Measurement of (n,α) Cross Section for Set of Structural Material Isotopes

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Motivation

- In the reactors structural material are used in intensive fast neutron flux.
- Structural material changing mechanical properties when concentrations of He and H are changed.
- Classical activation technique does not work (residual nuclei is stable).
- No experimental data for many reactions.

Some of structural material isotopes properties

Isotope	Natural abundance, %	(n,α) reaction Q-value, MeV
^{50}Cr, $T_{1/2}>1,8*10^{17}$ y, EC	4,345	+0,3213
^{52}Cr, stable	83,489	-1,2097
^{53}Cr, stable	9,501	+1,7903
^{54}Cr, stable	2,365	- 1,5466

Cr

Isotope	Residual nuclear	Stability
^{50}Cr	**^{47}Ti**	**Stable**
^{52}Cr	**^{49}Ti**	**Stable**
^{53}Cr	**^{50}Ti**	**Stable**
^{54}Cr	^{51}Ti	$T_{1/2}$=5,76 min

Fe

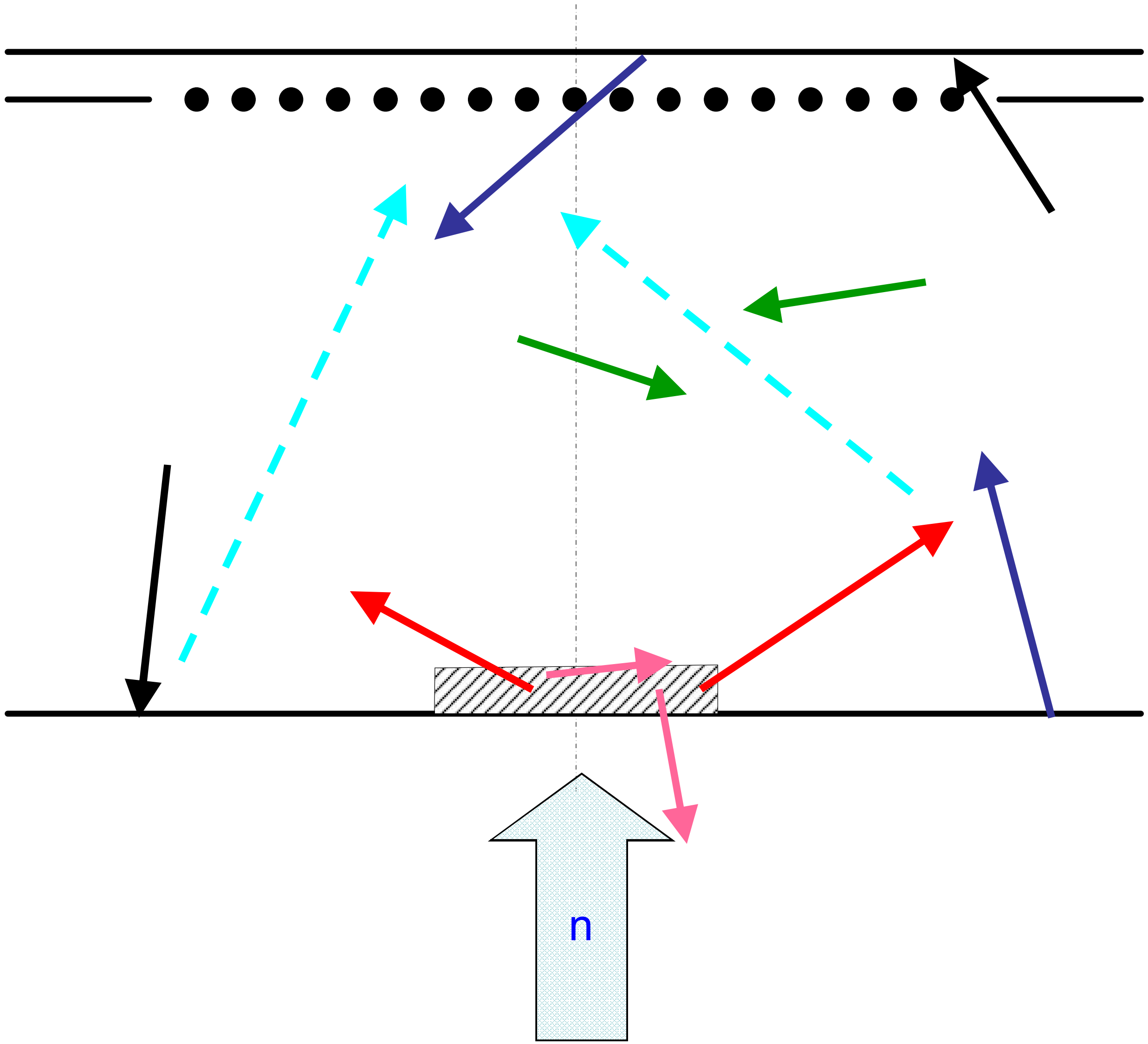
Isotope	Residual nuclear	Stability
^{54}Fe	**^{51}Cr**	**$T_{1/2}$=27,7 d, ec**
^{56}Fe	**^{53}Cr**	**Stable**
^{57}Fe	**^{54}Cr**	**Stable**
^{58}Fe	^{55}Cr	$T_{1/2}$=3,55 min

Ni

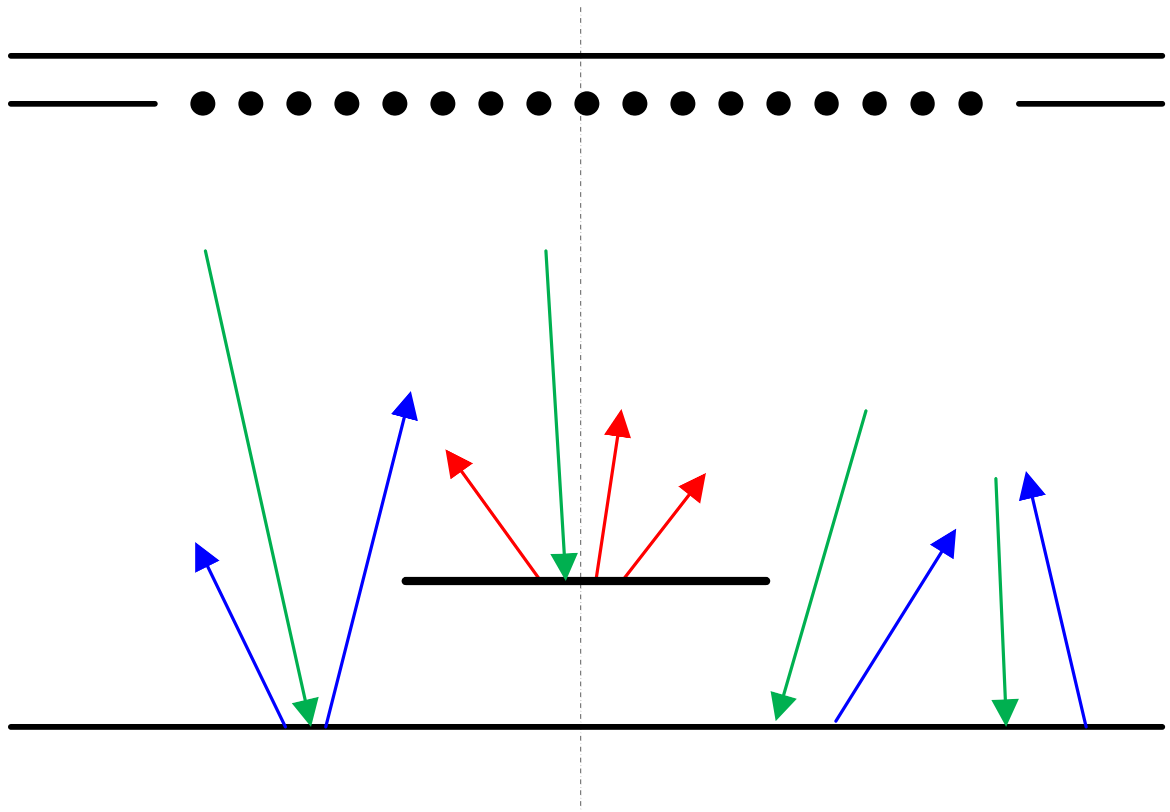
Isotope	Residual nuclear	Stability
^{58}Ni	**^{55}Fe**	**$T_{1/2}$=2,7 y, ec**
^{60}Ni	**^{57}Fe**	**Stable**
^{61}Ni	**^{58}Fe**	**Stable**
^{62}Ni	^{59}Fe	$T_{1/2}$=44,5 d

Classical spectrometer events classification

1. Target
2. Full absorption
3. Electrodes
4. Gas a-particles
5. Protons
6. Wall effect

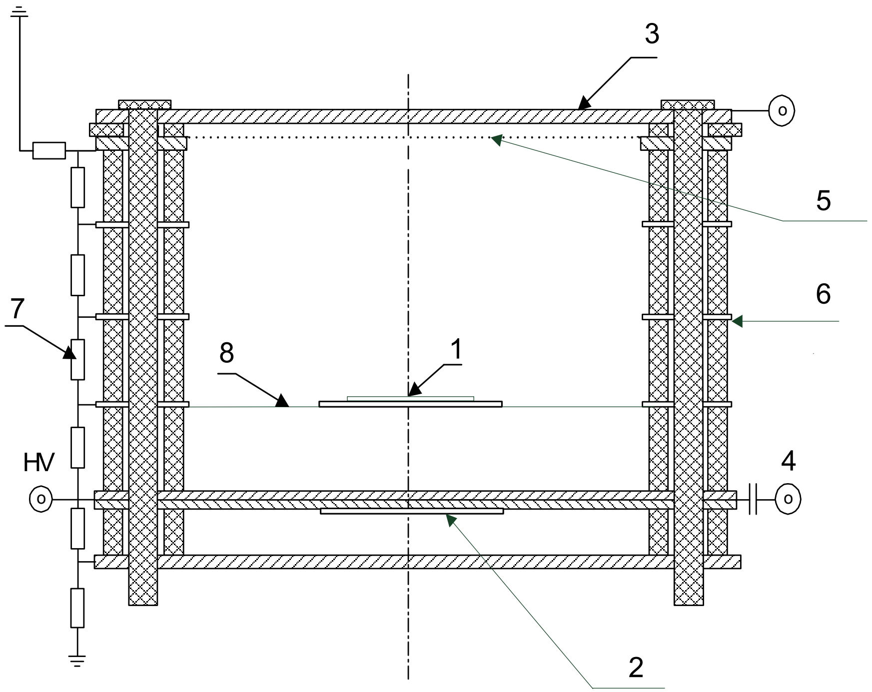


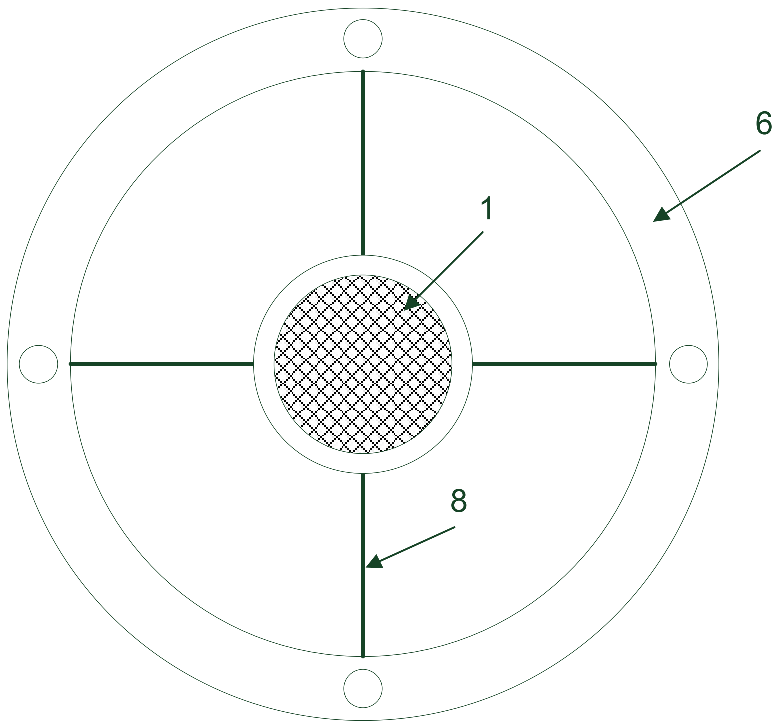
Motivations for removing solid target from cathode surface



1) Target surface 10 times less then cathode surface; Probability of gaseous particle absorption is proportional to the surface area.
2) Backing material – gold. Low probability for charge particle emission;

New chamber design

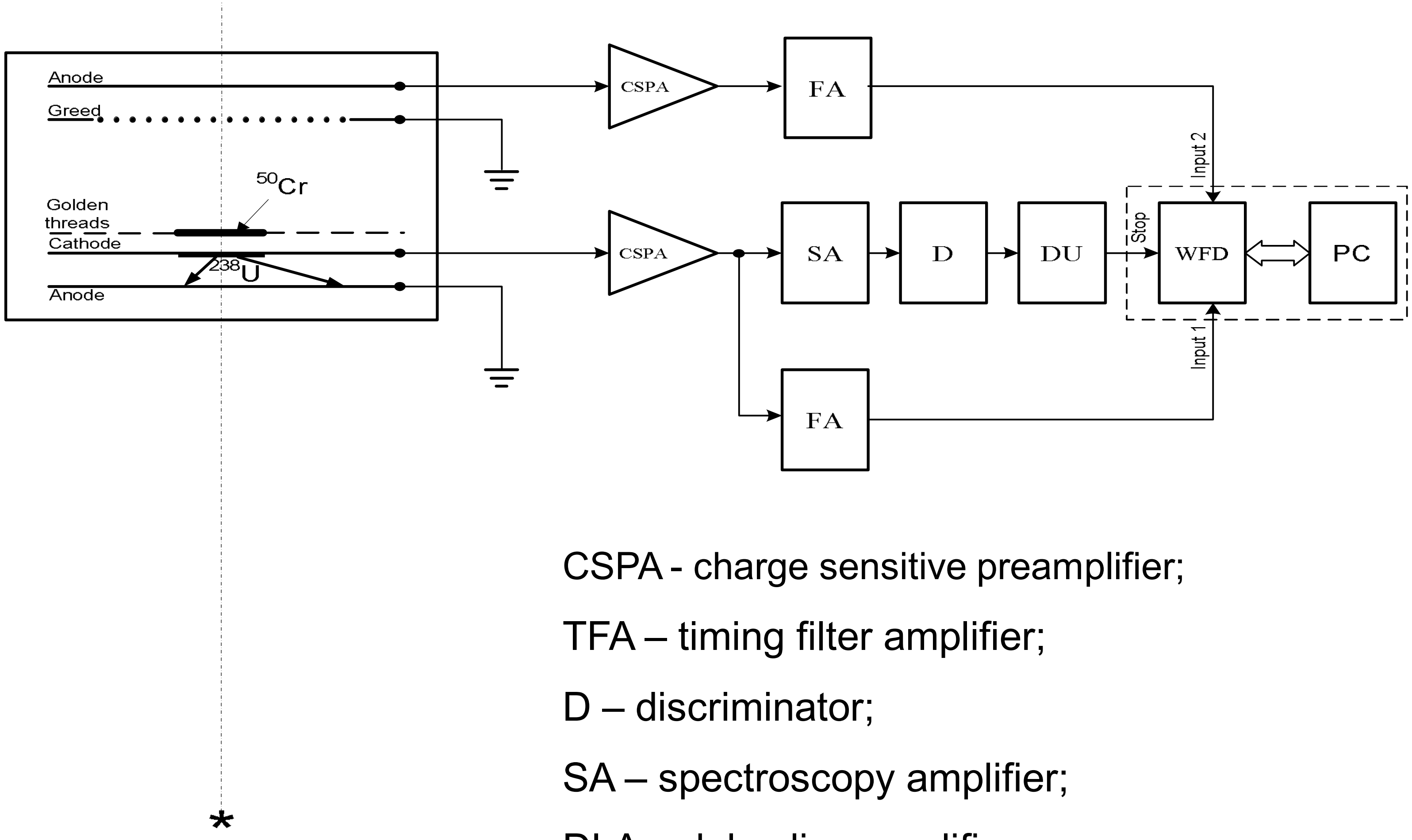




1) Cr target;
2) ^{238}U target;
3) Anode;
4) Anode signal connector;

5. Frisch grid;
6. Guard electrodes;
7. Resistor.
8. Golden threads

Scheme of the IPPE experimental setup



CSPA - charge sensitive preamplifier;

TFA – timing filter amplifier;

D – discriminator;

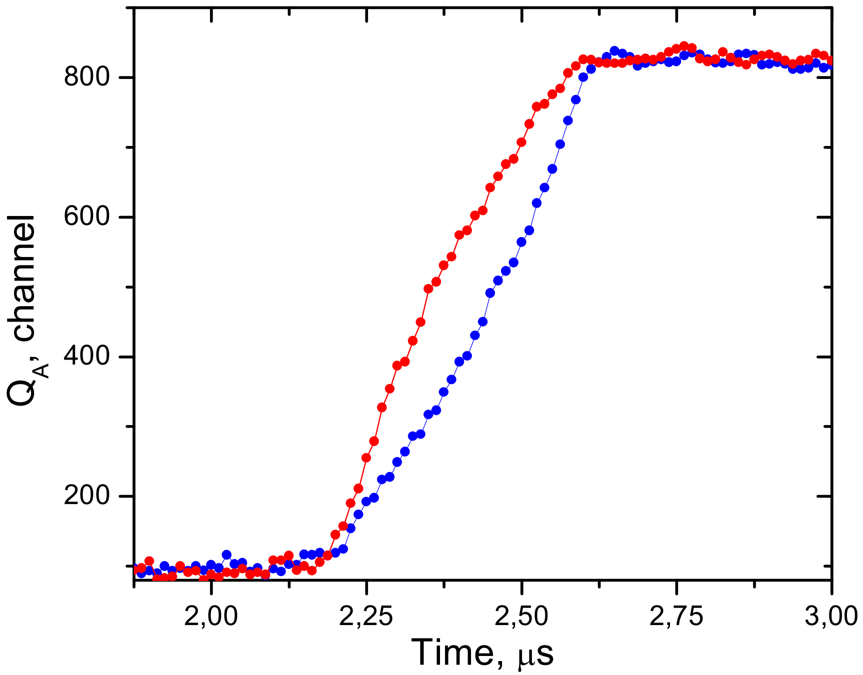
SA – spectroscopy amplifier;

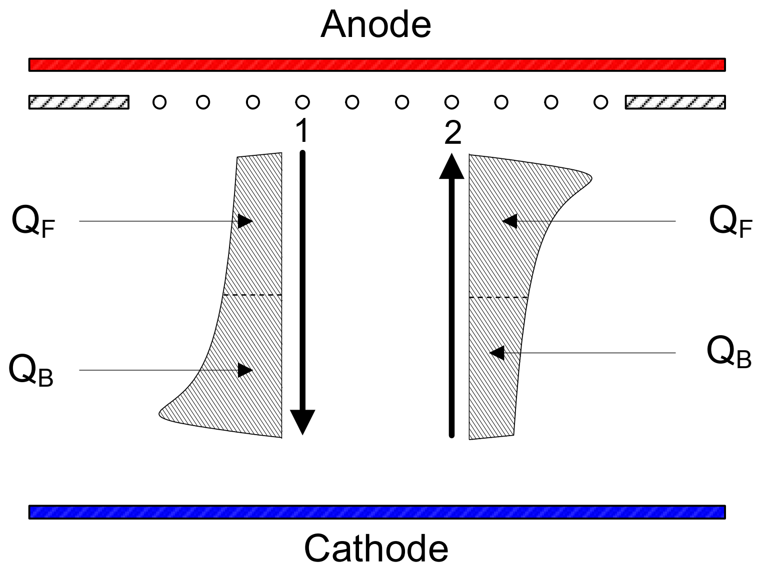
DLA – delay line amplifier

WFD – waveform digitizer

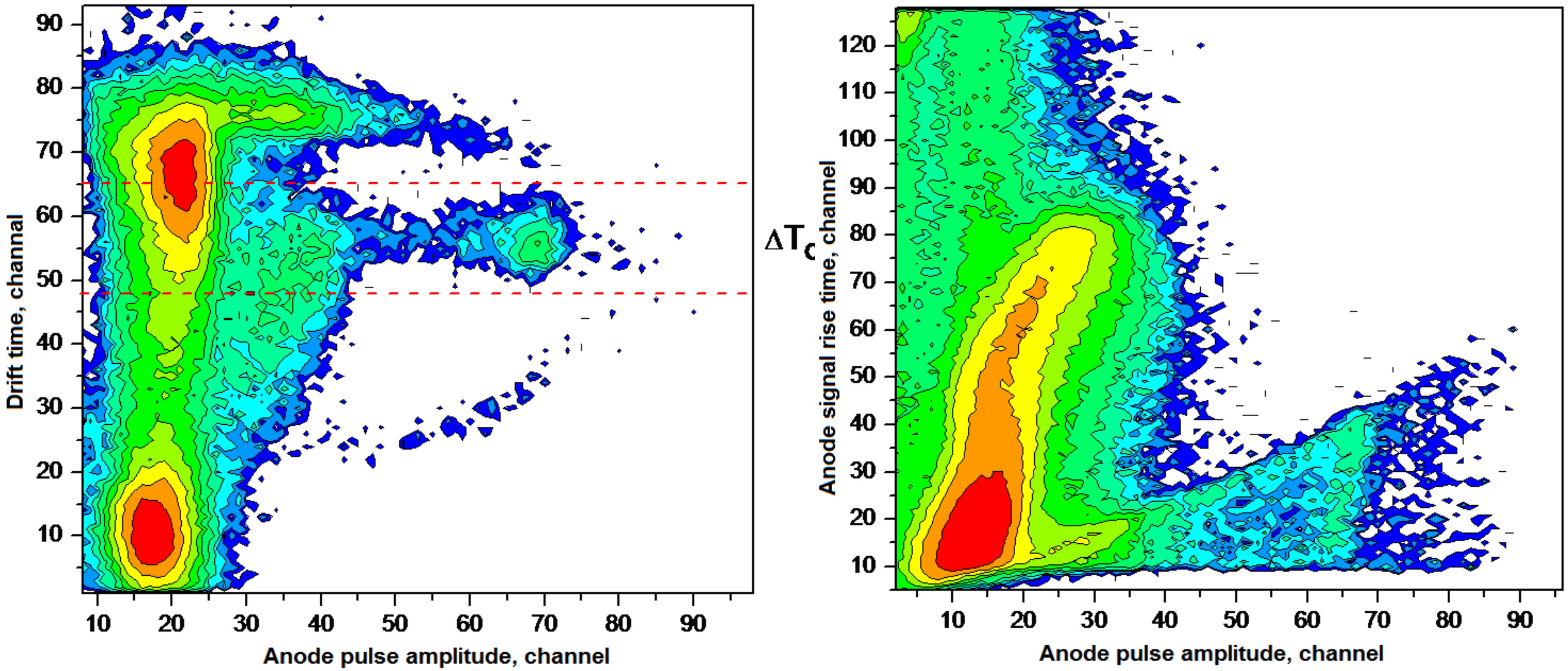
PC – personal computer.

α-particle directionality determination

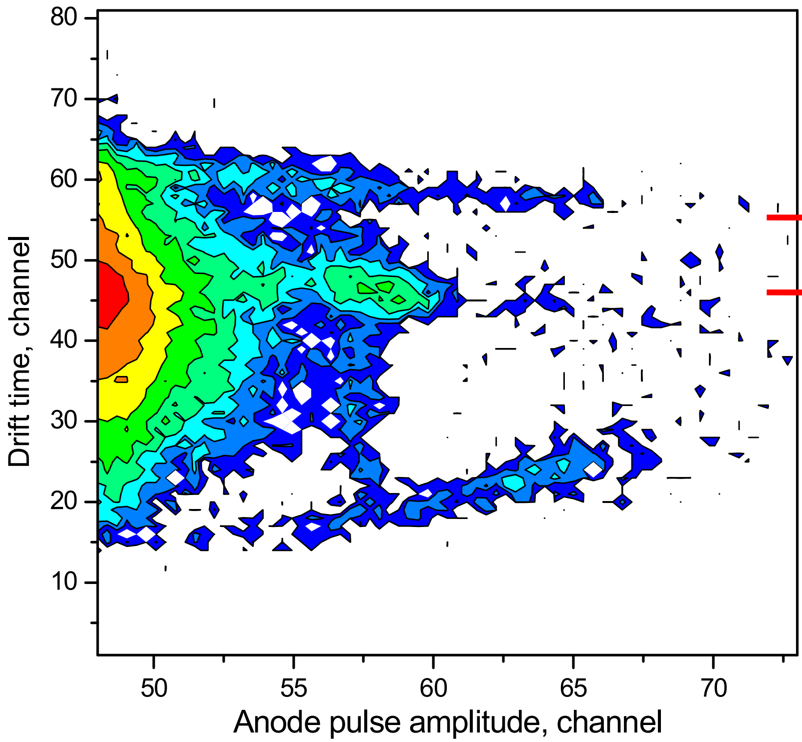


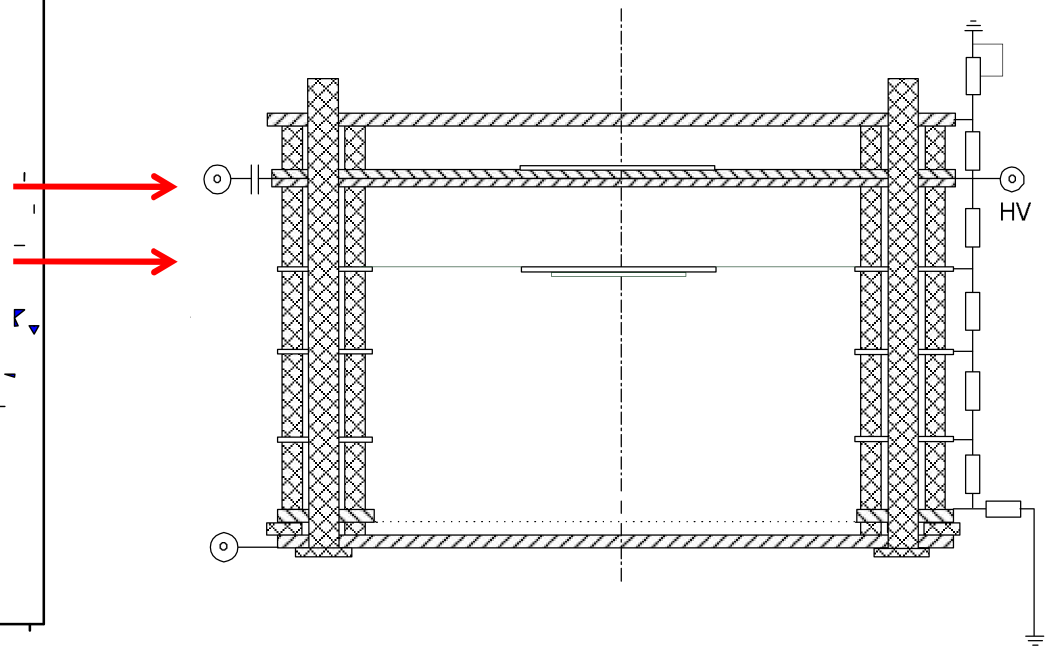


Particle position and type of particle determination

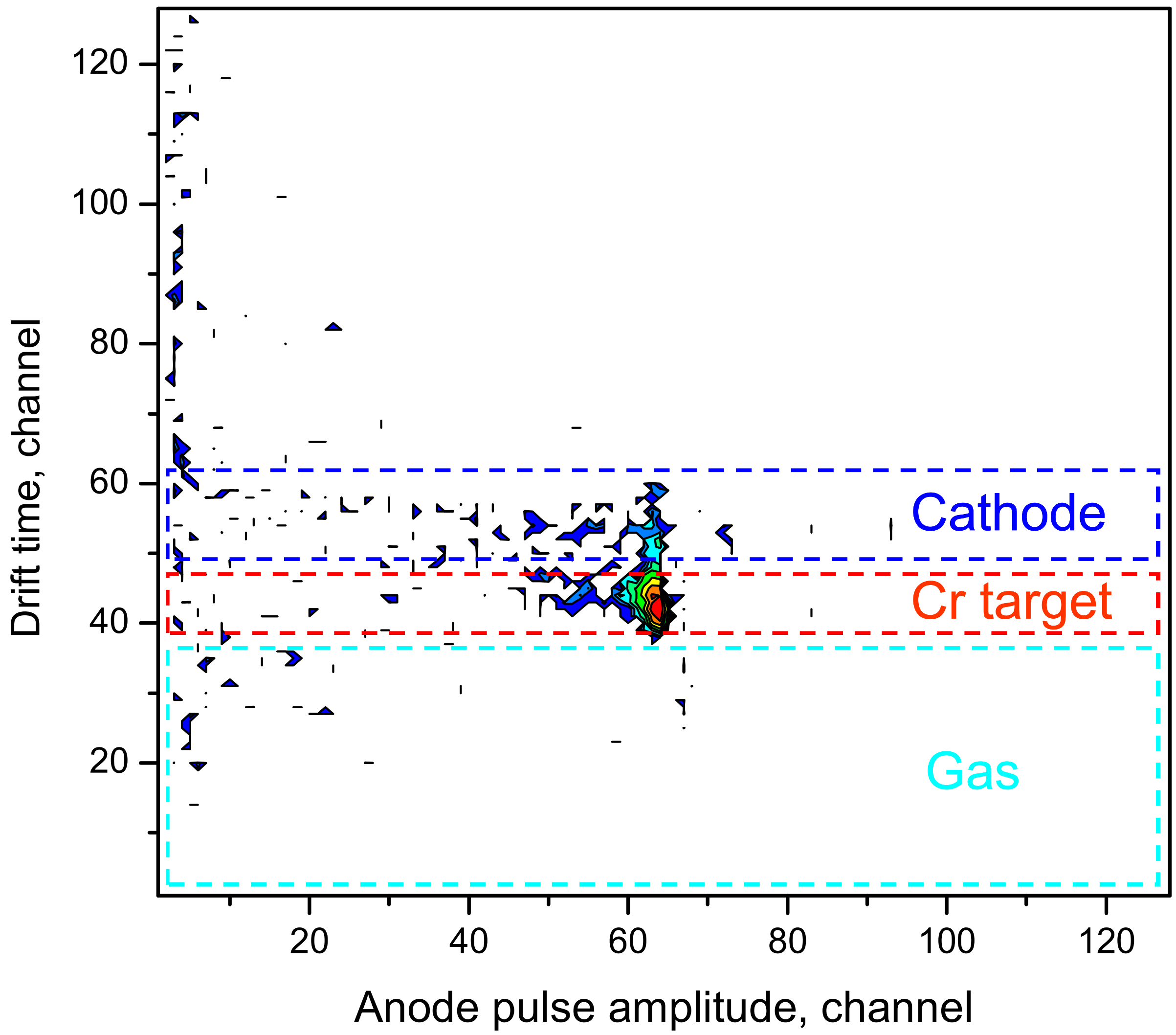


Drift time selection for α-particles only

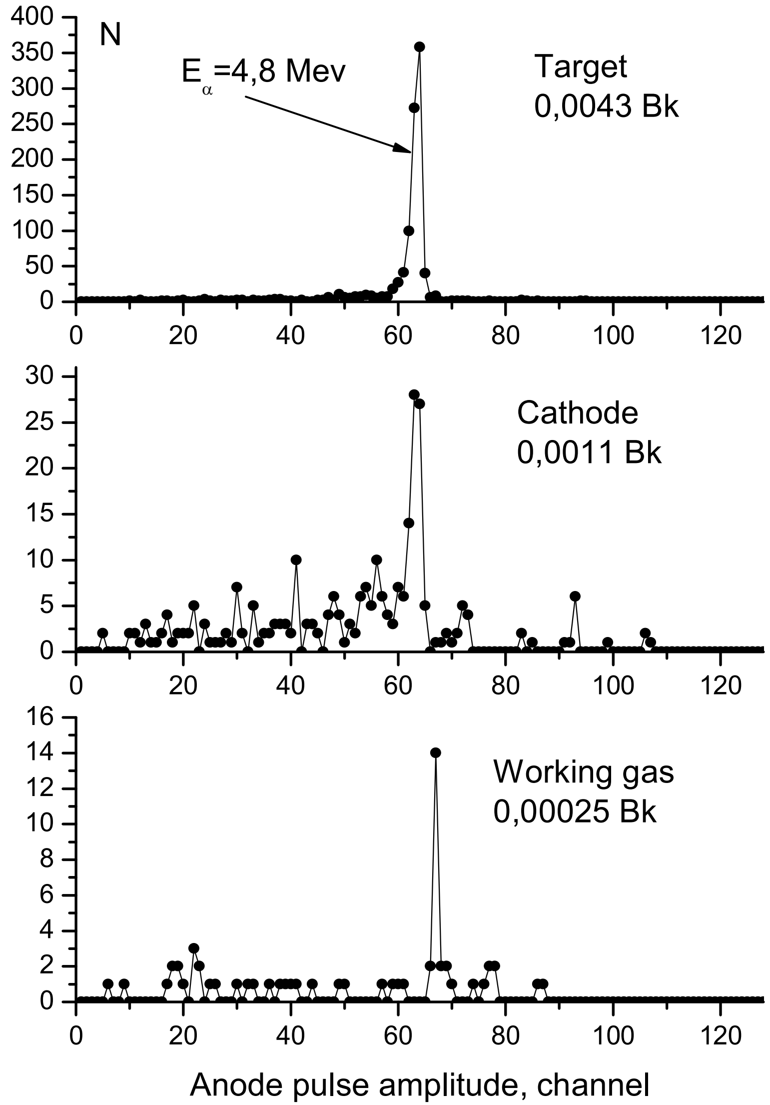




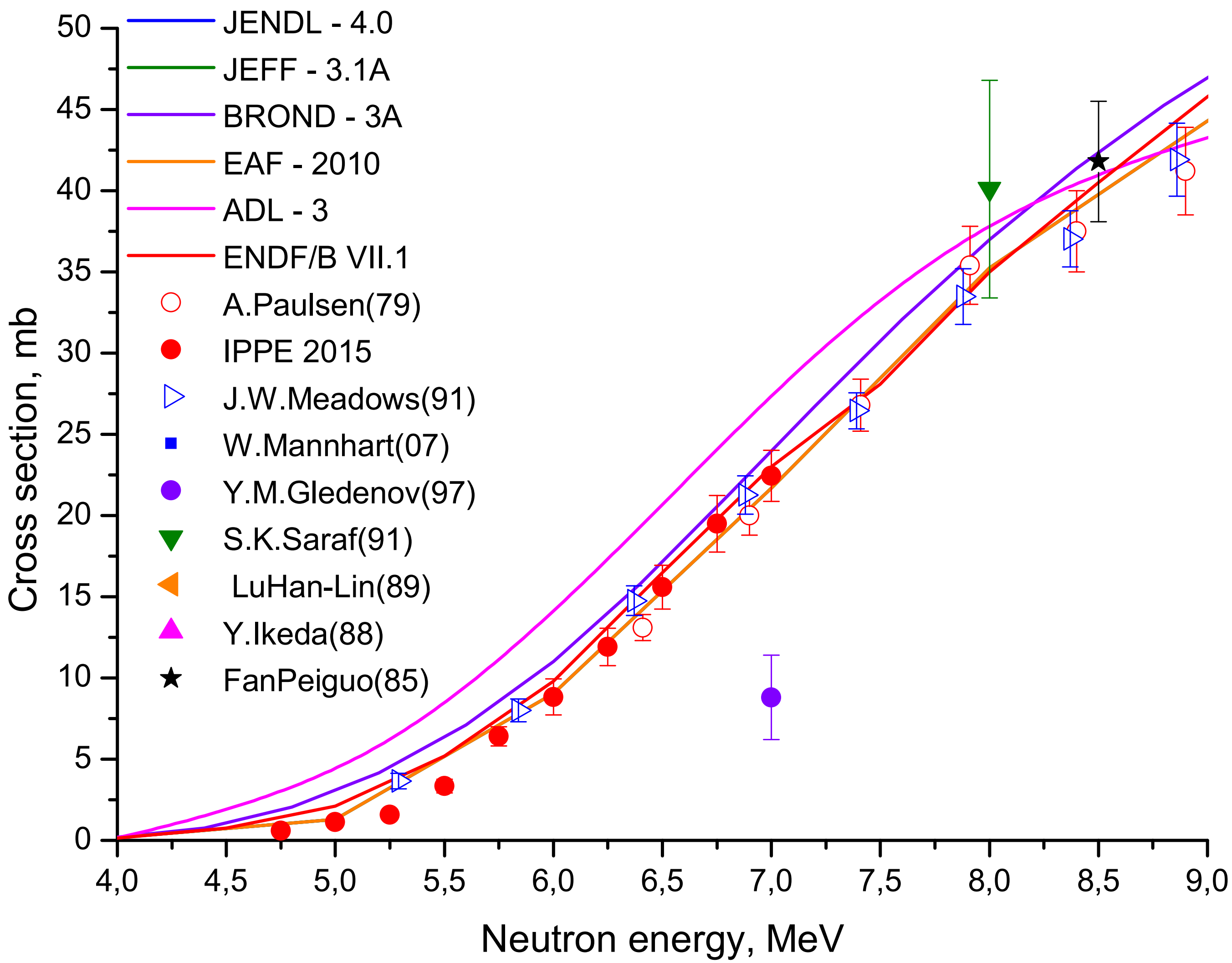
Background (neutron beam off)



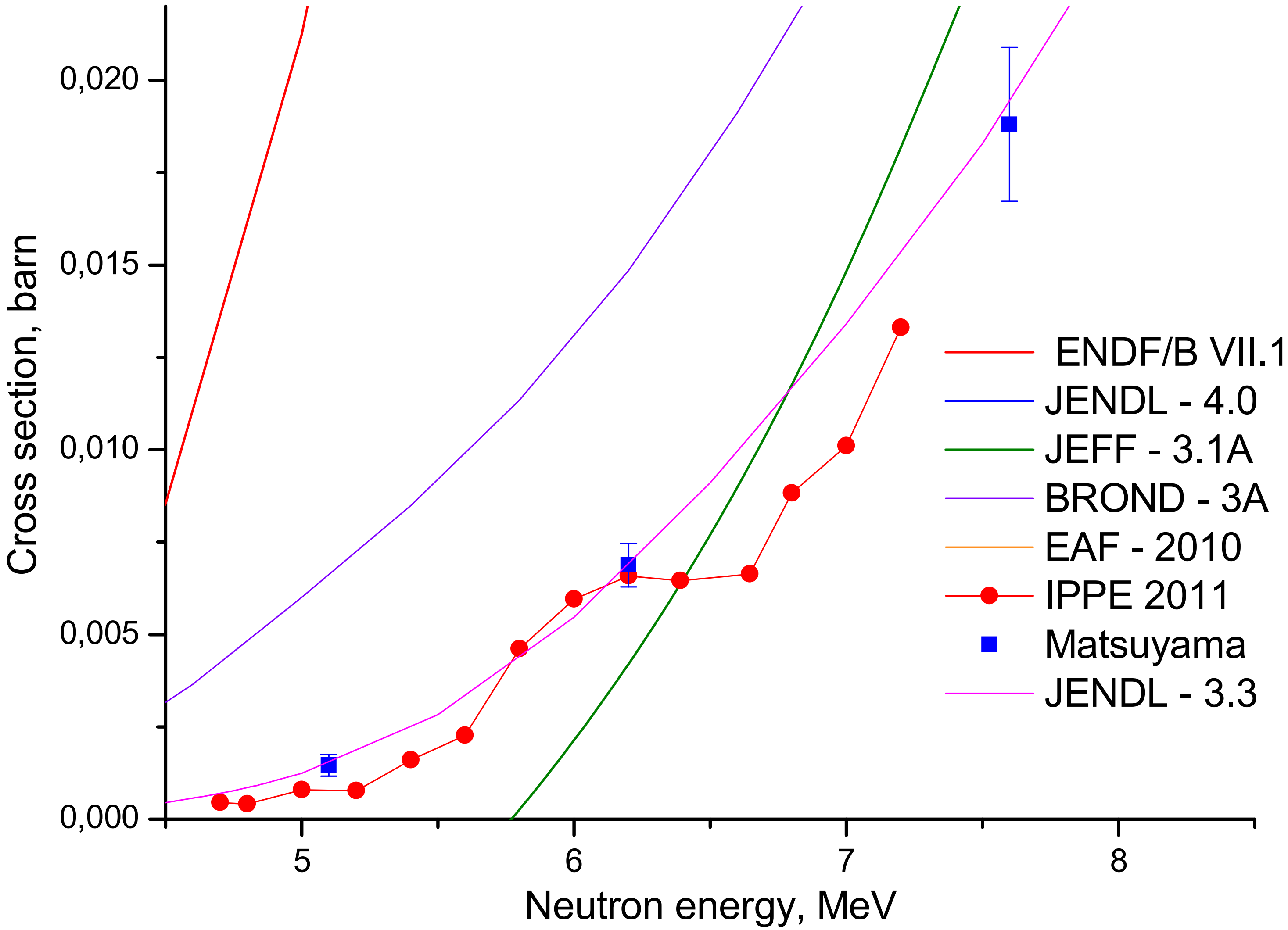
Own α - activity of the detector



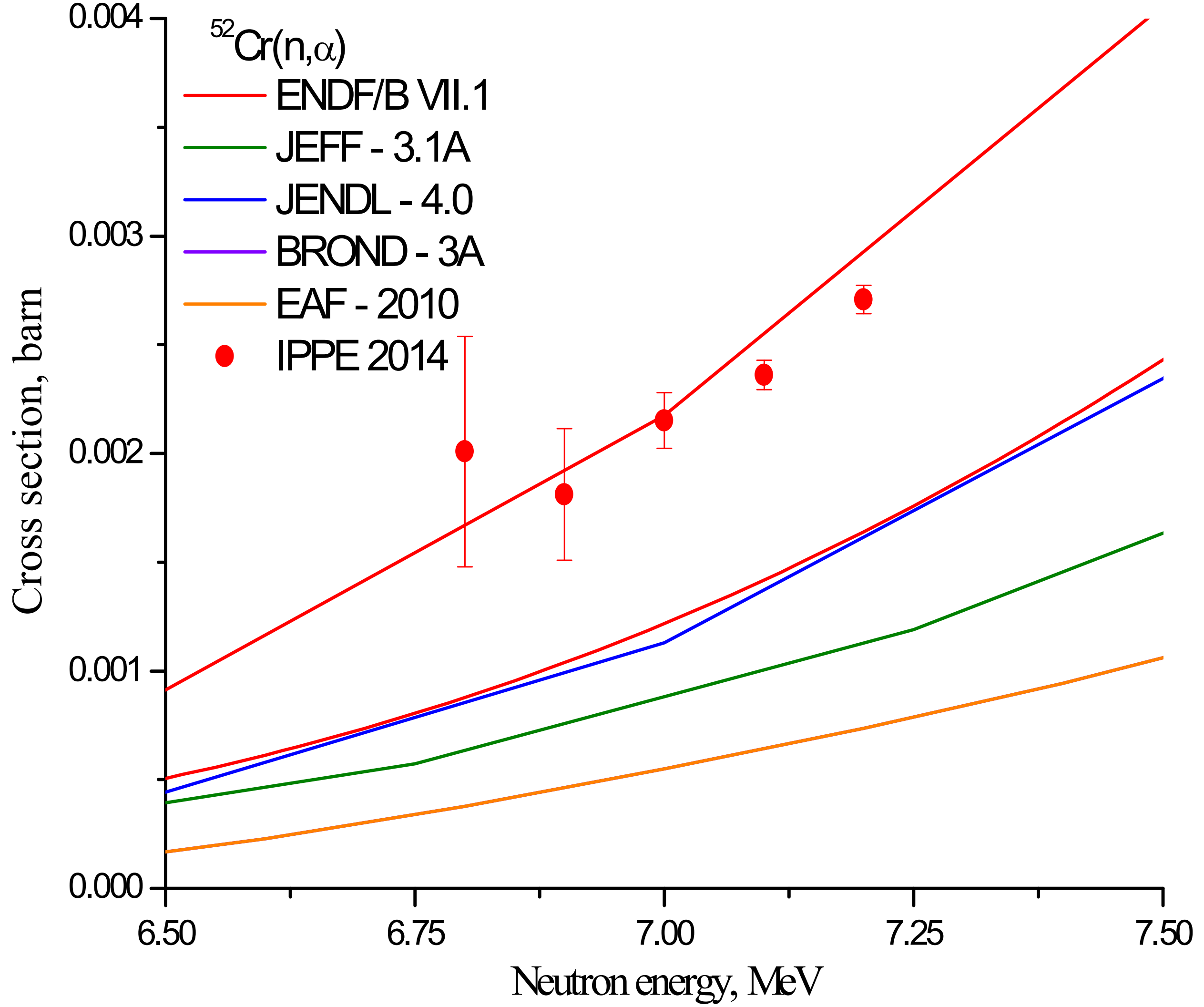
Result for $^{54}Fe(n,\alpha)^{51}Cr$ reaction cross section



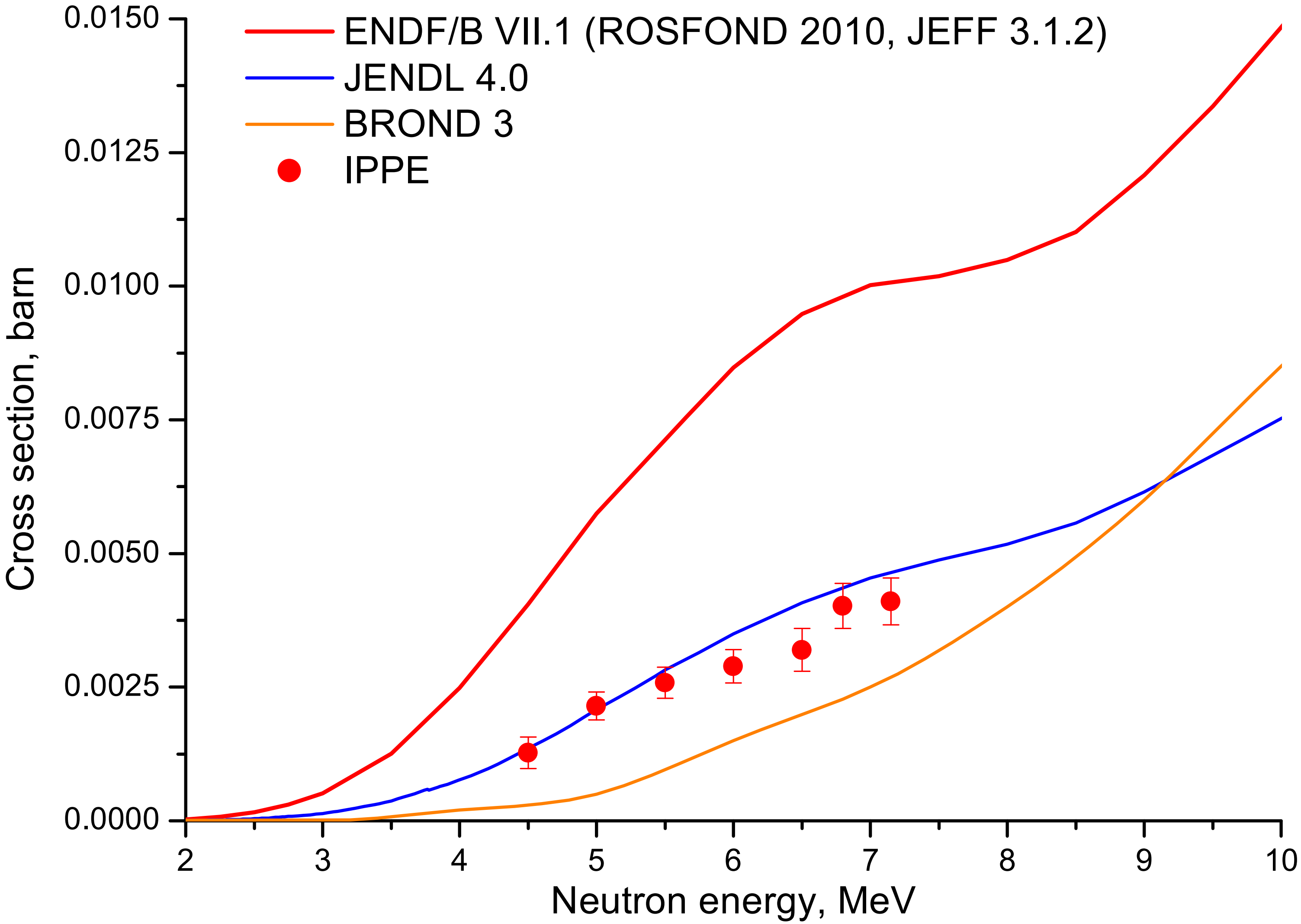
$^{50}Cr(n,\alpha)^{47}Ti$ reaction cross section



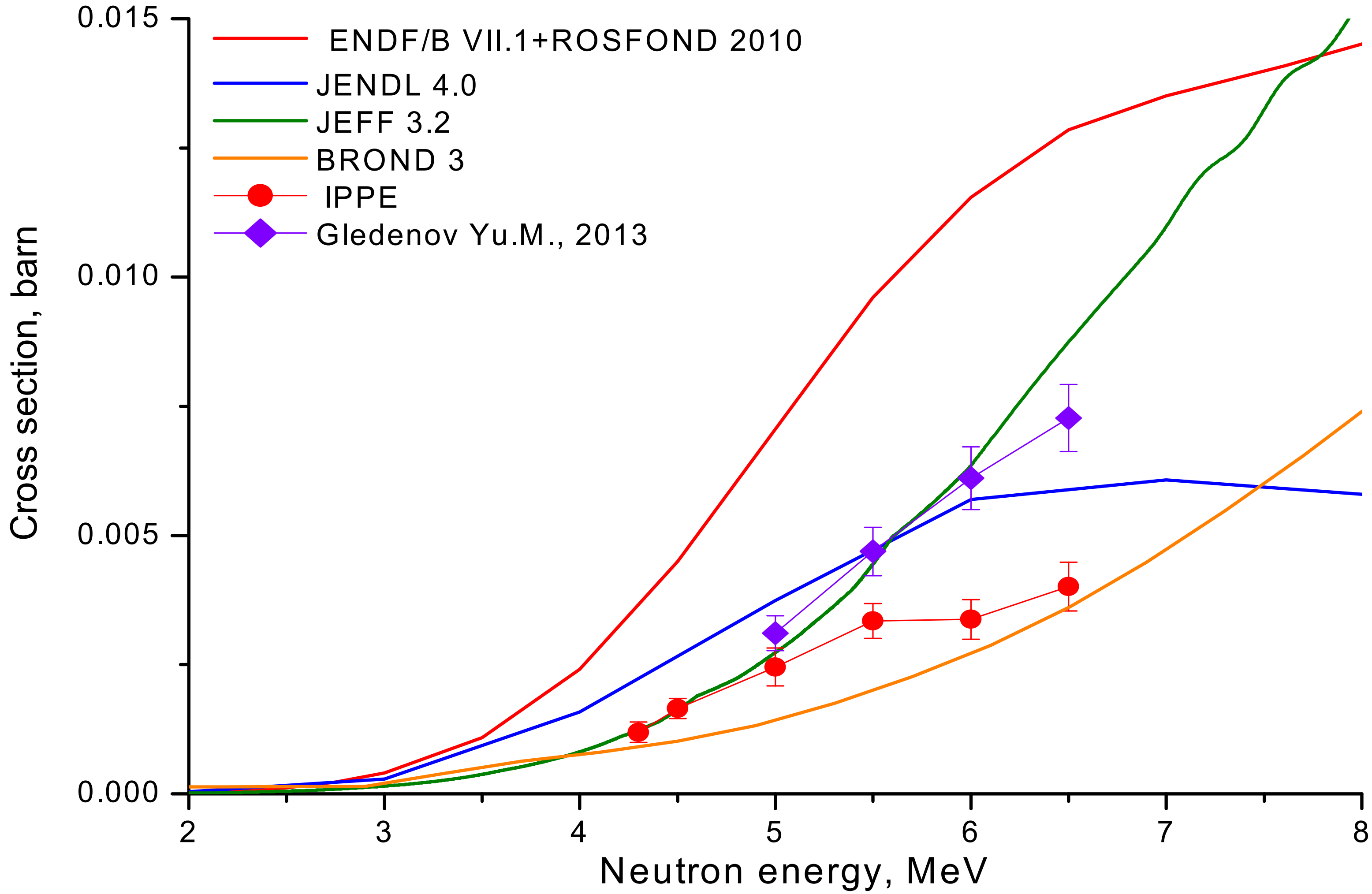
Result for $^{52}Cr(n,\alpha)^{49}Ti$ reaction cross section



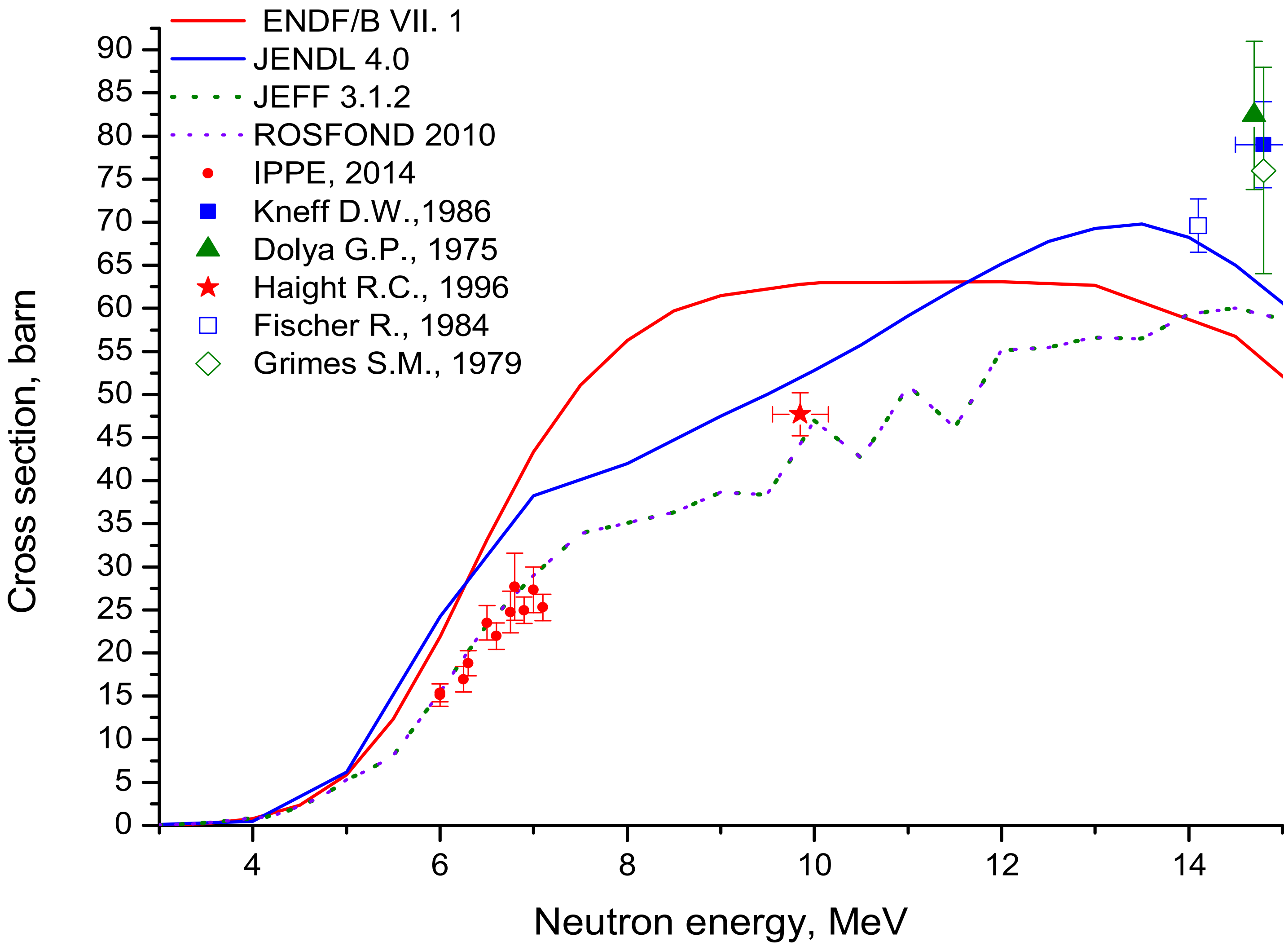
Result for $^{53}Cr(n,\alpha)^{50}Ti$ reaction cross section



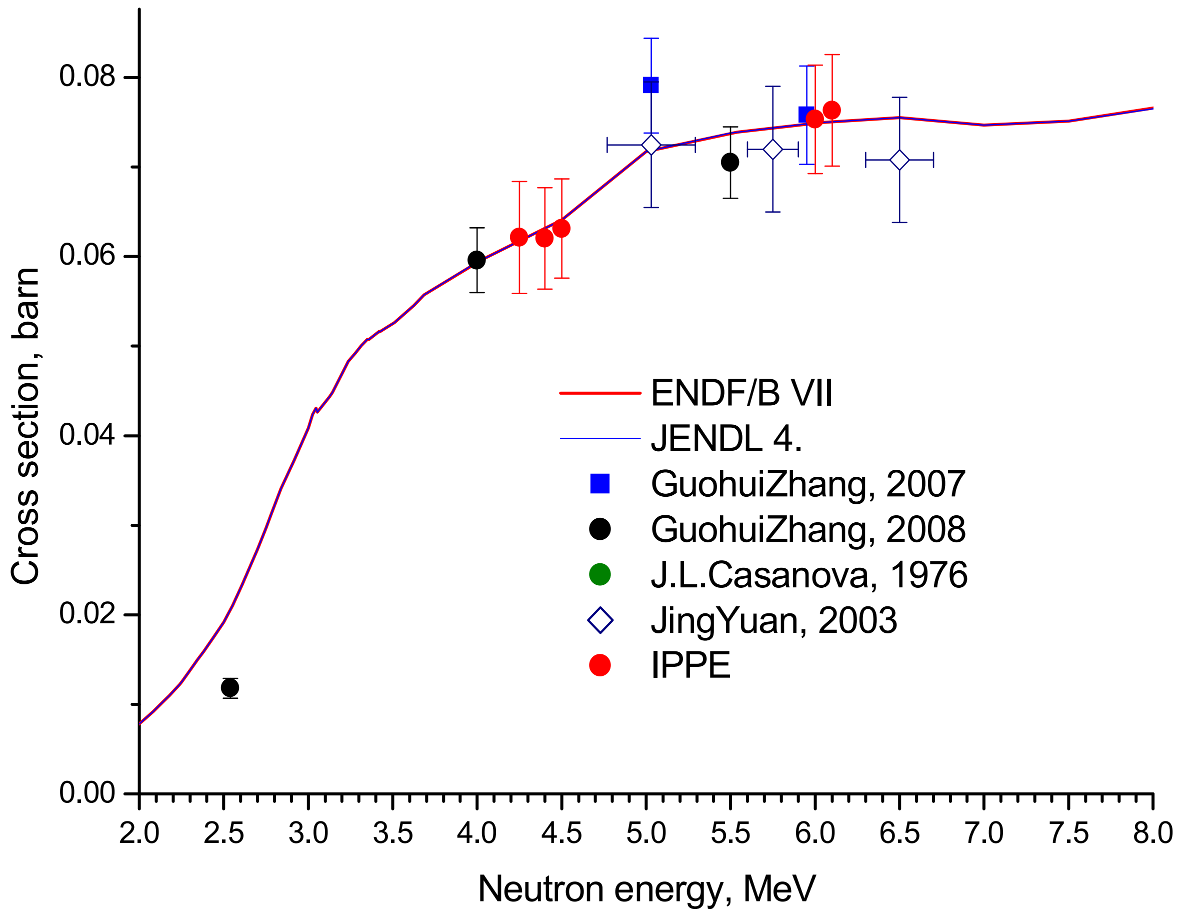
Result for $^{57}Fe(n,\alpha)^{54}Cr$ reaction cross section



Result for ^{60}Ni (n,α) reaction cross section



Result for $^{64}Zn(n,\alpha)$ reaction cross section



Conclusion

New digital technique for direct measurement of α – particles coming from (n,α) reaction on solid target was developed.

New data for:

1) $^{50}Cr(n, \alpha)$,
2) $^{52}Cr(n, \alpha)$,
3) $^{53}Cr(n, \alpha)$,
4) $^{54}Fe(n, \alpha)$,
5) $^{57}Fe(n, \alpha)$,
6) $^{60}Ni(n, \alpha)$,
7) $^{64}Zn(n, \alpha)$,,

was measured

Thank you for attention !