Proposed Changes to IP-BPMs

C.Perry - Oxford - 2017-03-10

Outline

What we're trying to do:	Objectives
	Decay Time
How to do it:	Indium Seal
	Reduced External Coupling
Details of the seal:	Indium Seal Design Considerations
	Indium Seal Design Concept
An unforseen problem:	Alignment Issues
	Preserving Alignment of A+B
	Alignment of C
A lesser problem:	Frequency Shifts
...and the usual one:	Schedule

Objectives

The present BPMs have a shorter decay time than necessary

- we are concerned at most with 2 bunch operation, ~280ns between bunches
- feeback performance depends only on measuring the first
- the second is needed to observe the performance, but can have more elaborate off-line processing

Short decay times always present problems with getting the best resolution

We have reliable figures for the resolution attainable with the present electronics at 30ns decay time

- it seems preferable to try operating in a similar region
- this ***may*** permit improved resolution

The present BPMs could be adapted to give this, without risking permanent harm to them

Conventional vacuum-brazed copper BPMs would be much nicer, but they would be a major and lengthy project

Decay Times

- the original copper BPMs were 30ns for Y
- design values for the aluminium BPMs were 17ns for Y
- measured for aluminium were
    - present IPA, IPB 10.5ns
    - previous IPC (now removed) 6.6ns
    - present indium sealed IPC 19ns
- decay times ~25ns would seem preferable
    - the present IPC would be (very) marginally acceptable
    - IPA and IPB are much too short

NB: loaded Q is about 40 times decay time in ns

Indium Seal

To raise the decay time, the internal Q has to be raised to something approaching the proper value

- since we want loaded Q ~1000, reasonable electrical efficiency implies internal Q at least 2000
- the only way that looks practical and not irreversible is to use indium to form an electrical seal

IPC:

- previous IPC had internal Q ~250, which a crude indium seal raised to ~2200
- new IPC (indium sealed) also has ~2200
- so either the present could be retained, or previous used with indium seal added
- choice depends on convenience: using the previous seemed easier

IPA and IPB:

- have internal Q much too low at ~700
- expect adding indium seal would bring this up similarly to IPC

Reduced External Coupling

The external coupling is too great to reach the desired decay time even with indium sealing

- while looser than designed, it will not permit a decay time over ~20ns on Y

Adding a spacer under the feedthroughs appears a satisfactory way of reducing the coupling

- this moves the coupling probes towards the wall of the waveguide sections
- it produces frequency shifts, but remains efficient
- the tests show external Q is comfortably controllable up to at least 4500
- target value is about 2000

This is Y: X is similar, though the present external coupling is considerably stronger.

- the changes apply in about the same way
- tests so far have admittedly been sketchy (but X performance is less important)

Indium Seal Design Consideration

- solid contact between cover and body for accuracy and mechanical stability of assembly
- adequate contact area because contact of indium on aluminium is not good because of oxide film
    - tests show it may be only in scattered small areas ~10um or less diameter
    - capacitance of the oxide film can guarantee low loss at RF, provided:
        - oxide film is thin enough (tests show it is likely to be)
        - there is sufficient area
- highest practical contact pressure to improve quality and stability of contact
    - cannot get enough pressure for a good metallic contact
    - indium does not weld to the aluminium under available pressure
- no unfilled 'crevice' on the cavity side of the seal
    - a continous space around the seal will give a frequency shift
- allow reproducible assembly
    - indium adequately located, wire rather than cut foil etc

Indium Seal Design Concept

The seal was intended to use a groove in a new side cover to avoid modifying existing parts:

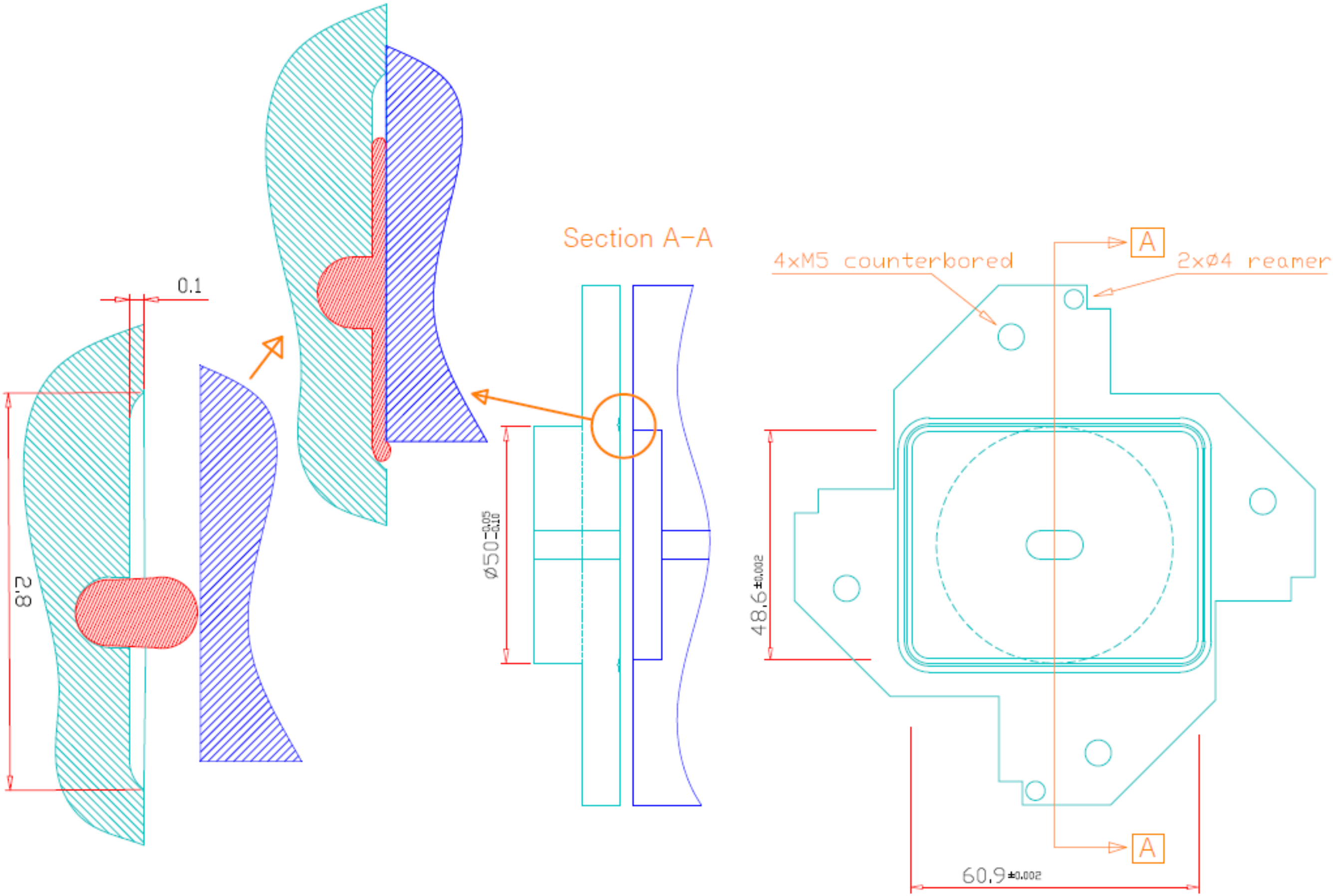
- much of the work could be done before receiving the BPMs
- in the event of problems, they could be re-assembled unaltered

Simply using a wire in a square groove would have been nice, but was rejected:

- if groove is over-filled, good contact, but will not bolt up aluminium to aluminium
- if groove is under-filled, little contact pressure and small area of contact

Proposed design uses 0.7mm indium wire:

- a broad (~2.5mm) shallow (~0.1mm) groove has a deeper narrow groove off-centre along its base
- the wire (slightly flattened laterally) locates in the narrow groove
- when the seal is made, the indium spreads in the shallow groove
- on the cavity side, it spreads just beyond the cavity side wall
- on the outer side, it is also unconstrained by the shallow groove being sufficiently wide



0.1
2.8
Section A-A
4xM5 counterbored
2xØ4 reamer
A
A
Ø50
48,6±0.002
60,9±0.002

Alignment Issues

We ***had*** assumed that if:

- new side covers were made to similar accuracy to the originals
- they were positioned using the locating holes provided
- the alignment between BPM A and B bodies was not disturbed

the new assembly would be a drop-in replacement.

This apparently is not true

Seem to be two issues with side cover alignment:

- affects orientation when mounted on movers... but don't these have a fair range of tilt adjustment?
- affects electrical axis of BPM from displacement of beam aperture... but don't know how much
    - which could prevent A+B assembly being aligned for no quadrature signals

But we don't know what the alignment tolerances are...

Are we talking about 20μm (easy...), 2μm (hard...), or 0.2μm (near impossible...) tolerances?

Preserving Alignment of A+B

We could preserve existing alignment of the A+B assembly by precise measurement and making the new assembly to match.

- easiest if only position of mounting bosses are critical
- a bit harder if only the position of the beam apertures are critical
- hardest if both are critical: end covers have to be made with errors precisely matching present ones

No case looks quick or easy.

Could circumvent the problem by retaining present covers and machining sealing groove in them

- machine precision locating holes through the side covers into the body of the assembly
- disassemble and machine the side cover grooves
- reassemble with seal, using pins to locate covers accurately in original positions

Relatively easy, but cannot restore original, unmodified assembly (eg in case of machining error)

(Adding these locating holes would help in the previous case to allow easy restoration to unmodified state)

Alignment of C

We had proposed modifying the previous BPM C which we have been using for tests

- leaves the present C unchanged so no problem in reverting back to present system
- with identical seal to A and B, should be no systematic tuning differences

In this case, we cannot preserve previous alignment (because it has been dismantled)

If alignment of BPM C is not critical, we might still prefer to use it

If it is, it looks best to use the new BPM C

- retain and do not disturb the present indium seal
- just add the spacers to the feedthroughs

Frequency Shifts

Changes to the BPMs are liable to shift their frequencies

- systematically, because of the changed nominal design
- randomly, because of tolerances in making the changes (believed to be insignficant)

Systematic shifts should mostly come from reducing the coupling

- expected to be about 4 or 5MHz on X and Y (but in opposite directions) from preliminary tests
- smaller shifts (estimated under 1MHz) could come from the seal design
- it is unclear if the overall shifts will stay within range of reference cavity tunability

These could be corrected by machining recesses in the face of the side cover

- not trivial
- particularly undesirable if existing covers to be modified
- not applicable if C is used without disturbing the seal

Schedule

Aim was:

- expect to be done for May running
- an easy option to restore the BPMs unchanged if we were late

Tight but reasonable. But any complications from alignment issues etc make it impractical

It might be ok were it acceptable to miss May, and install for June in the event of problems.

- the present BPM C only would be available in May
- unaltered, if old C is to be modified; otherwise, with probably with the spacers added

The same would apply if the intent was to install for June.

The natural solution would be to make the changes over the summer

- adequate time for preparation and a longer period for the work.

But from our perspective does not mesh well with the needs of our students.