ATF2 cavity BPM systems

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Apologies for people missed off...

CLIC08 workshop, LC test facilities group
16th October 2008

Outline

- ATF2 layout and cavity BPM systems
  - "Normal" quadrupole C-band cavities
    - LET, 50 nm resolution req.
  - Final focus S-band cavities
    - Final Focus, 1 micron resolution req.
  - RF processing electronics (image rejection mixer)
  - Digital acquisition (100 MHz digitizers)
  - Digital algorithms and control (Digital down conversion)
- Other BPMs (not discussed)
  - Feedback strip-lines
  - IP high resolution cavity BPMs

Similar design

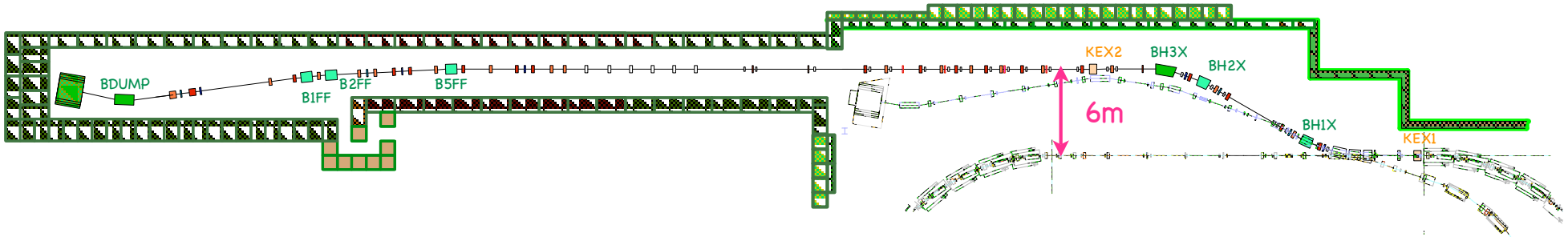
ATF2 BPM layout

Final Focus System

β mat-ching

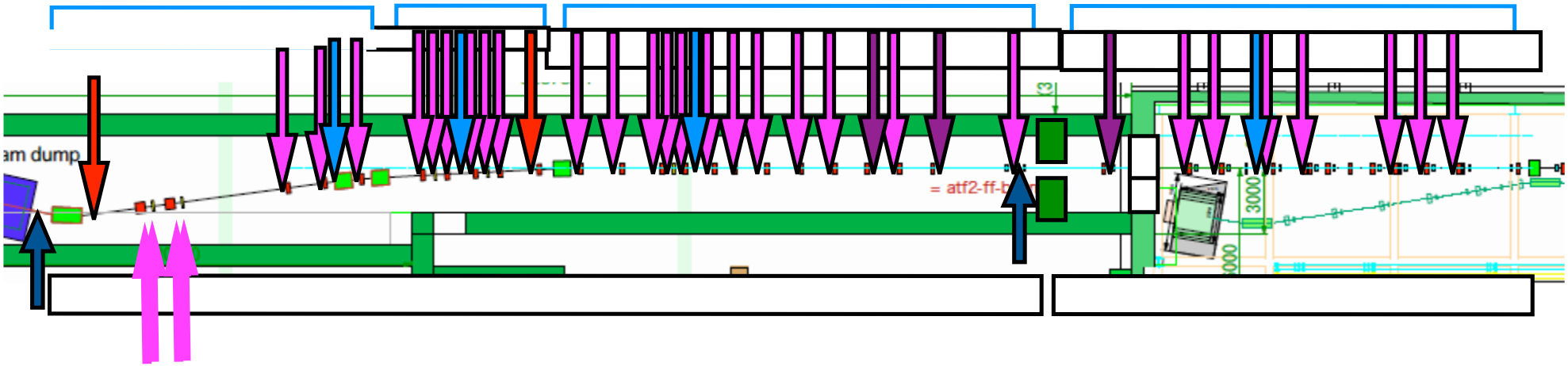
Diagnostic

Reconfiguration of extraction line for reduction of dispersion



See talk Tauchi-san on ATF2

C-Band (32 + 4 reference)



S-Band (4 + 1 reference)

Cavity BPM design (historical)

See overview by M. Wendt and R. Fandos (I. Syratchev) earlier

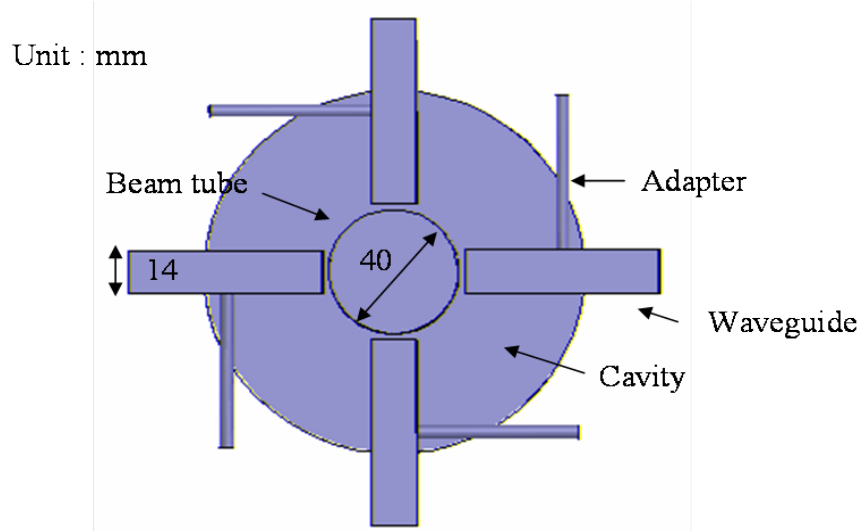
- BINP (nanoBPM, V. Vogel)
- KEK (Y. Honda *et al*)
- KEK/PAL/KNU/RHUL (A. Lyapin, Y. Honda, H.S. Kim *et al*)
- Monopole suppressing waveguides
  - Waveguide acts a HP filter, filtering out common mode
- Good x-y isolation
- Good beam coupling
- Electrically coupled antenna to extract signal
- Separate reference monopole cavity for charge normalization

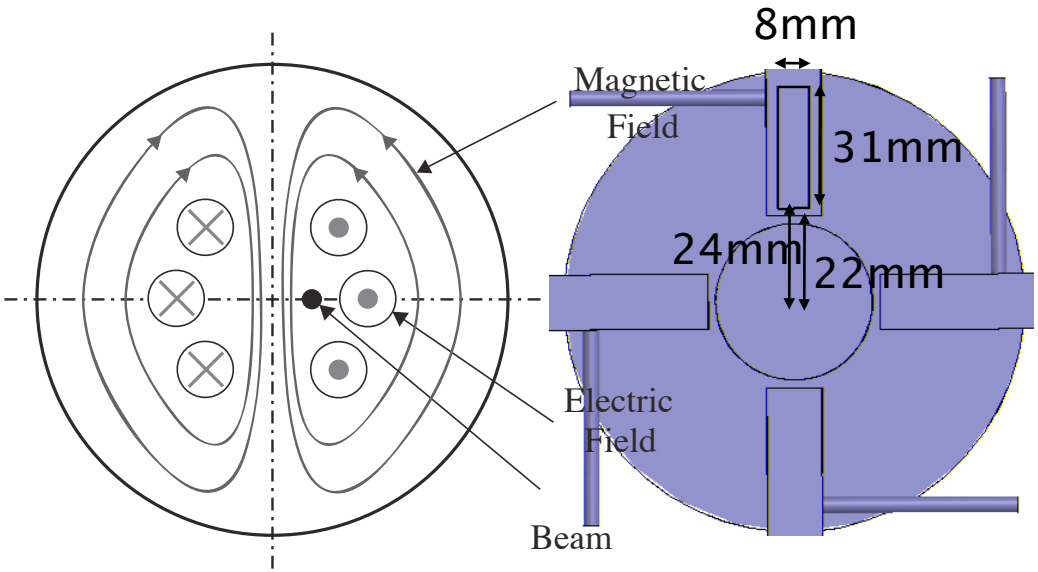
S-Band design

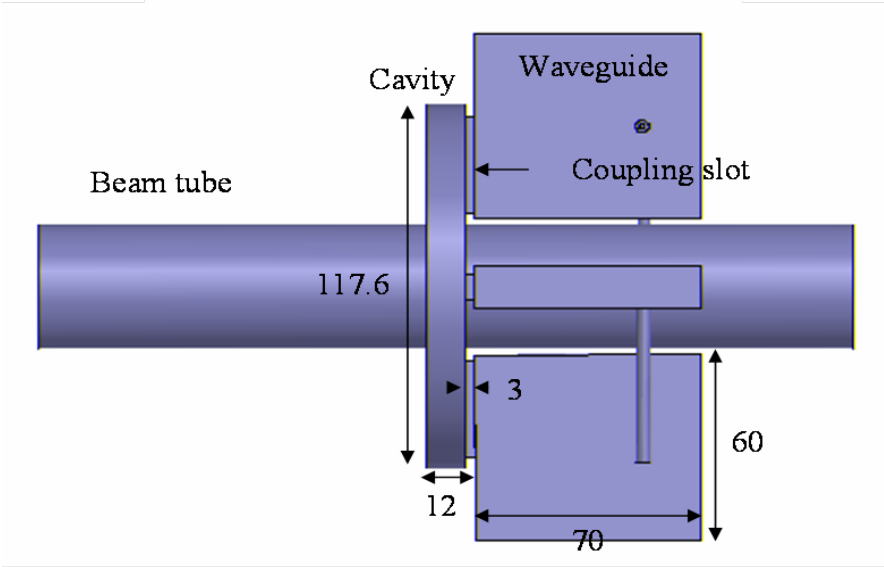
KNU/UCL

- S-Band design from KNU from initial design of UCL

Mode	f(GHz)	Q_L	Q_0	Decay Time
Dipole	2.878	650	5075	35ns







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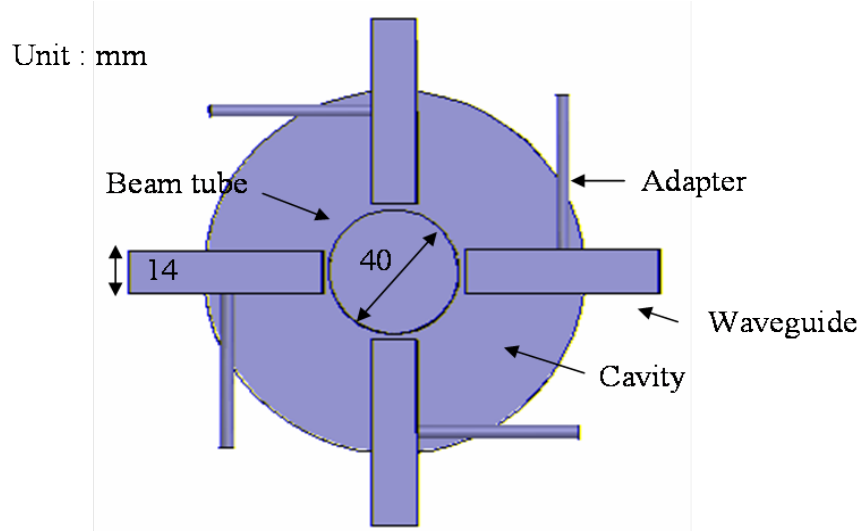
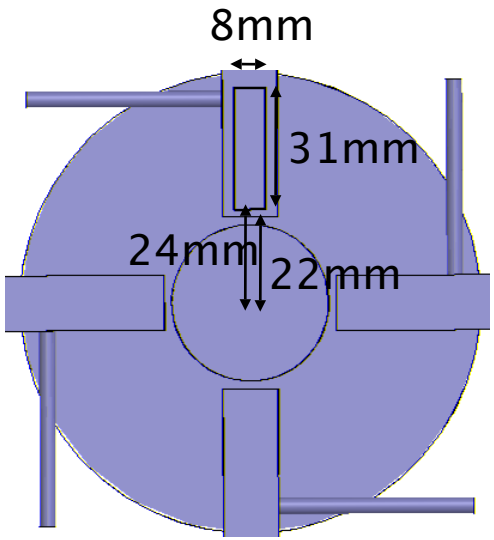
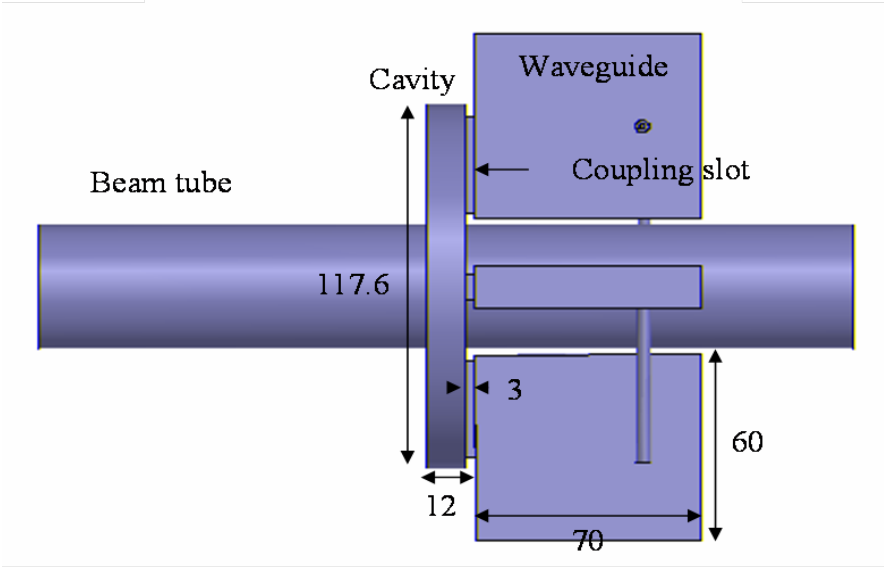
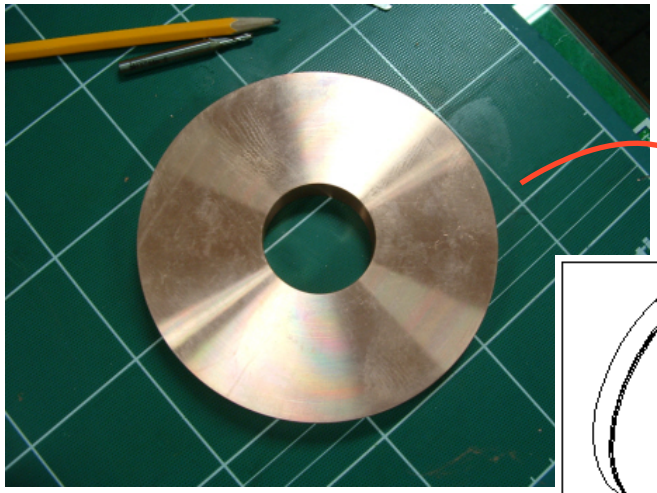


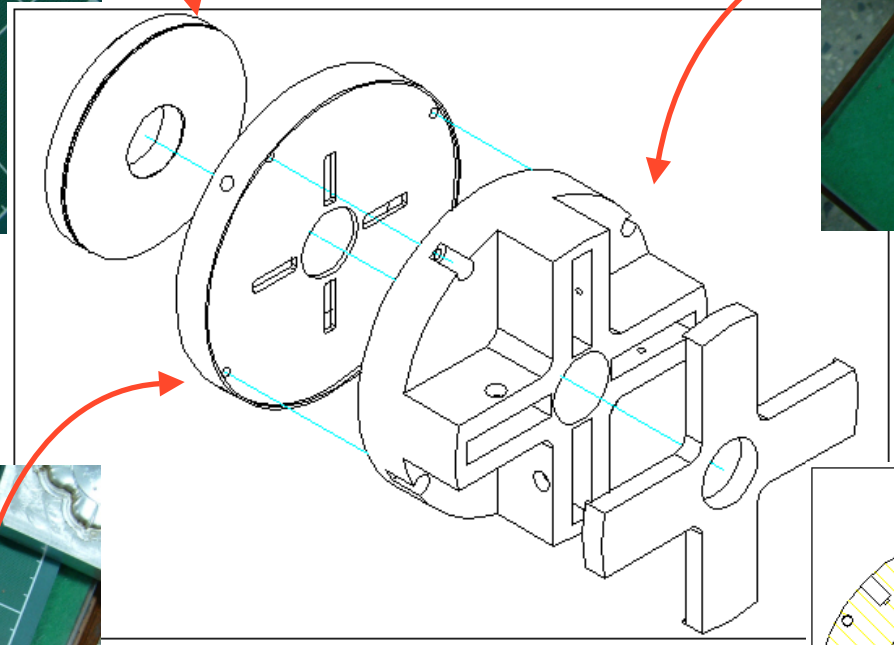


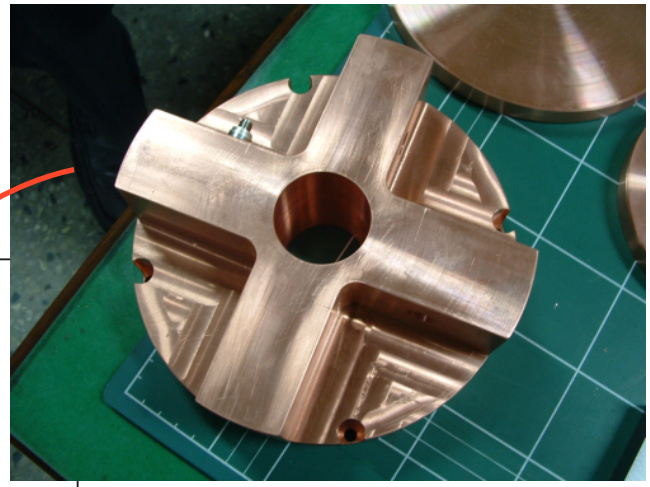


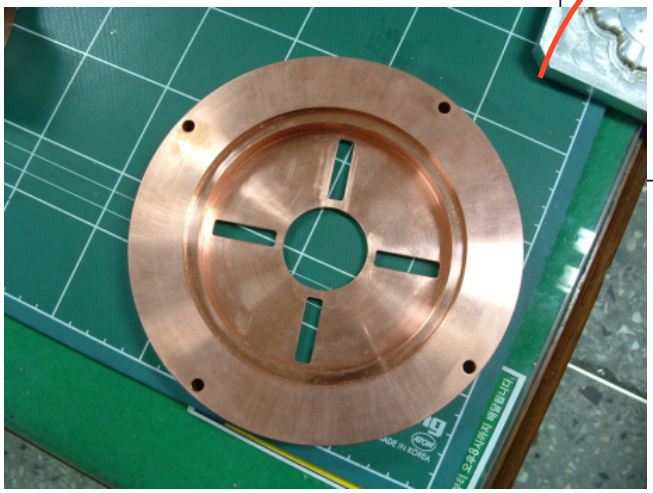
S-Band fabrication

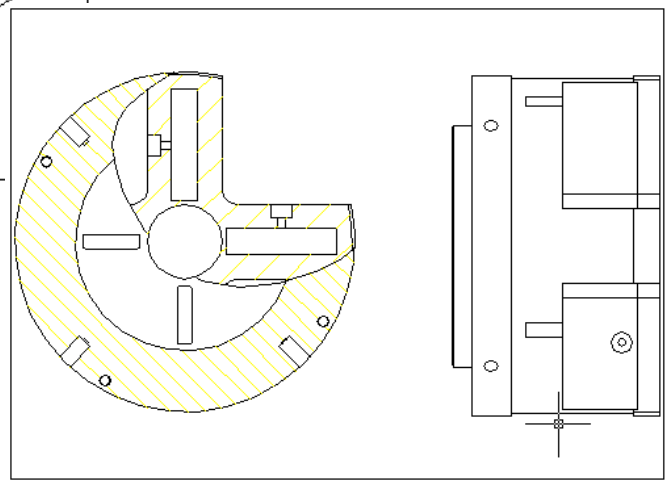
KNU





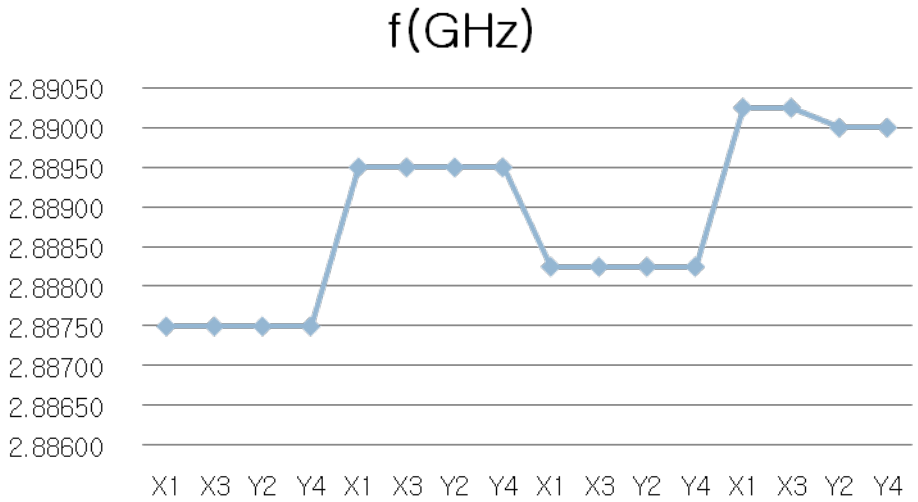


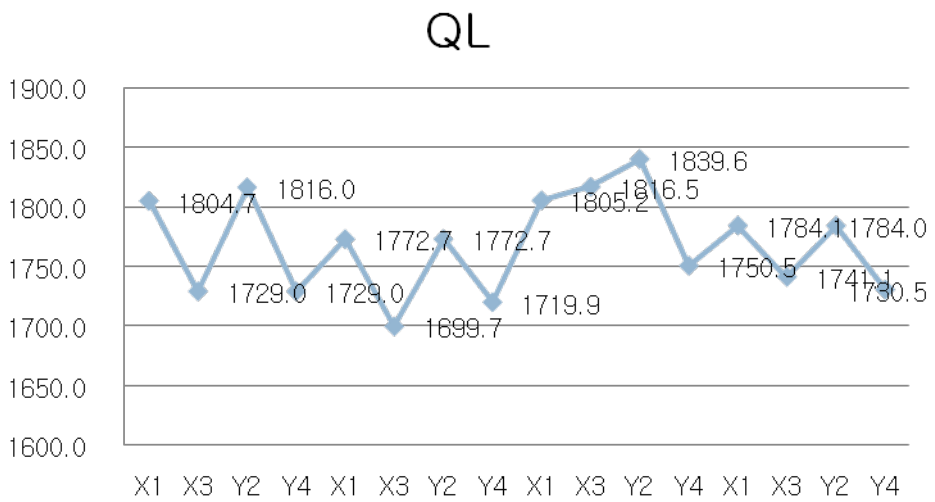


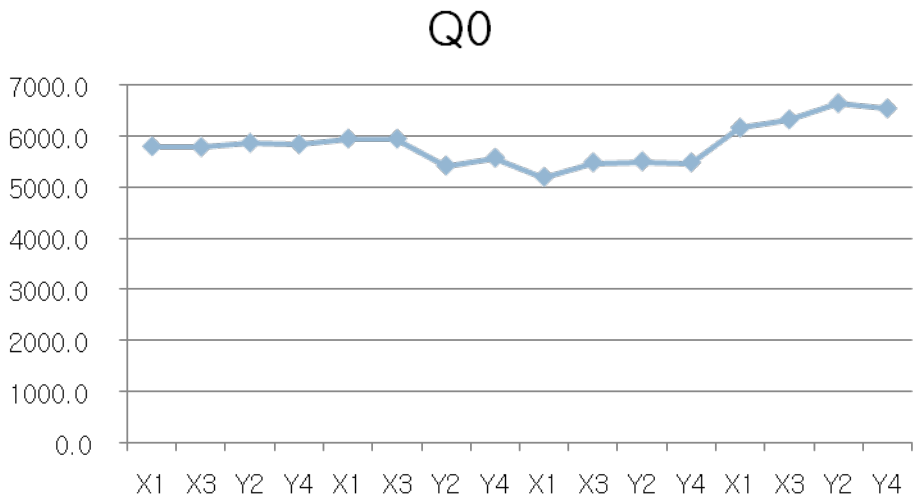


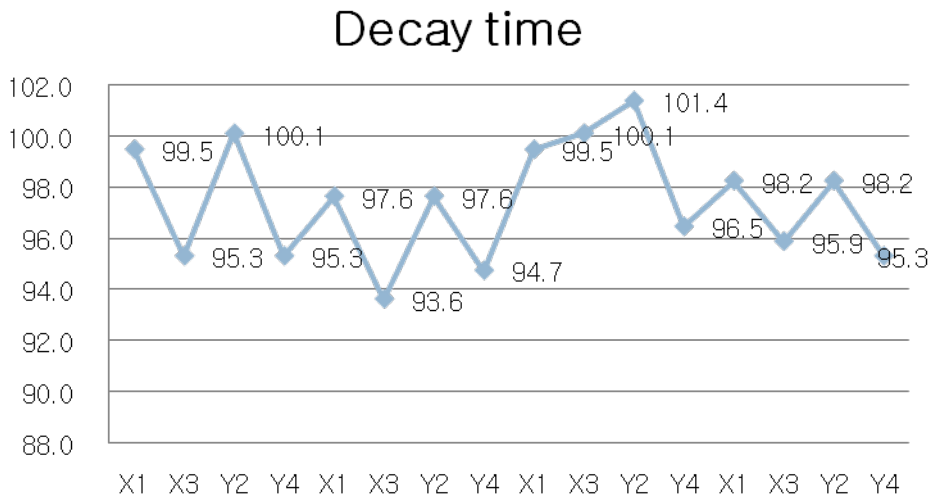
S-Band RF results

KNU



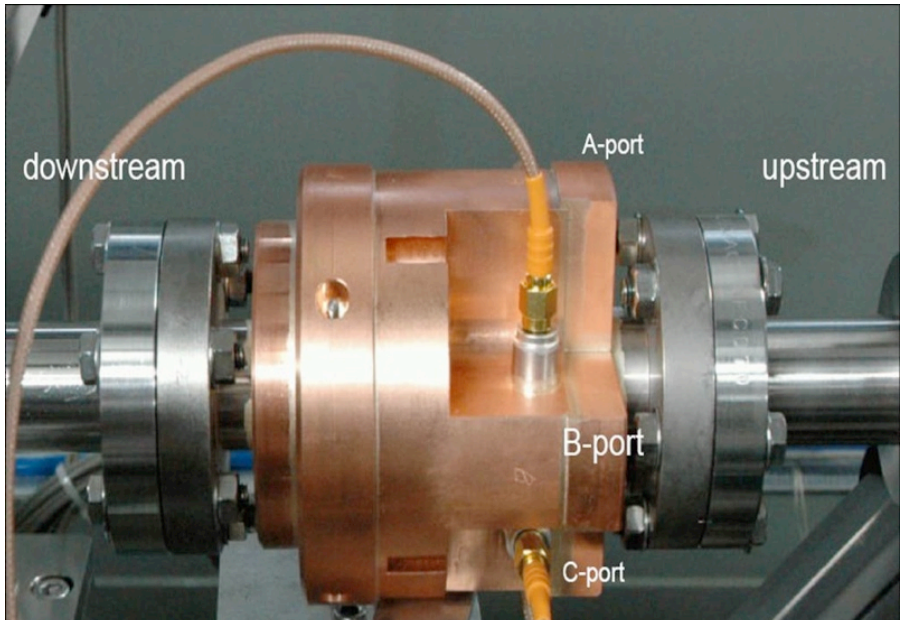




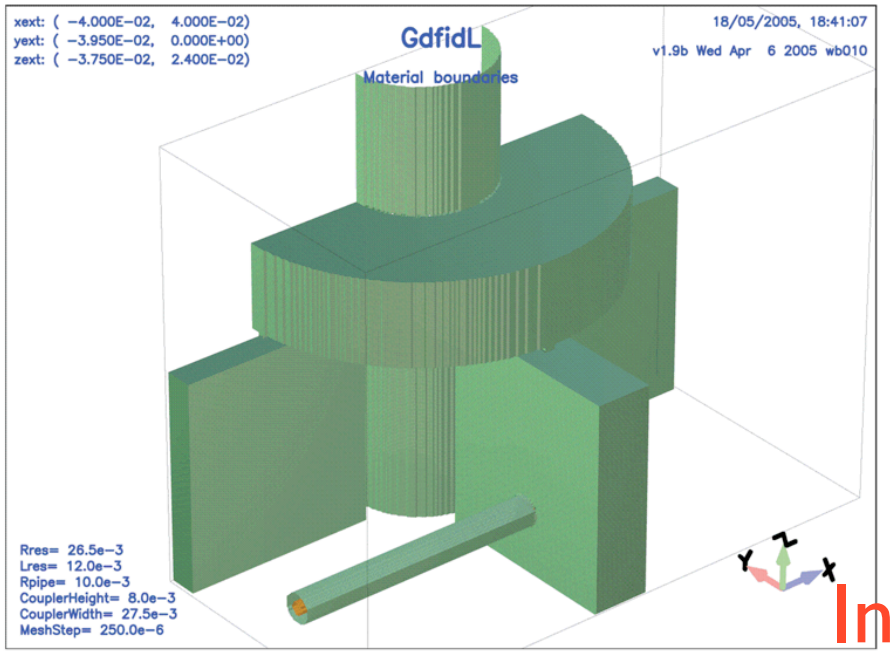


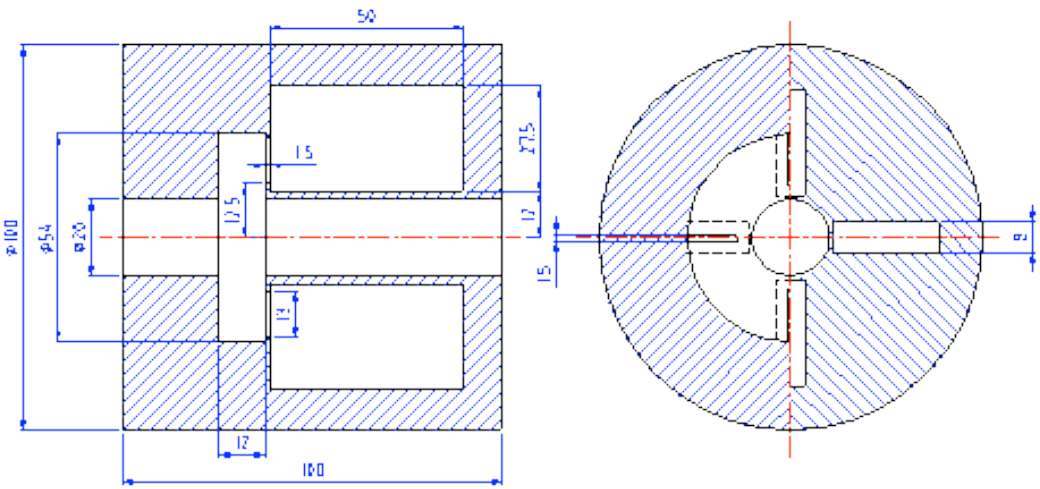
C-Band cavity design

KEK/UCL



- Design very similar to S-Band
- f = 6.426 MHz
- coupling factor ~ 0.6
- Q_{ext}~13,000



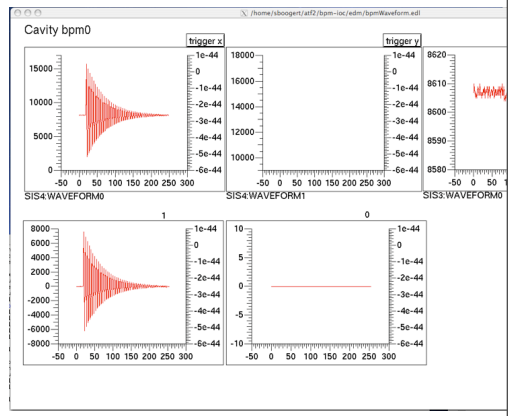


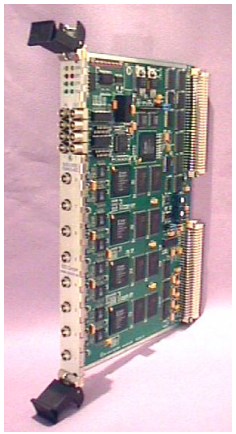
Information for design/prototype

BPM system overview

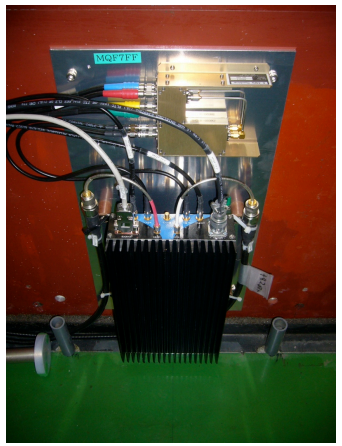
- C and S band systems similar processing
  - IF mixed (locally in tunnel) to 20 MHz for transmission and digitization
  - 20 MHz signal digitized with 100 to 120 MHz ADC
  - Digital mix down to baseband to extract phase and amplitude information
  - EPICS control/readout

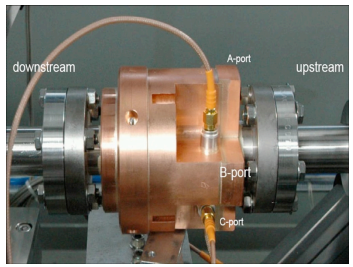
ADC/EPICS





mix to 20 MHz IF

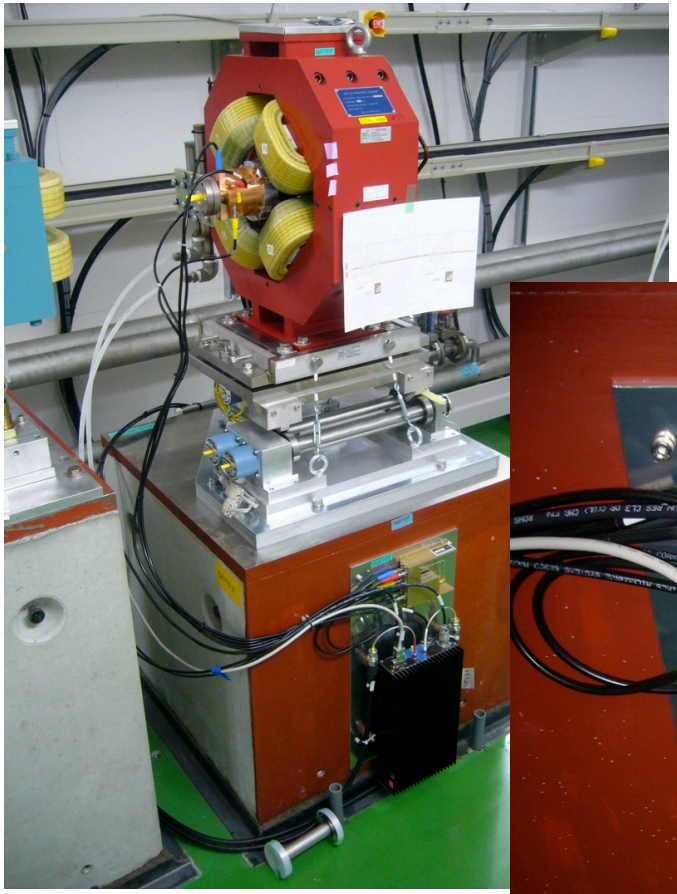




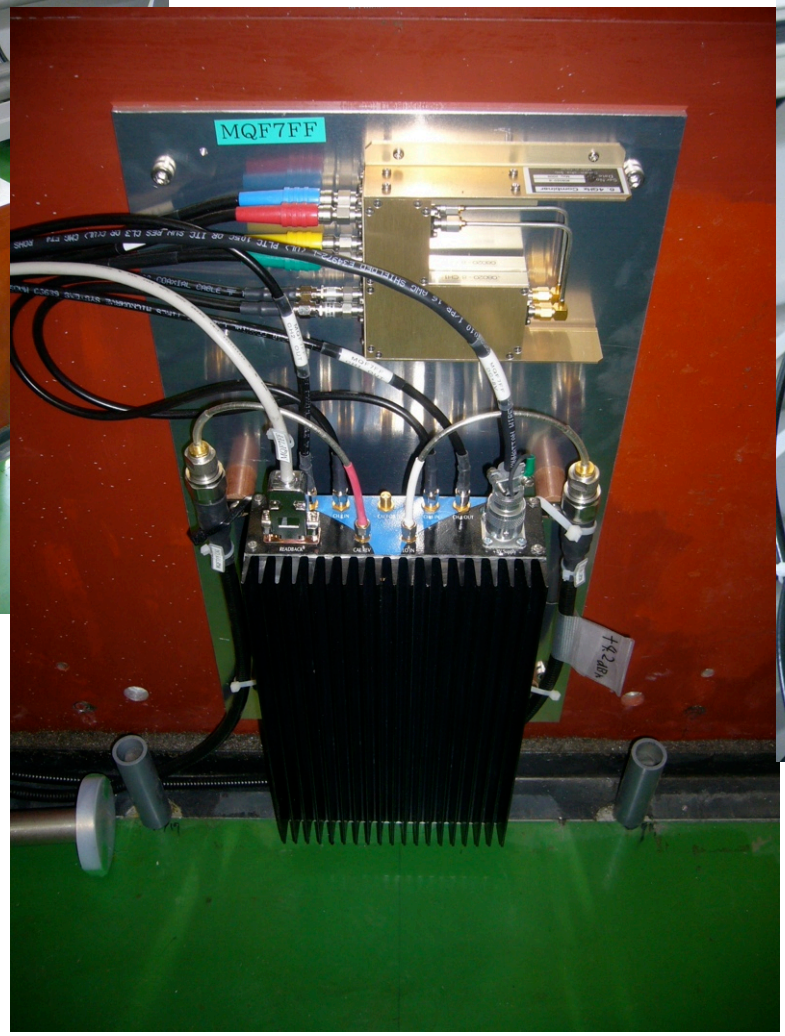
cavity output

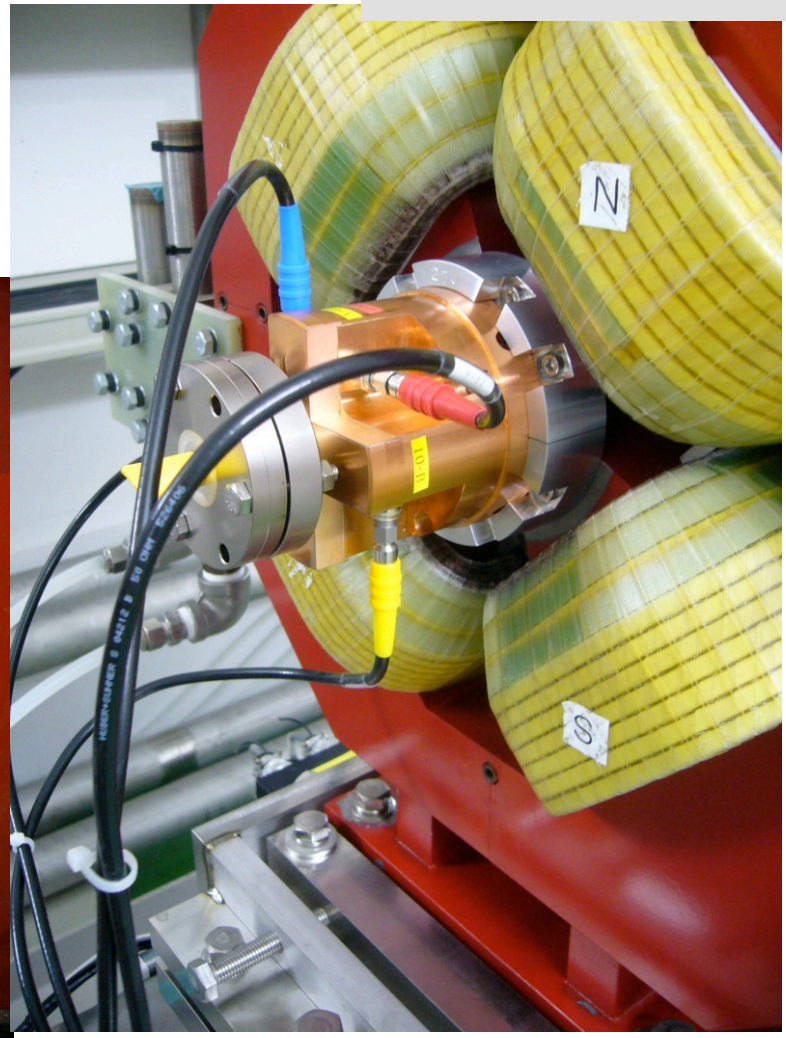
C-Band installation

SLAC/KEK



Quad package





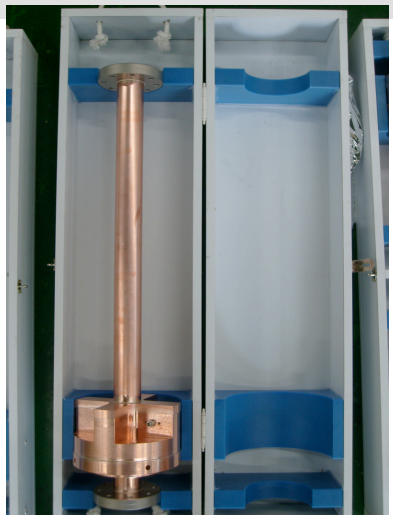
SLAC electronics

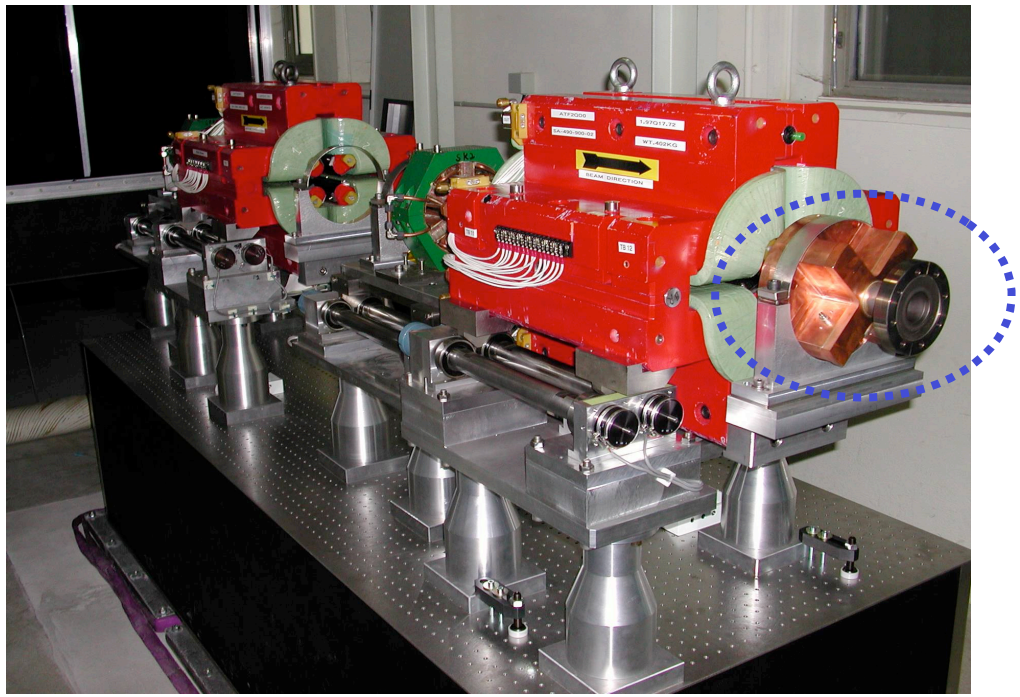
Cavity mounted in quad

S-Band installation

KEK/KNU/LAPP

- 4 Band BPMs have just been installed in ATF2
  - Split quadrupoles and sextuples of final focus system
  - Shown here in final doublet mock-up
- See talk of Tauchi-san with pictures of final S-band BPM installation in FF

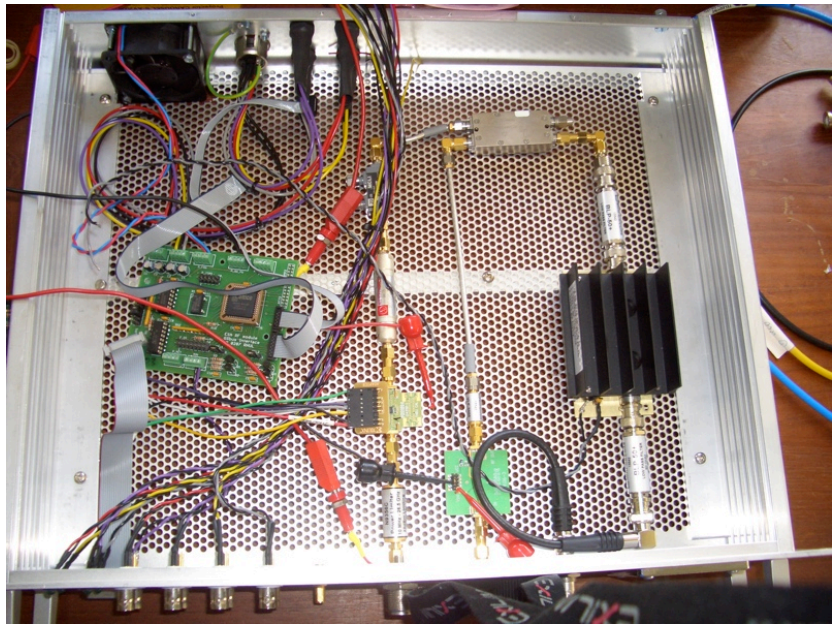




S-band electronics fabrication

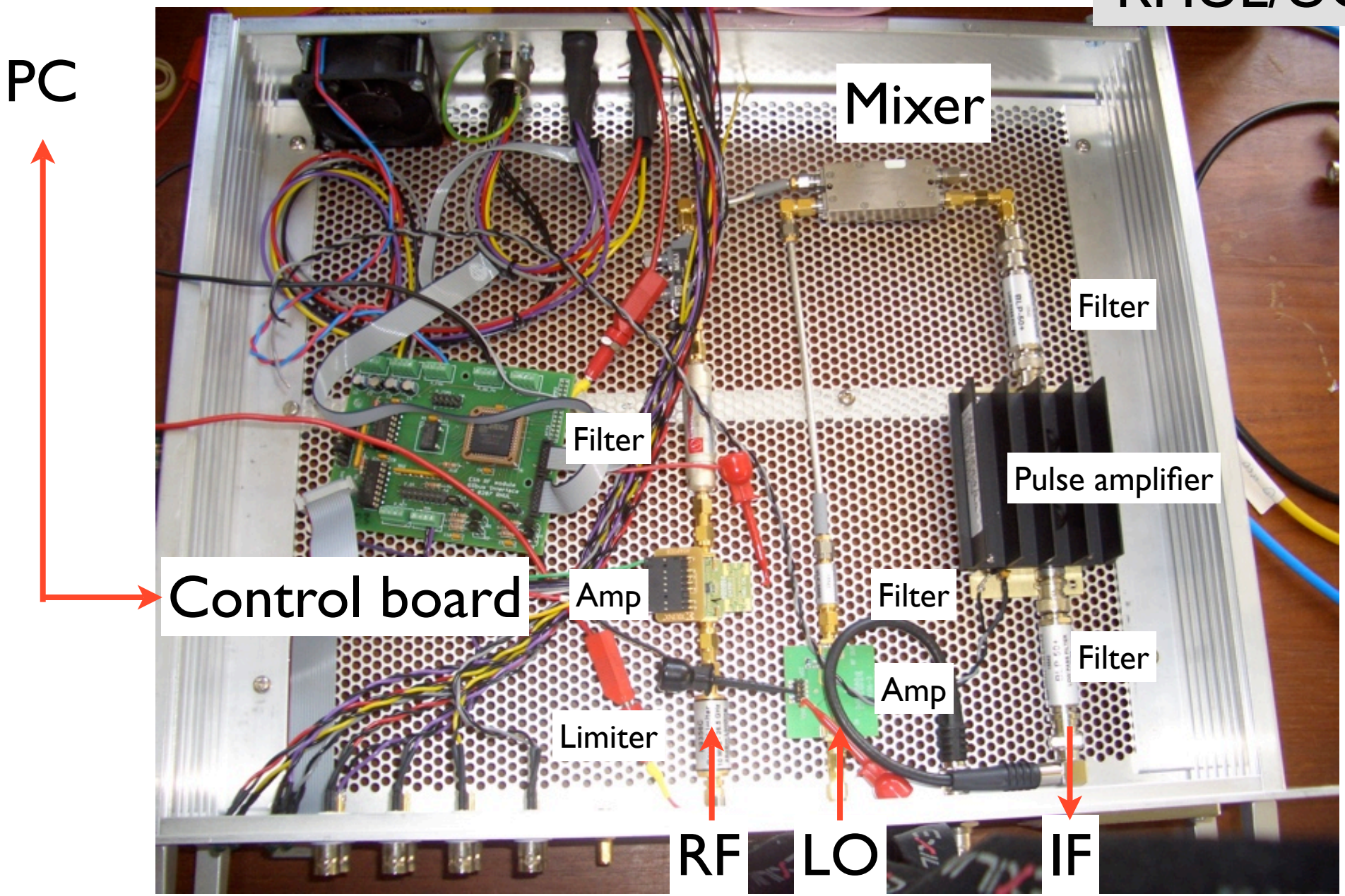
RHUL/UCL

- RHUL summer student constructed new processing boxes (9 total)
  - Each individual component tested
  - Improved since End Station A (T474) tests
  - Remote control of signal gain
- Deliver to KEK end of the month



S-band processing electronics

RHUL/UCL



Local oscillator system

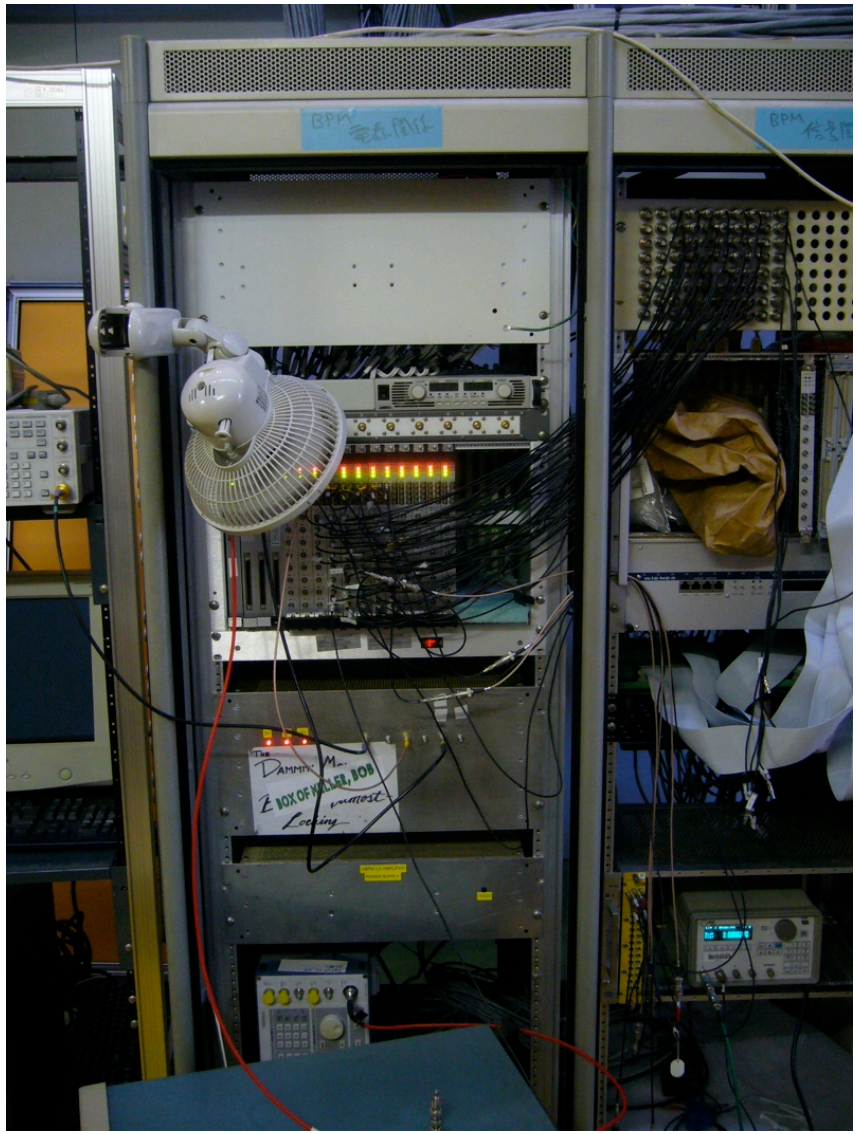
KEK/Cornell

- Master oscillator frequencies
  - 714 MHz
- C-Band system
  - Generate phase locked :
    - Local oscillator (6.446 GHz)
    - Digitizer clock (100 MHz)
- Stability of 714 MHz signal possibly an issue
- S-Band
  - RF Source for LO and 100 MHz internal digization clock
    - Need reference for phase

Digital system

SLAC/RHUL

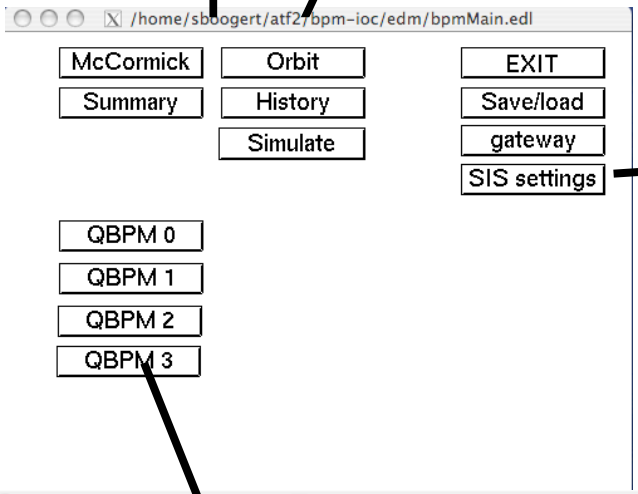
- Based on SIS3301 100 MHz 8 channel, 14-bit FADC digitizers
  - VME MVME167 CPU
  - VxWorks EPICS controller
  - External clock and trigger
  - Acquisition from VME to linux computer/ATF control system

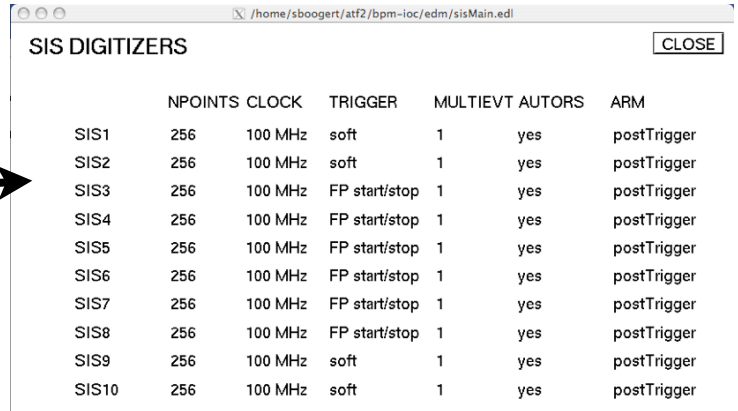


EPICS Control system

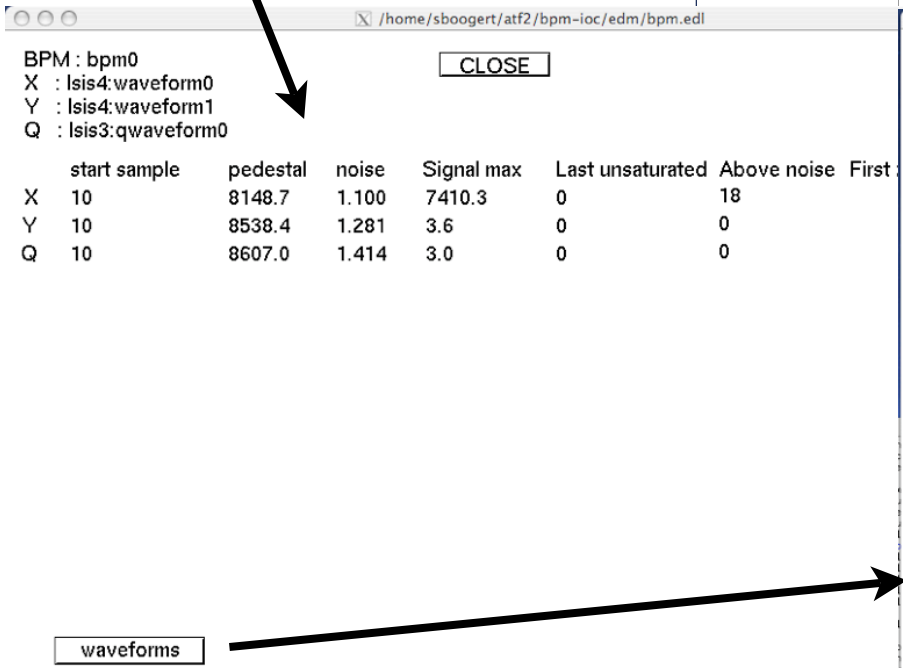
RHUL

Main display

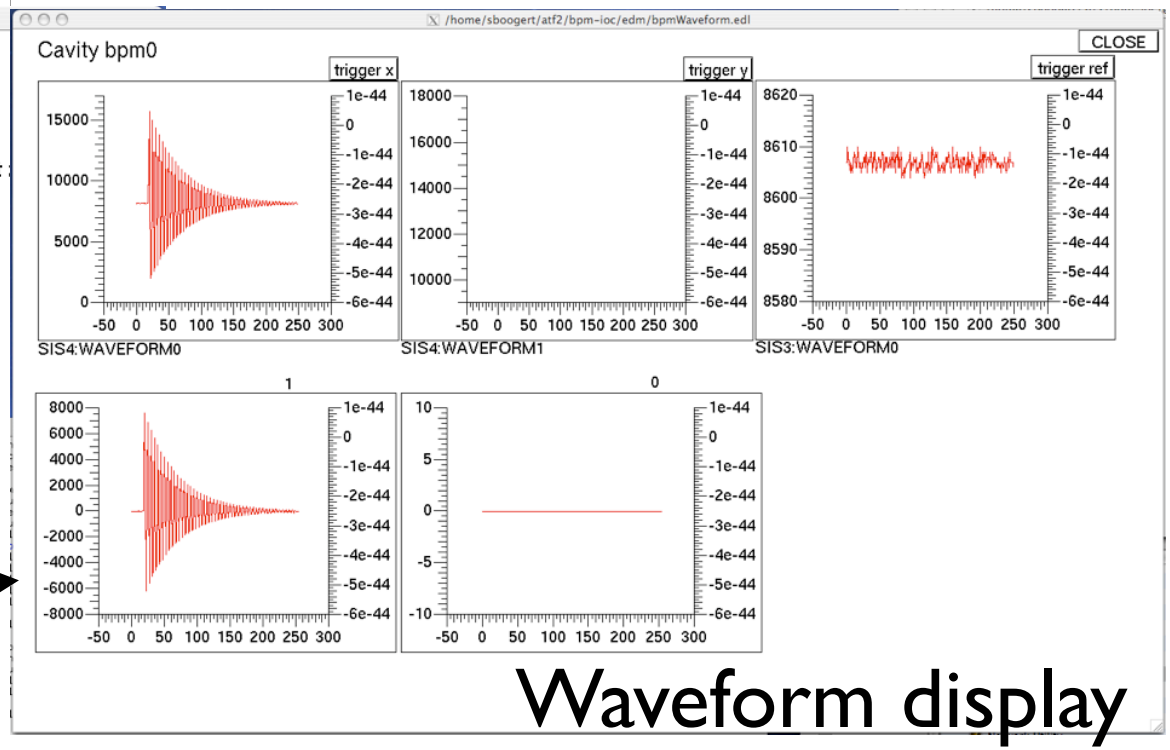




VME system status



BPM control

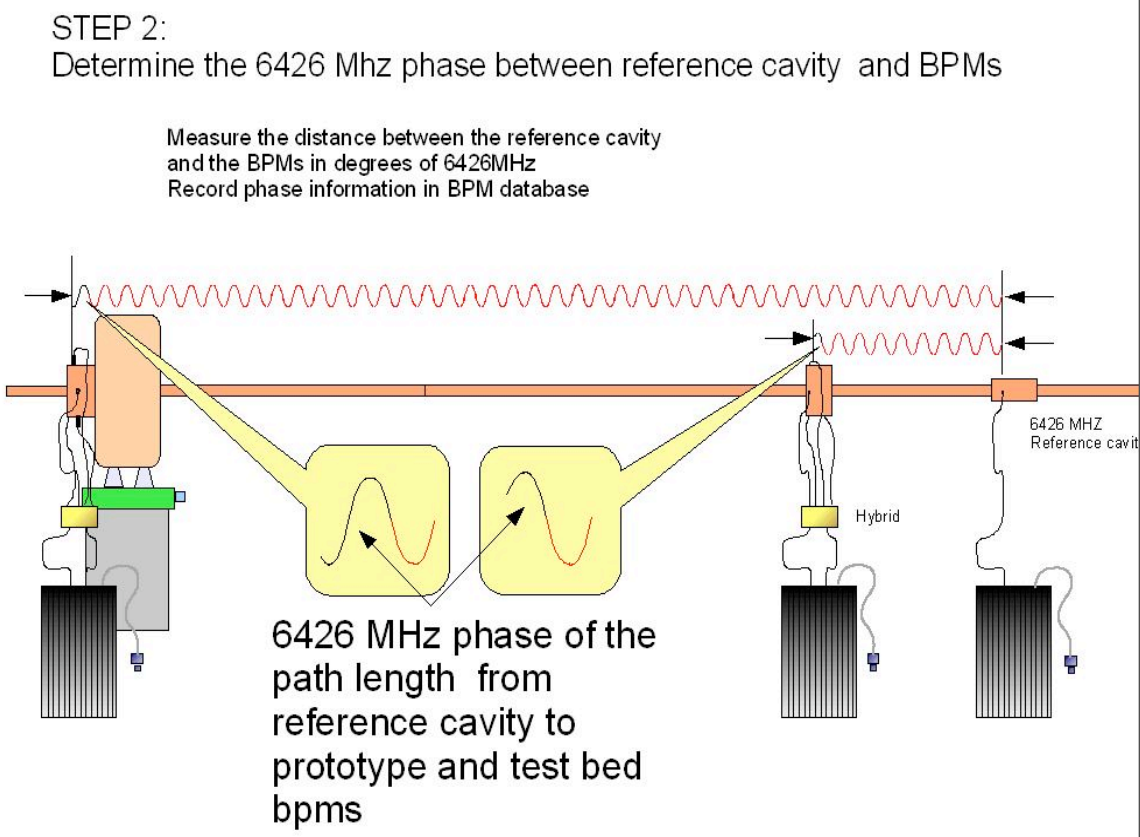


Waveform display

First pulse calibration

SLAC

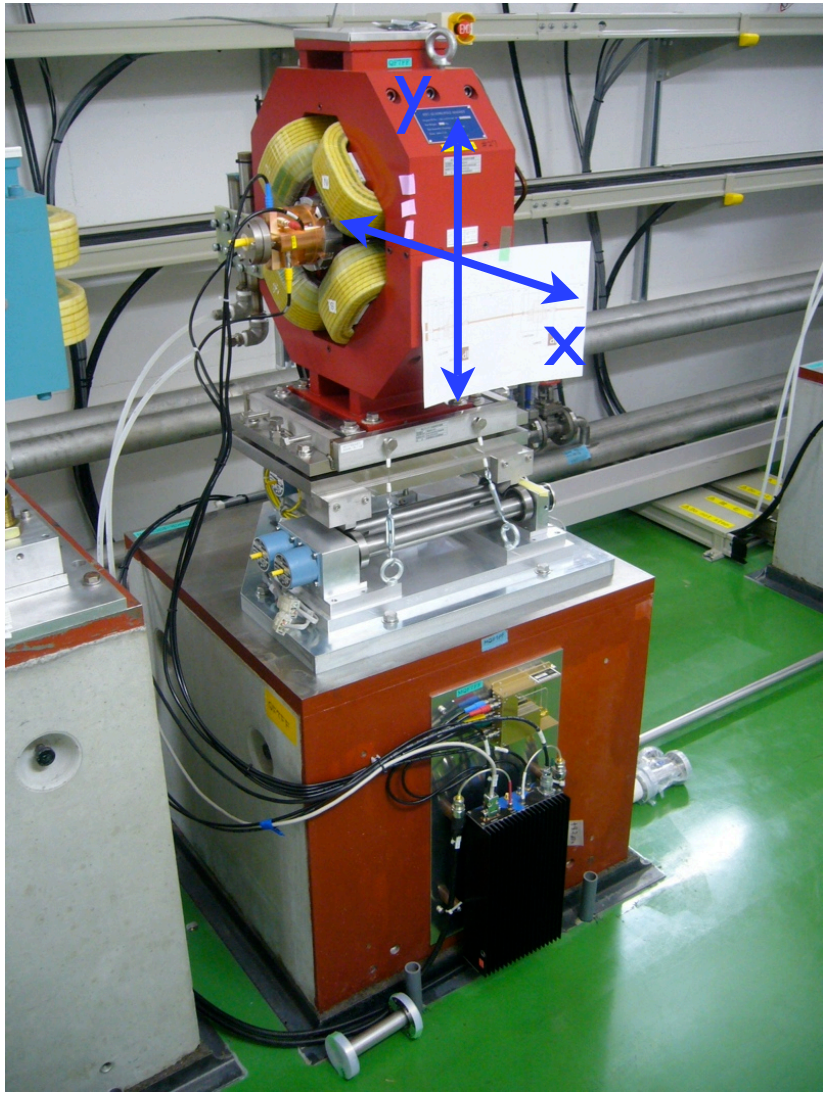
- Ab-inito calibration difficult
  - Centre defined by pi phase change
  - Find centre of first BPM
    - Measure all cable phases (LO and signal) and beam propagation time
    - Extrapolate to downstream BPMs
    - Still difficult but possible



Calibration

All!

- Use quadrupole/ sextuple mover system
  - Calibration range ~0.5 mm
  - Extract I-Q rotation and scale (mm/V)
  - Also
    - Orientation wrt movers and other BPMs
    - Cavity/wavequide alignment



Environmental monitoring

- Monitoring essential for long term operations
  - Electronics temperature (gain dependence)
  - Gain monitoring by RF tone injection
    - CW waveform generator
  - LO power monitoring
  - Attempt to avoid mover calibration procedure
  - Long term stability of cavity systems never verified
    - 1-2 days (periods between BBA)
    - 1 week? (typically ATF operates for 1 week)
    - ATF2 FF spot size tuning 2-3 days

Summary

- First beam next month
  - First pulse operation for large number of high resolution cavities difficult
  - Calibration
    - Move quad and BPM package, compare with BPM output and determine calibration coefficients (~40 cavities)
  - Environmental monitoring
    - Electronic temperature, LO power, mechanical movement of quadrupole package
- Test bed, operational example of the slot waveguide type BPM for long time scales, usability, performance