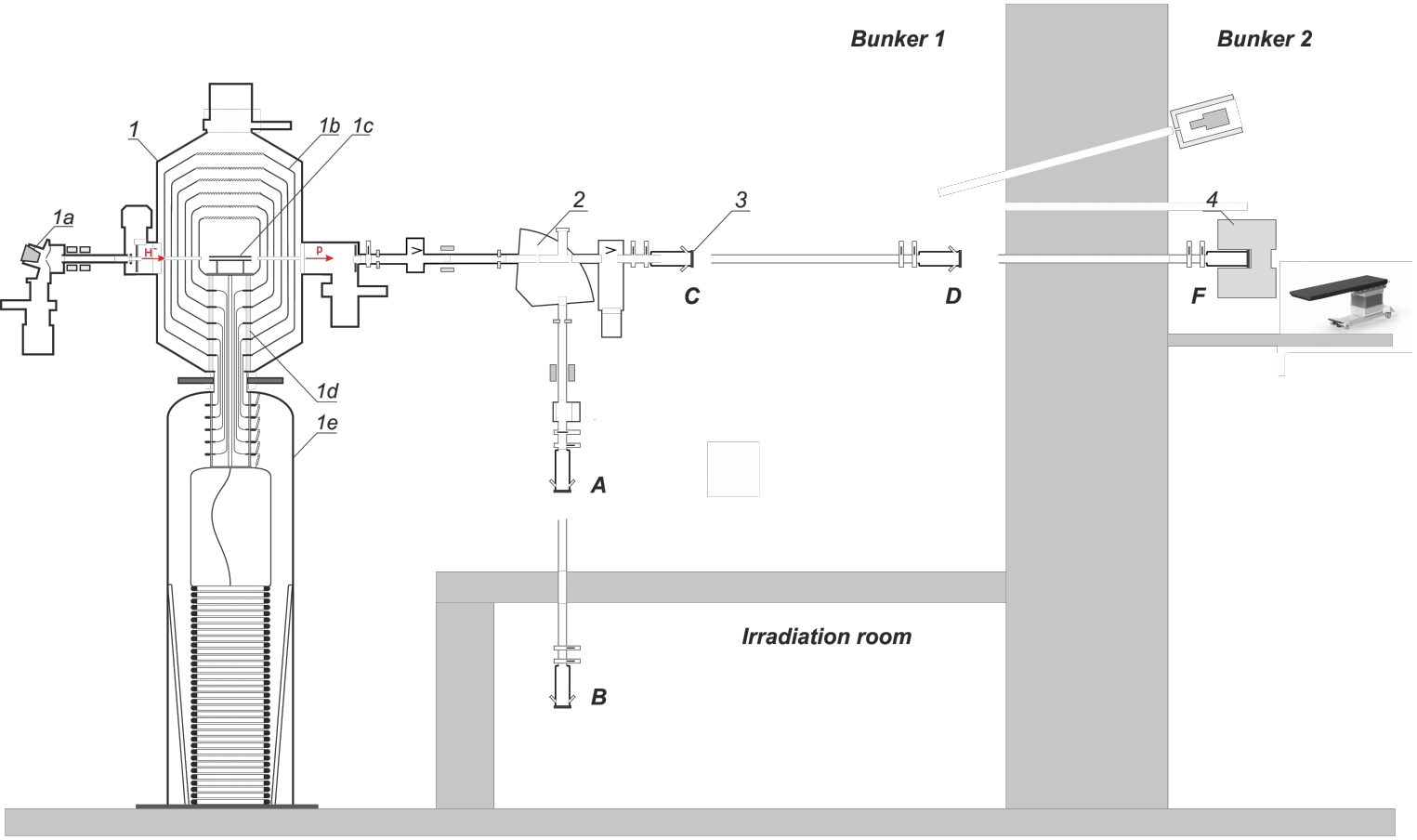
Accelerator based Neutron Source VITA

Sergey TASKAEV Budker Institute of Nuclear Physics, Novosibirsk, Russia
Novosibirsk State University, Novosibirsk, Russia

Sino-Russia meeting on frontiers of neutron scattering (SRNS-2024)
October 8–11, 2024, Ekaterinburg

Accelerator based Neutron Source VITA is hand-made state-of-art device comprising

- Vacuum Insulated Tandem Accelerator (VITA)
- solid lithium target
- beam shaping assemblies
- set of gamma, alpha and neutron spectrometers and detectors



Accelerator based Neutron Source VITA produces:

High power DC proton/deuteron beam (20 kW):
Energy: up to 2.3 MeV
Monochromaticity and stability: 0.1%
Current: up to 10 mA
Current stability: 0.4 %

High flux neutron beam (5 10^{12} s^{-1}):
- ✓ cold (D_2O moderator @ cryo temp.)
- ✓ thermal (D_2O or Plexiglas moderator)
- ✓ epithermal (MgF_2 moderator)
- ✓ exclusively epithermal (no fast and thermal)
- ✓ over-epithermal
- ✓ monoenergetic (kinematic collimation)
- ✓ fast

Bright source of photons – $^{7}Li(p,p'\gamma)^{7}Li$, $^{19}F(p,\alpha e^{+}e^{-})^{16}O$

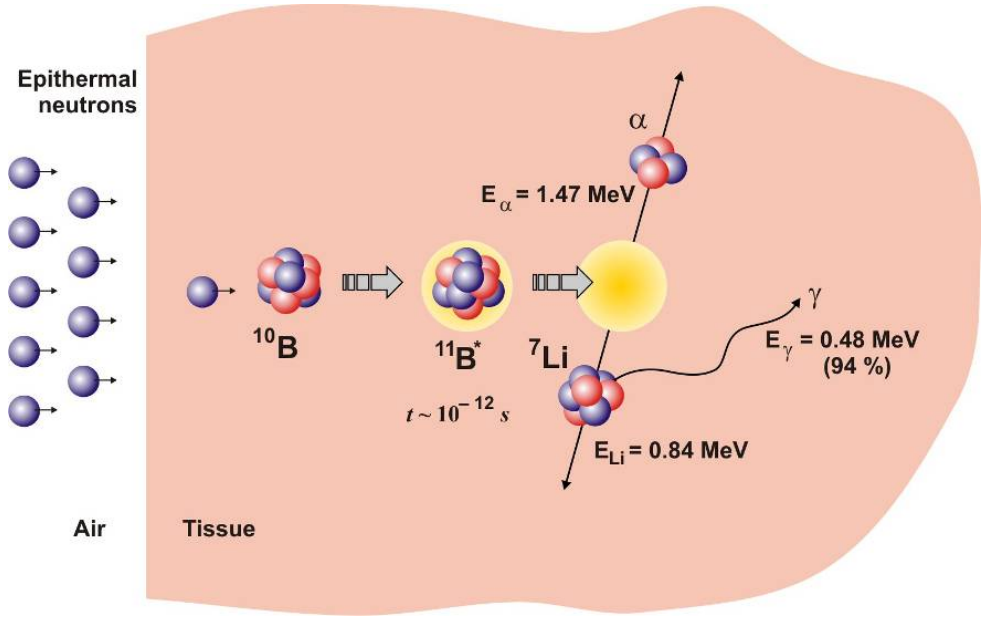
Bright source of α-particles – $^{7}Li(p,\alpha)\alpha$, $^{11}B(p,\alpha)\alpha\alpha$

Bright source of positrons – $^{19}F(p,\alpha e^{+}e^{-})^{16}O$

Bright source of neutrons – up to 10^{4} n/cm^{3} (in future)

Boron Neutron Capture Therapy (BNCT) is a binary form of radiation therapy using the high propensity of a the nonradioactive boron-10 to capture thermal neutrons (3840 b) resulting in the prompt nuclear reaction $^{10}B(n,\alpha)^{7}Li$.

The products of this reaction have high linear energy transfer characteristics, resulting an energy release limited to the diameter of a single cell.



Positive results were obtained in the treatment of the following tumors: malignant glioma, malignant melanoma, head and neck tumors, meningioma, pleural mesothelioma, hepatocellular carcinoma.

Clinical trials of the BNCT technique have begun:

- Japan – since 2020
- China – since 2022 (VITA)
- South Korea – since 2022
- Russia – since 2025 (VITA, in the plans)

Before BNCT
Cancer grew aggressively, rupturing the skin and emerging outside.

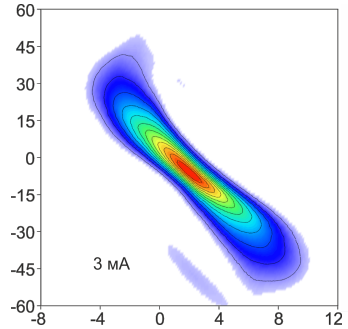
After BNCT
The tumor disappeared almost entirely. High quality of life (QOL) was achieved.

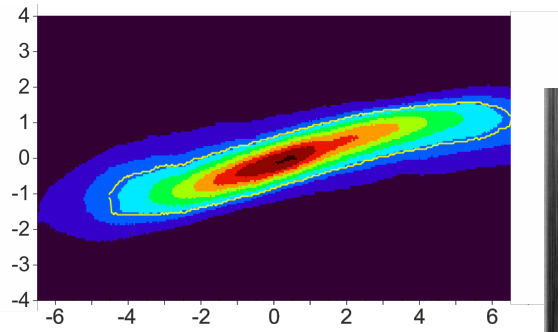
Budker Institute of Nuclear Physics (Russia) proposed and developed Accelerator based Neutron Source VITA as the best solution for BNCT

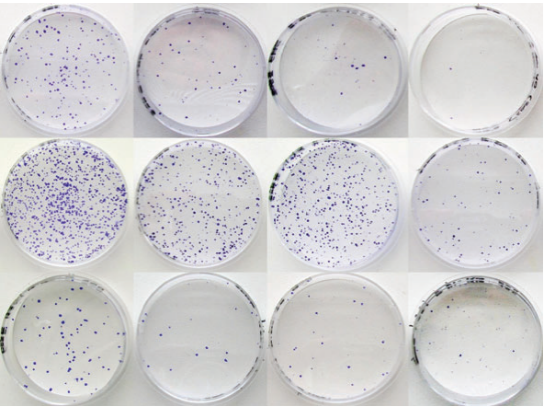
- therapeutic epithermal neutron flux = 10^9 cm^{-2} s^{-1}
- therapy time = 40 min

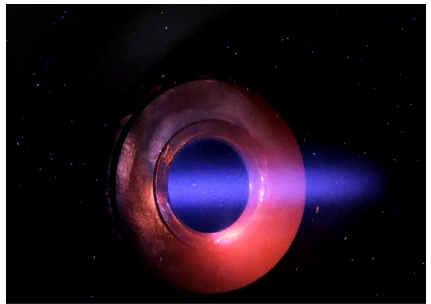
VITA in Novosibirsk (Russia) is used for a decade:

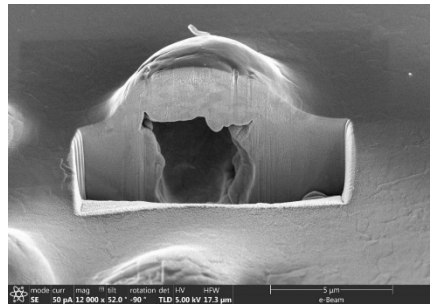
- to develop dosimetry tools and methods,
- to test new boron delivery drugs,
- to treat large domestic animals (cats and dogs),
- to develop lithium neutron capture therapy,
- to test promising materials for ITER and CERN,
- to measure the cross-sections of the nuclear reactions,
- etc.

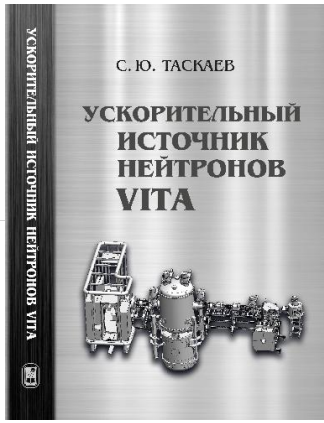










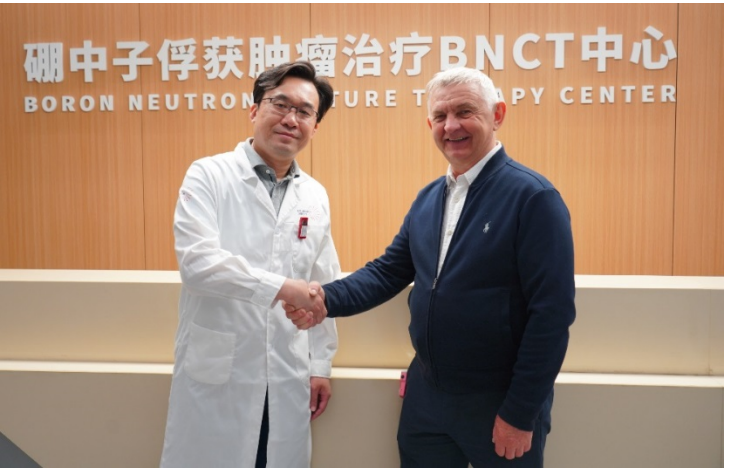


VITA-IIα in Xiamen (China) is used for successfully performed investigator-initiated trial on patients at the Xiamen Humanity Hospital BNCT Center in 2022-2023. In May 22, 2024, the Center began treating patients under the state program (commencement of Phase-I Trial). China has become the second country in the world to introduce a new cancer treatment technique.

VITA-IIβ made for Blokhin National Medical Research Center of Oncology in Moscow and will be put into operation the spring of 2025 to conduct clinical trials in the Russian Federation.

НМИЦ ОНКОЛОГИИ им. Н. Н. Блохина

VITA-IIIα will be made for the Burnazyan Federal Medical Biophysical Center in Moscow.



Thank you!