

Dose characteristics on and inside the spherical phantom MATROSHKA-R

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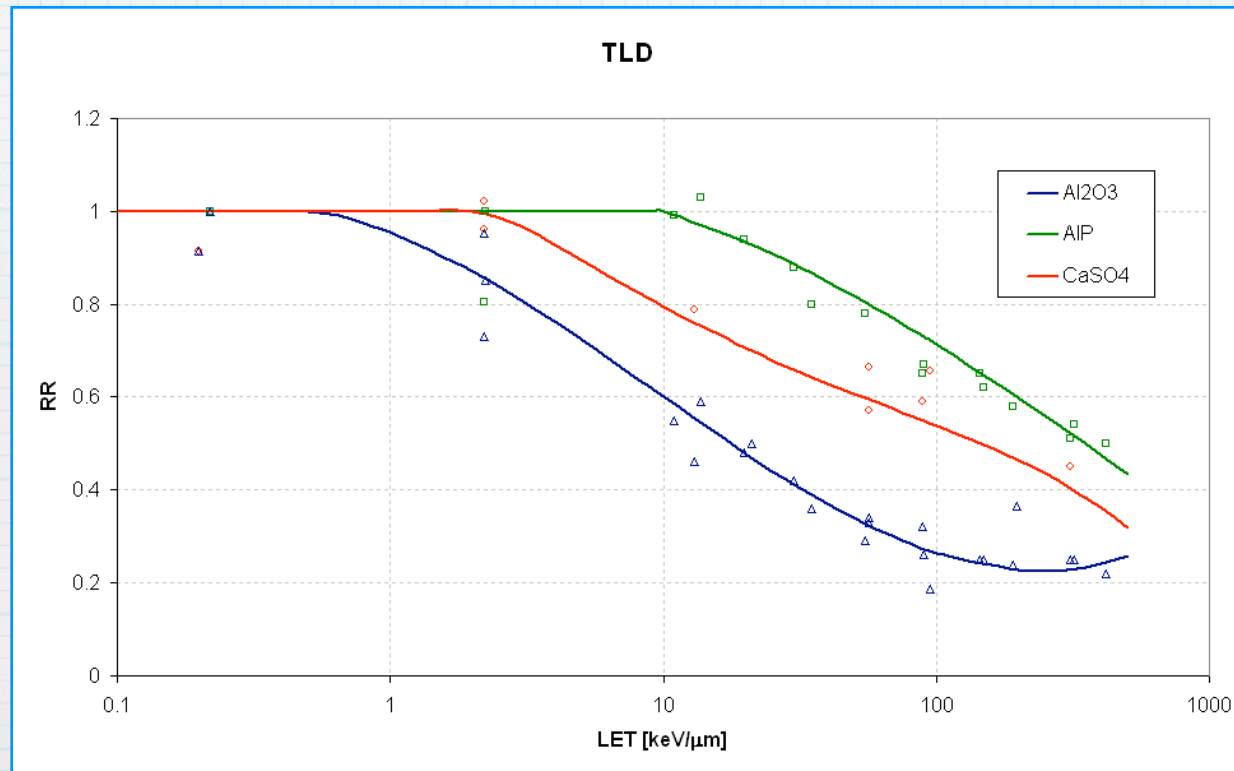
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Introduction

- * dosimetric characteristics and LET spectra onboard the ISS during MATROSHKA-R experiments
- * plastic nuclear track detectors (PNTD) and thermoluminescence detectors (TLD) at various locations on the surface of the spherical phantom; some TLD also inserted inside this phantom
- * experiment MTR-R 2008 – May to Dec. 2008 (206 days); Piers-1 module
- * comparison with experiment MTR-R 2006 – Dec. 2005 to Sep. 2006 (273 days); crew cabin

Thermoluminescence detectors

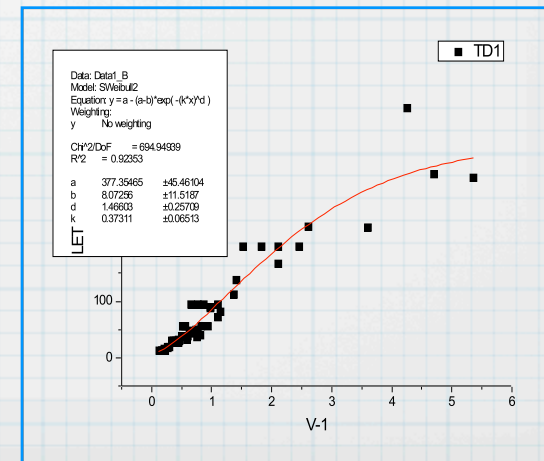
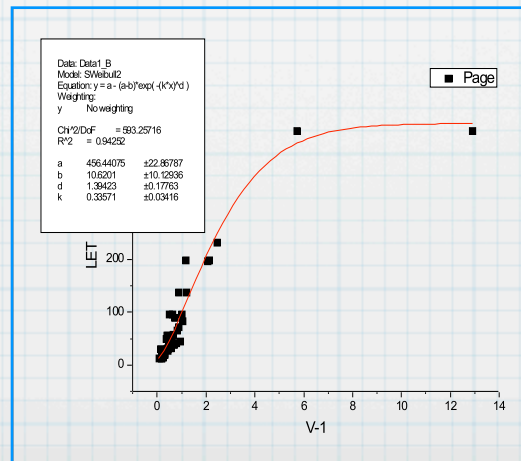
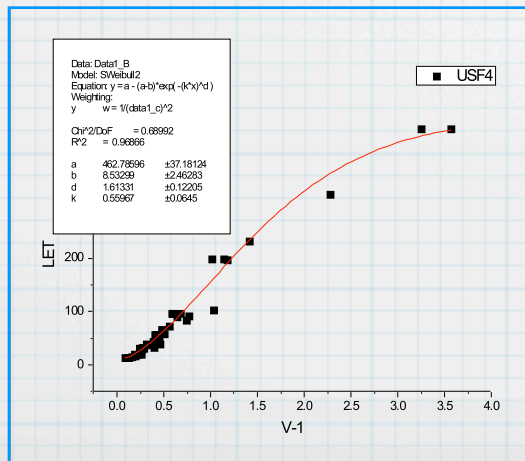
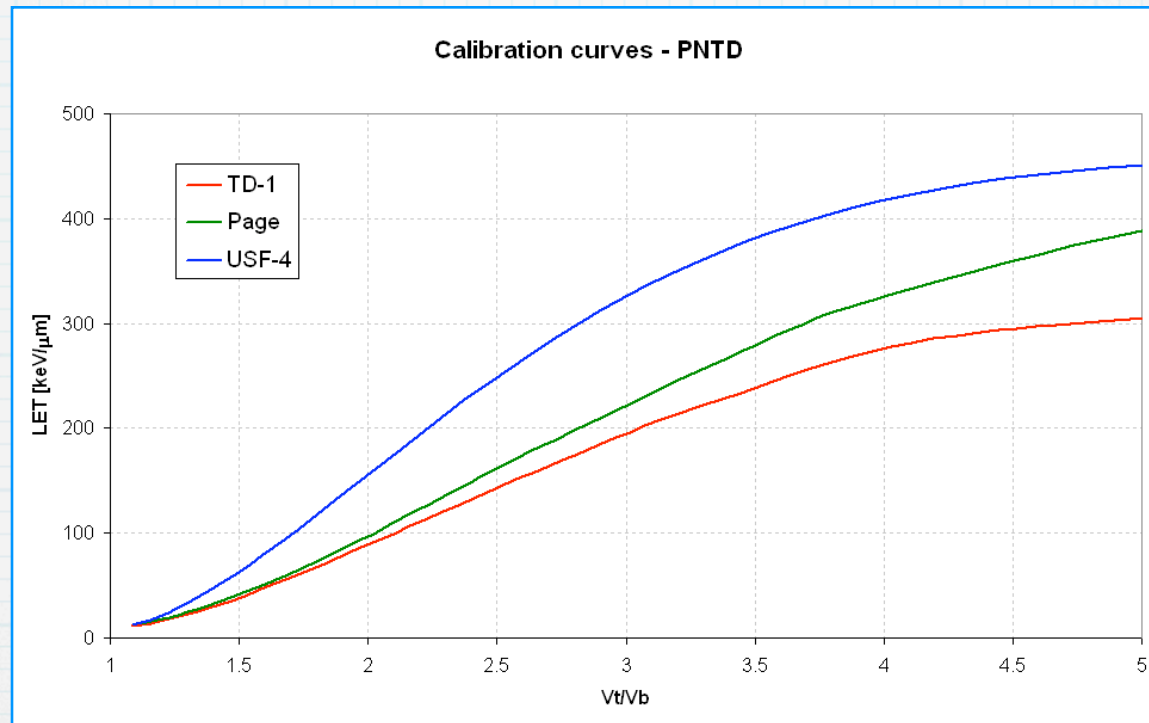
- * $\text{Al}_2\text{O}_3:\text{C}$
- * $\text{CaSO}_4:\text{Dy}$
- * Alumophosphate glasses (Al-P)



Plastic nuclear track detectors

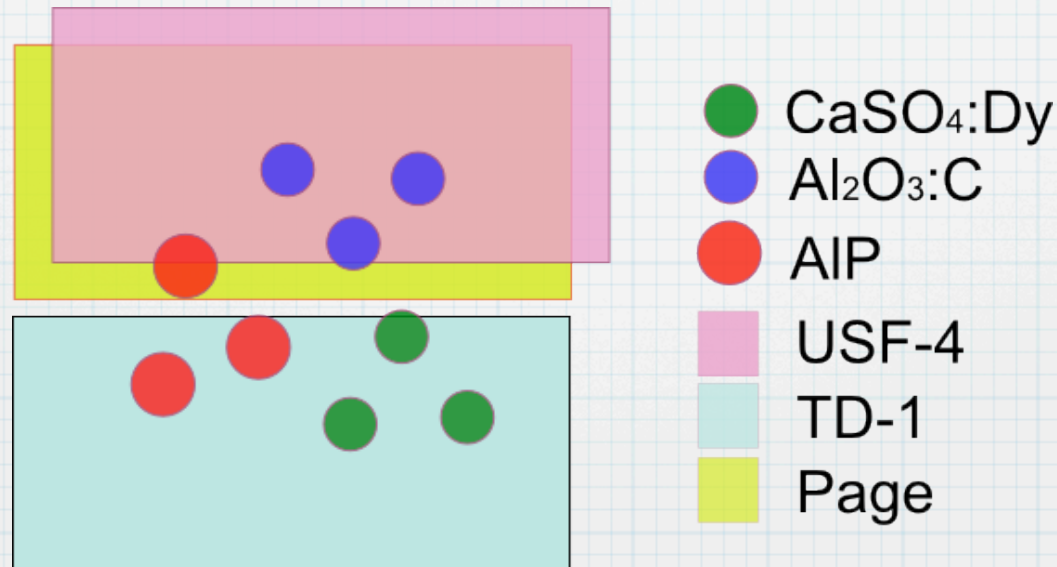
- * HARZLAS TD-1 (0.9 mm thick, produced by Fukuvi Chemical Industry Co., Ltd, Japan)
- * USF-4 (0.6 mm thick, produced by American Technical Plastics, USA)
- * Page (0.5 mm thick, produced by Page Mouldings, UK)
- * etching at 5 N NaOH at 70° for 18 hours (removed layer about 15–17 μm on each side of the detector)
- * measured and analyzed using LUCIA-NIS and HspFit
- * calibration mostly at HIMAC (ICCHIBAN projects, NPI project) or at JINR (Dubna)

Calibration curves



Detectors' package

- * TLD + PNTD
- * TLD were attached to PNTD
- * wrapped in black foil



MATROSHKA-R phantom

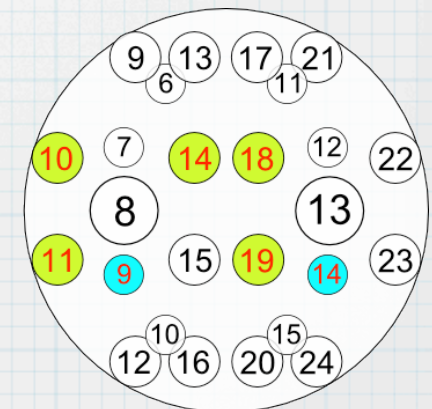
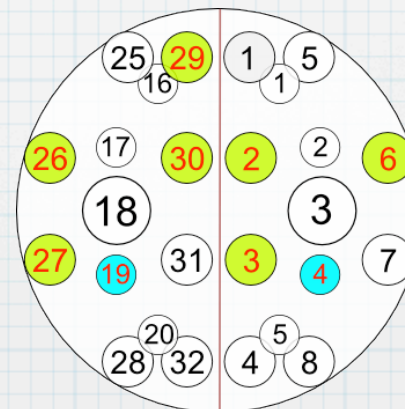
- * tissue-equivalent spherical phantom

- size 370 x 370 x 390 mm
- mass 32 kg
- 32 pockets
- 4 thick and 16 thin containers



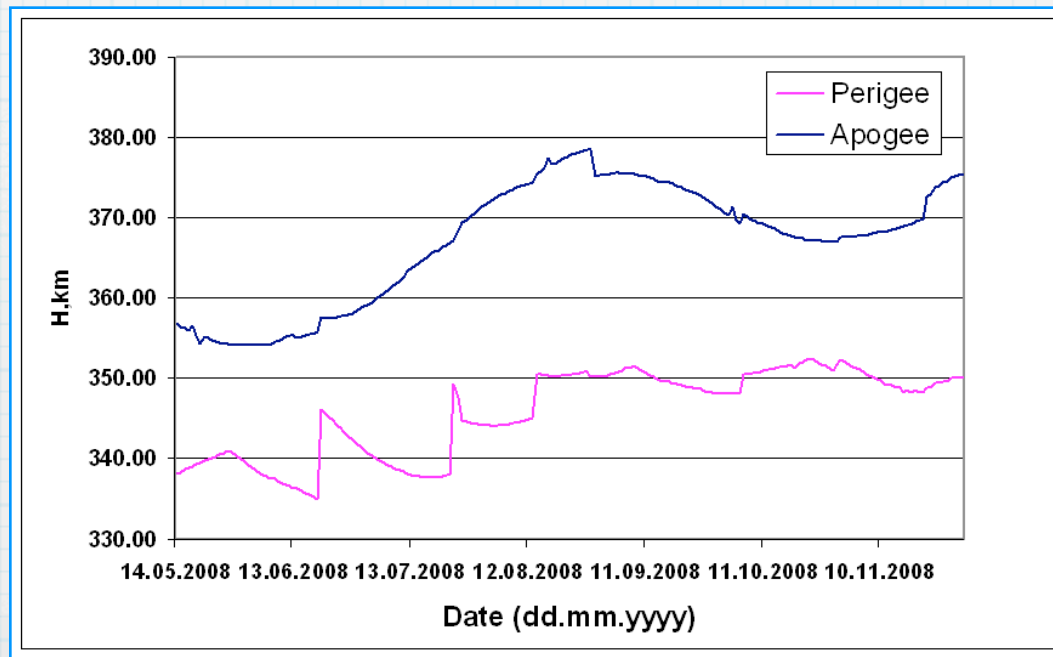
- * PNTD + TLD: 12 pockets (2, 3, 6, 10, 11, 14, 18, 19, 26, 27, 29, 30)

- * TLD ($\text{CaSO}_4:\text{Dy}$): inside 4 containers (4, 9, 14, 19)



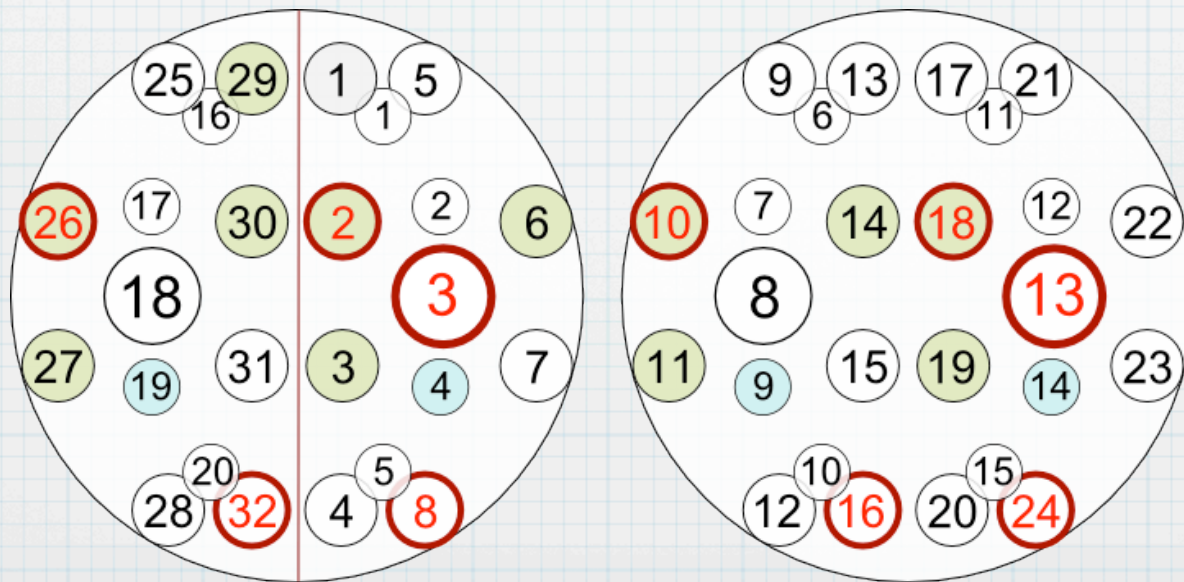
ISS parameters

- * exposure duration: May to December 2008 (206 days in total)
- * location of the phantom: Piers-1 module
- * averaged apogee altitudes: 367 km
- * averaged perigee altitudes: 346 km



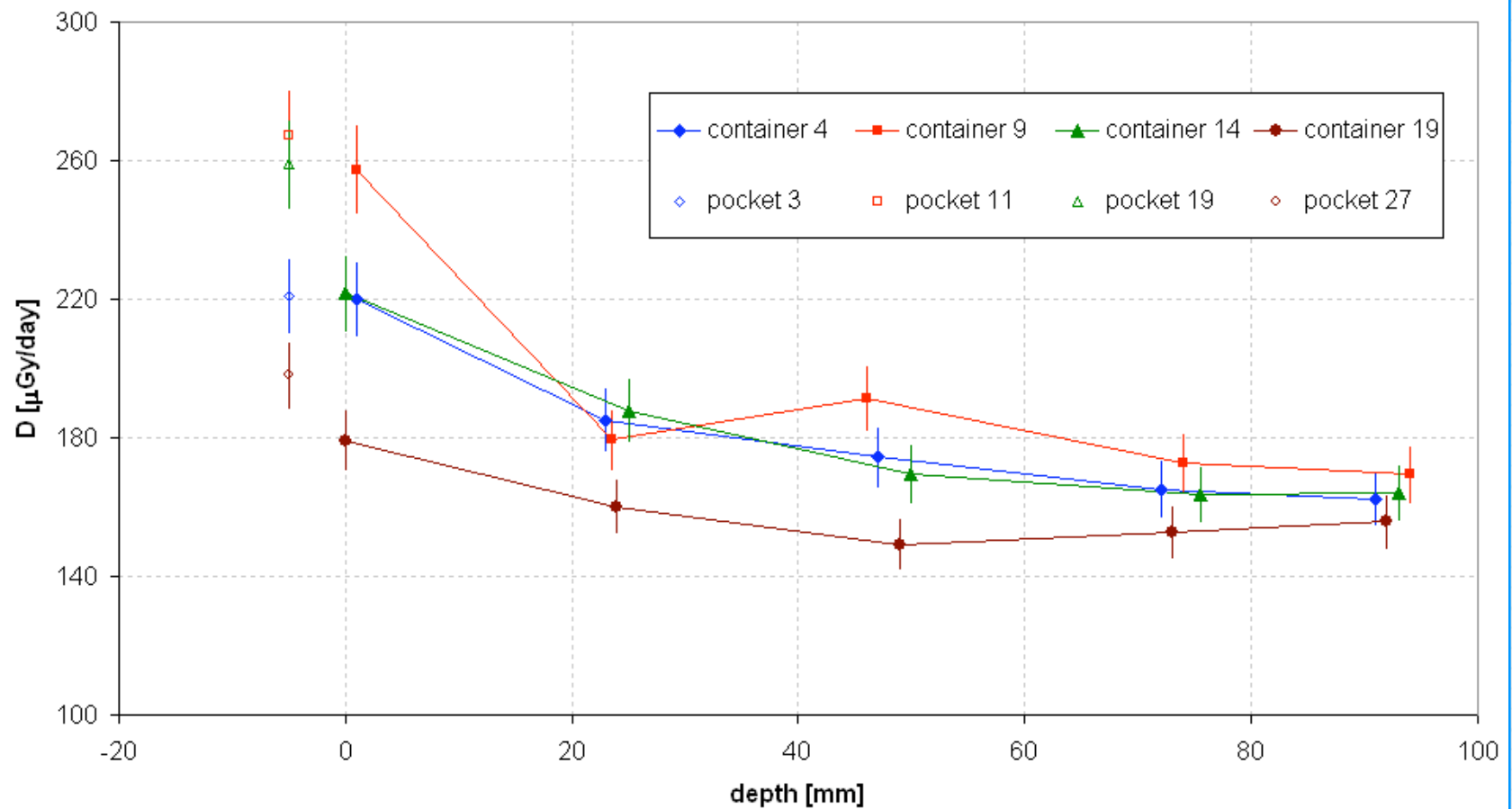
MTR-R 2006 experiment

- * December 2005 – September 2006 (273 days)
- * crew cabin
- * PNTD (Page, Tastrak) + TLD ($\text{Al}_2\text{O}_3:\text{C}$, Al-P, $\text{CaSO}_4:\text{Dy}$)
 - pockets 2, 8, 10, 16, 18, 24, 26, 32
 - container 3 and 13 (0 – 10 cm)

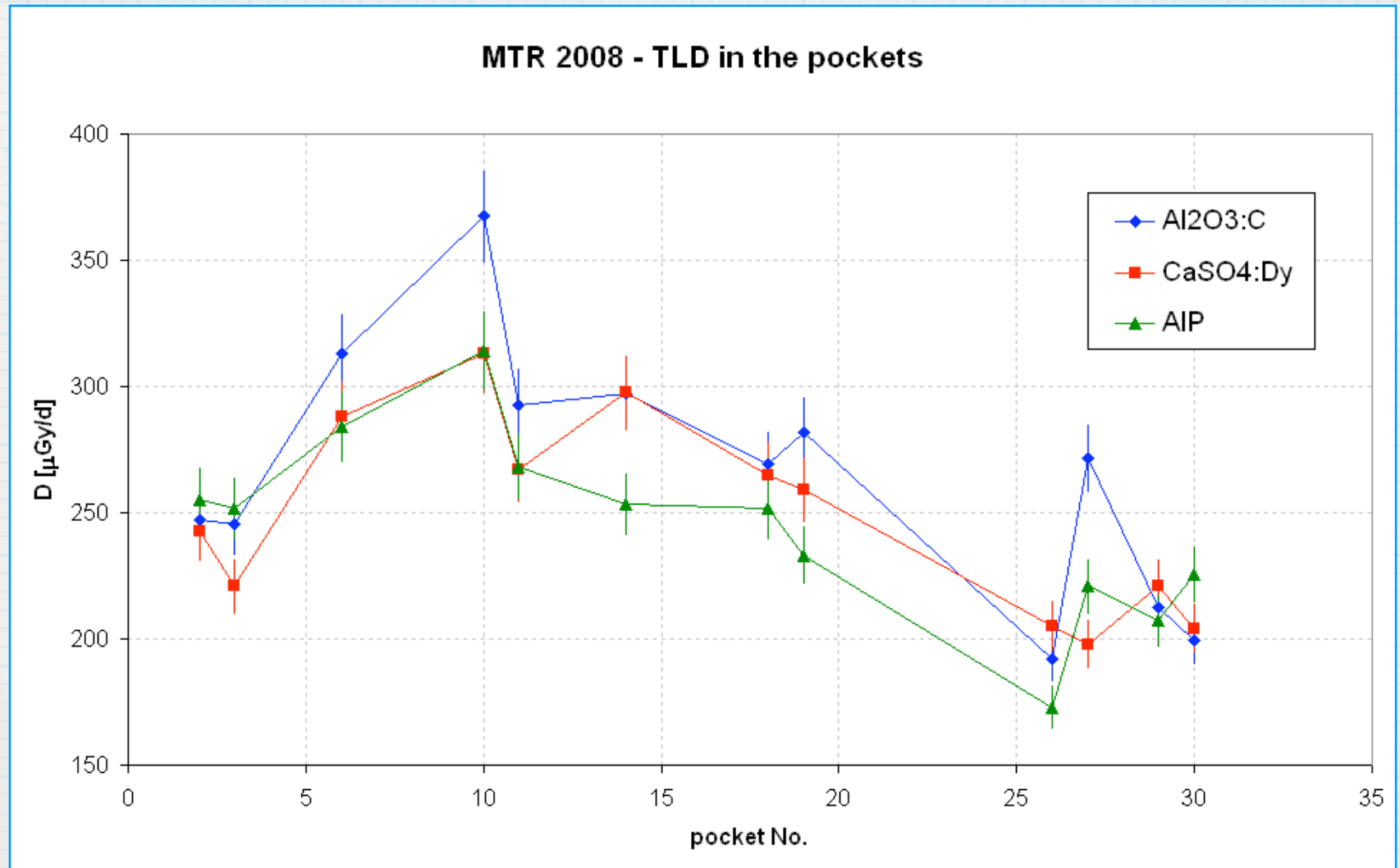


TLD inside the phantom

MTR 2008 - TLD inside the phantom



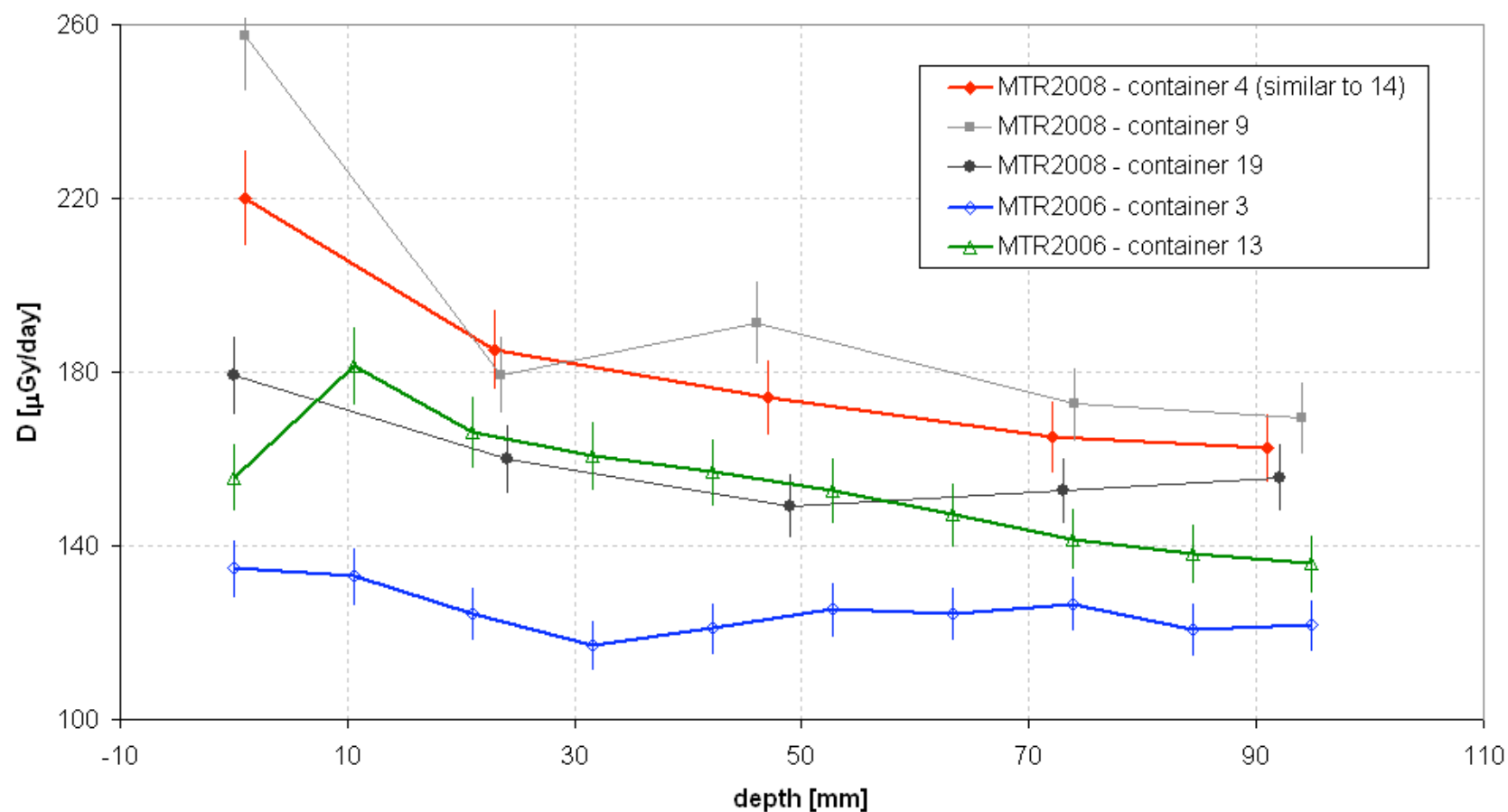
TLD on the phantom



Comparison MTR-R 2006 and 2008

Inside the phantom

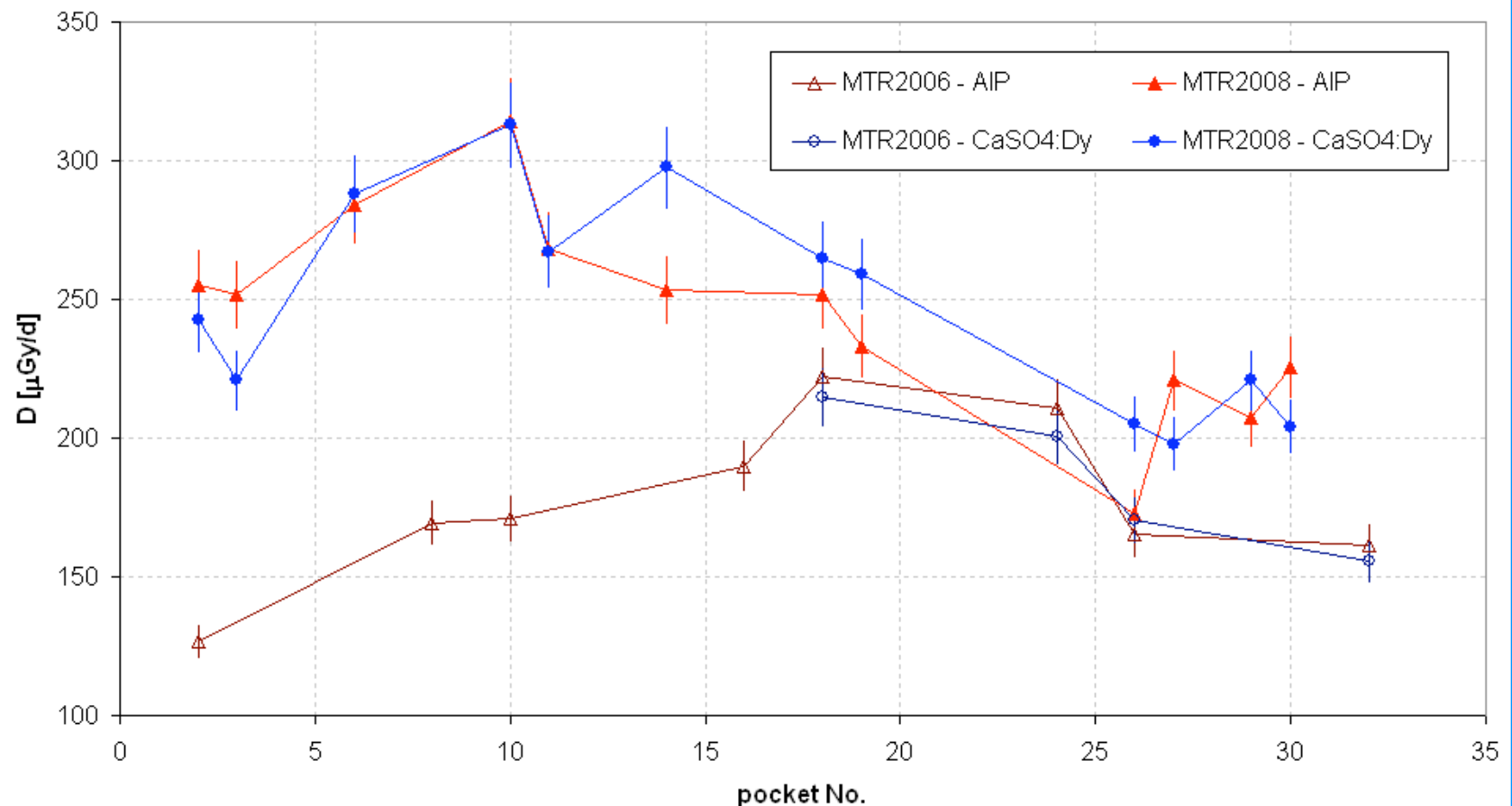
MTR 2006 and 2008 - TLD inside the phantom



Comparison MTR-R 2006 and 2008

On the surface of the phantom

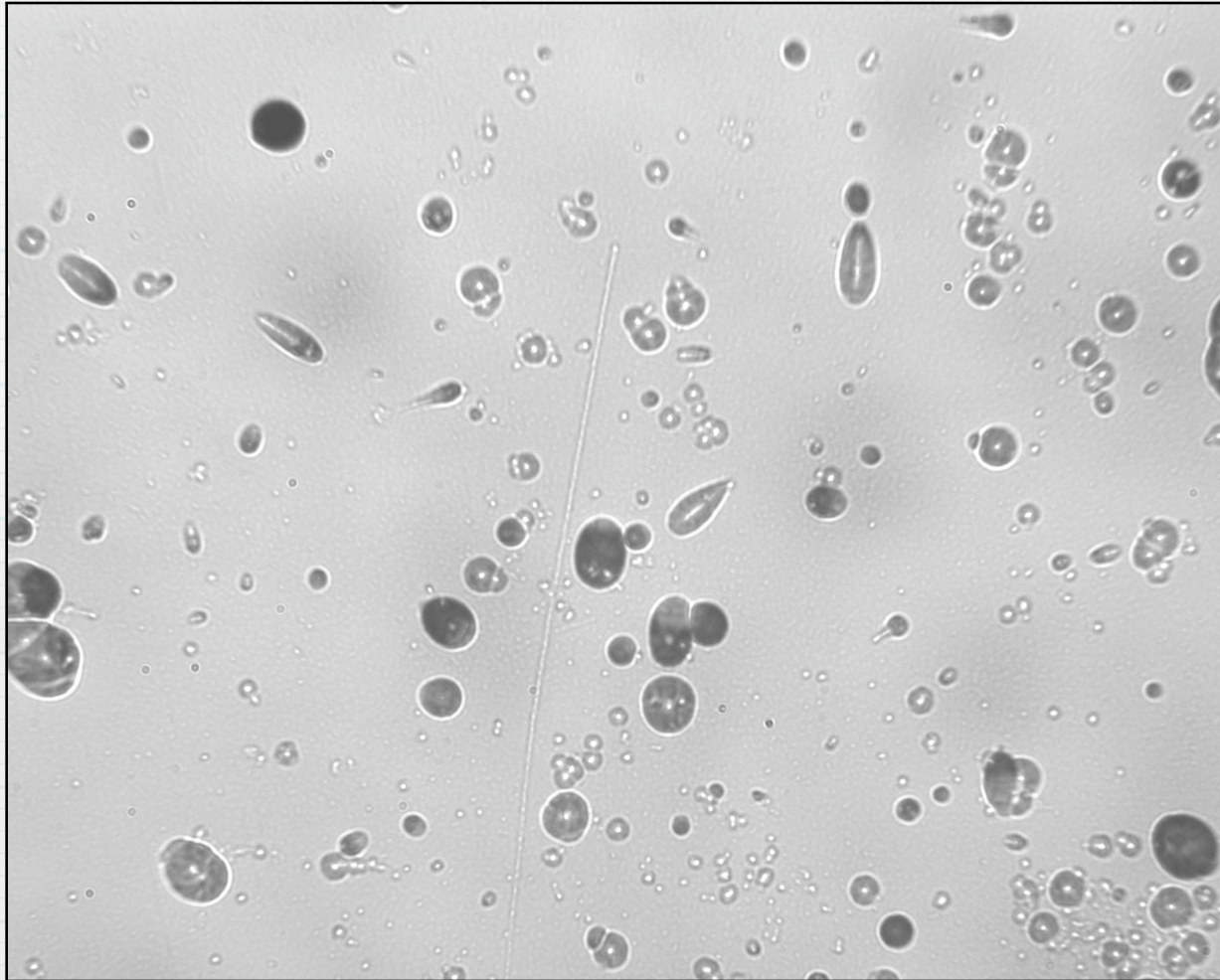
MTR 2006 and 2008 - TLD in the pockets



Conclusion – TLD

- * TLD inside the phantom (10 cm)
 - 2008: $D = 163 \pm 6 \mu\text{Gy/d}$
 - 2006: $D = 129 \pm 10 \mu\text{Gy/d}$
- * TLD in the pockets (average from all TLD)
 - 2008: $D = 251 \pm 44 \mu\text{Gy/d}$ (173 – 367 $\mu\text{Gy/d}$)
 - 2006: $D = 180 \pm 28 \mu\text{Gy/d}$ (127 – 222 $\mu\text{Gy/d}$)
- * D inside the phantom about 20%, on the surface about 30% lower in 2006 than in 2008

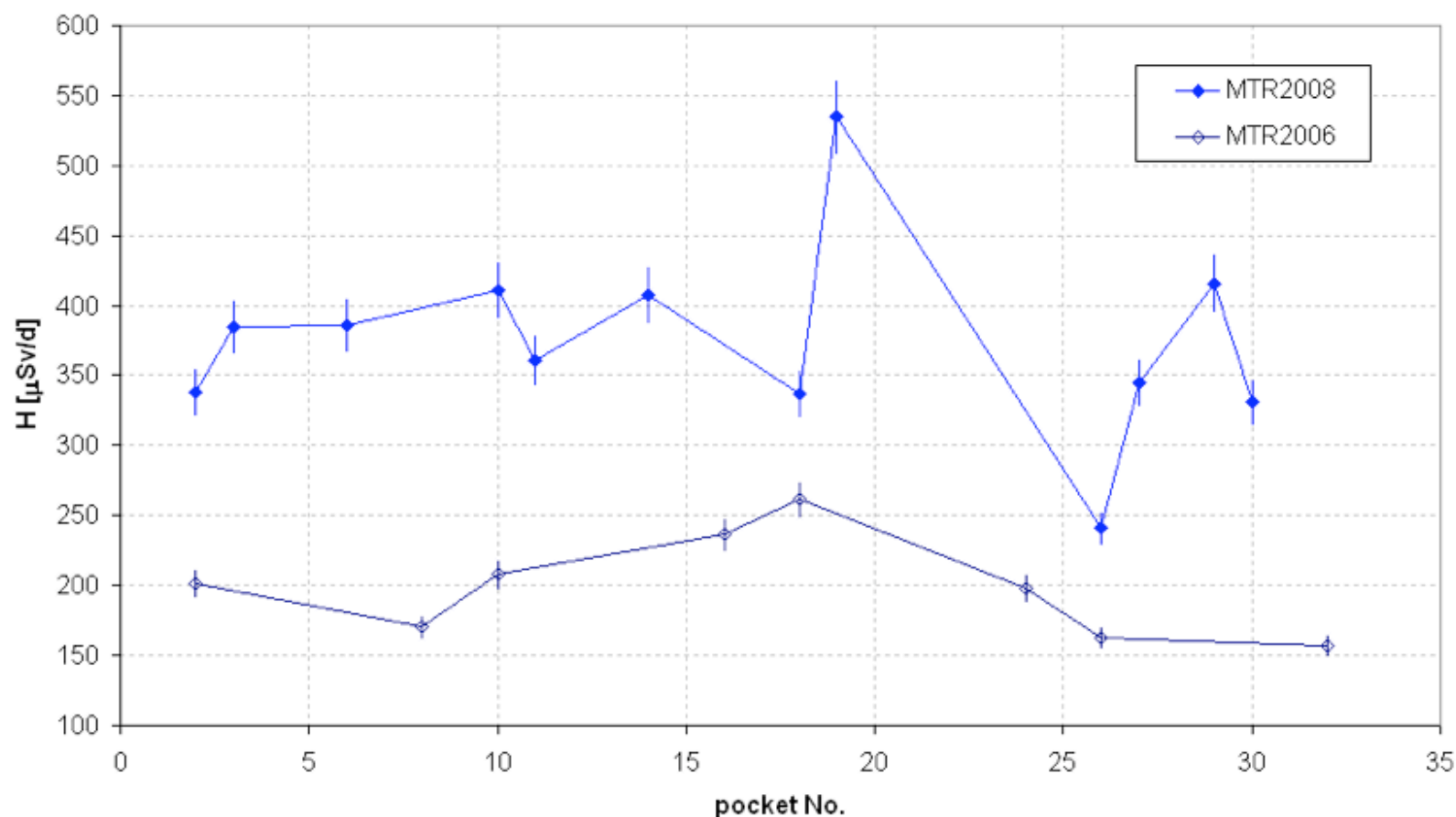
PNTD - Tracks



Comparison MTR-R 2006 and 2008

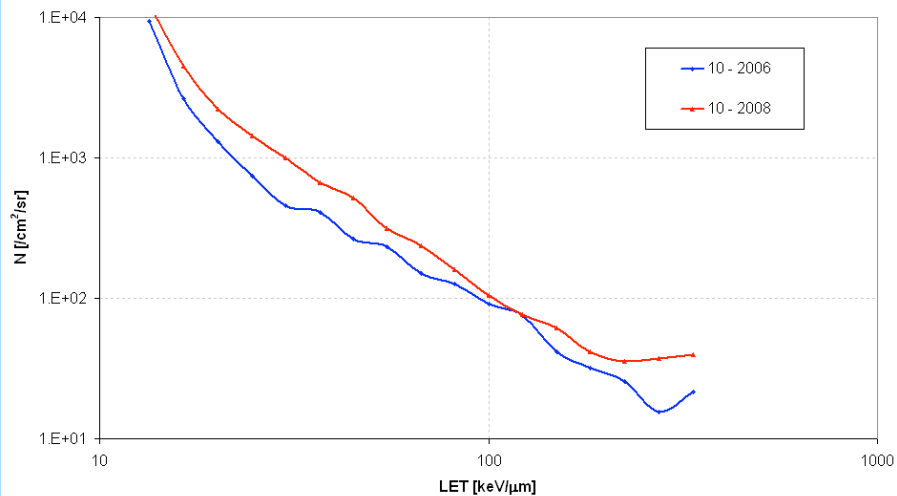
On the surface of the phantom

MTR 2006 and 2008 - TED (Page) in the pockets

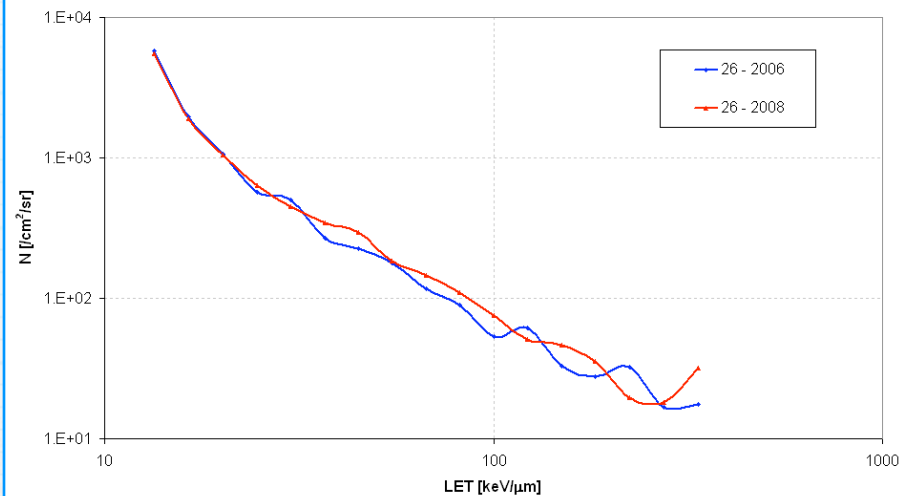


Comparison MTR-R 2006 and 2008 LET spectra

MTR 2006 and 2008 - Page



MTR 2006 and 2008 - Page



Conclusion – PNTD

* 2008

– Page: $D = 49 \pm 12 \mu\text{Gy/d}$ (27 – 76 $\mu\text{Gy/d}$)
 $H = 374 \pm 70 \mu\text{Sv/d}$ (241 – 535 $\mu\text{Sv/d}$)

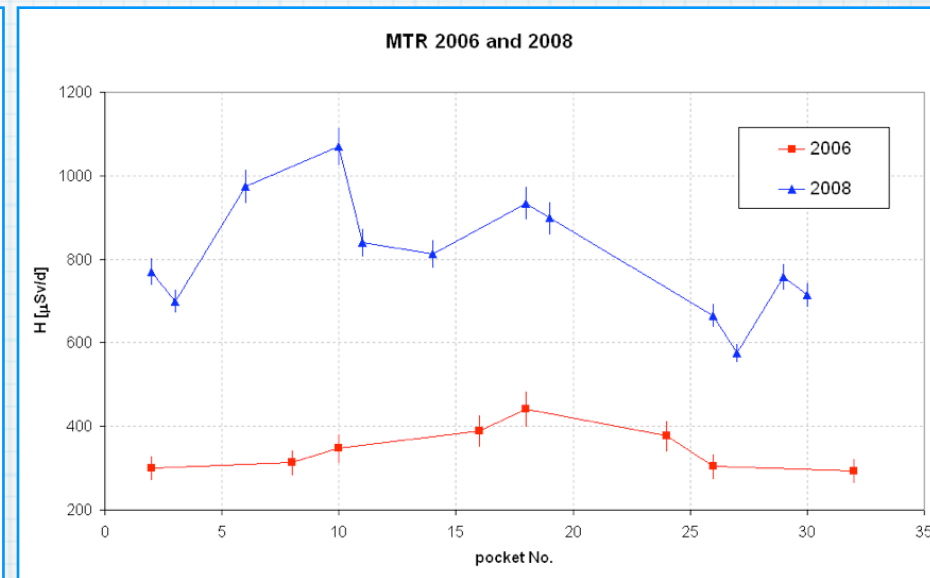
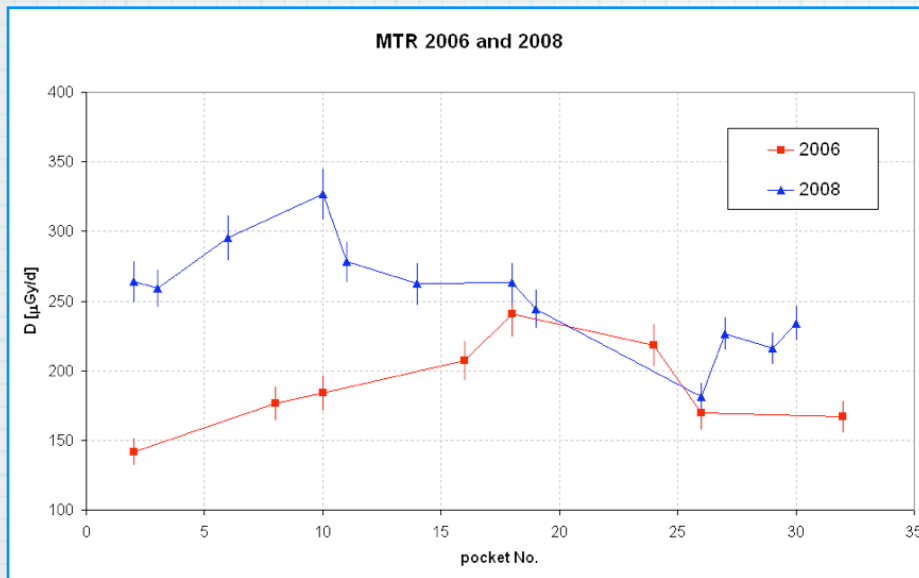
• 2006

– Page: $D = 27 \pm 6 \mu\text{Gy/d}$ (20 – 37 $\mu\text{Gy/d}$)
 $H = 199 \pm 36 \mu\text{Sv/d}$ (157 – 261 $\mu\text{Sv/d}$)

* D about 45%, H about 46% lower in 2006 than in 2008

TLD + PNTD

* TLD (AI-P) + Page



Conclusion – TLD + PNTD

* 2008

- $D = 254 \pm 38 \text{ } \mu\text{Gy/d}$ (181 – 327 $\mu\text{Gy/d}$)
- $H = 809 \pm 142 \text{ } \mu\text{Sv/d}$ (575 – 1070 $\mu\text{Sv/d}$)
- $Q = 3.0 \pm 0.4$ (2.5 – 3.7)
- $D(>10 \text{ keV}/\mu\text{m})/D(\text{total}) = 26\%$, $H(>10 \text{ keV}/\mu\text{m})/H(\text{total}) = 77\%$

• 2006

- $D = 173 \pm 29 \text{ } \mu\text{Gy/d}$ (125 – 217 $\mu\text{Gy/d}$)
- $H = 346 \pm 53 \text{ } \mu\text{Sv/d}$ (293 – 441 $\mu\text{Sv/d}$)
- $Q = 2.0 \pm 0.2$ (1.8 – 2.4)
- $D(>10 \text{ keV}/\mu\text{m})/D(\text{total}) = 16\%$, $H(>10 \text{ keV}/\mu\text{m})/H(\text{total}) = 58\%$

- average D about 32%, H about 57%, and Q about 33% lower in 2006 than in 2008

Acknowledgment

The studies have been partially supported through the grant of GAAV No. KJB100480901.