International Atomic Energy Agency

IAEA Nuclear Data Section
Evaluation plans

Paraskevi (Vivian) Dimitriou
Nuclear Data Section,
Division of Physical and Chemical Sciences,
International Atomic Energy Agency,
Vienna, Austria

Evaluation Activities at NDS

- **Most nuclear data evaluation activities covered by:**
  - ✓ CIELO evaluation plans by T. Kawano
  - ✓ PFSN overview by P. Talou
  - ✓ neutron Standards update by A. Carlson
- **In this presentation:**
  - ✓ new CRP on Testing and Validating the IRDFF library
  - ✓ new Data Development Project on evaluation of charged-particle induced reactions

CRP on International Reactor Dosimetry Library for Fission and Fusion (IRDFF) Testing and Validation

PO: S. Simakov, duration: 2013-2017

- **IRDFF 1.0:** extension of IRDF-2002 to cover fission, fusion and accelerator-driven applications

  - 4 new reactions: **^{67}Zn(n,p)^{67}Cu, ^{113}In(n,n')^{113m}In, ^{169}Tm(n,3n)^{167}Tm, ^{209}Bi(n,3n)^{207}Bi**
  - 32 updated evaluations
  - increases the end-point energy of the library from 20 to 60 MeV

- **Main objective:**

  test and validate 74 dosimetric cross sections (and also total and elastic cross sections for evaluation of self-shielding effect using appropriate decay data)

- **Outcome:**

  improved, tested and validated International Reactor Dosimetry and Fusion File (IRDFF) with proper decay data and documentation

  1st RCM Summary Report: INDC(NDS)-0639

  http://www-nds.iaea.org/indc-nds-0639.pdf

Validation plans:

- ✓ Reactor driven and spontaneous or induced fission spectra (thermal, fast)
- ✓ Maxwellian Averaged Cross Sections (5-500 keV)
- ✓ Fusion Energies (14 MeV) (status of D-T spectra and IRDFF)
- ✓ Medium Energies (5 - 50 MeV) (status of d-Be spectra and ^{59}Co(n,x))
- ✓ High Energies (15/20 - 60/200 MeV)

Processing plans: by NJOY-99.396 in ACE format for use with MCNP (LANL+NDS)

Evaluation plans:

- high threshold reactions with cross-section peaks located between 20 and 100 MeV
  i.e. **(n,3-6n) reactions on: ^{197}Au, ^{169}Tm, ^{209}Bi, ^{59}Co, ^{63}Cu, ^{89}Y, ^{93}Nb**

  to begin with:
  evaluation of the **^{197}Au(n,4n), ^{209}Bi(n,2n), ^{209}Bi(n,3n), ^{209}Bi(n,4n), ^{209}Bi(n,5n), ^{209}Bi(n,6n), ^{209}Bi(n,7n)**

- evaluate and add to the library
  - **^{27}Al(n,γ)^{28}Al** - often present in facilities, short-lived (2.24 min)
  - **^{94}Zr(n,γ)^{95}Zr , ^{96}Zr(n,γ)^{97}Zr** - first resonance at high/low (2.3/0.3 keV) energies
  - **^{70}Zn(n,γ)^{71}Zn** - first resonance at energy > 10 keV but low abundance (0.62%)
  - **^{117}Sn(n,n')^{117m}Sn**
  - **^{93}Nb(n,γ)$^{94g+m}$Nb and ^{94}Nb(n,γ)^{94m}Nb** - for burn up calculations
  - **^{113}In(n,γ)^{114m}In**

- **^{28}Si(n,p)^{28}Al** reaction cross section evaluation (and validation)

Participants

A. Arzu
P. Casoli
M. Chadwick
V. Chechev
C. Destouches
C. Konno
L. Greenwood
N. Kornilov
M. Majerle
P. Mastinu
R. Nchodu
A. Plompen
A. Trkov
H. Yashima

M. Angelone
P. Griffin
A. Klix
V. Pronyaev
F. Wissmann
K. Zolotarev

Project Officers
S. Simakov
R. Capote

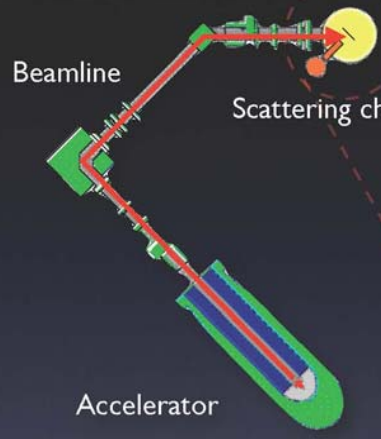
NDS Staff involved
R. Forrest
N. Otsuka
V. Semkova
M. Verpelli
V. Zerkin

Charged-particle induced reactions at low energies

for Ion Beam Analysis applications

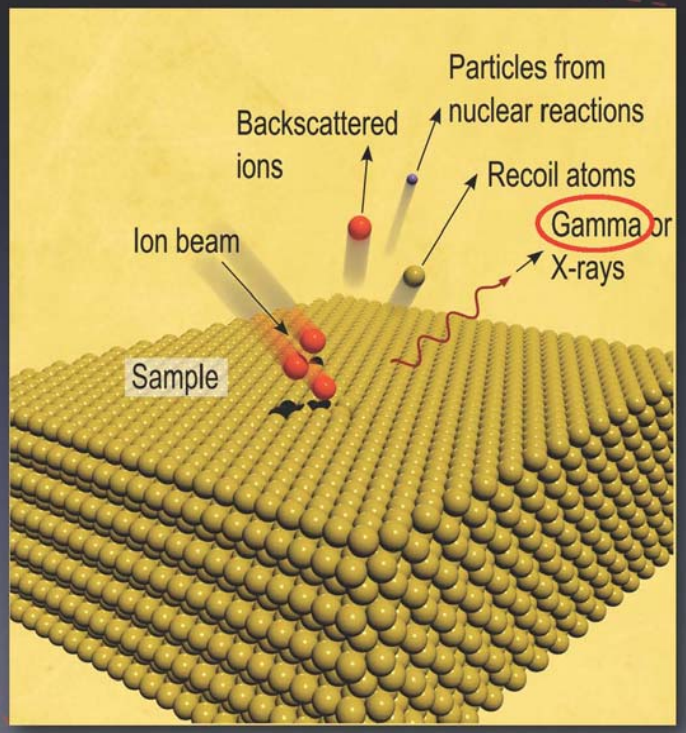
P. Dimitriou (IAEA), L. Leal (ORNL)

Ion Beam Analysis techniques



Beam IN	Beam OUT	Analytical technique
ion	ion	RBS, EBS*, NRA, PESA
ion	target	ERDA, SIMS, SNMS
ion	X-ray	PIXE
ion	Gamma-ray	PIGE, Activation Analysis
ion	hν	Ionoluminescence (IL)

* EBS is the general extension of RBS at higher energies, where the elastic scattering cross section is no longer Rutherford



by M. Chiari

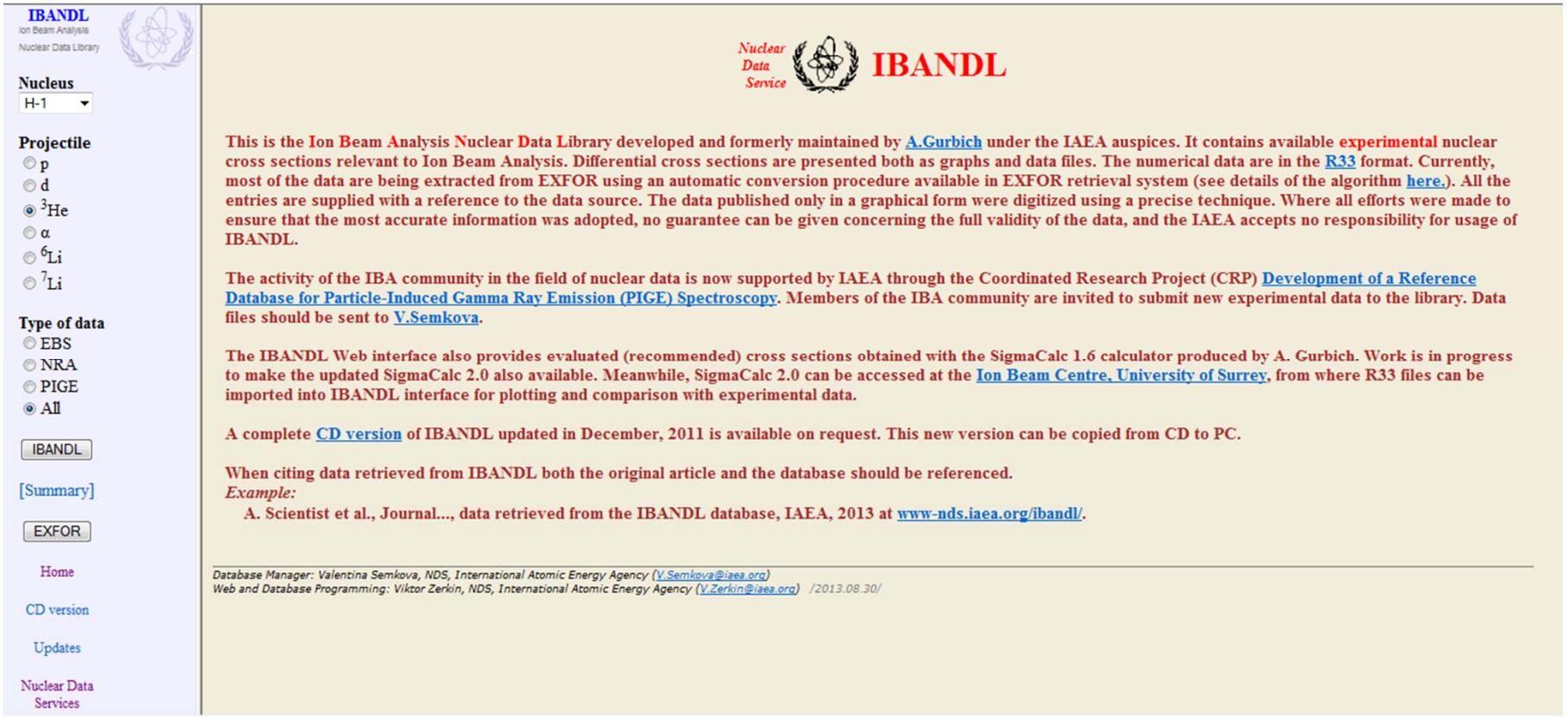
Nuclear data used in Ion Beam Analysis

Sort of data	Projectiles	Targets	Type of interaction	Energy range
Differential cross sections $d\sigma(E)/d\Omega$, γ-ray yields	p, d, ^{3}He, ^{4}He, heavy ions	All elements	Elastic scattering, nuclear reactions	0.5÷10 MeV

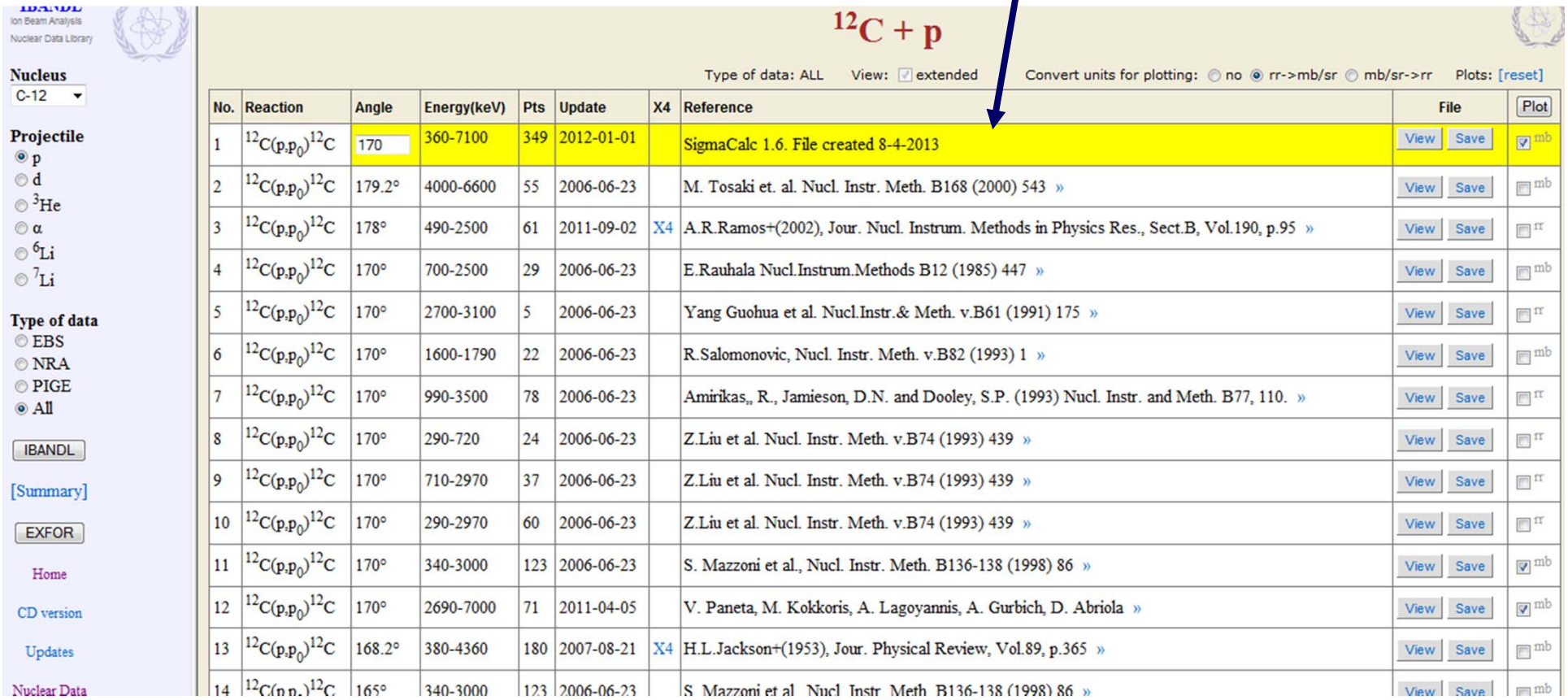
Ion Beam Analysis Nuclear Data Library

http://www-nds.iaea.org/ibandl/

IAEA CRP 2005-2009



SigmaCalc calculator: evaluated cross sections by A. Gurbich



IBANDL
Ion Beam Analysis Nuclear Data Library

Nucleus
C-12

Projectile
- p
- d
- ^{3}He
- α
- ^{6}Li
- ^{7}Li

Type of data
- EBS
- NRA
- PIGE
- All

IBANDL

[Summary]

EXFOR

Home

CD version

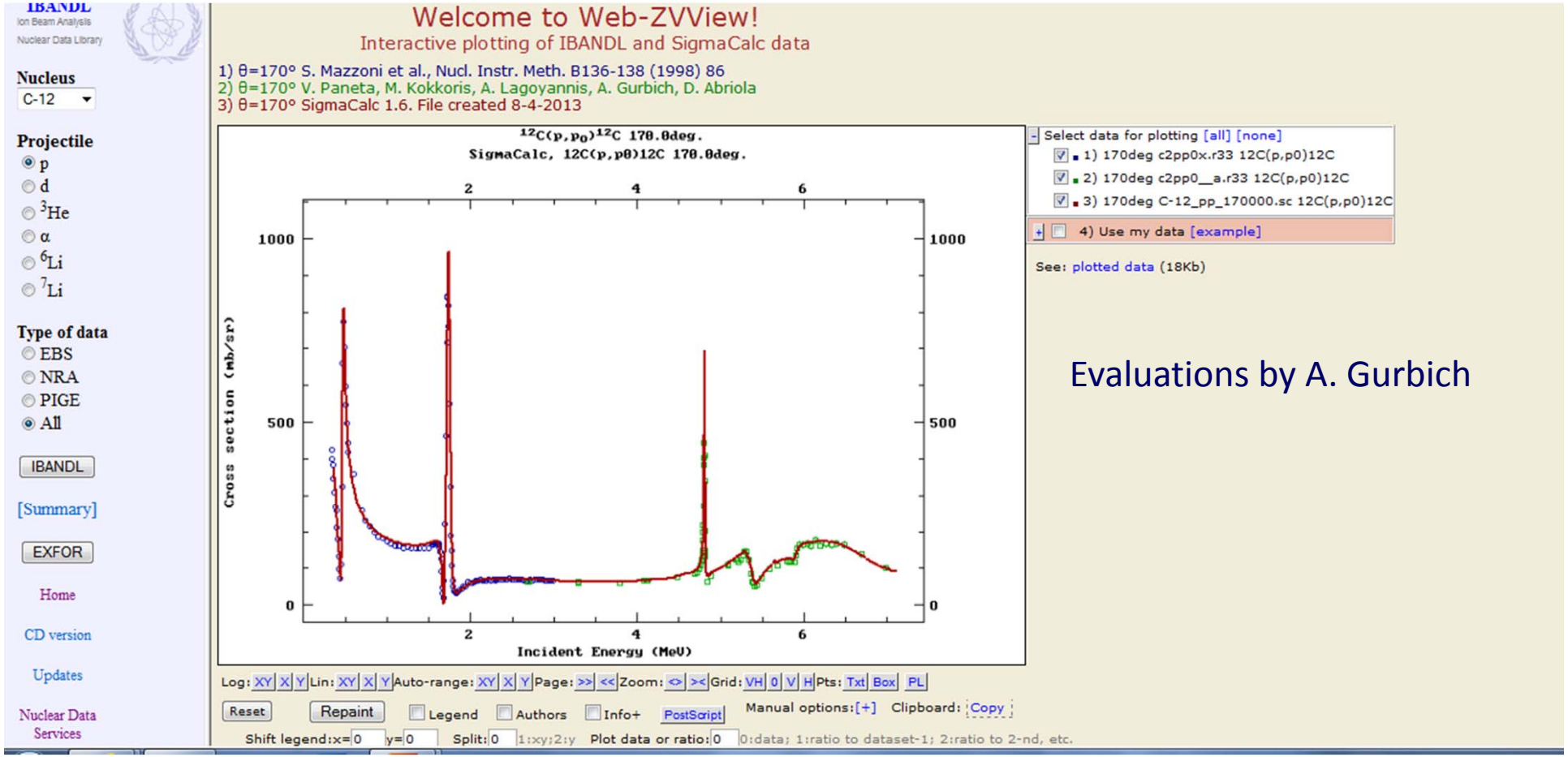
Updates

Nuclear Data

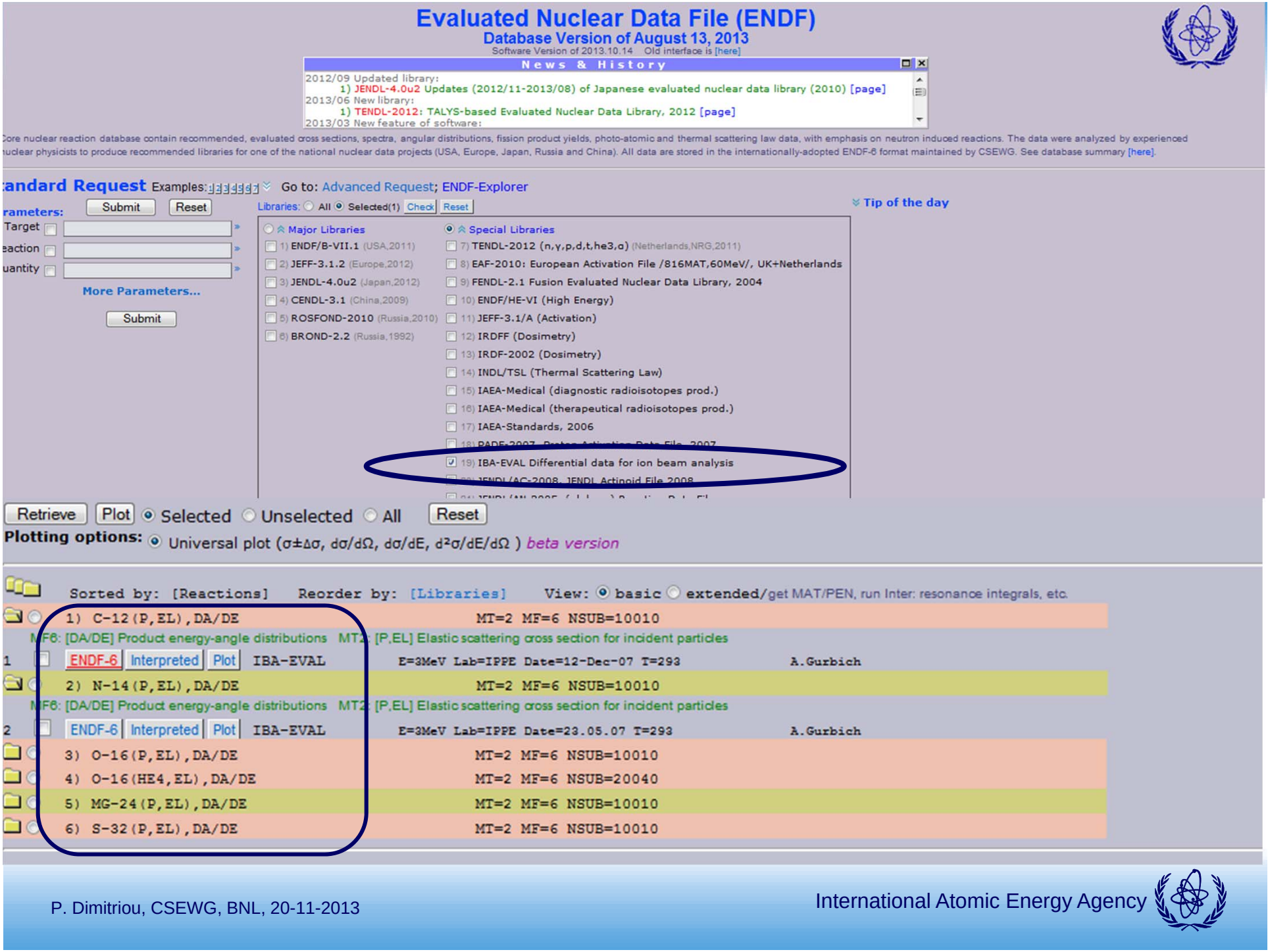
^{12}C + p

Type of data: ALL View: ☑ extended Convert units for plotting: ○ no ◉ rr->mb/sr ○ mb/sr->rr Plots: [reset]

No.	Reaction	Angle	Energy(keV)	Pts	Update	X4	Reference	File	Plot
1	^{12}C(p,p$_0$)^{12}C	170	360-7100	349	2012-01-01		SigmaCalc 1.6. File created 8-4-2013	View Save	☑ mb
2	^{12}C(p,p$_0$)^{12}C	179.2°	4000-6600	55	2006-06-23		M. Tosaki et. al. Nucl. Instr. Meth. B168 (2000) 543 »	View Save	☐ mb
3	^{12}C(p,p$_0$)^{12}C	178°	490-2500	61	2011-09-02	X4	A.R.Ramos+(2002), Jour. Nucl. Instrum. Methods in Physics Res., Sect.B, Vol.190, p.95 »	View Save	☐ rr
4	^{12}C(p,p$_0$)^{12}C	170°	700-2500	29	2006-06-23		E.Rauhala Nucl.Instrum.Methods B12 (1985) 447 »	View Save	☐ mb
5	^{12}C(p,p$_0$)^{12}C	170°	2700-3100	5	2006-06-23		Yang Guohua et al. Nucl.Instr.& Meth. v.B61 (1991) 175 »	View Save	☐ rr
6	^{12}C(p,p$_0$)^{12}C	170°	1600-1790	22	2006-06-23		R.Salomonovic, Nucl. Instr. Meth. v.B82 (1993) 1 »	View Save	☐ mb
7	^{12}C(p,p$_0$)^{12}C	170°	990-3500	78	2006-06-23		Amirikas,, R., Jamieson, D.N. and Dooley, S.P. (1993) Nucl. Instr. and Meth. B77, 110. »	View Save	☐ rr
8	^{12}C(p,p$_0$)^{12}C	170°	290-720	24	2006-06-23		Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439 »	View Save	☐ rr
9	^{12}C(p,p$_0$)^{12}C	170°	710-2970	37	2006-06-23		Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439 »	View Save	☐ rr
10	^{12}C(p,p$_0$)^{12}C	170°	290-2970	60	2006-06-23		Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439 »	View Save	☐ rr
11	^{12}C(p,p$_0$)^{12}C	170°	340-3000	123	2006-06-23		S. Mazzoni et al., Nucl. Instr. Meth. B136-138 (1998) 86 »	View Save	☑ mb
12	^{12}C(p,p$_0$)^{12}C	170°	2690-7000	71	2011-04-05		V. Paneta, M. Kokkoris, A. Lagoyannis, A. Gurbich, D. Abriola »	View Save	☑ mb
13	^{12}C(p,p$_0$)^{12}C	168.2°	380-4360	180	2007-08-21	X4	H.L.Jackson+(1953), Jour. Physical Review, Vol.89, p.365 »	View Save	☐ mb
14	^{12}C(p,p$_0$)^{12}C	165°	340-3000	123	2006-06-23		S. Mazzoni et al., Nucl. Instr. Meth. B136-138 (1998) 86 »	View Save	☐ mb



Evaluations by A. Gurbich


Evaluated Nuclear Data File (ENDF)
Database Version of August 13, 2013
Software Version of 2013.10.14 Old interface is [here]
News & History
2012/09 Updated library:
1) JENDL-4.0u2 Updates (2012/11-2013/08) of Japanese evaluated nuclear data library (2010) [page]
2013/06 New library:
1) TENDL-2012: TALYS-based Evaluated Nuclear Data Library, 2012 [page]
2013/03 New feature of software:
Core nuclear reaction database contain recommended, evaluated cross sections, spectra, angular distributions, fission product yields, photo-atomic and thermal scattering law data, with emphasis on neutron induced reactions. The data were analyzed by experienced nuclear physicists to produce recommended libraries for one of the national nuclear data projects (USA, Europe, Japan, Russia and China). All data are stored in the internationally-adopted ENDF-6 format maintained by CSEWG. See database summary [here].
andard Request Examples:
Go to: Advanced Request; ENDF-Explorer
rameters:
Submit
Reset
Target
eaction
uantity
More Parameters...
Submit
Libraries: All Selected(1) Check Reset
Major Libraries
1) ENDF/B-VII.1 (USA,2011)
2) JEFF-3.1.2 (Europe,2012)
3) JENDL-4.0u2 (Japan,2012)
4) CENDL-3.1 (China,2009)
5) ROSFOND-2010 (Russia,2010)
6) BROND-2.2 (Russia,1992)
Special Libraries
7) TENDL-2012 (n,γ,p,d,t,he3,α) (Netherlands,NRG,2011)
8) EAF-2010: European Activation File /816MAT,60MeV/, UK+Netherlands
9) FENDL-2.1 Fusion Evaluated Nuclear Data Library, 2004
10) ENDF/HE-VI (High Energy)
11) JEFF-3.1/A (Activation)
12) IRDFF (Dosimetry)
13) IRDF-2002 (Dosimetry)
14) INDL/TSL (Thermal Scattering Law)
15) IAEA-Medical (diagnostic radioisotopes prod.)
16) IAEA-Medical (therapeutical radioisotopes prod.)
17) IAEA-Standards, 2006
19) IBA-EVAL Differential data for ion beam analysis
Tip of the day
Retrieve
Plot
Selected
Unselected
All
Reset
Plotting options: Universal plot (σ±Δσ, dσ/dΩ, dσ/dE, d²σ/dE/dΩ) beta version
Sorted by: [Reactions] Reorder by: [Libraries] View: basic extended/get MAT/PEN, run Inter: resonance integrals, etc.
1) C-12(P,EL),DA/DE MT=2 MF=6 NSUB=10010
MF6: [DA/DE] Product energy-angle distributions MT2: [P,EL] Elastic scattering cross section for incident particles
1 ENDF-6 Interpreted Plot IBA-EVAL E=3MeV Lab=IPPE Date=12-Dec-07 T=293 A.Gurbich
2) N-14(P,EL),DA/DE MT=2 MF=6 NSUB=10010
MF6: [DA/DE] Product energy-angle distributions MT2: [P,EL] Elastic scattering cross section for incident particles
2 ENDF-6 Interpreted Plot IBA-EVAL E=3MeV Lab=IPPE Date=23.05.07 T=293 A.Gurbich
3) O-16(P,EL),DA/DE MT=2 MF=6 NSUB=10010
4) O-16(HE4,EL),DA/DE MT=2 MF=6 NSUB=20040
5) MG-24(P,EL),DA/DE MT=2 MF=6 NSUB=10010
6) S-32(P,EL),DA/DE MT=2 MF=6 NSUB=10010

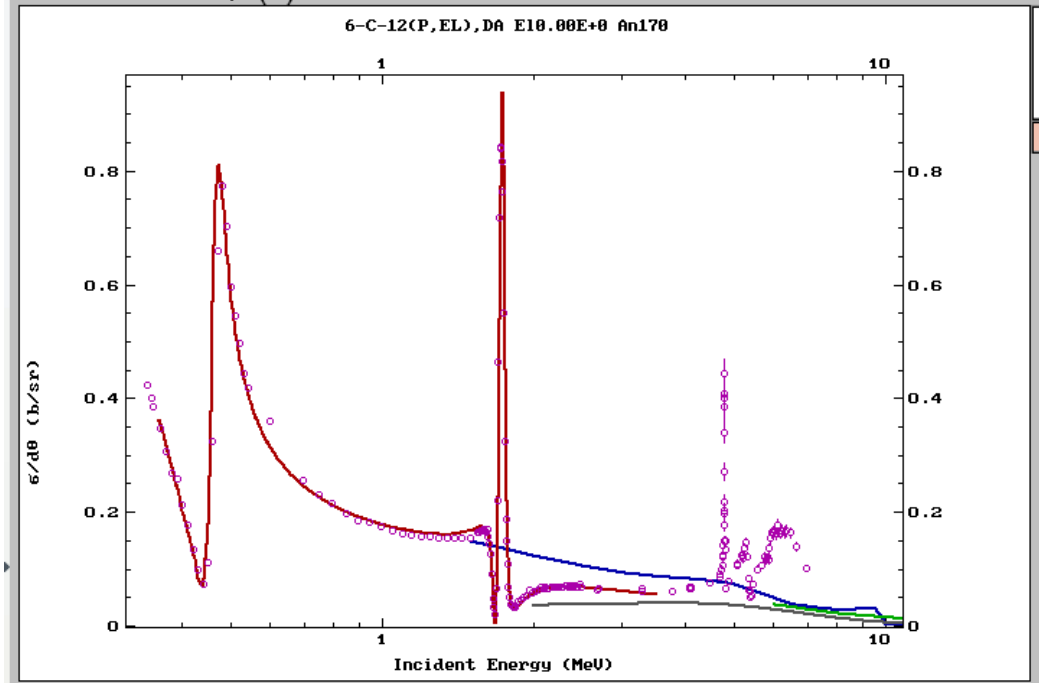
1276:930 - http://www-nds.iaea.org/exfor/servlet/X4sProcessC4make1zvd - Opera

http://www-nds.iae... | IBANDL

http://www-nds.iaea.org/exfor/servlet/X4sProcessC4make1zvd

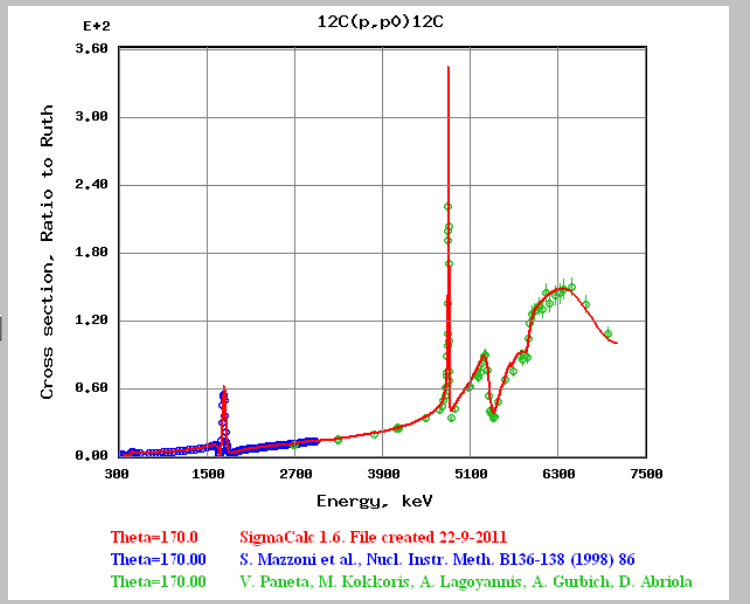
EXFOR-Request #-1 ENDF-Request #10400

Selected Plots: +1(3)



1) ENDF/B-VII.0:C-12 El0.00E+0 An170
2) JENDL/HE-2007:C-12 El0.00E+0 An170
3) IBA-EVAL:C-12 El0.00E+0 An170
4) TENDL-2010:C-12 El0.00E+0 An170
5) Use my data [example]

See: plotted data (12Kb)



Log: XY | X | Y Lin: XY | X | Y Auto-range: XY | X | Y Page: >> | << Zoom: <> | >< Grid: VH | 0 | V | H Pts: Txt | Box | PL | Print

Reset | Repaint | Legend | Authors | Info+ | PostScript | Manual options: [-]

Y: Axis: Auto Min: 0. Max: 0.96946 Units: b

X: Axis: Auto Min: 0.311654 Max: 10.8526 Units: MeV

Title: 6-C-12(P,EL),DA El0.00E+0 An170

Title-2:

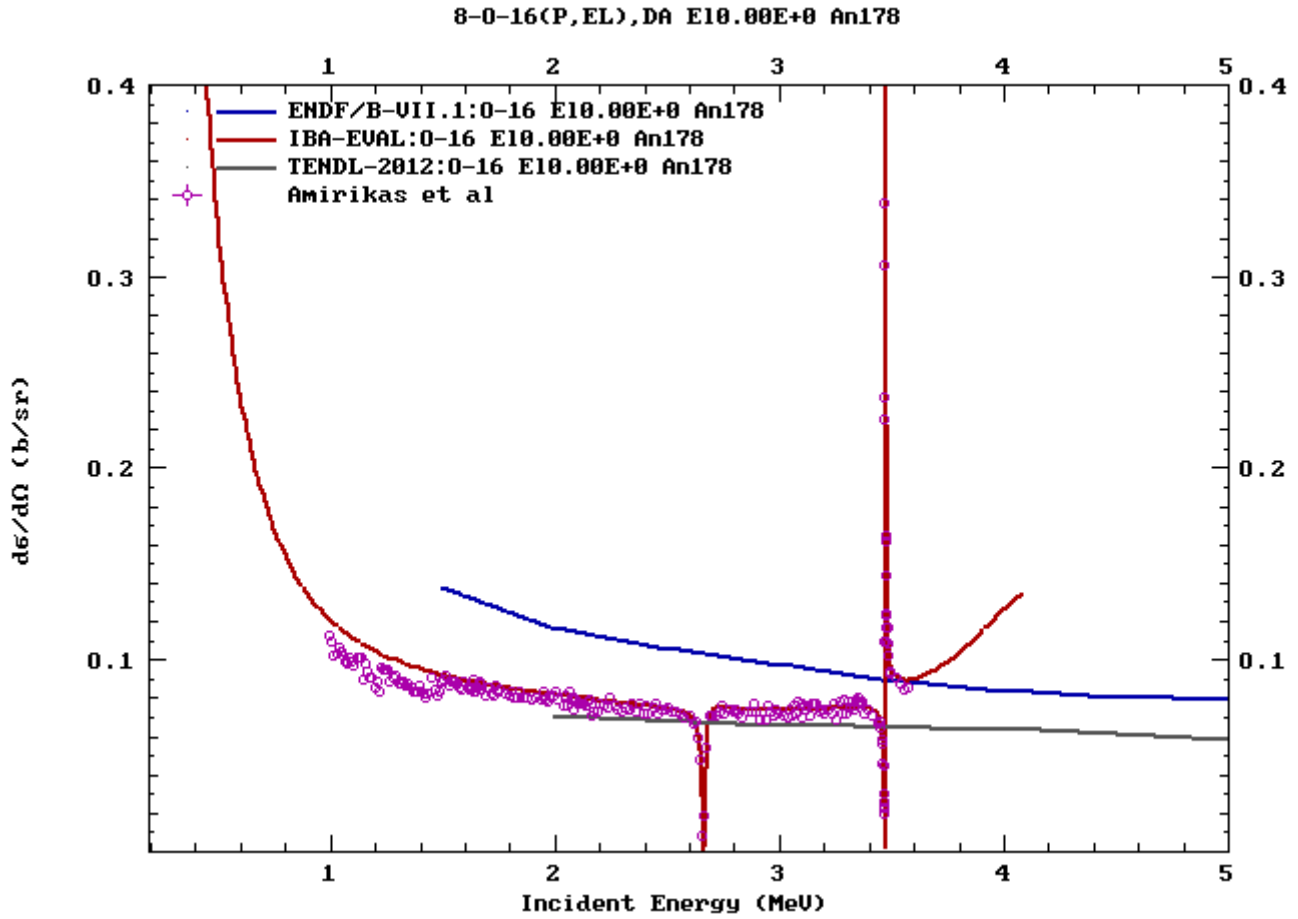
Shift legend: lx=0 ly=0 Split: 0 0:none; 1:xy; 2:y

Picture-size: lx=700 ly=500 600*400 | 700*500 | 800*600 | 900*700

Data for plotting: ZVD (8Kb), send to ZVView; download ZVView; upload and plot your ZVD file

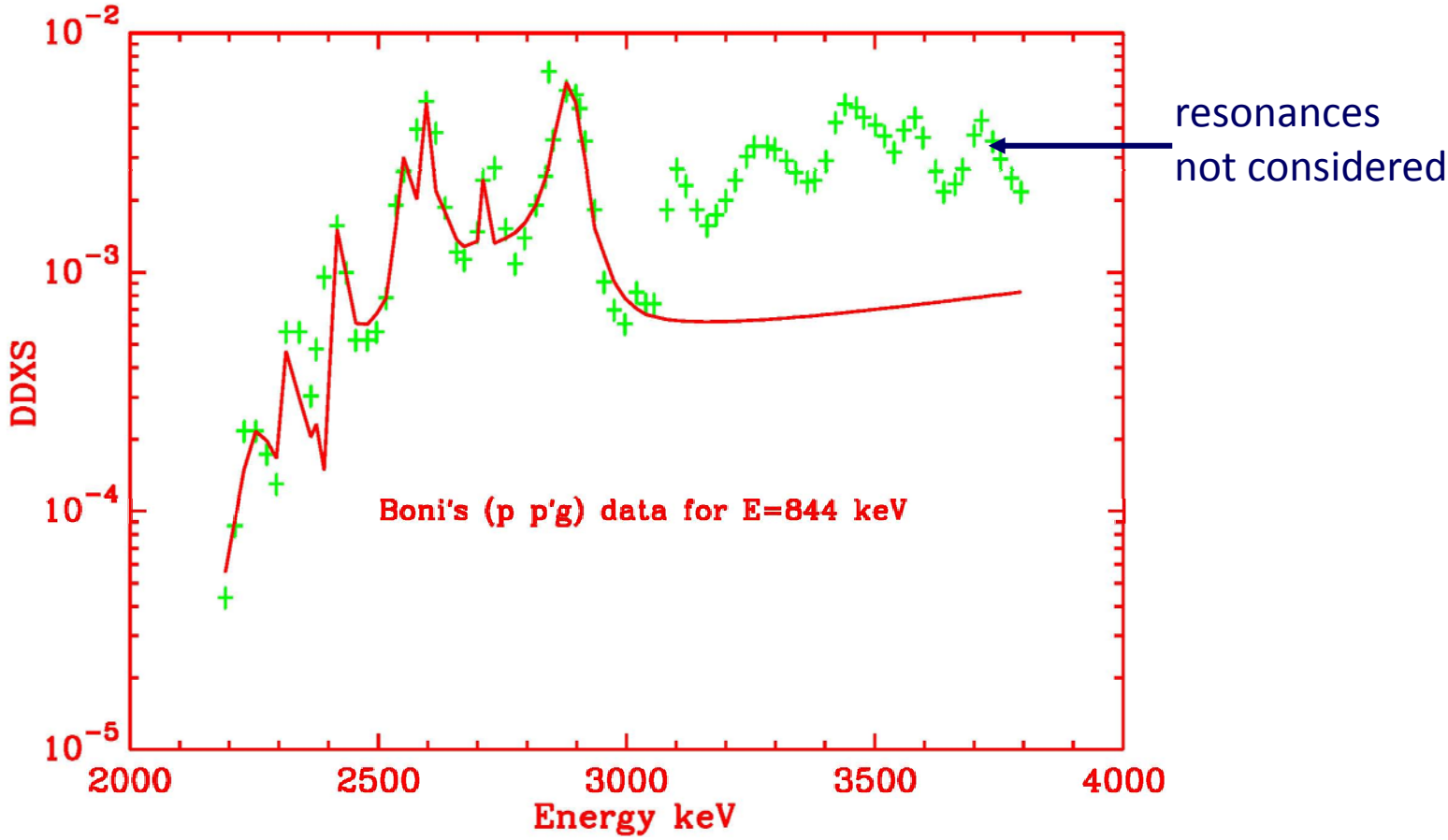
Note. Zoom and other interactive plotting features were tested under Web-browsers:
MS-Internet Explorer 5.5, Firefox 2.0, Safari, Opera 9.1, Netscape v-7.2

Page generated: 2011/09/22,15:15:01 by X4-Servlet on www-nds.iaea.org
Project: "Multi-platform EXFOR-CINDA-ENDF", V.Zerkin, IAEA-NDS, 1999-2011
Request from: robust.ippe.ru (212.193.160.62) [fwd:172.20.6.104]


8-O-16(P,EL),DA E10.00E+0 An178
ENDF/B-VII.1:O-16 E10.00E+0 An178
IBA-EVAL:O-16 E10.00E+0 An178
TENDL-2012:O-16 E10.00E+0 An178
Amirikas et al
dσ/dΩ (b/sr)
Incident Energy (MeV)
0.4
0.3
0.2
0.1
1
2
3
4
5

Data Development Project on
Evaluations of Charged-particle reactions relevant to IBA applications
(and other ex. Nuclear Astrophysics)

- ✓ Use multi-level multi-channel R-matrix code SAMMY
- ✓ Take into account experimental uncertainties: systematic+statistical
- ✓ Produce uncertainties and covariance matrices
- ✓ ENDF format
- ✓ Start with isotopes most widely used in IBA applications
- ✓ Consider cases useful for Nuclear Astrophysics



Work in progress: evaluate all available data on ^{27}Al i.e. (p,p_0), (p,p'γ), (p,α)