BNCT 최신동향 소개
Boron Neutron Capture Therapy

2021. 5. 12.

서효정
다원메닥스

목차

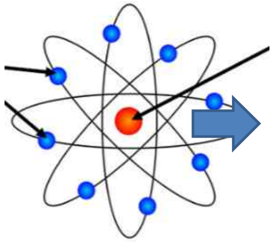
중성자와 BNCT

Neutron

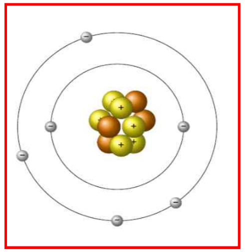
1932: James Chadwick's Letter to *Nature* on the Neutron

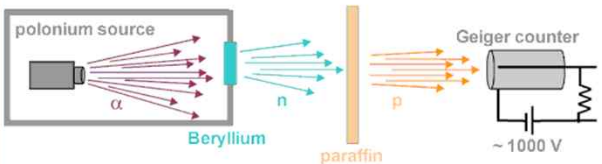
James Chadwick

Rutherford's model



Chadwick's model





Chadwick, J. (1932) "Possible Existence of a Neutron," *Nature* 129 (3252): 312.
Chadwick, J. (1932) "The Existence of a Neutron," *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* 136(830): 692.
https://www.aps.org/publications/apsnews/201402/physicshistory.cfm

BNCT

1934 : Goldharber

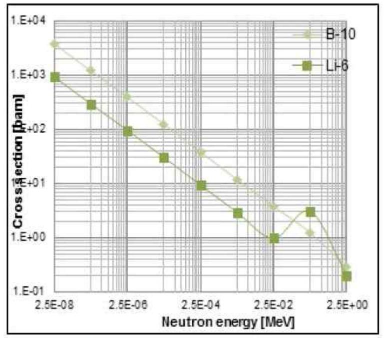


Figure 2) Neutrons capture cross sections for ^{10}B and ^{6}Li isotopes

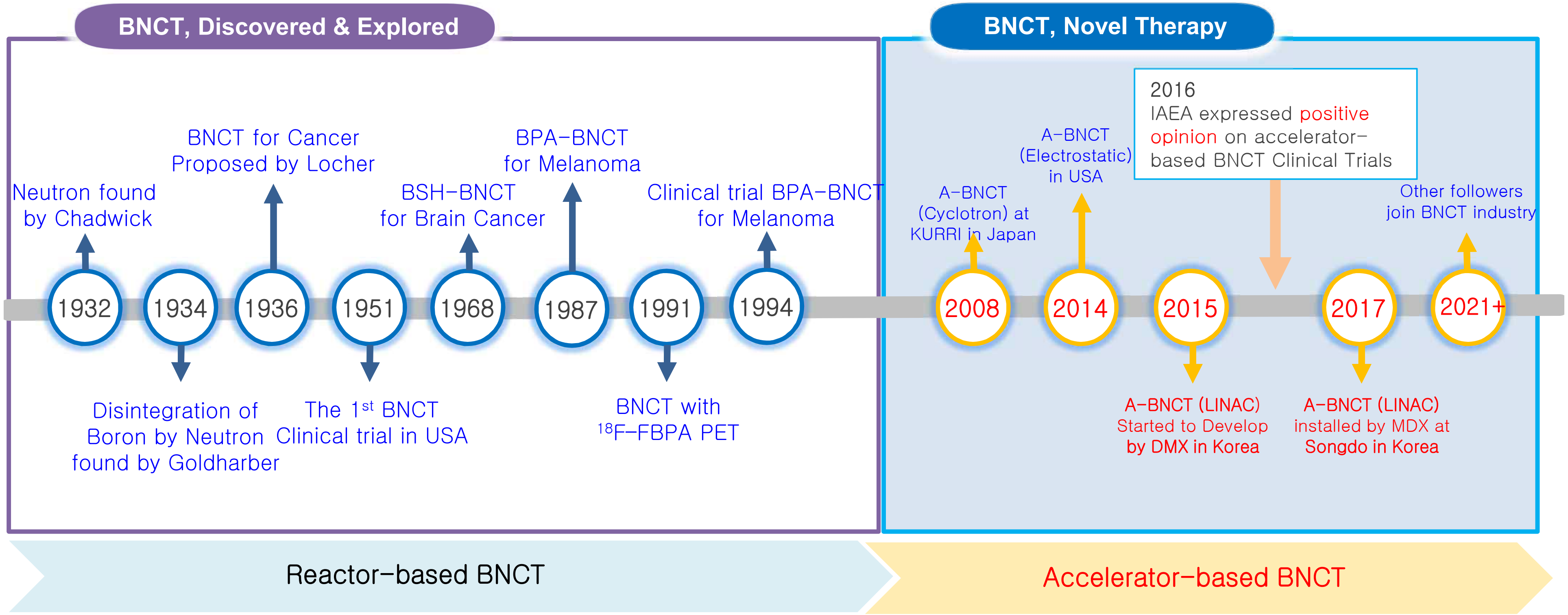
Capture Cross section for slow neutrons

1936: Gordon Locher

BNCT in 1936 and hypothesized that if **boron could be selectively concentrated in a tumour mass** and the volume then exposed to **thermal neutrons**, a higher radiation dose to the tumour relative to adjacent normal tissue would be produced

Locher, G. Biological effects and therapeutic possibilities of neutrons. Am J Roentgenol Radium Ther. 1936;36(1):1–13

BNCT 발달 역사



Challenges on BNCT development at Early stage
- Poor accessibility to reactor and poor quality of Neutron beam
- Poor ^{10}B uptake due to limited selectivity of boron compounds
- Improper clinical protocols with unoptimized Boron concentration and Neuron dose

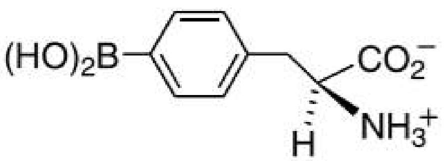
BNCT becomes Practical & Novel Therapy
- Hospital Set-up with improved Neutron Beam
- Cancer specific ^{10}B uptake with BPA
- Improved clinical protocols with knowledge & experience accumulated

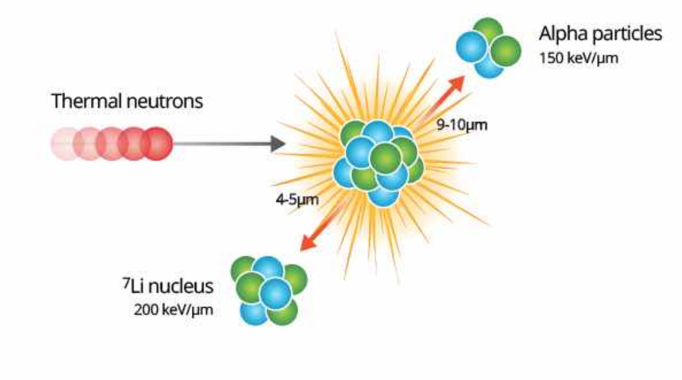
BNCT 원리

Neutron

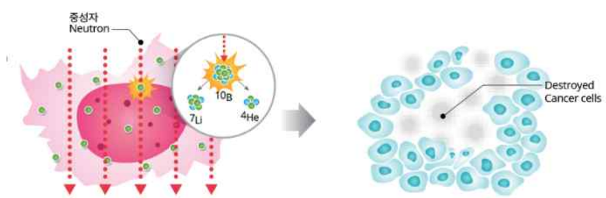
- ✓Thermal (En < 0.5 eV)
- ✓Epithermal (0.5 eV < En < 10KeV)
- ✓Fast (En>10 keV)

^{10}B enriched Boronophenylalanine (BPA)



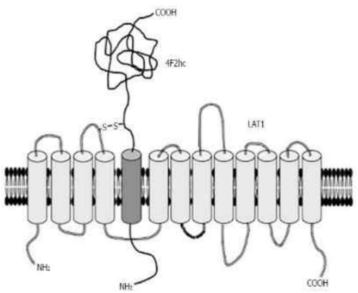


^{10}B: High cross section
: thermal neutron
3840 barn

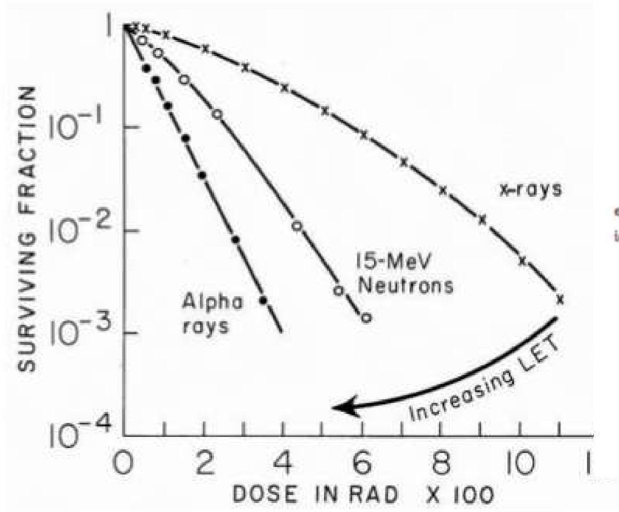


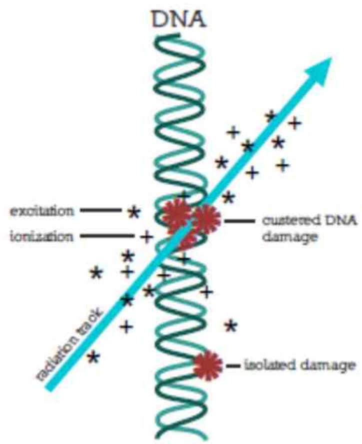
Physical advantage + Biological selectivity

Tumor cell selectivity
L-type Amino Acid
Transporter 1 (LAT1)
High expression



2017 Hayashi K et al. WJGO



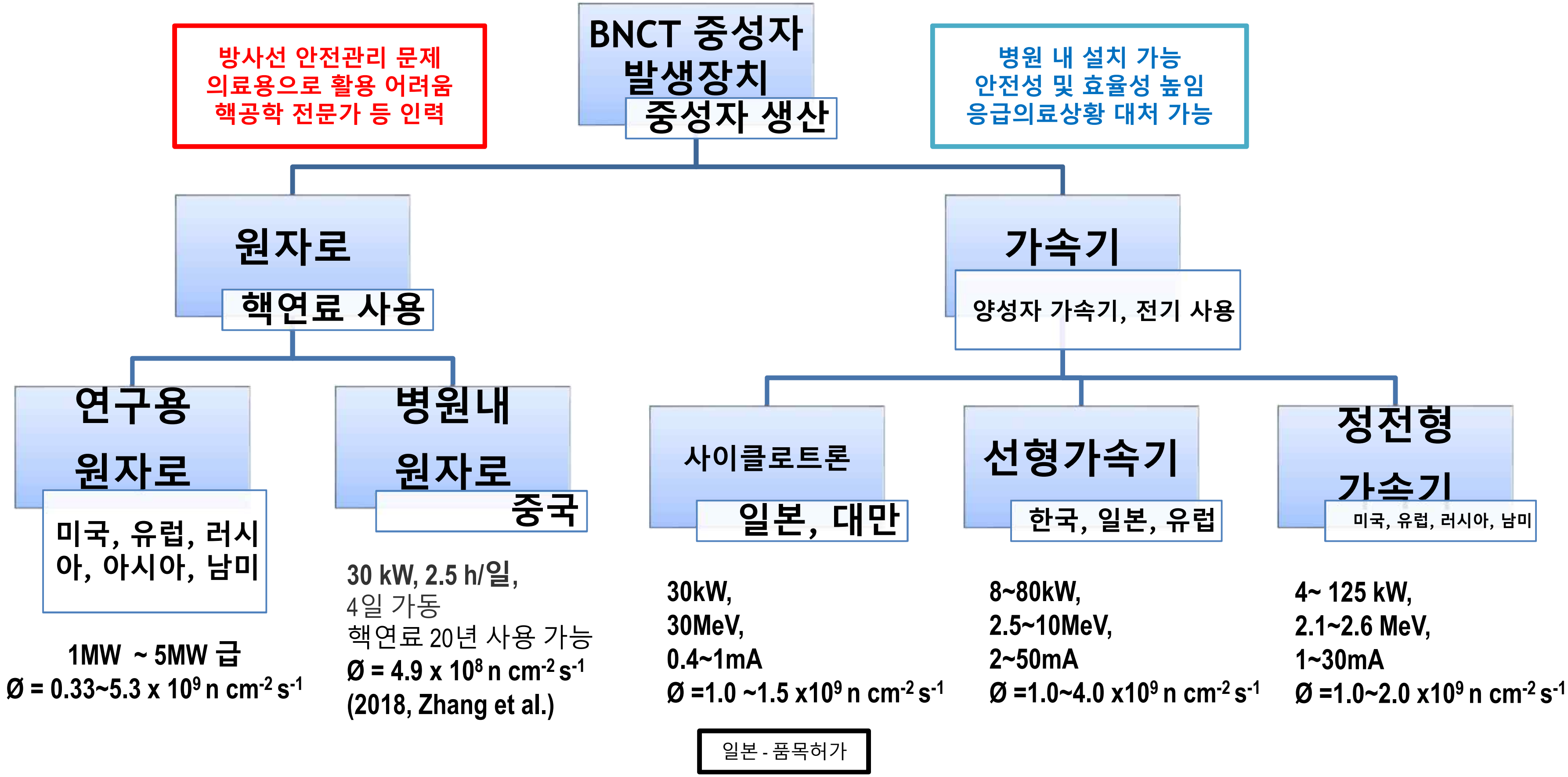


2019 I. Porras

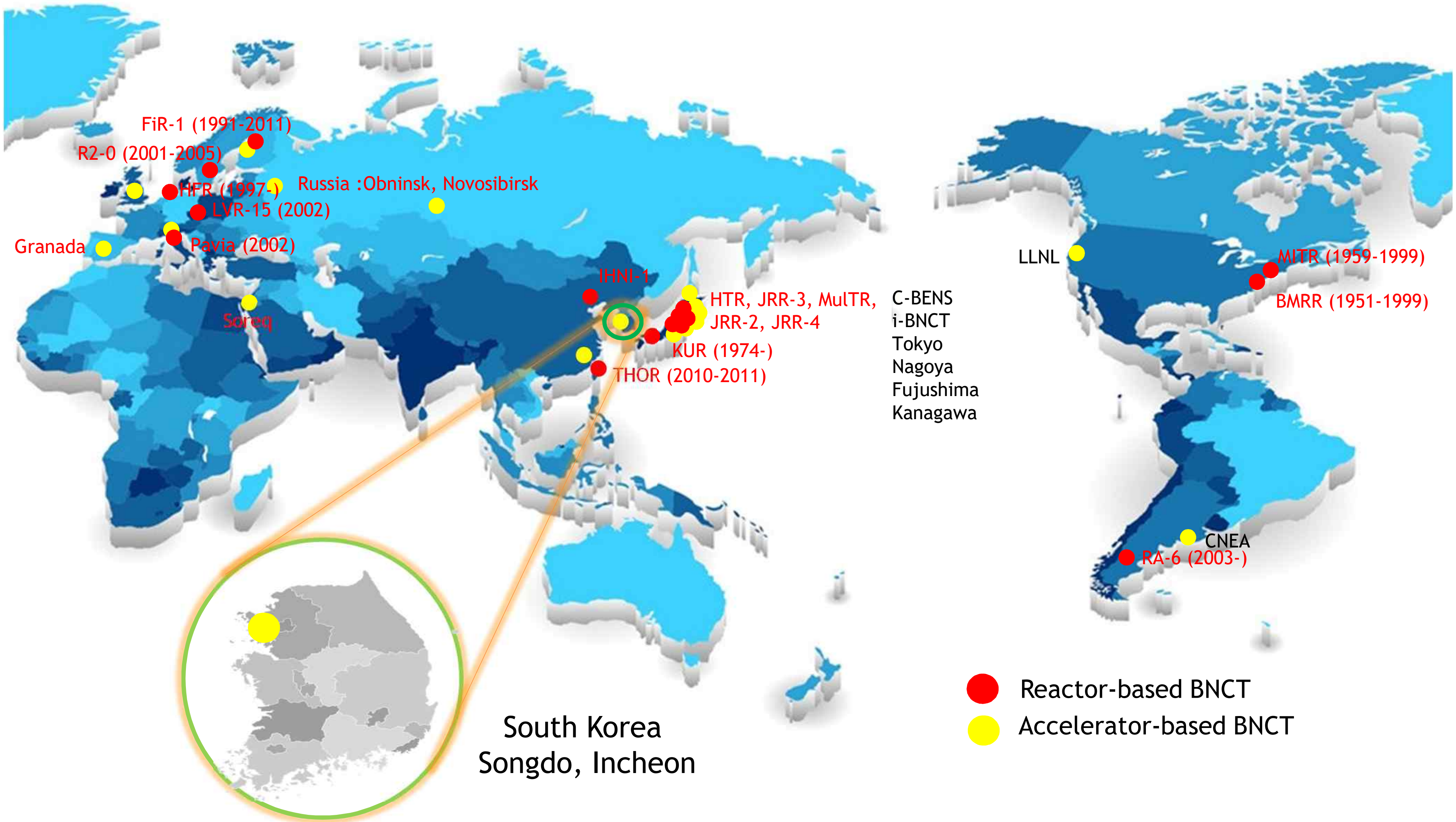
$^{10}B + n_{th} \rightarrow {}^{4}He + {}^{7}Li$ + 2.79 MeV (6%)

$^{10}B + n_{th} \rightarrow {}^{4}He + {}^{7}Li$ + 2.31 MeV + γ0.48 MeV (94%)

원자로와 가속기기반 중성자원



전세계 BNCT 센터



Modified from AIP Conference Proceedings (2019)

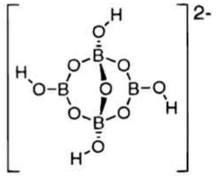
가속기 기반 BNCT 사양 및 현황 (2020 IAEA Technical meeting 취합 및 자료 정리)

Type	Company	Institute	Accelerator	Beam energy	Intensity	Reaction	Max. n Energy	Current status
Linear	DAWONMEDAX, Korea	Gachon Univ. Gil Med. Center, S.Korea	RFQ-DTL[a]	10 MeV	8 mA	^{9}Be(p,n)	8.1 MeV	비임상시험
	Toshiba, MHI, Japan	Tsukuba Univ., Japan	RFQ-DTL[a]	8 MeV	10 mA	^{9}Be(p,n)	6.1 MeV	비임상시험
	CICS, Japan	National Cancer Center, Edogawa Hospital BNCT center, Japan	RFQ[a]	2.5 MeV	20 mA	^{7}Li(p,n)	0.79 MeV	비임상시험
[a] RFQ stands for Radio Frequency Quadrupole and DTL for Drift Tube Linac.	-	SOREQ, Israel	RFQ-DTL[a]	4 MeV	2 mA	^{7}Li(p,n)	2.3 MeV	개발중
	-	INFN, Italia	RFQ[a]	5 MeV	50 mA	^{9}Be(p,n)	3.1 MeV	개발중
Electrostatic	Neutron Therapeutics, US	Helsinki Univ. Cent. Hospital, Finland	Hyperion	2.6 MeV	30 mA	^{7}Li(p,n)	0.89 MeV	임상시험 (2021)
	TAE LS, US	Xiamen Humanity Hospital, China	VITA	2.5 MeV	10 mA	^{7}Li(p,n)	0.79 MeV	개발중
	-	CNEA Bs. As., Argentina	Tandem Electrost. Quadrupole	1.4 MeV 2.5 MeV	30 mA 30 mA	^{9}Be(d,n) ^{7}Li(p,n)	5.7 MeV 0.79 MeV	건설중
	-	Birmingham Univ., UK	Dynamitron	2.8 MeV	1 mA	^{7}Li(p,n)	1.1 MeV	개발중
	-	Nagoya Univ., Japan	Dynamitron	2.8 MeV	15 mA	^{7}Li(p,n)	1.1 MeV	커미셔닝
	-	LBNL, USA	Electrostatic	2.5 MeV	50 mA	^{7}Li(p,n)	0.79 MeV	NA
	-	Granada Univ., Spain	Hyperion	2.1 MeV	30 mA	^{7}Li(p,n)	0.35 MeV	개발중
	-	Budker Institute, Novosibirsk, Russia	Vaccum insulated Tandem	2 MeV	2 mA	^{7}Li(p,n)	0.23 MeV	비임상시험
	-	IPPE Obninsk, Russia	Cascade generator KG-2.5	2.3 MeV	3 mA	^{7}Li(p,n)	0.57 MeV	개발중
	-	KIRAMS, S. Korea	electrostatic	2.4MeV	15mA	^{7}Li(p,n)	0.79 MeV	개발중
Cyclotron	Sumitomo H.I, Japan	Osaka Medical College, Japan	Cyclotron	30 MeV	1 mA	^{9}Be(p,n)	28 MeV	품목허가 완료

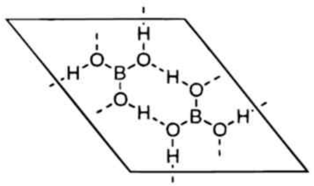
붕소의약품 개발

1st Generation

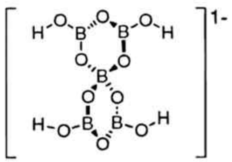
Borax ($Na_2B_4O_7 \cdot 10H_2O$)



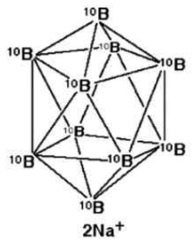
Boric acid [$B(OH)_3$]



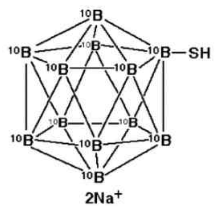
Pentaborate ($NaB_5O_8 \cdot 4H_2O$)



2nd Generation

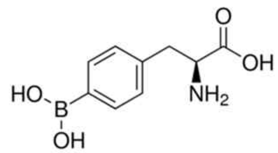


Decahydrodecaborate-^{10}B
(GB-10, $Na_2{}^{10}B_{10}H_{10}$)



Mercaptoundecahydrododecaborate-^{10}B
(Sodium borocaptate -^{10}B, BSH, $Na_2{}^{10}B_{12}H_{11}SH$)

3rd Generation

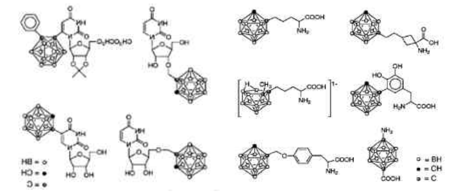


BPA
(Borono-phenylanaline)

Cancer-
Targeted
Delivery

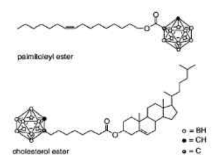
Candidates of 4th Generation

Cellular Building Block

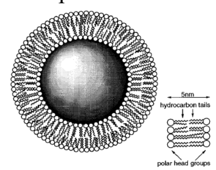


Boron-Containing Nucleic Acid Precursors and Amino Acids

Lipoproteins

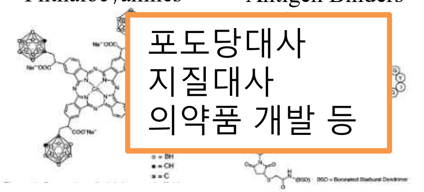


Liposomes

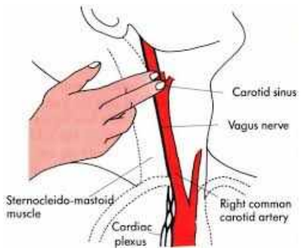


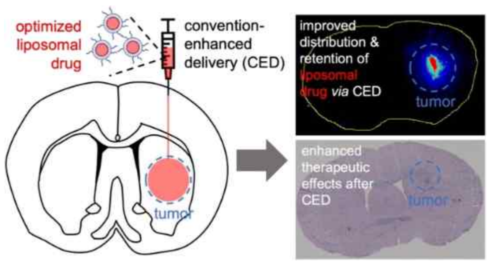
Porphyrins and Phthalocyanines

Receptors Antigen Binders



포도당대사
지질대사
의약품 개발 등





Drug delivery system

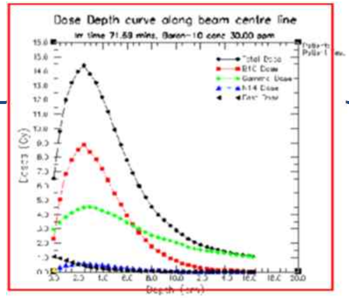
Intra-arterial injection

Han, Y., et al 2020

Intravenous injection

BNCT 선량평가

Physical dose



X CBE/RBE

BNCT Dosimetry

Gy-Eq : Equivalent Dose

BNCT Dosimetry

$^{10}B(n,\propto)^{7}Li$ — Boron Dose — CBE

Depending on boron concentration and thermal neutron flux

$^{14}N(n,p)^{14}C$ — Nitrogen Dose — RBE $_{Nitrogen}$

Nitrogen in tissues with thermal neutron (E_p=0.58 MeV)

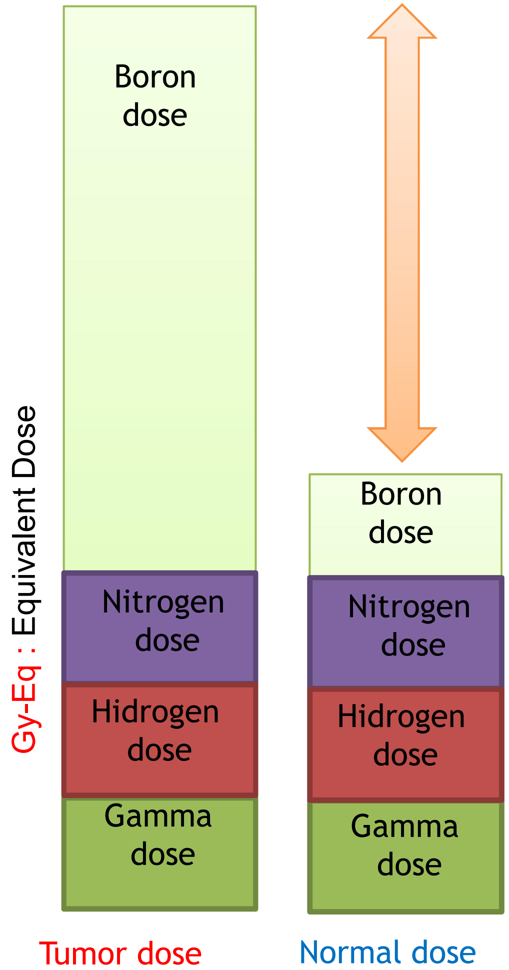
$^{1}H(n,n)p$ — Hydrogen Dose — RBE $_{Fast\ neutron}$

Hydrogen in tissues with fast neutrons

$^{1}H(n,\gamma)^{2}H$ — Gamma-ray Dose — RBE$_\gamma$

Total Dose

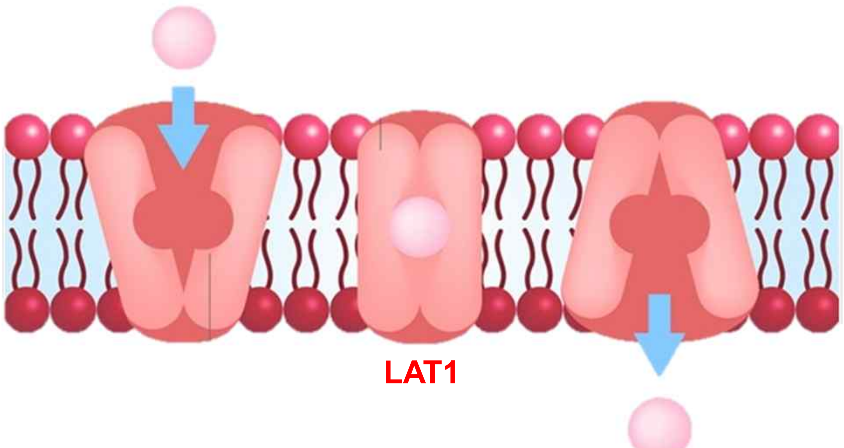
Primary gamma-ray dose from beam port (E_g=2.2 MeV)
Secondary gamma-ray dose generated in neutron and hydrogen



M.S. Herrera et al. / Physica Medica 29 (2013) 436e446

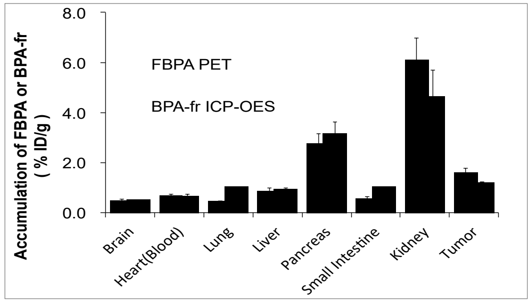
붕소농도평가 및 체내 붕소농도 대사영상

BPA accumulates selectively in cancer cells at much higher levels than normal cells



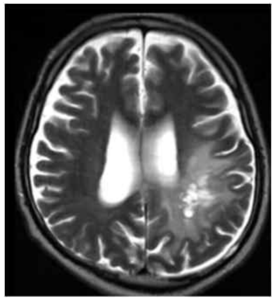
BPA is taken up selectively by LAT1, which is highly expressed in Cancer Cells

^{18}F-FBPA PET clearly shows location of tumor mass

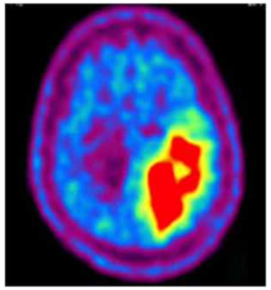


2014 Hanaoka K et al.

MRI Brain Image

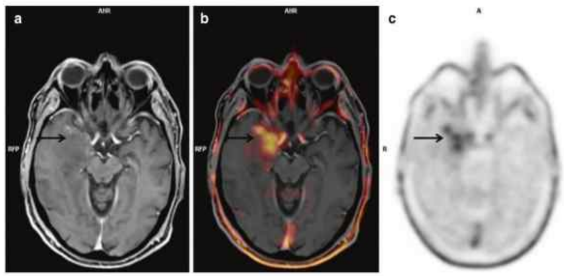


^{18}F-FBPA PET Image



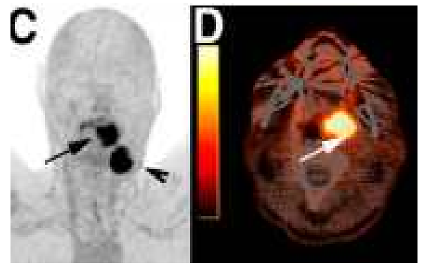
Miyatake et al, 2014, Radiation Oncology 9:6

^{18}F-FET PET Image



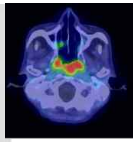
Muoio, B. et al. 2017, Current Medicinal Chemistry.

^{18}F-FMT PET Image

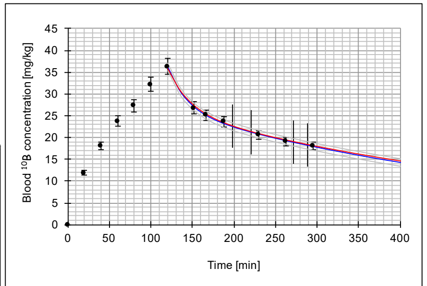


Burger, I. A et al. 2014, JNM

BNCT 치료방법

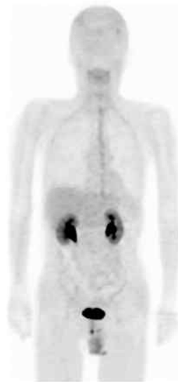


H. Tani et al. 2014



Finland data

Finnish Nuclear Reactor



Blood sample

Screening Initial PET/CT

Treatment planning & simulation

BPA IV 400mg/kg/2hr 500mg/kg/3hr

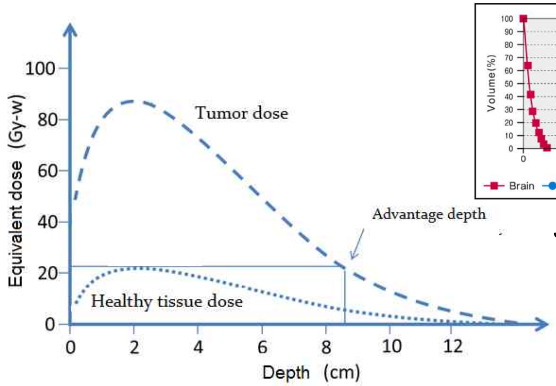
Neutron Irradiation

Hydration & Monitoring in Hospital

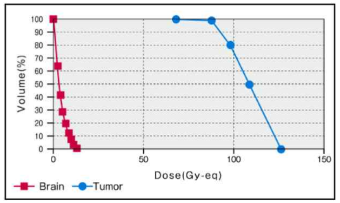
Follow-up

Multidisciplinary team

Physicians
Radiation oncologists
Nuclear medicine physicians
Medical physicists
Radiation technologists
Pharmacists
Nurses
etc.



Ignacio P. 2019 in Korea



JSNCT, DVH

*Coderre and Morris 1999

Dose component
D_B - boron dose $^{10}B(n,a)^7Li$
D_N - nitrogen dose $^{14}N(n,p)^{14}C$
D_{fast_n} - fast neutron dose $^1H(n,n')p$
D_g - photon dose $^1H(n,g)^2H$

× CBE/RBE factors
D_B Cancer 3.8 Brain 1.3
Oral mucosa 2.5 (Finland)
4.9 (Taiwan, Japan)
D_N and D_{fast_n} 3.2
D_g 1

임상시험 결과의 과거와 현재

BGRR Clinical trial 1951-1959

⇩

MIT Named in Lawsuit Over Radiation Deaths

Adriane Chapman--The Tech

Today, the fourth patient is slated to begin testing a new radiation treatment in this facility at the Nuclear Reactor Laboratory. MIT is named in a lawsuit filed on behalf of brain tumor patients treated with an experimental radiation treatment at the reactor in the 1960s.

Preliminary scanning of the cancer patients

Gross calculation of tumor size and volume from the preliminary scanned images

18F-FBPA PET scan Image to check the uptake of boron drug by tumor cells

Epithermal neutron beam irradiation

Administration of BPA drug

Treatment plan and simulation

BNCT : Lysis of tumor cells

Successful Clinical Trials

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Boron Neutron Capture Therapy Back in Limelight After Successful Trials

Andrew Green, IAEA Office of Public Information and Communication

SEP 27 2016

Saverio Altieri from the University of Pavia in Italy presents promising clinical results of Boron Neutron Capture Therapy. (Photo: A. Green/IAEA)

A cancer treatment involving irradiated boron isotopes has been explored as a therapeutic option for several decades but with very little clinical success. But thanks to recent advances in technology, it is now seeing renewed interest after successful clinical trials to treat certain types of cancer, namely melanoma of the skin, parotid cancer and head and neck cancer. Patients with brain

Related Stories

- Reining in Costs and Ensuring Feasibility of Proton Beam Therapy Key to Modern Radiation Oncology
- Reducing Cancer Deaths by a Third in 15 Years: How the IAEA can Help
- Together We Can Do More

Related Resources

- IAEA 60th General Conference, 26-30 September 2016
- IAEA General Conference, Photo Gallery
- Scientific Forum, 28-29 September 2016
- Division of Human Health
- Department of Nuclear Sciences and Applications

재발성 또는 국소진행성 두경부암 임상2상 결과보고 (가속기)

2021 Hirose et al.

Boron neutron capture therapy using cyclotron-based epithermal neutron source and borofalan (10B) for recurrent or locally advanced head and neck cancer (JHN002): An open-label phase II trial

* 사이클로트론 가속기 + BPA 의약품 사용

Response to BNCT.

Response	SCC (n = 8)	nSCC (n = 13)	Total (n = 21)
Response, No. (%)			
Complete response	4 (50)	1 (8)	5 (24)
Partial response	2 (25)	8 (62)	10 (48)
Stable disease	1 (13)	4 (31)	5 (24)
Progression	0 (0)	0 (0)	0 (0)
Not evaluable	1 (13)	0 (0)	1 (5)
ORR, % (95% CI)	75 (35–97)	69 (39–91)	71 (48–89)
DCR, % (95% CI)	88 (47–100)	100 (79–100)	95 (76–100)
Proportion OS at 2 years, % (95% CI)	58 (18–84)	100 (79–100)	85 (61–95)

The results were from central review at day 90 after BNCT in JHN002 trial. Abbreviations: BNCT, boron neutron capture therapy; SCC, squamous cell carcinoma; nSCC, non-squamous cell carcinoma; ORR, objective response rate; CI, confidential interval; DCR, disease control rate; OS, overall survival.

표재성 흑색종 장기추적 임상결과 (원자로)

2020 Hiratsuka et al.
Long-term outcome of cutaneous melanoma patients treated with boron neutron capture therapy (BNCT)

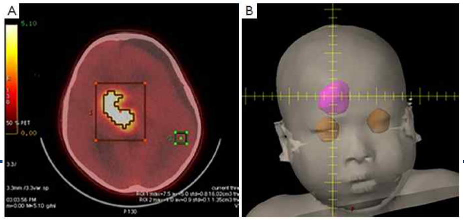
* 원자로 (KURRI) + BPA

대상 환자군 : 병기 cT1-2N0M0, performance scores <2.

Table 3. Treatment administered and clinical outcome

Patient No.	Minimum tumor dose (Gy-eq)	Maximum skin dose (Gy-eq)	Adverse reaction	Tumor response	Locoregional control (years)	Survival
1	37	14	Grade 2	CR	12.6	12.6 years (death due to pneumonitis)
2	25	14	Grade 2	CR	6.9	6.9 years (death due to advanced age)
3	25	12	Grade 2	CR	5.5	5.5 years (death due to advanced age)
4	48	15	Grade 1	CR	8.2	8.2 years (alive with NED[a])
5	50	13.5	Grade 2	PR	7.5	7.5 years (alive with PR)
6	41	12	Grade 2	CR	7.5	7.5 years (alive with NED)
7	33	8	Grade 1	PR	6.0	7.1 years (alive with recurrence in 6 years after NCT)
8	25	8	Grade 1	CR	5.6	5.6 years (alive with NED)

[a]NED = no evidence of disease.



재발성 소아뇌종양환자의 구제치료로서 정확한 BNCT 활용 (원자로)

2020 Chen et al. Using precise boron neutron capture therapy as a salvage treatment for pediatric patients with recurrent brain tumors

* 원자로 (Center of National Tsing-Hua University to use the Tsing-Hua Open Pool Reactor (THOR)) + BPA

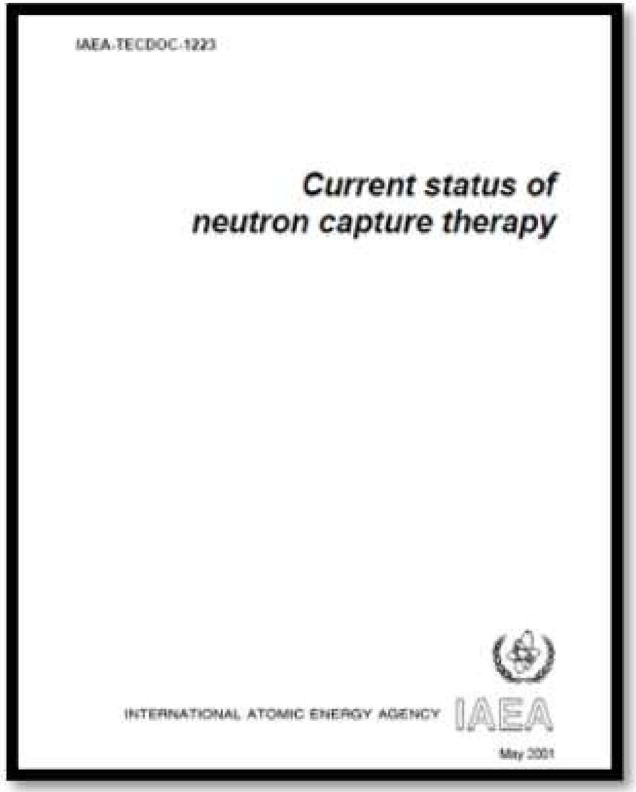
Table 1 Pediatric brain tumor BNCT patients' characteristics and outcomes

Tx serial No.	Pt No.	Sex	Age at initial diagnosis	Diagnosis	Tumor location	Previous Tx history	BNCT age	BNCT date	Response (one month after Tx)	Relapse status	Time from BNCT to progression (months)	Time after BNCT to death (months)	Last status
1	1	M	2	2nd GBM	R't thalamus	Craniotomy for Bx & low dose RT	8	2017/6/30	near CR	Y	5	9	Dead
2	1	M	2	2nd GBM	R't cerebellum (Seeding)	Salvage 1st BNCT	8	2017/11/8	SD	Y	3	4	Dead
3	2	F	6	MB; 2nd GBM	Post fossa; L't frontal	Craniotomy, RT & CHT	11	2017/11/29	PD	Y	5	6	Dead
4	2	F	6	MB; 2nd GBM	Post fossa; L't frontal	Craniotomy, RT & CHT	11	2017/11/29	PD	Y	5	6	Dead
5	3	M	6	GBM	Brainstem	Craniotomy for 3 times	7	2018/3/23	PR	Y	3	4	Dead
6	4	F	3	GBM	Left parietal	Craniotomy & CCRT	5	2019/3/15	PR	Y	3	–	Alive
7	4	F	3	GBM	Left parietal & splenium	Craniotomy & salvage 1st BNCT	5	2019/5/24	PR	Y	3	–	Alive
8	4	F	3	GBM	Splenium	Salvage 2nd BNCT	5	2019/8/14	SD	Y	3	–	Alive
9	5	M	7	HGG (Favor GBM)	Brainstem	Biopsy and CCRT	8	2019/3/15	SD	Y	5	6	Dead
10	5	M	7	HGG (Favor GBM)	Brainstem	Salvage 1st BNCT	8	2019/4/19	SD	Y	4	5	Dead

Tx, treatment; Pt, patient; M, male; F, female; 2nd, secondary; GBM, glioblastoma; MB, medulloblastoma; HGG, high grade glioma; R't, right; L't left; Bx, biopsy; RT, radiotherapy; BNCT, boron neutron capture therapy; CHT, chemotherapy; CCRT, concurrent chemoradiotherapy; CR, complete response; SD, stable disease; PD, progressive disease; PR, partial response; Y, yes.

IAEA BNCT 기술미팅 시행 (27th-31th, July, 2020)

IAEA TECDOC-1223
May 2001

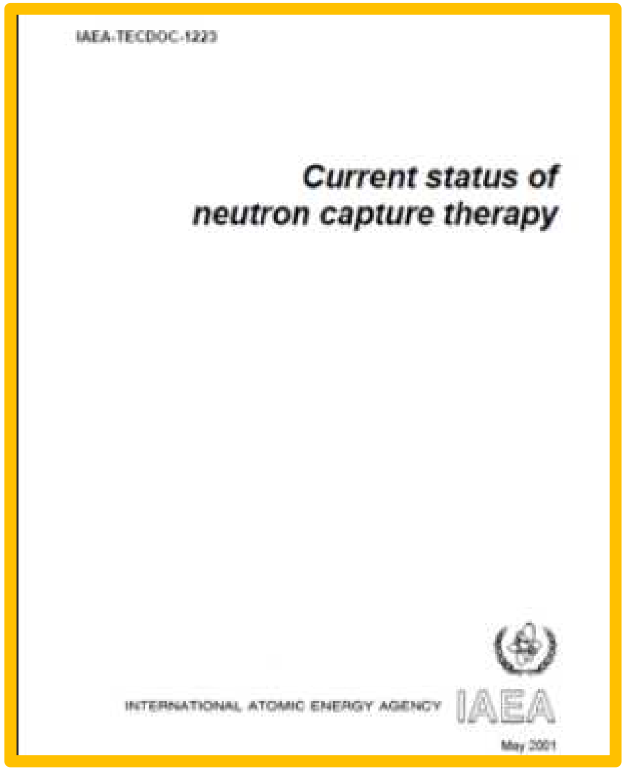

IAEA-TECDOC-1223

Current status of neutron capture therapy

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

May 2001

New Technical document
2021~2022


IAEA-TECDOC-1223

Current status of neutron capture therapy

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

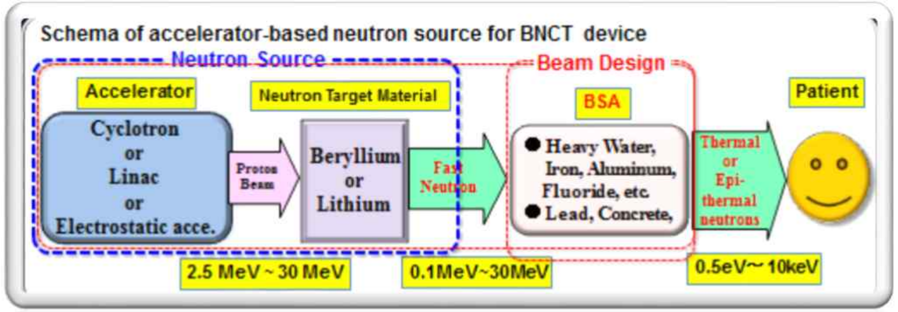
May 2001

IAEA BNCT 기술미팅 시행 (27th-31th, July, 2020)

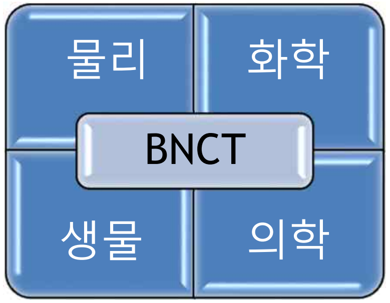
온라인 미팅	주요 논의 주제
월 (7월 27일)	**Neutron beam design, desired parameters & measurement** Prerequisites for neutron beam parameters: David Nigg, Iiro Auterinen Beam design considerations : Hiroaki Kumada, Jacek Capala Physical dosimetry of BNCT: determination of beam parameters: Hiroki Tanaka, Daniel Santos
화 (7월 28일)	**Source and facility design, mgmt, and regulatory aspects** Neutron sources for BNCT treatment facilities : Yoshiaki Kiyanagi, Andres Kreiner Organization, operation and management of a BNCT treatment facility : Koji Ono, Yoshihiro Takai Treatment facility design : Liisa Porra, Akira Matsumura Regulatory aspects : Sandro Rossi, Noah Smick
수 (7월 29일)	**Boron compopunds, BNCT radiobiology & Boron imaging** Boron compound : Hiroyuki Nakamura, Eva Hey-Hawkins Radiobology : Amanda Schwint, Mitsuko Masutani Boron concentration determination and imaging : Saverio Altieri, Sasana Nievas
목 (7월 30일)	Prescribing and treatment planning for BNCT : Hanna Koivunoro, Yoshinori Sakurai Dose reporting in BNCT : Wolfgang Sauerwein, Shin-Ichi Miyatake Clinical trial design and procedures for BNCT : Adrea Wittig, Hiroshi Igaki
금 (7월 31일)	Friday session IAEA TM on Advances in Boron Neutron Capture Therapy : Ignacio Porras, Minoru Suzuki

IAEA BNCT 기술미팅 시행 (27th-31th, July, 2020)

New TEC-DOC



1. New TECDOC is devoted to Accelerator Based Neutron Sources
2. Radiobiology measurements are key
3. Important a good characterization of the beam
4. Diverse n producing reactions 7Li(p,n), 9Be(p,n), 13C(d,n), 9Be(d,n)
5. Operation & management of facilites: previous TECDOC is not suitable
6. Treatment facility design
7. Radiation protection
8. Cost similar to proton beam therapy but can be reduced in existing hospital
9. There is not muh knowledge from authorities about BNCT facilities, longer time for approval, some educatyion is required
10. Dose calculations of BNCT



New TEC-DOC
set of consensus on

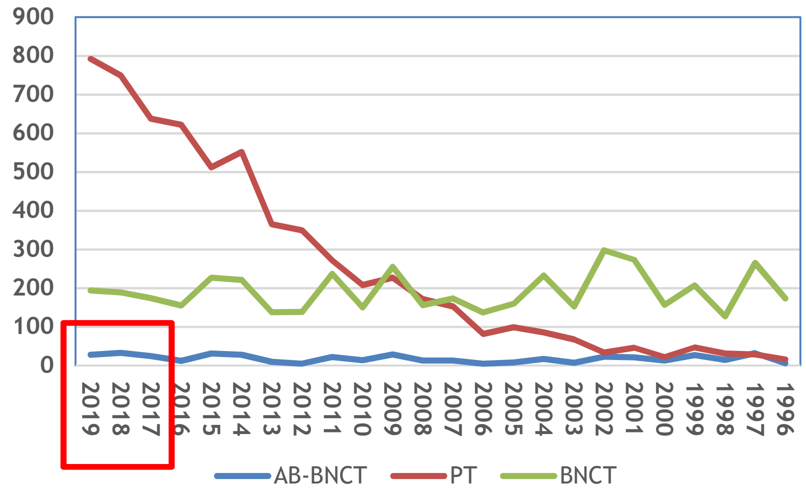
1. recommend solutions and frame of guidance for "BNCT-specific" clinical trial methodology
   - Ease regulatory procedures
2. indispensable parameters, which are to be defined in study protocols and which have to be reported in publications
   - Global exchange
   - Quality assurance
   - Opening up financing opportunities
3. preclinical/translational strategies which ease clinical procedures
   - Effective developments through collaborative research

연구경향 : “Neutron Capture Therapy” OR “Neutron Therapy” OR “BNCT”

By Countries

Countries with more than 100 publication

country	documents	citations
Argentina	190	1917
Australia	102	2771
England	215	6834
Finland	125	1572
France	139	4033
Germany	363	8980
Iran	102	597
Italy	358	7405
Japan	979	16901
Netherlands	145	5996
Peoples R China	228	3353
Russia	294	3514
South Korea	113	1104
Sweden	165	3663
Taiwan	127	1196
USA	1534	41742



Yaser Kasesaz, Wolfgang Sauerwein, Afsaneh Karami, 2020, IAEA TM Scientometric analysis of BNCT research and development

국내 A-BNCT 개발 – 다원메닥스

DAWON MEDAX

- ❒ **Project Name :** Development of the accelerator based Boron Neutron Capture Therapy system for the cancer treatment within 1 hour therapeutic time
- ❒ **Project Period :** 2016 . 5 ~ 2021 . 6 (MOTIE project) and continuous development
- ❒ **Leading Organization :** Dawonmedax & Dawonsys Inc.
- ❒ **Participating Organizations :** Gachon Univ Gil Medical Center,, PAL, KAERI and KBSI
- ❒ **Developed Items :** Proton Linac, Be Target / Moderator Assembly, Radiation Safety & Licensing, Boron Compounds, TPS, Dosimetry (n&γ), Biological Experiment (cells, animals) Clinical Trials

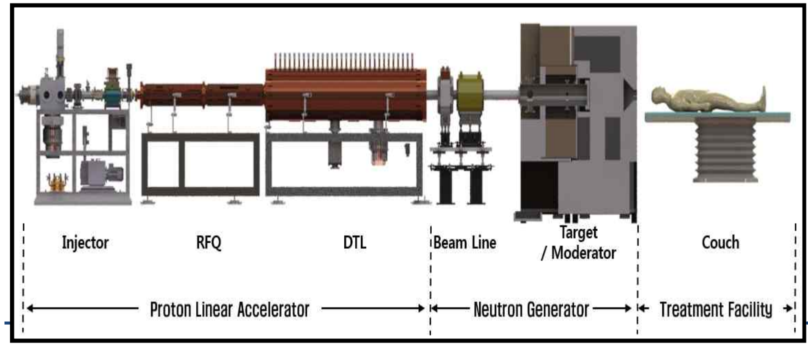
❖ Supported by Ministry of Trade, Industry and Energy (MOTIE) project

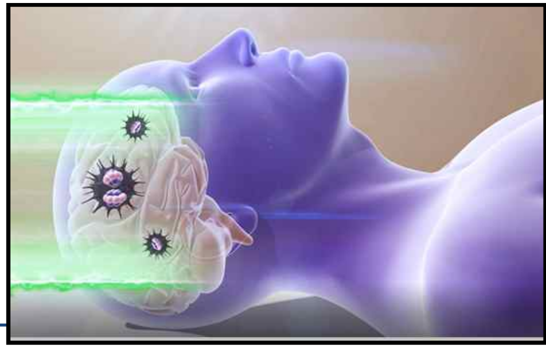
A-BNCT Facility

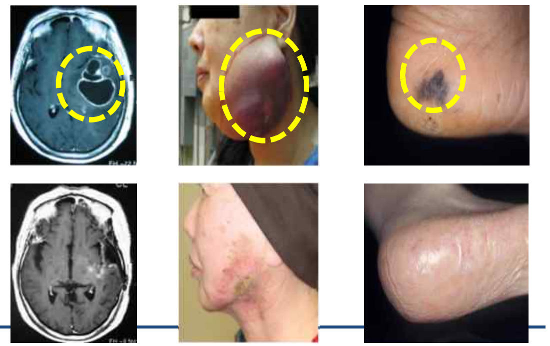
Dosimetry & TPS

Clinical Trials

Brain Tumor | Head &Neck Cancer | Malignant Skin Cancer

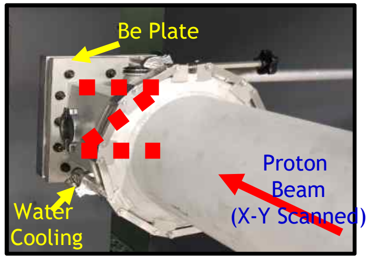


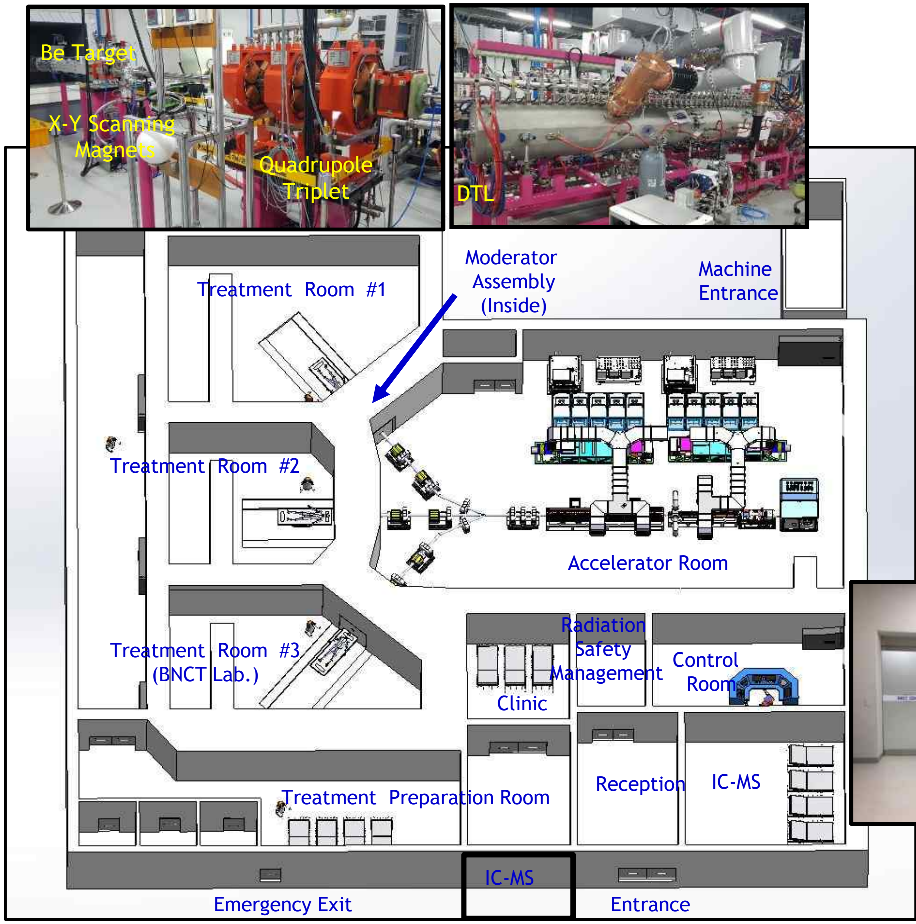


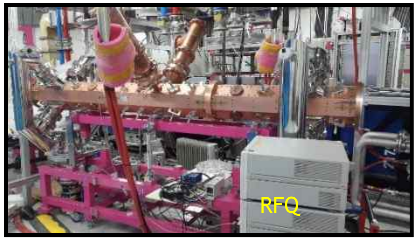


A-BNCT 센터 Songdo, Incheon

A-BNCT 센터







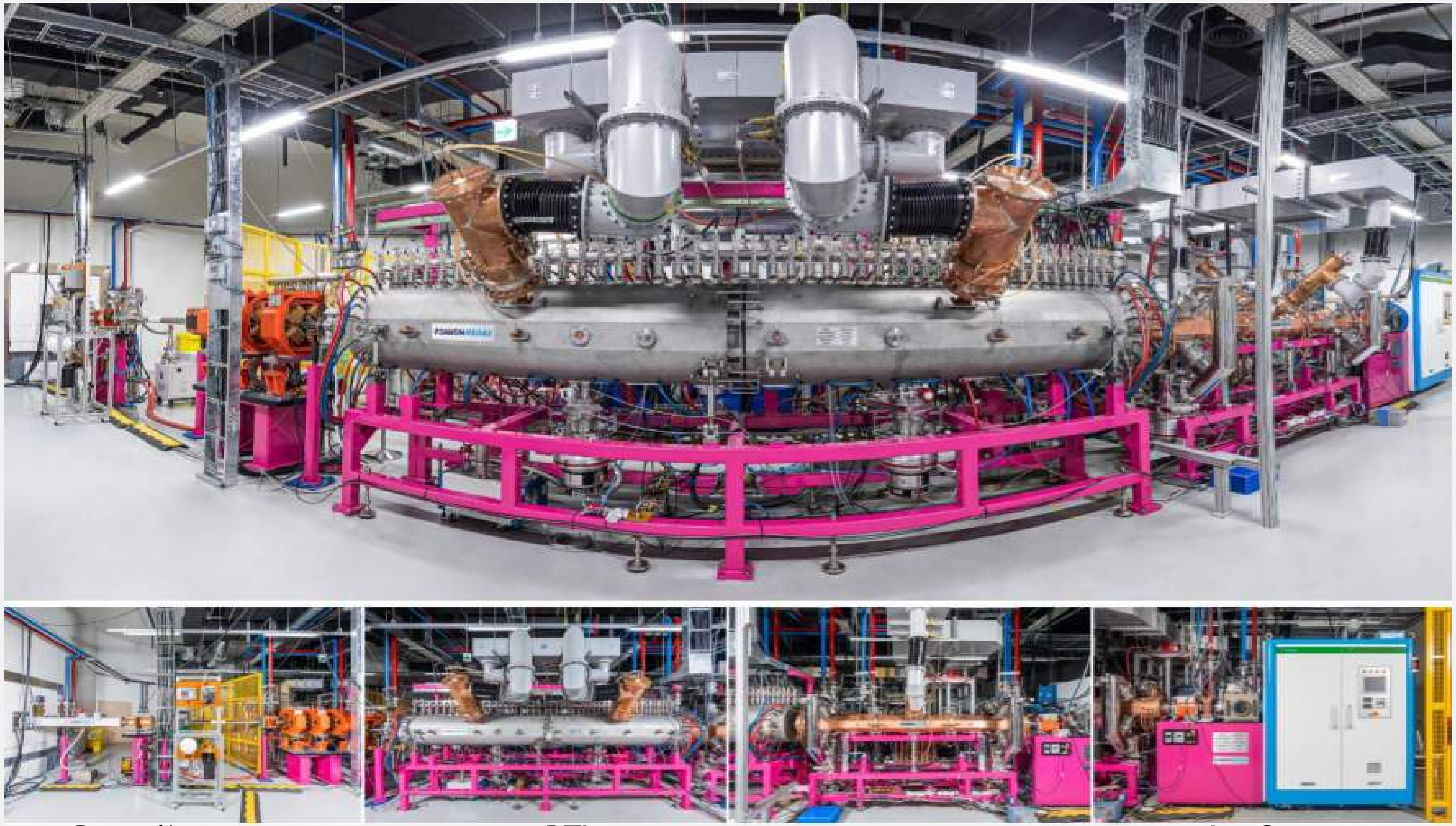
Treatment room

Building : 35.3 x 21.8 m^2 with shielding

Utility : Electricity, Cooling, Air Cond.

A-BNCT 센터

DawonMedax' Linear Accelerator (LINAC)



Beam lines ← DTL (Drift Tube LINAC) ← RFQ (Radio Frequency Quadrupole) ← Ion Source

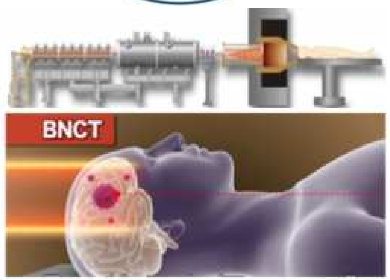
의료기기, 의약품 및 치료계획시스템 인허가 프로세스

[Class III] Medical device

LINAC based BNCT

[Class II] Software

Treatment planning system



[New drug] Boron Drug

BPA DP

MFDS requires the submission of 'Technical Documents' for the certification and approval for BNCT medical devices.
BNCT is categorized as Class Ⅲ devices.

Test report, comparison data, mode of action, safety & performance process, Clinical study, usage Status at Overseas etc.

Nuclear Safety and Security Commission | Korea Testing Laboratory | Ministry of Food and Drug Safety

Selected as a High Tech Medical Device and
Innovative Medical Device Company by Medical device Industry Law

Radiation Safety Approval of facilities LINAC based BNCT
Selected as a medical device approval guide program of MFDS

Preclinical study → Clinical trial I/IIa → Clinical trial IIb

Selected as a Pharm Navi guide program of MFDS

MFDS requires the safety & efficacy data, specifications & test methods, Drug Master Files (DMF), certificate of manufacturing and marketing(Imported Pharmaceutical) Data such as name and address of manufacturers of active pharmaceutical ingredients.
Evaluation data of conducting of Good Manufacturing Practice (GMP)

International Society for Neutron Capture Therapy (ISNCT)

ISNCT: Involves multidisciplinary researchers in the field in a spirit of close collaboration
Promotes the future development of BNCT

www.isnct.net

Current Members of the Executive Board

- Ignacio Porras (President)
- Akira Matsumura (Vice President)
- Silva Bortolussi (Secretary General)
- Fong-In Chou (Immediate Past President)
- Javier Praena (ICNCT Chair 2020)
- Michal Gryzinski (ICNCT Chair 2022)
- Yuan-Hao Liu (Member at Large)
- Minoru Suzuki (Technical Chair - Medicine)
- Hiroaki Kumada (Technical Chair - Physics)
- Hiroyuki Nakamura (Technical Chair - Chemistry)
- Amanda Schwint (Technical Chair - Biology)

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End of term 2020

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- Andres Kreiner
- Luigi Panza
- Ming-Hua Hsu
- Minoru Suzuki
- Koji Ono
- Desire Ngoga
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- Ignacio Porras
- Tetsuya Yamamoto

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- Junichi Hiratsuka
- Amanda Schwint
- Hiroyuki Nakamura
- Yuan-Hao Liu
- Natsuko Kondo
- Sara Gonzalez
- Simonetta Crich
- Sang-Hue Yen
- Yi-Weh Chen
- Hanna Koivunoro

End of term 2024

- Shin-Ichi Miyatake
- Hyo Jung Seo
- Andrea Monti Hughes
- Shin-Ichiro Masunaga
- Po-Shen Pan
- Mitsunori Kirihata
- Hiroki Tanaka
- Saverio Altieri
- Leena Kankaanranta
- Stuart Green

국내 중성자포획치료 학회 구성 필요

Neutron Capture Therapy
Boron (B) & Gadolinium (Gd)

BNCT 임상적응증 현재와 미래

환자 삶의 질 (QOL)

뇌종양

두경부암

피부암

골육종

희귀
난치성

완화치료

- 뼈전이
- 전신전이 환자의 국소병변제어

* 폐암, 유방암, 간암, 전립선암, 대장암 등

환자 치료효과 증대

수술 전
병변축소 및
전처치

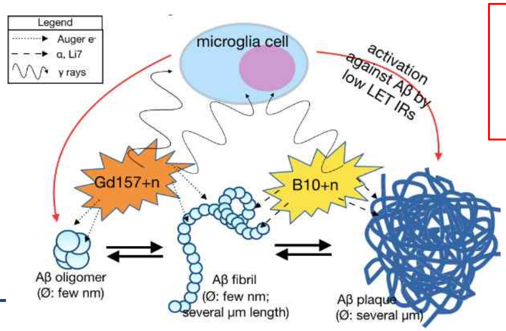
수술 후
미세침습 및
전이 예방

방사선치료
(RT, IMRT
등) 병용치
료

면역치료
병용치료

항암화학
요법
병용치료

고형암 치료 확대
- 방사선저항성 암
- 저산소증암
- 미세침습암
- 미만성암
- 전구성암 등



양성질환 연구
- 혈관염, 관절염
- 방사선치매치료 연구

A nectar against Alzheimer the "Neutron Capture-enhanced Treatment of neurotoxic Amyloid aggRegates" project. / By Nicoleta Protti.

양성질환
치매
혈관염
관절염 등

감사합니다
THANK YOU