



IAEA

60 Years

Atoms for Peace and Development

Nuclear Data for Ion Beam Analysis Applications

Paraskevi (Vivian) Dimitriou, Valentina Semkova, and Viktor Zerkov

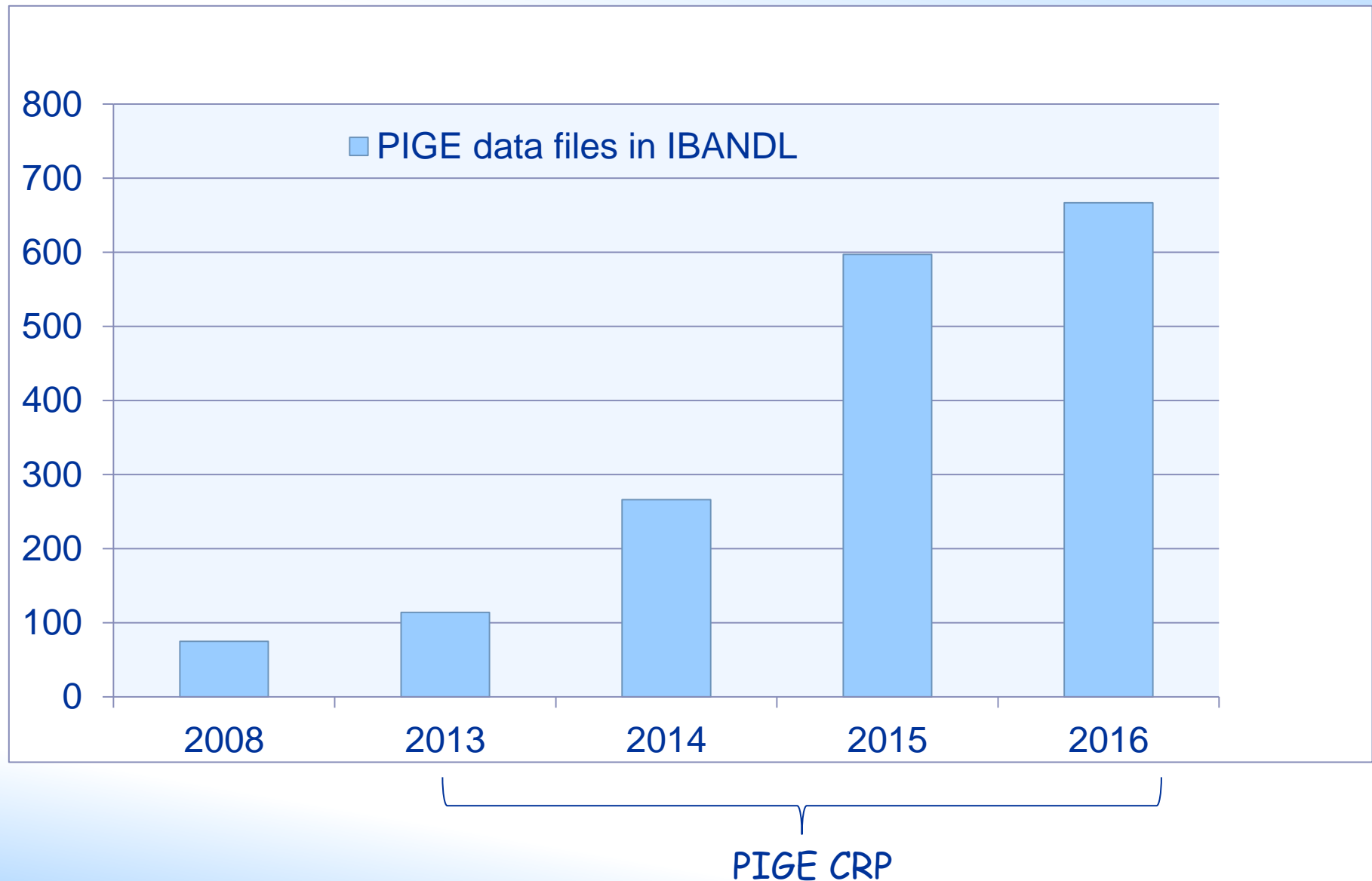
Nuclear Data Section, Division of Physical and Chemical Sciences, Dept. of Nuclear Sciences and Applications

Outline

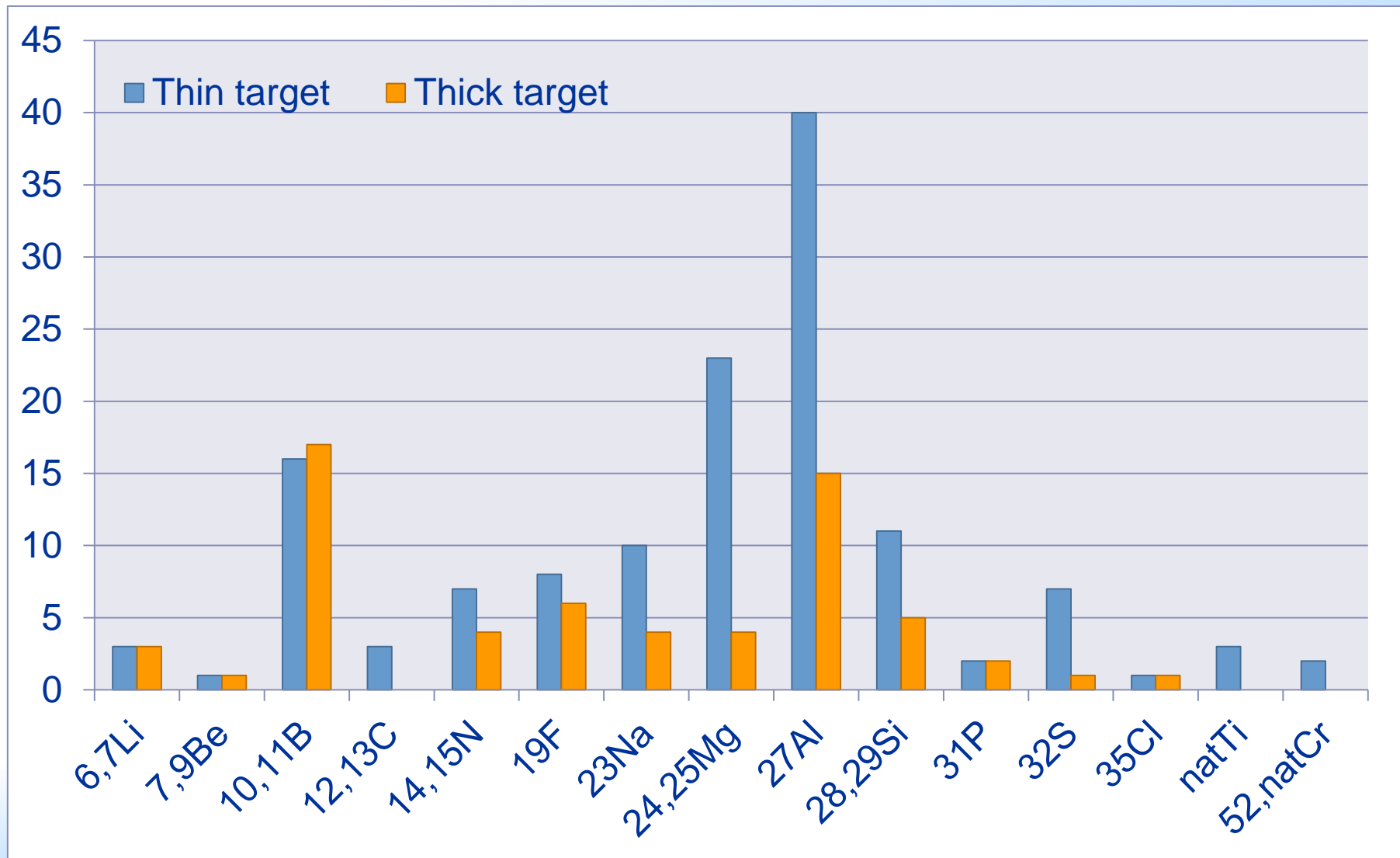
- History
- Results from last CRP on PIGE
- Status of IBANDL - new features
- Recent efforts
- Future

- **Year 2003: IAEA-NDS Technical Meeting**
Creation of Ion Beam Analysis Nuclear Data Library on NDS server:
merging of Sigmasbase and NRA database
- **Years 2005-2009: CRP on Development of Reference Database for Ion Beam Analysis (IAEA-TECDOC 1780)**
Development of IBANDL: interface, database structure, graphical viewer
New Measurements of EBS, NRA cross sections
Evaluation: SigmaCalc (A. Gurbich, IPPE) made available through IBANDL
- **Years 2011-2015: CRP on Development of Reference Database for Particle-Induced Gamma-ray Emission spectroscopy (PIGE)**
Review literature for relevant data
New measurements of PIGE cross sections to fill gaps or resolve discrepancies
Development of software for standardless PIGE
Evaluation (INDC(NDS)-0660)

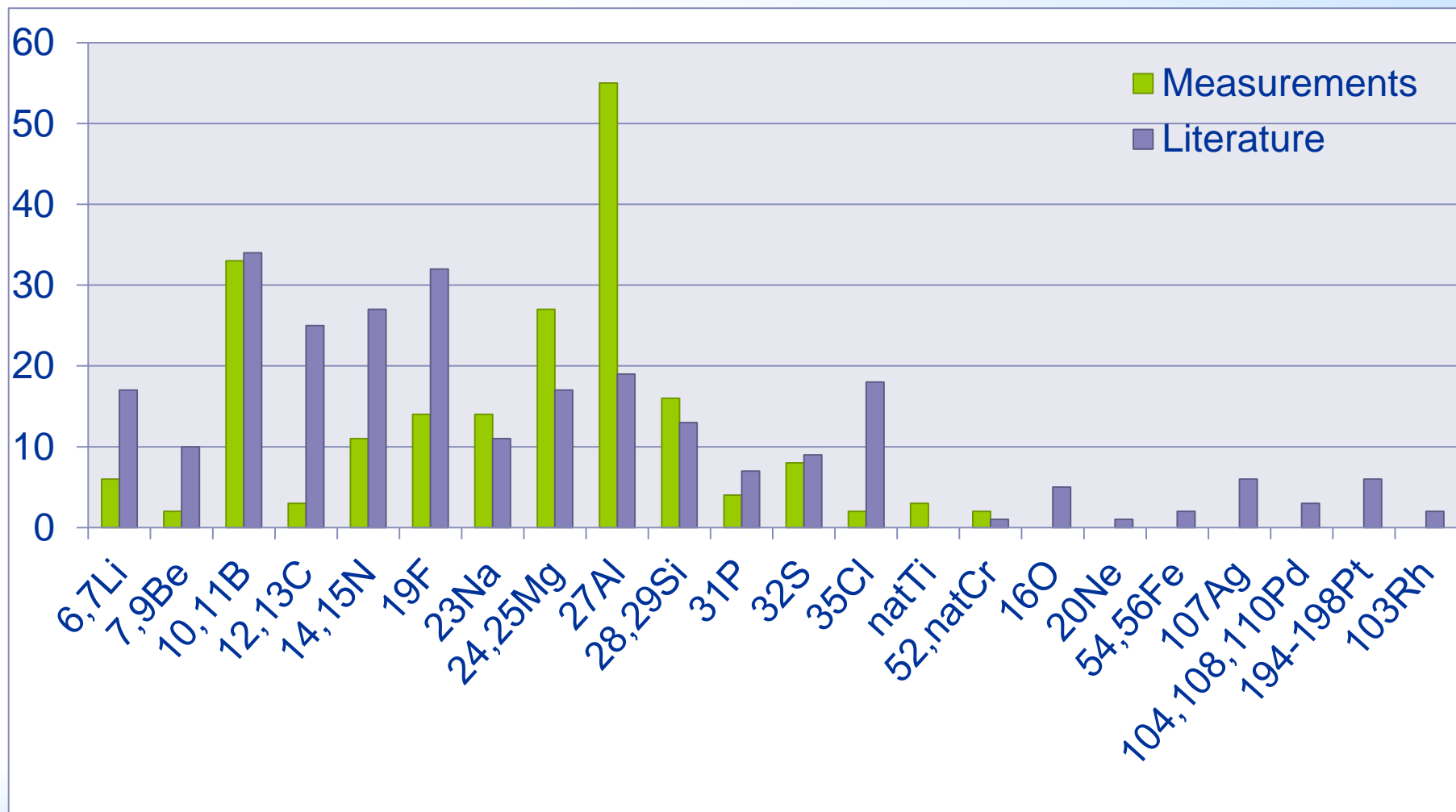
PIGE CRP 2011-2015 (Final report in preparation)



PIGE CRP: Measurements

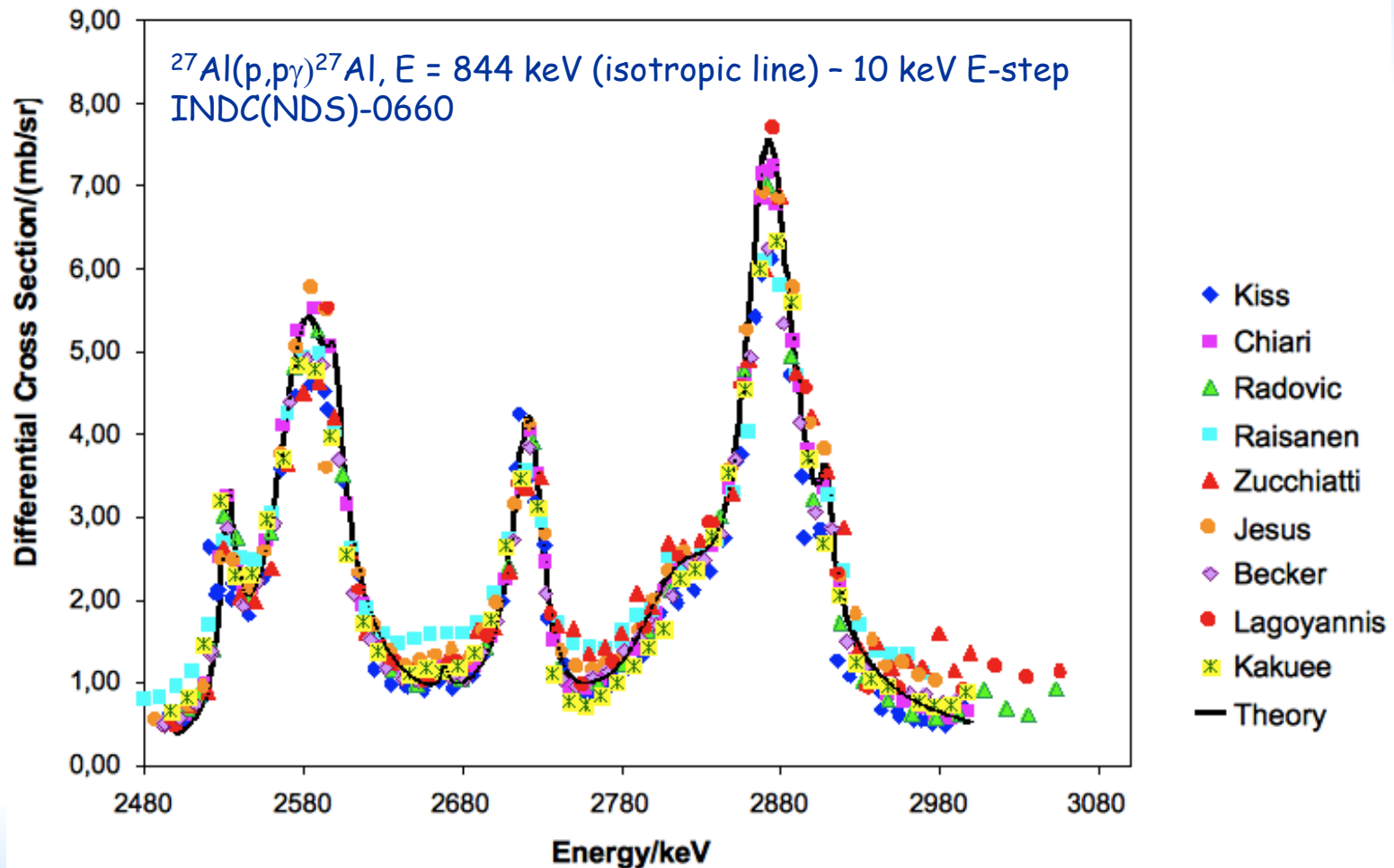


PIGE CRP: Literature Search



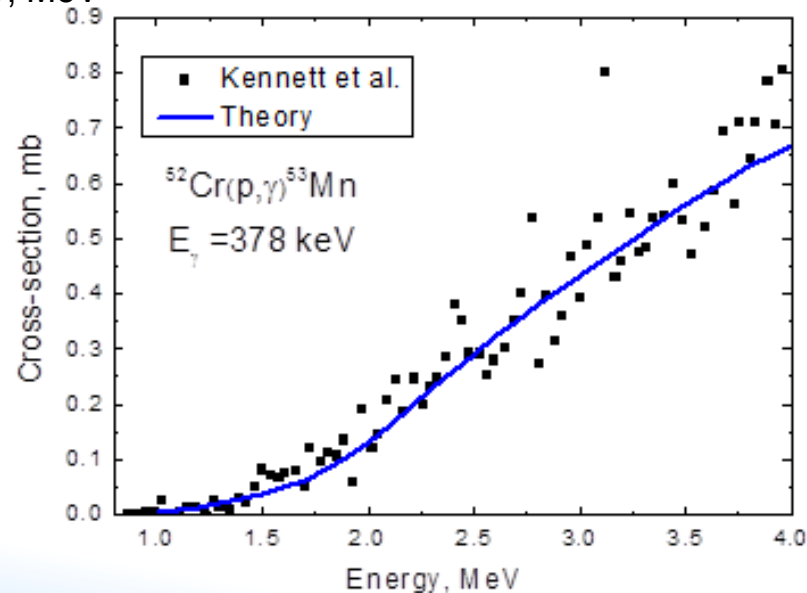
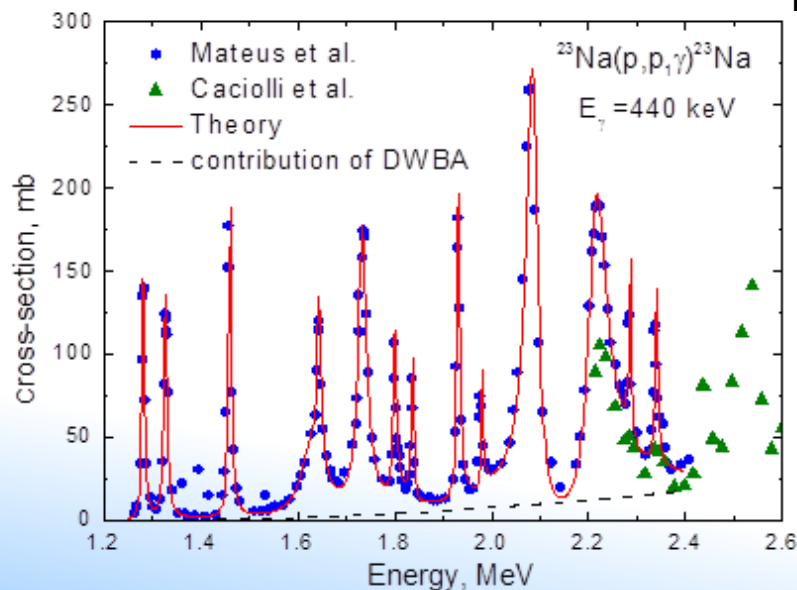
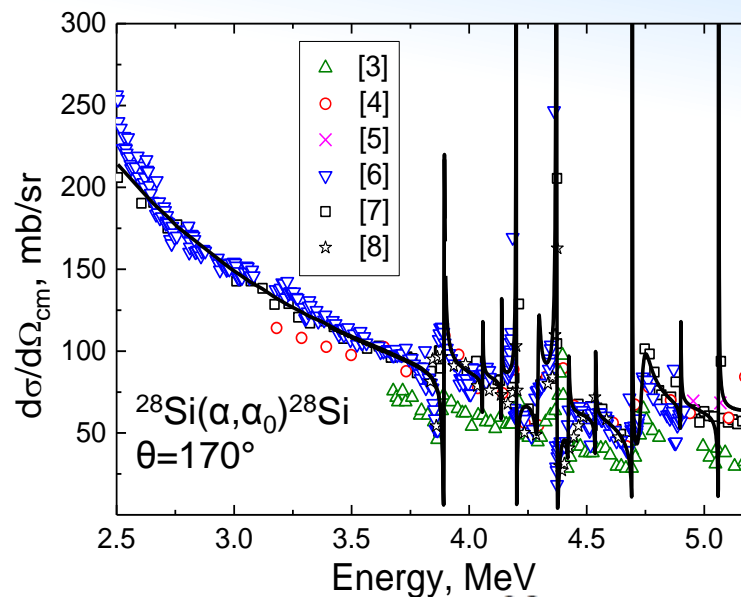
Coordinated Cross-Section Measurement

To assess systematic problems with thin-target measurements at different facilities and check Quality Assurance



Evaluations

- SigmaCalc (A. Gurbich, IAEA Contracts) at <http://sigmacalc.iate.obninsk.ru/>



Bulk Analysis - Standardless PIGE

- ERYA code for testing standardless PIGE bulk analysis: calculates mass fraction of the elements in a given sample by integrating relevant nuclear reaction cross sections along its depth
- Distributed to CRP members for testing/Upgraded for PIGE depth profiling

LATR

 Print |  Portuguese Version

Laboratory of Accelerators and Radiation Technologies | Campus Tecnológico e Nuclear | Instituto Superior Técnico (UTL)

ERYA

Emitted Radiation Yield Analysis

ABOUT LATR

LATR STAFF

Nuclear Reactions Group

Last update 07-04-2014

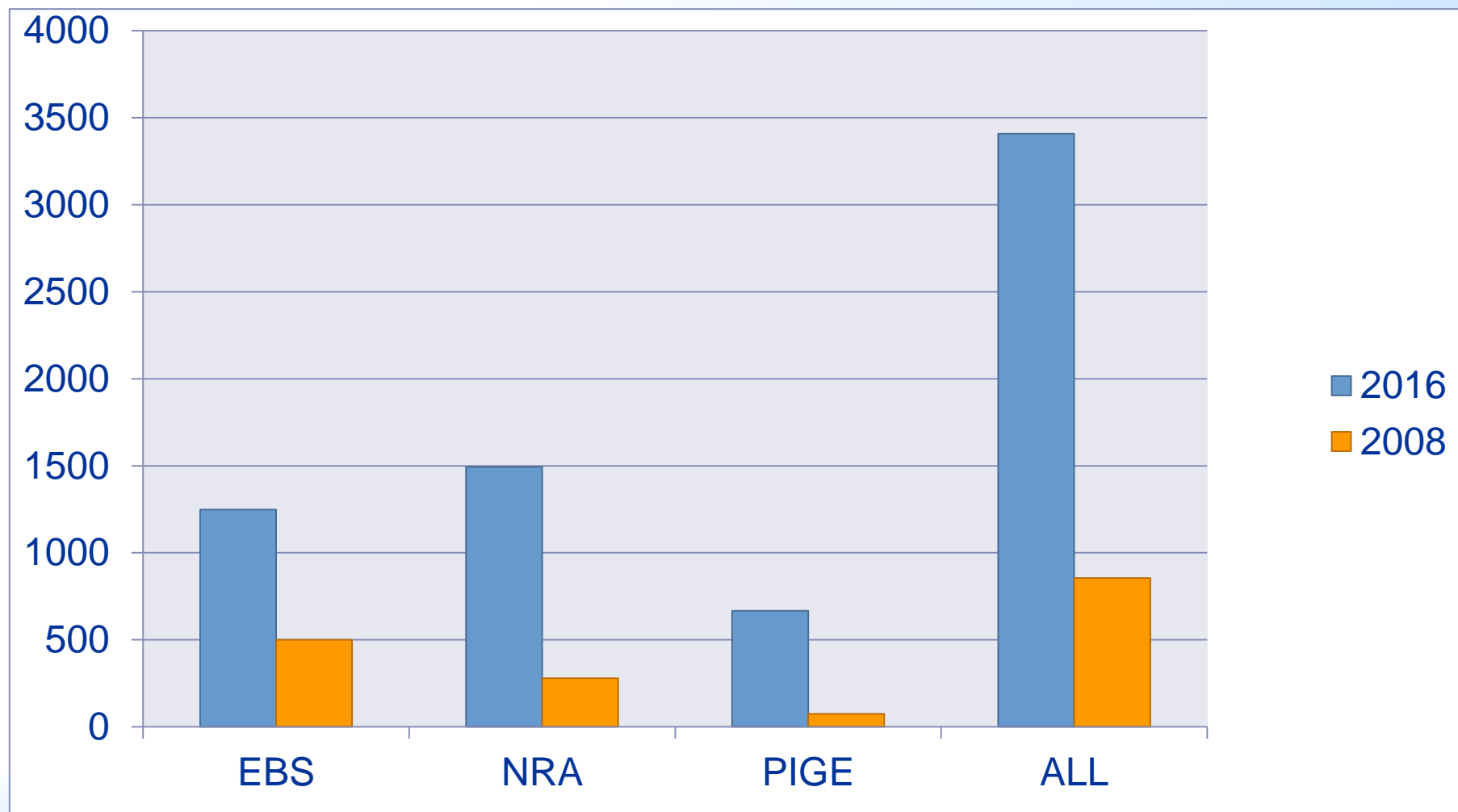
1. Introduction

ERYA (Emitted Radiation Yield Analysis) is a Labview program dedicated to PIGE (Particle Induced Gamma-ray Emission). ERYA calculates the mass fraction of the elements present in a given sample, by integrating the relevant nuclear reaction cross sections along its depth.

The free version of ERYA can be found in here. Choose the Installer according to your screen resolution:

- [Installer 1366x768 \(12M\)](#) and [Installer 1920x1080 \(13M\)](#).
No Labview software is needed.
[The tutorial can be found here.](#)

IBANDL after CRPs





60 Years
Atoms for Peace and Development

Ion Beam Analysis Nuclear Data Library

IBANDL

Ion Beam Analysis
Nuclear Data Library



Nucleus

H-1

Projectile

- ☐ p
- ☐ d
- ☒ ^3He
- ☐ α
- ☐ ^6Li
- ☐ ^7Li

Type of data

- ☐ EBS
- ☒ NRA
- ☐ PIGE
- ☐ All

IBANDL

[Summary]

EXFOR

Home

CD version

Updates

Nuclear Data
Services

Nuclear
Data
Service



IBANDL

This is the Ion Beam Analysis Nuclear Data Library developed and formerly maintained by A. Gurbich under the IAEA auspices. It contains available **experimental** nuclear cross-sections relevant to Ion Beam Analysis. Differential cross sections are presented both as graphs and data files. The numerical data are in the **R33** format. Currently, most of the data are being extracted from EXFOR using an automatic conversion procedure available in **EXFOR retrieval system** (see details of the algorithm [here](#)).

The Coordinated Research Project (CRP) on **Development of a Reference Database for Particle-Induced Gamma Ray Emission (PIGE) Spectroscopy** concluded in 2015 with over 500 new experimental data sets uploaded in IBANDL. The activity of the IBA community in the field of nuclear data is further supported by the IAEA through the Technical Meeting on **Benchmarking Experiments for Ion Beam Analysis**, 26-29 May 2015, and the nuclear data evaluation project initiated with the Consultant's Meeting on **R-matrix Codes for Charged-particle reactions in the Resolved-Resonance Region**, 7-9 December 2015.

Members of the IBA community are invited to submit new experimental data to IBANDL. Numerical data (in R33 or any other format) including references should be sent to the contact person: **V. Semkova** (IAEA-NDS).

The IBANDL Web interface also provides evaluated (recommended) cross sections obtained with the SigmaCalc calculator developed by A. Gurbich. Evaluated cross-section data produced by SigmaCalc up to October 2013 are available for easier access and plotting. In addition, the user is offered the option to obtain SigmaCalc files on-the-fly, through remote access to the **SigmaCalc** calculator. R33 files can be also downloaded from SigmaCalc and imported into IBANDL. Users are cautioned however, that the 'on-the-fly' calculations can experience significant delays due to problems related with the connection to the external Web server. The IAEA therefore accepts no responsibility for usage of this option.

A complete **CD version** of IBANDL updated in March, 2014 is available for downloading or can be sent on request. This new version can be copied from CD to PC.

When citing data retrieved from IBANDL both the original article and the database should be referenced.

Example:

A. Scientist et al., Journal..., data retrieved from the IBANDL database, IAEA, 2014 at <http://www-nds.iaea.org/ibandl/>.

Statistics of usage: visits: 66, data search: 111, since 29-Aug-2016

Total datasets: 3408
Reactions: 164 Targets: 81 (34 elements)
References: 831
SigmaCalc data: 44

IBANDL: features

- IBANDL: development and maintenance by NDS since 2013
 - Web and Database Programming (Viktor Zerkin)
 - Data Compilation (Valentina Semkova)
 - Supervision in collaboration with IBA community
- Major effort to link IBANDL to EXFOR database:
more information on IBANDL datasets and related references in EXFOR can be accessed through links
- New features:
 - Conversion between units
 - Graphical comparison with User-supplied dataset
 - Cross sections in Inverse kinematics
- Current version of IBANDL can be downloaded directly
(<https://www-nds.iaea.org/cdroms/>)
- Evaluated cross sections available through link to SigmaCalc
(<http://sigmacalc.iate.obninsk.ru/>)

Example: Conversion of units in IBANDL

IBANDL

Ion Beam Analysis
Nuclear Data Library



Nucleus

C-12

Projectile

- ☒ p
- ☐ d
- ☐ ³He
- ☐ α
- ☐ ⁶Li
- ☐ ⁷Li

Type of data

- ☒ EBS
- ☐ NRA
- ☐ PIGE
- ☐ All

IBANDL

[Summary]

EXFOR

Home

CD version

Updates

Nuclear Data
Services

¹²C + p

Type of data: EBS

View: ☒ extended ☐ inverted

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	179	360-7100	349	2012-01-01		Evaluated data from SigmaCalc archive (A.Gurbich, 2011)	View Save	<input type="checkbox"/> mb
							Evaluated data from current version of [SigmaCalc] >>> Calculate (timeout=5min)		
2	¹² C(p,p ₀) ¹² C	179.2°	4000-6600	55	2006-06-23	X4	M. Tosaki et. al Nucl. Instr. Meth. B168 (2000) 543 »	View Save	<input type="checkbox"/> 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	<input type="checkbox"/> rr
4	¹² C(p,p ₀) ¹² C	170°	700-2500	29	2006-06-23	X4 ⁻	E.Rauhala NuclInstrum.Methods B12 (1985) 447 »	View Save	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> rr
6	¹² C(p,p ₀) ¹² C	170°	1600-1790	22	2006-06-23	X4 ⁺	R.Salomonovic, Nucl. Instr. Meth. v.B82 (1993) 1 »	View Save	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> 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	<input checked="" type="checkbox"/> rr
11	¹² C(p,p ₀) ¹² C	170°	340-3000	123	2006-06-23	X4 ⁺	S. Mazzoni et al, Nucl Instr. Meth. B136-138 (1998) 86 »	View Save	<input checked="" type="checkbox"/> mb
12	¹² C(p,p ₀) ¹² C	170°	2690-7000	71	2011-04-05	X4 ⁺	D.Abricola+(2011), Jour. Nucl Instrum. Methods in Physics Res., Sect.B, Vol269, p.2011 »	View Save	<input checked="" type="checkbox"/> 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, Vol89, p.365 »	View Save	<input type="checkbox"/> mb
14	¹² C(p,p ₀) ¹² C	165°	340-3000	123	2006-06-23	X4 ⁺	S. Mazzoni et al, Nucl Instr. Meth. B136-138 (1998) 86 »	View Save	<input type="checkbox"/> mb

Conversion of units

IBANDL
Ion Beam Analysis
Nuclear Data Library



Nucleus

C-12

Projectile

- ☒ p
☐ d
☐ ³He
☐ α
☐ ⁶Li
☐ ⁷Li

Type of data

- ☒ EBS
☐ NRA
☐ PIGE
☐ All

IBANDL

[Summary]

EXFOR

Home

CD version

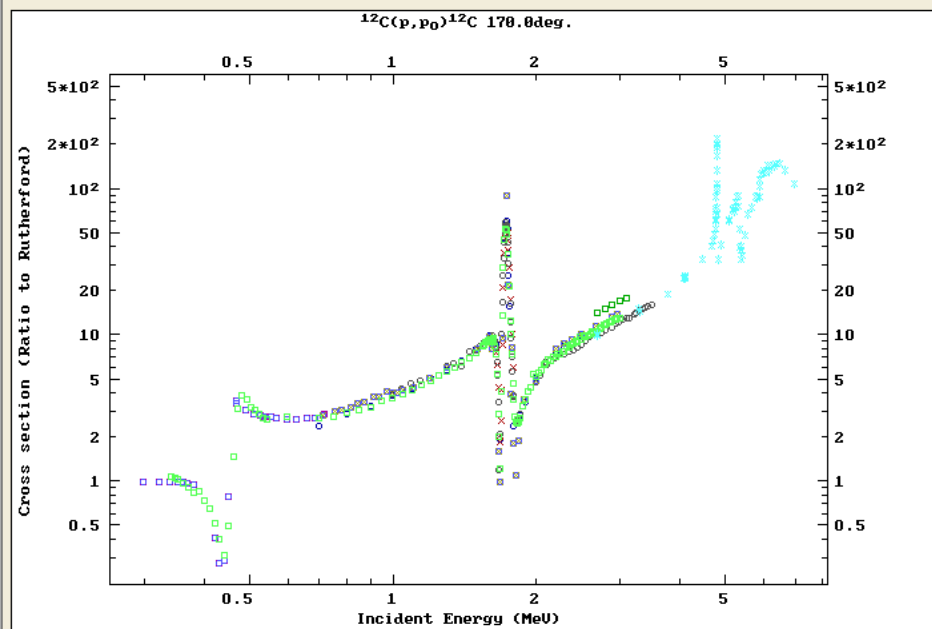
Updates

Nuclear Data
Services

Welcome to Web-ZVView!

Interactive plotting of IBANDL and SigmaCalc data

- 1) $\theta=170^\circ$ $E_1=0.7\text{-}2.5\text{MeV}$ Source: E.Rauhala Nucl.Instrum.Methods B12 (1985) 447
- 2) $\theta=170^\circ$ $E_1=2.7\text{-}3.1\text{MeV}$ Source: Yang Guohua et al. Nucl.Instr.& Meth. v.B61 (1991) 175
- 3) $\theta=170^\circ$ $E_1=1.6\text{-}1.8\text{MeV}$ Source: R.Salomonic, Nucl. Instr. Meth. v.B82 (1993) 1
- 4) $\theta=170^\circ$ $E_1=1\text{-}3.5\text{MeV}$ Source: Amirikas,, R., Jamieson, D.N. and Dooley, S.P. (1993) Nucl. Instr. and Meth. B77, 110.
- 5) $\theta=170^\circ$ $E_1=0.3\text{-}0.7\text{MeV}$ Source: Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439
- 6) $\theta=170^\circ$ $E_1=0.7\text{-}3\text{MeV}$ Source: Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439
- 7) $\theta=170^\circ$ $E_1=0.3\text{-}3\text{MeV}$ Source: Z.Liu et al. Nucl. Instr. Meth. v.B74 (1993) 439
- 8) $\theta=170^\circ$ $E_1=0.3\text{-}3\text{MeV}$ Source: S. Mazzoni et al., Nucl. Instr. Meth. B136-138 (1998) 86
- 9) $\theta=170^\circ$ $E_1=2.7\text{-}7\text{MeV}$ Source: D.Abriola+(2011), Jour. Nucl. Instrum. Methods in Physics Res., Sect.B, Vol.269, p.2011



Select data for plotting [all] [none]

☒ 1) 170deg c2pp0a.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 2) 170deg c2pp0i.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 3) 170deg c2pp0j.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 4) 170deg c2pp0n.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 5) 170deg c2pp0p.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 6) 170deg c2pp0q.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 7) 170deg c2pp0r.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 8) 170deg c2pp0x.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$
☒ 9) 170deg c2pp0_a.r33 $^{12}\text{C}(p,p_0)^{12}\text{C}$

☐ 10) Use my data [example]

See: plotted data (17Kb)

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

Reset

Repaint

☐ Legend

☐ Authors

☐ Info+

☐ PostScript

Manual options: [+]

Clipboard:

☐ Copy ☐ Paste

Shift legend: x=0 y=0 Split: 0 1:xy;2:y Plot data or ratio: 0 0:data; 1:ratio to dataset-1; 2:ratio to 2-nd, etc.

Example: Inverse Kinematics in IBANDL

Flag to transform data to invert kinematics

when presenting data

IBANDL
Ion Beam Analysis
Nuclear Data Library

Nucleus
H-1

Projectile
☐ p
☐ d
☒ ³He
☐ α
☐ ⁶Li
☐ ⁷Li

Type of data
☐ EBS
☐ NRA
☐ PIGE
☒ All

IBANDL
[\[Summary\]](#)

EXFOR

[Home](#)

¹H + ⁷Li

Type of data: ALL View: ☒ extended ☐ inverted 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	¹ H(⁷ Li, ¹ H) ⁷ Li	45°	2280-5700	29	2006-06-23	-	Z. Siketic et al., Nucl. Instr. and Meth. B 229 (2005) 180 »	View Save	<input checked="" type="checkbox"/> mb
2	¹ H(⁷ Li, ¹ H) ⁷ Li	30°	2280-5700	29	2006-06-23	-	Z. Siketic et al., Nucl. Instr. and Meth. B 229 (2005) 180 »	View Save	<input type="checkbox"/> mb

Datasets: 2 Reactions: 1 Points: 58 References: 1
[Add your dataset in R33 format for plotting](#)

1 Comment: Automatically converted from EXFOR by the IAEA-NDS EXFOR Web-Retrieval System program version-2015/02/20, by V.Zerkin.
"The elastic scattering of protons by lithium"
W.D.Warters, W.A.Fowler, C.C.Lauritsen
EXFOR: A1401003 Created: 1980-07-28 Updated: 2014-11-13
X4Reaction:3-LI-7(P,EL)3-LI-7,,DA,,EXP; X4Points:295
Converted from C.M. to Lab.: Data (assumed DATA-CM), Theta
DataLab= DataCM/0.9664059
ThetaCM: 89.2

☒ plot
Transform:
☒ invert kinematics
Convert units:
☐ no
☒ rr->mb/sr
☐ mb/sr->rr
[View](#)
Example: [\[1\]](#) [\[2\]](#)

Legend:
X4 link to the dataset in EXFOR database retrieval system
+ search in EXFOR database the data of given reaction published by given author
mb Cross section, mb/sr
rr Ratio to Rutherford
ru Cross section, Relative Units
tot Cross section, mb
yield Yield, Ngamma/sr/uC

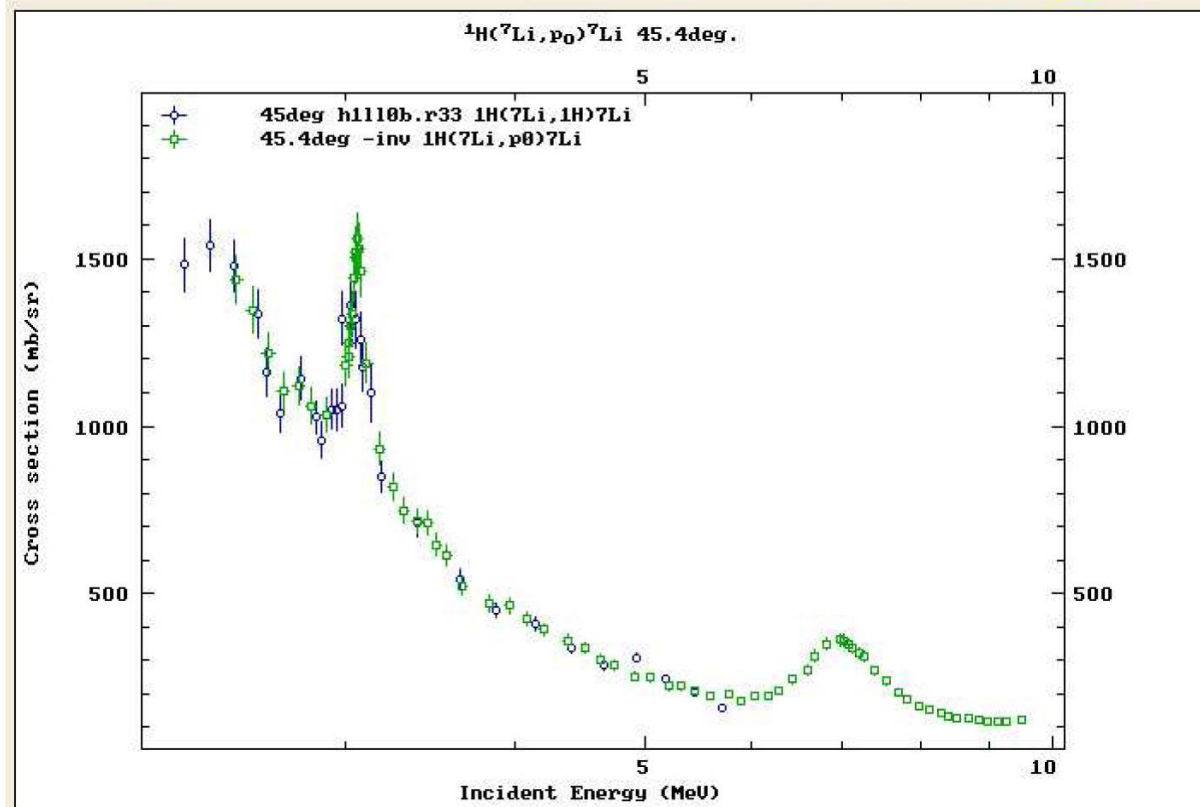
IBANDL contains angular distributions $d\sigma/d\Omega(\theta, E)$ for incident charged particle reactions

Welcome to Web-ZVView!

Interactive plotting of IBANDL and SigmaCalc data

1) $\theta=45^\circ$ $E_1=2.3-5.7\text{MeV}$ Source: Z. Siketic et al, Nucl. Instr. and Meth. B 229 (2005) 180 [+](#)

2) $\theta=45.4^\circ$ $E_1=2.5-9.5\text{MeV}$ Source: W.D.Warters+(1953), Jour. Physical Review, Vol.91, Issue.4, p.917 [\[inv\]](#) Original: ${}^7\text{Li}(p,p_0){}^7\text{Li}$ $E_1=0.4-1.4\text{MeV}$ $\phi=45.4^\circ$ $\theta=81.1^\circ$ [+](#)



Select data for plotting [\[all\]](#) [\[none\]](#)

☒ 1) 45deg h1110b.r33 1H(7Li,1H)7Li

☒ 2) 45.4deg -inv 1H(7Li,p0)7Li

☐ 3) Use my data [\[example\]](#)

See: [plotted data \(6Kb\)](#)

Details of
calculations

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](#)

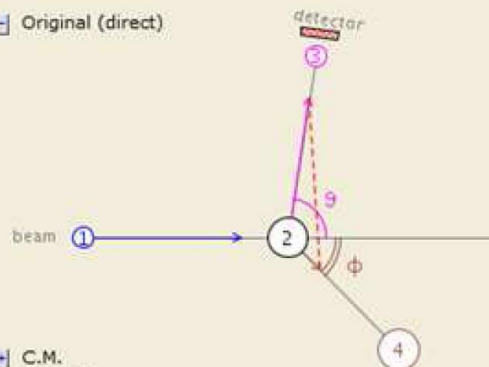
[Reset](#) [Repaint](#) ☒ Legend ☐ Authors ☐ Info+ [PostScript](#) Manual options: [\[+\]](#) Clipboard: [Copy](#) [Paste](#)

Shift legend: x=[0](#) y=[0](#) Split: [0](#) 1:xy;2:y Plot data or ratio: [0](#) 0:data; 1:ratio to dataset-1; 2:ratio to 2-nd, etc.

Data for plotting: [ZVD \(4Kb\)](#), [send](#) to ZVView; [download](#) ZVView; [upload](#) and plot your ZVD file

Inverse Kinematics in IBANDL

Original (direct)



Original (direct)

Reaction: ${}^7\text{Li}(p,p_0){}^7\text{Li}$ Qvalue=0 nPoint:71

M1: Incident p $M_1=1.007825$ $E_1=1367.0\text{keV}$

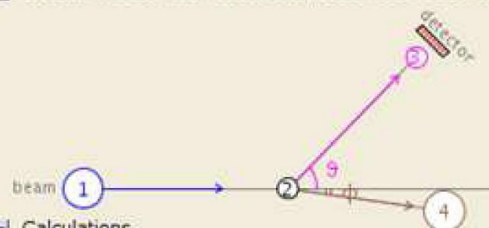
M2: Target ${}^7\text{Li}$ $M_2=7.0160046$

M3: Scattered p $M_3=1.007825$ $E_3=1070.6\text{keV}$ $\theta=81.1^\circ$ $\sigma(\theta)=45.1053\text{mb/sr}\pm 5.0\%$

M4: Recoil ${}^7\text{Li}$ $M_4=7.0160046$ $E_4=296.4\text{keV}$ $\varphi=45.4^\circ$

C.M.
Inverse

Result: inverse-kinematics data presented in R33 format



Result: inverse-kinematics data presented in R33 format

Reaction: ${}^1\text{H}({}^7\text{Li},p_0){}^7\text{Li}$ Qvalue=0 nPoint:71

M1: Incident ${}^7\text{Li}$ $M_1=7.0160046$ $E_1=9516.4\text{keV}$

M2: Target ${}^1\text{H}$ $M_2=1.007825$

M3: Ejectile p $M_3=1.007825$ $E_3=2061.1\text{keV}$ $\theta=45.4^\circ$ $\sigma(\theta)=122.484\text{mb/sr}\pm 5.0\%$

M4: Residual ${}^7\text{Li}$ $M_4=7.0160046$ $E_4=7455.3\text{keV}$ $\varphi=8.2^\circ$

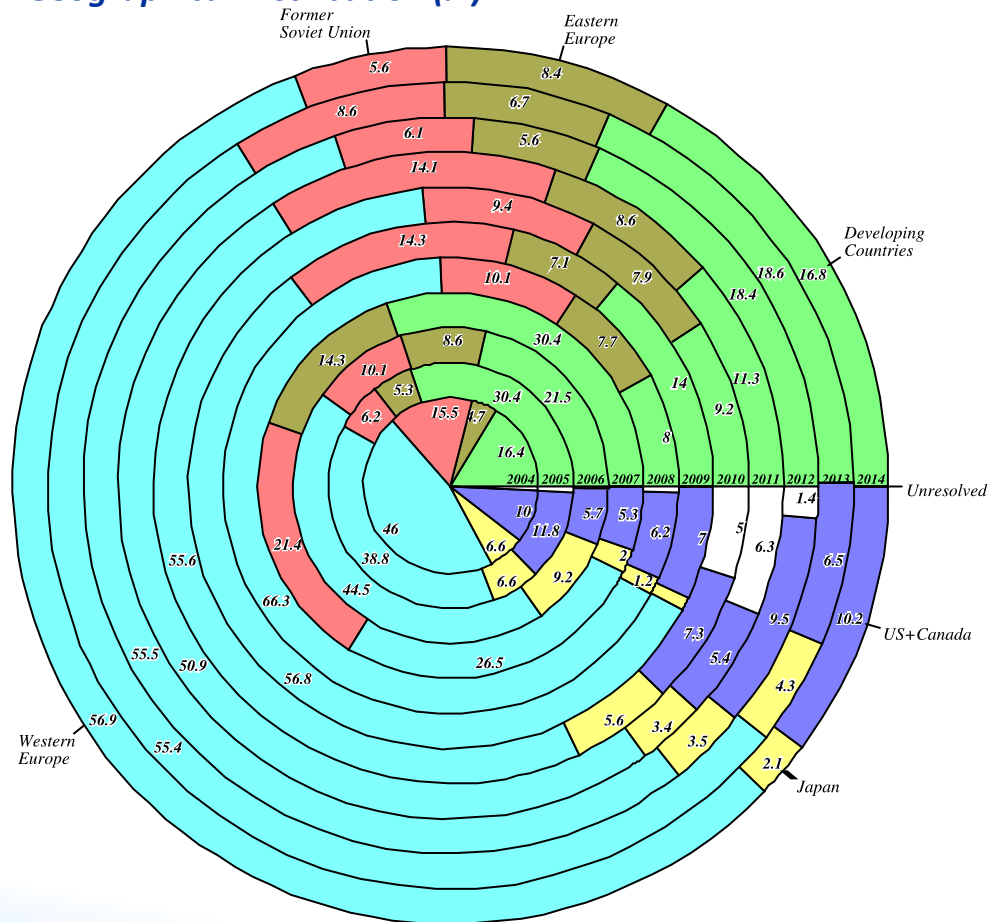
Calculations

#	Original (lab.): ${}^7\text{Li}(p,p_0){}^7\text{Li}$ Q=0							Center of mass							Inverse kinematics							
	E_1 , keV	θ°	$\sigma(\theta)$, mb/sr	φ	$\sigma(\varphi)$	E_3	E_4	E'_{cm}	θ'	φ'	$\sigma'(\theta')$	E'_1	E'_2	E'_3	E'_4	E_2''	φ''	$\sigma''(\varphi'')$	θ''	$\sigma''(\theta'')$	E_3''	E_4''
1	358.6	81.1	529.741	45.4	4.35366e6	280.851	77.7494	313.558	89.3	90.7	511.914	274.174	39.3842	274.174	39.3842	2496.4	45.4	1438.52	8.2	164261.	541.3	1955.2
2	368.3	81.1	497.427	45.4	4.08809e6	288.447	79.8525	322.04	89.3	90.7	480.687	281.591	40.4495	281.591	40.4495	2563.9	45.4	1350.77	8.2	154241.	555.9	2008.
3	378.5	81.1	450.076	45.4	3.69894e6	296.436	82.064	330.959	89.3	90.7	434.93	289.389	41.5698	289.389	41.5698	2634.9	45.4	1222.18	8.2	139559.	571.3	2063.6
4	388.2	81.1	407.779	45.4	3.35132e6	304.033	84.1671	339.441	89.3	90.7	394.056	296.805	42.6351	296.805	42.6351	2702.5	45.4	1107.33	8.2	126444.	585.9	2116.5
5	398.4	81.1	413.26	45.4	3.39637e6	312.021	86.3786	348.359	89.3	90.7	399.353	304.604	43.7553	304.604	43.7553	2773.5	45.4	1122.21	8.2	128143.	601.3	2172.1
6	407.1	81.1	391.875	45.4	3.22062e6	318.835	88.2649	355.967	89.3	90.7	378.687	311.256	44.7108	311.256	44.7108	2834	45.4	1064.14	8.2	121512.	614.5	2219.6
7	417.8	81.1	382.085	45.4	3.14016e6	327.215	90.5848	365.323	89.3	90.7	369.227	319.437	45.886	319.437	45.886	2908.5	45.4	1037.55	8.2	118476.	630.6	2277.9
8	432.2	81.1	435.468	45.4	3.57888e6	338.493	93.7069	377.914	89.3	90.7	420.813	330.446	47.4675	330.446	47.4675	3008.8	45.4	1182.52	8.2	135029.	652.3	2356.4
9	433.7	81.1	445.21	45.4	3.65895e6	339.668	94.0321	379.226	89.3	90.7	430.227	331.593	47.6322	331.593	47.6322	3019.2	45.4	1208.97	8.2	138050.	654.6	2364.6
10	434.2	81.1	461.032	45.4	3.78898e6	340.059	94.1405	379.663	89.3	90.7	445.517	331.976	47.6872	331.976	47.6872	3022.7	45.4	1251.94	8.2	142956.	655.4	2367.3
11	435.1	81.1	480.354	45.4	3.94778e6	340.764	94.3357	380.45	89.3	90.7	464.189	332.664	47.786	332.664	47.786	3029	45.4	1304.4	8.2	148948.	656.7	2372.2
12	437	81.1	493.156	45.4	4.05299e6	342.252	94.7476	382.111	89.3	90.7	476.56	334.116	47.9947	334.116	47.9947	3042.2	45.4	1339.17	8.2	152917.	659.6	2382.6

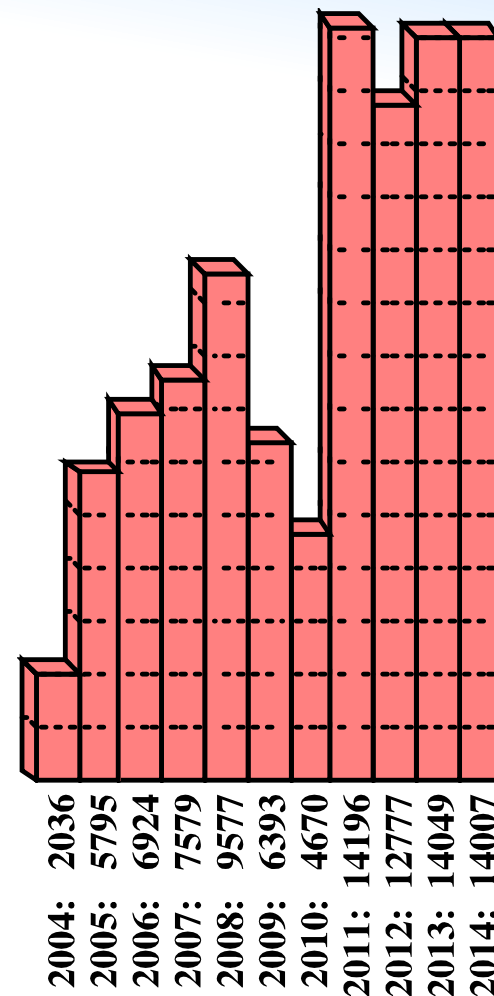
IBANDL Web Statistics

2004-2014

Geographical Distribution (%)



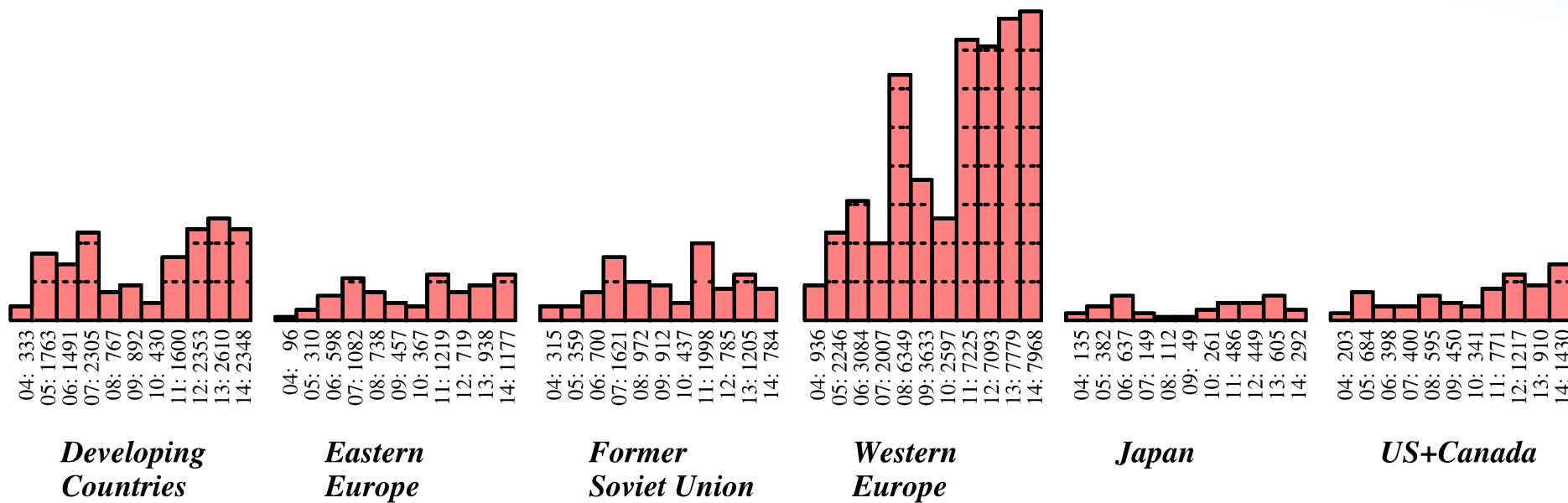
Total per Year*



Prepared by V.Zerkin, IAEA-NDS, 20-Apr-2015

IBANDL Web Statistics

Total per Year by Areas*



Prepared by V.Zerkin, IAEA-NDS, 20-Apr-2015

IBA Benchmarking Measurements

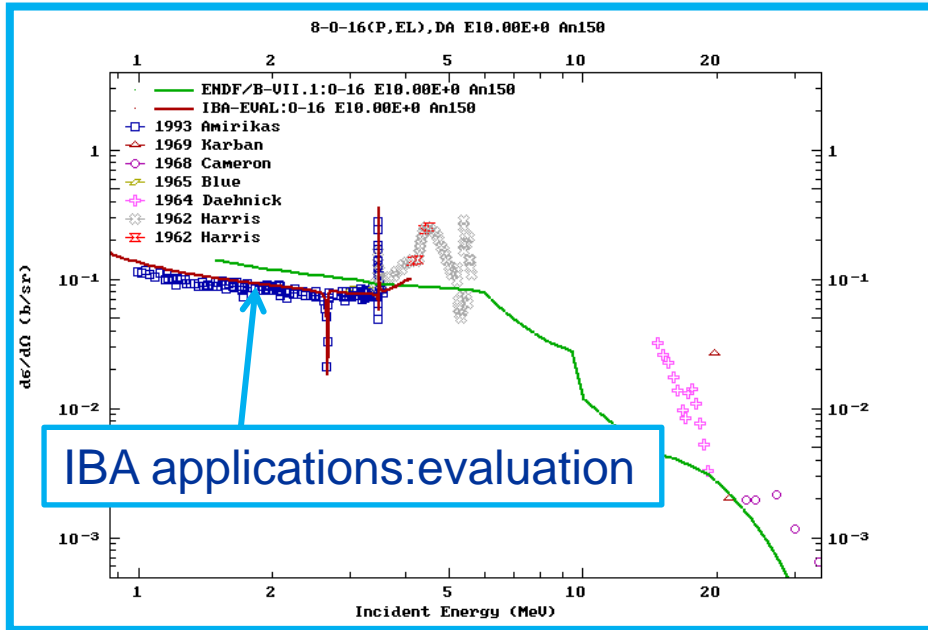
- IAEA Technical Meeting, 26-29 May 2015

Purpose

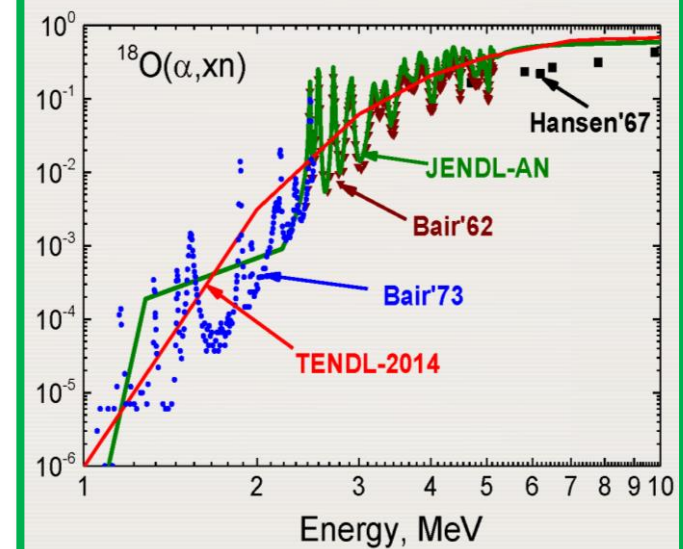
- Define methodology for benchmarking measurements
- Proposed Guidelines for EBS, NRA and PIGE
- Describe a Proficiency Benchmarking Measurement for EBS
- Produce a list of priority benchmark experiments for EBS, NRA and PIGE
- Data dissemination: benchmark data in IBANDL + calculational tools to produce thick-target spectra on-the-fly

Report: INDC(NDS)-0690

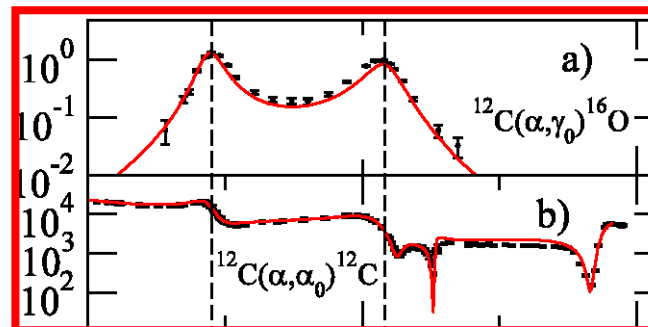
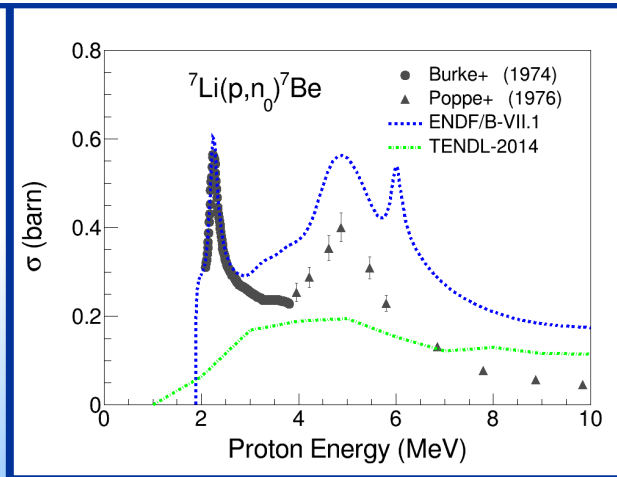
R-matrix Codes for Evaluation



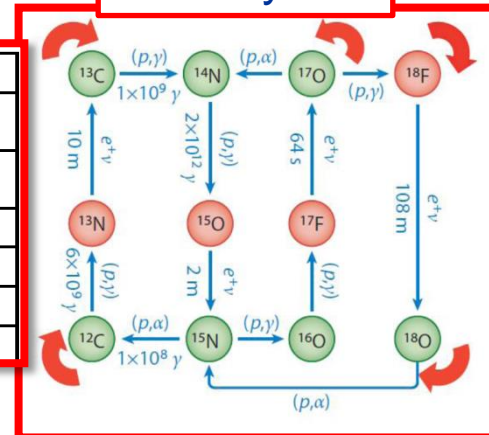
Spent fuel management: neutron production



$^7\text{Li}(p,n)^7\text{Be}$ reaction is a promising candidate for neutron source, e.g., BNCT, in a resonance range



CNO cycles



R-matrix Codes for Evaluation

- IAEA Consultant Meeting on R-matrix codes for Charged-particle Reactions in the Resolved Resonance Region, 7-9 Dec. 2015 ([INDC\(NDS\)-0703](#))

Purpose

- Compare existing R-matrix codes used in different fields of nuclear sciences (nuclear data evaluation, nuclear astrophysics, Ion Beam Analysis etc)
- Define a common platform for all the codes: input/output resonance parameters can be understood and used by all codes
- Propose a methodology for evaluation of cross-sections in the resolved resonance region followed by PIGE)
- Produce evaluated cross sections in ENDF-6, R33 and simple format for users in specific and broader scientific community
- Data dissemination

Presentations

#	Author	Title	Link
1	P. Dimitriou	Motivation-Background information; $p+^{27}\text{Al}$ using SAMMY	PDF
2	R.J. deBoer	AZURE2: An R-matrix Code for Nuclear Astrophysics	PDF
3	M. Paris	R-Matrix Analysis of Multichannel REaction Data with EDA	PDF
4	I.J. Thompson	Widening the Scope of R-matrix Methods	PDF
5	L. Leal	Brief descriptions about the SAMMY Code	PDF
6	A. Trkov	Charged-Particle Resonance Data in ENDF-6 Format	PDF
7	S. Kunieda	Present status of R-matrix code AMUR and analysis for ^8Be and ^{17}O systems	PDF

- 2nd CM on R-matrix codes for charged-particle reactions in the resolved resonance region, Dec. 2016
 - R-matrix codes: common platform for using input/output resonances
 - Evaluation methodology: statistical treatment, uncertainties
 - Evaluated data files: frozen version will be produced and made available (in various formats: R33, ENDF-6, ascii files)
- Thick-target yields from Benchmarking measurements:
 - Data will become available in IBANDL
 - On-the-fly calculations of thick-target yields for comparison
- Continuous maintenance and development of IBANDL



IAEA

60 Years

Atoms for Peace and Development

Thank you!

