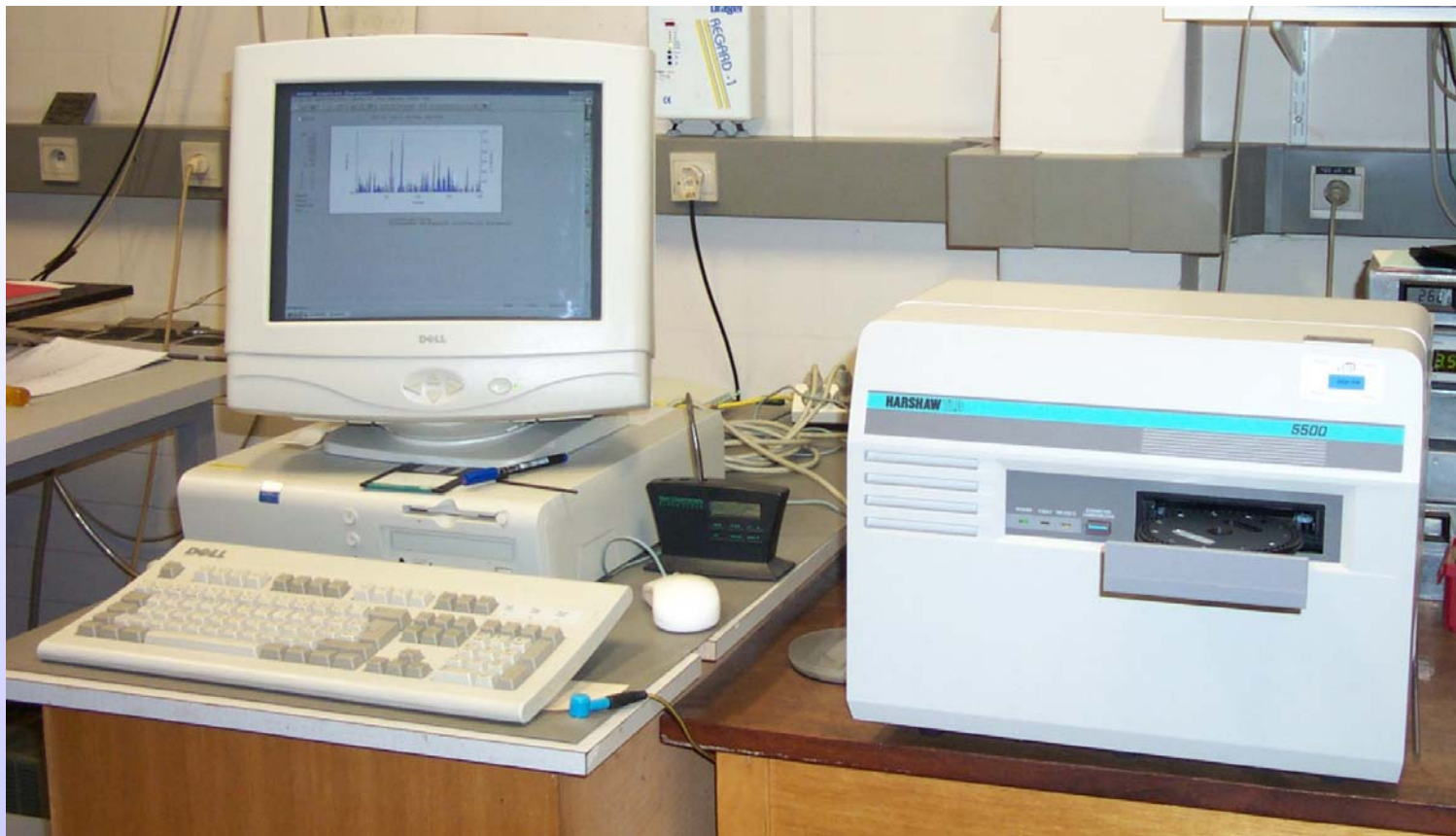

Recent results of TLD and OSL measurements on board of the ISS

F. Vanhavere (SCK•CEN, Belgium)

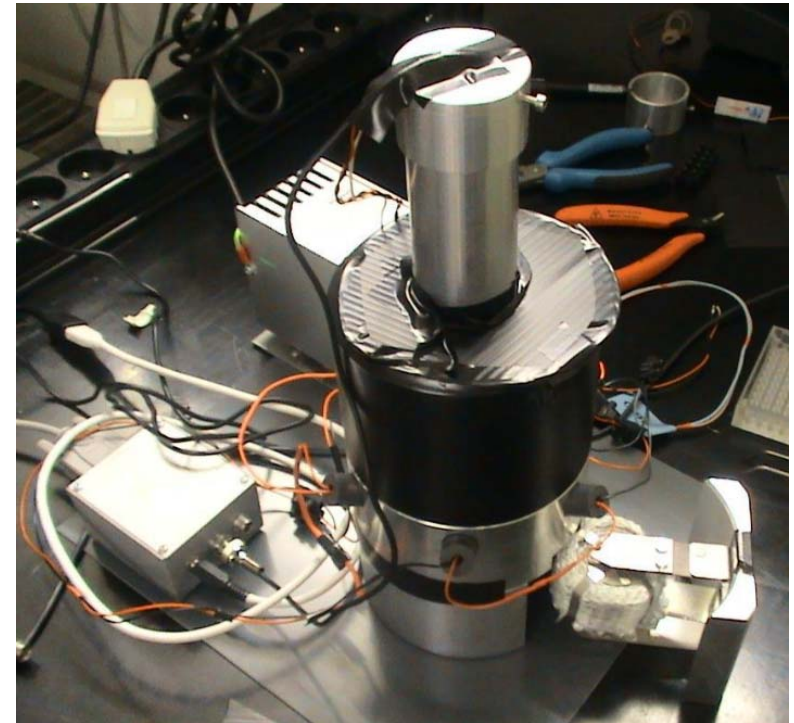
Types of dosemeters: passive and small

- **Thermoluminescence detectors**
 - LiF:Mg,Ti
 - LiF:Mg,Cu,P
- **Optically Stimulated luminescence detectors**
 - Al₂O₃:C (Luxel, TLD500)

Thermoluminescence: Harshaw 5500



OSL: Ar-ion laser or home made device (diodes)



Measurement technique

- TLD

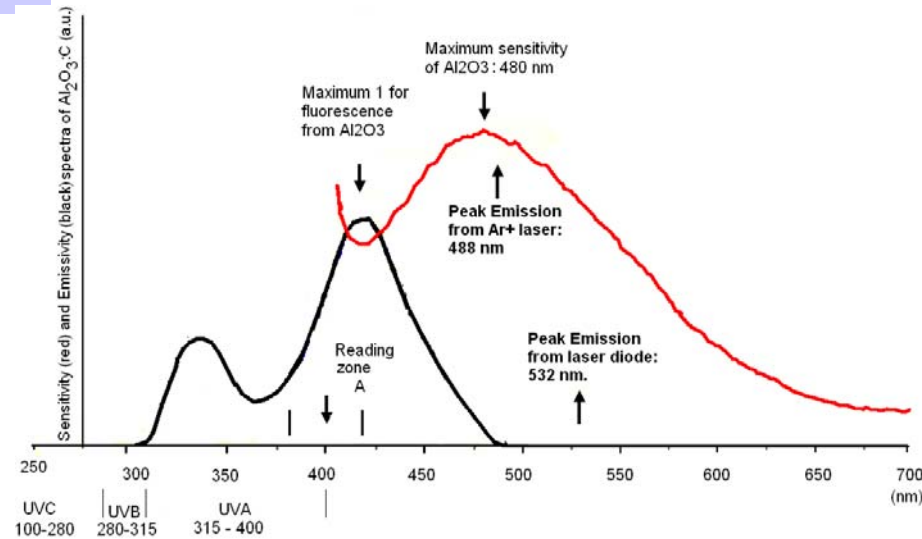
- 1°C/s
- Integration of area under glow curve

- OSLD

- Ar-ion laser: 488 nm, 120 mW
- 100 seconds of stimulation
- Continuous mode
- Discrimination through filter pack: only blue peak

- Calibration with Co-60

- In the middle of exposure period (so fading is included)
- Single element correction factor
- Results in absorbed dose to water
- Background detectors
- Uncertainties: calibration, spread different detectors, individual sensitivity

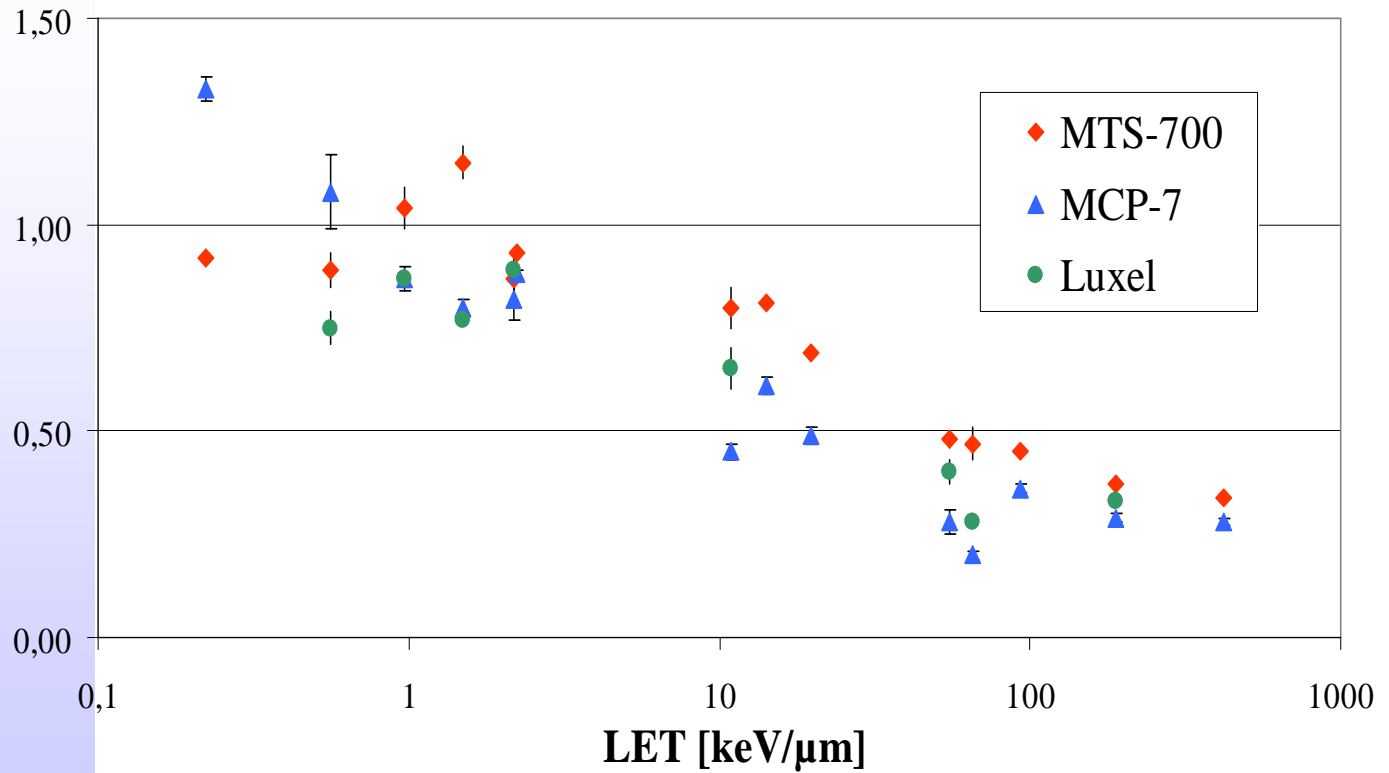


Detector characterisation

- Different types of detectors give different results for low LET part of dose
 - Because of different efficiencies for high LET radiation
- Characterisation TLD and OSL
 - Dependent on technique and on material
- Participation to ICCHIBAN series and other irradiations

Efficiency curve

Overview LET dependencies



Previous space measurements with biological experiments

Four shuttle flights:

- **MESSAGE 2:** effects of the space flight conditions on bacterial gene expression
 - ♣ October 2003: 10 days

- **MOBILIZATION:** gene transfer between model bacteria :
 - ♣ april 2004: 11 days

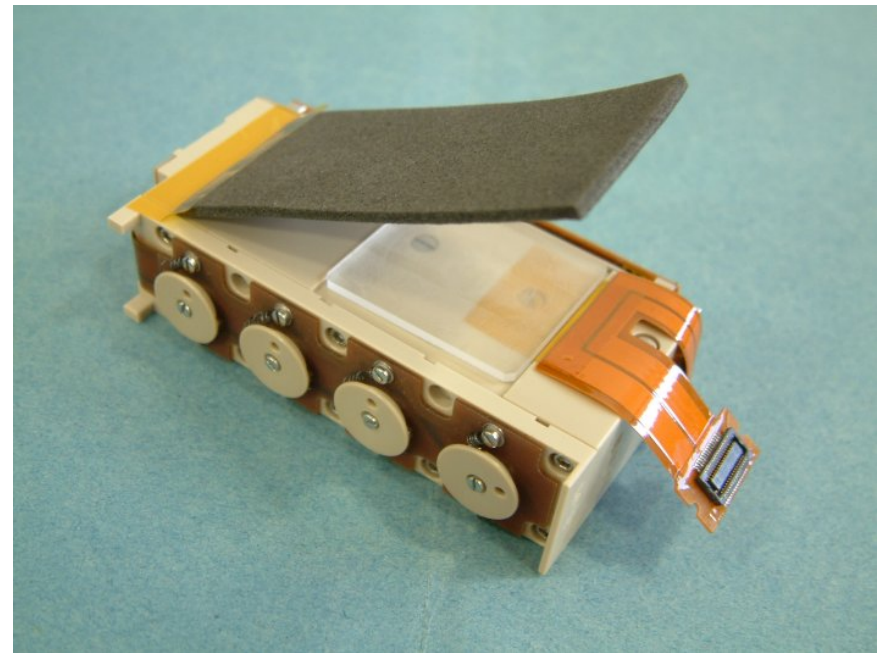
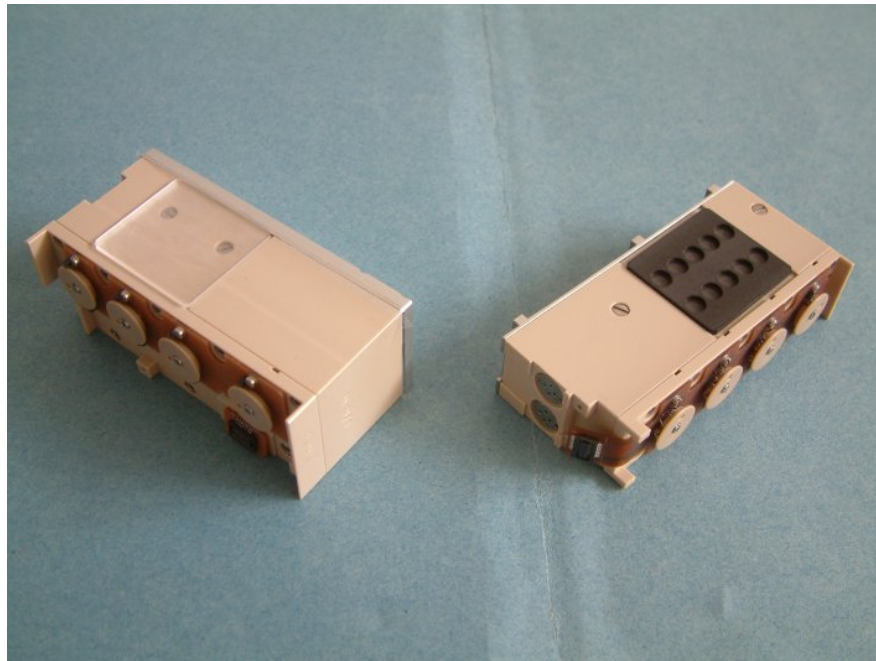
- **BASE A:** bacterial adaptation to space flight environments:
 - ♣ September 2006: 11 days

- **BASE B/C:** bacterial adaptation to space flight environments:
 - ♣ October 2008: 11 days

MESSAGE, MOBILIZATION

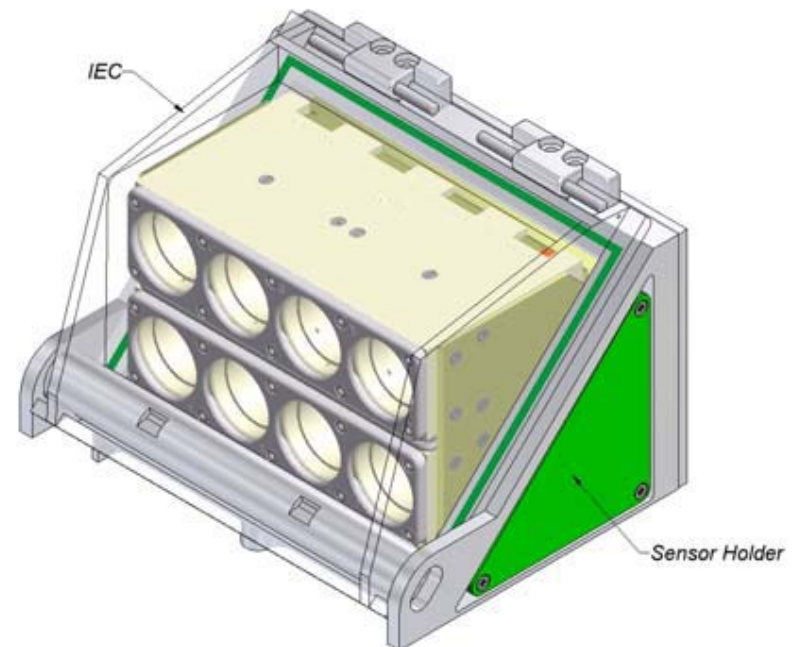
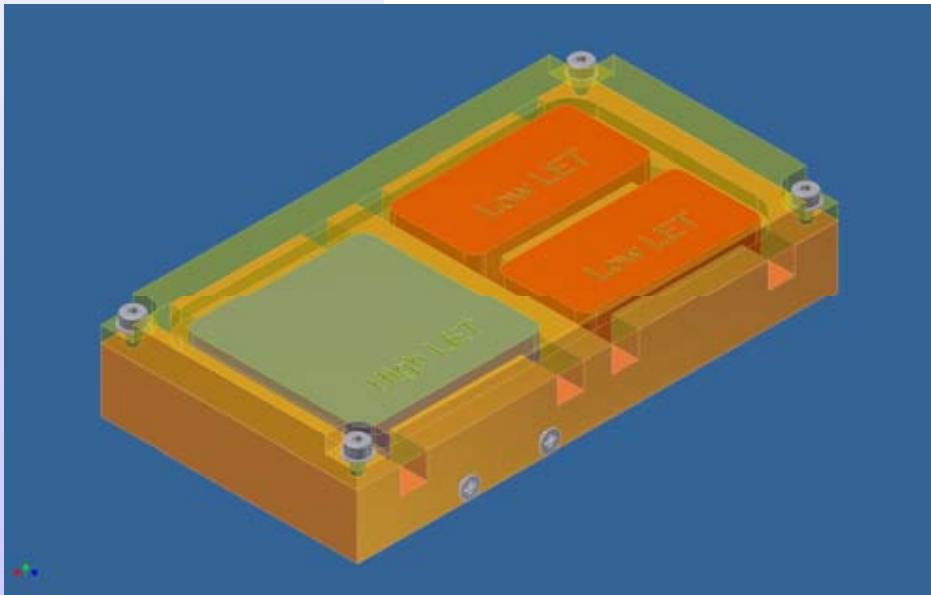


BASE B/C experiment



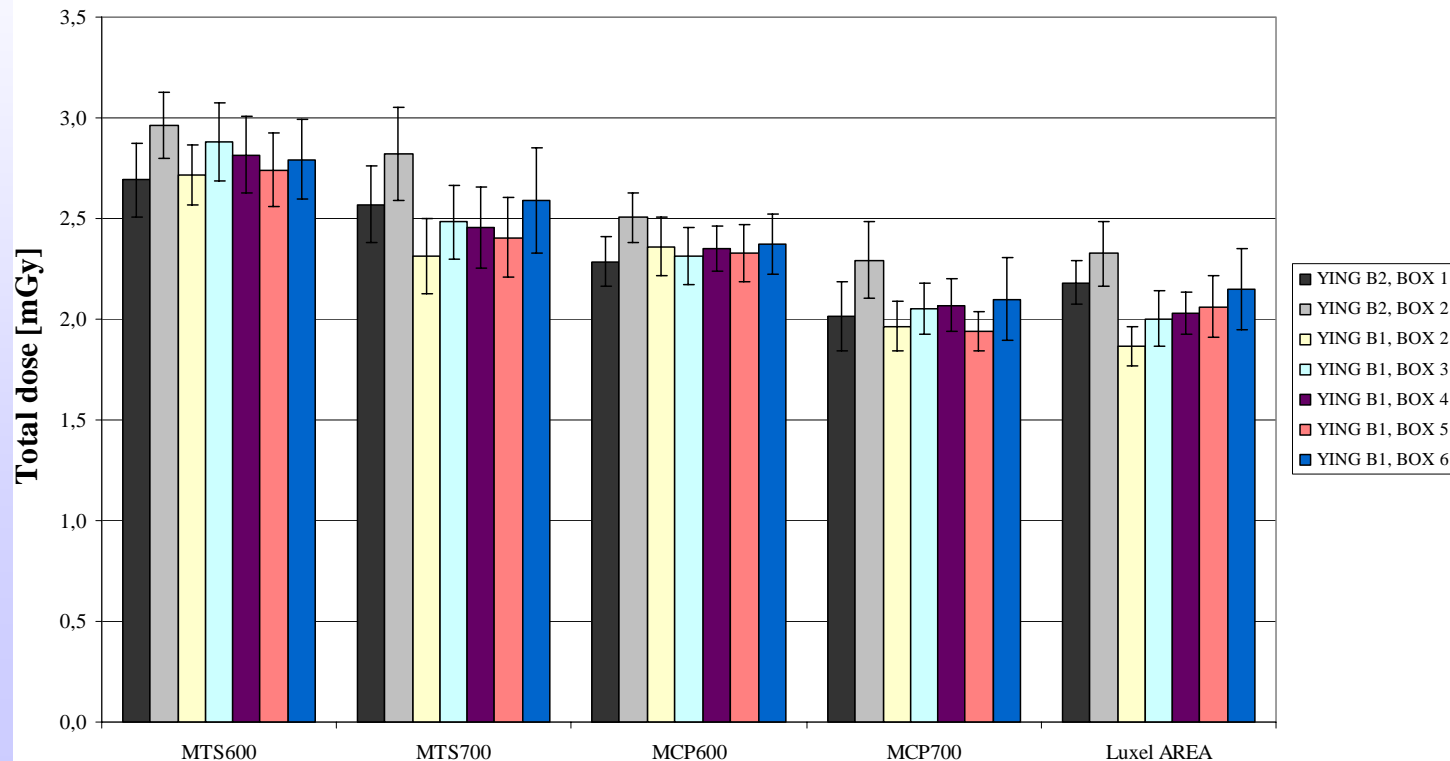
YING B1/B2 (Yeast in No Gravity)

- Flight 30-09-2009 to 11-10-2009
- boxes 2, 3, 4, 5 for Ying B1 and triangle 1, 2 for Ying B2



YING B1/B2

- **Difference per box?**
 - No statistically significant difference
 - YING B2, BOX 2 a little higher
 - Spread between boxes smaller than 5%



YING B1/B2

- **Comparison SCK·CEN - NPI**
 - One type of TLD can be compared: MCP detectors
 - Agreement within uncertainties

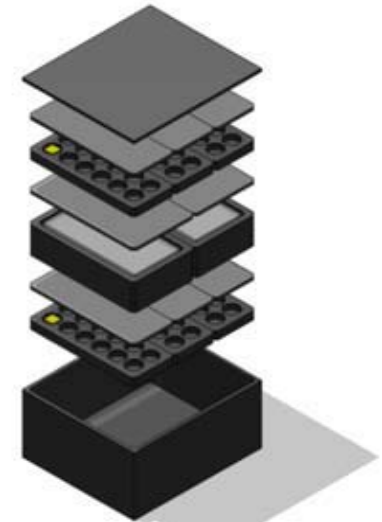
YING B1 [mGy]	NPI	SCK	
Box 2	2,11	1,96	0,12
Box 3	2,17	2,05	0,13
Box 4	2.09 ± 0.09	2,07	0,13
Box 5	2,12	1,94	0,10
Box 1	2.02 ± 0.09	2,02	0,17
Box 2	2.29 ± 0.10	2,29	0,19

Comparison with previous flights

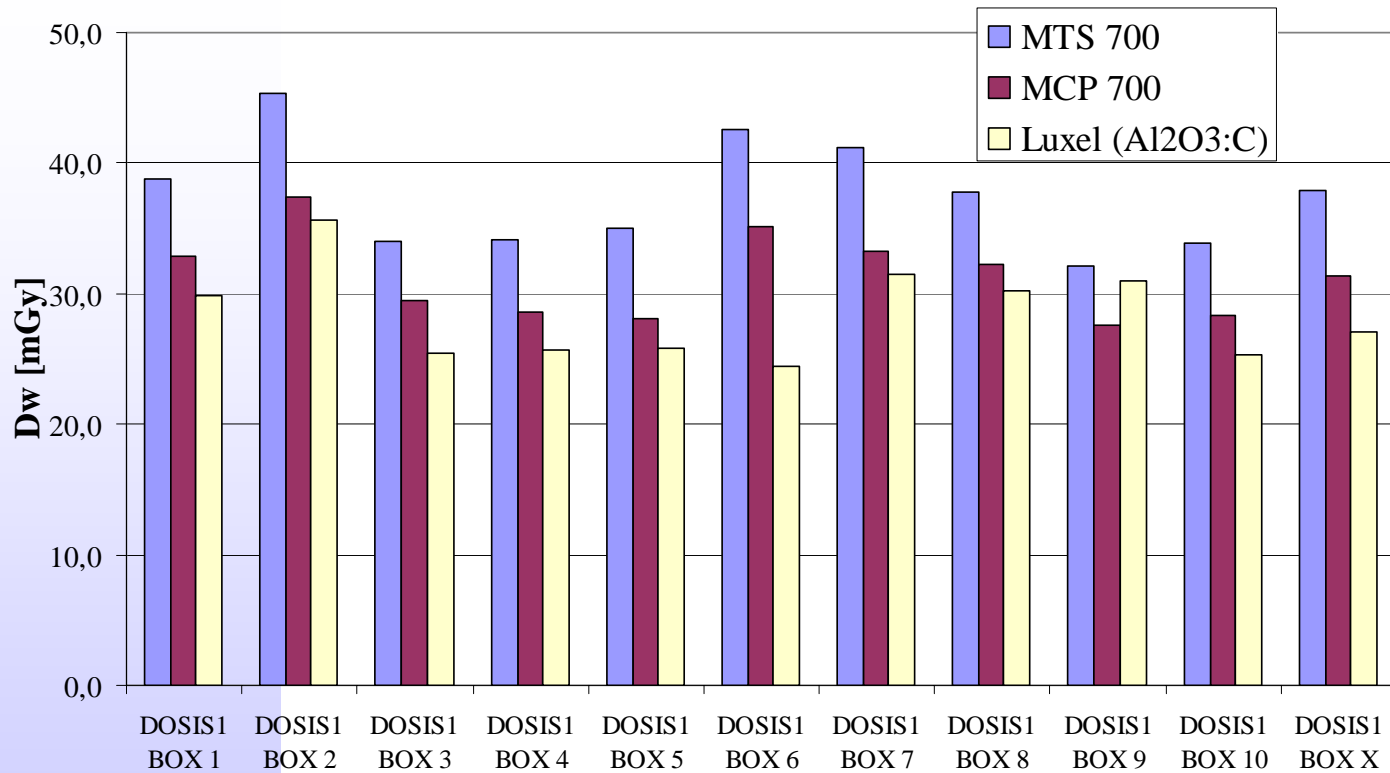
Institution	Material	Techn.	ISS-7S 2003 [$\mu\text{Gy d}^{-1}$]	ISS-7S 2003 [$\mu\text{Gy d}^{-1}$]	ISS-8S 2004 [$\mu\text{Gy d}^{-1}$]	ISS-13S 2006 [$\mu\text{Gy/day}$]	BASE B/C: 2008 [$\mu\text{Gy/day}$]	YING 2009 [$\mu\text{Gy/day}$]
SCK-CEN	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	148 ± 5	162 ± 3	157 ± 7	-	284 ± 12	187 ± 17
OSU	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	170 ± 2	165 ± 2	163 ± 5	-	293 ± 7	
SCK-CEN	$^7\text{LiF}:\text{Mg,Ti}$	TL	152 ± 8	194 ± 17	-	208 ± 23	290 ± 15	225 ± 23
SCK-CEN	$^6\text{LiF}:\text{Mg,Ti}$	TL	-	-	-	212 ± 21	308 ± 24	243 ± 17
SCK-CEN	$^7\text{LiF}:\text{Mg,Cu,P}$	TL	143 ± 1	154 ± 4	-	199 ± 21	249 ± 15	183 ± 13
SCK-CEN	$^6\text{LiF}:\text{Mg,Cu,P}$	TL	-	-	-	217 ± 9	241 ± 8	206 ± 13
NPI	$\text{LiF}:\text{Mg,Cu,P}$	TL	-	154 ± 12	118 ± 7		229 ± 22	186

DOSIS 1

- Dose mapping of Columbus module
- Passive detectors in 10 locations
- Launch february 2009

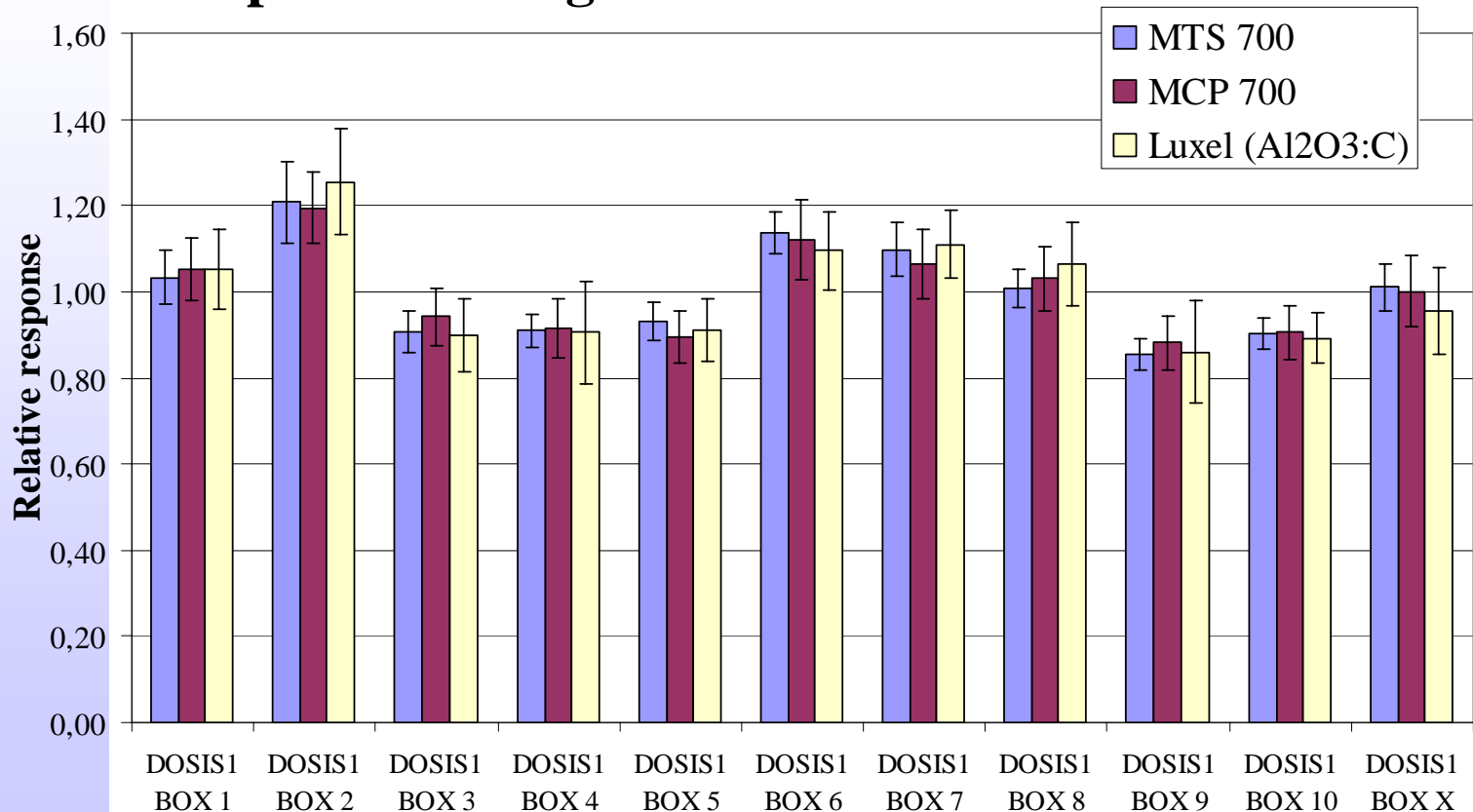


DOSIS 1 results



Differences between boxes

- Normalization
- Agreement between detectors
- Some points are higher or lower: **+20%** **-10%**

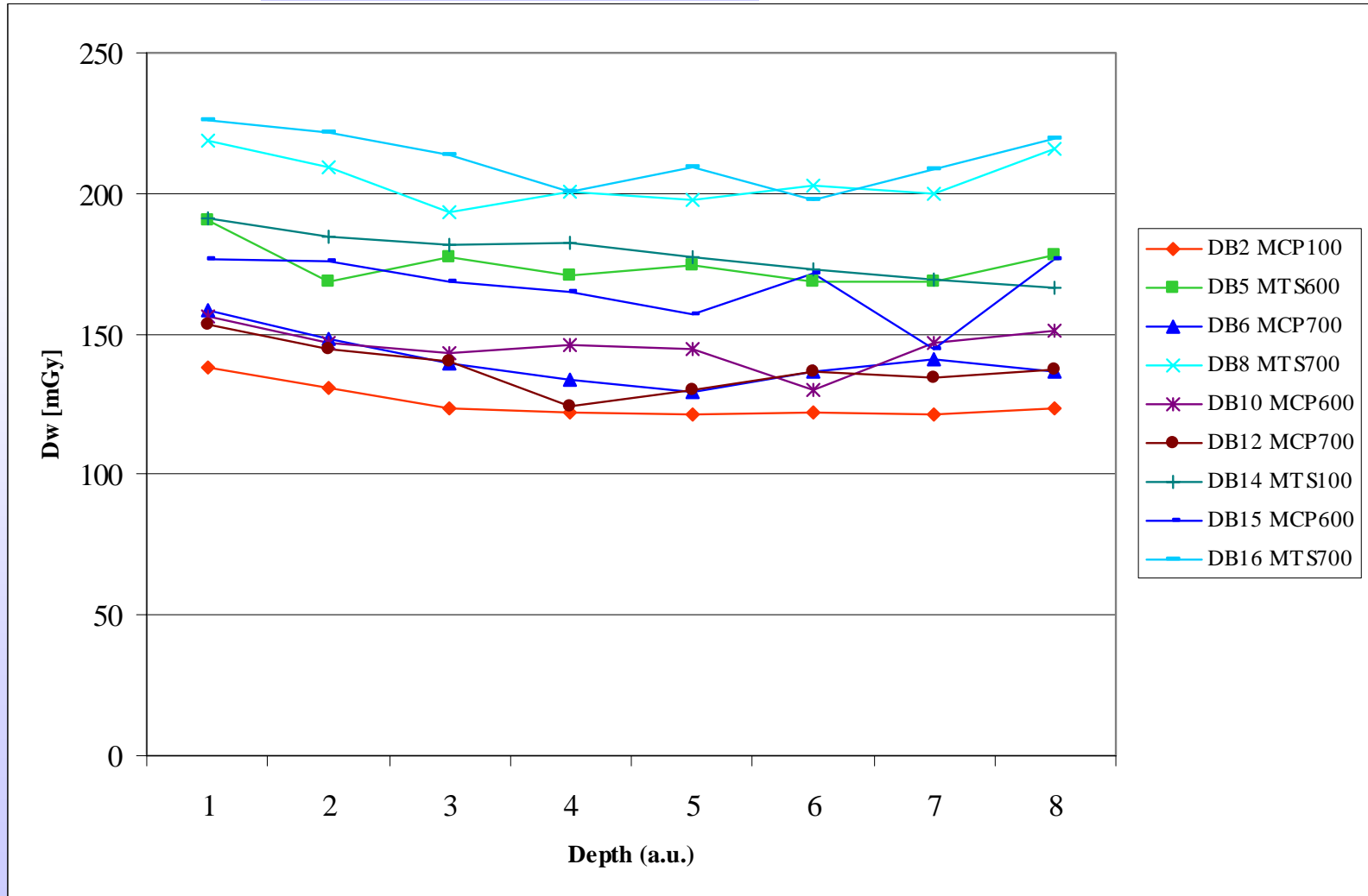


EXPOSE-E on EUTEF

- **Attached to Columbus:**
 - outside ISS
- **Space exposure about 600 days**
- **Detectors on top layer (stack)**
- **Detectors for depth dose**



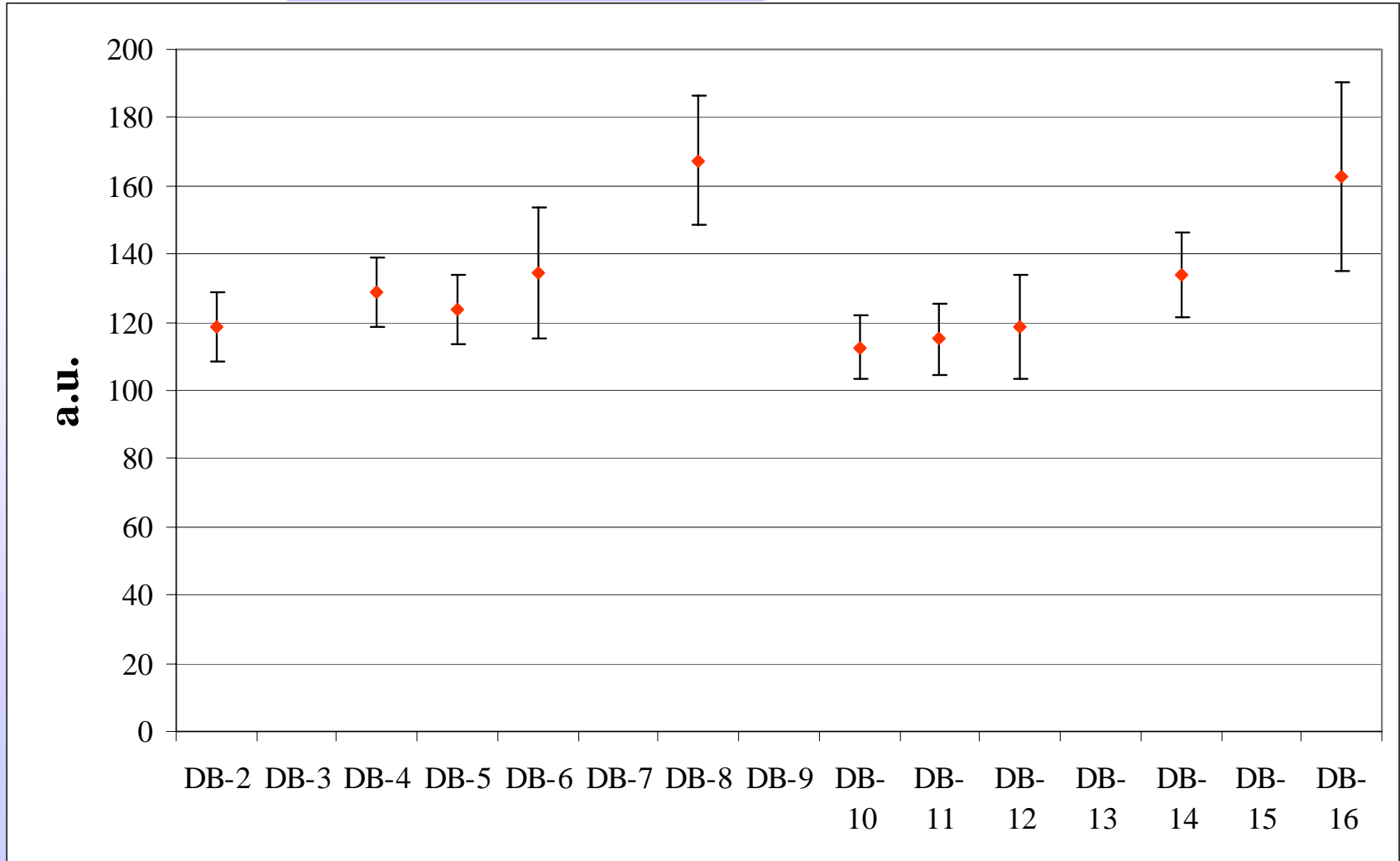
Results EXPOSE: top layer



Results EXPOSE

Dw	[mGy]											
Depth _{dose}	MTS100		MTS600		MTS700		MCP100		MCP600		MCP700	
DB-1												
DB-2	136	5			135	5			138	12	114	4
DB-3												
DB-4	162	9	140	5	143	5	139	9	140	5	127	5
DB-5			140	8			119	4	143	5	142	11
DB-6	165	6	151	6	158	12	117	4				
DB-7												
DB-8			186	7	208	8	162	10	201	17	164	6
DB-9												
DB-10	135	5	130	8			108	4	124	5	123	9
DB-11			132	5	133	10	111	4	138	12	118	4
DB-12	149	9			145	5	110	7	128	5	120	5
DB-13												
DB-14	153	6	164	10	141	5					132	10
DB-15												
DB-16	136	8	195	7	215	17	163	6	186	7		

Results EXPOSE



Comparing the ratios of the detectors

	ISS-7S 2003 [$\mu\text{Gy d}^{-1}$]	ISS-7S 2003 [$\mu\text{Gy d}^{-1}$]	BASE B/C: 2008 [$\mu\text{Gy/day}$]	YING 2009 [$\mu\text{Gy/day}$]	DOSIS	EXPOSE
MTS/MCP	1,06	1,26	1,16	1,23	1,20	1,23
MCP/Al₂O₃:C	0,93	0,95	0,88	0,98	1,10	
MTS/Al₂O₃:C	1,03	1,20	1,02	1,20	1,32	

Conclusion

- Fully operational to measure doses in (biological) experiments in space
 - ♣ Different passive and small detectors
 - ♣ Often combined with TED from other groups
- Consistent data for a number of spaceflights
 - ♣ New experiment next month: CFSA
- A lot of data processing to be done
 - ♣ Detailed analyses, correct for efficiencies, combine with TED results,...