Fission of U-238 and Pu-239 production in subcritical assembly

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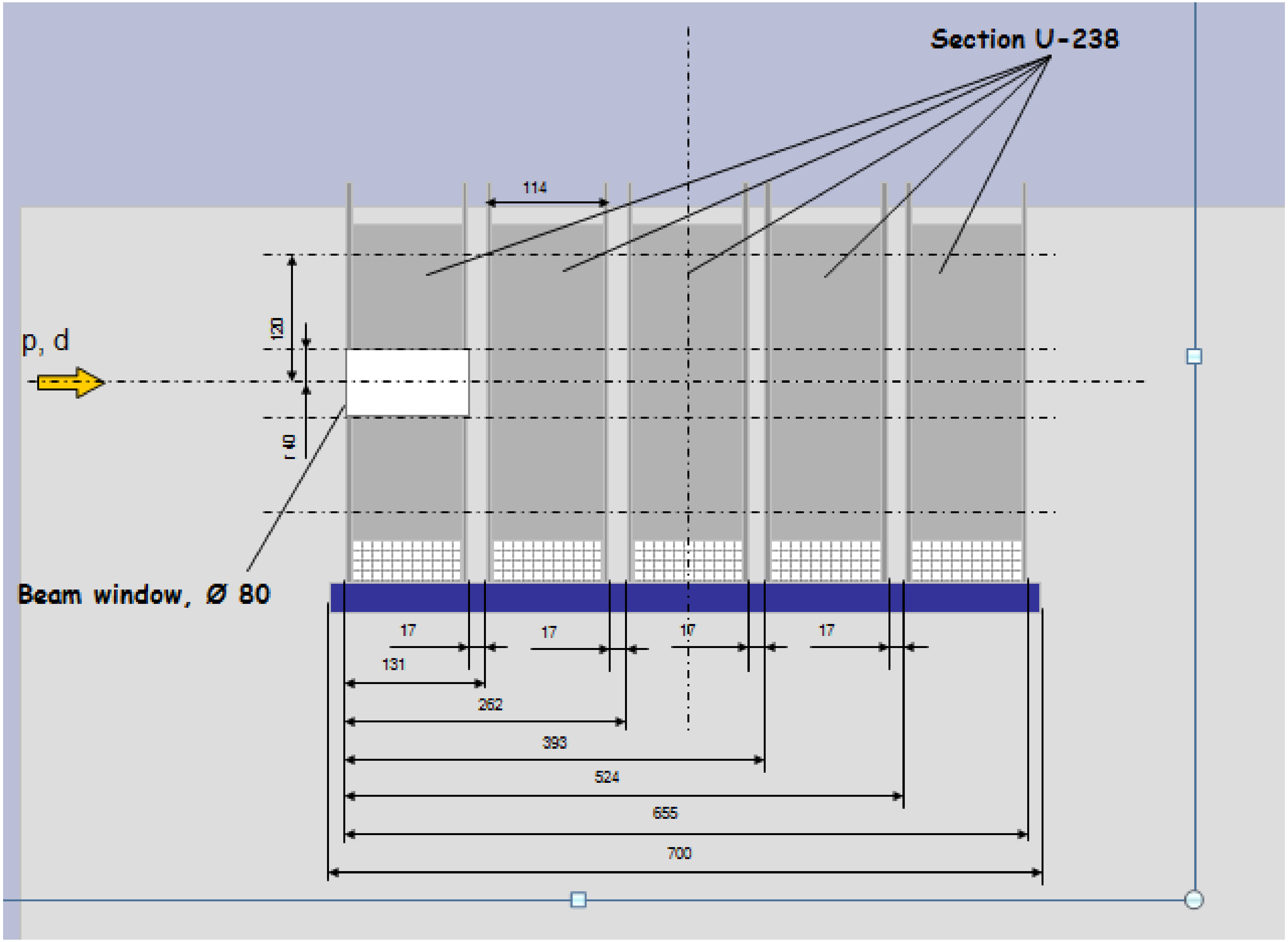
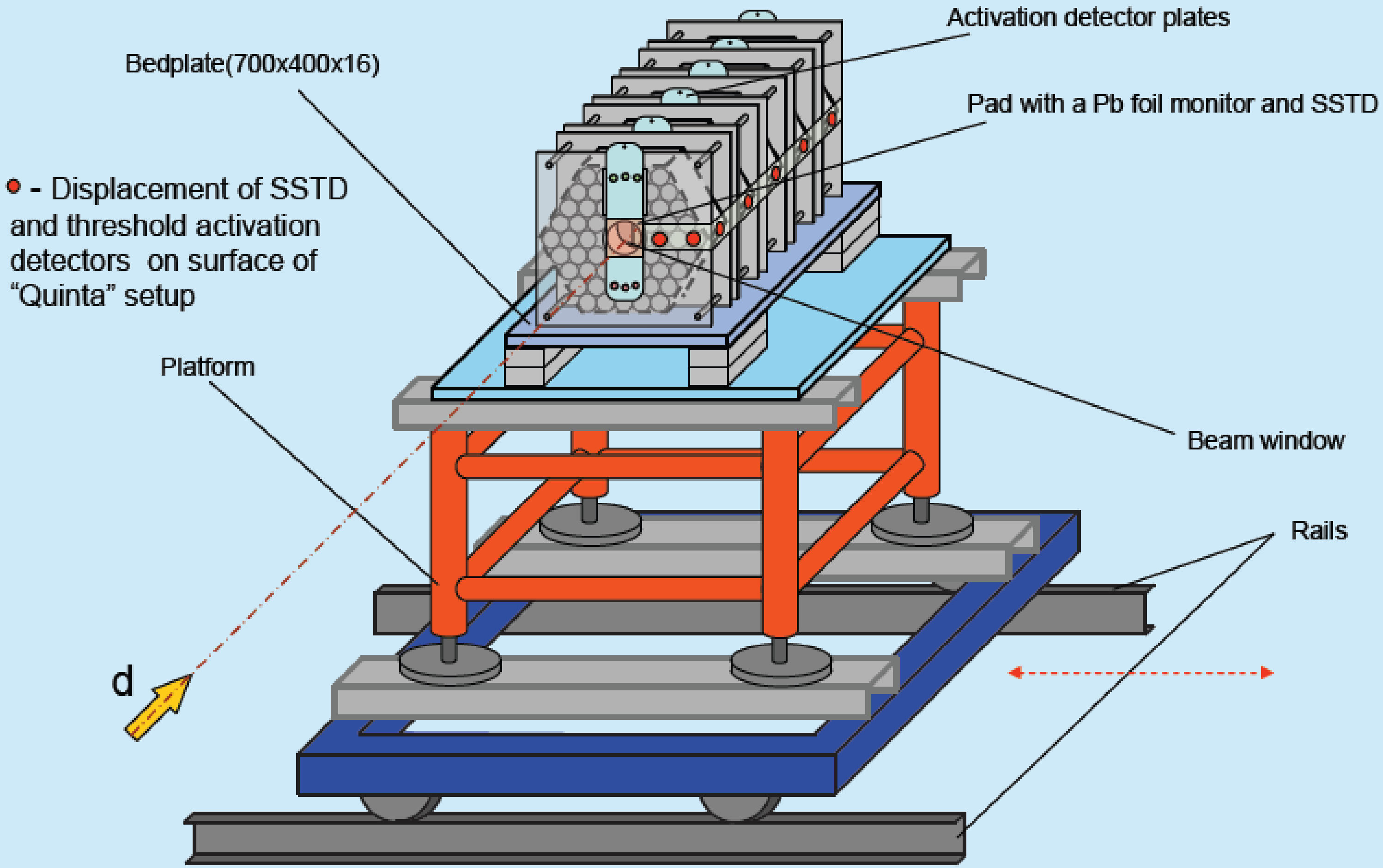


Section U-238
114
p, d
120
r 40
Beam window, Ø 80
17
17
17
17
131
262
393
524
655
700

Layout of upgraded target assembly "Quinta" at the irradiation position

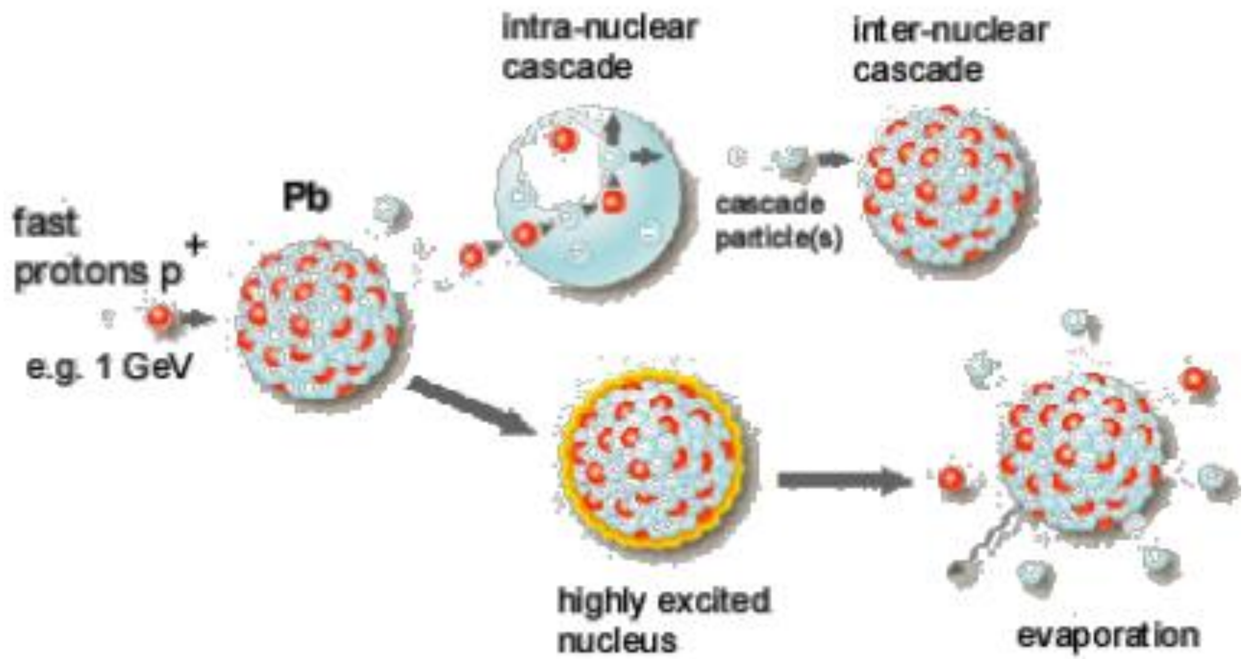


- Experiment was run with using a PHASOTRON in Dzhelepov Laboratory of Nuclear Problems in JINR, Dubna
- Exercise is based on the results of experimental collaboration **„Energy and Transmutation of Radioactive Wastes"**
- **Project supervisor**: SergeyTiutiunnikov
- **Members of a group** : Russia (JINR Dubna, CPTP Atomenergomash, Moscow, Russia, Obmińsk),Belaruss, Poland, Czech Republic, Germany, France, Greece, Mongolia, Ukraine, Australia.
- Experimental data comes from experiment run by prof. Voronko and his group of scientist from Ukraine. Experiment took place in November 2014 in **Laboratory of Information Technologies in Dubna**
- Research connected with particle beam profile was run by Lukas Zavorka from Czech Republic
- **Experimental data are obtained for activation detector**

Purpose of the project?

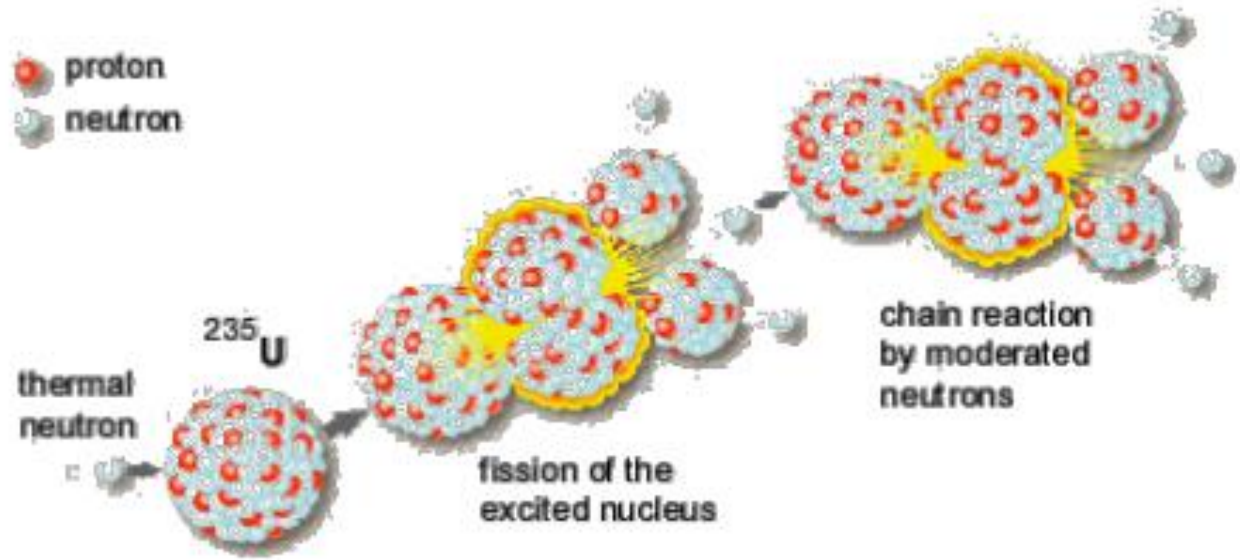
- Computer simulation in MCNPx code
- Comparison the results to experimental data derived from the experiment executed in Dubna in November 2014
- **Researching the way of using the fission of U238 in nuclear energy sector**
- **Researching Pu239 production**

Sources of neutrons - spallation



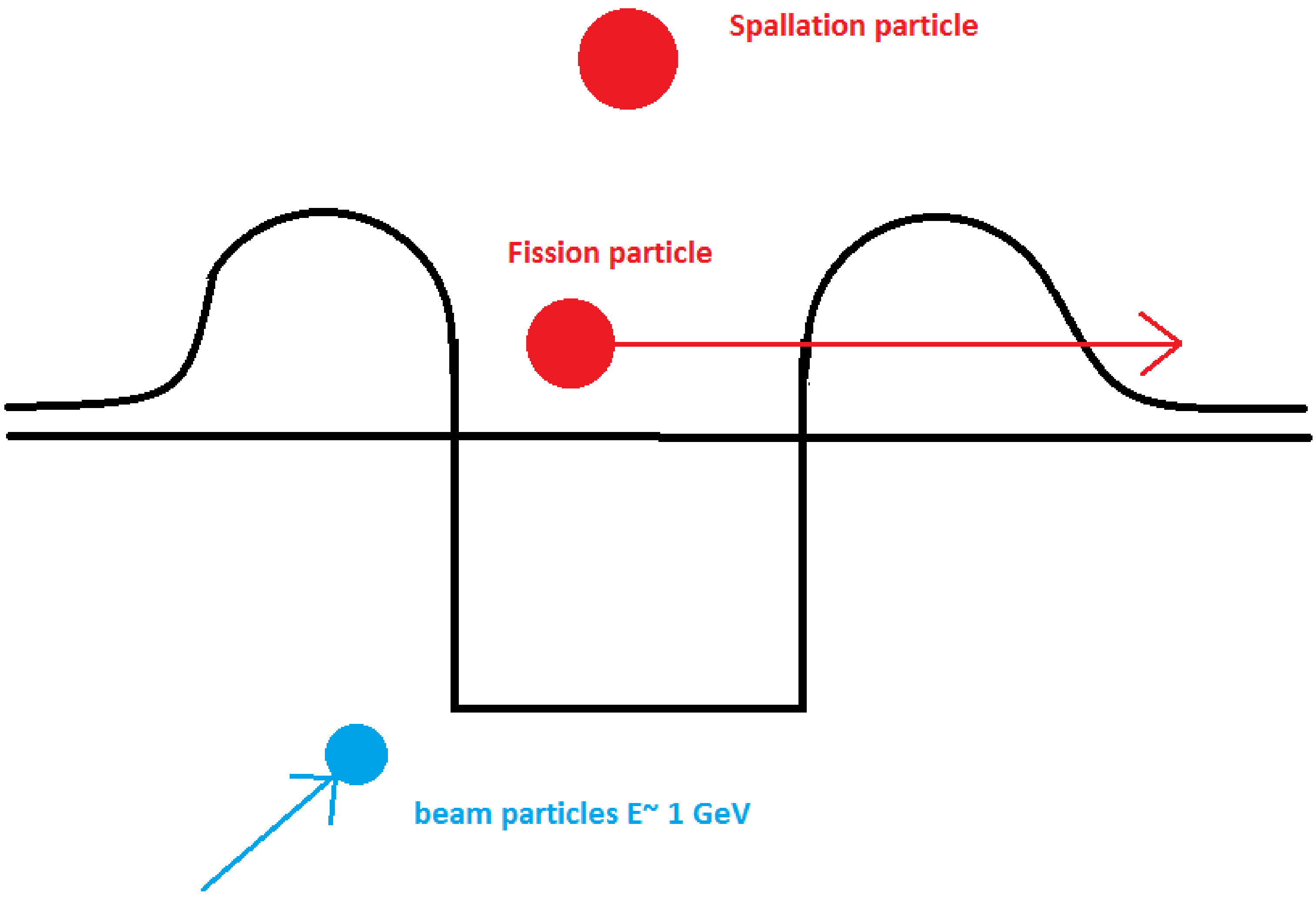
- It happens in a short time – 10^{-23} [s]
- Not a chain reaction – pulsed operation
- Accelerator driven – high energy protons E~1 [GeV]
- ~ 20 neutrons/proton when E=0.66 [GeV] (U238 target)
- ~ 60 neutrons/proton when E=1.5 [GeV] (U238 target)

Sources of neutrons - fission



- process slower than spallation – may occur after spallation
- Chain reaction
- Continous flow
- ~ 2.5 neutron/fission

Spallation vs fission

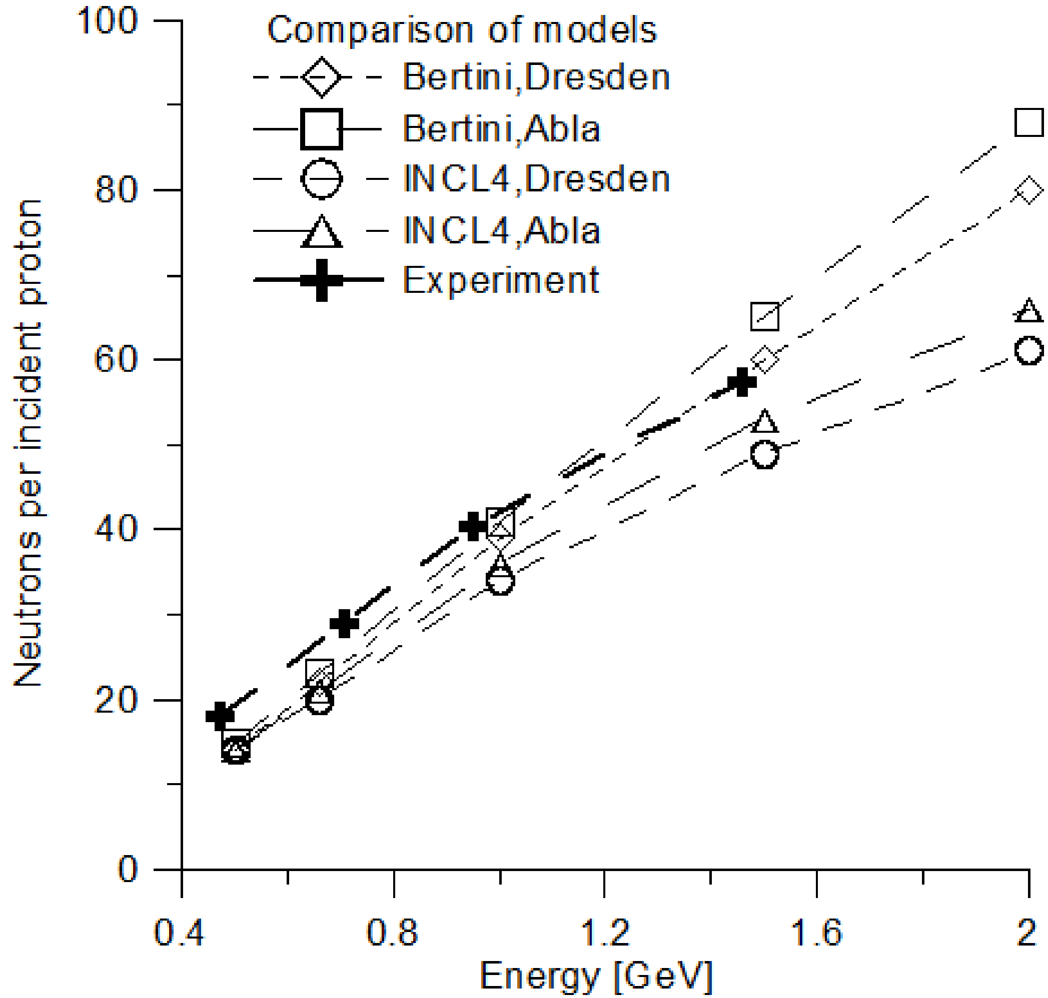


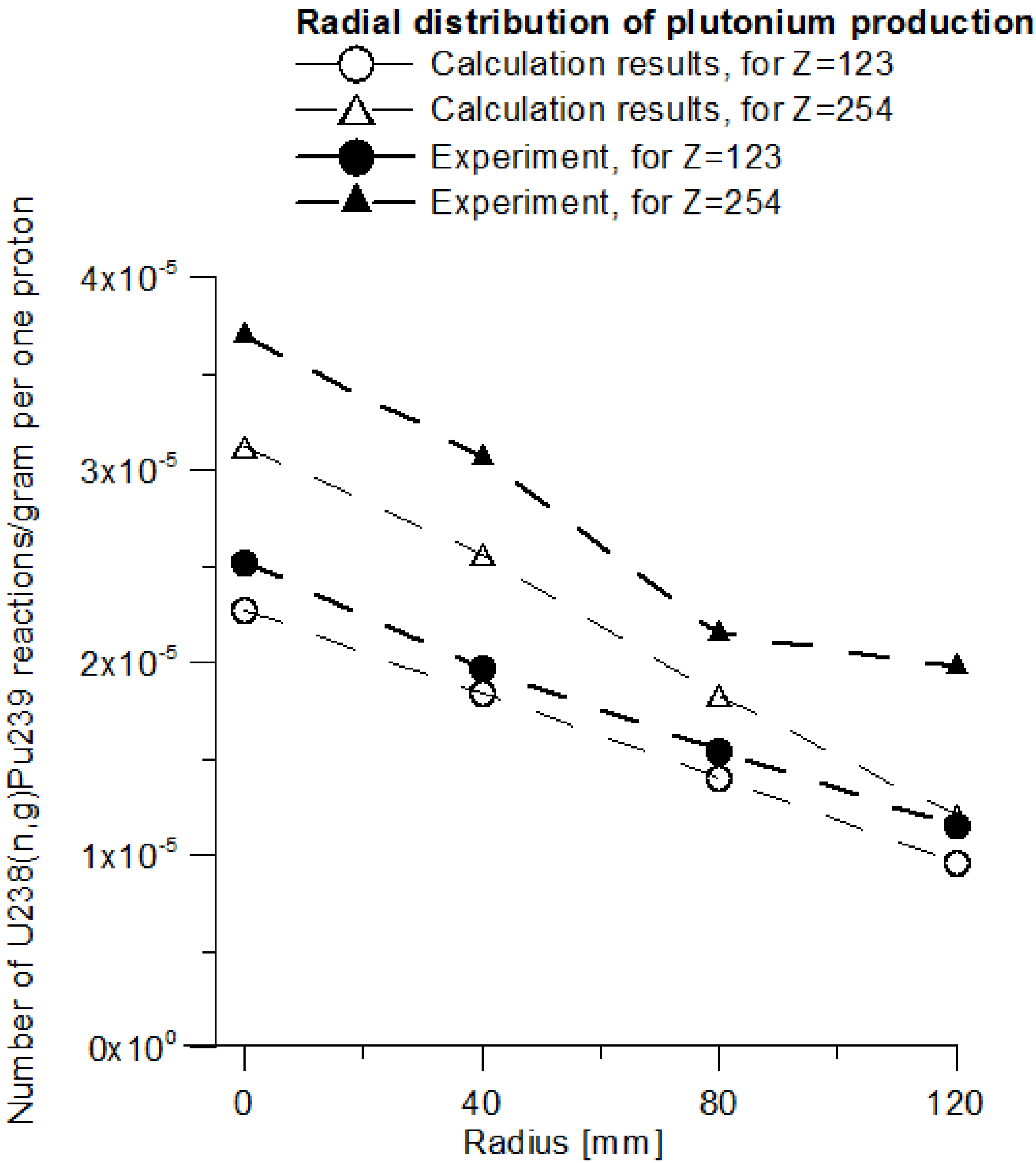
Source of experimental data:

Measured Spallation Neutron Yield vs. Proton Energy for Various Targets, J. Frazer, et al. (1965)

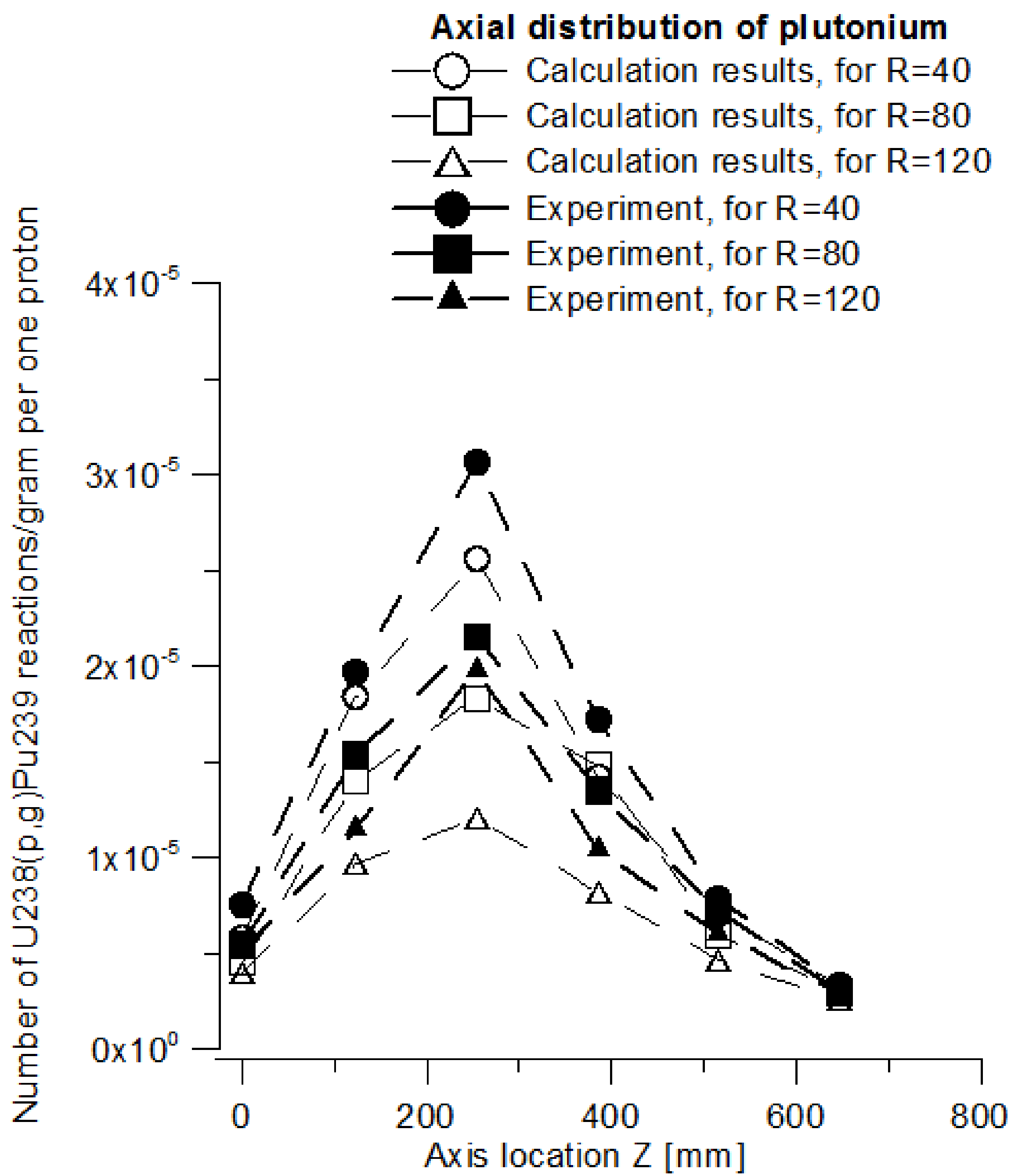
For E=<660 MeV models gives results less than experimental data about 17%

Measured spallation neutron yield vs proton energy for uranium target compared to calculations



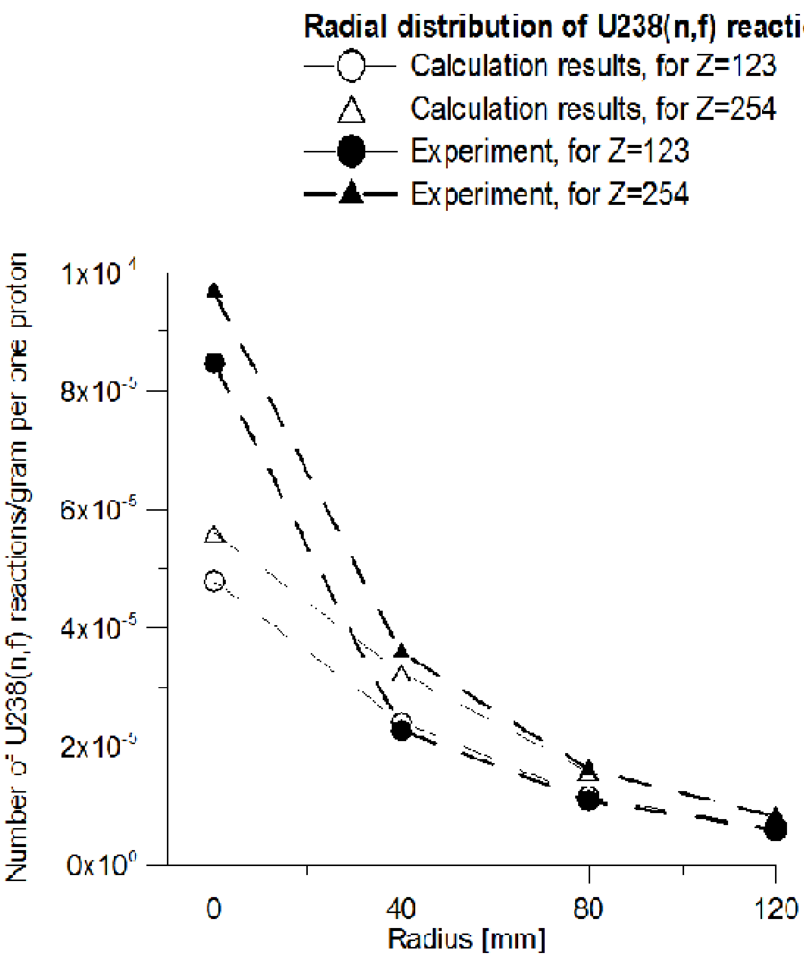


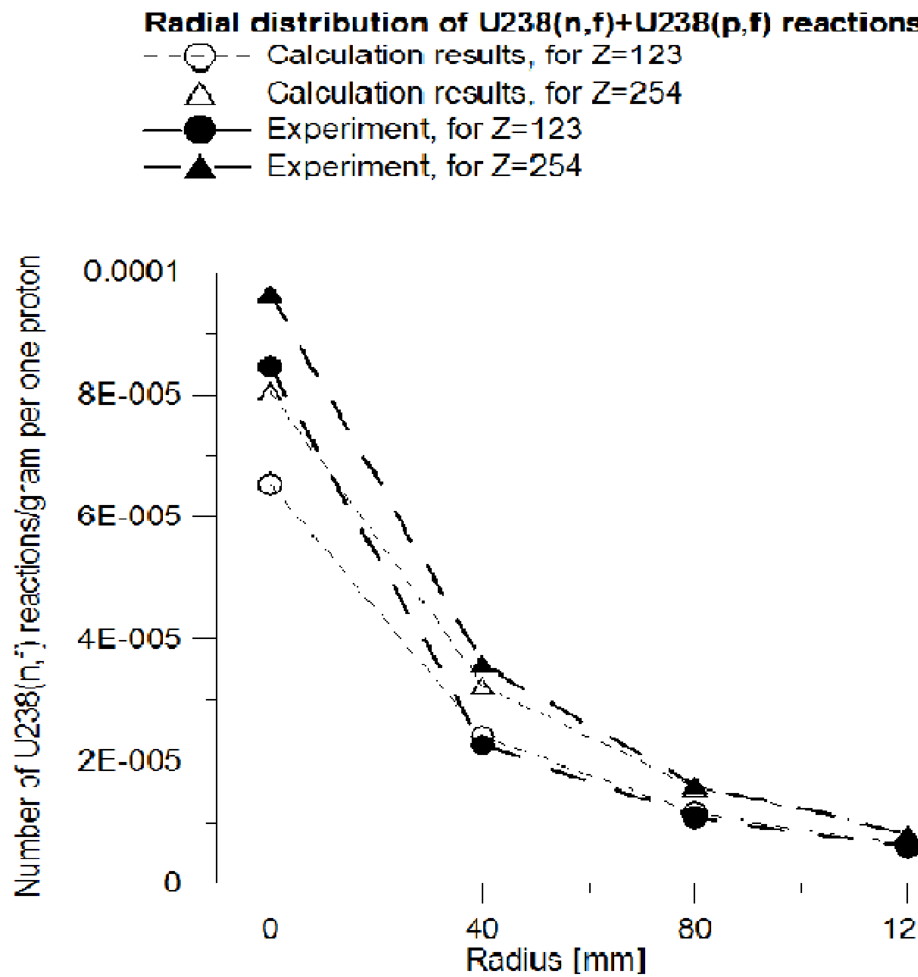
Radial distribution of plutonium production
Calculation results, for Z=123
Calculation results, for Z=254
Experiment, for Z=123
Experiment, for Z=254
Number of U238(n,g)Pu239 reactions/gram per one proton
4x10-5
3x10-5
2x10-5
1x10-5
0x100
0
40
80
120
Radius [mm]

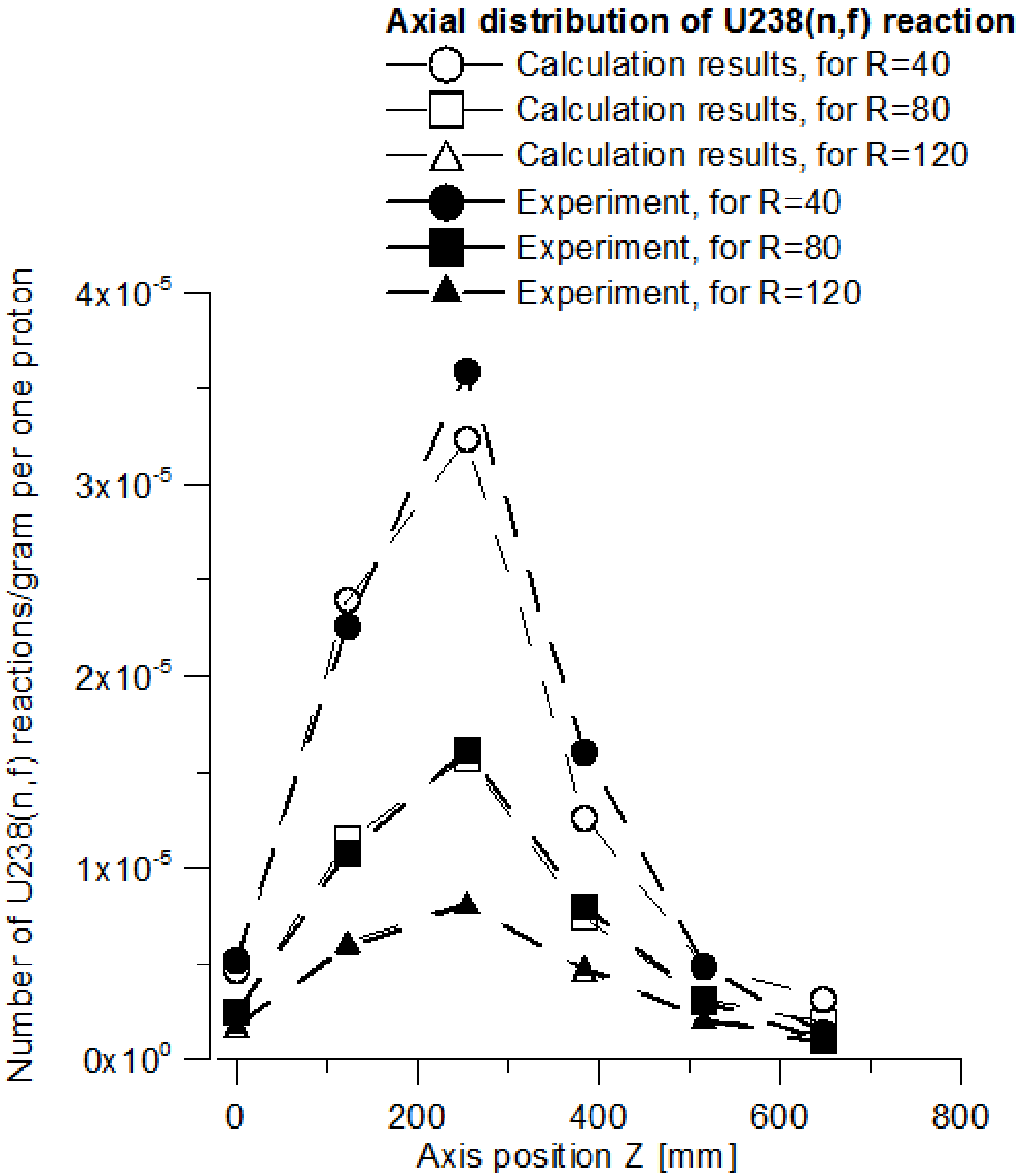


Axial distribution of plutonium
Calculation results, for R=40
Calculation results, for R=80
Calculation results, for R=120
Experiment, for R=40
Experiment, for R=80
Experiment, for R=120
Number of U238(p,g)Pu239 reactions/gram per one proton
4x10-5
3x10-5
2x10-5
1x10-5
0x100
0
200
400
600
800
Axis location Z [mm]

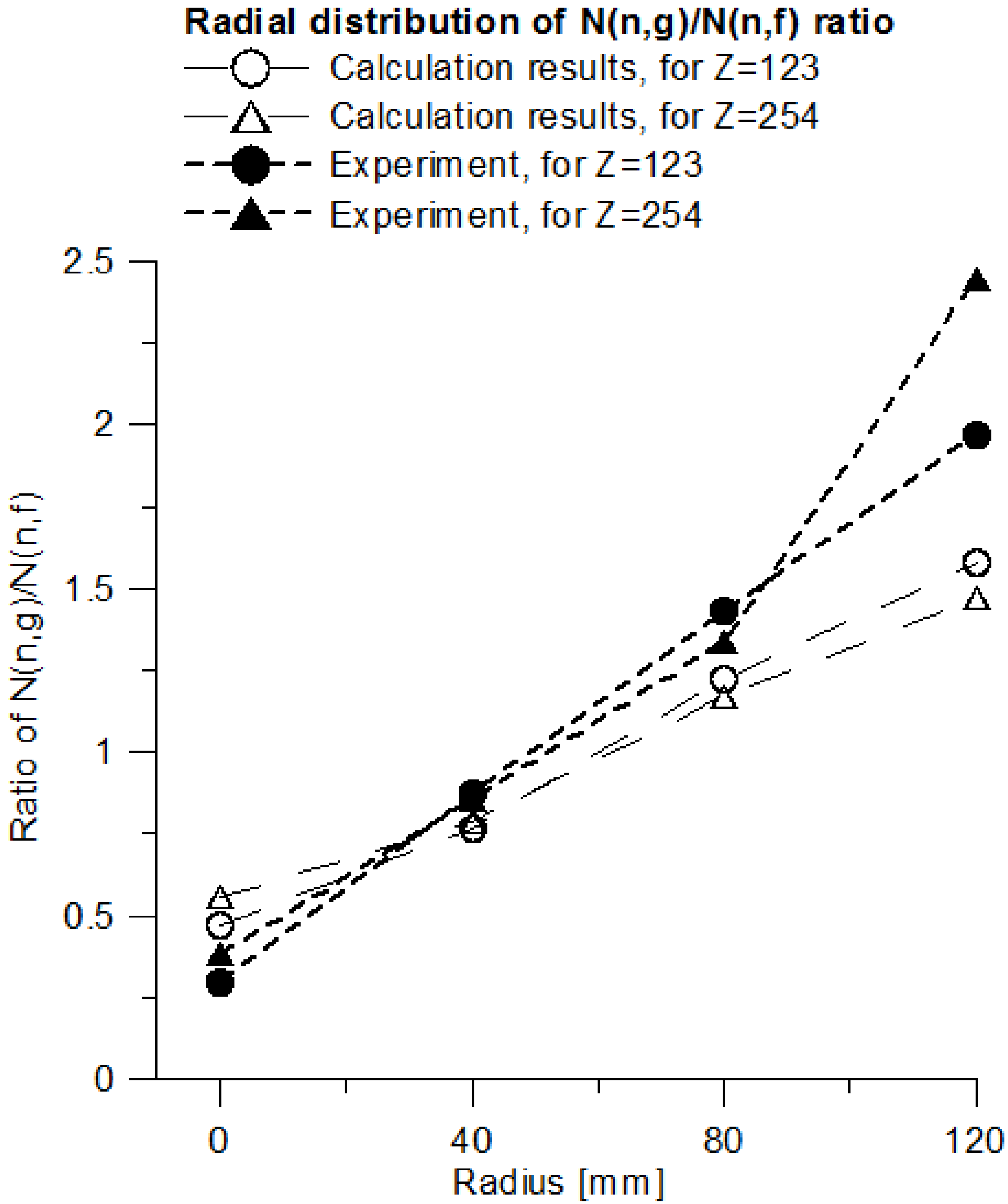
Comparison – before and after considering proton flux resulted by spallation reaction





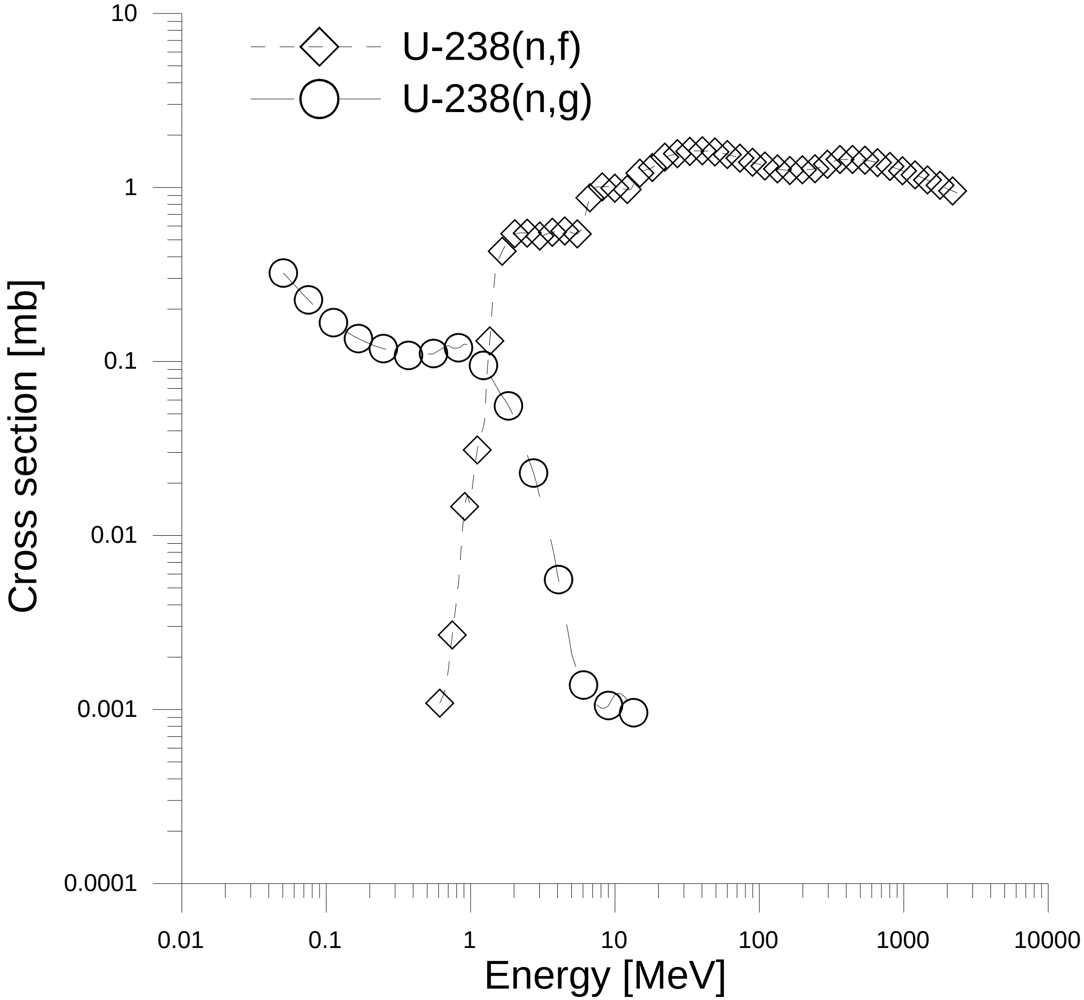


Axial distribution of U238(n,f) reaction
Calculation results, for R=40
Calculation results, for R=80
Calculation results, for R=120
Experiment, for R=40
Experiment, for R=80
Experiment, for R=120
Number of U238(n,f) reactions/gram per one proton
4x10^-5
3x10^-5
2x10^-5
1x10^-5
0x10^0
0
200
400
600
800
Axis position Z [mm]


Radial distribution of N(n,g)/N(n,f) ratio
Calculation results, for Z=123
Calculation results, for Z=254
Experiment, for Z=123
Experiment, for Z=254
Ratio of N(n,g)/N(n,f)
2.5
2
1.5
1
0.5
0
0
40
80
120
Radius [mm]

Conclusions

- The spectral index is increasing because the average energy of neutrons decreases radially



Conclusions

- Bertini, Dresden model seems to be the most accurate to calculate the amount of neutrons coming from spallation; Most accurate fo E= 1[GeV]; the bigger energy of a particle the bigger difference between results of the models
- Bigger number of both U(n,f) and U(n,g) reactions occurs closer to the axis (the smaller radius the more reactions)

Conclusions

- We observe the hugest number of both reactions in the middle of uranium target assembly because of the geometry – in the middle there is the smallest escape probability
- During modeling the radial distribution of both U(n,f) and U(n,g) reactions it is more reliable to assume also U(p,f) reactions (by spallation)- more accurate results
- For E=<660 MeV models gives results less than experimental data about 17%; it is a main reason that the experimental data are greater than calculation results particullary U(n,g) reaction

Conclusions

- The results for U(n,f) reaction are more accurate to experimental data; it suggests that models used to calculations simulates neutron flux better for higher energy neutrons (>2 MeV) and worse for lower energies

Thank you for your attention!