Collaboration meeting on the Q-BPM of the ATF2 with PAL group

We have following 5 colleagues from PAL, Korea for 9 - 10, May 2005, at KEK.

Jung Yun Huang: Physicist
- contact person and electrical test

Eun-San Kim: Physicist
- Electrical design (simulation and wake field calculation)

Heung-Sik Kang: Physicist
- Electrical test

Seung-Hwan Kim: mechanical Engineer
- Mechanical design and fabrication with brazing

In Soo Park: mechanical Engineer
- Electrical test with an antenna method

On 9th May:

1. at 10am - noon

Y. Honda explained the present performance of KEK Nano-BPM system, which consists of 3 cavity-BPMs on active movers as well as "alignment" movers and a granite support table, by beam test. All the movers are controlled by piezo devices. The alignment movers can change x, y and x', y' positions in the range of +/- 100um and +/-50urad, respectively. The active mover can stabilize the x and y positions at less than 1 nm at 100Hz by using a laser interference fringe detection. Also, the structure of the KEK cavity-BPM was explained.

Q: What is symmetry accuracy of 4-pole wave guides?
A: Present performance: the mechanical center is coincident with the electrical one within 50um.

Q: What is a cutting method of the slit/slot in wall between the senser cavity and the wave guide ?
A: Wire cutting

Q: How much is inductance in the cavity ?
A: I donot know.

KEK design of electronics is based on an analog technique; i.e. mixing and phase detection with the frequency conversion from 6.5GHz to 714MHz, while SLAC one is digital. Precise timing is provided by a reference cavity connected to the cavity-BPM. Matching of the phase is importance for discrimination position signal from angular one.

The calibration was done by the movers with about 300nm step.

Q: Why is the 300nm step?
A; It corresponds to 1/2 of laser wavelength, where the mover position can be set by the laser interference fringes. So, it is precisely known length.

The present position resolution was measured to be 72nm in a few um range at the ATF extraction line, while it was 116nm in full range of about 10um. The full range data must have effects from fluctuations of beam intensity and large angular jitter.

Q:What is the condition of beam?
A: single bunch operation at 3 Hz, and the beam intensity was 7 x 10^9/bunch. The resolution may depend linearly on the intensity.

Q: What is noise level and how to measure it?
A: 25nm and it was estimated by disconnecting the feedthrough connector, i.e. open cable. So, it corresponds to the noise of electronics with a long (30m) cable.

There was a problem of signals with bipolar while it should be monopole. This distortion may have contributions from common mode signal.

Q-BPMs at the ATF2:

The total number of Q-BPMs is 22 at the ATF2 final focus system.
The position resolution and dynamic range are 100nm and 100um, respectively. The x and y isolation must be less than -30dB. The decay time must be shorter than the ILC bunch separation of about 300nsec.

Q: Q-BPMs must be operated for the multi-bunch beams with 2.8nsec separation in order to increase Compton yields from the Shintake monitor (beam size monitor based on the laser interference fringe).
A: In principle, the design can be adjusted for coherent signals from bunches. Noise associated with the principle accelerating RF frequency must be carefully investigated.

Overall size of Q-BPM is 100 x 100 x 100 mm^3, without a reference cavity. The inner bore diameter is 20mm which is larger than 10mm of the KEK/BINP cavity BPMs.

The Q-BPM is modification from the KEK design for shorter decay time, larger coupling (beta=0.6) of waveguide to cable and less x-y isolation. Brazing technique must be improved, since we observed increase of x-y isolation from -30dB to -20dB as well as frequency change of 200kHz between x and y directions after the brazing.

2. at 3pm-5pm

We have a detailed discussion on the design of prototype Q-BPM.
Agreements are summarized as follows;

(1) Q-BPM is made from 4 pieces, i.e. 2 endcaps, senser cavity and waveguide (resonance cavity), and they are brazed.

- We discussed on a possibility of one-body fabrication of sensor cavity and waveguide without brazing at 1mm thick wall between them. Both engineers (Seung-Hwan Kim of PAL and Noboru Kudou of KEK) agreed that the 1mm thickness it too thin to be manufactured . So, one body fabrication was not chosen.

(2) Asymmetric structure with the frequency difference of a few MHz; i.e. adding two small holes on up and down outer surface of the sensor cavity.

(3) Adjustable structure of cavity resonant frequency and x-y isolation as the BINP design

(4) optimization of feedthrough position by simulation -- off-center ?
The feedthrough must be brazed at 780 deg.C .

(5) two types of prototype; i.e. brazed and non-brazed ones (KEK) or single type where non-brazed performance can be measured before the brazing (PAL). KEK and PAL will fabricate them at the same time.

(6) Estimation of machining errors, e.g. slot tilt, thickness, symmetries etc. .

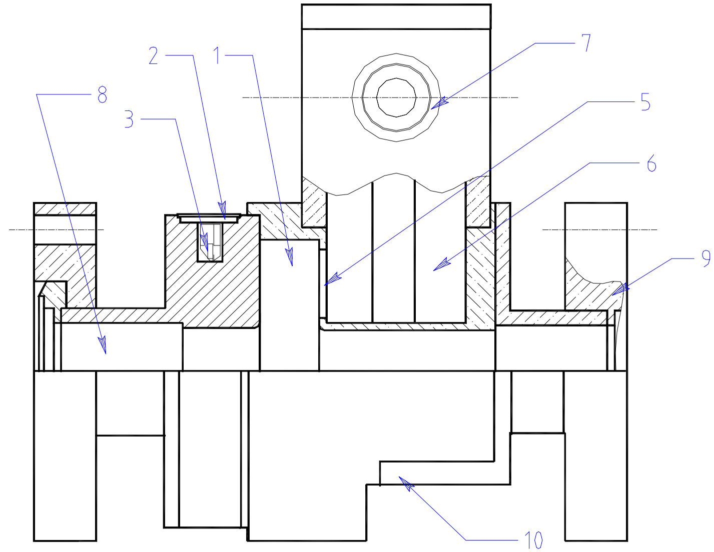
(7) Surface requirement for alignment
- flat surfaces for the precise alignment on the waveguide and the sensor cavity (top and bottom).

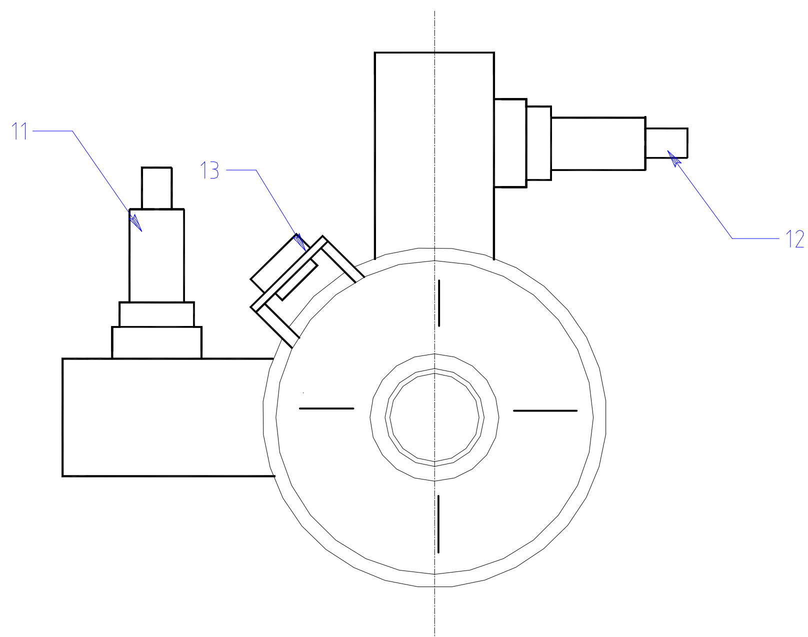
(8) Mechanical structure of 1mm thick wall between the sensor cavity and the waveguide

(9) In the design of real Q-BPM with a beam pipe; possibility of flange brazing after installation of the beam pipe inside Q-magnet ? Evaluation of pro and cons.

(10) Do not forget the reference cavity fabrication.

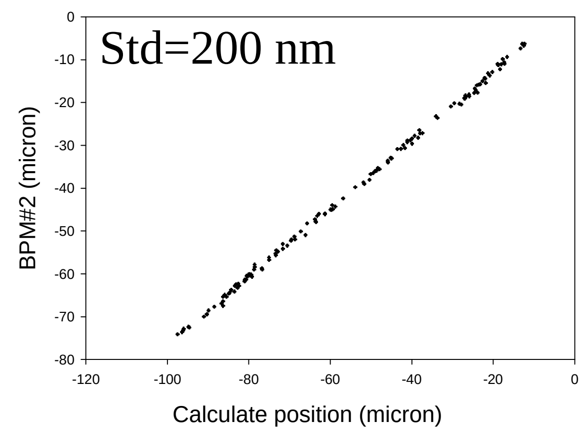
Honda will make a sketch of the above design for visual inspection at next meeting.

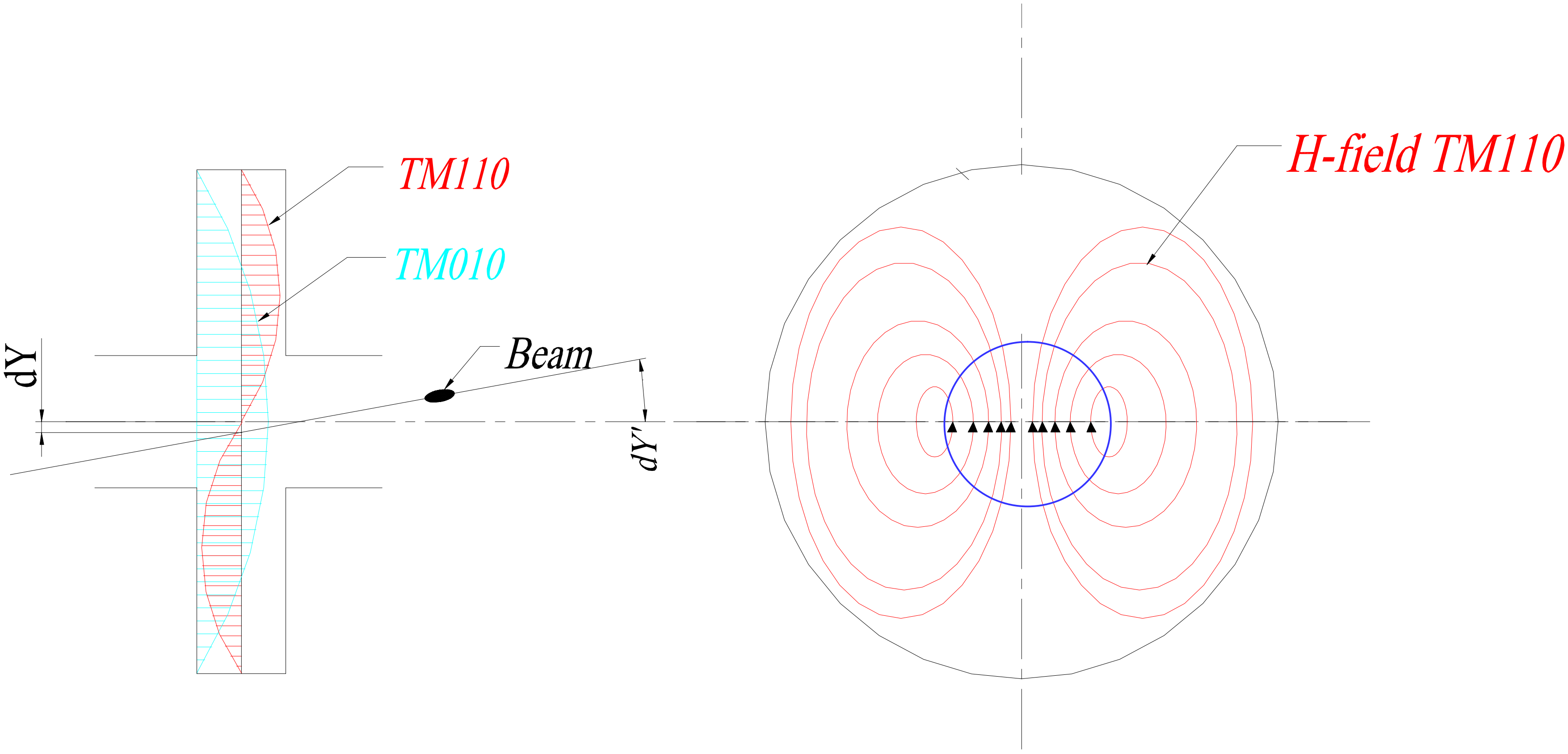




Cross-sectional view of BINP cavity BPM 6426 MHz, (5p. in KEK ATF + 1p.). 2000.

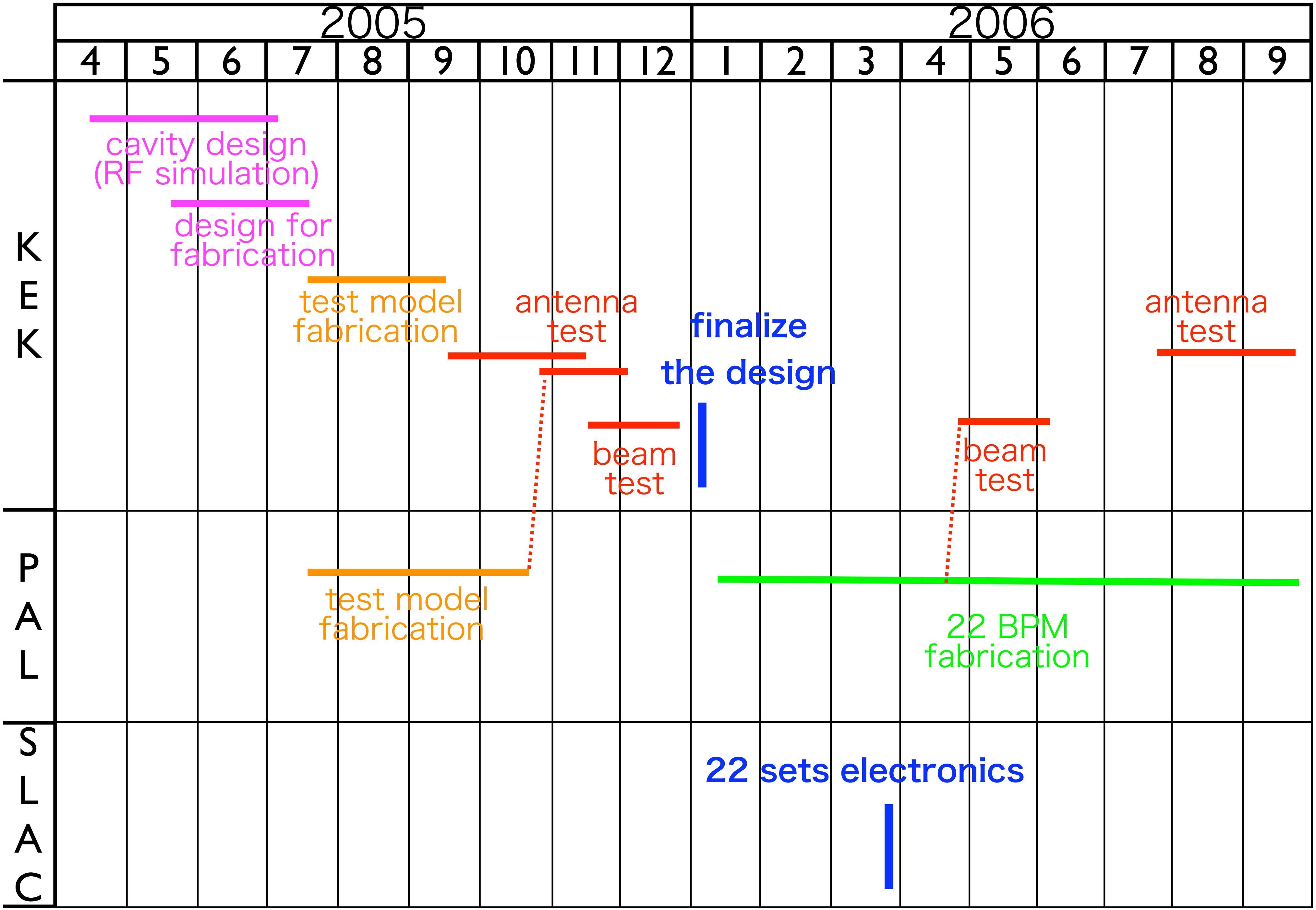
1.- Cavity sensor .
2- Heater.
3 – Temperature sensor.
5 – Coupling slot.
6 – Output waveguide.
7 – Output feedthrough.
8 – Beam pipe.
9 – Vacuum flange.
10 – Support plate.
11 – Y position output.
12 - X position output.
13 – Heater control connector.





$$V(d)=qw(R/Q)^{0.5}\frac{\sin(j_{cav}/2)}{j_{cav}/2}\frac{J_1(k_{11}d)}{J_{1max}}\exp(-j^2_b/2)b\left(\frac{R_{load}}{Q_l}\right)^{0.5}$$

Schedule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KEK
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22 BPM
fabrication
SLAC
22 sets electronics