Status Report of the ICCHIBAN Experiments

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ICCHIBAN Projects

- WRMISS
  - The objective of the workshop was to elaborate an optimal set of instruments for radiation protection issues and to develop and agree on methodologies so that data from these instruments can be compared and properly interpreted. (a excerpt from 3rd WRMISS recommendation)
- Intercalibration campaigns
  - During the 4th WRMISS in Farnborough, all participants agreed that it is necessary to establish a process for calibration and intercomparison of space radiation dosimeters. (http://wrmiss.org)
- Ground-base inter-comparison experiments using accelerators
  - The first exposures were performed with heavy ion beams; several 100 MeV/nucleon He to Xe at the HIMAC , named as intercompare radiation instruments designed for use in space as part of a newly initiated InterComparison for Cosmic-ray with Heavy Ion Beams At HIMAC (ICCHIBAN) project.
  - The experiments have been spread to other facilities (BNL-NSRL, CERN-CERF, LLUMC and NCCHE) on the framework of the ICCHIBAN project.
- Intercomparisons of detectors on ISS also have been performed as BRADOS, Space-ICCHIBAN , Matroshka-R etc.

ICCHIBAN Project

一番

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

NASA-JSC, JAXA, IBMP, DLR, … 13 countries, 21 institutes

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

- 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.

Proton ICCHIBAN

- To understand responses of detectors for <u>Low LET</u> components
  - Main objects: TLD, OSL, glass, etc.
  - To expose detectors with same conditions, the ICWG (ICCHIBAN Working Group) prepared “Standard Packages”.
- Construction of radiation field for low LET particles at accelerators.
- Past experiments
  - 1st Proton ICCHIBAN (LLUMC)
    - Proton 250 MeV
    - Sep, 2003
  - 2nd Proton ICCHIBAN (NIRS Cyclotron)
    - Proton 40, 70 MeV
    - Jan, 2010
  - 3rd Proton ICCHIBAN (NIRS Cyclotron, NCCHE)
    - proton 30, 235 MeV
    - Feb., 2011
  - 4th Proton ICCHIBAN...

Standard package

Next Plan of Proton ICCHIBAN

- Accelerator : NIRS-Cyclotron
  - General purpose radiation room (C-8)
  - Easy to get machine times and to be controlled by ourselves.
    - The NIRS-HIMAC is not established for proton beams officially.

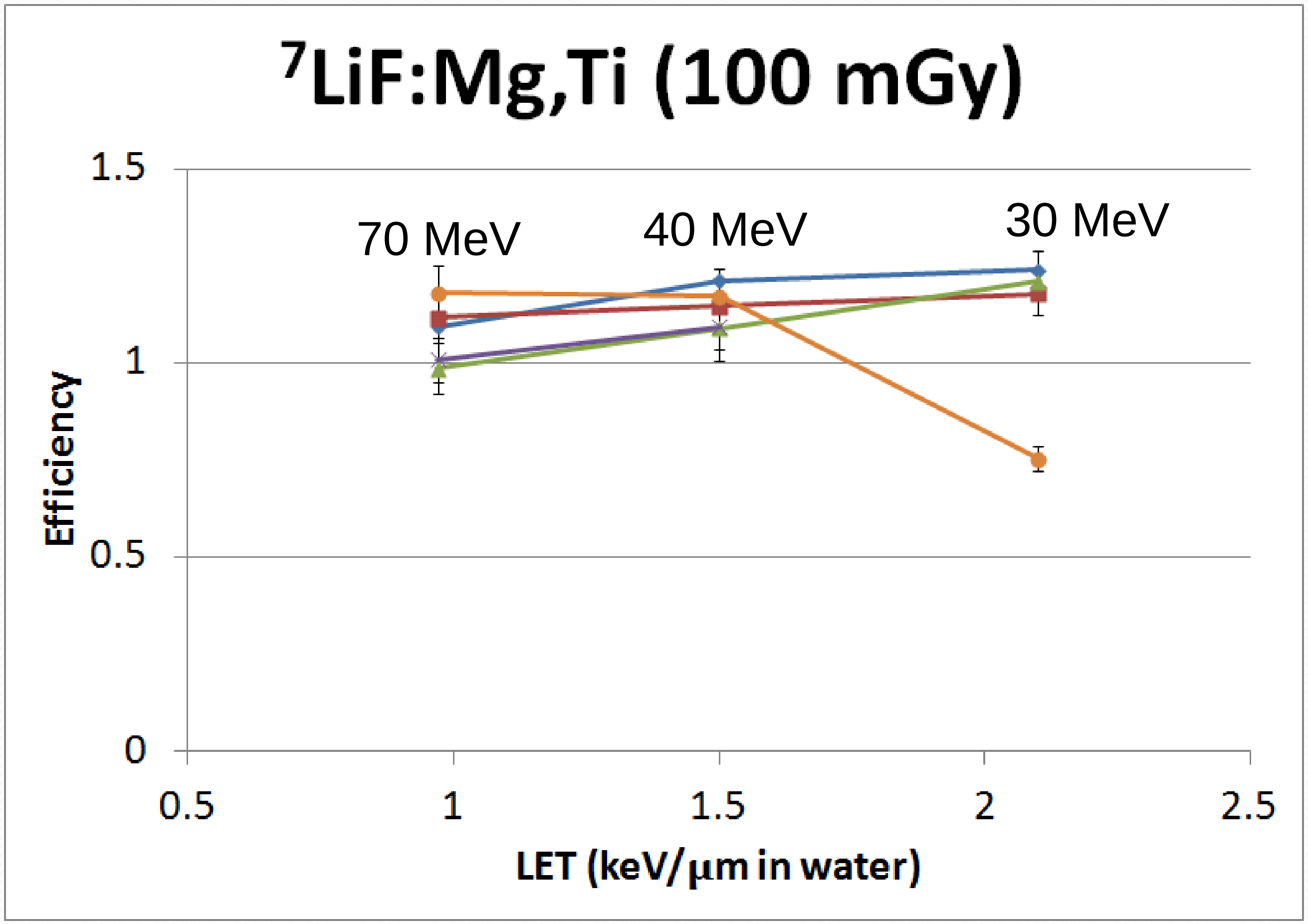
- Usable Beams
  - Proton: 25, 30, 40, 50, 60, 70, 80 MeV (80 MeV is maximum energy)
  - ^{4}He: 100 MeV

Selection of Energy and ion

"Preliminary Results of Proton ICCHIBAN Experiments", H.Kitamura, et al., WRMISS 17

- Luminescence efficiencies are almost constant in 1-2 keV/um LET region.
- But, some detectors showed slight increases in luminescence efficiencies with LET increasing.
  - Because of the shorter range of 30 MeV proton beam, thickness of detectors should be considered to calculate the exposed doses.
  - The ICWG should check the real thickness of the standard packages and the time variation of the calibrated ion chamber to evaluate the beam monitor.
- → low energy and high LET beams are not good for the inter-comparison experiments.

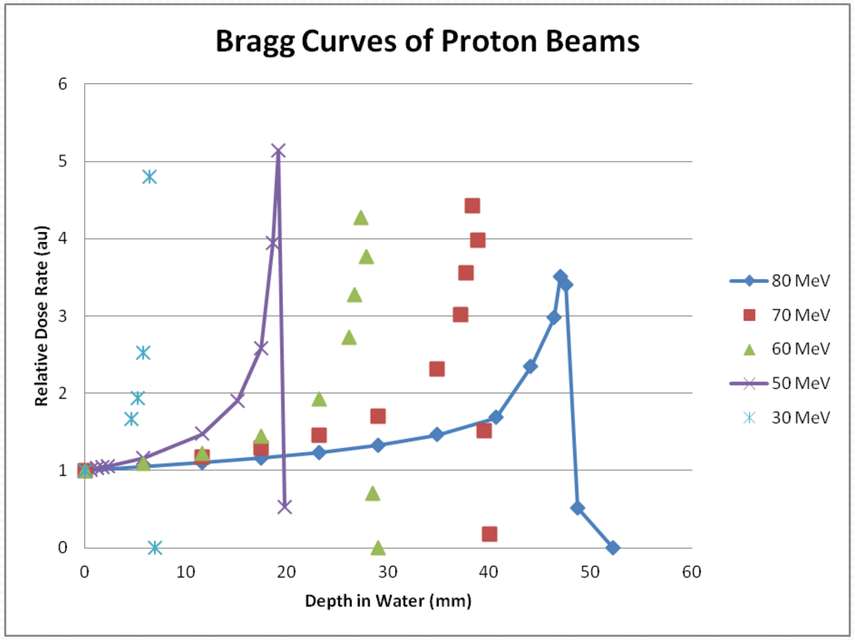
TLD (^{7}LiF:Mg,Ti)



4^{th} Proton ICCHIBAN

- Plan of the next experiments
  - Energy: proton 50, 80 MeV
  - NIRS-Cyclotron Facility
  - May. 2014

Beam Energy (MeV)	50	80
Actual Energy (MeV)	46	77
LET in Water (keV/um)	1.33	0.89

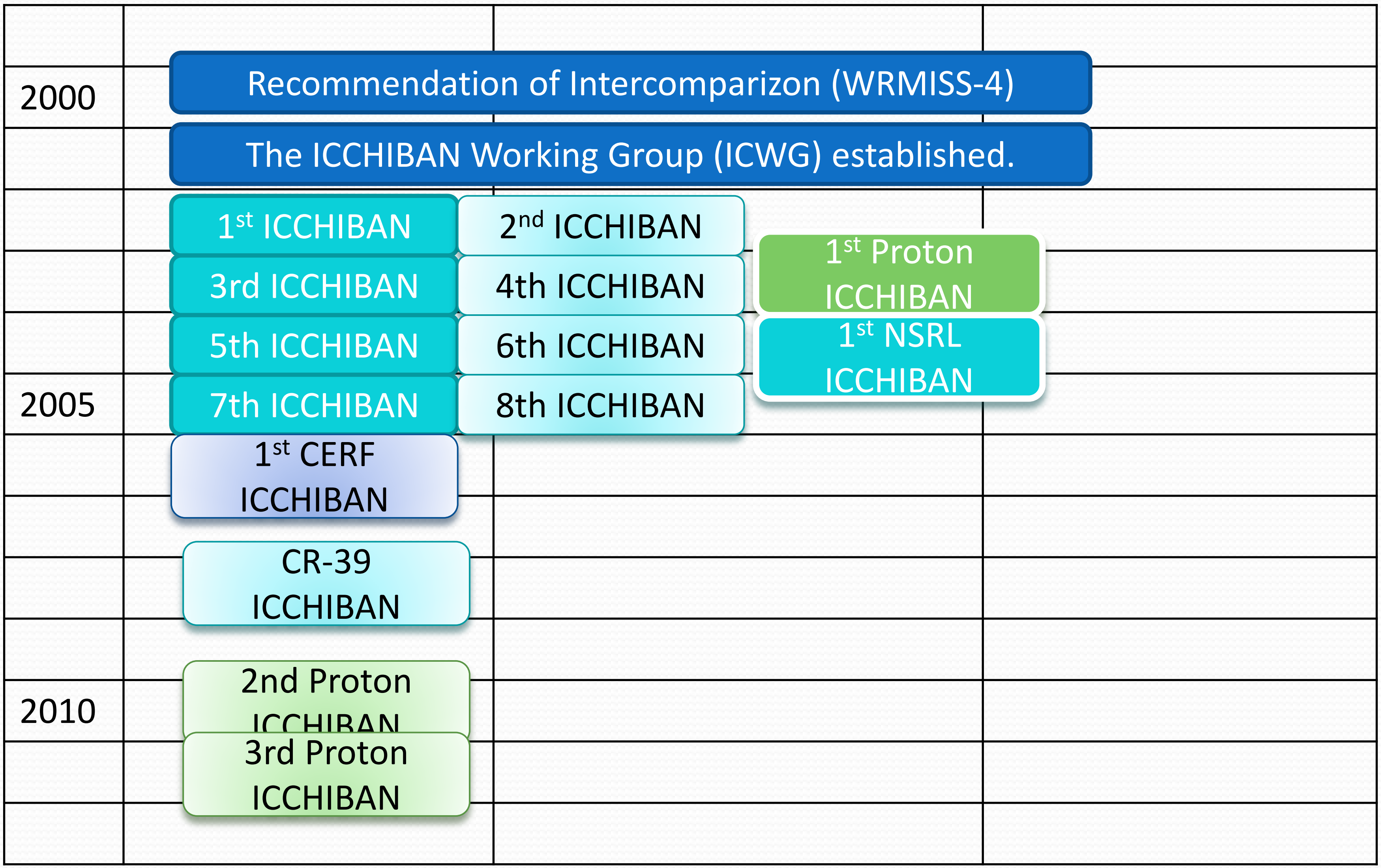


Summary

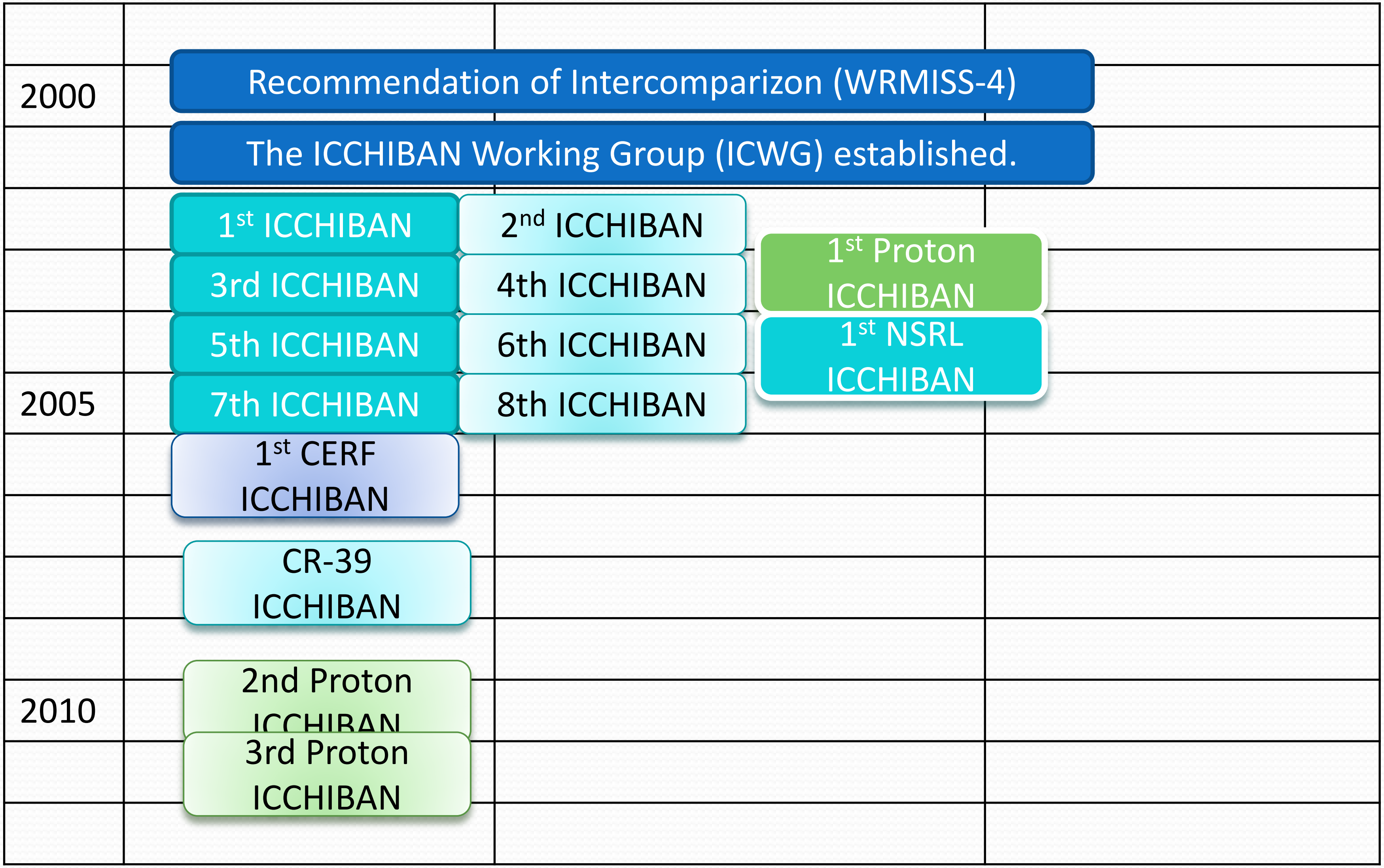
- We are planning of 4th Proton ICCHIBAN experiments using 50 and 80 MeV for passive dosimeters at the NIRS-Cyclotron facility.
- We are not planning of ICCHIBAN experiments for active dosimeters because of shortages of human resources. But, we are willing to support your calibration experiments using the NIRS accelerators.
  - Deadline of new proposals:
    - HIMAC: December 2013
    - Cyclotron: January 2014

Thank you for your attention.

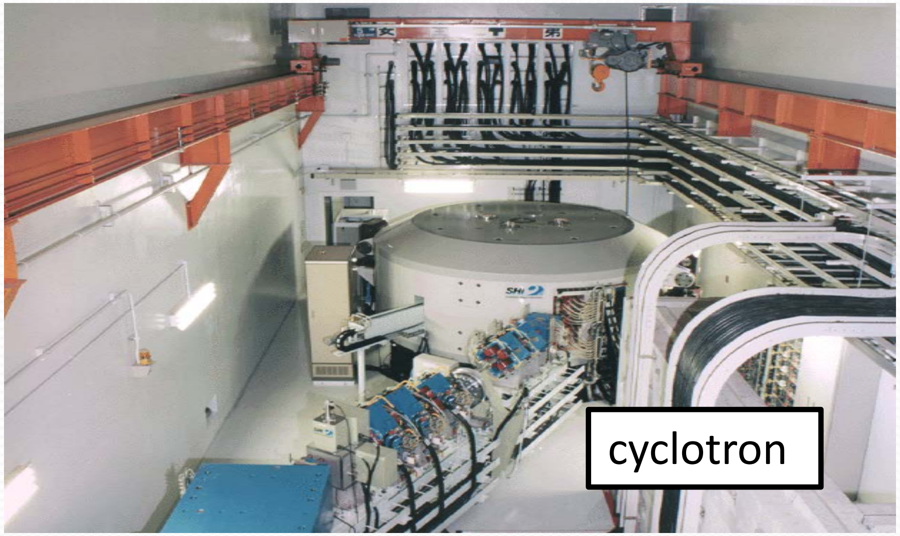
Brief History of ICCHIBAN Project



Brief History of ICCHIBAN Project



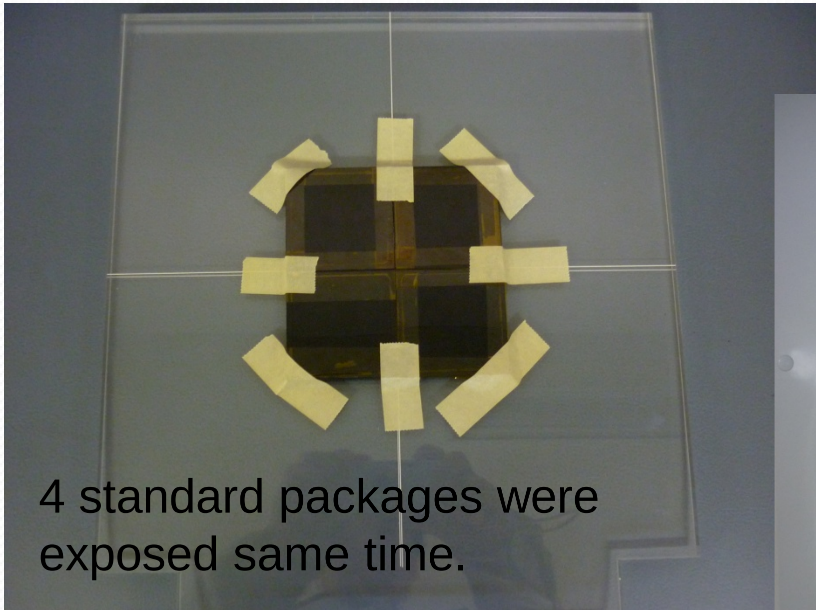
National Cancer Center Hospital East (NCCHE) Cyclotron

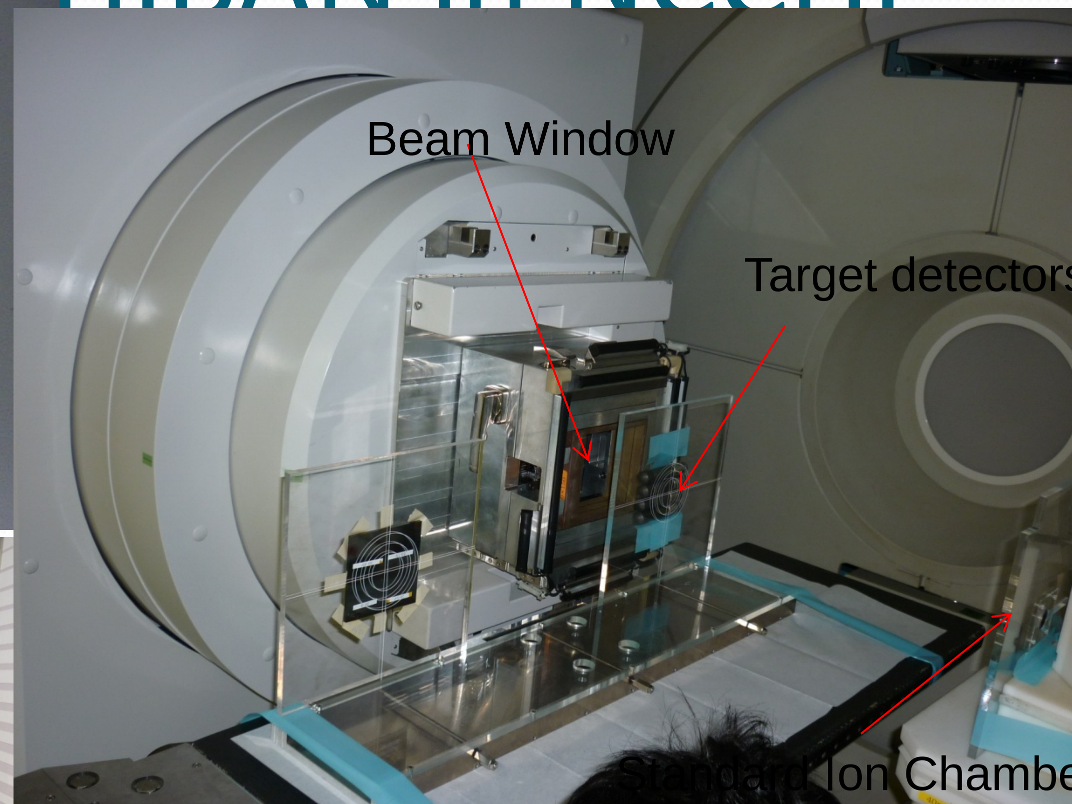


- Place: Kashiwa-City, Japan
- Establish: April 1997
- Purpose: Cancer Therapy
- http://www.ncc.go.jp/en/ncce/about/hospital_e.html

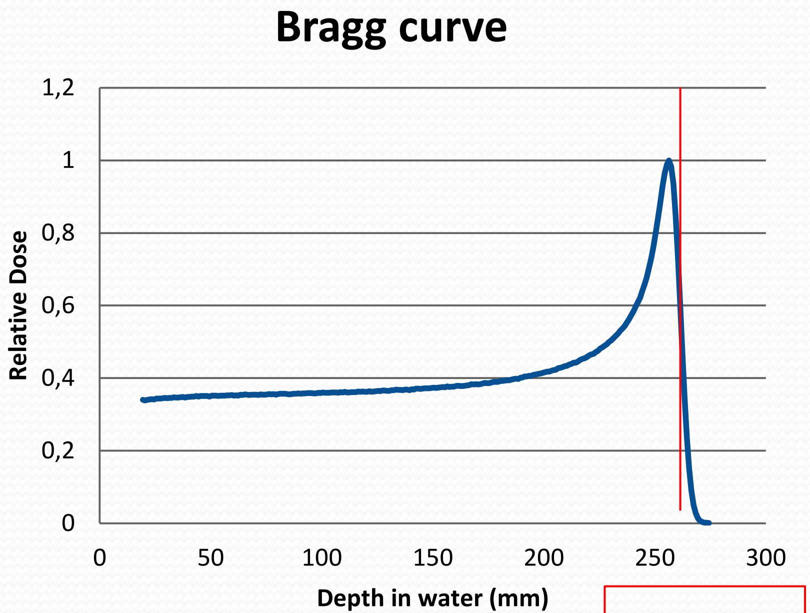
- Type: AVF-Cyclotron
- Beam: Proton 235 MeV
- http://www.shi.co.jp/quantum/eng/product/proton/proton.html

HIBAN in NCCHE

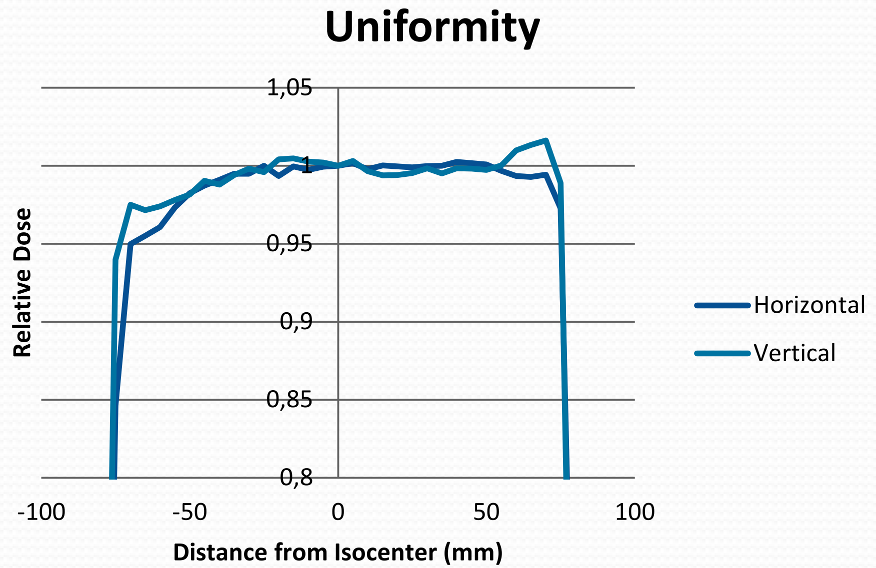




Characteristic of 235 MeV beam



range 262mm



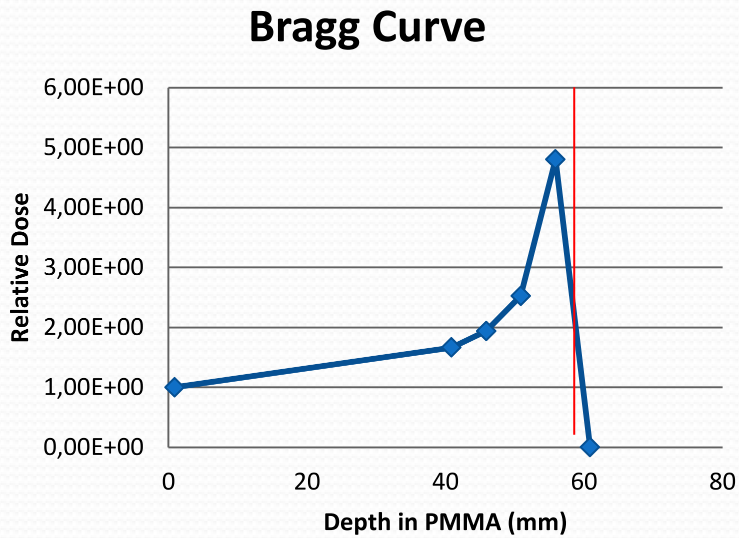
Energy: 203 MeV
LET in water: 0.45 keV/μm
(SRIM 2008)

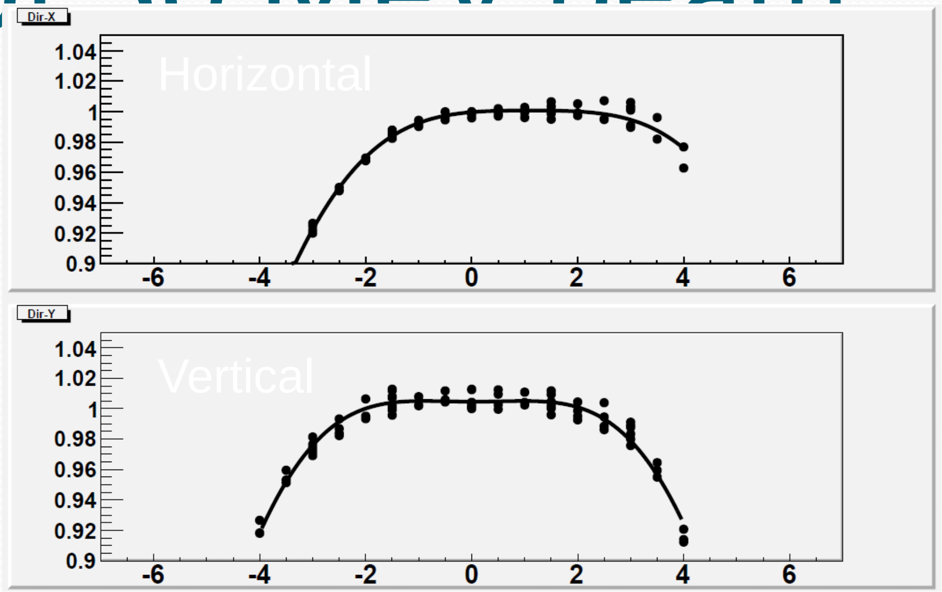
Uniformity: ±5%
within 140 mm diameter

Exposures of proton 235 MeV beam in the NCCHE cyclotron

- Result from range measurement, energy of the beam is 203 MeV, not 235 MeV. #But, I use 235 MeV in this presentation.
- This is the first trial for the NCCHE cyclotron to be used as "reference field".
  - Exposed doses are almost 80% for nominal doses and have large errors because the nominal doses are smaller than the typical clinical doses.
  - We will evaluate the exposed dose, again.

Characteristic of 30 MeV beam





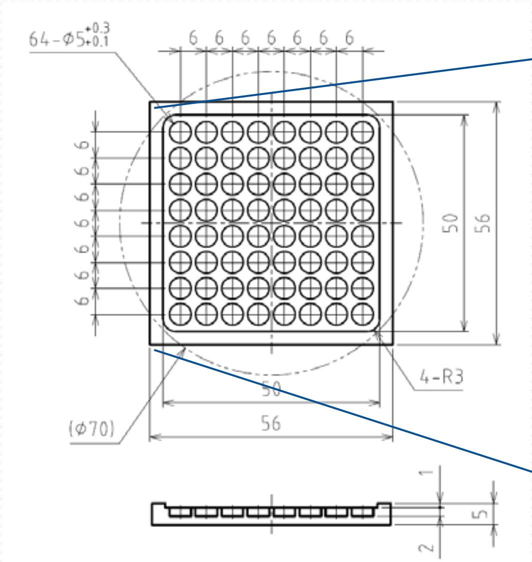
range
5.8 mm

Energy: 26 MeV
LET in water: 2.1 keV/μm
(SRIM 2008)

Uniformity: ±5%
within 70 mm diameter

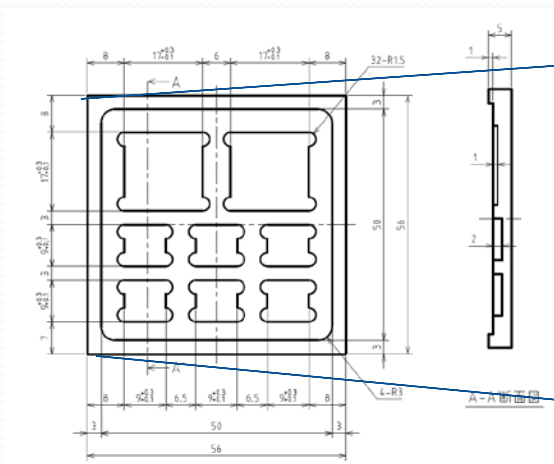
Relative exposed dose* for 30MeV proton at position of the standard packages

Type A Package



0.956	0.973	0.981	0.986	0.987	0.987	0.984	0.978
0.974	0.985	0.992	0.994	0.995	0.995	0.994	0.990
0.983	0.992	0.997	0.998	0.999	0.999	0.998	0.996
0.987	0.996	0.999	1.000	1.000	1.000	1.000	0.998
0.987	0.996	0.999	1.000	1.000	1.000	1.000	0.998
0.983	0.993	0.997	0.998	0.998	0.998	0.998	0.995
0.973	0.985	0.991	0.994	0.994	0.994	0.992	0.988
0.957	0.972	0.980	0.984	0.986	0.985	0.982	0.976

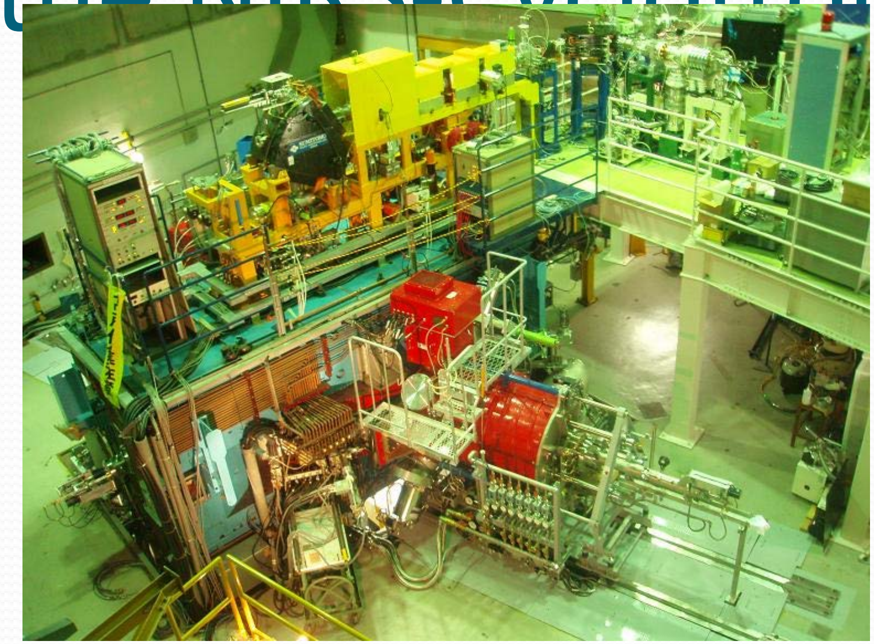
Type C Package



0.990	0.996	
0.991	0.999	0.999
0.976	0.990	0.990

* Not available for 235 MeV proton beam

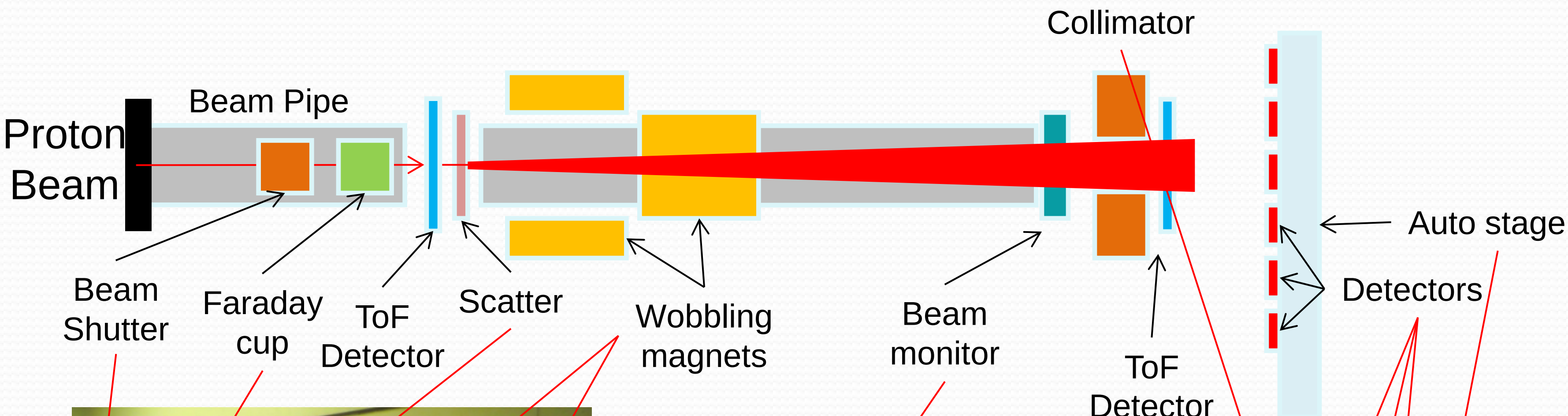
Specification of the NIRS-Cyclotron

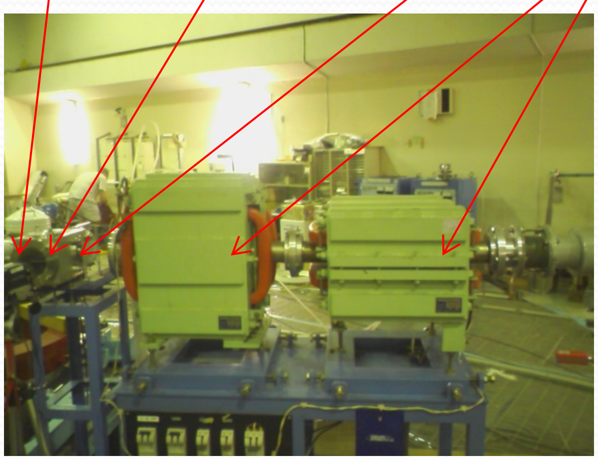


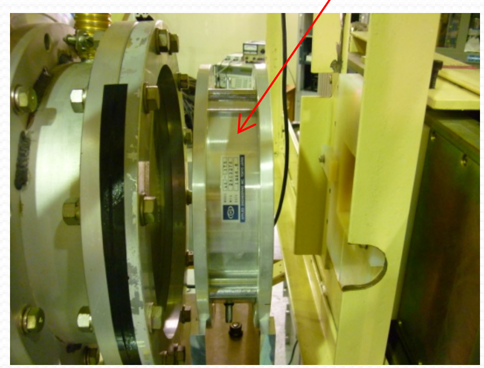
- Type: AVF Cyclotron
- Beams:
  - proton 5-80 MeV
  - deuteron 10-55 MeV
  - ^{3}He 18-147 MeV
  - ^{4}He 20-110 MeV
  - Heavy ions …

- This cyclotron is used to produce radioisotopes for SPECT/PET mainly.
- It is usable for scientific experiments about one day per a week.
- Typical experiment time is from 11 am to 7 pm (8 hours).

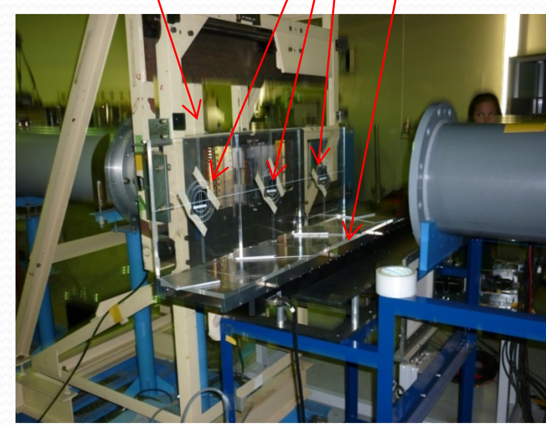
Reference Radiation Field (C-8 course)







Beam monitor is an ionizing chamber with 17cm diameter aperture.



List of Participants

1	Armenia	YPI (Yerevan Physics Institute, Yerevan)
2	Austria	ATI (Atomic Institute of the Austrian Universities, Vienna)
3	Belgium	SCK-CEN (Belgian Nuclear Research Center, Mol)
4	Czech Rep.	NPI (Nuclear Physics Institute, Prague)
5	Germany	DLR (German Aerospace Center, Cologne)
6	Greece	AUT (Aristotle University of Thessaloniki)
7	Hungary	KFKI AEKI (KFKI Atomic Energy Research Institute, Budapest)
8	Japan	JAXA (Japan Aerospace Exploration Agency, Tsukuba)
9	Japan	NIRS (National Institute of Radiological Sciences, Chiba)
10	Poland	IFJ (Institute of Nuclear Physics, Krakow)
11	Russia	IMBP (Institute of Biomedical Problems, Moscow)
12	USA	Eril Research Inc. (Stilwater)
13	USA	NASA-JSC (NASA Johnson Space Center, Houston)
14	USA	Oklahoma State University (Stilwater)

Exposure list (PI-2)

- Proton 70 MeV
  - 1mGy, 10 mGy, 50 mGy, 100 mGy
  - 50 mGy with 5 mmt aluminum
- Proton 40 MeV
  - 1mGy, 10 mGy, 50 mGu, 100 mGy
  - 50 mGy with 3 mmt Alminum
- Blind
  - #1 70 mGy Proton 70 MeV
  - #2 50 mGy ^{4}He 2.2keV/u
  - Extra #3 52 mGy ^{12}C 11 keV/μm,
  - Extra #4 200 mGy Proton 40 MeV,

    20 mGy ^{12}C 11 keV/μm, 10 mGy ^{28}Si 55 keV/μm