JINR
114 Flerovium
FLNR
Dubna

NRV web knowledge base: scientific and educational applications

http://nrv.jinr.ru

V. Rachkov, JINR, Dubna

- *What is "Knowledge base"*
- *Scientific application*
- *Educational potential*

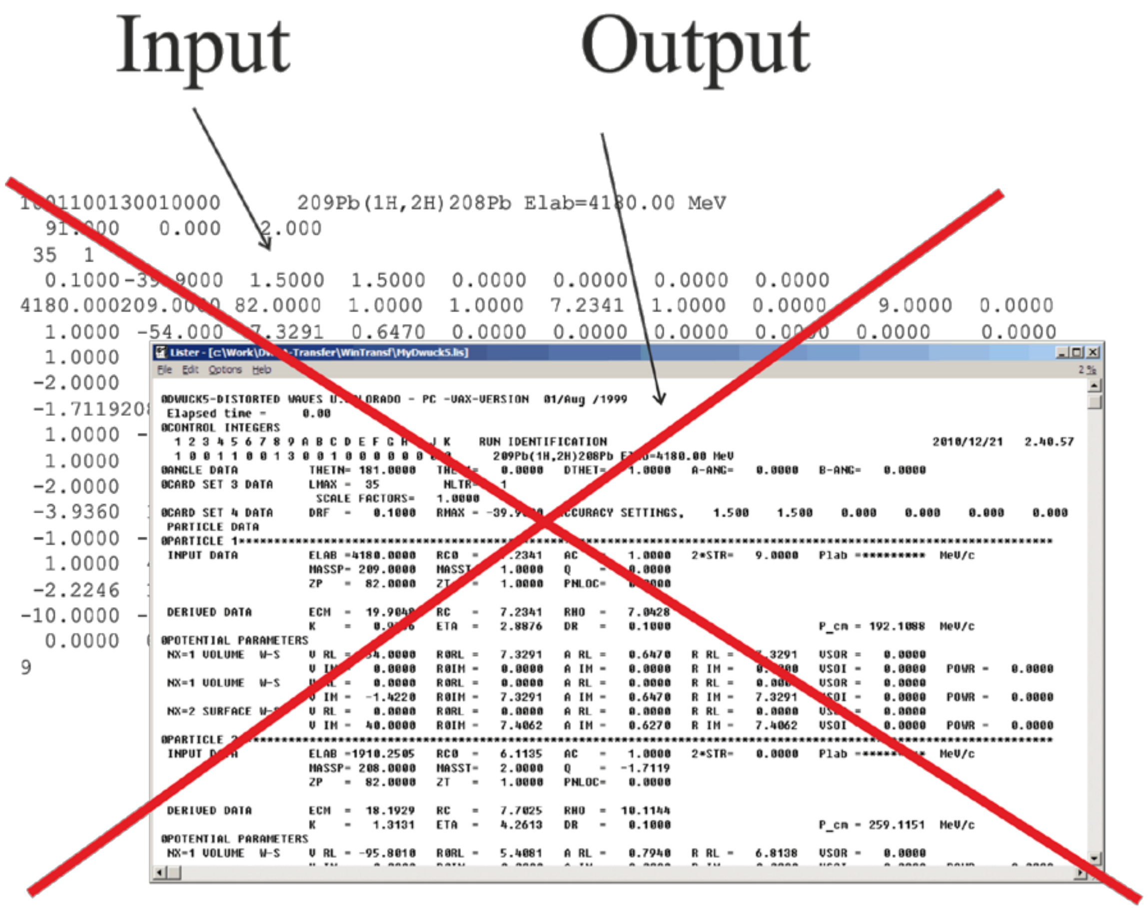
Supported by:

- **JINR**
- **JINR-SAR cooperation program**

GRID 2018, JINR DUBNA, 10.09.18

What is Web Knowledge base?

Typical situation with scientific codes



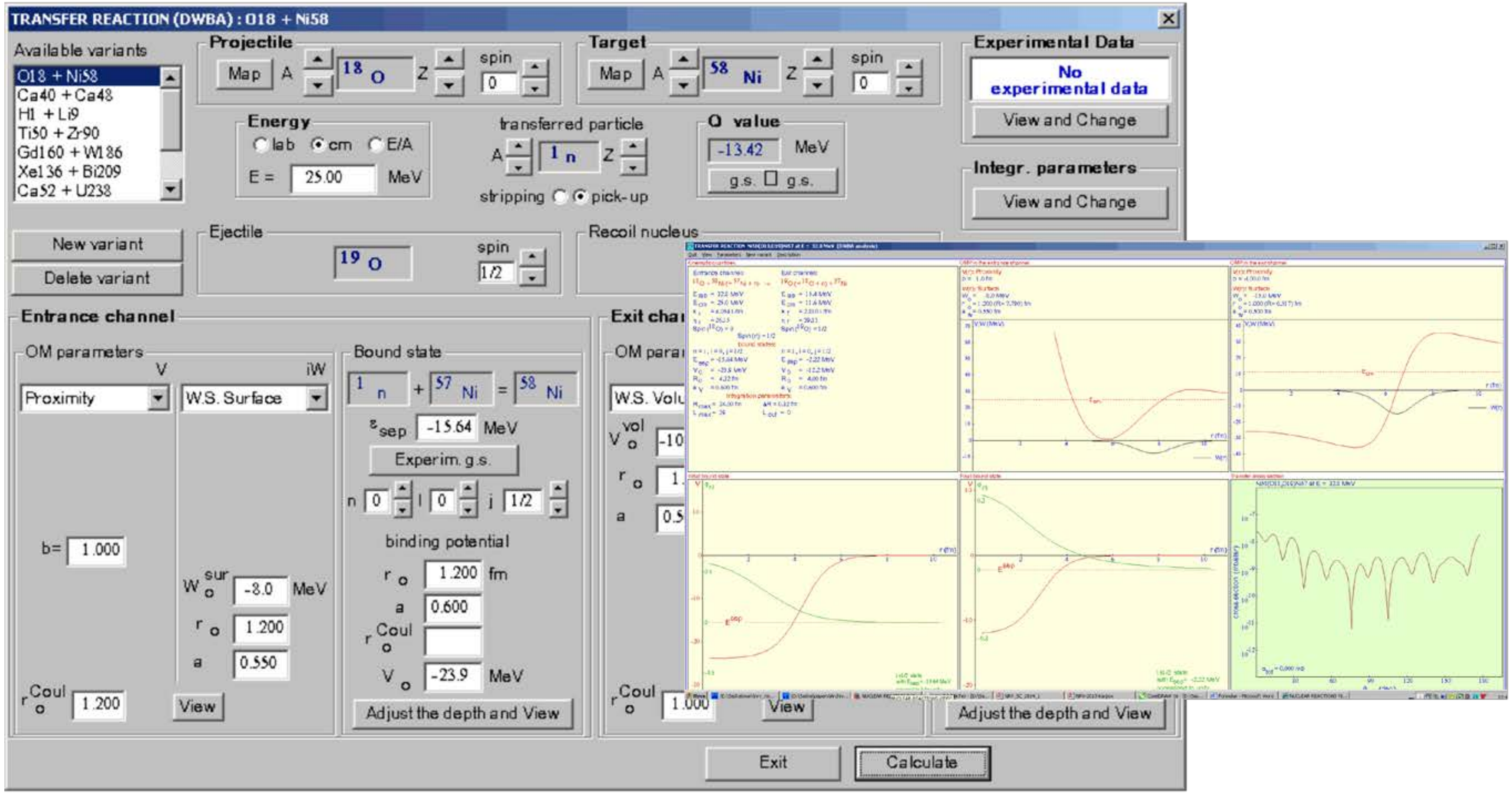
- meaning of parameters?
- preparation of inputs?
- processing of outputs?
- no graphics
- OS dependent
- difficult to update

Solution: Interactive interface for codes with Graphics

What is Web Knowledge base?

First, it was done for Windows!
(25 years ago by V. Zagrebaev and A. Kozhin)

But, what about Linux, MacOS, Android, etc.?.. Does not work!



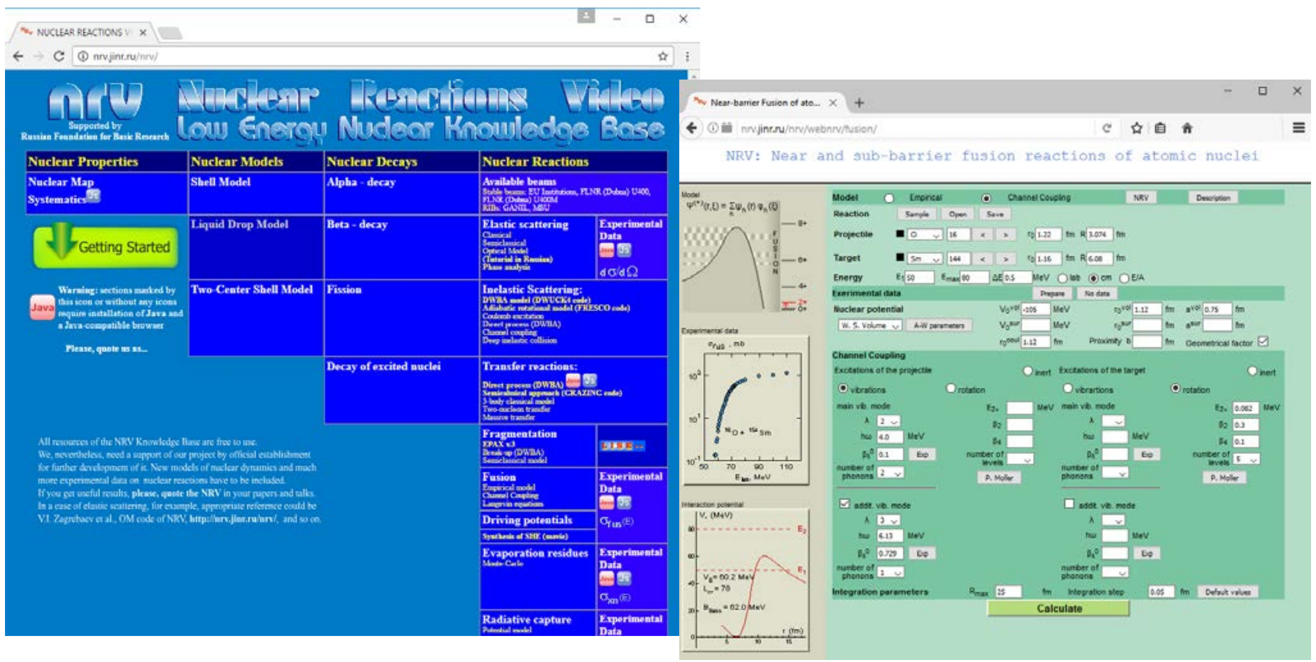
Solution: Do the same working in Internet Browsers

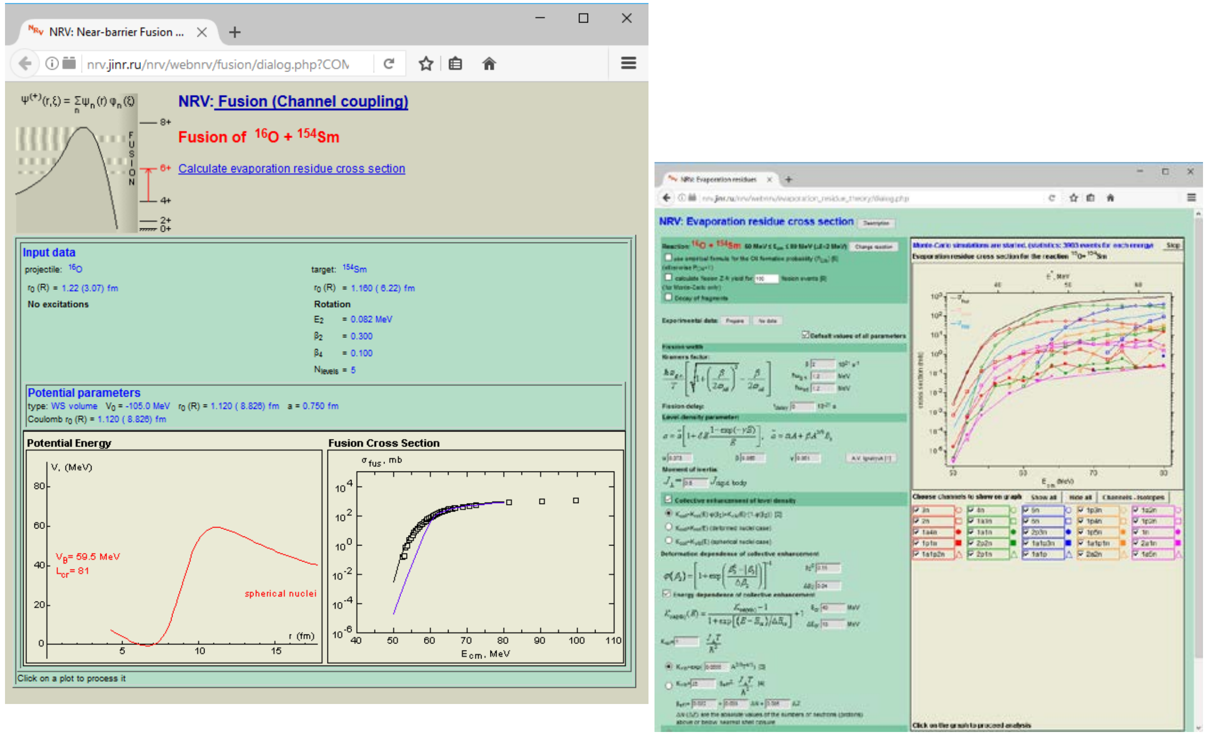
The interactive nuclear knowledge system

http://nrv.jinr.ru/

The NRV web knowledge base is a unique interactive research system:

- Allows to run complicated computational codes
- Works in internet browser supporting Java
- Has graphical interface for preparation of input parameters and analysis of output results
- Combines computational codes with experimental databases on properties of nuclei and nuclear reactions
- Contains detailed description of models

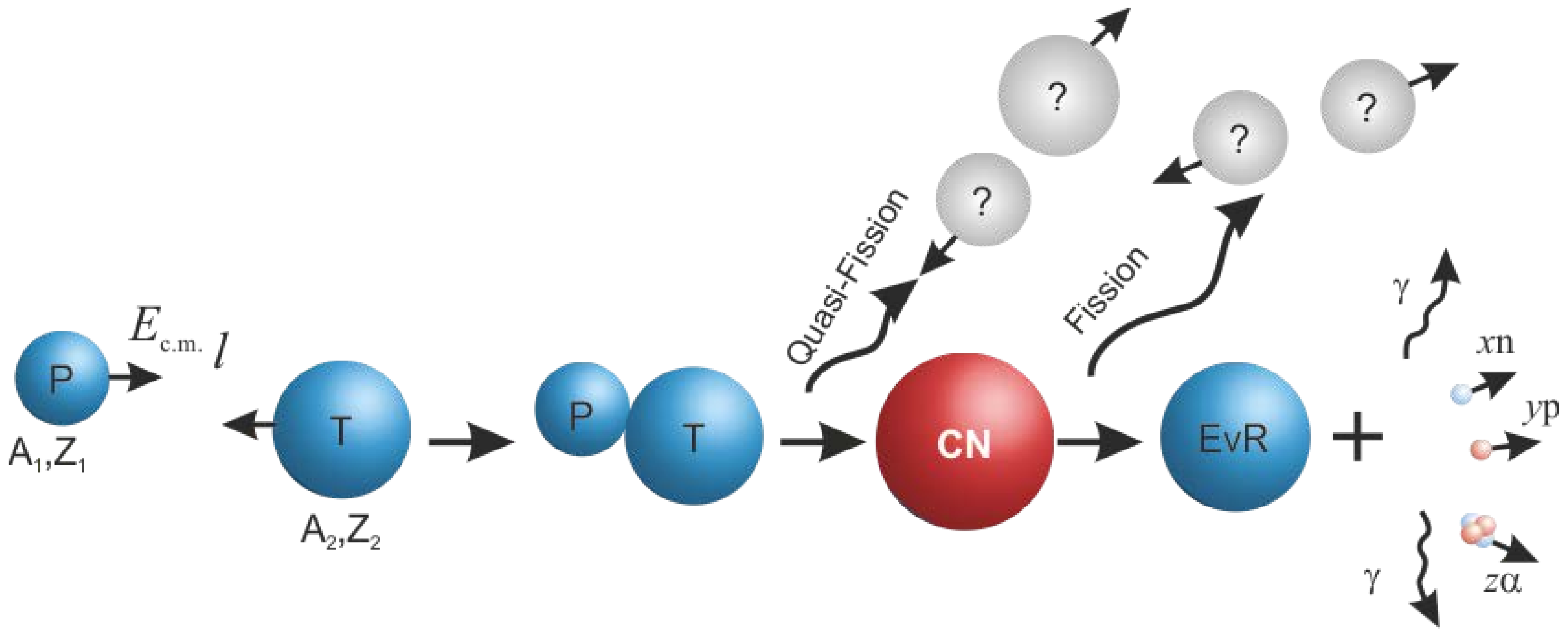




А. В. Карпов, и др.; Ядерная Физика. — 2016. — Т. 79, №.5. — С. 520.

A.V. Karpov et. el. Nucl. Instrum. Methods Phys. Res. Sect. Accel. Spectrometers Detect. Assoc. Equip. 2017. Vol. 859, Supplement C. P. 112.

Scientific application: Synthesis of SH nuclei in fusion reactions



Cross section of SH elements production in fusion reactions with the emission of particles:

$$\sigma^{xn,yp,z\alpha}_{EvR}(E) = \underbrace{\frac{\pi\hbar^2}{2\mu E}\sum_{\ell=0}^{\infty}(2\ell+1)\cdot P_{capt}(E,\ell)}_{\text{Capture cross section (QCC and ECC model)}} \cdot \underbrace{P_{CN}(E^*,\ell)}_{\text{CN formation probability for SH systems}} \cdot \underbrace{P_{xn,yp,z\alpha}(E^*,\ell)}_{\text{Survival probability}}$$

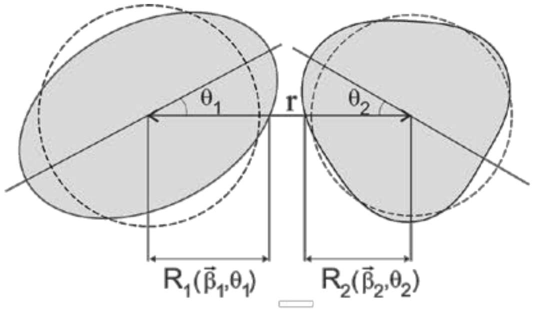
Capture cross section (QCC and ECC model)

CN formation probability for SH systems

Survival probability

N.V. Antonenko, et. al Phys. Lett. B. 319 (1993) 425

Fusion: Quantum channel-coupling model



$$R(\vec\beta,\theta)=\tilde R\cdot\left(1+\sum_{\lambda\ge2}\beta_\lambda Y_{\lambda0}(\theta,0)\right)$$

$$\tilde R = Ro/[1+\frac{3}{4\pi}\sum_\lambda \beta_\lambda^2+\ldots]^{1/3}$$

$$V_{12}(r;\vec\beta_1,\theta_1,\vec\beta_2,\theta_2)=V_C(r;\vec\beta_1,\theta_1,\vec\beta_2,\theta_2)+V_N(r;\vec\beta_1,\theta_1,\vec\beta_2,\theta_2)+\frac{1}{2}\sum_{i=1}^{2}\sum_\lambda C_{i\lambda}\cdot\beta_{i\lambda}^2$$

$$H=-\frac{\hbar^2\nabla_r^2}{2\mu}+V_C(r;\vec\beta_1,\theta_1,\vec\beta_2,\theta_2)+V_N(r;\vec\beta_1,\theta_1,\vec\beta_2,\theta_2)+\underbrace{\sum_{i=1,2}\frac{\hbar^2\hat I_i^2}{2J_i}+\sum_{i=1,2}\sum_{\lambda\ge2}\left(-\frac{1}{2d_{i\lambda}}\frac{\partial^2}{\partial s_{i\lambda}^2}+\frac{1}{2}c_{i\lambda}s_{i\lambda}^2\right)}$$

$$H\Psi=E\Psi$$

$$H_{\text{int}}\varphi_\nu(\vec\alpha)=\varepsilon_\nu\varphi_\nu(\vec\alpha)$$

$$\Psi_{\vec k}(r,\vartheta,\vec\alpha)=\frac{1}{kr}\sum_{l=0}^{\infty}i^l e^{i\sigma_l}(2l+1)\chi_l(r,\vec\alpha)P_l(\cos\vartheta)\,,$$

$$\chi_l(r,\vec\alpha)=\sum_\nu y_{l,\nu}(r)\cdot\varphi_\nu(\vec\alpha)$$

$$y''_{l,\nu}-\frac{l(l+1)}{r^2}+\frac{2\mu}{\hbar^2}\left[E-\varepsilon_\nu-V_{\nu\nu}(r)\right]y_{l,\nu}-\sum_{\mu\ne\nu}\frac{2\mu}{\hbar^2}V_{\nu\mu}(r)y_{l,\mu}=0$$

boundary conditions

$$y_{l,\nu}(r\to\infty)=\frac{i}{2}\left[h_l^{(-)}(\eta_\nu,k_\nu r)\cdot\delta_{\nu0}-\left(\frac{k_0}{k_\nu}\right)^{1/2}S^l_{\nu0}\cdot h_l^{(+)}(\eta_\nu,k_\nu r)\right]$$

$$y'_{l,\nu}(r<R_{\text{fus}})\sim -ik_{l,\nu}y_{l,\nu}(r)$$

flux in channel ν

$$j_{l,\nu}=-i\frac{\hbar}{2\mu}\left(y_{l,\nu}\frac{dy^*_{l,\nu}}{dr}-y^*_{l,\nu}\frac{dy_{l,\nu}}{dr}\right)\Big|_{r\le R_{\text{fus}}}$$

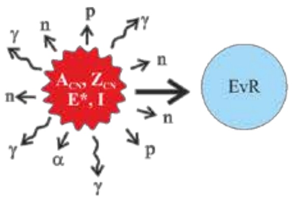
$$T_l(E)=\sum_\nu j_{l,\nu}/j_0$$

$$\sigma_{\text{fus}}(E)=\frac{\pi}{k_0^2}\sum_{l=0}^{\infty}(2l+1)\cdot T_l(E)$$

CCFULL code (Hagino, Rowley, Kruppa)

NRV-codes: Fusion-CC (*Samarin, Zagrebaev*)

Decay of excited nuclei (Statistical model)



✓ Level Density

$$\rho(Z,A,U,I) = \rho_{\rm int}(Z,A,U,I)\cdot K_{coll}(Z,A,U)$$

$$\rho_{\rm int}(Z,A,U,I) = \frac{(2I+1)\sqrt{a}}{24\left(U-\Delta-\frac{\hbar^2 I(I+1)}{2J_\perp}\right)^2}\left(\frac{\hbar^2}{J_\perp}\right)^{3/2}\exp\left[2\sqrt{a\left(U-\Delta-\frac{\hbar^2 I(I+1)}{2J_\perp}\right)}\right]$$

$$a = \tilde{a}\left[1+\delta U\,\frac{1-\exp(-\gamma_D U)}{U}\right]$$

$$U = E^* - \Delta$$

✓ Decay Widths

$$\Gamma_{A\to B+a}(E^*,I) = \frac{1}{2\pi\rho_A(E^*,I)}\int_0^{E^*-B_a}\sum_{l,j}T_{lj}(e_a)\sum_{I'=|I-j|}^{I'=|I+j|}\rho_B(E^*-B_a-e_a,I')\,de_a \quad (a=n,p,\alpha)$$

$$\Gamma_\gamma^L(E^*,I) = \frac{1}{2\pi\rho_A(E^*,I)}\int_0^{E^*}f_L(e_\gamma)\sum_{I'=|I-L|}^{I'=|I+L|}e_\gamma^{2L+1}\rho_A(E^*-e_\gamma,I')\,de_\gamma$$

$$\Gamma_{fiss}(E^*,I) = \frac{K_{\rm Kramers}(\text{friction})}{2\pi\rho_A(E^*,I)}\int_0^{E^*}T_{fiss}(e)\rho_A^{saddle}(E^*-e,I)\,de$$

T_{lj} - transmission coefficient for a particle emission

f_L - strength function of γ-quanta emission

T_{fiss} - transmission coefficient for fission

✓ Monte Carlo method

$$P_x = \frac{\Gamma_x}{\Gamma_{tot}} \qquad P_f = \frac{\Gamma_f}{\Gamma_{tot}} \qquad \Gamma_{tot} = \sum_{i=n,p,\alpha,\gamma,f}\Gamma_i \qquad E^*(n) = E^*(n-1) - B_x - E_{particle} \qquad E^* > \min(B_a, B_f)$$

decay probabilities

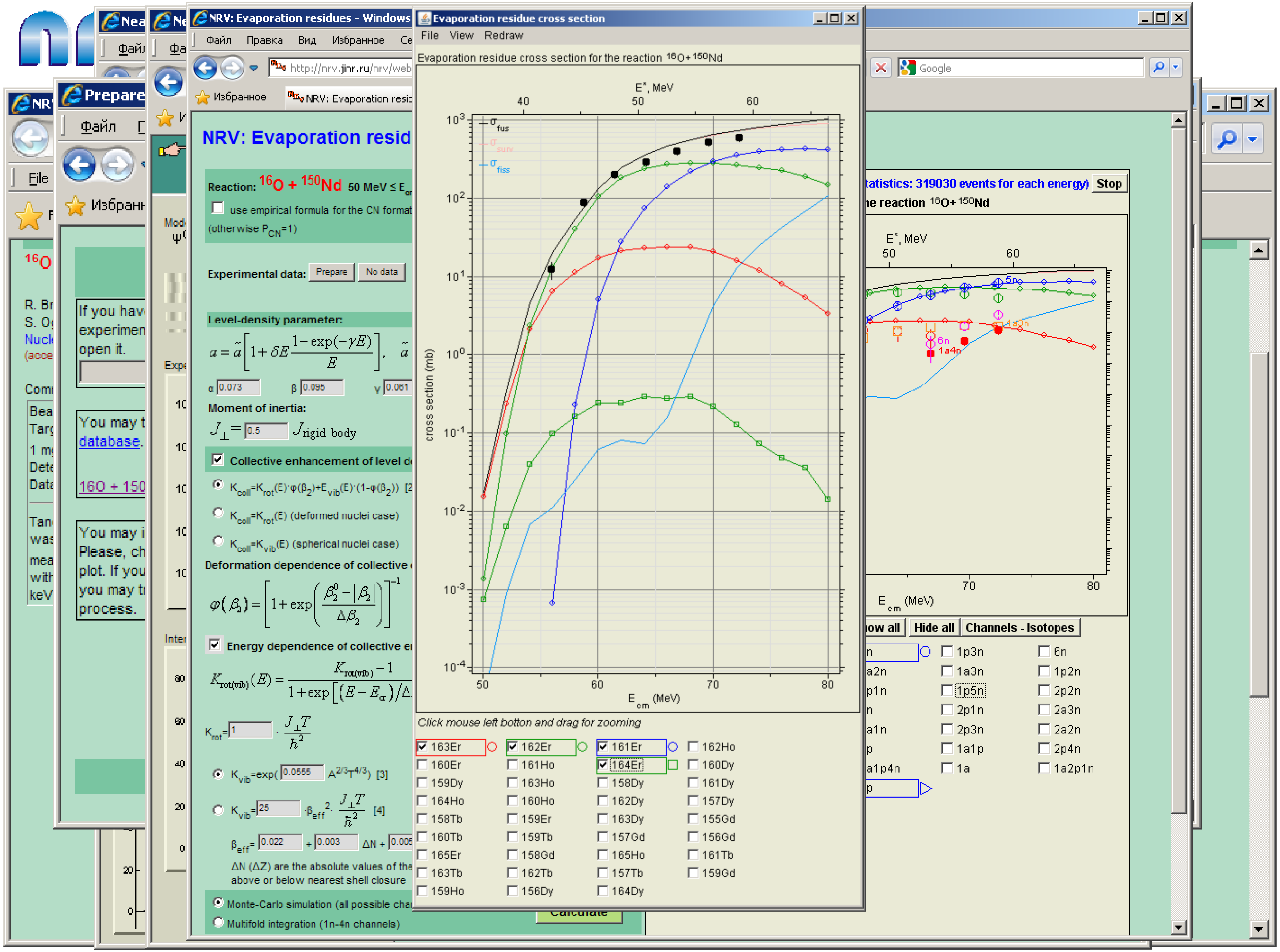
✓ Multifold integration method

$$P_{xn} = \int_0^{E_0^*-B_n(1)}\frac{\Gamma_n}{\Gamma_{tot}}(E_0^*,I_0)\cdot W_n(E_0^*,e_1)de_1\int_0^{E_1^*-B_n(2)}\frac{\Gamma_n}{\Gamma_{tot}}(E_1^*,I_1)\cdot W_n(E_1^*,e_2)de_2\ldots$$

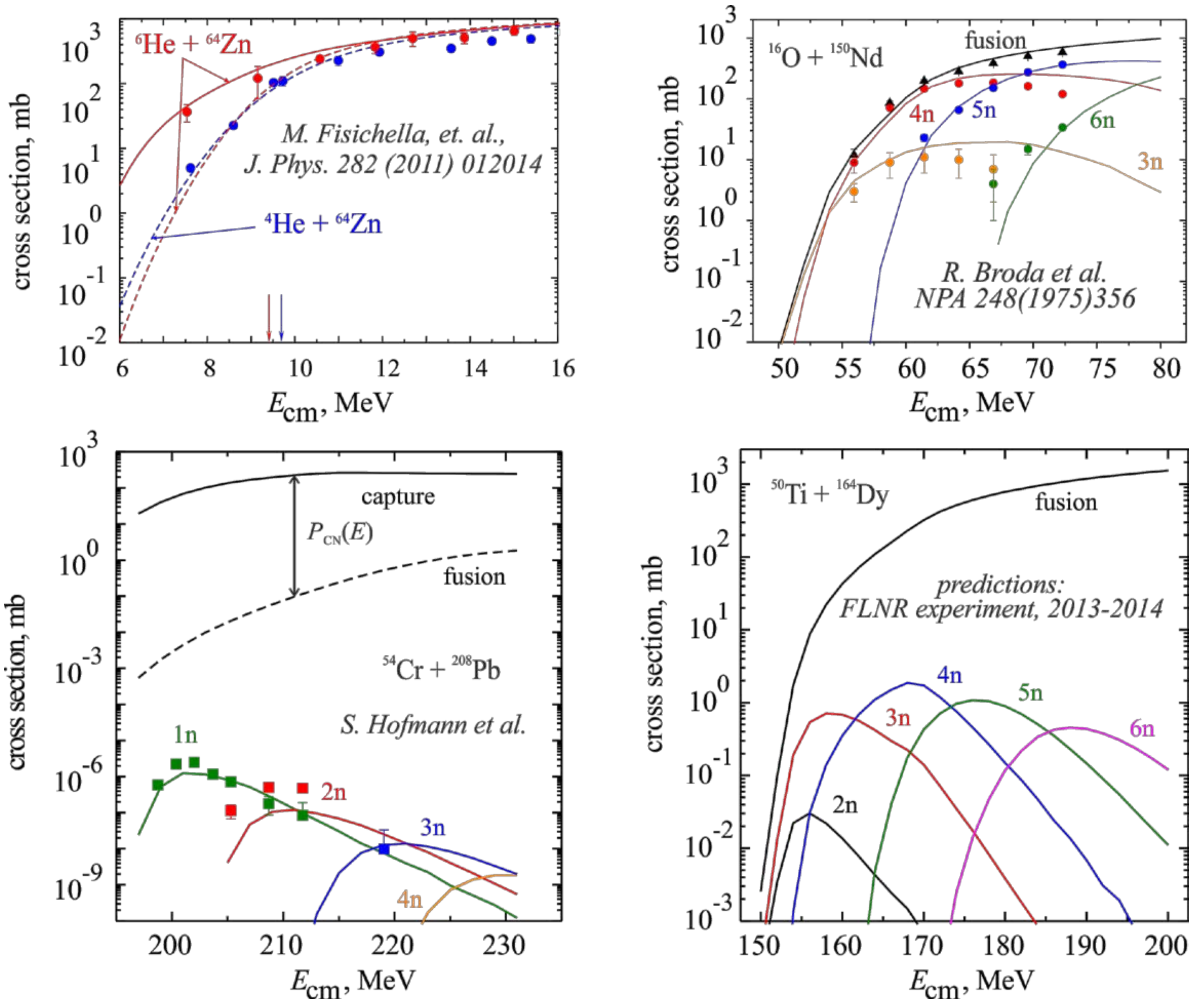
x-fold integration for survival probability in xn channel

$$\int_0^{E_{x-1}^*-B_n(x)}\frac{\Gamma_n}{\Gamma_{tot}}(E_{x-1}^*,I_{x-1})\cdot W_n(E_{x-1}^*,e_x)\cdot\prod_{i=1}^{N}\frac{\Gamma_\gamma}{\Gamma_{tot}}(E_i^*,I_i)\cdot de_x$$

Nuclear Models: Fusion-fission-surviving


NRV: Evaporation residues - Windows
Evaporation residue cross section
File View Redraw
Evaporation residue cross section for the reaction 16O+150Nd
E*, MeV
σfus
σsurv
σfiss
cross section (mb)
E cm (MeV)
Click mouse left botton and drag for zooming
163Er
162Er
161Er
162Ho
160Er
161Ho
164Er
160Dy
159Dy
163Ho
158Dy
161Dy
164Ho
160Ho
162Dy
157Dy
158Tb
159Er
163Dy
155Gd
160Tb
159Tb
157Gd
156Gd
165Er
158Gd
165Ho
161Tb
163Tb
162Tb
157Tb
159Gd
159Ho
156Dy
164Dy
NRV: Evaporation resid
Reaction: 16O + 150Nd
use empirical formula for the CN format
Experimental data:
Prepare
No data
Level-density parameter:
Moment of inertia:
Collective enhancement of level d
Kcoll=Krot(E) (deformed nuclei case)
Kcoll=Kvib(E) (spherical nuclei case)
Deformation dependence of collective
Energy dependence of collective e
ΔN (ΔZ) are the absolute values of the
above or below nearest shell closure
Monte-Carlo simulation (all possible cha
Multifold integration (1n-4n channels)
Calculate
tatistics: 319030 events for each energy)
Stop
Hide all
Channels - Isotopes
1p3n
6n
1a3n
1p2n
1p5n
2p2n
2p1n
2a3n
2p3n
2a2n
1a1p
2p4n
1a
1a2p1n
http://nrv.jinr.ru/nrv/web
Google
Файл
Правка
Вид
Избранное
If you have experimen open it.
You may database.
16O + 150
Please, ch plot. If you you may t process.

Tool for analysis and prediction

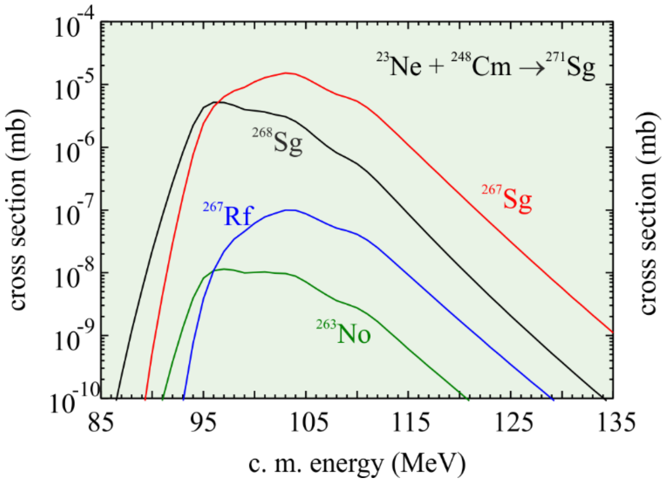


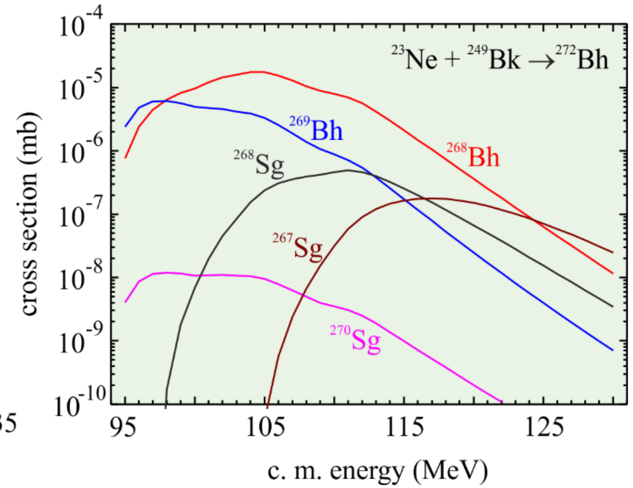
Tool for prediction: New isotopes with Z =102 – 107

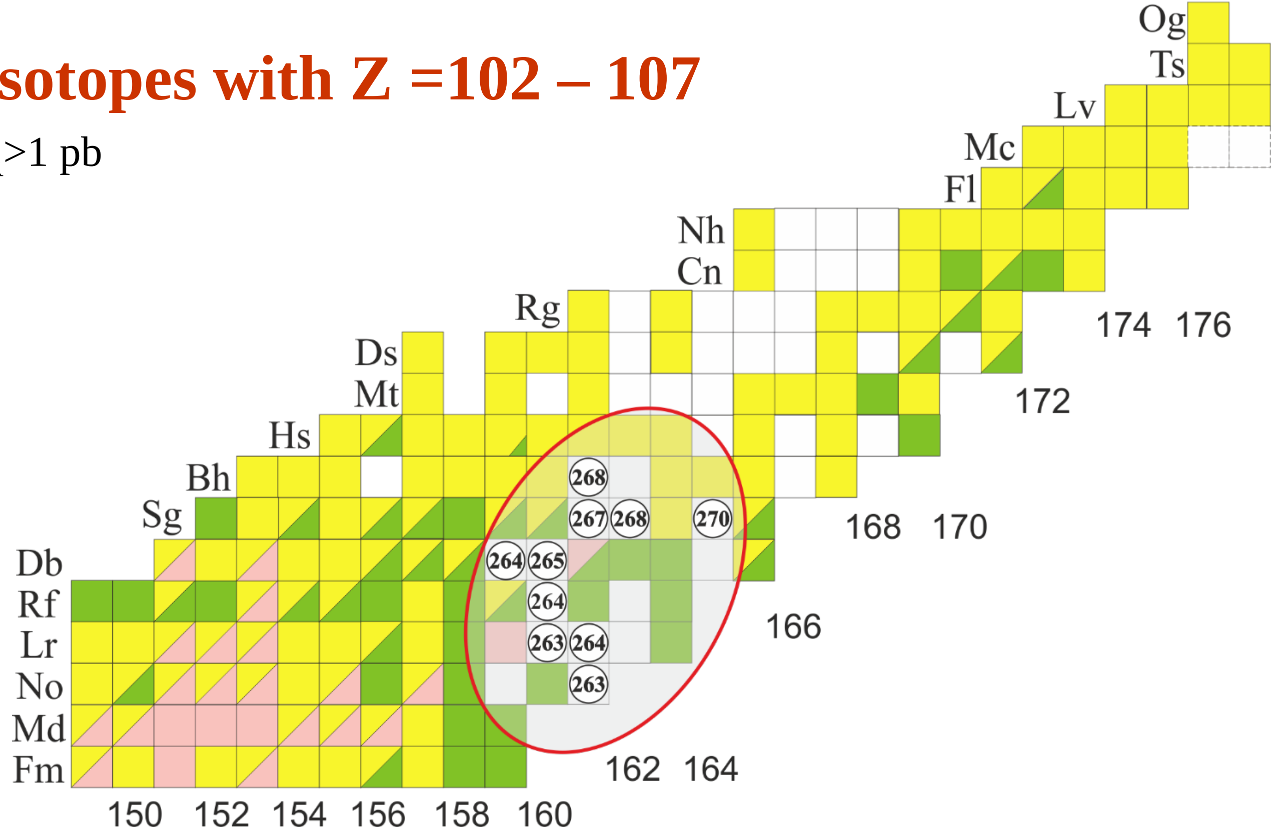
Projectile + target systems were chosen for which σ_{ER}>1 pb

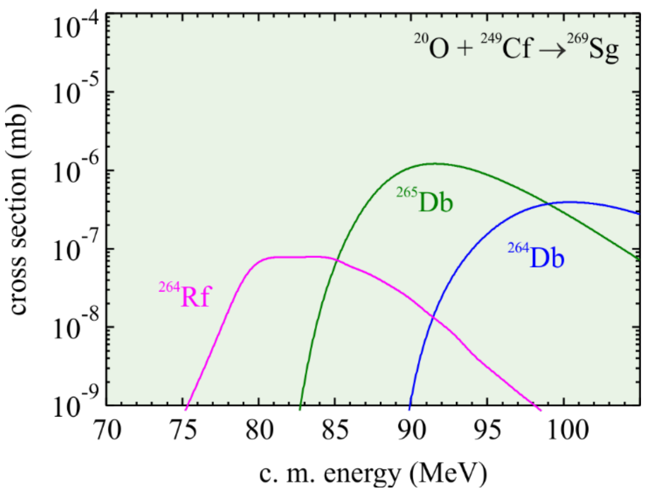
Projectile
^{22}Ne, ^{23}Ne, ^{20}O

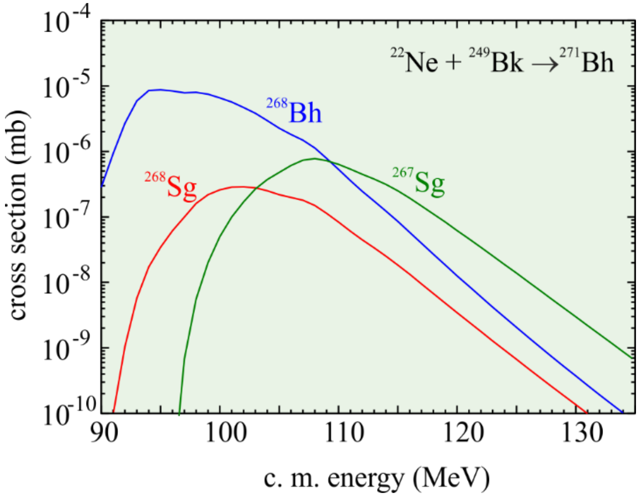
Targets
^{248}Cm, ^{249}Cf, ^{249}Bk

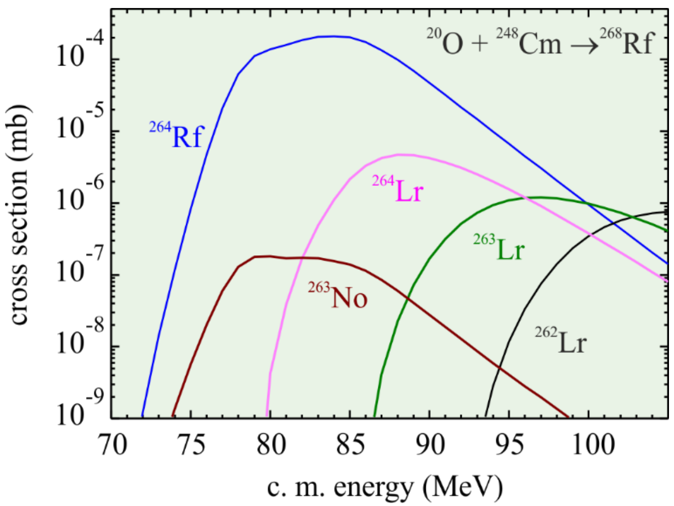












A.V. Karpov, V.A. Rachkov, V.V. Saiko, LPEPAN (2018)

Statistics of use of the Knowledge base

http://nrv.jinr.ru

Year	**Nuclear data** Nr. of searches	**Computational codes** Nr. of runs
2011	17 000	20 000
2012	36 000	21 000
2013	197 000	32 000
2014	199 000	36 000
2015	96 000	36 000
2016	115 000	60 000
2017	165 000 / year ~450 / day 1 every 3 minutes!	170 000 / year ~460 / day 1 every 3 minutes!

The most intensively using countries except Russia (*according to feedbacks and journal citations*):

USA, Egypt, Germany, France, China, India, Italy, Poland

Educational potential of the NRV system

Background:
many-years experience of the NRV use for education in Dubna University and UC JINR Summer Student Programme.

Purpose:
development of practical courses on nuclear physics based on the NRV

Collaboration:
common project with UNISA (Prof. M.L. Lekala) started 2016

nrv

http://nrv.jinr.ru

Unique on-line research instrument

Everyone, Everywhere, Free

The NRV Team:

Prof. V. Zagrebaev
The project founder
(1950-2015)

Dr. A. Karpov

Dr. A. Denikin

Todays project leaders

A. Alekseev

Web programmer

V. Rachkov

M. Naumenko

Prof. V. Samarin

V.V. Saiko

Prof. M.L. Lekala
UNISA

Students…