Ideas for a new Bunch-by-Bunch application

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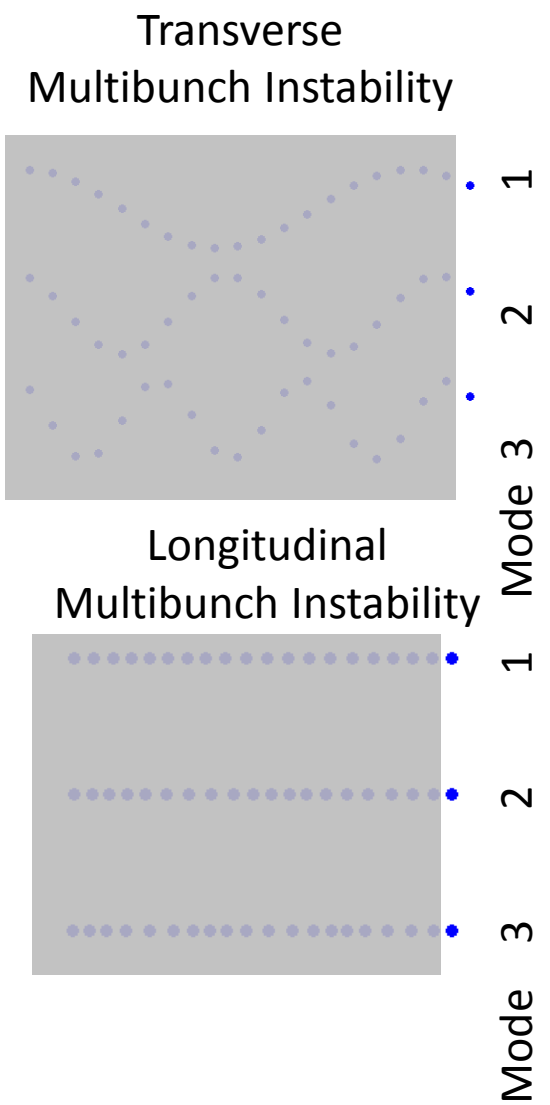
Outline

- Purpose of Bunch-by-Bunch (BbB) Feedback
- What's the need for a new system?
- Which components / specs / functionality
  - Should stay the same
  - Would we desire to be different
  - Would we like to add

Purpose of BbB Feedback

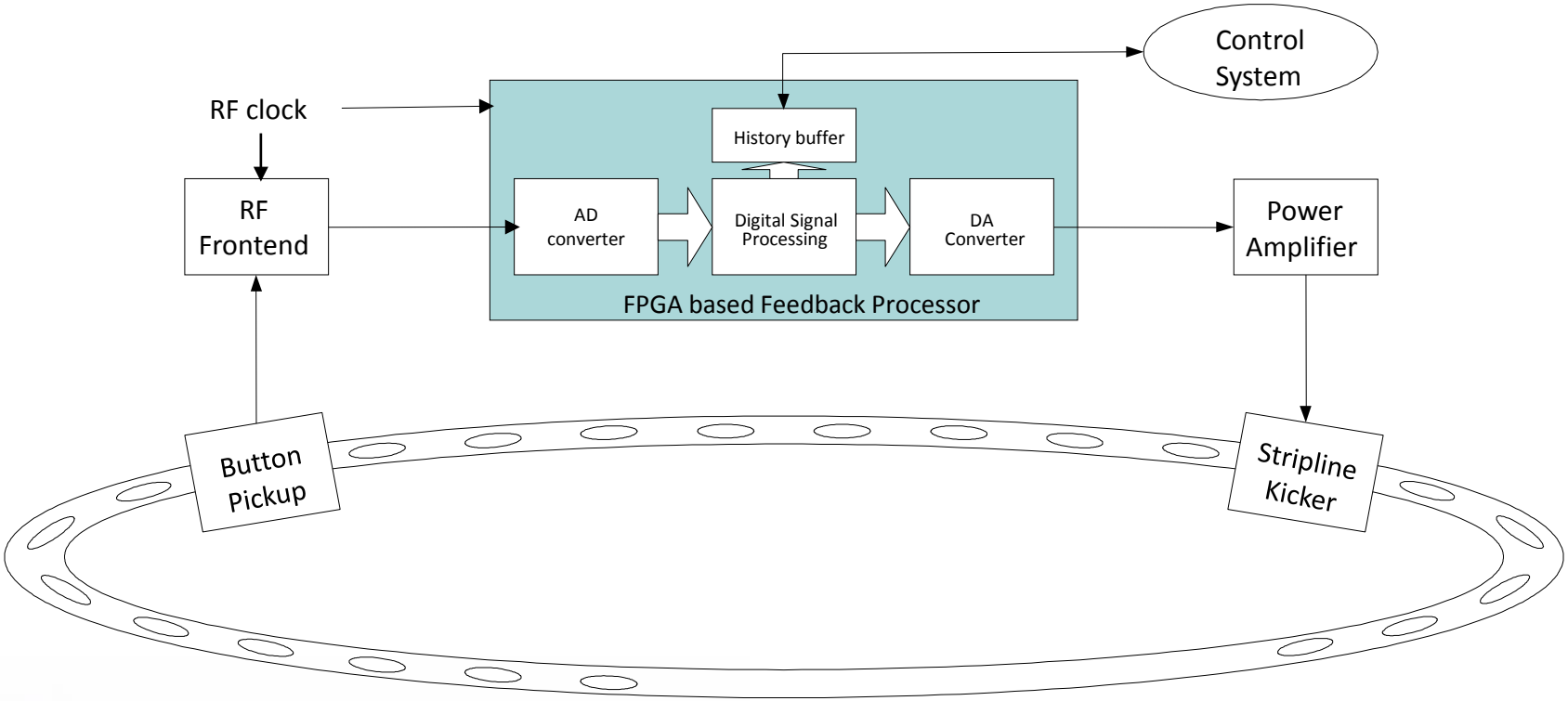
- A BbB feedback will add negative feedback at betatron or synchrotron oscillation frequency of each individual bunch.
- By doing so, it supresses oscillations of **each** individual **bunch** and as a consequence also of **any mode** of oscillation of many or all bunches
- Thus it is used to supress transverse or longitudinal multibunch instabilities, which can be caused by wakefield or ion trapping



Top Level Requirements

- Each bunch needs acting upon, typically only 2ns between bunches
- Each oscillation mode is associated with a frequency, these span 0 to half bunching frequency, typically **0-250 MHz bandwidth**
- All modes need to receive negative feedback:
  - **Phase response** of the whole loop over the whole bandwidth needs to be **flat to a few 10 degree**, otherwise driving some modes instead of damping
  - **Amplitude response** should be **flat to within 3dB**, otherwise very little damping for some modes

Digital BbB Feedback



- A/D and D/A run synchronous to bunches, every bunch measured
- Longitudinal feedback similar with longitudinal kicker (and modulator before amp)
- Different feedback parameters/actions for individual bunches possible

Why a New System? Why Now?

- Existing Libera BbB is based on obsolete technology
- Resources in ‘good old’ Virtex 2 Pro are limited
- Not a good choice for new projects thus
- Some ‘lessons learned’ could be incorporated in a new development
- Libera Spark (based on Zynq SoC) is potentially ‘half of a B-b-B Feedback’ already

More than Feedback

- Besides the fundamental task of B-b-B feedback the power for the FPGA offers lots of other opportunities:
  - BbB observation to assess motion in any mode (250 MHz instantaneous bandwidth spectrum analyser)
  - BbB manipulation:
    - Exciting bunch with small oscillation for measurement of tunes
    - Exciting bunches with large oscillation for bunch clearing
    - Different feedbacks / actions for different bunches at different times
  - Mode by Mode manipulation:
    - Excite individual modes and observe natural and forced damping
    - Different feedback for different modes (idea for future!)
- All this requires FPGA/memory/network resources

Existing / proposed frontend

- Keep hybrids for ABCD to XY processing:
  - ABCD digitisation as in EBPMs would just be a burden
  - Scaling of X/Y with bunch charge is not an issue, in fact it provides automatically more gain at higher stored current
  - handling of large ABCD to look at the differences is not good for S/N
- Keep RF frontend:
  - 250 MHz bandwidth requires this as undersampling would deteriorate S/N too much
- Possibly double up to have I/Q mixers rather than synchronous mixers which require phasing of LO
  - Process I/Q through digital processor all the way to output as I/Q

Existing / Proposed BbB Processor

	Existing Libera BbB	Proposal
FPGA	Virtex 2 Pro	Xilinx 7 Series
DSP (multipliers) blocks	136	740 (top of 'entry level' Artix)
Clock rate	125 MHz (4 parallel)	250 MHz (2 parallel)
ADC	4*125MS/s 14 bit	2*500MS/s 14 bit
DAC	1*500MS/s 14 bit	2*500MS/s 14 bit
ADC/DAC coupling	AC/AC	DC/DC
On board RAM	128MBytes	Several GBytes
Network	100MB Ethernet through CEP	1GB Ethernet through CPU
Streaming	(not available)	Direct 10GB Ethernet?

Embedded or Modular?

Embedded	Modular
Extremely compact (1/2 size 1U)	Compact 1U
Fixed ADC/DAC	Choice of ADC/DAC through FMC
Fixed FPGA size	Choice of FPGA through carrier
Fixed CPU	Choice of CPU through crate / module
Standalone	Crate could house several channels
One specific use	Adaptable use
All built for one purpose with system performance in mind	Combination of modules with reliance on standardised interfaces
Significant development cost/time	Potentially available ‘off the shelf’
Lower production cost	Higher production cost

Conclusion/Discussion

- Thank you for your attention and input so far.

- Who else is looking for a Bunch-by-Bunch feedback or other high throughput system?
- What else could/should be accomodated?
- Opinions, please!