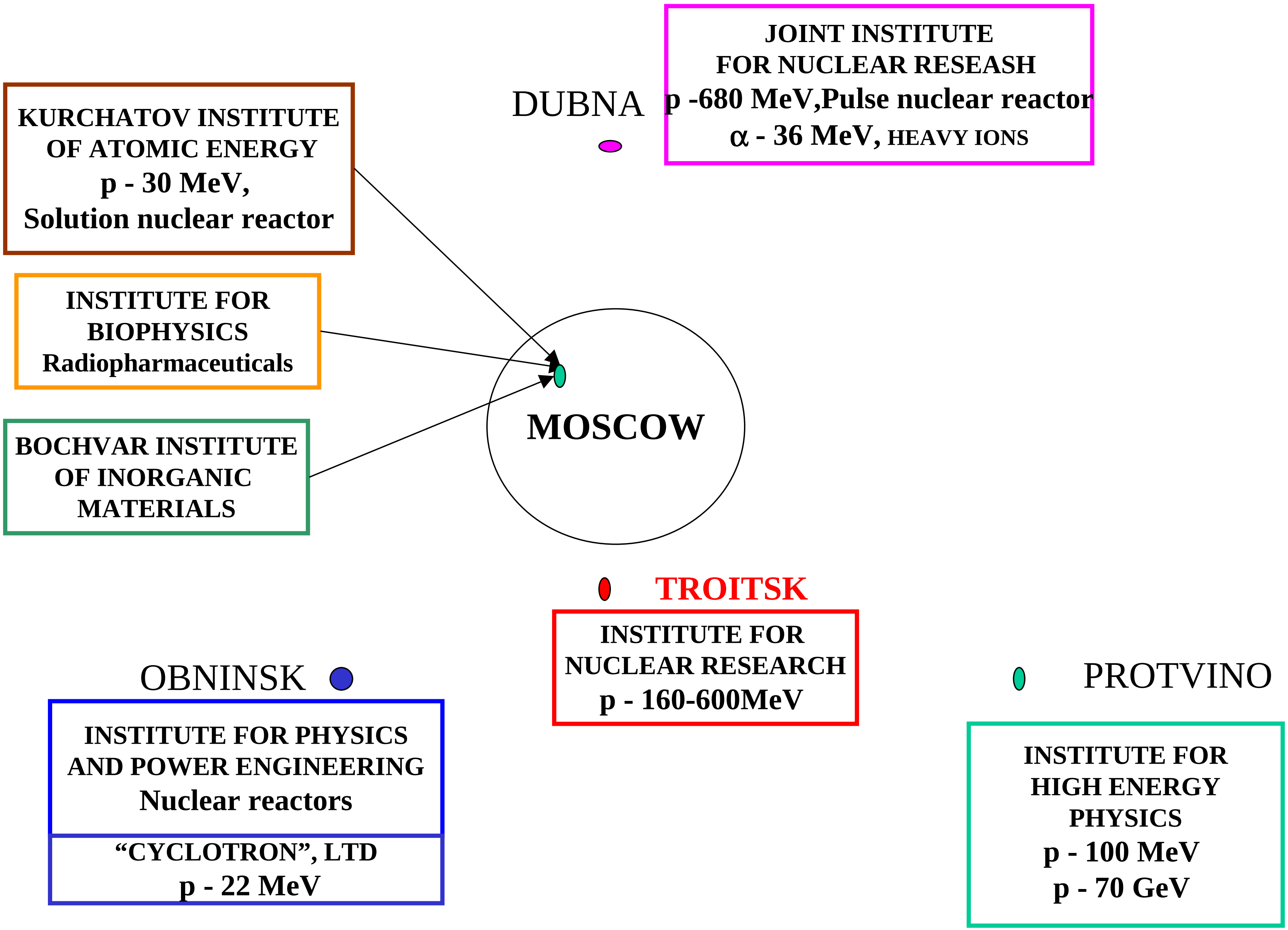
B.L.ZHUIKOV

Radioisotope Investigation and Production at the Institute for Nuclear Research, Moscow - Troitsk

- 1. INR’s main facilities.
- 2. INR radioisotope production facility.
- 3. Targetry investigations.
- 4. Radioisotope production for biomedical application.
- 5. Cross-section study for investigation of nuclear reaction mechanism.


JOINT INSTITUTE
FOR NUCLEAR RESEASH
p -680 MeV,Pulse nuclear reactor
α - 36 MeV, HEAVY IONS
DUBNA
KURCHATOV INSTITUTE
OF ATOMIC ENERGY
p - 30 MeV,
Solution nuclear reactor
INSTITUTE FOR
BIOPHYSICS
Radiopharmaceuticals
BOCHVAR INSTITUTE
OF INORGANIC
MATERIALS
MOSCOW
TROITSK
INSTITUTE FOR
NUCLEAR RESEARCH
p - 160-600MeV
OBNINSK
INSTITUTE FOR PHYSICS
AND POWER ENGINEERING
Nuclear reactors
“CYCLOTRON”, LTD
p - 22 MeV
PROTVINO
INSTITUTE FOR
HIGH ENERGY
PHYSICS
p - 100 MeV
p - 70 GeV

INR’S MAIN FACILITIES:

1. **Moscow Meson Factory with neutron source and isotope production facility**:

   High current linear proton accelerator H^+ and H^-, up to 600 MeV, beam current up to 0,5 mA.

2. **Baksan Neutrino Observatory:**

   60 tons of metallic gallium under 3500 m mountain rock for solar neutrino detection.

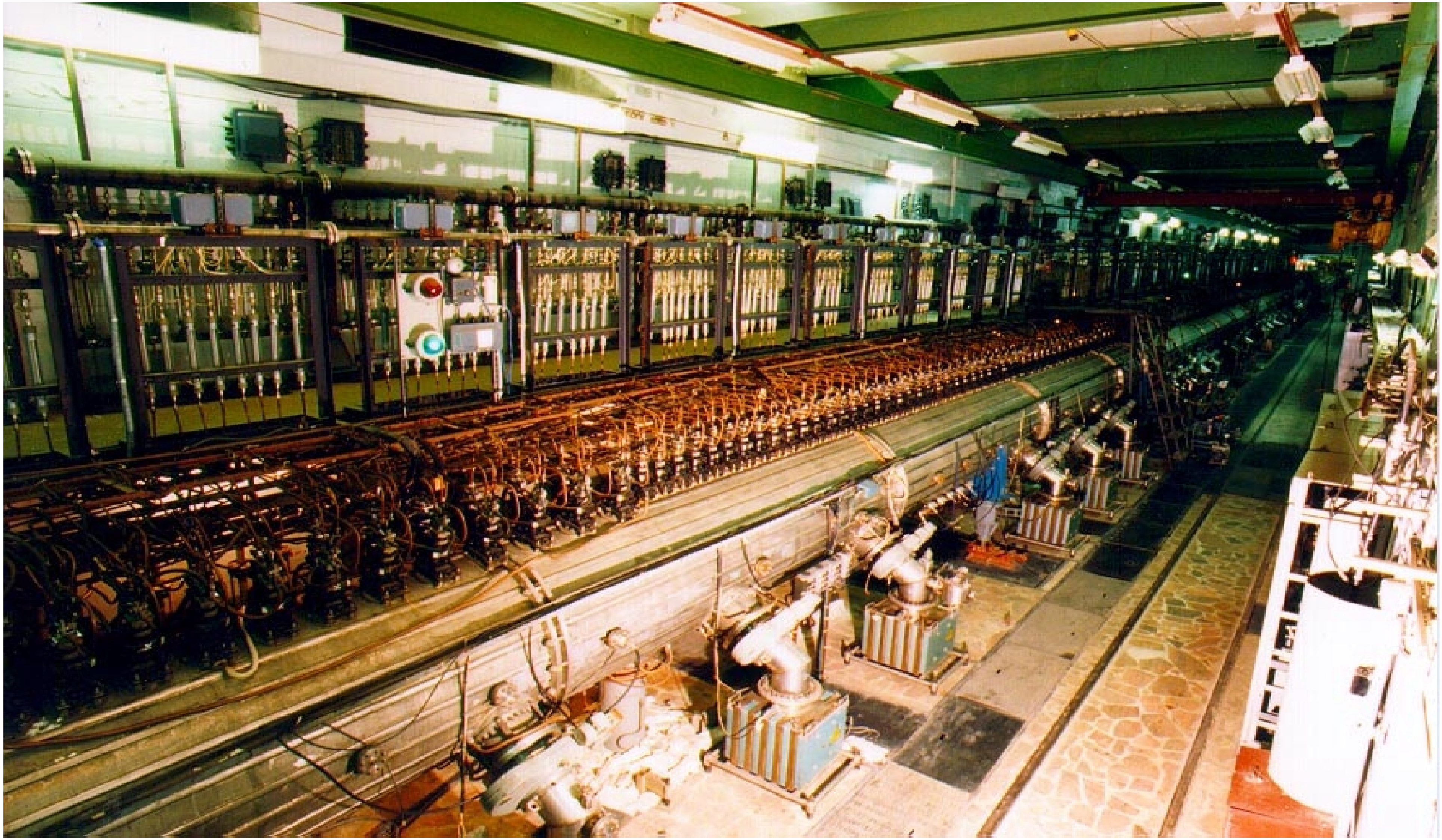
3. **Baikal Deep Underwater Neutrino Telescope:**

   Cherenkov’s water detector of neutrino and high-energy muons in cosmic rays at a depth of 1200m.

4. **Troitsk Neutrino Mass Setup:**

   Electron neutrino mass measurements via tritium beta-decay (best world’s result <2,3 eV/sec^2)

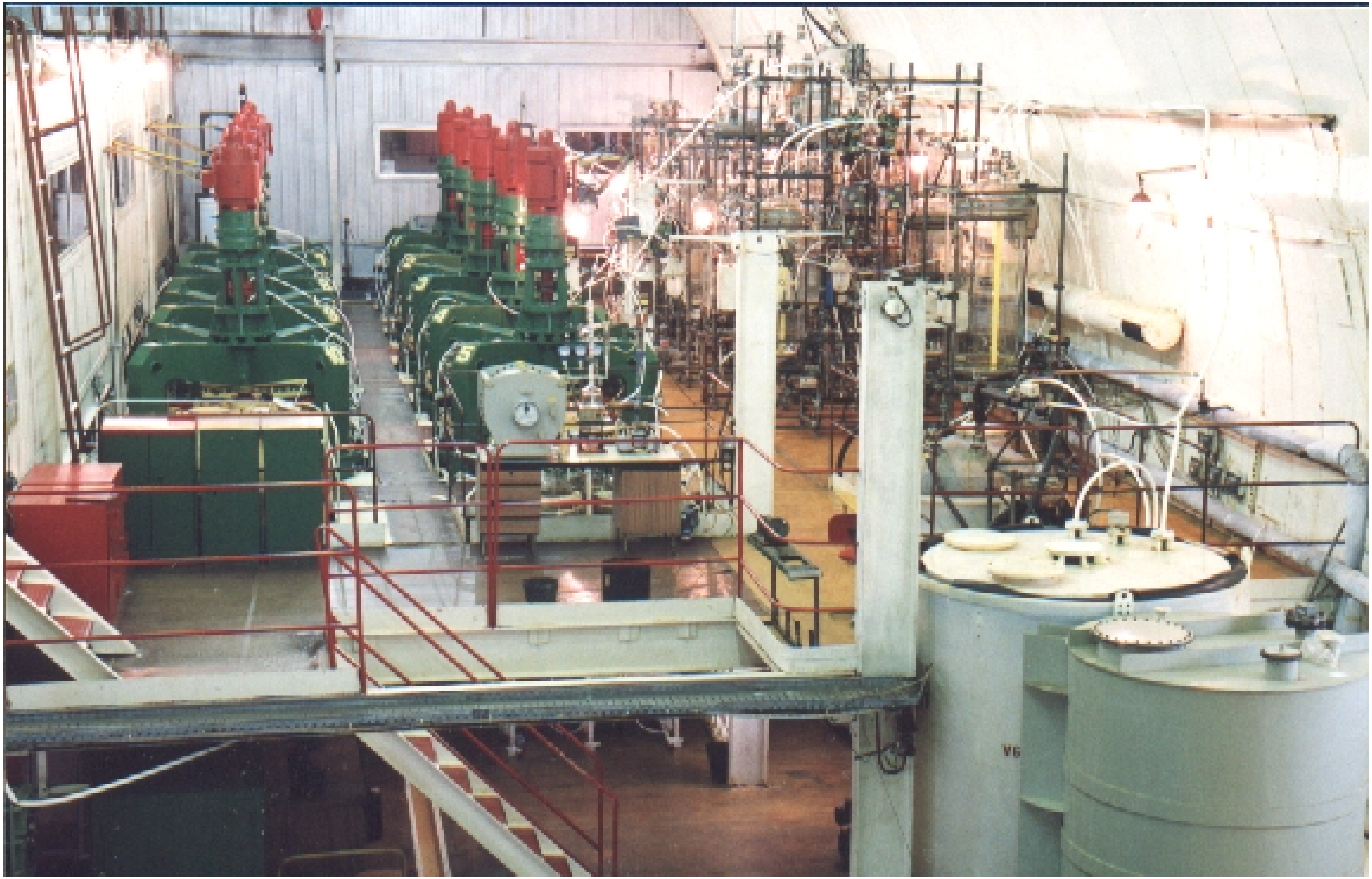
INR Linear Proton Accelerator Troitsk, Moscow Region



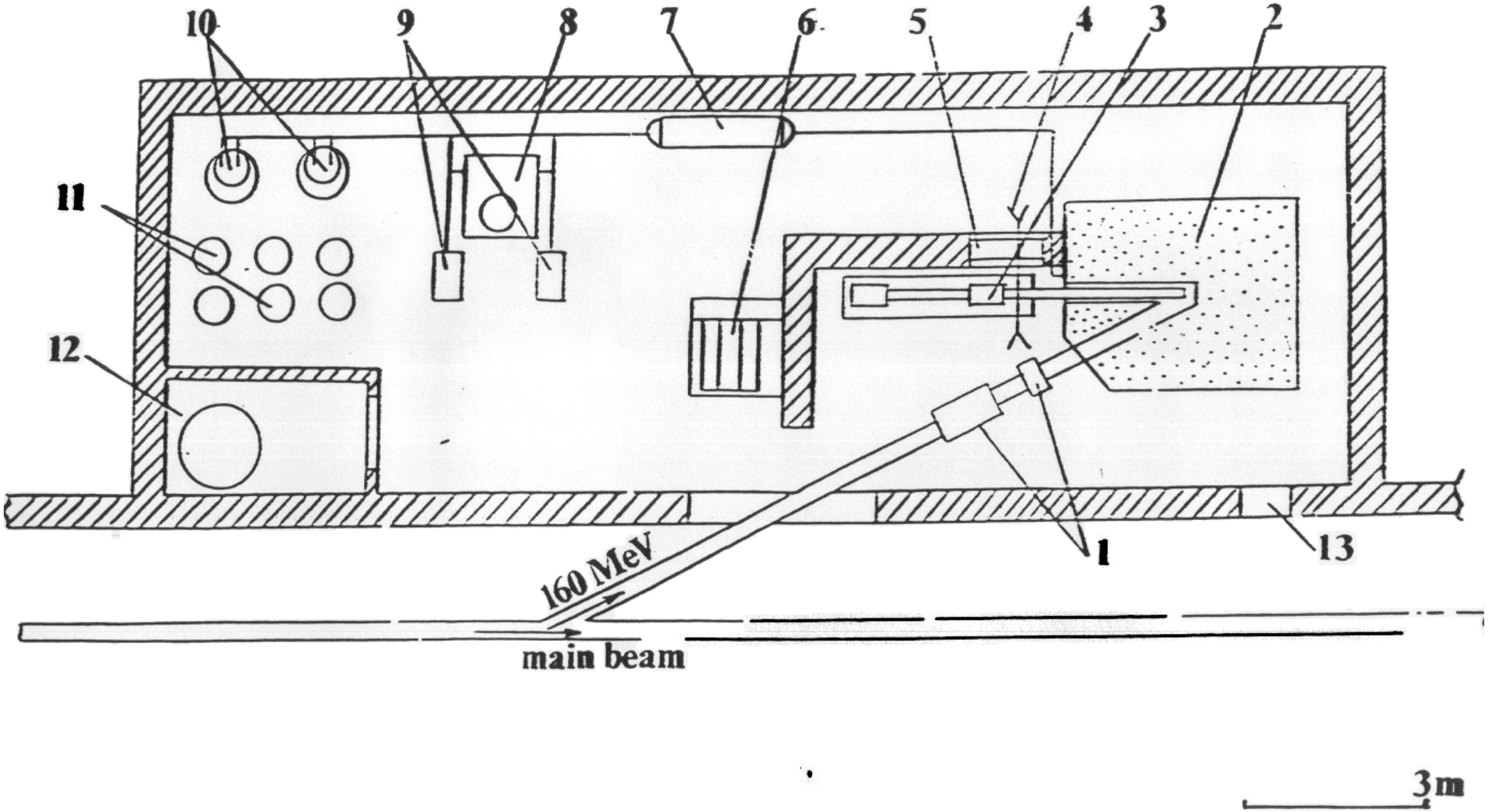
Neutron Source

Baksan Neutrino Observatory

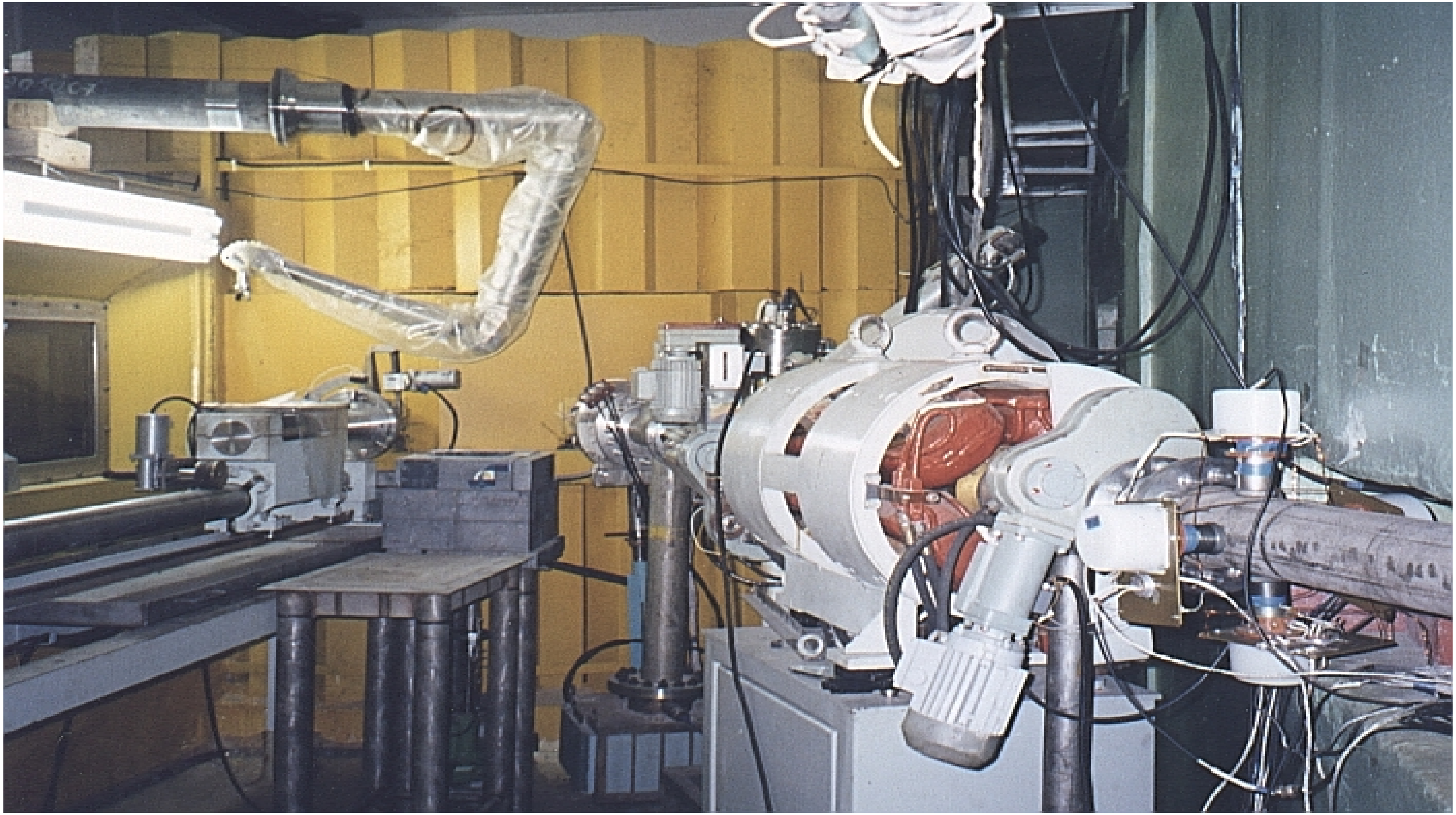
Baksan Underground Facility



Floor Plan of INR
Isotope Production Facility



INR Irradiation Facility

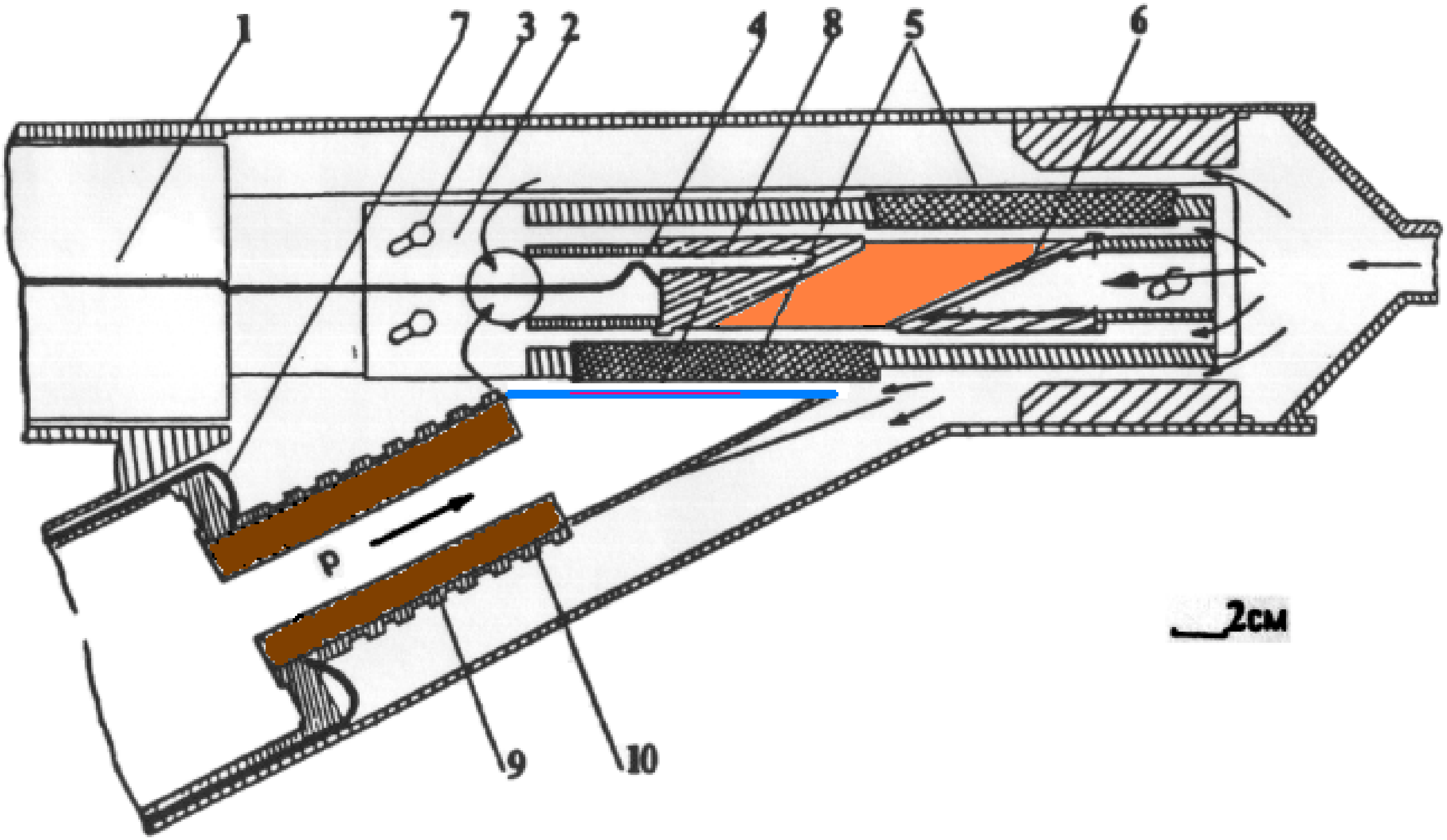


BEAM PARAMETERS AT ISOTOPE PRODUCTION FACILITY

- Proton beam energy at Irradiation Facility: 158 MeV
- Maximum Average Current: 140 microamps
- Pulsed beam:
  - Peak beam current 24 mA
  - 50 Hz
  - 120 microsecond pulse width

TARGET IRRADIATION CELL

WITH GRAPHITE COLLIMATORS AND LITHIUM BEAM WINDOW



Target composition for irradiation at 160 MeV

Silver or aluminum target (145-110 MeV): Pd-103, Na-22

Rubidium target (100-40 MeV): Sr-82

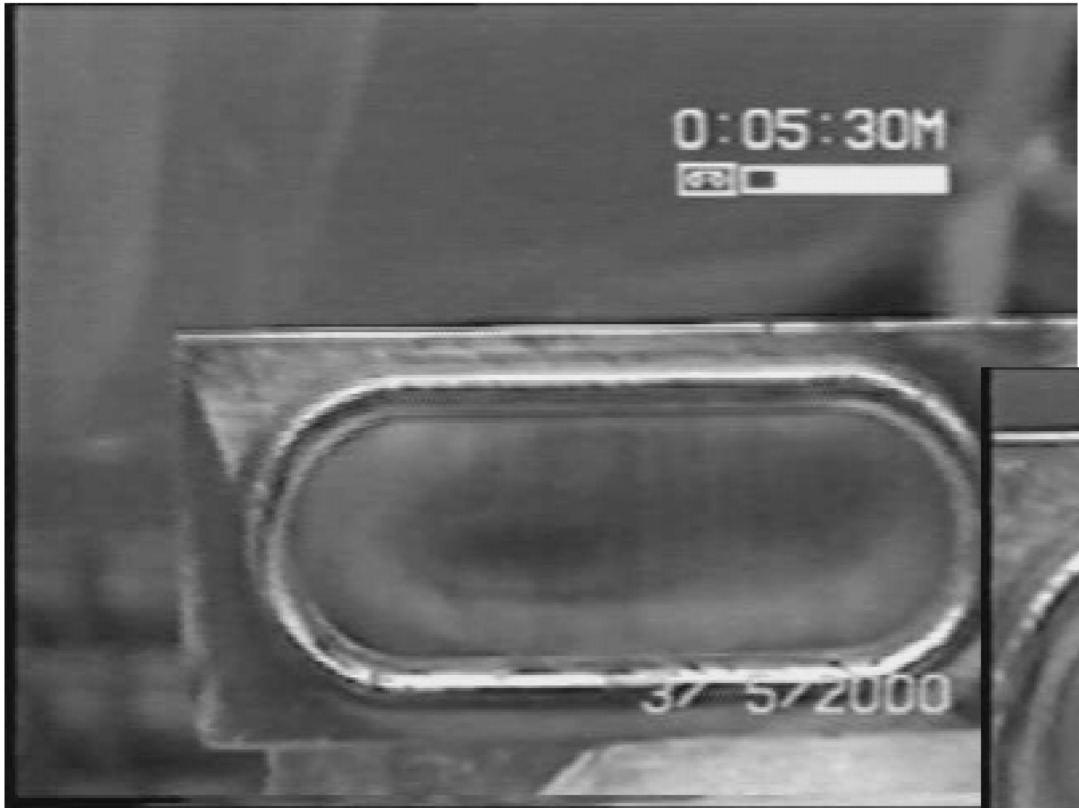
Gallium target (30-10 MeV): Ge-68

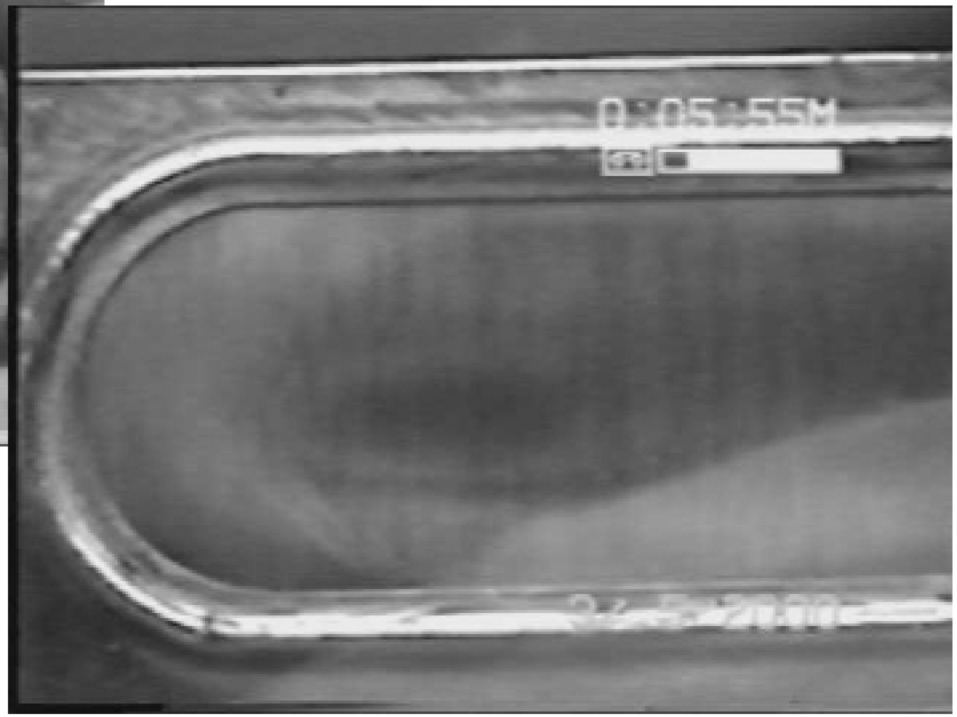
Aluminum Target Destroyed by Proton Beam 120 μA, 8000 μA.hr


27/10/2000

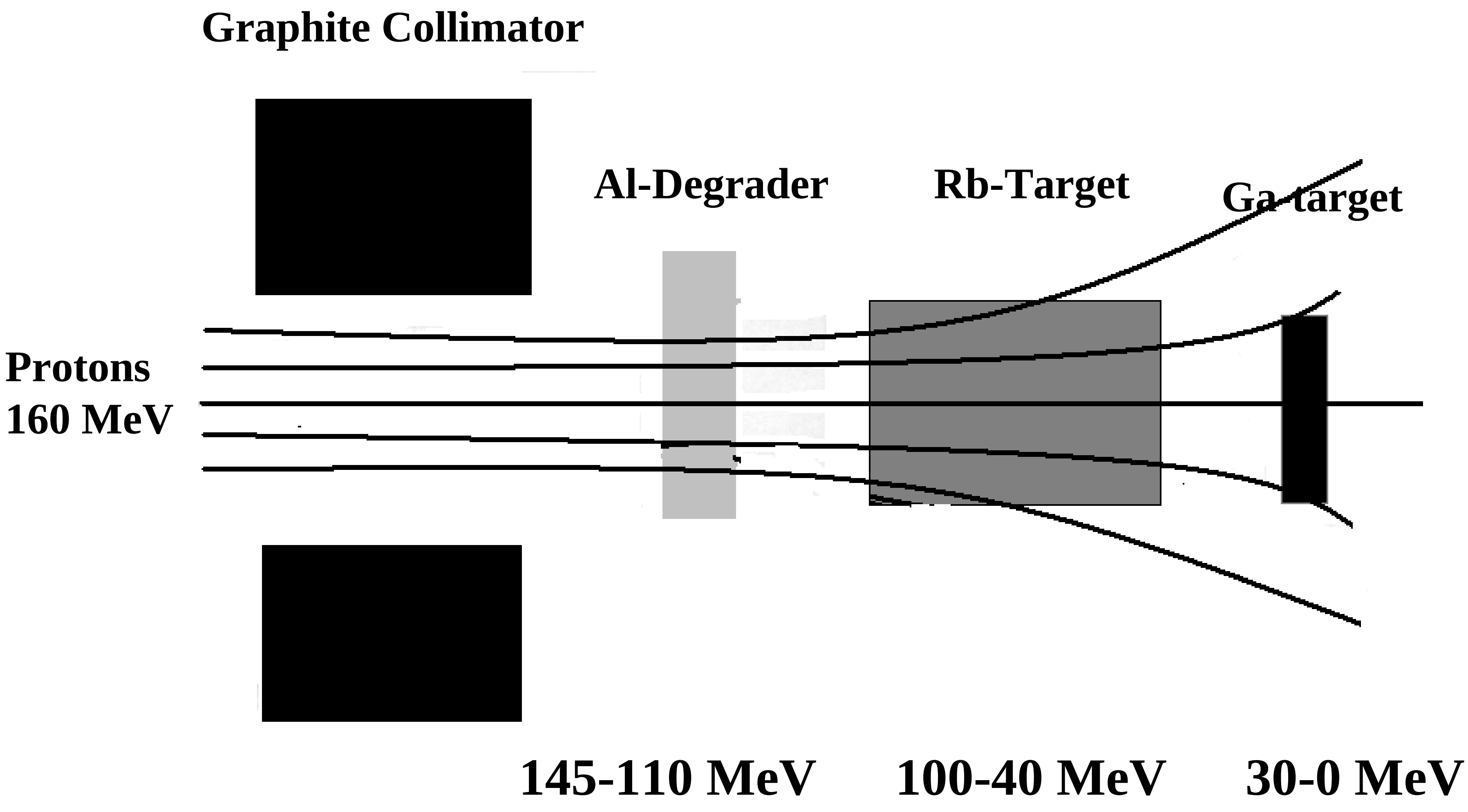
Molybdenum Target Destroyed by Proton Beam

Rubidium Target Irradiated by Intensive Proton Beam





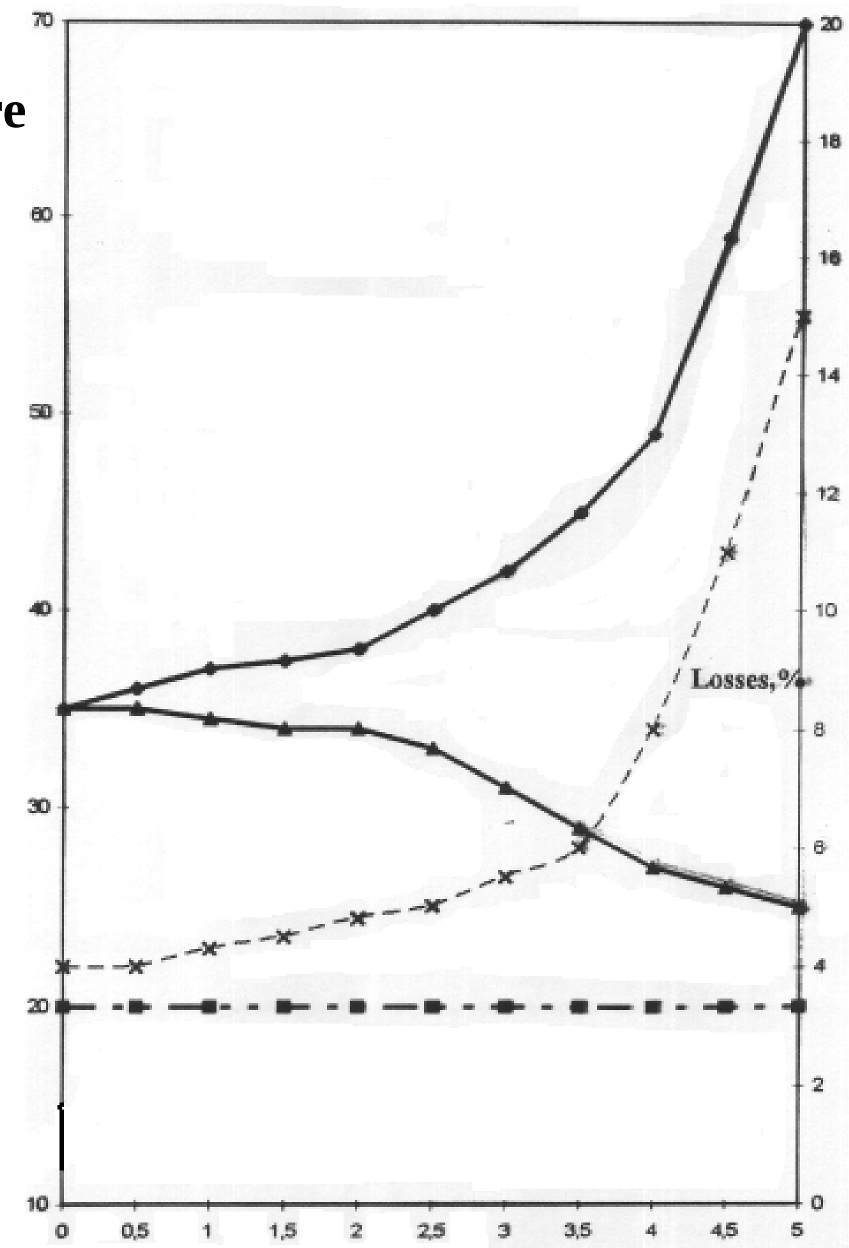
Beam Angle Scattering on Targets



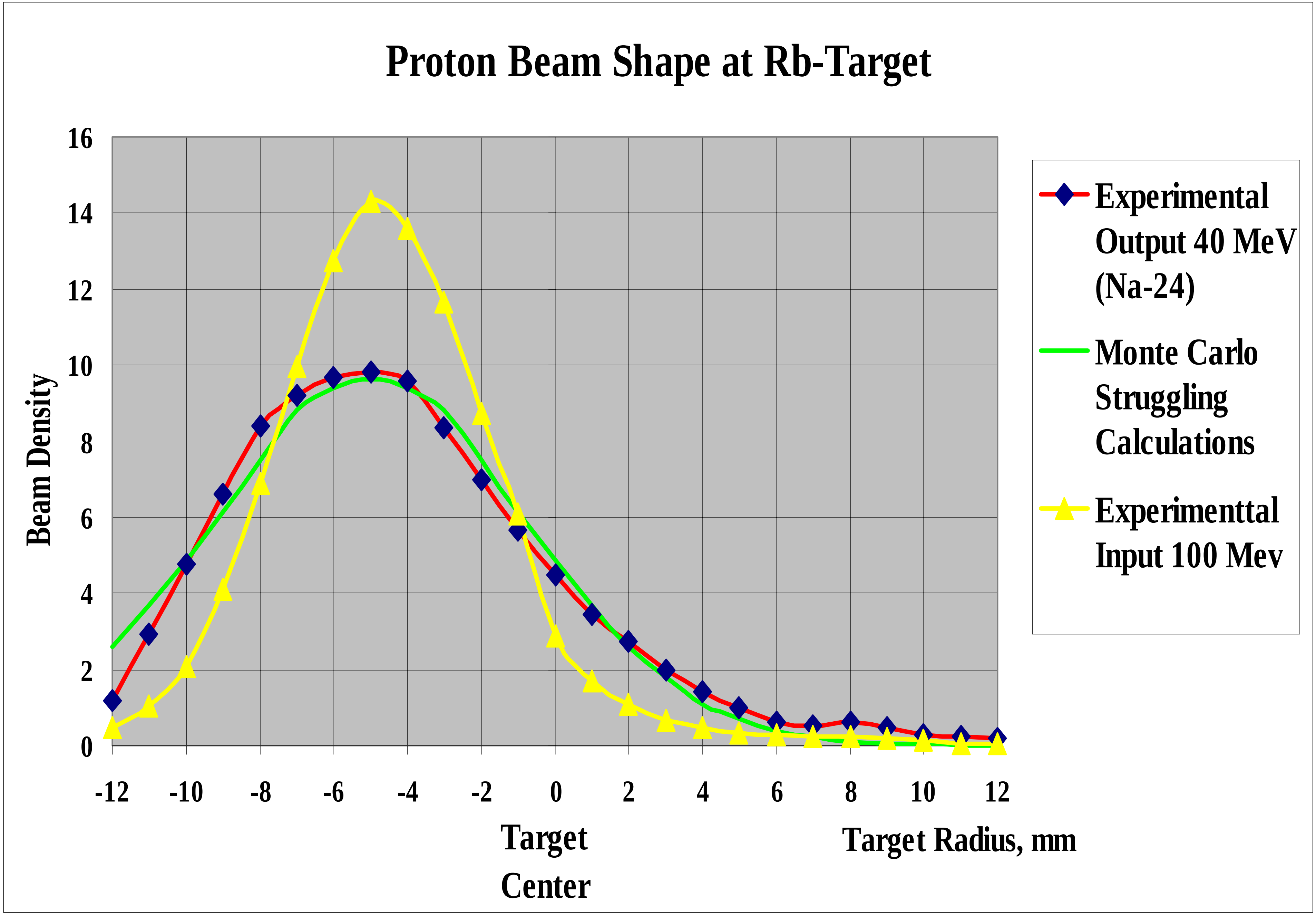
Temperature on Graphite Collimators and Beam Losses

Collimator temperature

Beam losses, %



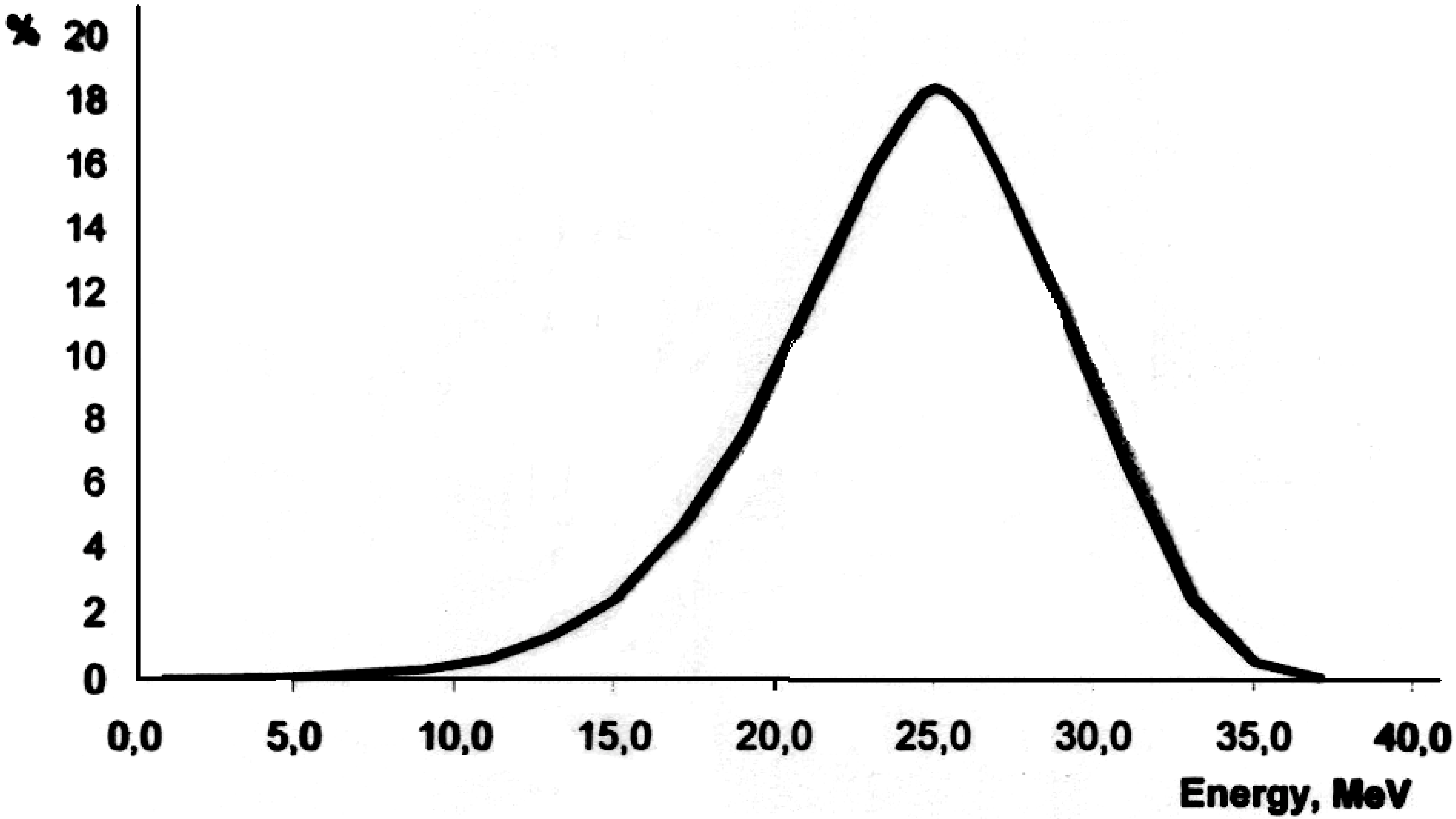
Beam shift, mm



Proton Beam Shape at Rb-Target
Beam Density
16
14
12
10
8
6
4
2
0
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Target Center
Target Radius, mm
Experimental Output 40 MeV (Na-24)
Monte Carlo Struggling Calculations
Experimenttal Input 100 Mev

Energy Scattering on Ga-Target

Initial monochromatic beam 160 MeV



Production Possibility at Radioisotope Facility of Institute for Nuclear Research (Troitsk) at 160 MeV Proton Beam (120 μA)

Radio-nuclide	Half life Period	Target	Energy Range, *MeV*	Bombardment period, *hr*	Activity produced in one run at EOB, *Ci*
Sr-82 *	25.3 d	Rb	100-40	250	8
Na-22	2.6 y	Mg, Al	150-35	250	2
Cd-109	453 d	In	150-60	250	2
Pd-103	17 d	Ag	150-50	250	70
Ge-68*	288 d	Ga, GaNi	50-13	250	0.5
Se-72	8.5 d	GaAs	60-45	250	3
Co-57	271 d	Ni	28-15	250	1
Ti-44	47.3 y	Sc	60-20	250	0.01
I-123	13 hr	NaI	80-50	2	0.2
I-121*	2 hr	NaI	90-50	2	0.2
Tl-201	73 hr	Pb	60-52	25	2
Cu-67	62 hr	Zn-68	150-70	100	10
Sn-117m	13.6 d	Sb X	150-40	250	

* Isotopes used in Positron Emission Tomography

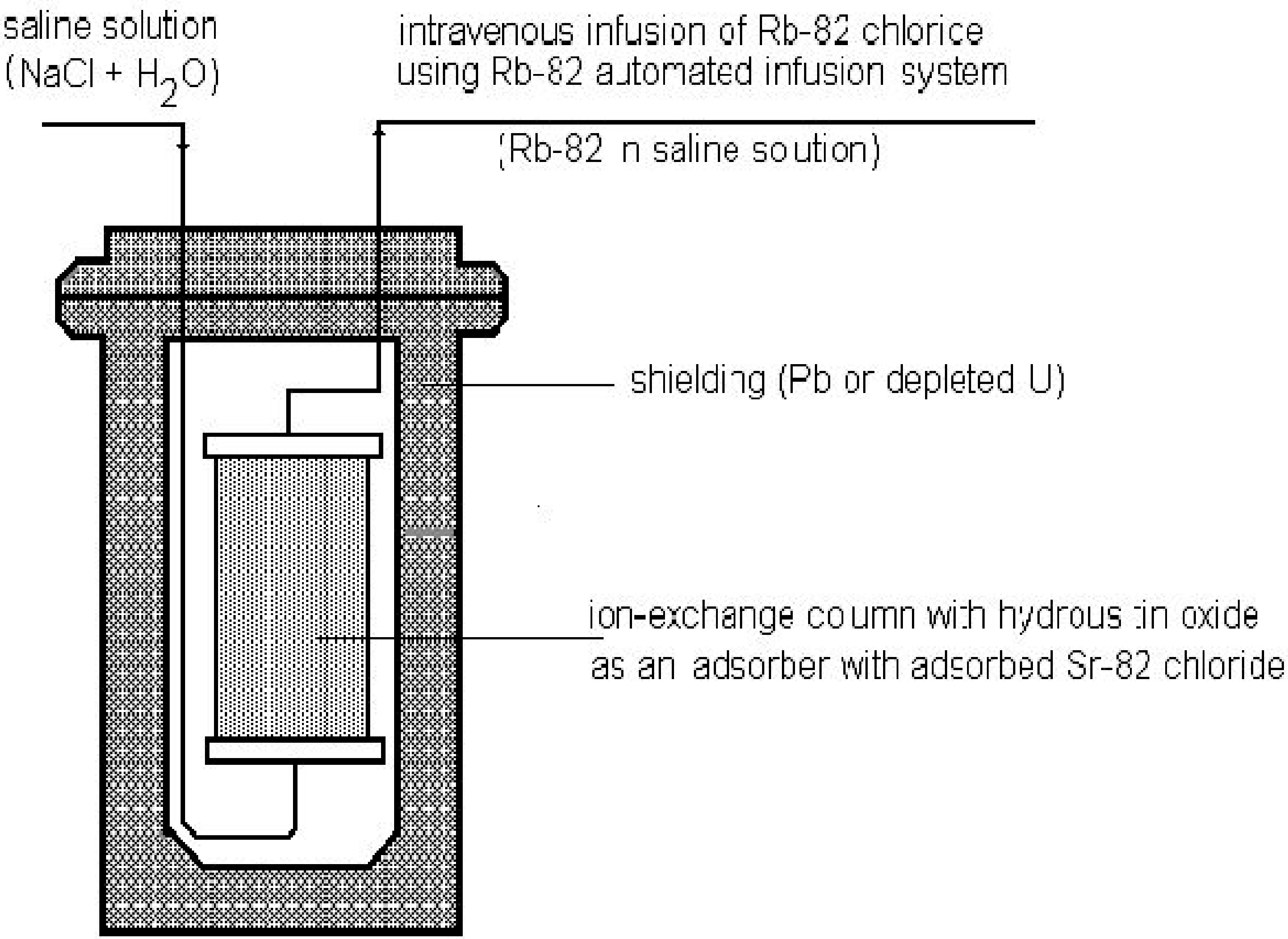
- Twelve 250 hr accelerator runs per year are feasible

Bold - isotopes have been already produced at the facility

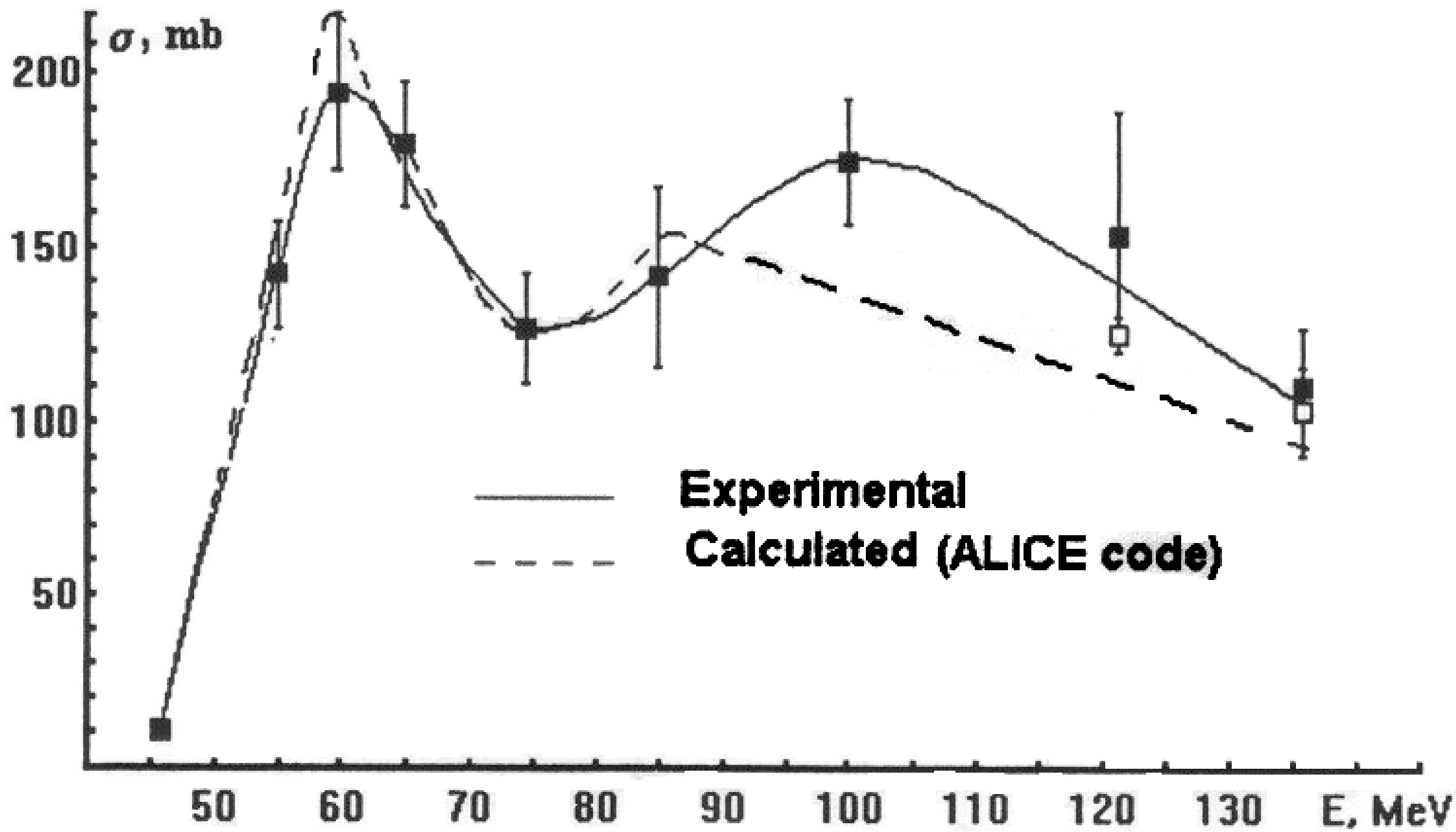
ANNUAL PRODUCTION POSSIBILITY OF SOME RADIONUCLIDES AT INR ACCELERATOR IN TROITSK

	Possible Production, Ci/year	World Consumption, estimate	Applications
Sr-82	30	30	PET Tomography:Cardiology, Full diagnostics of blood flow
Pd-103	500	3000	Therapy of prostate, including cancer
Cu-67	300	3000	Therapy of cancer "in vivo"
Ge-68	4	7	Calibration of PET medical equipment
Na-22	20	3	Moesbauer spectrometry in scientific investigations
Cd-109	20	10	X-Ray fluorescence analysis of materials and samples
Tl-201	200	3000	Cardiology diagnostics
I-123	200	2000	Diagnostics of disease of kidney, glands, brain, etc.

Sr-82/Rb-82 Generator for PET
Cardio Diagnostics and Blood Flow Studies
RUSSIAN-CANADIAN PROPOSED PROJECT



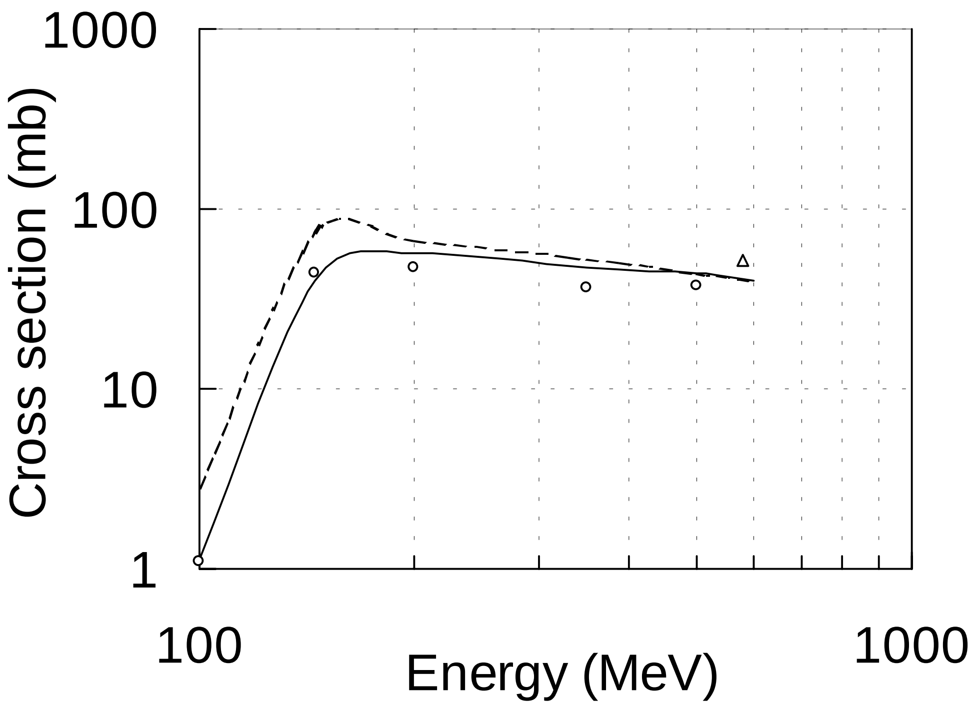
Cross-Sections of Pd-103 Cumulative Formation on Silver Target Irradiated by Protons



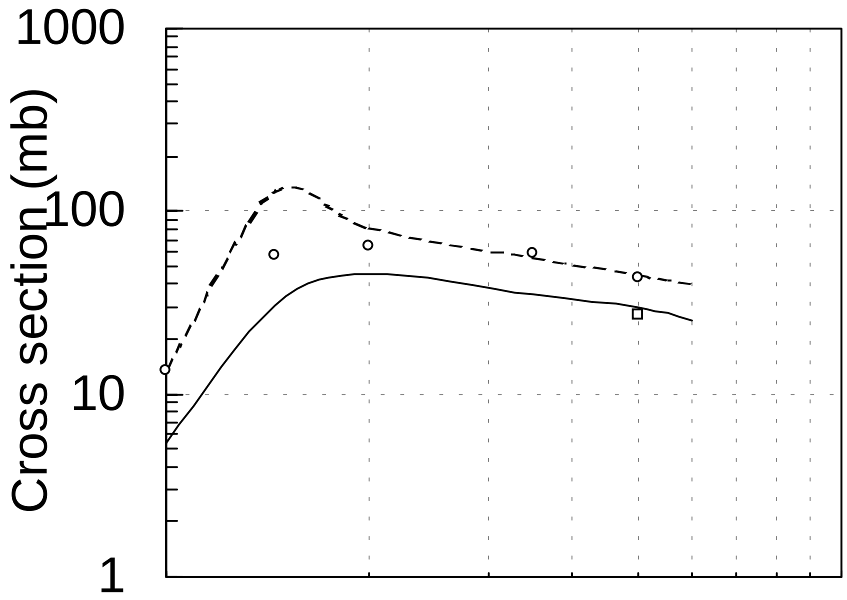
Cross Section Measurements

- Tantalum target irradiated by protons
- Gamma spectrometry after chemical separation:
  ion exchange of sulfate and fluoride anion complexes
- Theoretical calculations:
  ALICE (dashed) and Cascade Evaporation Model

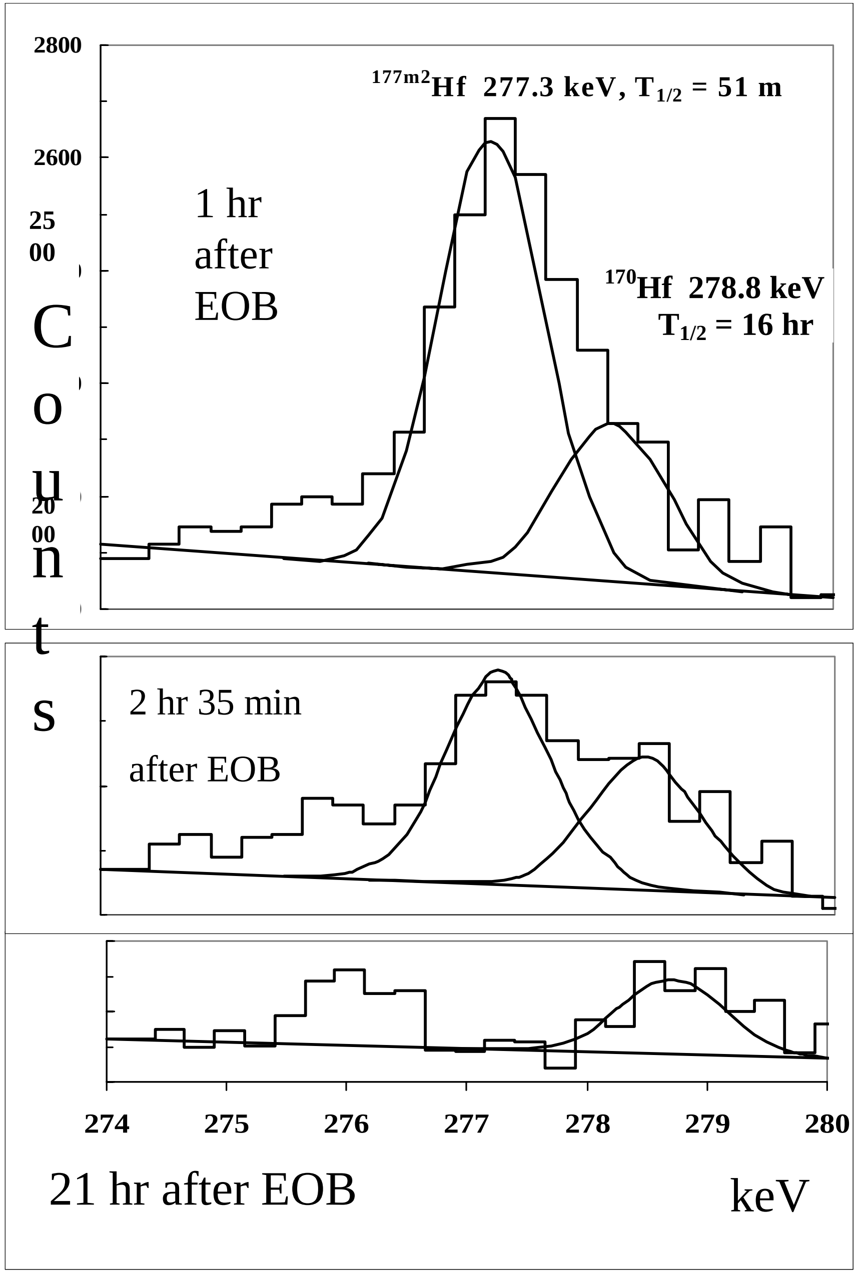
Lu-169 (1.42 days)



Hf-170 (16 hr)



Gamma Spectrum of High Spin Isomeric State (-37/2) of Hf-177m2 (half life - 51min, σ = 0.038 mbarn)



Cross-Sections, σ^m (mb) and σ^m/σ^g (numbers in brackets) for Excitation of High-Spin Isomers at Proton Irradiation of ^{181}Ta

σ^m - experimental, σ^g - Cascade Evaporation Model calculations

Isomer (spin) Half-Life	Reaction	Proton Energy, MeV				
		100	145	200	350	500
^{178m}Ta (7^-) 2.45 hr	^{181}Ta(p,p3n)	**34.2±2.5** (0.39±0.03)	**25±2** (0.37±0.04)	**21.7±2.0** (0.38±0.03)	**17.4±1.2** (0.40±0.02)	**13.1±1.5** (0.37±0.08)
^{177m}Lu (23/2-) 160 d	^{181}Ta(p,3p2n)	**0.022±0.002** (0.023±0.002)	**<0.25** (<0.1)	**0.040±0.013** (0.012±0.004)	**0.068±0.008** (0.016±0.002)	**0.11±0.03** (0.025±0.006)
^{179m2}Hf ($25/2^-$) 25 d	^{181}Ta(p,2pn)	**0.42±0.04** (0.020±0.002)	- -	**0.44±0.04** (0.019±0.002)	**0.39±0.03** (0.016±0.001)	**0.41±0.03** (0.018±0.001)
^{177m2}Hf ($37/2^-$) 51m	^{181}Ta(p,1p3n)	**0.038±0.010** (0.0015± 0.0004)	**<1.0** (<0.02)	**<0.085** (<0.0034)	**0.036±0.004** (0.0016±0.0002)	**0.05±0.01** (0.0024±0.0007)
^{180m}Hf (8^-) 5.5 hr	^{181}Ta(p,2p)	**0.44±0.13** (0.011±0.003)		**1.17±0.09** (0.024±0.002)	**1.60±0.11** (0.030±0.002)	**1.71±0.2** (0.033±0.004)

Production and Transportation Scheme of Sr-82