KEK Testing Programs toward X-band CLIC

X-band structure design and testing program workshop
CERN, June 18-19, 2007

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1. KEK staffs for X-band activity
2. Klystron test stand and on-going test
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4. Fabrication facility
5. Plans in our mind and possible collaborations.

KEK staffs working on X-Band
about 4~5 FTE now

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Nextef

- History
  - X-band facility GLCTA for GLC was converted to XTF for general studies with X-band. Now it was moved to KEKB injector area and is under re-commissioning.

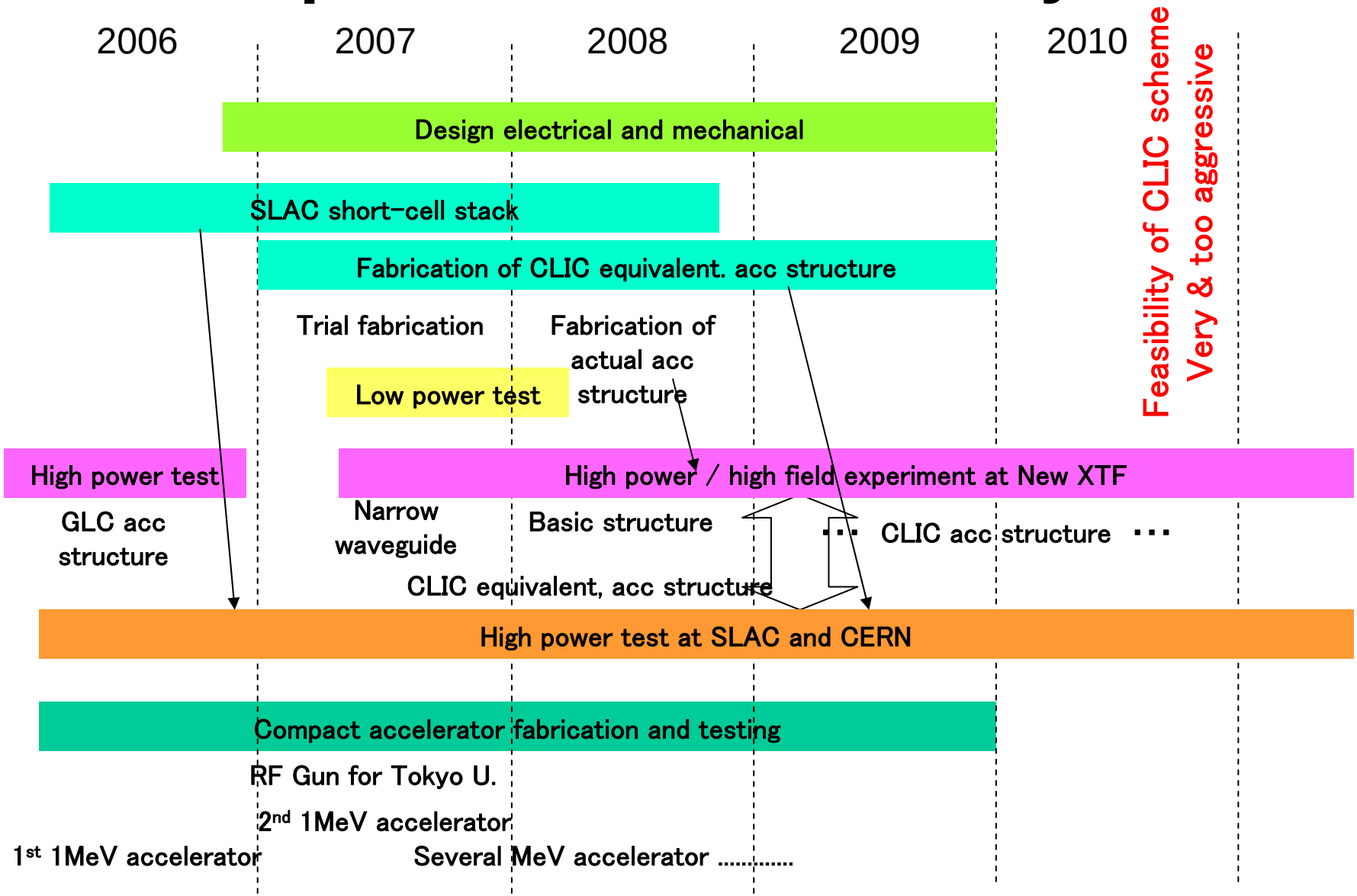
- It was newly named recently as "Nextef."

  NExt X-band TEst Facility

  aiming at exploring the study for any next project.

- Home page is seen from
  - Inside KEK: http://www-linac2.kek.jp/nextef/
  - Outside KEK: http://www-linac.kek.jp/nextef/

Global plan of X-band activity at KEK



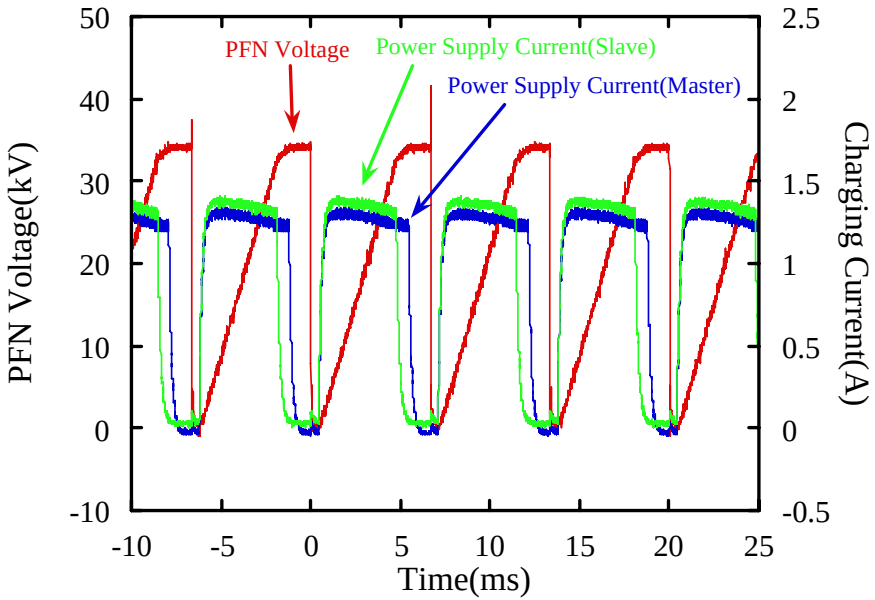
Legacy of GLC X-band

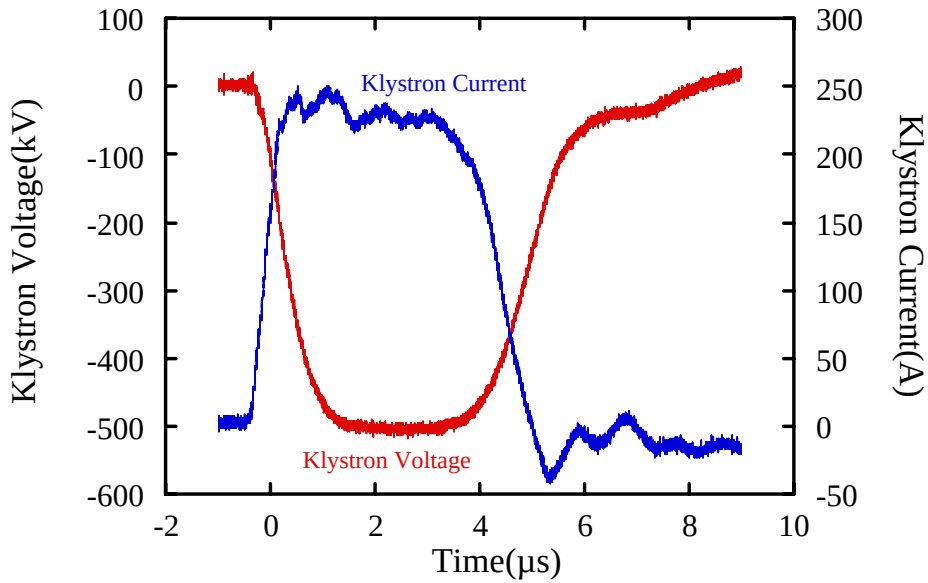
Main items we preserved.

- Modulators
  - 1-kly drive, 2-kly drive
- Klystrons
  - 3 PPM’s to be used, 1PPM to be rebuilt
- Accelerator structures
  - CZ 30cm-long, DS &DDS 60cm long
- Waveguide components
  - WR90, low-loss (SLAC)

XTF Modulator (test result and operation)

Klystron : 1, Inverter PS : 4, Repe. Rate : 150 Hz, Vpfn : 35 kV





Pule width : 4.5 μs
Flat-top width : >1.6μs(±0.5%)
Rise time : 0.9μs(10-90%)
Pulse voltage stability : ±0.15%

- Two modulators have been operated stably.
- Modulator with driving two-klystrons will be done in Nextef. Now 50Hz but if adding INV-PS then 150Hz is possible.

PPM X-band Klystron for Nextef

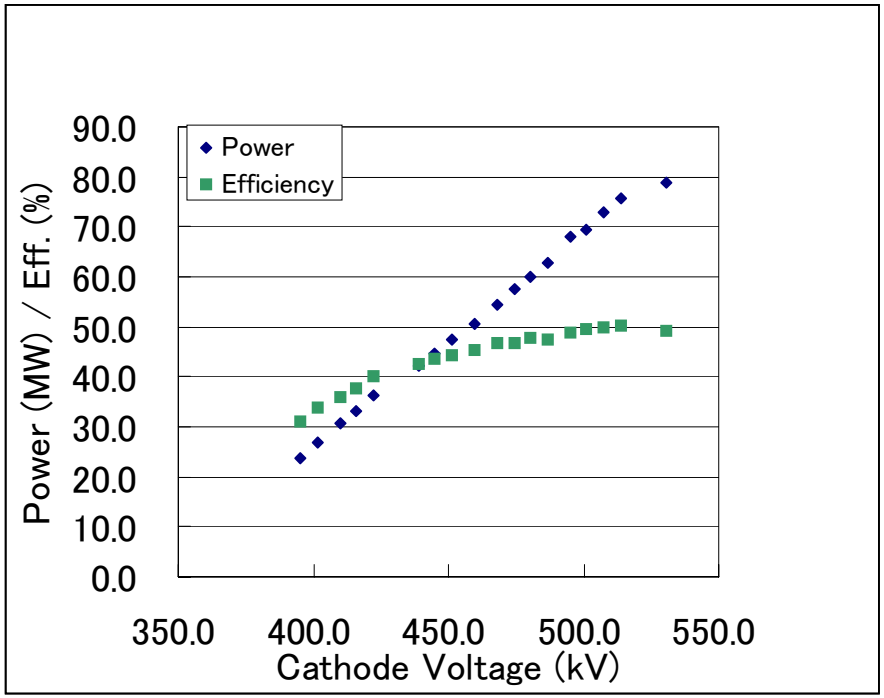
Operation Parameters

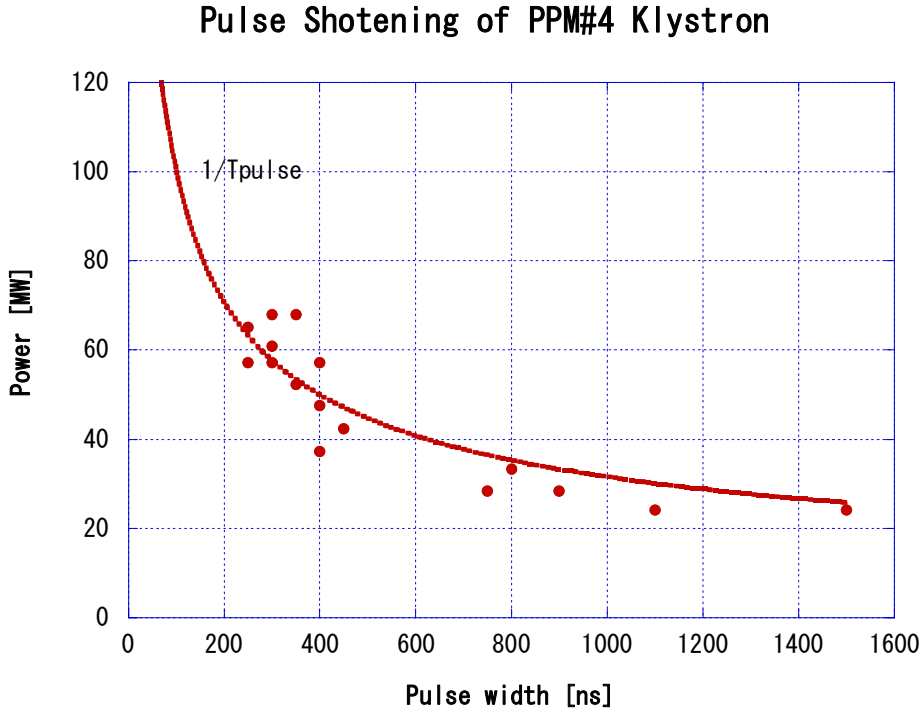
• Operating Frequency	11.424 GHz
• RF Pulse Width	0.5 μs
• Peak Output Power	50 MW
• Beam Voltage	460 kV
• Repetition Rate	50 pps
• Efficiency	43 %

•The klystrons have been developed as prototypes of the GLC 75MW klystron.
•4 klystrons are alive.
•2 klystrons waiting for Nextef and 1 klystron running at Klystron Test Stand.
•We plan to rebuild 1 klystron in this FY.

Klystron performance

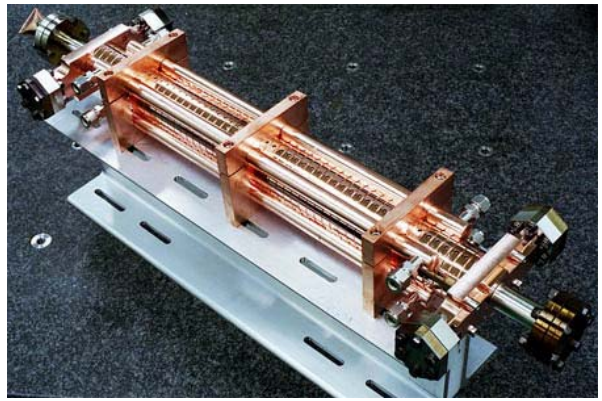
PPM#4



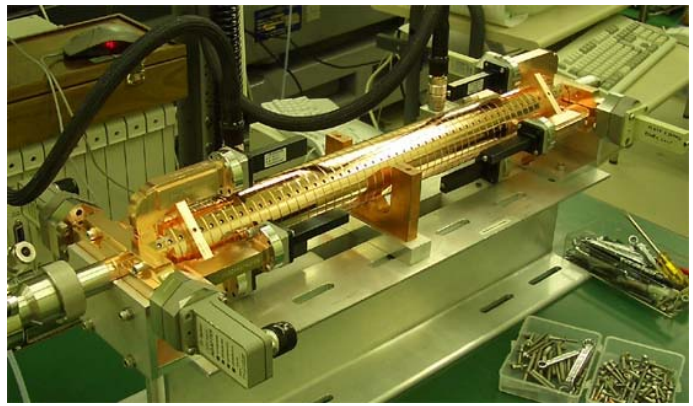


Recent 60cm structures made by KEK and tested at old XTF

- KX01(DS)
  - Tested up to 75MV/m, 400ns in 1200 hrs



- KX02(DDS cells)
  - Tested up to 85MV/m, 400ns in 400hrs
- KX03(DDS & HOM damp)
  - Tested up to 75MV/m, 400ns in 400 hrs



Cells were fabricated, chemically cleaned at KEK.
Bonding was performed at Toshiba due to limited volume of our furnace.
Basically we re-establish the KEK procedures + bonding inhouse.

X-band related facilities

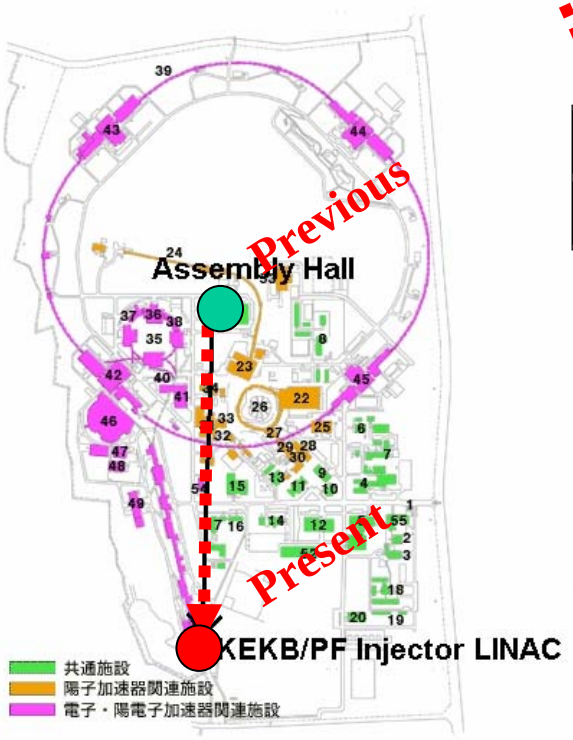
Klystron test station in operation

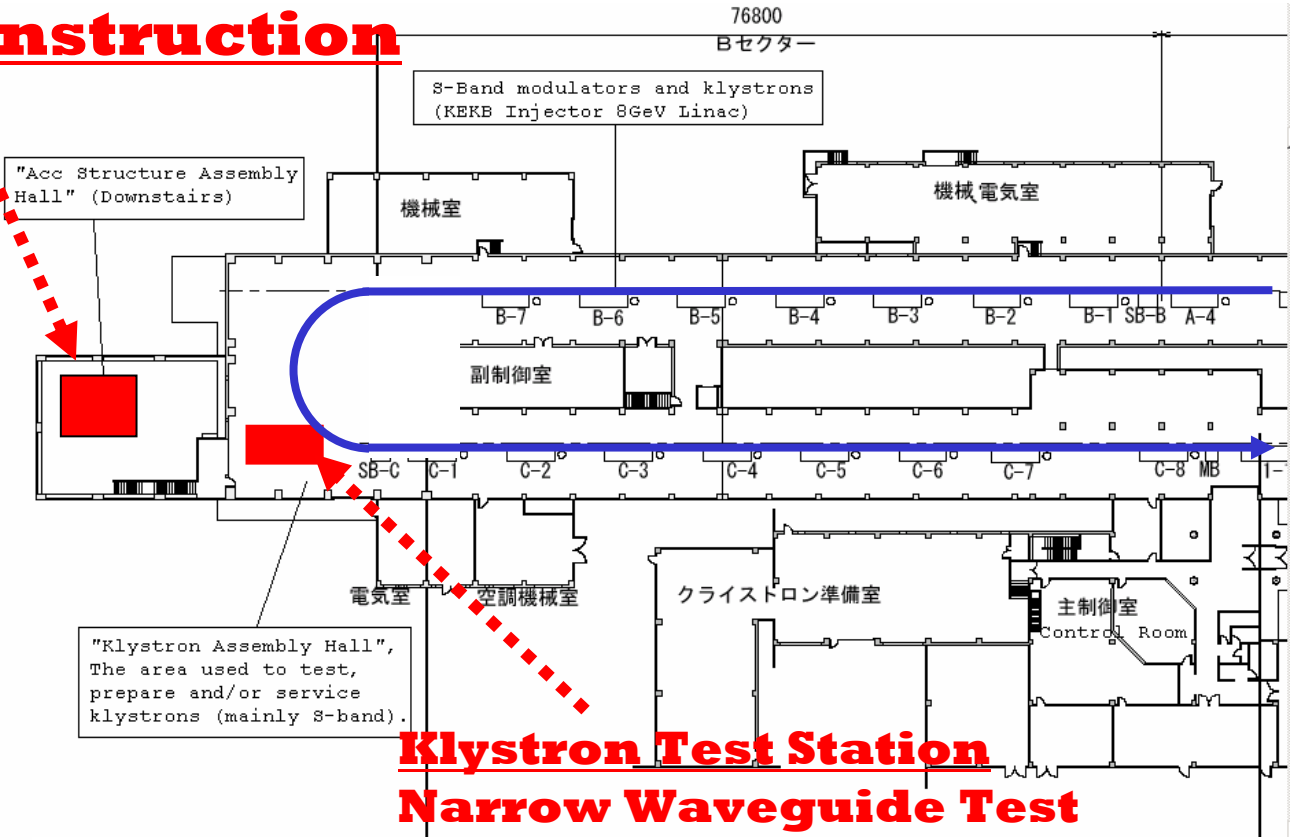
and

Nextef under development

“New” X-band Test Facilities

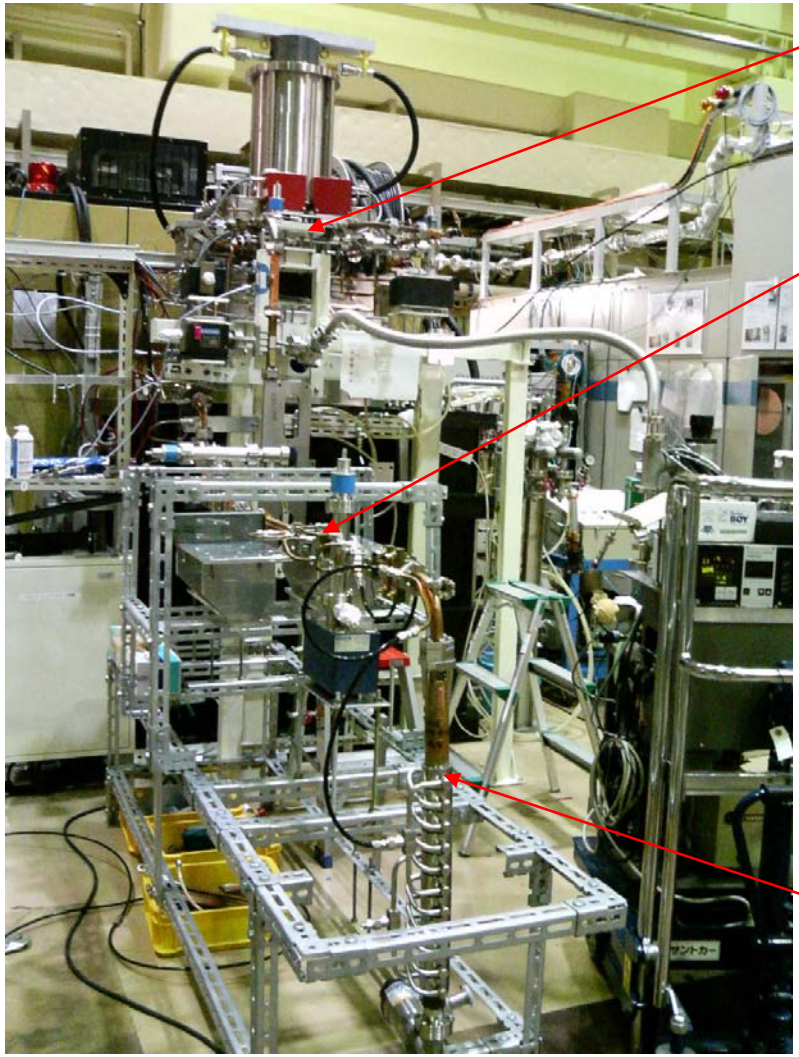
Nextef
under construction





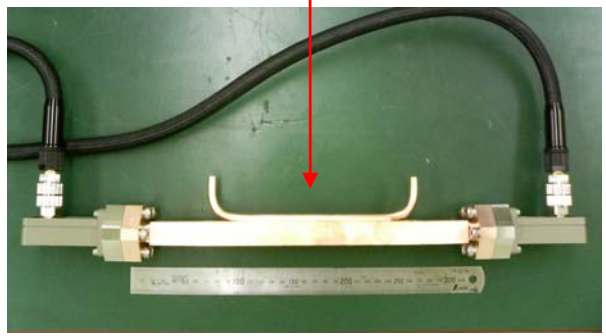
Plan view of KEKB Injector

Klystron test station high field test underway



PPM Klystron

Narrow waveguide
in 5mm lead shield

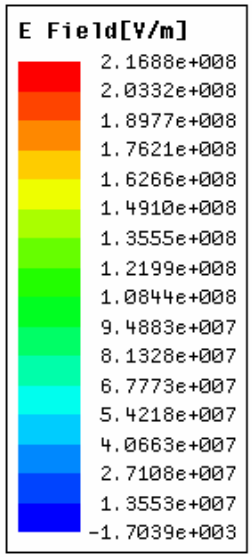


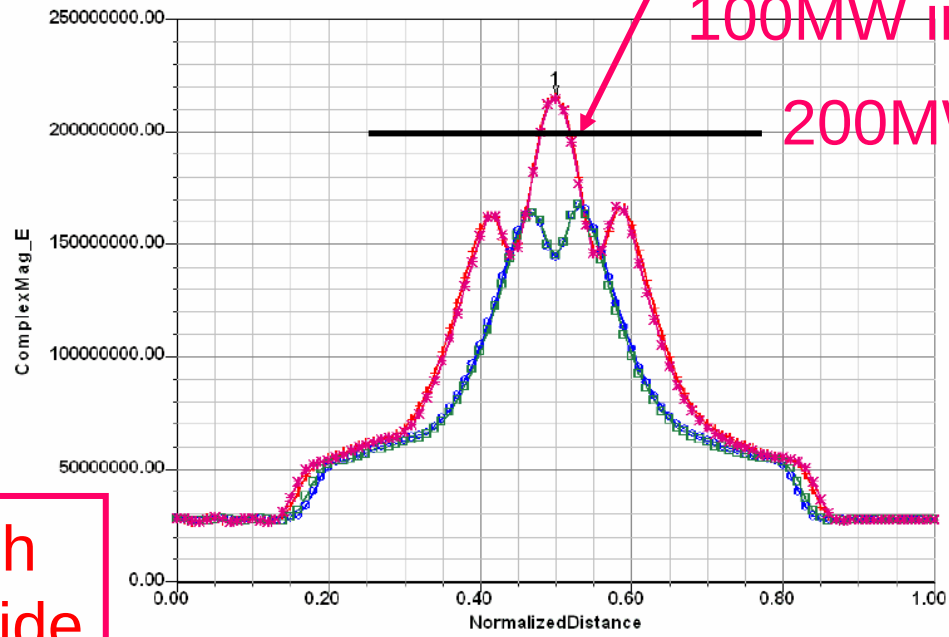
High Power
Dummy Load

Narrow Waveguide Design

Present design at
100MW input

200MW

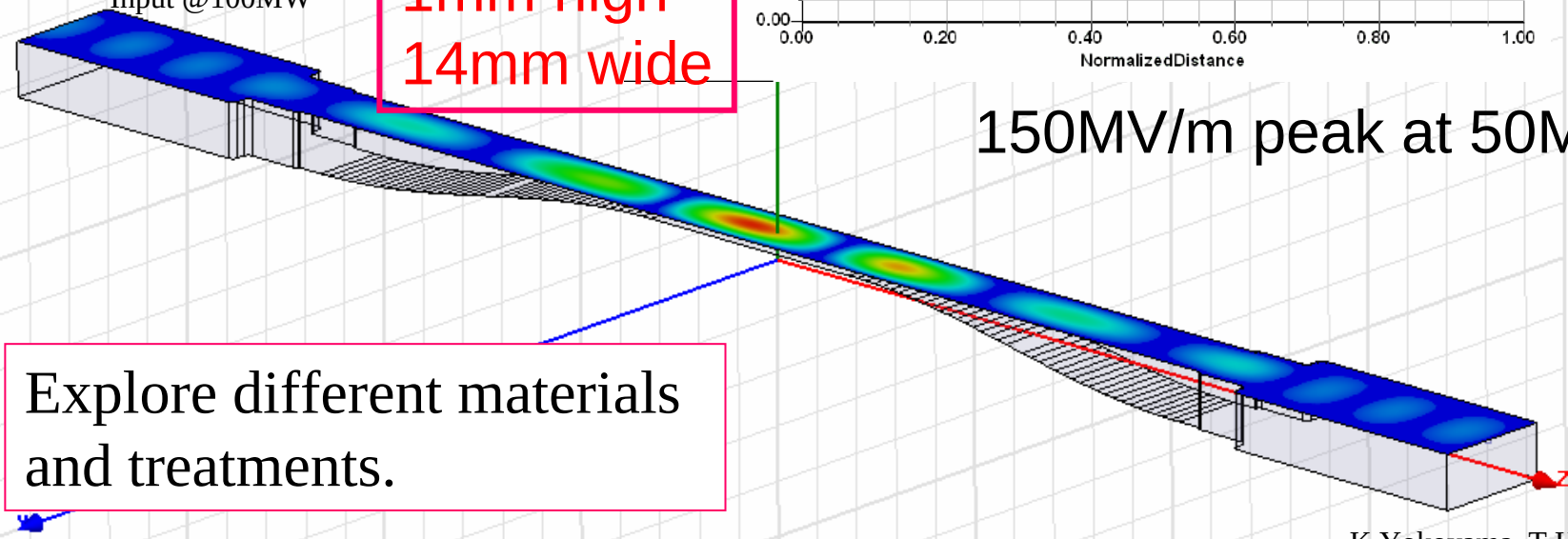




Input @100MW

1mm high
14mm wide

150MV/m peak at 50MW

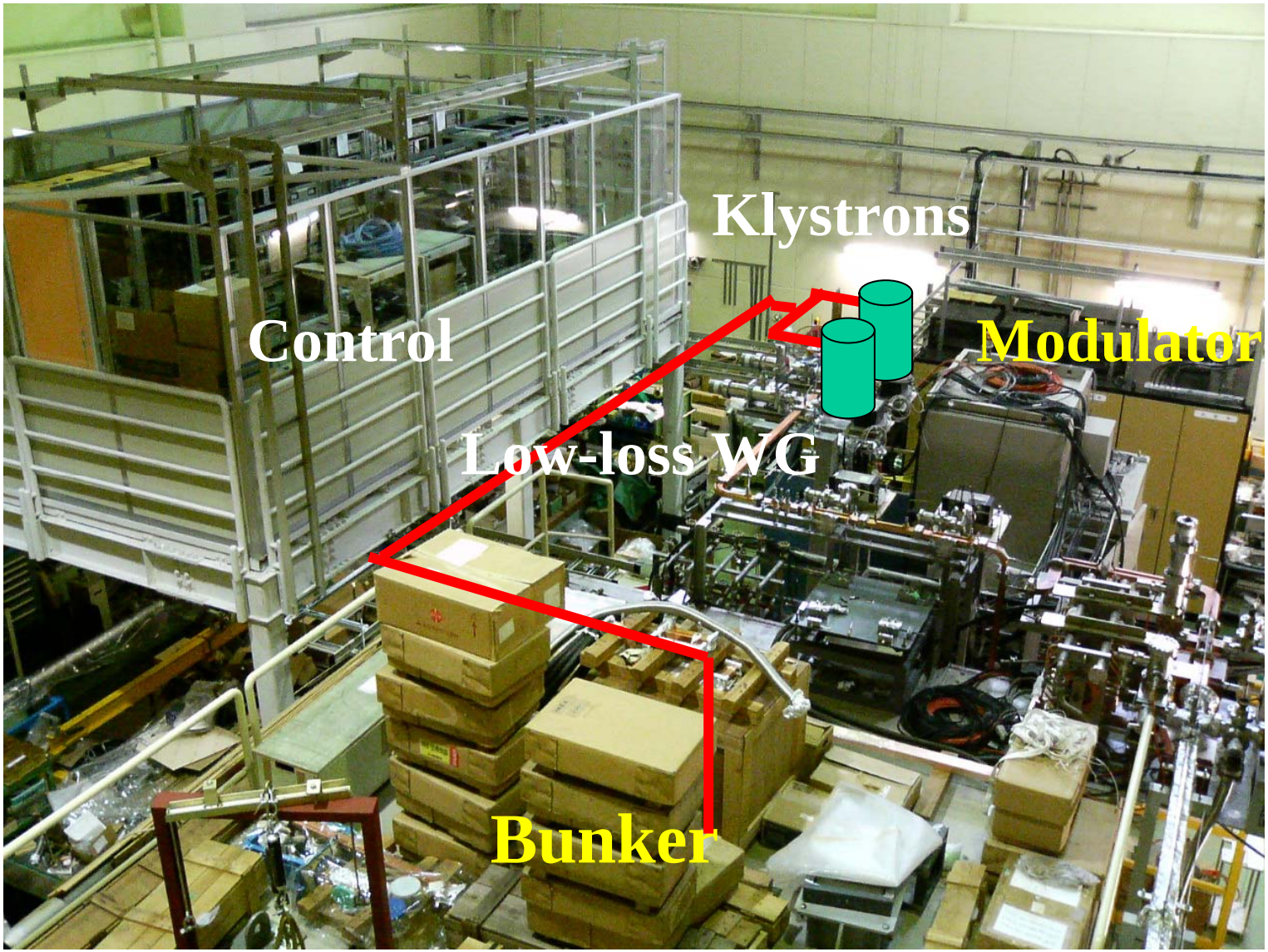


Explore different materials and treatments.

Cu-002 after high-power processing

RF

Nextef



Features of the facility

(100MW, 400ns, 50pps), 24hr/day

50cm-thick concrete shield room

Control system adapted to KEKB Injector control system

- Data acquisition through LINUX and storage with EPICS

RF pulse shape recording for BD and preceding pulses

- Evaluation with stopping operation from the beginning
- Pulse-to-pulse evaluation to be done later (dep. on money)
- Phase measurement not yet planned

Dark current evaluation

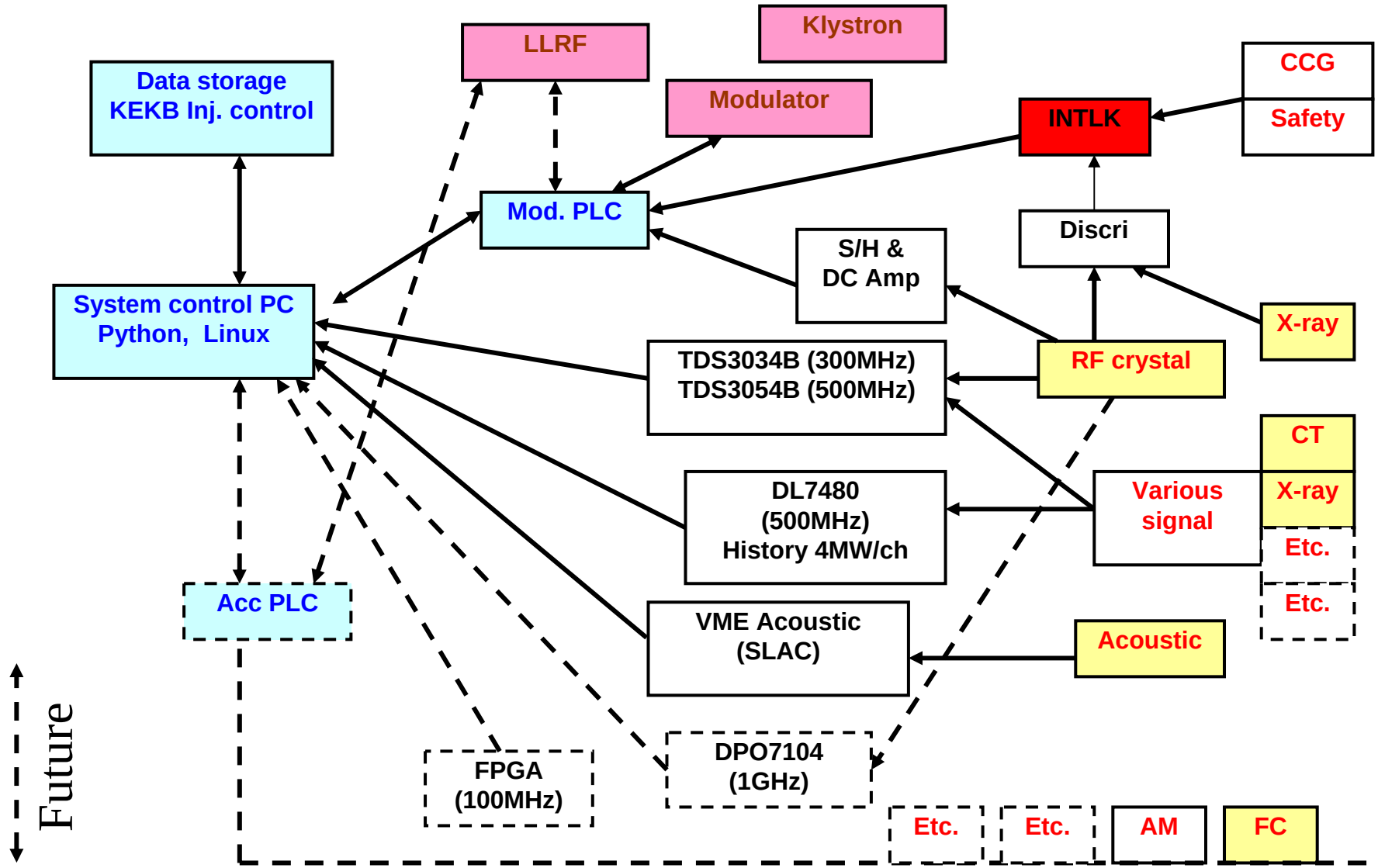
- Charge by FC, pulse shape with CT and energy by analyzer magnet

Acoustic measurement (developed by SLAC)

X-ray measurement with small plastic scintillators with PMT's

Q-mass monitoring

Nextef control system



Construction status of Nextef

1. Startup with each klystron will be in July.
2. Operation with two klystrons combined will be after linac summer shutdown.
3. Sophisticated measurement system will be established in fall.
4. System check by existing KEK structure.
5. High power test of CLIC structure late this year.

Mode of operation in these new facilities

- We can run the system with 24-hours continuous run during linac operation. Linac operators with take care of the system. More than 5000hrs/year will be possible.

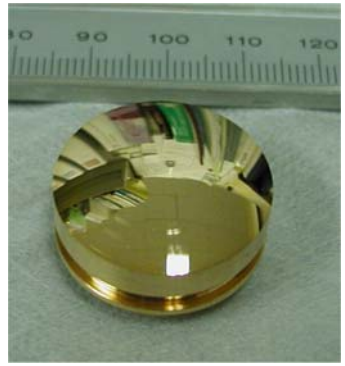
- We try to make the similar continuous operation during shutdown period, but it will be difficult due to the linac maintenance requirement.

Need further implementation?

We will start without the following features.

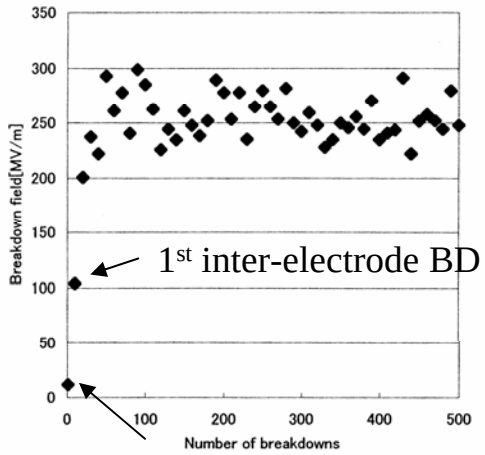
- Pulse-to-pulse analysis
  - Energy deposit of each pulse
  - Apply scheme of linac monitor group using oscilloscope with fast communication
- Phase information
- Power more than 100MW
- Longer pulse than 400ns
- Higher rep-rate than 50Hz
- Automatic with variable width & rep-rate
- Clean system and environment
- Baking at much higher than 200C
- Anything more?

DC High voltage breakdown experiment at Saitama U.



- Pulse with 80kV, 60microsec.
- 500-times BD treatment
- In-situ surface evaluation by AES, XPS
- In-situ baking
- Diamond-turned copper buttons were tested
  - H_2 furnace treatment was found effective to speedup conditioning
- But we have been stopping X-band related activity.

After hydrogen brazing



Fabrication facilities

Mechanical engineering center

Present and future direction

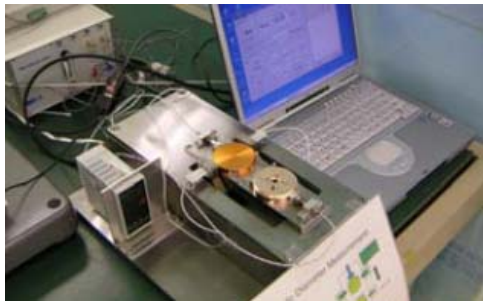
- Present MEC
  - Staff 6 for X-band (21 in total)
  - Machines 5 for high-precision (100 in total)
  - Projects 1 for X-band (30 in total)
- As a next step
  - MEC will set the X-band project as one of the major projects.

Present equipments

Diamond turning lathe

High-precision milling

3D CMM

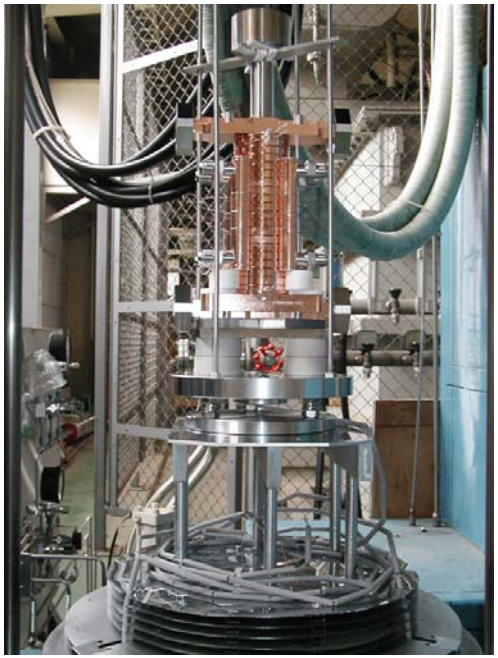


Diameter meas.

Parts rinsing

SEM

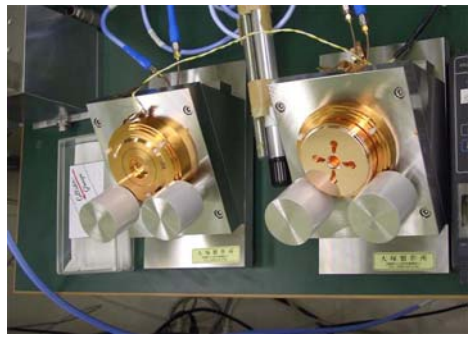
Present equipments



Hydrogen furnace
(20cm structure)

VAC furnace

Furnace for DB
and baking etc.



RF measurement

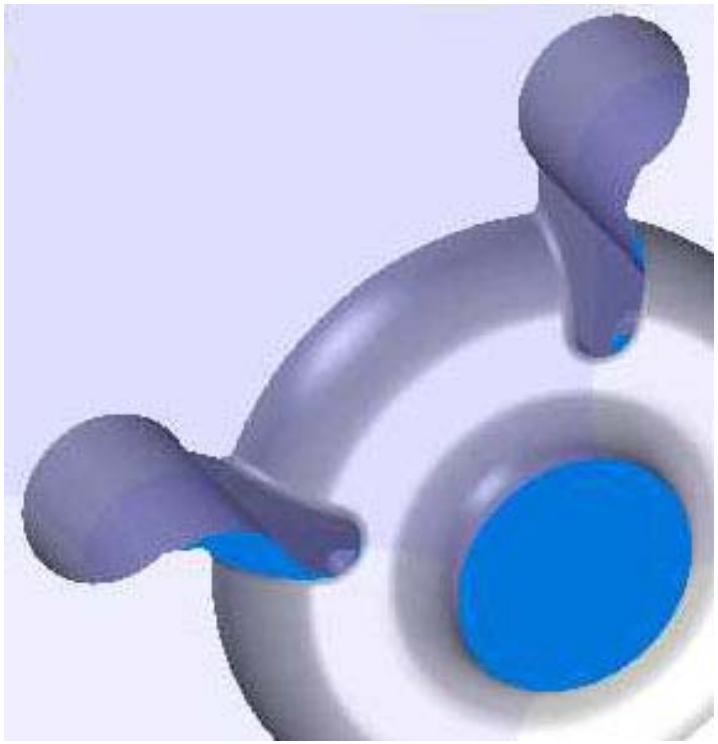
Recent activities
related to accelerator structure

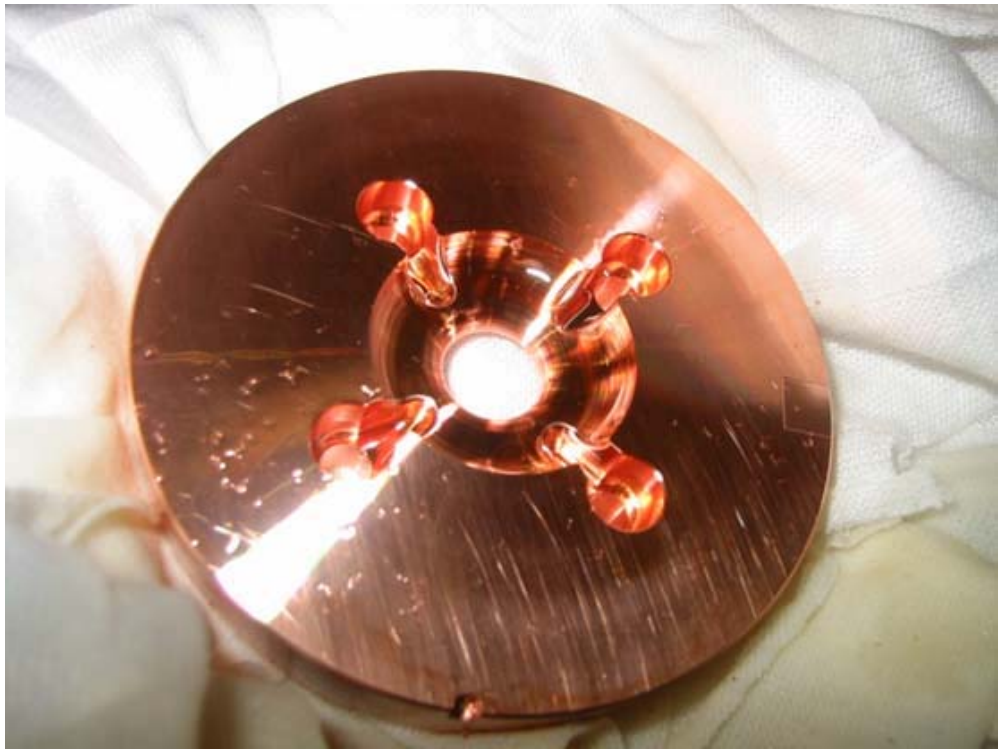
- Turning
  - Rough~medium machining is done by outside vendor, followed by diamond turning at KEK.
- High-precision milling
  - Pilot fabrication study of RDDS was done at Yasuda co.
- Furnace
  - Mostly hydrogen furnace, sometimes vacuum
- Surface treatment
  - We developed a chemical treatment setup following SLAC recipe for diamond-turned copper

Mechanical machining

- 60cm structures for GLC
  - Milling ~several-micron by outside company
  - Add high-precision diamond turning ~1microns at KEK
- Boosting milling capability for CLIC
  - We have a precision milling machine ~1microns but the spindle not very rigid and with limited-speed ~5000rpm
  - We have ordinal-precision machines ~50microns
  - Further development work was performed with a company, Yasuda co., a leading milling machine vendor.
  - We want to develop a milling capability suitable to CLIC structures.

RDDS disk test fabrication by Yasuda co.



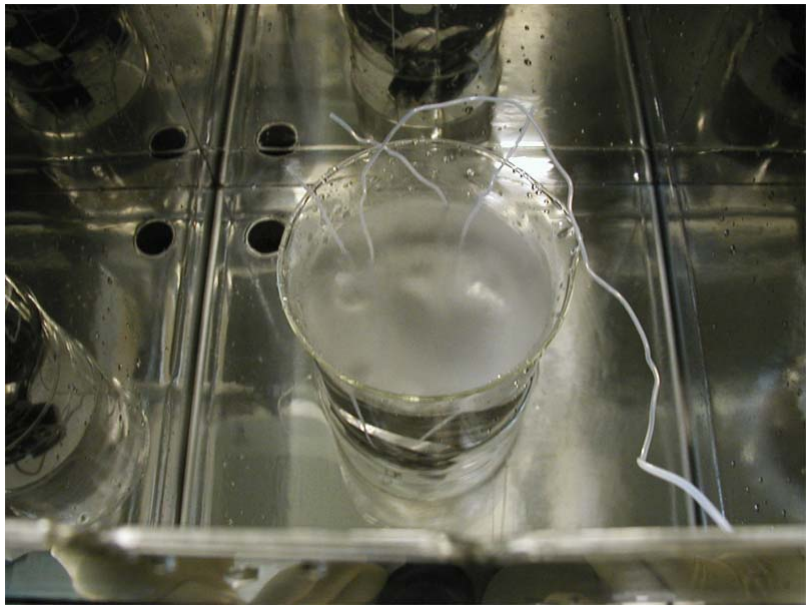


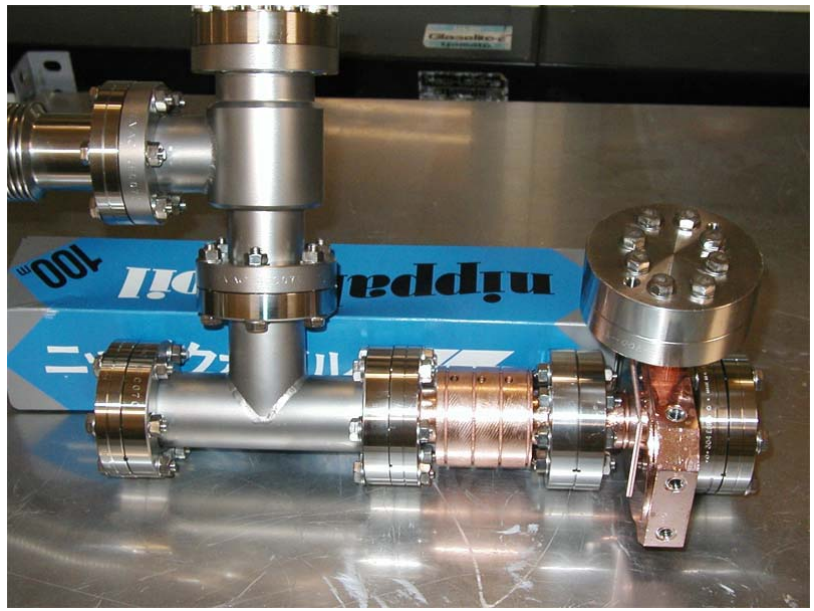
Done with ball-end mill.
Smooth connection from flat through round ridge to key holes.

Thinking surface improvement

- Material
  - HIP?, Single-crystal?, Vacuum melted Mo?
- Chemical rinsing setup
  - Present: Following SLAC recipe, or commercial for good vacuum
  - We will explore better surface treatment method
    - Mega-sonic rinsing
    - Semi-conductor wet cleaning solution
- Surface treatment at high temperature
  - Evaluate high-temperature ~500C baking in closed volume
  - Hydrogen furnace, VAC furnace with Ti foil, …
- Particle free and possibly chemically clean
  - Learn from ILC clean technology
- STF? (in future)
  - EP facility now being developed for ILC

2nd Single cell SW structure preparation





A-02 solution + Megasonic cleaning

960kHz, 600 W, 5 minutes operation

Ultra Pure Water

All parts were applied megasonic cleaning

Assemble envelopment: Class 10

No vacuum leak

300 degC baking, period : 5days

Still needs to improve the cleaning techniques

Collaboration with Kobe Univ.

Exploring machining techniques for accelerator structure

- Fine fly cutting of refractory metals.
  - Moly narrow waveguide will be made.
- Diamond tool
  - Milling with a tool vibrating in ultra-sound ellipsoidal motion.
- Long period is needed now for milling large area.
  - Need evaluation of effectiveness.
  - Need speed-up for practical use?

Overall testing plan

X-band activities at KEK in 2007

- Discuss with CERN and SLAC on collaboration
- High-field test with narrow waveguide
  - –Cu with various surface condition
  - –Comparison among materials, Cu, SUS, Mo, Ti, ….??
- High-field test at Nextef
  - –Establish high-power test system with existing structure
  - –Test on CLIC accelerator structure
- Test fabrication of CLIC structures
  - –Acquire the experience of CLIC design
- Fabrication of cavities for test at SLAC KLY lab.
  - –Surface treatment method
- Fabrication of compact accelerator
  - –1MeV accelerator, RF Gun, etc.

How to establish high gradient

To obtain high-gradient accelerator structure

- We learned from SLAC-KEK program for GLC
  - Several-tens of structures were tested.
  - Still yet to be understood how the final performance was determined.
  - Design parameters, details of the preparation processes, all these should be interrelated.
  - We need more statistics for important evaluation.

- Take the spirit of the S0 task force in ILC
  - S0 is evaluating the same cavity in three regions. Three cavities made in each region are evaluated three times in each region.
  - Important decision should be done with enough statistic and cross checking.

Nextef plan in 2007

- KLY test station (50MW level)
  - –Apr.-July: Narrow waveguide high-field test
  - –Summer~: Continue waveguide components tests
  - –Jan.~: Rebuilt klystron test

- Nextef (100MW level)
  - –July-Aug.: Check two klystron operation
  - –Sept.~: Operation with combining two klystrons
  - –Oct.~: Startup high field study system with an old GLC structure
  - –Nov.~: High-field test of CLIC-related structure
  - –As needed: Narrow waveguide test, single-cell test, etc.
  - –Welcome any high power test plan

Conclusion

- We pursue three main items
  - High power test of structures.
  - Fabrication of structure for CLIC design.
  - Study basic high field and related surface issues.
- Funding and manpower are tight
  - We need to get competitive funding.
  - We try to organize more staffs.
  - We try to extend formal budgetary support from KEK by identifying our work as KEK's well-acknowledged work.
- To promote X-band activity at KEK
  - We want to make this collaboration formality effective for improving X-band activity at KEK.