



CNPq

Brazilian Center for Research
in Energy and Materials



Brazilian Synchrotron
Light Laboratory

Status of MicroTCA.4 Technology at Sirius

MTCA Workshop 2020 – Hamburg (Virtual)

Daniel Tavares

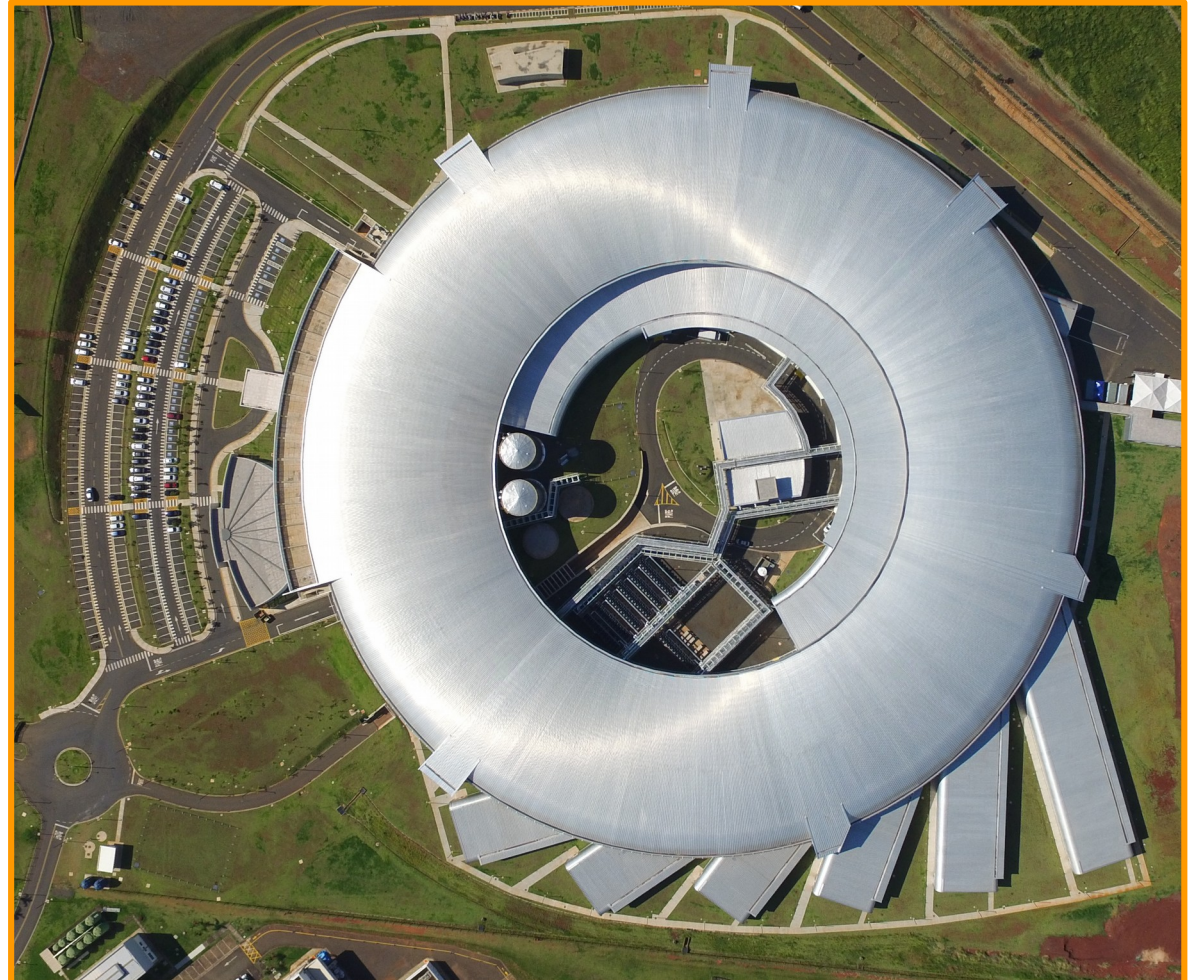
December 1st, 2020

Outline

- MicroTCA.4 at Sirius
- AMC FMC Carrier
- New Developments and Highlights
- openMMC
- Integration to Control System
- Operations Experience
- Conclusion

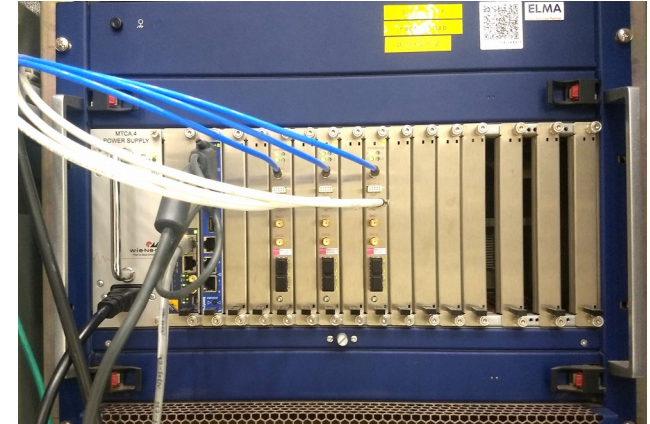
Sirius

- 4th generation synchrotron light source
- Natural emittance 0.25 nm.rad at 3 GeV
- Diffraction-limited for 10 keV photons

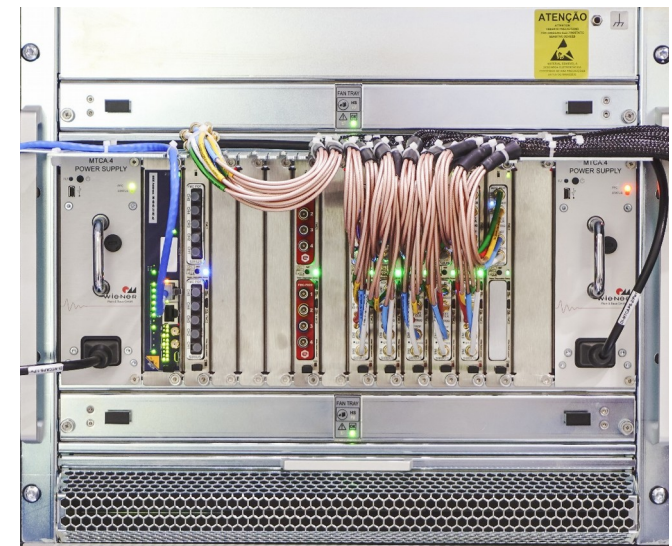


- **LINAC LLRF Crate – provided by SINAP**
 - 3x Struck SIS8300-L2
 - 3x Struck DRTM-DWC8VM1
 - FPGA gateware and software provided by SINAP
- **BPM Electronics and Orbit Feedback Crate**
 - Pentair/Schroff 12-slot Crate with JSM
 - N.A.T. PHYS80 MCH + μ RTM COMex CPU
 - Wiener Low Noise 1 kW Power Supply (redundant)
 - CAENels FMC-Pico-1M4
 - CAENels FMC-4SFP+
 - **Open Hardware AMC FMC Carrier (AFC)**
 - **Open Hardware FMC ADC 16-bit 250 MS/s**
 - **Open Hardware FMC POF (plastic optical fiber)**
 - **Open Hardware μ RTM 8-SFP**
 - **Open Hardware RTM Fast Orbit Corrector Power Supply**
 - **Open source MMC firmware (openMMC)**
 - **Open source gateware and software for controls and data acquisition**

Linac LLRF
1 crate



BPM and FOFB
21 crates



• AMC FMC Carrier (AFC)

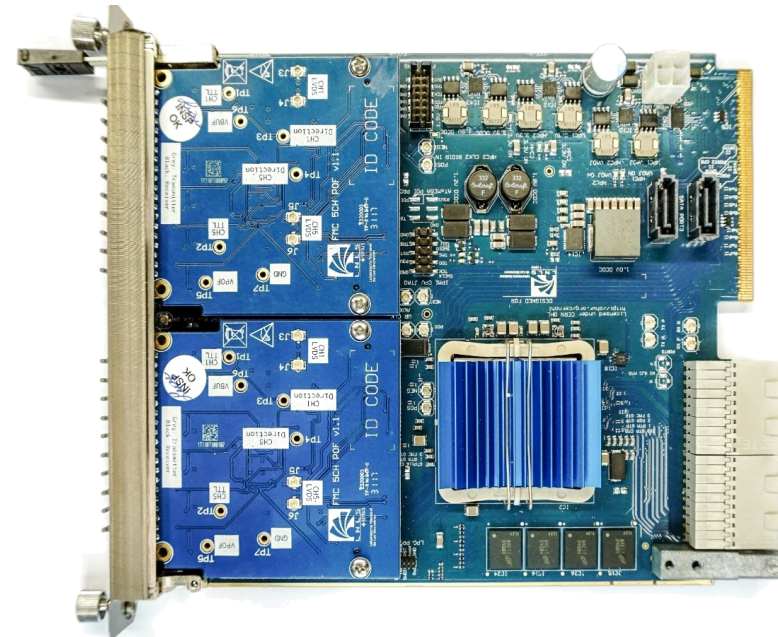
- Cheap: based on Xilinx Artix-7 200T (< 200 USD)
- Versatile: 2x HPC FMC slots, RTM D1.3 slot, flexible clocking scheme, 2 GB DDR3 memory
- Open Hardware design available at: <https://www.ohwr.org/project/afc>

• AFC v3.1

- Needed design improvements
- Recent evaluation from MTCA TechLab orded by GSI

• AFC v4

- **The project is led by WUT (Mikolaj Sowinski, Tomasz Przywózki and Grzegorz Kasprowicz)**
- Clean up and other improvements on schematics
- Replace the JTAG switch (SCANSTA111) with a simpler mechanism to allow access to FMC JTAGs
- Simplification of I²C bus
- Replace ADN4604 (16x inputs, 16x outputs) clock crossbar by IDT 8V54816A (16x bidirectional input/outputs)
- Reduce board thickness
- Provide alternative assembly option:
 - Option 1: 2x HPC FMC slots + partially pin assigned RTM
 - Option 2: 1x HPC FMC slot + 1x LPC FMC slot + fully pin assigned RTM slot
- M-LVDS circuit improvement: higher speed, lower skew



GSI AFC PCIe issue investigation

B. Issues found on AFC Board

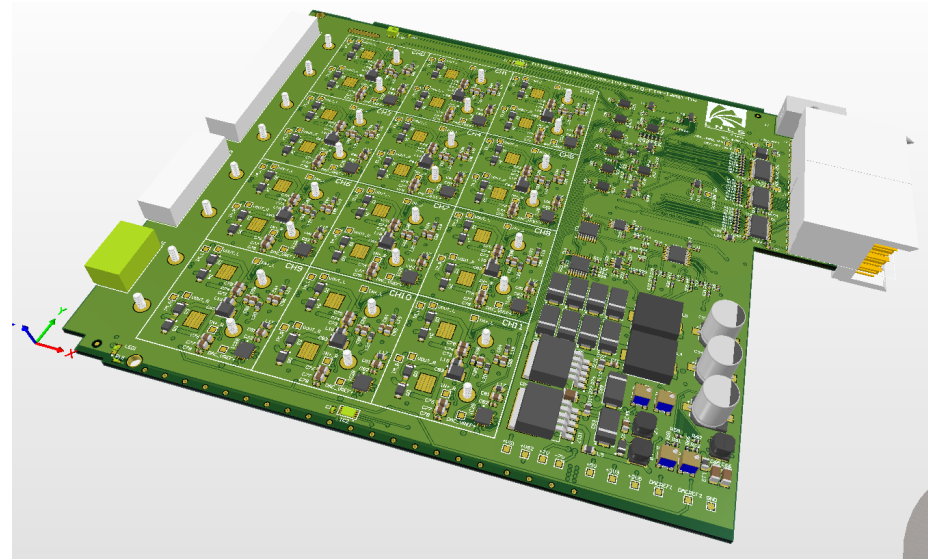
During the measurement/investigation session, many issues of the AFC board were identified that lead to reduced board performance.

Issue	Effect
Wrong termination voltage on clock multiplexer	wrong duty cycle/excessive jitter (not observed)
Clock distribution via passive unmatched Y-branch	reflections and marginal signal integrity on clock line (observed)
Connection between chassis and logic ground	violation of the standard, return currents via front panel
Inadequate filtering on MGTAVTT power rail (described before)	excessive noise on transceiver power (observed)
Inadequate layout for MGTAVTT power rail: single via (described before)	insufficient transient load regulation (not observed)
Shared power rail of MGTAVCC and FPGA core power (described before)	excessive noise on transceiver power (observed)
Board thickness violation	violation of the standard
Wrong pull-up resistors for Si570	Si570 can not be programmed
Current leaking between 3V3MP and 12VPP	startup issues of components (not observed)

Courtesy Tobias Hoffmann (GSI)

- **Specifications:**

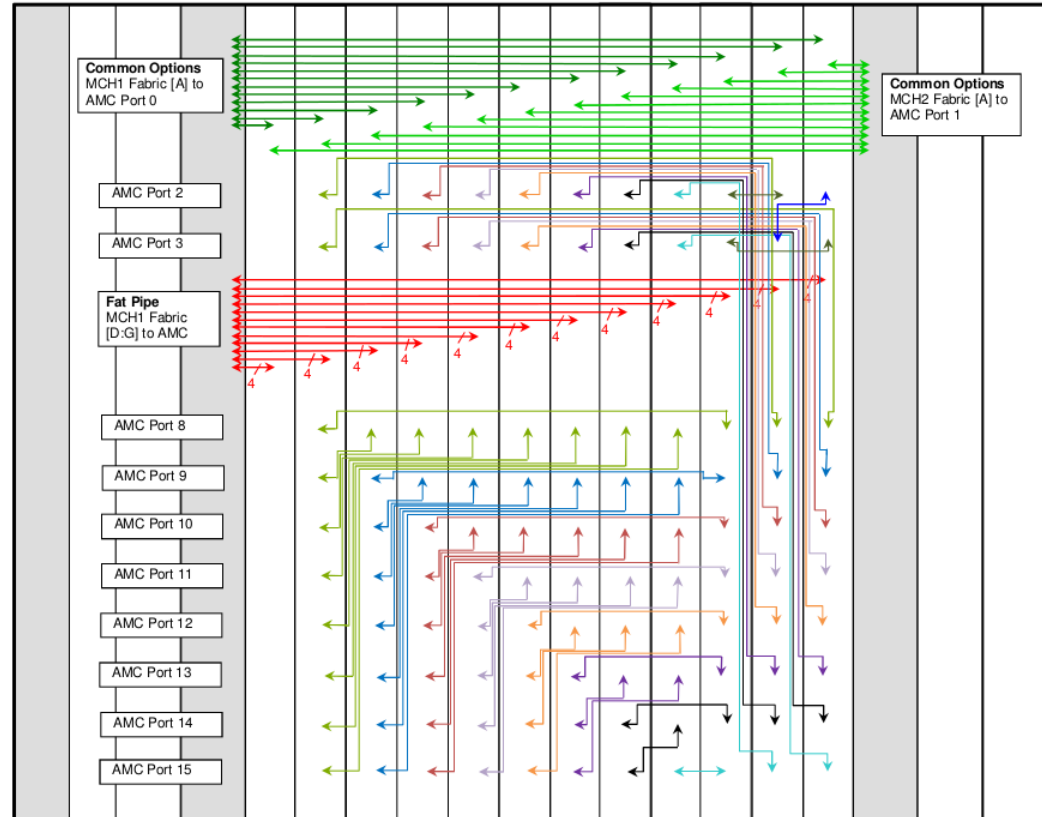
- 12 channels
- ± 1 A per channel
- 10 kHz small signal bandwidth
- Nominal Load: $1\ \Omega$, 3.5 mH
- Designed to comply with the MicroTCA RTM specification
- High efficiency DCDC converter ($> 92\%$)
- Supports an external 12V power for applications that require more than 36W
- Can be assembled with a heat sink if necessary
- First prototype boards expected to arrive at the end of January 2021



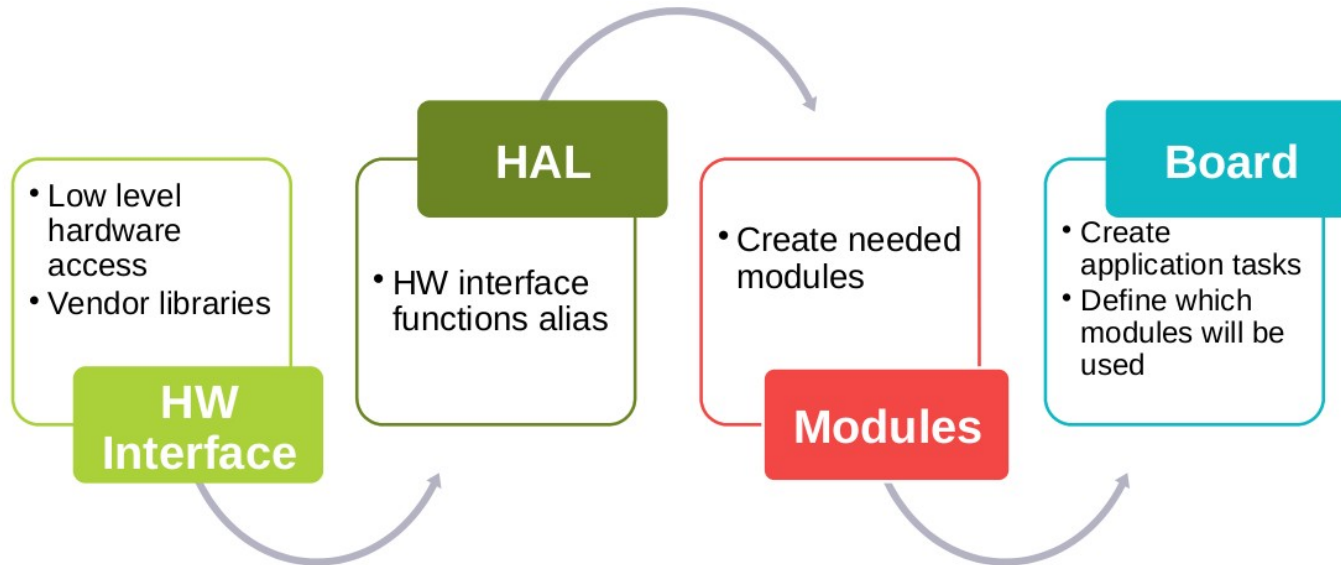
- Open Hardware design available at:

- Hardware: <https://github.com/Inls-dig/rtm-lamp-hw>
- Gateware: <https://github.com/Inls-dig/rtm-lamp-gw>

- 11-slot full mesh on AMC ports 2-3 and 8-15



Courtesy Schroff

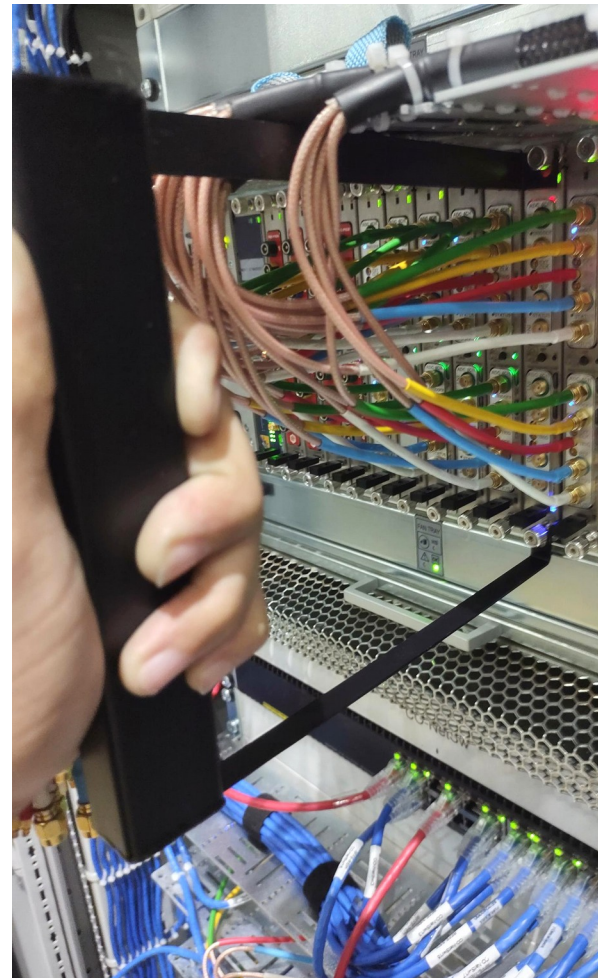


- **openMMC has been adopted by other facilities**
 - openMMC is built on top of FreeRTOS
 - Adopted by Sirius and CERN – collaborative development
 - GPL code available at: <https://github.com/Inls-dig/openMMC>

- Tool for removing AMC modules



Gustavo Bruno
Fernando Cambaúva
Ricardo Fujihira



- **Heidelberg University's epics-ipmitool [1]:**

- Depends on external ipmitool
- Template EPICS database created via iocsh command `ipmiDumpDatabase`
- Seems unmaintained

- **SLAC's ipmiComm [2]:**

- No external dependencies (only the typical asyn)
- Predictable EPICS database templates already in place
- Little support at the time (2018-2019)
- Maintained by SLAC and other partners

- **FRIB's mtca-ipmi [3]**

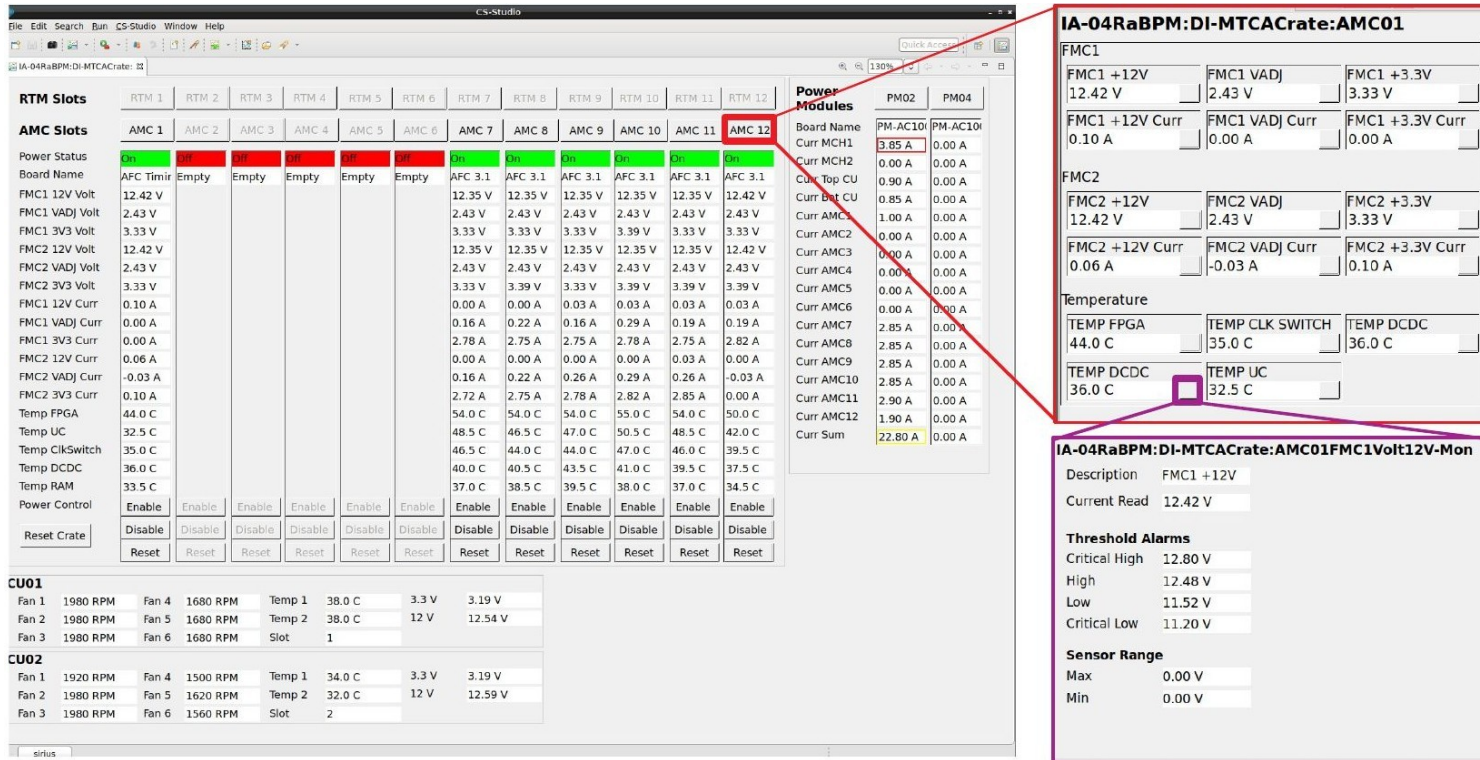
- Depends on external ipmitool (breaks compatibility with each version)
- EPICS database templates already in place
- Maintained by FRIB
- Easiest to setup and use (with example GUI for 12-slot crate)

[1] <https://github.com/sus-ziti-uni-hd/epics-ipmitool>

[2] <https://github.com/slac-epics-modules/ipmiComm>

[3] https://github.com/frib-bim/mtca_ipmi

- FRIB's mtca-ipmi was selected to use at Sirius:
 - But still searching for a module non-dependant of ipmitool
 - SLAC module (and others) could be revisited in the future



RTM Slots

	RTM 1	RTM 2	RTM 3	RTM 4	RTM 5	RTM 6	RTM 7	RTM 8	RTM 9	RTM 10	RTM 11	RTM 12
AMC Slots	AMC 1	AMC 2	AMC 3	AMC 4	AMC 5	AMC 6	AMC 7	AMC 8	AMC 9	AMC 10	AMC 11	AMC 12
Power Status	On	Off	Off	Off	Off	Off	On	On	On	On	On	On
Board Name	AFC Timir	Empty	Empty	Empty	Empty	Empty	AFC 3.1	AFC 3.1	AFC 3.1	AFC 3.1	AFC 3.1	AFC 3.1
FMC1 12V Volt	12.42 V						12.35 V	12.35 V	12.35 V	12.35 V	12.35 V	12.42 V
FMC1 VADJ Volt	2.43 V						2.43 V	2.43 V	2.43 V	2.43 V	2.43 V	2.43 V
FMC1 3V3 Volt	3.33 V						3.33 V	3.33 V	3.33 V	3.39 V	3.33 V	3.33 V
FMC2 12V Volt	12.42 V						12.35 V	12.35 V	12.35 V	12.35 V	12.35 V	12.42 V
FMC2 VADJ Volt	2.43 V						2.43 V	2.43 V	2.43 V	2.43 V	2.43 V	2.43 V
FMC2 3V3 Volt	3.33 V						3.39 V	3.33 V	3.39 V	3.39 V	3.39 V	3.39 V
FMC1 12V Curr	0.10 A						0.00 A	0.00 A	0.03 A	0.03 A	0.03 A	0.03 A
FMC1 VADJ Curr	0.00 A						0.16 A	0.22 A	0.16 A	0.29 A	0.19 A	0.19 A
FMC1 3V3 Curr	0.00 A						2.78 A	2.75 A	2.75 A	2.78 A	2.75 A	2.82 A
FMC2 12V Curr	0.06 A						0.00 A	0.00 A	0.00 A	0.00 A	0.03 A	0.00 A
FMC2 VADJ Curr	-0.03 A						0.16 A	0.22 A	0.26 A	0.29 A	0.26 A	-0.03 A
FMC2 3V3 Curr	0.10 A						2.72 A	2.75 A	2.78 A	2.82 A	2.85 A	0.00 A
Temp FPGA	44.0 C						54.0 C	54.0 C	54.0 C	55.0 C	54.0 C	50.0 C
Temp UC	32.5 C						48.5 C	46.5 C	47.0 C	50.5 C	48.5 C	42.0 C
Temp ClkSwitch	35.0 C						46.5 C	44.0 C	44.0 C	47.0 C	46.0 C	39.5 C
Temp DCDC	36.0 C						40.0 C	40.5 C	43.5 C	41.0 C	39.5 C	37.5 C
Temp RAM	33.5 C						37.0 C	38.5 C	39.5 C	38.0 C	37.0 C	34.5 C
Power Control	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable
Reset Crate	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable	Disable
	Reset	Reset	Reset	Reset	Reset	Reset	Reset	Reset	Reset	Reset	Reset	Reset

Power Modules

	PM02	PM04
Board Name	PM-AC10	PM-AC10
Curr MCH1	3.85 A	0.00 A
Curr MCH2	0.00 A	0.00 A
Curr Top CU	0.90 A	0.00 A
Curr Bot CU	0.85 A	0.00 A
Curr AMC1	1.00 A	0.00 A
Curr AMC2	0.00 A	0.00 A
Curr AMC3	0.00 A	0.00 A
Curr AMC4	0.00 A	0.00 A
Curr AMC5	0.00 A	0.00 A
Curr AMC6	0.00 A	0.00 A
Curr AMC7	2.85 A	0.00 A
Curr AMC8	2.85 A	0.00 A
Curr AMC9	2.85 A	0.00 A
Curr AMC10	2.85 A	0.00 A
Curr AMC11	2.90 A	0.00 A
Curr AMC12	1.90 A	0.00 A
Curr Sum	22.80 A	0.00 A

IA-04RaBPM:DI-MTCAcrate:AMC01

FMC1

FMC1 +12V	12.42 V	FMC1 VADJ	2.43 V	FMC1 +3.3V	3.33 V
FMC1 +12V Curr	0.10 A	FMC1 VADJ Curr	0.00 A	FMC1 +3.3V Curr	0.00 A

FMC2

FMC2 +12V	12.42 V	FMC2 VADJ	2.43 V	FMC2 +3.3V	3.33 V
FMC2 +12V Curr	0.06 A	FMC2 VADJ Curr	-0.03 A	FMC2 +3.3V Curr	0.10 A

Temperature

TEMP FPGA	44.0 C	TEMP CLK SWITCH	35.0 C	TEMP DCDC	36.0 C
TEMP DCDC	36.0 C	TEMP UC	32.5 C		

IA-04RaBPM:DI-MTCAcrate:AMC01FMC1Volt12V-Mon

Description FMC1 +12V

Current Read 12.42 V

Threshold Alarms

Critical High	12.80 V
High	12.48 V
Low	11.52 V
Critical Low	11.20 V

Sensor Range

Max	0.00 V
Min	0.00 V

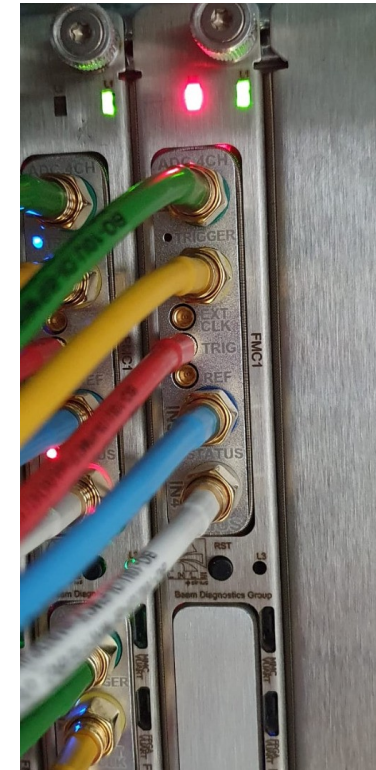
CU01

Fan 1	1980 RPM	Fan 4	1680 RPM	Temp 1	38.0 C	3.3 V	3.19 V
Fan 2	1980 RPM	Fan 5	1680 RPM	Temp 2	38.0 C	12 V	12.54 V
Fan 3	1980 RPM	Fan 6	1680 RPM	Slot	1		

CU02

Fan 1	1920 RPM	Fan 4	1500 RPM	Temp 1	34.0 C	3.3 V	3.19 V
Fan 2	1980 RPM	Fan 5	1620 RPM	Temp 2	32.0 C	12 V	12.59 V
Fan 3	1980 RPM	Fan 6	1560 RPM	Slot	2		

- **μRTM COMex CPU gets stuck from time to time**
 - No entries in syslog and persistent logs in systemd-journald
 - No crash dump when using kdump
 - MCH notices no failure – all sensors are good
 - No ping response, no display port nor USB ports activity
- **MCH gets stuck from time to time**
 - ssh, telnet and web interface is unresponsive
 - Only restored after power cycle
- **AFC spontaneous resets**
 - Sporadic power cycle
 - Reconfigures FPGA
 - PCIe link goes down and up
- **AFC loses communication with MCH**
 - Only recoverable by **hard_reset** command
- **One of a kind mysterious event**
 - AFCs from 3 distant crates (different machine sectors) simultaneously fail
 - MCH reports overcurrent when trying to power cycle the boards – **hard_reset** doesn't help
 - Only recovered when redundant Power Module was manually powered on – remote commands have no effect



- **MTCA.4 crates are routinely used in operations of all Sirius machines**
 - Linac: LLRF
 - Transfer lines, booster and storage ring: electron and photon BPMs, Fast Orbit Feedback, energy ramp power supplies' timing
- **Standardized hardware platform allowed system evolution by mixing open hardware and COTS modules**
- **Open source MMC code (openMMC) was key to improve system reliability**
- **Special 11-mesh backplane for low latency feedbacks**
- **New developments:**
 - RTM Fast Orbit Corrector Power Supply – RTM-LAMP
 - Module mechanical extractor
 - AFC v4 (led by WUT)
- **Many open issues to be tackled – machine operations are significantly impacted by MTCA.4 crates failures**

Thank you!



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