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

- 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

- 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

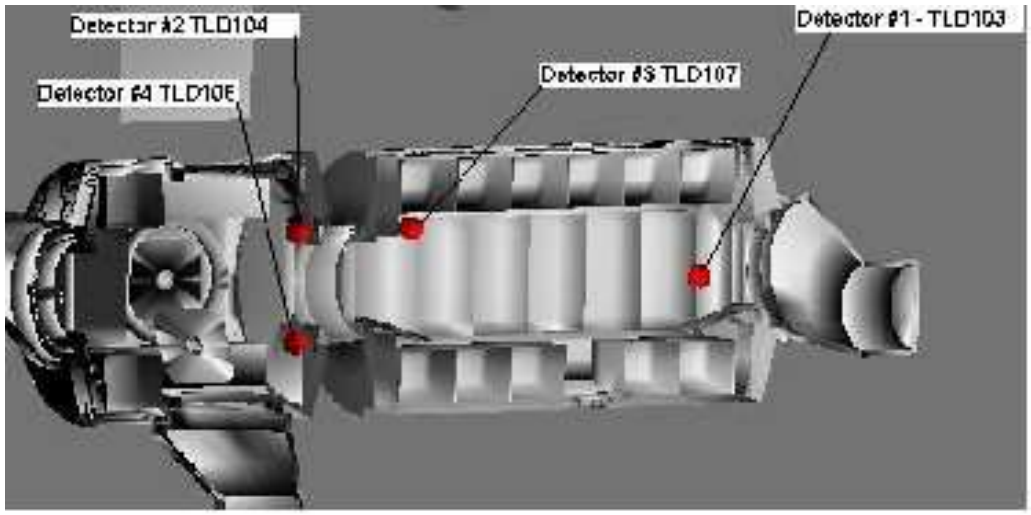
X-Axis Perpendicular to Orbit Plane (*XPOP*)

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	95.72	-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	380.59	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	-80.86	-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 (μGy/minute)	Dose Eq. Rate (ICRP-60, μSv/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	378.9	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	377.606	GCR	SM Panel 327	9.0033
7/6/2001 10:35	0.128	0.901	125.468	-37.503	377.469	GCR	SM Panel 327	10.0033
7/6/2001 10:36	0.122	0.456	129.215	-39.87	377.362	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)

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

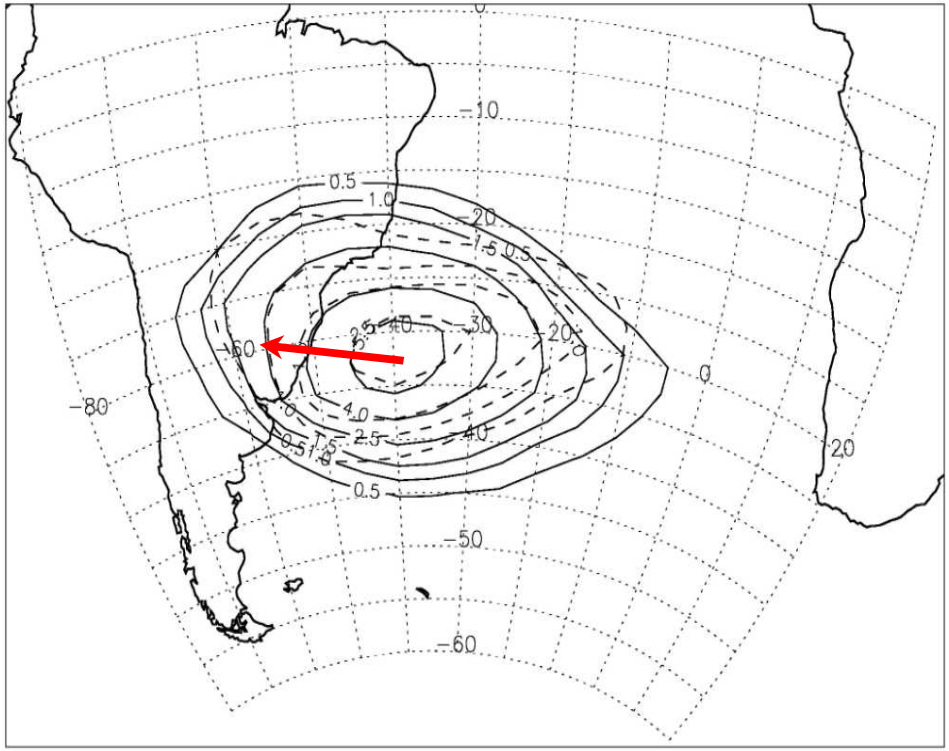
1	• Solar modulated neutron albedo. • Dynamic/directional geomagnetic cutoffs. • O'Neill (JSC) 2004 GCR model. • LaRC GEORAD-a modulated, drifting, directional trapped proton/electron model.
2	• Web based HZETRN (OLTARIS site).
3	• ISS-6A Liulin / TEPC shield models from (JSC).
4	• Liulin MDU#1 - MDU#4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

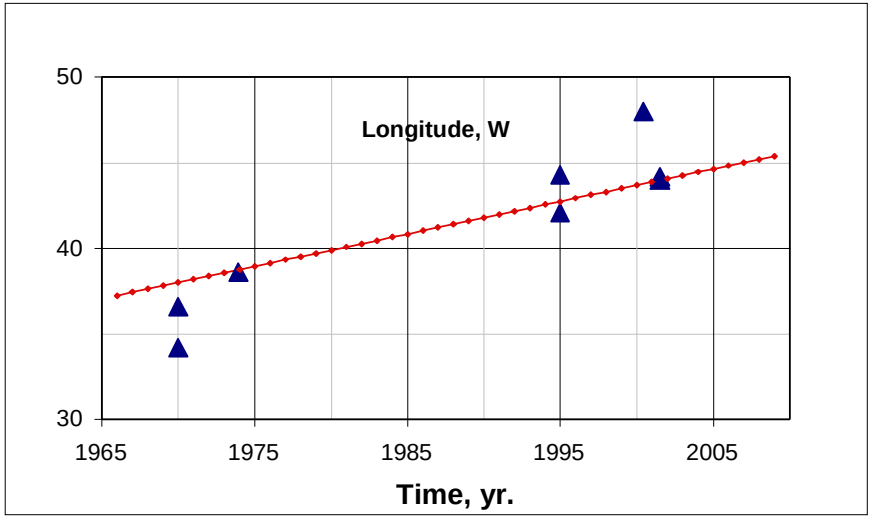
III

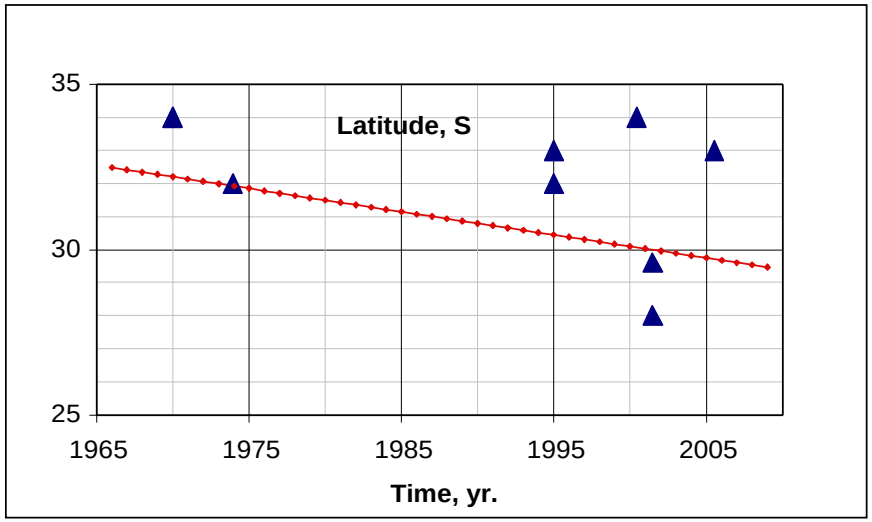
Basic Proton Field Distributions

(with drifting latitude and longitude)

Solid: AP8MIN 1965 map
Dashed: AP8MAX 1970 map

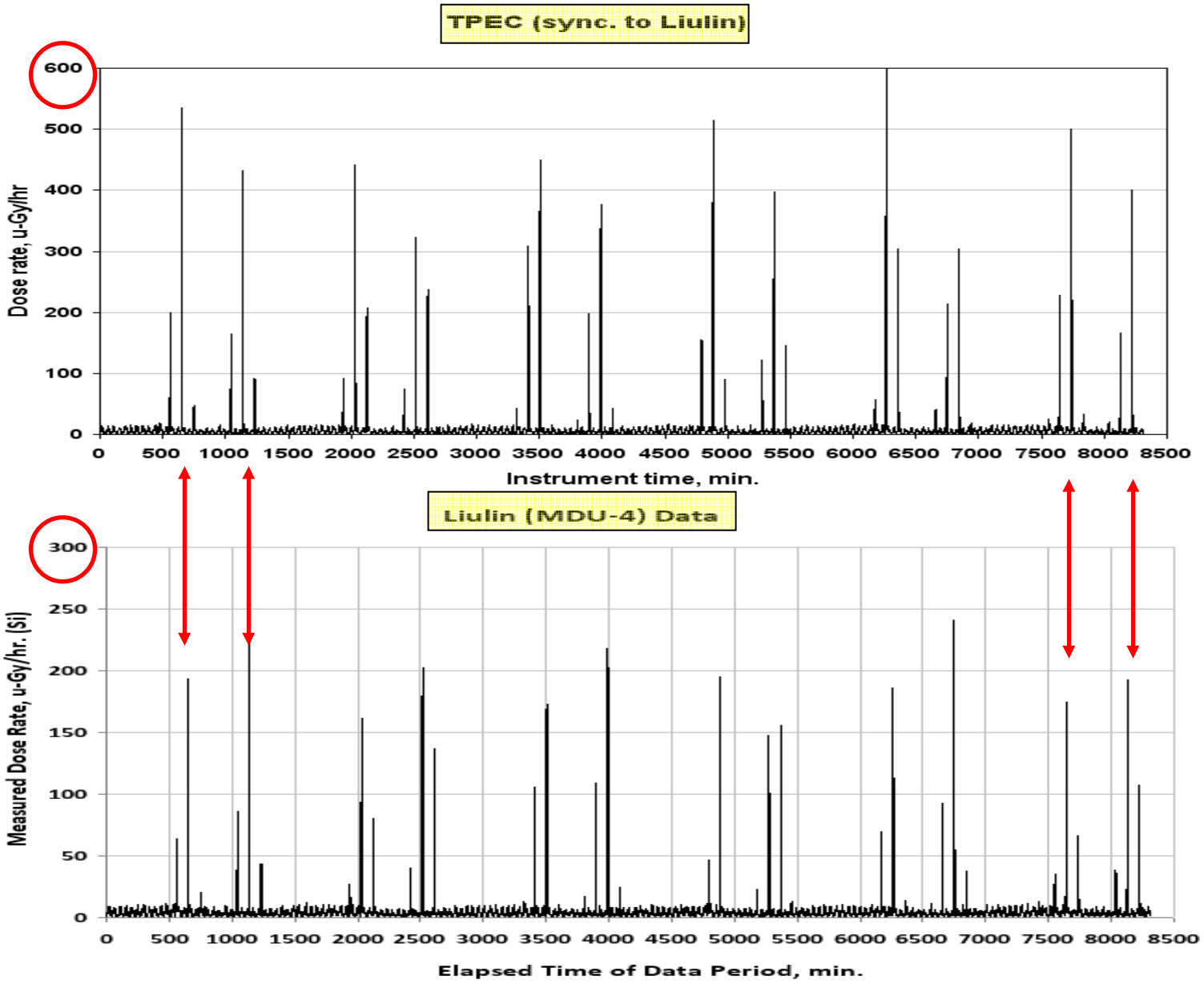






IV

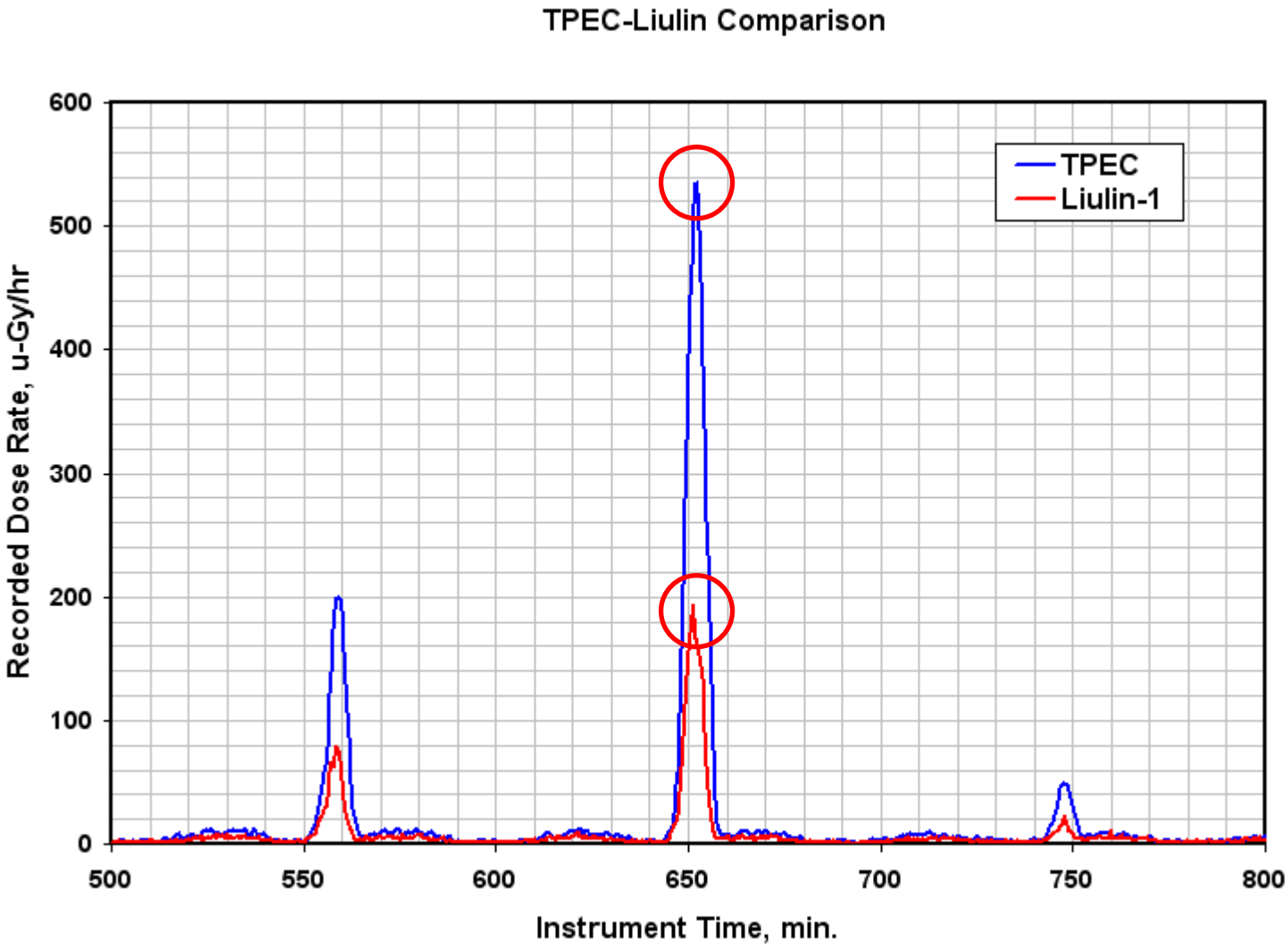
MDU / TEPC Correlation (6-13 July 2001)



IV

MDU / TEPC Correlation

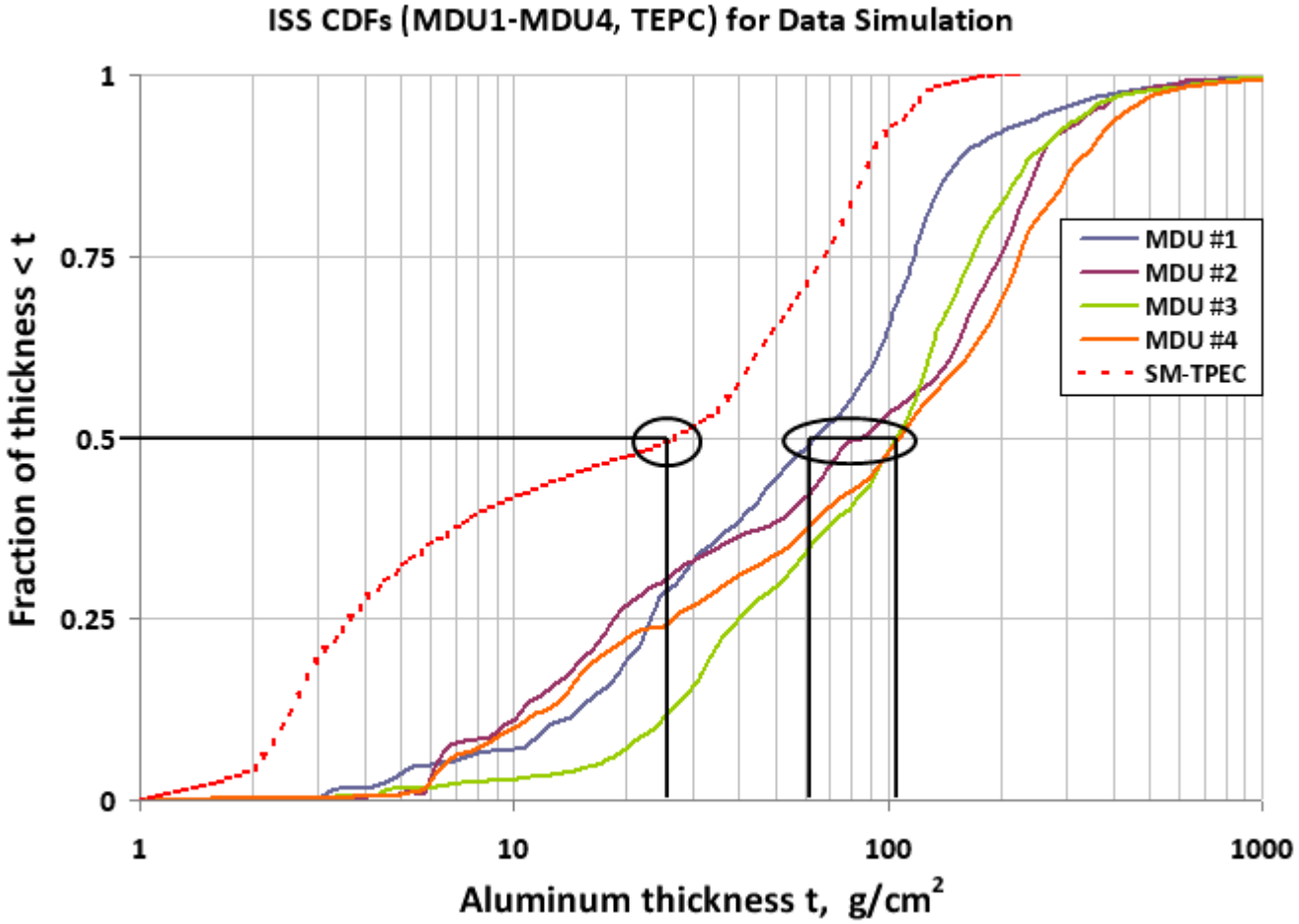
(6-13 July 2001)



IV

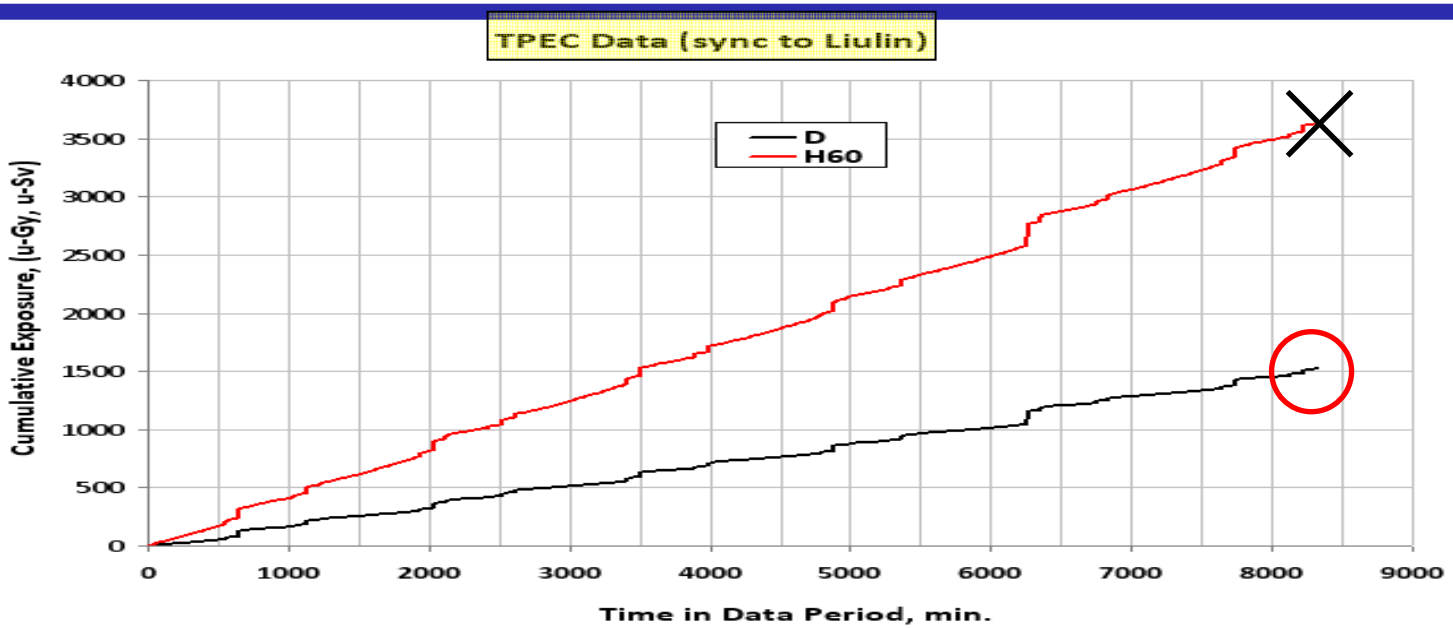
CDF for MDU1 - MDU4 and TEPC

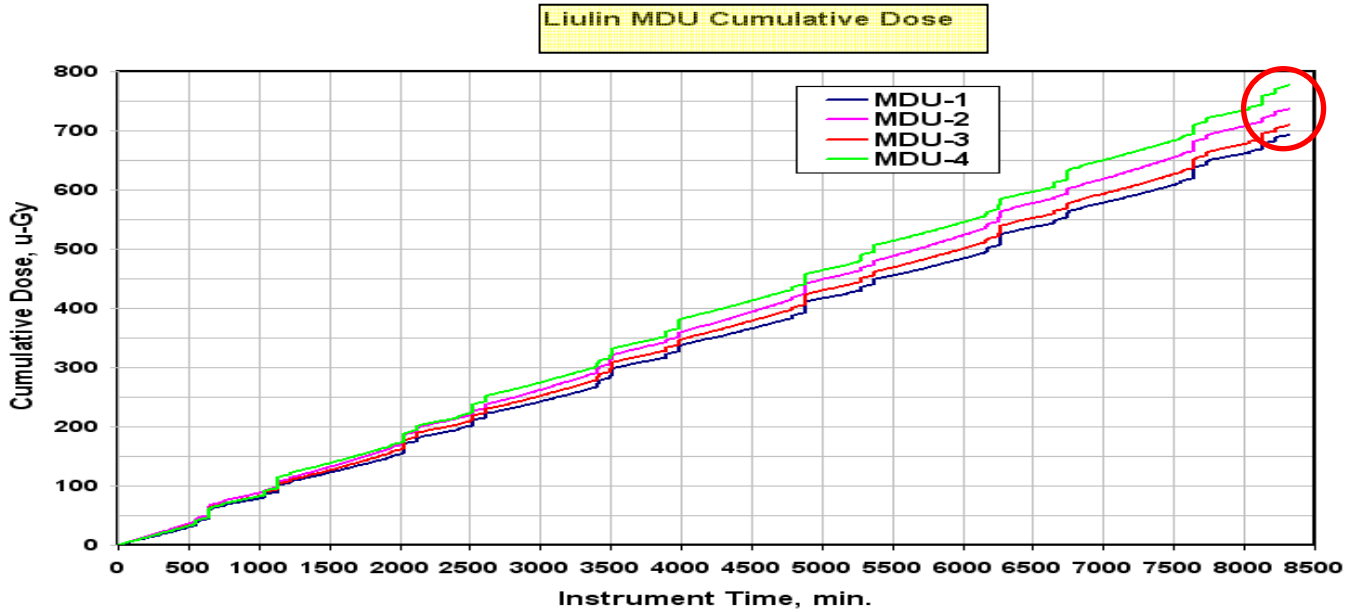
(6-13 July 2001)



IV

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

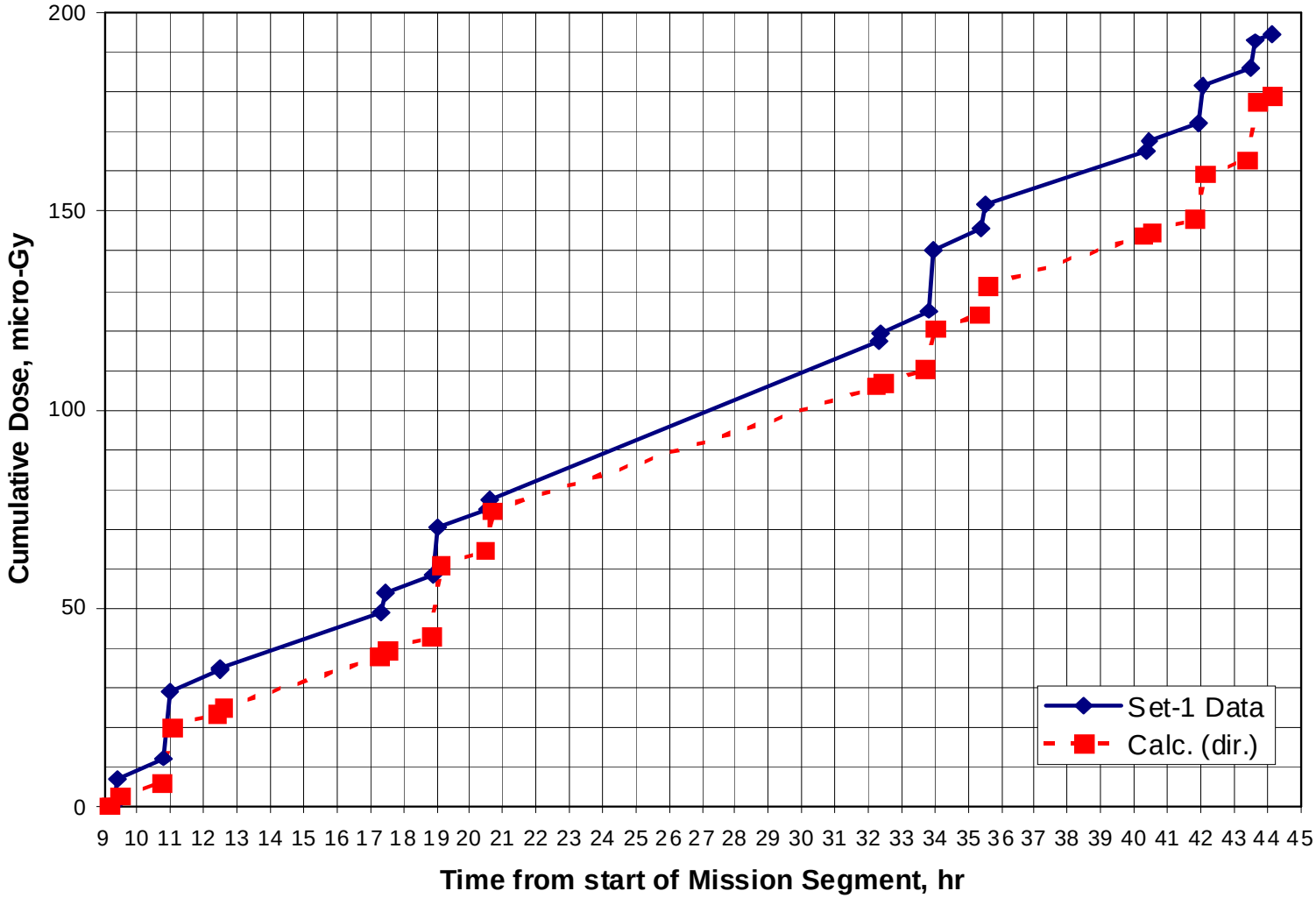




V

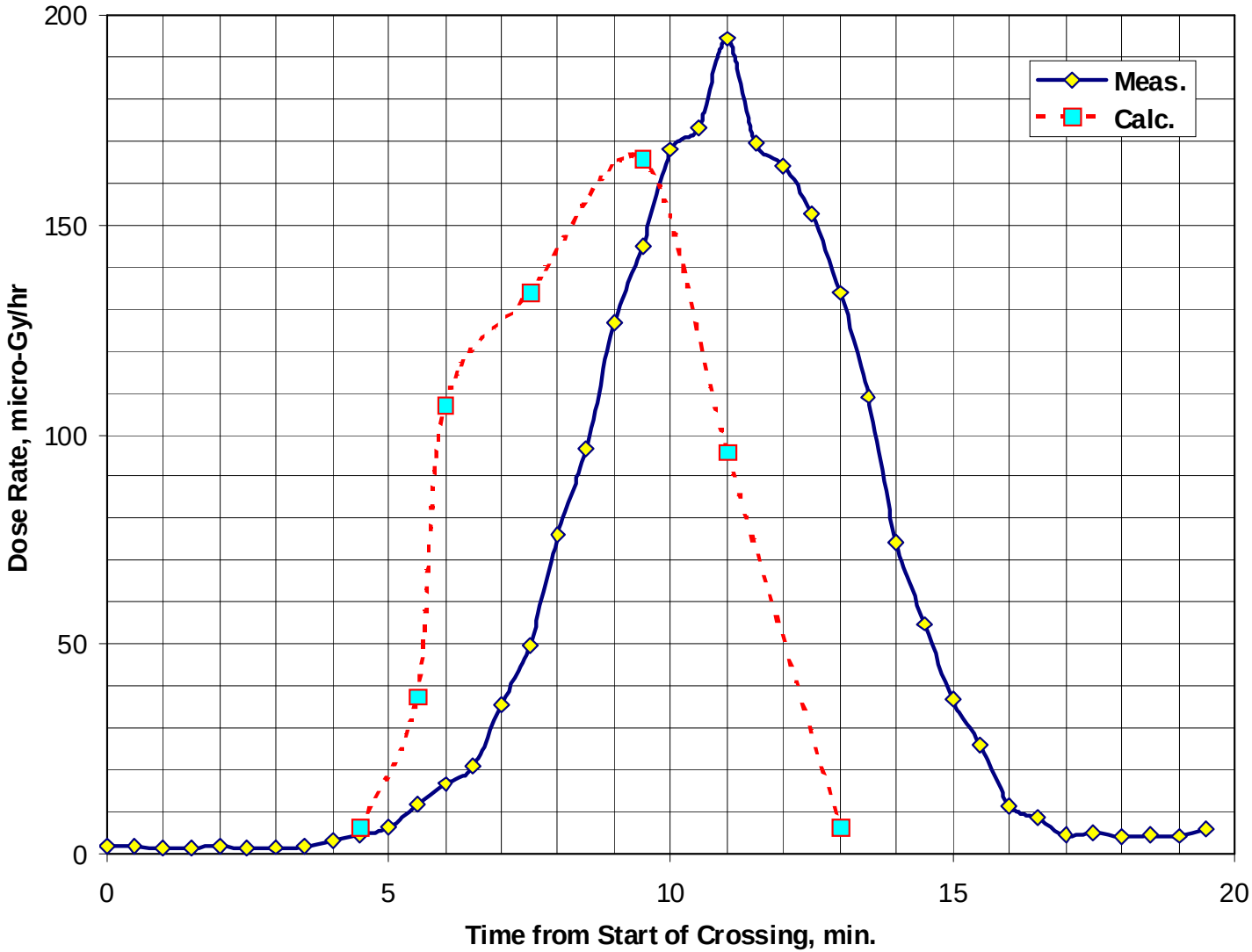
Cumulative Dose V & V

(MDU-1, 45 hrs.)



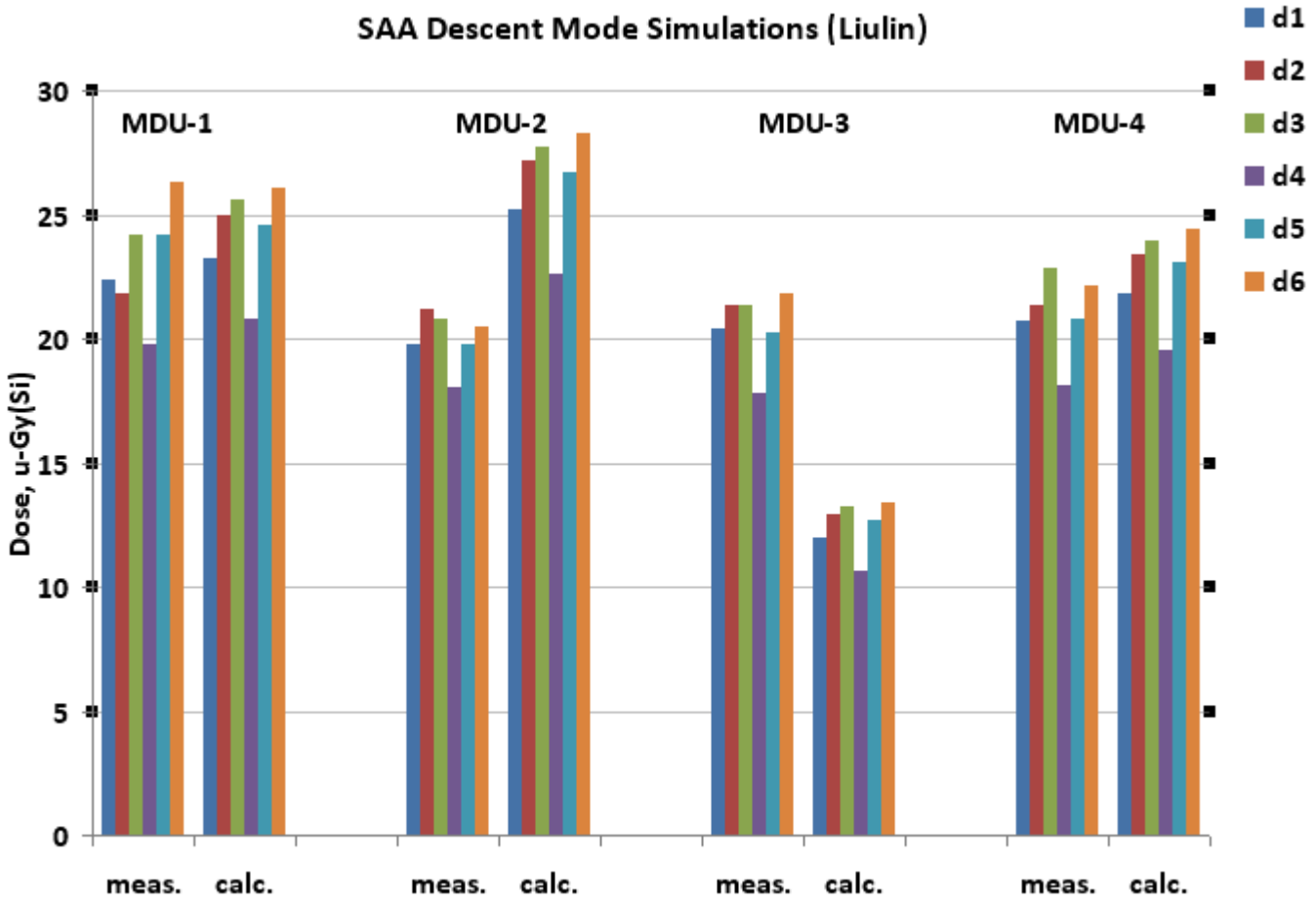
V

One SAA pass V & V (6 July 2001)



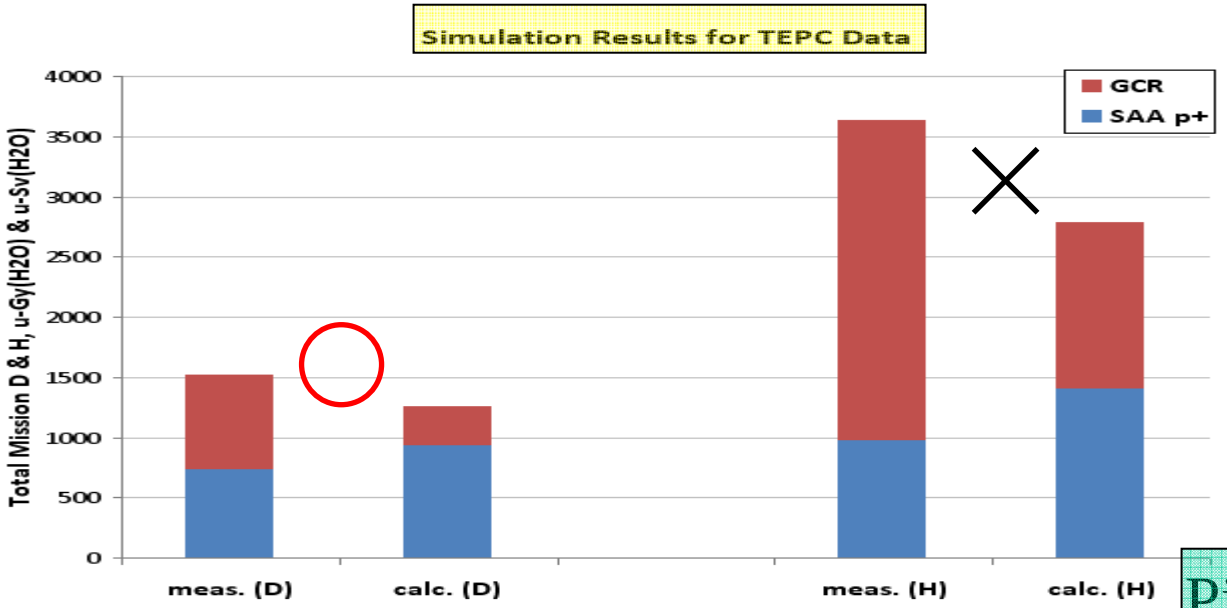
V

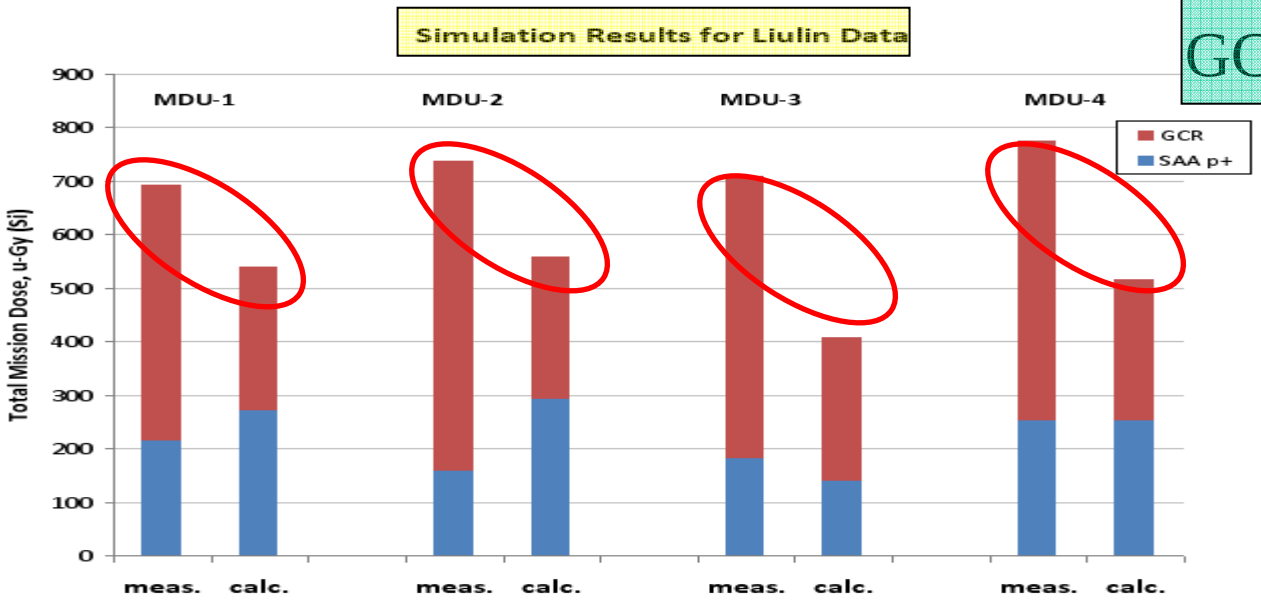
6 SAA Passes V&V (desent)



V

Cumulative V&V (6-13 July 2001)





Pions/Kaons ???

$GCR_{solarmax}$???

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

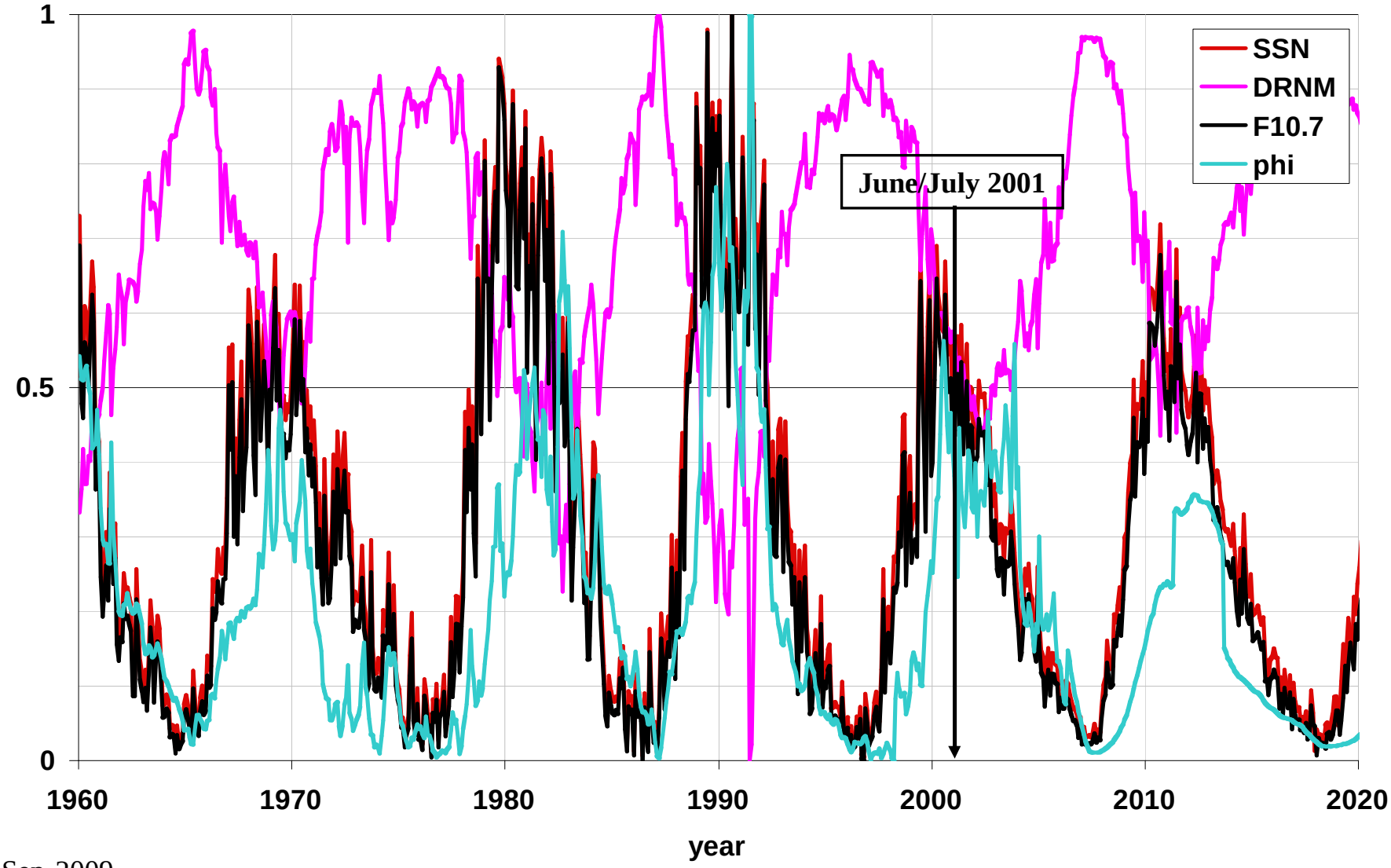
Acknowledgement

(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

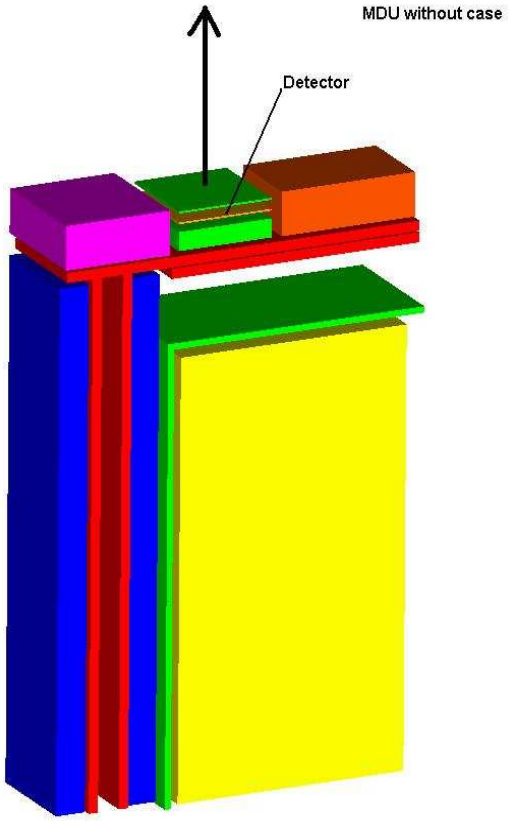
Measured and Projected Modulation Parameters



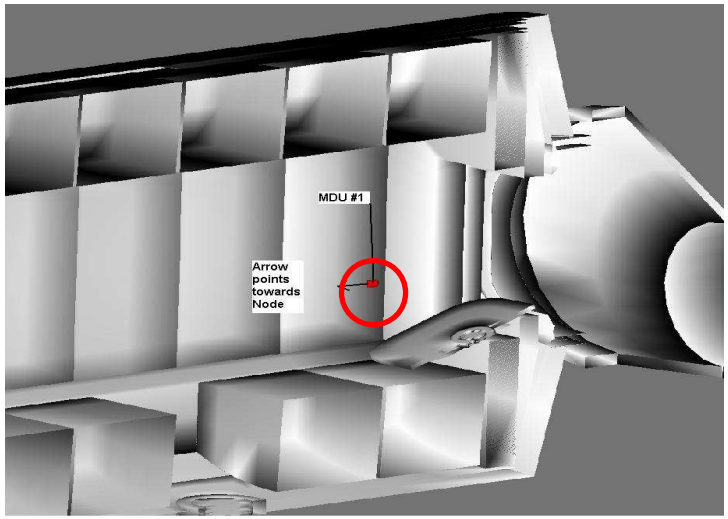
II

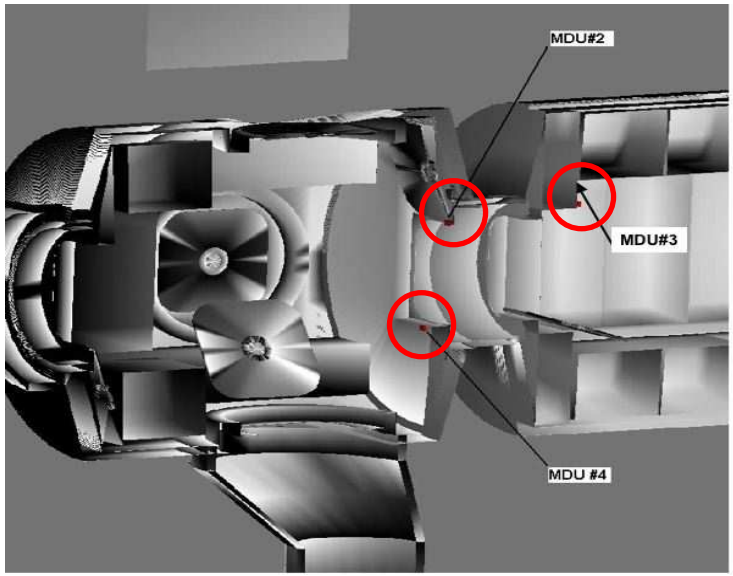
ISS 6A Liulin MDU1-MDU4 Location/Orientation

(6-13 July 2001)



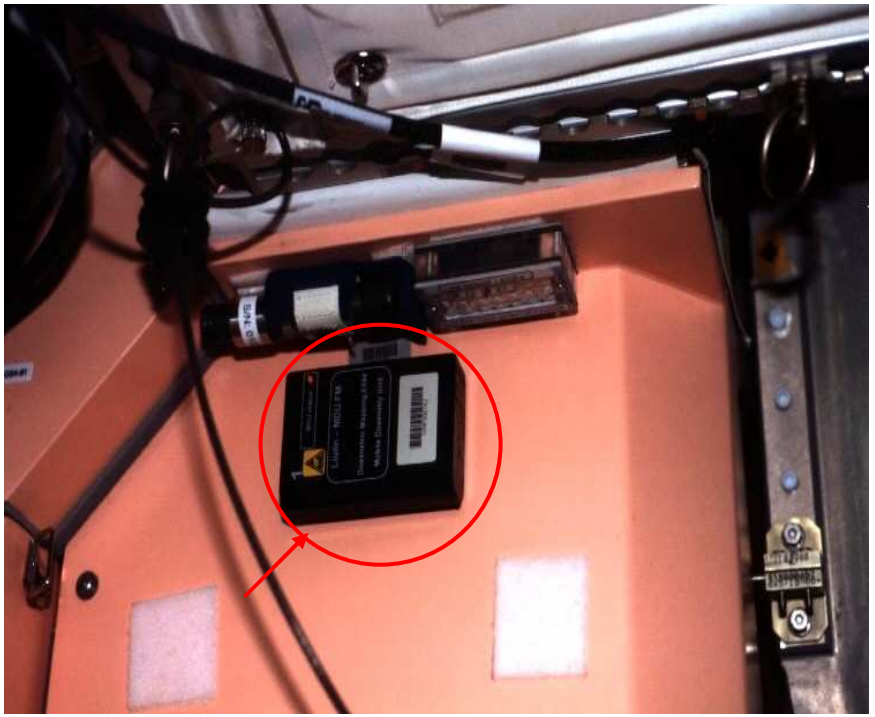
Liulin detector CAD model
(MDU1 – MDU4)





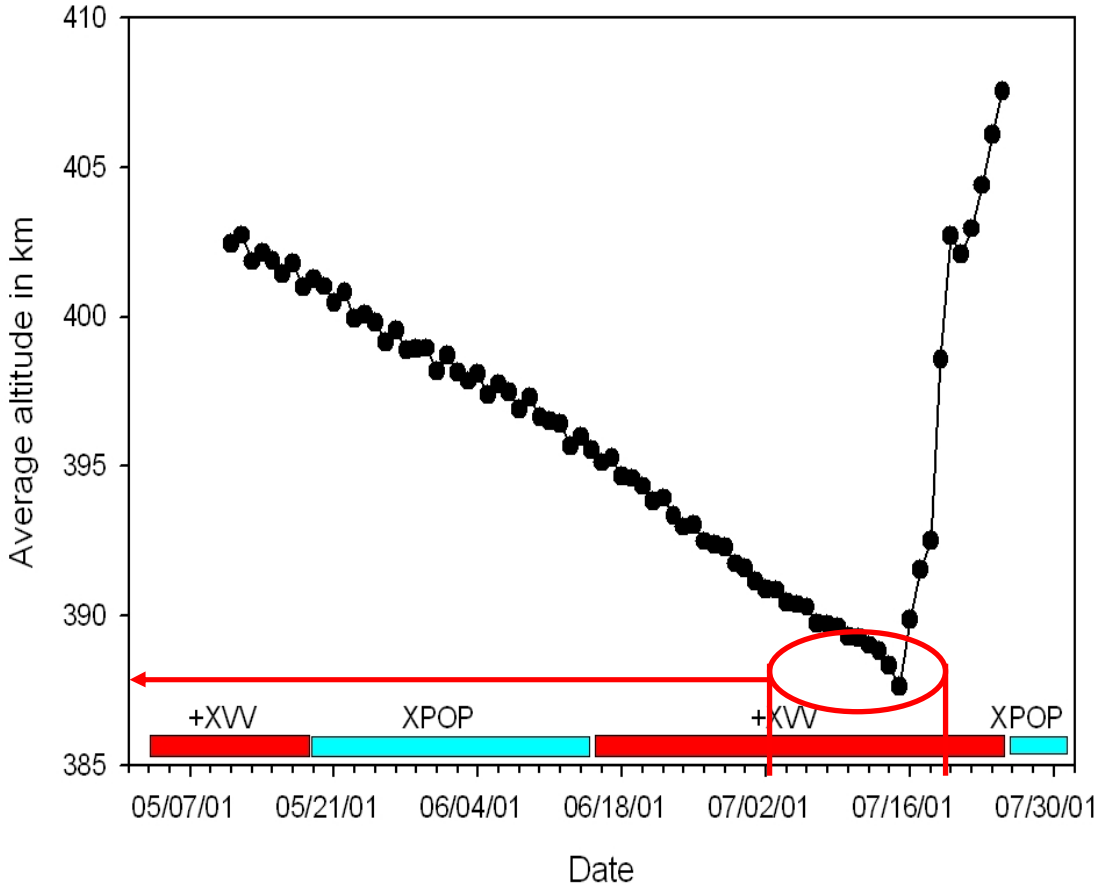
II

ISS 6A-Configuration with Liulin Dosimeters



III

ISS-6A Flight Trajectory Data (six DOF)



Ref. Borislav T. Tomov (STIL)