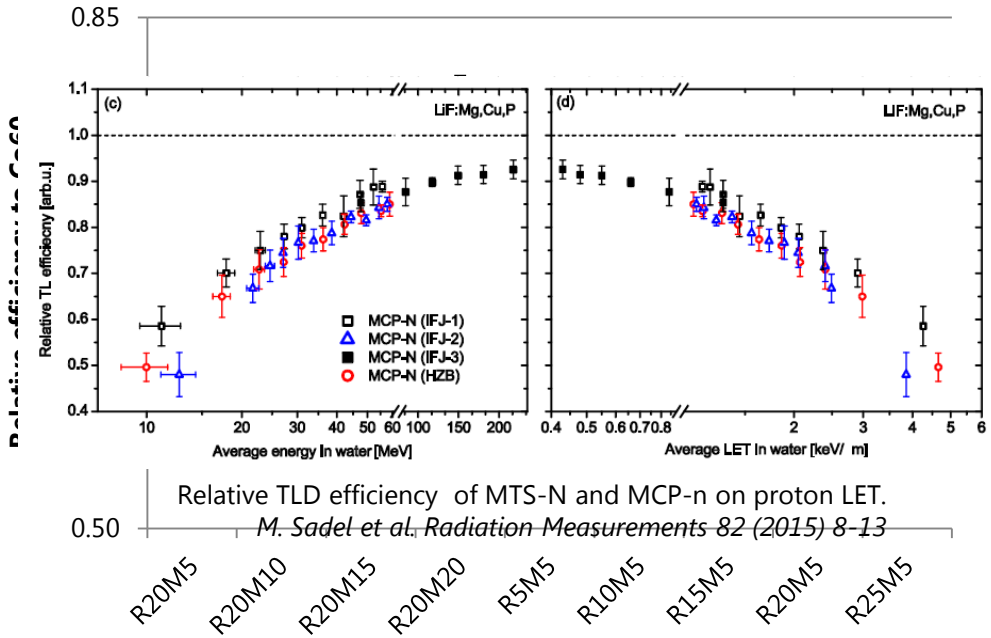


	Alanine	
Institute	ISS	UH
Dosimeter reproducibility	0.67%	0.62%
Batch reproducibility	0.81%	0.38%

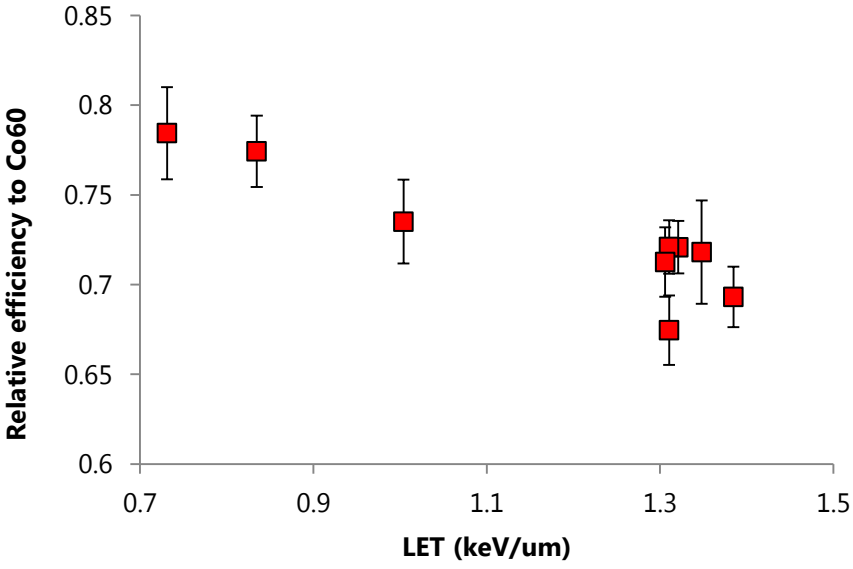
Response MCP-n

- Relative response to Co60 between 0.67 and 0.78
- Increased response for increasing modulation (same range)
- No influence on response changing the range (same modulation)
- Response is inversely proportional to LET

	TLD (MCP-n)
Dosimeter reproducibility	1.94%
Batch reproducibility	1.78%

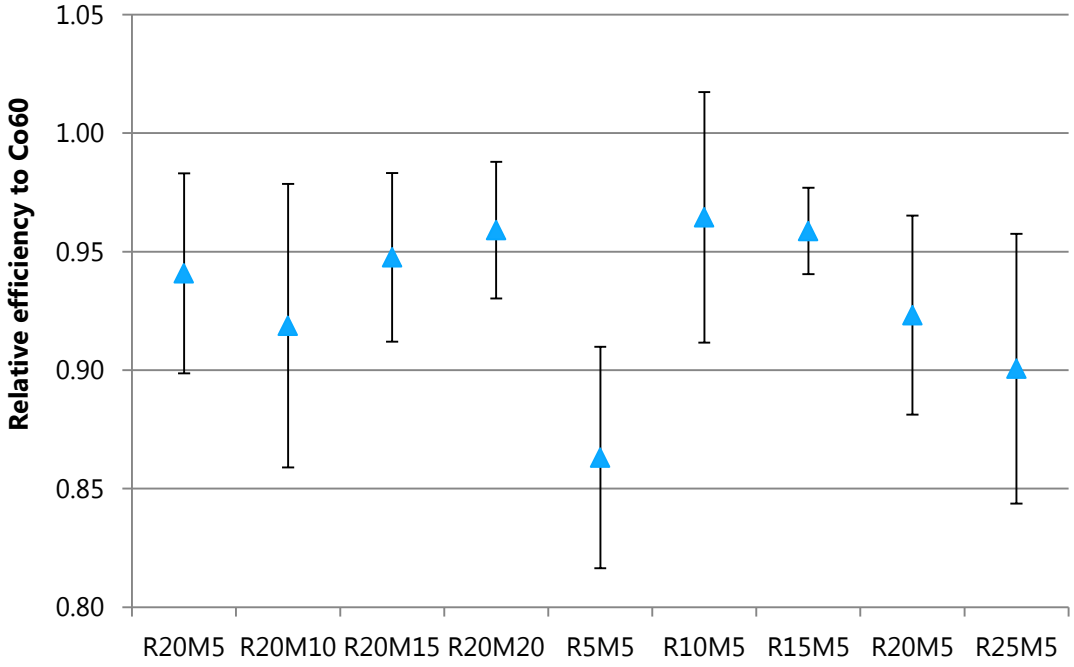


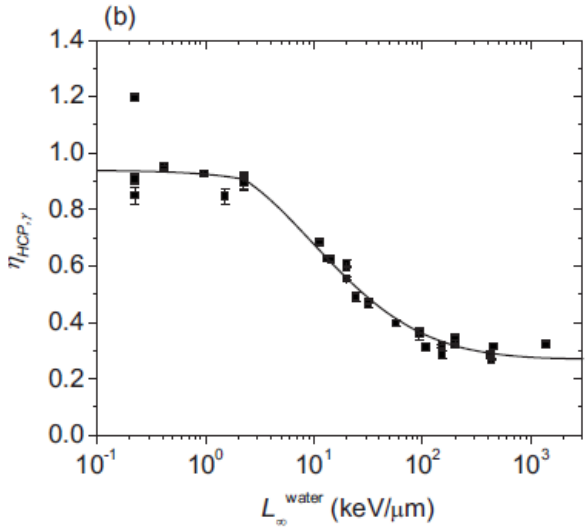
Relative TLD efficiency of MTS-N and MCP-n on proton LET.
M. Sadel et al. Radiation Measurements 82 (2015) 8-13



Response OSL

- Relative response to Co60 between 0.86 and 0.96
- No difference observed for changing modulation/range
- Large error bars (1.8-6 %)
  - Sample holder positioning not dedicated for Luxel pellets
  - Repositioning in reading system

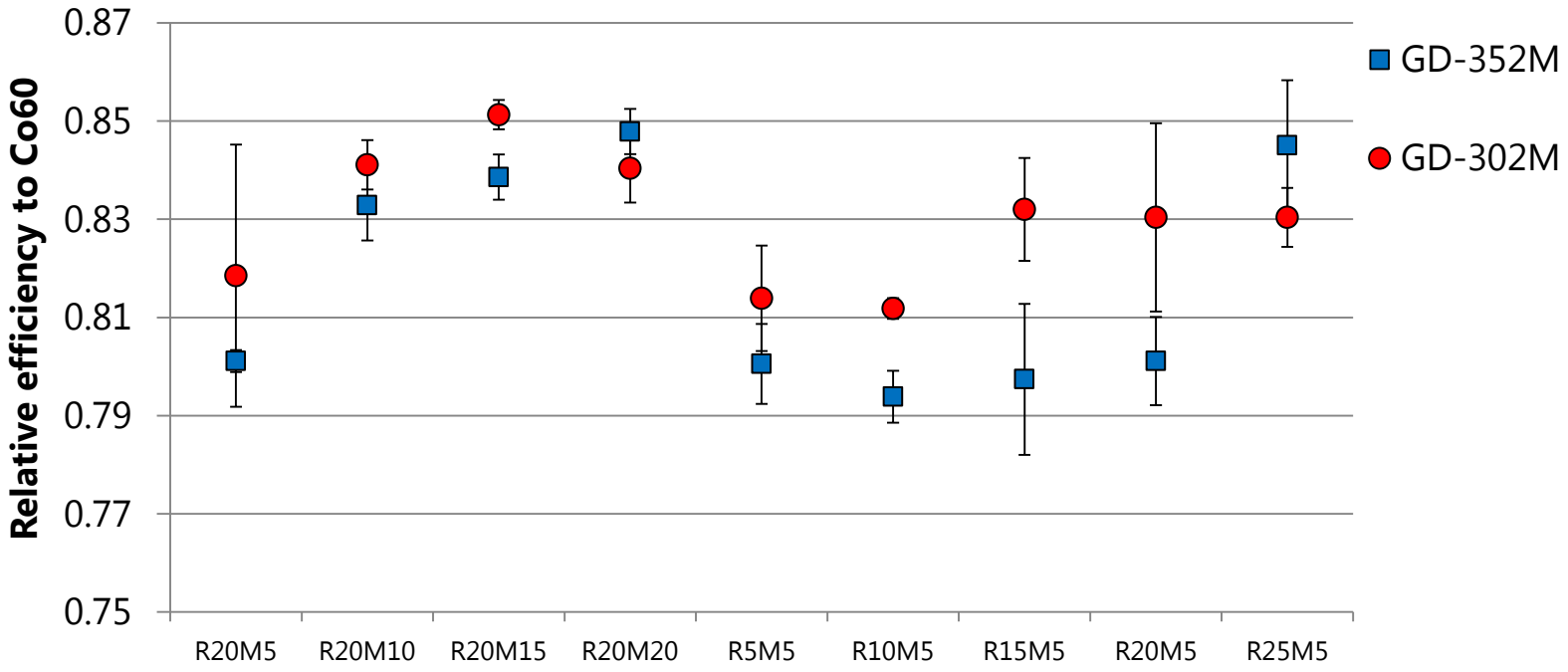




Sawakuchi, et al. AIP 2008

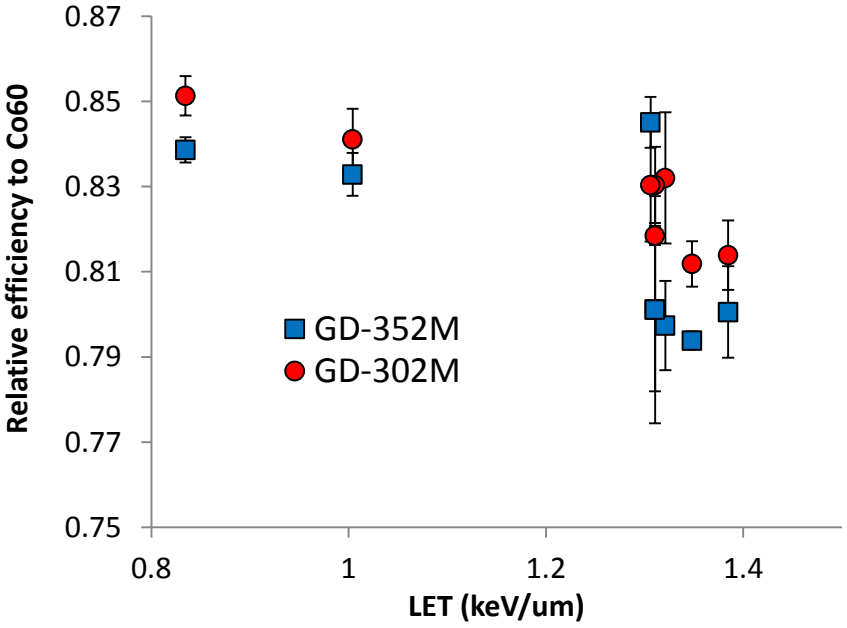
Response RPL

- Relative response to Co60 between 0.79 and 0.85
- GD-302M (without filter) has higher response compared to GD-352M (with filter) except for R20M20 and R25M25



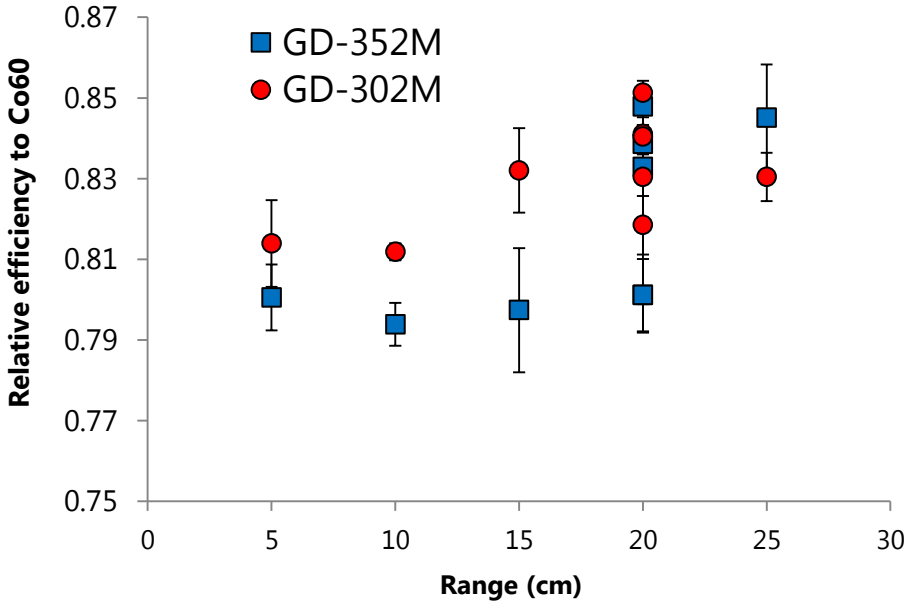
Response RPL

LET dependance of RPL detectors



Response inversly proportional to LET
Similar for GD-352M and GD-302M

Response in function of range



Increased response for higher range

Conclusions and future steps

Response of different passive detector systems in clinically used proton spot scanning beam

- Alanine most promising
- TLD (MCP-N)
  - Response inversely proportional to LET - Corrections will be needed
- OSLd (Luxel) large uncertainties
- RPL – LET dependent

Auditing of PT centres with detectors from different institutes (2017)

- PTCOG/Eurados
- Perform auditing of 10 centres for eye proton therapy
- Alanine pellets from 3 different institutes (IFJ, ISS, Uhasselt) as well as RPLs (RBI)

EURADOS European Radiation Dosimetry Group

THANKS!!!

SCK•CEN
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CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

universiteit hasselt

RB

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