

EU Scientific Seminar 2023:

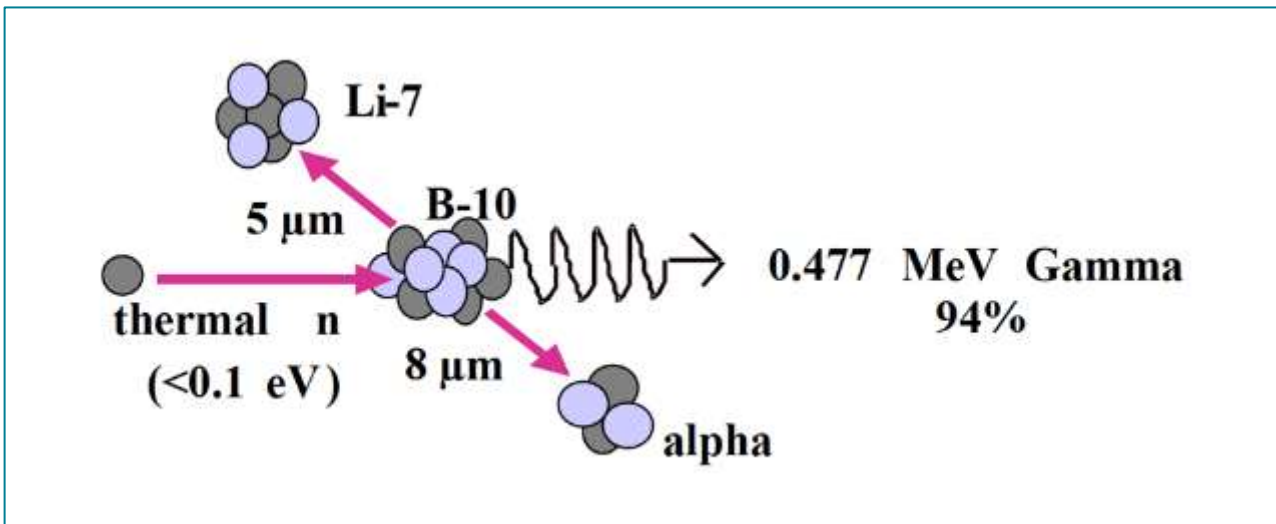
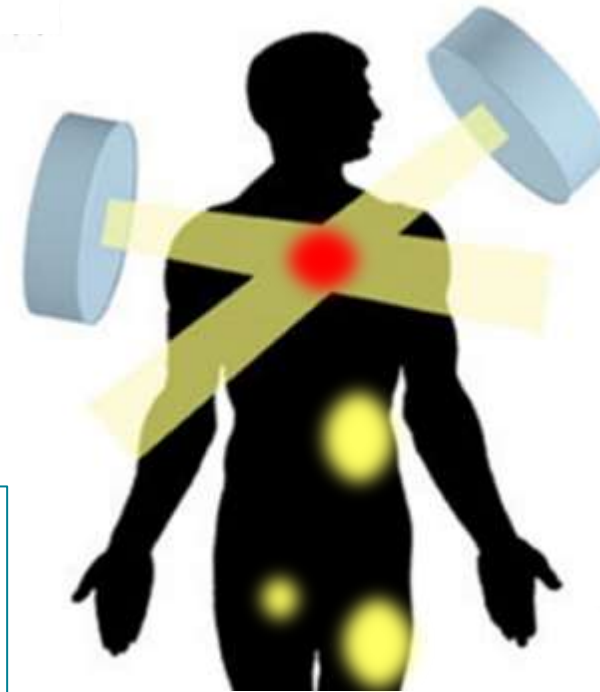
Radiation protection Issues in modern external beam radiotherapy

# ACCELERATOR BASED BORON NEUTRON CAPTURE THERAPY (BNCT)

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# BORON NEUTRON CAPTURE THERAPY

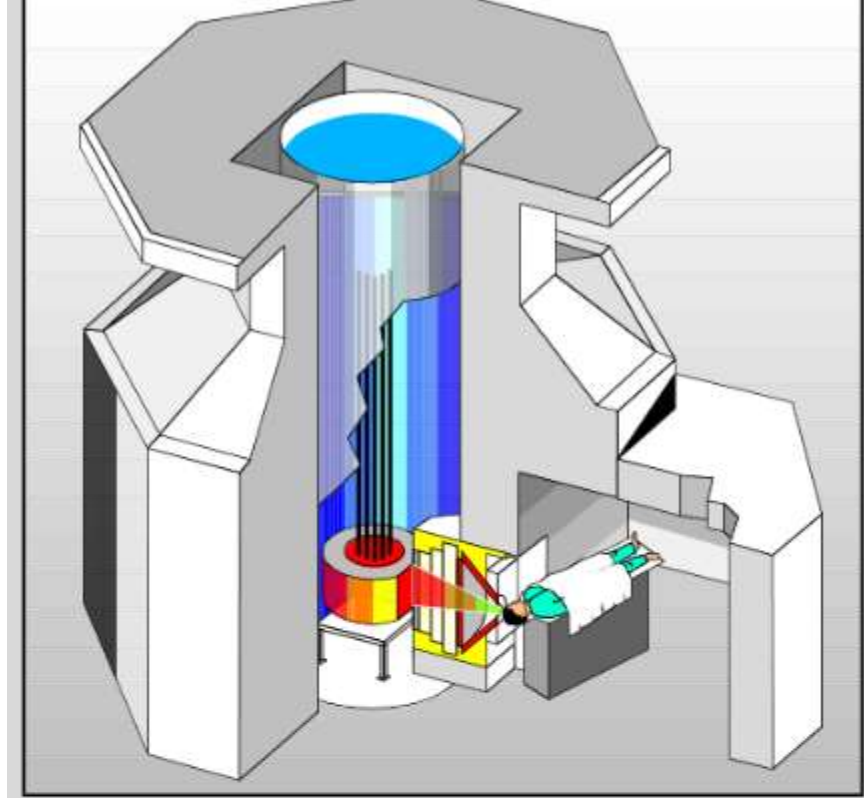
- Boron infusion accumulates in the tumor, but also in other areas of the body
- Tumor area is treated with neutron beam, which activates boron only in the treated area and produces high radiation dose to the target



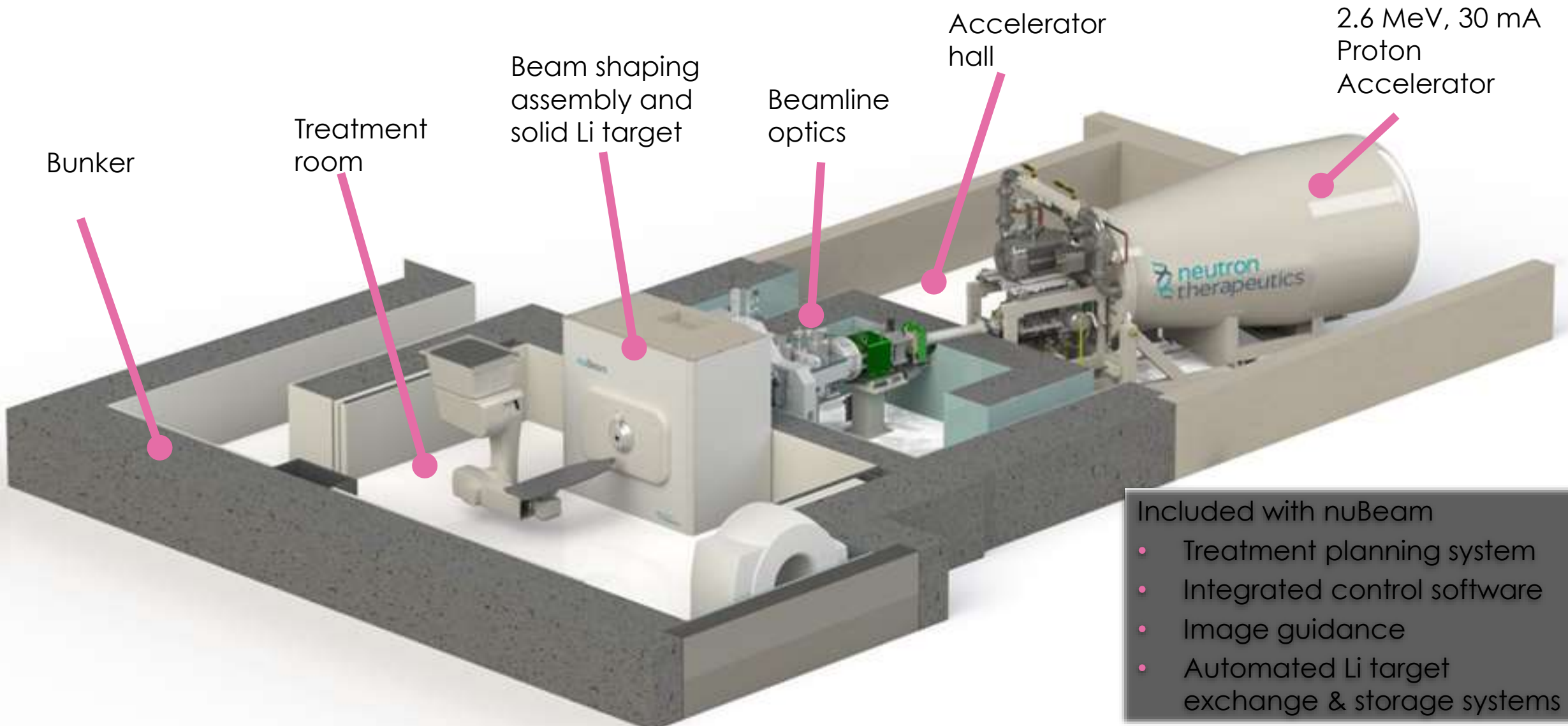
# BNCT IN FINLAND (PAST)

## Research reactor FiR 1

- 250 kW TRIGA Mark II
- Epithermal neutron beam  $>10^9$  n/cm<sup>2</sup>/s
- Closed 2/2012
  
- Patient treatments 1999–2012
- 249 patients >300 treatments
  - 101 patients within clinical trials
  - Patients from Finland, Sweden, Norway, Estonia, Italy, Monaco, Japan and Australia
  - Boron phenylalanine (BPA) as <sup>10</sup>B carrier
  - Brain cancer
  - Head&Neck cancer



# NUBEAM BNCT FACILITY AT HELSINKI UNIVERSITY HOSPITAL



2.6 MeV, 30 mA  
Proton  
Accelerator

Accelerator  
hall

Beamline  
optics

Beam shaping  
assembly and  
solid Li target

Treatment  
room

Bunker

- Included with nuBeam
- Treatment planning system
  - Integrated control software
  - Image guidance
  - Automated Li target exchange & storage systems

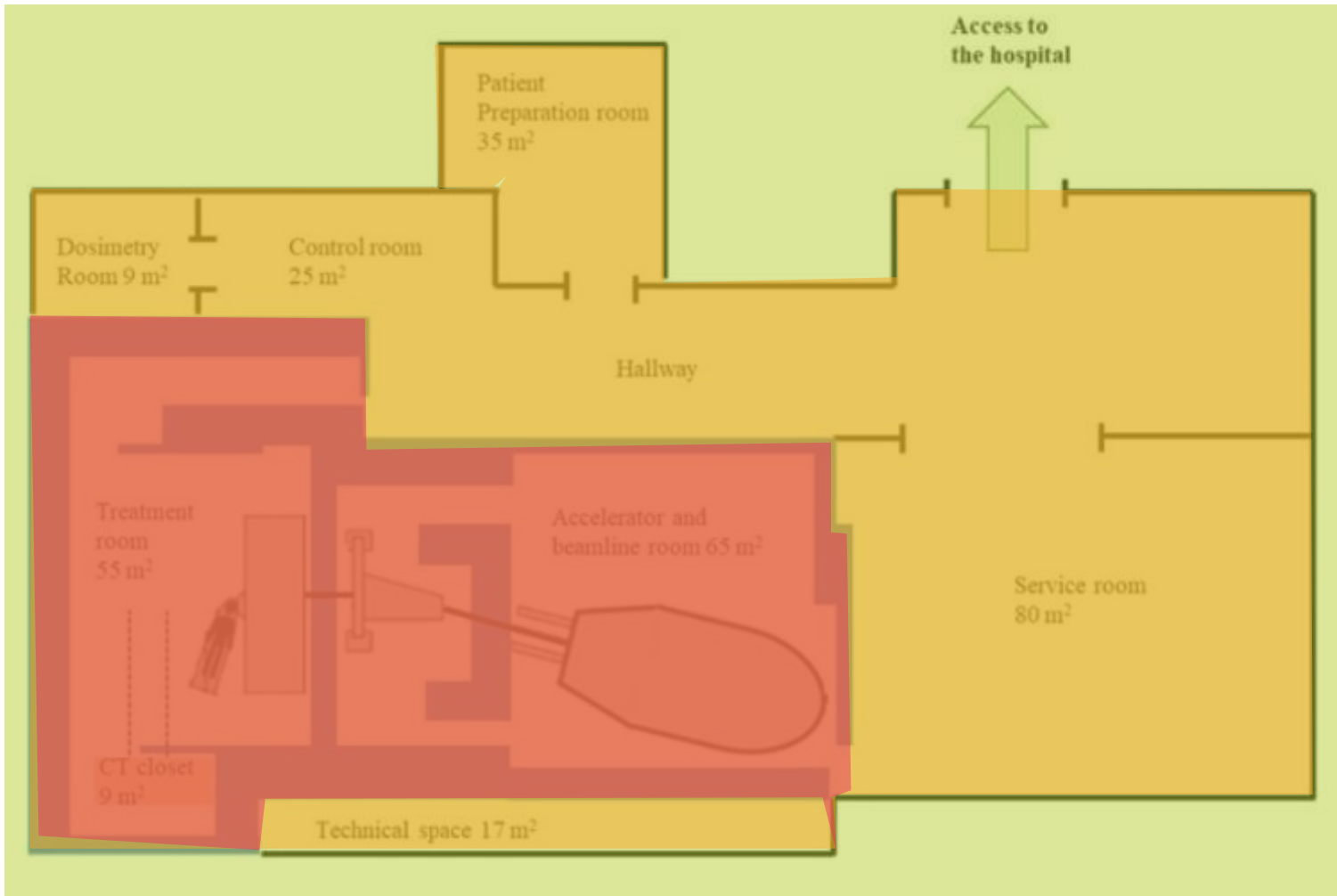
# BNCT TREATMENT ROOM

- Beam shaping assembly and a lead shield
- Robotic couch that allows patient positioning and CT imaging
- In-room sliding gantry CT
- The room is covered with on-activating material





# RADIATION SAFETY



## Area classifications:

**Controlled Radiation Area: > 6 mSv annually**

**Supervised Radiation area: < 6 mSv annually**

**Unclassified Radiation area: < 0.3 mSv annually**

# RADIATION SAFETY

## Neutron field

Activation of materials

- Selected materials in the treatment room
- Boronated or lithiated plastic
  - Slow down and absorb the neutrons
- Electronics behind shielding
  - CT in a closet
- Patient safety
  - Implants, fixation

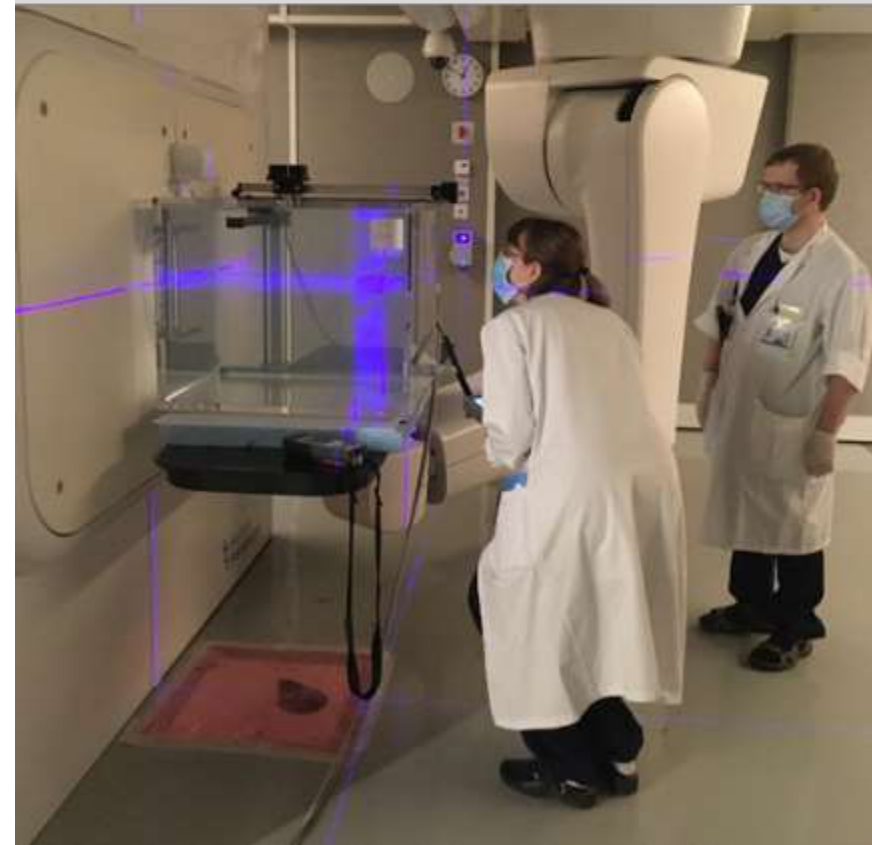
## Gamma field

Beam gamma and residual activation

- Bunker walls: Heavy concrete
- Treatment room residual activity is constantly monitored with a gamma probe
- Red light outside the room indicates when the dose rate is too high
- In practice, people can safely enter in the room a few minutes after the treatment
- A beam shutter shield may be used in front of the collimator

# NEUTRON BEAM DOSIMETRY

- Activation foils / wires
  - Al/Au Al/Mn
  - Spectrum set
- Ionization chambers
  - Tissue equivalent TE(TE)
  - Mg(Ar)
- Phantoms
  - Water phantom
  - PMMA phantom
- Treatment planning system
  - Verification and validation
- Blood boron concentration
  - ICPS-OES







## Monitoring

- Gamma dose probe in the treatment room
- Portable gamma and neutron dosimeters
- Personal dosimeters
  - Active
  - Passive
- Patient monitoring before leaving hospital

# Kiitos!

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 Et al...

