My 35-years Activities at KEK

Shin-ichi Kurokawa
Professor Emeritus of KEK
Vice President of Cosylab
Energy reached by a DC accelerator was limited by insulation between plates. In order to overcome this difficulty, AC acceleration was invented by Wideroe in 1928.
Now Rolf Wideroe is ubiquitous

- (Betatron)

- Linear accelerator and principle of AC acceleration

- Principle of a storage ring and a collider (Patent)
Tale of Buddha and Son-Goku

- One novel “Journey to the West” was written in China in 15 century.

- In this novel, there is a story about Buddha and a super-monkey, Son-Goku.

- Son-Goku challenged Buddha as stating that he could reach the end of the
  world. He flew and flew and finally found a mountain with five peaks. He
  thought that this was the end of the world.

- As a proof of arriving at the end of the world, he wrote one character at
  each peak and then returned back to Buddha. Buddha showed to Son-
  Goku his fingers with characters written by Son-Goku.

- Buddha thus showed to Son-Goku that he could only fly within a palm of
  Buddha.

- We, present accelerator physicists, are still on a palm of Wideroe. All high-
  energy accelerators are AC accelerators and the highest energy
  accelerators are colliders.
Tale of Buddha and Son-Goku

• One novel “Journey to the West” was written in China in 15 century.

• In this novel, there is a story about Buddha and a super-monkey, Son-Goku.

• Son-Goku challenged Buddha as stating that he could reach the end of the world. He flew and flew and finally found a mountain with five peaks. He thought that this was the end of the world.

• As a proof of arriving at the end of the world, he wrote one character at each peak and then returned back to Buddha. Buddha showed to Son-Goku his fingers with characters written by Son-Goku.

• Buddha thus showed to Son-Goku that he could only fly within a palm of Buddha.

• We, present accelerator physicists, are still on a palm of Wideroe. All high-energy accelerators are AC accelerators and the highest energy accelerators are colliders.
History of KEK

'55 : Institute of Nuclear Studies (INS) was founded.

'61 : 1.3 GeV Electron Synchrotron of INS became operational.

'71 : KEK was founded.

'76 : 12 GeV Proton Synchrotron of KEK became operational.

'81 : Start of construction of TRISTAN

'82 : 2.5 GeV linac/ '83 Photon Factory Commissioned.

'86 : TRISTAN collider started beam collision.

'94 : Construction of KEKB started

'98 : KEKB collider started beam collision.

'01 : J-PARC was approved.

'05 : Proton Synchrotron of KEK was shut down.

'08 : J-Parc commissioned

'08 : KEKB's shut down and start of construction of SuperKEKB

'10 : KEKB's shut down and start of construction of SuperKEKB

'73 SK joined himself to KEK
Professor Tetsuji Nishikawa (1926-2010)
The founder of KEK
KEK in 1971
KEK in 1971
KEK in 1971
• During the construction period of PS, I engaged myself in design and construction of low-energy Kon and antiproton beamlines in Physics Department.

• I learned beam-optics, magnets, vacuum, computer control, etc. by this work, which became the basis of my future works at KEK.
Fig. 1. Layout of K3 beam.
gap of mass slit: 2 mm
600 MeV/c
separator: 600 kV

Count of $\pi^+$ (x10^3)

Count of $K^+$ (x10^3)

Crossed magnetic field (arbitrary scale)
History of KEK

- '55 : Institute of Nuclear Studies (INS) was founded.
- '61 : 1.3 GeV Electron Synchrotron of INS became operational.
- '71 : KEK was founded.
- '76 : 12 GeV Proton Synchrotron of KEK became operational.
- '81 : Start of construction of TRISTAN. SK moved to TRISTAN.
- '82 : 2.5 GeV linac/ '83 Photon Factory Commissioned.
- '86 : TRISTAN collider started beam collision.
- '94 : Construction of KEKB started.
- '98 : KEKB collider started beam collision.
- '01 : J-PARC was approved.
- '05 : Proton Synchrotron of KEK was shut down.
- '08 J-Parc commissioned.
- '10 : KEKB's shut down and start of construction of SuperKEKB.
- '10 : KEKB's shut down and start of construction of SuperKEKB.
TRISTAN 30 x 30 GeV e+e- collider

Construction
1981-86
The highest energy e+e- collider at that time
Superconducting RF cavities of TRISTAN

The first large-scale application of SCRF cavities in the world
• In 1981 I moved to Accelerator Department and worked for TRISTAN computer control system.

• TRISTAN was the first fully computer-controlled accelerator in Japan.

• TRISTAN control system was NODAL based distributed control system.
NODAL language – an example

1.10 DIM A(10)
1.20 EXEC <MG0> 2 A; WAIT<MG0>
1.30 FOR I=1, 10; TYPE I A(I);
1.40 END

2.10 FOR I=1, 10; SET A(I)=MAG(I, ‘CUR’) 
2.20 REMIT A
• NODAL was easy to learn and to write programs. Not only control group members but also almost all of scientists and engineers wrote their programs.

• Speed of TRISTAN NODAL system is ~1/1000 of present EPICS based control system; however, TRISTAN was really controlled by this NODAL system.
**History of KEK**

- **1950**: Institute of Nuclear Studies (INS) was founded.
- **1960**: 1.3 GeV Electron Synchrotron of INS became operational.
- **1970**: KEK was founded.
- **1976**: 12 GeV Proton Synchrotron of KEK became op’l.
- **1981**: Start of construction of TRISTAN
- **1982**: 2.5 GeV linac/ ‘83 Photon Factory Commissioned.
- **1986**: TRISTAN collider started beam collision.
- **1990**: From 90 SK worked for KEKB as Project Leader
- **1994**: Construction of KEKB started
- **1998**: KEKB collider started beam collision.
- **2000**: ‘98 : KEKB collider started beam collision.
- **2005**: Proton Synchrotron of KEK was shut down.
- **2008**: J-Parc commissioned
- **2010**: ‘08 J-Parc commissioned
- **2010**: ‘05 : Proton Synchrotron of KEK was shut down.
- **2010**: ‘01 : J-PARC was approved.
- **2010**: ‘10 : KEKB‘s shut down and start of construction of SuperKEKB
- **2010**: ‘10 : KEKB‘s shut down and start of construction of SuperKEKB
KEKB = Asymmetric Double-Ring Collider for B-Physics
8 GeV Electron + 3.5 GeV Positron

Superconducting cavities (HER)

ARES copper cavities (HER)

ARES copper cavities (LER)

TRISTAN tunnel

8 GeV e- 3.5 GeV e+ Linac

e+ target

Belle detector

KEKB B-Factory

KEKB is an upgrade of TRISTAN and the world highest luminosity collider
• KEKB was the most successful collider in terms of the peak and integrated luminosity.

• However, year 2000 was the year of crisis of KEKB.
Luminosity of KEKB and PEPII

Increase of Peak Luminosity

10.567 /nb/s on 2003/5/13 (KEKB)
6.485 /nb/s on 2003/6/8 (PEP-II)

One year stagnation of luminosity
Electron Cloud Instability
Electron Cloud Formation without Solenoid
Coupled bunch instability

Single bunch instability
Fight against Electron Cloud Instabilities by Winding Solenoids at KEKB LER
Effect of solenoid in a physics fill pattern (4 rf buckets spacing)

After last installation of solenoid, blowup was disappeared up to 1300mA.
Present Status in Asian Accelerators

- We have witnessed rapid progresses in accelerator sciences in Asian region these years.

- Asian accelerator sciences have caught up those of forerunners, namely, Europeans and Americans. (Major facilities: KEKB, J-Parc, SPring-8, SACLAL, RIBF, BEPC-II, and Shanghai Light Source).

- There still remains wide difference within Asia in terms of accelerator sciences; therefore, we need to strengthen collaborations among Asian countries.

- Future of Asia is bright!
ACFA

Asian Committee for Future Accelerators

Officially established in the First Plenary ACFA meeting held in 1996 at POSTECH, Korea
ACFA Members

Total population of ACFA-member countries = 3.42 billion
(53.8% of the world population)
Creation of APAC, and then IPAC

• ACFA created APAC in 1998 as Asian regional accelerator conference taking place every third year. I was instrumental to the creation of APAC.

• Since PAC was held in odd years and EPAC in even years, every time APAC collides either PAC or EPAC.

• From 2005 discussion started among three regions how to avoid this collision; I participated in this discussion as representative of APAC.

• Consensus was reached in 2008 to create IPAC and the first IPAC was held in Kyoto in May 2010. I worked as honorary Chair of the conference.
Summary

• I was lucky to be able to participate in major projects of KEK with motivated colleagues.

• Our generation owes much to the broader perspectives and deep insights of founders of KEK led by late Professor Tetsuji Nishikawa.

• By Asian’s rise the IPAC series conferences will surely become truly internationalized.