National Synchrotron Light Source II

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

VM2E: VME to Ethernet

-- Common hardware platform for legacy VME module upgrade

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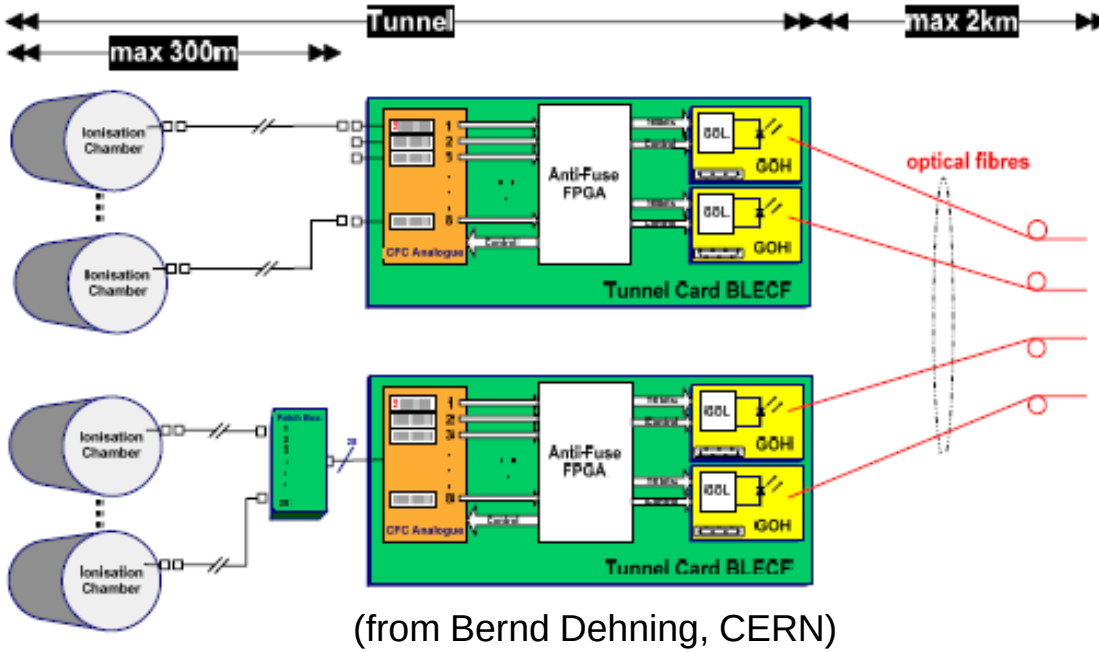
Outline

- VME system: a brief review
- VME modules at NSLS-II and upgrade plan
- VM2E: common platform for legacy VME module upgrade
- Summary

VME system: a brief review

Let’s travel back to 1980-1990’s: beam loss monitor system at LHC



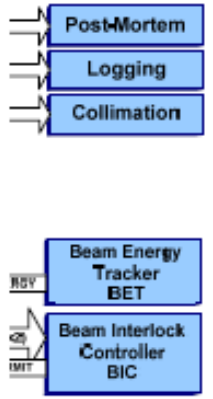
(from Bernd Dehning, CERN)

4000 detectors in LHC tunnel

A distributed system

- Mechanical: reliable, well defined crate to host many boards
- Electrical: common power supplies, cooling fan
- Computing:
  - Powerful CPU
  - Data communication with CPU
  - Real time operating system

VME Crate



BLM and control

VME: a brief review

Front-end computer (FEC) improvement:

1979: Motorola 68000 (m68k): 68k transistor, 3.5um technology, 4-16.67MHz

1988: MVME147 MC68030: 16-33MHz, 4K SRAM, 32MB DRAM

1992: MVME162, 1.6million transistor, 90-120MHz, 0.5um technology,

2010:MVME3100, PowerPC MPC8540, 1GHz, 500MB DDR, 2eSST

Operating system: real-time OS

VxWorks/Tornado (WindRiver Systems)

RTEMS (OAR Corp)

LynxOS (Lynx Real Time Systems)

OS-9 (MicroWare)

SPECTRA/VRTX (Microtech Research)

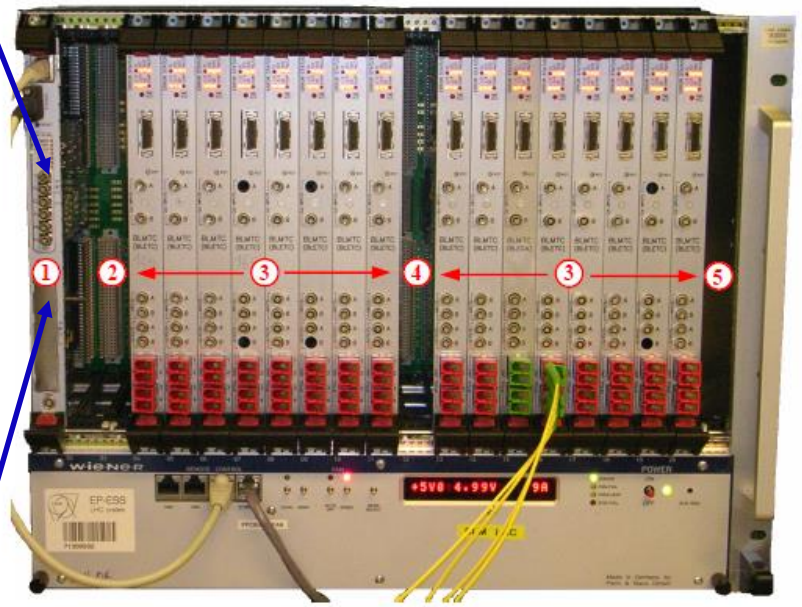


Figure 1: VME Crate's arrangement for the BLM system: 1. Crate's CPU, 2. Timing card (CTRV), 3. Processing modules (BLETC), 4. Timing card (BOBR), 5. Combiner card (BLECOM).

(from Bernd Dehning, CERN)

Back plane improvement:

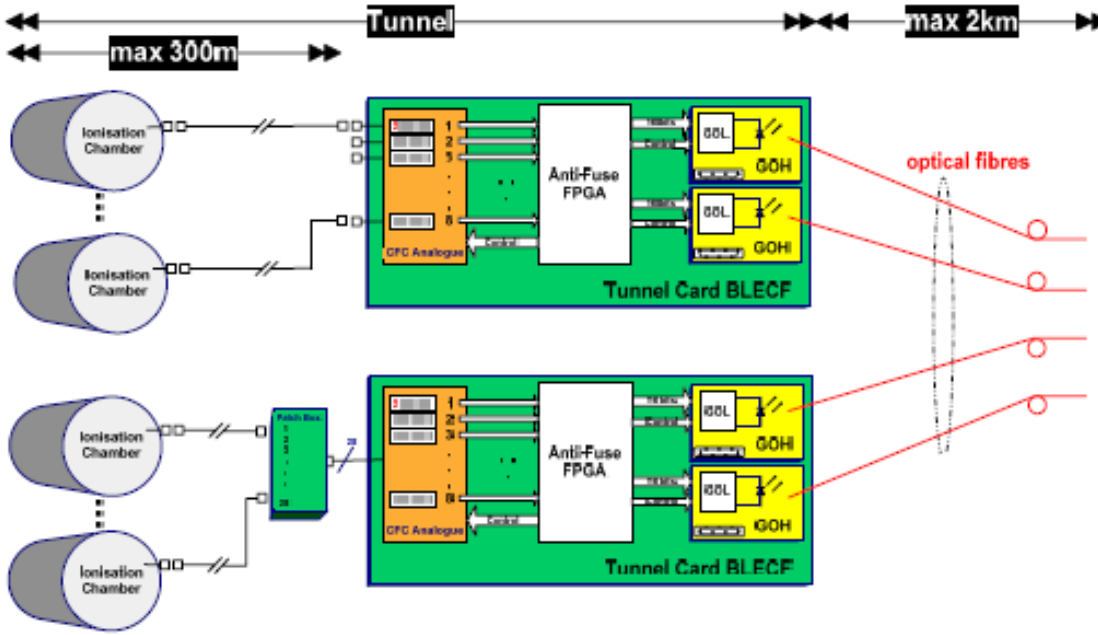
1981: VMEbus (40MB/s)

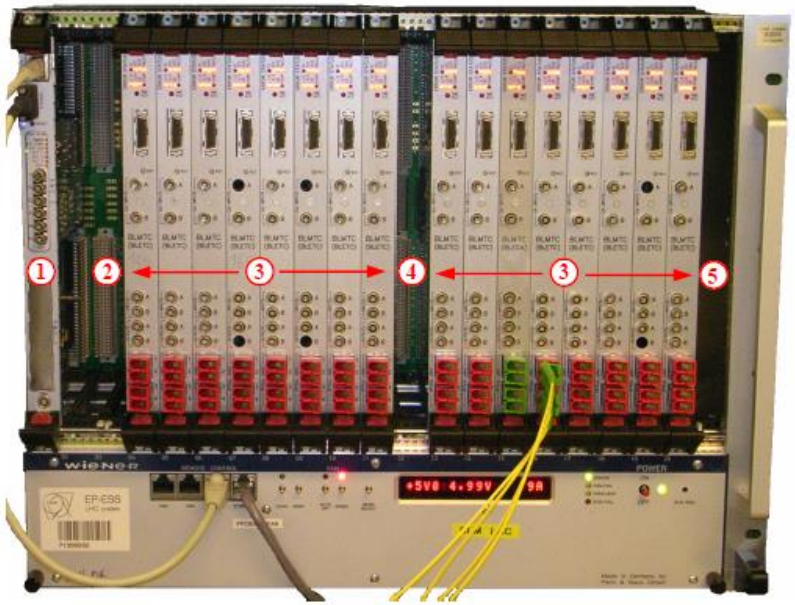
1994: VME64 (80MB/s)

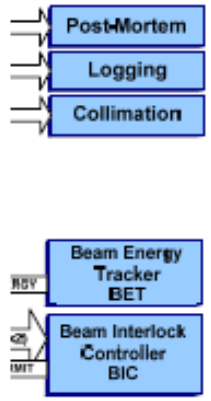
1997: VME64x (160MB/s)

1997: VME320/2eSST (320MB/s)

VME system: a brief review







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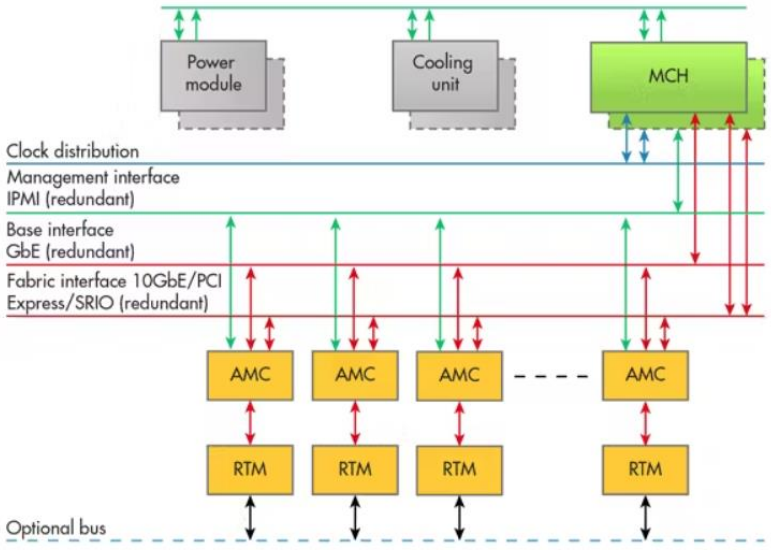
BLM and control

VME did its work !

VME system: a brief review

3 area VME has been improving:

- Front-end computer (FEC)
- Operating system: real-time OS
- Back plane communication

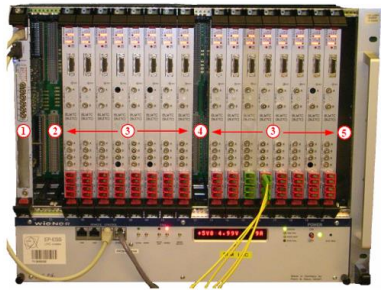


Architecture of ATCA or microTCA

Challenges for VME system

1. VME protocol is based on master-slave communication: backplane is shared by all VME boards -- basically this is a sequential operation.
2. When new devices, such as FPGA, is more powerful, each VME module can have huge parallel computing power. How to release each module's computing power ?
3. FPGA is a hard real-time operating system. It can process all the fast data. Do we still need real-time operating system on the FEC ?
4. FEC and RTOS support become challenging.

VME



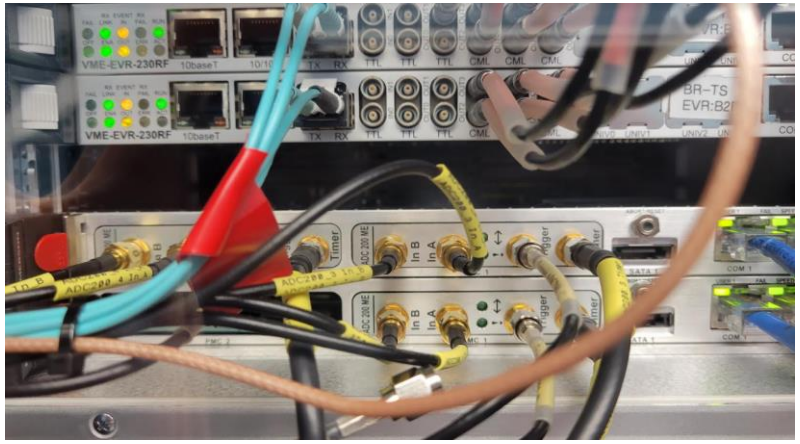
Replaced by

ATCA or microTCA

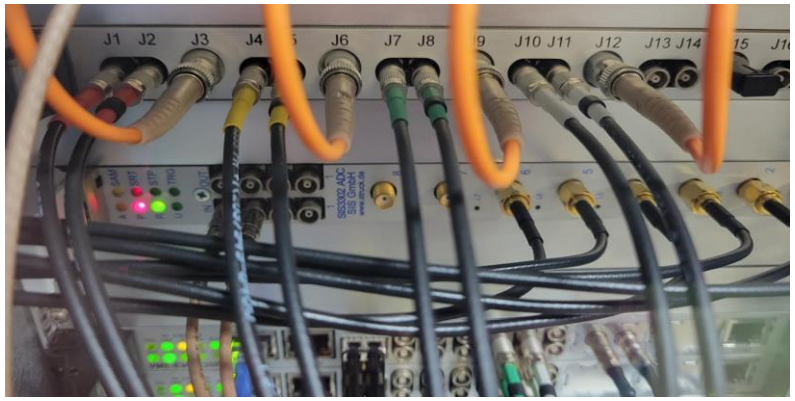
Figure 3. Typical 12-slot MicroTCA Shelf

But, how to upgrade for the existing VME modules without being fully replaced by uTCA ?

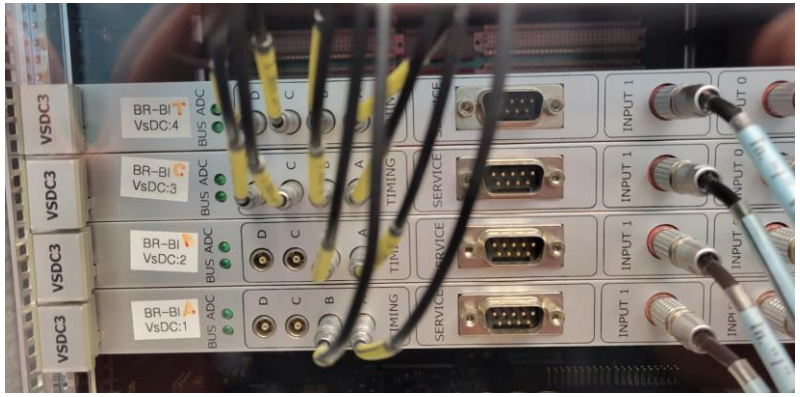
VME modules at NSLS-II and upgrade plan



MRF EVR and 200MSPS ADC (obsolete)



Struck 16-channel 100MSPS ADC



4-channel 1MSPS ADC cards (obsolete)

VME system obsolete issues:
- FEC
- OS support
- VME module

Upgrade path

Design new boards:
- No need to communicate with FEC through backplane.
- Each module has own Ethernet port for communication.
- Use VME form factor for one-to-one replacement.
- Only use power/ground from the VME backplane.
- ERV to Ethernet.

VM2E: common platform for legacy VME module upgrade

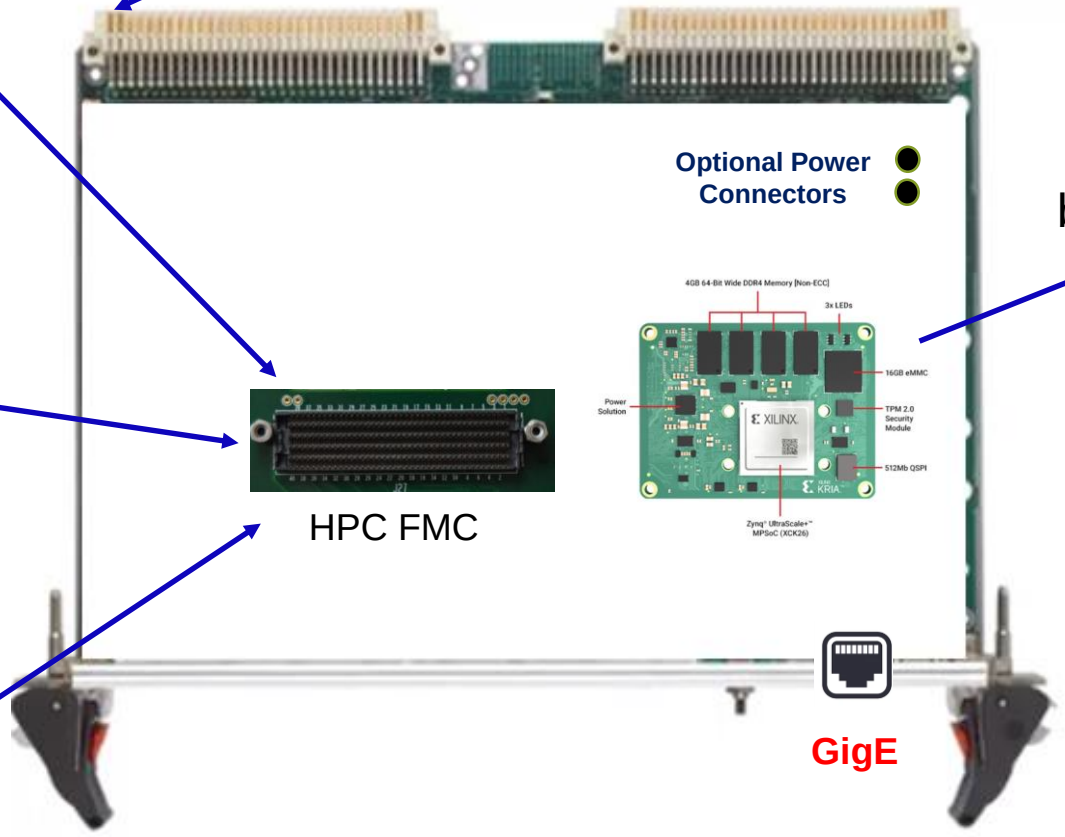
FMC215: 12bit 4GPS ADC and 12bit 4.5GSPS DAC

2-channel 500MSPS ADC

16 channel input and 16 channel output

FMC ecosystem

DC power and ground



back

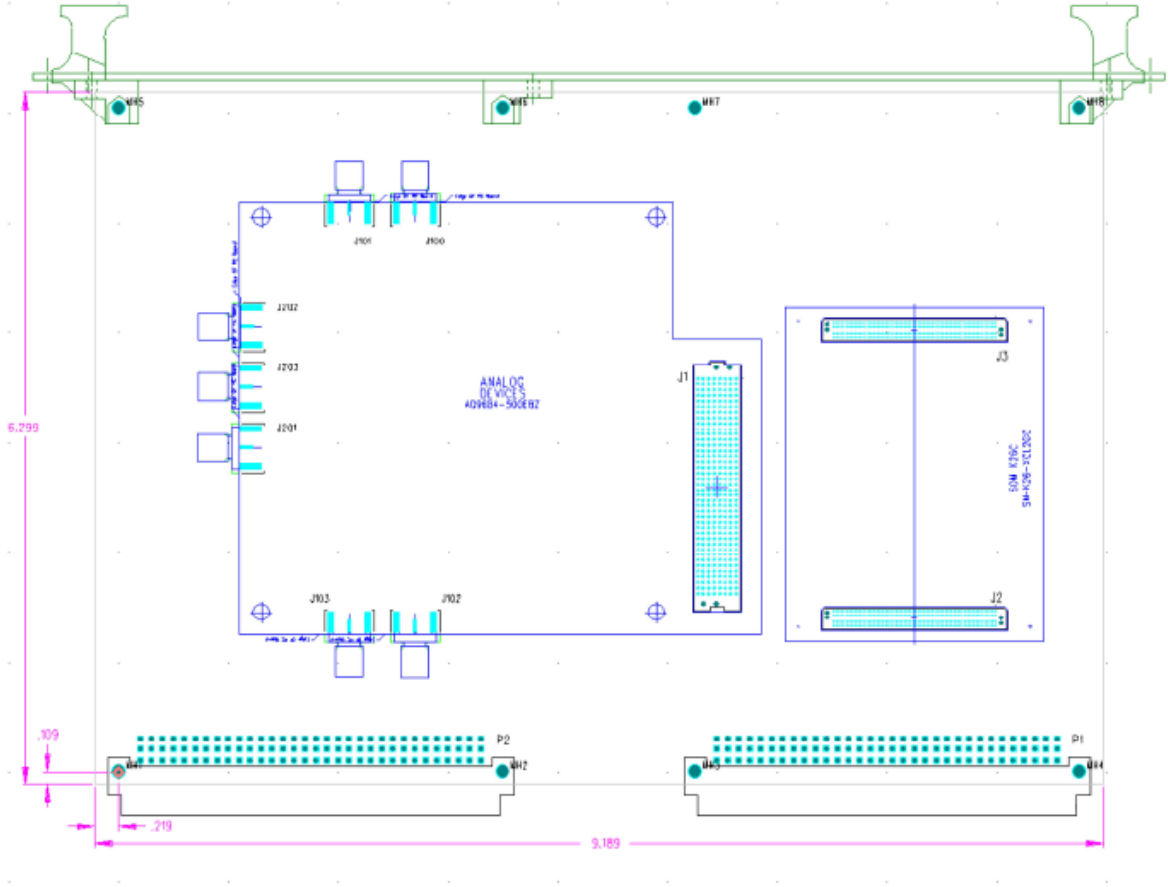
Xilinx ultrascale+ SOM (Kira26)

- Low cost (~$300)
- 4GB DDR4 for waveform storage
- 256K logic cells
- 64-bit quad-core arm A53
- 1Gb to 40Gb Ethernet
- 26.6Mb SRAM
- 4 12.5Gb/s GTH transceiver
- 1248 DSP48 blocks
- 1.4 TOPS
  (Trillions Operations per Second)
- 245 IO

Xilinx SOM ecosystem

Design goal: common FPGA board with VME form factor
→ Common platform for legacy VME module upgrade

VM2E modules status



Status

- Project is founded in March, 2023.
- PCB design on going.
- SOM, ADC purchased.
- FPGA design in progress.
- EPICS driver (pscDrv).
- EPICS IOC: in program.
- CSS page: will be same as the existing pages.

Summary

- VME system was a huge success.
- VME communication protocol is master-slave based mode. It can be upgraded to switch-based communication such as ACTA/microTCA.
- When ACTA/microTCA is not applicable, in-place upgrade using FPGA/Ethernet could remove the obsolescence issues of FEC and the operating system.
- Latest FPGA SOM and HPC FMC will make the design a common platform for legacy VME module upgrade.
- VM2E: common hardware platform for in-place upgrade.