PRELIMINARY RESULTS OF 2ND AND 3RD PROTON ICCHIBAN EXPERIMENTS

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ICCHIBAN Project

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

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

- 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

2nd and 3rd Proton ICCHIBAN

- To understand responses of luminescence detectors for Low LET 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.

Standard package

2nd and 3rd Proton ICCHIBAN

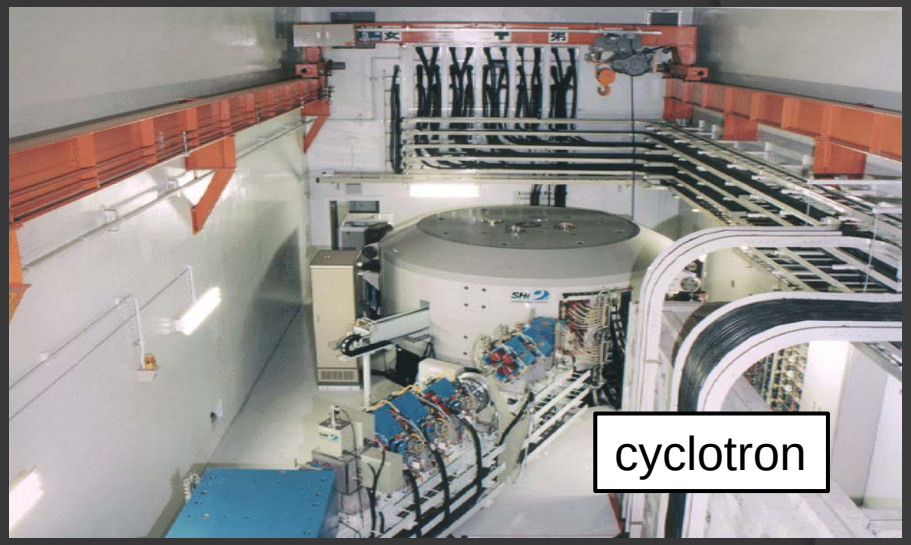
- 2nd Proton ICCHIBAN (PI-2)
  - proton 70 MeV (Jan.29th 2010) @ NIRS-Cyclotron
  - Proton 40 MeV (Feb. 5th 2010) @ NIRS-Cyclotron

    See Uchihori et. al. “The preliminary results of the Proton ICCHIBAN 2 experiments for luminescence detectors”. http://www.wrmiss.org/workshops/fifteenth/Uchihori.pdf
- 3rd Proton ICCHIBAN (PI-3)
  - proton 30 MeV (Feb. 4th 2011) @NIRS-Cyclotron
  - proton 235 MeV (Feb. 7th 2011) @ NCCHE-Cyclotron

- Covered LET(in water): 0.45 – 2 keV/μm

National Cancer Center Hospital East (NCCHE) Cyclotron

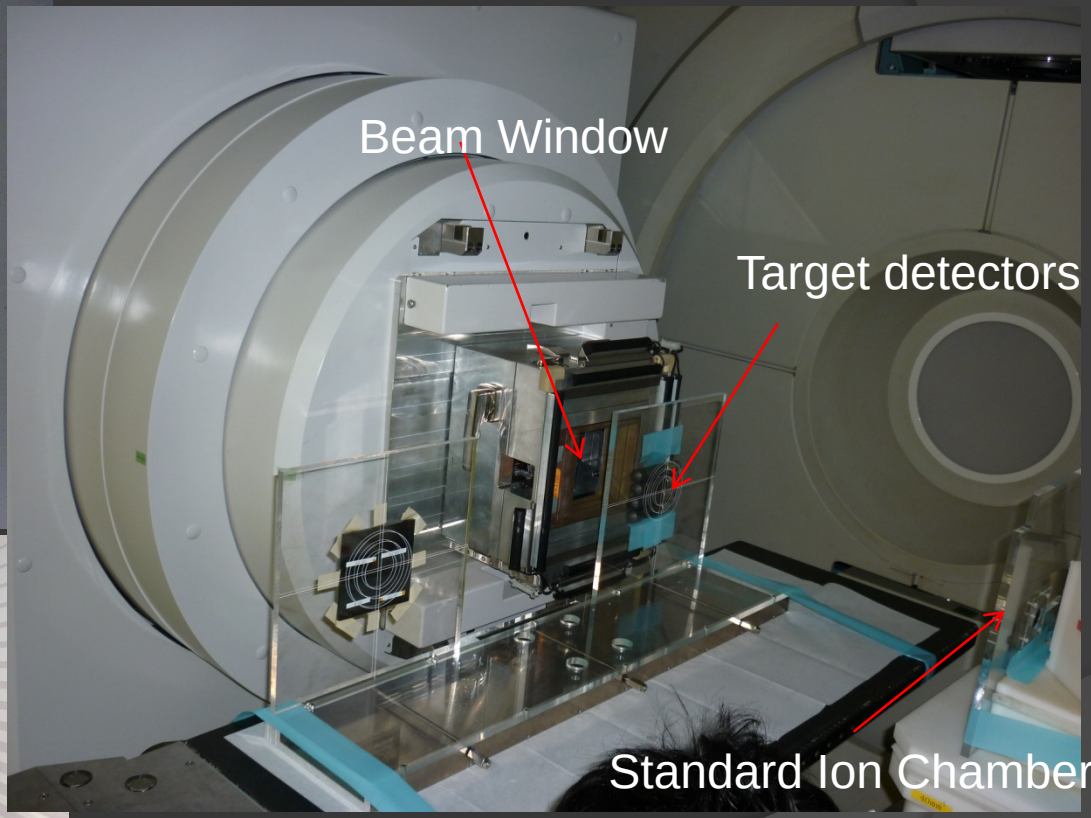
- Place: Kashiwa-City, Japan
- Establish: April 1997
- Purpose: Cancer Therapy
  - http://www.ncc.go.jp/en/ncce/about/hospital_e.html

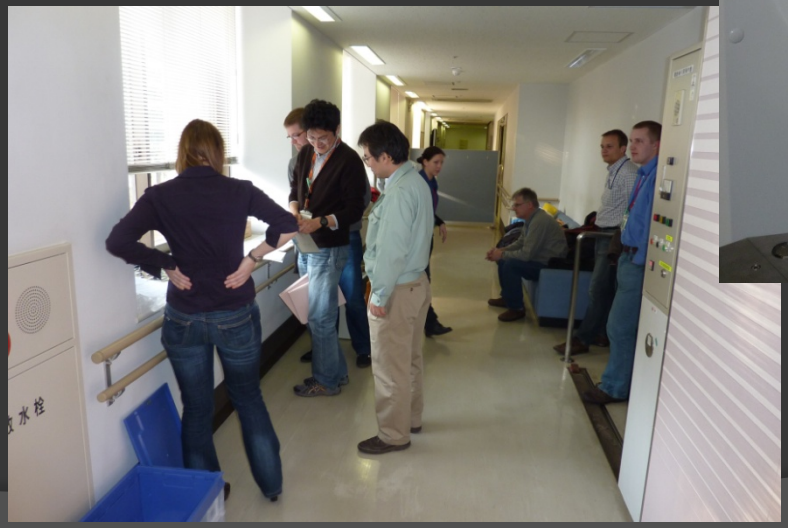


- Type: AVF-Cyclotron
- Beam: Proton 235 MeV
  - http://www.shi.co.jp/quantum/eng/product/proton/proton.html

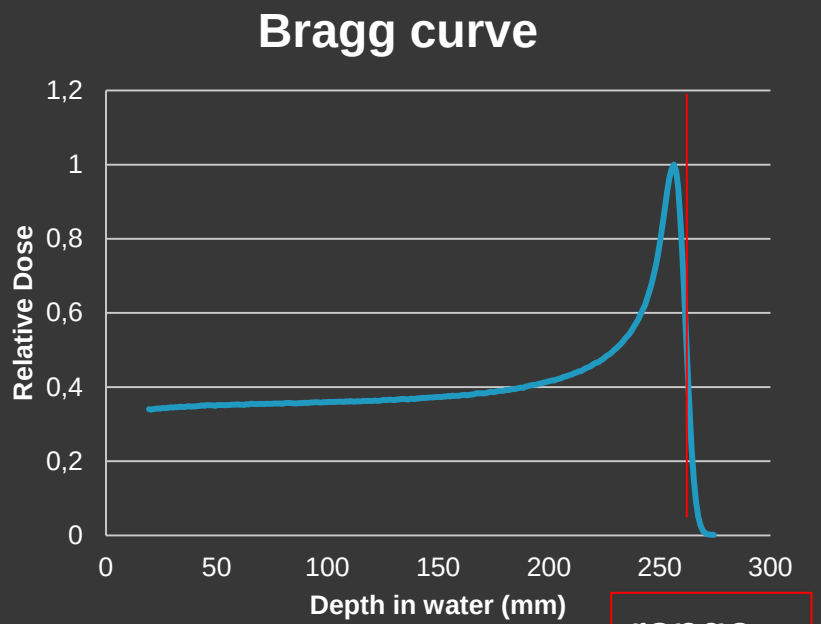
3rd Proton ICCHIBAN in NCCHE

4 standard packages were exposed same time.

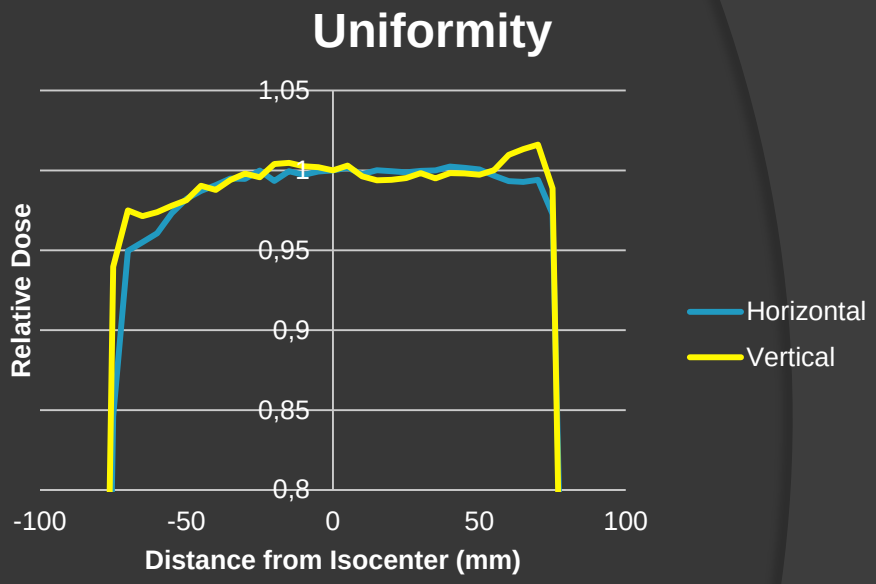




Characteristic of 235 MeV beam



range 262mm



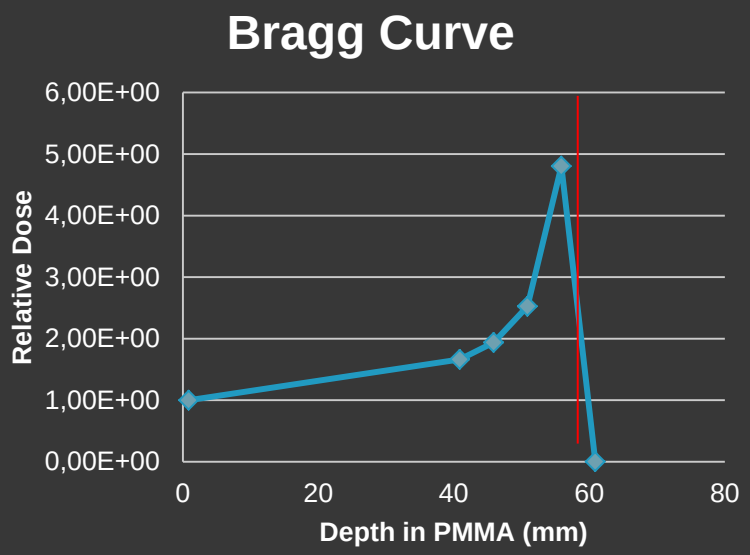
Energy: 203 MeV
LET in water: 0.45 keV/μm
(SRIM 2008)

Uniformity: ±5%
within 140 mm diameter

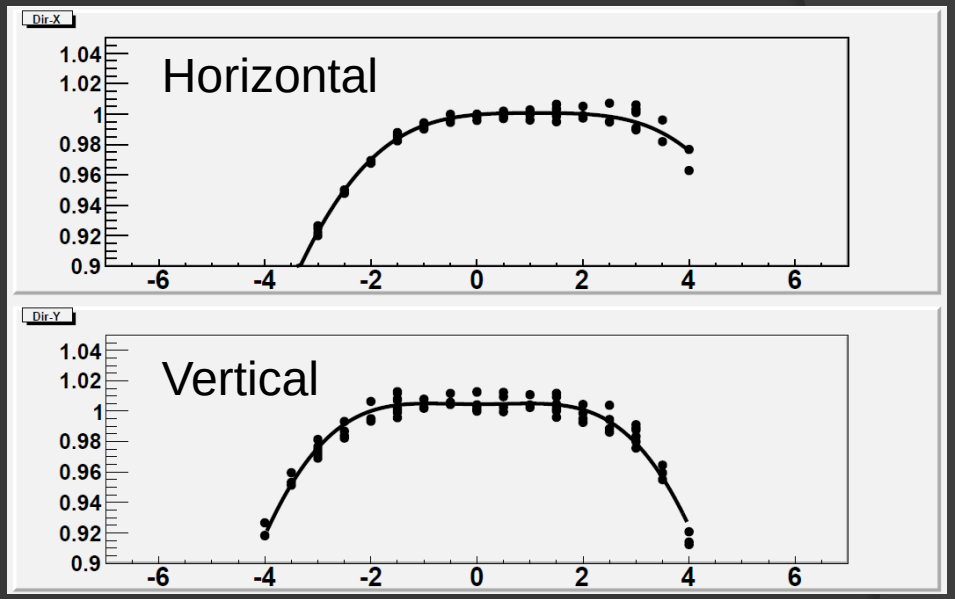
Exposures of proton 235 MeV beam in the NCCHE cyclotron

- 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
58 mm

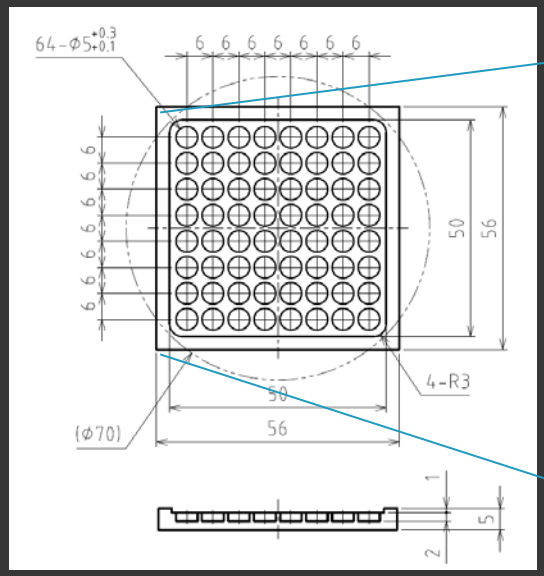


Energy: 26 MeV
LET in water: 2.1 keV/μm
(SRIM 2008)

Uniformity: ±5%
within 70 mm diameter

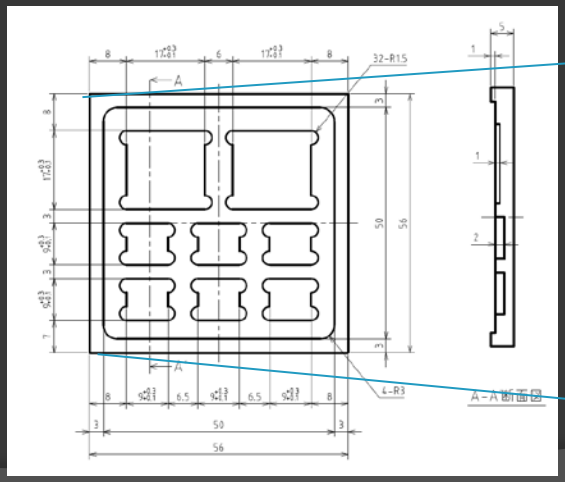
Relative exposed dose* for 30MeV proton at position of the standard packages

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

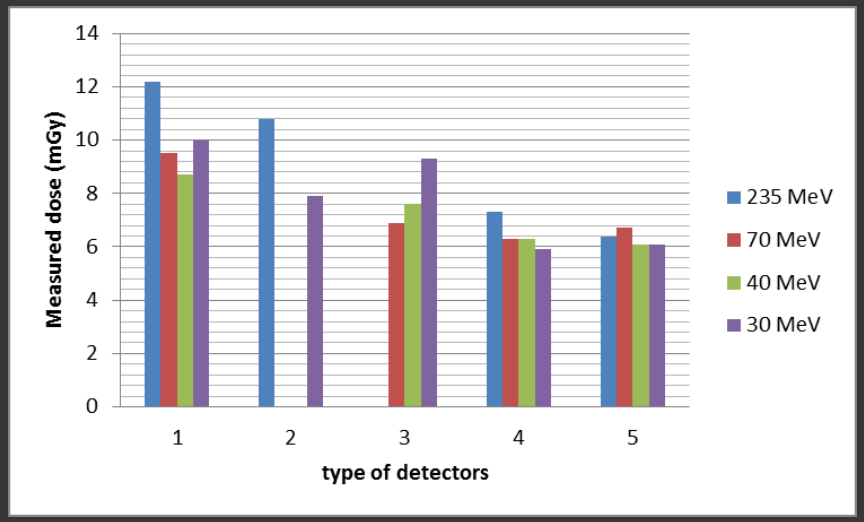
* Not available for 235 MeV proton beam

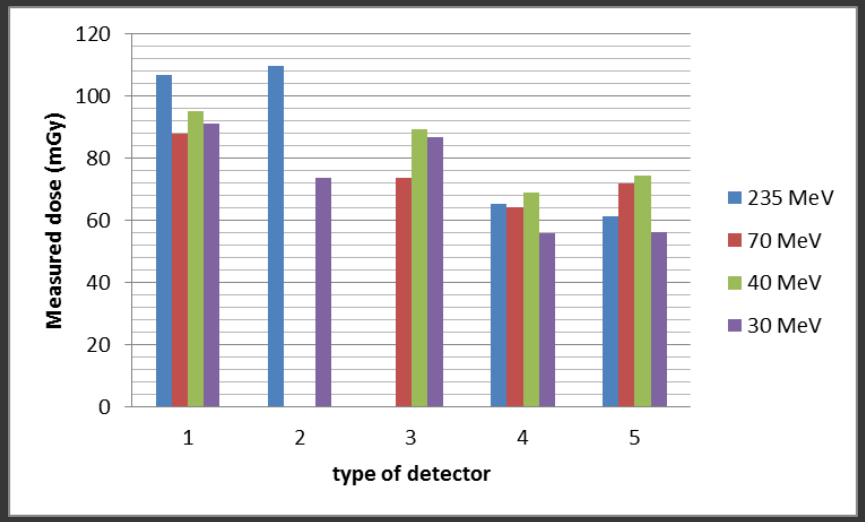
Exposure List

	30 MeV	40 MeV	70 MeV	235 MeV*
LET(keV/μm)	2.1	1.5	0.97	0.45
Linear	1 mGy	1 mGy	1 mGy	-
	10 mGy	10 mGy	10 mGy	10 mGy (8 mGy)
	50 mGy	50 mGy	50 mGy	50 mGy (40 mGy)
	100 mGy	100 mGy	100 mGy	100 mGy (80 mGy)
	-	-	-	300 mGy (240 mGy)
Aluminum Plate	50mGy with 1mmt	50mGy with 3mmt	50mGy with 5mmt	-

* Values in brackets are typical exposed dose measured by the ion chamber.

Examples of results

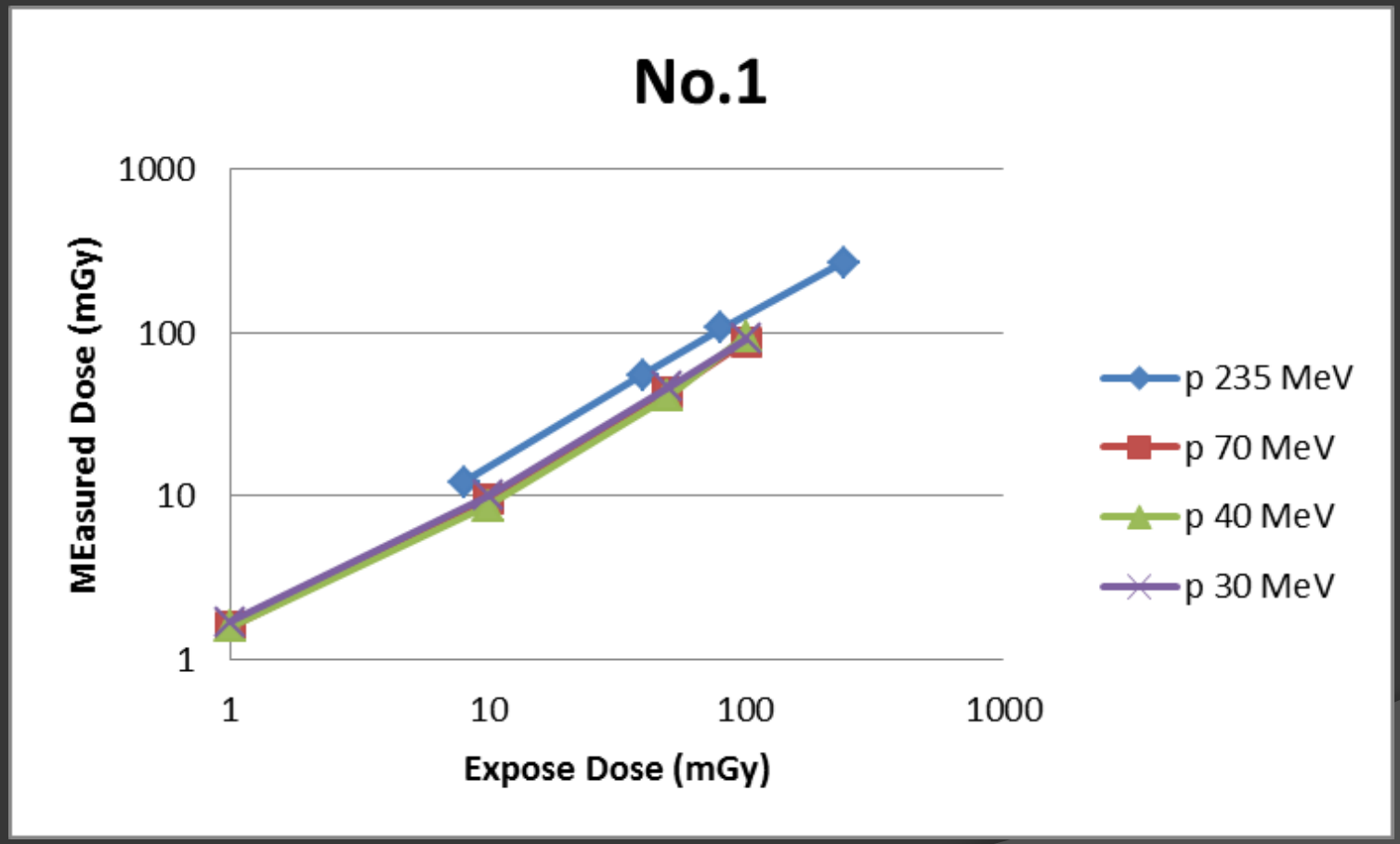




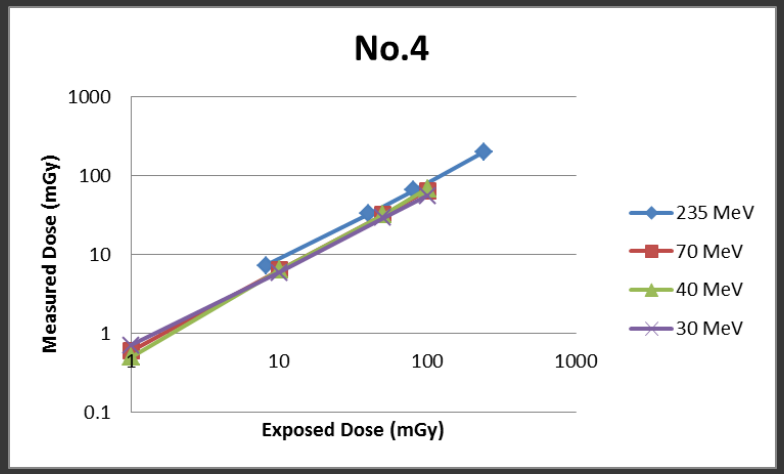
Nominal Dose 10 mGy
(8 mGy for 235MeV)

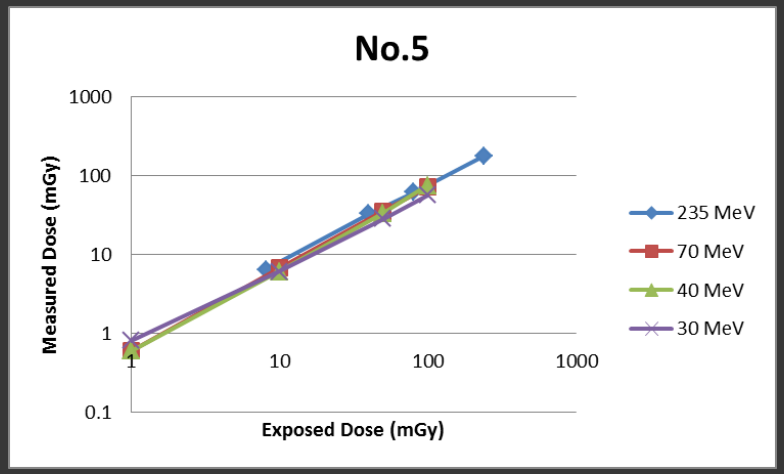
Nominal dose 100 mGy
(80 mGy for 235MeV)

Example of results



Comparison between different types of detectors





Conclusion

- In order to intercompare and calibrate luminescence detectors for space radiation dosimetry, 2nd and 3rd Proton-ICCHIBAN were performed.

- We used two accelerators for PI-3. Addition to the NIRS cyclotron, the NCCHE Cyclotron was used to expose higher energy proton beams.

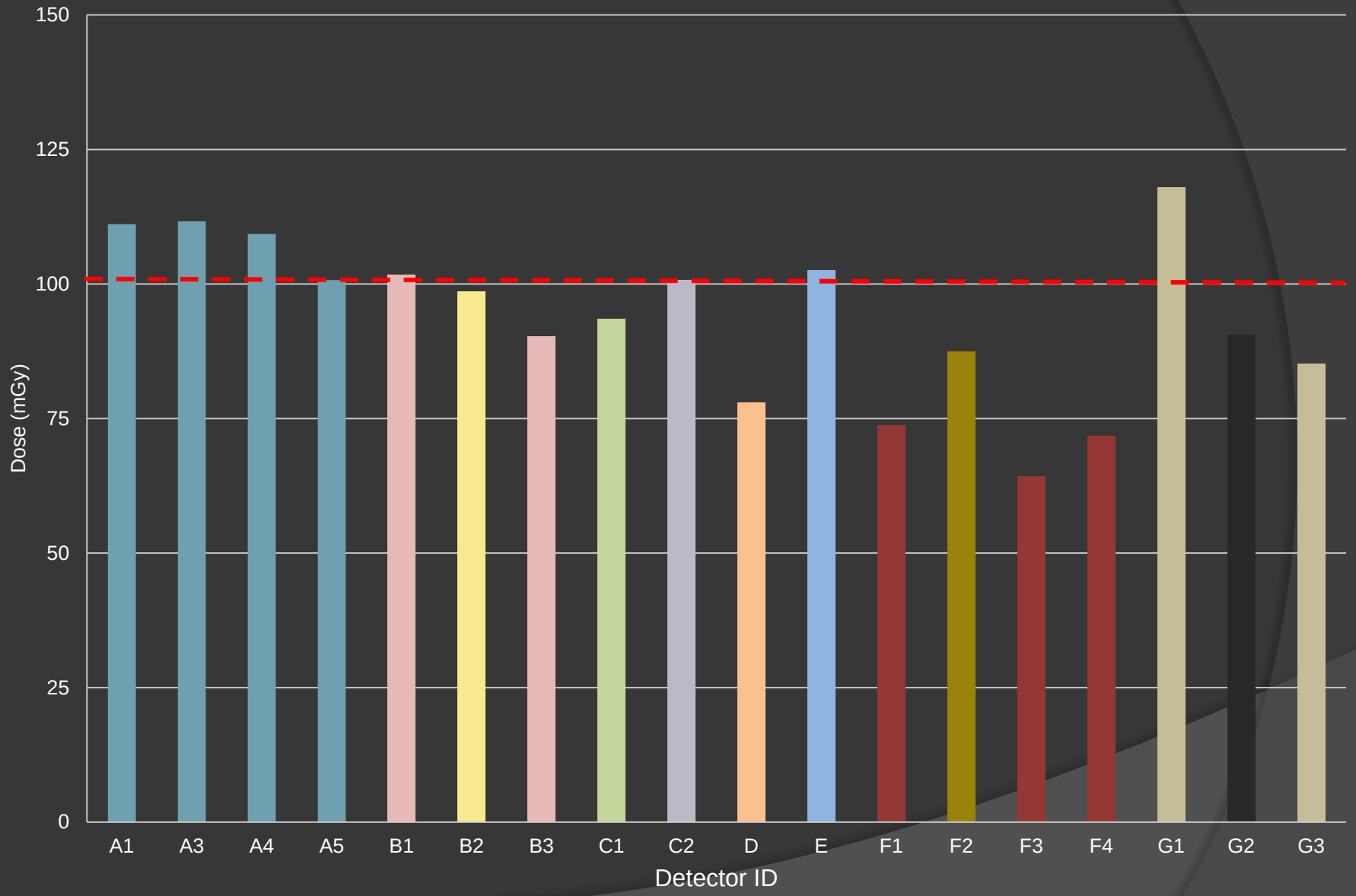
- After the accident of Fukushima Dai-ichi nuclear power plant, we must concentrate it. Now, we start to promote ICCHIBAN project !
- To ICCHIBAN participants, please send the data for the PI-2 and PI-3.

Acknowledgement

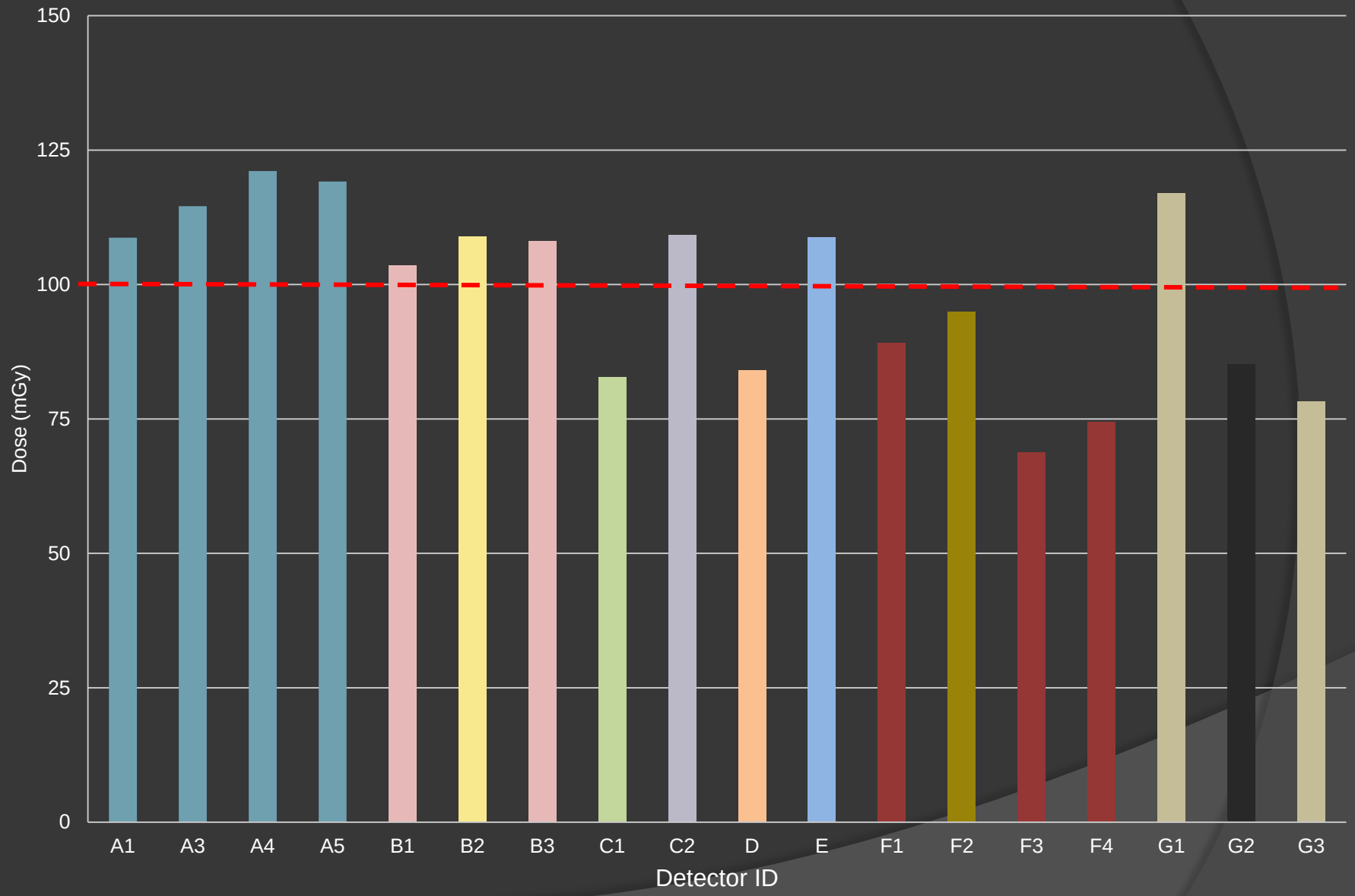
- Staffs of the NIRS-Cyclotron facility
- Dr. Teiji Nishio and stuffs of the cyclotron in National Cancer Center Hospital East
- “To friends around the world, thank you for your support.”

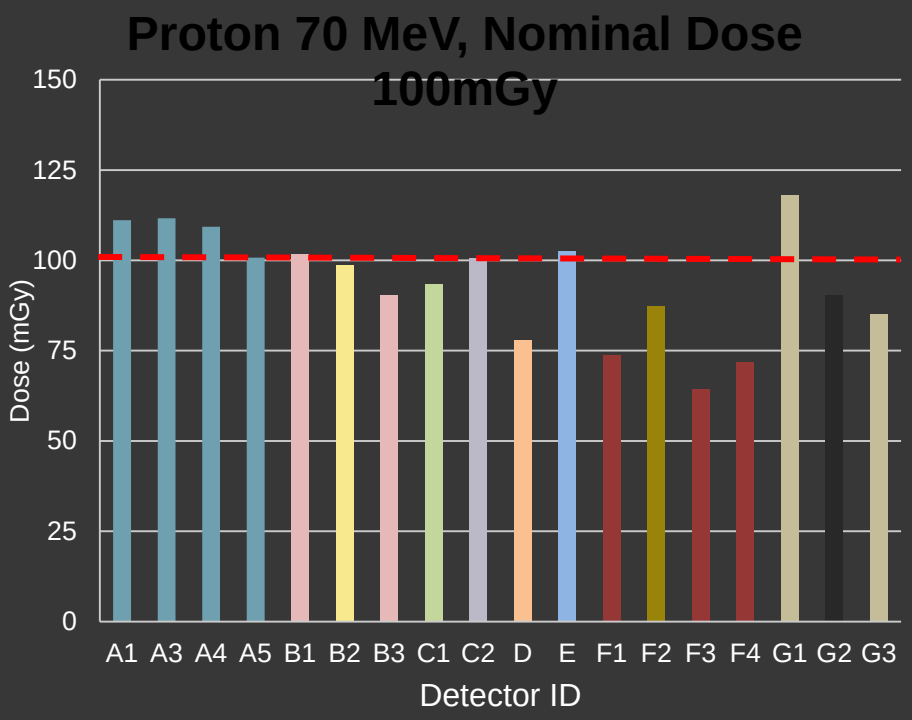
Thank you for your attention.

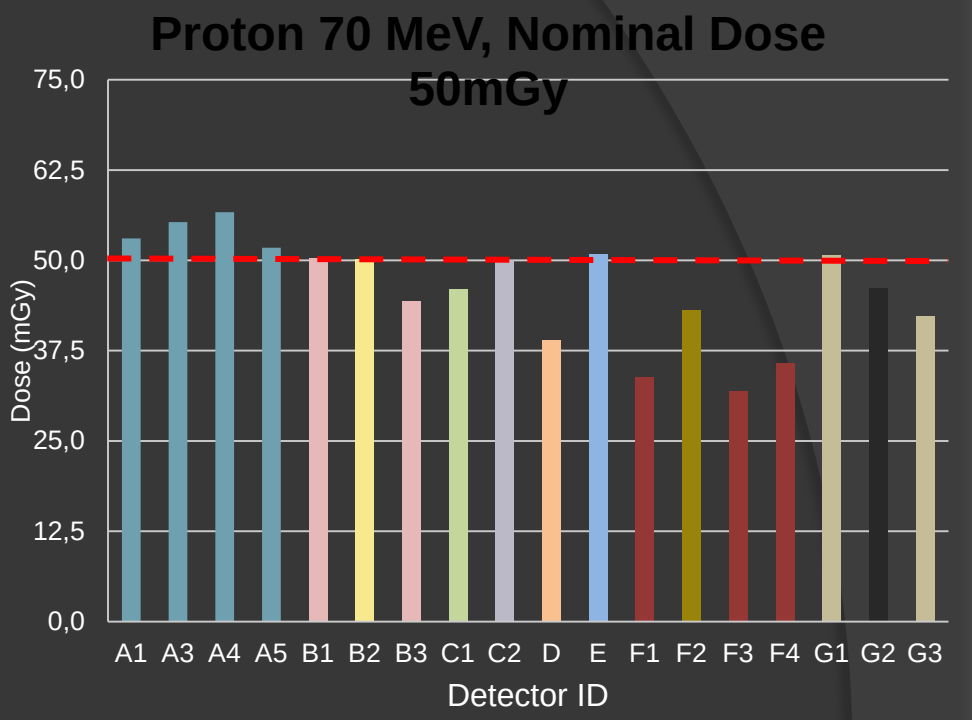
Proton 70 MeV, Nominal Dose 100mGy

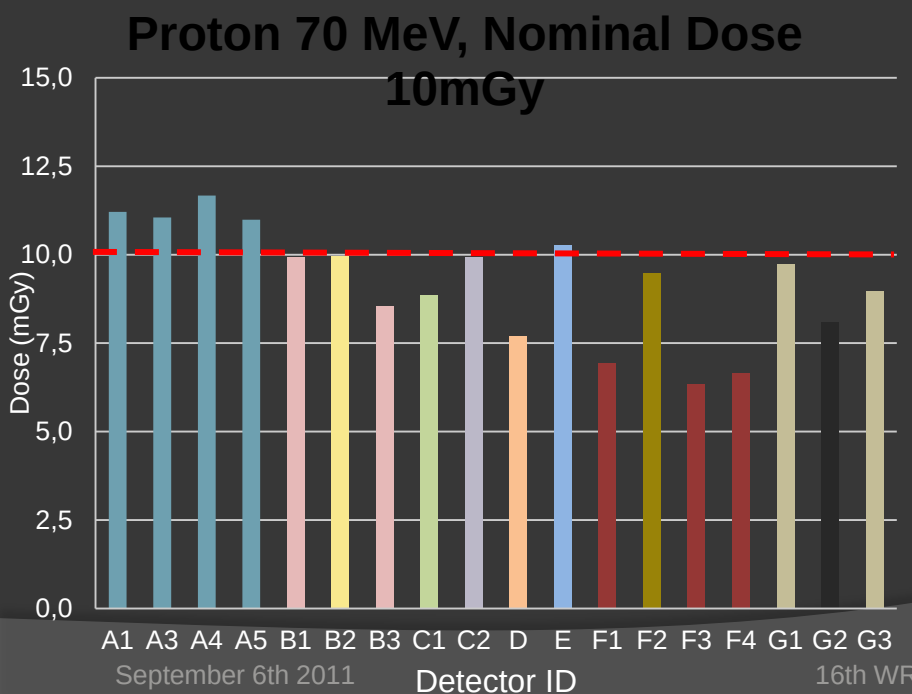


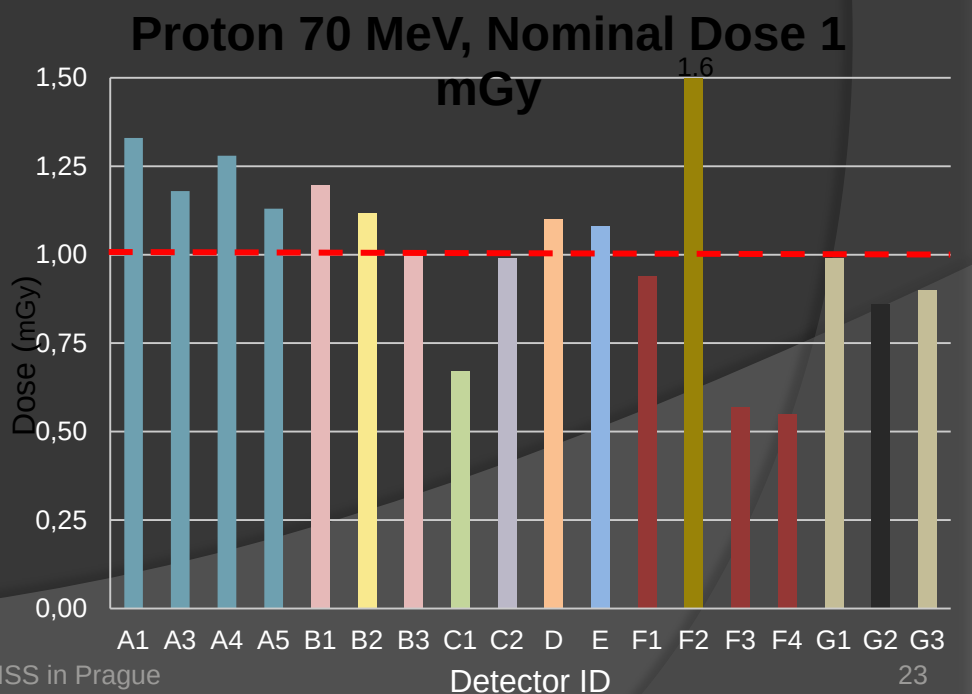
Proton 40 MeV, Nominal Dose 100mGy

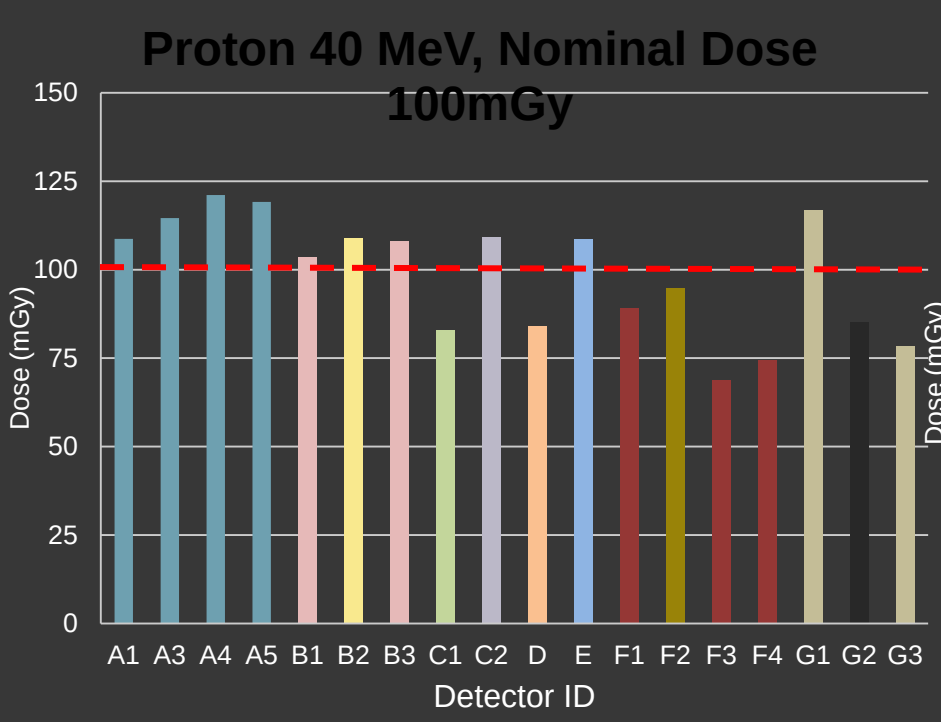


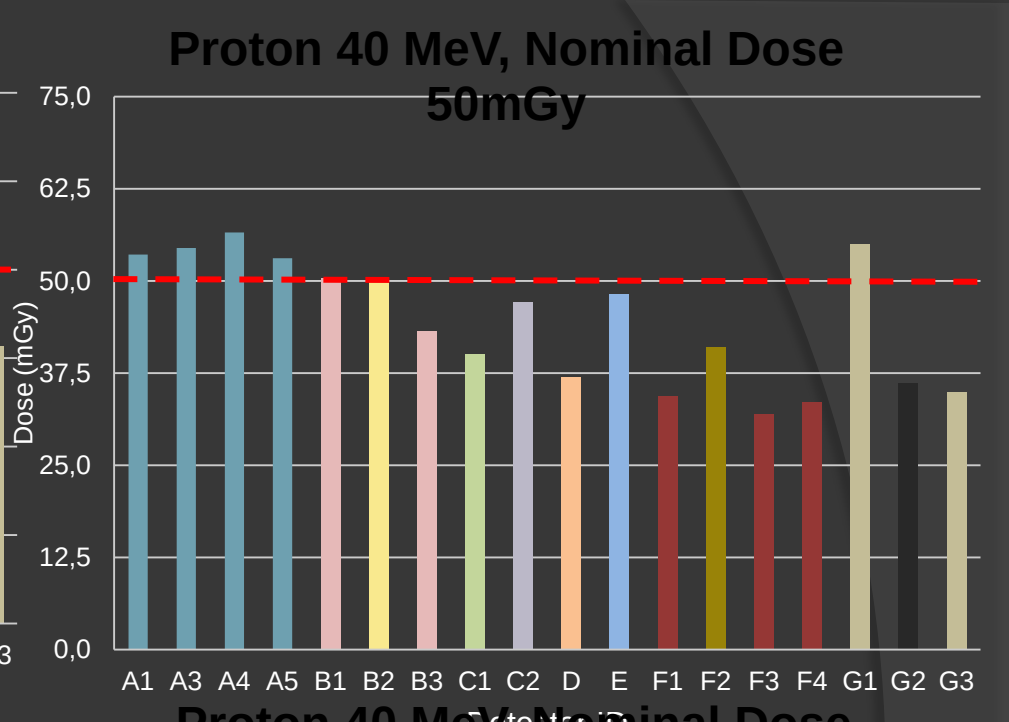

Proton 70 MeV, Nominal Dose 100mGy
150
125
100
75
50
25
0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

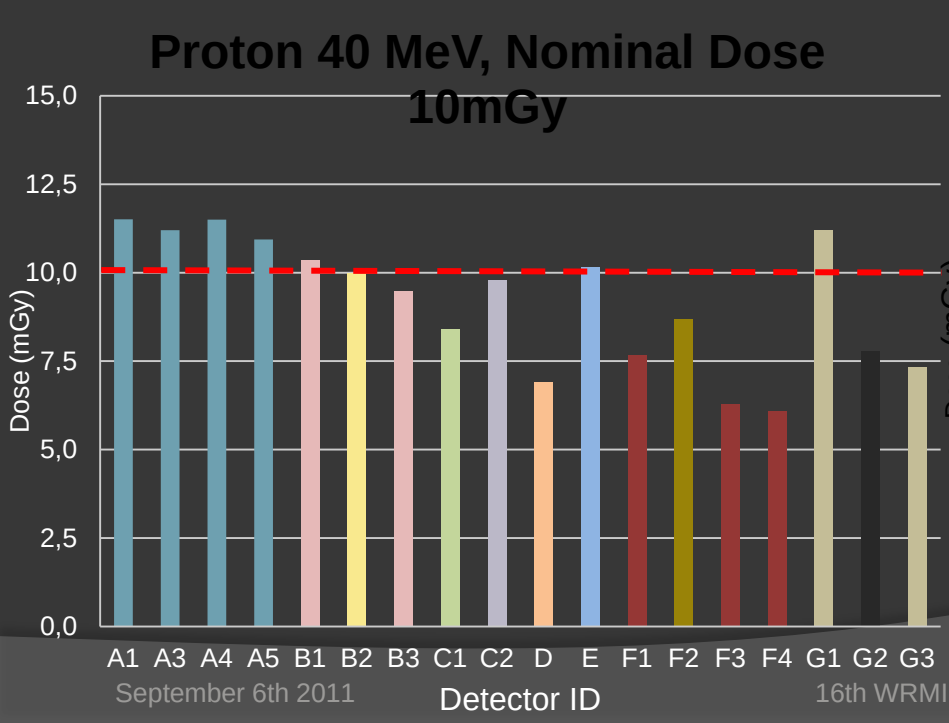

Proton 70 MeV, Nominal Dose 50mGy
75,0
62,5
50,0
37,5
25,0
12,5
0,0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

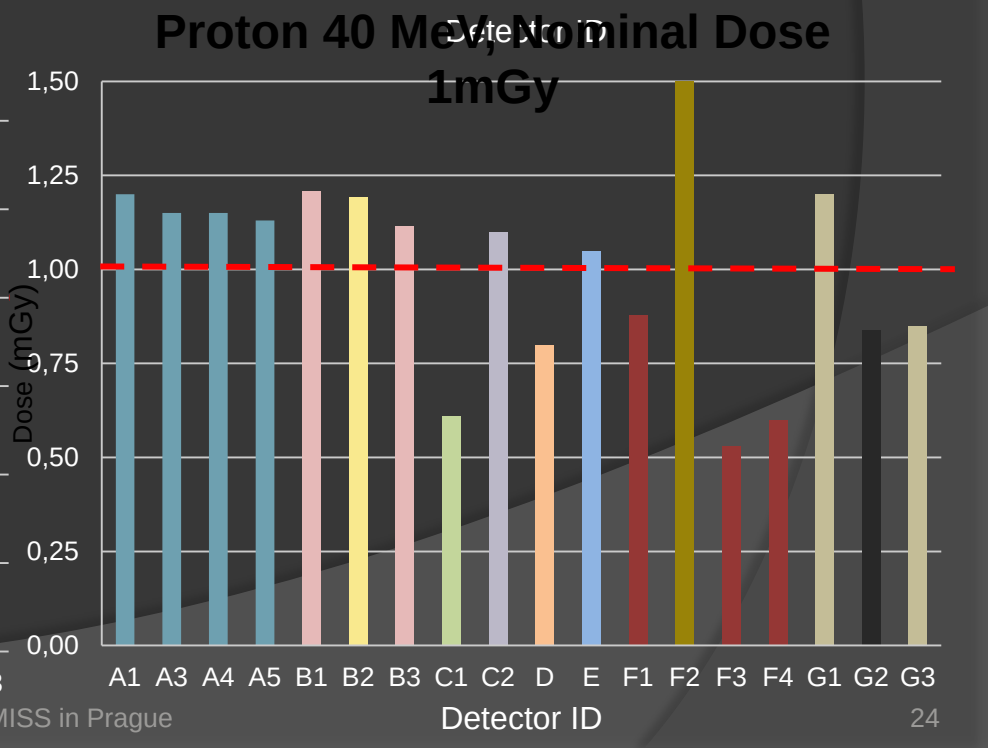

Proton 70 MeV, Nominal Dose 10mGy
15,0
12,5
10,0
7,5
5,0
2,5
0,0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

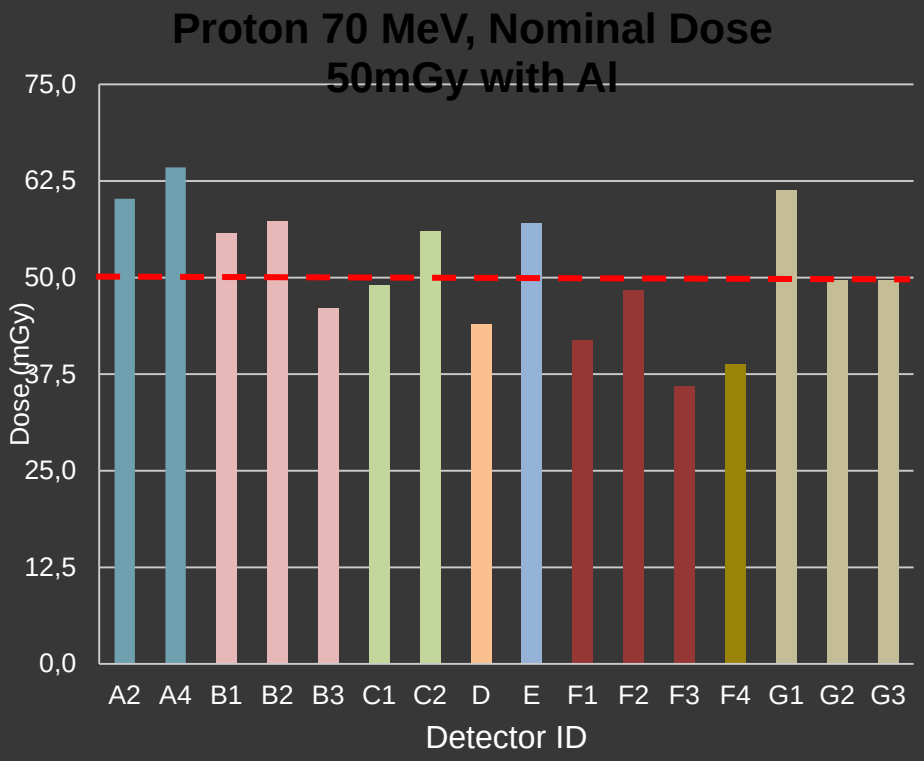

Proton 70 MeV, Nominal Dose 1 mGy
1,50
1,25
1,00
0,75
0,50
0,25
0,00
Dose (mGy)
1.6
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

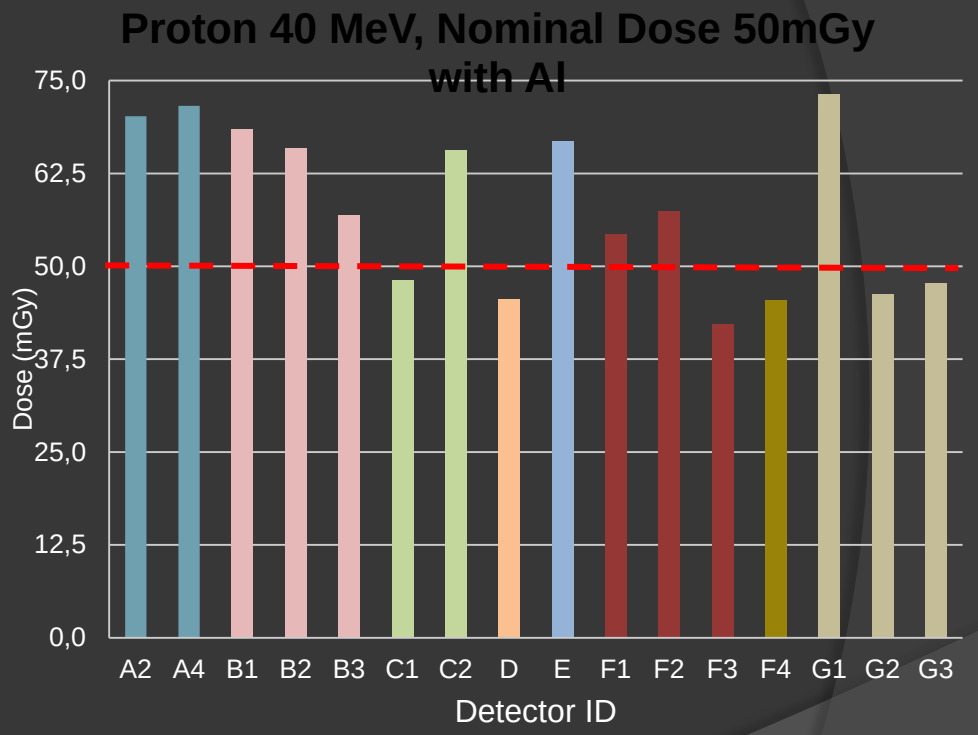

Proton 40 MeV, Nominal Dose
100mGy
150
125
100
75
50
25
0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

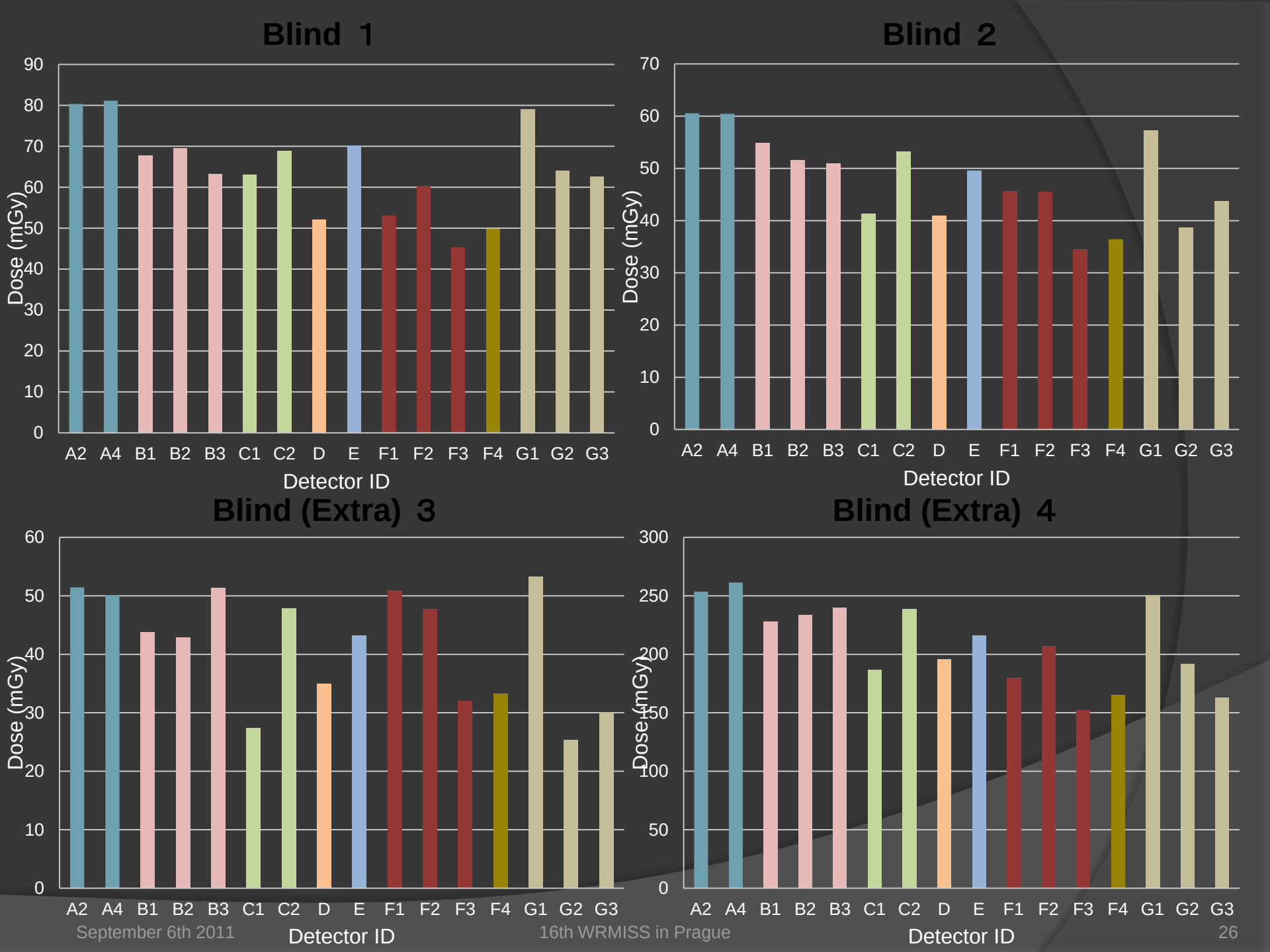

Proton 40 MeV, Nominal Dose
50mGy
75,0
62,5
50,0
37,5
25,0
12,5
0,0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

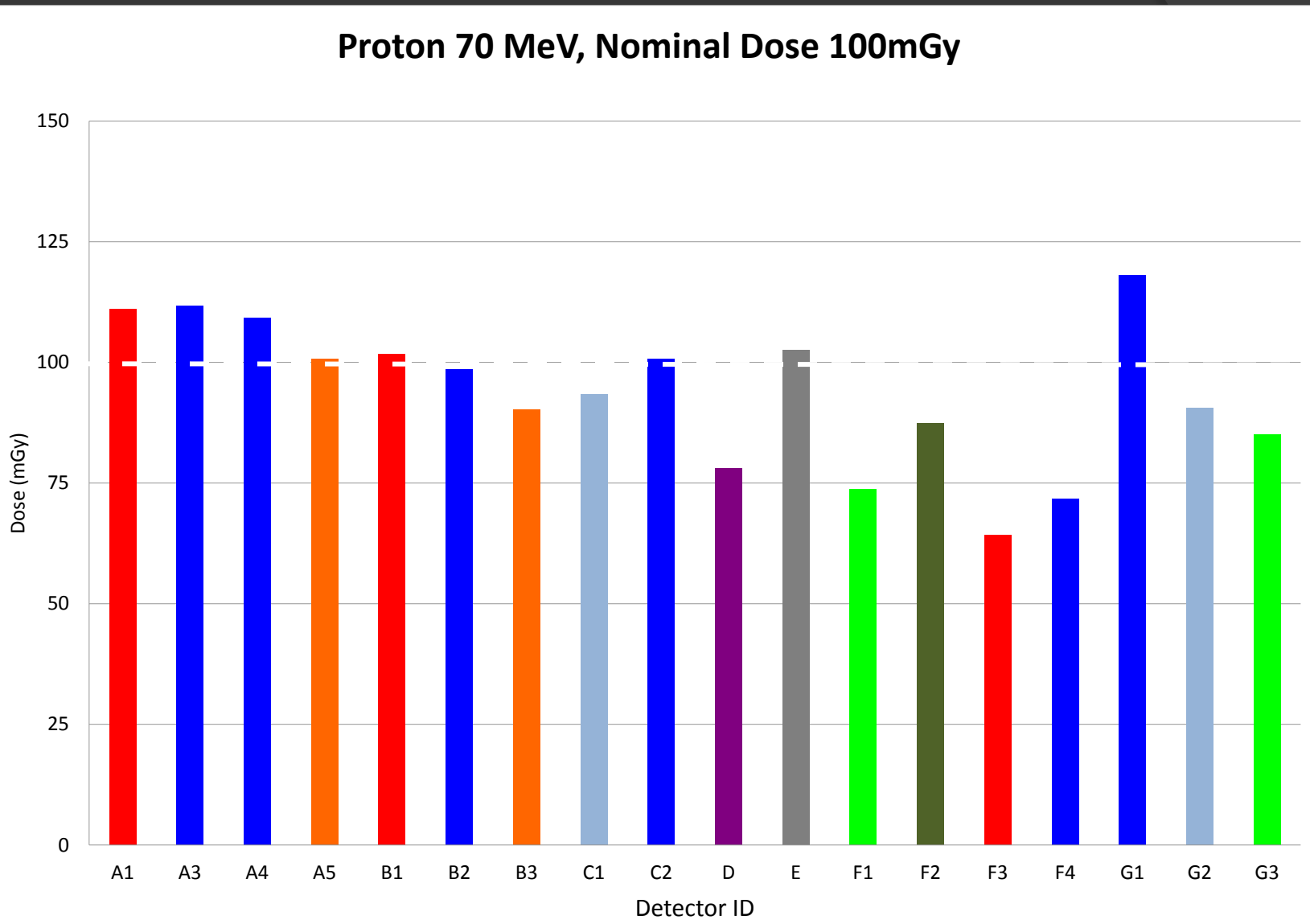

Proton 40 MeV, Nominal Dose
10mGy
15,0
12,5
10,0
7,5
5,0
2,5
0,0
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID


Proton 40 MeV, Nominal Dose
1mGy
1,50
1,25
1,00
0,75
0,50
0,25
0,00
Dose (mGy)
A1 A3 A4 A5 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

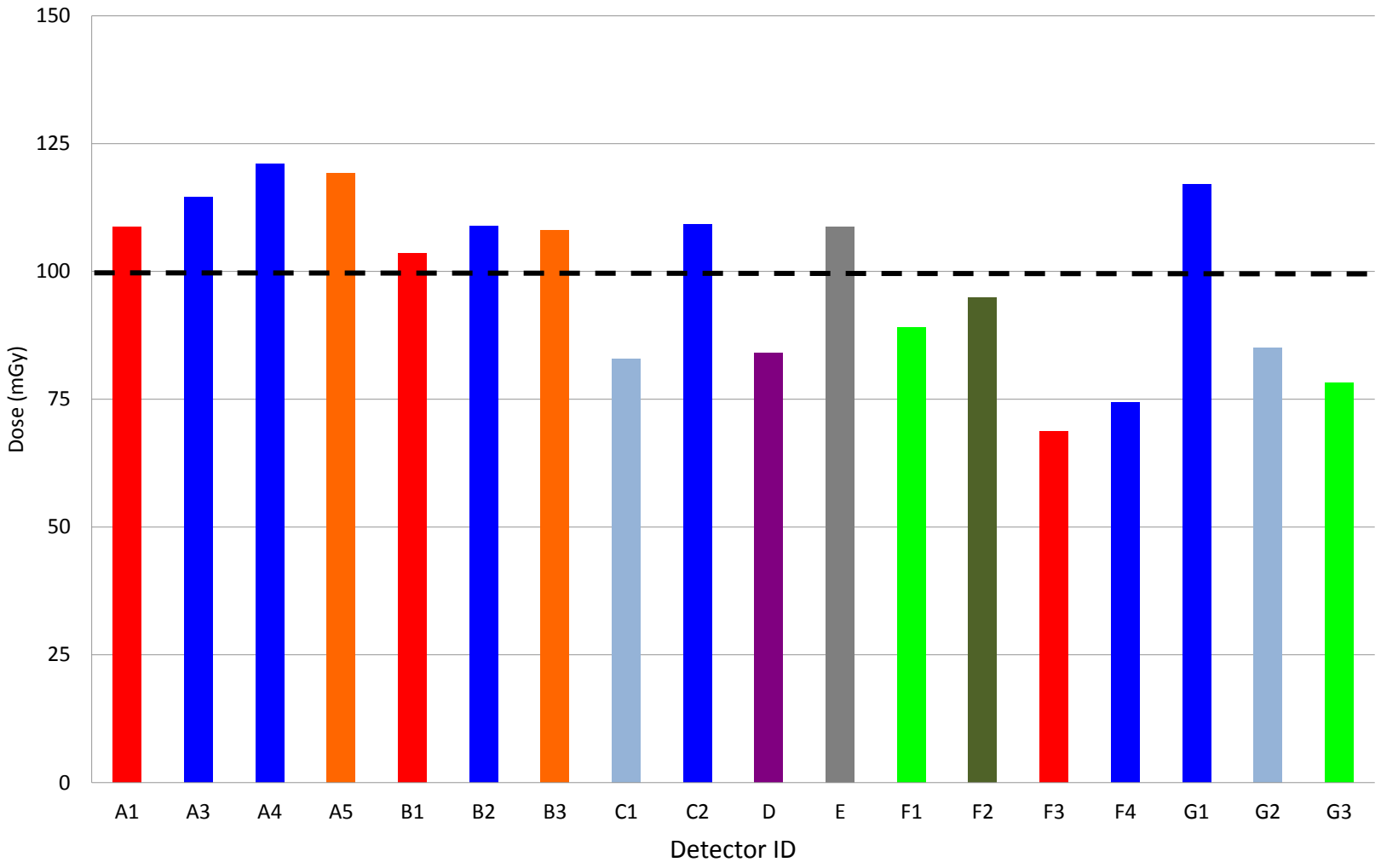

Proton 70 MeV, Nominal Dose 50mGy with Al
75,0
62,5
50,0
37,5
25,0
12,5
0,0
Dose (mGy)
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

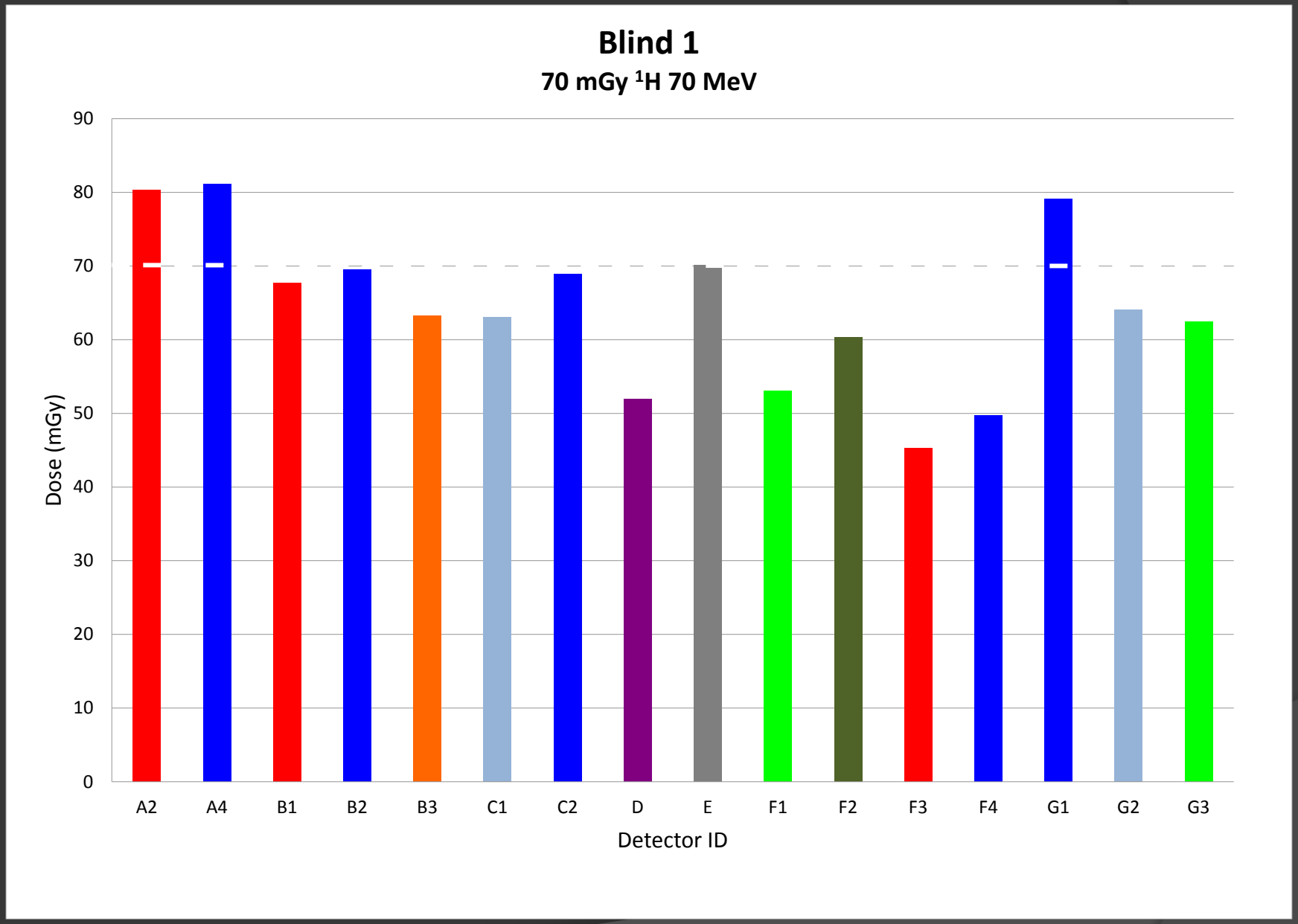

Proton 40 MeV, Nominal Dose 50mGy with Al
75,0
62,5
50,0
37,5
25,0
12,5
0,0
Dose (mGy)
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Detector ID

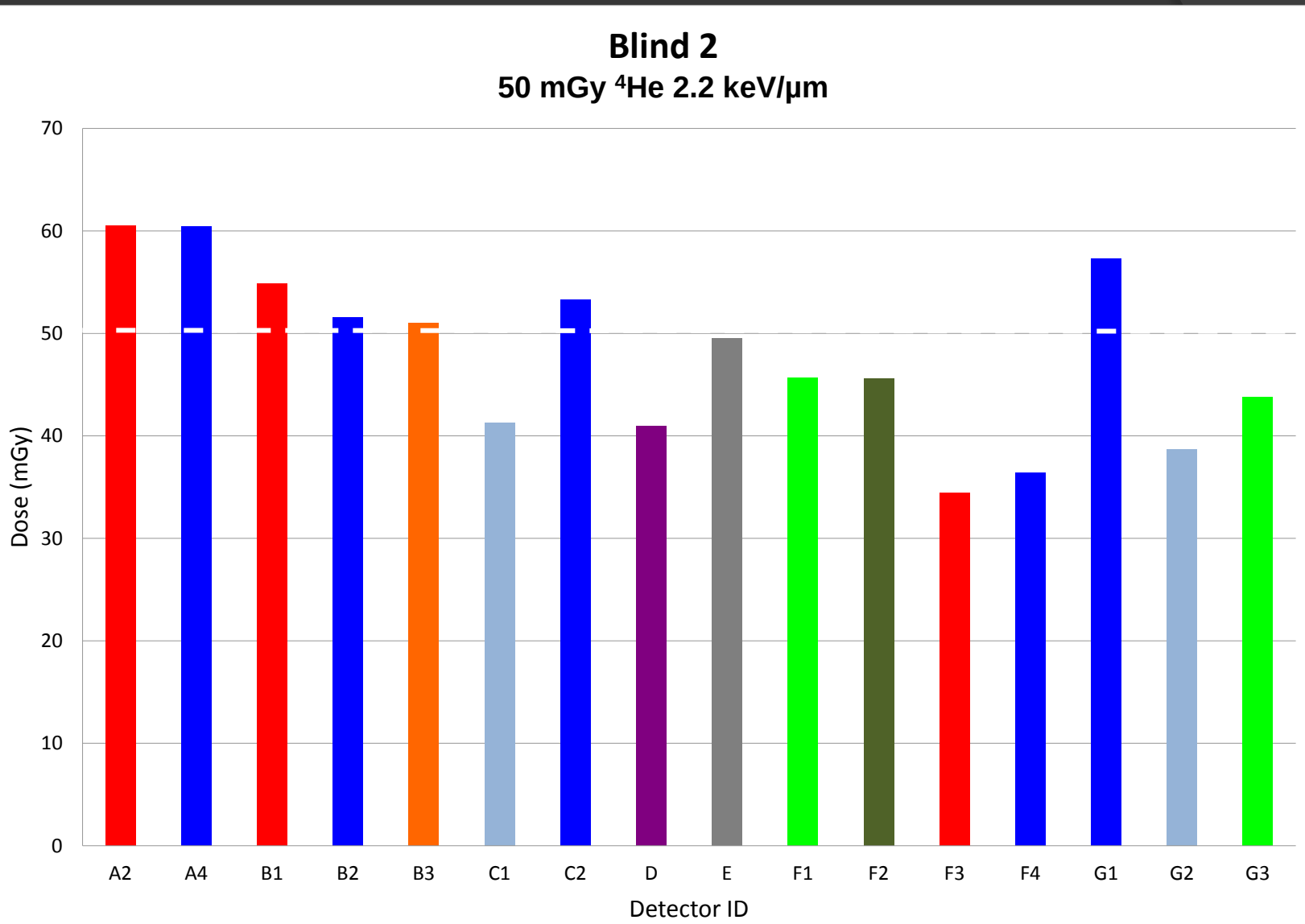

Blind 1
Dose (mGy)
Detector ID
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Blind 2
Dose (mGy)
Detector ID
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Blind (Extra) 3
Dose (mGy)
Detector ID
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3
Blind (Extra) 4
Dose (mGy)
Detector ID
A2 A4 B1 B2 B3 C1 C2 D E F1 F2 F3 F4 G1 G2 G3

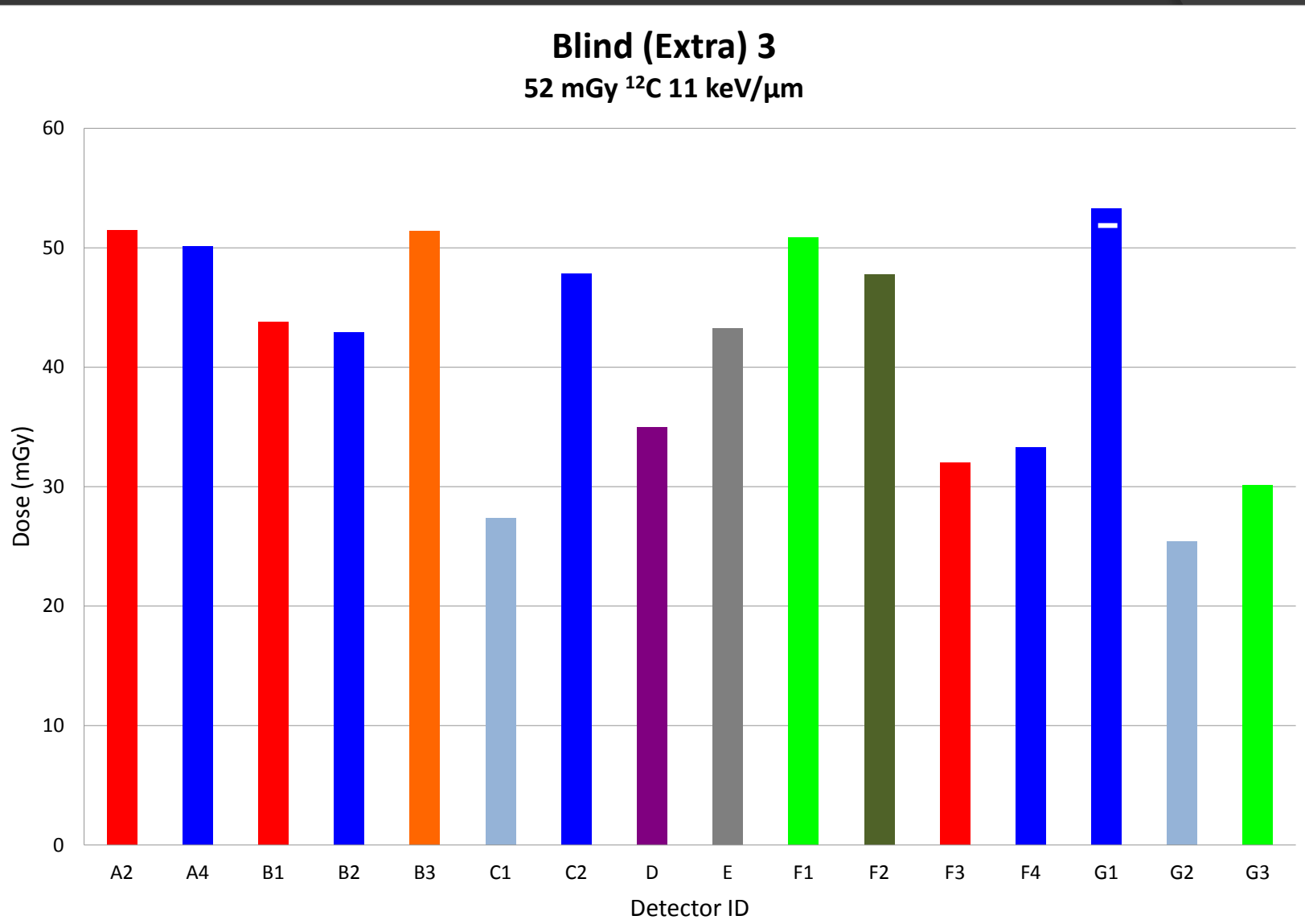

Proton 70 MeV, Nominal Dose 100mGy
150
125
100
75
50
25
0
Dose (mGy)
A1
A3
A4
A5
B1
B2
B3
C1
C2
D
E
F1
F2
F3
F4
G1
G2
G3
Detector ID

Proton 40 MeV, Nominal Dose 100mGy



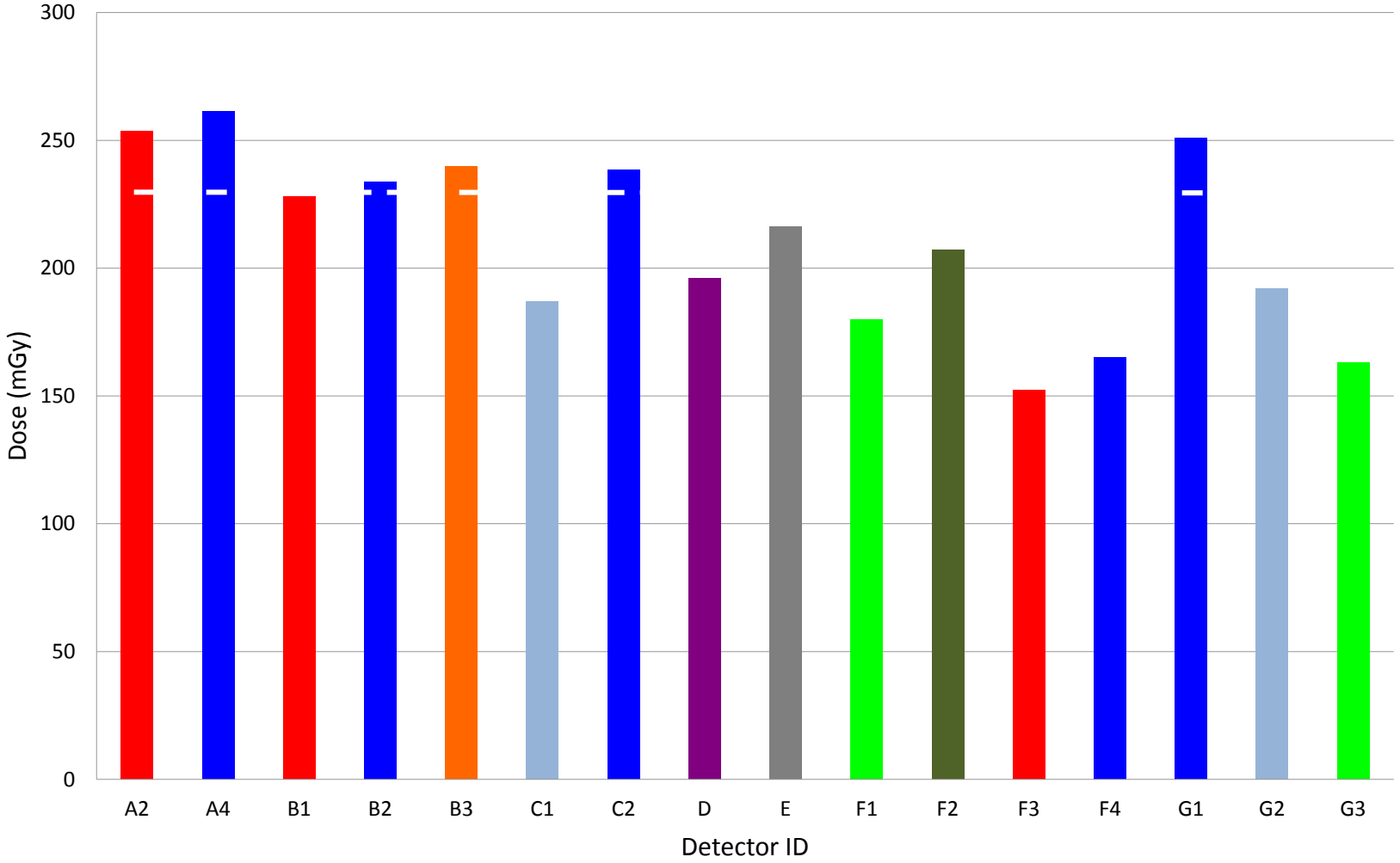

Blind 1
70 mGy 1H 70 MeV
Dose (mGy)
90
80
70
60
50
40
30
20
10
0
A2
A4
B1
B2
B3
C1
C2
D
E
F1
F2
F3
F4
G1
G2
G3
Detector ID


Blind 2
50 mGy 4He 2.2 keV/µm
Dose (mGy)
70
60
50
40
30
20
10
0
A2
A4
B1
B2
B3
C1
C2
D
E
F1
F2
F3
F4
G1
G2
G3
Detector ID

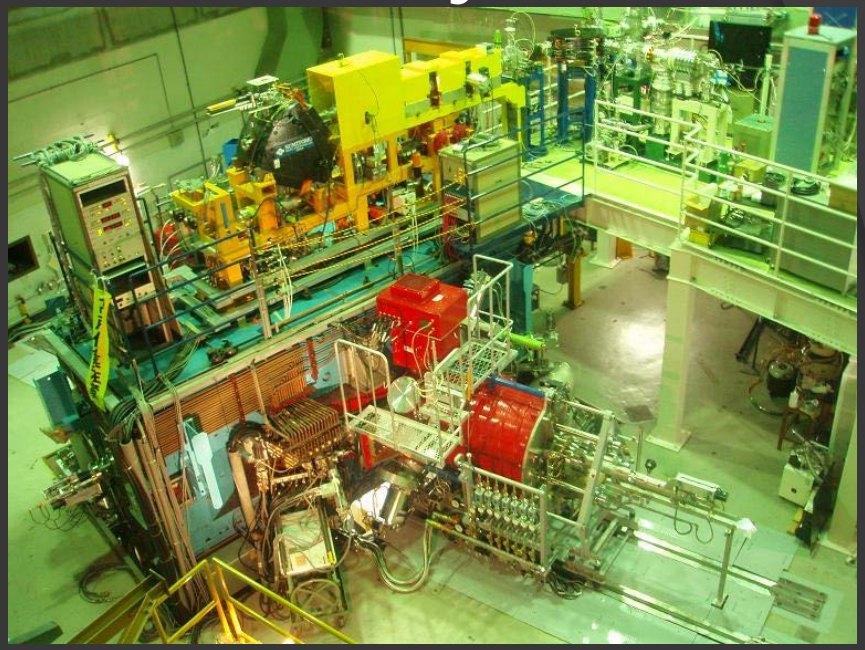

Blind (Extra) 3
52 mGy 12C 11 keV/µm
Dose (mGy)
60
50
40
30
20
10
0
A2
A4
B1
B2
B3
C1
C2
D
E
F1
F2
F3
F4
G1
G2
G3
Detector ID

Blind (Extra) 4

200 mGy ^{1}H 40 MeV, 20 mGy ^{12}C 11 keV/µm, 10 mGy ^{28}Si 55 keV/µm

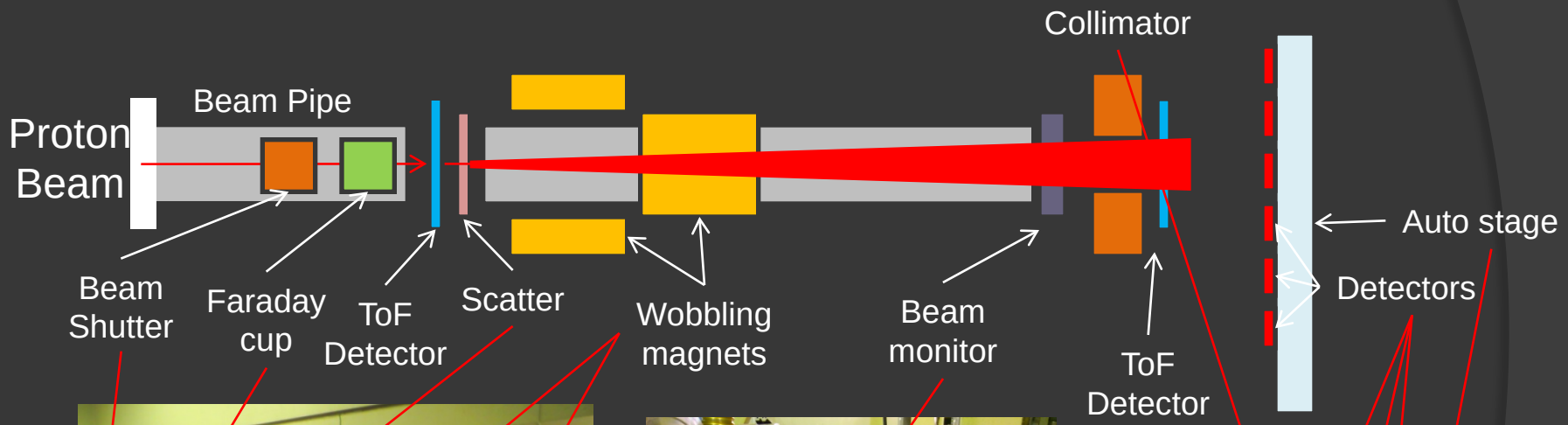


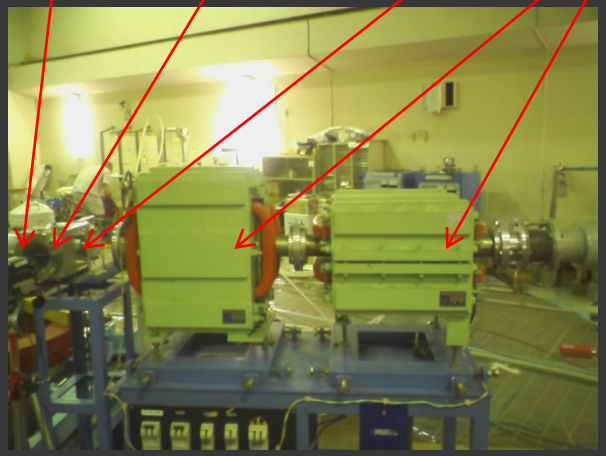
Specification of the NIRS-Cyclotron

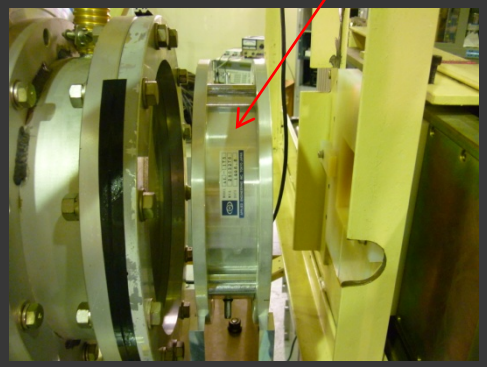


- Type: AVF Cyclotron
- Beams:
  - proton 5-80 MeV
  - deuteron 10-55 MeV
  - ^{3}He 18-147 MeV
  - ^{4}He 20-110 MeV
  - Heavy ions …
- This cyclotron is used to produce radioisotopes for SPECT/PET mainly.
- It is usable for scientific experiments about one day per a week.
- Typical experiment time is from 11 am to 7 pm (8 hours).

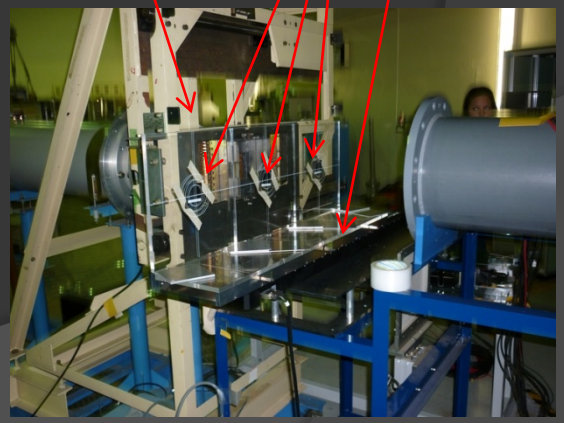
Reference Radiation Field (C-8 course)







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

Exposure List (Blind)

	package	
2nd Proton ICCHIBAN	#1	70 mGy Proton 70 MeV
	#2	50 mGy ^{4}He 2.2keV/μm
	#3	52 mGy ^{12}C 11 keV/μm
	#4	200 mGy Proton 40 MeV, 20 mGy ^{12}C 11 keV/μm, 10 mGy ^{28}Si 55 keV/μm
3rd Proton ICCHIBAN	#1	50 mGy Proton 30 MeV with 1mmt Al
	#2	200 mGy Proton 30 MeV with 1mmt Al
	#3	100 mGy Proton 30 MeV with 1mmt Al 200mGy Proton 235 MeV
	#4	