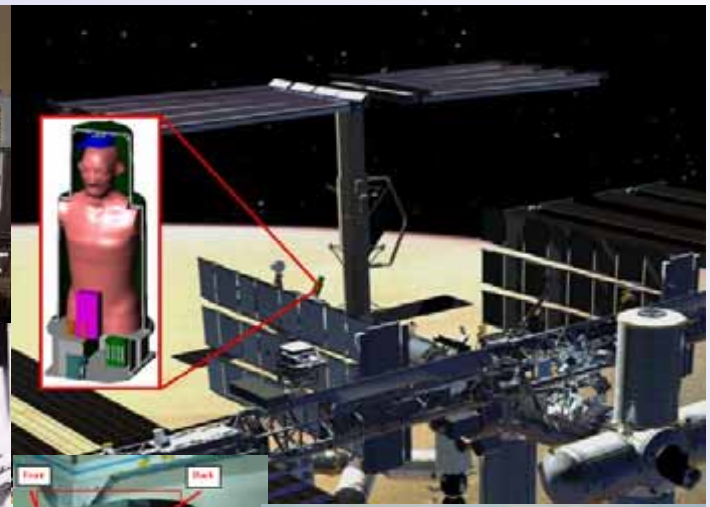
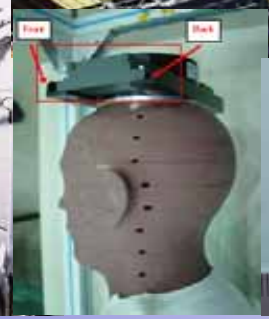
Dosimetry for space radiation in ISS lifescience experiments using PADLES system






Hiroko tawara *KEK / JAXA*

Mitsuyo masukawa, Aiko Nagamatsu *JAXA*

Hidenori kumagai *AES*

Plan of Presentation

1. Introduction

2. PADLES system
   - Ground-based experiments
   - Programs developments
   - PADLES demonstration

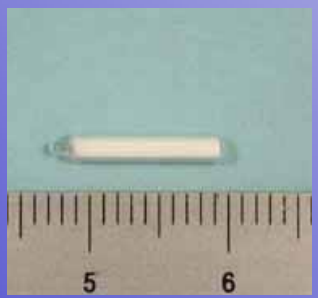
3. Dosimetric results in ISS ZVEZDA using AUTO PADLES

4. A support for life science experiments on ISS JEM

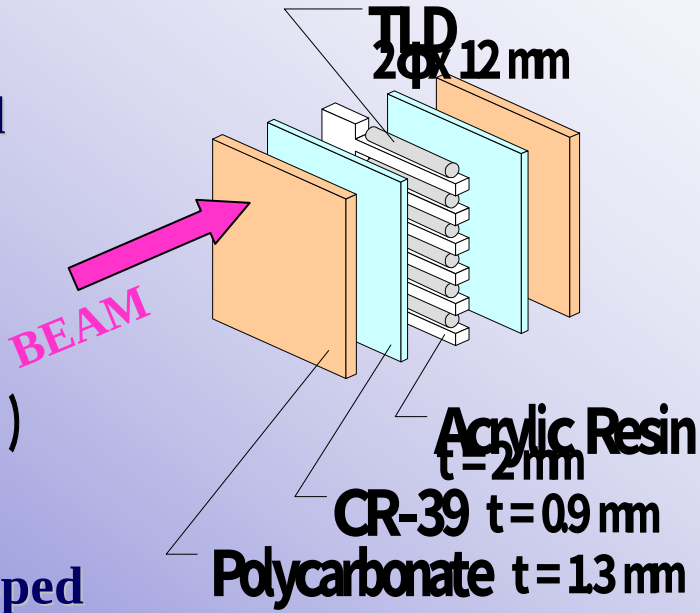
Constituent Elements

PADLES
(Passive Dosimeter for Lifescience Experiment in Space)

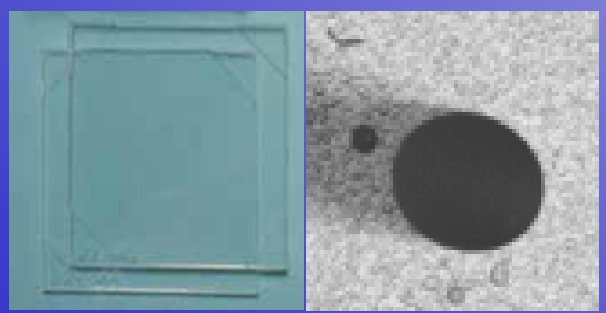
TLD-MSO-S (thermoluminescent dosimeters)



Mg_2SiO_4:Tb powder enclosed
a pyrex glass with Ar gas
(Kasei Optonics industry)



CR-39 (plastic nuclear track detectors)



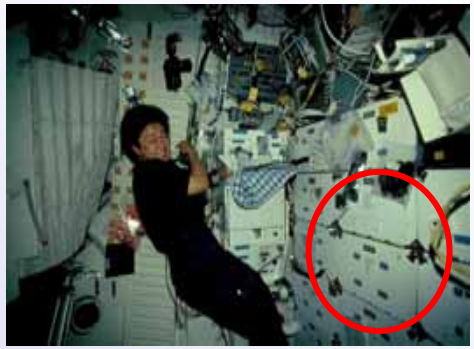
HARZLAS TD-1 are doped
with 0.1%wt NAUGARD 445
(Fukuvi Chemical industry)

Flight experiments

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

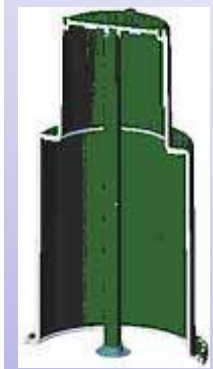
31/8/2001 – 10/11/2002 (71-446 days)

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）

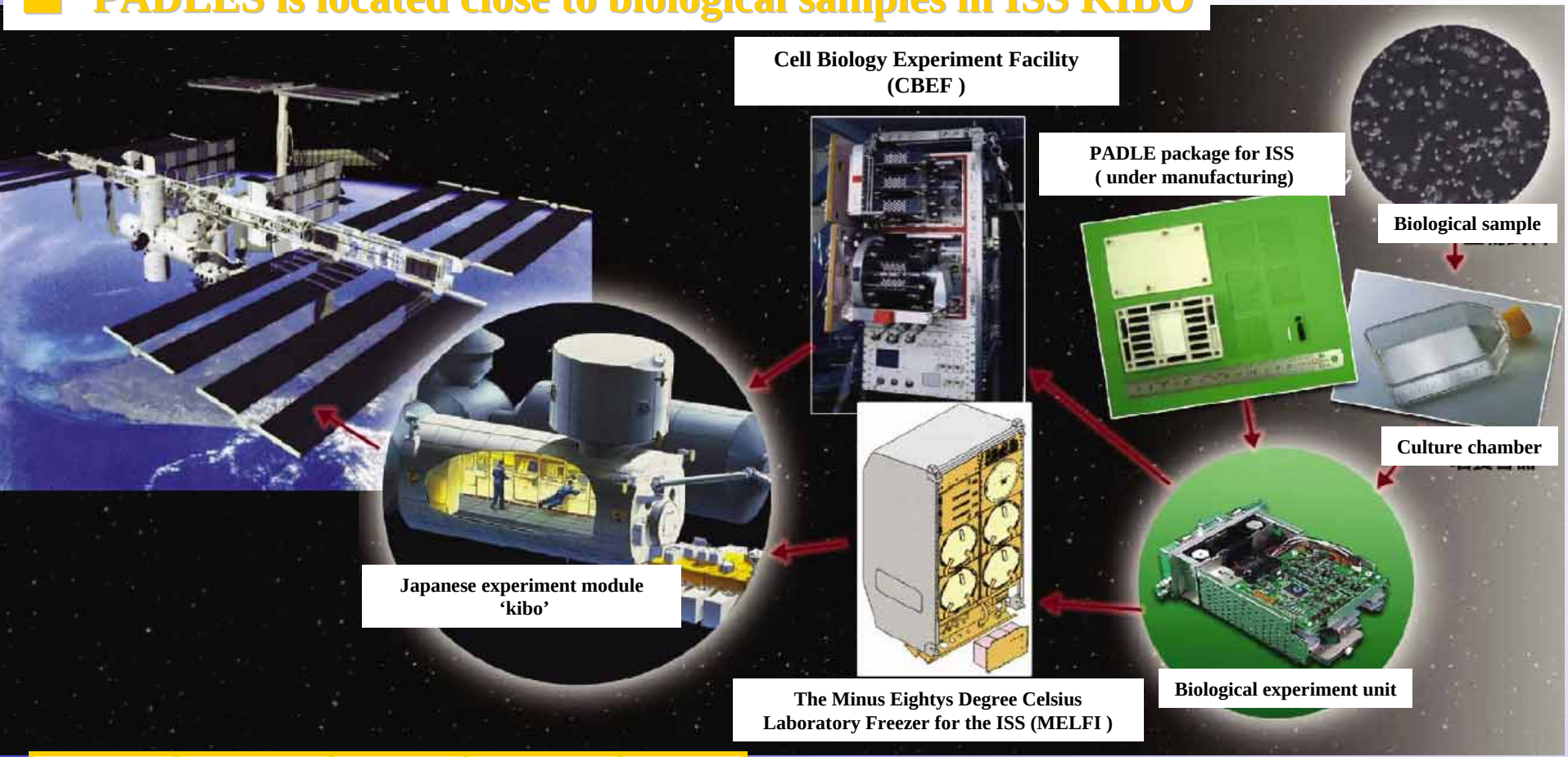
Title：Detection of Changes in LOH Profile of TK mutants of Human Cultures Cells

Biological sample ：human glioma cell lines

Conditions：not yet decided

2. PADLES system

PADLES is located close to biological samples in ISS KIBO



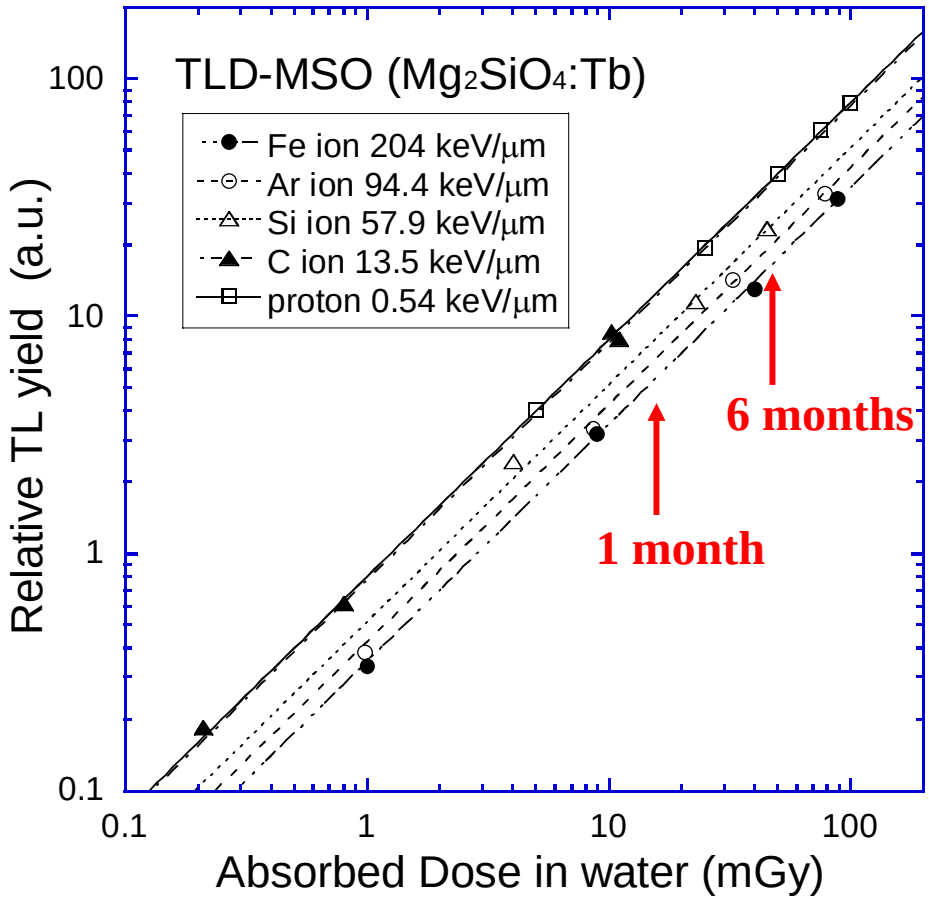
Irradiation temperature	Storage temperature	Sample Condition	Storage on ISS KIBO	Facility
-60℃	-80℃	freezing	freezers	MELFI
-20℃	-20℃	freezing	freezers	MELFI
+4℃	+4℃	cold	refrigerators	MELFI
+25℃(RT)	+25℃(RT)	culture	incubator	CBEF
+37℃	+37℃	culture	incubator	CBEF

Load period：3～6 months

temperature：-80℃～37℃

Ground-based experiments in HIMAC

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



Absorbed doses on a space shuttle

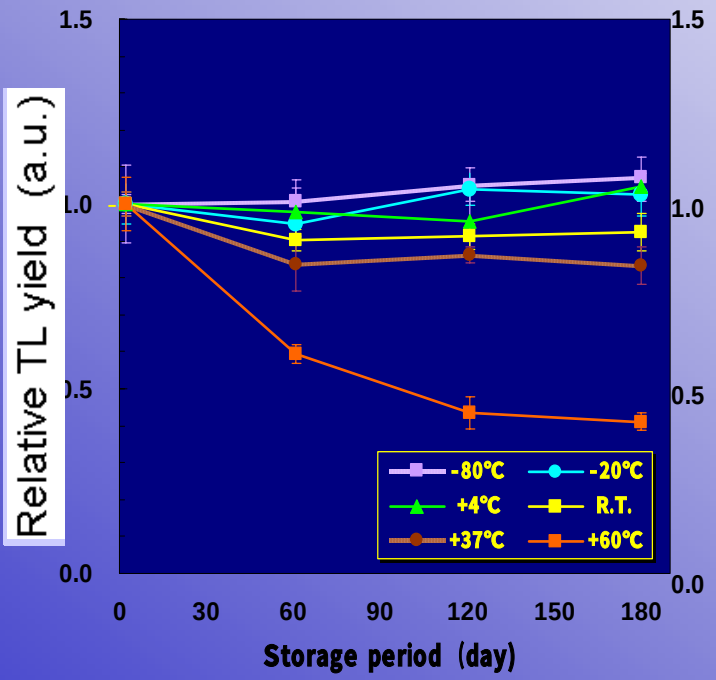
(An altitude and An angle of inclination are equivalent to ISS, STS-89,-91)

0.34mGy/day
10.08mGy/month
60.48mGy (0.064Gy) /6 month

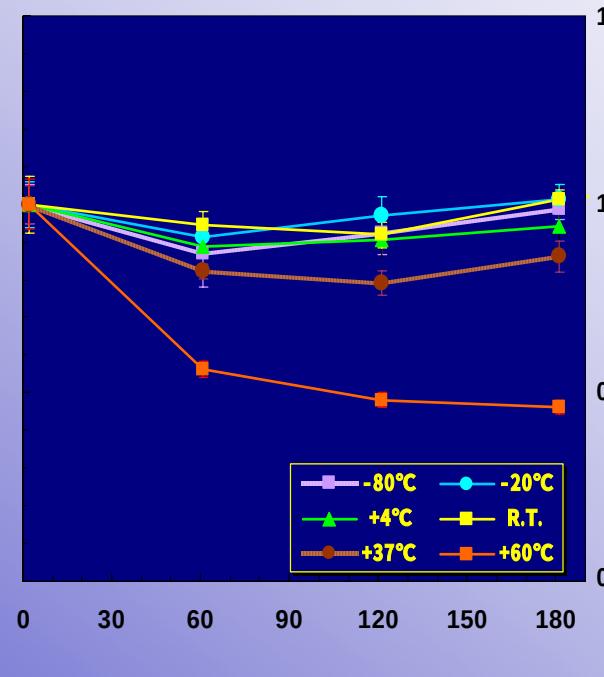
Ground-based experiments in HIMAC

TLD-MSO：Fading effects for heavy ions

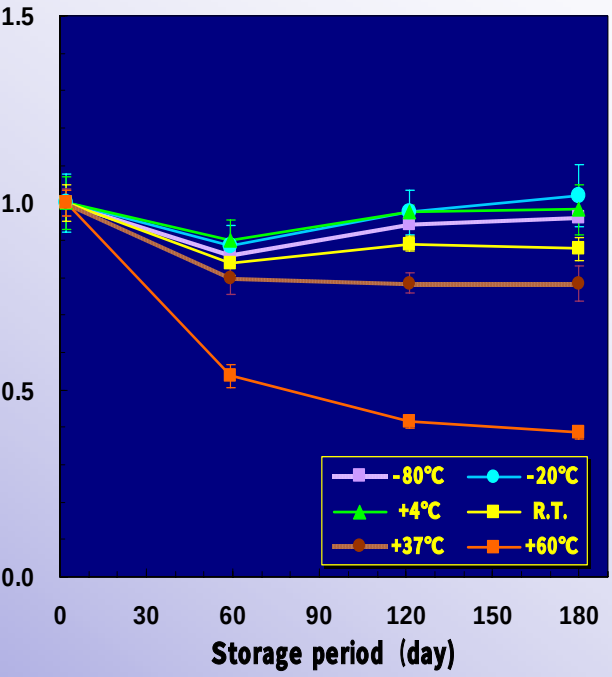
H 0.54keV/μm, 10mGy



He 2.3keV/μm, 50mGy

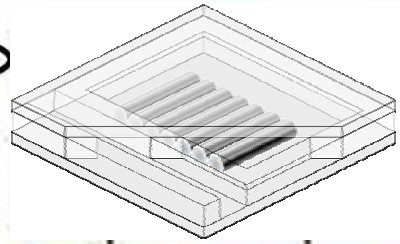


Fe 200keV/μm, 50mGy



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

Programs – PADLES analysis procedure –



Sample return

Flight Experiments

TLD-MSO

CR-39

Chemical Etching

8 μm short ething for SRP
23 μm long ething for LRP
7N NaOH

Microscope Image scanning

TL read-out

Image processing

Measurement of etch pit opening shape

TLD PADLES

Data-base for TLD individual data

AUTO PADLES

LET distribution

A dose equivalent
<10 keV/μm

An absorbed dose
≧10 keV/μm

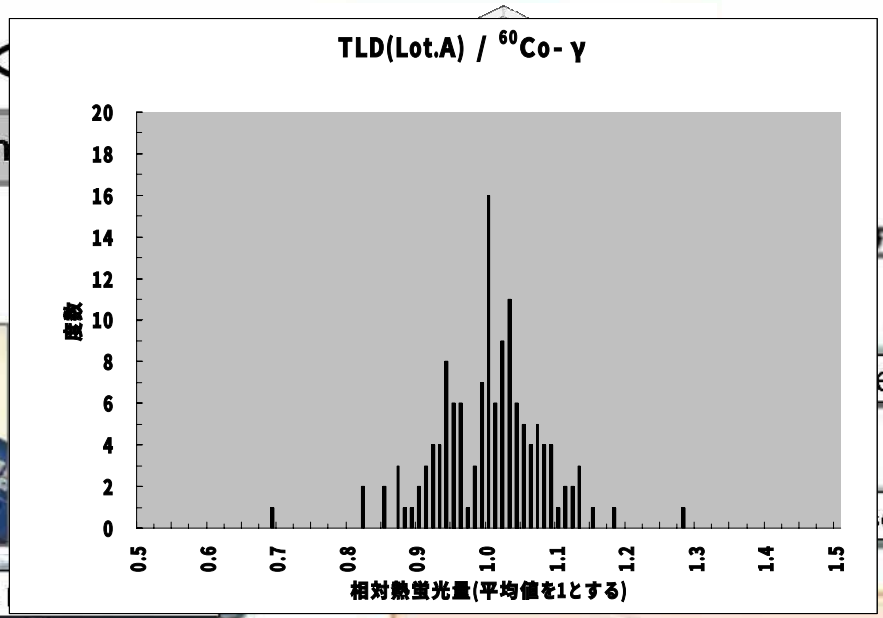
A dose equivalent
≧10 keV/μm

Data offering to biological researchers

Total absorbed dose

Total dose equivalent

Programs -an improvement of the precisions-



Flight Experimen

R-39

emical Etching

cope Image scann

TL

TLD PADLES

Data-base for TLD individual data

Image processing

Measurement of etch pit opening shape

AUTO PADLES

LET distribution

An absorbed dose
≧10 keV/μm

A dose equivalent
≧10 keV/μm

tal absorbed dose

Total dose equivalent

Data offering to biological researchers

CR-39 data-base

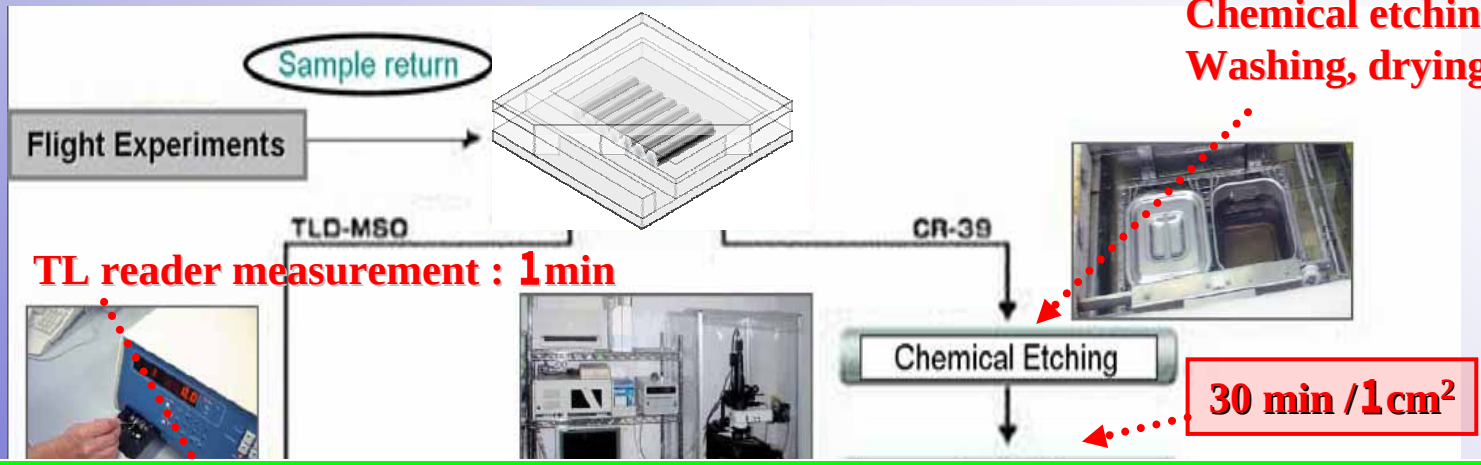
- A calibration curve
- Calibration curves at various incident angles

TLD-MSO data base

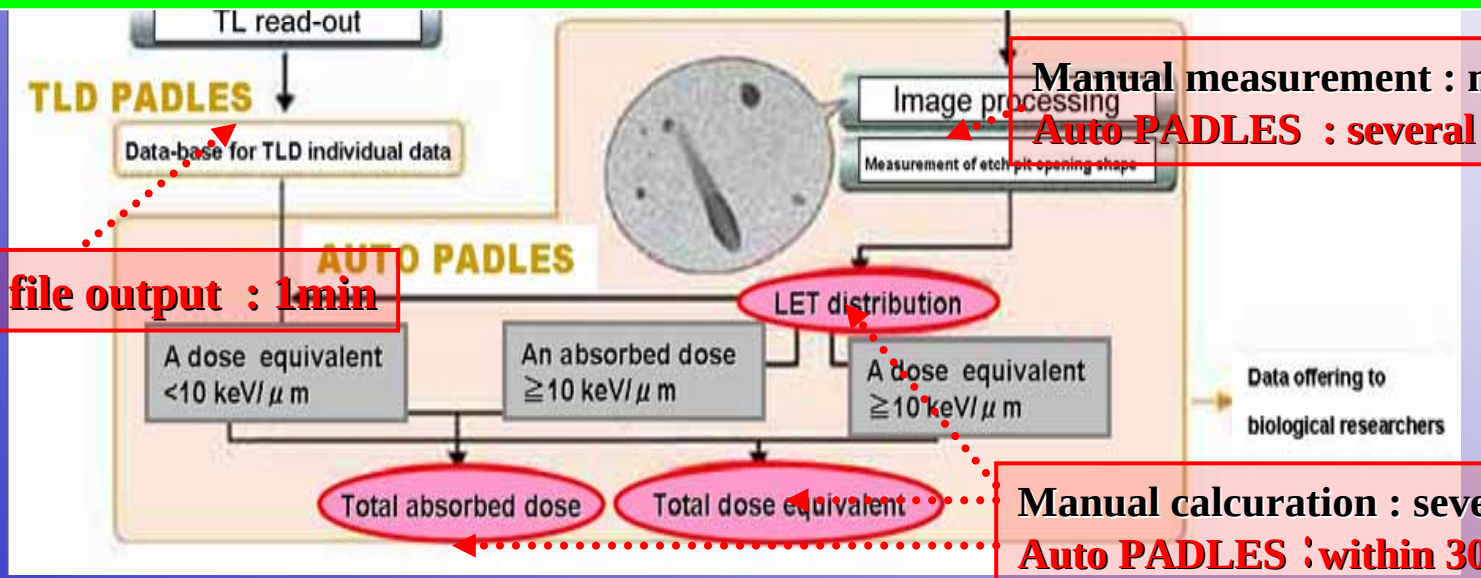
- The calibration factors (Co-60、Cs-137、Proton)
- LET response functions
- Fading effects

Programs-High-speed and semi automatic analysis-

Materialization of high speed analysis by JAXA

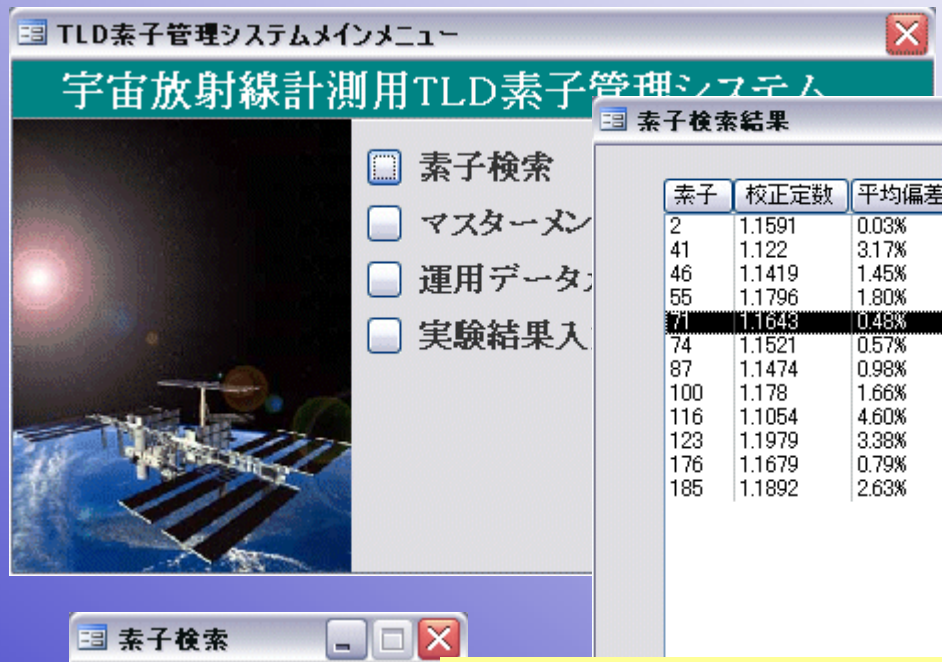


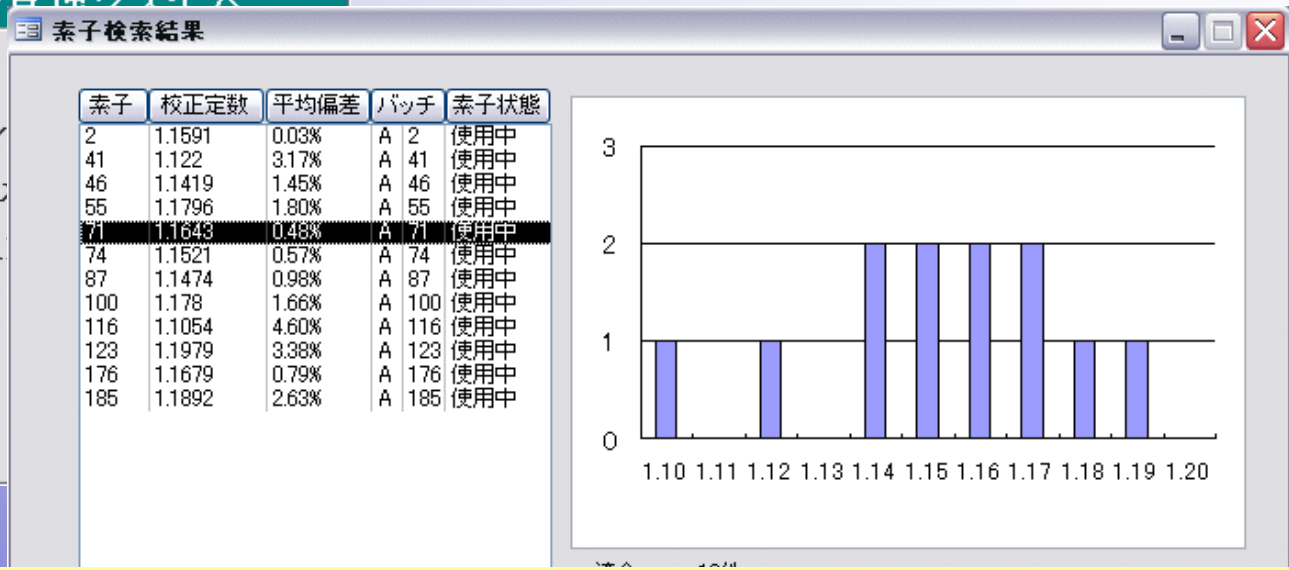
The maximum analysis and data offering time to about 2 weeks for each experiment

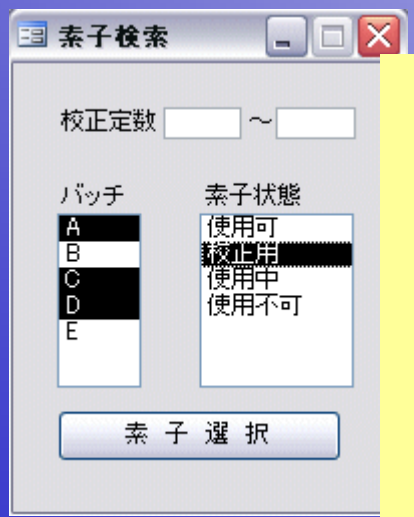


PADLES demonstration

TLD PADLES







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**

PADLES demonstration

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	☑	
13	テスト1	Cs-137	2.2345E+00	2004/01/08	2004/01/08				0.0000E+00	☑	
14	テスト1	Co-64	3.2345E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
15	テスト2	Cs-137	1.2344E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
16	テスト2	Co-64	2.4567E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
17	テスト3	proton	1.1111E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
18	テスト3	Co-64	2.0980E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
19	テスト4	Cs-137	1.3422E+00	2004/01/08	2004/01/08				0.0000E+00	☐	
*	(ﾊﾞｰ)		0.0000E+00						0.0000E+00	☐	

実験結果登録

テスト1(Cs-137 12)

id　　校正定数

素子id	バッチ	バッチ	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

PADLES demonstration

AUTO PADLES

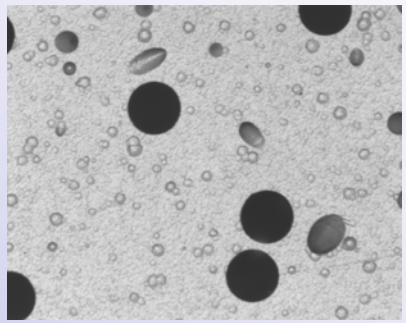
- The Experiment data-base section
- The CR-39 processing section
- The dose estimation section

The TLD PADLES
TL readout output files

input

A large amount of
microscope images

input



output

The Experimental data files

The CR-39 processing

An elipse-fiting

Measurements of
the major and minor axis

CR-39 response database
for heavy ions from ground
-based study

TLD-MSO response
database for heavy ions
from ground-based study

The dose estimation
(1) LET distributions
(2) Absorbed doses
(3) Dose equivalents

output

AUTO PADLES for CR-39 analysis

The CR-39 processing section - microscope image scan -

LuzexSE

Focus : Auto-focus with an infrared marker

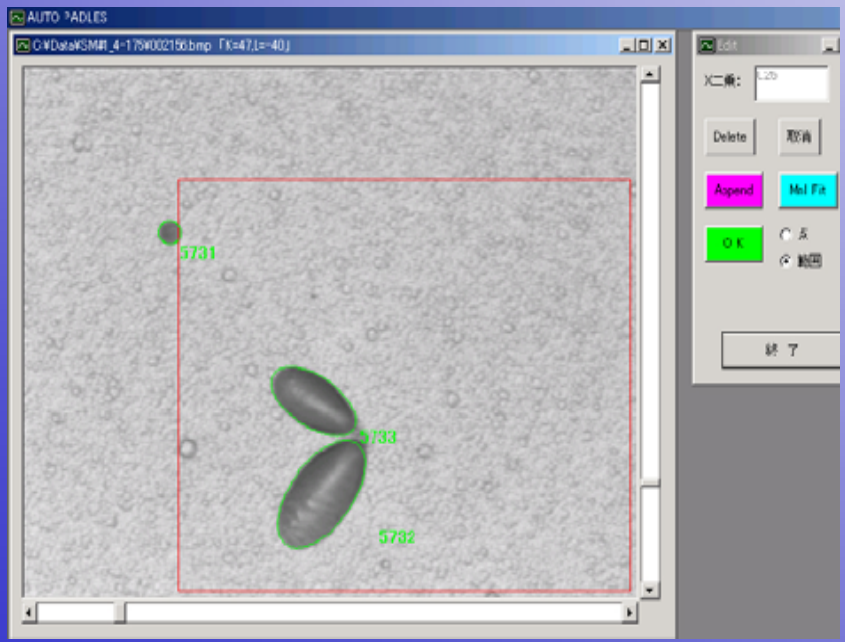
Scan speed : 0.4sec/image
30 min/1cm^2
(4000 images)

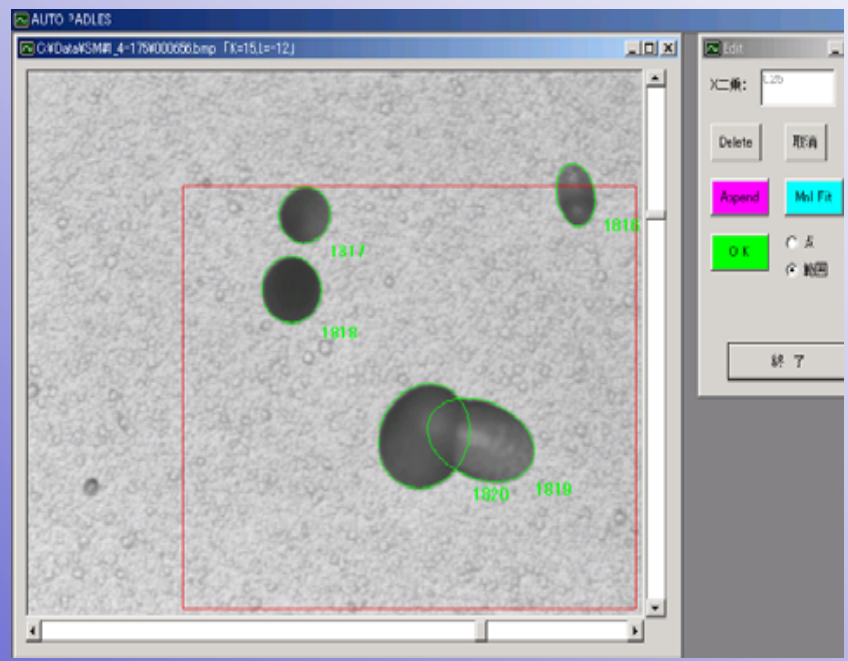
File form : BMP

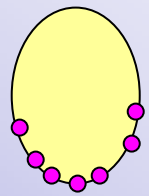
AUTO PADLES for CR-39 analysis

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.

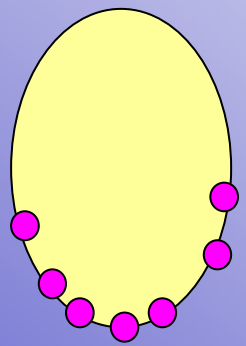




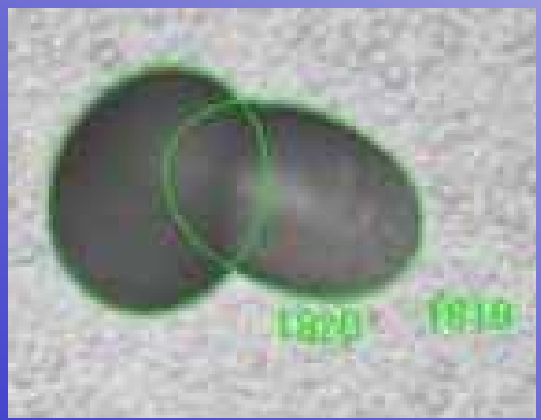


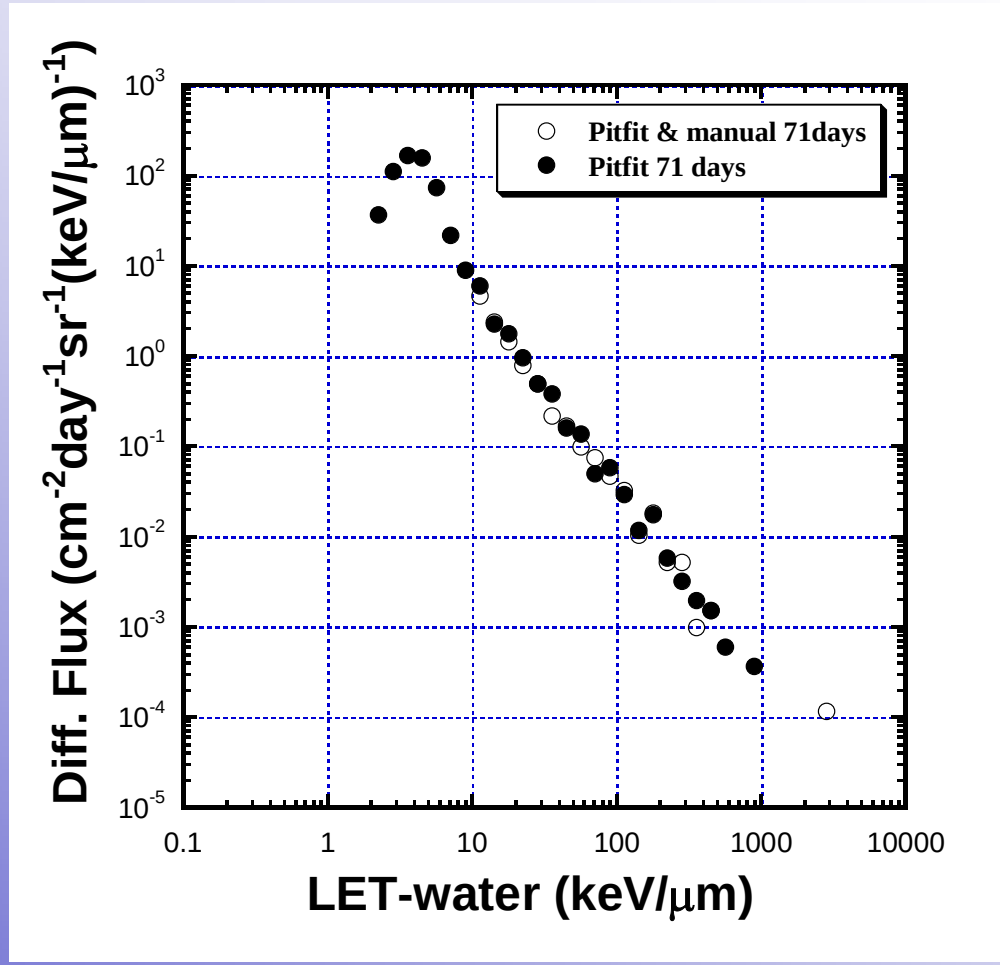
3. Dosimetric results in ISS ZVEZDA using AUTO PADLES

Differences of LET distribution caused by measurement methods



1. Manual measurement

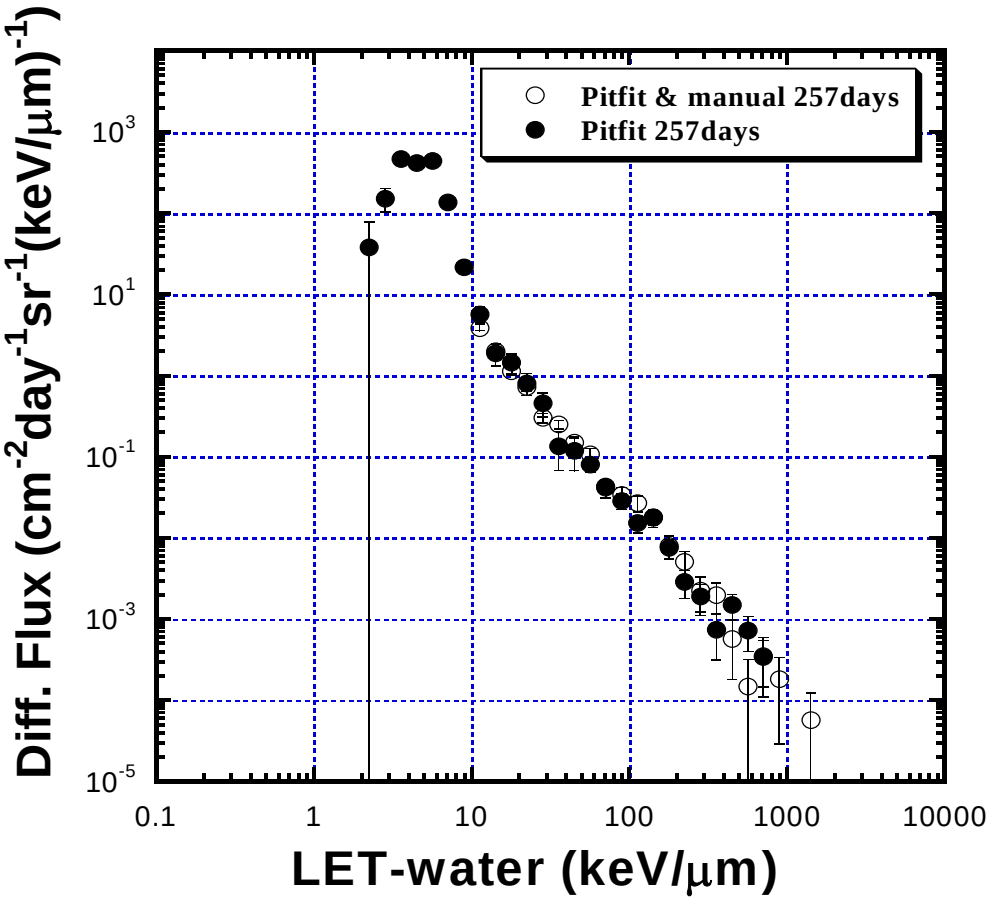


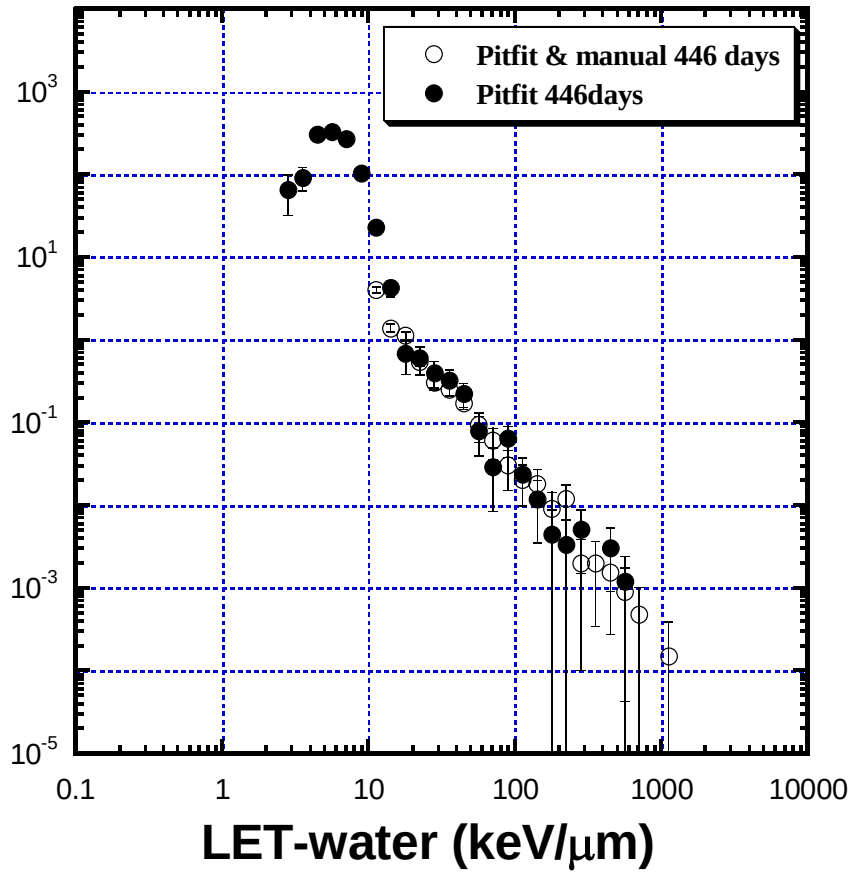


2. Pit analysis measurement (automatic)

3. Dosimetric results in ISS ZVEZDA using AUTO PADLES

Differences of LET distribution caused by measurement methods



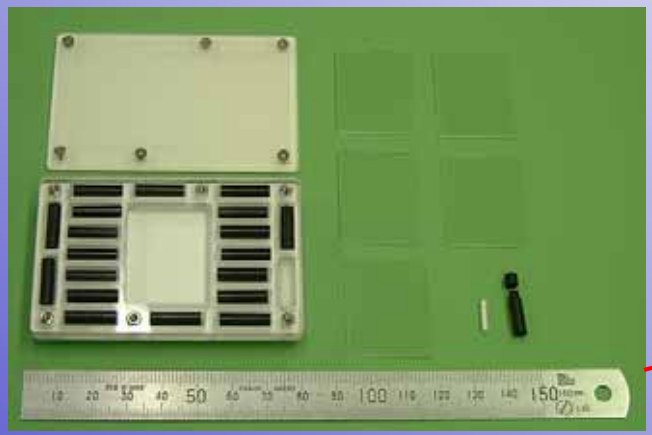


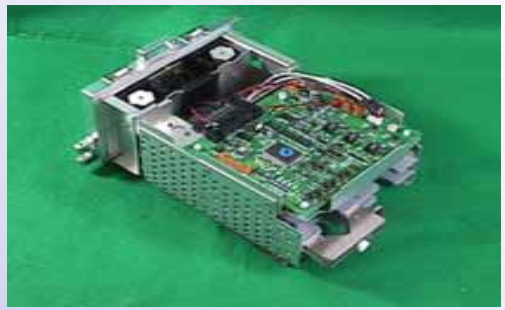
	71 days	257 days	446days
Absorbed Dose	2.0%	1.2%	2.4%
Dose Equivalent [mSv]	6.6%	5.6%	10.4%

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)





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

1 PADLES : CR-39 16 sheets
(minimum analysis area 1cm^2)
TLD-MSO 160

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

4. A support for life science experiments on ISS JEM

The comparison with scan speed

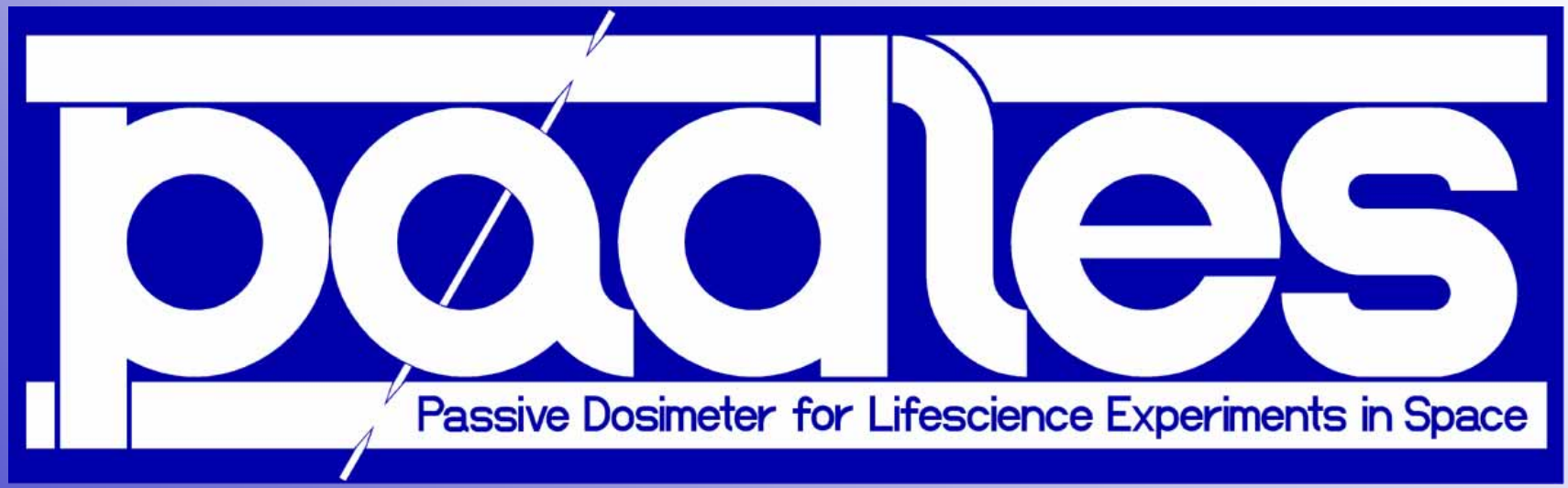
1 lifescience experiment need up to 10~1

- 1 sheet of CR-39 : 178μm×132μm /field, 1cm²
  → 4800 fields/sample
- Plural life science experiments will be conducted

We will reduce the maximum analysis and da
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	2^3×1^5 (0.7×35mm)	0.35	Line scan	30sec or less


pades
Passive Dosimeter for Lifescience Experiments in Space