Measurements of Longitudinal Coupled Bunch Instabilities and Status of New Feedback System

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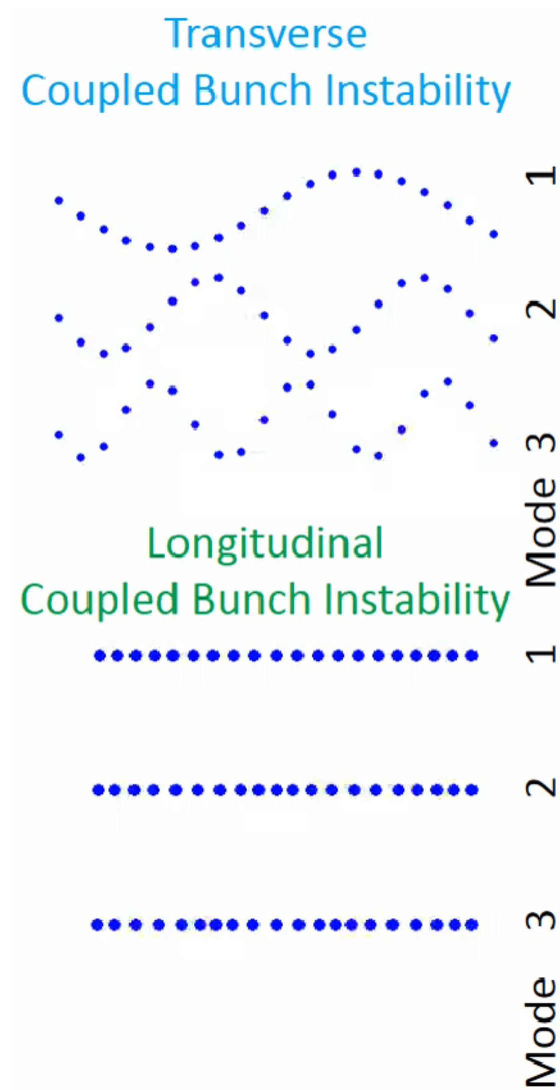
Outline

- Motivation / Introduction
- Measurements of longitudinal CBI using existing electronics
- Status of new feedback electronics
- Conclusions

Purpose of BbB Feedback

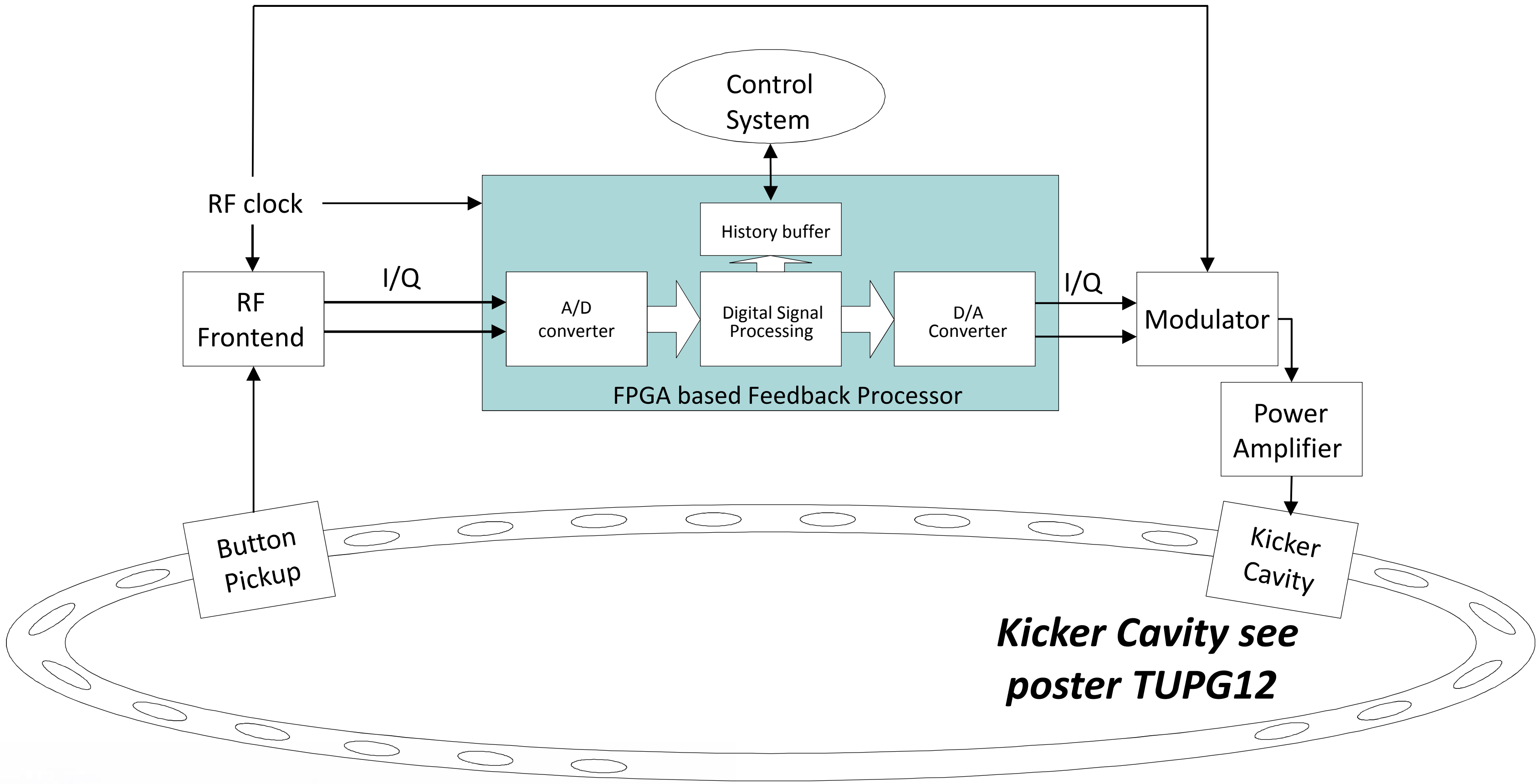
- A BbB feedback will add negative feedback at betatron or synchrotron oscillation frequency of each individual bunch.
- By doing so, it supresses oscillations of **each** individual **bunch** and as a consequence also of **any mode** of oscillation of many or all bunches
- It is used to supress transverse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



Need for Longitudinal Feedback

- Diamond has currently two **super conducting** cavities installed (Cornell type)
- Two **normal conducting** cavities (HOM damped design) to be installed in Summer 2017
- BESSY 2, MLS, DELTA have these HOM damped NC cavities, still need longitudinal BbB FB
- **Diamond needs longitudinal BbB FB ready to operate before NC cavity installation to ensure operation at 300mA**

Digital Longitudinal BbB Feedback



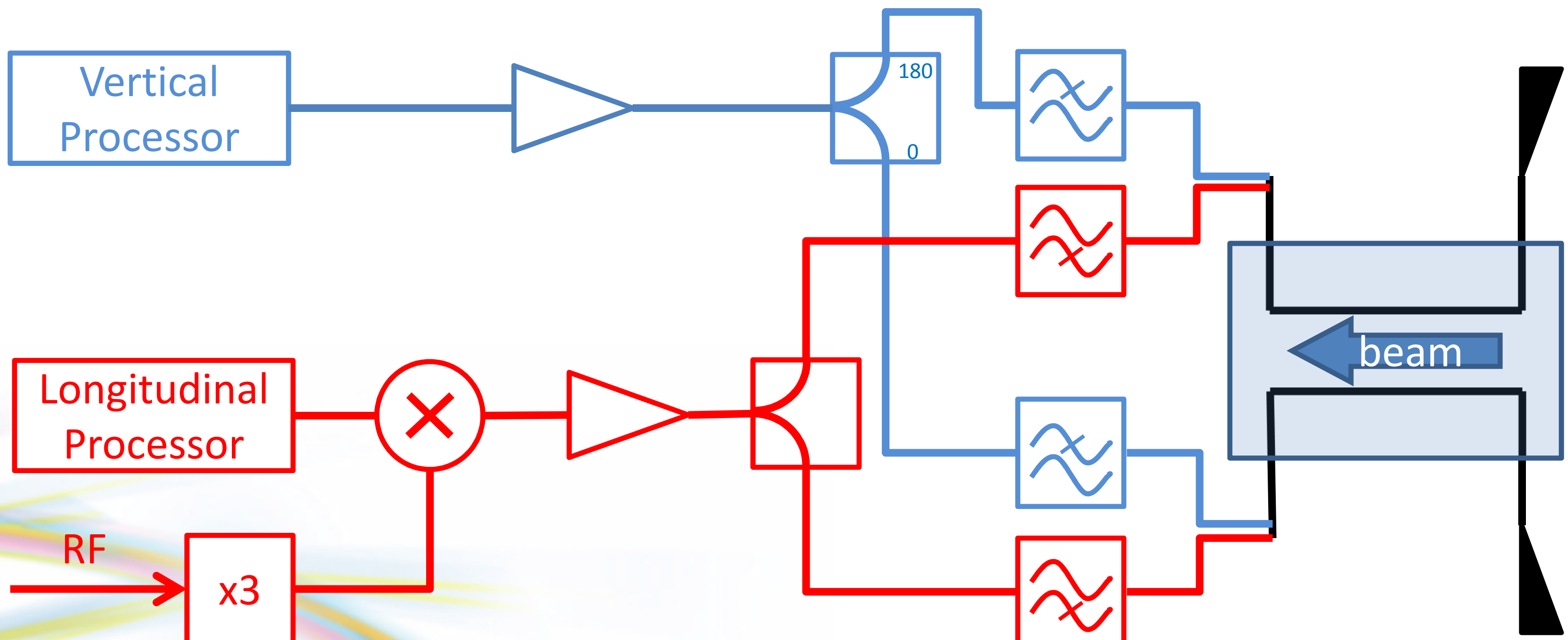
Kicker Cavity see poster TUPG12

- A/D and D/A run synchronous with bunches, every bunch measured
- RF frontend can be shared between transverse and longitudinal
- Different feedback parameters/actions for individual bunches possible

Stripline as Longitudinal Kicker

Temporary system before kicker cavity gets installed:

- Transverse kicks at baseband (0-250 MHz) in differential mode
- Longitudinal kicks upconverted to $3f_{RF}$ in common mode
- Diplexers combine signals to allow concurrent use as vertical and longitudinal kicker

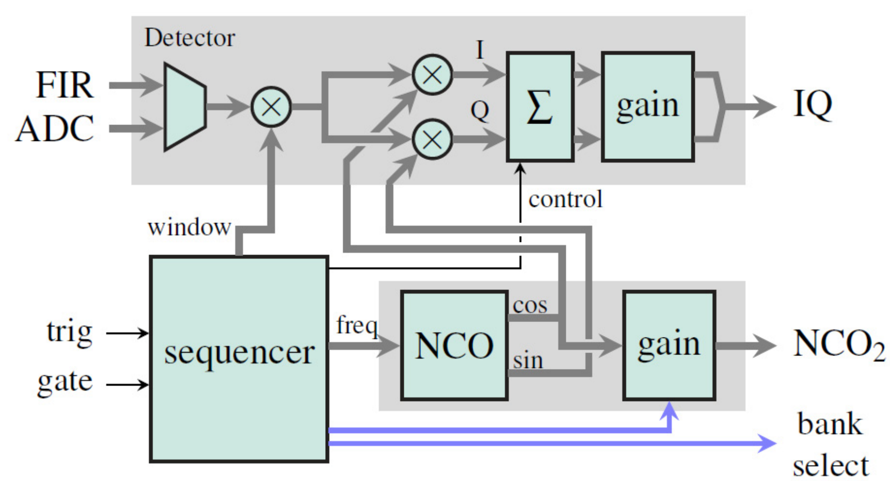


Exciting Longitudinal Modes

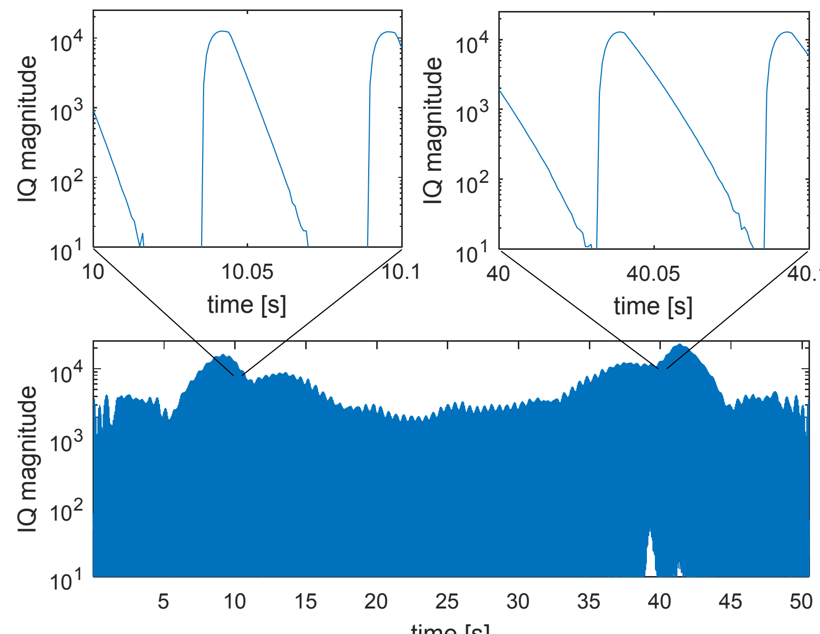
- Each mode μ is associated with one frequency:

$$\omega = (pM + \mu)\omega_0 + \omega_S$$

- Program sequencer to step through μ=0...935, excite 4800 turns, measure 24000 turns.
- Average I/Q for two synchrotron periods

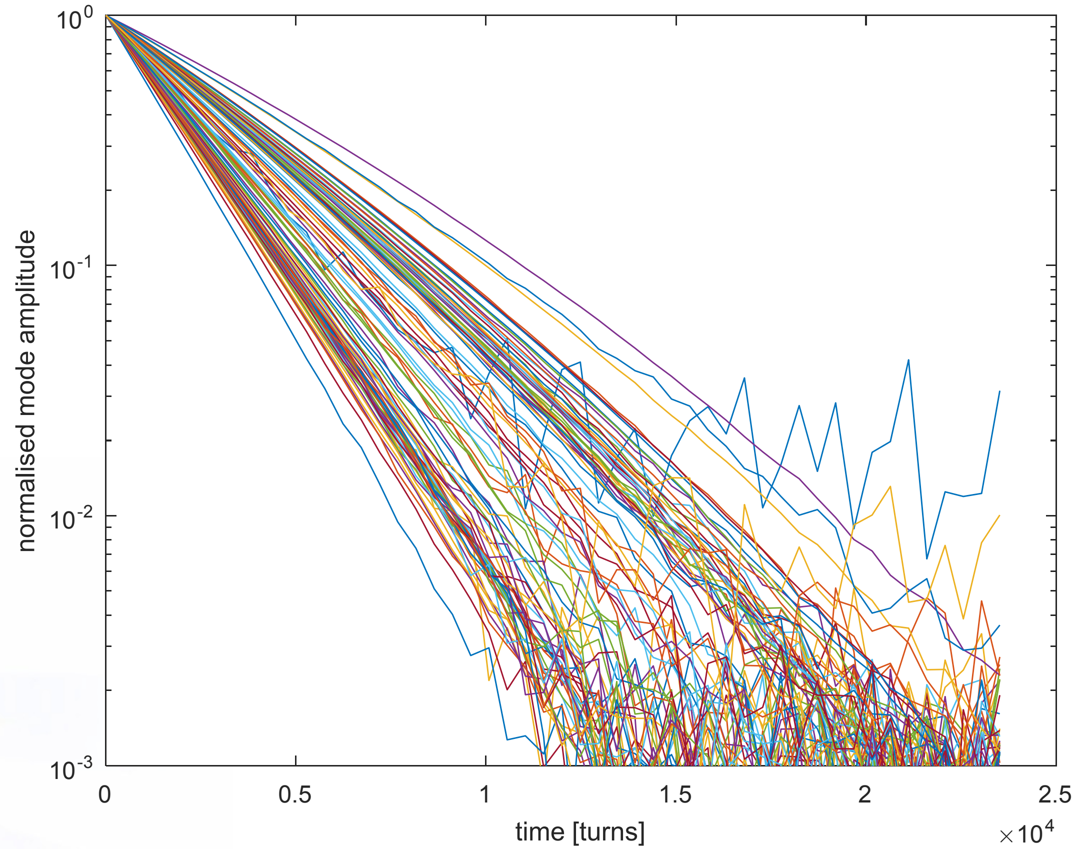


Abbott et. al. MOPGF097, ICALEPCS2015

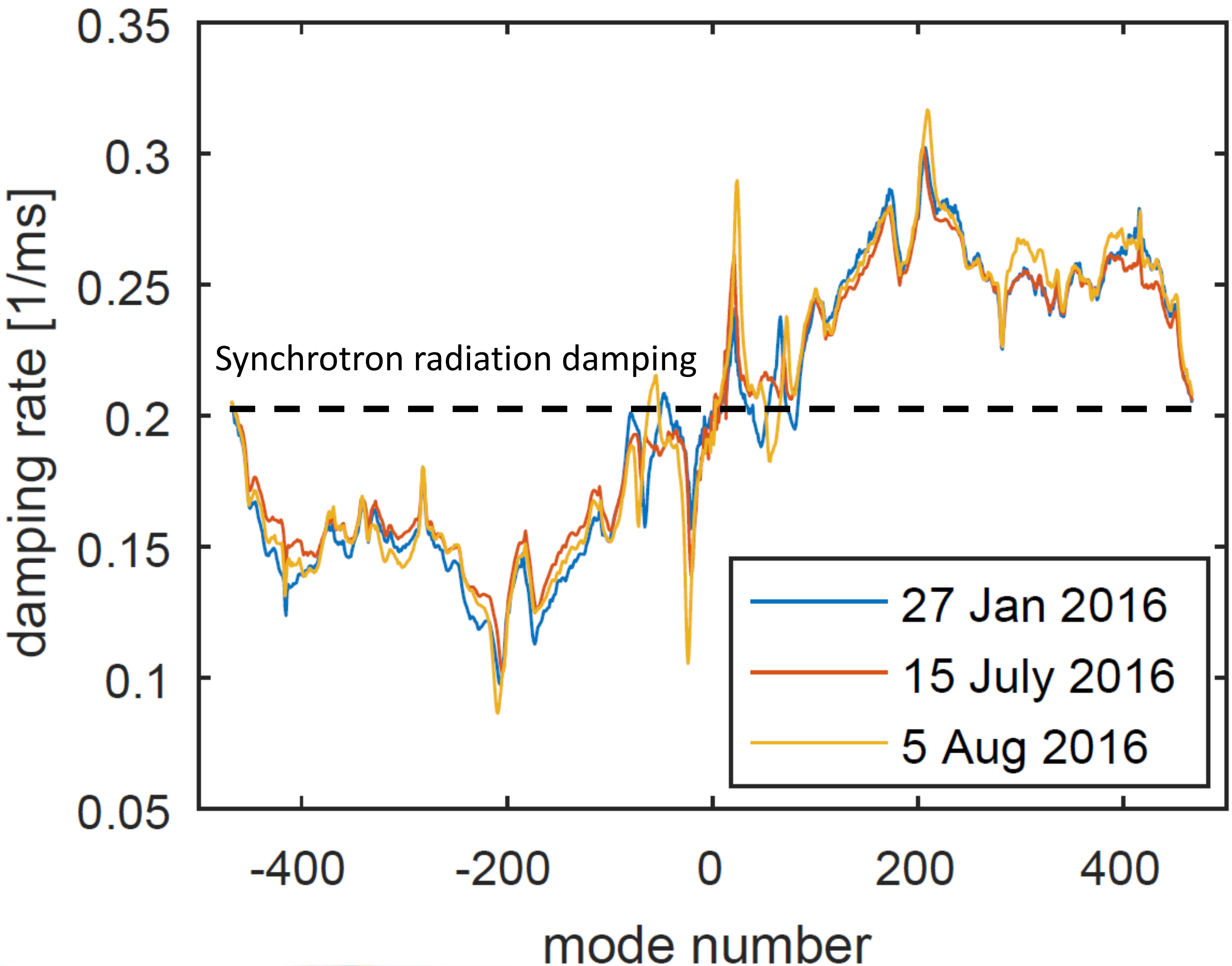


Extracting Damping Rates

- Extract only times of damping
- Normalise to peak for plotting
- Fit logarithm of magnitude with straight line for damping rate



Longitudinal Damping Rates



Top Level Requirements

- Each bunch needs acting upon, typically 2ns between bunches
- Each oscillation mode is associated with a frequency, these span **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

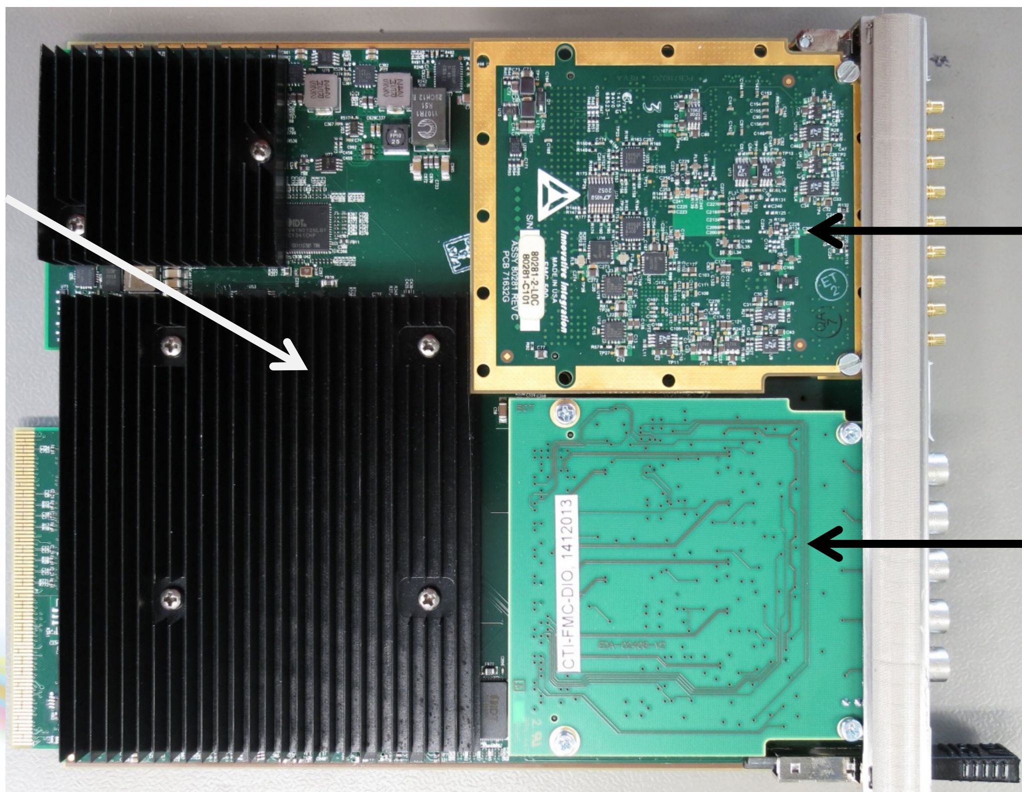
diamond

New Feedback Electronics

- Decided on modular approach using MTCA
- One AMC carries two FMC modules to implement two channels BbB at up to 500MS/s

Vadatech AMC 525
Xilinx Virtex-7 690T
2GB DDR3 RAM

PPC2040 with 32GB SD for FPGA programming

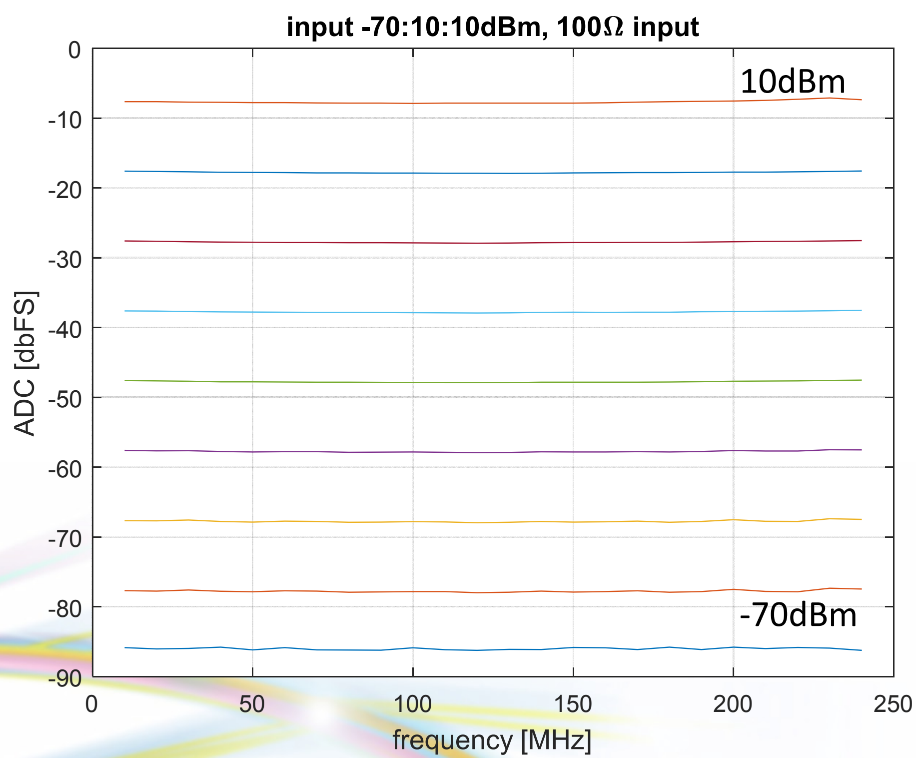


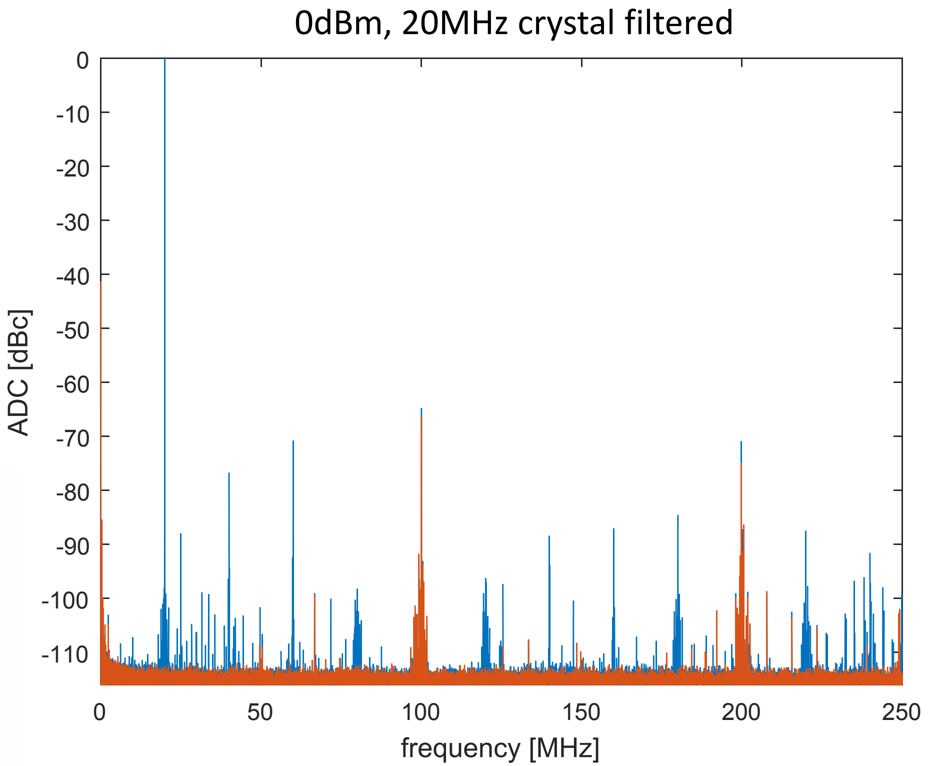
Innovative Integration
FMC-500
2x500MS/s ADC, 14b
2x1230MS/s DAC, 16b
DC coupled, external sample clock

CERN Open Hardware
FMC-DIO-5Ch-TTL-A
5 Channel in/out
for triggers

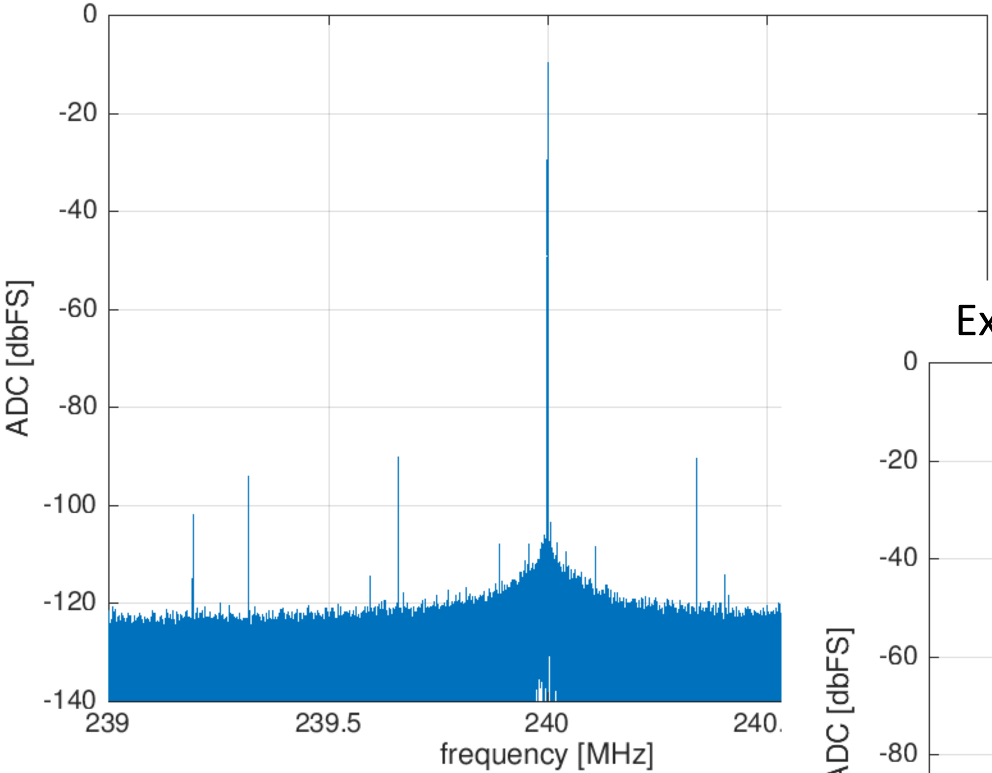
ADC performance verification

- ADC to on board RAM to CPU RAM implemented
- Using external clock directly gives best results

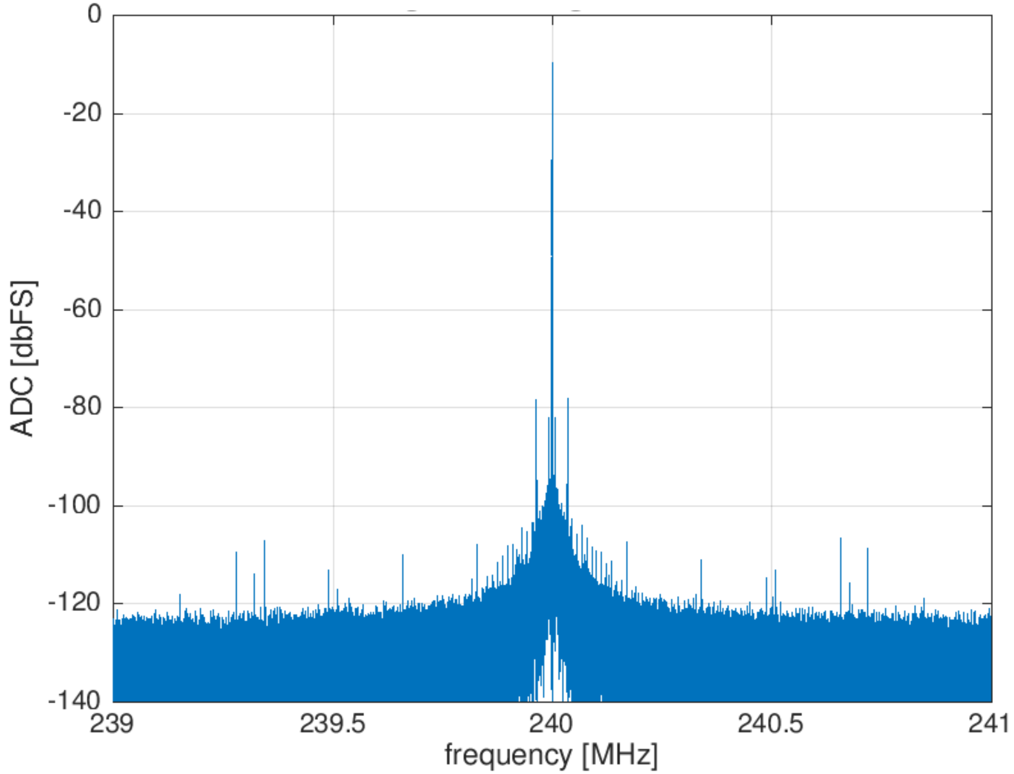




External clock driving ADC directly

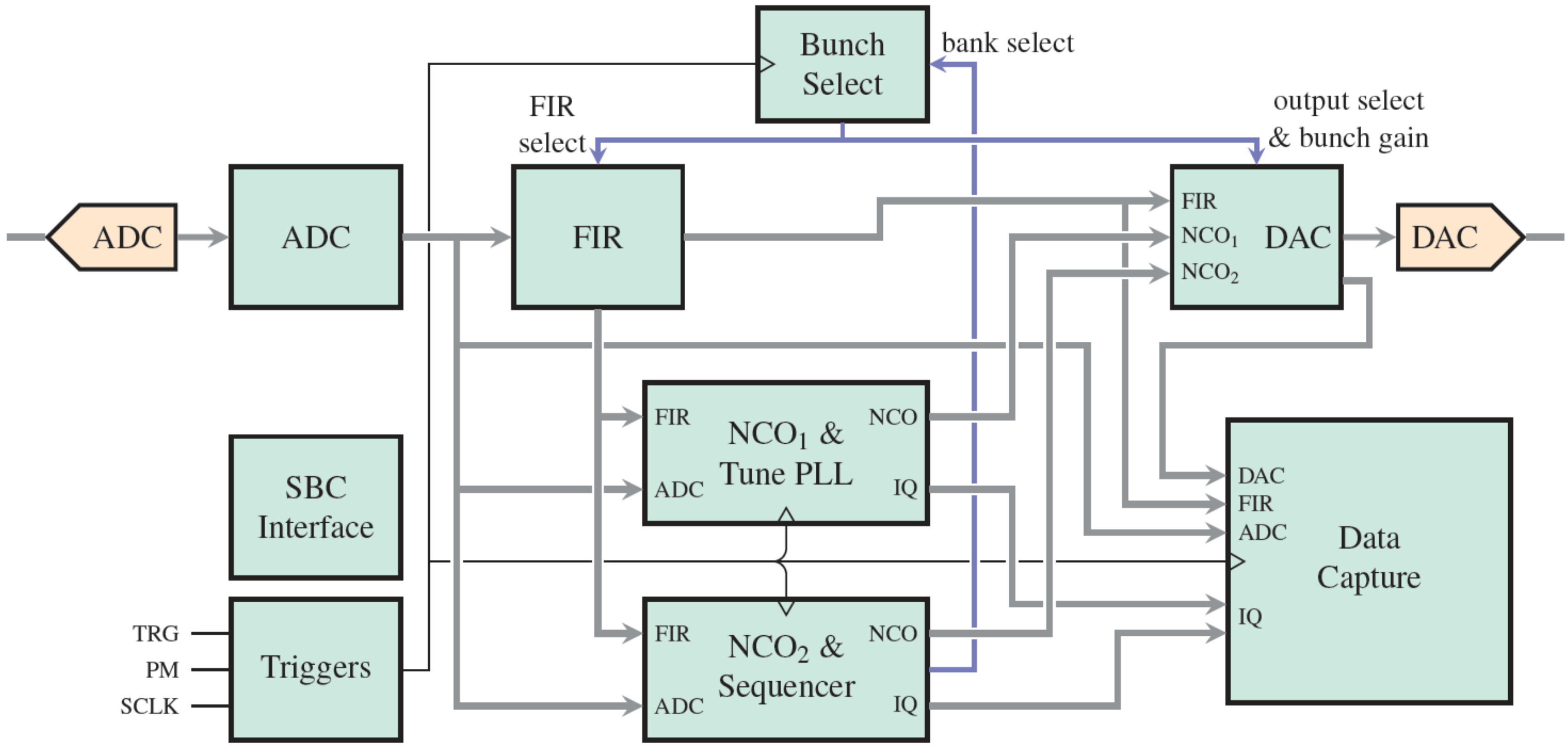


External clock as reference for on board PLL



DSP Firmware to be added

- In-house developed firmware in VHDL will be ported from TMBF to new hardware



Abbott et. al., MOPGF097, ICALEPCS15

Conclusions

- Investigations using vertical stripline as longitudinal kicker show clear impact of varying longitudinal impedance
- New BbB System will be based on MTCA technology with firmware/software ported from existing TMBF
- Mode-by-mode drive/damp experiments are key to characterising stability margin of all modes

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