Current and Future Status of ICCHIBAN Project and Reanalysis of Dosimeteric Data from ICCHIBAN-1 and ICCHIBAN-3

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Today's Menu of ICCHIBAN

- Y. Uchihori : Current and future status of ICCHIBAN project and reanalysis of dosimetric data from ICCHIBAN-1 and ICCHIBAN-3
- H. Kitamura : Future ICCHIBAN Experiments Using Proton Beams
- N. Yasuda : Brief results from the ICCHIBAN/Space intercomparison 2 and ongoing experiments to resolve differences in CR-39 PNTD measurements
- I. Jadrnickova : Studies of various influence of various factors on dose quantities measured with CR-39 detectors onboard spacecraft
- S. Kodaira : Variation of dose quantities from CR-39 detectors onboard ISS Russian segment: etching and angular correction

ICCHIBAN Project

一番

InterComparison for Cosmic-rays with Heavy Ion Beams At NIRS

- Determine the response of space radiation dosimeters to heavy ions of charge and energy similar to that found in the galactic cosmic radiation (GCR) spectrum.
- Compare response and sensitivity of various space radiation monitoring instruments. Aid in reconciling differences in measurements made by various radiation instruments during space flight.
- Establish and characterize a heavy ion "reference standard" against which space radiation instruments can be calibrated.

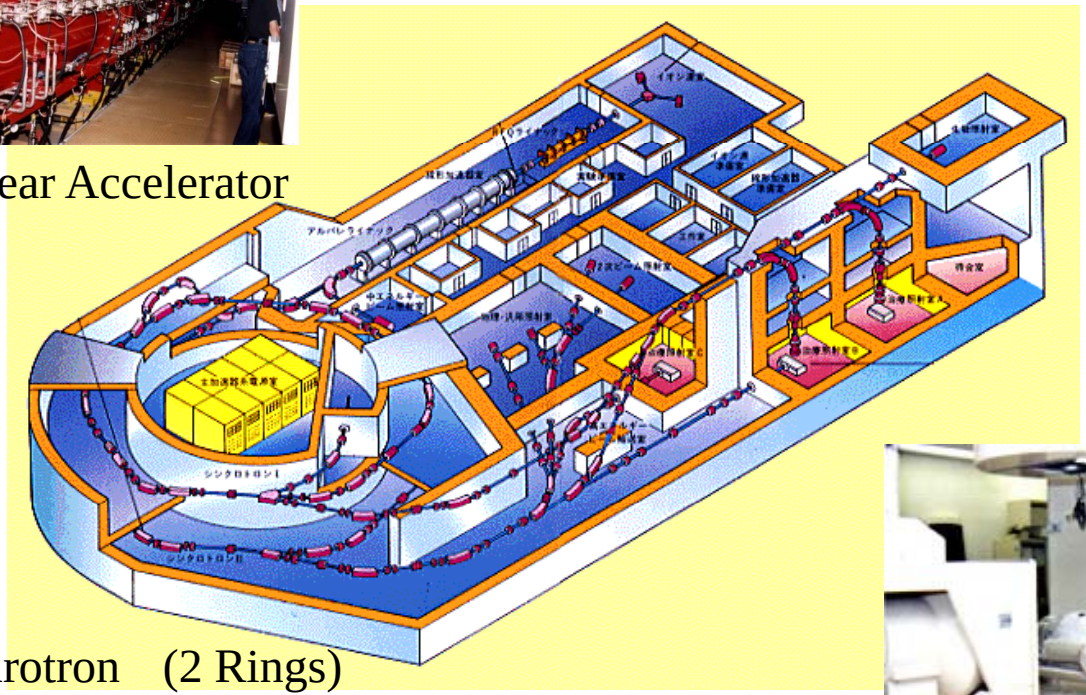
http://www.nirs.go.jp/ENG/rd/1ban/index.html

The Past Experiments

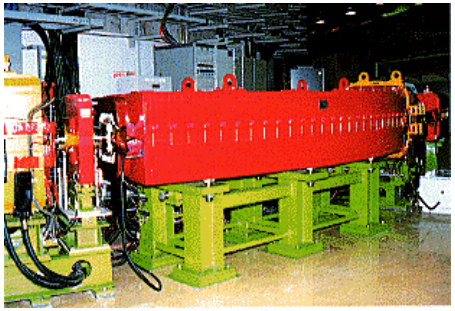
Feb. 11-13, 2002	1st ICCHIBAN Experiment (For Active Detectors)	C400, Fe400
May 23-28, 2002	2nd ICCHIBAN Experiment (For Passive Detectors)	He150, C400, Si490, Fe500
Feb. 3-6, 2003	3rd ICCHIBAN Experiment (For Active Detectors)	Si800, Fe500
May 19-30, 2003	4th ICCHIBAN Experiment (For Passive Detectors)	He150, C400, Ne400, Fe500, …
Sep. 6-7, 2003	1st Proton ICCHIBAN Experiment (For All Detectors)	p70-250
Feb. 14-17, 2004	5th ICCHIBAN Experiment (For Active Detectors)	He150
June 4-15, 2004	6th ICCHIBAN Experiment (For Passive Detectors)	C135, Ar500, Kr400, …
Sep. 24-26, 2004	1st NSRL ICCHIBAN Experiment (For All Detectors)	p1000, O1000, Fe1000
Sep. 13-17, 2005	7th and 8th ICCHIBAN Experiment (For Active and Passive Detectors)	O400, Fe300, He150, C400, ...
Oct. 26-27, 2006	1st CERF ICCHIBAN Experipment (For All Detectors)	≤200 GeV neutrons

HIMAC (Heavy Ion Medical Accelerator in Chiba)

Linear Accelerator



Synchrotron (2 Rings)



Available Ions

p, He, C, Ne, Si, Ar, Fe, Kr, Xe, …

(Carbon for Therapy)

Energies

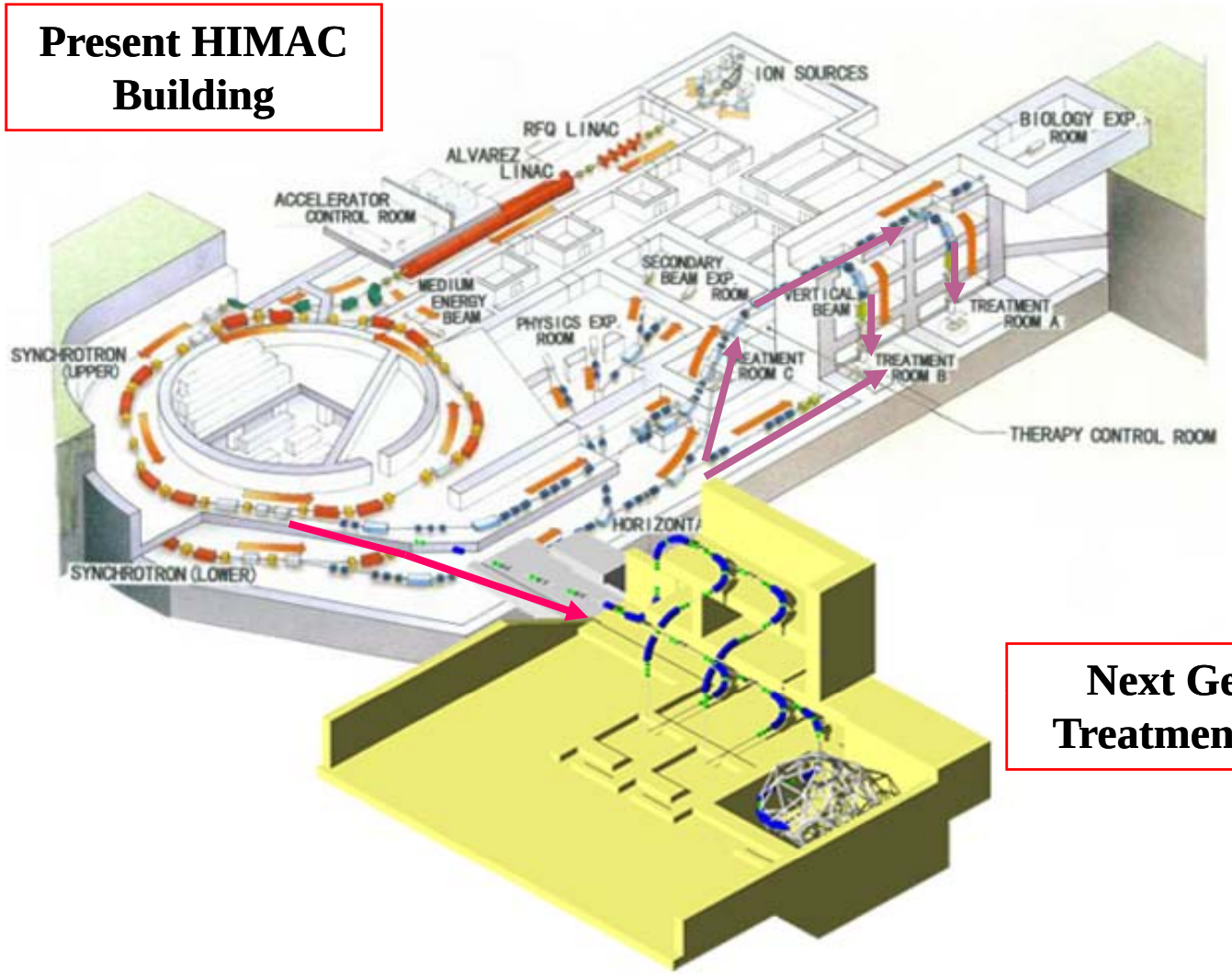
125～800MeV/u

3 Treatment Rooms

There are exposure rooms for physical and biological experiments.

Next Generation Treatment Building

Present HIMAC Building



Next Generation Treatment Building

Participants

1	Armenia	YPI (Yerevan Physics Institute, Yerevan)
2	Austria	ARCS (Austrian Research Centers, Seibersdorf)
3	Austria	ATI (Atomic Institute of the Austrian Universities, Vienna University of Technology, Vienna)
4	Belgium	SCK-CEN (Belgian Nuclear Research Center, Mol)
5	Bulgaria	STIL-BAS (Solar Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, Sofia)
6	Czech Rep.	NPI (Nuclear Physics Institute of the Academy of Sciences of the Czech Republic, Prague)
7	Germany	DLR (German Aerospace Center, Cologne)
8	Germany	Kiel University (Kiel)
9	Hungary	KFKI AEKI (KFKI Atomic Energy Research Institute, Hungarian Academy of Sciences, Budapest)
10	Japan	JAXA (Japan Aerospace Exploration Agency, Tsukuba)
11	Japan	NIRS (National Institute of Radiological Sciences, Chiba)
12	Japan	Waseda University (Tokyo)
13	Poland	INP (Institute of Nuclear Physics, Polish Academy of Sciences, Krakow)
14	Russia	IMBP (Institute of Biomedical Problems, State Research Center of the Russian Federation, Moscow)
15	UK	HPA (Health Protection Agency, Chilton)
16	USA	BNL (Brookhaven National Laboratory, New York)
17	USA	CARR (NASA Center for Applied Radiation Research, Prairie View)
18	USA	Eril Research Inc. (Stilwater)
19	USA	LBNL (Lawrence Berkeley National Laboratory, Berkeley)
20	USA	NASA-JSC (NASA Johnson Space Center, Houston)
21	USA	Oklahoma State University (Stilwater)

Participants for Active Detectors

Institution	Country	Name of Detectors	Detection Principle
ARCS	Austria	TEPC SiPC	Proportional Counter
BNL	USA	NSRL Dosimeters	Ion Chamber
CARR	USA	Shuttle-style TEPC	Proportional Counter
Eril Research	USA	Dosimeter Package	TLD+CR-39
IMBP	Russia	DB-8 ISS-Liulin	Silicon
JAXA/ISAS	Japan	Reference Detectors	Silicon&SC
Kiel Univ.	Germany	DOSTEL-1, 2, D	Silicon Telescope
LBNL	USA	Ground Base Detector	Silicon Stack + SC
NASA-JSC	USA	Shuttle & ISS-TEPC IV-CPDS	Proportional Counter Silicon Telescope + C
NIRS	Japan	NIRS Detectors Liulin-4J	PSD, SC, Binary Filter, Silicon
STIL-BAS	Bulgaria	Liulin E087 Liulin-5	Silicon
Waseda Univ. & JAXA	Japan	RRMD-III	Silicon Telescope

Participants of Passive Detectors

Institution	Country	Detectors
ATI	Austria	TLD-600 (6LiF:Mg, Ti), TLD-700 (7LiF:Mg, Ti), CR-39 PNTD
DLR	Germany	TLD-100 (LiF:Mg,Ti)
ERI	USA	CR-39 PNTD, TLD-700 (7LiF:Mg, Ti)
HPA (NRPB)	UK	PADC PNTD
IMBP	Russia	TLD-100 (LiF:Mg,Ti), CR-39 PNTD, Biomarker Seeds
INP	Poland	TLD-100 (LiF:Mg,Ti), LiF:Mg,Cu,P TLD, LiF:Mg,Ti, CR-39 PNTD
JAXA/NASDA & KEK	Japan	MSO TLD (Mg2SiO4:Tb), CR-39 PNTD
KFKI AEKI	Hungary	Pille TLD System(CaSO4:Dy), CR-39 PNTD
NASA JSC	USA	TLD-100 (LiF:Mg,Ti), TLD-300 (CaF2:Tm), TLD-600 (6LiF:Mg, Ti), TLD-700 (7LiF:Mg, Ti)
NIRS	Japan	Luilin-4J MDU, CR-39 PNTD(TD-1), CR-39 PNTD(TT-P1), TLD-100 (LiF), Al2O:C Luxel, Glass-Ag(GD&GR)
NPI	Czech Rep.	CR-39 PNTD, Melinex/Bi PNTD, Al2O3:C TLD, Al-P Glass
OSU	USA	Al2O3:C OSL, Luxel Al2O3 OSL, Al2O3:C TLD, TLD-100 (LiF:Mg,Ti)
SCK-CEN	Belgium	TLD (MCP-7, TLD-700), OSL
YPI	Armenia	Nuclear Emulsion Sheet

Schedule of SpaceIntercomparison

SpaceIntecomparison-1 experiment

- Detectors were launched from Jan 29 - Apr 30, 2004 (91.5 days).
- 4 institutes were participated

SpaceIntecomparison-2 experiment

- Detectors were launched from May 15 - Oct 21, 2007. (160 days).
- 12 institutes participated.

SpaceIntecomparison-3 experiment

- Detectors was launched on May 2008.
- 12 institutes have participated.

The Future Experiments

- CR-39 ICCHIBAN
  - In 2008, CR-39 ICCHIBAN has been performed by N. Yasuda, I. Jadrnickova and H. Kitamura.
  - The current status will be presented by N. Yasuda.
- Proton-ICCHIBAN-2
  - Proton-ICCHIBAN-2 will be performed using Medical-Cyclotron in NIRS in FY2009.
  - The detail will be presented by H. Kitamura.
- Space-Intercomparison
  - Space-Intercomparison-3 is now on going. The detectors will be returned on Oct., 2008 and delivered to the participants in this winter.
- The Next HIMAC-ICCHIBAN
  - Not scheduled but your proposal with new idea is welcomed.

Request of Reports of Active Detectors in IC-5, 7, NSRL-IC and others

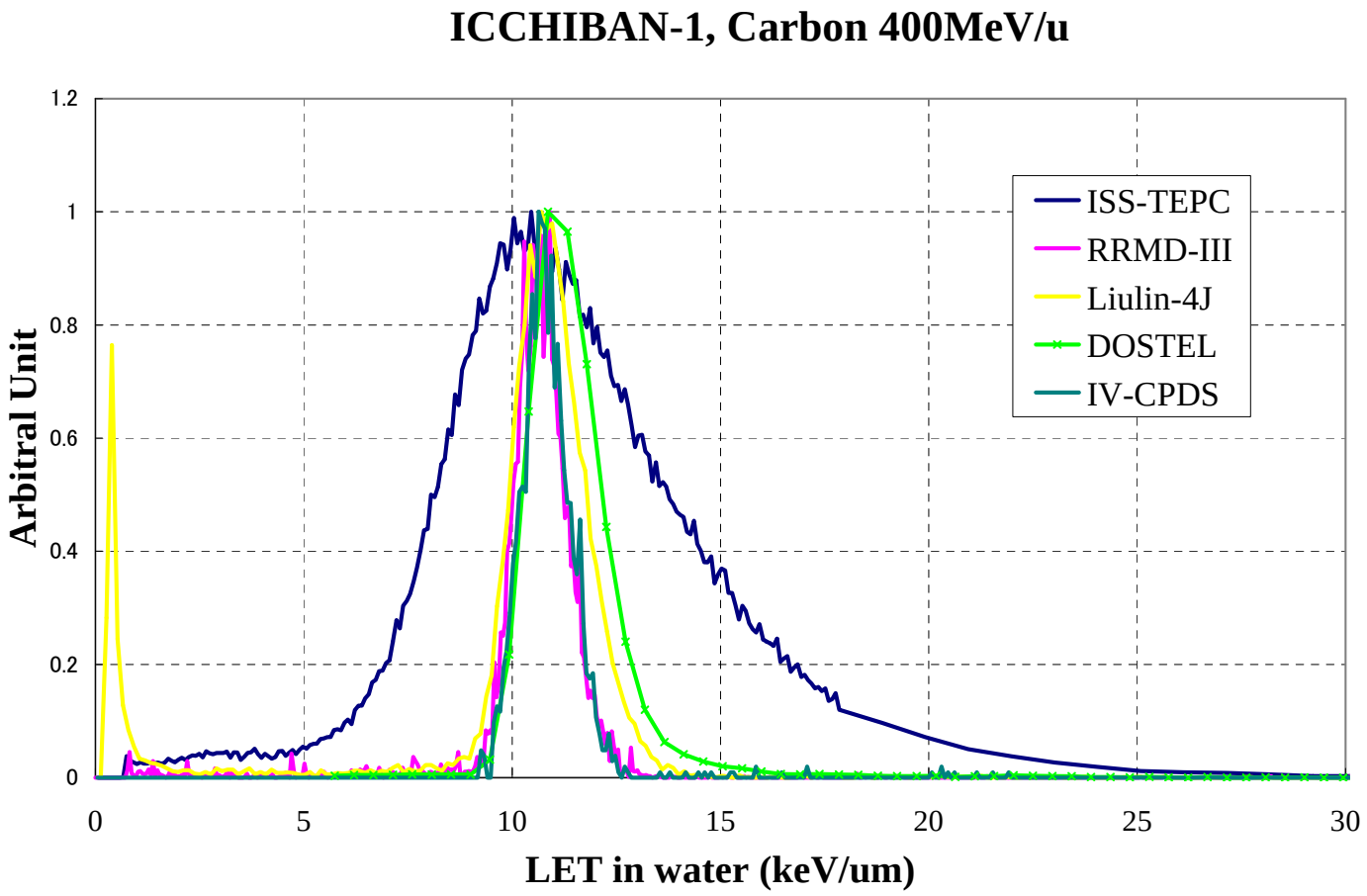
- Now, we would like to start to gather your reports of experiments for the active detectors.
- To avoid your additional and bored works, we request that you prepare some spread sheets of your data and analysis results.
- However, if you have not yet written ICCHIBAN reports, we request your reports including of the detail of your instruments and analysis methodologies.

Guidance of Calculation of Dosimeteric Parameters

- Because of lack of common guideline of calculation methods of dosimeteric parameters, it has been not easy to compare these parameters in the reports of ICCHIBAN-1 and -3.

- So, the guideline is shown and we request your calculation for the next reports following this guideline.

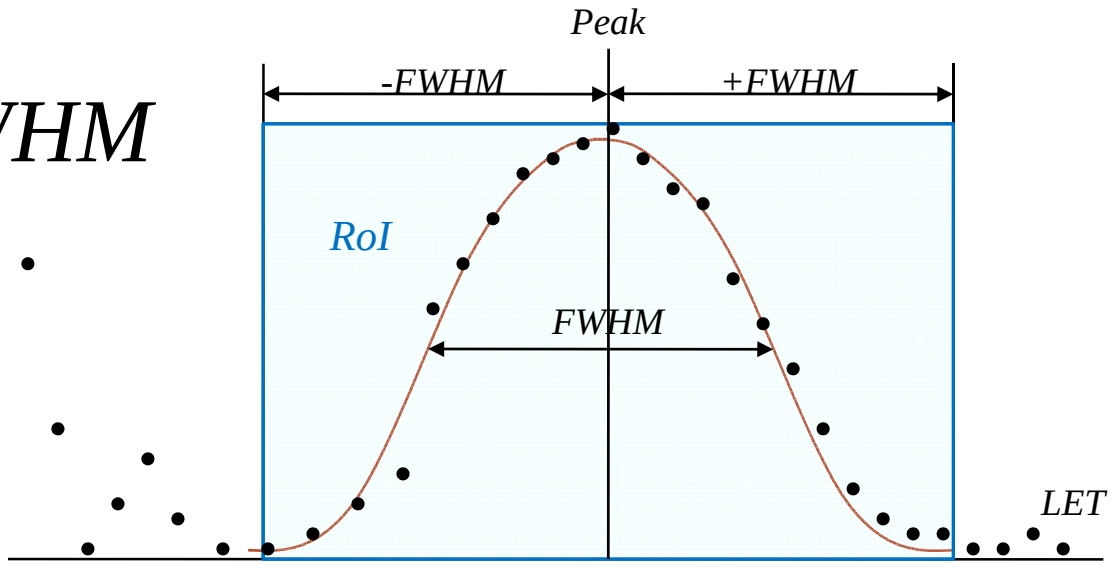
Re-analysis for ICCHIBAN-1



Region of Interest

- To calculate dose and dose equivalent for a particle, the Region of Interest (RoI) is defined.
- Gaussian distribution is fitted to the LET distribution and obtain a peak of LET and standard deviation. Then, a FWHM is calculated as $FWHM = 2.3548 \times \sigma$.
- Using these parameters, the RoI is defined as the following.

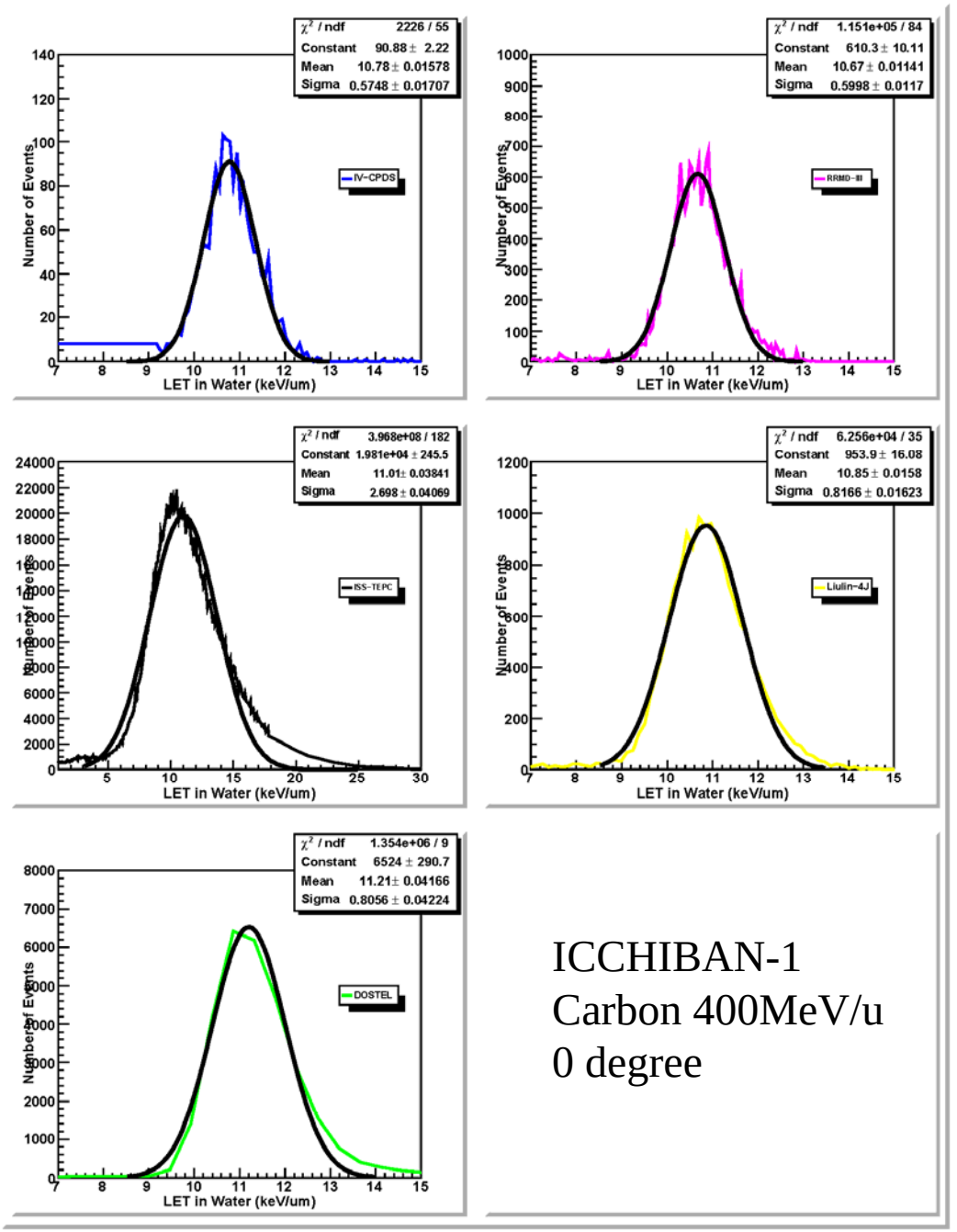
$$RoI = Peak \pm FWHM$$



Fitting

Gaussian distributions have been fitted to LET distributions of IV-CPDS, ISS-TEPC, DOSTEL, RRMD-III and Liulin-4J.

Detector	Peak	FWHM
IV-CPDS	10.78	1.35
ISS-TEPC	11.01	6.35
DOSEL	11.21	1.90
RRMD-III	10.67	1.41
Liulin-4J	10.85	1.92



ICCHIBAN-1
Carbon 400MeV/u
0 degree

Calculation of Dose per One Particle

- Calculation of Dose(D)

$$D = \int D(L)\, dL = \int \frac{k}{\rho}\phi(L)\, L\, dL = \int \frac{k}{\rho}\frac{n(L)}{S} L\, dL = \frac{k}{\rho \cdot S}\int n(L)\, L\, dL$$

L: Unrestricted LET, k: Conversion Factor, ρ : Density of Medium,
ϕ: Fluence of Particles, $n(L)$: Number of Particles, S : Area of Detector

- Calculation of Dose per One Particle (D_1)

$$D_1 = \frac{\int \frac{k}{\rho}\phi(L)\, L\, dL}{\int \phi(L)\, dL} = \frac{\int \frac{k}{\rho}\frac{n(L)}{S} L\, dL}{\int \frac{n(L)}{S}\, dL} = \frac{\frac{k}{\rho \cdot S}\int n(L)\, L\, dL}{\frac{N}{S}} = \frac{k}{\rho \cdot N}\int n(L)\, L\, dL$$

N: Total Number of Particles

Dosimeteric Parameters

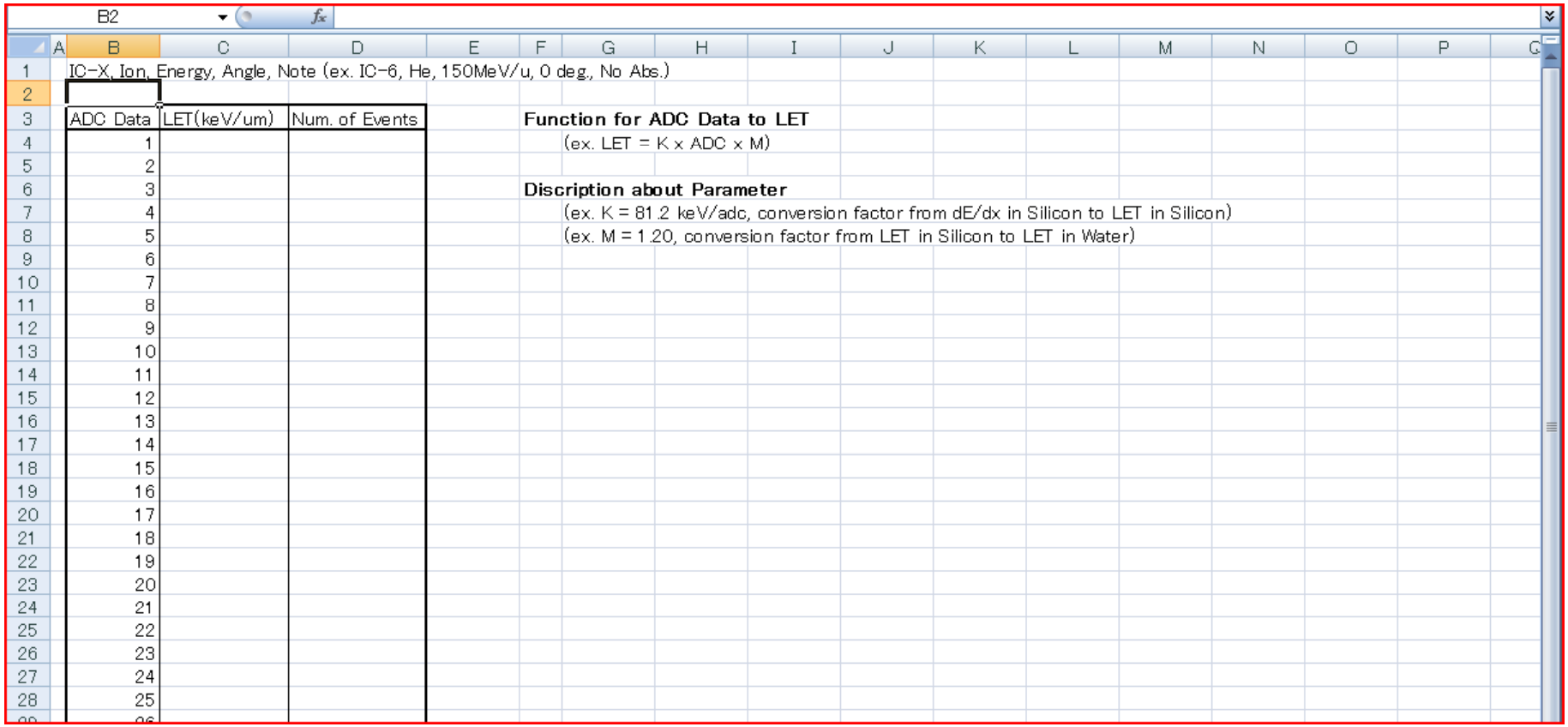
All data were analyzed by Y.Uchihori and there are no responsibilities for the participants.

ICCHIBAN-1
Carbon 400MeV/u
0 degree

Detector	Peak of LET	FWHM of LET	Range of LET*		Avg. LET	Avg. Q.F. ICRP60	Avg. Dose per ion	Avg. Dose Eq. per ion
			Min.	Max				
IV-CPDS	10.78	1.35	9.43	12.13	10.80	1.26	17.31	21.97
ISS-TEPC	11.01	6.35	4.66	17.36	11.26	1.56	18.04	30.68
DOSTEL	11.21	1.90	9.31	13.11	11.02	1.33	17.66	23.65
RRMD-III	10.67	1.41	9.26	12.08	10.69	1.23	17.13	21.20
Liulin-4J	10.85	1.92	8.93	12.77	10.89	1.30	17.45	22.92
Calculation (Mono Energy)					10.88 (keV/um)	1.29	17.43 (nGy)	22.48 (nSv)

* Range of LET is expected PeakLET -+ FWHM.
** All dosimeteric data are expected to average in the above range of LET.

Formats for the next Reports (1)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1		IC-X, Ion, Energy, Angle, Note (ex. IC-6, He, 150MeV/u, 0 deg., No Abs.)															
2																	
3		ADC Data	LET(keV/um)	Num. of Events			**Function for ADC Data to LET**										
4		1					(ex. LET = K x ADC x M)										
5		2															
6		3					**Discription about Parameter**										
7		4					(ex. K = 81.2 keV/adc, conversion factor from dE/dx in Silicon to LET in Silicon)										
8		5					(ex. M = 1.20, conversion factor from LET in Silicon to LET in Water)										
9		6															
10		7															
11		8															
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26		23															
27		24															
28		25															

Formats for the next Reports (2)

IC	Condition	Peak of LET (keV/um)	FWHM of LET (keV/um)	Range of LET* Min.	Range of LET* Max.	Avg. LET (keV/um)	Avg. Q.F. ICRP60	Avg. Dose per ion (uGy)	Avg. Dose Eq. per ion (uSv)
1									
1									
1									
1									
3									
3									
3									
3									
5									
5									
5									
5									
7									
7									
7									
7									
Proton									
Proton									
Proton									
Proton									
NSRL									
NSRL									
NSRL									
NSRL									

* Range of LET is expected PeakLET -+ FWHM.

** All dosimetery data is expected to average in the above range of LET.

IC-X-A | Summary

Conclusion

- 11 ICCHIBAN experiments were performed on the ground base accelerator facilities and 2 space intercomparison experiments in the frame of ICCHIBAN project were performed.
- Analyzed data of ICCHIBAN-1- 8, Proton, NSRL and CERF will be gathered by ICCHIBAN Working Group with the manners on the guidelines. The deadline is Dec. 1st, 2008.
- Several ICCHIBAN experiments are scheduled in near future. The detail of these experiments will be presented in the next talks. If you would like to participate to these experiments, please let us know. We welcome your new idea for these experiments.