Preliminary Results from the first two ICCHIBAN Intercomparisons of Space Radiation Detectors

Y.Uchihori, K.Fujitaka, N.Yasuda (NIRS, Japan)
and E. Benton (Eril Research Inc.)
on behalf of ICCHIBAN Working Group
and Participants

Working Group

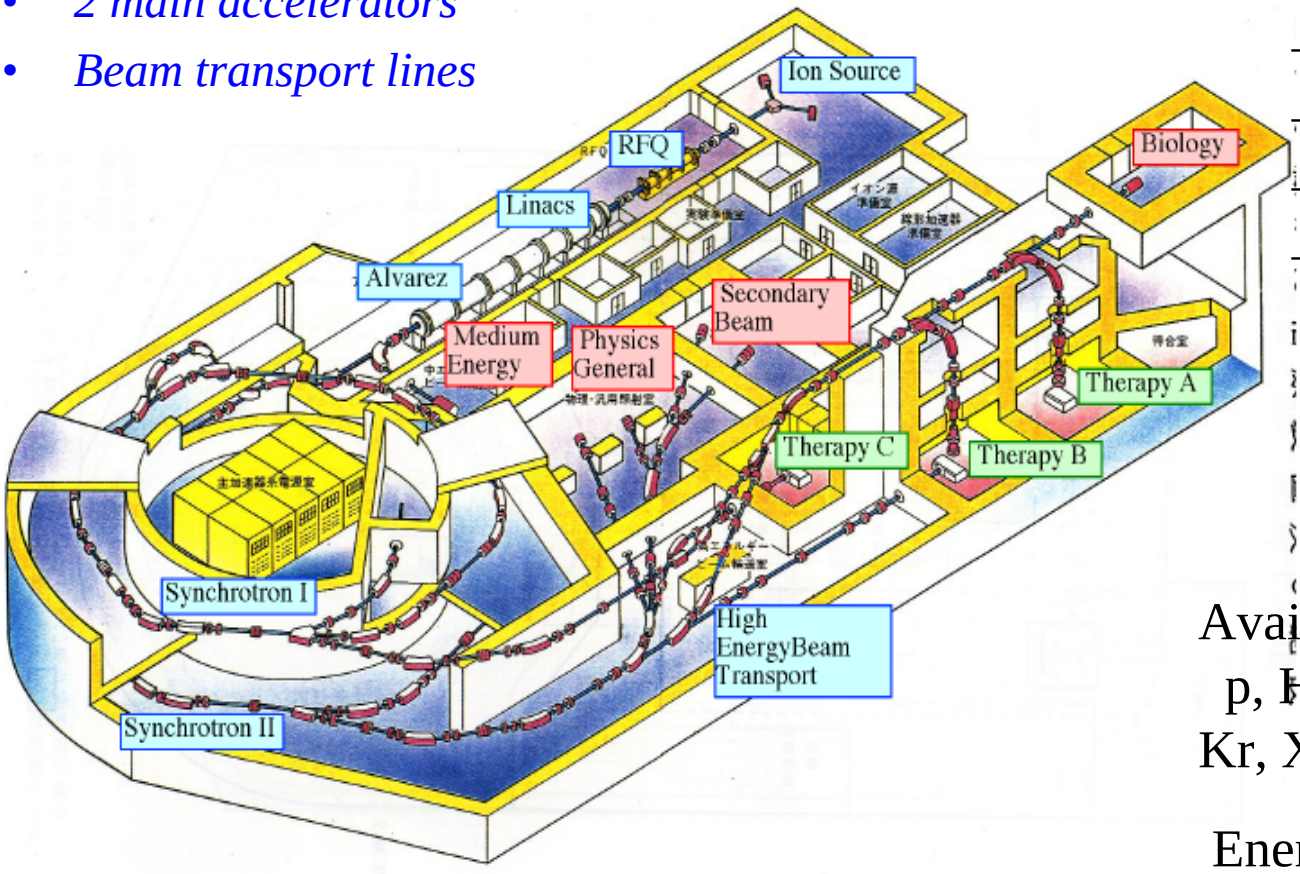
- Yukio Uchihori (Project Coordinator), NIRS, Japan
- Kazunobu Fujitaka (Chair), NIRS, Japan
- Eric Benton (Deputy Project Coordinator), Eril Research, USA
- Nakahiro Yasuda (Deputy Project Coordinator), NIRS, Japan
- Hisashi Kitamura, NIRS, Japan
- Tatsumi Koi, NIRS, Japan
- Masashi Takada, NIRS, Japan
- Tadayoshi Doke, Waseda University, Japan
- Cary Zeitlin, LBNL, USA
- Jack Miller, LBNL, USA
- Takeshi Takashima, Nagoya Univ., Japan

Objectives of ICCHIBAN

- Establish and characterize a heavy ion "reference standard" against which space radiation instruments can be calibrated.
- 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.

Bird's Eye View of HIMAC

- *3 ion-sources*
- *2 linacs*
- *2 main accelerators*
- *Beam transport lines*



- *3 therapy rooms*
- *4 experiment caves*
  - ***Medium energy port***
  - ***Physics & general port***
  - ***Secondary beam port***
  - ***Biology experiment po***

Available Ions
p, He, C, Ne, Si, Ar, Fe, Kr, Xe, …

Energies
125〜800MeV/u

History

Sep. 12, 2001	6th WRMISS Workshop at Oxford
Feb. 11-13, 2002	1st ICCHIBAN Experiment (For Active Detectors)
May 23-28, 2002	2nd ICCHIBAN Experiment (For Passive Detectors)
Sep. 2-4, 2002	7th WRMISS Workshop on Paris

1st ICCHIBAN Run

1st ICCHIBAN Run

We have performed 1st ICCHIBAN run for active detectors on Feb. 11 to Feb. 14, 2002 with 10 foreign and 15 Japanese investigators.

Feb. 11	Mon	11:00~7:00	20 hrs	All Group	C(400MeV/u)
Feb. 12	Tue	21:00~7:00	10 hrs	1st Group	Fe(400MeV/u)
Feb. 13	Wed	21:00~7:00	10 hrs	2nd Group	Fe(400MeV/u)

1st ICCHIBAN Participants

Monitor Name	Institution	Nation	Detection Principle	Type
RRMD-III	Waseda Univ.	Japan	Silicon Telescope	Active
DOSTEL-1	Kiel Univ.	German	Silicon Telescope	Active
DOSTEL-2	Kiel Univ.	German	Silicon Telescope	Active
DOSTEL-D	Kiel Univ.	German	Silicon Telescope	Active
Shuttle-TEPC	NASA-JSC	USA	Proportional Counter	Active
ISS-TEPC	NASA-JSC	USA	Proportional Counter	Active
IV-CPDS	NASA-JSC	USA	Silicon Telescope + Č	Active
Liulin-4J	NIRS	Japan	Silicon	Active
Liulin E087	STIL-BAS	Bulgaria	Silicon	Active
Dosimeter Package	Eril Research	USA	TLD+CR-39	Passive
Dosimeter Package	NASDA	Japan	TLD+CR-39	Passive
Ground Base Detector	LBNL	USA	Silicon Stack + SC	Active

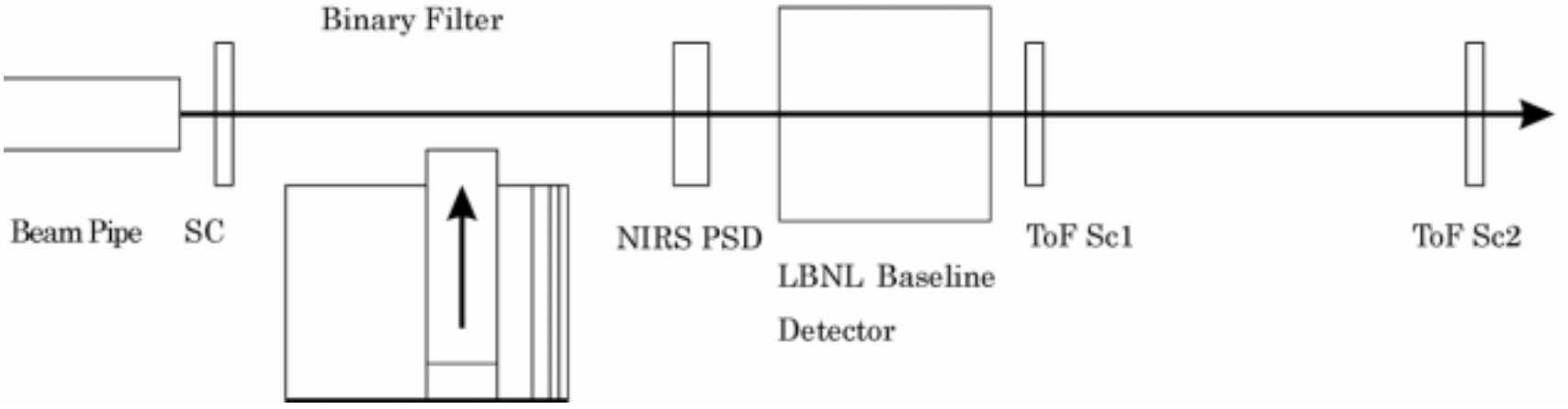
Beam Condition in 1st ICCHIBAN

- Beam Intensity was tuned $3x10^2$ particles per spill.
  1 spill every 3.3 sec. Spill distribution is about 0.7 sec.

- The beam spot was tuned as 20 mm diameter circles.

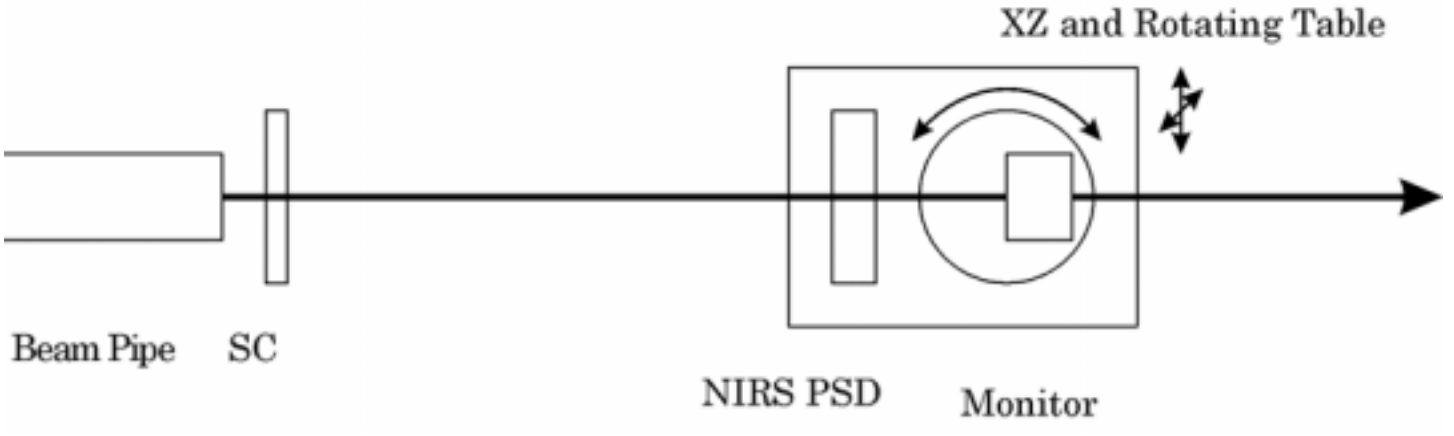
Reference Measurements

- Single Spill Profile --- ZnS Fluorescence Sheet + Video Camera
- Average Beam Profile --- CR-39
- Real Time Beam Profile --- PSD
- Beam Intensity --- Plastic Scintillation Counter
- Total Beam Energy --- Silicon Stack + ToF SC
- Range of Beam --- Binary Filter System + Plastic SC



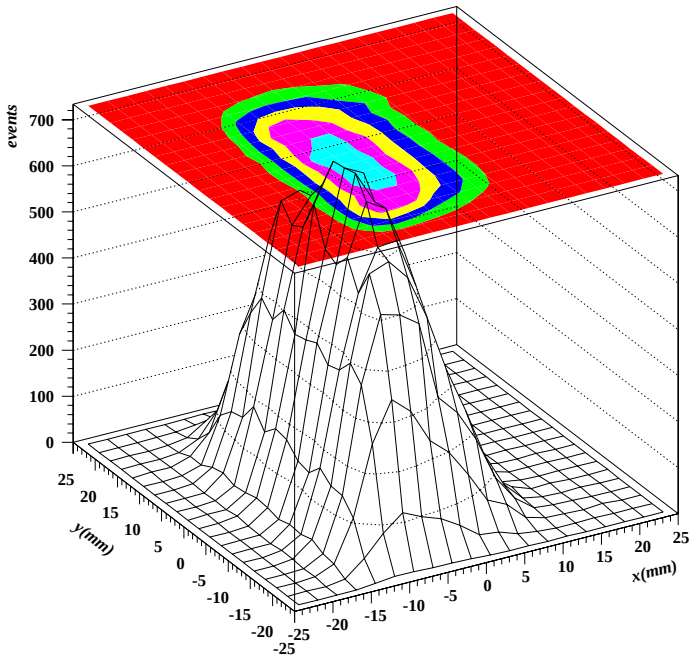
Exposures of Instrument

- Intensity of beam : A thin scintillation counter (SC).
- Beam profile; A position sensitive silicon detector (PSD).
- The instrument was put on rotation and XZ stage.

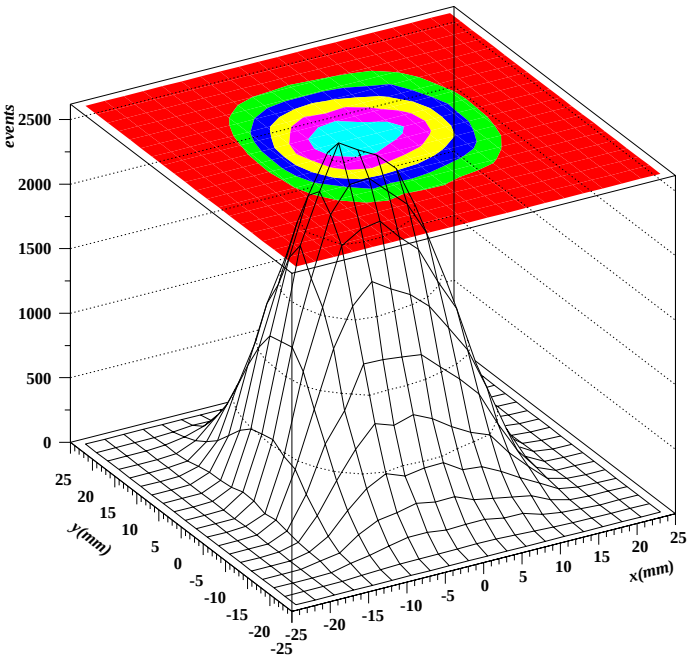


Beam Profile by NIRS-PSD

Carbon 400 MeV/u

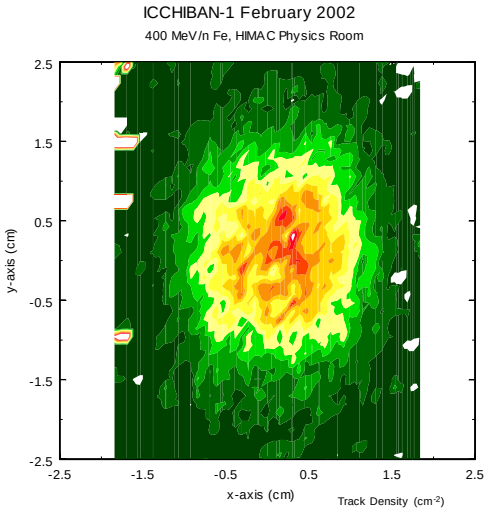


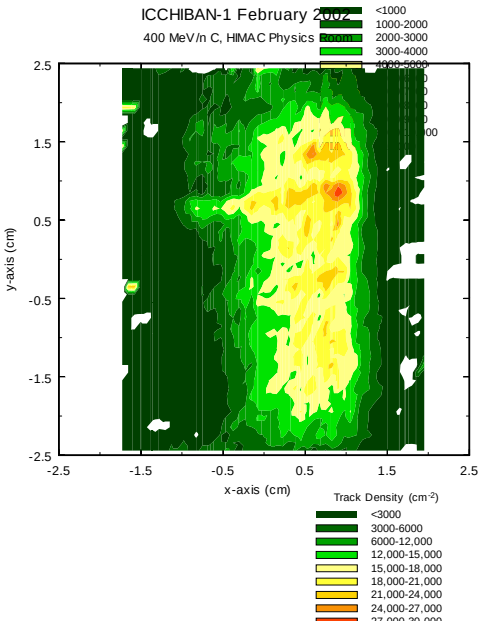
Iron 400 MeV/u



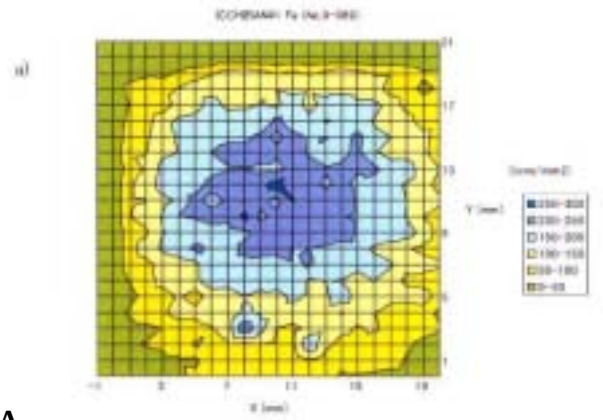
Beam Profile by CR-39 of ERI and NASDA

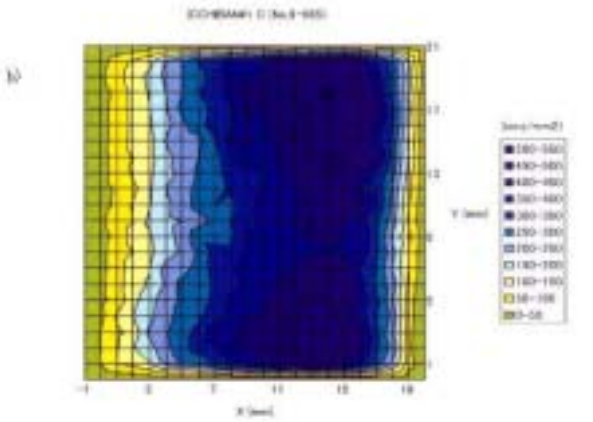
ERI
CR-39



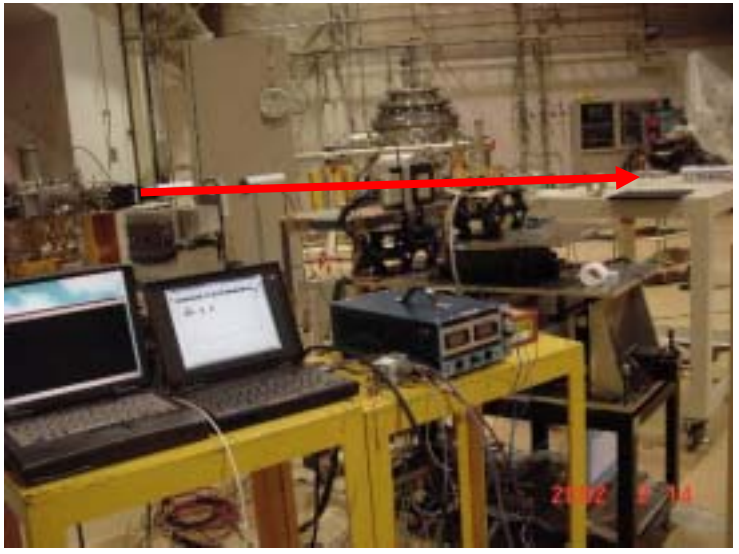


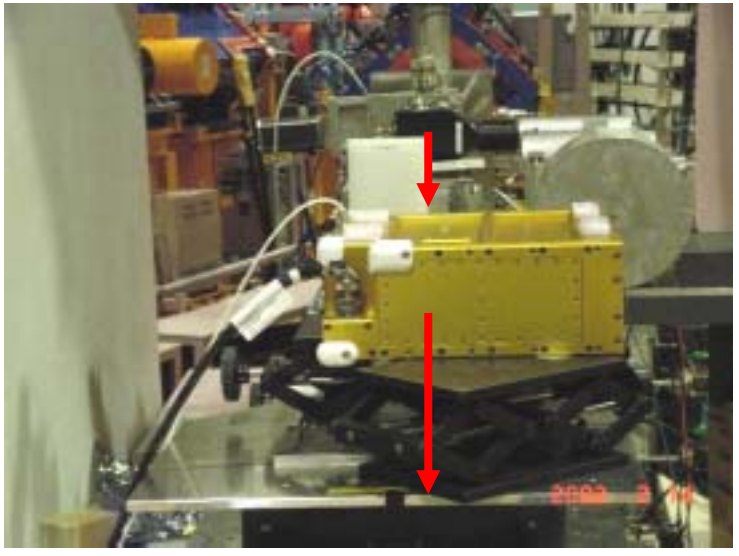
NASDA
CR-39





Photographs of 1st ICCHIBAN run

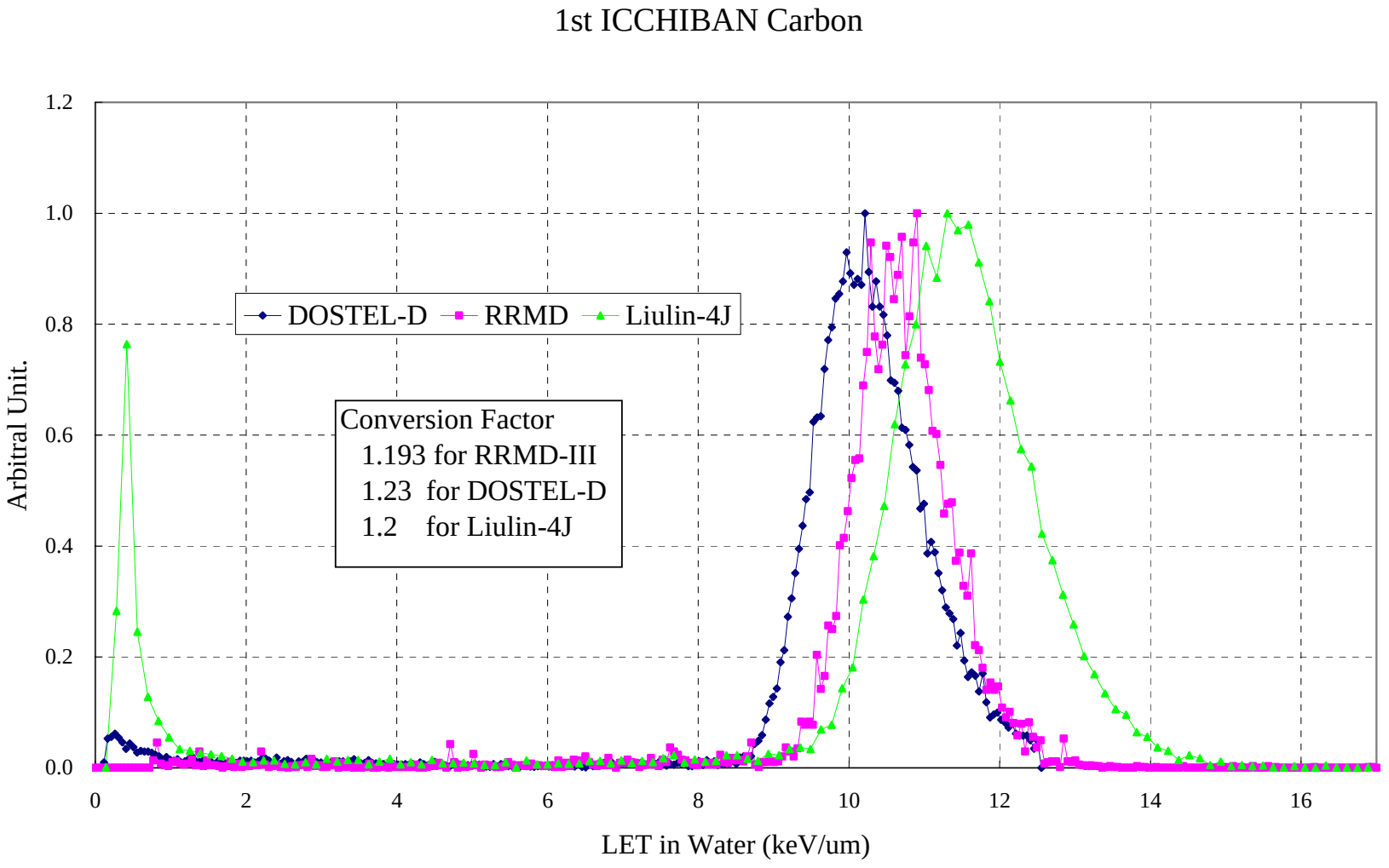




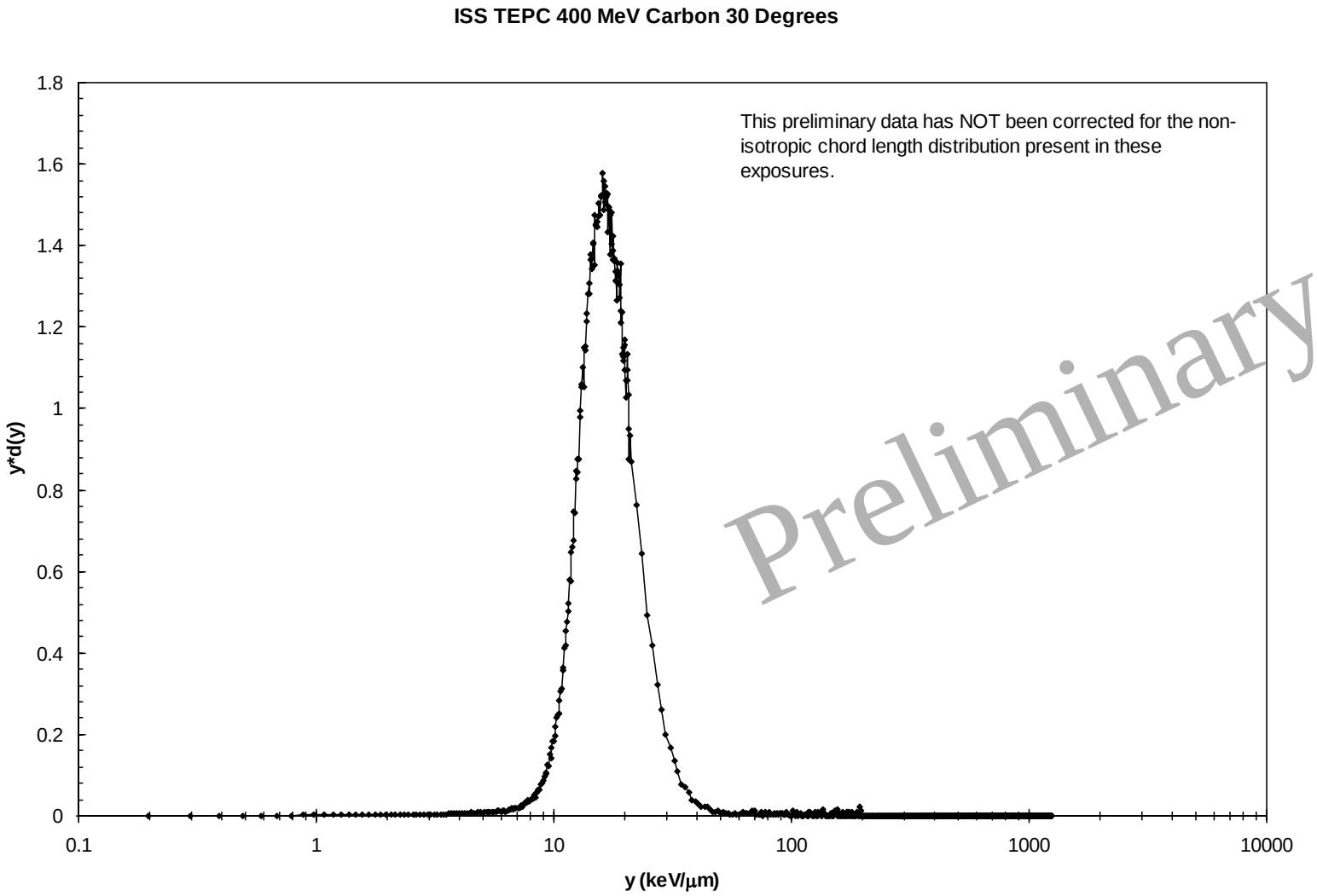
Requirement for Participant after Experiment

- LET or y Distribution
- Energy Spectrum
- Mean Quality Factor
- How to obtain Dose and QF. Method used in reducing data.

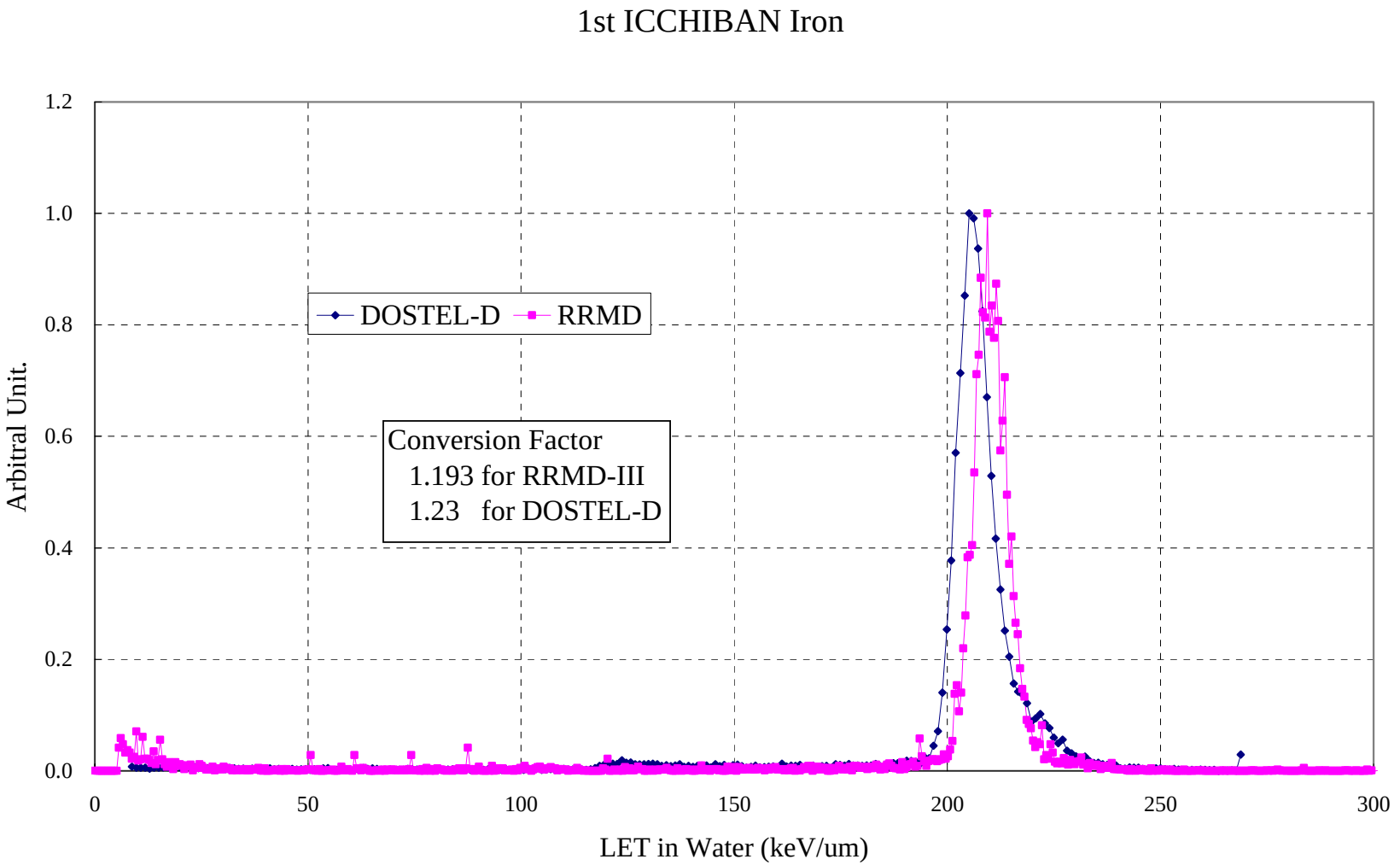
Comparison for Carbon Run



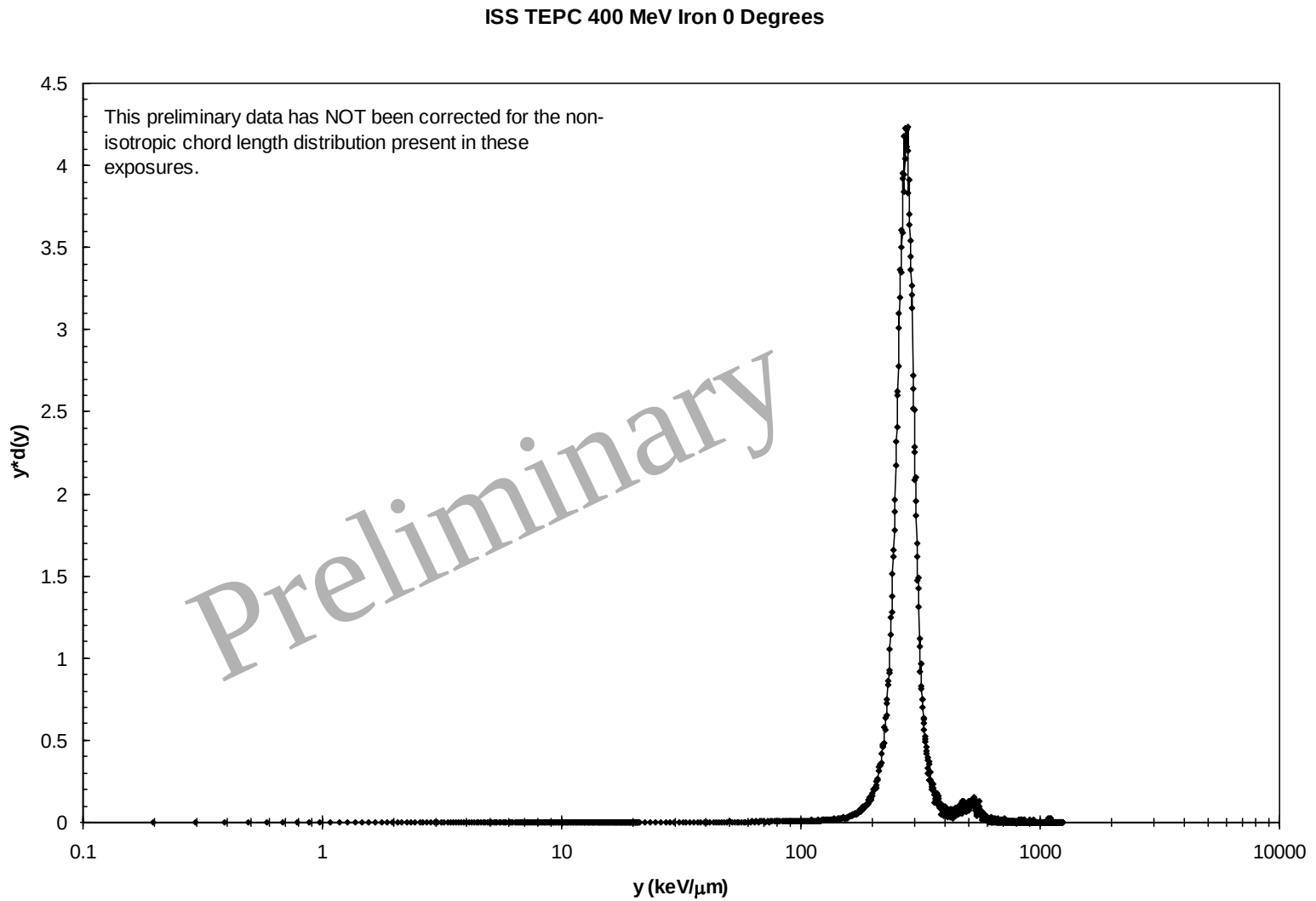
NASA-JSC ISS-TEPC for Carbon



Comparison for Iron Run



NASA-JSC ISS-TEPC for Iron



Discrepancy of Conversion Factor to LET(water)

DOSTEL

$$LET_{\infty} = 1.23 \times LET_{silicon}$$

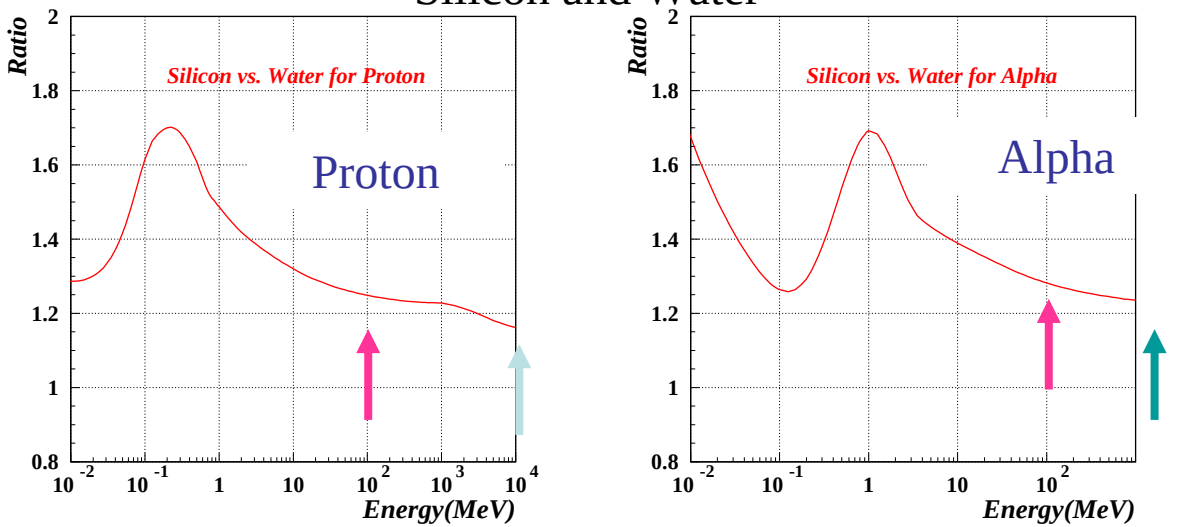
Assuming 100MeV

RRMD-III

$$LET_{\infty} = 1.193 \times LET_{silicon}$$

Assuming Relativistic Velocity

Ratio of Stopping Power between
Silicon and Water



Comparison Table

Ion	Detector	Condition	$LET_{(Avg.)}$	$LET_{(FWHM)}$	dLET/LET
Carbon	DOSTEL-2	Center	9.836	1.665	16.9%
	DOSTEL-D	Center	10.204	1.615	15.8%
	RRMD-III	Center	10.716	1.418	13.2%
		Corner	10.701	1.398	13.1%
		Aluminum	10.999	1.421	13.1%
		30 deg.	10.731	1.493	13.9%
		45 deg.	10.693	1.614	15.1%
		60 deg.	11.553	2.518	21.8%
	Liulin-4J	Center	11.471	2.034	17.7%
		Corner	11.419	2.071	18.1%
		Aluminum	11.747	2.092	17.8%
		30 deg.	11.320	1.896	16.7%
		45 deg.	11.202	1.735	15.5%
		60 deg.	11.060	1.519	13.7%
Iron	DOSTEL-D	Center	206.280	9.681	4.7%
	RRMD-III	Center	210.263	9.518	4.5%
		Corner	210.633	9.405	4.5%
		Aluminum	242.123	10.532	4.4%
		30 deg.	210.764	9.820	4.7%
		45 deg.	209.097	12.406	5.9%

2nd ICCHIBAN Run

2nd ICCHIBAN Run

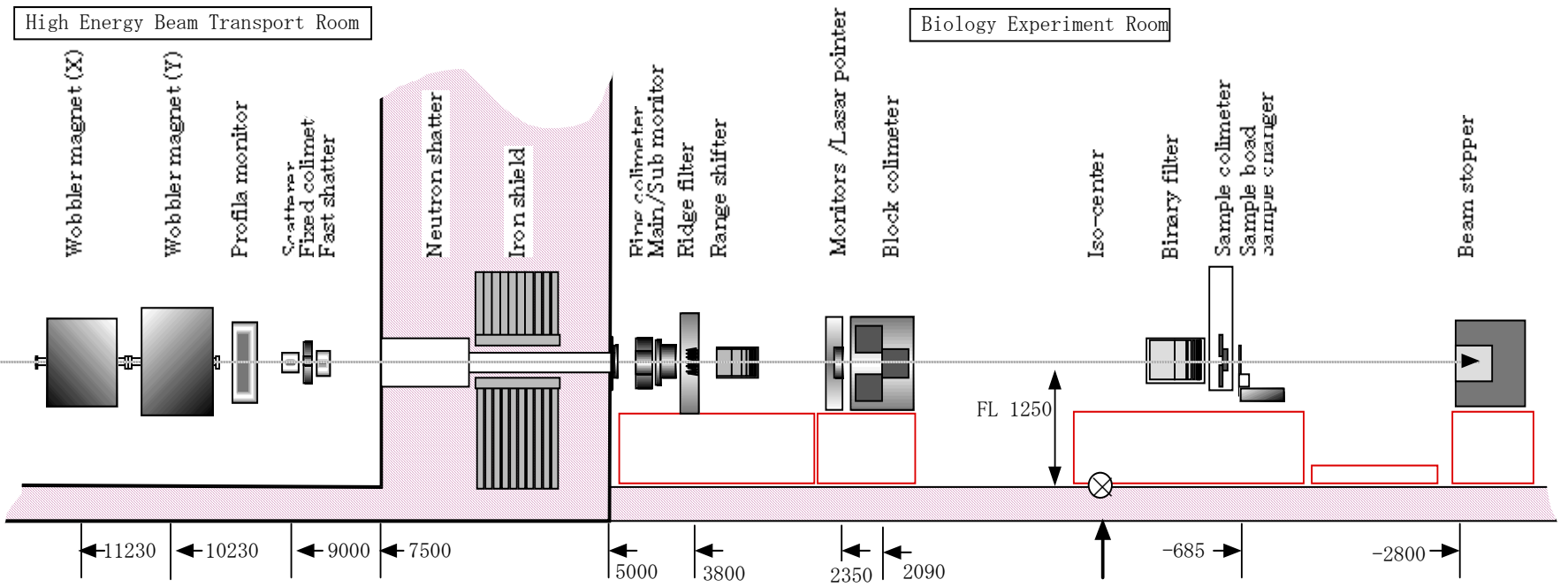
We have performed 2nd ICCHIBAN run for passive detectors on May 23 to May 28, 2002 with 3 foreign and 10 Japanese investigators.

May 23	Thu	22:00~7:00	9 hrs	Si(490MeV/u)	55 keV/um
May 24	Fri	22:00~7:00	9 hrs	He(150MeV/u)	2.2 keV/um
May 25	Sat	10:00~19:00	9 hrs	C(400MeV/u)	11 keV/um
May 28	Tue	22:00~7:00	9 hrs	Fe(500MeV/u)	191 keV/um

2nd ICCHIBAN Participants

Participants	Nation	Nation	Detector Type
E. Benton	Eril Research Inc.	USA	CR-39 + TLD
E. Semones	NASA-JSC	USA	TLD
Y. Akatov & V.Shurshakov	IBMP	Russia	CR-39+TLD + Biomarker
D.Bertlett & L.Harger	NRPB	UK	CR-39
F.Spurny & K.Turek	NPI/DRD	Czech Republic	CR-39 + TLD
H.Tawara, A.Nagamatsu & M.Masukawa	KEK & NASDA	Japan	CR-39 + TLD
N.Vana & T.Berger	AAU	Austria	CR-39 + TLD
S.McKeever & E.Yukihara	Oklahoma State Univ.	USA	TLD + OSL
P.Pilsky & P.Olko	INP	Poland	CR-39 + TLD
S.Deme & I.Apathy	KFKI AEKI	Hungary	TLD
G.Reitz	DLR	German	TLD

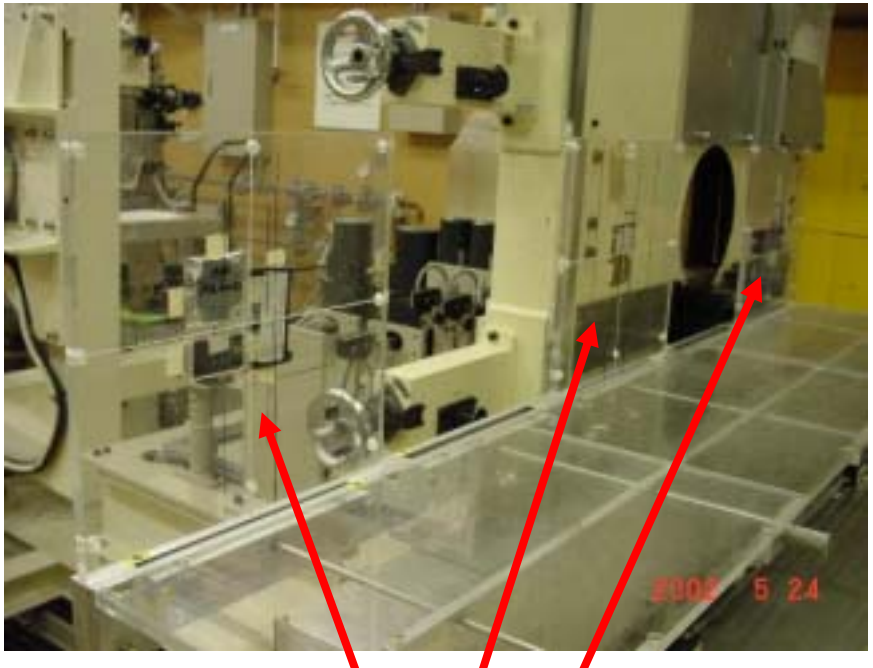
HIMAC Biology Experiment Cave



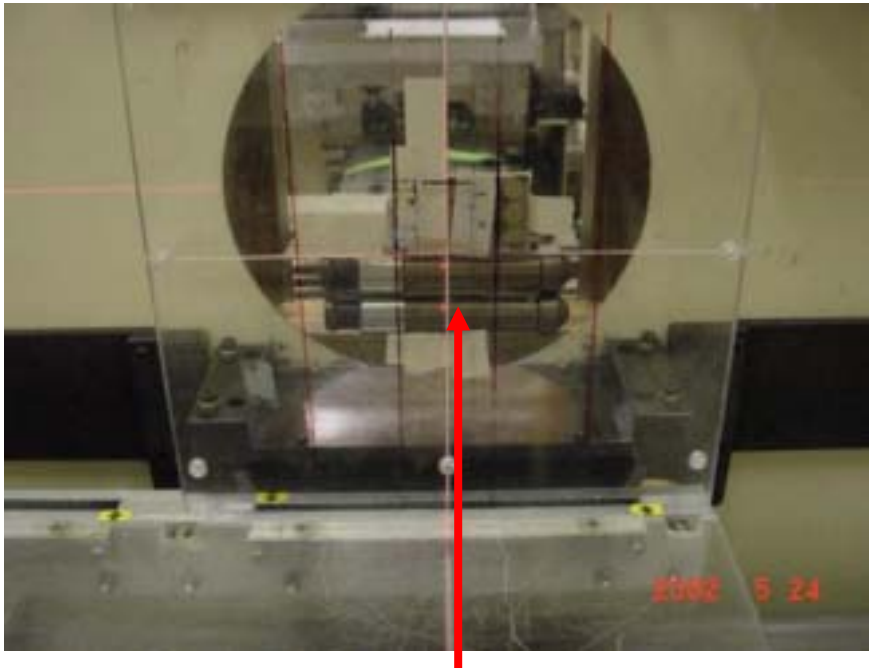
Overview of HIMAC Biological Experiment Cave

- *Ion beams used for experiments*
  - *H: 160 MeV/u mono & SOBP*
  - *He: 150 MeV/u mono & SOBP*
  - *C: 135 / 290 / 350 / 400 MeV/u mono*
  - *C: 290 MeV/u, 60 / 120 mm SOBP*
  - *Ne: 135 / 230 / 400 MeV/u mono*
  - *Ne: 400 MeV/u 60 mm SOBP*
  - *Si: 490 MeV/u mono*
  - *Ar: 550 MeV/u mono*
  - *Fe: 200 / 500 MeV/u mono*
  - *X: 150 kVp*

Setup of Detectors

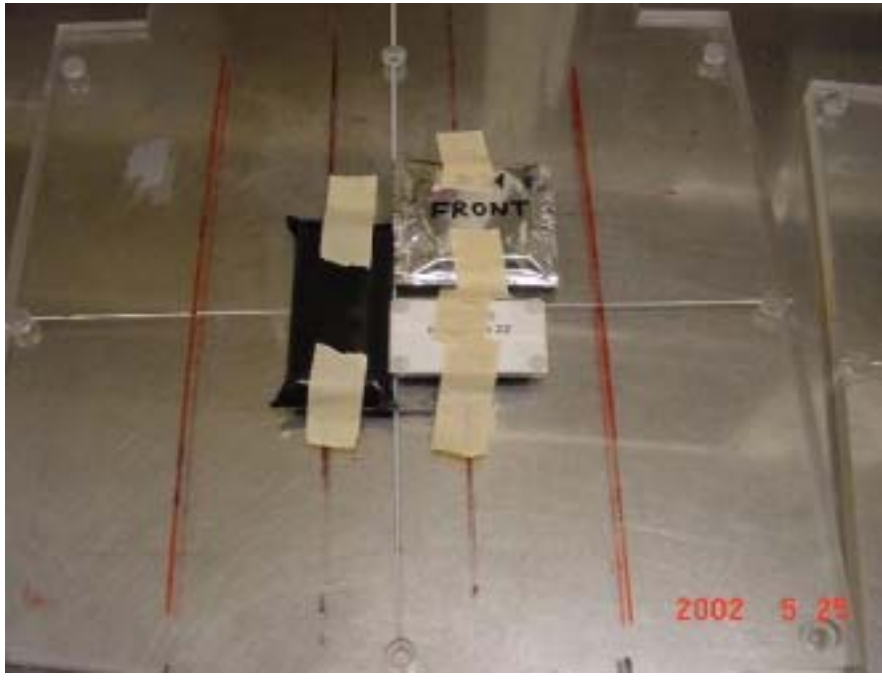


Detectors



Detectors

Preparation of Detectors



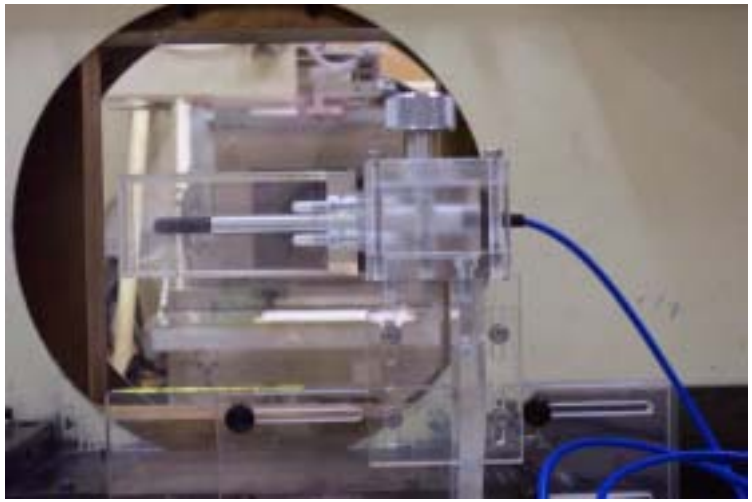
Reference Measurement

1. We used an ion chamber (PTW-30001) as the reference of ion exposure. The chamber was calibrated in a secondary standard field and it is used in the biological experiment and the therapy for patient.

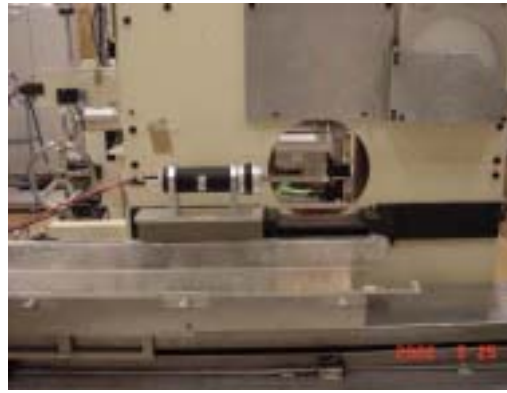
2. Using the ion chamber, another ion chamber (Main Monitor) was calibrated and the Main Monitor had measured the exposed dose during exposure.

3. For low intensity beam, a scintillation counter was used to confirm the number of ions because the Main Monitor has no response for such low intensity beam.

2. Main Monitor

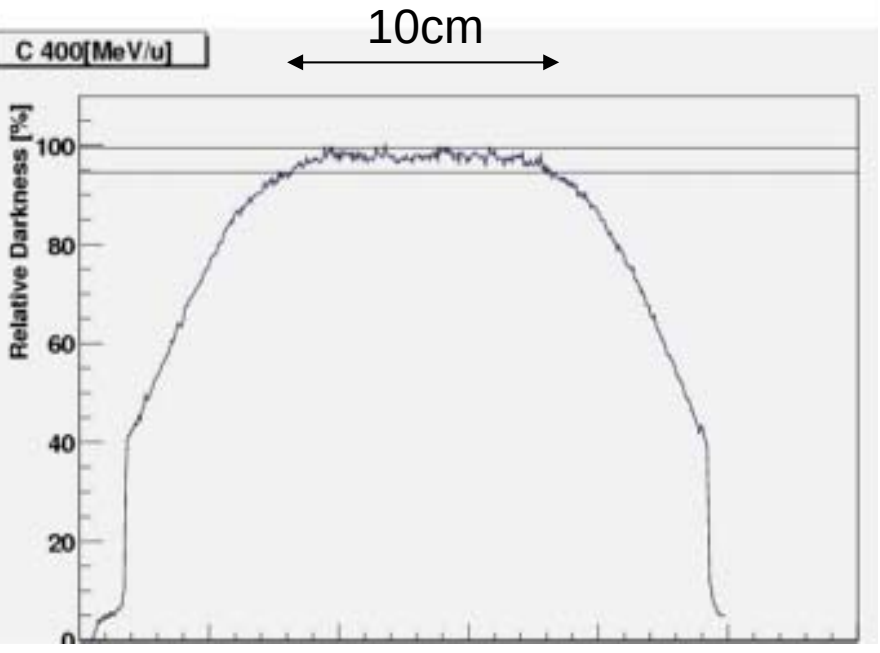


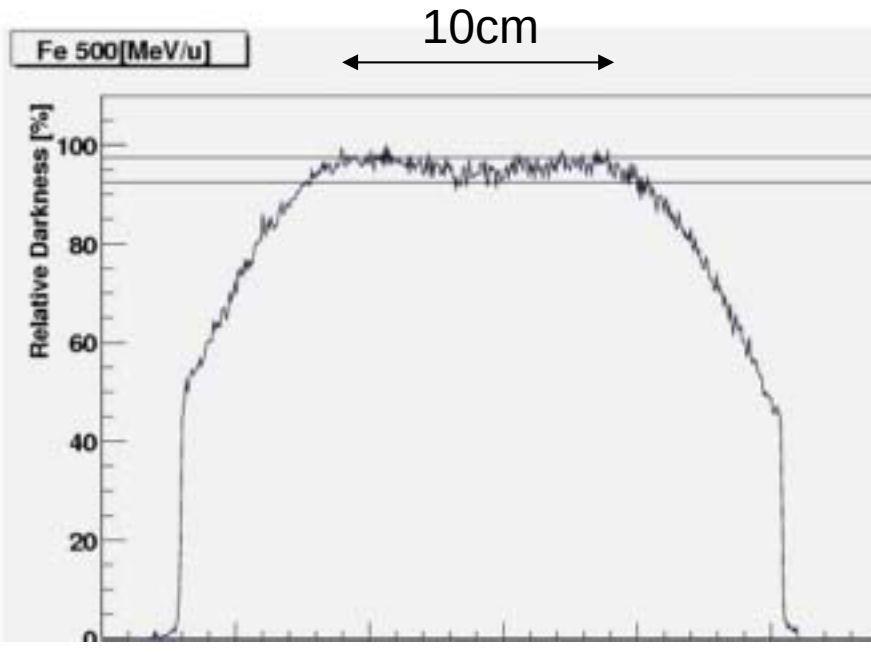
1. Ion Chamber



3. Scintillation Counter

Beam Profile

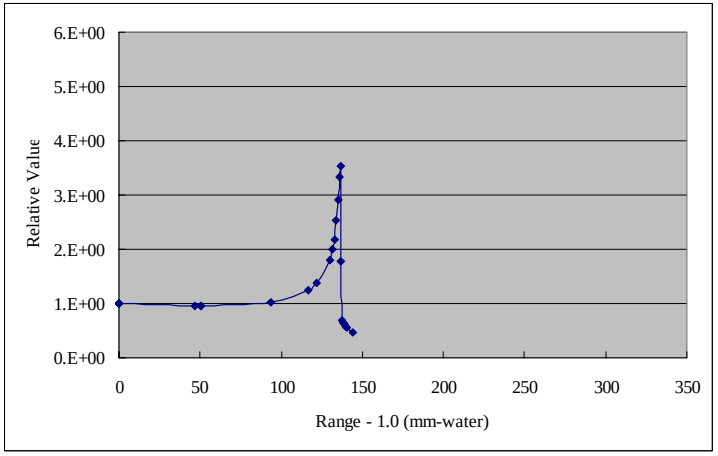




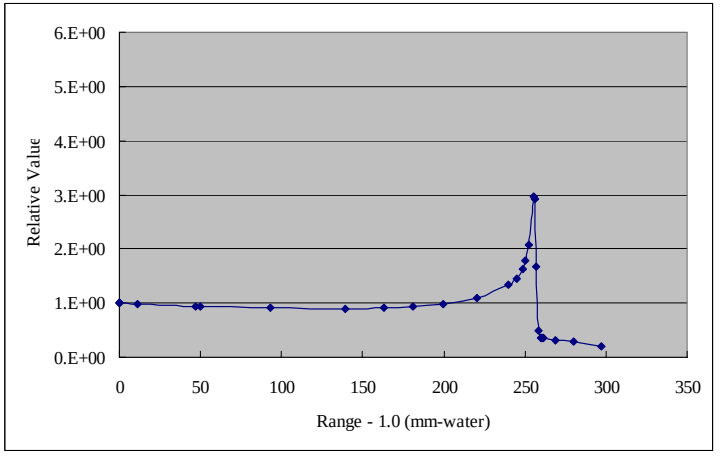
The uniformity of beam profile has been confirmed with X-ray film.

Range of beam

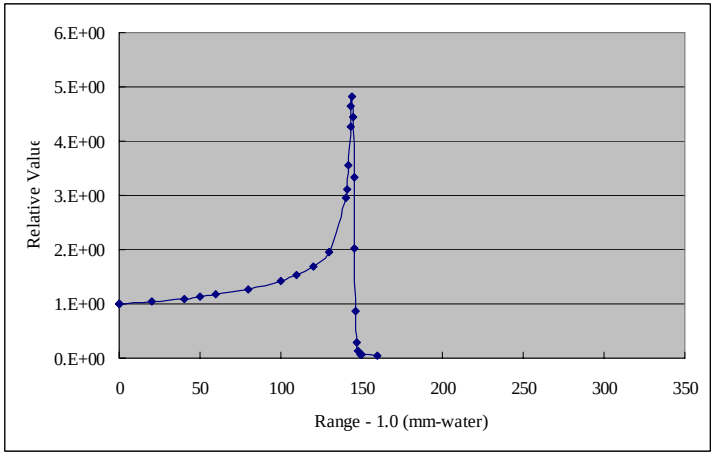
Si(490MeV/u)



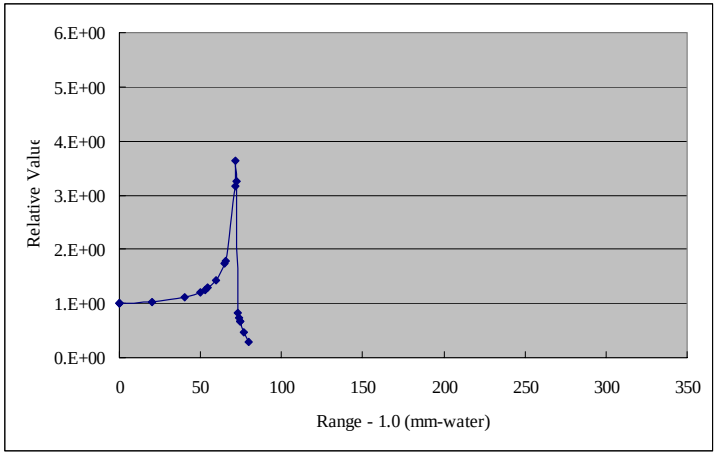
C(400MeV/u)



He(150MeV/u)



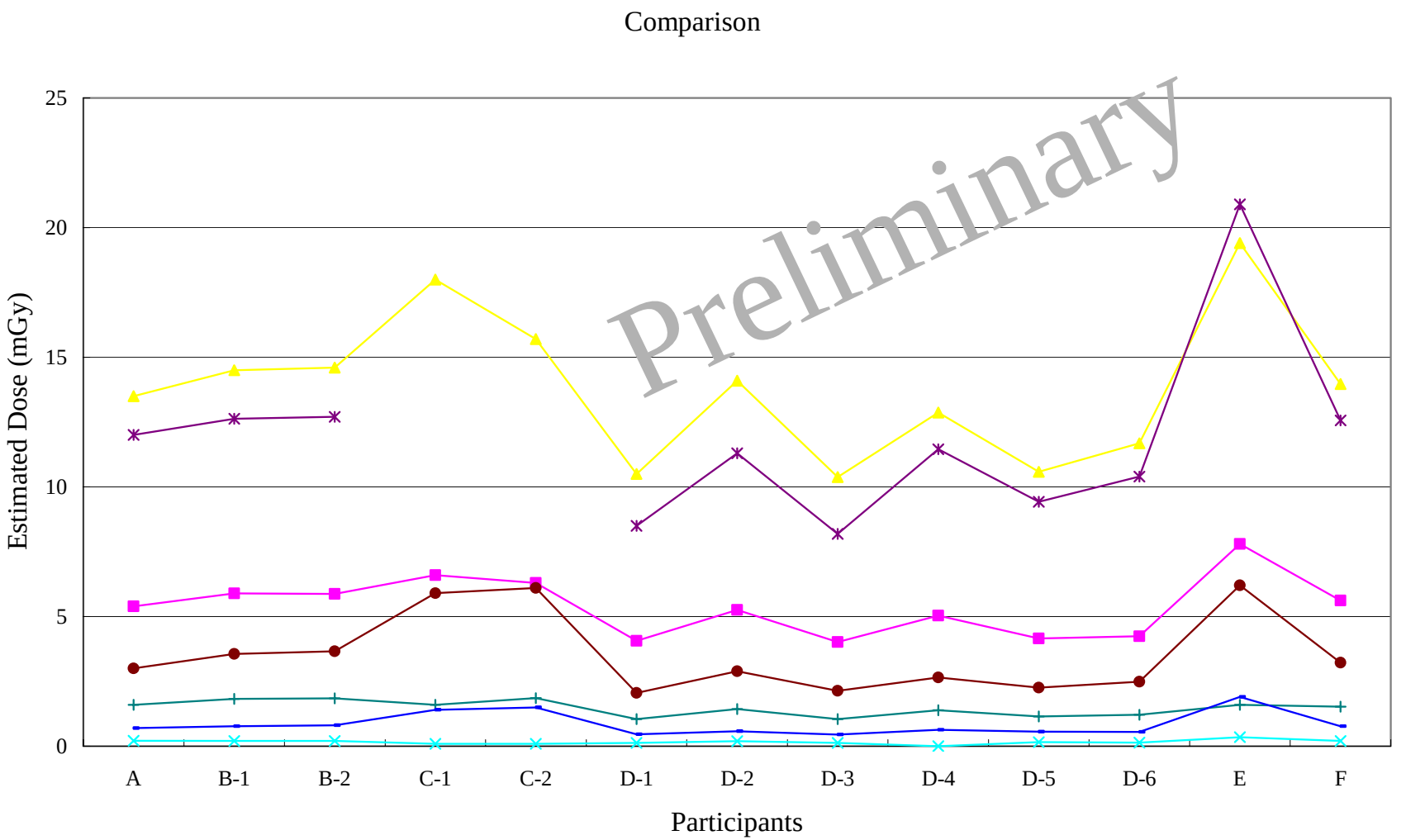
Fe(500MeV/u)



Run Condition

Linearity	Linearity 1 mGy	He, C, Si, Fe
	Linearity 10 mGy	He, C, Si, Fe
	Linearity 50 mGy	He, C, Si, Fe
	Linearity 100 mGy	He, C, Si, Fe
Fragment	Fragment 4000 ions / cm2	C, Si, Fe
Blind	Blind -1	(He, C, Si, Fe)
	Blind -2	(He, C, Si, Fe)
	Blind -3	(He, C, Si, Fe)
	Blind -4	(He, C, Si, Fe)
	Blind -5	(He, C, Si, Fe)
	Blind -6	(He, C, Si, Fe)
	Blind -7	(He, C, Si, Fe)
	Blind -8	(He, C, Si, Fe)

Comparison for Blind Run



Time Schedule

Feb. 11-13, 2002	1st ICCHIBAN Experiment (For Active Detectors)
May 23-28, 2002	2nd ICCHIBAN Experiment (For Passive Detectors)
Sep. 2-4, 2002	7th WRMISS Workshop on Paris
Feb. 3-6, 2003	3rd ICCHIBAN Experiment (For Active Detectors)
May - July, 2003	4th ICCHIBAN Experiment (For Passive Detectors)
July 31-Aug. 7, 2003	The International Cosmic Ray Conference (ICRC2003) in Tsukuba, Japan

Conclusion

- 1st and 2nd ICCHIBAN runs were carried out successfully at HIMAC in 2002.
- We are analyzing the results to compare each other. Still don't have all data.
- We wish to publish the results of intercomparison as HIMAC report in NIRS this autumn (Nov. 30, 2002).
- Next 3rd and 4th ICCHIBAN run will be performed on Feb. and May 2003. We welcome your participation to these runs.

Thank you very much for your participation and your support for ICCHIBAN project!

ICCHIBAN

(InterComparison for Cosmic-rays with Heavy Ion Beams At NIRS)

Y.Uchihori, K.Fujitaka, N.Yasuda and E.Benton

ICCHIBAN Annoucements (I)

- ICCHIBAN-3 Feb. 3-6, 2003
  - 800MeV/n Si, 400MeV/n Fe, Active detectors - fragmentation
- We plan tosend inquiry to all potential participants in near future for ICCHIBAN-3.
- Investigators who did not participate in I-1, but are interested in participating in I-3, please contact me (uchihori@nirs.go.jp)

ICCHIBAN Announcements (II)

- ICCHIBAN-4 May-Jul, 2002 Ions/Energies not yet determined.
  - Passive detectors, including blind exposures
- Investigators who did not participate in I-2, but are interested in participating in I-4, please contact me (uchihori@nirs.go.jp)

ICCHIBAN Announcements (III)

- All ICCHIBAN-1 & 2 participants please submit report with results to Uchihori by Nov. 30, 2002 for inclusion in NIRS Technical Report
  - ICCHIBAN Working Group will compare results and prepare report for inclusion in NIRS Technical Report and paper in Radiation Measurements.

Super ICCHIBAN

(InterComparison for Cosmic-rays with HIgh energy Beams in America and Nippon)

Y.Uchihori, E.Benton, J.Miller,…

Super ICCHIBAN

- Planning Proton ICCHIBAN at Loma Linda for summer/autumn 2003.
  - Simulate SPE in interplanetary space and LEO passage through SAA.
  - Local coordinator is Eric Benton (eric@erilresearch.com)
- Will have BAF ICCHIBAN when BAF is operational (late 2003-2004).
  - 1 GeV protons, Higher Z ions than HIMAC
  - Local coordinator is Jack Miller (j_miller@lbl.gov)