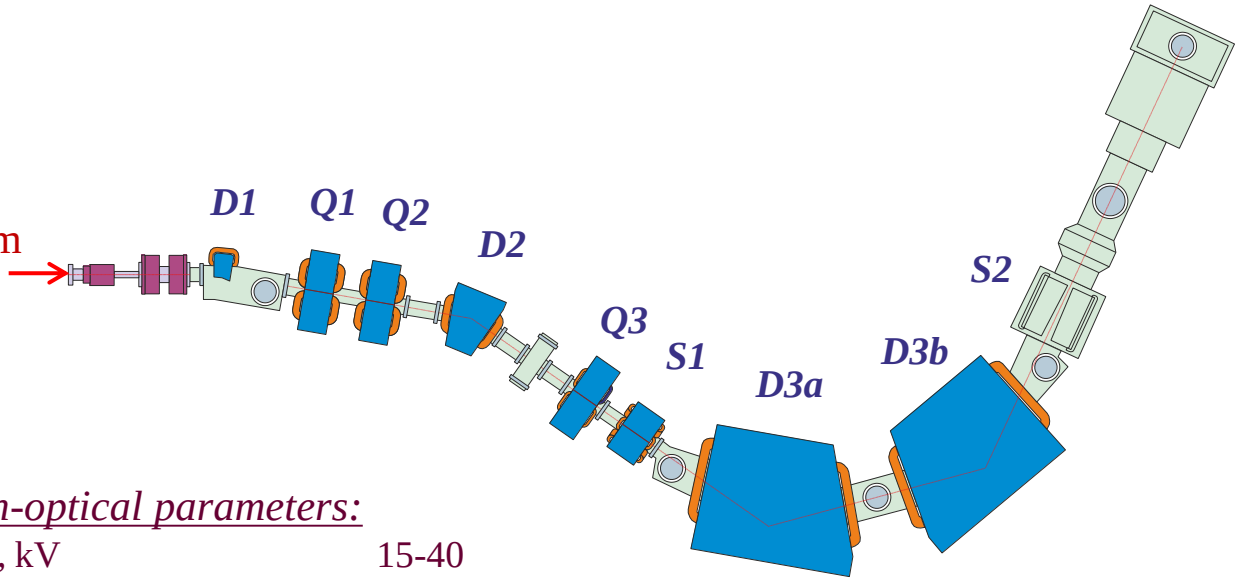
Mass spectrometer MASHA – complete assembly testing on the heavy ion beam

A.M.Rodin, A.V.Belozerov, E.V.Chernyshova, S.N.Dmitriev, A.V.Gulyaeva, M.G.Itkis, J.Kliman, L.Krupa, A.N.Lebedev, Yu.Ts.Oganessian, V.S.Salamatin, I.Sivacek, D.V.Vanin, S.A.Yuchimchuk

Contents

Introduction

MAss
Separator of
Heavy
Atoms



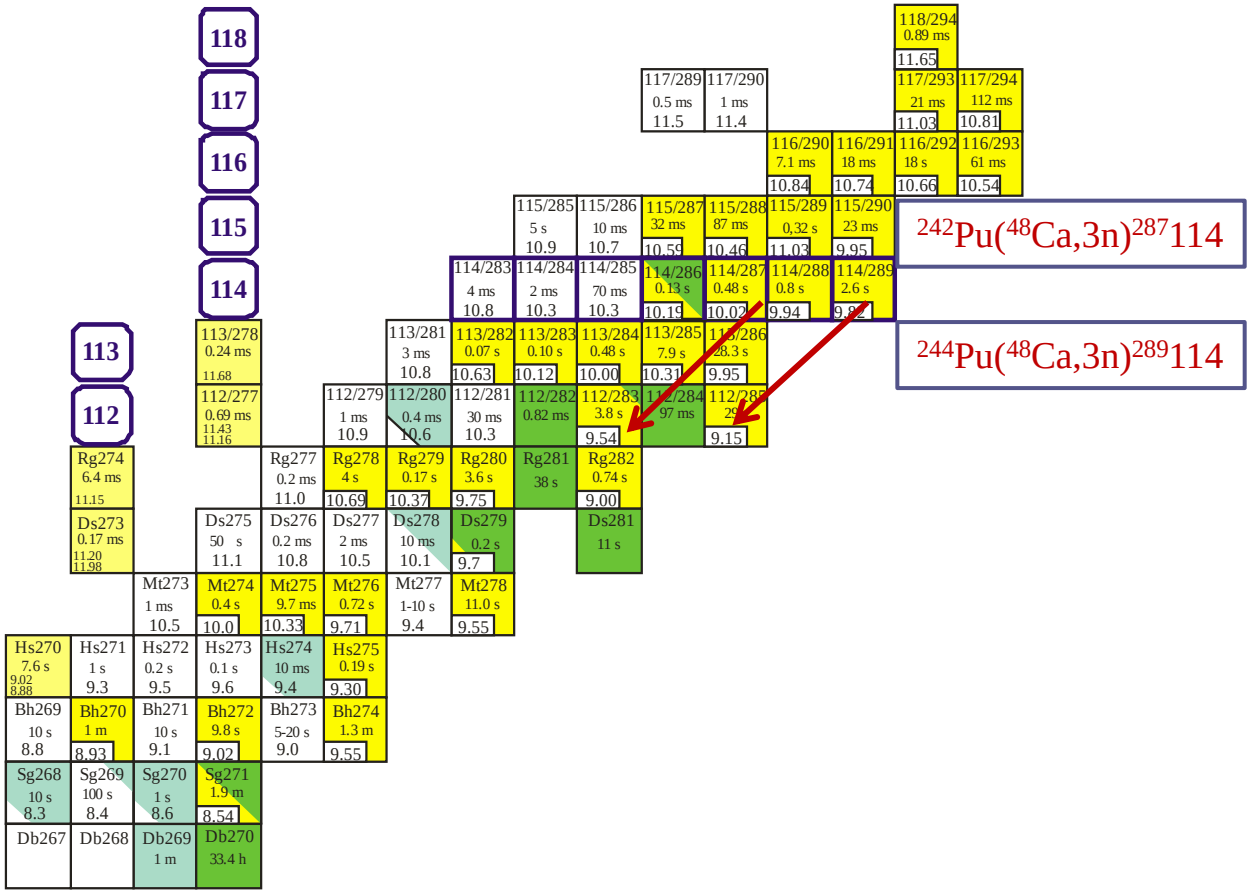
General ion-optical parameters:

Range of energy variation, kV	15-40
Range of *Br* variation, Tm	0.08-0.5
Mass acceptance, %	2.8
Angular acceptance, mrad	14
Diameter the ion source exit hole, mm	5.0
Horizontal magnification at F1/F2	0.39/0.68
Mass dispersion at F1/F2, mm/%	1.5/39.0
Linear mass resolution at F1	75
Mass resolution at F2	

ISOL technique

- Lifetime for some SHE isotopes > 0.5 s
- 112 and 114 elements have high volatility

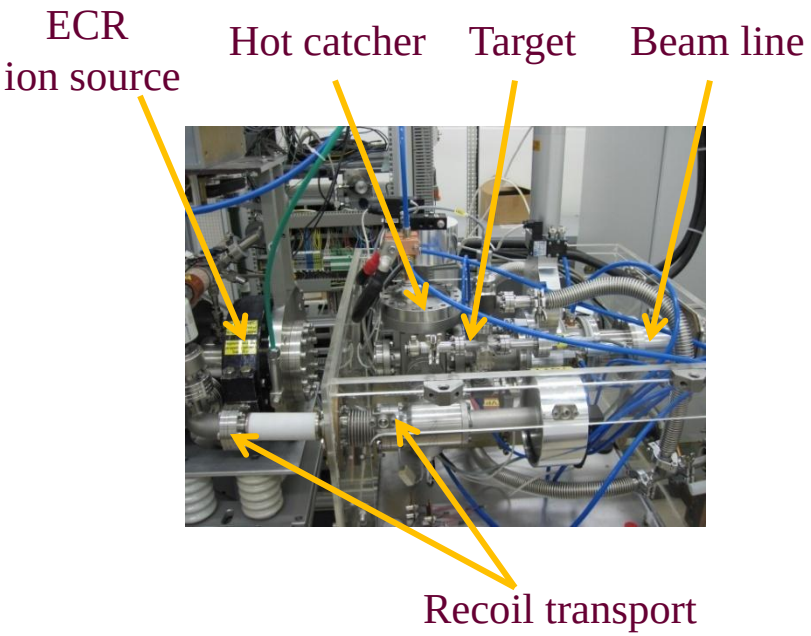
First experiments for mass measurement of SHE

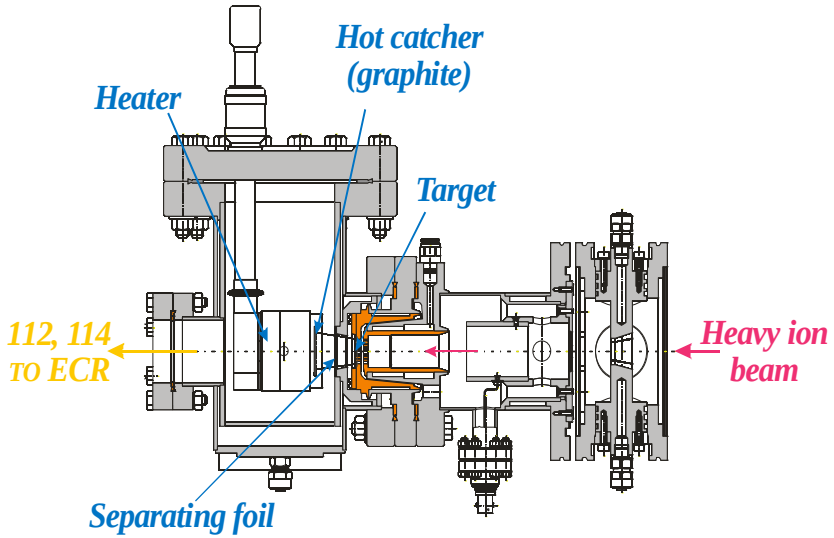


Mass-spectrometer “MASHA” status

Mass-spectrometer “MASHA” at the beam line of the cyclotron U-400M

Hot catcher scheme



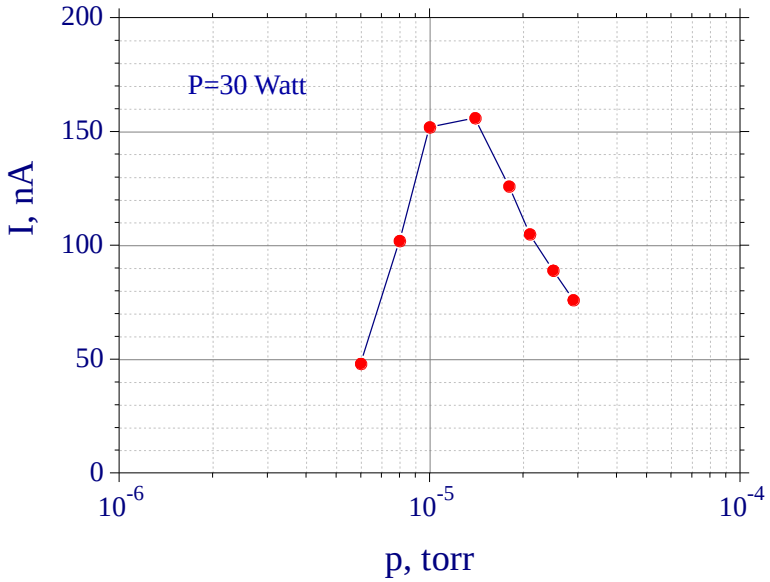


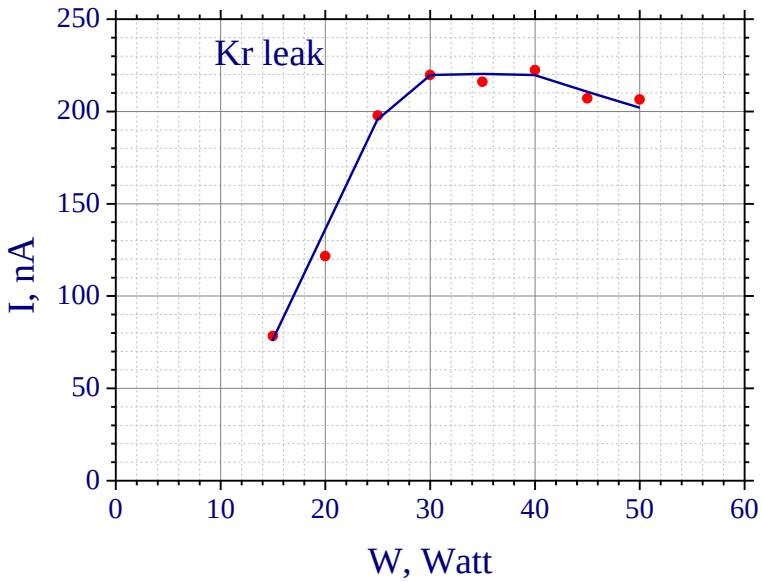
Material of the catcher – flexible graphite

Operating temperature of hot catcher – 1500-1800^{o}C

Delivery time of atoms from hot catcher to the ECR ion source ~ 2 s

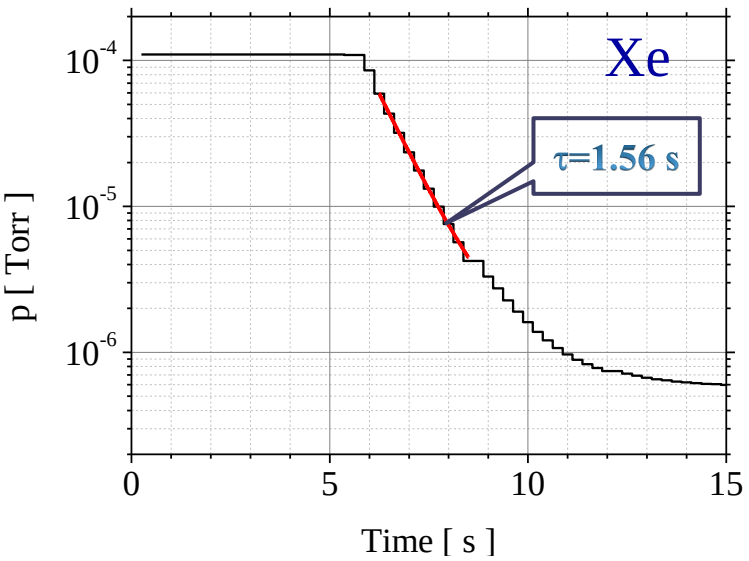
ECR ion source tuning

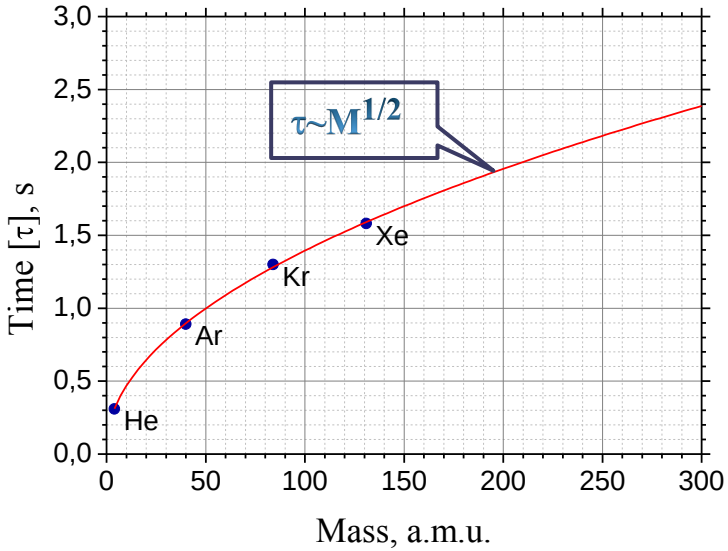




Test measurement with calibrated noble gas leak

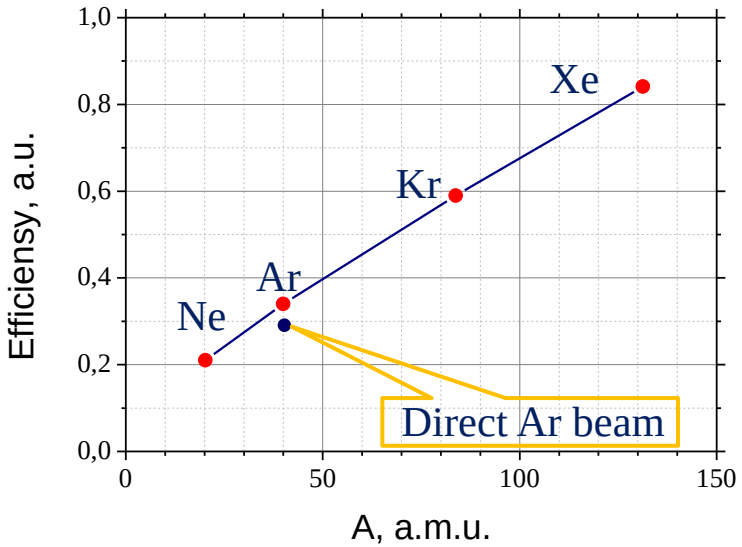
Delivery time from hot catcher to ECR ion source for volatile elements

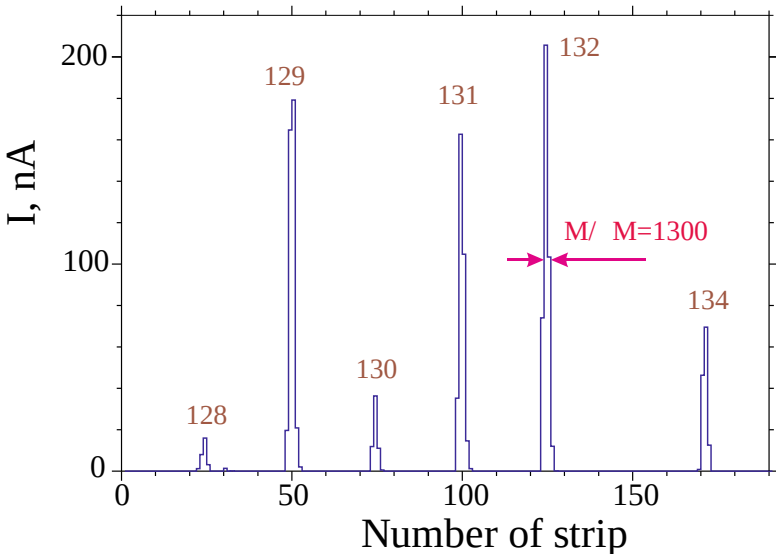




Time dependence of the pressure at the pumping hot catcher camber through the extraction diaphragm of the ECR source (d=5 mm)

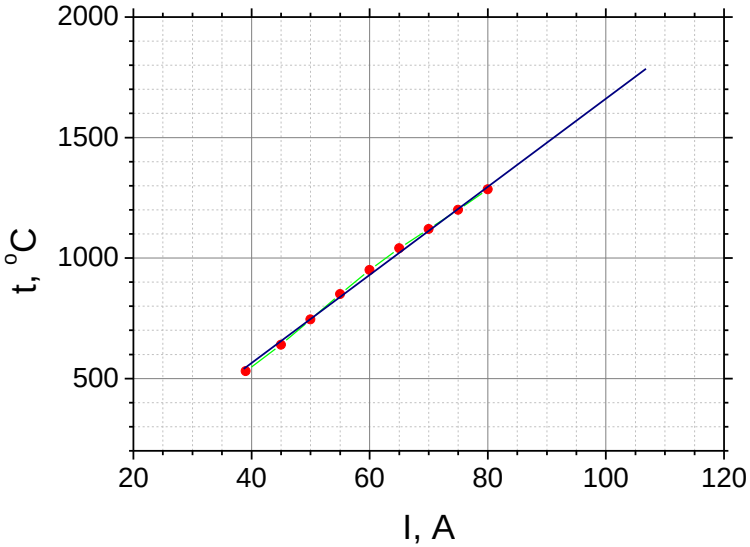
Test measurements with the calibrated gas leak

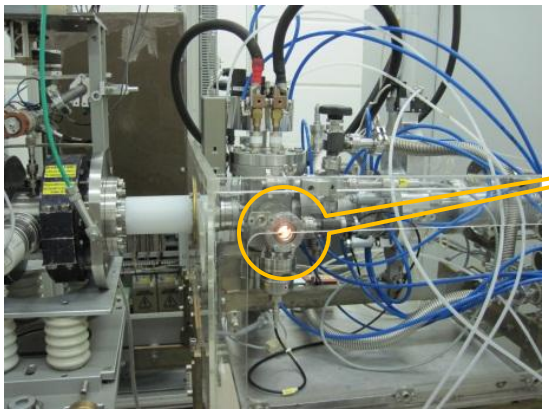


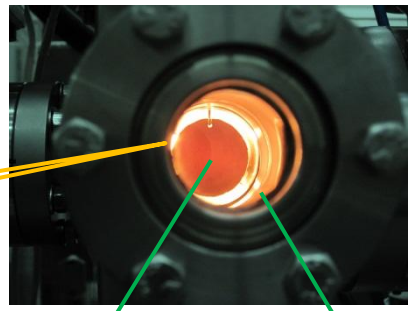


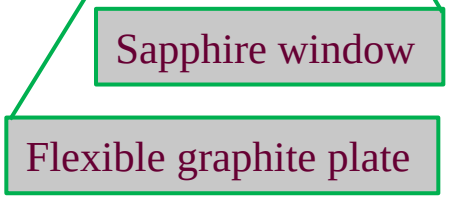
Total efficiency ~ 84% (for Xe)
Mass resolution – M/ΔM=1300
Mass measurement accuracy – 1.3×10^{-5}

Temperature calibration of the hot catcher



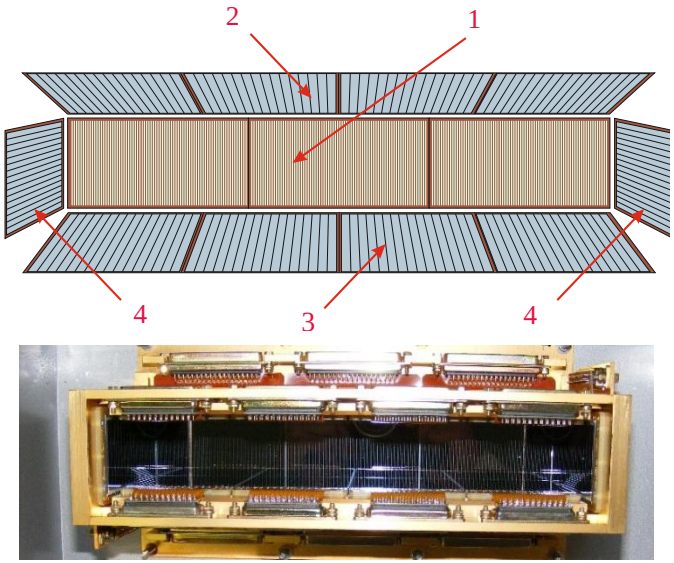




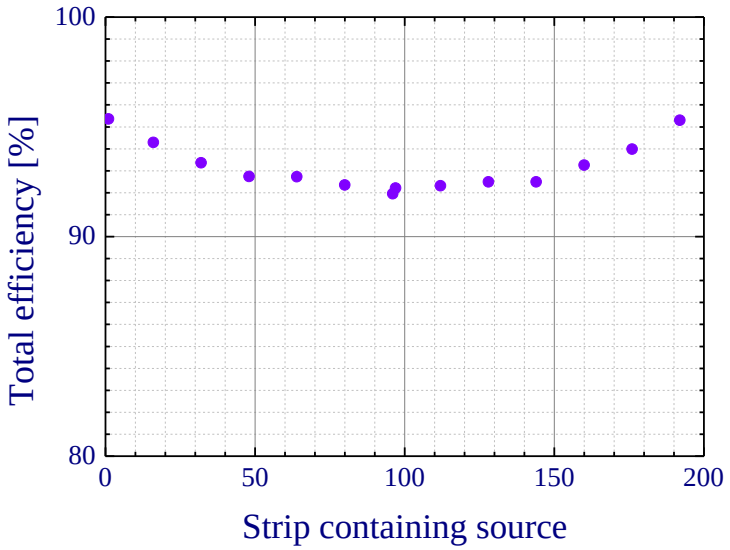


Temperature of the hot graphite plate versus direct current of the Ta heater

Focal plane silicon multi strip detector

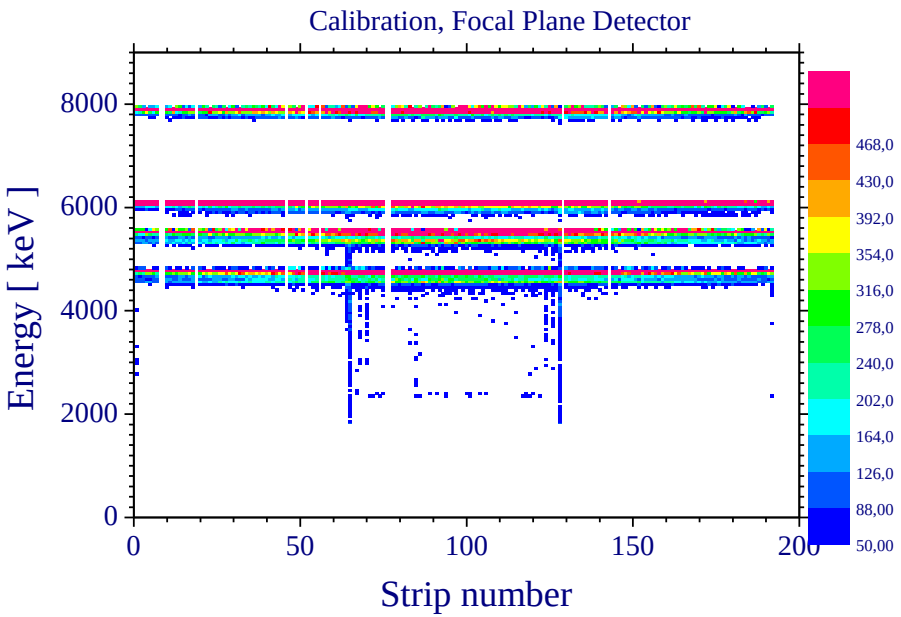


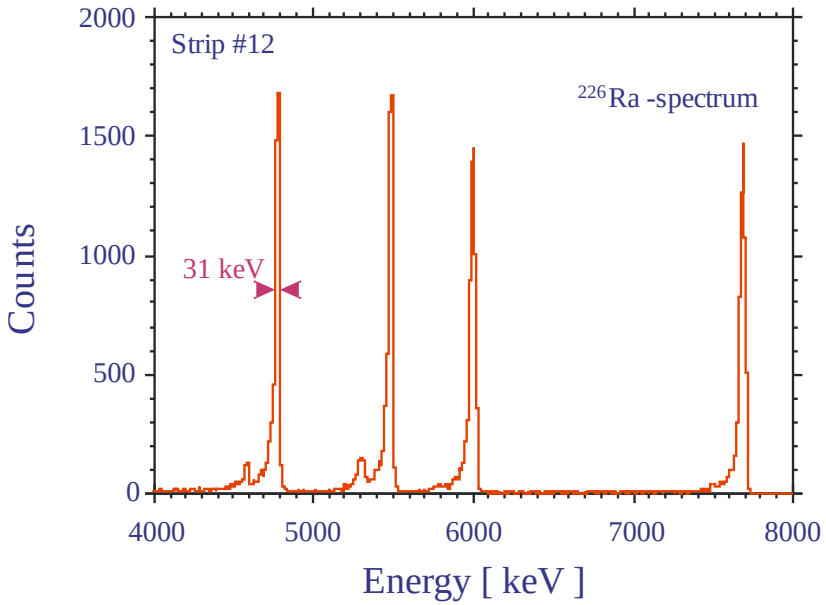
Configuration – well type
Number of the focal strips – 192 (step – 1.25 mm)
Number of the back side strips – 160 (step – 5 mm)
Efficiency ≥ 92% for first alpha decay
Energy resolution ~ 30 keV (for 5.5 MeV alpha)



Geometry efficiency for the first α-decay (simulation)

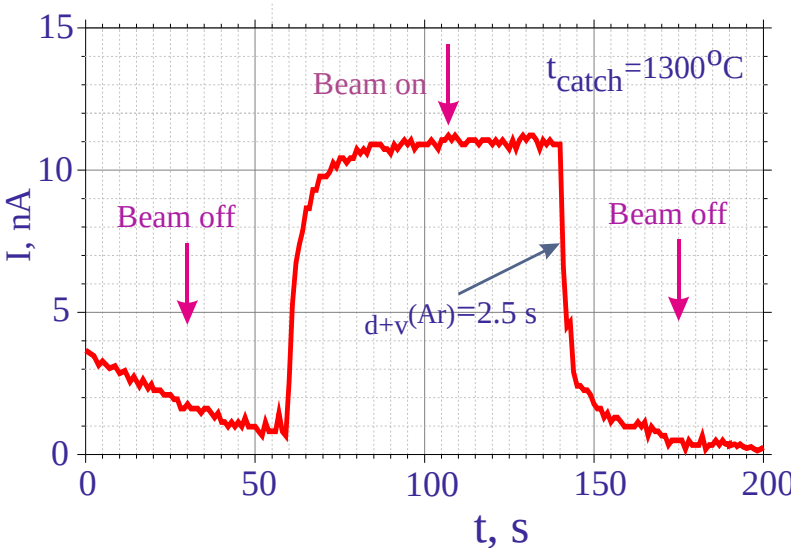
Focal plane silicon multi strip detector

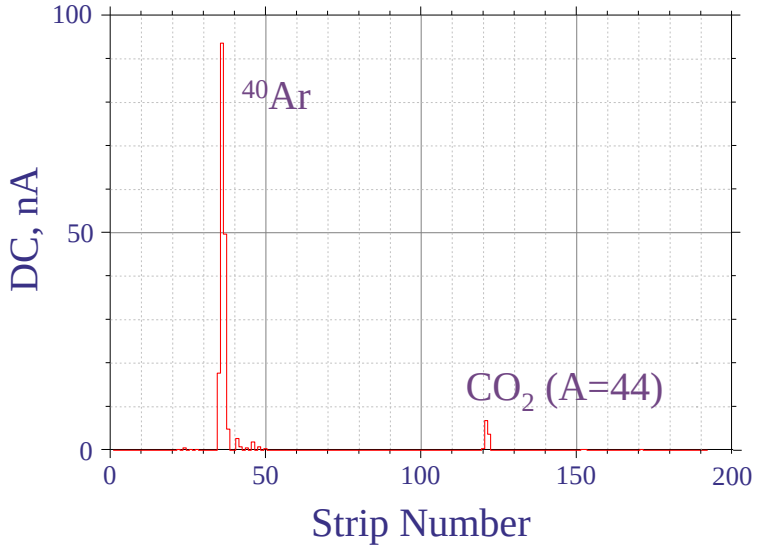




Calibration spectrum for ^{226}Ra source

Measurement test on the direct argon beam





The ^{40}Ar intensity time variation in the focal plane with chopping the beam at the catcher

Test experiments

Fusion evaporation reaction:

$^{40}Ar+^{nat}Sm \rightarrow {}^{nat-xn}Hg+xn$ – mercury isotopes

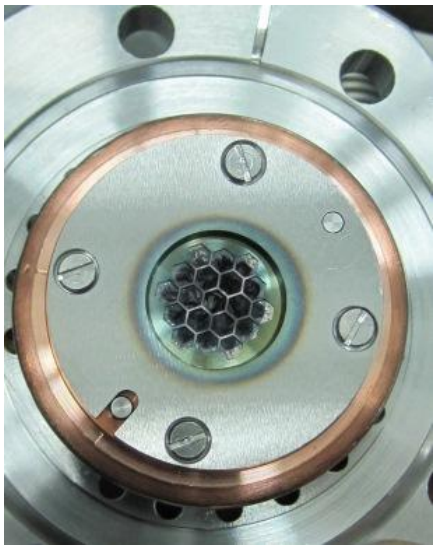
$^{40}Ar+^{166}Er \rightarrow {}^{206-xn}Rn+xn$ – radon isotopes

Targets:

^{nat}Sm – Sm_2O_3, d=0.63 mg/cm^2 (for Sm) on Ti foil 3.14 μm

^{166}Er – Er_2O_3, d=0.67 mg/cm^2 (for Er) on Ti foil 3.14 μm

Method of the manufacturing – molecular electrodeposition



View of the immovable target placed between two honeycomb water cooling holder 85% transparency

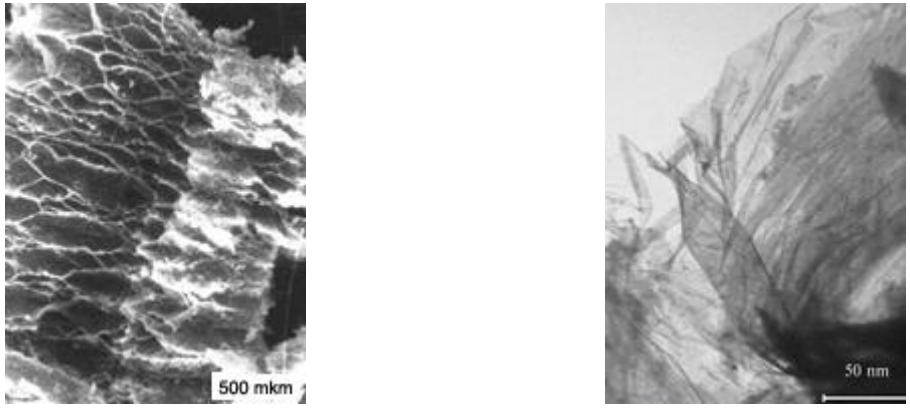
Test experiments

Beam:

^{40}Ar, E=284 MeV (2.5 %) – on the cyclotron extraction
Average intensity – $1.2 \cdot 10^{12}$ pps

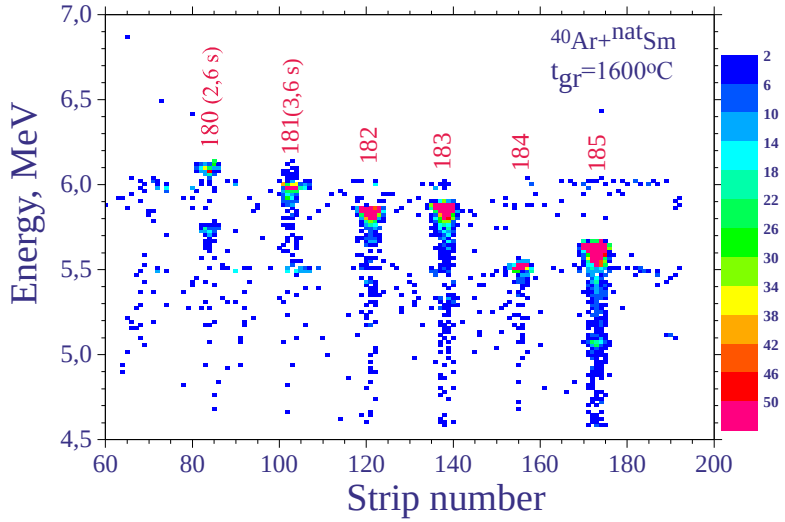
Hot catcher:

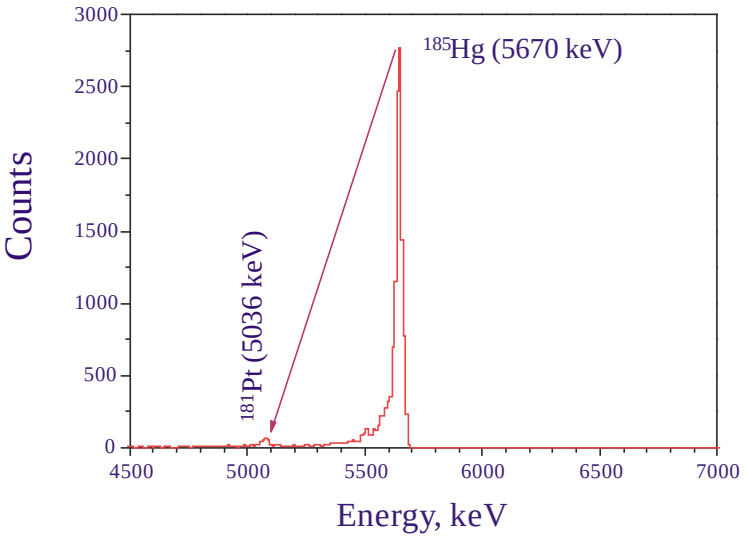
Material – flexible graphite (expanded graphite), density 1.0 g/cm^3
Form – disk by the diameter 30 mm thickness 0.5 mm
Operating temperature – 1200-2000ºC
Type of heating – illumination from hot Ta foil

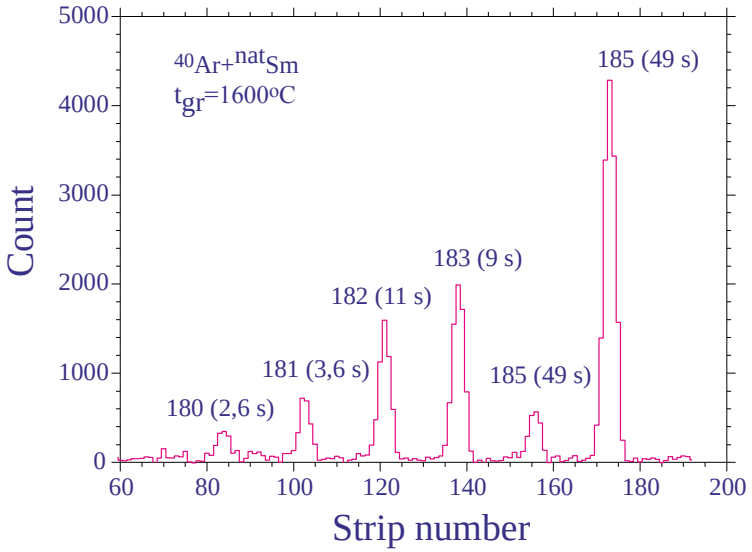


Geometry structure of the flexible graphite

$^{40}Ar+^{nat}Sm$ reaction

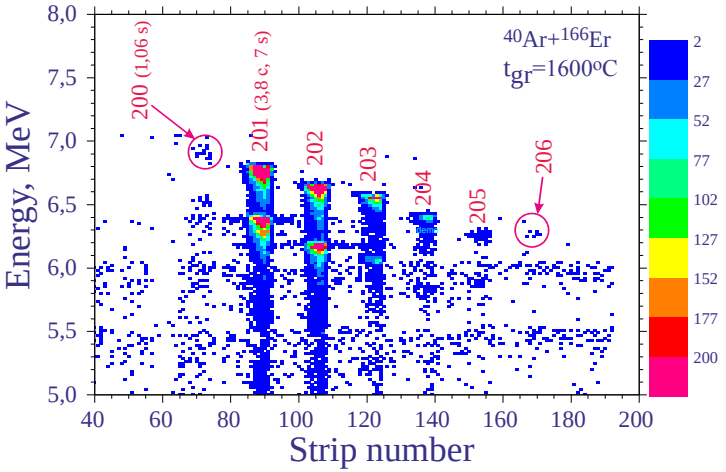


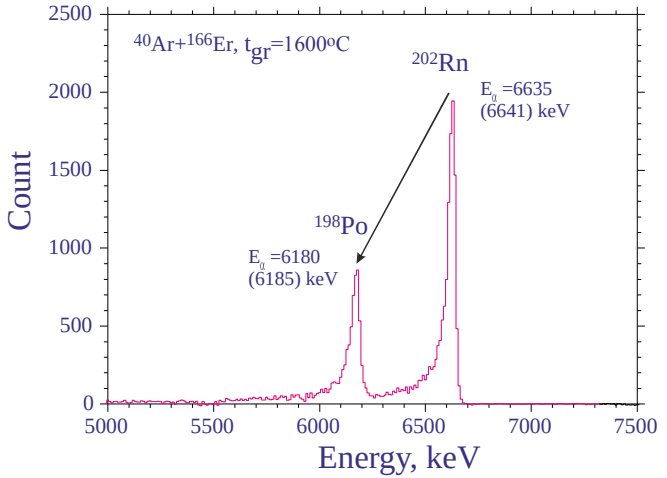


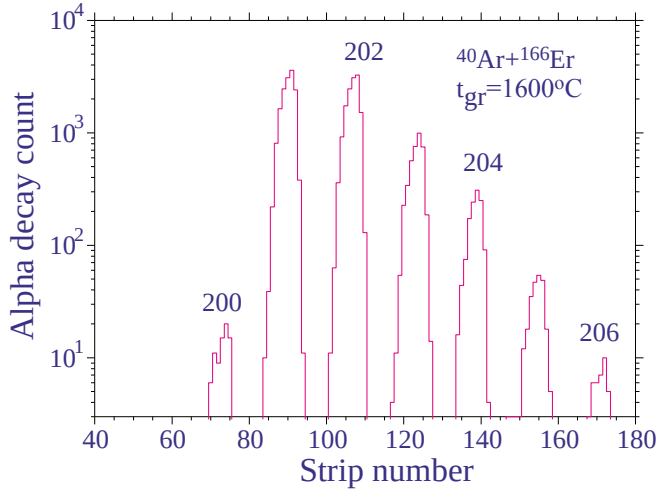


- Hot catcher temperature – 1600°C
- Target – Sm (0.63 mg/cm^2) with natural isotopes mix
- Beam energy (^{40}Ar) – E_{lab}=255 MeV
- Total flux (^{40}Ar) – $3.7 \cdot 10^{17}$ ions

$^{40}Ar+^{166}Er$ reaction

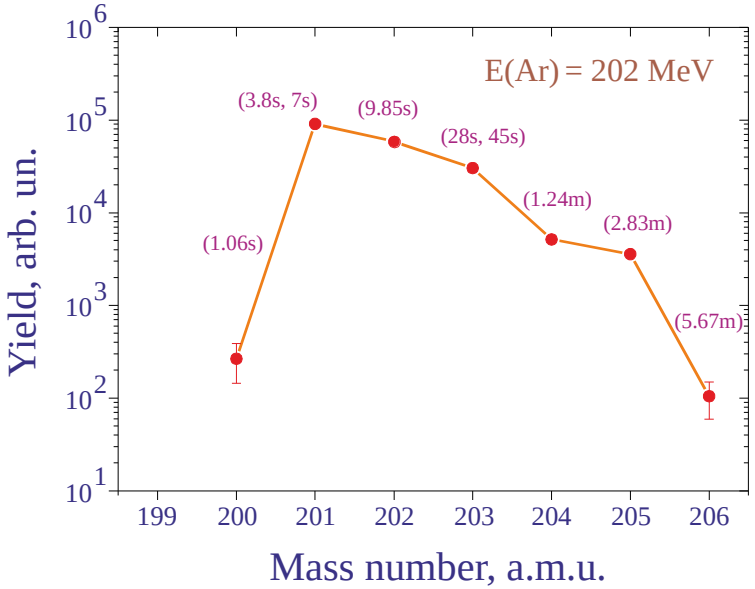


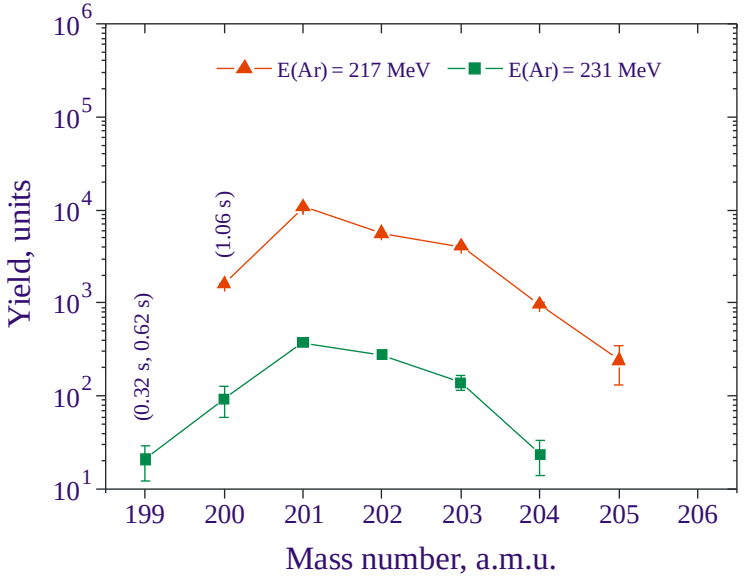




- Hot catcher temperature - 1600 C
- Target – ^{166}Er (0.67 mg/cm^2)
- Beam energy (^{40}Ar) – E_{lab}=202 MeV
- Total flux (^{40}Ar) – $4 \cdot 10^{17}$

Yield of Rn isotopes for $^{40}Ar+^{166}Er$ reaction





Nearest future

- Efficiency and operation speed measurement in the $^{40}Ar+^{144}Sm$ reaction

- Mass measurement of the 112 and 114 isotopes synthesized in the reaction $^{244}Pu(^{48}Ca,3n)^{289}114$

Thank you for your attention!