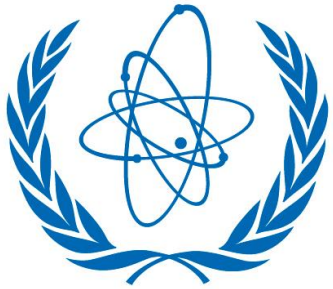


IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Compact Accelerator based Neutron Sources and the IAEA

Ian Swainson, Haifa Ben Abdelouahed, Sotirios Charisopoulos, Kalliopi Kanaki, Milan Matos, Danas Ridikas, Natko Skukan

Physics Section, IAEA

Considerations around a (first) Research Reactor

- Build the legal and regulatory framework in the country
- Obtain operating experience with aim of supporting eventual nuclear power program
- Build overall technical capacity in the country
- National pride
- Isotope production
- Research possibilities with neutrons
- Public opposition
- Capital expense
- Fuel security (suppliers)
- Physical security
- High level nuclear waste
- Decommissioning expense

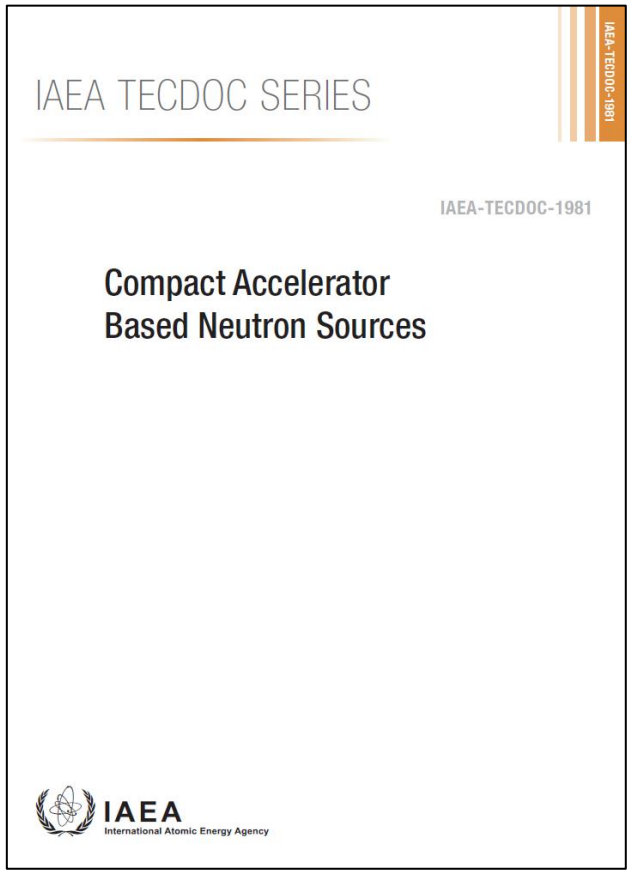
Considerations around a (first) CANS

- Build the legal and regulatory framework in the country
- Obtain operating experience with aim of supporting eventual nuclear power program
- Build overall technical capacity in the country
- National pride
- Isotope production
- Research possibilities with neutrons

- Public opposition
- Capital expense
- Fuel security (suppliers)
- Physical security
- High level nuclear waste
- Decommissioning expense

Technical Meeting on non-spallation neutron production

- The output in 2021 was an IAEA report on CANS (the first one ever)
- The intent was to provide an overview of accelerator technologies, choices, costing, regulatory outlook etc.
- And to provide a document that can be cited during proposals for CANS.

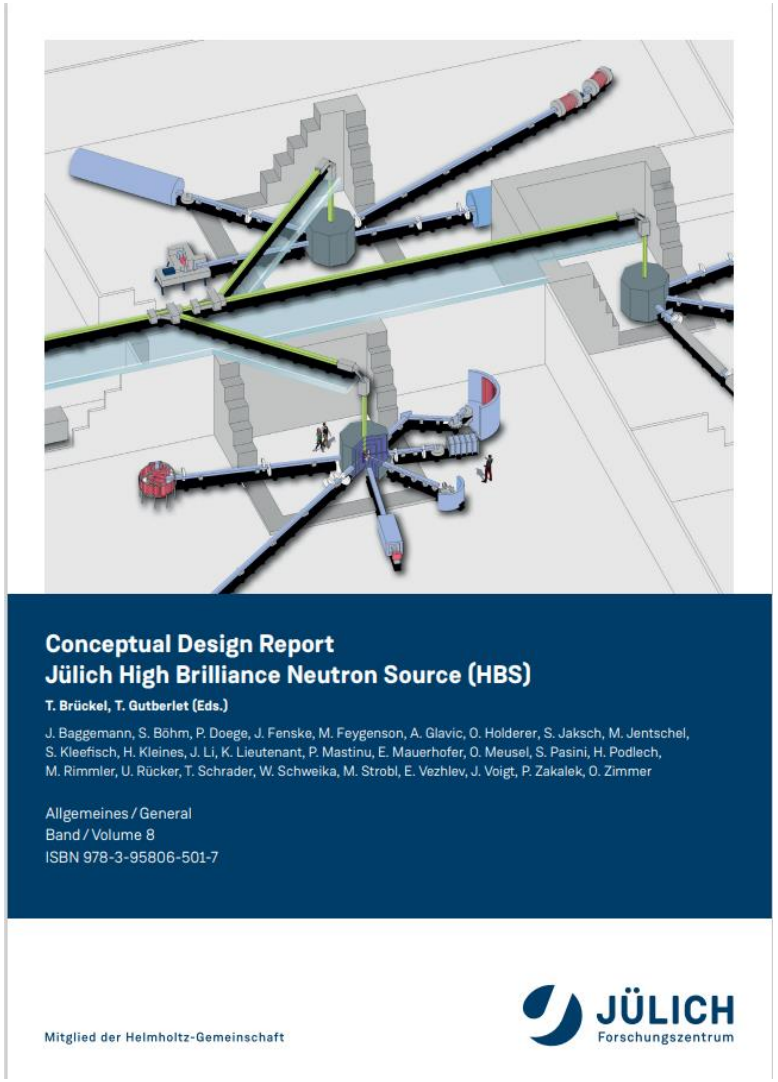


https://www-pub.iaea.org/MTCD/publications/PDF/TE-1981web.pdf

A very few printed copies available

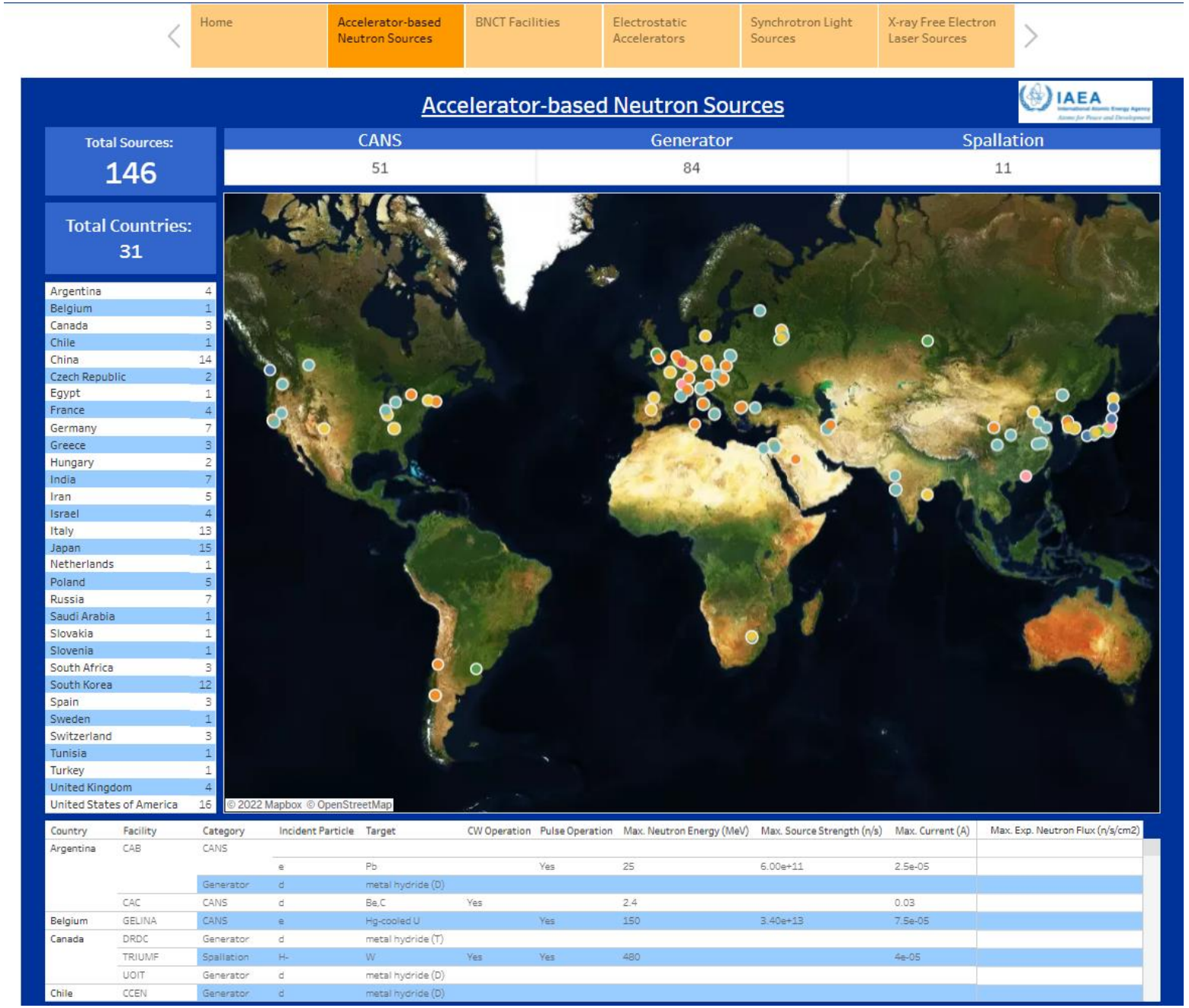
Neutron scattering sources

- Two example CDRs developed by FZ Julich
- Local source for a university based around commercial electrostatic accelerator
- National neutron source to “replace” RR based around high-current linac.



IAEA Databases

- Include CANS, BNCT, but also ion beam accelerators, synchrotrons
- Allied databases on food irradiators and fusion facilities, medical cyclotrons neutron scattering instruments.
- Please feed back any updates/corrections



https://nucleus.iaea.org/sites/accelerators/Pages/default.aspx

Boron Neutron Capture Therapy

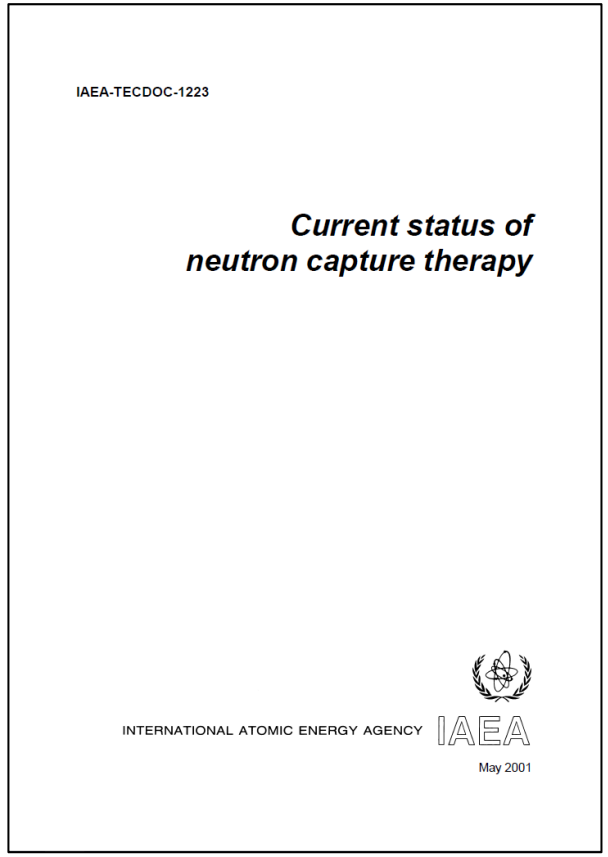
- In 2001, IAEA published TECDOC-1223, “Current status of neutron capture therapy”
- RRs were the only neutron source strong enough for use. $\Phi_{epi} > 5 \times 10^8$ cm^{-2}s^{-1}

2.6. Accelerators

An accelerator would be a useful NCT neutr… …easons. First, accelerators are much more a… …nerally involves fewer compli… …uclear fuel. It … …e technology is not yet … …erator is considered as the most promisi… …enerate a high current of protons with an energy slightly … …shold (1.88 MeV) for the ^{7}Li (p,n) ^{7}Be reaction. The resulting neutrons … …erally require less moderation than those from a reactor.

The future is now!

- Almost all the RRs involved in clinical trials for BNCT in 2001 are now closed.
- TECDOC-1223 remained a standard reference for the field but was in need of updating



BNCT Facilities

IAEA International Atomic Energy Agency
Atoms for Peace and Development

Total BNCT Facilities: 31

Total Countries: 12

Reactor/Accelerator: All

Linac	Electrostatic	Cyclotron	Reactor
8	12	4	7

Argentina	3
China	4
Finland	1
Israel	1
Italy	3
Japan	10
Russia	2
South Korea	2
Spain	1
Taiwan, China	1
Thailand	1
United Kingdom	2

TABLE 5. CURRENT STATUS AND PERFORMANCE OF THE DIFFERENT ACCELERATORS INTENDED FOR AB-BNCT FACILITIES

Institute	Machine status	Target reaction	Beam energy (MeV)	Current goal (mA)	Final power (kW)	Refs.
		CYCLOTRONS				
Kyoto University, Japan	Clinical trials and research	5.5 mm ^{9}Be(p,n)	30	1	30	[7, 29]
Southern Tohoku Hospital, Japan	Treatments covered by insurance	5.5 mm ^{9}Be(p,n)	30	1	30	[7, 29 54]
Kansai BNCT Research Center, Japan	Treatments covered by insurance	5.5 mm ^{9}Be(p,n)	30	1	30	[7, 29, 31]
		ELECTRODYNAMIC LINEAR ACCELERATORS				
A-BNCT, DawonMedax, South Korea	RFQ-DTL: Preclinical	Thick ^{9}Be(p,n)	10	8	80	[55]
Tsukuba, Japan	RFQ-DTL: Preclinical	0.5 mm ^{9}Be(p,n)	8	10	80	[32, 71]
SARAF, Soreq, Israel*	RFQ-DTL: Under development	Liquid jet Li(p,n)	2.5	20	50	[34]
INFN, Legnaro, Italy*	RFQ: Under development	Solid ^{9}Be(p,n)	5	30	150	[56]
IHEP, BNCT-01, Dongguan, China	RFQ: Operational	Solid ^{7}Li(p,n)	3.5	5	17.5	[57]
IHEP, BNCT-02, Dongguan, China	RFQ: Operational	Solid ^{7}Li(p,n)	2.8	20	56	[57]
National Cancer Center, Tokyo	RFQ: Clinical trial	Solid ^{7}Li(p,n)	2.5	20	50	[33,37,38, 58]
Edogawa Hospital, Japan	RFQ: Commissioning	Solid ^{7}Li(p,n)	2.5	20	50	[7]
		ELECTROSTATIC ACCELERATORS				
Budker Institute, Novosibirsk, Russia*	VITA: Operational	Solid ^{7}Li(p,n)	2.0–2.3	10	23	[46]
Blokhin Cancer Center, Moscow, Russia	VITA: Under construction	Solid ^{7}Li(p,n)	2.3	7	20	[59]
Xiamen Humanity Hospital, China	VITA: Commissioning	Solid ^{7}Li(p,n)	2.5	10	25	[46, 60, 61]
CNAO, Pavia, Italy	VITA: Under construction	Solid ^{7}Li(p,n)	2.5	10	25	[46]
Nagoya University, Japan	Dynamitron: Commissioning	Solid ^{7}Li(p,n)	2.8	15	42	[62, 63]
Birmingham University, UK*	Single ended: Under installation	Solid ^{7}Li(p,n)	2.6	30	78	[64, 65]
Helsinki University Hospital, Finland	Single ended: Commissioning	Solid ^{7}Li(p,n)	2.6	30	78	[66]
Shonan Kamakura Hospital, Japan	Single ended: Under installation	Solid ^{7}Li(p,n)	2.6	30	78	[67]
University of Granada, Spain	Single-ended: Under development	Solid ^{7}Li(p,n)	2.1	30	63	[68, 69]
CNEA, Buenos Aires, Argentina	ESQ: Under development	^{9}Be(d,n) thin 8 μm ^{13}C(d,n) thick	1.45	30	43	[7, 8, 9]
KIRAMS	ESQ: Under development	^{9}Be(d,n) thin 8 μm ^{13}C(d,n) thick	1.45	30	43	[7, 8, 9]

Notes: *Non-clinical facilities. The KIRAMS project is within a collaborative agreement with CNEA, Argentina.

30 MeV cyclotron at Kansai BNCT Medical Center

BNCT: not a simple regulatory environment

- For clinical use, approval of the accelerator [medical device], a treatment planning system [software as a medical device], and a B-containing pharmaceutical [new drug submission] are required.
- In Japan, approval route was of all three was via “SAKIGAKE”, similar to “Breakthrough therapy” [USA], “”Priority Medicines” [EU]

Accelerator + dose engine:
Sumitomo Heavy Industries

Treatment planning system:
RayStation

Pharmaceutical:
Stella Pharma


Products

Sumitomo Heavy Industries, Ltd. obtains medical device approval for manufacturing and sales of accelerator based BNCT system and the dose calculation program in Japan. - World’s first BNCT systems as medical device -


RaySearch Laboratories

BOOK A DEMO >EN MENU

November 11, 2020

RAYSTATION SUPPORT FOR BORON NEUTRON CAPTURE THERAPY NOW IN CLINICAL USE IN JAPAN

PDF

RaySearch Laboratories AB (publ) has announced that treatment planning system RayStation® is now in clinical use with boron neutron capture therapy (BNCT) – along with treatment machine from Sumitomo Heavy Industries, Ltd. (SHI) – at two leading cancer clinics in Japan.


STELLA PHARMA

News Release

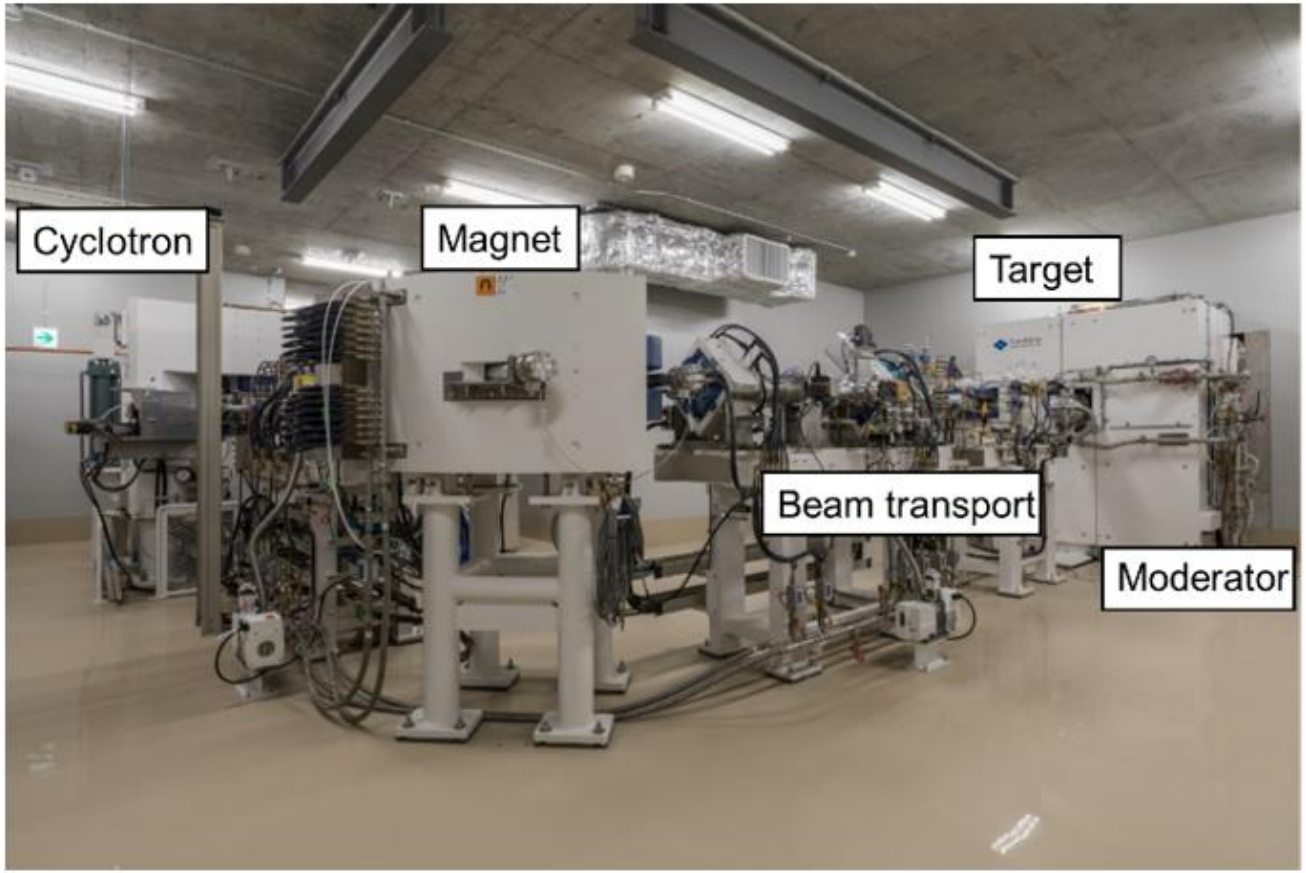
March 25, 2020

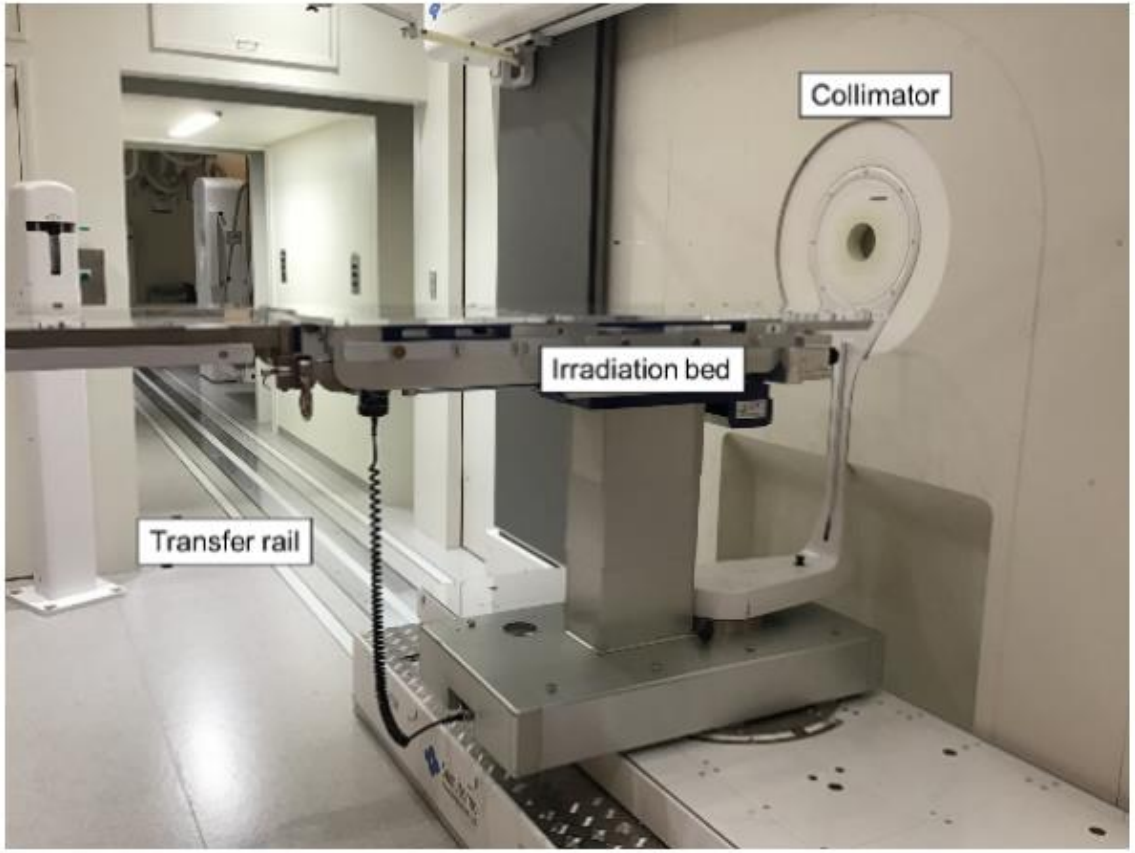
STELLA PHARMA CORPORATION

STELLA PHARMA Receives Marketing and Manufacturing Approval in Japan for “Steboronine® Intravenous Drip Bag 9000mg/300mL”
～ World’s First BNCT Drug ～

The first clinical application concerns treatment of unresectable recurrent head and neck tumors and is covered by Japanese national health insurance since June 1, 2020.

30 MeV cyclotron at Kansai BNCT Medical Center





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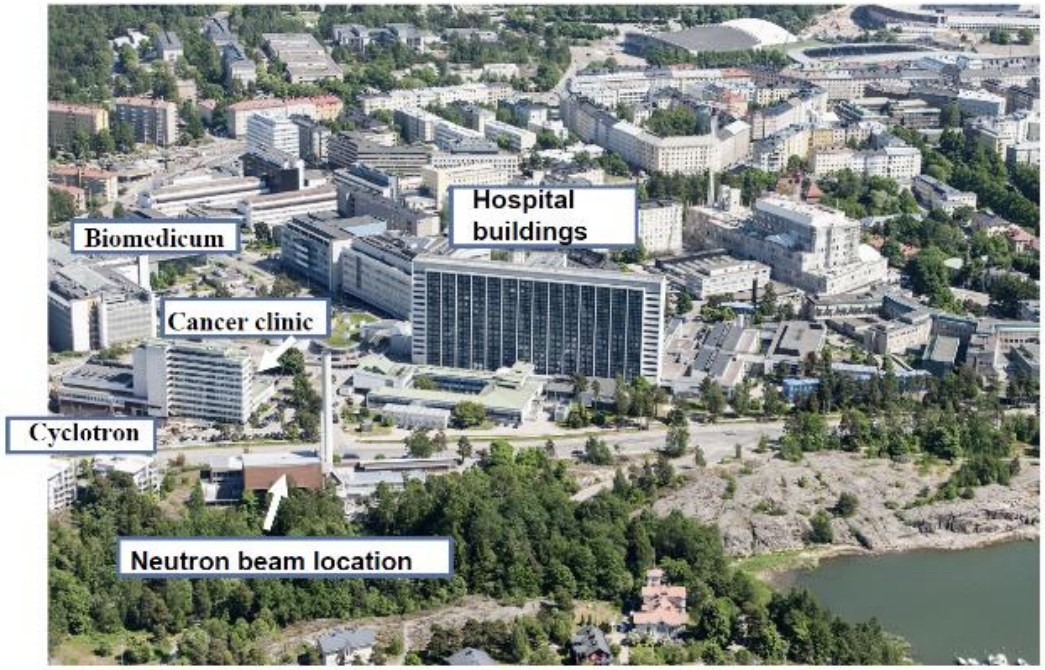
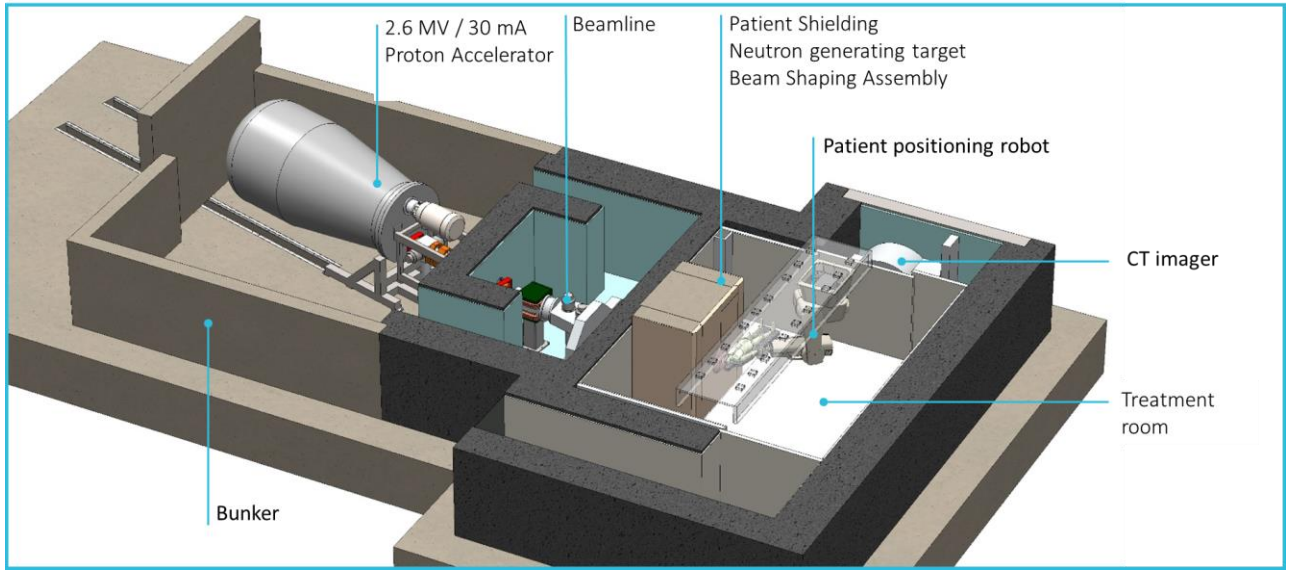
Accelerator based BNCT: status in Finland



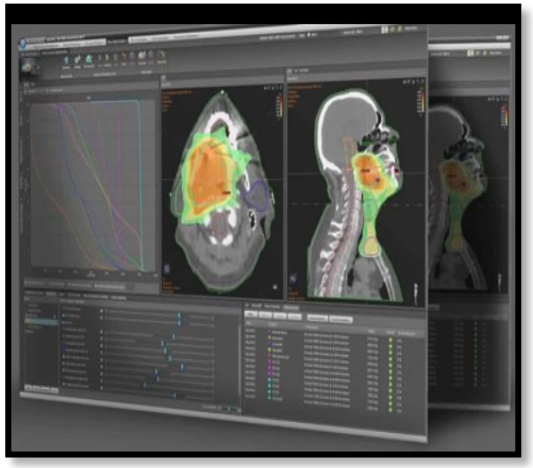


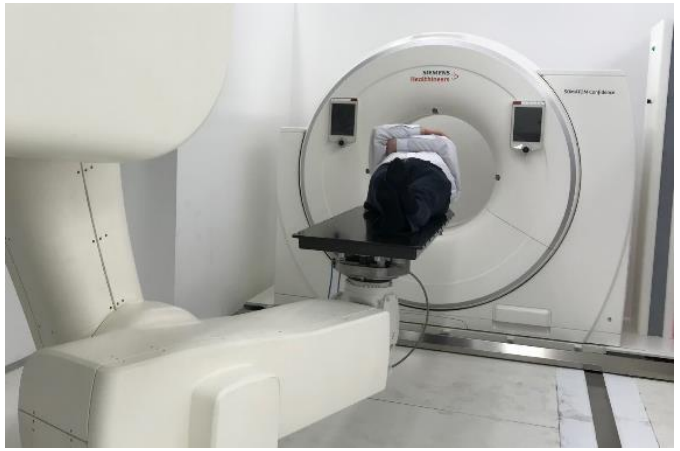
Imaging Position

Treatment Position

RayStation

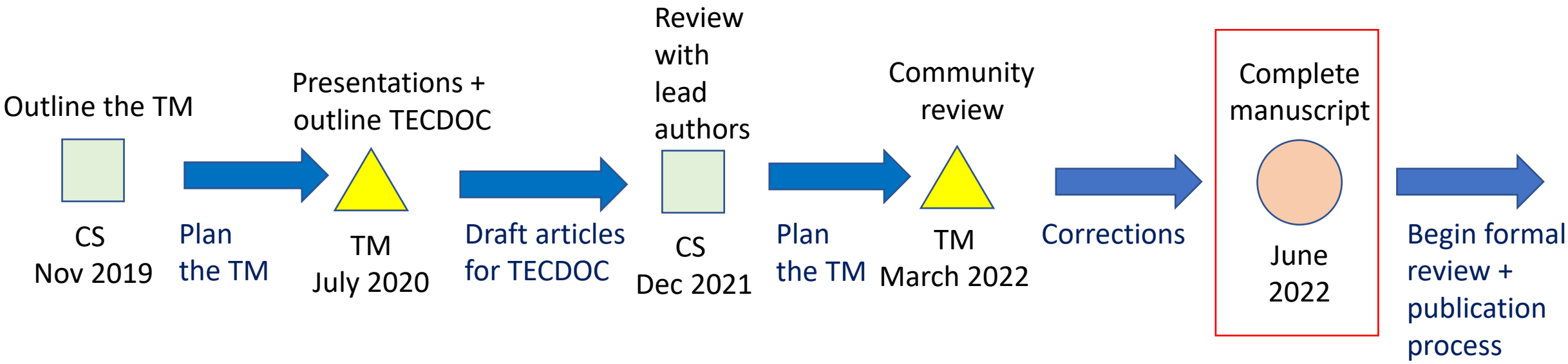
RaySearch Laboratories





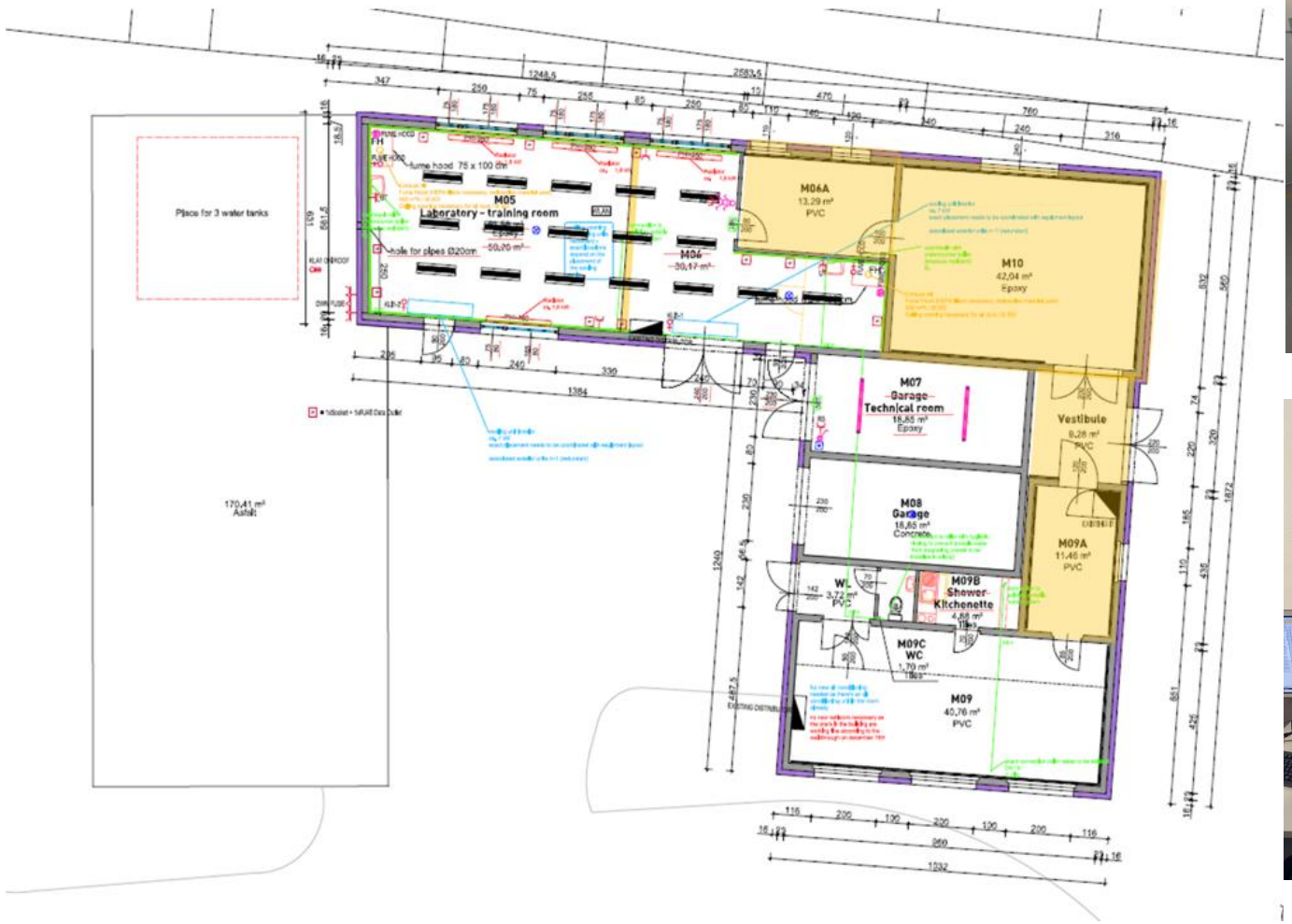
Advances in Boron Neutron Capture Therapy

- The process leading to development of the TECDOC is outlined below
- As of today, we are fixing the last few small corrections before we begin the formal submission process.



CONTENTS

Neutron science facility at Seibersdorf



Neutron Science Facility at Seibersdorf

- Consists of a pair of neutron generators: 1 D-D and 1 D-T
- DD operational. DT being commissioned shortly
- Development of teaching curriculum underway

- Intended for demonstration and training of neutron based techniques
- Neutron activation analysis
- Prompt gamma analysis
- Delayed neutron analysis
- Neutron imaging
- Production of tracers