Interesting experiences in nuclear data physics activities in India

Presented by
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THANK YOU ALL FOR THIS OPPORTUNITY

My sincere thanks are due BARC, DAE-BRNS and NDPCI
Thanks are due to all the organizers and supporters of this Workshop. This 2nd Asian Nuclear data Development Workshop, 5-9 Sep. 2011, Beijing is supported by China Nuclear Data Center (CNDC), Science and Technology on Nuclear Data Laboratory and the Asia-Africa Science Platform Program (AASPP) of the Japan Society for the Promotion of Science (JSPS). This workshop is being organized by CNDC, China Institute of atomic Energy (CIAE).
THANKS TO ALL OF THEM.

NUCLEAR DATA ACTIVITIES IN INDIA

- ***Basic nuclear data physics measurements. FOTIA (BARC), BARC-TIFR Pelletron, PURNIMA (BARC) D-D, D-T sources),*** **Photon induced reactions (Electron accelerator based bremstrahlung at Kharghar); Pune 14 MeV facility. IPR 14 MeV facility**
- **New facilities for data measurements (being discussed)**
- ***EXFOR compilations. Four successful workshops thus far: 2006 (Mumbai) , 2007 (Mumbai) , 2009 (Jaipur), 2011 (Chandigarh, Panjab University, April 4-8).***
- ***Nuclear model based calculations. Codes such as EMPIRE, TALYS ETC.***

NUCLEAR DATA ACTIVITIES IN INDIA
(Continued from the previous slide)

- ***Processing of evaluated nuclear data files** to produce plug-in libraries for indigenous development of discrete ordinates and Monte Carlo codes for thermal, fast, fusion and ADSS applications. Software development.*
- ***Efforts to digest the status of covariance error methodology** in nuclear data and its applications.*
- ***Preparation of integral Indian experimental criticality benchmarks** for integral nuclear data validation studies. (KAMINI, PURNIMA-II benchmarks completed and accepted by the US-DOE). PURNIMA-I benchmarking in final stage of progress.*
- *Nuclear data sets and reactor sensitivity studies –AHWR, CHTR (RPDD, BARC); Fast Reactors (IGCAR), ITER-Test Blanket Module & Indian Fusion Reactors (IPR and BARC).*

Activities/Mandate of the Nuclear data Physics Centre of India include catalyzing and enhancing the activities mentioned in previous slides and include the following activities:

1. Coordinate programmes in nuclear data involving IAEA-Nuclear Data Section and other bilateral collaborations. Identify specific areas, priorities, milestones etc.
2. Organize theme meetings, national conferences and training workshops on nuclear data physics
3. Provide financial support for joint experiments in nuclear data physics in India and abroad (e.g., CERN n_TOF and Korea)
4. Provide support for development of computer programmes with updated nuclear physics databases of interest to current and future reactor applications (such as PHWR, AHWR, CHTR, PFBR etc.) over the entire nuclear fuel cycle.
5. Provide fellowships to visiting research students and summer students of PG and UG level.

The 4th DAE-BRNS Theme Meeting on EXFOR Compilation of nuclear data, (April 4– 8, 2011), Punjab University, Chandigarh was phenomenally successful making more than 80 Indian new EXFOR entries into the IAEA database increasing visibility to India's nuclear physics experiments and data generated in Indian experiments.

http://physics.puchd.ac.in/events/exfor2011/

The second DAE-BRNS Workshop on Covariance error matrix and its applications in reactor fuel cycle and technology", November 29 - Dec. 3, 2010, Vel Tech Dr. RR& Dr.SR Technical University, Chennai, Tamilnadu. This meeting was partially funded by DAE-BRNS (NDPCI) and was very successful.

NDPCI is identifying University staff and awarding contracts on EXFOR compilations.

"EXFOR COMPILATION OF NUCLEAR REACTION DATA" Sanctioned by DAE-BRNS to North eastern University, Shillong. Project in early 2011 successfully in Progress.

Project awarded to Prof. B. Jyrwa, North eastern univesity, Shillong, Meghalaya in May 2011:

Another EXFOR COMPILATION Project under Nuclear data Physics Centre of India entitled, "EXFOR COMPILATION OF NUCLEAR REACTION DATA": A project Proposal has been submitted by Gopal Mukherjee, VECC for a project in Vishva-Bharati University, Shantiniketan.

Application submittal and review in progress.

Efforts to digest the status of covariance error methodology in nuclear data and its applications. A beginning with a priject of NDPCI at the Statistics Department, Manipal University DAE-BRNS Project has been made.

Phase-I of Covariance project 2007-2011 successfully completed at the Statistics Department, Manipal University. Project closed.

Phase-2 of covariance project at Manipal University:

"Establishing methodology and evaluation of Indian nuclear data file for a few selected neutron induced nuclear reactions including covariance error matrix for applications to advanced nuclear systems in India"

Project proposal from Manipal university in proposal stage. (In Preparation).

ON-GOING PROJECTS in NDPCI

Title: Theoretical simulation of induced activity and production cross section of radionuclides in neutron and charged particle induced reactions. Principle Investigator: Dr. Sneh Lata Goel, Guru Jambheshwar University of Science & Technology, Hisar GJUST, Hisar, Haryana (North Western India)Project in progress.

NDPCI DAE-BRNS Project in nuclear data physics in Bharatiyar University (Principal Investigator (PI): Dr. M. Balasubramaniam) is successfully on-going.

The NDPCI project by Prof. A.K. Jain (IIT-R) "Improved Nuclear Structure and Decay Data for Nuclear Models in the Heavy Nuclides Region" has been formulated, processed and sanctioned. –ENDSDF work

The annual O & M fee for BARC-CERN n_TOF collaboration (Geneva) is supported by the NDPCI

MORE DETAILS ON EXFOR COMPILATIONS UNDER THE AUSPICES OF THE NEWLY FORMED NUCLEAR DATA PHYSICS CENTRE OF INDIA

EXFOR compilations

Before 2006: Indian experiments were directly compiled into EXFOR database by the IAEA Staff, thanks to the IAEA-NDS in Vienna.

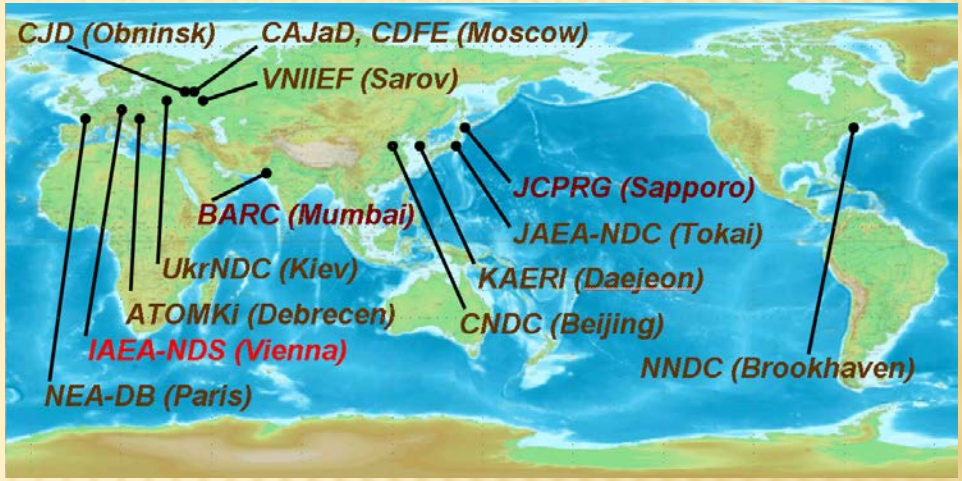
Since 2006:
International community (NRDC) took note of India contributing more than 200 Indian EXFOR entries based upon Indian nuclear physics experiments since 2006.

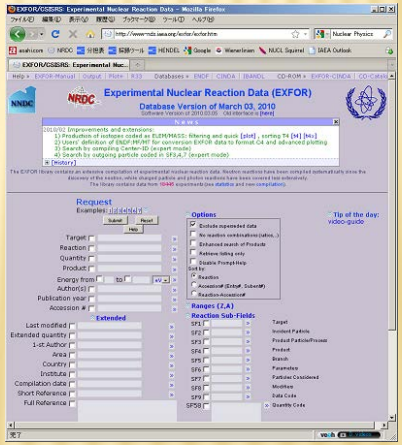
Increased visibility to India's work in nuclear physics data generation

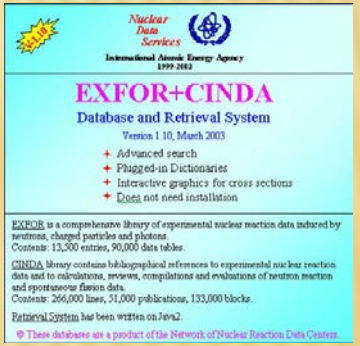
Introduction of a new Experimental Nuclear Physics Database culture in India- A challenge.

INTERNATIONAL NETWORK OF NUCLEAR REACTION DATA CENTRES (NRDC)

- NNDC
- NEA-DB
- IAEA-NDS
- CJD, CAJaD, CDFE, CNPD
- ATOMKI
- CNDC
- JCPRG, JAEA
- KAERI
- UkrNDC
- BARC







NDPCI is responsible for all EXFOR compilations in India.

BARC was invited and joined as a full member of NRDC in September 2008.

The 4th DAE-BRNS theme meeting on EXFOR compilation of nuclear data , 4–8 April 2011 at the Department of Physics, Panjab University, Chandigarh, India

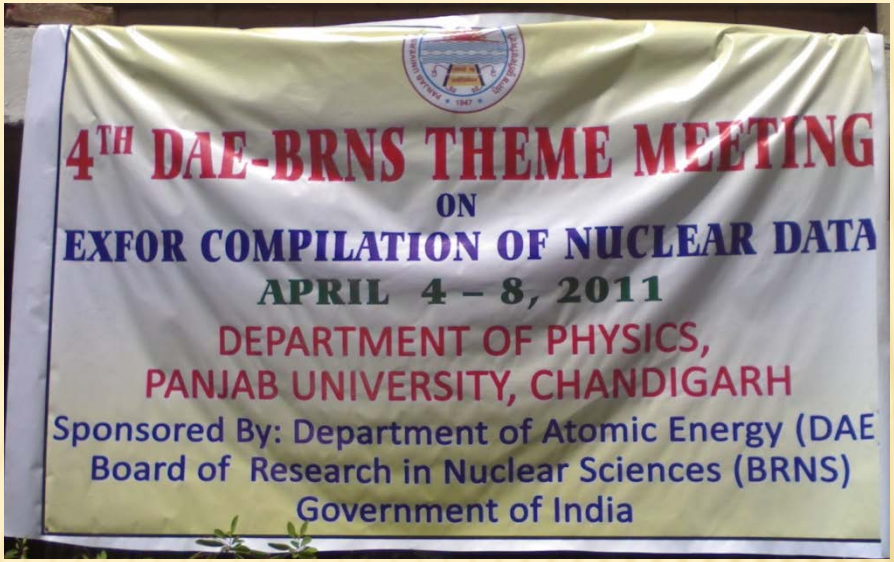
was highly successful as were the Indian EXFOR Workshops in 2006, 2007, 2009.

See: http://physics.puchd.ac.in/events/exfor2011/

S. Ganesan (BARC), A. Saxena (BARC) and B. Behera (Panjab University) were main organizing committee members as Chairman, Technical convener and local convener respectively.

FACULTY INCLUDED:

- **NAOHIKO OTSUKA (IAEA-NDS)**
- **SVETLANA DUNAEVA (Russsia, Ex-IAEA STAFF)**
- **Svetlana also visited VECC, Kolkata (G. Mukherjee, VECC) and BARC (NDPCI)**


4TH DAE-BRNS THEME MEETING
ON
EXFOR COMPILATION OF NUCLEAR DATA
APRIL 4 – 8, 2011
DEPARTMENT OF PHYSICS,
PANJAB UNIVERSITY, CHANDIGARH
Sponsored By: Department of Atomic Energy (DAE
Board of Research in Nuclear Sciences (BRNS)
Government of India

The 4th DAE-BRNS theme meeting on EXFOR compilation of nuclear data , 4–8 April 2011 at the Department of Physics, Panjab University, Chandigarh, India

During the workshop itself more than 25 entries were finalized

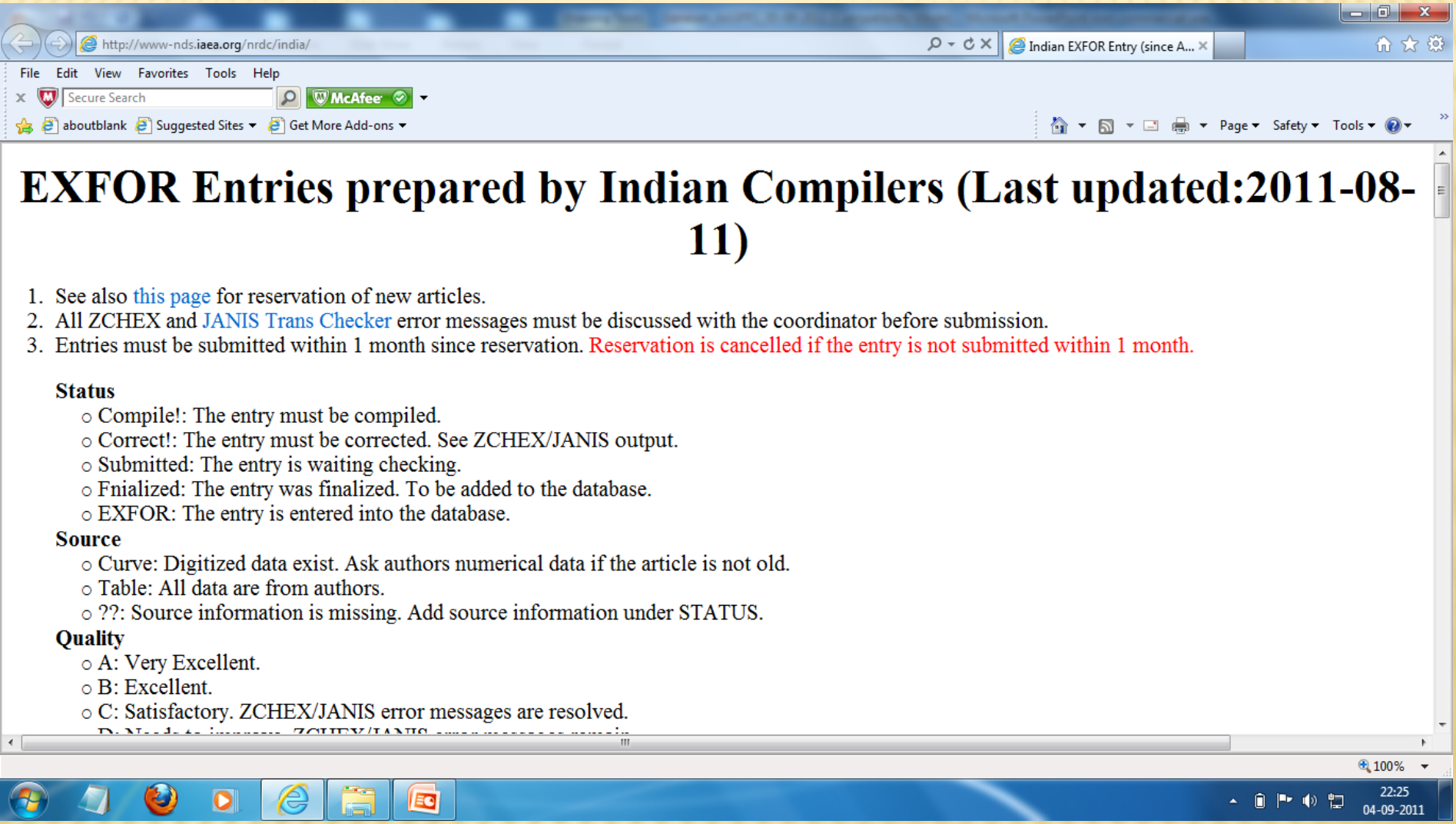
Following up the EXFOR compilations to its peer-review, completion and acceptance after the workshop is vital to the success of the workshop.

The number of participants was 75 ++. The list of participants is available in the meeting website:
http://physics.puchd.ac.in/events/exfor2011/participants.html

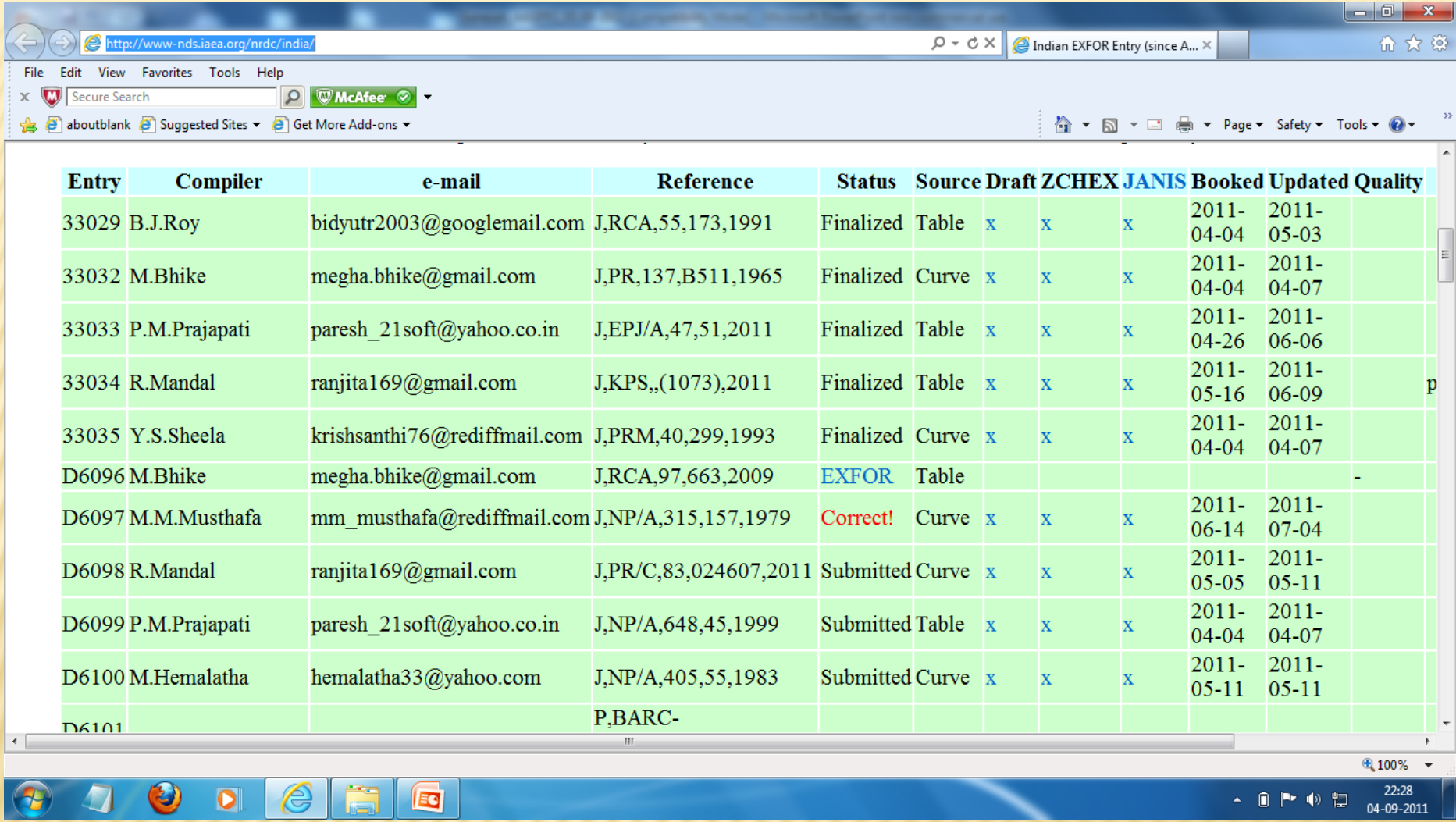
EXFOR Entries prepared by Indian Compilers.

See: http://www-nds.iaea.org/nrdc/india/

Extracts from this website as on 23 May 2011 are shown in the next few slides



http://www-nds.iaea.org/nrdc/india/



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33032	M.Bhike	megha.bhike@gmail.com	J,PR,137,B511,1965	Finalized	Curve	x	x	x	2011-04-04	2011-04-07		
33033	P.M.Prajapati	paresh_21soft@yahoo.co.in	J,EPJ/A,47,51,2011	Finalized	Table	x	x	x	2011-04-26	2011-06-06		
33034	R.Mandal	ranjita169@gmail.com	J,KPS,,(1073),2011	Finalized	Table	x	x	x	2011-05-16	2011-06-09		p
33035	Y.S.Sheela	krishsanthi76@rediffmail.com	J,PRM,40,299,1993	Finalized	Curve	x	x	x	2011-04-04	2011-04-07		
D6096	M.Bhike	megha.bhike@gmail.com	J,RCA,97,663,2009	EXFOR	Table						-	
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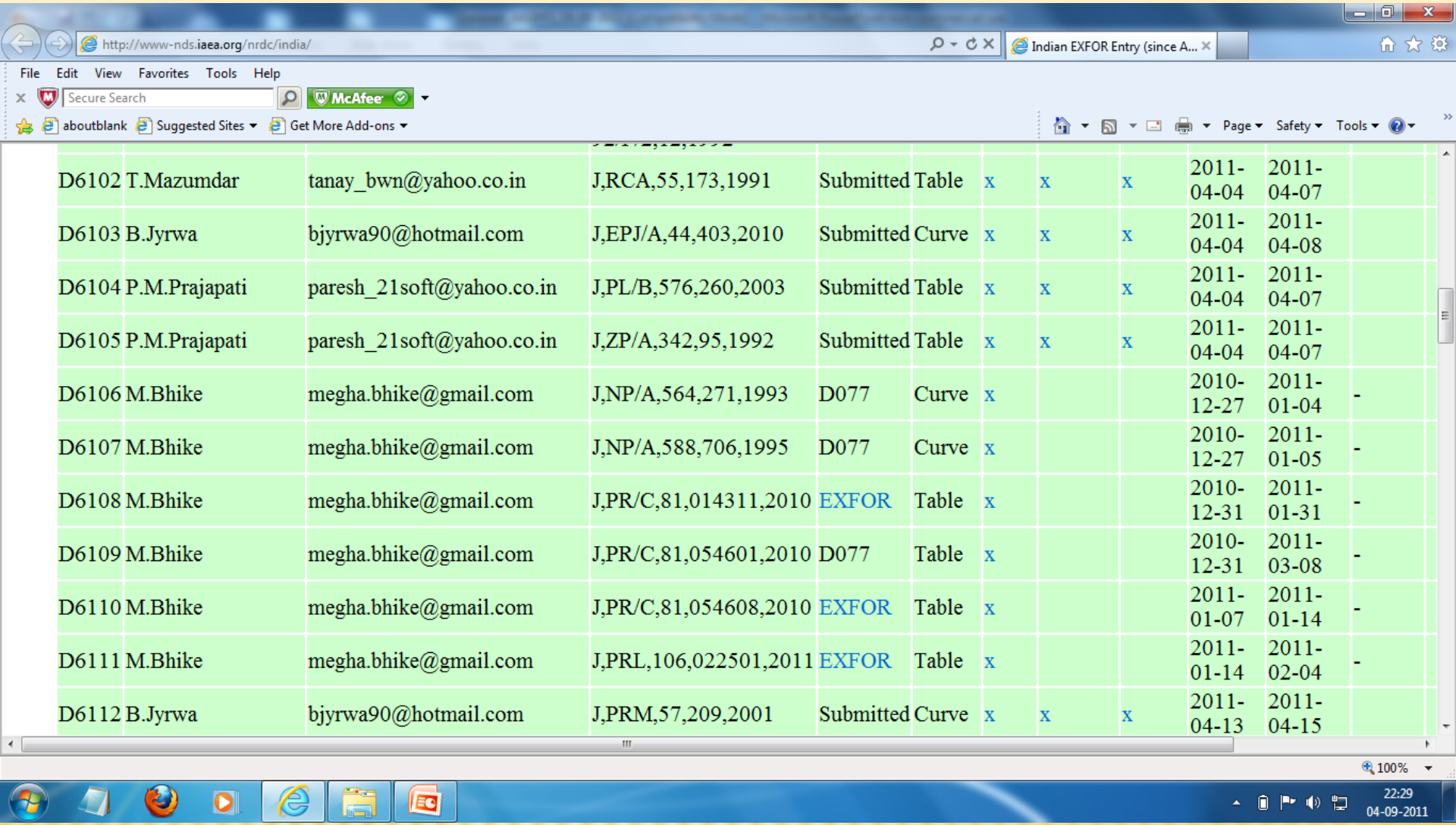
D6101			P,BARC-									

http://www-nds.iaea.org/nrdc/india/



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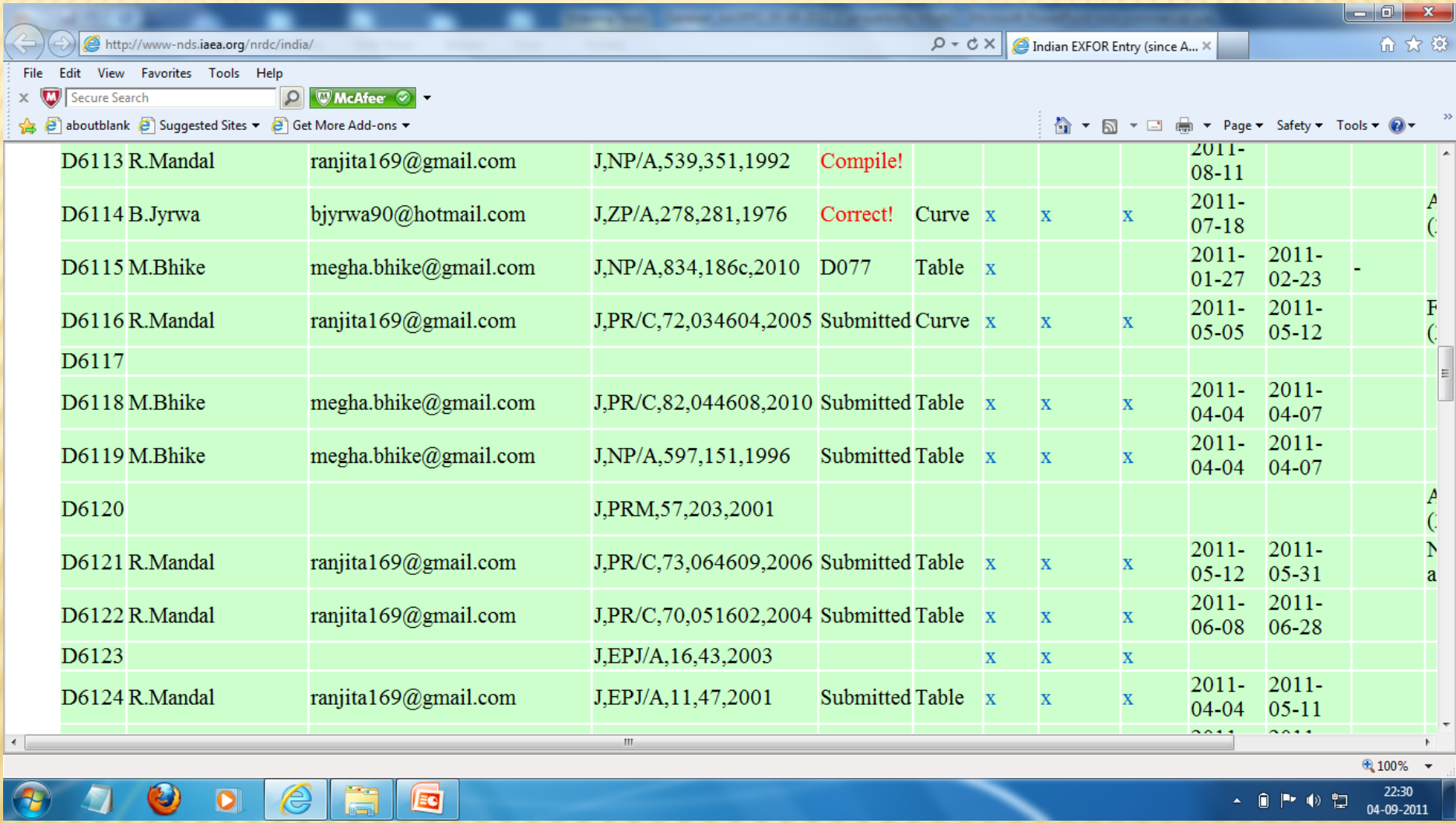

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D6117												
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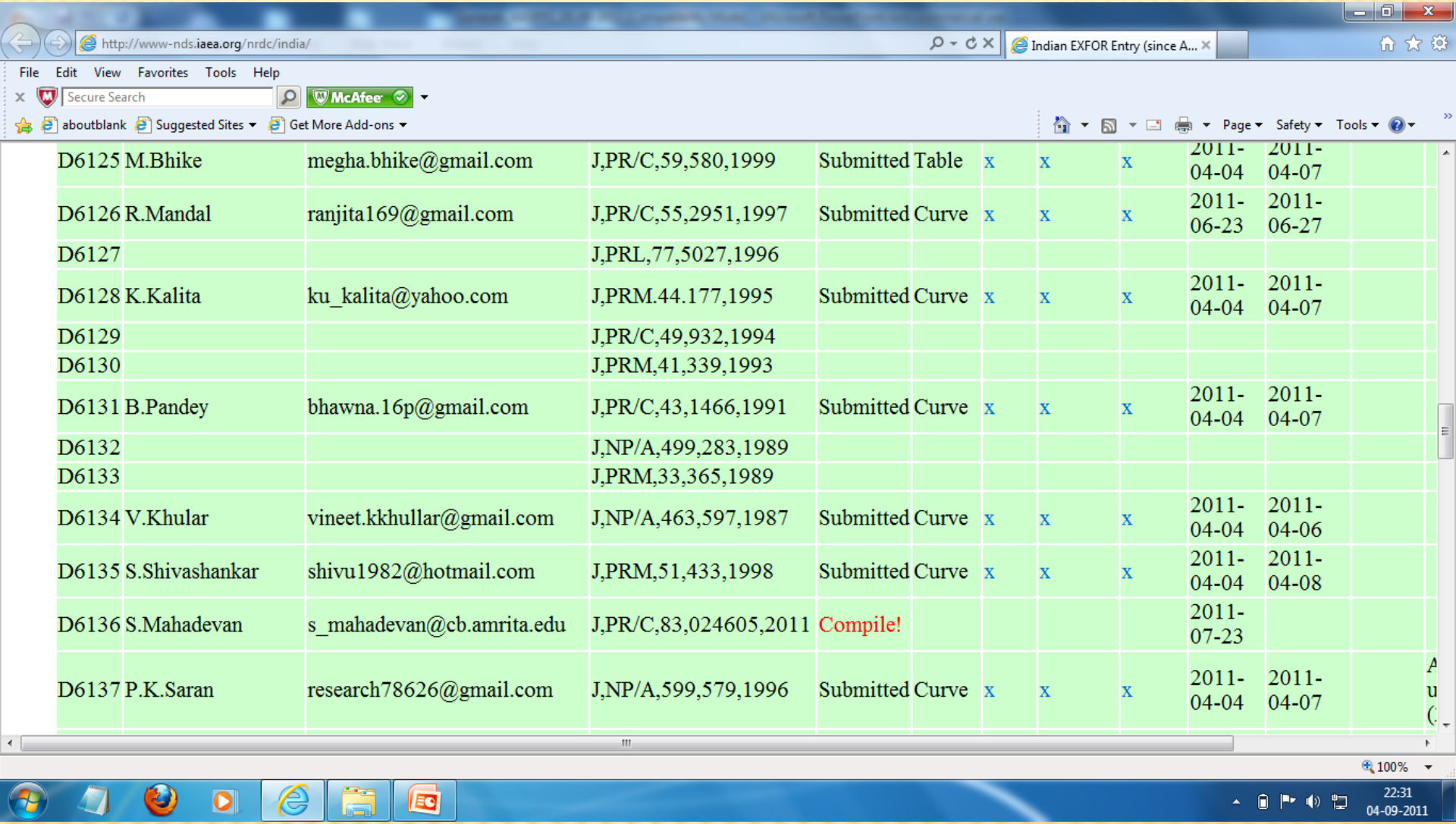

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D6134	V.Khular	vineet.kkhullar@gmail.com	J,NP/A,463,597,1987	Submitted	Curve	x	x	x	2011-04-04	2011-04-06	
D6135	S.Shivashankar	shivu1982@hotmail.com	J,PRM,51,433,1998	Submitted	Curve	x	x	x	2011-04-04	2011-04-08	
D6136	S.Mahadevan	s_mahadevan@cb.amrita.edu	J,PR/C,83,024605,2011	Compile!					2011-07-23		
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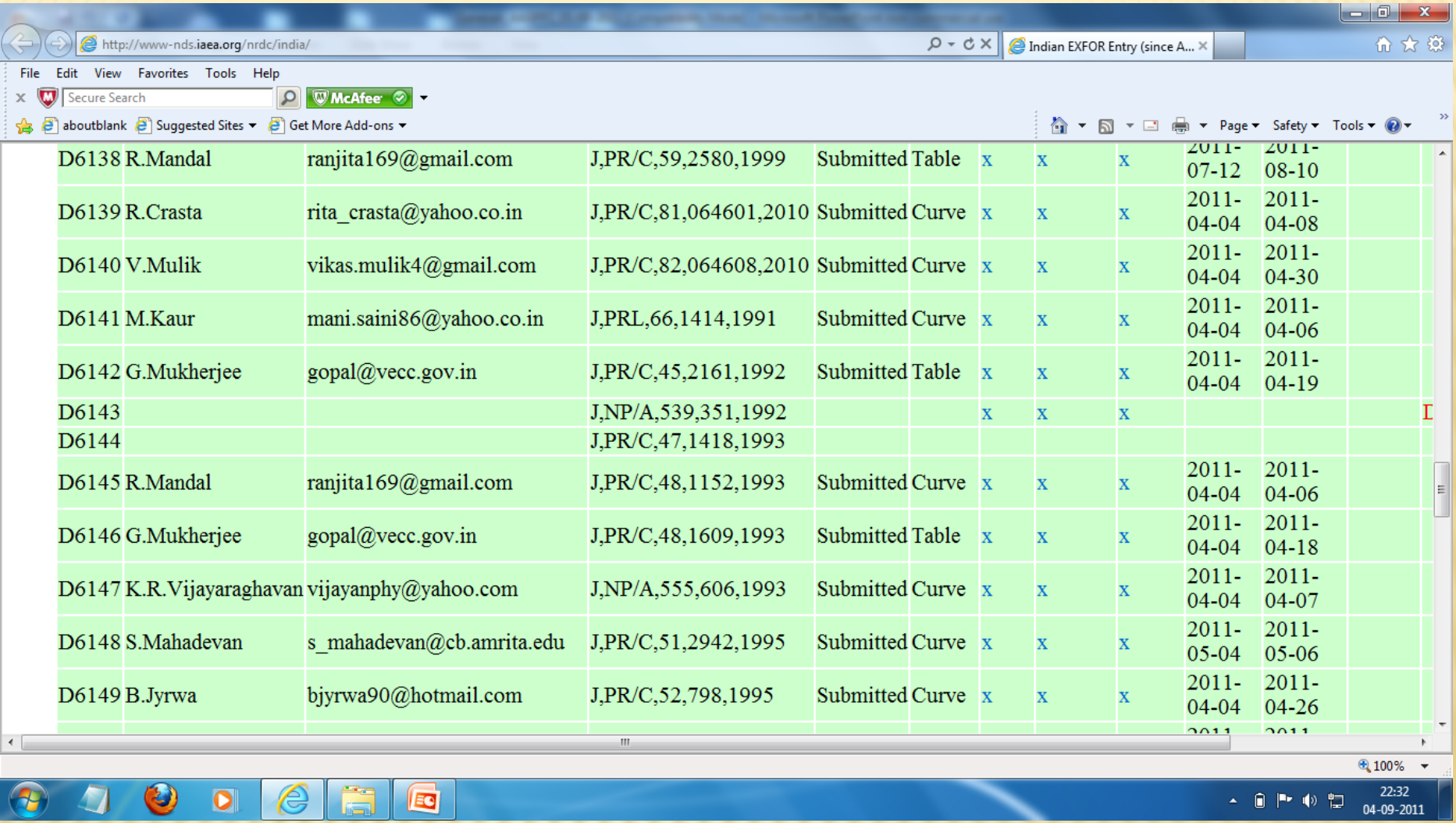

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D6147	K.R.Vijayaraghavan	vijayanphy@yahoo.com	J,NP/A,555,606,1993	Submitted	Curve	x	x	x	2011-04-04	2011-04-07	
D6148	S.Mahadevan	s_mahadevan@cb.amrita.edu	J,PR/C,51,2942,1995	Submitted	Curve	x	x	x	2011-05-04	2011-05-06	
D6149	B.Jyrwa	bjyrwa90@hotmail.com	J,PR/C,52,798,1995	Submitted	Curve	x	x	x	2011-04-04	2011-04-26	

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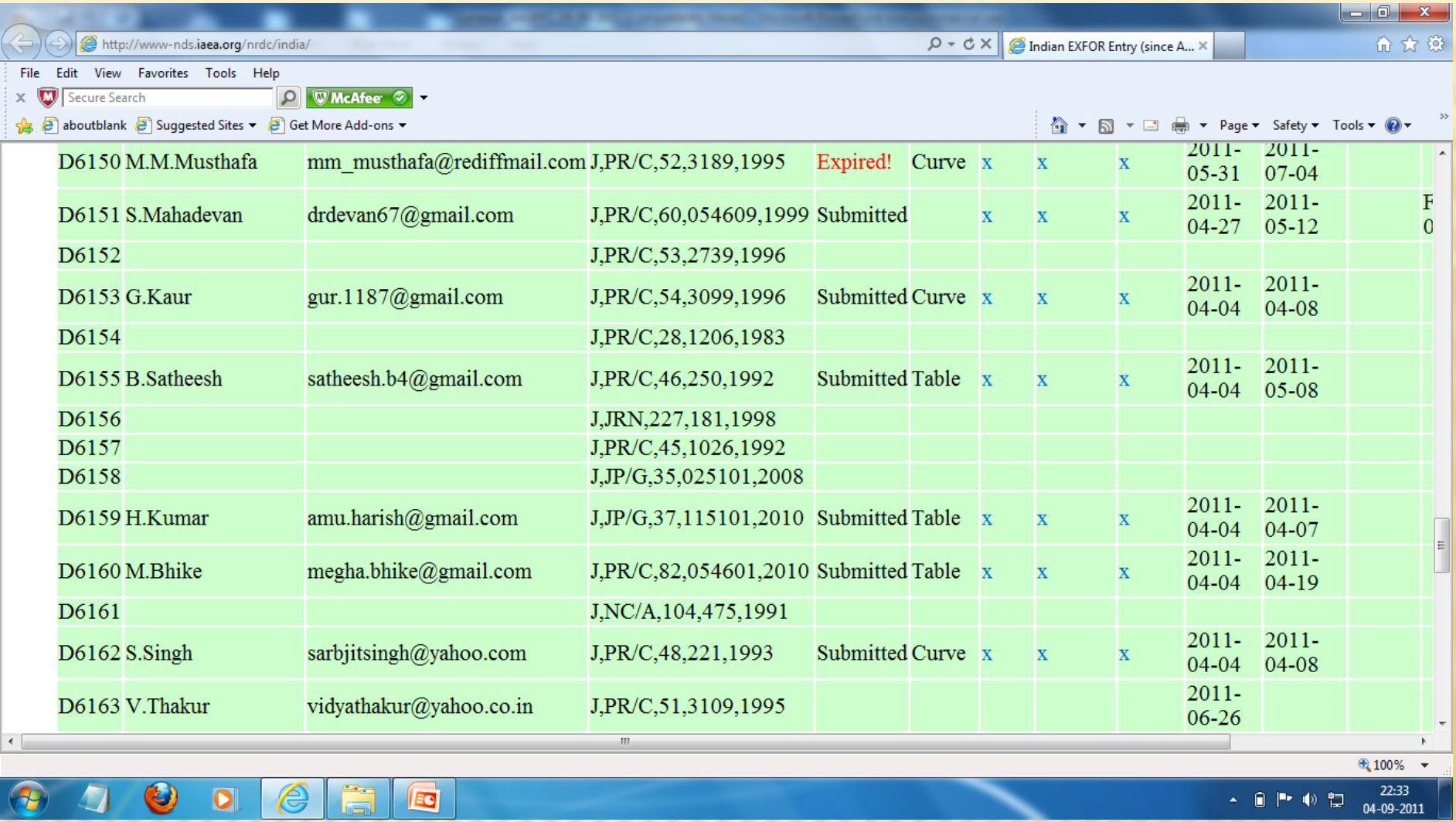

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D6159	H.Kumar	amu.harish@gmail.com	J,JP/G,37,115101,2010	Submitted	Table	x	x	x	2011-04-04	2011-04-07		
D6160	M.Bhike	megha.bhike@gmail.com	J,PR/C,82,054601,2010	Submitted	Table	x	x	x	2011-04-04	2011-04-19		
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D6162	S.Singh	sarbjitsingh@yahoo.com	J,PR/C,48,221,1993	Submitted	Curve	x	x	x	2011-04-04	2011-04-08		
D6163	V.Thakur	vidyathakur@yahoo.co.in	J,PR/C,51,3109,1995						2011-06-26			

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D6170	S.Shivashankar	shivu1982@hotmail.com	J,JRN/L,119,303,1987	Submitted	Table	x	x	x	2011-04-18	2011-04-19	
G0501	P.M.Prajapati	paresh_21soft@yahoo.co.in	J,NP/A,853,1,2011	Finalized	Table	x	x	x	2011-04-04	2011-04-07	
G0502	R.Mandal	ranjita169@gmail.com	J,RM,46,413,2011	Finalized	Curve	x	x	x	2011-04-04	2011-05-13	2 J
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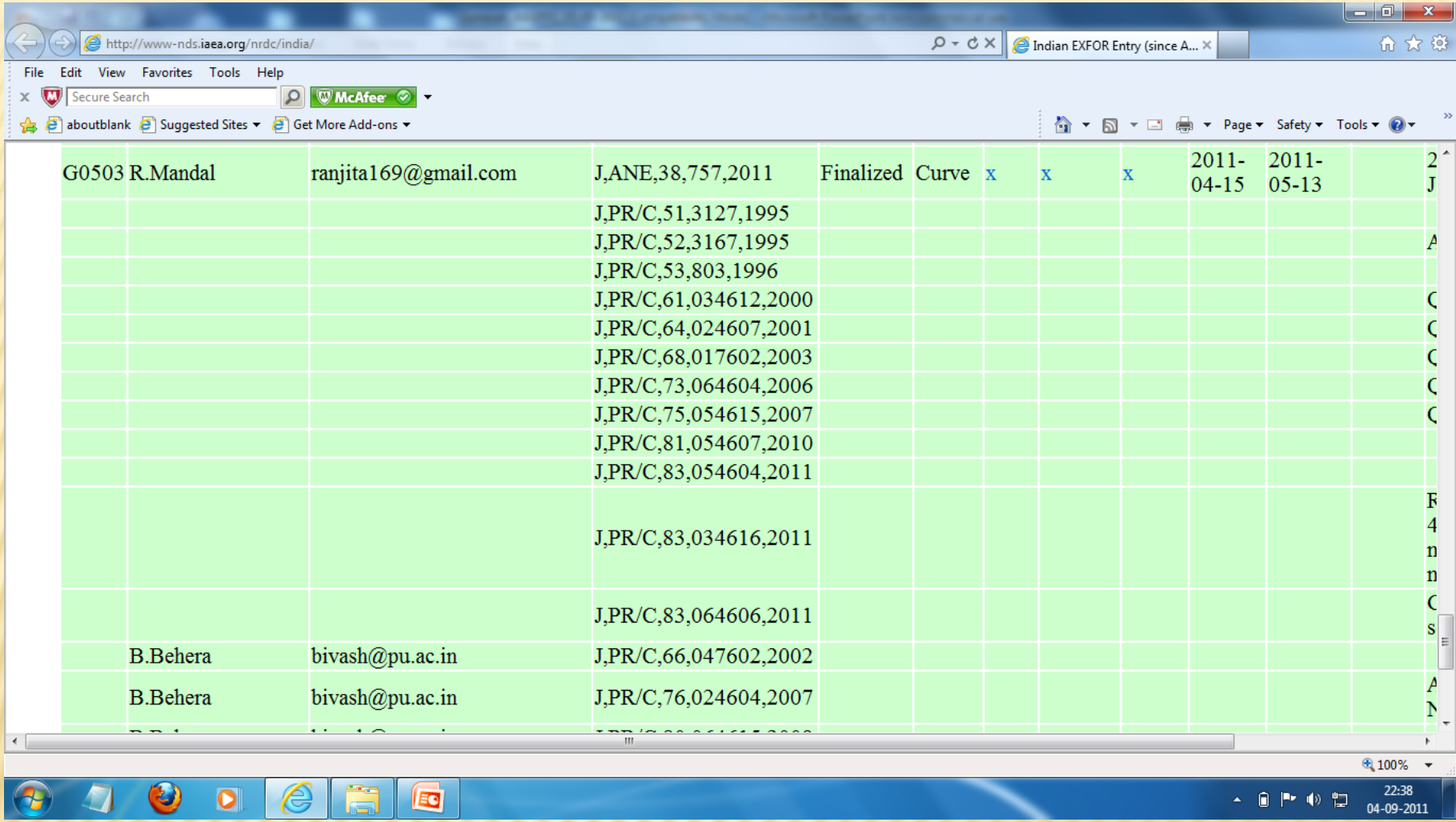

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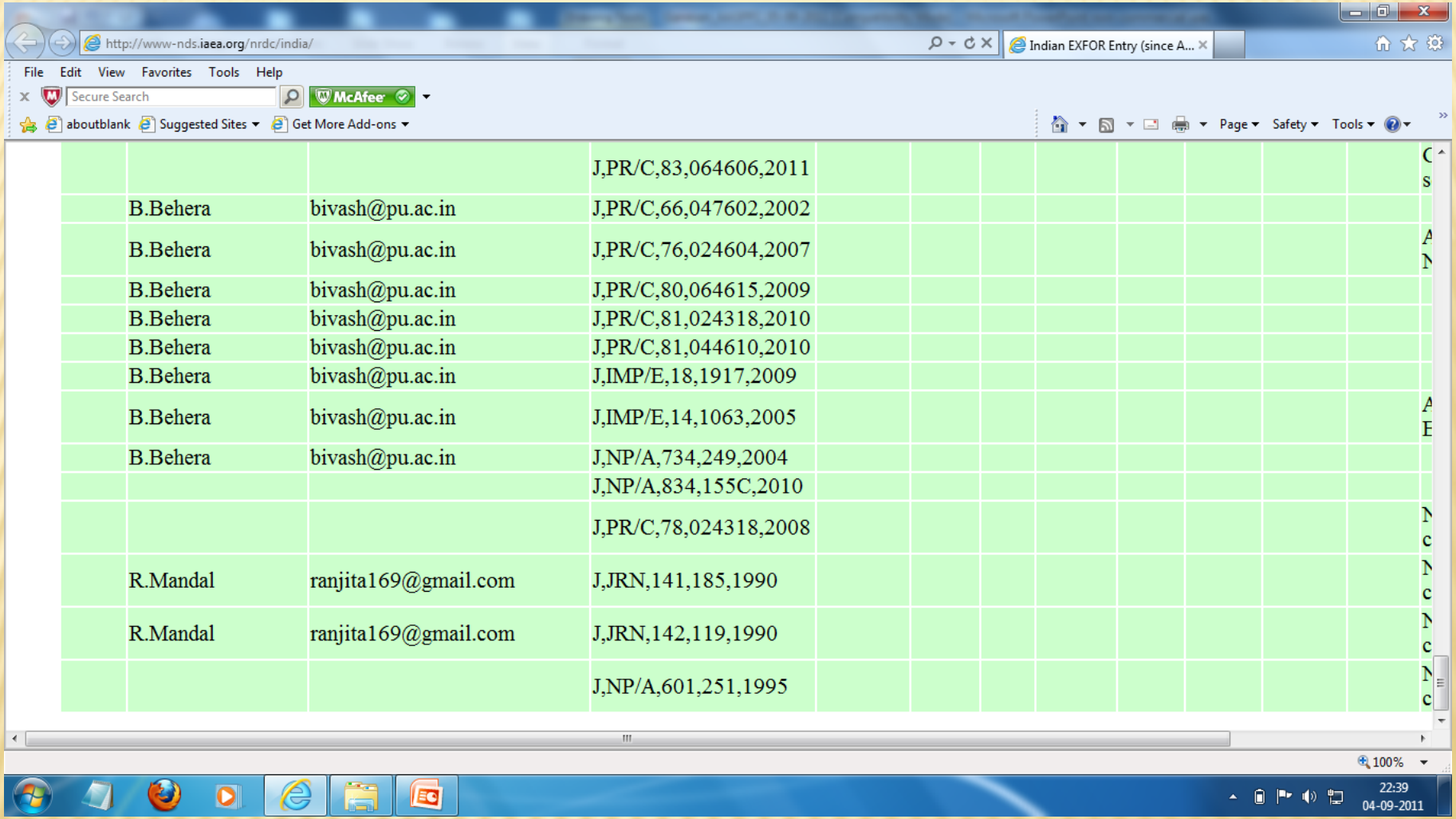
	B.Behera	bivash@pu.ac.in	J,PR/C,76,024604,2007									A N

http://www-nds.iaea.org/nrdc/india/



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	R.Mandal	ranjita169@gmail.com	J,JRN,141,185,1990									N c
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			J,NP/A,601,251,1995									N c

http://www-nds.iaea.org/nrdc/india/

EXFOR WORKSHOPS IN INDIA IS A NEW & UNIQUE MANGERIAL INITIATIVE AND HAVE BEEN PHENOMENALLY SUCCESSFUL.

Introduction of EXFOR culture in people including in basic nuclear physics has become relatively an easier task with the new managerial initiatives of holding EXFOR workshops in India.

NDPCI has been very successful to bring people in various fields (e.g., Nuclear Physics, Reactor and Radiochemistry Divisions of BARC, IGCAR, VECC etc.) and students and staff from various Universities across India. A very unique activity. Both experimentalists, theoreticians were covered.

NDPCI is evolving a strong community of EXFOR compilers in India.

At present, NDPCI does not have regular staff in BARC.

Regular staff to perform EXFOR compilations are planned.

This arrangement is being formulated at this time.

NDPCI itself is functioning as a virtual centre and funds have been allocated for a 3 year period. 2011-2014.

NDPCI is identifying University staff and awarding contracts on EXFOR compilations.

The first such DAE-BRNS contract has already been awarded to Prof. B. Jyrwa, North Eastern Hill Univesity (NEHU), Shillong, Meghalaya in May 2011.

Two Project assistants (M.Sc. (Physics) Level qualification) Ms. Ritaparna GHOSH and Ms. Sylvia Badegar were recruited by NEHU for a 2-year period on contract.

- Thus far, since 2006, INDIA contributed in all more than 200 new Indian EXFOR entries based upon experimental data generated in Indian nuclear physics experiments

- The identification for coding into EXFOR of all the suitable Indian articles published in the literature was done in consultation with and by the IAEA-NDS staff.

- India successfully contributed more than 200 EXFOR entries. These include the following.
  - 10 new entries in 2006 Workshop (Faculty: Otto Schwerer Manual entries)
  - 31 new entries in 2007 Workshop (Faculty: Svetlana DUNAEVA, EXFOR editor)
  - 55 new entries in 2009 Workshop (Faculty: Svetlana DUNAEVA, EXFOR editor software used)
  - 80 + new entries in 2011 EXFOR Workshop

The details of new Indian EXFOR entries are, for instance, available in "Full EXFOR Compilation Statistics", in the IAEA-NDS site: http:www-nds.iaea.org.exfor-master.x4compil.exfor_input.htm

MAY 2010, IAEA-NDS, VIENNA, EXFOR WORKSHOP

S.V. Surayanarayana and H. Naik participated

:May 2011, IAEA-NDS, VIENNA, EXFOR WORKSHOP

Sarbjit Singh and Megha Bhike participated.

AASPP-1, 2010, Hokkaido University: Attended by S. Ganesan, Devesh Raj, Paresh Prajapati and H. Naik.

AASPP-2: 2011: Beiging, China: Attended by H. Naik, Dr. M. Balasubramaniam and S. Ganesan

IN SUMMARY, NDPCI promotes several nuclear data physics activities in India . The activities include the following.

- *Basic nuclear data physics measurements.*
- *EXFOR compilations.*
- *Nuclear model based calculations.*
- *Processing of evaluated nuclear data files including development of codes to produce plug-in lprocessed nuclear data ibraries for Indian discrete ordinates and Monte Carlo codes.*
- *Efforts to digest the status of covariance error methodology in nuclear data and its applications.*
- *Preparation of integral Indian experimental criticality benchmarks for integral nuclear data validation studies. (KAMINI, PURNIMA-II benchmarks completed and accepted by the US-DOE). PURNIMA-I benchmarking is in final stage of completion.*
- *Reactor parameters sensitivity to nuclear data files and studies –AHWR, CHTR (RPDD, BARC). Study of basic nuclear data errors and propagations in simulations.*

INTEGRAL NUCLEAR DATA VALIDATION STUDIES

India is a contributor to the experimental nuclear criticality benchmarks of the International Criticality safety Benchmark Evaluation Project (ICSBEP) of the US-DOE/NEA-DB.
For details, please visit the URL: http://icsbep.inl.gov/

History of previous benchmarking tasks by India:

2005: India contributed the KAMINI experimental benchmark

(ICSBEP Reference: U233-MET-THERM-001)

2008: India contributed the PURNIMA-II experimental benchmark

(ICSBEP Reference: U233-SOL-THERM-007)

2009: Work started on PURNIMA-I (PUO2 fast system)

2010: PURNIMA-I (Completed; Critical internal review in progress)

India's nuclear power programme.

See for instance:

- **http://www.dae.gov.in/ and various links therein.**
- **http://www.npcil.nic.in/main/AllProjectOperationDisplay.aspx**
- **http://www.npcil.nic.in/main/ProjectConstructionStatus.aspx**
- **http://www.igcar.gov.in/**

- **The Indian nuclear programme envisages multiple fuel cycles including throum utilization with closed fuel cycle options of INPRO/GEN-IV equivalent.**

- **A programme of study of propagation of uncertainties in the form of variance-covariances in nuclear data physics (Topic of this IAEA TM) in relation to target accuracies and sensitivity studies is of great importance to Indian nuclear programme**

In proposal stage: DAE-BRNS EXFOR WORKSHOPS Under the auspices of the Nuclear data Physics Centre of India, DAE-BRNS,

The 5th Indian EXFOR compilation workshop is planned for 2012 and the 6th one in 2013.

The dates and venues in India will be fixed in due course by NDPCI in consultation with local hosts.

Status of 2012 and 2013 Indian EXFOR Workshops:

Under informal discussions.
Application for funding will be made.
To be organized by the NDPCI.

“The first Indian DAE-BRNS Workshop on “Nuclear data evaluation techniques including covariances” being proposed by the NDPCI for 2012 Spring.

The dates and venue in India will be fixed in due course by NDPCI in consultation with hosts.

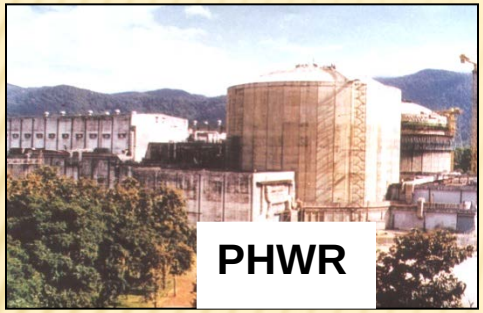
Status:
Application for funding is being made. To be organized by the NDPCI.

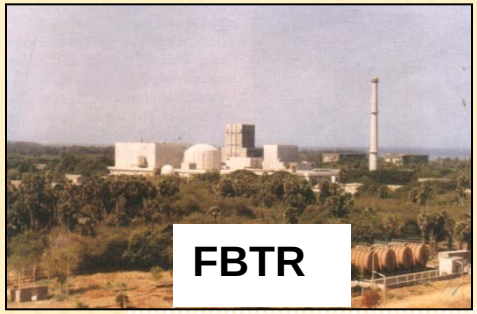

中国孔子基金会
天天特价书展
AASPP Workshop
The 2nd Asian Nuclear Reaction Database Development Workshop
アジア・アフリカ
学術基盤形成事業
AA Science Platform Program
独立行政法人
日本学術振興会
Japan Society for the Promotion of Science

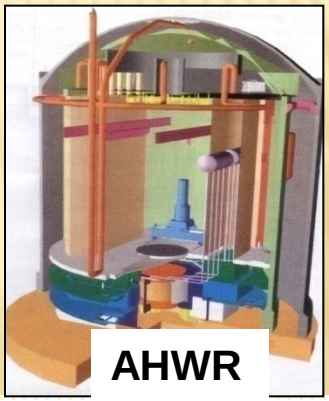
THANK YOU

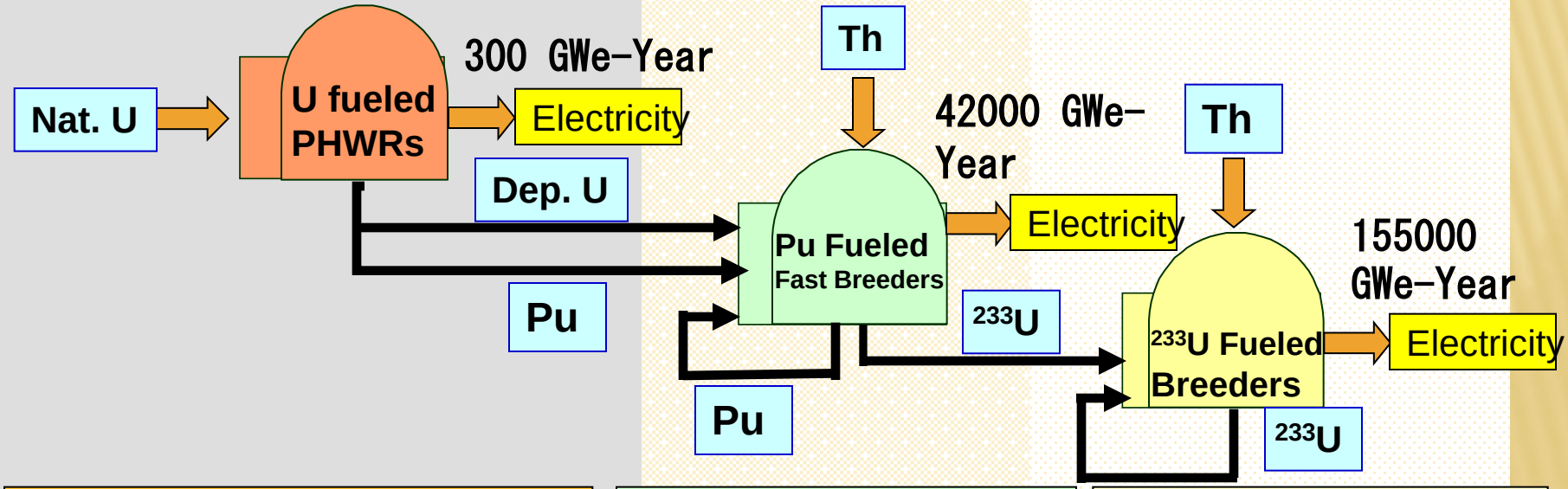
THREE-STAGE INDIAN NUCLEAR PROGRAMME

Thorium in the centre stage









Power generation primarily by PHWR
Building fissile inventory for stage 2

Stage 1

Expanding power programme
Building ^{233}U inventory

Stage 2

Thorium utilization for
Sustainable power programme

Stage 3

Three Stage Nuclear Power Programme- Present Status

Stage – I PHWRs

- 17 - Operating
- 5 - Under construction
- Several others planned
- Scaling to 700 MWe
- Gestation period has been reduced
- POWER POTENTIAL ≅ 10,000 MWe

LWRs

- 2 BWRs Operating
- 2 VVERs under construction

Stage - II

Fast Breeder Reactors

- 40 MWth FBTR - Operating since 1985, Technology Objectives realized.
- 500 MWe PFBR- Under Construction .
- Stage-II POWER POTENTIAL : ≅ 530,000 MWe

Stage - III

Thorium Based Reactors

- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Under Development

POWER POTENTIAL FOR STAGE-III IS VERY LARGE

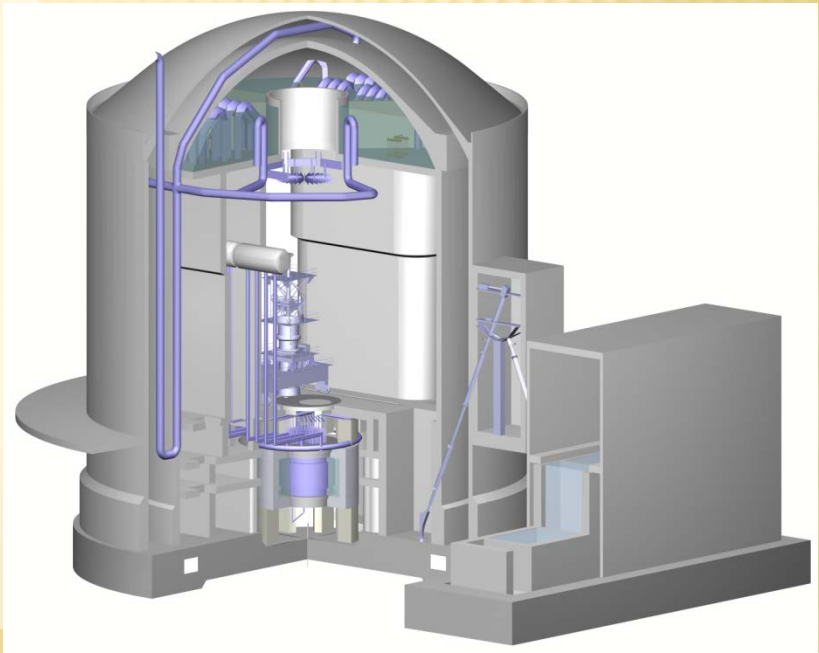
Availability of ADS can enable early introduction of Thorium and enhance capacity growth rate.

ADVANCED HEAVY WATER REACTOR (AHWR)

Major Design Objectives

- **Power output – 300 MWe with 500 m^3/d of desalinated water.**
- **Core heat removal by natural circulation**
- **A large fraction (65%) of power from thorium.**
- **Extensive deployment of passive safety features – 3 days grace period, and no need for planning off-site emergency measures.**
- **Design life of 100 years.**
- **Easily replaceable coolant channels.**

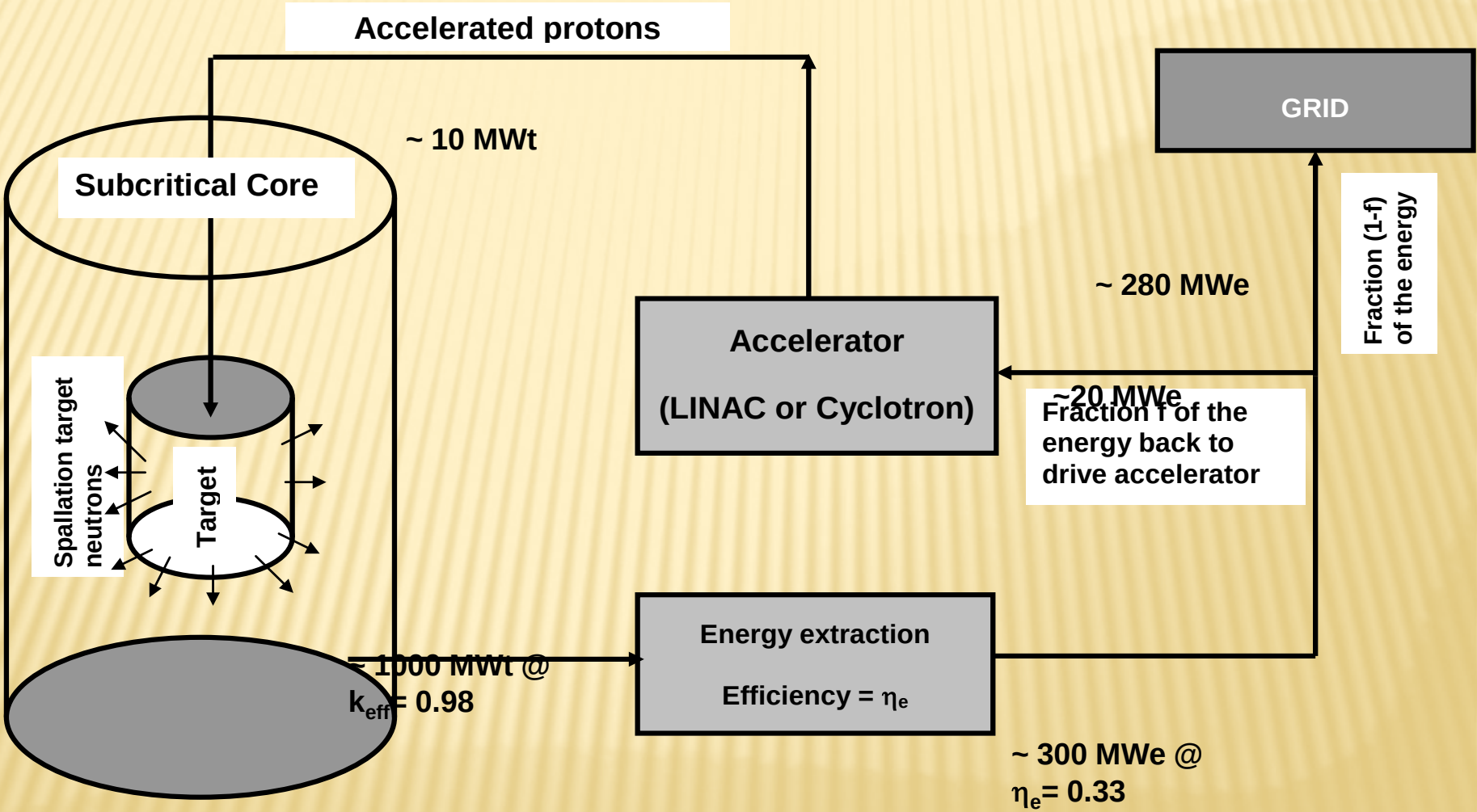
Technology demonstration for large-scale thorium utilization



- **Vertical pressure tube.**
- **Boiling light water cooled.**
- **Heavy water moderated.**
- **Fuelled by ^{233}U-Th MOX and Pu-Th MOX.**

- **Currently under Pre-Licensing Safety Appraisal by AERB.**
- **International recognition as an innovative design.**

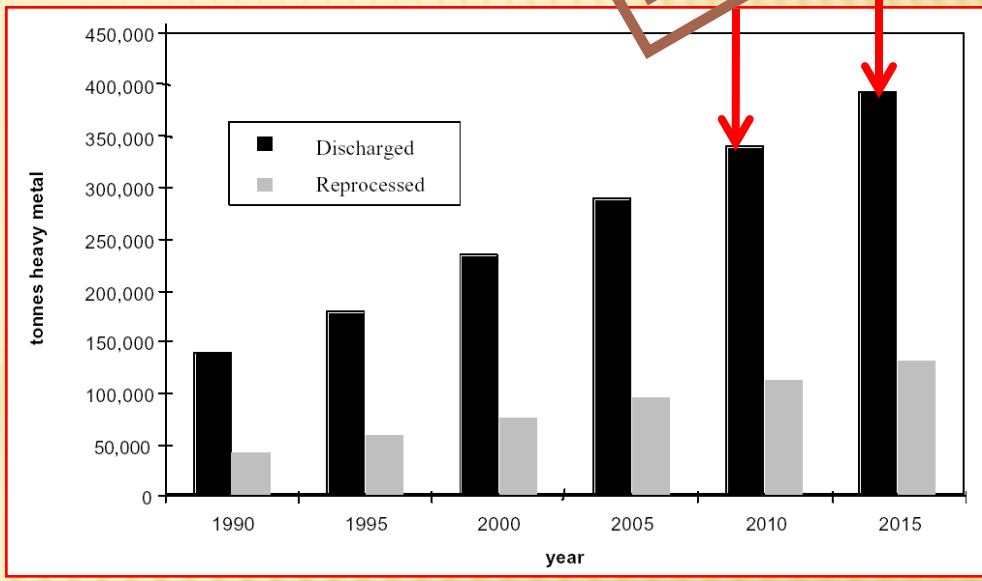
SCHEMATIC OF ADS- ENERGY BALANCE

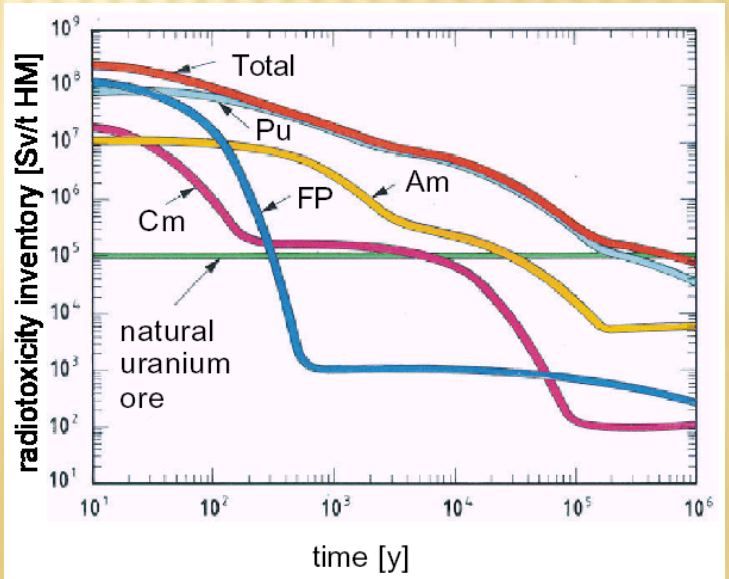


Uncertainties in nuclear data significantly affect the design of ADSS.

NUCLEAR WASTE DISPOSAL BY *TRANSMUTATION*

- **Accumulation of spent fuel: a global issue.**
- **Spent fuel requires > 100,000 years to decay.**
- **Transuranic elements (TRUs: Np, Pu, Am & Cm) + a few long-lived fission products (FPs): decay very slowly.**
- **Bulk of FPs decay to safe disposal levels in 3-5 centuries.**
- **If TRUs transmuted into FPs by fission: bulk of FPs decay very fast.**





THANK YOU