Status of KEK X-band Test Facility and its future plans

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Contents

- The “New” X-band Test Facility (XTF) and X-band Klystron Test Stand
- Ongoing High Power Test at Klystron Test Stand: Narrow Waveguides
- Other X-band research
- Future plans and possible collaborations.

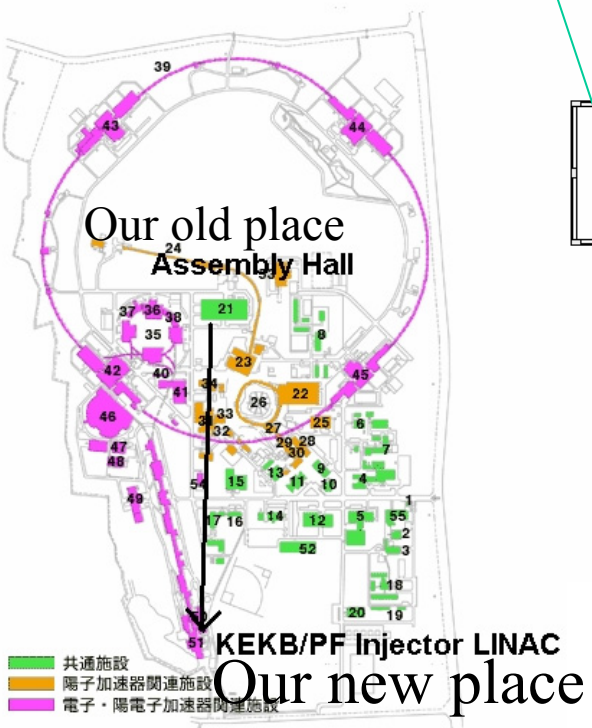
- Summary

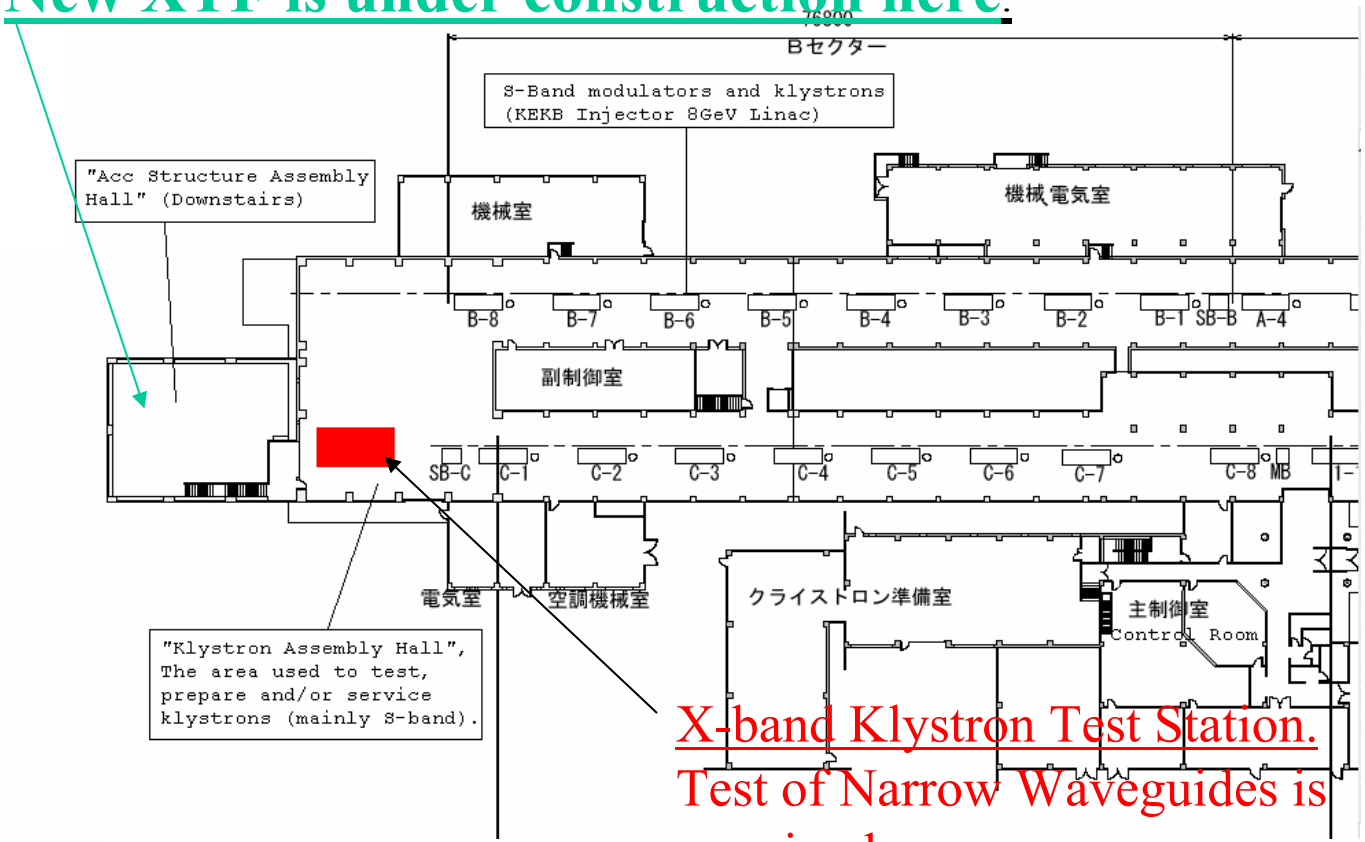
(Re-)Construction of “New XTF” is underway..

- The work started in Jan. 2007, moving the equipment to new place, KEKB Injector Area.
- The operation of New XTF with a single klystron will be ready at the end of July. Half of the power (50MW) is available.
- The operation with two klystrons is possible after the reinforcement of the wall plug power completes (Additional power line will be placed). The work is planed to be done during this summer.
- The full power (100MW) operation of New XTF will be ready in September.

“New” X-band Test Facility (XTF) and X-band Klystron Test Stand

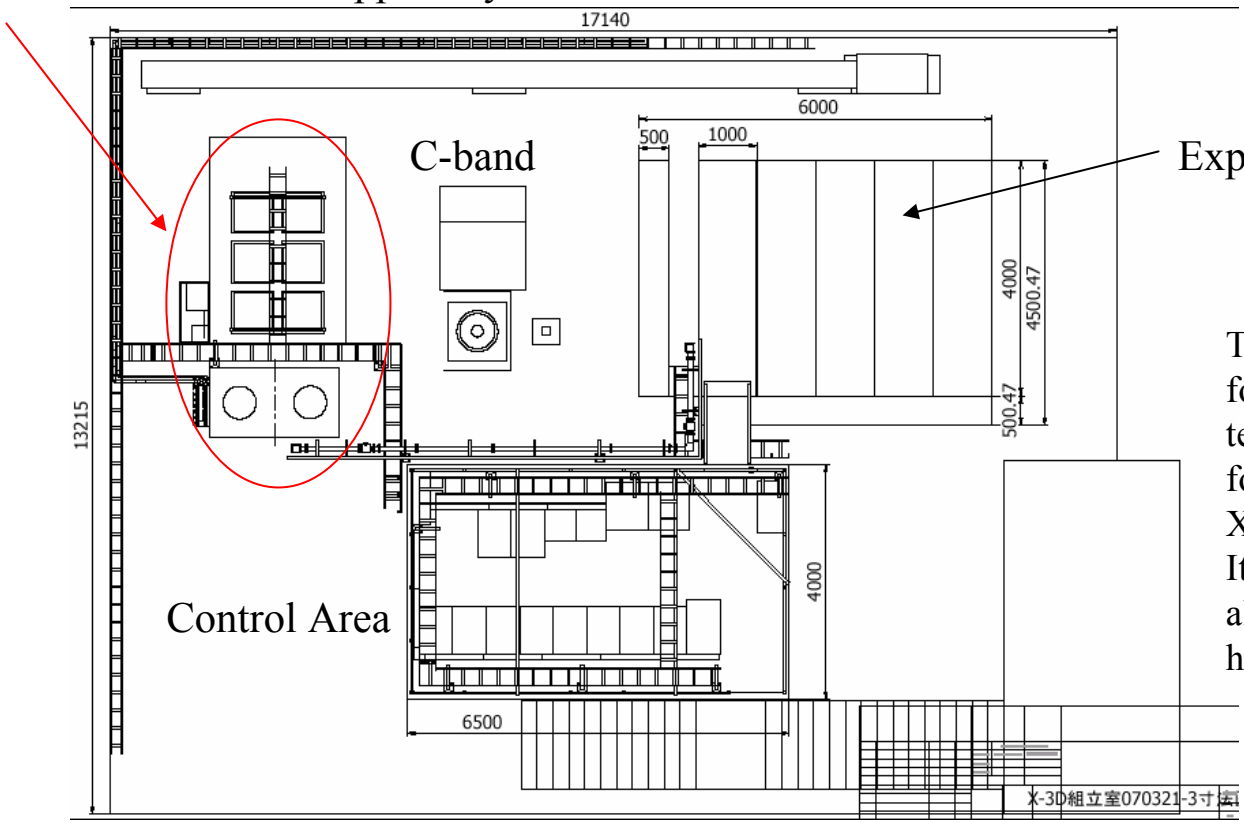
New XTF is under construction here.





Plan view of KEKB Injector

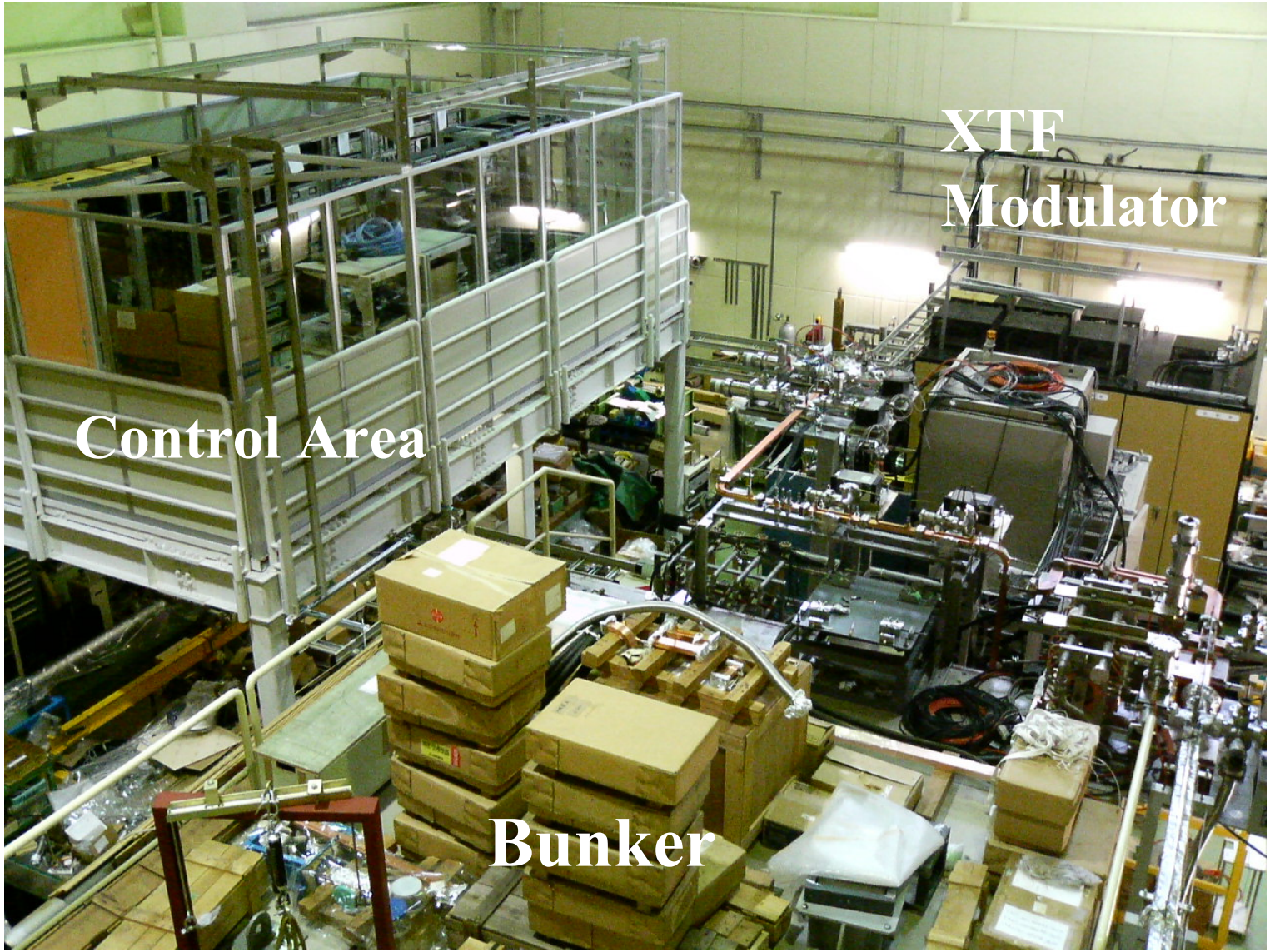
XTF modulator and X-band ppm Klystrons



This hall was used for S-band structure tests first, followed by C-band, and X-band this time. It is possible to use all these frequencies here.

Plan view of Acc structure assembly hall, KEKB Injector.

- XTF Modulator drives two PPM X-band klystrons.
- The combined power from the klystrons is guided into the experimental area (bunker).
- The control/monitor station is located between the power source and the bunker.


XTF
Modulator
Control Area
Bunker

Features of the facility

–(100MW, 400ns, 50pps), 24hr/day

–50cm-thick concrete shield room (bunker)

–Control system will be basically from scratch, adapting control to KEKB Injector area

- Data acquisition and storage through LINUX and 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

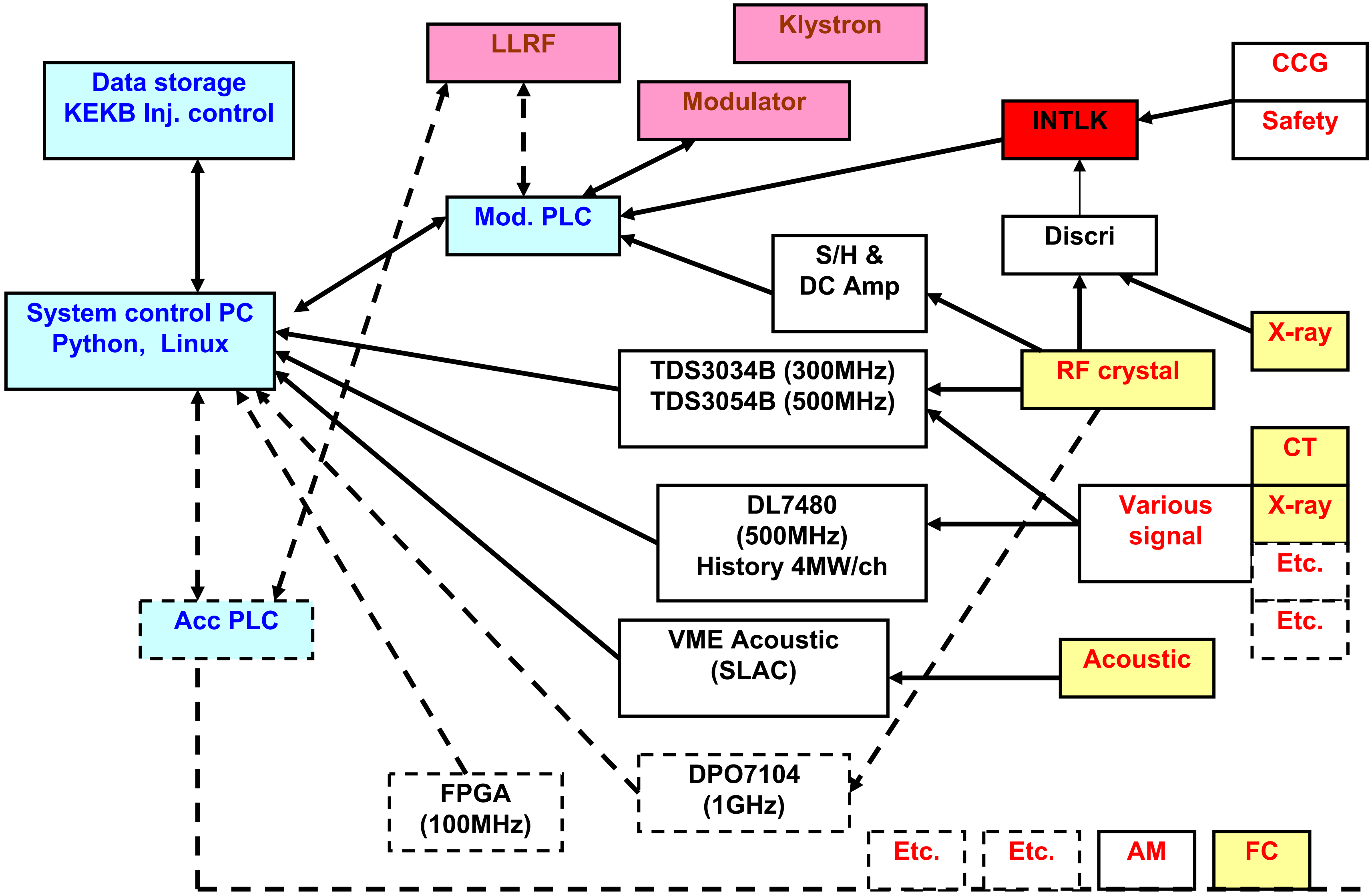
- Charge by FC, pulse shape with CT and energy by analyzer magnet

–Acoustic measurement (developed by SLAC)

–X-ray measurement with small PMT’s

–Q-mass monitoring

New XTF control system



New XTF control system: from the beginning, later

XTF Modulator

• Line-type modulator combined with Inverter charging, Thyratron switched and Pulse Transformer. Conventional design, high reliability.

•The modulator installs two PFNs and thyratrons in parallel. It enables to drive two klystrons simultaneously.

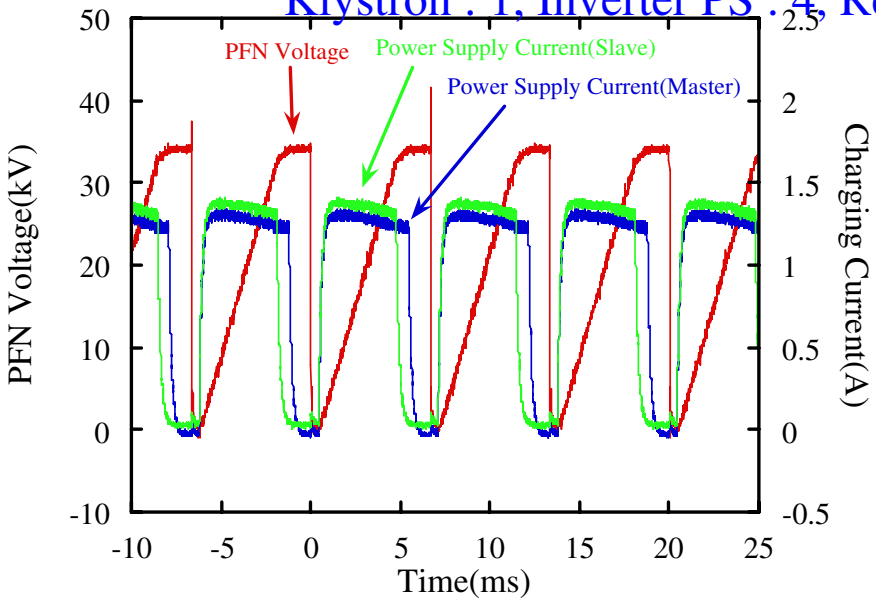
•The first modulator was made in 2003 *in full spec*, while the second one in 2004 mounts a single PFN and is “half” spec.

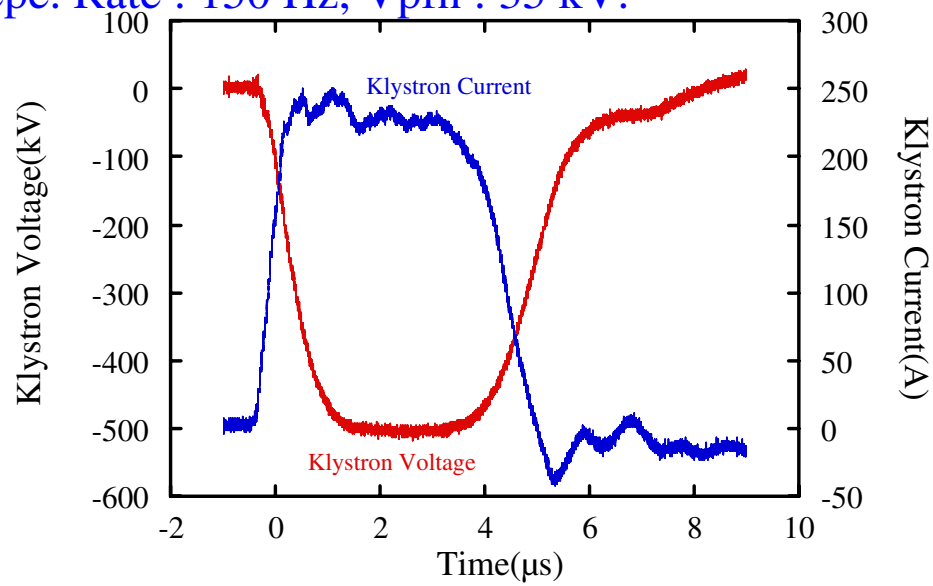
•The first will be used for New XTF. The second is used for klystron testing. It runs at Klystron Test Station (in KEKB Injector) to drive a single klystron.

XTF Modulator (test result and operation)

The test was successfully done.

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





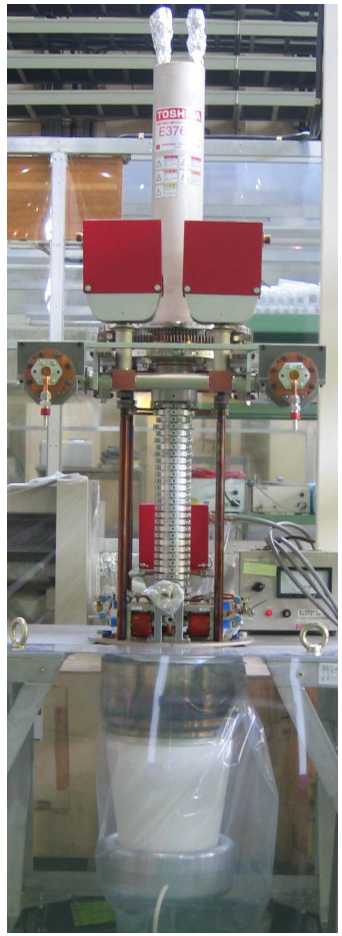
Pule width : 4.5 μs
Flat-top width : >1.6μs(±0.5%)
Rise time : 0.9μs(10-90%)
Pulse voltage stability : ±0.15%

- We have operated both of the modulators for past one to two years. The operation has been stable.
- We have had no chance to do the two-tube operation so far. This is to be done in NEW XTF.

PPM X-band Klystron for XTF

Operation Parameters for XTF

• Operating Frequency	11.424 GHz
• RF Pulse Width	0.4 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 New XTF
• 1 klystron: running at Klystron Test Stand.
•We plan to rebuild 1 klystron in this FY.

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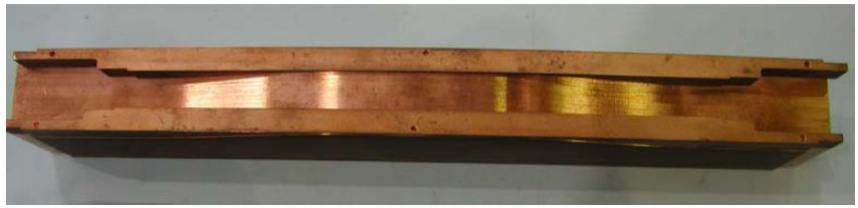
- Summary

Narrow Waveguides

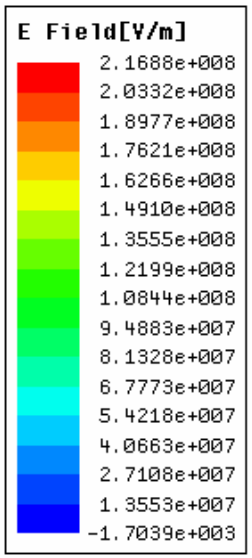
- To study the characteristics of different materials (Cu, SUS, Mo, Ti, etc.) on high-field rf breakdown we designed a simplified waveguide, as the field of 200MV/m being realized at rf power of 100MW.
- Prototype Cu002 had been tested at (Old) X-Band Test Facility (XTF) for about a month. We have observed rf breakdowns by bursts of x-rays, flashes of visible lights and acoustic signals.
- Test of Type SUS003 has just been started at Klystron Test Stand.

K.Yokoyama, T.Higo, N. Kudoh

Design of the Narrow Waveguide

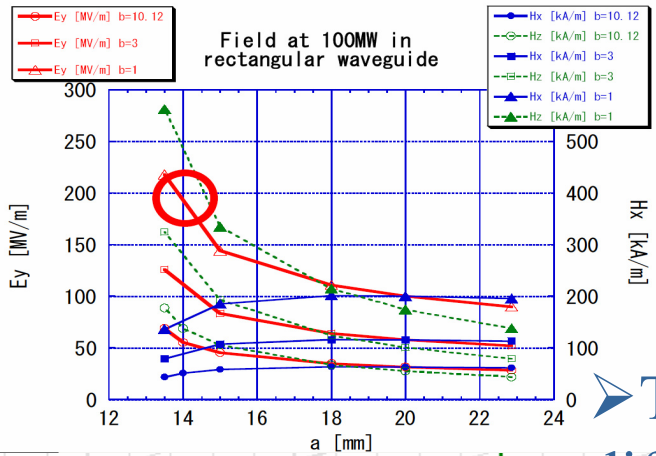


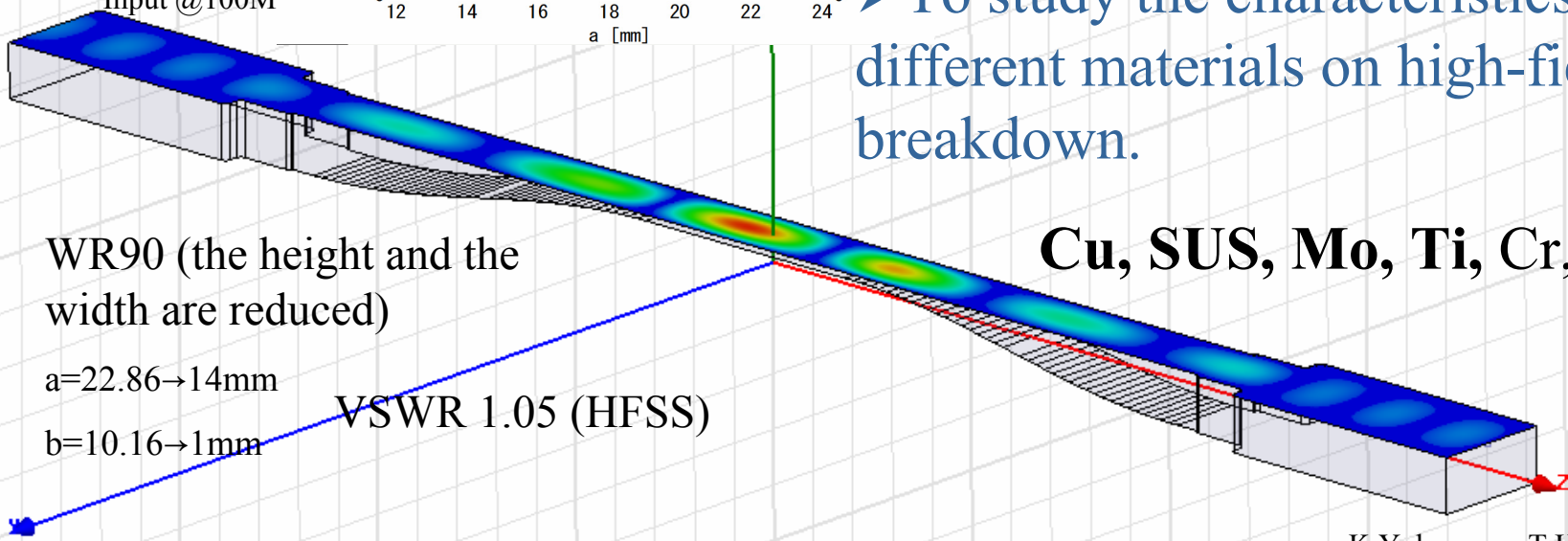
Type of Cu002



Input @100M

200MV/m@100MW





➢To study the characteristics of different materials on high-field rf breakdown.

Cu, SUS, Mo, Ti, Cr, etc.

WR90 (the height and the width are reduced)

a=22.86→14mm

b=10.16→1mm

VSWR 1.05 (HFSS)

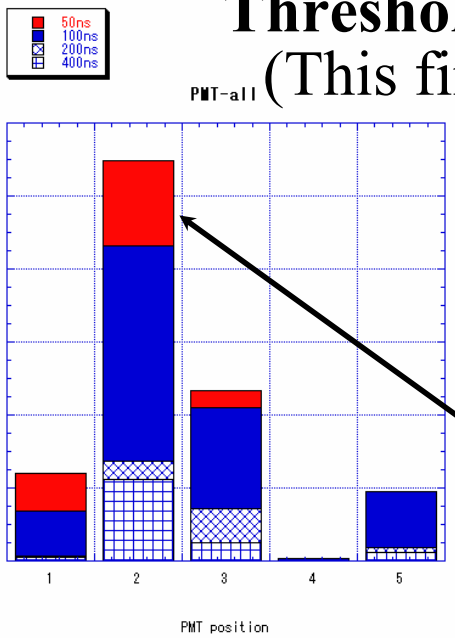
K.Yokoyama, T.Higo, N. Kudoh

Ongoing Test

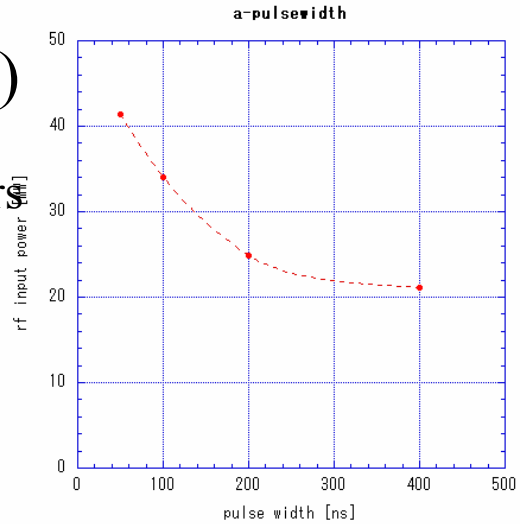
Breakdown Location and Threshold （Prototype Cu002）

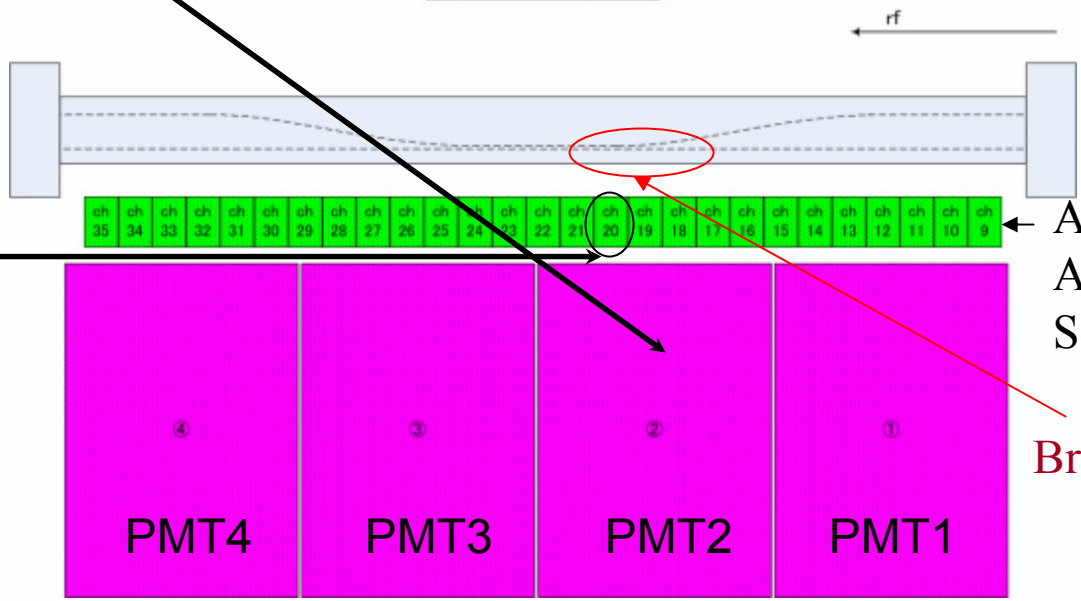
(This first test was done at Old XTF.)

Observed BD Threshold was much lower than expected.



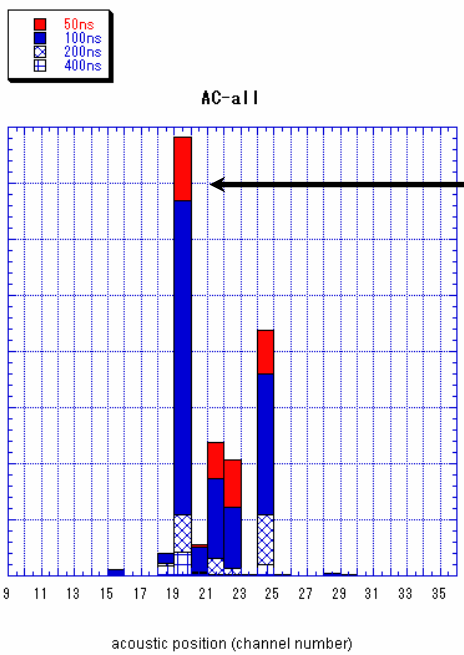
Locations of PMTs and acoustic sensors





Array of Acoustic Sensors

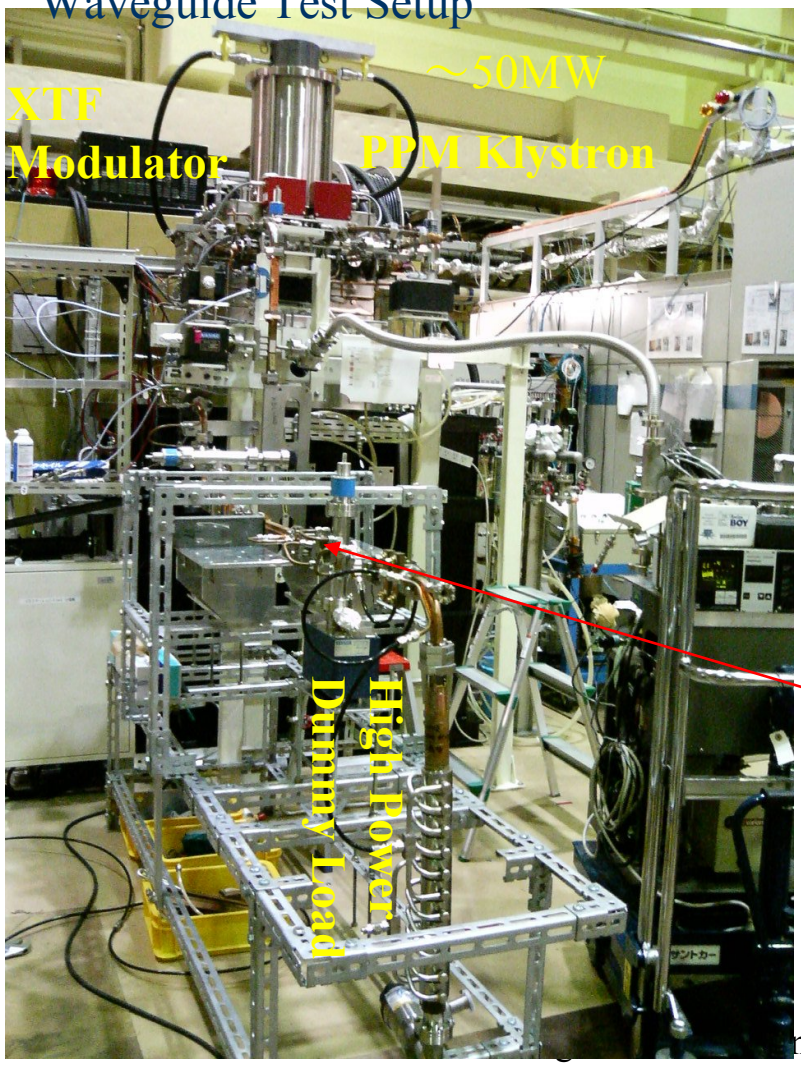
Breakdowns



K.Yokoyama, T.Higo, N. Kudoh

Narrow Waveguides Test has just (re)started at X-band Klystron Test Stand

Klystron Test Stand with Narrow Waveguide Test Setup



Apr 16: Installation started

Apr 25～27: Baking

May 7～: RF ON, system check

May 21～: Testing of Narrow waveguides made of SUS (SUS003)

Jun. ～: Testing of Narrow waveguides made of Cu (Cu004)

Sep. ～: High gradient Testing is started at new XTF(once avilable).

5mm thick Lead Shield Box

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- Ongoing High Power Test at Klystron Test Stand: Narrow Waveguides
- Ongoing X-band research: Surface Treatment and RF BD and/or Dark Current
- Future plans and possible collaborations.

- Summary

Attempt on small amount of dark current and breakdown rate at high gradient by removing particles and metal impurities on the cavity surface

Recipe for the surface treatment

removing particles and metal impurities techniques

- Using a semiconductor wet cleaning solution and Mega-sonic

Making thin Cu_2O layer on the cavity surface

- Vacuum baking at 500 deg.C

Keeping good cleanness at installation into the high gradient test setup

- Making class 100 environment

High gradient test structures

- Single and 3-cell SW structure

Test data analysis

- Needs statistically analysis

- Single cell : 7 structures, 3-cell : 5 structures should be required

removing particles and metal impurities techniques

Catalogs data of Si wafer cleaning by KANTO CHEMICAL CO. Ltd.
We use Frontier Cleaner W-A02

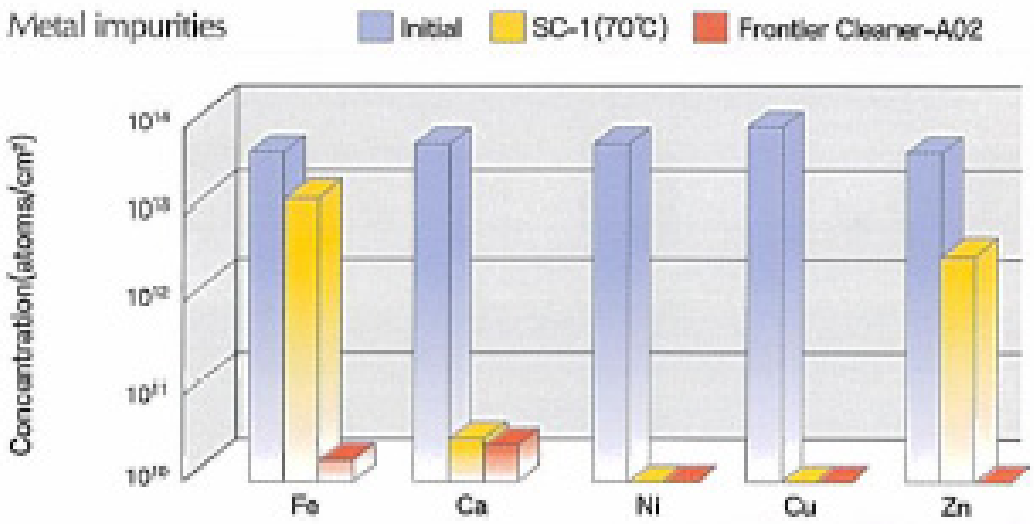


Fig1. Cleaning performance for metal impurities

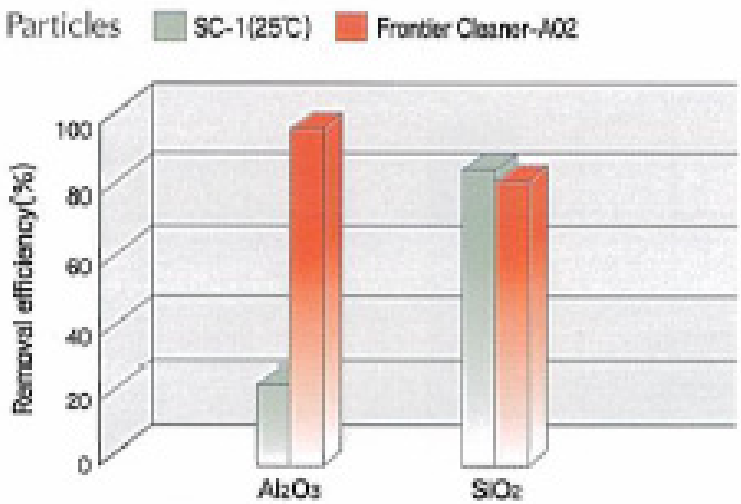
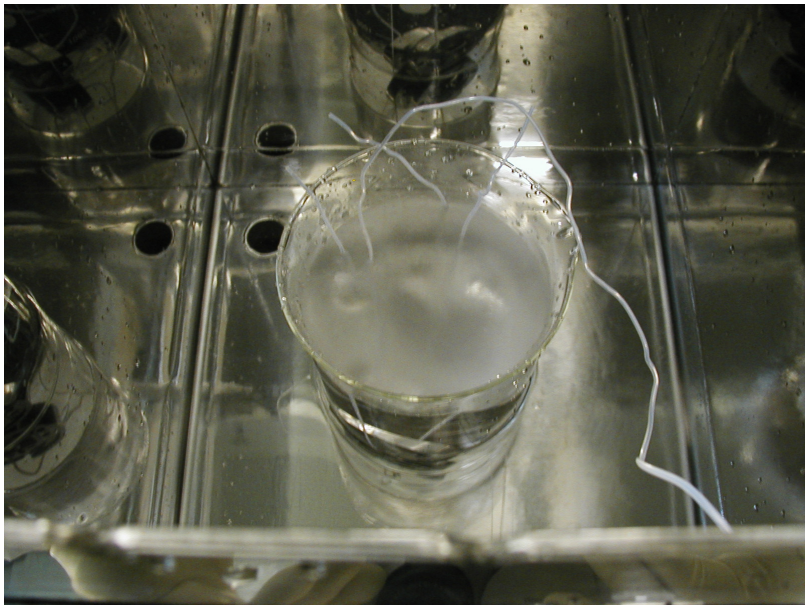
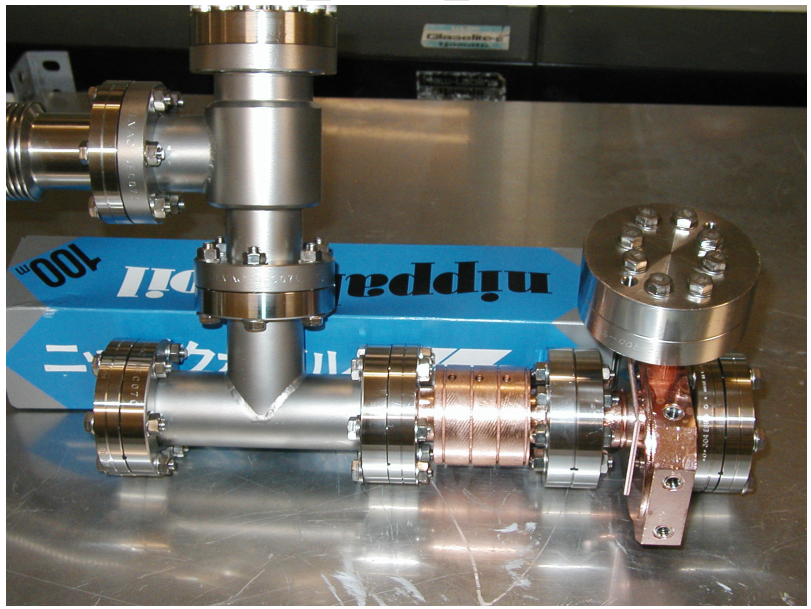


Fig2. Cleaning performance for particles

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

These structures may be tested once New XTF starts up.

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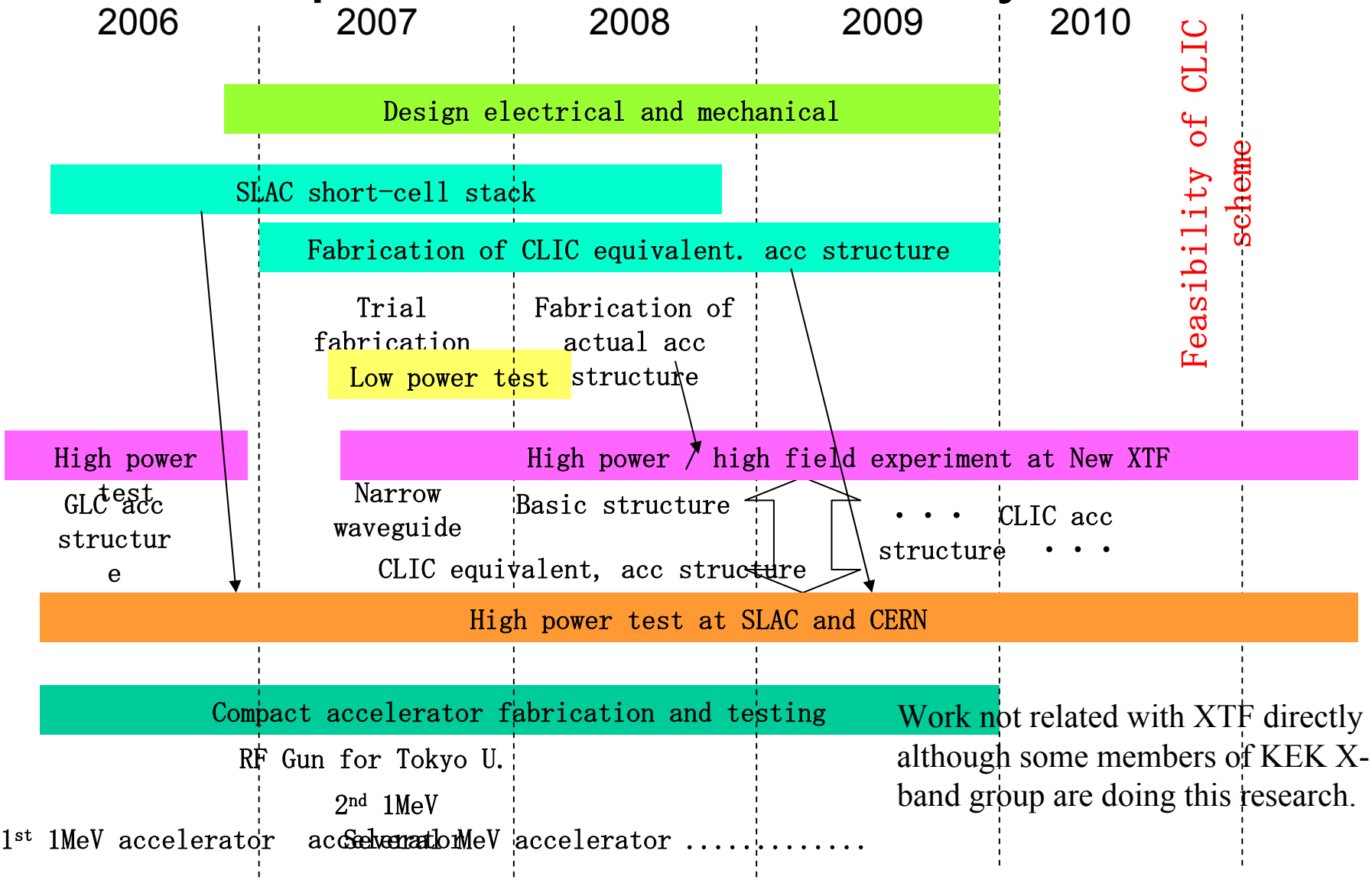
Whole plan of X-band activity at KEK



Work not related with XTF directly although some members of KEK X-band group are doing this research.

X-band activities in 2007

- Discuss with SLAC and CERN on collaboration
- High-field test with narrow waveguide
  - –Cu with various surface condition
  - –Comparison among Cu, SUS, Mo, Ti, ….
- High-field test at new XTF
  - –Firstly establishing high-power test system
  - –Accelerator structure test
  - –High-field tests in general
- Test fabrication of CLIC structure (with MEC)
  - –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.

XTF plan in 2007

- KLY test station (50MW level)
  - –Apr.-July: Narrow waveguide high-field test
  - –Summer~: Continue waveguide components tests
  - –Jan.~: Rebuilt klystron test
- New XTF (100MW level)
  - –June-July: Check two klystron operation
  - –Aug.-Sept.: Operation with combining two klystrons
  - –Oct.: Startup high field study system with an old GLC structure
  - –Nov.-Dec.: High-field test of CLIC-related structure
  - –As needed: Narrow waveguide test, single-cell test, etc.
  - –Welcome any high power test plan

Summary

1. X-band activity in KEK will continue at least the next few years in close relationship with KEKB Injector RF and ACC groups.
2. 50MW X-Band Klystron Station is running. 100MW "New XTF" (name not fixed yet) will be ready to go half in summer and full in autumn 2007 .
3. We expect 100MW 0.4us 50pps pulses available at New XTF.
4. These X-band facilities are open to (international) collaborations.
5. KEK X-band group conducts basic RF breakdown experiments as well as the accelerating structure and component tests.
6. Development of the key devices or the components, such as a klystron, will be continued (although the budget is very tight.)

KEK X-Band Group:

List of the peoples participate in these researches

Mitsuo Akemoto, Shigeki Fukuda, Toshiyasu Higo,
Takuya Kamitani, Noboru Kudoh, Shuji Matsumoto,
Tetsuo Shidara, Kazue Yokoyama, Mitsuhiro Yoshida

Accelerator Laboratory, KEK

Yasuo Higashi, Toshikazu Takatomi, Kenji Ueno

Mechanical Engineering Center, KEK