Experimental activities NEA DB

Arjan Plompen

EC-JRC-IRMM, SN3S unit

www.jrc.ec.europa.eu

Content

Experimental activities

Sources: NDW fall 2013, NEEDS
ERINDA final workshop
ANDES final workshop
IRMM
n_TOF

ANDES

Accurate nuclear data for nuclear energy sustainability

Coordinator: Enrique Gonzalez Ciemat

Measurements, evaluation, validation

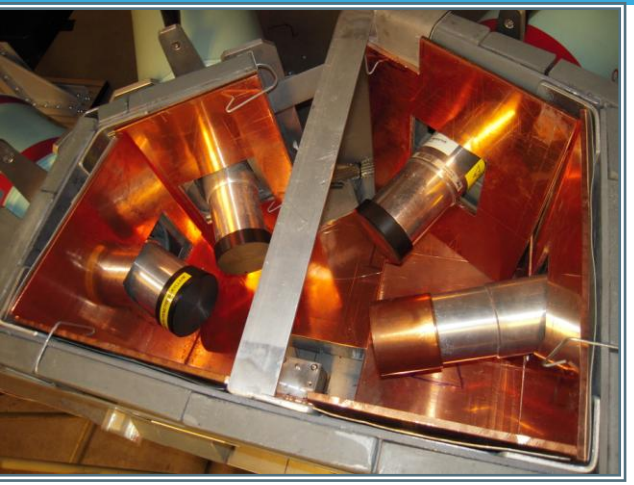
3 M€ EC contribution, ~6M€ total effort

20 partners, 2010-2013

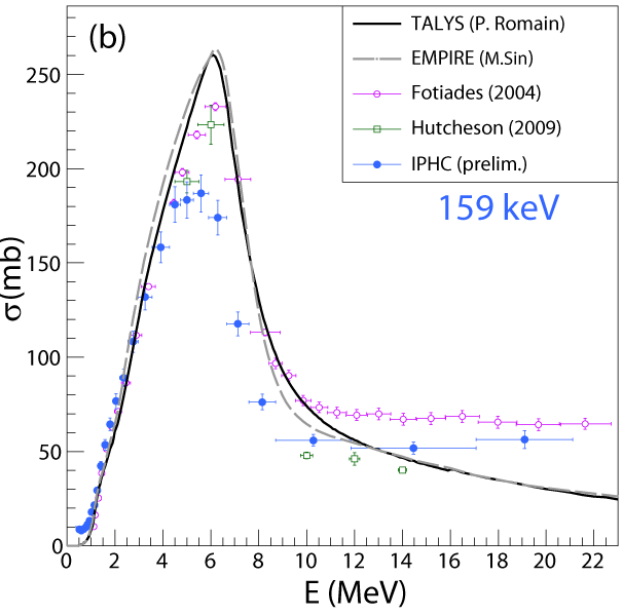
Inspired by HPRL, SG26, SG25, MANREAD, EUROTRANS-NUDATRA, CANDIDE

ANDES WP1

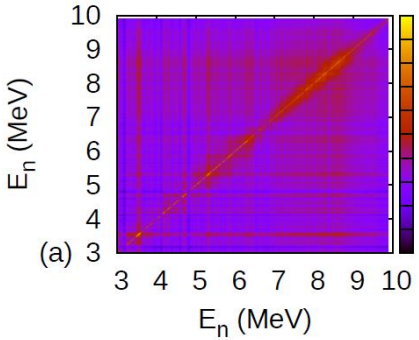
European Commission

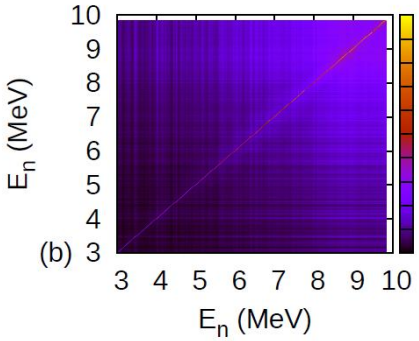


^{238}U(n,n'g)
Bacquias et al.
IPHC

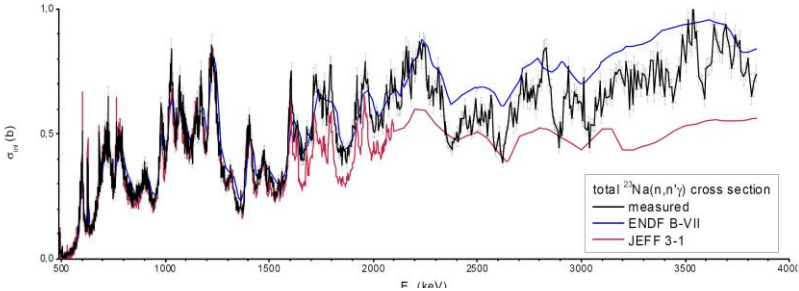


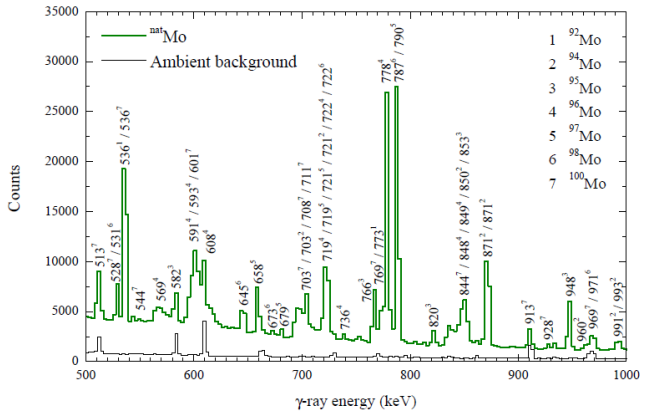
Covariances
Negret et al.
IFIN-HH





Na,Zr,Mo(n,n'g)
C. Rouki, N. Nyman et al.
IRMM





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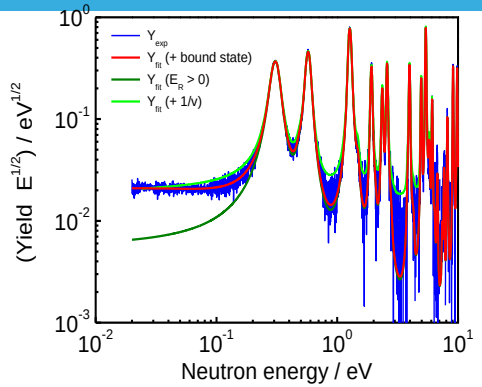
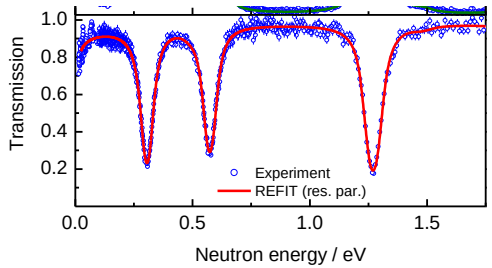
Publications

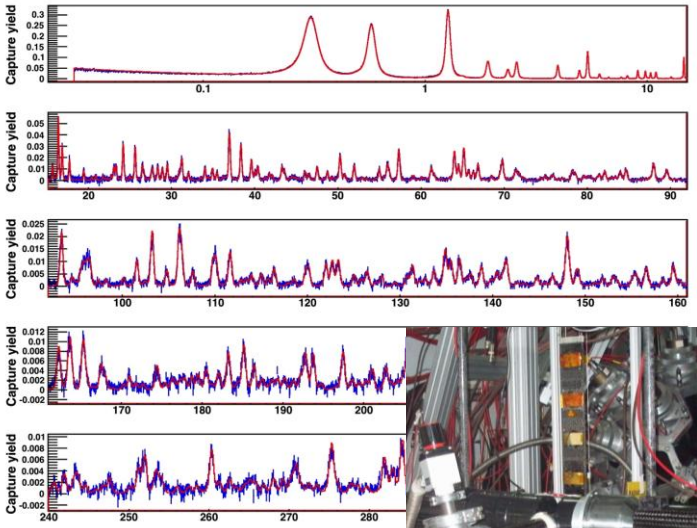
^{235}U(n,n'g)	M. Kerveno et al. (IPHC)	PRC 87 (2013) 024609
^{28}Si(n,n'g)	A. Negret et al. (IFIN-HH)	PRC 88 (2013) 034604
^{23}Na(n,n'g)	C. Rouki et al. (IRMM)	NIM A 672 (2012) 82
^{23}Na(n,n'g)	P. Archier et al. (CEA/Cad)	NDS in print (eval.)

JEFF-3.2: ^{23}Na evaluation based on new data
EXFOR: data sent

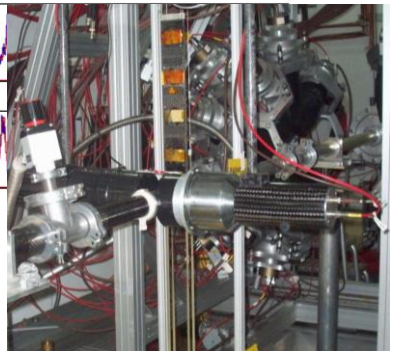
ANDES WP1
^{241}Am(n,g)

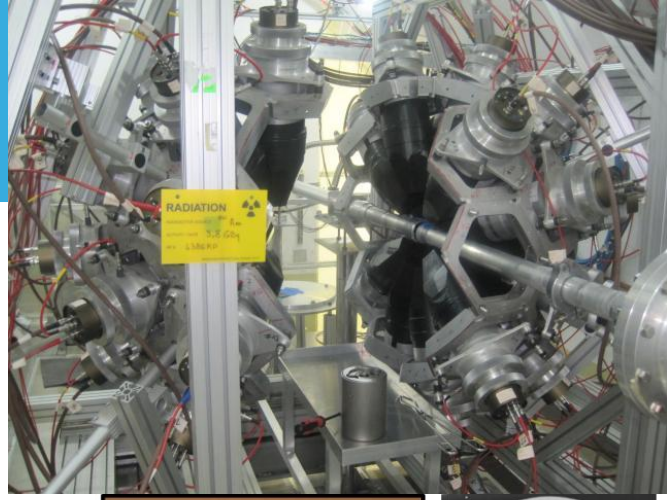


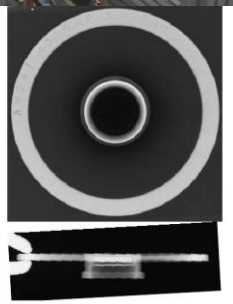




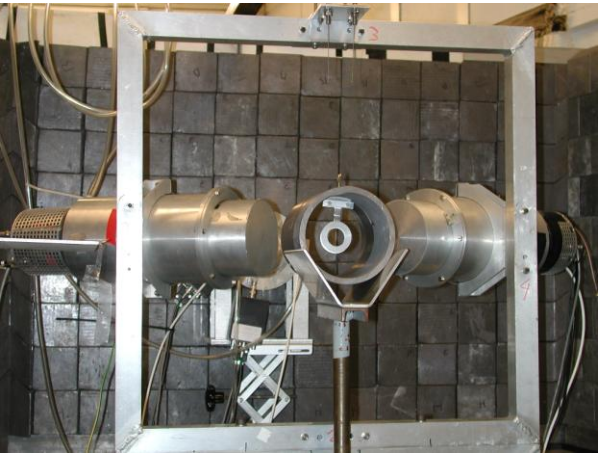
Fraval et al.



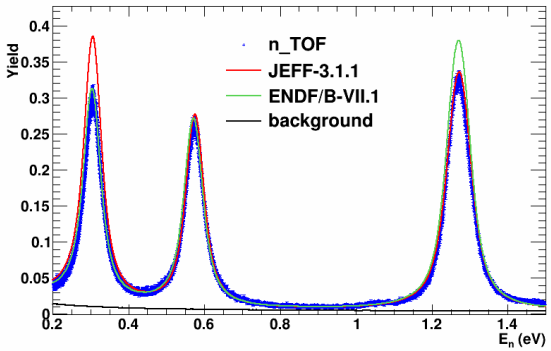


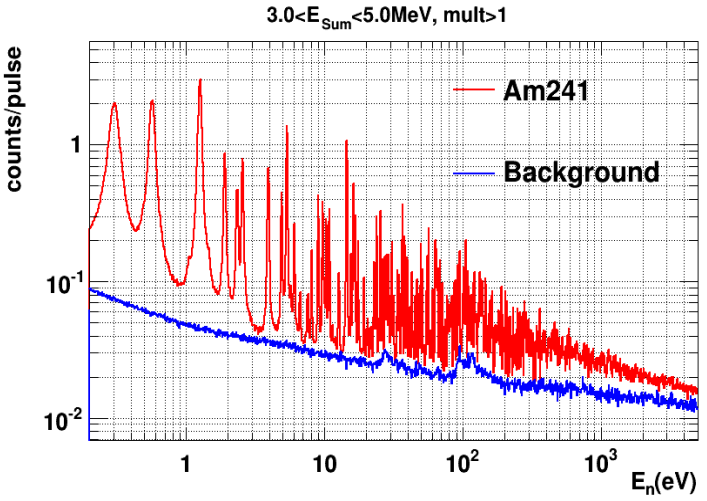


Mendoza et al.



Schillebeeckx et al.





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Publications

^{241}Am(n,g+tot) C. Lampoudis et al. EPJ+ 128 (2013) 86 (IRMM)
^{241}Am(n,g) K. Fraval et al. PRC 89 (2014) 044609 (CERN n_TOF, C6D6)

JEFF-3.2: ^{241}Am evaluation based on new data IRMM

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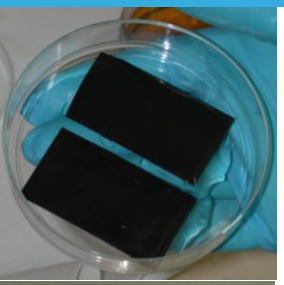
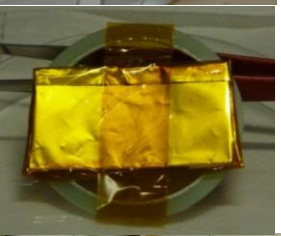
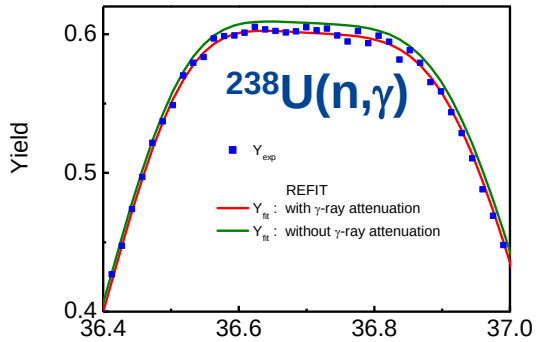
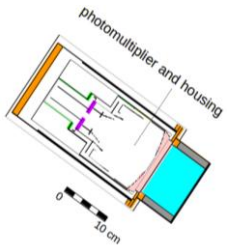
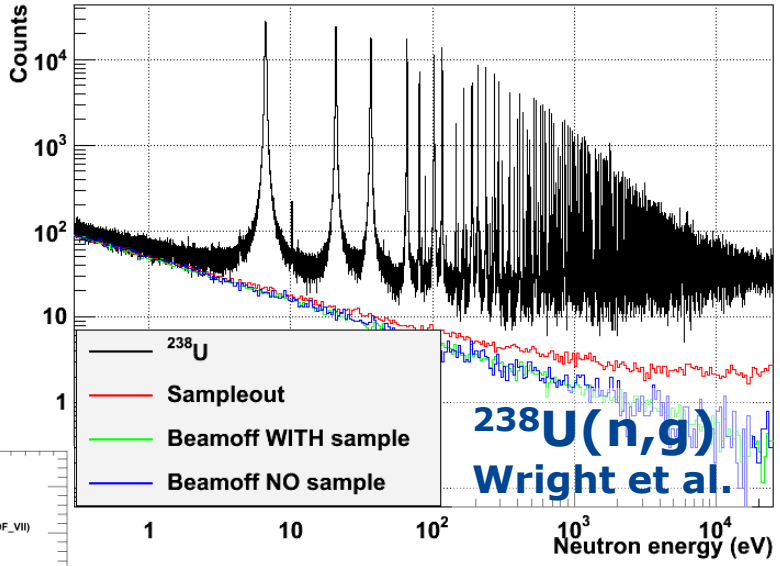




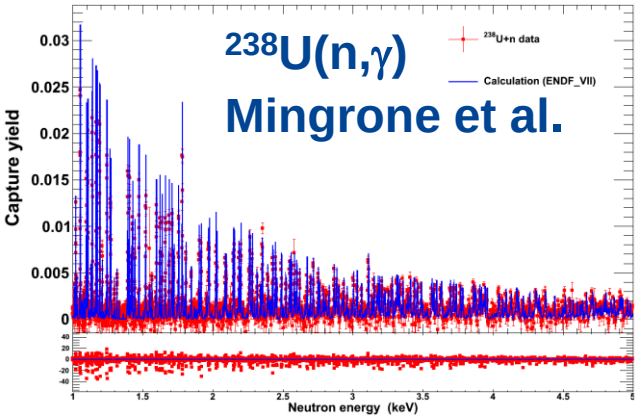


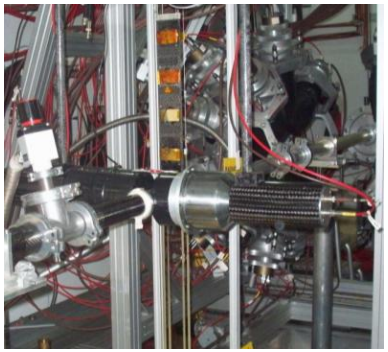
Lampoudis et al.

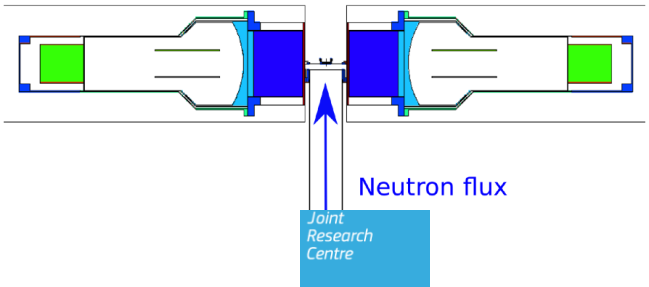




238U(n,g)
Wright et al.







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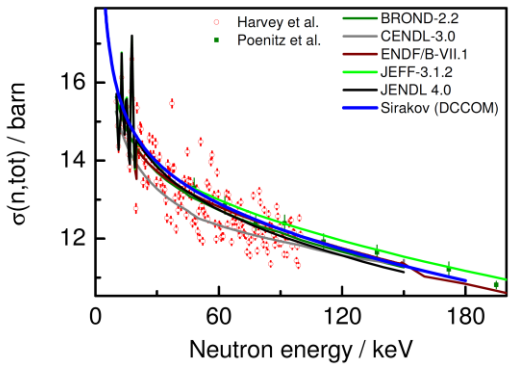
Status ^{238}U RR

See summary Schillebeeckx SG-40 CIELO

^{238}U(n,tot) in URR



Scattering radius RRR

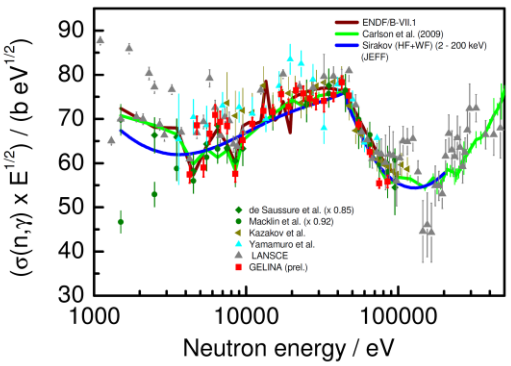
- ENDF-B/VII.1 : R' = 9.48 fm
- REFIT : R' = 9.65 fm

Scattering radius URR

- **at 0 eV : R' = 9.6 fm**

$S_0 = 1.06\ 10^{-4}$
$S_1 = 1.64\ 10^{-4}$
$S_2 = 1.38\ 10^{-4}$

^{238}U(n,γ) in URR



Scattering radius RRR

- ENDF-B/VII.1 : R' = 9.48 fm
- REFIT : R' = 9.65 fm

Scattering radius URR

- **at 0 eV : R' = 9.6 fm**

$S_0 = 1.06\ 10^{-4}$
$S_1 = 1.64\ 10^{-4}$
$S_2 = 1.38\ 10^{-4}$

$T_{\gamma,1/2+} = 6.48\ 10^{-3}$
$T_{\gamma,1/2-} = 6.46\ 10^{-3}$

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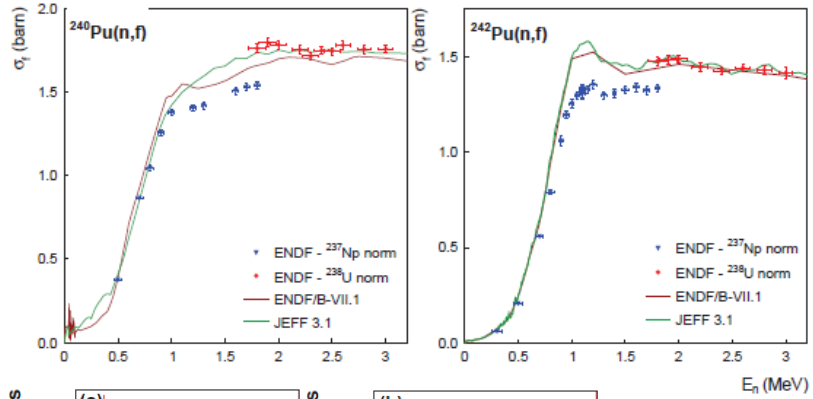
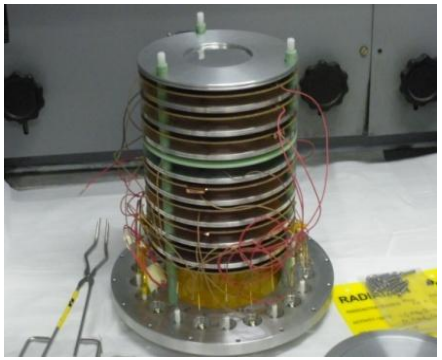
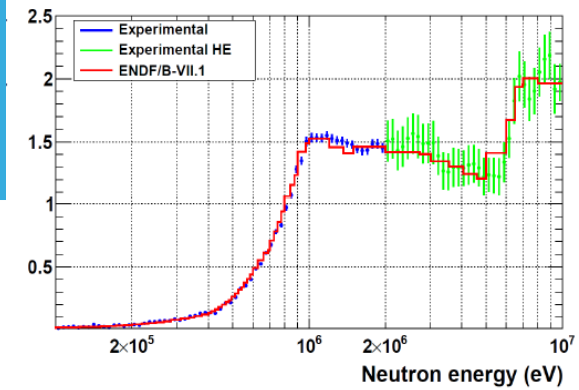
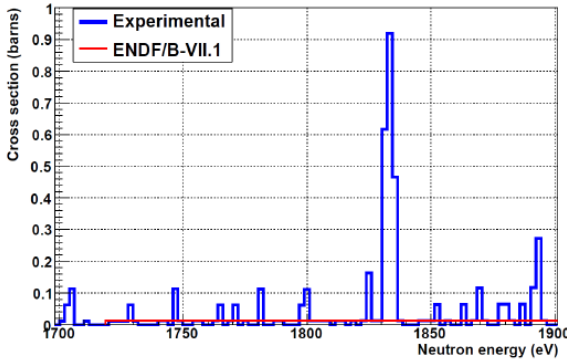
^{240,242}Pu(n,f)

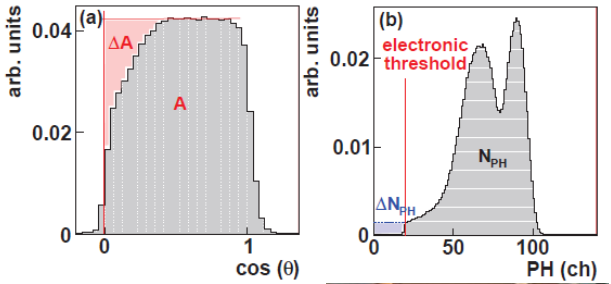
European Commission

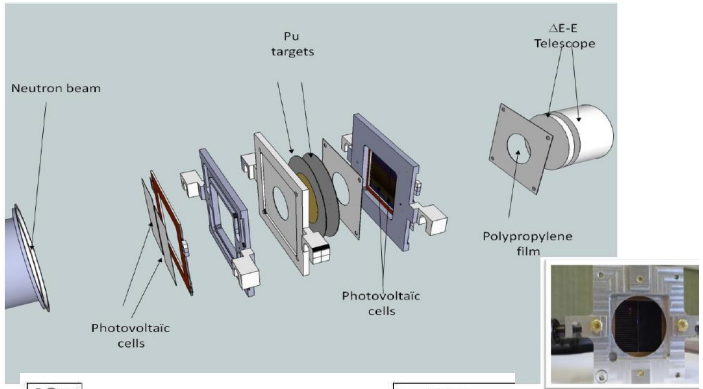


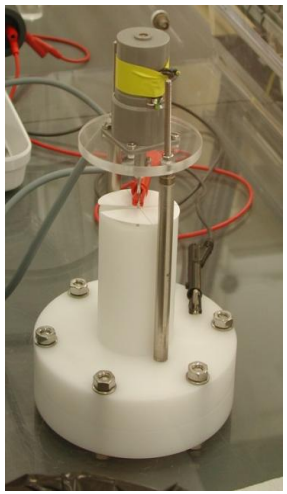


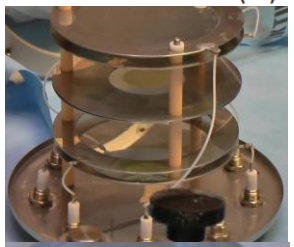


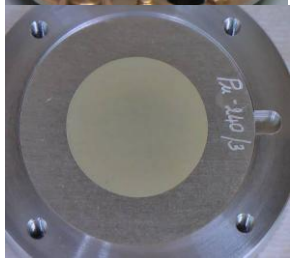


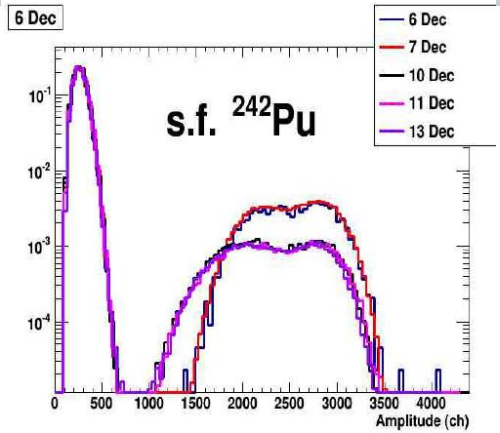


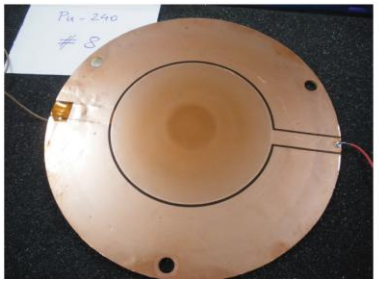


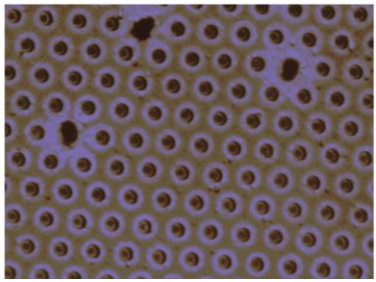












N_TOF: A. Tsinganis et al.
IRMM: P. Salvador et al.
CENBG: M. Aïche et al.

Status

Ongoing work:

check normalization vs ^{237}Np(n,f)

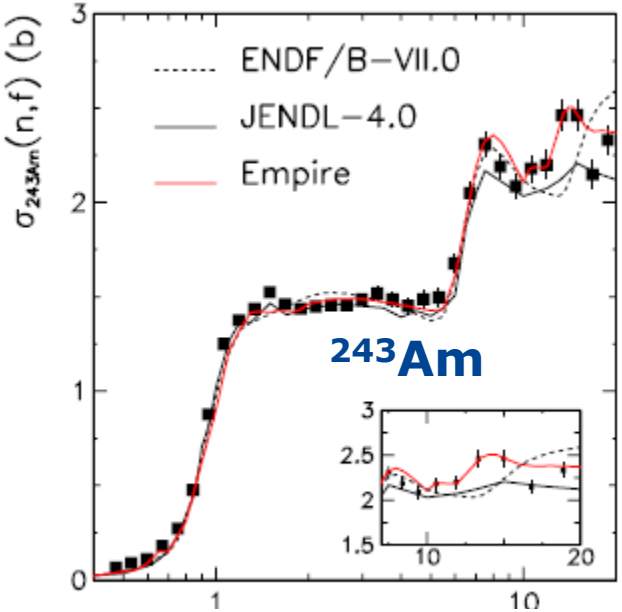
data analysis remaining measurements IRMM, n_TOF, CENBG

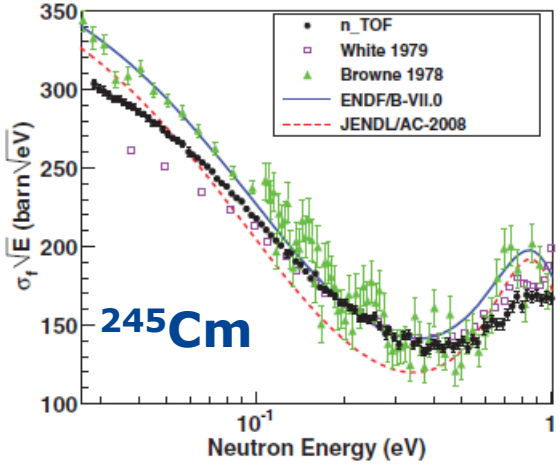
Salvador-Castiñeira et al., Highly accurate measurements of the spontaneous fission half-life of ^{240,242}Pu, PRC 88 (2013) 064611

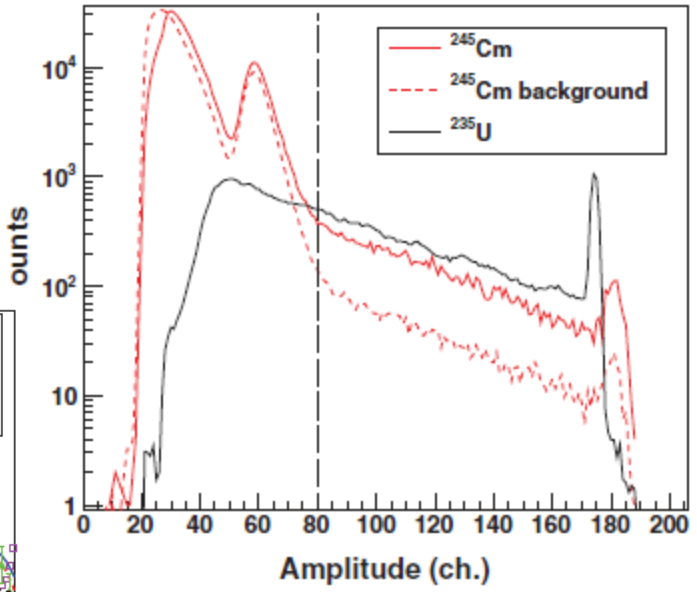
ANDES WP1

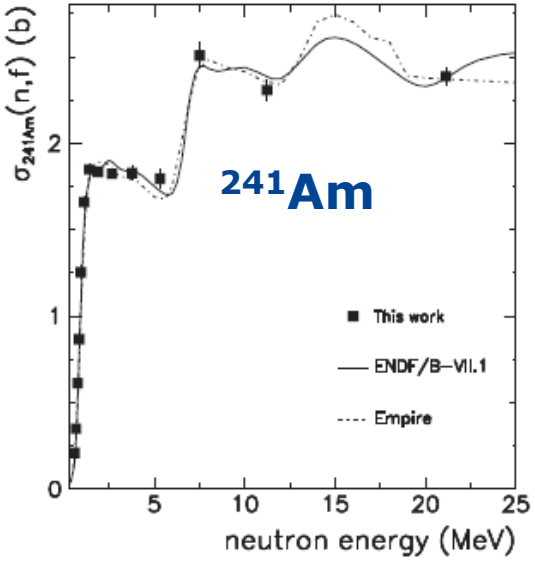
^{241,243}Am,^{245}Cm(n,f)

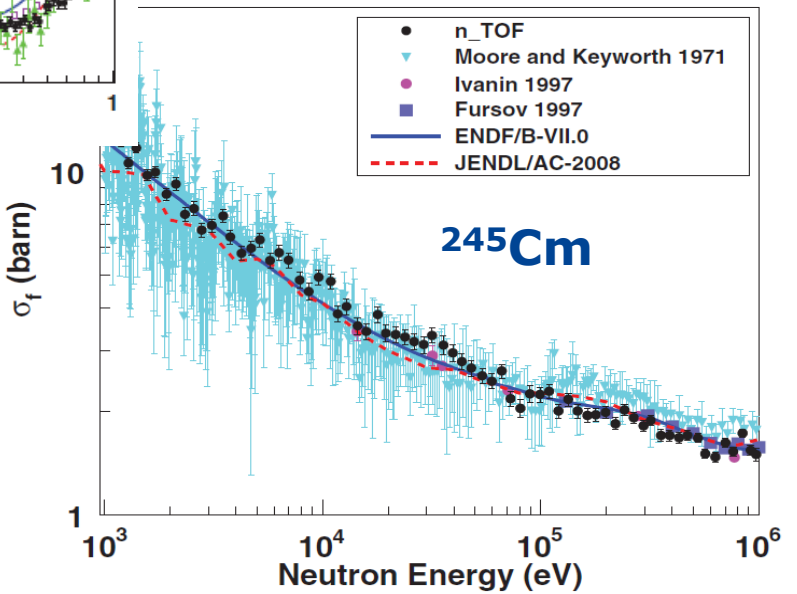
European Commission











Calviani et al.: ^{245}Cm(n,f), PRC85(2012)034616

Belloni et al., ^{241}Am(n,f) EPJA49(2013)2

Belloni et al., ^{243}Am(n,f) EPJA47(2011)160

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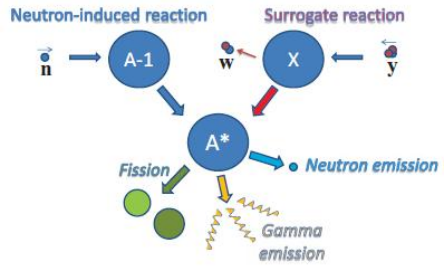
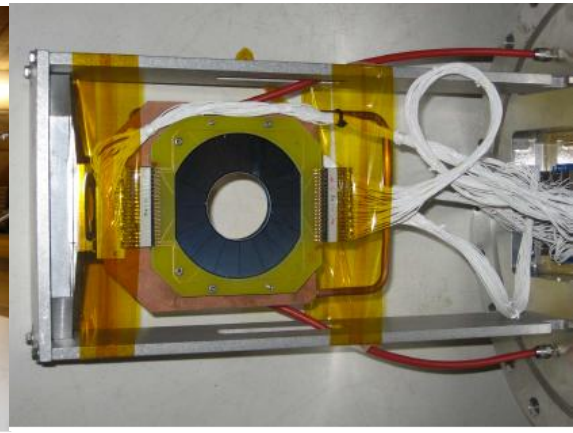
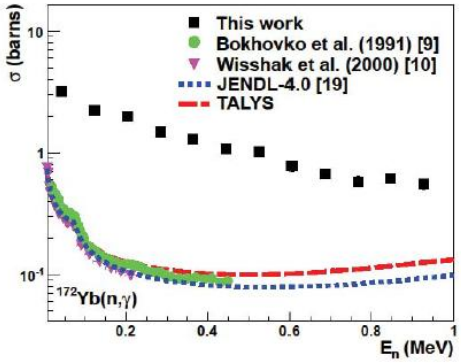
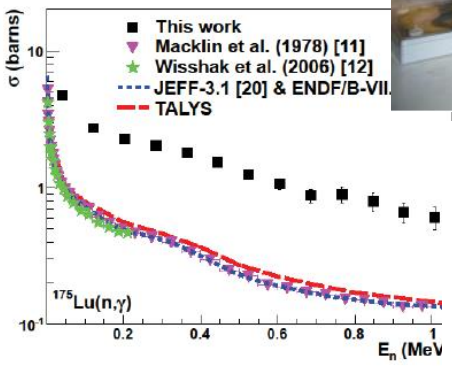
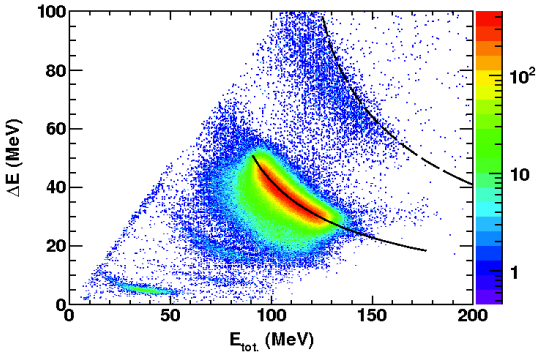
ANDES WP1
Surrogatia

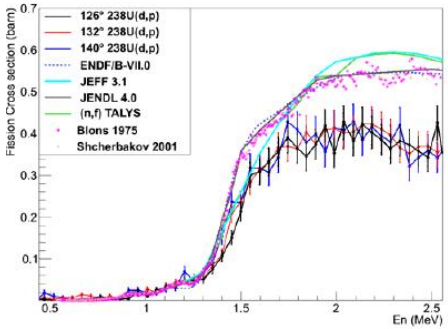


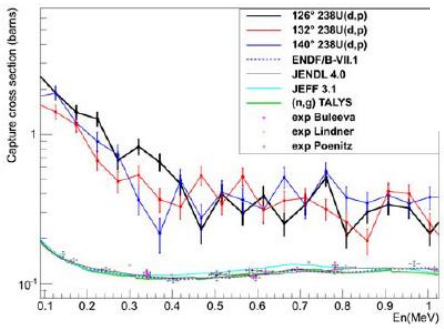


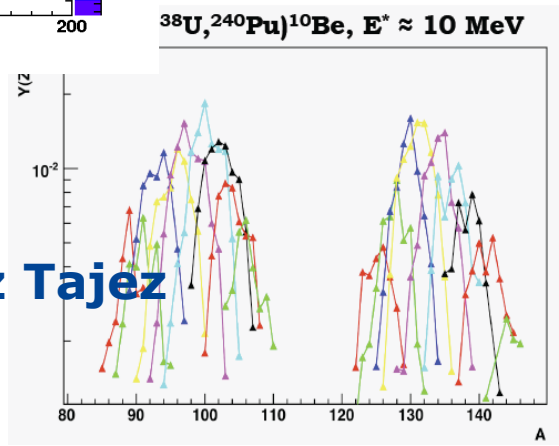








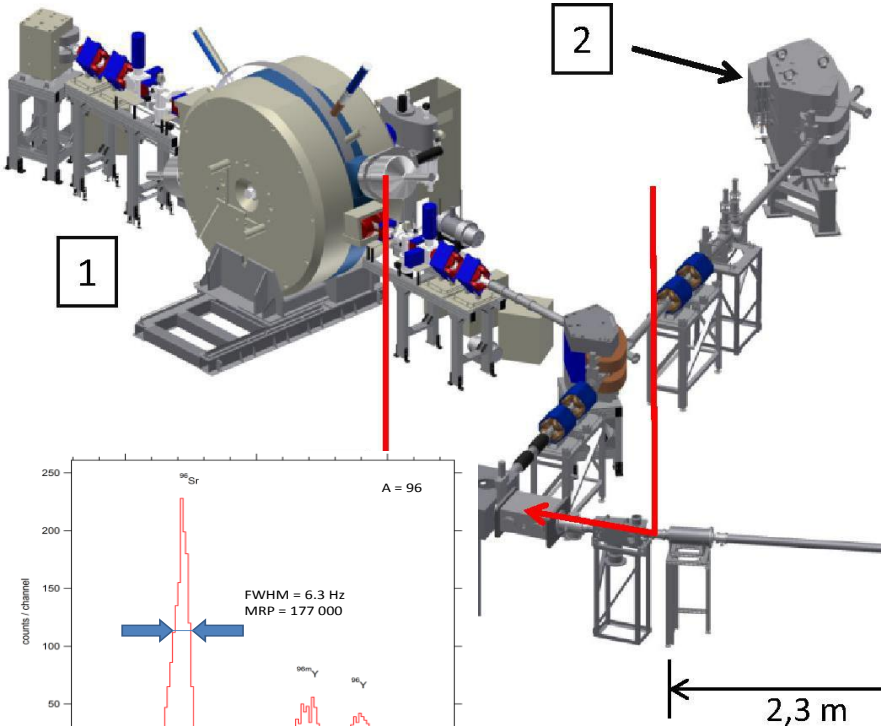


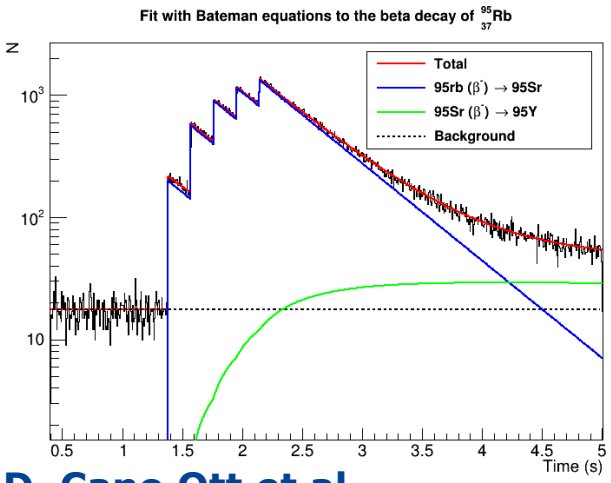


B. Jurado, S. Czajkowski et al.

F. Farget, X, Derckx, C. Rodriguez Tajes et al.

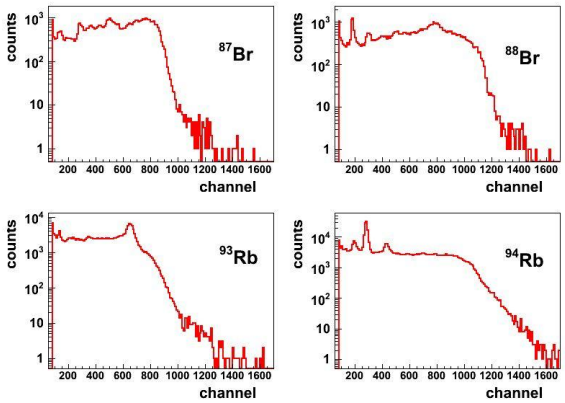
ANDES WP1
Decay data

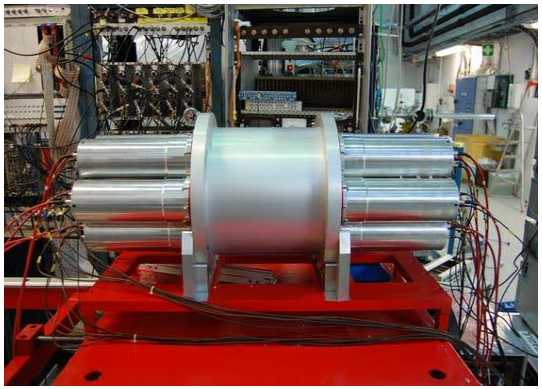


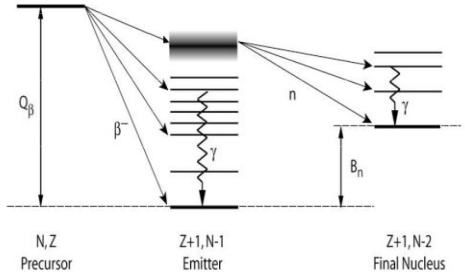


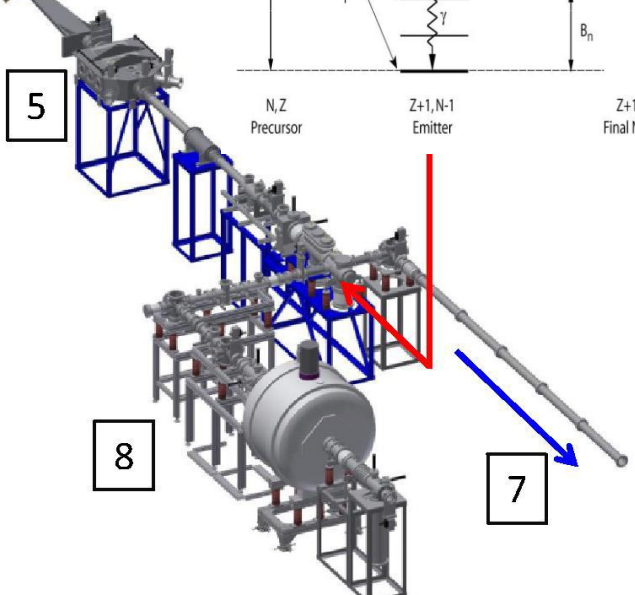
A.R. Garcia, D. Cano Ott et al.

H. Penttilä, A. Algora, J Tain et al.









ERINDA

European research infrastructures for nuclear data applications

Coordinator: Arnd Junghans HZDR

Transnational access to facilities

1 M€ EC contribution, >2x total effort

16 partners, 2010-2013

Objectives: waste transmutation and Gen-IV

31 experiments, 3200 beam hours

HPRL as reference

*Within the framework of its Transnational Access Activities the **ERINDA** consortium offers at least a total of **2500** supplementary data-taking hours to external users at the facilities:*

nELBE	40 MeV superconducting electron linac + neutron TOF facility D-T neutron generator	FZ Dresden (Germany)
GELINA and VdG	150 MeV electron linac + neutron TOF facility 7 MV Van de Graaff accelerator	IRMM Geel (Belgium)
n_TOF	20 GeV proton beam of the PS + spallation neutron source + neutron TOF facility	CERN Geneva (Switzerland/France)
AIFIRA	3.5 MV Van de Graaff accelerator	CENBG Bordeaux (France)
Tandem-ALTO	15 MV tandem and photo-fission source	IPN Orsay (France)
TSL	Cyclotron (180 MeV p)	UU-TSL Uppsala (Sweden)
PIAF	3.7 MV Van de Graaff accelerator Cyclotron (19 MeV p and d, α)	PTB Braunschweig (Germany)
NPI	Cyclotron (20 MeV p and d, α)	NPI Řež (Czech Republic)
BRR	10 MW research reactor	IKI Budapest (Hungary)
JYFL	130 MeV heavy ion cyclotron 30 MeV high intensity cyclotron + IGISOL	JYFL, Jyväskylä (Finland)
IFIN HH	9 MeV Tandem accelerator (p to Au)	IFIN HH, Bucharest (Romania)
NPL	3.5 MeV Tandem Van de Graaff accelerator	NPL, Teddington (Great Britain)
FRANZ	500 keV RFQ + proton linac	GUF, Frankfurt (Germany)
CEA	4 MV Van de Graaff accelerator 7 MV tandem accelerator	CEA Bruyéres-le-Chatel (France)

Grosse, HZDR @ NDW 2013, NEA

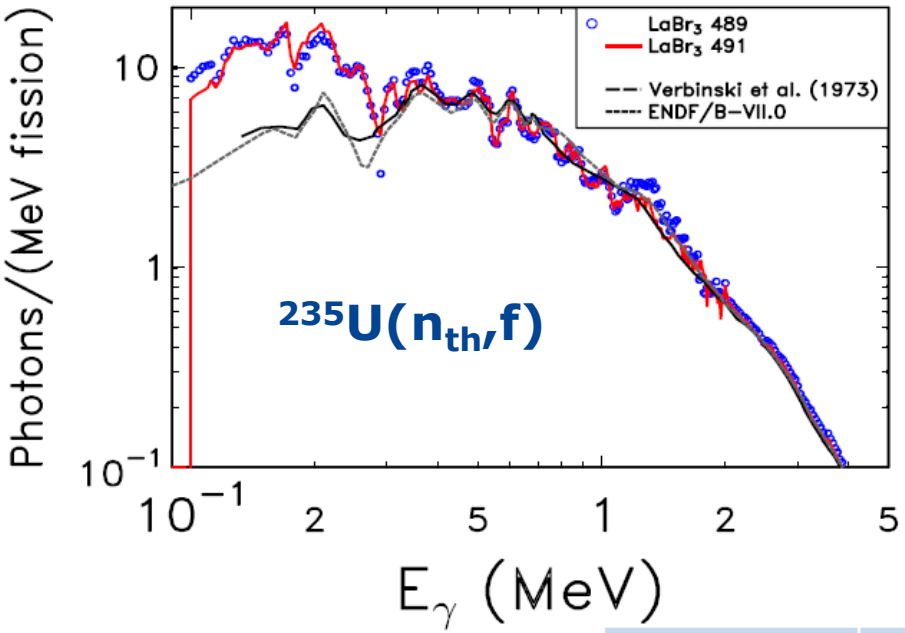
TAA: Publications

- "Measurement of thermal neutron capture cross sections of 237Np and 242Pu using prompt gamma neutron activation", C. Genreith, M. Rossbach, et al., J. Radioanal Nucl Chem (2012) DOI: 10.1007/s10967-012-2080-8
- "Neutron measurements with lanthanum-bromide scintillation detectors - a first approach", A. Oberstedt, R. Billnert and S. Oberstedt, Nucl. Instr. and Meth. A 708 (2013) 7
- "Improved values for prompt fission gamma- ray spectra characteristics from the reaction 235 U (nth , f)", A. Oberstedt, et al., Phys. Rev. C 87 (2013) 051602(R)
- "Determination of resonance parameters and their covariances from neutron induced reaction cross section data", P. Schillebeeckx, B. Becker, Y. Danon, K. Guber, H. Harada, J. Heyse, A.R. Junghans, S. Kopecky, C. Massimi, M.C. Moxon, N. Otuka, I. Sirakov and K. Volev, Nuclear Data Sheets 113 (2012) 3054–3100
- "Data Reduction and Uncertainty Propagation of Time-of-Flight Spectra with AGS", B. Becker, C. Bastian, F. Emiliani, F. Gunsing, J. Heyse, K. Kauwenberghs, S. Kopecky, C. Lampoudis, C. Massimi, N. Otuka, P. Schillebeeckx, and I. Sirakov, 2012 JINST 7 P11002
- "The extrapolated-efficiency method, a new technique to determine the γ-cascade detection efficiency in experiments based on the surrogate-reaction method", G. Boutoux, B. Jurado et al., Nucl. Instr. and Meth. A (article in press)
- "Study of the surrogate-reaction method applied to neutron-induced capture cross sections", G. Boutoux, B. Jurado, et al., Physics Letters B 712 (2012) 319–325
- "^{243}Am neutron-induced fission cross section in the fast neutron energy range", G. Kessedjian, et al., PHYSICAL REVIEW C **85**, 044613 (2012)
- "Measurement of ^{235}U($n,n\gamma$) and ^{235}U($n,2n\gamma$) reaction cross sections", M. Kerveno et al., PHYSICAL REVIEW C **87**, 024609 (2013)
- "Neutron resonance spectroscopy for the characterization of materials and objects", P. Schillebeeckx et al., *J. of Instrumentation* 7 (2012) C03009
- Results of total cross section measurements for ^{197}Au in the neutron energy region from 4 to 108 keV at GELINA, I. Sirakov et al. submitted to EPJ

Grosse, HZDR @ NDW 2013, NEA

Experimental developments:

Measurement of fission γ-rays with lanthanum–bromide scintillation detectors



Oberstedt et al. Phys. Rev. C 87, (2013) 051602(R) $^{235}U(n_{th},f)$

Billnert et al. Phys. Rev. C 87, (2013) 024601 $^{252}Cf(sf)$

Oberstedt et al., submitted, $^{241}Pu(n_{th},f)$

$^{239}Pu(n_{th},f)$ planned

Reference	*year*	ν_γ *(per fission)*	ε_γ *(MeV)*	$E_{\gamma,tot}$ *(MeV)*
average over all detectors	*this work 2013*	**7.60(7)**	**0.88 (2)**	**6.87(9)**
Verbinski	*1973*	**6.7(5)**	**0.97(3)**	**6.5(3)**
ENDF/B-VII.1	*2012*	**6.72**	**0.975**	**6.55**

Supported by the EFNUDAT & ERINDA programmes
of the European Commission (agreement numbers 31027 & 269499)

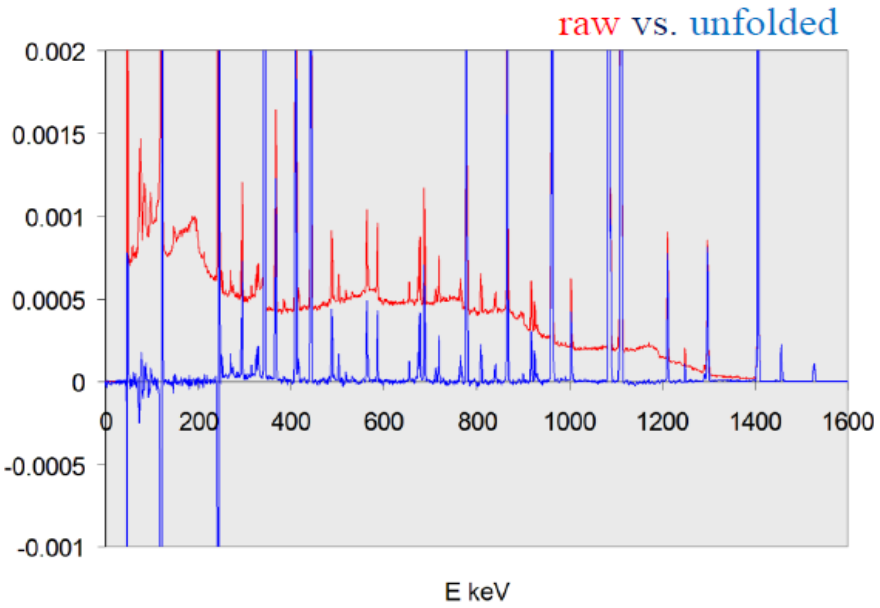
R. Billnert, PhD thesis (Chalmers TU)

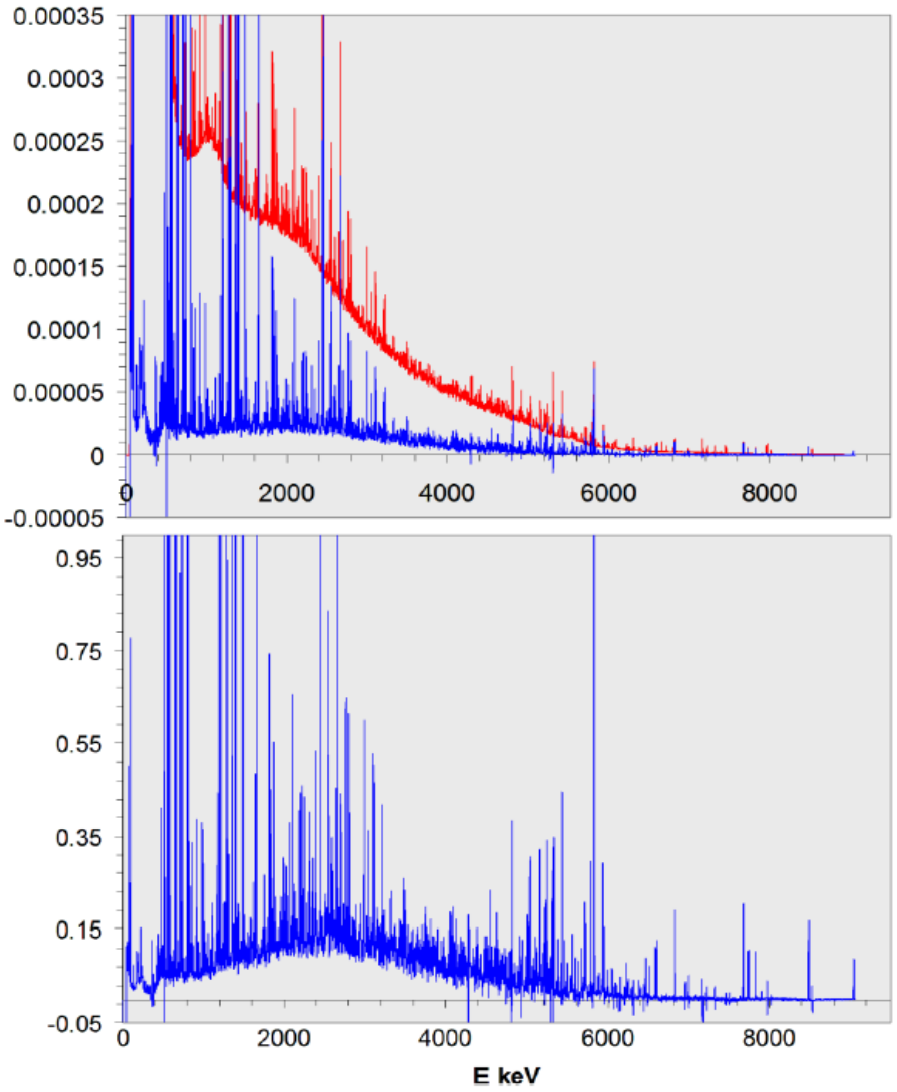
Grosse, HZDR @ NDW 2013, NEA

Improved data analysis:

Ge-detector spectra from $^{113}Cd(n_{therm},\gamma)$

Test of unfolding procedure with $^{152}Eu(\beta_{decay},\gamma)$





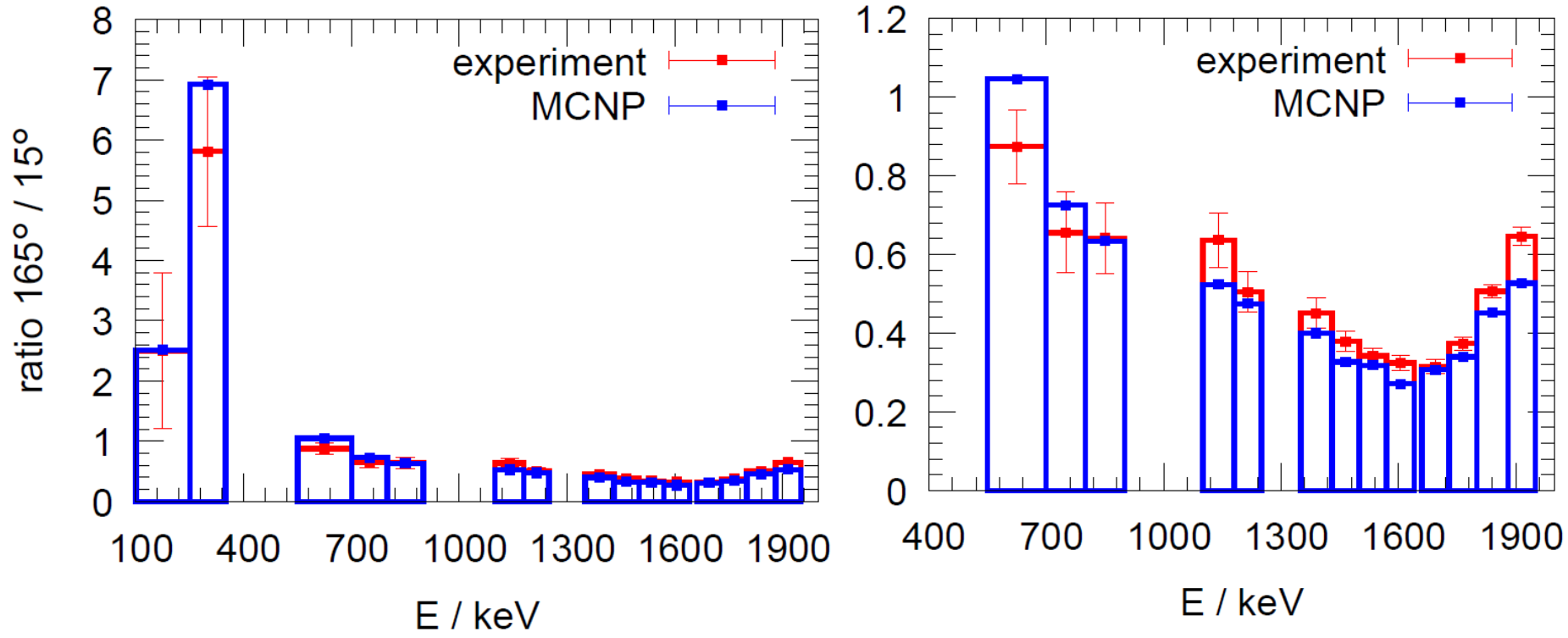
The unfolded, efficiency corrected spectrum shows quasi-continuous broad distribution peaking at 2.5 MeV => *primary photons*

secondary peaks on top

T. Belgya, HAS-Budapest => *simulation with γDEX (HZDR-Dresden)*

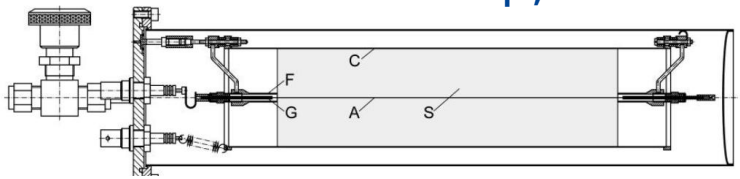
Grosse, HZDR @ NDW 2013, NEA

Results compared with MCNP & ENDF/B-VII
ERINDA, HZDR (IRMM) $^{2}H(n,n)^{2}H$



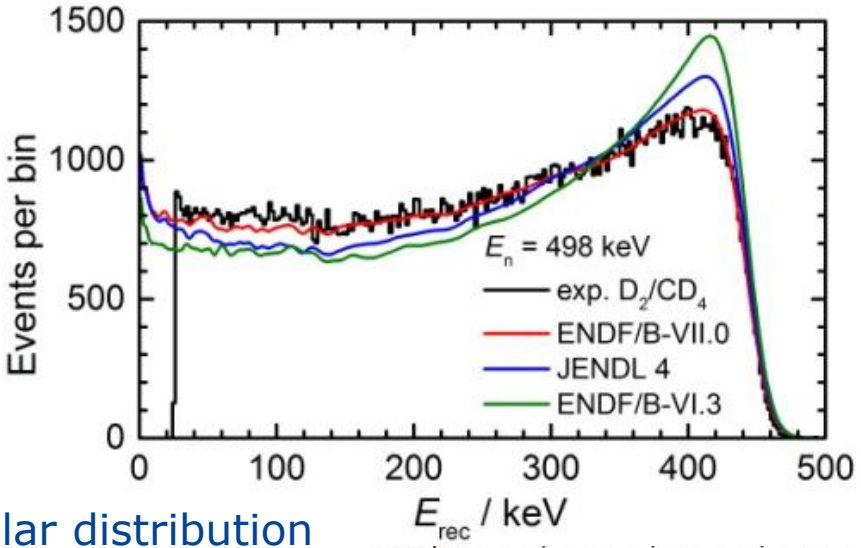
Scattering n+d,

PC PTB, Nolte, Plompen et al.
ERINDA workshop, NDS in print



$$E_R = E_n \frac{4A}{(A+1)^2} \frac{1+\cos(\Theta'_r)}{2}$$

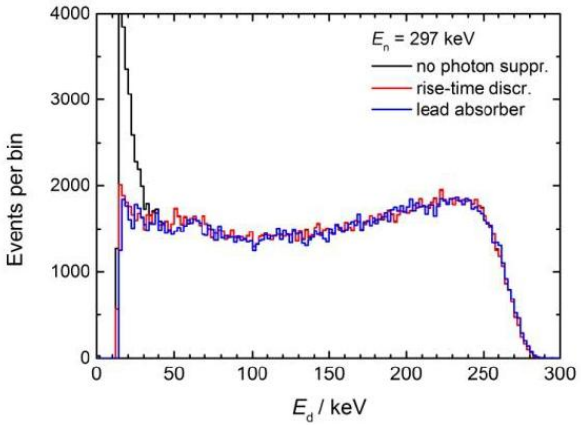
$$\left(\frac{d\sigma_{el}}{dE_R}\right) = \frac{4\pi}{E_R^{max}} \left(\frac{d\sigma_{el}}{d\Omega'_n}\right)(E_R)$$

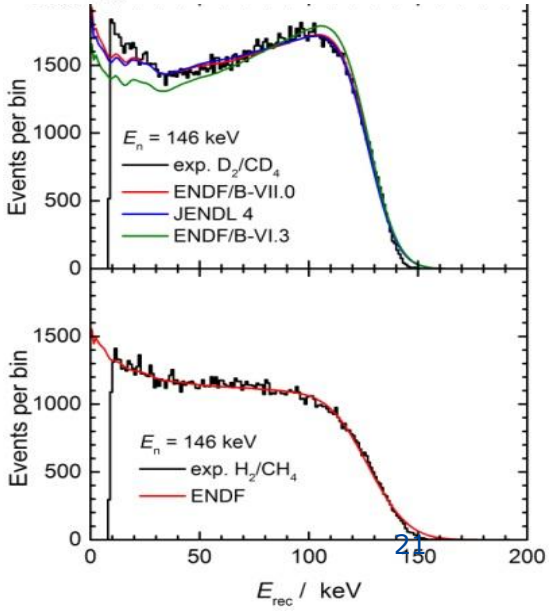


Angular distribution not isotropic in COM from 146 keV up

Good agreement with ENDF/B-VII and JENDL-4 (except 500 keV)

E_n 145, 201, 248, 297, 498 keV





CHANDA

CIEMAT, ANSALDO, CCFE, CEA, CERN, CNRS, CSIC, ENEA, GANIL, GSI, HZDR, IFIN-HH, INFN, IST-ID, JRC, JSI, JYU, KFKI, NNL, NPI, NPL, NRG, NTUA, PSI, PTB, SCK, TUW, UB, UFrank, UMainz, UMan, UPC, UPM, USC, UU, UOslo

Challenges in nuclear data for the safety of European nuclear facilities

Coordinator: Enrique Gonzalez
Infrastructure coord. & development

5.4 M€ EC contribution, ≈10M€ total
36 partners, 2013-2017

New neutron beams, new experimental equipment, new evaluation methods, Myrrha safety case, access to validation experiments, transnational access

European Commission

Nuclear Data Week, fall 2013
JEFF meeting spring 2014

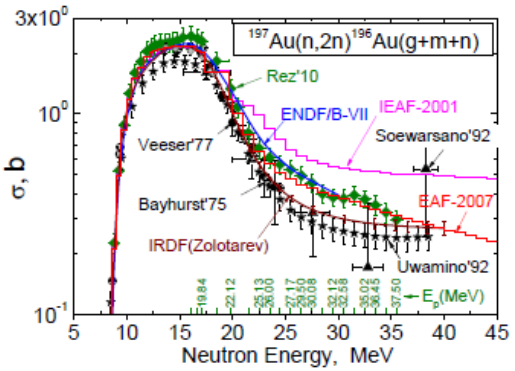
NEEDS program, France
JEFF contributions

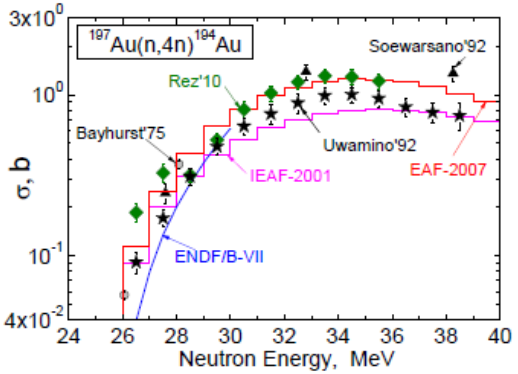
Joint Research Centre

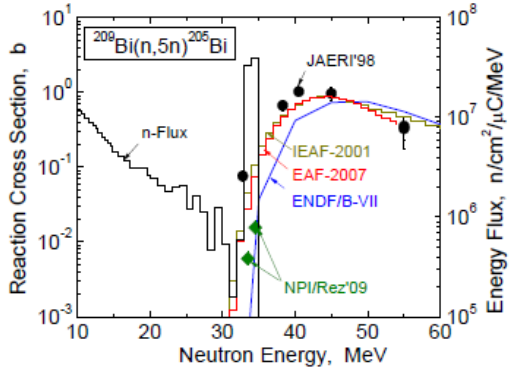
Revised neutron cross-sections of Au and Bi (F4E-2008-GRT-014 and TW7-TTMN-002B)

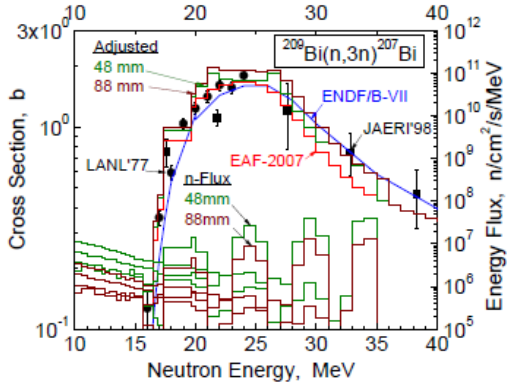
NPI: P. Bém, M. Honusek, M. Götz, M. Majerle, J. Novák, E. Šimečková

KIT: U. Fischer, S. Simakov



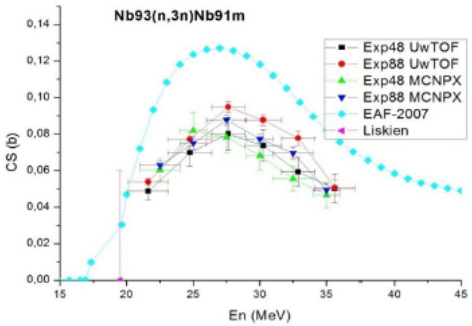


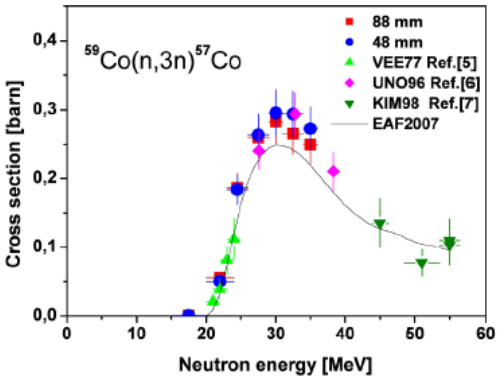




Honusek, J,KPS,59,1374,2011

Šimečková, J,KPS,59,1801,2011



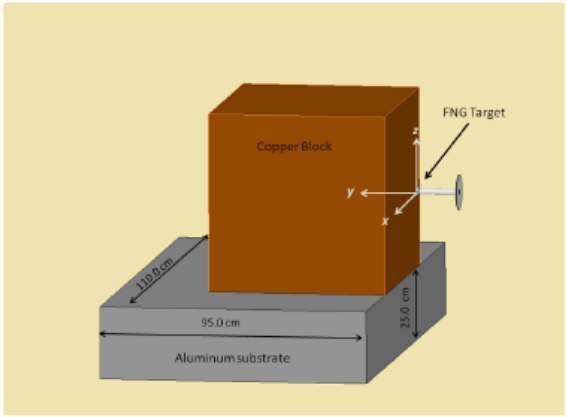


$^{93}Nb(n,3n)^{91m}Nb$

ENEA Frascati

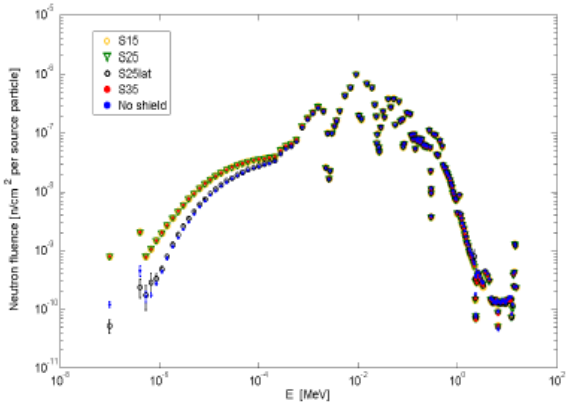
M. Angelone et al.

Design of a copper benchmark experiment at the Frascati Neutron Generator.



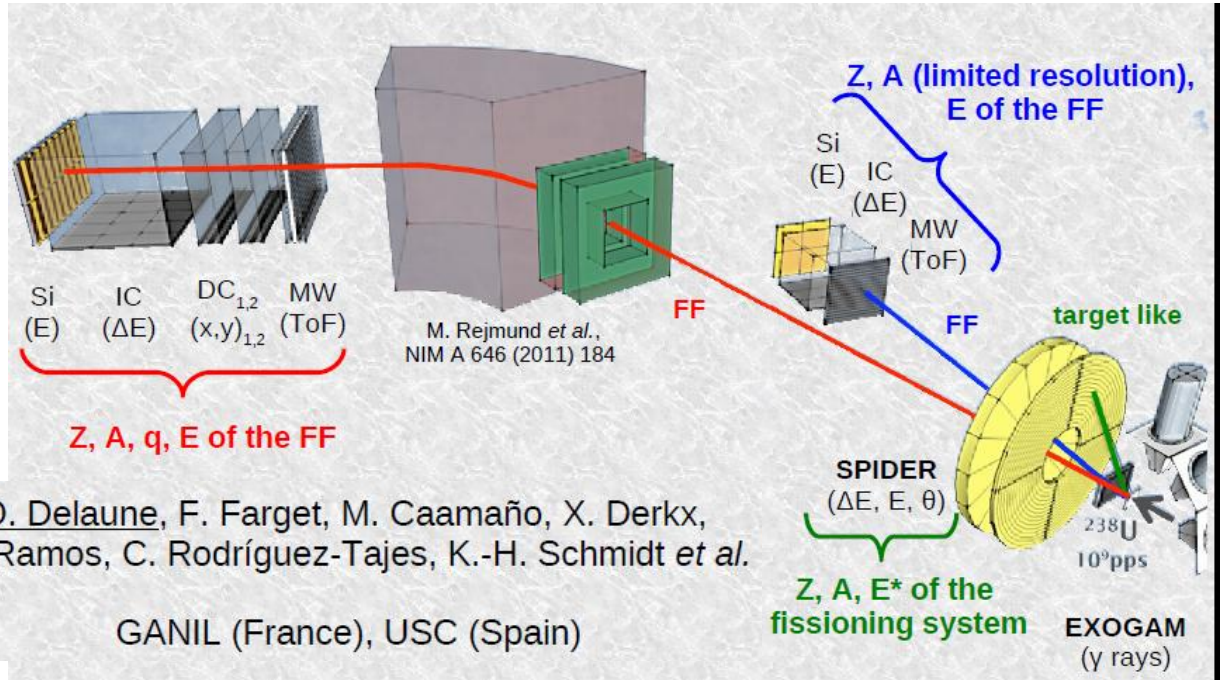
3-D view of the Copper Block on top of the Aluminium support

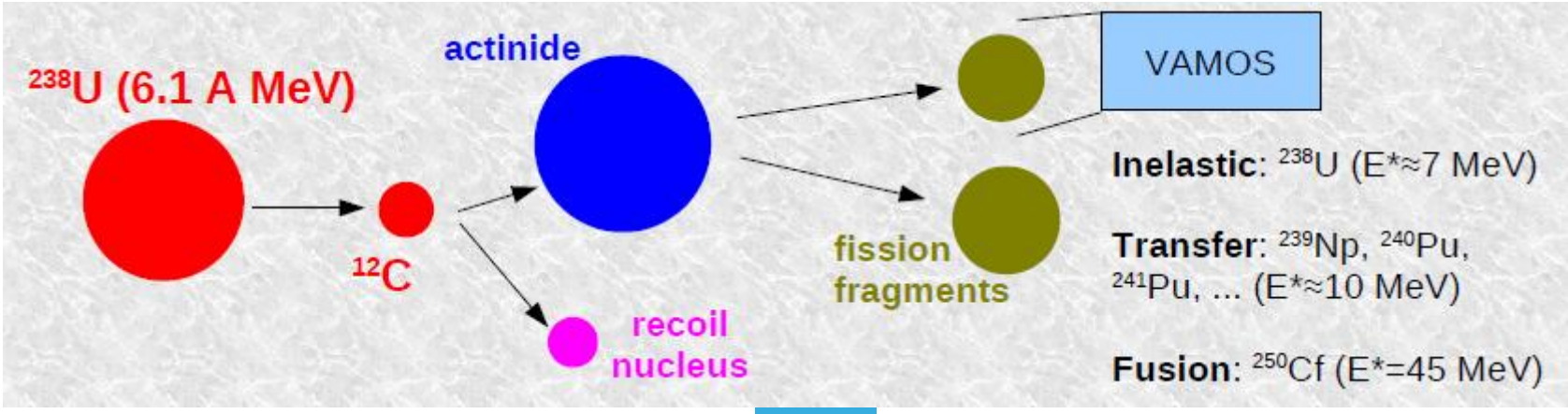
Calculated Neutron Flux spectra in the deepest experimental position using polyethylene shields of different thickness



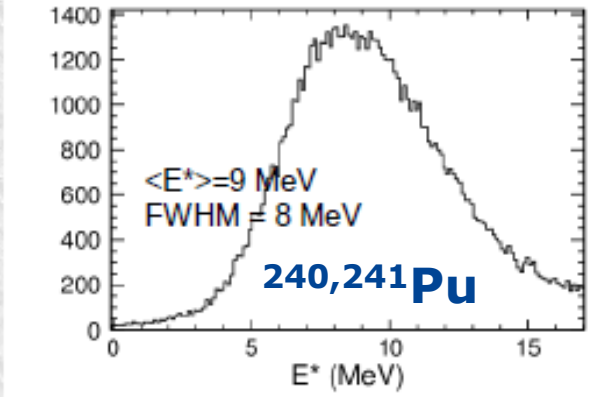
Experimental Fission yields at GANIL

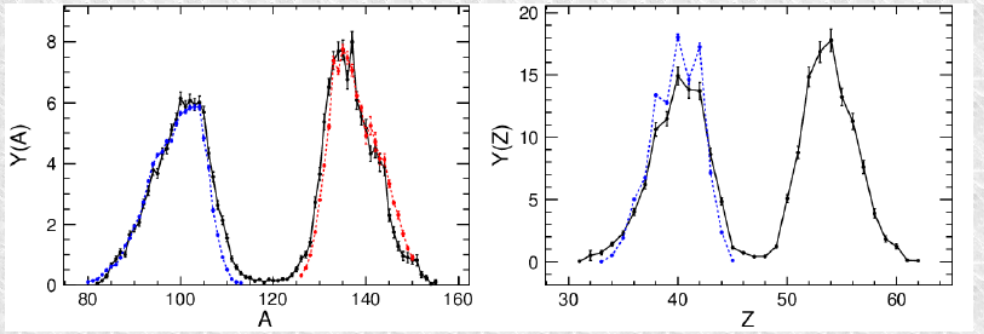
$^{238}U+^{12}C$
6.14 MeV/u fission
Spider dE-E,
VAMOS, EXOGAM





Extraction of E* from E and θ



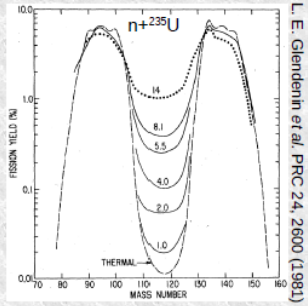


C. Schmitt *et al.* NPA 430(1) :21 – 60, 1984.
A. Bail *et al.* PRC 84, 034605 (2011)

Good agreement with previous measurements
=> Validity of our reconstruction method

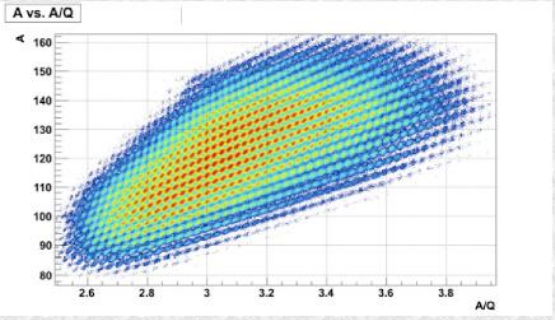
Influence of the excitation energy
=> Peak/valley ratio
=> Odd-even effect

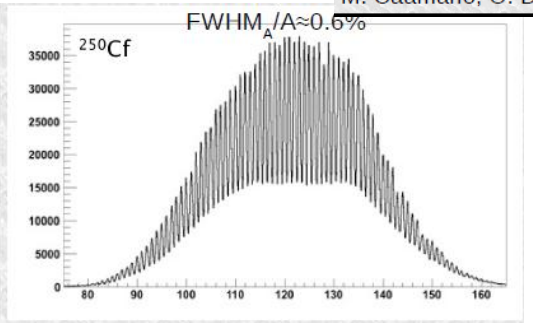
240,241Pu

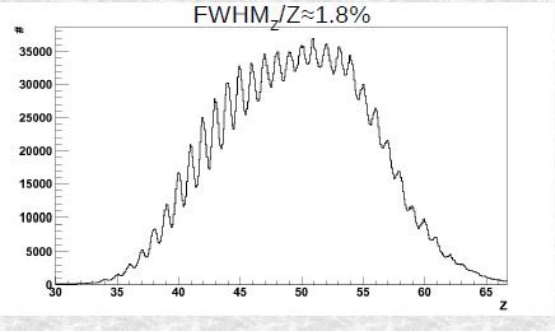


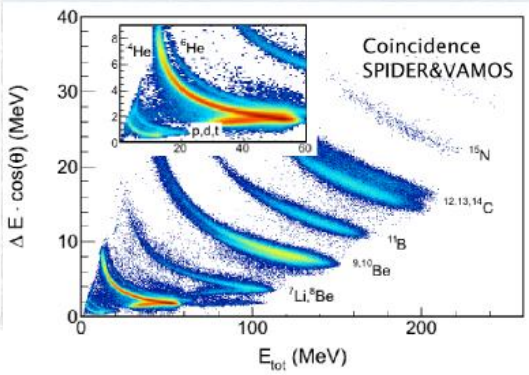
L. E. Glendenin *et al.* PRC 24, 2600 (1981)

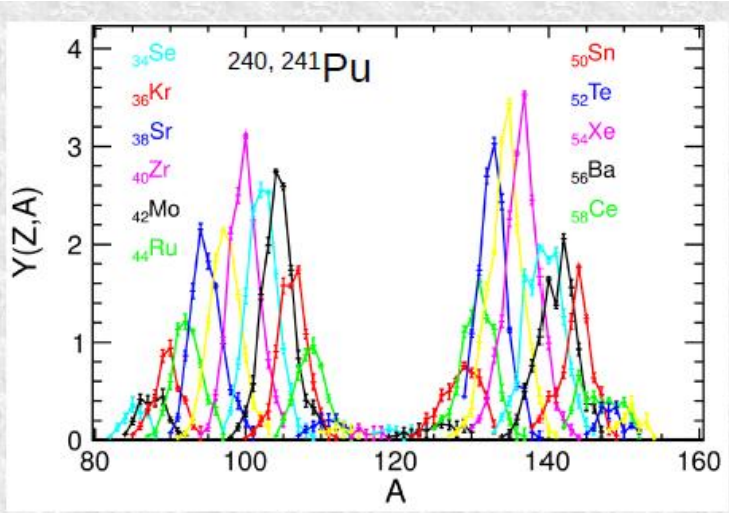
M. Caamaño, O. Delaune *et al.*, Phys. Rev. C 88 (2013)







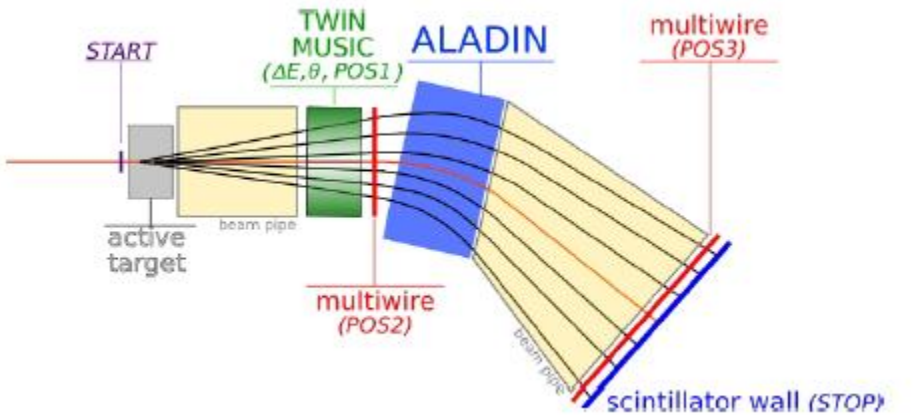


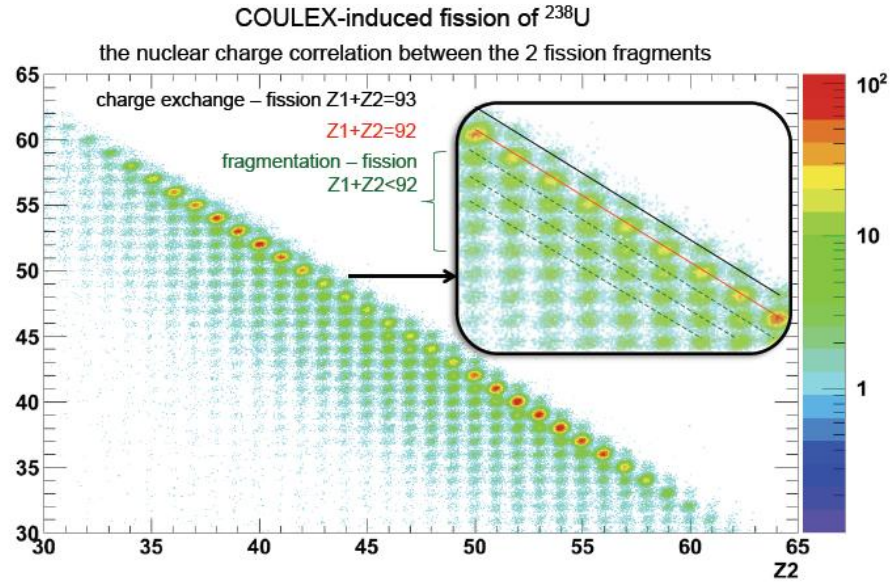


Transfer – fission (E* ≈ 9 MeV)
asymmetric fission

Fission yields at GSI

Studies of fission with Aladin
Coulex-induced fission of relativistic projectiles (A<238),
600 MeV/u ^{238}U(γ,f)
Full A and Z resolution both fragmen
First runs: applications 50% of beam time
Under development





ACCURATE MEASUREMENT OF FISSION FRAGMENTS YIELDS

fission of heavy actinides (^{234}U,^{235}U,^{238}U,^{237}Np,^{238}Np) for *application* purpose

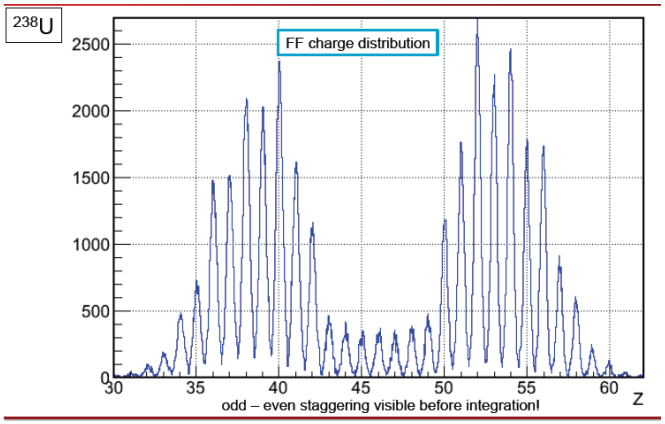
SOFIA
STUDIES ON FISSION WITH ALADIN

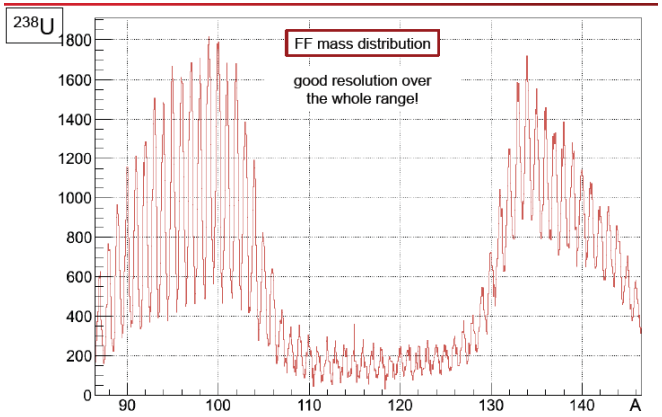
The SOFIA and SOFIA-2 experiments at GSI

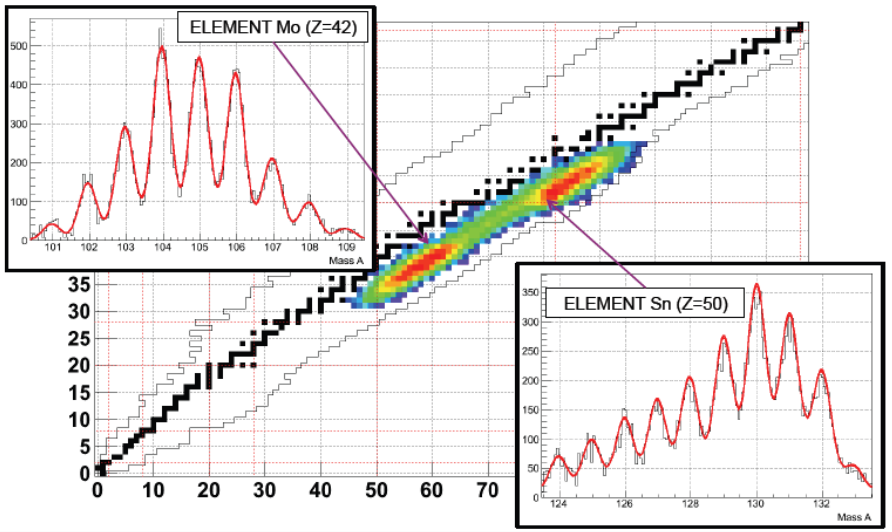
T. Gorbinet (CEA, DAM, DIF) for the SOFIA collaboration

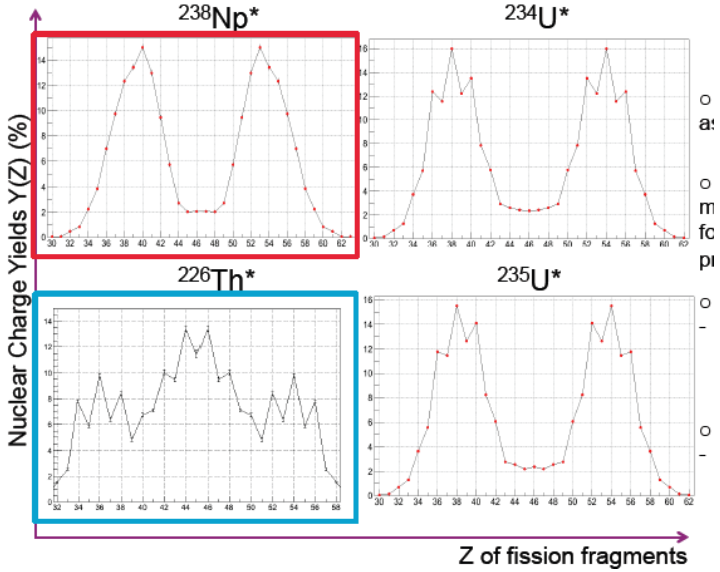
- CEA, DAM, DIF, FRANCE
- IPNO, FRANCE
- CENBG, FRANCE
- GANIL, FRANCE
- GSI, GERMANY
- UNIVERSITY OF SANTIAGO DE COMPOSTELA, SPAIN
- UNIVERSITY OF VIGO, SPAIN
- TECHNICAL UNIVERSITY OF CHALMERS, SWEDEN

SOFIA


238U
FF charge distribution
odd – even staggering visible before integration!
Z


238U
FF mass distribution
good resolution over
the whole range!
A

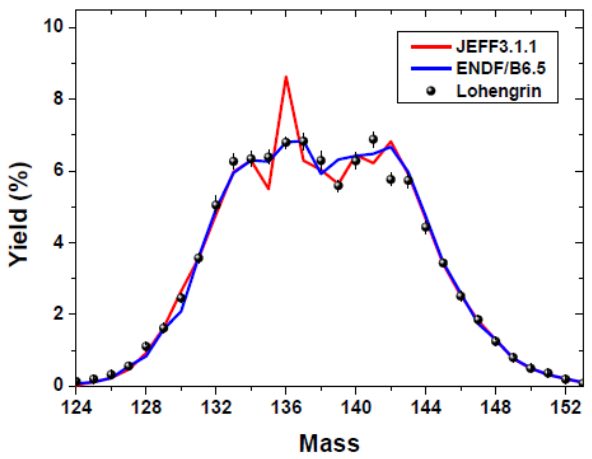

ELEMENT Mo (Z=42)
ELEMENT Sn (Z=50)
Mass A
17/24

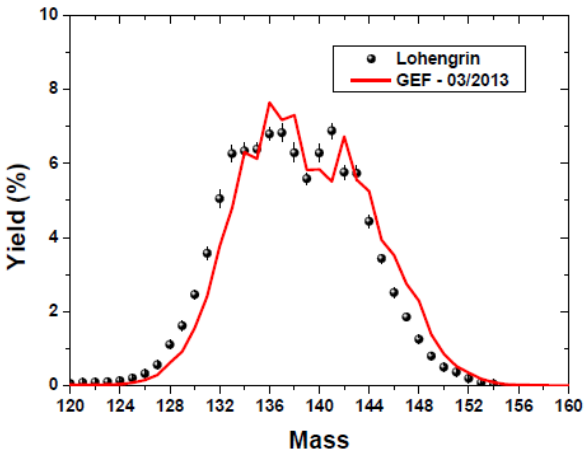

238Np*
234U*
226Th*
235U*
Nuclear Charge Yields Y(Z) (%)
Z of fission fragments

Lohengrin,
Serot et al.

$^{233}U(n_{th},f)$

PhD thesis, F. Martin (Dec. 2013)
F. Martin et al., *IEEE Conf. Proc.* of ANIMMA, Ghent, Belgium, 2011.

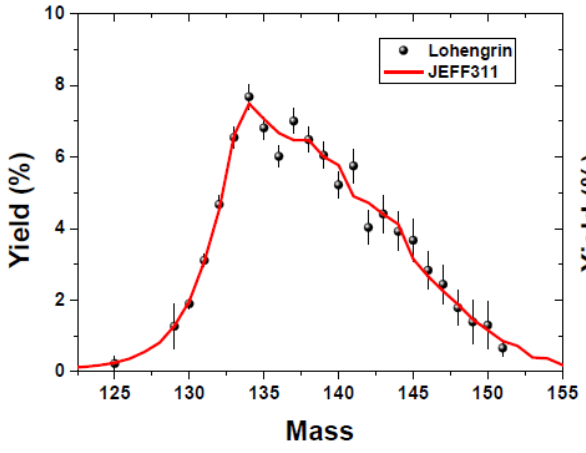


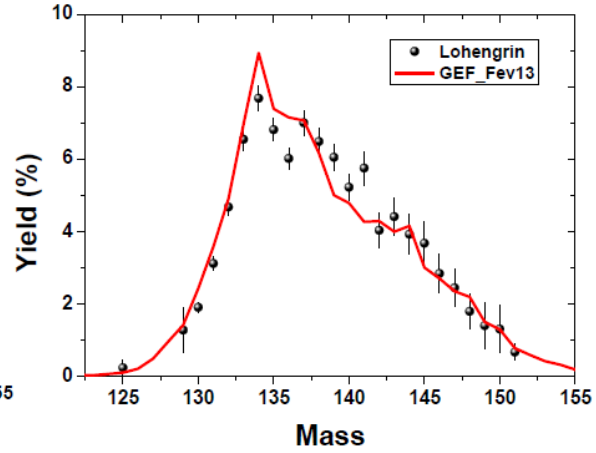


Reasonable agreement with JEFF except for the mass 135 and 136, 141 and 142.
A shift in the wings of the distribution is again observed with the GEF results

$^{241}Pu(n_{th},f)$

PhD thesis, F. Martin (Dec. 2013)





Good agreement (within the error bars) was obtained with JEFF3.1.1 and with the GEF-code (K.-H. Schmidt)

Thesis

- ✓ Adeline BAIL (2009)
- ✓ Florence MARTIN (Dec. 2013)
- ✓ Charlotte AMOUROUX (Oct. 2014)
- ✓ Abdelhazize CHEBBOUBI (Oct. 2015)

TAS measurements for reactor antineutrino and decay heat calculations

A. Porta, M. Fallot and A. Zakari

On-behalf of the TAS Collaboration

J. Agramunt[1], A. Algora[1], J. Äystö[4], V.M. Bui[2], D. Cano-Ott[5], C. Domingo-Pardo[1], V. Eloma[4], E. Estévez[1], T. Eronen[4], M. Fallot[2], W. Gelletly[3], G. Giubrone[1], J. Hakala[4], A. Jokinen[4], M.D. Jordan[1], A. Kankainen[4], E. Mendoza[5], F. Molina[1], ,I. Moore[4], S.E.A. Orrigo[1], A. Pérez[1], Zs. Podolyák[3], H. Penttilä[4], A.Porta[2], P. H. Regan[3] S. Rice[3], J. Rissanen[4], B. Rubio[1],J.L. Taín[1], E. Valencia[1], C. Weber[4], A. Zakari[2] + IGISOL people

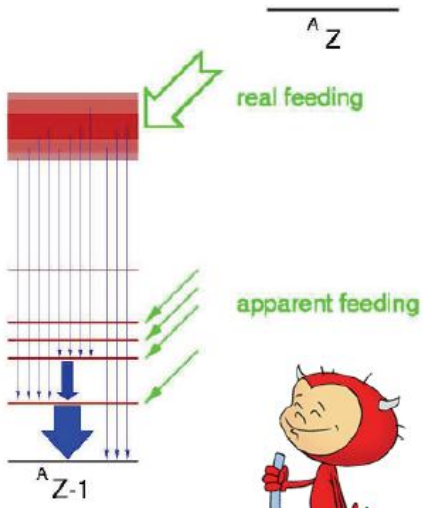
1 IFIC, CSIC-Univ. Valencia, Valencia, Spain

2 Subatech, CNRS/IN2P3, Univ. Nantes, EMN, Nantes, France

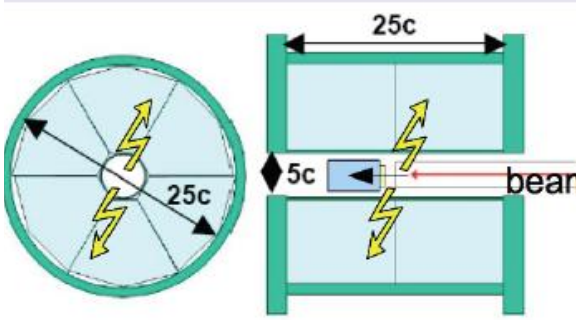
3 Univ. Surrey, Guilford, UK

4 IGISOL, Univ. Jyväskylä, Finland

5 Ciemat- Madrid, Spain



Picture from A. Algora



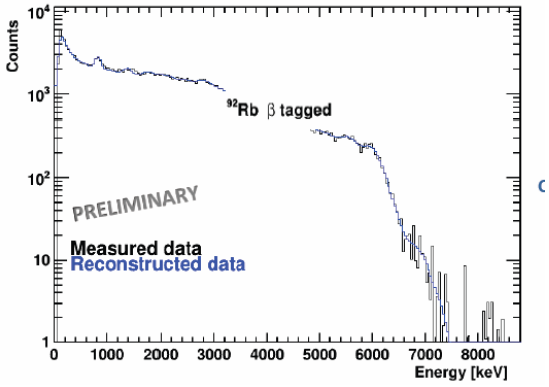
- Low-efficiency high resolution detectors vs high-efficiency low resolution detectors.
- Summing calculations of known transitions do not give the correct sum.

** J.C.Hardy et al., Phys. Lett. B, 71, 307 (1977)

The case of ^{92}Rb

^{92}Rb, pandemonium case

Large contribution to neutrino spectrum 6-8 MeV



⇒ neutrino fundamental physics

- ✧ Measurement of the θ_{13} oscillation parameters. Experiments Double Chooz, Daya Bay, Reno
- ✧ Sterile neutrino measurement to explain the « reactor anomaly »

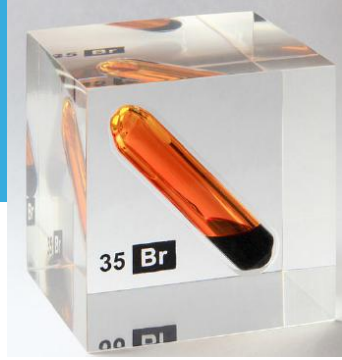
⇒ reactor applied physics

- ✧ Fuel composition monitoring for non-proliferation:
  - ➢ IAEA ad-hoc Working Group (WG) created in 2010
  - ➢ ESARDA sub-WG on reactor antineutrino detection in Novel Tecnology WG
- ✧ Reactor monitoring: direct relationship between antineutrino flux and energy with thermal power and fuel content (burnup)

Joint Research Centre

Gamma de-excitation above Sn: what TAS measurements can provide

Alejandro Algora
IFIC (CSIC-Univ. Valencia), Spain



Total Absorption Spectrometry

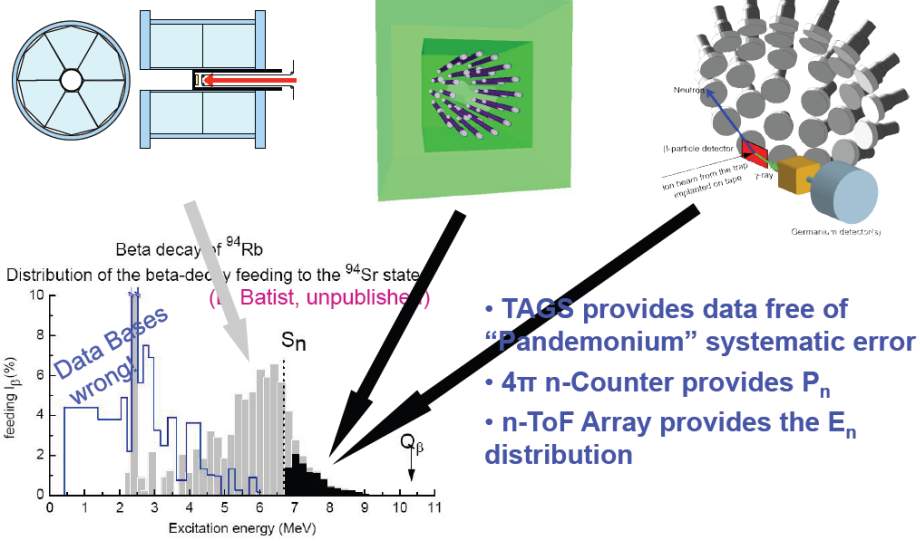
A. Algora et al.

Beta strength measurements: combination of techniques

Total Absorption γ-Ray Spectrometer

4π Neutron Counter

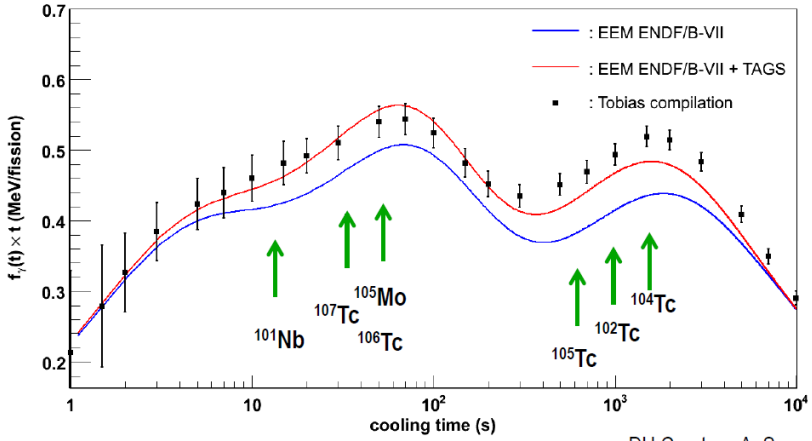
Neutron Time of Flight Spectrometer



- TAGS provides data free of "Pandemonium" systematic error
- 4π n-Counter provides P_n
- n-ToF Array provides the E_n distribution

Impact of the results for ^{239}Pu: electromagnetic component

Motivated by Yoshida *et al.* (Journ. of Nucl. Sc. and Tech. 36 (1999) 135) and WPEC-25

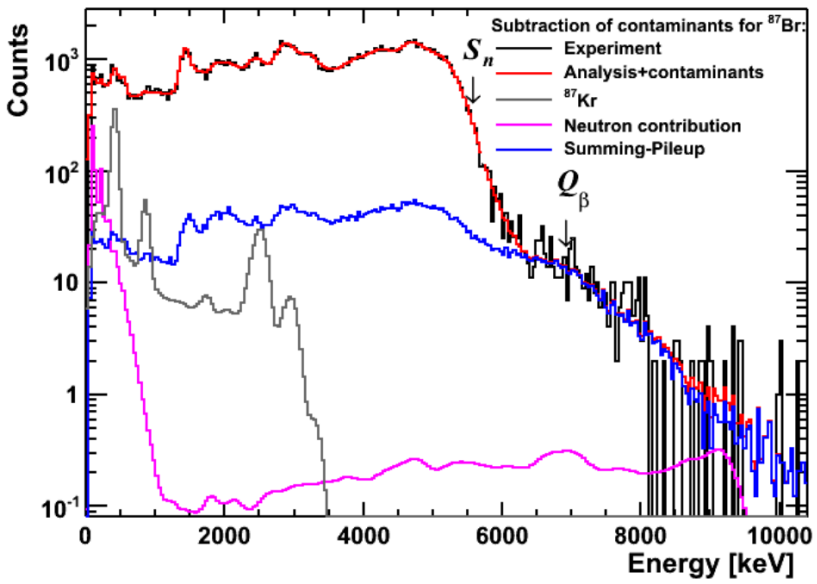


Algora, Phys. Rev. Letts. 105, 202505, PhD Thesis D. Jordan, K. P. Rykaczewsky, Physics 3, 94 (2011)

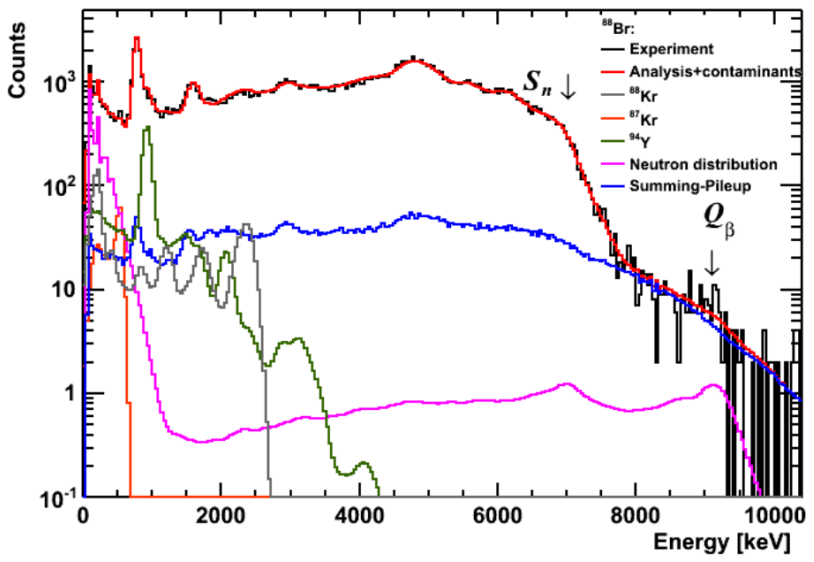
DH Courtesy A. Sonzogni

Results also confirmed by R. W. Mills using JEFF 3.1

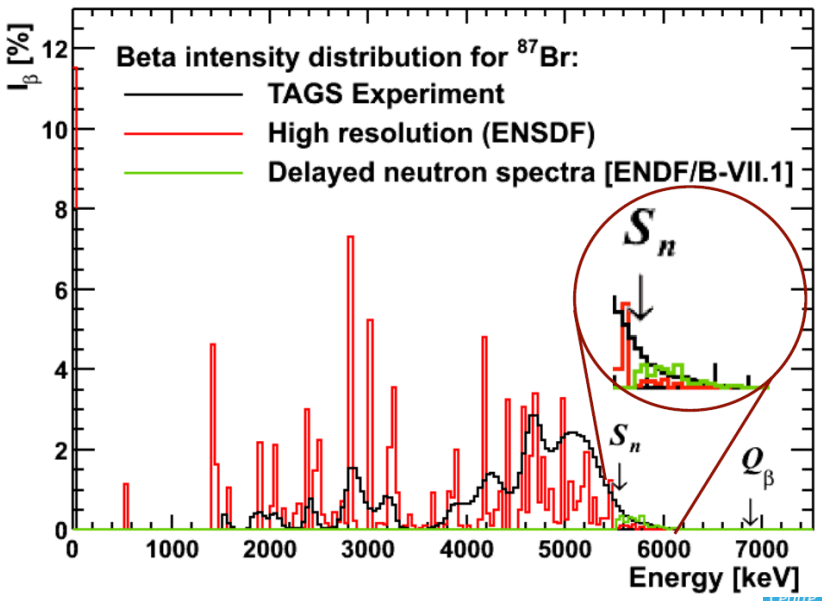
^{87}Br: meas. spectrum + contaminants + analysis



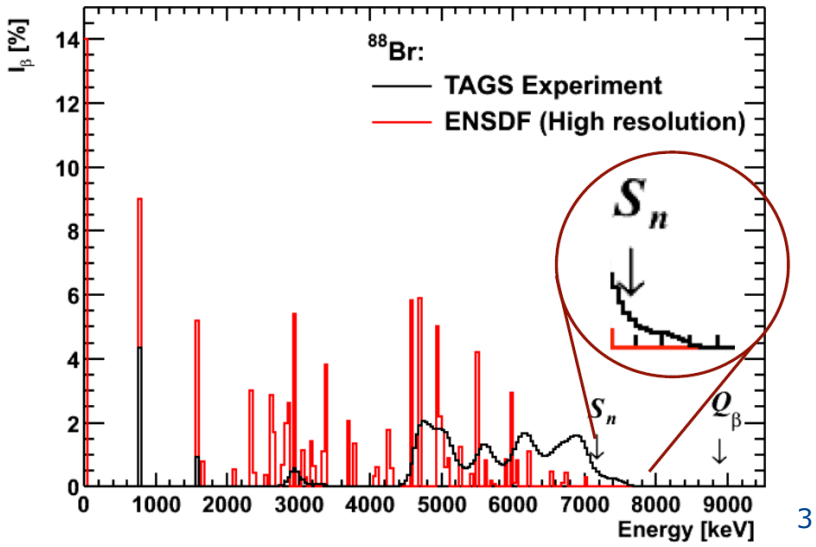
^{88}Br: meas. spectrum + contaminants + analysis



Deduced feedings from 87Br decay



Deduced feedings from ^{88}Br decay

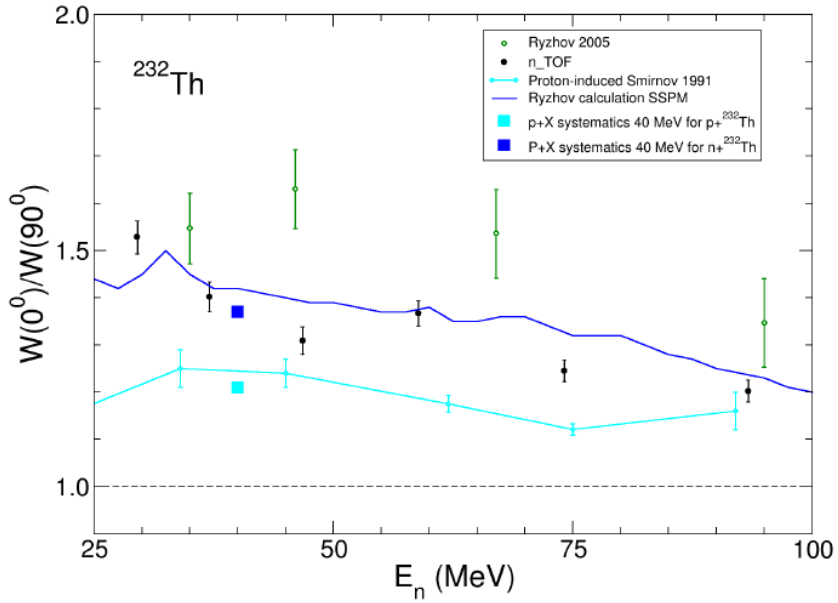


^{232}Th fission fragment angular distributions
^{231}Pa(n,f) status

L. Tassan-Got, L. Audouin, L.S. Leong, C. Le Naour, C.O. Bacri CACAO, NEEDS
IPN Orsay-France

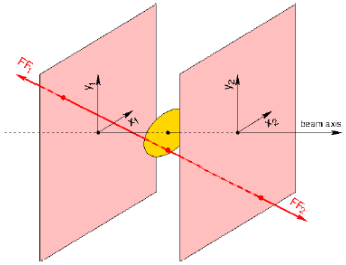
I. Duran , C. Paradela, D. Tarrio
Santiago de Compostela - Spain

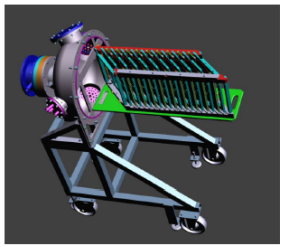
n_TOF collaboration
CERN - Switzerland



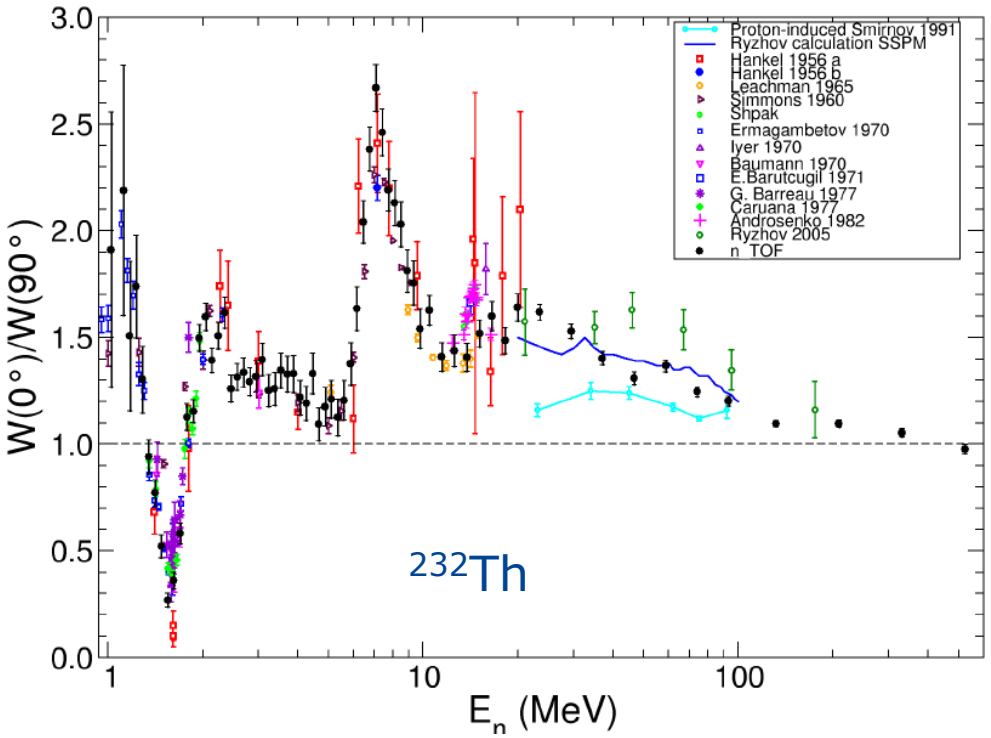
^{232}Th fission fragment angular distribution (FFAD)

- Detection of the 2 fission fragments
- Fission direction given by the positions of the 2 fragments





- 9 Targets and 10 detectors tilted by 45°
- 1x^{235}U 1x^{238}U 1x^{237}Np 6x^{232}Th



Determining inaccessible neutron-induced cross sections with the help of surrogate reactions

B. Jurado, Q. Ducasse, M. Aiche, S. Czajkowski, P. Marini, L. Mathieu, I. Tsekhanovich
CENBG, Bordeaux, France

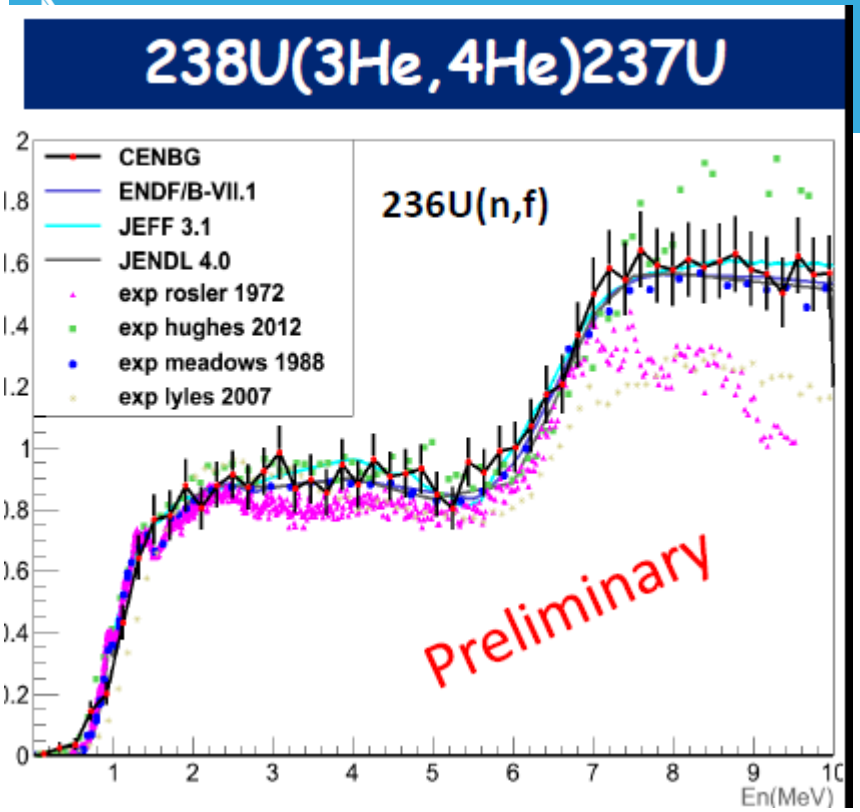
J. Wilson, L. Audouin, L. Tassan-Got,
IPN, Orsay, France

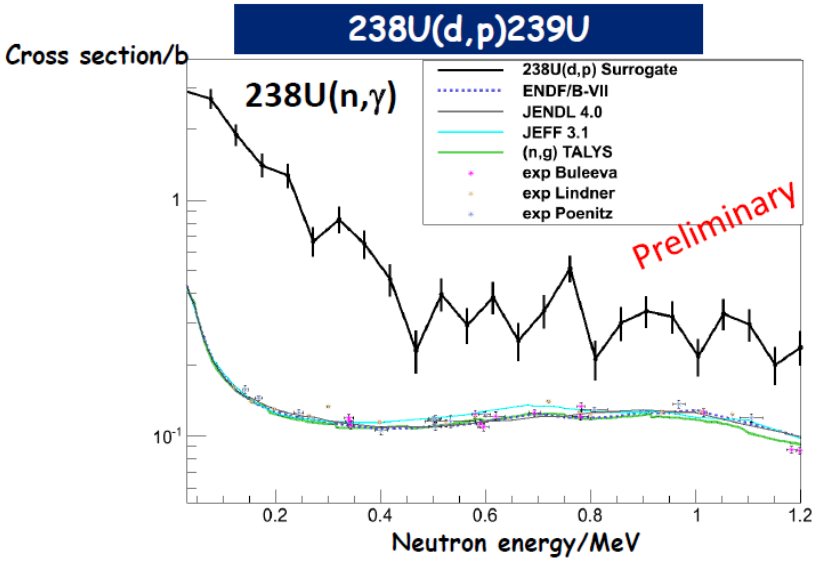
O. Sérot
CEA Cadarache, France

V. Méot, O. Roig, G. Boutoux, P. Chau, B. Morillon
CEA DAM, France

J. Escher
Lawrence Livermore National Laboratory, USA

Neutron-induced fission cross sections obtained via the surrogate-reaction method





1. Predict spin/parity distribution
2. Model CN decay (Hauser-Feshbach calculation)
3. Use surrogate data to fix the parameters of the HF calculation (level densities, gamma-strength functions…)
4. Calculate desired (n,γ) cross section

Collaboration between theoreticians and experimentalist mandatory!
No theoreticians interested in Europe concerning point 1.?
Strategy currently being tested by Jutta Escher at Livermore, USA!

DE LA RECHERCHE À L'INDUSTRIE

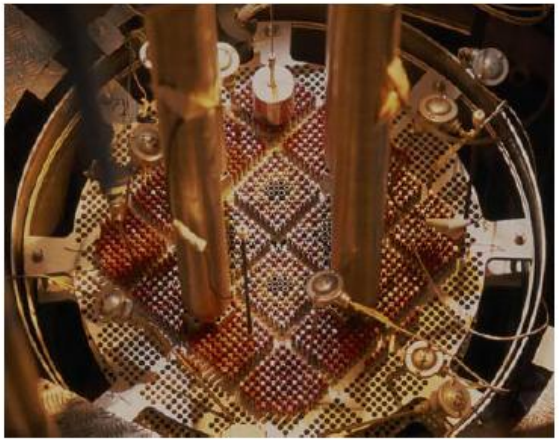
cea

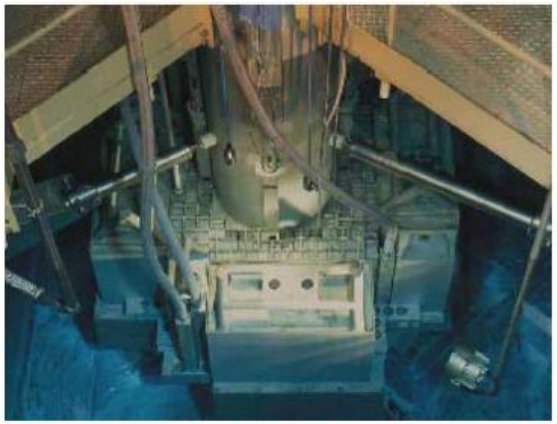
OPENING

THE **EOLE** AND **MINERVE** FACILITIES

TO THE NUCLEAR DATA COMMUNITY

MINERVE with its pile-oscillator





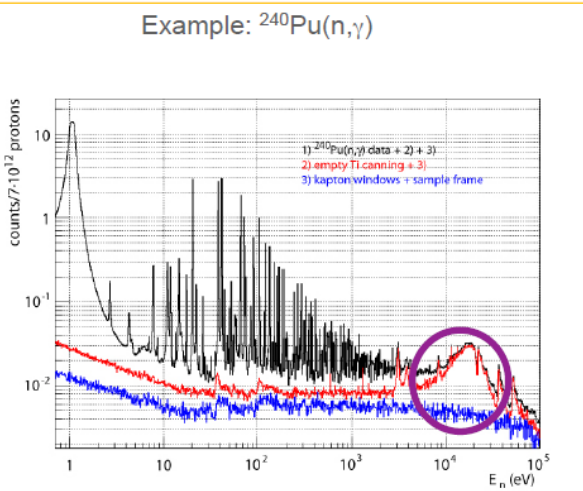
Pierre Leconte et al. DEN/DER/SPRC

bert Jacqmin

- **International collaboration**
  - CHANDA
    → Proposal for a collaborative work on ^{241}Am and ^{99}Tc capture cross sections
  - INSPIRA: **I**nternational **N**eutron **S**cattering **P**rogramme for **I**mproved Nuclea**R** Dat**A** and **R**eactor **A**ssessment
    → Elastic / Inelastic scattering on key materials (^{238}U, ^{23}Na, ^{1}H) for GEN-III and GEN-IV
  - Other initiatives

Step up in quality of experiments by improved characterisation and modeling: Example MAESTRO project

n_TOF



F. Gunsing et al.
Two measurement campaigns
2002-2004
2009-2012
Many recent publications and ongoing measurement and analysis campaigns

EXFOR compilation ongoing

Phase 2:
235U(n,g)+(n,f) simult.
87Sr(n,g) spins
63Ni, 197Au, 241Am(n,g)
240,242Pu(n,f)
(n,a)

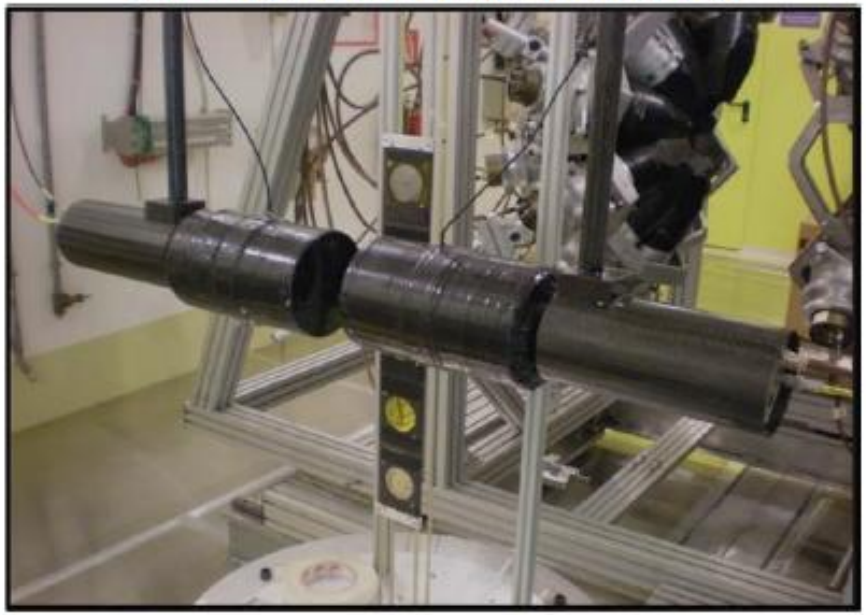
capture C_6D_6	capture BaF_2	fission FIC	fission PPAC
^{24,25,26}Mg	^{197}Au	^{232}Th	^{nat}Pb
^{56}Fe	^{233,234}U	^{237}Np	^{209}Bi
^{90,91,92,93,94,96}Zr	^{237}Np	^{233,234,235,236,238}U	^{232}Th
^{139}La	^{240}Pu	^{241,243}Am	^{237}Np
^{151}Sm	^{243}Am	^{245}Cm	^{233,234,235,238}U
^{186,187,188}Os			
^{197}Au			
$^{204, 206, 207,208}$Pb			
^{209}Bi			
^{232}Th			

n_TOF Phase2 (2009-2012):
Stellar nucleosynthesis cross section measurements

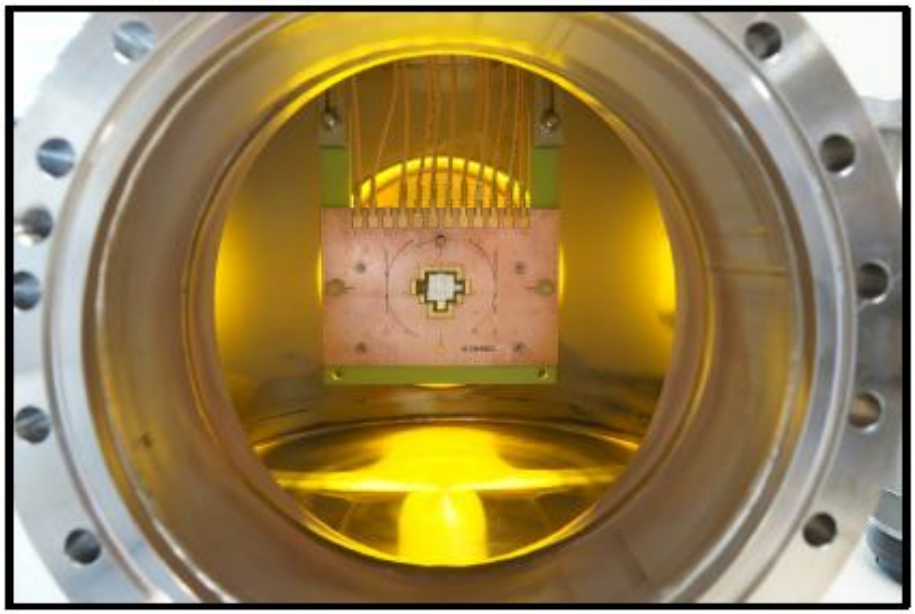
Neutron capture and (n,α) cross sections for the *s*-process:

σ(n,γ): ^{25}Mg, ^{54,56,57}Fe, ^{58,62,63}Ni and ^{93}Zr
σ(n,α): ^{33}S and ^{59}Ni

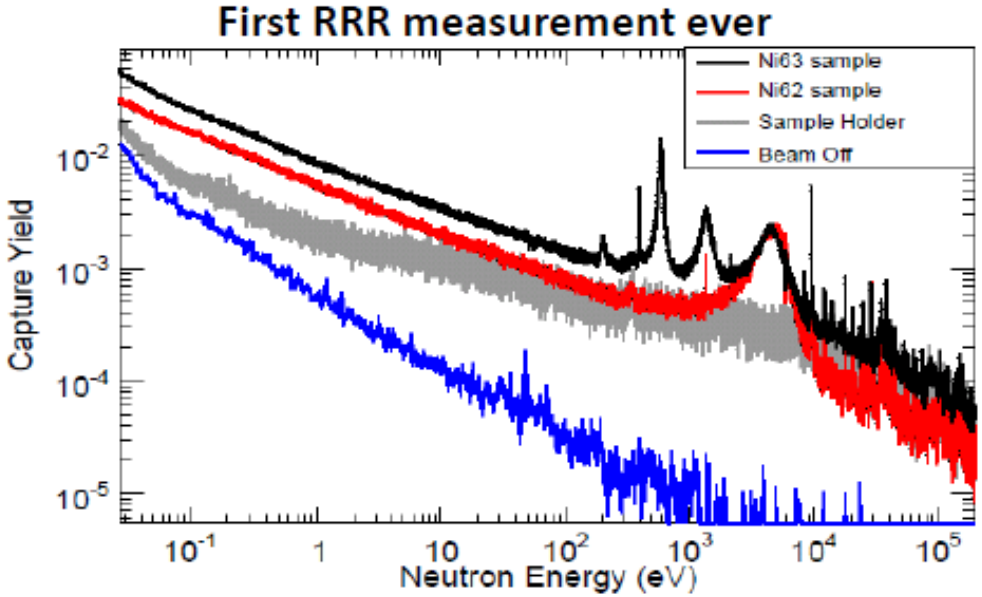
C6D6 (carbon fiber) scintillators

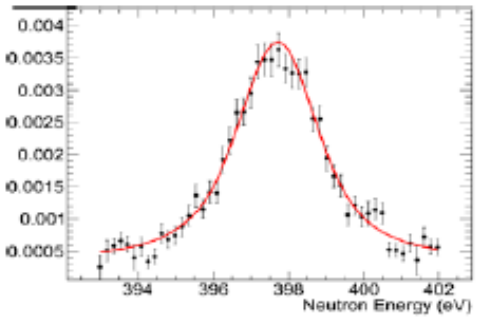


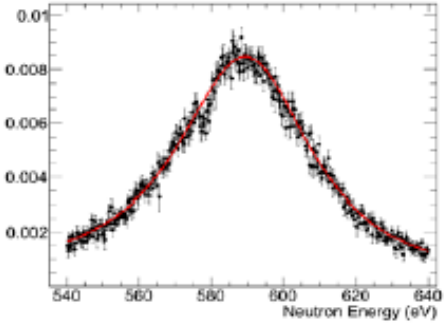
mosaic-sCVD diamond detector



^{63}Ni(n,g) MACS in the keV region



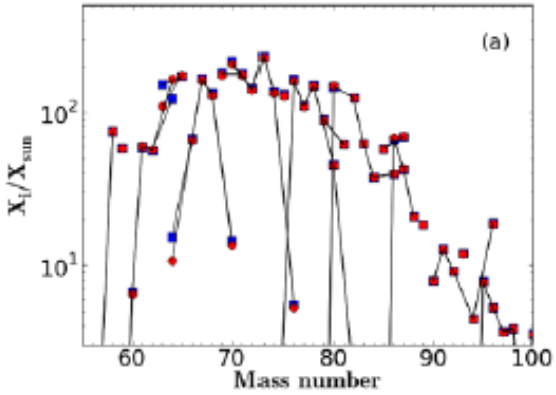


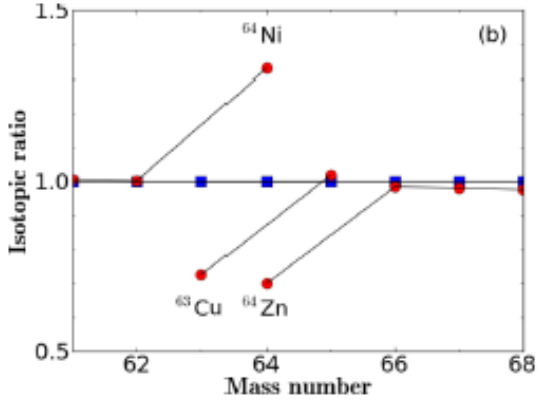


C. Lederer et al., Phys. Rev. Lett. **110** (2013) 022501

Measured MACS 2-2.5 higher than the model calculated values:

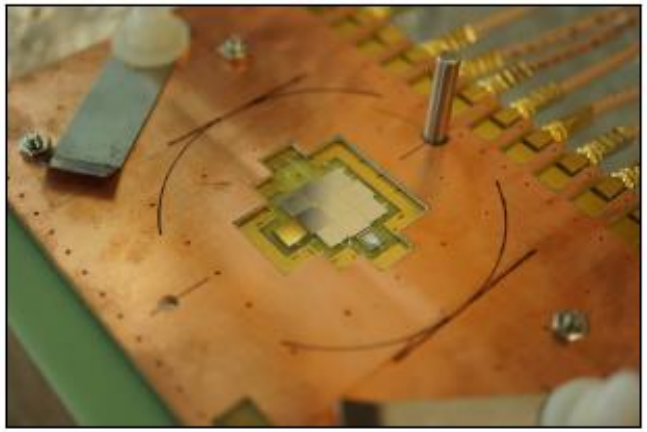
some isotopic stellar abundances (^{64}Ni, ^{63}Cu, ^{64}Zn) change up to ~40%.

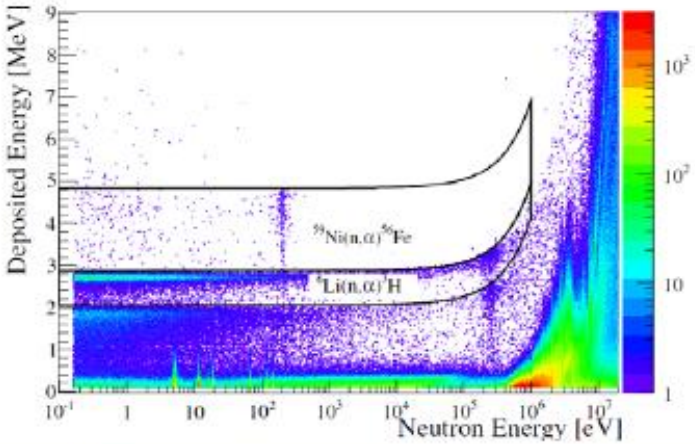




^{59}Ni(n,α) resonance at 200 eV

Development of diamond array for (n,chp) reactions

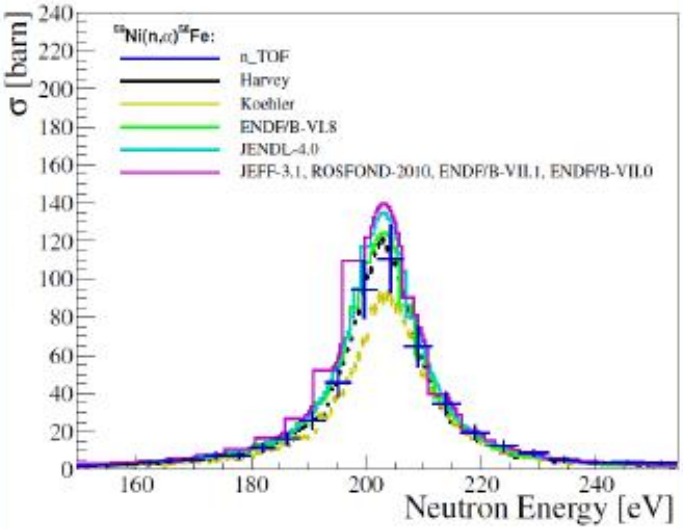




C. Weiss et al., "The (n,α) reaction in the *s*-process branching point ^{59}Ni", Nuclear Data Sheets (2013) (in press)

Solved the 30% discrepancy between the two previous measurement.

New recommendation for evaluated nuclear data files.



Opens the door to a new type of measurements, in particular at the new 20 m beam line n_TOF-EAR2.

Publications n_TOF

C. Lederer, n_TOF, Ni62(n,g) and Ni63(n,g) cross sections measured at the n-TOF facility at CERN, Physical Review C 89, 025810 (2014).

P. Zugec, n_TOF, Experimental neutron capture data of 58Ni from the CERN n-TOF facility Physical Review C 89, 014605 (2014).

G. Tagliente, n_TOF, The 93Zr(n,g) reaction up to 8 keV neutron energy Physical Review C, 87, 014622 (2013).

C. Lederer, n_TOF, Neutron capture cross section of unstable Ni63: Implications for stellar nucleosynthesis, Phys. Rev. Lett., 110 022501 (2013)

K. Fraval et al., n_TOF, Measurement and analysis of the Am241(n,g) cross section with liquid scintillator detectors using time-of-flight spectroscopy at the n_TOF facility at CERN, Phys. Rev. C 89, 044609 (2014)

Cross section of neutron induced reactions on ^{197}Au (Becker, NEMEA-7)

Standard cross section ^{197}Au(n,γ)
- Thermal (0.0253 eV)
- 200 keV and 2.5 MeV

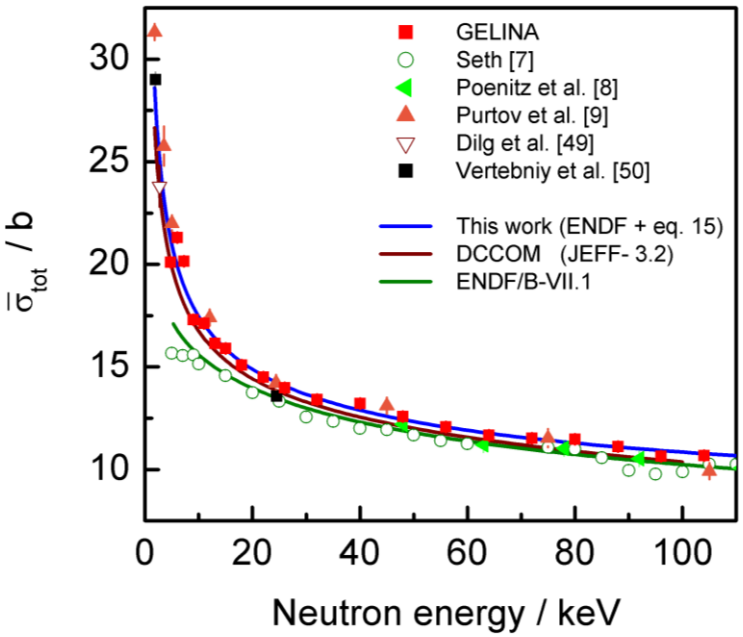
HPRL: ^{197}Au for neutron induced reactions between 4 keV and 200 keV

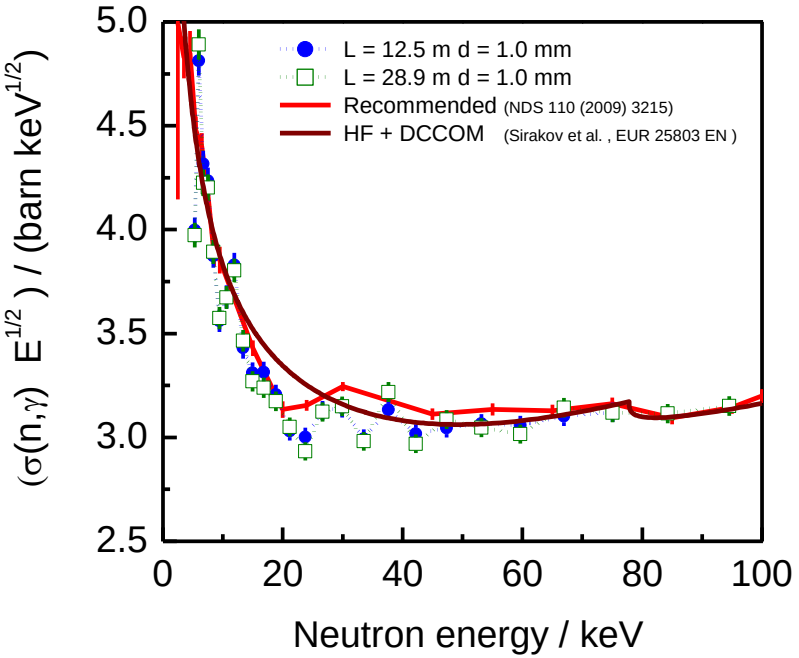
Reference cross section for astrophysical calculations

Test-case for many nuclear reaction model codes

- I. Sirakov et al., "Results of total cross section measurements for ^{197}Au in the neutron energy region from 4 to 108 keV at GELINA", ***Eur. Phys. J. A 49 (2013) 144***
- C. Massimi et al., "Neutron capture cross section measurements for ^{197}Au from 4 to 80 keV at GELINA", in preparation

^{197}Au(n,tot) & ^{197}Au(n,γ) cross section





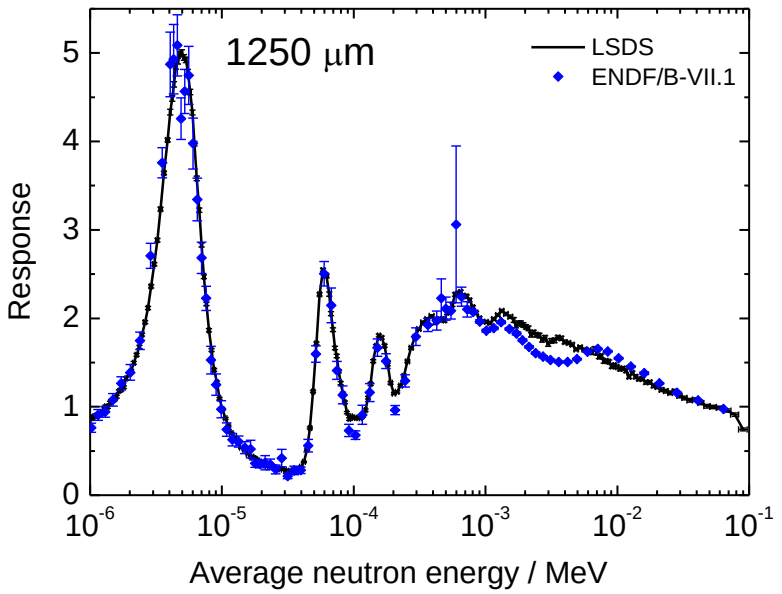
LSDS measurements

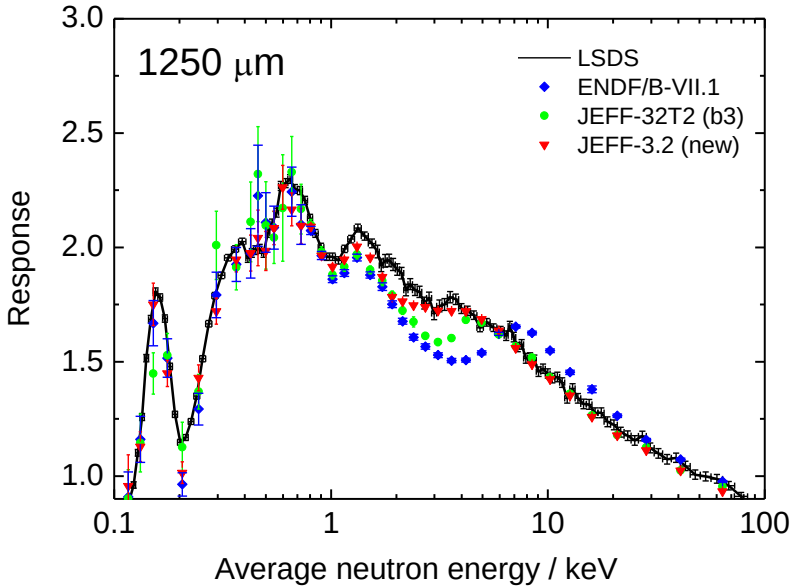
Simulation of a LSDS measurement from LPSC IN2P3:

- MCNP simulation
- Cross section data preparation with NJOY
- Simulation includes resolution of the spectrometer

Independent of the measurements to deduce the cross section.

Challenging method for capture.





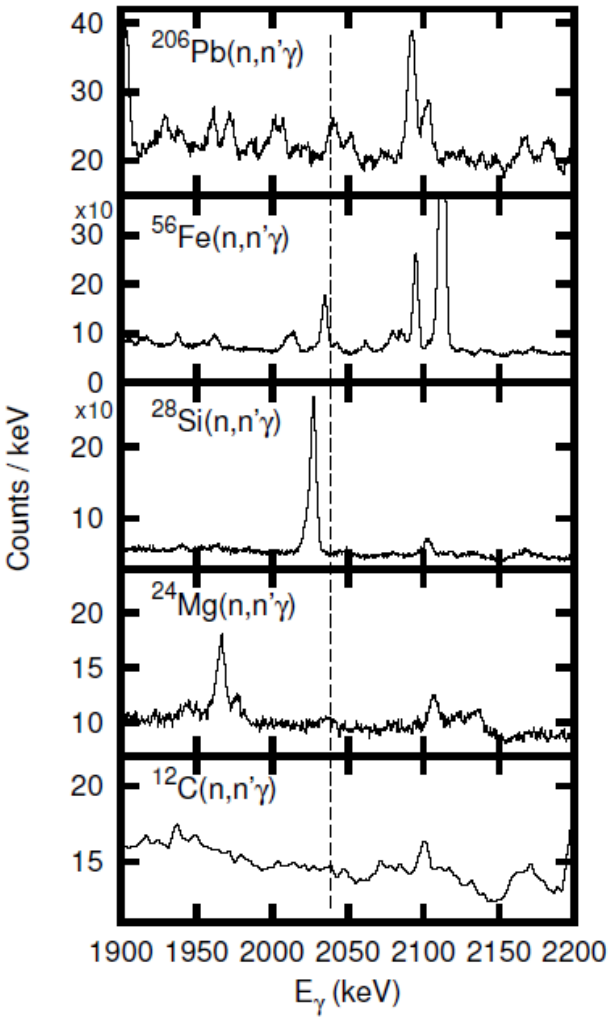
Background 0ν2β experiments

European Commission

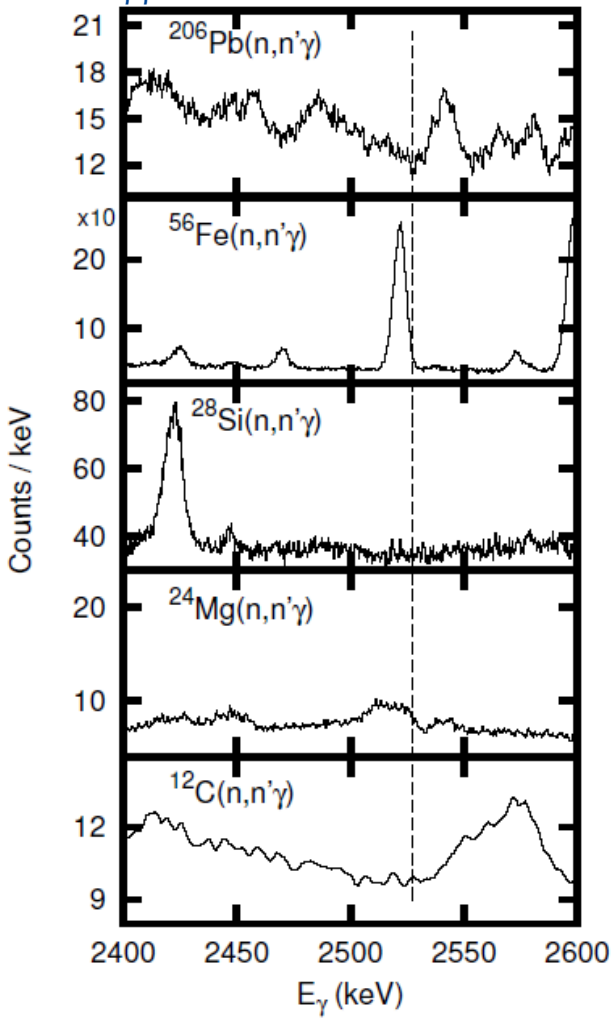
^{206}Pb, ^{56}Fe, ^{28}Si, ^{24}Mg, ^{12}C Shielding or construction materials

A. Negret, C. Borcea, and A. J. M. Plompen, Phys. Rev. C 88 (2013) 027601

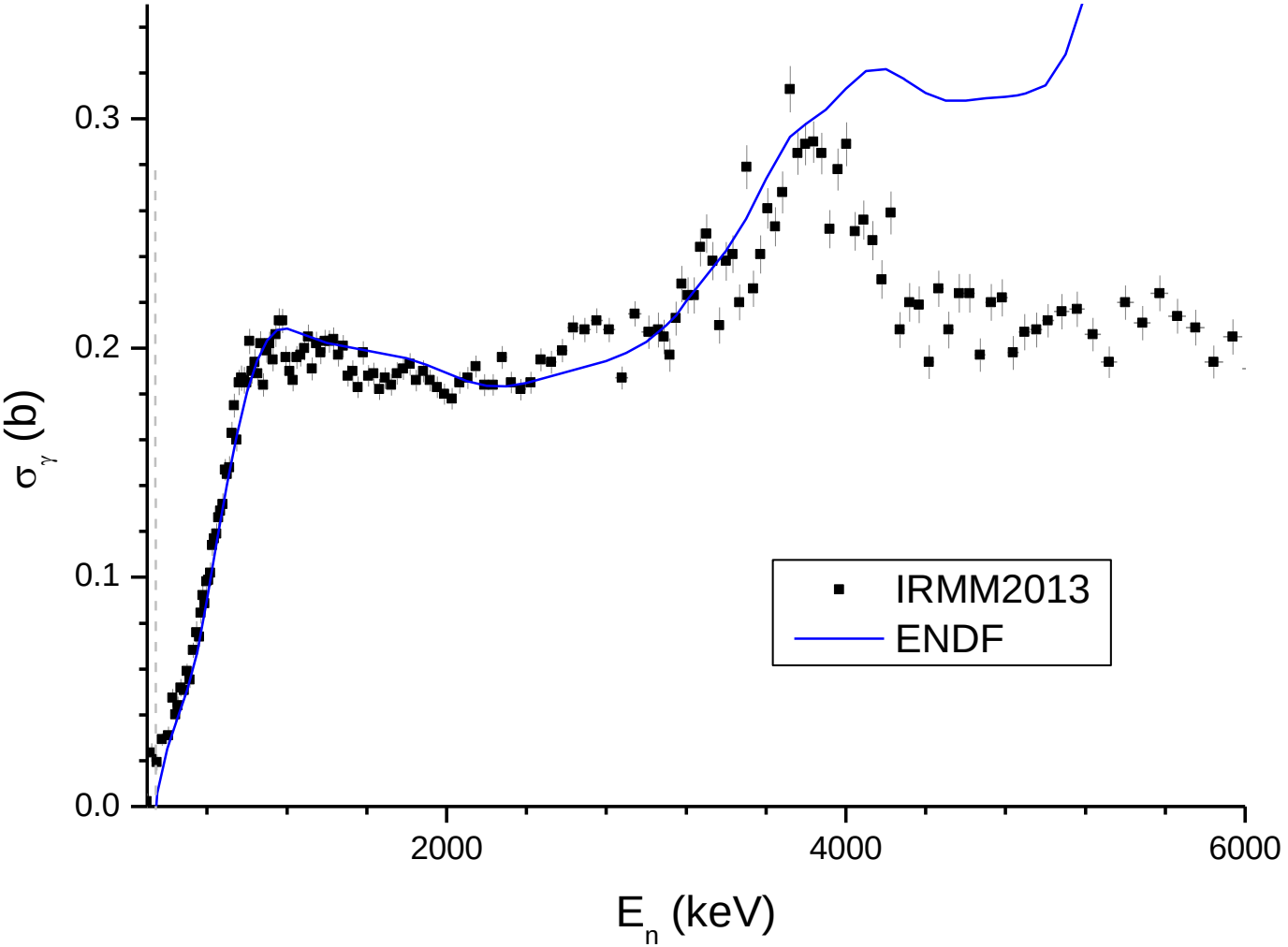
$Q_{\beta\beta}$(76Ge) 2039 keV



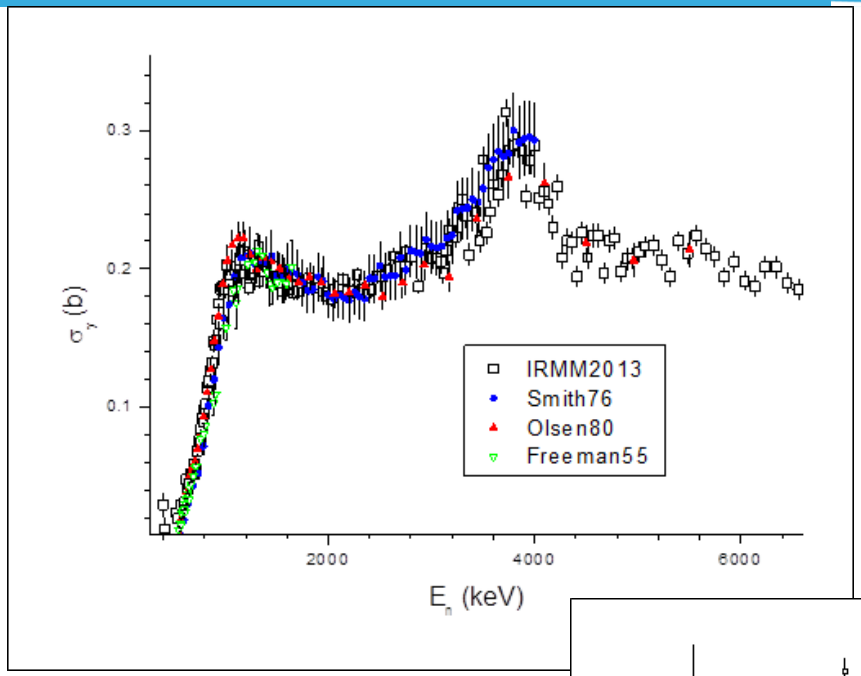
$Q_{\beta\beta}$(130Te) 2528 keV

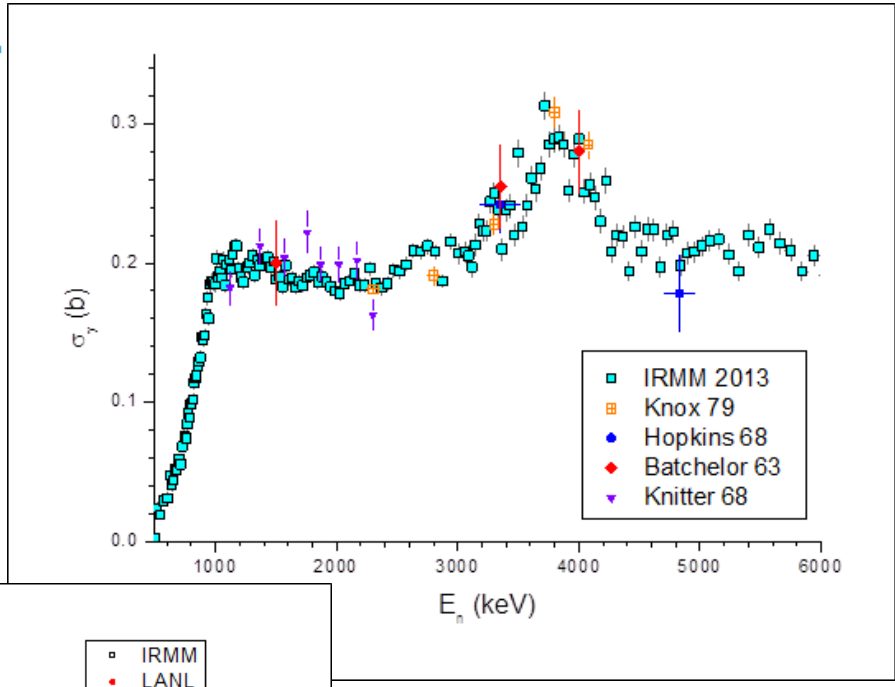


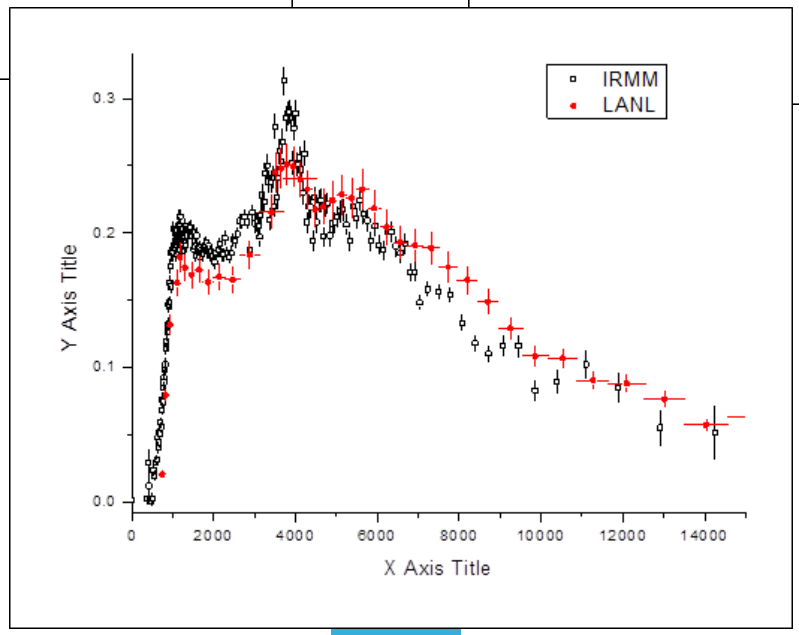
^{7}Li(n,n'g)
A possible γ-standard?



^{7}Li(n,n'g)
A possible γ-standard?







HZDR

NPA paper Beyer et al. 56Fe(n,n'g) appeared 2014.
Of interest to CIELO.
Contact A. Junghans or R. Schwengner of HZDR.
Data appear to be in good agreement with IRMM data.

Summary

- Broad range of experimental activities in EU
- National programs (main source of funding)
- European coordination (ANDES, ERINDA, EUFRAT all ended)
- CHANDA aims at new capabilities: method development, new facilities
- Nuclear Data Weeks at OECD-NEA connect JEFF evaluation work and experimental efforts aimed at application (role EWG)