X-band high gradient activities at KEK

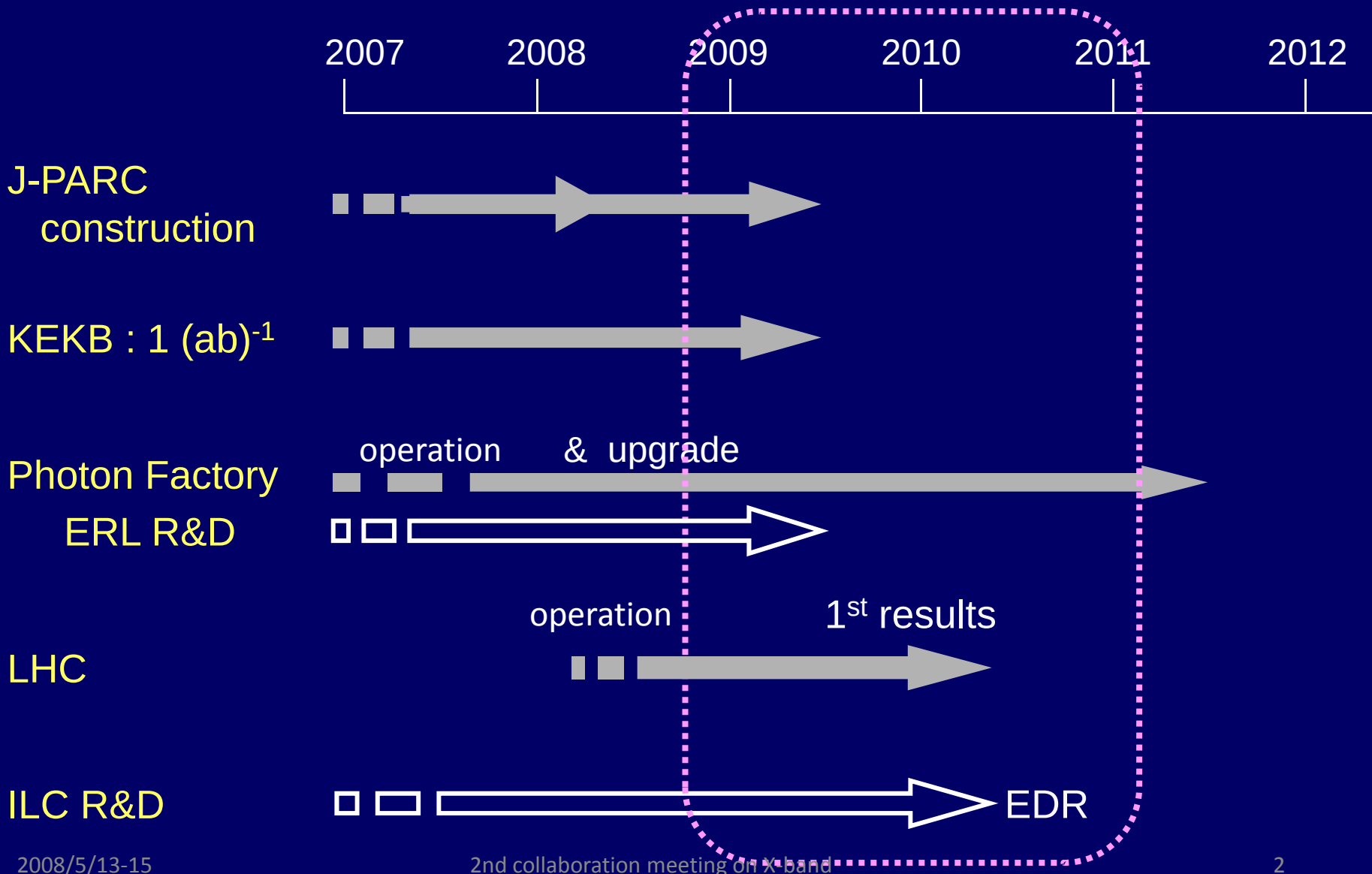
May 13-15, 2008

2nd Collaboration meeting on X-band Accelerator Structure Design and Test Program

T. Higo, KEK

Roadmap by DG, Mar. 08

Timeline of Current Project



Roadmap by DG, Mar. 08

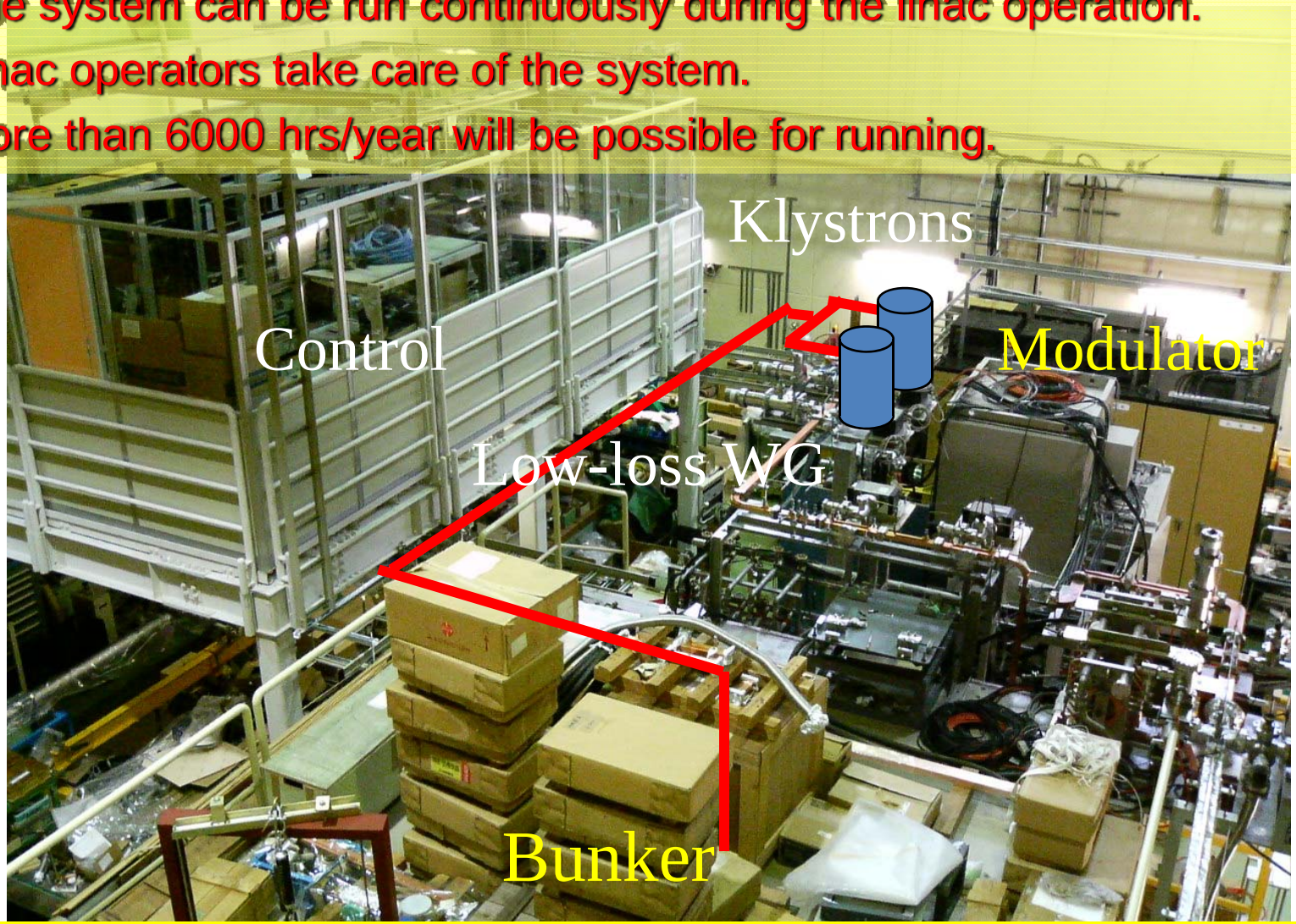
Roadmap -High Energy Physics-

- According to the JAHEP community's master plan,
  - Highest priority is given to ILC
  - Before ILC, promote flavor physics at KEKB and J-PARC
- Action before the ILC approval
  - ILC R&D
  - Completion/commissioning of J-PARC
    - Considering the world competition, it is urgent to improve neutrino intensity
  - Continuation of KEKB/Belle with upgrade

KEK Testing Programs toward X-band CLIC

MOU : KEK - CERN (July 2007)

- The system can be run continuously during the linac operation.
- Linac operators take care of the system.
- More than 6000 hrs/year will be possible for running.



Appeared in the Roadmap by DG, Mar. 08, just as a basic research for high energy machine.

KEK roadmap and X-band stance

- J-Parc: On going at top priority
- Super B: Higher luminosity after $1ab^{-1}$
- ILC: Toward higher energy based on SCC
- Next: Mini ERL as a prototype machine

X-band R&D

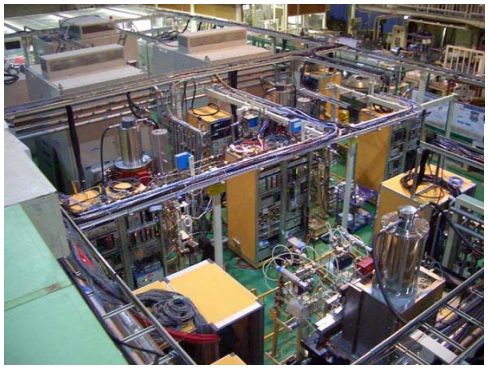
- We continue as a basic research for one of the key technologies of the high-gradient acceleration.
- Accelerator laboratory set the high-frequency and high-gradient acceleration as one of its missions.

Boundary conditions of X-band research activities at KEK

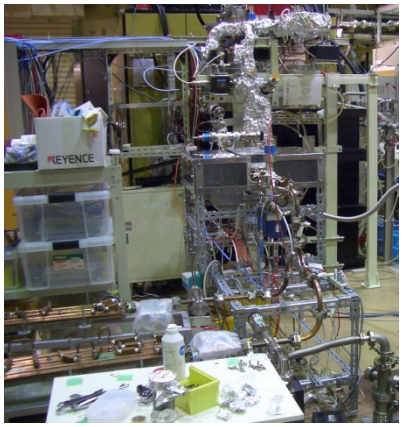
- For high energy machine
  - Driven as one of the KEK missions, “high energy”
- For application
  - Collaboration with Tokyo Univ.

- Budget source
  - Some from ACC operation/maintenance funding
  - CERN CLIC collaboration
  - US/Japan cooperation for high energy physics
- Manpower
  - ACC: X-band G in KEKB injector with the help by operators of KEKB
  - MEC: Based on previous X-band people
- Collaboration
  - CERN, SLAC

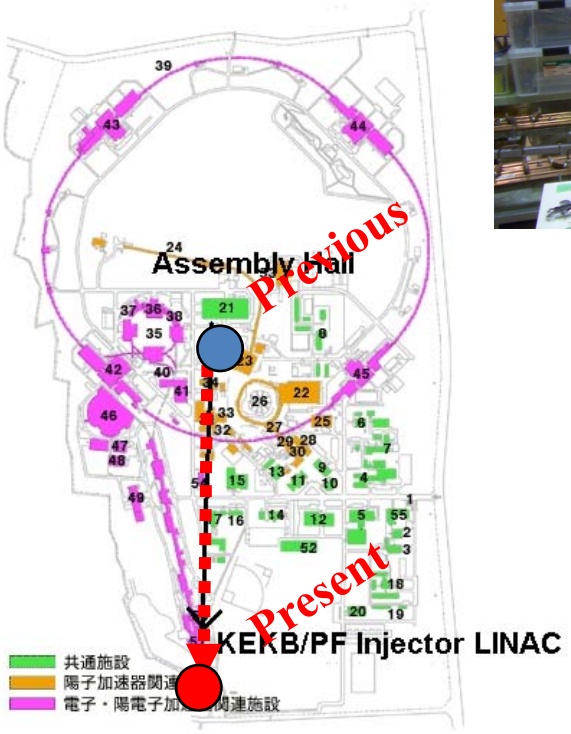
Wandering of X-band test stand



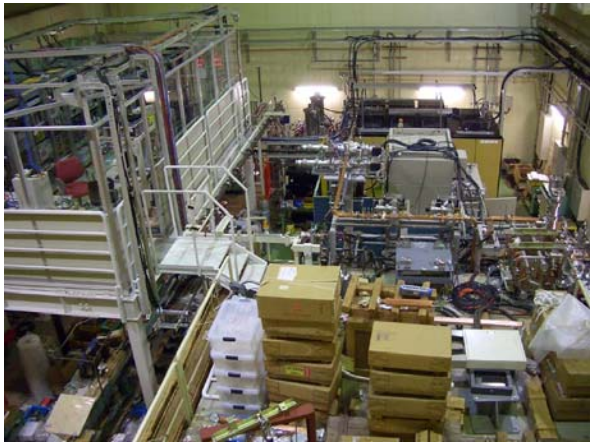
GLCTA before ITRP
2003-04
→XTF after ITRP
2004-06



1 klystron setup
KT-1
2007



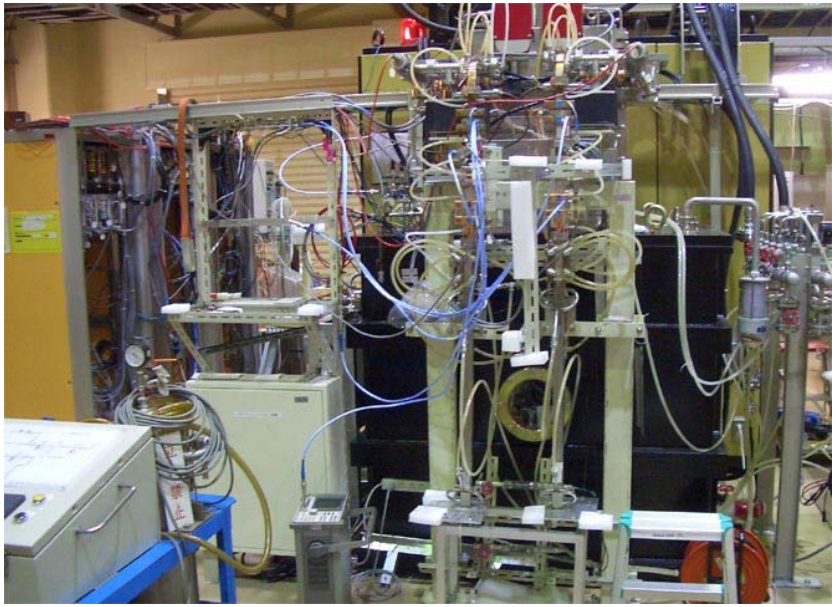
Moving
Early 2007



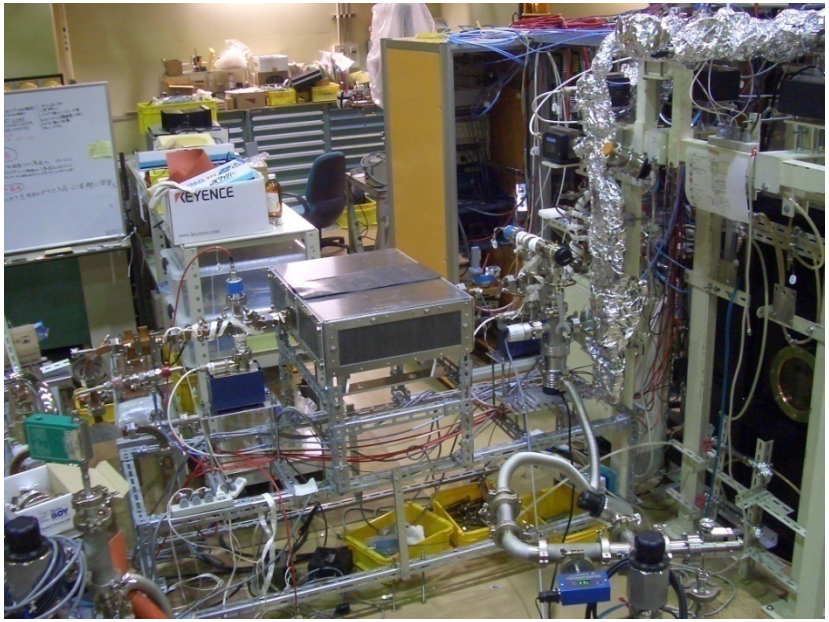
Nextef
2007-08

KT-1

Test stand for
klystron itself, component, high field study, etc.

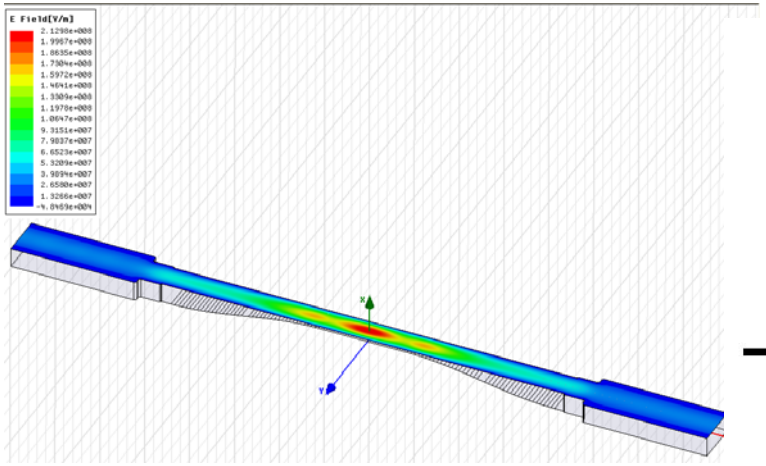


Single klystron for various tests

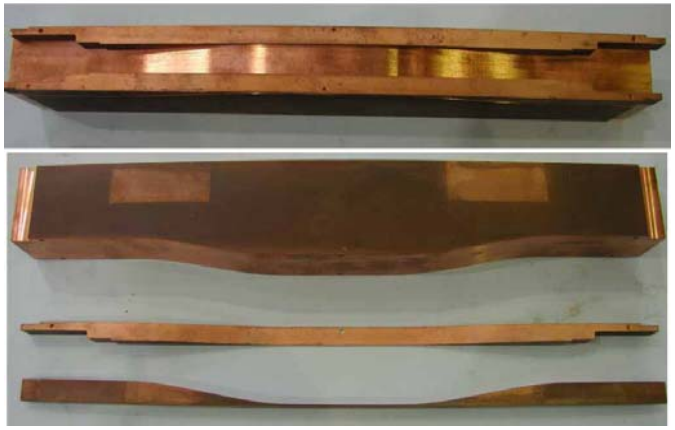


High field study with narrow-cross section waveguide

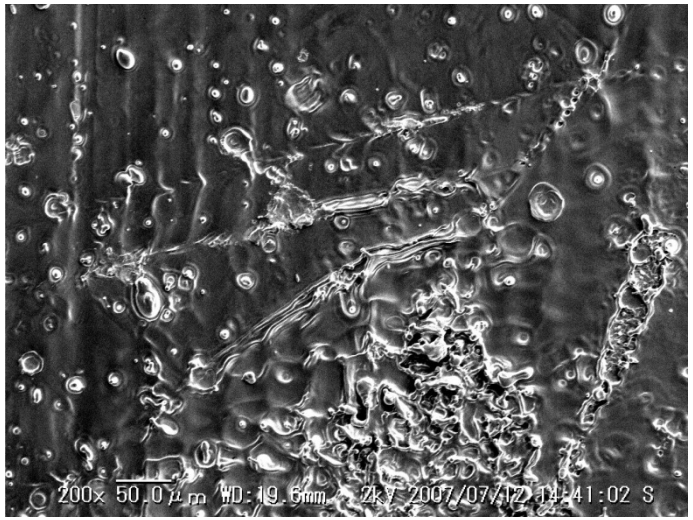
High field study with Narrow WaveGuide



RF

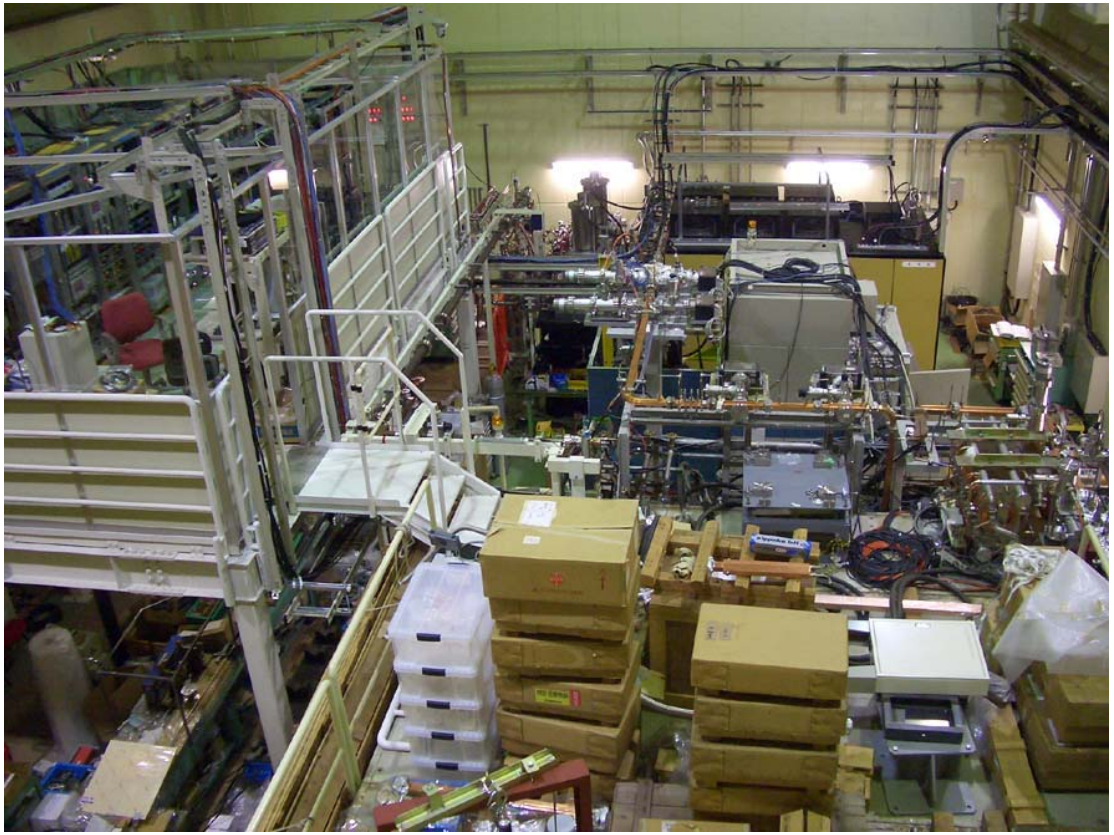


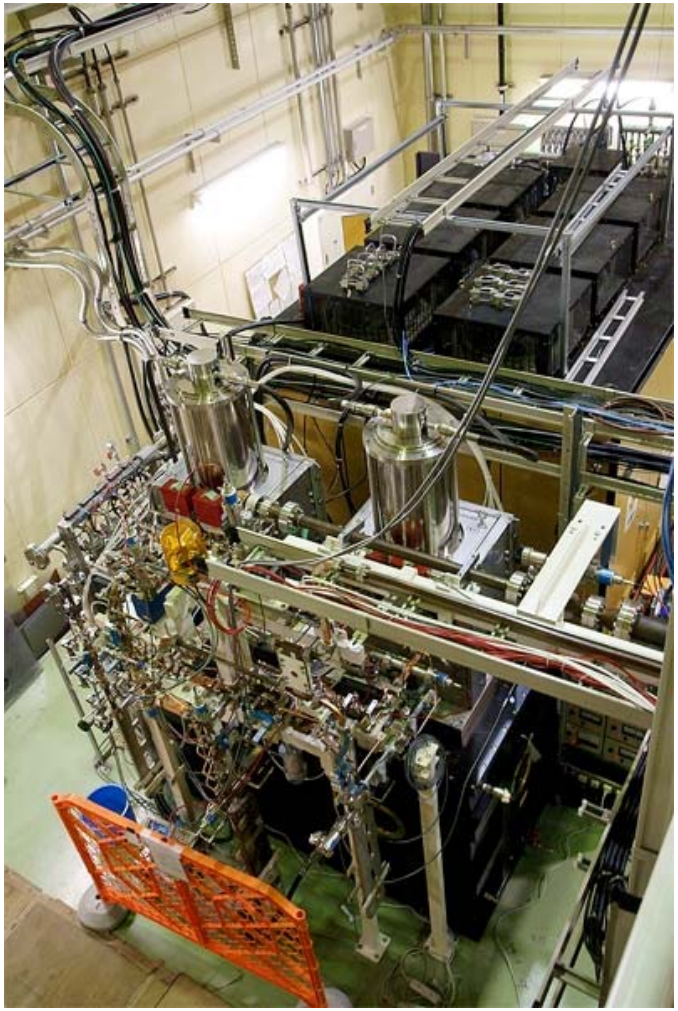
Cu case



Nextef progress

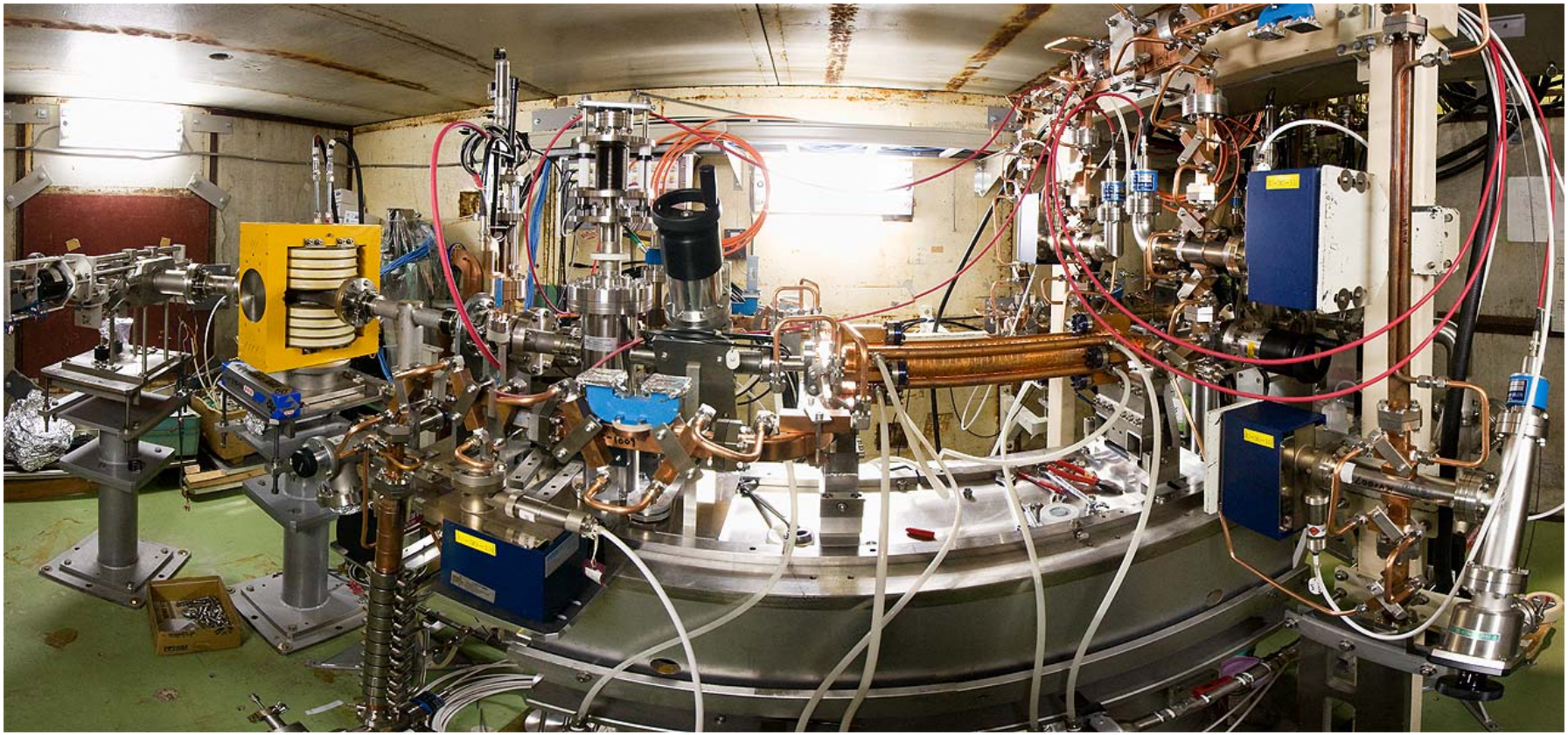
Establishing power generation and transport in 2007





Nextef inside shield room

most basic components are now in line.



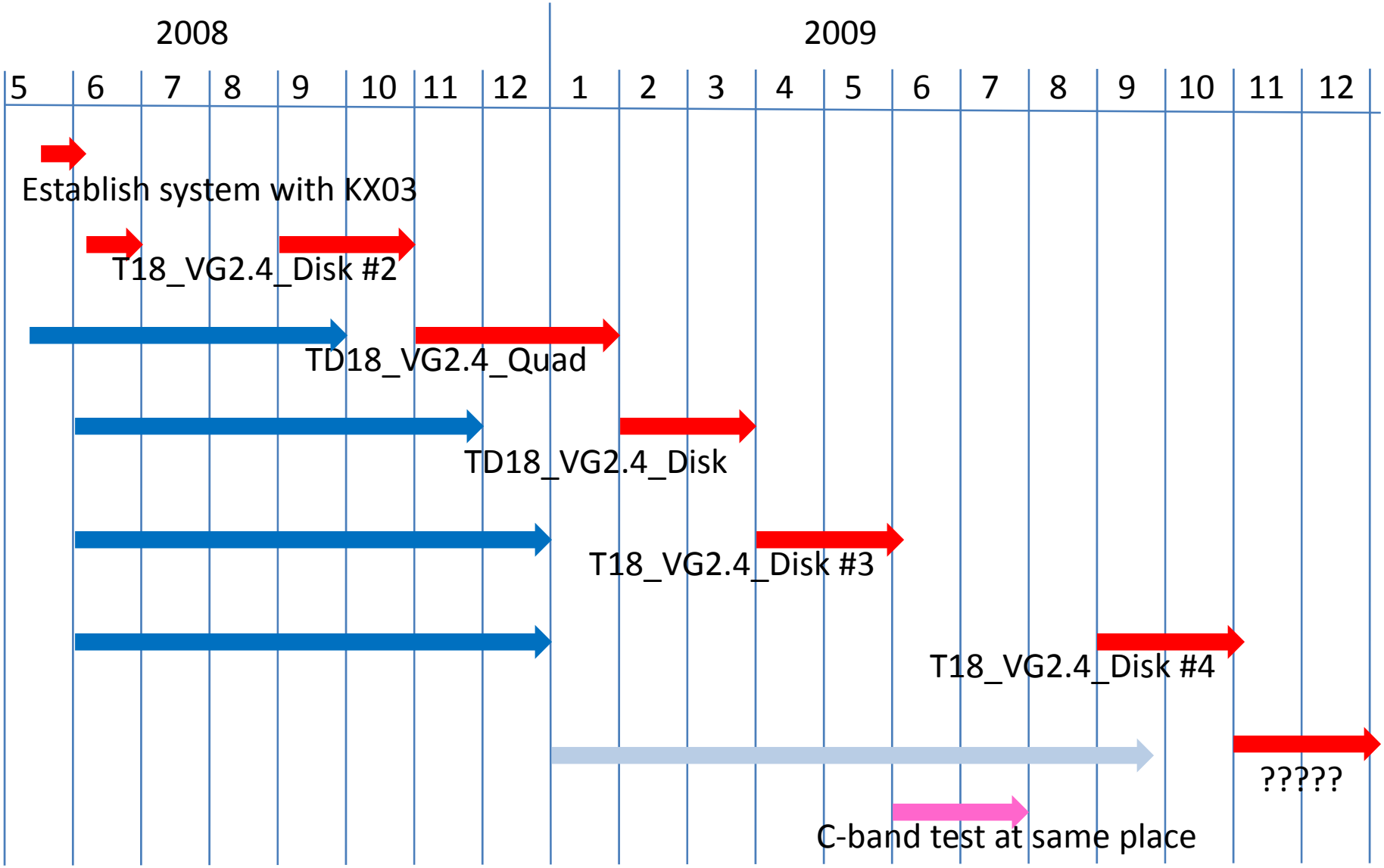
Nextef recent footprint

- 2007 Feb. Moved to KEKB Injector area.
- 2007 Jun. Each klystron tested at new stand, both driven by one pulse transformer.
- 2007 Aug. Power combination was done.
- 2007 Nov. Drive KX03 for a moment.
- 2008 Feb. Tried to establish more power in a stable condition.
- 2008 Mar. Lounine load was found degraded. 400ns, 25Hz, 40MW.
- 2008 Apr. Power establishing with two Ohtsuka loads. Some waveguide components are found arcing at 400ns, 25Hz, 50MW.
- 2008 May Back to KX03 system to finally establish breakdown study system.
- 2008 Jun. Start actual study of CLIC_VG1 (T18_VG2.4_Disk)
- 2008 Jul. KEKB summer shutdown. Need to stop Nextef?

Status and problems encountered in Nextef commissioning stage

- Problems in establishing power level
  - Realized 50MW level for 300ns at the structure input, but ….
  - Power reading uncertainty exists,
    - Among crystals, calorimetric and peak power meter, +-10% level?
    - 70MW at 2-klystron combiner and 50MW at accelerator structure. Is this consistent to the estimated transmission loss of ~20%?
  - We have not established enough power even for low v_g structure?
    - More power will be confirmed in a system with a structure KX03.
- Problems in establishing quality and stability
  - Only square pulse shape is available
    - Deformed in 20% level at ramping .
  - Power jitters typically by a few percents
    - It depends on klystron working point and should be estimated/optimized.
  - System breakdowns at a rate ~ 1BD/hr
    - Mostly at loads and waveguide components.
    - We hope it will be gradually improved.

Nextef planning



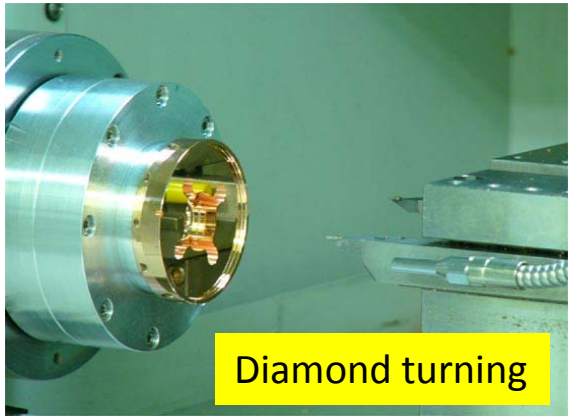
Structures planned to be tested at Nextef

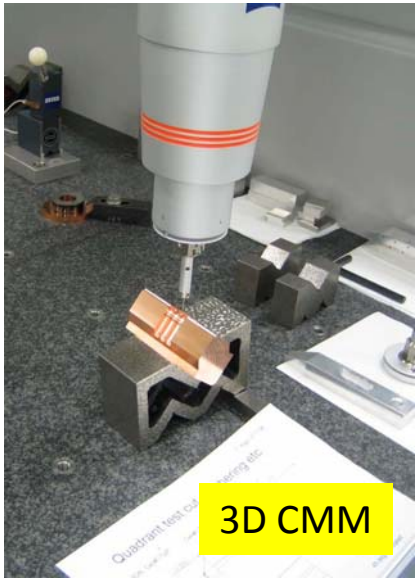
- T18_VG2.4_Disk #2
  - startup Nextef
- TD18_VG2.4_Quad
  - Taste quad
- TD18_VG2.4_Disk
  - comparison disk/quad
- T18_VG2.4_Disk #3?
  - Statistics?
  - Diff. treatment?
  - etc.
- T18_VG2.4_Disk #4?
  - ??
- Plan from this meeting
  - ??

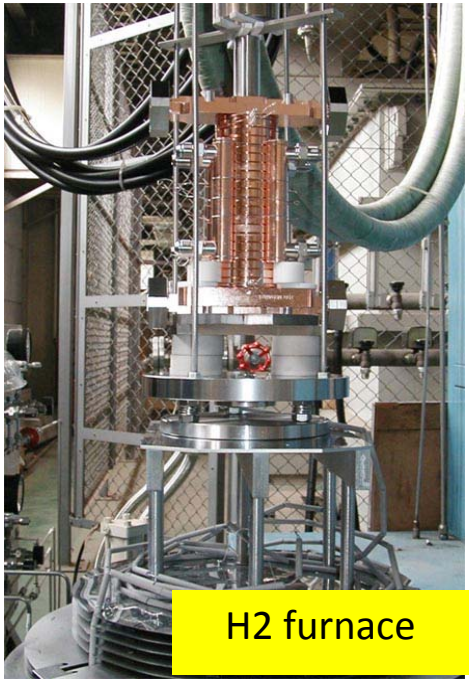
Accelerator structure fabrication

- Main resource: MEC
  - Fabrication
    - High precision turning and milling
    - High temperature bonding
    - Chemical surface treatment
  - Evaluation
    - 3D coordinate measurement
    - RF low power measurement by ACC
    - High power evaluation by Nextef and other labs, SLAC and CERN.
- Cultivating outside companies
  - Vendors
    - Previous: Morikawa as in GLC era
    - New comer: Hitachi, U-corp and others
  - Strategy
    - Taking the vendor's facilities and experiences
    - Discussing technical details to some depth
      - Hopefully freely between KEK and vendor, as long as apparent problems exist
    - Reflect the discussion back to the design

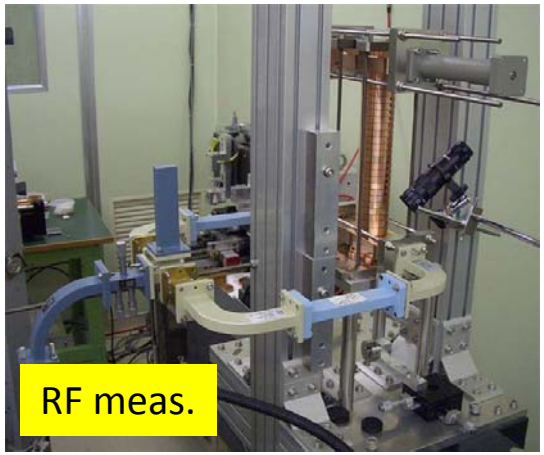
Fabrication activities at KEK


Diamond turning

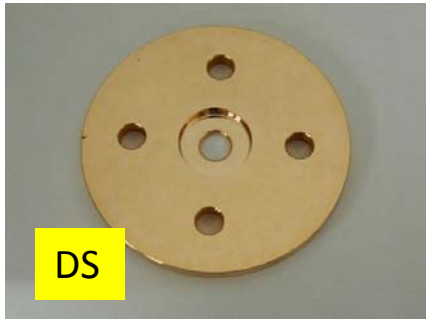

3D CMM

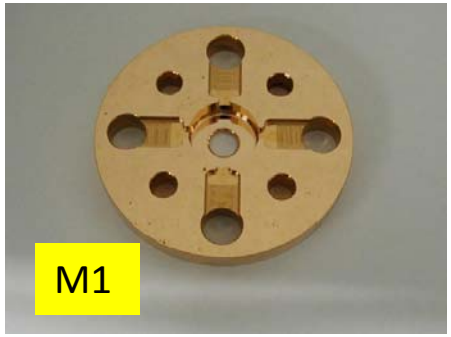

H2 furnace

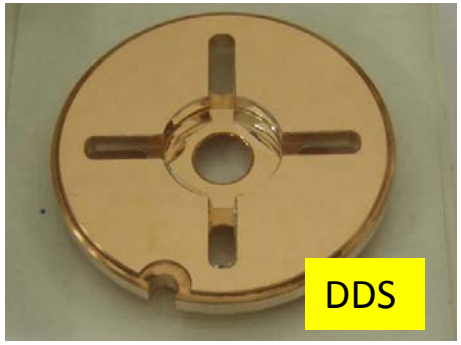

Chemical treatment


RF meas.

Disk based fabrication



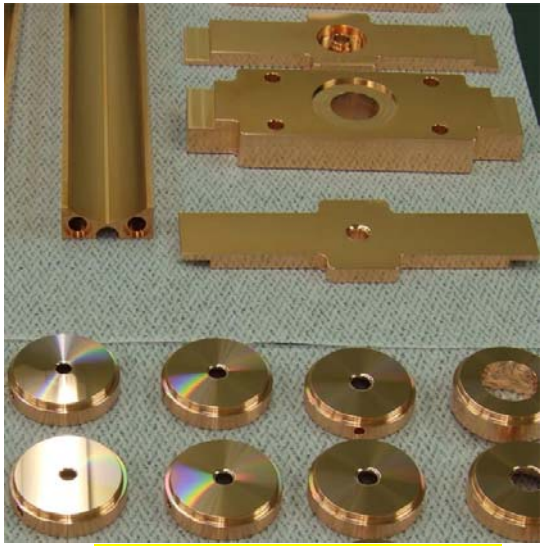




Butterfly cell;
Cuts are fully extended out

RDDS1
Sharp edge but precise dimension control

HDDS outside vendor + KEK final



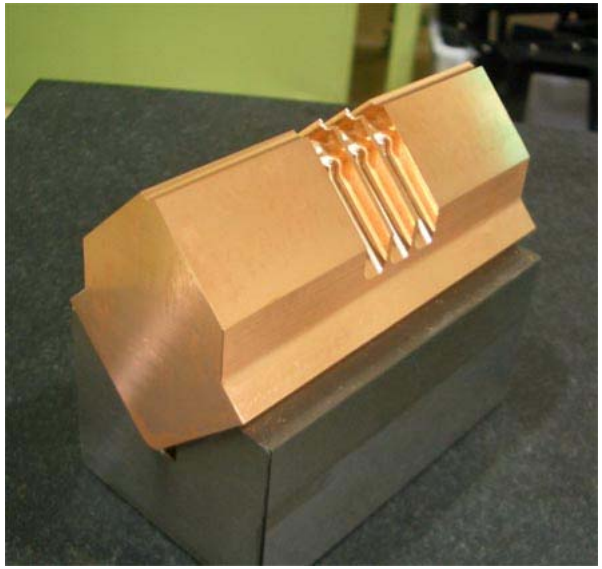
CLIC_VG1 by outside vendor

From ultra-precision turning to precise milling

- Disk without damping
  - Ordered to outside, such as T18_VG2.4_Disk
- Disk with medium damping
  - Milling by outside vendor + precise turning by KEK, such as HDDS of GLC stage
- Disk for heavy damping
  - No recent experience, but should be an extension of HDDS
- Quadrant for heavy damping
  - Being studied

- We have enough experience of disk-based fabrication and hope to obtain a quadrant-type fabrication smoothly.

Quadrant fabrication in three stages



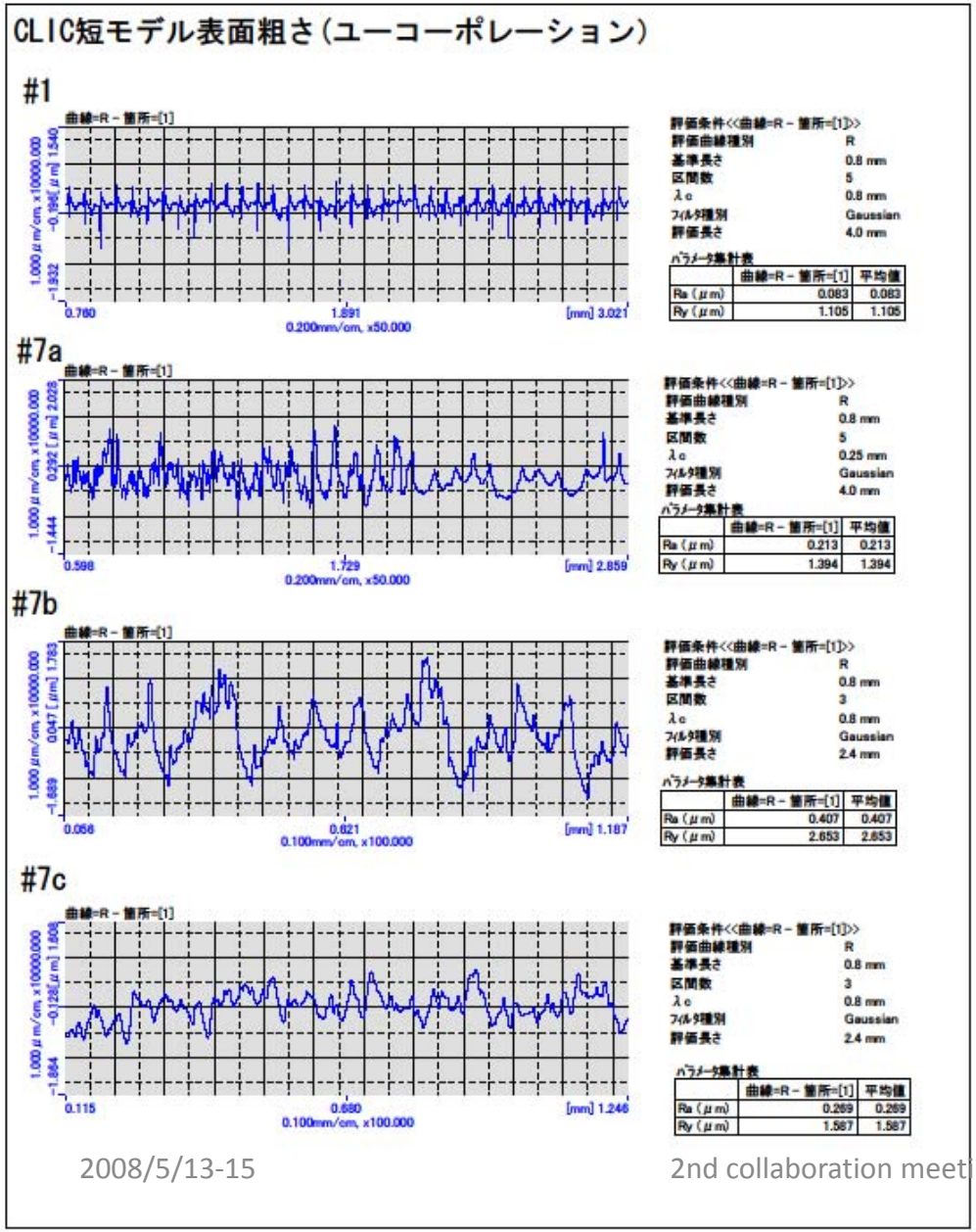
2007

Apr. 2008

Summer 2008

A complete structure for high power test.

Surface roughness



Present Ra ~ 0.2—0.4 micron

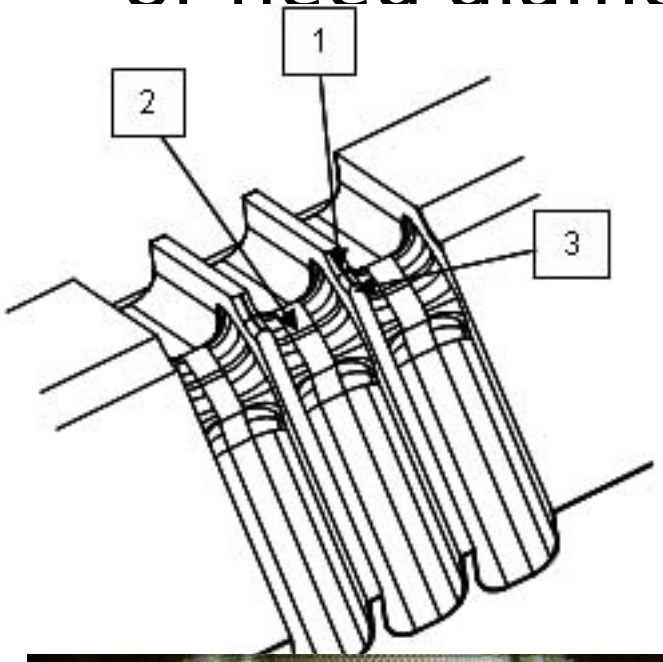
To be studied whether absolutely needed to reach specified Ra~0.1 micron.

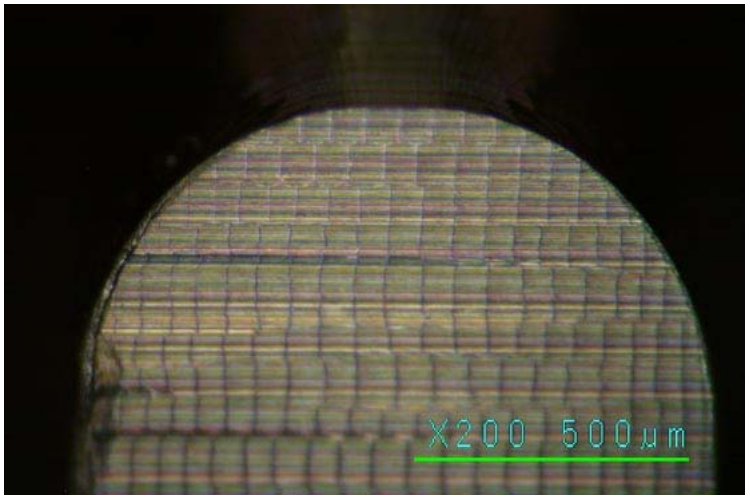
This spec is related to the surface treatment.

&

Big but smooth variation should be OK. The cutoff wave length can be larger.

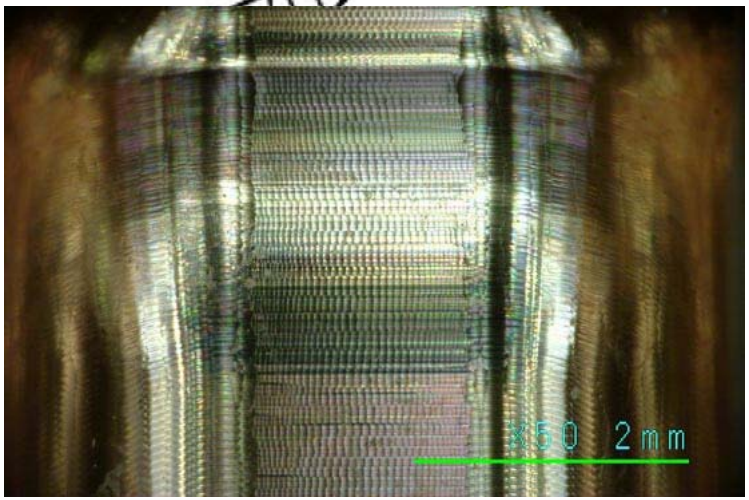
OK with present carbide tool or need diamond tool in future??

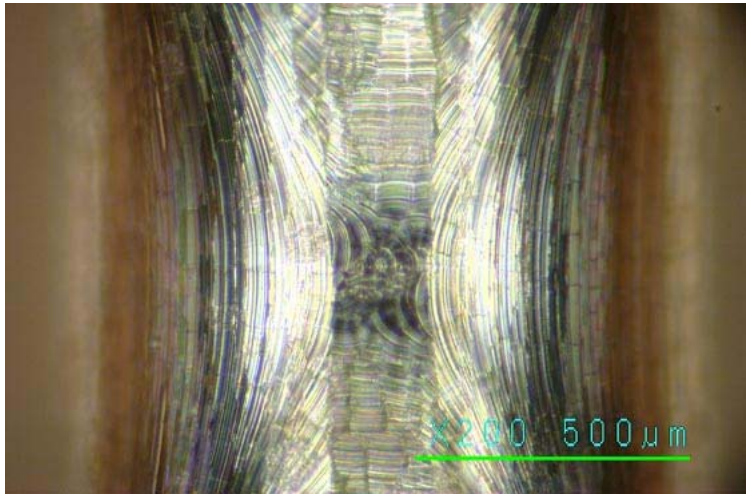




3

2

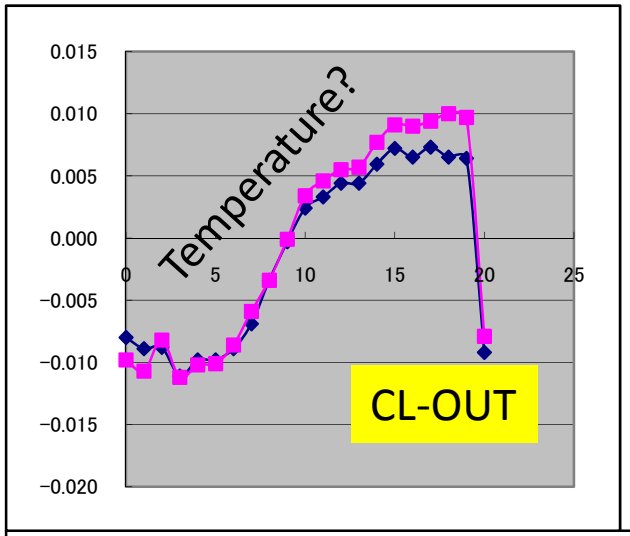


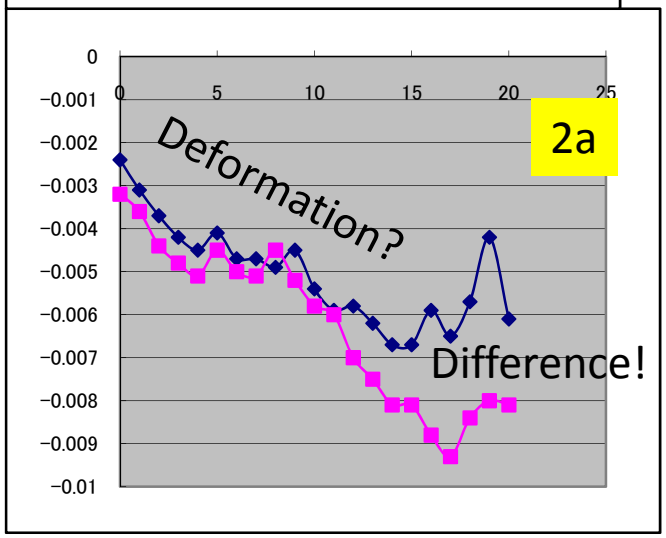


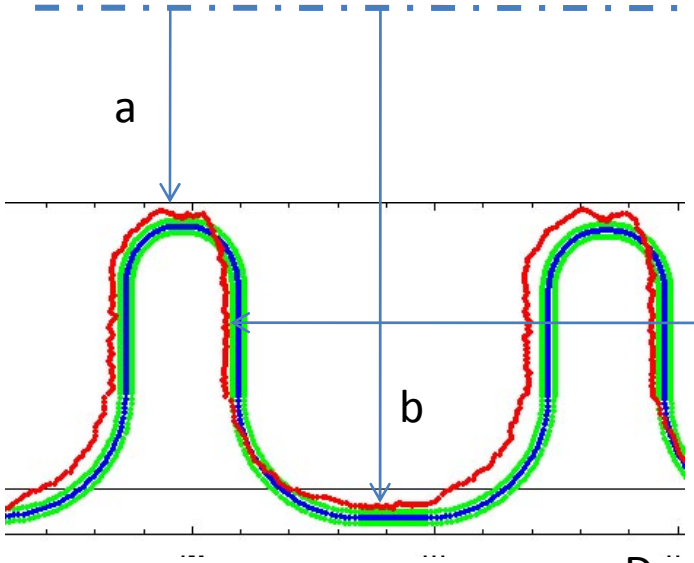
1

Dimension control

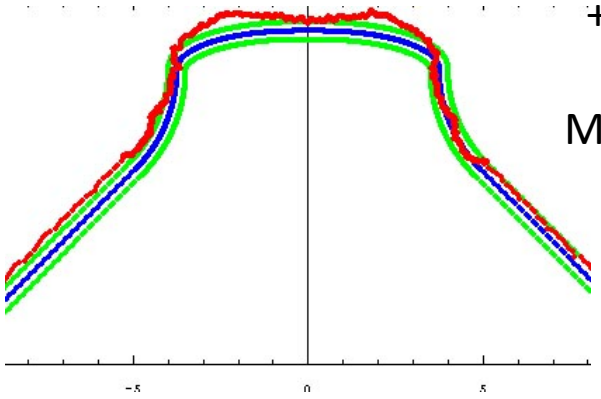
KEK meas. vs. Vendor meas.







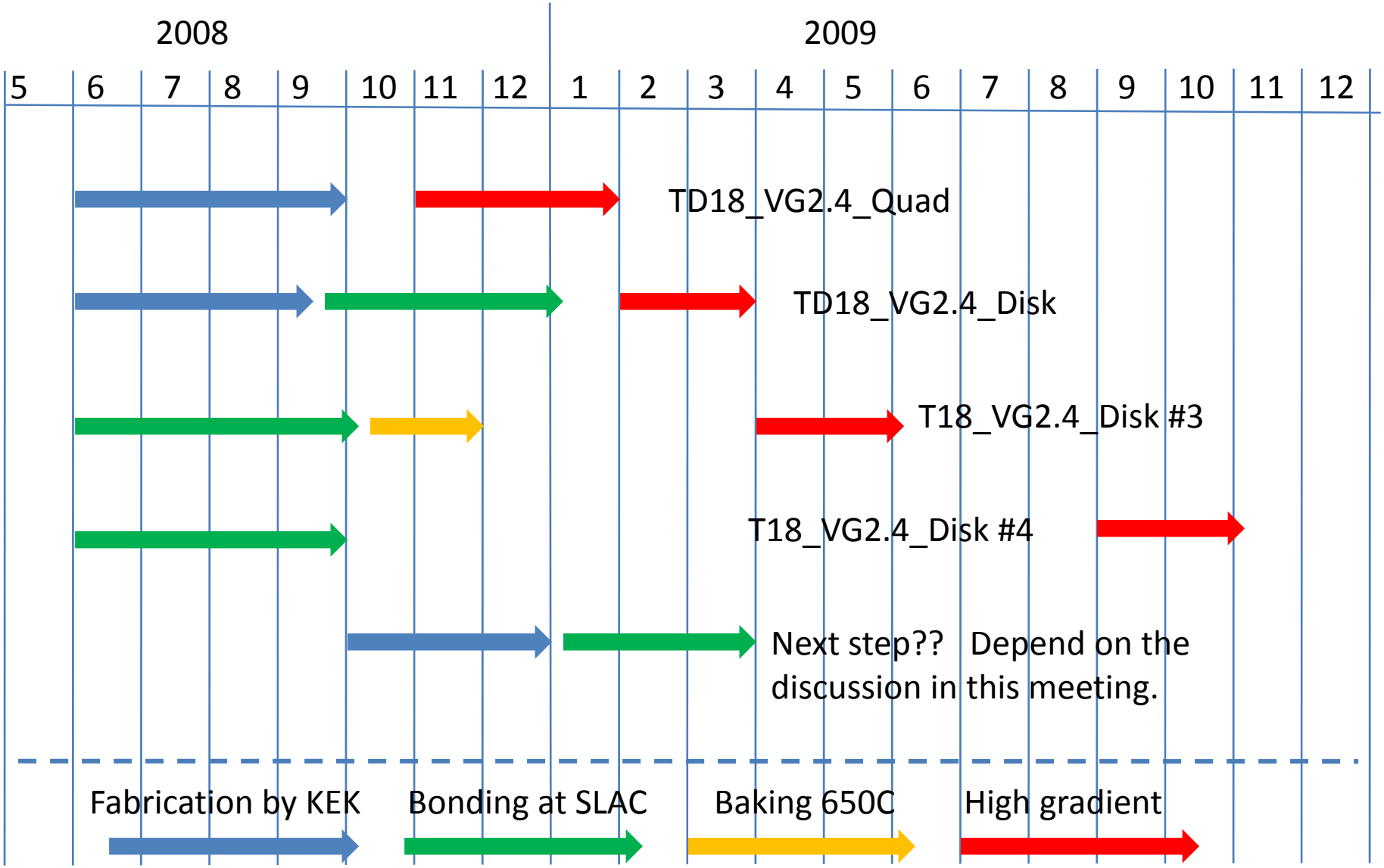
Deviation from +-2.5 microns



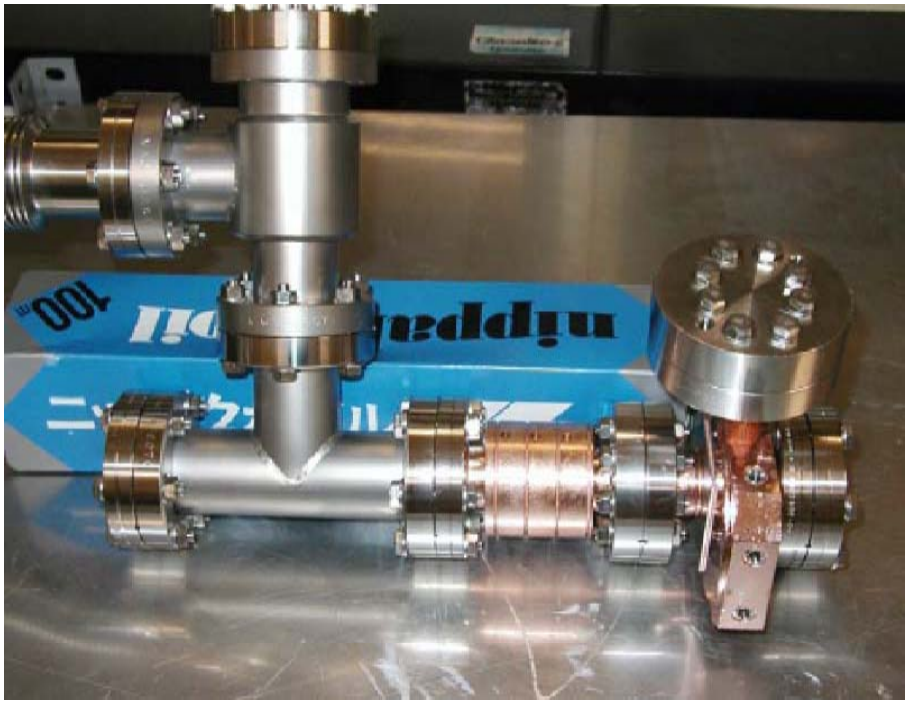
Meas. by KEK

Present level is about 10 microns. We understand the need of the improvement by at least a factor two.

Structure fabrication planning/proposal



Study for higher field and to understand physics behind



On various
- Materials,
- Shapes,
- Surface treatments
- Crystal structures
- etc.

are prepared by KEK (Higashi's talk) and being tested at SLAC test stand.

Conclusion: Work to be done in near future (1)

- Establish the Nextef, at the top priority, as soon as possible for a series of high gradient tests to meet the demand given from the discussion of this meeting.
- Conduct the X-band long-term run at practical field level at Nextef.
- Establish the fabrication of damped structure with cultivating outside vendors.
- Collaborate with CLIC to get essential idea and technology on high gradient to confirm feasible level of gradient.
- Collaborate with SLAC to gain understanding and technology for higher field and higher power.
- Make a collaboration framework in Japan to make a wide range of team for high energy machine developments.

Conclusion: Work to be done in near future (2)

- Propose a practical design of high-energy accelerator based on independent RF systems.
- Try to find a place to accelerate a beam in a high gradient and test various performance including other features than high gradient.
- Try to find a place of practical accelerator application using the present X-band RF technology, with possibility to taste high gradient performance.

- Conclusion: In order to plan these activities, the input from this meeting is critical.