

# Correlating the ISS-6A Liulin / TEPC Measurements with Simulation Using HZETRN

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# Outline

- **I – LaRC background** and **motivation** behind correlating Liulin / TEPC measurements with simulation.
- **II – Review** of the ISS Liulin / TEPC data sets as provided to LaRC.
- **III – A brief** discussion of the LaRC Radiation transport / analysis code **HZETRN** and the **ISS environment** at **LEO**. The emphasis of the talk will be on analyzing measurements and not numerical work.
- **IV – Liulin / TEPC** data correlation.
- **V – V&V** between **Liulin / TEPC** measurements and **OLTARIS (HZETRN)** simulation.
- **VI – Summary** and future work
- **VII – Acknowledgement**

# I

## Background and Motivation

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- **I – Historically**, of all tasks assigned to LaRC, the most important one has been to develop fast particle transport algorithms (PN, BRYNTRN, HZETRN (lab./space), OLTARIS (space)).
- **II – V & V** is the established protocol for checking engineering software (HZETRN, etc...). Hence there is always a need for reliable measurements to perform V & V.
- **III – HZETRN** is now a WWW application (OLTARIS) and is available to all (almost ?). To perform V & V on OLTARIS in a complex environment (e.g. ISS at LEO), LaRC approached STIL (BAS) and SRAG (JSC) for ISS measurements.
- **IV –** Both STIL and SRAG generously provided ISS dosimetric data to LaRC. For ISS-6A config. (circa July 2001 (solarmax)), STIL supplied the Liulin (Si) and SRAG the TEPC (tissue) measurements.

# II

## ISS-6A Liulin / TEPC Dosimeter Data Format

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- Liulin dosimeters at 4 different locations in **lab. module**. Present data analysis includes all 4 datasets (**MDU1 - MDU4**).
  - Liulin (**MDU1- MDU4**) data were recorded at **30-s.** intervals.
  - Data for each of 4 instruments consisted of **166XX** records (**~140 hrs.**) with no gaps.
- 
- TEPC dosimeter at one location in service module.
  - TEPC data were recorded at **60-s.** intervals.
  - Data for TEPC consisted of **8313** records (**138.5 hr**) with **65 min.** of gaps.
- 
- Liulin / TEPC data included orbital parameters as well as dose rates.
  - Measurements were for **July 7-13, 2001 (near solarmax, GCR ???)**.

# II

## Description of Liulin Locations

	MDU#1	MDU#2	MDU#3	MDU#4
11-30/5/2001 mix	Dloc 102	Dloc 113	Dloc 114	Dloc 107
31/5/2001- 6/6/2001 mix	Dloc 105	Dloc 106	Dloc 109	Dloc 110
7-14/6/2001 XPOP	Dloc 103	Dloc 104	Dloc 108	Dloc 109
15-25/6/2001 mix	Dloc 105	Dloc 106	Dloc 110	Dloc 111
26/6/2001- 5/7/2001 +XVV	Dloc 112	Dloc 113	Dloc 114	Dloc 102
6-13/7/2001 +XVV	Dloc 103	Dloc 104	Dloc 107	Dloc 108
14-25/7/2001 +XVV	Dloc 111	Dloc 112	Dloc 113	Dloc 114

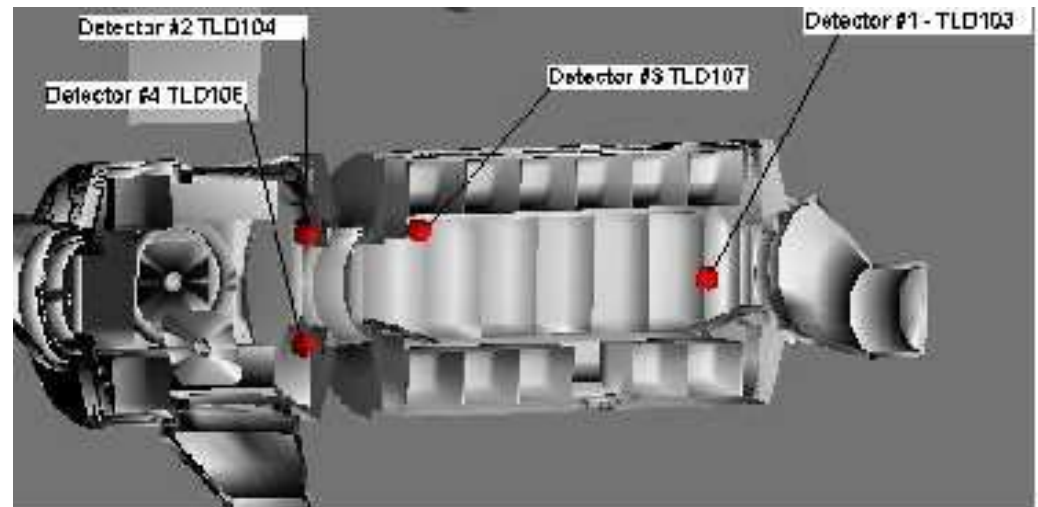
X-Axis Perpendicular to Orbit Plane (XPOP)

X-Axis along Velocity Vector (XVV)

# II

## ISS 6A-Configuration with Liulin Dosimeters

(6-13 July 2001)



# II

## ISS-6A Liulin Dosimeter Data Format

1ch1	1ch2	1ch3		1ch242	1ch243	1ch256	TIME	BMAG	L	LONG180	LAT	ALT	AscDesc	DOSE1	FLUX1
9	9	1	...	0	0	0	6-Jul-01	0.37	1.06	99.72	-6.33	380.55	D	1.94568	0.39063
6	7	4	...	0	0	0	6-Jul-01	0.37	1.08	96.83	-7.87	380.58	D	0.83999	0.32552
8	12	5	...	0	0	0	6-Jul-01	0.38	1.1	97.95	-9.4	380.55	D	1.64568	0.48177
8	12	7	...	0	0	0	6-Jul-01	0.39	1.13	99.08	-10.92	380.59	D	1.24283	0.44271
:	:	:	...	:	:	:	:	:	:	:	:	:	:	:	:
:	:	:	...	:	:	:	:	:	:	:	:	:	:	:	:
8	14	7	...	0	0	0	13-Jul-01	0.24	1.24	-85.22	-30.9	383.32	A	1.57711	0.48177
12	21	3	...	0	0	0	13-Jul-01	0.23	1.22	-83.73	-29.53	383.03	A	1.73997	0.48177
5	12	3	...	0	0	0	13-Jul-01	0.23	1.2	-82.27	-28.15	382.76	A	2.02282	0.45573
6	9	6	...	0	0	0	13-Jul-01	0.22	1.19	-80.85	-26.74	382.51	A	1.68854	0.58594

$$Dose = 0.008571 \sum_1^N (n+1) C_n$$

$$Flux = 0.01302 \sum_1^N C_n$$

MDU1: 16633 records  $t_0 = -1.5$  min.

MDU2: 16686 records  $t_0 = -12.0$  min.

MDU3: 16625 records  $t_0 = -0.5$  min.

MDU4: 16631 records  $t_0 = -1.5$  min.

Time sync: point @ 10.92S, 99.08E, correspond to 6 Jul 01 10:26:00 Z (GMT)

# II

## ISS-6A TEPC Dosimeter Data Format

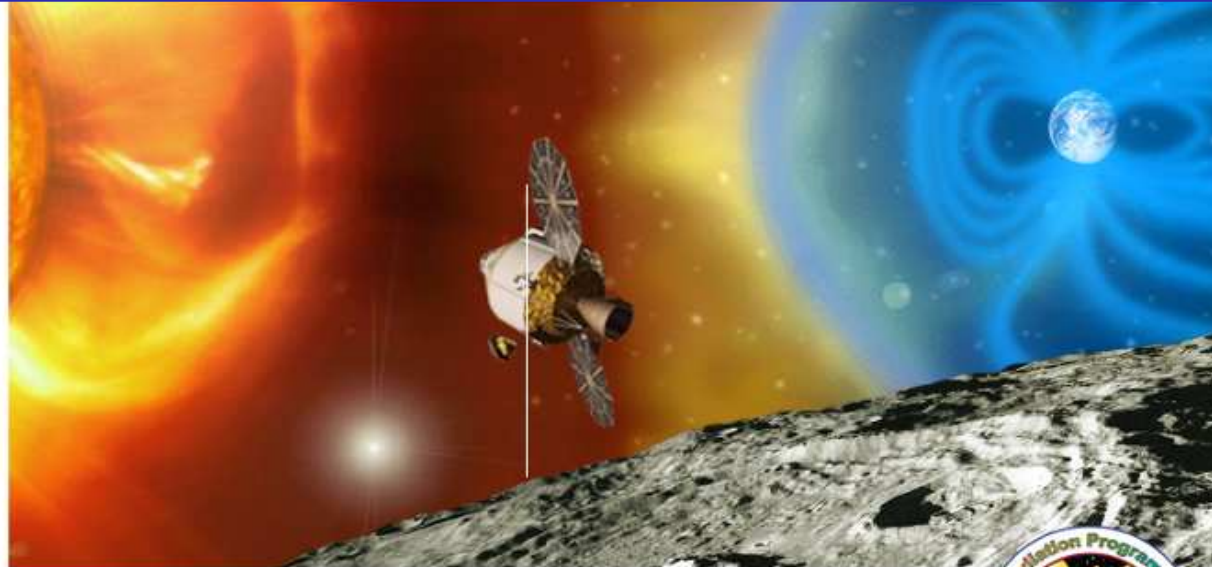
Date (GMT)	Dose Rate ( $\mu\text{Gy}/\text{minute}$ )	Dose Eq. Rate (ICRP-60, $\mu\text{Sv}/\text{minute}$ )	Longitude (degrees)	Latitude (degrees)	Altitude (kilometers)	GCR/Trapped	TEPC Location	time, min
7/6/2001 10:25	0.065	0.078	97.894	-9.242	379.768	GCR	SM Panel 327	0.0032959
7/6/2001 10:26	0.035	0.041	100.165	-12.275	379.478	GCR	SM Panel 327	1.0033
7/6/2001 10:27	0.044	0.051	102.495	-15.285	379.195	GCR	SM Panel 327	2.0033
7/6/2001 10:28	0.076	0.266	104.899	-18.264	378.91	GCR	SM Panel 327	3.0033
7/6/2001 10:29	0.086	0.144	107.396	-21.206	378.656	GCR	SM Panel 327	4.0033
7/6/2001 10:30	0.086	0.792	110.004	-24.101	378.407	GCR	SM Panel 327	5.0033
7/6/2001 10:31	0.076	0.107	112.743	-26.94	378.174	GCR	SM Panel 327	6.0033
7/6/2001 10:32	0.092	0.214	115.635	-29.713	377.961	GCR	SM Panel 327	7.0033
7/6/2001 10:33	0.122	0.444	118.703	-32.408	377.771	GCR	SM Panel 327	8.0033
7/6/2001 10:34	0.123	0.448	121.972	-35.01	377.600	GCR	SM Panel 327	9.0033
7/6/2001 10:35	0.128	0.901	125.468	-37.503	377.460	GCR	SM Panel 327	10.0033
7/6/2001 10:36	0.122	0.456	129.215	-39.87	377.302	GCR	SM Panel 327	11.0033
7/6/2001 10:37	0.154	0.586	133.24	-42.09	377.289	GCR	SM Panel 327	12.0033
7/6/2001 10:38	0.212	0.639	137.562	-44.14	377.251	GCR	SM Panel 327	13.0033
7/6/2001 10:39	0.198	0.512	142.196	-45.994	377.249	GCR	SM Panel 327	14.0033
7/6/2001 10:40	0.185	0.518	147.148	-47.625	377.286	GCR	SM Panel 327	15.0033
7/6/2001 10:41	0.235	0.76	152.408	-49.007	377.362	GCR	SM Panel 327	16.0033
7/6/2001 10:42	0.116	0.365	157.95	-50.112	377.478	GCR	SM Panel 327	17.0033

Time sync: point @ 10.92S, 99.08E, correspond to 6 Jul 01 10:26:00 Z (GMT)



# III

## HZETRN in web mode (OLTARIS)



User Name:   
Password:

**OLTARIS**  
On-Line Tool for  
the Assessment of  
Radiation In Space



[Register](#) | [Forgot my password](#) | [Change password](#)

**ITAR controlled ( account holder must be a US. person)**  
**limited to 3 materials, Aluminum, PE and tissue (x-vehicle mode)**  
**Unlimited materials (slab mode)**

**Account requests: <http://oltaris.larc.nasa.gov>**

# III

## V&V requirements at LEO

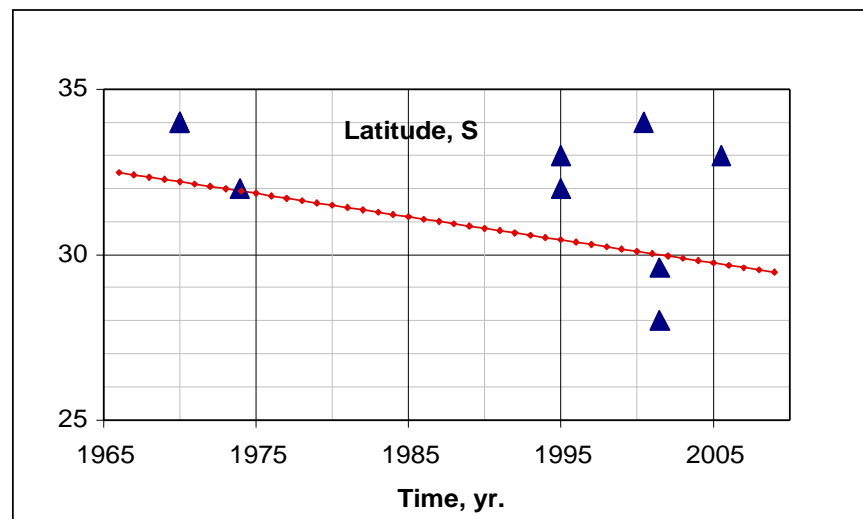
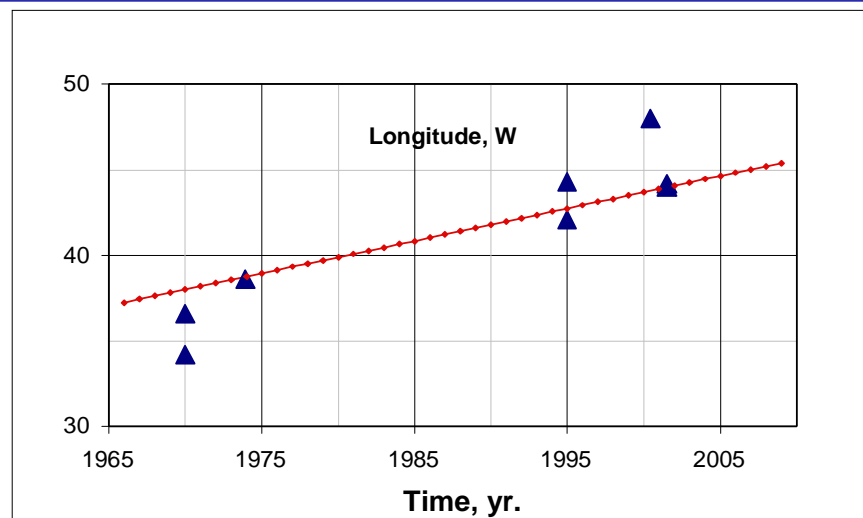
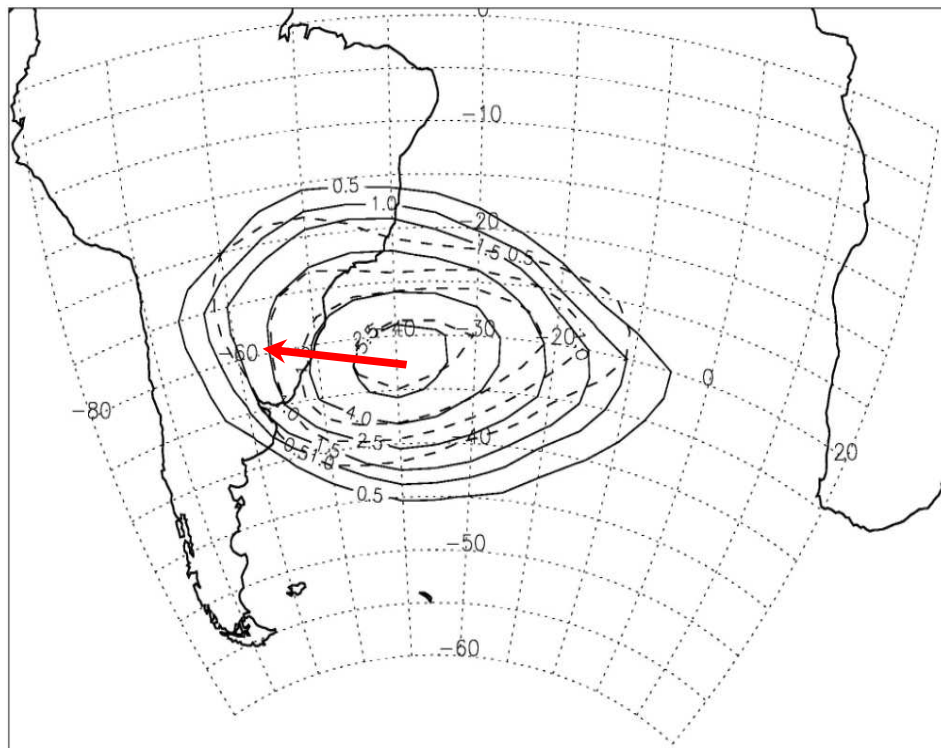
- 1
  - Solar modulated neutron albedo.
  - Dynamic/directional geomagnetic cutoffs.
  - O'Neill (JSC) 2004 GCR model.
  - LaRC GEORAD-a modulated, drifting, directional trapped proton/electron model.
- 2
  - Web based HZETRN (OLTARIS site).
- 3
  - ISS-6A Liulin / TEPC shield models from (JSC).
- 4
  - Liulin MDU#1 - MDU#4 (STIL) and TEPC (SRAG) data sets.



# Basic Proton Field Distributions

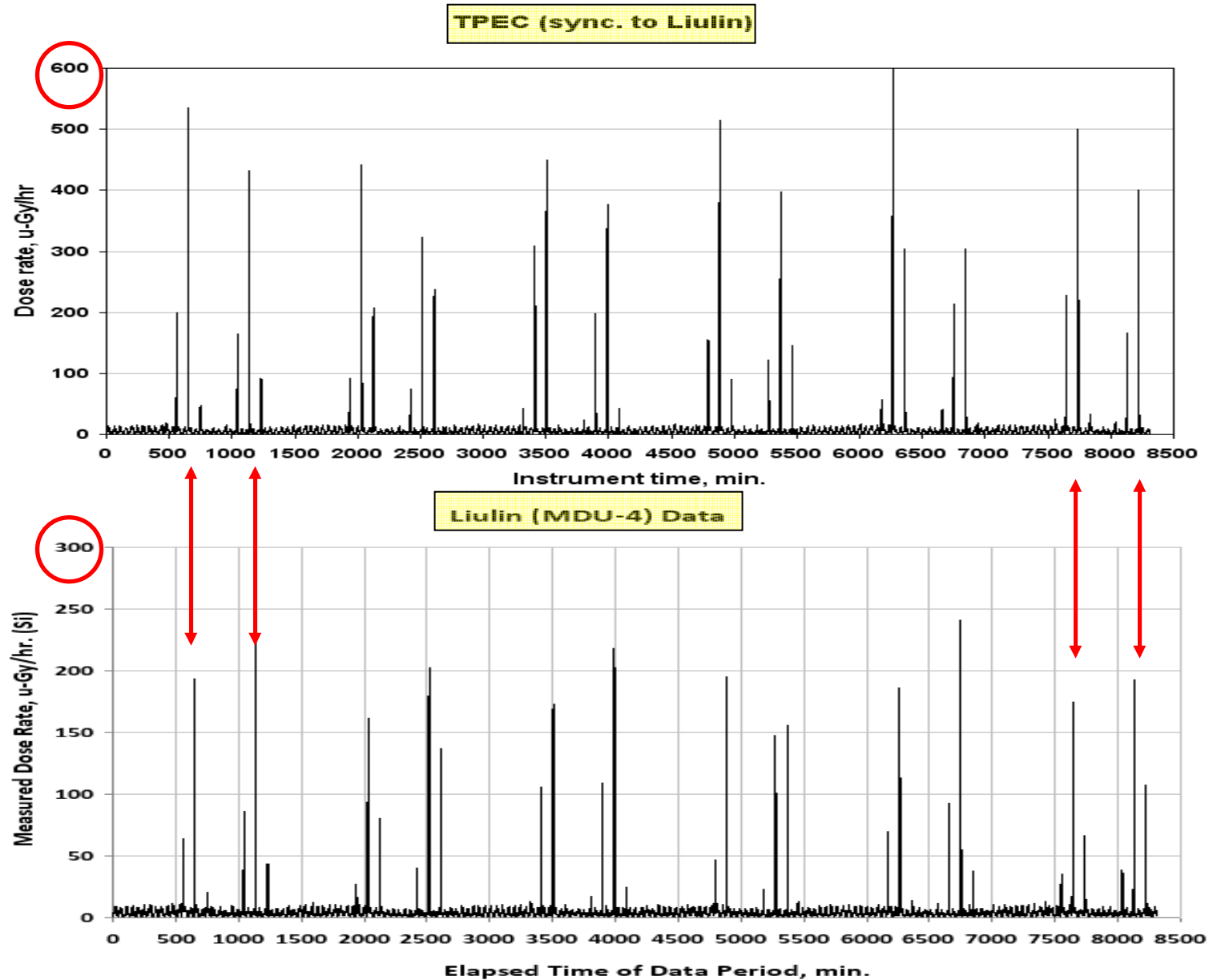
(with drifting latitude and longitude)

Solid: AP8MIN 1965 map  
Dashed: AP8MAX 1970 map



# IV

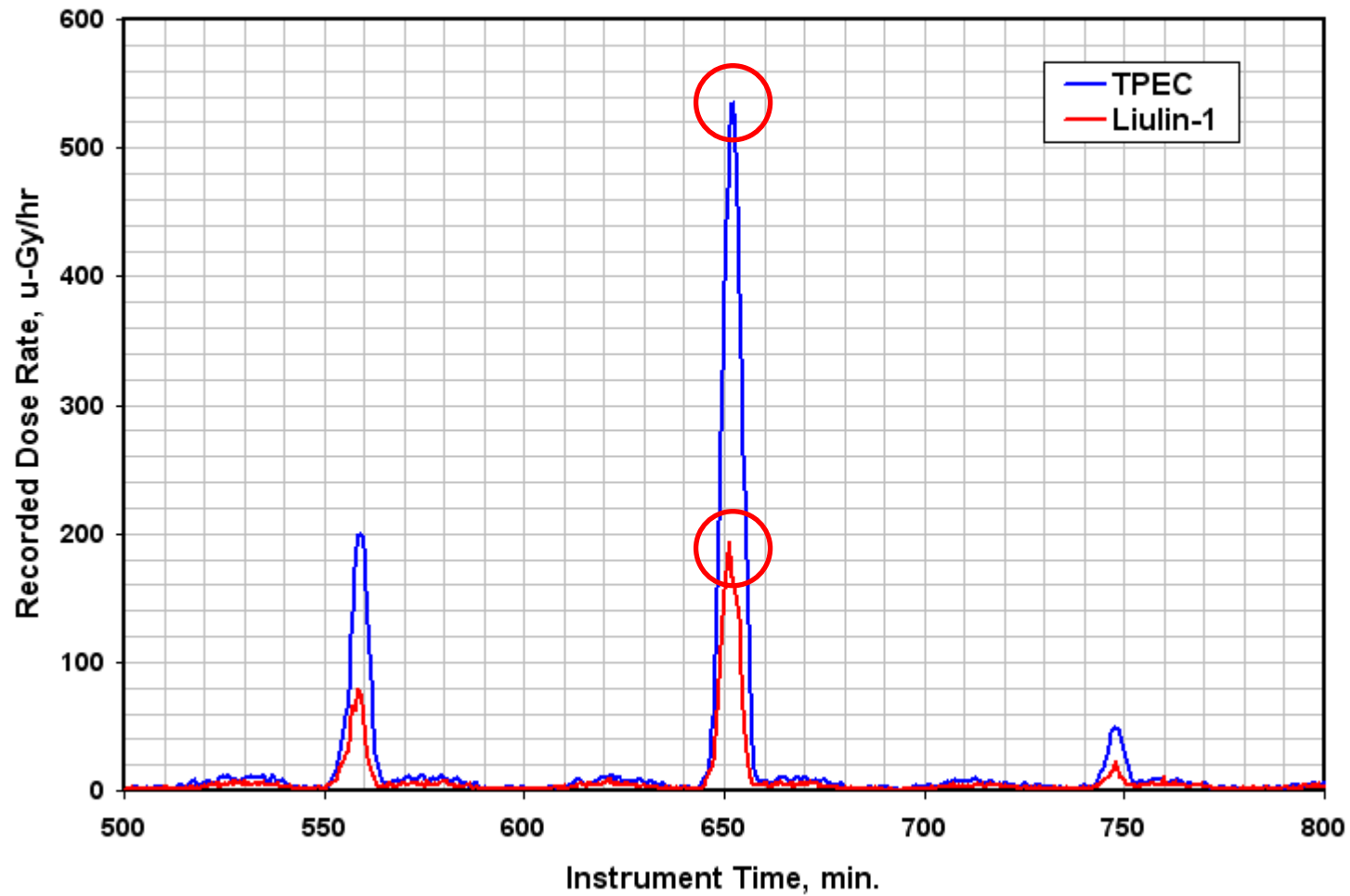
## MDU / TEPC Correlation (6-13 July 2001)



# IV

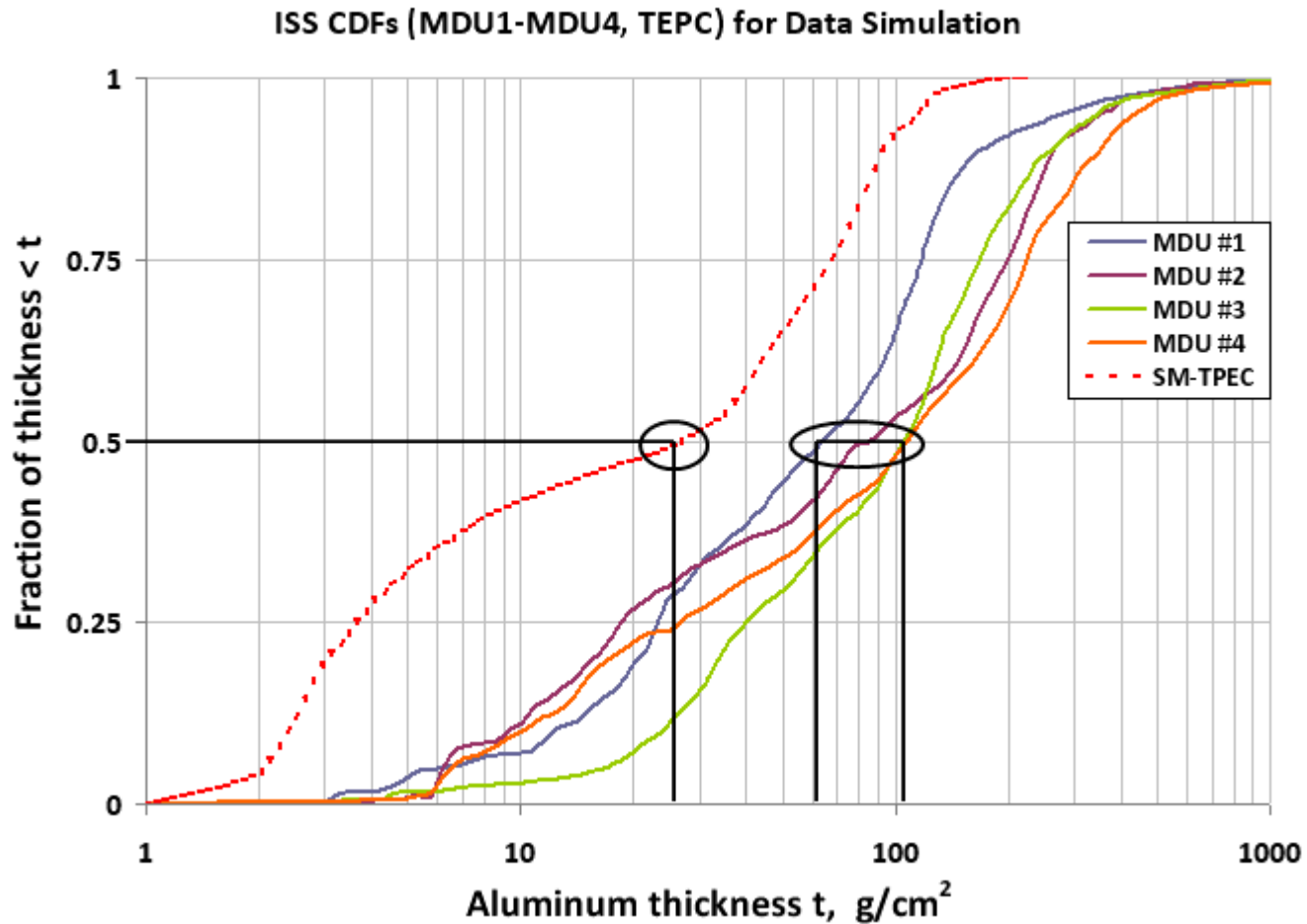
## MDU / TEPC Correlation (6-13 July 2001)

TPEC-Liulin Comparison



# IV

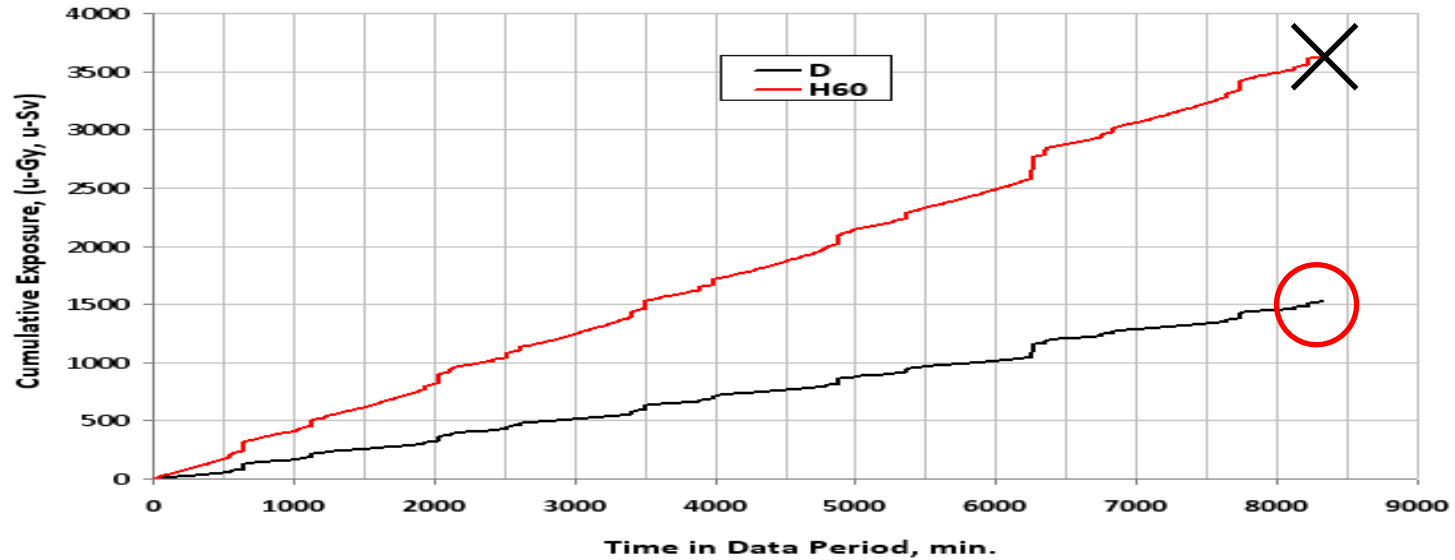
## CDF for MDU1 - MDU4 and TEPC (6-13 July 2001)



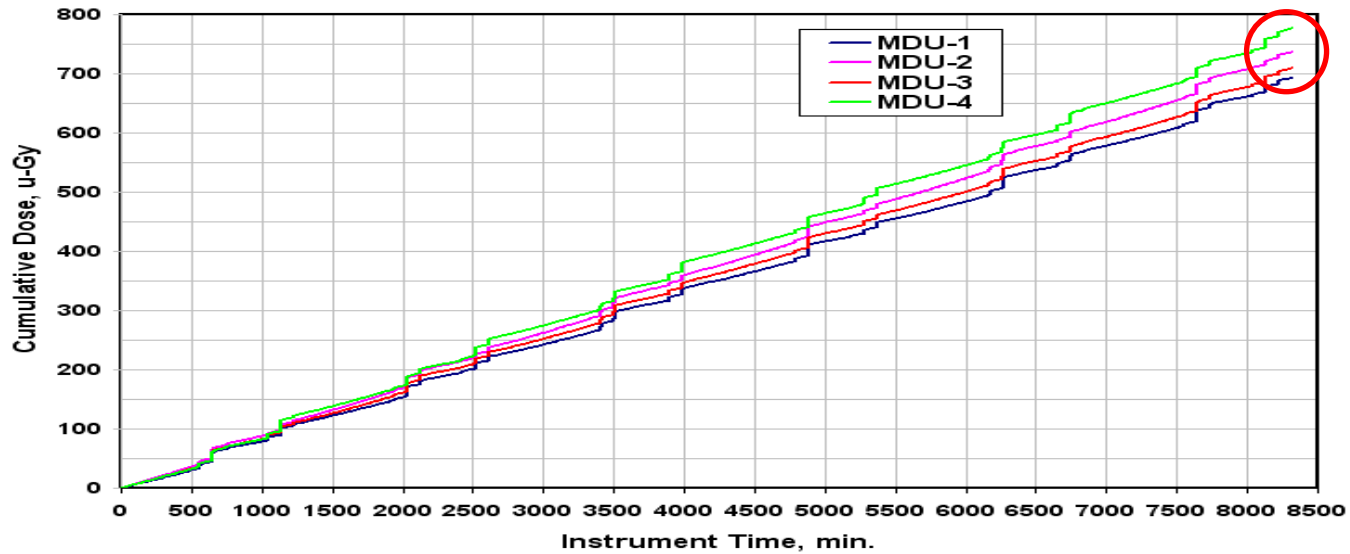
# IV

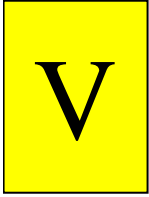
## IV-Cumulative MDU / TEPC Correlation (6-13 July 2001)

TPEC Data (sync to Liulin)



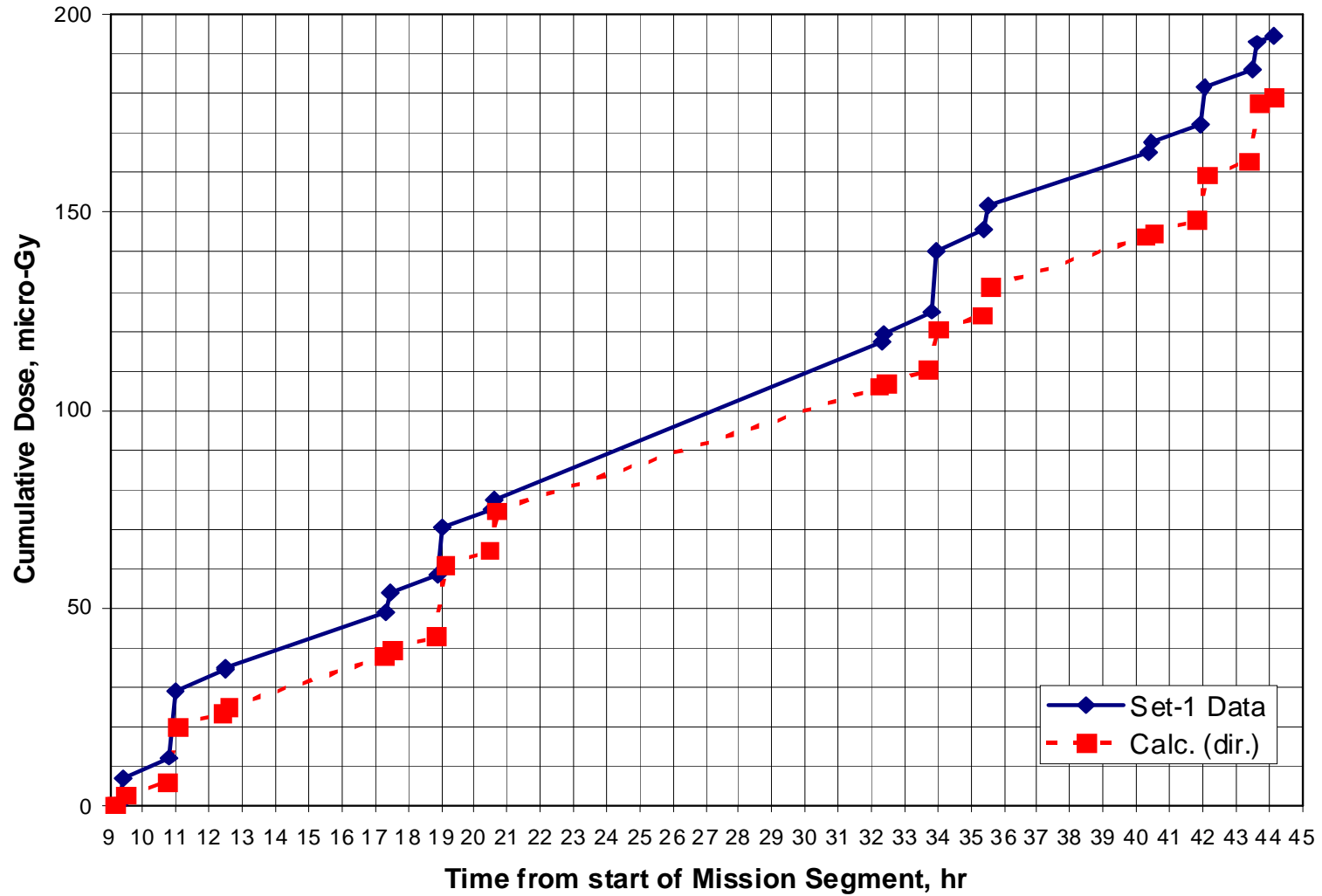
Liulin MDU Cumulative Dose



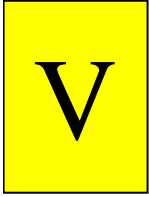


# Cumulative Dose V & V

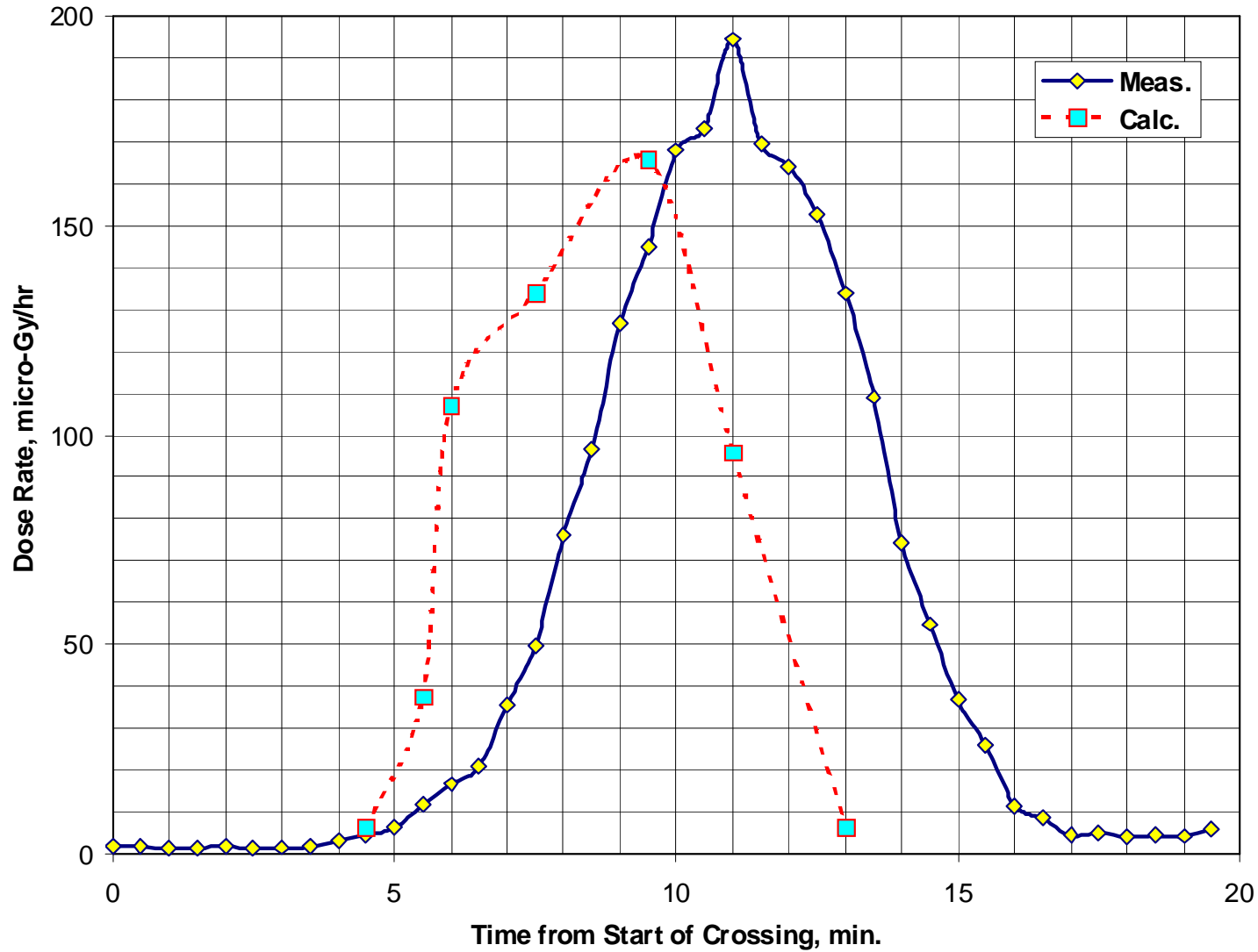
(MDU-1, 45 hrs.)

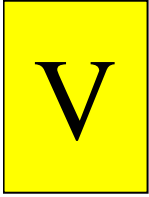




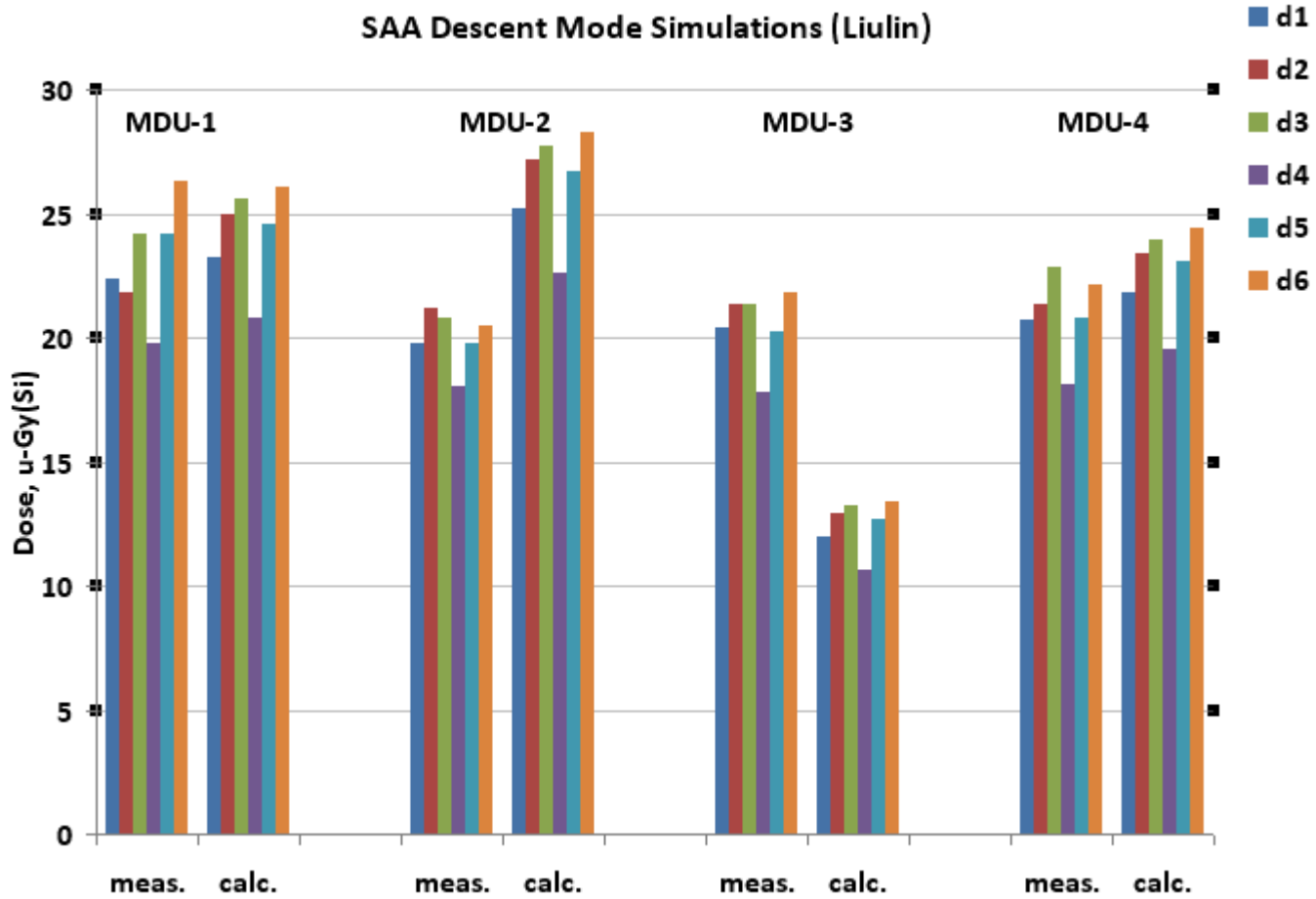


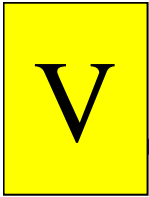
## One SAA pass V & V (6 July 2001)



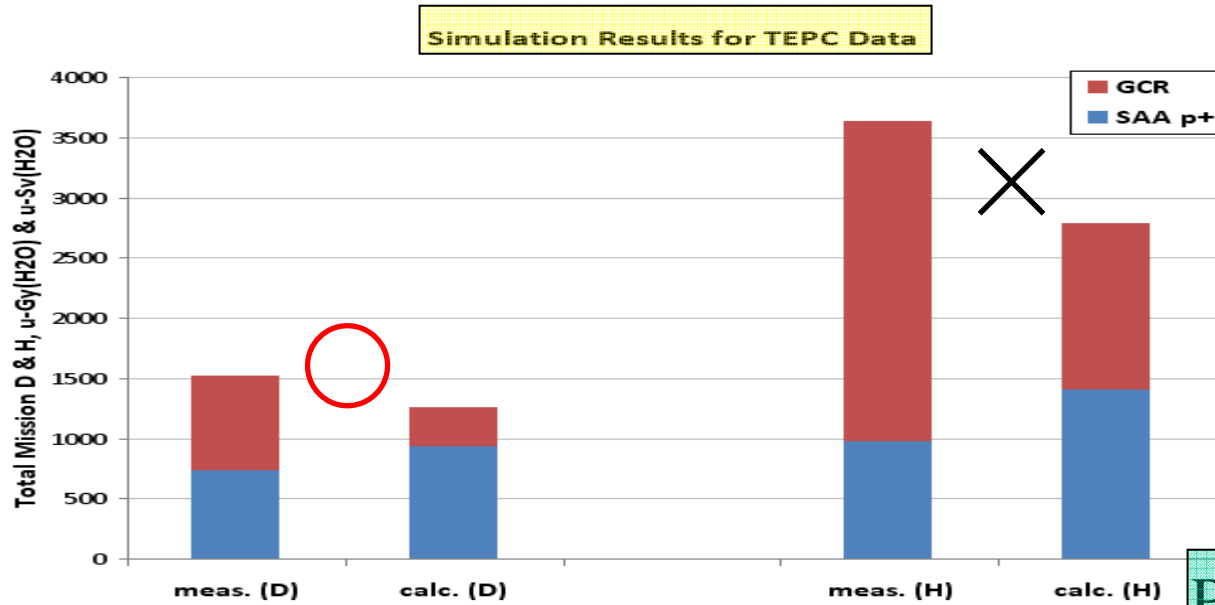


## 6 SAA Passes V&V (desent)

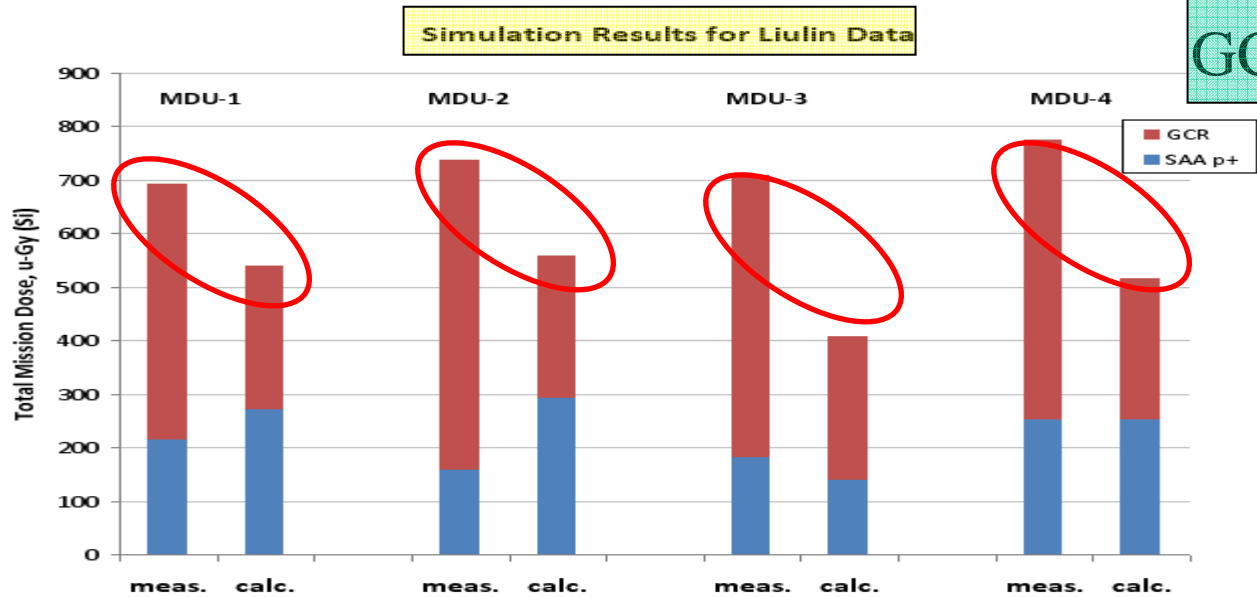




# Cumulative V&V (6-13 July 2001)



Pions/Kaons ???  
GCR<sub>solarmax</sub> ???



# VI

## Summary and Future Work

- The presentation represented only a **very brief look** at the data provided by the Liulin (MDU1 – MDU4) and TEPC instruments.
- The **temporal analysis** has indicated that the GCR model may be deficient near solar maximum (**i.e. 2001**) intensity.
- The SAA region is well mapped by Liulin and TEPC in the 2001 time frame; the current LaRC environment code package (**GEORAD**) has imposed a westward drift of the AP8 models to conform to observations by **SKYLAB** and **MIR**.
- Further V&V of HZETRN vs. Liulin and TEPC data is practically a mandate for future work.
- LaRC hope is to have models (**environment** and **transport**) which can more reliably predict radiation levels within a space structure. This will provide a validation tool to spacecraft designers.

# VII

## Acknowledgement

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(Liulin ISS measurements)

*Tsvetan Dachev*

*Solar-Terrestrial Influences Laboratory (STIL),  
Bulgarian academy of Sciences (BAS), 1113 Sofia, Bulgaria*

(TEPC ISS measurements)

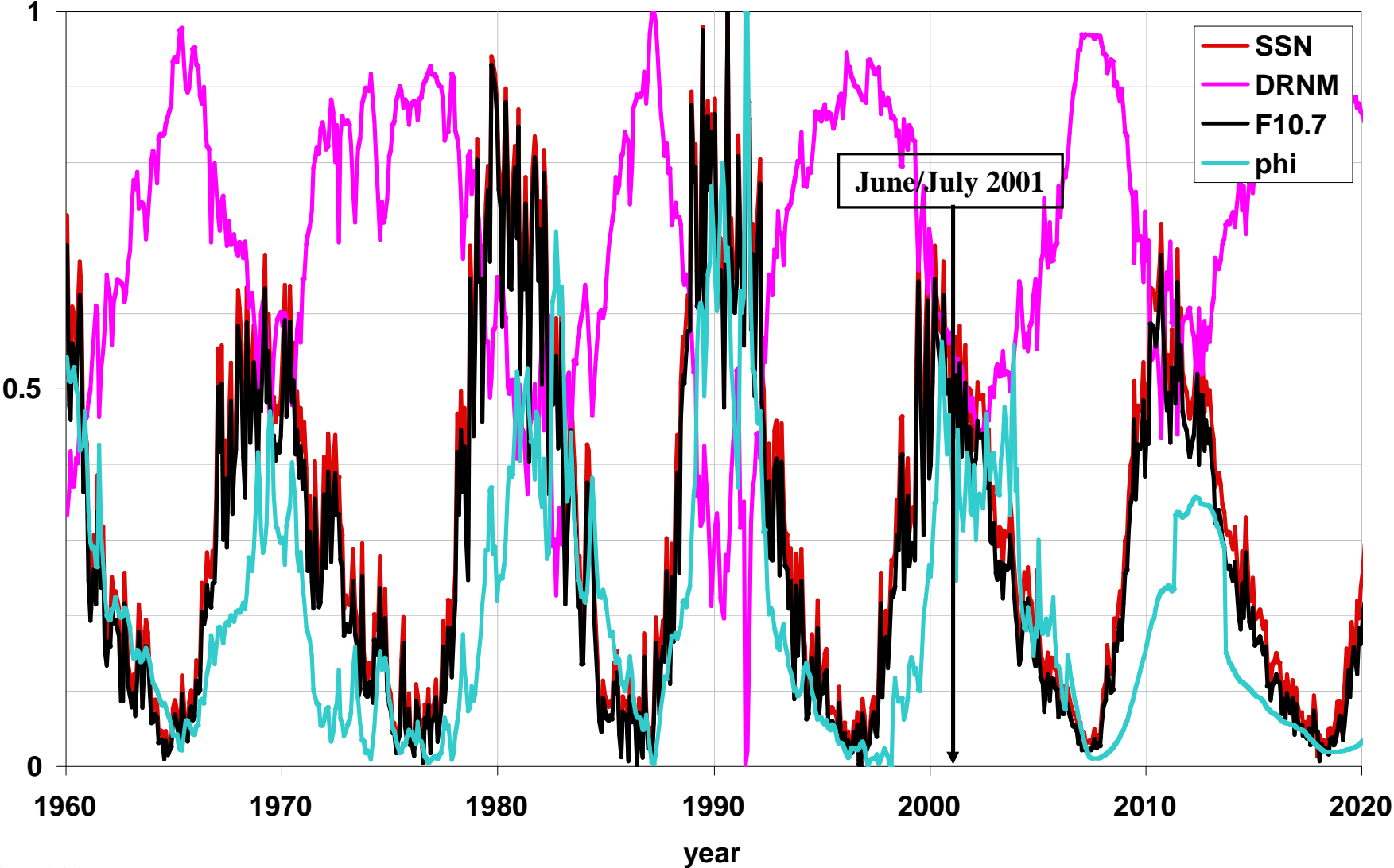
*Neal Zapp, Bob Rutledge, Kerry Lee, Edward Semones and etc...*

*Space Radiation and Analysis Group (SRAG),  
Johnson Space Center (JSC), Houston, Texas, USA*

# Backups

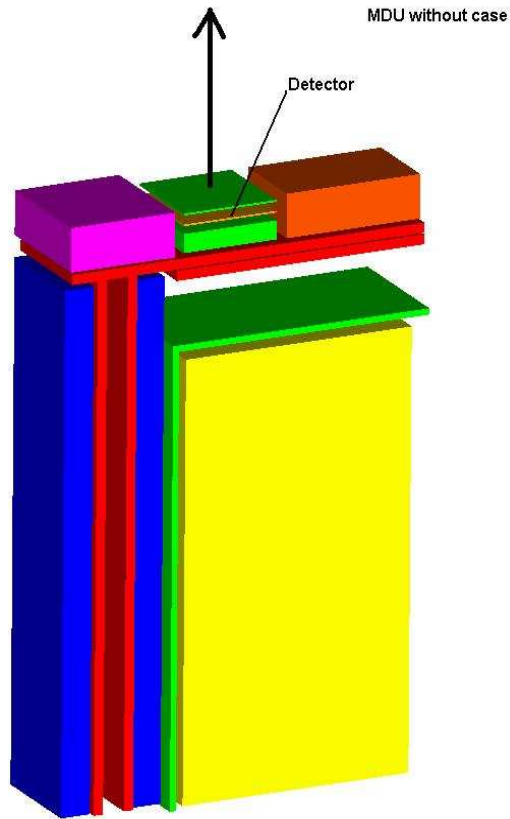
10-Sep-2009

# Measured and Projected Modulation Parameters

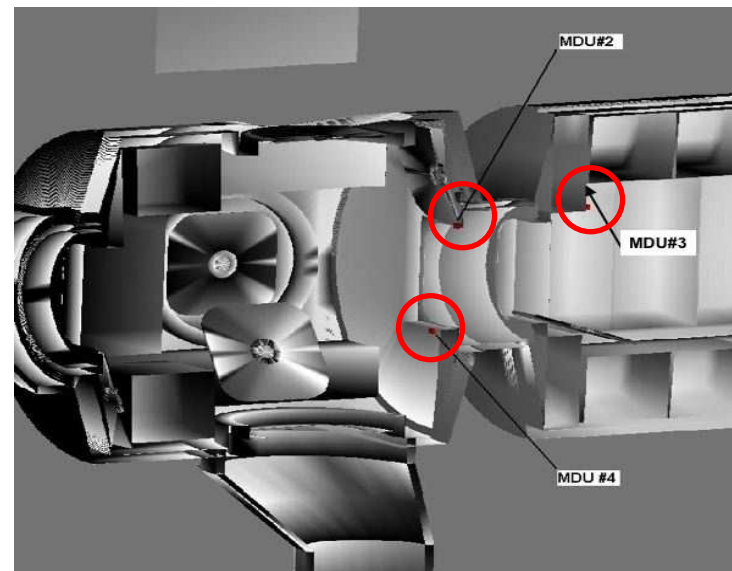
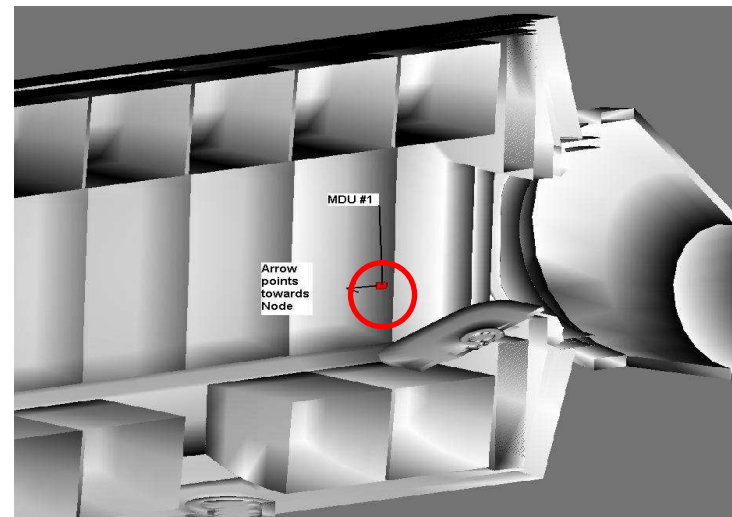




# ISS 6A Liulin MDU1-MDU4 Location/Orientation (6-13 July 2001)



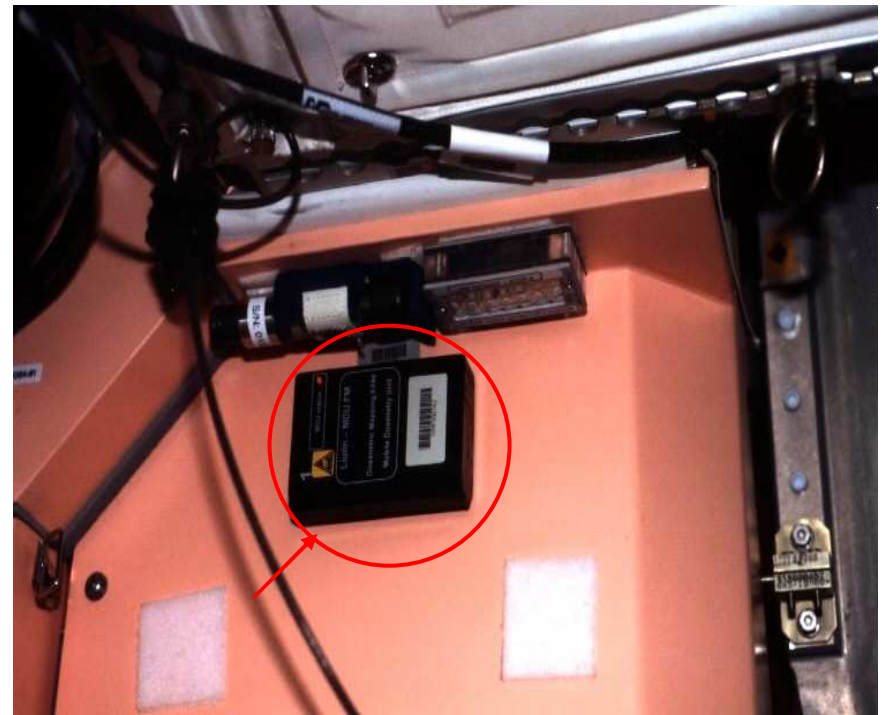
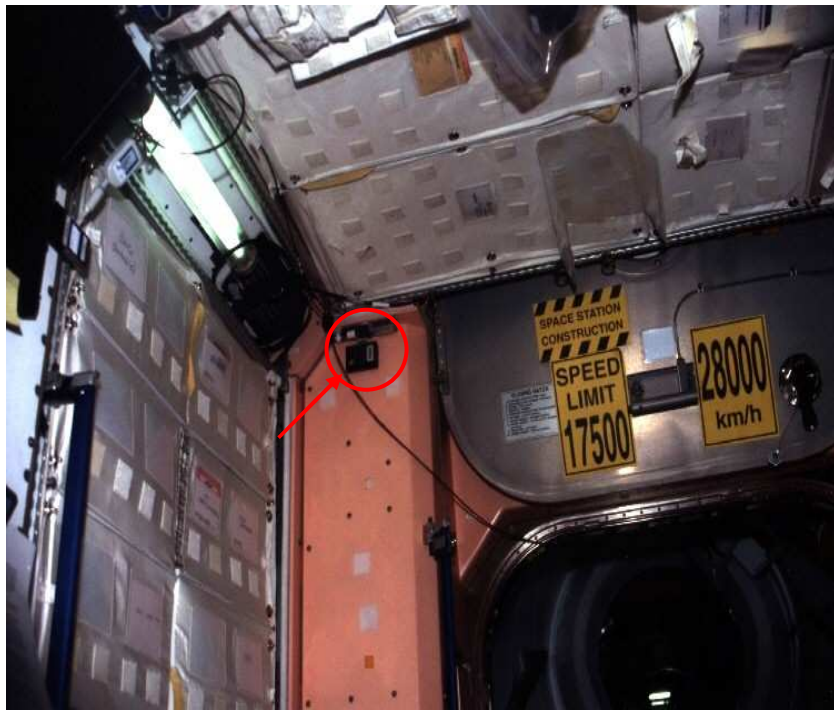
Liulin detector CAD model  
(MDU1 – MDU4)





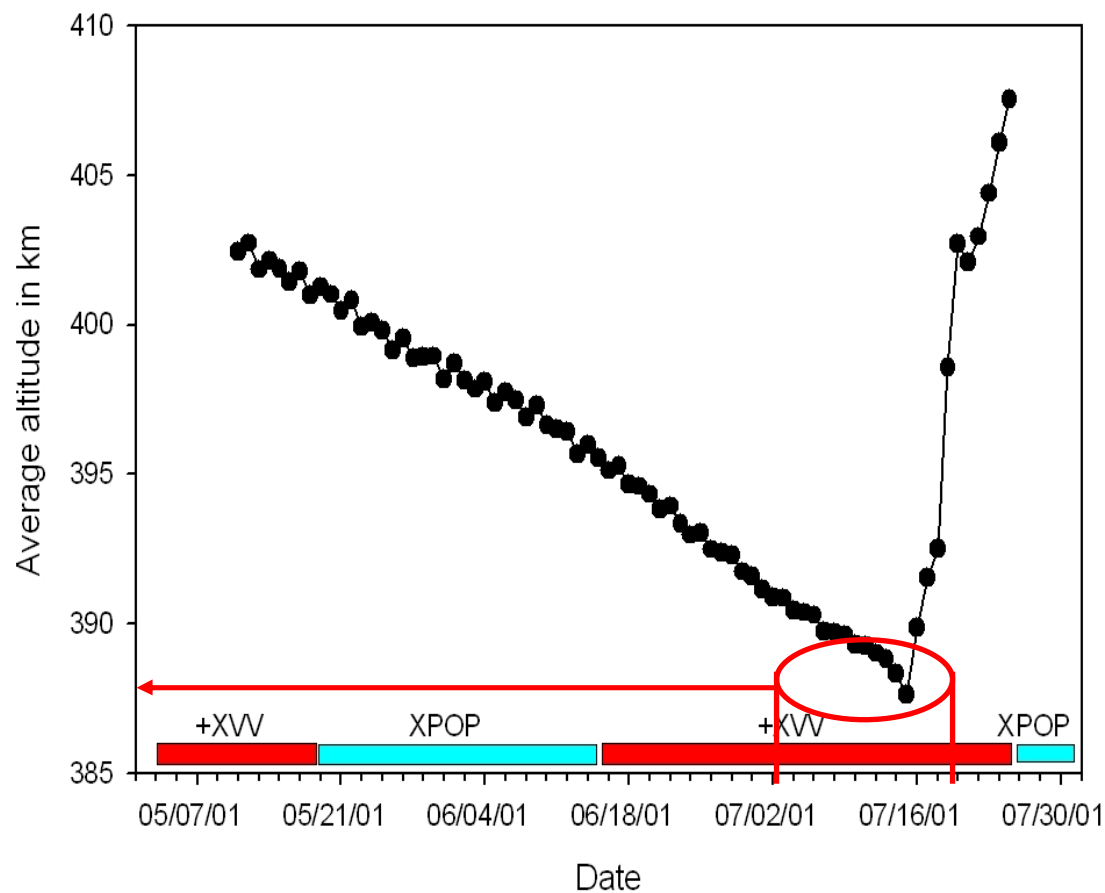


# ISS 6A-Configuration with Liulin Dosimeters





# ISS-6A Flight Trajectory Data (six DOF)



Ref. Borislav T. Tomov (STIL)