MicroTCA Image Processing System at SPring-8

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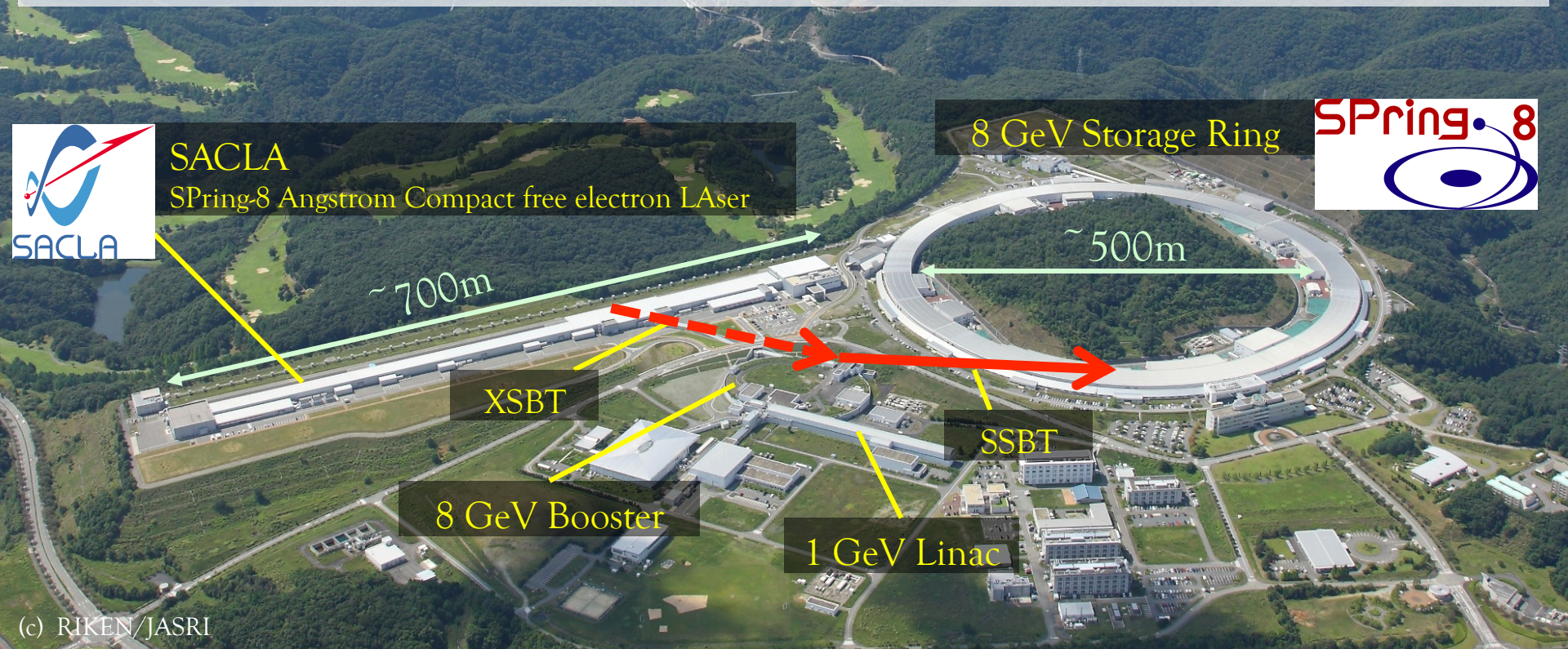
JASRI/SPring-8

Agenda

- **Overview of SPring-8/SACLA**
- **Motivation**
- **System Development**
- **Applications**
  - 2D synchrotron radiation interferometer
  - OTR monitor at the injection point of the storage ring
  - Beam profile monitors at the 1 GeV linac
- **Future plan**
  - MTCA.4-based image processing system
- **Summary**

Overview of SPring-8/SACLA

- **SPring-8 is a 3rd generation light source facility.**
  - Largest synchrotron radiation facility for 18 years
- **SACLA is an X-ray Free Electron Laser facility. [operated since 2011]**
  - High-peak brilliance, spatial coherent, ultrafast X-ray pulse
  - It will inject ultra-short-pulse electron beam to the SPring-8 storage ring.



MicroTCA Image Processing System – Motivation

- **Evaluation of MTCA platform**
  - as the next-generation FE controller as the successor of VME
  - Started at 2011
- **Final target : MTCA.4**
  - Considering practical usage for the accelerator controls.
    - Card size, RTM, trigger/clock signal distribution, …
  - MTCA.4 products were expensive at the point of 2011.
  - Very limited choices of MTCA.4 AMCs

→Decided to start our evaluation by using MTCA.

MicroTCA Image Processing System – Motivation

- **Strategy of our development**
  - We have built an MTCA-based image processing system with Camera Link I/F for beam diagnostics of the SPring-8 accelerators.
    - 1st target : Replacement of a PC-based old system for the 2D Synchrotron Radiation Interferometer at the storage ring.

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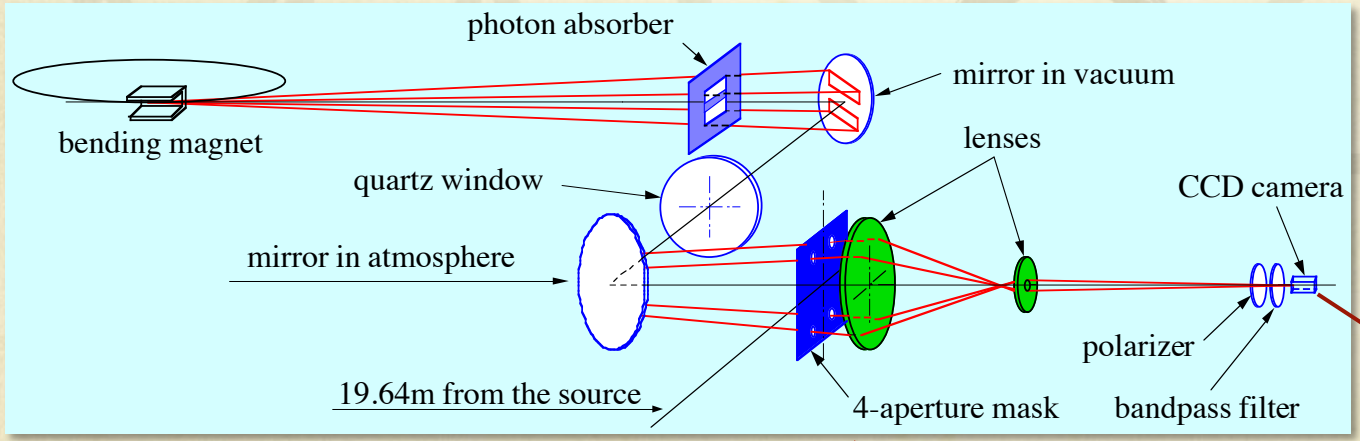
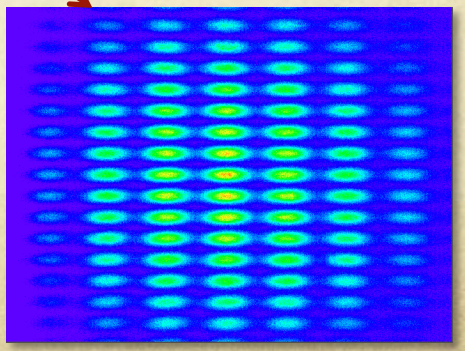
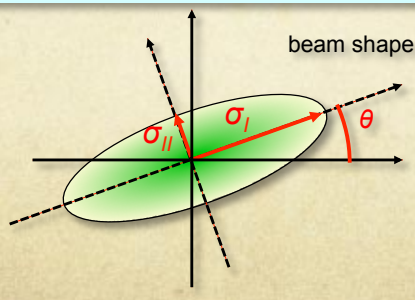


observed interferogram





2D-Fitting

transverse beam size (σ_I , σ_{II}) and tilt angle (θ) can be obtained

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    - 1st target : Replacement of a PC-based old system for the 2D Synchrotron Radiation Interferometer at the storage ring.
  - We have used COTS products to minimize development costs & time.
  - We have newly developed FPGA IP cores compliant with AXI4 open bus to maximize reusability.
    - AXI4 : Advanced eXtensible Interface 4

MicroTCA Image Processing System – System Development

- **Hardware components**
  - We have utilized COTS products for the hardware components

Image processing system for 2D SR interferometer

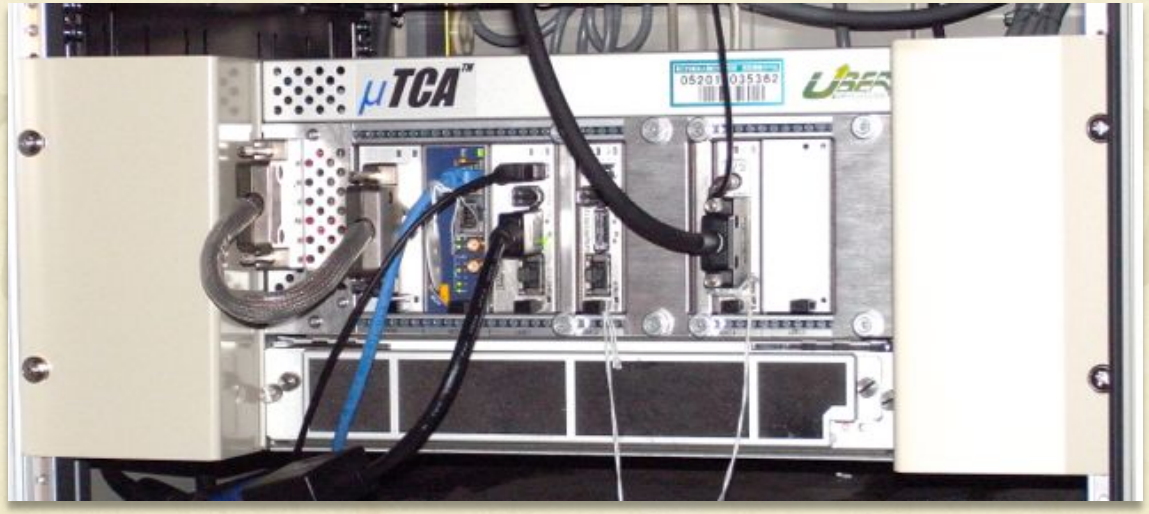

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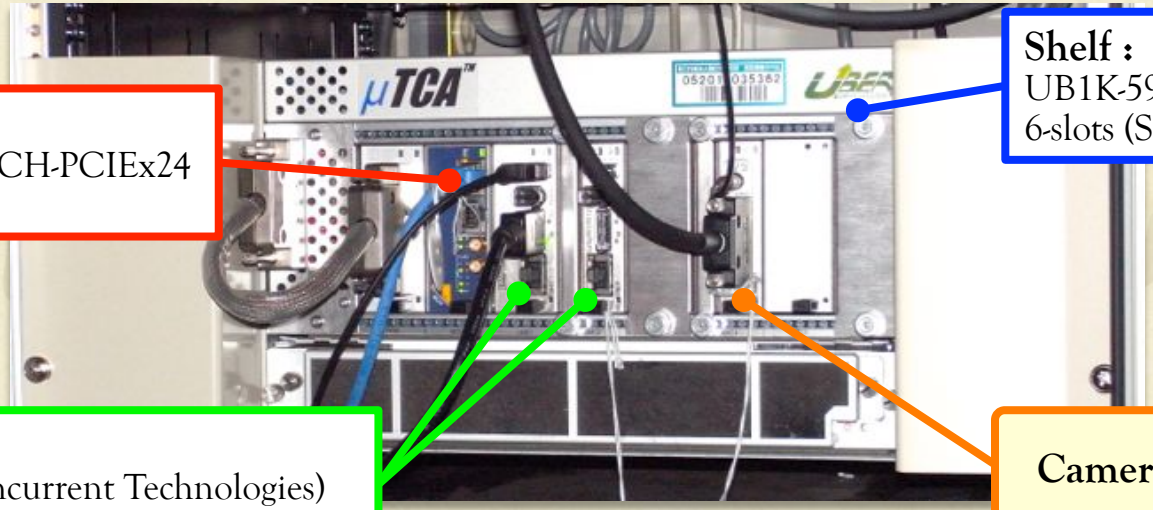
Image processing system for 2D SR interferometer



MCH :
NAT-MCH-Base6-SSCH-PCIEx24
(N.A.T. GmbH)

Shelf :
UB1K-5946 (Uber Co. LTD)
6-slots (Single width/Full size)

Processor AMCs :
AM310/AM312 (Concurrent Technologies)
2.2GHz (2 cores) / 2.0 GHz (4 cores) Core i7

Camera Link I/F Card :

MicroTCA Image Processing System – System Development

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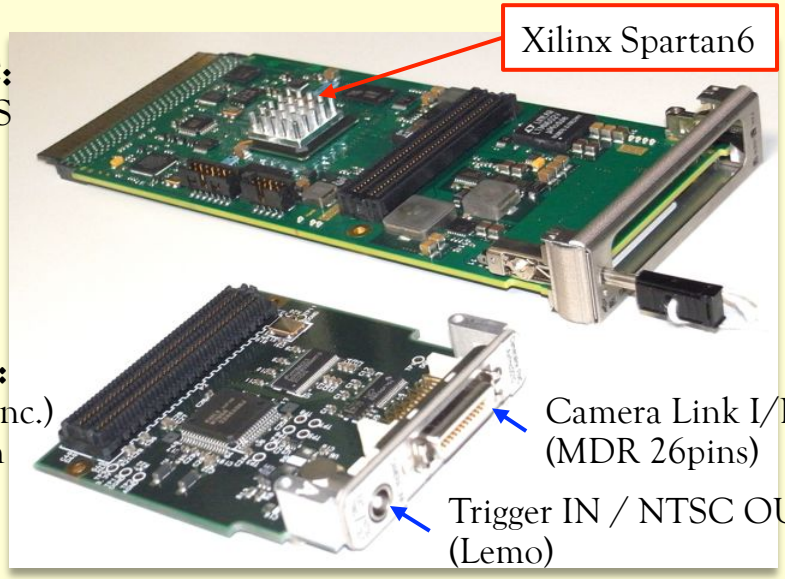
/Full size)

Camera Link I/F Card :
Combination of FMC carrier AMC + Camera Link FMC

FMC Carrier AMC:
TAMC631-16R (TEWS Technologies GmbH)
- LPC FMC slot x1
- PCIe x1
- 256MB DDR3

Camera Link FMC:
Axfmc0010 (ARKUS Inc.)
- Base configuration
- LPC connector

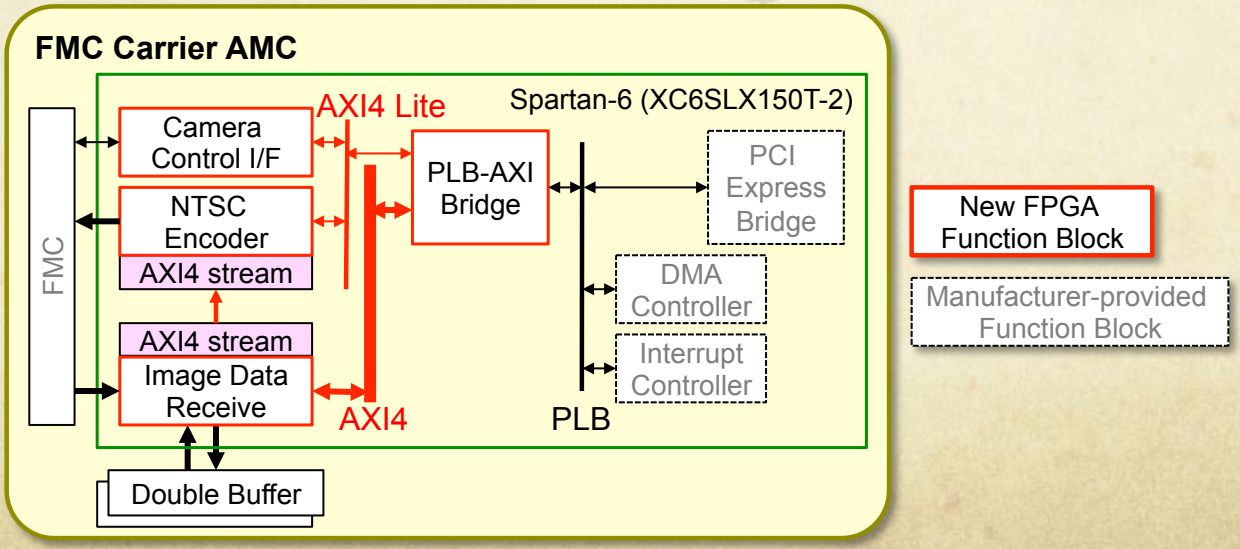


→We have newly developed FPGA logics for the Camera Link FMC.

MicroTCA Image Processing System – System Development

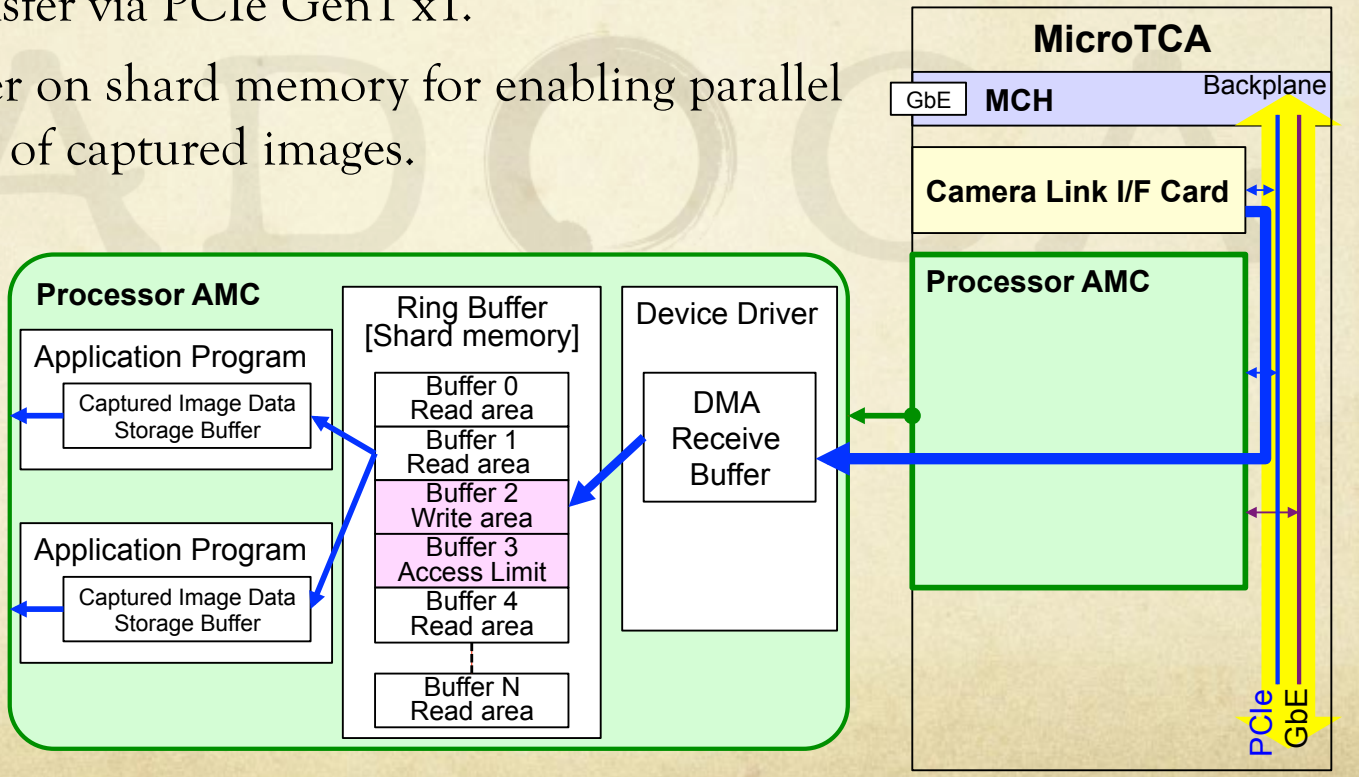
- Camera Link IP core
  - Development policies:
    - To maximize reusability for next development.
      - e.g. We are starting to port these IP cores to Xilinx Zynq.
    - To maximize expandability of function blocks.
      - e.g. planning to add new functions of image compression, pre-processing, etc.

→Employ AXI4 open bus for interconnection between function blocks.



MicroTCA Image Processing System – System Development

- **Linux device driver and API library**
  - Based on the manufacture-provided device driver.
  - Following functions were newly developed;
    - DMA transfer via PCIe Gen1 x1.
    - Ring buffer on shard memory for enabling parallel processing of captured images.

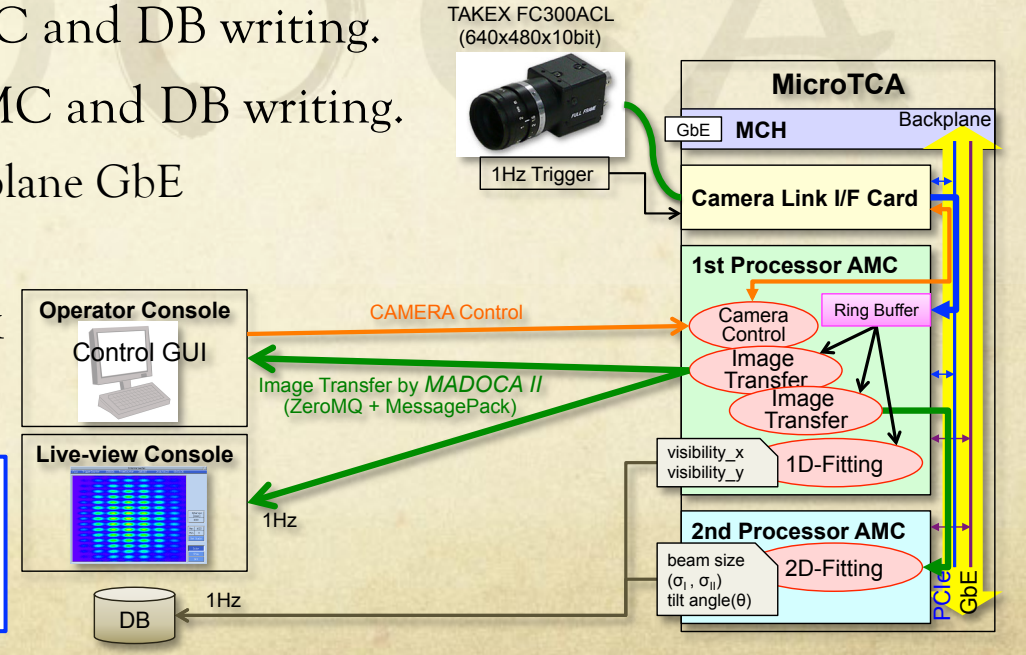


MicroTCA Image Processing System – Applications

- **2D SR interferometer**

  1st target of the MTCA image processing system with Camera Link I/F

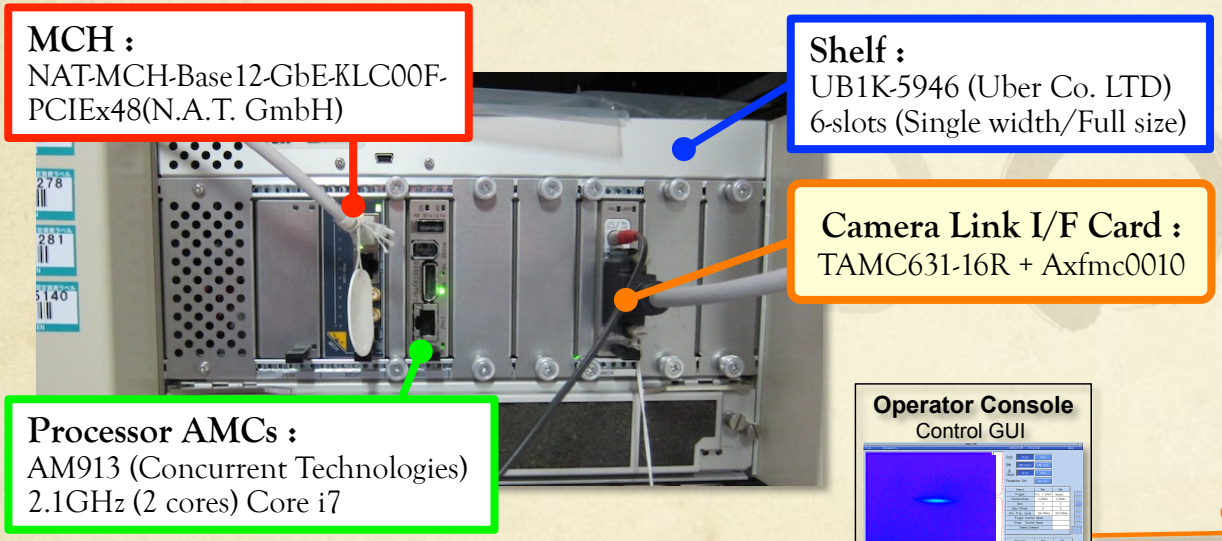
  - This system achieves
    - Camera control by GUI on operator console.
    - 1Hz live view on operator console.
    - 1Hz 1D-fitting on 1st PrPMC and DB writing.
    - 1Hz 2D-fitting on 2nd PrPMC and DB writing.
      - Image data is sent via backplane GbE from 1st PrPMC.
  - Use *MADOCA II* framework to build the software.

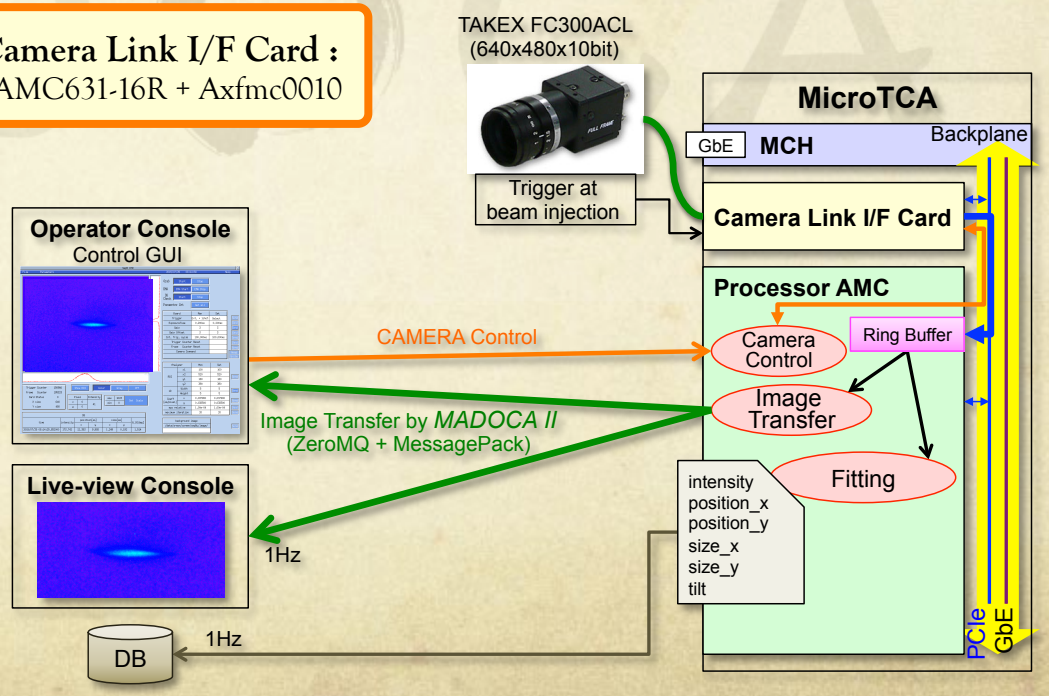


It has been 24x7 operating since October 2013.

MicroTCA Image Processing System – Applications

- OTR monitor at the injection point of the SR
  - We have replaced PC-based old system with the MTCA image processing system.

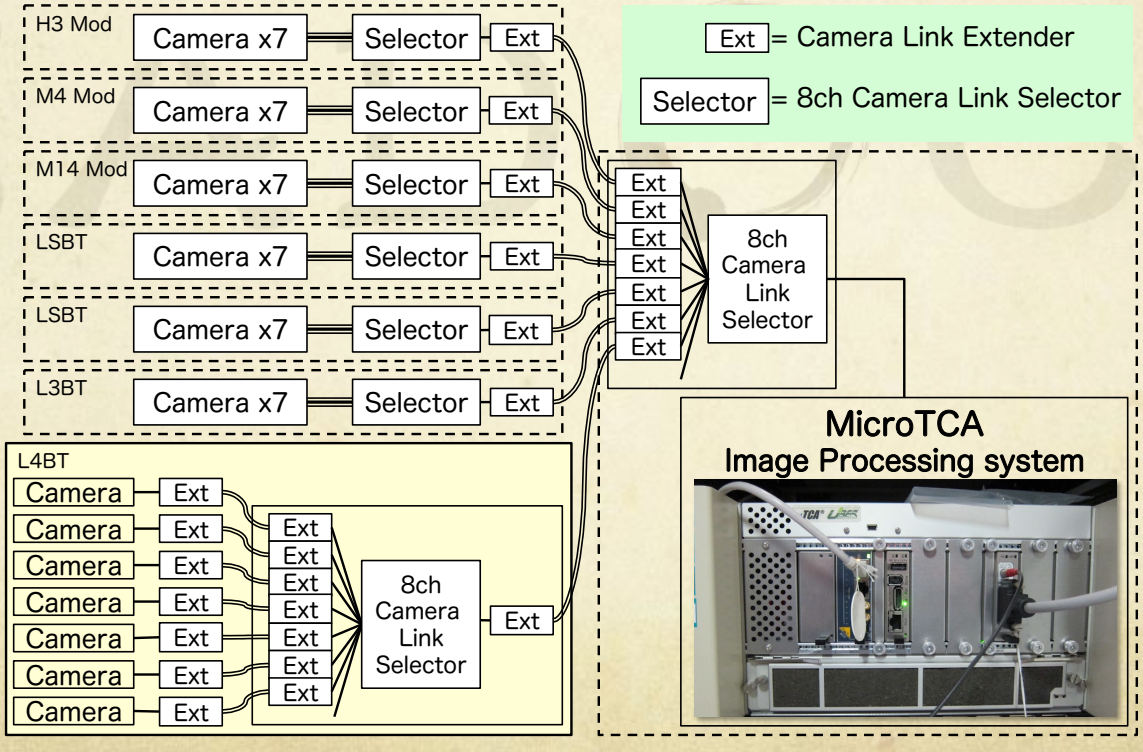




It has been stably operating since April 2015.

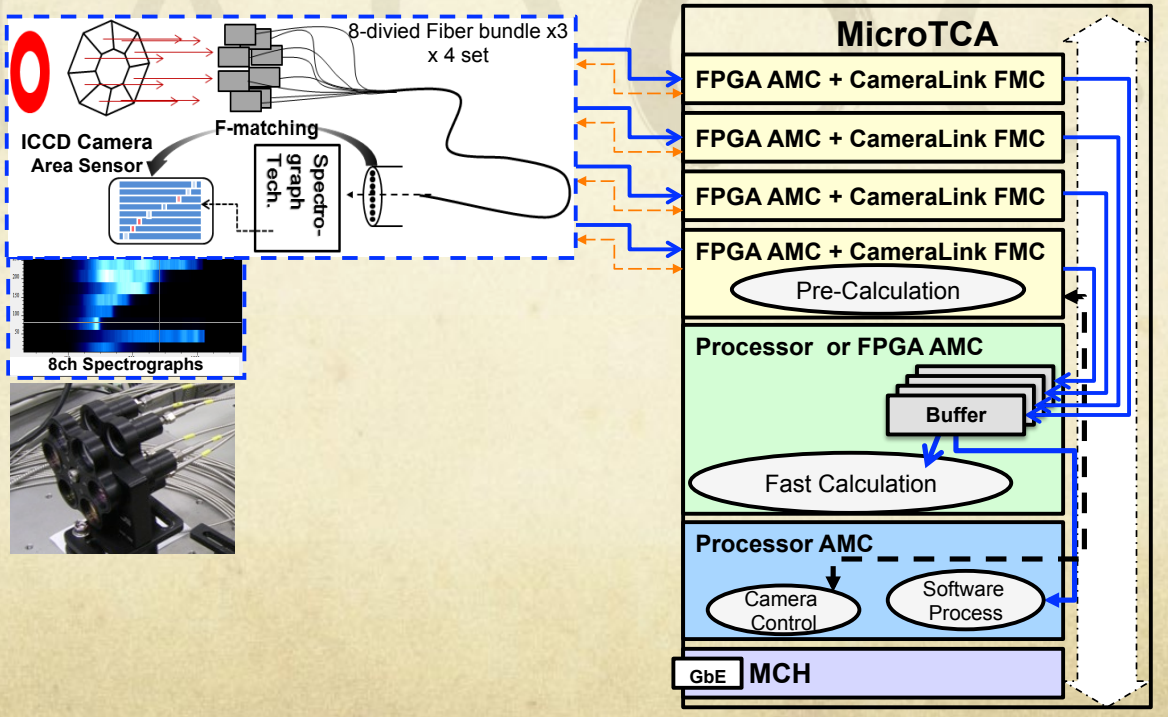
MicroTCA Image Processing System – Applications

- **Beam profile monitors at the 1 GeV linac**
  - Plan to replace analogue cameras for 49 beam profile monitors with Camera Link CCD cameras and the MTCA image processing system.
  - This project has just started.



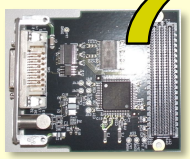
MicroTCA Image Processing System – Future Plan

- **Developing MTCA.4-based image processing system**
  - for 3D Bunch Charge Distribution Monitor that will be installed into beam-transport line from SACLA to SPring-8 (XSBT).
    - We will reconstruct 3D bunch charge distribution of the injected beam with 60Hz repetition by real-time processing of 4 ~6 sets of image data.

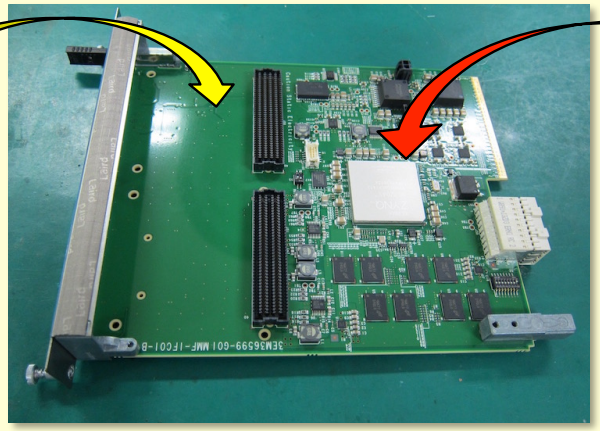


MicroTCA Image Processing System – Future Plan

- **MTCA.4 FMC carrier with Xilinx Zynq + Camera Link FMC**
  - will provide more powerful and flexible pre-process capability by using Zynq (FPGA + ARM core).
  - Trigger signal distribution via backplane is available.

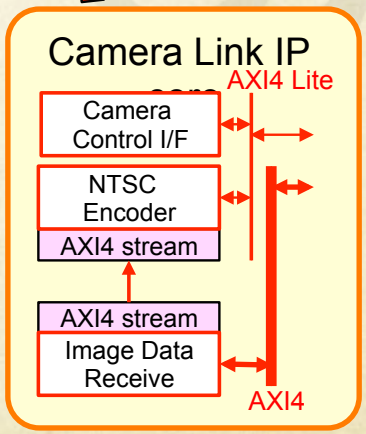


CameraLink FMC



MTCA.4 FMC carrier with Xilinx Zynq
(Mitsubishi Electric TOKKI System Co.)
- HPC x1 + LPC x 1
- PCIe x4

Camera Link IP ported to Zynq



Summary

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- **MTCA image processing system with Camera Link I/F has been developed successfully.**
  - This system has been applied to some beam diagnostic systems for the SPring-8 accelerators.
- **We are developing MTCA.4-based image processing system for more powerful and flexible solution.**

Summary

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  - This system has been applied to some beam diagnostic systems for the SPring-8 accelerators.
- **We are developing MTCA.4-based image processing system for more powerful and flexible solution.**
- **Evaluation and design of MTCA.4-based LLRF and BPM systems for the SPring-8 upgrade plan (SPring-8-II) has been started.**