PYF2-based technique for measuring effective energy of beam-generated neutrons provoked fission in interior of thick uranium targets

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Prepositions

While determining the viability of NRT the information on neutron energy spectra in the interior of quasi-infinitive uranium targets is critical.

Prepositions

The detectors settled externally enable to record only leaking neutrons with energy spectrum, which differs from that inside the target.

So, the low-volume neutron spectrum sensors placeable inside the targets are

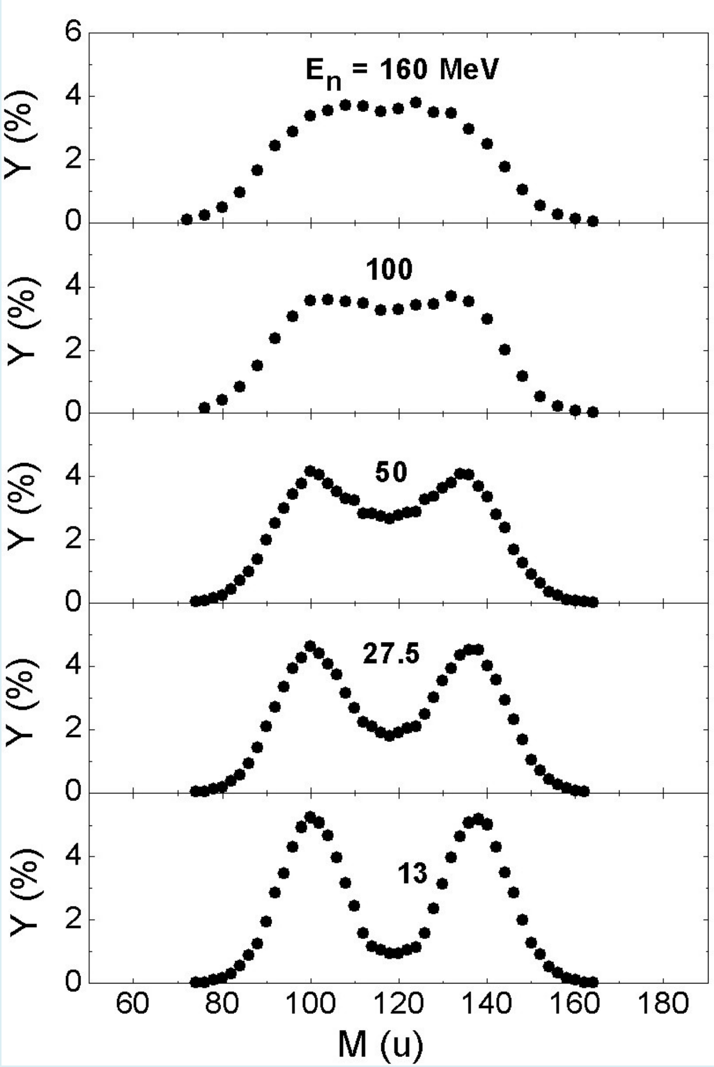
Prepositions

Neutron-activation technique required a complicated analysis due to irregular behavior of cross-sections and insufficient accuracy of library data at high neutron kinetic energies.

Proposal

Under these circumstance, we would like to propose a technique that exploits a rather *strong dependence* of the shapes *of fragment mass distributions* from fission of actinide nuclei *on incident neutron kinetic energy*

The mass yields form neutron induced fission



C.M. Zöller, *Ph. D. Thesis*, TU Darmstadt, Germany, 1995.

The P/V ratios from neutron and proton induced fission

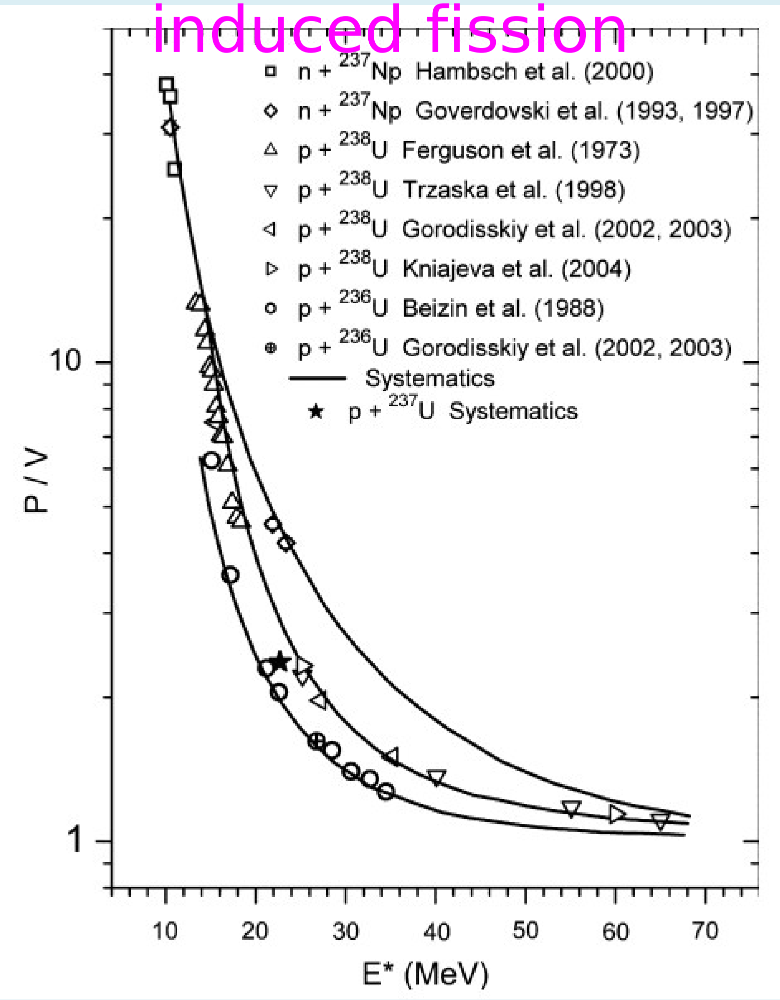
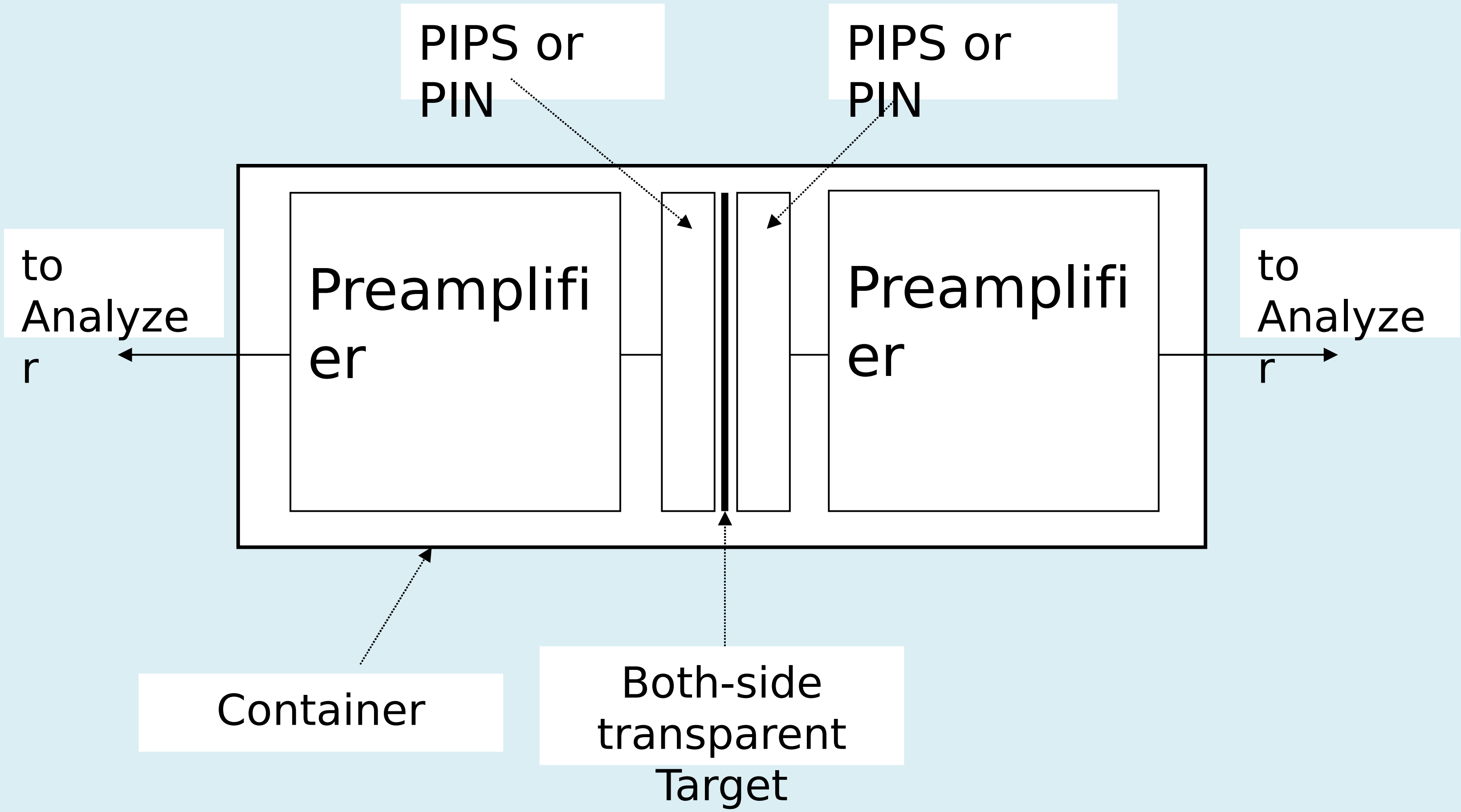


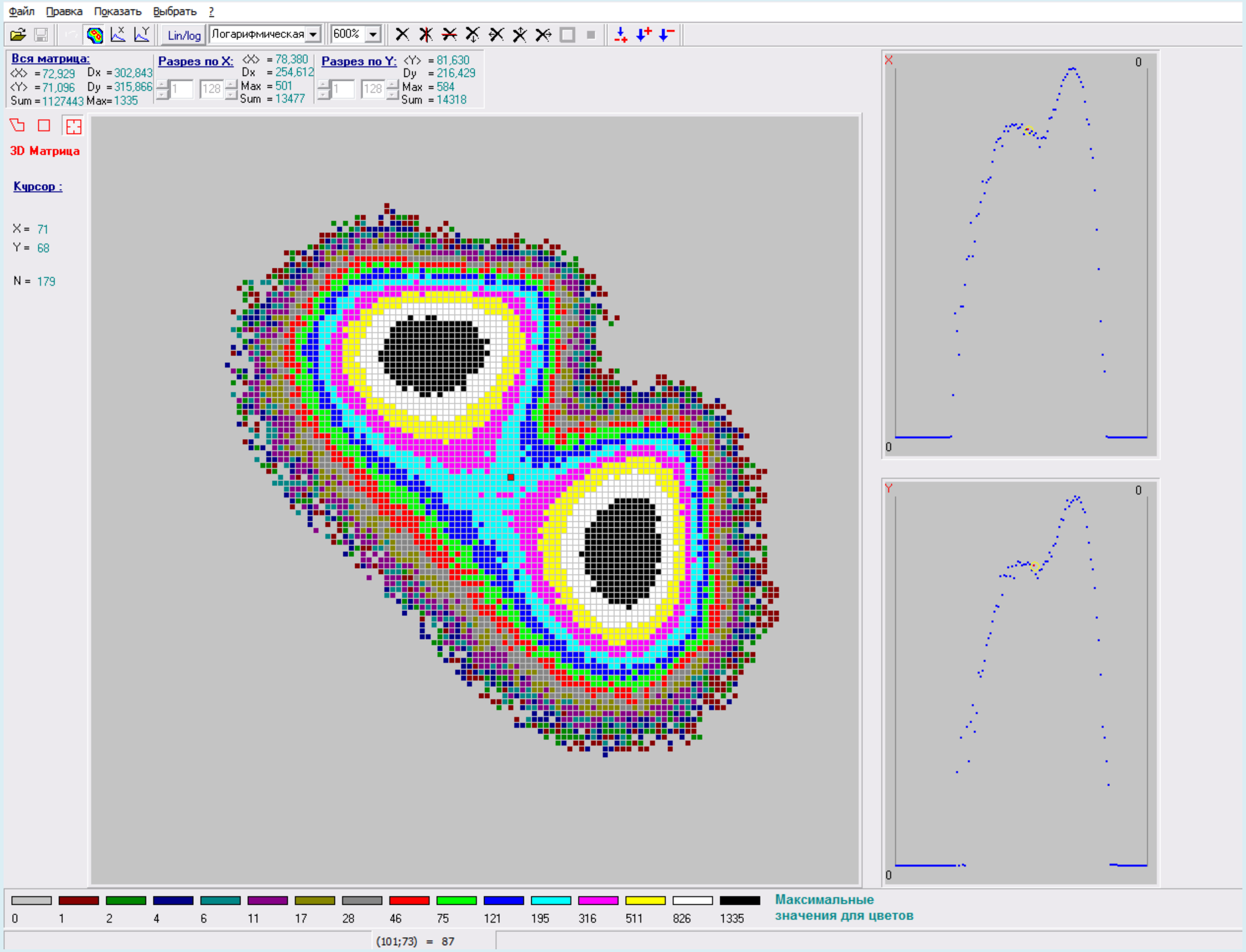
Figure from D.M. Gorodisskiy et al. / Annals of Nuclear Energy 35 (2008) 238–245

Block Diagram of the two-detector Sensor



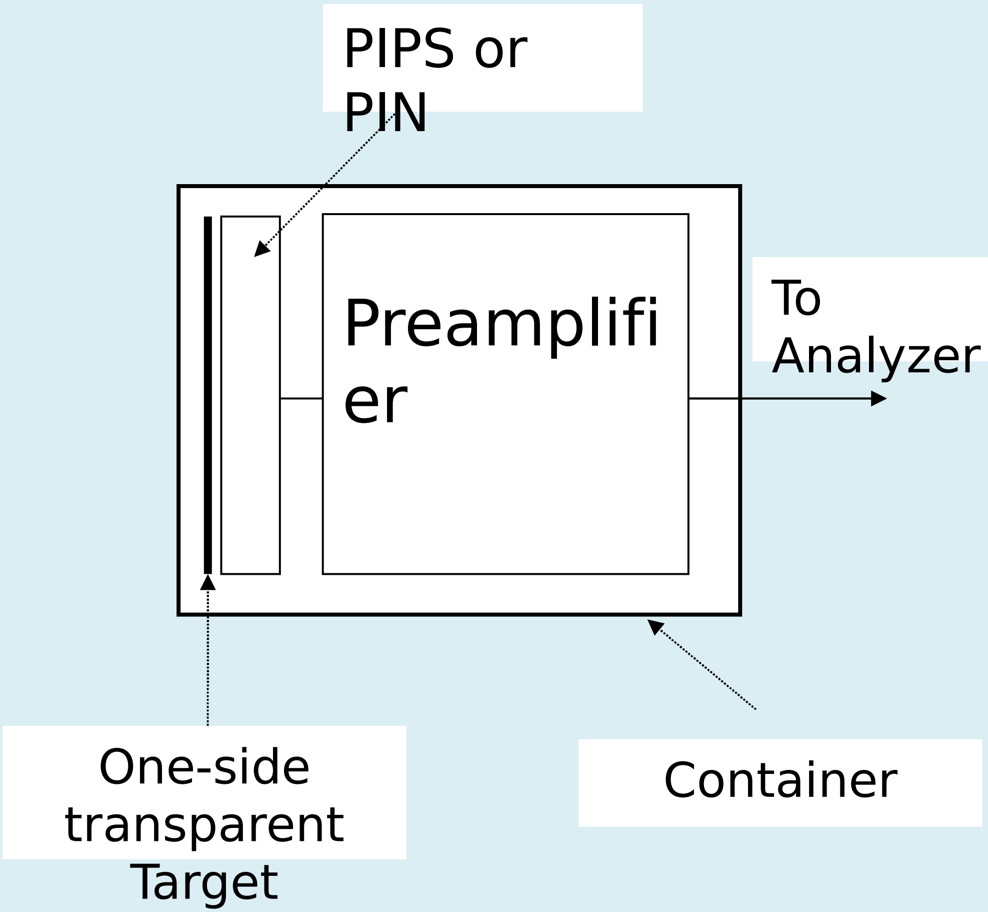
Sensor volume less 15 cm3

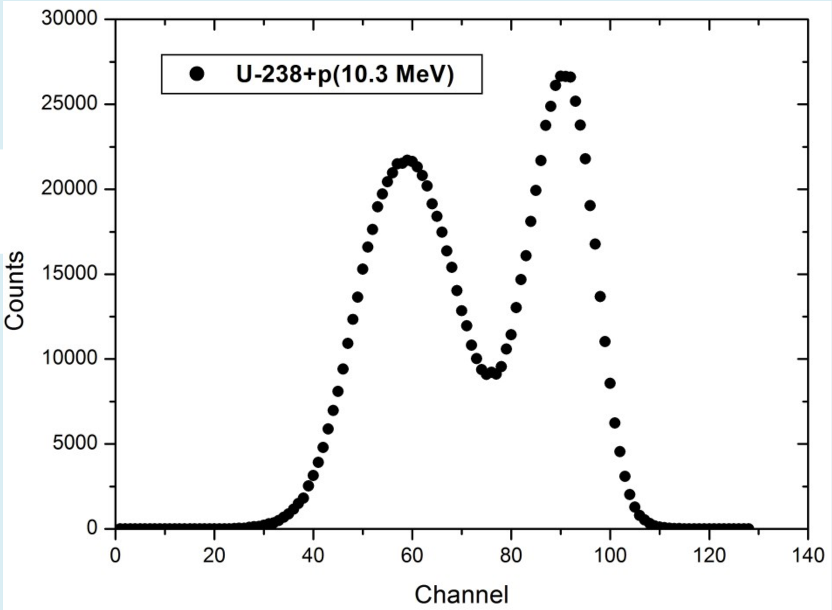
The matrix of coincide pulses from 10.3 MeV proton induced fission of 238U



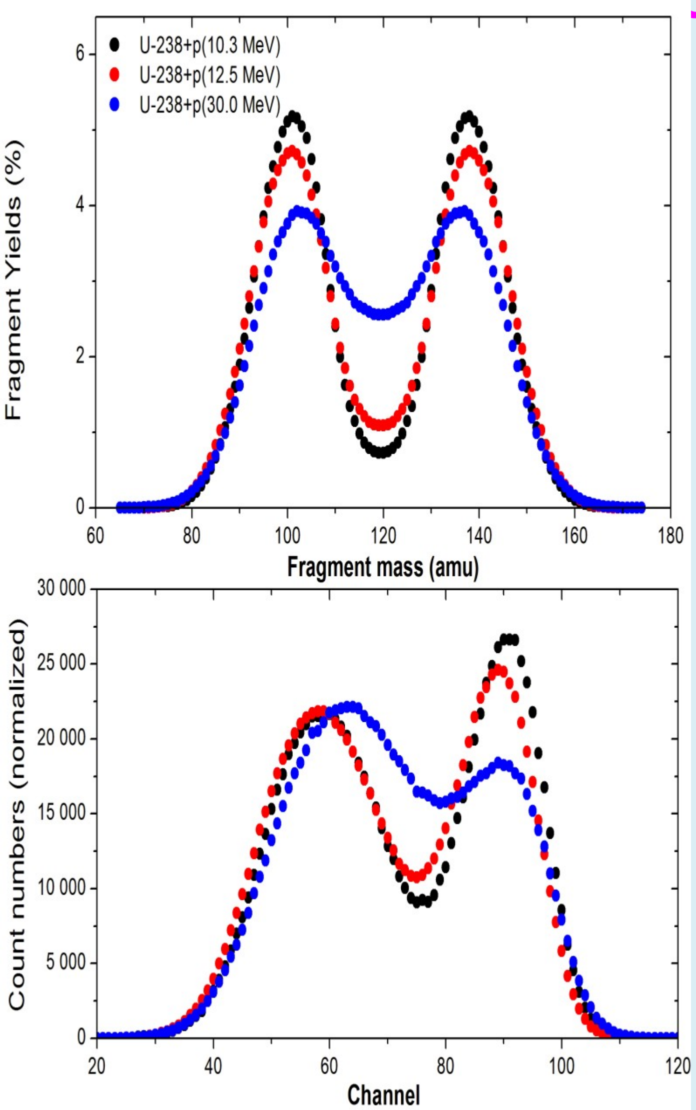
That is all we need for determining the shape of fission fragment mass distribution, in other words, *the energy of incident particle*.

Block Diagram of the one-detector Sensor





Fragment mass yields and correspondent Linear pulse spectra



The changes in Linear spectra clear reflect the alterations in Mass distributions.

The quantitative interpretation will additionally require a *E-model* for energy distributions of fragments with fixed mass, which, when necessary, could be easily developed on the basis of experimentally revealed features of such distributions reported, for instance, in:

1) *D.M. Gorodisskiy et al. / in Fission product yield data for the transmutation of minor actinide nuclear waste. – Vienna : International Atomic Energy Agency, 2008, ISBN 92–0–115306–6;*

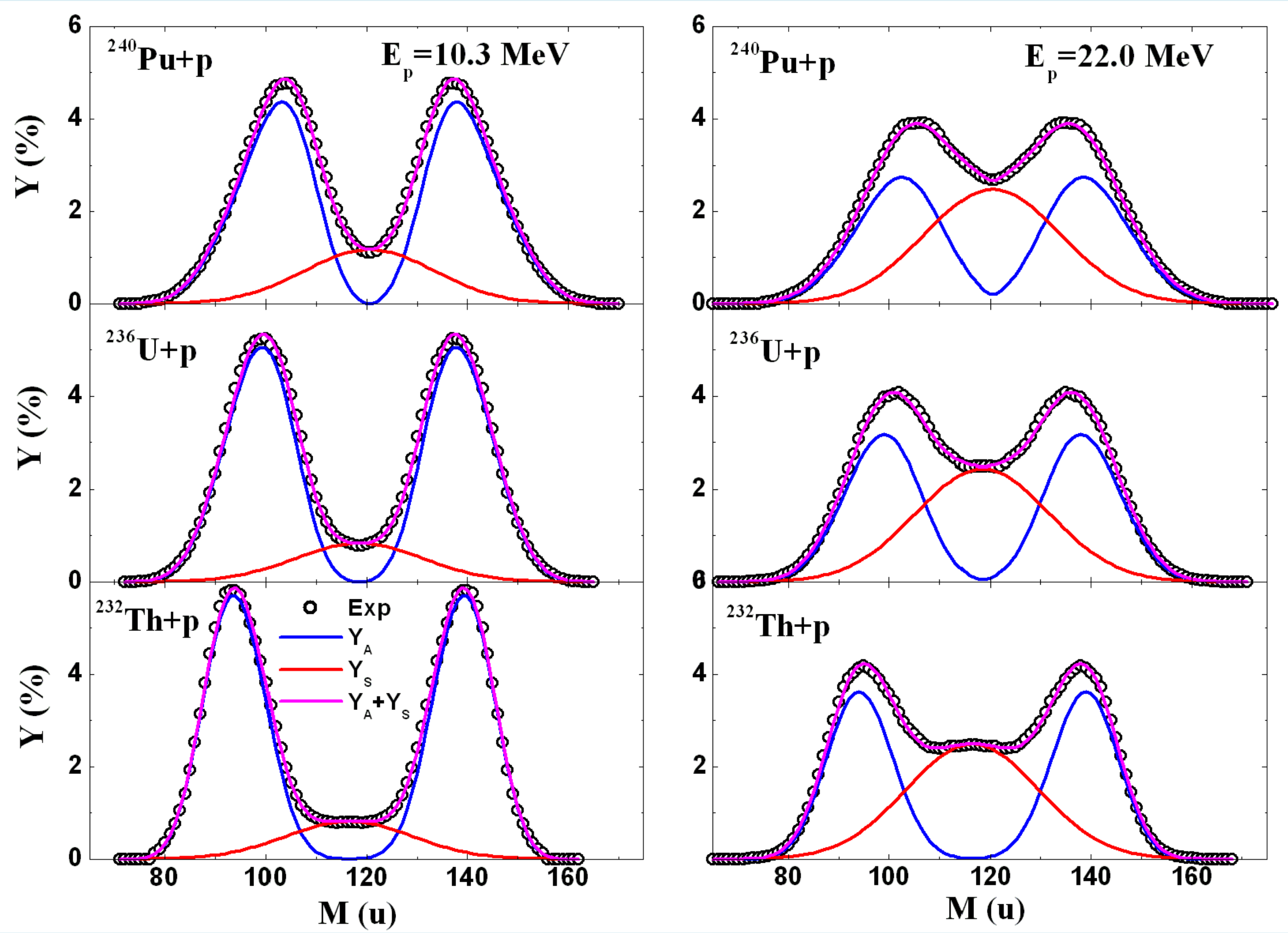
2) *D.M. Gorodisskiy et al. / in Proceedings of 5th International Conference "Dynamical aspects of Nuclear fission" – World Scientific Publishing Co*

Processing of measured data

The quantitative interpretation of the fragments mass yields in terms of effective energy of neutrons caused the fission could base on the PYF2.2 code.

Background of PYF2.2

Two-modal approximation: YS /YA, □S, □A,



Y(MH)=(2□)-1/2{(YS/□S)exp(–uS2/2)+(YA/□A)exp(–uA2/2)[1–□1(3uA–uA3)/6+□2(uA4–6uA2–3)/24]},

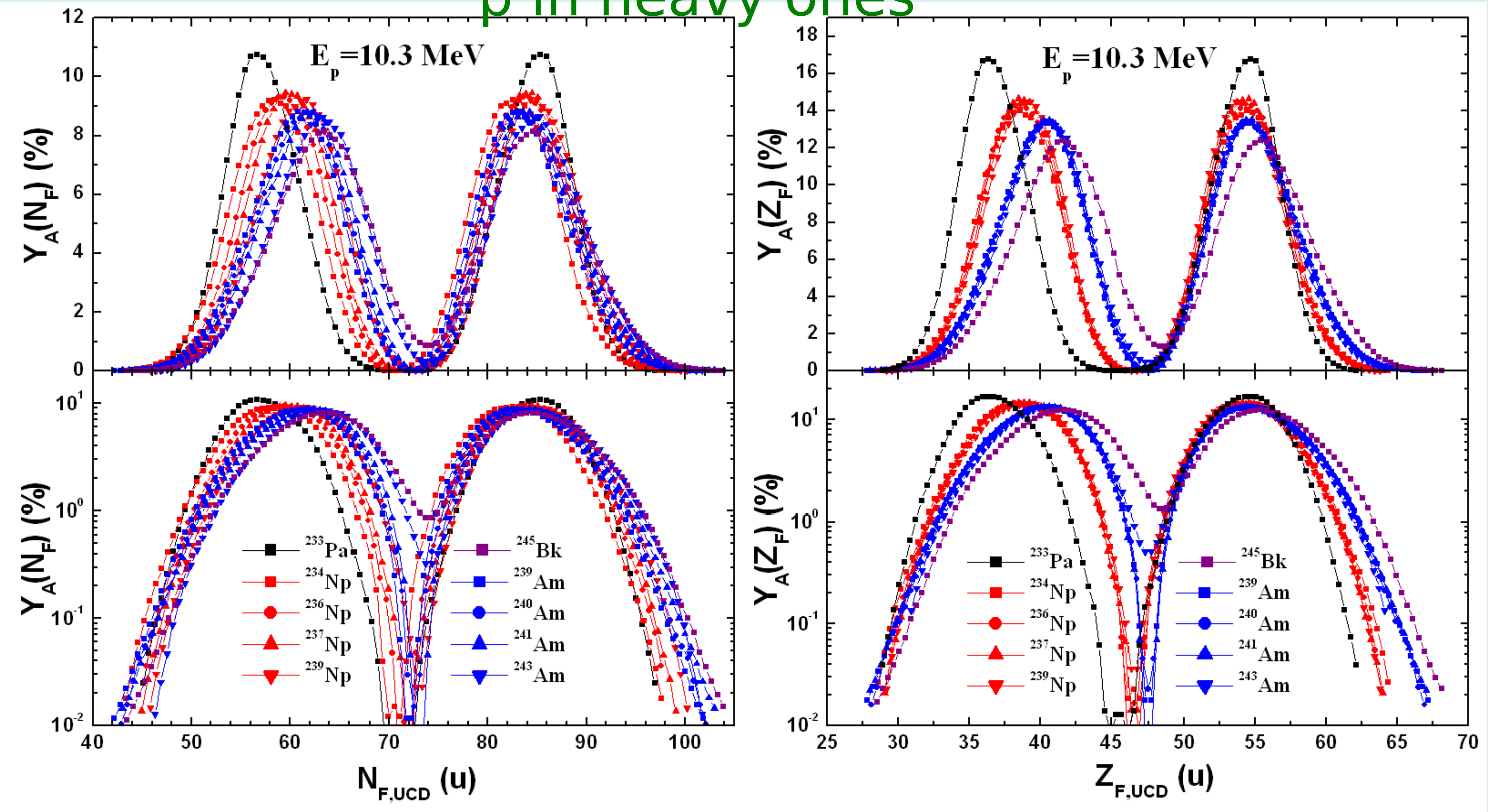
Y(ML=ACN–MH)=Y(MH), uS=(MH−ACN/2)/□S, uA=(MH−MH,A/2)/□A,

ACN=AT+1–□pre

Unchanged Charge Density (UCD) hypothesis:

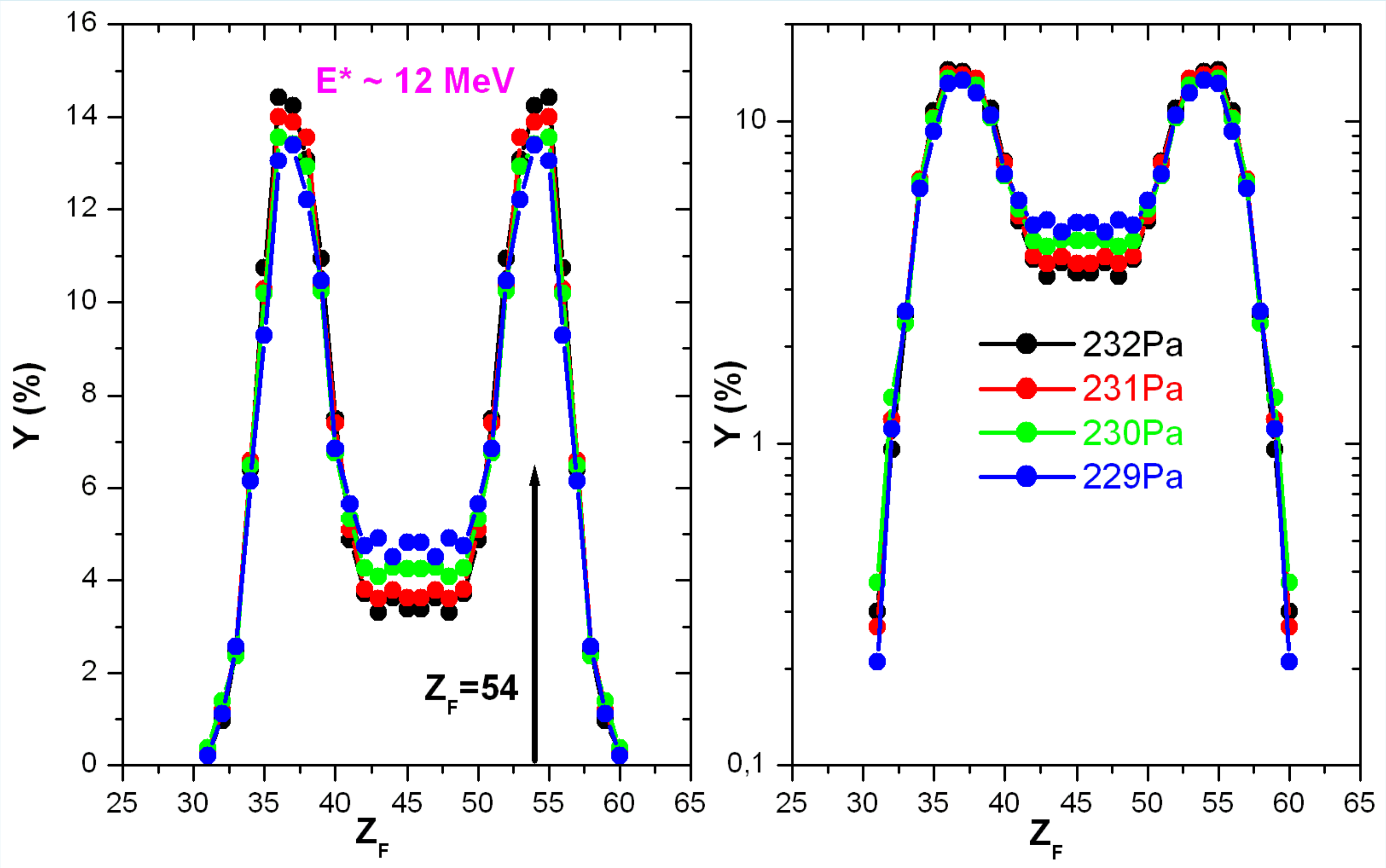
ZF,UCD= (ZCN/ACN)*M; NF,UCD= (NCN/ACN)*M;

ZF,true- ZF,UCD +0.5 p in light fragments and -0.5 p in heavy ones



D.M. Gorodisskiy et al./ Physics Letters B 548 (2002) 45–51

Electromagnetically induced fission



Experimental data on Y(ZF) from: K.-H. Schmidt, et al., Nucl. Phys. A 665 (2000) 221;

K.-H. Schmidt, et al., Nucl. Phys. A 693 (2001) 169

Background of PYF2.2

- For all actinide nuclei with equal ZCN the relative charge yields *YA(ZF) are virtually coincide, almost independently of NCN.*
- The shapes of YA(ZF) *weakly depend on excitation energy.*

Experimental data used for the PYF 2.2 adjustment

S.I. Mulgin, V.N. Okolovich, and S.V. Zhdanov, *Phys. Lett. B* **462** 29 (1999).

D.M. Gorodisskiy, et al., *Proc. Int. Conf. on Dynamical Aspects of Nuclear fission, Casta-Papiernica, Slovak Republic, (2001),* World Scientific, Singapore, 287 (2002).

D.M. Gorodisskiy, et al., *Phys. Lett. B* **548** 45 (2002).

D.M. Gorodisskiy, et al., *Phys. At. Nucl.* **66** 1190 (2003).

S.I. Mulgin, et al., *Nucl. Phys. A* **824** 1 (2009).

F.-J. Hambsch,et al., *Nucl. Phys. A* **679** 3 (2000).

A.I. Sergachev, et al., *Sov. J. Nucl. Phys.* **7** 475 (1968).

B.D. Kuzminov, A.I. Sergachev, and L.D. Smirenkina, *Sov. J. Nucl. Phys.* **11** 166 (1970).

F. Vivès, et al., *Nucl. Phys. A* **662** 63 (2000).

S. Oberstedt, F.-J. Hambsch, and F. Vivès, *Nucl. Phys. A* **644** 289 (1998).

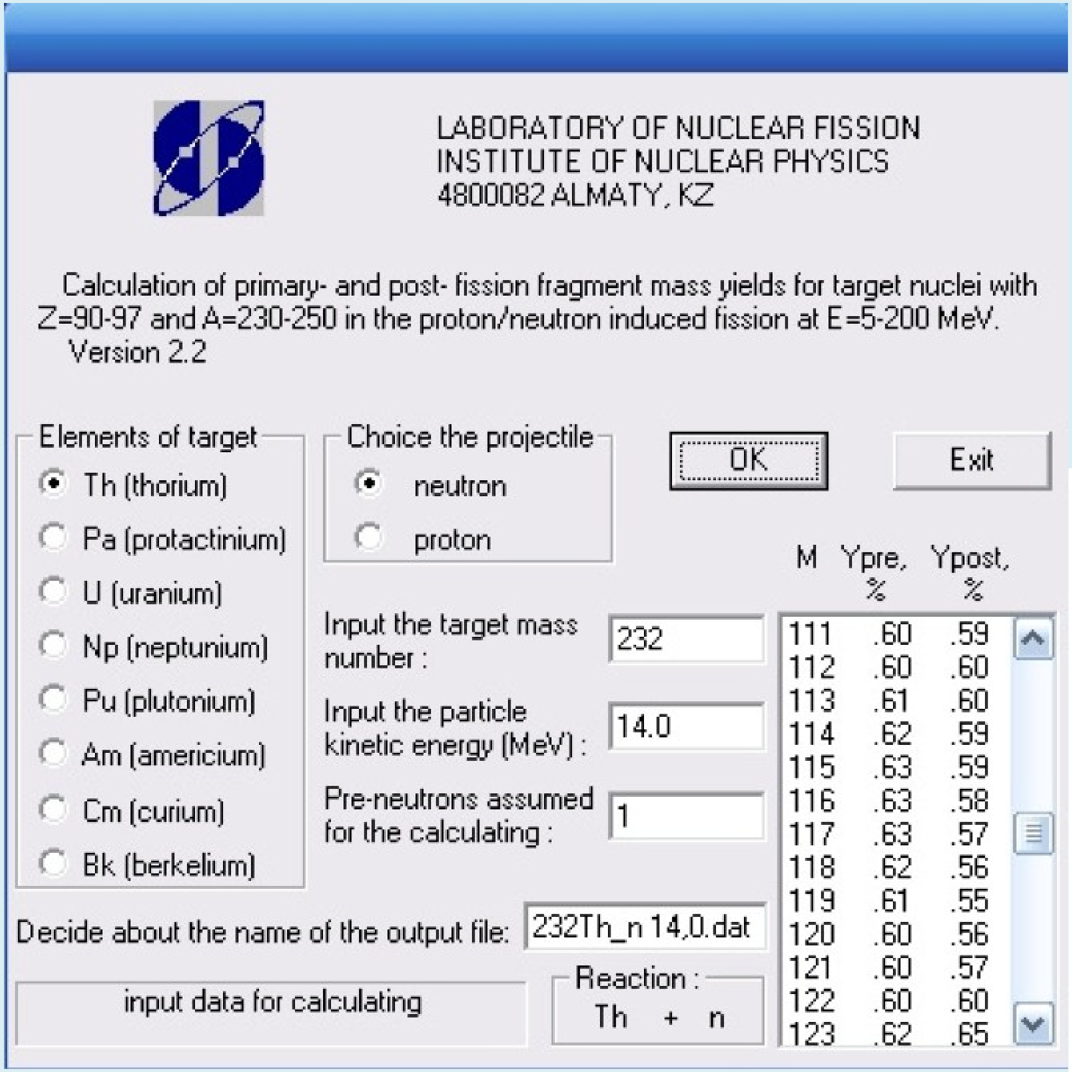
A.A. Goverdovski and V.F. Mitrofanov, *Phys. At. Nucl.* **56** 24 (1993).

A.A. Goverdovski, et al., *Phys. At. Nucl.* **60** 1441 (1997).

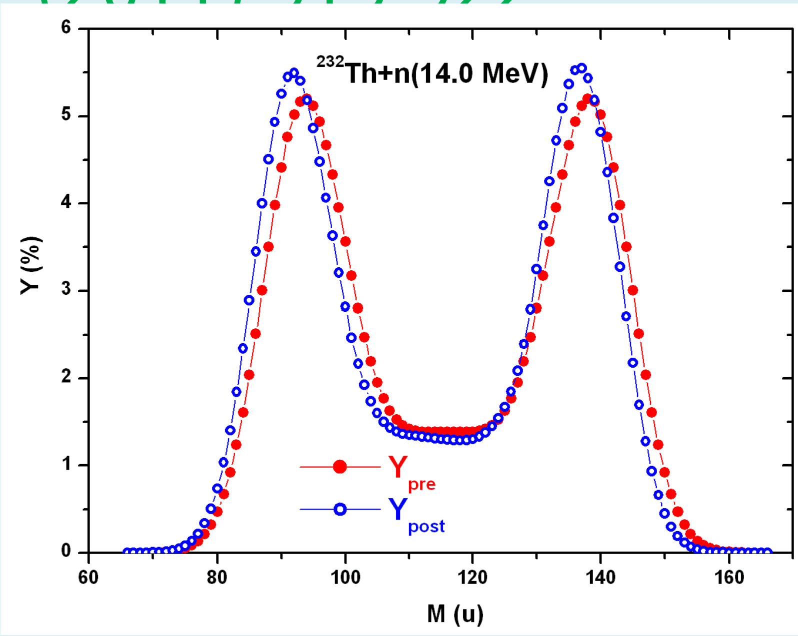
C.M. Zöller, *Ph. D. Thesis*, TU Darmstadt, Germany, 1995.

T. Kawano, et al., *Phys. Rev. C* **63** 034601 (2001).

Interface of the PYF 2.2

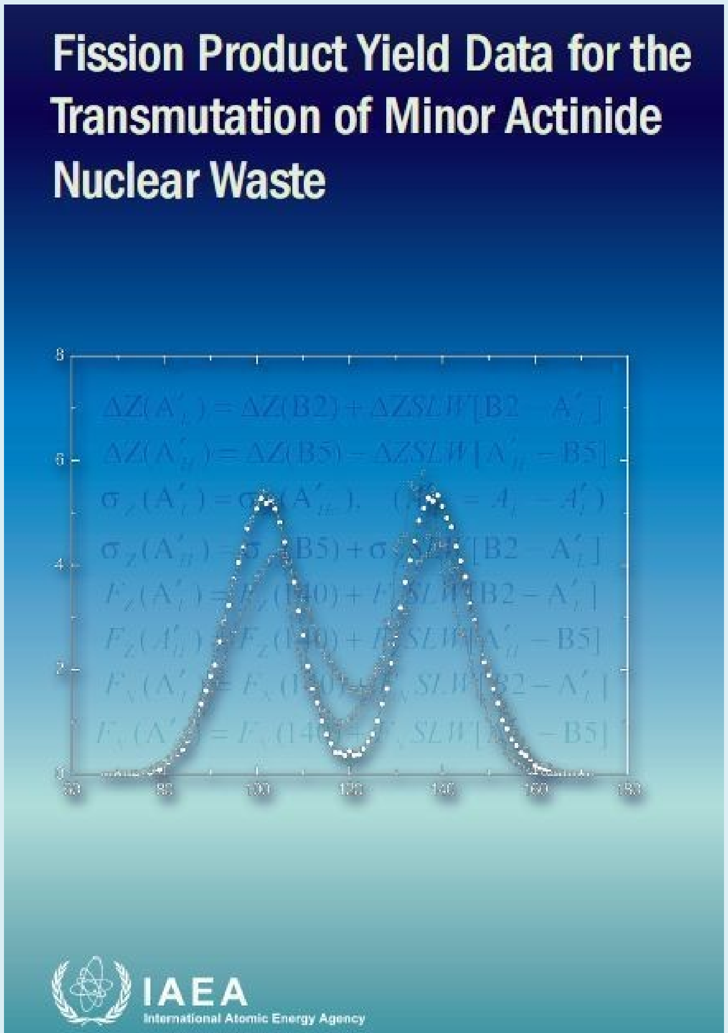


Description at: D.M. Gorodisskiy, et al., Annals of Nuclear Energy 35 (2008) 238; JKPS Vol. 59 No. 2 (2011) 919-922



Available free at http://www.inp.kz/laboratoryrus/lpdpyf.php

PYF 2.2, Wahl's and Talys calculations are taken from



This publication reports on a coordinated research project devoted to the development of methodologies designed to derive recommended fission yields for direct application in studies of the transmutation of nuclear waste. Emphasis is placed on the derivation of adequate systematics and models for the calculation of energy dependent fission yields up to 150 MeV incident neutron energy. A benchmark exercise revealed the worth and predictive capabilities of the proposed systematics and theoretical models. These methods of analysis have the potential to give reliable predictions after implementation of further improvements suggested in this report. A brief introduction and the various studies undertaken by individual participants are given at the beginning of this publication, followed by a detailed description of the resulting overall achievements, conclusions and recommendations of the coordinated research project, and a summary of the benchmark exercise and results. Additional material is contained on a CD-ROM, including various compilations of the fission product yields, unedited papers and full details of the benchmark exercise.

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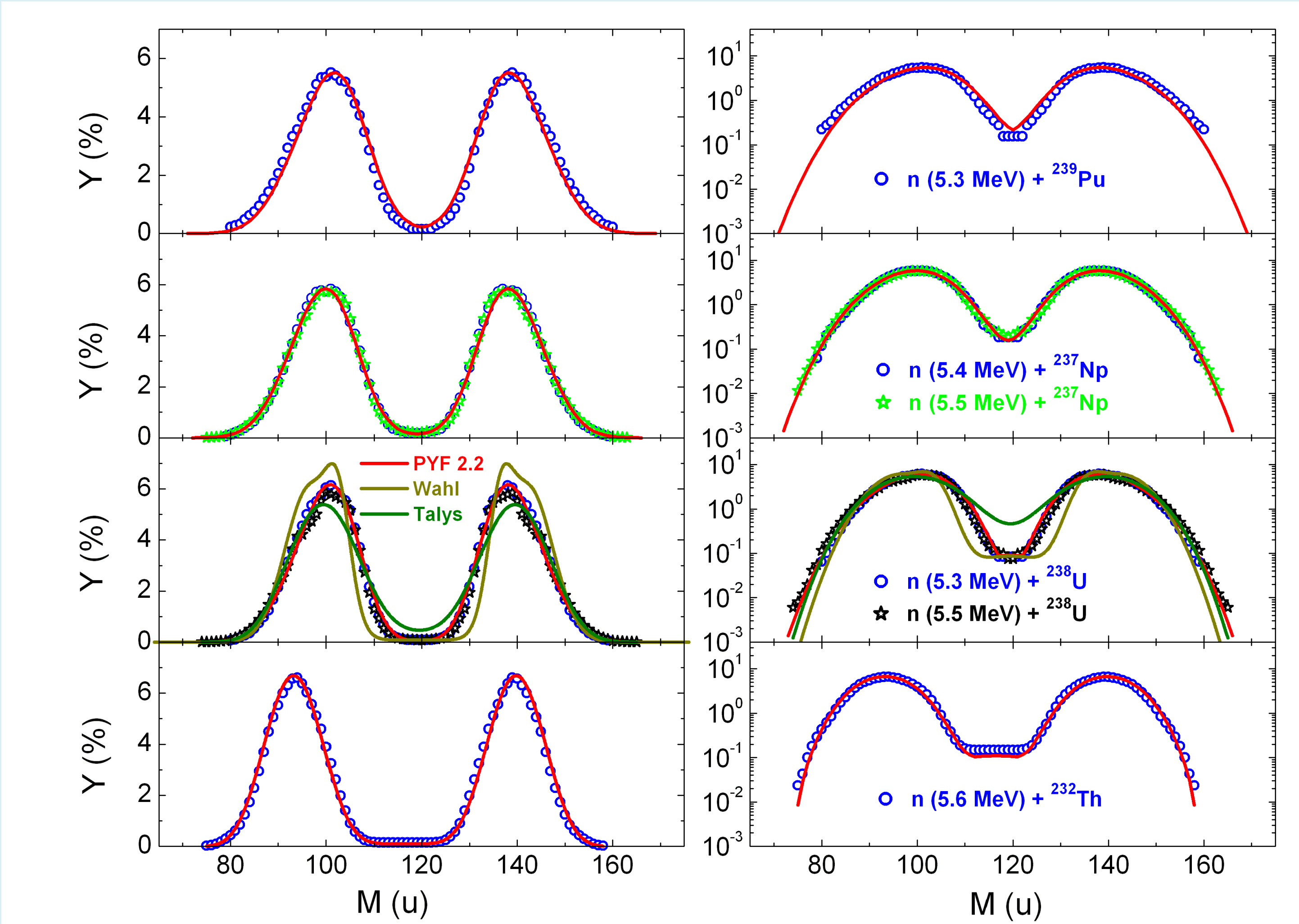
ISBN 92-0-115306-6

The 5 MeV neutron induced fission

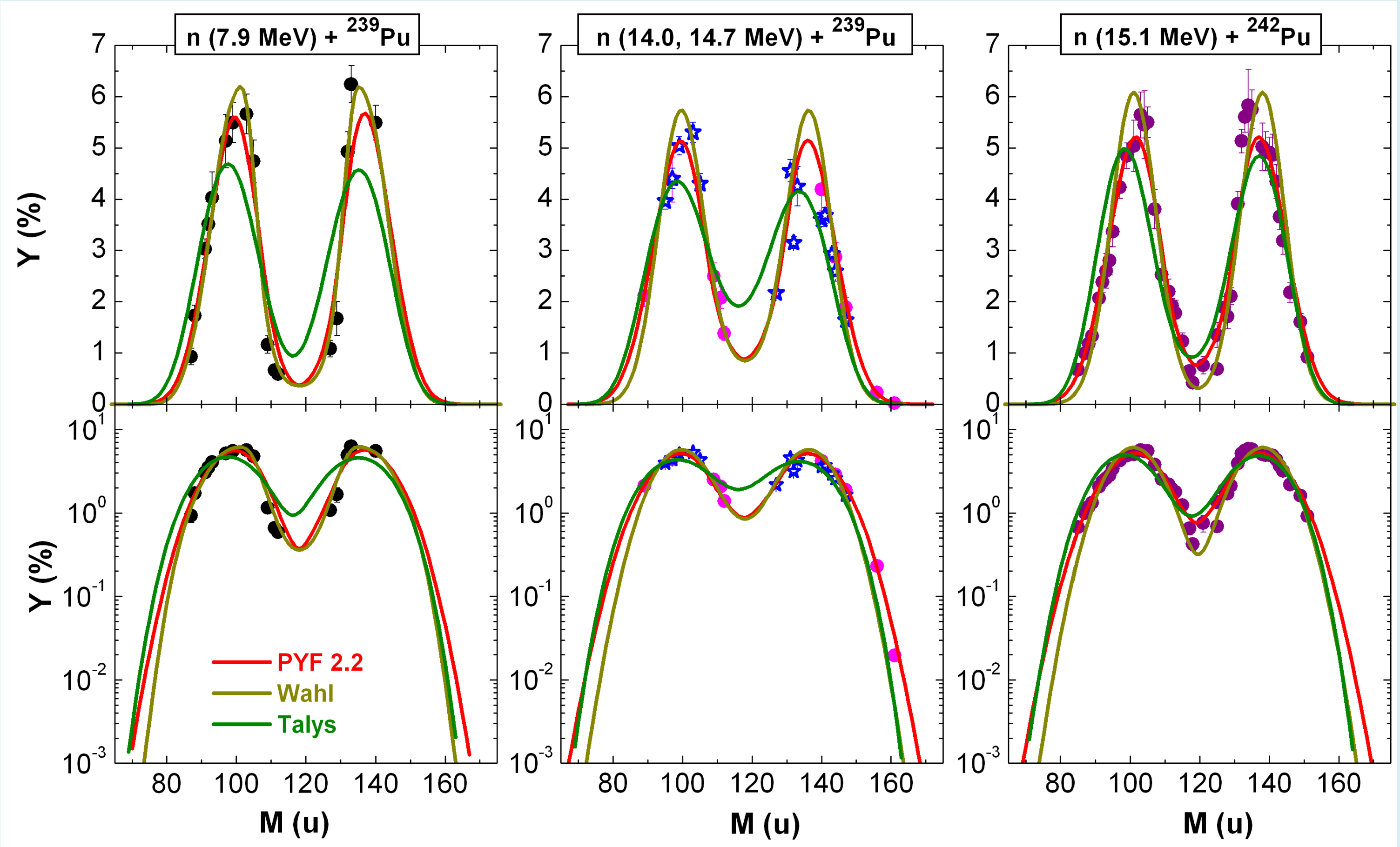


Experiment: A.I. Sergachev, et al., *Sov. J. Nucl. Phys.* **7** 475 (1968);

F.-J. Hambsch,et al., *Nucl. Phys. A* **679** 3 (2000);

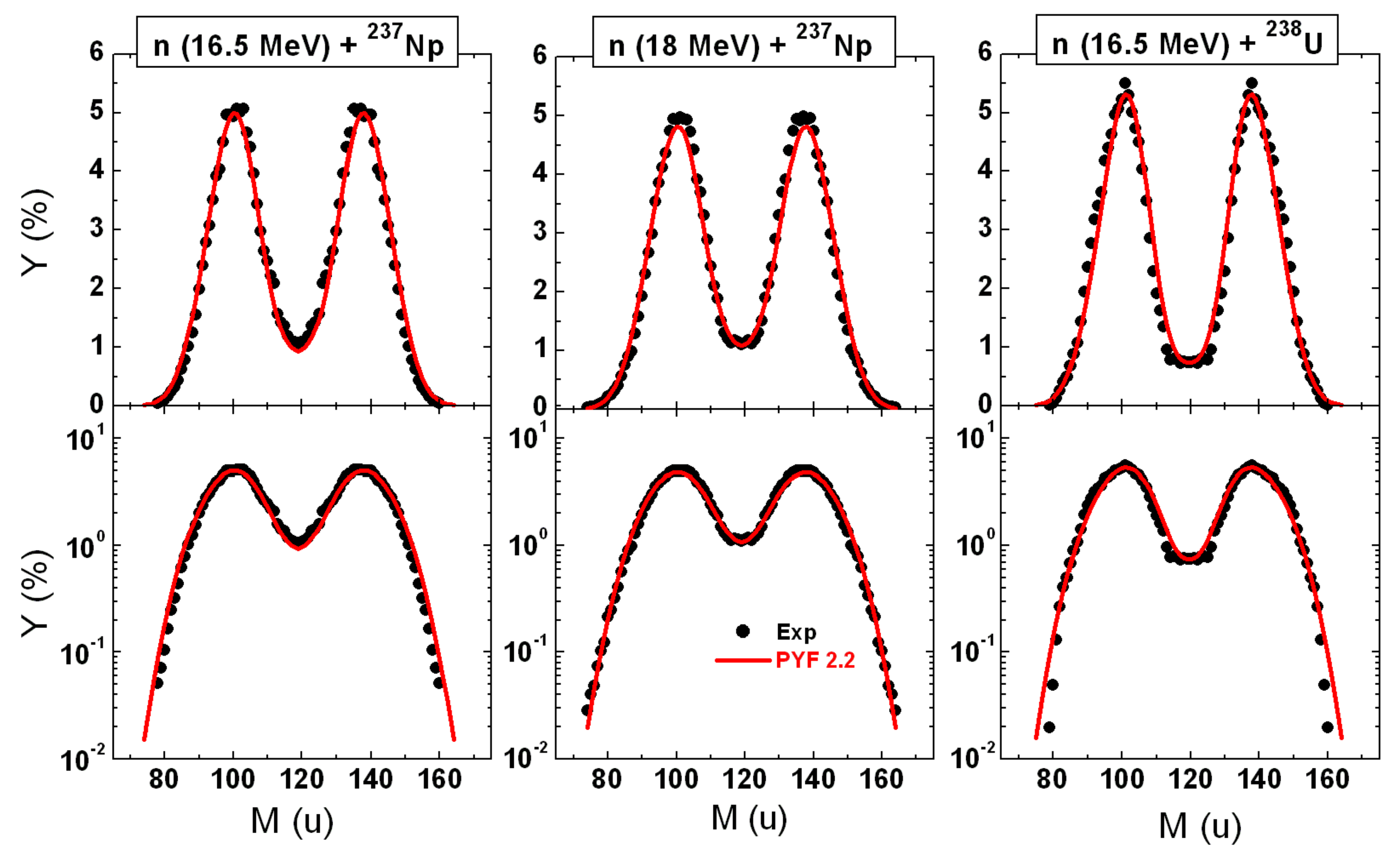
S. Oberstedt, et al., *Nucl. Phys. A* **644** 289 (1998)

The 8-15 MeV neutron induced fission



Experiment: J.E. Gindler, et al., *Phys. Rev. C* **27** 2058 (1983).
G.P. Ford and A.E. Norris, *Report LA-6129-MS*, Los Alamos, USA, 1976.
J. Laurec, A. Adam, Th. de Bruyne, *EXFOR 2000*, AN: 21707, 21708.
J. Winkelmann and D.C. Aumann, *Phys. Rev. C* **30**

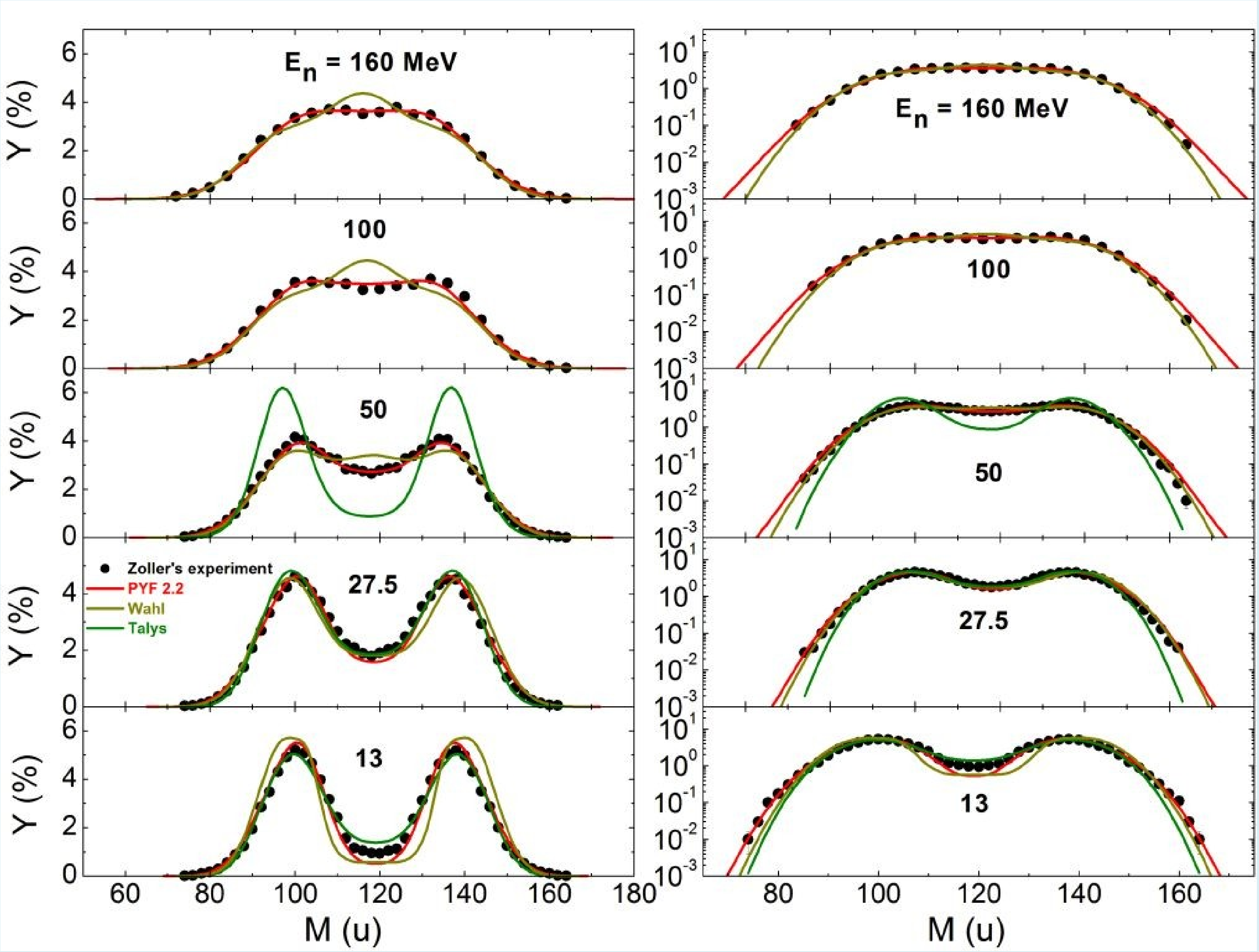
The 16-18 MeV neutron induced fission



Experiment: A.A. Goverdovski and V.F. Mitrofanov, *Phys. At. Nucl.* **56** 24 (1993).

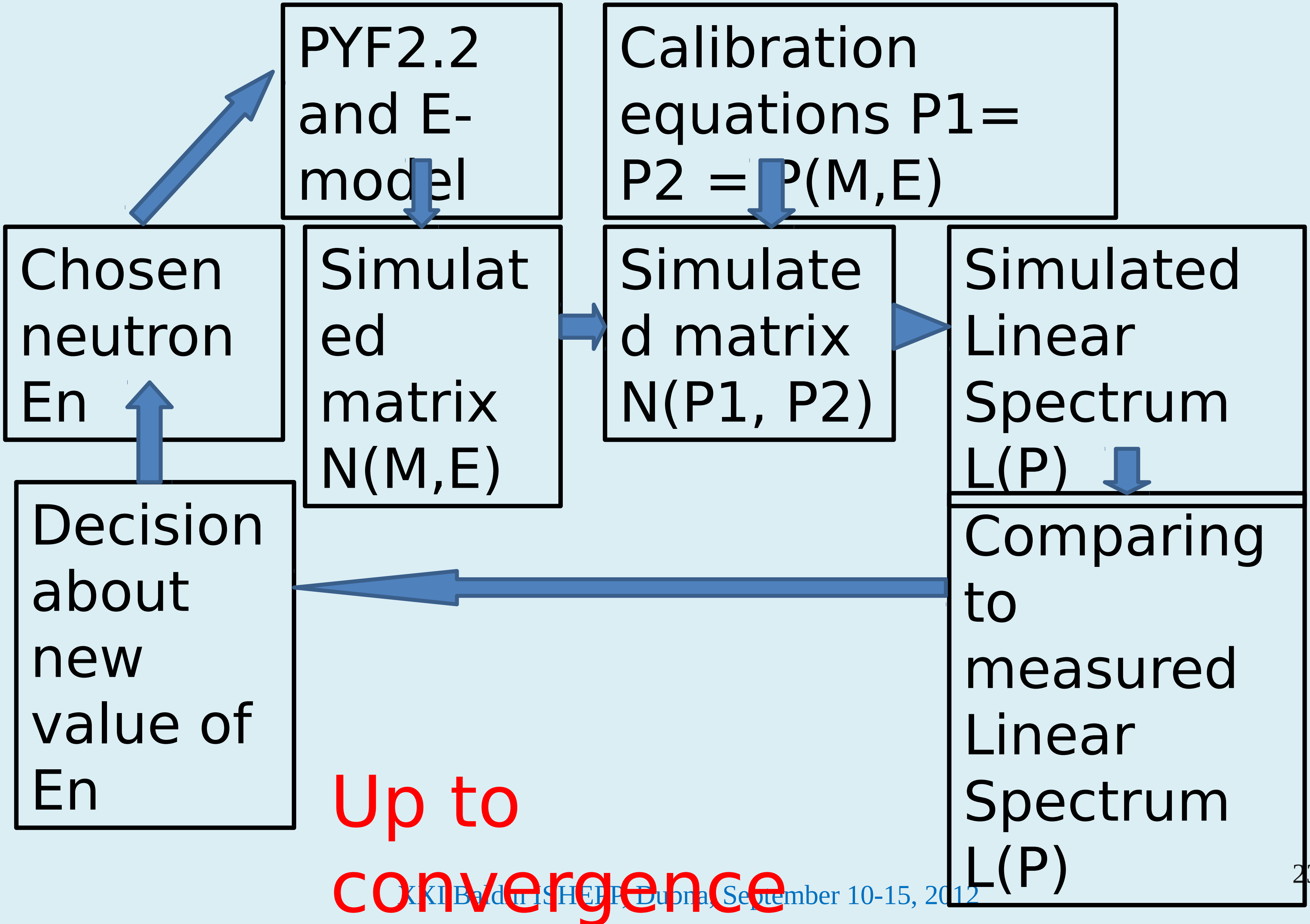
A.A. Goverdovski, et al., *Phys. At. Nucl.* **60** 1441 (1997).

The 13-160 MeV neutron induced fission of



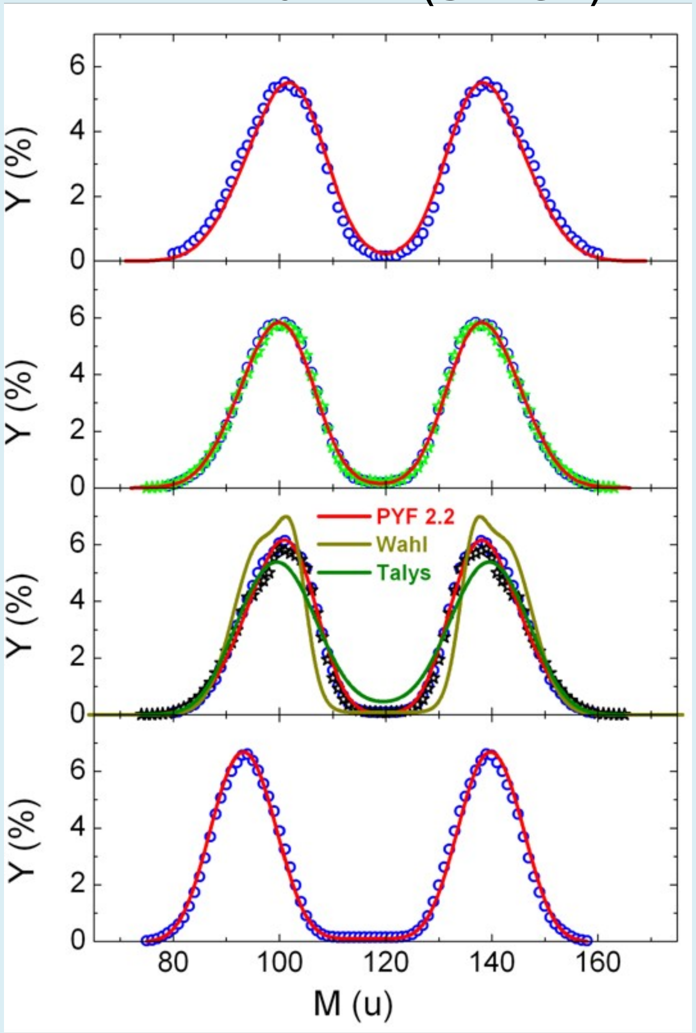
Experiment: C.M. Zöller, *Ph. D. Thesis*, TU Darmstadt, Germany, 1995.

Processing of measured data

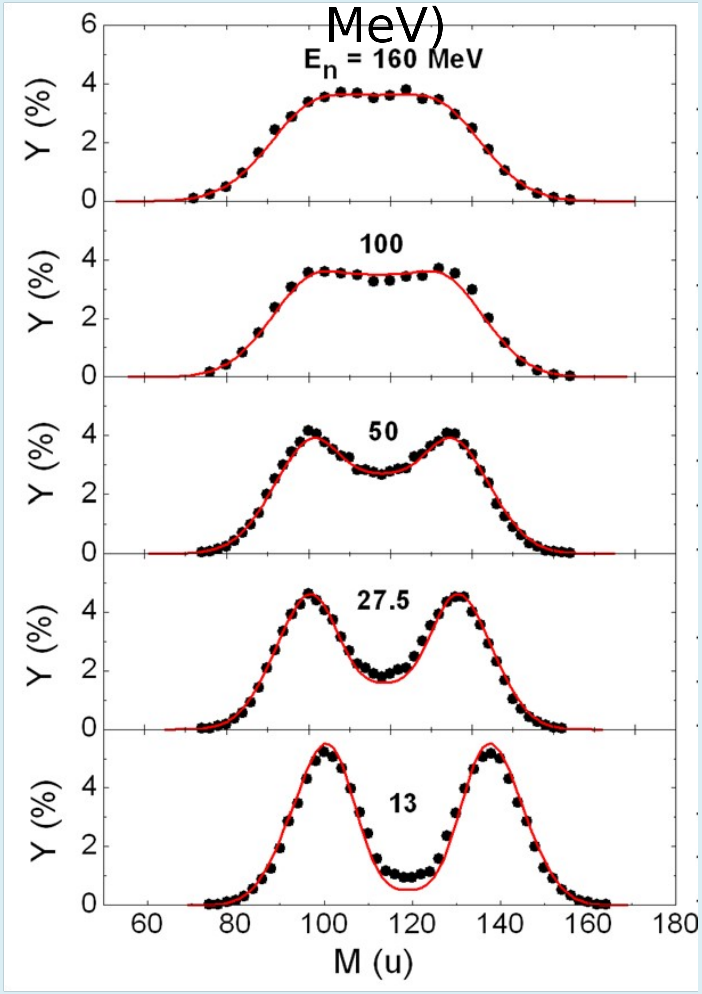


Sensitivity range 5-70 MeV

Th-Pu + n (5 MeV)



238U + n (13-160 MeV)



Radiation damage limits

PIPS-detectors:

Safe fast neutron fluence □ 5*1011 n/cm2

When actinide Target thickness □ 300 □g/cm2, number of fission events recordable by a detector of 1 cm2 at the fluence □ 3*105.

That is enough for calibrating detectors with the 14 MeV neutrons and *measuring shapes of experimental Linear Spectra*.

Conclusions

Proposed technique is suitable for measuring the effective energy of relativistic beam-generated neutrons caused fission in thick uranium targets.

Considered limitations seem not contain the grounds for refusal of its testing in experiments aimed at the development of Nuclear Relativistic Technologies.

Thank You for attention!