European Commission

Experimental activities NEADB

Arjan Plompen
JRC-Geel, SN3S unit

Serving society
Stimulating innovation
Supporting legislation
www.jrc.ec.europa.eu

Joint Research Centre

Sources

NEA Nuclear Data Week, 24-28 November 2014

French NEEDS program and JEFF

NEA Nuclear Data Week, 27-30 April 2015

EU CHANDA program and JEFF

RCM-2 IRDFF, IAEA, 16-20 March 2015

JRC-Geel work program

European Commission

JRC-Geel work program

European Commission

On the methodology to calculate the covariance of estimated resonance parameters

B. Becker , S. Kopecky and P. Schillebeeckx
International workshop of nuclear data covariances
28 April – 1 May , 2014, Santa Fe (USA)

Summary

- **Determination of covariance in resonance region**
  - **Covariance of T_{exp} and Y_{exp} well understood**
  - **URR : well understood**
  - **RRR : more research required**

Nuclear Data Sheets 123 (2015) 171–177

Schillebeeckx et al., Nuclear Data Sheets 113 (2012) 3054 - 3100

De Saint Jean et al., NSE 161 (2009) 363 – 370

- **Problems in RRR**
  - **Mainly related to propagate the covariance of experimental parameters**
  - **GLSQ + CUP : relies on a perfect reaction and experimental model**
    - **Requires verification of the quality of the model**
  - **GLSQ + MC: conservative**
    - **In case the quality of the experimental model cannot be verified (e.g. retroactive approach) this approach is strongly recommended**
- **Transmission measurements on homogeneous well-characterized samples can be considered as one of the most accurate integral experiments to validate cross data in the RRR.**
- **Integral data obtained with powder samples might be biased!**

Validation of nuclear data libraries by NRTA

- **Covariances for W isotopes** (NDS, various publications)

- **Validation experiment: determine areal density by NRTA**
  - **Sample: metallic disc of ^{nat}W**
    - Homogeneous sample
    - Areal density n : from weight and area
    - $\Rightarrow u_n/n < 0.2\%$
  - **Transmission : absolute measurement**
    - Absolute measurement
    - Methodology well understood (background, dead time correction,…)
      Nuclear Data Sheets 113 (2012) 3054 – 3100
    - $\Rightarrow u_{T_{exp}}/T_{exp} < 0.3\ \%$

$\Rightarrow$ **One of the most accurate integral experiment to validate resonance parameters**

Reference	$100 \times n_{FIT}/n$
Lynn et al.	*98.3 (1.0)*
ENDF/B - VI.8	109.7 (0.5)
JENDL - 3.3	111.3 (0.5)
ENDF/B - VII.1	111.3 (1.1)
JEFF - 3.2	100.2 (0.5)

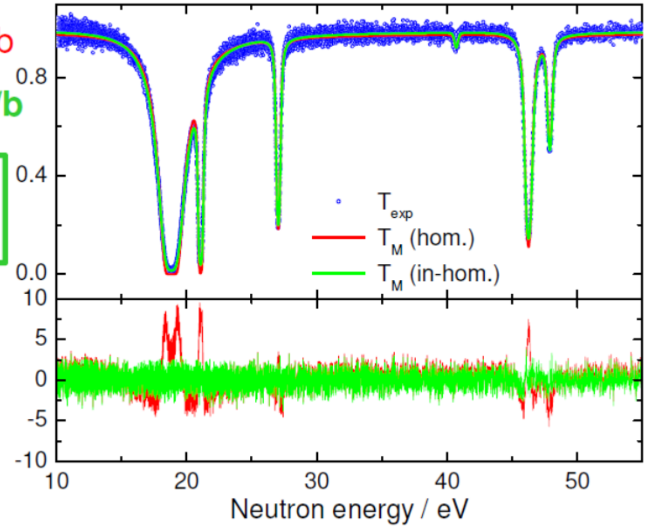
^{nat}W-powder mixed with ^{nat}S-powder
(80 cm diameter, 14 g ^{nat}W, 3.5 g ^{nat}S)

Declared : $n_W = (1.084 \pm 0.014)\ 10^{-3}$ at/b

T_M (hom.) : $n_W = (0.939 \pm 0.003)\ 10^{-3}$ at/b

T_M (inhom.) : $n_W = (1.096 \pm 0.003)\ 10^{-3}$ at/b

$$\overline{T} = \int T(n')p(n')dn' = \int e^{-n'\sigma_{tot}} p(n')dn'$$



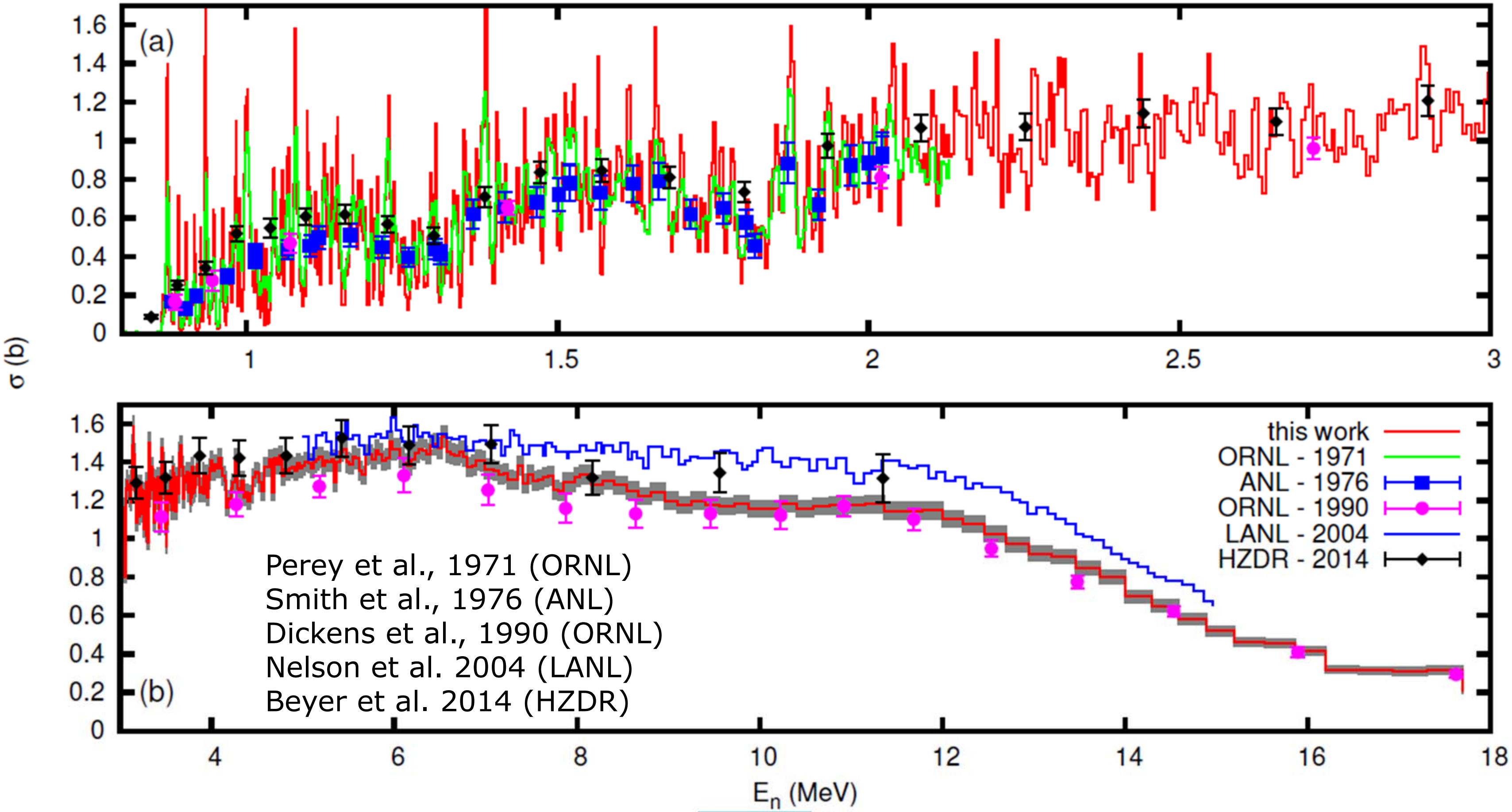
LP Model
Levermore, Pomraning et al., J. Math. Phys. 27, 2526, 1986

Implemented in REFIT
Becker et al., Eur. Phys. J. Plus 129 (2014) 58 - 9

$^{56}Fe(n,n'\gamma)$

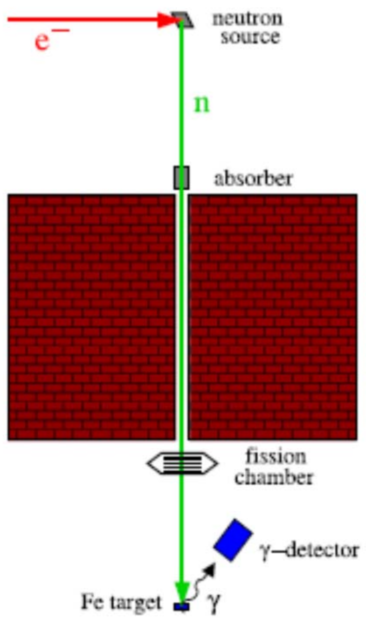
A. Negret et al. PRC90(2014)034602

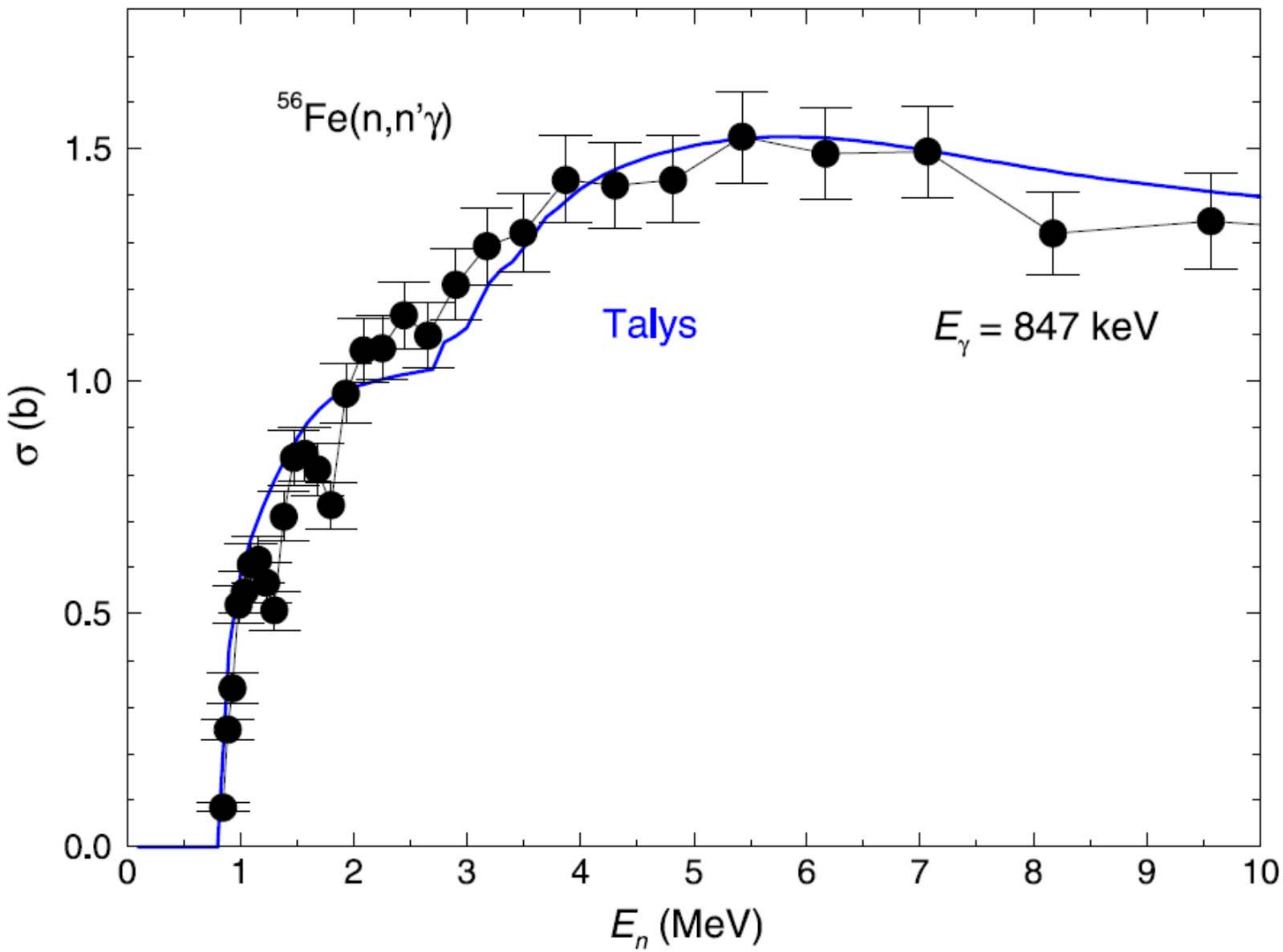
847 keV gamma-ray (L1-g.s.)



HZDR work program:

R. Beyer et al. / Nuclear Physics A 927 (2014) 41–52

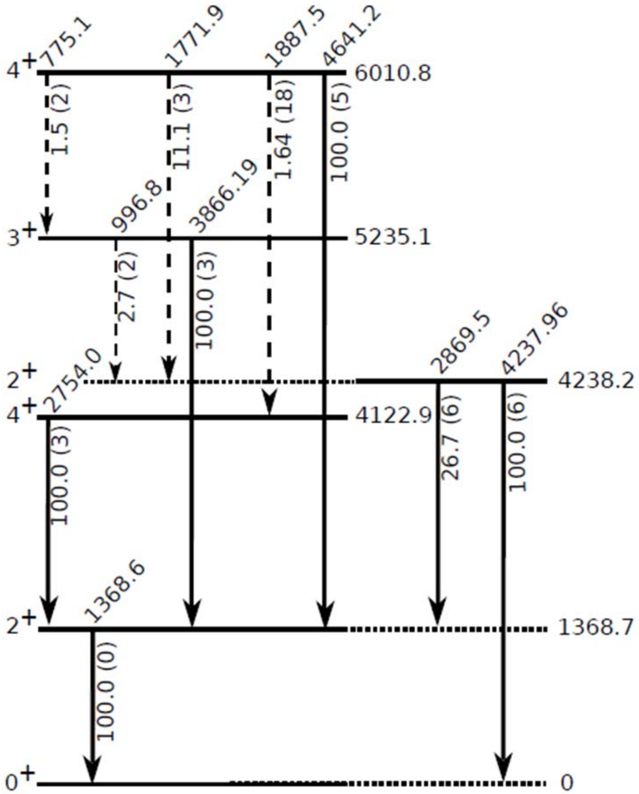




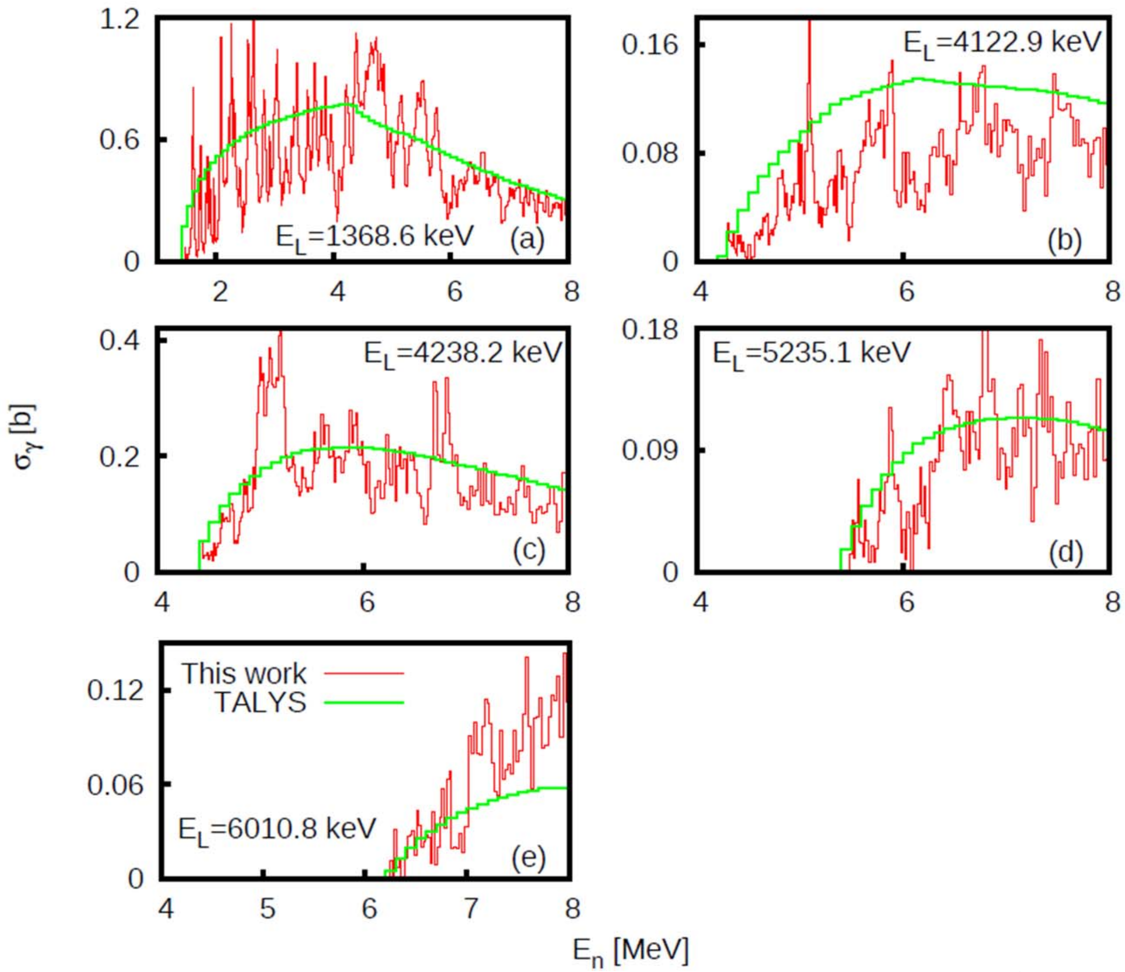
European Commission

$^{24}Mg(n,n'g)$

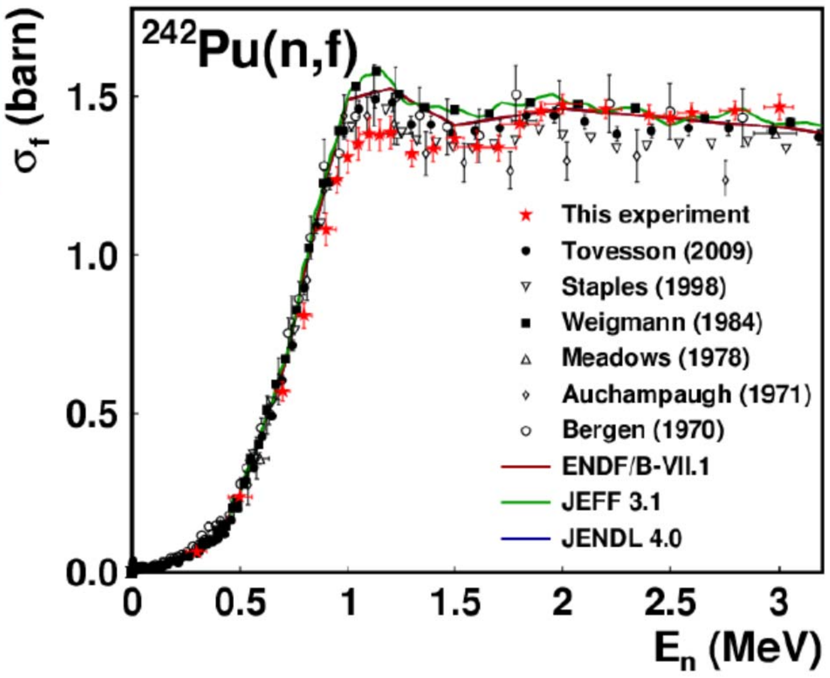
A. Olacel et al. PRC90(2014)034603

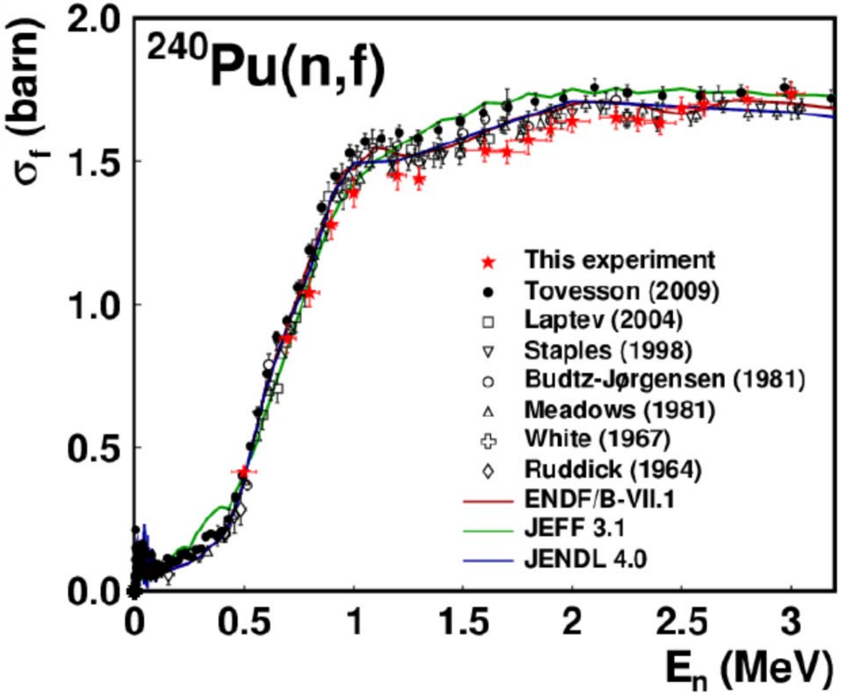


Level cross sections



Joint Research Centre





Submitted for publication to PRC

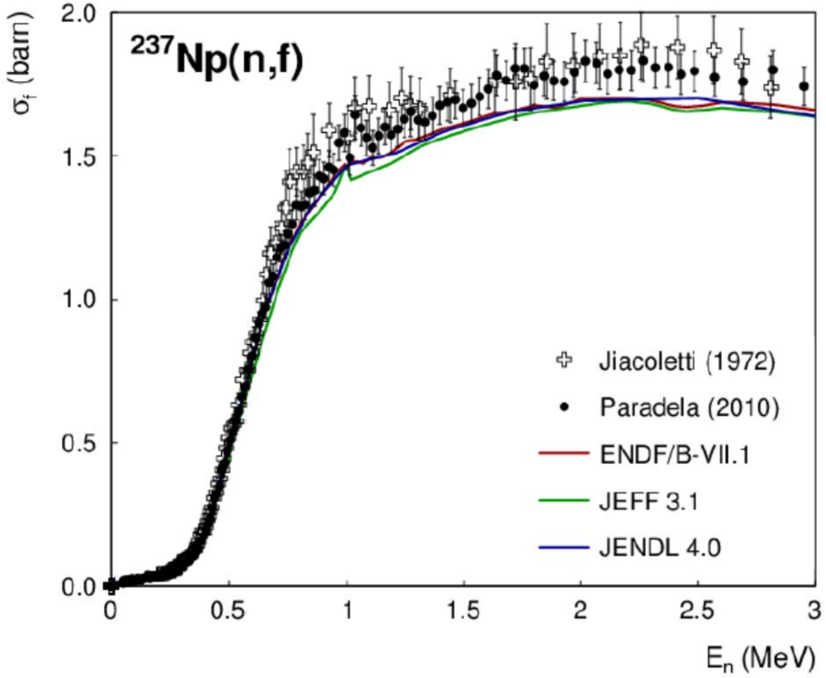
Collab with UPC Barcelona

MCNP modeling of setup

Thin ^{242}Pu target

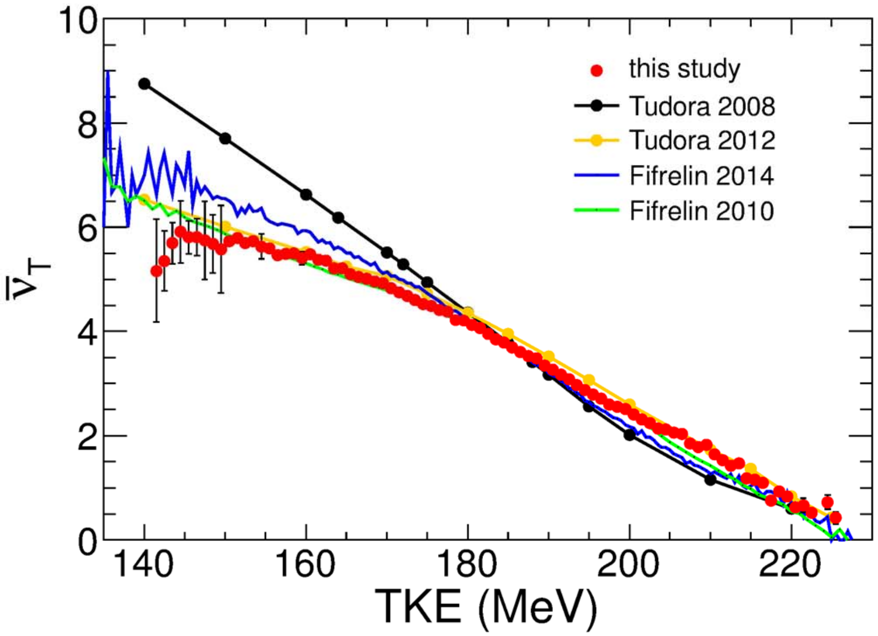
Reference Targets:

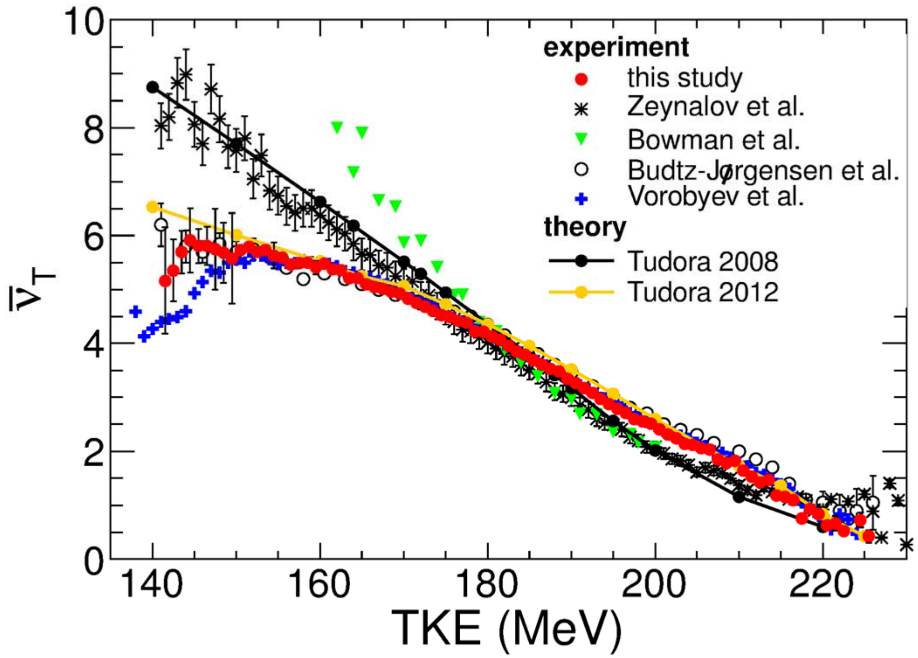
^{235}U, ^{237}Np, ^{238}U



^{235}U, ^{239}Pu n-multiplicity fluctuations for new evaluations

- measure multiplicity and fragment properties in resonances
- Feasibility study done with ^{252}Cf





Prompt fission γ-rays from $^{241}Pu(n_{th},f)$

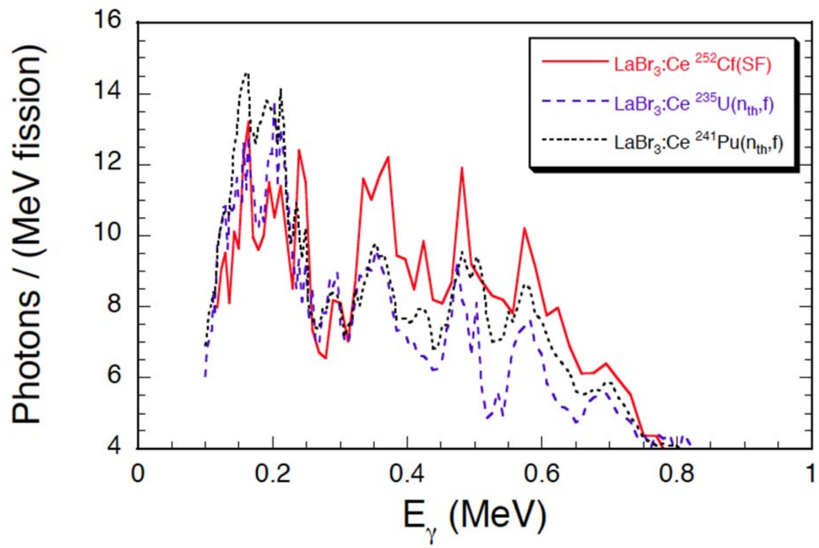
European Commission

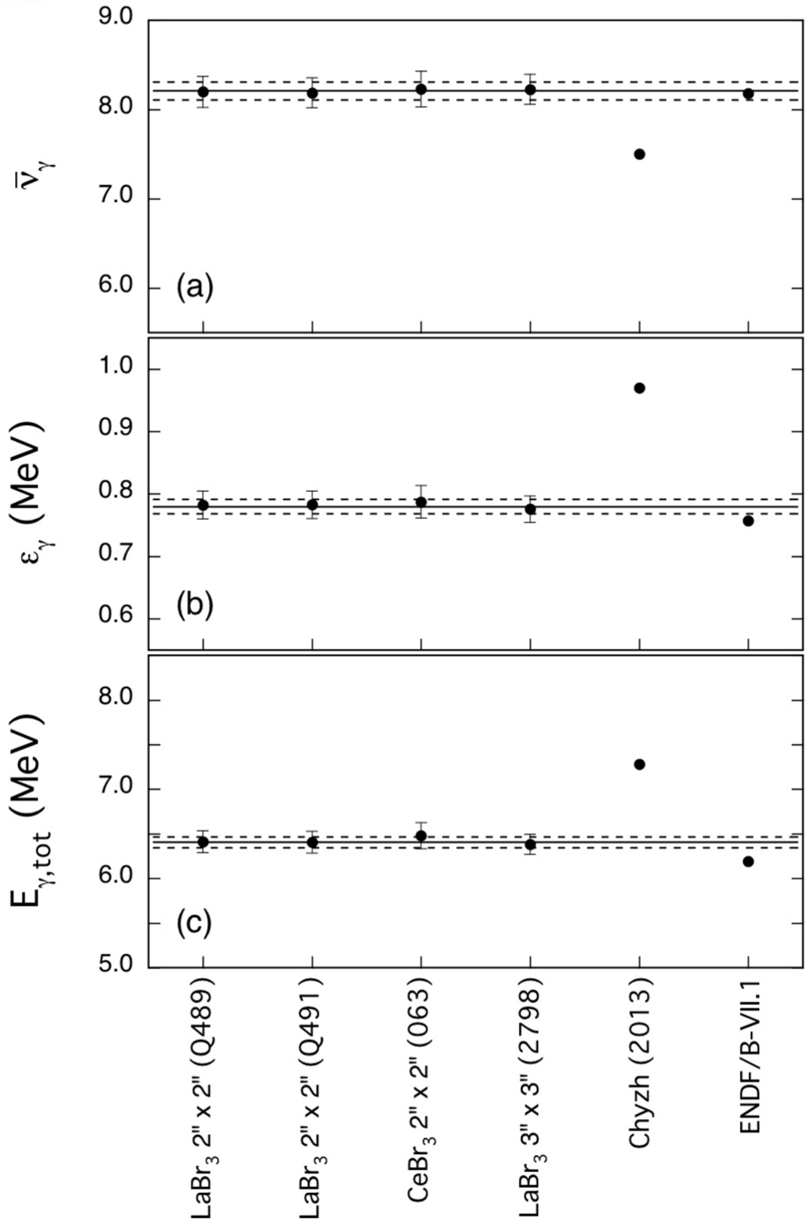
In response to an OECD/NEA high-priority data request

Relevant for γ heating

Data for benchmarking nuclear models

High-precision prompt γ-ray spectral data





Mass-dependent prompt fission γ-rays

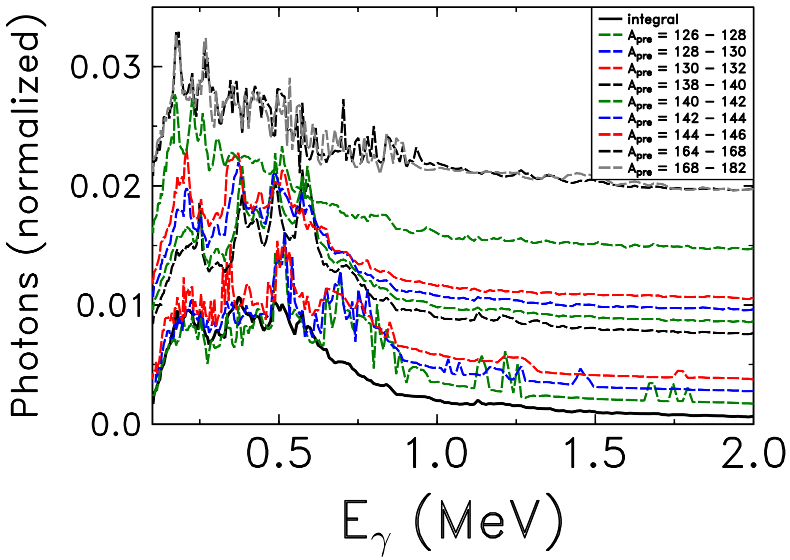
European Commission

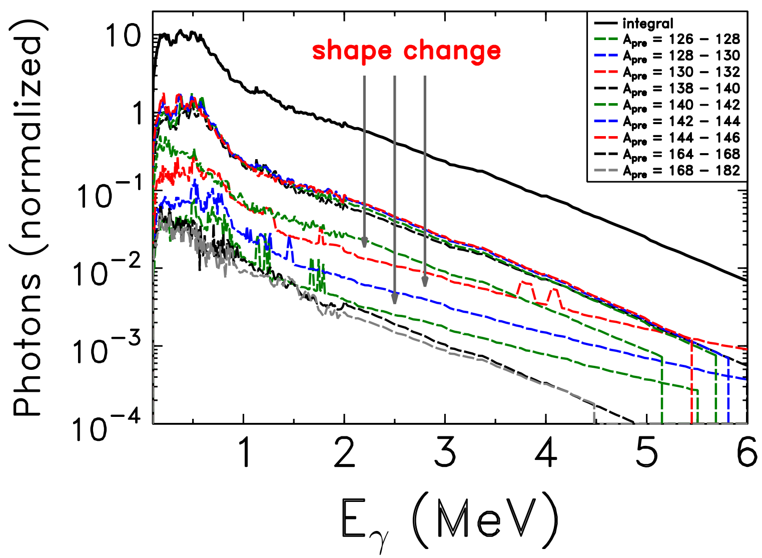
First spectra taken for selected fragment mass ratios

Distinct features at low energies

HE shape change close to symmetric fragmentation

Input to model codes like GEFF, FIFRELIN, …





PhD thesis work of R. Billnert

S. Oberstedt et al., Nucl. Dt. Sheets 119 (2014) 225
R. Billnert et al., Phys. Procedia 59 (2014) 017
A. Oberstedt et al, Phys. Procedia 59 (2014) 024
S. Oberstedt et al., Phys. Rev. C90, 024618 (2014)
A. Oberstedt et al, Phys. Procedia, in press
A. Oberstedt et al., Phys. Rev. C, *in press*

Energy dependence of prompt fission γ-rays

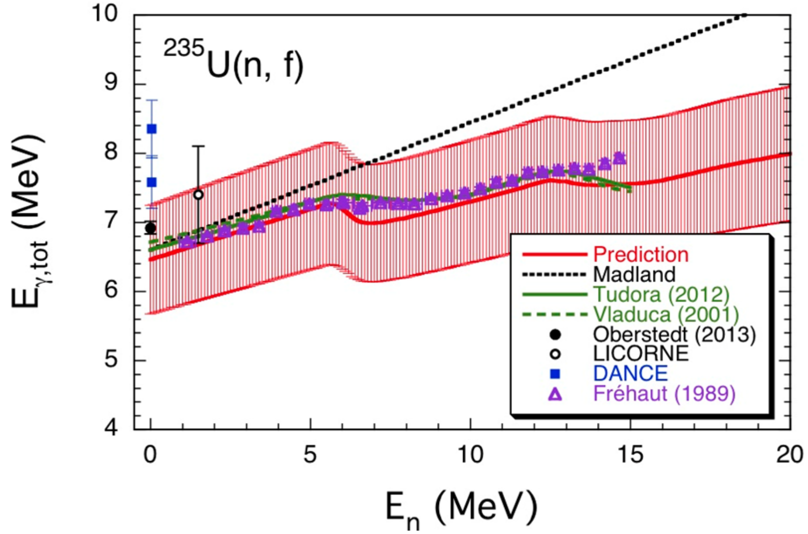
European Commission

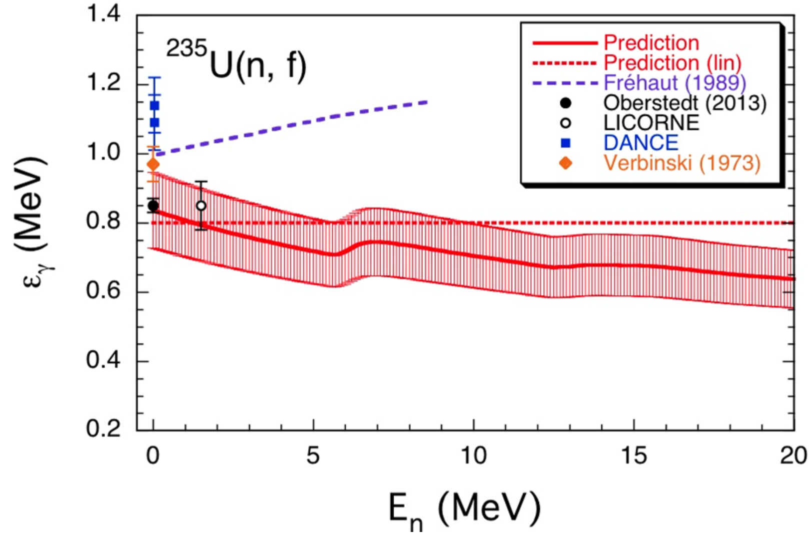
From a systematic analysis of existing PFGS and PFNS data:

Prediction of average characteristics up to E_n = 20 MeV

Verification with first PFGS data from fast-neutron induced fission on ^{235}U

A. Oberstedt et al., submitted for publication





European Commission

University of Uppsala

Slides contributed by Stephan Pomp

Measurement of nubar(A,E) and PFNS for ^{235}U and ^{237}Np at IRMM

A. Al Adili[1], A. Göök[2], K. Jansson[1], F.-J. Hambsch[2], S. Oberstedt[2], V. Rakopoulos[1], A. Solders[1], D. Tarrio[1], S. Pomp[1]

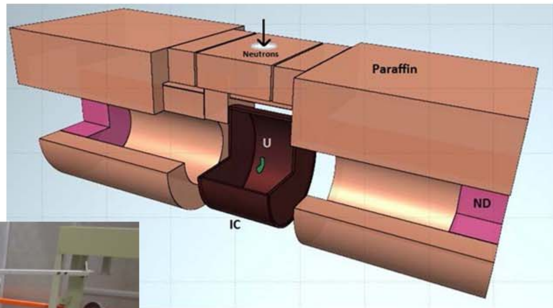
[1]Uppsala University, Sweden [2]JRC-IRMM, Belgium

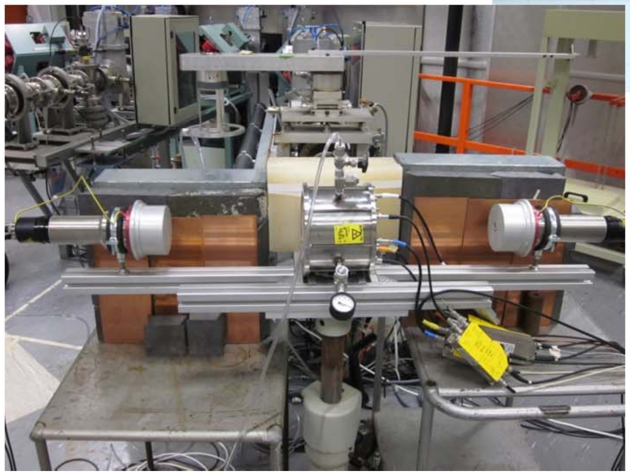
Aim: Measure nubar and PFNS as function of energy and mass for various targets

Method: Frisch-Grid Ionization Chamber + neutron detectors from SCINTIA setup

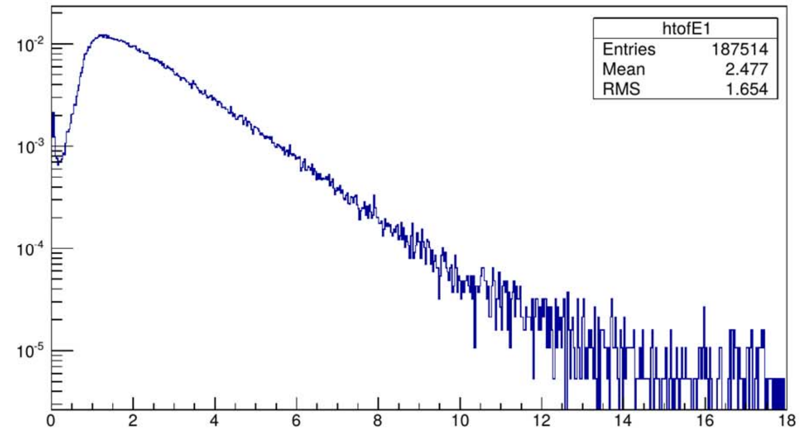
Data: First measurements with thermalized neutrons from IRMM Van De Graaff
New run at higher energy (6 MeV?) planned fro autumn 2015.

Drawing for FLUKA simulations





Setup with FGIC, 2 neutron detectors, moderator and shielding



VERY preliminary result for U-235 PFNS

Measuring ^{6}Li (n,α) at IRMM with the GELINA white spectrum neutron source

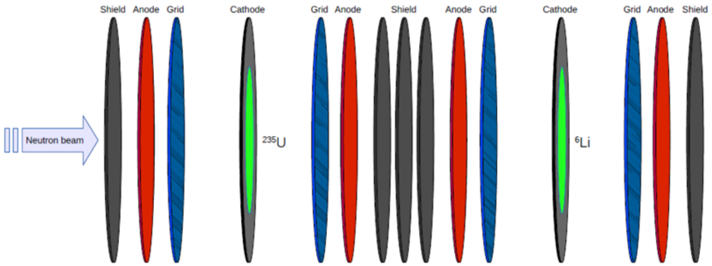
UPPSALA UNIVERSITET

K. Jansson[1], A. Al Adili[1], C. Gustavsson[1], F.-J. Hambsch[2], S. Oberstedt[2], D. Tarrio[1], S. Pomp[1] , et al.

[1]Uppsala University, Sweden [2]JRC-IRMM, Belgium

Aim: Measure ^{6}Li(n,α) cross section up to several MeV for extension of neutron standard

Method: Twin Frisch-Grid Ionization Chamber (with P-10) at GELINA facility using LiF targets and U-235 as reference; digital DAQ



TFGIC with U-235 and LiF target

Part of licentiate thesis (half-time PhD) of Kaj Jansson (kaj.jansson@physics.uu.se) to be presented on May 29, 2015.

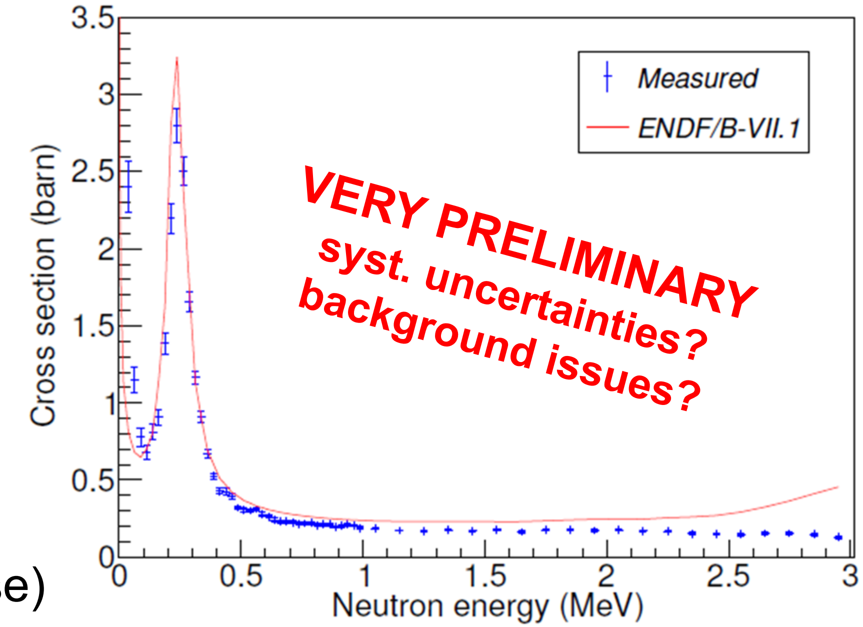


Figure 3.13. Preliminary cross section of the ^{6}Li(n,α) reaction, the error bars represent statistical uncertainties only. To obtain absolute values the ^{235}U cross section from ENDF/B-VII.1 evaluation [16] has been used. The measured fission counts have been extrapolated in the $|\cos\theta| \in [0, 0.3)$ region assuming an isotropic emission. Agreement in the low and high energy region is not so good but around the resonance region our measured data agrees well with the evaluation.

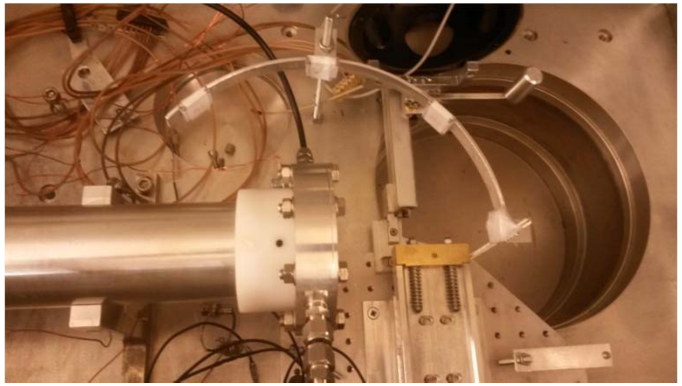
UPPSALA UNIVERSITET

Towards measuring neutron-induced independent fission yields at IGISOL

A. Al Adili, B. Eriksson, M. Lantz, A. Mattera, S. Pomp, A. Prokofiev, V. Rakopoulos and the JYFL IGISOL team

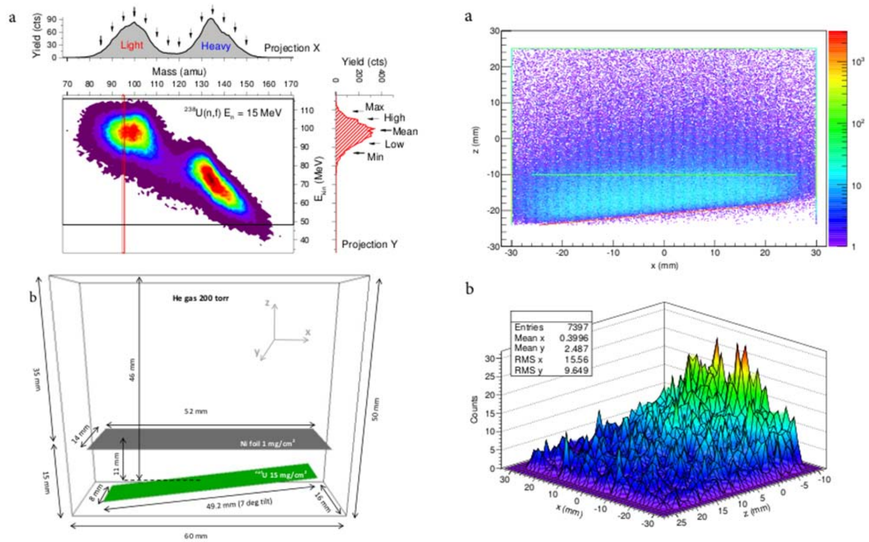
Goal: Obtain high quality data for better understanding of the fission process and for better use of resources in present and future nuclear systems.

Method: Measurements of neutron-induced independent fission yields from different fissile isotopes (^{235,238}U, ^{239,240}Pu, ^{241,243}Am) with fast and thermal neutrons.

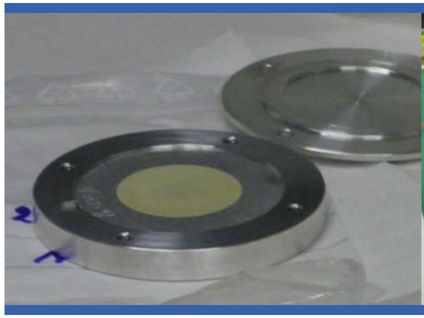
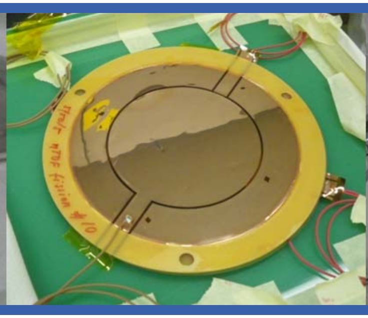
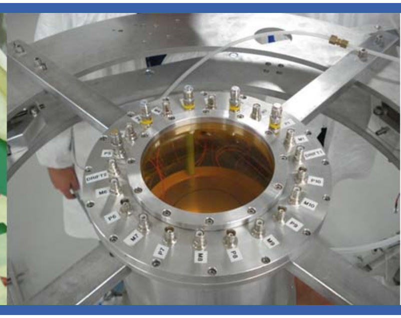
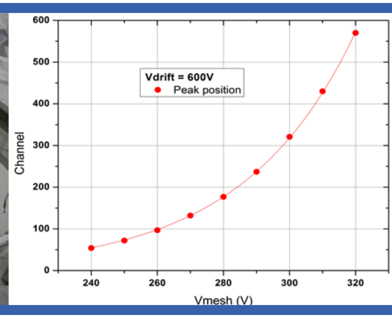


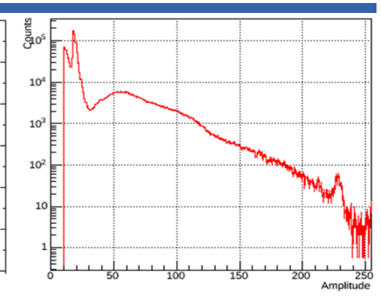
Characterization of Be(p,xn) neutron field with activation plates

A. Solders et al., NDS 119 (2014) 338
A. Smirnov et al., NIM A 687 (2012) 14
A. Al Adili et al., EPJA (2015) accepted



Studies of mass- and energy dependence of fission product extraction efficiencies.

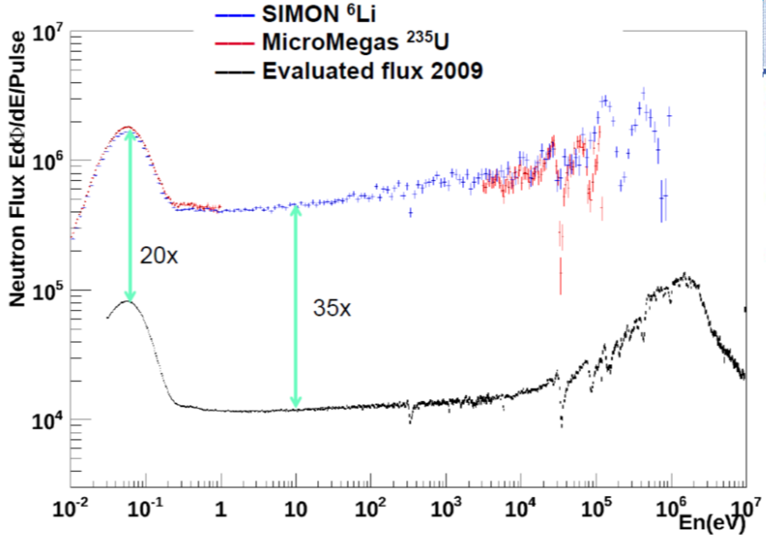







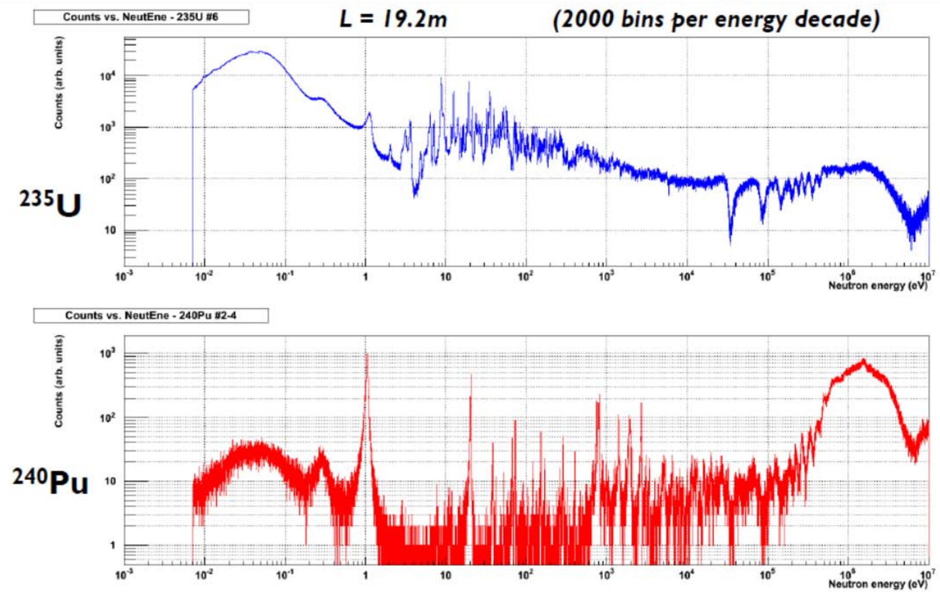
Measurement of the ^{240}Pu(n,f) cross-section at n_TOF EAR-2

A. Tsinganis (NTUA), A. Stamatopoulos (NTUA), N. Colonna (INFN-Bari), R. Vlastou (NTUA), P. Schillebeeckx (IRMM), A. Plompen (IRMM), J. Heyse (IRMM), M. Kokkoris (NTUA), M. Barbagallo (INFN-Bari), E. Berthoumieux (CEA-Saclay), M. Calviani (CERN), E. Chiaveri (CERN) and the n_TOF Collaboration

CHANDA-JEFF Workshop
Paris, April 27-29, 2015

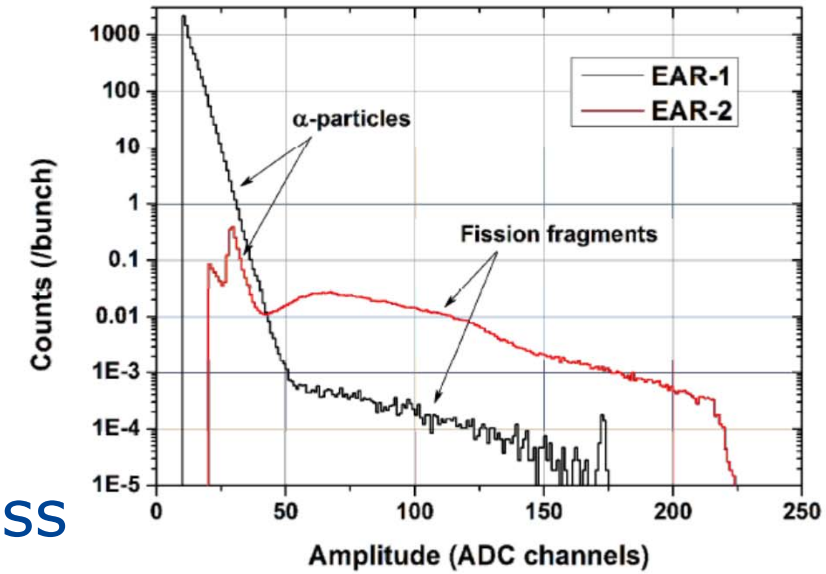


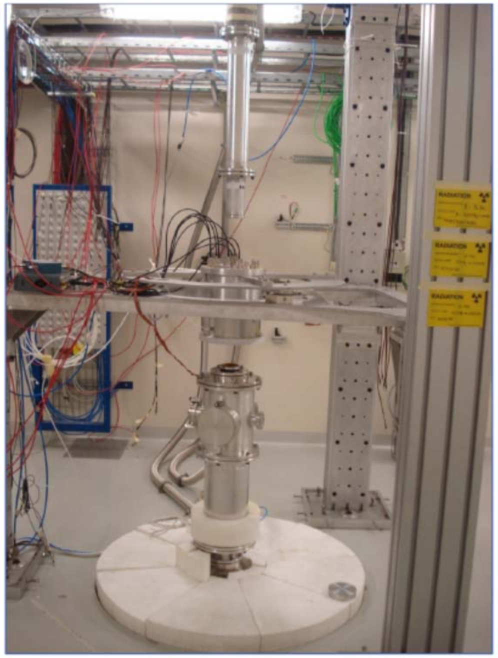
Fission counts



Amplitude spectra

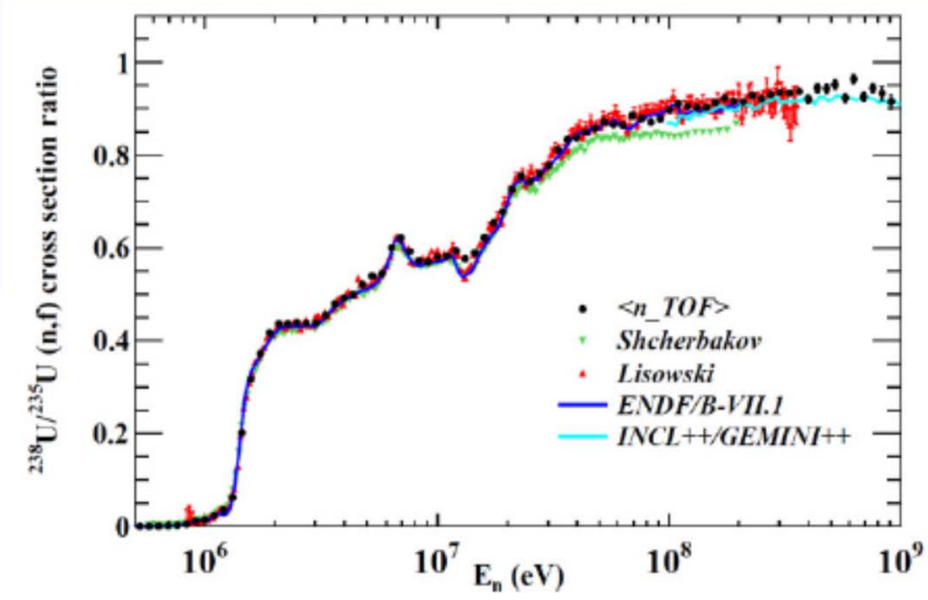
- Comparison with EAR-1
- Extremely improved conditions
  - Increased flux
  - Better background suppression

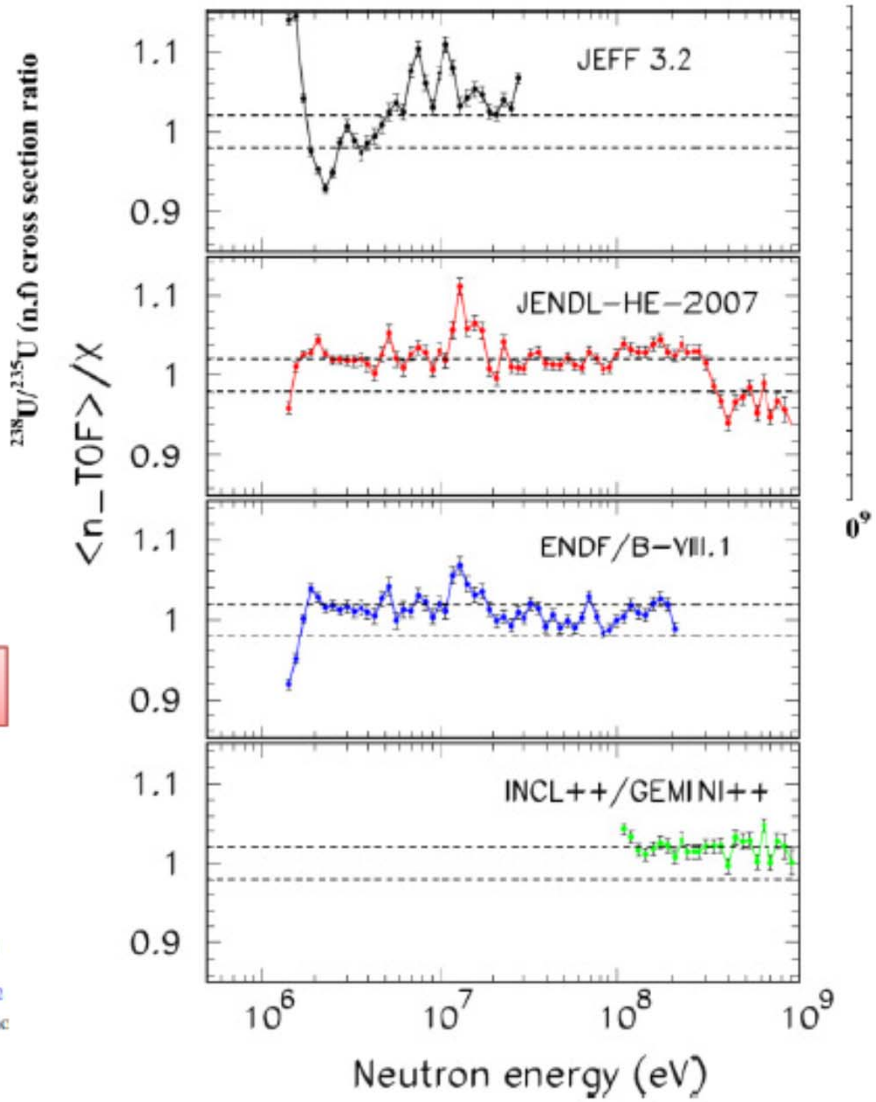




Work in progress

The $^{238/235}U(n,f)$ cross section ratio





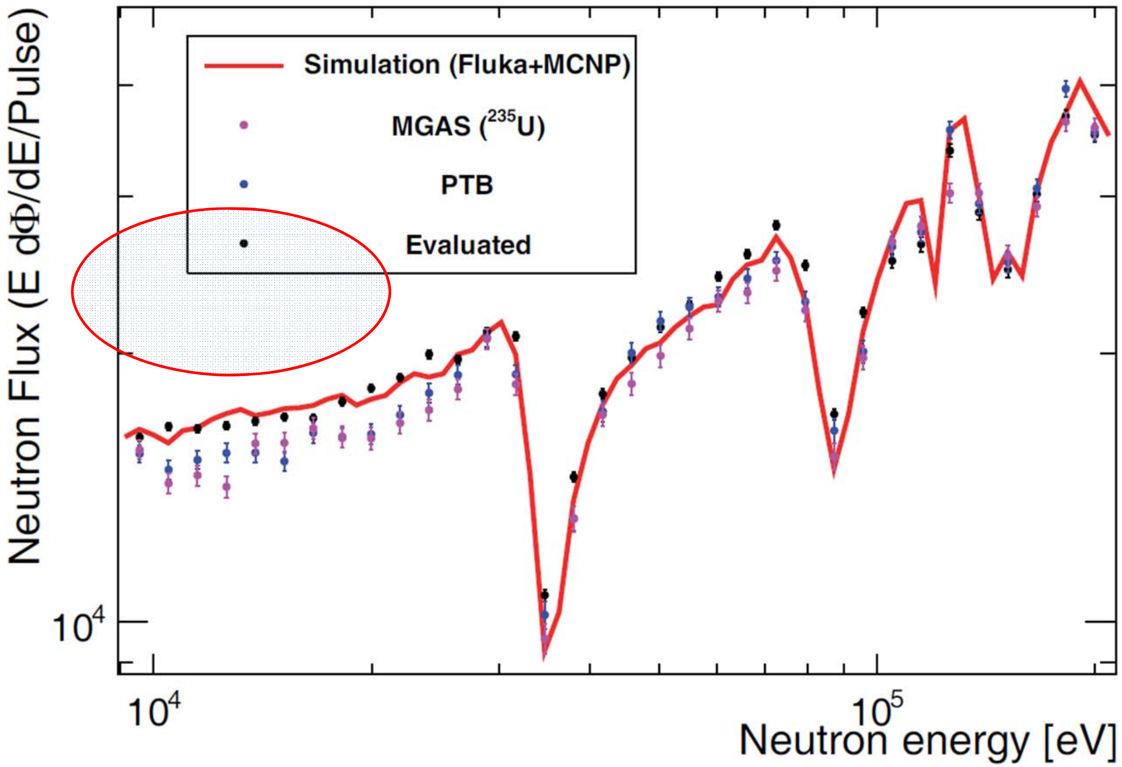
JEFF 3.2 needs a revision on this important ratio

PHYSICAL REVIEW C 00, 004600 (2015)

High-accuracy determination of the $^{238}U/^{235}U$ fission cross section ratio up to ≈ 1 GeV at n_TOF at CERN

C. Paradela,[1,2] M. Calviani,[3] D. Tarrío,[1,4] E. Leal-Cidoncha,[1] L. S. Leong,[5,6] L. Tassan-Got,[5] C. Le Naour,[5] I. Duran,[1] N. Colonna,[7,*] L. Audouin,[5] M. Mastromarco,[7] S. Lo Meo,[8] A. Ventura,[9] G. Aerts,[10] S. Altstadt,[11] H. Álvarez,[1] F. Álvarez-Velarde,[12] S. Andriamonje,[10] J. Andrzejewski,[13] G. Badurek,[14] M. Barbagallo,[7] P. Baumann,[15] V. Bécares,[12] F. Bečvář,[16] F. Belloni,[2] B. Berthier,[5] E. Berthoumieux,[10] J. Billowes,[17] V. Boccone,[3] D. Bosnar,[18] M. Brugger,[3] F. Calviñc

^{235}U(n,f) between 10 and 30 keV



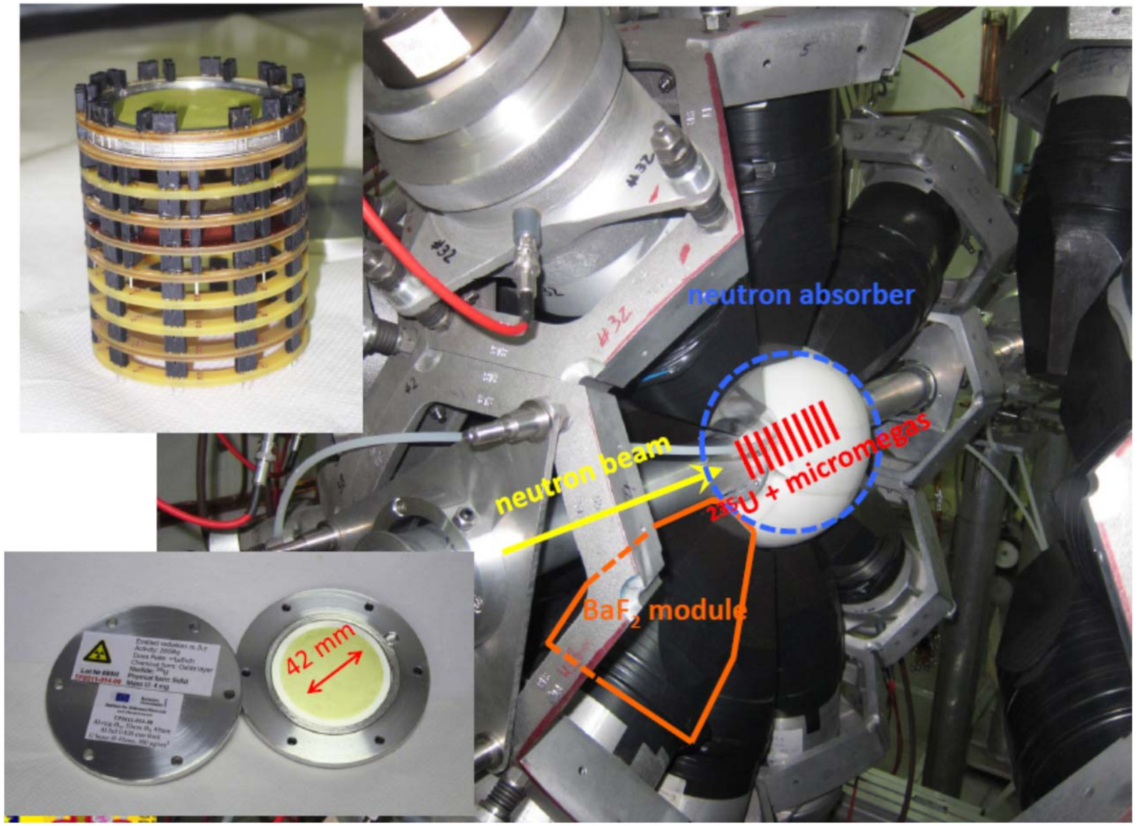
The **flux** calculated on the basis of the ^{235}U(n,f) cross section **found systematically lower** than "expected" in the 10-30 keV range (***M. Barbagallo et al., Eur. Phys. J A 49 (2013) 156***).

The (n,f) cross section in this range potentially overstimated by 6-8%.

Measurement of (n,γ) cross sections of fissile isotopes: the test case of ^{235}U

[1] J. Balibrea, [1] D. Cano-Ott, [1] E. Mendoza et al.
CIEMAT
The n_TOF collaboration

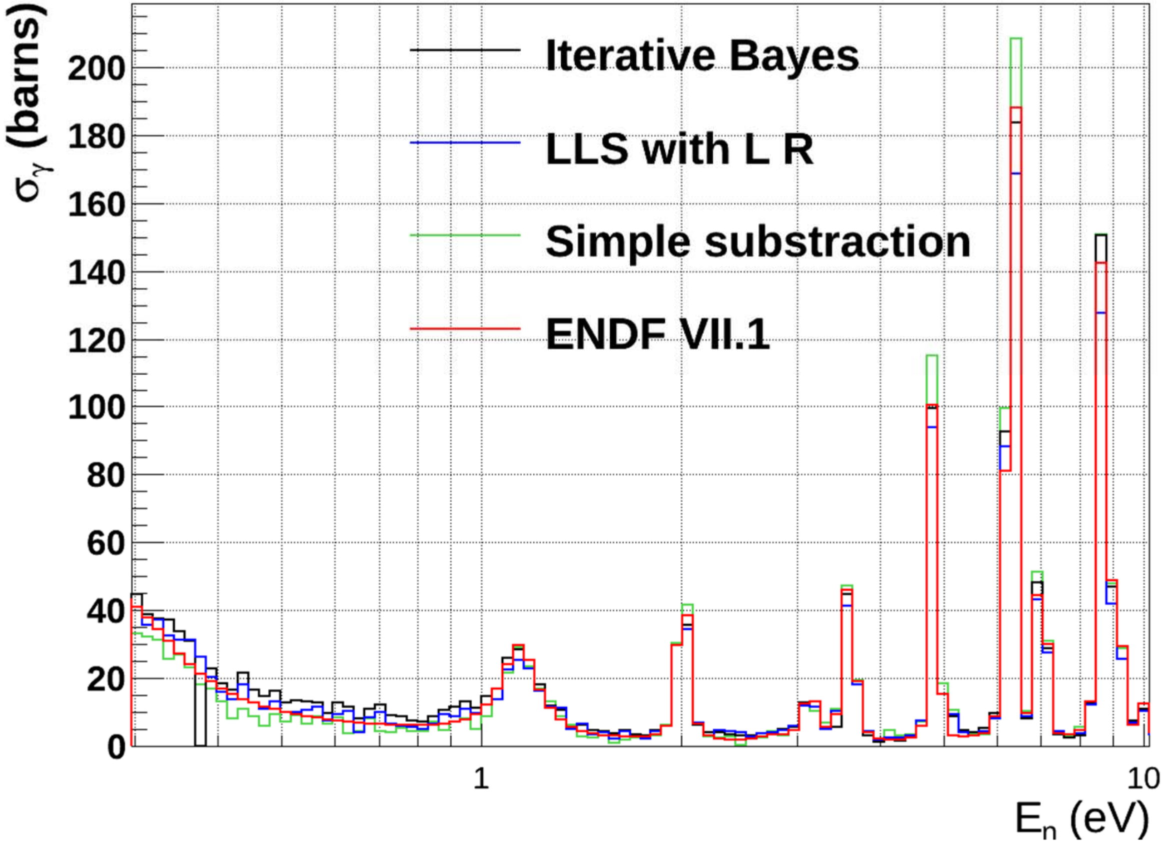
The TAC & fission tagging



Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

First tests and yields (educated rubbish!)

The author was unduly rough on himself. Check the presentation for the careful work that is being done. (AP)



Most of the de-convolution algorithms have been programmed but have not yet been fully debugged. The bin to bin deconvolution is a very time consuming procedure.

STUDY OF PROMPT NEUTRON/GAMMA EMISSION IN FISSION WITH LICORNE

M. Lebois, Q. Liqiang, J.N. Wilson, A. Oberstedt, S. Oberstedt, P. Halipré, G. Belier, J-A. Briz-Monago, A. Chatillon, M. Fallot, J-M. Laborie, B. Laurent, P. Marini, I. Matea, A. Porta, A. Sardet, J. Taieb, C. Varignon, C. Schmitt

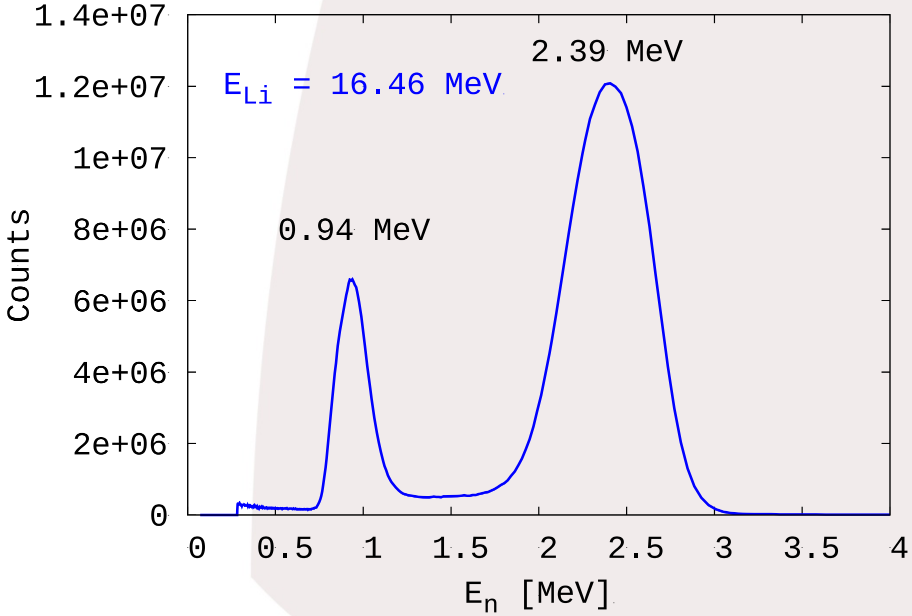
Hydrogen gas cells

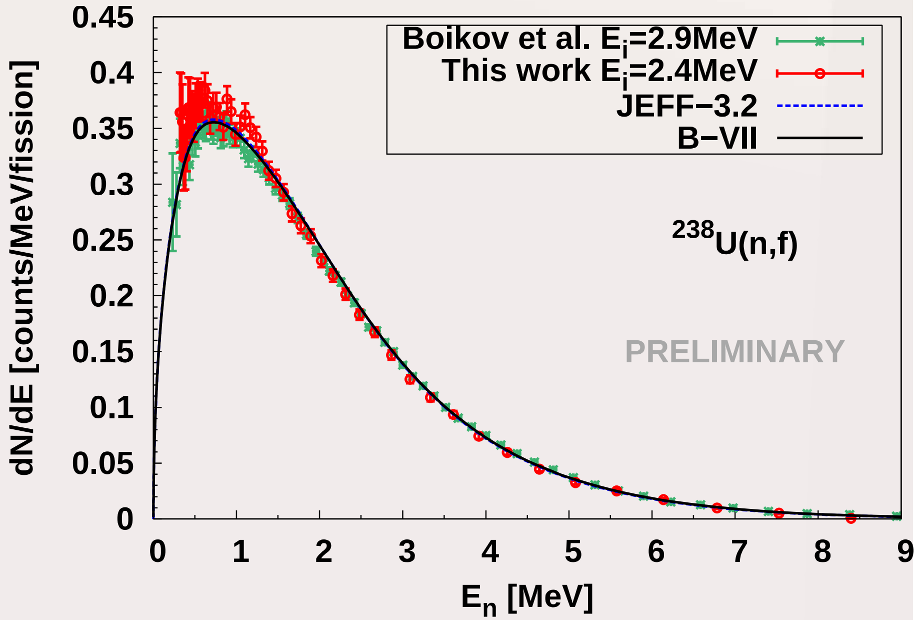
Kinematically focused neutron source $p(^{7}Li,n)^{7}Be$ inverse reaction

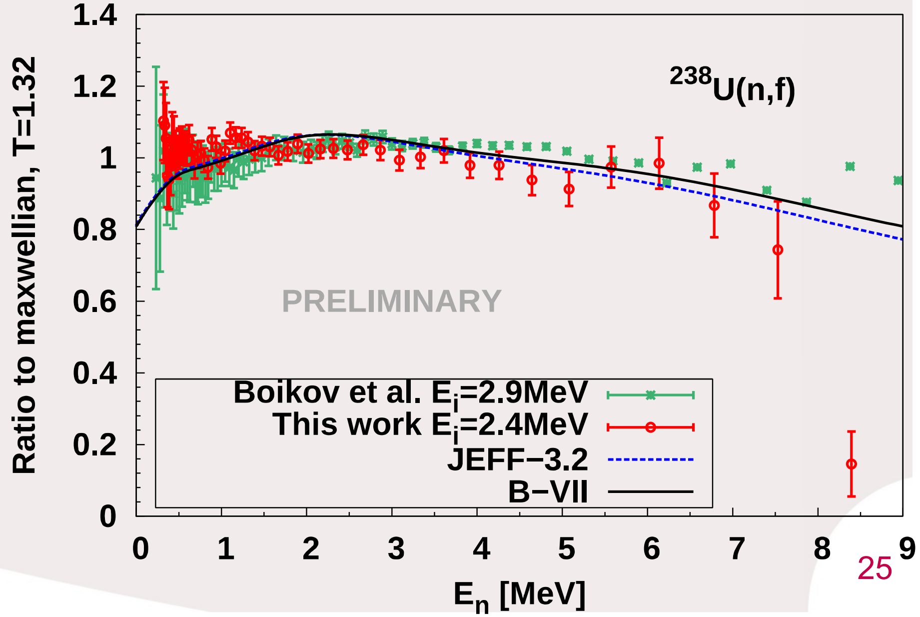
M.Lebois, et al., Nucl. Instrum. Meth. A 735 145 (2014)

PRELIMINARY RESULTS ON NEUTRON EMISSION

A. Sardet (CEA/DAM Ile-de-France)
PhD Thesis

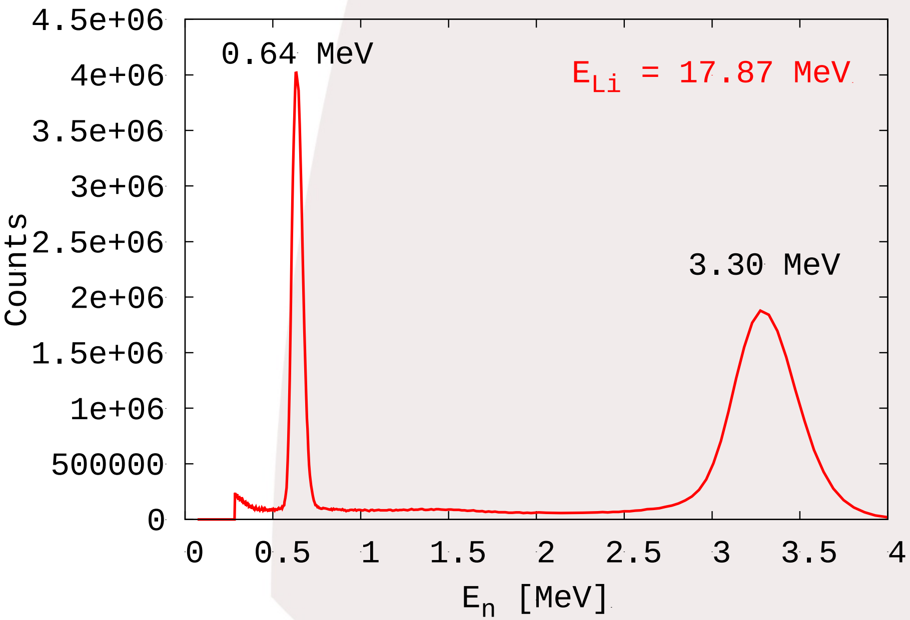


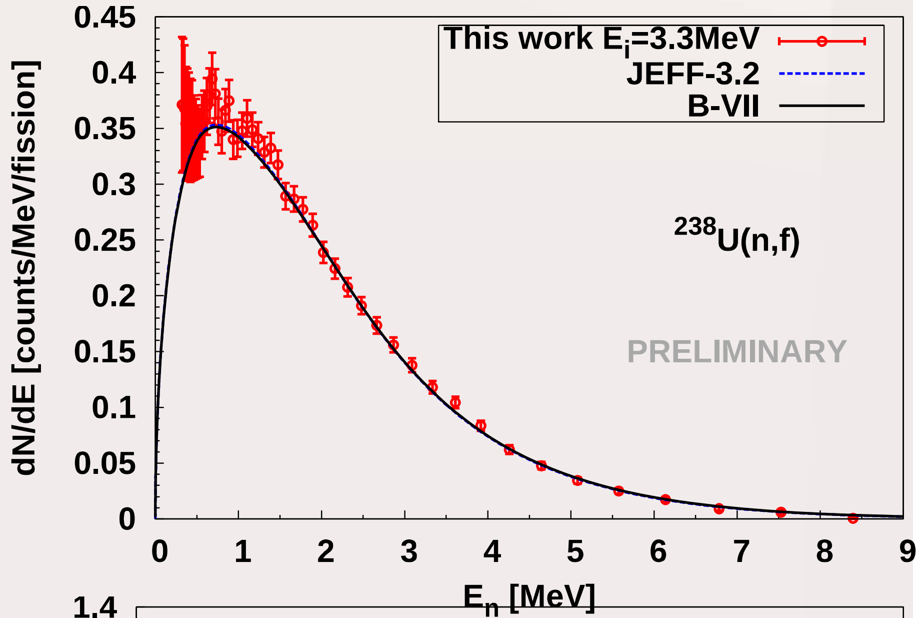


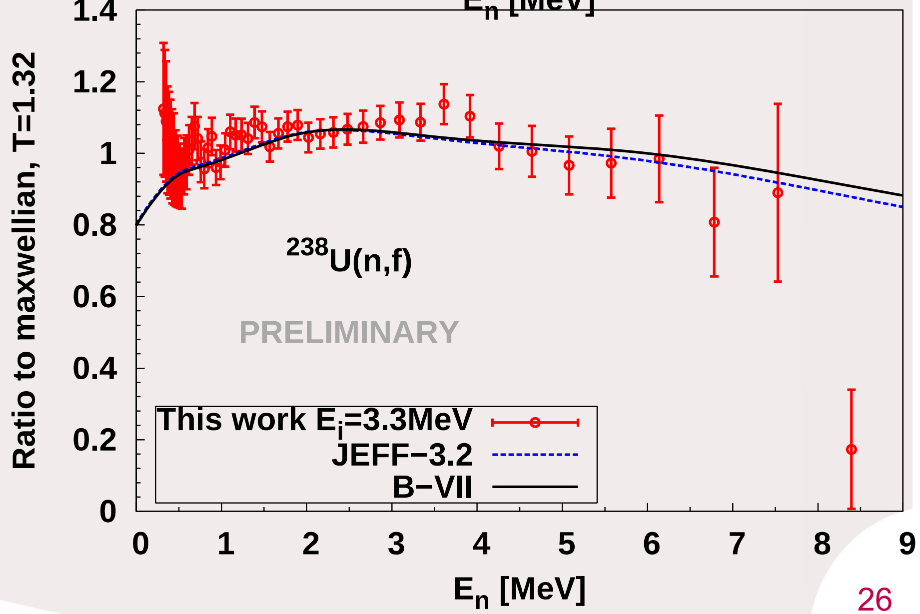


PRELIMINARY RESULTS ON NEUTRON EMISSION

A. Sardet (CEA/DAM Ile-de-France)
PhD Thesis

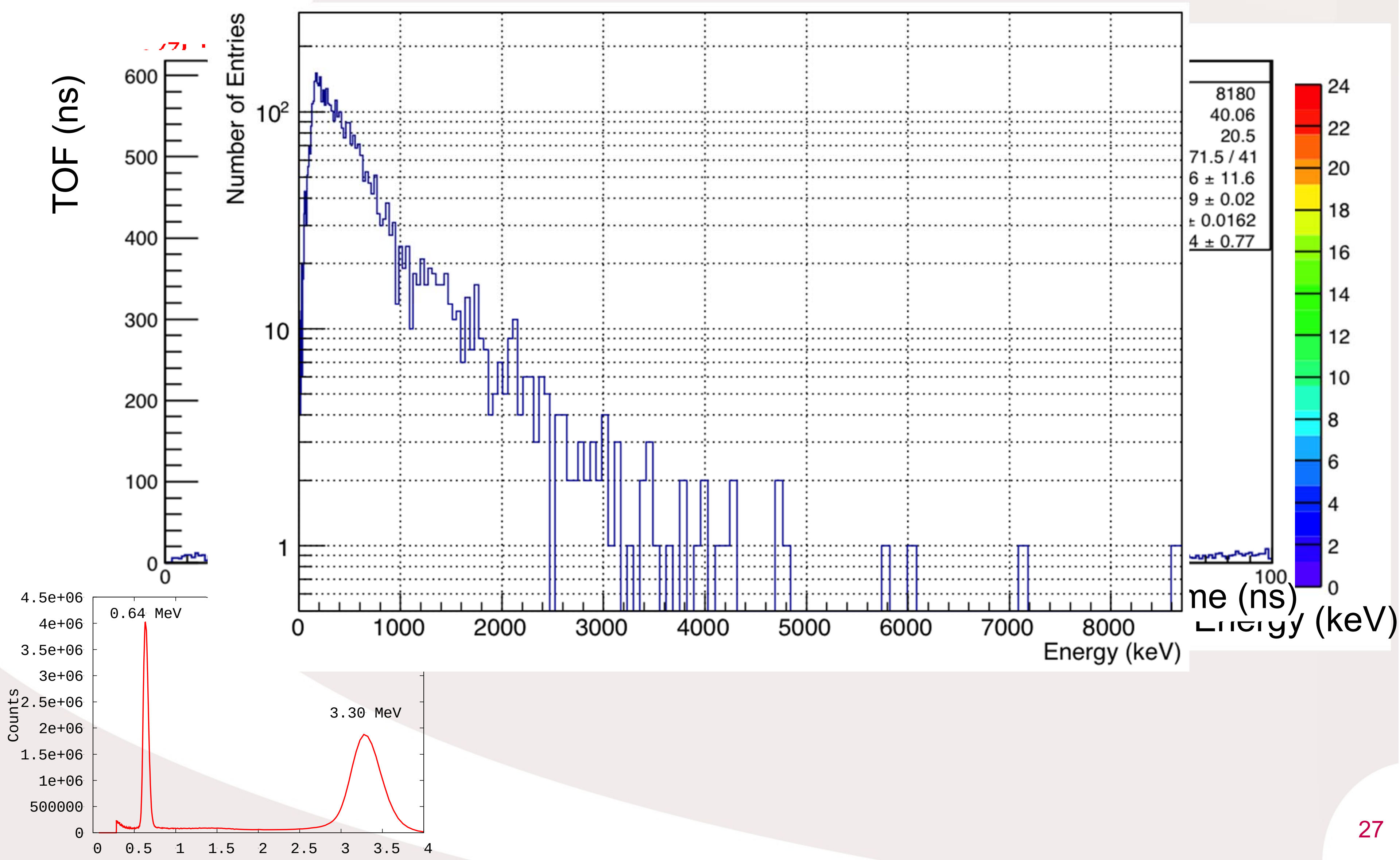






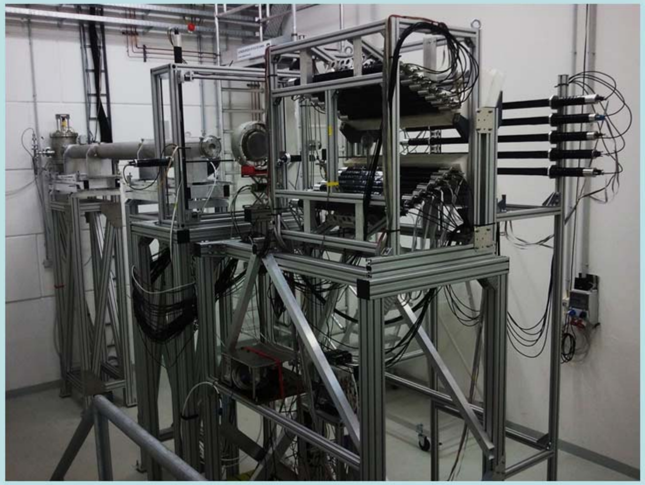
PROMPT FISSION GAMMA SPECTRUM

PRELIMINARY



New time of flight measurements at nELBE

Transmission set-up for total cross sections

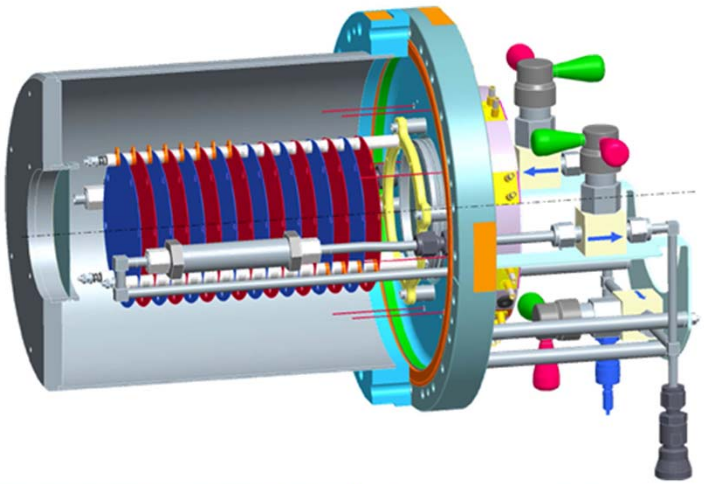


Double time of flight for inelastic neutron scattering

HPGe + $LaBr_3$ for angular distributions and Inelastic neutron scattering

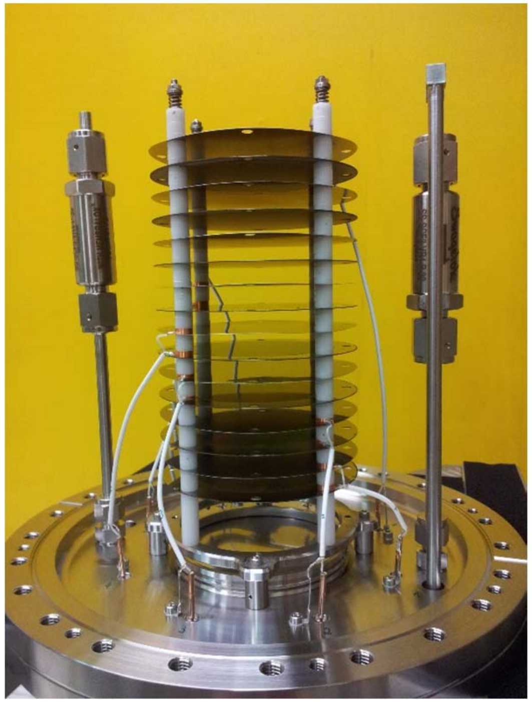
Neutron induced fission with two fission chambers

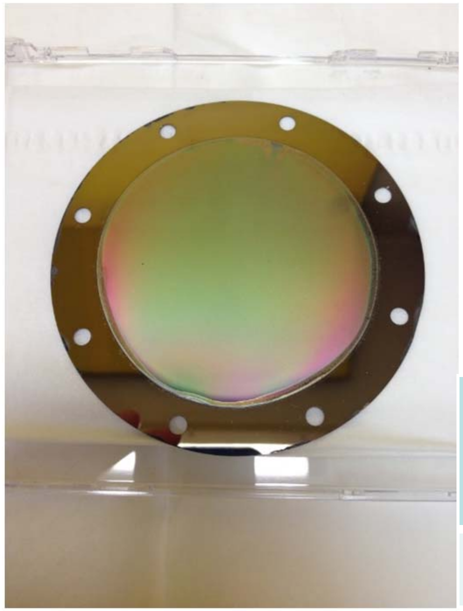
Neutron induced Fission of ^{242}Pu



- Parallel plate fission chambers high-vacuum metal sealed vessel (^{235}Uran and ^{242}Pu)
- P10 Gas flow through ultrapure gas filters

- 37.3 mg ^{242}Pu (99,959% + ^{xxx}Pu) α-activity of ≈ 8.7 MBq distributed on 8 targets produced in Jan. 2014
→ separate readout necessary
use of fast pre-amplifiers (development of HZDR) to reduce pile-up
Typical efficiency for neutron detection $\varepsilon \approx (1\text{-}3)\mathrm{x}10^{-5}$

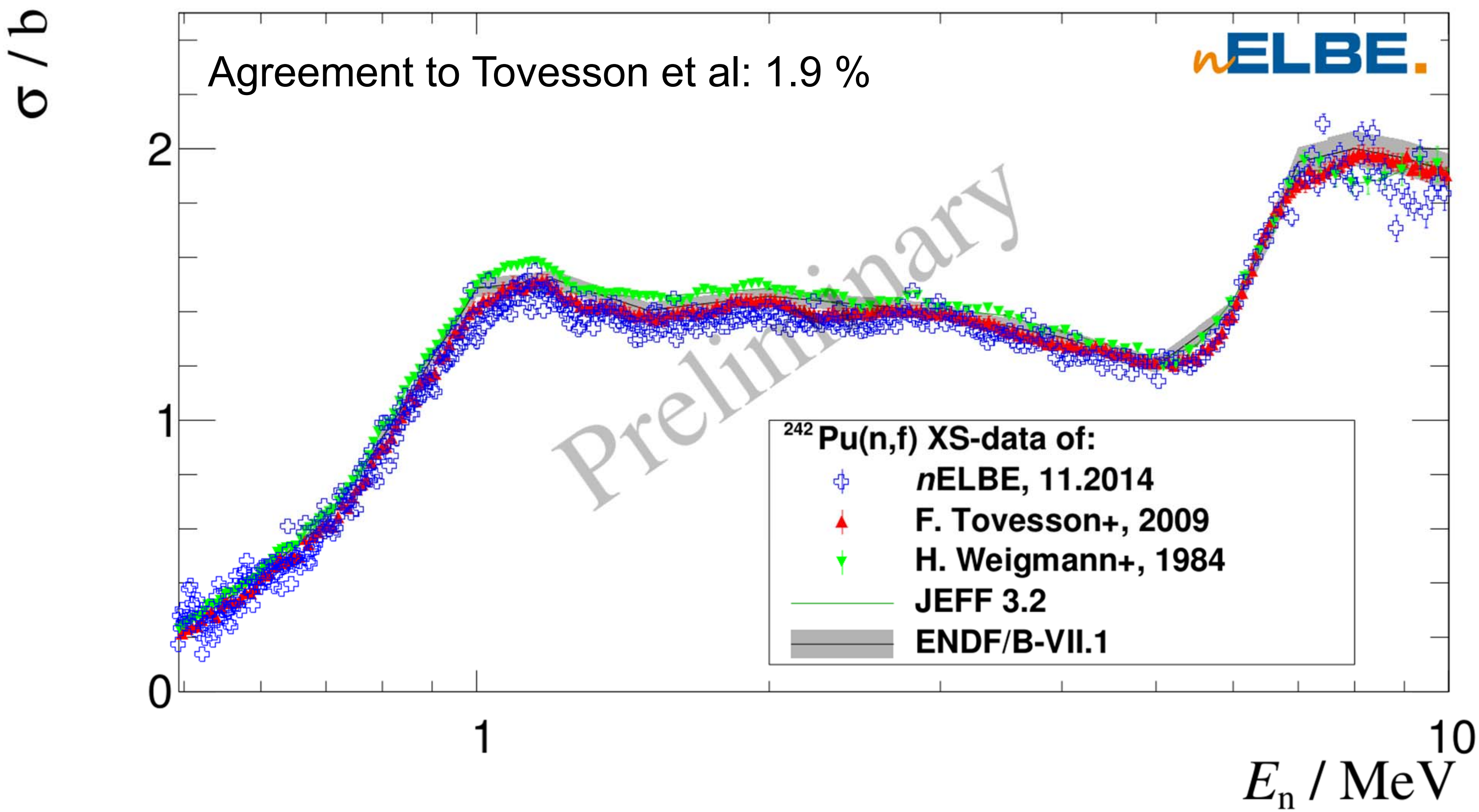




^{242}Pu deposits made at
Institut für Kernchemie, Univ. Mainz
K. Eberhardt, J. Runke, A. Vascon

Deposit	Diameter (mm)	Areal density (µg/cm²)	Thickness (nm)
^{242}Pu	74 ± 0.5	≈110±10	≈ 100

Neutron-induced fission cross section of ^{242}Pu



SOFIA: Studies On FIssion with Aladin

Fission yields measured in inverse kinematics at relativistic energ

Joint CHANDA-JEFF Workshop, Paris

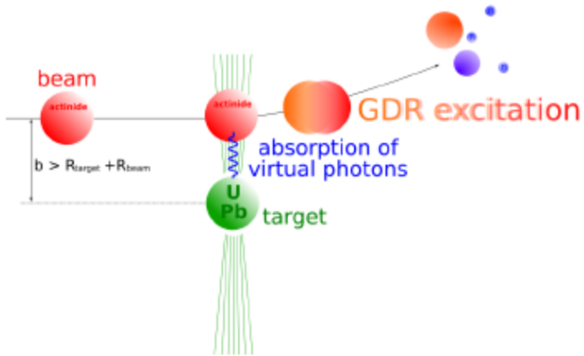
April 27, 2015

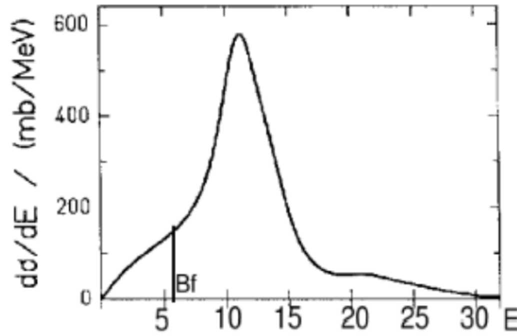
G.Bélier,
A. Chatillon (CEA, DAM, DIF) for the SOFIA collaboration

STUDIES ON FISSION WITH ALADIN

Virtual photon induced fission

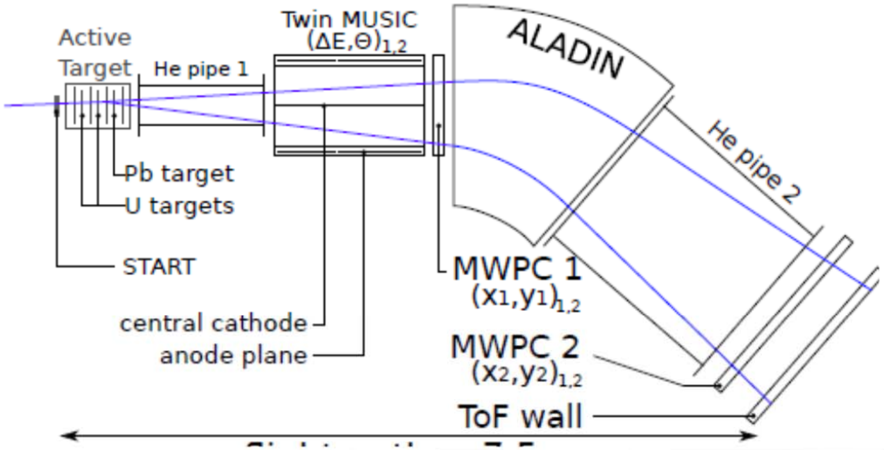
LOW ENERGY FISSION @ RELATIVISTIC ENERGIES

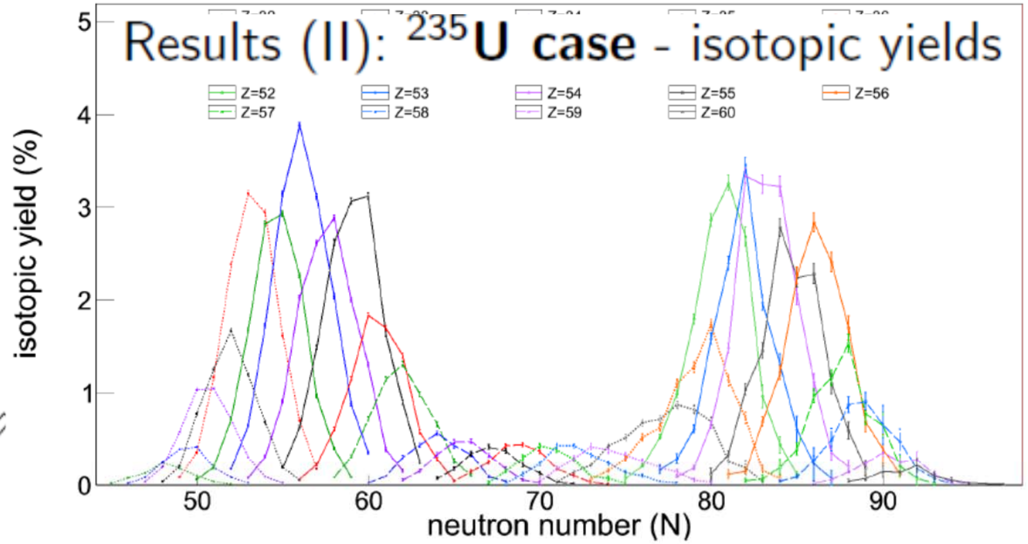


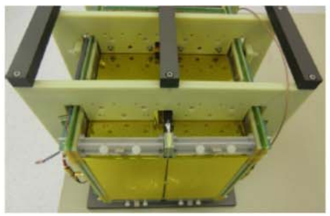


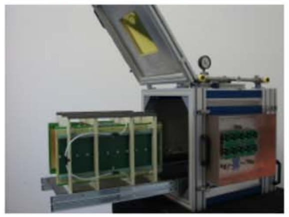
- E^* around 12 MeV $\Longleftrightarrow$ 6 MeV neutron induced fission

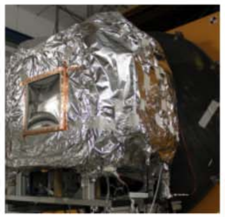
ΔE - Bρ - ToF method







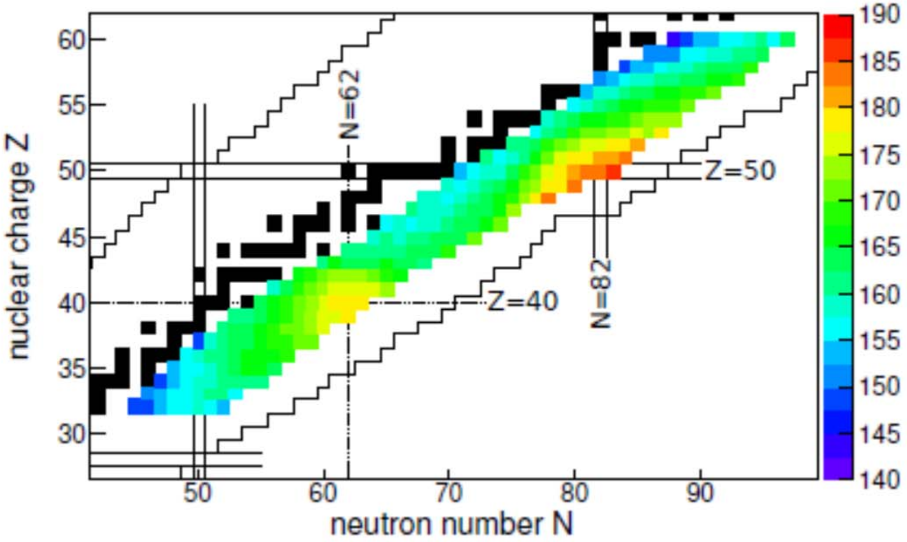




Analysis by J.-F. MARTIN (PhD)
and G. BOUTOUX

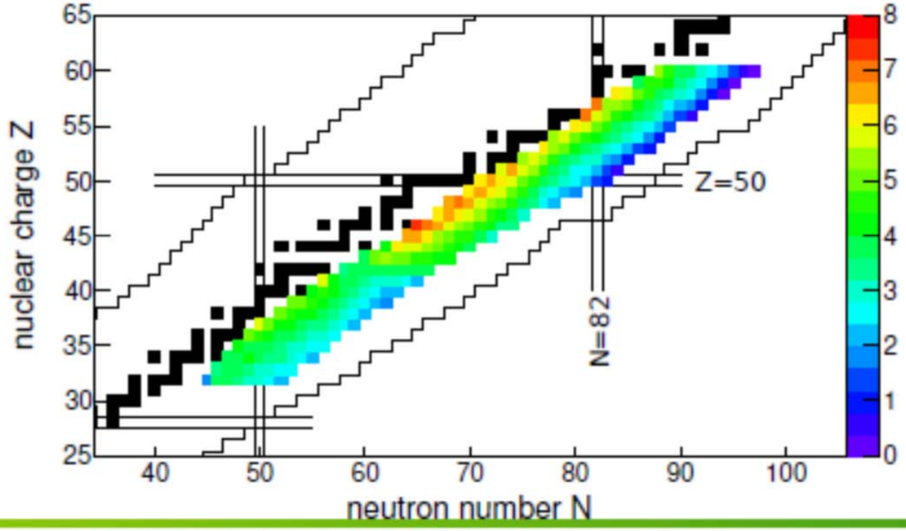
Results (III): ^{235}U case - neutron multiplicity and TKE

Analysis by J.-F. MARTIN (PhD)



$\langle \mathrm{TKE} \rangle$ vs (N_{FF}, Z_{FF})

- high TKE for ST1 mode
  $\Rightarrow$ compact configuration
- low TKE for SL mode
  $\Rightarrow$ large deformation



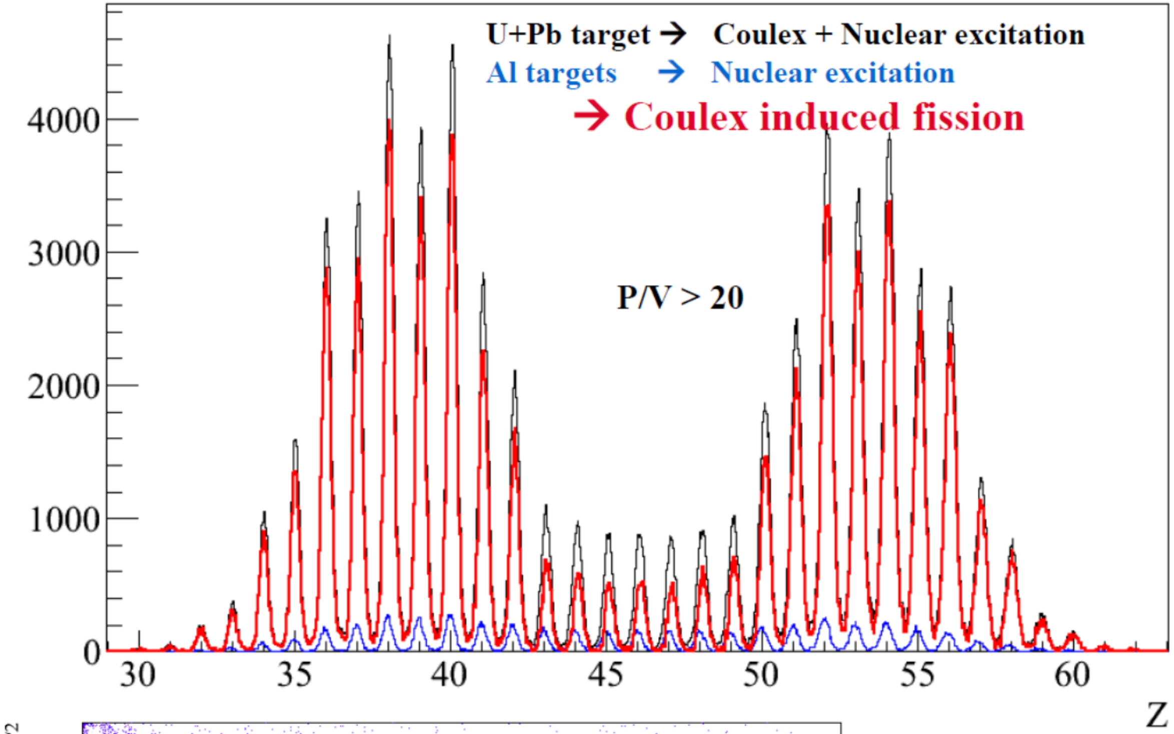
$\langle \nu_{tot} \rangle$ vs (N_{FF}, Z_{FF})

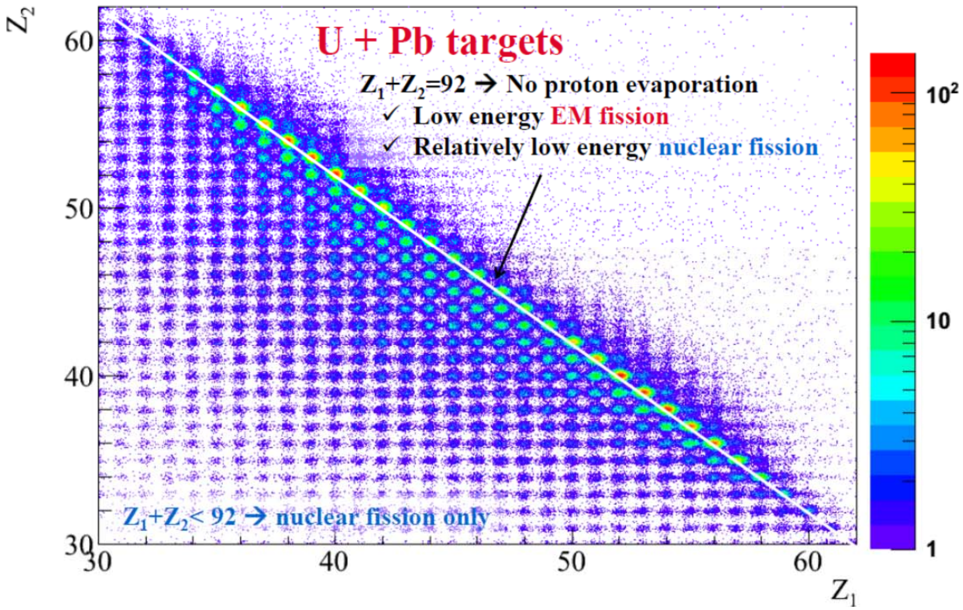
- high $\langle \nu_{tot} \rangle$ when TKE is low
  $\Rightarrow$ part of deformation energy is converted into excitation energy in the fission fragments

Charge distribution – ^{236}U

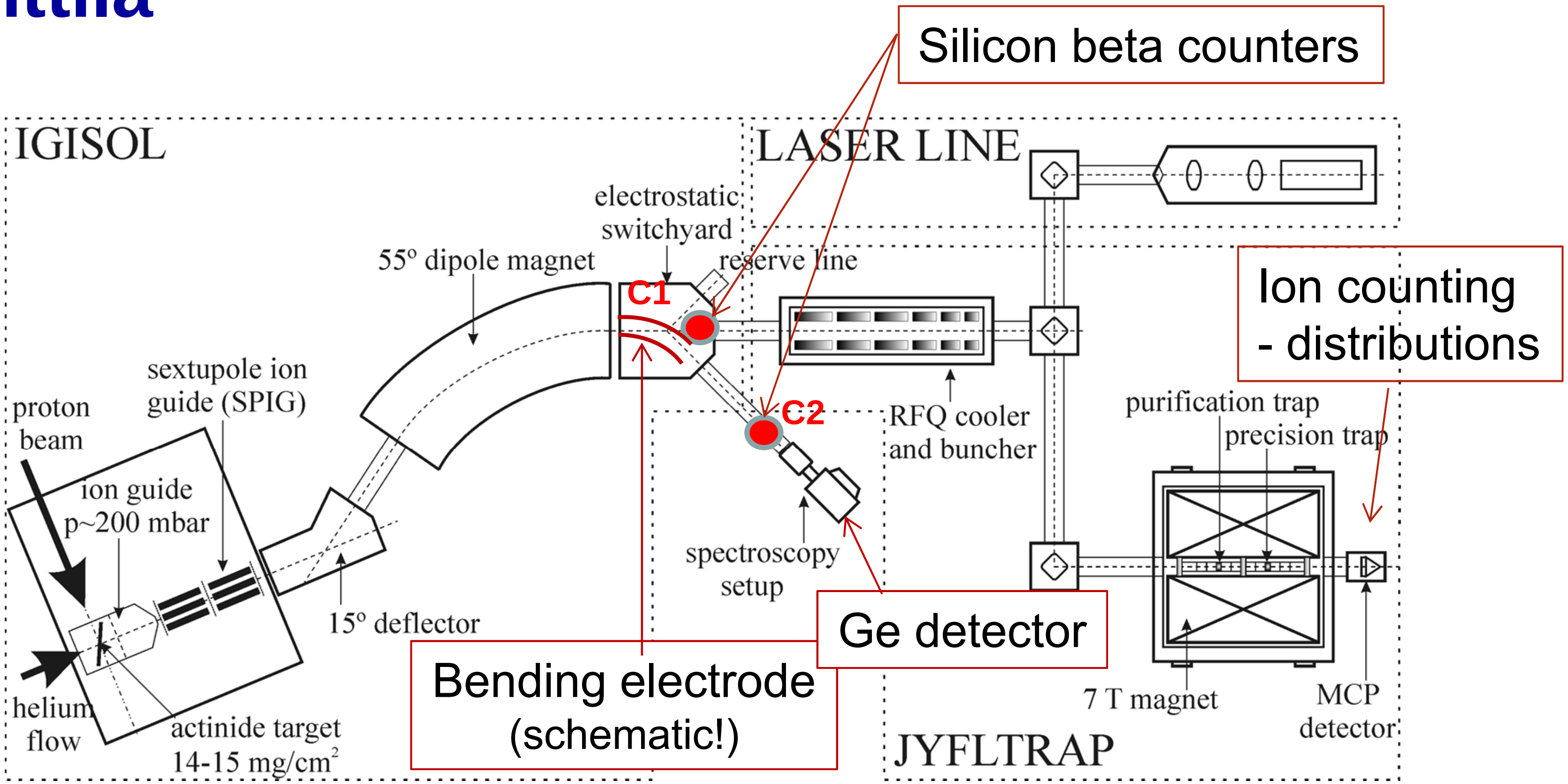
L. Grente

PRELIMINARY RESULTS FROM THE SOFIA2 EXPERIMENT





"Raw" fission yield at IGISOL-4 – for spectroscopy
H. Penttilä



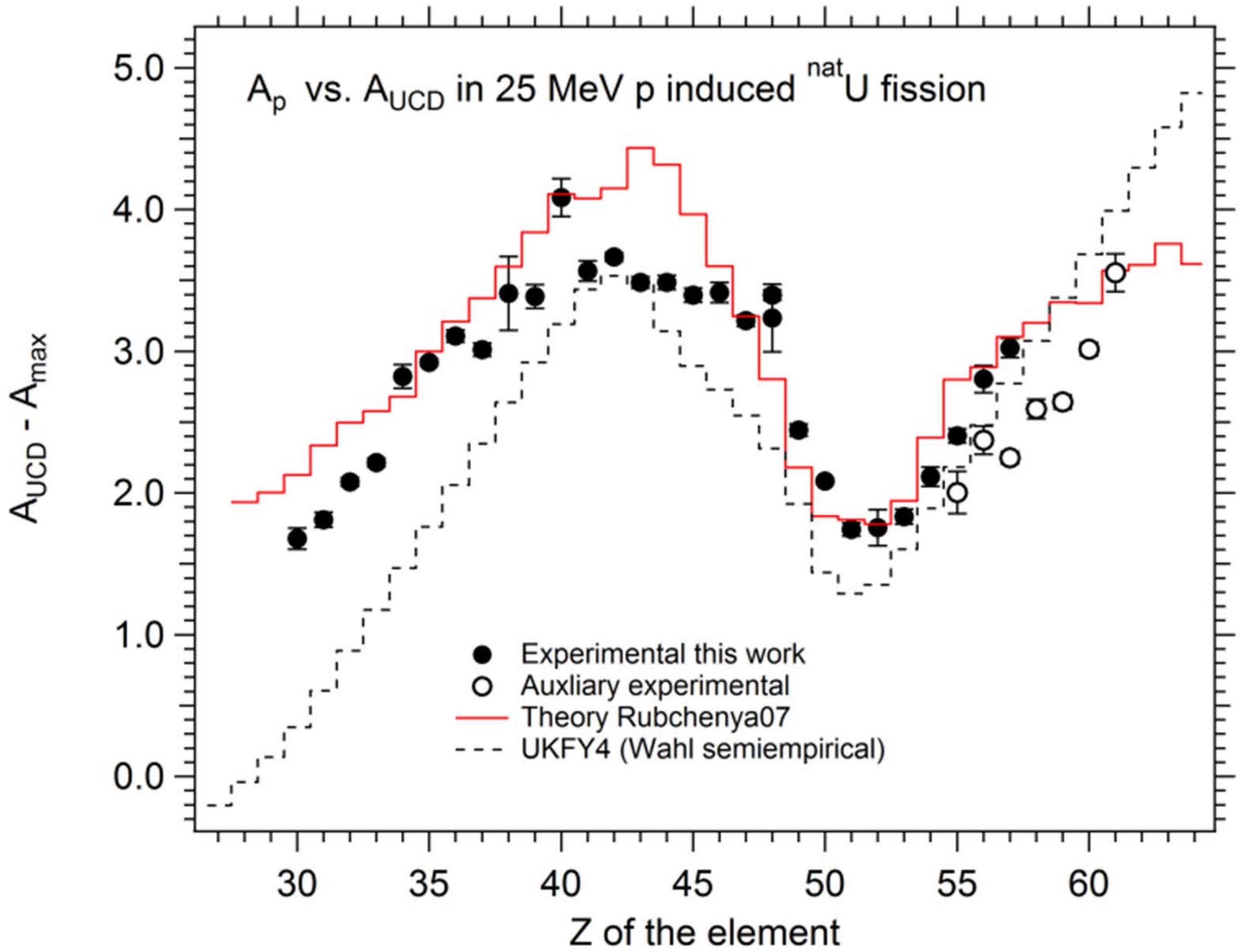
Fission yield to the spectrosopy line 1400 atoms/(μC * mbarn)

Transmission to FC2 in spectroscopy line ≈ 50 %

Fission yield to the central line ≈ 2800 atoms/(μC * mbarn)

UNIVERSITY OF JYVÄSKYLÄ

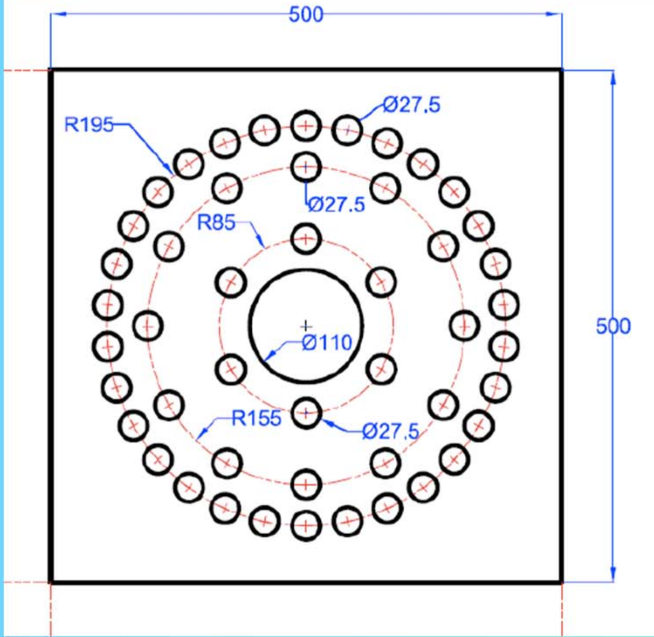
Fission yield at IGISOL-4 – proton induced

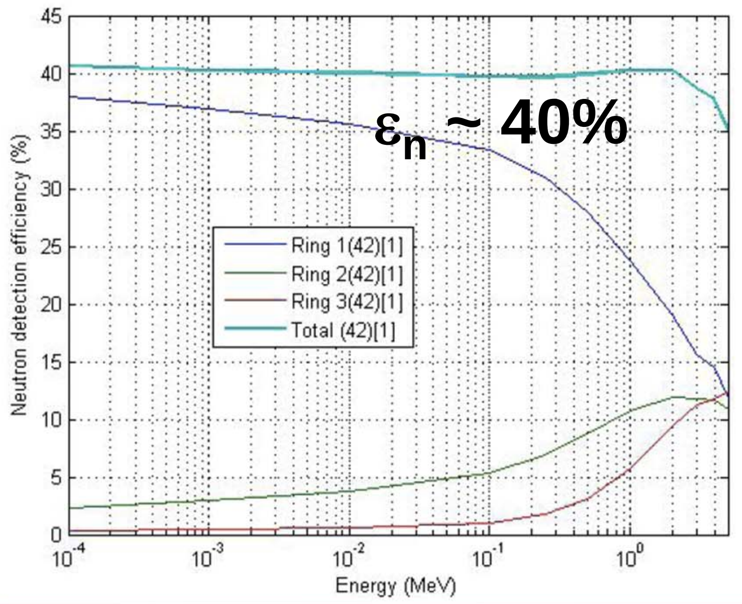


November 2014

I162: BELEN-48a

48x 3He tubes @ 8 & 10 atm

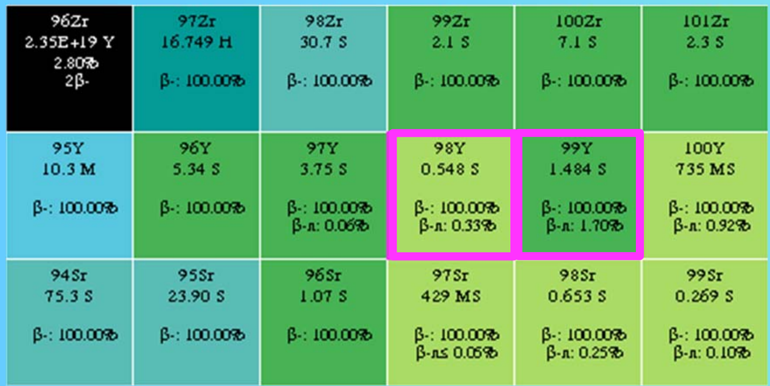


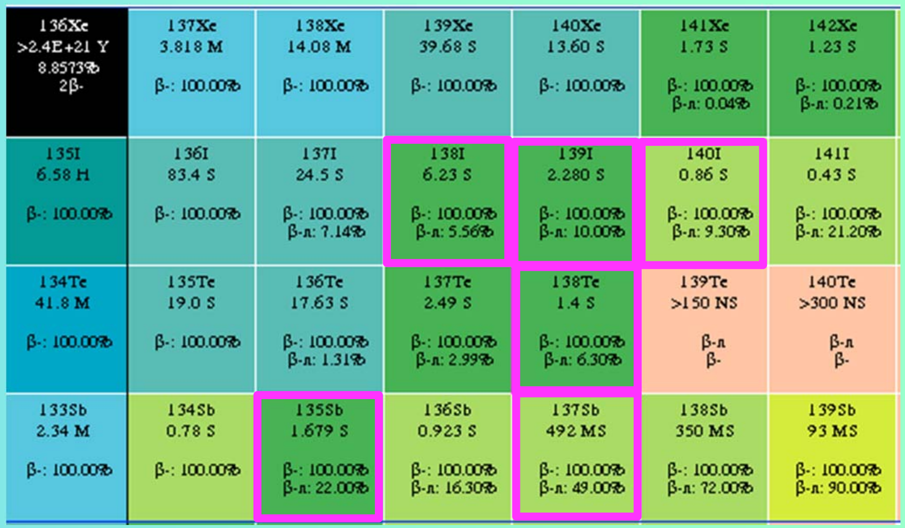


Beta detector: Plastic Scint.

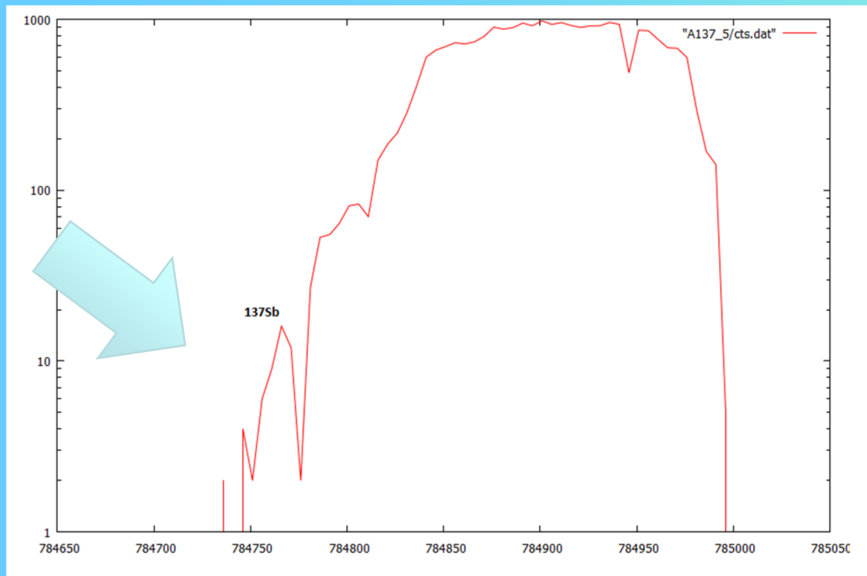
Setup with HPGe detector

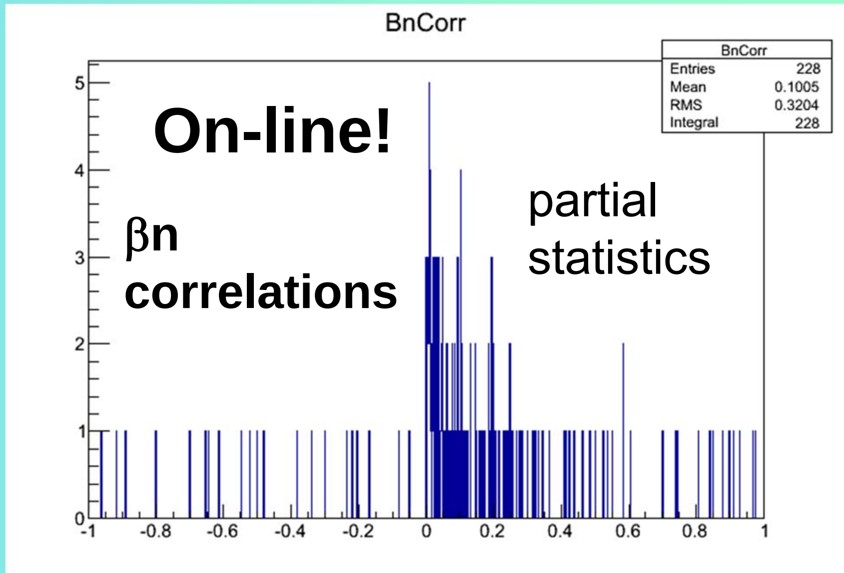
Data acquired for: $^{98,98m,99}Y$, $^{135,137}Sb$, ^{138}Te, $^{138,139,140}I$





Most challenging ^{137}Sb: implantation rate: 0.5cps

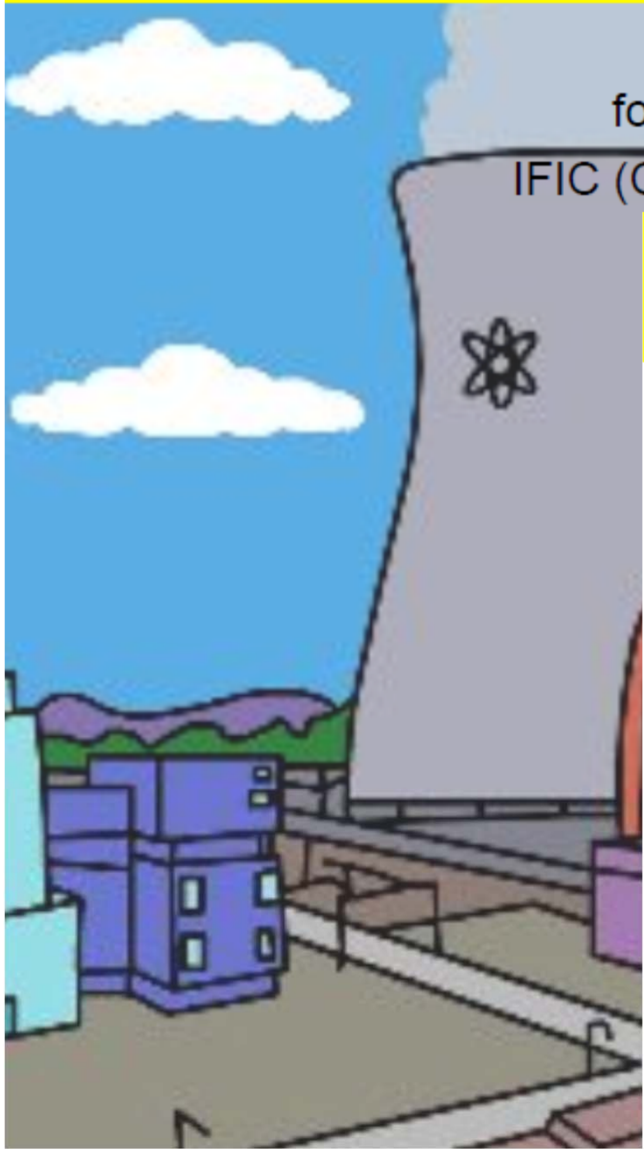




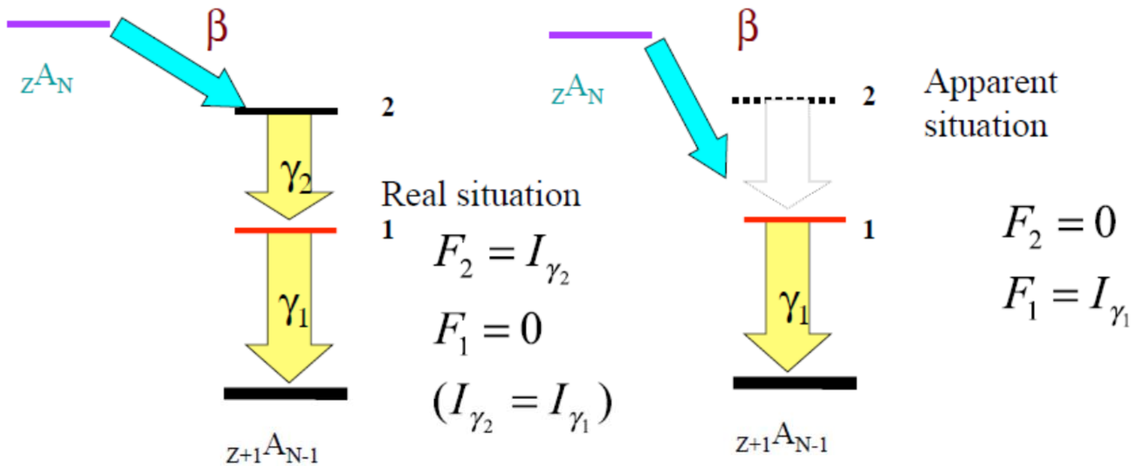
Off-line analysis to be done

Total absorption measurements for reactor applications

A. Algora
for the I136 and I153 experiments
IFIC (CSIC-Univ. Valencia, Valencia), Spain

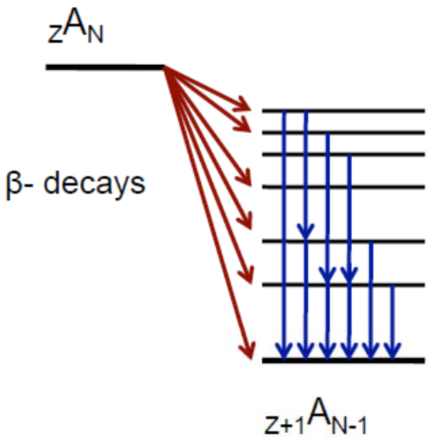


The problem of measuring the β- feeding (no delayed part.emission)

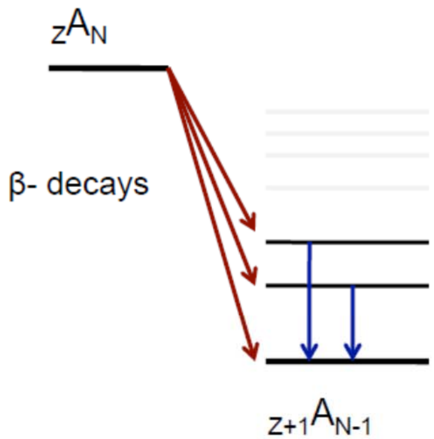


- We use Ge detectors to construct the level scheme populated in the decay
- From the γ intensity balance we deduce the β-feeding
- What happens if we miss some gamma intensity???

Isotope	Energy type	TAGS [keV]	JEFF-3.1 [keV]	ENDF/B-VII [keV]	Difference [keV]
^{101}Nb (7.1 s)	beta	1797 (133)	1863 (307)	1966 (307)	-67/-169
	gamma	445 (279)	245 (22)	270 (22)	200/175
^{102}Tc (5.28 s)	beta	1935 (11)	1945 (16)	1945 (16)	-10
	gamma	106 (23)	81 (5)	81 (5)	25
^{104}Tc (1098 s)	beta	931 (10)	1595 (75)	1595 (75)	-664
	gamma	3229 (24)	1890 (31)	1890 (31)	1339
^{105}Tc (456 s)	beta	764 (81)	1310 (173)	1310 (205)	-546
	gamma	1825 (174)	668 (19)	665 (19)	1157/1160
^{105}Mo (35.6 s)	beta	1049 (44)	1922 (122)	1922 (122)	-873
	gamma	2407 (93)	551 (24)	552 (24)	1856/1855
^{106}Tc (35.6 s)	beta	1457 (30)	1943 (69)	1906 (67)	-486/-449
	gamma	3132 (70)	2191 (51)	2191 (51)	941
^{107}Tc (21.2 s)	beta	1263 (212)	2056 (254)	2054 (254)	-793/-791
	gamma	1822 (450)	515 (11)	515 (11)	1307



Real situation



Pandemonium situation

Results published up to now

As a result of the Pandemonium, betas and neutrinos are estimated with higher energies from databases. This is why TAS data is very important

List of collaborators in these experiments

J. Agramunt[1], A.R. García[2], A. Algora[1], J. Äystö[3], J. Benlliure[7], R.Caballero[4], F.Calviño[4], D. Cortina[7], D.Cano-Ott[2], G.Cortés[4], T. Davinson8, I.Dillmann[6], C. Domingo-Pardo[1], T.Eronen[3], T. Faesterman[11], F. Farinon[6], D. Galaviz[8], H.Geissel6, W. Gelletly[5], R. Gernhäuser[11], M.B.Gómez-Hornillos[4], V. Gorlychev[4], V. Guadilla[1], J.Hakala[3,], C. Hinke[13], A.Jokinen[3], D.Jordan[1], A.Kankainen[3], V.Kolkinen[3], J. Kurcewicz[6], Z. Liu[8], I. Mukha[1], L. Maier[13], T.Martínez[2], G. Martínez-Pinedo[6], P.J.Mason[5], A. Montaner[1], F. Montes[9], I.Moore[3], C. Nociforo[6], P. Regan[5], Yu. Penionzkevich[10], H. Penttilä[3], J. Pereira[9], S. Pietri[6], C.Pretel[4], A. Poch[4], Z.Podolyak[5], M.Reponen[3], A.Riego[4], J.Rissanen[3], B.Rubio[1], A.Saastanoinen[3], P. Salvador[4], H. Schaffner[6], H. Schatz[9], Ch. Scheidenberger[6], V. Smirnov[10], K.I. Smith[9], E. Sokol[10], K. Steiger[13], J.L.Taín[1], D.A. Testov[10], E.Valencia[1], H.Weick[6], J. Winfield[6], M. Winkler[6], P.J. Woods[8], H.J. Wollersheim[6],…

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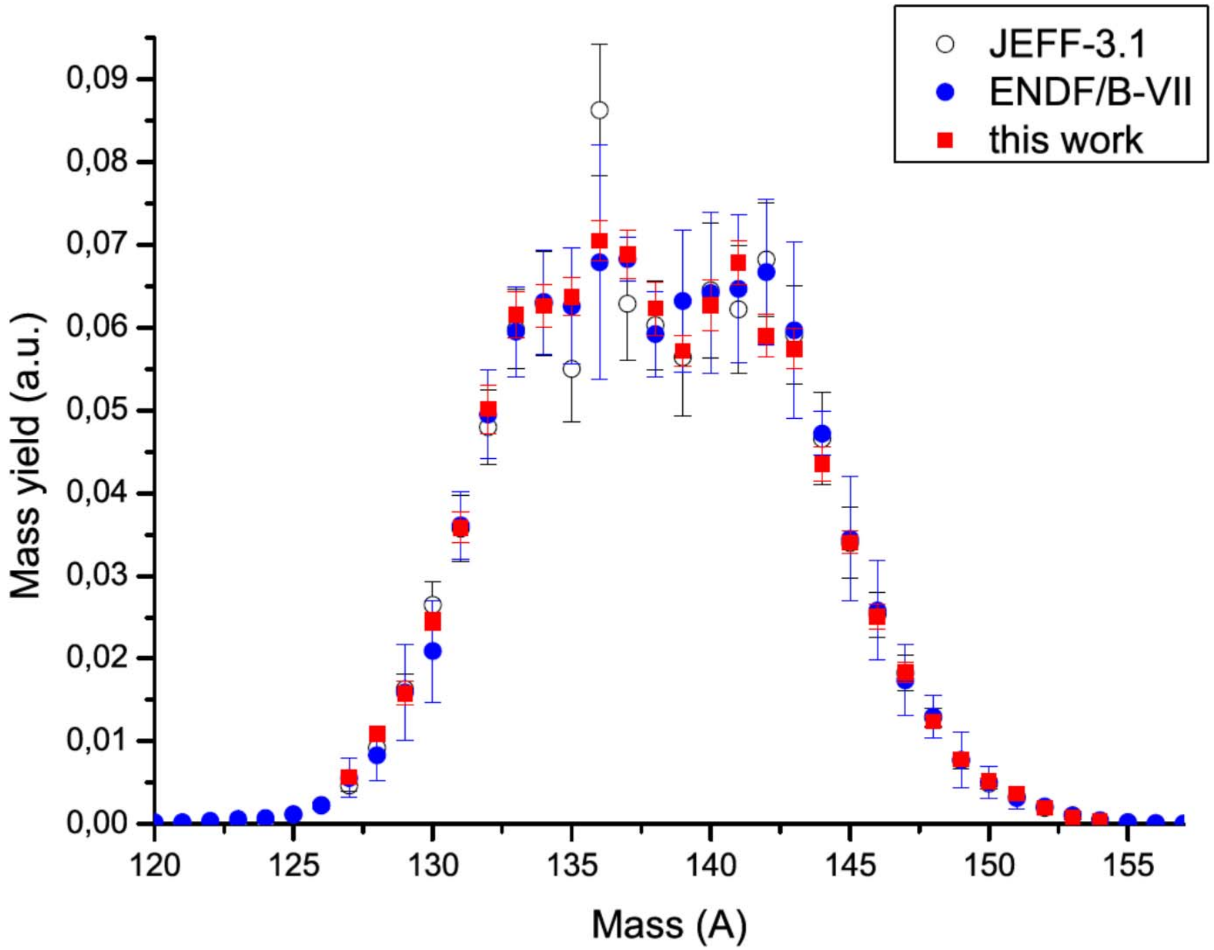
5 Dept. of Physics, University of Surrey, UK
6 GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany
7 University of Santiago de Compostela, Spain,
8 University of Edinburgh, UK
9 NSCL-MSU, East Lansing, USA
10 JINR, Russia
11 Technische Universität Múnchen, Germany

example : Mass measurements @ Lohengrin

e.g. $^{233}U(n_{th},f)$ mass yields in heavy mass region :

→ quasi absolute measurement : self-normalization

→ partial results using 2 targets

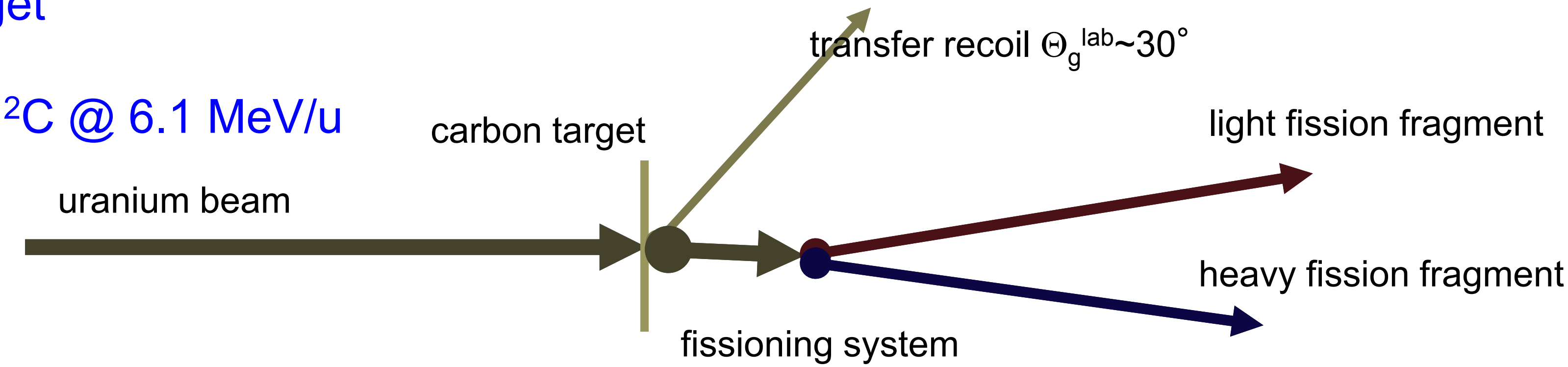


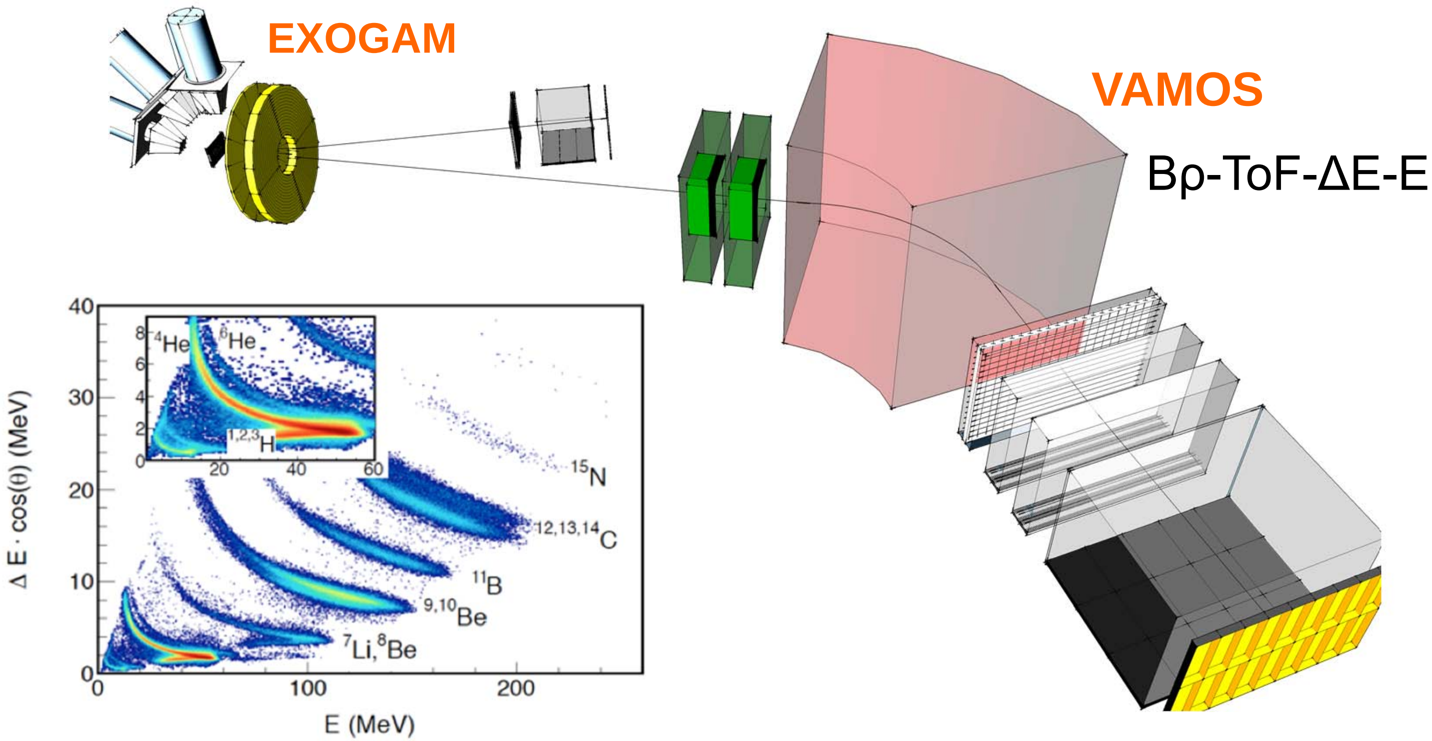
PhD thesis
F. Martin

Isotopic Fission Yields from
Compound Nuclei Produced in Transfer Reactions @ GANIL

F. Farget

$^{238}U + ^{12}C$ @ 6.1 MeV/u





Reaction
Elastic
Inelastic, E_x >4 MeV
$^{12}C(^{238}U,^{237}U)^{13}C$
$^{12}C(^{238}U,^{236}U)^{14}C$
$^{12}C(^{238}U,^{239}Np)^{11}B$
$^{12}C(^{238}U,^{240}Pu)^{10}Be$
$^{12}C(^{238}U,^{241}Pu)^{9}Be$
$^{12}C(^{238}U,^{242}Pu)^{8}Be$
$^{12}C(^{238}U,^{243}Am)^{7}Li$
$^{12}C(^{238}U,^{244}Cm)^{6}He$
$^{12}C(^{238}U,^{246}Cm)^{4}He$

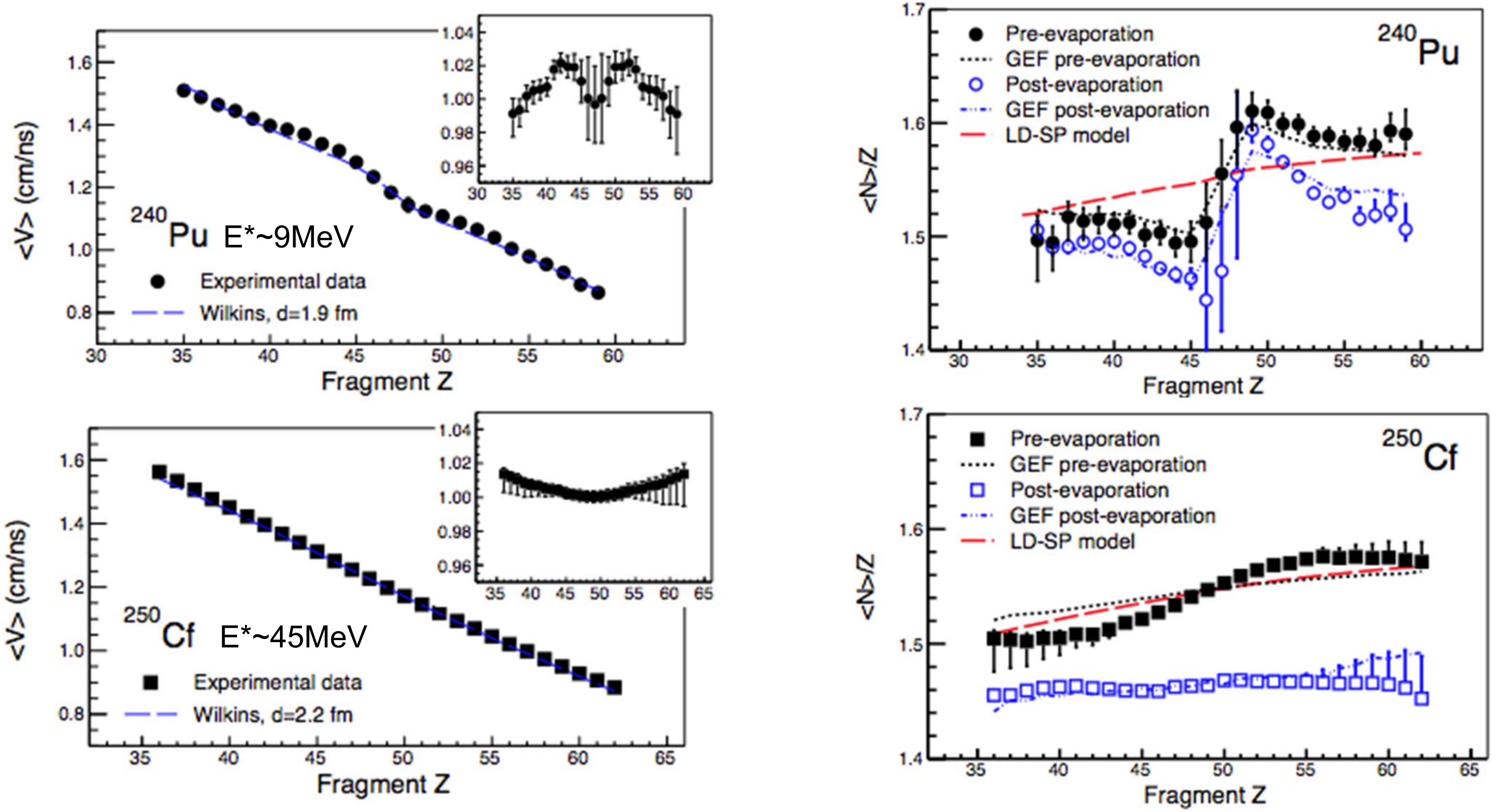
From Velocity Measurement:
Scission fragment characterization !!

$$<V>(Z) = \frac{\sum_A Y(A,Z)V(Z,A)}{\sum_A Y(A,Z)}$$

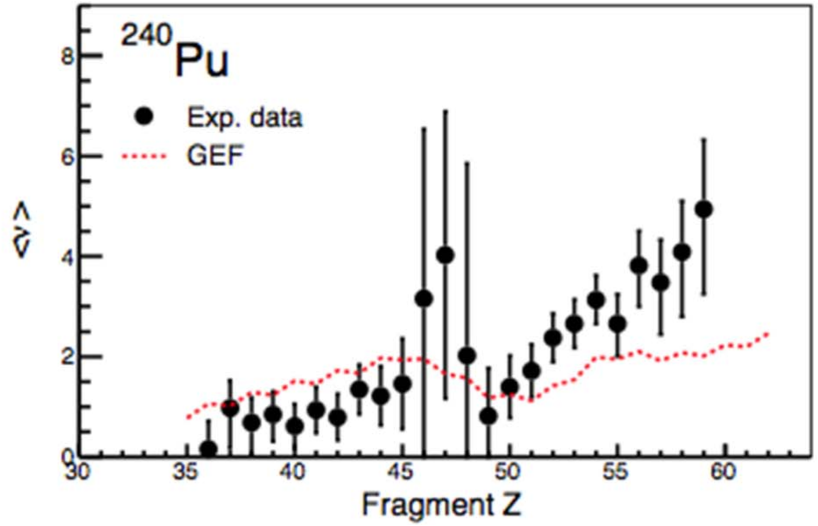
$$\frac{V_1}{V_2} = \frac{A_2^*}{A_1^*}$$

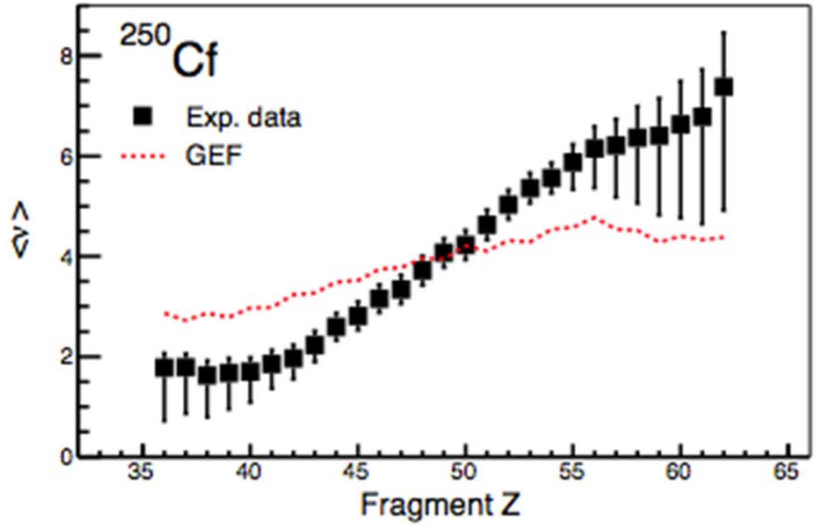
$$<A_1^*> = A_{FS}\frac{<V_2>}{<V_1>}$$

$$<A_2^*> = A_{FS} - <A_1^*>$$

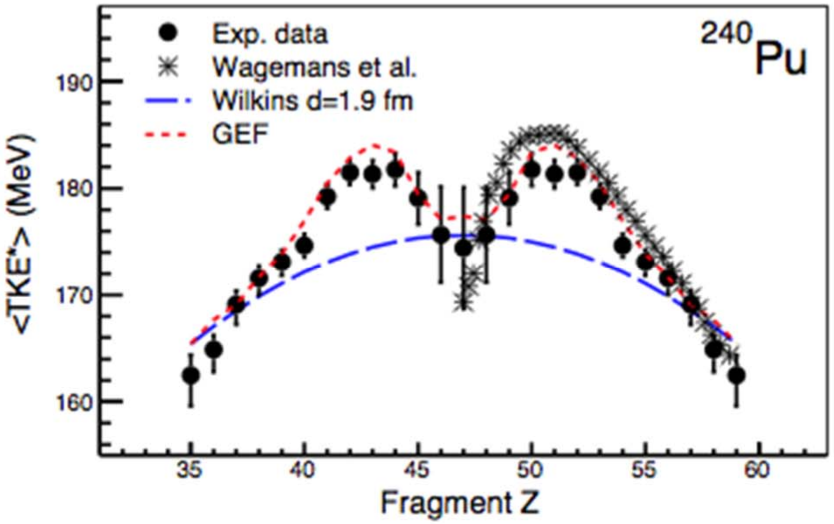


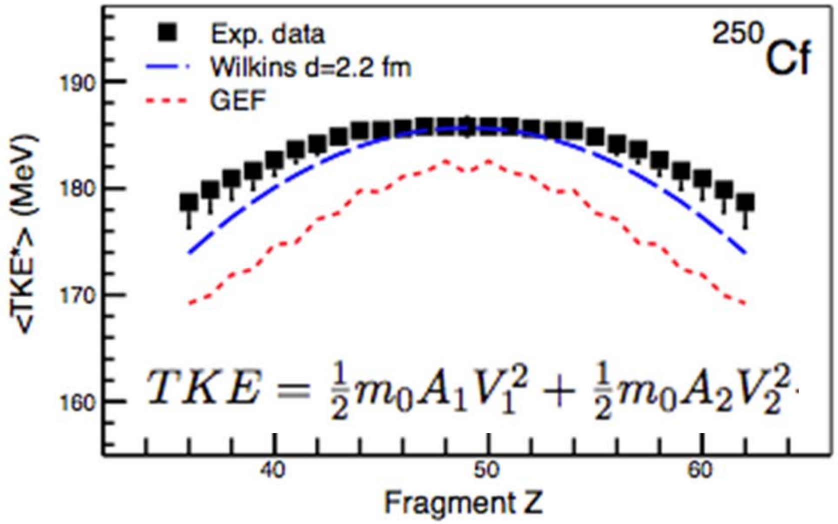
Post-scission neutron evaporation $\langle \nu \rangle (Z) = \langle A^{*} \rangle (Z) - \langle A \rangle (Z).$





Total Kinetic Energy Deformation at scission !!





M. Caamaño, F. Farget et al.,

Advanced techniques for spallation and fission investigations

Joint CHANDA-JEFF workshop on Nuclear Data Measurements

José Benlliure

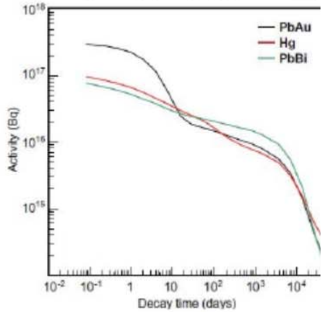
Universidad de Santiago de Compostela
Spain

Spallation neutron targets

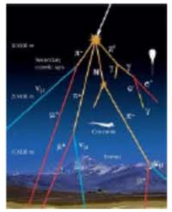
Lead-bismuth eutectic, mercury or alloys using tungsten or tantalum are common target materials irradiated with relativistic protons for neutron production.

An accurate inventory of all nuclear species produced in these reactions is mandatory for radiation safety and handling of the target.

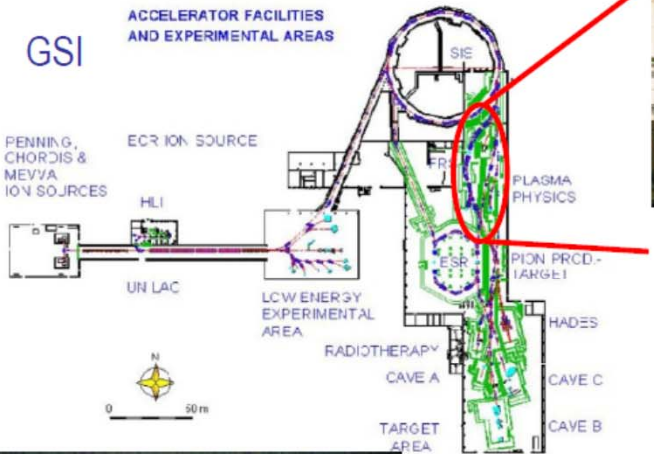
From a radiological view point, heavy spallation residues (^{207}Bi, $^{208-210}$Po, ^{204}Tl, …) are of major concern however, gaseous fission residues (Kr or Xe) are also important because of their volatility

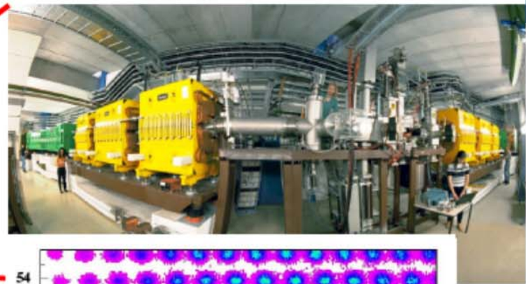


Many other applications

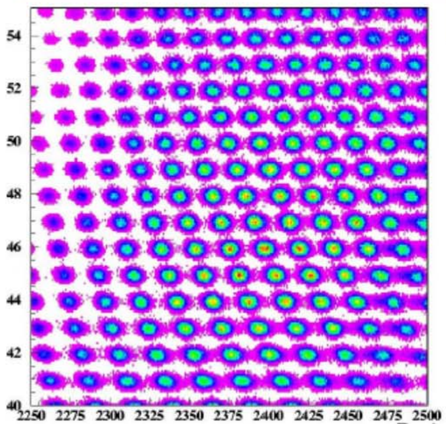


Inverse kinematics measurements at the FRS



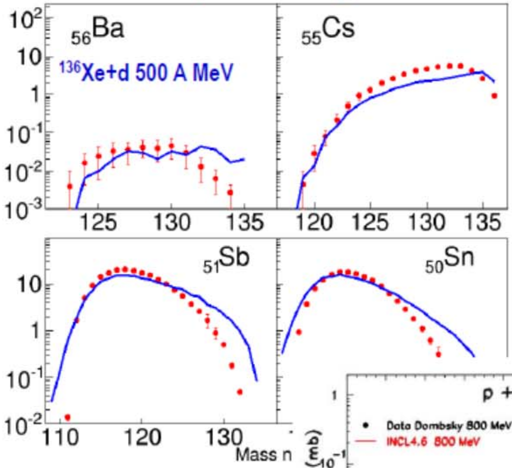


More than 1000 fission fragments identified in the reaction ^{238}U(1 A GeV)+d



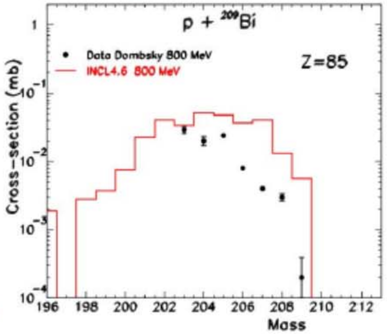
Open issues: description of heavy residues

Limited predictive power for the production of heavy residues



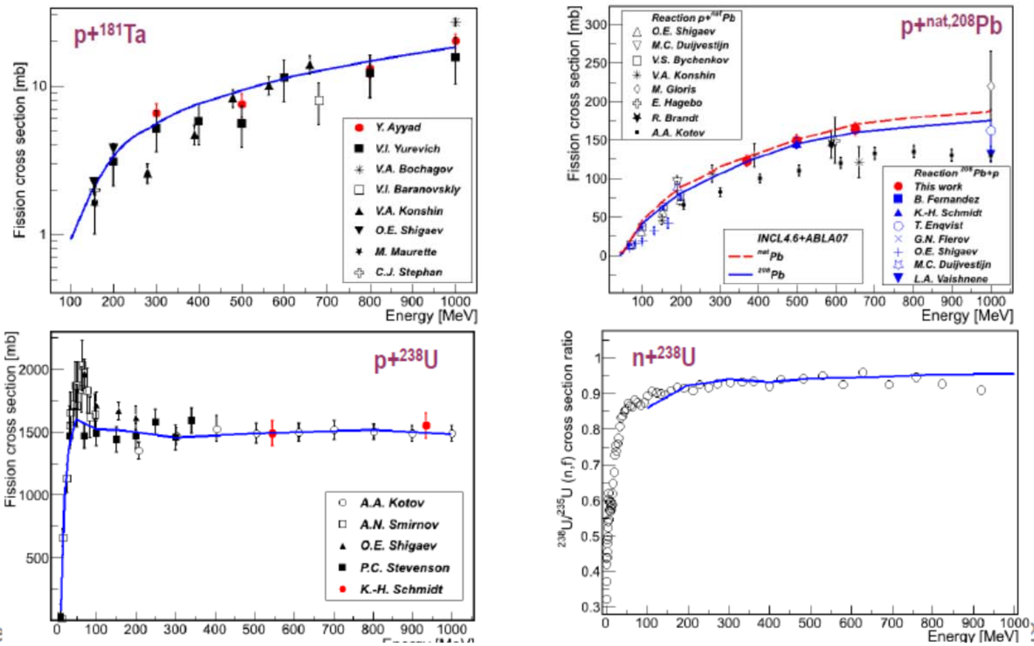
Heavy residual nuclei produced in peripheral collisions in:
- Charge exchange processes.
- Nucleon knock-out.

Those processes are very sensitive to:
- Relative abundance of protons and neutrons at the nuclear periphery.
- Long- and short-range correlations in nuclei.



Open issues: modeling high-energy fission

Description of total fission cross sections with INCL4.6+ABLA07



Overview of Experimental Activities

(F4E Grant FPA-395_01)

Maurizio Angelone

(Consortium Coordinator)

Unità Tecnica FUSIONE

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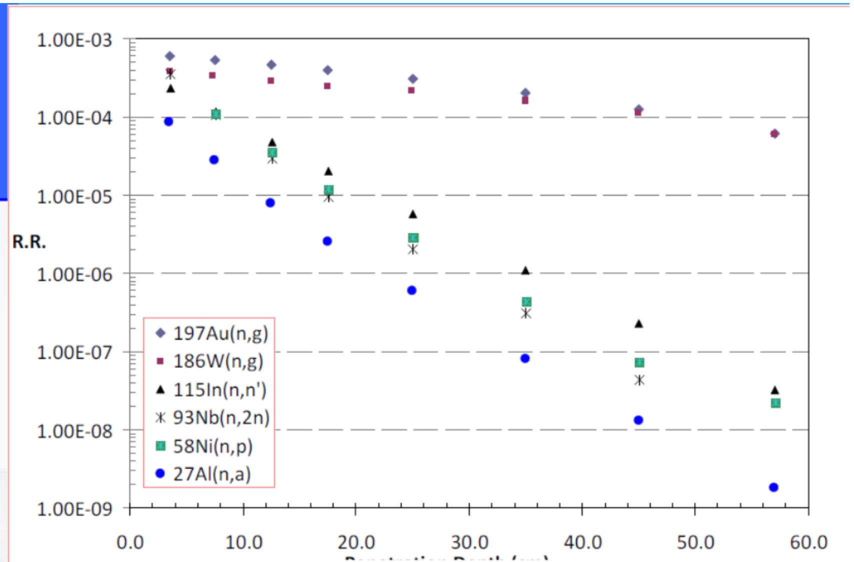
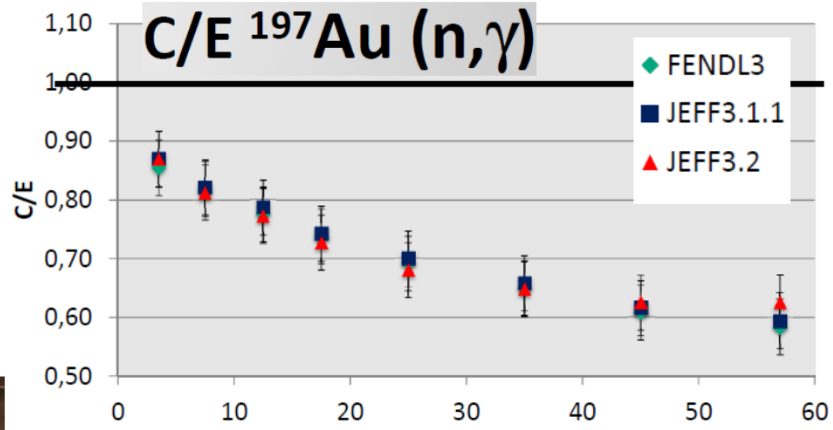
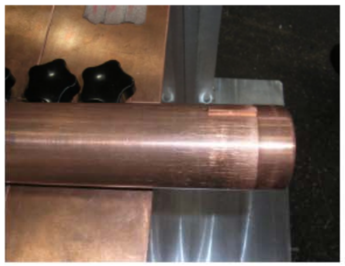
ENEA
ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

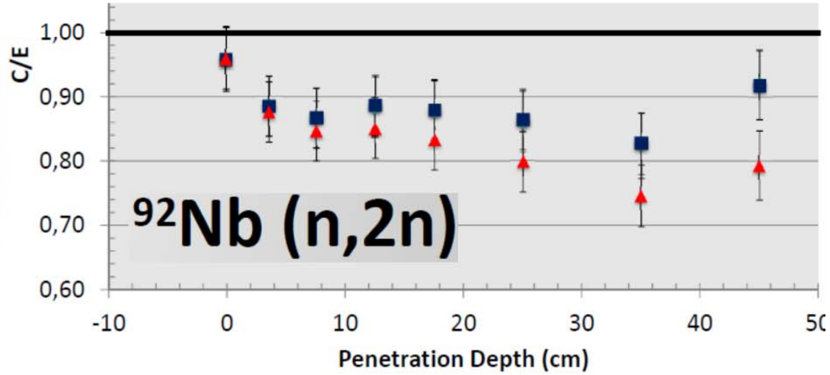






The block is made by Seven Cu plates (Oxigen Free) 60x60x10 cm^3 each **(~ 2,25 tons total)**

Experimental positions reached through *vertical rods* equipped with detector holders

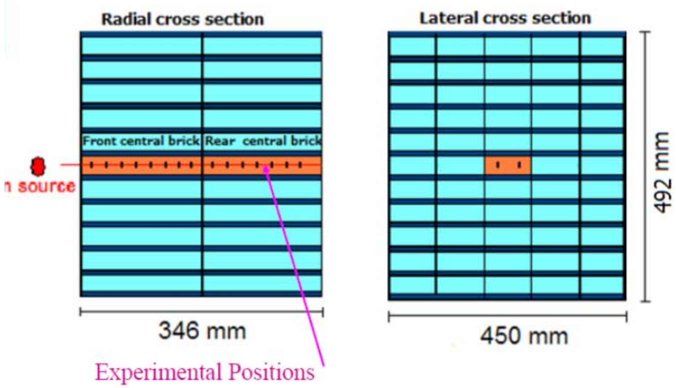


The Cu block at FNG

JRC

TBM-HCLL benchmark experiment at FNG

TBM - HCLL mock-up (LiPb, 15.7 at% nat-Li)



Stainless steel (N.12 cooling plates, thickness 6.5 mm)

LiPb - Li content 15.7±0.5 at%, i.e. 0.62±0.03 wt%

N. of bricks: 2 (radial) x 11 (poloidal) x 5 (toroidal) = 110

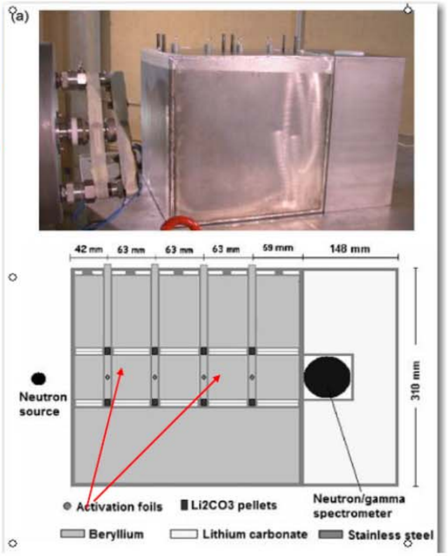
Size of bricks: 173 mm (rad) x 36 mm (pol) x 90 mm (tor)

Weight of 1 brick = 5.74 Kg /Total weight = 630 Kg

Measurements :

- *Reaction Rates*
- *Tritium Production*

HCPB Benchmark Experiment



Helium cooled pebble bed (HCPB)

Containing Berillium

Lithium is in the form of Lithium Carbonate (Li_2CO_3)

Measurements :

-*Reaction Rates*

-*Tritium production*

The re-analysis using FENDL-2.1 & IRDF 2002 or IRDFF_v1.0 and FENDL-3 & IRDF 2002 or IRDFF_v1.05 does not show significative differences for THRESHOLD reactions (within 1-2 %)

A large difference (~ - 15 %) is observed for $^{197}Au(n,\gamma)^{198}Au$ reaction when using IRDFF_v1.05 respect to IRDF 2002 (version 2005) results.

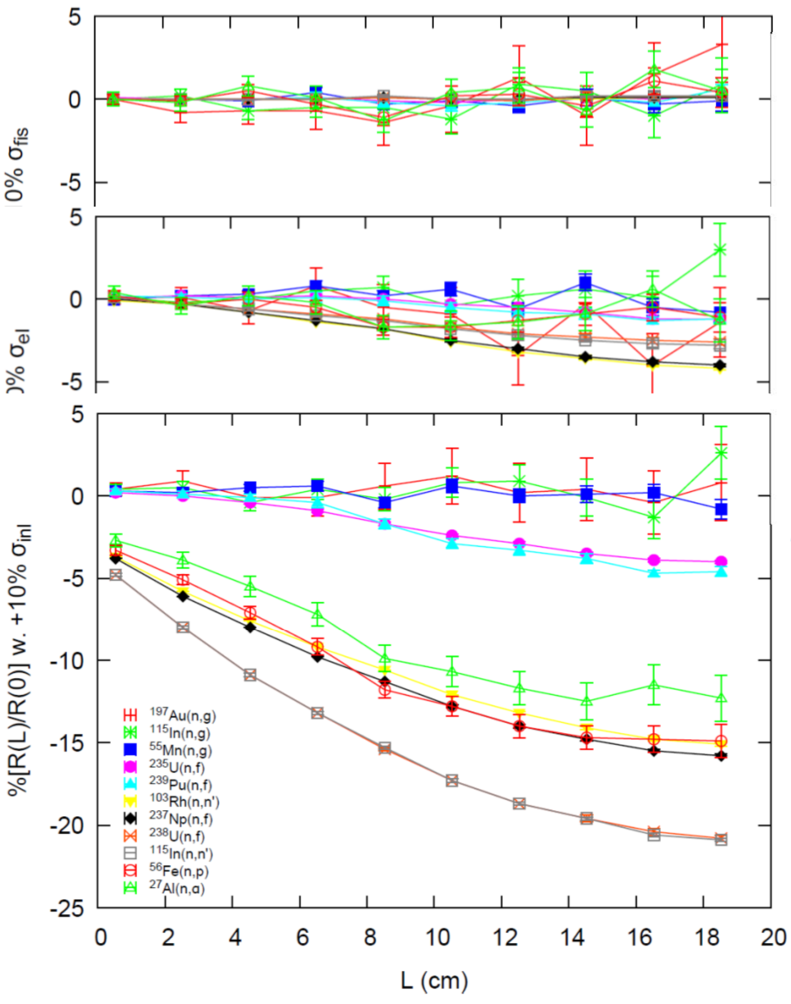
The cause is under investigation but, as shown by the results it is due to foils tickness → self-shielding effect.

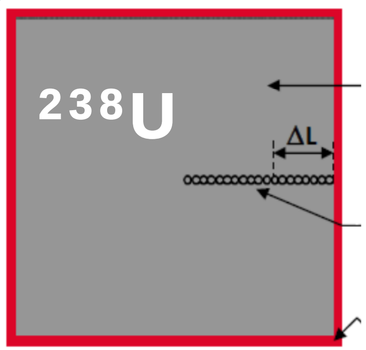
For *"void → infinite diluition"* and *thin foils* (≤ 10 μm) agreement between the two files still good both for HCLL and HCPB experiments.

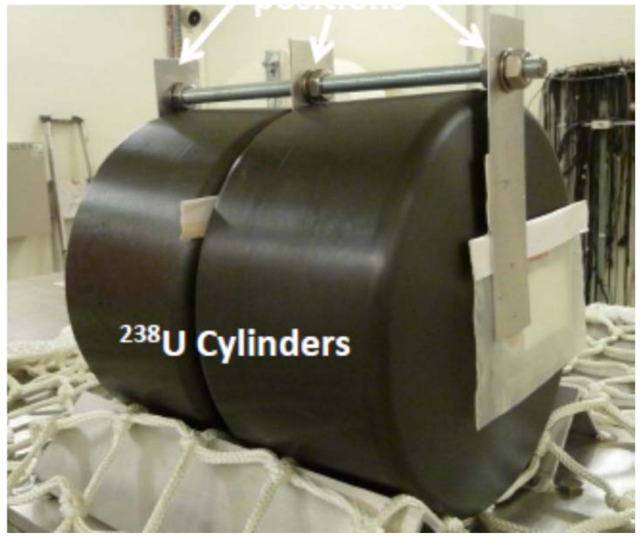
EXCALIBUR

Pierre Leconte, David Bernard

An Integral Experiment for $^{238}U(n,n')$ Validation at CALIBAN







Experiment done
Analysis Ongoing
See CIELO report
Leconte

CHANDA, NEEDS & JEFF

A considerable portion of work is about very promising developments of methods, techniques and facilities.

For sake of brevity I have eliminated a lot but have a look at the online presentations at NEA of the April 2015 NDW.