ARES CAVITY

T. KAGEYAMA

KEKB RF
ARES CAVITY GROUP

KEKB REVIEW

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OUTLINE:

- INTRODUCTION

- CAVITY OPERATION
  INCLUDING ACCESSORY HARDWARE

- TROUBLES AND FEEDBACK
  TO MAINTENANCE

- CONCLUSION

**ARES stands for
Accelerator Resonantly coupled with Energy Storage.**

The resonant coupling means that
the accelerating and storage cavities are coupled
via a non-excited coupling cavity and operated
in the π/2 standing wave mode.

The π/2-mode operation with the coupling cavity
enables the following key design features
of the ARES structure:

· The π/2 mode is the most stable
  against tuning errors and heavy beam loading.

· The stored energy ratio *Us : Ua* can be adjusted
  by changing the coupling factor ratio *ks : ka* .

· The parasitic 0 and π modes can be selectively
  damped by installing a coaxial antenna-type
  damper in the coupling cavity.

· The damped 0 and π modes are located nearly
  symmetrically with respect to the π/2 mode.
  Therefore, their impedance contributions
  to the beam instability cancel out each other.

· The coupling cavity functions as a filter
  to isolate the storage cavity from the HOM's
  of the accelerating cavity.

- Energy Storage Cavity

    a large cylindrical cavity (ø1070 mm x 1190 mm)

    a steel structure whose inner surfaces are copper-plated (bath: copper pyrophosphate)

    operated in the TE013 mode (Q = 165000)

- Accelerating Cavity

    a HOM damped copper structure brazed
    in a vacuum furnace

    four rectangular HOM waveguides for damping
    the monopole HOM's and also the dipole HOM's
    deflecting the beam in the vertical direction

    two grooved beam pipe at both endplates for
    damping the dipole HOM's deflecting the beam
    in the horizontal direction

- Coupling Cavity

    a copper structure
    directly brazed to the accelerating cavity

    equipped with a coaxial antenna coupler for
    damping the parasitic 0 and π modes (QL ~ 100)

- Half-Cell Coupling Cavity

    a copper structure brazed at the opposite side
    terminating with the π/2 mode boundary condition

ARES CAVITY
PRODUCTION AND INSTALLATION

· The 1st production & installation phase

    24 ARES cavities produced.

    All cavities pre-processed in a teststand
    before installation.

· The 1st stage of KEKB operation
  Dec. 1998 ~ Jul. 1999

    LER: 12 ARES cavities in Fuji RF sections D7 & D8
         Vc (total) 5 MV

    HER: 6 ARES cavities in Oho RF section D5
         (4 SC cavities in Nikko RF section D11)
         Vc (total) 9 MV

ARES CAVITY
PRODUCTION AND INSTALLATION

(continued)

• The 2nd production & installation phase

    12 more ARES cavities produced.

    8 more ARES cavities installed
    in the summer of 1999.

• The 2nd stage of KEKB operation   Oct. 1999 ~

    LER: 16 (12 + 4) ARES cavities
        Vc (total) 5 MV

    HER: 10 (6 + 4) ARES cavities
        Vc (total) 9 MV --> 11 MV   Jan. 25, 2000 ~

CAVITY OPERATION

· Cavity voltage

LER   HER
0.31 ~ 0.42 MV / ARES (the design voltage 0.5 MV)

all production cavity tested up to 0.55 MV
the prototype ARES96 tested up to 0.8 MV

· Tuners for accelerating and storage cavities

---> Both tuners function well

· Input couplers (type OUC and CHK)

---> Both types function well

except a few widow arcing trips per day @D7A-2

· Coupling cavity damper

---> Successful

except a trouble of cooling water leakage
of the 40-kW dummy load @D8C-1.

CAVITY OPERATION

(continued)

- **HOM loads**

  ---> function well

    HOM power @ 500 mA in LER

      500 W for SiC Bullets per cavity

      ~ 300 W for SiC Tiles per cavity

- **Routine RF conditioning recommended for stable operation**

    --> several hours per week

    --> Trip rate reduced below 0.1 /cavity/day
        in steady operation

TROUBLES

- Burning of rubber vacuum seal
  @ ARES D8C-1 (LER) in Apr. 1999

    The rubber vacuum seal at the flange connection
    between the coupling and storage cavities was
    burned due to RF power leakage.

    ---> The contacting surface of the storage cavity
    side not perfectly machined.

    The storage cavity was replaced with a good
    one during the spring shutdown (May 1999)
    for BELLE roll-in.

    Rubber vacuum seal at the flange connection
    temporarily used for pre-processing in the
    teststand and also in the KEKB tunnel
    for early commissioning stages.

    Every ARES cavity for LER was sealed
    by welding the stainless-steel lips at the flange
    connection after removing the rubber seal
    during the summer shutdown of 1999.

    For HER --->
    scheduled in the summer shutdown of 2000.

TROUBLES
(continued)

· **Burning of the doorknob of the input coupler
@ ARES D7D-2 (LER)   Jan. 11, 2000**

Frequent RF reflection trips occurred
during RF conditioning for start-up
after the New Year holidays.

The doorknob (copper) of the input coupler
burned and partly melted down.

---> the thin copper dome not perfectly
brazed to the outer stiffener ring ?
(under investigation)

Fortunately, the doorknob and surrounding
waveguide parts replaced without breaking
vacuum.   ---> recovered in ~ 6 hours

FEEDBACK

Monitoring the doorknob temperature
for all installed input couplers and systematic
maintenance according to the temperature data
reduced window arcing trips.

CONCLUSION

· All installed ARES cavities including accessory hardware function well.

· Cavity vacuum steadily improved.
For every cavity in HER, the temporary rubber vacuum seal at the flange connection will be removed in the summer of 2000.

· Logging and systematic feedback to maintenance are important. Monitoring the doorknob temperature of every input coupler and systematic maintenance according to the data reduced window arcing trips.

· Operational experience acquired through the early stages of KEKB commissioning is valuable to improve and enhance the performance of the ARES cavity under high current beam environment.

π/2 - mode basics
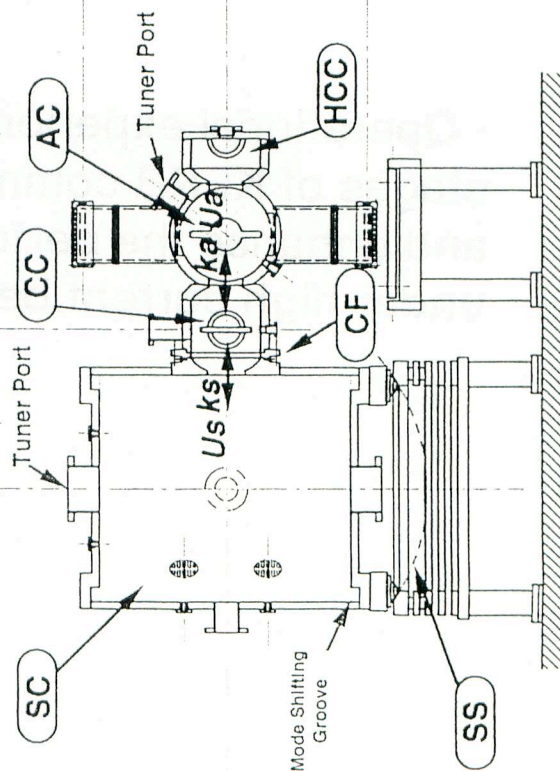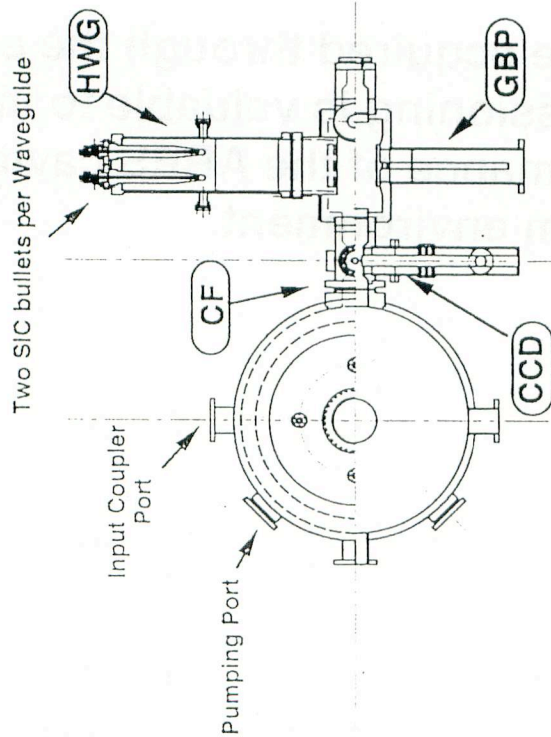
$$Ua / Us = ks^2 / ka^2$$

RF Parameters of the π/2 Accelerating Mode

$Ua : Us = 1 : 9$
$R/Q = 15\ \Omega$
$Q = 1.1 \times 10^5$
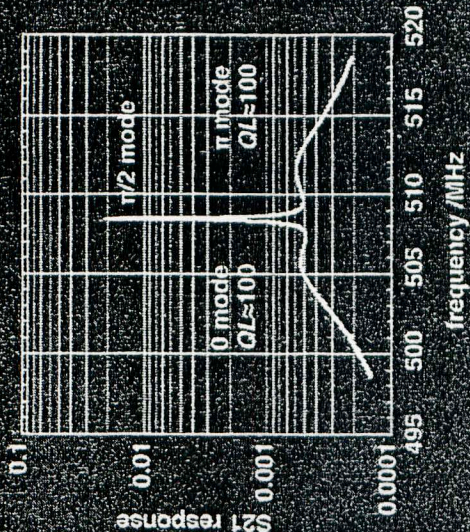
High-Power Performance

$Pc = 150$ kW / ARES Cavity (KEKB Design)
generating
$Vc = 0.5$ MV

Maximum Continuous
$Pc = 380$ kW
Maximum for 20 minutes
$Pc = 450$ kW

S21 response vs frequency/MHz

π/2 mode
π mode QL≈100
0 mode QL≈100

HWG
GBP
Two SIC bullets per Waveguide
Eight SIC tiles per Groove

HWG
GBP
CF
CCD
Input Coupler Port
Pumping Port
Two SIC bullets per Waveguide

AC
CC
HCC
CF
Tuner Port
SC
SS
Mode Shifting Groove
$Us\ ks$
$Ka\ Ua$
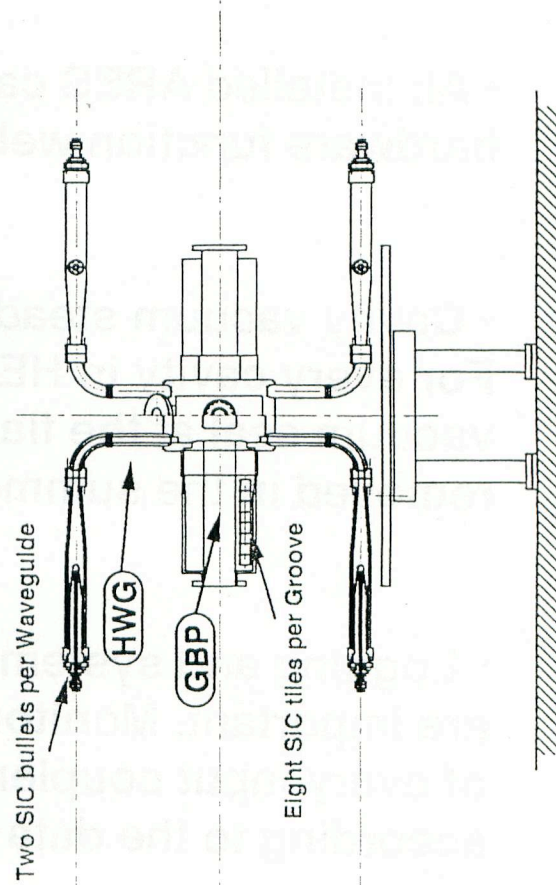
AC) Accelerating Cavity
with four HOM rectangular waveguides (HWG's) for damping monopole and dipole-V HOM's,
with two Grooved Beam Pipes (GBP's) at both end plates for damping dipole-H HOM's.

CC) Coupling Cavity functions as the keystone of the ARES structure
and equipped with a Coupling Cavity Damper (CCD) to damp the parasitic 0 and π modes.

CCD) Coupling Cavity Damper for reducing the impedances of the parasitic 0 and π modes.
The π/2 coupling mode is damped about $Q_L \approx Q_{ext} \approx 50$.
Both 0 and π modes are damped about $Q_L \approx 100$.

CF) Connecting Flange
The Storage Cavity (SC) and the Coupling Cavity (CC) are mechanically connected at rectangular flanges
with bolts, and vacuum-sealed by TIG-welding the lips around the flanges.

GBP) Grooved Beam Pipe selectively lowers the cutoff frequency of the TE11 traveling wave
and damps dipole HOM's in the acclerating cavity.
Each groove has 8 SiC ceramic tiles brazed to a water-cooled copper plate.

HCC) Half-cell Coupling Cavity restores the symmetry of the accelerating cavity (AC)
with respect to the mid vertical plane including the beam axis.

HWG) HOM Wageguide (240 mm x 28 mm) for damping monopole and dipole-V HOM's.
Two bullet-shape sintered SiC ceramic absorbers are inserted from the end plate of each waveguides.

SC) Storage Cavity is a cylindrical steel cavity with electro-plated copper surfaces.
The operating mode is the TE013 mode with $Q_0 = 165000$.

SS) Supporting Strucutre allows the storage cavity (SC) the x- and y-parallel motions in the horizontal plane
and the pitch-, roll- and yaw-motions with respect to the connecting flange (CF) direction.
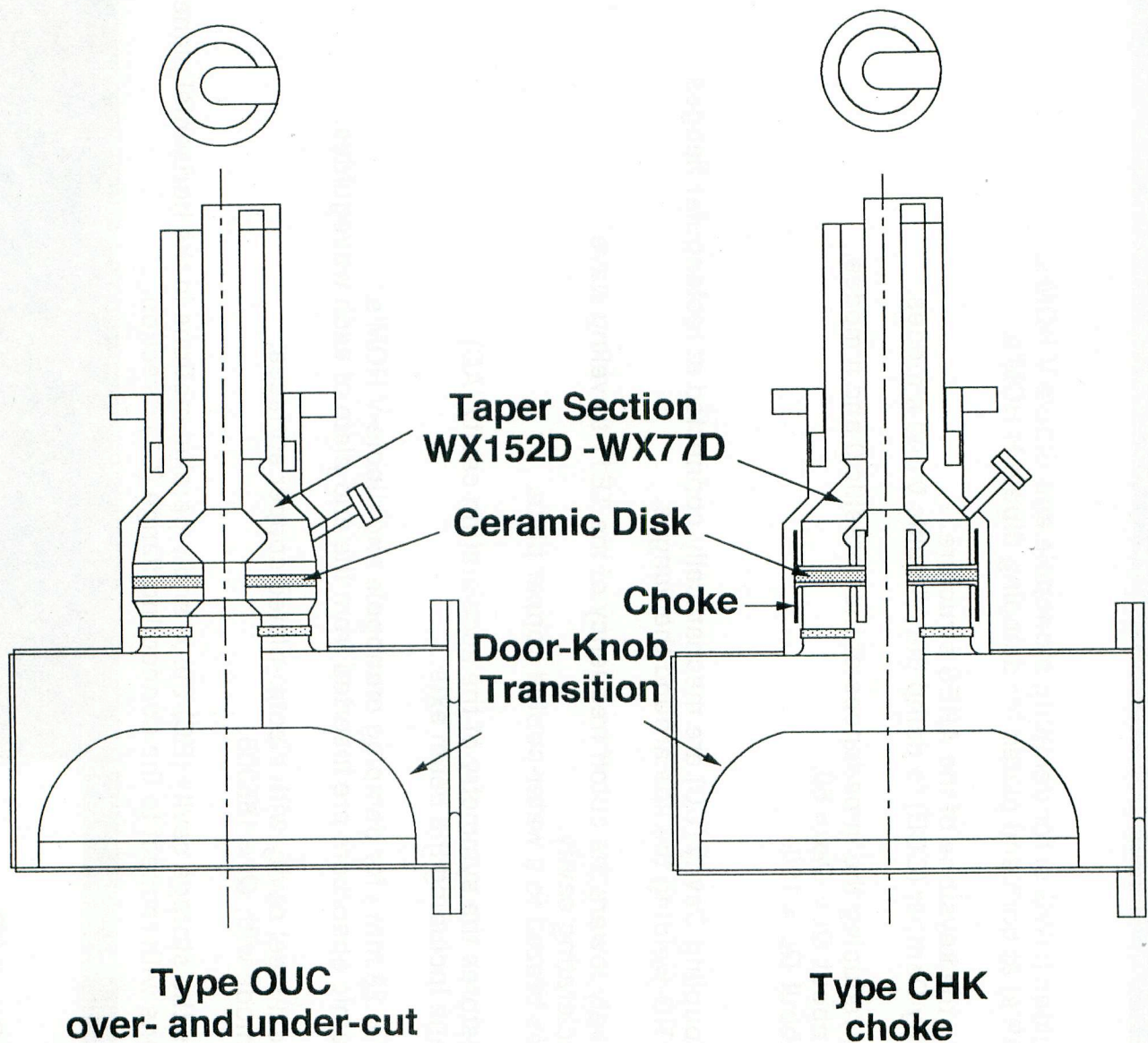
U_a : the stored energy in AC
U_s : the stored energy in SC
k_a : the coupling factor between AC and CC
k_s : the coupling factor between SC and CC

INPUT COUPLERS

Taper Section
WX152D -WX77D

Ceramic Disk

Choke

Door-Knob
Transition

Type OUC
over- and under-cut

Type CHK
choke

- **Input couplers with two different window matching structures (OUC and CHK) have been developed.**

- **Both types have been tested over the design RF input power of 400 kW and up to 950 kW.**

COUPLING CAVITY DAMPER

Antenna

WX120D

A Ceramic Disk →
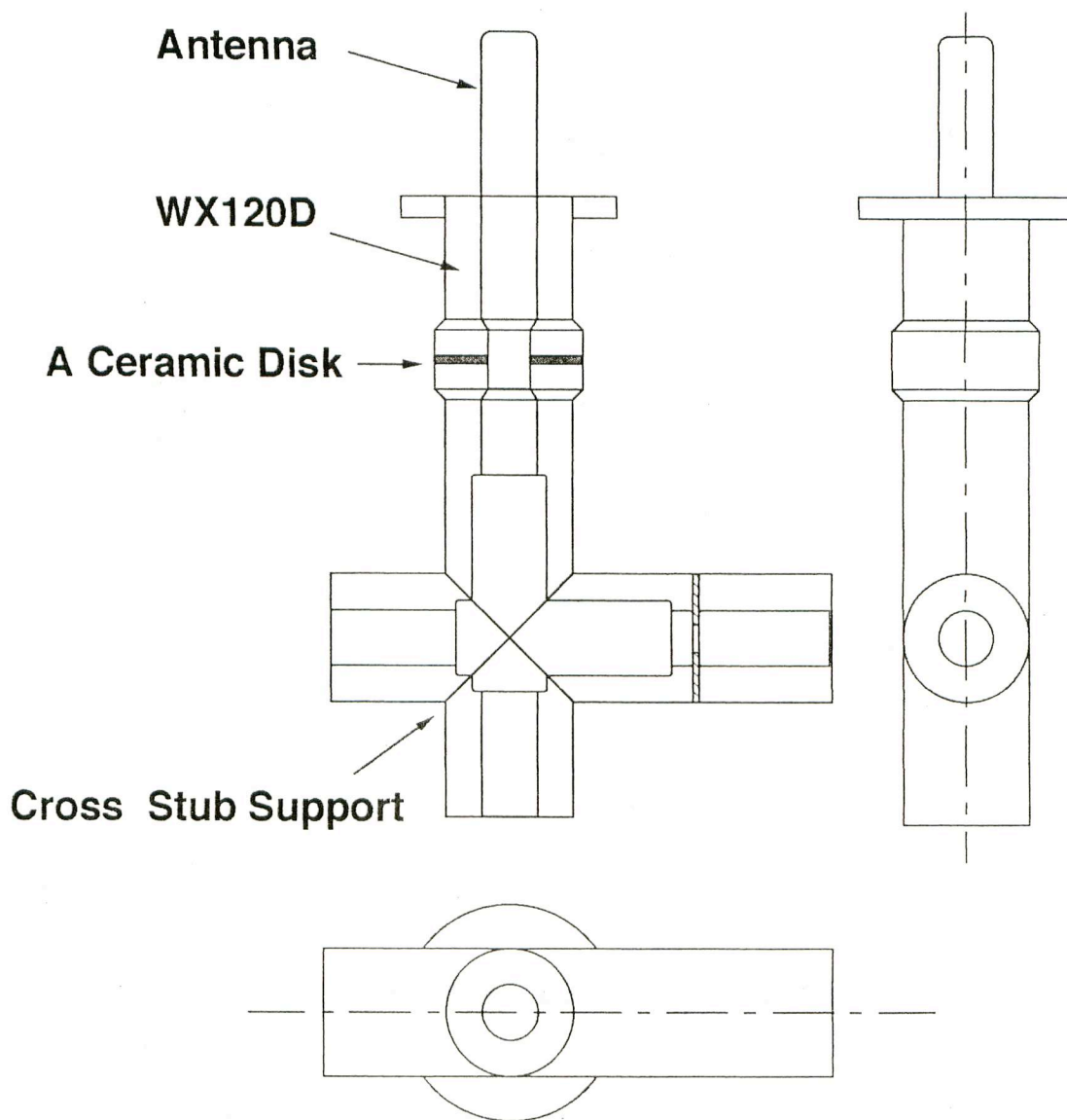
Cross Stub Support

RF power is extracted from the coupling cavity (Qext ~ 50)
through a coaxial waveguide (WX120D)
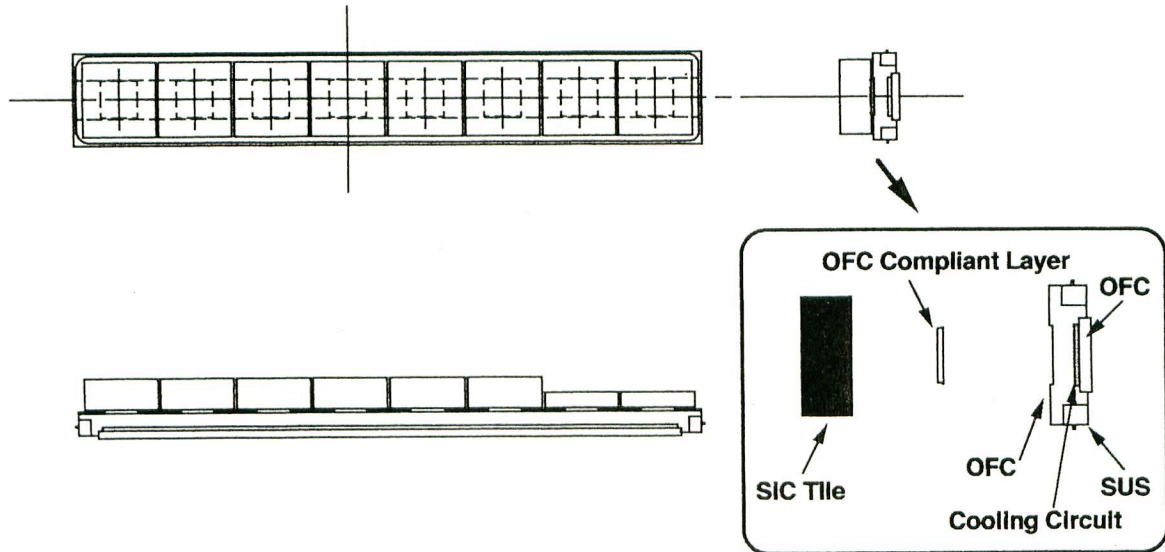with a disk-type ceramic window and a cross stub support.

Power capability tested up to ~ 20 kW CW
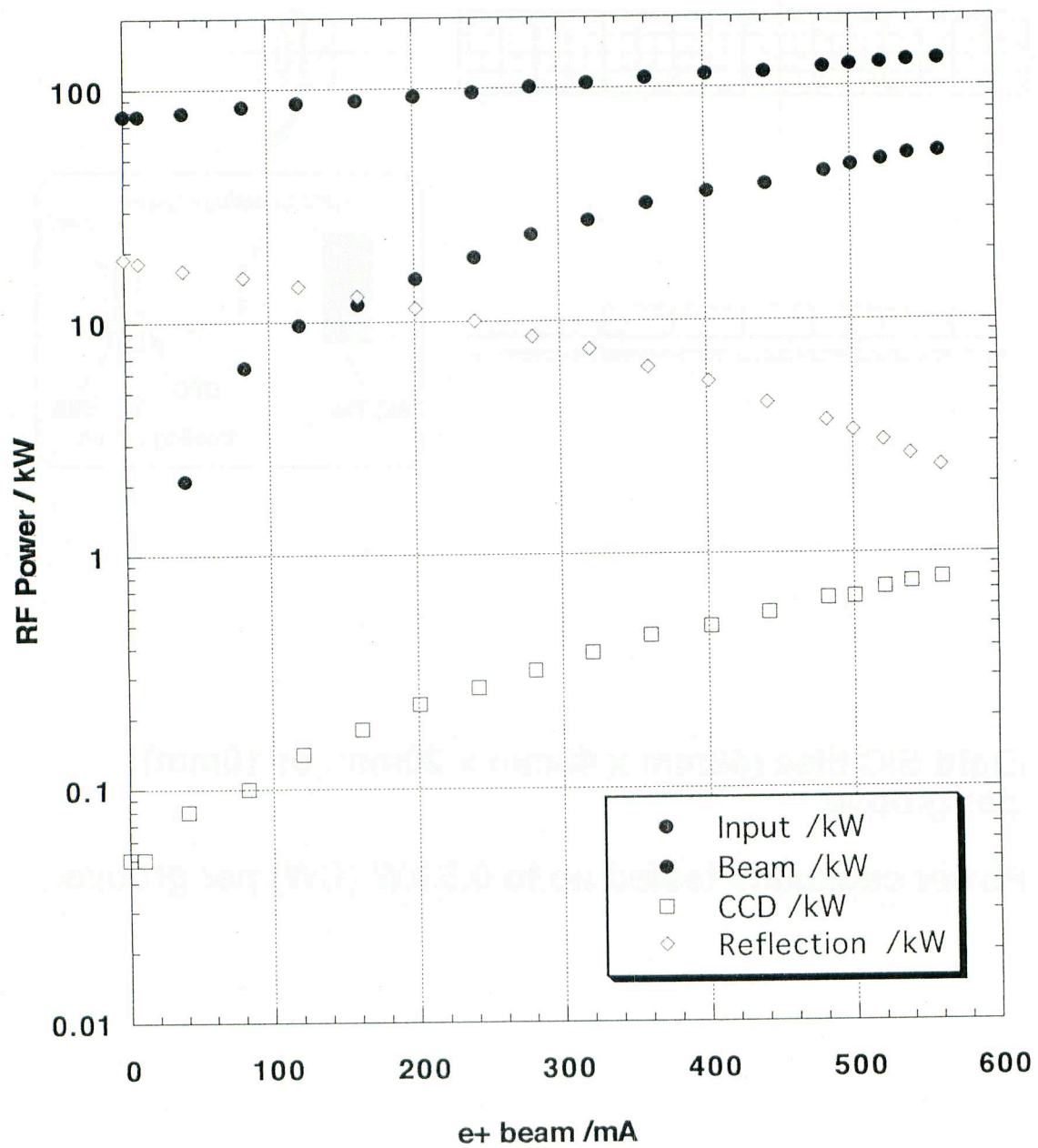
Bullet-shape sintered SiC Ceramic Absorber
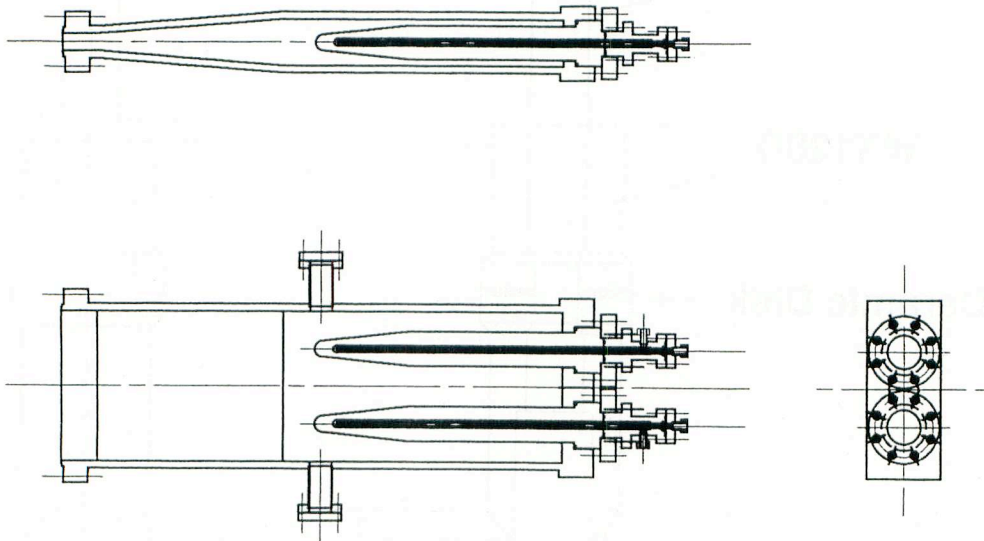
- Two absorbers (ø55mm x 400mm)
  per HOM waveguide.

- Power capability tested up to 3.3 kW (CW)
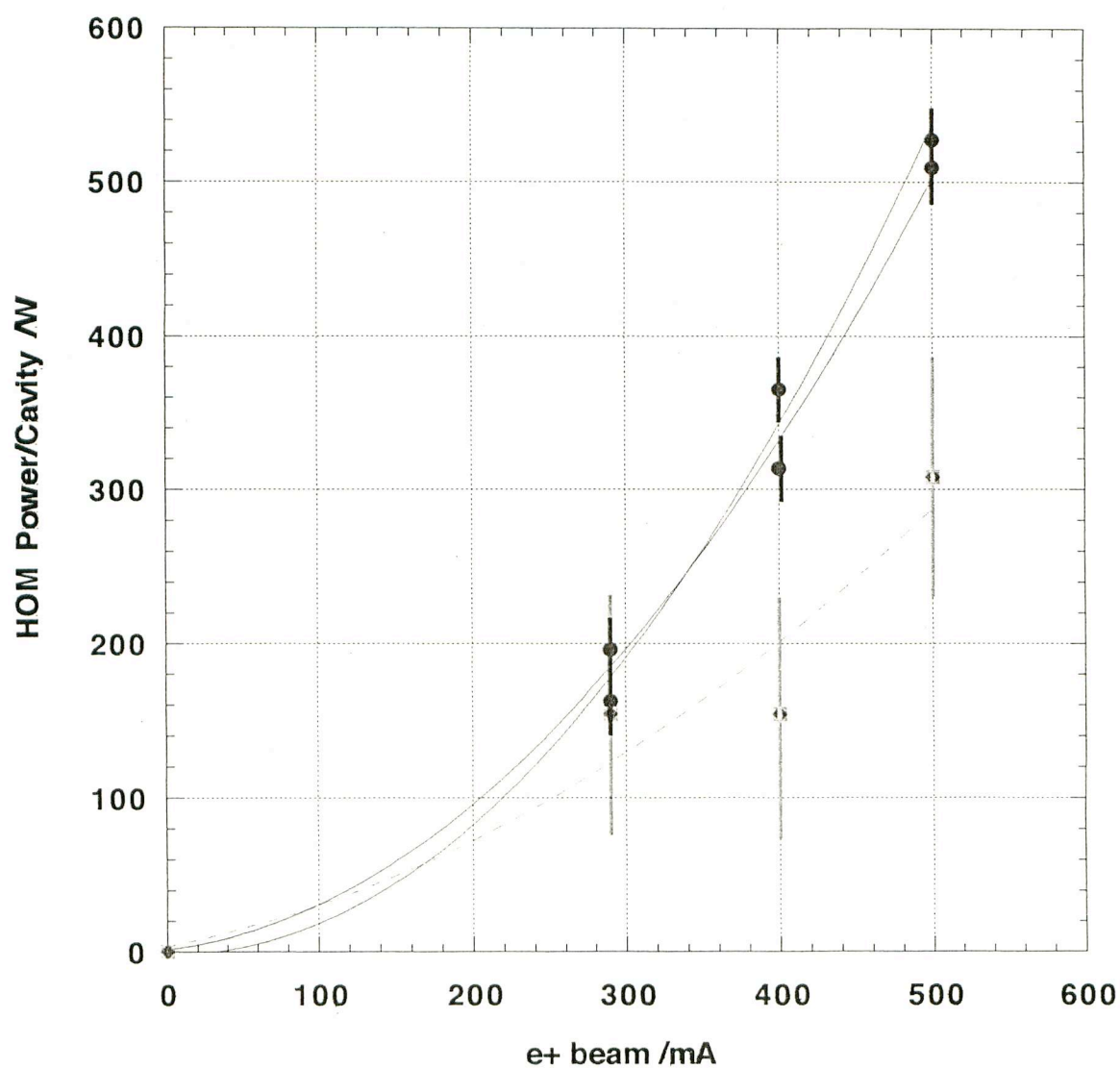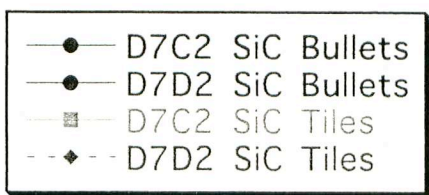 per absorber.

SiC Ceramic Tiles for GBP HOM Load

OFC Compliant Layer

OFC

SiC Tile

OFC

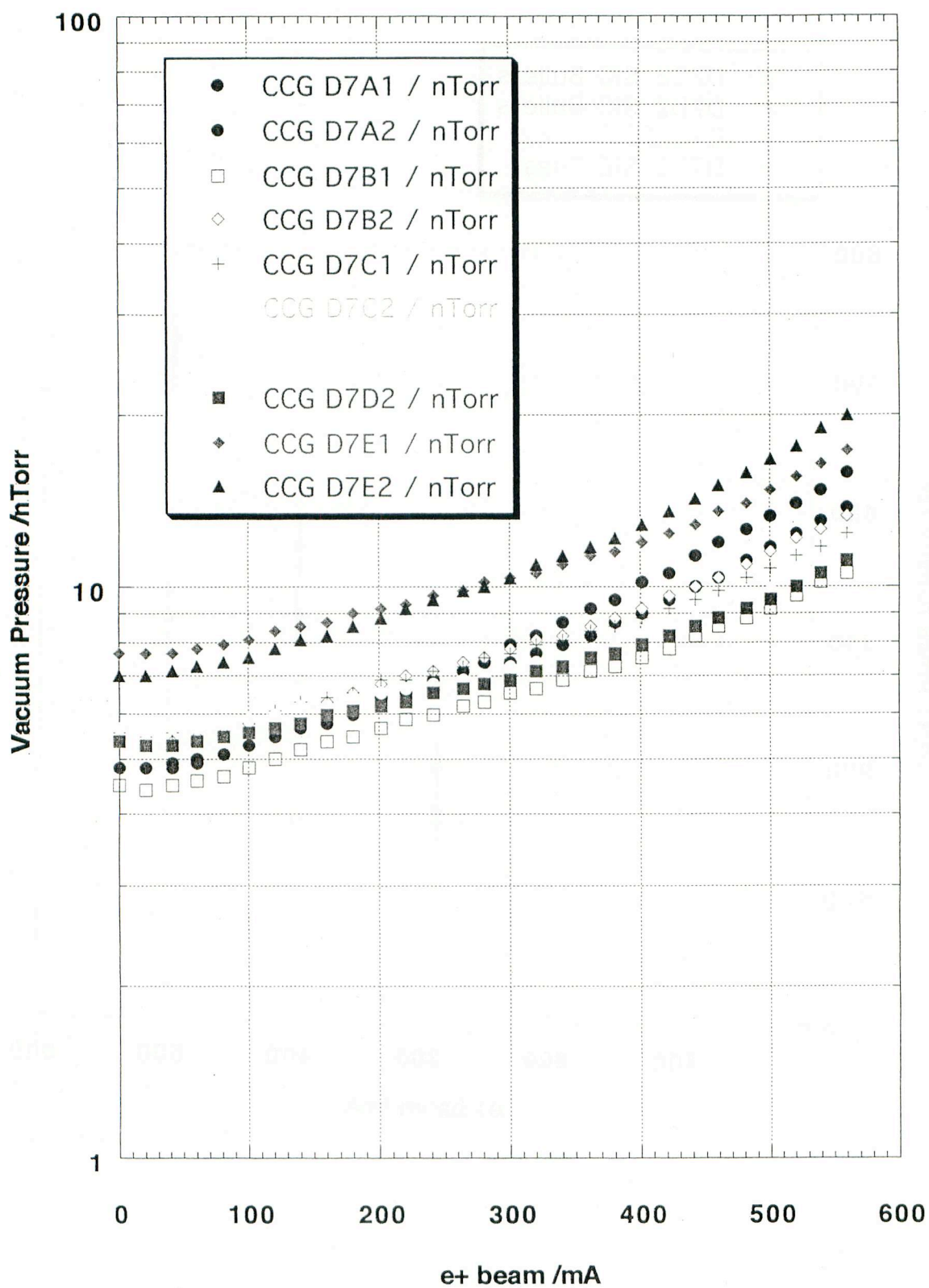**SUS**

Cooling Circuit

- **Eight SiC tiles (48mm x 48mm x 20mm, or 10mm) per groove.**

- **Power capability tested up to 0.5 kW (CW) per groove.**

RF Pwrs (ARES D7C-2) vs e+ beam 000124

Legend:
- ● Input /kW
- ● Beam /kW
- □ CCD /kW
- ◇ Reflection /kW

x-axis: e+ beam /mA

y-axis: RF Power / kW

Legend:
- D7C2 SiC Bullets
- D7D2 SiC Bullets
- D7C2 SiC Tiles
- D7D2 SiC Tiles

Y-axis: HOM Power/Cavity /W (0, 100, 200, 300, 400, 500, 600)

X-axis: e+ beam /mA (0, 100, 200, 300, 400, 500, 600)

Vacuum Pressure Response to e+ beam   1/24/2000

Chart — Vacuum Pressure /nTorr (y-axis, log scale 1 to 100) vs. e+ beam /mA (x-axis, 0 to 600)

Legend:
- CCG D7A1 / nTorr
- CCG D7A2 / nTorr
- CCG D7B1 / nTorr
- CCG D7B2 / nTorr
- CCG D7C1 / nTorr
- CCG D7C2 / nTorr
- CCG D7D2 / nTorr
- CCG D7E1 / nTorr
- CCG D7E2 / nTorr

THE ARES CAVITY FOR KEKB

T. Kageyama, Y. Takeuchi, N. Akasaka, H. Mizuno, F. Naito, H. Sakai,
K. Akai, K. Ebihara, E. Ezura, H. Nakanishi, Y. Yamazaki and S. Yoshimoto
Accelerator Laboratory, KEK, Oho 1-1, Tsukuba, Ibaraki, 305, JAPAN

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KB Low Energy Ring (LER) and High Energy Ring
have been commissioned, respectively, with 12
conducting accelerating cavities named ARES
rator Resonantly coupled with Energy Storage) and
combination of 4 superconducting cavities and 6
cavities. The ARES structure is a coupled cavity
developed for use under heavy beam loading
ment of KEKB, where its accelerating cavity is
tly ($\pi/2$-mode) coupled with an energy storage
ia a c   .ing cavity equipped with a coaxial antenna
· reducing the impedances of the parasitic 0 and π
The accelerating cavity itself is a Higher Order
HOM) damped cavity employing Grooved Beam
BP) method also devised in KEK. It should be noted
· $\pi/2$-mode operation of the ARES coupled cavity
is the most important key to success. This paper
brief review of the ARES cavity system including its
ory hardware and a report on the commissioning

1 INTRODUCTION

peration of conventional copper cavities under
beam loading in KEKB would give rise to a serious
ility problem. That is the longitudinal coupled
instability driven by the accelerating mode itself.
sonant frequency of the accelerating mode should
uned   m the RF frequency toward the lower side
er to compensate for the reactive component of the
y voltage induced by the beam. In KEKB, the
red detuning frequency will exceed the revolution
ency, leading to the large excitation of a coupled-
h synchrotron oscillation.

n RF structure named ARES [1] has been developed
countermeasure against the above problem. In the
S scheme, an accelerating cavity and an energy
ge cavity operated in a high-Q mode such as the
mode are resonantly coupled via a coupling cavity
own in Fig. 1. The energy storage cavity is employed
duce the required detuning frequency, which is
sely proportional to the ratio of the electromagnetic
d energy with respect to the reactive part of the
-field interaction energy.

ow to couple the storage cavity with the accelerating
y is the most important problem. Employing a storage
y brings on other problems such as parasitic modes

arising in the accelerating passband. For example, a
direct coupling scheme operated in the π mode like the
LEP normal conducting cavity system would come up
with several difficulties when applied to KEKB.

The ARES scheme solves the above problems brought
by the parasitic modes in the accelerating passband. The
name ARES stands for Accelerator Resonantly coupled
with Energy Storage. The resonant coupling means that
the accelerating and storage cavities are coupled via a
non-excited coupling cavity and operated in the $\pi/2$
standing wave mode. The $\pi/2$-mode operation with the
coupling cavity enables the following key design features
of the ARES cavity system.

- The $\pi/2$ mode is the most stable against tuning errors
  and heavy beam loading.
- The stored energy ratio $U_s: U_a$, where U_s is the stored
  energy in the storage cavity and U_a in the accelerating
  cavity, can be easily adjusted by changing the coupling
  factor ratio $k_s : k_a$, where k_s is the coupling factor
  between the storage and coupling cavities and k_a
  between the accelerating and coupling cavities.
- The parasitic 0 and π modes can be selectively damped
  by installing a coaxial antenna-type damper in the
  coupling cavity.
- The damped 0 and π modes are located nearly
  symmetrically with respect to the $\pi/2$ mode as shown
  in Fig. 2. Therefore, their impedance contributions to
  the beam instability cancel out each other.
- The coupling cavity functions as a filter to isolate the
  storage cavity from the HOM's of the accelerating
  cavity.

Needless to say, the accelerating cavity itself is
required to be a HOM-damped cavity in order to reduce
the HOM impedances also driving longitudinal and
transverse coupled-bunch instabilities. Two ARES
prototype cavities with different HOM damping structures
were developed: ARES95 [2] with Quadrupole Counter
Mixing (QCM) choke method [3], and ARES96 [4] with
Grooved Beam Pipe (GBP) one [5]. Both prototypes were
successfully demonstrated through a series of high-power
RF tests and high-current beam experiments carried out in
the TRISTAN accumulation ring (AR) in 1996 [4], [6], [7].

2 CAVITY SYSTEM INCLUDING ACCESSORY HARDWARE

Figure 1 shows a schematic drawing of the ARES
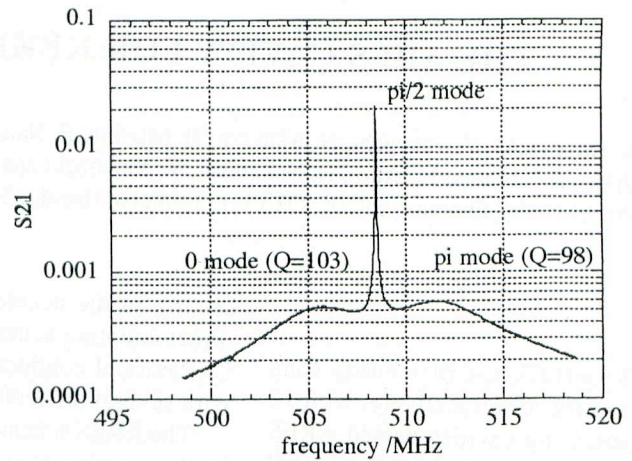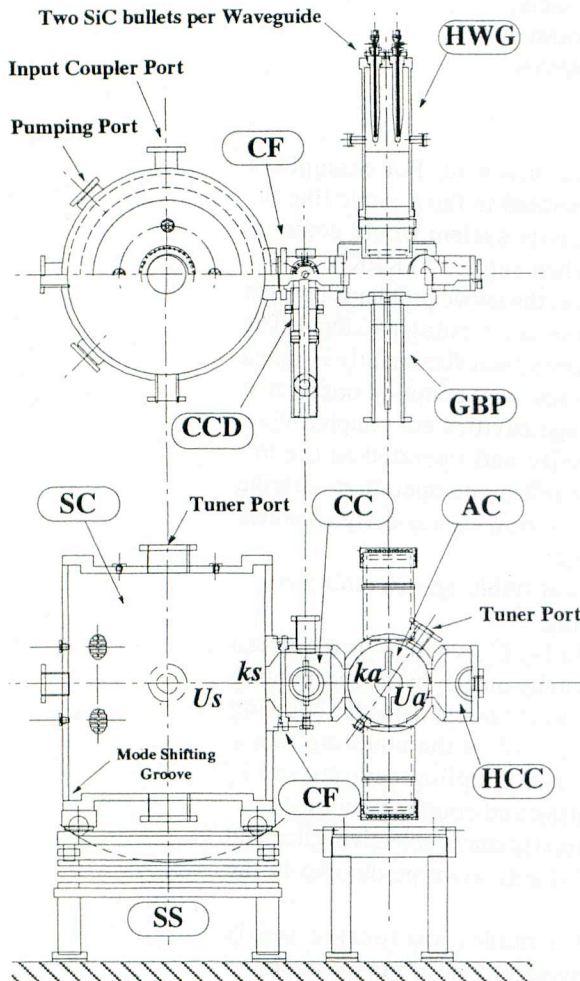production model, whose RF design is based on ARES96.

Two SiC bullets per Waveguide

Input Coupler Port

Pumping Port

(HWG)

CF

CCD

Figure 2 graph:

0.1

0.01

0.001

0.0001

S21

pi/2 mode

0 mode (Q=103)   pi mode (Q=98)

495   500   505   510   515   520

frequency /MHz

Figure 2: The $\pi/2$ accelerating mode and the damped parasitic 0 and π modes when $Q_c \approx 55$.

SC   Tuner Port   CC   AC

GBP

Two SiC bullets per Waveguide

(HWG)

Tuner Port

(GBP)

ks ka

U_s U_a

Mode Shifting Groove

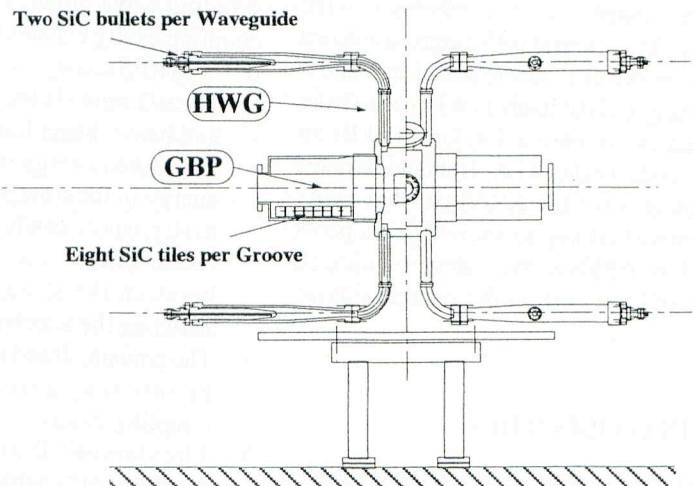CF

HCC

Eight SiC tiles per Groove

SS

Figure 1: A schematic drawing of the ARES production model based on the prototype ARES96.

AC: Accelerating Cavity with four HOM rectangular waveguides (HWG's) for damping the monopole
        and the dipole-V HOM's, and with two Grooved Beam Pipes (GBP's) at both end plates
        for damping the dipole-H HOM's.

CC: Coupling Cavity functions as the keystone of the ARES structure, and is equipped with
        a Coupling Cavity Damper (CCD) to damp the parasitic 0 and π modes.

CCD: Coupling Cavity Damper for reducing the impedances of the parasitic 0 and π modes.
        Both 0 and π modes are damped about $Q_L \approx 100$.

CF: Connecting Flange
        The Storage Cavity (SC) and the Coupling Cavity (CC) are mechanically connected at rectangular flanges
        with bolts, and its vacuum-seal is obtained by TIG-welding the lips around the flanges.

GBP: Grooved Beam Pipe selectively lowers the cutoff frequency of the TE11 traveling wave
        and damps the dipole HOM's in the accelerating cavity. Each groove has 8 SiC ceramic tiles brazed
        to a water-cooled copper plate.

HCC: Half-cell Coupling Cavity restores the symmetry of the accelerating cavity (AC)
        with respect to the mid vertical plane including the beam axis.

HWG: HOM Waveguide (240 mm by 28 mm) for damping the monopole and dipole-V HOM's.
        Two bullet-shape sintered SiC ceramic absorbers are inserted from the end of each waveguides.

SC: Storage Cavity is a steel cylindrical cavity with electro-plated copper surfaces,
        and operated in the TE_{013} mode with $Q_0 = 165000$.

SS: Supporting Structure allows the storage cavity (SC) the x- and y-parallel motions in the horizontal plane,
        and the pitch-, roll- and yaw-motions with respect to the connecting flange (CF) direction.

Severe high-power testing of ARES96 as the production prototype was further continued after the beam test in order to verify its long-term reliability. The basic RF parameters are listed in Table 1, together with the high power test records.

The accelerating cavity is a HOM damped OFC (Oxygen Free Copper) structure brazed in a vacuum furnace. As shown in Fig. 1, four straight rectangular waveguides are directly brazed to the upper and lower sides of the accelerating cavity in order to damp the monopole HOM's and also the dipole ones deflecting the beam in the vertical direction. The HOM waveguide width was chosen 240 mm, which gives a cutoff frequency of 625 MHz for the dominant TE_{10} wave. An E-bend waveguide is attached to the end of each straight one to guide the extracted HOM RF power in the horizontal direction toward the two bullet-shape sintered SiC ceramic absorbers inserted at the waveguide end. Each SiC absorber with dimensions of 55 mm in diameter and 400 mm in length including a tapered section is directly cooled by water flowing in the channel bored inside as shown in Fig. 3. Its power capability was verified up to 3.3 kW per bullet at a HOM load teststand with use of a L-band CW klystron.

The beam pipes attached to both end plates of the accelerating cavity are grooved at its upper and lower sides as shown in Fig. 1 in order to damp the dipole HOM's deflecting the beam in the horizontal direction. The GBP (Grooved Beam Pipe) method [5] is very effective for heavily damping the dipole HOM's. The cutoff frequency of the TE_{11} wave, which couples with the cavity HEM_{11} modes, can be selectively lowered by grooving the inner wall of the beam pipe. The groove dimensions are chosen 30 mm in width and 95 mm in depth, which lowers the TE_{11} cutoff frequency below 650 MHz for the circular beam pipe with an inner diameter of 150 mm.

The GBP HOM load consisits of eight SiC ceramic tiles arranged in a line in each groove, where each tile is brazed to a water-cooled OFC plate with an OFC compliant layer as shown in Fig. 4. The high power tests for the GBP HOM load were also carried out with use of the L-band CW klystron. The power capability was tested up to 0.5 kW per groove, upgraded from 0.25 kW per groove for the prototype ARES96 with each tile attached with a bolt to a water-cooled stainless steel plate with a soft metal (gold) sheet sandwiched between. The HOM loads developed for ARES96 were reported in detail in Ref. [8].

The coupling cavity, the keystone of the ARES system, is also an OFC structure directly brazed to the accelerating cavity, and electromagnetically coupled through a rectangular aperture of 120 mm by 160 mm. Another half-cell coupling cavity is brazed at the opposite side for the $\pi/2$-mode termination in order to restores the accelerating cavity symmetry with respect to the mid vertical plane including the beam axis.

Table 1: RF design parameters of the ARES production model, and the high-power test records achieved with the production prototype ARES96.

$$
\begin{aligned}
f_{RF} &= 508.887 \text{ MHz} \\
Ua : Us &= 1 : 9 \\
R / Q &= 15 \ \Omega \\
Q &= 1.1 \times 10^5 \ \dagger
\end{aligned}
$$

Pc = 150 kW per ARES Cavity generating
Vc = 0.5 MV (KEKB Design)

High-Power Performance
Maximum Continuous: Pc = 380 kW
Maximum for 20 minutues: Pc = 450 kW

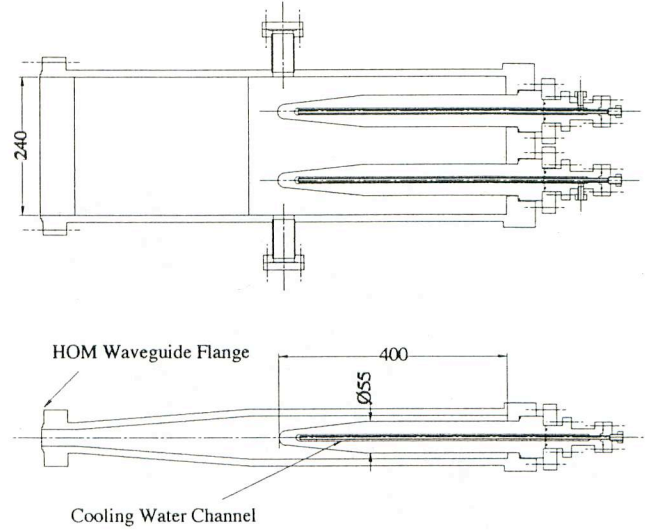$\dagger$: in high-power operation with Pc = 150 kW

Figure 3: Two bullet-shape sintered SiC ceramic absorbers inserted at the end of each HOM waveguide.
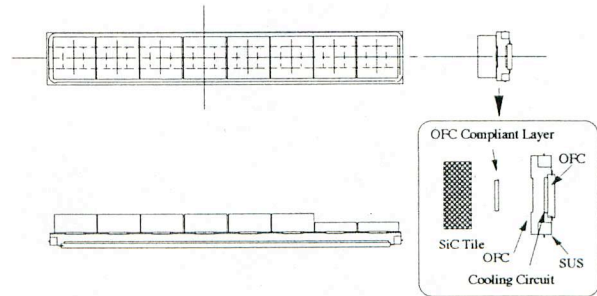

Figure 4: The Grooved Beam Pipe HOM load with SiC ceramic tiles brazed to the water-cooled OFC plate.
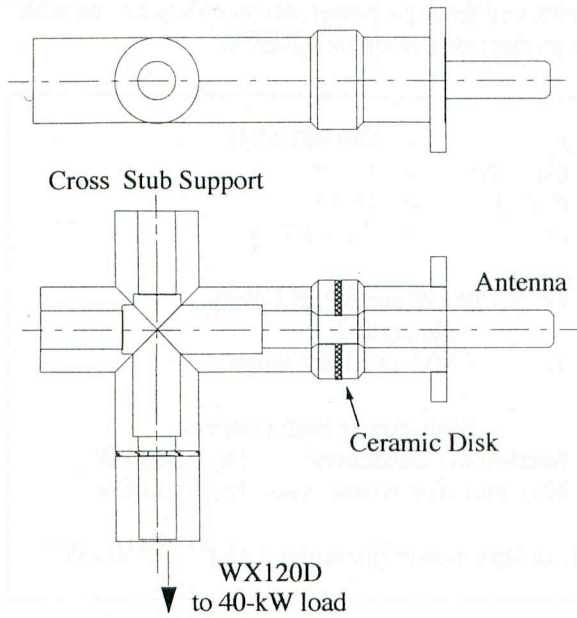
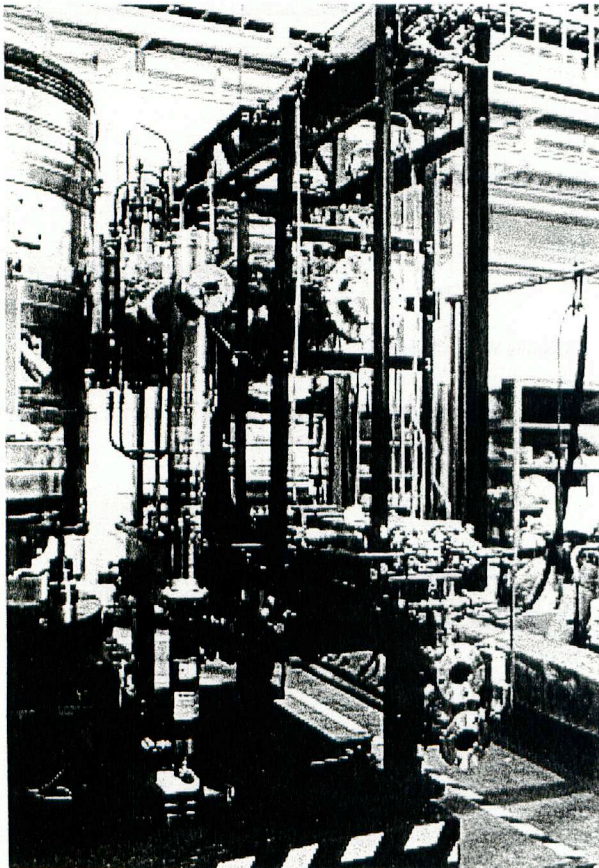Figure 5: A schematic drawing of the coupling cavity damper.

Figure 6: A coupling cavity damper with a 40-kW load.

A coaxial-type antenna coupler [9] is installed in the coupling cavity in order to damp the parasitic 0 and π modes down to loaded-Q values of about 100. The coupler is a coaxial waveguide (WX120D) complex with a cross stub support and a disk-type ceramic window as shown in Fig. 5. The extracted RF power is guided through a tapered coaxial waveguide (WX120D-WX77D) in the vertical direction to a water-cooled dummy load (CW 40 kW) at the bottom end (see Fig. 6).

The energy storage cavity is a large cylindrical cavity with dimensions of 1070 mm in diameter and 1190 mm in axial length. The storage cavity is a steel structure whose inner surfaces are copper-plated. About 90% of the electromagnetic energy of the $\pi/2$ accelerating mode is stored in the storage cavity operated in the TE_{013} mode. The Q value of the TE_{013} mode achieved with the electroplated copper surfaces is 1.65×10^5, which is 85% of the theoretical value of 1.94×10^5 calculated assuming a copper electrical conductivity of 5.81×10^7 S/m. The reduction is due to the surface imperfections and the coupling and port apertures. The degeneracy of the TM_{113} and the TE_{013} modes is resolved with a mode-shifting circular groove at each endplate. A movable tuning plunger with a diameter of 200 mm and a travel of 60 mm is installed in the central port of the upper endplate, while a fixed one in the central port of the lower endplate.

The storage and coupling cavities are coupled through a rectangular aperture of 120 mm by 180 mm, and mechanically connected with rectangular flanges with bolts. Thin stainless steel lips around both flanges are to be TIG-welded for the final vacuum sealing after installed in the KEKB tunnel. For high power testing above the
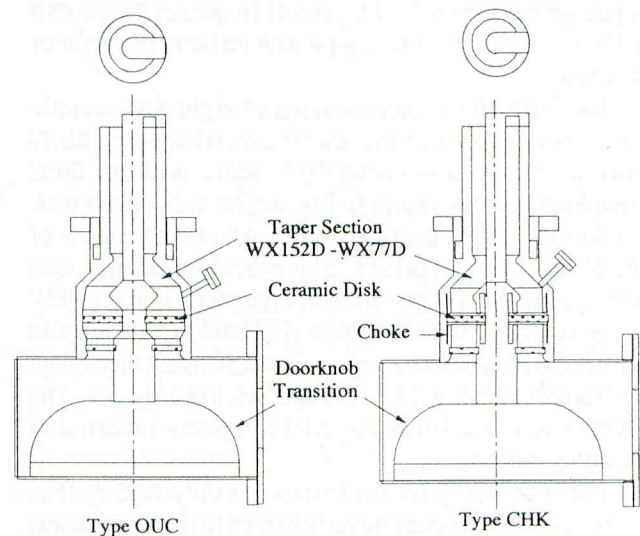

Figuire 7: Two types of input couplers newly developed for the ARES cavity. The left one with the over- and under- cut window matching structure and the right one with the choke matching structure.
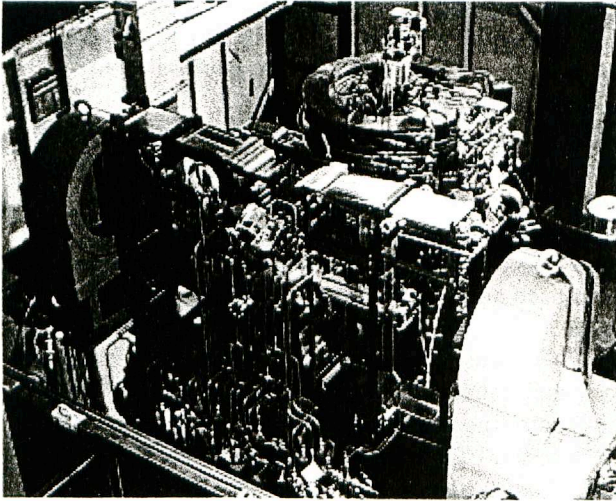
Figure 8: A close-up view of the cavity teststand.

Figure 9: The assembly line for high power testing of production cavities.

ground, a rubber gasket was temporarily used instead. That is because the storage and acceleratng cavities are to be separately installed in the tunnel.

The RF power is fed to the ARES cavity system through an input coupler installed in one of the three circular ports located at the middle level of the storage cavity. Two types of input couplers with different window matching structures shown in Fig. 7 were developed [10]: the over- and under-cut type, and the choke one. The RF power is transferred from the rectangular waveguide (WR1500) input, via a doorknob transition with a capacitive iris, to the coaxial waveguide (WX152D) with a disk-type ceramic window. The coaxial waveguide is tapered down (WX77D), and ends with a magnetic coupling loop. Both types were successfully high-power tested up to 950 kW [10], far above the design power capability of 400 kW for KEKB.

3 CAVITY PRODUCTION AND INSTALLATION

The first produciton of 24 ARES cavities began in April 1997. Every production cavity was RF-conditioned in a dedicated teststand shown in Figure 8 and 9. Figure 10 shows the conditioning history of a production cavity, where the RF input power is plotted as a function of the net elapsed time. The RF power was controlled by a PC and gradually increased keeping the vacuum pressure below $\sim 3 \times 10^{-7}$ Torr. Usually, it took about 40 hours to reach the final target power of 180 kW, which is 120% of the design input power and limited by radiation safety regulations.

To save the time for RF conditioning at the teststand, an input coupler with a cylindrical ceramic window developed in 1980's for the TRISTAN APS cavity was
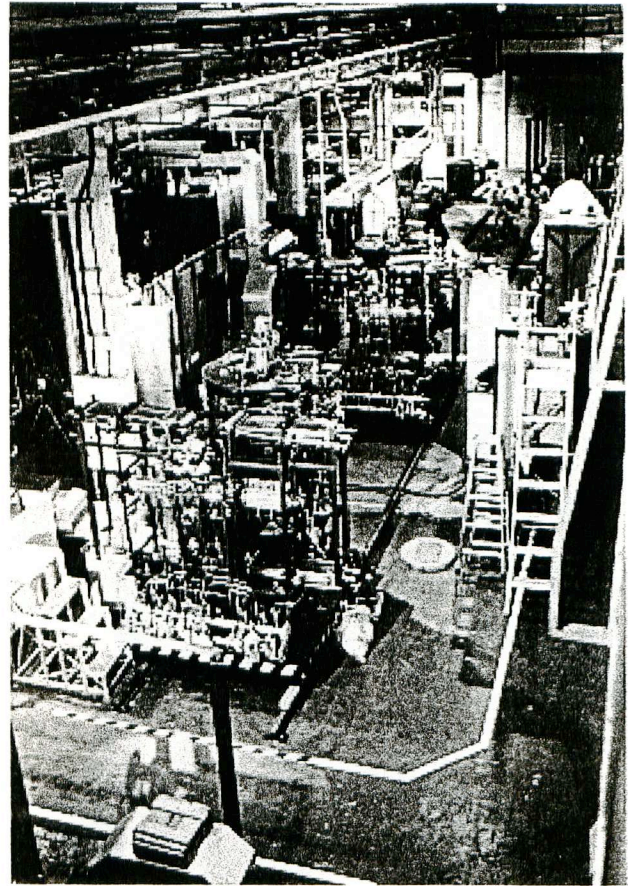
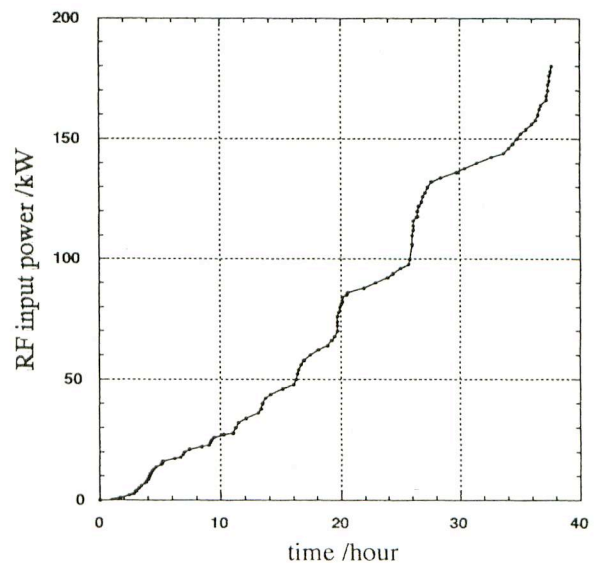

Figure 10: The RF conditioning history curve of a production cavity.

Figure 11: ARES cavities in the LER RF section D7.

commissioning were 540 mA and 520 mA for LER and HER, respectively. Through the operation of the 18 ARES cavities, it was found that routine several-hour RF conditioning per week reduces the fault rate in steady operation below 0.1 per cavity per day.

The worst trouble that we have encountered up to now is that the rubber vacuum seal was burned due to RF power leakage at the flange connection between the coupling and storage cavities of an ARES installed in the LER RF section D8. It was found that the power leakage was caused since part of the contacting surface of the storage cavity side had not been perfectly machined. The rubber seal was to be temporarily used in the teststand above the ground and also in the KEKB tunnel for early commissioning stages. In this summer, every ARES cavity in the LER RF sections was vacuum-sealed by welding the stainless steel lips at the flange connection after removing the rubber seal.

5 CONCLUSION

All installed ARES cavities including accessory hardware have functioned well although operated at 0.4 MV per cavity, which is 80% of the design voltage. Our operational experience acquired through the early commissioning stage is valuable to improve and enhance the performance of the ARES cavity system for KEKB.
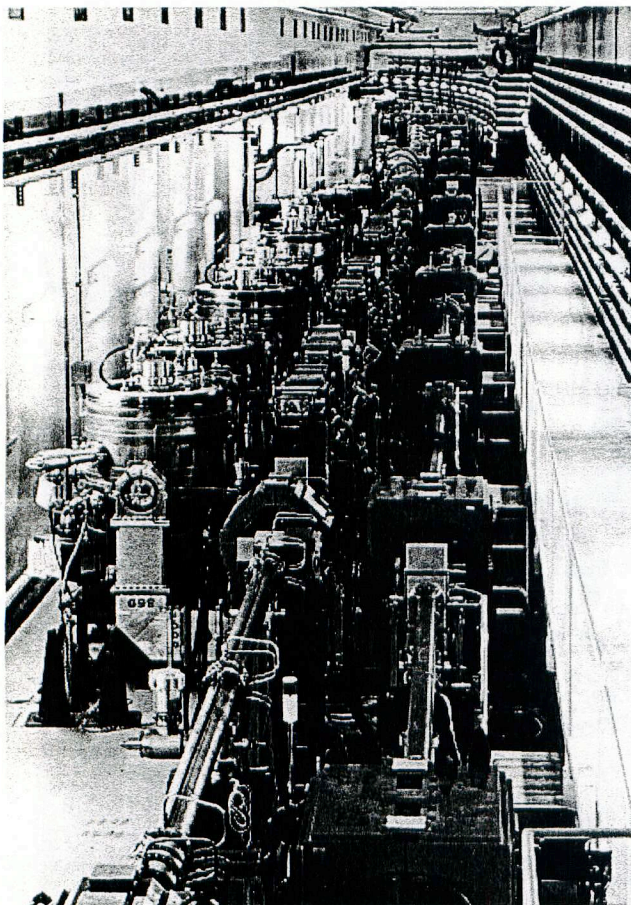
employed. According to our experience, the cylindrical window type, whose power capability is limited below 300 kW, is durable under a poor vacuum of $\sim 1 \times 10^{-6}$ Torr. On the other hand, the disk window type newly developed for KEKB should be carefully conditioned under a vacuum $< 1 \times 10^{-7}$ Torr.

For the first stage of KEKB commissioning, 18 out of the 24 production cavities were installed during the period from April to October in 1998. For LER, 12 cavities were installed in the Fuji RF sections D7 and D8, where 6 cavities in each section. Figure 11 shows the ARES cavities in the RF section D7. The rest of 6 cavities were installed in the Oho RF section D5 for HER.

4 COMMISSIONING STATUS

The commissioning of HER was first started with a combination of 6 ARES cavities and 4 superconducting cavities (SCC) in December 1998, and followed by the commissioning of LER with 12 ARES cavities in January 1999. The typical operational RF voltages were 0.4 MV per ARES cavity and 1.5 MV per SCC. The stored beam currents for both rings were gradually increased. The maximum e+ and e- currents achieved in the first stage of

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