Experience of Academia-Industry Collaboration on Accelerator Technologies and Projects in Asia

Akira Yamamoto
KEK

To be reported the IPAC-2010, Kyoto, May 26, 2010
Outline

• Introduction
  – Overview of Accelerators for Research and Medical Applications in Asia

• Academia and Industry Collaborations
  – Status in China, Korea, India, and in Japan

• Advanced Accelerator Association, Japan
  – Cooperation among “Industry-Academia-Government” to promote science and technology

• Summary
  – Toward Asian Collaboration for future projects
Acknowledgments

• Many thanks for the information provided by
  – Jie Gao (IHEP, China),
  – Chuangxian Tang (Tsinghua U., China)
  – Kexin Liu (PKU, China)
  – Eun-San Kim (KNU, Korea)
  – Amit Roy (IAUC, India),
  – Lyn Evans (CERN), and
  – Other Many Collaborators
Research and Medical (proton/Heavy-Ion) Particle Accelerators in Asia

**Japan:**
- KEK,
- RIKEN
- Spring 8
- Universities

**Medical**
- [proton]
  - Tsukuba-U
  - Nt‘l Canc.C
  - Shizuoka CC
  - Truruga
  - S. Tohoku
  - NRIM

**Heavy Ion**
- NRIM
- Gunma

**Korea:**
- KNU
- Pohang
  - Pusan

**India:**
- IUAC
- RRCAT
- TIFR
- VECC
- BARC

**Jordan:**
- SESAME

**Thailand:**
- NSRC

**China:**
- IHEP
- SSRF
- (Beijing)
- Suzhou
- (Shanghai)

**Taiwan:**
- NSRRC
- (Taiwan)
# Academia-Industry Collaboration in Particle Accelerators

<table>
<thead>
<tr>
<th></th>
<th>Research</th>
<th>Medical</th>
<th>Notes on Academia-industry Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>IHEP, SSRF</td>
<td>山東、蘇州(Beijing, Shanghai)</td>
<td>In-house fabrication Collaboration Increasing</td>
</tr>
<tr>
<td>China-Taiwan</td>
<td>NSRRC</td>
<td>NSRRC</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>Pohang/POSTECH PEFP, KNU and ..</td>
<td>Soel</td>
<td>Inevitable</td>
</tr>
<tr>
<td>India</td>
<td>IUAC, RRCAT, TIFR, VECC</td>
<td></td>
<td>In-house fabrication Some particular cases</td>
</tr>
<tr>
<td>Japan</td>
<td>KEK, RIKEN, Spring-8, Universities</td>
<td>NIRS Tsukuba, Nt’l CC, Shizuoka, Gunma,</td>
<td>Inevitable and close collaboration</td>
</tr>
<tr>
<td>Jordan</td>
<td>SESAME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>NSRC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Outline

• Introduction
  – Overview of Accelerators for Research and Medial Applications in Asia

• Academia and Industry Collaborations
  – Status in China, Korea, India, and in Japan

• Advanced Accelerator Association, Japan
  – Cooperation among “Industry-Academia-Government” to promote science and technology

• Summary
  – Toward Asian Collaboration for future projects
China: IHEP Contribution
FLASH/XFEL-Prototype Cryomodule

• Reported by H. Weise at TTC, FNAL, April 19, 2010.

Beam started already, April, 2010

Cryomodule/Cryostat
Manufactured by 航天晨光股份有限公司 (Airspace CHEN GUANG company limited) under Supervision of IHEP
In cooperation with INFN/LASA

Courtesy: Jie Gao (IHEP)
IHEP

SCRF Cavity Development

• SCRF cavity fabricated at IHEP in cooperation with ‘Beijing Institute of Aviation Materials’

Courtesy: Jie Gao (IHEP)
Peking University
SCRF Cavity Development

EBW: Cooperation with Harbin Institute of Technology

 Courtesy: Kexin Liu (PKU)
PKU, IHEP
Collaboration w/ Industry, on Nb Sheet

• Cooperation with Ningxia Orient Tantalum Industry to develop Nb material, high temperature annealing for cavities, to develop accelerator cavities in future.
Tsinghua University
Low Energy Electron Linac Development as a Fabricator for Medical Applications

TW 10MeV Linac BJ-10
SW 6MeV Linac WDVE-6
SW 14MeV Medical Linac
SW 20MeV Linac with ES

Certesy: Chuanxian Tang (Tsinghua Univ.)
Korea: Pohang Acc. Lab/POSTECH
Pohang Light Source Upgrade

PLS Upgrade  PLS-1 → PLS-2
Ring energy   2.5 GeV 3 GeV
Ring emittance 18.9 nm 5.7 nm
Number of ID  10 20
Linac energy  2.5 GeV 3 GeV

XFEL (Plan 2011-2015)
• 10 GeV S-band Linac (~ 550 m long)
• ~60 m undulator w/ gap of 5.3 mm

Courtesy: Eun-San Kim
KNU
beam diagnostics with industry
Several Industrial Manufacturing at Korea

- DTL
- RFQ
- S-band RF system

Magnet

Beam diagnostics
Heavy-ion Accelerators (Plan)
Industry collaboration expected

Research (Nuclear Physics)
- Rare Isotope Accelerator
- 200MeV/n SCRF linac + In-Flight
- 200 MeV proton cyclotron + ISOL
- Beam current: U : 2pμA
- 2010 -2015 ( CDR stage at present)

Medical Application
- Carbon beam : 400 MeV/n
- Consists of Linac and Synchrotron
- Period : 2010 – 2015
- Location : Pusan
India: IUAC

SCRF Cavity In-house Effort: QWRs for Linac

12 QWRs + 15 Slow Tuners were ready by Aug./Sept. 2009. 3 QWRs to be ready by June 2010.

Courtesy: Amit Roy (IUAC)
IUAC In-House Cavity Facility

EBW machine

EP set-up

Vac furnace

12 QWR fabricated

Test Cryostat

A, Yamamoto, 10-05-26
Asian Experience
Collaborations – IUAC & Fermi Lab

Single Spoke Resonator – SSR1 (niobium portion) for Project-X at Fermi National Accelerator Laboratory, USA. $\beta = 0.22$, $f = 325$ MHz

IUAC is presently fabricating two Single Spoke Resonators.
Collaboration – RRCAT & IUAC with Fermilab

- RRCAT, Indore & IUAC in collaboration have fabricated two Tesla-type Single Cell Cavities with niobium.
- The plan is to eventually build a complete 9-Cell Cavity.
- All the tooling for the fabrication has been built at RRCAT. Several fixtures have been built in consultation with IUAC.
- IUAC facilities (EBW, SPL etc.) have been used for the fabrication.
- Presently the Cavities are at Fermi Lab for further processing and cold testing.
  - One of the Cavities has been electropolished & rinsed (HPR) at ANL and undergone cold test. Achieved 21 MV/m on first cooling.

1.3 GHz Tesla-type Niobium Single Cell Cavity
Japan: KEK, RIKEN, Spring-8, HIMAC and others...
CERN-LHC Inner Triplet
CERN, Fermilab KEK, Industry Collaboration

CERN, FERMILAB, & KEK Collaboration with Cooperation with Japanese Industries
ATLAS Superconducting Solenoid
CERN-KEK collaboration with Japanese Industries
Contribution from Asia for LHC as part of global collaboration
Outline

• Introduction
  – Overview of Accelerators for Research and Medical Applications in Asia

• Academia and Industry Collaborations
  – Status in China, Korea, India, and in Japan

• Advanced Accelerator Association, Japan
  – Cooperation among “Industry-Academia-Government” to promote science and technology

• Summary
  – Toward Asian Collaboration for future projects
AAA: Advance Accelerator Association established, Japan, in 2008

• In collaboration of
  – Industries
  – Government, and
  – Academia

• **Thanks for previous effort by “Linear Collider Forum, Japan”**
  – as a preliminary step, in collaboration between
    • Industries, and
    • Academia
  – **Special acknowledgment for Mr. N. Ozaki**
    (Chairing this session)
AAA Member as of April, 2010

Total 112

Industry 7576
Academia 3734

【Academia】
KEK
RIKEN
JAEA
Tokyo University
Tohoku University
Kyoto University, and
Others

【Industries】
M H I
Toshiba Co.
Hitachi Ltd
Mitsubishi Electric Co
KASHIMA Co
IBM Japan, KYOCERA
TEPCO, and
Others
AAA motivated to

• Promote science and technology with joint effort with Industries-Government-Academia cooperation,

• Seek for and create industrial applications of advanced accelerator technologies, in such fields of
  – Advanced material, biotechnology, medical use, and various innovative applications
Organization and Activities

Group Activities:

- Technologies
- Outreach
- Intellectual Properties
- Large Projects
Technology Group Activities

Organization

• Steering in cooperation of academic organization and industries
  — Composed with KEK and Industries

Activities:

• Lectures/Seminar Series

• Working groups:
  — Superconducting Accelerator Technology
  — Conventional Facilities
<table>
<thead>
<tr>
<th>#</th>
<th>Dates</th>
<th>Focusing</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008–08–29</td>
<td>Basic</td>
<td>Introduction for Advance Accelerator</td>
</tr>
<tr>
<td>2</td>
<td>08–09–16</td>
<td>Basic</td>
<td>Status of SC Accelerator Technology and Prospect</td>
</tr>
<tr>
<td>3</td>
<td>08–10–08</td>
<td>Basic</td>
<td>Accelerator and Conventional Facility Technology</td>
</tr>
<tr>
<td>4</td>
<td>08–10–29</td>
<td>Basic</td>
<td>Superconducting RF Cavity Technology</td>
</tr>
<tr>
<td>5</td>
<td>08–11–12</td>
<td>Basic</td>
<td>High-Legel RF Technology</td>
</tr>
<tr>
<td>6</td>
<td>08–12–19</td>
<td>Appl.</td>
<td>Adv. Accelerator and Synchrotron Radiation Science</td>
</tr>
<tr>
<td>7</td>
<td>09–01–14</td>
<td>Basic</td>
<td>Adv. Accelerator and Cryogenic Engineering</td>
</tr>
<tr>
<td>8</td>
<td>09–02–18</td>
<td>Appl.</td>
<td>Adv. Accelerator and Neutron Science</td>
</tr>
<tr>
<td>9</td>
<td>09–03–18</td>
<td>Basic</td>
<td>Adv. Accelerator and Control/Instrumentation</td>
</tr>
<tr>
<td>10</td>
<td>09–05–13</td>
<td>Appl.</td>
<td>Industrial technology and application supporting A. Acc.</td>
</tr>
<tr>
<td>11</td>
<td>09–07–27</td>
<td>Basic</td>
<td>General activity reports</td>
</tr>
<tr>
<td>12</td>
<td>09–10–28</td>
<td>Appl.</td>
<td>Adv. Accelerator and Medical Application</td>
</tr>
<tr>
<td>14</td>
<td>10–04–15</td>
<td>Project</td>
<td>ILC R&amp;D Progress and Prospects</td>
</tr>
</tbody>
</table>
As a core study theme:

**ILC: SCRF-ML Technology**

<table>
<thead>
<tr>
<th>RDR Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.M. Energy</td>
<td>500 GeV</td>
</tr>
<tr>
<td>Peak luminosity</td>
<td>$2 \times 10^{34}$ cm$^{-2}$s$^{-1}$</td>
</tr>
<tr>
<td>Beam Rep. rate</td>
<td>5 Hz</td>
</tr>
<tr>
<td>Pulse time duration</td>
<td>1 ms</td>
</tr>
<tr>
<td>Average beam current</td>
<td>9 mA (in pulse)</td>
</tr>
<tr>
<td><strong>Av. field gradient</strong></td>
<td><strong>31.5 MV/m</strong></td>
</tr>
<tr>
<td># 9-cell cavity</td>
<td>14,560</td>
</tr>
<tr>
<td># cryomodule</td>
<td>1,680</td>
</tr>
<tr>
<td># RF units</td>
<td>560</td>
</tr>
</tbody>
</table>

*Asian Experience*

RDR $\rightarrow$ SB2009
### Global Plan for SCRF R&D

<table>
<thead>
<tr>
<th>Year</th>
<th>07</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td></td>
<td>TDP-1</td>
<td></td>
<td></td>
<td></td>
<td>TDP-2</td>
</tr>
<tr>
<td>Cavity Gradient in v. test to reach 35 MV/m</td>
<td></td>
<td></td>
<td></td>
<td>→ Yield 50%</td>
<td></td>
<td>→ Yield 90%</td>
</tr>
<tr>
<td>Cavity-string to reach 31.5 MV/m, with one-cryomodule</td>
<td></td>
<td></td>
<td>Global effort for string assembly and test (DESY, FNAL, INFN, KEK)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Test with beam acceleration</td>
<td></td>
<td></td>
<td></td>
<td>FLASH (DESY), NML (FNAL)</td>
<td></td>
<td>STF2 (KEK, test start in 2013)</td>
</tr>
<tr>
<td>Preparation for Industrialization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Production Technology R&amp;D</td>
<td></td>
</tr>
</tbody>
</table>
Superconducting Accelerator Technology WG: Studying Industrialization and the R&D model

<table>
<thead>
<tr>
<th>WG</th>
<th>#</th>
<th>Dates</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>WG1</td>
<td>09-04-08</td>
<td>Nb material, Surface cleaning</td>
</tr>
<tr>
<td>SC</td>
<td>WG2</td>
<td>09-06-04</td>
<td>Ceramics, Electron Beam Welding</td>
</tr>
<tr>
<td>SC</td>
<td>WG3</td>
<td>09-09-10</td>
<td>Cavity fabrication</td>
</tr>
<tr>
<td>SC</td>
<td>WG4</td>
<td>10-01-14</td>
<td>Cavity surface polishing</td>
</tr>
<tr>
<td>SC</td>
<td>WG5</td>
<td>10-5-20</td>
<td>Cavity fabrication: pressing and blanking</td>
</tr>
</tbody>
</table>

Outlook from SC Acc. Tech. WG (recommendation): Industrialization study: Cavity Fabrication R&D Facility
Industrialization of Cavity Fabrication

R&D Facility to be established

- Based on a recommendation given by AAA in cooperation of industry - academia
Summary

• Industry-Academia Collaboration critically important to open a door to realize future, energy/power frontier particle accelerators

• We may need to:
  – First, Create new industrial applications including medical, power, material, biotechnology, transportation, and various application, the
  – Then, Realize a true ‘International Particle Accelerator Collaboration’ ---- IPAC !