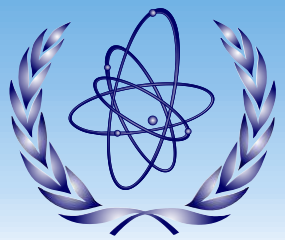


International Atomic Energy Agency

IAEA's Nuclear Data Program

D. Abriola

Nuclear Data Section
Department of Nuclear Sciences and Applications

USNDP Meeting, BNL, Nov. 2012

IAEA Nuclear Data Section

Nuclear Data Section

Organization Chart
(June 2012)

Section Office (and INDC Secretariat)

Section Head: **R.A. Forrest**
Nuclear Data Physicist
(21709/21710)

Deputy Section Head: **D. Abriola**
Nuclear Data Physicist
(21712/21711)

Section Secretary: **L. Vrapcenjak**
(21710)

Nuclear Data Services Unit	Nuclear Data Development Unit	Atomic & Molecular Data Unit
S. Simakov Unit Head (21717)	**D.H. Abriola** Unit Head (21712)	**B.J. Braams** Unit Head (21731)
V. Zerkin Software Engineer (21714)	**R. Capote Noy** Nuclear Physicist (21713)	**W.M. Costello** (IT Systems Analyst) (21724)
V. Semkova Nuclear Physicist (21727)	**P. Demetriou** Nuclear Physicist (21708)	**H.-K. Chung** Atomic Physicist (21729)
N. Otsuka Nuclear Data Physicist (21715)	**K. Nathani** Clerk (21711)	**Marco Verpelli** Systems Analyst/Programmer (21722)
J. Roberts Nuclear Data Services Assistant (21725)		**K. Sheikh** Database Assistant (21730)
A. Oechs Clerk (21716)		**A. Vasaros** IT Systems Engineer (temp.) (21724)
		M. O'Connell (25%) **Applications Programmer** **(21722)**

Three Units

17 staff

IAEA Activities Relating to NSDD

- Coordinated Research Projects (CRPs)
- ENSDF evaluations
- Financial support for ENSDF evaluators and horizontal evaluation/compilation activities
- Coordination of the NSDD network
- Workshops
- Dissemination

Nuclear Data Projects – Status, Nov 2012

Coordinated Research Projects

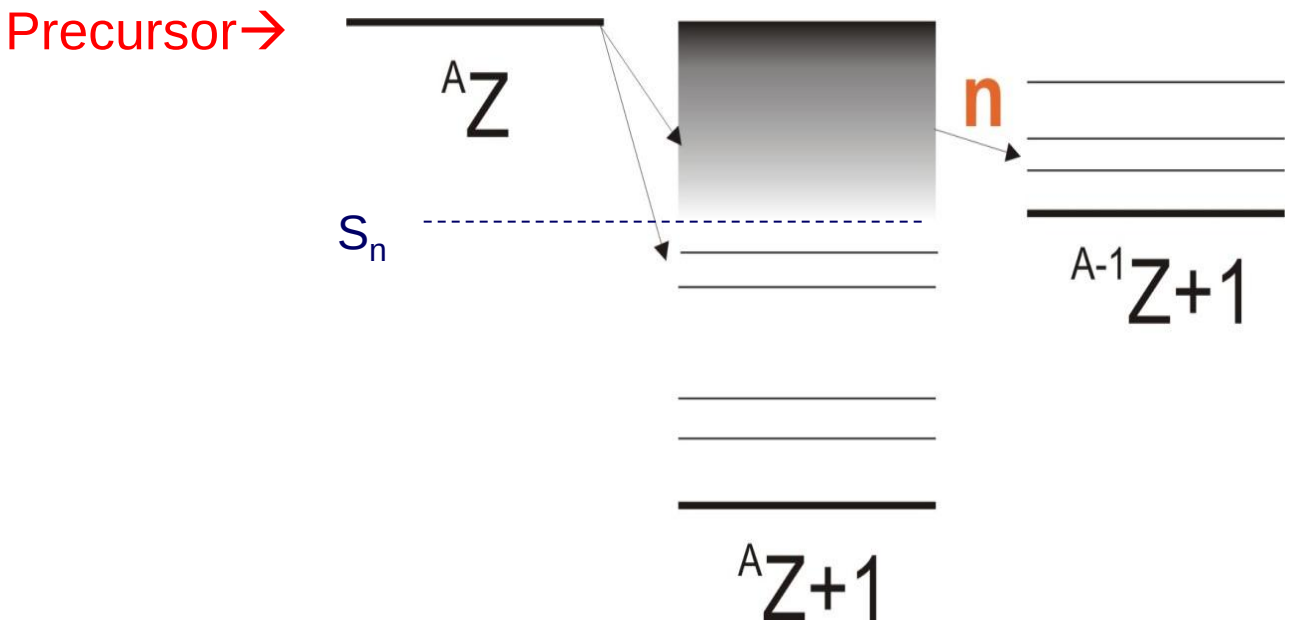
- 4 completed
- 6 active

Data Development Projects + additional tasks

- 11 active

Beta-delayed neutron emission evaluation

$S_n < Q_\beta$



Important nuclear structure information
P_n : β-strength above S_n
$t_{1/2}(^AZ+1)$: sensitive to low-lying β-strength

Beta-delayed neutron emission evaluation (2013-2017) D. Abriola

Motivation:

- Beta-delayed neutrons are important for energy production, astrophysics and nuclear theory
- Most of the data available are from precursors coming from fission fragments
- New experimental facilities are available which will be able to produce new precursors in the neutron-rich region
- Last evaluation with theoretical comparisons is from 2002
- There is no database that compiles all relevant data

Beta-delayed neutron emission evaluation

Possible participants in a CRP

USA	– BNL, LANL, MSU/NSCL, ORNL
CANADA	– McMaster U., Triumf, Univ. Guelph
GERMANY	– GSI Darmstadt/ Univ. Giessen
SPAIN	– IFIC Valencia, CIEMAT Madrid, UPC Barcelona
FRANCE	– Orsay, GANIL, LPC Caen, ILL Grenoble
CHINA	– Chinese Acad of Sci, Lanzhou
FINLAND	– Jyvaskyla (JYFL)
JAPAN	– JAEA, RIKEN
RUSSIA	– JINR Dubna, IPPE Obninsk
SOUTH KOREA	- KAERI
ARGENTINA	– CNEA
BRAZIL	– U. Sao Paulo
INDIA	– VECC, Kolkata

Beta-delayed neutron emission evaluation

Suggested Objectives:

- To create a reference database of evaluated data for beta-delayed neutron emission
- The database should contain evaluated half-lives, emission probabilities and neutron spectra for individual precursors.
- The evaluation methodology should be described
- Agregate quantities like group values should be derived and stored in the database
- The CRP should produce a priority list for evaluations and new experiments and improvements in the theoretical predictions

Beta-delayed neutron emission evaluation

Suggested Outputs:

- **Priority list for measurements**
- **Database of evaluated data (format should be defined)**
- **Old and New measurements compiled into database**
- **Agregate quantities like group values stored in the database**
- **Technical report**

ENSDF evaluations (D. Abriola)

- Collaboration with A. Sonzogni,
  A=72 NDS 111 (2010) 1-140
- ICTP exercise M=211 (see B. Singh)
- New Mass chain A=144 to be submitted in collaboration with A. Sonzogni
  (17 nuclei, 93 new experimental references,
  21 XUNDL-files)

6+2+2 Contracts – 2010…2012

1. Joshi and Jain (India)
2. Wang and Audi (China) Atomic Mass Evaluation (Horizontal)
3. Zuber (Poland)
4. A. Negret (Romania)

5. J. Timar – Z. Elekes (Hungary)

6. N. Stone (USA)
   Nuclear Moments (Horizontal):
   Compilation and evaluation

7. Lalkovski (Bulgaria)

8. Abusaleem Kalifeh (Jordan)

9. S. Erturk (Turkey 2012)

10. Sukhjeet Singh DHINDSA (India 2012)

International Network of NSDD evaluators

Biennial meetings of the International Network of Nuclear Structure and Decay Data Evaluators (NSDD) are funded and organized under the auspices of NDS

The 19th meeting of NSDD network was held at the IAEA Vienna, Austria, 4–8 April 2011 (INDC(NDS)-0595). This meeting was attended by 35 scientists from 20 Member States

International Network of NSDD evaluators

International Network of NSDD evaluators

14 Centres

A-Chain Evaluation Responsibility

Center	Mass Chains	Center	Mass Chains
a. US/NNDC	45-50,57,58,60-73(ex 62-64),82-88 (ex83), 94-97,99,118,119,136-148,150, 152-165 (ex 164), 180-183, 185, 189, 230-240,>249	g. Russia/StP	130-135,146
		h. PRC	51-56,62,63,195-198
		i. France	113-117
		j. Japan	120-129
b. US/NDP	241-249	k. Kuwait	74-80
c. US/LBNL	21-30,59,81,83,90-93,166-171,184,186,187, 191-193,210-217	l. Canada	1,31-44,64,89,98,100,149, 151,164,188,190,194
d. US/TUNL	2-20	m. Australia	172-175
e. US/ANL	106-112,176-179,199-209	n. Hungary	101-105
f. India	218-229		

International Network of NSDD evaluators

Specific mass chain activities, horizontal evaluations and technical issues

Problems are still being experienced in maintaining suitable numbers of mass chain evaluators (expressed as FTE – Full Time Effort)

Thanks to IAEA efforts, evaluators are being supported and are actively performing evaluations

NDS staff will continue to support new evaluators and collaborate in mass chain evaluations

International Network of NSDD evaluators

List of 51 actions

			references that prove hard to acquire.
27	NNDC	XUNDL compilation date	Expand XUNDL index to show compilation date by nuclide.
28	Firestone	ENSDF into XML	Look into possibilities working with LLNL.
29	Kibedi	Calculate conversion coefficients. *Recommendation*	Mixing ratio default to be determined statistically or by evaluator, in either case comments should appear.
30	Kibedi	Mixing ratio for E0, E2, M1.	Suggest changes to format in order to define mixing ratios.
31	Sonzogni, Kibedi	Improve data that quantify Auger electron and continuum beta spectra.	Develop and recommend analysis codes to provide more detailed presentations of Auger electrons and continuum beta spectra.
32	Network	New production code for Nuclear Data Sheets.	Provide comments to B. Singh based on two mass chains (A=40, A=182) placed on the web site.
33	NNDC	Checking code *Recommendation*	Download Mitropolski code and incorporate into FMTCHK.
34	All evaluators	Atomic masses *Recommendation*	Use 2011AuZZ masses and quote 2003Au03 in a comment.
35	Audi	Atomic masses	Provide 2011 evaluation to NNDC by end of April 2011 (2011AuZZ).
36	Evaluators	BE2 compilation	Comments and feedback on the presentation and the paper attached to B. Prytichenko and B.Singh.
37	All	Masses *Recommendation*	To obtain masses for new nuclides, communicate directly with AMDC

International Network of NSDD evaluators

Bilateral visits:

- **M.A. Kellett (IAEA-NDS) to CIEMAT. Attendance at the 3rd Workshop of Radioactive Decay Data Evaluators. 9–11 June 2010**
- **D.H. Abriola (IAEA-NDS) to NNDC. Attendance at USNDP meeting and carry out ENSDF evaluation work. 20 Oct–3 Nov 2010**
- **B. Pritychenko, NNDC to NDS. Install and load NSR database on NDS MySQL database server, discuss NSR compilations and revise technical procedures. 19–26 November 2010**

International Network of NSDD evaluators

- ***Bilateral visits (cont.):***

- **B. Singh, McMaster University to NDS. Collaborate on the update of the most neutron deficient nuclides of A=148: 148Tm, 148Er and 148Ho for ENSDF database. 14–16 June 2011**

- **D.H. Abriola (IAEA-NDS) to McMaster University. Collaborative work with B. Singh on beta-delayed neutron emission evaluation. 7–11 November 2011**

- **D.H. Abriola (IAEA-NDS) to NNDC. Attendance at USNDP meeting, and carry out ENSDF work. 13–23 November 2011**

- **B. Pritychenko, NNDC to NDS. Install and load NSR database on NDS MySQL database server and revise technical procedures. 21–25 November 2011**

International Network of NSDD evaluators

Next meeting in Kuwait, January 2013

http://www-nds.iaea.org/nsdd/#int

KFAS &
Physics Department K.U.

KUWAIT UNIVERSITY

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Miguel Embid
Sefa Erturk
Manssour Fadil
George Fai
Robin A. Forrest
Mohini Gupta
Gulhan Gurdal

INTERNATIONAL NETWORK OF NUCLEAR STRUCTURE AND DECAY DATA EVALUATORS (NSDD)

Scientific Secretary: Daniel Abriola

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Announcements

The 20th IAEA meeting of the NSDD network will be hosted by the Kuwait Foundation for the Advancement of Sciences (KFAS).

The meeting will be held at the premises of KFAS in Kuwait, from 27-31 January 2013.

List of Actions for 20th NSDD network meeting

KFAS has generously offered to contribute towards the expenses of the meeting.

More information will be announced as it becomes available.

Workshops 2010

1. Nuclear Structure and Decay Data: Theory and Evaluation, ICTP, Trieste, 11-15 October 2010 HOSTED

Workshop Directors: J.K. Tuli, D.Abriola

Objective

- To familiarize students with new experimental data that characterize the nucleus
- Modern nuclear models
- Train participants in methodology of NSDD evaluations
- Production of evaluated nuclear structure and decay data (as ENSDF mass-chain evaluations)

Workshops 2012

1. Nuclear Structure and Decay Data: Theory and Evaluation, ICTP, Trieste, August 2012 Joint IAEA-ICTP

Workshop Directors: J.K. Tuli, D.Abriola

Topics

- ENSDF evaluation philosophy and analysis programs
- NSDD network, relevant IAEA activities, access to appropriate web pages and Nuclear Reactions
- Nuclear models
- Radioactive Decays
- Adopted Levels
- Databases and Web resources

Workshops 2012

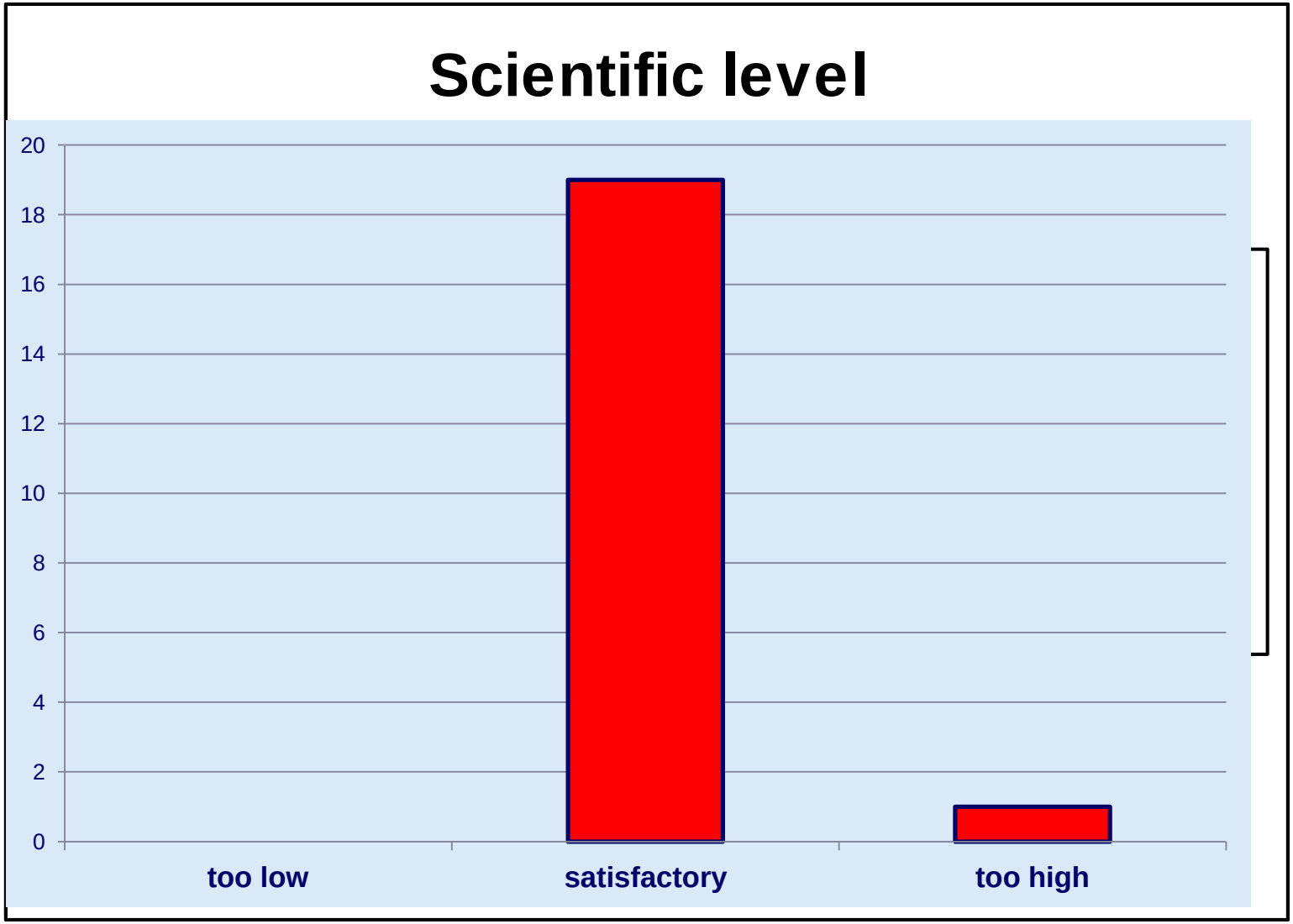
1. Nuclear Structure and Decay Data: Theory and Evaluation, ICTP, Trieste, August 2012 Joint IAEA-ICTP

Topics

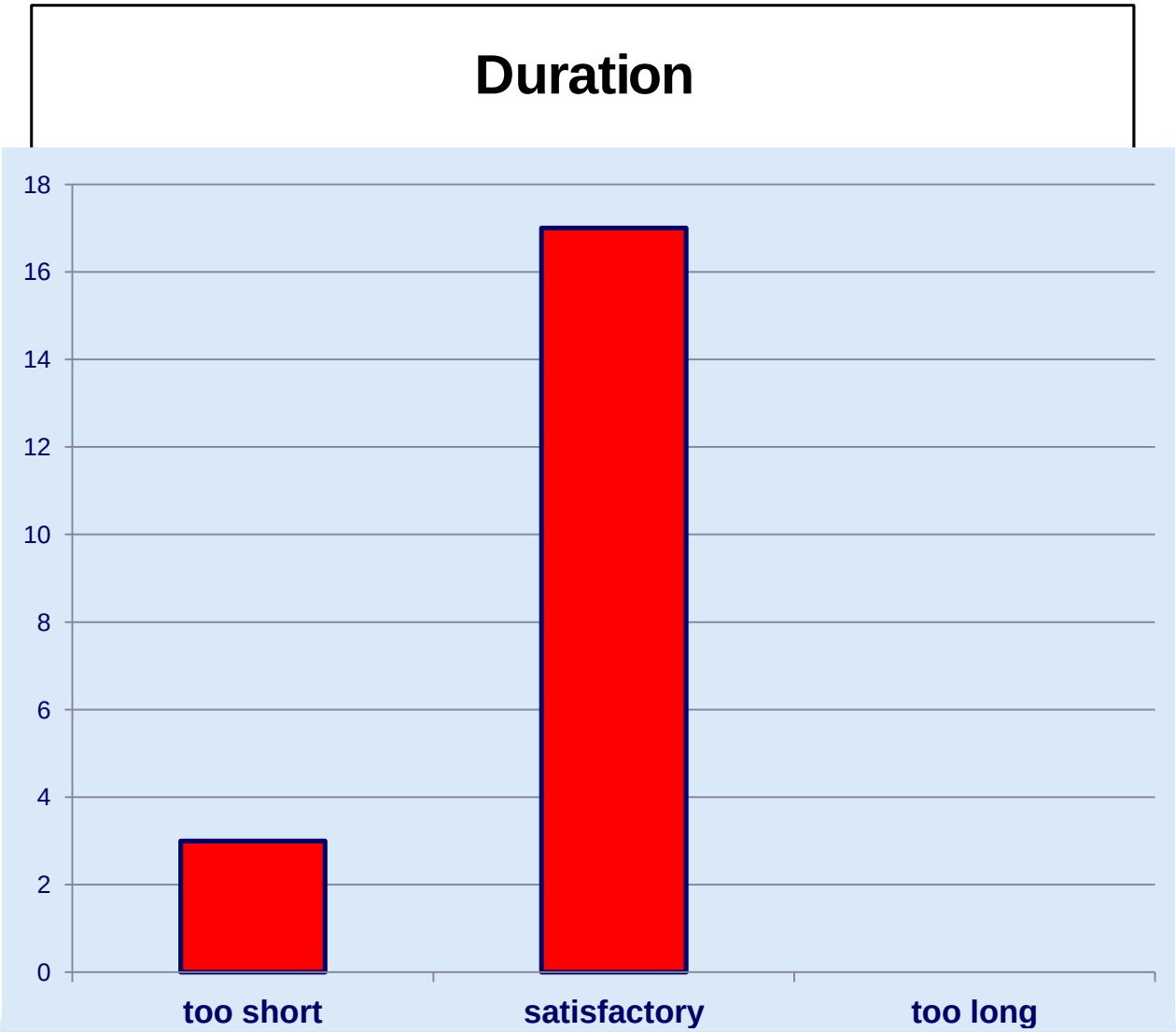
Ten lecturers, delivered a two-week course to
24 participants from
16 countries
Lectures were presented during mornings while afternoons were dedicated to training sessions with practical evaluation activities:

six student groups
B. Singh was the main organizer of the Workshop activities:
Mass A=211 (see B.Singh)

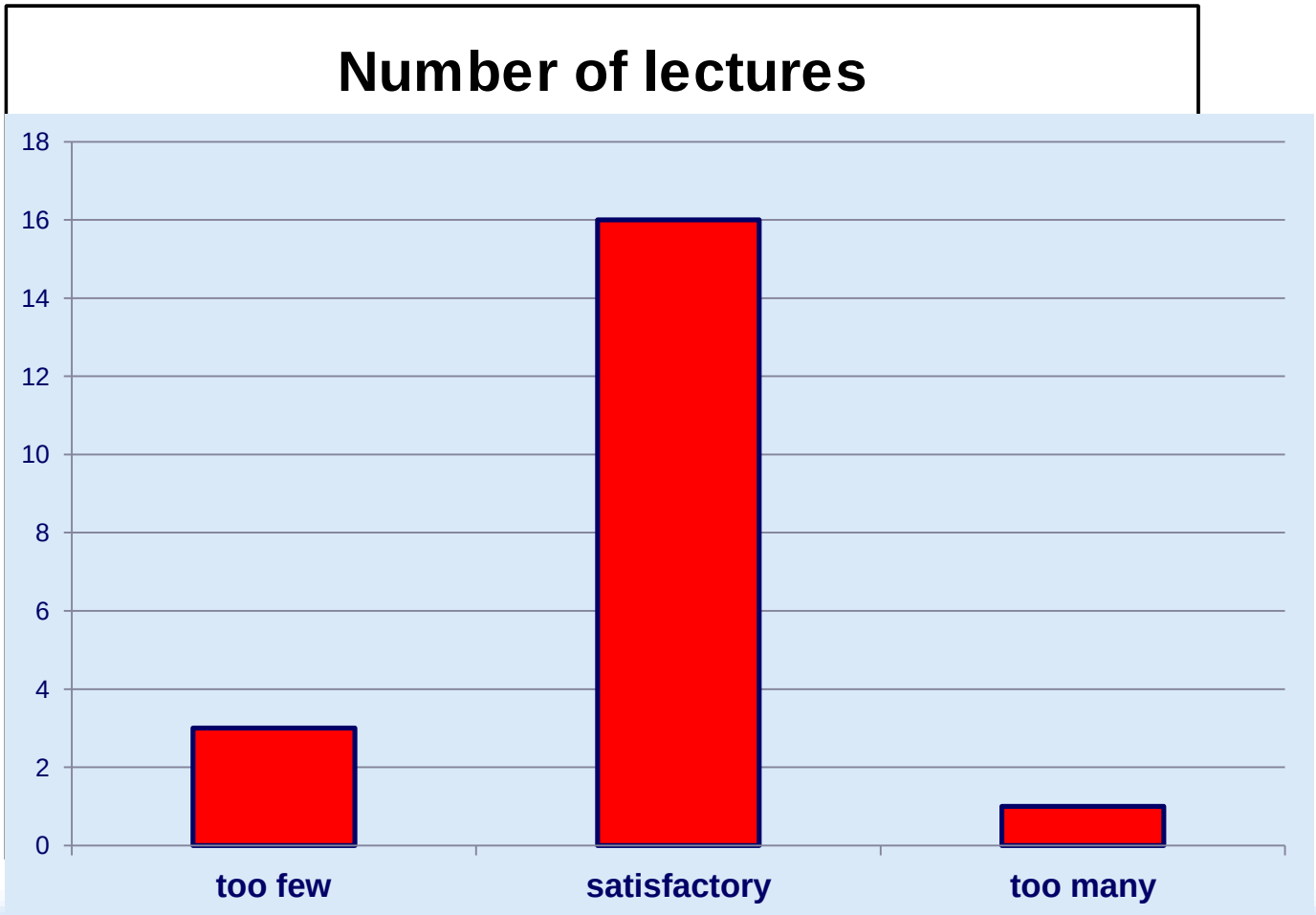
Workshop on NSDD: theory and evaluation



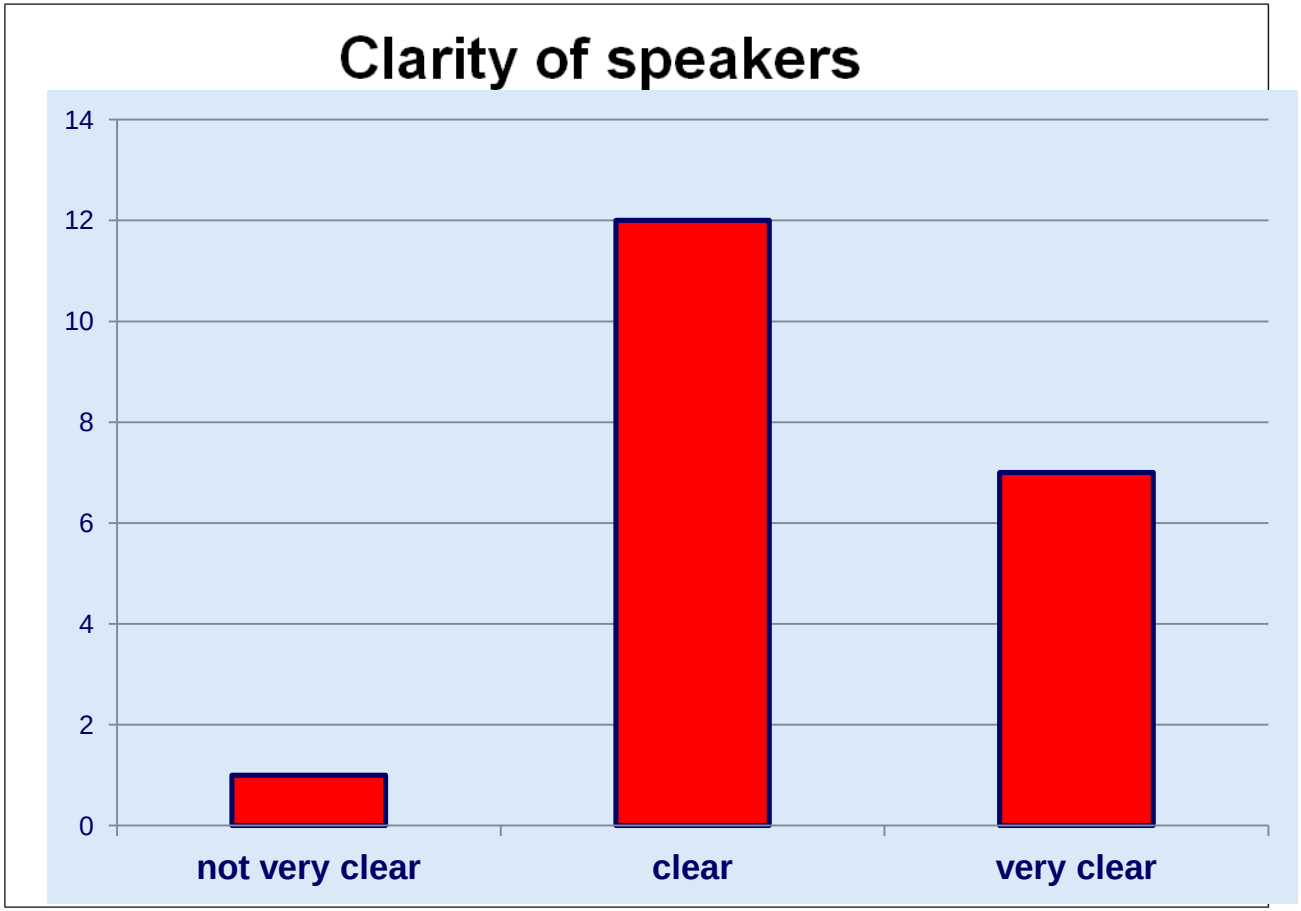
Workshop on NSDD: theory and evaluation



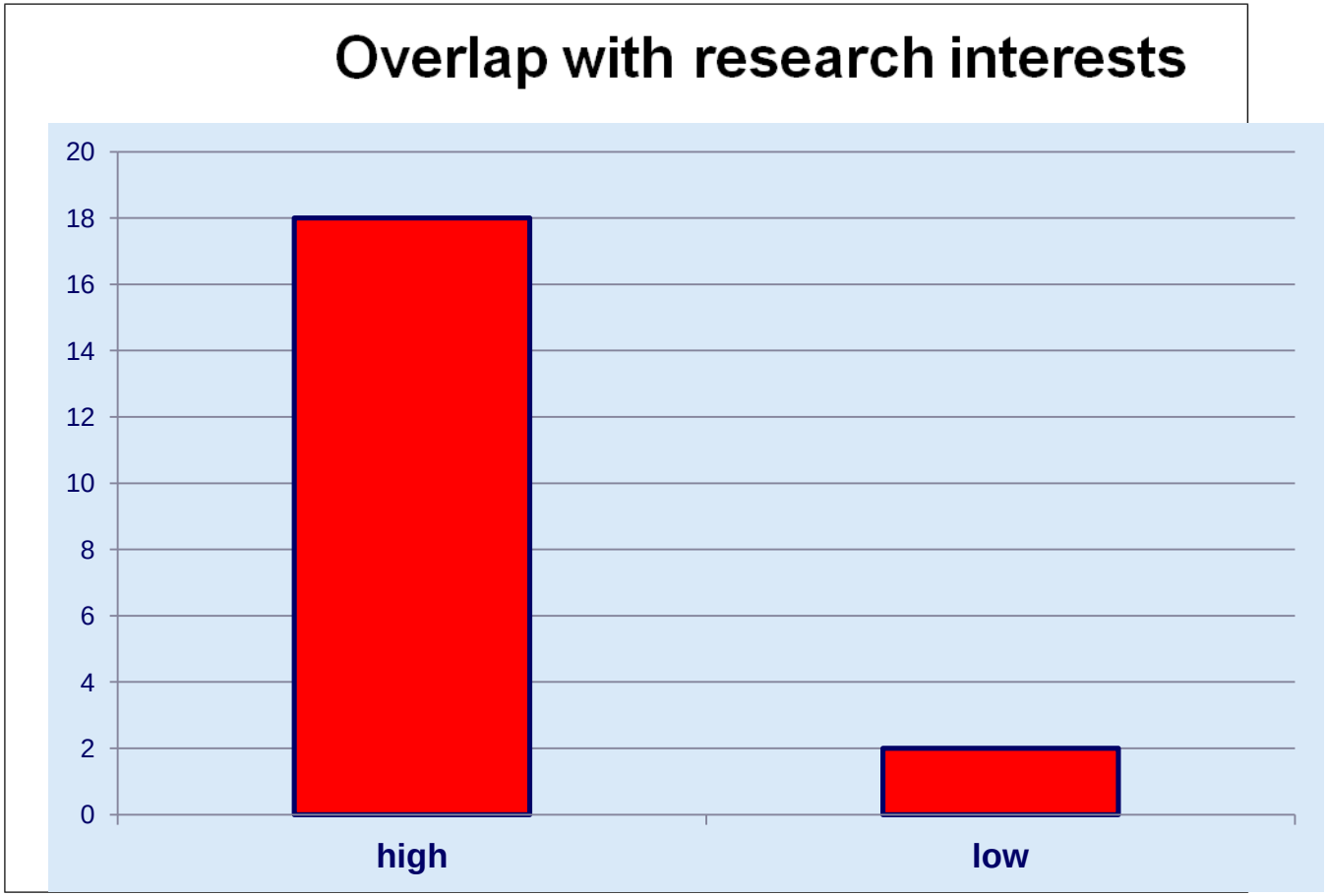
Workshop on NSDD: theory and evaluation



Workshop on NSDD: theory and evaluation



Workshop on NSDD: theory and evaluation



How could lectures be improved

- More interaction
- Program details
- Demonstration in lab
- Less lectures, more exercises
- More lectures on exp. Phys.
- More about ENSDF format & applications
- Prepare summary sheets for practical exercises
- Video recording
- More theory

Suggestions

- Neutron capture
- one workshop per year
- More lectures on use of codes
- Less lectures more exercises
- Student presentations optional
- practical exercises

10. Comments on facilities

- Superb!
- Very good!
- Excellent
- WiFi in rooms need improvement
- Need air-conditioned rooms
- Different food for lunch and dinner!

Workshop on NSDD: theory and evaluation

Workshop on NSDD: theory and evaluation

Workshop on NSDD: theory and evaluation

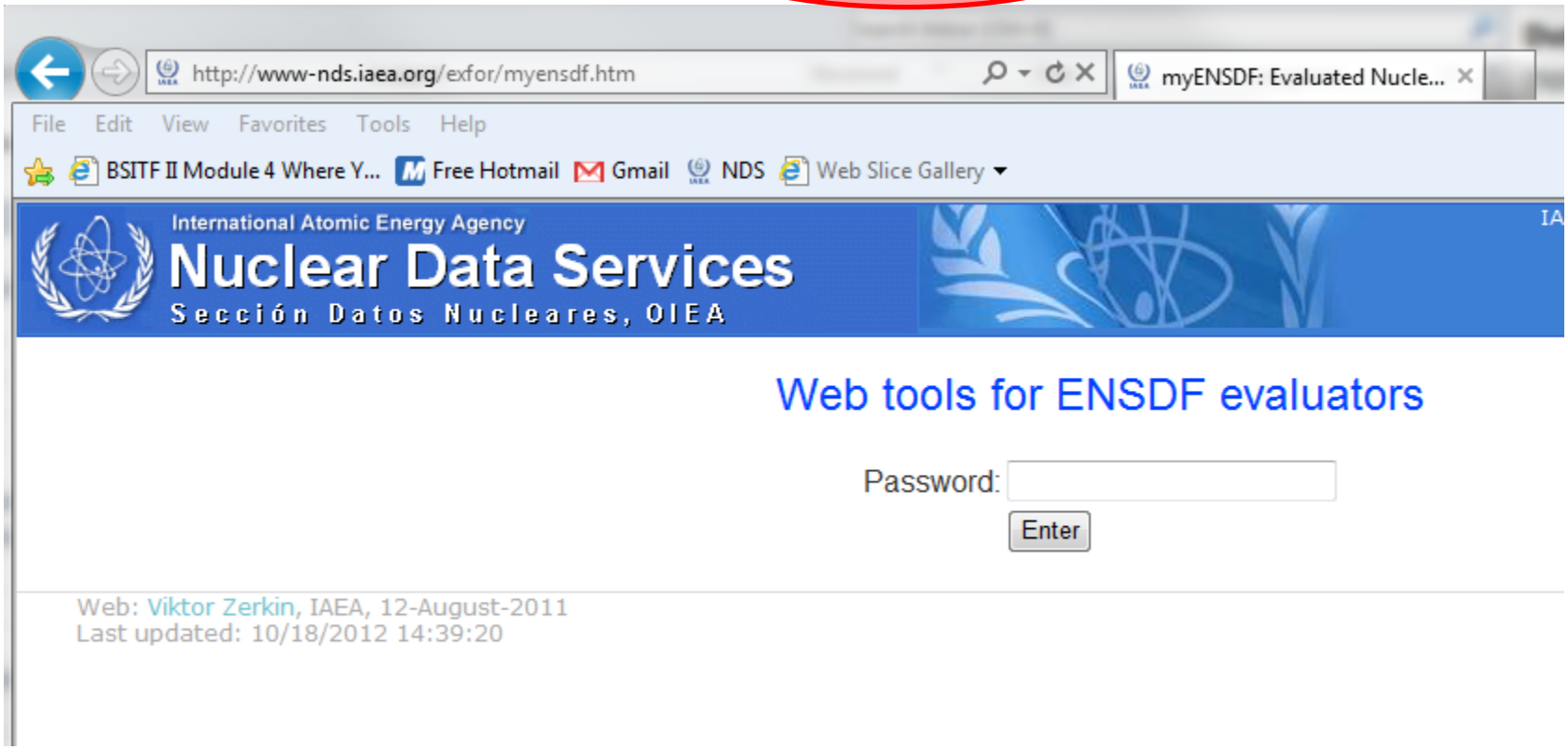
Workshop 2014

x. Nuclear Structure and Decay Data: Theory and Evaluation….

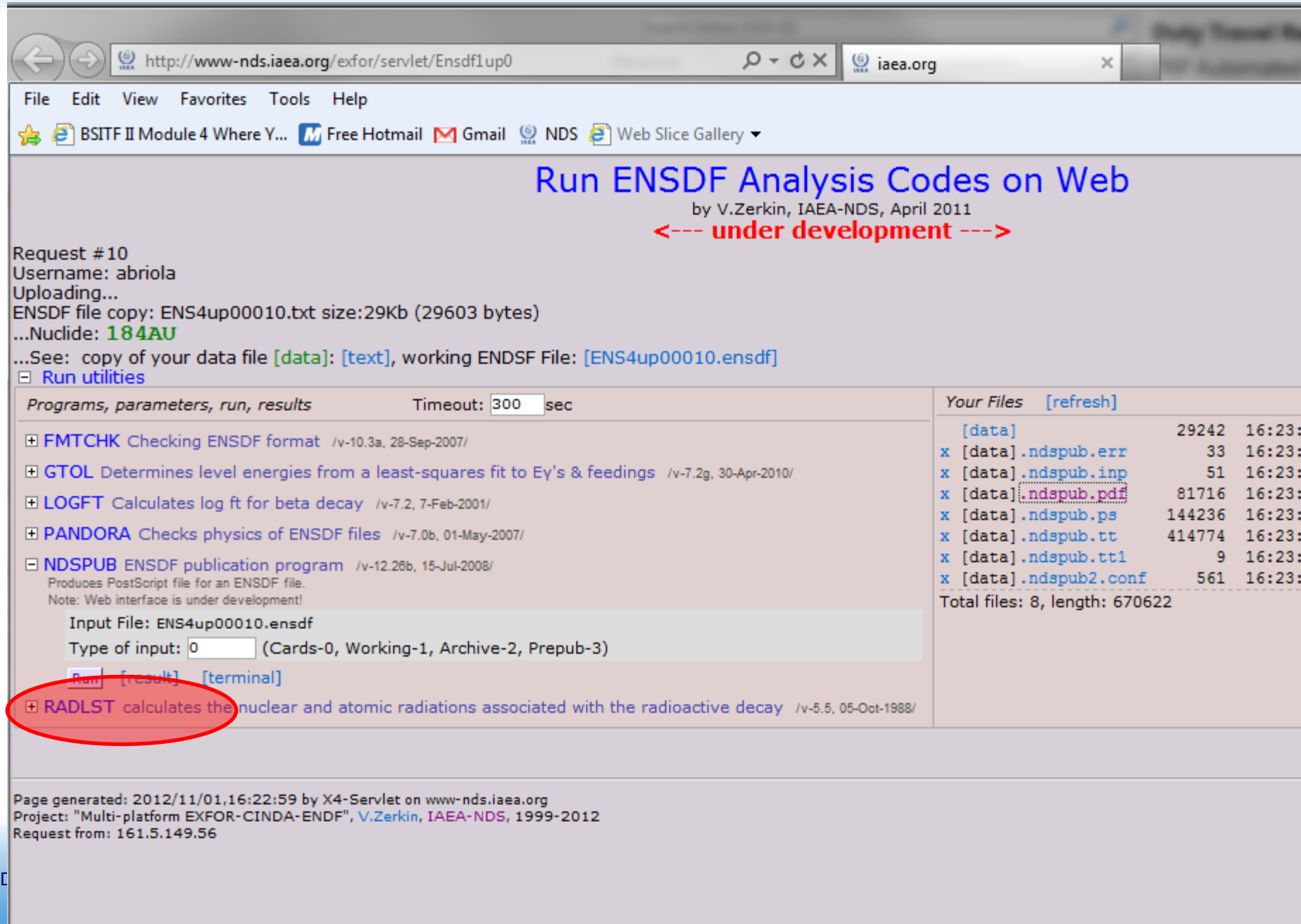
Workshop Directors: ?

Dissemination

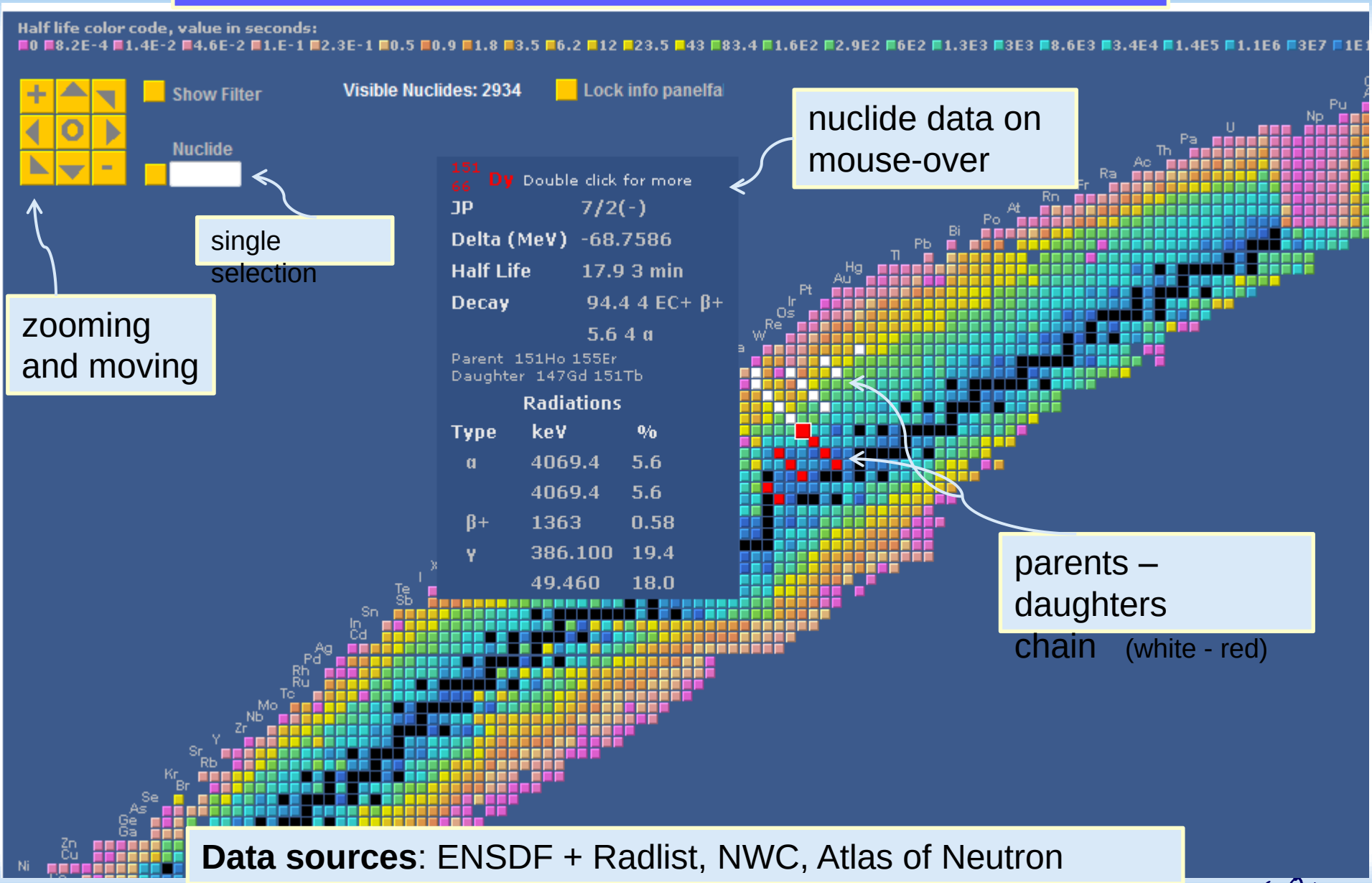
Pass: nsdd123$



Dissemination



Livechart display



Data sources: ENSDF + Radlist, NWC, Atlas of Neutron Resonance

All ENSDF decay datasets parsed in a relational database.

Web-page display overview

Deposited energy, β and Breemstrahlung spectra

Parent	$T_{1/2}$	E [keV]	Jp order	Decay	$Q_{gs \to gs}$	Daughter	Deposited Energy [keV]										
							Alpha	Beta	CE & Auger	γ	Unplaced γ	Recoil	Neutrino	Absorbed	Total	Q * BR	Delta
$^{135}_{54}Xe_{81}$	9.14 h *2*	0.0	3/2+	β- 100 %	1164.218 *4456*	$^{135}_{55}Cs_{80}$	0.000 *0.000*	304.716 *12.505*	14.988 *0.727*	248.490 *7.537*	0.000 *0.000*	0.003 *0.000*	595.922 *24.255*	568.197 *14.619*	1164.119 *28.320*	1164.218	0.099

see the ENSDF source

Beta -

Fed level	Jp	End Point	Avg Energy	Intensity	LogFT	Unforb.
1062.420 *14*		(101.7980) *4*	26.9 *11*	0.123 *6*	5.71 *6*	
981.315 *22*		(182.9030) *45000*	50.0 *12*	0.075 *5*	6.71 *5*	
608.186 *14*	5/2+	(556.032) *4*	173.3 *15*	3.11 *14*	6.67 *3*	
407.989 *13*		(756.229) *4*	248.1 *16*	0.59 *3*	7.86 *3*	
249.793 *12*	5/2+	910 *10*	310.2 *16*	**96** *4*	5.94 *2*	

Gamma

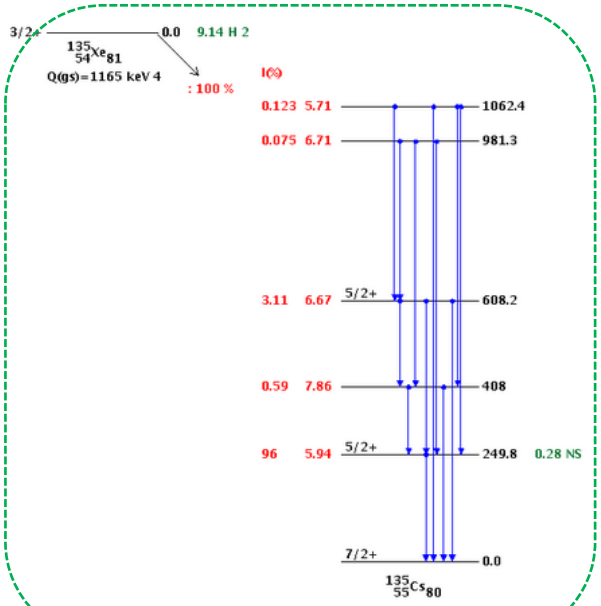
Start level	Jp	Final Level	Jp	Energy	Intensity	Mixing	Multipol.	Tot. Conv. Coeff.
407.989 *13*		249.793	5/2+	158.197 *18*	0.289 *14*			
608.186 *14*	5/2+	407.989		200.19 *10*	0.012 *50*			
249.793 *12*	5/2+	0.0	7/2+	249.794 *15*	**90**	1.0	M1(+E2)	0.0737 *20*
608.186 *14*	5/2+	249.793	5/2+	358.39 *3*	0.221 *11*		M1,E2	0.0265 *17*
981.315 *22*		608.186	5/2+	373.13 *10*	0.015 *30*			
407.989 *13*		0.0	7/2+	407.99 *2*	0.358 *17*			
1062.420 *14*		608.186	5/2+	454.2 *2*	0.0040 *8*			
981.315 *22*		407.989		573.32 *9*	0.0048 *7*			
608.186 *14*	5/2+	0.0	7/2+	608.185 *15*	2.90 *13*	0.5	M1(+E2)	0.0073 *23*
1062.420 *14*		407.989		654.432 *16*	0.05 *0*			
981.315 *22*		249.793	5/2+	731.52 *2*	0.055 *30*			
1062.420 *14*		249.793	5/2+	812.63 *3*	0.070 *30*			
1062.420 *14*		0.0	7/2+	1062.41 *2*	0.0041 *8*			

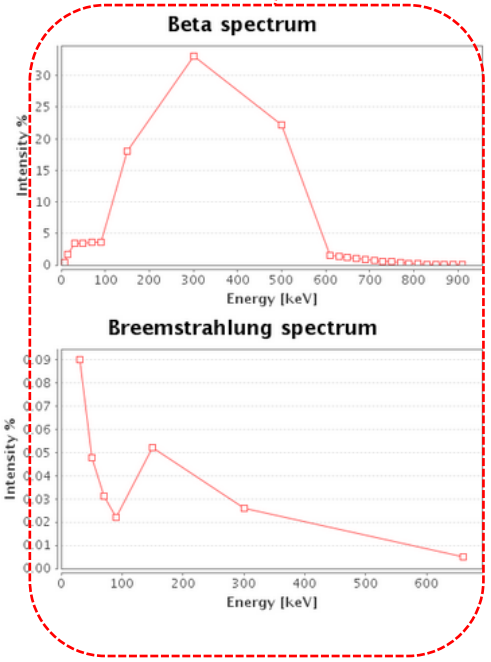
X-rays

Type	Energy	Intensity
X L	4.290	0.61 *3*
X KA2	30.6251 *3*	1.43 *7*
X KA1	30.9728 *3*	2.64 *13*
X KB3	34.92	0.25 *1*

Electrons

Type	Energy	Intensity
AU L	3.550	5.25 *24*
AU K	25.50	0.59 *3*
CE K	213.809 *15*	**5.6** *4*
CE L	244.080 *15*	0.82 *11*





Schema plotting

Details for
β- , β+, EC, α, ϒ, electrons, X-ray

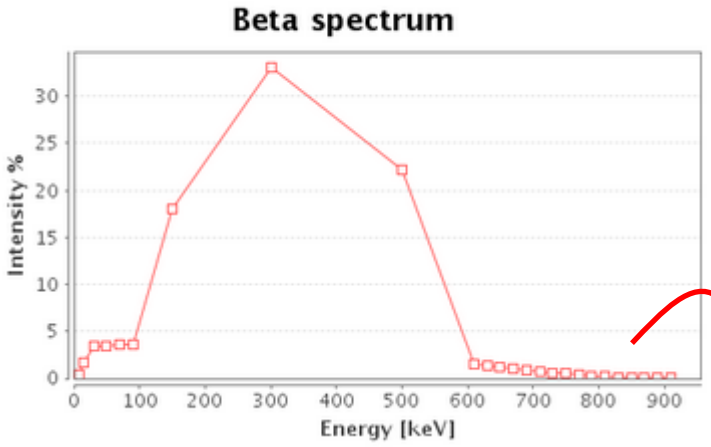
Detail of the web page content

Parent	$T_{1/2}$	E [keV]	Jp order	Decay	$Q_{gs \rightarrow gs}$	Daughter
$^{135}_{54}Xe_{81}$	9.14 h *2*	0.0	3/2+	β- 100 %	1164.218 *4456*	$^{135}_{55}Cs_{80}$

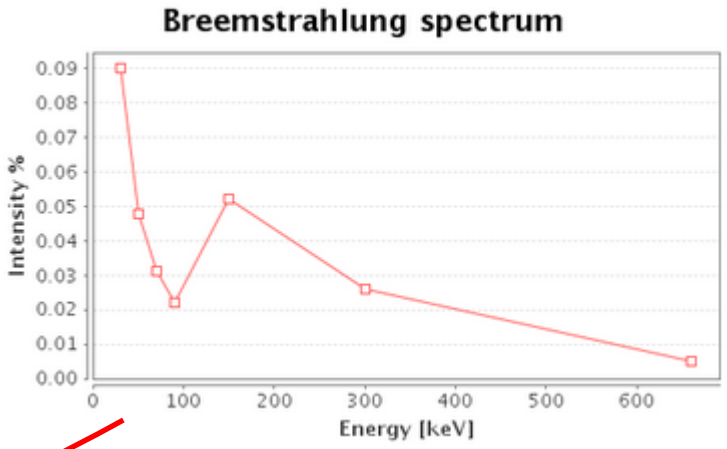
see the ENSDF source

Decay info - Q from AMDC 2011.
Link to the ENSDF source

Deposited Energy [keV]										
Alpha	Beta	CE & Auger	γ	Unplaced γ	Recoil	Neutrino	Absorbed	Total	Q * BR	Delta
0.000 *0.000*	304.716 *12.505*	14.988 *0.727*	248.490 *7.537*	0.000 *0.000*	0.003 *0.000*	595.922 *24.255*	568.197 *14.619*	1164.119 *28.320*	1164.218	0.099



Deposited energy, B, and breemstr. from Radlist



Detail of the web page content

Delayed particles

Fed level	Jp	Particle	Energy	Intensity	Energy interm.	Width	Ang. Trans.
0	3/2+	N	71	2.6 *4*	6515		
0	3/2+	N	71	0.0000014 *2*	6515		
0	3/2+	N	71	0.78 *16*	6515		
0	3/2+	N	115	2.4 *4*	6561		

Beta -

Fed level	Jp	End Point	Avg Energy	Intensity	LogFT	Unforb.
1062.420 *14*		(101.7980) *4*	26.9 *11*	0.123 *6*	5.71 *6*	
981.315 *22*		(182.9030) *45000*	50.0 *12*	0.075 *5*	6.71 *5*	

Full detail for each radiation type.

Circled are the info not available in the previous version

Electron Capture and Beta+

Fed level	Jp	Energy EC	Avg Energy β+	Intensity EC	Intensity β+	LogFT	Unforb.
1925.3 *15*	1+	(1324.955) *13*	112 *23*	0.5	2	1.2	
1602.2 *15*	1+	(1648.055) *13*	253 *22*	0.010	1.0	3.1	

Gamma

Start level	Jp	Final Level	Jp	Energy	Intensity	Mixing	Multipol.	Tot. Conv. Coeff.
407.989 *13*		249.793	5/2+	158.197 *18*	0.289 *14*			
608.186 *14*	5/2+	407.989		200.19 *10*	0.012 *50*			

Alpha

Fed level	Jp	Energy	Intensity	Hindrance
163.0 *1*	4+	4038 *5*	0.078 *12*	40
49.55 *6*	2+	4151 *5*	20.9 *27*	1.4

X-rays

Type	Energy	Intensity
X L	4.290	0.61 *3*
X KA2	30.6251 *3*	1.43 *7*

Electrons

Type	Energy	Intensity
AU L	3.550	5.25 *24*
AU K	25.50	0.59 *3*

Examples of queries

Nuclear medicine: e+ emissions with filter on half-life, energy, and intensity

LEVELS - Bands - Decay Radiations

Energy 0 ≤ keV ≤ 47,300

Decays B.R. ≤ % ≤ Only Ground State and Metastables Isospin

Half Life 1 min ≤ $T_{1/2}$ ≤ 10 min Stable J^{π} weak order π any

Magn. dipole μ -20 ≤ μ_N ≤ 38 Electr. quadrupole Q -219 ≤ barn ≤ 64

Decay radiation Energy 1000 ≤ keV ≤ 2000 key lines 2 Intensity 60 ≤ % ≤ 100 type β+ process - shell -

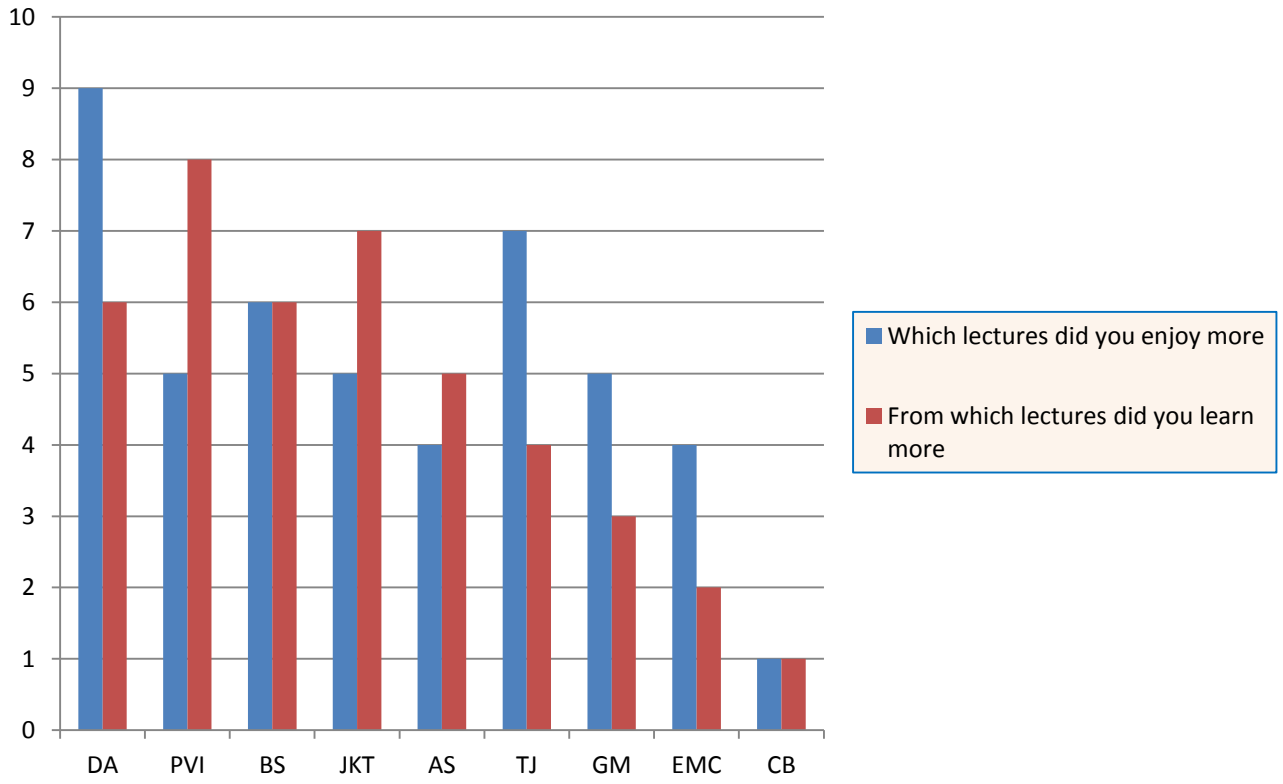
β End point 0 ≤ keV ≤ 8,723 1.2 ≤ log FT ≤ 24.3 α 0.077 ≤ Hindrance ≤ 6,077

Electron Capture and Beta+

Fed level	Jp	Energy EC	Avg Energy β+	Intensity EC	Intensity β+	LogFT	Unforb.	Parent	$T_{1/2}$	E [keV]	Jp order	Decay	$Q_{gs \to gs}$	Daughter
498.01 *5*	3/2+	(3415.285) *17*	1076.7 *79*	26.7 *9*	**60.3 *19***	4.691 *18*		$^{113}_{51}Sb_{62}$	6.67 min *7*	0.0	5/2+	ec β+ 100 %	3913.295 *17402*	$^{113}_{50}Sn_{63}$
670.1 *3*	1+	(3500.721) *2*	1099 *6*	2.80 *24*	**70 *6***	4.4 *1*		$^{60}_{30}Zn_{30}$	2.38 min *5*	0.0	0+	ec β+ 100 %	4170.821 *1769*	$^{60}_{29}Cu_{31}$
0.0	0+	(3573.784) *3585*	1142.7 *19*	5.49 *6*	**80.9 *4***	4.75 *1*		$^{78}_{35}Br_{43}$	6.45 min *4*	0.0	1+	ec β+ ≥ 99.99 %	3573.784 *3585*	$^{78}_{34}Se_{44}$
0.0	0+	(3656.639) *3059*	1188.6 *14*	24.3 *2*	**73.2 *3***	4.525 *13*		$^{118}_{51}Sb_{67}$	3.6 min *1*	0.0	1+	ec β+ 100 %	3656.639 *3059*	$^{118}_{50}Sn_{68}$
2167.5 *3*	2+	(3746.555) *500*	1212.08 *20*	0.516 *5*	**99.333 *13***	4.9746 *11*		$^{38}_{19}K_{19}$	7.636 min *18*	0	3+	ec β+ 100 %	5914.055 *347*	$^{38}_{18}Ar_{20}$
0.0	0+	(3731.489) *19933*	1224.4	32.7 *5*	**62.0 *5***	4.883 *16*		$^{134}_{57}La_{77}$	6.45 min *16*	0.0	1+	ec β+ 100 %	3731.489 *19933*	$^{134}_{56}Ba_{78}$
3189.33 *14*	6+	(3853.051) *300*	1264.00	0.664 *7*	**99.336 *7***	4.163 *10*		$^{42}_{21}Sc_{21}$	61.7 s *4*	616.28 *6* m	(7)+	ec β+ 100 %	6426.101 *225*	$^{42}_{20}Ca_{22}$
0.0	0+	(3958.896) *872*	1316.0 *24*	2.02 *1*	**97.20 *2***	5.2		^{62}Cu	9.673 min *8*	0.0	1+	ec β+ 100 %	3958.896 *872*	^{62}Ni

Thank you

Thank you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