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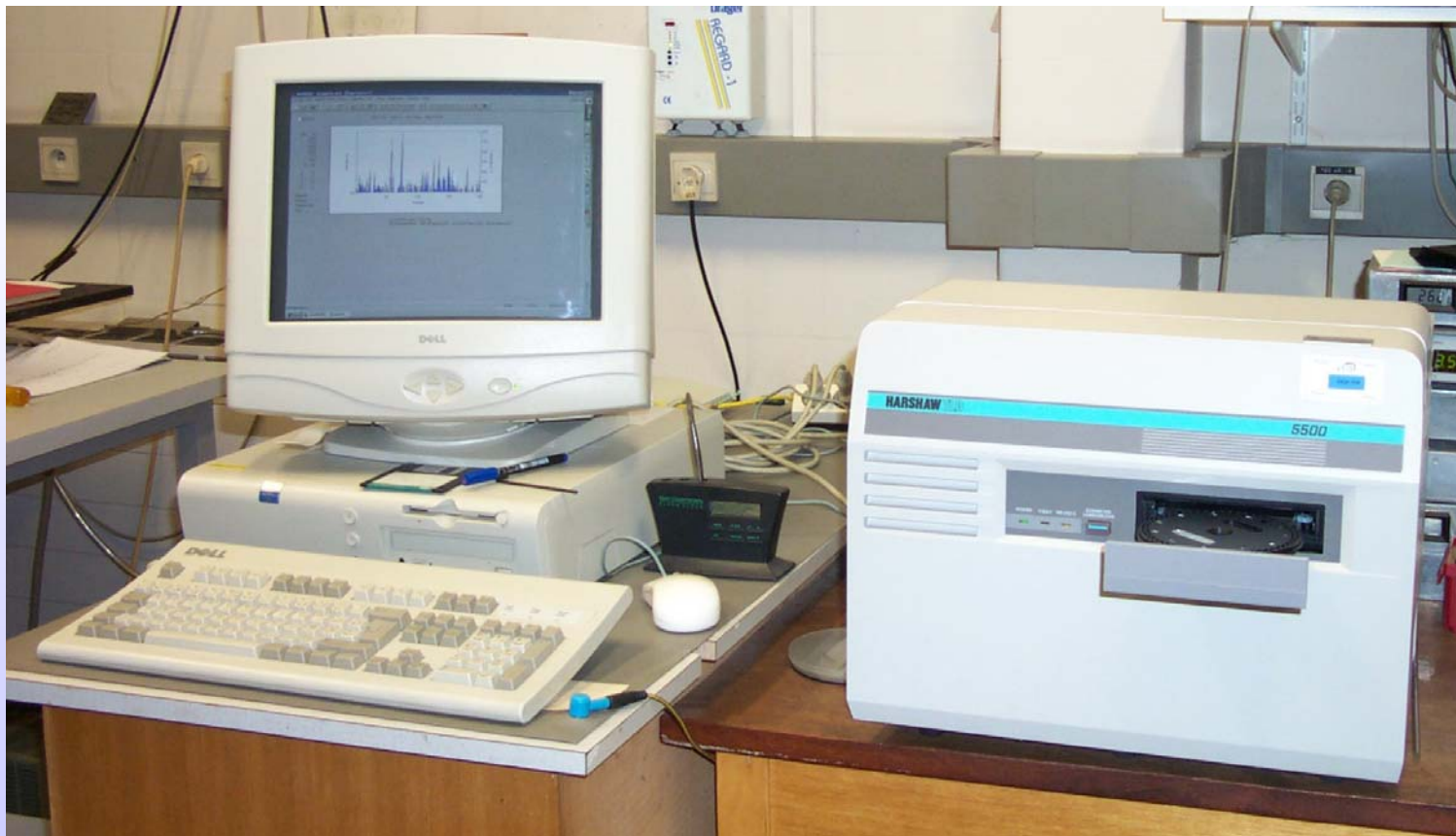
# Recent results of TLD and OSL measurements on board of the ISS

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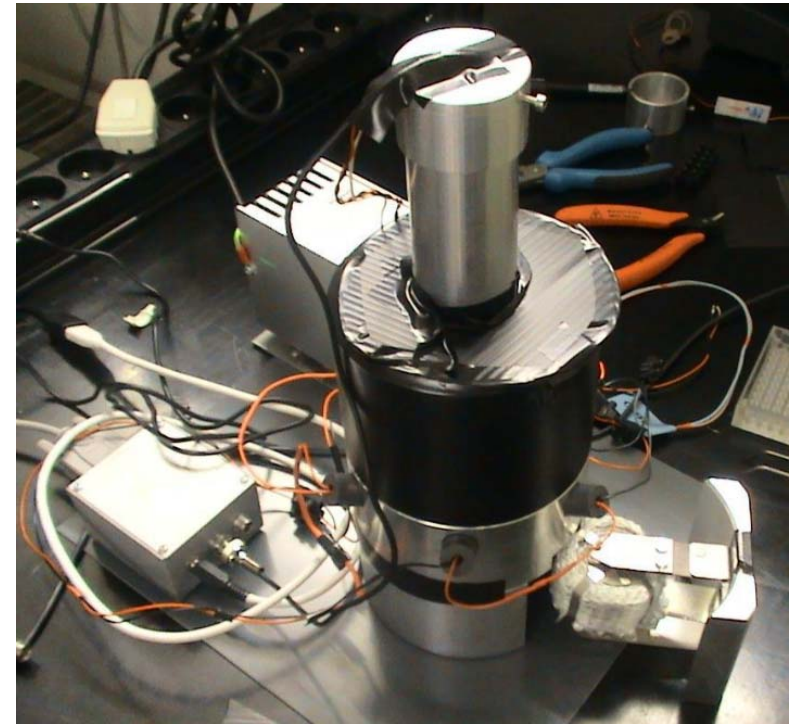
# Types of dosimeters: passive and small

- **Thermoluminescence detectors**
  - LiF:Mg,Ti
  - LiF:Mg,Cu,P
- **Optically Stimulated luminescence detectors**
  - Al<sub>2</sub>O<sub>3</sub>:C (Luxel, TLD500)

# Thermoluminescence: Harshaw 5500



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



# Measurement technique

- TLD

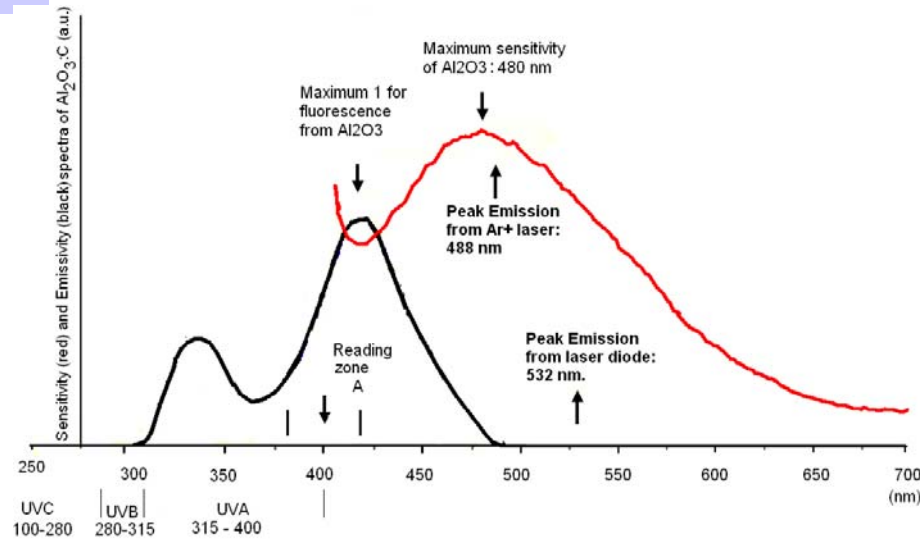
- 1°C/s
- Integration of area under glow curve

- 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



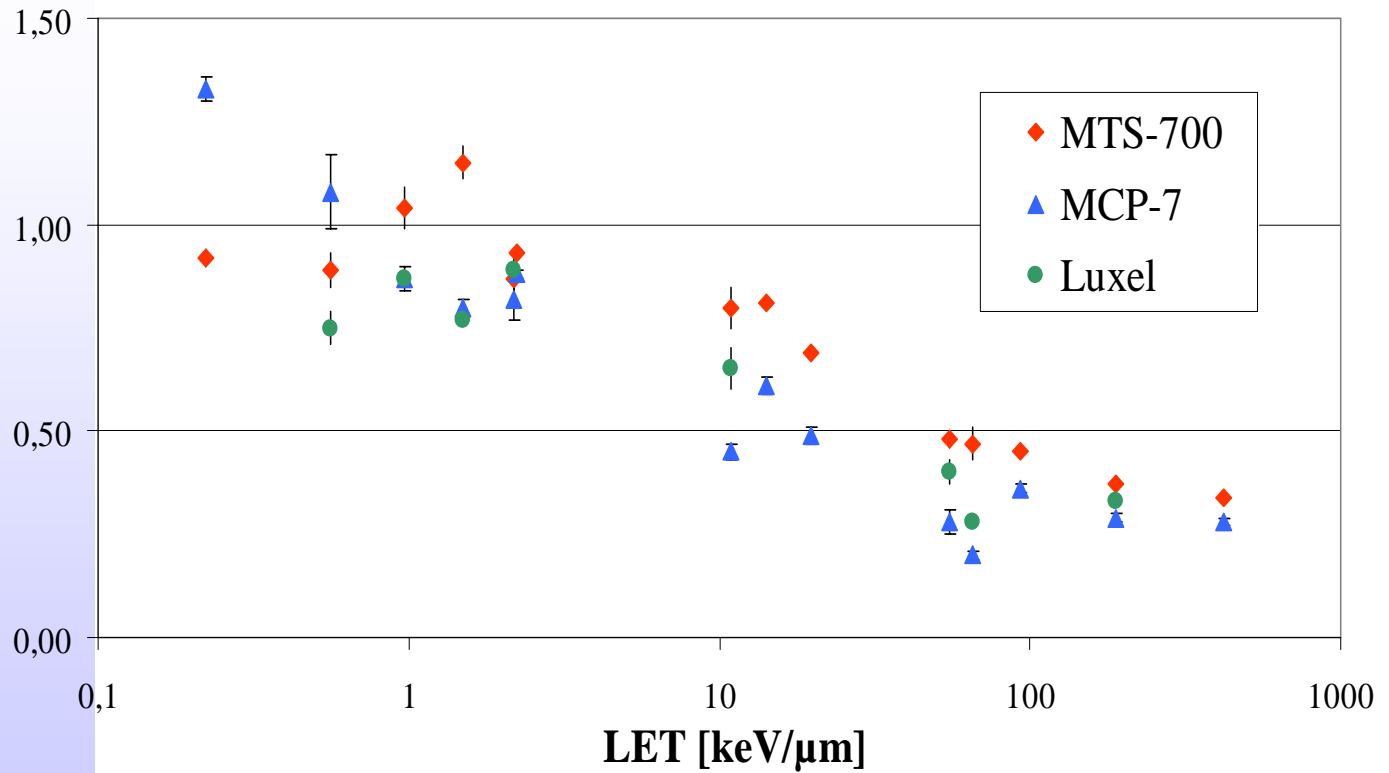
# Detector characterisation

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- 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



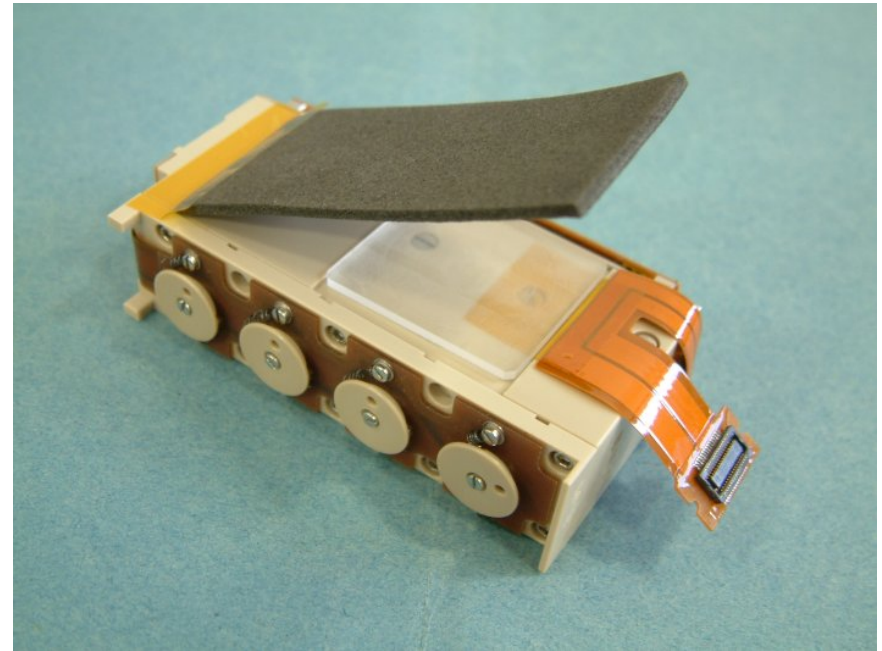
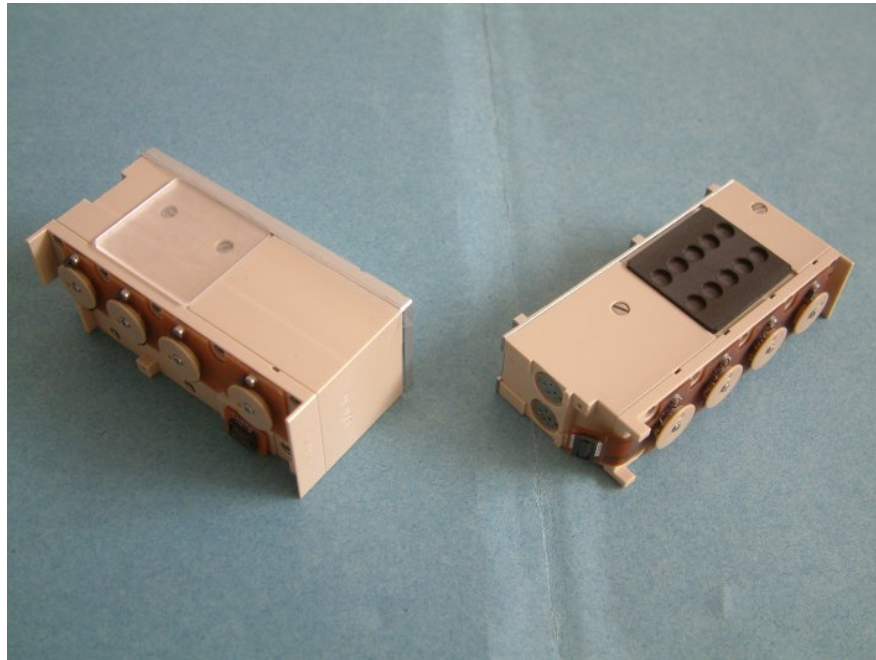
# Previous space measurements with biological experiments

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

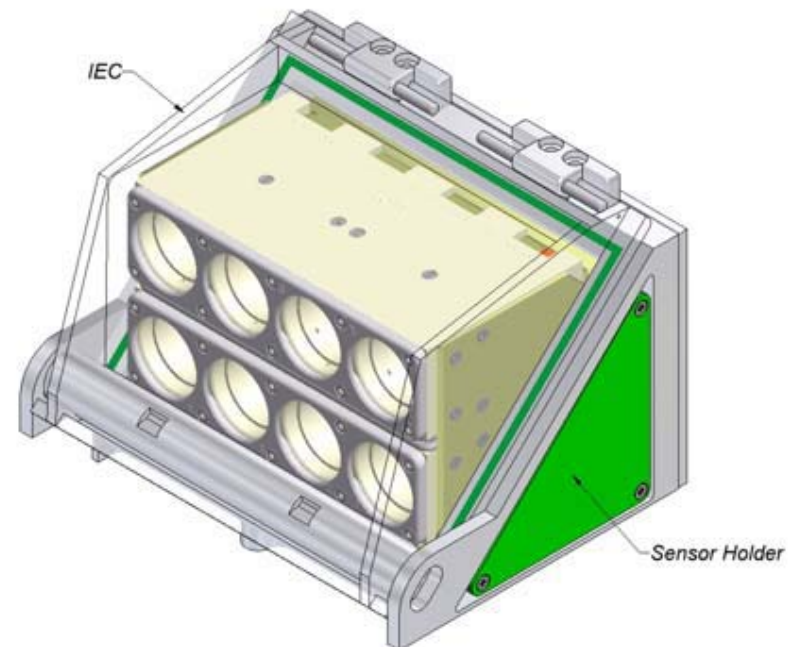
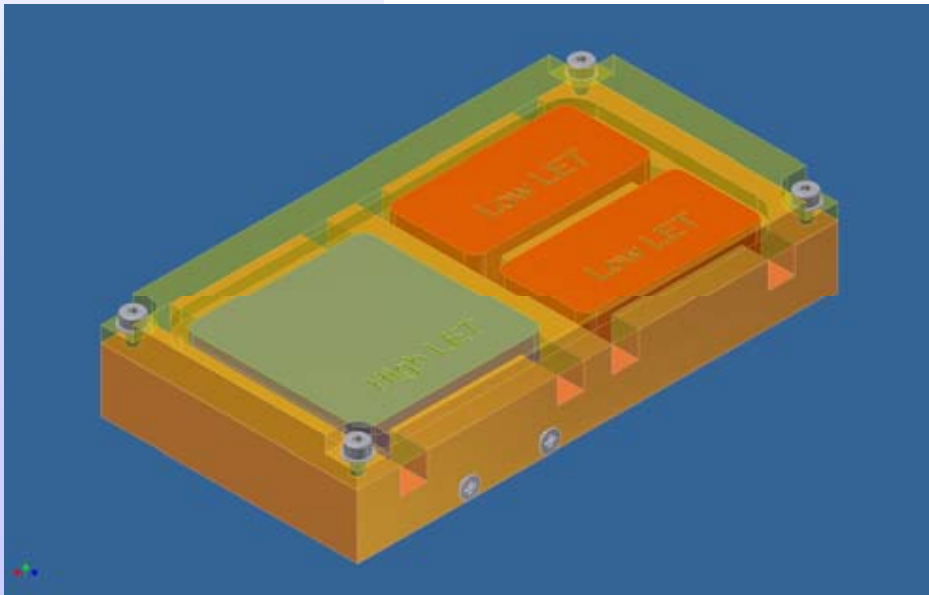


# BASE B/C experiment



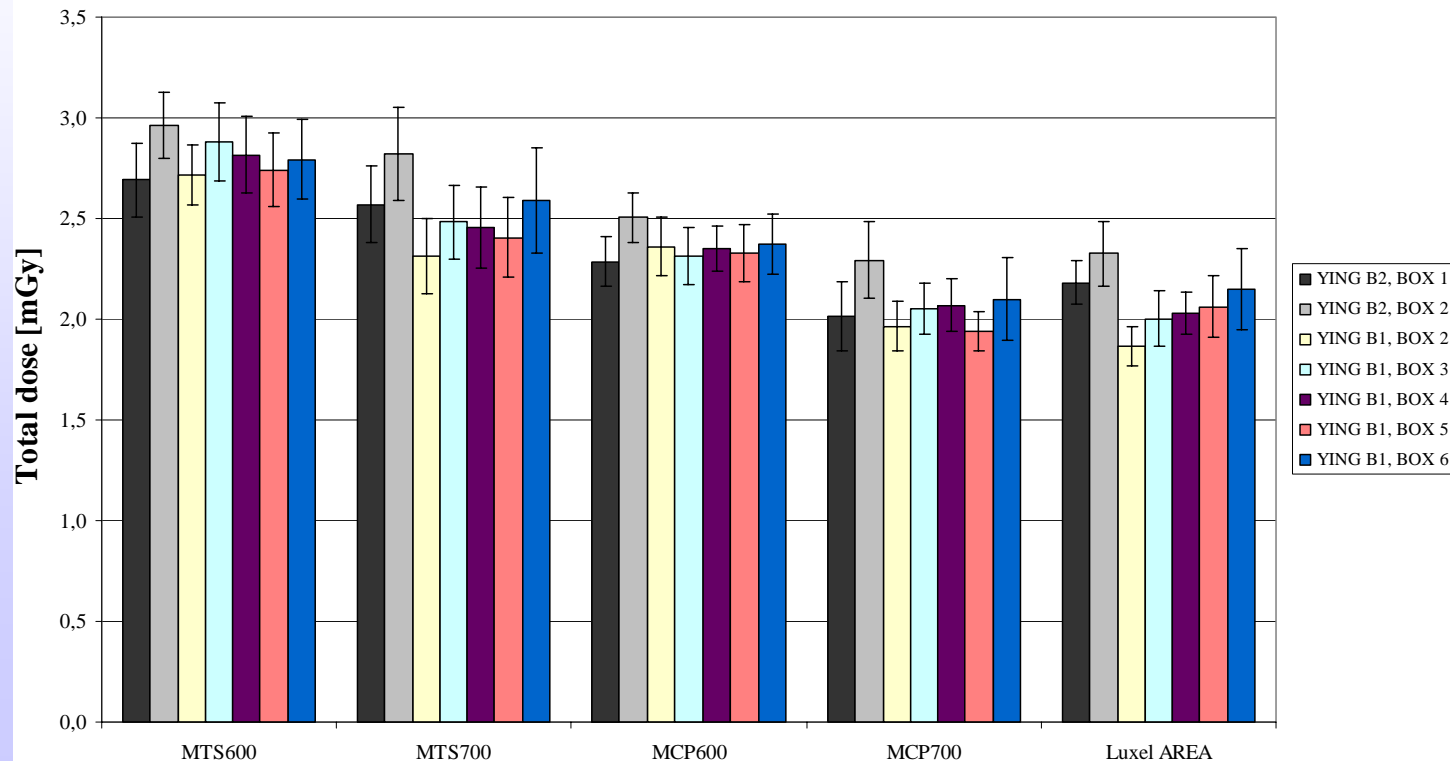
# YING B1/B2 (Yeast in No Gravity)

- 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

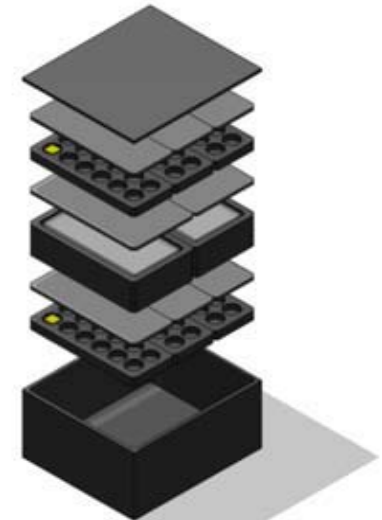
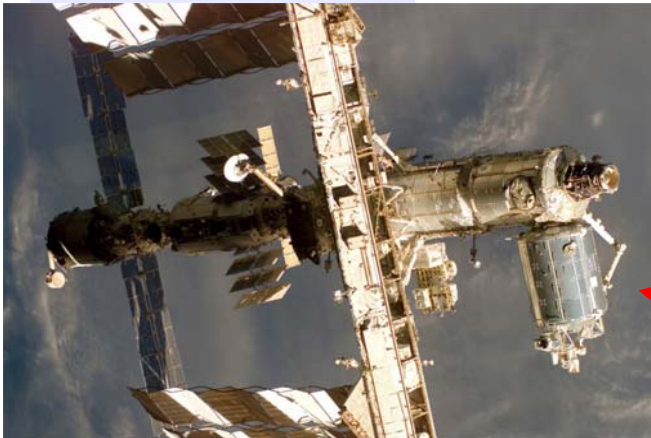
YING B1 [mGy]	NPI	SCK	
Box 2	2,11	<b>1,96</b>	0,12
Box 3	2,17	<b>2,05</b>	0,13
Box 4	2.09 ± 0.09	<b>2,07</b>	0,13
Box 5	2,12	<b>1,94</b>	0,10
Box 1	2.02 ± 0.09	<b>2,02</b>	0,17
Box 2	2.29 ± 0.10	<b>2,29</b>	0,19

## Comparison with previous flights

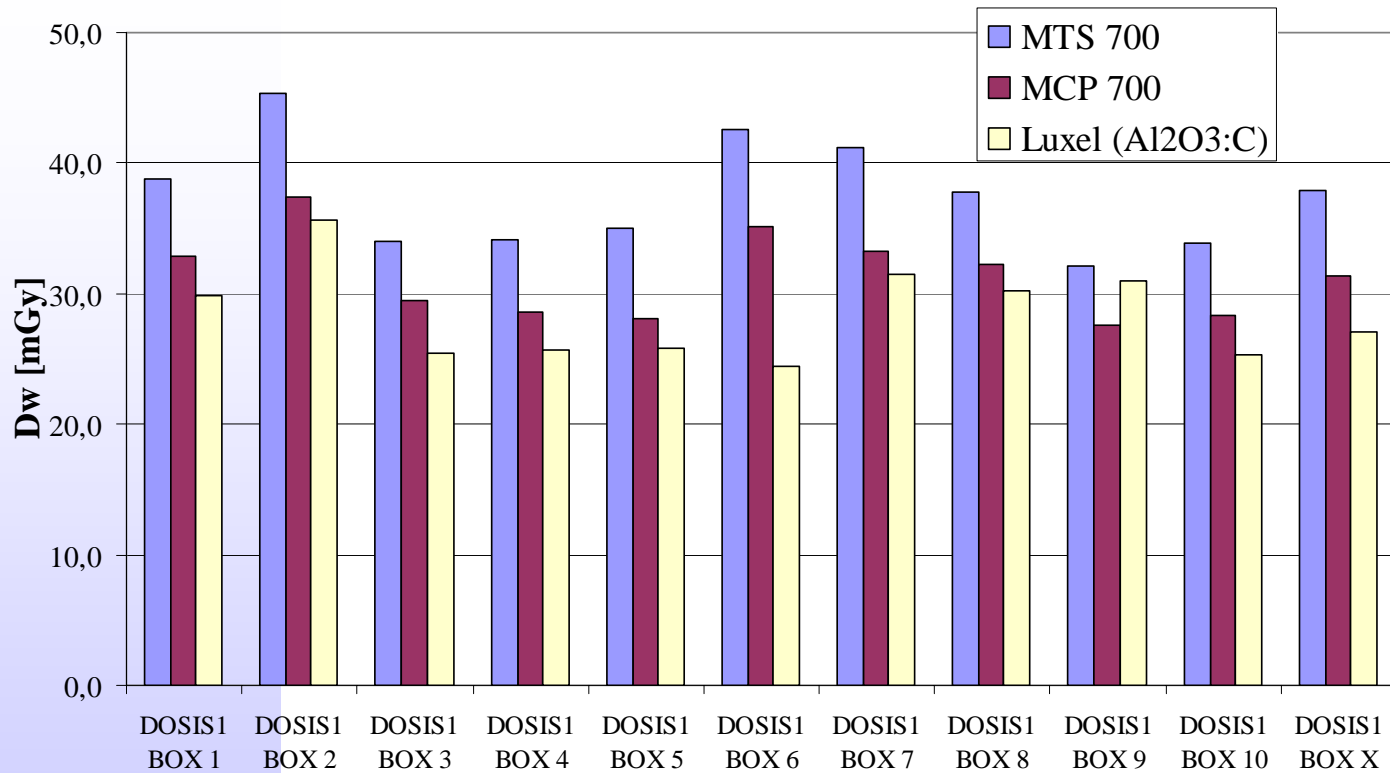
Institution	Material	Techn.	ISS-7S 2003 [ $\mu\text{Gy d}^{-1}$ ]	ISS-7S 2003 [ $\mu\text{Gy d}^{-1}$ ]	ISS-8S 2004 [ $\mu\text{Gy d}^{-1}$ ]	ISS-13S 2006 [ $\mu\text{Gy/day}$ ]	BASE B/C: 2008 [ $\mu\text{Gy/day}$ ]	YING 2009 [ $\mu\text{Gy/day}$ ]
SCK-CEN	$\text{Al}_2\text{O}_3:\text{C}$	CW-OSL	$148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

# DOSIS 1

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

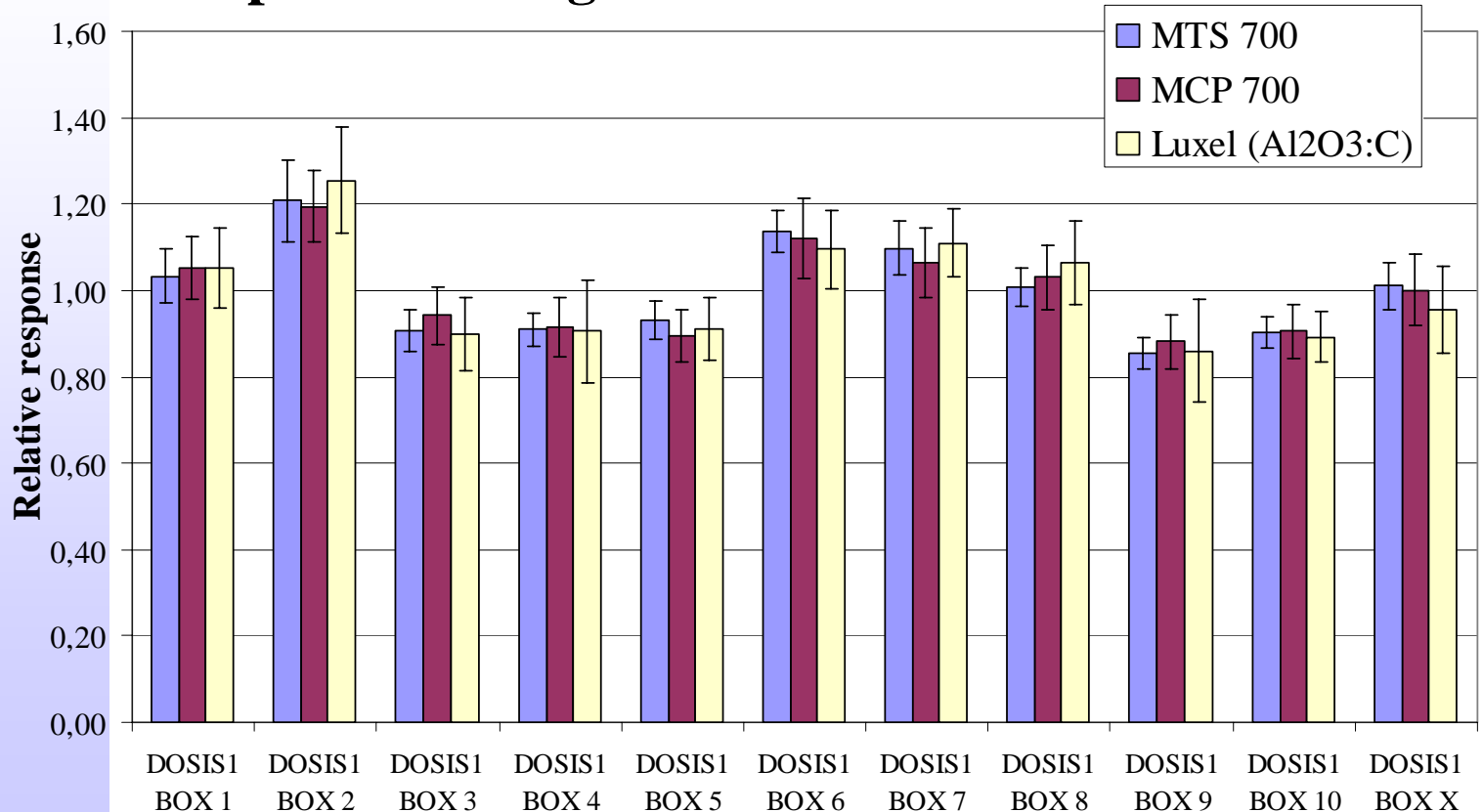


# DOSIS 1 results



# Differences between boxes

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

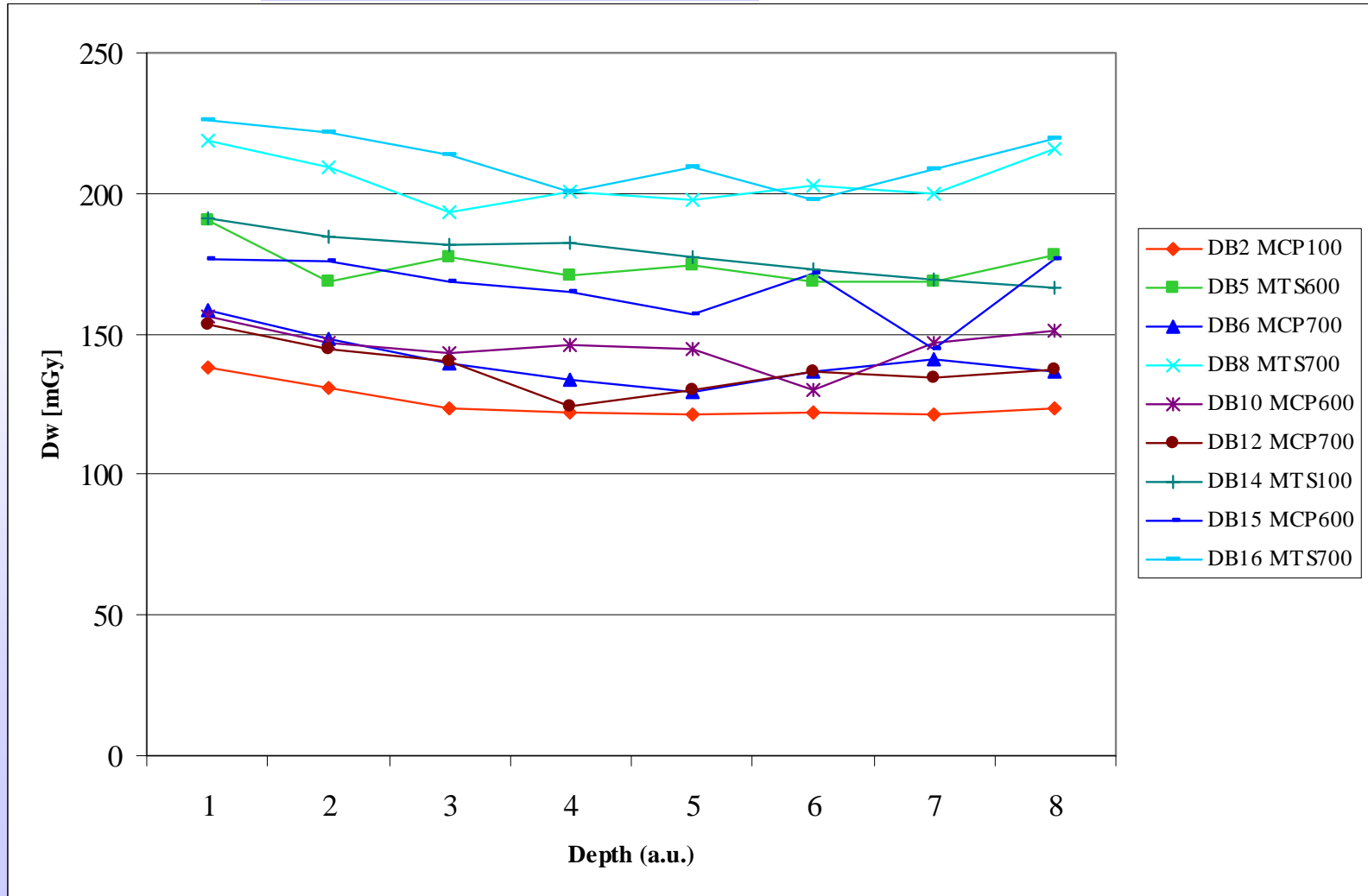


# EXPOSE-E on EUTEF

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



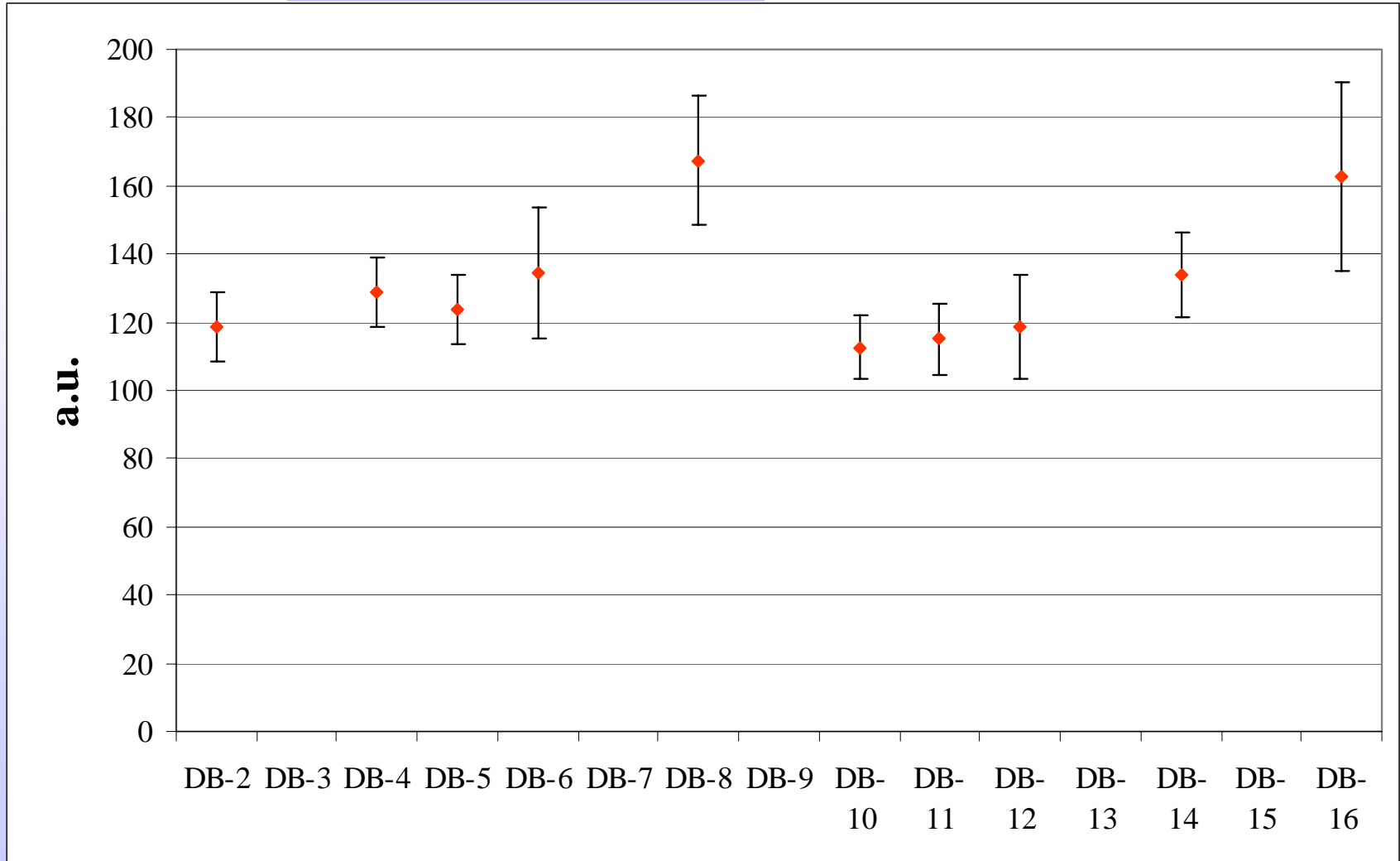
# Results EXPOSE: top layer



# Results EXPOSE

Dw	[mGy]											
Depth <sub>dose</sub>	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

	<b>ISS-7S</b> 2003 [ $\mu\text{Gy d}^{-1}$ ]	<b>ISS-7S</b> 2003 [ $\mu\text{Gy d}^{-1}$ ]	<b>BASE</b> B/C: 2008 [ $\mu\text{Gy/day}$ ]	<b>YING</b> 2009 [ $\mu\text{Gy/day}$ ]	DOSIS	EXPOSE
<b>MTS/MCP</b>	<b>1,06</b>	<b>1,26</b>	<b>1,16</b>	<b>1,23</b>	<b>1,20</b>	<b>1,23</b>
<b>MCP/Al<sub>2</sub>O<sub>3</sub>:C</b>	<b>0,93</b>	<b>0,95</b>	<b>0,88</b>	<b>0,98</b>	<b>1,10</b>	
<b>MTS/Al<sub>2</sub>O<sub>3</sub>:C</b>	<b>1,03</b>	<b>1,20</b>	<b>1,02</b>	<b>1,20</b>	<b>1,32</b>	

# 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,...