

*INTERNATIONAL SCHOOL
ON HIGH ENERGY PHYSICS, ACCELERATOR TECHNOLOGY
AND NUCLEAR MEDICINE
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**PRODUCTION OF RADIOPHARMACEUTICALS AT
THE INSTITUTE OF NUCLEAR PHYSICS**

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What is nuclear medicine?

Nuclear medicine is a specialized area of radiology that uses very small amounts of radioactive materials, or radiopharmaceuticals, to check organ **function** and structure (for diagnosis) or to treat diseased organs or tissue (for treatment).

Nuclear medicine methods:

1. Radionuclide diagnostics or imaging

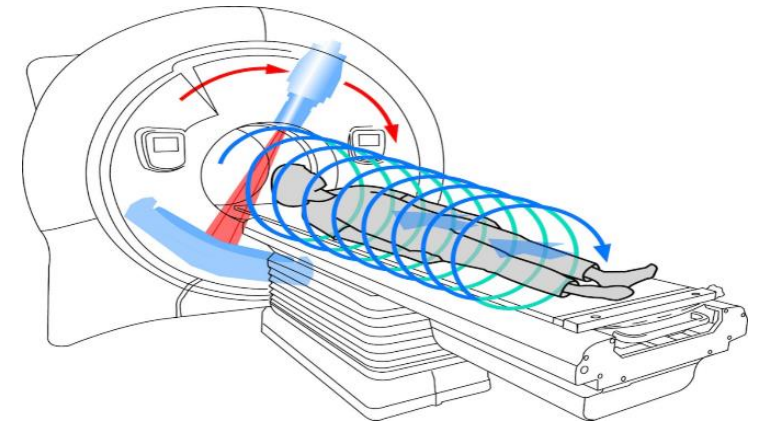
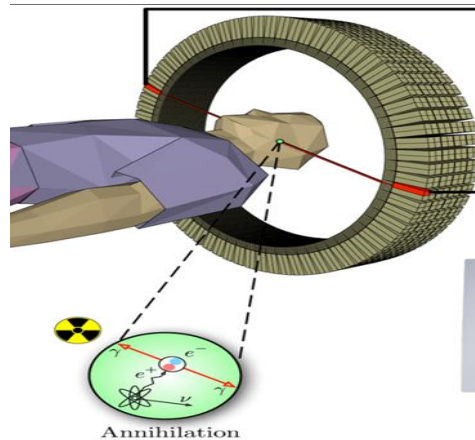
- SPECT, SPECT-CT, SPECT-MRI ^{99m}Tc , ^{123}I , ^{67}Ga , ^{201}Tl ...
- PET, PET-CT, PET-MRI ^{18}F , ^{68}Ga , ^{11}C , ^{64}Cu ...

2. Radionuclide therapy

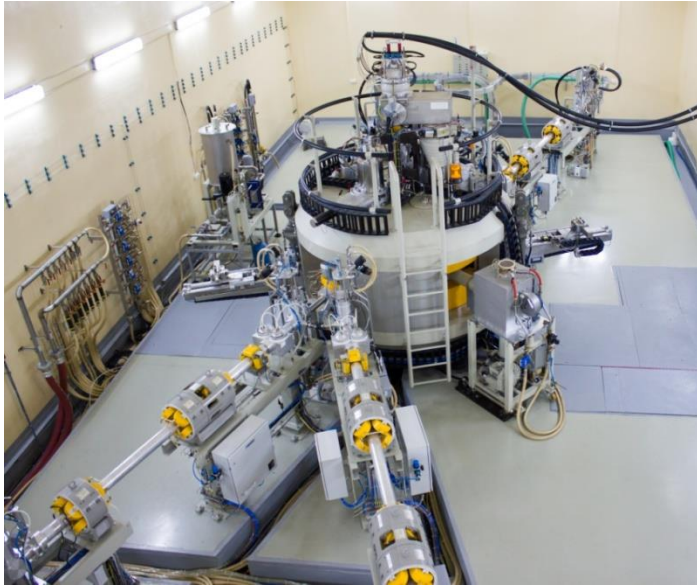
^{131}I , ^{153}Sm , ^{177}Lu , ^{223}Ra , ^{225}Ac ...

3. Theranostic

^{68}Ga -PSMA or ^{18}F -PSMA \rightarrow ^{177}Lu -PSMA or ^{225}Ac -PSMA,
 ^{99m}Tc -PSMA \rightarrow ^{177}Lu -PSMA, ^{64}Cu ...



Isotope production



C-30:

Proton: max. 30 MeV,
3 solid targets, 2 liquid targets

^{18}F , ^{57}Co , ^{109}Cd



WWR-K, 6 MW

Max thermal neutron flux:
 $2.2 \cdot 10^{14} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$

$^{99}\text{Mo}/^{99\text{m}}\text{Tc}$, ^{131}I , ^{153}Sm , ^{177}Lu ,
 ^{192}Ir , ^{60}Co , ^{124}Sb , ^{204}Tl , ^{85}Sr , ^{134}Cs

Radiopharmaceutical production facility

Radiochemical building:

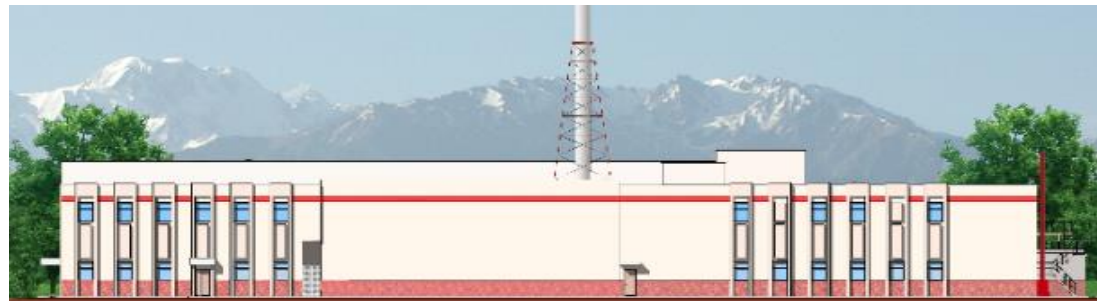
- R&D laboratories
- Hot cells
- Microbiological laboratory, Class A, B, C and D
- Clean rooms, class C and D

} ~800 м²

Radiopharmaceutical building:

- Clean rooms, Class C and D
- Hot cells, Class A, B, C and D
- QC laboratory, Class D

} ~ 730 м²



^{99m}Tc

Sodium pertechnetate ^{99m}Tc , injection from $^{99}\text{Mo}/^{99m}\text{Tc}$ gel-generator

Irradiation: reactor WWR-K, $1 \cdot 10^{14}$, $\text{n} \cdot \text{s}^{-1} \cdot \text{cm}^2$,
 $^{98}\text{Mo} (\text{n } \gamma) ^{99}\text{Mo} (\beta^-) \rightarrow ^{99m}\text{Tc}$,
molybdenum oxide, 15 g., 120 h.

^{99}Mo bulk solution production- alkaline
dissolution

Premises: **class C**

$^{99}\text{Mo}/^{99m}\text{Tc}$ gel-generator

production/assembling: hot cells **class C**

Production: 2 times/month, 18 GBq



^{99m}Tc

“Gel” method concept

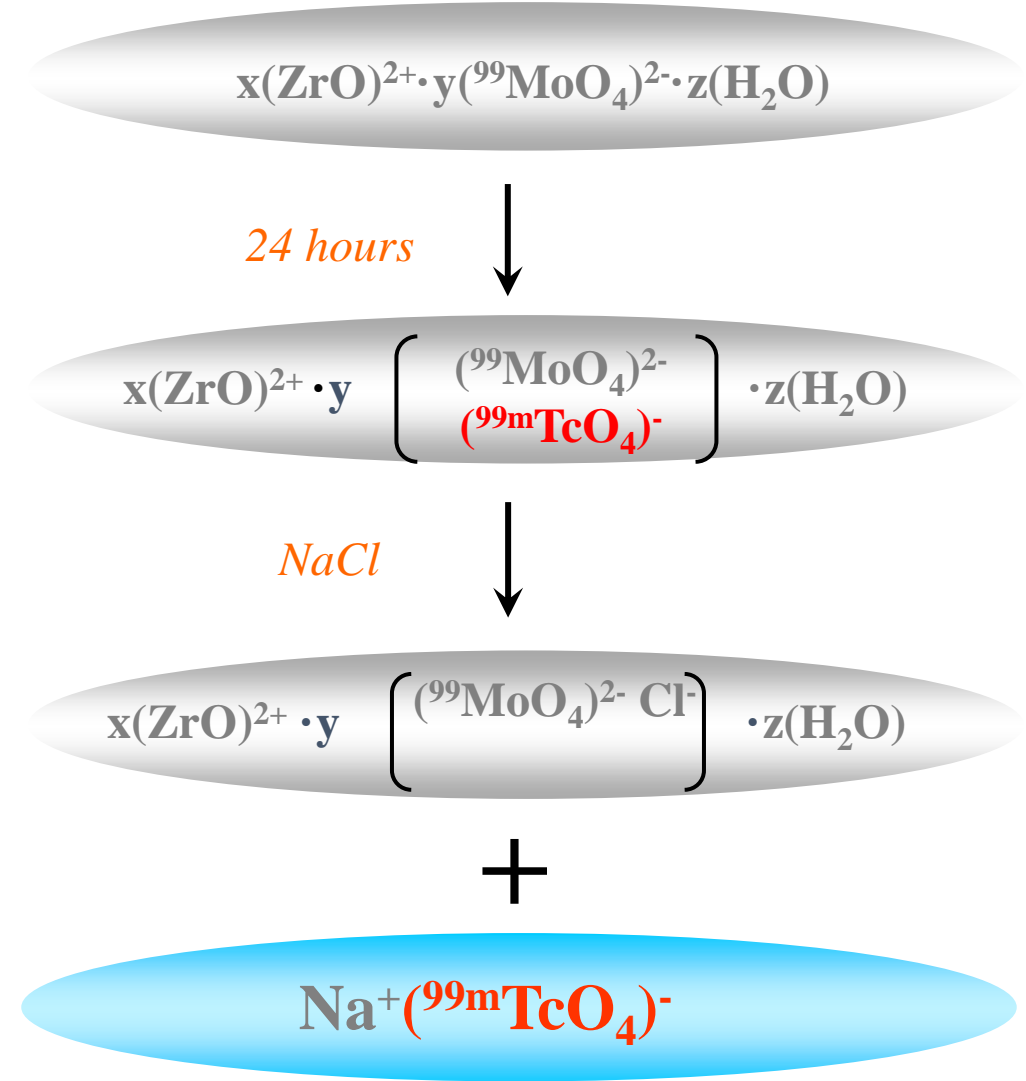
Direct conversion of (n, gamma) ^{99}Mo into insoluble zirconium polymolybdate “gel” that contains 25-40 wt.% of molybdenum.

The gel is a cation exchanger with an open structure which allows free diffusion of pertechnetate anion under simple elution by saline.

Additional Al_2O_3 column is needed to prevent molybdenum break-through

•P.W.Moore, M.E.Shying, J.M.Soeau, J.V.Evans, D.J.Maddalena and K.H.Farrington. Zirconium molybdate gel as a generator for ^{99m}Tc – II. High activity generators//Appl.Radiat.Isot. – 1987. – Vol.38, № 1. – P.25-29.

•R.E.Boyd. The gel generator: a viable alternative source of ^{99m}Tc for nuclear medicine//Appl.Radiat.Isot. – 1997. – Vol.48, № 2.



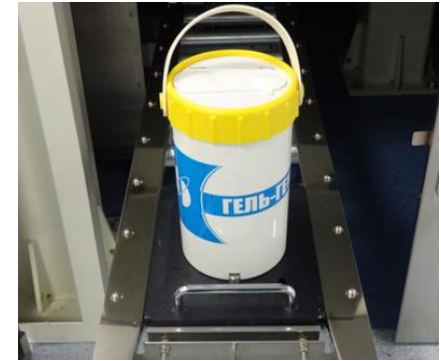
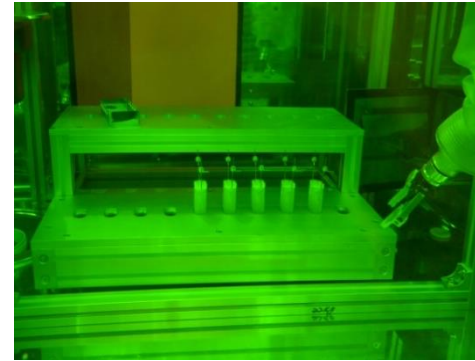
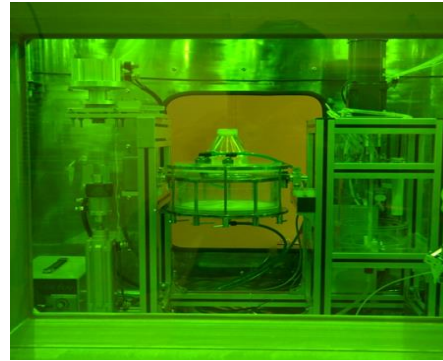
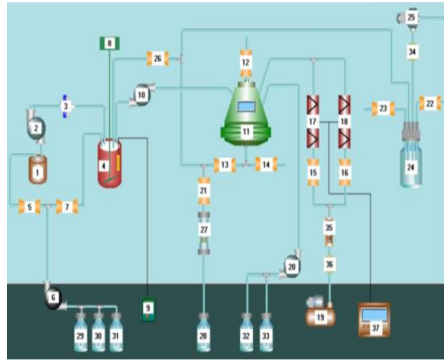
^{99m}Tc

Production of $^{99}\text{Mo}/^{99m}\text{Tc}$ gel generators

Premises – **class C**

Hot cell 1- for synthesis of ^{99}Mo -Zr gel and filling of generator's columns - **class C**

Hot cell 2 - for steam sterilization of cartridges and assembling of generators - **class C**



Design and production of hot cell equipment for ^{99}Mo -Zr gel preparation, Pat. 27786 RK

Design of $^{99}\text{Mo}/^{99m}\text{Tc}$ gel generator, Pat. 28157 RK

131I

Sodium iodide ^{131}I for therapy

Irradiation: reactor WWR-K, $1 \cdot 10^{14}$, $\text{n} \cdot \text{s}^{-1} \cdot \text{cm}^2$,

$^{130}\text{Te} (\text{n } \gamma) ^{131}\text{Te} (\beta^-) \rightarrow ^{131}\text{I}$,

tellurium oxide, 20 g., 72-120 h.

^{131}I bulk solution production: reactor
radiochemical hot cells, dry distillation
process, 700°C

Premises: **class D**

Production/dispensing/sterilization: hot cells
class C



^{18}F

Fluorodeoxyglucose ^{18}F injection

Irradiation: cyclotron C-30, 18 MeV, $^{18}\text{O}(\text{p},\text{n})^{18}\text{F}$

2 ml enriched water, 2- 3 h.

Syntheses modules: Synthera, Neptis, dispensing -
Thymotheo LT

Premises: **class C**

Production: hot cells **class C**

Dispensing/membrane sterilization: hot cells **class A**

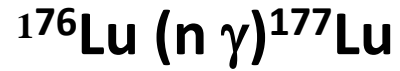
Production: 3 times/day

Transportation: 1- 7 h



^{177}Lu

Lutetium chloride ^{177}Lu , solution for labeling



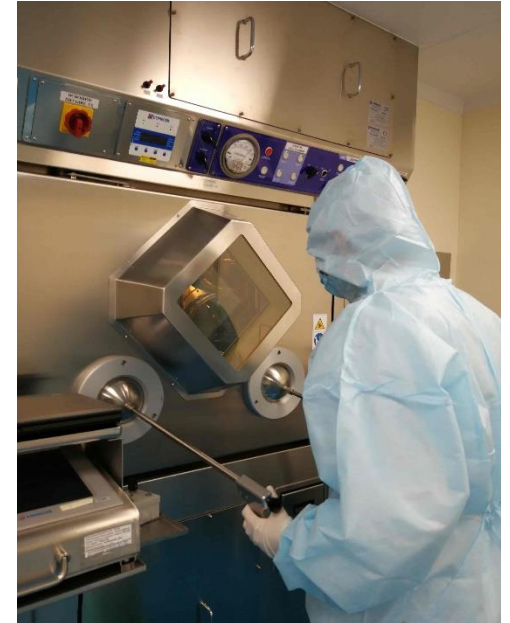
Irradiation: reactor WWR-K, $1 \cdot 10^{14}$, $\text{n} \cdot \text{s}^{-1} \cdot \text{cm}^2$, 18 days

Lutetium oxide, 20 mg

Premises: **class D**

Production/dispensing/
sterilization: hot cells

class C



Status of Nuclear Medicine in Kazakhstan

9 working Centers of Nuclear Medicine

3 Centers of Nuclear Medicine is in process of building

Radiopharmaceuticals:

- $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ gel generator, from 2001
- “Sodium iodide ^{131}I , oral solution” for therapy, from 2002
- “Fludeoxyglukose ^{18}F , injection”, from 2021



INP fully covers local demand in radiopharmaceuticals with $^{99\text{m}}\text{Tc}$ and ^{131}I and 70% of local demand in radiopharmaceuticals with ^{18}F