Impact of Pohang Accelerator to Large-scale Science Programs in Korea

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Outlines

• Brief Facts about Korea

• Large-scale Science Programs in Korea
  - PLS at POSTECH
  - Hanaro, KSTAR, PEFP, ITER-Korea

• Government R&D
  - S&T budget and Policy

• Industrial Company for Global Competitiveness
  - Samsung, POSCO, Hyundai Heavy

• Summary
Brief Facts about Korea

**People & Language:** Korean (~4,500 yrs in the area)

**Area (South):** ~100,000 km² (~38,000 sq. mi.)

**Population (South):** 48.5 million

**Recent History:**
- 1945: Divided into North and South
- 1950~1953: Korean Conflict
- 1960~1970: Modernization (Migration to cities)
- 1970~1980: Industrialization (Heavy Industries)
- 1990~2008: High-tech oriented

**Leading Industries:**
- Electronics, Steel, Ship-building, Automobile,
- Chemicals, Construction, Textiles

**Economy:** GDP = 970 B$, 20 k$/capita in 2007

**Religion:** Christian (~30%), Buddhism (~30%)

**Education:** > 80% high-school seniors go to college
## Large-scale Science Programs in Korea

### On-going programs:

<table>
<thead>
<tr>
<th>Program</th>
<th>Construction period</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLS - Light Source:</td>
<td>1988 - 1994</td>
</tr>
<tr>
<td>KSTAR - Fusion Tokamak:</td>
<td>1996 - 2008</td>
</tr>
<tr>
<td>PEFR - Proton Linac:</td>
<td>2002 - 2012</td>
</tr>
<tr>
<td>ITER-Korea – ITER member:</td>
<td>2006 - 2016</td>
</tr>
</tbody>
</table>

### Proposals:
- X-ray FEL
- 2\textsuperscript{nd} Light Source
- Heavy Ion accelerator
Established by POSCO, a steel company, in 1986

One of the leading S&T Universities in Korea along with SNU in Seoul and KAIST in Daejeon

11 Academic Departments in Science and Engineering

Students: Undergraduate: 1,200
         Graduate: 1,500

Faculty members: ~240
POSTECH Campus and PAL
• In 1987, POSTECH, a newly established university, proposed to construct a synchrotron light source on its campus.

• PLS is a 3rd generation synchrotron radiation source:
  - 2 GeV injector linac and storage ring with upgrade option to 2.5-GeV.

• Construction Project: April 1988 ~ December 1994
  - Funded by POSCO (60%) & Government (40%)

• Operation: funded by Government (80%) & POSCO (20%)
Pohang Light Source (PLS) at PAL
Statistics for Experiments and Users at PAL
Number of Publications at PAL

Note: Data for 2007 is tentative
Examples of Research at PLS: Academic and Industry

- Molecular Cell
  * Researcher: Professor Joo (2012)

- The 8 to Z of DNA
  * Researcher: Professor Kim (2013)

- Nature
  * Researcher: Professor Kang (2014)

- Nature
  * Researcher: Professor Jo (2015)

- Future LCD and Bio-tech Field

- Plasma Gas Curing

- LNG converter
  * Researcher: POSCO (2005)
Hanaro Overview

- **Research Nuclear Reactor**
  - 30-MW open-tank-in-pool type
  - 20% $U_3Si$-Al Fuel

- **National users’ facility**
  - Intense neutron source for neutron science
  - Medical & industrial application of Radioisotopes


- **First Criticality Achieved**: Feb. 1995

- **Construction & Operation by**: Korea Atomic Energy Research Institute (KAERI)
Hanaro Reactor
KSTAR Overview

• Fusion Research Tokamak
  - All Super-conducting magnets
  - Steady-state capable tokamak with a major radius of 1.8 m

• National users’ facility
  - Long-pulse tokamak plasma research
  - Heating and current drive for steady-state operation

• Project Period: Jan. 1996 - June 2008

• First Plasmas: June 2008 (Cool-down started in April 1, 2008)

• Construction & Operation by National Fusion Research Institute (NFRI)
KSTAR Experimental Buildings
KSTAR Project Chronology

- **1995. 12.** Start of KSTAR Project (Phase I)
- **1996. 11.** KSTAR Concept Review
- **1997. 12.** KSTAR Tokamak Systems Engineering Review
- **1998. 09.** Start of KSTAR Project (Phase II)
- **1999. 08.** KSTAR Magnet System Review
- **2000. 09.** KSTAR EU Workshop (Engineering Review)
- **2002. 06.** Start of KSTAR Project (Phase III)
- **2004. 01.** Start of Assembly
- **2004. 08.** Completion of VV and Cryostat Fabrication
- **2006. 03.** Completion of TF Magnet Structure Fabrication
- **2006. 11.** Completion of All Magnet System
- **2007. 04.** Installation of Cryostat Lid
Installation of Cryostat Cylinder
ITER Design and Technology Development

**Central Solenoid Model Coil**
- Radius 3.5 m
- Height 2.8 m
- $B_{\text{max}} = 13$ T
- $W = 640$ MJ
- $0.6$ T/sec

**Divertor Cassette**
- Heat Flux > 15 MW/m², CFC/W
- Attachment Tolerance ± 2 mm

**Vacuum Vessel Sector**
- Double-Wall, Tolerance ± 5 mm

**Remote Maintenance of Divertor Cassette**

**Blanket Module**
- HIP Joining Tech
- Size: 1.6 m x 0.93 m x 0.35 m

**Remote Maintenance of Blanket**

**Toroidal Field Model Coil**
- Height 4 m
- Width 3 m
- $B_{\text{max}} = 7.8$ T
- $I_{\text{max}} = 80$ kA

**REMOTE MAINTENANCE OF DIVERTOR CASSETTE**
<table>
<thead>
<tr>
<th>Item</th>
<th>Total Value (kIUA)</th>
<th>KO</th>
<th>KO Value (kIUA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TF Conductor</td>
<td>215.0</td>
<td>20%</td>
<td>43.0</td>
</tr>
<tr>
<td>2. Vacuum Vessel</td>
<td>124.2</td>
<td>20%</td>
<td>24.84</td>
</tr>
<tr>
<td>3. Vacuum Vessel Ports</td>
<td>78.5</td>
<td>76%</td>
<td>59.66</td>
</tr>
<tr>
<td>4. Blanket First Wall *</td>
<td>87.0</td>
<td>10%</td>
<td>8.7</td>
</tr>
<tr>
<td>5. Blanket Shield Block</td>
<td>58.0</td>
<td>10%</td>
<td>5.8</td>
</tr>
<tr>
<td>6. Assembly Tooling</td>
<td>22.0</td>
<td>100%</td>
<td>22.0</td>
</tr>
<tr>
<td>7. Thermal Shield</td>
<td>28.8</td>
<td>100%</td>
<td>28.8</td>
</tr>
<tr>
<td>8. Tritium SDS *</td>
<td>14.5</td>
<td>88%</td>
<td>12.76</td>
</tr>
<tr>
<td>9. AC/DC Converters</td>
<td>82.2</td>
<td>38%</td>
<td>31.24</td>
</tr>
<tr>
<td>10. Diagnostics</td>
<td>137.5</td>
<td>3.3%</td>
<td>4.54</td>
</tr>
</tbody>
</table>

**Total KO Value 241.34 kIUA (≒ 342.7 M€)**

 ITER-Korea Procurement Items

Critical Path
Tokamak Main
Ancillary
**Proton Engineering Frontier Project**

- **High-Power Proton Accelerator**: Staged construction of 1.0 GeV, 20 mA proton linac  
  - 100 MeV: New Frontier Program (2002-2012)  
  - 1.0 GeV: Under R&D Study

- **Government decided the construction site in Gyeongju**  
  - Near KTX station (March 2006)

- **National Users’ Facility**: Intense neutron source for basic and applied science research

- **Lead Lab.**: Korea Atomic Energy Research Institute (KAERI)
PEFP 20 MeV Linear Accelerator
Proton Accelerator Site

Express Railway (KTX)
Under Construction

Gyeong-Bu Expressway (No.1)
Korean Government Reorganization

- The new administration combined *Ministry of Education* and *Ministry of Science and Technology* in March 2008.

- A bureau for large-scale science programs is established

- There are growing demands for promoting basic sciences and multi-disciplinary users’ facilities
Science and Technology Budget in Korea

![Bar chart showing the Science and Technology Budget in Korea from 1995 to 2007. The budget increased significantly from 1995 to 2007, with the budget for 2007 being the highest.]
### 2008 Korean Government R&D Budget

<table>
<thead>
<tr>
<th>Category</th>
<th>Budget (10.8 T KRW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Science</td>
<td>3.0 T KRW</td>
</tr>
<tr>
<td>Nano &amp; Space</td>
<td>1.8 T KRW</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1.3 T KRW</td>
</tr>
<tr>
<td>Information Science</td>
<td>1.1 T KRW</td>
</tr>
<tr>
<td>Training &amp; Infra</td>
<td>2.0 T KRW</td>
</tr>
<tr>
<td>Special Fund Support</td>
<td>1.6 T KRW</td>
</tr>
</tbody>
</table>

Total: 10.8 T KRW

Note: 1 T KRW ~ 1 B U$
Types of Science & Technology Policy

- Basic Research
- Applied Research
- Development
- Products

- Advanced Countries
- Logical Approach
- Reversed Approach

New areas
Leading industrial companies in Korea built-up their own R&D capability for global competitiveness, for examples,

Electronics
Iron & Steel
Shipbuilding
Automobile
Communications
POSCO Plants in Pohang & Gwangyang

Established: 1968
Employees: 17,300
Steel Production: 31.3 M tons (2007)
Revenue: 23.9 B$
Net Profit: 4.0 B$
## Big Industrial Companies in Korea

<table>
<thead>
<tr>
<th>Units (Trillion KRW)</th>
<th>Samsung Electronics</th>
<th>POSCO Steel</th>
<th>Hyundai Heavy Ship building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>Net Profit</td>
<td>Revenue</td>
<td>Net Profit</td>
</tr>
<tr>
<td>2005</td>
<td>57.0</td>
<td>22.0</td>
<td>10.0</td>
</tr>
<tr>
<td>2006</td>
<td>59.0</td>
<td>20.0</td>
<td>13.0</td>
</tr>
<tr>
<td>2007</td>
<td>63.0</td>
<td>22.0</td>
<td>16.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University</th>
<th>SKK University</th>
<th>POSTECH</th>
<th>Ulsan University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Area</td>
<td>KSTAR SC Coil R&amp;D</td>
<td>PAL Accelerator</td>
<td>KSTAR Vacuum Chamber</td>
</tr>
</tbody>
</table>
Summary

- **Korea has successfully improved her economic condition through industrialization. The underline driving force is considered as, not only the government planning but also the trained man-power available through individual education.**

- **Education has been the top priority in a normal family:**
  More than 80% of high-school senior goes to colleges.
  *(One may note that the largest student body in USA is Korea)*

- **Trained man-power returned home for academic and industrial positions along with improved economics.**

- **Academic research condition is now much improved to train man-power domestically.**
With the success of the light source, research reactor, and tokamak projects,
- There are growing demands for more multi-user facilities such as light sources.
- Government now established a bureau for large-scale science programs including space science and fusion research.

Industry built-up its own R&D capability for global competitiveness and they start to recognize supports for basic sciences.

For the large-scale science projects, we need consensus among scientists in this economy-oriented society.