NIRS

Intercalibration of Space Radiation Monitors
with Heavy Ion Beams

ISRL

一番
ICCHIBAN

InterComparison for Cosmic-ray with Heavy Ion Beams At NIRS

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and
E.Benton (Eril Research Inc., USA)

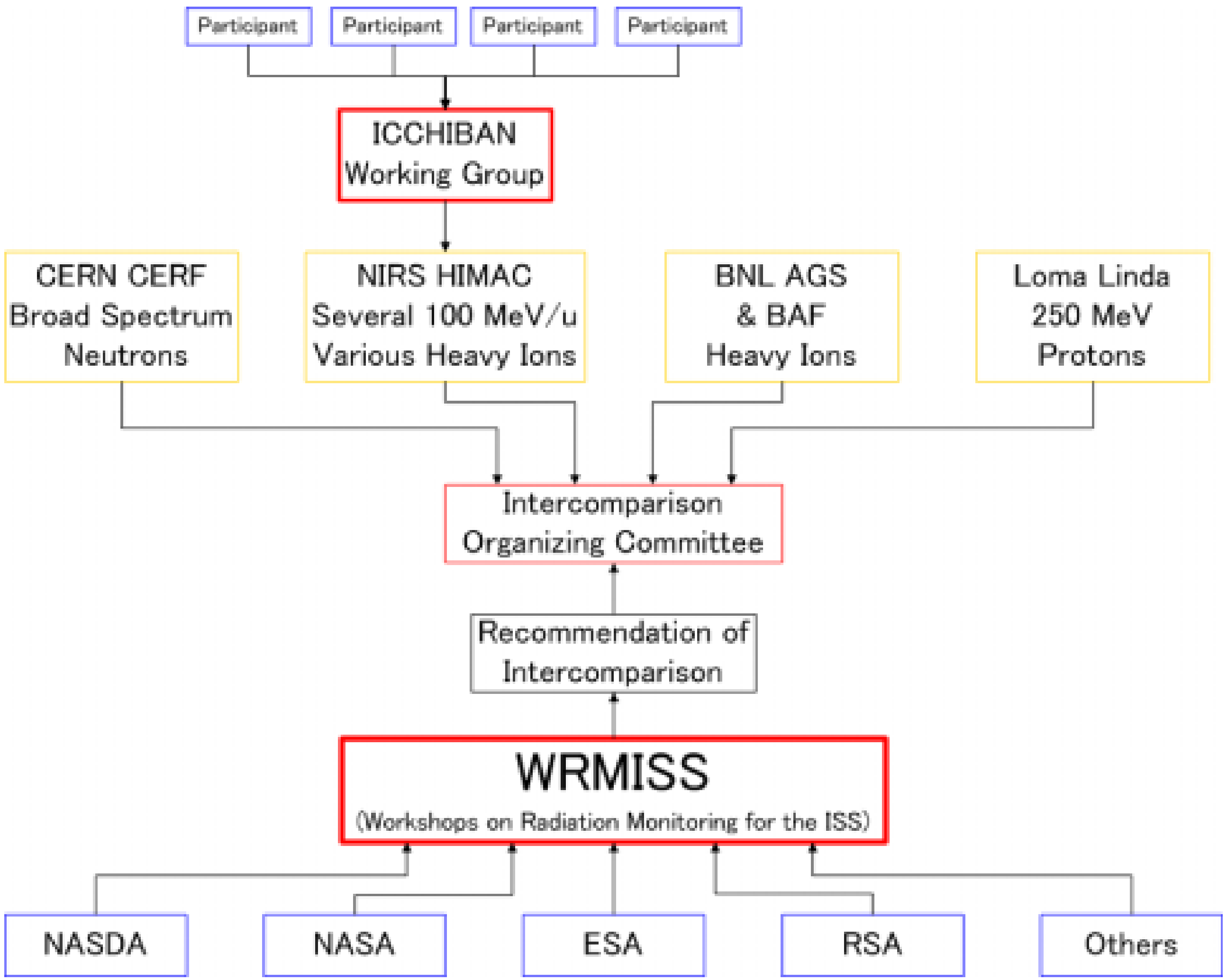
NIRS # Objectives of ICCHIBAN *ISRL*

- 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.
- Aid in reconciling differences in measurements made by various radiation instruments during space flight.

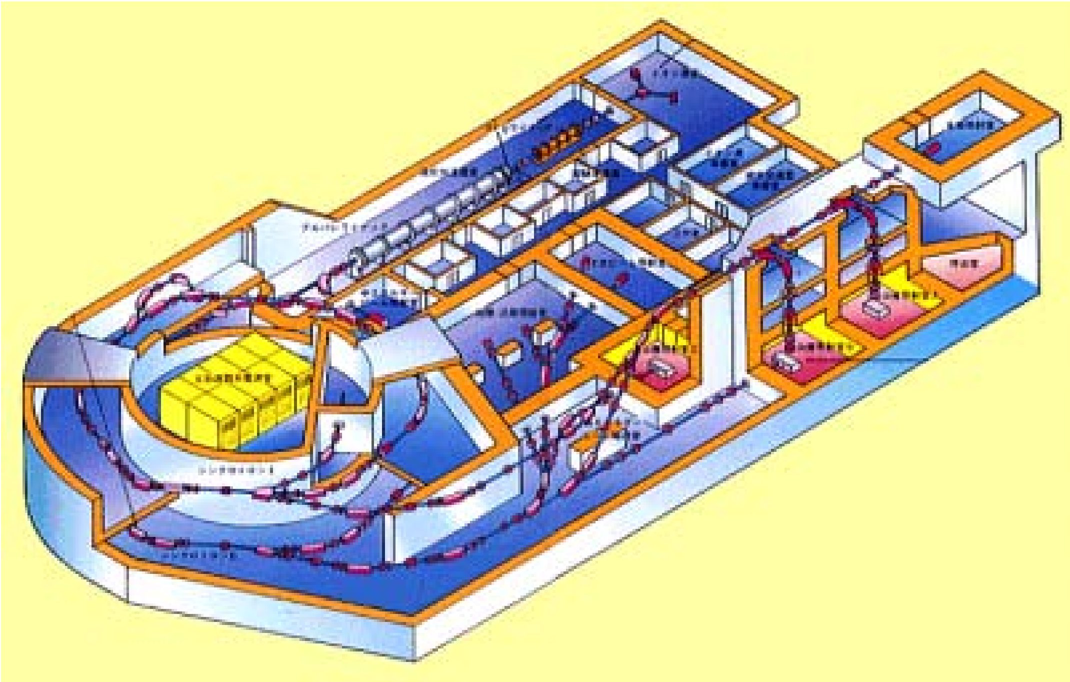
ICCHIBAN Runs

- Opportunity for two or three runs per year.
- 1st ICCHIBAN: active detectors, shake down run
- 2nd ICCHIBAN: passive detectors
- Participants/Detectors not included in first two runs will have opportunity later.

NIRS # Intercomparison Program ISRL



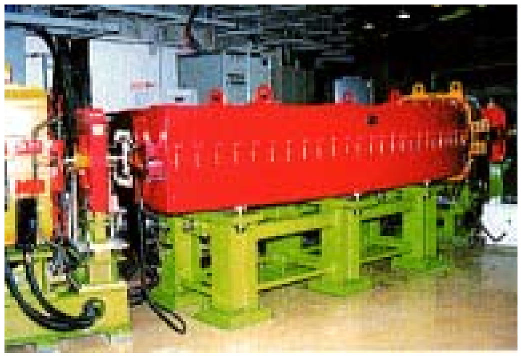
HIMAC (Heavy Ion Medical Accelerator in Chiba)



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

Energies
125〜800MeV/u

Linear Accelerator

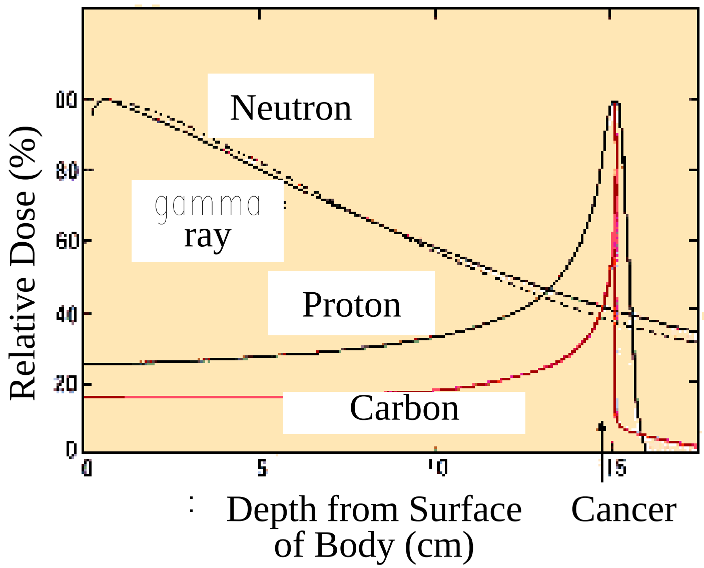


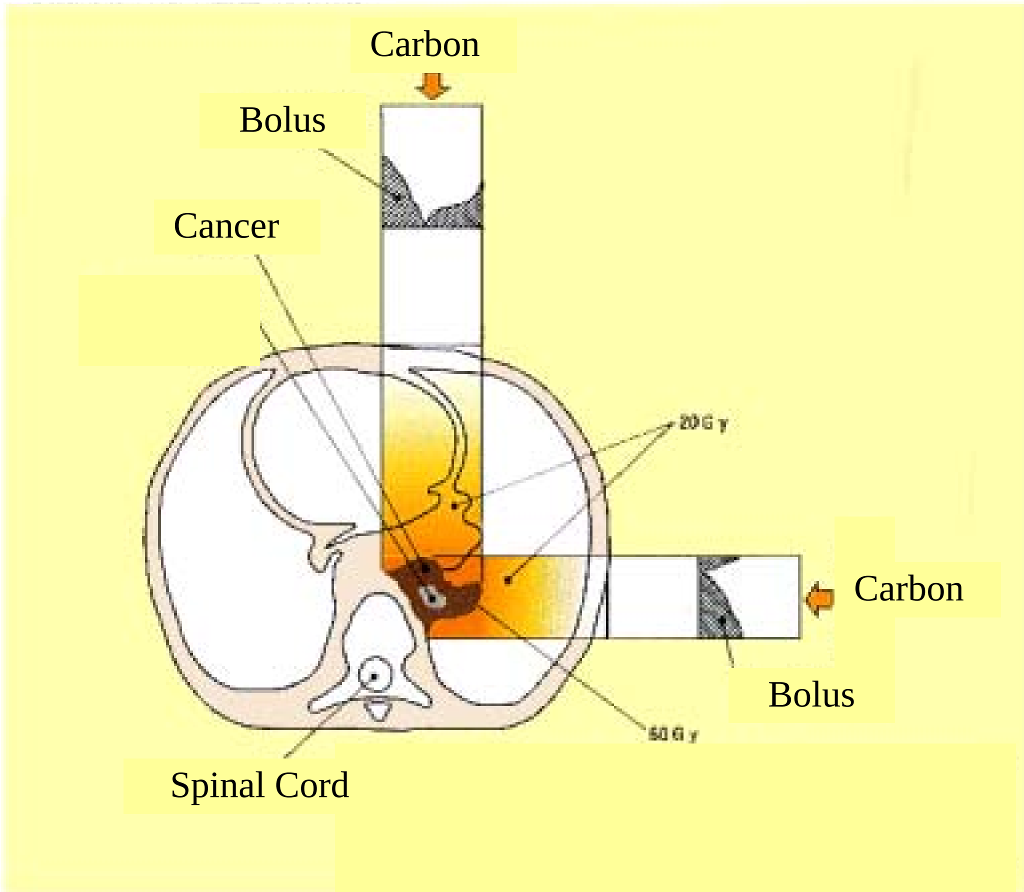
Synchrotron

2 Rings

HIMAC Cancer Therapy

Dose distribution of various radiations





About 1000 patients had treatment in HIMAC.

Operation of HIMAC

- During day time on week day, HIMAC ion beams are used for the treatment of patients.

- During night time on week day or day time on weekend, they are used for the biology and physics experiments.

Mon		Tue		Wed		Thu		Fri		Sat		Sun	
day	night	day	night	day	night	day	night	day	night	day	night	day	night
Maintenance		Treatment		Treatment		Treatment		Treatment				No Service	No Service

☐ Physics and Biology Experiments are available.

Treatment Maintenance No Service

NIRS Irradiation Room in HIMAC *ISRL*

- Treatment Rooms for Patient --- 3 rooms

  (Upper & Lower Ring)

- A Biological Experiment Room (BIO)

  (Upper Ring)

- Physics Experiment Rooms
  - Direct Beam Courses --- 2 courses (PH1, **PH2**)
  - Secondary Beam Courses --- 2 courses (SB2, SB3)

    (Lower Ring)

Treatment Room

NIRS ICCHIBAN Working Group *ISRL*

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

NIRS *ISRL*

Organizing Committee of WRMISS Intercomparison

- Guenther Reitz (Chair), German Aerospace Center (DLR), Germany
- Kazunobu Fujitaka, National Institute of Radiological Sciences (NIRS), Japan
- Jack Miller, Lawrence Berkeley National Laboratory, USA
- Thomas Borak (Liaison with WG), Colorado State University, USA
- Rudolf Beaujean, University of Kiel, Germany

NIRS Participants for 1st ICCHIBAN (to date) *ISRL*

Participants	Nation	Detector Name	Detector Type
T. Doke	Japan	RRMD-III	Silicon Stack Detector
R. Beaujean & G. Reitz	German	DOSTEL	Silicon Stack Detector
JSC, NASA	USA	TEPC + CPDS	TEPC + Silicon&C
Y. Uchihori	Japan	Liulin-4J	Mobile Si Dosimeter
Y. Tawara & N. Yasuda	Japan	CR-39 + TLD	CR-39 + TLD
E. Benton	USA	CR-39 + TLD	CR-39 + TLD
C. Zeitlin & J. Miller	USA	Grand Base Detectors	Silicon Stack Detector

Schedule of 1st ICCHIBAN

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

Requirement for Participants after Experiments

- LET or y Distribution
- Mean Quality Factors
- Dose (to Tissue) per 10^6 Particles
- Dose Equivalent per 10^6 Particles
- To be determined

NIRS Available Beam in 1st ICCHIBAN *ISRL*

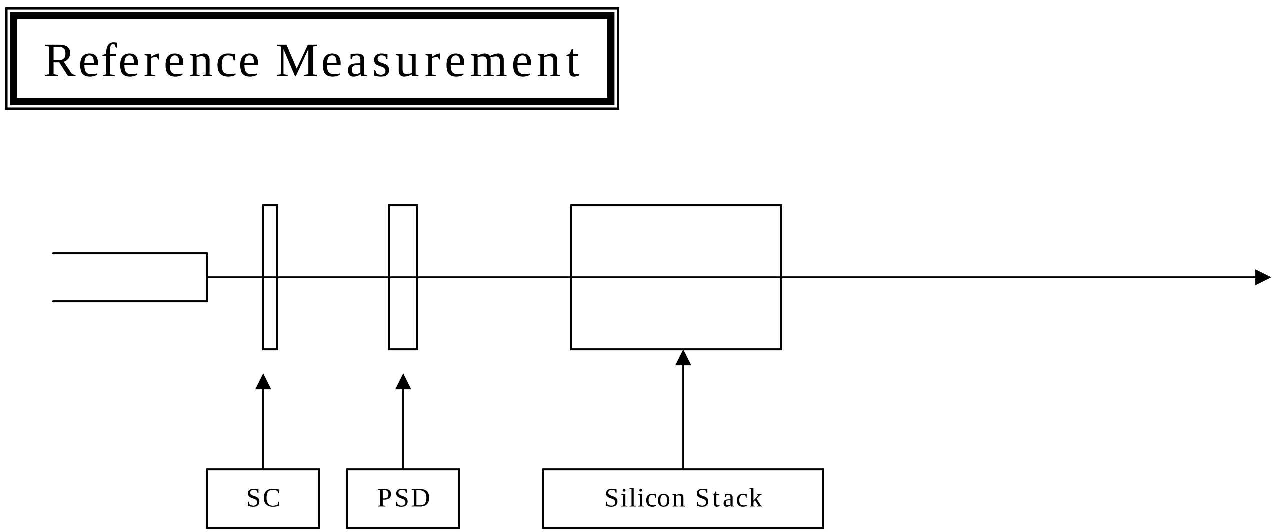
- HIMAC Committee realized importance of our project and approved 4 nights ~ 40 hours for 1st ICCHIBAN runs.
- 2 nights for Carbon (400MeV/u) and 2 nights for Iron (400MeV/u) are available.
- Beam Intensity will be tuned $3x10^2$ particles per spill. 1 spill every 3.3 sec. Spill distribution is about 0.7 sec.
- The beam spot will be tuned as 20 mm diameter circles.

Beam Characteristics to be provided to participants

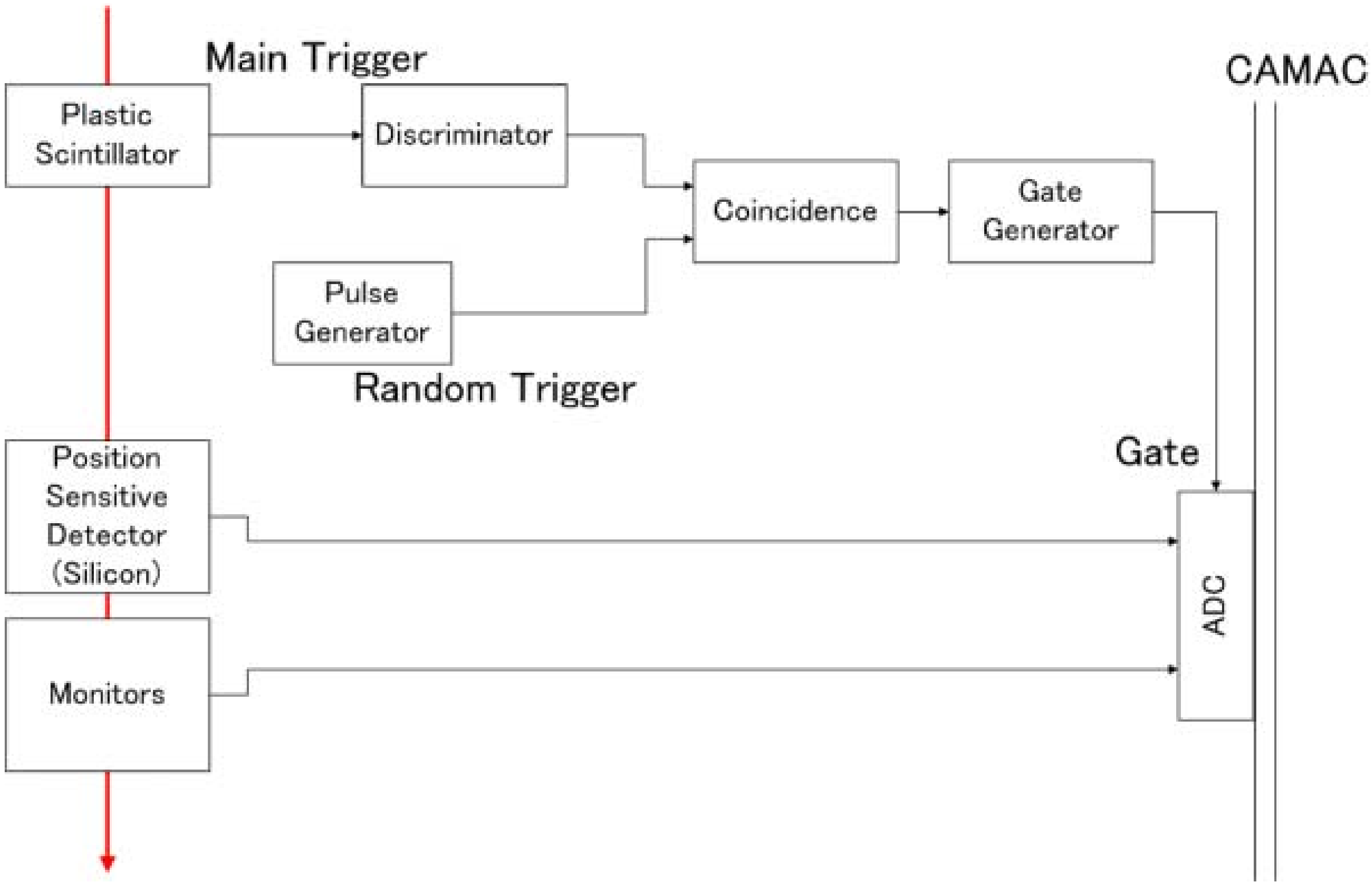
- Actual Beam Energy at Detector
- Geometric Beam Profile (We can provide position of each particle.)
- Time Structure of Beam
- Fluence and Average Beam Intensity

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



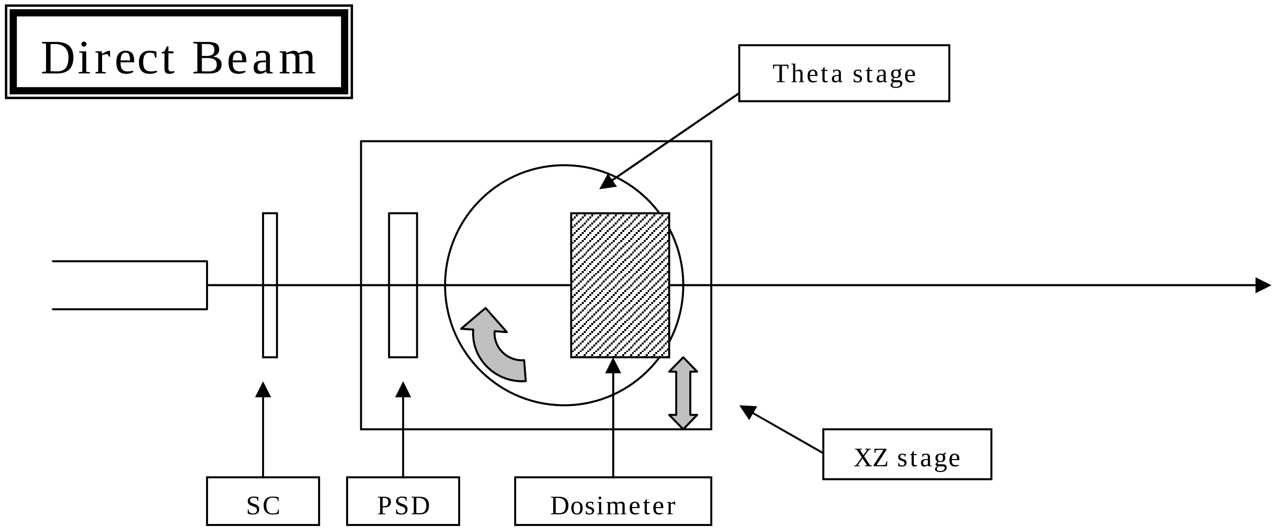
Trigger System



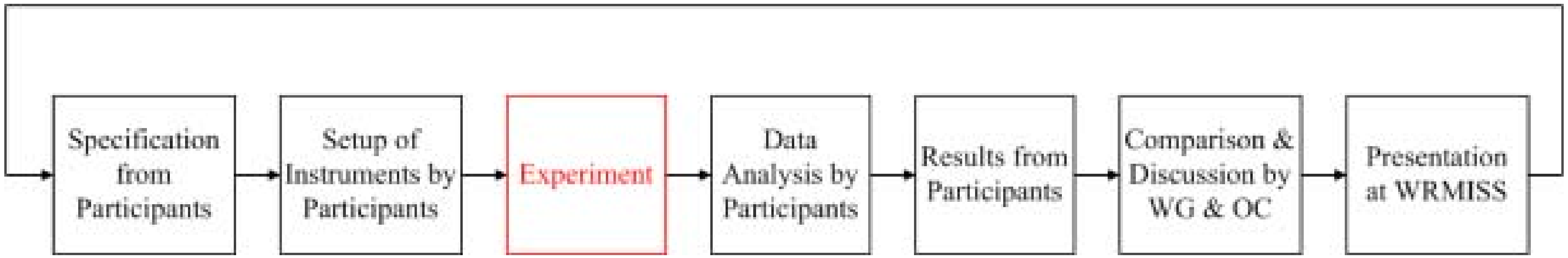
Exposures of dosimeters

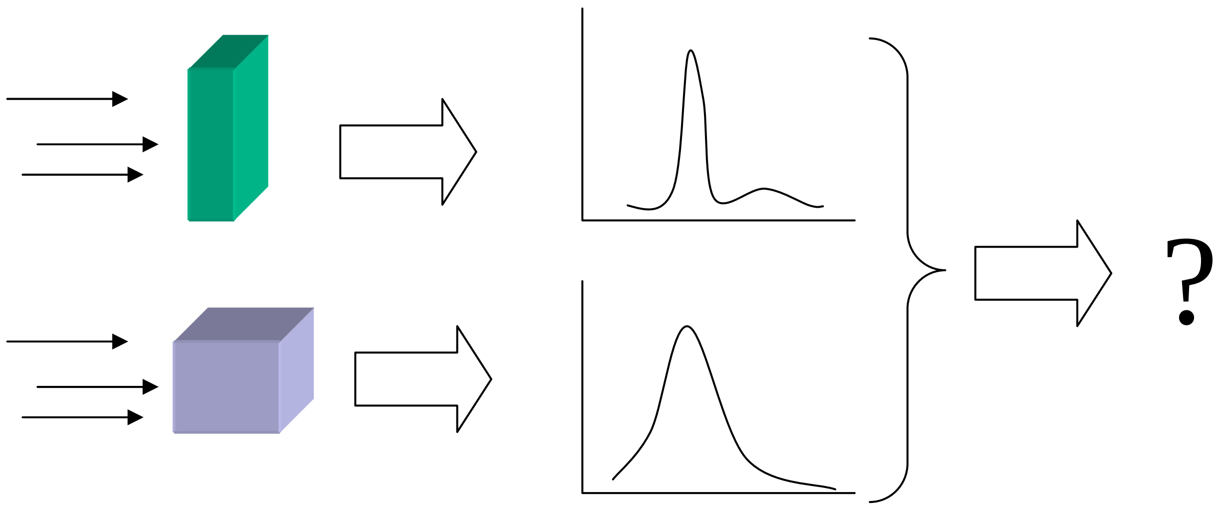
- Dosimeters will be irradiated for direct beam after transmitting a thin scintillation counter. The scintillation counter will count the beam intensity and give trigger signal for the dosimeter if required.

- Detectors can be rotated with the Theta stage and it will be irradiated with several incident angles.



NIRS Flow Chart of ICCHIBAN Exposure *ISRL*





Time Schedule

NIRS *ISRL*

Date	Event
Sep. 12, 2001	6th WRMISS Workshop at Oxford
Oct. 15, 2001	2nd Circular
Nov. 30, 2001	Procedure for Radiation Control, Visiting Researcher and Hotel reservation
Feb. 10-13, 2002	1st ICCHIBAN Experiment
Apr. 30, 2002	Preliminary Report of data
May, 2002	2nd ICCHIBAN Experiments (For Passive Detectors)
Jun. 15, 2002	Suggestions for next accelerator run, (i.e. ions, energy, dates)
(End, 2002)	3rd ICCHIBAN Experiment

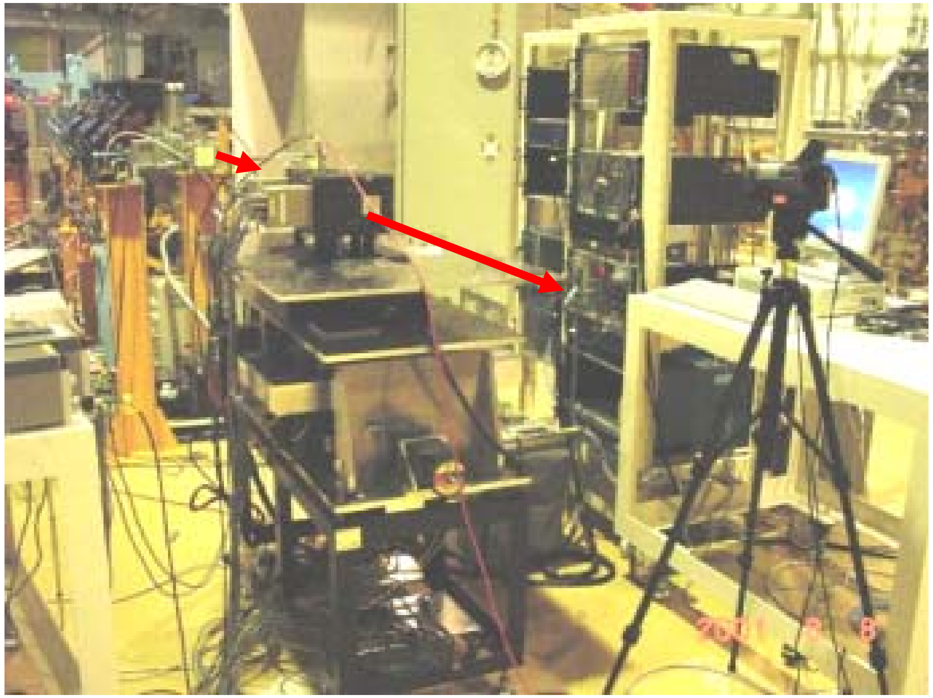
will continue for two more years

NIRS 2nd ICCHIBAN Experiments *ISRL*

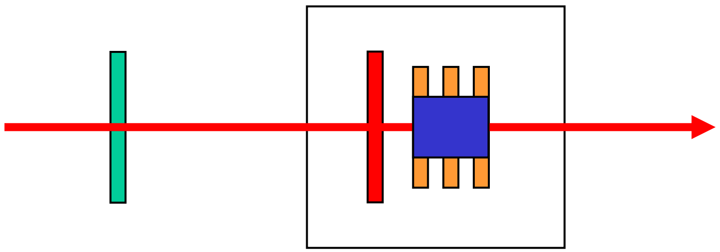
- 2nd ICCHIBAN Experiment will be held on May, 2002 and it will be concentrated with “Passive Detectors”. These exposures will be done in “Biology Room (BIO)”.
- Possibility to include “unknown ions” (blind exposures) in addition to “known ions”.
- Participants with passive detectors need not attend in person (send detectors to ICCHIBAN WG).

Pre-Experiment

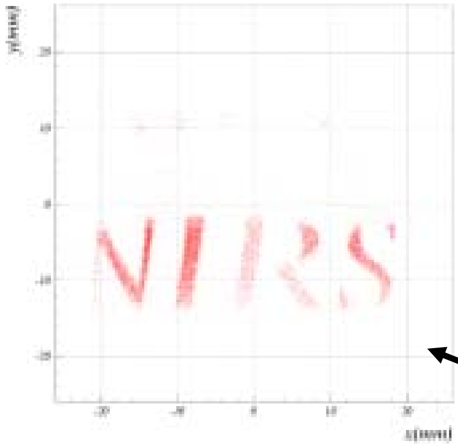
- Aug. 8th, 2001
- Iron 500 MeV/u
- Intensity ~ $10^{3\sim6}$ particles per spill
- Beam Profile ~ 2cm circle

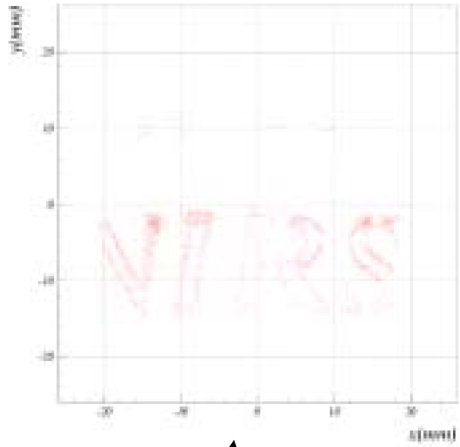


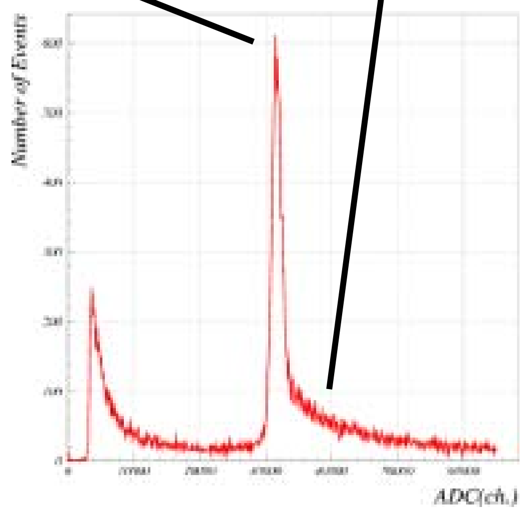
- Detectors
  - Silicon stack detector
  - CR-39
  - Liulin-4J



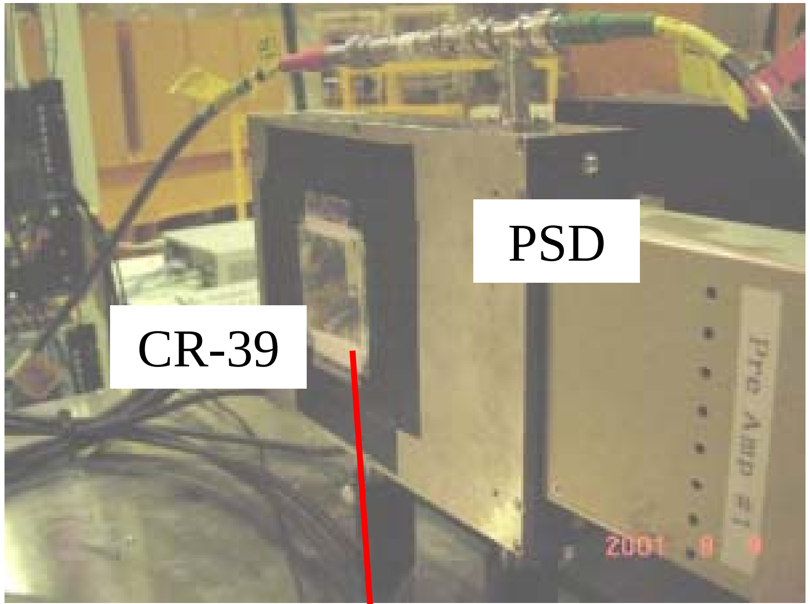
NIRS PSD Position Resolution *ISRL*

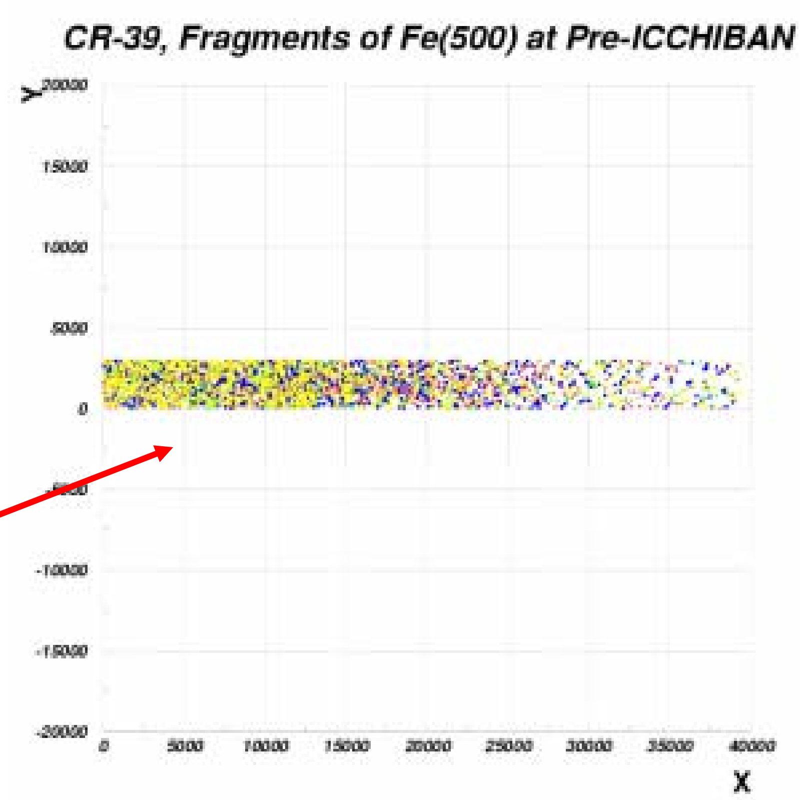






CR-39 and PSD





Scanning region

10 mm

40 mm

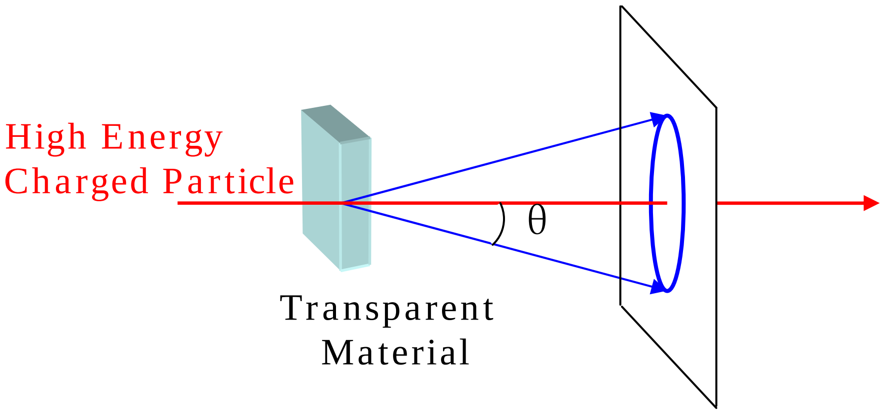
Call for ICCHIBAN

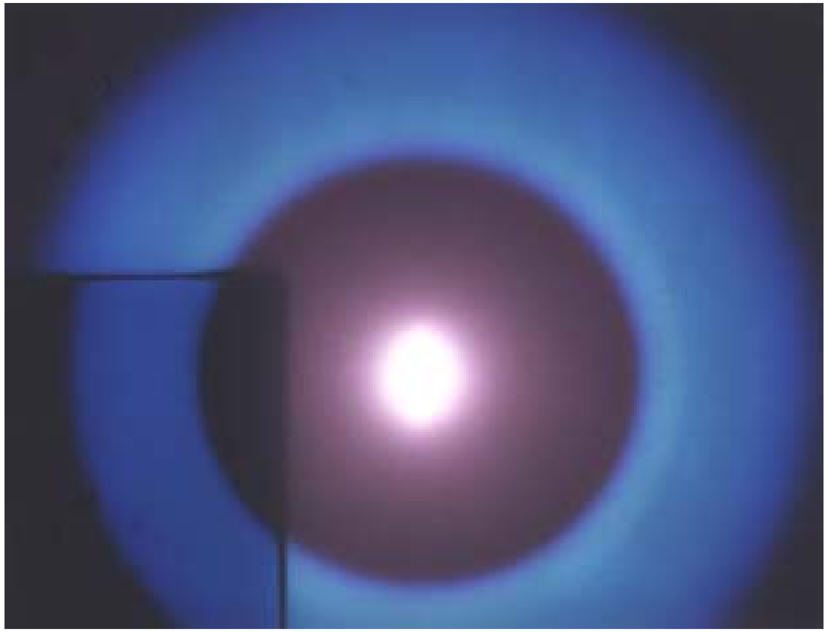
- We hope this project will succeed and it will contribute to our understanding of space radiation instruments.

- We are eager for your participation to ICCHIBAN.

- If you have interest in ICCHIBAN, please contact me (uchihori@nirs.go.jp).

RICH (Ring Image Cherenkov)





$$N\,d\nu\,dx = \frac{2\pi e^2 z^2}{\text{[illegible]}^2}\left(1 - \frac{1}{n^2\beta^2}\right)d\nu\,dx$$

$$\cos(\theta_\lambda) = \frac{1}{n_\lambda \beta}$$

N:Number of Photons

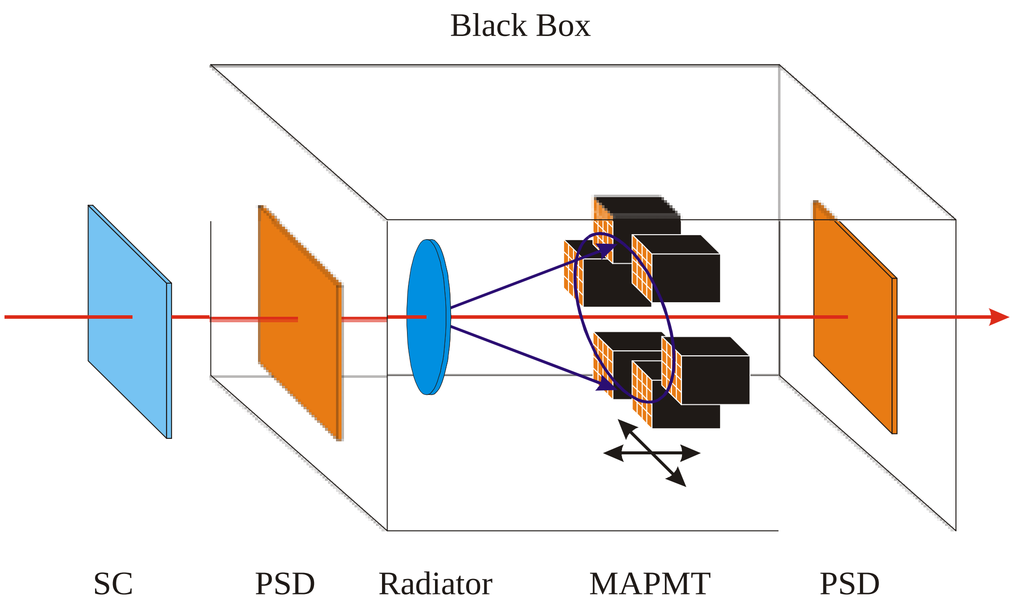
ν:Frequency of Light

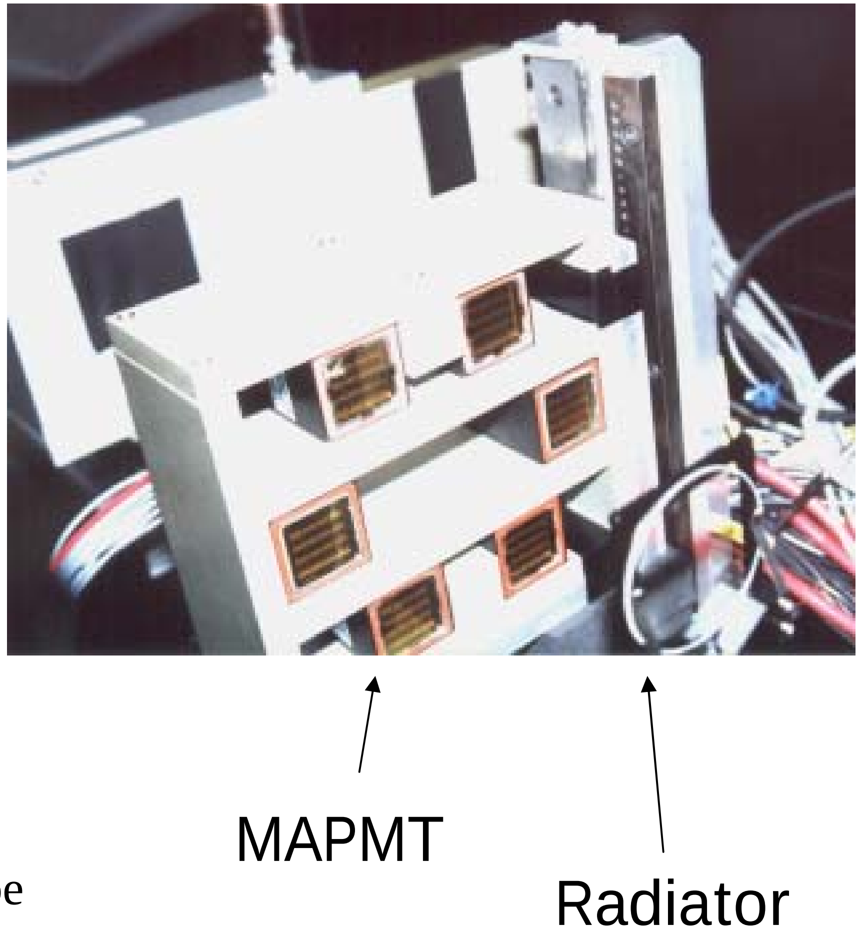
z:Charge of Particle

b : Velocity of Particle(v/c)

n:Refractive Index

RICH Setup



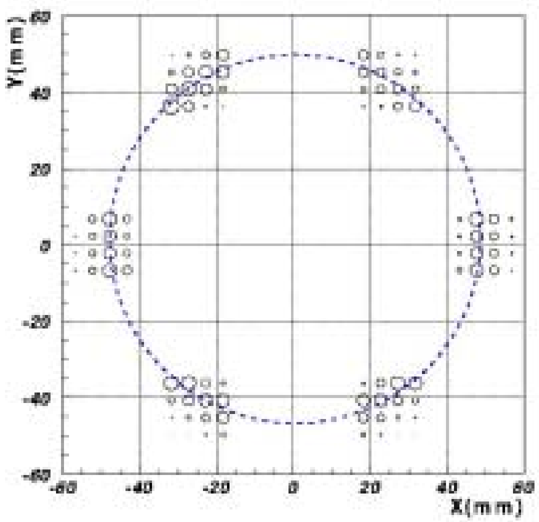


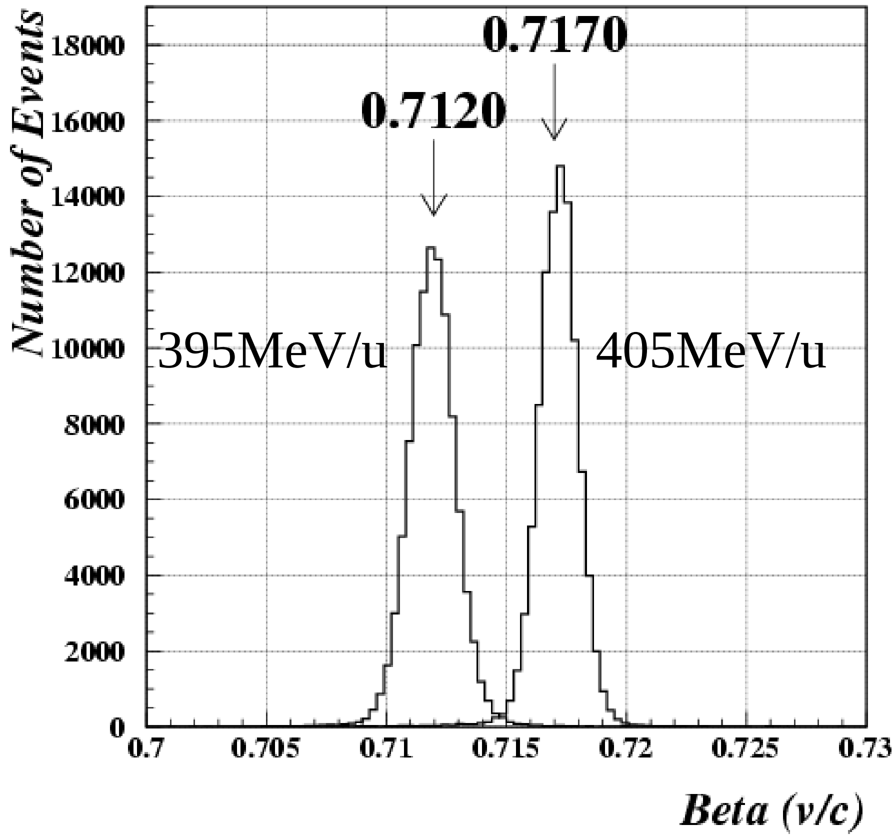
SC : Scintillation Counter

PSD : Position Sensitive Si Detector

MAPMT : Multi-Anode Photo-Multiplier Tube

NIRS Velocity Distribution by RICH *ISRL*





Δ β / β
∼0.2%

Velocity Distributions Observed by RICH for Si beam.
Both results for 405MeV/u and 395MeV/u are shown.

Liulin-4J

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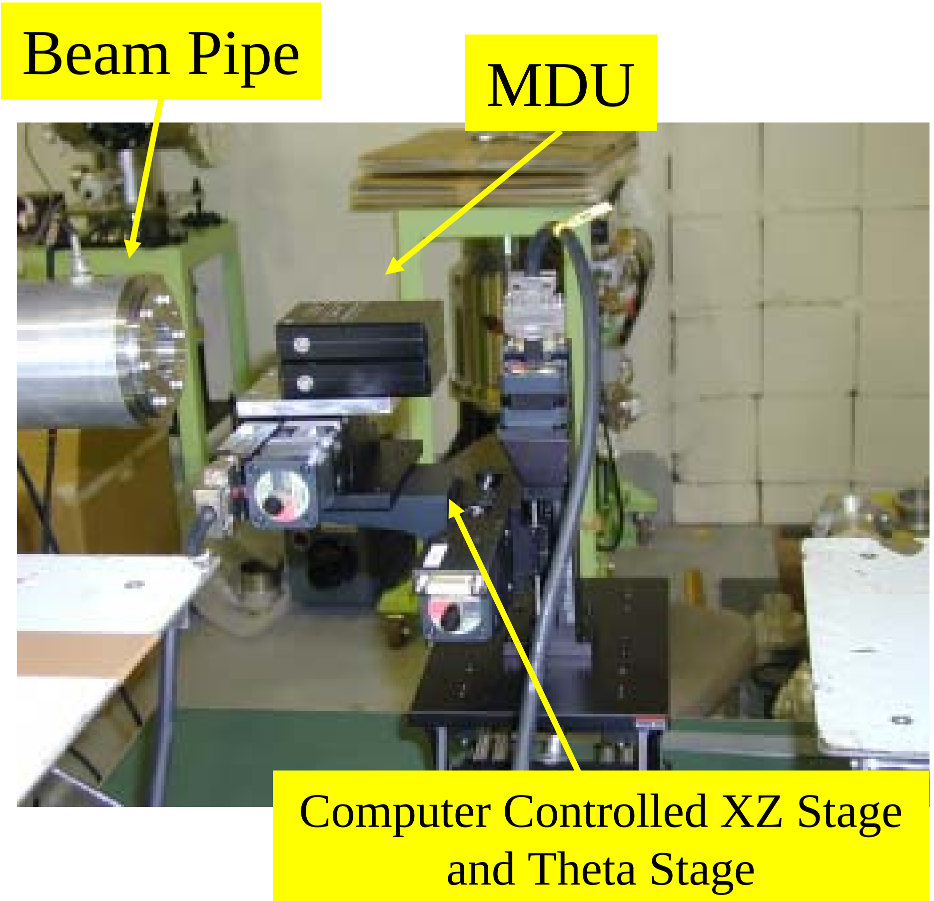
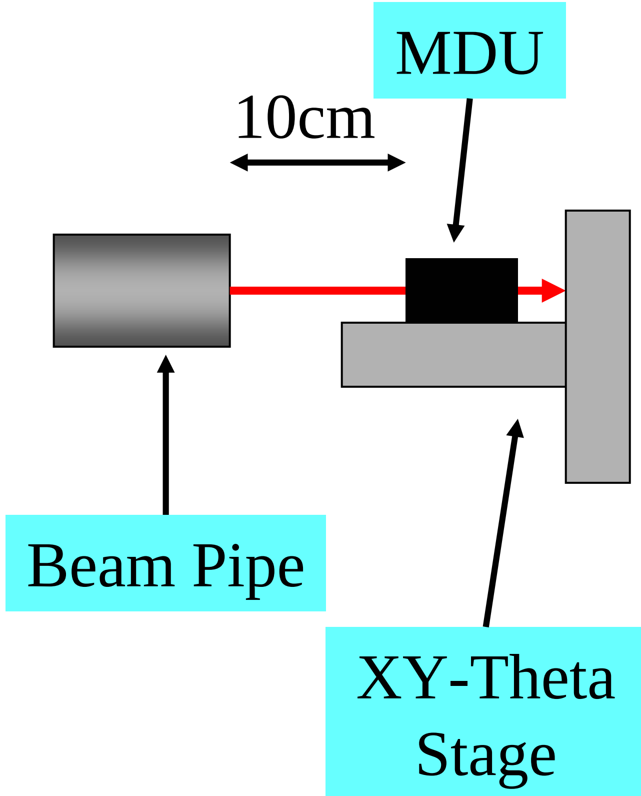
30 - 70 MeV
Proton Beam





NIRS

Liulin-4J Calibration

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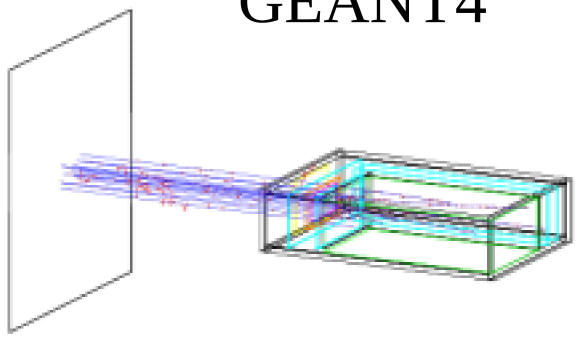
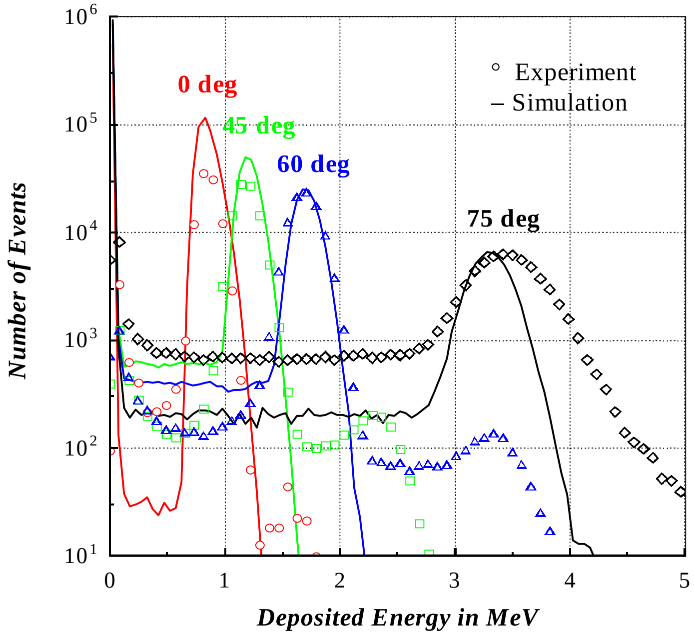
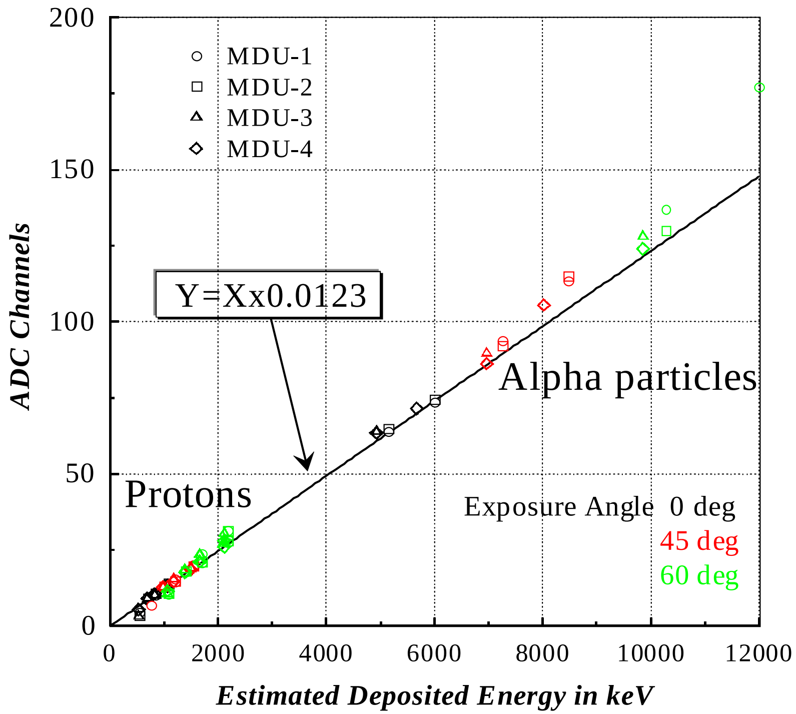
GEANT4







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HIMAC Exposures

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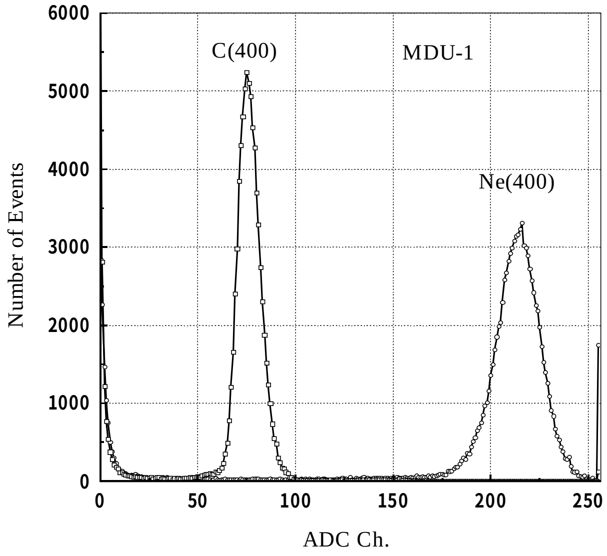
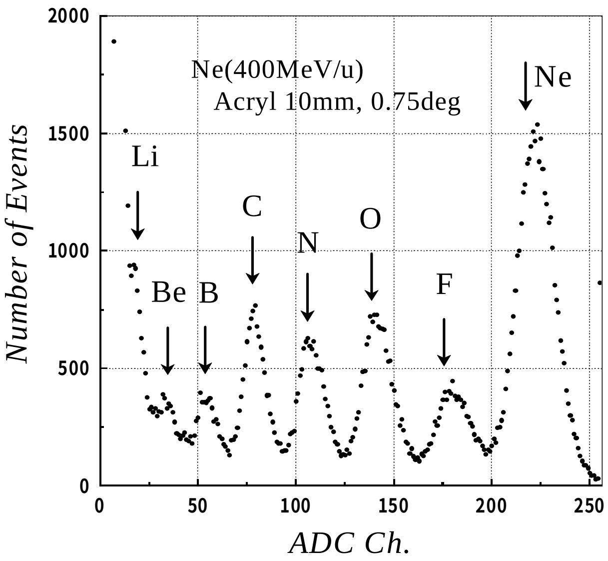
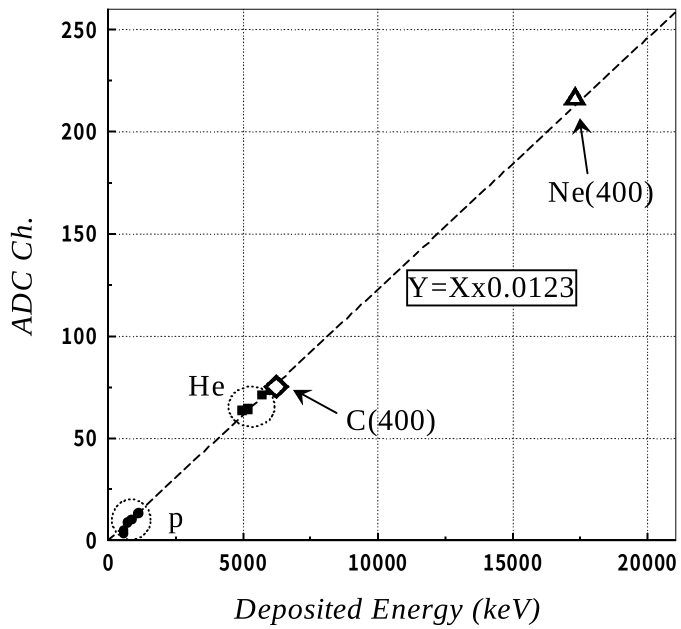




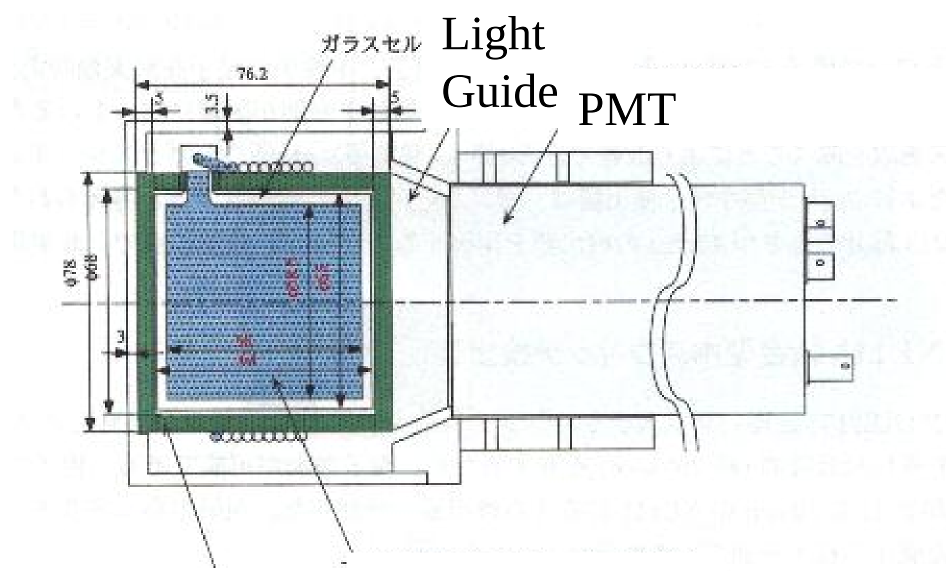


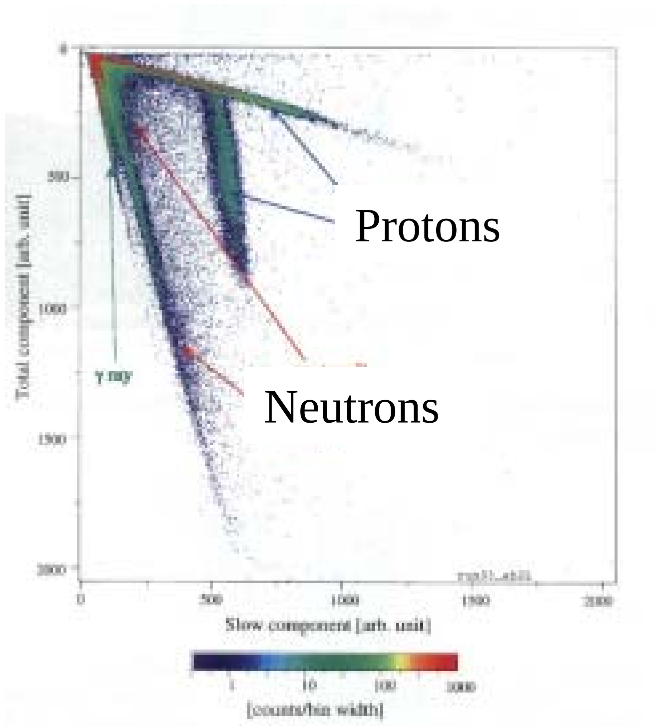
Diamond Detector

- Artificial diamond detector is developed with collaboration with Kanagawa Univ., Japan.
- Diamond has characters which is radiation hardness, low noise and tissue equivalent.
- The energy resolution of diamond detector is corresponding to surface barrier silicon detector.
- Because of tissue equivalent, diamond detector will be used as radiation protection monitor.

Phoswich Neutron Detector

By Masashi Takada





Scintillation Fiber Detector

By Tatsumi Koi