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# Present Status of the Accelerator Industry in Asia

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## Introduction

- "Accelerators Industry" includes all accelerator vendors who supply entire accelerator machines for medical therapy, Irradiation, NDT and Ion Implantation.
  - Central facilities for users to do research works are not included.
  - Devices at very low energy, such as x-ray tubes, electron microscopes or lithography systems are not included.
  - The accelerator related technologies, such as rf tubes, modulators, magnets, vacuum devices, cooling system, ion and electron sources, beam diagnostic instrumentations, ..., are not included.
  - The accelerator users are not counted as "accelerator industry".
- Asia is still importing lots of accelerators, for example, from VARIAN, SIEMENS, IBA, GE and so on. And most of them established accelerator factories in Asia. They are also not included here.
- Medical therapy, Irradiation and NDT are still the main applications of the accelerators in Asia.
- The vendor list is changing all the time.



# **Medical Applications**

- Proton/Ion Radiotherapy
- Electron and X-ray Radiotherapy
- Radio-Isotope Production

### Proton/Ion Radiotherapy

- Overall property of proton/ion radiotherapy
  - Because of the characteristic Bragg peak of proton and ion, proton or ion radiotherapy permit one to control very precisely the shape of the dose distribution, and the dose delivered by a proton or ion beam can be well localized at the tumor.
  - The proton/ion radiotherapy facilities are very expensive and need large space to install.
- Accelerators:
  - Cyclotron, synchrotron, ion linac, FFAG ..
- Main Vendors in Asia:
  - Mitsubishi (JAPAN), Synchrotron, Proton & Ion Therapy
  - Sumitomo (JAPAN), Cyclotron, Proton Therapy
  - HITACHI (JAPAN), Synchrotron, Proton Therapy, Ion Therapy (developing)

Laser

**cceleration** 

- Proton/ion Radiotherapy R&D in Asia:
  - HIMAC (Japan), Synchrotron, carbon beam
  - Institute of Morden Physics (IMP) of China, Synchrotron, carbon beam
  - Joint Institute for Nuclear Research (JINR) of Russia, Cyclotron, Proton
- The demands for ion radiotherapy are increasing fast in Asia.

#### Mitsubishi Electric

- Synchrotron therapy systems
  - Proton type (70 250 MeV)
  - Proton (70 250 MeV) /carbon (70 380 MeV/u) type.



From 1994, four systems manufactured by Mitsubishi have been installed and another three systems under construction



http://global.mitsubishielectric.com/, (2010).

#### HIRFL-CSR at IMP

Courtesy of Mingtao Song



## Electron and X-ray Radiotherapy

- Most of the electron and x-ray therapy equipments are based on S-band rf linear accelerators. X and C band linacs can be more compact. X-band linacs have been used in Cyberknife and Mobetron. C-band is been developing.
- The products from VARIAN, SIMENS, ELEKTA still occupy a very large part of market in Asia. And they have branches in Asia.
- Main Vendors in Asia:
  - SHINVA (CHINA)
  - HaiMing (CHINA)
  - HITACHI (JAPAN)
  - SAMEER (INDIA)
  - NPKLUTS (RUSSIA)







XHA600C of SHINVA

SL75-5-MT of NPKLUTS

Siddharth of SAMEER

### **Radio-Isotope Production**

- RI production for PET normally adopts 10-30MeV cyclotrons.
- The main vendors of the Cyclotron machines for RI production in Asia are
  - Sumitomo (Japan),
  - Samyoung Unitech (Korea).
- R&D of Cyclotrons for RI production:
  - NPKLUTS (Russia)
  - CIAE, IMP and CAEP (China)



Sumimoto: 10MeV,12MeV and 18MeV(HM-18)

http://www.shi.co.jp/quantum/e ng/product 2010



KIRAMS-13 of Samyoung Unitech

Courtesy of W.Namkung



**RITs-30 of NPKLUTS** 

M. F. Vorogushin, Atomic Energy, Vol. 95, No. 1, 2003, P493

# **EB** Irradiation

- Electron RF Linacs (S-band, L-band)
  - Easy to get high electron energy
  - Hard to get very high electron beam power (<60kW)</li>
  - Vendors:
    - IHI (Japan)
    - HTA , EL Pont , Ningbo, NUCTECH, IHEP, CIAE...(China)
    - EB-Tech, POSTECH & KAPRA (Korea)
    - RRCAT , BARC (India)
- DC High Voltage Accelerators
  - Easy to get high electron beam power
  - Hard to get high electron energy (<5MeV)</li>
  - Vendors:
    - NHV (Japan)
    - EL Pont , FERES, CJDS, IMP , SINAP ...(China)
    - EB-Tech (Korea)
    - RRCAT , BARC (India)
    - BINP (Russia)
- RF High Power Accelerators-ILU
  - Can be suitable for both high energy and high power
  - Vendor: BINP (Russia)

#### L-band Linacs developed by KAPRA and POSTECH



Courtesy of W.Namkung

#### L-band Linacs developed by IHEP

- Beam energy: 10 MeV
- **Tube structure: Travelling wave**
- Frequency: 1300 MHz
- Beam average 40 kW power:
- Beam stability: 5 %
- Scanning width: 1 m
- Scanning5 20 Hzfrequency:(adjustable)



#### Courtesy of R.J. Shi and L. Lin

#### ELV and ILU developed by BINP

Two kinds of widely used irradiation accelerators in Asia: ELV-DC high voltage type, and ILU based on RF acceleration.





The electron beam power of ELV-12 can reach 400kW with electron energy of 0.6-0.9MeV, and the electron energy of ELV-8 can be 1.0-2.5MeV with beam power of 90kW.

ILU covers the energy range from 0.6MeV to 5 MeV, and the maximum beam power is 50 kW. A 5MeV/300kW ILU accelerator is developing now.

Yu.I. Golubenko, et al, "Electron Accelerator of ELV-Type And Their Worldwide Application", APAC2007,THPMA118. V.L. Auslender, et al, "Industrial High Energy Electron Accelerators Type ILU", Proceedings of RuPAC 2008, P367(2008).

# Non-Destructive Test

- Electron linacs of 1MeV-16MeV are mainly used for NDT application.
  - X-ray photography (digital image or film)
    - RIAMB, HTA, Granpect, SPRI, IHEP (China)
    - NPKLUTS (Russia)
  - Industrial Computer Tomography (ICT)
    - Granpect, SPRI, IHEP (China)
    - Hitachi (Japan)
  - Cargo Inspection
    - NUCTECH (China)
- The linac is specially designed to get small spot size, for the spot size is very important for high spatial resolution of a NDT system.

## X-ray photography



X-ray photography application of linacs of RIAMB, and the application areas of the RIAMB linacs

Courtesy of Y.B.Guo





HEXTRON-3000 linac developed by Granpect and TUB, and the ICT image with it.

C. Tang, H.B. Chen and Y.H. Liu, "Electron Linacs for Cargo Inspection and Other Industrial Applications", IAEA Proceedings of International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, 4-8 May 2009, Vienna. SM/EB-28. IAEA, Vienna, 2010, STI/PUB/1433, ISBN 978-92-0-150410-4, ISSN 1991-2374.

### Cargo Inspection System developed by NUCTECH

#### Fixed





RF source: 5MW klystron Electron Energy: 9MeV Dose Rate: 30 Gy/min-m

#### Relocatable



#### mobile





Electron energy 6MeV Dose rate ~12cGy/min RF Source: 2.6MW Magnetron





X-band 2.5MeV SW Tube SW Tube Powered by a 1MW 9300MHz MG5125 magnetron magnetron

### Cargo Inspection System developed by NUCTECH



9/6 MeV dual energy linac



Dual energy image of a van with different materials inside.



The image of the dual energy cargo inspection system combined with fast scan technology

C. Tang, H.B. Chen and Y.H. Liu, "Electron Linacs for Cargo Inspection and Other Industrial Applications", IAEA Proceedings of International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, 4-8 May 2009, Vienna. SM/EB-28. IAEA, Vienna, 2010, STI/PUB/1433, ISBN 978-92-0-150410-4, ISSN 1991-2374.

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 National laboratories and universities play an important role at the R&D of accelerators in Industry. And the situation is different from country to country in Asia.



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# Summary

- The accelerator industry in Asia is mainly at the area of medial therapy, NDT, irradiation and radioisotope production.
- New application area of accelerator means new market and new opportunity of accelerator industry. For example the cargo inspection.
- There are lots of accelerator facilities in Asia, such as synchrotron radiation light sources. They are playing an important role for developing new accelerator applications.
- For an accelerator, even a small one, is never a simple industry product, the academia-industry collaboration is always an essential issue for the accelerator industry.

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## Thanks for your attention!