Introduction of China Nuclear Data Center & Nuclear Data Activities in China

GE Zhigang

China Nuclear Data Center(CNDC)
China Committee of Nuclear Data(CCND)
China Institute of Atomic Energy(CIAE)
P.O.Box 275-41,Beijing 102413, P.R.China
E-Mail:gezg@ciae.ac.cn

CHINA NUCLEAR DATA CENTER

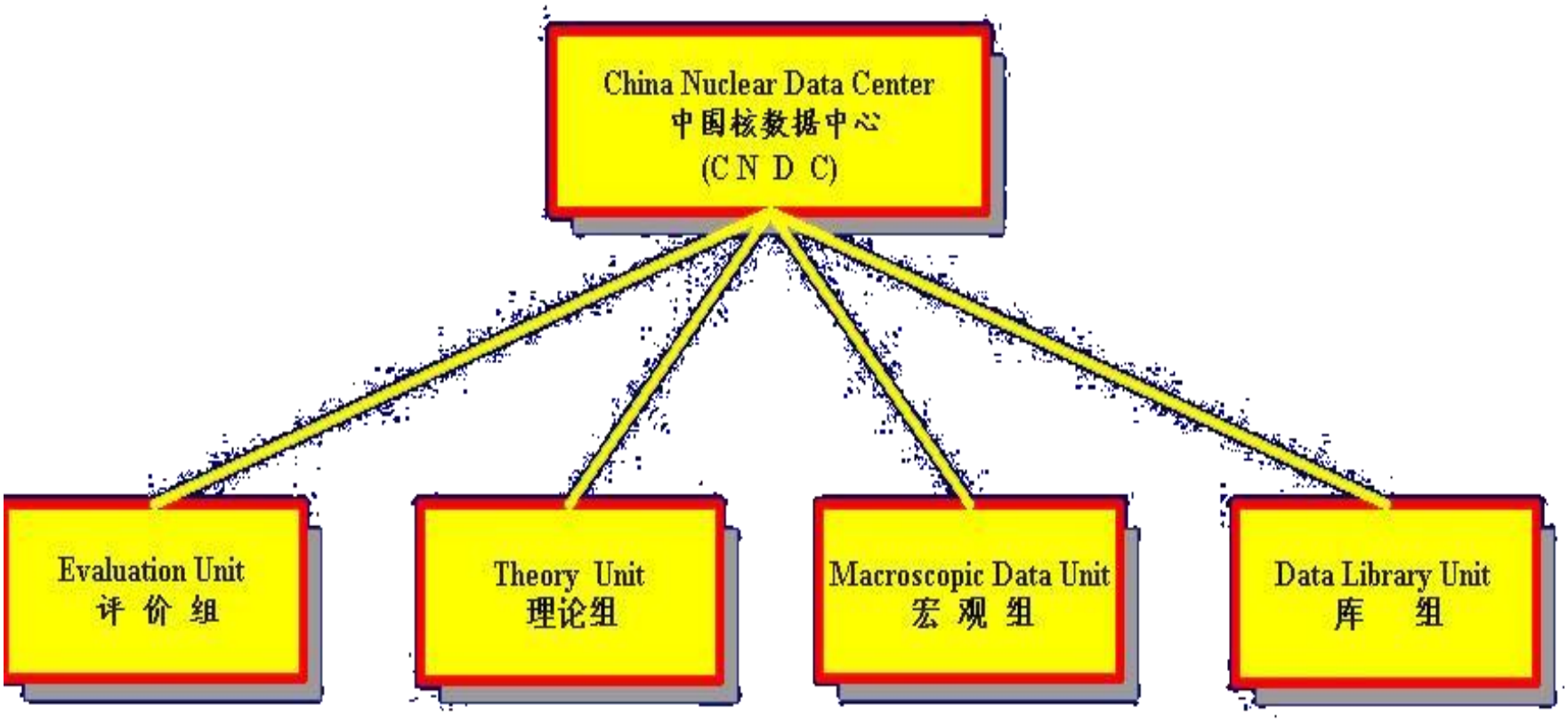
1. General Overview of China Nuclear Data Center (CNDC)

1.1 CNDC View

China Nuclear Data Center (CNDC) was established in 1975 and joined the nuclear data activities of IAEA as the national nuclear data center of China since 1984.

The main task of CNDC:

- ✓ ***The nuclear data evaluations, libraries and relevant technique researches.***
- ✓ ***The exchange of nuclear data activities with IAEA, foreign nuclear data centers and agencies.***
- ✓ ***The management of domestic nuclear data activities.***
- ✓ ***The services for domestic and foreign nuclear data users.***



CNDC Organization Structue

1.2 Staff Information of CNDC

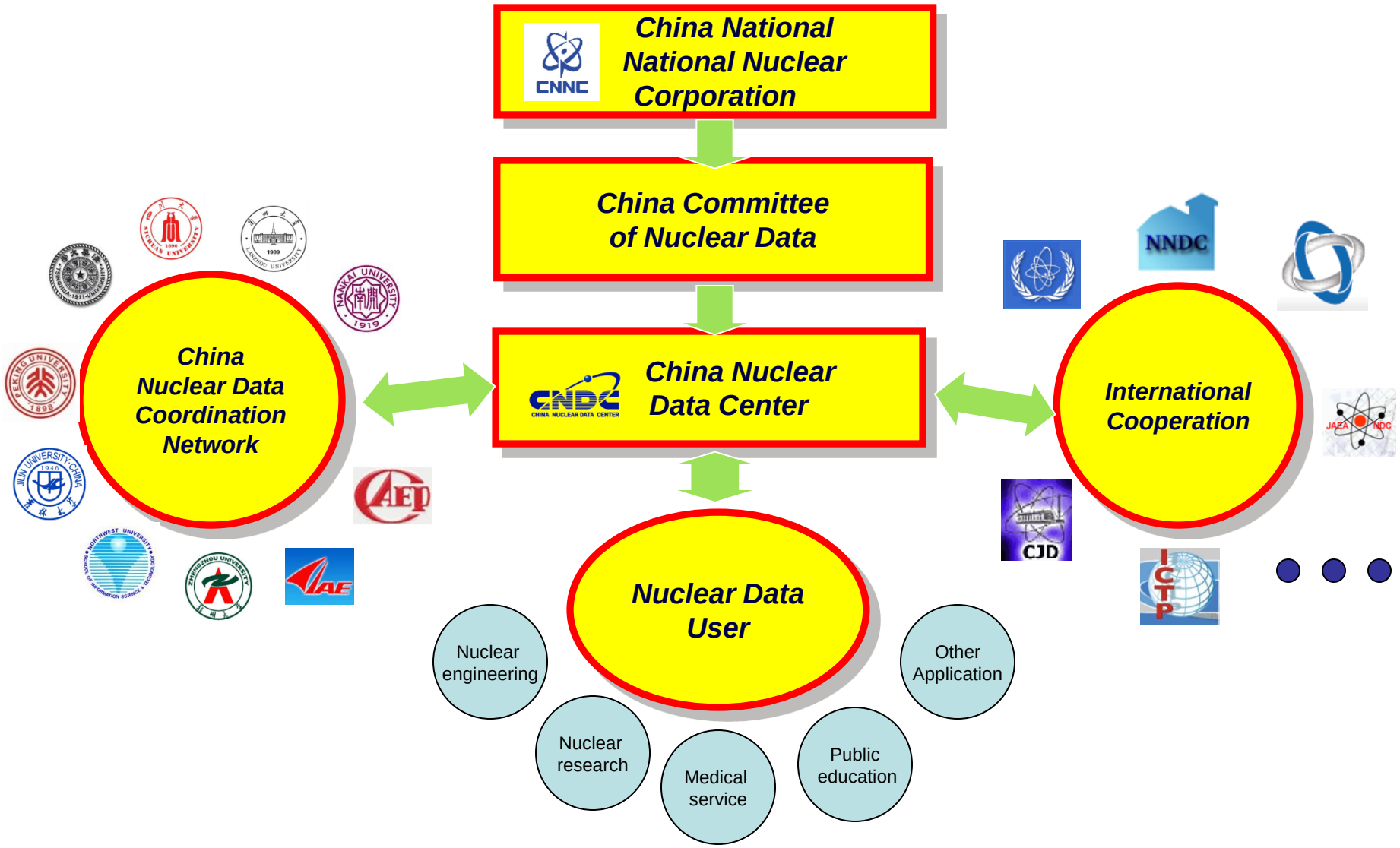
CNDC consists of the four units + an office:

Evaluation Unit	*Head: Dr. Huang Xiaolong*	*4 official staff*
Theory Unit	*Head: Dr. Ge Zhigang*	*8 official staff*
Macroscopic Data Unit	*Head: Dr. Liu Ping*	*5 official staff*
Data Library Unit	*Head: Dr. Shu Nengchuan*	*5 official staff*
Secretary Office		*2 official staff*

Director of CNDC: Dr. Ge Zhigang

24 official staff and 5 technical support experts(senior) working at the CNDC and 4 graduate students and 3 Ph.D students are studying at CNDC.

The Chinese Nuclear Data Activity Structure



1.3 Brief Introduction of Nuclear Data Activities in China and China Nuclear Data Coordination Network(CNDCN)

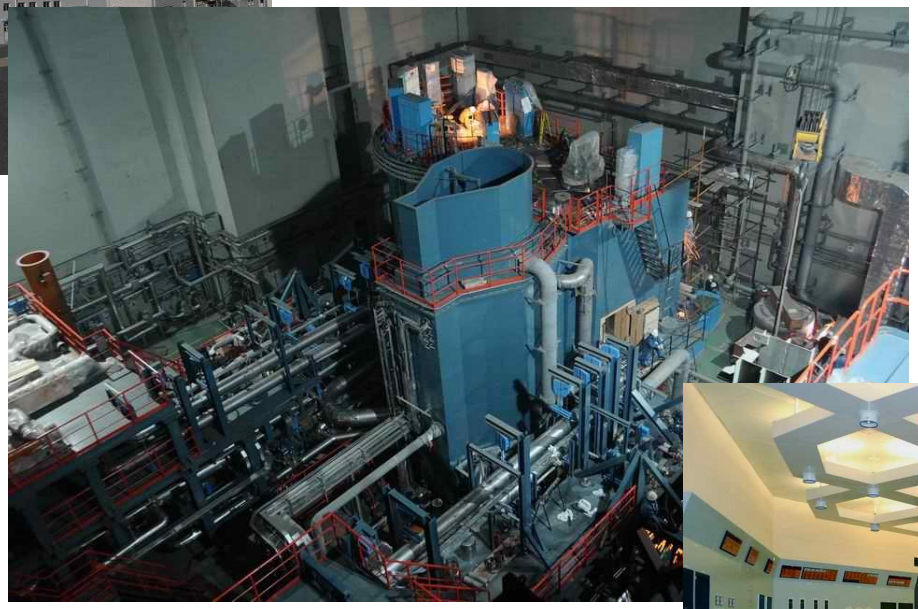
The facilities are used for the nuclear data measurements and studies including

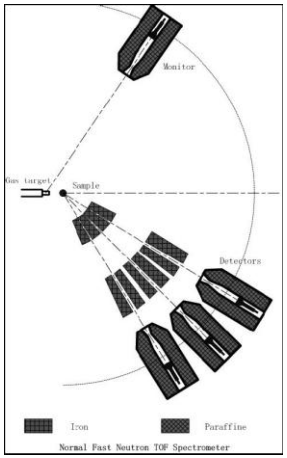
- *China's first experimental heavy water reactor (stopped, CIAE).*
- *The HI-13 tandem accelerator(CIAE).*
- *600kV-Cockcroft-Walton accelerator(CIAE).*
- *5SDH-2 tandem accelerator(CIAE).*
- *4.5-MV Van de Graaff accelerator(Peking University).*
- *300kV -Cockcroft-Walton accelerator(Lanzhou University).*
- *Some other facilities……*

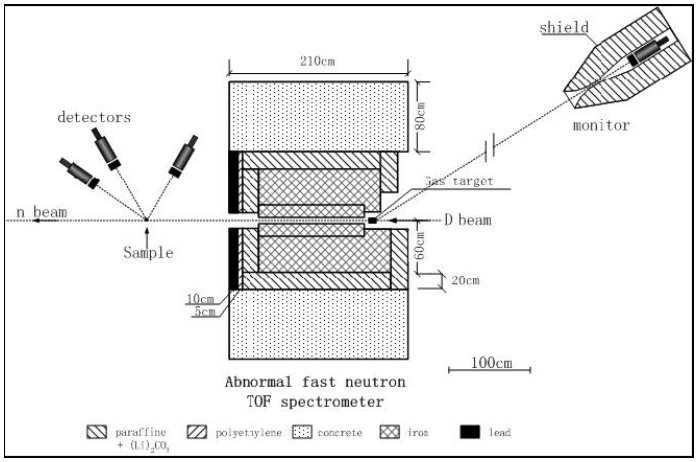
The two new facilities at CIAE will be used for nuclear data related research.

The China advanced research reactor (60MW , neutron flux: 8×10^{14}n/cm^2·s), which has been reached the critical on 13, May 2010.

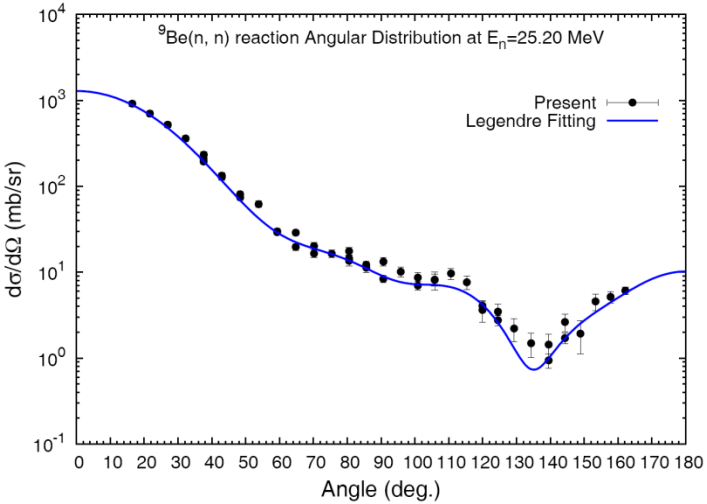
The China Experimental Fast Reactor (CEFR, 65 MW) was reached the critical on 21 June 2010, CIAE.





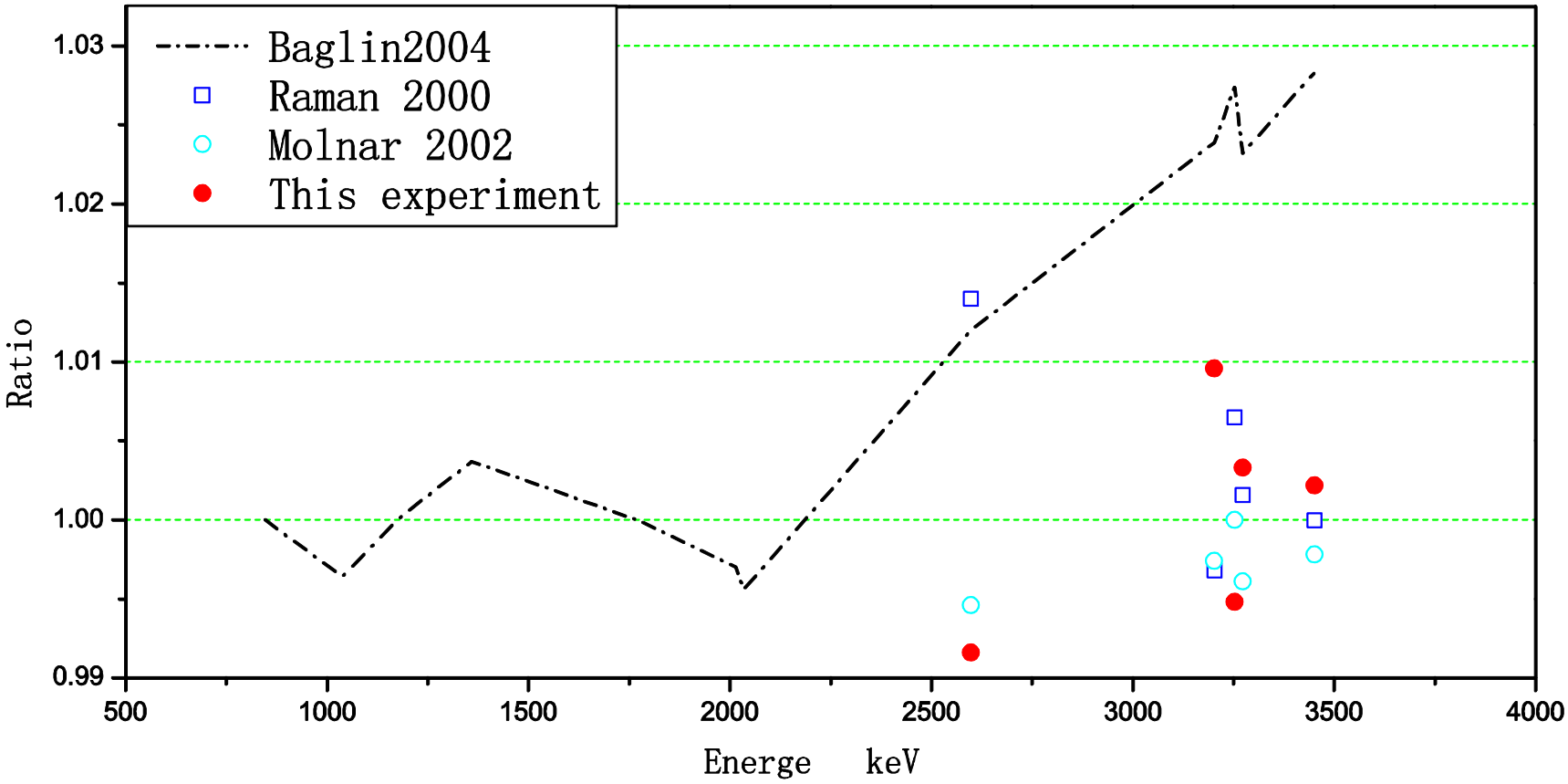


Schematic view of normal(left) and abnormal(right) fast neutron and TOF spectrometer.



Elastic angular distribution (including 1st ~ 5th inelastic scattering) or ^{9}Be at 25.20 MeV

GTAF(Gamma Total Absorption Facility) detector in CIAE



Comparison of present evaluation to Baglin's evaluation and modified measurements for ^{56}Co

E_γ (keV)	Measurements				Evaluations		Modified values			
	Molnar[(Budapest)	Raman	Baglin (Berkeley)	Present	Browne	Present	Molnar	Raman	Baglin	Present evaluation
833.6	15.92(6)	16.02(24)	15.94(14)	15.85(17)	15.94	15.92(5)				
1039.4	100.0(3)	100.0(16)	100.0(9)	100.0(5)	100.0	100.0				
1333.2	3.171(13)	3.17(5)	3.20(3)	3.15(2)	3.16	3.17(1)				
1918.8	5.360(23)	5.33(8)	5.44(6)	5.36(4)	5.38	5.37(2)				
2189.9	14.39(6)	14.54(21)	14.50(13)	14.12(12)	14.32	14.37(5)				
2422.9	5.072(24)	5.12(8)	5.15(6)	5.17(4)	5.08	5.10(2)				
2752.3	61.34(26)	61.2(8)	61.5(6)	60.80(40)	61.35	61.22(20)	60.60(48)	60.84(91)	60.6(9)	60.71(6)
3229.2	4.087(22)	4.06(8)	4.07(4)	4.00(6)	4.08	4.08(2)	3.989(49)	4.01(9)	3.96(7)	3.99(1)
3381.4	3.950(23)	3.96(8)	3.99(4)	3.83(4)	3.94	3.94(2)	3.847(52)	3.91(9)	3.87(7)	3.86(2)
4086.5	3.455(20)	3.38(8)	3.42(4)	3.36(5)	3.43	3.44(2)	3.406(34)	3.35(9)	3.37(5)	3.37(1)
4806.6	5.04(3)	4.93(11)	5.00(7)	4.99(8)	5.03	5.02(3)	5.06(4)	4.94(11)	4.95(7)	4.99(3)

Recent measured and evaluated relative γ-ray emission probabilities for ^{66}Ga

The measurements of neutron reaction and nuclear decay data performed.

A lot of neutron cross section, angular distribution, neutron emission spectra, double differential cross section and nuclear decay data for a mount of nuclei have been measured and the results have been evaluated and provide to the users.

Many method studies of the nuclear data measurements were performed and some study fruits of them have been used in our nuclear data measurements.

CNDCN was established in 1975, the most famous universities, institutes and agencies in China joined CNDCN as the collaborators.

A great achievement on the nuclear data measurements, evaluation and benchmark has been obtained. Now most of them are still doing their contributions to the nuclear data work. Following shows the main collaborators of CNDCN and their task in recent years.

No.	Name of Copartner	Major Task
1	*Peking University (Beijing)*	Nuclear reaction cross section and energy spectra data measurement, structural materials nuclei and actinides data evaluation, Fission yield data evaluation.
2	*Tsinghua University (Beijing)*	Light nuclei data evaluation and related method study.
3	*Nankai University (Tianjing)*	Structural materials nuclei data evaluation and reaction model study in medium-high energy(10keV-250MeV).
4	*Jilin University (Jilin)*	Nuclear structural and decay data evaluation.
5	*Zhenzhou University (Zhenzhou)*	The covariance of nuclear data evaluation and study for structural nuclei.
6	*Northwest University (Xi'an)*	Structural materials and medium nuclei data evaluation.
7	*Lanzhou University (Lanzhou)*	Nuclear reaction data measurement.
8	*China Institute of Atomic Energy (Beijing)*	Nuclear reaction, structure and decay data measurement, evaluation and relative methods studies, et al.

2. Nuclear Data Evaluation and Related Study

2.1 Nuclear Data Evaluation

2.1.1 Neutron Reaction Data

The updated CENDL-3.1 is a general purpose evaluated nuclear data file.

CENDL-3.1 contains the evaluated data for reactions with incident neutrons on about 240 nuclides in neutron energy region of 10^{-5}eV-20MeV.

The UNF code system used for model calculations for light elements, structural, fission product and actinide nuclei.

For important nuclides, the MF1-MF6 et al. are presented and MF33-34 for some nuclei also included in CENDL-3.1.

All new evaluated files obtained according to the evaluations of experimental data and theory predictions.

For most important nuclei of this library, the validations with hundreds of benchmarks have been performed.

The CENDL3.1 has been official released on Dec. 24, 2009.

- ✓ ***IAEA*** http://www-nds.iaea.org/exfor/endf.htm
- ✓ ***NNDC*** http://www.nndc.bnl.gov/exfor/endf00.jsp
- ✓ ***NEA-DB*** http://www.nea.fr/dbdata/data/nds_eval_libs.htm
- ✓ ***…… and CD*** 

The Nuclides of CENDL-3.1

Nucl.	Content of Nuclei
Light Elements	$^{1\text{-}3}$H, ^{3,4}He, ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C, ^{14}N, ^{16}O, ^{19}F
Structural Materials	^{23}Na, $^{24\text{-}26}$Mg, ^{27}Al, $^{28\text{-}30}$Si, ^{31}P, ^{0}S, ^{0}Cl, ^{0}K, ^{0}Ca, $^{46\text{-}50}$Ti, ^{0}V,
	$^{50,52\text{-}54}$Cr, ^{55}Mn, $^{54,56\text{-}58}$Fe,^{59}Co, $^{58,60\text{-}62,64}$Ni,^{0,63,65}Cu, ^{0}Zn, ^{0}Ge,
	$^{90\text{-}92,94,96}$Zr, $^{92,94\text{-}98,100}$Mo,^{0,107,109}Ag, ^{0}Cd, ^{0}Sn, $^{174,176\text{-}180}$Hf,
	^{181}Ta, ^{0}W, ^{197}Au, ^{0}Hg, ^{0}Tl, $^{204,206\text{-}208}$Pb, ^{209}Bi
Fission Products & Medium Elements	^{69,71}Ga, $^{70\text{-}78}$Ge, ^{75,77,79}As, $^{83\text{-}86}$Kr, ^{85,87}Rb, $^{88\text{-}90}$Sr, ^{89,91}Y, ^{93,95}Zr
	^{93,95}Nb, ^{99}Tc, $^{99\text{-}105}$Ru, ^{103,105}Rh, ^{105,108}Pd, ^{113}Cd, ^{113,115}In,
	$^{112,114\text{-}120,122,124}$Sn, ^{121,123,125}Sb, ^{130}Te, ^{127,129,135}I
	$^{123,124,129,131,132,134\text{-}136}$Xe, $^{133\text{-}135,137}$Cs, $^{130,132,134\text{-}138}$Ba, ^{139}La
	$^{136,138,140\text{-}142,144}$Ce, ^{141}Pr, $^{142\text{-}148,150}$Nd, ^{147,148,148m,149}Pm
	$^{144,147\text{-}152,154}$Sm, $^{151,153\text{-}155}$Eu, $^{152,154\text{-}158,160}$Gd, ^{164}Dy
Actinides	^{232}Th, $^{232\text{-}241}$U, $^{236\text{-}239}$Np, $^{236\text{-}246}$Pu, $^{240\text{-}244,242m}$Am, ^{249}Bk, ^{249}Cf

The CENDL-3.1 content of ENDF/B format

MF	Light Elements	Structural Materials	Actinides	Fission Products	Total
MF1-5	14	72	34	120	240
MF6	10	59	4	31	104
MF12-15	11	65	4	31	111
MF31-35	4	2	0	0	6

2.1.2 Nuclear Structural and Decay Data Evaluation

The nuclear structure and decay data evaluation group in CNDC has permanent responsibility for evaluating and updating NSDD for A=51,195-198; temporary for A= 67 and 174. In recent 2 years, the mass chain A=174, 195 and 198 have been revised using available experimental decay and reaction data. A=198 was published in 2009. Now A=174 and 195 are being updated. The status is as follows:

Mass chain A	Status	Evaluators
51	NDS,107,2131(2006)	Huang Xiaolong
195	being updated	Huang Xiaolong
196	NDS,108,1093(2007)	Huang Xiaolong
197	NDS,104,283(2005)	Huang Xiaolong, Zhou Chunmei
198	NDS,110,2533(2009)	Huang Xiaolong
67	NDS,106,159(2005)	Huo Junde, Huang Xiaolong ,J.K.Tuli
174	being updated	F.G.Kondev, T.Kibedi, Huang Xiaolong

2.1.2 Nuclear Excitation Function Data Evaluation

The more than 50 excitation functions of (n,2n),(n,3n),(n,γ) and some charged particle introduced reactions et al. for some most important target are reevaluated according the new experimental information and new evaluation methodologies.

2.1.3 Nuclear Fission Yield Data Evaluation

A semi-empirical model. based upon Multi-Modal Random Neck-Rupture Model, is introduced for yield-energy relations, and the potential energy was simplified and parameterized, which included the parts of liquid model and shell affections. Two sets of parameters were obtained by fitting to experimental data.

A new systematics on independent yield with Zp model is developed and the parameters of this systematics were determined by fitting experimental data, which are come all experimental data of independent yield data for ^{235}U, ^{238}U and ^{239}Pu. The independent yield and its uncertainty of any product nuclide with mass number A can be calculated in the energy region from thermal energy to 30 MeV for ^{235}U.

Based on the methods mentioned above and collected exp. Information, a lot of new evaluations for the fission yields were performed in the past years.

2.1.4 The Characteristics of Isotopes Compilation

With the collaboration with Russia institutes, a new compilation of the characteristics of isotopes was done and a new chart nuclides was published.

2.2 The Methods of Evaluation, Benchmark/validation and Studies

As an important field for nuclear data production, benchmark/validation and application, CNDC also pay more attention to the development the related methodologies. During recent years, we got much progress in following item study.

- ✓ ***Nuclear data model improvement and code development***
- ✓ ***Nuclear data covariance evaluation method study and evaluation system establishment***
- ✓ ***The systematic study of fission yield data and the study on the dependence of yield on energy***
- ✓ ***Nuclear library benchmark system establishment***

3. EXFOR Compilation Activities

3.1 Compilation Group

A new EXFOR compilation group is set up, which consists of 5 staff (4 from evaluation unit and 1 from data library unit), 4 of them have the Ph.D and some have the background of nuclear experiments. Compilation restarted in end of 2009.

3.2 Compilation Situation of CNDC

CNDC is charged for compilation of EXFOR for the journals published in China. The journals related to nuclear data measurements are show in below table.

Name and Code of Journal	History of Journal	Time	Situation
Journal of High Energy Physics and Nuclear Physics (HEN/PHE??)	1997 established (Chinese) 2007 Chinese Physics C (English)	1997-1995 1996-2006 2007-2009	done plan
Atomic Energy Science and Technology(CST)；	1959 established (Chinese)	1959-1974 1975-1988 1989-2009	plan done
Journal of Nuclear and Radiochemistry (HFH)	1979 established (Chinese)	1979-1993 1994-2009	done plan
Nuclear Physics Review	1984 established (Chinese)	1984-2009	plan
Nuclear Technology(CNST)	1978 established (Chinese) 1989 Nuclear Science and Technology (English)	1978-2009	plan
Chinese Physics Letters (CPL)	1989 established (English)	1984-2003 2004-2006 2007-2009	plan done

Note:

There haven't "Edition/code" as "Reference" part for Journal of Nuclear Physics Review. So we suggest to adopt "NPR" or "CNPR" as it's edition code.

3.3 EXFOR Compilation Task and Plan

A detail working plan of compilation has been made. We have restarted compiling work for EXFOR since Dec. of 2009 and more than ten entries of Chinese publications of 2009 have been finished .

No	Publications name and code	Title of article	Entry No
1	Nuclear Physics Review,s1, 2009;	π~0 Photoproduction on Deuteron for Photon Energies from 0.6 to 1.15 GeV	S0057
2	Nuclear Physics Review,s1, 2009;	Study of Proton Resonances in ^{22}Mg by Resonant Elastic Scattering of ^{21}Na+p and Its Astrophysical Implication in ^{18}Ne(α,p) ^{21}Na Reaction Rate	S0060
3	Nuclear Physics Review,2009;	Neutron spectra measurement with activation method in sample place of on-line neutron activation analysis system	32674
4	Chinese Physics Letters 2009 26 (7): 072401	Angular Distribution of the (^{6}He, ^{7}Li)^{11}B Reaction	S0052
5	Chinese Physics Letters 2009 26 (2): 022503	Optical Potential Parameters for Halo Nucleus System ^{6}He+ from Transfer Reaction ^{11}B(^{7}Li, ^{6}He)	S0056
6	Chinese Physics Letters 2009 26 (8): 082501	Quasi-Elastic Scattering of from at 47.5 MeV/Nucleon,	S0059
7	Chinese Physics C ;2009 33 (05): 378-382	Measurement of the neutron spectrum of a Pu-C source with a liquid scintillator	32675
8	Chinese Physics C ;2009 33 (05): 350-353	Measurement of the astrophysical S factor for the low energy ^{2}H(d,γ)^{4}He reaction	S0058
9	Atomic Energy Science and Technology, vol.43, No.1, Jan. 2009;	Neutron spectrum measurement from Am-Be neutron source in radiation shield cavity	32672
10	Atomic Energy Science and Technology, vol.43, No.9, Sep. 2009	Measurement of Secondary Neutron Emission Double Differential Cross Section for Natural Iron Induced by 8.17 MeV Neutron,	32673

4. Nuclear Data Libraries

The following nuclear databases have been established at CNDC, and the most of them are available for users.

- ✓ ***Chinese Evaluated Nuclear Data Library (CENDL)***
  - ***CENDL-1, 1985 version 36***
  - ***CENDL-2, 1992 version 68***
  - ***CENDL-3.0, (Testing version) ~200***
  - ***CENDL-3.1, 2009.12 240***
- ✓ ***Nuclear Structure and Decay Data Library (NSDD)***
- ✓ ***Fission Product Yield Data Library (FPYD)***
- ✓ ***Charged-Particle Nuclear Data Library (CPND)***
- ✓ ***Neutron Activation Dosimetry Data Library***
- ✓ ***Program Library***
- ✓ ***Input Parameter Library for nuclear data model calculation***

5. Nuclear Data Service

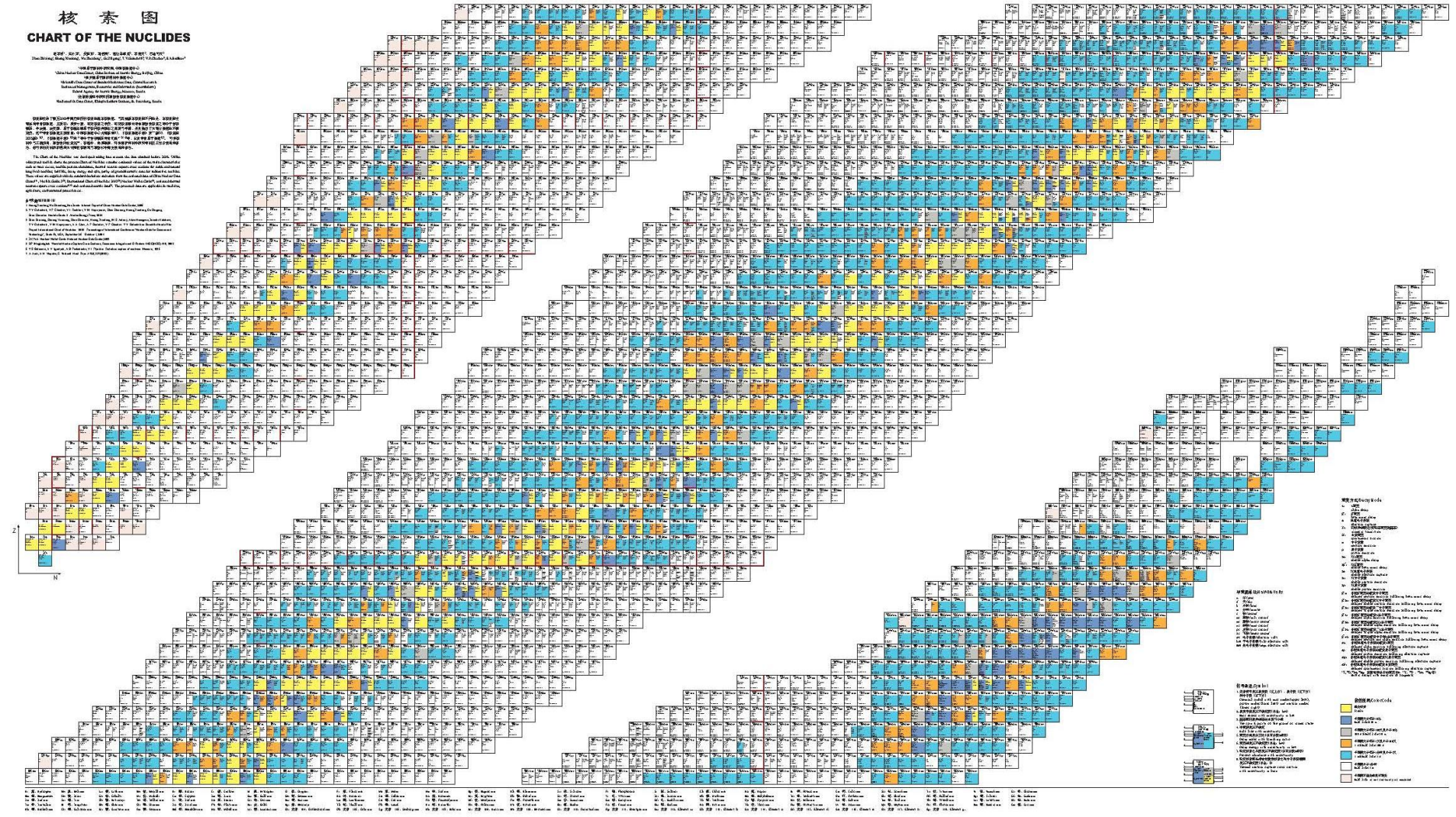
The perennial nuclear data service for the users is provided by CNDC. The service contains including the nuclear data support, data process and technology support for nuclear data application et al.

Publication:

✓***A nuclear data journal (in English)***
«Communication of Nuclear Data Progress» published twice a year.

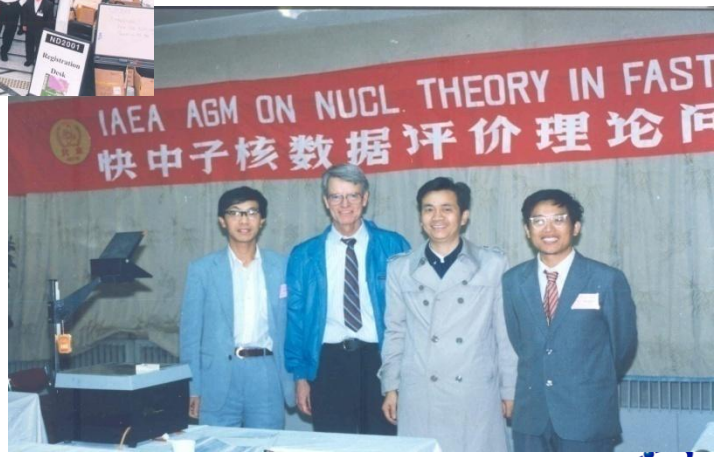
✓***A nuclear data newsletter (in Chinese)***
« Nuclear Data News in Brief » published nonscheduled.

✓***A lot of nuclear data technical reports, books, etc.***

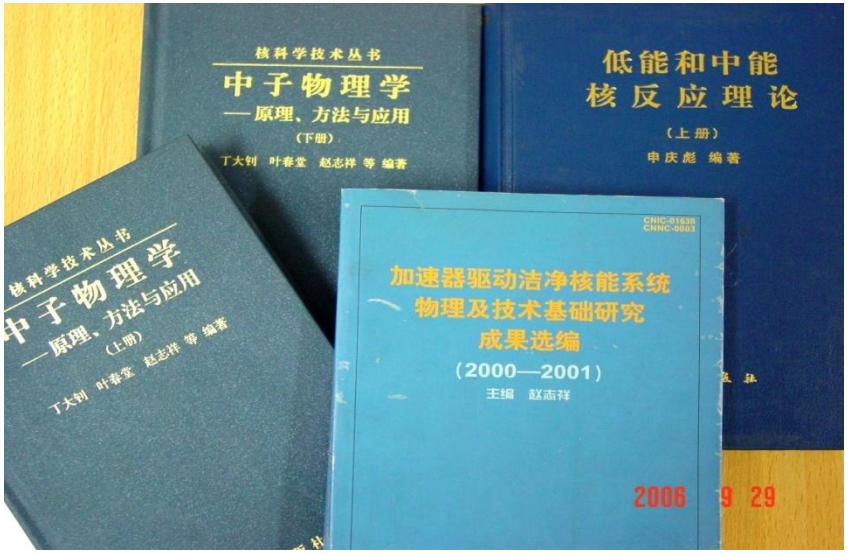

核 素 图
CHART OF THE NUCLIDES


MEETING OF INTERNATIONAL NUCLEAR DATA COMMITTEE
十六届国际核数据委员会会议


International Conference on Nuclear Data
for Science and Technology

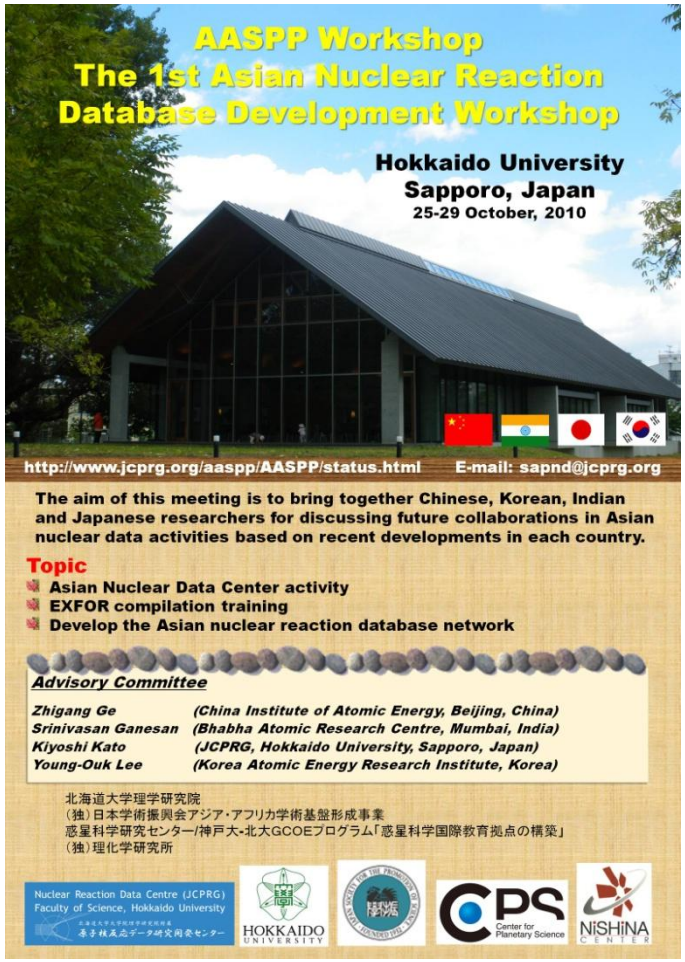

IAEA AGM ON NUCL THEORY IN FAST
快中子核数据评价理论


China Topic Exhibits for 50th Anniversary of IAEA
Nuclear Safeguards
China Nuclear Data Center (CNDC)
CAEA
中国国家原子能机构
CHINA ATOMIC ENERGY AUTHORITY


核科学技术丛书
中子物理学
—原理、方法与应用
(下册)
丁大钊 叶春堂 赵志祥 等 编著
低能和中能
核反应理论
(上册)
申庆彪 编著
加速器驱动洁净核能系统
物理及技术基础研究
成果选编
(2000—2001)
主编 赵志祥
2006 9 29


中国核数据中心
CHINA NUCLEAR DATA CENTER
REFERENCE FISSION YIELD DATA
USER MANUAL of UNF CODE
ZHANG Jingshang
China Nuclear Data Center
China Institute of Atomic Energy, P.O. Box 275(41)
Beijing, 102413, P.R. China
December 3, 2001
USER MANUAL
COMMUNICATION OF
NUCLEAR DATA PROGRESS
No. 30 (2006. 4)
2006 9 29

Thank you for your attention !
Comments and suggestion welcome !



Sincerely wish the success of AASPP Workshop.

Thanks JCPRG very much for organizing this activity.