核数据中的光核反应

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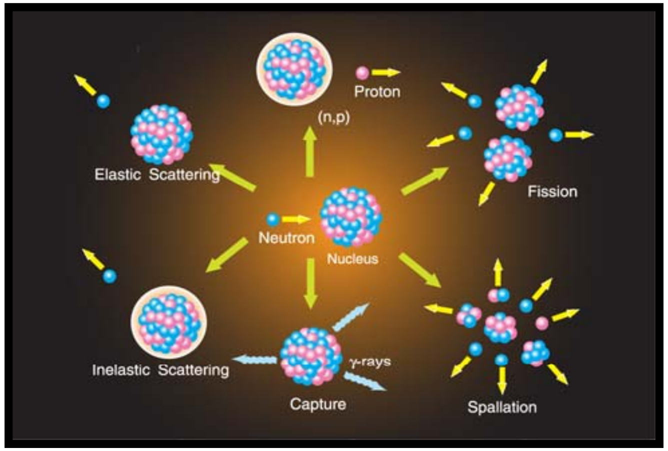
2016-06

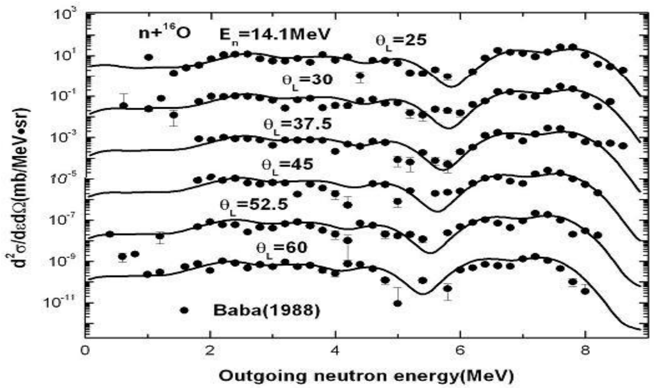
内 容

核数据通常可分为两类：

一、描述原子核与γ射线或与其他核相互作用性质的核反应数据。如全套中子反应数据、光子反应数据、带电粒子反应数据、裂变产额等

二、单个核基本性质的核结构与放射性衰变数据。如能级纲图、衰变数据、质量等等。

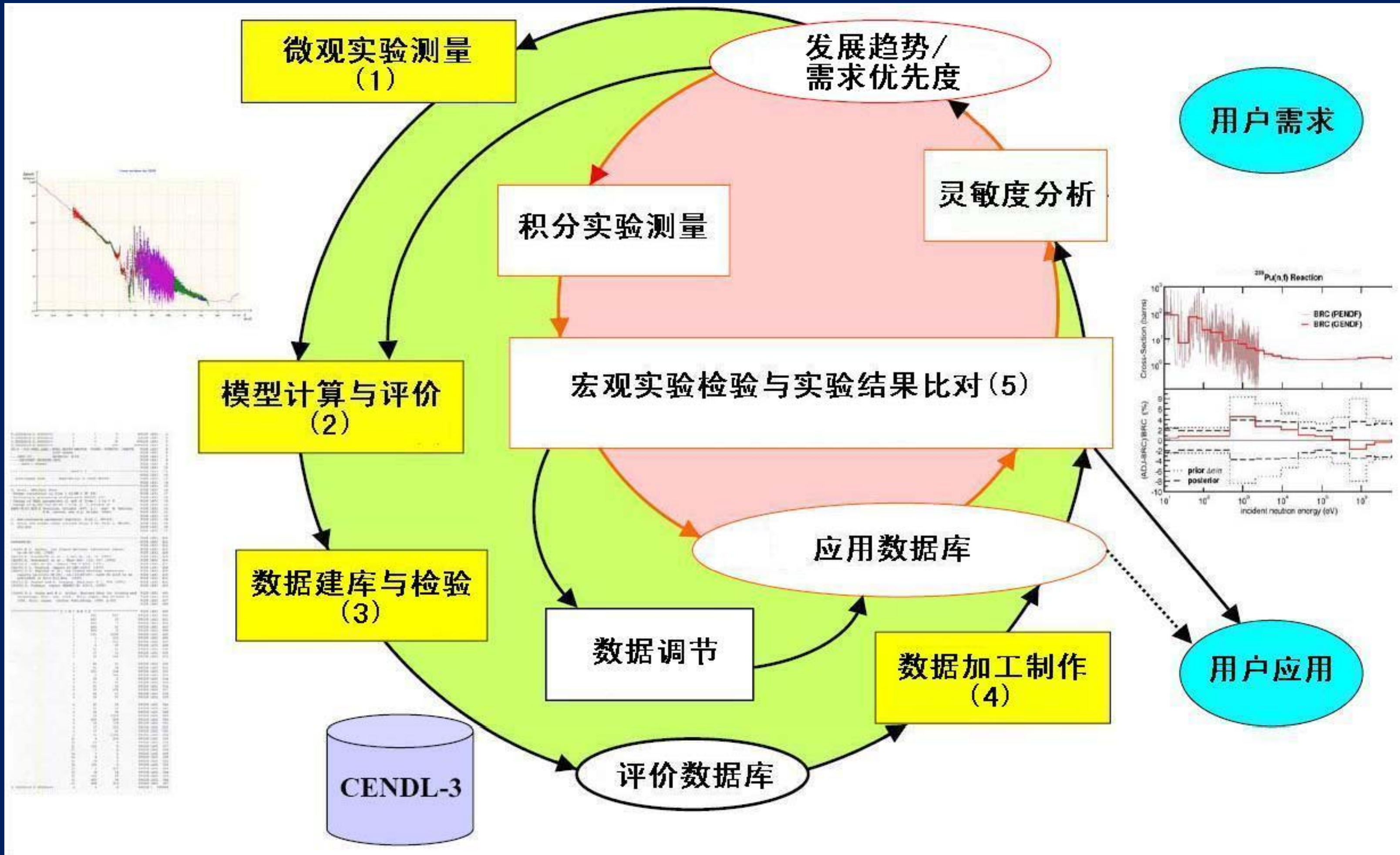




核数据：*核科学与工程应用*所需的基本数据；搭建了*核基础物理*与*核工程应用*的桥梁。

核数据制作流程

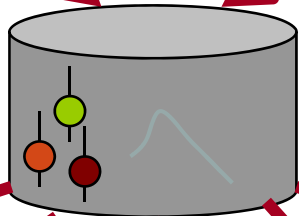
核数据产生流程示意图



用途广泛的核数据

数据测量
结构数据
反应数据
积分实验
……

模型理论
核反应、
核结构、质量
……



核数据库
- 实验核数据库
- 评价核数据库

专用数据库（WT库等）

科学研究:
核物理，
反应堆物理，
……

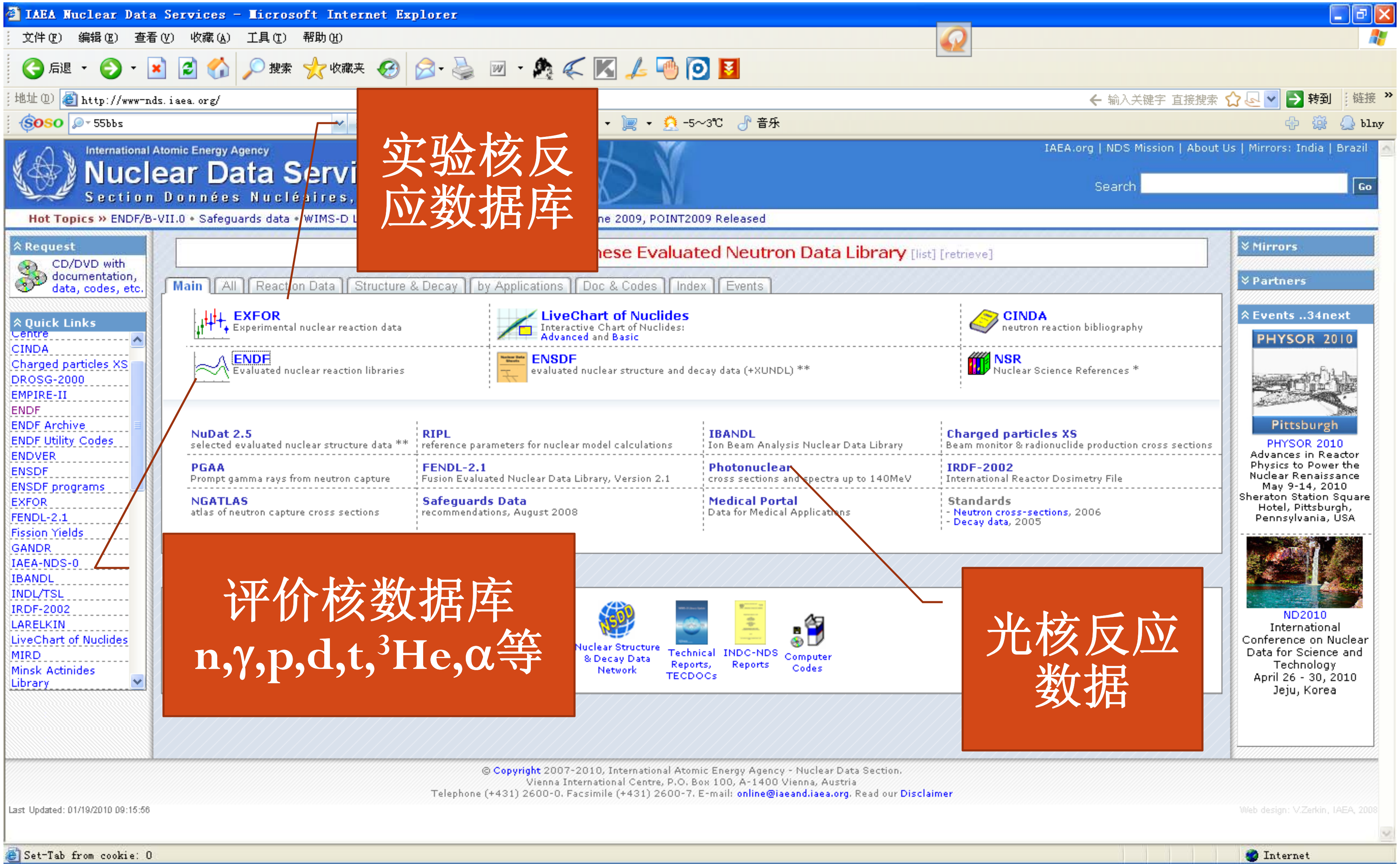
核技术应用:
核医学,
核探测技术，
……

核能发展:
核电发展,
核燃料循环,
……

国防建设:
设计,测试,维护贮存
核动力，
……

公众教育:
科普教育,
专业教育,
……

国际原子能机构核数据科IAEA/NDS（www-nds.iaea.org）

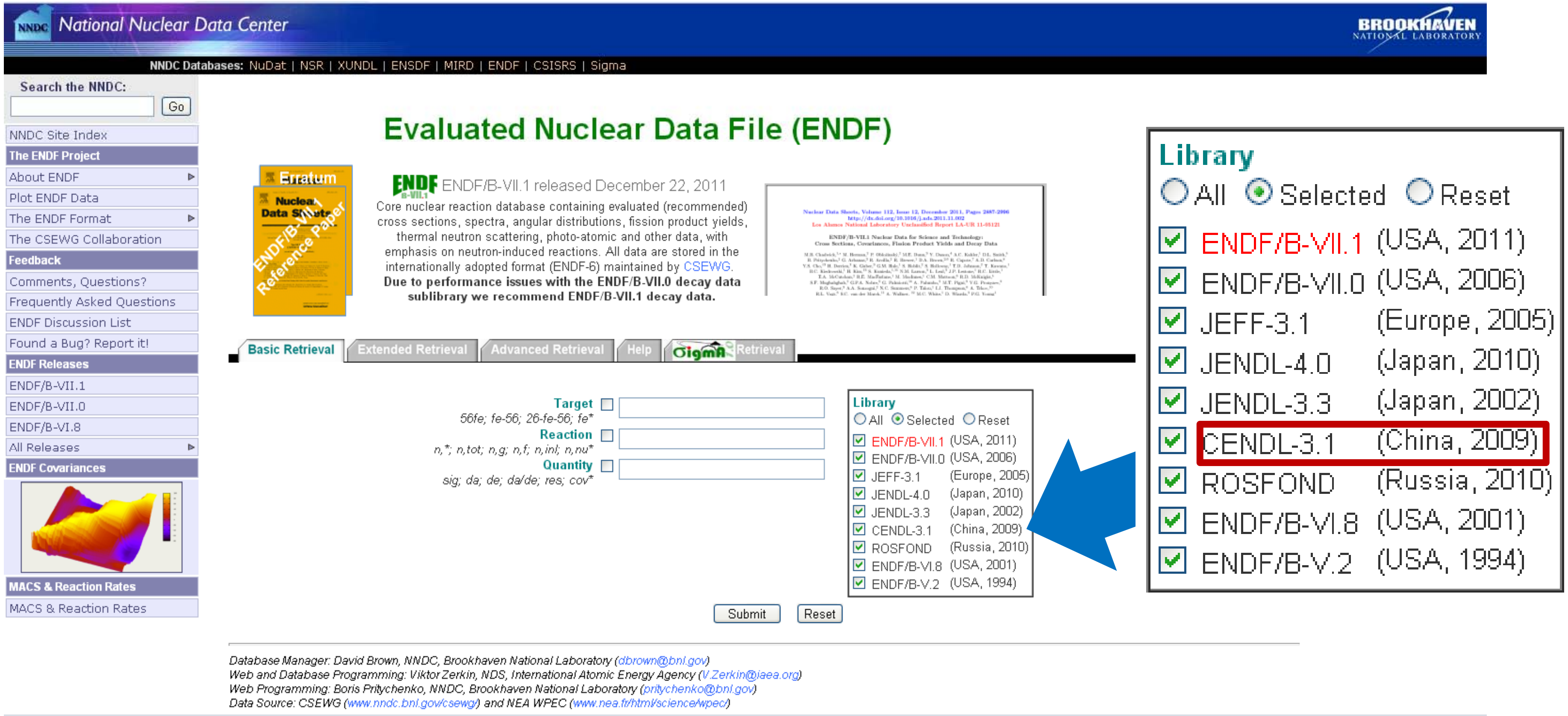


实验核反应数据库

评价核数据库 n,γ,p,d,t,^{3}He,α等

光核反应数据

中国CENDL库是目前国际公认的国际五大评价数据库之一



内 容

光核反应数据应用

1、加速器辐射安全相关

- 电子直线加速器屏蔽设计
- 安全剂量
- 活化材料的处理

2、医药诊断相关

- 高能γ射线治疗

3、核安全与防治核武器扩散相关

- 非摧毁性的核测试来探测易裂变材料

4、核嬗变

5、国防……

IAEA核数据科的*Simakov*研究员

Introduction: CRP on IRDFF validation and IRDFF database

《国际反应堆剂量与聚变库》的测试与改进研究中

IAEA CRP F41031 "Testing and Improving the International Reactor Dosimetry and Fusion File (IRDFF)":
https://www-nds.iaea.org/IRDFFtest/ (period 2013 – 2017)

RCM-2, 16 - 20 March 2015, Summary *Report INDC(NDS)-0682, page 15 (Actions):*

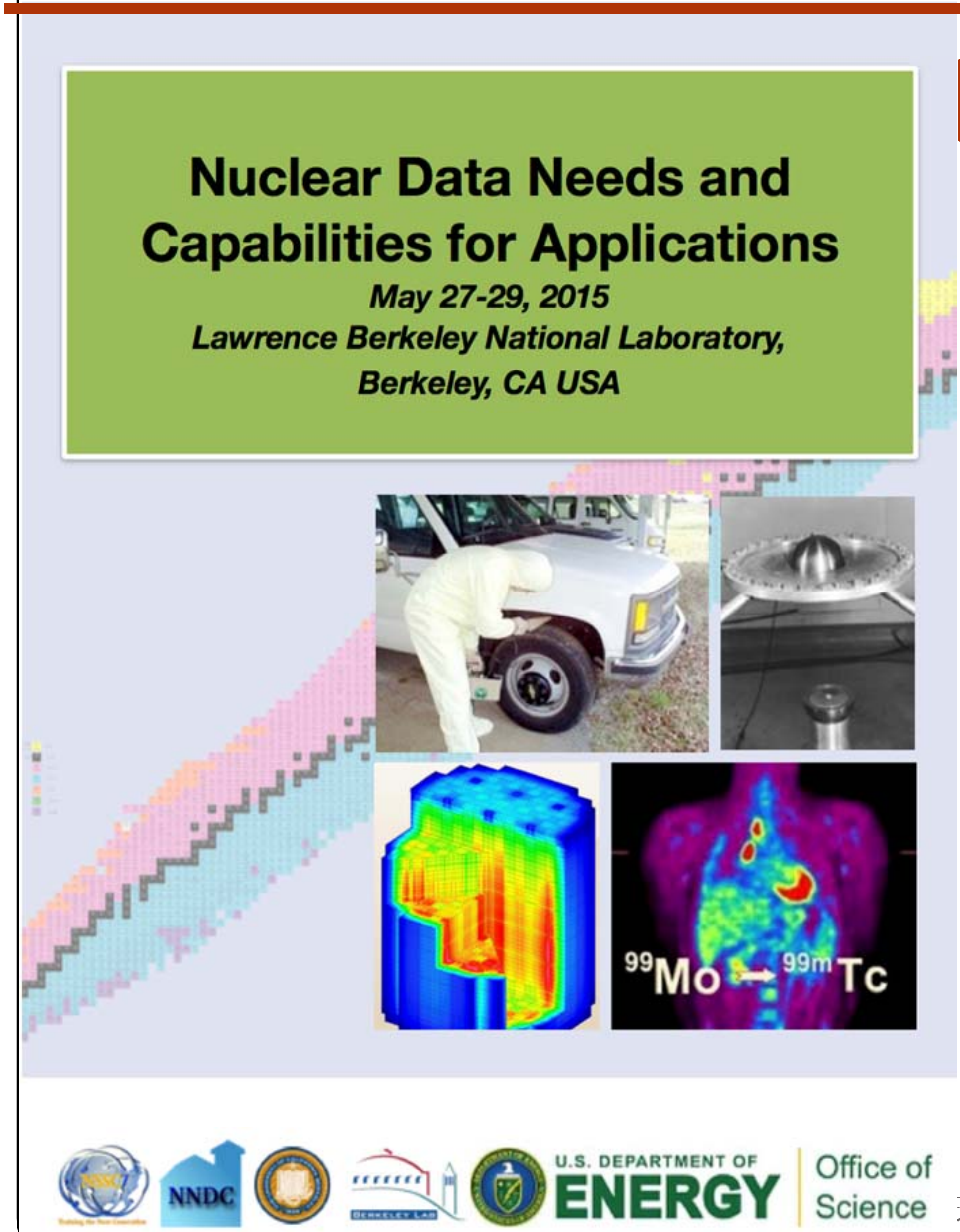
"There is a 15% discrepancy between the IRDFF and measured spectrum averaged cross section for $^{238}U(n,2n)$ in the ^{235}U thermal neutron field. The reason could be due to the contribution from the competing reaction (γ,n) which also leads to ^{237}U. A similar problem may exist with (n,fission) and photo-fission reactions for ^{238}U. Additional effort is needed to simulate such experiments and to determine how to properly use current nuclear data. Validation of photonuclear data on SINBAD benchmarks with MCNP will be done."

IAEA IRDFF database: https://www-nds.iaea.org/IRDFF/

IAEA

用于澄清关键核素中子数据分歧原因

光核反应数据应用



2015年美国核数据需求白皮书中提到：

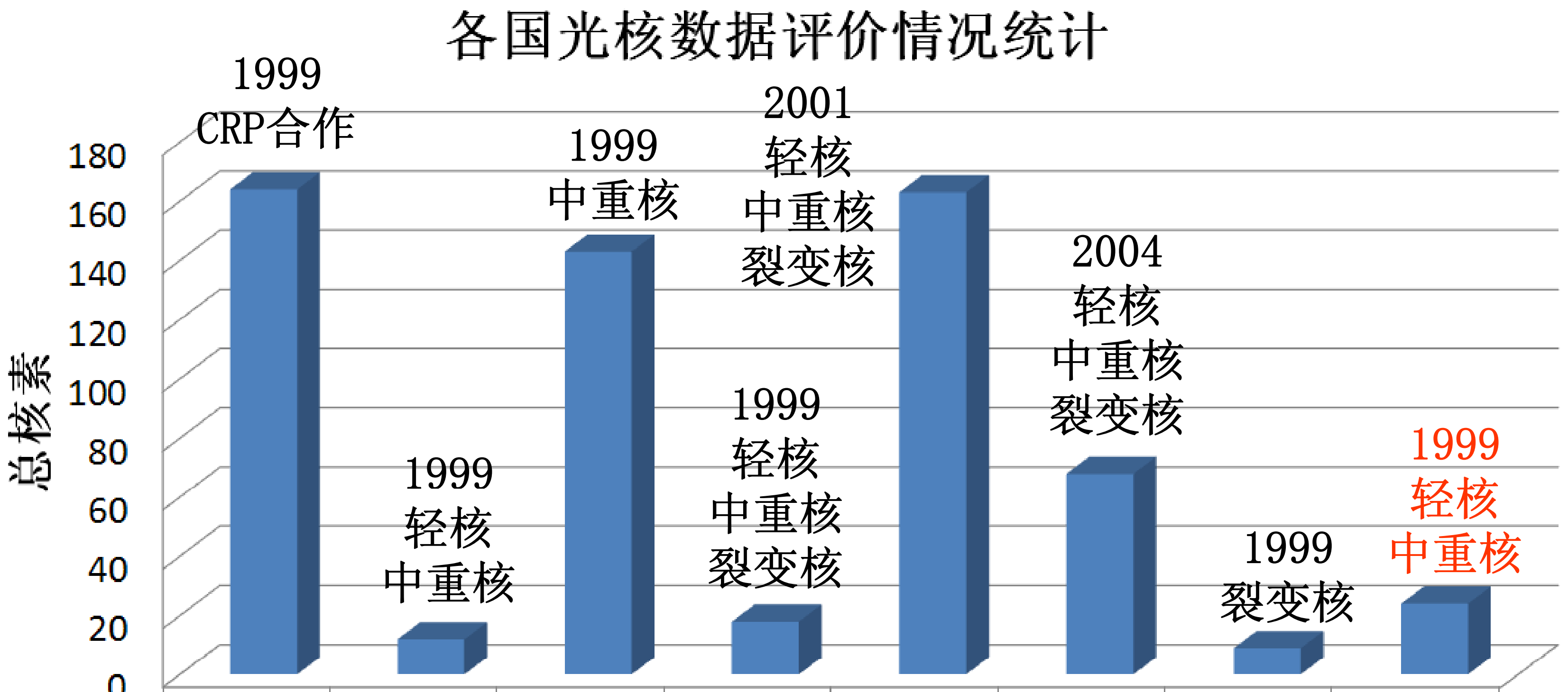
给出高能光子入射反应：

$^{68}Zn(\gamma,p)^{67}Cu$; $^{100}Mo(\gamma,n)^{99}Mo$;
$^{104}Pd(\gamma,n)^{103}Pd$; $^{124}Xe(\gamma,n)^{123}Xe$;
$^{232}Th(\gamma,f)^{99}Mo$; $^{238}U(\gamma,f)^{99}Mo$

A "third class" of facility discussed here is the High Intensity Gamma Source (HIGS), which produces monoenergetic photon beams through the use of a free electron laser: **This provides a unique capability for measuring (γ, γ') and (γ,n) cross sections.** ***These cross sections are needed for a number of national security applications, and were specifically called out as requiring additional measurement in the talks by Quiter and Cerjan.***

国防需求

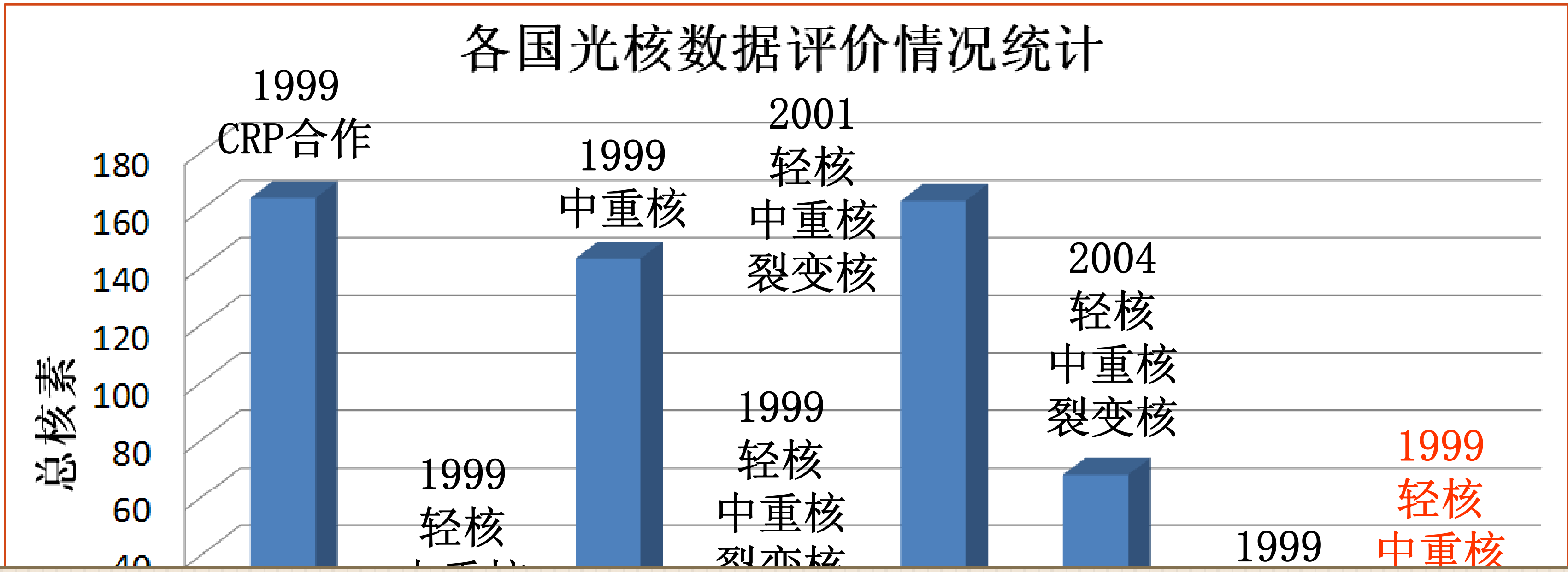
光核反应数据现状



	IAEA CRP1999	美国 LA-150	韩国 KAERI	日本 JENDL	美国 ENDF-VII	日本 JENDL-PD	俄罗斯 BOFOD	中国 CNDC
系列1	164	12	143	18	163	68	9	24

- ●俄罗斯国立大学（**MSU**）：**V.V.Varlamov** 评价大量核素与反应道的实验数据（ CDFE (Photonuclear Data Index at the Center for Photonuclear Experiments Data) ）
- ●荷兰（**TENDL-2014**）：**2629**个核素，^{6}**Li — 114-14-289**

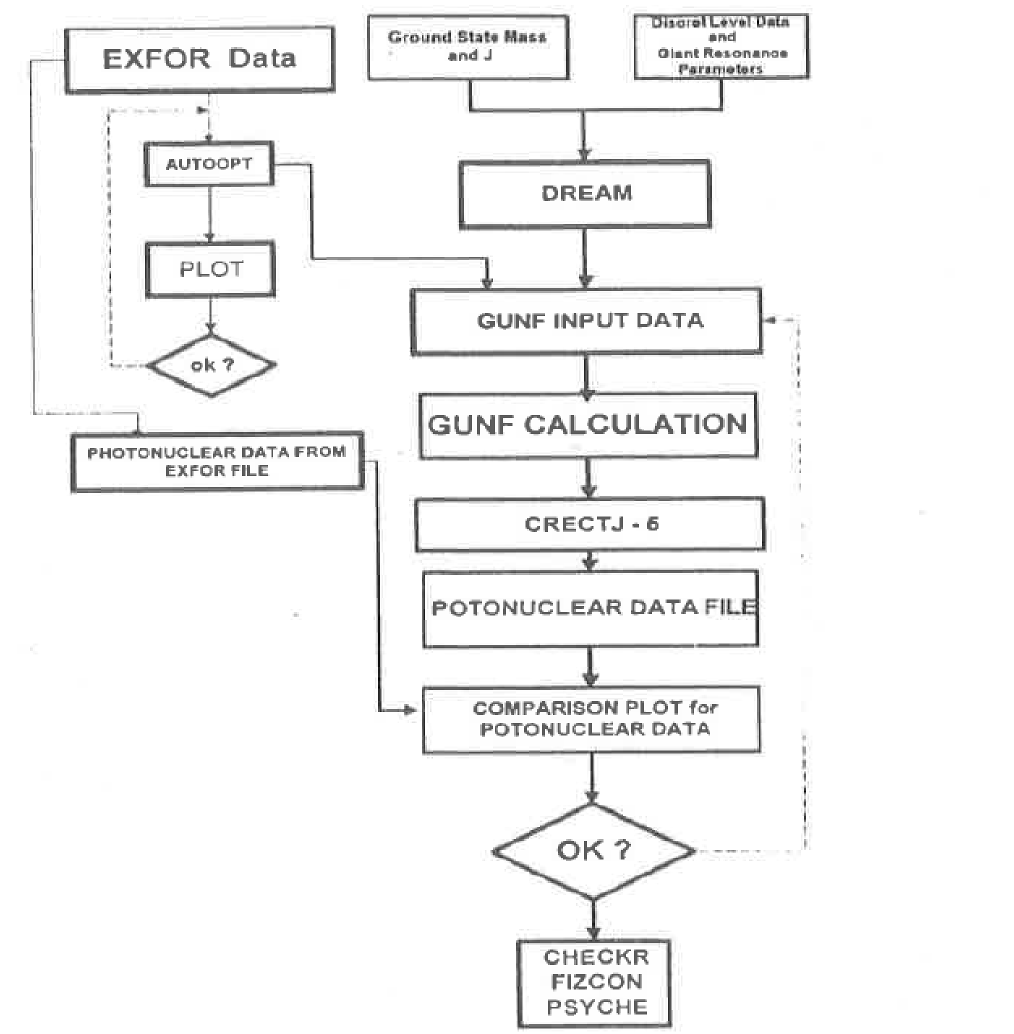
光核反应数据现状



- 国际各评价库中光核总量相比中子数据而言总量而很小，130多个核素（稀土区）的光核数据来自于理论计算，没有实验数据指导
- 我国光核数据研究从1999年后停滞，总量也与实际应用需求存在差距
- **俄罗斯学者Varlamov从1970's开始，对从^{6}Li到^{239}Pu的58个核素实验数据进行评价，推荐给出大量重要反应道的截面数据。经讨论提出，2005之前的光子中子测量大多存在问题，不建议考虑！（最高能量为50-60MeV）**
- 日本库评价结果在不断更新，今年9月即将释放181个核素版本的

光核反应数据现状

Schematic flow of evaluation for photonuclear data in previous CRP



CRP No.8833 (1996-1999)

主要参与人员:

张竞上, 于保生, 韩银录

中国库(up to 30MeV):

^{9}Be, ^{27}Al, ^{51}V, ^{50,52,53,54}Cr, ^{54,56,57,58}Fe, ^{63,65}Cu, ^{90,91,92,94,96}Zr, ^{180,182,183,184,186}W, ^{209}Bi

程序:

GLUNF(^{9}Be),

GUNF(中重核)

核反应:

(γ,abs),(γ,n), (γ,p), (γ,α), (γ,^{3}He), (γ,d), (γ,t), (γ,2n), (γ,np), (γ,nα), (γ,2p), (γ,3n)

数据类型:

反应截面（MF=3），能谱（MF=6）

光核反应数据现状

IAEA: 1996-1999年的光核反应CRP总结报告

Compilation and Evaluation of Photonuclear Data for Applications (1996 – 1999)

MF	MT	Quantity
1	451	Description and Dictionary
3	3	Photoabsorption cross section
3	4	Cross section for $(\gamma, 1n)$
3	16	Cross section for $(\gamma, 2n)$
3	17	Cross section for $(\gamma, 3n)$
3	50,51,...,66,...,91	Cross sections for partial excited states, from ground state to the highest state and continuum
3	102,...,107,111	Cross sections for (γ,γ), $(\gamma, 1p)$, $(\gamma, 1d)$, $(\gamma, 1t)$, $(\gamma, 1\ {}^3He)$, $(\gamma, 1\alpha)$ and $(\gamma, 2p)$
6	16,17,22,28,91	Double differential cross sections for $(\gamma, 2n)$, $(\gamma, 3n)$, $(\gamma, n\alpha)$, (γ, np) and $(\gamma, n$ continuum)

截面数据是首要关注点

(1) Evaluations are completely obtained based on the experimental data for ^{9}Be, ^{27}Al, ^{63,65}Cu, ^{51}V, ^{182,184,186}W, ^{209}Bi for MF=3: (γ, abs),(γ,2n), (γ,3n);

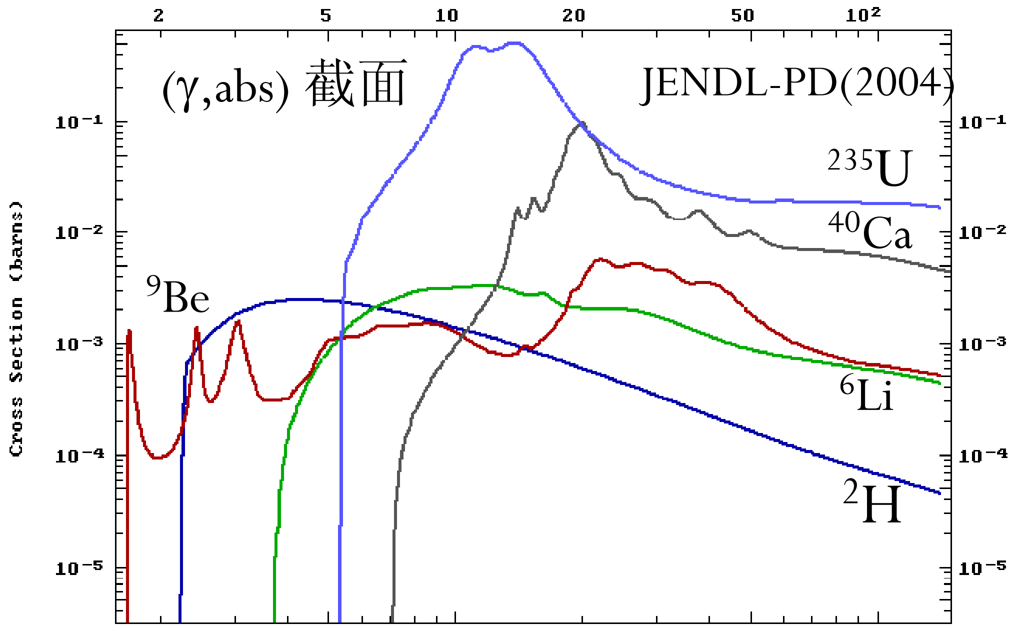
光核反应数据现状

File Structure: New JENDL/PD

2016版

- MF1: General Information
  - MT451: Descriptive data and Dictionary
  - MT452: Number of neutrons per fission
  - MT455: Delayed neutron data
  - MT456: Number of prompt neutrons per fission
- MF3: Reaction Cross Sections
  - MT3: MT5+MT18
  - MT5: Photo-absorption cross section
  - MT18: Fission cross section
- MF4: Angular distributions
  - MT18: Fission cross section
- MF5: Energy distributions
  - MT18: Fission cross section
  - MT455: Delayed neutron data
- MF6: Product energy-angle distributions
  - MT5: Production cross sections
    Energy-angle distributions of emitted particles

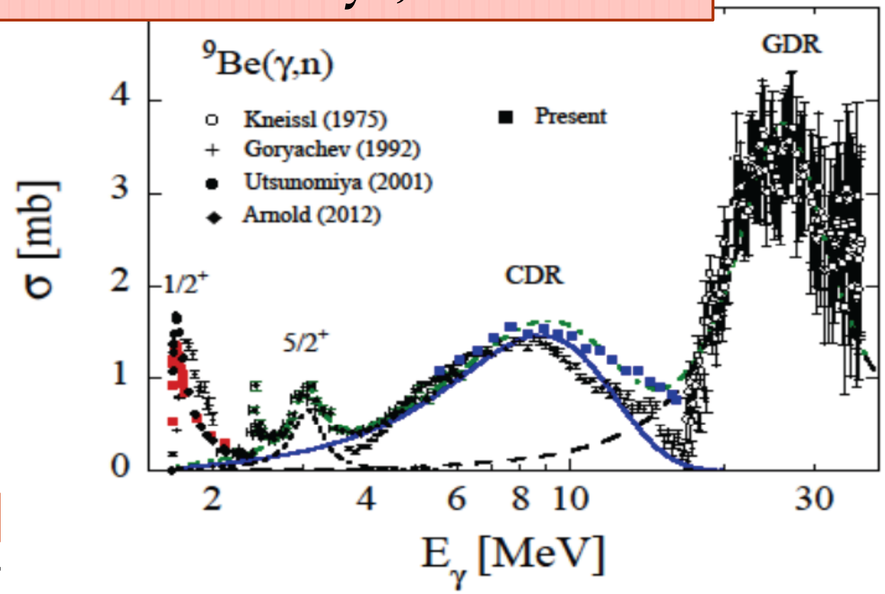
光核反应数据现状

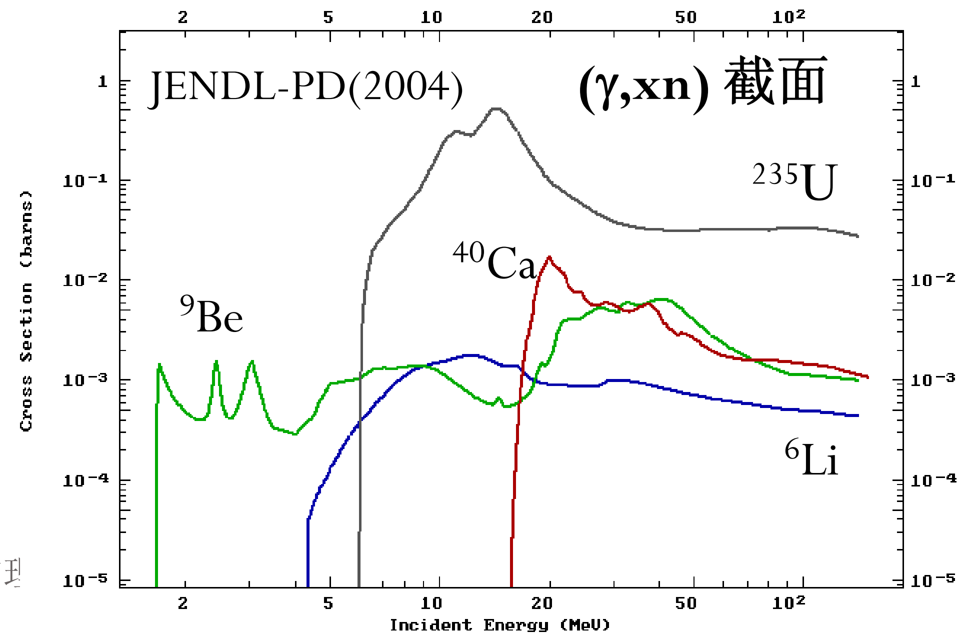


研究时需重点关注：

- 光子吸收截面
- 光子-中子截面
  （总截面 + 分截面）

2015 Utsunomiya, Konan 大学





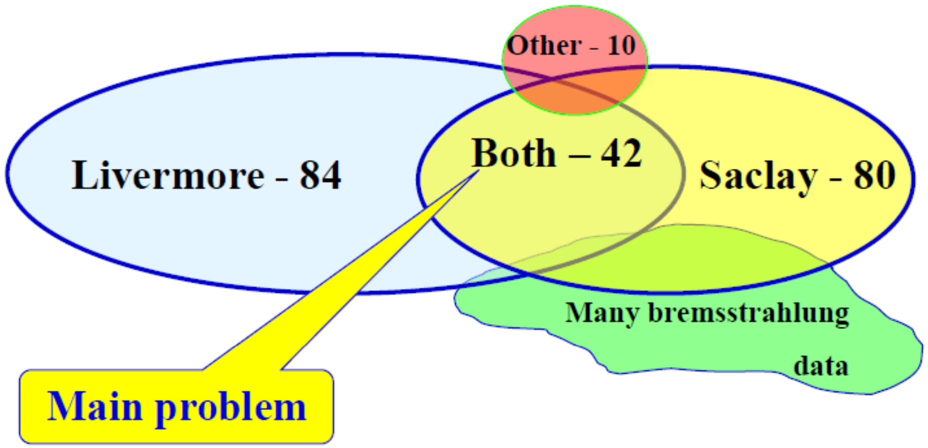
内　容

问题一：分光子中子截面测量分歧

俄罗斯学者V. Varlamov提出：GDR能区（γ能量在8-20MeV范围内）

Present situation of photoneutron cross sections data in the GDR region

- Most of the photoneutron cross section measurements were performed using quasi-monochromatic annihilation – QMA photons using positron in flight annihilation at two major facilities:
  - Saclay (France)
  - Lawrence Livermore National Laboratory (USA)
- Large discrepancies in (γ,xn) c.s. measured at the two facilities:
  - (γ, 1n) c.s. are generally noticeably larger at Saclay than at Livermore
  - (γ, 2n) c.s. are generally larger at Livermore than at Saclay.



No systematic way to resolve the discrepancies: <u>New and reliable measurements are required!</u>

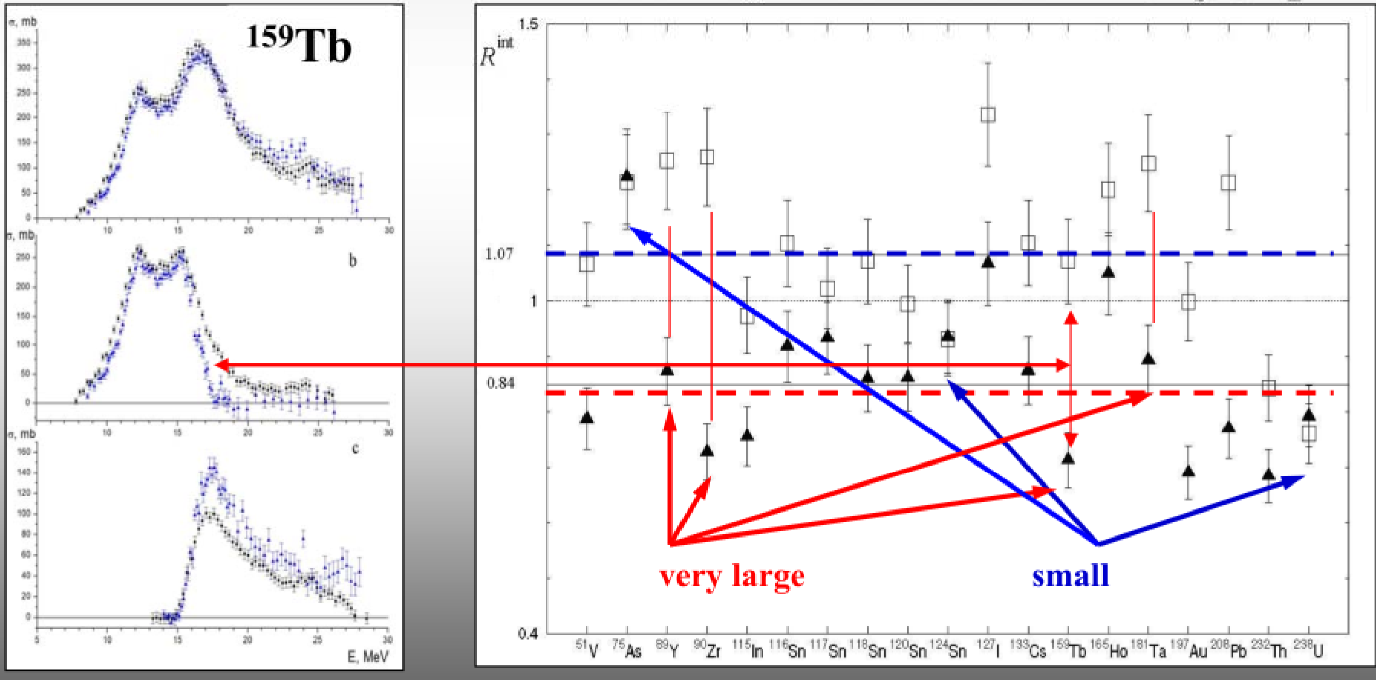
问题一：分光子中子截面测量分歧

Main problem for 19 nuclei investigated in both Labs:

(γ, 1n) cross sections are larger at Saclay but those for (γ, 2n) - at Livermore.

V.V.Varlamov, N.N.Peskov, D.S.Rudenko, M.E.Stepanov. Consistent Evaluation of Photoneutron Reaction Cross Sections Using Data Obtained in Experiments with Quasimonoenergetic Annihilation Photon Beams at Livermore (USA) and Saclay (France). INDC(CCP)-440, IAEA NDS, Vienna, Austria, 2004, p. 37.

Ratios of integrated cross sections $R^{int} = \sigma^{int}_S / \sigma^{int}_L$



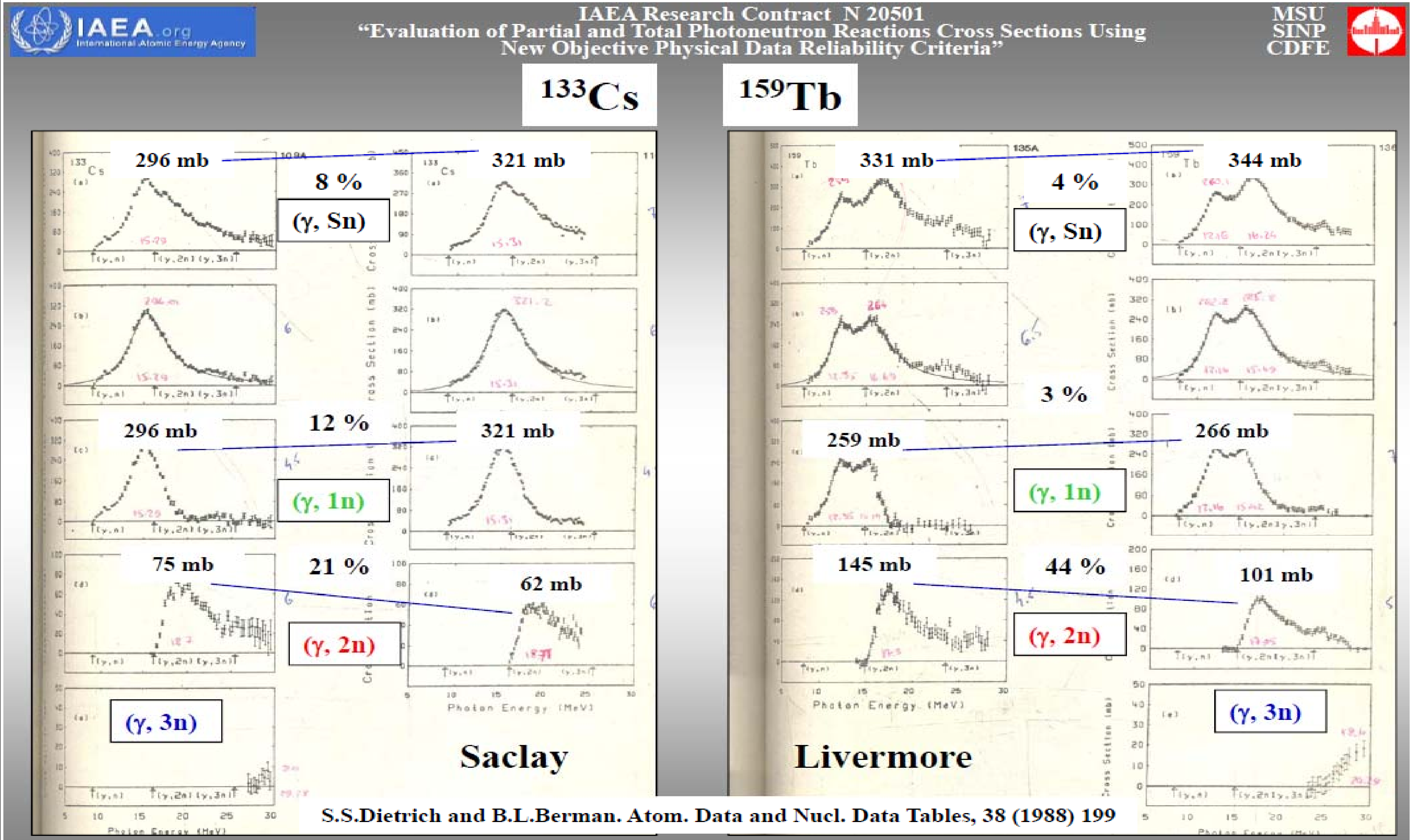
Squares - ■ - ratios for (γ, 1n) reactions – are larger than 1.0:

<R> ~ 1.07.

Triangles - △ - ratios for (γ, 2n) reactions – are smaller than 1.0:

<R> ~ 0.84.

问题一：分光子中子截面测量分歧



中国原子能科学研究院
中核集团 CHINA INSTITUTE OF ATOMIC ENERGY

问题一：分光子中子截面测量分歧

俄罗斯学者V.Varlamov提出：实验数据检验标准

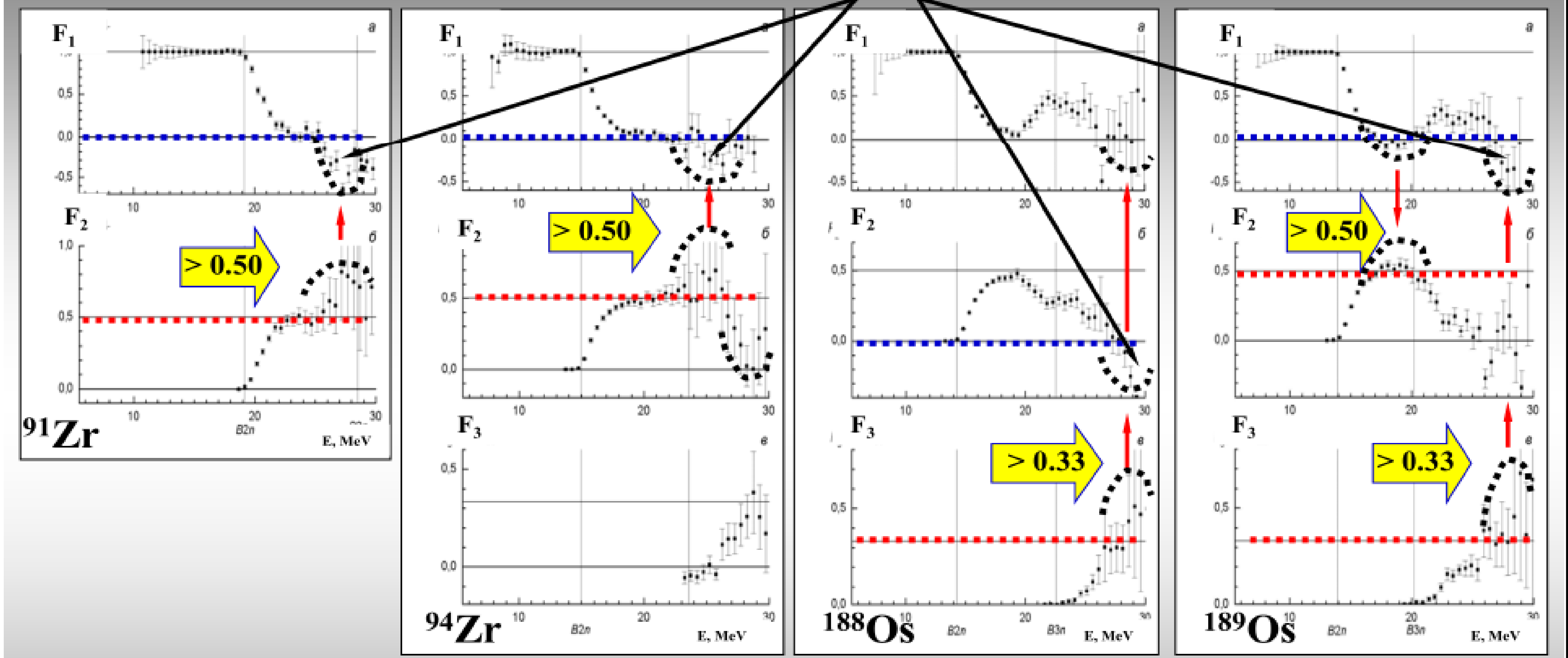
There are additional physically natural criteria:

$F_1 = \sigma(\gamma, 1n) \ / \ \sigma(\gamma, Sn) < 1.00$

$F_3 = \sigma(\gamma, 3n) \ / \ \sigma(\gamma, Sn) < 0.33$ etc.

More examples

Physically forbidden negative cross section values



The reliability of many data is doubtful.

Many data should be reanalyzed and re-evaluated!

问题一：分光子中子截面测量分歧

Possible reasons for clear systematic disagreements

The same neutron multiplicity sorting by neutron kinetic energy measurement was used in both Labs based on supposition that one neutron from (γ, 1n) reaction has energy larger than both neutrons from reaction (γ, 2n) but experimental methods for neutron energy measurements were different:

- at Saclay the large Gd-loaded liquid scintillator was used ("suffered from a high background rate, made up largely of 1n-events, which introduced larger uncertainties in the background subtraction and pile-up corrections" – citation from B.L.Berman and S.C.Fultz, Rev.Mod.Phys., 47, 713 (1975));

- at Livermore so-called "ring-ratio" method was used (concentric rings of counters in paraffin moderator): low-energy neutrons (from reaction (γ, 2n)) should have enough time for moderation in the way to inner ring but high-energy neutrons (from reaction (γ, 1n)) should go to the outer ring passing inner ring (due to multiple scattering high energy neutron could return to inner ring).

实验分歧原因初步分析

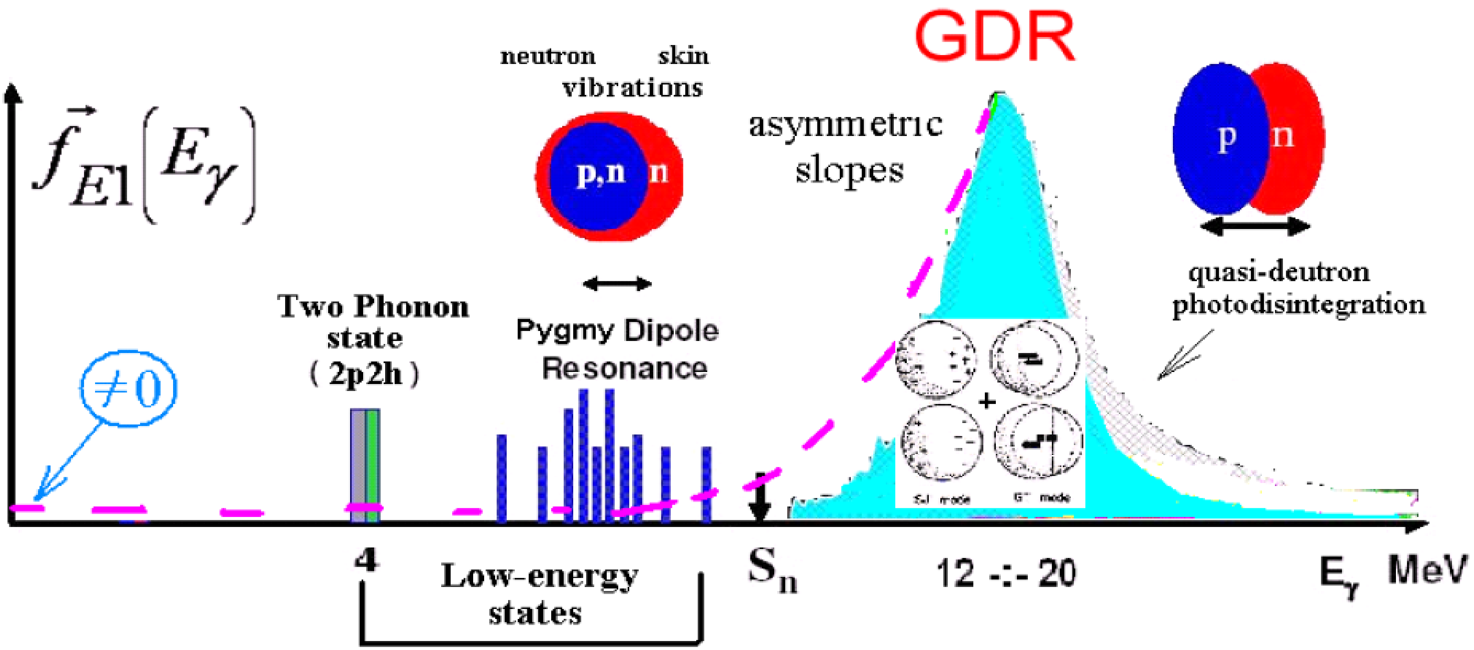
问题二：Eγ<Sn，PSF研究具有挑战

目前核数据理论工作考虑的主要贡献来自 E1（M1），根据情况再考虑：E2等。M1近年来也受到较多关注。

CLOSED-FORM MODELS OF E1 PSF

Dipole electric gamma-transitions are dominant ones, if they take place together with transitions of other multipolarities and types

Nuclear states excited by E1 field

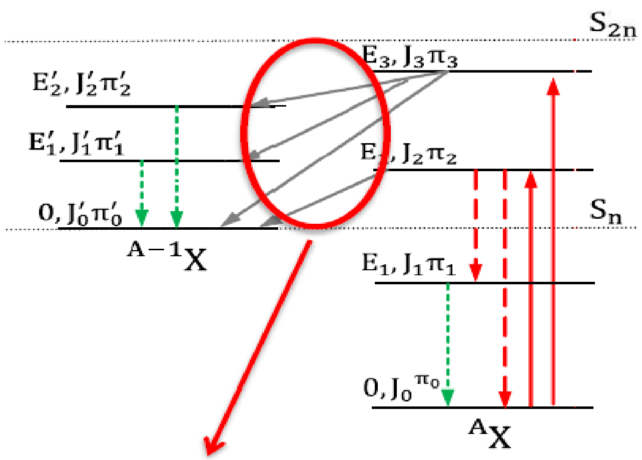


问题二：Eγ<Sn，PSF研究具有挑战

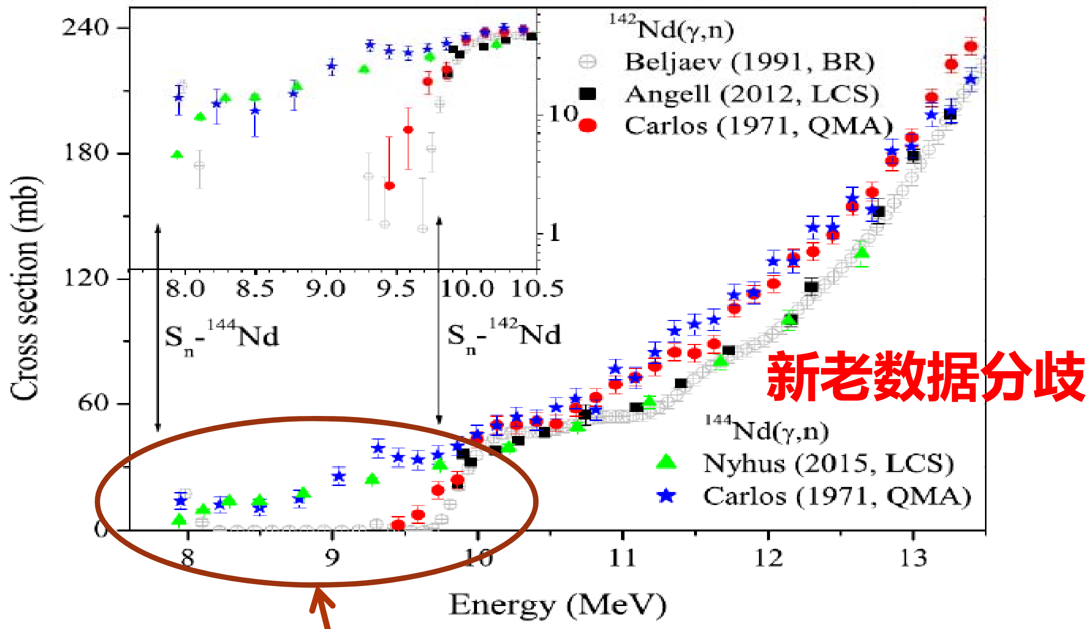
中核集团 CHINA INSTITUTE OF ATOMIC ENERGY 中国原子能科学研究院

For (γ,1n) cross sections – measurements using LCS γ-ray beam and the high efficiency neutron detector developed at GACKO offer the required precision and reliability

$E_\gamma < S_{2n} \Rightarrow (\gamma,1n)$



Average energy E_{avg} determined using the ring ratio method



Pgymy 共振产生机理之一：原子核中稳定核芯外的自由粒子相对核芯的运动引起的共振

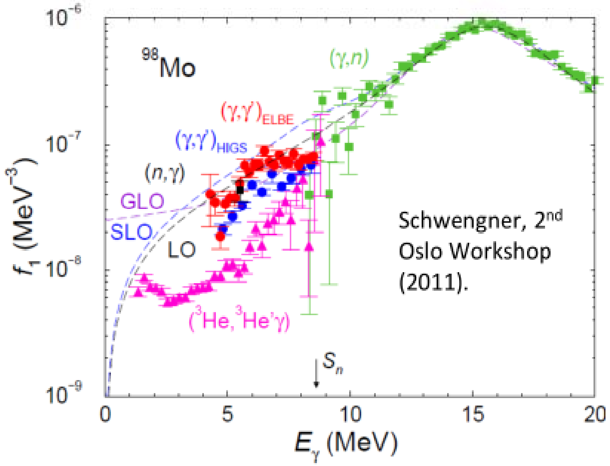
原子核壳效应影响

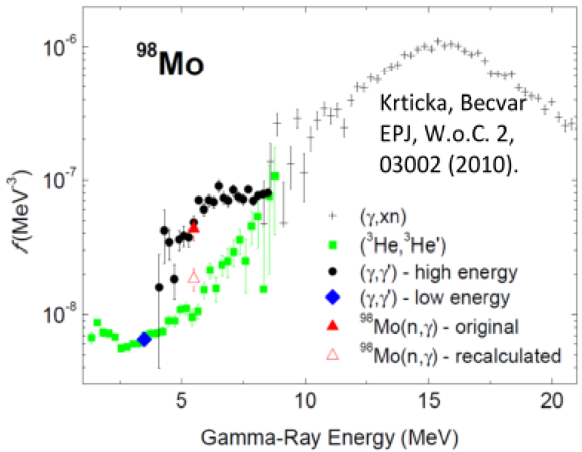
^{142}Nd： Z=60， N=82

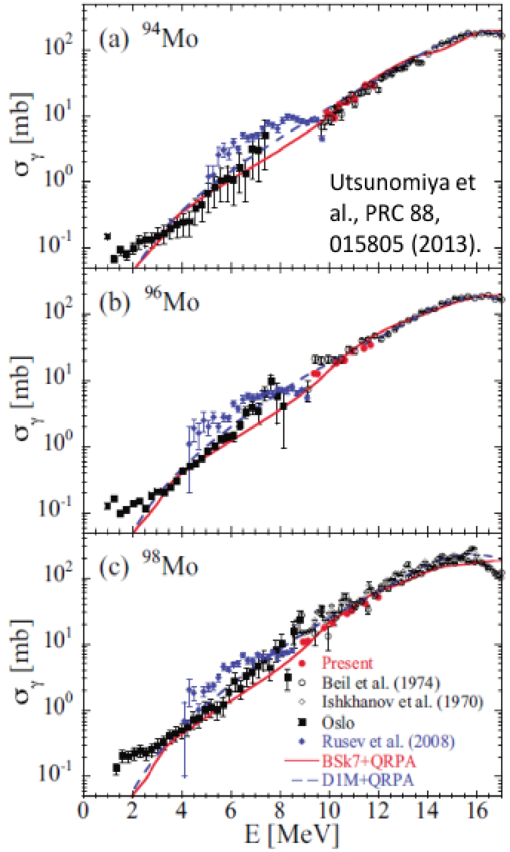
^{144}Nd： Z=60， N=84

问题二：Eγ<Sn，PSF研究具有挑战

Data Mismatch below S_n 数据存在分歧







- Inconsistencies between results of charged particle reaction results and (n,g) TSC but also mismatch between (γ,γ') (also between different (γ,γ') experiments.
- ELBE – HIGS Normalization problems?
- ELBE-CPR Normalization or measurement problems?
- Appropriate uncertainty estimates?
- Why the differences?

Mathis Wiedeking，iThemba LABS，南非

问题二：Eγ<Sn，PSF研究具有挑战

理论公式　Closed form PSF with response of GDR

Standard Lorentzian (SLO) *Brink(1955)& Axel(1962)*

Depressed Lorentzian (DLO) *Lane&Lynn(1960)*

Fermi liquid model (KFM) *Kadmensky, Markushev, Furman(1983)*

Enhanced Generalized Lorentzian (EGLO) *Kopecky& Uhl(1993)*

Hybrid model (GH) *Goriely (1998)*

Modified Lorentzian model (MLO) *Plujko et al (1999)*

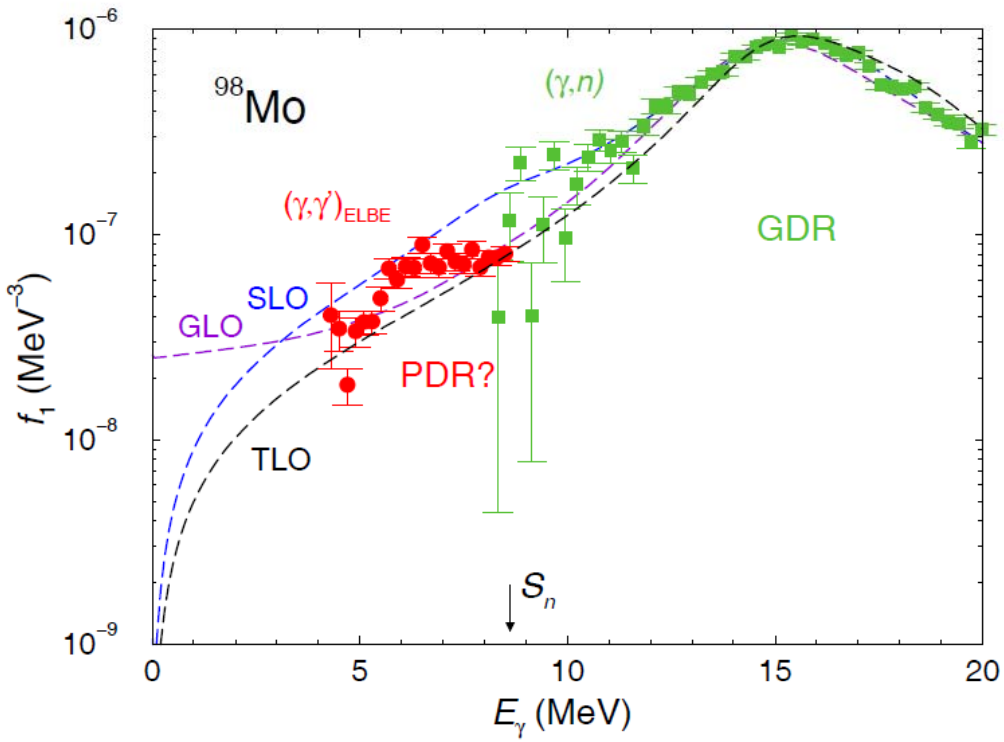
Generalized Fermi liquid model (GFL) *Mughabghab&Dunford (2000)*

Triple (triaxial) Lorentzian model (TL) *Junghans et al (2008)*

CNDC正在发展：基于RQRPA理论（Gogny力）的PSF研究工作，中重核区

问题二：Eγ<Sn，PSF研究具有挑战

Electric dipole strength in nuclei



Absorption cross section σ_γ

Dipole strength function
$f_1 = \sigma_\gamma / [3(\pi \hbar c)^2 E_\gamma]$

Standard Lorentz SLO
Generalized Lorentz GLO
Three-fold Lorentz TLO

Implications for reaction rates in astrophysics and nuclear technology?

中国原子能科学研究院 中核集团 CHINA INSTITUTE OF ATOMIC ENERGY

问题三：光核数据宏观检验未全面开展

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OECD BETTER POLICIES FOR BETTER LIVES

Nuclear science > Working Party on Scientific Issues of Reactor Systems (WPRS)

WPRS

WPRS Expert Groups

- Expert Group on Reactor Fuel Performance (EGRFP)
- Expert Group on Reactor Physics and Advanced Nuclear Systems (EGRPANS)
- Expert Group on Radiation Transport and Shielding (EGRTS)
- Expert Group on Uncertainty Analysis and Modelling (EGUAM)

Databases under WPRS

- International Fuel Performance Experiments (IFPE) database
- Shielding Integral Benchmark Archive

Radiation shielding

Shielding Integral Benchmark Archive and Database (SINBAD)

A new release of the radiation shielding experiments database (SINBAD) was issued in 2012. Currently the SINBAD database contains compilations for 46 reactor shielding, 31 fusion neutronics and 23 accelerator shielding experiments. This work is jointly carried out by the Radiation Safety Information Computational Center (RSICC) and the NEA Data Bank. Data for 100 experiments has been collected. The major emphasis has so far been on fission reactor shielding. Facilities used for measurements have now been closed down and there was an urgent need to preserve the data. Data for fusion blanket neutronics are also considered, the rest being made up of accelerator shielding experiments. More data sets are in the process of being identified for future release. Emphasis will be on quality of the experiments and new compilations will address cases not yet sufficiently covered by the present set.

Abstracts of the data compiled in SINBAD, can be found also in:

- SINBAD reactor shielding benchmark experiments
- SINBAD accelerator shielding benchmark experiments
- SINBAD fusion neutronics benchmark experiments

The database of shielding experiments (SINBAD) is hosted by the RSICC and is maintained as a basis for computer code, model and nuclear data

For more detailed information, consult the indices of the experiments sorted by shielding material, facility, originating establishment and summary descriptions of the SINBAD evaluations carried out at the NEA Data Bank. Further information can be requested through the Data Bank Computer Program Services (Search for 'SINBAD' or visit the abstract search list for SINBAD).

SATIF Expert Group Meetings

Information on meetings of the Shielding Aspects of Accelerators, Targets and Irradiation Facilities (SATIF) expert group are available here. A list server for e-mail discussion amongst SATIF members is also available. To join SATIF, send an e-mail to SATIF-request@oecd-nea.org .

美国核临界安全手册的最高版本我们无法获取，SINBAD目前仍对我国存在技术封锁，相关宏观检验中子泄露、γ泄露等）实验数据虽多次申请，但仍未果，需要开展我国自己的实验工作。

24

问题四：其他

The IAEA Co-ordinated Research Project on Compilation and Evaluation of Photonuclear Data for Applications (1996 – 1999):

- Evaluations for 164 isotopes of 48 elements (from ^{2}H to ^{241}Pu);
- Various nuclear modeling codes
  - GNASH (Los Alamos),
  - ALICE-F and MCPHOTO (Tokai),
  - GUNF and GLUNF (Beijing),
  - XCFISS (Obninsk);
- Initial experimental data - photoabsorption cross sections

$$\sigma(\gamma, abs) = \sigma(\gamma, 1n) + \sigma(\gamma, 1n1p) + \sigma(\gamma, 2n) + \sigma(\gamma, 2np) + \sigma(\gamma, 3n) + \ldots + \sigma(\gamma, F) + \sigma(\gamma, 1p) + \sigma(\gamma, 1d) + \sigma(\gamma, 1d1p) + \ldots + \sigma(\gamma, 1\alpha) \approx \sigma(\gamma, tot) + \sigma(\gamma, \text{charged particles});$$

- In many cases $\sigma(\gamma, tot)$ were used instead of $\sigma(\gamma, abs)$; evaluations have been done in order to model accurately experimental $\sigma(\gamma, tot)$ data;
- Calculation the $(\gamma, 1n)$, $(\gamma, 2n)$, etc. excitation functions, and comparison against available data.
- Calculated results were converting into the ENDF format.

问题四：其他

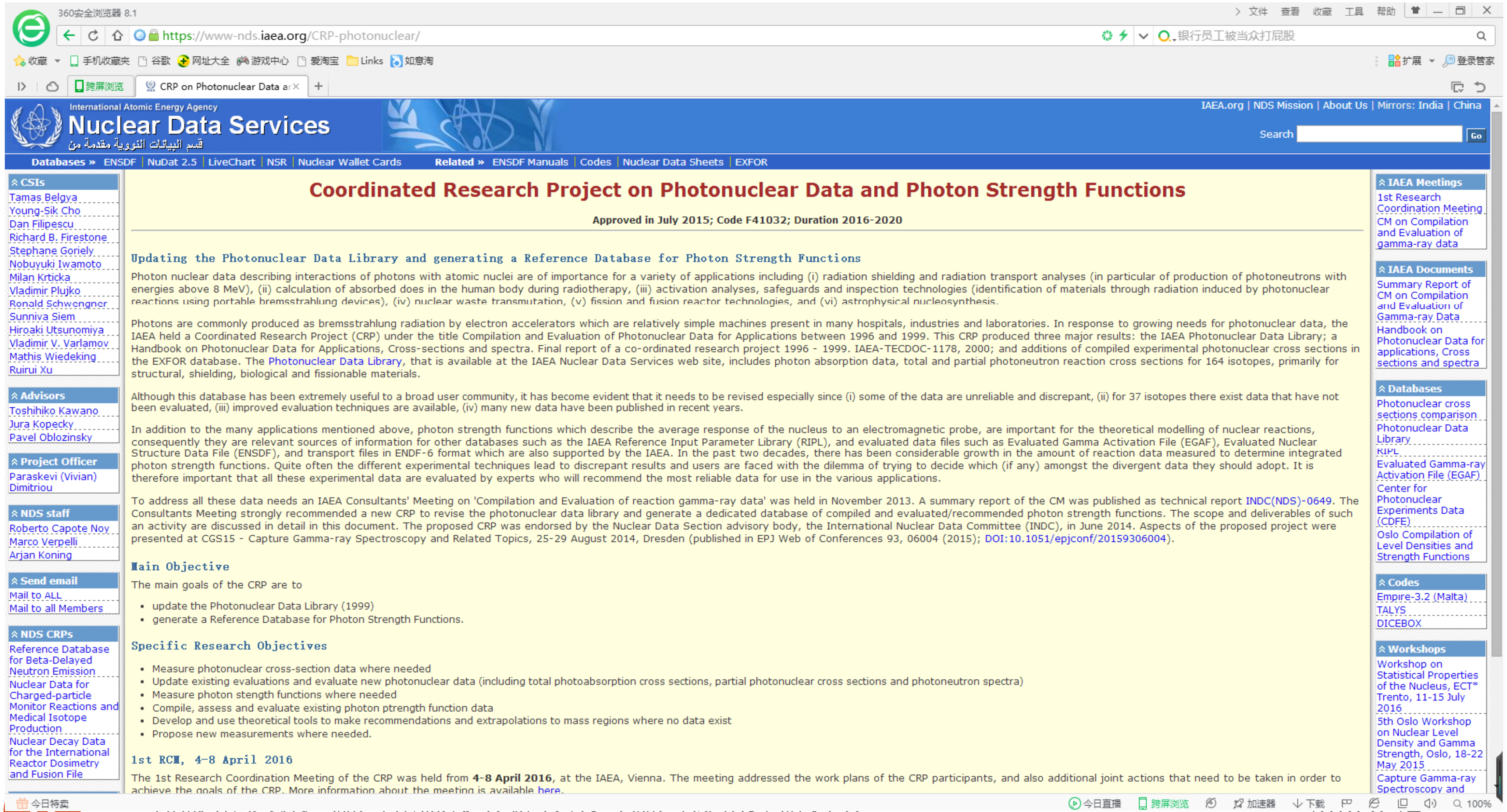
Some needs for updating previous CRP evaluations:

1. In many cases σ(γ, tot) was used instead of σ(γ, abs) - systematic errors in σ(γ, tot) are noticeable and different for different nuclei;
2. In many cases evaluations have been done in order to model accurately experimental data which are not satisfied new data reliability criteria;
3. Some experimental data have been obtained after 2000 year using alternative methods disagree with multiplicity sorting method data;
4. Some new advanced theoretical models have been developed till now;
5. Evaluations have not been done (though experimental data exist in EXFOR library) for 37 isotopes for which data are needed not only for applications but for basic research (not only nuclear physics but nuclear astrophysics, etc.) also:

   ^{3}H, ^{3}He, ^{6,7}Li, ^{10,11}B, ^{14}C, ^{19}F, ^{45}Sc, ^{75}As, ^{76,78,80,82}Se, ^{89}Y, ^{103}Rh, ^{115}In, ^{138}Ba, ^{139}La, ^{140,142}Ce, ^{142,143,144,145,146,148,150}Nd, ^{153}Eu, ^{160}Gd, ^{175}Lu, ^{186,188,189,190,192}Os, ^{237}Np.

内 容

IAEA发起了新一期CRP合作 (2016-2020)



IAEA发起了新一期CRP合作 (2016-2020)

International Atomic Energy Agency
Nuclear Data Services

Databases » ENSDF | NuDat 2.5 | LiveChart | NSR | Nuclear Wallet Cards Related » ENSDF Manuals | Codes | Nuclear Data Sheets

CSIs
Tamas Belgya
Young-Sik Cho
Dan Filipescu
Richard B. Firestone
Stephane Goriely

Coordinated Research Project on Photo

Approved in July 2015; C

The 1st Research Coordination Meeting of the CRP was held from **4-8 April 2016**, at the IAEA, Vienna. The meeti
achieve the goals of the CRP. More information about the meeting is available here.

我们在国内现有的研究基础上，开展模型理论方法学上的改进，以及对光核数据的更新。

- **28个核素（增加了4个轻核）**
- **核理论工作（~200MeV），已初步完成MEND程序中光核反应的研制**
- **基于新设备与方法的实验数据的评价工作**
- **国际交流**

CNDC参与
编号：20466

IAEA
Atoms For Peace

الوكالة الدولية للطاقة الذرية
国 际 原 子 能 机 构
International Atomic Energy Agency
Agence internationale de l'énergie atomique
Международное агентство по атомной энергии
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E-mail: Official.Mail@iaea.org • Internet: http://www.iaea.org

IAEA Research Contract No: 20466

Research Contract

This Research Contract is entered into between the International Atomic Energy Agency (hereinafter referred to as the "IAEA"), an intergovernmental organization established by its Statute, whose address is Vienna International Centre, P.O. Box 100, 1400 Vienna, Austria; and the China Institute of Atomic Energy CIAE (hereinafter referred to as the "Contractor") whose address is:

China Institute of Atomic Energy CIAE
PO Box 275-59
102413 Beijing
China.

Hereinafter, the IAEA and the Contractor will also be referred to individually as a "Party" and collectively as the "Parties"

Whereas, the IAEA is authorized under its Statute and the decisions of its competent organs to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world, and this mandate includes the encouragement and assistance to research on, and the development of, practical applications of atomic energy for peaceful purposes throughout the world by, inter alia, entering into contracts for research and development; and

Whereas, the Contractor is able and willing to carry out the Research Project in cooperation with the IAEA under this Research Contract (hereinafter referred to as the "Contract").

Now, therefore, the Parties hereby agree as follows:

Article 1
Scope of the Research Project

1. The Contractor undertakes to perform the Research Project entitled "Calculation and Evaluation of Photonuclear Cross Sections and Y-Ray Strenght Functions for Light and Medium Heavy Nuclei" (hereinafter referred to as the "Research Project") which forms a part of the IAEA's Coordinated Research Project "F41032", entitled "Updating Photonuclear Data Library and Generating a Reference for Photon Strength Functions".

2. The Chief Scientific Investigator shall be Ms Ruirui Xu.

3. The programme of work to be performed under this Research Project shall be:

28 nuclei are planned to involve in this CRP (nuclei in red are in this contract):

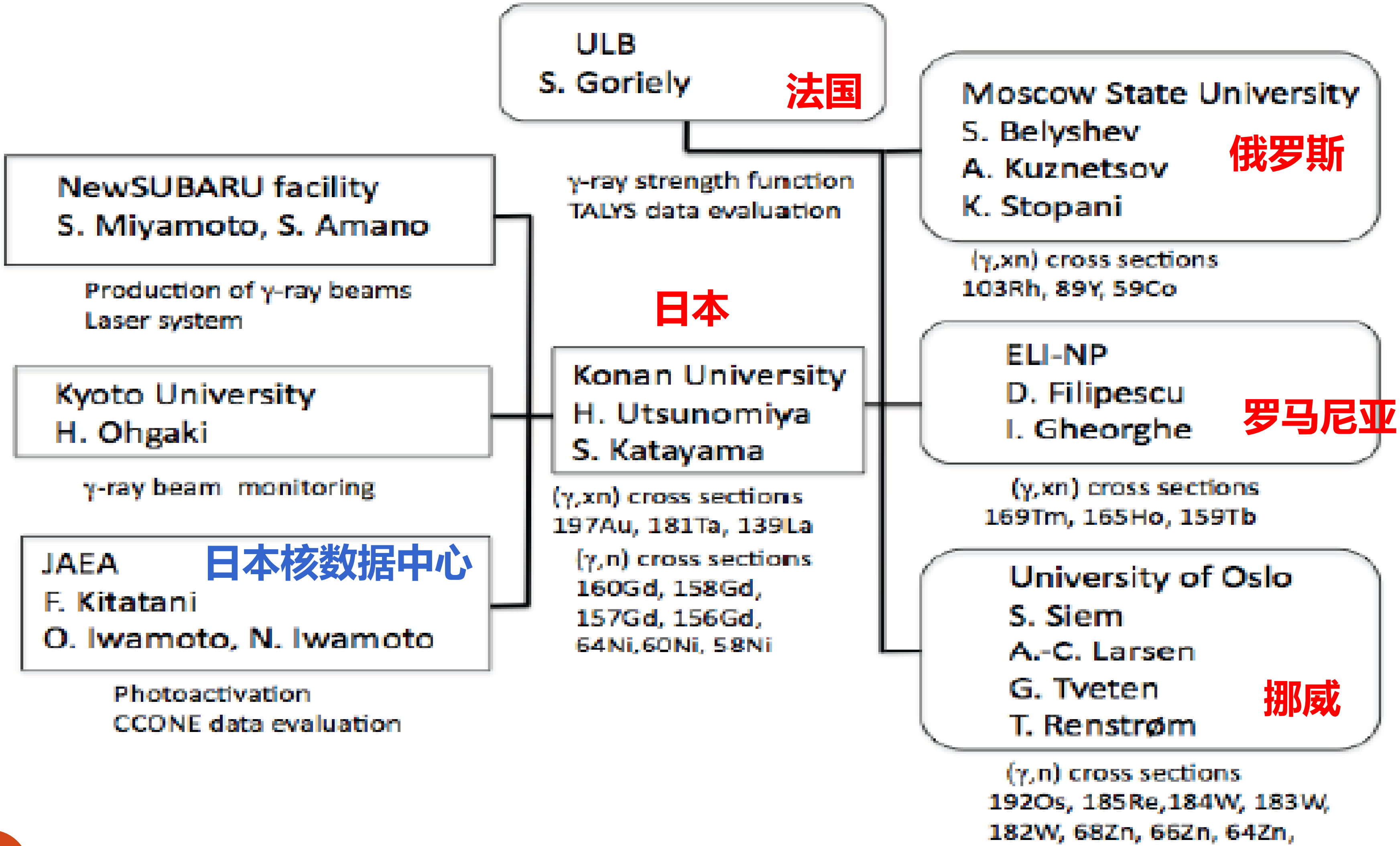
- Update the data for ^{9}Be, ^{27}Al, ^{51}V, ^{50,52,53,54}Cr, ^{54,56,57,58}Fe, ^{63,65}Cu, ^{90,91,92,94,96}Zr, ^{180,182,183,184,186}W, ^{209}Bi;
- New evaluations for ^{6,7}Li, ^{10,11}B.

Motivation:

Phoenix 合作

1、 Updating photonuclear data library

2、 Generating a reference database for photon strength function



Phoenix* Collaboration -1-

Updating the Photonuclear Data Library (IAEA-TECDOC-1178)

Purpose: Resolving the long-standing problem of the discrepancy between the Livermore and Saclay data

(γ,xn) cross sections (x=1-3) for 11 nuclides

The Konan team: ^{197}Au, ^{181}Ta, ^{139}La, ^{9}Be

The ELI-NP team: ^{209}Bi, ^{169}Tm, ^{165}Ho, ^{159}Tb

The MSU team: ^{103}Rh, ^{89}Y, ^{59}Co

?轻核，裂变核测量数据

* **Pho**to**ex**citation and **n**eutron em**i**ssion cross (**x**) sections

Phoenix Collaboration -2-

Generating a Reference Database for Photon Strength Functions

Purpose: Providing new PSF data for the reference database

(γ,n) cross sections for 18 nuclei

The Konan team: ^{160}Gd, ^{158}Gd, ^{157}Gd, ^{156}Gd, ^{64}Ni, ^{60}Ni, ^{58}Ni

The Oslo team: ^{205}Tl, ^{203}Tl, ^{192}Os, ^{185}Re, ^{184}W, ^{183}W, ^{182}W, ^{89}Y, ^{68}Zn, ^{66}Zn, ^{64}Zn

Time Schedule of Phoenix Collaboration

2015

(γ,xn)（x=1-3）: 209Bi, 9Be

PSF: 205Tl, 203Tl, 89Y

Done

2016

(γ,xn)（x=1-3）: 197Au, 169Tm, 89Y

PSF: 192Os, 185Re, 64Ni, 60Ni, 58Ni

2017

(γ,xn)（x=1-3）: 181Ta, 165Ho, 59Co

PSF: 184W, 183W, 182W, 68Zn, 66Zn

2018

(γ,xn)（x=1-3）: 159Tb, 139La, 103Rh

PSF: 160Gd, 158Gd, 157Gd, 156Gd, 64Zn

小结

尽可能为我国核工程与科学用户提供完整的、高质量的核数据一直我们工作的宗旨。

对于核数据评价工作者而言，有可靠的实验测量，并且可以掌握丰富的实验信息是至关重要的！很可惜由于设备的限制，我国在该领域的核物理实验还未系统开展。

需要开展：

- 针对关键核素和反应道开展我国自己的光核反应测量，澄清分歧，能量区域需要从域能-200MeV，特别是高能区光子吸收截面、光子-中子截面等
- 中子出射能谱测量，检测能谱“硬尾”现象，指导预平衡激子态贡献
- 我国自己的宏观基准实验，用于检验数据结果的可靠性。

17

Brief explanation of the CCONE code for photon-induced reactions

Compound decay: statistical model

- n,p,d,t,He3,α,γ emissions
- Optical model (n,p,d,t,He3,α emiss.)
  - OMP potential = RIPL-3
- Discrete level data
  - RIPL-3 (2012)
- Gilbert-Cameron type level density
  - Constant temperature model
  - Mengoni-Nakajima Fermi-gas model
- Photon strength function
  - E1 transition (9 options)
  - M1,E2 transition (SLO type) = RIPL-1+Kopecky-Uhl
- Quasideuteron dissociation model

Precompound decay: two comp. exciton model + gamma emiss.