Particle Accelerators in Korea

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Pohang 790-784, Korea

Outlines

- *Brief Facts about Korea*
  - Government Organization for R&D and Budget Trend

- *Large-scale Science Programs*
  - Accelerator, Nuclear, Fusion, Space Programs

- *Accelerators:*
  - PLS and PLS-II at POSTECH
  - Proton Linac at KAERI
  - Plasma Wakefield Acceleration at GIST
  - Medical Accelerators
  - Heavy Ion Accelerator

- *R&D Collaboration with Industrial Companies*

Brief Facts about Korea

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

Area (South)**:** ~100,000 km^2 (~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 = 929 B$, 19 k$/capita in 2008

Religion: Christian (~30%), Buddhism (~30%)
Education: > 80% high-school seniors go to college

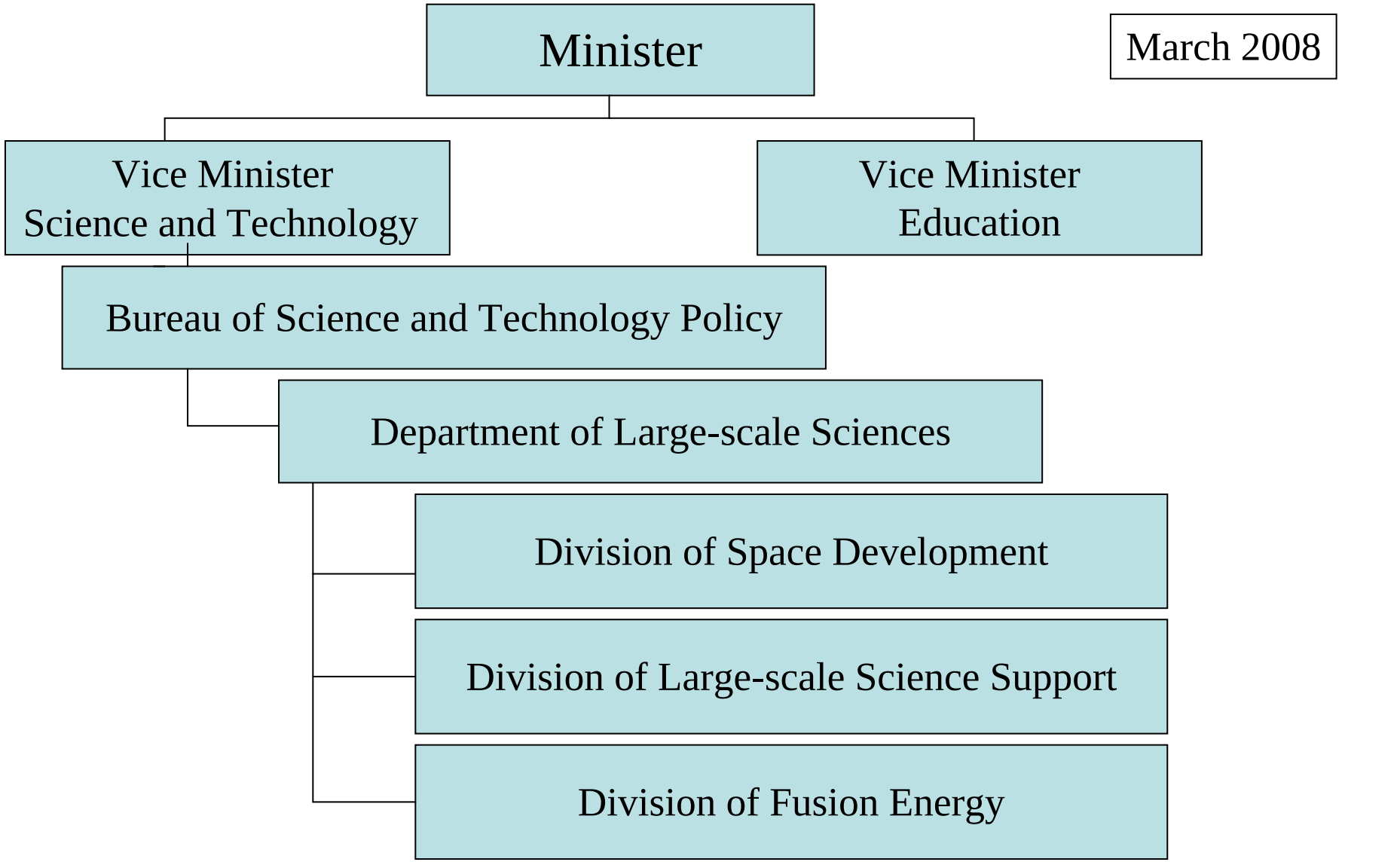
Korean Government Reorganization

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

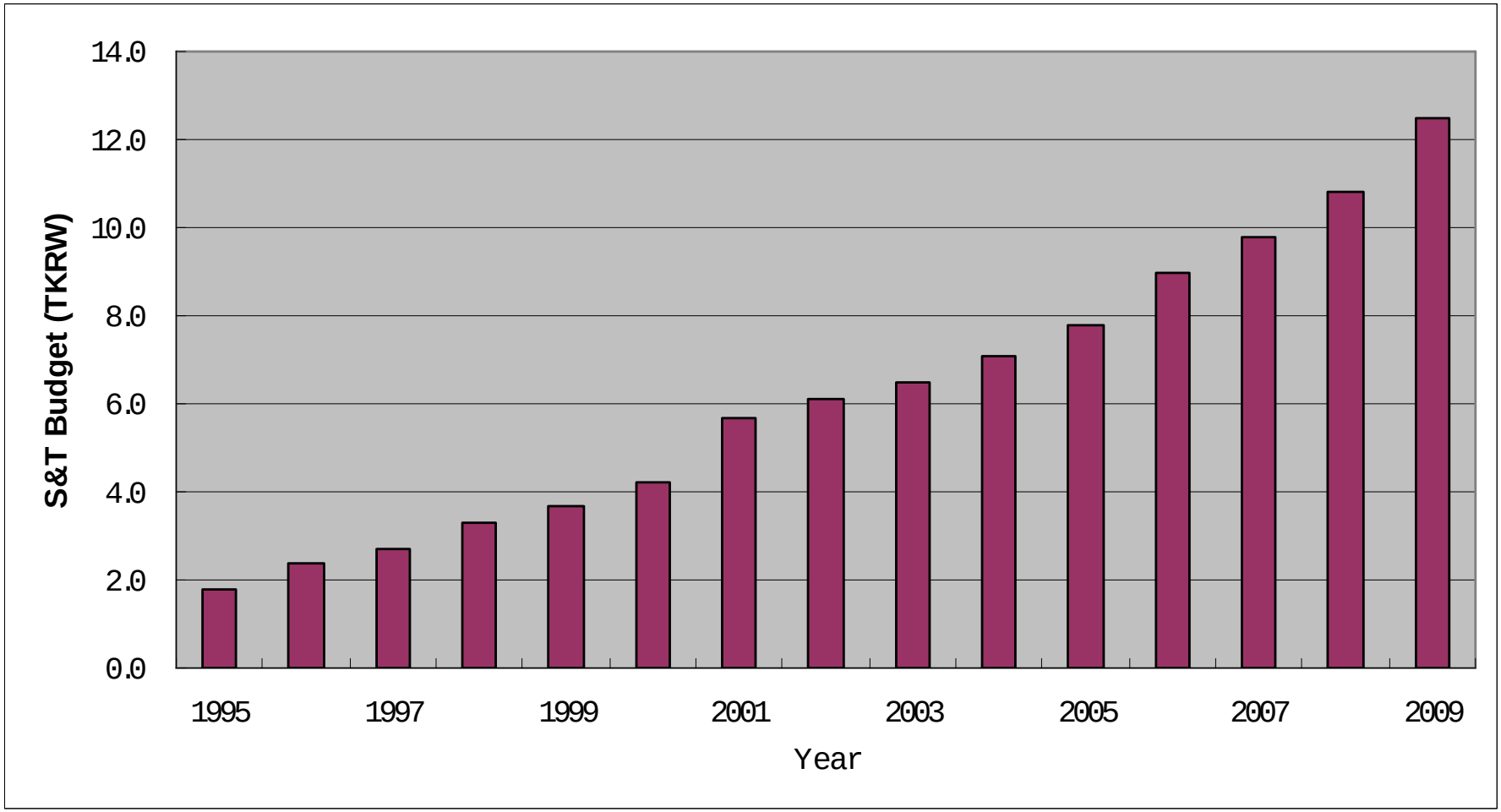
- *A bureau for large-scale science programs is established*

- *There are growing demands for promoting basic sciences and multi-disciplinary users' facilities*

Ministry of Education, Science and Technology (MEST)



Science and Technology Budget in Korea



Large-scale Science Programs in Korea

On-going programs:

	(construction)
PLS - *Light Source:*	1988 - 1994
Hanaro - *Research Reactor:*	1988 - 1994
KSTAR - *Fusion Tokamak:*	1996 - 2008
PEFR - *Proton Linac:*	2002 - 2012
ITER-Korea – *ITER member:*	2006 – 2016
PLS-II – *Light Source Upgrade*:	2009 – 2011
Scientific Satellite:	2009

Proposals: - *X-ray FEL (PAL)*
- *Heavy Ion accelerator*

Hanaro Overview

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

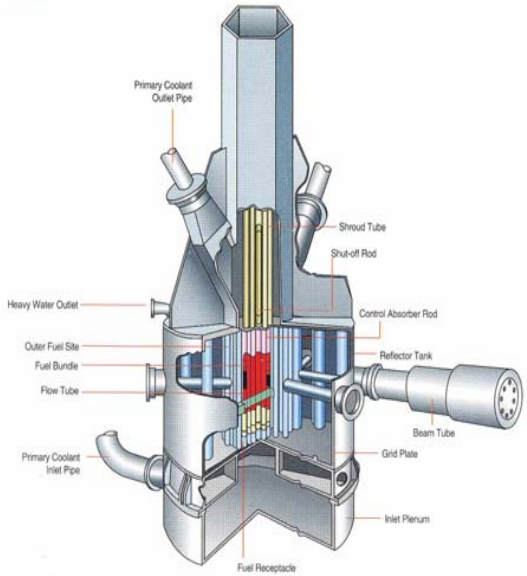
- *National users' facility*
  - *Intense neutron source for neutron science*
  - *Medical & industrial application of Radioisotopes*

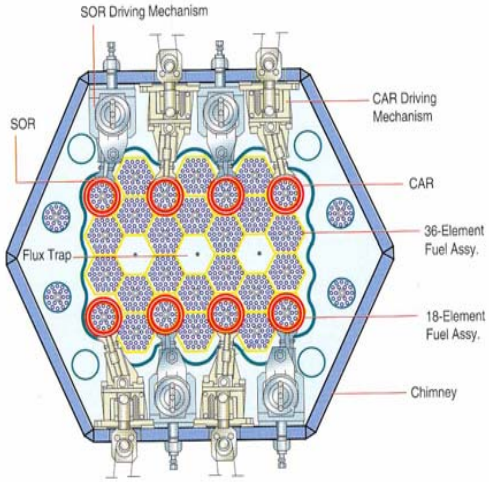
- *Construction: Feb. 1988 ~ Dec. 1994*
  - *First Criticality Achieved: Feb. 1995*

- *Construction & Operation by Korea Atomic Energy Research Institute (KAERI)*

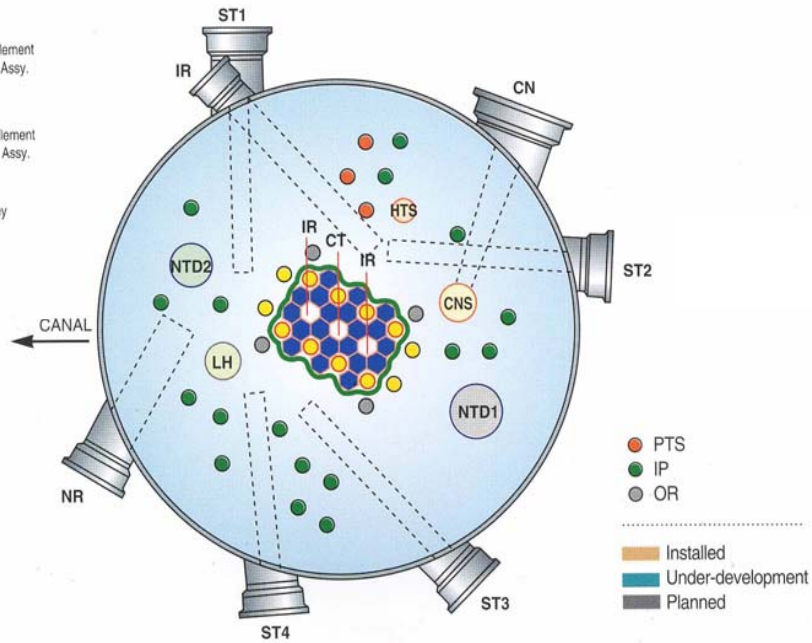
⇒ 20 reactors are in operation (30 ~ 40 %) and 6-units are under construction with the Korea Standard Type

Hanaro Reactor





Reator structure assembly



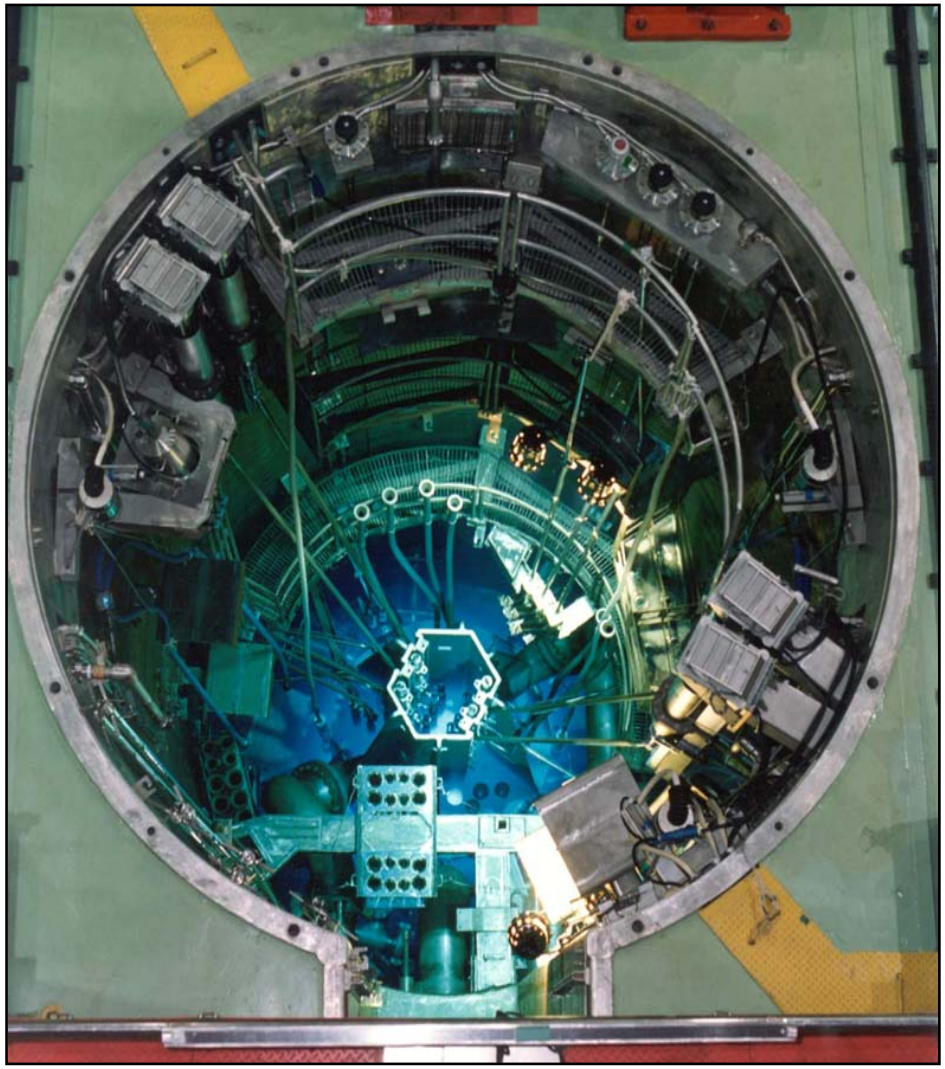
Horizontal Experimental Tubes

- ST1 : Polarized Neutron Spectrometer
- ST2 : High Resolution Powder Diffractometer / Four Circle Diffractometer
- ST3 : Neutron Reflectometer / Medium Resolution Powder Diffractometer
- ST4 : Triple Axis Spectrometer
- CN : Small Angle Neutron Spectrometer
- IR : Boron Neutron Capture Therapy Facility
- NR : Neutron Radiography Facility

Vertical Experimental Holes

- IR, CT : Capsule Irradiation Facility
- LH : Fuel Test Loop
- OR : Capsule Irradiation / RI Production
- IP : RI Production
- HTS : Hydraulic Transfer System for RI Production
- PTS : Pneumatic Transfer System for Neutron Activation Analysis
- NTD : Neutron Transmutation Doping of Silicon
- CNS : Cold Neutron Research Facility

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 Plasma: June 2008*

- *Construction & Operation by National Fusion Research Institute (NFRI)*

KSTAR Experimental Buildings

KSTAR Construction Progress

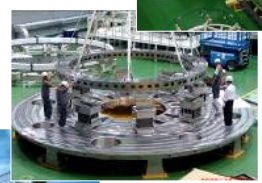
Operation
(09.4 ~)

Commissioning &
1st Plasma (07.9 – 08.6)

Machine Construction
(02.6 - 07.8)

Engineering Design
(98.9 - 02.5)

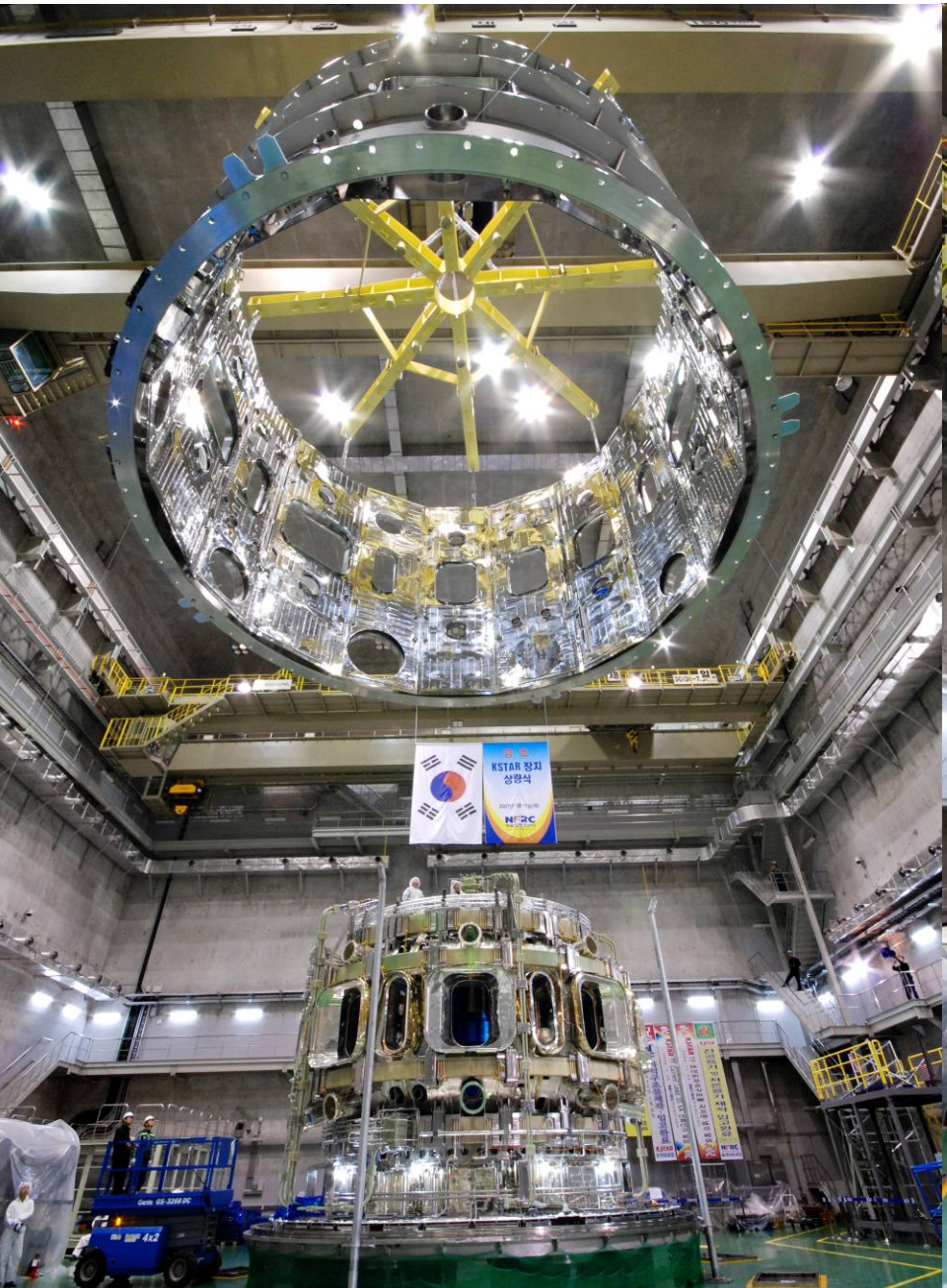
Basic R&D, Conceptual Design (95.12 – 98.8)

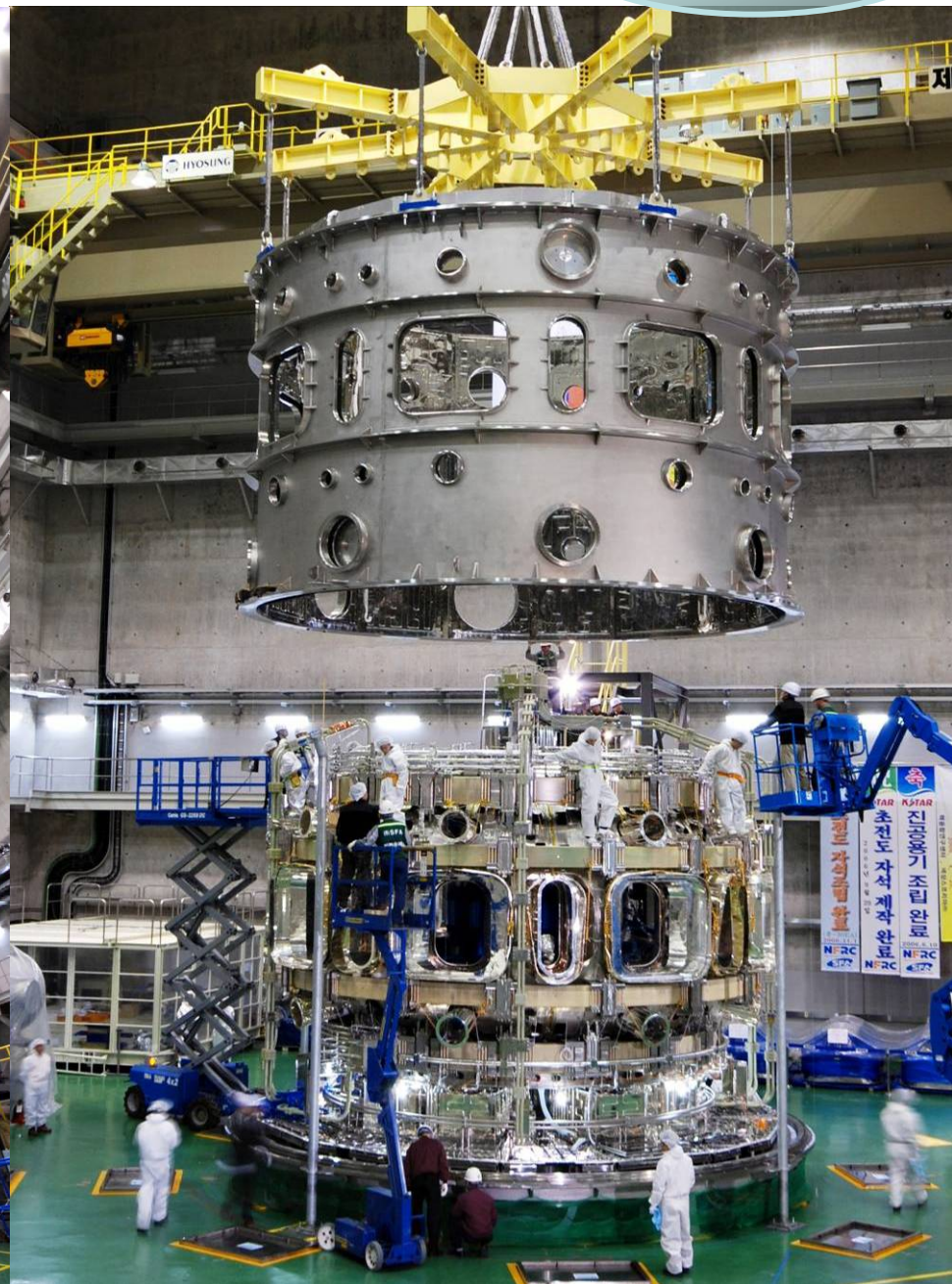


G. S. Lee, NFRI

Installation of Cryostat Cylinder

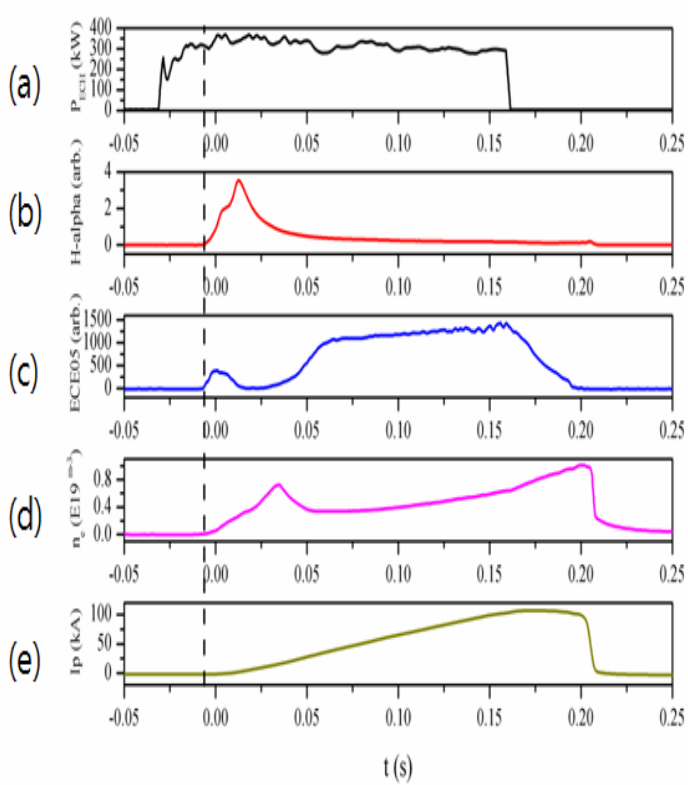
2007. 1





ECH Pre-ionization (POSTECH Group)

2nd Harmonic ECH Start-up



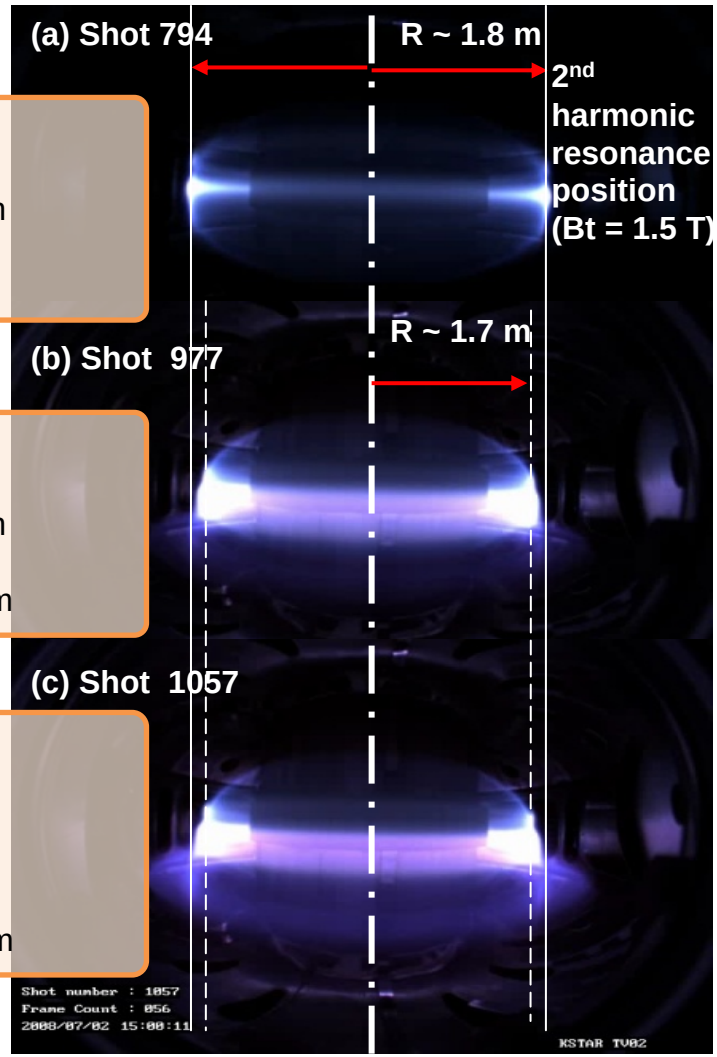
- **Using ECH, successful plasma discharge at low Ohmic voltage !**

ECH Pre-ionization

- Shot no. 794
  Conventional mode
  Perpendicular launch
  EC beam target:
  Z=0m, R=~1.8 m

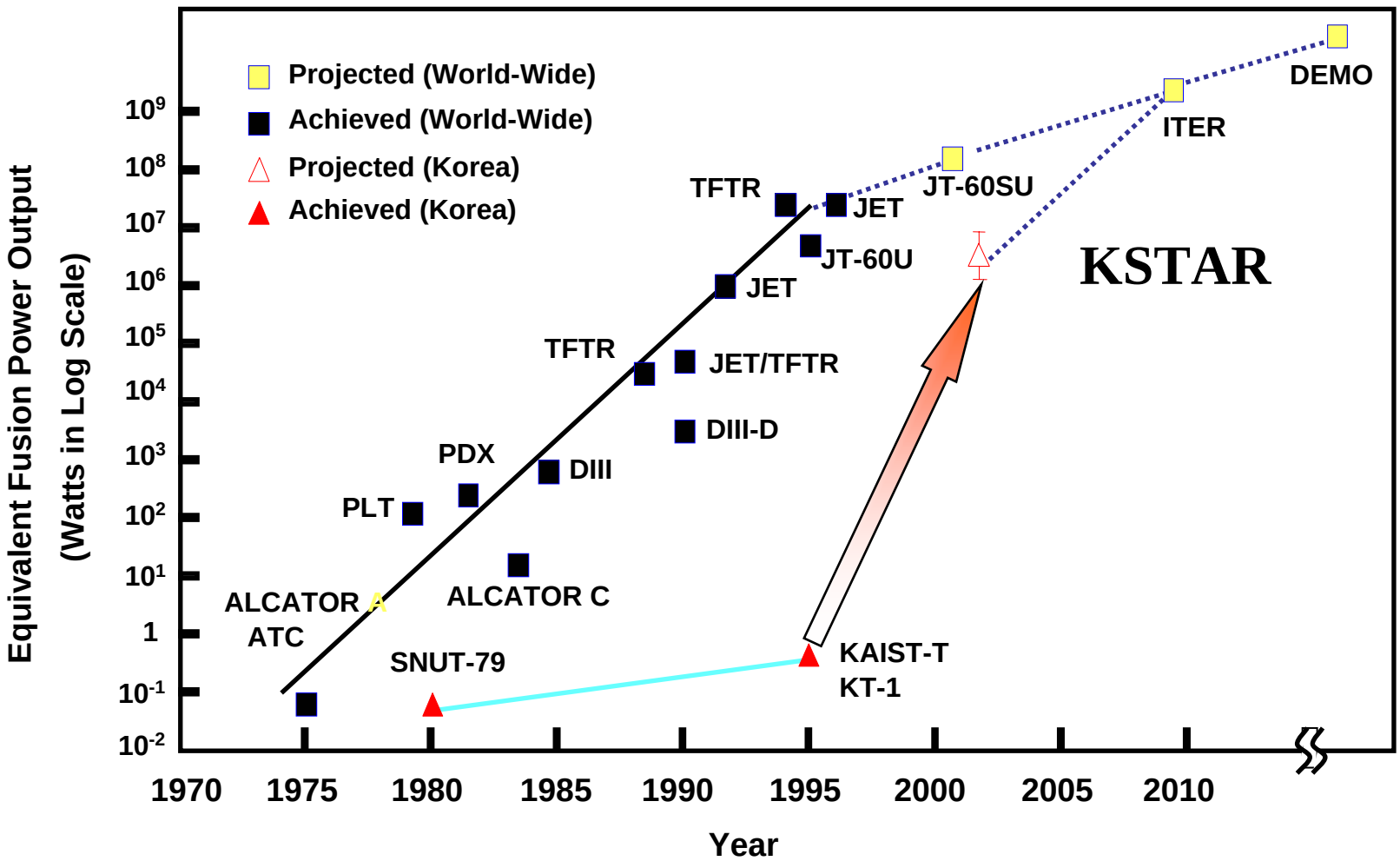
- Shot no. 977
  Dipole-like mode
  Perpendicular launch
  EC beam target:
  Z=~ -0.1m, R=~1.7 m

- Shot no. 1057
  Dipole-like mode
  Oblique launch
  (tor. angle=-10°)
  EC beam target:
  Z=~ -0.1m, R=~1.7 m



* Achieved Loop voltage : less than 0.3 V/m, ~ 2.0 V

Joining in ITER



G. S. Lee (1995), NFRI

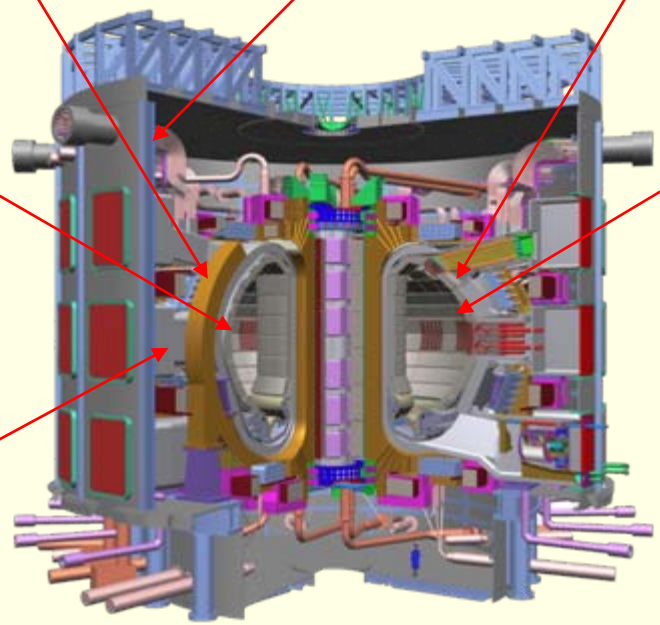
ITER-Korea Procurement Items

1. TF Conductor
Total Value (kIUA) : 215.0
KO : 20%
KO Value (kIUA) : 43.0

7. Thermal Shield
Total Value (kIUA) : 28.8
KO : 100%
KO Value (kIUA) : 28.8

4. Blanket First Wall *
Total Value (kIUA) : 87.0
KO : 10%
KO Value (kIUA) : 8.7

2. Vacuum Vessel
Total Value (kIUA) :124.2
KO : 20%
KO Value (kIUA) : 24.84



5. Blanket Shield Block
Total Value (kIUA) : 58.0
KO : 10%
KO Value (kIUA) : 5.8

3. Vacuum Vessel Ports
Total Value (kIUA) : 78.5
KO : 76%
KO Value (kIUA) : 59.66

6. Assembly Tooling
Total Value (kIUA) : 22.0
KO : 100%
KO Value (kIUA) : 22.0

8. Tritium SDS *
Total Value (kIUA) : 14.5
KO : 88%
KO Value (kIUA) : 12.76

9. AC/DC Converters
Total Value (kIUA) : 82.2
KO : 38%
KO Value (kIUA) : 31.24

10. Diagnostics
Total Value (kIUA) :137.5
KO : 3.3%
KO Value (kIUA) : 4.54

Total KO Value 241.34 kIUA (342.7 M€)

Critical Path | Tokamak Main | Ancillary

Space Program

- 6 communication satellites built in the past 20 years
- First Korean astronaut in 2008
- Launching site has been built
- First launch of scientific satellite (~100 kg) is expected in 2009

Pohang University of Science and Technology (POSTECH)

- *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: ~ 250*

POSTECH Campus and PAL

PLS Overview

- *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.*

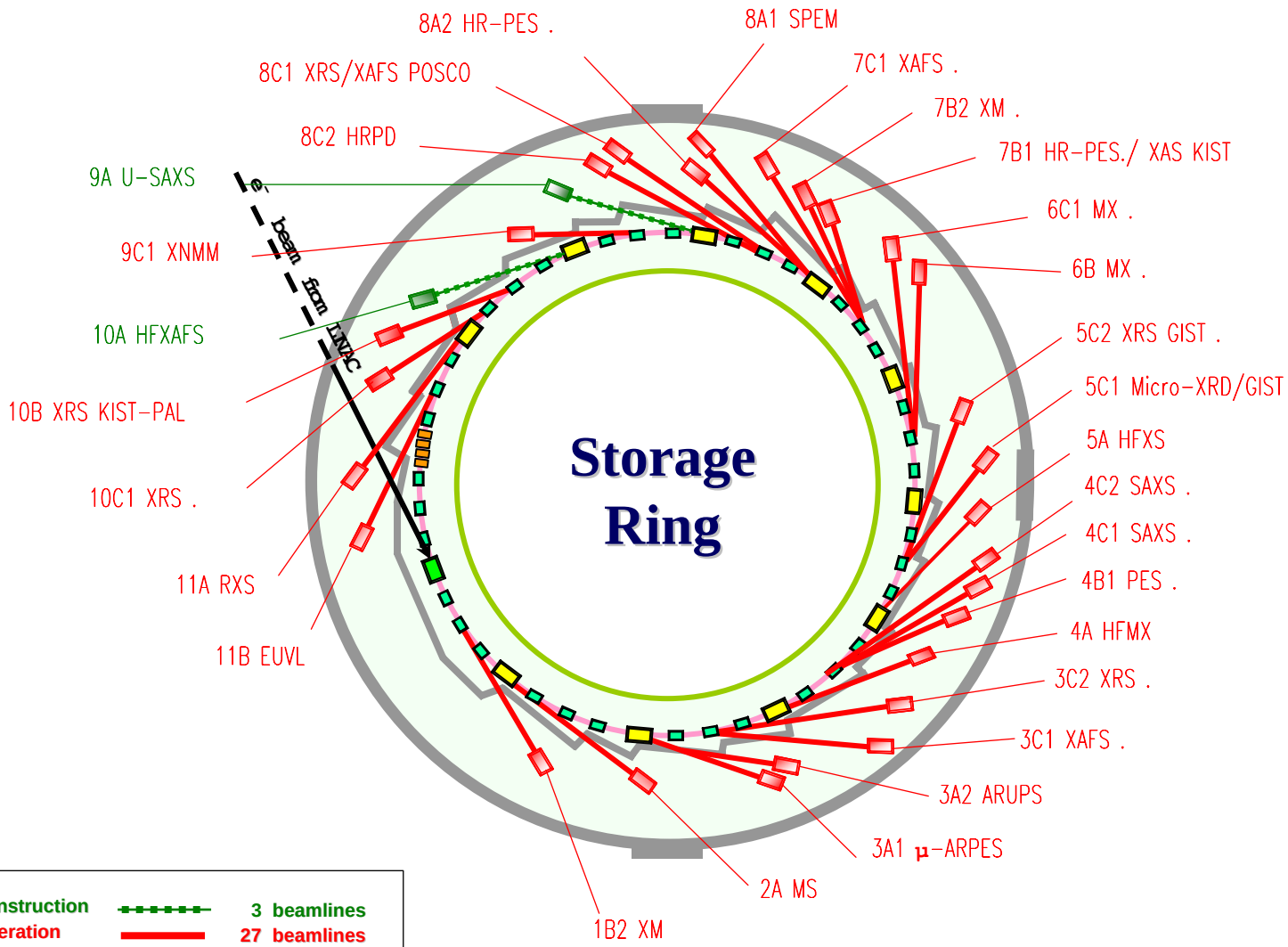
- *Construction Project: April 1988 ~ December 1994*
  - *Funded by POSCO (60%) & Government (40%)*

- *Operation: funded by Government (80%) & POSCO (20%)*

Pohang Light Source (PLS) *at PAL*

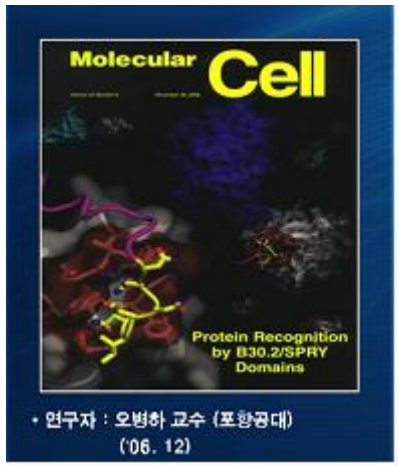
PLS Beamline Status

February 2009



*Technical Building II : Fs-THz beamline

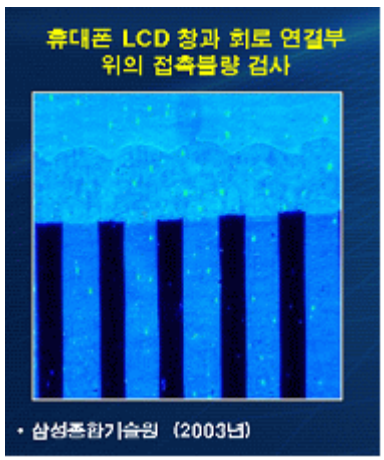
Examples of Research at PLS: Academic and Industry



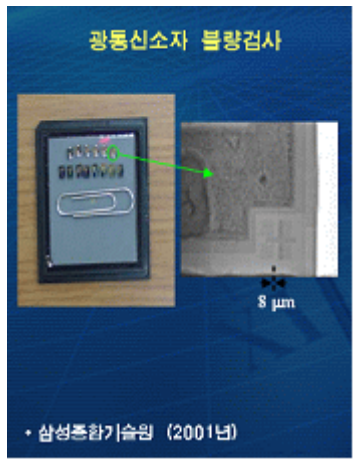
• 연구자 : 오병하 교수 (포항공대)
('06. 12)

• 연구자 : 김경규 교수 (성균관대)
김양균 교수 (중앙대), ('05. 10)

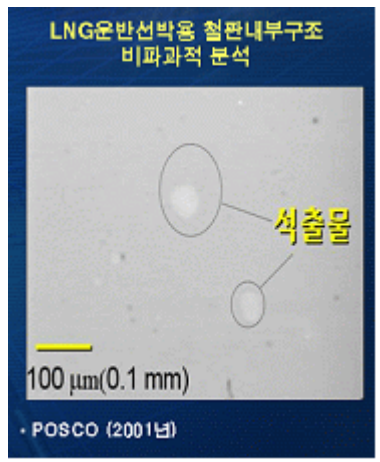
• 연구자 : 조중명 박사 (크리스탈 지노믹스)
('03. 9)



• 삼성종합기술원 (2003년)

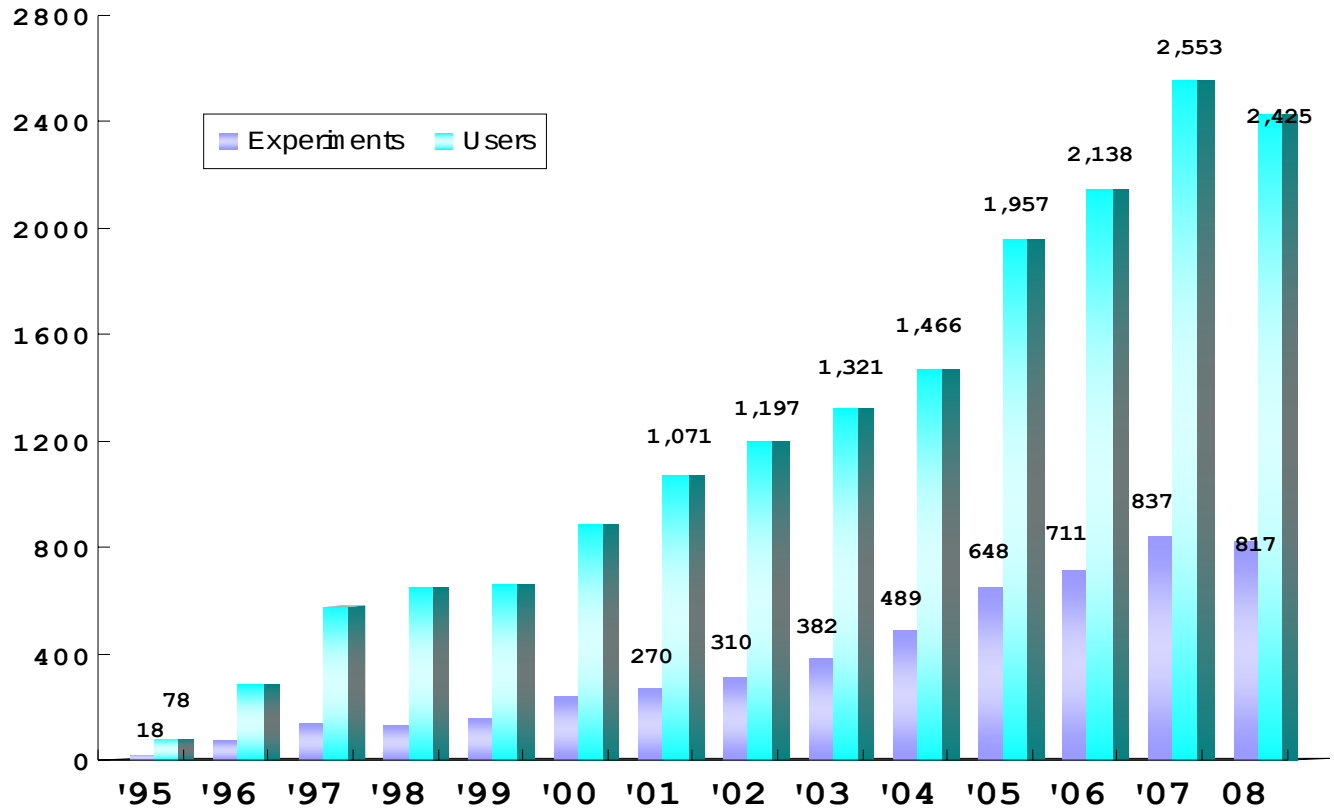


• 삼성종합기술원 (2001년)



• POSCO (2001년)

Statistics for Experiments and Users at PAL



’08 data is tentative

PLS-II Overview

- *PLS –II is the upgrade program of PLS after 15-yr's:*
  - *3.0 GeV injector linac and storage ring with DBA lattice and lower emittance (20 straight sections for users)*
- *Project period: January 2009 ~ December 2011*
  - *Funded by Government (100%)*
- *This afternoon, 17:00 at TH4PBC03 "PLS-II at PAL,"*

  by S. Nam.

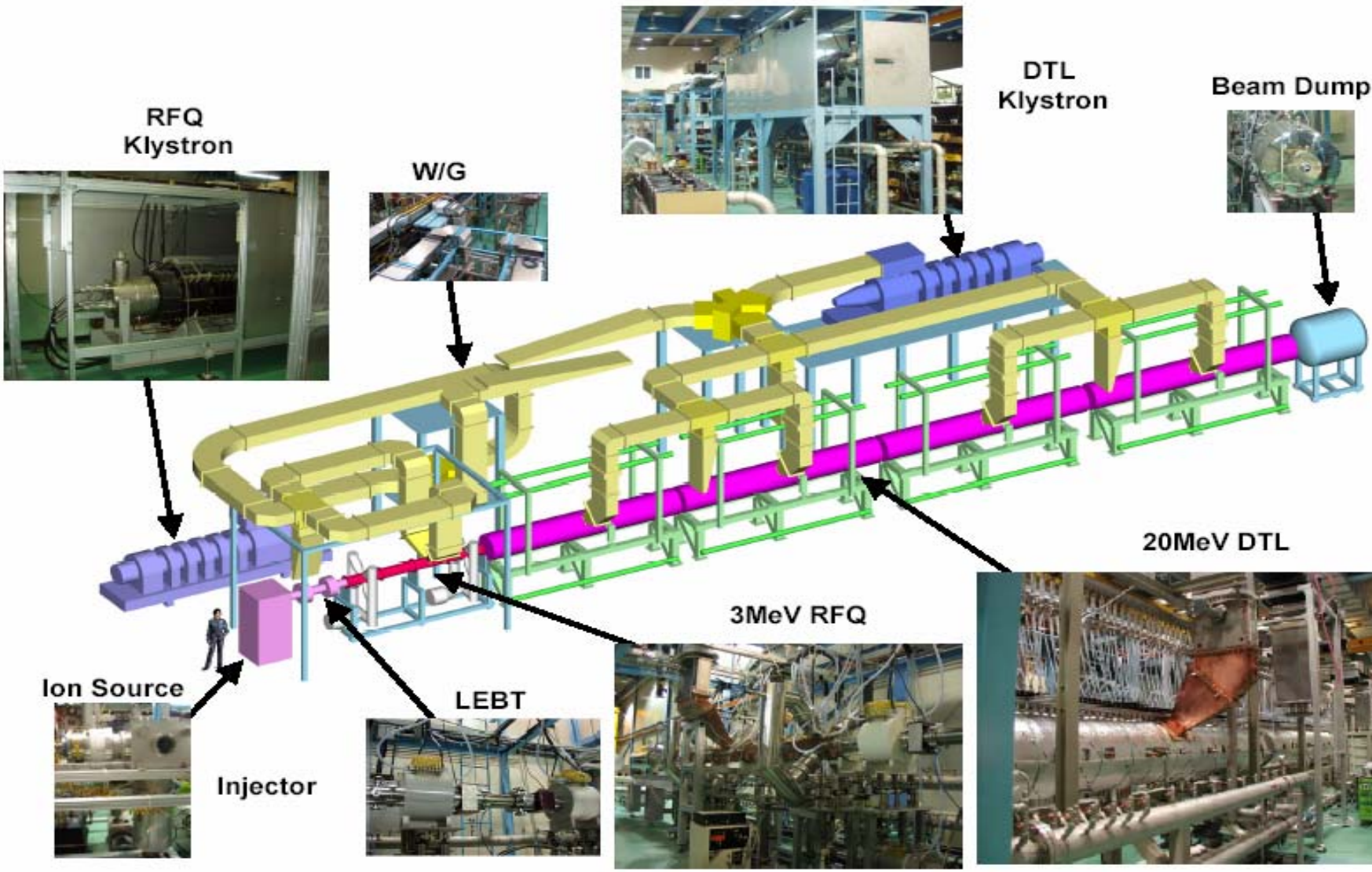
Proton Engineering Frontier Project

- *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*

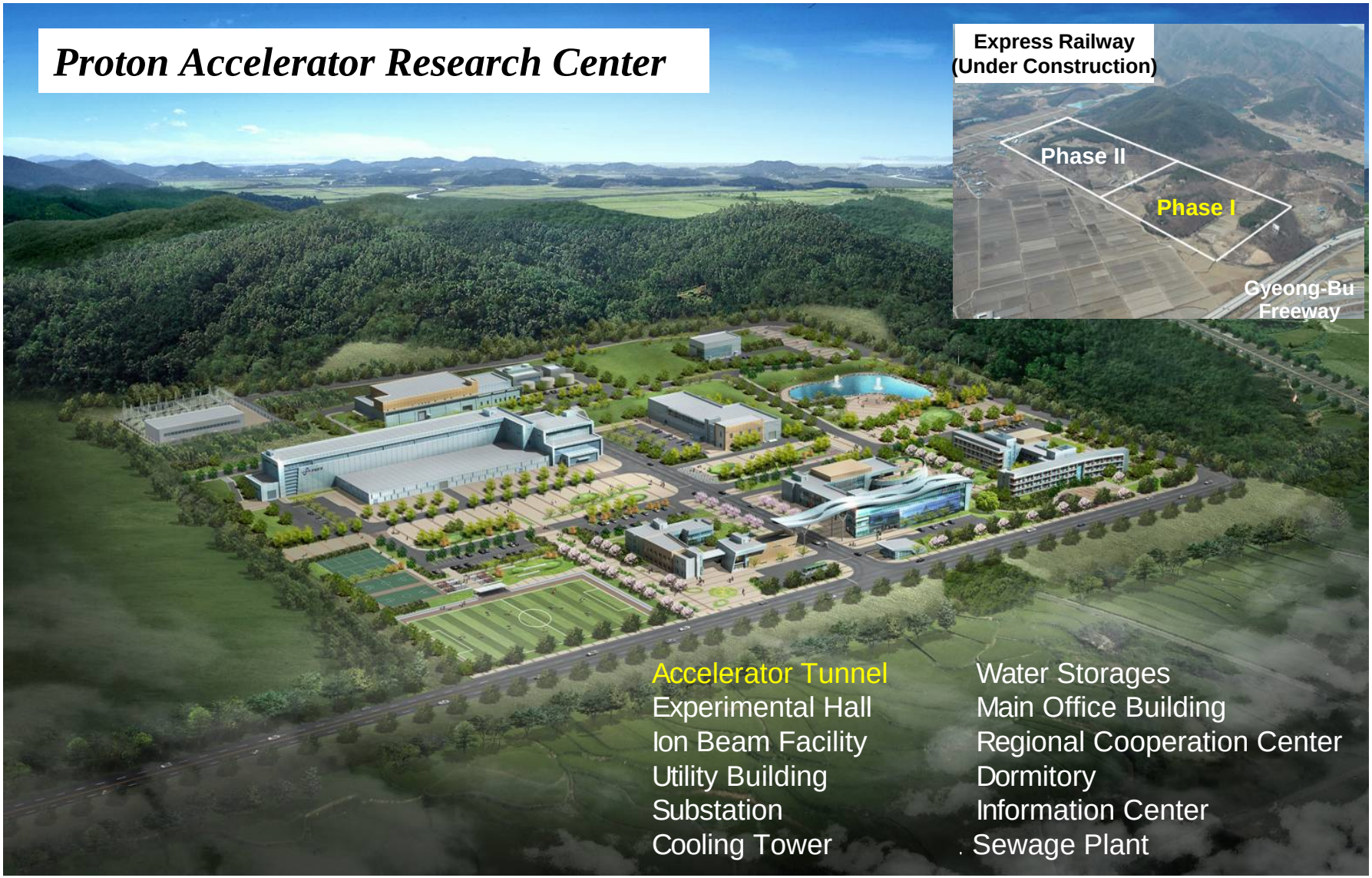
- *Government decided the construction site in Gyeongju*
  - *Near the KTX station (March 2006)*

- *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

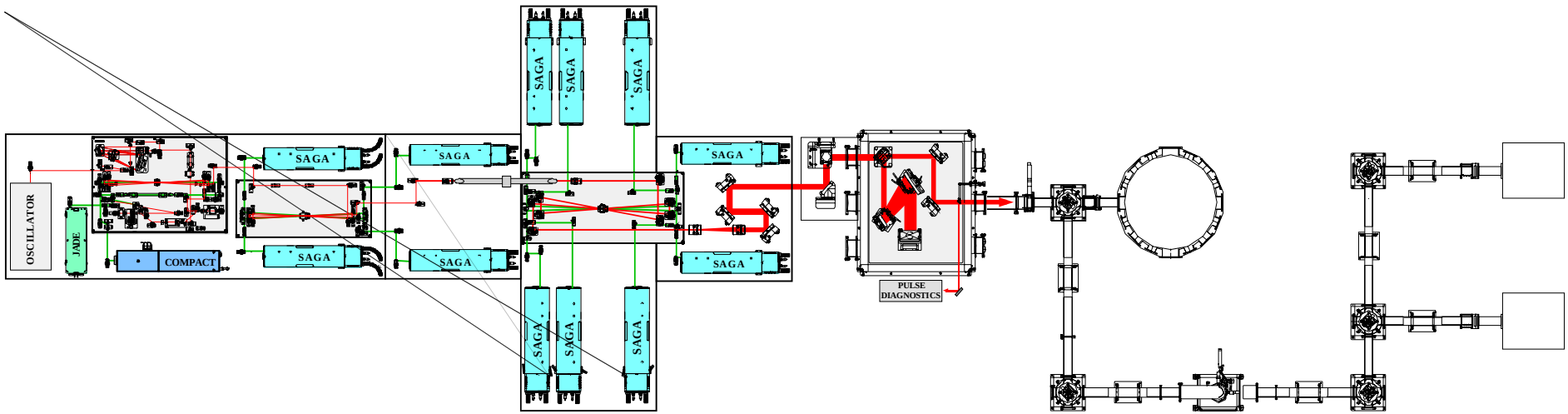


Site Plan for the PEFP

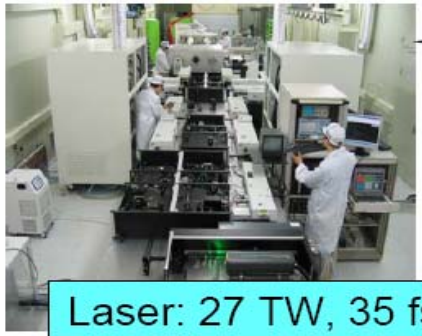


Laser-Plasma Wakefield Acceleration at GIST

- Peak power : 100 TW
- Pulse duration : 30 fs
- Wavelength : 800 nm
  (Ti:sapphire)
- Energy stability ~1.4% rms



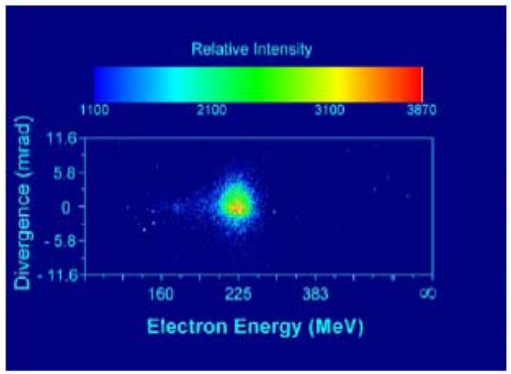
Experimental Results



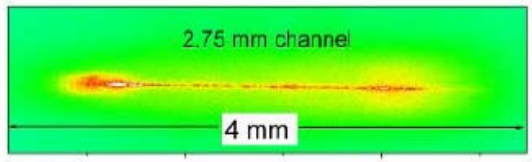
GIST-APRI 100TW 30fs laser

Some sub-GeV electron beams from 1cm gas jet

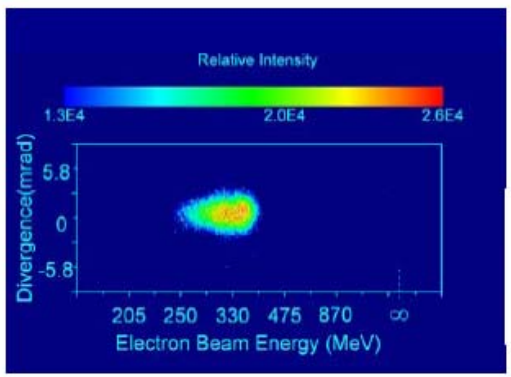
Laser: 27 TW, 35 fs Plasma: 7×10^{18}cm^{-3}



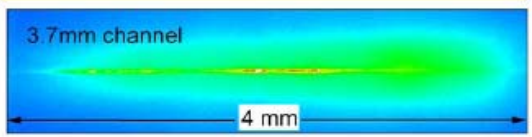
E = 225 MeV ΔE/E =17%
Divergence ~a few mrad
Charge ~100pC



Laser: 50 TW, 35 fs, Plasma: 6.6x 10^{18}cm^{-3}

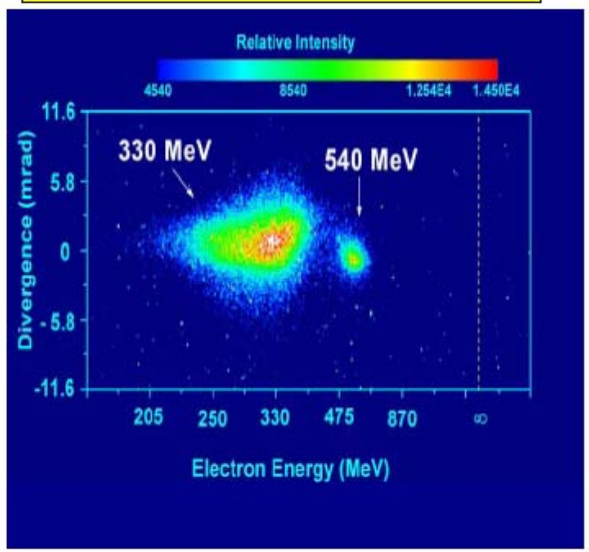


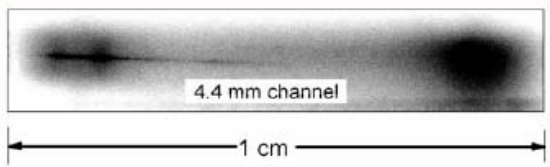
E = 330 MeV ΔE/E =10%
Divergence ~a few mrad
Charge ~500pC



Laser: 50TW, 35fs
Plasma: 3.4×10^{18}cm^{-3}

E_1=540 MeV, ΔE/E =11%
E_2=330 MeV, ΔE/E =33%
Q_1=20pC, Q_2=200pC





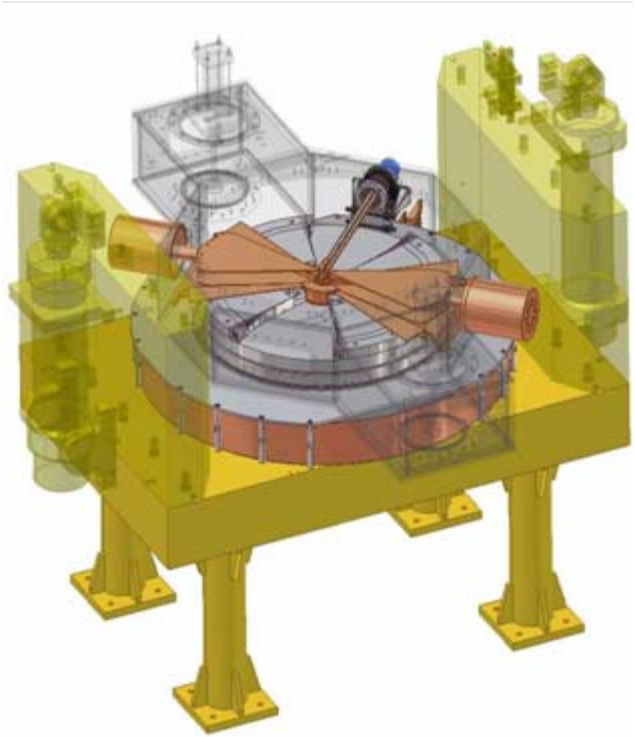
N. M. Hafz et al., Nature Photonics (2008)

Constructed New Research Bldg.

- Opened in Nov., 2008

Laser system upgrade to 500 TW is now underway in the new research building and it will be finished by 2010

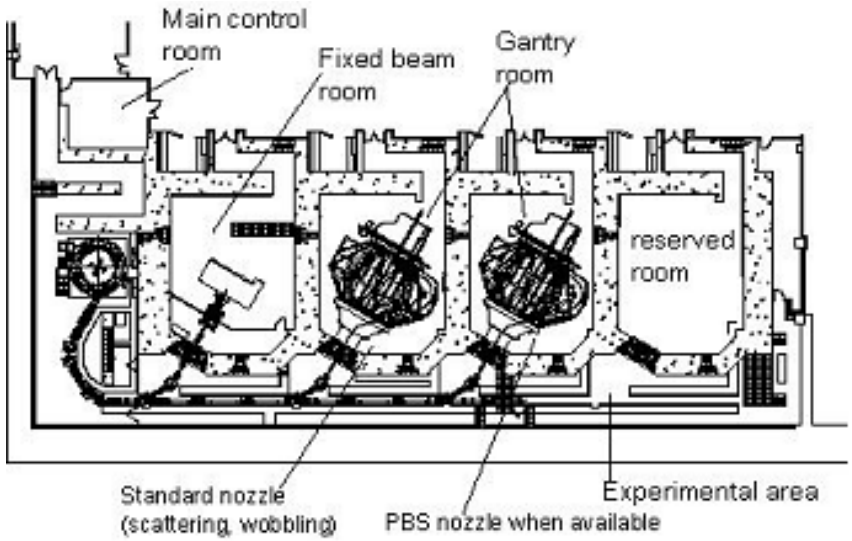
KIRAMS-13 Cyclotron



KIRAMS-13 installed at Kyungpook National University Hospital

Regional Cyclotron Center in KOREA

Proton therapy facility, National Cancer Center



Treatment of the first patient

- **2002 July: Contract with IBA**
- **2003 Jan: Complete the building design**
  June: Start the building construction
- **2005 Jan: Site survey**
  Feb: Starting the installation
  Oct: Beam test begin
- **2006 Dec: Acceptance of 1st gantry room**
  +2nd gantry room+ fixed beam room
- **2007 Mar 19: Treatment of the first patient (prostates)**
  July: 2nd gantry room is used to treat patient
  Aug-Oct: Fixed beam treatment room to be used
  Dec: End of one year operation by IBA
- **2008 Dec: total treatment of 370 patients**

KoRIA: Korea Rare Isotope Accelerator

- Multipurpose HI accelerator for RIB:

  - Nuclear and Astro-nuclear Physics
  - Nuclear Data Production for Applications
  - Materials Science using RIB
  - Bio and Medical Science with RIB and HI

- Planning: 2009 ~ 2012:

  - CDR started in 2009

- Construction: Planned in 2012 ~ 2016

Industrial Companies for Global Competitiveness

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

Gwangyang Plant

Established:	1968
Employees:	17,300
Steel Production:	~ 30.0 M tons
Revenue:	30.6 B$
Net Profit:	4.4 B$

Pohang Plant

R&D Collaboration with Industrial Companies

	Samsung		POSCO		Hyundai Heavy	
units (Trillion KRW)	Electronics		Steel		Ship building	
	Revenue	Profits Net / Business	Revenue	Profits Net / Business	Revenue	Profits Net / Business
2006	59.0	7.9 / 6.9	20.0	3.2 / 3.9	13.0	0.7 / 0.9
2007	63.0	7.4 / 5.9	22.0	3.7 / 4.3	16.0	1.7 / 1.8
2008	73.0	5.5 / 4.1	30.6	4.4 / 6.5	20.0	2.3 / 2.2
University	SKK University		POSTECH		Ulsan University	
Scientific Area	KSTAR SC Coil R&D		PLS Accelerator		KSTAR Vacuum Chamber	

Summary

- Korea has successfully improved her economic condition through industrialization. The underline driving force is considered as, not only the government planning but also trained man-power available through individual education.
- With the success of light source, research reactor and tokamak,
  there are growing demands for more multi-user facilities, such as light sources, heavy ion accelerator, and others.
- Government now established a bureau for large-scale science programs including space science and fusion research.
- For the large-scale science projects, we need consensus among scientists in this economy-oriented society.