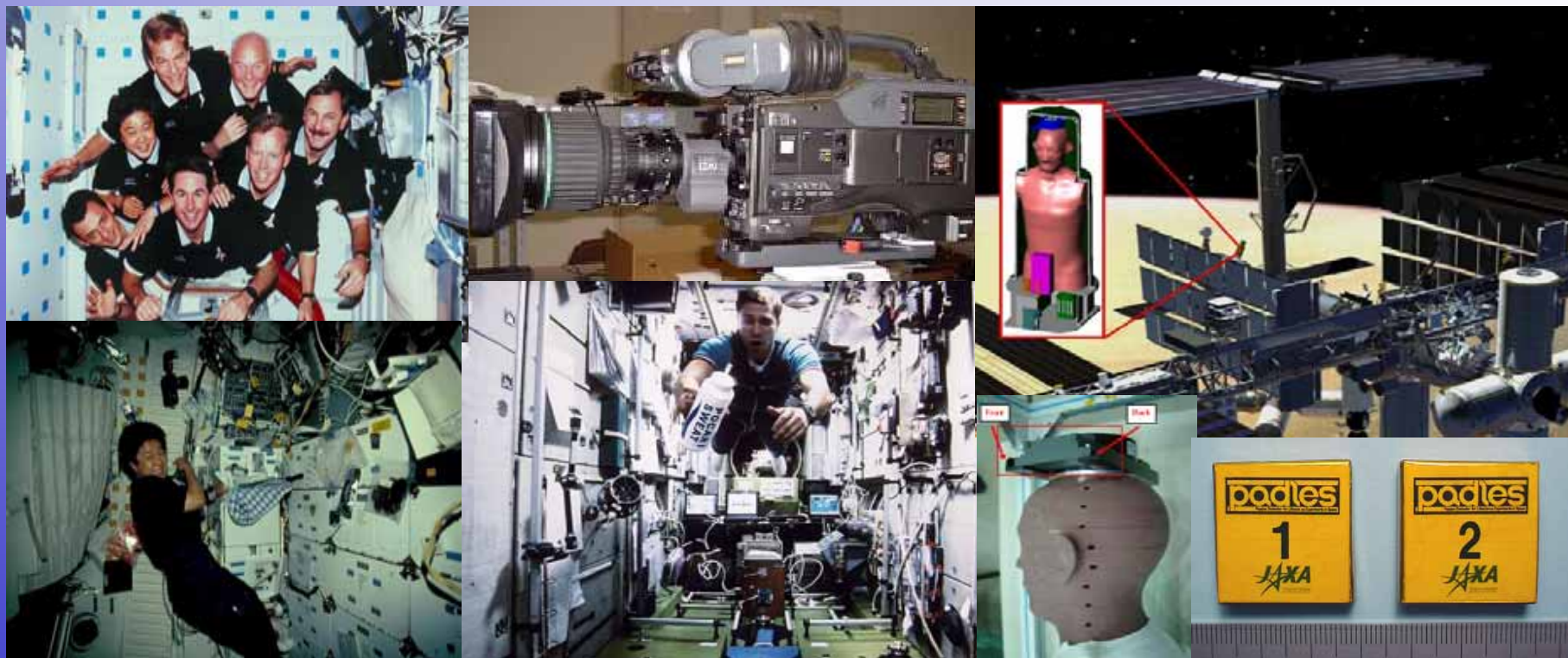


Dosimetry for space radiation in ISS lifescience experiments using PADLES system



Hiroko tawara **KEK / JAXA**

Mitsuyo masukawa, Aiko Nagamatsu **JAXA**

Hidenori kumagai **AES**



1. Introduction

2. PADLES system

Ground-based experiments

Programs developments

PADLES demonstration

3. Dosimetric results in ISS ZVEZDA using AUTO PADLES

4. A support for life science experiments on ISS JEM

PADLES

(Passive Dosimeter for Lifescience Experiment in Space)

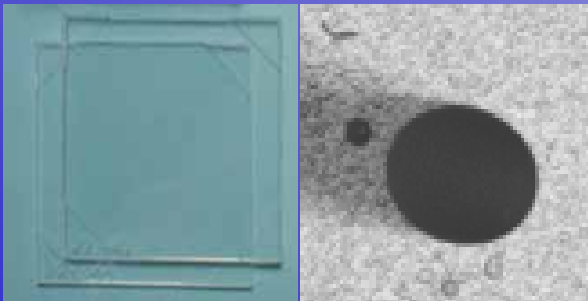
TLD-MSO-S (thermoluminescent dosimeters)



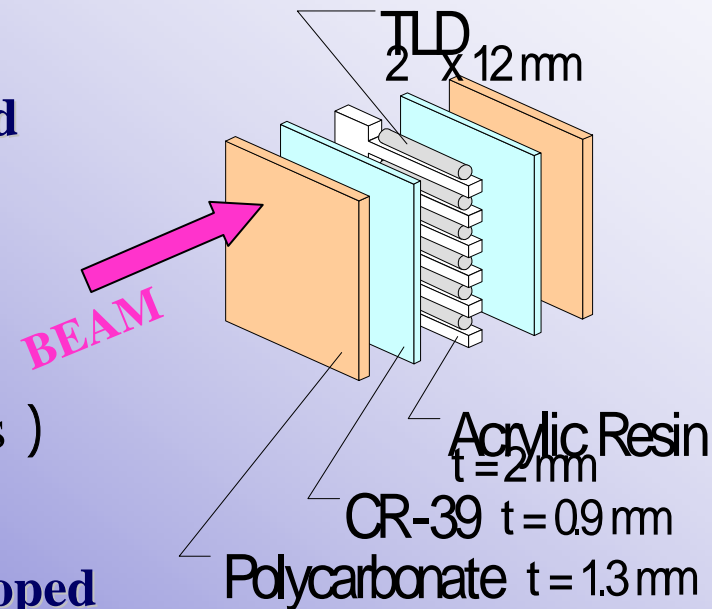
**Mg₂SiO₄:Tb powder enclosed
a pyrex glass with Ar gas
(Kasei Optonics industry)**

CR-39

(plastic nuclear track detectors)



**HARZLAS TD-1 are doped
with 0.1%wt NAUGARD 445
(Fukuvi Chemical industry)**

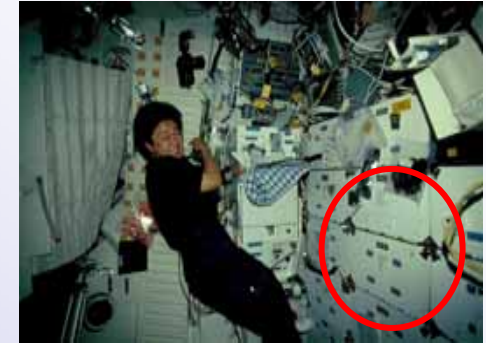


STS-95 flight experiment



29/10/1998 – 7/11/1998 (8.9 days)

Genetic change induced in human cells
in space shuttle experiment



ISS Russian segment flight experiment



31/8/2001 – 10/11/2002 (71-446 days)

Space radiation damage test of
HDTV CCD device for HTDV images

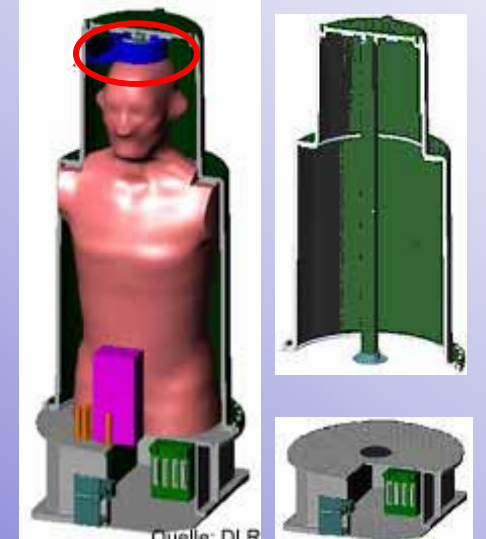


The MATROSHKA project.



29/1/2004 – (1 year)

Simulation as exact as possible an astro-
naut while he leaves the 'protective'
area of the spaceship to carry out work
in space





2. PADLES system ~ from 2008 ~



1. The first KIBO utilization solicitation (Dr. M. Majima Kagoshima univ.)

Title : Biological effects of space radiation and microgravity on mammalian cells

Biological sample : Human neuron progenitor cells

Conditions : Experimental unit(37), 1-3 months

2. The international announcements of opportunity (Dr. Y. Furusawa Kyoto institute)

Title : Biological Response of the Silkworm, *Bombyx mori*, in Space

Biological sample : The egg of the Silkworm

Conditions : MELFI(4) & CBEF(RT), 6 months

3. The international announcements of opportunity (Dr. T. Onishi Nara Medical univ.)

Title: Gene expression of p53-regulated Genes in Mammalian Cultured Cell after Expose to Space Environment

Biological sample : human glioma cell lines, mouse lymphoma cell line

Conditions : CBEF(37), 2 weeks

4. The international announcements of opportunity (Dr. F. Yatagai RIKEN)

Title: Detection of Changes in LOH Profile of TK mutants of Human Cultures Cells

Biological sample : human glioma cell lines

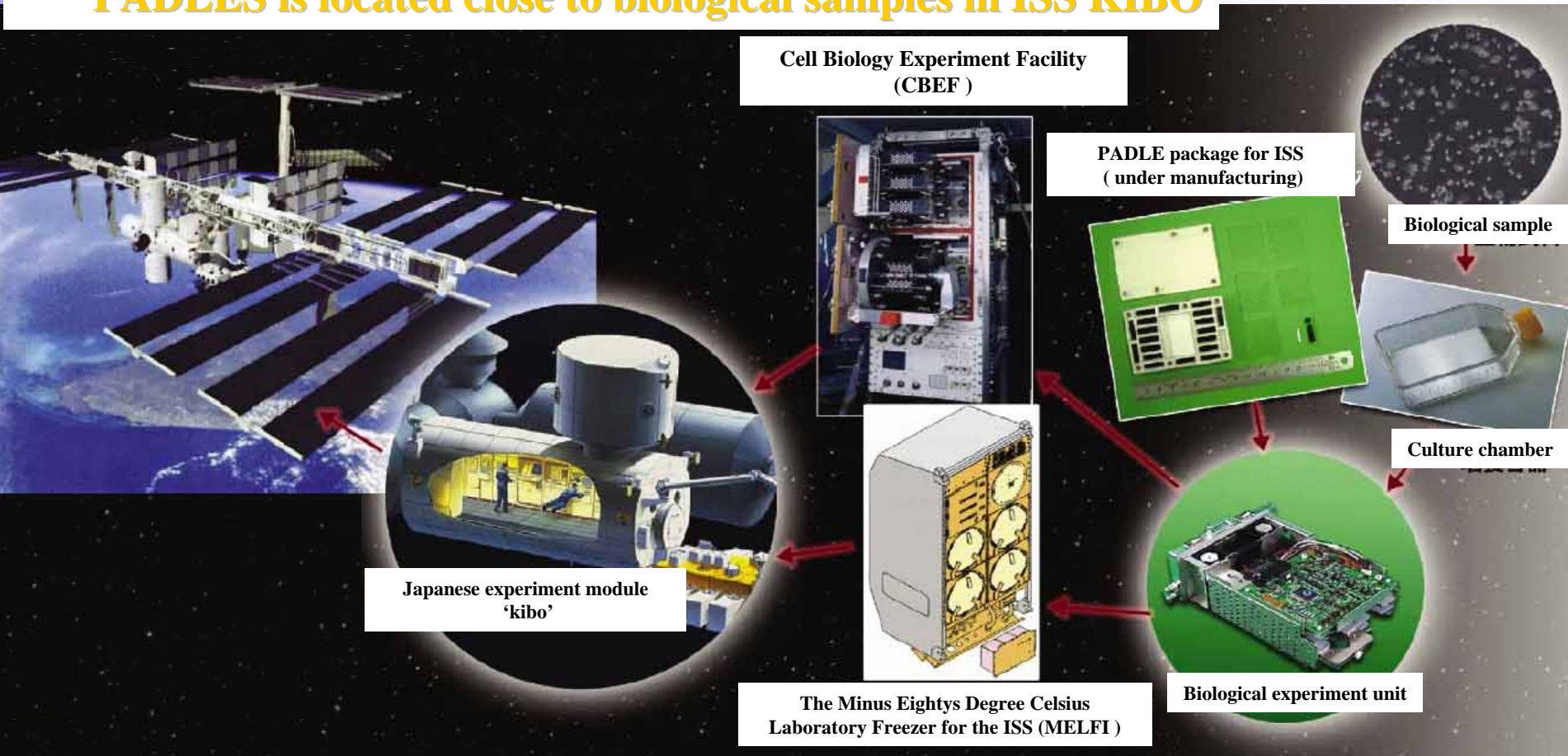
Conditions : not yet decided



2. PADLES system



PADLES is located close to biological samples in ISS KIBO

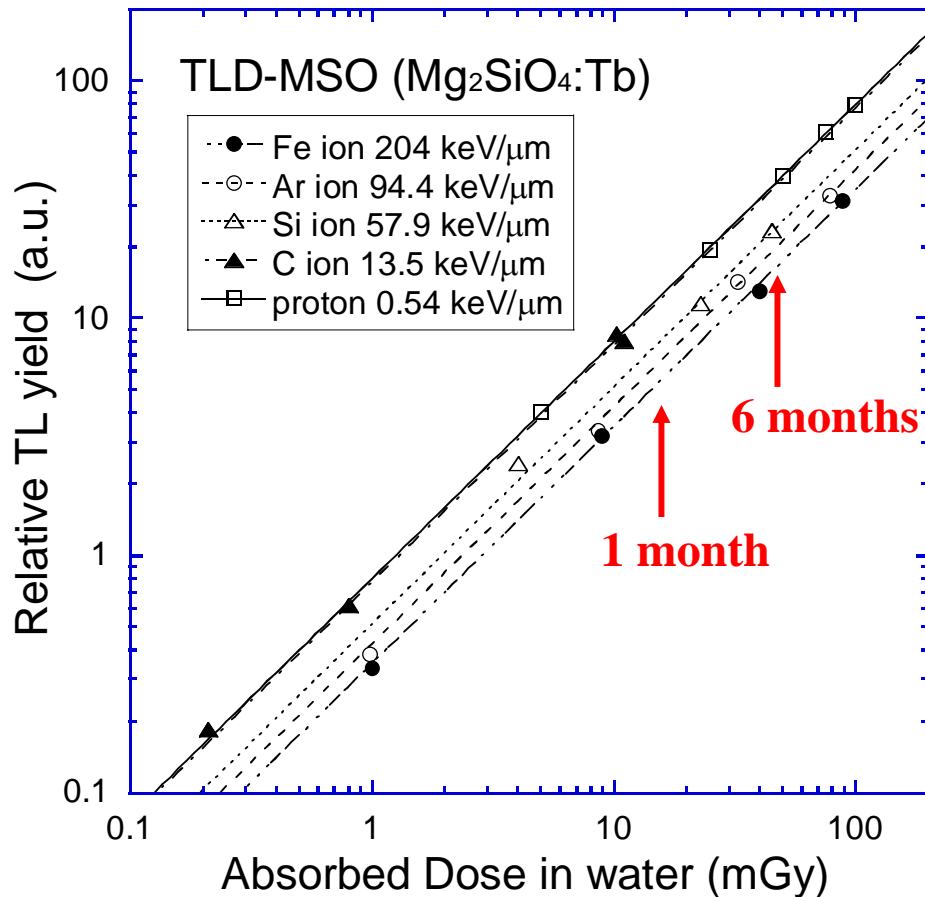


Irradiation temperature	Storage temperature	Sample Condition	Storage on ISS KIBO	Facility
-60°C	-80°C	freezing	freezers	MELFI
-20°C	-20°C	freezing	freezers	MELFI
+4°C	+4°C	cold	refrigerators	MELFI
+25°C(RT)	+25°C(RT)	culture	incubator	CBEF
+37°C	+37°C	culture	incubator	CBEF

Load period : 3 ~ 6 months

temperature : -80 ~ 37

TLD-MSO : The dose response between load period of months



Absorbed doses on a space shuttle
 (An altitude and An angle of inclination are equivalent to ISS, STS-89,-91)

0.34mGy/day

10.08mGy/month

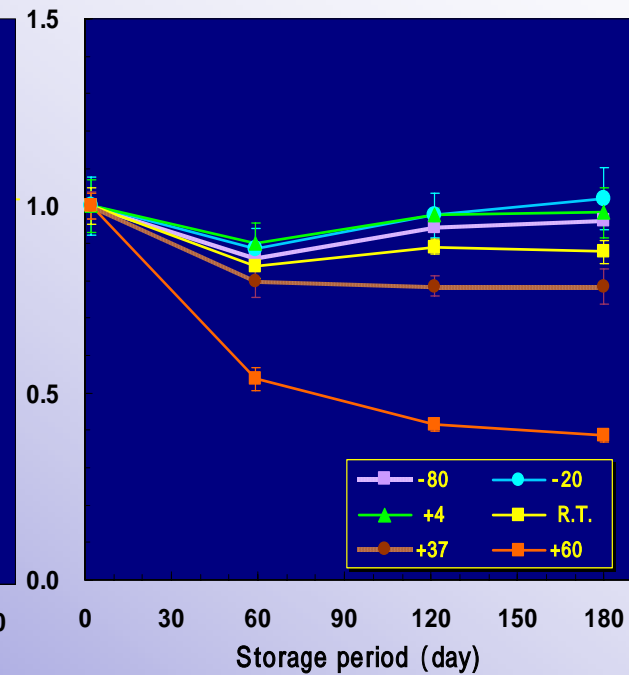
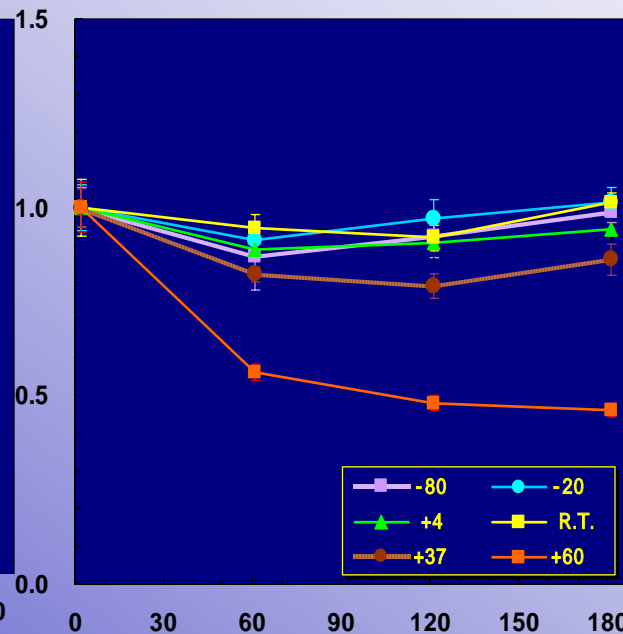
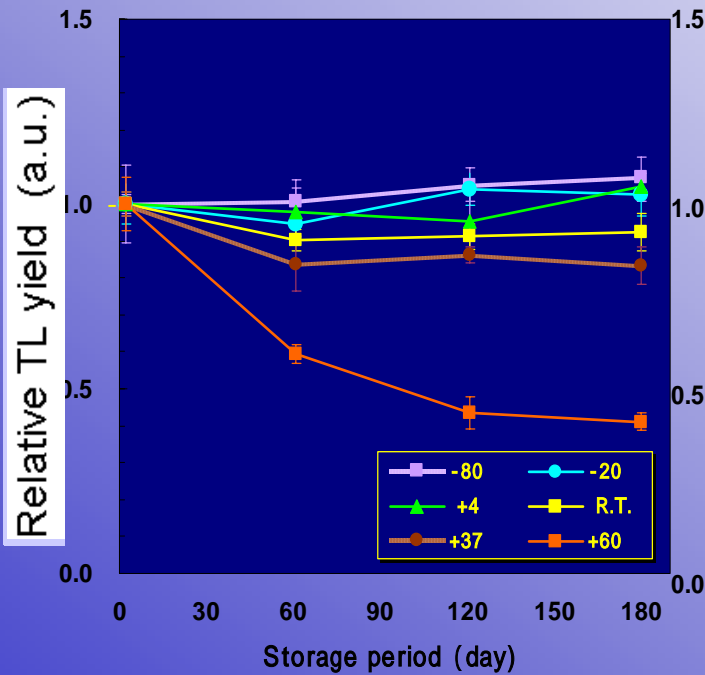
60.48mGy (0.064Gy) /6 month

TLD-MSO : Fading effects for heavy ions

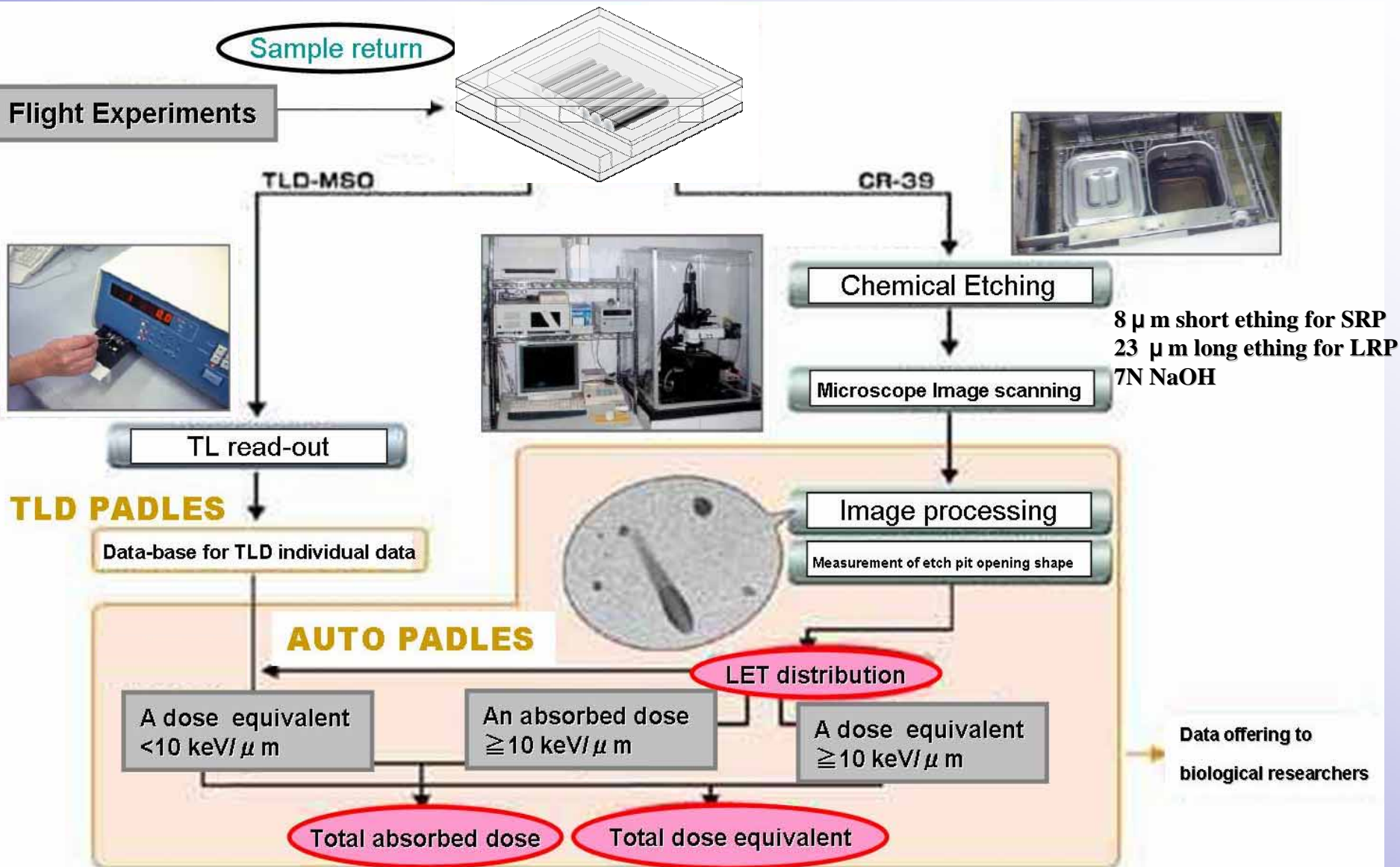
H 0.54keV/ μ m, 10mGy

He 2.3keV/ μ m, 50mGy

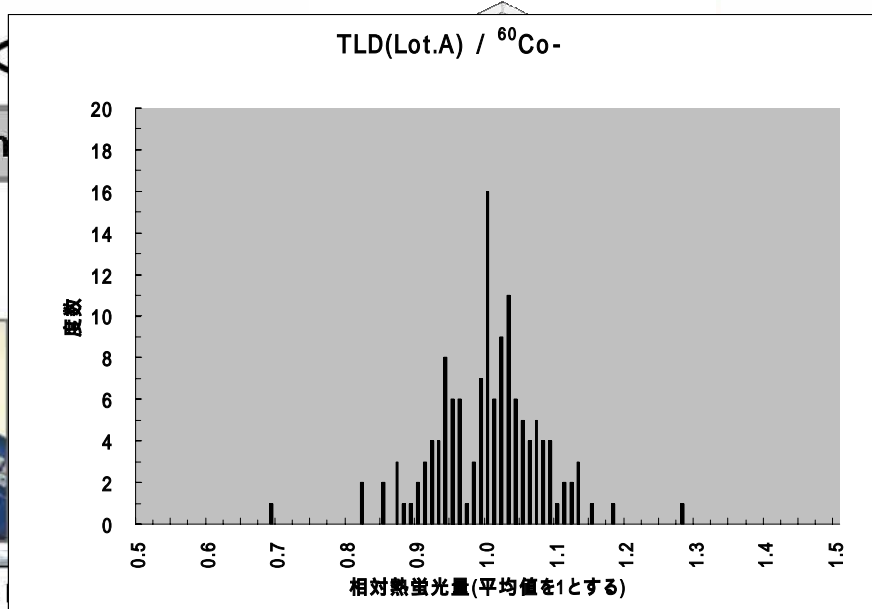
Fe 200keV/ μ m, 50mGy



	RT	+37	+60
Proton	Within 10%	17%	60%
He	Within 12%	22%	54%
Fe	Within 17%	22%	62%



Flight Experiment



CR-39 data-base

- A calibration curve
- Calibration curves at various incident angles

TLD PADLES

Data-base for TLD individual data

AUTO PADLES

Image processing

Measurement of etch pit opening shape

LET distribution

An absorbed dose $\geq 10 \text{ keV}/\mu\text{m}$

A dose equivalent $\geq 10 \text{ keV}/\mu\text{m}$

Total absorbed dose

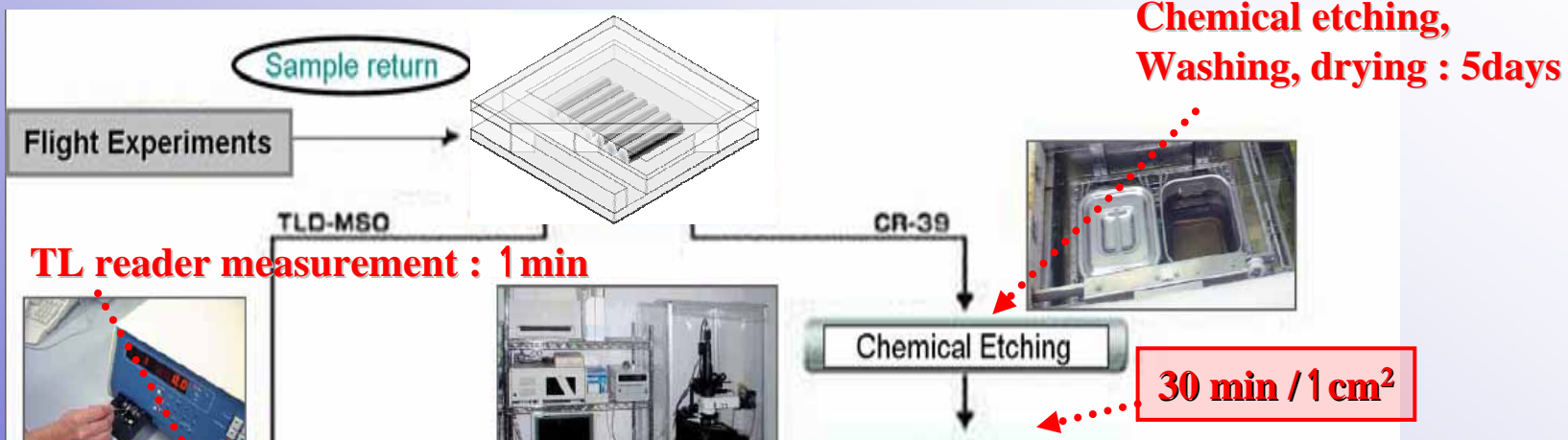
Total dose equivalent

Data offering to biological researchers

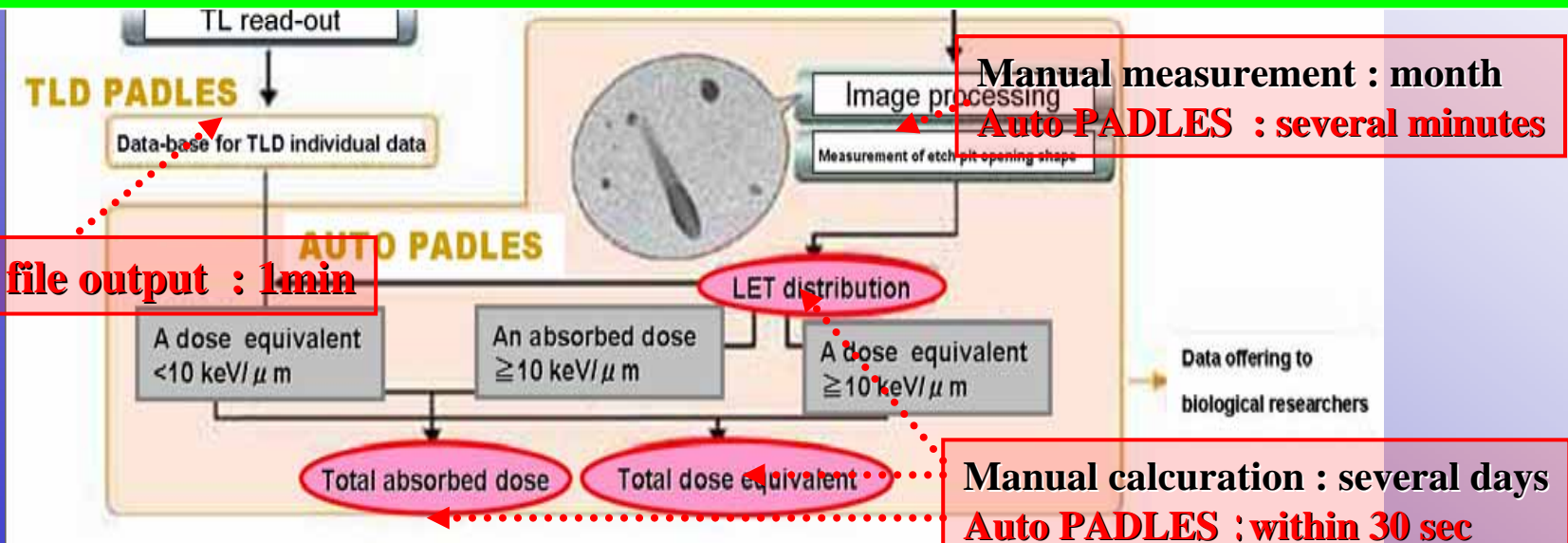
TLD-MSO data base

- The calibration factors (Co-60, Cs-137, Proton)
- LET response functions
- Fading effects

Materialization of high speed analysis by JAXA



The maximum analysis and data offering time to about 2 weeks for each experiment



Data input, file output : 1min

Manual calculation : several days
Auto PADLES : within 30 sec

TLD PADLES

TLD素子管理システムメインメニュー

宇宙放射線計測用TLD素子管理システム

- 素子検索
- マスターメン
- 運用データ
- 実験結果入

素子検索結果

素子	校正定数	平均偏差	バッチ	素子状態
2	1.1591	0.03%	A 2	使用中
41	1.122	3.17%	A 41	使用中
46	1.1419	1.45%	A 46	使用中
55	1.1796	1.80%	A 55	使用中
71	1.1643	0.48%	A 71	使用中
74	1.1521	0.57%	A 74	使用中
87	1.1474	0.98%	A 87	使用中
100	1.178	1.66%	A 100	使用中
116	1.1054	4.60%	A 116	使用中
123	1.1979	3.38%	A 123	使用中
176	1.1679	0.79%	A 176	使用中
185	1.1892	2.63%	A 185	使用中

素子検索

校正定数 ~

バッチ 素子状態

A 使用可
B 校正中
C 使用中
D 使用中
E 使用不可

素子選択

Handy for reference and selecting automatically

- The serial number, Lot
- Response rate for gamma-rays, High-energy protons
- The history of use
- Available/Non Available
- Under use/ Preservation

TLD PADLES

実験登録

id	大実験名称	線源名	LET	アニール日	照射日	測定日	保存温度	保存期間	吸収線量	継続	備考
12	テスト1	proton	1.1234E+00	2004/01/08	2004/01/08				0.0000E+00	<input checked="" type="checkbox"/>	
13	テスト1	Cs-137	2.2345E+00	2004/01/08	2004/01/08				0.0000E+00	<input checked="" type="checkbox"/>	
14	テスト1	Co-64	3.2345E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
15	テスト2	Cs-137	1.2344E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
16	テスト2	Co-64	2.4567E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
17	テスト3	proton	1.1111E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
18	テスト3	Co-64	2.0980E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
19	テスト4	Cs-137	1.3422E+00	2004/01/08	2004/01/08				0.0000E+00	<input type="checkbox"/>	
* 1	リザーブ		0.0000E+00						0.0000E+00	<input type="checkbox"/>	

実験結果登録

テスト1 (Cs-137 12)

id	校正定数	ReadOut	出力	備考
5	B 5 1.1428	3.33E-03	Yes	
13	B 13 1.1984	3.22E-03	Yes	
27	B 27 1.1456	2.33E-03	Yes	
44	A 44 1.1195	3.34E-03	Yes	
50	A 50 1.1209	3.44E-03	Yes	
53	A 53 1.1387	4.02E-03	Yes	
68	A 68 1.1794	4.11E-03	Yes	
81	A 81 1.1111	4.44E-03	Yes	
95	A 95 1.1043	3.33E-03	Yes	
104	A 104 1.1309	3.23E-03	Yes	
147	A 147 1.1733	2.32E-03	Yes	

13 B 13 1.1984 mSV

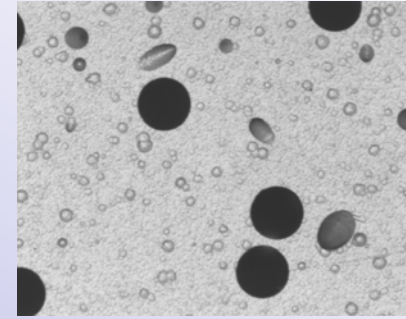
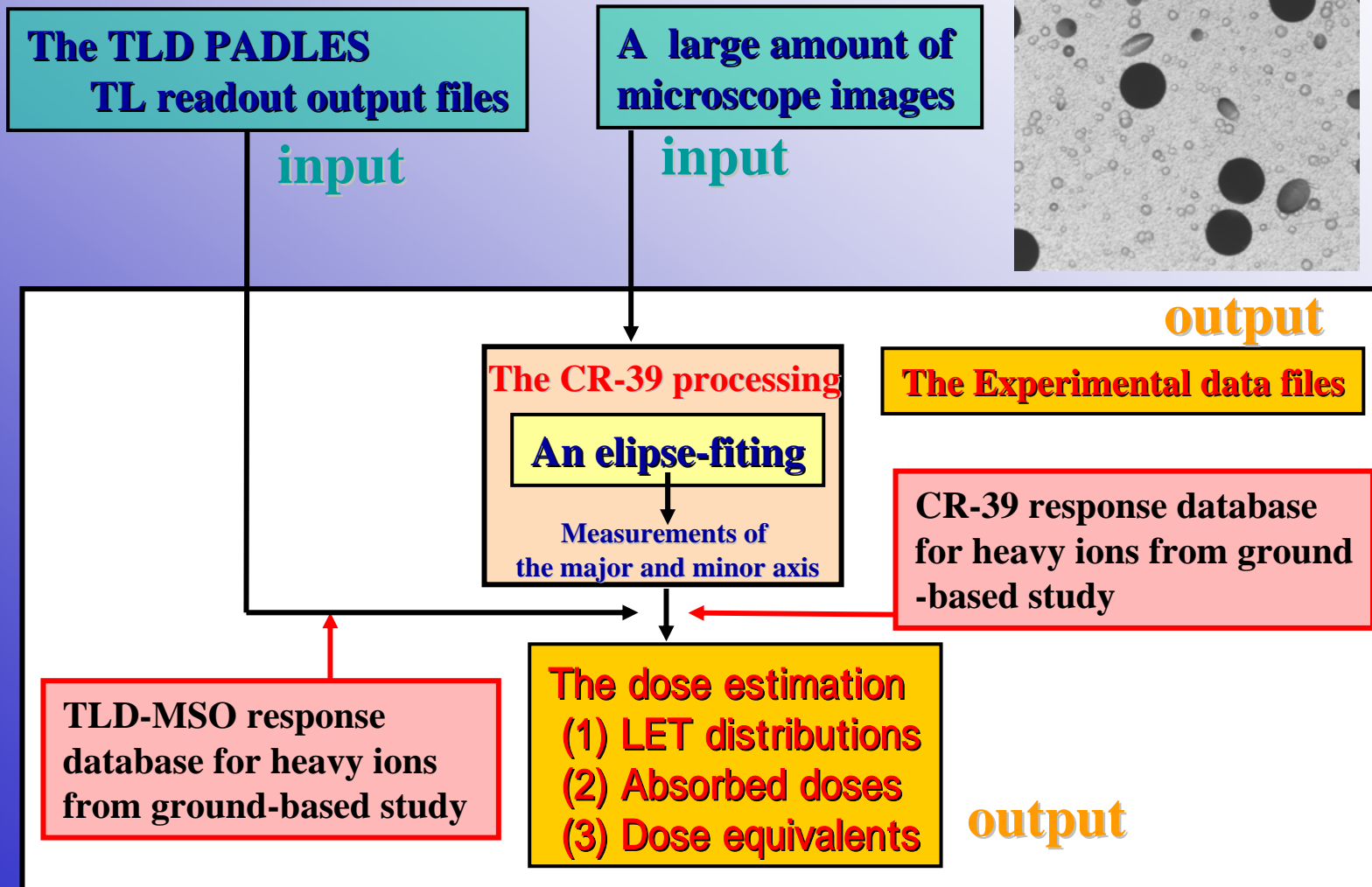
出力ファイル名

Managing the individual data of TLD elements and make the output files for AUTO PADLES

- Tserial number, Lot
- The calibration factors obtained for gamma-rays, High-energy protons
- The history of use
- TL readouts on past flight experiments

AUTO PADLES

- The Experiment data-base section
- The CR-39 processing section
- The dose estimation section



The CR-39 processing section - microscope image scan -



LuzexSE

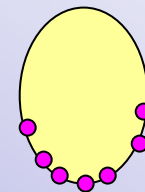
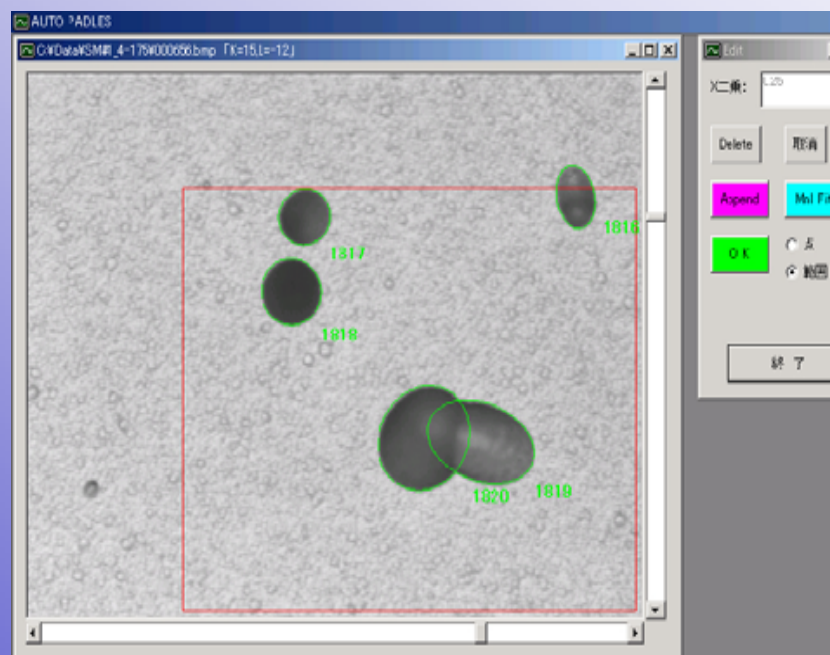
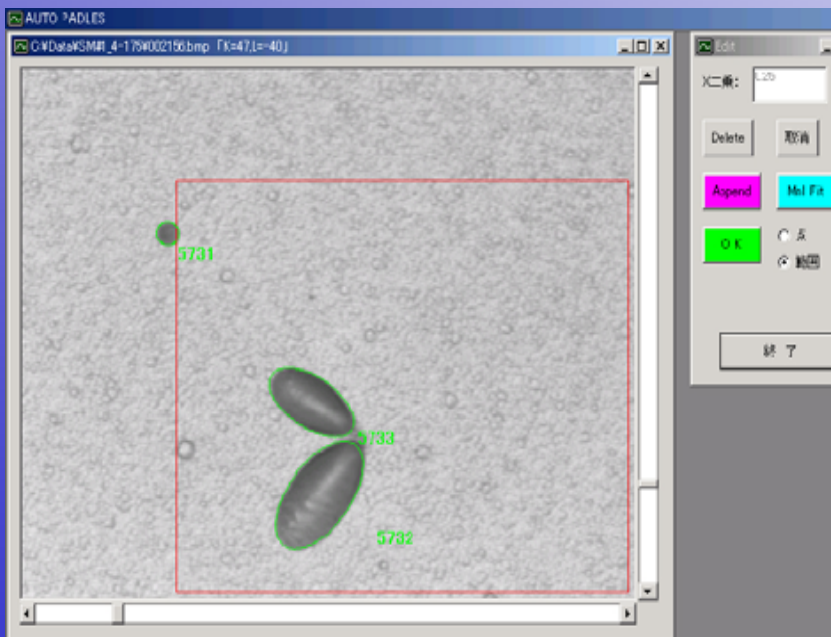
Focus : Auto-focus with an infrared marker

Scan speed : 0.4sec/image
30 min/1 cm²
(4000 images)

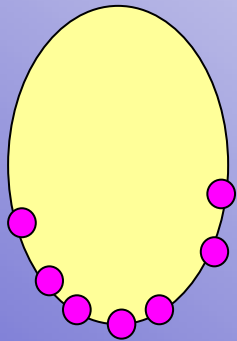
File form : BMP

The CR-39 processing section - an ellipse fitting -

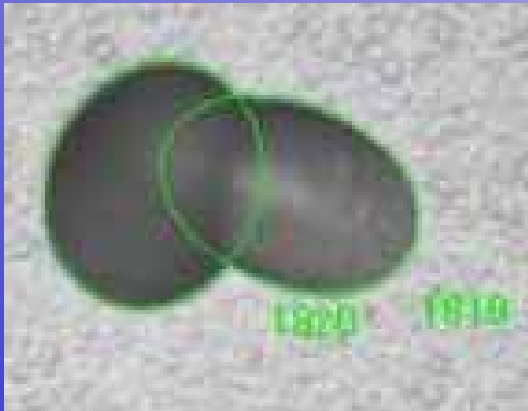
A high-speed and semi-automatic analysis system for track detectors with an ellipse fitting algorithm developed by NIRS, SEIKO precision inc.



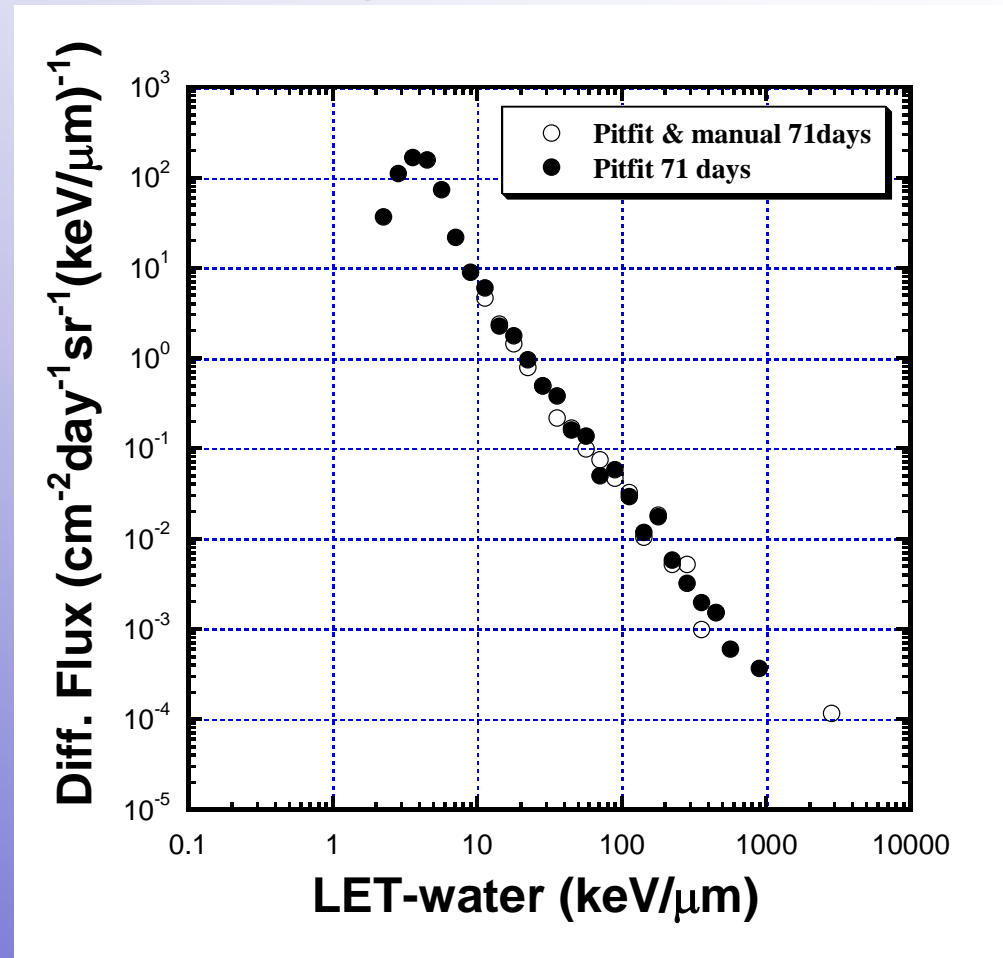
Differences of LET distribution caused by measurement methods



1. Manual measurement



2. Pit analysis measurement (automatic)

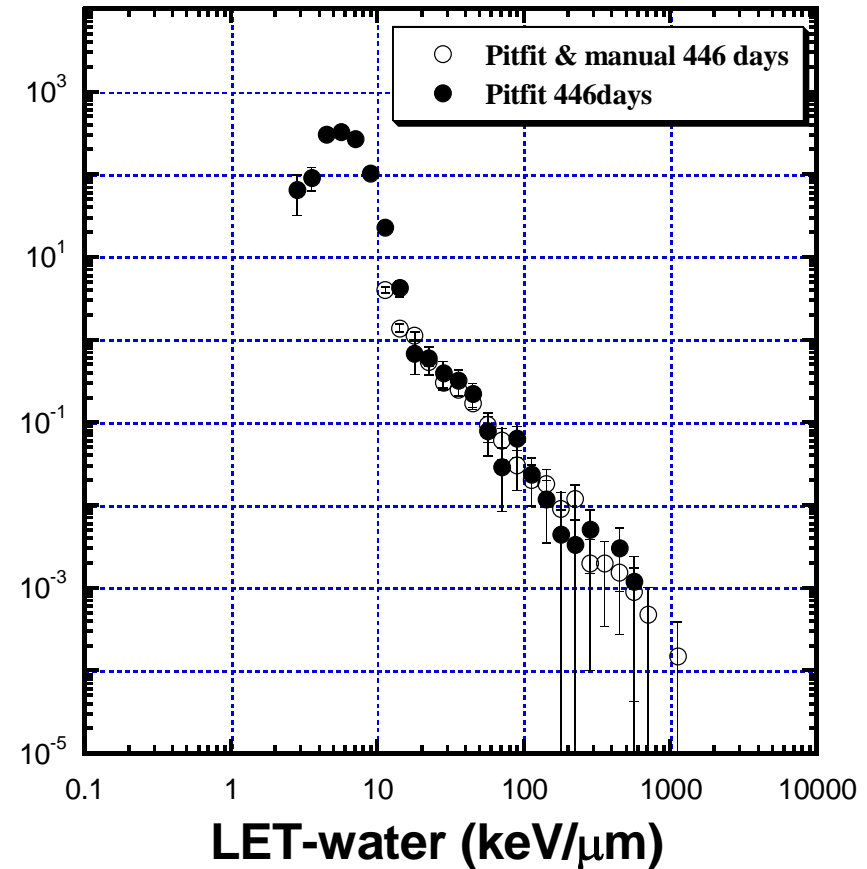
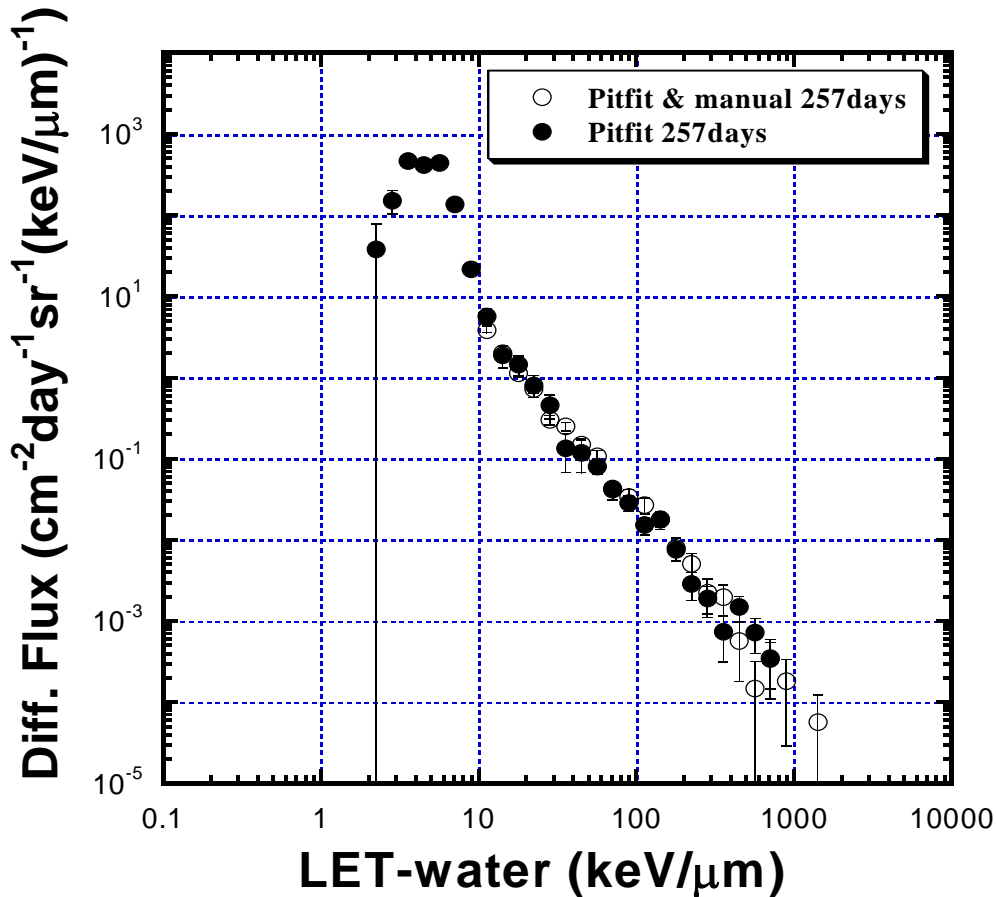




3. Dosimetric results in ISS ZVEZDA using AUTO PADLES



Differences of LET distribution caused by measurement methods



	71 days	257 days	446days
Absorbed Dose	2.0%	1.2%	2.4%
Dose Equivalent [mSv]	6.6%	5.6%	10.4%

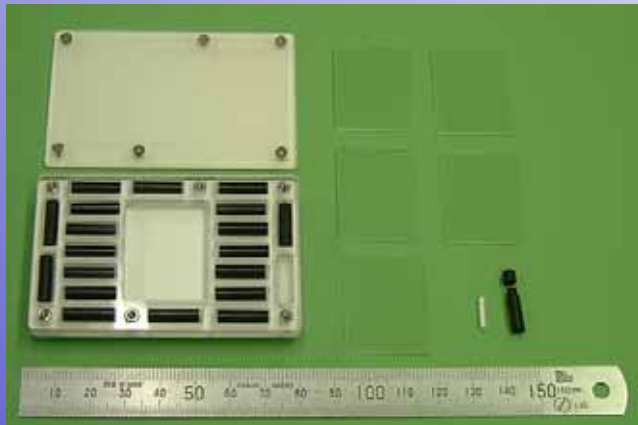
Contributions of total absorbed dose 400keV/μm



4. A support for life science experiments on ISS JEM



ISS biological research experiments proposed in the first KIBO utilization solicitation (**PADLES for experimental unit M type**)



1 PADLES / 1 unit **total 8 PADLES** will be needed.
(Without ground control)

1 PADLES : **CR-39** 16 sheets
(minimum analysis area 1cm²)
TLD-MSO 160



Analysis time required : **26 days** (208 h : 8h/day work time)

The comparison with scan speed

1 lifescience experiment need up to 10~100 sheets of CR-39

- 1 sheet of CR-39 : $178 \mu\text{m} \times 132 \mu\text{m}$ /field, 1cm^2 **4800 fields/sample**
- Plural life science experiments will be conducted on ISS JEM

We will reduce the maximum analysis and data transfer time for each experiment



We need more and more speedup of analysis time !!

Microscope type	Focus	Size of sensor (pixl)	resolu um/p		
Leica	Contrast of image processing	764 × 574	0.33	Step scan	7h 1min
Luzex	Auto-focus with an infrared marker	768 × 493	0.38	Step scan	32min
HSP-1000	Cylindrical	$2^3 \times 1^5$ (0.7 × 35mm)	0.35	Line scan	30sec or less



Passive Dosimeter for Lifescience Experiments in Space