MicroTCA-based LLRF Controller at KEK

Kazuro Furukawa
for RF Groups (cERL/STF, SuperKEKB)
LLRF Controler
and for Control Group (SuperKEKB)
EPICS IOC

< kazuro.Furukawa @ kek.jp >
October 13, 2010.

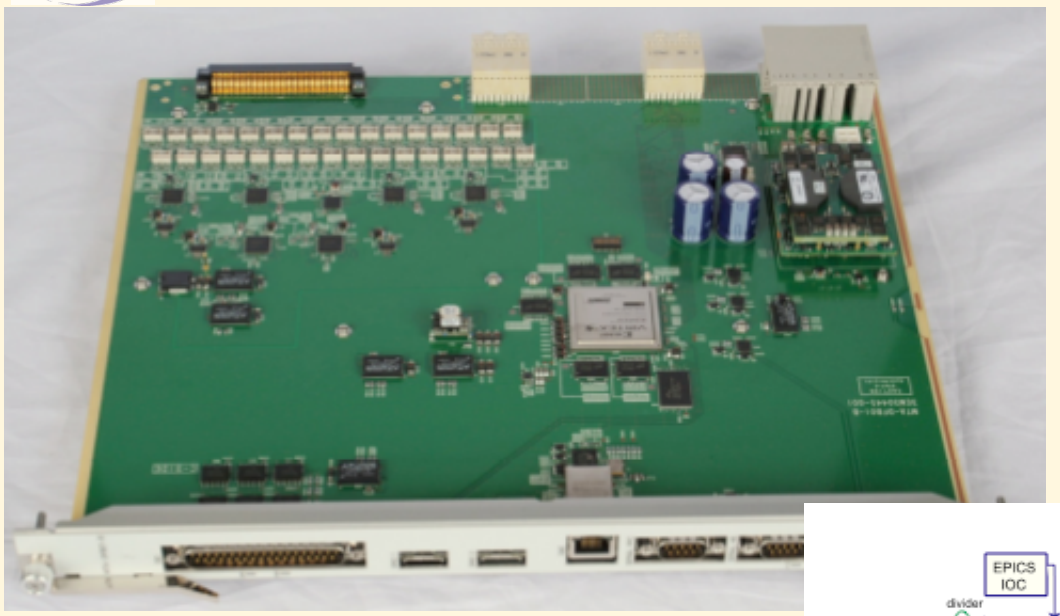
EPICS

RF Group

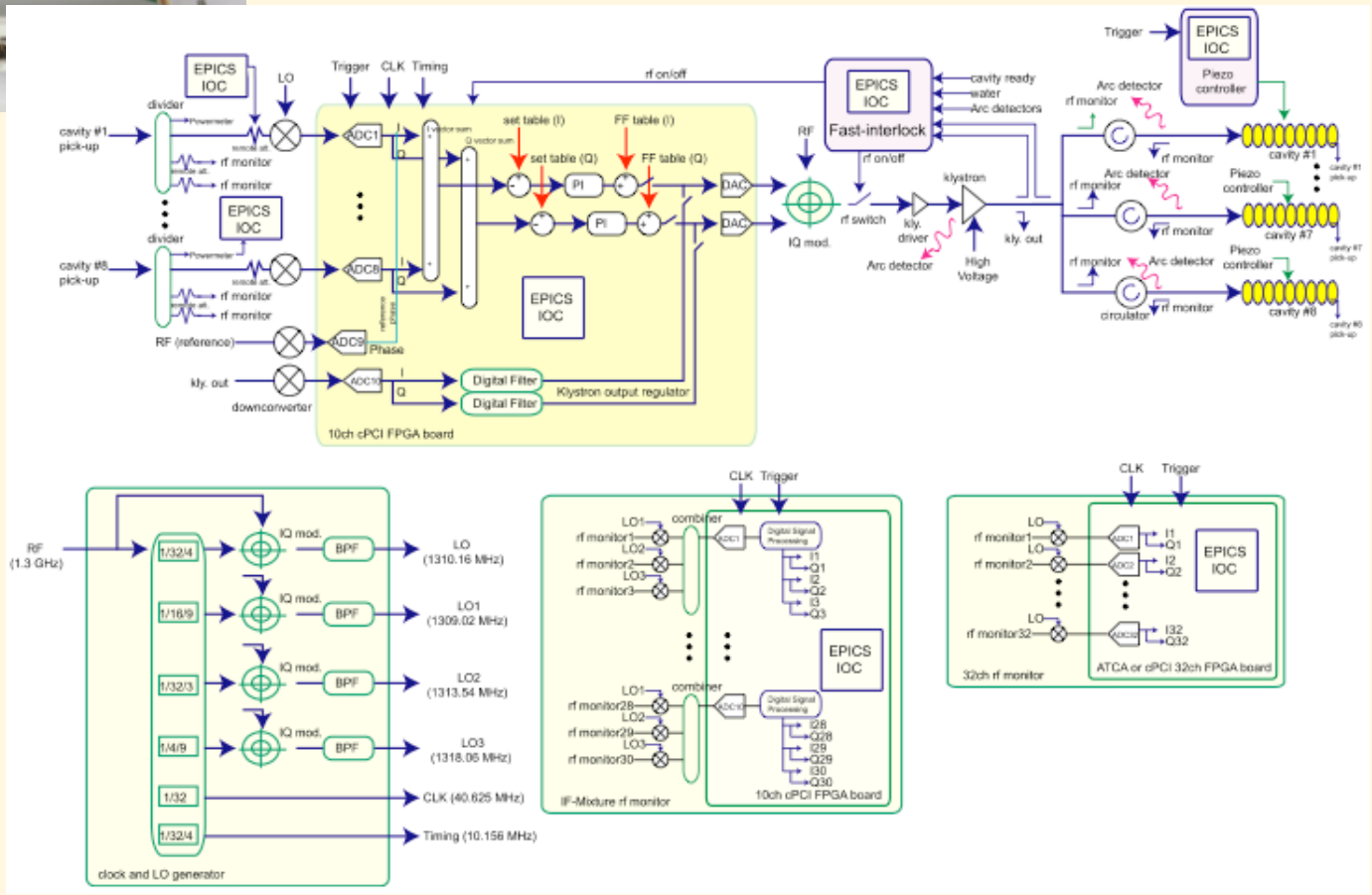
LLRF Controlers at KEK

- **J-PARC**
  - CompactPCI-based DSP/FPGA system
    - Communication to PLC-based Power supply controllers
    - Since ~2003
- **ILC and STF development**
  - Started with CompactPCI-based controller
    - Based on J-PARC experiences
      - Ten 16bit ADC, two 14bit DAC, Virtex2pro
  - ATCA-based controller (being developed)
    - For ILC “baseline” design
      - Large card (14bit ADC x “32”, 16bit DAC x4, FPGA, etc)
      - Reliability for large number of components
- **Choice of bus was difficult**
  - VME was old
  - No good standard was available for cPCI with PCIe

RF Group



ATCA LLRF card as an example



RF Group

LLRF Controlers at KEK

- ATCA development in ILC collaboration
- DESY chose AMC cards on ATCA
  - AMC == Advanced Mezzanine Card
- cERL
  - CW, under construction, for ERL nearer future
  - AMC or MicroTCA-based LLRF Controller
    - Future stability of 0.01% in amplitude, 0.01degree in phase
    - For now, 0.1% in amplitude, 0.1degree in phase, 1μs loop delay
- SuperKEKB
  - CW, under designing, starting part of construction
  - Synergy between projects - MicroTCA
- STF/ILC for S1 global
  - New RF system configuration , “DRFS” design
  - ATCA > MicroTCA

MicroTCA (μTCA)

- **ATCA (2003)**
  - New computing standard for telecommunication and industry
    - After CompactPCI (1993), for reliability with higher performance
  - Many serial interconnects on backplane
    - 2.5Gbps each (10Gbps in the future)
      - One card covers all phones in a small city with a certain implementation
  - IPMI surveillance/remote-management for reliability
- **AMC (Advanced Mezzanine Card for ATCA)**
  - Serial interconnects, IPMI, good part of ATCA
    - Like IP-module to VME, PMC to cPCI
- **MicroTCA (2008)**
  - AMC card itself is powerful
  - Direct slot-in AMC cards in a Box
    - Commercial I/O cards for industry are available

Accelerator Controls

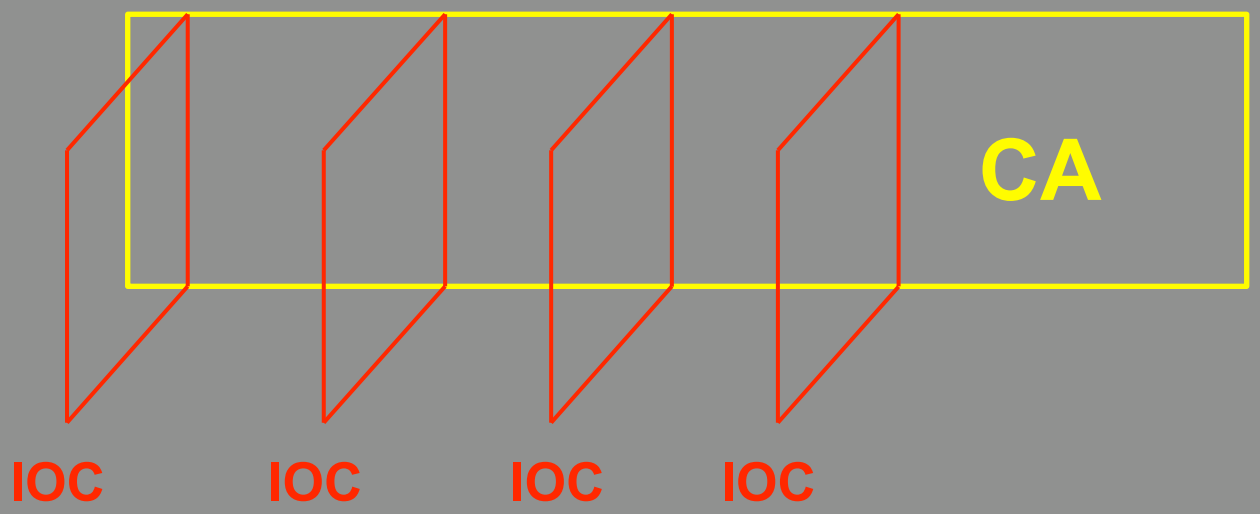
- VME + Unix (1990~)
  - Standard EPICS configuration
    - With many third layer field networks

- Every controller on network (1993~)
  - Single layer in physical, two layer in logical

- Every controller with EPICS IOC (2005~)
  - Channel Access everywhere
    - For longer term maintenance

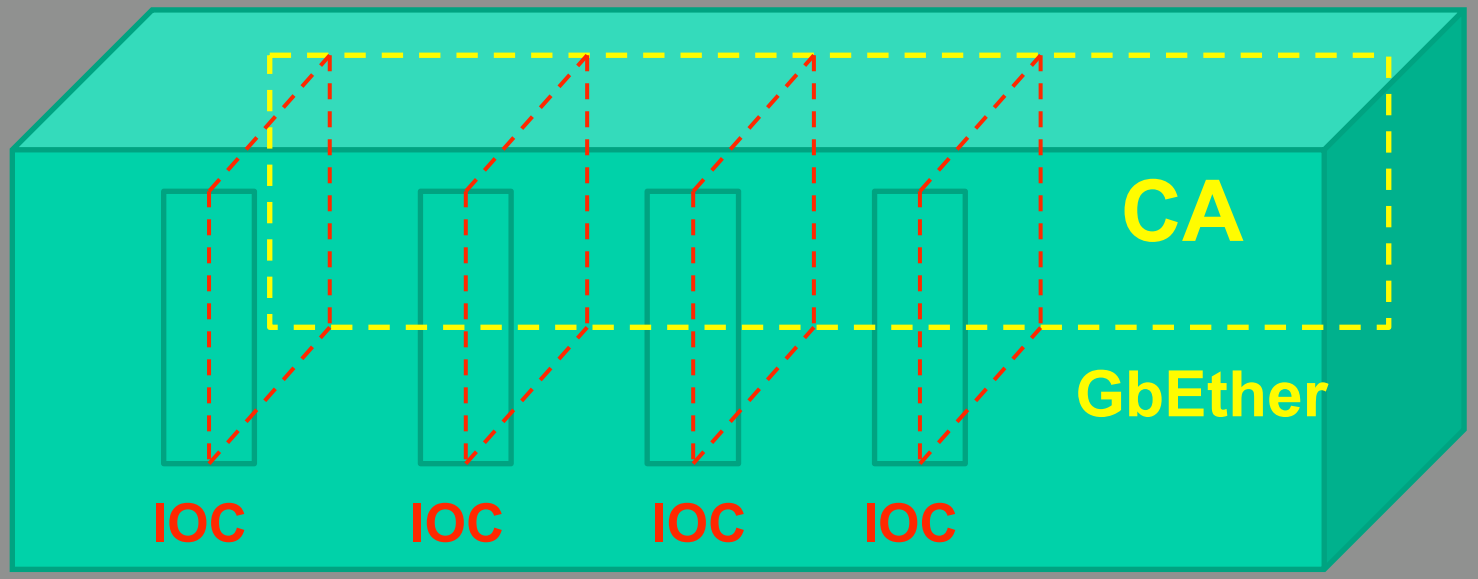
Standard EPICS

CA as "Software bus"



Channel Access on MicroTCA Backplane

CA on Hardware “bus”



MicroTCA

Picture by J.Odagiri

- Let's employ Channel Access on μTCA Backplane !
- Let's embed EPICS IOC on to Each μTCA/ AMC Card !

Miura and Furukawa

IOC on MicroTCA

- Natural to put IOC on μTCA LLRF Controller
  - And on ATCA LLRF Controller
- Chose GbEthernet as a main media on the backplane interconnect
  - Somewhat unique
  - Some other institutes chose PCIe as the media
- Chose PowerPC core on Virtex5
  - ML507 of Xilinx as a good reference
- Linux on PowerPC
  - No realtime processing is necessary
    - In the future, we may use realtime (<100μs) feature of Linux

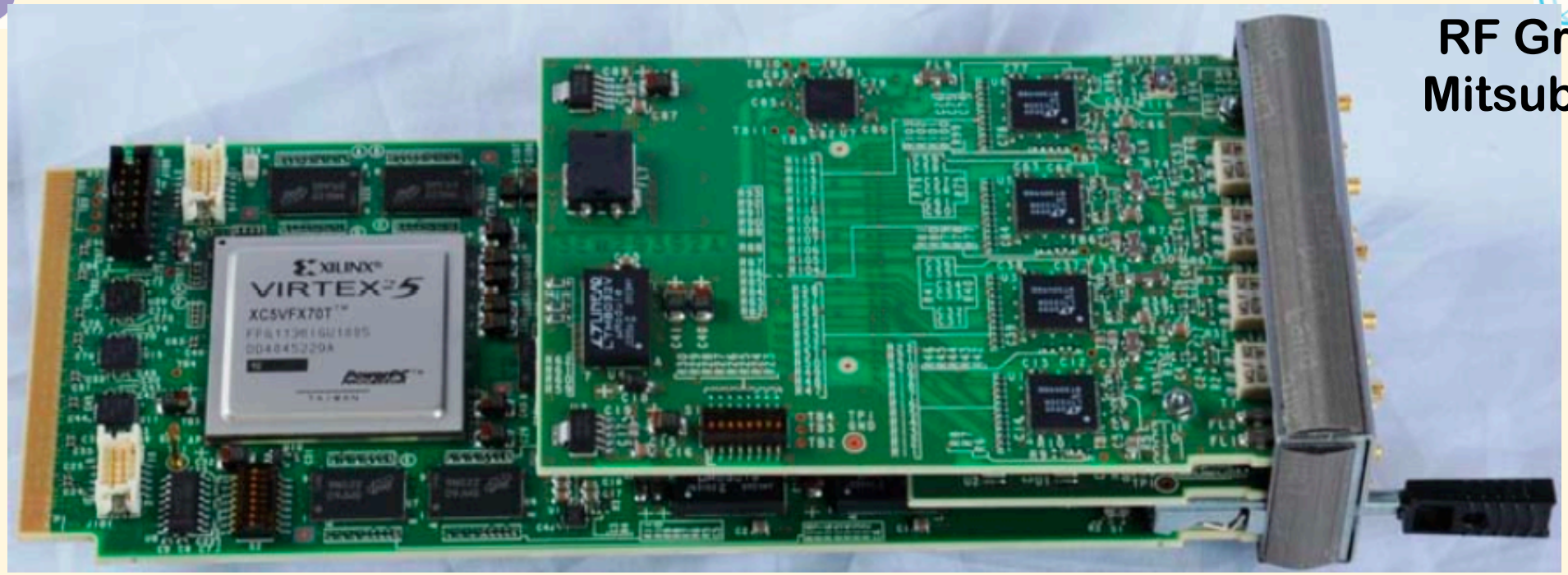
RF Group

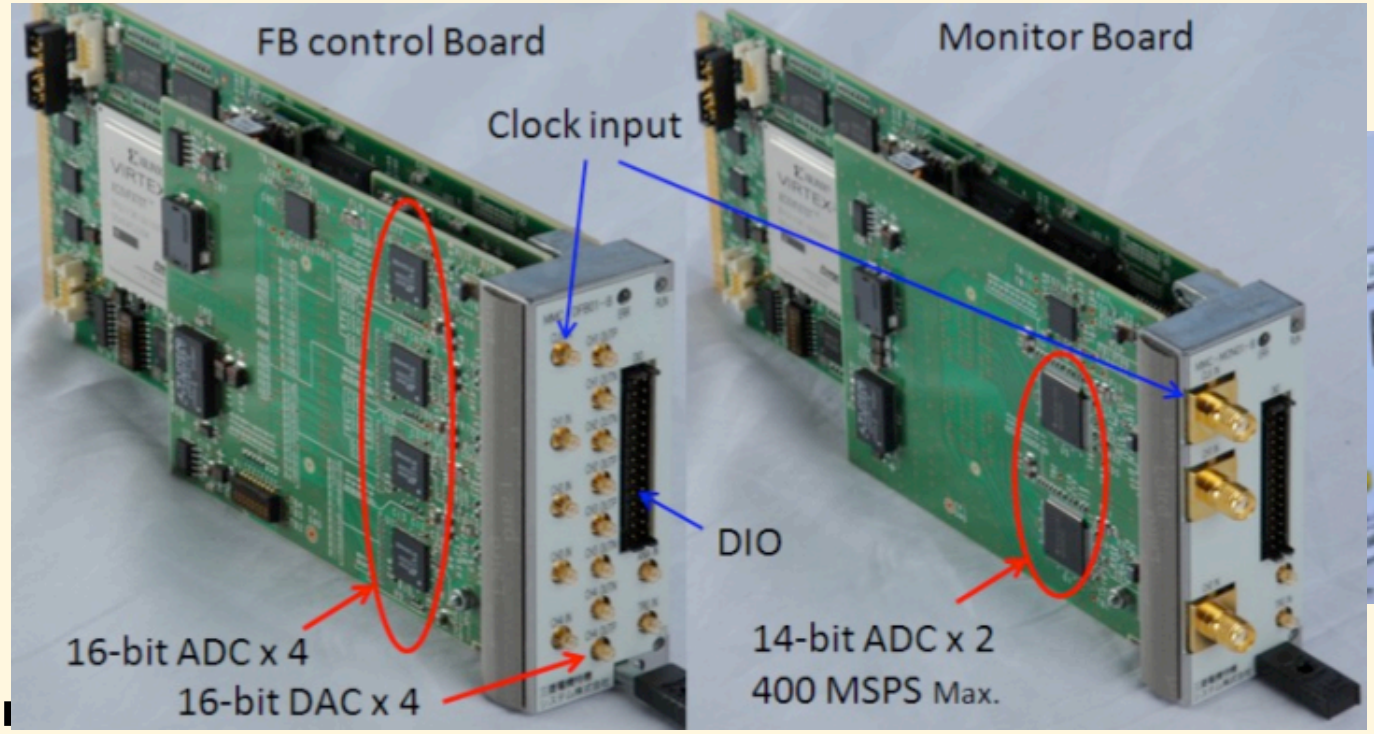
MicroTCA based LLRF Controller

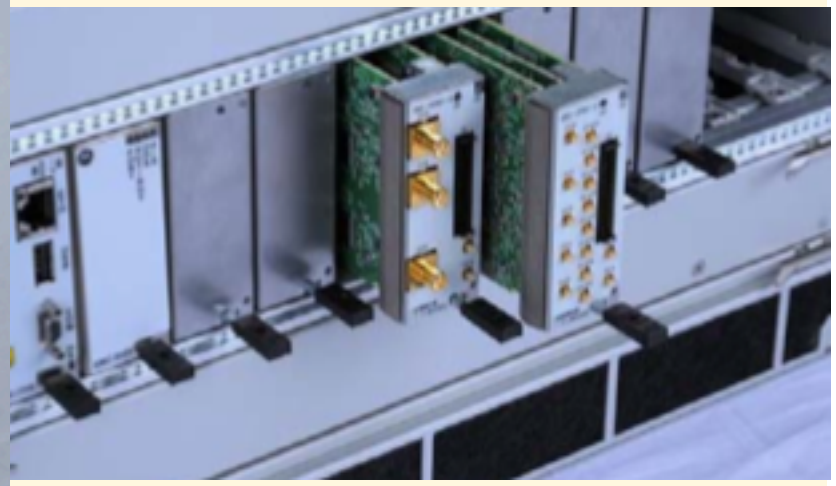
- Single-width full-height module
- Without physics experiment extension (we started earlier)
  - Front-panel connectors (rather busy)
- Digital part and Analog part are separate
  - ADC 16bit, 130Msps, x4
  - DAC 16bit, 500Msps, x4
  - Virtex5 with PPC440
  - RAM 640MB, Flash 64MB
  - Also monitor card with the same digital part
    - ADC 14bit, 400Msps, 1.4GHz, x2
- Fabrication subcontracted
  - Mitsubishi Electric Tokki System
  - Windriver Linux (ML507 is supported)

EPICS

RF Group
Mitsubishi



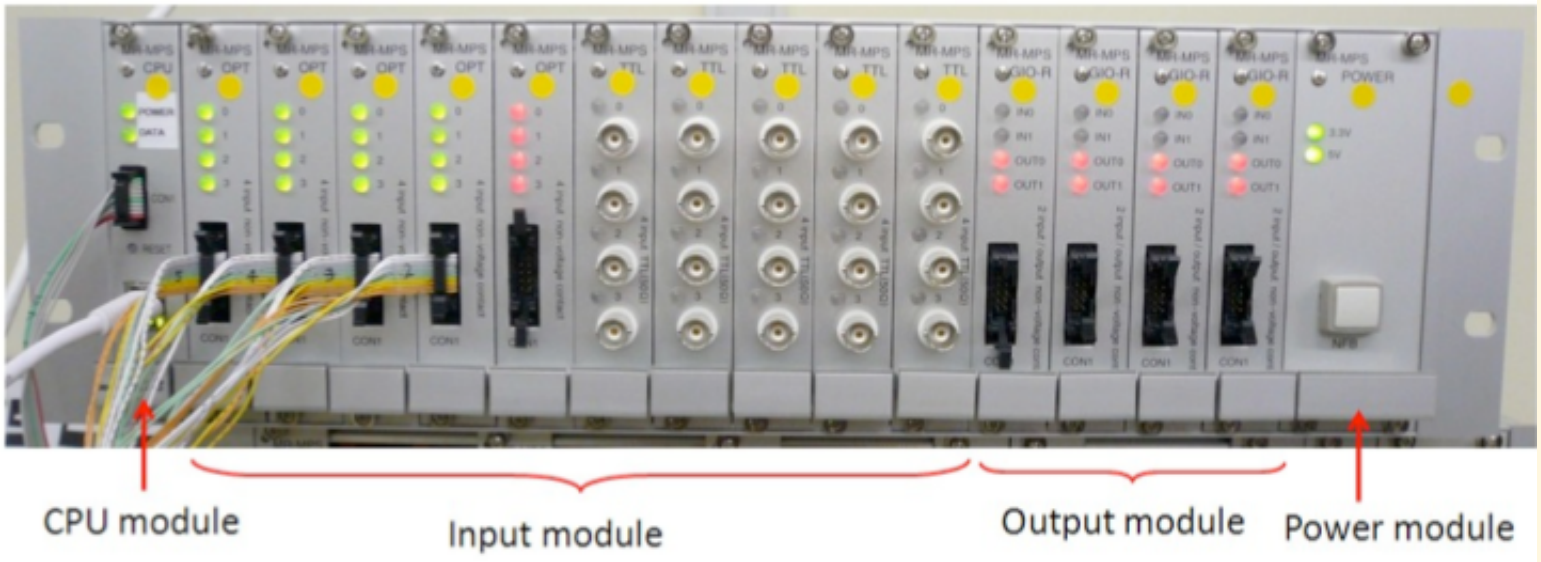




EPICS IOC on MicroTCA LLRF Controller

- Linux 2.6 on Virtex5
  - Boot from Flash
  - EPICS from NFS, or from Flash
  - Slight difficulties because …
    - Lack or experiences
    - Difference (memory size etc.) between ML507 and the real card
  - Relatively straight forward
- EPICS 3.14.9 for now
  - Driver to FPGA (with mmap)
    - Scalar values directly, and waveforms through ringbuffer
  - Channel access on backplane interconnect
  - Directly connected to outside at first
    - Possible to install gateway at local CPU if necessary

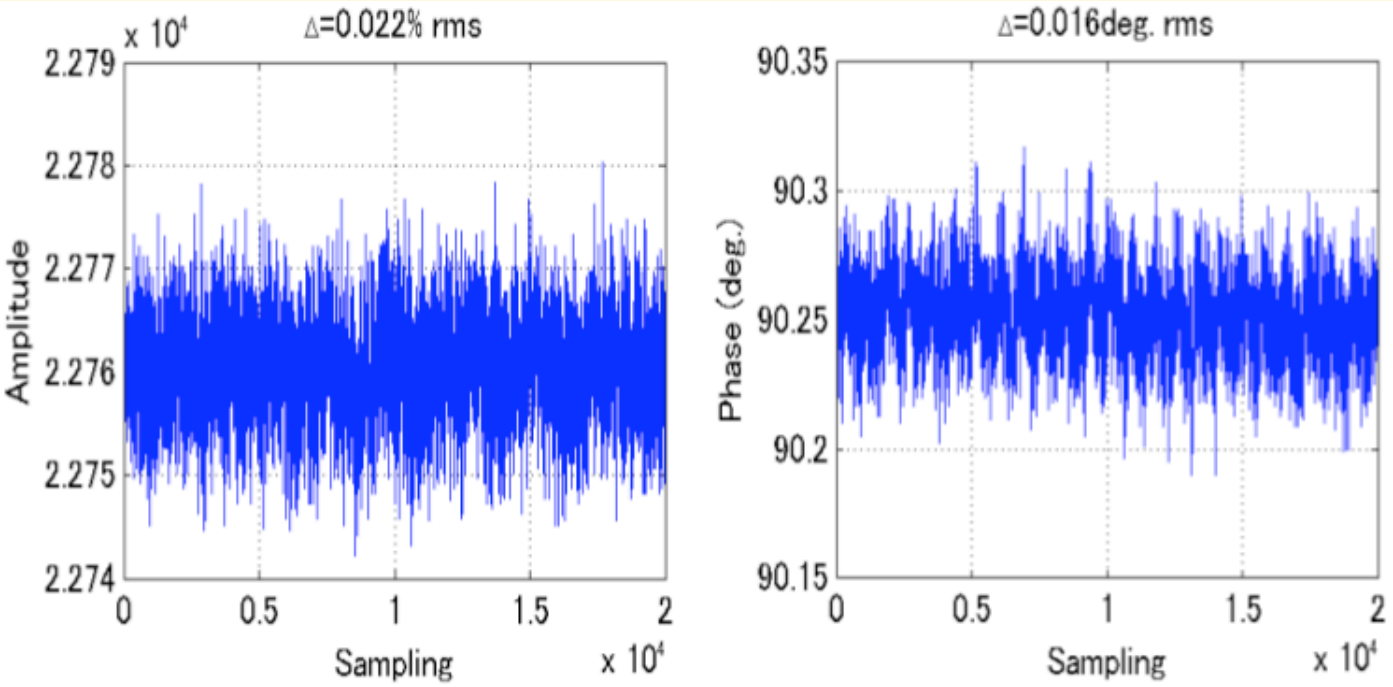
- Slow control with PLC
  - Embedded IOC
- MPS with FPGA/PPC
  - Embedded IOC



RF Group

Under Evaluation

- **Preliminary I/Q control stability results**
  - **Much better than the specification**
    - **~0.022% in amplitude, ~0.016degree in phase**



More development

- FPGA controller is ready (Sep.2010)
- EPICS IOC and local display application
  - With EDM under development
- μTCA management capabilities over IPMI
- Commissioning in 2011 for STF and cERL
  - Slightly later for SuperKEKB
- Future
  - Comparison to ATCA
  - Move out of Windriver Linux (?)
  - Redundant System (?)
  - …

Conclusion

- Collaboration between RF group, Mitsubishi Elec. Tokki System, and Control group went well
- All components embed EPICS IOC
  - μTCA FPGA controller, PLC controller, MPS controller
- Performance test was acceptable
- Showed μTCA capability

- Controls Have Interface to Every System
  - We can Enjoy Accelerators
  - With Phronesis (Ability to understand the Universal Truth)

Thank you