High Efficiency Accelerator Driven Reactor

Ganapati Rao Myneni

Accelerator Division, Jefferson Lab,
Materials Science and Engineering and
Engineering Physics, University of Virginia
&
International Symposium On Hydrogen In Matter (ISOHIM)

Third Thorium Energy Alliance
Future Energy Conference
Top of the Hill Conf. Center – Washington, DC
May 12, 2011

Overview

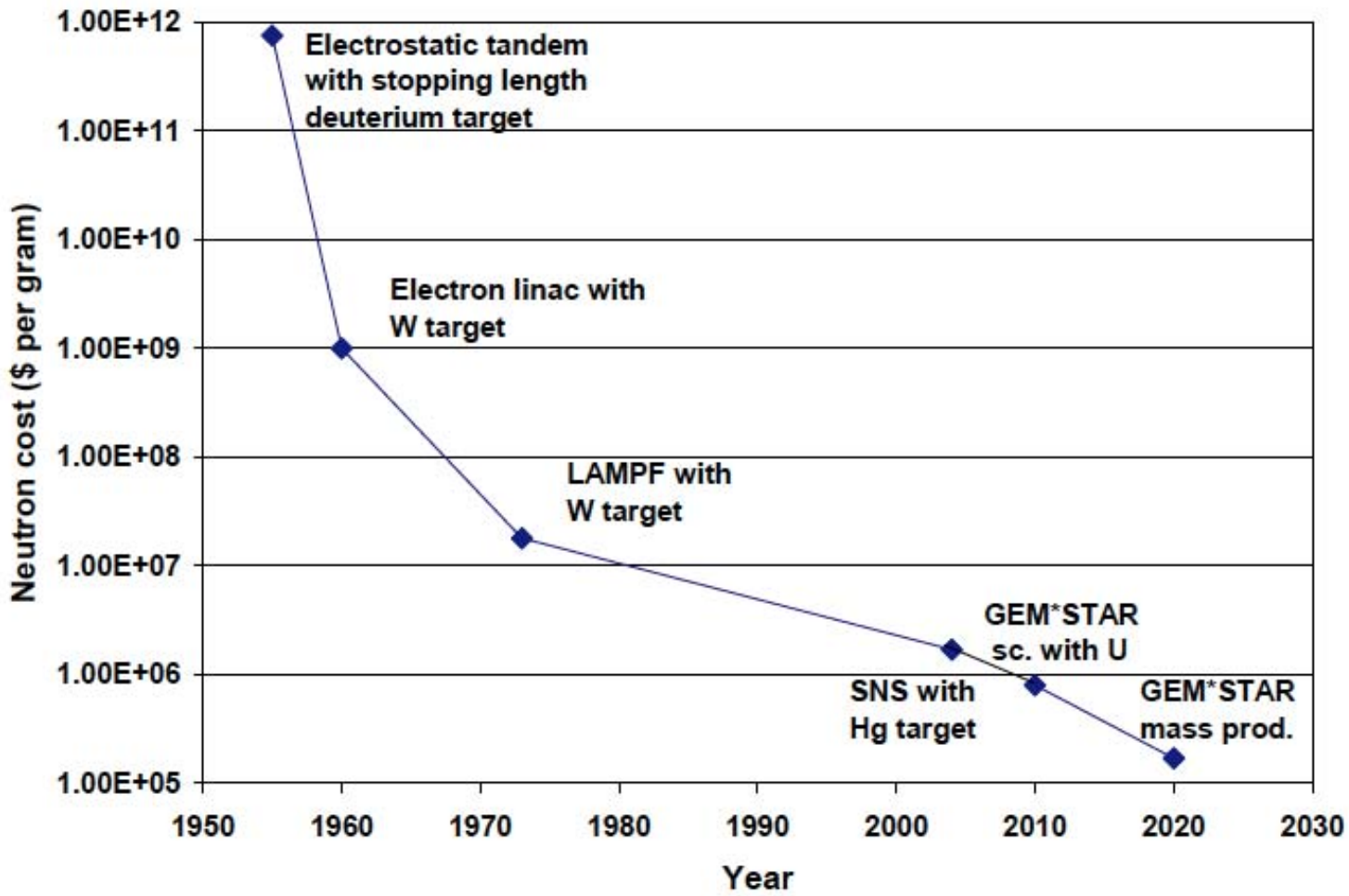
- Brief History
- Initial Contacts with India – 2005-2006 (thorium)
- BARC – JLab MOA (CW SRF with low RRR ingot Nb-2007)
- HBNI – UVa MOA 2009
- DAE – Virginia Thorium Energy Discussions
- International ADS-Th Utilization Workshops

Brief Early History of ADS

- 1950 – U. E. O. Lawrence, High power accelerators for producing fissile materials
- 1952 – W. B. Lewis, proposed use of thorium with intense neutron generator
- 1992 – V. Bowman, Energy generation with ATW
- 1993 – C. Rubbia, Energy amplifier

Thorium – non proliferation, no melt down, safe and least NRC involvement

Charlie Bowman's Neutron Cost Estimates



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Nuclear power: Thorium

physicsworld.com

Enter the thorium tiger

India has a unique vision for a secure nuclear-energy future based on thorium. As the UK enters a new era of civil nuclear collaboration with India, **Matthew Chalmers** tours India's nuclear labs with a British High Commission team helping to bring physicists from both countries together

Department of Atomic Energy (DAE, Government of India) Institutions

- Tata Institute of Fundamental Research (A deemed University, 1943, Homi Bhabha)
  - TIFR-Hyderabad Center, Andhra Pradesh
- Bhabha Atomic Research Center (Homi Bhabha, AEET 1954, 1957 Nehru, 1967 Indira Gandhi)
  - BARC-Vizag Center, Visakhapatnam, Andhra Pradesh
- Saha Institute of Nuclear Physics
- Nuclear Power Corporation of India (NPCIL)
- Variable Energy Cyclotron Center (VECC)
- Tata Memorial Center
- Indira Gandhi Center for Atomic Research (IGCAR)
- Raja Ramanna Center for Advanced Technology (RRCAT)
- Institute of Mathematical Sciences
- Institute of Physics
- Harish-Chandra Research Institute
- Institute of Plasma Research (IPR – ITER partner Institution)

✓ Except for TIFR and NPCIL – the rest are Constituent Institutes of Homi Bhabha National Institute (HBNI, a Deemed Government of India University)

UVa-HBNI Thorium Energy Discussions

Green Energy - Thorium

World Thorium Resources

Country	Reserves (tons)
Australia	300,000
India	290,000
Norway	170,000
USA	160,000
Canada	100,000
S. Africa	35,000
Brazil	16,000
Malaysia	4,500
Other Countries	95,000
World total	1,200,000

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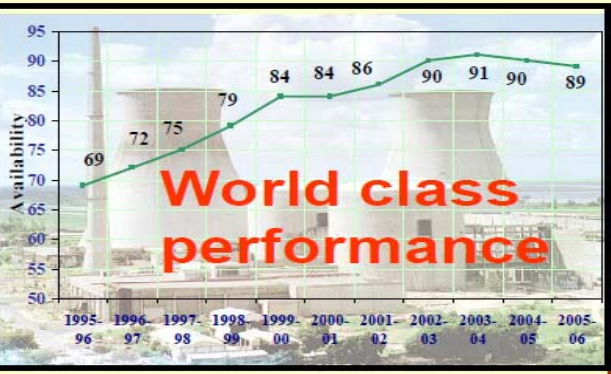
Dr. Banerjee

India's Nuclear Energy R&D Programs

Three Stage Nuclear Power Programme- Present Status



Stage – I PHWRs

- 15 - Operating
- 3 - 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
- POWER POTENTIAL ≅ 530,000 MWe

Stage - III
Thorium Based Reactors

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

POWER POTENTIAL IS VERY LARGE

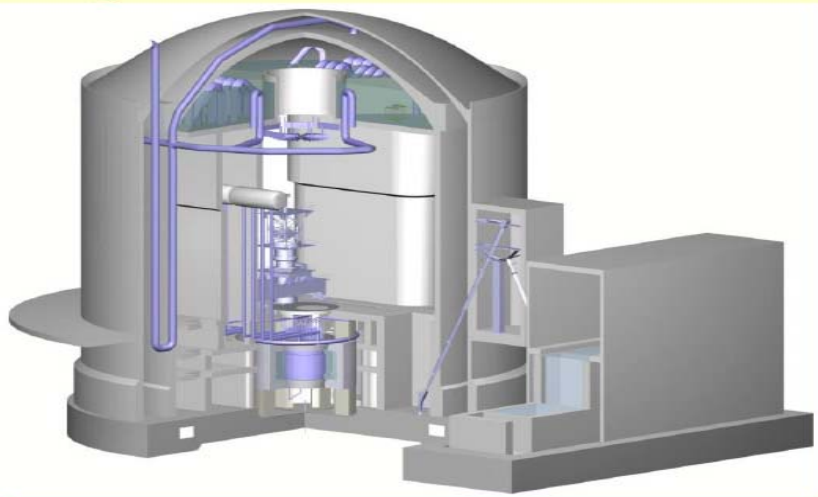
Availability of ADS can enable early introduction of Thorium and enhance capacity growth rate.

India's Advanced Reactor

Advanced Heavy Water Reactor (AHWR)

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

Technology demonstration for large-scale thorium utilization



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

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.

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Ingot Niobium: Frontier Technology for Nuclear Power

Ganapati Rao Myneni

Accelerator Division , Jefferson Lab

&

Department of Physics, University of Virginia

Bhabha Centenary Symposium
TIFR, Mumbai, India
December 3-5, 2009

This technology will improve the Qo of the Linacs ~ 3 there by reducing the Cryogenic System costs by ~ 60% and reduce the operating costs ~3

http://conferences.jlab.org/sstin/index.html

Initial vision

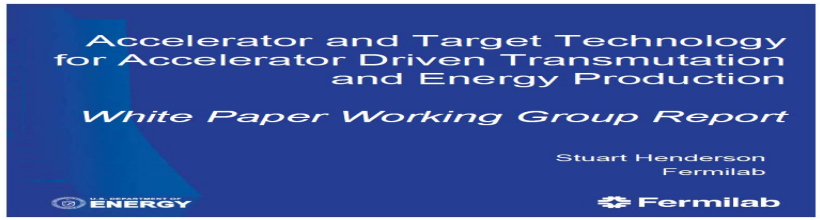
- Small Electron Linac Driven Sub-critical Thorium Systems (AD-STS) in India and USA
- Full fledged US facility 300 MWe AD-STS (USA?)
- Vision: India & US teams jointly work on implementing one each AD-STS in US and India

International ADS-Th Utilization Workshops

First workshop was jointly Organized by Virginia Tech and Jefferson Lab Sept 22-24, 2010

http://www.phys.vt.edu/~kimballton/gem-star/workshop/index.shtml

Dr. Stuart Anderson of FNAL presented the DOE Office of Science Committee report



Finding #2

Accelerator-driven sub-critical systems offer the potential for safely burning fuels which are difficult to incorporate in critical systems, for example fuel without uranium or thorium.

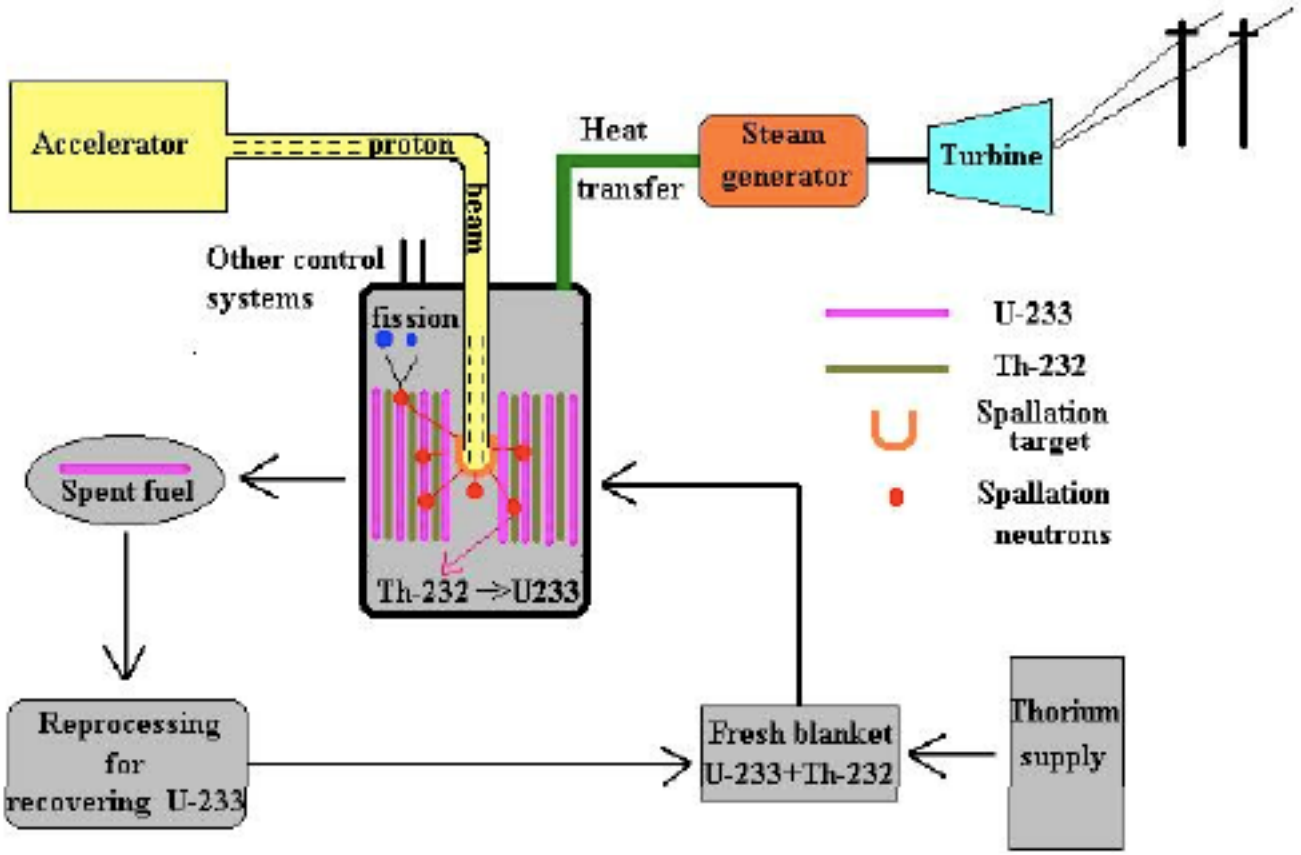
Finding #3

Accelerator driven subcritical systems can be utilized to efficiently burn minor actinide

Finding #4

Accelerator driven subcritical systems can be utilized to generate power from thorium-based fuels

Thorium utilizing ADS Scheme



Schamtic of an Accelerator Driven Sub-critical System to produce electricity as well as breed fissile Uranium-233

Dr. S. Banerjee AEC/DAE India, UVa Presentation, UVa May 2010

2nd International ADS & Thorium Utilization Workshop Dec 11-14, 2011 Mumbai, India

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