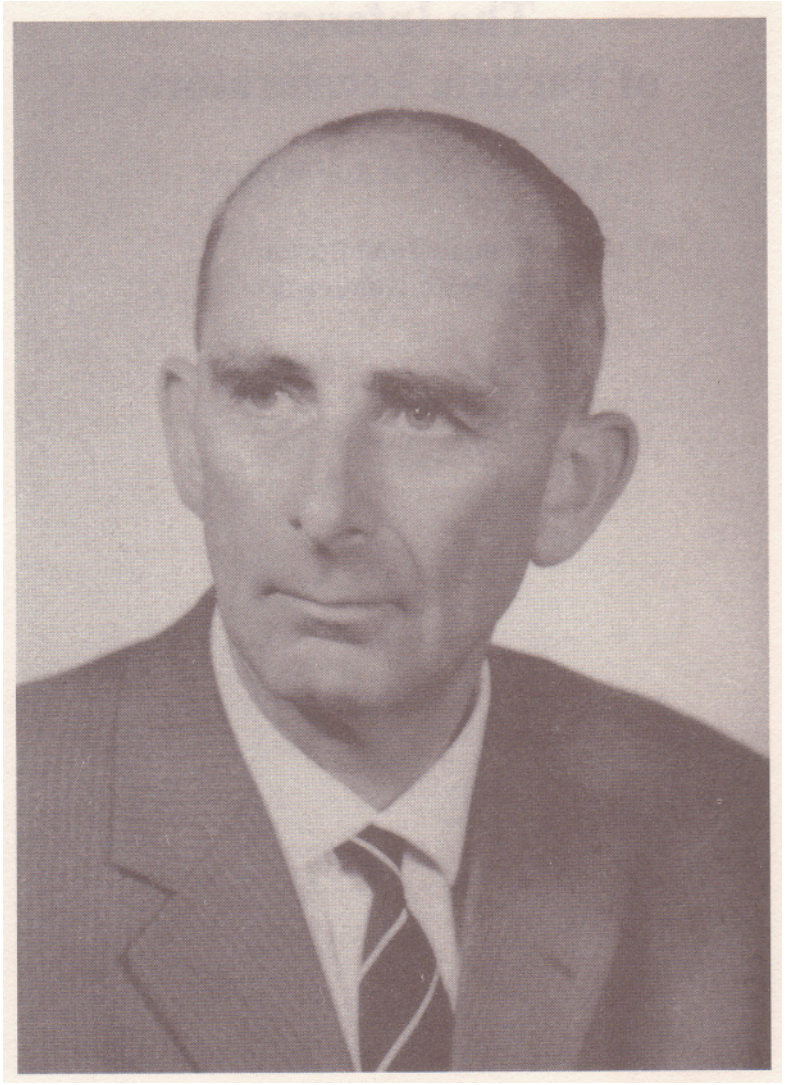
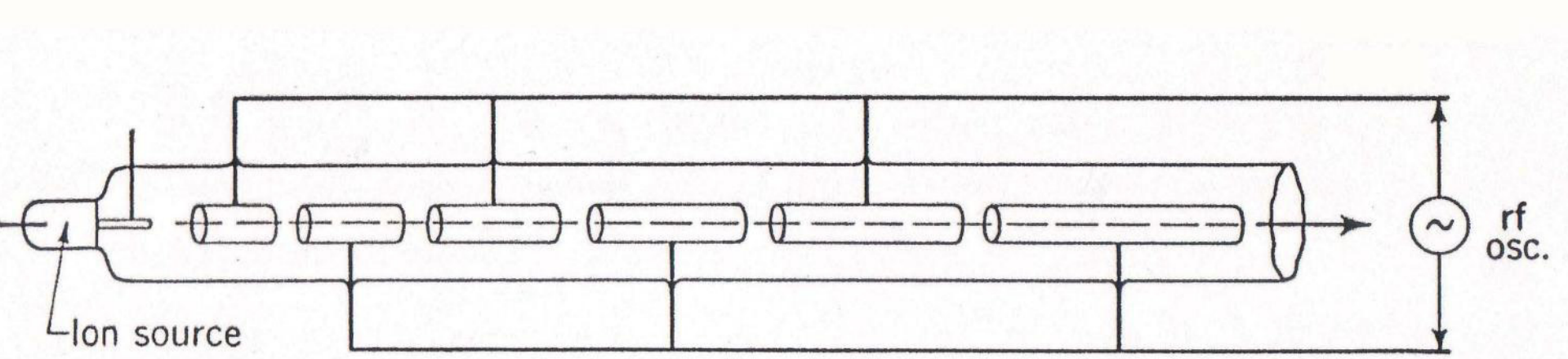
My 35-years Activities at KEK

Shin-ichi Kurokawa
Professor Emeritus of KEK
Vice President of Cosylab

Rolf Wideroe 1902-1995



Energy reached by a DC accelerator was limited by insulation between plates. In order to overcome this difficulty, AC acceleration was invented by Wideroe in1928.



Wideroe Linac

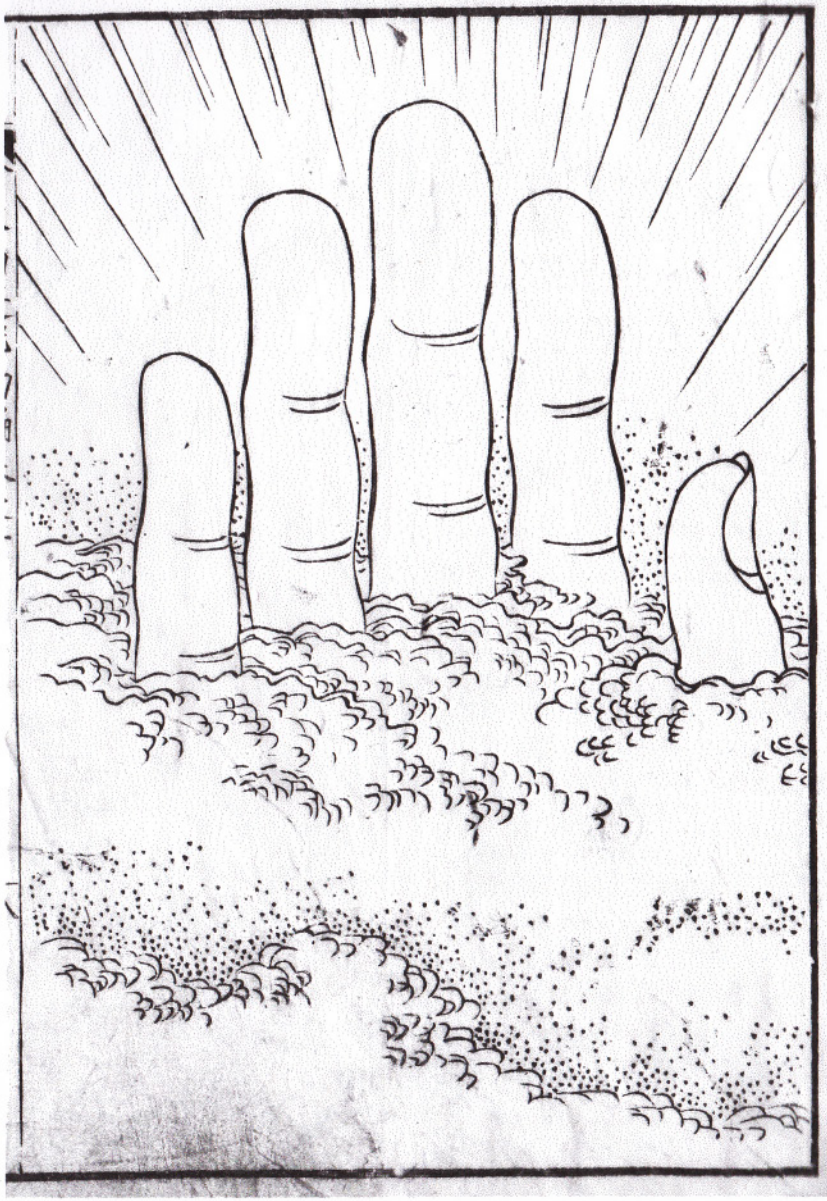
Now Rolf Wideroe is ubiquitous

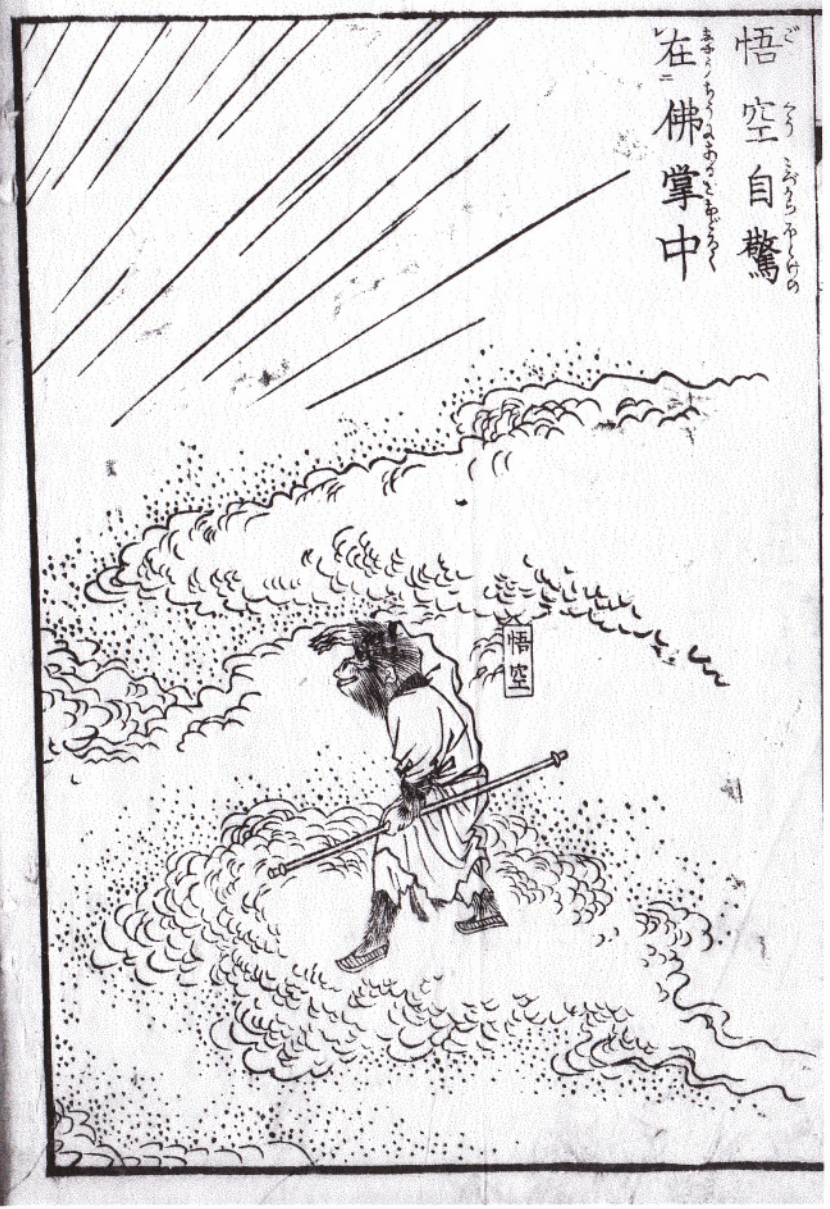
- (Betatron)
- Linear accelerator and principle of AC acceleration
- Principle of a storage ring and a collider (Patent)

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.

悟空自驚
在佛掌中





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History of KEK

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

2010

’08 J-Parc commissioned

‘05 : Proton Synchrotron of KEK was shut down.

‘01 : J-PARC was approved.

2000

‘98 : KEKB collider started beam collision.

‘94 : Construction of KEKB started

1990

‘86 : TRISTAN collider started beam collision.

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

1980

’81 : Start of construction of TRISTAN

‘76 : 12 GeV Proton Synchrotron of KEK became op’l.

’73 SK joined himself to KEK

1970

‘71 : KEK was founded.

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

1960

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

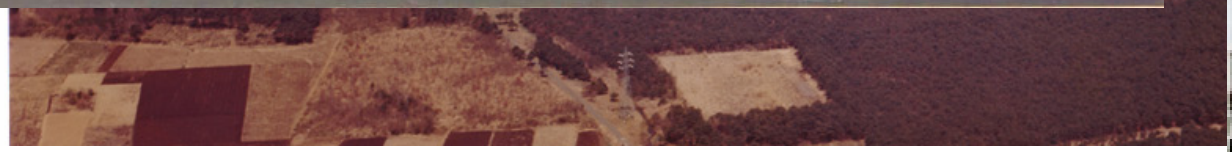
1950

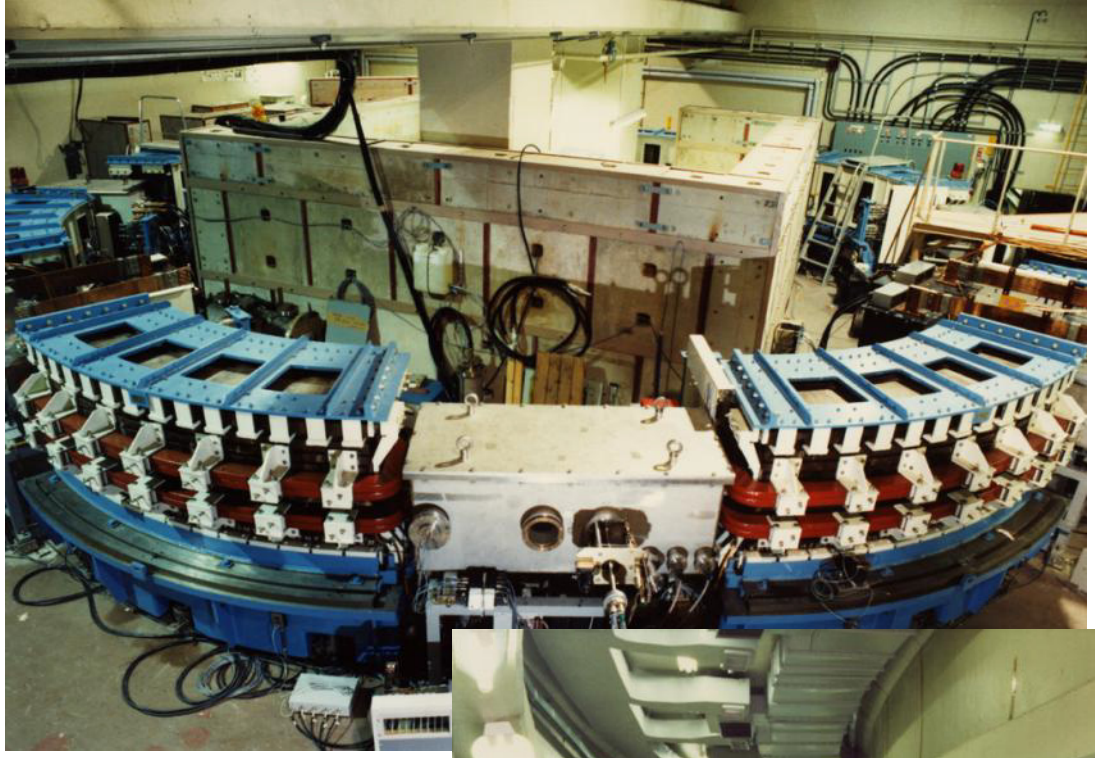
Professor Tetsuji Nishikawa (1926-2010)
The founder of KEK

KEK in 1971

KEK in 1971

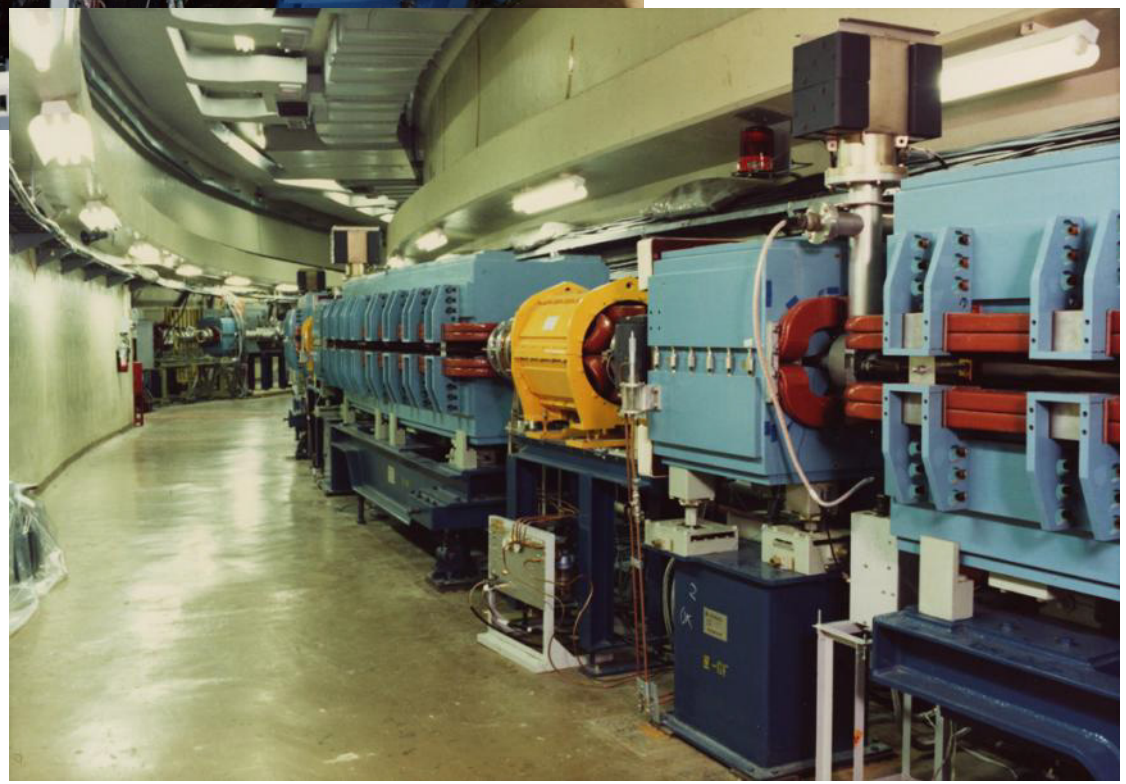
KEK in 1971





500 MeV Booster

12 GeV PS



- 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.

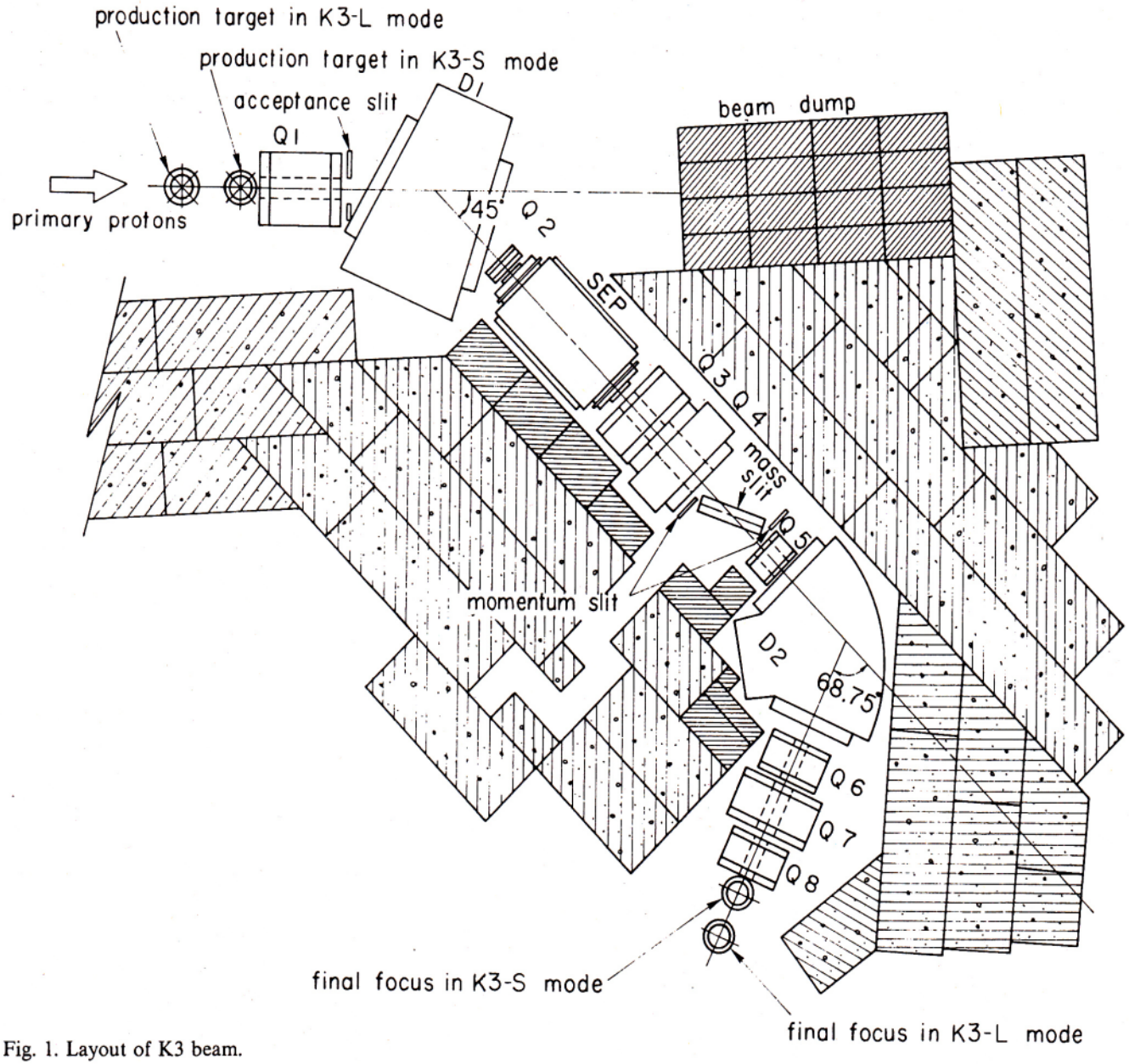
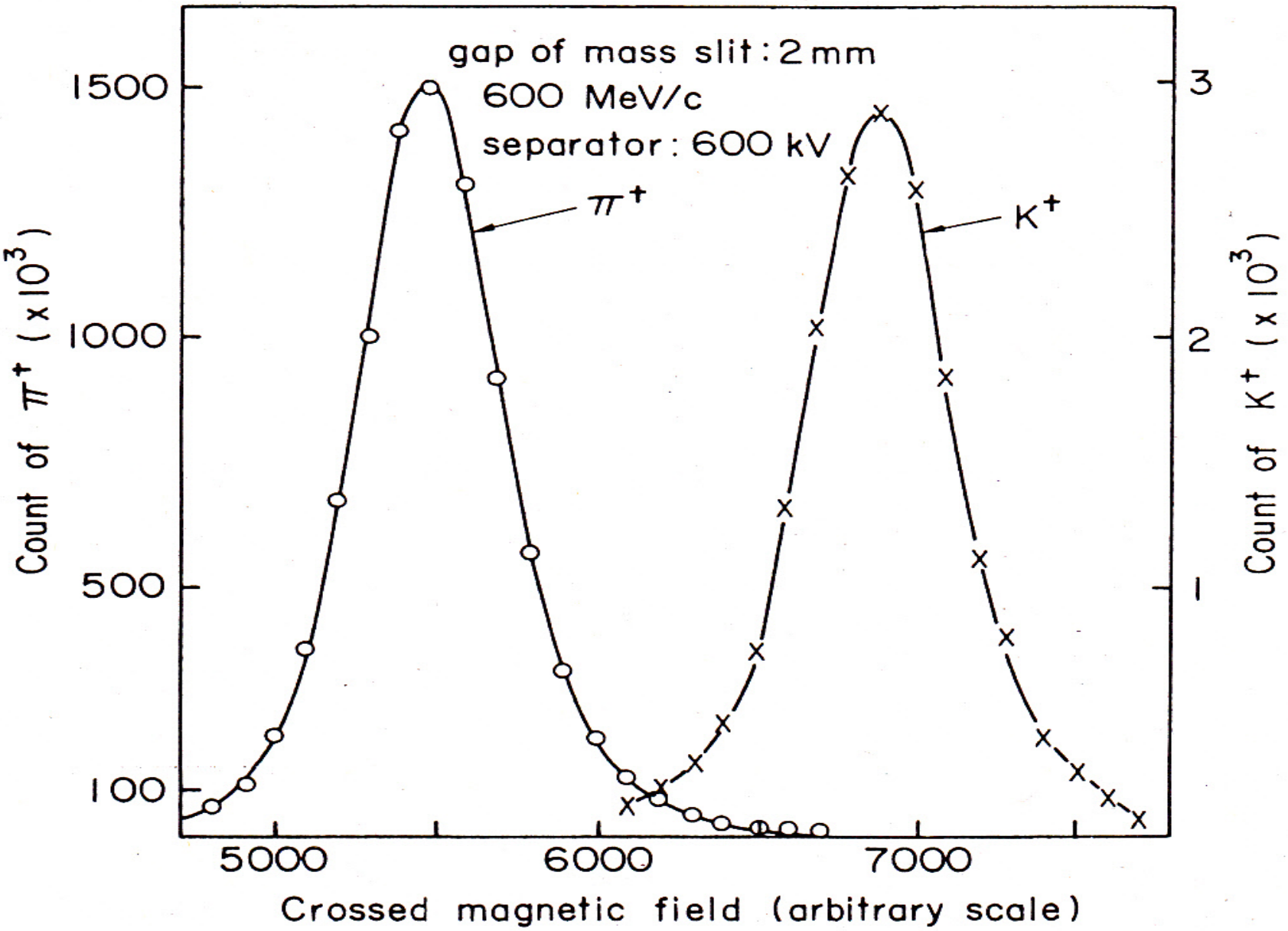
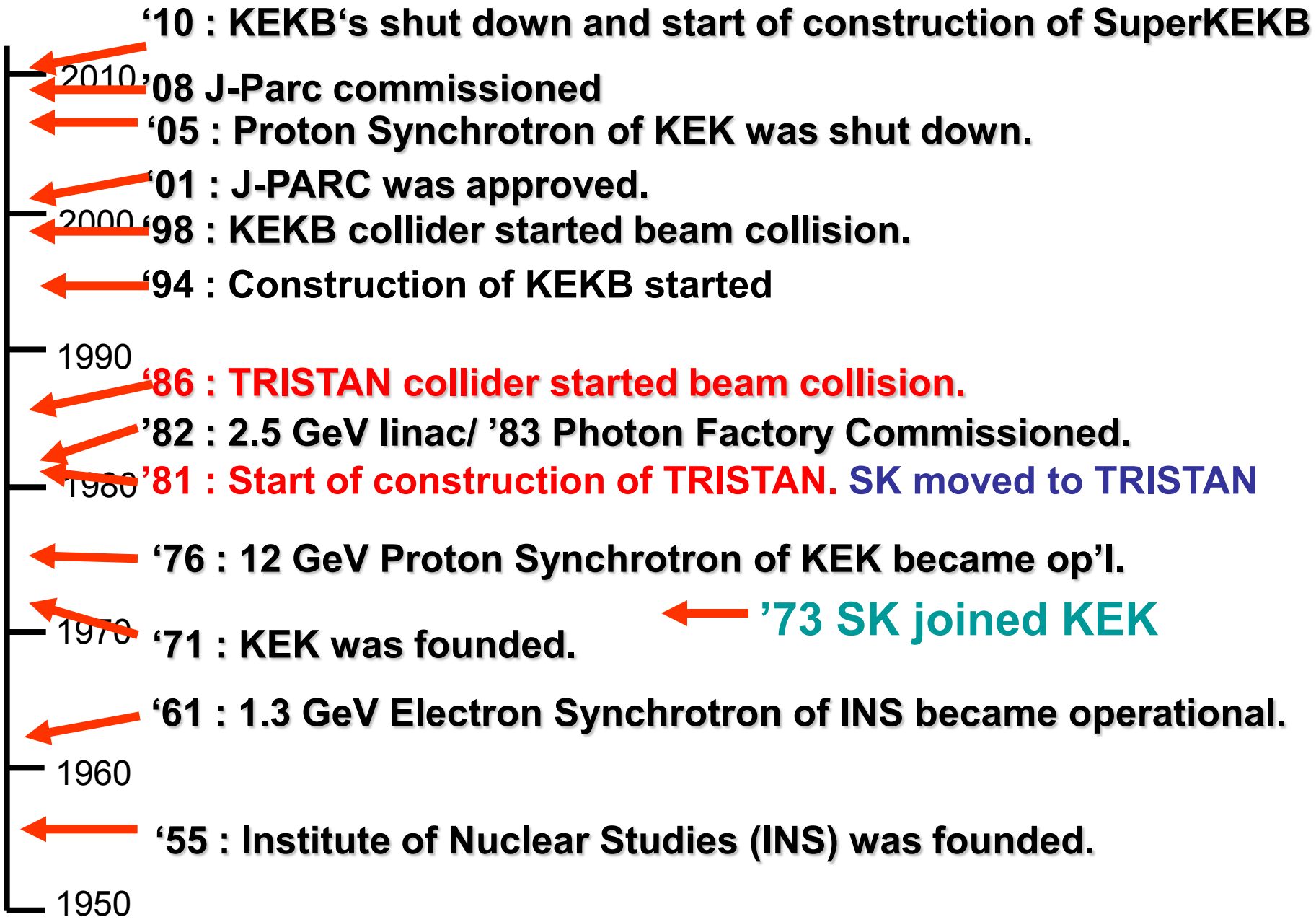


Fig. 1. Layout of K3 beam.

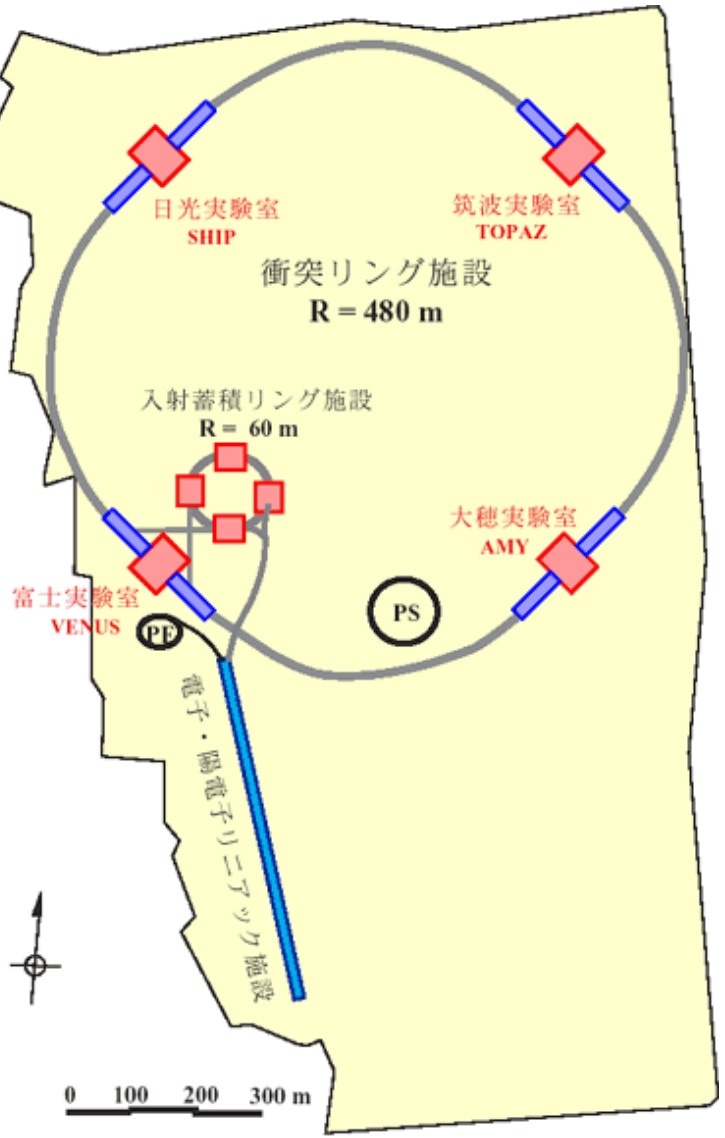

gap of mass slit : 2 mm
600 MeV/c
separator : 600 kV
π+
K+
1500
1000
500
100
3
2
1
5000
6000
7000
Count of π+ (x10^3)
Count of K+ (x10^3)
Crossed magnetic field (arbitrary scale)

History of KEK



TRISTAN 30 x 30 GeV e+e- collider

Construction 1981-86
The highest energy e+e- collider at that time



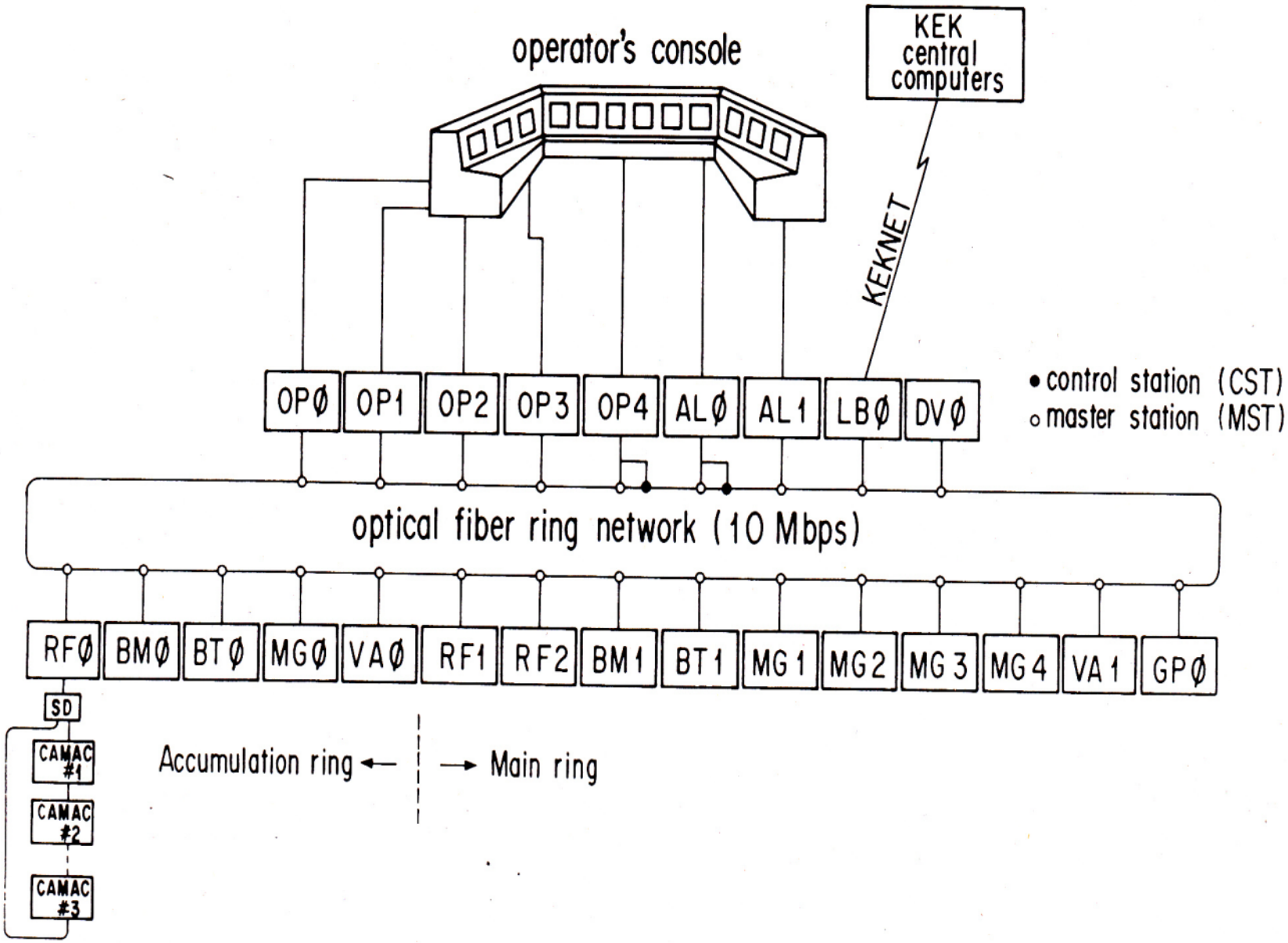
TRISTAN Ring

Superconducting RF cavities of TRISTAN

The first large-scale application of SCRF cavities in the world

BANZAI!

- 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.


operator's console
KEK central computers
KEKNET
OPØ
OP1
OP2
OP3
OP4
ALØ
AL1
LBØ
DVØ
• control station (CST)
○ master station (MST)
optical fiber ring network (10 Mbps)
RFØ
BMØ
BTØ
MGØ
VAØ
RF1
RF2
BM1
BT1
MG1
MG2
MG3
MG4
VA1
GPØ
SD
CAMAC #1
CAMAC #2
CAMAC #3
Accumulation ring
Main ring

NODAL language – an example

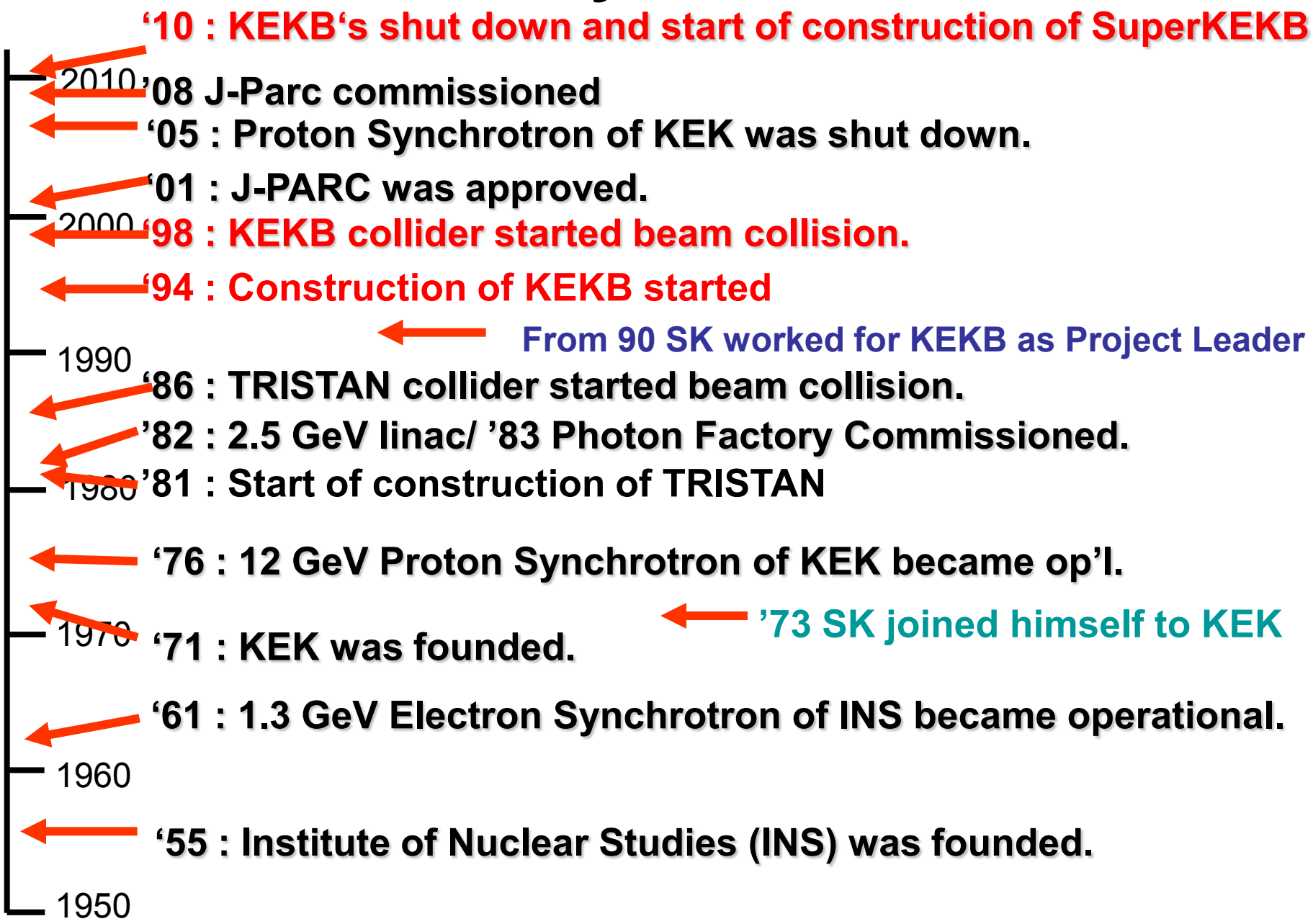
```
1.10 DIM A(10)
1.20 EXEC  <MG0> 2 A; WAIT<MG0>
1.30 FOR I=1, 10; TYPE I A(I);
1.40 END

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.

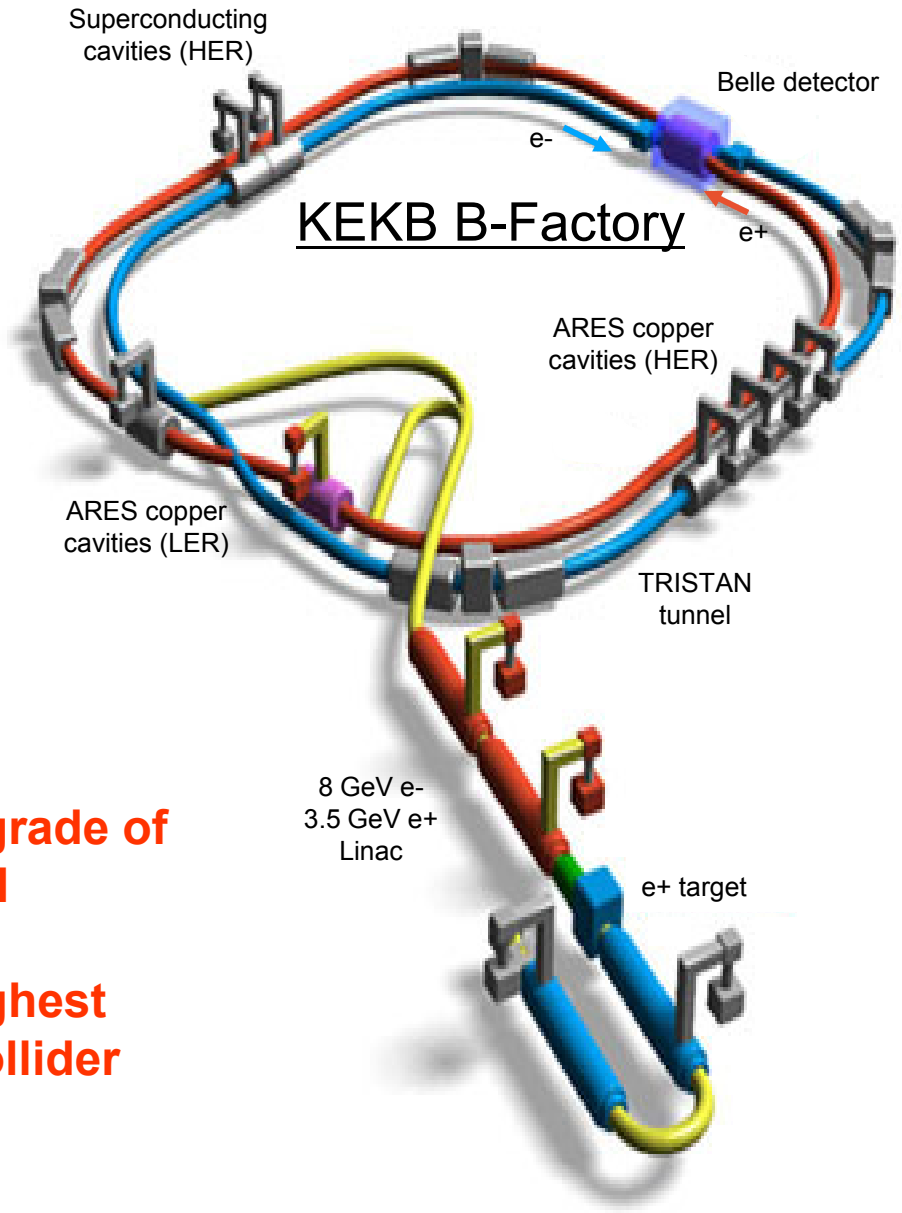
- Speed of TRISTAN NODAL system is ~1/1000 of present EPICS based control system; however, TRISTAN was really controlled by this NODAL system.

History of KEK



KEKB = Asymmetric Double-Ring Collider for B-Physics

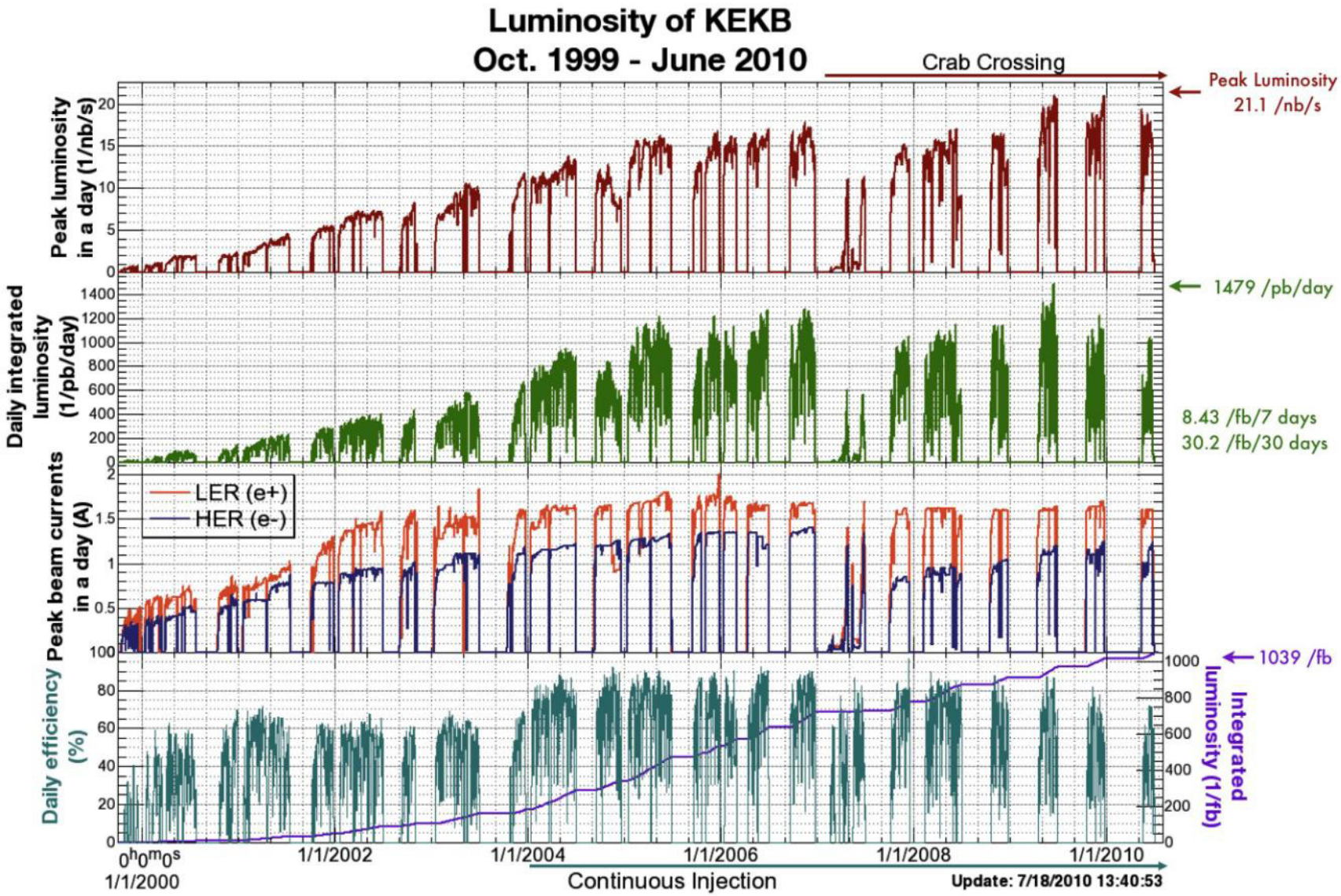
8 GeV Electron + 3.5 GeV Positron



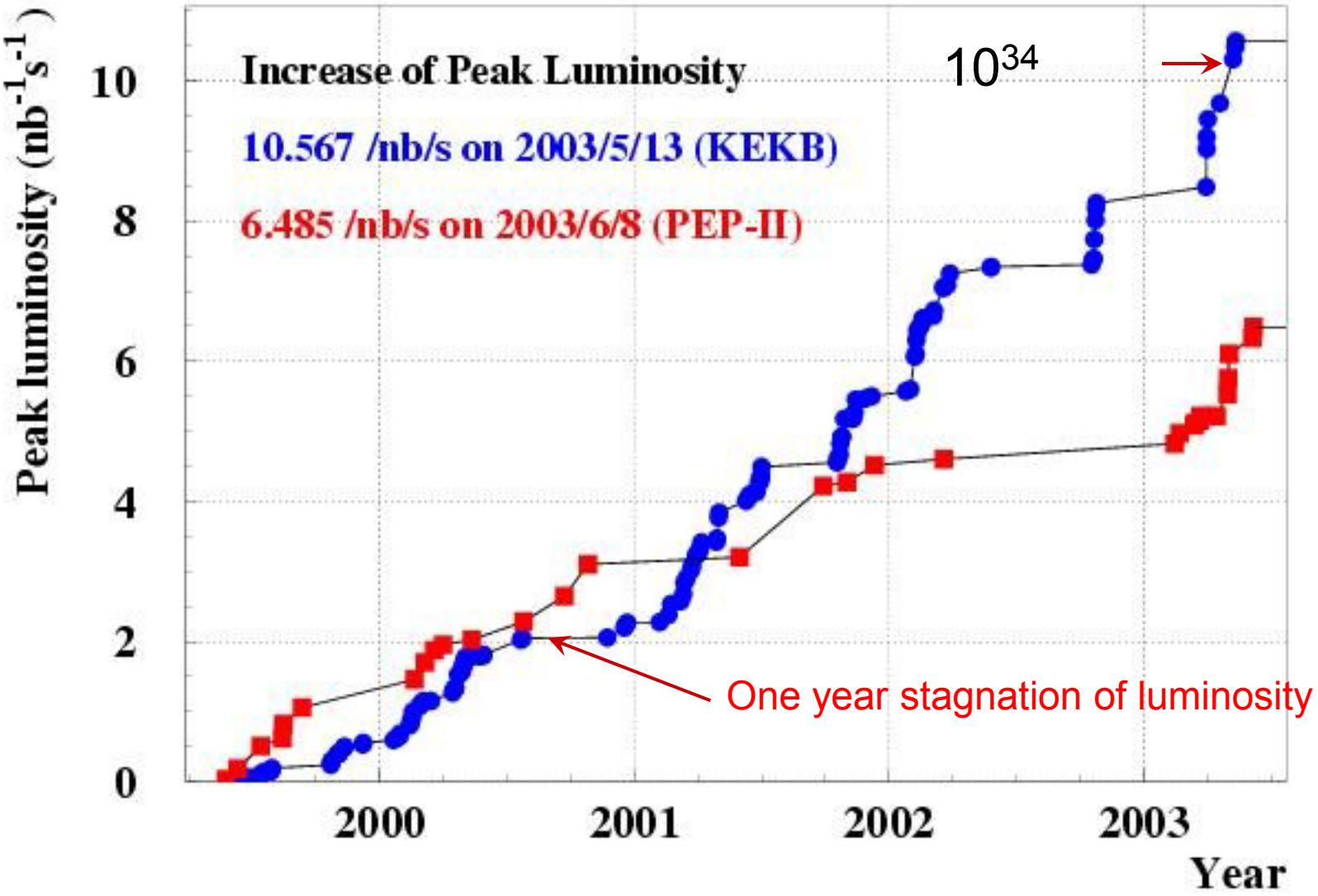
KEKB is an upgrade of TRISTAN and the world highest luminosity collider

- KEKB was the most successful collider in terms of the peak and integrated luminosity.

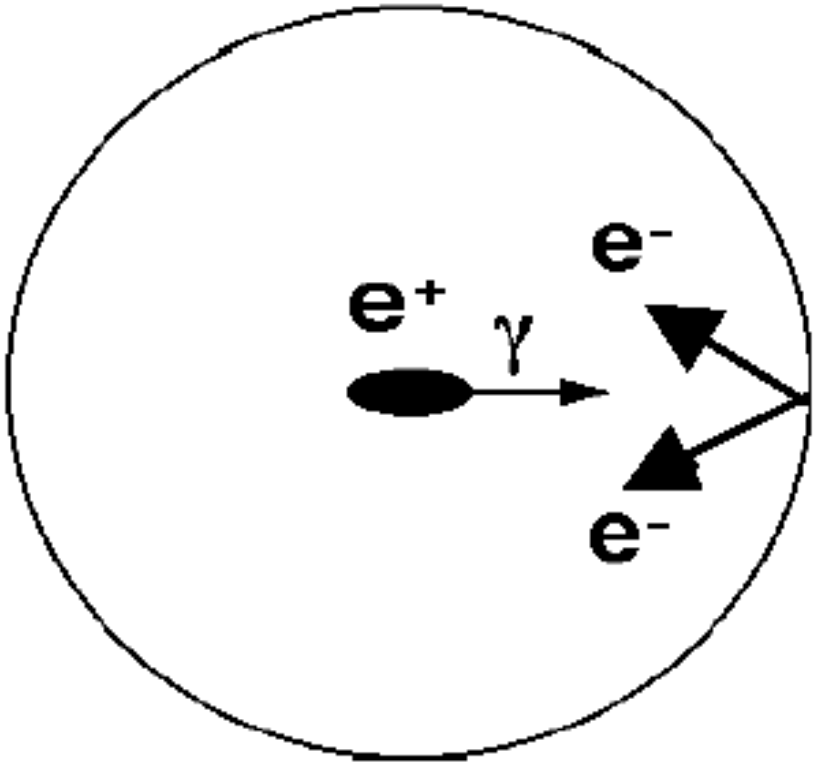
- However, year 2000 was the year of crisis of KEKB.


Luminosity of KEKB
Oct. 1999 - June 2010
Crab Crossing
Peak Luminosity
21.1 /nb/s
Peak luminosity in a day (1/nb/s)
1479 /pb/day
Daily integrated luminosity (1/pb/day)
8.43 /fb/7 days
30.2 /fb/30 days
LER (e+)
HER (e-)
Peak beam currents in a day (A)
1039 /fb
Integrated luminosity (1/fb)
Daily efficiency (%)
0h0m0s
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
1/1/2010
Continuous Injection
Update: 7/18/2010 13:40:53

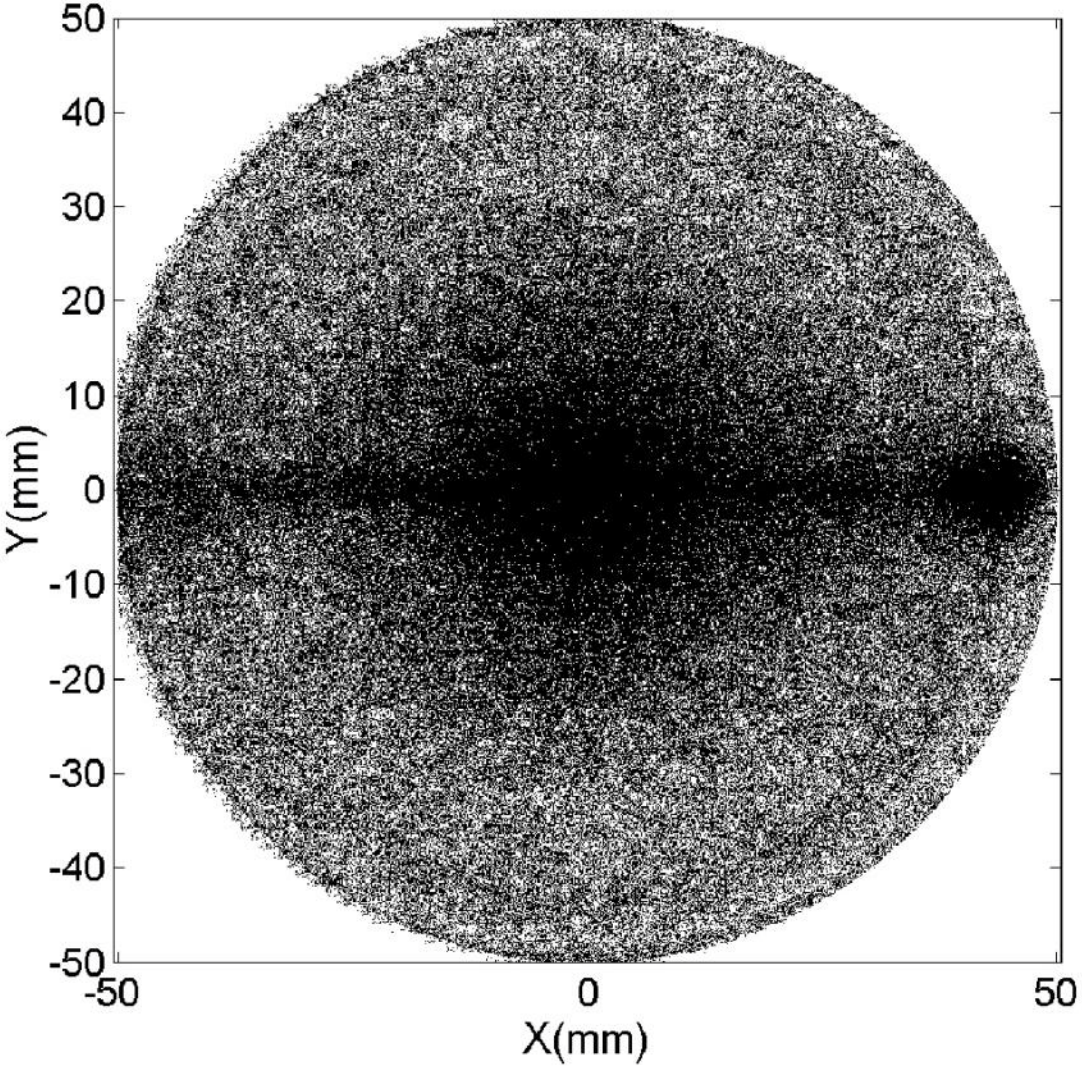
Luminosity of KEKB and PEPII



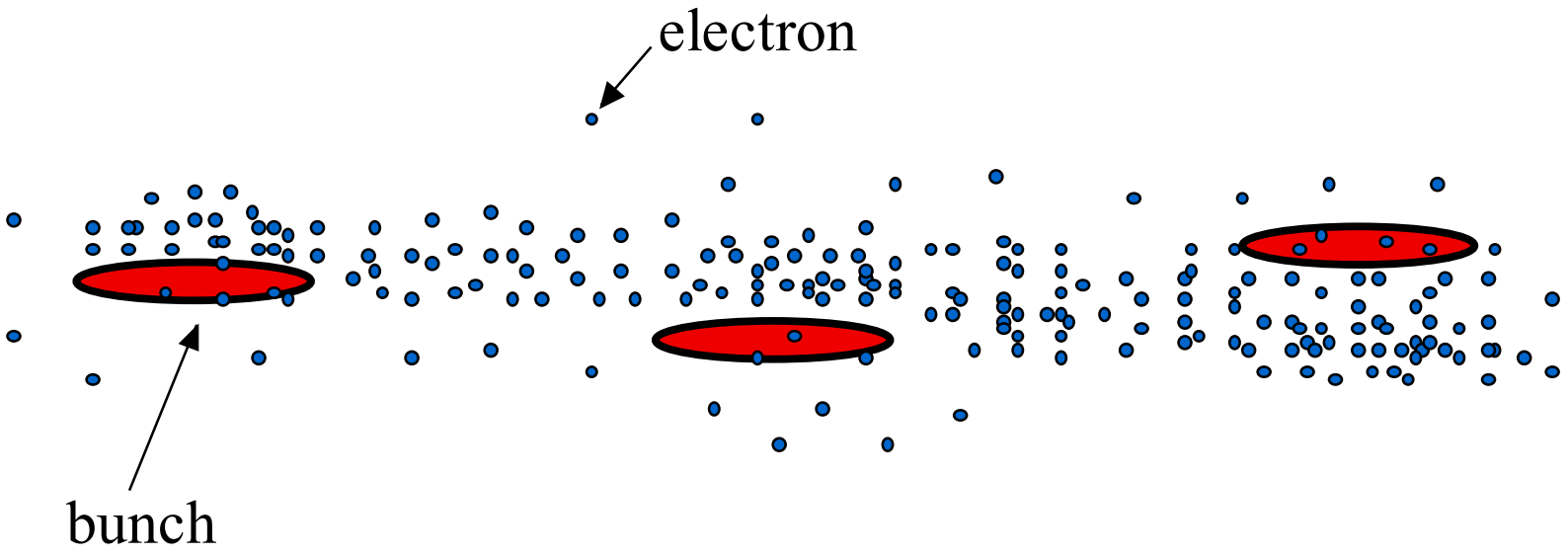
Electron Cloud Instability



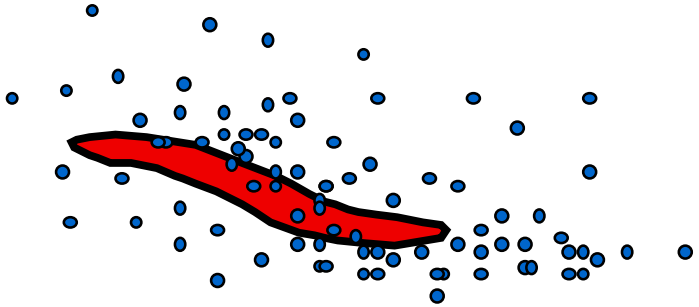
Electron Cloud Formation without Solenoid



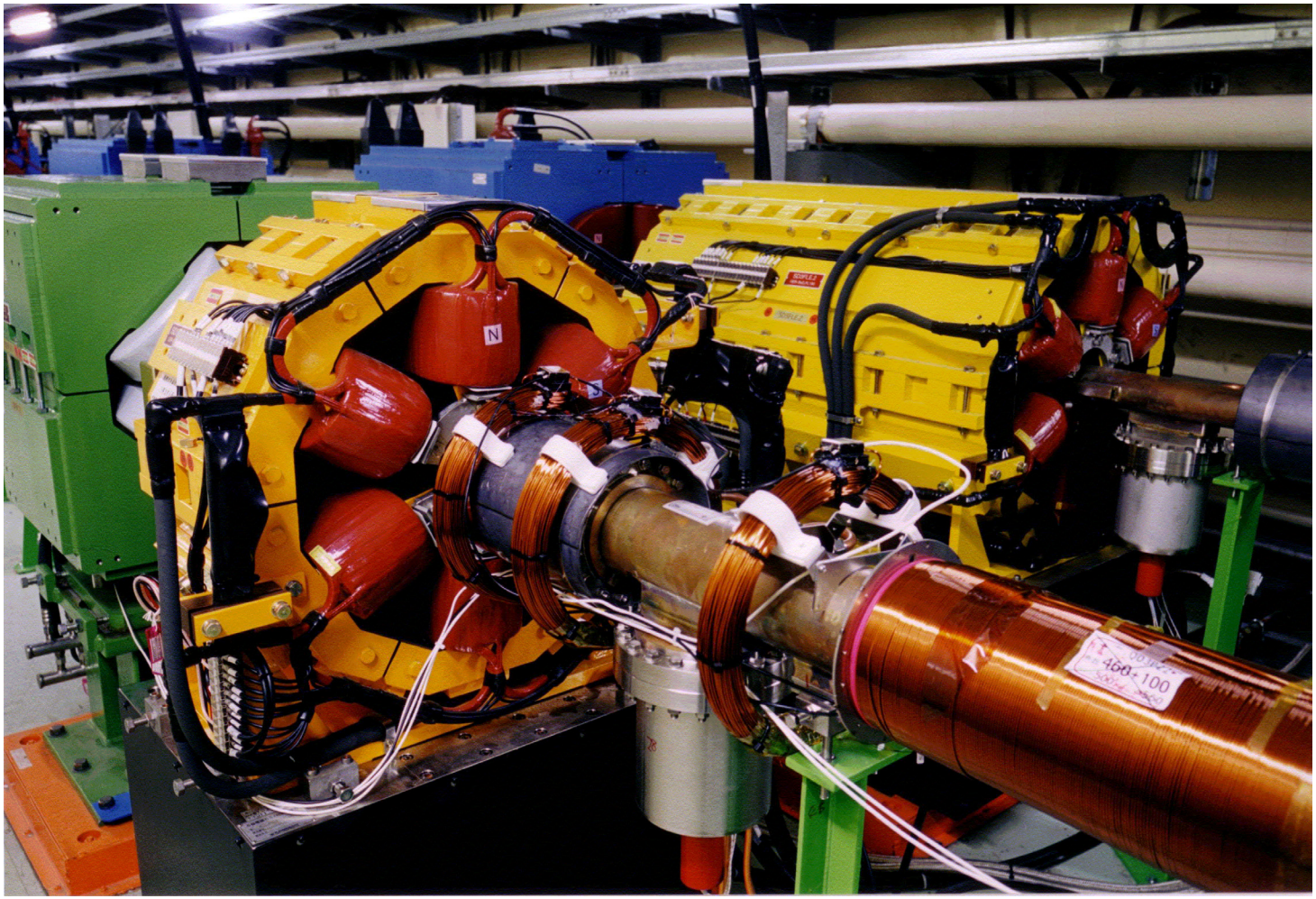
Coupled bunch instability

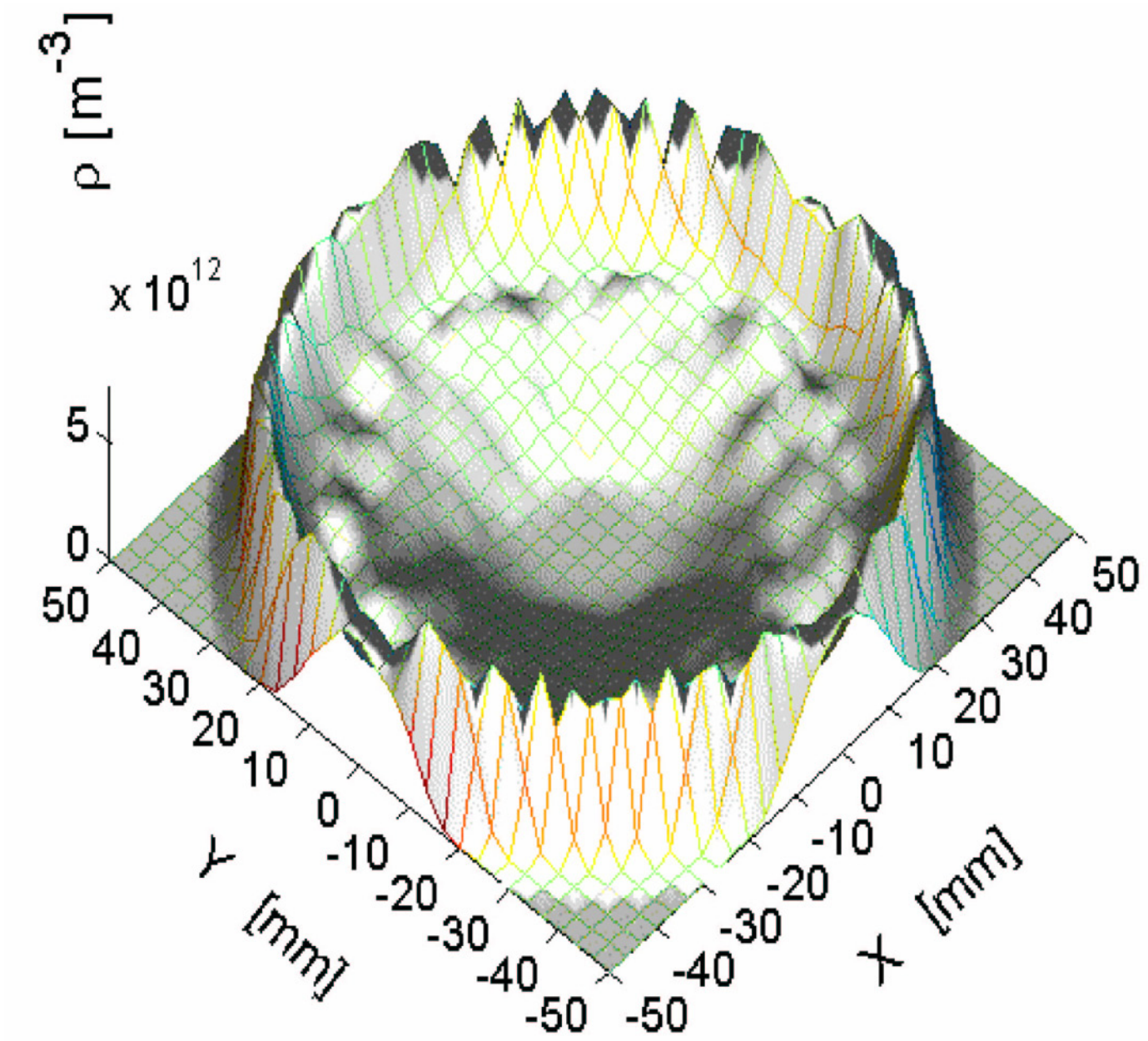


Single bunch instability

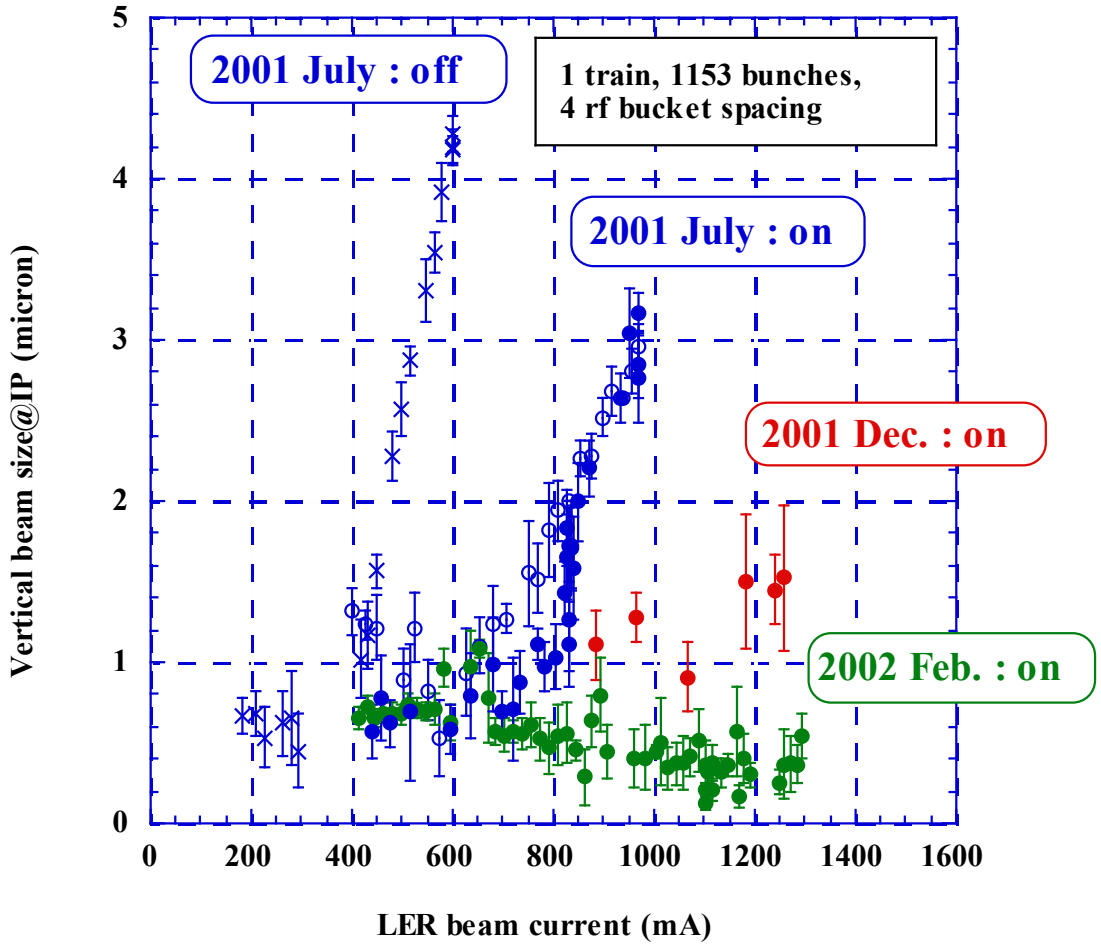


Fight against Electron Cloud Instabilities by Winding Solenoids at KEKB LER




ρ [m^-3]
x 10^12
5
0
50
40
30
20
10
0
-10
-20
-30
-40
-50
y [mm]
-50
-40
-30
-20
-10
0
10
20
30
40
50
x [mm]

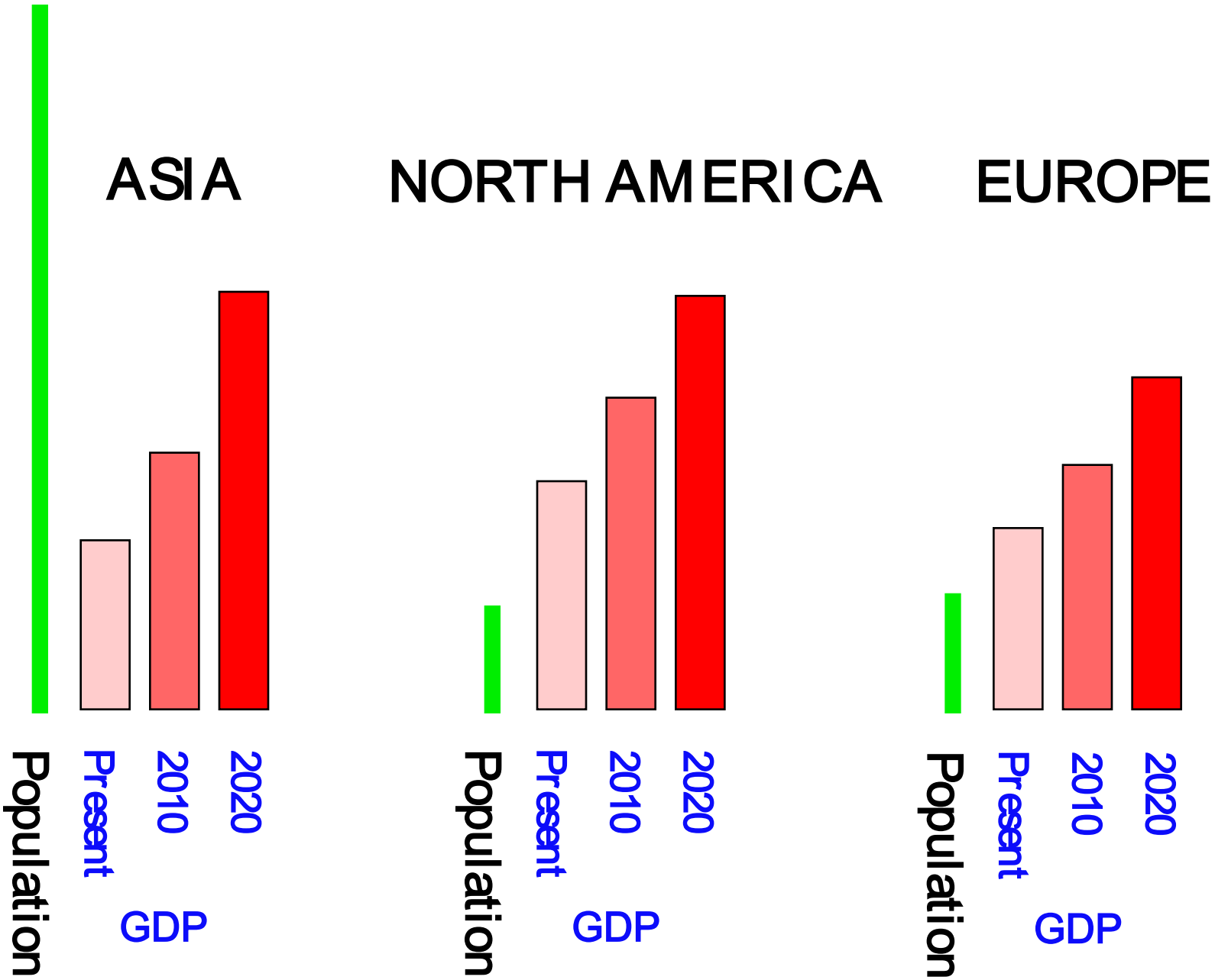
Effect of solenoid in a physics fill pattern (4 rf buckets spacing)



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, SACLA, 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!

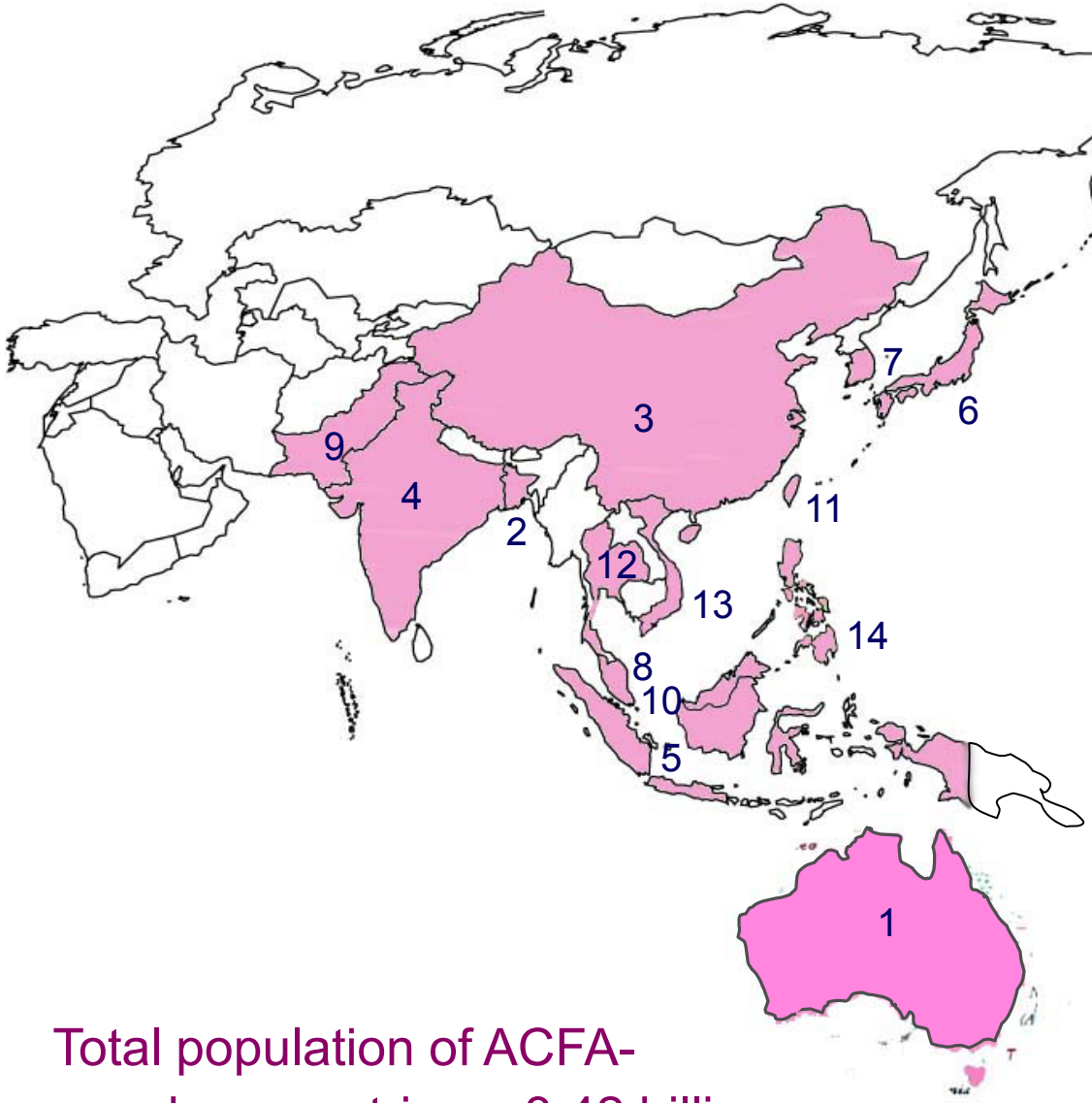

ASIA
NORTH AMERICA
EUROPE
Population
Present
2010
2020
GDP
Population
Present
2010
2020
GDP
Population
Present
2010
2020
GDP

ACFA

Asian Committee for Future Accelerators

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

ACFA Members



1. Australia
2. Bangladesh
3. China
4. India
5. Indonesia
6. Japan
7. Korea
8. Malaysia
9. Pakistan
10. Singapore
11. Taiwan
12. Thailand
13. Vietnam
14. The Philippines

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.