Collaboration on Linac, ILC and ATF2

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IHEP, CAS, China

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Core-University Collaborative Program

2009.4.8

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- **ILC effort beam dynamics**
- **ILC effort on ATF2**
- **ILC effort on positron source**
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- **Advanced Accelerator Technology**

  laser-plasma acceleration
- **Conclusions**

Introduction

Subjects of R&D on ILC

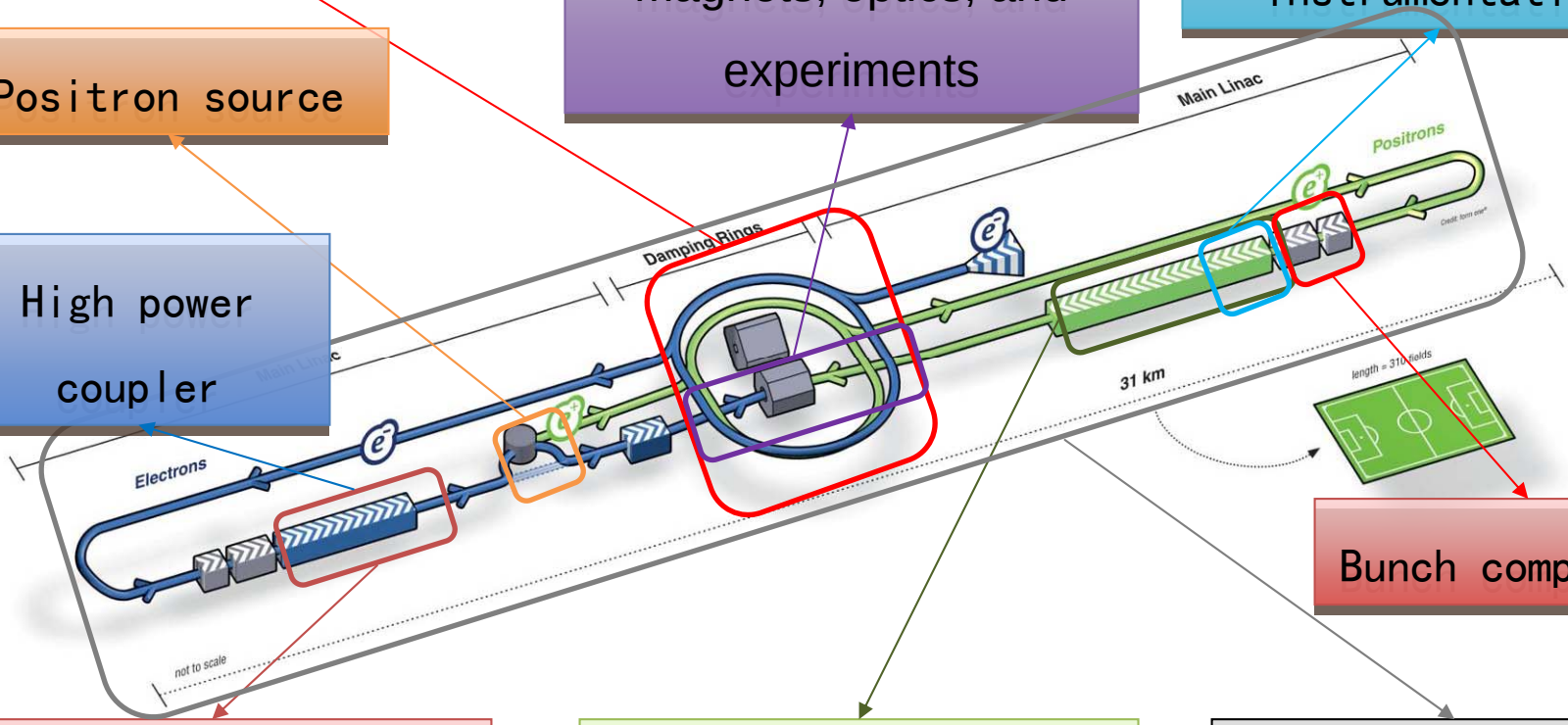
ILC Damping Ring

Final focus ATF2 magnets, optics, and experiments

LLRF、instrumentation

Positron source

High power coupler



Bunch compressor

SC cavity

Cryomodule

Beam dynamics

Researches in ILC

global design, beam dynamics

and damping ring

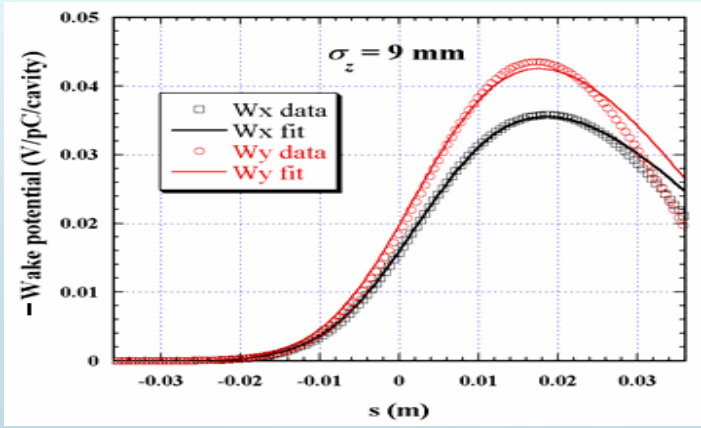
ILC main linac beam dynamics

Miss WANG Dou (Ph. D Student) worked with Dr. Kubo on beam dynamics of ILC since Jan-March 2009.

Subjects of research:
Emittance perservation in main linacs (ILC).

Due to excellent work of D. Wang, Dr. Kubo strongly asked to continue this collaboration.

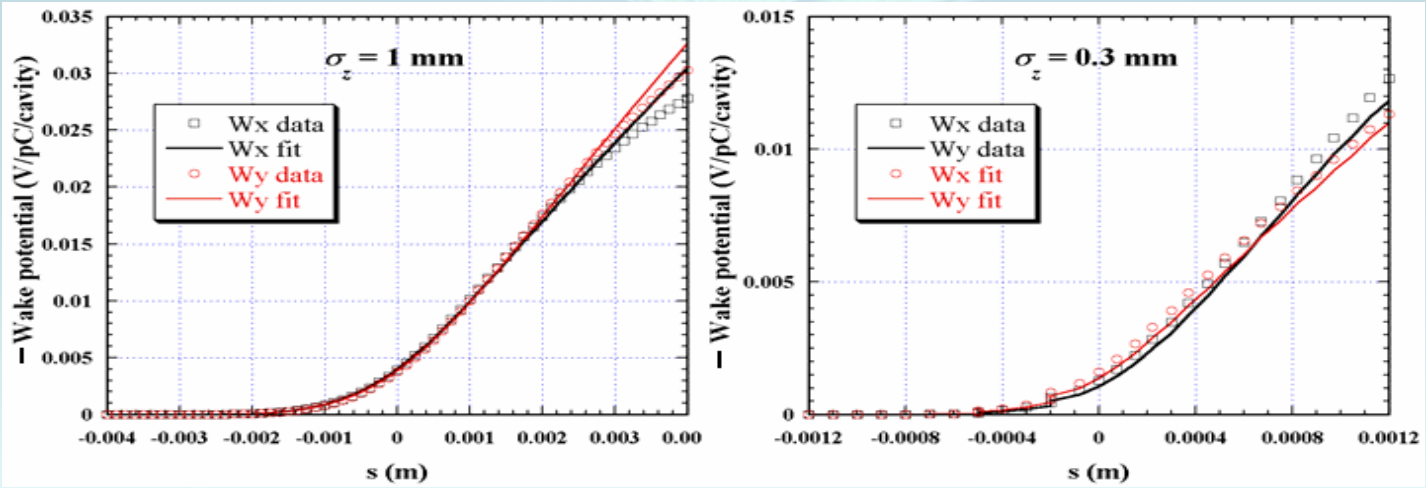
ILC main linac beam dynamics in collaboration with KEK K. Kubo



Coupler's wakefields

Emittance growth study in bunch compressors

PH.D student WANG Dou of J. Gao



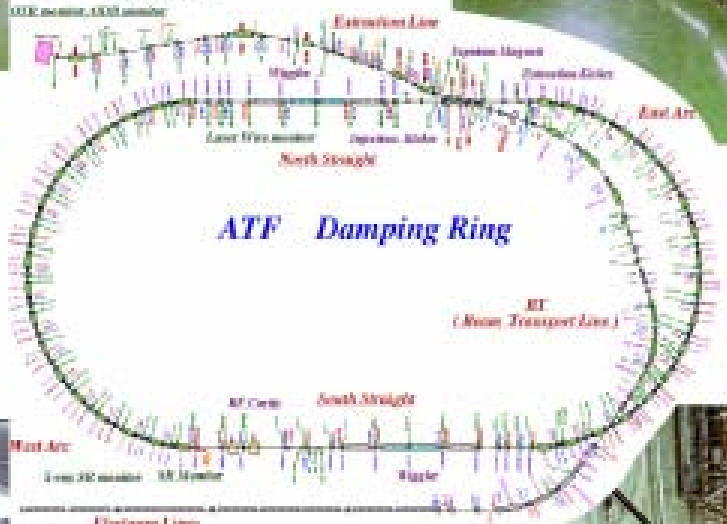
Collaborate with KEK on the beam dynamics with K. Kubo
(WANG Dou visit KEK 3month in 2009)

ILC effort on ATF2

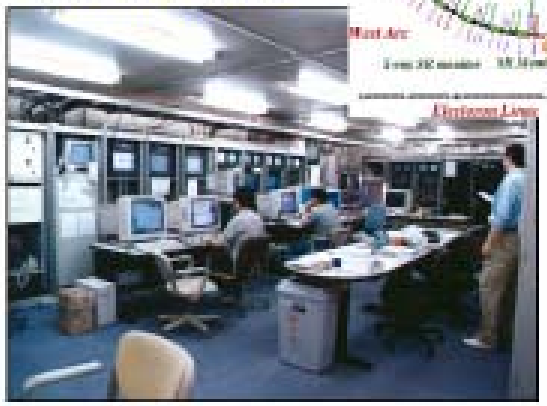
ILC R&D KEK ATF → ATF2

Extraction Line

Damping Ring



Control Room



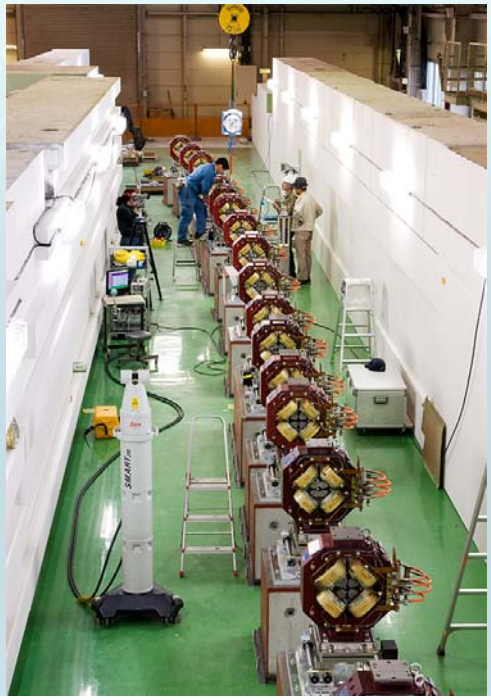
Linac

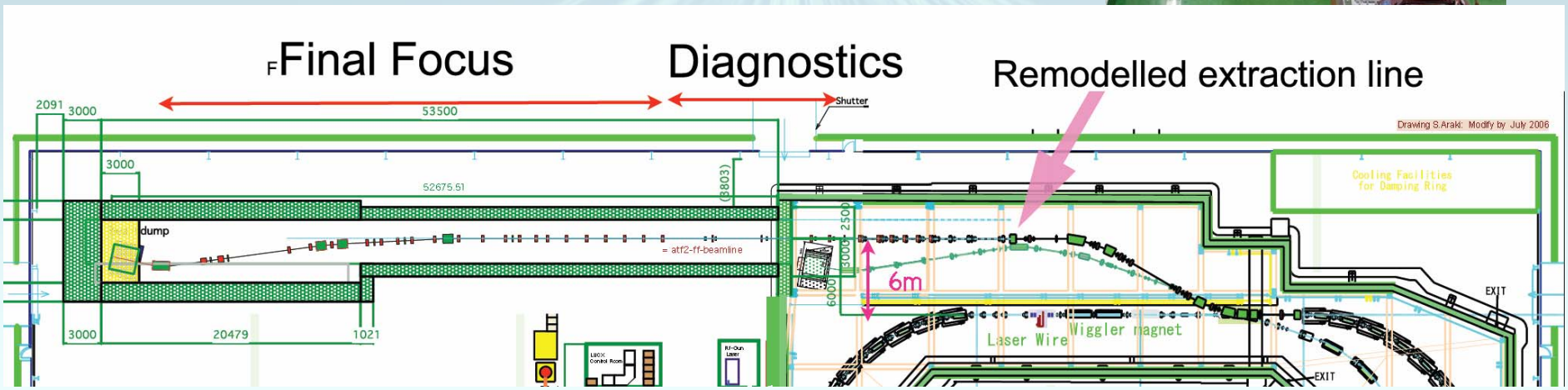
ILC-IHEP on ATF2

1) Hardware fabrication:
34 Q mangnets and 3 dipoles

2) Optics optimization in Collaboration with LAL:
Sha BAI, P. Bambamde, J. Gao

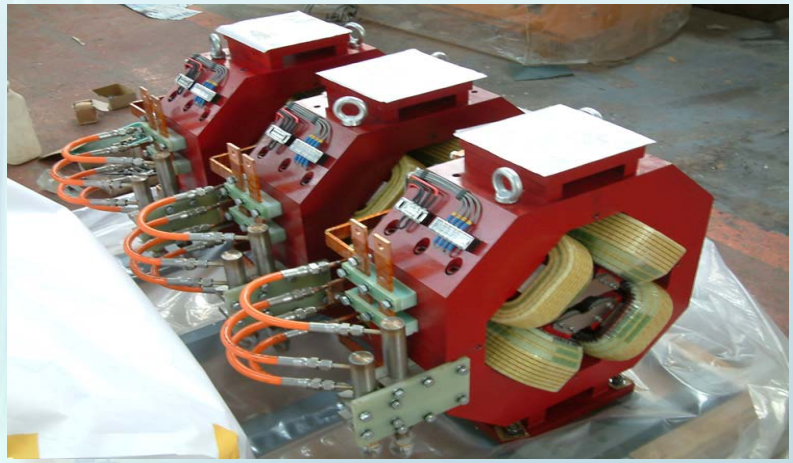
3) Particitating experiments:
Sha BAI

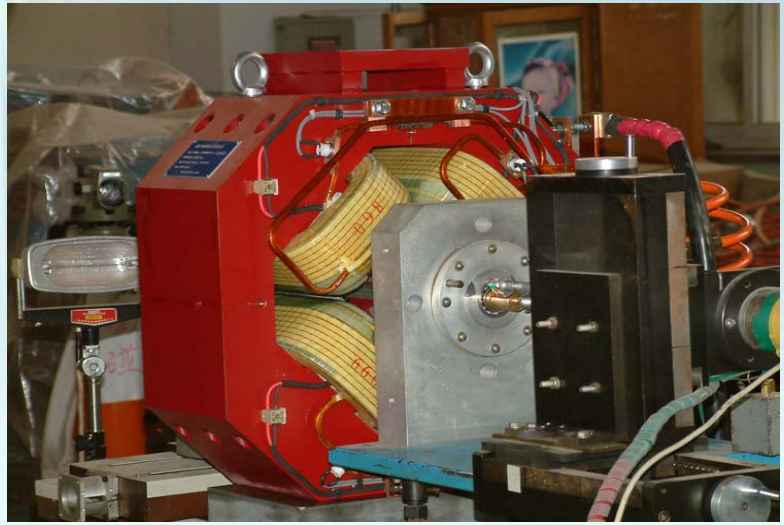




IHEP fabricated 34 Q magnetsfor ILC-ATF2,

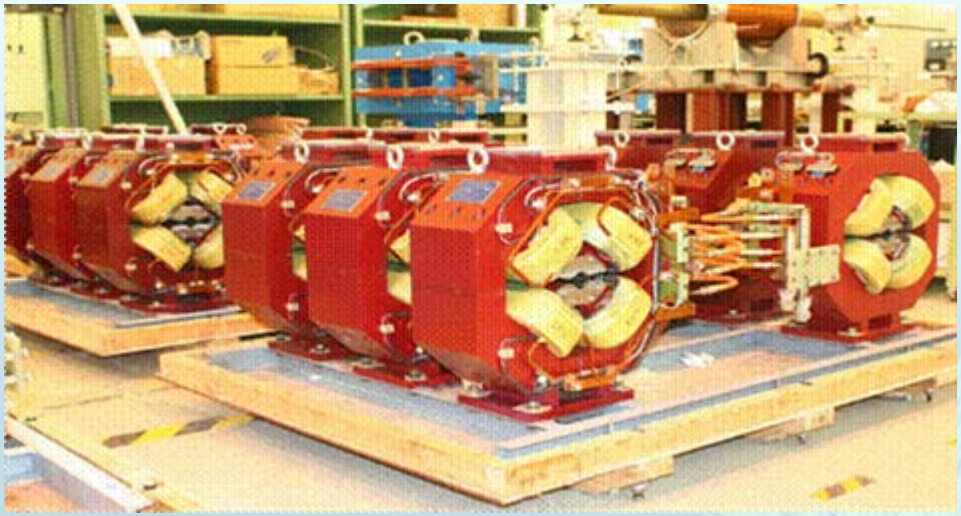
ATF2 dipole fabrication is underway at IHEP





Prof. C.T. Shi of IHEP-ILC Group and IHEP factory

ATF2 Construction



Q magnets arrived at KEK

3 Doples ready for delivery from IHEP to KEK

Jan.1.08

May.12.08

Jul.2.08

IHEP fabricated magnets

IHEP -LAL/Orsay-KEK Collaboration on ILC/ATF2 final focus theoretical research

Variable beam size at IP

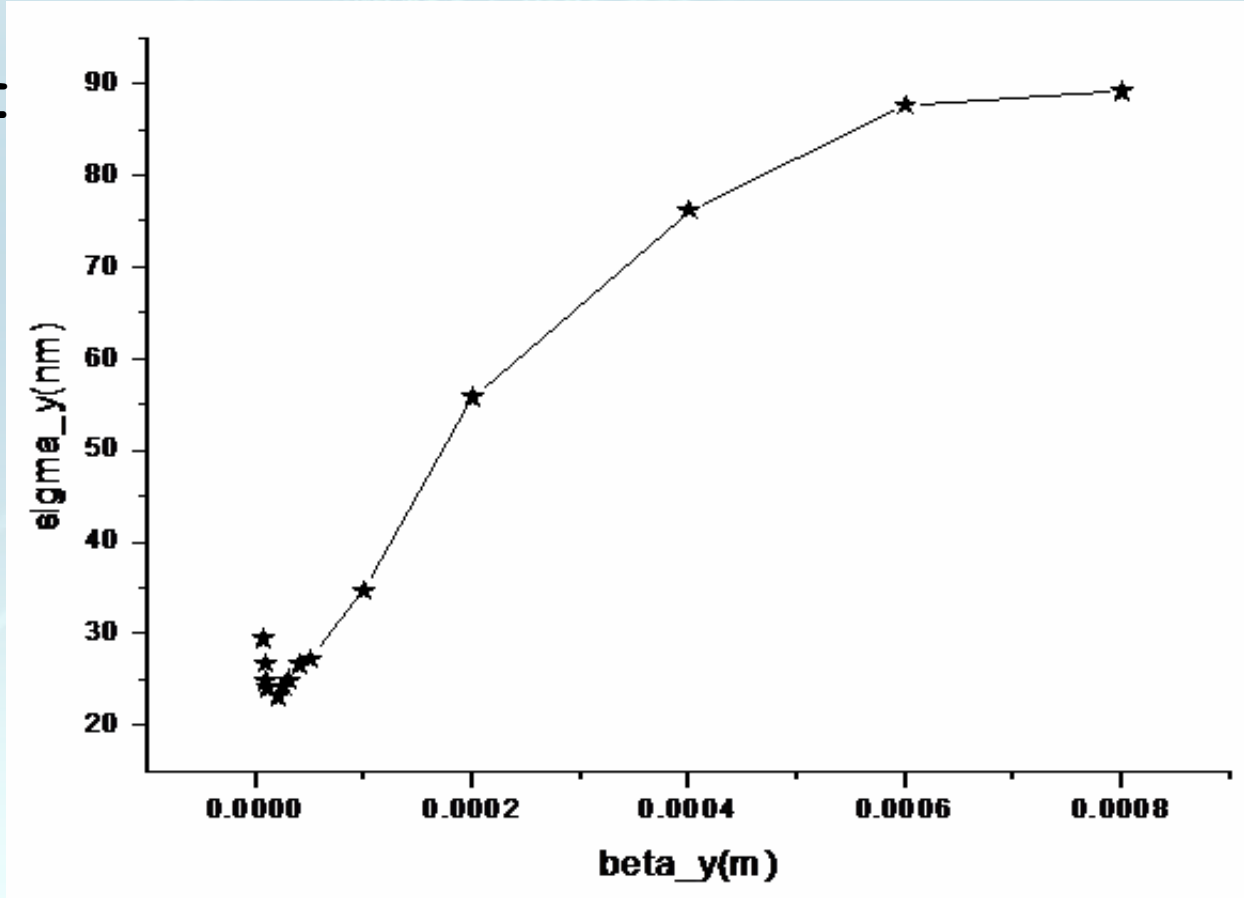
- Decrease β_{IP} to get the minimum σ_{IP} ~20nm, β_{IP} =3×10^{-5}m

Experimental Goal: Beamsize ~35nm (now down to 20nm)

Ph.D Student Sha BAI

J. Gao (IHEP)
P. Bamdabe (LAL)

S. BAI is visiting ATF2 at KEK on ATF2 Beam experiment From Jan.-June 2009



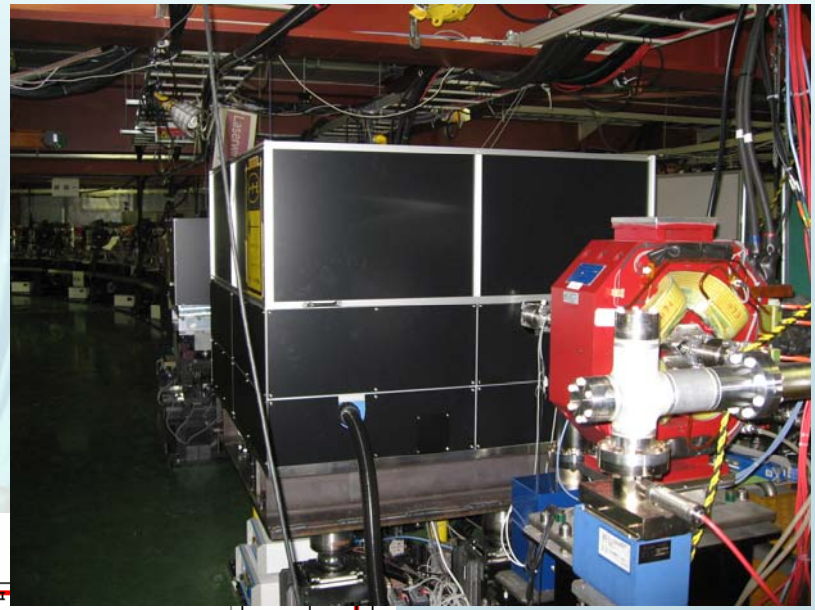
First ATF2 experimental result

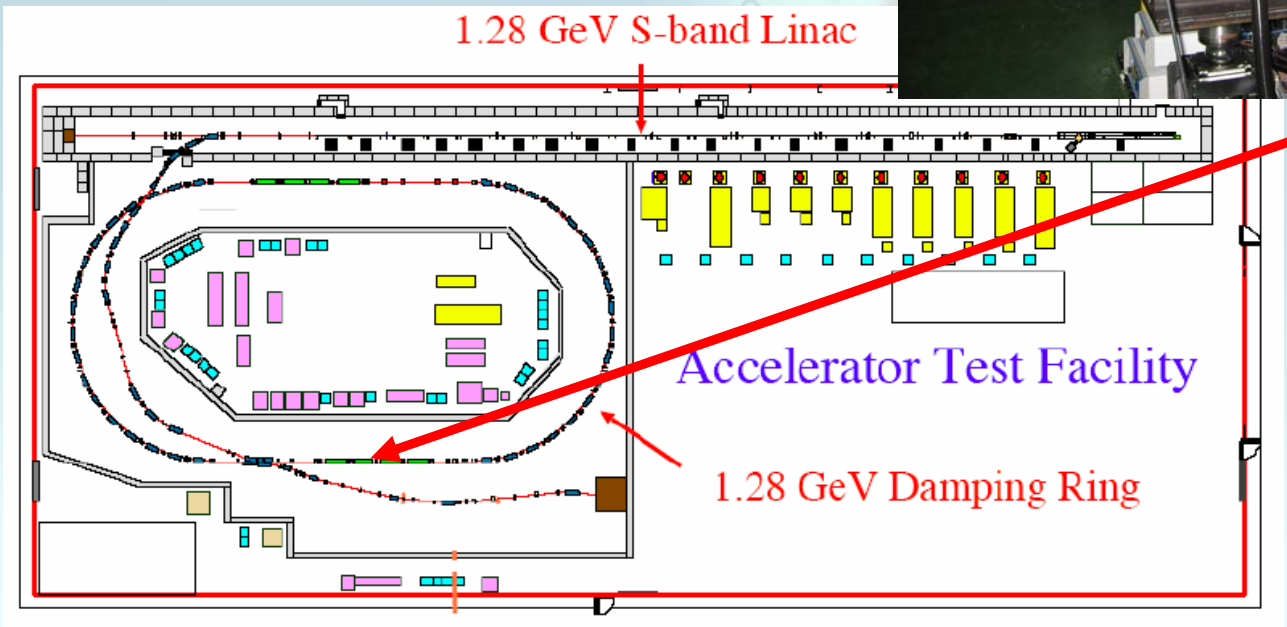
ILC effort on positron source

Experimental set-up at KEK-ATF

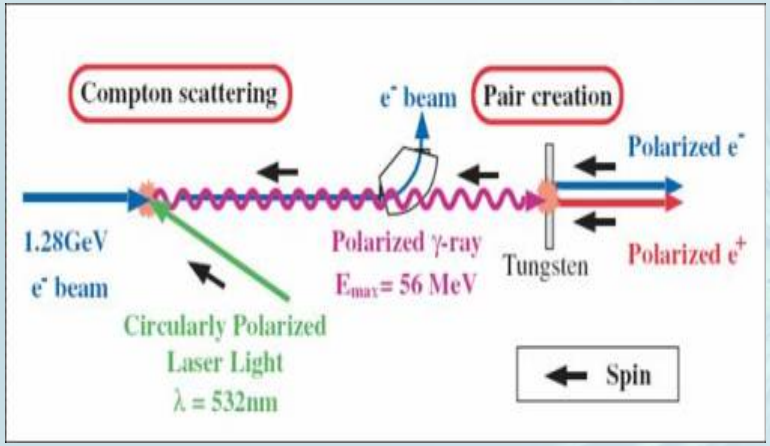
10W-1064nm polarized laser stored in the optical cavity

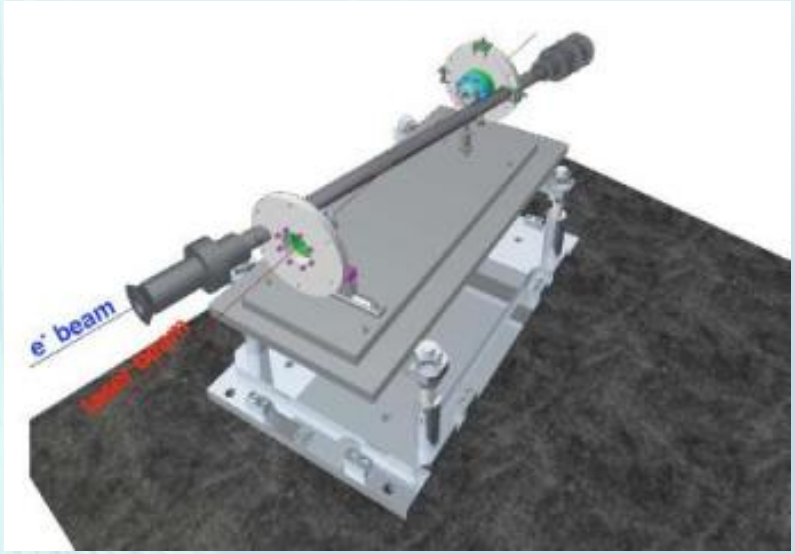
interacts with 1.28Gev electron beam to produce polarized Gamma ray.





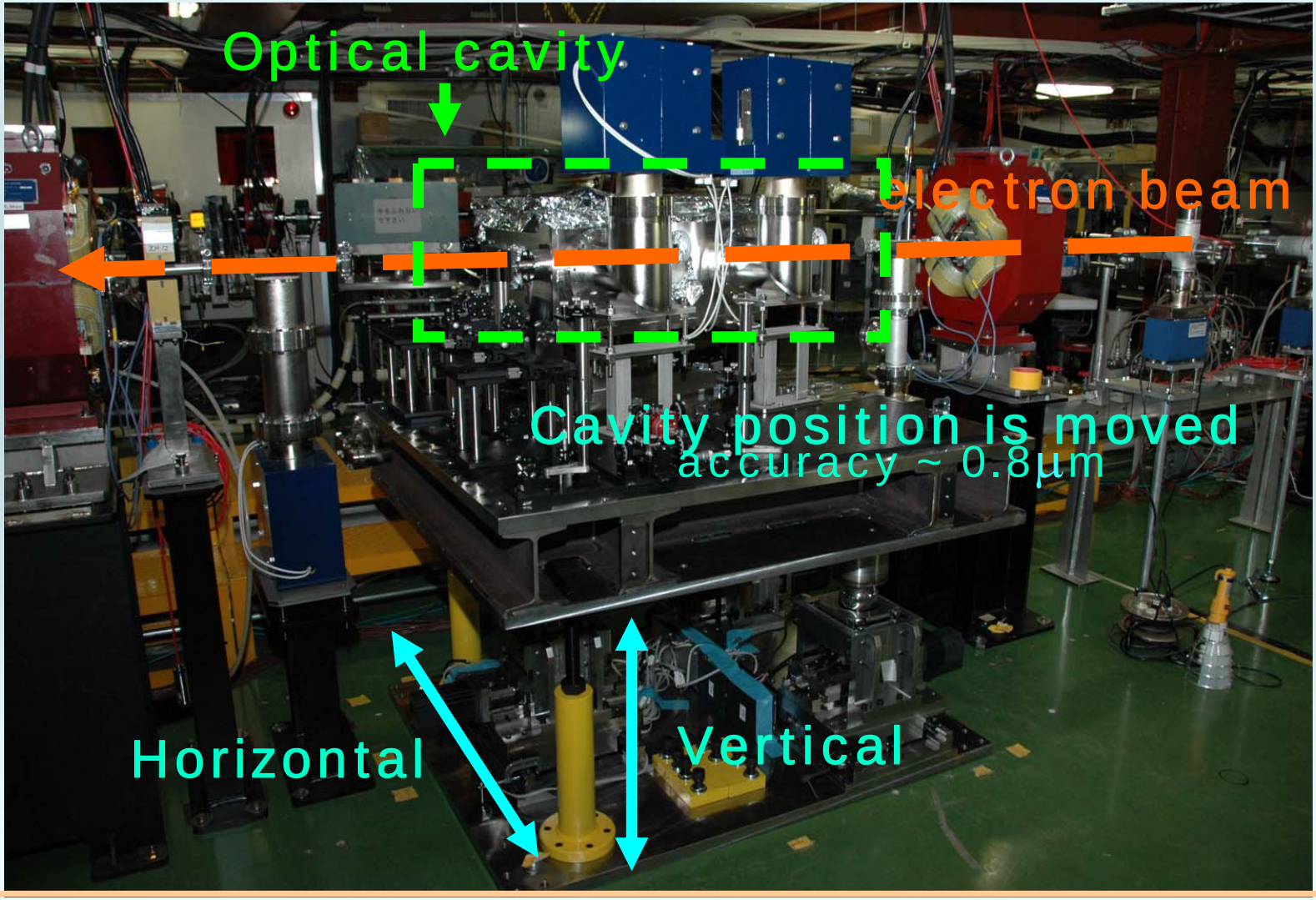
IHEP-ILC Group Collaborate with KEK on Positron Source Studies at ATF



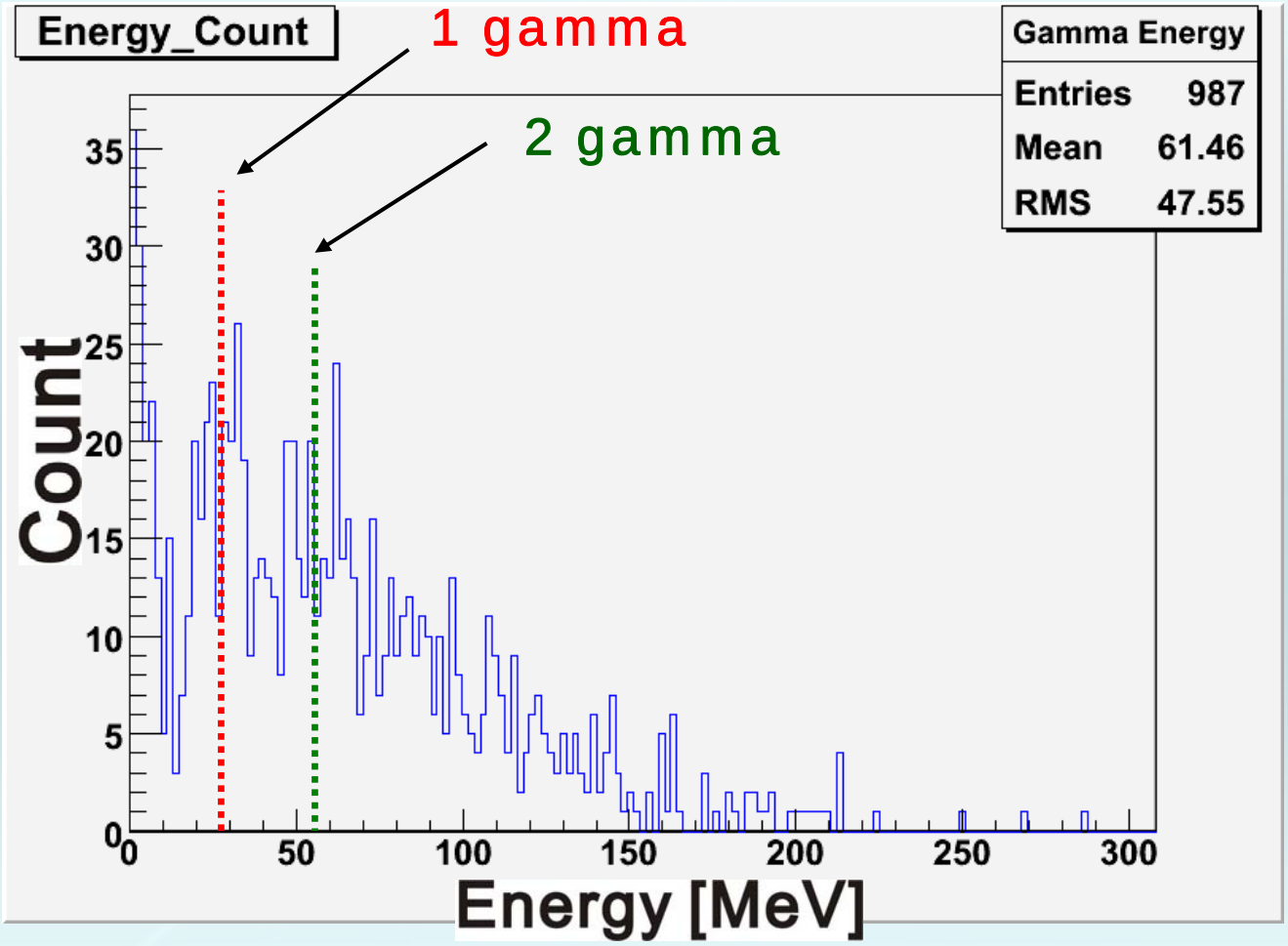


IHEP-ILC member X.P. Li and G.X. Pei collaborate with Omori

Experiment set-up at KEK ATF



Priliminary experimental results

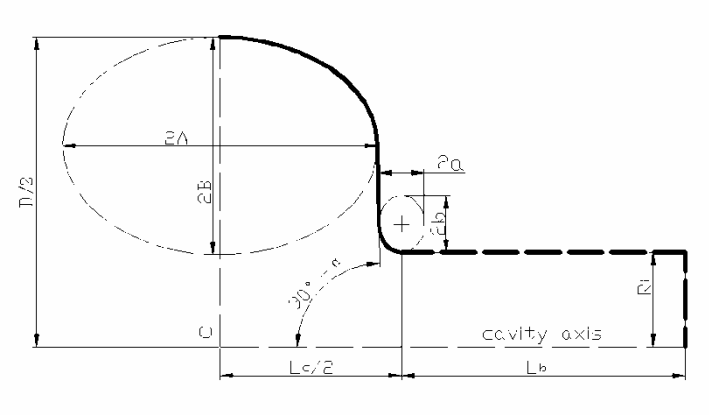


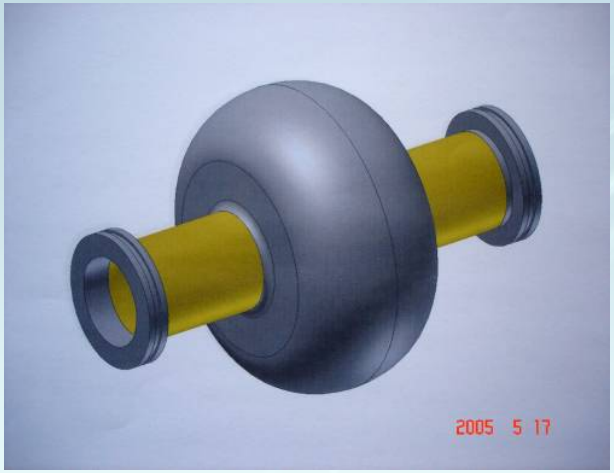
探测器探测到的**Gamma**光子束能谱

Measured Gamma ray energy spectrum

ILC effort on SC technology

Low loss type cavity design





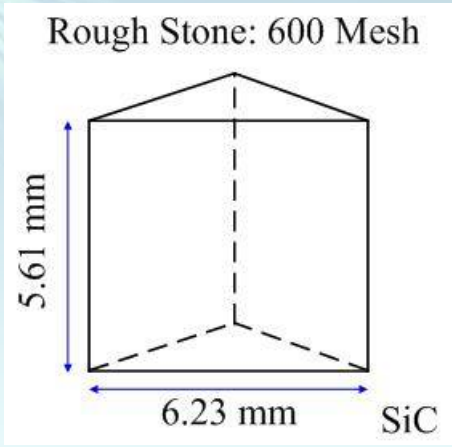
1.3GHz单cell高梯度低损耗超导腔	π模式无束管	0模式带束管
相速度β	1	1
单元腔长L_c (mm)	115.38	115.38
腔壁倾斜角（°）	1	1
颈孔半径R_i (mm)	30	30
腔直径D (mm)	196.66	196.66
腔颈椭圆短半轴a (mm)	7.25	7.25
腔颈椭圆长半轴b (mm)	9.05	9.05
腔顶椭圆长半轴A (mm)	50.00	50.00
腔顶椭圆短半轴B (mm)	34.50	34.50
束管长（mm）	-	100
频率f_0 （MHz）	1300	1289.34
$G=R_s*Q$ (Ohm)	285	283
R/Q (Ohm)	133.1	138.2
E_p/E_{acc}	2.3	2.1
H_p/E_{acc} (Oe/(MV/m))	36.06	35.46
耦合系数K_{cc}（%）	1.54	-

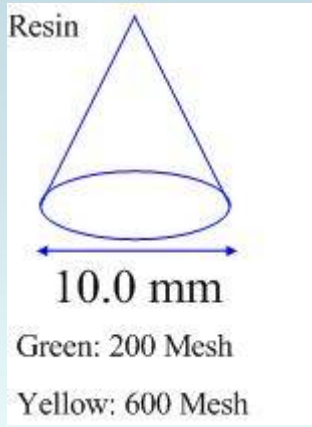
IHEP fabricated 6 single cavities

Two large grain cavities

IHEP made Saito-type CBP

IHEP made Saito Type CBP）





CBP processing

before

after 100 μ m removed









EBW – CBP (150) – Vertical CP (50) – Horizontal CP (40) – Anealing (3 hrs*750 °C)

Horizontal CP (10) – HPR(2 hrs) – Baking (48 hrs *120 °C) – Vertical test

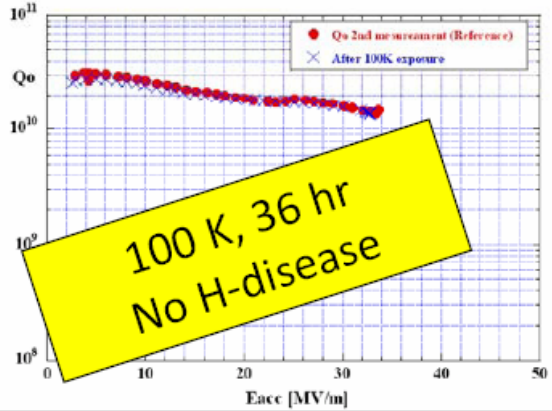






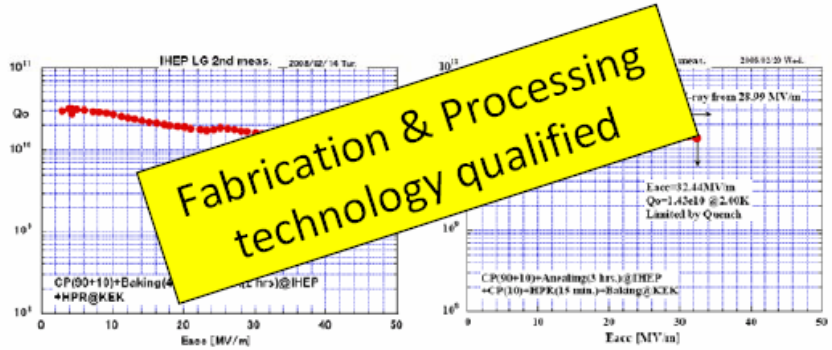
1-2. Hydrogen Q-disease check

Following the IHEP LG#2 2nd test, the cavity was exposed 100K for 36 hr to see hydrogen Q-disease.
No hydrogen Q-disease was found.
China cavity processing has been qualified from point of view hydrogen Q-disease.



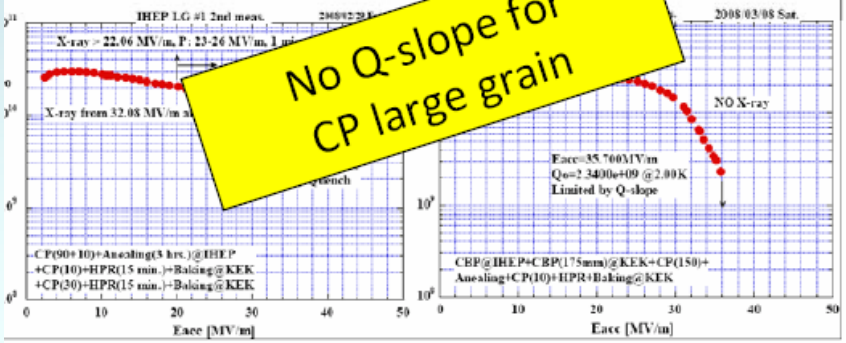
1-3. Qualification of China Processing technology (CBP+AN+BCP+Baking)

To qualify China cavity processing (CBP+Annealing+BCP+Baking), IHEP LG#1 cavity was tested, which was fabricated and made CBP+Annealing in IHEP side. The cavity was taken BCP 10μm + HPR(15min) + Baking(48hr) at KEK. The cavity test result was compared with IHEP LG#1 result (2nd measurement). Both showed very similar result.
Thus China cavity processing technology has been successfully qualified.



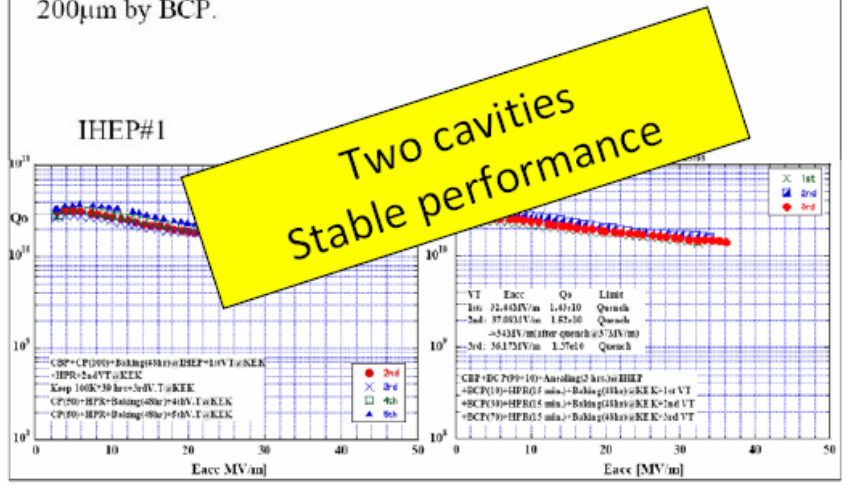
Comparison between NingXia large grain and fine grain cavities

IHEP#3 has achieved 35.7MV/m but heavy Q-slope appeared even after baking (120°C 48hr).
Q-slope in chemical polished cavity is not always removed by baking. It will be recovered by EP+ Baking. Unfortunately his schedule is too tight to confirm it.



3. Effort for high gradient on Large grain cavity by BCP

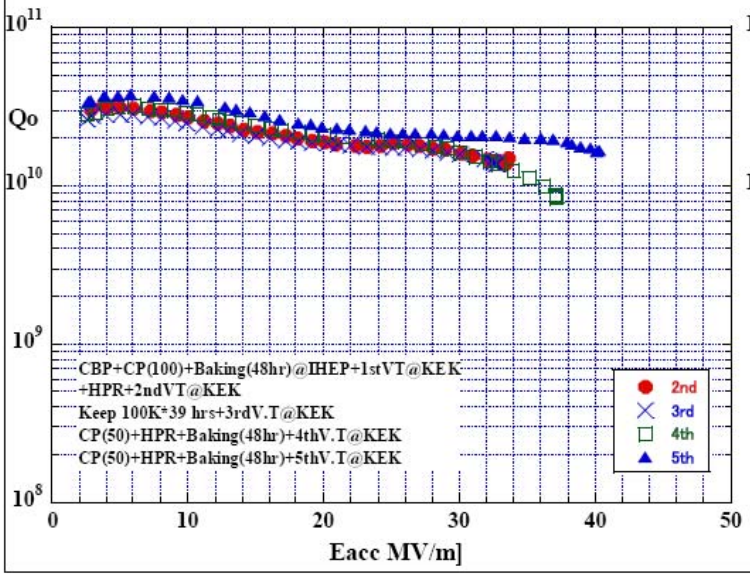
High gradient study was made using IHEP LG#1 and #2.
#2 cavity has achieved Eacc 40MV/m after total material removal of 200μm by BCP.



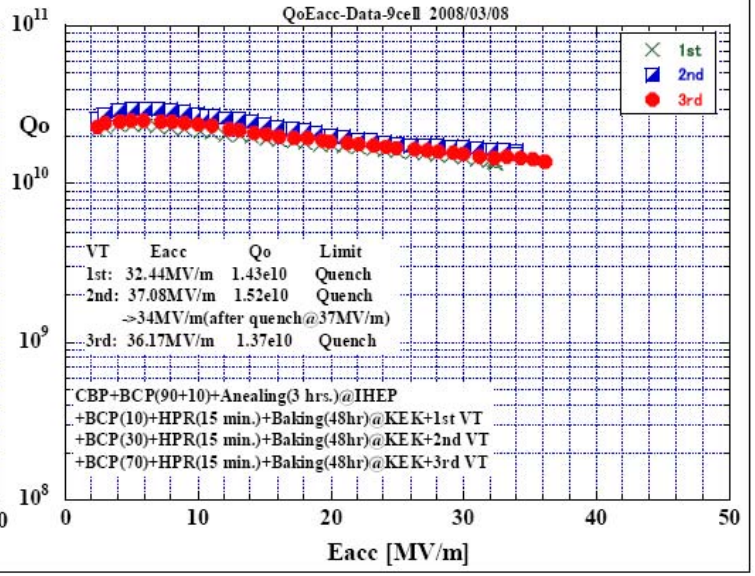
3. Effort for high gradient on Large grain cavity by BCP

Maximum accelerating field **40 MV / m is reached without using EP**

IHEP#1



IHEP#2



Surface treatment is done at IHEP and final measurement is done at KEK (Saito's test stand)

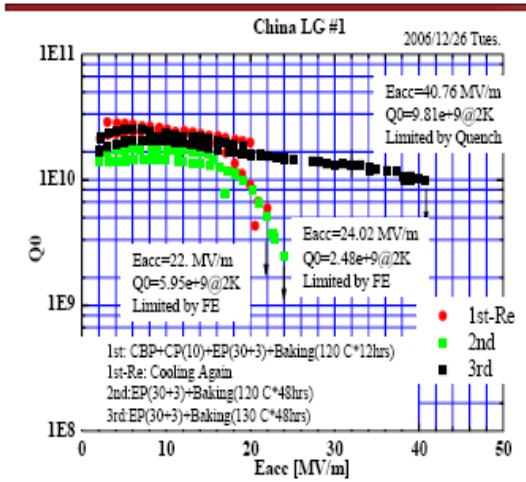
2006 KEK-IHEP made 3 LLSC with Ning Xia large grain material at KEK

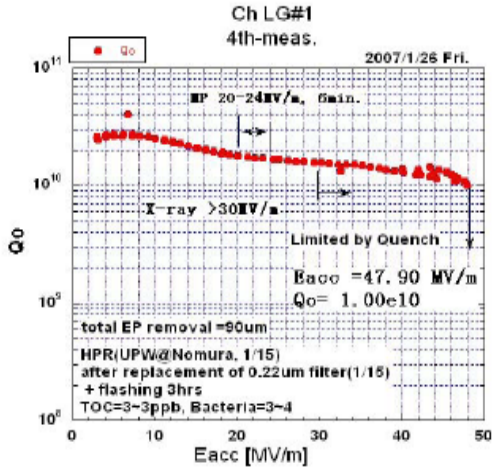
With EP, Emax=**48 MV / m**。

This is first time KEK use large grain Nb, and this experience leads Saito's Explore large grain 9 cell LLSC.

J.Y. Zhai worked at KEK on KEK Large grain 9 cell LLSC.

Results of Cryogenic Vertical Tests- China LG #1





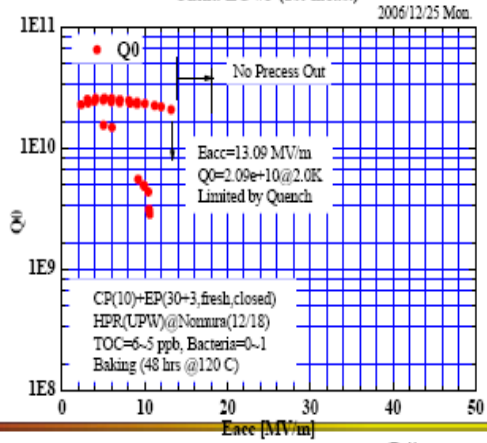
1.China LG #1 would be removed 30 micron per step by EP and the relationship of Eacc,max and thickness removed by EP was expected to achieve by serials of tests.

2.In the first two test, FE was very strong with large X-ray and limited maximum Eacc.

3.In the third test, the gradient once reached to 40.76 MV/m and the quality factor is almost 1.0 E+10.

4.For the 2nd and 3rd test, the cavity has been baked for 48 hours and no evidence of a strong degradation of the quality factor is seen in these tests.

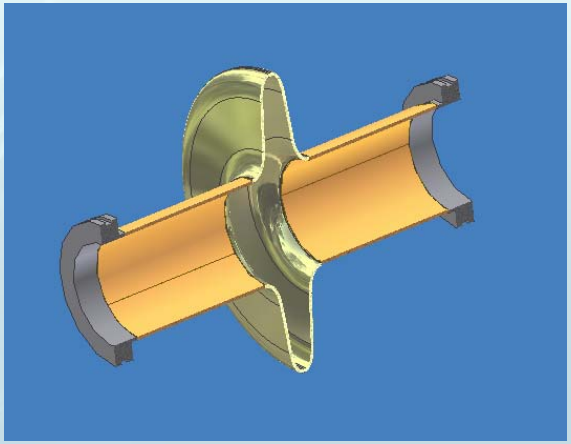
5.China LG #3 was tested vertically only once. In the test, FE is very strong and the cavity is limited by quench. The roughness of the inner surface is very large without CBP. More EP and vertical tests would be continued.



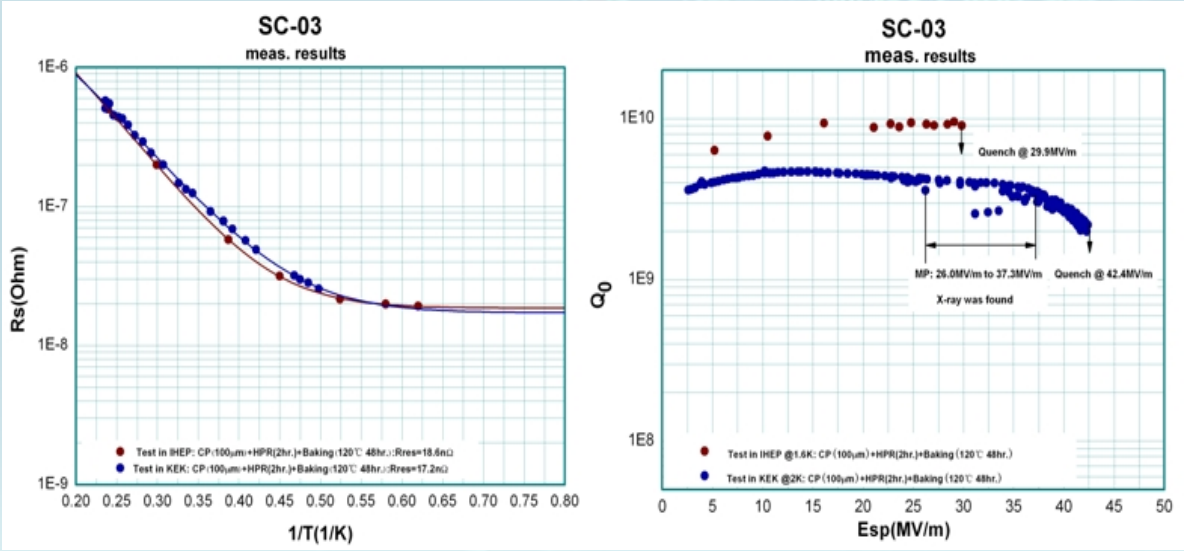
Chinese Large Grain LLSC Cavity at KEK

IHEP 1.3 GHZ Medium β SC Cavity measured at KEK (Ge Ming Qi)

1.3GHz/β=0.45 SC Cavity Maximum Surface Electric Field: Esp=42.4MV/m

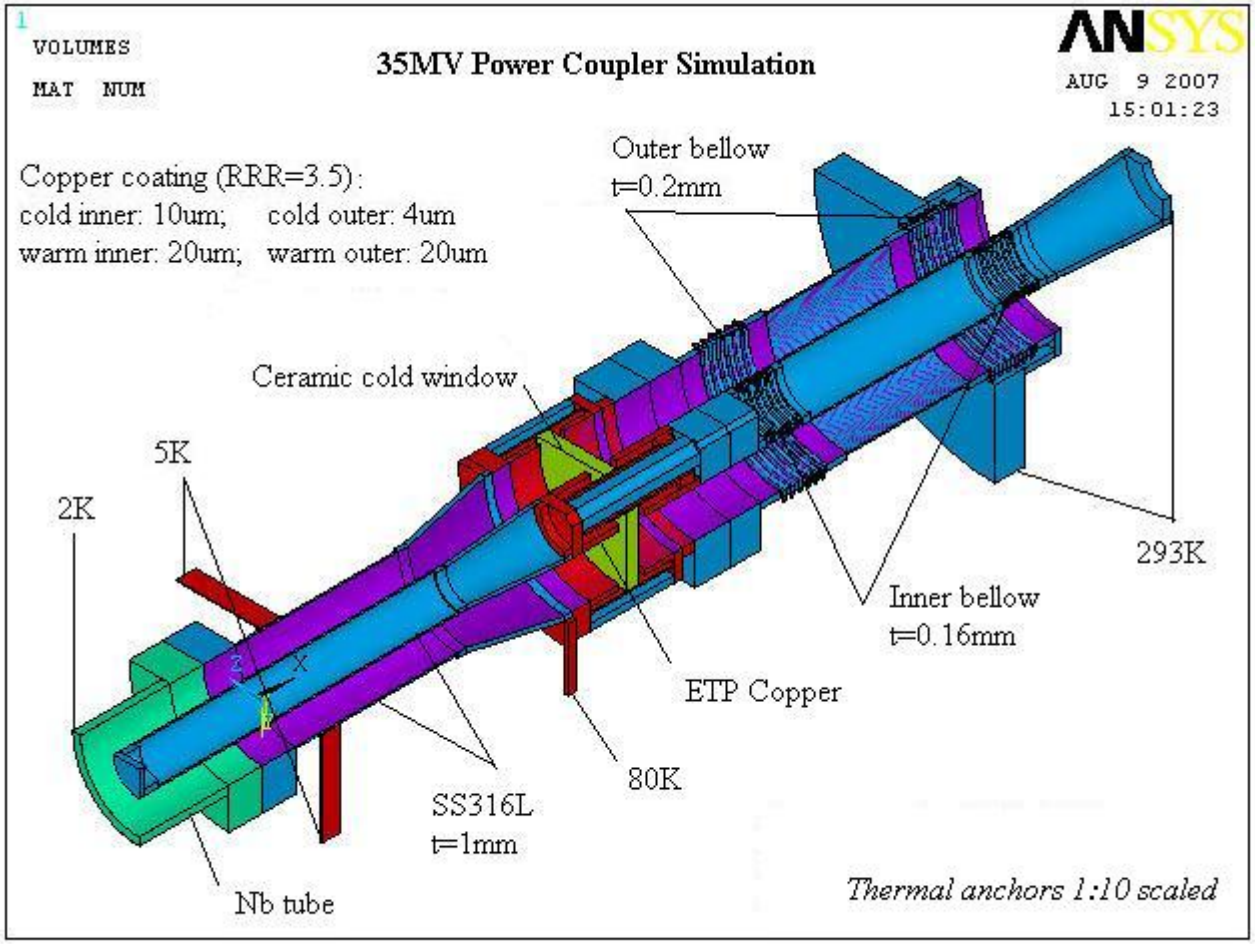


1.3GHz/β=0.45



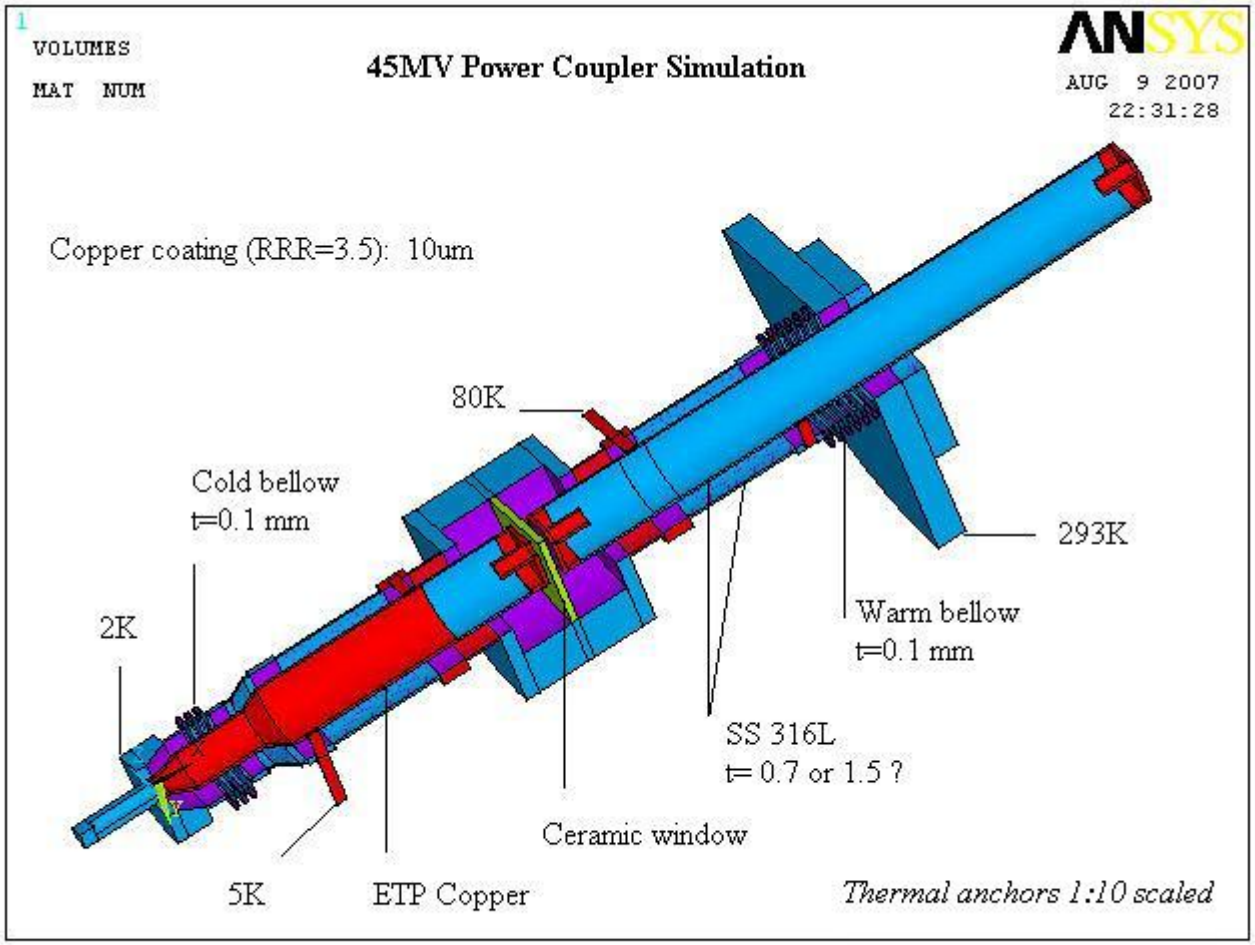
IHEP-ILC Group Contributes KEK High Power Coupler Simulations at KEK (Q.J. Xu)

35MV Power Coupler Simulation



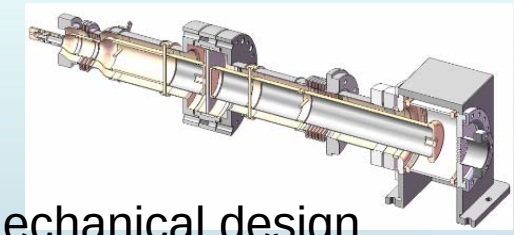
Simulation model of the 35MV power coupler

45MV Power Coupler Simulation

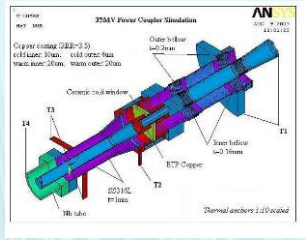


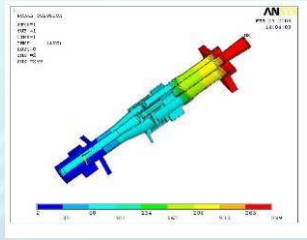
Simulation model of the 45MV power coupler

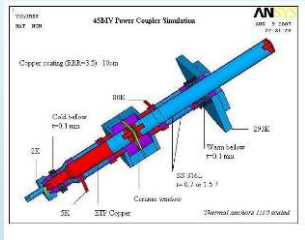
IHEP-ILC Group Contributes KEK High Power Coupler Simulations (Q.J. Xu, J.Y. Zhai and T.X. Zhao)



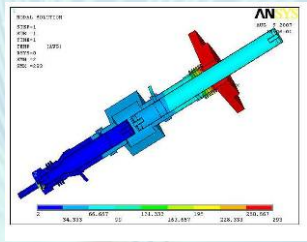
Mechanical design

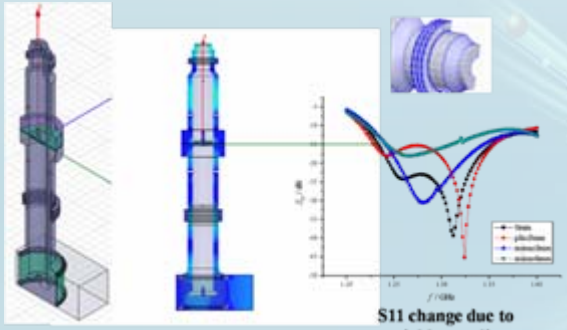




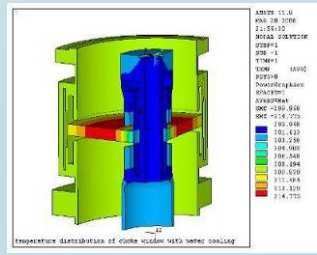


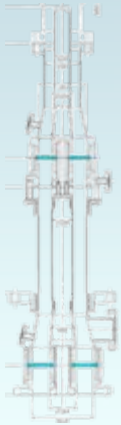
Heat load simulation

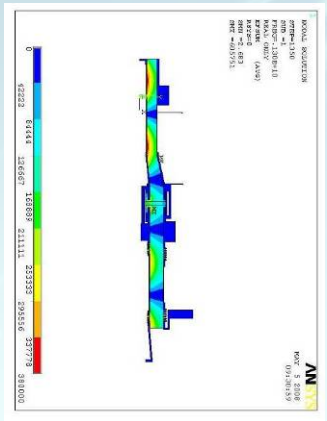


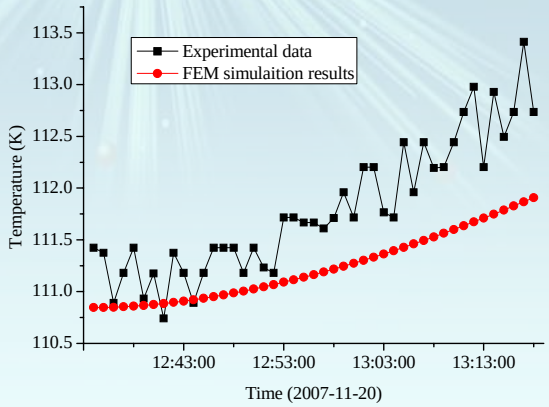


RF calculation









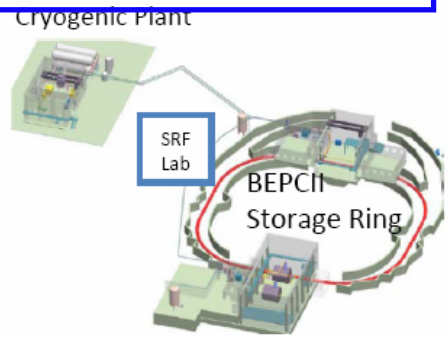
KEK coupler dynamic heat load simulation is similar to experimental measurement result.

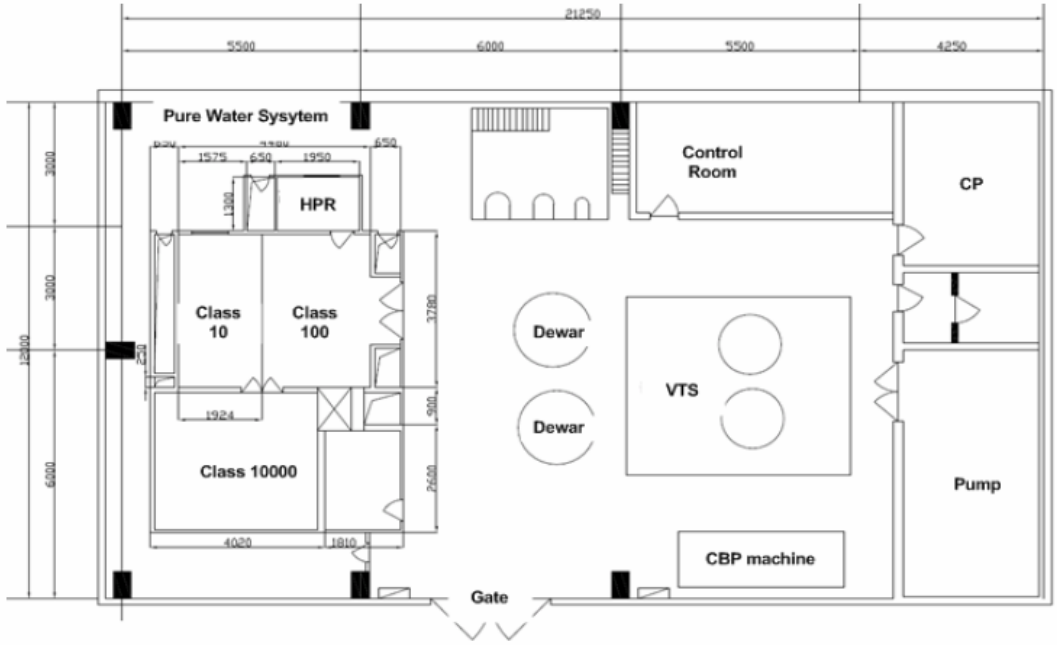
BEPCII coupler tested at KEK 270 kW

IHEP SCRF Lab and Facilities

Superconducting Accelerating Unit Project:
– two low loss type 9 - cell cavities using large grain niobium from Ningxia, China
– one bare tube (2009), one with full end group (2009-2010)

- 230 m^2 SRF Lab, initially for high current proton linac cavity research and BEPCII spare cavity
- Civil construction, infrastructures and current facilities: 2002-2004





10MΩ-cm water system 6m²

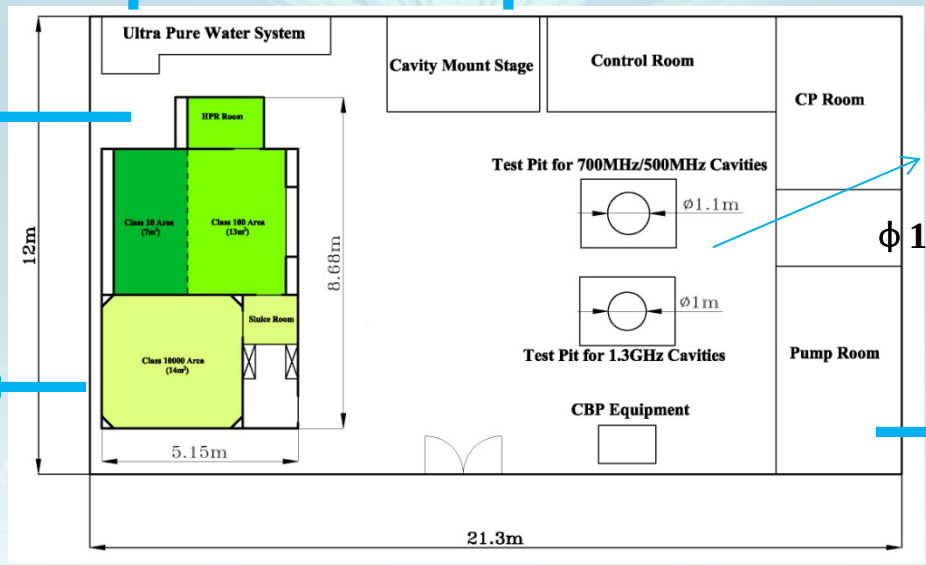
3 × 4.4 × 5.2m Mounting Stage

LLRF Control 15m²

BCP 8m²

ϕ 1.1m Depth6m/ ϕ 1m Depth 6m

Class 100 Area HPR 2.7m²



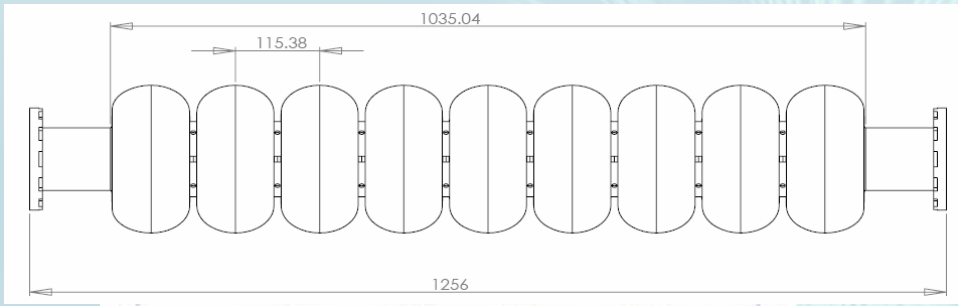
Clean Room 40m²

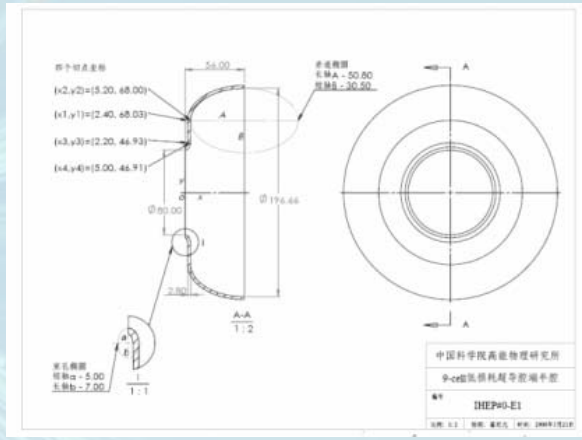
230 m² SRF Lab

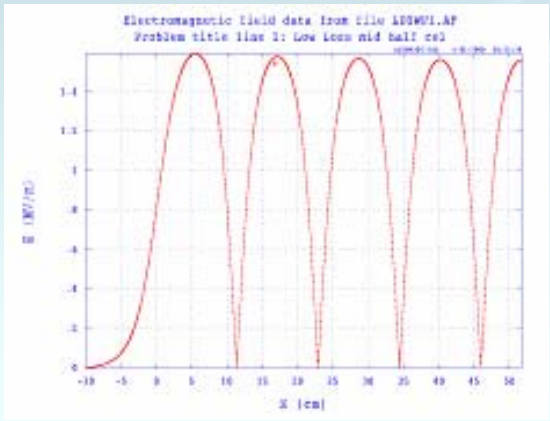
Pumps 18m²

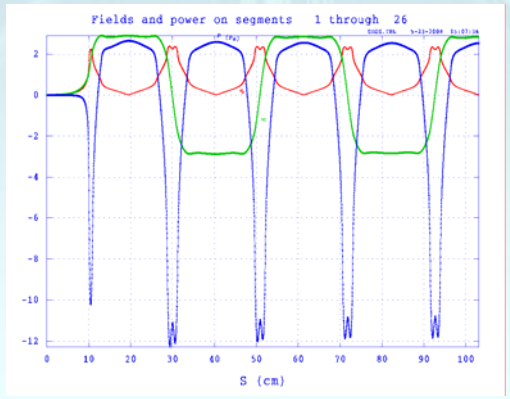
IEHP SC Lab obtained many helps from K. Saito's suggestions

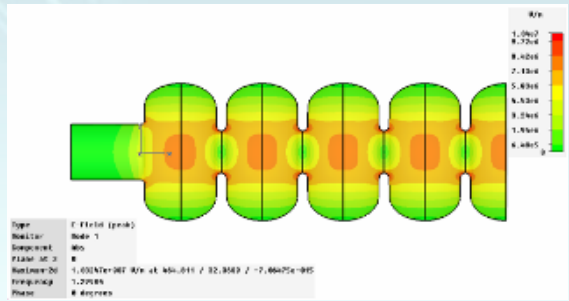
IHEP Started 1.3GHz 9 – cell cavity fabrication



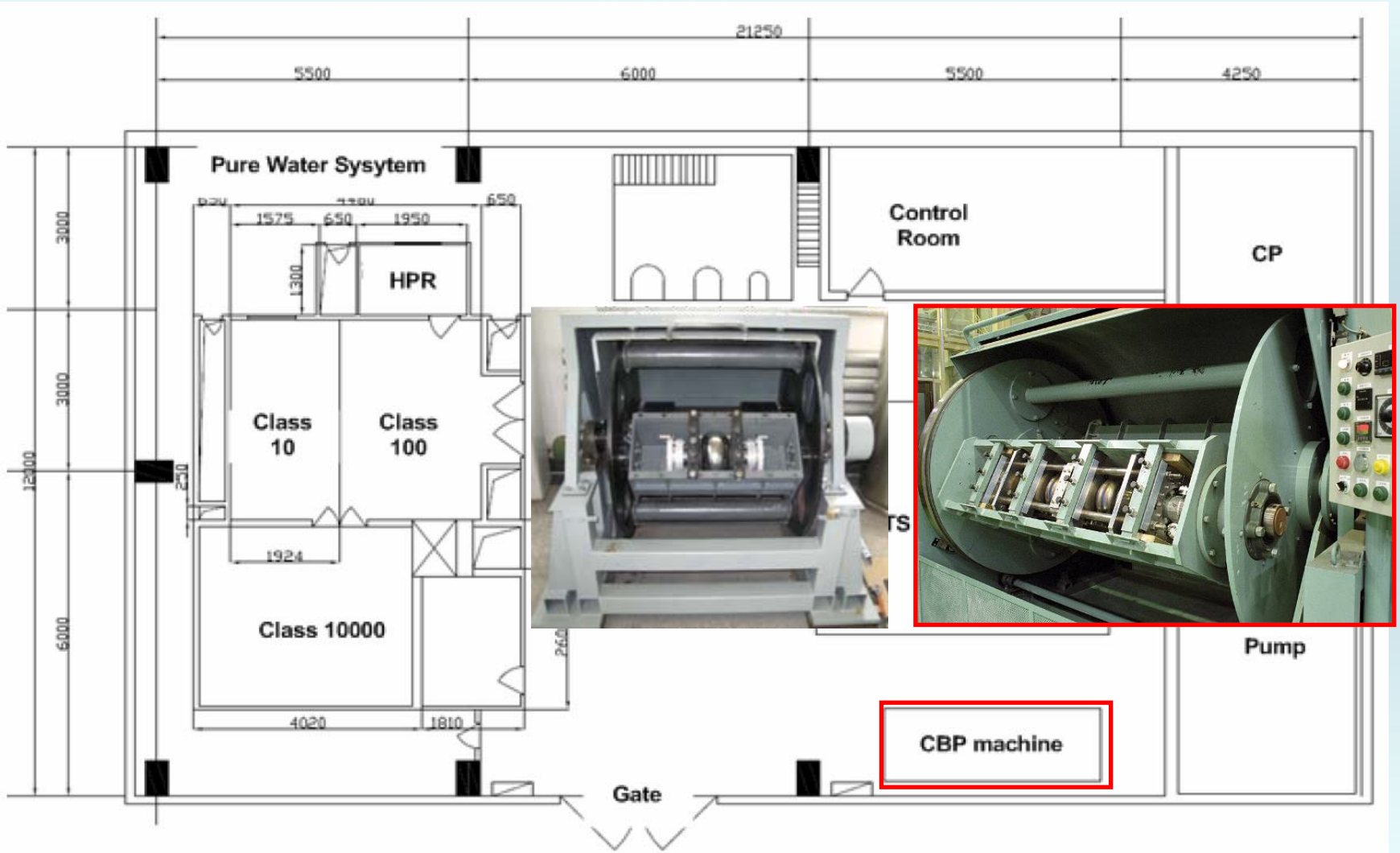






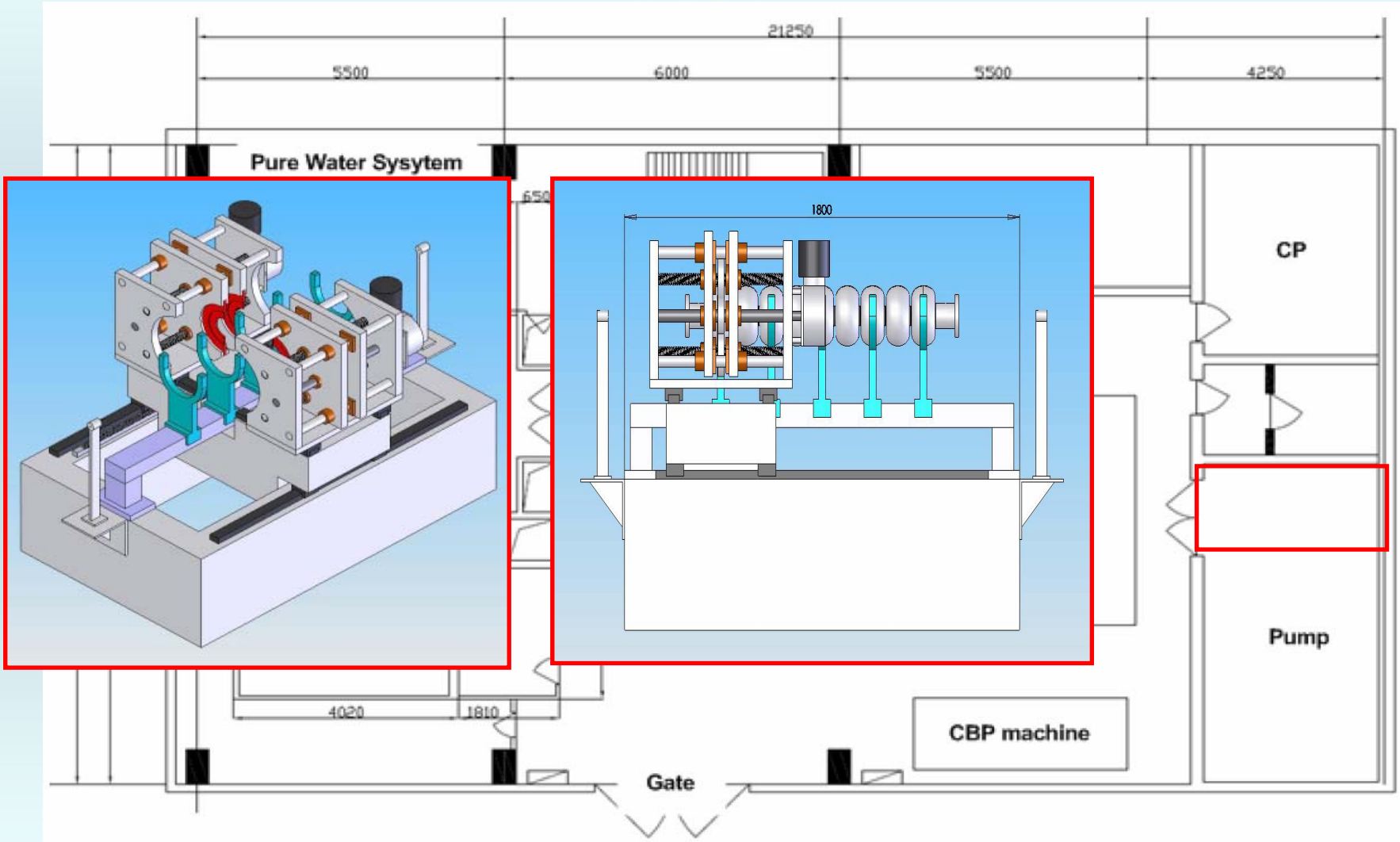


New CP machine for 9 – cell cavity with Saito design as reference



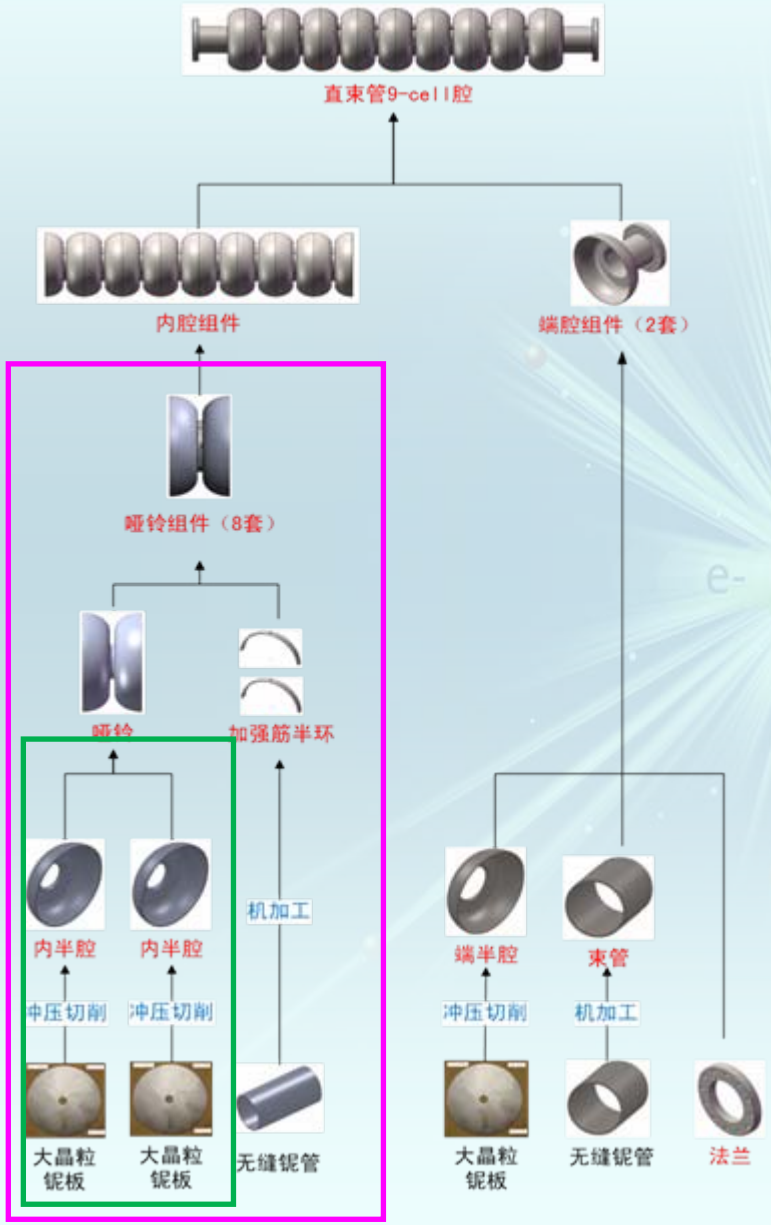
SCRF Lab

Pretuning Machine for 9 – cell cavity with KEK design as reference



SCRF Lab

Bare Tube 9-Cell Cavity Fabrication



1. Buffered chemical polishing of niobium sheet
2. Niobium sheet annealing
3. Ultrasonic Niobium sheet Check
4. Deep-draw of four test niobium mid cup
5. Cleaning (by ultra sonic [us] cleaning +rinsing)
6. Trimming of iris region
7. Cleaning
8. Mechanical measurement

Done for four test mid cups

9. Rf measurement of cups

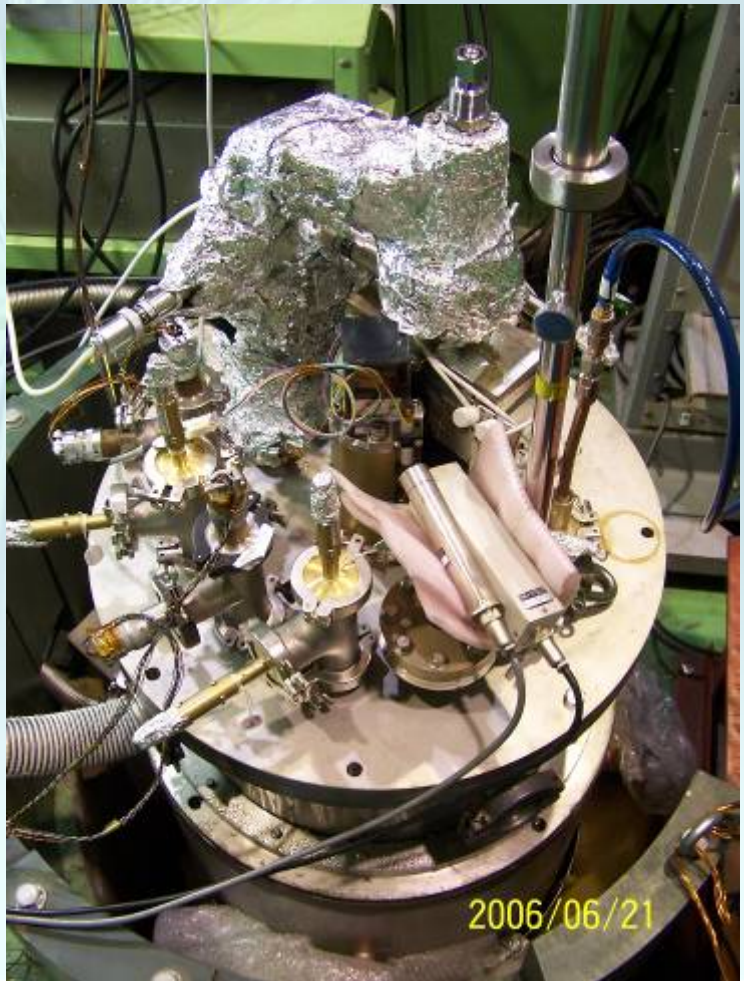
10. Buffered chemical polishing +
11. Welding of Iris
12. Welding of stiffening rings
13. Mechanical measurement of dumb-bells
14. Reshaping of dumb bell if needed
15. Cleaning
16. Rf measurement of dumb-bell
17. Trimming of dumb-bells (Equator regions)
18. Cleaning
19. Intermediate chemical etching +Rinsing
20. Visual Inspection of the inner surface of the dumb-bell
21. local grinding if needed + (second chemical treatment + inspection)

Dumb-bell ready for cavity

IHEP-ILC group member participated KEK STF Tesla and LLSC type 9 cell SC cavity test

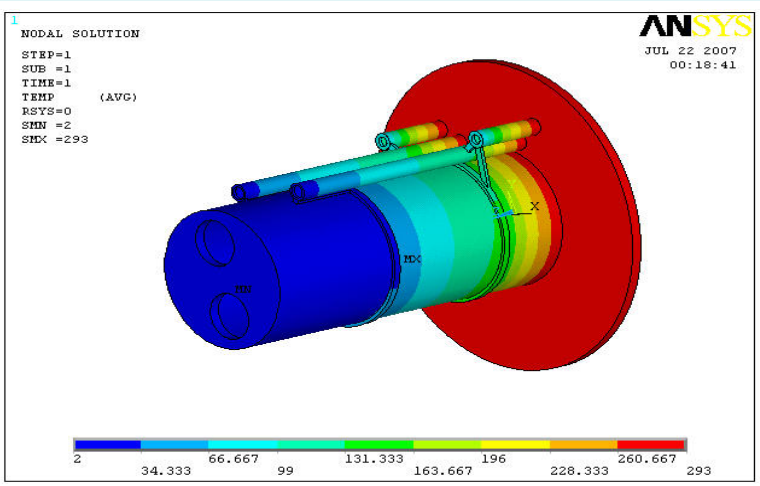
Q.J. Xun and T.X. Zhao worked in the group of Nauguchi On TESLA type 9cell

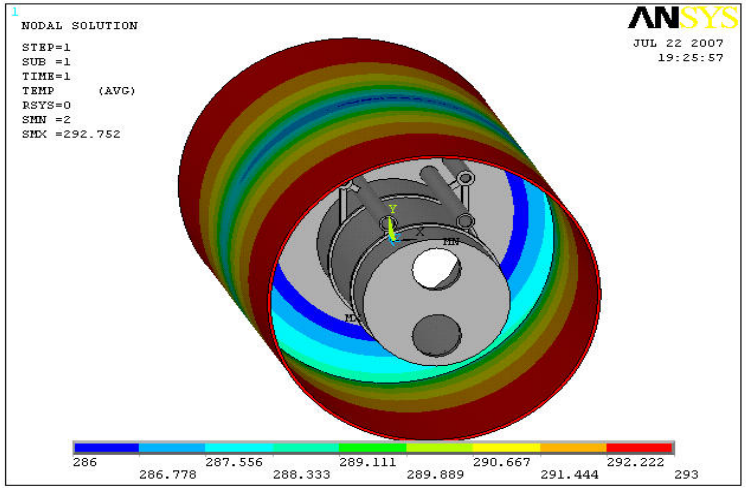
Ji Yuan Zhai worked in the group of K. Saito on LLSC 9cell both fine and large grain Nb

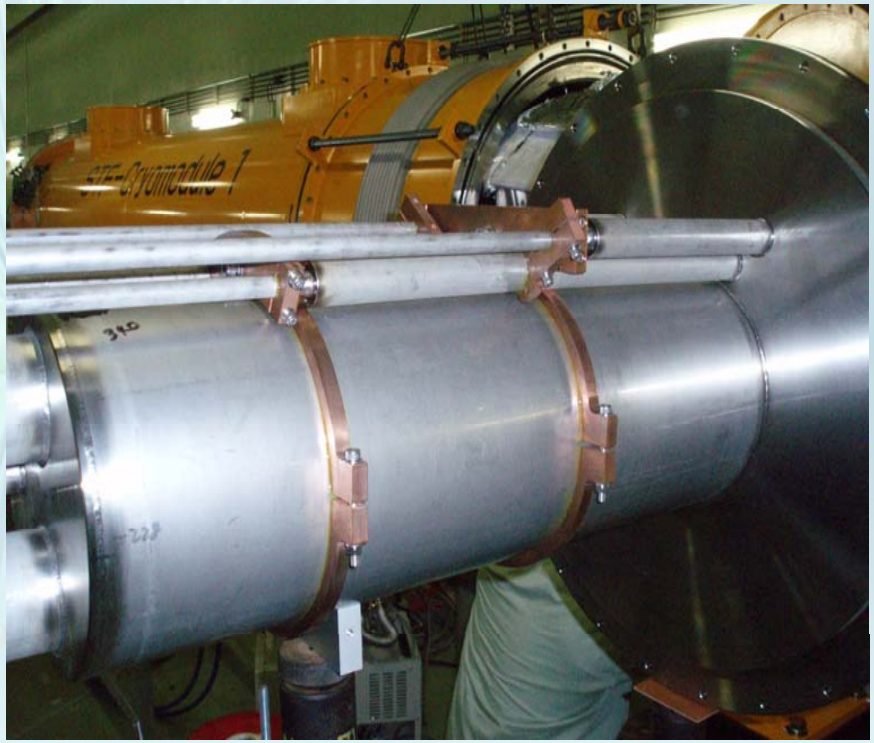


IHEP-ILC Group Collaborate with KEK

on STF Cryomodule Design



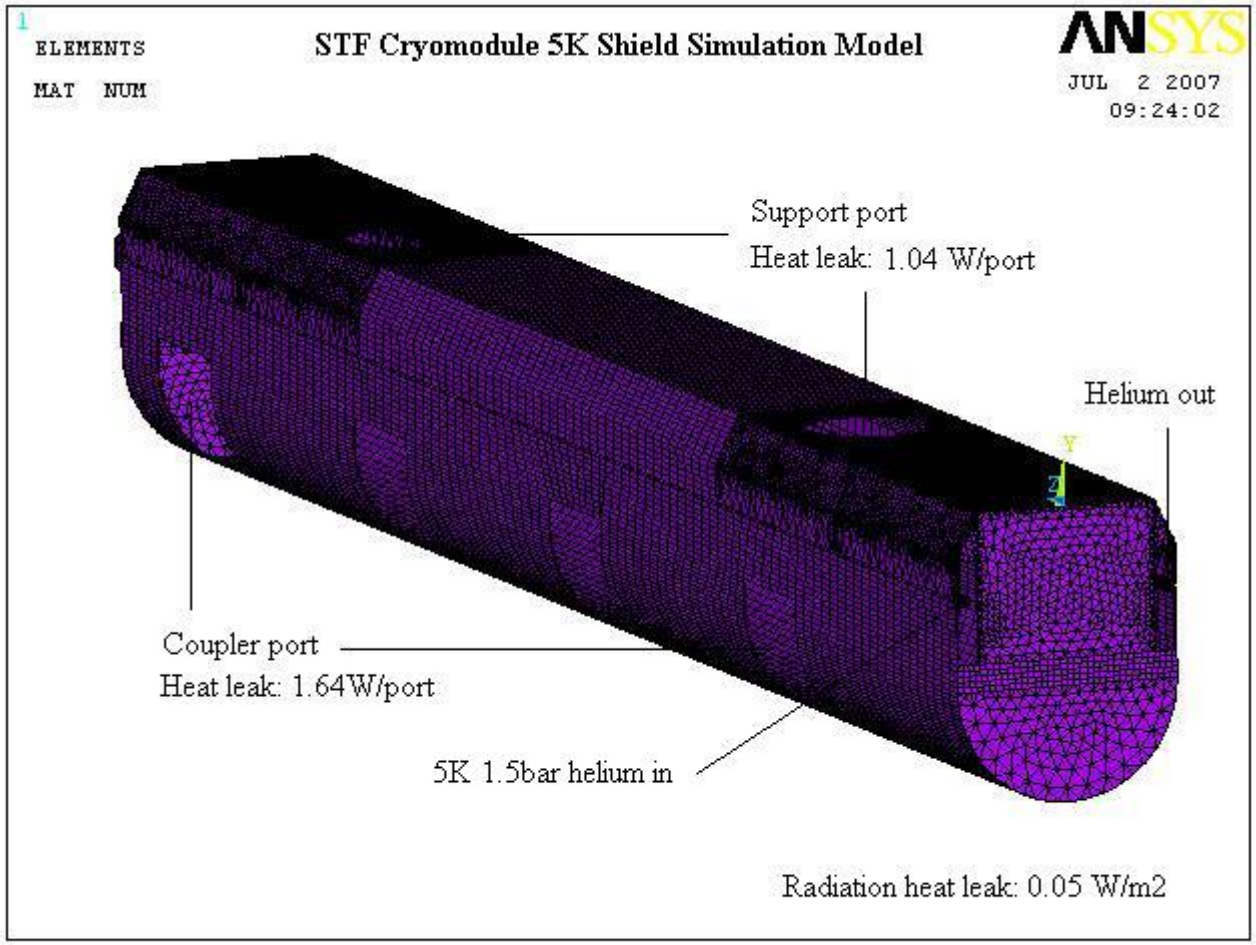




The vacuum barrier for STF cryomodule designed by Q.J. Xu of IHEP-ILC Group

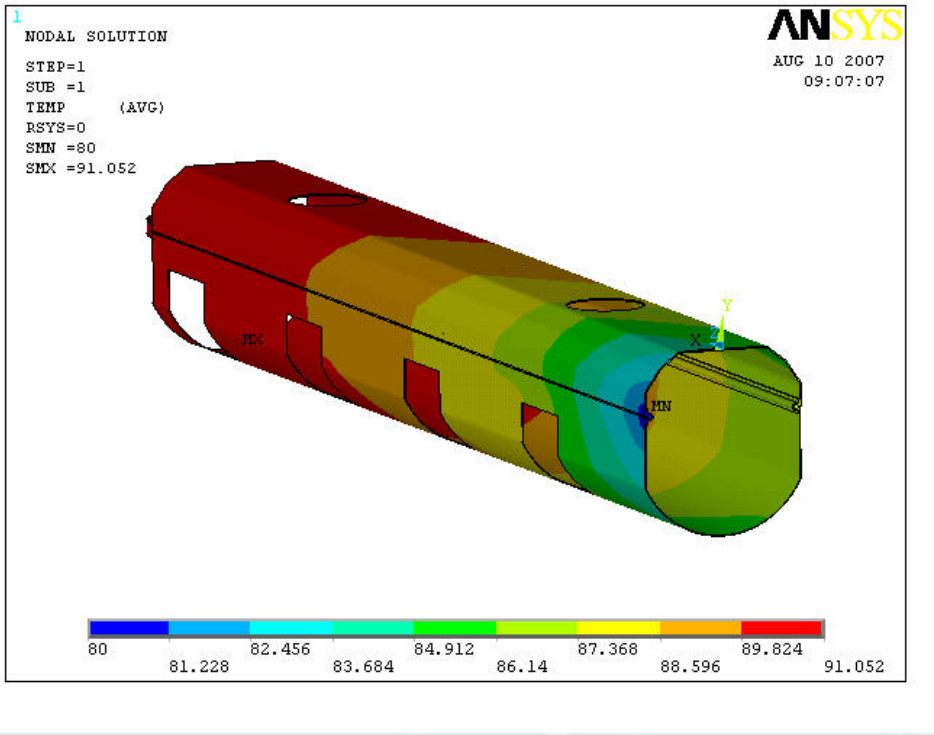
IHEP-ILC Group Contributes KEK STF Simulations (Q.J. Xu)

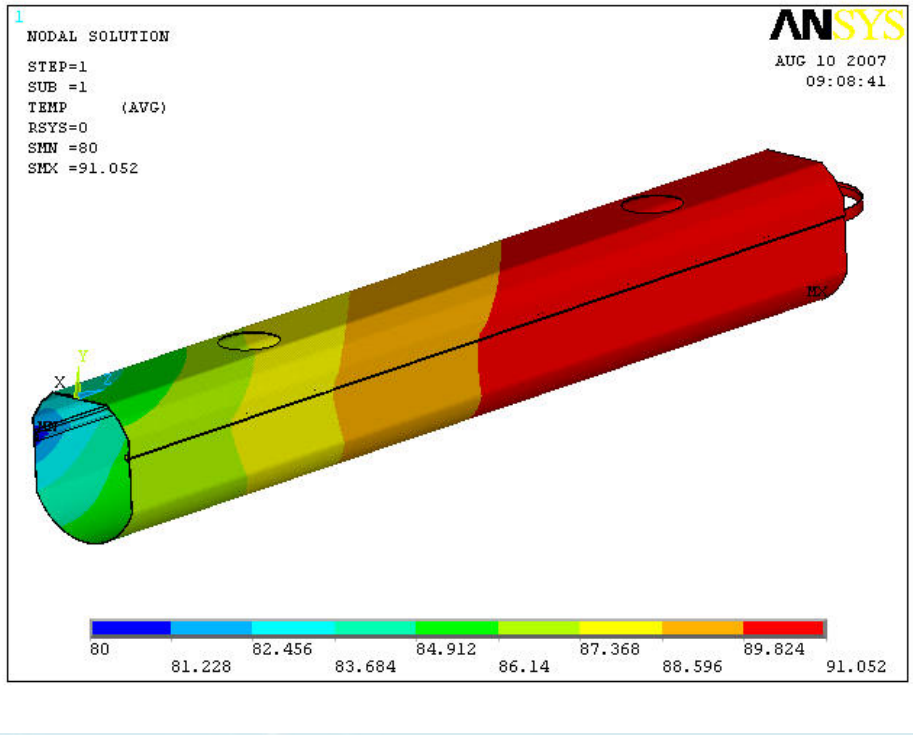
STF 5K shield simulation



Simulation model of the STF 5K shield

STF 80K shield simulation (Q.J. Xu)





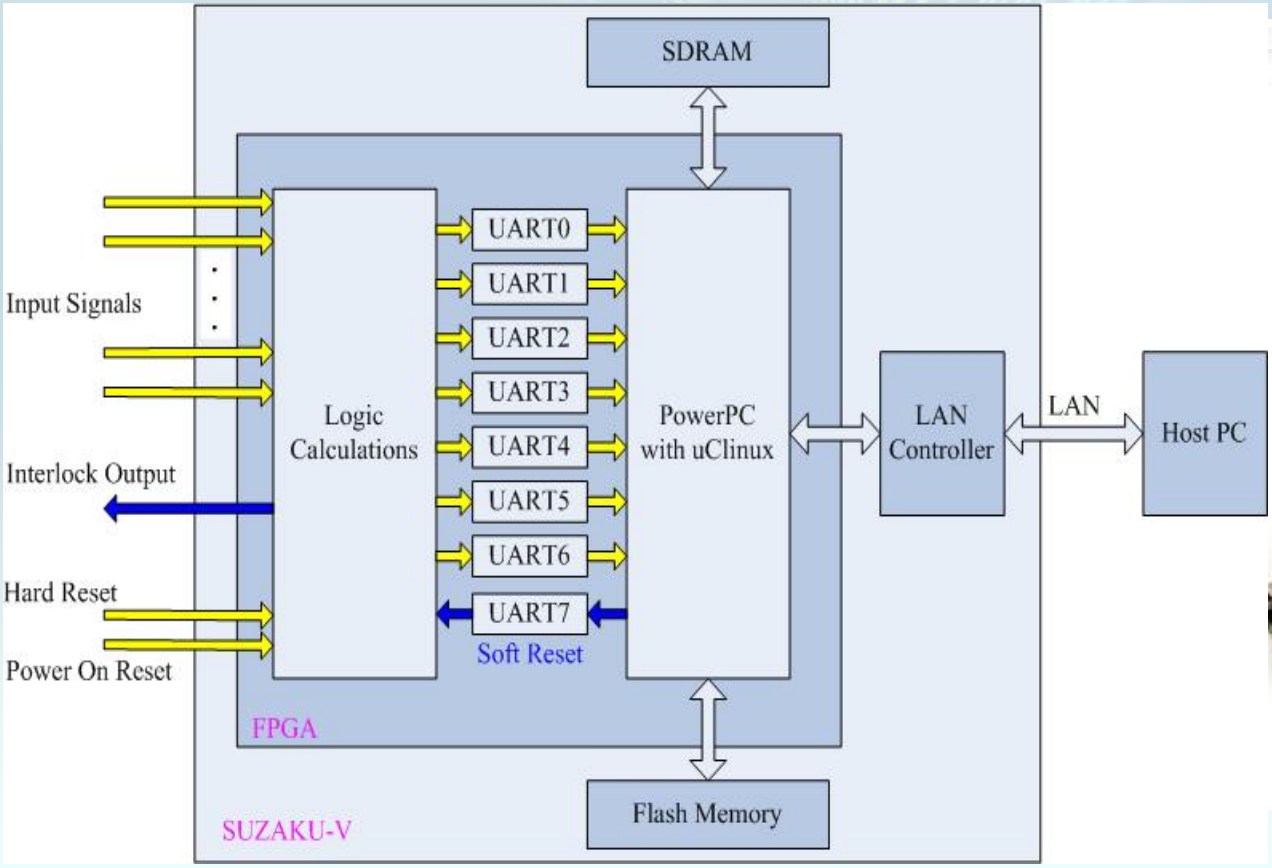
Temperature distribution of the STF 80K shield (1 coupler)

Mass flow rate of nitrogen: 1 g/s
Nitrogen inlet temperature: 80 K
Nitrogen outlet temperature: 86.8 K

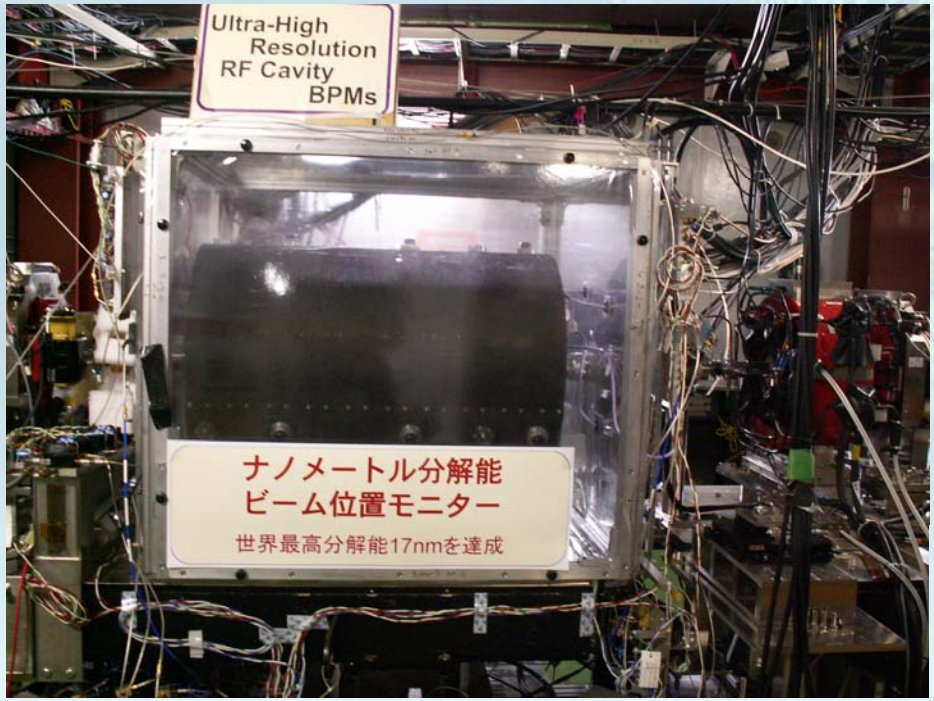
Maximum temp. difference: 11.05K
Hot spot temp. (shield end): 91.05K

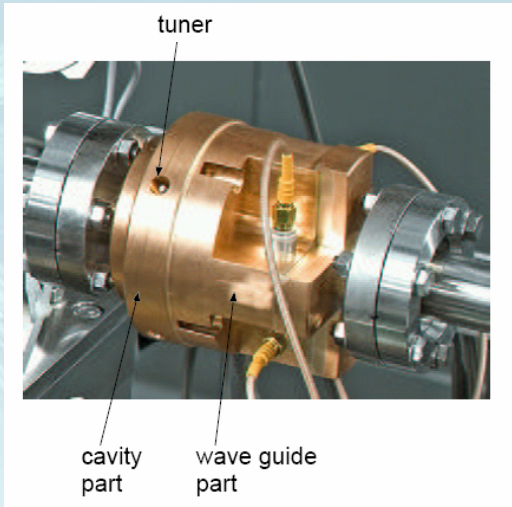
ILC-IHEP member Geng Zhe Qiao works on LLRF for STF of KEK

1. STF Cavity Simulator-Controller Design
2. Fast Interlock System Design for STF



ILC-IHEP member worked at KEK on instrumentation (Yue Jun Hui)





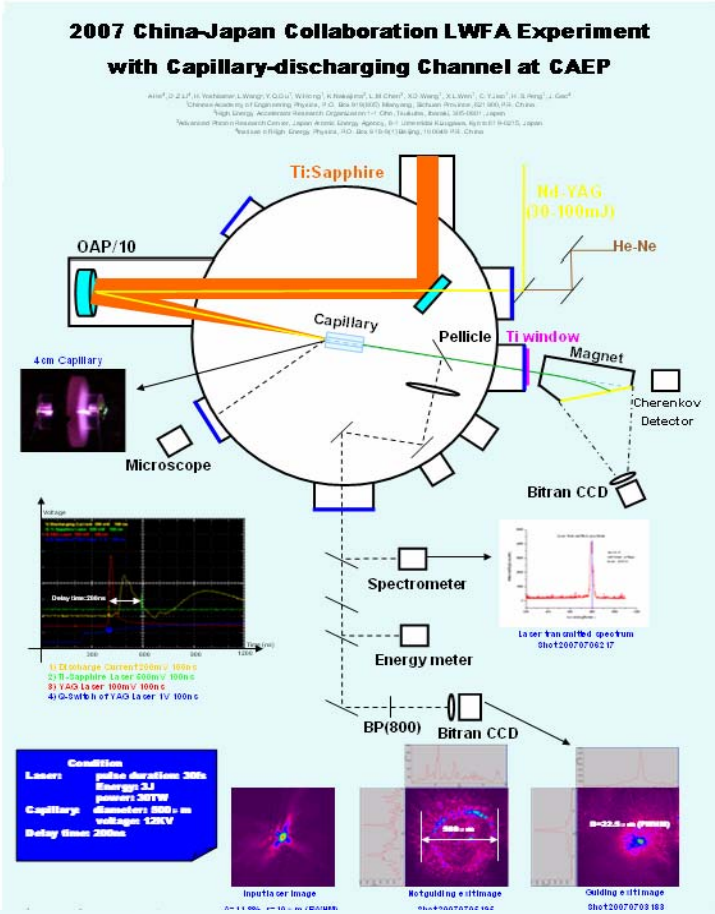
Two kinds of advanced BPMs

Advanced Accelerator Technology

laser-plasma acceleration

IHEP-KEK collaborates on laser plasma acceleration R&D activities (J.Gao and Nakajima)

ZHU Xiong Wei, Ph.D students: Li Da Zhang and He An



From 2007 Aug. 1-26, Li Da Zhang and He An visited KEK and attended 2nd Asia Laser-plasma Acceleration School supported by JSPS.

Exchange Visitors ATF

- 2000.11.13 Pei Guoxi(30days), Guo Zhiyuan(21days) and Qin Qing(14days), ATF and PEI collaborations;
- 2002.2.27~3.19 Cao Jianshe, ATF collaboration;
- 2002.10.3~10 Wang Jiuqin and Liu Shenguan, ATF and PEI collaborations;
- 2002.11.10~29 Dong Dong, IWAA2002 in Japan;
- 2003.1.6~12 D. Dong, QAB03 in Japan;
- 2003.9.7~27 Dai Jianping, Photo-cathode RF Gun;
- 2004.2.15~2.29, Liu Bo and Pei Shilun, KEKB linac pre-injector and beam physics;
- 2004.3.14 Dai Jianping(18days) and Fang Shouxian, Qin Qing(2days), Joint Workshop for 4th Beam Physics Seminar and 9th ATF International Collaboration Meeting
- 2004.6.6~12, Chi Yunlong and Hou Mi, KEKB Linac collaboration

Exchange Visitors ATF (cont.)

- 2000.9.7~11 Junji Urakawa, Kiyoshi Kubo, Shigeru Kuroda, Masao Kuriki, Toshiyuki Okugi, Takashi Naito, Sakae Araki (KEK), Hiroshi Sakai (Kyoto University), Tae-Yeon Lee, Eun-Sam Kim (PAL); first collaboration meeting at Beijing;
- 2001.9.19~21 T. Kamitani, "KEK-B positron source and two bunch acceleration";
- 2001.9.25~27 M. Akemoto , "Solid State Klystron Modulator R&D at KEK" ;
- 2002.3.21~23 J. Urakawa and M. Akemoto, ATF collaboration;
- 2002.12.9~15 Shigeki Fukuda and Yasuhiro Yano, the Mini-Workhop on Phasing System;
- 2003.2.27 J. Urakawa, T. Nobuhira, K. Hasegawa, T. Takatomi, the Seminar on FEL RF un;
- 2003.3.18, T. Higo, M. Kuriki, M. Akemoto, S. Ohsawa, M. Ikeda, ATF collaboration;
- 2003.3.25, J. Urakawa, T. Muto, Y. Honda, ATF collaboration.
- 2003.10.28~11.2, S. Fukuda, Osawa, Furukawa, Suwada, to attend the Mini-workshop on Linac Injector.
- 2004.7.5~9, S. Fukuda, discussion on klystron and phasing

ILC-IHEP Collaboration with KEK
the visitors sent to KEK in 2005 and 2009

ILC in general: J. GAO

SC technology: M.Q. Ge, Q.J. Xu, Z.G. Zong, J.Y. Zhai, T.X. Zhao

LLRF SC: Z.Q. Gen

Positron Source: X.P. Li

Beam dynamics: D. WANG, X.W. Zhu, S.L. Pei

Instrumentation: J.H. Yue, J.X. Zhao

Magnet measurement: Yuan Chen, X.J. Sun

STF Cryomodule and coupler: Qing Jin XU

ATF2: Sha BAI

Laser Plasma Acceleration: LI Da Zhang and HE An

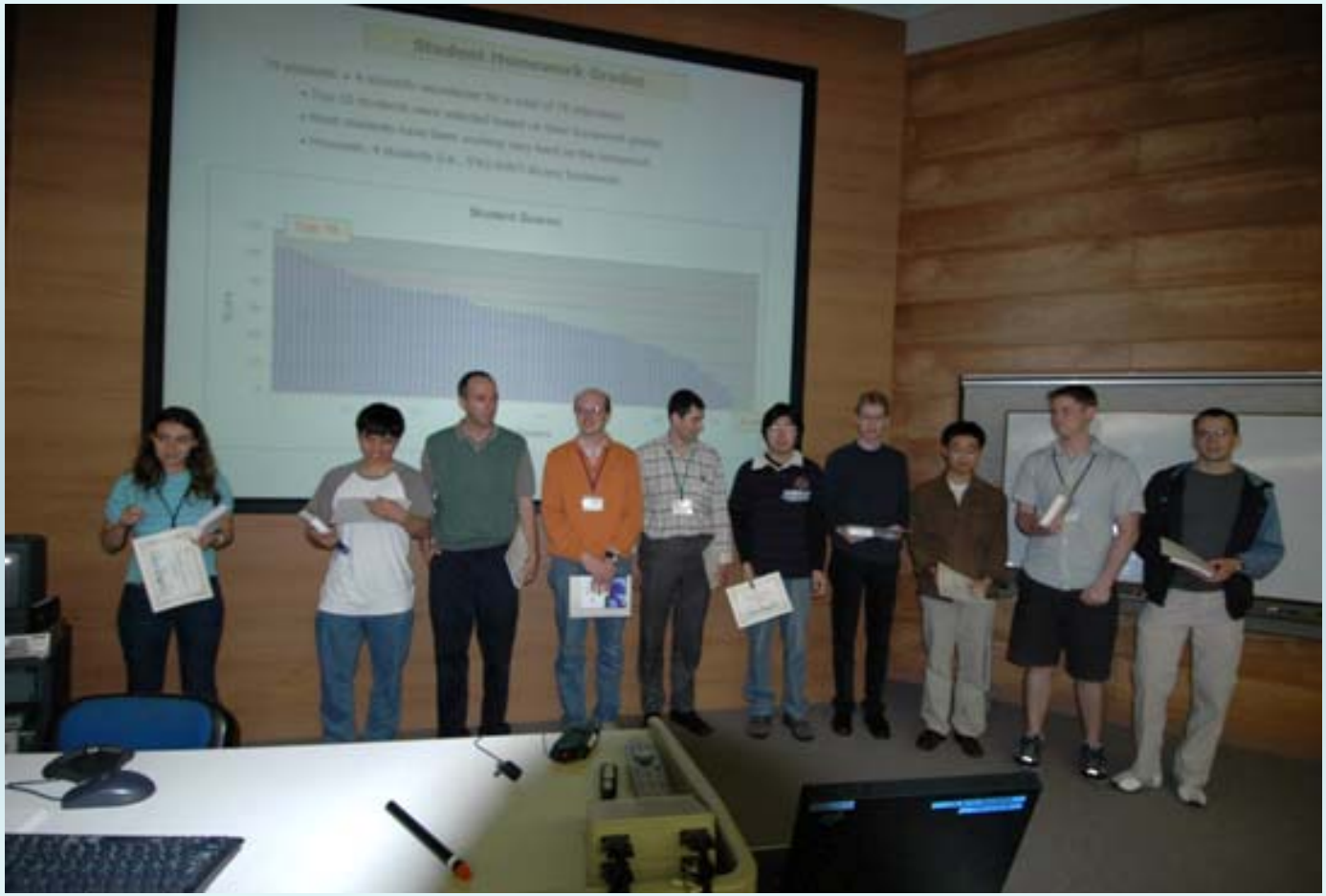
JSPS supported Chinese students in attending ILC Accelerator School

In 2006, ILC Accelerator School students selected from China:

a) Beijing University, 1.5 student
b) Tsinghua University, 1 student
c) SINAP, 1 student
d) IHEP, 1+0.5+0.5 student
e) Institute of Physics and Chemistry, 0.5 student
f) Taiwan, 1 student

Totally, 7 students from China

ILC Accelerator School studies with excellent results



Chinese students obtained 3 places in top 10 students
2nd-Dr. S.L. Pei, 4th-Mr. Y.P. Sun, and 8th-Mr. Du

Conclusions

1) JSPS－IHEP collaboration has provided an excellent platform for Chinese Project like BEPCII linac, ILC

Asia Regional Collaboration and advanced accelerator technology research in general with a large accelerator R&D subject spectrum.

2）JSPS-IHEP collaboration is a great example of mutual beneficial collaboration.

3) JSPS-IHEP collaboration promoted people exchange and students training.

Thanks to JSPS-IHEP Collaboration!